Empowering Energy Efficiency: Reducing Energy Consumption in Student Housing at George Washington University

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Abstract

Although everyone knows that energy usage contributes significantly to greenhouse gas emissions, reducing energy consumption continues to pose a challenge to communities around the world. This research aims to analyze how informational campaigns may impact individual energy use habits. Reported below are the results of an intervention to reduce energy consumption in George Washington University student housing. (Energy and electricity are both used interchangeably in this report and refer to the kilo-Watt hour usage by individuals and buildings.)

This project was conducted in three stages: initial research and preliminary energy data observations, implementation of informational materials and gathering experimental data, and analysis of changes in energy consumption. Within JBKO Hall and Fulbright Hall, the two experiment dorms, there were different levels of intervention. In JBKO Hall magnets with facts on energy-saving habits were distributed, as well as posters with more in-depth information on reducing energy consumption. Fulbright Hall received only posters (Figure 1.1 and Figure 1.2). The data showed that JBKO did have a decrease in energy usage from January to March, showing a correlation between the timeline of educational material disbursement and the subsequent change in energy use patterns. Further research is needed to determine if the intervention was the cause of the drop in energy usage or if the impacts on electricity use require systemic, technological change.

Introduction

Background

Energy is invisible, but it is all around us. From solar panels to light bulbs, changes in energy usage can originate from sources far and wide, but one key question remains: is energy consumption determined by structural or individual drivers? In recent years, GW has made significant progress towards a more energy efficient campus. Our project seeks to discover whether influencing individual habits to be more energy efficient will lead to further reductions. Addressing this problem is important to determine whether GW would be better off pursuing structural solutions to reducing energy use or if behavior change will be sufficient to address the underlying problem of the Foggy Bottom campus' energy usage.

Problem Statement

A lack of transparency surrounds energy consumption and technological infrastructure within the dormitories at George Washington University, specifically on the Foggy Bottom Campus. Generating electric power is known to be the second largest contributor to total U.S. greenhouse gas emissions with a twenty-five percent share ("GW Named," 2019). While people have become more aware of the dangers of GHGs, current trends in electricity and energy use do not reflect the urgency of this global problem. Having made commendable strides in energy efficiency, George Washington University's commitment to sustainability should be further reflected in the attitudes and actions of its faculty, staff, and students, rather than administrative decisions to install energy efficient devices. Therefore, the university and its students need to address energy use in GW's dormitories and find ways to lower it.

Purpose and Objective

The overall goal of this project is to reduce energy consumption on campus and to promote energy-conscious practices within the student body. We will address energy use in GW's dormitories by analyzing the preexisting data from the last five years, distributing informational materials to teach students about sustainable habits that can reduce overall energy usage, and investigating whether these efforts have changed energy use trends.

Scope

The scope of the project strictly focuses on on-campus student housing. More specifically, choosing three dorms to be the focal points of research. Munson Hall served as the control, in which there was no intervention to create the baseline for tracking students' current energy habits. JBKO Hall and Fulbright Hall were the two test buildings. In JBKO, posters were hung, tabling with hand-outs was carried out, and educational magnets were distributed to each student room. In Fulbright, student residents engaged with the material through posters and tabling but were not provided magnets. To track any potential changes, data that covered the last five years of electricity data in kWh were utilized. Our primary focus in this report is energy statistics, however, information provided by other data could be employed to explain possible irregularities or data trends.

Literature Review

The goal of this literature review is to provide a theoretical background for the foundation of this project as well as to demonstrate the previous studies that have been conducted on energy use in dormitories.

Theory of Planned Behavior

The first study conducted by Dr. Jia Du and Dr. Wei Pan at the University of Hong Kong examines how internal factors, such as student behaviors, impact energy consumption. The report utilizes the framework of the Theory of Planned Behavior. This theory assumes that most individuals will follow their personal moral norm, which refers to one's sense of moral obligations. In other words, individuals will act in accordance with what they believe to be morally right (Du & Pan, 2020). This personal moral norm is an added layer to the idea of a subjective norm, which is what individuals assume are socially obligated of them, based on other peoples' opinions. In addition to this personal moral norm, there are two other factors that motivate individuals: attitude and perceived behavioral control. Attitude refers to the way in which an individual views a certain behavior (Du & Pan, 2020). Do they think it is generally good or bad? Perceived behavioral control is how difficult a behavior will be to do (Du & Pan, 2020). This also includes the resources available that make this behavior easier to implement. For example, if someone is trying to determine which sustainable habits are easier to implement, having to drop off compost weekly is more difficult compared to turning the lights off after leaving a room.

