Energy Usage and Behavior of Students Living in Boston College Residence Halls

Zachary Muzdakis
Summer Zacca

Boston College
Environmental Studies Seminar

Table Of Contents

ABSTRACT

This research paper identifies energy consumption trends in Boston College campus residence halls based on student behaviors and appliance usage. The researchers chose to analyze energy consumption trends in order to direct consumer conscious as well as administrative trends towards a more energy efficient campus. Students are unaware of the amount of energy their appliances use, and act in ways that aren't energy conscious. This paper serves as an analysis of what demographics of students are consuming the most energy, as well as what appliances and behaviors contribute the most to energy inefficient practices. The researchers engaged with students through in person surveys, online surveys, and in person energy audits to glean energy consumption information. The researchers then performed a series of statistical procedures on the collected data and reported the relevant, statistically significant data and trends. It was found that women consume more energy from appliances than men on average, and that hair dryers are the main culprit of inefficient energy practices. It is hoped that this study will be utilized by students and administrators alike to engage Boston College students and campus in energy efficient practices.

INTRODUCTION

People can be indifferent to their energy usage when their electricity is provided and they never see the bill. This inattentive can easily cause someone to excessively consume energy through simple actions such as leaving a lamp on or phone plugged into charge. Increased energy consumption uses more electricity, which means that more oil, natural gas or renewables are needed to generate that electricity. From the burning of those fuels comes uniformly mixing and local air pollutants, such as greenhouse gasses, that are released into our atmosphere. If a Boston resident uses one kilowatt hour of electricity, he or she is essentially emitting around 7.19 pounds of CO_2eq, which is equivalent to driving 7.8 miles in a 4 door 2 axle passenger car (EPA, 2017). Excessive energy usage is widespread in society and unfortunately, the Boston College student body has not been exempt. It is important that BC students learn to limit their energy usage

With this study the researchers attempted to assess the student behaviors that result in the consumption of the most energy and we hope to shed light on areas in which students may scale back their consumption without noticing differences in daily life. The researchers also elicited an plan hoped to be effective for those external to BC in how they should conduct their early actions to reduce energy consumption. A study like this is especially beneficial the city of Boston, home to 35 colleges, universities, and community colleges and over 137,000 students (City of Boston, 2015). Through survey collection and energy audits of individual student rooms, the researchers monitored appliances such as televisions, coffee makers, and phone chargers in order to discover what appliances students use the most and what effect they have on energy overconsumption.

Other studies like this have been previously conducted by students at different universities. Britni Steingard from Smith College in Northampton, MA, conducted research similar to ours in 2009 in order to make energy savings recommendations to the school administrators. The study identified six appliances responsible for approximately 70% of student energy use: clothes washer, mini refrigerator, coffeemaker, hair dryer, clothes dryer, and laptops. In 2007 students at Oregon University tested "electrical consumption patterns as characterized primarily by student status, student traits, housing unit characteristics and price levels" They found that energy consumption differed significantly between grade levels, decreasing as the grade level increased, and concluded that "the longer a student lives away from home and parents, the more aware of their electrical use they become".

The project focuses mainly on the difference in energy usage between different student demographics, i.e. freshmen vs seniors and males versus females. The researchers chose to examine different grade levels in order to determine if students, on average, develop better energy conservation habits over their 4 years at Boston College, and if so then why. By examining men versus women we hoped to find specific appliances that men are more likely to own than women, or vice versa, and if those specific appliance require more energy than others.

Before beginning our audits, we consulted our project advisor, John MacDonald, Boston College's Energy Manager. He explained to us that BC is always looking for ways to decrease their energy usage for both financial and environmental reasons. He provided us with "Kill-A-Watt" handheld energy monitors and helped us with the conversion equations in order to determine the average amount of energy a single appliance uses.

METHODS

Various methods were utilized in order to obtain quantitative and qualitative data regarding appliance usage and energy consumption of Boston College students on campus. Since this study included personal interaction with human subjects, the researchers filed for exempt IRB approval. After several rounds of revisions, and corrections, IRB approval was obtained and the researchers were granted permission to move ahead with data collection. Data collection involved several methods for collection of quantitative data, which will be discussed in detail in the following paragraph. Qualitative data was also obtained and recorded for supporting evidence pertaining to student's behaviors and activities.

During the collection of quantitative data, online surveys, as well as in-person surveys were utilized to collect information on student appliance usage. The survey was comprised of 4 questions to categorize the participants by gender, grade, residence hall, and number of roommates, followed by questions asking if the participant owns any of 11 specific appliances and how many they own, how long they leave it plugged in, and how long they use it per day. These questions had three parts which asked for number of appliances owned, the number of hours the appliance was plugged into an outlet each day, and the number of hours used in a day. The researchers did not have access to mass email listservs and therefore utilized social media platforms as the main sourcing area for the online survey. The online survey was constructed through the online site Qualtrics* and consisted of an informed consent agreement as part of the survey. The researchers supplied the hyperlink to the survey on Facebook, specifically located in the Boston College Class of 2017 group. All online survey responses were recorded and translated into a Google


Gender __M X F
Grade __Freshman __Sophomore __Junior X Senior
Res Hall STAYER
people in room 6

Do you have these appliances in your dorm?

