CHAPTER 1: ENERGY EFFICIENCY ON THE MAIN CAMPUS

Author: Jennifer Bowen

1.1 Introduction

This chapter of the 2015 Audit focuses on Chapman University's monthly energy consumption on the main campus and projects future consumption with the new construction of the Musco Center for the Arts and the Center for Science and Technology. While total energy consumption on the main campus has increased steadily over the last 15 years, the monthly distribution of electricity and natural gas usage has remained consistent. It is important for the university to evaluate methods of optimizing energy demands in the summer and winter months, such that the university can maintain building use efficiency with future building construction and reduce energy bills for each fiscal year. Specifically, this chapter will examine:

- Monthly electricity and natural gas consumption in main campus buildings
- Electricity consumption and cost per fiscal year with new building construction
- Results from the Chapman University 2015 Environmental Audit Survey: Energy and Building Construction
- Methods of energy reduction in main campus buildings
    - Indoor air and water temperature adjustments
    - Battery storage and solar energy

In response to the 2013 Environmental Audit, this chapter will provide a more detailed analysis of the energy consumption on the main campus and will evaluate energy cost savings from recommendations provided in the original 2013 Audit. This chapter will provide recommendations for implementing energy efficient procedures and optimizing energy consumption on the main campus.

1.2 History of Energy Conservation at Chapman

Since the 2013 Audit, there have been numerous energy conservation efforts considered for implementation on Chapman's main campus. The Energy Conservation and Sustainability Manager in Facilities Management has initiated lighting retrofits and retro commissioning projects in specific main campus buildings and requested site proposals for energy storage methods on the main campus. Many of these energy conservation efforts, including the replacement of burnt out light bulbs with more efficient bulbs and having desktop computers turned off over night, were recommended in the 2013 Audit and have that have yet to be investigated, such as adjusting indoor temperature in classrooms, installing solar panels, and assessing peak building energy consumption. This chapter will evaluate these specific methods of energy conservation to maintain long-term building use efficiency with future building construction.

1.3 Current Status of Energy Use on the Main Campus

When evaluating annual energy usage in academic buildings, it is important to consider both the base and seasonal loads. The base loads of energy consumption are sources that use a consistent amount of energy throughout the fiscal year. These systems include lighting, ventilation, appliances, office equipment, and water heating (Energy Accounting and Analysis). Together these systems use approximately 68% of total electricity and 6% of natural gas consumption in academic buildings (see Introduction, Figure 4). This chapter will evaluate methods of reducing base load from water heating sources in academic buildings (for details about reducing base load from lighting retrofits, see Chapter 3).

Seasonal loads of energy consumption are sources that change demand based on outside weather and building operation schedule. Considering seasonal loads are extremely important for universities that have different building operation schedules during the academic year and summer season. These systems include space heating and air conditioning (Energy Accounting and Analysis). Together these systems use approximately 19% of total electricity and 85% of natural gas consumption in academic buildings (see Introduction, Figure 4). This chapter will evaluate methods of reducing seasonal load from indoor temperature adjustments during the summer and winter months.

1.3.1 Electrical Energy

While total campus electricity consumption has increased an average of 12,940,000 kWh per fiscal year (see Introduction, Figure 8), the distribution of monthly electricity consumption remains consistent over time. The monthly consumption of electricity in kilowatt-hours (kWh) for the 2013-2014 fiscal year is given in ***Figure 1.1***. The base load of electricity is approximately 963,000 kWh per month and has increased each fiscal year.

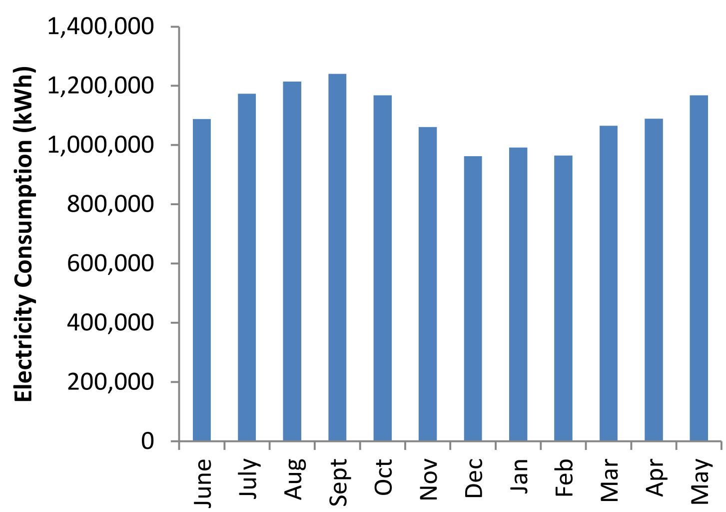


Figure 1.1. *Electricity consumption in kilowatt hours on the Main Campus for the 2013-2014 fiscal year.*

has increased each fiscal year. Electricity consumption in kWh is consistently higher during the summer months and lower during the winter months. This is likely due to the increased use of air conditioning during warmer summer months.

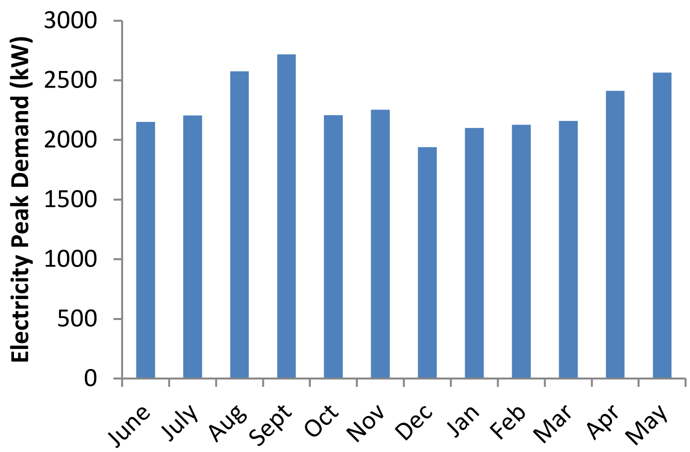


Figure 1.2. *Monthly electricity peak demand in kilowatts on the Main Campus for the 2013-2014 fiscal year.*

Monthly peak demand in kilowatts (kW) for the 2013-2014 fiscal year is given in **Figures 1.2**. The peak demand is determined by the highest usage during a 15-minute interval from the billing month (see Introduction, 3. Rates of Electricity and Natural Gas). Peak demand in kW increases during the summer months from April to September, with the highest consumption during those months in the academic year. Peak demand in kW is lowest in the winter months, however, notably decreases during December due to the winter break in the academic calendar.

