



2015 – 2016

Campus Annual Energy Use Report

2015 -2016 Macalester College Campus Energy Use Report

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Year at a Glance

Utility Costs:

- Total Utility Costs: \$1,773,497 (FY 2014-2015: \$1,983,851)
 - Electricity: \$1,105,847 (FY 2014-2015: \$1,106,639)
 - Fuel: \$383,749 (FY 2014-2015: \$641,195)
 - Water/Sewer: \$283,851 (FY 2014-2015: \$236,017)

Weather Normalized Energy Consumption:

- Total Energy Consumed: 143,071,038 KBTUs (FY 2014-2015: 143,791,095 KBTUs)
 - Fuel: 101,452,753 KBTUs (FY 2014-2015: 100,691,656 KBTUs)
 - Electricity: 41,618,285 KBTUs (FY 2014-2015: 43,099,439)

Water Consumption:

- Total Water Consumed: 40,013 CCF (FY 2014-2015: 40,251 CCF)

Performance vs. 3% Annual Energy Reduction Goal:

- Electricity: Goal was nearly achieved: Normalized consumption was 2.6% less than FY 2013-2014 baseline year.
- Fuel: Goal was missed: Normalized consumption was 3% more than FY 2013-2014 baseline year.

2015-2016 Energy Conservation Projects & Initiatives:

- Lighting Retrofits:
 - Kagin Commons ballroom lighting redesign study
 - Janet Wallace Fine Arts custom LED retrofit – 24,700 KWH
 - George Draper Dayton Hall custom LED retrofit – 1,790 KWH
 - Campus-wide replacement of incandescent lamps w/10 Watt LED – 3,800 KWH
 - Residence halls replacement of circular fluorescent lamps w/custom LED – 17,000 KWH
- Electrical/Mechanical:
 - Neill Hall air handling unit fan motor upgrade – 960 KWH
 - Chapel idle transformers decommissioning – 32,600 KWH

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Executive Summary

This report summarizes the energy and water consumed on Macalester College's campus during FY 2015 – 2016. Previous annual energy reports showed only the electricity, natural gas, and fuel oil used by the College's central plant for heating and cooling. This report shows energy consumption data for the College's central plant but also includes data for the electricity, non-heating plant natural gas, and water consumed across the entire campus.

Starting with FY 2015-2016, Macalester College has set a goal of a 3% reduction in overall energy consumption per year, with a cumulative goal of a 15% reduction in energy used in the following five year period. FY 2013-2014 was selected as the baseline period for measuring progress toward the consumption targets. In order to achieve these goals Macalester has increased its ongoing energy conservation efforts via the creation of a new energy manager position, participation in Xcel Energy's Commercial Energy Efficiency Program, implementation of additional lighting efficiency and control projects, and the deployment of other new technologies.

Macalester College utilizes electricity, natural gas, and #2 fuel oil as its primary sources of energy. Each energy source provides different amounts of energy per unit and at a significantly different cost per unit of energy. For example, the electricity consumed in FY 2015-2016 comprised only about 32% of the total energy consumed across the campus but accounted for nearly 63% of the College's total expenditures for energy.

Since the energy used by Macalester College's central plant is highly affected by seasonal weather variations the fuel used by the heating plant and the electricity used by the chiller plant are presented in both an actual and weather normalized basis to provide a standardized method of measuring year-to-year progress toward the College's energy reduction goals. The electricity used for lighting, distributed mechanical equipment, and building plug loads has not been shown to be weather dependent and thus has not been normalized in this report. The quantity of natural gas used for heating the houses on campus is weather dependent but represents only about 10% of the campus' overall energy consumption so has not been adjusted for weather in this report.

Macalester nearly achieved the 3% reduction goal for electrical consumption for 2015-16 but missed the reduction goal for fuel consumption. After weather normalization, the amount of fuel consumed in FY 2015-16 was almost exactly the same as in the previous year and was 3% greater than the amount of fuel consumed in the 2013-2014 baseline year.

After normalizing for seasonal weather variations, Macalester College consumed approximately 143,000,000 KBTUs of energy during FY 2015-2016, at a cost of approximately \$1,490,000. For purposes of comparison, during FY 2014-2015 the College consumed slightly less total energy (141,000,000 KBTU) but at a considerably higher cost (\$1,748,000). The higher expense in FY 2014-2015 was primarily due to the higher use of fuel oil vs. natural gas in the heating plant.

In addition to the expense for fuel & electricity, in FY 2015-2016 Macalester consumed approximately 40,000 CCF of water, at a cost of approximately \$284,000. (1 CCF = 100 Cubic Feet = 748 Gallons.) Although the total amount of water consumed by the campus has remained fairly constant for the last three years the cost of that utility has increased by about 18%, representing an additional cost of \$40,000 in FY 2015-16.

Fuel Consumption & Cost

Campus Fuel Consumption & Cost

Approximately 88,000,000 KBTUs of natural gas was consumed on campus during FY 2015-2016. Due to the mild winter during that fiscal year weather normalization of the energy consumed by the heating plant increased the campus total to roughly 101,000,000 KBTUs. After weather normalization the fuel energy consumed in FY 2015-2016 was approximately 3,300,000 KBTUs more than the amount of energy consumed in the 2013-2014 baseline year, representing an increase of approximately 3%. No fuel oil was used by the central heating plant during the year.

86% of the fuel energy consumed on campus during FY 2015-2016 was used by the central heating plant, with the balance used for space heating, water heating, and cooking applications in the various buildings and houses on campus that have individual natural gas meters. The Art building's kilns and forges are another significant consumer of natural gas on campus.

The total cost for the natural gas consumed on Macalester College's campus in FY 2015-2016 was \$384,000, which compares very favorably with the previous two years' costs of \$641,000 and \$908,000. The reduced cost in FY 2015-2016 is in large part due to not having to use # 2 fuel oil and not to a reduction in the amount of energy consumed.

Boiler Plant Fuel Consumption & Cost

Macalester College's central heating plant consumed approximately 74,000,000 KBTUs of natural gas & fuel for heating the campus during FY 2015-2016. For purposes of comparison, the average actual energy consumption for the boiler plant during the previous five year period ending with FY 2014-2015 was about 82,300,000 KBTUs; ranging from a minimum of approximately 64,600,000 KBTUs in FY 2011-2012 to a maximum of about 97,000,000 in FY 2012-2013.

An energy utilization index (EUI) value can be calculated for any facility in order to allow benchmarking of its energy consumption performance against itself as well as to allow comparison with other similar facilities. The EUI value is presented in KBTUs/GSF/Year. (1 KBTU = 1,000 BTUs; GSF = Gross Square Feet).

After weather normalization, the total energy consumed by the central heating plant in FY 2015-2016 fiscal year was adjusted to approximately 87,200,000 KBTUs, which equates to an energy utilization index (EUI) value for the facility of 67.5 KBTU/GSF/YR. The boiler plant's normalized EUI value for FY 2015-2016 was the highest value recorded in any of the previous five years. During that time period the average weather normalized EUI value for the heating plant was 63.5 KBTU/GSF/YR.

In addition to weather normalization, another common method for comparing the year-to-year performance of heating systems is to divide the energy used by the boiler plant by both the area served in gross square feet (GSF) and the monthly heating degree days (HDD). For Macalester College the best correlation between fuel energy consumption and weather data was found using 65° HDD data. Over the last five years this value has averaged at about 9 KBTU/GSF/HDD; ranging from a low of 8.8 KBTU/GSF/HDD in FY 2012-2013 to a high of 9.5 KBTU/GSF/HDD in FY 2014-2015.

The cost of the natural gas and #2 fuel oil consumed by Macalester College's boiler plant in FY 2015-2016 was approximately \$288,000, which compares very favorably with the \$518,000 spent on fuel in FY 2014-2015 and

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\$754,000 spent on fuel in FY 2013-14. The higher cost for fuel in the two prior years was caused by the use of #2 fuel oil in that year, as mandated by Macalester College's use of an interruptible fuel rate for the heating plant. (Macalester benefits from a lower price for natural gas from Xcel year-round, provided that the heating plant switches from natural gas to fuel oil at Xcel's request during periods of extremely cold weather.) One gallon of fuel oil contains more heating energy than one Therm of gas (140,000 vs. 100,000 BTUs) but is much more expensive on cost per unit of energy basis: In FY 2013-2014 Macalester College's cost for #2 fuel oil was \$22.17/MMBTU while the cost per MMBTU for natural gas was \$5.26/MMBTU.

Electricity Consumption & Cost

Campus Electricity Consumption & Cost

Macalester College consumed approximately 12,248,000 KWH of electricity across its campus in FY 2015-2016. After adjusting the amount of electricity consumed by the chiller plant for seasonal weather variations the campus' total electricity consumption during FY 2015-2016 was about 12,198,000 KWH. For purposes of comparison the FY 2015-2016 normalized total was about 410,000 KWH less than the 2013-2014 baseline period, representing a decrease of 2.6%.

87 % of Macalester's total electric energy was used for the electrical loads that are monitored at the campus main electric meter, such as building lighting, distributed mechanical equipment, and plug loads. Approximately 9% of the campus' total electric energy was used by the chiller plant, and the 4% balance was used in the various campus buildings and houses that have individual electric meters.

The total cost for electricity consumed on Macalester College's campus in FY 2015-2016 was approximately \$1,105,000, which is nearly identical to the previous year's cost of \$1,107,000.

Chiller Plant Electricity Consumption & Cost

During FY 2015-2016 the chiller plant's actual electricity consumption was approximately 1,114,000 KWH, which converts to approximately 3,800,000 KBTUs. (One KWH = 3,412 BTUs). For purposes of comparison, the chiller plant's actual energy consumption during the previous five year period ending with FY 2013-2014 fiscal year was about 1,078,000 KWH. The annual consumption during this period ranged from a minimum of approximately 800,000 KWH in FY 2009-2010 to a maximum of about 1,555,000 KWH in FY 2011-2012, when renovation of the Music Building significantly impacted the amount of energy used by the chiller plant.

As noted for the boiler plant, a linear regression model using cooling degree day (CDD) data and the campus square footage was developed to better evaluate year-to-year performance of the chiller plant. For Macalester College's chiller plant the best correlation between energy usage and weather was found using 55° CDD data. In FY 2015-2016 the chiller plant consumed electricity at a rate of 1.7 BTU/GSF/CDD, which is the same as the average rate recorded over the previous six years.

After weather normalization the chiller plant consumed approximately 3,600,000 KBTUs of electrical energy in FY 2015-2016, resulting in an energy utilization index (EUI) value for the chiller plant of 3.7 KBTU/GSF/Yr. This rate of consumption is the same as the electric consumption and EUI recorded during the previous five years.

The cost of the electricity consumed by Macalester College's chiller plant in FY 2015-2016 was about \$160,000. For purposes of comparison, the average amount spent annually during the previous 5 year period was

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approximately \$140,000. The average price paid per KWH of electricity (including demand charges and all other fees) for the chiller plant in FY 2015-2016 was \$0.144/KWH. For comparison, the average price paid over the previous 5 year period was \$0.132/KWH; ranging from a minimum of \$0.112 in FY 2011-2012 to a maximum of \$0.162/KWH in FY 2013-2014.

Water Consumption & Cost

During FY 2015-2016 Macalester College consumed 40, 000 CCF of water, or approximately 30,100,000 gallons (1 CCF = 100 Cubic Feet = 748 gallons). This quantity of water would fill 30 swimming pools that are each 267 feet long by 50 feet wide to a depth of 10 feet. The total amount of water consumed during FY 2015-2016 was nearly identical to the amount consumed during FY 2014-2015, although there was variation on a monthly basis. Note: some of the College's smaller buildings are billed for water & sewer on a quarterly basis, so the amount of water shown in the graphs and data tables for the months of February, May, August, & November are larger than they would be if the all of Macalester's buildings were billed on a monthly basis.

Macalester College's total water & sewer charges in both FY 2015-2016 were approximately \$284,000, which represents 16% of the College's total expenditures for electricity, fuel, and water/sewer. After dropping slightly from FY 2013-2014 to FY 2014-2015, the cost per CCF of water rose significantly in FY 2015-2016. When all of the costs & fees shown on the College's water bills are aggregated and divided by the volume of water consumed, the cost for water & sewer services increased from an average of \$5.90/CCF during the previous two year period to \$7.00/CCF, representing an increase of nearly 19%.

Energy Conservation Initiatives & Projects

As noted in the Executive Summary, starting with FY 2015-2016 Macalester College has set a goal of reducing the energy consumed across campus by 3% each year compared to FY 2013-2014. In order to reach that goal Macalester is participating in Xcel Energy's Commercial Energy Efficiency Program. Under the first phase of the agreement several of the College's largest energy consuming buildings were audited by Michaels Energy in December 2015 to identify energy conservation opportunities (ECOs) and calculate their associated estimated savings and respective implementation costs. Michaels Energy completed their study in March 2016 and determined that Macalester College should be able to reduce the energy consumed in the Leonard Center, Olin-Rice, and Campus Center by nearly 1,400,000 KWH and reduce the College's annual expenditures for electricity by approximately \$87,000 if all of the ECOs that they identified were implemented. Their recommendations include building automation system recommissioning opportunities, lighting efficiency and controls retrofit projects, and mechanical equipment upgrade projects. Those recommendations will be implemented as resources are available.

