ENGINEERS AND CLIMATE CHANGE: WHAT YOU NEED TO KNOW

There's no doubt about it: Climate change *is* happening. But what are the implications for engineering, and how will engineers take this new dynamic into account in ways that are cost effective and protect the public?

BY DAVID LAPP, P.ENG.

Florida experienced four hurricanes in a span of six weeks this past fall. Edmonton had two once-in-100-years storms in two weeks, followed by a hail storm that required backloaders to clear away the debris. Something is going on. But what?

The "what" behind these weather events is climate change, an emerging issue that will become an integral part of many areas of engineering practice. While the full implications are not yet known, engineers will need to consider the impact of climate change on engineering works in the interests of public health, safety and welfare–the cornerstones of professional engineering.

Factor	Temperature	Timescale
Greenhouse gases	Increase	Decades/centuries
Ozone depletion	Increase	Decades/centuries
Tropospheric aerosols/sulphur	Decrease	Weeks
Volcanic activities	Decrease	Years
Nuclear explosions/asteroids	Decrease	Immediate
Land use changes	Either	Varies
Changed solar output	Either	Varies
Ocean circulation	Either	Varies

Figure 1: Impact on global temperatures

What is climate change?

Climate change is concerned with changes in key climate variables: temperature, precipitation, atmospheric moisture, snow cover, sea level and the extent of land and sea ice. It also involves the changing patterns in atmospheric and oceanic circulation, extreme weather events and long-term climate trends.

Climate change is affected by radiation that is received or retained in the atmosphere, and the redistribution of energy within the atmosphere and among the atmosphere, land and oceans. Greenhouse gases (GHGs) have long been blamed for climate change, of course. But many other natural and human factors, such as volcanic activity and tropospheric aerosols (very fine particulate suspended in air), and the combustion of fossil fuel, have an impact on global temperatures, too. How all of these factors affect climate change varies (Figure 1).

Is it really happening?

Climate change is a naturally occurring phenomenon and Earth has experienced many different climate regimes throughout geological history. The question is whether what's happening now is really different than this naturally occurring phenomenon. The answer is yes.

Ice cores tell the story. Ice cores show a direct relationship between atmospheric temperature changes and changes in GHG levels. During the past 10,000 years or so, atmospheric CO_2 concentrations have remained at close to the typical interglacial concentration of 280 parts per million (ppm). However, about 200 years ago things began to change. Concentrations of GHGs began to increase rapidly, primarily due to emissions from the combustion of fossilized carbon in coal, oil and natural gas and, to a lesser extent, land use change activities (Source: CDIAC website at http://cdiac.esd.ornl.gov/trends/trends.htm). Today, concentrations are at about 375 ppm–more than 30 per cent above pre-industrial era levels. This concentration appears to be unprecedented in the 400,000-year ice-core records, and has catapulted us so far out of the known historical ranges that we're not sure what all of the impacts will be.

Some impacts are beginning to show, however. The global mean surface temperature of the Earth (combined land/ocean) is rising. Between 1919 and 1945 there was a pronounced warming, followed by a modest cooling between 1945 and 1975. Since then, there has been a return to rapid warming, and the rate of warming for the past 30 years is somewhat greater than for the earlier warming period. So, what does all of this mean? Simply, that the world is going to become much, much warmer during this millennium. Even with the most optimistic estimate, the projected warming by 2100 is likely to be unprecedented in human history.

Sea ice will retreat, particularly in summer. Sea levels will rise due to thermal expansion of the warmer water, receding mountain glaciers and large-scale melting of the polar ice sheet. The Intergovernmental Panel on Climate Change (2001) estimates a global sea level rise of between 9 and 88 cm by 2100. Due to the slow response of oceans to climatic changes, sea levels will continue to rise for centuries, causing many flooding events. Extreme weather events will increase in frequency and intensity. Climate change impacts and effects will be highly variable and localized. Some areas are projected to be colder than at present, but overall and in some areas our temperatures will be warmer.

At what cost?

The cost of climate change to society is difficult to predict, but there are some indicators. For example, insurance claims for property loss have grown exponentially since the 1950s, and 85 per cent of them are weather-related. According to Bruno Porro, chief risk officer, Swiss Re, "The world is entering a future in which risks are more concentrated and more complex. That is why we are pressing for policies that reduce those risks through preparation, adaptation and mitigation. That will be cheaper than covering tomorrow's losses after disaster strikes."

Implications for engineering

As engineers, we don't necessarily care why climate change is happening. We just need to know that it is, because there will be many implications. For example, there will be increased capacity demands on sewage and water control, pressures on source water resources, and degraded water quality. Climate change will have social and economic impact (e.g. tourism and recreation). The consequences for human health may include more vector- and water-borne diseases, extreme heat and cold events, and deteriorated air quality. In terms of the environment, there may be changes in the frequency of forest fires, disease, insect infestation, and the nature of and distribution of forests. Some plants and animals may be stressed to the point of extinction.

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Because so much of the world will be affected, so too will much of the engineering profession. Most engineering disciplines will be touched by climate change, including civil, geotechnical, municipal, environmental, hydrotechnical, mining, materials, and structural. This is by no means an exhaustive list.