	How Many	Hours/minutes plugged in (per day)	Hours/minutes used per day
Computer Charger	1	8 hrs	8 hrs
Phone Charger	1	12 hrs	8 hrs
Desk Lamp	1	24 hrs	2 hrs
Hairdryer	1	15 mins	15 mins
TV	1	24 hrs	1 hr
Xbox/PlayStation/Wii	1	24 hrs	30 mins
Speakers	1	24 hrs	1 hr
Keurig/Coffee Maker	1	24 hrs	5 mins
Mini Fridge	1	24 hrs	
Microwave	1	24 hrs	5 mins
Blender	1	15 mins	15 mins

Would you be willing to have us do an energy audit of your room? X Yes __ No
If yes, please provide your email: example@bc.edu

Fig 1: Example of answered survey. Note: this survey was filled in by the researchers solely for the purpose of providing an example, and does not contain information used in the study.

Sheets spreadsheet for data storage. Respondents were not given a time limit on how long they had to respond, but data collection ceased 1 week after posting the survey.

The researchers also collected quantitative data by administering surveys in person. The researchers engaged in two tabling sessions at the on-campus dining halls, for 1.5 hours each time. Surveys in paper form were provided, and students passing by were recruited to take the survey using language such as “Please take our short survey on energy consumption amongst students.” No incentives were provided for taking the survey, and all student responses were recruited randomly. Paper survey responses were then transferred to the online Google Sheet spreadsheet, and locked in the advisor’s office.

Further quantitative data was collected during the energy audit phase of the study. students were offered the option of providing their email address at the end of the survey if they were interested in having the researchers audit their room. Room’s for selection were chosen at random from a clustered sample by the researchers. The clusters were organized by building, and then respondents were randomly chosen by the researchers. The researchers assigned each respondent a value between 0 and 1 with equal spacing between each respondent’s value. Then a random number generator was utilized to select respondents. Respondents were contacted after selection and sent a doodle in order to schedule a time to audit their room. After time slot selection, respondent’s rooms were visited by the researchers, where they recorded wattage outputs of appliances stated upon the collected survey. These wattage outputs were recorded in the same Google Sheet spreadsheet as the survey data.

The quantitative data collected through survey responses and in-person energy audits was then transferred into SPSS for statistical analysis. The statistical analysis run on the data will be further discussed at length within the results and discussion sections of this paper.

Qualitative data was collected during the in-person energy audits conducted by the researchers. The major qualitative data collected pertains to reasons why students did not think to unplug their appliances when leaving for class, the gym, going out etc. Reasons were recorded and will be discussed within the results and discussion sections of this paper.

RESULTS

General Descriptive Statistics

During the two weeks we allotted for tabling and online survey collection we received 89 responses to our survey, all of which gave us enough data to perform our tests within a 17% margin of error at the 90% confidence level. Our margin of error is much greater than we'd like and is due to lack of respondents during surveying; however we could not control willingness to participate in our study and due to the small standard deviation in each response to our survey, we believe that our results are an accurate representation of the student body.

Gender	Number of Responses
Males	34
Females	55

Grade	Number of Response
Freshmen	32
Sophomores	24
Juniors	11
Seniors	22

Tables 1 & 2 Classification of responses based on gender and grade.

Once all surveys were collected, the researchers performed energy audits on 11 student rooms (9 female, 2 male) from our random sample based on student's continued willingness to participate in the audit and his or her availability. From the energy audits, the mean watts of electricity used by each appliance were found to be:

Appliance	Mean (Watts)	Std. Deviation
Computer charger	47.91	12.98
Phone charger	4.77	1.30
Desk Lamp	16.80	24.59
Hair Dryer	1814.05	2923.41
TV	61.33	52.07
Game system	39.5	20.98
Coffee Maker	738.50	588.62
Speakers	14.50	20.41
Mini Fridge	8.33	4.85
Microwave	1276.67	248.47
Blender	222.98	110.31

Table 3: Mean watts of electricity used by each appliance

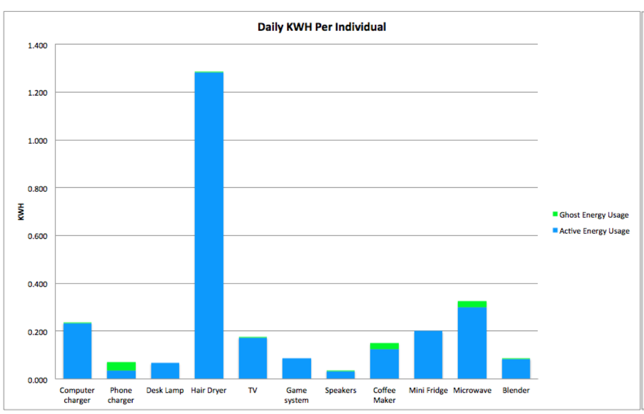
On average, hair dryers required the the most watts of electricity per use but had the highest relative standard deviation between samples; the researchers believe this is due to difference in efficiency between make and model of hair dryers as cheaper ones usually do not get as hot or blow as forcefully (Baird, J. and Brier, J., 1981) . Microwaves required the second most watts and had a lower relative standard deviation that hair dryers, leading the researchers to believe that most microwaves are close in efficiency.

