Shaping Tomorrow's Built Environment Today

ASHRAE Position Document on

CLIMATE CHANGE

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ASHRAE is a global professional society of over 55,000 members, committed to serve humanity by advancing the arts and sciences of heating, ventilation, air conditioning, refrigeration and their allied fields (HVAC&R). ASHRAE position documents are approved by the Board of Directors and express the views of the Society on specific issues. These documents provide objective, authoritative background information to persons interested in issues within ASHRAE's expertise, particularly in areas where such information will be helpful in drafting sound public policy. The documents also clarify ASHRAE's position for its members and building professionals.

Climate Change is a Public Interest Issue

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

In each of its quadrennial reports, the Intergovernmental Panel on Climate Change (IPCC) has documented increased atmospheric levels of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). While emissions of chlorofluorocarbons (CFCs), which have extremely high global warming potential (GWP), have been decreasing, emissions of hydrochlorofluorocarbons (HCFCs), which are transitional substitutes for CFCs, continue to increase. Emissions of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) all continue to increase relatively rapidly, but their contributions to radiative forcing are less than 1% of the total (Hartmann et al. 2013). The IPCC predicts continuing increases in global temperatures resulting from emissions of these greenhouse gases (GHGs). One effect of global temperature changes is a possible increase in extreme weather events such as hurricanes, glacier/snow pack melt, floods, sea level rise, and drought.

On 15 October 2016, parties to the Montreal Protocol met in Kigali, Rwanda, and adopted a new amendment to gradually phase out the use of HFCs over the next 20–30 years. This means that in most applications HFCs will gradually be replaced by the next generation of products with much lower GWP, including hydrofluoroolefins (HFOs), hydrocarbons, CO_2, and ammonia, as well as other gases.

The global climate is controlled by the equilibrium between incoming solar energy and outgoing radiated energy from the earth. This state of equilibrium is dependent 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. GHGs, 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 warmer than it would be if these gases and particles were not present.

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

While climate change and variability occur naturally, the concern is the potential for human activities to enhance the greenhouse effect. If unmitigated by 2100, these releases of GHGs due to human activity could lead to concentrations that are more than double preindustrial levels. 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 (Hansen et al. 2008).

Why ASHRAE Takes Positions on Climate Change

Policy focus on global climate change has significantly increased in the past decade with greater confidence in our ability to estimate the projected effects of climate change. HVAC&R systems and total building performance offer significant opportunities for climate change mitigation and adaptation, making this a key area for ASHRAE and its members.

Buildings and their HVAC&R systems contribute to GHG emissions through their energy use and cooling or refrigeration systems. Energy used in buildings is largely generated from combustion of fossil fuels (resulting in CO_2 emissions) either through direct fossil fuel use in buildings or indirectly through the use of electricity, which is often produced through fossil fuel combustion. Another source of GHGs are emissions such as refrigerant leakage.

Rigorous energy and resource conservation measures can reduce the climate change foot- print resulting from direct emissions and the approximately 19% of total societal CO_2 emissions resulting from building energy consumption. Refrigerant emissions from air-conditioning and refrigeration systems occur during installation, replacement, and maintenance and as a result of malfunctions or breakage. These are also significant GHG emissions; the effects can be reduced through use of lower GWP refrigerants as well as improved equipment designs or installation and maintenance procedures to reduce the release of refrigerants.

ASHRAE is committed to a leadership role in reducing climate change contributed to by building systems and responding to climate change experienced in the built environment. Heating, ventilating, air conditioning, and refrigerating (HVAC&R) systems contribute to GHG emissions through direct refrigerant emissions (CFCs, HCFCs, and HFCs) and indirect CO_2 emissions associated with the energy needed for operating buildings and building systems. Therefore, ASHRAE's direct interest in and concern regarding GHGs and climate change is reflected in its activities in HVAC&R technologies and applications. In addition, ASHRAE's direct interest in occupant health and safety within the built environment drives the Society's commitment to research, educate, advocate and respond to occurring climate change with the intent to guide resilient infrastructure, building systems, and community designs. This is done through continuously updated design guide documents, handbooks, standards, and other publications that reflect the best current understanding of design conditions, including expected climatic conditions. As a result, ASHRAE and its members have an important role in mitigating and adapting to climate change.

