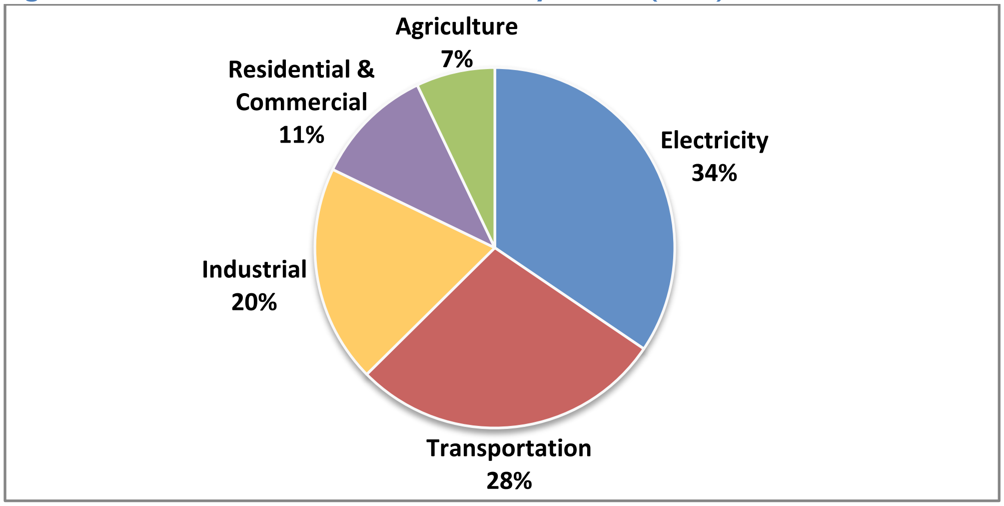
Residential and Commercial Emissions in the United States

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 and 6 percent of total GHG emissions in the United States (see Figure 1).

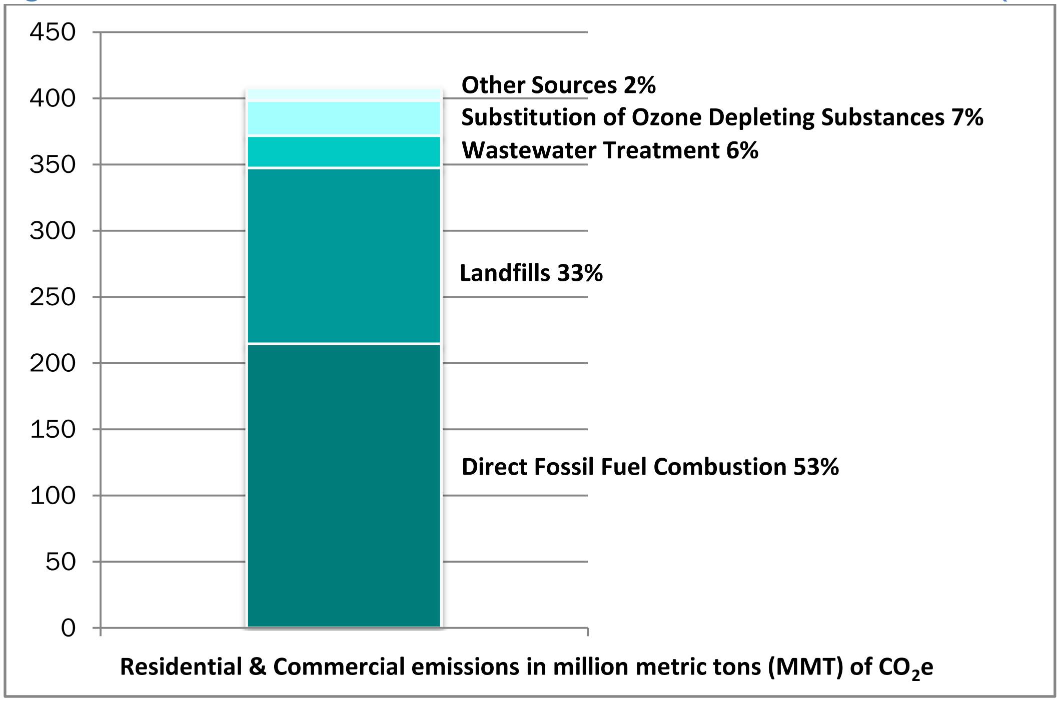
Figure 1: U.S. Greenhouse Gas Emissions by Sector (2007)



Source: Environmental Protection Agency (EPA), *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007*, Table ES-7, 2009.