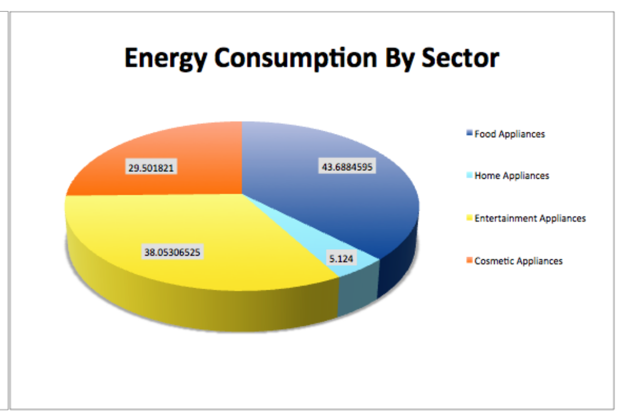
In the next step of data analysis, the researchers used the equations to calculate KWh used per day based on no factors, gender, and grade.

$$\text{Active energy KWh} = \frac{Watts \times hours\ used}{1000} \quad \& \quad \text{Ghost energy KWh} = \frac{Watts \times (hours\ plugged\ in - hours\ used)}{1000}$$

Appliance	Average amount per individual	Hours plugged in per day	Hours used per day
Computer charger	[1, 2]	[11.72,15.18]	[4.25, 5.77]
Phone charger	[1, 2]	[18.46, 21.11]	[6.69, 8.69]
Desk Lamp	[1, 2]	[21.51, 23.63]	[3.75, 6.09]
Hair Dryer	[0, 1]	[.41, 4.41]	[.27, 2.43]
TV	[0, 1]	24	[2.38, 4.23]
Game system	[0, 1]	[18.99, 23.47]	[1.89, 3.37]
Speakers	[0, 1]	[11.19, 17.13]	[1.162, 3.58]
Coffee Maker	[0, 1]	[13.99, 21.09]	[.16, .27]
Mini Fridge	[1, 2]	24	24
Microwave	[0,1]	[23.54, 24]	[.13, 1.70]
Blender	[0,1]	[2.58, 11.99]	[.25, .57]

Table 4: The average amount of appliances owned per individual, and 90% CIs for average time plugged in and average time used per day for each appliance. Note: Computer charger, phone charger, desk lamp, and hair dryer were measured based on individual students, and TV, game system, speakers, coffee maker, mini fridge, microwave, blender amounts were measured based on an individual room.





Charts 1 & 2: The average daily energy consumption of an appliance per individual, measured in kilowatt hours and percent of daily total energy used by certain types of appliances

Examining the results based on individuals (regardless of gender or grade) the researchers found that students consume an average of 0.1904 KWh of Ghost energy and 1.1347 totaling to 1.3251 KWh per day. Students owned more phone chargers, computer chargers, desk lamps, and mini fridges than other appliances, between 1 and 2 per student/room. This is expected, as every student owns a phone and laptop and both desk lamps and mini fridges are resident life recommended appliances to bring to school and sometimes provided by Boston College. Blenders and coffee makers were owned by the least amount of students, only owned by about 25% and 39% of the participants, and the researchers believe this is the case for two main reasons: Only students living in suites or apartments are allowed to have coffee makers, and neither blenders nor coffee makers are considered "necessary" by the students that are allowed to have them.

Desk lamps, TV's, mini fridges and microwaves were left plugged in the longest out of all the appliances, and computer chargers and phone chargers were used for the longest amount of time per day. Most of the total energy consumed per day, 44% was from use of home appliances such as microwaves and coffee makers, followed closely by 38% from entertainment appliance use, such as phone and computer chargers, televisions, and game systems.

Descriptive Statistics Based on Gender

Gender	Female			Male		
Variable	Mean	LB	UB	Mean	LB	UB
Computer Charger	1.350	1.201	1.499	1.030	0.945	1.115
Time Plugged In hrs	13.418	11.243	15.593	12.636	9.959	15.313
Time Used	4.907	3.933	5.881	5.188	3.998	6.378
Phone Charger	1.450	1.291	1.609	1.150	1.027	1.273
Time Plugged In	19.670	17.951	21.389	20.120	18.168	22.072
Time Used	7.801	6.448	9.154	7.515	6.105	8.926
Desk Lamp	1.393	1.145	1.641	1.029	0.700	1.359
Time Plugged In	22.319	20.942	23.697	23.044	21.470	24.617
Time Used	5.698	4.150	7.246	3.158	2.045	4.271

Hair Dryer	0.664	0.483	0.845	0.235	-0.060	0.530
Time Plugged In	1.865	0.034	3.695	0.750	0.339	1.161
Time Used	0.703	0.506	0.900	0.750	0.339	1.161
TV	0.650	0.520	0.780	1.060	0.801	1.319
Time Plugged In	24.000	24.000	24.000	24.000	24.000	24.000
Time Used	3.074	2.299	3.849	3.477	1.789	5.165
Game system	0.440	0.161	0.719	0.850	0.608	1.092
Time Plugged In	20.192	15.965	24.419	21.895	19.502	24.288
Time Used	2.436	1.077	3.795	2.767	1.993	3.541
Speakers	0.510	0.320	0.700	0.970	0.672	1.268
Time Plugged In	12.900	8.710	17.090	15.421	11.368	19.474
Time Used	2.741	0.497	4.985	2.000	1.219	2.781
Keurig/Coffee	0.310	0.207	0.413	0.500	0.341	0.659
Time Plugged In	21.031	17.694	24.367	14.487	9.364	19.609
Time Used	0.222	0.151	0.292	0.214	0.150	0.278
Mini Fridge	1.180	0.962	1.398	1.320	0.996	1.644
Time Plugged In	24.000	24.000	24.000	24.000	24.000	24.000
Time Used	24.000	24.000	24.000	24.000	24.000	24.000
Microwave	1.000	0.879	1.121	0.880	0.788	0.972
Time Plugged In	24.000			22.707	21.209	24.205
Time Used	0.224	0.161	0.287	0.312	0.198	0.426
Blender	0.290	0.180	0.400	0.210	0.094	0.326
Time Plugged In	12.068	5.525	18.611	0.461	0.212	0.711
Time Used	0.381	0.599	0.163	0.461	0.212	0.711

Table5: The average amount of appliances owned per male and female students, and bounds for 90% CIs for average time plugged in and average time used per day for each appliance