Positions and Recommendations

ASHRAE Takes the Positions 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 GHG emissions. These include refrigerant selection and practices, demand load reductions, energy efficiency, and use of renewable energy.
- Changes in climate result in changes to the design conditions for HVAC systems.
- ASHRAE members and staff should become actively involved worldwide with policy-setting entities to encourage sound, balanced, and innovative actions to address long-range environmental problems and the conditions that result from them.

ASHRAE Recommends that:

- Additional and continuing research be conducted on the following:
    - Improving energy efficiency/utilization in HVAC&R technology to minimize energy-use CO_2 emissions.
    - Design, integration, and operation 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 a building's lifetime.
    - Continuing to update ASHRAE climate and HVAC design data to reflect changing climate and weather conditions.
    - Characterizing the properties of the next-generation refrigerants and the necessary design changes and refrigerant management procedures to use them safely.
    - Development and testing of non-compressor-based cooling and heat pump technologies.
    - Development of improved primary energy and GHG emissions data and performance metrics for determining real-time energy and emissions performance of building operations.
    - Assessing region-specific climate change risks and creating adaptation recommendations in areas where our competence and expertise can satisfy the public need.

ASHRAE Commits to:

- Taking a leadership role in responding to climate change by developing and achieving ASHRAE goals such as those outlined in *ASHRAE Vision 2020: Producing Net Zero Energy Buildings* (ASHRAE 2008) and in ASHRAE's Sustainability Roadmap (ASHRAE 2006).
- Developing strategic collaborations with other societies and organizations 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 GHG emissions by HVAC&R systems and the buildings 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 curricula 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 technology-related issues.
- Participating in the research and testing required to implement transition to more climate-friendly technologies.
- Participating within and supporting the Resilience Building Coalition and their international efforts in research, planning, advocacy, and response to climate change with the goal to provide resiliency within communities and their built environments.

Appendix A—Background Information

Summary of IPCC 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 IPCC Fifth Assessment Report (AR5; IPCC 2014a), released in four parts between September 2013 and November 2014, was authored by more than 830 experts (IPCC 2015).

According to the IPCC (2013), the atmospheric CO_2 concentration has increased from a preindustrial value of about 280 ppm to 391 ppm in 2011 (+40%)—primarily from burning of fossil fuels and from land-use change. The CH_4 concentration of 1803 parts per billion (ppb) is about 150% its preindustrial value. The concentration of N_2O in 2011 was 324 ppb, about 20% higher than its preindustrial value.

Environmental impacts from increased GHG concentrations have also been observed and reported by the IPCC (2013). Between 1880 and 2012, the globally averaged combined land and ocean surface temperature warmed 0.85°C (0.65°C to 1.06°C) (1.53°F [1.17°F to 1.91°F]). Over the last two decades, the Greenland and Antarctic ice sheets have been losing mass, glaciers have continued to shrink almost worldwide, and arctic sea ice and northern hemisphere spring snow cover have continued to decrease in extent.

Even if GHG 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 GHGs will remain in the atmosphere for many decades or even centuries. Therefore, existing atmospheric GHG 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 GHG emissions and about carbon cycle feedbacks.

Appendix B summarizes likely environmental impacts from rising average global temperatures. It also, for several different future GHG emission scenarios, gives projected changes in global mean surface air temperatures and global mean sea level rise, as estimated by the IPCC (2014b).

Excerpts from the AR5 Synthesis Report

The IPCC, in the AR5 Synthesis Report (IPCC 2014b, p. 2), states:

> Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had wide- spread impacts on human and natural systems. Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and the sea level has risen. Each of the last three decades has been successively warmer at the Earth's surface than any other preceding decade since 1850.

In the discussion of causes of change, the Synthesis Report says:

> Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever. This has led to atmospheric concentrations of carbon dioxide, methane and nitrous oxide that are unprecedented in at least the last 800,000 years. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed warming since the mid-20th century. (IPCC 2014b, p. 4)

In regards to future climate conditions, the Synthesis Report states:

> Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe,

> pervasive and irreversible impacts for people and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks. (IPCC 2014b, p. 8)

The Synthesis Report also states the following:

> Impacts from recent climate-related extremes, such as heat waves, droughts, floods, cyclones, and wildfires, reveal significant vulnerability and exposure of some ecosystems and many human systems to current climate variability (very high confidence). (IPCC 2014b, p. 53)

