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ASHRAE Position Document on

CLIMATE CHANGE

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The ASHRAE Position Document on Climate Change was developed by the Society's Climate Change Position Document Committee.

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Executive Summary

Policy focus on global climate change has significantly increased in the past decade, along with science certainty. HVAC&R systems, and total buildings, offer significant opportunities for climate change mitigation and adaptation, making this a key area for ASHRAE and its members.

In each of its quadrennial reports, the Intergovernmental Panel on Climate Change (IPCC) has noted increased atmospheric levels of CO_2, CH_4, N_2O and the industrial gases CFCs, HCFCs and HFCs in recent decades. The IPCC predicts continuing increases in global temperatures resulting from these greenhouse gases.

Buildings and their HVAC&R systems contribute to greenhouse gas emissions through electricity consumption largely generated from combustion of fossil fuels (resulting in CO_2 emissions) and from industrial gas emissions. Rigorous energy and resource conservation measures can reduce the building climate change footprint resulting from direct emissions and the approximately 39% of total societal CO_2 emissions resulting from building energy consumption. The global building sector has the greatest potential for economical greenhouse gas mitigation between now and 2030.

ASHRAE is committed to a leadership role in responding to and reducing building climate change footprints.

Issue

Worldwide concern for changes in global climate has escalated as the scientific evidence has become more definitive linking increased concentrations of atmospheric greenhouse gases with increased global temperatures. The Kyoto Protocol adoption in 1997, with entry into force on 16 February 2005, and the ongoing international efforts to address this issue are responses reflecting this heightened concern level.

Global climate is controlled by the equilibrium between incoming solar energy and outgoing radiated energy from the earth. This state of equilibrium is dependant on the interactions between natural processes on the land and in the oceans and the earth's atmosphere. Approximately one-third of the solar radiation (sunlight) reaching the earth is reflected back into space by clouds, small particles in the atmosphere, and the earth's surface. The remaining energy is absorbed by the earth's surface and by atmospheric gases. Greenhouse gases, such as carbon dioxide (CO_2) and water vapor, as well as small particles, trap heat – maintaining the average temperature of the earth's surface about 34^{o}C (61^{o}F) warmer than it would be if these gases and particles were not present.

Increases in greenhouse gases in the atmosphere will alter the historic interactions between the earth and the sun's radiation. Along with carbon dioxide (CO_2), other significant greenhouse gases include methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6). These greenhouse gases impact penetration of the atmosphere by infrared radiation emitted by the earth's surface. Greater concentration levels of these gases in the atmosphere increase the "energy-trapping" capabilities of the lower troposphere.

While climate change and variability occur naturally, the current concern stems from the potential for human activities to enhance the greenhouse effect. If unmitigated, these releases of greenhouse gases due to human activity could lead to concentrations by 2100 that are more than double pre-industrial values. This is forecast to result in a climate shift beyond any experienced in recorded human history. Such CO_2 levels would be well in excess of those determined from geological records for the past several hundred thousand years.

ASHRAE's direct interest in, and concern regarding, greenhouse gases and climate change is reflected in its activities in heating, ventilating, air conditioning and refrigerating (HVAC&R) technologies and applications. HVAC&R systems contribute to greenhouse gas emissions through refrigerant release (CFC, HCFC, and HFC) and through CO_2 releases associated with the energy needed for operating buildings and building systems. As a result ASHRAE and its members have an important role in mitigating and adapting to climate change.

Background

Summary of IPCC (Climate Change) Findings

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 to assess climate change information and to provide reliable, relevant (and unbiased) information on all climate change science aspects. The IPCC is an independent international body, cosponsored by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO). The 2007 fourth assessment report issued by the IPCC was prepared and reviewed by more than 2000 experts.

According to the IPCC, the atmospheric carbon dioxide concentration has increased from a pre-industrial value of about 280 ppm to 379 ppm in 2005 [+35%]--primarily from burning of fossil fuels and from land use change. The CH_4 abundance of about 1774 parts per billion is more than double its pre-industrial value. The concentration of N_2O in 2005 was 319 parts per billion, about 18% higher than its pre-industrial value. The concentration of HFCs has been rising steadily over the last decade as these chemicals have moved into the marketplace to replace the Montreal Protocol gases, CFCs and HCFCs. HFC-134a, for example, grew from 1 part per trillion in 1995 to 35 part per trillion ten years later. All of the halocarbons (CFCs, HCFCs and HFCs) contribute to global warming. Even though CFCs and HCFCs are being phased out, their present atmospheric concentrations account for 95% of the halocarbon component of warming.