Although peak demand follows the same monthly trend as kWh, the monthly kW and rate of relative demand highly impact the total electricity bill. For example, during the 2013-2014 fiscal year, the average rate of relative demand was $14.53 per kW, while the average rate of total electricity was $0.017 per kWh (see Appendix). The timing of monthly and daily demand is instrumental in determining the highest usage from the billing month and can be strategically predicted and avoided.

During the 2013-2014 fiscal year, the average time of day at which the main campus had the highest usage was 3:00pm. Reducing the daily electricity consumption between the hours of 1:00pm and 5:00pm would have a positive impact on the monthly electricity bill due to the reduced consumption during times of peak consumption. These trends further indicate the importance of evaluating both electricity consumption and timing of peak demand in academic buildings to reduce electricity bills for the main campus.

Considering the total monthly cost of electricity, the blended rate of electricity per kWh was $0.17/kWh in the summer months (June – September) and $0.10/kWh in the winter months (October – May) for the 2013-2014 fiscal year (see Introduction, 3. Rates of Electricity and Natural Gas). The higher blended rate of electricity in the summer months is evident in the higher total cost from electricity to an average of $205,000/month during June, July, August, and September in **Figure 1.3.** This higher blended rate in the summer months is largely due to higher relative demand during the warmer summer season.

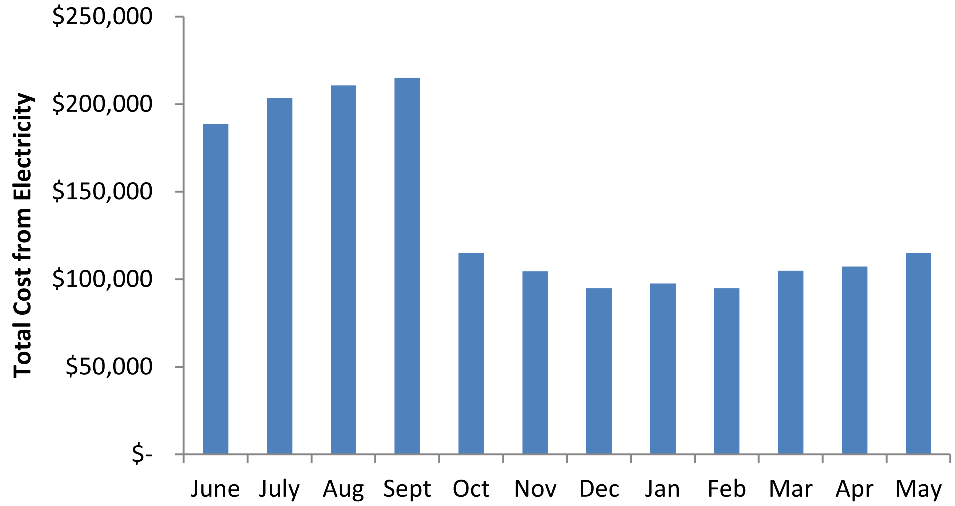


Figure 1.3. *Total monthly cost from electricity on the Main Campus for the 2013-2014 fiscal year.*

1.3.2 Natural Gas

Similar to electricity consumption, the distribution of monthly natural gas consumption is consistent over time and dependent on seasonal and base loads (**Figure 1.4**). The base load of natural gas is approximately 17,800 Btu per month and has increased each fiscal year (see Introduction, Figure 6). The winter months from October to March exhibit the highest natural gas usage, at 55,000 Btu, relative to the rest of the fiscal year. This is likely due to a large portion (85%) of natural gas used in space heating (see Introduction, Figure 4). Efforts to reduce natural gas usage from space heating during the winter months would positively impact the campus seasonal load during the winter months.

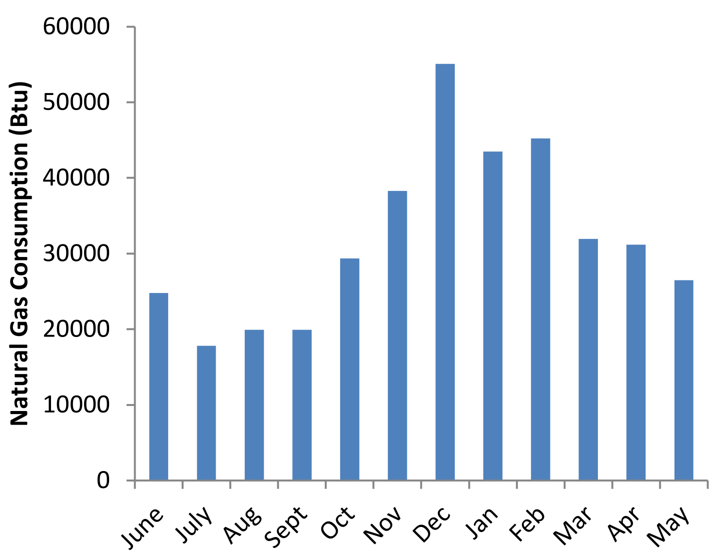


Figure 1.4*. Monthly natural gas consumption in Btu on the Main Campus for the 2013-2014 fiscal year.*

The rate of natural gas is relatively consistent between months, with an average rate of $0.73 per Btu during the 2013-2014 fiscal year. The average blended rate of natural gas has ranged between $0.91/Btu and $0.68/Btu since the 2010-2011 fiscal year (see Introduction, Figure 6). This is a surprisingly high rate of natural gas considering the main campus monthly consumption is much higher than 3918 Btu for the Tier 3 rate of $0.08/Btu. This higher rate is due to the charge of multiple natural gas meters across the main campus, each consuming less than 3918 Btu. The total monthly cost from natural gas consumption on the main campus follows a similar trend as the monthly consumption in Btu (**Figure 1.5**).

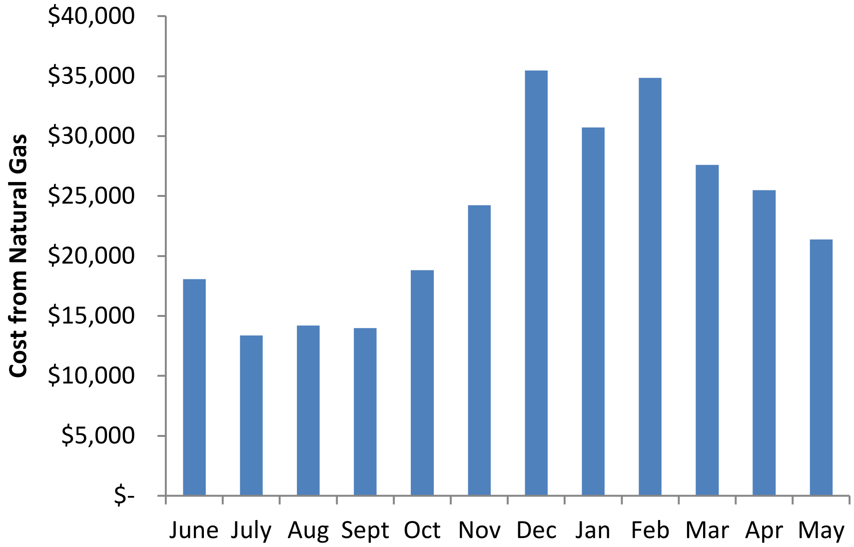


Figure 1.5*. Total monthly cost from natural gas on the Main Campus for the 2013-2014 fiscal*

