NATURAL GAS IN COMMERCIAL BUILDINGS

CENTER FOR CLIMATE AND ENERGY SOLUTIONS

Discussion Questions:

1. **If natural gas promises lower operating costs, lower emissions, and greater efficiency over utility grid delivered electricity, why is the commercial sector slow to increase use?**
2. **Can new financing options increase natural gas access retrofits for commercial buildings?**
3. **How can utilities and commercial building operators become more comfortable with CHP systems?**
4. **How can up-to-date commercial building codes be instituted and met in states and localities?**
5. **How should building codes and environmental certifications consider the use of natural gas and electricity?**

HIGHLIGHTS

- There were more than 4.8 million commercial buildings in the United States in 2003.
- Space heating and lighting are the largest uses of energy in commercial buildings, representing 38 percent and 20 percent of total site use respectively.
- The choice of electricity or natural gas use within the sector is dependent on building use, size, and geographic location.
- Health care and educational buildings use natural gas more commonly than other commercial building types.

This is a joint project between the Center for Climate and Energy Solutions and the University of Texas Energy Management and Innovation Center

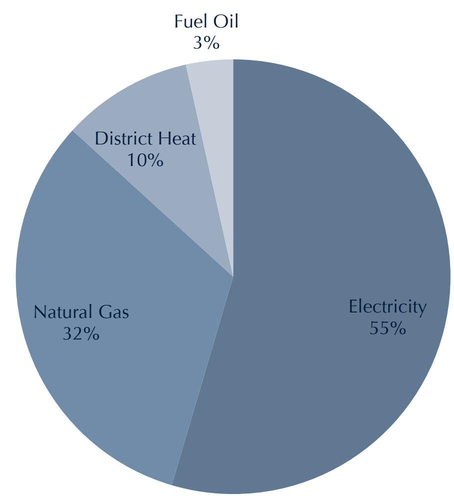
THE UNIVERSITY OF TEXAS AT AUSTIN McCOMBS ENERGY MANAGEMENT AND INNOVATION CENTER

INTRODUCTION

Energy is delivered to 4.8 million commercial and institutional buildings in the United States via four primary means: electricity, natural gas, district heat, and fuel oil. Electricity and natural gas accounted for 87 percent of all commercial energy in 2003 (**Figure 1**). 2003 was the last time that the US Energy Information Administration (EIA) conducted the Commercial Building Energy Consumption Survey (CBECS) and the next survey is scheduled to begin in April 2013. The latest survey collected data on nearly 7,000 buildings that were selected to statistically represent the more than 4.8 million commercial buildings in the U.S.[1] The commercial building sector is not dominated by any one building type or use. Office buildings are the most common type (as defined by floor space), followed by mercantile, warehouse and storage, and education. Small buildings (1,000 to 5,000 square feet) account for more than half of all buildings (as defined by the number of buildings) but only 10 percent of total energy use. Energy use in these buildings varies substantially, reflecting the diversity of size, purpose, and location. For example, buildings used for health care are very energy intensive, consuming 9 percent of total energy, but accounting for just 3 percent of buildings. Conversely, warehouse and storage buildings account for 14 percent of floor space but only 7 percent of total energy.

Building activity also influences the type of energy used. Office buildings tend to utilize electricity rather than natural gas because many of their primary loads such as lighting, elevators, personal computers and servers, scanners, printers, and others cannot be served by natural gas. Lodging, health care, and food service, in contrast can more easily use natural gas for cooking, hot water, cleaning, and laundry. Consequently, these facilities use proportionally more natural gas than office buildings.

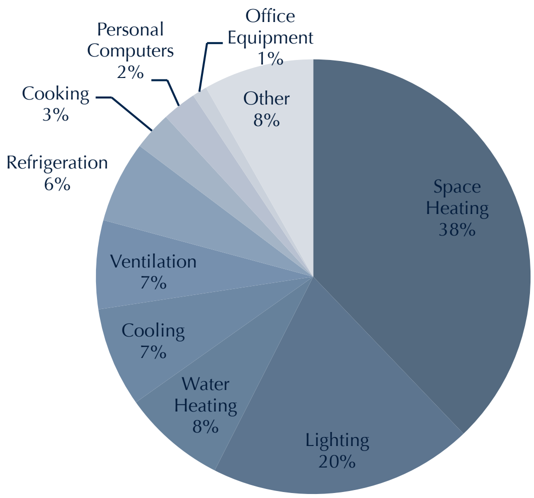
FIGURE 1: U.S. Commercial Energy Consumption by Source, 2003



Source: EIA 2003

In the residential energy sector, space and water heating are the two largest energy loads. In the commercial sector, space heating and lighting are the two largest energy loads (**Figure 2**). The third largest energy use is roughly shared between water heating, space cooling, ventilation, and refrigeration.

