Grand Challenges 2: Proposal Overview

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Georgia Tech: Grand Challenges
Team 11: UrbEnergy

I. HOW MIGHT WE PROBLEM STATEMENT

How might we reduce electricity usage in Georgia Tech Freshmen Experience dorms?

II. DESCRIPTION OF THE PROBLEM

Electricity is not captured directly from the natural environment, but rather is generated from other energy sources [1]. In 2013, 67% of electricity produced in the U.S. came from burned fossil fuels (coal, oil, and natural gas), with an efficiency of approximately 40% [2,3]. According to the Earth Policy Institute, coal accounts for 40% of CO_2 emissions, oil accounts for 36% of CO_2 emissions, and natural gas accounts for 20% of CO_2 emissions [4]. In 2012, electricity generation accounted for approximately 39% of the United States' energy-related CO_2 emissions, which translates to 2,039 million metric tons of CO_2 emitted into the atmosphere [5]. Residential electricity usage accounted for 36.3% of the total usage in the United States in 2013, according to the U.S. Energy Information Administration (USIEA) [6]. The World Bank calculated that in the United States electricity consumption per capita is approximately 4.3 times that of the world average [7].

According to the Union of Concerned Scientists USA, a worldwide temperature increase of 2 degrees Celsius would be detrimental for the environment. For example, with a 2 degree Celsius rise in global temperature, sea levels are expected to rise between 12 to 40 feet due to melting ice sheets and would kill many ecosystems upon which humans rely for their own survival. In order to decrease the probability of such a temperature rise to below 50% by 2050, the United States needs to reduce its carbon emissions by 80% by 2050, which equates to a 3.2% decrease in carbon emissions every year from 2000 to 2050 [8]. However, the electricity consumption per capita in the United States only decreased an average of 0.0195% per year from 2000-2013 [7]. As electricity generation accounts for over a third of the U.S.'s carbon emissions, and since residential electricity consumption accounts for over a third of national electricity consumption, the stagnant rate of electricity usage per year is problematic.

The emissions inventory for Georgia Tech for June 2009 through June 2010 showed that operations on Georgia Tech campus created 329,853 metric tons of CO_2 emissions, which translates to 16.3 metric tons of CO_2 per full-time enrolled student per year. Of this total, purchased electricity accounted for 216,566 metric tons of CO_2 emissions, or 65.6% of Georgia Tech's total CO_2 emissions. Georgia Tech has not purchased any carbon offsets or Renewable Energy Certificates, indicating that the university has not taken any major steps to reduce its electricity consumption [9].

Over a 5-year period, from 2009 to 2014, 13,778 freshmen enrolled at Georgia Tech, approximately 12,400 (90%) of which lived in on-campus freshman residence halls [10,11]. Georgia Tech residences comprise 29% of the total building space on campus [9]. Therefore, as a large CO_2 emitter, and as a college that markets itself as sustainability-minded [12], Georgia Tech has the responsibility to reduce its current electricity consumption. It has the capability to do so by presently influencing the freshmen students who live on campus to reduce their electricity consumption.

III. PROJECT GOAL

Scope: The goal of this project is to conduct an experiment to test if various factors reduce Georgia Tech freshman energy consumption through behavioral change.

Rationale: Georgia Tech presents an excellent environment for attempting to reduce energy consumption through behavioral change and raised awareness. However, the university's lack of carbon offsets and Renewable Energy Certificates indicates that Georgia Tech is not utilizing its capacity for on-campus energy reduction. Furthermore, since the budget of the Georgia Tech's Housing Department's is limited and tightly controlled, low-cost, low impact solutions to reduce Georgia Tech residential housing's energy consumption should be highly coveted. [13]. In 2013, 34.6% of the residential electricity usage in the U.S. came from appliances, electronics, and lighting, which are all utilities frequently used by college students [14]. Since college students also tend to be more receptive to energy conservation and social change relative to other demographic groups, Georgia Tech has an effective way to reduce its electricity use and CO_2 emissions through relatively low cost awareness-raising strategies. [15]

Impact: Achieving this goal will reduce Georgia Tech's negative impact on the environment, reduce the institutions energy bills, and enable the university to further promote itself as environmentally sustainable. Any achieved habitual change will foster long-term sustainable behavior, which will in turn lead to environmentally aware population of future graduates and members of society.