1.3.3 Main Campus Energy Consumption

1.3.3.1 Compared Monthly Energy Usage

In order to determine methods for the university to reduce seasonal and base load, the monthly distribution of electricity and natural gas consumption must be evaluated. Both values of kWh and Btu were converted to a comparable unit of MMBtu (see Appendix). The distribution of monthly electricity and natural gas consumption in MMBtu is given in **Figure 1.6**. Consistent with that previously mentioned, electricity consumption increases during the summer months and natural gas consumption increases during the winter months. Overall, the total monthly energy usage has an average of 6947 MMBtu per month with the highest total values during the winter months: November, December, January, and February (see Appendix).

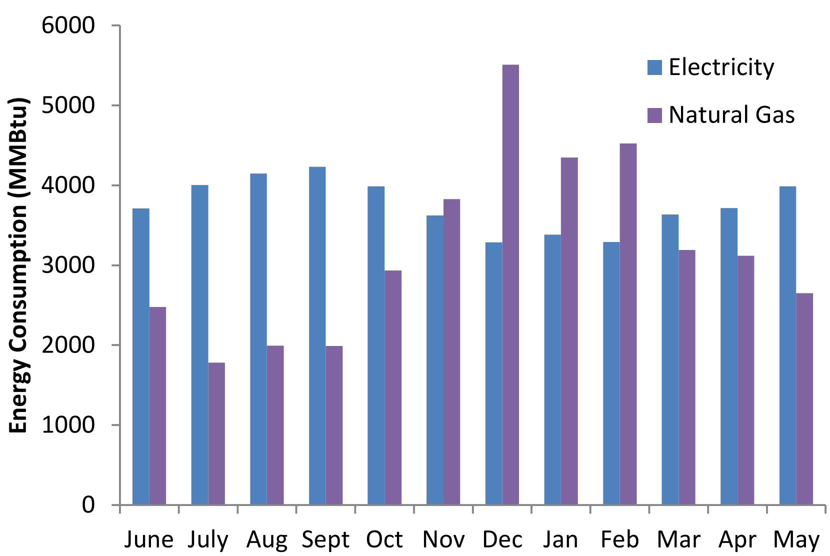


Figure 1.6*. Monthly electricity and natural gas consumption in MMBtu on the Main Campus for the 2013-2014 fiscal*

While the distribution of electricity and natural gas in MMBtu are comparable, there is a significant difference in total cost between electricity and natural gas (**Figure 1.7**). This comparison shows the importance of reducing both seasonal and base load of electricity.

The average total cost of electricity for the summer months from June to September is $204,000 per month, while that for the winter months is $104,000 per month. Efforts to reduce the summer kWh usage to near base load values (a conservative reduction of 125,000 kWh/month from June to September) would save a total of $86,000 (see Appendix).

Reducing this seasonal load of electricity, however, is more difficult than simply restricting electricity usage in main campus buildings during the summer months. This reduction requires strategic evaluation of current usage toward systems of base and seasonal load and effective ways to optimize the system's consumption. For example, minimizing electricity usage for air conditioning during the summer months would significantly impact the monthly electricity bill.

This chapter will evaluate the total cost savings per fiscal year for minor adjustments in the indoor temperature of main campus buildings during the summer and winter months. In addition, the cost savings will be calculated for reducing the outgoing temperature of water for distribution throughout an academic building. Optimizing building use on the main campus during the summer months would also significantly impact summer electricity consumption. This can be accomplished by implementing a classroom scheduling and building use policy (see Chapter 8 for more details).

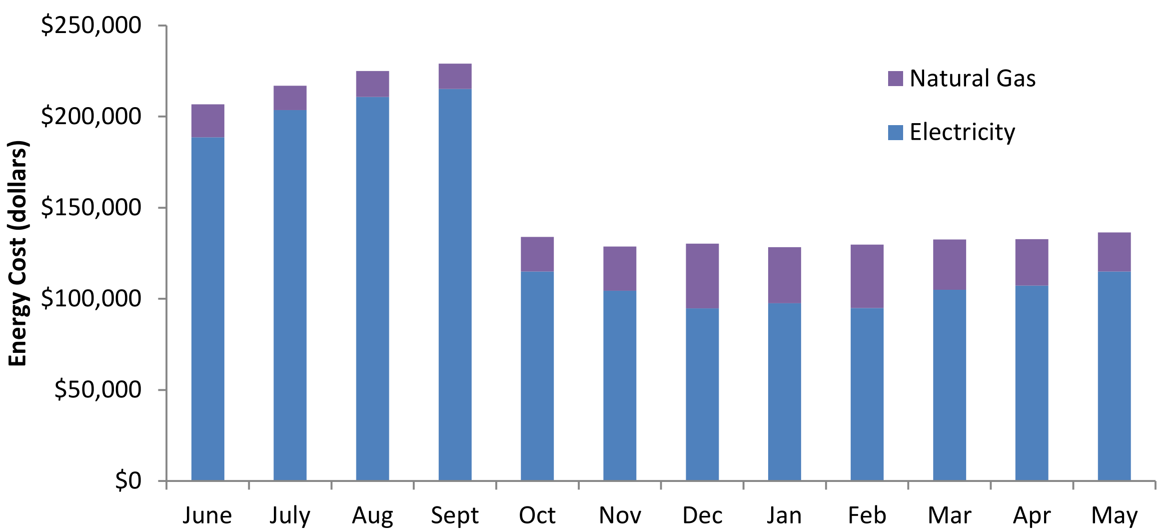


Figure 1.7. *Monthly cost of electricity and natural gas consumption on the Main Campus for the 2013-2014 fiscal year.*

1.3.3.2 Projected Main Campus Electricity Usage

Evaluating measures for the main campus to reduce seasonal and base loads is important for optimizing energy building use efficiency. However, the university should consider long-term energy management with the new construction of the Musco Center for the Arts in 2015 and the Center for Science and Technology in 2018 as these buildings will contribute to main campus energy demand.

Assuming the total campus building square footage increases at an average rate of 132,094 sqft per year (see Introduction, Figure 2) and electricity consumption per sqft remains at 6.06 kWh per sqft (see Introduction, Figure 10), the total electricity usage on the main campus will reach 3,397,727 kWh or $2,470,827 in the year 2018 (**Table 1.1**, see Appendix). This increase by 2,401,469 kWh or $288,176 from the year 2015 to 2018 will have a large impact on current university budgeting for electricity consumption alone.

