INTRODUCTION: ENERGY AND BUILDING CONSTRUCTION

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0.0 Campus Population and Building Square Footage

Over the last five years, the total population at Chapman University has increased steadily (***Figure 1***; Chapman University Institutional Research). Staff and faculty populations have increased an average of 13% and 30% each year, respectively. The student population has increased an average of 18% each year, suggesting that the campus could surpass approximately 10,000 students in the 2020-2021 academic year. Understanding the demand of an increasing campus population is important for projecting future campus energy consumption.

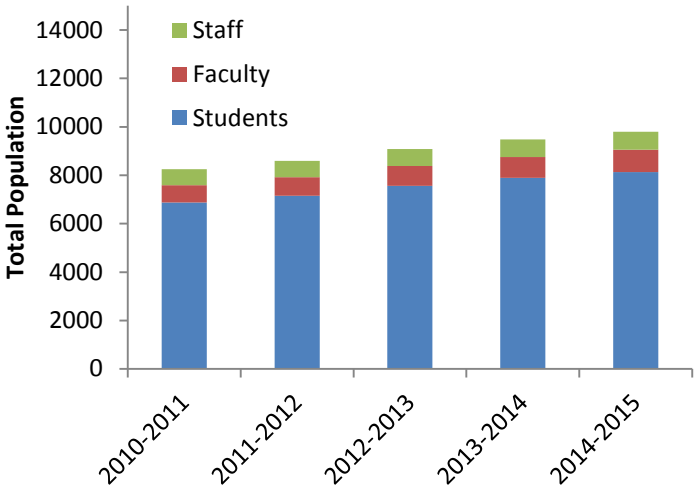

Figure 1*. Total population of students, faculty, and staff at Chapman University from 2010 to 2015*

Similar to the increase in campus population, the total square footage of campus buildings has dramatically increased over the last twenty years (***Figure 2*** Chapman University Campus Planning & Operations). This history of building construction began with the addition of Argyros Forum in 1992 (99,448 sqft). Since 1992 numerous academic, athletic, residential, and administrative buildings have been added to the main campus. Both Beckman Hall (112,797 sqft) and Kennedy Hall (136,962 sqft) were constructed in 1998, Leatherby Libraries (100,106 sqft) was constructed in 2004, and Marion Knott Studios (76,193 sqft) was constructed in 2006.

The total campus building square footage has increased at an average rate of 132,094 sqft per year between 1996 and 2015. The new construction of the Musco Center for the Arts (88,142 sqft) is included in the 2015 total square footage in ***Figure 2***. The projected increase in campus building square footage in Figure 2 (red) includes the addition of the Center of Science and Technology (295,466 sqft). Considering the rate of additional square footage each year, the campus is projected to reach a total of 3,583,037 sqft in the year 2020-2021.