The residential sector's direct GHG emissions are dominated by the combustion of fossil fuels for heating and cooking, with less than 5 percent of direct emissions coming from the substitution of ozone depleting substances 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).[1]

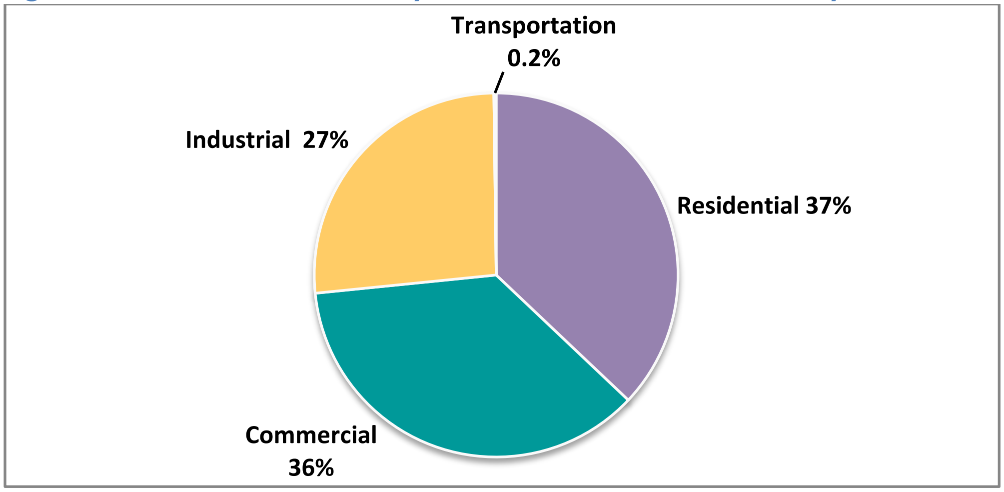
Figure 2: Direct Emissions of Greenhouse Gases in the U.S. Commercial Sector (2007)



Source: EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007*, Table 2-12, 2009.

- **End-use emissions**
  U.S. electricity sales are roughly evenly split among the residential, commercial, and industrial sectors, with the residential and commercial sectors accounting for 37 and 36 percent of sales, respectively, or nearly 70 percent of all electricity sales (see Figure 3).

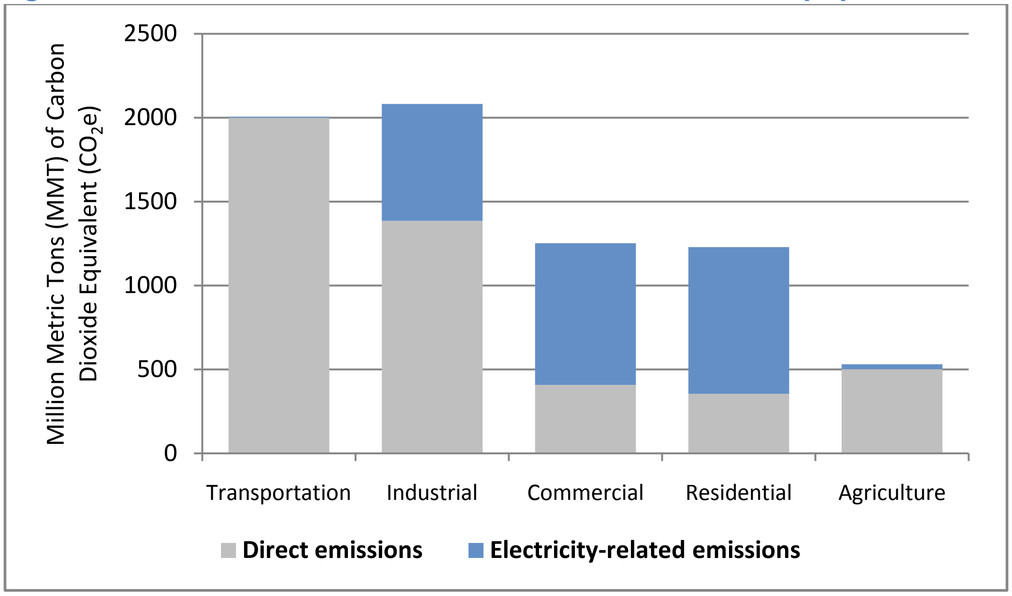
Figure 3: Retail Sales of Electricity to Ultimate Customers, Total by End-Use Sector (2008)[2]



