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The Effects of Energy Dashboards and Competition Programming on Cyclic Electricity Consumption on a College Campus

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THE EFFECTS OF ENERGY DASHBOARDS AND COMPETITION PROGRAMMING ON CYCLIC ELECTRICITY CONSUMPTION ON A COLLEGE CAMPUS

by

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This report examined issues pertaining to the efficacy and cost effectiveness of energy dashboards in the effort to influence electricity-related behavior change on college campuses. Given the increasing popularity of energy dashboards along with a lack of data to support their effectiveness, more rigorous research to evaluate the efficacy of this technology is necessary. An intervention including the installation of physical and internet based energy dashboards along with an energy reduction competition was evaluated. A literature review and long term cyclical data on energy use is included that provides arguments against the potential for long-term effectiveness of these interventions despite publications claiming the opposite. Results from this study support conclusions from the literature and are discussed along with a call for a critique of the methods typically used to evaluate similar interventions.

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INTRODUCTION

As building technologies become increasingly efficient, energy-related behavior change strategies have been dubbed the next frontier for public building energy use reduction (York, Molina, Neubauer, Nowak, Nadel, Chittum, Elliott, Farley, Foster, Sachs, & Witte, 2013). As an attempt to induce behavior changes that reduce energy consumption, many college campuses have installed real-time electricity displays (energy dashboards) to provide feedback to energy users. Energy dashboards monitor the energy consumption of a facility and present the data to building occupants interactively either on touchscreen television kiosks or on a website. Data displayed are typically aggregated for an entire building and may show electricity data alone or in combination with water and natural gas usage. The Association for the Advancement of Sustainability in Higher Education (AASHE) reports that 70 of its member universities and colleges have installed energy dashboards in at least one of their campus buildings (AASHE, 2015).

Companies that create and sell energy dashboards and the associated software suggest anecdotally that building occupants will change their behavior as a result of receiving feedback showing the amount of energy being utilized in that building along with access to the educational components of the dashboards designed to give occupants instructions about how to conserve energy (Lucid Design Group, 2015). Previous research, however, has found feedback alone to be ineffective in changing resource use behavior in residential and master-metered settings (Geller, Erickson, & Buttram, 1983; Winett, Kagel, Battalio, & Winkler, 1978). Similarly, information on how to save energy and feedback likely plays an important role in interventions where participants are required to use it in order to gain access to other components such as rewards. However, when relied upon alone, this strategy has been found to have little or no effect on conservation behavior (Abrahamse, Steg, Vlek, & Rothengatter, 2005; Geller, 1981; Geller et al, 1983). A popular argument supporting the use of feedback and information includes the notion that attitude change is a necessary precursor to behavior change (Lehman & Geller, 2004). This assumption has not been validated in numerous research studies (Werner, Turner, Shipman, Twitchell, Dickson, Bruschke, & Bismarck, 1995; Geller, 1992).

Feedback and information have been successfully leveraged to create behavior change, but only when they are linked together with consequences. For homeowners, these consequences can come in the form savings on the utility bills. For the occupants of non-residential buildings, or residents living in master-metered apartments, other consequences would need to be programmed in order for feedback or information to have a behavioral impact. Rewards are commonly used in this context, in the form of group electricity reduction programs or competitions. Following a 1975 report by the Midwest Research Institute finding that master-metered apartments used 10-25% more electricity than individually metered residences, a number of research studies focused on addressing this issue through group contingencies (Cross, 1975).

The dependent variable used in the majority these studies was a measurement of the electricity used by the group over a period of time which was then used as a prediction of future use. Calculations were made between the predicted and actual consumption to obtain a percentage reduction. The reduction percentages were used as performance feedback for building occupants during the interventions (Bekker, Cumming, Osborne, Bruining, McClean, & Leland, 2010; McClelland & Cook, 1980; Petersen, Vladislav, Janda, Platt & Weinberger, 2007; Slavin, Wodarski & Blackburn, 1981; Walker, 1979; Winett, Kagel, Battalio, & Winkler, 1978). One study used an additional measure that included compliance with a provided checklist that included ideal thermostat settings and window and door status. Compliance was checked weekly at random (Walker, 1979).

Individual rewards have been a method for these group electricity reductions. Rewards typically come in the form of monetary rebates or cash payments that were either presented in predetermined amounts or were based on the amount of money saved through conservation. Slavin, et al. (1981) provided residents of master-metered apartments with rebates connected to the magnitude of their electricity savings and found an average of 6.2% to 6.9% reductions in electricity. Winett, et al. (1978) found that when compared to written feedback on electricity use, conservation information, or a low rebate, households responded best to a high rebate and reduced electricity use by 12%. Walker (1979) found as much as an 8.6% reduction in electricity use when providing rewards to individuals based on their observed curtailment behaviors.

Another method pits groups against each other in competitions to achieve the highest conservation rates. Rewards were then distributed to the entire winning group and consisted of sums of money, prizes such as building embellishments, or funds for group parties. Bekker, et al. (2010) found 3.5% to 16.2% reductions in dorm hall electricity use after providing visual prompts and daily electricity use feedback to students. Only one published study utilized real-time energy dashboards as part of a competition. The study took place on a college campus and the buildings included in the competition were dormitories. Up to 55% reductions in electricity use were reported (Petersen, Shunturov, Janda, Platt, & Weinbergr, 2007). While this seems like a significant decrease in electricity consumption, it should be noted that the dataset is quite small, comprising only seven weeks. A three-week baseline period was used to calculate electricity reductions during a two-week period where dormitories competed against each other to reduce energy use. A discontinuous two-week follow-up period was used to determine treatment maintenance effects. The authors reported a continued decrease in electricity use during follow up, a possible indication of a downward trend throughout the entire data collection period. Data were only reported on a bar graph so it was not possible to track trending in baseline and treatment data.