IV. STAKEHOLDERS

Students: Georgia Tech students act as the subjects of the project experiment and those affected by its results. As this project might have future implications for sustainability practices toward Georgia Tech students, future students might be affected by its results.

Grand Challenges Program: The Grand Challenges program is interested in the successful completion of this project, as the success of student project is a determinant of the success of the program itself.

Georgia Tech Housing Department: The Housing Department provides information about dorms and electricity metering and access to dorms and student emails. The department has also expressed interest in the results of the experiment due the prospect of a future dorm with a heavy sustainability focus.

Georgia Tech Facilities Department: The Facilities Department provides access to electricity metering data collected from Georgia Tech dorms used in the experiment. As this project is one of the only projects for which access to data is given, the department is interested in the proper use of the data in addition to the results of the experiment. Since there are several parties interested in access to campus electricity metering data, the successful implementation, analysis, and completion of this project might provide opportunities for future access to this data for other groups.

Georgia Tech Sustainability Department: The Sustainability Department is interested in the outcome and completion of this experiment, because it is one of the only sustainability experiments implemented by undergraduate students. This department also provides administrative support.

Georgia Tech Administration: The upper Georgia Tech administration is interested in the successful completion and outcome of the experiment because it provides justification for marketing the university and its students as sustainably minded. In addition, several times the administration, namely Vice President Paul Strouts, has facilitated help from the Georgia Tech departments.

Community of University Sustainability Efforts: Sustainability departments at other universities have provided aid in the background research for this project and are interested in its outcome, as this experiment is both novel and will contribute to the body of knowledge about university sustainability efforts.

V. EXTERNAL ADVISORS

Dan Morrison, *Director of Residence Life at Georgia Tech*. Dan Morrison provided contextual information of how the Georgia Tech Housing Department is able to assist in the creation of this experiment as well as provided additional contact information to Ernesto Olivares.

Ernesto Olivares, *Senior Director of Facilities Management at Georgia Tech.* Ernesto Olivares has provided information from the Utilities Department about the mechanical equipment in the dorms, which has been beneficial in selecting the dorms for the experiment.

Namrata Kolla, *Co-Chair of SGA Sustainability Committee & QEP Student Advisory Board Member*. Namrata Kolla initially provided awareness of the Georgia Tech 2020 Quality Enhancement Program, which will have a major component of sustainability. Knowledge of the QEP has given a context in which to implement the proposed experiment, as well as a potential future direction for the application of the experiment results.

Beril Toktay, *Faculty Director of Center for Business Strategies for Sustainability, Co-Director of QEP*. Beril Toktay serves as a role of an external advisor for the experiment and provides feedback for the direction of the experiment once a month, as well as provides resources for literature about environmental sustainability.

Michael Leasure, *Associate Director of Energy Conservation at Georgia Tech*. Michael Leasure provided information of the mechanical utilities in the Georgia Tech dorms and gave advice for selecting dorms for the experiment.

Paul Wiley, *Utilities Manager at Georgia Tech*. Paul Wiley gave us access to WebReach, which is a software system that will allow access to the electricity data for the dorms in the experiment.

V. OBJECTIVES

A. Objective 1: Preparation and Planning of the Experiment

Planning must be completed prior to the deployment and analysis of the experiment and will serve as the framework for the experiment. Objective 1 serves to ease deployment and analysis of the experiment and will allow more time to address unforeseen challenges. Planning involves four major tasks: 1) preparing for the experiment, 2) designing the experiment, 3) designing the communication methods, and 4) preparing and verify experimental details.

The first task is to prepare for the experiment, which requires researching previous literature and creating a hypothesis. Based on research of pre-existing field experiments and independent research, the variables of education, feedback, and comparative feedback are the three independent variables that will be used in this experiment [16]. An individual dorm will be assigned to each independent variable (IV) to measure the effects of the overall dorm electricity consumption in response to a change in varying the information communicated to students about their electricity behavior over an eight-week time period in Spring 2015. The education dorm (ED) observes the impact on overall dorm electricity consumption by providing students with information about the importance of conserving electricity. The feedback dorm (FD) observes the impact of providing students with contextualized information about their per capita electricity usage in comparison to their dorm's previous electricity usage. The comparative feedback dorm (CFD) observes the impact of providing students with contextualized information about their dorm's total electricity usage in comparison to the total electricity usage of another comparison dorm in the experiment. All independent variables dorms (IVDs) are expected to display a decrease in overall

dorm electricity usage, with the CFD expected to have the highest decrease in electricity usage [16].