Source: U.S. Energy Information Administration (EIA), *Electric Power Monthly*, Table 5.1, April 22, 2009.

When GHG emissions from electricity generation are distributed across the end-use sectors, the residential and commercial sectors become more significant contributors to GHG emissions, each responsible for 17 percent of total U.S. emissions (see Figure 4). Electricity-related GHG emissions account for 70 percent of total residential emissions and 67 percent of total commercial emissions.

Figure 4: GHG Emissions from Direct Combustion and Electricity by End-Use Sector (2007)



Source: EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007*, Table 2-14, 2009.

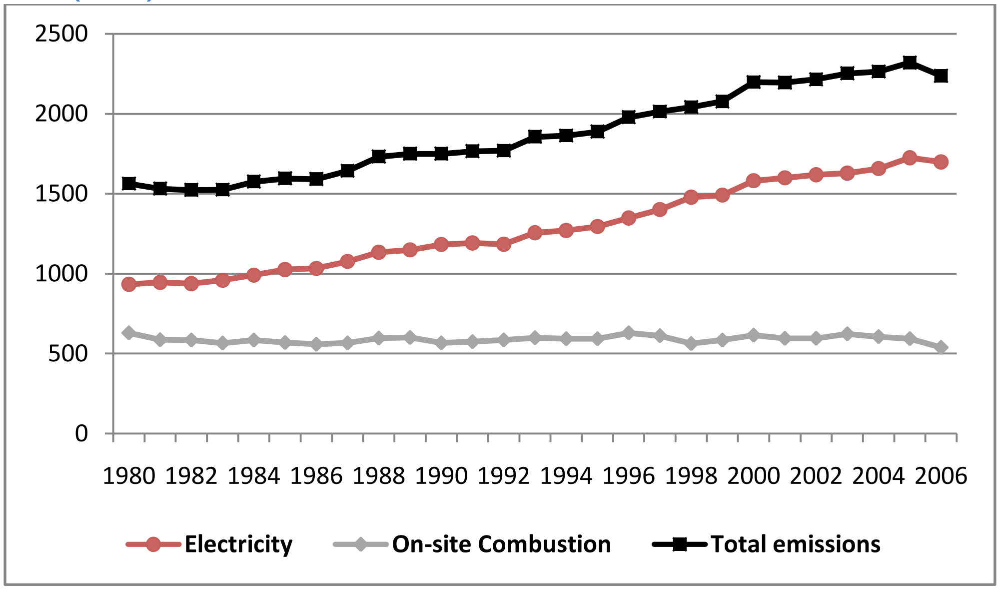
Buildings: Key Drivers of Residential and Commercial Emissions

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. A variety of diverse factors determine the amount of energy buildings consume; these range from the size of the building to the design and materials used to 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 38 percent of total U.S. carbon dioxide (CO_2) emissions and 8 percent of global CO_2 emissions in 2006.[3] 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_2 Emissions for U.S. Residential and Commercial Buildings, by Year in Million Metric Tons (MMT)[4]