These data are also equivocal, because no statistical analysis of the results is presented and energy use is known to vary widely over short durations (Johnson, Xu, Brewer, Lee, Katchuck, & Moore, 2012). Most important, no trend data were presented and no references were made to previous years for trend comparisons. Furthermore, this research design makes it impossible to tease out the effects of the dashboard aside from the competition. All of these factors make it difficult to conclude that the findings presented in this study were significant despite the magnitude of the reported change.

Of further concern is the use of a follow up survey seeking to document and detail students' resource use behavior. Many answered that they engaged in behaviors such as unplugging vending machines and turning off hallway lights. They acknowledged that these practices were not maintainable after the competition ended even though the energy use continued to decline. The students also reported that they were already engaging in many of the more individually impactful behaviors such as turning off room lights and computer monitors before the competition started. This provides further evidence of the potential that extraneous variables could have contributed to the large reductions in electricity use.

A major issue with this entire body of research is the longevity of the results. Slavin et al. (1981), reported a diminishing treatment effect during the intervention. Winett et al. (1978) questioned the existence of any durable changes following the conclusion of programming. Only one study reported reliable levels of behavioral maintenance in the weeks following the intervention, but did not continue follow-up after five weeks (Walker, 1979). All the studies discussed the costs and benefits of long-term programming, seemingly under the assumption that the majority of the effects would diminish with time. However, no known research has evaluated a long-term consequence based behavioral program using incentives.

A final concern addresses the implementation of programming based on reduction percentages and the problems that arise when making these calculations. These calculations are particularly important because they are used not only to assess the success of the intervention, but also to calculate pay offs and reward distributions for participants. All interventions were reported to be effective with energy reductions of 6-20% and 50% in the case of the Petersen et al. (2007) study. However, concerns have been raised about the accuracy of these calculations given the need for weather normalization along with their fairness based on their dependence on baseline periods used to calculate the results. In a study designed to reward reduction in electricity consumption resulting from use of air conditioning, Winett, et al. (1978) noted that the magnitude of the rewards provided were bound to changes in weather in addition to the curtailment behaviors of interest. McClelland & Cook (1980) discovered that continuous feedback and rewards tied to energy reduction had more impact during months with extreme weather. Johnson, et al. (2012) have discussed these issues in depth and call for a reevaluation of all findings using the baseline to treatment reduction comparison.

A cost-benefit approach is also missing from previous research. Energy dashboard touchscreens can cost between $5000 and $9000 per building to install. They may also necessitate the installation of additional electricity metering technology. There are also yearly fees for software and data management subscriptions along with a dedicated staff member who need to be assigned to run dashboard programming components and to function as a liaison between the organization and energy dashboard software company. If the electricity cost-savings from occupant behavior change can be calculated, then a pay off period can be estimated, a calculation commonly required for other energy efficiency projects.

This study is designed to address questions pertaining to efficacy and cost effectiveness of energy dashboards as part of a Honeywell funded project at Western Michigan University. Given the increasing popularity of energy dashboards along with the lack of data supporting their effectiveness, more rigorous research utilizing this technology is necessary. The purpose of this study was to break down and compare the effects of energy dashboards and competition programming separately and in combination.

METHOD

Setting

The research took place on Western Michigan University's main campus and included residence halls, academic and classroom buildings, and specialized use buildings.

Materials and Equipment

For measurement and data collection, the study utilized energy consumption meters that report data to a central campus server. The energy dashboards consisted of an internet dashboard website and an interactive touchscreen kiosk developed and maintained remotely by Lucid Design Group.

Dependent Variables

Energy Use

Building electricity consumption data were collected from two sources. One source was the WMU energy system, which retained data beginning in 2006. This system automatically reported monthly electricity information for each meter and these reports can be pulled individually to collect electricity consumption data. Many buildings contain more than one meter, so calculations are necessary to determine building-wide consumption. These data were only available from the university on a monthly timescale.

A second source was through Lucid Designs' BuildingOS website, a back-end tool for the energy dashboard requiring a username and password. Through BuildingOS, meter-level data can be queried and automatically calculated to provide reports for entire buildings on timescales as small as 15 minutes. These data were made available for the previous two years in 22 buildings, including all the buildings involved in the study.

Dashboard Interaction

Dashboard interaction data were also collected for the internet-based dashboard website. The information reported included the number of page views, the number of individual users, and website sessions totaled since August 2013 and sorted by date. These data were collected and reported by Lucid using Google Analytics.

Survey Data

A survey was sent to residents of the dormitories that included questions about whether and how they used the physical and internet based dashboards during an energy reduction competition called Eco-Thon (reference Appendix A). The survey also assessed their knowledge about the competition itself.

Independent Variables

Three independent variables were included in the study. The first was the addition of the Lucid Designs Kiosk touchscreen in eight buildings on Western Michigan University's campus. The buildings included the Bernhard Center, Henry Hall, French Hall, Moore Hall, Sangren Hall, Seibert Administration Building, Eich/LeFevre Hall, and the Office for Sustainability. The touchscreens displayed a rotating screen with electricity consumption data for all buildings included in the study. Building occupants could interact with the screen to create graphs comparing buildings, explore usage patterns in individual buildings, get information about campus “Green Features” including solar panels and electric vehicle charging stations, get tips about how to conserve resources, and look at the current and predicted weather for Kalamazoo.

