Pilot Study Analysis: Energy Behavior Change in Illinois Community Colleges

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EXECUTIVE SUMMARY

Recent building technology research examines innovative energy conserving methods that include new and/or improved lighting and HVAC equipment, insulation technologies, phase change materials, smart systems and controls, load shifting, rating procedures, and renewables. These building systems and technological advances are well covered in the literature on energy conservation and efficiency (Fanger & Toftum, 2002; Klein et al., 2012). The noted system improvements, however, seldom recognize the critical human component that both operates the building systems and occupies the building spaces. *Failure of recognizing this 'human component' can result in significantly higher energy consumption, missed opportunities, and unrealized potential.* Linking knowledge from the fields of environmental sustainability and psychology is crucial for addressing major environmental issues, such as climate change, because "environmental problems are really behavioral problems: They are caused by the thoughts, beliefs, values, and worldviews upon which humans beings act" (Winter & Koger, 2010, p. 2).

Although significant research has examined human behavior in residential settings, far less research examines the complexities of human energy behavior in academic settings. This pilot study aims to fill this gap by examining academic buildings on four different Illinois community college campuses. In the most general sense, this study was centered on one broad question statement – Can the combination of energy behavior change campaigns and energy dashboards change occupants' energy attitudes, behaviors, and ultimately conserve energy?

In order to grapple with the complexity of this question statement we approached the research from two different angles, which are reflected in the two sections of this report. **Section 1** is focused on determining if building energy consumption decreased (from what was predicted) after the "intervention" (i.e., behavior change campaign and energy dashboard installation) was commenced. **Section 2** describes how comparative surveys were used to help understand whether building occupant energy attitudes or behaviors significantly changed after the study intervention. Key findings from both of these sections are summarized below:

- Overall energy consumption decreased significantly (natural gas approximately 7to 10 percent, and electricity approximately 53 to 60 percent) over the two-month behavior change campaign at each community college. This decrease is normalized for weather variation.
- A statistically significant difference in reported indirect and direct energy behaviors was not observed at any of the four community colleges. These measurements are based upon returned self-reported surveys.
- Survey response rates from facility managers was generally very low. Reported ability to detect and correct building energy issues, however, was reported by campaign managers. In fact, the energy dashboards helped two of the four colleges detect significant heating, ventilation, and air conditioning (HVAC) system scheduling errors.

Based upon these findings (among others included within the subsequent two sections), and our own experiences with this research, we recommend the following:

Recommendations: Future Behavior Change Campaigns

Each energy behavior change campaign was ideally supposed to incorporate the following measures: 1) formation of "Energy Team" and student volunteer corps; 2) monitoring and measuring strategies; 3) communication / engagement techniques; 4) targeted training; and 5) creation of incentives. Although many of the components above were planned and discussed, many of the colleges did not necessarily implement them fully. For example, not all colleges created direct incentives, targeted training of all relevant facility managers did not occur at some of the colleges, some student volunteer corps were not fully established, and communication / engagement techniques that might have been strong at the beginning of the campaign tapered off in the end. Also, some colleges had difficulty with the energy dashboard display.

Recommendations: Methodology and Future Research

In addition to highlighting improvement areas for future behavior change campaigns, this study also brought forth many ways we could improve our research methodology. We will take special note of the lessons learned for studying future behavior change campaigns:

- Increasing response rates - survey response rates were generally low across the study, but especially low for faculty, staff and facility management groups. More appealing email design and wording, coupled with more reminder emails, could be methods of improving these response rates.
- Qualitative Data – it is likely that semi-structured interviews with key facility managers, occupants, and campaign leaders would provide more informative information than structured surveys.
- Individualization of energy conservation behaviors – there are a wide variety of indirect and direct energy behaviors that could be examined. Prior to survey creation and distribution, these behaviors should be identified by brainstorming with each campus individually.
- Self-reported behavior - behaviors reported by individuals is not always accurate. Therefore, other data and methods, such as cross-sectional surveys on observed energy behavior, could be collected and used in addition to survey data.

SECTION 1: ENERGY ANALYSIS

1 Introduction

As the world population continues to increase from its present 7 billion mark, the demand for our limited natural resources such as water, coal, oil, and natural gas increases as well. With time, this trend can lead to a gradual depletion of these resources, which in turn will become a greater challenge for future generations who will have to deal with even higher population densities and fewer resources. In the United States, the building sector is responsible for more than 40% of total energy consumption (U.S. Department of Energy, 2011). In addition, our lifestyle is contributing to the era of an ever-increasing amount of emission of toxic gases and other pollutants that harm our environment

Because of limited natural resources, and to reduce the emission of greenhouse gases by reducing the use of fossil fuels to generate electricity, great emphasis is lately being placed on energy consumption as one significant aspect of sustainability. It is well known that occupant energy behaviors have a major role in regards to building energy performance. Thus far, most efforts to improve building energy use have focused on energy-conserving technologies such as demand controlled-ventilation, PV cell, or high-efficiency boilers and chillers (Jain, Taylor & Culligan, 2013); however, the effect of people's behaviors on energy consumption has yet to be fully acknowledged.

This paper aims to address the effects of end-users' energy behaviors on building energy performance. The study group includes four community colleges in the State of Illinois, which have been participating in a behavioral change study—a "green campaign"—to change occupants energy behaviors and their underlying attitudes toward energy savings in the built environment. As a part of this campaign, survey questionnaires have been circulated among building occupants evaluating their energy attitudes and behaviors before and after the initiation of campaign, and energy dashboards have been installed in prominent locations to display the real-time energy use. In this study, the gas usage is primarily attributed to heating purposes. The electricity energy, on the other hand, is used for various purposes of which space cooling is one.

2 Energy behavior

Many studies have shown that occupant behaviors can have a significant effect on building energy use (Azar & Menassa, 2012; Yu, Fung, Haghighat, Yoshino & Morofsky, 2011; Chen,J.; Taylor & Wei, 2012). In fact, engaging occupants in building energy management is a reliable method to reduce energy consumptions. For instance, studies have shown that building occupants who actively seek daylighting as opposed to artificial lighting can reduce overall primary energy expenditure in a building's perimeter zones by more than 40%, when compared to a constant use of artificial lighting (Bourgeois, Reinhart & Macdonald, 2006)

In addition, it is important to note that while physical energy efficiency measures such as daylighting could enhance the overall building energy performance, the so-called "take-back effect" could effectively erase some of the advantages gained by these measures (Haas, Auer & Biermayr, 1998). The take-back effect involves building occupants adopting inefficient energy use behaviors that could reduce the energy savings gained by the "green" retrofits. To ensure non-reversible energy-saving gains, one may need to accompany the energy reduction measures with increasing building occupants' awareness toward sustainability and energy conservation. Therefore, there is urgency for developing tools and technologies to not only monitor the energy usage in the built environment but also to promote the energy efficient behaviors by building occupants.

Equally important, providing occupants with direct feedback on their energy behaviors could encourage them making more efficient use of energy. Studies have shown that energy savings ranging from 3% to 13% with an average of 7% could be resulted from this approach (Faruqui, Sergici & Sharif, 2010).

Energy dashboards that provide occupants with real-time energy use information could be an effective way to help change their attitudes toward energy consumption. Energy bills, which are currently the most common way of reporting energy use, usually include little or no detailed feedback about occupant personal energy usage. A power utility bill provides information about a month's total energy consumption and a total price to be paid, leaving occupants to guess what factors, including external influences and internal behaviors, might explain a higher or lower than usual bill. Earlier studies have shown that by only acquiring and viewing raw energy usage, an energy expenditure reduction by 5%–15% could take place (Darby, 2006).

It is known that providing users with knowledge about the relationship between their activities and energy consumption, and with suggestions for energy reduction, could lead to more substantial decreases in overall consumption (Chen, Cook & Crandall, 2013). This view is supported by an increasing body of work that links awareness of energy consumption and its impact to behavioral change (Darby, 2006; Riche, Dodge & Metoyer, 2010). This highlights the importance of engaging energy end-users in any energy-conserving efforts.

3 Energy analysis

John A. Logan College, Southwestern Illinois University, College Lake County, and Prairie State College are the four schools that have participated in the green campaign. Energy benchmarking for each facility was first conducted to gain an understanding of existing energy use intensities and use the monthly utility data, along with corresponding weather data, to develop a regression equation. This regression equation was then used to predict expected energy usage during the energy campaign. The predicted energy usage uses actual weather data. Actual energy consumption is then compared to the predicted consumption to determine if energy savings were realized. Using actual weather data to normalize consumption data is an important component of this effort since all of the facilities, particularly their gas consumption, is very dependent on weather conditions.

3.1 John A Logan College

John A. Logan (JAL) College is a community college in Carterville, Illinois. The study building in this research is Building G with an approximate area of 45,232 sqft. JAL has one electric and one gas meter for the entire campus meaning that there is no historical gas or electrical consumption data for any building on campus. Therefore, to benchmark Building G, SEDAC developed an eQuest model to estimate annual gas and electrical consumption. eQuest uses a typical meteorological year (TMY) data set for climatic conditions. The TMY file represents a long-term average for a particular location. For JAL, the TMY3 file for Carbondale/St. Louis was used. Figure 1 provides a picture of the facility and a graphic representation of the eQuest model.

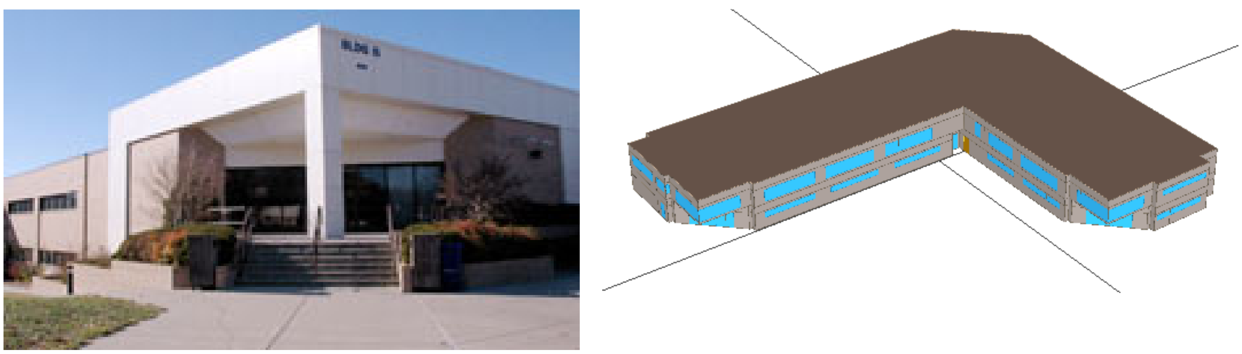

Figure 1. JAL Building G

Figure 2 shows the relationship between monthly natural gas consumption and heating degree days (HDD). Gas consumption clearly follows heating degree days (HDD) indicating that the primary use for gas is for heating purposes. There is incidental gas usage for domestic hot water (DHW) during summer months.

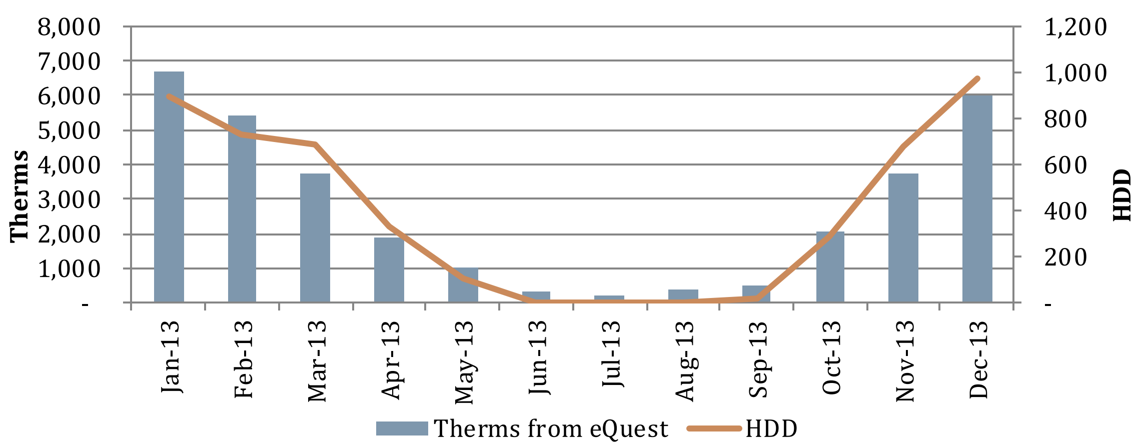

Figure 2: JAL Natural Gas Consumption versus HDD

SECTION 1: ENERGY ANALYSIS

Based on eQuest results, Figure 3 shows monthly electrical consumption versus cooling degree days (CDD). The large electrical consumption decrease during the months of June and July is due to most of the building being shut-down during summer months.

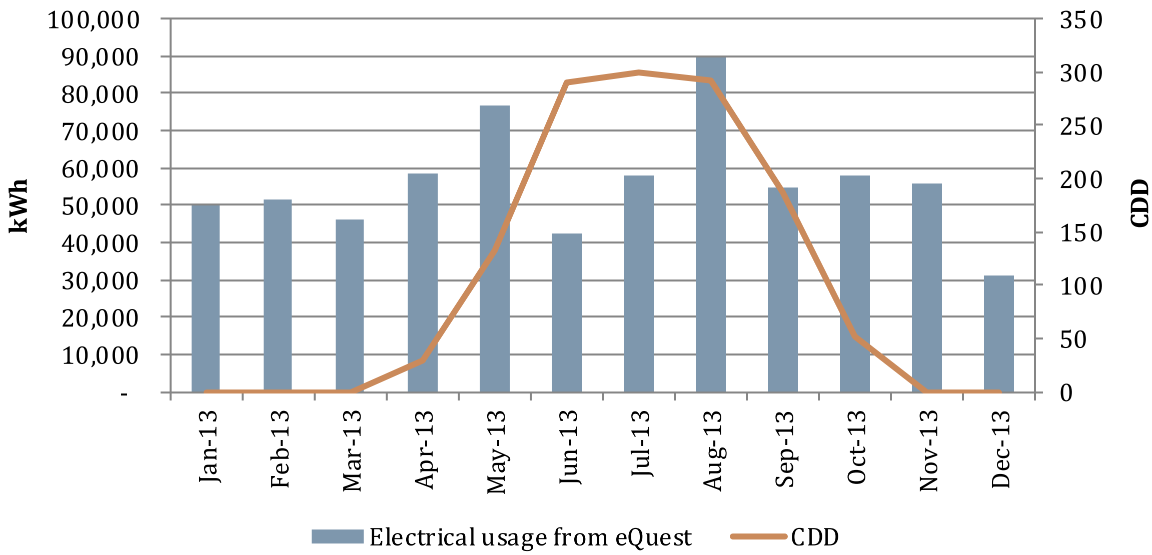

Figure 3: JAL Building G electricity consumption versus CDD

Table 1 shows the benchmarking for Building G based on eQuest results.

Tables 1. Energy benchmarking for Building G

Energy Benchmarking For JAL Building G						
	Annual Consumption		Annual Costs ($)		Average Unit Cost	
Electricity	695,360	kWh	$33,205	77%	0.05	$/kWh
Natural Gas	32,313	Therms	$10,004	23%	0.31	$/therm
		Total Cost ($)	$43,209	100%		
		Floor Area	45,232	ft²		
Electric Use Intensity	15.37	kWh/ft²/yr	**Gas Use Intensity**	0.71	therms/ft²/yr	
Energy Use Intensity (EUI)	124	kBtu/ft²/yr	**Energy Cost Intensity (ECI)**	$0.96	$/ft²/yr	

Figure 4 plots eQuest natural gas usage in therms versus HDD on a scatter plot. A linear regression was performed on this data: the independent variable being HDD and dependent variable being therm usage. The regression equation is then used to predict what future gas usage would be using actual HDD. Actual gas usage recorded by the dashboard is than compared to this prediction to determine if there is a decrease or increase in energy use.

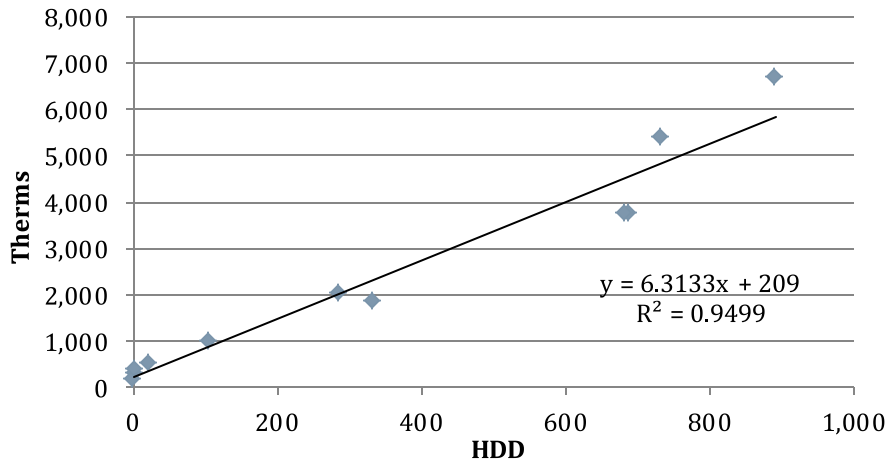

Figure 4: JAL Predicted gas usage versus HDD

Figure 5 shows predicted gas usage and actual gas usage. The dashboard did not start collecting data until June therefore actual consumption numbers are not available for the beginning of 2013. Gas usage was greater than predicted in September, but less in October through December.

