Saving Energy by Behavioral Changes

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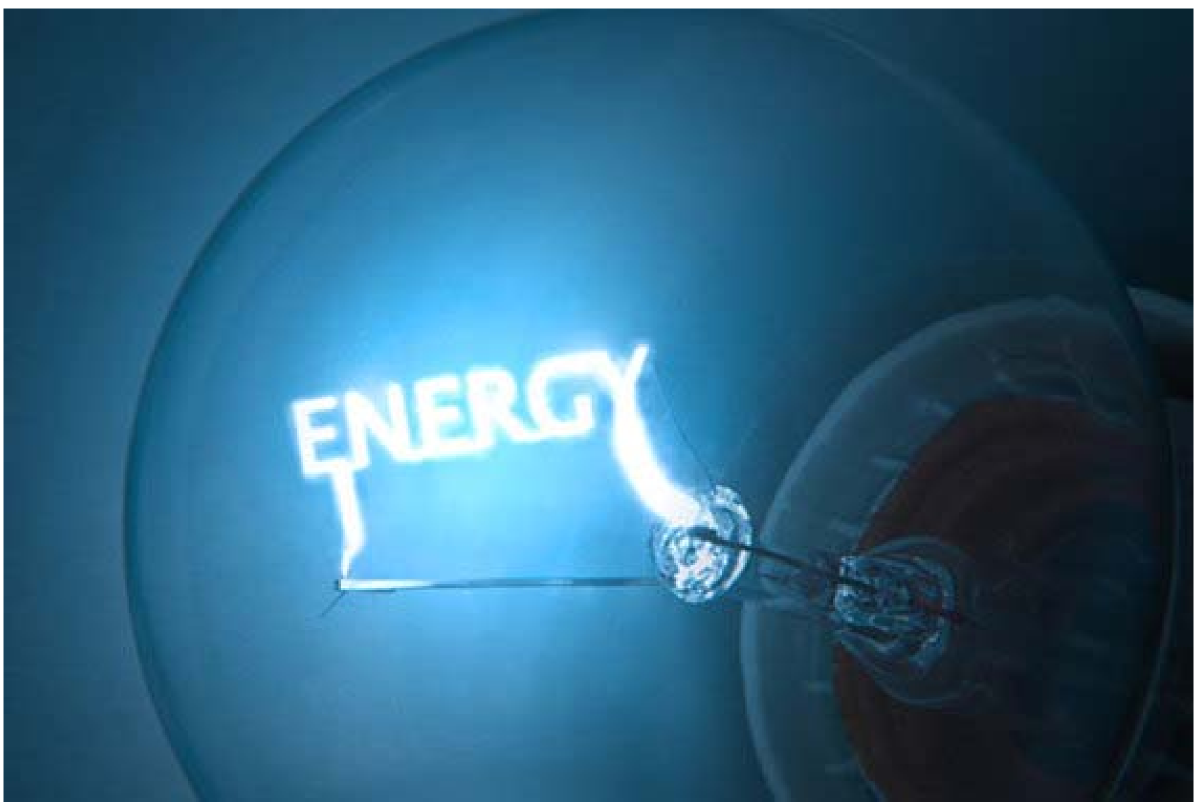


Introduction

We all know saving money is good. But what about saving energy when it comes to college campuses? How do you go about making changes to bring about a good amount of savings? You can always make changes to the infrastructure and the pieces of equipment that become outdated as years go on. Those things end up costing a lot of money to start and then years later you run into the same problems updating out of date equipment. So why not make a change in an individual person’s behavior, a change that helps promote energy savings. Now, if we can get a mass involvement in this type of change on college campuses it will not only help save energy now, but also promote behavior change to last.

So how do we go about making these types of changes? First, we want to see how much energy savings are possible through some behavioral changes. We can do this by looking at experimental practices other colleges have tried, see what their programs have saved and estimate what a behavior program will save here at K-State. The next step is to look at what the best practices are in order to start programs that will create behavior changes and save energy on a campus setting. Finally, we want to look into ways to put a tangible measurement on the potential savings from the desired behavior changes. We can look at how other campuses behavioral energy savings programs actually got this measurement and their results. Reviewing successful changes that have been made at other universities would be a good place to begin. Another option would be to conduct our own experiment here on campus and observe those results. This is definitely a different approach to saving energy on a campus setting and there are some obstacles to overcome, but in the end I think we as a collective can make a difference and save energy.

Research Review

Question 1: *How much energy can we save from behavioral efforts on campus?*

The goal of question one is to find what the potential energy savings are through the creation of behavioral changes on a campus setting. In order to do that we researched how much energy is being used by certain appliances that are found in different campus buildings. This chart from Tulane University ("Energy Star Chart" 2013) does a great job of breaking down the appliances that are in some dorm rooms. There are two categories of appliances, Energy Star appliances and non-energy star appliances. They showed the number of hours ran, how much energy is consumed by each appliance in kilowatts and then found the cost of using those appliances in dollars per kilowatt-hour. They also showed what it would cost in a year, which was based on 9-month average and 3600 students. As you can see, by using energy star appliances it only cost about 70,000 dollars vs. 131,000 dollars for the non-energy appliances

Tulane University ENERGY STAR Showcase Dorm Room, 2008							
		Energy Star Appliances		Non Energy Star Appliances			
Appliance	Estimated Time Running	Energy Used*	Cost to Run**	Energy Used*	Cost to Run**	Savings	
	Hours (Active/On/Standby)	kWh (Nine Months)	$ (Nine Months)	kWh (Nine Months)	$ (Nine Months)	Dollars	Lbs of CO2***
MicroFridge Model MF-3TP	24 Hours	217.50	21.29	274.50	26.87	5.58	87
Lenovo ThinkPad X61 Tablet computer	1 Hour / 2 Hours / 6 Hours	20.79	2.03	24.84	2.43	0.40	6
Lenovo ThinkPad X61 Tablet computer	1 Hour / 2 Hours / 6 Hours	20.79	2.03	24.84	2.43	0.40	6
Canon PIXMA MP530 All in one printer	.5 Hour / 1 Hour / 4.5 Hours	21.14	2.07	45.75	4.48	2.41	38
GE-Jasco Floor Lamp	5	31.05	3.04	135.00	13.21	10.17	160
GE Soft White 60 CFL Light Bulb (2)	5	40.50	3.96	162.00	15.86	11.89	187
GE- Jasco Desk Lamp	2	37.26	3.65	54.00	5.29	1.64	26
Panasonic SC-PM23 Executive Micro Audio	2 Hours / 2 Hours / 20 Hours	18.90	1.85	48.06	4.70	2.85	45
Sharp DKA1 i-Elegance Music System	24	9.07	0.89	25.92	2.54	1.65	26
Panasonic 5.8 GHZ Cordless Phone	24 Hours	16.43	1.61	25.79	2.52	0.92	14
	Total For One Room (2 person)	**433.43**	**$42.42**	**820.70**	**$80.33**	**$37.91**	**594**
	Total For One Person	**216.71**	**$21.21**	**410.35**	**$40.16**	**$18.95**	**297**
	Estimate for all 3257 students in residence halls		**$69,085.96**		**$130,814.36**	**$61,728.40**	**968,073**

*Average for one school year (nine months) =(W/1000)x(hours on)x(30 days)x(9 months)
Estimates for Non Energy Star Appliances based on averages obtained from Energy Star. For Energy Star appliances, both ES averages and model-specific figures are used.
** Energy Used times Tulane's May 2008 electricity price ($.097878/kWh)
***Uses a national average of 1.535lbs of CO_2/kWh.