The second task for objective 1 is to design the experiment, which requires determining which dorms will be used in the experiment and determining the software system that will be used of measure the electricity usage in each dorm. Six dorms are in the experiment, one dorm for each independent variable, one dorm for the control variable, and two dorms that will be used as a comparison dorm for the comparative feedback dorm. The dorms in the experiment are Caldwell, Folk, Armstrong, Hefner, Montag, and Freemen. The dorms for the experiment are all Georgia Tech Freshmen Experience dorms located on West Campus, with co-ed occupancy. Additionally, each dorm's latest renovation occurred in the 2000s. Each dorm's electricity usage will be collected on a daily basis through the WebReach software system provided by the Georgia Tech Utilities Department. After each week of the experiment, daily data from each of the dorms will be compiled into an excel template for further data analysis. Historical data from each dorm will be retrieved to observe the trends in electricity consumption throughout the year.

The third task for objective 1 is to design the communication methods of each dorm. The media of communication for all the IVDs will be constant, where emails, poster, and flyers are the primary sources of communicating information. All IVDs will provide tips for students to decrease individual electricity consumption; however, the remaining informational content will vary for each dorm. Only the content of the education, feedback, and comparative feedback dorms will vary. Frequency of communication for each independent variable dorm will also be constant. Emails will be sent to all students twice a week during the duration of the experiment. Posters will be updated in each dorm every two weeks. Flyers are updated in the dorm bathrooms once a week. Posters will be placed at dorm entrances and above water fountains; these are heavily trafficked areas were posters are likely to be seen by most residents. Flyers will be placed in bathroom stalls on each dorm floor.

The fourth task of objective 1 is to prepare and verify experimental details. In order to plan for the implementation of the experiment, materials will need to be bought to create the posters and flyers. Templates for the poster, flyers, emails, and excel data sheet will not require expenditure of money. However, the creation of the templates are crucial in planning the experiment, since the templates will allow for efficient transfer of information into the mediums of communication. After the creation of the templates, the content for each medium must be researched. An example content topic for the mediums of communication is an explanation with statistical data of how unnecessary electricity consumption can cause adverse affects on the environment and public health. Verifying the experiment details requires verifying the accessibility to the dorms in the experiment, locating a similar location in each dorm where posters and flyers are placed, retrieving access to data from the WebReach software system, and retrieving access to student emails to send out weekly emails. Objective one will be completed after the templates for the emails, posters, flyers, data analysis have been completed prior to the implementation of the experiment.

Limitations in planning the project are the possibility of one or more dorm being invalid for the experiment, not retrieving access to enter the dorms or retrieve student email addresses, and not finding a suitable location in the dorms to place posters and flyers. According an interview with Georgia Tech's Associate Director of Energy Conservation, one of the selective dorms may be invalid for the experiment because of the possible of that dorm containing the central heating system for the water on West Campus, which would cause that dorm to have a higher overall electricity usage in comparison to the other dorms in the study. [17]

In order to address the issue of a dorms being potentially invalid for the experiment, either Montag or Freeman will be used as control dorms. Both Montag and Freeman are pre-health dorms, however the social effects of Montag and Freeman are assumed to be negligible in impacting the electricity consumption of each respective dorm. If complications occur when retrieving access to enter the dorms and/or retrieval of student email addresses, Dan Morrison will be contacted to assist the access of the dorms as well as the retrieval of the emails. If a constant location to place posters is not available in all the dorm floors, then the posters will be placed in the lobbies of all the dorms. Similarly if a constant location for flyers is not available, flyers will also be placed in the lobbies of dorms.