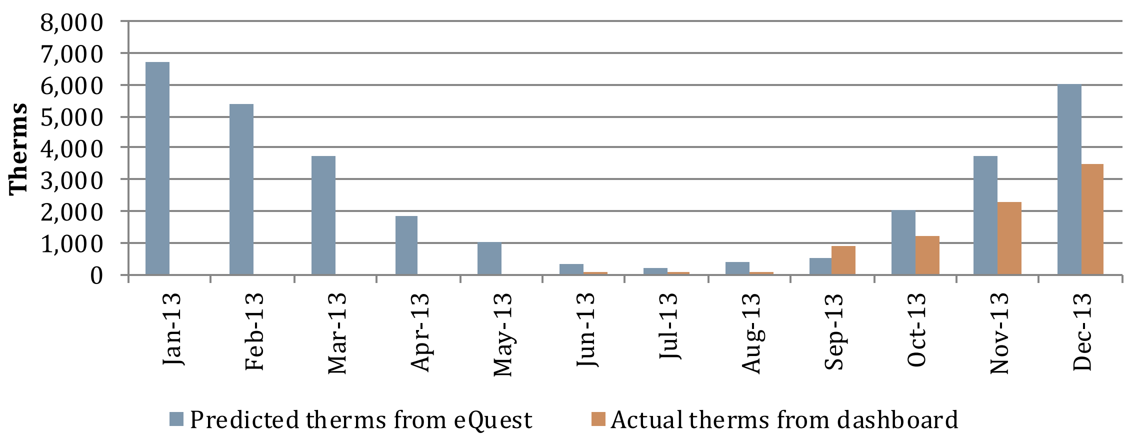

Figure 5: JAL Predicted gas usage versus actual gas usage

A similar type of analysis was conducted for electrical usage where model results were in this case plotted against CDD to develop a linear regression. Figure 6 is the predicted kWh usage from the eQuest model and the regression equation.

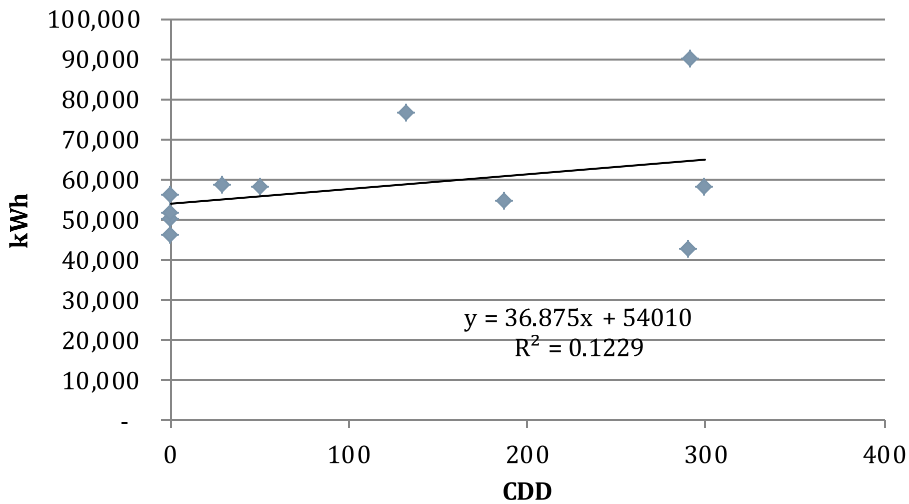

Figure 6: JAL kWh versus CDD

The regression equation was then used with actual weather data from 2013 to predict electrical usage. Figure 7 illustrates predicted electrical usage and actual electrical usage.

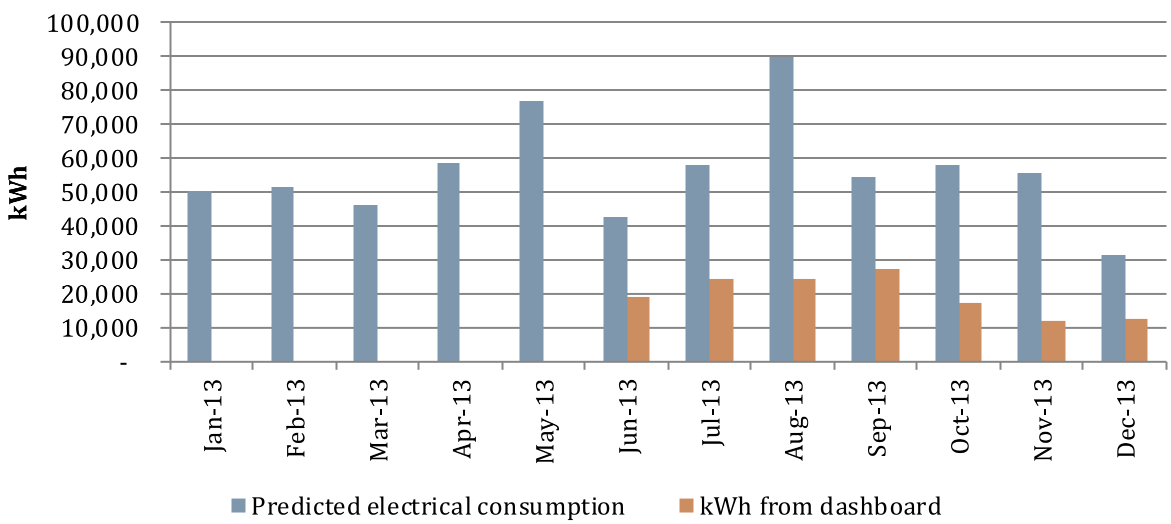

Figure 7: JAL Predicted kWh usage versus actual from dashboard

3.2 Southwestern Illinois College

Southwestern Illinois College (SWIC) has three campuses: Belleville, Sam Wolfe and Red Bud. This study examined the Belleville campus building which is consists of a single building that has a total area of 117,824 sqft (see Figure 8).

Figure 8: Southwestern Illinois College

The Belleville campus building has both electric and gas meters. SWIC provided several years of actual electrical and gas consumption data. Figure 9 illustrates monthly natural gas consumption and HDD for 2011 and 2012. The gas consumption tracks HDD quite closely indicating that gas is used primarily for heating purposes.

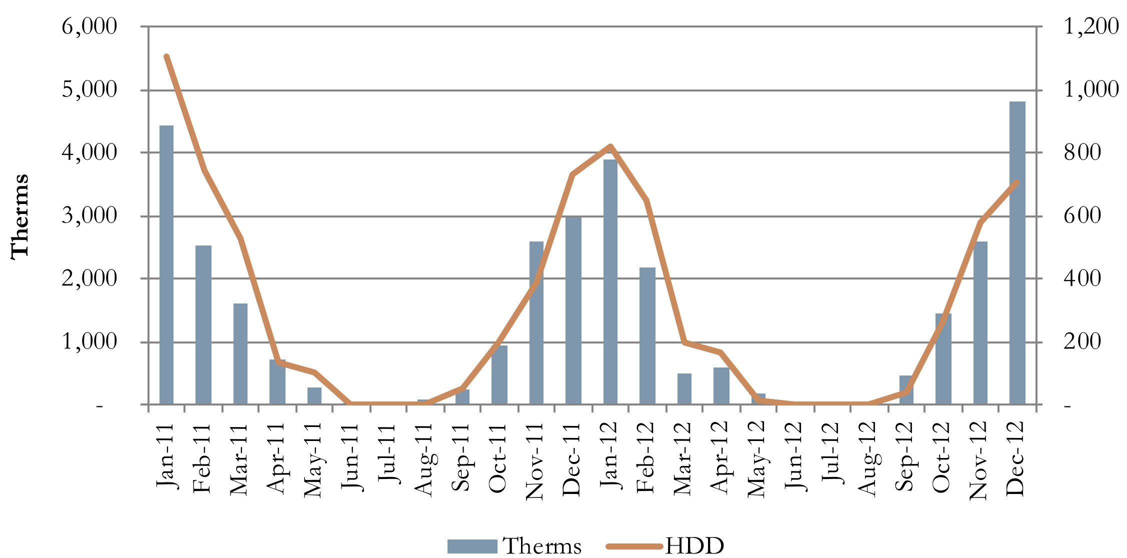

Figure 9: SWIC Monthly natural gas consumption versus HDD

Figure 10 illustrates monthly electrical consumption and CDD. Increases in electrical consumption during summer months are indicative of cooling loads.

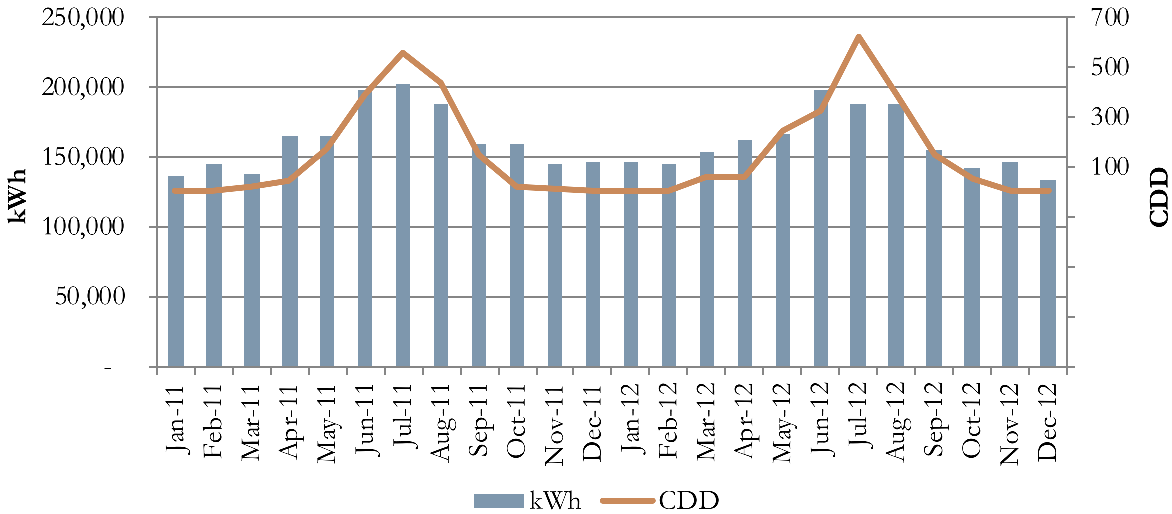

Figure 10: SWIC Electricity consumption versus CDD

2012 energy consumption data was used to benchmark the building (see Table 2). Of interest is that gas consumption represents only 5% of SWIC's annual energy costs.

Table 2: SWIC energy benchmarking

Energy Benchmarking For SWIC (Belleville Campus)						
	Annual Consumption		**Annual Costs ($)**		**Average Unit Cost**	
Electricity	1,956,913	kWh	$97,846	95%	$0.05	$/kWh
Natural Gas	15,097	Therms	$11,473	5%	$0.76	$/them
		Total Cost	$109,318			
		Floor Area	117,824	ft^2		
Electric Use Intensity	16.61	kWh/ft^2/yr	**Gas Use Intensity**	0.13	therms/ft^2/yr	
Energy Use Intensity (EUI)	70	kBtu/ft^2/yr	**Energy Cost Intensity (ECI)**	0.93	/ft^2/yr	

Figure 11 plots monthly gas consumption versus HDD for 2011. The $R^2 = 0.93$ indicates that there is a strong correlation between gas usage and weather.

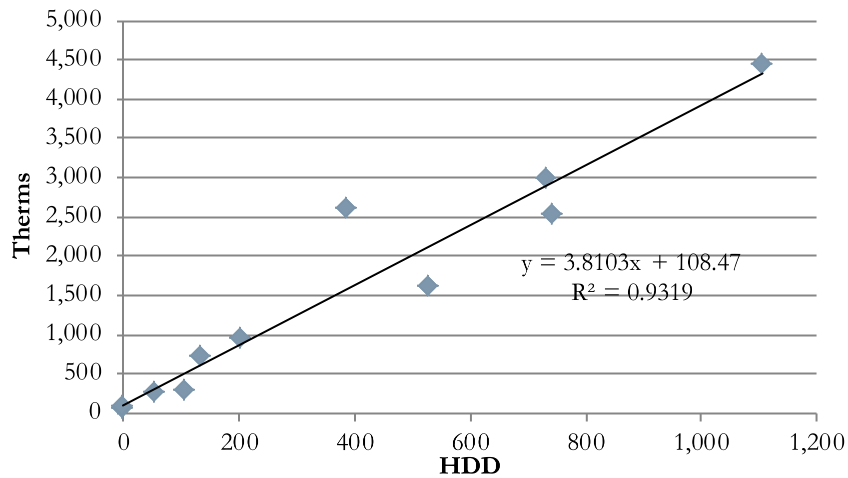

Figure 11: SWIC Gas consumption versus HDD

Using 2013 weather data, the linear regression equation in Figure 11 was used to predict gas usage for 2013. Gas consumption recorded by the dashboard was then compared to the prediction to see if there was an increase or decrease in energy consumption. Figure 12 shows this comparison.

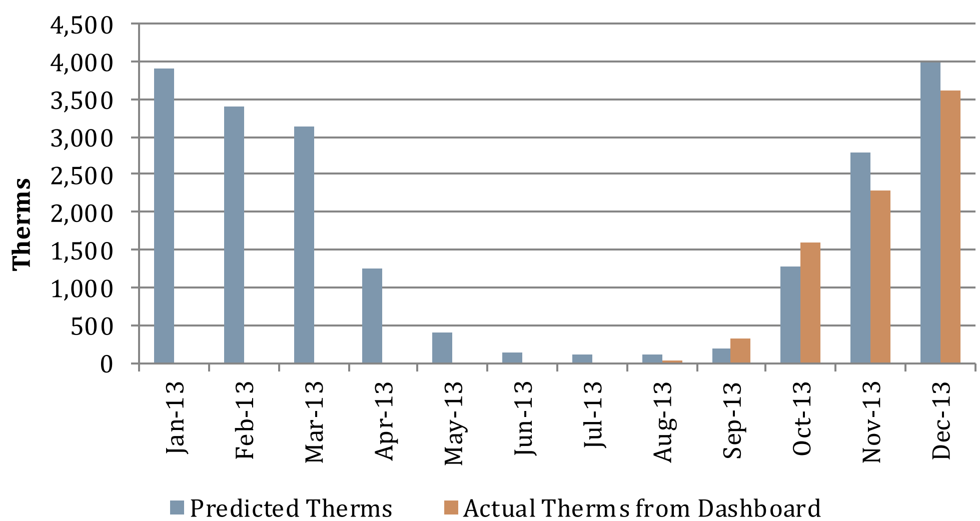

Figure 12: SWIC Predicted gas consumption versus actual gas consumption

A similar type of analysis was conducted for electrical usage where actual electrical consumption was plotted against CDD to develop a linear regression (see Figure 13).

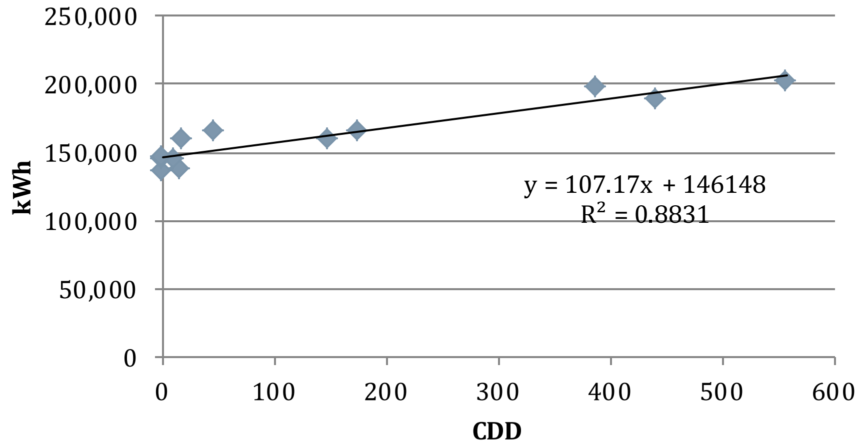

Figure 13: SWIC electrical consumption versus CDD

The regression equation in Figure 13 and actual weather data from 2013 was used to predict electrical usage for 2013. Figure 14 illustrates predicted electrical usage and actual electrical usage.

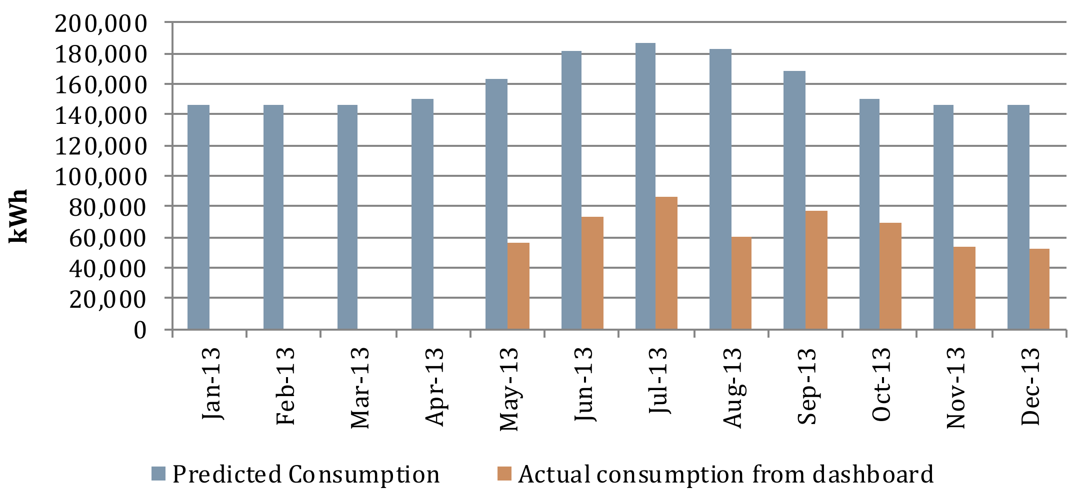

Figure 14: SWIC Predicted electrical consumption versus actual electrical consumption

3.3 College of Lake County

The College of Lake County (CLC) is a community college in Grayslake, Illinois. The building is 57,891 sqft. and has both an electrical and gas meter.

