

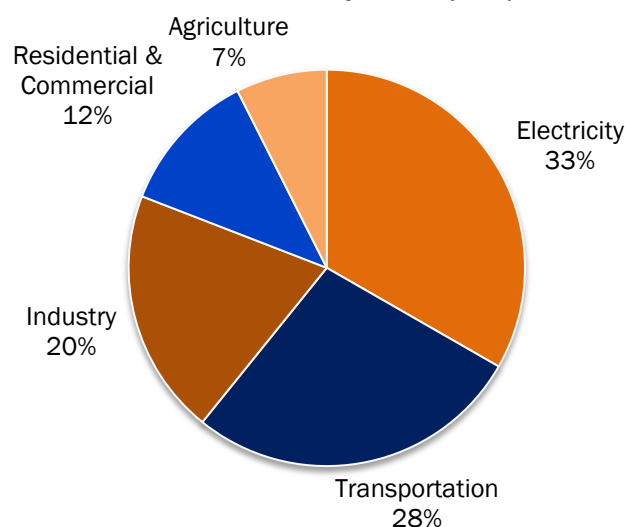
### Residential and Commercial Emissions in the United States

Greenhouse gas (GHG) emissions data can be reported either by economic sector, which includes electric power generation as a separate sector, or by end-use sector, which distributes the emissions from electricity generation across the economic sectors where the electricity is used. The residential and commercial sectors are large consumers of electricity, so it is appropriate to address both emissions from direct sources and electricity end-use for these sectors.

- **Direct emissions**

Direct emissions from the residential and commercial sectors respectively account for 5.4 and 6.2 percent of total GHG emissions in the United States (see Figure 1).

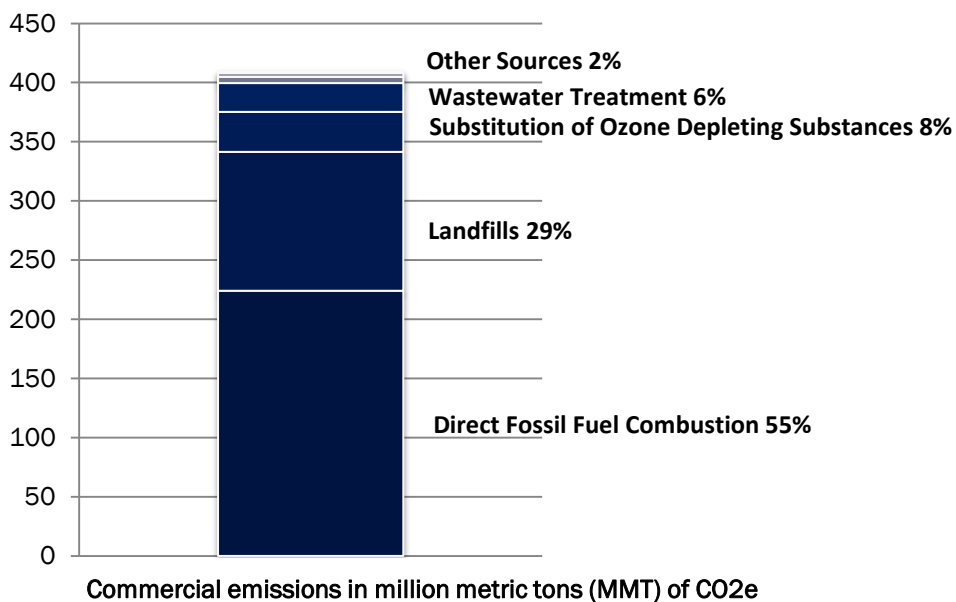
**Figure 1: U.S. Greenhouse Gas Emissions by Sector (2009)**



Source: Environmental Protection Agency (EPA), [Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009](#), Table ES-7, 2011.