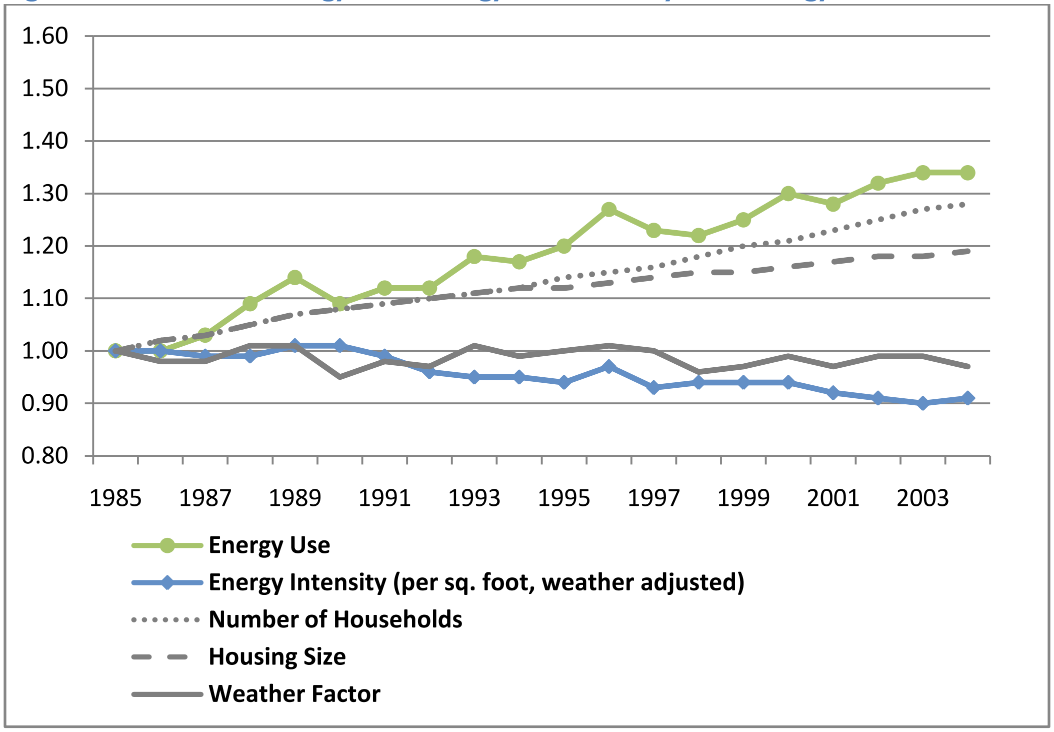
Source: U.S. Department of Energy (DOE), *2008 Buildings Energy Data Book*, Section 1.4.1, 2008.

Increased GHG emissions from buildings have corresponded with a general trend of increased building size. In the residential sector, a larger proportion of the population has opted for single-family homes and the size of these homes has also been increasing over time.[5] As homes grow larger, more energy is generally needed for heating, cooling, lighting, and the larger number of appliances and consumer electronics. Even as residential energy use has increased overall, improvements to energy efficiency have led to a decrease in the amount of energy used per square foot of residential buildings relative to the amount of energy used per square foot in 1985, a measure of energy intensity (see Figure 8).

Energy intensity indicators are used to compare energy use in buildings through time. These indicators are used to examine energy-use trends in the diverse building stocks that make up 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 the energy intensity; using more energy per unit increases the energy intensity. Since energy intensity indicators are intended to show trends in energy use, a weather factor is used to take into account the impacts of annual weather variation on energy consumption.[6]

Figure 6 shows trends in residential energy use and intensity over time. The total amount of energy consumed, the number of households, and the size of residences have all increased in recent decades. Meanwhile, the energy intensity of residences on a square footage basis has decreased, likely due to the increased efficiency of consumer appliances and recent regional building trends (see Figure 6).