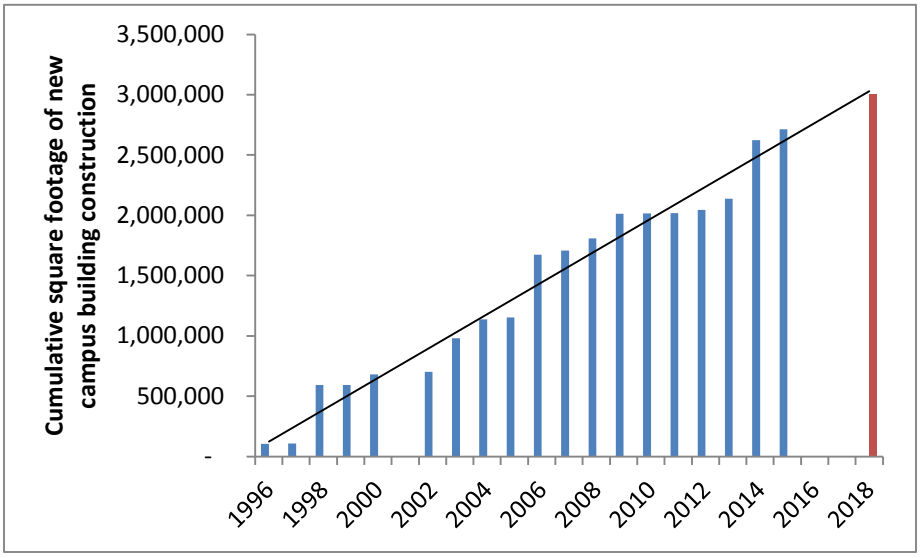

Figure 2. *Cumulative square footage of new building construction on campus from 1996 to 2015. The projected (red) total building square footage in 2018 includes the new construction of the Center of Science and Technology.*

0.1 Building Functions

Since the hiring of an Energy Conservation and Sustainability Manager in Facilities Management, Chapman University has more efficiently managed campus energy consumption. For example, sub-metering was installed into each campus building in the summer of 2012, allowing for evaluation of the energy consumption in each building. Measures such as these are necessary to assess energy reduction strategies and long-term energy conservation planning.

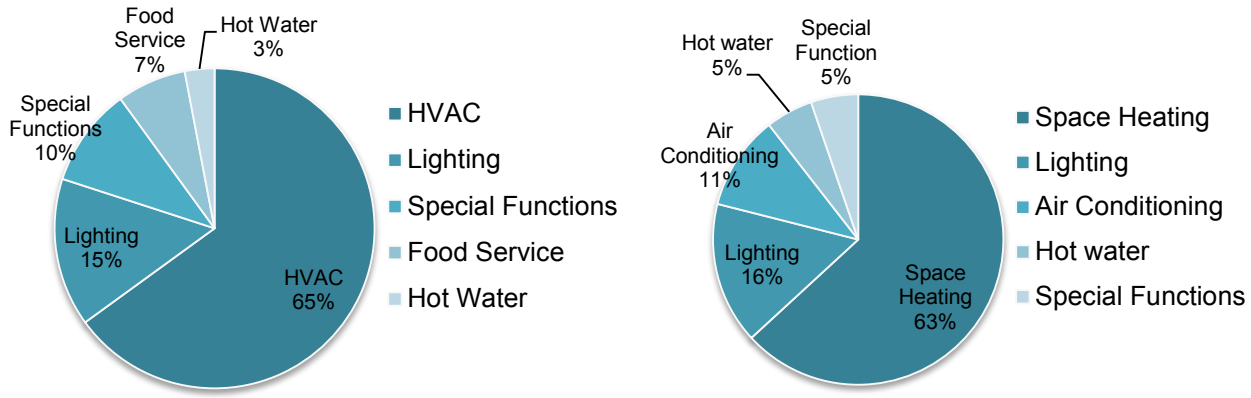

Figure 3. *Distribution of energy use in academic (left) and residential buildings (right).*

The distribution of energy for specific functions throughout an academic building is given in **Figure 3.** This distribution shows the majority of energy consumed in academic buildings is used for heating, ventilation, and air conditioning (HVAC). Lighting is the next largest energy consuming function in an academic building. Together, lighting and HVAC contribute to 80% of building energy consumption.

The distribution of electricity and natural gas usage for specific building functions are given in **Figure 4.** Approximately 39% of electricity is used for lighting, while 28% is used for HVAC. Lighting and HVAC should be frequently assessed to maximize building electricity

use efficiency over time. The majority of natural gas is used for space heating in academic buildings, suggesting strategic energy reduction in this area would have a significant impact on total natural gas consumption