Ninety-four percent of the residential sector's direct GHG emissions come from the combustion of fossil fuels, primarily for heating and cooking. Less than 6 percent of direct emissions come from the substitution of ozone depleting substances<sup>1</sup> and other minor sources. In the commercial sector, just over half of direct emissions come from on-site fossil fuel combustion. Other sources of direct commercial emissions include landfills, wastewater treatment, the substitution of ozone depleting substances, and other minor sources (see Figure 2).<sup>2</sup>

**Figure 2: Direct Emissions of Greenhouse Gases in the U.S. Commercial Sector (2009)**

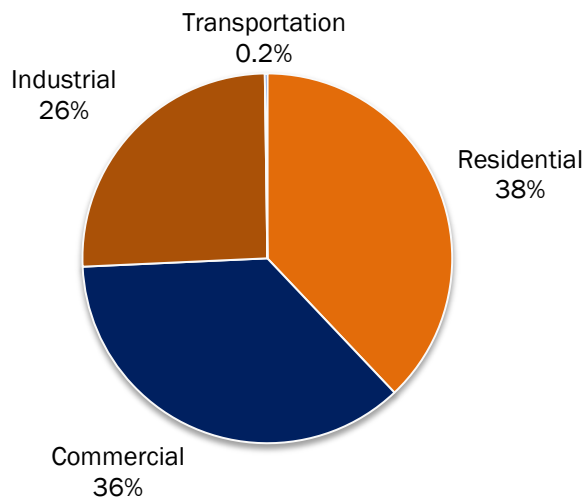


Source: EPA, [Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009](#), Table 2-12, 2011.

- End-use emissions**

U.S. electricity sales are split among the residential, commercial, and industrial sectors, with the residential and commercial sectors accounting for 38 and 36 percent of sales, respectively. (see Figure 3).

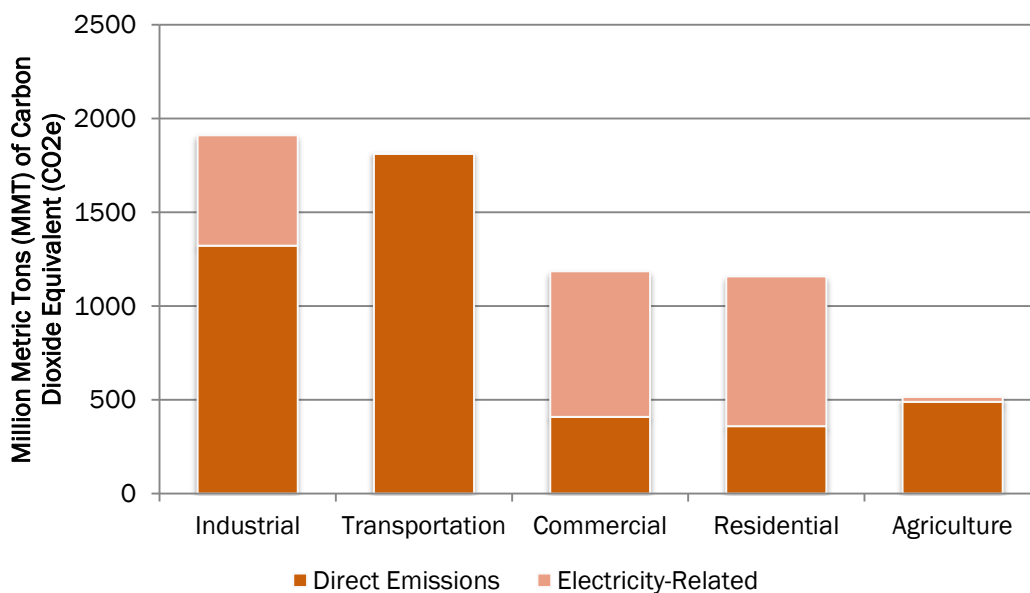
**Figure 3: Retail Sales of Electricity to Ultimate Customers, Total by End-Use Sector (2009)**



Source: U.S. Energy Information Administration (EIA), [Electric Power Monthly](#), Table 5.1, March 11, 2011.

When GHG emissions from electricity generation are attributed to end-use sectors, the residential and commercial sectors become greater contributors to GHG emissions, each responsible for 18 percent of total U.S. emissions (see Figure 4). Electricity-related GHG emissions account for 69 percent of total residential emissions and 65 percent of total commercial emissions.