This study highlighted two major limitations to data on energy consumption habits. First, there is a general lack of research on the habits that motivate individuals to act sustainably. Second, there is a research gap specifically exploring these behaviors within student dormitory housing. However, the results of this study concluded that individuals' personal moral norms have a significant influence on students' intention of energy saving habits, even more than perceived behavioral control and attitude.

Additionally, based on this conclusion, the study offered recommendations for ensuring long-term energy saving habits. The first was the implementation of individual feedback systems, which would allow students to directly see how their choices could reduce overall energy usage. The second was the implementation of educational campaigns that help to provide students with the knowledge necessary to act more sustainably.

Energy Transparency

This second study was conducted at University of Oberlin to test how information feedback can result in more environmentally conscious choices in student housing. A key foundation for this study is that up to 50% of residential energy use is dependent on individual activities and choices (Peterson et al., 2007). Additionally, the underlying theoretical framework is the idea that many do not experience the direct impacts of their daily choices. Thus, this study began with the idea that students will not change their habits to be more energy-friendly unless they can understand the direct consequences and connections of their behavior to the environmental outcomes.

In this experiment, a data monitoring system was used to provide students with feedback to their energy usage choices. Some key findings determined that with these feedback systems, coupled with educational campaigns and incentives, there was a 32% reduction in electricity use (Peterson et al., 2007).

The results of this research provide evidence that real-time resource feedback systems, when combined with education and an incentive, can motivate college students to reduce their energy usage in dorms.

Key Takeaways

These two studies both demonstrate that students are willing to change their habits, if provided with the resources to do so and the information on how to implement these practices. Another important conclusion is the significance of energy transparency. Energy is invisible, and students need to see and understand how their habits can make an impact. Additionally, these studies both provided strong evidence for further exploration of energy efficient habits in student housing specifically. This research paper aims to tackle the first issue, regarding the lack of resources and information about energy efficiency.

Methodology

This project utilized a combination of qualitative research and experimental research methodologies. First, the project chose three dorms on the Foggy Bottom campus to compare based on previous data and specific criteria to evaluate the similarity of buildings including their existing technology, individual dorm floor plan, full building size, and years built. The technology criteria included aspects such as the availability of kitchen appliances, updated light fixtures, and other school-provided technology that may impact energy use in the dorms. When examining the dorm floor plans, the size of the rooms, including how many bedrooms are available, the unit size (L x W x H), whether it has a kitchen, and how many residents are slotted to inhabit the space were considered. Lastly, the size of the building, including how many floors the building has and how many rooms per floor contributed to the assessment. As seen below, the buildings were found to have the following comparisons:

Criteria	**Munson**	**JBKO**	**Fulbright**	**Closest Match**

In-Dorm Kitchen	Yes	Yes	Yes	ALL
Year Built; Year Renovated	1945; 2018	1945; 2018	1950; 2016	Munson & JBKO
# of Bedrooms/Unit Type	76% Studios, 24% 1-bedrooms	88% Studios, 12% 1-bedrooms	Studio	Munson & JBKO
Square Footage of Entire Dorm (Avg. & Approx.)	400 sq. ft- 600 sq. ft	500 sq. ft- 1500 sq. ft (depending on room type)	530 sq. ft	Munson & Fulbright
# of Residents in Dorm Unit	82% 3-person, 18% 2-person	76% 2-person, 21% 3 person, 3% 1- person	100% 3-person	Munson & JBKO
# of Floors in Building	8	8	8	ALL
# of Dorm Units per Floor	9	16	10	Munson & Fulbright

Note: Square Footage of Entire Dorm based on virtual tours (https://www.tours.vividmediany.com/3d-model/fulbright-studio-4person/fullscreen/) using the measurement tool on the overhead floor plan and then plugging the results into Chat GPT to do the square footage calculations.

The two buildings that have the closest compatibility in these aspects are JBKO and Munson which were decided to become the full experiment and control buildings respectively. Fulbright's similarity to both JBKO and Munson allowed it to act as the secondary experiment building.