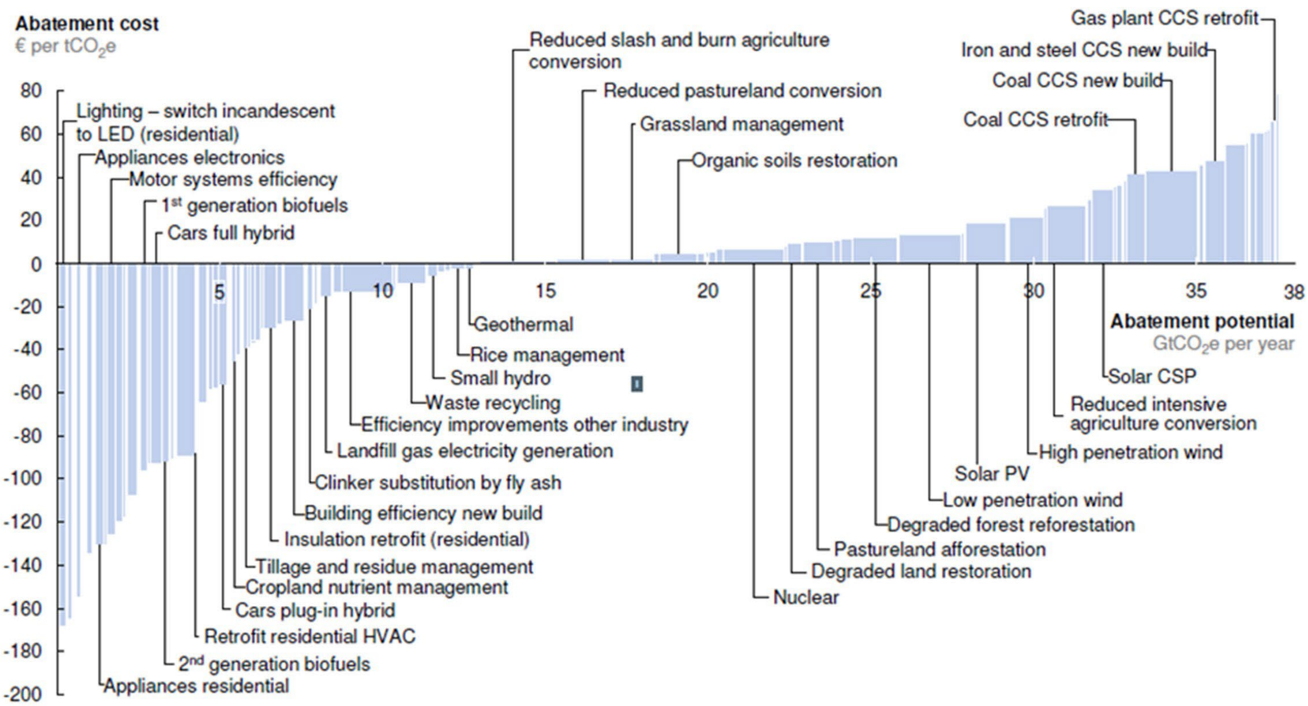
Relevance to HVAC&R

HVAC&R systems contribute to GHG emissions through direct emissions from fossil fuel combustion on site and from refrigerant leakage and through indirect CO_2 emissions resulting from the energy used to power the HVAC&R systems. This energy can be provided by electricity, where CO_2 is released during the generation of the electricity, by on-site combustion of fossil fuels, or during the sourcing, processing, and transportation of the fuels. As a result of these factors, ASHRAE and its more than 50,000 members have the opportunity to make a marked contribution to reducing GHG emissions.

Figure A.1 summarizes the maximum potential of technical abatement measures to reduce GHG emissions at a cost up to 80 euros per ton of CO_2 equivalent avoided emissions. The range of emission reduction actions reflects what is possible with available technologies or potential technologies that have a high degree of certainty in a 2030 time horizon. The least-cost options on the left of the abatement curve mostly relate to energy use in buildings, which are within the responsibilities of ASHRAE and its members. The negative costs associated with HVAC&R- related technical abatement measures (e.g., insulation retrofit, lighting, HVAC) highlight the opportunities for the sector to contribute to global emission reduction compared to the investment-intensive measures on the right of the curve.

Note that the market costs of these technologies can and have changed and that the relative abatement costs of the individual technologies may have changed since the development of this curve. For example, the costs of solar photovoltaics (PV) and wind energy have decreased substantially and can compete with efficiency measures in some circumstances. In addition, Figure A.1 does not address issues such as low GWP refrigerants or refrigerant management practices.