The results show that nearly fifty percent savings are possible by simply being consumer conscious. If we can get students to either limit their usage of these appliances or switch to energy star appliances, it would help the university save money. The fact that these kinds of savings are possible by switching appliances puts emphasis on creating individual awareness.

So what things can be done to help us save money? There was another article (‘Energy conservation initiative draft report’2008) from the St Mary’s college of Maryland. They looked at a couple of behavioral ideas that are based off simple training programs. One path they chose was looking into bad behaviors we do like not turning off lights, taking too long of showers, turning off our power bars and habits of that nature. They discuss putting in an incentivized training program that would be in collaboration with the psychology department. They estimated the operational costs to be about 400 dollars a year. The authors hypothesized that if they could get at least 10 percent of students to take shorter showers potential savings could be $6,600 a year. Changing the electricity-based energy wasting behaviors, like turning off lights and power bars, could save at least 2400 KWh which turns into only saving $264 a year, also at 10% participation. As you can see, that is only 10% of students. If we could make these types of training programs mandatory, or simply include them into freshman orientation, participation rates would be directly affected. After practicing this for a number of years in succession the savings would only increase.

Another area they looked into was changing student’s washing machine habits. They estimated it would cost $2000 dollars to set up a program and they would end up saving $11485 dollars a year, so after a couple years we would be seeing savings. They put the dryers into consideration as well. If they could get students to use clotheslines instead of dryers it would cost about $1000 dollars to initiate and it would actually end up saving about $4,400 dollars a year. This is how they got the estimate

Cost:

10 clothesline at $100 each = $1,000

Annual Resource Saving

: 15% x 48 electric dryers (3,400 W) used 6 hours a day x 270 days = 39,658 KWh

Annual cost saving

: 39,658 KWh x $0.11/KWh = $4,362 ("Energy conservation initiative draft report",p33)

We can see that there is some research into the best ways to save energy by trying behavioral changes instead of infrastructure changes that can be costly.

Another approach to savings was real time visual feedback with an incentive reward system. One study, *Dormitory residents reduce electricity consumption when exposed to real-time visual feedback and incentives*, found that they were able to save about 69,000 kWh, which came out to be about $5,200 dollars in saving.

Question 2: *What are some good practices to encourage behavior changes for energy savings in a campus setting?*

The majority of research done in the past on the subject of changing social behaviors to be more environmentally sustainable has shown that education, availability of environmentally friendly options, perceived effectiveness of those options, and motivational incentives are key drivers in leading to a desirable behavior change. Economic incentives and reassurance that one's actions are making an impact are two important motivational factors. One of the studies we reviewed, *Environmental knowledge and other variables affecting pro-environmental [behavior]: comparison of university students from emerging and advanced countries* (Vicente-Molina et al., 2013) surveyed university students from one school in four countries. Two developed countries and two developing countries were selected (USA, Mexico, Spain, Brazil). It found that most of the independent variables stated later were significant to at least one of the countries. They were significant in that they had a positive effect on pro-environmental behavior. The indicators of pro-environmental behavior were recycling, public transit use, and green purchasing. ”Spanish students stand out for their recycling behavior, Mexican and Spanish students show a greater tendency to use public transport and USA students show far higher buying behavior than any of the others but are the least likely to use public transport. These patterns are probably due to the different cultural habits and structures that exist in each country.”(Vicent-Molina at al., 2013)The independent variables listed in this study were; attitudes, motivations, gender, academic discipline and number of environment-related subjects studied, informal education, and country-specific factors such as access to environmental structures and cultural differences. Also, pre and post survey environmental knowledge was measured and collected. The variables that were found to be significant were; pre-survey knowledge and post-survey knowledge, formal education, motivation, PCE, and gender. The most significant variables to all countries were pre- and post-survey environmental knowledge, motivation, and Perceived Consumer Effectiveness.

Since education is an apparent key variable in boosting ecological behavior, decisions need to be made on when people should be taught environmentally positive behavior. One study we reviewed showed that teaching young kids about human interactions with the environment and conserving its natural systems is very important to ensuring that the youth hold to their ecological values into the future (Spearman & Eckhoff 2012).

Another study shows that geographical location and size also play a roll. Town populations of 50,000 – 100,000 had higher environmental attitudes (Torgler & Garcia-Valinas 2006). Town sizes both larger and smaller had lower environmental attitudes. The authors hypothesized that smaller communities may not have enough funding or organizational power to start initiatives and the larger cities may be hard to motivate as a whole due to a more diverse population with different values. This study also noted that regional social and cultural differences play into effect, therefor, the authors supposed decentralization of policies would be more sufficient. Different regions require different needs, especially in a country the size of the United States. With the many different climates, terrains, and political attitudes of the U.S. decentralization of environmental policies is needed to have success. One model we found, The Corporate Sustainability Model, developed by Marc J. Epstein breaks down how different inputs into various aspects of a corporate system, with leadership being a central element, will create desired outputs. It should be noted that the authors put heavy emphasis on the leadership factor and how much it plays into causing an outcome (Epstein & Buhovac 2010).

BJ Fogg’s Behavior Model (Fogg, B.J.) clearly demonstrates the importance of applicable motivators and triggers when trying to create a desired behavior change and how these variables function together. Motivation is one of the axes of Fogg’s model. Some people will have personal motivators and goals in place to assist in accomplishing a certain task. Others will need incentive-based motivators. Reward based system are usually effective, but when trying to change environmental behaviors, the positive environmental impacts obtained from the behavior change should be tied into the incentive so the individual doesn’t get reliant on be handed a reward. Fogg states that the motivation variable can be broken down into three different types; Pleasure/Pain, Hope/Fear, and Social Acceptance/Rejection. The other axis on the model is ability. If someone doesn't have the tools at hand to fix a problem then we cannot expect anything to become better. So if we want to create a particular behavior change we have to be sure that most people can participate by considering all limitations (physical, time, money, social deviance, non-routine, brain cycles) that may prevent someone from participating in an activity and creating easy access to alternatives. The most important variable of the model is the trigger. Without a trigger no action will happen and no change will be made. Fogg also breaks this variable down into three other components or possibilities; facilitator, signal, and spark. The trigger can be anything thing from a sudden realization of what needs to be done, or it could be the construction of an alternative, less impacting way of doing things.

Question 2: How would we develop a highly effective campus-wide behavioral energy initiative?

The second part of our research question is, how do we get the behavior changes needed in order to increase sustainability at KSU? First Kansas State must define sustainability. Sustainability can be described in three ways, practiced in three areas; environmental, social, and economic. Some people like to separate the three into a Venn diagram insisting that each system can operate on its own, but we know that to be false. The economy cannot exist without society just like society cannot exist without a providing environment. Therefore, when thinking about sustainability and designing a master plan, all three realms must be considered in order to be effective. Moganadas et al. compiled definitions on campus sustainability from various sources to build his own comprehensive definition of systemic campus sustainability:

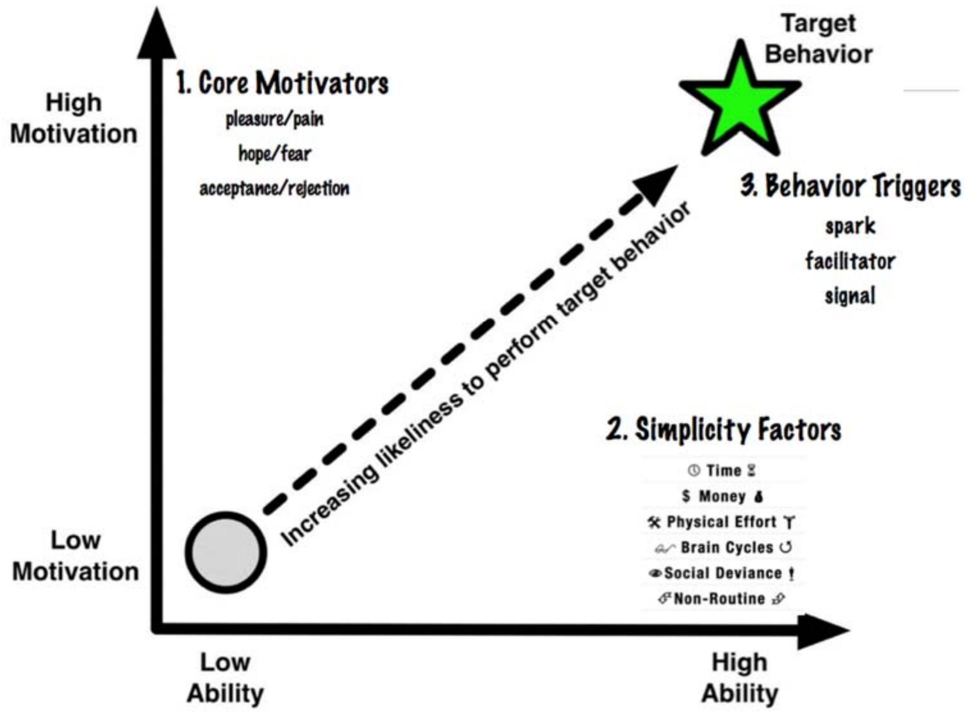
> "The capacity of an academic institution to explicitly recognize the responsibilities, advocate participation and integrate the functions of all its human resources, students, activities, processes

and stakeholders toward conserving and regenerating natural, human, social, manufactured and financial capitals for a continuous future." (Moganadas et al.)

After a specific idea of what sustainability means to K-State is created, we can then figure out how we want to get the student body and faculty to participate. Administration needs to know what aspects of K-State life and what behaviors need/can be changed in order to increase sustainability. For that, University leaders need to find out where the largest energy sinks are and what costs will it take to reduce or eliminate the waste. These areas of losses will vary from campus to campus. The issues can be related to infrastructure efficiency or lifestyle and educational accommodations. Our area of focus was mostly on personal energy consumption reduction and what variables may limit someone from reducing his or her impact.

Human behavior has long been a topic of great interest to social researchers. Behavior change has become an area of greater interest in recent decades. Recently, the Fogg Behavioral Model has been receiving much attention for its accurate breakdown of what correlating factors cause behavior change. It was developed by B.J. Fogg of Stanford University. Fogg's Behavior Model (FBM) has three components that must exist when behavior change is a goal; motivation, ability, and trigger. (Fogg, B.J.)

Below is figure (1) representing Fogg's Behavior Model (Fogg, B.J.) and the key elements of each axis:

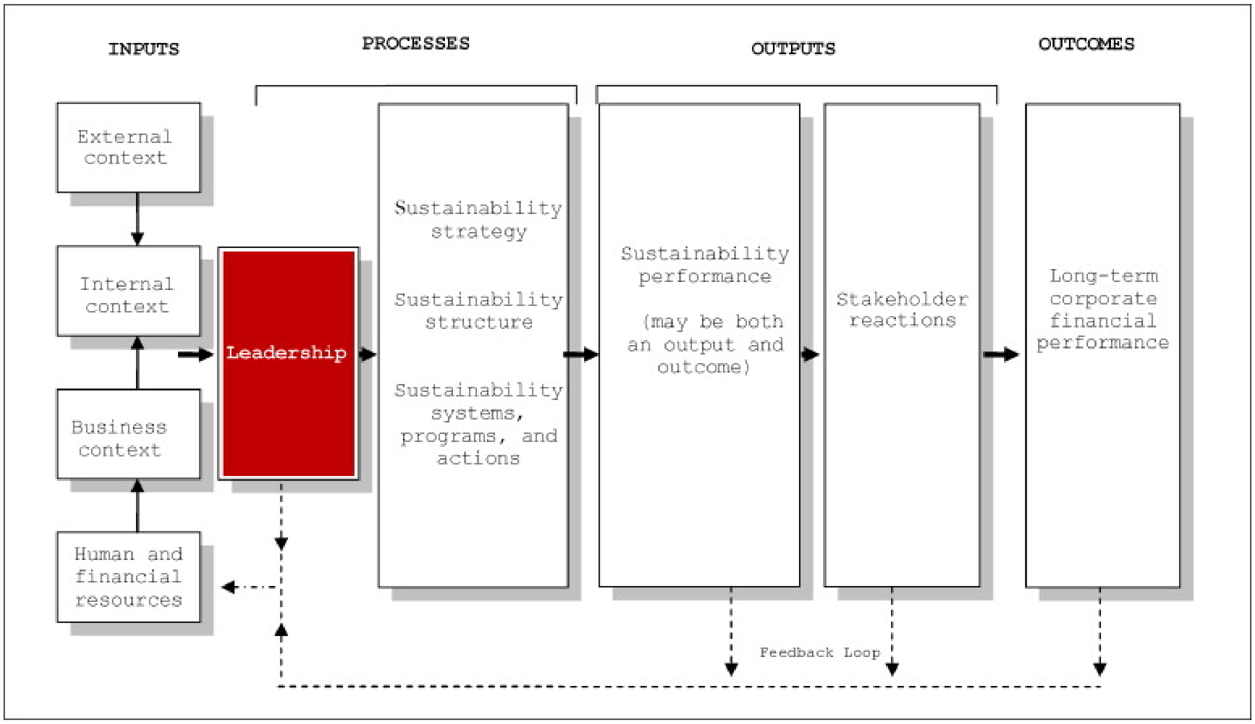


Motivation and ability are the two axes of the model. In Figure (1), motivation is the vertical axis. Fogg describes the motivation axis as having three type of elements that can create a higher values; pleasure/pain, hope/fear, and social acceptance/rejection.

An example of a pleasure/pain response would be people who enjoy the outdoors and have a natural obligation of preserving and restoring its beauty, for them the work is enjoyable. Some people are concerned with future generations of the planet, their well-being, and the disheartening statistics that lead to cynical, doomsday perspectives. This dark perspective would be a pain response. Some communities have programs and initiatives to promote sustainable behavior. Just a few types of incentives include reduced costs on alternative energy sources, providing alternative fuel stations, free recycling, and public transit options. But on the other end of the spectrum, some communities put additional costs and fees on installing solar panels on homes, which repels green consumers and more business in this sector. Political and cultural atmospheres of a particular place can push someone away from sustainability for fear of social rejection. These communal differences are the types of social acceptance and rejection elements that Fogg describes. These examples also show how regional differences can play into effect (Torgler & Garcia-Volinas, 2006). The social acceptance and rejection elements of the motivation axis are somewhat interchangeable with the social deviance element of simplicity discussed later.

The horizontal axis represents ability and how capable a person is at performing a target behavior. The conceptual scale of this axis works in the same manner as the motivation axis. In figure 1, ability increases to the right and decreases towards the left. Suppose a target behavior is to get all professors to turn off their lights every time they leave their room. Every teacher has the ability to flip a switch, so ability is very high. But if a target behavior were as challenging as getting students and faculty to ride a bike to campus every day, then ability would rank low. Some people may not have, or be able to afford, a bicycle. Others may have physical limitations keeping them from participating.

According to Moganadas et al.'s definition of systemic campus sustainability, it is the institutions responsibilities to recognize the issues, advocate participation, and use its resources in a proper manner. Therefore, if systemic sustainability is a goal for KSU, then leading by example is the best path to take. In the Corporate Sustainability Model developed by Epstein and Buhovoc, leadership is the driving force behind all success. "At the core of the model is the *leadership* function. The role of committed leadership can never be overstated. Management commitment to sustainability as a core value, and management recognition that sustainability can create financial value for the organization through enhanced revenues and/or lower costs are critically important." (Epstein & Buhovoc. 2010. pg 4) Below is Epstein's Corporate Sustainability Model



In their description of the model, they state that financial revenues and lowered costs are the motivation for sustainability in the Corporate Model. Social and environmental welfare are not considered to be as important in this model, but that is to little surprise.