The energy conservation projects listed below were completed in fiscal year 2015-2016:

- Lighting:
 - Kagin Commons ballroom lighting redesign study
 - Janet Wallace Fine Arts custom LED retrofit – 24,700 KWH
 - George Draper Dayton Hall custom LED retrofit – 1,790 KWH
 - Campus-wide replacement of incandescent lamps w/10 Watt LED – 3,800 KWH
 - Residence halls replacement of circular fluorescent lamps w/custom LED – 17,000 KWH
- Electrical/Mechanical:
 - Neill Hall air handling unit fan motor upgrade – 960 KWH

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- Chapel idle transformers decommissioning – 32,600 KWH
- Renewables:
 - Markim Hall – installation of 13 KW solar photo-voltaic panels

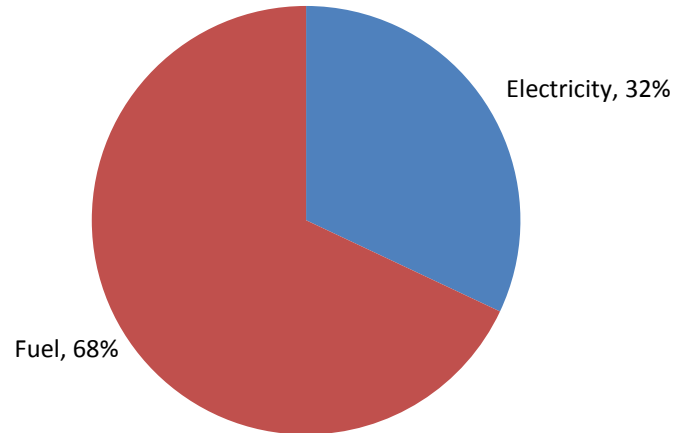
The projects and initiatives listed below are planned for implementation during FY 2016-2017:

- Lighting:
 - Campus walkway lighting – conversion of low pressure sodium light fixtures to LED
 - Parking lot lighting – conversion of low pressure sodium light fixtures to LED
 - 1550 Summit Avenue building – replacement all of the building’s incandescent, fluorescent, metal halide, and low pressure lighting with LED lamps
 - Campus Center stairwell lighting – test replacement of the existing fluorescent stairwell fixtures with LED fixtures that have integrated occupancy sensors
 - Leonard Center – replacement of the fluorescent & metal halide lighting in the hallways, pool area, fitness center, and racquetball courts with LED; also installation of vacancy controls for lighting in the racquetball courts, gym, and field house
 - Kagin Commons – retrofit of the existing halogen & incandescent fixtures with custom LED emitters
 - Chapel – replacement of incandescent spotlights with LED
- Electric/Mechanical:
 - Stadium – replacement of the electric resistance heating equipment with high-efficiency boilers and hot water perimeter radiation
- HVAC Equipment Recommissioning & Controls:
 - Campus Center – installation of variable speed drives and controls to implement demand controlled ventilation for the kitchen hoods and their associated makeup air units
 - Chiller plant & chilled water system distribution – recommissioning of the chiller plant’s controls and operation based on analysis completed by Trane Company and partially funded by Xcel Energy
 - Olin-Rice, Campus Center, and Leonard Center – set point and schedule changes as recommended by the Michaels Energy recommissioning study
 - Trial subscription to BuildPulse automated HVAC fault detection software
- Sub-metering & Reporting:
 - Subscription to GRITS (Green Revolving Investment Tracking System) for tracking of energy conservation projects
 - Continued installation of web-enabled Mamac sub-meters for monitoring electrical consumption and steam condensate in all major campus buildings
 - Trial subscription to Singh360 web-based energy use reporting software for preparation of annual reports, identification of energy conservation opportunities, and measurement and verification of completed projects

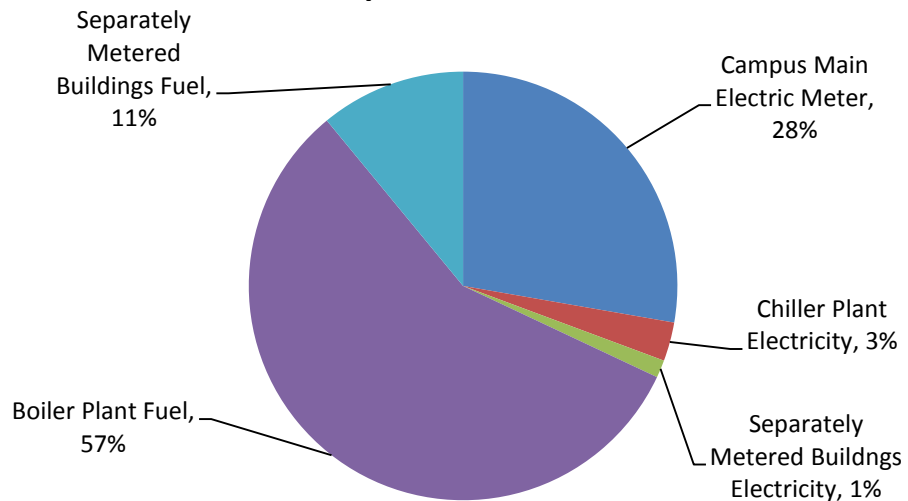
Charts & Graphs

Campus Total Energy Consumption Graphs

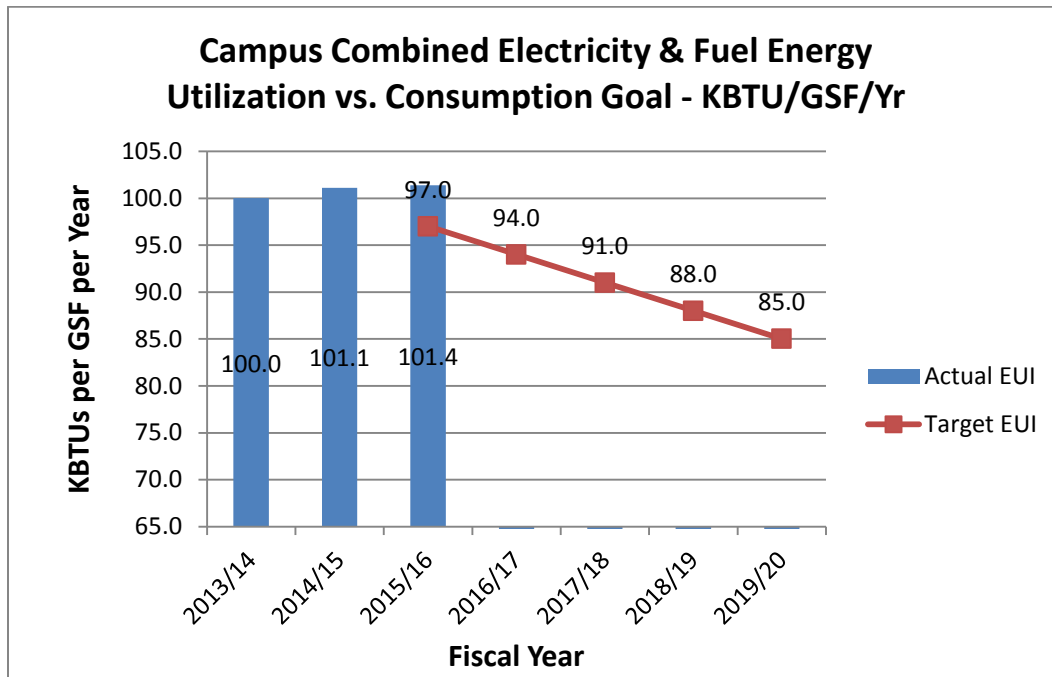
2015-16 Campus Combined Fuel & Electricity Consumption Summary - KBTUs



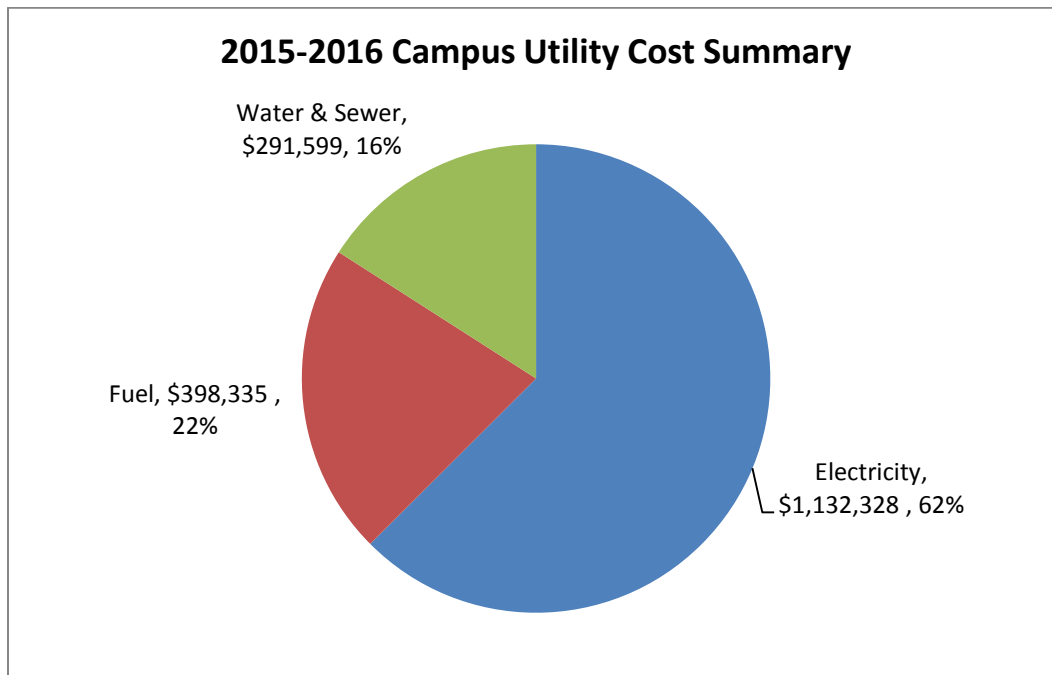
2015-2016 Campus Combined Fuel & Electricity Consumption Details - KBTUs