FIGURE 2: U.S. Commercial Energy Consumption by Use, 2003

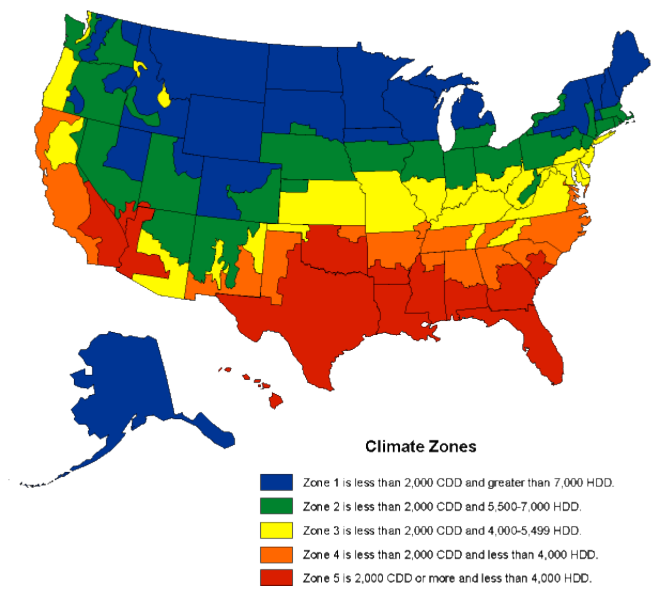


Source: EIA 2003

Of course, Figures 1 and 2 represent an average for the country across all commercial segments, building types, sizes, ages, and climate zones. Climate plays a large role in determining what type and how energy is used; the majority of commercial buildings reside in colder climate zones (zones 1 to 4), which includes much of the country except for the Deep South and the arid Southwest. In these zones, winters are cold enough for frequent, substantial space heating, and the average amount of energy needed to heat a building during the winter, measured in Heating Degree Days (HDDs), is two to four times the average amount of energy needed to cool a building during the summer, measured in Cooling Degree Days (CDDs) (**Figure 3**).[2] For space heating, natural gas is the predominate fuel in colder climate zones, providing heat for 69 to 75 percent of all floor space in the coldest zones but dropping to 47 percent in zone 5, the warmest region.[3] Therefore, natural gas is the lead fuel source for heating in commercial buildings nationally.

Electricity is nearly ubiquitous in commercial buildings throughout the United States, but natural gas use is closely correlated to specific commercial sectors. The three most energy intensive sectors (in Btu per square foot) are food service, food sales, and health care, which use 258, 200, and 188 Btu per square foot respectively.[4] While 84 percent of food service square footage is served by natural gas, for food sales, that figure is only 60 percent. This difference is due to the large amount of thermal energy required in cooking and cleaning in the food service sector, while food sales energy use is predominantly for refrigeration. Likewise, 95 percent of in-patient health care building stock is served by gas due to food preparation, hot water, and cleaning demands, while only 59 percent of outpatient health care facilities use gas.[5]

FIGURE 3: U.S. Climate Zones, Heating Degree Days vs. Cooling Degree Days Source: US EIA 2004



Source: US EIA 2004

Building size also plays a major role in energy consumption and fuel source. As shown in **Table 1**, buildings over 100,000 square feet account for only 2 percent of the total number of buildings but account for greater than 40 percent of total energy use. Of these large buildings over 100,000 square feet, 77 percent use natural gas for space heating.[6] This predominance of natural gas use for heating in the largest of buildings, food service, and in-patient hospitals, can be directly attributed to the greater overall efficiency of natural gas over electricity for thermal applications such as space heating, water heating, and cooking.

TABLE 1: Number of Buildings & Total Consumption by Size, 2003

BUILDING FLOORSPACE (SQUARE FEET)	TOTAL BUILDINGS (THOUSAND)	PERCENT OF BUILDINGS	CUMULATIVE PERCENT OF BUILDINGS	TOTAL CONSUMPTION (TRILLION BTU)	PERECNT OF CONSUMPTION	CUMULATIVE PERCENT OF CONSUMPTION
1,001 to 5,000	2,586	53.2	53.2	685	10.5	10.5
5,001 to 10,000	948	19.5	72.7	563	8.6	19.1
10,001 to 25,000	810	16.7	89.4	899	13.8	32.9
25,001 to 50,000	261	5.4	94.8	742	11.4	44.3
50,001 to 100,000	147	3.0	97.8	913	14.0	58.3
100,001 to 200,000	74	1.5	99.3	1,064	16.3	74.6
200,001 to 500,000	26	0.5	99.99	751	11.5	861.
Over 500,000	8	0.2	100.0	906	13.9	100.0