The second variable was a website which made available all the features provided on the physical dashboard kiosk. The dashboard website was available from both on and off campus and showed the same information as the kiosk, but in a format created for personal computers. Both the physical and internet based dashboards functioned identically to those used in the Petersen, et al. (2007) research studying energy dashboards in a dormitory. Internet dashboards were available for all of the residence halls at WMU along with buildings that received physical dashboards. They were advertised in conjunction with the Eco-Thon competition described below.

The third variable consisted of a resource use reduction competition, called Eco-Thon, which takes place every February in WMU’s 13 residence halls. Eco-Thon is organized by WMU’s Residence Life Department and is run by the resident staff in each hall. Events and information sessions are organized encouraging students to reduce electricity and water use and increase recycling rates. Two weeks following the conclusion of the competition, winners were chosen from three campus “neighborhoods” and prizes included a pizza and ice cream party or money to fund small projects such as the installation of bottle filling stations. For the 2015 Eco-Thon competition, real-time standings were displayed on the on tabs labeled for the competition and reflected on each participating building’s “homepage” on the physical and internet dashboards.

Research Design

Interventions were implemented in an approximate multiple baseline design across the 10 buildings included in the study, with rollouts occurring periodically over time. All buildings began in a baseline phase with no intervention. For the dataset from the WMU system, this baseline period began in January, 2006. The dashboard website was activated beginning in April, 2013, but was not advertised widely until February, 2015. Dashboard touchscreen installation took place between September, 2014 and March, 2015. Dashboards were removed in 2016.

RESULTS

Figures 1 and 2 show results for a sample of 6 buildings included in the study. These sample buildings were chosen because they have the most complete datasets. The monthly data reports from WMU's system were utilized because they were found to be the most reliable. These decisions are discussed in greater detail in the following section.

Building electricity data showed somewhat similar patterns of monthly consumption, with higher rates during the academic year than during the summer months. The Bernhard Center was the only exception, with higher rates during summer months in every year except 2008. The Bernhard Center included the student union and is the only sample building that utilized air conditioning. It was open year-round and housed a number of staff and administrative offices along with student group spaces, a cafeteria, and a number of shops. It was also used during summer months for campus tours for prospective students. It is hypothesized that the higher rates are a result of the air conditioning system along with this consistent summertime utilization.

A physical dashboard was installed in the Bernhard center at the beginning of September, 2014. The touchscreen was located near the welcome desk at the main entrance, on the primary path for all foot traffic through the building. The internet dashboard was available starting in

April, 2013, but not advertised. In Figure 1, energy use shows a dramatic drop after the installation of the physical dashboard. This reduction appears to be part of a trend that began in the mid-summer 2014. This downward trend from June or July through December is reflected in multiple other years, most particularly 2010, 2011, 2012, and 2013. This reoccurring pattern of consumption indicates that the reduction following dashboard installation is most likely a result of variables other than the dashboard itself. Additionally, the reduction does not fall below levels of previous years, suggesting that there were no significant electricity savings as a result of the dashboard. Using Figure 2 for a direct comparison to corresponding months, with the exception of 2013, each treatment month falls within or slightly above historical rates of electricity consumption, again suggesting no significant effect from dashboard installation.

Looking closer, the trends during the months of September through December clearly depict the repetitive downward trend every year except 2012 (Figure 3). While the level of electricity consumption in 2014 was slightly lower than 2013, it is again directly comparable to historic electricity use.

Eicher/LeFevre was a residence hall used primarily during the school semesters and was shut down during the summer months. This usage pattern is reflected in the dips in electricity usage during the summer months. Data are missing for a portion of 2013. Data for 2014 did not reflect the same trends as previous years, including a data point in August 2014 that was near zero, an impossible rate of consumption for this building. Additionally, data are missing from September 2014 and January 2015. These clues indicate potential metering system issues, calling into question the accuracy of the remaining data recorded during the interventions. However, Eicher/LeFevre was the only residence hall building where a dashboard was installed separately from the Eco-Thon competition, other residence halls received toushscreen dashboards in tandem with Eco-Thon. Eicher/LeFevre is therefore the only building that received all three independent variables at separate points in time and was included in this analysis for reference.

Eicher/LeFevre received a physical dashboard at the beginning of September 2014 and participated in Eco-Thon during February 2015. The continuous monthly data in Figure 1 show relatively high, but variable rates of electricity use following dashboard installation. Relatively lower rates are seen during and after the Eco-Thon competition. However, when referenced against the monthly comparisons in Figure 2, it is hypothesized that these data are part of an overall downward trend during the months of February and March beginning in 2011. Figure 2 also shows that in the months leading up to Eco-Thon, the dashboard alone created no change in electricity consumption.

Henry and Draper/Siedschlag Halls were also residence halls and show patterns of electricity consumption similar to Eicher/LeFevre. A dashboard was installed in Henry at the same time the Eco-Thon competition began on February 1st, 2015. Draper/Seidschlag participated in Eco-Thon, but only received an internet dashboard and no physical dashboard kiosk. Both halls showed no change in electricity consumption during treatment months as shown in Figure 1 or Figure 2. Figure 2 shows that both may have experienced a slight downward trend over the past ten years. It is possible that this trend is a reflection of the increasingly efficient technologies utilized in dorm rooms such as compact fluorescent light bulbs and low energy televisions and electronics.

The Dalton Center and Moore Hall both served as control buildings. Moore Hall received a physical dashboard that was never activated due to software complications. Both buildings had dashboard websites that were made available beginning in April 2013, but were never advertised to building occupants. Visual inspection of the data for both buildings in Figure 1 and 2 show relatively stable patterns of electricity consumption, indicating that there were no extraneous variables impacting the data during treatment periods in the other buildings.