**Figure 4: GHG Emissions from Direct Combustion and Electricity by End-Use Sector (2009)**



Source: EPA, [Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009](#), Table 2-14, 2011.

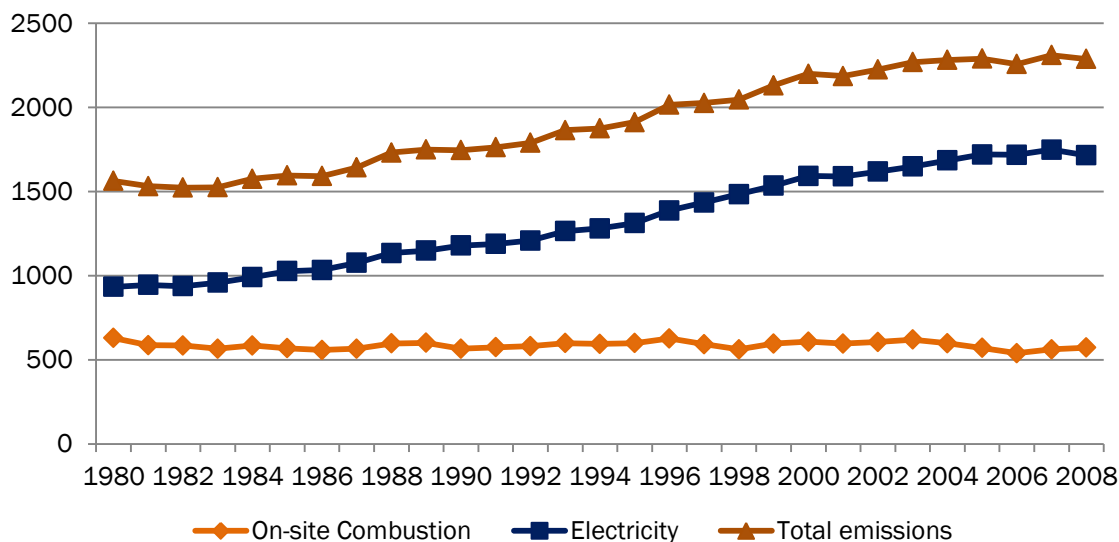
## **Buildings: Key Drivers of Residential and Commercial Emissions**

Emissions from the residential and commercial sectors, including both direct emissions and end-use electricity consumption, can largely be traced to energy use in buildings. Diverse factors determine how much energy buildings consume; these include the size of the building, the design and materials used, and the kinds of lighting and appliances installed.

### **Building Trends for GHG Emissions, Size, and Energy Use Intensity**

Total GHG emissions, including both direct and end-use emissions, from residential and commercial buildings in the United States accounted for about 39 percent of total U.S. carbon dioxide (CO<sub>2</sub>) emissions and 7 percent of global CO<sub>2</sub> emissions in 2008.<sup>3</sup> GHG emissions attributable to buildings have been steadily increasing; in recent decades, emissions from the on-site combustion of fossil fuels have remained relatively steady while electricity consumption has increased (see Figure 5).

Figure 5: CO<sub>2</sub> Emissions for U.S. Residential and Commercial Buildings, by Year in Million Metric Tons (MMT)<sup>4</sup>