Figure 15: College of Lake County

CLC provided almost two years of actual electrical and gas consumption data. Figure 16 illustrates monthly natural gas consumption and HDD for 2011 and 2012. Noteworthy is that although gas consumption tracks HDD quite well, there is a significant baseload of natural gas usage during the cooling season. This is probably for reheat purposes.

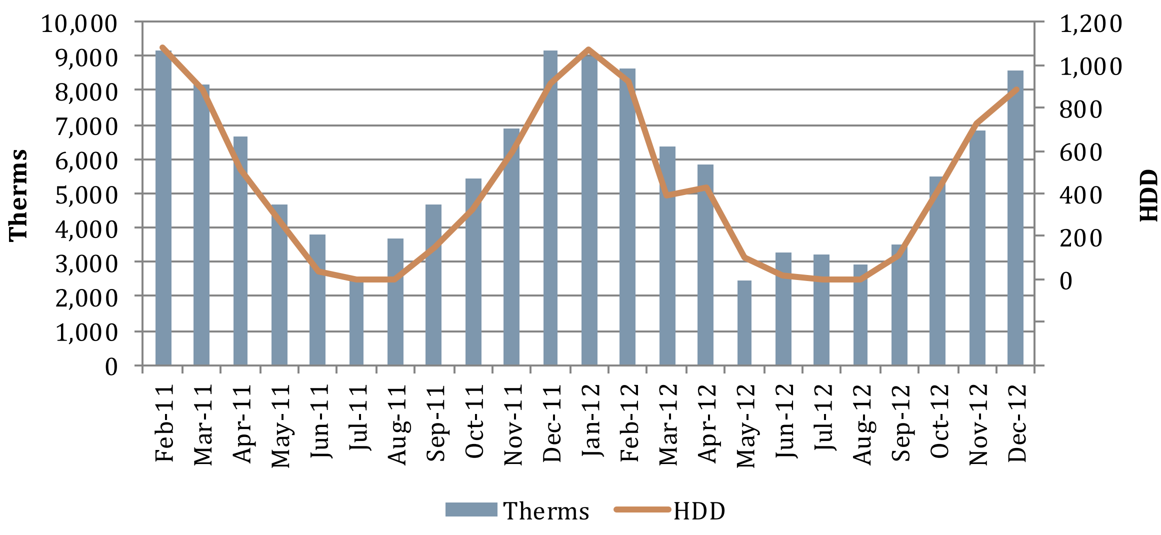

Figure 16. CLC Natural Gas Consumption versus Heating Degree Days

Figure 17 illustrates monthly electrical consumption and CDD. Increases in electrical consumption during summer months are indicative of cooling loads.

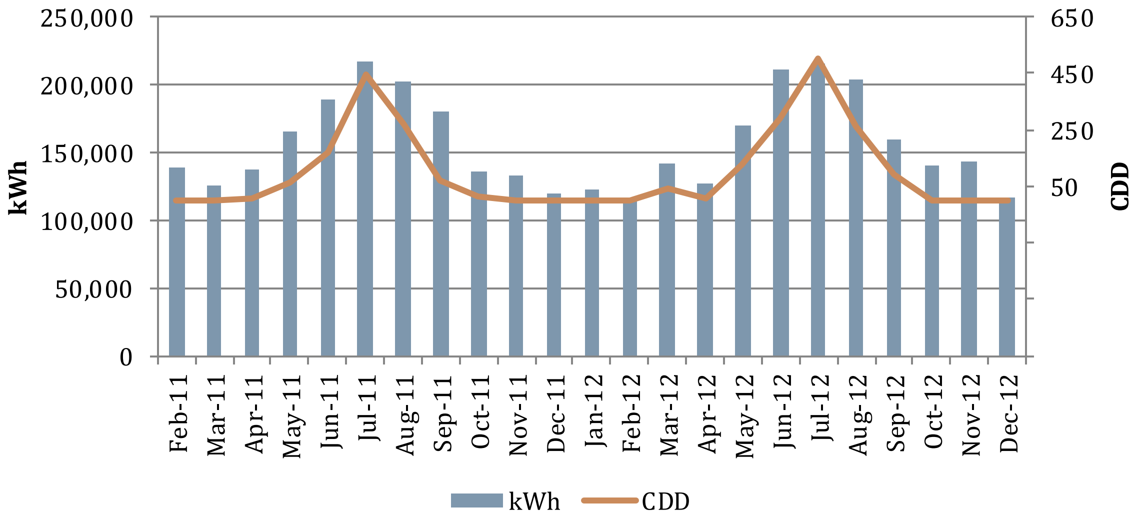

Figure 17. CLC Electricity consumption versus Cooling Degree Days

Gas consumption but no costs were provided so SEDAC used a gas cost of $0.65/therm for the benchmarking which is shown in Table 3.

Table 3. CLC energy benchmarking

Energy Benchmarking For CLC						
	Annual Consumption		**Annual Costs**		**Average Unit Cost**	
Electricity	1,865,025	kWh	$88,757	67%	0.05	$/kWh
Natural Gas	66,196	Therms	$43,027	33%	0.65	$/therm
		Total Cost	$131,785			
		Floor Area	57,891	ft^2		
Electric Use Intensity	32	kWh/ft^2/yr	**Gas Use Intensity**	1.14	therms/ft^2/yr	
Energy Use Intensity (EUI)	224	kBtu/ft^2/yr	**Energy Cost Intensity (ECI)**	2.28	$/$ft^2$/yr	

The following figure shows the regression analysis indicating the correlations between gas usage and HDD.

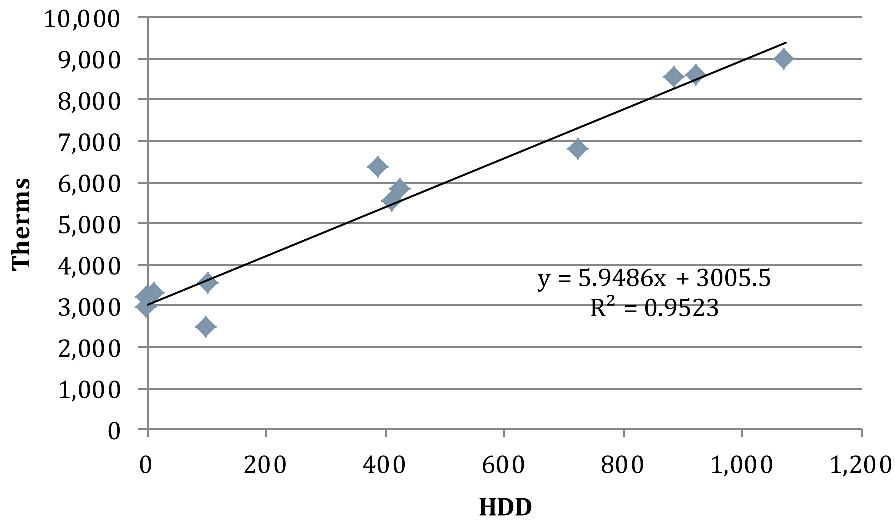

Figure 18: CLC gas consumption versus HDD

Unfortunately, at the time of this writing, dashboard data from CLC was unavailable therefore no comparison could be made between predicted and actual consumption.

A similar type of analysis was conducted for electrical usage where actual electrical consumption was plotted against CDD to develop a linear regression.

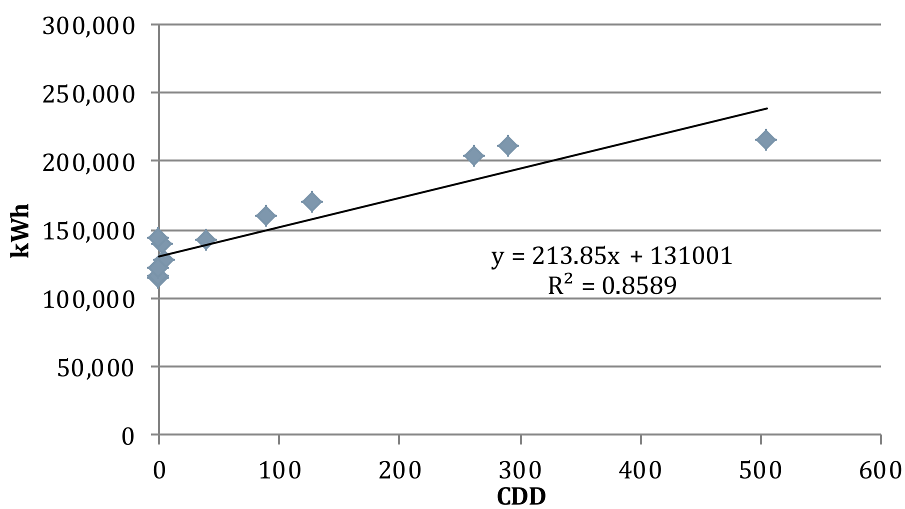

Figure 19: CLC electrical consumption versus CDD

3.4 Prairie State College

Prairie State College (PSC) is a community college based in Chicago Heights, Illinois with a total area of 38,022 sqft.

Figure 20: Prairie State College

PSC provided several years of actual electrical and gas consumption data although electrical consumption from June through December 2011 was missing. Figure 21 illustrates monthly natural gas consumption and HDD for 2011 and 2012.

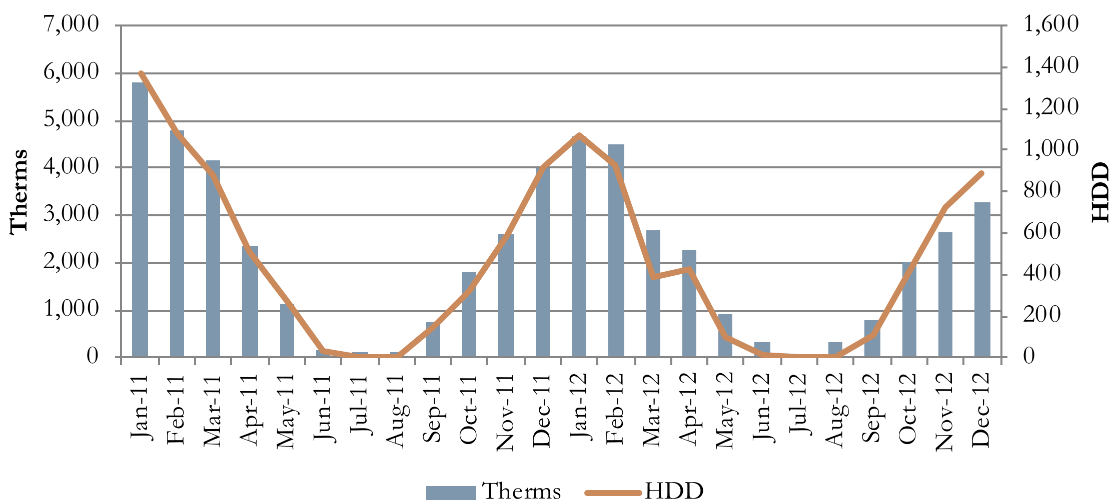

Figure 21. PSC natural gas consumption versus HDD

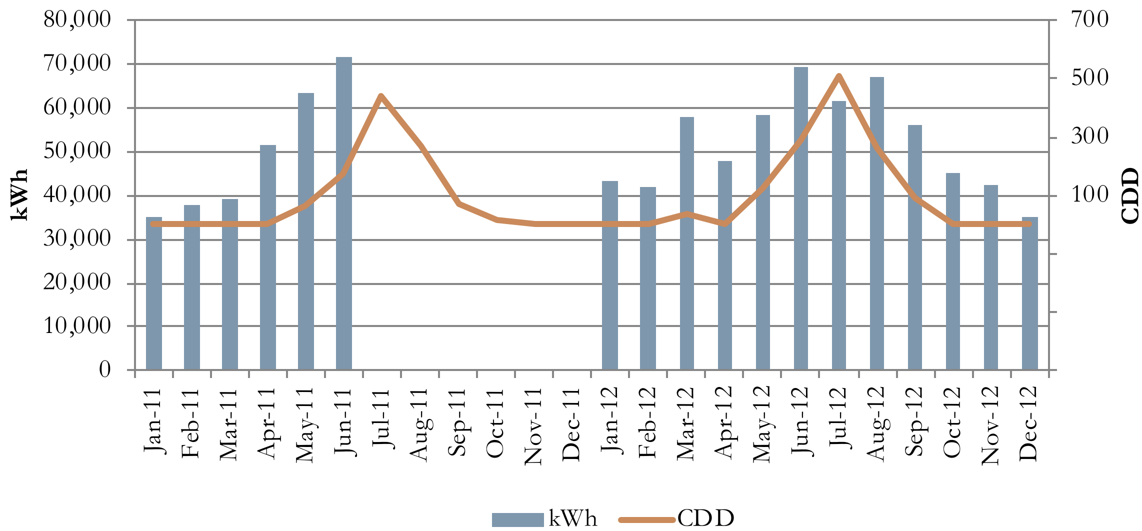

Figure 22. PSC electrical consumption versus CDD

Electrical costs were not provided so SEDAC used an electrical unit cost of $0.05/kWh. for the benchmarking which is shown in Table 4.

Table 4. PSC energy benchmarking

Energy Benchmarking For PSC						
	Annual Consumption		Annual Costs		Average Unit Cost	
Electricity	626,109	kWh	$31,305	72%	0.05	$/kWh
Natural Gas	24,470	Therms	$12,410	28%	0.51	$/therm
		Total Cost	$43,716			
		Floor Area	38,022	ft^2		
Electric Use Intensity	16	$kWh/ft^2/yr$	**Gas Use Intensity**	0.64	$therms/ft^2/yr$	
Energy Use Intensity (EUI)	121	$kBtu/ft^2/yr$	**Energy Cost Intensity (ECI)**	1.15	$\$/ft^2/yr$	

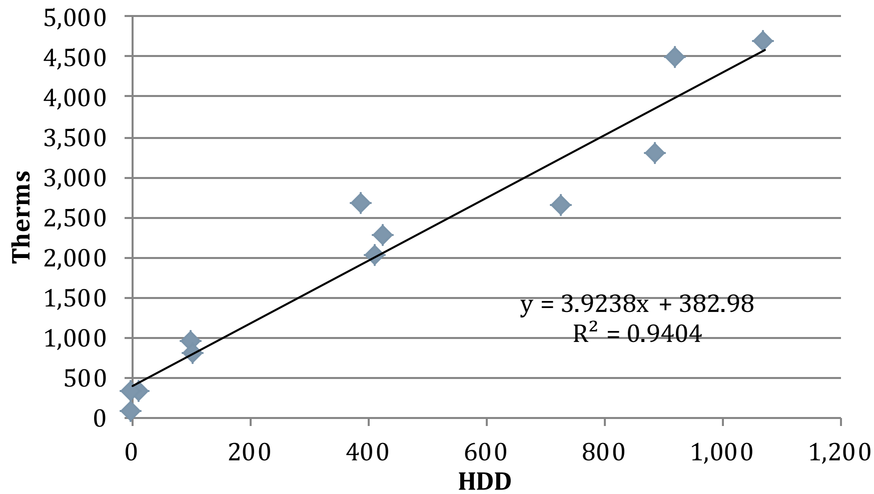

Figure 23: PSC therms consumption versus HDD

Using 2013 weather data, the linear regression equation in Figure 23 was used to predict gas usage for 2013. Gas consumption recorded by the dashboard was then compared to the prediction to see if there was an increase or decrease in energy consumption. Figure 24 shows this comparison.

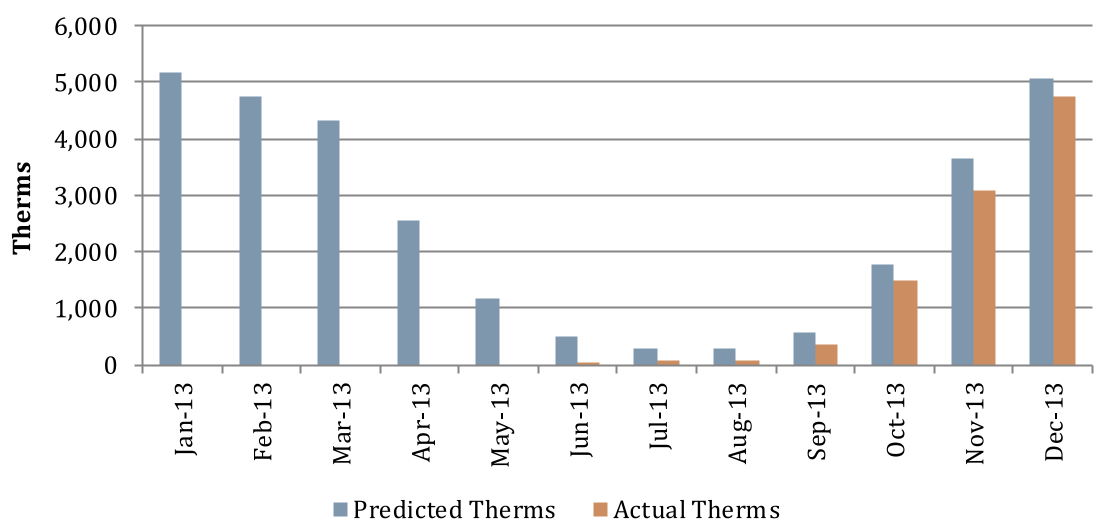

Figure 24. Normalized gas usage (above); monthly gas consumption comparison (below)

Figure 25 illustrates the relationship between electricity consumption. The R^2 =0.58 for this relationship is not good indicating that something other than weather is influencing electrical consumption.