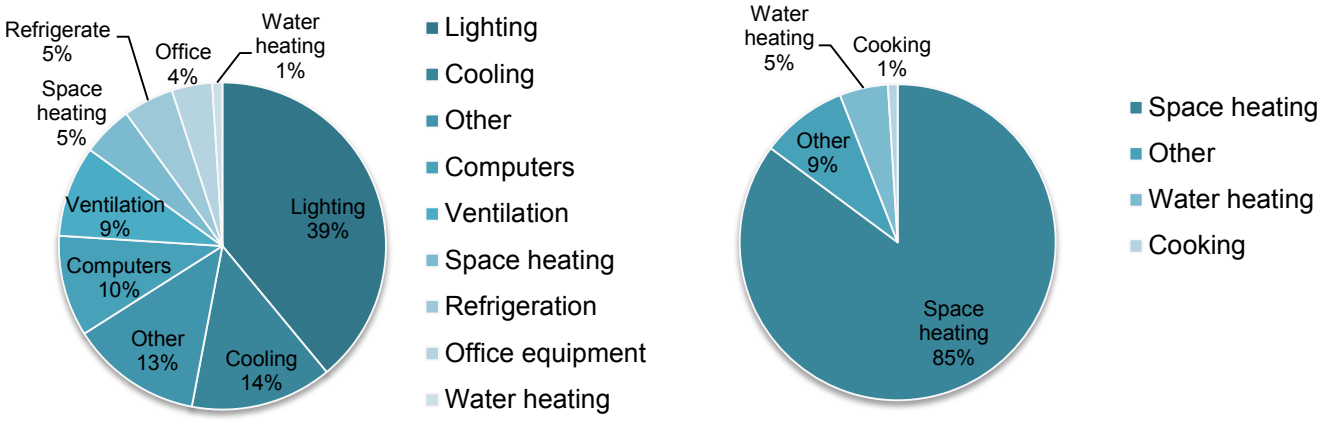

***Figure 4**. Distribution of electricity (left) and natural gas (right) usage in academic buildings.*

0.3 Rates of Electricity and Natural Gas

Southern California Edison (SCE) provides electricity to Chapman University. The university is billed based on a monthly demand of electricity in kilowatts (kW) and monthly electricity consumption charge in kilowatt hours (kWh). The peak demand is based on the highest usage in a 15-minute interval during the billing month.

For the Chapman University 2015 Energy and Building Construction Audit (2015 Audit), the cost of electricity and natural gas will be calculated using a blended rate. The blended rate of electricity usage was calculated as the total monthly consumption in kilowatt hours divided by the monthly total cost. SCE charges different rates for the summer (June – September) and winter (October – May) months. As a result, the blended rate of electricity for the fiscal year was determined by separately calculating the blended rate for the summer and winter months (**Figure 5**). The blended rate of electricity in the summer

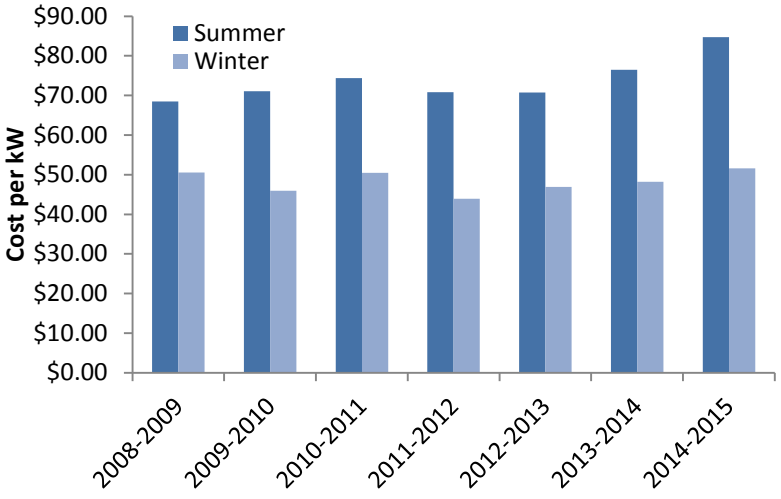

***Figure 5.** Blended rate of electricity cost per kWh for each fiscal year in the summer and winter months from 2008 to 2015.*