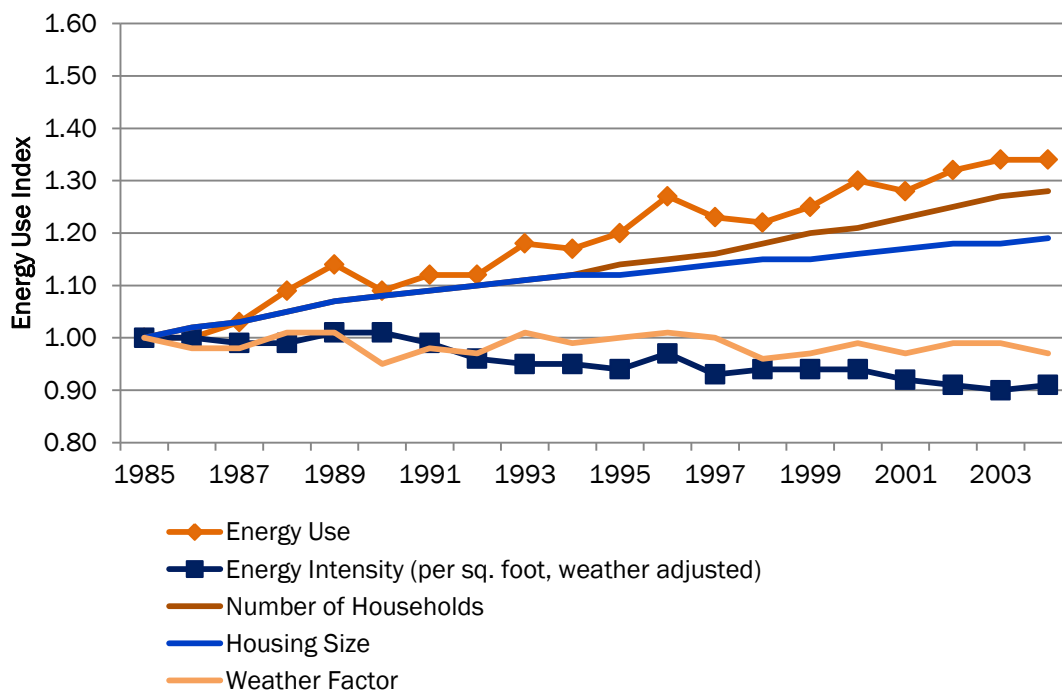


Source: U.S. Department of Energy (DOE), [2010 Buildings Energy Data Book](#), Section 1.4.1, 2011.

GHG emissions from buildings have increased as building size has increased. In the residential sector, the number of homes and the size of these homes have been increasing over time.<sup>5</sup> As homes grow larger, more energy is generally needed for heating, cooling, and lighting. Over time, homes also have added more appliances and consumer electronics.

Even as residential energy use has increased overall, the amount of energy used per square foot of residential buildings, a measure of energy intensity, has decreased, due to the increased efficiency of consumer appliances and recent regional building trends, such as improved residential building energy codes.<sup>6</sup> (see Figure 6) Energy intensity indicators are used to compare energy use in buildings through time. These indicators are used to examine energy-use trends in the different types of buildings in the residential and commercial sectors. They show how the amount of energy used per unit of output or activity has changed over time. Using less energy per unit of output reduces energy intensity; using more energy per unit increases the energy intensity. A weather factor is used to take into account the impacts of annual weather variation on energy consumption.<sup>7</sup>

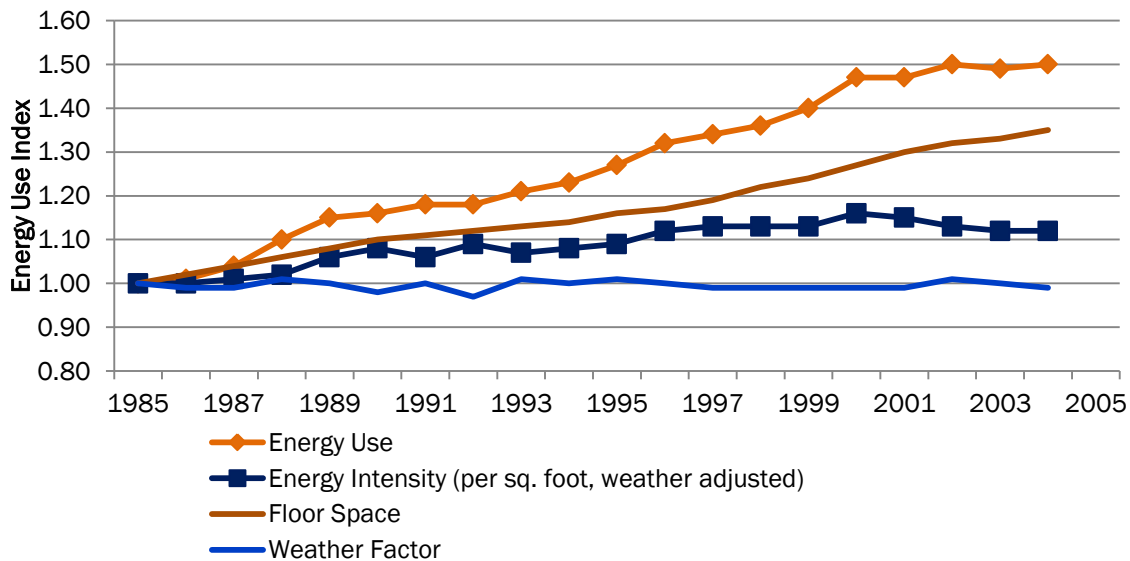
**Figure 6: Residential Energy Use, Energy Use Intensity, and Energy Use Factors**