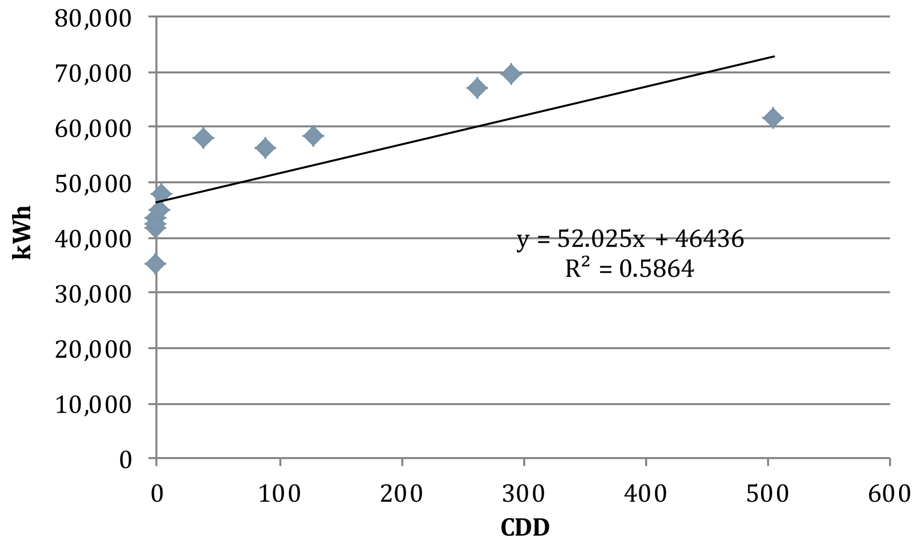

Figure 25: PSC electricity usage verses CDD

The regression equation in Figure 26 and actual weather data from 2013 was used to predict electrical usage for 2013. The following figure illustrates predicted electrical usage and actual electrical usage.

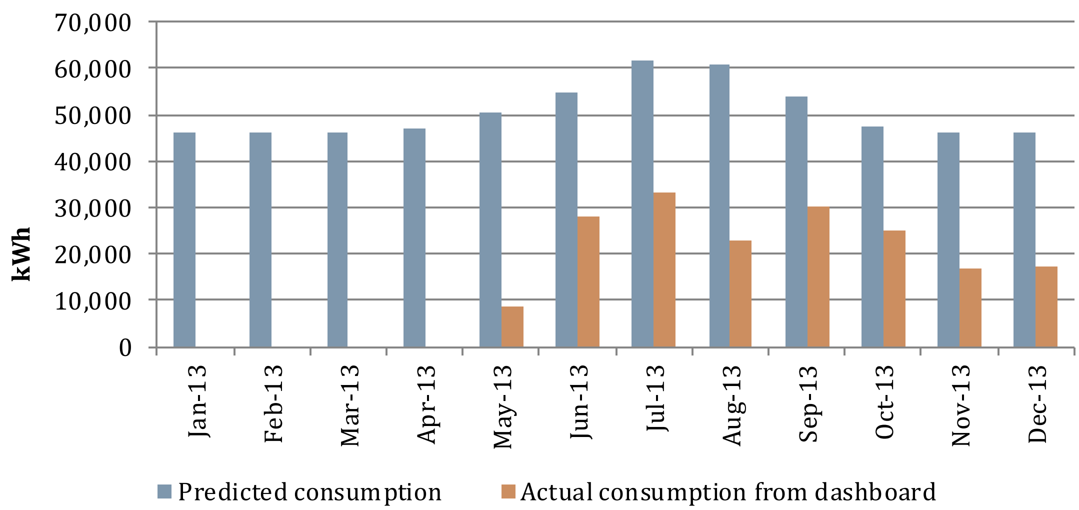

Figure 26: PSC predicted versus actual electrical consumption

4 Discussion of results

4.1 John A Logan College:

The regression analysis shows a strong linear positive correlation between gas consumption and HDD.

Based on gas consumption data downloaded from the dashboard on 1/24/2013, it appears that:

- The pulse meter didn't start recording until September 13, 2013
- The dashboard lost communication with the pulse meter for seven days in October
- The dashboard lost communication with the pulse meter for 12 hours in November

Table 5 shows the difference between predicted gas consumption calculated by the eQuest model and actual gas consumptions recorded by the dashboard. Due to the communications interruptions, the dashboard recorded data is incomplete for October and November.

Table 5: JAL predicted gas consumption versus actual consumption

Date 2013	Predicted Gas Usage (Therms)	Dashboard Gas Usage (Therms)	% Reduction
October	2,045	1,232	40%
November	3,762	2,289	39%
December	6,017	3,467	42%
Oct. – Dec.	**11,824**	**6,988**	41%

The results for November, which is only missing 12 hours of data, and December, which is complete, show a reduction in gas consumption of approximately 40%. Bear in mind that the actual consumption figures are being compared to results from an eQuest model that SEDAC was not able to calibrate. Typically when SEDAC develops an energy model, results from the model are compared to actual consumption data to verify that it is a fair representation of actual conditions. This was not possible with the JAL model.

However, now that the JAL dashboard is collecting actual data, this year's consumption data can be normalized for weather and then be compared to this next year's data to see if there have been any reductions in energy consumption. One important benefit of the dashboard is that electrical and gas consumption for Building G is now being recorded. This is a huge step in the right direction.

The $R^2 = 0.12$ from the regression comparing electrical consumption from eQuest to weather data indicates that electrical consumption does not correlate well with weather data. Unlike natural gas consumption which is used predominantly for space heating, electricity is used for much more than just space conditioning (cooling). The poor correlation between electrical usage and CDD is due to the diversity of electrical loads, the reduced schedule during summer months, and the reduced cooling loads during high CDD periods. Nevertheless, the regression equation was used to predict energy usage to compare actual usage to as shown in the following table.

At JAL, the first full day that electrical consumption data was recording was May 7th, 2013. Only one day of data appears to be missing on June 30, 2013.

Table 6: JAL predicted electrical consumption versus actual consumption

Date 2013	Predicted Electricity Usage (kWh)	Dashboard Electricity Usage (kWh)	% Reduction
June	42,650	19,144	55%
July	57,800	24,310	58%
August	89,570	17,418	81%
September	54,520	27,439	50%
October	58,120	17,461	70%
November	55,820	11,672	79%
December	31,160	12,389	60%
June-December	**371,998**	**174,066**	67%

The data shows a considerable difference between predicted and actual consumption. However, once again, bear in mind that the actual consumption figures are being compared to results from an eQuest model that SEDAC was not able to calibrate therefore drawing conclusions from this comparison are dubious.

As stated for the gas comparison, the benefit of the dashboard will be in the future when after normalization for weather conditions, actual current consumption can be compared to actual past consumption. These efforts will however require not only recording of past and present weather conditions, but the knowledge of how to normalize consumption values so that a legitimate comparison is being made.

4.2 Southwestern Illinois College

Based on observation of data downloaded from the dashboard, it appears that the dashboard started recording pulse readings on September 23, 2013. Then there is a four day interruption in communications between the dashboard and the pulse meter beginning in the afternoon of September 29th and ending the morning of October 3rd. There is an additional day of missing data between the 9th and 10th of October. Thereafter the dashboard appears to have functioned properly.

The regression analyses for SWIC demonstrate a strong correlation between energy consumption and weather data. Based on this, and assuming that building use between years remains the same, it is fair to assume that predicted consumption based on the regression equation and weather data from 2013 should be reasonably accurate.

The following table describes the difference between predicted gas consumptions and actual energy data obtained from the dashboard.

Table 7: SWIC predicted gas consumption versus actual consumption

Date 2013	Predicted Gas Usage (Therms)	Dashboard Gas Usage (Therms)	% Reduction
October	1,274	1,603	-26%
November	2,779	2,274	18%
December	3,999	3,611	10%
October-December	8,052	7,488	7%

The data shows a 7% reduction in gas usage for the three months that the dashboard was recording gas consumption.

The following table describes the difference between predicted electrical consumptions and actual consumption obtained from the dashboard.

Table 8. SWIC predicted electrical consumption versus actual consumption

Date 2013	Predicted Electricity Usage (kWh)	Dashboard Electricity Usage (kWh)	% Reduction
June	181,300	73,020	60%
July	186,658	85,935	54%
August	182,371	60,735	67%
September	168,118	77,434	54%
October	150,435	69,587	54%
November	146,148	53,176	64%
December	146,148	51,966	64%
June-December	**1,161,178**	**471,853**	**59%**

The data shows a considerable difference between predicted and actual consumption. The sustainability campaign did not start until mid-September yet actual consumption values are significantly less than predicted values from well before the campaign started. The regression analysis conducted on actual consumption data and weather data had an $R^2 = 0.88$ indicating a positive correlation between the two variables. Therefore one can assume that the predicted values should be fairly close to what would be expected consumption. Following is a list of potential causes for this disparity:

- Sometime during early 2013 significant changes were made to operational procedures of mechanical systems. One change that could result in such drastic reductions is implementation of mechanical system schedules where there were none before.
- The dashboard is not recording all of the electrical energy flowing into the building. Are all three phases being recorded?
- Incorrect consumption data for 2011/2012 was supplied for the study.

Without further inquiry it is impossible to draw definitive conclusions on the above data.

4.3 College Lake County

The analysis shows that there is a strong correlation between weather and building energy consumption. However, due to the lack of dashboard information, the comparison between predicted energy consumptions and the actual energy data could not be completed.

It should be mentioned that the benchmarking of the CLC facility disclosed a very high energy use intensity of 224 kBtu/SF/yr. ENERGY STAR Target Finder indicates the median for a college type facility in this climate to use approximately 126 kBtu/SF/yr. The graphing of gas consumption data also disclosed significant gas usage during summer months. This usually indicates gas used for reheat purposes which can in some instances be significantly reduced.

4.4 Prairie State College

At PSC there was a strong correlation between gas consumption and weather, however, electrical consumption was not closely related to weather.

Based on observation of data downloaded from the dashboard, it appears that the dashboard started recording pulse readings on September 21, 2013. However, there appear to be frequent interruptions in communications between the pulse meter and the dashboard during September and October. From November 1, 2013 onward, there were no interruptions.

Table 9: PSC predicted gas consumption versus actual consumption

Date 2013	Predicted Gas Usage (Therms)	Dashboard Gas Usage (Therms)	% Reduction
November	3,658	3,094	15%
December	5,081	4,746	7%
Nov. – Dec.	**8,739**	**7,840**	**10%**

The dashboard started recording electrical consumption on May 22, 2013. There was only one interruption in the recording on June 29, 2013. The $R^2 = 0.58$ from the regression comparing actual consumption to weather data indicates that electrical consumption does not correlate particularly well with weather data. Nevertheless, the regression equation was used to predict energy usage to compare actual usage to as shown in the following table.

Table 10: PSC predicted electrical consumption versus actual consumption

Date 2013	Predicted Electricity Usage (kWh)	Dashboard Electricity Usage (kWh)	% Reduction
June	54,944	27,996	49%
July	61,878	33,312	46%
August	60,961	22,997	62%
September	54,084	30,301	44%
October	47,551	25,199	47%
November	46,290	16,785	64%
December	46,290	17,477	62%
June-December	**371,998**	**174,066**	**53%**

As with SWIC, the data shows a considerable difference between predicted and actual consumption. The sustainability campaign did not start until mid-September yet actual consumption values are significantly less than predicted values from well before the campaign started. Following is a list of potential causes for this disparity:

- Sometime during the early 2013 significant changes were made to operational procedures of mechanical systems. One change that could result in such drastic reductions is implementation of mechanical system schedules where there were none before.
- The dashboard is not recording all of the electrical energy flowing into the building. Are all three phases being recorded?
- Incorrect consumption data for 2011/2012 was supplied for the study.

Without further inquiry it is impossible to draw definitive conclusions on the above data.

5 Energy Comparison

The following table shows the energy use comparison between the four colleges based upon the available energy bills from SWIC, CLC, and PSC. eQuest results were used for JAL. The summary shows that CLC with an EUI of 224 kBtu/sqft-year and SWIC with an EUI of 70 kBtu/sqft-year have the highest and lowest energy consumptions, respectively.

Table 11. Energy consumption comparison

	John A. Logan	Southwestern Illinois College	College of Lake County	Prairie State Junior College
Area (sqft)	45,232	117,824	57,891	38,022
HDD/CDD	4,721/ 1,281	3,441 / 1,913	5,065 / 1,324	5,065 / 1,324
Annual Consumption and EUI				
Electricity (kWh)	695,360	1,956,913	1,865,025	626,109
Electric Use Intensity (kWh/sqft-year)	15.37	16.61	32.22	16.47
Natural Gas (Therms)	32,313	15,097	66,196	24,470
Gas Use Intensity (Therms/sqft-year)	0.71	0.13	1.14	0.64
Energy Use Intensity (EUI) (kBtu/sqft-year)	124	70	224	121
Annual Costs and ECI				
Electricity ($)	$33,205	$97,846	$88,757	$31,305[1]
Natural Gas ($)	$10,004	$11,473	$43,027[2]	$12,410
Total Cost ($)	$43,209	$109,319	$131,785	$43,716
Energy Cost Intensity (ECI) ($/sqft-year)	0.96	0.93	2.28	1.15
Average Unit Cost				
Electricity ($/kWh)	0.05	0.05	0.05	0.05
Natural Gas ($/therms)	0.31	0.76	0.65	0.51

[1] Assumes an energy cost of $0.05/kWh.

[2] Assumes an energy cost of $0.65/therm.

Probably the most interesting item that Table 11 illustrates is the unusually high electric use intensity of 32.22 kWh/SF/yr, and EUI of 224 kBtu/SF/yr for CLC. Naturally, this high rate of energy consumption also has cost consequences. The cost to operate CLC on a square foot basis far exceeds the other colleges.

5.1 Dashboard Data

Download of energy consumption data from the dashboard can also be used to examine operational trends of mechanical systems. For example, Figurer 27 shows electrical consumption taken at 15-minute intervals at JAL from 9-15-2013 to 10-20-2013. Several trends are clearly evident:

- Weekday usage is higher than weekend usage
- The first three weekends something must have been occuring at Building G whereas the following weekends the building was clearly shut-down.
- Peak electrical consumption during the week reduced during this time period as the weather became cooler.

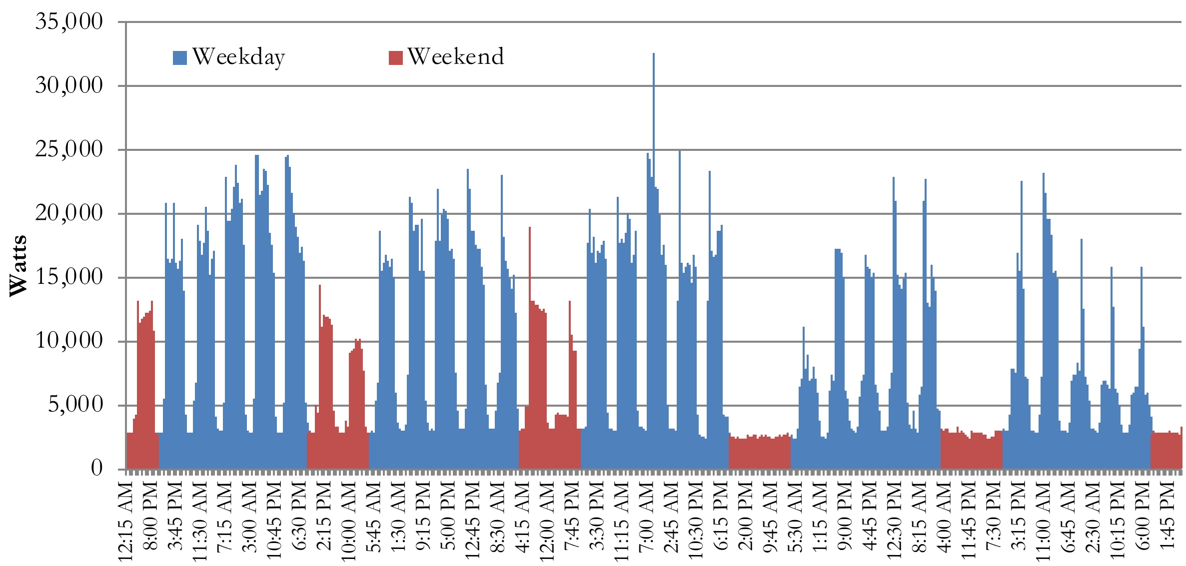

Figure 27: JAL electrical consumption from 9-15-2013 to 10-20-2013

This type of data visualization can quickly identify operational anomalies, and/or mechanical scheduling problems. Data can also be examined at a much finer resolution to observe consumption and operational characteristics throughout the day. This type of analysis may disclose frequent chiller cycling, scheduling issues, and more.

The same type of graph was created for SWIC including daily mean temperatures (see Figure 28). Again, weekend consumption is clearly less than weekday consumption and consumption appears to be reducing as daily mean temperatures fall. This would be expected as cooling loads reduce.