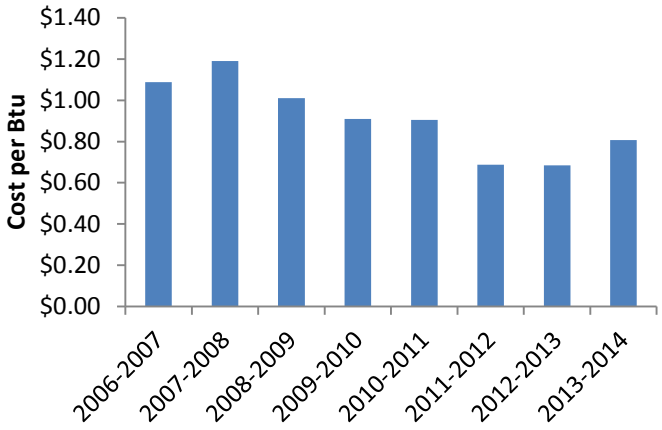

Figure 6. *Blended rate of natural gas cost per Btu for each fiscal year from 2006 to 2014.*

months increased from an average of $0.14/kWh before 2013 to an average of $0.18 after 2013. The blended rate of electricity in the winter months has increased gradually over the last four years, reaching an average of $0.10/kWh.

The Southern California Gas Company So-Cal Gas Company provides natural gas to Chapman University. Natural gas is billed on a tiered system in British Thermal Units (Btus). The university is charged monthly for Tier 1(< 250 Btu) with a rate of $0.50/Btu, Tier 2 (251-3917 Btu) with a rate of $0.25/Btu, or Tier 3 (> 3918 Btu) with a rate of $0.08/Btu. The blended rate of natural gas was calculated as the total consumption in Btus divided by the total cost per fiscal year (**Figure 6**). The blended rate of natural gas has decreased from an average of $1.05/Btu before 2010 to an average of $0.77/Btu after 2010.

While the cost of electricity increases as consumption increases, the opposite is true for natural gas. The rate of natural gas has decreased over time due to higher supply in the United States (U.S. Energy Information Administration). The higher blended rate of natural gas than Tier 3 is likely due to a greater number of campus meters that are individually charged for natural gas consumption.

0.4 History of Electricity Consumption

0.4.1. Sources of Electricity

The distribution of energy sources that Southern California Edison (SCE) provides to Chapman University has changed significantly since the Chapman University 2013 Environmental Audit (see 2013 Audit, Figure 4.1). While energy sources such as natural gas and renewables have remained consistent since 2011, the contribution of nuclear energy to the SCE grid mix has decreased from 24% in 2011 to 6% in 2013 (**Figure 7**). This decrease in nuclear energy distribution is due to the closing of the San Onofre Nuclear Generating Station in June of 2013 (Nuclear Regulatory Commission. As a result, the contribution from unspecified sources of energy has increased from 15% in 2011 to 34% in 2013. Renewable sources of energy increased from 19% in 2011 to 22% in 2013.