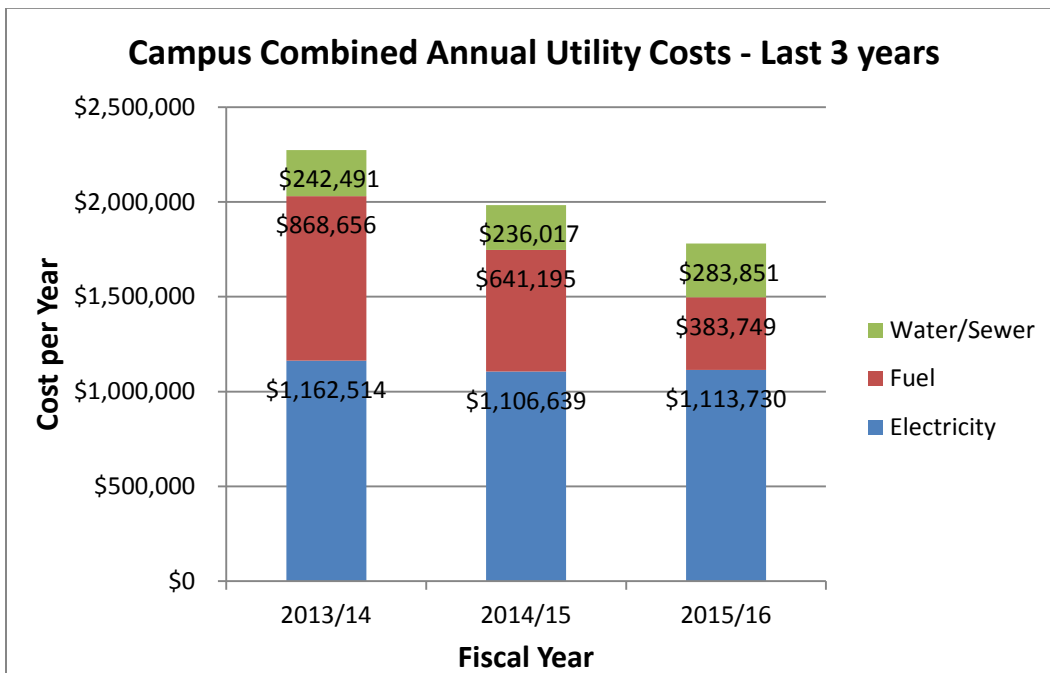
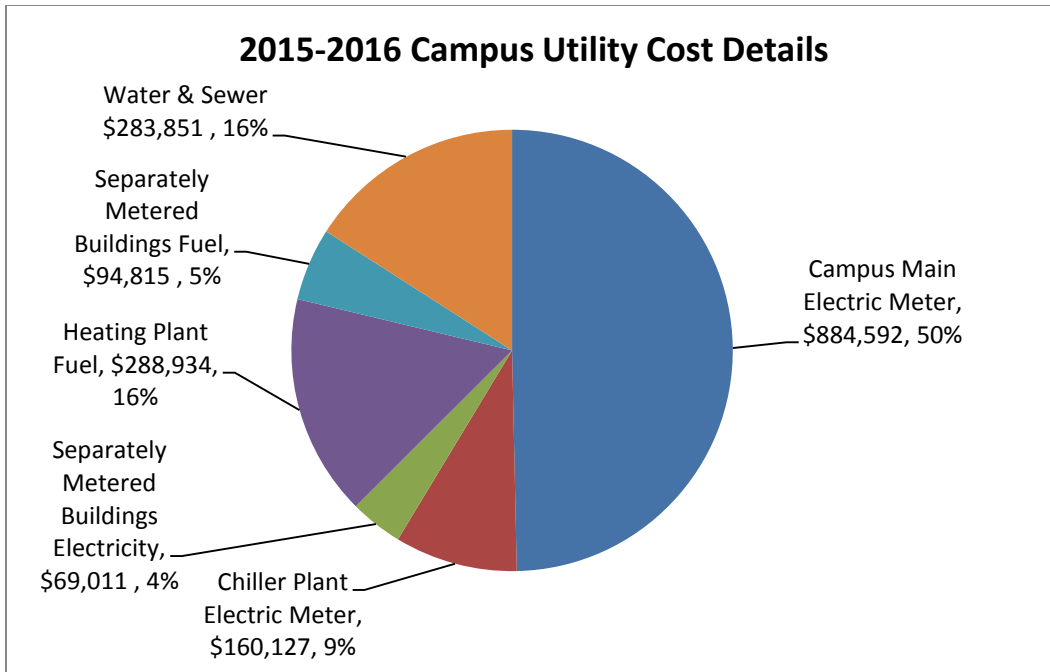
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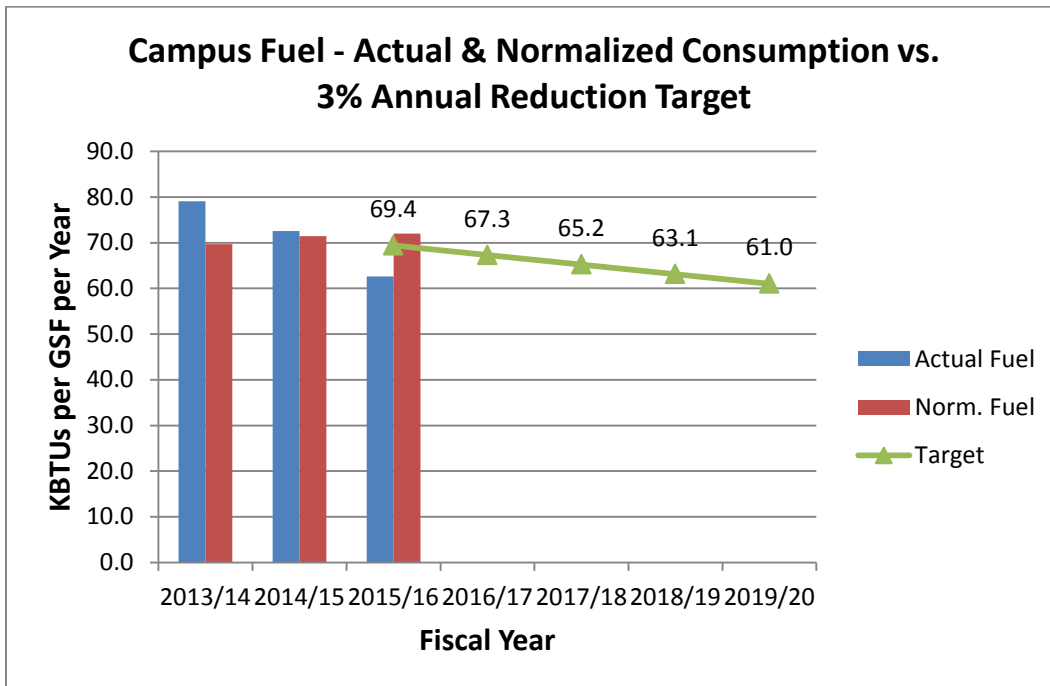
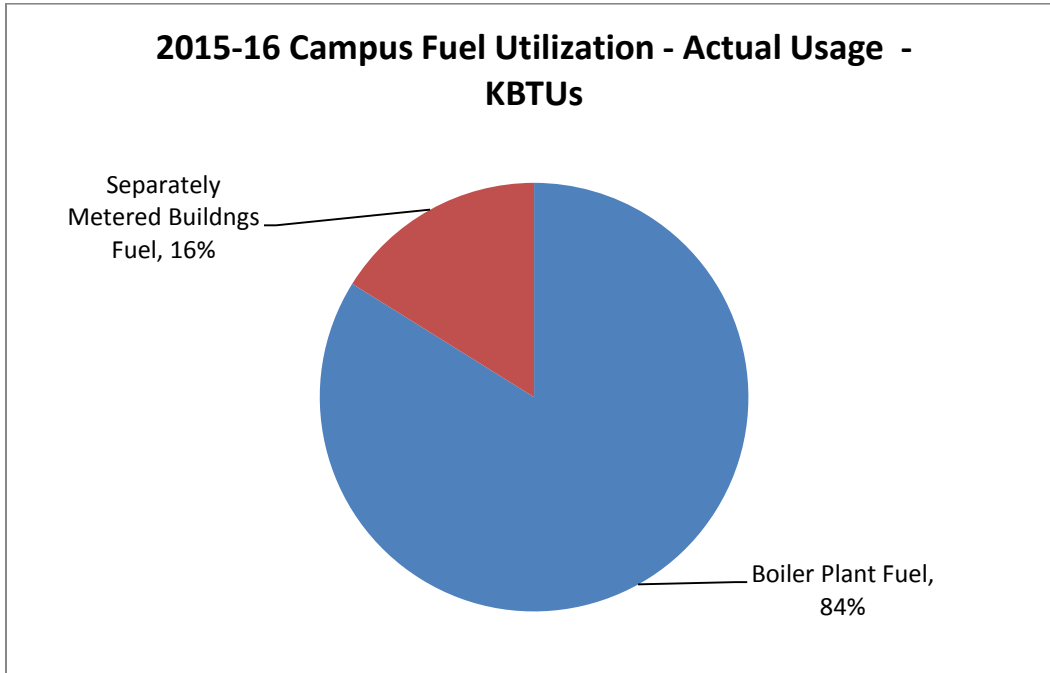
Campus Total Utility Cost Graphs



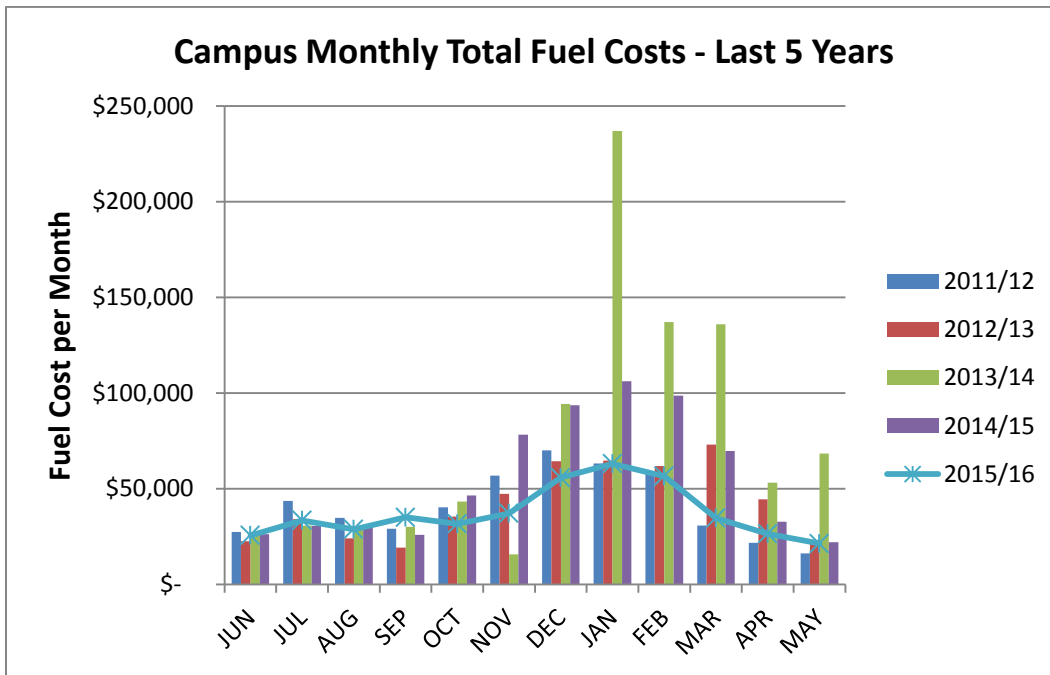
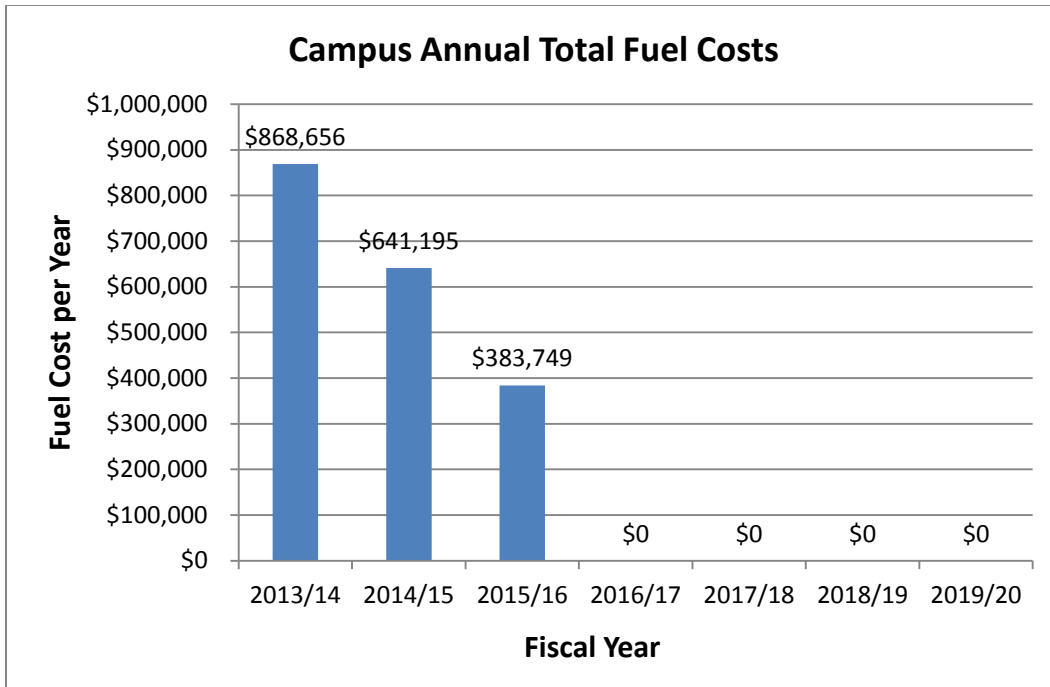
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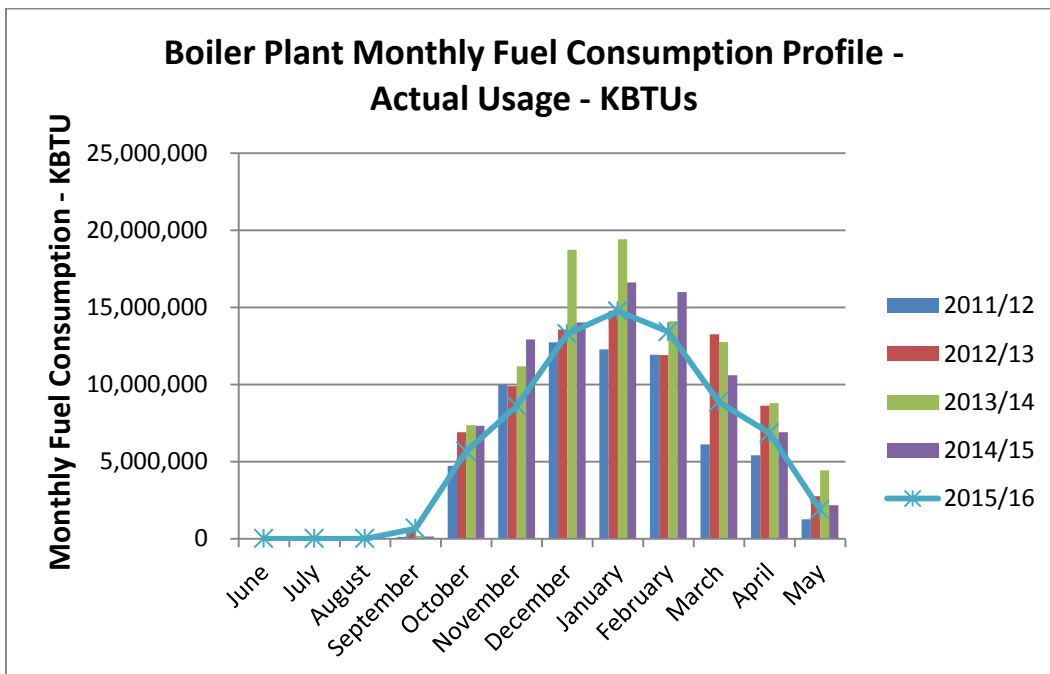
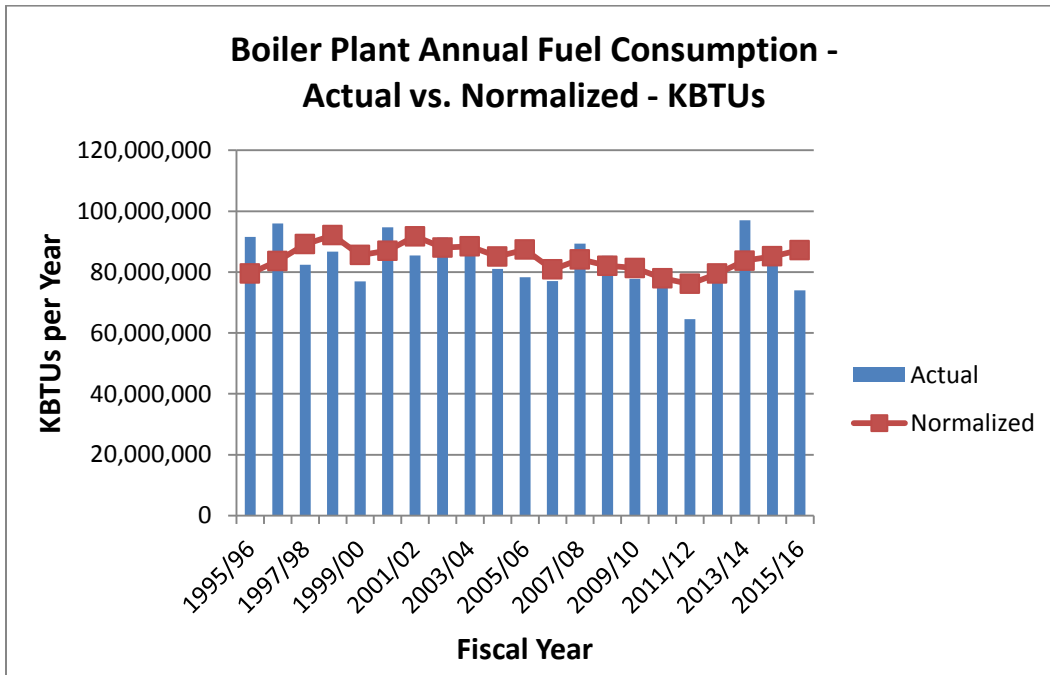
Campus Fuel Consumption & Cost Graphs