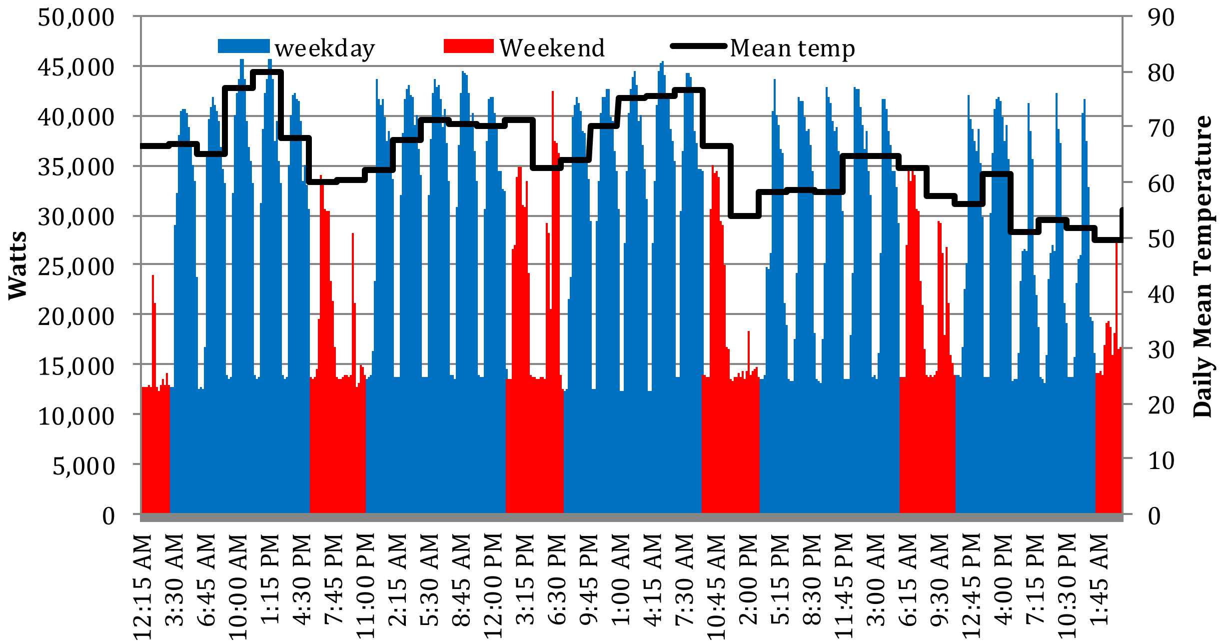

Figure 28: SWIC electrical consumption from 9-15-2013 to 10-20-2013

Note that the gaps between weekdays, which represent evening, nighttime and early morning hours, are wider in the JAL graph than in the SWIC graph. This indicates that more equipment is turning off for longer periods during unoccupied hours at JAL than at SWIC. There may be several explanations for this, but SWIC building operators may want to examine the scheduling of building systems to determine if they are optimized. Being able to widen the gap would translate into energy and cost savings.

Figure 29 shows a comparison of electrical use per square foot for PSC, JAL, and SWIC. CLC was not included since dashboard information was not available. Several things can be observed:

- JAL consistently uses less energy per square foot than the other facilities.
- JAL almost consistently shuts-down mechanical equipment on weekends
- Both SWIC and PSC appear to be turning off mechanical equipment on weekends, but for very short periods of time.
- The energy consumption for all three schools drops dramatically as outside temperatures decrease towards the end of the data collection period.

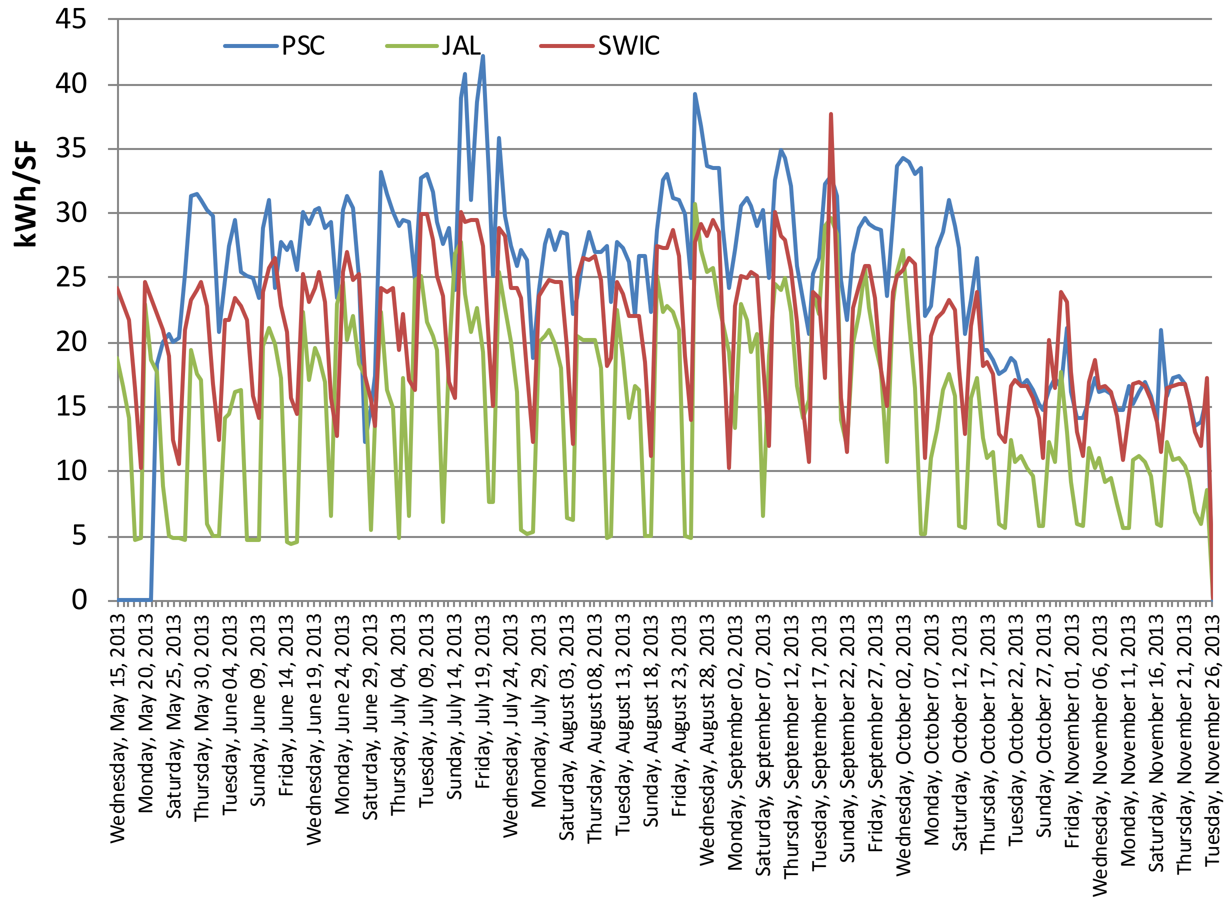

Figure 29: Electrical use per square foot for PSC, JAL, and SWIC

5.2 Dashboard Issues

Download of dashboard data revealed that there were several instances, particularly for natural gas consumption during the initial phase of the study, that something was wrong with the data collection equipment. Whether it was a meter failure, communications failure, or other is unknown. Even at the time of this writing, there appear to be communications problems at SWIC as illustrated in the figure below. Several hours of electrical consumption have not been recorded. The Meter Status box below the graph indicates that the dashboard is "NOT RECEIVING DATA'.

Having intermittent data makes any type of analysis far more difficult, and if these missing values aren't noticed and accounted for, conclusions are incorrect. Dashboards offer a unique opportunity for real-time data visualization, but it appears that data collection issues still need to be resolved.

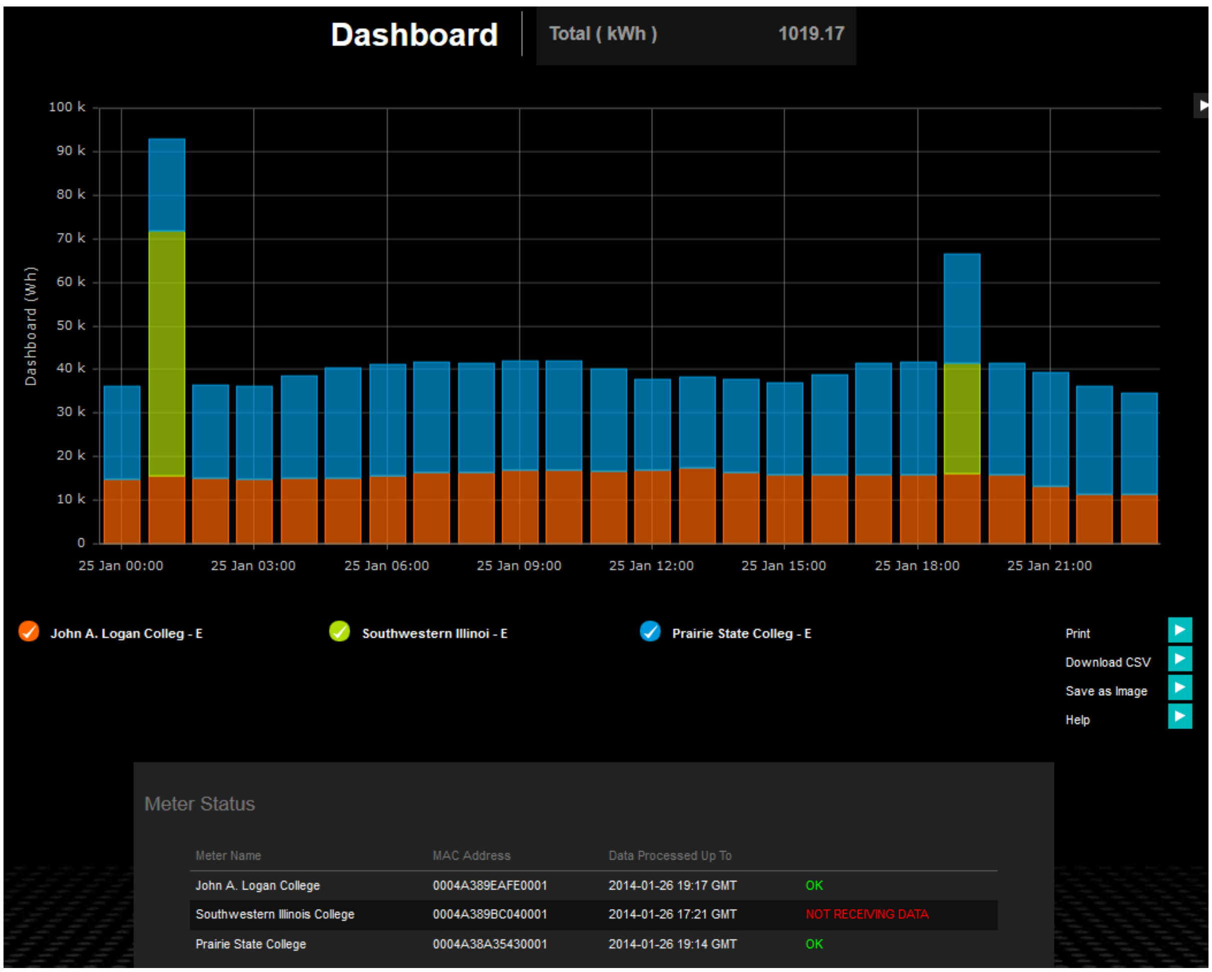

Figure 30: Dashboard for 1-25-2013

6 Conclusion and future research

This research aimed to evaluate whether the installation of dashboards, which makes energy consumption visible to building occupants, in conjunction with a sustainability campaign, which increases building occupant awareness of energy related issues, could result in energy savings. The first part of this study examined energy consumption pre and post sustainability-campaign, and the second part of this study examines building occupants' pre and post energy attitudes and behaviors.

Overall energy consumption decreased significantly (natural gas approximately 7to 10 percent, and electricity approximately 53 to 60 percent) over the two-month behavior change campaign at each community college. This decrease is normalized for weather variation. Whether this savings can be attributed to the dashboards is questionable since some of these reductions appear before the campaign was even rolled-out. It is possible that facility managers looked at data as soon as the dashboards were installed, realized that operating schedules were not adjusted properly, and immediately adjusted them. This actually happened at JAL. The data disclosed that mechanical systems were shutting-down Friday evening and turning back on at midnight on Saturday rather than Sunday. Building Automation System (BAS) schedules were then modified to keep equipment off from midnight on Saturday until midnight on Sunday. These types of scheduling adjustments can result in significant energy and cost savings. SEDAC frequently finds these types of scheduling problems in our retro-commissioning projects. They are unfortunately quite common.

The regression analysis showed that natural gas consumption at all four colleges are highly dependent on the outside temperatures. The regression equations for electrical consumption and weather had a strong correlation at SWIC and CLC, but poor correlation at JAL and PSC. The poor correlation could be due to issues such as buildings not being used during periods of high CDD and thus not being cooled. Additionally, electricity is used for much more than space conditioning which can influence the effectiveness of trying to establish a relationship between electrical use and weather.

Although findings regarding energy savings during this study are inconclusive, the study has shown that certain data obtained from the dashboard can be of great value. Graphing of consumption data can show daytime and weekend scheduling problems. Additionally, now that the dashboards are collecting data, it can be used as a baseline to compare future consumption values to, with the caveat being the data needs to be checked for consistency and be adjusted for weather. The dashboards also have the capability to be enhanced with additional inputs that could monitor individual pieces of mechanical equipment. This could eventually be of great value. Sub-metering of building mechanical systems is gaining increasing attention in the energy field since it allows operators to disaggregate energy consumption and gain insights into how, where, and in what quantities energy is being consumed within a building.

Energy dashboards by themselves do not save energy. It is their capability to present historical and real-time consumption data that can increase occupant and facility managers' awareness, and provide insights to operational issues that may lead to energy savings. Facility operator training of how dashboard data can be used to identify problems and opportunities should be an important component of any dashboard installation. Data alone is of little value, it is when the data is processed, interpreted, and acted upon that it becomes valuable.

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1 Introduction

Discourse relating to environmental sustainability has become ubiquitous over the past 40 years due to a growing awareness of interrelated issues such as climate change, air pollution, and national security (among many others). Energy conservation in particular, has emerged as a key factor in addressing many of these global environmental problems. Buildings are responsible for 40 percent of energy use worldwide, and in the United States alone, energy consumption in buildings costs more than $400 billion each year (Omer, 2008; US Department of Energy, 2013). Many governments and non-profit organizations have attempted to address these issues through implementation of a variety of energy conservation programs, policies, and technologies.

Recent building technology research examines innovative energy conserving methods that include new and/or improved lighting and equipment, insulation technologies, phase change materials, smart systems and controls, load shifting, rating procedures, and renewables. These building systems and technological advances are well covered in the literature on energy conservation and efficiency (Fanger & Toftum, 2002; Klein et al., 2012). The noted system improvements, however, seldom recognize the critical human component that both operates the building systems and occupies the buildings spaces. *Failure of recognizing this 'human component' can ultimately result in significantly higher energy consumption.* Linking knowledge from the fields of environmental sustainability and psychology is crucial for addressing major environmental issues, such as climate change, because "environmental problems are really behavioral problems: They are caused by the thoughts, beliefs, values, and worldviews upon which humans beings act" (Winter & Koger, 2010, p. 2).

This pre-post / comparative field study examines four case study community college buildings in Illinois in order to identify the impact behavior change campaigns, coupled real-time energy feedback (i.e., the intervention), had on student, faculty, administrative staff, and facility managements' energy attitudes and behaviors.

2. Literature Review

2.1. Theories of Pro-Environmental Behavior

Social, behavioral, and cognitive psychological theories have indicated that a wide variety of dynamic factors can influence pro-environmental behavior, or "behavior that consciously seeks to minimize the negative impact of one's actions on the natural and built world (e.g., minimize resource and energy consumption…)" (Kollmuss & Agyeman, 2002, p. 240). Many theoretical models have been developed that contribute to our conceptual understanding of the underlying human causes of direct and indirect pro-environmental behaviors. Two theories that have arguably generated the most empirical support are the Theory of Planned Behavior and the Values Beliefs Norms Theory (Ajzen, 1991; Stern, 2000). The Values Beliefs Norms theory (VBN theory) generally states that a causal chain of personal values; beliefs (which includes a combination of ecological worldview, adverse consequences for valued objects, perceived ability to reduce threat); and personal norms lead to a given pro-environmental behavior. This theoretical framework is depicted schematically in Figure 1 below.

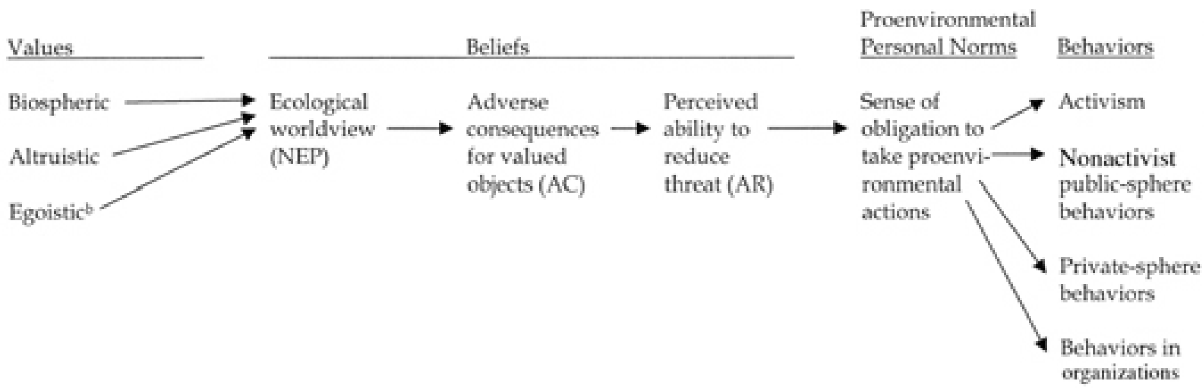

Figure 1: Values Beliefs Norms Theory – figure reproduced from (Stern, 2000, p. 412).

The Theory of Planned Behavior, on the other hand, states that an individual's intention to behave a certain way is the best predictor of pro-environmental behavior. Behavioral intentions are thought to be a function of three interconnected elements – attitude, subjective norms, and perceived control (Ajzen, 1991) (see Figure 2 below). This theory, therefore, supports research that has shown attitude alone is not a strong predictor of behavior, which is a common misconception seen in environmental education and policy (Kaiser & Schultz, 2009; Kollmuss & Agyeman, 2002).