Refrigerants play a vital role in society by their use in systems to preserve food and medicine, to produce ice, to condition space for human welfare and controlled environments, and to support industrial processes. The impact of refrigerants 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 low GWP refrigerants such as natural refrigerants or hydrofluoroolefin (HFO) refrigerants is also an option, but safety and energy efficiency must not be compromised. The benefits of reducing refrigerant emissions extend beyond climate change because refrigerant loss during HVAC&R operation reduces system performance and reliability and may increase energy demand and operational costs. The use of non-compressor-based or not-inkind cooling technologies that eliminate the need for refrigerants may also be an option in some applications.



Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €80 per tCO_2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.
Source: Global GHG Abatement Cost Curve v2.1

Figure A.1 Global GHG Abatement Cost Curve beyond business as usual.
(McKinsey and Company 2010)

Table A.1 (EPA 2015) presents information on the amount and relative magnitude of HFC emissions from HVAC&R systems as these refrigerants have largely replaced the ozone-depleting substances (ODSs; CFCs and HCFCs) over the last 20 years, although some older equipment still uses ozone-depleting substances. HFC refrigerant release is a relatively small component of total GHG emissions, contributing only 2.56% of total GHG emissions, and the majority of that is from the transportation sector, not the buildings sector (EPA 2015).

Figure A.2 (EIA 2015) quantifies the component of building energy usage resulting from HVAC&R systems. Buildings represent a significant portion of global energy consumption. In the United States, 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).

Table A.1 U.S. Annual Emissions of HFCs (Tg CO_2 eq) from Their Use as ODS Substitutes
(EPA 2015)

Sector	1990*	2005	2011	2015	Percent**
Transportation	+	67.1	60.2	45.1	0.91%
Industrial	+	7.4	17.1	24.7	0.31%
Commercial	+	17.6	42.1	50.2	0.61%
Residential	0.3	7.7	25.9	48.4	0.55%
Total	0.3	99.8	145.3	168.4	2.56%

* "+" indicates less than 0.05 million metric ton equivalent CO_2 emissions.
** Percentage of total GHG emissions in 2015, which are from HFC emissions.