Table 1.1. *Estimated electricity consumption and cost per fiscal year with new building construction.*

	Square footage (sqft)	Projected Electricity Consumption (kWh)	Projected Cost per fiscal year	Electricity Consumption based on Building Function (kWh)	Cost based on Building Function per fiscal year
Musco Center for the Arts (2015)	88,142	534,140	$ 64,097	1,101,775	$ 132,213
Center for Science and Technology (2018)	295,466	1,790,523	$ 214,863	4,934,282	$ 592,114
Total (2015)	3,001,445	18,188,757	**$ 2,182,650**	*Corrected Total:*	**$ 2,250,767**
Total (2018)	3,397,727	20,590,226	**$ 2,470,827**		**$ 3,109,514**

Musco Center for the Arts is projected to consume approximately 534,140 kWh each fiscal year based on current trends in Chapman's main campus consumption. This consumption would total $64,097 each fiscal year assuming the blended rate of electricity remained constant at $0.12 per kWh from the 2013-2014 fiscal year. However, these projections do not consider the specific building function. The estimated electricity consumption for performing arts centers increase to 12.5 kWh per sqft (U.S. EIA), reaching a total of 1,101,775 kWh or $132,213 each fiscal year.

The Center for Science and Technology is projected to consumed approximately 1,790,523 kWh or $214,863 each fiscal year based on the trends of main campus consumption. Considering the center's building function with laboratories, the estimated consumption is approximately 16.7 kWh per sqft (U.S. EIA), reaching a total of 4,934,282 kWh or $592,114 per fiscal year. Including the higher estimated electricity consumption of these new constructions based on building function, the total electricity usage on the main campus will reach $3,109,514 in the year 2018.

Efforts to reduce the main campus electricity load and accommodate future building construction will require more strategic systems for electricity storage and distribution. This chapter will evaluate the total cost savings for the installation of a battery storage unit and solar panels for the main campus. Both of these systems would effectively reduce electricity consumption during peak hours and allow for efficient electricity distribution in main campus buildings.

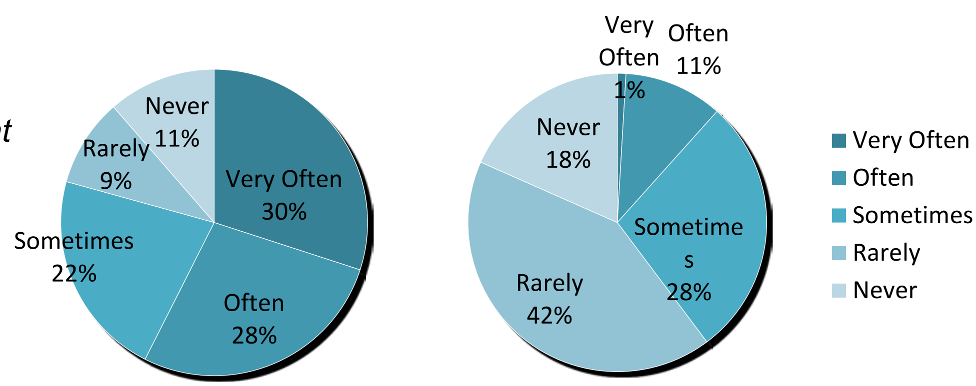
1.3.4 Chapman University 2015 Environmental Audit Survey

1.3.4.1 Indoor Temperature Adjustments

It is important to evaluate student, faculty, and staff satisfaction of the current indoor temperature prior to making university-wide temperature adjustments. The Chapman University Survey 2015 Energy and Building Construction Audit (2015 Survey) asked the question “How often do you do the following: Find a classroom too cold and Find a classroom too warm.” While 58% of students find a classroom cold often or very often, only 12% find a classroom warm often or very often (**Figure 1.8**). Faculty and staff responded with a similar frequency, where 41% and 12% find a classroom too cold and too warm, respectively. These results suggest cold indoor temperature is of more concern to students, faculty, and staff than warm temperature in classrooms.

The 2015 Survey asked the question “To what degree would you support the

Figure 1.8. *Percentage of student survey participants find a classroom a) too cold or b) too warm (n = 430).*



following energy saving measures in the Main Campus buildings: Slightly warmer classroom temperatures during the warmer months and slightly cooler classroom temperatures during the cooler months.” The results showed 59% of student and 59% of faculty and staff participants support or strongly support slightly warmer classroom temperatures during the

the warmer months (**Figure 1.9**). Similarly, 54% of student and 61% of faculty and staff participants support or strongly support slightly cooler classroom temperatures during the cooler months (**Figure 1.10**).

These survey results suggest the majority of student, faculty, and staff participants are in support of temperature adjustments to reduce energy consumption in the classroom; however, it is equally important to evaluate faculty and staff satisfaction of office indoor temperature. Faculty and staff participants with an office were asked “How often do you do the following: Find your office too cold and Find your office too warm” (n = 218). The results showed 34% of faculty and staff find it too cold often or very often, while 15% find it too warm often or very often. While faculty and staff did not exhibit significantly different frequency of cold or warm temperatures in the office, university-wide temperature standards would ensure consistent temperature throughout all rooms of a building.

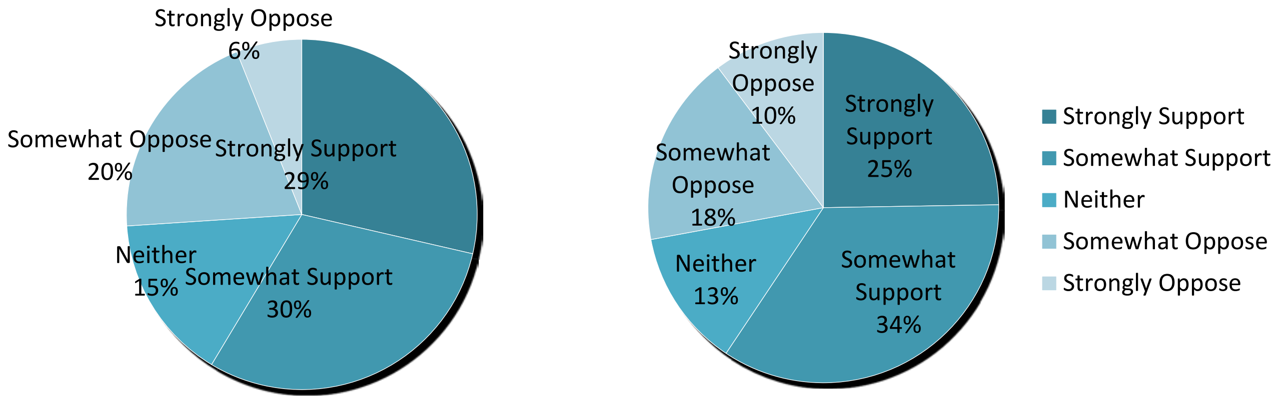


Figure 1.9. *Percentage of a) student, b) faculty and staff (n = 283) survey participants that support slightly warmer classroom. Temperatures during the warmer months.*