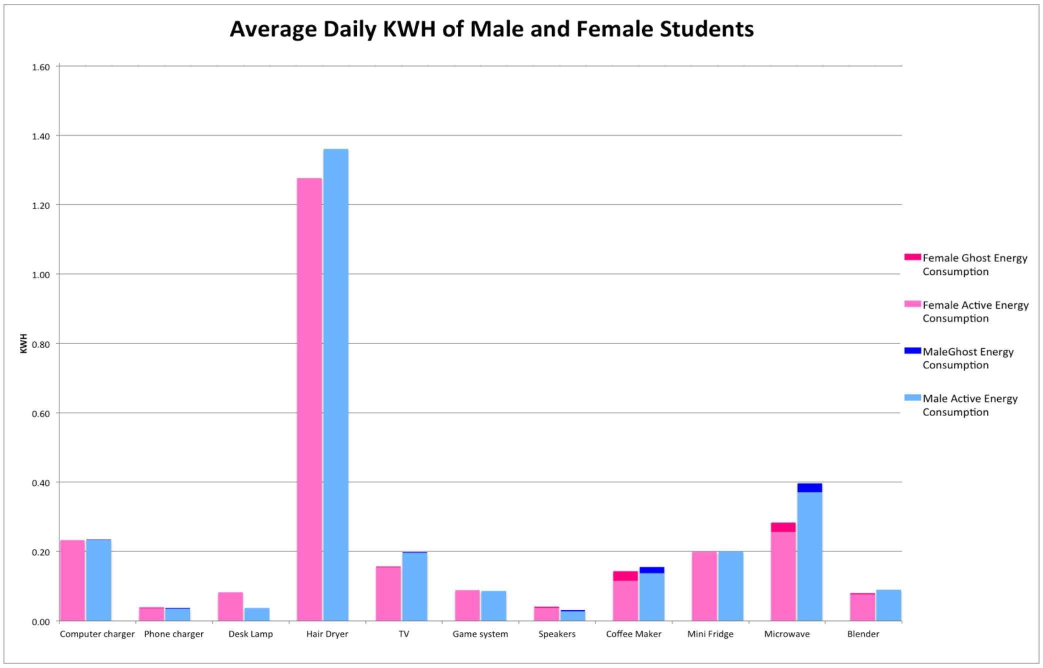


Chart3: The average daily energy consumption of an appliance for male and female students, measured in kilowatt hours.

Average active and ghost energy consumption for male students were .977 KWh and .178 KWh, respectively, totally to 1.154 KWh per day, and for female students 1.232 KWh per hour and .198 KWh per day totalling to 1.430 KWh per day.

Confidence intervals were calculated using the z statistic because the sample sizes were greater than 30.

Descriptive Statistics Based on Grade

	Freshman			Sophomore			Junior			Senior		
Variable	Mean	LB	UB	Mean	LB	UB	Mean	LB	UB	Mean	LB	UB
Computer Charger	1.219	1.067	1.371	1.208	0.993	1.423	1.545	0.912	2.178	1.091	0.978	1.204
Time Plugged In hrs	14.167	10.983	17.351	11.609	8.427	14.791	15.955	9.351	22.559	13.143	9.220	17.066
Time Used	6.097	4.334	7.860	4.913	3.612	6.214	3.45	1.992	4.908	4.295	3.086	5.504
Phone Charger	1.375	1.203	1.547	1.292	1.091	1.493	1.636	0.899	2.373	1.182	1.030	1.334
Time Plugged In	19.767	17.298	22.236	18.261	15.450	21.072	22	17.947	26.053	20.333	17.447	23.219
Time Used	9.2258	7.288	11.163	6.3913	4.890	7.892	6.5455	4.051	9.040	7.4659	4.888	10.044
Desk Lamp	1.03125	0.816	1.247	1.27604	0.823	1.729	1.81818	0.962	2.674	1.27273	0.738	1.807

Time Plugged In	22.2692	20.133	24.405	21.9241	19.330	24.518	24	24	24	23.25	21.838	24.662
Time Used	5.136	2.982	7.290	4.444	2.341	6.547	5.929	1.018	10.840	4.7	1.482	7.918
Hair Dryer	0.313	0.167	0.459	0.688	0.307	1.069	0.364	-0.048	0.776	0.636	0.123	1.149
Time Plugged In	5.1111	-0.958	11.180	0.6267	0.188	1.066	1.5			0.4417	0.114	0.769
Time Used	0.8167	0.411	1.223	0.5433	0.149	0.937	1.5			0.4417	0.114	0.769
TV	0.531	0.338	0.724	0.833	0.657	1.009	0.727	0.442	1.012	1.227	0.816	1.638
Time Plugged In	24	24	24	24	24	24	24	24	24	24	24	24
Time Used	3	0.797	5.203	2.5	1.901	3.099	2.563	1.374	3.752	3.321	2.255	4.387
Game system	0.406	0.135	0.677	0.458	0.194	0.722	0.636	0.224	1.048	1	0.306	1.694
Time Plugged In	21	13.166	28.834	21.367	15.709	27.025	24	24	24	19.6	13.500	25.700
Time Used	4	-4.429	12.429	2.225	0.242	4.208	2	0.769	3.231	2.65	1.772	3.528
Speakers	0.281	0.119	0.443	0.833	0.449	1.217	0.818	0.284	1.352	1.045	0.577	1.513
Time Plugged In	5	-5.038	15.038	17.9231	12.597	23.249	14	1.808	26.192	14.7	8.839	20.561
Time Used	1.2	-0.967	3.367	2.4	0.939	3.861	1	0.416	1.584	3.4308	-0.006	6.867
Keurig/Coffee	0.063	-0.013	0.139	0.542	0.327	0.757	0.636	0.328	0.944	0.545	0.348	0.742
Time Plugged In	24	24	24	19.6809	13.810	25.552	17.2371	6.829	27.645	15.3309	7.982	22.680
Time Used	24			0.27	0.138	0.402	0.18	0.126	0.234	0.18	0.094	0.266
Mini Fridge	0.938	0.782	1.094	1.625	1.224	2.026	0.727	0.332	1.122	1.5	0.932	2.068
Time Plugged In	24	24	24	24	24	24	24	24	24	24	24	24
Time Used	24	24	24	24	24	24	24	24	24	24	24	24
Microwave	0.781	0.651	0.911	1.167	0.934	1.400	1.091	0.907	1.275	0.909	0.796	1.022
Time Plugged In	24	24	24	23.957	23.879	24.035	22.818	20.423	25.213	24	24.0	24.0
Time Used	2.68875	-0.293	5.671	0.15682	0.104	0.210	0.13	0.051	0.209	0.36778	0.190	0.546
Blender	1	1.000	1.000	1	1.000	1.000	1	1.000	1.000	1.167	0.732	1.602
Time Plugged In	24	24	24	0.3329	0.028	0.638	0.0267	-0.265	0.318	14.7	-2.602	32.002
Time Used	0.625	0.095	1.155	0.3329	0.028	0.638	0.08	0.080	0.080	0.75	0.154	1.346

