1. Climate Change and the Built Environment

Is there really such a phenomenon as climate change? Is it, as some have said, simply a natural occurrence over which we have no control? Or does human activity—from vehicles, buildings, power plants, industry, etc.—contribute to or even cause climate change?

Furthermore, if climate change—natural or man-made—is taking place, how serious a threat is it to humanity, the environment, the world economy? And, assuming that climate change is a threat, what, if anything, can we do to mitigate it or, if possible, eliminate it altogether? And what role, in particular, should those responsible for designing, constructing, owning, and developing homes and buildings play in such an effort?

In this, our sixth White Paper on Sustainability, the editors of *Building Design+Construction* offer what we trust is an objective overview of climate change and what it means to those who shape the built environment—architects, engineers, builders, property owners, and real estate developers. Beyond merely providing information, however, we have set ourselves the task of offering practical suggestions—an Action Plan—to engage AEC professionals and firms in addressing climate change.

Our cause has been driven by a rapidly accelerating sense of urgency, which derives from three basic facts. First, it has been established beyond a reasonable doubt that the planet is heating up at a rate that could prove disastrous to humanity and the natural world in a relatively short period of time. Further, it has become increasingly likely, based upon intense scientific review and analysis over the last 20 years, that human activity is the primary source of the problem. Finally, there is the growing sense that without timely human intervention, the situation could prove catastrophic.

It is equally clear that the built environment plays a significant role in contributing to climate change, and that those who are responsible for creating the built environment can—and must—take a leadership role in solving the climate crisis. As we shall see, no matter where you stand personally on the social, economic, political, or environmental issues related to climate change, you will soon have no choice but to factor it into your professional work. That is because federal agencies, state and local governments, Fortune 1000 corporations, real estate developers, tenant representatives, property brokers, and building owners soon will demand to know your experience and expertise in addressing climate change before awarding projects to your firm. You can also expect to see greater emphasis on climate change in building and energy codes and regulations. In many respects, these events are already starting to unfold.

The editors will support the above statements with what we believe to be the most objective information and analysis we can provide. With these consider-

1. Second Assessment Report, Summary for Policy Makers, p. 412. "Aerosols" refers to tiny particles that float in the air, including sulfur emissions from coal-fired power plants.

2. "Science Panel Calls Global Warming 'Unequivocal,'" The New York Times, 3 February 2007.

Scope and Purpose of the White Paper

Because climate change is such an extremely wide-ranging subject, the editors wish to make it clear what we hope to achieve with this White Paper, what we cannot do, and how we can most benefit our readers.

First, we are not climatologists, so we will be relying heavily on the expertise of the 1,250 scientists and 2,500 technical reviewers who contributed to the Intergovernmental Panel on Climate Change's Fourth Assessment Report. This report, known as IPCC AR4, spans three volumes totaling 2,823 pages and weighs in at over 18 pounds—plus a 73-page "synthesis" report. AR4 represents the consensus not only of the scientific community, but also of the 113 national governments (including the United States) that signed off on it. The Fourth Assessment Report is hardly perfect, but we believe it to be the most scientifically valid and politically unbiased resource on climate change available today.

We have also been scrupulous in our efforts to avoid political partisanship and to separate the social, economic, ethical, and geopolitical aspects of climate change from the scientific and technical considerations. As this White Paper goes to press, the 2008 election process will be reaching its climax. We note that both Presidential candidates indicated their support for action on climate change during the election campaign.

Even though we recognize that many AEC professionals and firms that rely on us as an information resource are doing work in the Middle East, Eastern Europe, China, India, Russia, and other parts of the world, for logistical and practical reasons we have focused our geographic perspective on the U.S. and Canada.

Practical considerations also have prompted us to limit our discussion as much as possible to climate change as it relates to the built environment. This leaves many important issues related to climate change beyond our purview, including threats to biodiversity, rampant deforestation, human health impacts, Third World poverty, economic fairness between developed and developing nations, nuclear power safety, vehicle emission standards, and national security considerations, to name a few. We encourage our readers to become engaged in these issues, of course, but we must restrict our efforts to the chief goal of inspiring them to utilize their intellect, skills, and expertise to address climate change in their daily work as designers, builders, property owners, and developers.

ations in mind, let us turn to the scientific evidence on climate change.