Source: DOE, Energy Efficiency and Renewable Energy (EERE), "[Trend Data: Residential Buildings Sector](#)," updated 14 May 2008.  
 Note: The indicators on this chart are based on an Energy Use Index that is calibrated to 1985 levels.

In the commercial sector, both energy use and energy intensity have generally increased in recent decades. The general rise in energy intensity since 1985 has shown, however, a modest decline in recent years (see Figure 7). Commercial buildings have shown steady growth in size in recent years, as reflected by the increase in average floor space through time..

**Figure 7: Commercial Energy Use, Energy Use Intensity, and Energy Use Factors**

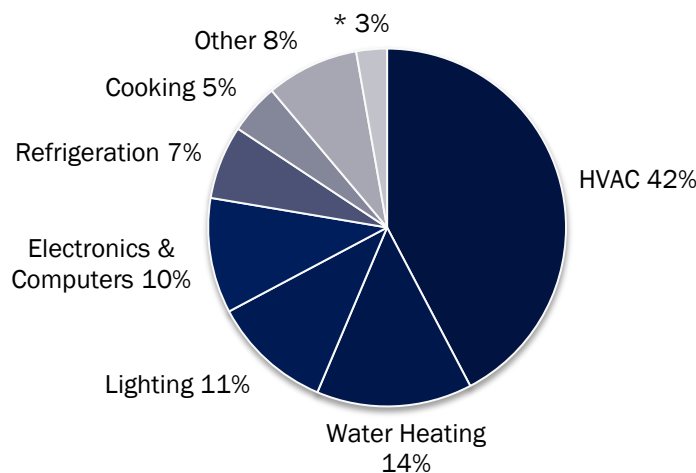


Source: DOE, EERE, "[Trend Data: Commercial Buildings Sector](#)," updated 14 May 2008. . Note: The indicators on this chart are based on an Energy Use Index that is calibrated to 1985 levels.

## Energy End Use in Buildings

The primary end uses of energy vary between the residential and commercial sectors. In the residential sector, heating, ventilation, and air conditioning (HVAC) account for 42 percent of total energy use. Since HVAC uses more than a third of energy use in the residential sector, total energy demand from this sector is fairly sensitive to weather and varies both by region in a single year, as well as through time in a given location. Other significant end uses of energy in the residential sector include lighting, water heating, electronics, refrigeration, and cooking (see Figure 8).

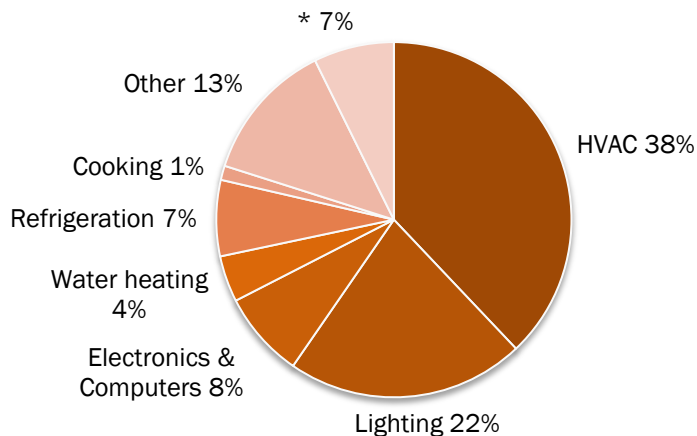
**Figure 8: Residential Buildings Total Energy End Use (2008)**



\* This pie chart includes an adjustment factor used by the EIA to reconcile two datasets.  
 Source: DOE, [2010 Buildings Energy Data Book](#), Section 2.1.5, 2011.