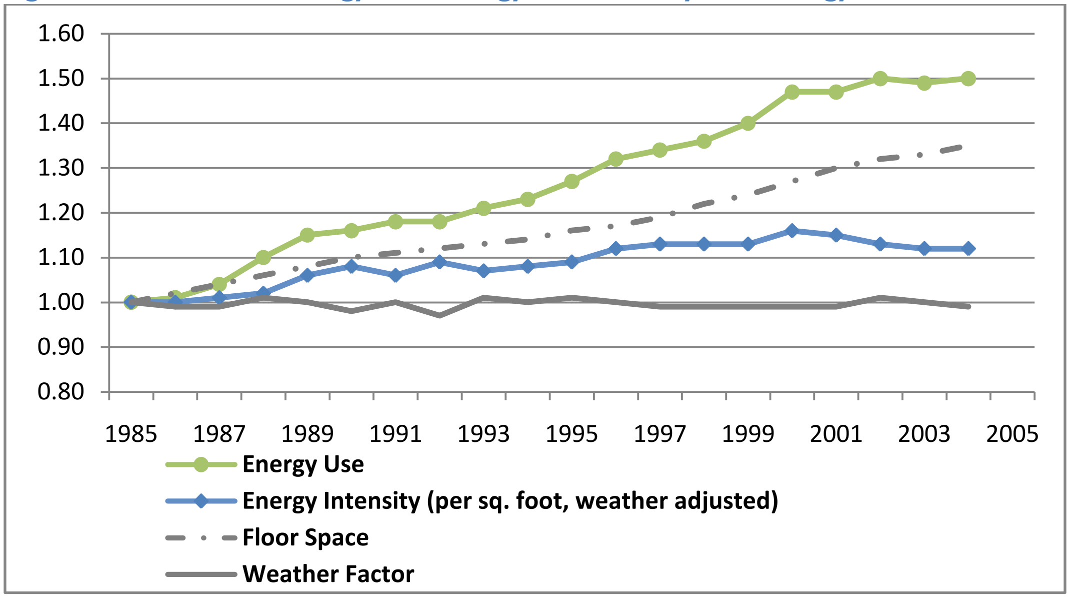
Figure 6: Residential Energy Use, Energy Use Intensity, and Energy Use Factors



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, however, shown a modest decline in recent years (see Figure 7). Commercial buildings have shown steady growth in recent years, as is reflected by the increase in floor space through time. Indeed, some estimates suggest that about a half million new commercial buildings are constructed every five years.

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

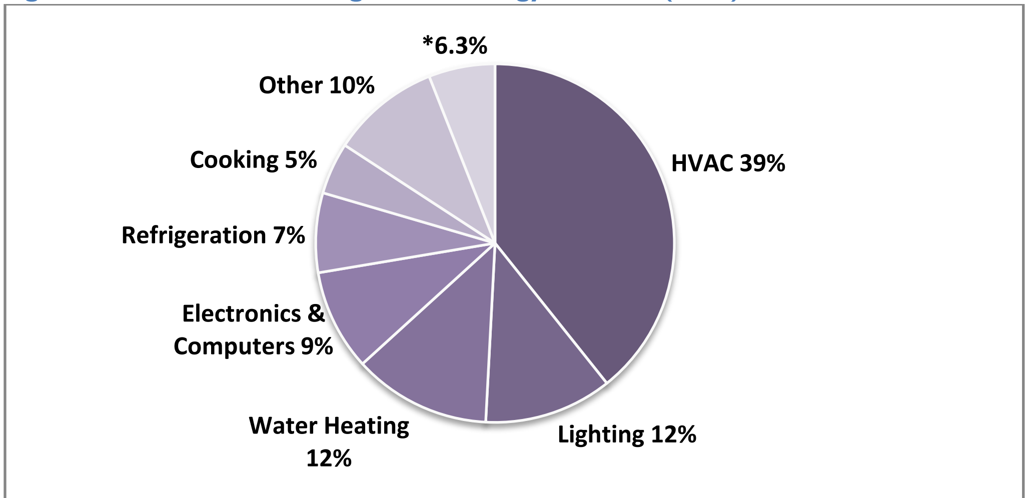


Source: DOE, EERE, "Trend Data: Commercial Buildings Sector," updated 14 May 2008. . Note: The indicators on this chart are based on an Energy Use Index that is calibrated to 1985 levels.