Specifically, climate change will have major effects on the development of building standards and environmental regulations. In turn, engineers will have to learn to interpret these new standards and regulations properly.

Building condition and monitoring will change, and so will the whole building design approach, including risk management (screening, evaluation and retrofitting for existing buildings).

It will not be enough for research and development to focus just on technically acceptable solutions, but it will also have to have a greater focus on financially and socially acceptable solutions that have environmental benefits.

It will be necessary to consider the impact of climate change on the design life of engineering works. Works with a design life of 20, 30 or 50 years will likely see significant changes in the climate in their lifetimes–changes that will need to be considered in their design and operation over a complete life cycle.

Mitigation and adaptation

Addressing climate change through engineering will require a combination of two strategies. The first, mitigation, will slow the rate of climate change and may take the form of new techniques in the design, construction, maintenance and renewal of buildings for the purpose of reducing GHGs. The second, adaptation, will require the adjustment of systems in response to actual or expected climate changes. This, too, will require the use of new techniques for the design, construction, maintenance and renewal of buildings, but with the objective of preparing for the increased probability and consequences of severe natural hazards as a result of climate change.

All parties to the UN Framework Convention on Climate Change (Kyoto) have a requirement under articles 4.1 and 4.8 to assess their national vulnerability and develop strategies for adaptation to climate change. They are also required to invest in climate research and integrated risk assessment, and to communicate this knowledge both nationally and internationally. The first report is due this year.

The Conference Board of Canada, one of Canada's foremost independent organizations in the areas of applied research in economic trends and public policy issues, concluded in a recent report that, “Canada will continue to experience the impacts of climate change regardless of any actions it takes to reduce its own emissions. It will, therefore, be important to provide adequate resources for adaptation: actions that can assist communities and regions that are likely to suffer the negative impacts of a changing climate.”

Some examples of adaptation strategies that engineers will want to consider include:

- developing an approach and practices for protecting and improving existing construction against effects of climate change;
- developing an approach and practices for design, operation and maintenance of new buildings (such as additional cooling requirements in the summer and heating in the winter);
- revising codes, such as flood plain mapping, climate data and return frequencies for hazard-prone areas to adjust to new realities (e.g. higher snow and wind loads, once-in-100-years floods that have become once-in-10-years floods);
- considering land use restrictions on new construction, especially for flood plains, coastal shoreline and landslide-prone areas.

Some strategies may not directly involve engineering, but will be influenced by engineering (e.g. planning decisions). Key for engineers considering adaptation strategies is to define the risks and to make choices based on them. A risk-management process facilitates the selection of adaptation strategies by providing a framework for managing them.

CAN/CSA Q850-97 *Risk Management Guideline for Decision-Makers–A National Standard for Canada* is a useful guide that defines the terms and lays out the steps of the risk-management process in Canada. The challenge will be how to deal with the issue of uncertainty in climate change projections for design. Risk assessment will be a key element in dealing with this issue.

CCPE action plan

The Canadian Council of Professional Engineers' (CCPE) Climate Change Impacts and Adaptation Action Plan (CCAP) was developed by the Environment and Sustainability Committee of the Canadian Engineering Qualifications Board. It is based on the results of the Climate Change Impact and Adaptation Workshop–*Adapting to Climate Change–the Role of Canada's Engineers*, February 2003.

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CCPE is also working in partnership with all 12 associations/ordre on climate change adaptation, and with federal, provincial and municipal governments on the CCAP. The action plan was approved by the CCPE board of directors in February 2004.

Strategies include educating engineering students and professional engineers, and raising awareness of the profession, industry, decision makers and the public on the need to consider the impacts of climate change. CCPE will actively seek out experts who can help the profession increase its awareness of climate change and its potential impact.

The plan's goals also include developing standards and codes of practice to incorporate into engineering design, and establishing formal, sustained links between scientists and engineers.

Another particularly important strategy is to put together engineering infrastructure expert working groups to identify and recommend research, development and pilot/demonstration projects. These working groups will assist in reviewing existing national codes, standards, policies and practices, and provide advice to federal government departments.

Engineers must adapt

Climate change is inevitable. Mitigation may slow the rate of climate change, but nothing will reverse current trends. So, as engineers, we have no choice but to incorporate climate change into our practice to adapt and serve the public interest in terms of health, safety and welfare. After all, it is our ethical obligation. Climate change will be a challenge, but it may also offer an opportunity for great engineering innovations.

For more information

- www.climatechange.gc.ca
- www.ec.gc.ca/climate (Environment Canada)
- www.adaptation.nrcan.gc.ca (Natural Resources Canada)
- www.c-ciarn.ca (Climate Change Impacts and Adaptation Research Network)
- www.cics.uvic.ca (University of Victoria Canadian Institute for Climate Studies)
- www.csa.ca (Canadian Standards Association)
- www.infrastructurecanada.gc.ca
- www.ipcc.ch (Intergovernmental Panel on Climate Change)
- www.unfccc.int (Kyoto Protocol)
- www.climatechangecentral.com (Climate Change Central)

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