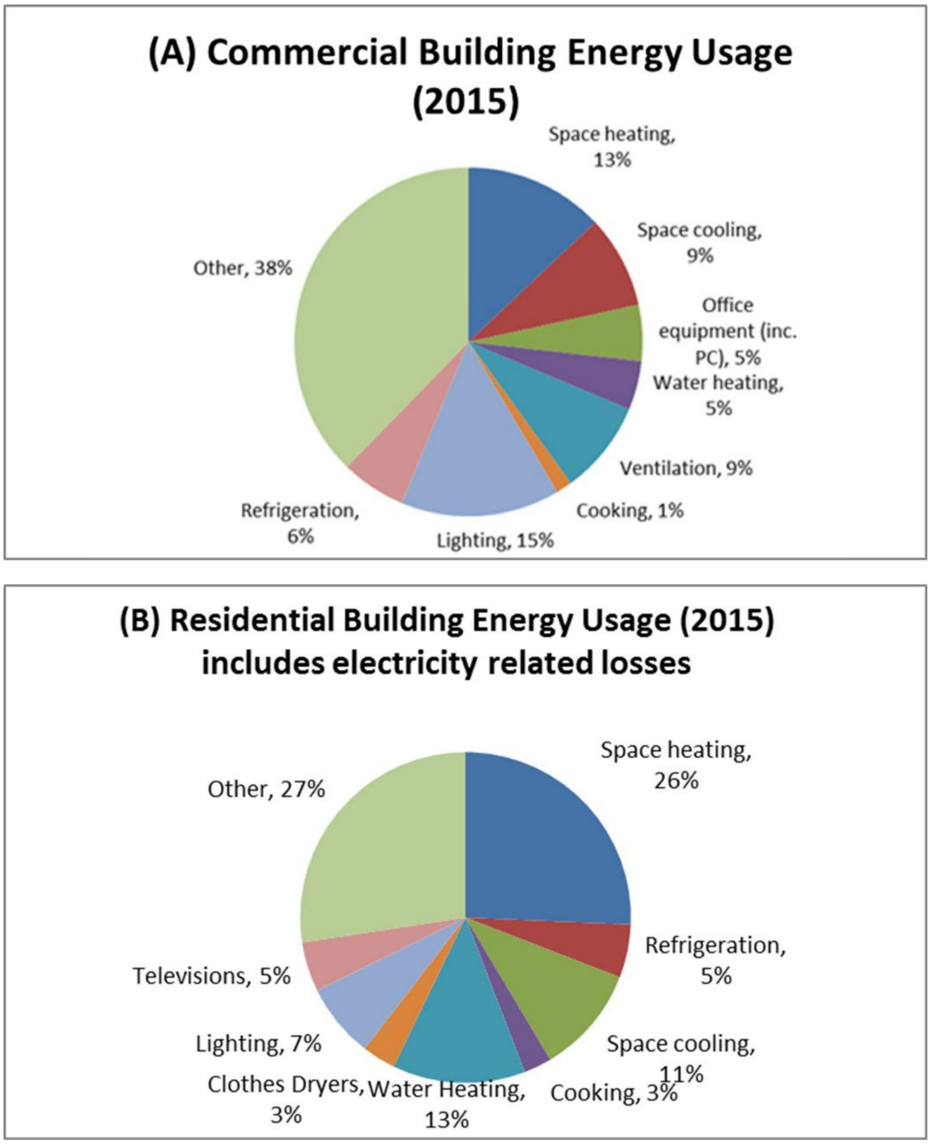


Figure A.2 Impacts of HVAC&R services on U.S. building energy usage.
(EIA 2015)

Minimizing energy use by HVAC&R systems involves optimizing energy efficiency during design and ensuring efficiency through controlled operation and equipment maintenance. Operational issues such as temperature set points and setbacks, natural ventilation and energy recovery, and integrated building operations have an impact on 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. See Appendix B for a list of related documents.

Other design and construction choices influence HVAC&R systems and their associated GHG 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 GHG emissions associated with HVAC&R equipment, ASHRAE has formed linkages with organizations representing other segments of the building industry. The Advanced Energy Design Guides are examples of successful collaborations on comprehensive building energy savings.

Renewable energy and other energy sources that do not result in CO_2 emissions also provide opportunities to reduce GHG emissions. These can be either from the use of on-site renewable energy or from grid-based electricity produced from zero-carbon sources. In many locations, options are available to purchase electricity from power suppliers with a higher percentage of renewable energy. Both site-based and grid-based renewable energy use will result in reduced GHG emissions for society. It should be noted that site-based renewable energy use is a design decision, resulting in long-term reduced GHG emissions, while grid- based renewable energy use is typically an operations decision, resulting in savings only if the facility operator chooses to continue to purchase renewable energy instead of conventional energy sources. However, grid-based renewable energy is often substantially less expensive than site-based renewables due to economies of scale.

The natural hazards that are projected to occur with climate change pose a threat to life and property. ASHRAE members should carefully consider the impact of possible extreme weather events when designing facilities and consider the possibility of increased severity of extreme weather events occurring over the multi-decade life of a structure. Efforts of the Society, its members, and its bodies should be directed at all times to enhancing public health, safety and welfare. Consistent with ASHRAE’s code of ethics, the Society is committed to research and guidance of materials, design, construction, and operation of buildings and infrastructure to adapt to changing environments.

Recent Regulatory Developments

The following are some recent international developments related to GHG emissions and refrigerant usage.

- **The November 2016 entry into force of the Paris Agreement, under which participating United Nations member countries take on commitments to reduce their GHG emissions.**

  The primary goal of the Agreement is to strengthen the global response to the threat of climate change by keeping the global temperature rise this century below 2°C (3.6°F) above pre-industrial levels and to further pursue efforts to limit the temperature increase to 1.5°C (2.7°F).

  Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. Appropriate financial support, a new technology framework, and an enhanced-capacity building framework will be put in place, thus supporting actions by developing countries and the most vulnerable countries in line with their own national objectives. The Agreement also provides for enhanced transparency of action and sup- port through a more robust transparency framework.

  This agreement is not legally binding.