The dashboard website was advertised to occupants of dormitories during the Eco-Thon competition. The competition tabs showed results for all 12 dormitories on campus, with real-time data for buildings connected through Lucid and manually entered data for the remaining buildings. The website address was shared by residence life staff through hall meetings and posted signage. Interaction data from Google Analytics showed a total of 533 page views by 284 users. This represents only 6.7% of the 4,239 students living in dormitories. The rate of page views peaked during the second week of the competition. Week one saw 12 page views, week two had 92, week three had 34, and week four of the competition had just two page views.

Results from the survey indicated low levels of awareness about the Eco-Thon competition and both versions of the dashboard. 51% of the 135 students who responded to the question “Did a sustainability competition take place on campus?” answered, “I don’t know.” Only 23% out of 40 correctly answered when the competition took place and 35% could name it. In response to a question asking how they viewed results during competition, 62% of 37 students indicated that they used methods other than the touchscreens or internet dashboards to check results. These methods included written communications posted by their resident assistants, hallway posters, word of mouth, and Facebook updates. 53% of 26 the students who answered the question asking for the method they used to check results indicated that they were not aware of any methods for tracking results. Reference Appendix A for a summary of survey results.

Eco-Thon winners were announced mid-April 2015. French Hall and Valley I (a combination of Ackley/Shilling and Britton/Hadley) were named neighborhood winners and

Ackley/Shilling was named the overall winner. French Hall and Valley I were offered their choice of reward to be used before the end of April.

DISCUSSION

The dataset presented in this study is a more complete representation of building electricity than those presented in previous research studies, as it covered a number of years rather than weeks. It shows a number of trends that cycle yearly; an observation that simultaneously strengthens the argument made by Johnson et al. (2012) to abandon the practice of measuring behavior change through a calculated percentage reduction in kWh consumed from a single baseline period and brings into question the results of previous studies. Because of the apparent cyclic nature of electricity use, baseline periods followed directly by treatment may indicate the apparent effectiveness of the treatment because of a downward trend in consumption during that time period that operates regardless of treatment. This makes it impossible to tease out the effects of interventions against the backdrop of trends in electricity use that are a result of these yearly cycles.

An analysis of this dataset as a whole showed that any reductions in electricity use following the installation of physical dashboards, competition programming, or online dashboard websites were likely the result of downward segments of cycles also present in previous years. Additionally, levels did not fall significantly below those seen in previous years during the same time periods.

If these data had been analyzed using methods similar to other studies, an intervention effect would have been fallaciously confirmed. Figure 4 shows a comparison with data from two publications analyzing the effects of aggregated real-time feedback and programming. All data are shown as a percentage reduction from a baseline rate measured immediately preceding the intervention. Western Michigan University's Bernhard Center is used as an example building from the current study because it was the first building to receive a physical energy dashboard and is one of the highest trafficked buildings on campus. For this example, a baseline period of only the four weeks of September, 2014 are used. This represents the beginning of the school year and fulltime classes. The dashboard was installed during this month. The intervention period used to calculate a percentage reduction included data from October – December, 2014, the months immediately following dashboard installation. Analyzing the data in this in this manner, with a reduced baseline period and no consideration for cyclical patterns, the Bernhard Center shows a 32% reduction in electricity use. This is identical to the average reduction found by Petersen et al. (2007) and significantly higher than Bekker et al. (2010).

Based on this analysis alone it would be erroneously concluded that the introduction of a dashboard in the Bernhard Center resulted in a significant decrease in electricity use. However, if the same calculations are made for similar months in previous years, it becomes apparent that the Bernhard Center regularly uses less electricity in the months of October – December compared to September. In 2013 it used 22% less electricity, in 2012 it used 17% less, and in 2011 it used 37% less. No behavioral interventions were implemented during these years, meaning all reductions were most likely the result of a seasonal downward trend in consumption which correlates with cooler outdoor air temperatures and reduced need for air conditioning Yearly trend comparisons such as this are not found in the Petersen et al. (2007) or Bekker et al. (2007) reports.

Data Collection

These data are not without flaws, however. An ideal analysis would include data for smaller segments of time in addition to the monthly consumption rates presented here. This would enable a deeper understanding of what happens to electricity use immediately following treatment implementation. Hypothetically, it is possible that small reductions may have occurred following installation of dashboards or the beginning of the competition, but that the novelty of these interventions caused those reductions to diminish over the month and resulted in data points that look similar to historical data.

An analysis of this sort was attempted utilizing data downloaded through Lucid's BuildingOS system. However, due to unresolved software issues, these data were found to be inaccurate. Reference Figure 5 for a comparison of these data to data pulled directly from WMU's central data server. The dates reflected represent August 31st through September 7th, 2015. The Building OS software allows a user with appropriate permissions the option of exporting data directly to an excel file. These data can be generated as a cumulative number of kilowatt hours over any period of time, presented in five minute increments. These are the data used to calculate the "Lucid Raw" dataset by subtracting the number of kilowatt hours used by the end of each day by the number used at the beginning of each day. BuildingOS also provides the option of downloading daily data, which should be the exact same number, pre-calculated for the user by BuildingOS. However, as seen in Figure 5, no data downloaded from BuildingOS matches the data from WMU's meters. Additionally, the BuildingOS data reflects impossibilities such as zero electricity consumption for multiple days, providing further evidence of its inaccuracy.