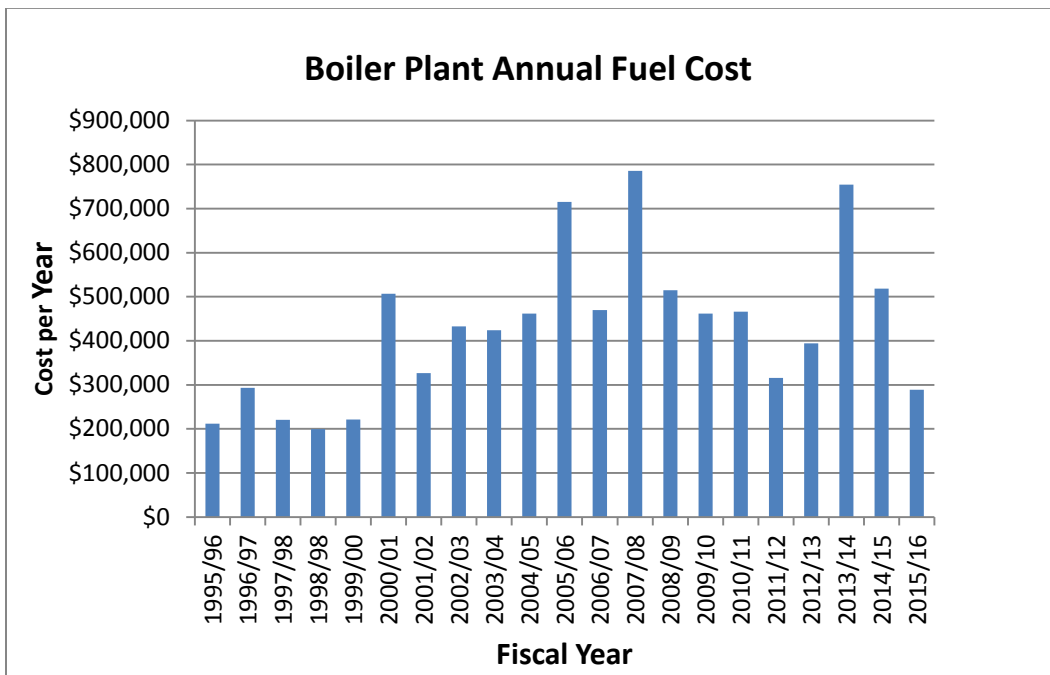
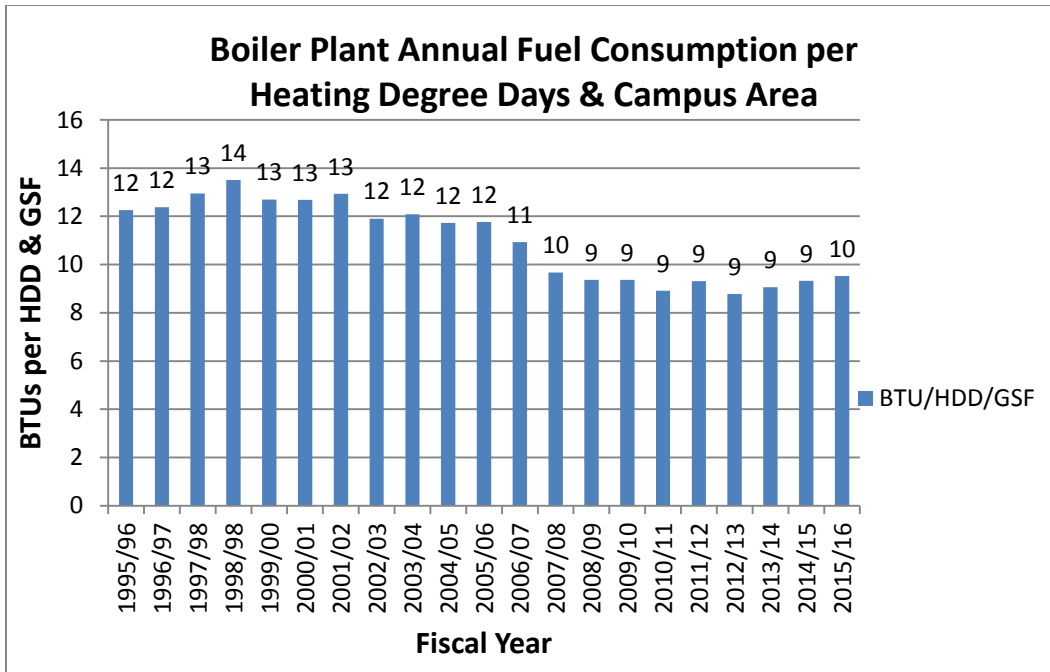
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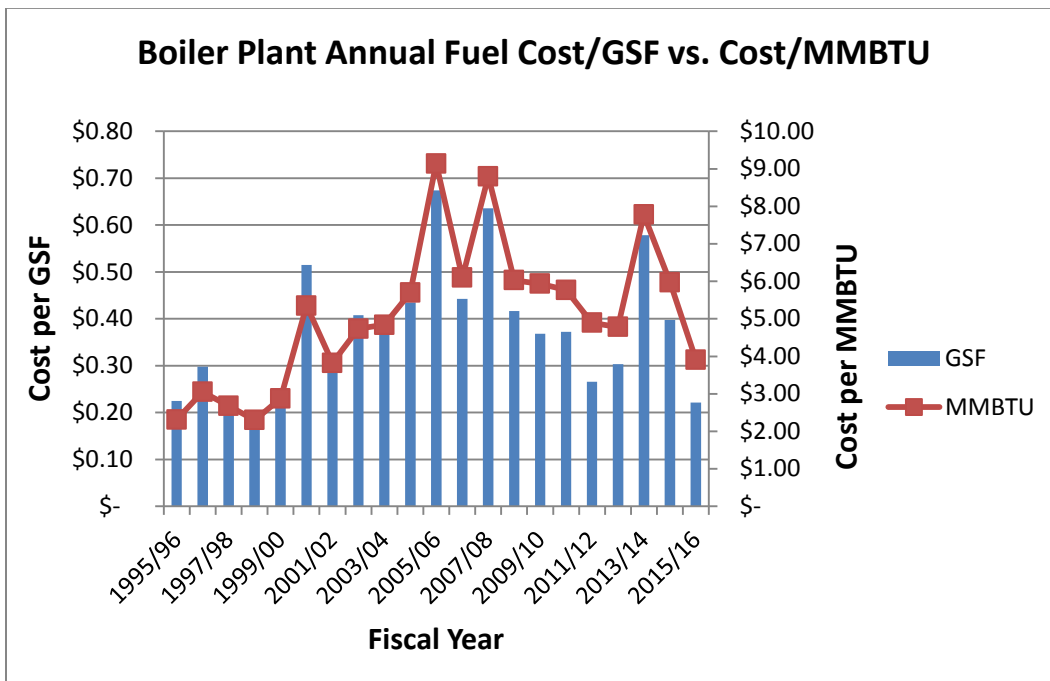
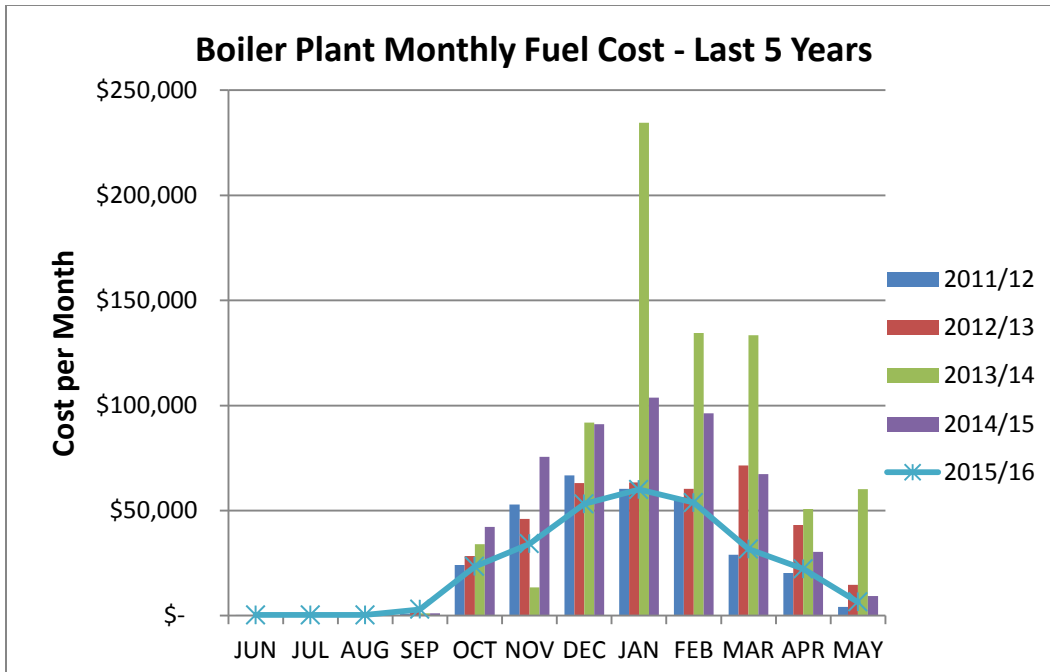
Boiler Plant Fuel Consumption & Cost Graphs