Although the international focus on climate change is centered in the UN Framework Convention on Climate Change the "The Montreal Protocol…is mitigating climate emissions by 11 billion metric tons of CO_2 equivalent between 1990 and 2010, delaying climate change up to 12 years…. Overall, protecting the ozone layer is delaying climate change 35-41 years when earlier voluntary efforts and national measures are considered along with the Montreal Protocol." Guus J. M. Velders, et al*., The Importance of the Montreal Protocol in Protecting Climate,* 104 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES 4814 (2007)

Environmental impacts from increased greenhouse gas concentrations have also been observed and reported by the IPCC. Over the 100 year period between 1906 and 2005, the earth's surface temperature has risen 0.07^{o}C per decade [± 0.02^{o}C/decade]. The rate for the 50 years from 1955 to 2005 has been 0.13^{o}C per decade, with the rate increasing to 0.18°C per decade in the 1980-2005 period. Since 1961, the global mean sea level has risen at an average rate of 1.8 mm/yr [with error bounds of 1.2 to 2.3 mm/yr], and since 1993 at an average annual rate of 3.1 mm/yr [i.e., 2.4 to 3.8 mm/yr].

Even if greenhouse gas emissions were held constant at today's level, warming would continue for several more decades until the earth-atmosphere system reached temperature equilibrium. Carbon dioxide and some of the other greenhouse gases will remain in the atmosphere for many decades or even centuries. Therefore, existing atmospheric greenhouse gas impacts will continue for decades and the effects will persist for centuries. The magnitude, timing and regional characteristics of end-of-century climate change are uncertain because of uncertainty about future greenhouse gas emissions and about carbon cycle feedbacks.

Using several different climate models, the IPCC analyzed a variety of future CO_2 emissions scenarios ranging from CO_2 emissions peaking in 2030 to continued emission growth out to 2100. Over the range of scenarios, the mean global temperature increase is projected to be in the range of 2.0 to 6.1^{o}C [3.6 to 11^{o}F] by 2100; and the mean sea level rise is predicted to be in the range of 0.4 to 3.7 meters, primarily due only to thermal expansion. The Annex at the end of this document provides the IPCC's assessment of global impacts from climate change.

Excerpts from the IPCC Assessment Report 4 [AR4] Synthesis Report

The IPCC, in the AR4 Synthesis Report, states that:

> "[The term] 'Climate change' in IPCC usage refers to a change in the state of the climate that can be identified … by changes in the mean and/or variability of its properties and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity…"

In the discussion of Causes of Change, the Synthesis Report says that:

> "There is *very high confidence* that the global average net effect of human activities since 1759 has been one of warming … " and further that " Most of the observed increase in global average temperature since the mid-20th century is *very likely* due to the observed increase in anthropogenic [caused by humans] GHG concentrations…"[1]

In the discussion of Observed Changes, the Synthesis Report says that:

> "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level."

In the discussion of Responses to Climate Change, the Synthesis Report says that:

> "A wide range of mitigation options is currently available or projected to be available by 2030 in all sectors." And further that "Mitigation efforts and investments over the next two to three decades will have a large impact on opportunities to achieve lower stabilisation levels. Delayed emissions reductions significantly constrain the opportunities to achieve lower stabilisation levels and increase the risk of more severe climate change impacts."

[1] The italics are those of the IPCC and are used to identify terms where they have provided very explicit interpretations in the Synthesis Report.

Relevance to HVAC&R

HVAC&R systems contribute to greenhouse gas emissions through refrigerant release and through CO_2 releases resulting from the energy used to power the HVAC&R systems. This energy can be provided by electricity, where the CO_2 is released during the generation of the electricity, or by the on-site combustion of fossil fuels. As a result of these factors, ASHRAE and its over 50,000 members have the opportunity to make a marked contribution to reducing greenhouse gas emissions.