This issue raises an additional concern. The real-time data that Lucid displayed on the physical and internet based dashboards were based on these more granular data, meaning that potentially all of the data used to provide feedback to building occupants were not accurate. This hypothesis is untestable because of the difficulty of pulling granular data from WMU's system, however. For the few buildings that were cross-referenced, large discrepancies were apparent. There is a chance that this issue may have contributed to the failure of the dashboards and programming to elicit electricity reductions.

The monthly data reported from WMU's server were also not without fault. The server is set up to automatically run and archive monthly reports for each meter. Many buildings have multiple meters that need to be added to or subtracted from in order to calculate the entire building's electricity use. In many cases, reports were missing for one or more meters or indicated that some data was missing for some months. Months with missing meter data were not included in the results. Because of the high rate of missing data reported, in some cases as much as 75% of all data for entire buildings, reports with missing data were not included in the results. The WMU server records electricity data from meters every 15 seconds. Gaps in data could have comprised a time period as short as a 15-second increment or as large as multiple days. The reports do not provide this information, only a notice indicating that a monthly report for a building is missing data points. 12 buildings were originally slated for inclusion in the study and 6 were excluded due to data accuracy issues.

The reason for missing data, as provided by WMU's electrical engineer, lies in the intricacies of the wireless transfer of information. In order to calculate the total monthly electricity use for one single building, one or more building meters send data wirelessly to WMU's central server every fifteen minutes. If one of these building meters, or if the central server, fails to have a wireless connection at the exact moment the meter sends data, that data point is lost.

Future Research

The interaction data and results from student surveys indicate that the Eco-Thon competition programming was weak, especially when compared to the strong results documented in previous studies (Petersen et al., 2007). In order to directly compare our findings to those of previous research, a similar model must be adopted with higher levels of publicity and communications with students about the dashboards and the competition. Beyond the competition, greater promotion of the dashboard websites is necessary. Within the timeframe of the current study, websites were not advertised prior to Eco-Thon in an effort to increase the potential for effects to be seen from the competition. Furthermore, dashboard websites were not advertised using any methods beyond what the Residence Life department utilizes for Eco-Thon communications, which heavily depends on student staff in each residence hall. Additional promotion of the dashboards by the university at large is the next logical step.

A resolution to the electricity metering issues will result in a wealth of additional data and potential for analysis. It is currently believed that the issue lies within the connection between Lucid and the WMU server and involves the Siemens software that is installed on the server computer. This issue will take time to resolve, but has the potential to provide retroactive data in 15-minute increments for all buildings involved in the study. The ability to measure data on this timescale will open the possibility of additional control measures. Implementing a reversal design would be the most effective method for measuring effects of the dashboard alone. With data available for increments throughout each day, reversal conditions could be implemented. A reversal condition could include covering select dashboards for short periods of time and then reintroducing them after a number of days or weeks. This would help to elucidate the impact of the dashboard on electricity use by further eliminating extraneous variables.

In the absence of additional retroactive data, the continuation of monthly data collection may also prove to be fruitful. Utilizing the monthly data alone means that currently no building has more than 7 months of treatment data and some only have two. This simply is not enough data to draw firm conclusions. Continuing this system of data collection into the future would provide enough data to compare against historical yearly trends and make it possible to draw further conclusions about the existence or absence of electricity use reductions.

Conclusion

It is apparent that our attempts to produce electricity reduction through dashboard feedback and competition programming were not effective. This study presents the most comprehensive dataset found in the literature. It upholds the concerns of Johnson et al. (2012), that calculating electricity reduction based on a static and short baseline period is fundamentally inaccurate. Consequently, this research calls into question the results from all other research focused on the efficacy of energy dashboards. Our findings indicate that installation of energy dashboards may not be recommended as a cost-effective means of electricity reduction in campus buildings. However, given that much of the electricity feedback provided during the study was most likely inaccurate, it is clear that the primary independent variable was not implemented with integrity and therefore no conclusive statements can be made.

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Appendix A

Summary of Survey Responses

Question 1: Did a sustainability competition take place on campus?		
Yes	No	I don't know
5	5	11
3	0	1
2	0	4
8	5	19
9	0	23
4	2	5
18	1	4
2	2	2

Question 2: When did it take place?	
i can't remember	few weeks ago
Idk spring semester	in march i think
Middle of spring	In the spring.
Spring Semester	Last month maybe?
February	March
idk	Mid spring semester
last month	No clue
last month	Second semester
February	Spring
Feburary or March	February
idk	February
March	February
?	February
beginning of April	February
February	February
February	February
I don't know	I do not know
March?	in each building
April	
earlier in second semester	
I don't remember	

Begining of April	
Early in the spring semmester	

Question 3: When did it take place?	
i can't remember	I don't remember
Idk spring semester	Begining of April
Middle of spring	Early in the spring semmester
Spring Semester	few weeks ago
February	in march i think
idk	In the spring.
last month	Last month maybe?
last month	March
February	Mid spring semester
Feburary or March	No clue
idk	Second semester
March	Spring
?	February
beginning of April	February
February	February
February	February
I don't know	February
March?	February
April	February
earlier in second semester	I do not know
	in each building

Question 4: What was the name of the competition?	
i can't remember	I don't remember
Not sure	Safe the world shrug
Which house could have the highest recyclables	
Who could turn the lights off at all times	I don't remember
EcoThon	I don't remember.
idk	I dont know
Ecothon	I Dont Remember
I have no clue	IDK
i can't remember	Eco-Thon
I don't know	Eco-thon
idk	Eco-thon
Weigh in to Win	Eco-thon
? It honest	Ecothon
Eco-thon	Ecothon

I don't know	Ecothon
Penny war	Ecothon
Recycling Roundup	Ecothon
sustainability	Ecothon
Ecothon	recycle your ass off