Source: US EIA CBECs 2003

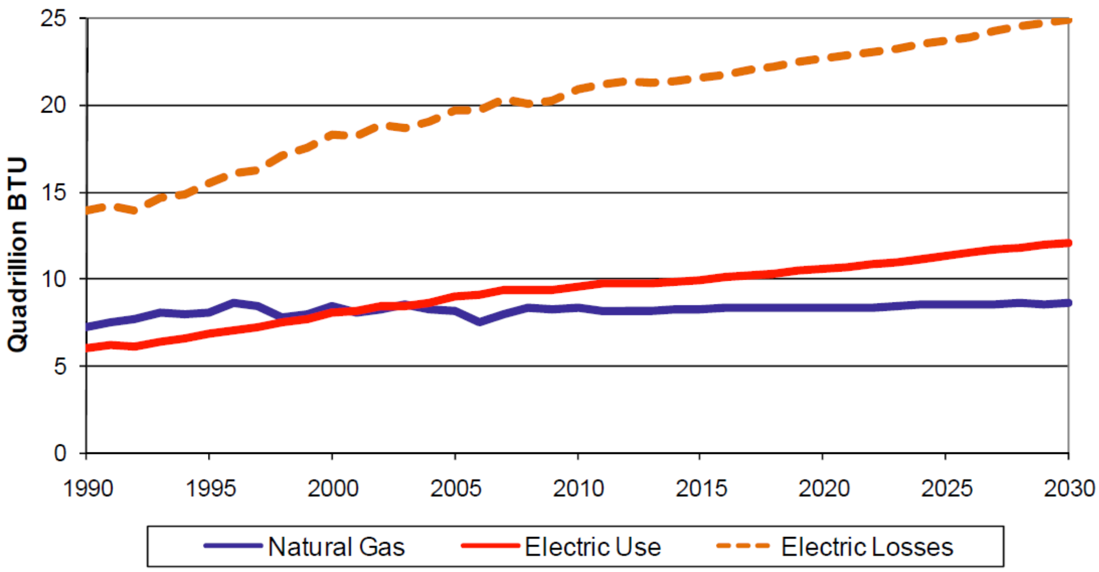
COMMERCIAL BUILDING EMISSIONS PROFILES

As discussed in the paper "Natural Gas Use in the Residential Sector," Full Fuel Cycle (FFC) efficiency and associated emissions analysis provides a true baseline comparison when evaluating the energy and emissions impacts of commercial buildings powered by different fuel sources. Due to the 32 percent average efficiency of grid-delivered electricity and the predominance of fossil-fuel-fired power plants in the United States, buildings that rely on grid electrical power for the majority of their energy use have the highest emissions profiles. Office space is the largest electricity consumer, responsible for the consumption of 2,170 trillion Btu of fuel needed to deliver the 719 trillion Btu of electricity these buildings consumed. Education is the second largest, responsible for the consumption of 1,121 trillion Btu of energy needed to deliver 371 trillion Btu of consumed electricity. These two type of commercial buildings account for 36 percent of all the electricity used in buildings and because they rely on grid-delivered electricity rather than on-site generation they also have the highest emissions profiles.[7]

In 2008, the Energy Information Administration reported that buildings consumed 40 percent of the country's primary energy resources and 74 percent of its electricity.[8] **Figure 4** shows that for 2008, the site consumption of gas and electricity by residential and commercial buildings was 8.28 and 9.37 quadrillion Btu respectively for a total site consumption of 17.65 quadrillion Btu. However, the losses associated with generating and delivering the 9.37 quadrillion Btu of electricity were more than 20 quadrillion Btu.[9] If grid-supplied electricity use continues to grow and natural gas use remains flat, as forecast by the EIA, growth in total energy consumed by buildings will be three times that of the growth in electricity consumed.