During the dorm experiment, the amount of educational material the students received during the trial period of February 12th - February 27th served as the independent variable. The dependent variable was the amount of energy usage during this same trial period. There were different amounts of educational material provided to the two experimental dorms - JBKO received hung and distributed posters and distributed magnets, while Fulbright only received posters in the common areas and through tabling. The difference in material between the two test buildings also allowed us to observe whether the amount or type of educational material provided impacts students' energy habits.

To create this educational material, action items and facts that students would be able to easily incorporate into their daily routine were researched. This included actions such as unplugging electric cords over long breaks or turning off the lights after leaving a room. It was deemed useful to create a complimentary hand out to provide a justification as to why students should care about implementing these changes.

Figure 1.1

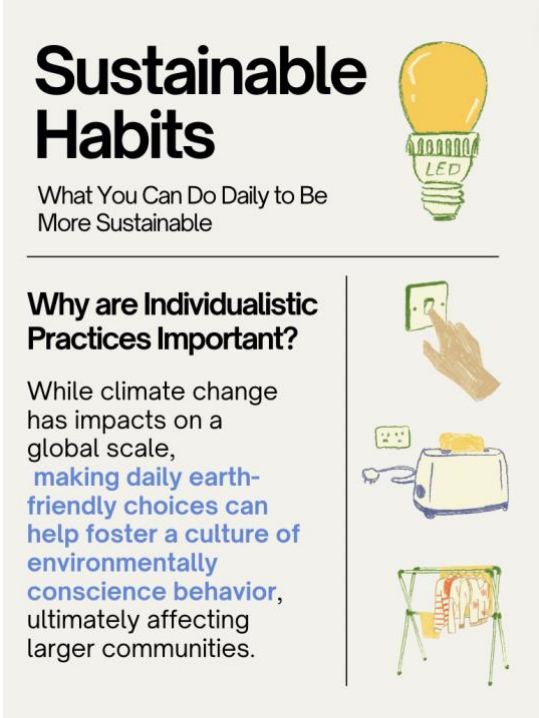

Figure 1.2

Implementation of Initiatives

The initial phase of the implementation strategy involved posting informative posters within the experimental dorms', JBKO and Fulbright, hallways. The Figure 1.2 poster explains why individualistic energy habits are important, emphasizing that daily earth-friendly choices can foster a greater culture of sustainability. Another poster, represented in Figure 1.1 provided students with practical tips to integrate such activities into their daily routines, including suggestions such as turning off lights, optimizing laundry habits, and unplugging idle electronics. The deployment of these posters was conducted on February 13th.

Next, the team engaged in direct outreach efforts in JBKO via the distribution of posters and magnets- which bore short, informative phrases such as "Save Energy, Save the Planet" and "Switch Off the Lights" next to engaging and memorable icons. These magnets were designed to accompany the message conveyed by the posters and facilitate an associative connection

between the two elements, reinforcing the overarching sustainability initiative. This was conducted on February 20th.

A similar outreach approach was used in Fulbright. However, this initiative exclusively focused on the distribution of posters without accompanying magnets. The posters retained the same informational content and icons. This measure was completed on February 27th.

Data Collection

Our quantitative data collection involved analyzing five years' worth of energy building data from January 2019 to March 2024 to examine the changes in overall energy consumption. The energy data was measured in kilo-Watt hours.

There was additional passive qualitative data collected throughout the course of this trial. While tabling took place, only a few individuals chose not to engage with the table at all. However, there were many who came up, asked questions, engaged with the handouts, and actively listened to the spiel given to explain the purpose of the handouts. For example, one student mentioned that they had reminded their roommates to unplug their appliances before spring break after seeing the information on the handout (figure 1.1). Another student commented on the fact that they were excited to see more environmental and energy-saving initiatives taking place in their own dorm, elated to engage with the table and handouts to learn more.

Results and Discussion

Pre-implementation Data

Since 2020, JBKO has followed a specific pattern where energy usage would decrease from January to February, and then increase from February and March, as seen in Figure 2.1. Munson and Fulbright both had no discernable trends in their energy usage data, as determined by Figures 2.2 and 2.3. Looking at Figure 2.4, the period from 2019 to 2023, Munson had overall the lowest average energy usage, while JBKO had the highest. Fulbright fell in between those two averages. Nothing during the research period explicitly explained these trends or the differences in building energy use as seen in Figure 2.4.

Another key trend to highlight is the data during the COVID-19 pandemic. Throughout Figures 2.1, 2.2, and 2.3, the data are shown by the red line. As students at GW were online during the 2020-21 academic year, the energy data for this period is significantly lower than the other years, making the line an outlier to any data trends. Due to the fact that students were not on campus in these buildings, there were no behavioral influences that could impact the data during this time period.