The IPCC Reports on Climate Change

The U.N. Intergovernmental Panel on Climate Change was established by the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) in August 1988, toward the end of a summer marked by record heat waves, forest fires, and the first warnings by scientists of a new phenomenon they tentatively labeled "global warming." The IPCC was established to evaluate the best scientific research available and reach consensus, with the world's national governments, as to what the science said about climate change. The IPCC itself does not conduct original research.

In its first report, in 1990, the IPCC found evidence of global warming (the preferred term at the time) but could not support human intervention as a cause.

Five years later, however, in its Second Assessment Report (SAR), the IPCC issued a historic statement. The "balance of evidence," it said, "suggests a discernible human influence on global climate." The IPCC went on to say that "these results indicate that the observed trend in global mean temperature over the past 100 years is unlikely to be entirely natural in origin. More importantly, there is evidence of an emerging pattern of climate response to forcings by greenhouse gases and sulphate aerosols in the observed climate record. Taken together, these results point towards a human influence on global climate."[1] This was the first confirmation by the world's scientific community of an anthropogenic role in climate change.

The Third Assessment Report (TAR), issued in 2001, upped the ante. Earth had warmed 0.6°C (1°F) in the previous 50 years, the IPCC said, and it was now "likely" that human activity was largely responsible for the increase. In IPCC terms, a "likely" rating means a probability of 66-90%.

On 2 February 2007, in its Fourth Assessment Report (AR4), the IPCC was even more emphatic. Human influence on climate was now "very likely," meaning that the probability of an anthropogenic role in climate change was greater than 90%. "February 2 will be remembered as the date when uncertainty was removed as to whether humans had anything to do with climate change on this planet," said UNEP executive director Achim Steiner. "The evidence is on the table."[2]

Based on the IPCC Special Report on Emissions Scenarios (2000), the Fourth Assessment Report projected an increase of global GHG emissions by 25-90% between 2000 and 2030. [SYR/SPM, p. 7][3]

In terms of buildings, the Fourth Assessment Report found that between 1970 and 1990 direct emissions from buildings grew by 26% and remained at approximately 1990 levels thereafter. However, the IPCC stated, "the buildings sector has a high level of electricity use and hence the total of direct and indirect emissions in this sector is much bigger (75%) than direct emissions." [WGIII/SPM, p.3]

For North America (chiefly the U.S. and Canada), projected impacts could include the following:

- There would be more heat waves in cities that currently experience heat waves, and they would be more intense and last longer. These heat waves would bring with them the "potential for adverse health impacts," with the elderly "most at risk." [WGII/SPM, p.15]
- Warming in the mountain regions of the western U.S. and Canada would be projected to cause more winter flooding, decreased snowpack, and reduced summer stream flows. Competition for "over-allocated" water resources would be made worse.
- "Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution." Factors contributing to possible increased vulnerability of coastal areas: population growth and the "rising value of infrastructure." If the intensity of tropical storms increases, so, too, would losses. "Current adaptation is uneven and readiness for increased exposure is low," the report warned. [WGII/SPM, p. 15]
- There has been "observational evidence" of an increase in intense tropical cyclone activity [which includes hurricanes] in the North Atlantic since about 1970. This increase has been correlated with an increase in tropical sea surface temperatures. However, there has been "no clear trend" in the annual number of tropical cyclones. [WGI/SPM, p. 9]
- "Disturbances" from fire, pests, and diseases would

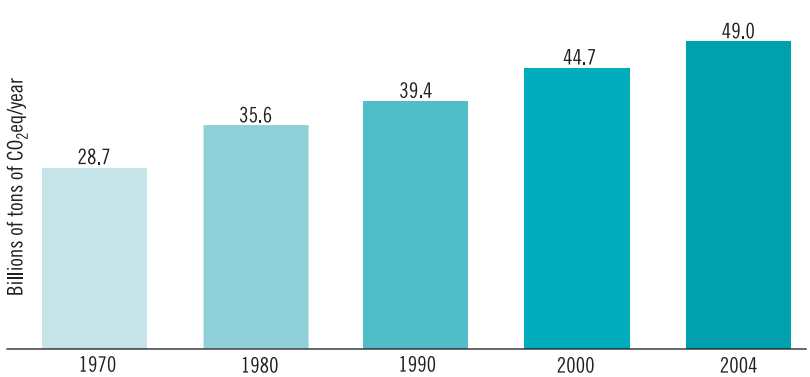
IPCC definition of climate change

Climate change in IPCC usage refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the U.N. Framework Convention on Climate Change, where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