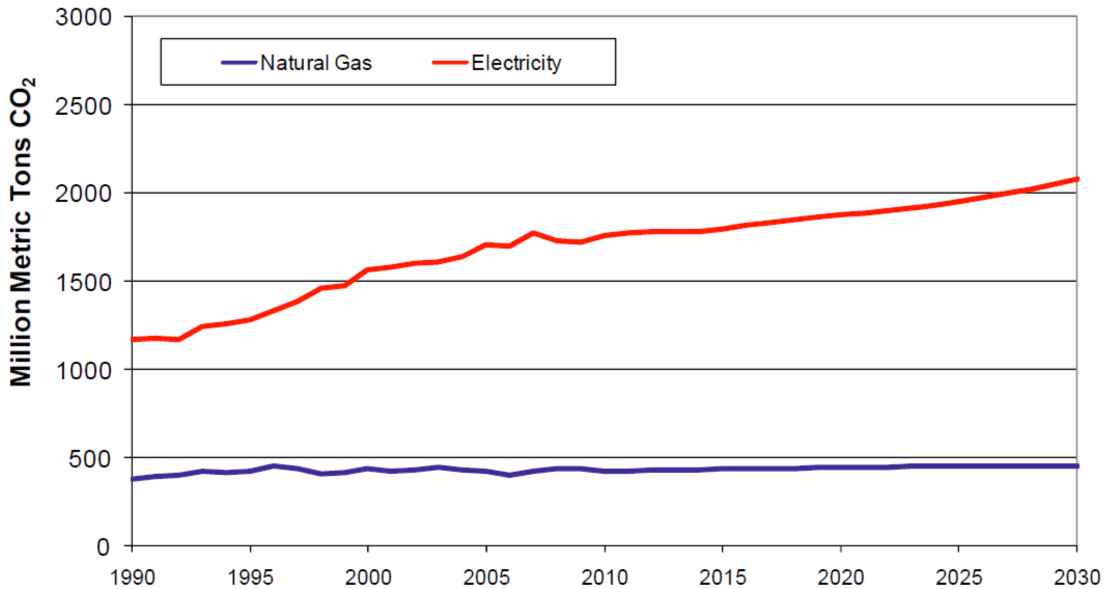
Commercial and residential energy use has been a growing contributor to CO_2 emissions for the last two decades, and the trend is forecast to continue, as shown in **Figure 5**.[10] This trend is being driven not only by the increase in electricity use, but also by the low average efficiency of on-grid electricity and the high average carbon fuel intensity of the U.S. electricity generation portfolio. Additionally, the high level of coal use in U.S. electricity production, leads to significant increases in sulfur dioxide (SO_2), nitrogen oxides (NO_x), and mercury emissions with increased electricity use.

FIGURE 4: Residential and Commercial Energy Use Trends



Source: EIA Annual Energy Outlook 2009

FIGURE 5: Combined Residential and Commercial CO_2 Emission Trends



Source: EIA Annual Energy Outlook 2009

Natural gas use provides a means to increase a building's total FFC efficiency and decrease its emissions profile. This improvement is most readily achieved in thermal applications, such as natural gas space heating and water heating. In these uses, while natural gas has a comparable or slightly lower site efficiency than electrical appliances, natural gas is two to three times more efficient than electricity, on an FFC basis.[11] Buildings with older natural gas- or oil-fired boilers and furnaces can also improve their efficiency and lower their emissions by upgrading to newer models.

Combined heat and power operations (CHP) also provide a means for buildings that have primarily electrical demand to make efficiency gains and emission reductions, as explained in the paper "Natural Gas in the Industrial Sector." Modern solid oxide fuel cell (SOFC) and micro-turbine technologies provide a means for buildings to generate their own electrical power, on site, with natural gas, at FFC electrical efficiencies as high as 50 percent. The waste heat generated by these devices can then be used for space heating, water heating, and other thermal loads to raise the overall FFC efficiency of the devices to greater than 80 percent.[12] These technologies and others are explained in the paper "Distributed Generation and Emerging Natural Gas Technologies."

The use of micro-turbines operating in CHP mode has gained acceptance primarily in the in-patient hospital, hotel, and resort sectors. These facilities have large electrical loads and nearly comparable thermal loads for space heating, water heating, cooking, and laundry. These large and year round (in the case of all but space heating) thermal loads provide a ready use for the waste thermal energy provided by the micro-turbine. This allows them to operate at near peak efficiency not only around the clock but also year round.