In the commercial sector, HVAC accounts for over one-third of total energy use and lighting accounts for just under one-fourth. Electronics, water heating, refrigeration, computers, and cooking also use significant quantities of energy in the commercial sector (see Figure 9). The commercial sector encompasses a variety of different building types, including schools, restaurants, hotels, office buildings, banks, and stadiums. Different building types have very different energy needs and energy intensities.

**Figure 9: Commercial Sector Buildings Energy End Use (2008)**



\* This pie chart includes an adjustment factor used by the EIA to reconcile two datasets.  
Source: DOE, [2010 Buildings Energy Data Book](#), Section 3.1.4, 2011.

For more information on buildings, see [CLIMATE TECHBOOK: Buildings Overview](#).

## Global Context

On a global scale, energy use and GHG emissions data for the residential and commercial sectors can be difficult to quantify. Globally, the amount of energy used attributed to buildings, as a proxy for the residential and commercial sectors, varies by country and climate. The energy consumption levels and primary fuel types of buildings in a specific country depend on economic and social indicators, such as national income and level of urbanization. Some key trends observed include:

- In general, developed countries consume more energy per capita than developing countries; developed countries tend to have bigger building sizes for comparable building functions, and they tend to use more appliances and other energy-using equipment than developing countries.
- Urban areas in developed countries use less energy per capita than rural areas; this is because of , district heating in higher-density areas, decreased transportation-related energy consumption, and other factors. However, the opposite effect can be seen in many developing countries where energy use is higher in cities than in rural areas because residents often have higher incomes and greater access to energy services.<sup>8</sup>
- In some countries, grid-connected power remains unavailable or unaffordable for households. In these areas, which include large portions of sub-Saharan Africa, as well as parts of India and China,

biomass and coal are often the primary fuels for heating and cooking.<sup>9</sup> This has important implications both for global greenhouse gas emissions and development goals, including:

- Global data on GHG emissions often do not account for emissions from biomass that is collected and burned locally. Household-level combustion of biomass and coal are estimated to account for about 10 percent of global energy use and 13 percent of direct carbon emissions.<sup>10</sup>
- The use of woody biomass, unless sustainably managed, can lead to widespread deforestation. Forests play important roles as local resources and as global carbon sinks.
- Indoor combustion of biomass and coal is a significant health concern; high rates of respiratory illness have been documented in areas that predominantly use biomass or coal for heating and cooking. Reducing GHG emissions through appropriate technology advances, energy efficiency improvements, and the use of alternative fuels will have important health co-benefits.
- Commercial energy intensity in developed countries, the energy use per dollar of income as measured by GDP, is currently almost twice that of developing countries. Commercial buildings' energy consumption is projected to be the fastest-growing end-use sector for energy in developing countries.<sup>11</sup> Economic growth in developing countries will likely lead to increased global demand for energy, and, without energy efficient products and practices, could lead to substantially higher global energy consumption and GHG emissions.

### **Residential and Commercial Sector Mitigation Opportunities**

Reducing emissions from the residential and commercial sectors can be done in a variety of ways and on a number of scales:

- **Addressing landfills**

Landfill waste can be reduced (thereby lowering the volume of decomposing material that produces methane, a powerful greenhouse gas) or harnessed as an energy source. Methane-capture systems in landfills prevent GHGs from being released into the atmosphere.

- **Reducing embodied energy in building materials**

*Embodied energy* refers to the energy used to extract, manufacture, transport, install, and dispose of building materials. Choosing low carbon materials—such as local materials, materials that sequester carbon, and products manufactured at efficient industrial facilities reduces emissions.

