Coffee Energy Audit:
An Analysis of Coffee Energy Consumption and Efficiency at Boston College

ENVS4943: Environmental Seminar
28 April 2015
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Abstract

Preparation by the consumer is one of the most crucial segments of coffee’s entire life cycle, producing 30% of its overall production-related emissions. Variability in both device technology and consumer behavior greatly affects overall emissions and economic cost. In order to minimize inefficiencies, this study sought to conduct quantitative analysis of coffee maker energy use in addition to qualitative analysis of consumer behavior within the offices and departments of Boston College. Results demonstrated that 75.4% of the energy used is expended while the machines are idle overnight, representing a large opportunity for improvement. Further, survey results suggest that many departments lack proper waste options to minimize post-production emissions. Based upon these data, it is recommended that departments and offices (1) unplug coffee appliances over night (2) switch from filter drip to single serving technology where economically feasible (3) institute composting options for the coffee ground waste of filter drip machines and (4) adoption of zero-waste reusable pods for single serving machines. Together, these steps can help to minimize the environmental impact and economic loss currently resulting from coffee production.

Introduction

In 2013, 54% of Americans identified as coffee-drinkers (HPSH, 2015). That same year, this population of more than 150 million consumed an average of 3.1 cups/day, totaling nearly 170 billion cups annually. At these rates of consumption, coffee has come to represent one of the most highly consumed beverages in the country alongside carbonated soda. In turn, it also represents a significant energy demand in its cultivation, processing, and consumption. Within this production chain, the preparation by the consumer is one of the most crucial parts of the entire life cycle of coffee, making up a share of 30% of its overall production-related emissions (Brommer, 2011). On account of this significant energy demand, the 2005 Energy Information Administration’s Residential Energy Consumption Survey (RECS) estimated that coffee makers accounted for anywhere from 0.5-4% of end use electricity consumption in residences and offices. The high variability of this statistic is based primarily on variation of two fundamental factors: device technology and consumer behavior. Both factors present points for which improvements in efficiency can be made in order to reduce overall energy consumption of this significant sector of the energy market. If improved, it can help to reduce both costs and emissions associated with this significant portion of energy usage.

Based upon their culture and demographics, college campuses are notorious coffee consumers and contribute significantly to the energy use required by coffee production. Currently, Boston College has a total of 14,100 enrolled students, 758 full time faculty, and
2,509 administrative, professional, and support staff (BCOIR, 2013). Of the students enrolled, 5,100 are required to purchase the mandatory meal plan while 4,000 additional students choose to participate in an optional meal plan. Thus, the total 3,267 faculty and staff at Boston College represent a significant portion of the coffee consumption that occurs in campus facilities. This is especially important considering that, unlike the coffee machines used in the campus dining halls, there is great variation in the types of coffee machines that are used in the University’s offices and departments.

Many different types of coffee machines are used within these campus offices and departments, including drip-brew filter, single serving pod/capsule, or espresso machines. The energy use phase throughout the day and during process of producing the coffee varies significantly among different machines. In some cases, electricity usage is high during the heating of water or standby mode.

Of these types, traditional drip-brew filter coffee machines still have the highest market share with 55% (Bush, 2011). These brewers produce coffee by allowing heated water to slowly drip through a filter containing ground coffee, after which they are collected in a continually heated reservoir. Despite their historical market dominance, these machines have experienced a -1.2% growth rate in sales between 2006 and 2010 (Simmerman, 2013). The majority of these types does not include auto-power-down features and, as a result, use about three quarters of their total electricity consumption in standby mode keeping beverages hot (Bush, 2009).

Single-serve coffee makers, on the other hand, brew coffee by forcing a precise amount of hot water through a small container of coffee grounds to make a single serving. The majority of energy use in these machines is expended in creating a pressurized pump of 3 bars that pushes water through the grounds (Energy Star, 2011). Due to their ease of use, single-serve coffee makers have become the quickest growing market in coffee machines with a 36% growth in sales between 2006 and 2010 (Simmerman, 2013). Alternative brewing methods such as French press and espresso machines are less prevalent in American markets and play a relatively minor role in workspace energy consumption.

No previous energy audit has been conducted on coffee machines at Boston College. Nor has a survey been conducted regarding which types of machines are utilized in various locations within campus facilities. Based upon this current lack of knowledge regarding energy use of
coffee consumption at Boston College, there is much room to optimize practices and increase efficiency.