Refrigerants play a vital role in society by their use in systems to preserve food and medicine, produce ice, to condition space for human welfare and controlled environments, and to support industrial processes. The impact of HFCs on climate change can be minimized by reducing their release from HVAC&R systems. This is achieved by incorporating rigorous refrigerant conservation measures during design, manufacture, installation, operation, service, recovery and ultimate disposal of equipment. Substitution of natural refrigerants for HFCs may also be an option, but only when energy efficiency and safety are not compromised. The benefits of reducing refrigerant emissions extend beyond climate change since refrigerant loss during HVAC&R operation reduces system performance and reliability and may increase energy demand and operational costs.

Table 1 presents information on the amount and relative magnitude of HFC emissions from HVAC&R systems as these refrigerants have replaced the ozone depleting substances (CFCs and HCFCs) over the last 20 years. HFC refrigerant release is a relatively small component of total greenhouse gas emissions, contributing only 1.6% of total greenhouse gas emissions, and the majority of that is from the transportation, not the buildings sector. (From U. S. EPA, *Inventory of U. S. Greenhouse Gas Emissions and Sinks, 1990-2006.*)

Table 1: U.S. Annual Emissions of HFCs (Megatonnes of CO_2 eq)
(From U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*)

Sector	1990	1995	2000	2005	2006	Percent*
Transportation	+	18.6	52.6	69.7	69.5	1.0%
Industrial	+	1.2	3.1	5.2	5.7	0.1%
Commercial	+	0.7	5.5	18.5	22.4	0.3%
Residential	0.3	8.1	10.1	11.9	12.9	0.2%
Total	0.3	28.5	71.2	105.4	110.4	1.6%

+ Does not exceed 0.05 Megatonnes CO_2 Eq.

* Percent of US greenhouse gas emissions for year 2006

Figure 1 quantifies the component of building energy usage resulting from HVAC&R systems. Buildings represent a significant portion of global energy consumption. In the U.S., buildings account for approximately 40% of total primary energy use and 39% of CO_2 emissions

(approximately equal to the combined total emissions of Japan, France and the United Kingdom). The IPCC Assessment Report 4 from Working Group III (Mitigation) indicated that the Buildings sector has the greatest potential for economical mitigation of greenhouse gas emissions between now and 2030 with 'costs' ranging from $20 to $100 per metric tons of CO_2 equivalent, as shown in Figure 2 with special highlight on the buildings sector portion.

Figure 1: Impacts of HVAC&R Services on U.S. Building Energy Usage
(From EIA, *Annual Energy Outlook, 2009*)