Source: IPCC Working Group II, Summary for Policymakers, p. 6

3. We use the following abbreviations for the IPCC Fourth Assessment Report (AR4): SPM, "Summary for Policymakers"; "WGI" (Physical Science Basis), "WGII" (Impacts, Adaptation and Vulnerability), and "WGIII" (Mitigation of Climate Change) in reference to the reports of the three IPCC Working Groups; SYR, Synthesis Report.

Chart 1.1
Global Annual Emissions of Man-made Greenhouse Gases, 1970-2004



Source: Climate Change 2007: Synthesis Report, Summary for Policy Makers, fig. SPM.3, p. 5.

Global greenhouse gas (GHG) emissions due to human activities have grown since pre-industrial times (year 1750), with an increase of more than 70% between 1970 (28.7 billion tons of CO_2eq) and 2004 (49.0 billion tons).

impact forests more heavily, with "an extended period of high fire risk and large increases in area burned." [WGII/SPM, p. 14]

The Fourth Assessment Report concluded that a certain amount of warming was almost inevitable: about 0.2°C (0.4°F) per decade for the next two decades. Even if greenhouse gases and aerosol concentrations could be kept at year 2000 levels, a further warming of 0.1°C (0.2°F) per decade would be expected. [WGI/SPM, p. 12]

The IPCC warned, however, that continued GHG emissions at or above current rate would "cause further warming and induce many changes in the global climate system during the 21st century that would very likely [>90% chance] be larger than those observed during the 20th century." [WGI/SPM, p.13]

Upon release of the report in February 2007, Dr. John P. Holdren, then president of the American Association for the Advancement of Science, told the *New York Times*, "Since 2001, there has been a torrent of new scientific evidence on the magnitude, human origins, and growing impacts of the climatic changes that are under way." The Fourth Assessment Report "powerfully underscores the need for a massive effort to slow the pace of global climatic disruption before intolerable consequences become inevitable," said Holdren, director of the Woods Hole (Mass.) Research Center and Heinz Professor of Environmental Policy at Harvard's Kennedy School of Government.[5]

The Intergovernmental Panel on Climate Change did not leave the world high and dry, with no suggestion as to how to launch the "massive effort" called for by Holdren and many others. The IPCC Fourth Assessment Report includes an entire 851-page volume on *mitigation*—how to reduce GHG emissions—and another 976 pages on *adaptation*—how humankind could find ways to live with the greatest level of prosperity and health under various climatic scenarios. We'll consider some of these strategies as they relate to the built environment later in this White Paper.

Major Findings of the Fourth Assessment Report

The IPCC's Fourth Assessment Report fills nearly three thousand pages over three-plus volumes. For the purposes of this White Paper, we have consolidated the major findings of the report, known as AR4, as follows:

- Warming of the climate system is "unequivocal," based on observations of increases in average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. [SYR/SPM, p. 2]
- Eleven of the previous 12 years (1995-2006) ranked among the 12 warmest years on record (since 1850). [SYR/SPM, p. 2]
- The 100-year linear trend of 0.6°C (1°F) in the Third Assessment Report (1901-2000) was revised upward to 0.74°C (1.2°F) in AR4 (1906-2005). [SYR/SPM, p. 30]
- Global greenhouse gas (GHG) emissions due to human activities have grown since pre-industrial times (before 1750), with an increase of 70% between 1970 and 2004—from 28.7 billion tons of CO_2eq in 1970, to 49 billion tons in 2004. Emissions of carbon dioxide, the most important anthropogenic GHG, grew by about 80% in this time frame, and by 28% just from 1990 to 2004. [WGIII/SPM, p. 3]
- "Most of the observed increase in global average temperatures since the mid-20th century is very likely [>90% chance] due to the observed increase in anthropogenic GHG concentrations. It is likely [66-90% chance] that there has been significant anthropogenic warming over the past 50 years averaged over each continent (except Antarctica)." [SYR/SPM, p. 39]
- Since the 1970s, more intense and longer droughts have been observed over wider areas, particularly in the tropics and subtropics. [WGI/SPM, p.8]
- "Heavy precipitation events" have become more frequent over most land areas. This is "consistent with warming and observed increases of atmospheric water vapor." [WGI/SPM, p.8]
- Over the last 50 years, widespread changes in extreme temperatures have been observed. "Cold days, cold nights, and frost have become less frequent, while hot days, hot nights, and heat waves have become more frequent." [WGI/SPM p.8]
- Many natural systems are being affected by regional climate changes, particularly temperature increases. These include changes in hydrological systems and snow, ice, and frozen ground (*high confidence*) and earlier timing of spring events and poleward and upward shifts in plant and animal ranges (*very high confidence*).[4] [SYR/SPM, p. 31]
- "Of the more than 29,000 observational data series, from 75 studies, that show significant change in many physical and biological systems, more than 89% are consistent with the direction of change as a response to warming." [SYR/SPM, p. 33]

Getting worse before it gets better

The Fourth Assessment Report raised the prospect that, through technologies that are currently available or in the pipeline, "stabilization" of climate change could be achieved. But what if climate conditions deteriorated beyond what the IPCC assessment of February 2007 foresaw?

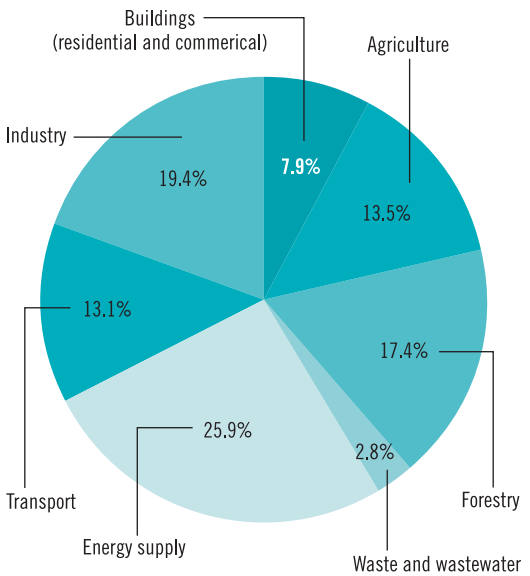
That seems to be the case. The most recent data, published 22 September 2008 in the *Proceedings of the National Academy of Sciences*, showed that the rate of greenhouse gas emissions has increased nearly fourfold since 2000. The Global Carbon Project, based in Canberra, Australia, put the growth rate of emissions from 2000 to 2007 at 3.5% per year, compared to a 0.9% per year growth rate from 1990 to 1999.

Emissions growth from 2000 to 2007 was greater than the most severe picture painted by the IPCC's Special Report on Emissions Scenarios, published in 2000.

The Global Carbon Project went on to report that:

- The annual mean growth rate of atmospheric CO_2 was 2.2 ppm per year in 2007, versus 1.8 ppm in 2006 and above the average of 2.0 ppm for the period 2000 to 2007.
- The biggest growth in emissions had taken place in developing countries, notably China and India, both of which have been building coal-fired power plants at incredible rates since 2000. By some reports, China is building one such plant every four days or so.
- China, which accounted for 60% of all growth in emissions from 2000 to 2007, has superseded the United States as the world's largest emitter of carbon