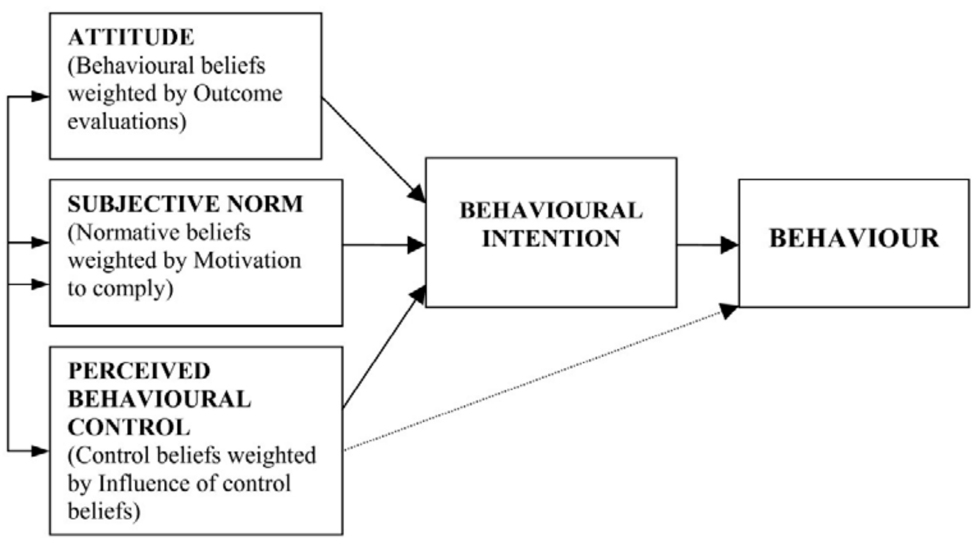

*Figure 1: **Theory of Planned Behavior – figure reproduced from (Ajzen, 1991, p. 182)***

Theory of planned behavior has incredibly high explanatory power. For example, in one study, the intentions predicted by the theory accounted for 95 percent of conservation behaviors (opposed to only 64 percent by the Values, Beliefs, Norms Theory) (Kaiser, Hübner, & Bogner, 2005). However, it is notable that both the Values, Beliefs, Norms Theory and the Theory of Planned Behavior include similarities in causal domains, which include cultural/social (e.g., social norms), personal (e.g, habits, values, beliefs, attitudes, knowledge of issues/action strategies, verbal commitment), and environmental (e.g., locus of control) factors (Hines, Hungerford, & Tomera, 1987; Manning, 2009). A selection of these elements are discussed further in section 10.2 below.

2.2. Factors Influencing Pro-Environmental Behavior

The factors that have been shown to influence pro-environmental behavior, as described below, are by no means comprehensive. Many other factors have been shown to weigh into whether a pro-environmental behavior is performed, which includes habits (McKenzie-Mohr, 2011), environmental awareness (Kollmuss & Agyeman, 2002), emotional involvement (Chawla, 1998), and values (Stern, 2000) (to name a few!). The factors outlined below, however, arguably have the most significant or foundational influence over many human behaviors.

2.2.1. Energy Beliefs and Attitudes

In the most general sense, a belief is an "understanding about people, objects, and concepts," whereas an attitude is "the enduring positive or negative feeling about some person, object or issue" (Kollmuss & Agyeman, 2002; Winter & Koger, 2010, p. 252). Attitudes are often categorized as either implicit (i.e., "traces of past experience [that] affect some performance, even though the influential earlier experience is not remembered in the usual sense – that is, it is unavailable to self-report or introspection") or explicit (i.e., written and discussed openly) (Greenwald & Banaji, 1995, p. 5; Winter & Koger, 2010). Although pro-environmental beliefs (which are shaped by environmental information) and attitudes are most commonly thought of as the "smoking gun" factor to pro-environmental behaviors, research has shown that this might not necessarily be the case (Diekmann & Preisendoerfer, 1992).

Most studies on environmental attitudes, however, have found that they at least indirectly influence pro-environmental behavior (Gigliotti, 1992, 1994; Grob, 1991). Several additional factors, such as those described below, can be thought of as barriers to a direct causal link. Additionally, in relation to the Theory of Planned Behavior discussed above that uses intentions to predict pro-environmental behavior, Levine and Strube's study of 90 college students found that only explicit attitudes strongly related to their environmental intentions, and intentions completely mediated the influence of explicit attitudes on behavior (2012).

2.2.2. Social Norms

Social norms, or behavioral expectations defined by society (or smaller group), have been found to be integral, and some argue the key, to understanding energy behaviors (Manning, 2009, p. 7; Winter & Koger, 2010, p. 96). Social norms can be defined as descriptive (i.e., beliefs how others behave in a given situation) or injunctive (i.e., beliefs about social approval for certain behaviors) – both of which occur simultaneously. Although many hold the belief that their behaviors result from independent thought and calculation, the reality is that an incredibly large portion of daily behaviors are done in accordance with social norms to gain approval, acceptance, or reward (Bandura, 1971; Kopec, 2012, p. 21; Manning, 2009, p. 7). This phenomena (modeling others behaviors) is referred to as social diffusion, modeling, or social/observational learning (Bandura, 1971; Winter & Koger, 2010, pp. 99–100).

Previous studies have highlighted the influence of social learning / social diffusion on energy conservation behaviors (Allcott, 2011; Nolan, Schultz, Cialdini, Goldstein, & Griskevicius, 2008). For example, an experiment examining the effectiveness of social comparison in over 600,000 United States residences found that providing social comparisons reduced energy use by 2.0 percent (with highest users decreasing their usage by 6.3 percent) (Allcott, 2011). Similarly, a study of 810 Californians showed that normative social influence (i.e., printed door hangers with a persuasive message and graphic) elicited the greatest change in behavior, even though respondents rated normative information as the least motivating (Nolan et al., 2008).

2.2.3. Behavioral Control

Behavioral control (or locus of control) refers to "how we view ourselves and our opportunities" (Winter & Koger, 2010, p. 113). Those with strong external locus of control believe that they are controlled by external forces, whereas those with strong internal locus of control believe that they control their own actions choices and pursuits. When sustainable behaviors are perceived to be out of an individual's control, individual action seems irrelevant (Levine & Strube, 2012). Locus of control determines if people think their behaviors are instrumental to goal attainment (Ajzen, 1991). For example, multiple studies have shown that even though one might prefer to take a more sustainable form of transportation (e.g., bicycle, walking), they will not if they feel their only option is the single occupancy vehicle (Crane & Crepeau, 1998; Ewing & Cervero, 2001). If they frequently take action and don't see a result a condition often referred to as learned helplessness, or behaving helplessly even though opportunities for improvement exist, may develop (Peterson & Seligman, 1995).

2.2.4. Information and Feedback

Existing literature that examines how energy use feedback impacts occupant behaviors largely focuses on the residential building sector (Darby, 2006; Parker, Hoak, & Cummings, 2008; JE Petersen, Shunturov, Janda, Platt, & Weinberger, 2007; John Petersen, Shunturov, Janda, Platt, & Weinberger, 2005). In her review of 38 energy use/feedback studies, Darby concludes that 'simple' feedback devices (e.g. regular meter reading) resulted in energy savings of 5-15% (2006). Darby notes that user-friendly displays and monitors that show instantaneous usage and historic feedback would likely be more effective in impacting occupant behavior than simple feedback (Darby, 2006). A study performed by Petersen et.al supports this conclusion, showing that sophisticated energy use feedback (e.g. real-time energy use data, user friendly display, etc.) installed in various college dormitories on the Oberlin College campus, coupled with an energy use competition, resulted in an energy use reduction of 56% over a two-week period (2007). Continuation of the energy savings after the competition ended, however, was not examined. It should be noted that in general, however, environmental campaigns solely focused on providing information are not typically very successful (Kollmuss & Agyeman, 2002, p. 250).

New technology and feedback mechanisms, such as personalized advice on bills, energy dashboards, building orbs have been accelerating the process of making energy consumption more visible. Energy dashboards, for instance, are digital information tools that display real-time energy consumption data (usually via a television or computer monitor) in a more engaging and easy to understand format than typical building information system software. Still, some building occupants find that these devices display too much information that they don't find exceptionally interesting or relevant. Building orbs, or round electronic devices that display a different spectrum of colors associated with energy consumption (e.g., red is displayed when energy consumption is well over average), are aimed at providing energy consumption in a way that is incredibly quick and easy to understand.

2.3. User Energy Attitudes and Behavior in Academic Buildings

The above literature does not necessarily indicate the energy savings found in some residential feedback/energy use studies will translate to academic buildings on community college campuses. This study will, therefore, empirically analyze if real-time energy feedback systems, coupled with energy behavior change campaigns (i.e., the study intervention), can impact facility management, students, and faculty/staff attitudes, and effectively motivate them to alter their energy behaviors in a manner that significantly affects measureable energy consumption patterns. If energy dashboards and behavior change campaigns are found to be an effective energy conservation motivator for any one of these groups (changing their behavior directly or indirectly), this would provide evidence to other community colleges that energy dashboards could be a worthwhile investment in terms of cost-savings and/or energy education.

3. Method

3.1. Sampling

3.1.1. Context and Target Population

In 2012, the Illinois Green Economy Network initiated a Pilot Program entitled *Behavior Change for Energy Efficiency* in order to understand if a combination of behavior change campaigns and real-time energy feedback could change reported energy attitudes/behaviors and measureable energy usage. Four Illinois community colleges participated in this study - John A. Logan Community College (Carterville), Southwestern Illinois College (Bellville), College of Lake County (Southlake), and Prairie State College (Chicago Heights). Each campus volunteered one building to use as a case study site for analyzing energy attitudes and behaviors. The unit of analysis for this study was the individual facility manager, faculty/staff member, or student. It was important to separate these three sub-groups, as each group has very different energy behavioral expectations and control. For example, if a building was being excessively heated/cooled we might expect a faculty member to report the issue, but we would expect a facility manager to correct the issue. This study can serve as an indicator that other community colleges within Illinois could expect similar attitude or behavioral changes (or lack thereof) if they commenced a similar energy behavior change campaign and installed an energy dashboard.

3.1.2. Design

Both a before-after *and* a comparative survey methodology was utilized in order to overcome significant sampling challenges encountered due to the dynamic nature of college campuses. Ideally, before-after surveys would be conducted with the exact same population sample who utilize each of the study buildings. This was unrealistic given the study's requirements for anonymity and the fact that many students do not use the study buildings consistently throughout the year. Therefore, to increase the validity of our results, our study examines both 1) the change in attitudes/behaviors over time (i.e., before and after) using comparisons from users with similar characteristics *and* 2) between control and treated groups (i.e., study building users vs. non-study building users). These methods, and the challenges associated with each, are outlined in Table 1 below.

Table 1: Survey Evaluation Design

	Method	Challenges
Treated group *Those who use the study building*	'Before' Baseline Survey → Intervention → 'After' Survey	• Respondent should not be influenced by anything but the campaign / dashboard – this is difficult to control
Un-treated group *Those who do not use the study building*	'Before' Baseline Survey → No Intervention → 'After' Survey	• Comparison requires respondents to have similar characteristics (e.g., area of study) as the treated group

The distributed surveys were based on a saturation sample, meaning *all* persons affiliated with the campus were sent an online survey. Thus, the most updated email list at the time of survey distribution at each individual college served as the sampling frame. In order to address the low response rate typically associated with mass-online surveys, reminder emails were also distributed. Final sample sizes, response rates, and confidence levels/intervals for the three sub-groups at each college are included within Table 2 below.

Table 2: Survey Responses and Representativeness

	Students		**Faculty / Staff**		**Facility Management**	
	Before	***After***	***Before***	***After***	***Before***	***After***
CLC						
Total Population	15,361	15,361	157***	157***	2	2
Survey Responses	495	153	10	14	1	1
Response Rate	3.2%	1.0%	6.7%	8.9%	50%	50%
Confidence Level / Interval	95% / 4.3%	95% / 7.9%	NR	NR	NR	NR
PSC						
Total Population	5,494	3,745*	391	465**	2	2
Survey Responses	197	53	49	64	2	0
Response Rate	3.6%	1.4%	12.5%	13.8%	100%	0%
Confidence Level / Interval	95% / 6.9%	95%/13.4 %	95% / 13.1%	95% /11.4%	Total population	NR
JAL						
Total Population	6,400	6,400	399	399	6	6
Survey Responses	164	62	74	9	0	1
Response Rate	2.5%	1.0%	18.5%	2.25%	0%	16.6%
Confidence Level / Interval	95% / 7.5%	95% / 12.4%	95% / 7.5%	NR	NR	NR
SWIC						
Total Population	37,464	32,988	1191	1191	74	74
Survey Responses	114	97	173	127	11	0
Response Rate	0.3%	0.3%	14.5%	9.38%	14.9%	0%
Confidence Level / Interval	95% / 9.1%	95% / 9.9%	95% / 6.9%	95% / 6.9%	NR	NR

*Note: Unless otherwise marked, these numbers are indicative of total campus population numbers. Updated population numbers were requested from each campus post-intervention. If response was not received, it was assumed population sizes were equivalent to pre-intervention. * Only students who were on campus during the "before" survey period were surveyed. **Does not include adjunct professors. ***Indicates response from only Southlake campus.*

The respondents from each college provide a reasonably representative profile of community college student populations. Demographic information is included within **Appendix A**. Faculty /staff and facility management responses are generally less representative, thus, this should be taken into account when reviewing analysis results.

3.2. Intervention

Behavior change campaigns were commenced September 10, 2013 and lasted until November 10, 2013 (a total of 60 days) with a goal of 5-10 percent reduction in energy usage. Although these campaigns varied slightly from campus to campus, most colleges included elements that focused on communication, incentives, training, education, technology, and organizational support. As part of the energy campaign, each building was also given an energy dashboard that displayed real-time data on energy consumption and educational information on a television screen located near the main entry of the building. Specific components of the behavior change campaigns included:

1. Formation of "Energy Team" and student volunteer corps;
2. Monitoring and measuring strategies
3. Communication / Engagement Techniques
4. Targeted Training
5. Creation of Incentives

Energy dashboards and sub-metering were installed in each case study building in May 2013.

3.3. Data Collection

The online survey format was considered most feasible (opposed to mail surveys, etc.) due to its relatively low cost and ease of distribution. The survey instrument was constructed using SurveyGizmo software and pre-tested with a convenience sample of 10 University of Illinois students and faculty/staff. Data for the "before" survey was collected in April 2013, while data for the "after" survey was collected in November/December 2013. The online survey was distributed by representatives from each of the four case study colleges to their respective campus populations. Some questions within the survey were hidden from respondents view based upon their answers to previous questions. For example, a respondent who stated that they were a student would not see questions related to correction and detection of building energy problems designed for facility managers. Reminder emails were sent out by three of the four colleges approximately 1 to 2 weeks following its initial distribution. No incentives were offered to respondents who completed the surveys.

3.4. Measures

3.4.1. Energy attitudes

Energy attitude could potentially be operationalized using survey questions asking something as simple as whether or not the respondent believes a specific energy behavior is "good" or "pleasant." However, in many instances it is more informative to identify the sub-dimensions of a specific attitude. Thus, students, faculty/staff, and facility managers were assessed through questions relating to sub-dimensions of energy attitudes including awareness of energy conservation matters, desire to learn more about energy conservation, motivations (i.e., reasoning) for conserving energy and perceived social norms. The vast majority of these items were arranged on a five-point Likert scale that ranged from 1 ("strongly disagree") to 5 ("strongly agree"); however, some (e.g., awareness of energy conservation matters) were asked on a three-point scale.

3.4.2. Energy behaviors

Energy behaviors of students, faculty/staff, and facility management were assessed through questions relating to reported indirect behaviors, direct behaviors, and ability to detect and correct building energy issues. These questions varied by group due to differences in perceived control and behavioral expectations. Students, were therefore only asked questions on indirect energy behaviors, faculty/staff were asked questions relating to both direct and indirect energy behaviors, and facility management were asked questions relating to their ability to correct and detect building energy issues. Similar to questions relating to energy attitudes, the majority of the items were designed as five-point Likert items that ranged from 1 ("strongly disagree") to 5 ("strongly agree").

3.4.3. Demographic variables

In addition to the abovementioned questions, the survey also contained questions relating to several personal characteristics of each respondent that were dependent on the sub-group they identified with. The characteristics collected included:

- Student – area of study;
- Faculty / Staff - how long respondent has worked at the college; subjects taught; and
- Facility management – how long respondent has worked at the college.

3.5. Analysis

Comparative data between treated and untreated groups (collected after the behavior change campaign ended) was analyzed using Mann-Whitney U statistical test. This test compares the differences between two independent groups when the dependent variable is ordinal (i.e., likert-type items) by testing differences in medians between groups. 'Before and after' data, however, was analyzed using Wilcoxon Signed Ranks Test. This statistical test was chosen due to the fact that survey items testing dependent variables were measured at the ordinal level and independent variable are two categorical "related groups" (i.e., before the campaign commences and after the campaign commenced). Paired samples were achieved by matching respondents' individual characteristics of respondents from before and after the intervention. It should be noted that only student data was analyzed using both tests, as this group is more dynamic than faculty, staff, and facility management, who are more likely to use the same buildings in similar ways throughout the duration of the campaign. SPSS statistical software was used to perform statistical analysis of the survey responses.

4. Results

This study separates the campus population of each community college into three groups – students; faculty/administrative staff; and facility management. Two hypotheses have been analyzed with respect to these each sub-groups – one that relates to their energy attitudes / beliefs and one relating to their reported energy behavior. These hypothesis areas and subdomains outlined in Table 3 below.