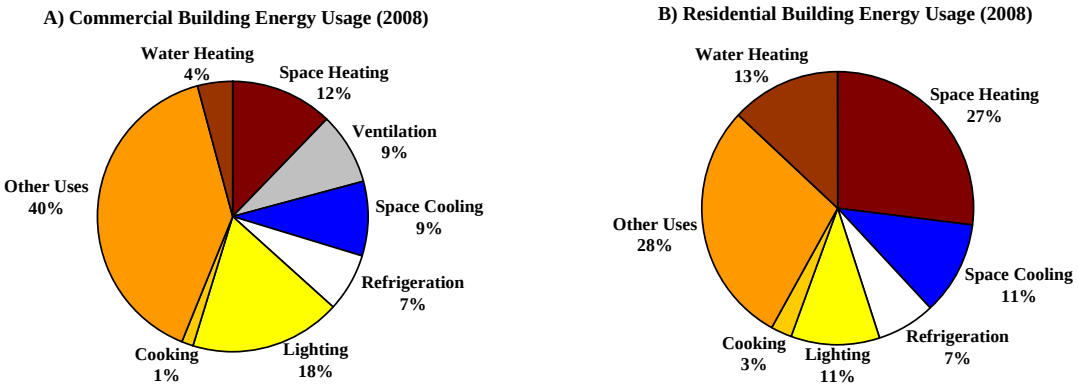
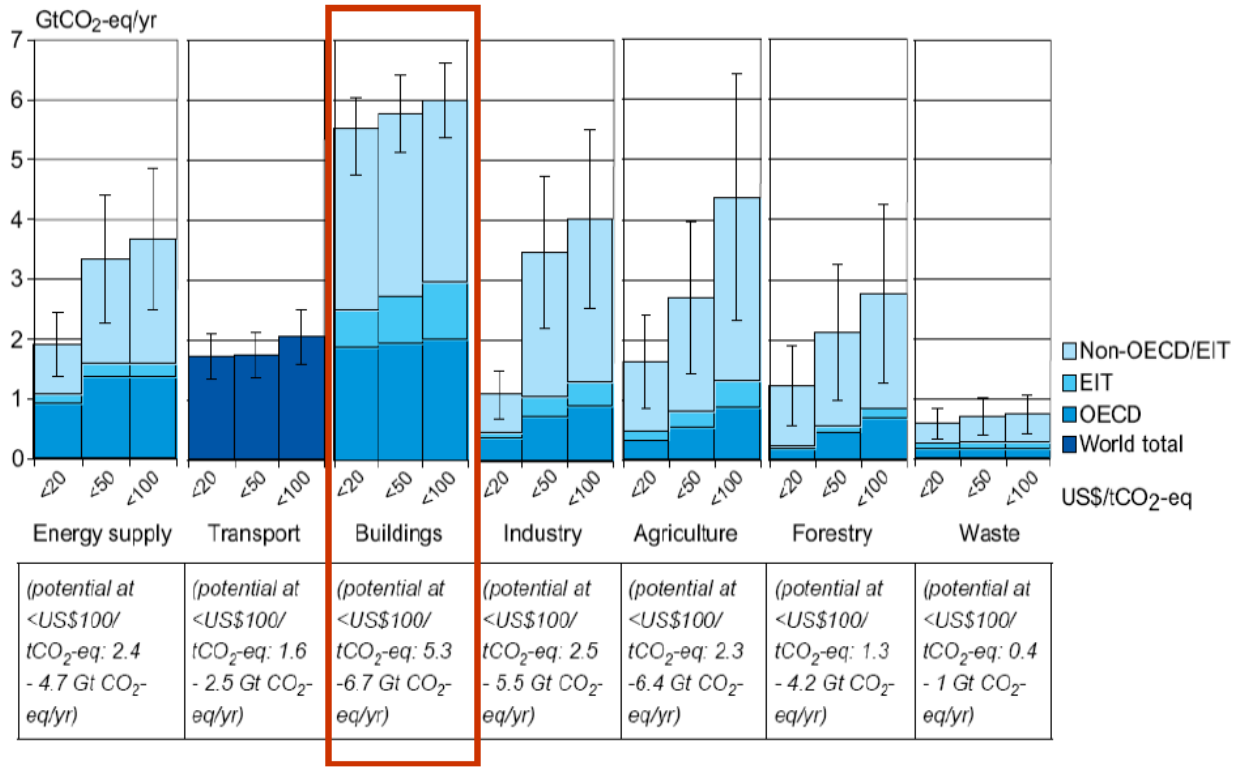


Figure 2: Economic Mitigation Potential by 2030
From IPCC Working Group III Contribution to the Summary for Policy Makers; The Fourth Assessment Report [2007]



Minimizing energy use by HVAC&R systems involves optimizing energy-efficiency at the point of design and ensuring efficiency through controlled operation and equipment maintenance. Operational issues such as temperature setpoints and setbacks, natural ventilation and energy recovery, and integrated building operations have an impact on the HVAC&R energy requirements and performance. Reducing the energy consumption of equipment, systems, and buildings and informing owners and operators of the importance of their actions on energy consumption can have a significant environmental benefit in the Buildings sector. ASHRAE standards and guidelines provide the tools for the design and application of comprehensive energy-savings techniques in buildings and for the selection and proper use of efficient equipment and system integration.

Other design and construction choices influence HVAC&R systems and their associated greenhouse gas emissions. These include factors such as building envelope choices, types and amounts of insulating materials, lighting and daylighting, glazing and fenestration, internal plug loads, and other features associated with the building envelope and loads.