The third, and required, factor in creating a desired behavior change is the trigger. When KSU leads the way increasing social awareness of sustainability issues, they are acting as the facilitator and creating the spark required. Even if the only innovation made at K-State is an energy saving initiative, then they would be providing a signal that will hopefully motivate others to change their behaviors. A key factor in increasing motivation is relating the subject material to the observer. There are triggers that exist that cannot be facilitated by just administration. Pro-environmental behavior should be encouraged through social acceptance, as well as negative environmental behavior being rejected and reversed. Those who deviate from positive environmental behavior should not be out-casted and given up on, the FBM is effective on different time scales. The triggers of other significant variables, like Perceived Consumer Effectiveness, can be dependent upon the manufacturers that sell the product. But also, increased education can give a person the proper knowledge to know which products are better for the environment and why.

If students and faculty do not have access to alternative means of consumption and production then ability ranks very low. “In general, persuasive design succeeds faster when we focus on making the behavior simpler instead of trying to pile motivation.” (Fogg, B.J. pg. 6) In the description of the ability axis of his model, Fogg lists six ‘elements of simplicity’; Time, Money, Physical Ability, Brain Cycles, Social Deviance, and Non-Routine.

Most of the elements are easy to understand. Brain cycles, social deviance and non-routine, however, may need some more description. When Fogg mentions brain cycles, he’s referring to the simplicity of concentrating on the task at hand. People tend to think in different patterns. If a task requires new or deep thought it becomes hard to accomplish. This decrease in simplicity leads to losses in participation. In the study by Vicente-Molina at al., gender was found to be a significant social deterrent from sustainable behavior. (Vicente-Molina et al. 2013) This phenomenon can fall under either the social deviance element of simplicity, or the rejection/acceptance variable of motivation in Fogg’s Model. (Fogg, B.J.) Ecological behavior is usually perceived as positive but in recent years it has irrationally been feminized. One possible result from this is males begin to commit environmental degradation to show their masculinity.

Further research will be needed to find the root of the feminizing action against ecology, but feminization is not the only variation of segregation that occurs. The back-to-the-land movements and commune living of the sixty’s hippy culture created a negative stigmatism against sustainable/simple living. In a Midwestern state conservative, right-wing ideologies are more popular. The political atmosphere in the United States creates lots of animosity and a division between the parties. This leads to conservative right-wings being led away from the conservative practices of the leftists for fear of being socially rejected from their political affiliation. Fogg’s Behavior Model states social acceptance and rejection as key motivators for creating behavior change. (Fogg, B.J.) Changing the language of sustainable behavior is one possible method of mitigating this development.

Changing language is an issue that has grown with the popularity of this science. Many people perceive sustainable development as an oxymoron. How can something be sustained and developed at the same time? The concept of sustainable development can be better understood through expanding education. But for some people ignorance and stubbornness is what is holding them back from making the transition to sustainable behavior. Improved communication can fall under the social elements of motivation and ability elements of Fogg's Model. Making strides in changing the language will make us more capable of relating the relevant information between different demographics. This will lead to more group inclusion, participation, and eventually to core altruistic values.

An example of a non-routine element would be implementing break rooms on each floor of a building, or a couple wings per floor, as well as restricting personal electric appliances. This would cause some disorientation and civil unrest for a little while, but eventually people would get acclimated. People do not like being told what to do, in any circumstance. So introducing different lifestyle changes in increments cannot be stressed enough. Adaptability is a key element of survival for any species. If we are unable to adapt to small lifestyle changes like walking down the hall to get coffee instead of on your own desk, then our future is bleak in terms of sustainability and therefor, our existence.

A factor that would limit ability for the hypothetical scenario of 50% bike traffic described previously would be the restrictive infrastructure. K-State's campus currently could not support that much bicycle traffic. It has been observed in society time and again that the construction of freeways and more roads on the grounds of reducing traffic congestion in fact induces more traffic. (Litman, T. 2014.) We believe that this would work in other areas of consumption as well. Putting caps on the amount of road construction could work similarly in office or dorm settings. Putting caps on the amount of electronic devices aloud in a room. We understand that this may be an unattractive option to some. Generally, people don’t like having reduced choices. Brain cycles and non-routine elements of simplicity under Fogg’s Behavior Model explain how this concept translates. But bad habits are broken best by creating new ones. Transitioning to alternative lifestyles, or behaviors, is easier the more available they are.

Perceived Consumer Effectiveness (PCE) was a variable used to measure how effective a person feels with their daily purchasing decision in a multi-dimensional survey. (Vicente-Molina et al. 2013) If a consumer senses that their purchasing impacts are minimal then they will choose cheaper, more convenient options, but at what long term price? PCE is an interesting and important variable in this research. One reason for its importance is because enhanced education could drastically improve PCE. The correlation between the two is very strong. Purchasing power is said to be one of the greatest strengths an individual can possess in influencing market trends. Combining PCE with increased awareness of environmental issues, especially with a mentality of, ‘What can I do to help?’ will be a direct feedback to their personal perception of their decisions.

Direct feedback is becoming a popular trend in boosting ecological behavior. Carbon Footprint Calculators have been a tool of growing popularity in recent years, especially in the digital age. These calculators give us a generalized, or detailed, feedback of our consumption. It is to be interpreted as; ‘If everyone on Earth lived as I do, how many earths would it take to keep our survival going?’ This kind of information system is motivational in that it encourages a hope/fear response. Again, more information (education) is received and ability increases as well.

Providing feedback on the results of our decisions is being seen as an effective method of changing behaviors. Direct feedback systems have been put into practice in some places in order to measure a building, a room, or an individual’s effectiveness in reducing energy consumption. The feedback systems are usually screens mounted onto a wall that display trends in consumption over a given period of time. Some systems give a real-time feedback, others are over longer intervals. In the Oberlin College of Ohio study they saw a direct reduction in energy consumed after installing the feedback systems. (Emeakaroha et al. 2007) The direct feedback systems can also be correlated with improving Perceived Consume Effectiveness. Again, K-State would be the facilitator trigger, but by providing a signal/spark trigger to each building, or individual. The smart sensor and monitor system would be expensive to implement, especially if it was done quickly and on a large scale, but it would improve almost every other element of simplicity. If competitions were held and incentives were produced after the installation people would become interested in reduction and it could become routine to conserve.

Part of our research method was conducting a survey of a campus building. When surveyed Throckmorton Hall we found that over 30% of the offices had their own coffee machines, and over 15% have their own mini-fridges. There is at least one break area on each floor already and some of these areas contain a microwave and/or a coffee machine. By making the break areas more appealing through comfort, simplicity, and through ease of access it would reduce the number of appliances used in personal office spaces. This practice would work the same for office appliances, such as printers, copiers, and phones.