Sustainability improvements, regardless of their scale, have the potential to reduce harmful effects of carbon emissions and dependence on fossil fuels. By improving energy efficiency and reducing energy usage, Boston College could help mitigate the causes and therefore the consequences of global climate change. These improvements, then, can be particularly relevant in the context of the Boston College community due to the university’s official sustainability mission statement which states that “Boston College recognizes that there are limits to the world's resources. To ensure the quality of life for future generations, Boston College seeks to demonstrate leadership in environmental stewardship and sustainability, living the motto 'ever to excel.' The university is committed to conserving resources and reducing the impact that its services and activities place on the environment” (IMP, 2009).

Thus, the goal of this study is to better understand Boston College’s coffee consumption and to identify opportunities for greater efficiency. Specific objectives for the investigation will include:

1. **Collect energy data from on-campus divisional coffee pots.** Right now, there is no information available about Boston College’s institutional energy use. These data will help create the bigger picture by establishing the scope and scale of the university’s usage as well as identify particular varieties of coffee brewers that are most efficient.

2. **Identify personal trends in coffee consumption.** This information will be used to provide a deeper understanding of the energy readings obtained in the department. No data are available regarding the actual usage of coffee makers on campus, nor are their data on how faculty and staff view the consumption of coffee.

3. **Establish recommendations to curb coffee brewer energy usage.** With the diversity of brewers available on campus and with the information obtained through the first two objectives, areas for improvement will be identified. Through these recommendations, which will be sent to Boston College Facilities, a University-wide policy can be established to minimize the University’s environmental impact and economic loss.
Various methods were employed to obtain both qualitative and quantitative information on the energy usage of coffee makers throughout different departments. Both aspects of energy usage were measured, as qualitative statements on coffee consumption were supplemented by quantitative data. Before this information could be obtained, researchers connected with departments and offices across Boston College seeking voluntary participants in the study. Four departments and four offices agreed to be included, for a total of eight participating parties. These included the Departments of Psychology, Chemistry, Environmental Studies, and Philosophy/Theology as well as the Offices of Facilities, Student Services, Health Services, and Vice President for Student Affairs. The variety of participating parties allowed for a significant and representative sample size of the Boston College faculty. This accounted for potential discrepancies between different departments due to size, specialty, or other unknown factors.

Faculty and staff in participating divisions were sent an introductory email, which consisted of an introduction to the experiment, a link to a qualitative survey (see Appendix I), and contact information for the four researchers. The researchers did not have personal access to the listservs for the divisions, so the emails were sent through departmental contacts, who were most often departmental heads or administrative assistants. Additionally, by virtue of emails coming from the department heads, it helped lend a sense of legitimacy to faculty and staff who may have ignored an email coming straight from the researchers. The survey contained fourteen questions specifically designed to measure amounts of coffee consumption, times of consumption, varieties of coffee brewers, and varieties of coffee. Respondents were also able to rate on a scale of 1 to 5 their opinions on divisional and campus-wide coffee consumption. Finally, participants were also able to give statements and suggestions about the sustainability of coffee consumption. As a whole, these survey questions and responses were used to establish background information that might not be established through purely looking at energy usage of coffee brewers. The respondents were originally given a two-week period to respond to the survey. However, due to the Easter holiday falling in the middle of this period and in an attempt to have as much data as possible, the response period was increased to four weeks. In order to increase the amount of responses, a reminder email was also sent after three weeks.
To measure the quantitative energy usage of coffee-brewers, a Kill-A-Watt energy meter was attached to each coffee maker for three consecutive days. Because Boston College generally holds class on a varying Monday/Wednesday/Friday and Tuesday/Thursday schedule, repeating measurements for three days could account for any differences in class schedule and the associated results of faculty habits. For example, if these data were only recorded on a Monday/Wednesday/Friday, the data set would not include faculty who might only teach on Tuesday and Thursday. Each meter was reset at 9:00 AM and energy was measured in kilowatt-hours until 5:00 PM. At the beginning of each hour, a researcher would record the cumulative energy use at that time. By doing hourly measurements over the course of a typical 8-hour workday, peak periods and low periods of energy usage could be identified by the hour. Hourly fluctuations of electricity usage were elucidated by this method, which would not be possible if energy was recorded less frequently.