Table 6: The average amount of appliances owned per freshmen, sophomores, juniors and seniors, and bounds for 90% CIs for average time plugged in and average time used per day for each appliance

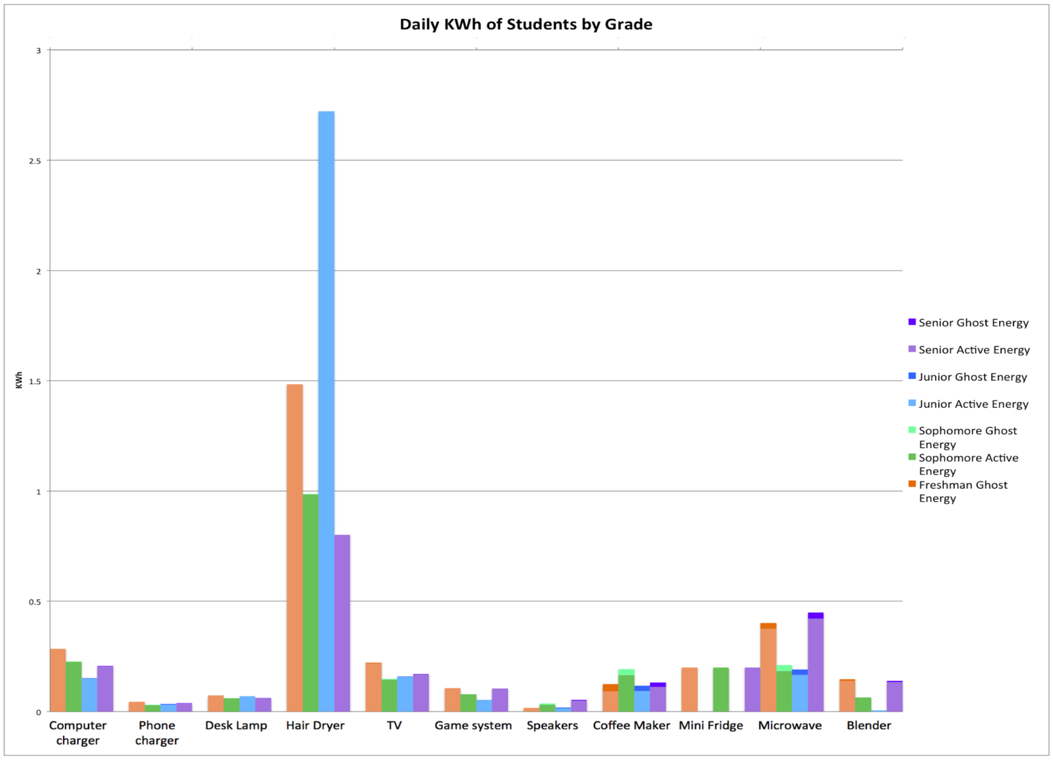


Chart 4: The average daily energy consumption of an appliance for freshmen, sophomores, juniors and seniors, measured in kilowatt hours.

Average active, ghost and total energy consumption for each grade are as follows: 1.205, .182 and 1.386 KWh for freshmen, .991, .010, and 1.185 KWh for sophomores, 1.118, .175, and 1.293 KWh for juniors, and 1.196, .206, and 1.403 KWh for seniors.

Confidence intervals were calculated using the t statistics with n-2 degrees of freedom, for both mean and standard deviation were estimated from the data. The intervals with a larger spread are due to a smaller sample size and thus a larger standard error.

Statistical Tests and Significant Results

Gender:

Examining the results based on gender and after performing a difference in mean t test, we found that there is no significant difference in the mean total energy usage between females and males at the 10% significance level. However there was a significant difference in the amount of each appliance owned between men and women at the 10% significance level. Women owned more computer chargers and phone chargers than men, and more women owned hair dryers, coffee makers, and blenders than men. On the other hand more men owned more TV's, game systems and speakers.

The researchers utilized an independent sample, difference in means t-test in order to determine whether the observed differences between men and women regarding appliance ownership and usage were statistically significant. The researchers discovered that women owned an average of 1.345 computer chargers compared to men owning only 1.029 computer chargers. When a difference in means t-test was ran, the researchers discovered that the difference in means was statistically significant at the .05 level (.003 < .05). The researchers discovered that on average women owned .664 hair dryers, while men owned .235 hair dryers. Similarly, when the researchers employed a difference in means t-test, the resulting p value equaled .047 which is significant at the .05 level (.047 < .05).