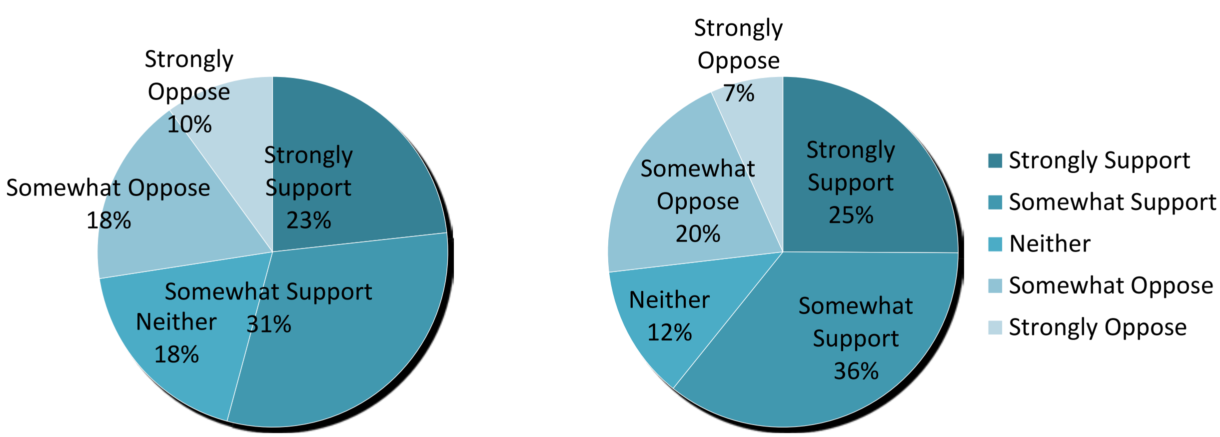


Figure 1.10. *Percentage of a) student, b) faculty and staff survey participants that support slightly cooler classroom temperatures during the cooler months temperatures during the warmer months.*

1.3.4.2 Water Temperature Adjustments

The 2015 Survey asked the question "To what degree would you support the following energy saving measures in the Main Campus buildings: Cooler water temperature in the restroom faucets." The results showed 64% of student participants were in support of cooler water temperatures, while 46% of faculty and staff participants were in support of cooler water temperatures (**Figure 1.11**).

In the 2014 Audit, approximately 67% of student, faculty, and staff participants were in support of a 2-3 degree increase in building water temperature (2014 Audit, Figure 1.7). The 2015 Survey results show further support of this change in building water temperature.

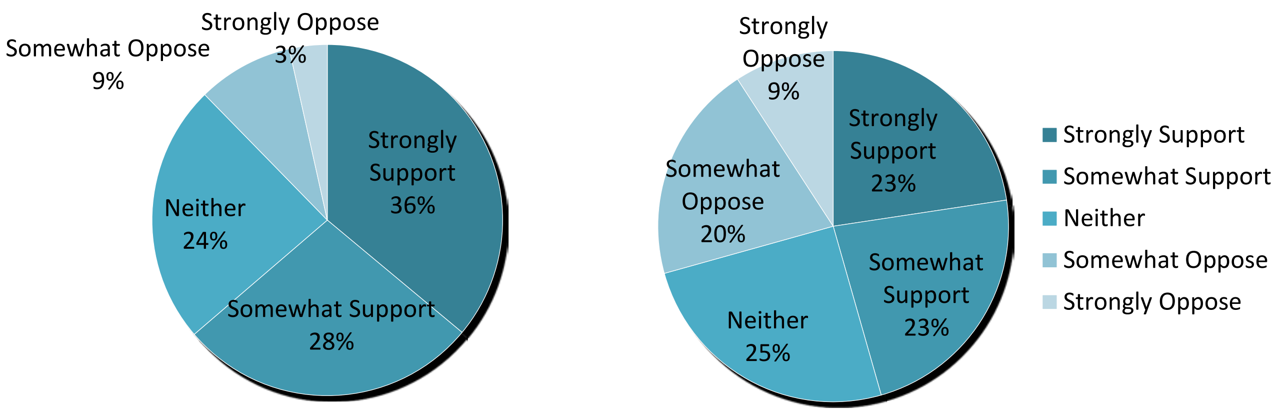


Figure 1.11. *Percentage of a) student, b) faculty and staff survey participants that support cooler water temperatures in the restroom faucets during the cooler months temperatures during the warmer months.*

1.3.5 Methods of Energy Reduction

1.3.5.1 Indoor Temperature Adjustments

Considering the high electricity usage for air conditioning in the summer months and the high natural gas usage for space heating in the winter months, reducing usage for these building functions would have an impact on total energy consumption. The 2013 Audit recommended increasing the temperature in classrooms by 1-2 degrees. However, the cost savings from specific temperature adjustments in the summer and winter months will be evaluated.

Assuming approximately 19% and 85% of electricity and natural gas, respectively, are used for building heating and cooling, electricity bills reach $40,000 in the summer months and natural gas bills reach $30,000 in the winter months (**Figure 1.12**). This inverse relationship between high electricity costs from cooling in the summer and high natural gas costs from heating in the winter further support the importance of assessing methods to optimize indoor air temperatures.

With the majority of student, faculty, and staff survey participants in support of indoor temperature adjustments to match the outside climate (Figures 1.9 and 1.10), the university would benefit from implementing a university-wide temperature standard that optimizes energy consumption from indoor air heating and cooling. Chapman University does not currently have a university-wide indoor temperature standard, allowing students, faculty, and