Table 3: Hypothesis and subdomains

Hypothesis		Subdomains
H_1	Energy Attitude	Desire to learn more
		Social Norms
		Motivation to conserve energy
		Energy awareness
H_2	Energy Behavior	Indirect behavior (students and faculty/staff)
		Direct behavior (faculty/staff)
		Detection and correction of energy use problems (facility management)

4.1. Students

Appendix A provides a profile of the students surveyed in terms of their area of study, student status (e.g., full-time, part-time, adult school), use of the study building, and overall time spent within the study building. The results indicate that respondents' area of study is relatively dispersed at all four colleges (no one category held more than 30 percent, with the exception of those response that were left blank or undecided), most were full-time students, and the majority spent less than 20 hours a week in the study building (refer to Appendix A, Table 1).

It should be noted that following completion of the behavior change campaign, Southwestern Illinois College reported issues with the energy dashboard, stating "unfortunately, the software for the education/messaging portion of the display was antiquated, limited and cumbersome and so we were not able to use the extra features to promote further education. We did create signs and other media information on our own flat screen kiosks." The campaign manager suggests that energy dashboard software used in the future should be "user-friendly and can easily…manipulated by staff on-site."

4.1.1. Energy Attitudes

The first hypothesis (H_1) this study tested focused on student energy attitudes, which were examined using four sub-domains: 1) desire to learn more; 2) perceived social norms; 3) motivations for energy conservation, and 4) energy awareness. Each sub-domain of attitude was considered independently. The null and alternative hypothesis were as follows:

> H_0: There will be no difference in student energy attitudes before the study intervention as compared to after the study intervention.
>
> H_1: Student attitudes toward energy conservation will be more positive after the study intervention.

This two-tailed hypothesis was tested at a 5% level of significance (i.e., $\alpha=0.05$) using the Wilcoxon-Signed Ranks Test, which resulted in only two significantly different results between pre and post intervention groups (refer to Appendix A, Table 2). Both significantly different responses were related to energy information sources – newspaper and energy bills. Students groups at the College of Lake County who reported use of newspapers to access energy conservation information were found to be significantly different pre-intervention as compared to post-intervention. After the intervention, reported newspaper reference went up to 61 percent, as compared to 52 percent before the intervention. This significant statistical difference was not substantially supported by the additional comparison conducted between the control student group and post intervention group, however. Although only 55 percent of the control group reported referencing energy information in newspapers (as compared to the 61 percent reported by the post-intervention sample), this did not fall into the 5 percent level of significance required to reject the null hypothesis (refer to Z scores reported in Appendix A, Table 2).

Furthermore, after the study intervention significantly less students at Southwestern Illinois College reported referencing energy bills for energy information (a drop from 92 percent pre-intervention to 73 percent post intervention). Once again, however, this finding was not supported by the additional comparison made between the control group and the post-intervention students, where reported reference to energy bills was essentially equivalent at 73 percent (refer to Z scores reported in Appendix A, Table 3).

4.1.2. Energy Behaviors

The second two-tailed hypothesis that was tested related to student indirect energy behaviors, which was also examined at a 5% level of significance (i.e., $\alpha=0.05$). The null and alternative hypothesis were:

> H_0: There will be no difference in reported indirect energy behaviors before the study intervention as compared to after the study intervention.
>
> H_2: Students who report indirect energy saving behaviors will increase after the study intervention.

The survey instrument specifically questioned student indirect energy behaviors including 1) voting for an energy conservation policy or program; 2) looking up energy information; 3) donating money or boycotting a company/product to contribute to energy conservation; 4) using the legal system to force compliance with environmental law; and 5) writing letters to politicians. Neither the pre-post analysis or the comparative analysis between the post-intervention and control groups resulted in uncovering statistically significant differences between the groups (refer to Z scores in Appendix A, Tables 2 and 3).

4.2. Faculty / Staff

Due to the fact that the faculty and administrative staff within community colleges are a less dynamic group than students (they more often use the same buildings, have more consistent schedules, etc.), only pre-post statistical tests were conducted. Results of this analysis are reported below.

4.2.1. Energy Attitudes

Similar to the student groups above, a two-tailed hypothesis relating to faculty and administrative staff energy attitudes were examined at a 5% level of significance (i.e., $\alpha=0.05$). The four sub-domains tested were the same as students - 1) desire to learn more; 2) perceived social norms; 3) motivations for energy conservation, and 4) energy awareness. The null and alternative hypothesis were:

> H_0: There will be no difference in reported faculty and staff energy attitudes before the study intervention as compared to after the study intervention.
>
> H_3: Faculty and staff who report energy positive energy conservation attitudes will increase after the study intervention.

Unfortunately, no faculty or administrative staff from the John A. Logan study building responded to the survey, so analysis could only be conducted on the three of the four colleges (i.e., Prairie State College, Southwestern Illinois College, and College of Lake County). The Wilcoxon Signed Rank test was used to compare pre and post-intervention groups, which resulted in only one significantly different response from Southwestern Illinois College. As with the students, this significant difference was in relation to reported reference to energy information in newspapers. Pre-intervention, 73 percent of the respondents reported referencing newspapers, while post-intervention, only 50 percent did. All other survey items analyzed did not result in statistically significant differences between pre and post-intervention groups (refer to Z scores in Appendix B, Table 1).

4.2.2. Energy Behaviors

Faculty and administrative staff within each study building were asked questions relating to both their indirect and direct energy behaviors. Thus, in addition to the same questions that were asked to students regarding actions such as voting for an energy conservation policy, they were also asked a series of questions relating to behaviors that would directly affect energy consumption within the study building (e.g., turning off lights; use of spaces heaters, etc.). Once again, a two-tailed hypothesis relating to these behaviors was examined at a 5% level of significance (i.e., $\alpha=0.05$). The null and alternative hypothesis were:

> H_0: There will be no difference in reported faculty and staff energy behaviors before the study intervention as compared to after the study intervention.
>
> H_4: Faculty and staff who report energy saving behaviors will increase after the study intervention.

The Wilcoxon Signed Rank test resulted in no statistically significant differences between the pre and post-intervention groups for any of the three colleges examined (refer to Z scores in Appendix B, Table 1).

4.3. Facility Management

Due to the low number of facility managers on community college campuses, and the sampling issues associated with this, inferential statistics were not able to be performed. Descriptive statistics, however, can provide some insight as to how energy attitudes and behaviors may have changed over time. Pre and post responses were only received from the College of Lake County, and post (but not pre-intervention) responses were received from John A. Logan College (refer to Appendix C). Post-intervention facility management responses were not received from Southwestern Illinois College or Prairie State College, thus these colleges are excluded from analysis.

Facility managers' energy attitudes were measured using the same domains used for students, faculty and staff - 1) desire to learn more; 2) perceived social norms; 3) motivations for energy conservation, and 4) energy awareness. We hypothesized that facility managers who report energy positive energy conservation attitudes would increase after the study intervention. Unfortunately, we only received one facility management survey back from College of Lake County (CLC) both pre and post-intervention and one response from John A. Logan College (JAL) post-intervention. Because we cannot assume that the responses from CLC are a matched pair (i.e., from the same facility manager) pre-post inferences regarding energy attitudes should not be made.

Energy behaviors for facility managers are markedly different from those indirect and direct behaviors reported by students, faculty, or staff. We hypothesized that facility managers would report greater ease in ability to detect and correct building energy issues after the study intervention. Although this information was not adequately collected by the survey, some informal follow-up conducted with the contacts at each of the study colleges indicated that ability to detect and correct energy issues was, in fact, less difficult. For example, the campaign manager at Southwestern Illinois College stated that "physical plant staff used the dashboard analytics to track energy use in the building and were then able to identify and correct a spike in electricity use that was occurring in the middle of the night." The campaign manager at Prairie State College reflected this stating that their building energy dashboard was "very" useful.

5. Discussion and Conclusions

The main purpose of this study was to determine if the combination of energy behavior change campaigns and installation of energy dashboards would substantially impact reported energy attitudes and behaviors within community college buildings. Although the study might is not entirely generalizable to all community colleges, it could indicate expected results a similar intervention would offer at different community college campuses.

A combination of 'before' and 'after' and comparative surveys were used to collect self-reported energy attitudes and behaviors. None of the energy attitude or behavior null hypotheses for any of the sample groups (students, faculty/staff, facility management) were able to be outright rejected. Thus, we cannot conclude with any certainty that the behavior campaign and dashboard installation did, in fact, significantly change energy attitudes and behaviors of the general student, faculty/staff, or facility management populations. These results are consistent with much energy behavior change literature (Costanzo, Archer, Aronson, & Pettigrew, 1986; Midden, Meter, Weenig, & Zieverink, 1983).

Although we found these results surprising, it does not necessarily indicate that the behavior change campaign and dashboards were completely unsuccessful. In fact, concurrent building energy analysis that was conducted on each of the study buildings show that energy consumption did, in fact, decrease over the length of the energy behavior change campaign (Ghoreishi et al, 2014). This perhaps suggests that some energy behavior change did occur, but in a way that was targeted by individuals who more directly influence building systems (facility managers) rather than widespread behavior change throughout all building users (i.e., students, faculty and staff). Although we cannot say that significant energy attitude and behavior change did result from our intervention, substantial information was still gleaned from this pilot study. In particular, ways to improve both energy behavior change campaigns and research examining these type of energy interventions.

As discussed above, each energy behavior change campaign was ideally supposed to incorporate the following measures: 1) formation of "Energy Team" and student volunteer corps; 2) monitoring and measuring strategies; 3) communication / engagement techniques; 4) targeted training; and 5) creation of incentives. Although many of the components above were planned and discussed, many of the colleges did not necessarily implement them fully. For example, not all colleges created direct incentives, targeted training of all relevant facility managers did not occur at some of the colleges, some student volunteer corps were not fully established, and communication / engagement techniques that might have been strong at the beginning of the campaign tapered off in the end. Also, as mentioned in Section 4.1, some colleges had difficulty with the energy dashboard display.

It is important to recognize that behavior change campaigns are significant and time consuming initiatives, and that leaders and program developers have to be fully committed and willing to engage with the populations it is targeting. Behavior change initiatives should build in accountability and reference community-based social marketing techniques throughout the campaign planning, preparation, and initiation (McKenzie-Mohr, 2011).

In addition to highlighting improvement areas for future behavior change campaigns, this study also brought forth many ways we improve our research methodology. We will take special note of the lessons learned for studying future behavior change campaigns:

1. Increasing response rates - survey response rates were generally low across the study, but especially low for faculty, staff and facility management groups. More appealing email design and wording, coupled with more reminder emails, could be methods of improving these response rates.
2. Qualitative Data – it is likely that semi-structured interviews with key facility managers, occupants, and campaign leaders would provide more informative information than structured surveys.
3. Individualization of energy conservation behaviors – there are a wide variety of indirect and direct energy behaviors that could be examined. Prior to survey creation and distribution, these behaviors should be identified by brainstorming with each campus individually.
4. Self-reported behavior - behaviors reported by individuals is not always accurate. Therefore, other data and methods, such as cross-sectional surveys on observed energy behavior, could be collected and used in addition to the survey data.

Overall, this pilot study on behavior change campaigns and real-time information feedback in community colleges was a useful step in furthering our understanding of energy behavior. These initial steps and lessons learned can help guide future research and more effective and long-lasting change.

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7 Appendix A – Student Characteristics and Statistical Results

Table 1 Respondent Characteristics – Pre and Post Intervention (Study Building Users), Comparison Group (Non-Building Users)

	CLC			PSC			JAL			SWIC		
	Pre n=104	Post n=32	Control n=121	Pre n=42	Post n=8	Control n=45	Pre n=62	Post n=22	Control n=40	Pre n= 45	Post n=63	Control n=34
Respondent's Area of Study												
1 Health and Medicine	16 (16%)	5 (16%)	12 (10%)	9 (21%)	1 (13%)	12 (27%)	19 (31%)	4 (18%)	2 (5%)	3 (7%)	10 (16%)	10 (30%)
2 Science, Math and Technology	20 (19%)	3 (9%)	18 (15%)	9 (21%)	2 (25%)	4 (9%)	14 (23%)	5 (23%)	3 (8%)	12 (27%)	12 (19%)	4 (12%)
3 Social Sciences	6 (6%)	2 (6%)	6 (5%)	8 (19%)	1 (13%)	5 (11%)	2 (3%)	1 (5%)	1 (3%)	2 (4%)	3 (5%)	1 (3%)
4 Trades and Personal Services	2 (2%)	1 (3%)	7 (6%)	0 (0%)	0 (0%)	0 (0%)	4 (7%)	2 (9%)	0 (0%)	4 (9%)	2 (3%)	3 (9%)
5 Arts and Humanities	4 (4%)	5 (16%)	13 (11%)	6 (14%)	0 (0%)	3 (7%)	3 (5%)	1 (5%)	1 (3%)	3 (7%)	7 (11%)	3 (9%)
6 Business	8 (8%)	3 (9%)	15 (12%)	4 (10%)	0 (0%)	6 (13%)	2 (3%)	0 (3%)	4 (10%)	8 (18%)	6 (10%)	0 (0%)
7 Public and Social Services	9 (9%)	5 (16%)	14 (12%)	1 (2%)	1 (13%)	6 (13%)	2 (3%)	3 (14%)	1 (3%)	4 (9%)	9 (14%)	1 (3%)
8 Blank / Undecided	38 (37%)	8 (25%)	36 (30%)	5 (12%)	3 (37%)	9 (20%)	16 (26%)	0 (27%)	29 (73%)	9 (20%)	14 (22%)	12 (35%)
Student Status												
Part-time	44 (42%)	17 (53%)	46 (38%)	13 (31%)	1 (13%)	18 (40%)	11 (18%)	4 (18%)	13 (33%)	30 (44%)	24 (38%)	20 (59%)
Full-time	50 (48%)	13 (41%)	67 (56%)	29 (69%)	7 (87%)	25 (56%)	47 (76%)	11 (50%)	12 (31%)	39 (56%)	38 (60%)	13 (38%)
Adult School	8 (8%)	2 (6%)	7 (6%)	0 (0%)	0 (0%)	2 (4%)	2 (3%)	3 (14%)	11 (28%)	0 (0%)	1 (2%)	1 (3%)
Other	2 (2%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (3%)	4 (18%)	3 (8%)	0 (0%)	0 (0%)	0 (0%)
How Respondent Uses Study Building												
Takes classes	101 (97%)	31(97%)	NA	38 (90%)	8 (100%)	NA	55 (89%)	18 (82%)	NA	42 (93%)	39 (95%)	NA
Use informal / lounge space	0 (0%)	0 (0%)	NA	4 (10%)	0 (0%)	NA	0 (0%)	0 (0%)	NA	0 (0%)	0 (0%)	NA
Have an office/lab or teach	0 (0%)	0 (0%)	NA	0 (0%)	0 (0%)	NA	1 (2%)	0 (0%)	NA	1 (2%)	0 (0%)	NA
Attend meetings/conferences	3 (3%)	1 (3%)	NA	0 (0%)	0 (0%)	NA	6 (10%)	4 (18%)	NA	2 (4%)	2 (5%)	NA
Average Time Spent within Building per Week												
None	5 (5%)	2 (6%)	NA	8 (19%)	4 (50%)	NA	0 (0%)	2 (9%)	NA	0 (0%)	1 (2%)	NA

	CLC			PSC			JAL			SWIC		
	Pre n=104	Post n=32	Control n=121	Pre n=42	Post n=8	Control n=45	Pre n=62	Post n=22	Control n=40	Pre n= 45	Post n=63	Control n=34
Less than 1 hour	7 (7%)	3 (9%)	NA	2 (5%)	0 (0%)	NA	4 (7%)	2 (9%)	NA	3(7%)	9 (14%)	NA
1-10 hours	77 (75%)	22 (69%)	NA	23 (55%)	3 (38%)	NA	42 (68%)	15 (68%)	NA	27 (60%)	43 (68%)	NA
11-20 hours	11 (11%)	4 (13%)	NA	6 (14%)	0 (0%)	NA	16 (26%)	3 (14%)	NA	7 (16%)	8 (13%)	NA
21+ hours	3 (3%)	1 (3%)	NA	3 (7%)	1 (13%)	NA	0 (0%)	0 (0%)	NA	8 (18%)	2 (3%)	NA

Table 2: Percent Agreement and Before and After Wilcoxon Signed Rank Test

Comparison groups are dependent

	CLC			PSC			JAL			SWIC		
	Pre n=104	Post n=32	Z score	Pre n=42	Post n=8	Z score	Pre n=62	Post n=22	Z score	Pre n=45	Post n=63	Z score
Energy Awareness Increased within Past 5 Years	77%	76%	-0.632	73%	63%	-1.000	71%	84%	-1.342	80%	72%	-0.258
Energy Information Sources (% of agreement (agree(4) + strongly agree (5))												
Energy bills	72%	71%	-0.539	79%	75%	-0.137	72%	74%	-0.863	92%	73%	-2.225*
Real-time energy displayed	NA	42%	NA	NA	57%	NA	NA	33%	NA	NA	53%	NA
Climate Issues	81%	75%	-0.436	72%	63%	-0.137	67%	53%	-1.581	59%	67%	-0.264
Newspaper	52%	61%	-2.319*	46%	43%	-0.707	46%	42%	-0.765	55%	51%	-0.225
Magazine	45%	59%	-1.911	51%	57%	-1.633	48%	33%	-0.777	63%	50%	-0.753
Friends / Family	48%	48%	-1.407	60%	71%	-0.828	38%	37%	-0.405	55%	48%	-0.319
Lectures	43%	44%	-0.603	48%	71%	-0.412	30%	27%	-0.184	36%	19%	-1.387
TV	62%	68%	-1.103	62%	75%	-0.816	50%	39%	-1.458	69%	63%	-0.411
Movies / Documentaries	61%	64%	-0.554	61%	75%	-0.368	54%	26%	-1.458	71%	59%	-0.643
Activists	30%	30%	-0.434	43%	63%	-0.378	31%	12%	-2.379*	31%	38%	-0.891
Physical Signs	67%	68%	-0.294	82%	50%	-1.841	75%	50%	-0.733	78%	73%	-1.713