B. Objective 2: Implementation of the Experiment

The second objective is to conduct an experiment in Freshman Experience, traditional-style dormitories. This objective consists of two primary tasks: 1) implementing the treatments into different dorms, and 2) maintaining organized and efficient management of the experiment throughout the implementation period. The subjects for this experiment are the residents of the three treatment and one control dorms. The dorm electricity meters will be used to measure and quantify the outcome of the experiment. This experiment will be conducted for two months, and therefore the objective will be fully completed two months after its initialization, regardless of outcome. After the first and second month, we will compare the monthly energy usage of each dorm with historical data of its energy usage, with the expectation that a noticeable decrease in energy consumption will occur in the treatment dorms.

The first task will be to implement these treatments into the different dorms. We will gain buzzcard access from the Georgia Tech Department of Housing to enter the halls to distribute the printed posters and fliers. Posters will be distributed every two weeks, while fliers will be distributed every week. We will attempt to keep their locations and the posters' orientations as uniform as possible despite differences in the architectural design and floor plan of each dorm. Finally, emails will be distributed using the resident email lists obtained from the Department of Housing.

For all three experimental subjects, any numerical data or facts presented in emails, posters or fliers will be contextualized. For example, instead of communicating to dorm residents their energy consumption in kilowatt-hours, we will provide context as to how this consumption compares to other buildings of similar function and size, as well as comparative forms of measurement (for example, consuming 0.2 kWh is equivalent to burning approximately 172 calories in terms of energy released).

The second and final task is to maintain organized and efficient management of the experiment throughout the two months. With the exception of the analysis and subsequent alterations made after the first month, no changes in the methods, modes, schedules, professionalism, commitment, etc. with which we carry out the experiment may be made; exceptions may be proposed if we dutifully document any changes, at the risk of compromising the validity of the data we produce. The planning process outlined in Objective 1 will therefore be crucial in ensuring that we can design an experiment that can feasibly be carried out with our limited resources and expertise, in order to fulfill the requirements of this task. By utilizing the pre-made poster, flyer, and email templates produced in the first objective, we can better ensure uniformity, reduce our workload, and improve the overall feasibility of the project.

Successful completion of this objective will present a number of challenges. Despite our best efforts to design a feasible experiment in terms of workload, we cannot be entirely sure of the true work requirement of the experiment until it commences. To mitigate this possibility, we have already begun to seek out and recruit new team members; the larger our team, the smaller the chance that an underestimation of the work requirement will result in a workload that is too large for our team to handle. Further mitigation of this possibility will be accomplished through the creation of posters, fliers, and email templates during the planning process. Modes of data contextualization, such as comparing data figures to units of measure familiar to college students, will be researched beforehand as well. These precautionary measures will decrease the amount of work we will have to complete during the experiment itself.

A third challenge will be reaching an agreement with FAB regarding the flyers. FAB is the only organization that puts flyers on the back of bathroom stalls, and so they may dislike the notion of sharing the space with another flyer. To mitigate this challenge, we will arrange a meeting with FAB to discuss our intentions and secure their agreement.

A fourth challenge will be ensuring that the posters and fliers remain correctly positioned and oriented when members check on the posters and flyers in the dorms. In our absence, posters may fall or be tampered with. The members of our team will take turns checking the posters each day to ensure that they remain in their correct position.

C. Objective 3: Analysis of the Experiment

The third objective is to analyze the electricity data of the dorms in the experiment before, during, and after the experiment. The data can then be compiled into a report detailing the results of the experiment and can be sent to interested parties such as the Georgia Tech Department of Sustainability and Georgia Tech Department of Housing. This objective is necessary to contextualize the results from the experiment. The results can then be put to use in future projects by other university entities. Failure to analyze the results of the experiment means that the experiment would have no meaning. This objective provides necessary closure to the experiment and is the only means by which results can be obtained and distributed.

The first task is to analyze and monitor the electrical data on the five dorms provided by the Georgia Tech Department of Facilities. The data comes in the form of daily power usage in kilowatts and the data exists for the year 2012 and up to the present. First, the data from previous years will be put into the excel template created for the experiment. Attention will be placed solely on the months of January, February, and March for each year for comparison to the months being studied in the experiment. Daily averages for each day of the four months can be taken and plotted for each dorm based on their historical data and these will be used to compare to the experimental data. Next, the electricity data for the experiment will be obtained and exported into the excel template. This data will be plotted in order to provide feedback to the dorms in the experiment that involve feedback as part of their variables. The last step is to obtain and export the electrical data for four weeks after the experiment has been completed. This is necessary for analyzing the lasting effects of each of the variables on students' electricity consumption.