- **The October 2016 adoption of the Kigali Amendment to the Montreal Protocol, which provides schedules for developed and developing countries to gradually phase down their production and consumption of HFCs over a period of 17–21 years.**

  The Kigali Amendment will result in gradual conversion of HVAC equipment using HFCs to the next generation of low GWP gases, including HFOs, hydrocarbons, CO_2, and others. The new refrigerants have different properties (some are flammable) and will require more research, testing, and training before they are widely adopted. Furthermore, preventing the leakage of refrigerant is crucial to the intent of the Kigali Amendment to the Montreal Protocol, as reduced emissions of high GWP fluids will reduce the growth in the GHG effect from the HVAC&R industry. Standards such as ASHRAE Standard 147-2013 specifically mention preventative leakage maintenance programs to inspect for evidence of refrigerant leaks annually. Equipment manufacturers and plant room operators can reduce the impact of HFCs on the climate from existing equipment through careful refrigerant management practices.

  The Kigali Amendment's approach is to cap and phase down HFC use over time rather than to ban products. This approach is supported by both the industry and the environ- mental community.

  Upon the amendment's entry into force, these phase-down schedules will become legally binding.

Appendix B—Temperature Change and Possible Climate Impacts

Figure B.1 shows Figure SPM.7 from the IPCC AR4 Synthesis Report (IPCC 2014b) issued in 2007. Though not from the most recent Assessment Report (AR5), it provides a concise summary of climate impacts versus temperature and is consistent with the conclusions of AR5 (IPCC 2014a). A similar concise summary of climate impacts versus temperatures is not avail- able in AR5.