To minimize the greenhouse gas emissions associated with HVAC&R equipment, ASHRAE must form linkages with organizations representing other segments of the building industry. ASHRAE's Advanced Energy Design Guides are examples of successful collaborations on comprehensive building energy savings.

Recommendations

ASHRAE holds a strong position that:

- Climate change is the most formidable environmental challenge ever faced by society.
- Opportunities exist within the HVAC&R industry to provide solutions to reduce greenhouse gas emissions. These include refrigerant selection and practices, demand load reductions, energy-efficiency, and use of renewable energy.
- ASHRAE members and staff need to become actively involved worldwide with policy-setting entities to encourage sound, balanced, and innovative actions to address long-range environmental problems and objectives.

ASHRAE recommends that further research be conducted on:

- Improving energy efficiency/utilization in HVAC&R technology to minimize energy-use CO_2 emissions
- Design and integration of all building systems and components to improve overall energy performance.
- Improving analysis tools to help engineers, designers, and owners make choices that are economically and environmentally sound over the building lifetime.

ASHRAE is committed to:

- Taking a leadership role in responding to climate change by developing and achieving ASHRAE goals such as those outlined in Vision 2020 Producing Net Zero Energy Buildings and in the Sustainability Roadmap
- Developing strategic collaborations with other societies and organizations in order to provide comprehensive approaches to climate change
- Developing and adopting designs, materials, components, systems, and processes that minimize environmental impacts, including climate change
- Promoting the use of life-cycle, environmental and economic impact assessments in HVAC&R design and operation.
- Developing and disseminating standards and guidelines supporting the minimization of greenhouse gas emissions by HVAC&R systems and the building sector.
- Informing designers and decision makers about practices that lower the risk of environmental degradation and its damaging effects on health and the economy worldwide through activities such as the development of green building design guides.
- Educating building owners and operators on effective use of life cycle cost techniques to empower them to make the best investment decisions.
- Recognizing and promoting case studies of high performance buildings that achieve high levels of energy efficiency and significant reductions in environmental impact.
- Working with educators to incorporate sustainability and energy conservation practices into the curriculum of engineering and design schools.
- Working with educators and school board administrators to improve science, technology, engineering and mathematics education across all grade levels to raise scientific literacy and public recognition of energy-related issues.

Related ASHRAE Documents

Standards

- ANSI/ASHRAE Standard 34, *Designation and Safety Classification of Refrigerants*
- ANSI/ASHRAE Standard 15, *Safety Standard for Refrigeration Systems*
- ANSI/ASHRAE Standard 147, *Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment*
- ANSI/ASHRAE/IESNA Standard 90.1, *Energy Standard for Buildings Except Low-Rise Residential*
- ANSI/ASHRAE Standard 90.2, *Energy Efficient Design of Low-Rise Residential Buildings*
- ANSI/ASHRAE Standard 100, *Energy Conservation in Existing Buildings*
- BSR/ASHRAE/IES/USGBC Standard 189.1P – Standard for the Design of High-Performance Green Buildings, Except Low-Rise Residential Buildings (Note: This standard is still in draft form and has not completed the development process.)

Design Guides

- *Advanced Energy Design Guide for K-12 School Buildings*
- *Advanced Energy Design Guide for Small Retail Buildings*
- *Advanced Energy Design Guide for Small Office Buildings*
- *Advanced Energy Design Guide for Small Warehouses and Self-Storage Buildings*