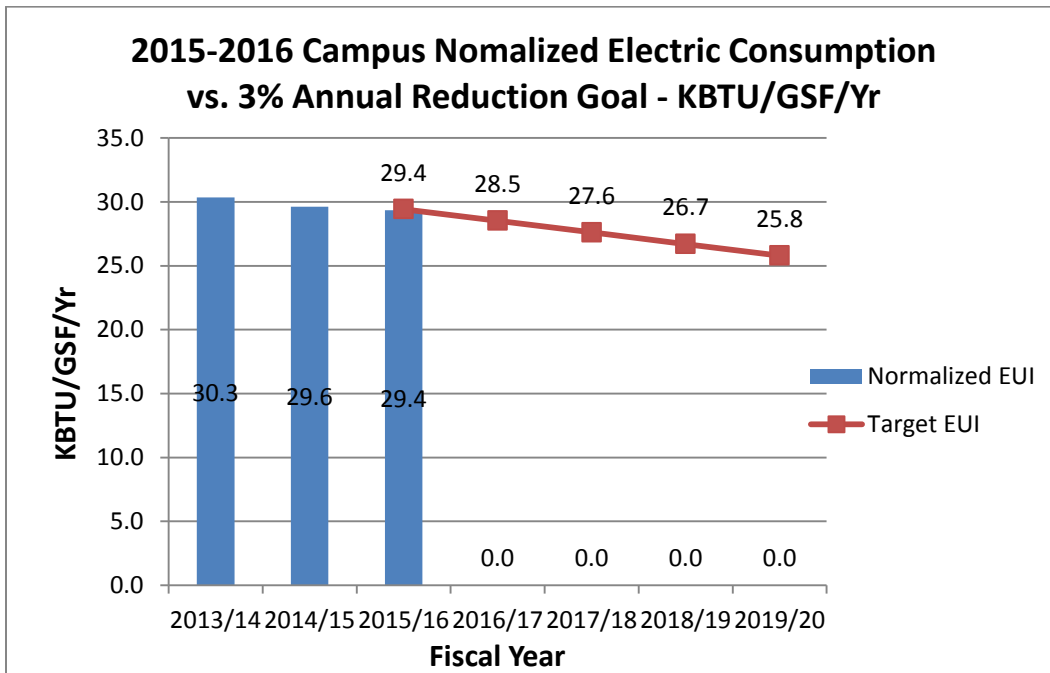
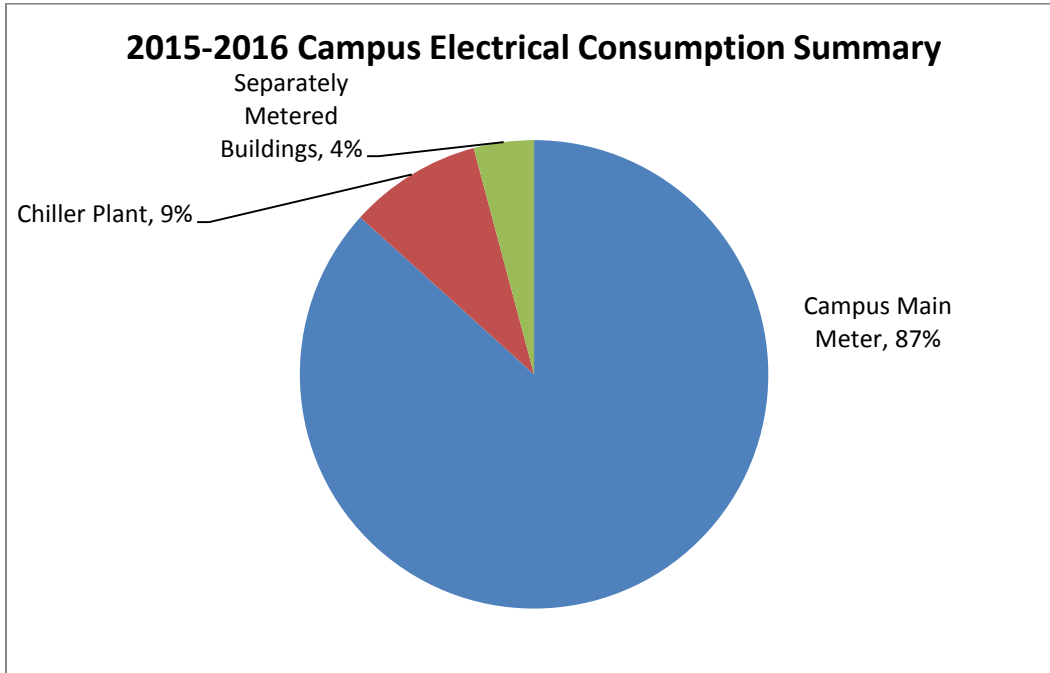
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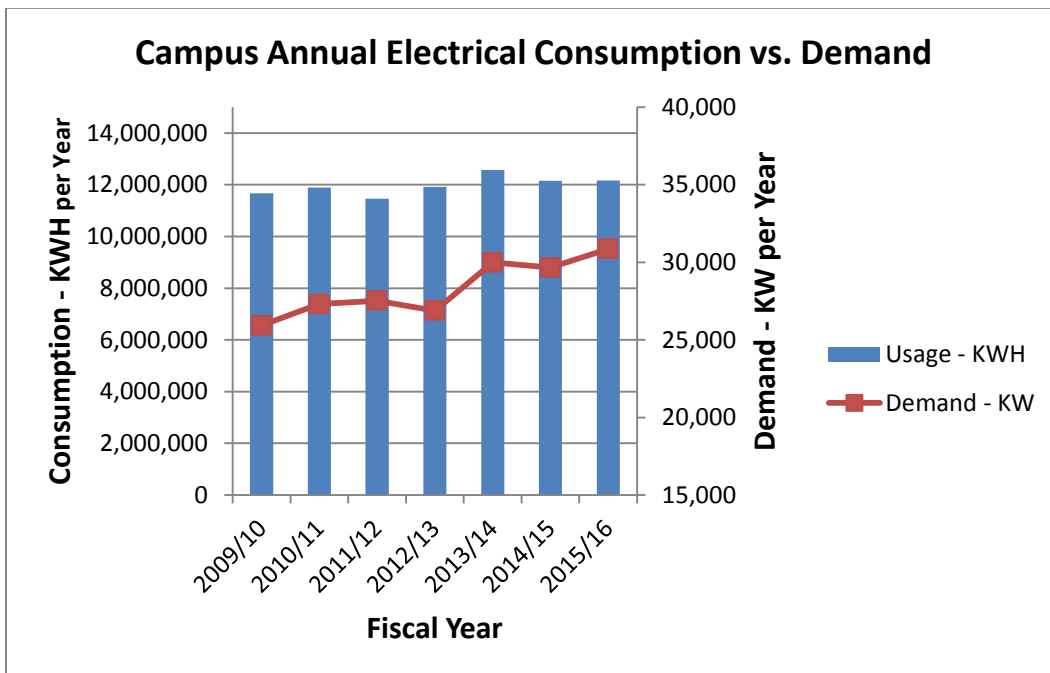
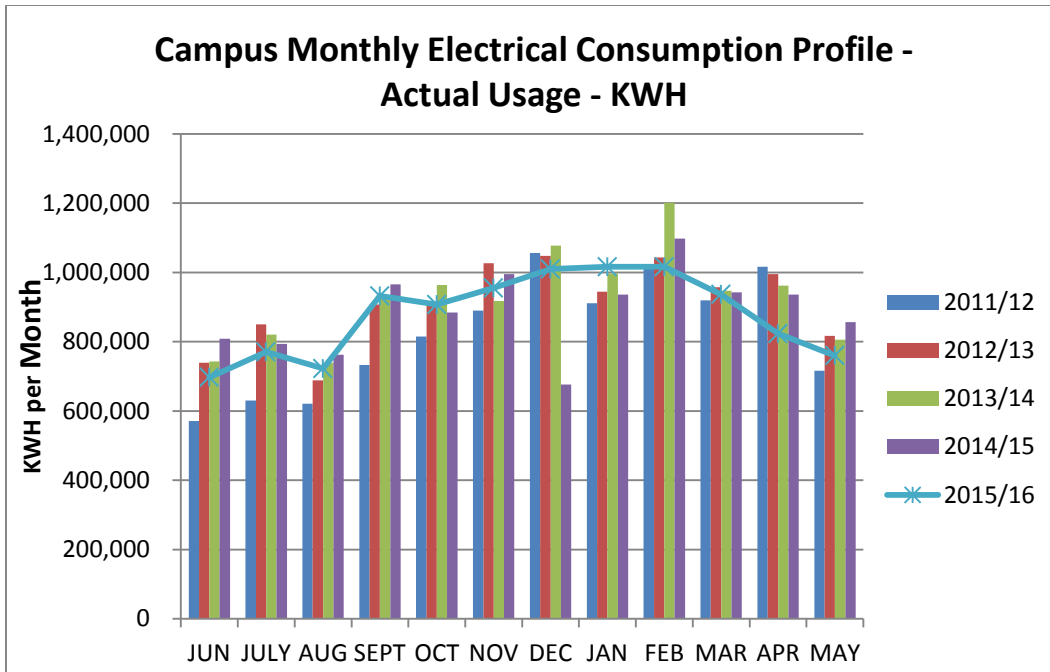
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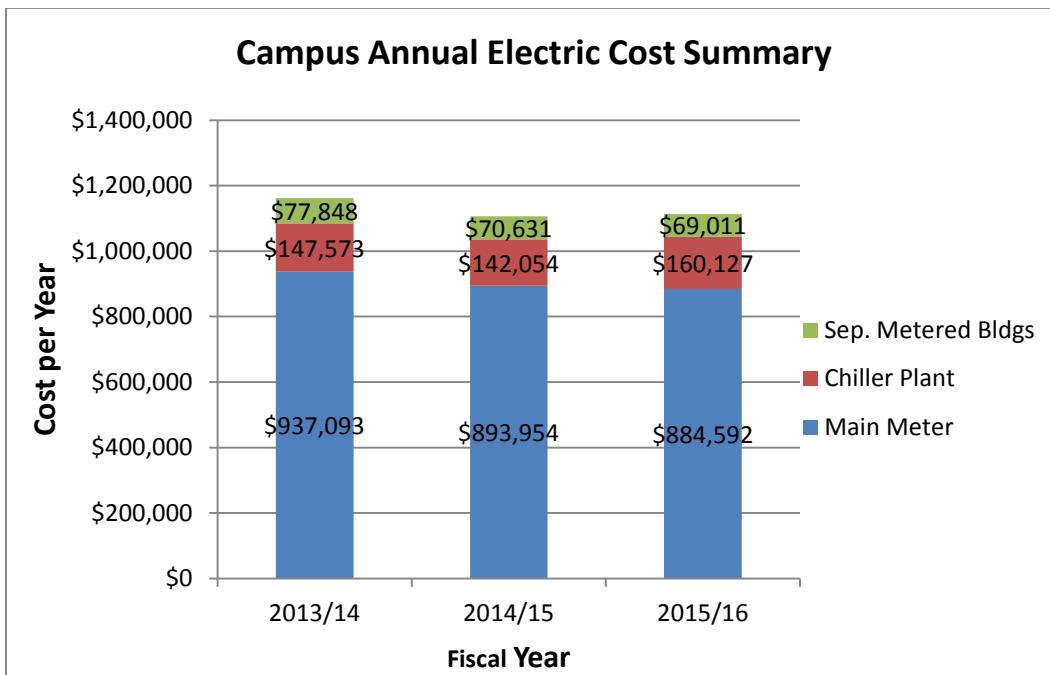
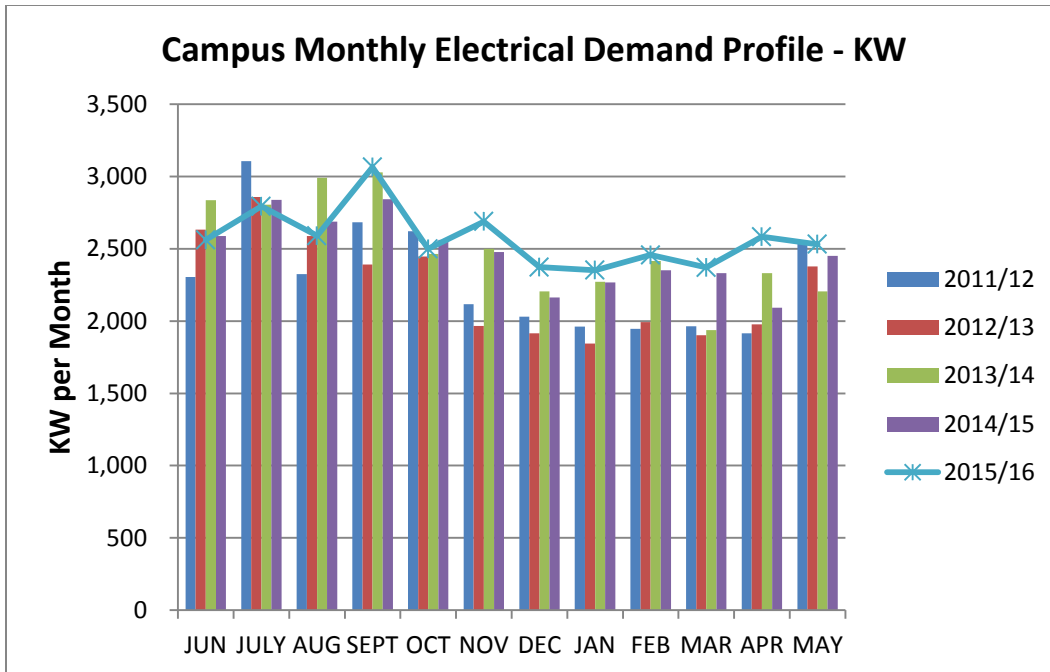
Campus Electricity Consumption & Cost Graphs