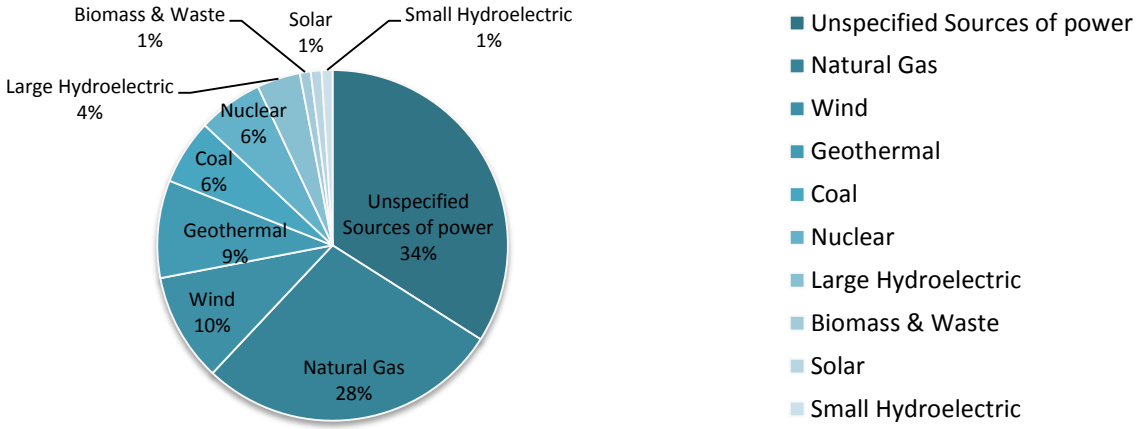

Figure 7. *Sources of energy for Southern California Edison in 2013.*

0.4.2. Electricity Consumption

The total campus electricity consumption has increased gradually for each fiscal year from 2001 to 2014 (**Figure 8**). While electricity consumption showed a decreasing trend until the 2010-2011 fiscal year in the 2013 Audit, consumption has since increased to an average of 12,940,000 kWh per fiscal year (see 2013 Audit, Figure 4.2). Acknowledging the trend of campus electricity consumption is important for long-term planning of campus energy consumption and cost.

Although the total electricity consumption per fiscal year gradually increased from the year 2011-2012, the amount electricity consumed per person is decreasing (**Figure 9**). This trend is likely due to the average 18.8% increase of the total campus population each year, relative to the 9.5% increase in electricity consumption each year since 2010-2011.

When considering the distribution of electricity usage throughout academic buildings, a high portion (59%) of electricity is used for functions dependent on population behavior, such as lighting, office equipment, and water usage. Although the campus population is growing at a fast rate relative to electricity consumption, a higher number of students are living off-campus and faculty members are part-time. This suggests the increase