The researchers found that men on average own more TV's than women do (1.059 > .655). This difference was also found to be significant at the .05 significance level with a p value equal to .026 (.026 < .05). Similarly, on average men were found to own more game systems than women (.853 > .436). This difference was found to be significant at the .1 significance level with a p-value of .067 (.067 < .1). Men were also found to own more speakers on average than women (.971 and .509 respectively). This difference in means was found to be statistically significant at the .05 level with a p-value equal to .036 (.036 < .05). Finally, the researchers found that women keep their blenders plugged in much longer than men do (12.068 and .4614 hours respectively). The difference in time plugged in for blenders was found to be statistically significant at the .05 level, with a p-value of .017 (.017 < .05).

The significance values stated above are displayed in the following table:

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Lower bound	Upper bound
Computer Charger	H(0)*	23.738	0	2.581	87	0.012	0.316	0.1125	0.5196
	H(A)**			3.031	80.675	0.003	0.316	0.1425	0.4896
Phone Charger	H(0)	11.338	0.001	2.258	87	0.026	0.3075	0.0811	0.5339
	H(A)			2.52	86.993	0.014	0.3075	0.1046	0.5104
Hair Dryer	H(0)	1.742	0.19	2.156	87	0.034	0.4283	0.0981	0.7586
	H(A)			2.035	57.562	0.047	0.4283	0.0764	0.7803
TV	H(0)	0.173	0.678	-2.54	87	0.013	-0.4043	-0.6689	-0.1396
	H(A)			-2.294	49.652	0.026	-0.4043	-0.6997	-0.1089
Game system	H(0)	0.024	0.878	-1.7	87	0.093	-0.4166	-0.824	-0.0091

	H(A)			-1.855	86.101	0.067	-0.4166	-0.7899	-0.0432
Time Plugged In	H(0)	19550.322	0	2.417	15	0.029	11.60657	3.1866	20.02655
	H(A)			2.916	9.026	0.017	11.60657	4.31234	18.9008

*H(0): The null hypothesis that the variances are equal

**H(A): The alternative hypothesis that the variances are not equal

Table 7: Displays the significant difference in means t-test results based on gender. The significance column is highlighted in yellow

Grade:

The researchers utilized independent t-tests in order to determine statistically significant differences in means between different grades, identical to the analysis used to determine differences between gender. The following paragraphs depict the relevant statistics discovered from the six independent sample t-tests run.

Freshmen V. Sophomores:

By running independent sample t-tests, the researchers determined that several differences between means observed were interesting and relevant enough to include within this paper. First, it was observed that on average freshmen use their phone chargers 2.845 hours more per day than sophomores (9.22 hours per day and 6.39 respectively). The phone charger usage difference between freshmen and sophomores was found to be statistically significant at the .05 level with a p-value of .045 (.045 < .05). The researchers believe that this observation could be due to several reasons. First of all, freshman may not have fully developed social circles, therefore spending more time on their phones, on social media and conversing with family and friends back home. Secondly, freshmen may have less homework and out of class obligations, causing them to use their phones more, and therefore use their chargers more often. Secondly, the researchers discovered that the difference between the number of speakers, and the amount of time they were plugged in was statistically significant at the .05 level each. Freshmen, on average owned .281 speakers while sophomores own .833 speakers, and freshmen plug their speakers in for 5 hours a day, while sophomores plug their speakers in for 17.92 hours per day. The difference in means for number of speakers yielded a p-value of .024 < .05, and the difference in means for the number of hours speakers were plugged in yielded a p-value of .02 < .05. The researchers postulate that sophomores own more speakers because they throw more parties than freshmen, where speakers are a necessity.

Freshmen V. Juniors:

Similarly to freshmen compared to sophomores, the relevant statistically significant difference in means between freshmen and juniors is related to speakers. Freshmen report on average owning .281 speakers, while juniors report owning .818 speakers. The difference in means is statistically significant at the .1 level, producing a p-value equal to .077 < .1. Similarly to sophomores, the researchers expect that juniors own more speakers since they typically engage in throwing more parties during the school year. Thus, juniors are more likely to own a party staple such as speakers. Further, freshmen report plugging their speakers in for only 5 hours a day, while juniors report plugging their speakers in for 14 hours a day. This difference is statistically significant at the .1 level, with a p-value of .094 < .1. Similar to owning more speakers, it is necessary that juniors charge their speakers more often since they are getting more use as well.

Freshmen V. Seniors:

Similarly to the previous two scenarios, the researchers discovered that the difference between number of speakers owned by freshmen and seniors was statistically significant and relevant. Freshman, as stated above own .281 speakers on average, while seniors own 1.045 speakers. The observed difference between freshmen and senior speaker ownership is statistically significant at the .05 level with a p-value of .01 < .05. The researchers believe that the perceived difference from above is due to the same reasoning for freshmen and juniors and freshmen and sophomores. Further, the researchers found that on average seniors owned more mini-refrigerators than freshman (1.5 and .938 respectively). The difference in mini-refrigerator ownership was also found to be statistically significant at the .1 level, with a p-value of .097 < .1. The researchers believe that seniors own more mini-refrigerators because they have higher alcohol consumption than freshmen, and need more space to store beverages.