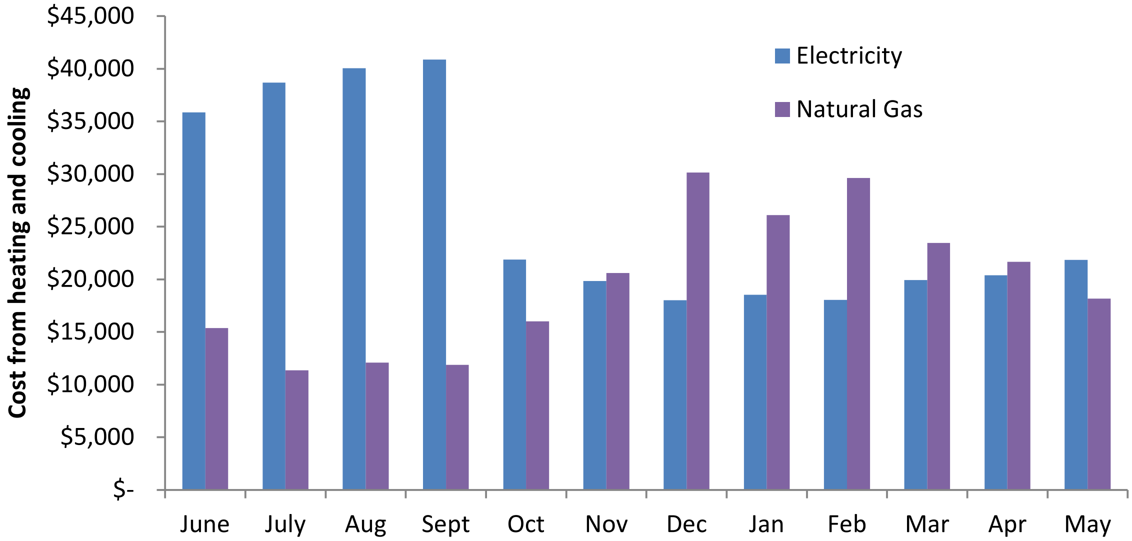


***Figure 1.12**. Estimated total cost of electricity and natural gas from building heating and cooling based on the 2013-2014 fiscal year during the cooler months temperatures during the warmer months.*

staff to adjust or request adjustments to the indoor building temperature. Having a standard operation schedule for indoor temperature would allow for the university to optimize energy consumption from heating and cooling and predict associated energy consumption from indoor temperature adjustments.

Chapman University Facilities Management currently operates indoor building temperature at approximately 68 ºF for heating and 72 ºF for cooling. With 59% of student, faculty, and staff survey participants in support of warmer indoor temperature during the warmer months, the university would have notable energy cost savings if the temperature-cooling standard increased to 76 ºF in summer months. Similarly, the university would have energy cost savings if the temperature-heating standard decreased to 66 ºF in the winter months.

These temperatures were chosen based on the assumption that during occupied hours the outside temperature ranges between the maximum and mean temperature (see Appendix Table 1.6), where the outside temperature was at the maximum temperature for 4 hours and at the mean temperature for 12 hours. Calculations for energy cost savings were based off the assumption that during unoccupied building hours, between 10:00pm and 6:00am, the indoor temperature would not be adjusted.

Table 1.2. *Estimated energy cost savings on the Chapman University Main Campus based on the 2013-2014 fiscal year.*

	Total monthly cost at the current 68 ºF (heating) and 72 ºF (cooling)	Estimated monthly cost with - 2 ºF (heating) and + *4 ºF (cooling)*	**Total Cost Savings**
June	$ 206,789	*$ 191,900*	($ 14,889)
July	$ 216,944	*$ 201,324*	($ 15,620)
August	$ 224,987	*$ 208,788*	($ 16,199)
September	$ 229,112	*$ 212,616*	($ 16,496)
October	$ 133,900	$ 129,080	($ 4,820)
November	$ 128,756	$ 124,121	($ 4,635)
December	$ 130,282	$ 125,592	($ 4,690)
January	$ 128,344	$ 123,724	($ 4,620)
February	$ 129,820	$ 125,146	($ 4,674)
March	$132,520	*$ 127,749*	($ 4,771)
April	$ 132,733	*$ 123,177*	($ 9,556)
May	$ 136,430	*$ 126,607*	($ 9,823)
TOTAL	**$ 1,930,618**	**$ 1,819,824**	**($ 110,794)**

The calculated energy cost savings as a result of 4ºF increase in the summer months and 2ºF decrease in the winter months is approximately $110,000 per fiscal year (**Table 1.2**, see Appendix). These data were calculated based on the assumption that there is a 1.8% energy cost savings per 1ºF for 8 hours (Mackenzie Crigger).

The current total cost and estimated total cost savings from the adjusted heating and cooling temperature standards are given in **Figure 1.13**. These temperature adjustments would notably reduce the seasonal load and the subsequent total energy cost during the summer months. If the total 16 hours of main campus building use from 6:00am to 10:00pm were considered in the calculations, the cost savings would be closer to $220,000 per fiscal year.

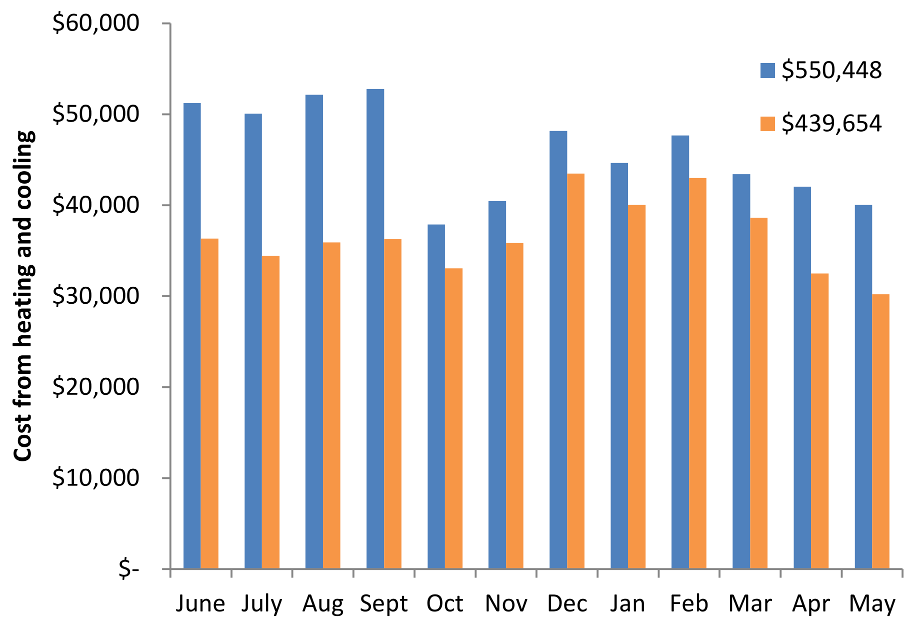


Figure 1.13. *Current total energy cost (blue) and estimated total energy cost from heating and cooling with the recommended indoor temperature adjustments (yellow) based on the 2013-2014 fiscal year.*

1.3.5.2 Water Temperature Adjustments

While a relatively small portion of electricity and natural gas are used for water heating in academic buildings, reducing usage from heating water at the boiler would save the university from unnecessary expenses. The 2013 and 2014 Audits recommended increasing the water temperature in restroom faucets by 1-2 degrees, with strong support from student, faculty, and staff survey responses. The cost savings of water temperature adjustments will be evaluated.

Assuming approximately 1% and 5% of electricity and natural gas, respectively, are used for building water heating, electricity bills reach $2,100 in the summer months and natural gas bills reach $1,800 in the winter months (**Figure 1.14**). Although only 1% is depicted of the monthly electricity cost, the electricity costs for water heating in the summer are noticeably higher relative to the natural gas costs in the winter.