We were able to talk to a few of the occupants of the office spaces. There were a few reoccurring comments. Office phones were said to be used very rarely. Most people said they used e-mail or their cell phones. Though office phones require little amounts of energy to operate, they are being used less and less. Since the office phone is becoming obsolete, removing them could be a consideration. Another issue was inconsistent heating during the winter that leads people to bring his or her own space heaters to work. Some people said repairs were made and they no longer used the space heater. Space heaters are very inefficient at performing their job, so any way of reducing the number of them on campus is encouraged. Inefficiencies in infrastructure are expensive to update and repair, this is well understood. But the long terms savings and impact reductions help pay off the installments and make us feel better about ourselves. We must remember, short-term economic gains are not the most important result we want from sustainability. Value cannot be placed solely on how much money is being saved, but the fact that *something* is being saved should motivate us. In Moganadas et al.'s definition of systemic campus sustainability, and through the rest of his article, he stresses the responsibilities that the educational institution carries. Institutions and corporations are the power players in today's society and if effective leadership positions are assumed, they should come from these sectors. A university is obligated to its student body to effectively prepare them for their futures. This is done by integrating all resources to creating, conserving, and regenerating social, financial, and environmental capital. A goal of any University is to increase enrollment and appeal. If K-State steps its leadership up to become an innovator in the area of sustainability, it can be hypothesized that the student body, the fan base, and the region would follow in example. Educational institutions house the brightest minds and ideas of the future and it is their responsibility to advocate the participation all of this potential in order to conserve our future.

Just like any other issue of social equity and human behavior, focusing education towards making the right decisions is a strong variable. The K-State 8 Curriculum is already a progressive approach to ensuring a well-rounded education. Social and natural sciences are already included in the curriculum, but with the results of our research we feel that implementing sustainability science and practice directly into all eight of the curricula, it would only benefit the student's knowledge base. After all, "it should be kept in mind that university students are the consumers, researchers and entrepreneurs of the future, and if future talent is able to make decisions that are beneficial to the environment, society is more likely to make progress along the path towards sustainability. In this sense, the level of environmental knowledge and the role of environmental education in changing and addressing lifestyles and attitudes could be crucial in altering individuals' behavior and in turning society towards sustainability." (Vicente-Molina et al. 2013. last paragraph) By educating people in the classroom about the right decisions, it is making their ability much higher by reducing brain cycles. If the knowledge is on the front of their mind an individual will not have to think as hard about what is right. This reduction in complex thought also saves time. By creating more environmental classes and increasing participation from each student, it pushes sustainability into the realm of a social norm. Imagine the improvement that could be made if everyone made his or her decisions based around sustainability.

Without a doubt changing Kansas State University's curriculum would be one of the biggest and more challenging alterations to increase pro-environmental behavior. Thus, other forms of educating the campus population must exist.

Recently a promotional event called Recycle mania took place on campus. At the end of the eighth week KSU was in 138th place out of 256 other campuses. (ksu.edu 2014) This is in the lower 50%! This shows that we have a lot of room for improvement. There are other incentive-based promotional methods that can be tried. For instance, we mentioned how competitions could be held with the monitor feedback systems. Promotional events for zero-emission transportation for a week, or for voluntary simple living practices could boost awareness of the environmental issues. Also, these types of promotional events can help people adjust to different lifestyles and change their daily routines, improving a person's ability.

There are smaller initiatives that can be started across campus to make incremental steps towards sustainability. For instance, since infrastructural modifications are expensive, setting a standard of replacing all electrical appliances with Energy Star or LEED certified products. Agreements could be made to ensure that campus buildings and affiliated stores sell and consume a certain percentage of recycled/reusable products and encourage purchasing energy star appliances. Encouraging e-mail and KSOL use by students and faculty in order to reduce paper consumption would be relatively easy. Starting initiatives for greener behavior should be a little easier in Manhattan due to our population size. A study we found stated that city population sizes between 50,000 and 100,000 were in the optimum range for attaining community involvement. (Torgler & Garcia-Valinas. 2006) Cities larger than 100,000 people typically have more cultural diversity. This makes it harder to centralize ideas and policy and get them into practice. Town sizes smaller than 50,000 have greater community involvement, but struggle to get funding to make the changes they need in their community.

Sustainable development doesn't come without its problems. Complacency occurs when sustainable development occurs, the public takes notice, but then feel the responsibility was taken from them and put somewhere else. Some people interpret the improvements as their job of being a steward is now complete and they can unwind their behaviors and regress some. This is a bad habit to get into. A comparative study of multiple Spanish communities showed that there was a reduction in eco-friendly behavior. "Furthermore, we find big differences between the first half (strong increase of the environmental attitudes) and the second half of the 90s (strong decrease). A possible reason for regional differences and the development over time is a higher satisfaction with the environmental policy." (Torgler and Garcia-Valinas. 2006)

As Kansas State University pushes to become more sustainable, because it has to happen, there will be pushbacks. Society must be resilient and adaptive while focusing on the task at hand, education. Higher education will always be a goal for any university, but by realizing our current societal path and the vagueness of predicting the future on it, the more tailoring our education to meet these demands is seen as essential. There is one thing that we can be certain of from our research, improvements can be made and potentials untapped.

Question 3: *How can/would we measure behavioral energy savings and be confident that we know how much we saved*?

The next step in trying to input an energy saving program campus wide is trying to figure out how to measure the savings. There are different methods that have been circulating to help illustrate the savings. Setting up display monitors in key locations of a building so the students, faculty, or the public can see how their consumption trends would be beneficial in several ways. One benefit would be that the monitors provide instant, or near-instant, feedback. Some people may find that the building they are in is using less energy than what they were expecting. The monitor method might be expensive to install due to the model types that are available on the market, as well as installation fees. The most expensive models show a more data and provide instant feedback. Also, we could set up a website that would allow the staff, students, or even the public to access the online program remotely, even when they are on breaks or out of country on trips.

The first experiment that we looked into comes from Oberlin College and their innovative Lewis Center for Environmental Studies, located in Oberlin, Ohio. The purpose of their study was to look into how different types of feedback could help the students living in the dorms conserve energy and water resources. They conducted this research through a dormitory competition and observed what dorms saved the most energy and water sources. To do this study the researchers looked through three different levels of depth while compiling the data. They showed the results to the occupants of the dorms according to the three levels of depth. The first issue they came across was how to measure water and electricity consumption in each dorm. "Researchers involved in this study developed a prototype system for metering, processing, and displaying data on resource use in dormitories." (Petersen & Shunturov & Janda & Platt & Weinberger, p20) One main reason for using this prototype is that during the time the study was being conducted and the data being gathered there was no item that was sold in stores that could help monitor and display real time feedback on these resources. "With funds obtained through a People, Prosperity and the Planet ("P3") grant from the US Environmental Protection Agency, a prototype wireless data monitoring and display system was developed that enabled easy observation and interpretation of real-time resources use in two dormitories on the Oberlin College campus." (Petersen&Shunturov&Janda&Platt&Weinberger,p21).

The items listed below are what the researchers used to make the sensing and monitoring prototype that they needed in order to complete the study.

- "Off- the-shelf" water and electricity flow sensors;
- Newly available and relatively inexpensive wireless data logging and networking hardware (www.xbow.com); and
- Networking, database management and display software custom developed by the research team" (Petersen&Shunturov&Janda&Platt&Weinbergerp21).

To use this new prototype to the full extent of its abilities they linked the sensors up with the machine rooms of the two dorms they were monitoring. From there, meter readings were sent to the researcher's base station where the data points were plugged into their designed software. The software then converts the data into a readable and applicable format that the researchers can post to the website for private and public use. They can see the variables being played as times-series graphs. The graphs show the average kilowatts used during a particular time interval. Someone visiting the building can see how much energy was consumed during the time they were there. The web site also refreshes the data every 20 seconds and its accessible in three different ways:

- Access to a web site to the students that lived in the dorms
- Two temporary kiosks were set up the dorms with real time data on their electricity use. Also a kiosk in the colleges science center (so they could run presentations on this studies)
- Lastly they made the website publically available on March 10, 2005.