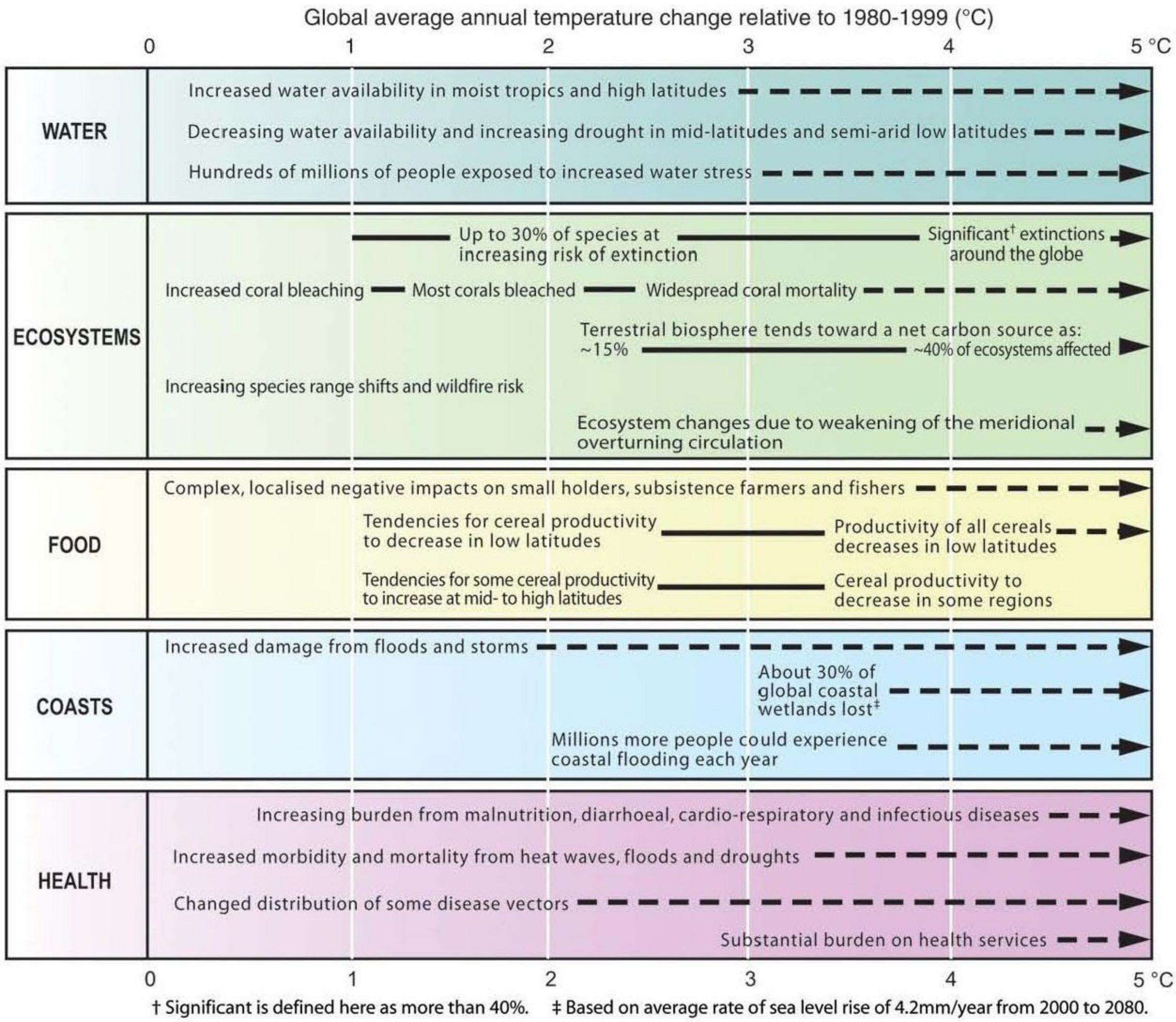


Figure B.1 Global average temperature change relative to 1980–1999 (°C).
(IPCC 2007d, Figure SPM.7)

Tables B.1 and B.2 are from the more recent AR5 Synthesis Report (IPCC 2014b) and provide the projected change in global mean sea surface temperature, in degrees Celsius (degrees Fahrenheit), and global mean sea level rise, in metres (feet), under the four representative scenarios of greenhouse gas emissions used in AR 5. These scenarios are RCP2.6, RCP4.5, RCP6.0, and RCP8.5, where *RCP* means "representative concentration pathways," and represent the total human-caused greenhouse gas impact on climate from greenhouse gas accumulation in the atmosphere, measured in watts per metre squared. For reference, the total radiative forcing from human-caused greenhouse gases in the atmosphere was 0 in pre-industrial times and was approximately 1.9 in the year 2000. The scenarios are named based on radiative forcing levels projected to occur at the end of the forecast period, in the year 2100.

These four emissions scenarios, in order of increasing levels of greenhouse gas emissions, are as follows:

- **RCP2.6.** This scenario represents the lowest level of human-caused greenhouse gas emission impact on climate of the four scenarios. Total annual emissions of greenhouse gases would be immediately limited to current levels and beginning in 2020 would be gradually reduced to approximately 10% of current levels in the year 2100.
- **RCP4.5.** Under this scenario, total annual greenhouse gas emissions would rise to 140% of year 2000 levels in the year 2040, then drop to 60% of year 2000 levels in the year 2080, then remain stable at 60% of year 2000 levels until 2100.
- **RCP6.0.** Under this scenario, greenhouse gas emissions would be limited to current levels until the year 2030, then allowed to rise. Total emissions under RCP6.0 actually are lower than under RCP4.5 until 2040 then rise to nearly double year 2000 levels in the year 2080. Emissions would then fall to approximately 120% of year 2000 levels in the year 2100.
- **RCP8.5.** Under this scenario, greenhouse gas emissions would continue to rise at current growth rates through the year 2060, then gradually slow after that, but would continue to rise through the entire forecast period. Greenhouse gas emissions would rise to 250% of year 2000 levels in the year 2050 and would be approximately 340% of year 2000 levels at the end of the forecast period in the year 2100.

Table B.1 Projected Change in Global Mean Surface Air Temperature and Global Mean Sea Level Rise for the Mid to Late Twenty-First Century relative to the Reference Period, 1986–2005 (SI) *(IPCC 2014b, Section 12.4, Table 12.2, Table 13.5)*

Scenario		**2046–2065**		**2081–2100**	
		Mean	**Likely Range***	**Mean**	**Likely Range***
Global Mean Surface Temperature Change, °C	RCP2.6	1.0	0.4 to 1.6	1.0	0.3 to 1.7
	RCP4.5	1.4	0.9 to 2.0	1.8	1.1 to 2.6
	RCP6.0	1.3	0.8 to 1.8	2.2	1.4 to 3.1
	RCP8.5	2.0	1.4 to 1.6	3.7	2.6 to 4.8
Global Mean Sea Level Rise, m	RCP2.6	0.24	0.17 to 0.32	0.40	0.26 to 0.55
	RCP4.5	0.26	0.19 to 0.33	0.47	0.32 to 0.63
	RCP6.0	0.25	0.18 to 0.32	0.48	0.33 to 0.63
	RCP8.5	0.30	0.22 to 0.38	0.63	0.45 to 0.82

* Calculated from 5% to 95% model ranges.