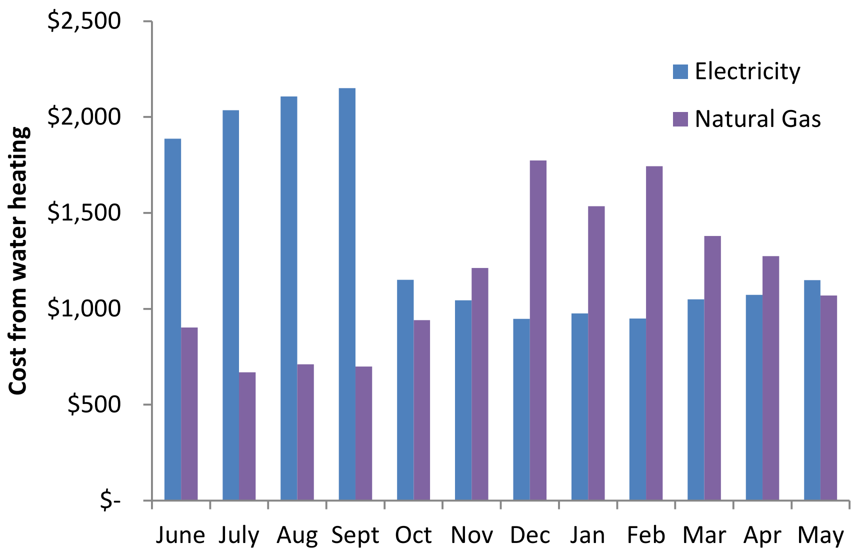


Figure 1.14. *Estimated total cost of electricity and natural gas from building water heating based on the 2013-2014 fiscal year.*

Water is delivered to buildings at approximately 60 ºC, where it is heated to 130 ºC and distributed throughout the building. With 64% of student participants in support of cooler water temperatures and 46% of faculty and staff participants in support of cooler water temperatures, it would be beneficial to evaluate the cost savings of reducing outgoing water temperature to 119 ºC.

Buildings with food services require faucet temperature to remain above 65 ºC, where the outgoing water temperature must be 130 ºC. As such, all calculations for water temperature adjusts exclude the following buildings: Argyros Forum and Beckman Hall. A reduction of the outgoing water temperature to 119 ºC would save an average of 3098 Btu or $3,500 per fiscal year, assuming an average 10.15% reduction in Btu consumed each fiscal year (**Figure 1.15**, see Appendix).

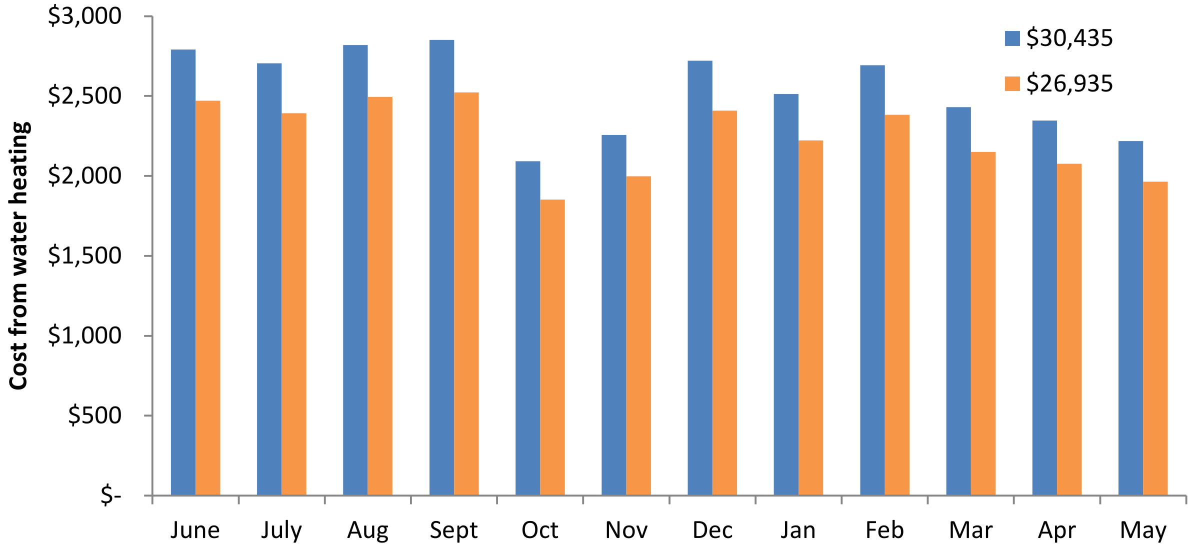


***Figure 1.15**. Current energy cost from water heating at 130 ºC (blue) and estimated total energy cost from water heating with the recommended outgoing temperature adjustments to 119 ºC (yellow) based on the 2013-2014 fiscal year.*

1.3.5.3 Battery Storage

While energy conservation methods have been evaluated to reduce natural gas and kilowatt hour consumption, it is equally important to assess methods of reducing peak demand during high consuming hours of the day. As previously mentioned, the highest usage during a 15-minute interval from the billing month was between 1:00pm and 5:00pm during the 2013-2014 fiscal year. Peak demand has a significant impact on the monthly electricity bill, as the average rate of relative demand is approximately $14.53 per kW, while the average rate of total electricity was $0.017 per kWh.

Battery storage may be used to consume electricity during off-peak hours of the day, store electricity, and power academic buildings during peak hours. An example of battery storage is the Stem Solutions Energy System.

Figure 1.16. *Stem Solutions Energy System.*

The Stem Energy System uses strategic energy storage to reduce building peak energy consumption (**Figure 1.16**). The system includes the PowerScope, PowerMonitor, and PowerStore to analyze energy consumption data and optimize daily consumption. Each PowerStore holds 18 kW / 20 kWh. In addition, the system requires no operational charges and will not need routine employee maintenance.

Chapman University Facilities Management requested site proposals for the Stem Solution in February of 2015 (**Table 1.3**). It was found that installation of the Stem Energy System in Hashinger Science Center could cover the electricity redistribution to all the main campus buildings. This energy conservation strategy would save the university approximately $79,781 in the first year and $979,212 after ten years (see Appendix).