Question 5: How did you check standings to see how your residence hall was performing?				
Touch screen dashboard (Henry Hall)	Internet dashboard/ Western View	Both touchscreen and internet dashboard	Other	Custom Responses
2	0	0	2	I didn't know where to find our standings
				i don't know
0	0	0	2	Hall director
				idk
0	0	0	2	I didn't
				no clue
1	0	1	3	I couldn't
				I didn't. I just know it happened
2	0	0	0	I didn't
				I didn't know that we could
				updates from RAs
				updates taped to front desk
0	0	1	1	(left blank)
1	2	3	12	An RA in my building was posting the standings on Facebook
				asking staff members
				Hall posters
				I didn't check standings
				I didn't know there was a way to check.
				I didnt
				My Hall Council
				none
				Online
				Poster
				Poster board outside Ackley dining hall entrance
				word of mouth
0	1	0	1	Did not care to check

Appendix B

Figures

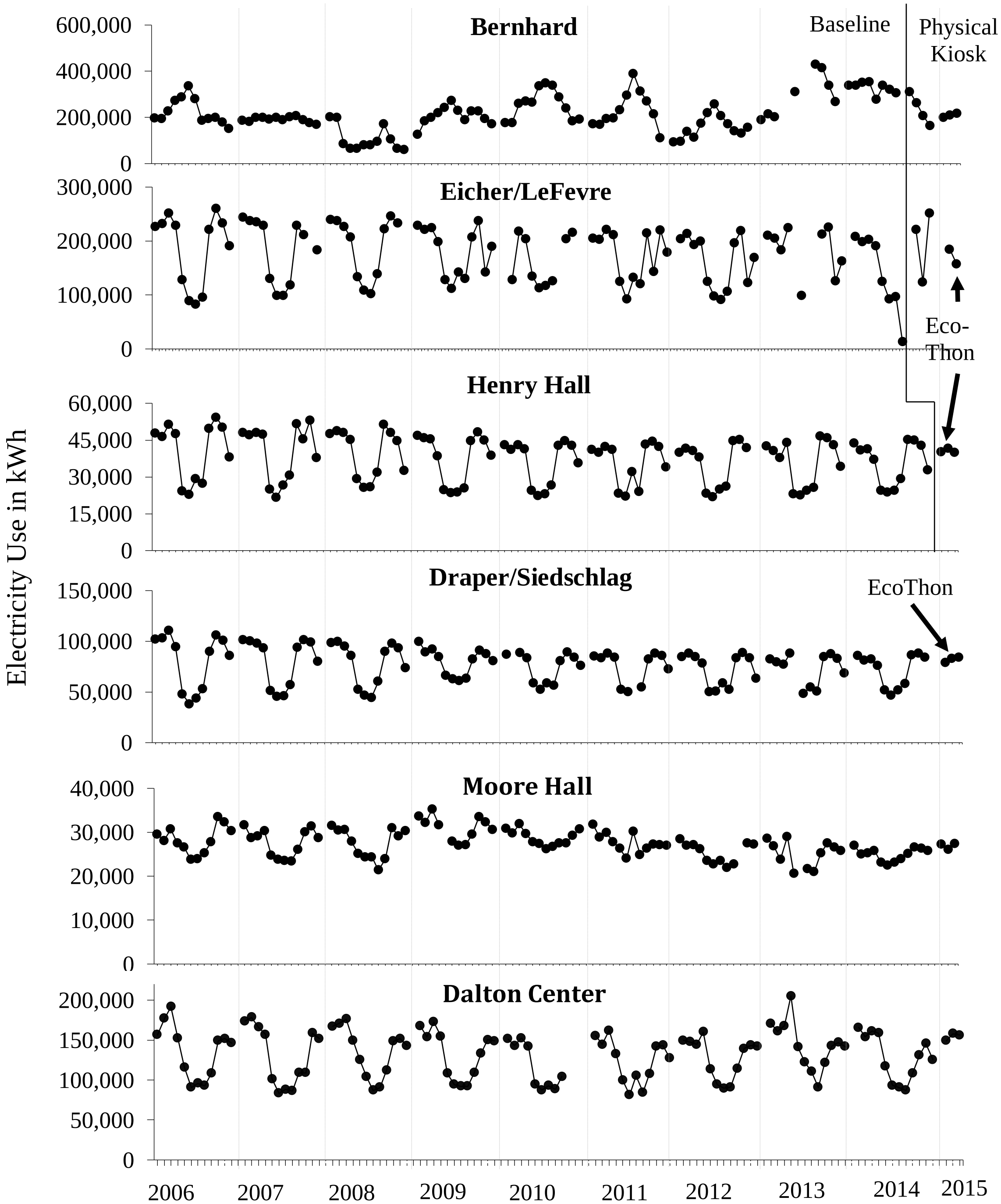

Figure 1. Consecutive Monthly Electricity Use

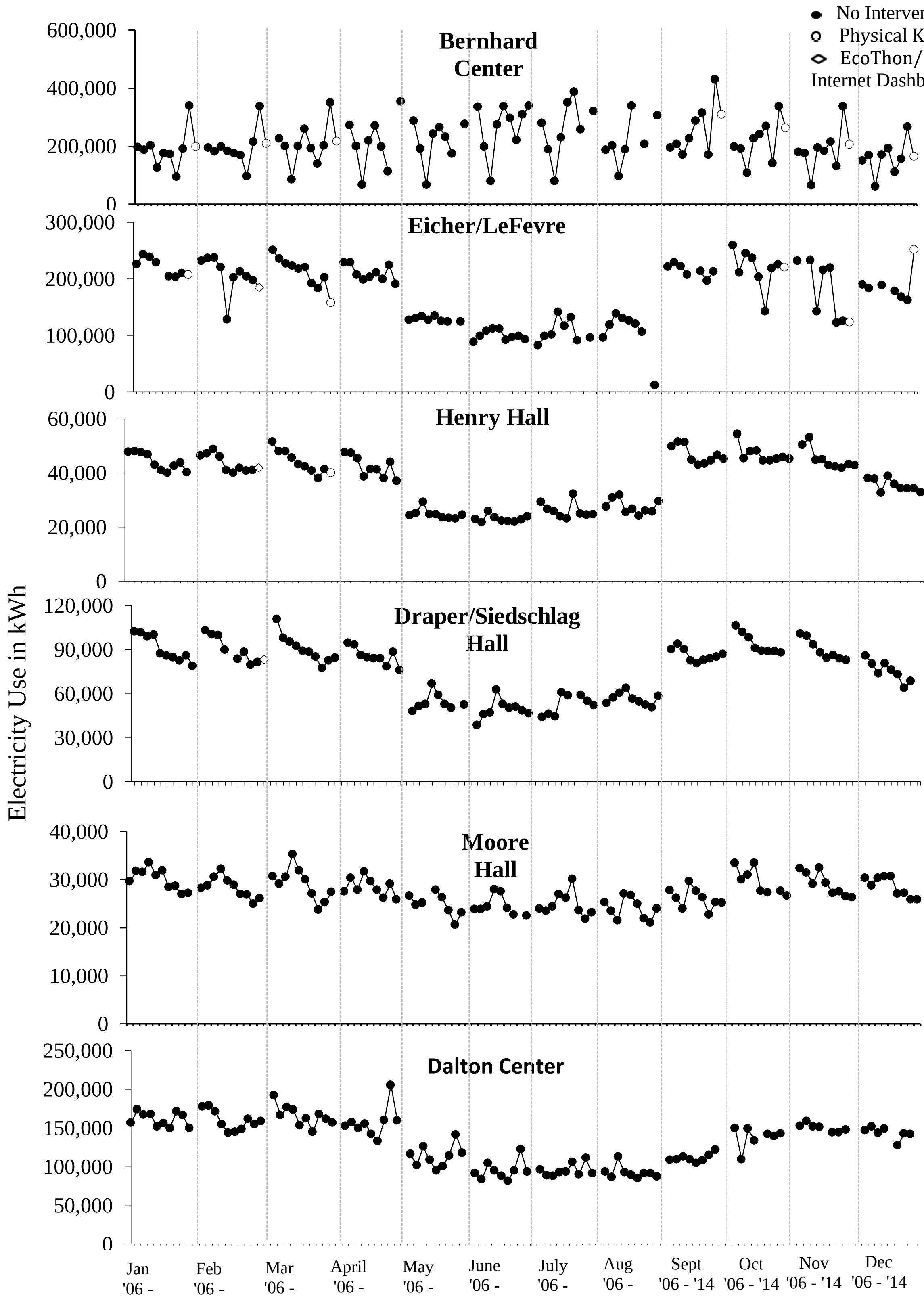

Figure 2. Monthly Electricity Use Grouped by Month

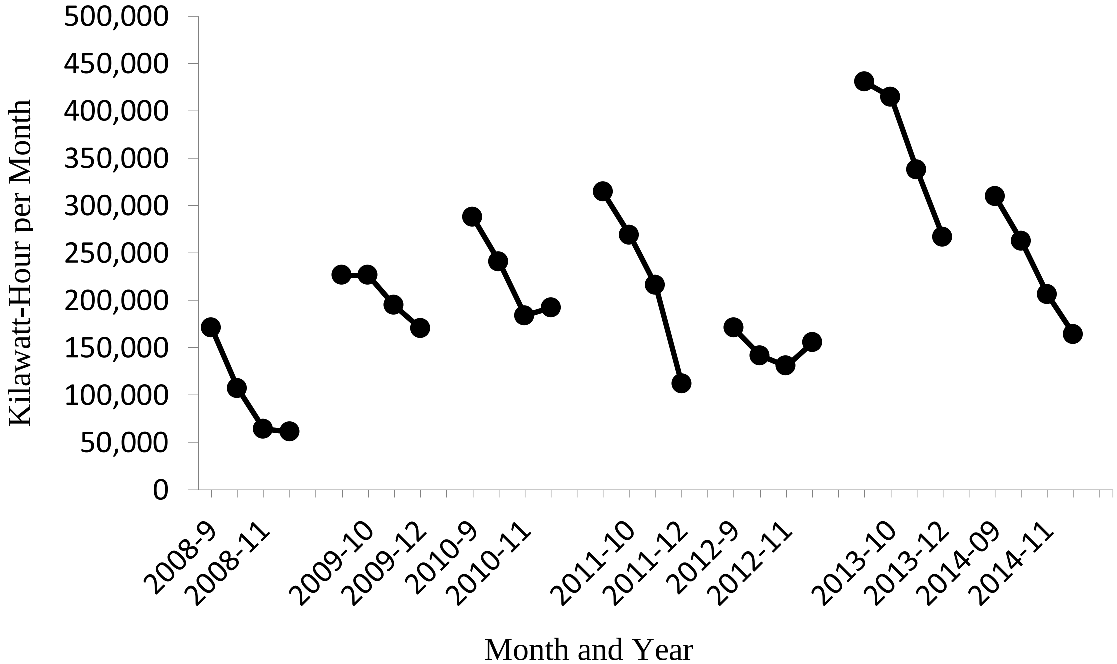

Figure 3. Electricity Use for the Months of
September through December in Bernhard