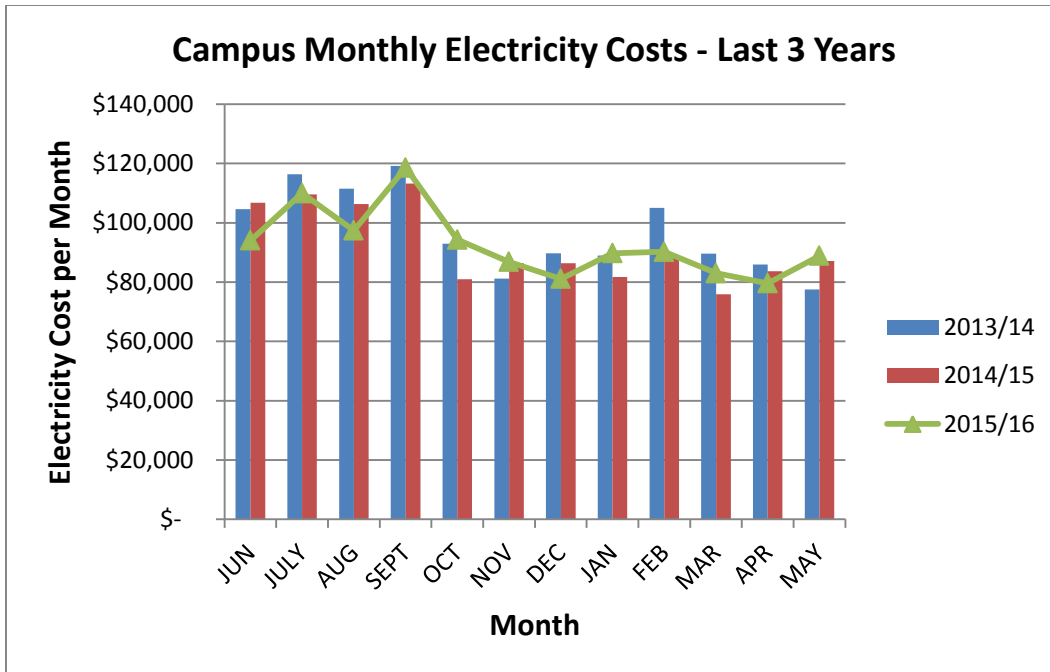
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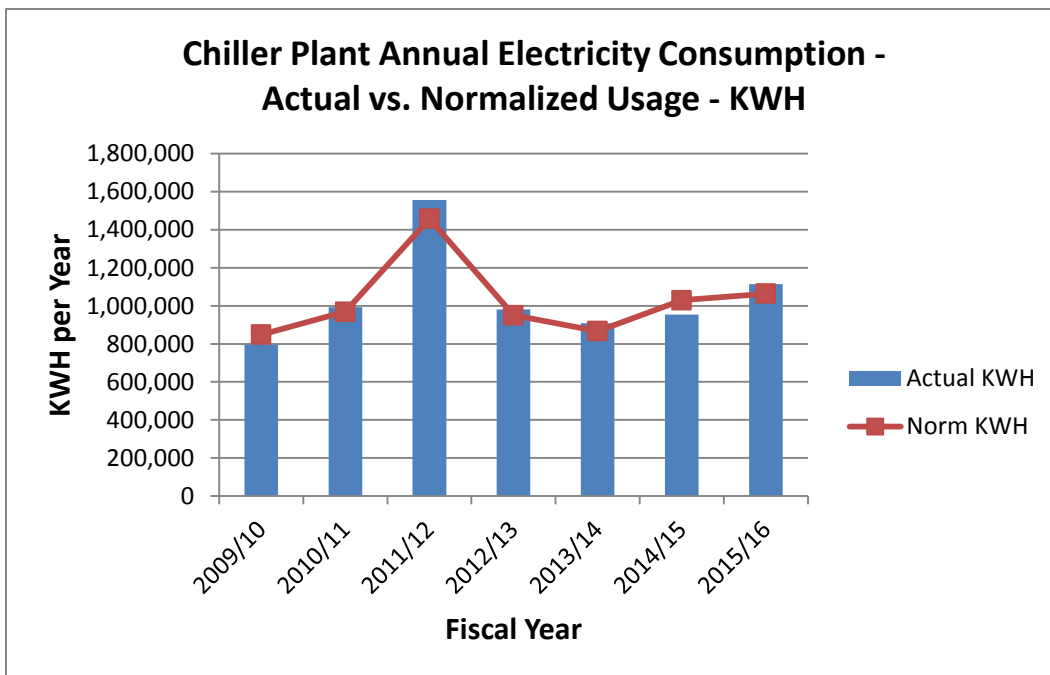
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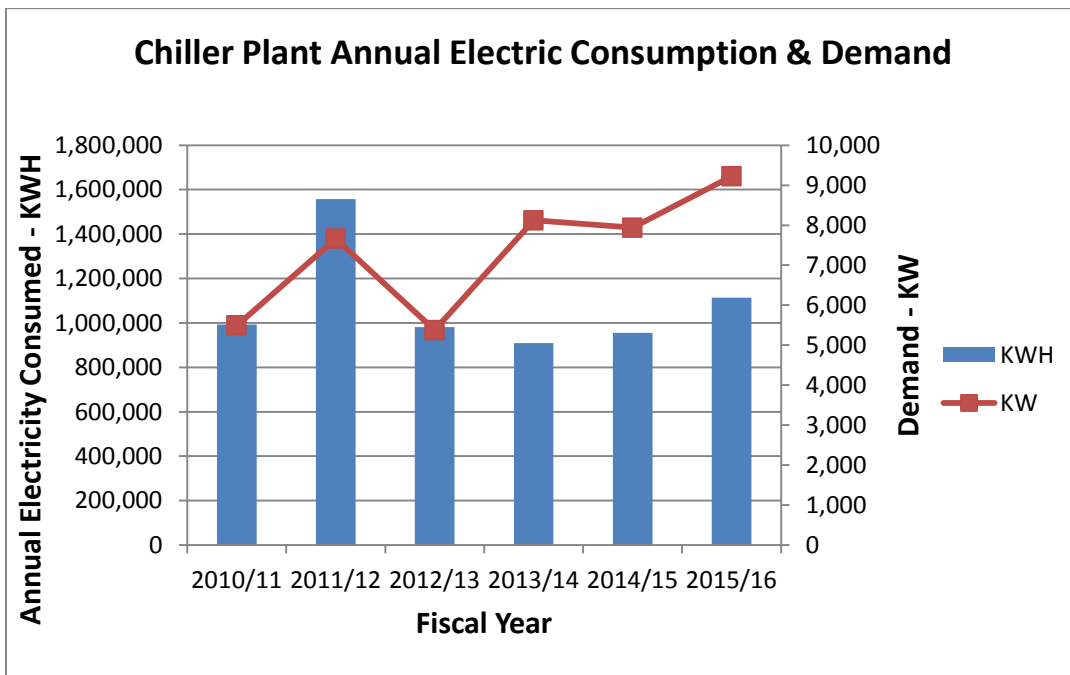
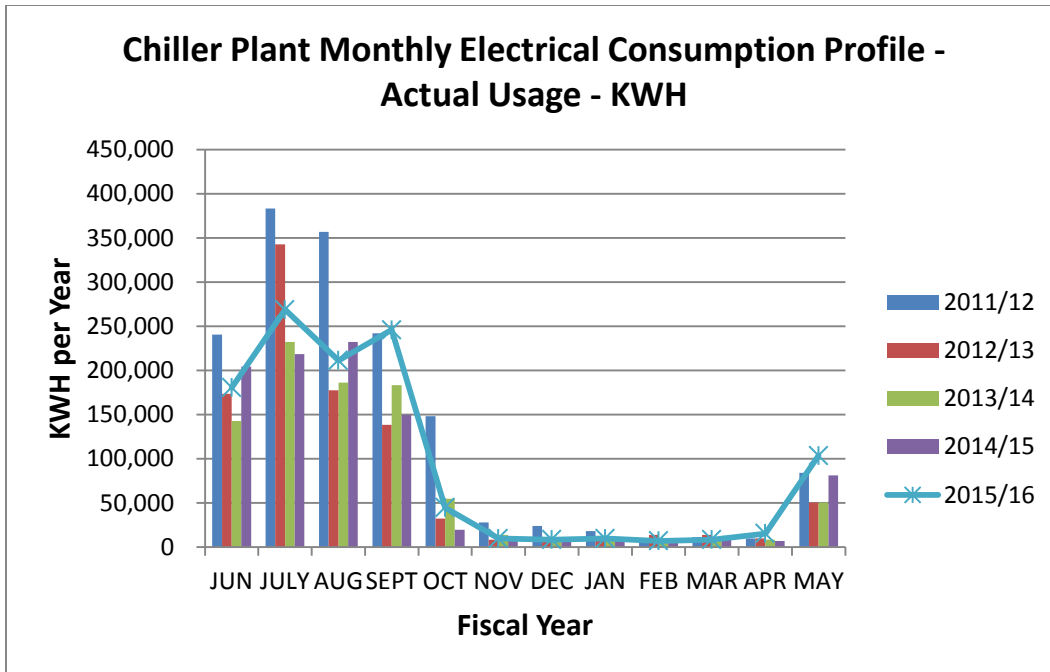
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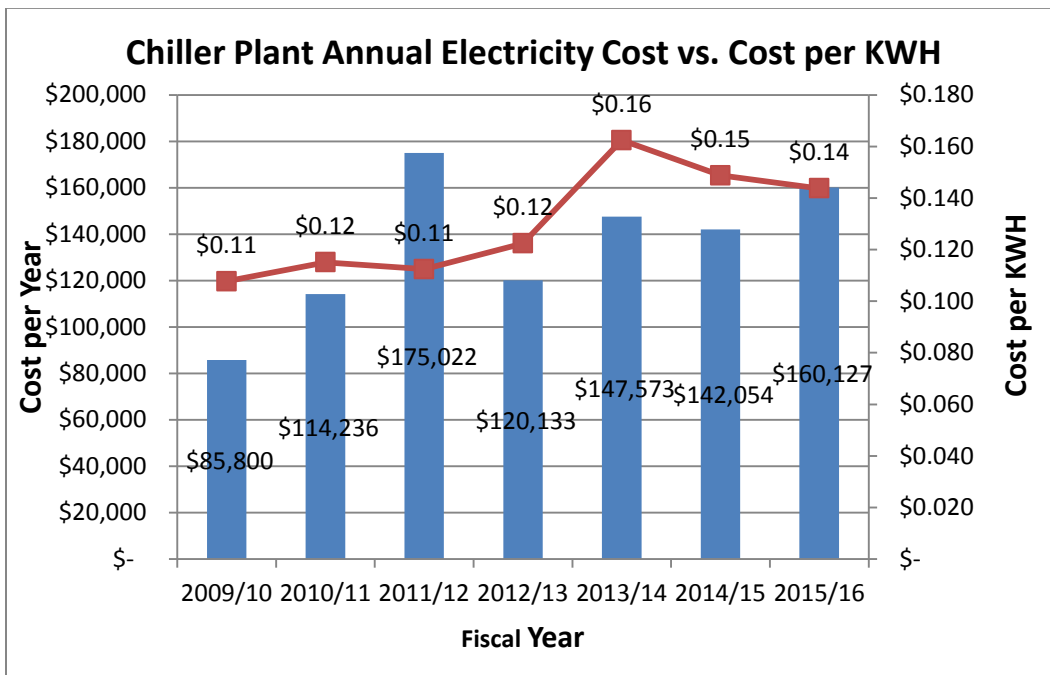
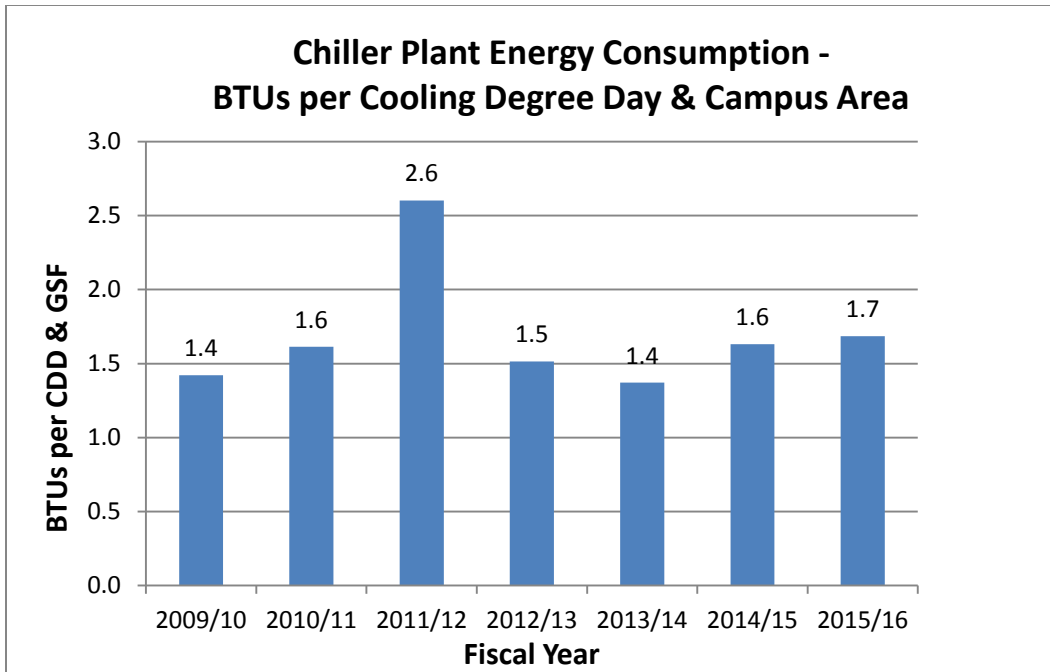


Chiller Plant Electricity Consumption & Cost Graphs

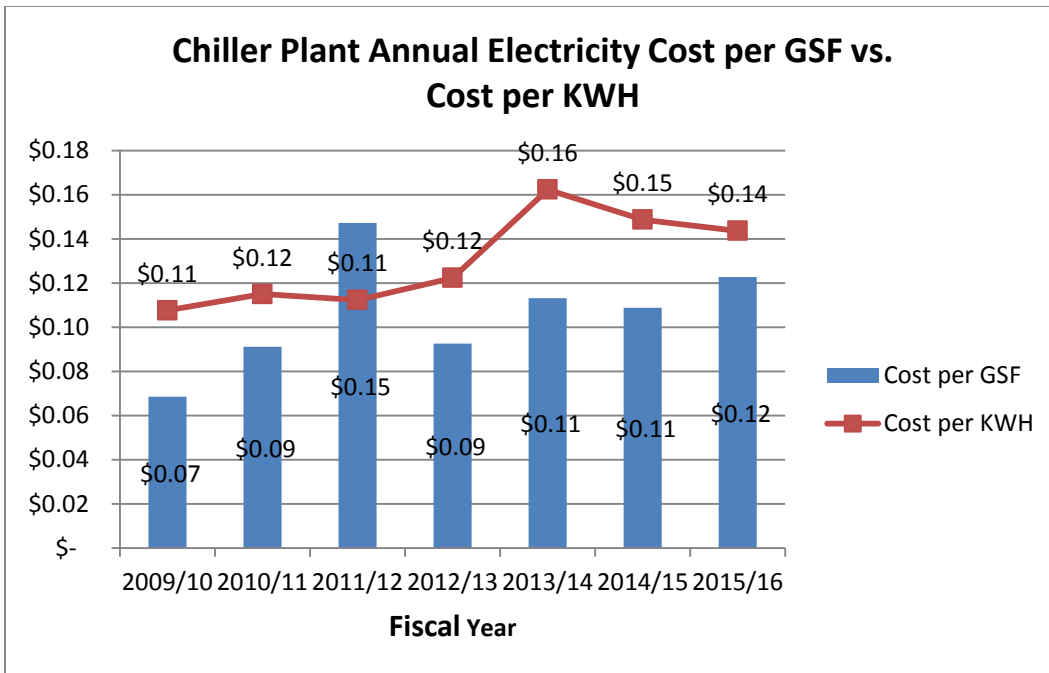
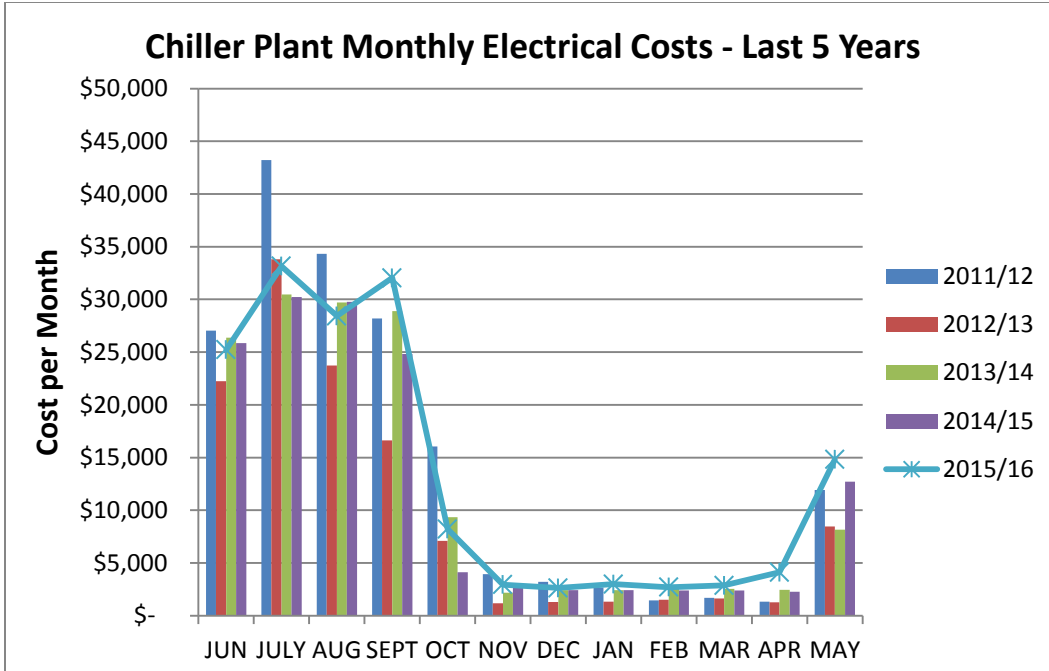