Table 1.3. *Net savings for 100kW/ 195kWh solar energy on the Chapman University Main Campus.*

	Year 1			Years 1 – 5	Years 1 – 10	
Current Electric Cost	Total Estimated Savings	(Total Estimated Payments)	Net Savings	Net Savings	Net Savings	Total Return on Payments
$ 1,891,886	$ 99,562	($ 19,781)	$ 79,781	$ 430,136	**$ 979,212**	590 %

Table 1.4. *Estimated energy cost savings on the main campus from the installation of solar panels on Argyros Forum, Leatherby Library, and Hutton Sports Center.*

Building	Main Campus Consumption (kWh)	PV Size (kW)	Solar Production (kWh)	Offset	Net Savings
Argyros Forum	13,187,488	141	220,947	1.68 %	**$ 26,514**
Leatherby Library		80	125,360	0.95 %	**$ 15,043**
Hutton Sports Center		127	199,009	1.51 %	**$ 23,881**
TOTAL	13,187,488	348	545,316	4.14 %	**$ 65,438**

1.4. Conclusions

1.4.1 Areas of progress

- Chapman University Facilities Management has requested site proposals for the installation of the Stem Solutions Energy System and SunEdison Solar Energy. These efforts show university interest in considering methods to reduce campus electricity consumption.
- Chapman University Facilities Management is considering the installation of solar panels on university buildings.
    - The site proposals for solar panels included the Main Campus, Law School (including Kennedy Hall, Bhathal Center, and Barrera Structure), Film School (including Marion Knott Studios and Knott Studios Lot), the Facilities Complex, and the Residence Halls.

1.4.2 Areas to improve

- Adding floor-level sub-meters to each main campus buildings would allow for a more comprehensive data analysis of electricity and natural gas consumption based on space type.
    - Building space types include office space, classrooms, open workspaces hallways, and facilities maintenance.
- Consolidate natural gas meters on the main campus to maintain consumption levels above 3918 Btu. This would keep natural gas usage in Tier 3 with a rate of $0.08/Btu.

1.4.3 Existing knowledge gaps

- The campus population demographics provided by Chapman Institutional Research Office (CIRO) for the public only includes data since the year 2010. Demographics data cannot be requested from CIRO for academic use. Providing more robust demographics data since the year 2000 on the DataMart webpage would be helpful for anyone seeking this information.
- An energy use building audit could be performed to further understand the energy distribution throughout academic buildings specific to Chapman's main campus. This would allow the university to effectively plan to optimize energy consumption and project future campus usage.

1.5. Recommendations

1.5.1 Low cost/effort

- Reduce outgoing water temperature at the boiler to 119 ºC for all academic buildings, except those with food services (Argyros Forum and Beckman Hall):
    - This adjustment to water temperature would save the university $3,500 each year.
- Increase indoor cooling temperatures to 76 ºF during the summer months (April – September):
    - This adjustment would save the university $82,584 each year.
- Decrease indoor heating temperatures to 66 ºF during the winter months (October – March):
    - This adjustment would save the university $28,210 each year.

1.5.2 Moderate cost/effort

- Implement a university indoor temperature operation schedule for specific campus buildings:
    - An operation schedule would ensure each building is functioning at optimal temperature and with efficient energy consumption for space heating and cooling.
- Require members of Facilities Management to record complaints of indoor temperature:
    - This data may be used to identify specific areas of the campus that have unusual temperatures. These temperature adjustments may then be added to the operation schedule for specific buildings.
- Require a member of Facilities Management to record indoor air temperatures in all main campus buildings every month:
    - This periodic collection of real-time temperature recordings would ensure main campus buildings are functioning within their operation schedule.
    - The frequency and location of temperature recordings may be determined by the building specifications identified in the operation schedule.
- Require a member of Facilities Management to oversee the smart control system. This system is used to alarm facilities when buildings are consuming electricity at peak prices.

1.5.3 High cost/effort

- Install the Stem Solutions Battery Storage in Hashinger Science Center:
  - This energy storage unit would save the university approximately $79,781 during the first year and $979,212 after ten years.
- Install solar panels on Argyros Forum:
  - This installation would save the university $26,514 each year.
  - The location of these solar panels would allow the university to generate its own electricity to power the Stem Solutions Battery Storage Unit.
- Install solar panels on Leatherby Library and Hutton Sports Center:
  - These installations would save the university $38,924 each year.
  - These high performing buildings have specific functions on the main campus. Analyzing energy usage data with solar could provide a pilot for future energy conservation plans.
- Install floor-level sub-metering into the high performing buildings on the main campus:
  - Argyros Forum is a high performing building with a variety of space types. Patterns of energy consumption could be analyzed for this building based on space type and time of day. These data could serve as a pilot for future energy conservation strategies.
- Implement a university energy consumption target goal to maintain electricity and natural gas consumption at efficient levels regardless of new building construction.

1.5.4 Future Areas of Research

- Evaluate energy consumption based on space type in the high performing buildings: Argyros Forum, Beckman Hall, Leatherby Library, Lastinger Athletics Complex, and Kennedy Hall.
- Research incentives provided by Southern California Edison to reduce on-peak consumption.
- Further evaluate methods to optimize seasonal load, base load, and daily relative demand.
- Research fuel cell technology that can be used to shift from electricity to natural gas usage.

1.6. Contacts

1. Mackenzie Crigger, Energy Conservation and Sustainability Manager, Chapman University Facilities Management (crigger@chapman.edu, 714-997-7370)

2. Marisol Arredondo, Director of Institutional Research, Chapman University Institutional Research (arredond@chapman.edu, 714-628-7339)

3. Brenton Burke, Assistant Campus Planner, Chapman University Campus Planning & Operations (bburke@chapman.edu, 714-744-7838)

4. Behrooz Esfandiari, Campus Planner, Chapman University Campus Planning & Operations (esfandia@chapman.edu, 714-997-6615)

5. Sheryl Boyd, Assistant Director of Parking and Transportation Services, Chapman University Public Safety (sboyd@chapman.edu, 714-997-6560)

6. Adrianna May, Equal Opportunity and Employee Relations Specialist, Chapman University Human Resources (amgonzal@chapman.edu, 714-628-7285)

7. Cameron McPherson, Manager of Engineering & Design Solutions, Southern California Edison Business Customer Division (Cameron.mcpherson@sce.com, 714-796-9992)

8. Linda Bowden, Account Coordinator, Southern California Edison Business Customer Division (linda.bowden@sce.com, 909-873-7955)

9. Blaine Waymire, Account Executive, Southern California Gas Company (bwaymire@semprautilities.com, 714-634-3249)

10. Christian Aparicio, Enterprise Account Executive, Stem Inc. (Christian.aparicio@stem.com, 714-642-5490)

1.7. References

1. Chapman University 2013 Environmental Audit.

2. Energy Accounting and Analysis. Handbook of Energy Audits. 2014.

3. Chapman University Institutional Research. https://webfarm.chapman.edu/datamart-reports/

4. Commercial Buildings Energy Consumption Survey. U.S. Energy Information Administration. www.eia.gov/consumption/commercial/building-type-definition

5. Chapman University 2014 Environmental Audit: Water and Landscaping.

6. Stem Solutions. www.stem.com/

7. Stem Solutions Battery Storage Site Proposal.

8. SunEdison. Solar Opportunity Site Proposal.