Finally, using the survey responses and energy data, a series of recommendations could be determined. By looking at both quantitative and qualitative data, general informational trends were deduced and isolated from the larger pools of data points. Identifying these trends and applying them to the larger Boston College population can establish a greater picture of the university's energy usage. These recommendations can be applied to reduce the impact coffee-makers, an ubiquitous aspect of college campuses, have on energy usage and the environment.

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**Results**

*Coffee consumption survey results*

A total of 90 responses were received for the survey, which were divided amongst departments and offices. Respondents were prompted to determine the number of cups of coffee consumed, the times of consumption, as well as give some information about the coffee itself, followed by information on their coffee consumption habits and their opinion on the matter. Table 1 summarizes the results that were received. It is important to note that 20 out of 90 respondents stated that they did not drink coffee, which is a lower percentage than the national average. However, these responses are still included as part of the analysis. Additionally, no responses were received from either Environmental Sciences Department or the Facilities Office.
Table 1. Summary of coffee consumed from survey results

<table>
<thead>
<tr>
<th>Location</th>
<th>Total number of responses</th>
<th>Total cups consumed</th>
<th>Average cups consumed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philosophy/Theology</td>
<td>8</td>
<td>14</td>
<td>1.75</td>
</tr>
<tr>
<td>Psychology</td>
<td>42</td>
<td>42</td>
<td>1.35</td>
</tr>
<tr>
<td>Chemistry</td>
<td>16</td>
<td>27</td>
<td>1.69</td>
</tr>
<tr>
<td>Vice President for Student Affairs</td>
<td>12</td>
<td>26</td>
<td>2.17</td>
</tr>
<tr>
<td>Student Services</td>
<td>11</td>
<td>17</td>
<td>1.55</td>
</tr>
<tr>
<td>Health Services</td>
<td>2</td>
<td>4</td>
<td>2.00</td>
</tr>
<tr>
<td>Other</td>
<td>10</td>
<td>25</td>
<td>2.50</td>
</tr>
<tr>
<td>Total</td>
<td>90</td>
<td>155</td>
<td>1.77</td>
</tr>
</tbody>
</table>

As mentioned above, the 90 responses were attributed to each department and office. On average, across all locations, 1.77 cups of coffee were consumed per day. The department with the most cups consumed on a daily basis is the Vice President for Student Affairs office (2.17 cups per day). The department with the least cups consumed on a daily average is the Psychology department (1.35 cup per day).

Cups were consumed at varying rates throughout the course of the day. Figure 1 contains details of the most common times of consumption per department. In general, accounting for all locations, 7am to 8am was the most common time people consumed coffee. This was closely followed by 8am to 9am, which indicates that upon arriving at Boston College, most coffee drinkers that consume in their departments or offices would get a cup of coffee. A smaller consumption peak appears in the early afternoon, but decreases promptly afterwards.
Table 2 summarizes the responses that were received on the coffee consumption habits. Somewhat surprisingly, the majority of coffee drinkers get their coffee off-campus. Only 37.7% (n = 34) of the respondents indicated that they use their department’s or office’s coffee maker. A smaller percentage, namely 18.8% (n = 17) of the respondents, chose to get their coffee at the dining hall.

In addition to prompting respondents about their coffee drinking habits, several qualitative questions regarding the coffee itself and coffee makers were asked. The two most popular types of coffee makers were the Automatic Drip Filter and the Single Serve (Keurig-type) makers. However, there was no such consensus on specific varieties of coffee.

Respondents were then asked whether they recycled coffee filters. They had the option to respond positively, negatively, stating that they did not have access to coffee filters, or to skip the question. Out of a total of 79 responses, 48.1% (n = 38) of respondents answered that they did not recycle the filters, while 41.7% (n = 33) answered that they had no access to the coffee filters. A small minority, 8.9% (n = 8), answered that they do recycle their coffee filters.