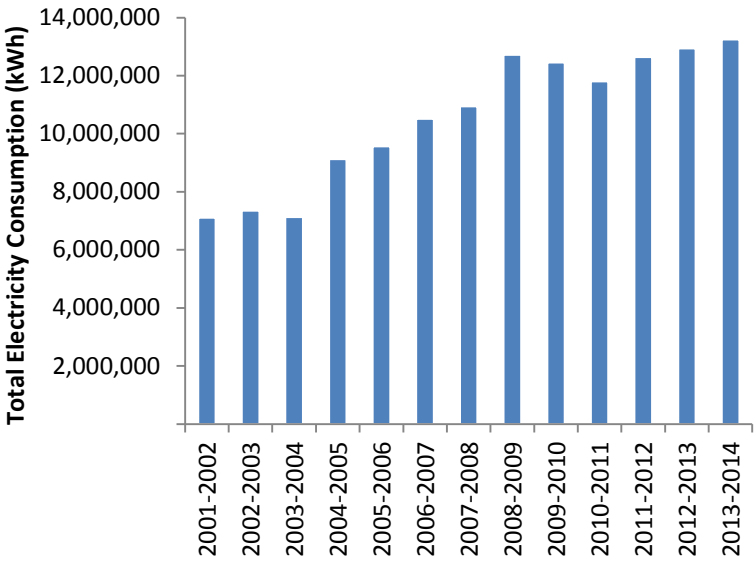

Figure 8. *Total electricity consumption per fiscal year.*

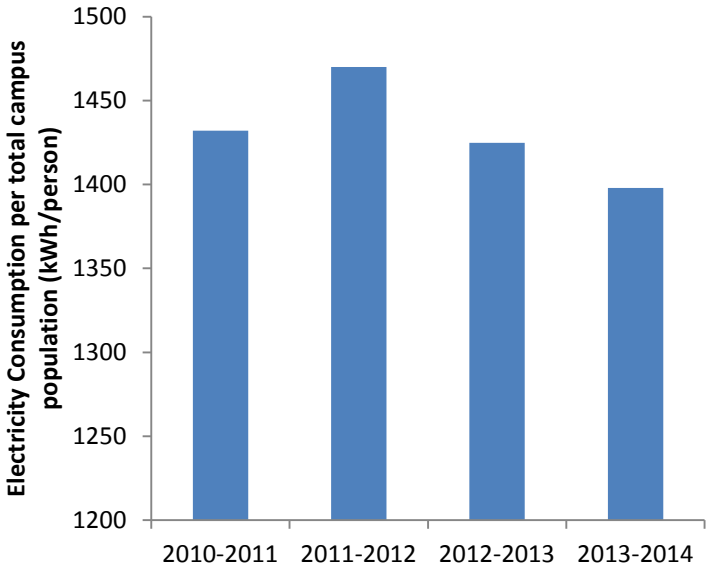

Figure 9. *History of electricity consumption per person from 2010 to 2014.*

in campus population is not necessarily resulting in an increase in building electricity usage.

The amount of electricity consumed per total campus square footage has remained consistent over the last ten years (**Figure 10**). The average electricity consumption per campus square foot was approximately 6.06 kWh/sqft between the years 2005 and 2013. Recently, this value has decreased to approximately 5.05 kWh/sqft in the year 2013-2014.

When considering the distribution of electricity in academic buildings, a low portion (28%) of electricity is used for heating, ventilation, and air conditioning (HVAC). These electricity-consuming functions are dependent on the growth of building square footage. This suggests the rate of electricity and building square footage are increasing at a

0.5 History of Natural Gas Consumption

Since the 2013 Audit, natural gas consumption trends have changed (**Figure 11**). Although the total consumption of natural gas increased each year until 2011, the total has decreased in recent years to an average of approximately 572,000 therms per fiscal year (see 2013 Audit, Figures 4.7). Acknowledging the trend of campus building natural gas consumption is important for long-term planning of campus energy consumption and cost.

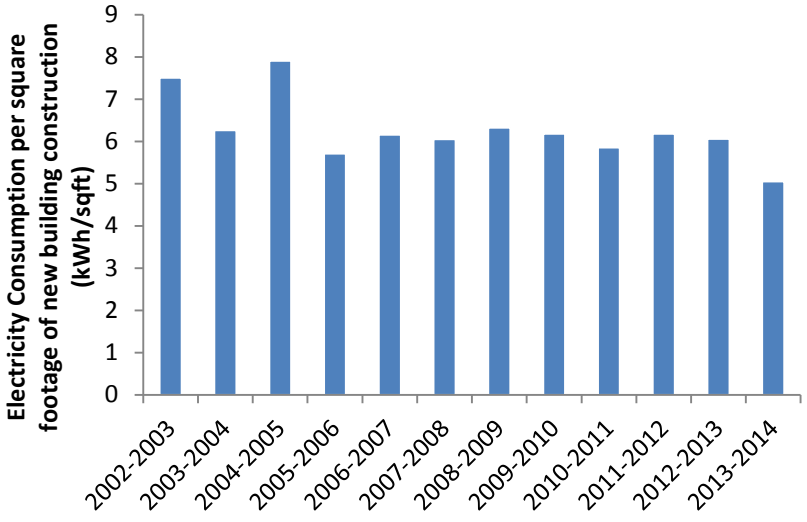

Figure 10. *History of electricity consumption per square footage of new building construction 2002-2014.*

Similar to the electricity consumed per person, the natural gas consumed per person has decreased since the year 2010 (**Figure 12**). This is likely due to the notable decrease in natural gas consumption since the year 2010. This is also likely due to the higher rate of campus population increase relative to natural gas consumption.