- *Advanced Energy Design Guide for Highway Lodging*

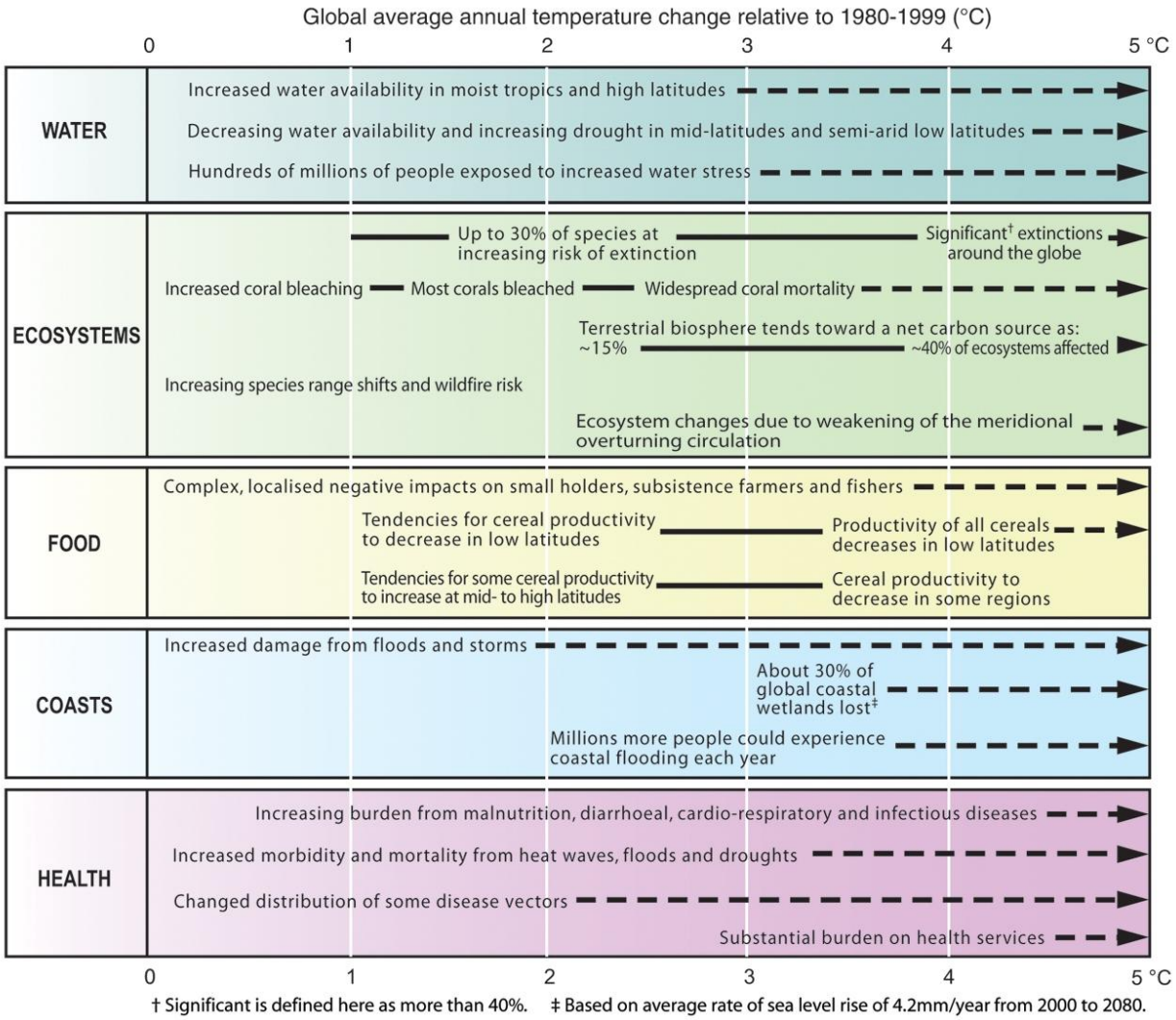
Position Documents

- Natural Refrigerants
- Energy

Strategic Documents

- Vision 2020 Producing Net-Zero-Energy Buildings
- Sustainability Roadmap

ANNEX Global Average Temperature Change Relative to 1980-1999 (°C)



Source: (IPCC *Climate Change 2007 Synthesis Report of the Fourth Assessment Report*)

Illustrative examples of global impacts projected for climate changes (and sea level and atmospheric CO2 where relevant) associated with different amounts of increase in global average surface temperature in the 21st century. The solid lines link impacts; broken-line arrows indicate impacts continuing with increasing temperature. Entries are placed so that the left-hand side of text indicates the approximate level of warming that is associated with the onset of a given impact. Quantitative entries for water scarcity and flooding represent the additional impacts of climate change relative to the conditions projected across the range of SRES scenarios A1FI, A2, B1 and B2. Adaptation to climate change is not included in these estimations. Confidence levels for all statements are high.