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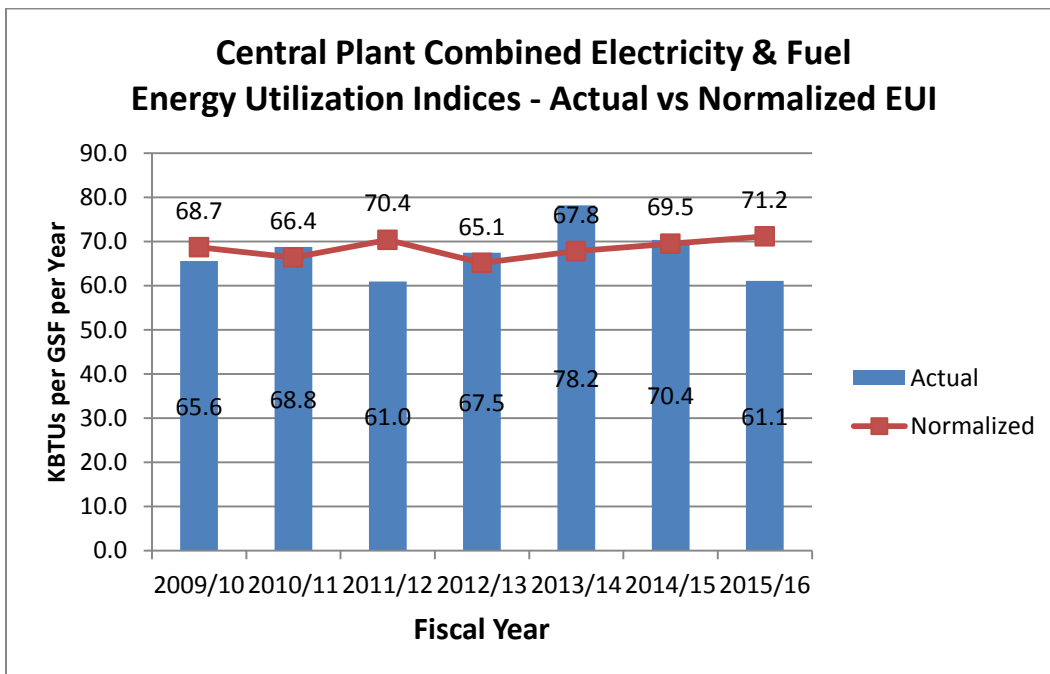
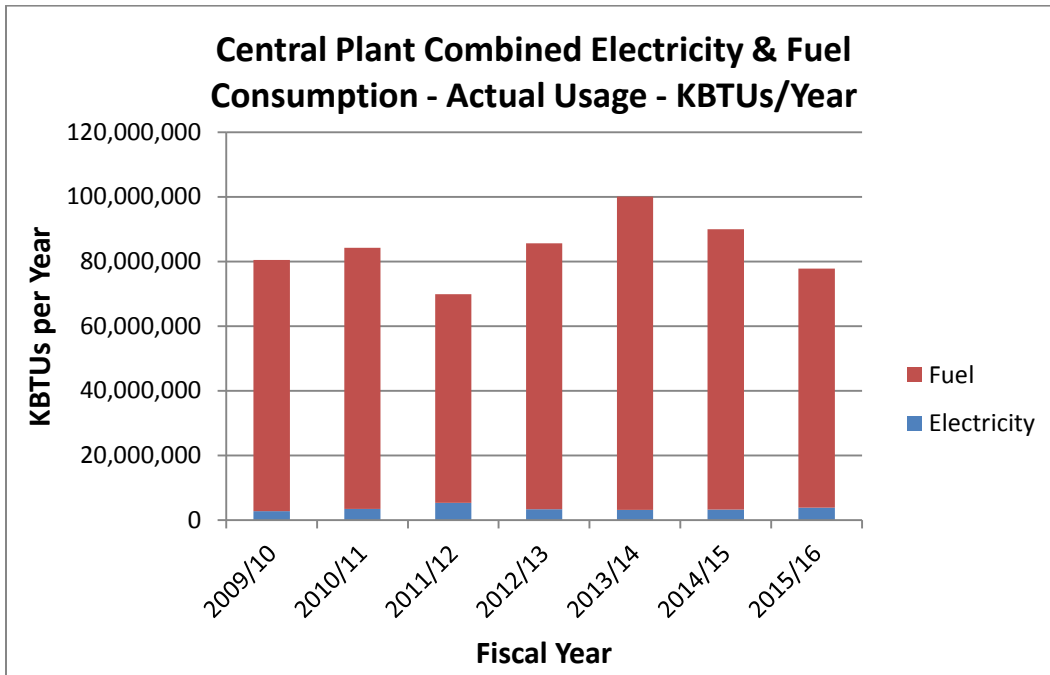




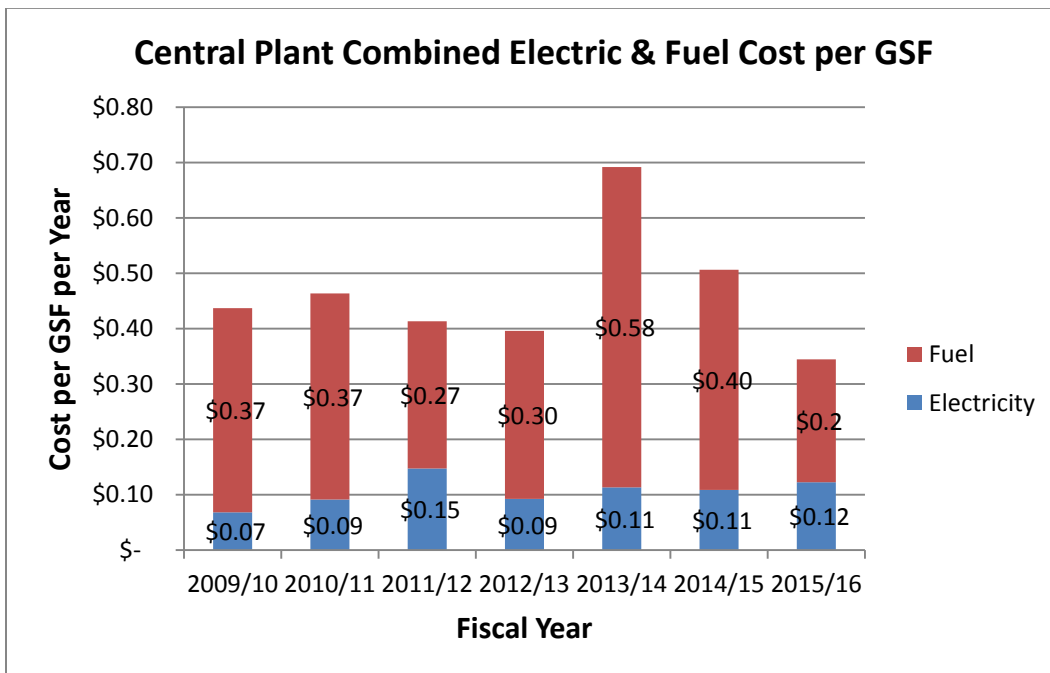
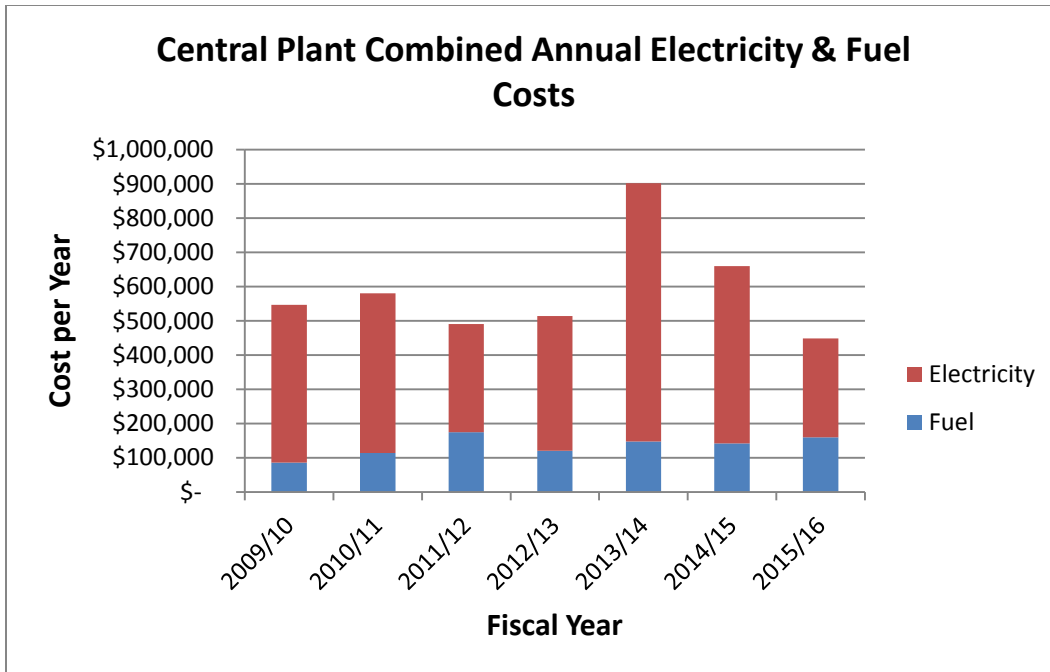
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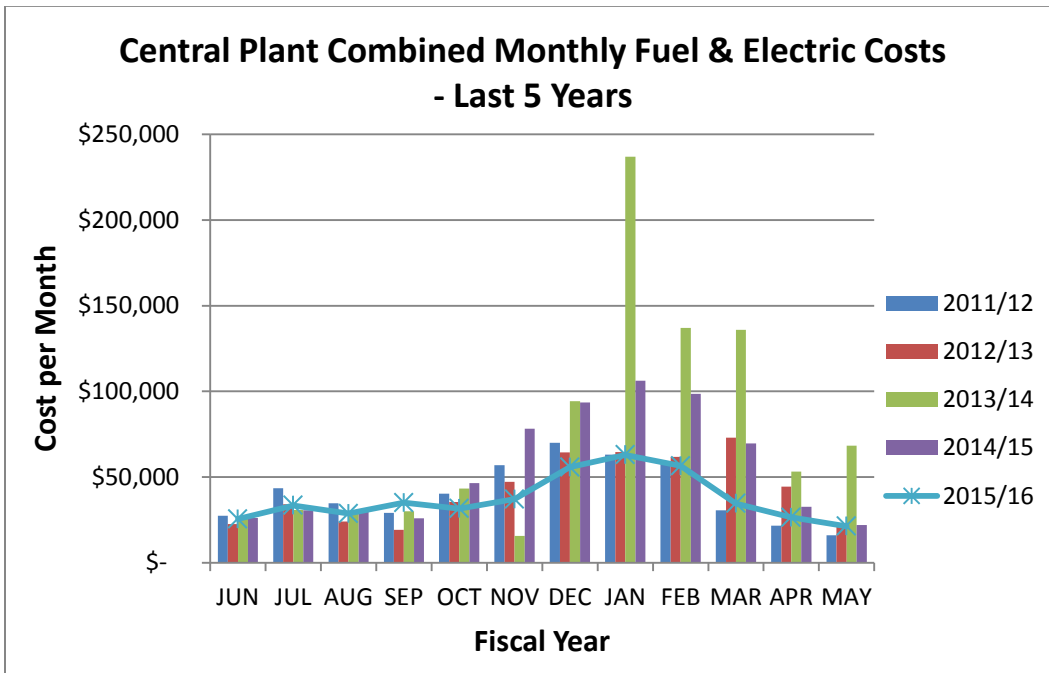
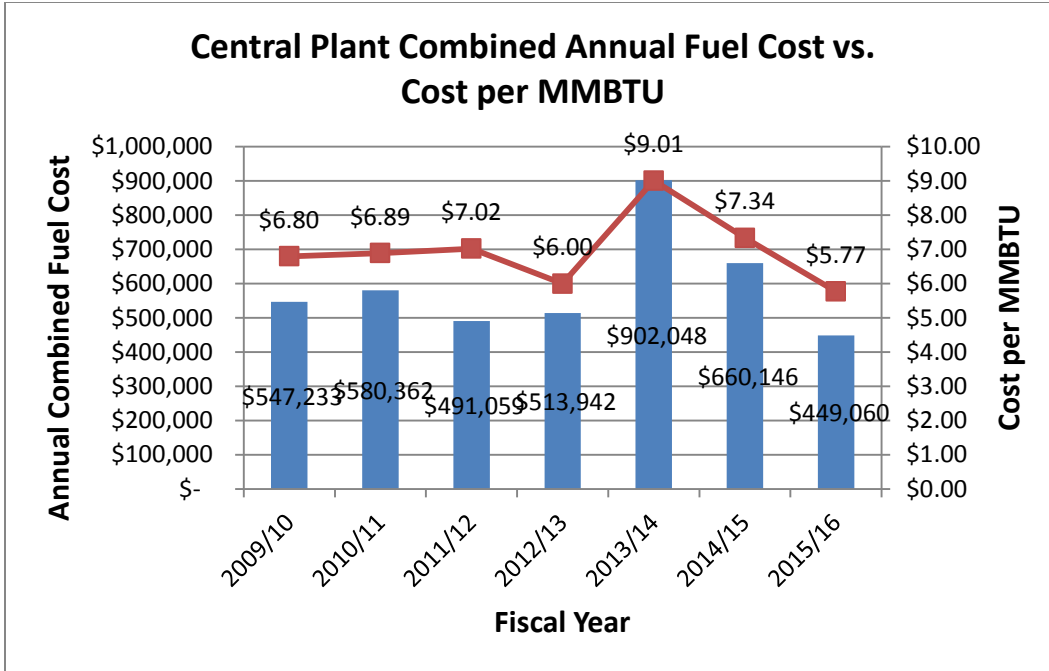