BARRIERS TO NATURAL GAS ACCESS AND EFFICIENCY IN THE COMMERCIAL SECTOR

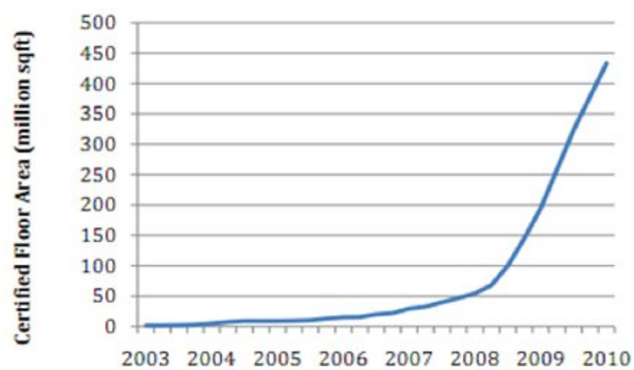
There are several barriers to increased use of natural gas in commercial buildings. One of the largest may be the high percentage of non-owner-occupied buildings and its influence in construction of commercial buildings. A large percentage of office and warehouse floor space is designated as non-owner operated. These buildings are designed and built by real-estate developers who then rent or lease the space to tenants. On a floor space basis, 49 percent of private commercial buildings are owner-occupied and 51 percent are non-owner-occupied.[13] The "for lease" building sector is extremely competitive and rental cost per square footage is a key metric in attracting renters. The focus on least cost development can drive builders to prioritize construction cost over minimizing operating costs (especially if operating costs are paid for by tenants and not building owners). This approach can preclude installation of high efficiency and lower emission systems that use fuel, on site, for electricity generation and heating applications.

Owner-operators, those who design and construct buildings for their own use, on the other hand, are more inclined to factor in operating costs of the buildings they construct and thus tend to install more energy efficient systems and subsystem components. This focus on the longer term operational costs of buildings and the advantage of higher efficiency systems is true in public and institutional buildings as well.

Commercial building codes, or lack thereof, are also a barrier to the development of higher efficiency and lower emissions buildings. In 1992, the building code requirements of the Federal Energy Policy Act, which were based on 1989 industry standards, were met by only five states. By 2008, 40 states had statewide commercial building codes that met or exceeded the 1989 Federal standards, but only twenty-seven met the higher standards issued by the Department of Energy in 2004. This lead/lag effect in the setting and meeting of standards is indicative of a non-owner-operated building market that still places operating costs at a lower priority than construction costs. Federal requirements, however, are not the only drivers. California for example, has sets standards higher than the federal government and some utilities such as Austin Energy in central Texas, have worked with the Austin city government to push standards and building codes beyond the industry norm. In both examples, it appears that civic concern and location have made a difference.

There is also some evidence that the introduction of non-government building standards such as the Leadership in Energy and Environmental Design (LEED) standards, developed and promoted by the U.S. Green Building Council, are helping to educate the real estate industry and potential tenants on the financial benefits of focusing on long-term operating and environmental costs. Many municipalities, school districts, counties and states have adopted LEED standards for their new buildings leading to an exponential growth in the number of LEED certified buildings, as shown in **Figure 6**.[14] This practice is having a spillover effect in the "build to suit" and lease markets as well. LEED, or similar, certifications are now often seen as a minimum requirement in building quality by potential renters and are being recognized by owners as contributing to increased resale value.

FIGURE 6: Growth of LEED Certified Space



Source: U.S. Green Building Council 2010

ENDNOTES

1 In the CBECS, the definition of commercial building is: all roofed and walled structures whose principal activities are nonresidential, nonagricultural, and nonindustrial and that are larger than 1,000 square feet.

2 Energy Information Administration, "U.S. Climate Zones," 2004. Available at http://www.eia.gov/emeu/recs/climate_zone.html

3 Energy Information Administration, Commercial Buildings Energy Consumption Survey 2009, Building Characteristics, Table B23.

4 Energy Information Administration, Overview of Commercial Buildings, 2003.

5 Energy Information Administration, Commercial Buildings Energy Consumption Survey 2009, Building Characteristics, Table B23.

6 Energy Information Administration, Commercial Buildings Energy Consumption Survey 2009, Building Characteristics, Table C31.

7 Energy Information Administration, Commercial Buildings Energy Consumption Survey 2009, Building Characteristics, Table C1.

8 Energy Information Administration, Annual Energy Outlook, 2009.

9 Energy Information Administration, Annual Energy Outlook, 2009.

10 Energy Information Administration, Annual Energy Outlook, 2009. Available at http://www.eia.doe.gov/oiaf/1605/ggrpt/excel/historical_co2.xls

11 Source Energy and Emission Factors for Building Energy Consumption 2009, Tech. rep., Gas Technology Institute, Natural Gas Codes and Standards Research Consortium, American Gas Foundation, Washington DC (2009).

12 U.S. Department of Energy, "Fuel Cell Technology Programs." Available at http://www1.eere.energy.gov/hydrogenandfuelcells/fuelcells/fc_types.html

13 U.S. Department of Energy, "Energy Efficiency Trends in Residential and Commercial Buildings, 2008. Available at http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/bt_stateindustry.pdf

14 U.S. Department of Energy, "Energy Efficiency Trends in Residential and Commercial Buildings, 2008. Available at http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/bt_stateindustry.pdf