Before they could calculate the savings from each building they had to come up with a way to calculate each of the buildings unique attributes. “Dormitories were assessed by comparing percent changes in resources use rather than by comparing absolute or per capita. Using percent change allowed us to compare changes across building of different vintages, different construction types, different solar exposure, and with different installed appliances (e.g. incandescent vs. fluorescents desk lighting” (Petersen & Shunturov & Janda & Platt & Weinberger, p25)

The changes in the percentages of each building were calculated by the following equation.

Percent reduction = 100 X [(average baseline period rate) – (average competition period rate)]/ (average baseline period rate).

The savings for each dorm was calculated by taking the difference in average consumption rates between the two periods by the elapsed time. Here is another example formula that was given to help us understand how this was done.

KWh= (baseline kW - feedback kW) X (24h X 7 days/week X 2 weeks).

(Petersen&Shunturov&Janda&Platt&Weinberger p 25)

Researchers looked at results after the calculations were completed to see what potential savings existed. During the calculation process they looked at the weather data from a regional airport. They figured daylights savings time into the calculations as well. They found out that the temperature during the baseline readings and after the completion of the experiment only changed an average of 2 degrees Fahrenheit. Light sensitivity during these longer days was also considered to see if it affected the outcomes. They found that there was not a major change in light sensitivity. They concluded that most of the change came from the students that lived in the dorms. After the competition and the final readings were done they found that the weather and lights changed greatly. The group decided that the due to the change of the unknowable condition (weather and light sensors), they decided to focus on the energy changes of the students. They concluded that most of the change came from the students that lived in the dorms.

The results of the competition of all 18 dorms saw a reduction of the watts during the competition. During the baseline readings they saw average watts of 367 and during the two-week competition they saw a reduction of 120 watts form the base line showing a 32 percent reduction of grid. They were able to save around 68, 300 kWh by all 18 dorms; most of the watts that were saved came from the high-resolution dorms that saved up to 55% compared to the other dorms. They got those findings based on the measurement system they used. In the end the college was able to calculate the savings to be around $5,368 dollars on the electricity and water reduction in the dorms.

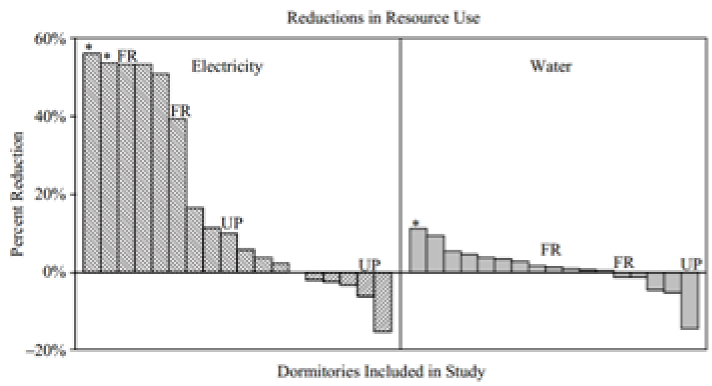


Figure 3. Percent reductions in electricity and water use between baseline and competition periods for all dormitories included in the study

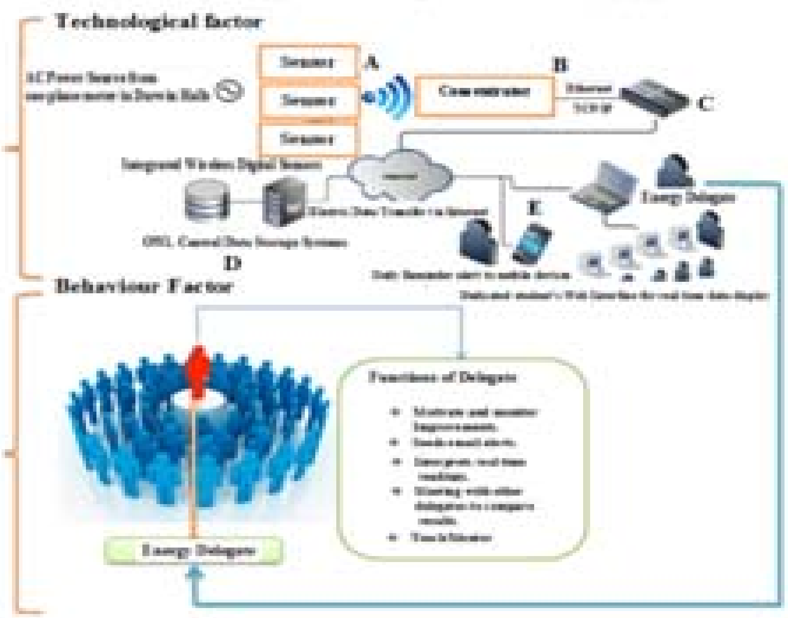
Notes: In each category, dormitories are sorted from highest to lowest percent reductions. Dormitories with a negative value for reduction increased their use. Symbols are used to identify dormitories receiving high-resolution feedback (*) and those that exclusively house freshman (FR) and upperclassmen (UP)

(Petersen&Shunturov&Janda&Platt&Weinberger,p 26)

If the college was to expand this type of experiment they would have to spend a total of $250,000 dollars to set up all 25 of their dorms with this technology to show the real time information on the website. If they were to do this the technology would be paying for the installation and they would make a profit only after two years. And get the measurement feedbacks they need

Another study looked at using smart sensors in the U.K. Their proposed system would work almost like the system above as far as the calculations. The difference though is that they would have an energy delegate located in each of the dorms they were testing and they would promote the behavior change. Below is a figure that shows how the technological factor worked as well as the behavior factor of this experiment.

Figure 9. Smart electricity sensors showing data feedback and display process.



(Emeakaroha&Ang&Yan, p 302)

This next figure shows all the major appliances and how much energy they used in a year.

Table 2. Total energy usage.

Electrical appliances	Total energy in KWh/Yr	Average used/student/KWh/yr	Cost in pounds/Yr	Carbon emission in tons/yr	Carbon offset cost/yr
TV	1216.18	24.32	160.29	0.77	5.39
Stereo	1459.00	29.18	192.29	0.92	6.44
Refrigerators	48,180.00	963.60	6,350.12	30.48	213.36
Incandescent bulbs	17,972.00	359.44	2,368.71	11.36	79.52
CFL Bulbs	3,507.68	70.15	462.31	2.22	15.54
Heater	184,928.00	3,698.56	24,373.25	116.99	818.93
Fan	350.40	7.01	46.13	0.22	2.33
Toaster	7,884.00	157.68	1,039.11	4.99	34.93
Iron	114.00	2.28	15.02	0.07	2.33
Microwave	1,095.00	21.90	144.32	0.69	4.88
Desktop	11,826.00	236.53	1,558.67	7.48	52.36
Laptop	15,815.04	316.30	2,084.22	10.00	70.00
Wash Machine	860.00	17.20	113.35	0.54	3.78
Others	6,246.00	124.92	823.22	3.95	27.65
Totals	**301,453.38**	**6,028.47**	**39,731.01**	**190.68**	**1416.94**

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Table 2. *Cont.*

This table shows the calculation of all the major appliances and how much energy was used during the studies first year on the campus. (Emeakaroha&Ang&Yan, p 310-311)

At the end of experiment they were able to identify the wasted energy on the campus they selected. They were able to help set up their plans and experiments on a small scale before moving on to their full scale.

The next study that we looked at dealt with energy conservation in work and teaching space at mid-size private college located in the southern United States. They wanted to test out two different types of feedback systems to see if they were affective on saving energy. The ideas were to provide feedback and a peer system to see if it would change any people in the study groups. They started off four months before the intervention and got a baseline reading in a similar way that the other two experiments did. They also included the past two years of energy bills that also took place during the same time period. The participants were also allowed to take a survey. The surveys were done during the baseline testing and during the final intervention. These surveys looked at the different ideas of the people taking the survey. They asked people if they themselves have changed their behaviors to save energy and what they thought of the program's goals and the attractiveness of the program.