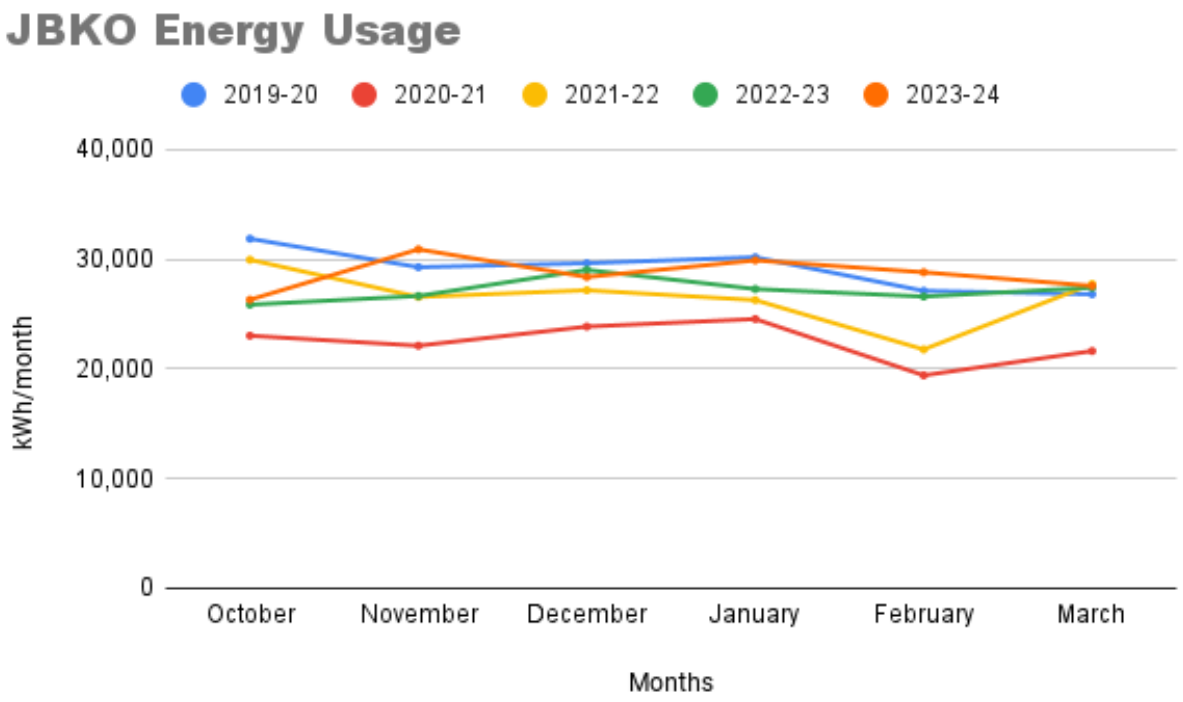

Figure 2.1

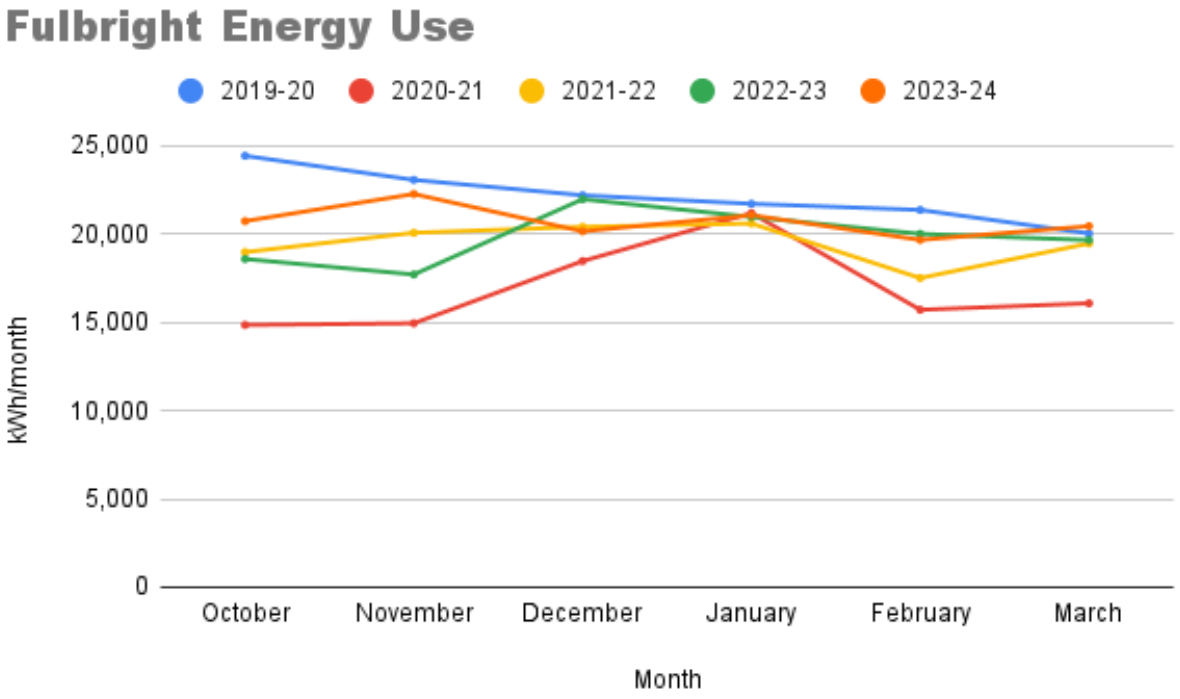

Figure 2.2

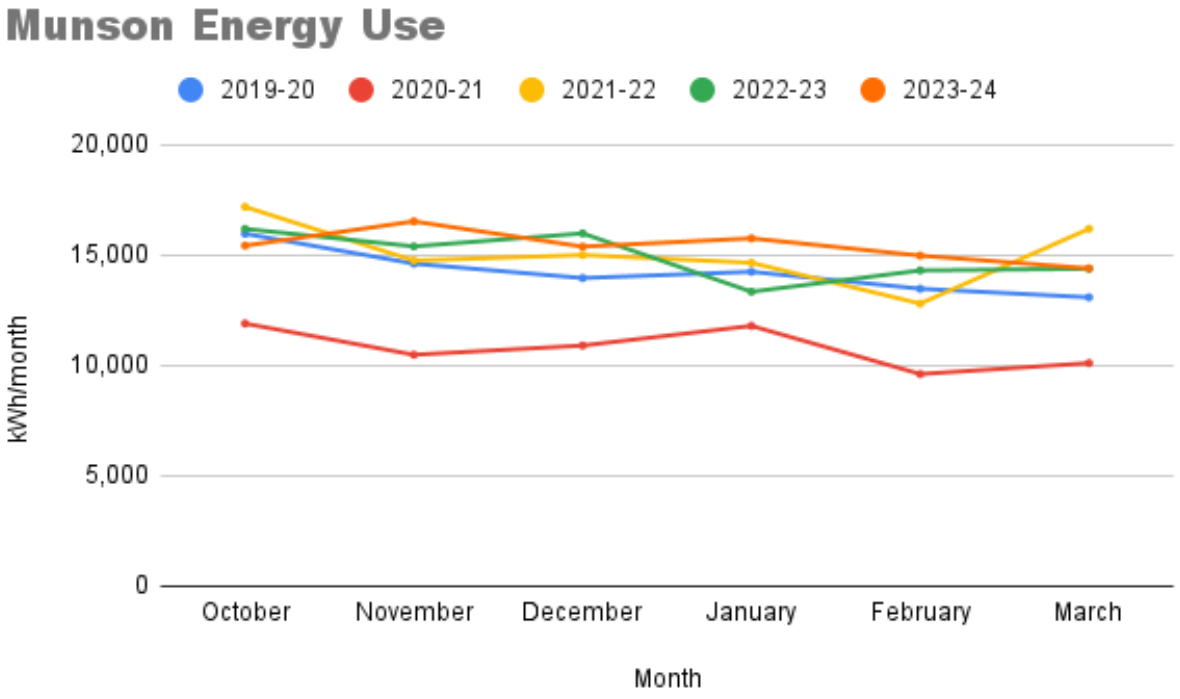

Figure 2.3

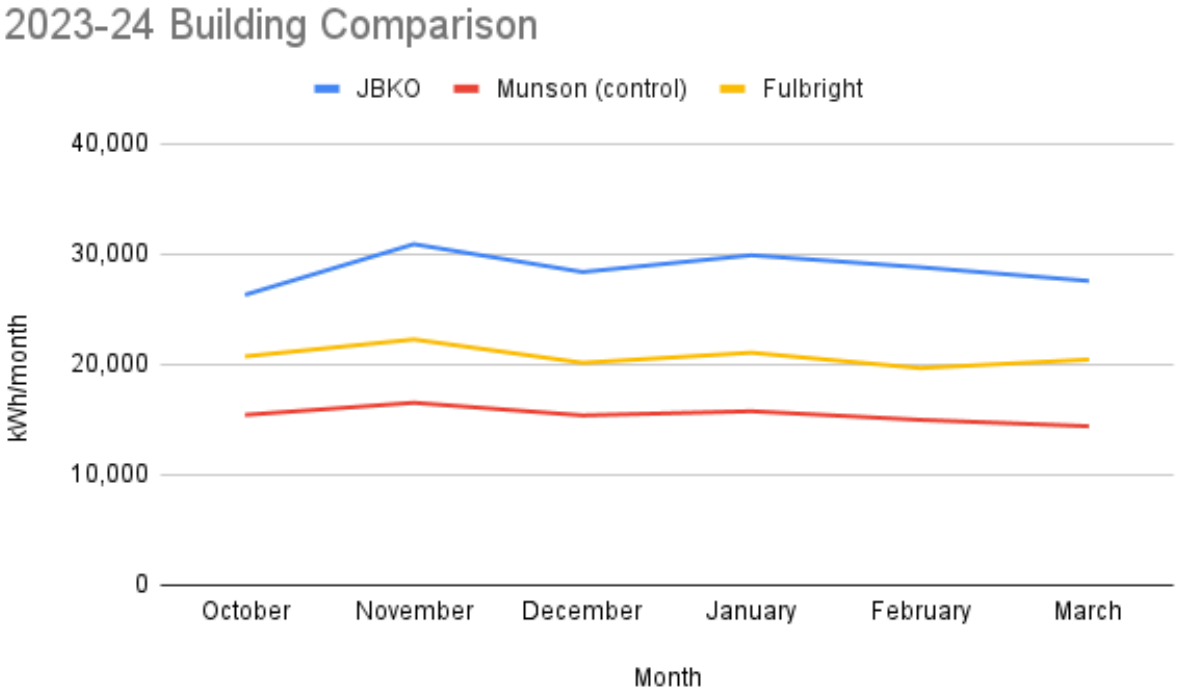

Figure 2.4

Post-implementation Data

Analyzing the patterns in energy data, the most notable result was that JBKO's energy trend decreased from January to February, which was before intervention began. This trend continued from February to March, a different pattern than the data had shown before, therefore creating a correlation between this project's initiatives and the reduction in energy usage in the dorm. It should be noted again that Munson and Fulbright both had no pattern once again, possibly demonstrating that the interventions in Fulbright were not effective enough or that external factors played into the results.

Interpretation of Results and Implications