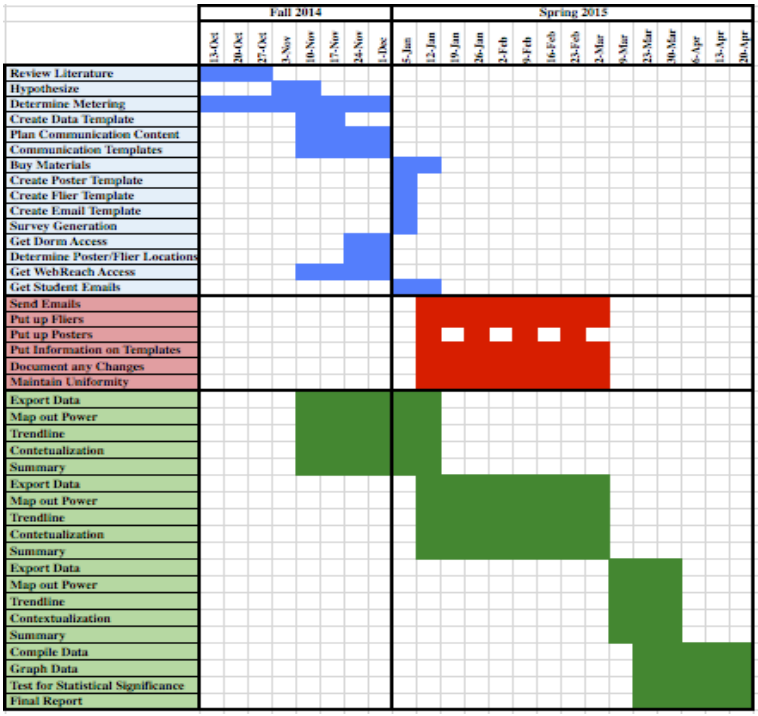
The second task is to analyze and compare all of the data. Trend lines will be created for the average previous years' data, the data from the experiment, and the data taken after the experiment. The trend lines will be plotted on the same graph and the area under each trend line will be found. The difference in these areas yields the net change in electrical consumption in terms of energy in kilowatt-hours. While statistical significance cannot be shown since the sample size would not be significant, the trends can still be analyzed as part of a pilot study. As a pilot study, this experiment will evaluate the feasibility and effect of a full study as well as any adverse effects a component of the study may have. This information is still viable and in fact necessary for Georgia Tech since its Sustainability Department has only just been recently updated.

The third task is to take the results from the experiment and compile them in a report for all interested parties. This report will contextualize the results based on the needs of the interested party. For instance, the Housing Department would be most concerned with the potential cost reduction of each method performed in the experiment. The net change in energy would be converted into the net gain or reduction in energy costs.

The anticipated issues in this objective are the large amounts of data being gathered for the experiment, what information each party desires as far as contextualizing the results, and that there will not be a standard report for the target audiences. As far as the data is concerned, one person will be designated to keep the data on a flash drive and have the data backed up on a hard drive. The data is the most valuable aspect of the experiment and disorganization of this data due to multiple people trying to use it would be detrimental to the entire project. Having the data located in a centralized location reduces the risk of mixing data points. Finding the necessary information to contextualize the results can be accomplished by asking each party about what information they would like to see come out of the experiment. Finally, a report detailing every possible implication of the results would be beyond the scope of an undergraduate research team. The report generated would have to be general enough to provide the basic information that each party requires. It will be up to those parties to figure out how to utilize that information for future sustainability projects on campus.

VI. TIMELINE

TABLE 1. FALL 2014 & SPRING 2015 TIMELINE



In the timeline above, tasks for each objective is provided in the left-hand column. Each objective is divided based on a specific color. The highlighted blue is for the task for objective 1. The highlighted red is for the task for objective 2. The highlighted green is for the task for objective 3.

The majority of the project planning will occur during Fall 2014, while the implementation will occur during Spring 2015. Part of the data analysis will occur in Fall 2014 and Spring 2015.