Sophomores V. Seniors:

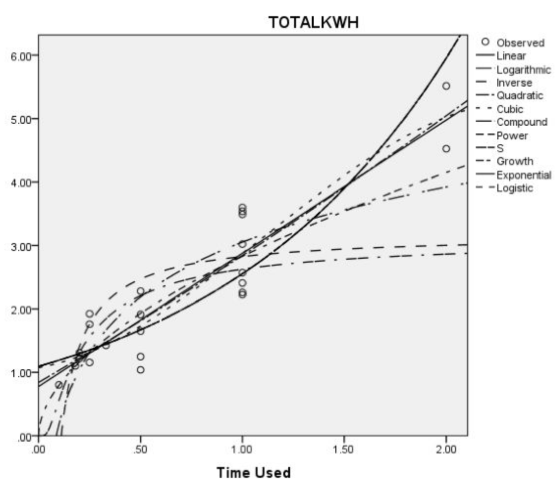
Differently than the previous scenarios, the researchers found statistically significant differences between blender usage and the amount of time that blenders were plugged in. Seniors leave their blenders plugged in for 14.7 hours while sophomores leave theirs plugged in for only .3329 hours. When compared with an independent t-test, a p-value of .065 was calculated which is significant at the .1 level (.065 < .1). Senior students also reported a higher average of blender usage than sophomores did. Seniors disclosed that on average they used their blender for .75 hours a day, while sophomores used their blenders .333 hours per day. When compared with an independent t-test, a p-value of .066 was calculated, which is statistically significant at the .1 level (.066 < .1). The researchers theorize that the reasoning behind increased blender usage amongst seniors is due to a rise in health conscious eating habits, as well as a goal to establish healthy food trends in post-collegiate life.

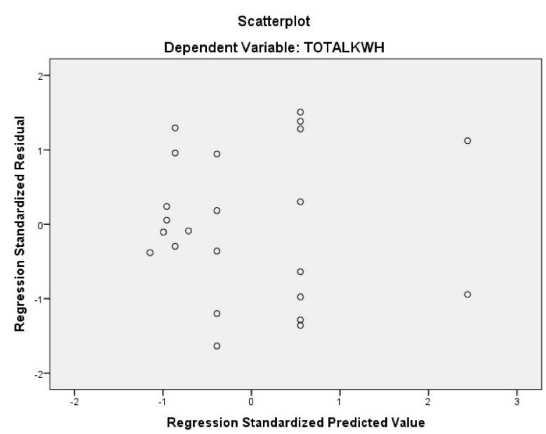
Juniors V. Seniors:

Similarly to sophomores v. seniors, the researchers found that blender usage was statistically significantly different between juniors and seniors. Senior respondents reported that on average they use their blender for .75 hours per day. On the other hand, juniors use their blenders a mere .08 hours per day. When compared with an independent t-test, a p-value of .014 was calculated which is significant at the .05 level (.014 < .05). The researchers believe that significant differences between juniors and seniors blender usage follows the same reasoning as stated before with sophomores and seniors.

Other Relevant Trends

Linear Regression Model (Total KWh and Hair Dryer Usage):





Scatter Plots 1&2: Display the curve estimations of Hair Dryer Time Used and Total KWh of energy consumption. Scatter Plot 2 displays the standardized residual and predicted values of the dependent variable.

The plots above show the regression model curve estimations created for predictor, amount of time hair dryer used, and dependent variable, total KWh of energy consumed. The data fits linear, logarithmic, power and s curves, but fits a linear regression model the best. The amount of time that a hair dryer is used explains for 85% of the variance within the dependent variable (total KWh consumed). Furthermore, the standardized partial regression coefficient is equal to .921, meaning that with a one standard deviation change in the amount of time that a hair dryer is used, we can expect a .921 standard deviation increase in total KWh of energy consumed. The researchers can conclude therefore that the amount of time a hair dryer is used is a strong predictor of the amount of total KWh of energy consumed. Scatterplot 2 allows the researchers to assess whether issues with homoscedasticity, linearity, or normality are present. Since the scatter of standardized residuals and predicted values are not clustered towards one end, and are rather evenly dispersed across the plot, the researchers have assured normality, linearity, and homoscedasticity.

DISCUSSION

An average Boston College student uses 1.325 KWh of energy per day from appliance usage alone. Based on the fuel mix and air emissions rates from electricity in New England (EPA, 2017), this is equivalent to emitting 9.57 lb of CO_2 equivalent or driving 10.4 miles in a 4 passenger car. The total resident student body, 7,266 students, emits 69,511 lbs of CO_2 equivalent per day, solely from their appliance usage. This is equivalent to driving 75,566 miles per day, or 27,581,590 miles per year.

In order to better understand students opinions on energy consumption, the researchers sent a second survey out to the student body. The survey asked how often students leave their appliances plugged in and to check as many as 6 possible reasons as to why: 1) “I never leave them plugged in”, 2) “I forget to unplug them after use”, 3) “It is easier to leave them plugged in when I am not using them”, 4) “I don't really think about unplugging them after use”, 5) “I don't think leaving them plugged in affect my energy usage”, and 6) Other. Out of the 60 responses, about 67% of the respondents checked #4, 48% checked #3, and no one responded that they never leave them plugged in.

Based on these answers, the researchers believe that most students are unaware of the impact of their energy consumption from appliance usage. Most people think that big corporations are the ones responsible for the GHG emissions, pollutions and other environmental damages, and they are hesitant to act in environmentally conscious ways because of the "difficulty individuals have in understanding how their seemingly minor actions … can accumulate into more serious, widespread harm" (Babcock, 2009). The researchers believe that if students were more informed about exactly how much energy they are consuming per day, and the consequences that consumption has, they would be more inclined to change their behaviours.