Central Plant Combined Energy Consumption & Cost Graphs

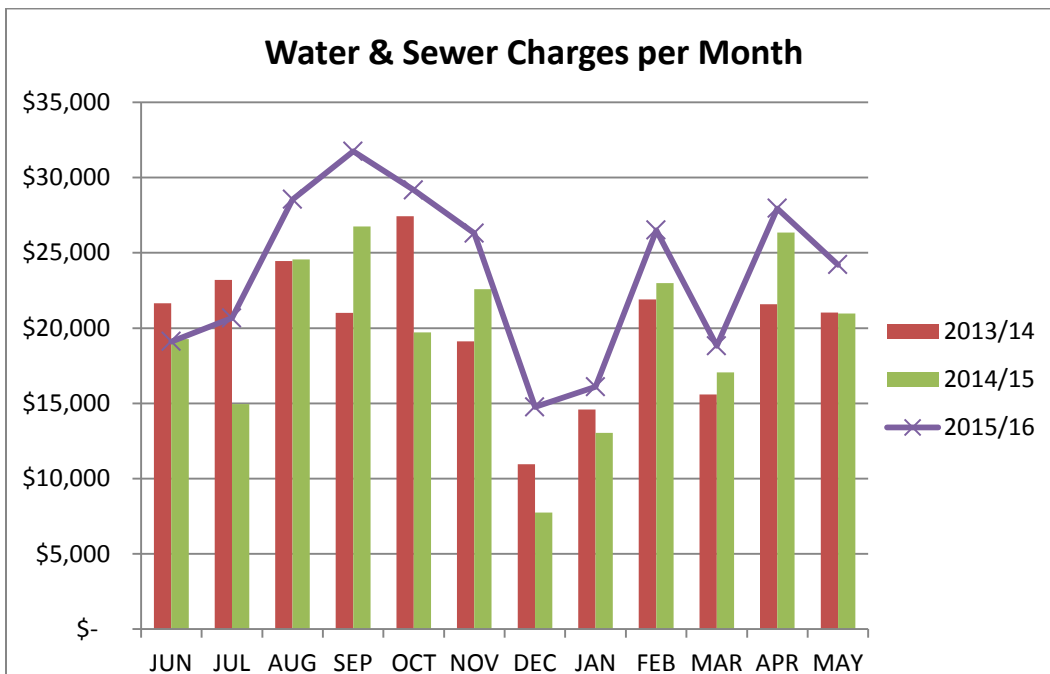
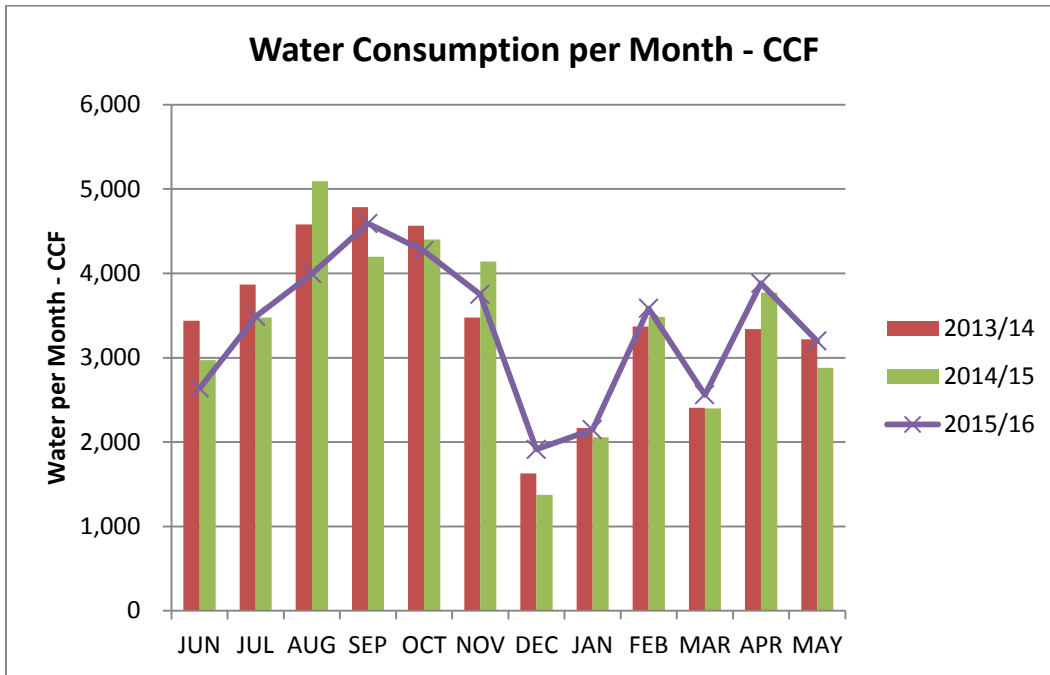


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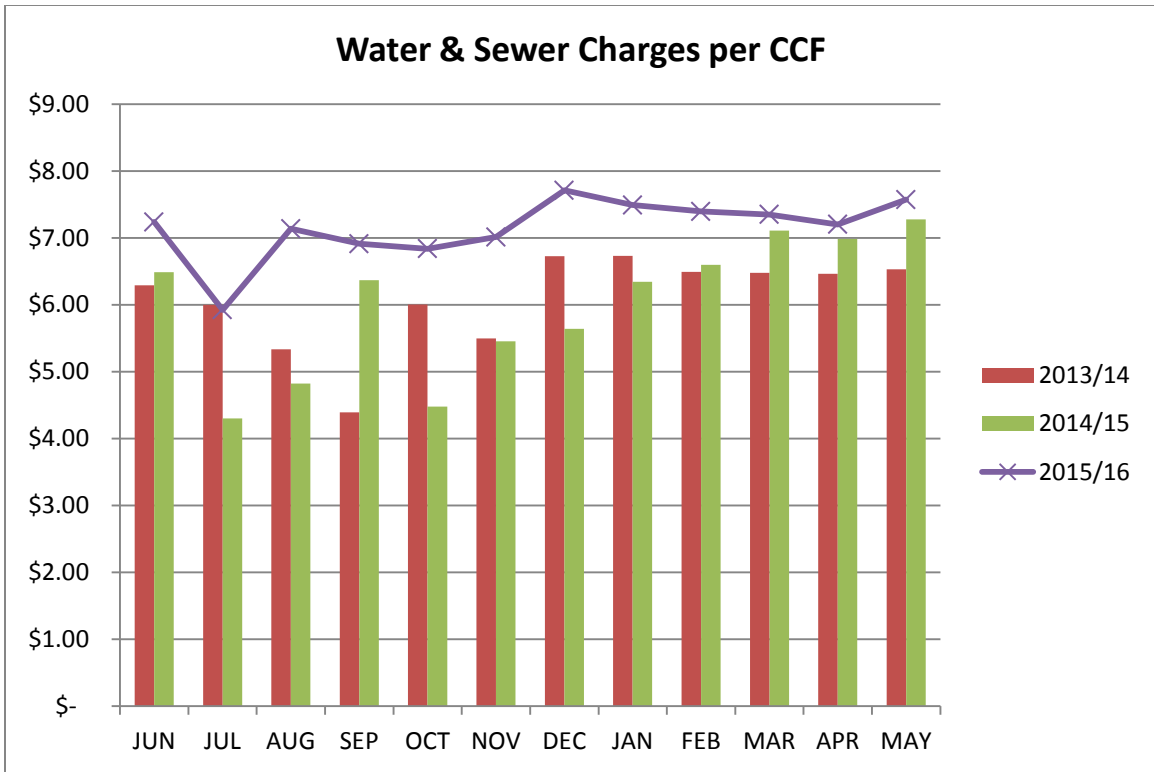




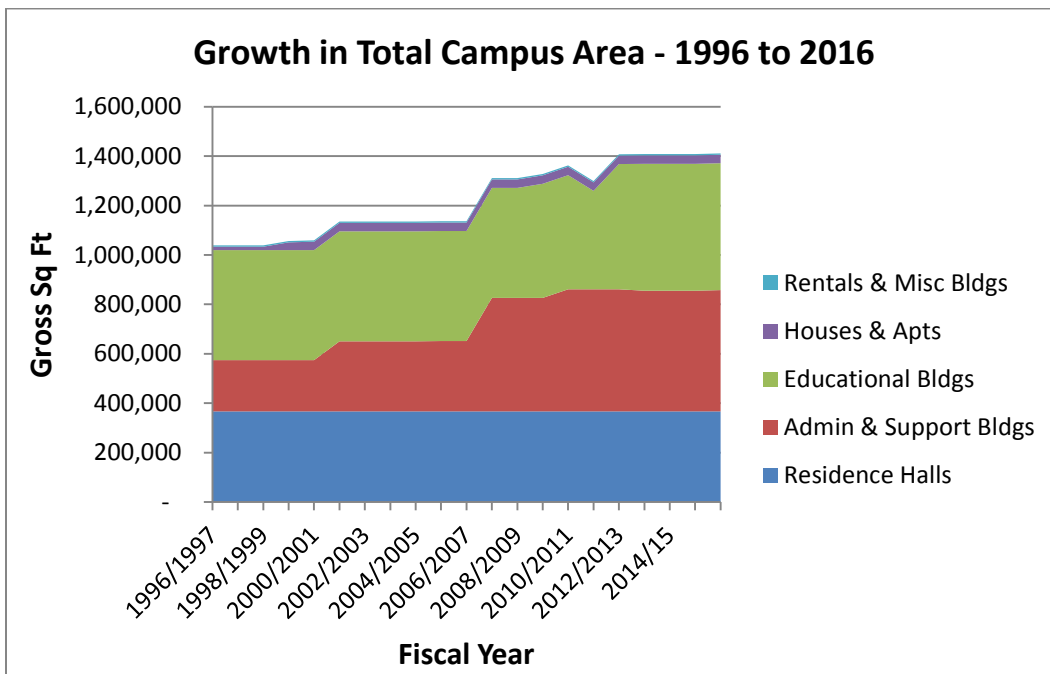
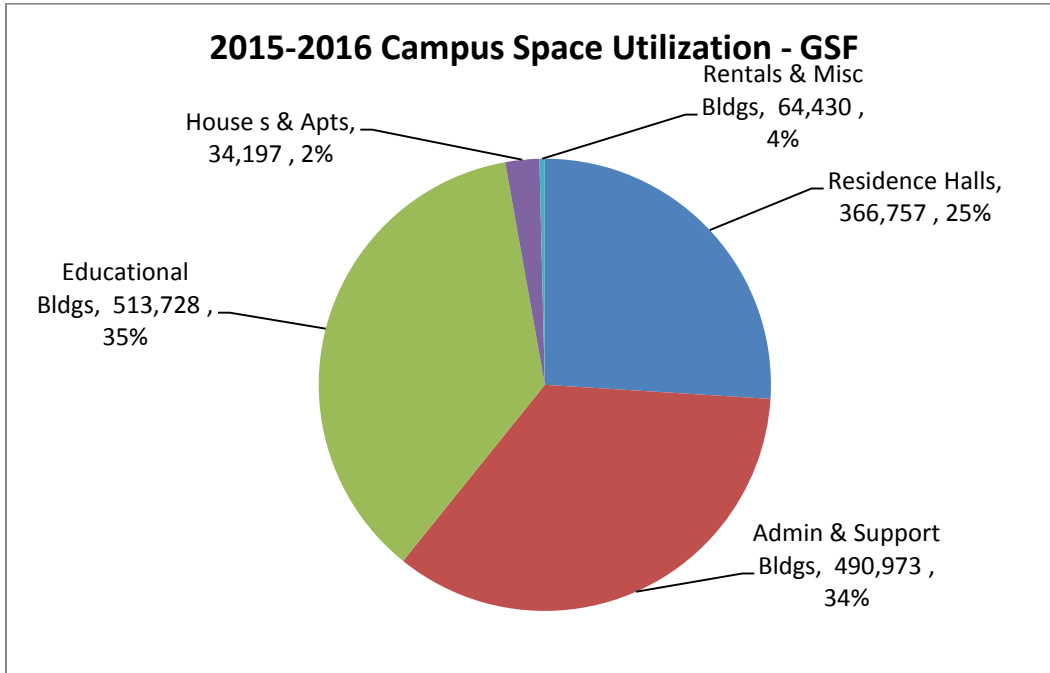
Water Consumption & Cost Graphs



2015 -2016 Macalester College Campus Energy Use Report



Campus Square Footage Information



2015-2016 GRITS Energy Project Data