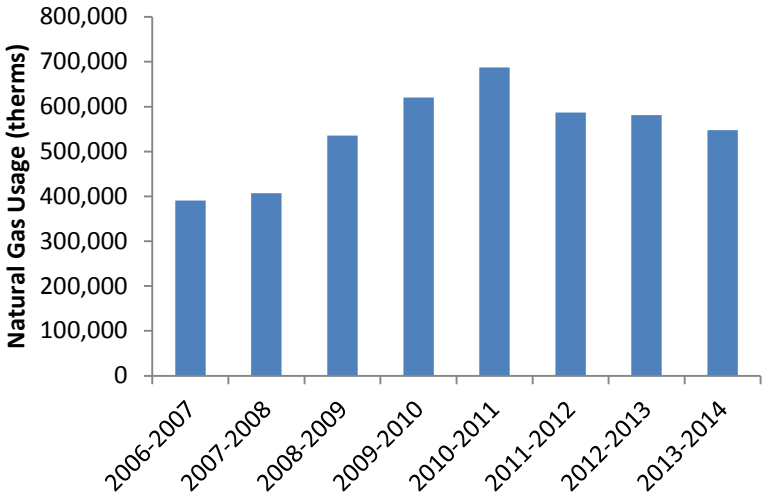

Figure 11. *Total natural gas consumption per fiscal year.*

Considering the distribution of natural gas throughout an academic building, a low portion (5%) of natural gas is used for water heating. Water heating is a building function that is dependent of population behavior that could be influenced by a growing campus population. However, the rate of populations most likely to consume energy in main campus and residential buildings – students living in the residence halls and faculty with full-time status – are much lower than the total population.

The natural gas consumed per building square foot follows the same decreasing trend as the natural gas consumption and that of campus population (**Figure 13**). Approximately 85% of natural gas is used in space heating, which is independent of campus population and dependent on building square footage. These suggest that the building square footage and natural gas demand has a larger impact on usage rates than population.

When the distribution of natural gas usage in academic buildings is considered, there has been a notably high portion (85%) of natural gas used for space heating. Space heating is a building function dependent on both population behavior and building square footage. These results suggest the rate of building square footage is increasing at a greater rate than natural gas consumption.

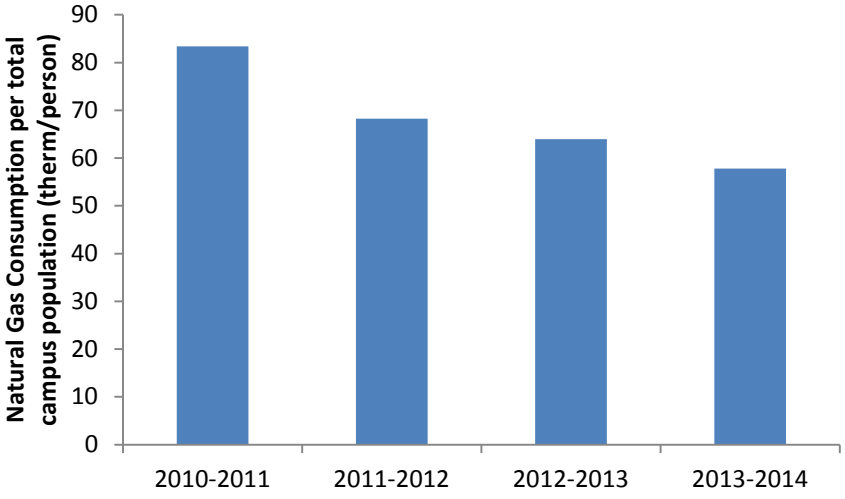

Figure 12. *History of natural gas consumption per total campus population from 2010 to 2014.*