The data suggest that these educational interventions had an impact on the energy consumption in JBKO. Specifically, deploying magnets, educational posters, and flyers throughout the building improved student energy habits during this semester. There were no clear results from Munson or the other experimental dorm, Fulbright, making it difficult to conclude that the interventions were the specific cause of the downward trend in energy consumption. In other words, there was a relationship between the initiative timeline and the reduction of energy usage in JBKO, but it cannot be determined that these interventions were the cause entirely. In order to make this conclusion, it is advisable to continue another semester of this project to gather and observe a longer period of data.

It should also be noted that the main difference between Fulbright and JBKO interventions was the use of magnets for students' fridges. This specific method of knowledge disbursement, connection-driving, and habit reinforcement could be particularly impactful for future iterations of this experiment.

Limitations

Time Constraints

There are several limitations to consider in this experiment. First, the implementation of educational material began in early- to mid-February and the data collection lasted from this date to the end of March. However, March 11th to March 15th was spring break for all students. Therefore, there was most likely a large amount of the students out of town for this period, which would result in the energy consumption going down.

Additionally, the study timeframe was only a total of two months, which only accounts for the short-term effects of the educational initiatives. It is most likely that an educational

campaign only has short-term impacts on student energy habits. A longer-term study would need to be conducted to test how to permanently reduce energy consumption. This issue coincides with the fact that different students move into the dorm each semester, meaning the interventions would need to be conducted frequently to have a sustainable impact.