Their sample size of the buildings included twenty-four buildings on the campus. The buildings that were selected only had office spaces and no energy-intensive laboratory environments. They were also not located on the list to get renovated during the time of this study. Employee numbers were located around an average of 88 people working each of the building. Each building had a range of 11,571 to 180,258 square feet. The online survey they would allow people to take part in was sent to around 2056 employees' emails that were available through each individual departments mail server.

The results of the program didn't meet the standards the researchers were hoping for. As they collected the results they noticed that the average kWh was still a little too high and the conservation behavior was not really being effective. They went through and looked at the different variables to see why the experiment failed. They noticed that reading the meters at the end of the month and not having enough observations really hurt them in the long run. They stated "Future research should consider collecting more frequent observations, particularly using self-report data, as well as examining the long-term effects of interventions on energy use behavior in general. This will allow for a more precise measurement of behavior and may expose more behavioral variance over time." (Carrico& Riemer. pg, 11).They also came to the conclusion that the common areas where they had appliances that everyone could use were not being turned off. So in the end their experiment sounded plausible and would work great if it had a few changes like in the observations and the frequency they read meters.

This next study shows how the researcher is looking at how different size and occupant levels affect the amount energy used on the campus of Smith College. The administration is looking at how to cut the footage of the campus and cut the energy bill they are accumulating through building usage. They were able to figure the number of (kWh) per-hours and (kWh) per week. “For most appliances, we multiplied the number of appliances owned by the students’ times the number of hours reported by the students, and then multiplied this number by the number of watts the appliances use and by 7 to get the weekly watt-hours. We then divided this number by 1000 to calculate kWh per week.” (Steingard, pg., 5).

**Values reported: 1 lamp with a 60-watt bulb that is on 5 hours per day

(1 lamp)*(5 hrs/day)*(60 W/lamp)*(7 days/week)/(1000 W/kW) = 2.1 kWh/week

After the data was converted to the desired variable they were able to start focusing on the weekly consumption of each of the participants, total sample weekly consumption, total appliances weekly consumption, average the appliance weekly consumption, and figure percentage of total weekly consumption used by each appliance. After all these calculations they started their data analysis of the occupant levels and per capita energy consumption. They started with a significance level of 0.05, with these analyses they started to generate linear, quadratic and cubic regressions as well as F-scores and p-values.

The results showed that the size of the building and the occupant levels are strongly related by the energy consumption. They also discovered through their multiple analyses that the building location on the campus might have an effect on the energy consumption. “On average students living in Upper and Lower Elm will use more energy than their classmates in the Center Campus, Green Street and the Quad.” (Steingard. pg., 13). During this experiment they decided that this theory might need to be tested on the fact that they were not able to have control over the locations of these buildings. They were able to come to this conclusion through a different study that was previously done. So they challenged the next group of students to test the theory that location will play a part in how much energy is consumed on campus. There was also a pattern that formed while they did their studies, the class of students might also have an effect of the energy consumption.

These studies can show us what we can possibly do on our campus. The first step is trying to figure out how we will approach the idea of getting the program off the ground and coming up with good solid measurements. Each of studies used smart sensors that showed real time data via their web sites that they setup. For us to use the smart sensors we would need to approach the university for money or try and apply for grants that could help cover some of the upfront cost of setting the program up.

Pros of these experiments are that they can give us some sort of starting structure for setting up our own program. The experiments can also be useful by us looking at the studies they went through and used to start their own study. By doing this we can put together parts of the experiments they would best fit our campus. They both can also give us ideas on what to look for while we are hooking up the smart sensors to the meters in the buildings. It might be a better idea to run a pilot test on a very small part of our campus to see if it will even be effective before trying a full-scale campus operation. They could also show us blue prints of how they set up measuring systems. It could also prove the point that if we were to set up the sensors and implement the behavioral changes we could show some of the same savings that these people got. And also allow us to get a timeline of when will the program start putting money back in the universities pocket.

Each program had faults in the experiment designs with their instruments and their ideas of motivation of students. The first study had problems with their sensors cutting out on them or people reading the senor and meters wrong. The way to fix this problem would to be having secondary sensors on location with the primary incase of failure and also have trained faculty that can read the meters instead of having a person that is not trained.

The second study had problems motivating their students during their first years of their studies to even give good data to get measurements. They could have set up a program to get the student interested in saving the resources in their living spaces. A big con is there is still not a lot of data out there that can really tell us what measurement system will work the best. This idea of behavioral change is a hard thing to do on a campus setting where you have so many students who don’t pay the bill. So it leaves us to take parts from these experiments and see what type of measurement system will work best for our campus setting. Its still a theory in the works so anything we do will help the future of implementing behavior change measurement systems in the future.

Data method:

So what we wanted to do was look more at question 1 on our experiment. In terms of how much is possible to save at Kansas State. Why do we want to look at this well its simple we want to come up with an estimate that shows savings. If we can show that we use a lot of energy and how much it actually cost us. Then show that just by changing a few choices we could possibly save money. So we did a very general overview of one of our buildings on campus. So for our own data collection on campus we are using the Throckmortan Plant and Science Building. Our first step is to do a survey of appliances we thought would be in offices and classrooms of this building. We just went through as many offices as we could and got a checklist. This checklist is based off of about 55 offices and classrooms.