Energy 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 39 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 (2006)

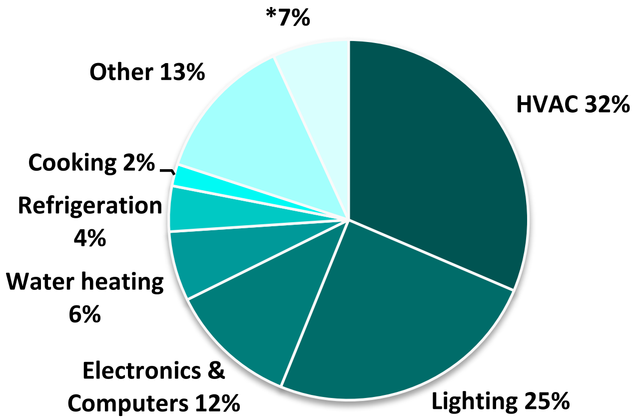


* This pie chart includes an adjustment factor used by the EIA to reconcile two datasets.

Source: DOE, 2008 Buildings Energy Data Book, Section 2.1.5, 2008.

In the commercial sector, HVAC accounts for nearly a third of total energy use and lighting accounts for a quarter. 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. These different building types can have very different energy needs and energy intensities.

Figure 9: Commercial Sector Buildings Energy End Use (2006)



* This pie chart includes an adjustment factor used by the EIA to reconcile two datasets.

Source: DOE, *2008 Buildings Energy Data Book*, Section 3.1.4, 2008.

For more information on buildings, see *CLIMATE TECHBOOK: Buildings Overview*.

Global Context

At the global scale, energy use and GHG emissions data for the residential and commercial sectors can be difficult to quantify. Globally, the amount of energy use attributed to buildings, as a proxy for the residential and commercial sectors, varies by country and climate. Energy consumption levels and primary fuel types are related to other 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 purposes, 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 greater efficiency from a variety of factors, including public transportation and district heating in higher-density areas. 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.[7]
- 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 used for heating and cooking.[8] 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.[9]
- 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 therefore may have important health co-benefits.

- Commercial energy consumption is currently almost 14 times higher in developed than developing countries; energy consumption by commercial buildings is projected to be the highest-growing end-use sector for energy in developing countries.[10] Economic growth in developing countries will likely lead to increased demand for energy and, without efficient products and practices, could lead to substantially higher energy global 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 material that when it decomposes 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. Emission reductions can be made by choosing low carbon materials—such as local materials, materials that sequester carbon, and products manufactured at efficient industrial facilities.

- **Improving building design and construction**
  Using building design and construction techniques to maximize the use of natural light and ventilation can minimize the need for artificial light and HVAC equipment. This can be achieved by using appropriate building shading techniques, installing windows that minimize or maximize solar intake (depending on the region), and insulating properly to prevent unwanted air flow between indoor and outdoor spaces. Many other options are available, and "green" builders are constantly 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).

Also, opting for smaller residential and commercial spaces can reduce the energy needed for building construction and operation.

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[1] Environmental Protection Agency (EPA), *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007*, 2009. http://www.epa.gov/climatechange/emissions/usinventoryreport.html

[2] This figure excludes commercial and industrial facility use of onsite net electricity generation, which was roughly 4 percent of net electricity generation in 2007.

[3] U.S. Department of Energy (DOE). *2008 Buildings Energy Data Book*. Prepared for the DOE Office of Energy Efficiency and Renewable Energy by D&R International, 2008. http://buildingsdatabook.eren.doe.gov/

[4] One million metric ton is equal to one teragram. For reference, one million metric ton of CO_2e 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, *2008 Buildings Energy Data Book,* 2008.

[5] DOE, *Energy Efficiency Trends in Residential and Commercial Buildings*, October 2008. http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/bt_stateindustry.pdf

[6] 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.

[7] International Energy Agency (IEA). *World Energy Outlook, 2008 Edition*. Paris: IEA, 2008. http://www.worldenergyoutlook.org/2008.asp

[8] Energy Information Administration (EIA), *International Energy Outlook 2008*, 2009. http://www.eia.doe.gov/oiaf/ieo/world.html

[9] 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.

[10] EIA. *International Energy Outlook 2008*, 2008. http://www.eia.doe.gov/oiaf/ieo/world.html