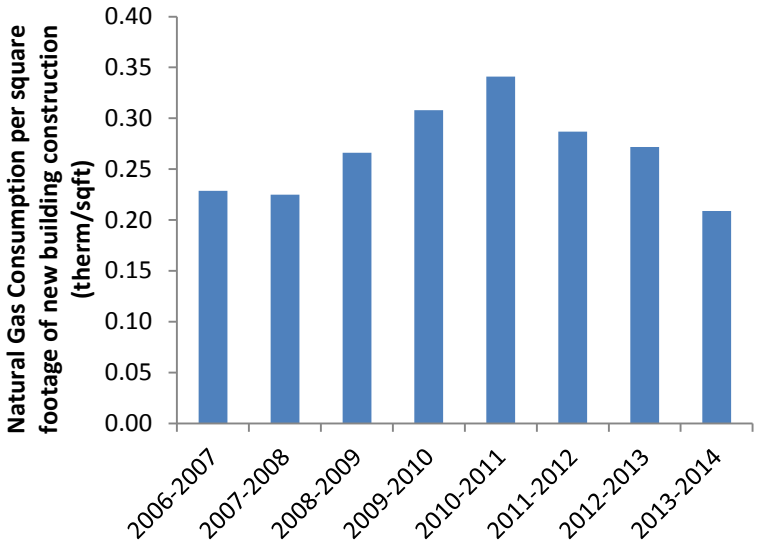

Figure 13. *History of natural gas consumption per square footage of new building construction from 2006 to 2014.*

The total cost of natural gas consumption per fiscal year between Residential and Main Campus buildings is given in **Figure 14**. While the 2013 Audit reported approximately 25% of the total cost of natural gas coming from Residential Halls, the 2012-2013 and 2013-2014 fiscal year data show an increase to 35% (see 2013 Audit, Figure 4.8). This change is evident in the decreased total cost in the Main Campus buildings from 2011 to 2014. There has also been an increase in the total cost from natural gas in the residence halls since the year 2011.

The decrease in total cost for the residential and main campus buildings from 2011 to 2014 relative to the 2010-2011 fiscal year is likely due to a decrease in both natural gas blended rate and natural gas consumption (Figures 6 and 11, respectively). This suggests the total natural gas bill for the university is dependent on both rate and consumption. Acknowledging these factors is important for long-term planning of campus energy usage.

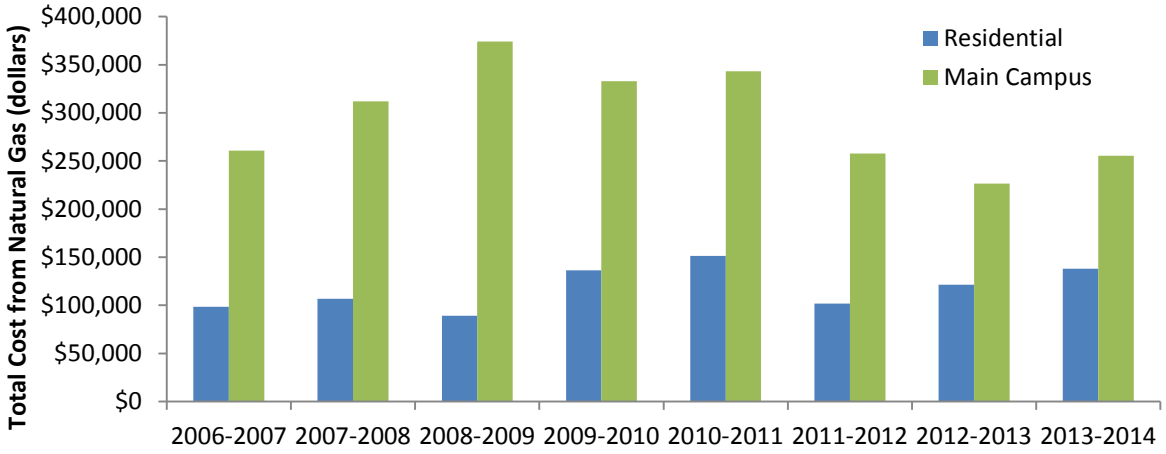

Figure 14. *Total cost of natural gas per fiscal year from Residential and Main Campus buildings.*

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