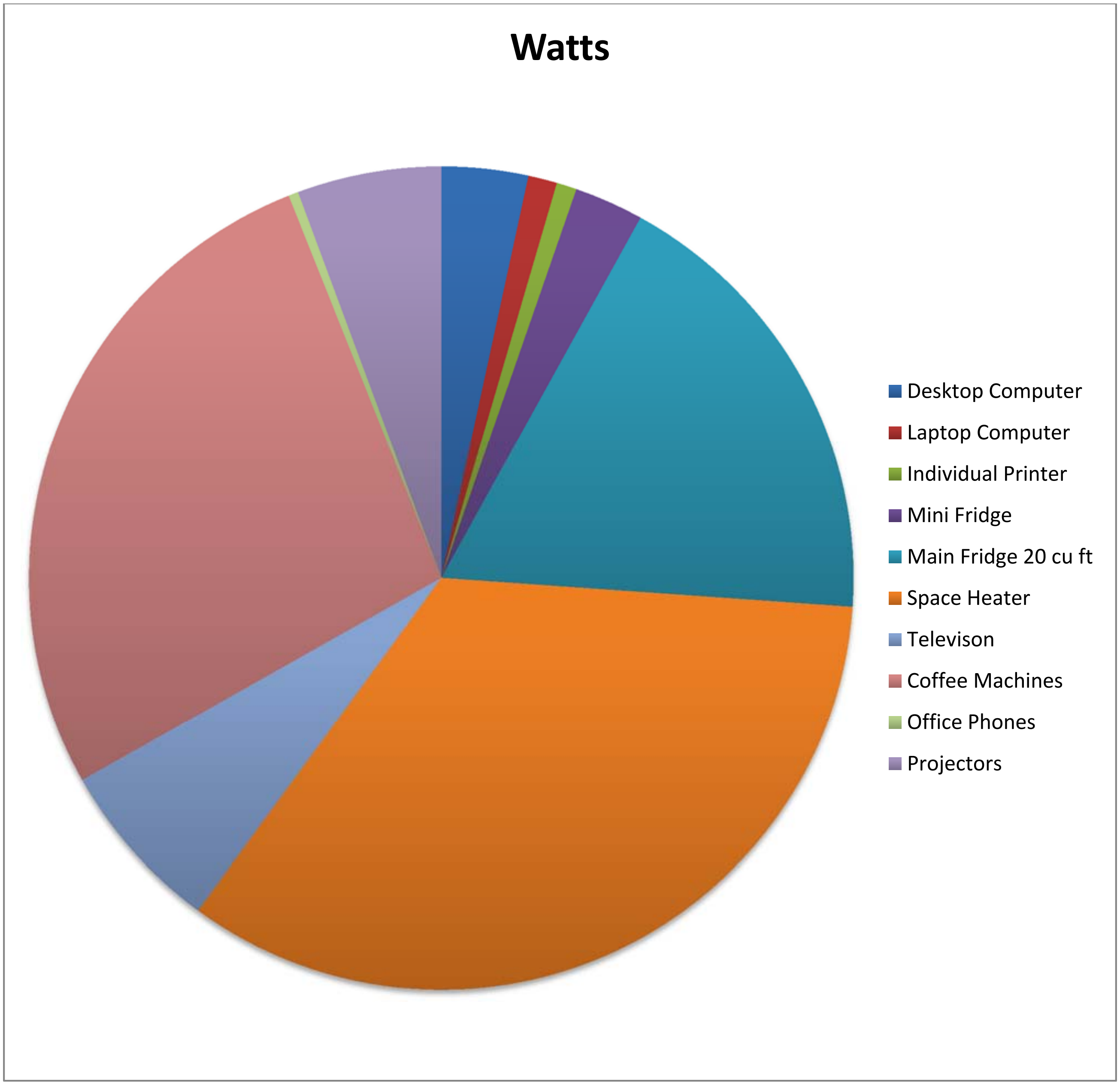
Electronic Device Checklist

Building Information: Throckmortan Plant and Science Building

Appliances	Numer of Appliances
Desktop Computer	50
Laptop Computer	30
Projector	16
Central Printer	4
Individual Printer	1
Central Fax	4

Individual Fax	0
Mini Fridge	11
Main Fridge	5
Floor Lamp	0
Desk Lamp	3
Floor Fan	2
Desk Fan	1
Space Heater	9
Television	18
Power Strip	35
Toaster	2
Microwave	14
Office Phones	24
Shredders	4
Phone Chargers	4

Next we looked at how many Watts the top 10 appliances had. Here is a simple graph showing how many watts each appliance consumes.



This next chart shows the top 10 appliances in the survey we did. But the only difference is we added in the kWh. To get those kWh we used this equation and an example of how we convert it. I did an assumption based on how long we thought each item was on per day. I did find out from the Office of Sustainability at Kansas State that the blended cost per kWh is .077. We gathered data from multiple sources to average out the watts for each appliance.

<u>Equation:</u> (Watts) x (Assumed Hours) / 1000 = kWh

Appliances	Assumed Hours	Watts	kWh
Desktop Computer	8 Hrs	150	1.2
Laptop Computer	8 Hrs	50	.4
Individual Printer	5 Hrs	35	0.175
Mini Fridge	Plugged in 24/7 but cycles about 6 Hrs	120	.72
Main Fridge 20 cu feet	Plugged in 24/7 but cycles about 6 Hrs	800	4.8
Space Heater	4 Hrs	1500	6
Television	7 Hrs	300	2.1
Coffee Machines	7 Hrs	1200	8.4
Office Phones	24 Hrs	17	.408
Projectors	8 Hrs	250	2

To figure out how much these cost on a yearly basis for Throckmortan We need to look at the chart above and times the kWh times how much it cost per kWh (.077) a day. Then take that answer times 365 to get how much it cost yearly to run. The equation will look like this:

Equation: **(kWh) x (cents per kWh) x 365 = Yearly cost to run Individual Appliance**

Appliances	kWh	Yearly Cost
Desktop Computer	1.2	$33.73
Laptop Computer	.4	$11.24
Individual Printer	.175	$4.91
Mini Fridge	.72	$20.24
Main Fridge 20 cu feet	4.8	$134.90
Space Heater	6	$168.63
Television	2.1	$59.02
Coffee Machines	8.4	$236.08
Office Phones	.408	$11.47
Projectors	2	$56.21

This shows the yearly cost to run the total amount of appliances surveyed in Throckmorton rooms broken down by each type of appliance. Count column is based off of 145 rooms. We excluded Laboratory rooms from our survey.

<u>Equation:</u> (count) x (yearly cost per individual appliance) = Total yearly cost of all appliances in Throckmorton.

Appliances	Count in Throckmorton (145 offices)	Yearly Cost
Desktop Computer	189	$6,374.97
Laptop Computer	61	$685.64
Individual Printer	84	$412.44
Mini Fridge	29	$586.96
Main Fridge 20 cu feet	16	$2,158.40
Space Heater	23	$3,878.49
Television	48	$2,832.96
Coffee Machines	52	$12,276.16
Office Phones	62	$711.14
Projectors	42	$2,360.82
Total		$32,277.98

So as you can see just this one building is expensive to run if we can implement some good behavior programs maybe some educational based programs are our best approach. It is possible in our opinion to cut this cost down. If we use Energy Star Appliances we could possible cut these in half or a third. Which is still saving our university money in the long run.

Conclusion:

A constants debate exists in attempts to decide whether it is an individual responsibility, or the responsibility of the leaders of society. There was a recent article that recently came out from the collaboration of Princeton Professor Martin Gilens and Northwestern Professor Benjamin I. Page. Their research on over a thousand public policy actions found that corporations and business had a majority of the influence in the outcome of decisions. The results also found that the individual person has a “near-zero statistically significant effect” on public policy. Since the results of this study show that the most affluent in society hold the greatest power to create change, most would recognize that this is where the responsibility lies as well. So one approach is to get these people to help get these policy changes to happen so that the individual can have an effect on saving energy in this country. That is an approach we could further look into is putting in policies to help with these behavioral programs.

Kansas State University is located in a small, tight-knit, agriculture community in the Midwest. The conditions here are optimal for creating a sustainable community. The only missing element(s) is the correct amount and implementation of motivators and triggers. Like stated earlier in the Fogg Theory. We came up with estimates on how much we believe we could save. And finally we looked at how do we measure that, is it by real time monitors or by other means not yet discovered. Our research shows that there are numerous areas of student, faculty, and operational life that can be improved on to reduce our impact. The observational study we conducted on campus showed that savings in the thousands of dollars are possible through a few simple behavior changes, in just one campus building. Reducing and/or eliminating human impact is gaining popularity as a lifestyle change and as a business practice across the world. In every one of these initiatives there is something that can be taken in, learned, and applied to our community.

During our researching and surveying process we decided to omit laboratory equipment. This specialized equipment would require in-depth research, as well as more time, to calculate their total impact. In order to fit our study into our time limit we ultimately decided to survey classroom and office space appliances only. For future research, we would suggest taking more time to survey an entire building, if not an entire campus, to calculate the total impact and cost of our plug-in devices. Future studies could also include the use of new technology similar to the instant feedback systems we reviewed in our research. Another thing we hoped we could have had time for was to put in a behavioral system ourselves in Throckmortan and to set up a way we can measure how much could have been saved. It would have helped shown how much could be saved in Throckmortan, which is only one building of many on campus.

Energy is expensive and costly to more than just a pocketbook. Institutions around the world are taking steps in improving campus life and the environment around them, simultaneously. K-State's Sustainability Plan needs to be at the top of the list of priorities for the 2025 plan. If we are proactive about sustainable development now it will cost us less in the future, whether it's the economy, society, or the environment. It starts to help promote energy saving friendly behavior. So just think if we can get this trend going here at Kansas State then maybe others will follow and help cut back on energy consumptions on universities around the United States.

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