Table B.2 Projected Change in Global Mean Surface Air Temperature and Global Mean Sea Level Rise for the Mid to Late Twenty-First Century relative to the Reference Period, 1986–2005 (I-P) *(IPCC 2014b, Section 12.4, Table 12.2, Table 13.5)*

Scenario		2046–2065		2081–2100	
		Mean	Likely Range*	Mean	Likely Range*
Global Mean Surface Temperature Change, °F	RCP2.6	1.8	0.7 to 2.9	1.8	0.5 to 3.1
	RCP4.5	2.5	1.6 to 3.6	3.2	2.0 to 4.7
	RCP6.0	2.3	1.4 to 3.2	4.0	2.5 to 5.6
	RCP8.5	3.6	2.5 to 2.9	6.7	4.7 to 8.6
Global Mean Sea Level Rise, ft	RCP2.6	0.80	0.56 to 1.05	1.31	0.85 to 1.80
	RCP4.5	0.85	0.62 to 1.08	1.54	1.05 to 2.07
	RCP6.0	0.82	0.59 to 1.05	1.57	1.08 to 2.07
	RCP8.5	0.98	0.72 to 1.25	2.07	1.48 to 2.69

* Calculated from 5% to 95% model ranges.

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Additional ASHRAE Resources

ASHRAE Standards

- ANSI/ASHRAE Standard 34, *Designation and Safety Classification of Refrigerants*
- ANSI/ASHRAE Standard 15, *Safety Standard for Refrigeration Systems*
- ANSI/ASHRAE Standard 55-2017, *Thermal Environmental Conditions for Human Occupancy*
- ANSI/ASHRAE Standard 147, *Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment*
- ANSI/ASHRAE/IES Standard 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*
- ANSI/ASHRAE Standard 90.2, *Energy Efficient Design of Low-Rise Residential Buildings*
- ANSI/ASHRAE/IESNA Standard 100, *Energy Conservation in Existing Buildings*
- ASHRAE/USGBC/IES Standard 189.1, *Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings*

ASHRAE Design Guides

- *Advanced Energy Design Guide for K-12 School Buildings—Achieving Zero Energy*
- *Advanced Energy Design Guide for Grocery Stores—Achieving 50% Energy Savings Toward a Net Zero Energy Building*
- *Advanced Energy Design Guide for Large Hospitals—Achieving 50% Energy Savings Toward a Net Zero Energy Building*
- *Advanced Energy Design Guide for Medium to Big Box Retail Buildings—Achieving 50% Energy Savings Toward a Net Zero Energy Building*
- *Advanced Energy Design Guide for K-12 School Buildings—Achieving 50% Energy Savings Toward a Net Zero Energy Building*
- *Advanced Energy Design Guide for Small to Medium Office Buildings—Achieving 50% Energy Savings Toward a Net Zero Energy Building*
- *Advanced Energy Design Guide for Small Hospitals and Healthcare Facilities—Achieving 30% Energy Savings Toward a Net Zero Energy Building*
- *Advanced Energy Design Guide for Small Office Buildings—Achieving 30% Energy Savings Toward a Net Zero Energy Building*

- *Advanced Energy Design Guide for K-12 School Buildings—Achieving 30% Energy Savings Toward a Net Zero Energy Building*
- *Advanced Energy Design Guide for Highway Lodging—Achieving 30% Energy Savings Toward a Net Zero Energy Building*
- *Advanced Energy Design Guide for Small Retail Buildings—Achieving 30% Energy Savings Toward a Net Zero Energy Building*
- *Advanced Energy Design Guide for Small Warehouses and Self-Storage Buildings—Achieving 30% Energy Savings Toward a Net Zero Energy Building*
- *The ASHRAE Guide for Buildings in Hot and Humid Climates*, Second Edition
- *Cold-Climate Buildings Design Guide*
- *Procedures for Commercial Building Energy Audits*, Second Edition

ASHRAE Position Documents

- ASHRAE Position Document on Refrigerants and Their Responsible Use

Strategic Documents

- ASHRAE's *Vision 2020: Producing Net Zero Energy Buildings*
- ASHRAE's Sustainability Roadmap
- Industry Statement on Resilience, http://aiad8.prod.acquia-sites.com/sites/default/files/2017-11/Statement_2017-1120.pdf

DOCUMENT REVISION COMMITTEE ROSTER

The ASHRAE Position Document on Climate Change was developed by the Society's Position Document Revision Committee, formed on April 25, 2017, with Donald Brundage as its chair.

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