Informing consumers is an aspect of energy efficiency that for a long time has been neglected and deemed inconsequential. However, organizations are beginning to reverse the apathetic neglect of demand side, consumer driven change. Opower, a data analytics company, has partnered with utilities in order to inform and change the behavior of consumers. Opower targets home energy costs and consumption through their Home Energy Reports (Buck, 2015). Opower uses its vast data analysis capabilities and sends reports to homeowners, detailing their consumption rates, and comparing them to averages within their neighborhood and nationwide. By not only receiving a bill, but by receiving a report catered to the individual, consumers are put on the forefront of energy efficiency. Opower works with consumers, using nudge theory techniques, in order to enhance their energy efficiency through buying efficient products, and engaging in energy efficient and cost effective behaviors. The central component of the Opower HER reports is the neighbor comparison (Buck, 2015). The neighbor comparison breeds friendly competition, and allows for energy reports to be viewed in context to one's neighbors. The beneficial effects of comparing households of neighbors is well documented in driving energy efficient behaviors and consumer demand (Buck, 2015). Finally, Opower includes recommendations on products to buy, and ways to save energy within the HER paper delivered to each household. As a result of consumer nudge tactics, and helpful recommendations, Opower has led the way in promoting demand side energy efficiency, putting the onus of responsibility upon the consumer.

RECOMMENDATIONS

The researchers have several recommendations for the Boston College students and administrators to reduce overall energy consumption. The first recommendation is for Boston College faculty, administrators and student clubs to distribute information to the student body on energy over-consumption and its environmental impacts as students. A few ways this can be accomplished is by publicising the facts during resident hall meetings, through tabling in the quad, and through posts on social media.

There are several ways the students can conserve energy by making minor changes to their daily routine. If students have many appliances plugged into a surge protector and find that they do not use them very often, they can simply turn off the surge protector to prevent ghost energy consumption from those appliances. This method is quicker and requires less physical energy than plugging them all out and back in again.

Another easy way to conserve energy is through using energy efficient appliances. Students can partake in "green purchasing" by using Energy_Star to check consumption rates, and identify energy efficient products for purchase (i.e. Drip coffee is more energy efficient than a Keurig). Students should also invest in energy efficient LED desk lamps, as they use approximately 40 KW/hr less than standard lamps, or they can contact The Office of Sustainability for one. Boston College can also mandate the use of energy efficient appliances by providing certain appliances in the dorms , such as putting energy efficient microwaves in apartment style housing and replacing the current common room standing lamps with LEDs.

The final recommendation is that Boston College Energy Management and Office of Sustainability models a study after Opower and sends energy consumption reports to rooms in each residence hall. These reports will include details of the room's energy consumption and a comparison to similar rooms' consumption, as well as the entire floor or building's energy consumption and a comparisons to similar buildings. It is no secret that Boston College students are competitive, and the researchers believe that using nudge theory tactics could evoke competition towards energy reduction within the student body that would effectively reduce overall consumption.

ACKNOWLEDGEMENTS

The researchers would like to thank their seminar Professor Daniel DiLeo for his help and support during the semester and wish him luck at his new position in Creighton. The researchers would also like to thank Energy Manager John MacDonald for his help with the project and providing us with the Kill-A-Watt monitors, Professor Tara Pisani Gareau for her ongoing support, and all of the students that completed the two surveys administered, and offered their rooms for audits. Finally, a special thanks to Amy Gaito, BC '17, who helped us format our paper and provided suggestions for energy reduction.

Works Cited

Babcock, Hope M, 2009. "Responsible Environmental Behavior, Energy Conservation, and Compact Fluorescent Bulbs: You Can Lead a Horse to Water, But Can You Make It Drink?," Hofstra Law Review: Vol. 37: Iss. 4, Article 3. Retrieved From: http://scholarlycommons.law.hofstra.edu/hlr/vol37/iss4/3

Baird, J. and Brier, J., 1981. Perceptual awareness of energy requirements of familiar objects. Retrieved from: http://psycnet.apa.org/index.cfm?fa=buy.optionToBuy&id=1981-13653-001

Buck, Charlie. 2015. Comments of Opower on California's Existing Buildings Energy Efficiency Action Plan. Retrieved from: http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-05/TN204288_20150421T154215_Charlie_Buck_Comments_Comments_of_Opower_on_California%E2%80%99s_Existi.pdf

City of Boston, 2015. *Boston By the Numbers*. Retrieved from: https://www.bostonplans.org/getattachment/1fd5864a-e7d2-4ebc-8d4a-a4b8411bf759

Energy Star, 2011. Energy Star Market and Industry Scoping Report Coffee Makers. Retrieved from https://www.energystar.gov/sites/default/files/asset/document/ENERGY_STAR_Scoping_Report_Coffee_Makers.pdf

EPA, 2017. *GHG equivalencies calculator*. Retrieved from: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

EPA, 2017. *Power Profiler.* Retrieved from: https://www.epa.gov/energy/power-profiler

Edgar, Joe; Gefre, Eric; Harbaugh, Bill, Prof., University of Oregon, 2007, *University Student Electrical Consumption Comparison and Analysis.* Retrieved From: http://economics.uoregon.edu/wp-content/uploads/sites/4/2014/05/EWEBConservation.pdf

Steingard, Britni, 2009. *A Study of In-Dorm Student Energy Use at Smith College.* Retrieved from: https://www.smith.edu/env/pdf%20files/2009/Steingard_EnergyUse_09.pdf

Trustees of Boston College. 2016. Boston College Fact Book. Retrieved from https://www.bc.edu/content/dam/files/publications/factbook/pdf/15_16/15-16_fact_book.pdf