Number of Students

As of this academic year (2023-2024), JBKO has 261 residents. In the past two years (2022-2023 and 2021-2022) JBKO had 239. Even though the number of residents in this dorm has not been constant, the data looks at decreases comparatively to the months before, not comparing total data from each year. With this in mind, the data from March 2024 had continued to decrease since January 2024, whereas in previous years this pattern was not evident. Since the data is only looking at whether or not there was an increase or decrease, not necessarily the total energy usage, the number of students is not a huge limitation to the accuracy of the data.

Climate and Weather

As climate change worsens, global warming of the planet has led to increasingly warmer years, summers, and winters. Global temperature increases can cause dorm buildings to run their AC systems further into transitional seasons or turn the systems on sooner than previously expected. This consideration offers a reason as to why total energy use may increase over the years. Outside of climate change, seasonal variance in temperature and weather must also be accounted for. As this report looks at an October to March timeline, it is important to note that the fall and spring seasons have relatively similar high and low temperatures, albeit the fall season is leading into colder temps while the spring season is leading into warmer temps. The winter season, in-

between these, relies on heat which, depending on the technology, can be produced by gas, not just electricity. This takes the load off the electric grid, but the gas usage increases. Air conditioning usually relies on electricity. This study can then be limited due to the use of gas to supplement electricity to provide heat, thereby reducing overall energy use in those seasons. This limits the study as it is not possible to calculate the exact amount of energy that was supplemented by gas usage.

Lack of Technology Information

Given the sheer amount of different energy objects both at-large and small, personal items, the research team was unable to get a full picture of the breadth of technology in the dorms that utilize electricity. Considerations include the types of lightbulbs, the number of lightbulbs in each room, and kitchen appliances, both those provided by the university—including the fridge, stove, oven, and microwave—and those brought by the resident, such as toasters, coffee makers, and air fryers. Technology that must also be considered include, but are not limited to, temperature control, A/C units, whether there is central air or heat technology, window efficiency (at trapping hot and cold air), and outlet efficiency. All these potential technology variations as well as the sheer number, types, efficiencies, size, and age, to name a few, pose limitations in comparing the data between these buildings.

Lack of Clear Trends in Data

The final limitation in this study takes the form of unclear trends in the data. This makes it difficult to draw concrete conclusions and can necessitate a larger sample size or more data collection. However, it can be said that no trends could be equal to a trend. There is too much

variability to make definite or precise claims, which demonstrates the need to collect more data before drawing conclusions.

Conclusion and Recommendations

The purpose of this study was to test how informational and educational campaigns can impact individual energy habits in GW student housing. The energy data from the past five years show that JBKO energy usage decreased from January to March for the first time since 2020. Typically, this data would decrease from January to February, and increase from February to March. These data demonstrate that there is a correlation between intervention and energy use, but not necessarily a causal relationship. For the initiatives to be proven as the main cause, it is necessary to continue this experiment for another semester, and test to see if there are similar results. Preliminary qualitative data suggests that student behavior can be influenced by magnets and other material and some students may already be reducing their energy use.

However, knowing that these simple posters and magnets were able to make a possible difference is extremely valuable to the future of energy conservation at GW. Energy is invisible, but it is present everywhere. An important part of reducing energy is making it visible, whether that be through educational materials or real energy data. Moving forward, it is imperative that GW makes more effort to communicate its energy usage to the students, as this can help them see the direct impacts of their individual actions on overall energy consumption. Most importantly, it is necessary to provide students with the tools and information they need to make the most energy-conscious decisions, which is what this project aimed to achieve. With further research into next semester, this study will expand on its initial findings and provide a more comprehensive conclusion on how individual student habits can play an important role in overall

energy usage or how GW can implement systemic technology infrastructure to curb electricity use.

In the extended study, future research should include a lengthened initiative timeline for further quantitative data collection. While educational initiatives are being carried out as well as after these efforts have concluded, there should be qualitative data collection taking place in the form of before and after surveys, questionnaires, and focus groups. With extra data to consider, multiple regression, statistical analysis, and other comparison charts created through R or other coding tools would help to draw sturdier conclusions and provide other visualizations. It would also be valuable to compare the gas use data with the electricity data to paint a larger picture into how gas supplements energy use. There should also be an inventory taken of the technology and energy resources used in each building and owned by GW. This would allow for further analysis into the impact of technology on energy data and usage. These additions to future research efforts would add substantive and valuable information and assertions to the evaluation as well as conclusion of the report.

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