When prompted about waste related to coffee (coffee grounds, coffee cups, etc.), respondents had the choice to give multiple answers. They could state that they recycled, composted, trashed, or state that they did not have access to the coffee waste. With a total of 102

![Average time of coffee consumption over the course of a day](image)

*Figure 1. Consumption time periods for all locations*
responses (multiple responses were allowed per respondent), approximately half (51.0%, n = 52) of the respondents indicated that they place coffee waste in the trash, while the rest were almost equally split between answering that they recycle (21.5%, n = 22) or answering that they do not have access to coffee waste (22.5%, n = 23). Furthermore, a few respondents (4.9%, n = 5) indicated that they compost their coffee waste.

Table 2. Summary of survey results

<table>
<thead>
<tr>
<th>Location</th>
<th>Average cups consumed</th>
<th>Most common time</th>
<th>Provenance of coffee</th>
<th>Coffee filters handling – recycle?</th>
<th>Coffee waste handling – recycle?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philosophy/Theology</td>
<td>1.75</td>
<td>7-8am</td>
<td>6 departments</td>
<td>7 no</td>
<td>3 recycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7 off-campus</td>
<td>1 no access</td>
<td>1 compost</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3 dining hall</td>
<td></td>
<td>5 trash</td>
</tr>
<tr>
<td>Psychology</td>
<td>1.00</td>
<td>6-7am</td>
<td>5 departments</td>
<td>1 yes</td>
<td>8 recycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>17 off-campus</td>
<td>10 no</td>
<td>3 compost</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 dining hall</td>
<td>13 no access</td>
<td>17 trash</td>
</tr>
<tr>
<td>Chemistry</td>
<td>1.69</td>
<td>7-8am</td>
<td>8 departments</td>
<td>4 yes</td>
<td>4 recycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9 off-campus</td>
<td>3 no</td>
<td>8 trash</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 dining hall</td>
<td>9 no access</td>
<td>6 no access</td>
</tr>
<tr>
<td>Vice President for Student Affairs</td>
<td>2.17</td>
<td>9-10am</td>
<td>6 departments</td>
<td>1 yes</td>
<td>4 recycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7 off-campus</td>
<td>5 no</td>
<td>7 trash</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3 dining hall</td>
<td>6 no access</td>
<td>2 no access</td>
</tr>
<tr>
<td>Student Services</td>
<td>1.55</td>
<td>8-9am</td>
<td>4 department</td>
<td>2 yes</td>
<td>1 recycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 off-campus</td>
<td>3 no</td>
<td>1 compost</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 dining hall</td>
<td>3 no access</td>
<td>4 trash</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6 no access</td>
</tr>
<tr>
<td>Health Services</td>
<td>2.00</td>
<td>N/A</td>
<td>2 off-campus</td>
<td>2 no</td>
<td>1 recycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 trash</td>
</tr>
<tr>
<td>Other</td>
<td>2.50</td>
<td>7-8am</td>
<td>5 departments</td>
<td>8 No</td>
<td>1 recycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6 off-campus</td>
<td>2 no access</td>
<td>10 trash</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 dining hall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1.77</td>
<td>7-8am</td>
<td>34 department</td>
<td>8 yes</td>
<td>22 recycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>52 off-campus</td>
<td>38 no</td>
<td>5 compost</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>17 dining hall</td>
<td>33 no access</td>
<td>52 compost</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>23 trash</td>
</tr>
</tbody>
</table>

Before the end of the survey, respondents were asked to make several ratings on a scale of 1 to 5 regarding coffee at Boston College. As seen in the top of Figure 2, faculty and staff of Student Services believe their department drinks a lot of coffee, while those in Psychology believe they have relatively modest consumption. In the middle of Figure 2, all offices except for the Vice President for Student Affairs believe that there is a need for more coffee makers on
Furthermore, these results are relatively clustered, which indicates the feeling of “need” is mutual across campus. Lastly, at the bottom, four divisions believe that Boston College’s coffee consumption practices are relatively sustainable compared to other universities. However, the feeling is not shared by Health Services and Psychology. Both of these divisions believe that Boston College can improve on the sustainability of their coffee consumption practices, with Psychology having the most negative view about the sustainability.