- **Improving building design and construction**

Building designs and construction techniques can maximize the use of natural light and ventilation, which minimizes the need for artificial light and HVAC equipment. Using building shading techniques, installing windows to minimize or maximize solar intake (depending on the region), and properly insulating against unwanted air flow between indoor and outdoor spaces improve energy use. Many

other options are available and “green” builders are continually creating innovative ways to maximize efficiency in building spaces.

- **Increasing end-use energy efficiency**

Using efficient appliances can minimize energy consumption and concomitant GHG emissions from electricity and direct fossil fuel combustion.

- **Adopting new energy-use habits**

Following conservation guidelines and making personal choices to reduce the use of appliances, artificial lighting, and HVAC equipment (for example, by shutting them off when they are not in use) will reduce energy use. Also, opting for smaller residential and commercial spaces can reduce the energy needed for building construction and operation.

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<sup>1</sup> Hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) are used as alternatives to several classes of ozone-depleting substances (ODSs) that are being phased out under the terms of the Montreal Protocol and the Clean Air Act Amendments of 1990. Ozone depleting substances—chlorofluorocarbons (CFCs), halons, carbon tetrachloride, methyl chloroform, and hydrochlorofluorocarbons (HCFCs)—are used in a variety of industrial applications including refrigeration and air conditioning equipment, solvent cleaning, foam production, sterilization, fire extinguishing, and aerosols. Although HFCs and PFCs are not harmful to the stratospheric ozone layer, they are potent greenhouse gases. Environmental Protection Agency (EPA), *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*, 2011. <http://www.epa.gov/climatechange/emissions/usinventoryreport.html>

<sup>2</sup> Environmental Protection Agency (EPA), *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*, 2011. <http://www.epa.gov/climatechange/emissions/usinventoryreport.html>

<sup>3</sup> U.S. Department of Energy (DOE). *2010 Buildings Energy Data Book*. Prepared for the DOE Office of Energy Efficiency and Renewable Energy by D&R International, 2011. <http://buildingsdatabook.eren.doe.gov/>

<sup>4</sup> One million metric ton is equal to one teragram. For reference, one million metric ton of CO<sub>2</sub>e is equal to 280,000 new cars each being driven 12,500 miles or 90 minutes of U.S. energy consumption or 1 day of U.S. energy emissions from lighting buildings, see DOE, *2010 Buildings Energy Data Book*, 2011.

<sup>5</sup> DOE, *Energy Efficiency Trends in Residential and Commercial Buildings*, August 2010. [http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/building\\_trends\\_2010.pdf](http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/building_trends_2010.pdf); U.S. Census Bureau, Housing Vacancies and Homeownership, <http://www.census.gov/hhes/www/housing/hvs/historic/index.html>.

<sup>6</sup> DOE 2010

<sup>7</sup> The weather factor is included to show variations in weather conditions that may have had an impact on energy use in a given year. Data that is weather-adjusted shows how the indicator would have performed under “normal” weather conditions; for example, data in years with extreme weather (such as unusually cool weather that would increase energy consumption for indoor heating) is adjusted to show performance without the influence of weather. As the figure indicates, weather conditions have remained fairly stable while other indicators have risen; this indicates that weather conditions do not have as much of an impact on energy use as other factors.

<sup>8</sup> International Energy Agency (IEA). *World Energy Outlook, 2010 Edition*. Paris: IEA, 2010. <http://www.worldenergyoutlook.org/2010.asp>. UNEP, Urban Density and Transport-related Energy Consumption, <http://maps.grida.no/go/graphic/urban-density-and-transport-related-energy-consumption>.

<sup>9</sup> Energy Information Administration (EIA), *International Energy Outlook 2010*. <http://www.eia.gov/oiaf/ieo/index.html>

<sup>10</sup> Smith, K. R. and E. Haigler. “Co-Benefits of Climate Mitigation and Health Protection in Energy Systems: Scoping Methods.” *Annual Review of Public Health* 29 (2008): 11-25.

<sup>11</sup> EIA. *International Energy Outlook 2010*, <http://www.eia.gov/oiaf/ieo/index.html>