VII. BUDGET

Fall 2014				
Objective	**Supplies**	**Quantity**	**Individual Cost**	**Cost**
N/A	N/A	N/A	N/A	$0
			Total Cost	**$0**

Spring 2015				
Objective	**Supplies**	**Quantity**	**Individual Cost**	**Cost**
Objective 2	Posters, 36x42	60	$9	$540
	Fliers, 8.5x11	1200	$0.19	$228
	Plastic Flier Sheath	300	$0.10	$30
	Adhesives	300	$0.15	$45
			Total	**$843**

Fall 2014 & Spring 2015	**Grand Total**	**$843**

Above are the components of the project budget, which are separated by semester. The grand total cost is listed at the bottom right.

REFERENCES

[1] Electricity - A secondary energy source. (2007). [Date Accessed: 1 November 9, 2014]. Available FTP: https://www.hagemeyerna.com/getdoc/38614c0f-9c1c-4bb3-9340-2541952ad475/Basics-of-ELECTRICITY-and-GLOSSARY.aspx

[2] Electricity Generation from Fossil Fuels. (2005). [Date Accessed: November 9, 2014]. Available FTP: http://www.mpoweruk.com/fossil_fuels.htm

[3] What is U.S. electricity generation by energy source?. (2013). [Date Accessed: November 9, 2014]. Available FTP: http://www.eia.gov/tools/faqs/faq.cfm?id=427&t=3

[4] Brown, L.R. The Great Transition, Part I: From Fossil Fuels to Renewable Energy. (2012). [Date Accessed: November 9, 2014]. Available FTP: http://www.earth-policy.org/plan_b_updates/2012/update107

[5] How much of U.S. carbon dioxide emissions are associated with electricity generation?. (2013). [Date Accessed: November 9, 2014]. Available FTP: http://www.eia.gov/tools/faqs/faq.cfm?id=77&t=3

[6] Electricity End Use. (2014).[Date Accessed: November 9, 2014]. Available FTP: http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_19.pdf

[7] Electric power consumption (kWH per capita). (2014). [Date Accessed: November 9, 2014]. Available FTP: http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC

[8] Mastrandrea, Hayhoe, Frumhoff, How to Avoid Dangerous Climate Change: A Target for U.S. Emissions Reductions by Amy L. Luers. (2007). [Date Accessed: November 9, 2014] Available FTP: http://www.ucsusa.org/sites/default/files/legacy/asset

s/documents/global_warming/emissions-target-fact-sheet.pdf
[9] American College and University's President Climate Commitment: GHG Report for Georgia Institute of Technology. (2010) [Date Accessed: November 9, 2014] Available FTP: http://rs.acupcc.org/ghg/1311/
[10] Georgia Tech Factbook: Admissions and Enrollment. (2013) [Date Accessed: November 9, 2014] Available FTP: http://factbook.gatech.edu/admissions-and-enrollment/freshman-admissions/
[11] Signs that the rate of Freshmen Survival is increasing. (2010) [Date Accessed: November 9, 2014] Available FTP: http://buzzpedia.lmc.gatech.edu/wiki/index.php/Signs_that_the_rate_of_Freshmen_Survival_is_increasing#cite_note-5
[12] Sustainable Management and Operations at Georgia Tech. (2014) [Date Accessed: November 9, 2014] Available FTP: http://www.af.gatech.edu/page/stewardship-home
[13] Dan Morrison. Director of Residence Life, Georgia Institute of Technology. Interview. Atlanta, GA. October 6, 2014.
[14] Residential Energy Consumption Survey. (2009) [Date Accessed: November 9, 2014] Available FTP: http://www.eia.gov/consumption/residential/
[15] Managing Energy Cost in Colleges and Universities. (2010) [Date Accessed: November 9, 2014] Available FTP: http://www.energyright.com/business/pdf/Colleges_Universities_ESCD.pdf
[16] Tammy Erlene Parece, Tamim Younos, Lawrence S. Grossman, E. Scott Geller, (2013) "A study of environmentally relevant behavior in university residence halls", International Journal of Sustainability in Higher Education, Vol. 14 Iss: 4, pp.466 – 481
[17] Michael Leasure. Associate Director of Energy Conservation, Georgia Institute of Technology. Interview. Atlanta, GA. November 7, 2014.