**Figure 2.** Average departmental responses to three survey questions.
Lastly, before submitting the survey, respondents were given the optional opportunity to leave suggestions on how Boston College can improve its coffee sustainability. The 34 received responses varied widely in terms of their suggestions, but some central themes were identified. For example, six respondents stated that they wished there were more ceramic mugs available on campus and bemoaned using so many paper cups. An additional three respondents stated that there should be more opportunities for composting of coffee on campus. For example, as one anonymous respondent stated (who listed their department as “Other”), “If there was a campus compost I could bring my coffee to I'd do it. I live in an apartment and don't have a good way of composting at home, so it goes in the garbage, which I feel bad about.” Finally, there seems to be a lot of missing information regarding the effectiveness and sustainability of different brewers. While some respondents applauded the usage of single-serve brewers, others desired a return to central filter drip pots. For those that used a pod-based system, which have compostable coffee inserts, there were concerns that the plastic packaging caused more pollution than Keurig-style plastic containers.

Energy audit results

As described in the methods section, energy input data in kilowatt-hours (kWh) were gathered for each department and office of our sample. The results were quite diverse, but several conclusions can still be made on the efficiency of coffee makers. Data range from 0 kWh to 0.89 kWh for the entire workday. Table 3 presents the results for Day 1 at all locations and serves as an illustration of the type and amount of data collected.

<table>
<thead>
<tr>
<th>DAY 1</th>
<th>Philo floor 2</th>
<th>Philo floor 3</th>
<th>Psycho</th>
<th>Chem</th>
<th>Envi Sciences</th>
<th>Facilities</th>
<th>Student Services</th>
<th>VPSA</th>
<th>Health Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10:00</td>
<td>0.02</td>
<td>0</td>
<td>0.11</td>
<td>0.07</td>
<td>0.03</td>
<td>0.09</td>
<td>0.13</td>
<td>0.28</td>
<td>0.12</td>
</tr>
<tr>
<td>11:00</td>
<td>0.03</td>
<td>0.01</td>
<td>0.16</td>
<td>0.23</td>
<td>0.09</td>
<td>0.15</td>
<td>0.21</td>
<td>0.3</td>
<td>0.21</td>
</tr>
<tr>
<td>12:00</td>
<td>0.05</td>
<td>0.03</td>
<td>0.19</td>
<td>0.31</td>
<td>0.11</td>
<td>0.23</td>
<td>0.27</td>
<td>0.37</td>
<td>0.29</td>
</tr>
<tr>
<td>1:00</td>
<td>0.07</td>
<td>0.05</td>
<td>0.26</td>
<td>0.41</td>
<td>0.12</td>
<td>0.29</td>
<td>0.32</td>
<td>0.42</td>
<td>0.36</td>
</tr>
<tr>
<td>2:00</td>
<td>0.08</td>
<td>0.07</td>
<td>0.29</td>
<td>0.48</td>
<td>0.15</td>
<td>0.33</td>
<td>0.36</td>
<td>0.48</td>
<td>0.4</td>
</tr>
<tr>
<td>3:00</td>
<td>0.09</td>
<td>0.08</td>
<td>0.37</td>
<td>0.59</td>
<td>0.17</td>
<td>0.38</td>
<td>0.41</td>
<td>0.54</td>
<td>0.49</td>
</tr>
<tr>
<td>4:00</td>
<td>0.09</td>
<td>0.12</td>
<td>0.42</td>
<td>0.68</td>
<td>0.18</td>
<td>0.44</td>
<td>0.48</td>
<td>0.56</td>
<td>0.55</td>
</tr>
<tr>
<td>5:00</td>
<td>0.1</td>
<td>0.14</td>
<td>0.46</td>
<td>0.77</td>
<td>0.18</td>
<td>0.47</td>
<td>0.51</td>
<td>0.62</td>
<td>0.52</td>
</tr>
</tbody>
</table>
After gathering all the data, the total kilowatt-hours per day as well as the average kilowatt-hours used per hour were calculated. After gathering all the observations, the total kilowatt-hours used per day as well as the average kilowatt-hours used per hour were calculated. Additionally, to eliminate any abnormal fluctuations in energy usage at any specific time period, each time period was averaged over the course of three days. Figure 2 illustrates this calculation. The department that uses the most energy is the Chemistry department, closely followed by the Vice President for Student Affairs office. These divisions use 0.82 kWh and 0.75 kWh, respectively, on average during the course of the day. The departments that use the least energy are the second floor of the Philosophy/Theology department (0.05 kWh on average), followed by the third floor of the Philosophy/Theology department (0.13 kWh) and Environmental Sciences (0.15 kWh). When divided on the basis of device technology, single serve machines were shown to expend an average of 0.385 kWh over the course of 9am-5pm on average, while filter drip machines used an average of 0.756 kWh (Table 4).