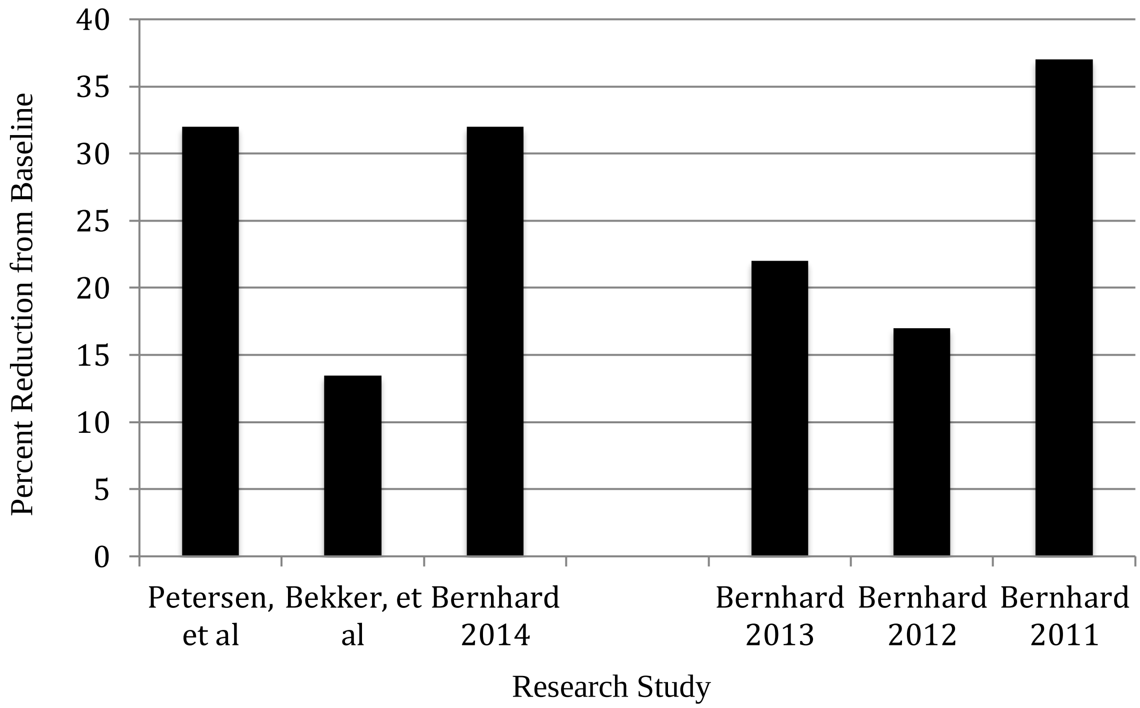

Figure 4. Comparison of Intervention Effect Sizes

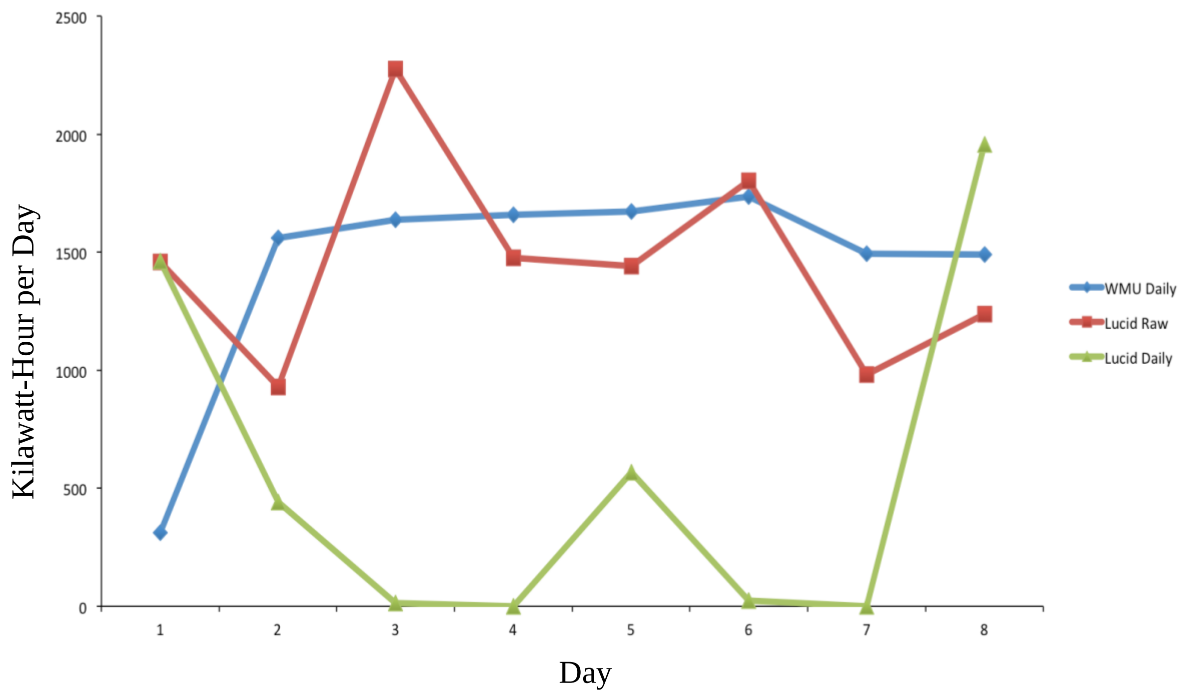

Figure 5. Comparison of Data Sources