	CLC			PSC			JAL			SWIC		
	Pre n=104	Post n=32	Z score	Pre n=42	Post n=8	Z score	Pre n=62	Post n=22	Z score	Pre n=45	Post n=63	Z score
College / University Education	53%	59%	-0.578	66%	50%	-2.121*	63%	44%	-0.424	59%	52%	-0.579
High School Education	31%	44%	-0.203	42%	43%	-0.368	36%	25%	-1.069	39%	39%	-0.734
Websites, blogs, or social media	47%	52%	-0.024	61%	50%	-0.577	53%	25%	-0.141	48%	55%	-0.329
Information from sustainability professionals	52%	54%	-1.090	52%	57%	-0.408	46%	50%	-0.159	51%	35%	-1.161
Energy Conservation Motivation												
Make others happy	56%	50%	-1.564	60%	43%	-1.414	43%	53%	-1.366	68%	54%	-0.093
Save money	86%	82%	-1.213	70%	88%	-0.378	87%	100%	-0.258	84%	79%	-0.480
Improve indoor air quality	91%	85%	-0.905	70%	75%	-0.425	82%	78%	-0.714	84%	73%	-0.134
Improve local air quality	90%	74%	-1.208	69%	75%	-0.604	78%	79%	-0.073	82%	73%	-0.269
Reduce greenhouse gas emissions	84%	70%	-0.962	77%	75%	-0.647	62%	52%	-1.147	82%	68%	-0.388
Reduce reliance on fossil fuels	87%	82%	-1.257	82%	75%	-0.412	69%	61%	-1.402	84%	69%	-0.145
I believe it is the right thing to do	90%	93%	.000	84%	86%	-0.707	83%	83%	.000	90%	83%	-1.232
Groups perceived to be trying to decrease energy consumption												
Their own group (i.e., students)	38%	38%	-0.894	35%	57%	-1.841	26%	26%	-0.751	48%	42%	-0.016
Professors / lecturers	43%	52%	-1.100	46%	63%	-1.511	45%	47%	-1.417	54%	47%	-0.851
Administrative staff	45%	43%	-1.344	49%	63%	-0.850	56%	42%	-1.144	49%	51%	-0.949
Facility management	55%	48%	-1.724	53%	63%	-1.134	58%	58%	-0.542	58%	57%	-1.003
Custodial staff	46%	48%	-1.532	37%	63%	-1.857	53%	53%	.000	51%	49%	-1.077
Desire to learn more about energy conservation	64%	66%	-0.153	70%	63%	-0.378	60%	53%	-0.277	61%	57%	-0.822
Energy Behaviors (% sometimes or often)												
Vote for energy conservation policy,	40%	41%	-0.800	61%	38%	-0.813	41%	37%	-0.091	48%	33%	-0.830

	CLC			PSC			JAL			SWIC		
	Pre n=104	Post n=32	Z score	Pre n=42	Post n=8	Z score	Pre n=62	Post n=22	Z score	Pre n=45	Post n=63	Z score
programs												
Look up information about energy conservation	70%	76%	-0.877	72%	75%	-1.00	54%	58%	-1.124	63%	63%	-0.260
Donate money or boycott a company / product to aid in energy conservation	24%	30%	-0.605	26%	38%	-0.184	23%	16%	-1.209	24%	17%	-0.769
Use legal system to force compliance with environmental law	9%	14%	-0.479	17%	13%	-1.382	11%	11%	-0.930	13%	16%	-0.028
Write letters to politicians	17%	31%	-0.602	26%	25%	-1.289	16%	26%	-0.672	12%	12%	-0.560

*significant at p<.05; **significant at p<.01; ***significant at p<.001

Table 2: Comparative Mann Whitney U Test

Note: Other buildings within the CLC comparisons have dashboards; Comparison groups are independent

	CLC			PSC			JAL			SWIC		
	Control n=121	Post n=32	Z score	Control n=45	Post n=8	Z score	Control n=40	Post n=22	Z score	Control n=34	Post n=63	Z score
Energy Awareness within Past 5 Years	69%	76%	-1.051	71%	63%	-0.473	88%	84%	-0.411	86%	72%	-0.460
Energy Information Sources												
Energy bills	71%	71%	-0.266	89%	75%	-2.441*	91%	74%	-1.193	73%	73%	-0.515
Real-time energy displayed	48%	42%	-0.368	56%	57%	-1.086	38%	33%	-0.200	33%	53%	-1.880
Climate Issues	72%	75%	-0.368	76%	63%	-0.739	74%	53%	-1.684	65%	67%	-0.496
Newspaper	55%	61%	-0.840	63%	43%	-1.098	55%	42%	-1.774	41%	51%	-0.609
Magazine	43%	59%	-1.776	55%	57%	-0.133	55%	33%	-1.941	43%	50%	-0.538
Friends / Family	55%	48%	-0.427	58%	71%	-0.347	56%	37%	-0.796	68%	48%	-1.343
Lectures	35%	44%	-0.689	36%	71%	-1.278	28%	27%	-0.434	28%	19%	-0.936
TV	60%	68%	-1.219	61%	75%	-0.276	55%	39%	-1.567	64%	63%	-0.854

	CLC			PSC			JAL			SWIC		
	Control n=121	Post n=32	Z score	Control n=45	Post n=8	Z score	Control n=40	Post n=22	Z score	Control n=34	Post n=63	Z score
Movies / Documentaries	61%	64%	-0.556	56%	75%	-0.424	60%	26%	-2.692**	68%	59%	-0.583
Activists	35%	30%	-0.13	46%	63%	-0.694	37%	12%	-2.311*	20%	38%	-0.223
Physical Signs	70%	68%	-0.263	78%	50%	-1.531	64%	50%	-0.677	69%	73%	-0.919
College / University Education	46%	59%	-1.256	54%	50%	-0.523	55%	44%	-0.181	57%	52%	-0.611
High School Education	34%	44%	-1.219	46%	43%	-0.225	31%	25%	-0.352	29%	39%	-1.221
Websites, blogs, or social media	55%	52%	-0.848	56%	50%	-0.281	46%	25%	-1.637	45%	55%	-0.532
Information from sustainability professionals	46%	54%	-0.702	67%	57%	-0.774	55%	50%	-0.732	45%	35%	-0.740
Energy Conservation Motivation												
Make others happy	53%	50%	-0.241	47%	43%	-0.931	45%	53%	-0.504	46%	54%	-1.375
Save money	83%	82%	-0.477	89%	88%	-1.111	91%	100%	-1.066	86%	79%	-0.292
Improve indoor air quality	83%	85%	-0.392	81%	75%	-1.134	88%	78%	-0.308	69%	73%	-0.215
Improve local air quality	82%	74%	-0.381	81%	75%	-1.134	84%	79%	-0.589	84%	73%	-0.757
Reduce greenhouse gas emissions	78.2	70%	-0.786	76%	75%	-0.968	81%	52%	-1.432	72%	68%	-0.602
Reduce reliance on fossil fuels	80%	82%	-0.288	73%	75%	-0.052	81%	61%	-1.517	80%	69%	-0.424
I believe it is the right thing to do	91%	93%	-0.070	89%	86%	-1.204	91%	83%	-2.458*	87%	83%	-0.365
Groups perceived to be trying to decrease energy consumption												
Their own group (i.e., students)	38%	38%	-0.664	37%	57%	-1.297	21%	26%	-0.521	28%	42%	-0.246
Professors / lecturers	50%	52%	-0.843	53%	63%	-0.412	32%	47%	-0.702	44%	47%	-0.152
Administrative staff	45%	43%	-1.510	45%	63%	-0.397	41%	42%	-0.507	45%	51%	-0.441
Facility management	55%	48%	-1.368	47%	63%	-0.228	43%	58%	-1.035	48%	57%	-0.446
Custodial staff	52%	48%	-1.750	45%	63%	-0.473	43%	53%	-0.534	45%	49%	-0.102
Desire to learn more about energy conservation	61%	66%	-0.689	73%	63%	-0.189	67%	53%	-1.261	57%	57%	-0.015

	CLC			PSC			JAL			SWIC		
	Control n=121	Post n=32	Z score	Control n=45	Post n=8	Z score	Control n=40	Post n=22	Z score	Control n=34	Post n=63	Z score
Energy Behaviors												
Vote for energy conservation policy, programs	40%	41%	-0.277	49%	38%	-1.168	44%	37%	-0.434	31%	33%	-0.209
Look up information about energy conservation	67%	76%	-0.947	56%	75%	-1.037	62%	58%	-0.396	48%	63%	-1.079
Donate money or boycott a company / product to aid in energy conservation	20%	30%	-0.666	35%	38%	-0.016	21%	16%	-1.634	17%	17%	-0.331
Use legal system to force compliance with environmental law	13%	14%	-0.289	14%	13%	-1.083	15%	11%	-1.271	7%	16%	-0.142
Write letters to politicians	12%	31%	-1.002	16%	25%	-0.468	15%	26%	-0.805	3%	12%	-0.221

*p<.05; **p<.01; ***p<.001

8 Appendix B – Faculty and Staff Statistical Results

Table 1: Before and After Wilcoxon Signed Rank Test

Note: No faculty or staff who used the study building from John A. Logan College participated in the post-intervention survey, thus comparative analysis was not possible.

	CLC			PSC			SWIC		
	Pre n=10	Post n=14	Z score	Pre n= 11	Post n=4	Z score	Pre n=73	Post n=38	Z score
Energy Awareness Increased within Past 5 Years	89%	86%	-1.732	64%	100%	-1.732	89%	89%	-.816
Energy Information Sources (% of agreement (agree+ strongly agree)									
Energy bills	80%	77%	-0.256	67%	100%	-1.414	80%	71%	-0.395
Real-time energy displayed	NA	73%	NA	NA	67%	NA	NA	45%	NA
Climate Issues	78%	86%	0.000	80%	75%	-1.000	68%	61%	-0.895
Newspaper	63%	79%	-1.276	80%	100%	-1.00	73%	50%	-2.115*
Magazine	44%	57%	-1.027	70%	67%	0.000	66%	53%	-0.528
Friends / Family	75%	54%	-0.276	50%	67%	-1.000	60%	61%	-0.056
Lectures	71%	36%	-0.136	33%	67%	-1.414	41%	22%	-1.445
TV	75%	54%	-0.431	80%	100%	-1.732	76%	55%	-1.369
Movies / Documentaries	75%	62%	-0.276	60%	100%	-1.414	63%	46%	-1.590
Activists	50%	31%	-0.343	20%	67%	-0.447	33%	30%	-0.309
Physical Signs	63%	85%	-1.089	80%	100%	-1.342	66%	74%	-0.521
College / University Education	88%	69%	-0.184	50%	100%	-1.000	63%	54%	-0.135
High School Education	29%	25%	-0.447	13%	0%	-1.000	26%	15%	-0.354
Websites, blogs, or social media	88%	46%	-0.272	56%	33%		47%	42%	-0.918
Information from sustainability professionals	67%	58%	-0.368	46%	100%	-1.342	67%	66%	-0.035
Digitally displayed building energy use	NA	64%	NA	NA	50%	NA	NA	42%	NA

	CLC			PSC			SWIC		
	Pre n=10	Post n=14	Z score	Pre n= 11	Post n=4	Z score	Pre n=73	Post n=38	Z score
Energy Conservation Motivation (% agree and strongly agree)									
Make co-workers happy	22%	50%	-0.857	55%	67%	-0.552	52%	44%	-0.687
Make students happy	33%	54%	-0.647	65%	67%	0.000	54%	42%	-0.045
Save money	89%	93%	-0.513	64%	100%	-1.000	94%	92%	-1.430
Improve indoor air quality	75%	93%	-0.137	91%	67%	-0.447	90%	89%	-0.382
Improve local air quality	63%	92%	-0.184	91%	67%	-0.447	90%	92%	-0.233
Reduce greenhouse gas emissions	85%	71%	-0.447	91%	100%	-1.414	79%	72%	-0.421
Reduce reliance on fossil fuels	78%	85%	-0.365	82%	100%	-1.000	83%	86%	-0.908
I believe it is the right thing to do	88%	92%	-0.272	73%	100%	-1.414	92%	94%	-1.030
Groups perceived to be trying to decrease energy consumption									
Students	33%	50%	-0.299	20%	0%	-1.134	40%	33%	-1.018
Their own group (professors)	67%	64%	-0.740	73%	75%	-0.577	61%	58%	-0.323
Their own group (admin staff)	67%	78%	-1.709	73%	100%	-0.447	69%	81%	-1.001
Facility management	67%	100%	0.000	82%	100%	.000	70%	81%	-0.888
Custodial staff	56%	64%	-0.497	55%	50%	-1.414	69%	77%	-1.106
Desire to learn more about energy conservation	56%	71%	-0.431	36%	100%	-1.342	61%	64%	-0.536
Direct Energy Behaviors (% often)									
Buying energy saving appliances	44%	57%	-0.962	55%	100%	0.000	56%	53%	-0.727
Buying recycled office products	33%	29%	-1.265	46%	50%	-1.342	46%	47%	-1.078
Turning off lights	78%	100%	-1.414	91%	100%	0.000	87%	78%	-1.403
Turning off computer and monitor	44%	57%	-1.414	82%	75%	0.000	70%	74%	-0.346
Using natural light	44%	64%	-1.163	73%	25%	-1.633	37%	39%	-1.009

	CLC			PSC			SWIC		
	Pre n=10	Post n=14	Z score	Pre n= 11	Post n=4	Z score	Pre n=73	Post n=38	Z score
Not using space heater or fan	56%	71%	-0.962	73%	50%	0.000	51%	39%	-1.009
Carpooling, biking or walking	22%	14%	-0.711	18%	25%	-0.447	19%	20%	-0.682
Indirect Energy Behaviors (% some, often)									
Vote for energy conservation policy, programs	33%	50%	-1.063	46%	33%	-0.816	27%	14%	-1.424
Look up information about energy conservation	67%	86%	-0.647	64%	100%	-1.732	26%	17%	-0.961
Donate money or boycott a company / product to aid in energy conservation	33%	36%	-0.085	27%	50%	0.000	9%	6%	-0.406
Use legal system to force compliance with environmental law	22%	21%	-0.171	27%	25%	-0.577	3%	3%	-0.728
Write letters to politicians	11%	29%	-0.345	18%	33%	-0.816	2%	6%	-0.218

*p<.05; **p<.01; ***p<.001

9 Appendix C – Facility Management Statistical Results

Note: There were no responses from facility managers from Southwestern Illinois College and Prairie State College.

Table 1: Before and After Wilcoxon Signed Rank Test

	CLC		JAL
	Pre n=1	Post n= 1	Post n=1
Energy Awareness Increased within Past 5 Years	Increased	No answer	Increased
Energy Information Sources (% of agreement (agree+ strongly agree)			
Energy bills	Agree	Strongly Agree	Strongly Agree
Real-time energy displayed	NA	Neutral	Strongly Agree
Climate Issues	Agree	Strongly Agree	Agree
Newspaper	Neutral	Strongly Agree	Neutral
Magazine	Neutral	Blank	Neutral
Friends / Family	Neutral	Agree	Neutral
Lectures	Neutral	Agree	Neutral
TV	Agree	Strongly Agree	Neutral
Movies / Documentaries	Neutral	Strongly Agree	Neutral
Activists	Neutral	Strongly Agree	Disagree
Physical Signs	Neutral	Strongly Agree	Agree
College / University Education	Agree	Strongly Agree	Strongly Agree
High School Education	Agree	Neutral	Disagree
Websites, blogs, or social media	Disagree	Strongly Agree	Neutral
Information from sustainability professionals	Agree	Agree	Not Applicable
Campus groups	No answer	Agree	Neutral
Energy Conservation Motivation (% agree and strongly agree)			
Fulfill duties outlined in my job description	Agree	Strongly Agree	Strongly Agree
Recognition for achievement beyond job description	Strongly Disagree	Strongly Agree	Neutral

	CLC		JAL
	Pre n=1	Post n= 1	Post n=1
Save money	Agree	Strongly Agree	Strongly Agree
Improve indoor air quality	Agree	Strongly Agree	Strongly Agree
Improve local air quality	Agree	Strongly Agree	Strongly Agree
Reduce greenhouse gas emissions	Agree	Strongly Agree	Agree
Reduce reliance on fossil fuels	Agree	Strongly Agree	Agree
I believe it is the right thing to do	Agree	Strongly Agree	Agree
I find it Difficult to:			
Quantify the energy efficiency impact when changes are made to this building	Neutral	Disagree	Disagree
Figure out when equipment (e.g., chillers, boilers) are not functioning as efficiently as they should	Neutral	Disagree	Agree
Determine the periods of peak energy consumption	Neutral	Disagree	Disagree
Groups perceived to care if the building is energy efficient:			
Students	Neutral	Agree	Neutral
Professors / Lecturers / Instructors	Agree	Agree	Agree
Administrative Staff	Agree	Agree	Strongly Agree
Their Own Group (Facility management)	Agree	Agree	Strongly Agree
Custodial staff	Agree	Neutral	Neutral
Desire to learn more about energy conservation	Agree	Strongly Agree	Strongly Agree
Actions that indicate people in the building care if the building is energy efficient			
They have contacted me directly with energy efficiency concerns	Unchecked	Checked	Checked
They have expressed interest in learning how the building systems work and how to improve them	Unchecked	Checked	Checked
General campus vibe	Unchecked	Checked	Unchecked

	CLC		JAL
	Pre n=1	Post n= 1	Post n=1
Other	Unchecked	"I believe, I have hope"	Unchecked

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