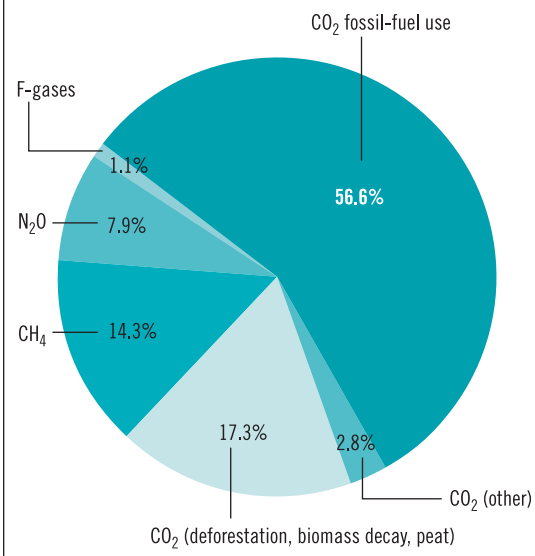
Chart 1.2
Share of Various Sectors in Total Man-made Greenhouse Gas Emissions in 2004 (CO_2eq)



Source: Climate Change 2007: Synthesis Report, Summary for Policy Makers, fig. SPM.3, p. 5.

The world's commercial and residential buildings account directly for <8% of GHG emissions, but the impact of buildings and homes is felt indirectly in every other sector, especially in energy supply (largely for electricity from power plants) and transport (cars, trucks, trains, airplanes, etc.).

Chart 1.3
Share of Various Man-made Greenhouse Gases in Total Emissions in 2004 (CO_2eq)



Source: Climate Change 2007: Synthesis Report, Summary for Policy Makers, fig. SPM.3, p. 5.

Carbon dioxide accounted for more than three-fourths (76.7%) of all anthropogenic GHG emissions in 2004. Percentages are based on carbon dioxide equivalents (CO_2eq). N_2O: nitrous oxide, from agriculture and other sources; F-gases: hydrofluorocarbons, perfluorocarbons, and sulfurhexafluoride.

dioxide. The U.S. maintains the distinction of being the largest emitter of greenhouse gases per person.

• Natural "sinks"—trees, plants, and the oceans—were becoming less efficient in their ability to absorb CO_2 emissions.

The bottom line: Atmospheric CO_2 rose to 383 ppm in 2007, putting it 37% higher than the concentration of greenhouse gases in the atmosphere at the start of the industrial revolution (280 ppm) in 1750. This was believed to be the highest concentration of greenhouse gases of the past 650,000 years and probably of the past 20 million years.

In sum, said Dr. Josep (Pep) Canadell, executive director of the Global Carbon Project, "This new update of the carbon budget shows the acceleration of both CO_2 emissions and atmospheric accumulation [is] unprecedented and most astonishing during a decade of intense international developments to address climate change."

How could this happen, and so quickly?

We put that question to Mark Maslin, head of the Department of Geography and Director of the Environment Institute at University College London.

"The key thing about the IPCC is that the 2007 report [AR4] is based on published work, which comes from early 2006 and before," said Maslin, author of the excellent primer *Global Warming: A Very Short Introduction* (Oxford University Press, 2004). "It's a long process, and every single line has to be agreed to by the co-authors, so they have to be naturally conservative. My feeling has always been that [the consensus process] will always underestimate the potential risk.

"One of the problems with the Fourth Assessment Report is that it used CO_2 increases calculated from their special report of 2000," said Maslin. "That report [Special Report on Emissions Scenarios] predicted the increase for the next 100 years and what it would look like. In 2000, this was a realistic forecast, but we've blown [that forecast] apart in the last eight years, due to China and India. In Asia, we're already above the highest predictions of the IPCC, so we're already off the curve."

In short, greenhouse gas emissions are going up faster than predicted, which makes it all the more imperative to start tackling the problem quickly. In subsequent chapters, we'll look at efforts by more than a score of organizations and entities to address climate change. We'll see how improvements to existing buildings and homes could play a crucial role in climate change mitigation. We'll review scenarios put forth by scientists, management consultants, and economists, and we'll take a brief excursion into the mysterious terrain of carbon cap and trade. Finally, as in several of our previous White Papers on Sustainability, we'll offer a detailed Action Plan for consideration by government, the private sector, and the AEC industry.

But first, let's look at where the U.S. design and construction community stands on climate change. **BD+C**

4. Under the IPCC confidence convention, "high confidence" means about an 8 out of 10 chance of being correct; "very high confidence" means at least a 9 out of 10 chance of being correct.

5. The New York Times, 3 February 2007.