Figure 2. Average energy consumption in kilowatt-hours over 3 days

Table 4. Average energy use from 9am to 5pm in kilowatt-hours

<table>
<thead>
<tr>
<th>Device Technology</th>
<th>Single Serve</th>
<th>Filter Drip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Energy Usage</td>
<td>0.385 kWh</td>
<td>0.756 kWh</td>
</tr>
</tbody>
</table>
Because Boston College structures class times differently on Monday-Wednesday-Friday than on Tuesday-Thursday, faculty and staff might have different habits depending on the day. However, some variation was observed but not enough to show a clear trend. Figure 3 displays the total energy input observed at the end of each day. It can still be seen that the Chemistry department and the office of the Vice President for Student Affairs are the two heaviest energy consumers, no matter what the day.

![Total kWh input per location over a 3-day period](image)

**Figure 3.** Total energy consumption per day and per location

The last measurements were taken overnight. Between final readings at 5pm and beginning readings at 9am, the average energy usage was 1.295 kWh. Table 4 lists the reading for each department, with the readings for two meters in Philosophy excluded. The brewers in Philosophy are not believed to be representative of the general coffee brewing apparatuses and, as a result, are excluded to obtain a more correct estimation of energy usage.
Table 5. Overnight measurements of energy consumption (kWh)

<table>
<thead>
<tr>
<th>Meter</th>
<th>Overnight Reading (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chem 1-2</td>
<td>1.21</td>
</tr>
<tr>
<td>Chem 2-3</td>
<td>1.07</td>
</tr>
<tr>
<td>EESC 1-2</td>
<td>0.73</td>
</tr>
<tr>
<td>EESC 2-3</td>
<td>0.71</td>
</tr>
<tr>
<td>Psycho 1-2</td>
<td>1.55</td>
</tr>
<tr>
<td>Psycho 2-3</td>
<td>1.58</td>
</tr>
<tr>
<td>Facilities 1-2</td>
<td>1.45</td>
</tr>
<tr>
<td>Facilities 2-3</td>
<td>1.5</td>
</tr>
<tr>
<td>SS 1-2</td>
<td>1.69</td>
</tr>
<tr>
<td>SS 2-3</td>
<td>1.69</td>
</tr>
<tr>
<td>VPSA 1-2</td>
<td>1.1</td>
</tr>
<tr>
<td>VPSA 2-3</td>
<td>1.11</td>
</tr>
<tr>
<td>UHS 1-2</td>
<td>1.45</td>
</tr>
<tr>
<td>UHS 2-3</td>
<td>Shut Off</td>
</tr>
<tr>
<td>Average</td>
<td>1.295</td>
</tr>
</tbody>
</table>

**Discussion**

*Survey Data Discussion*

While the sample size is somewhat limited, the fact that most people choose to get their coffee off-campus underlines the need for efficiency and energy-saving coffee makers across the spectrum, not just at Boston College.

As mentioned previously, 20 out of 90 respondents stated that they did not consume coffee, a lower percentage of non-coffee drinkers than the national average. This datum supports the assumption that college campuses consume coffee at higher rates than other sectors. The survey also reveals that 1.77 cups of coffee were consumed on an average day by faculty or staff. According to the National Coffee Association, published on the Harvard School of Public Health’s website (2015), Americans drink 3.1 cups (9 oz.) a day on average, which is a much larger amount. However, the data from this source likely does not include the non-coffee drinkers, so it is difficult to compare with precision. The relatively small size of the sample may prevent the construction of a significant average in this case.
The variation in the rate of coffee consumption over the course of the day reveals that most faculty and staff prefer their coffee in the morning but that there is a significant peak in the early afternoon. However, coffee consumption decreases sharply after 3pm, which indicates that coffee consumers may not need coffee machines to be kept on after that time, as will be discussed in the recommendation section.

The survey results indicated that recycling filters was a rare occurrence, often because of the lack of access to the filters themselves. While these results are not surprising given that a significant percentage of people get their coffee at the coffee shop or in the dining hall, it indicates the possibility of efficiency improvements, since recycling coffee filters is an easy way to reduce waste. Participants that indicated that they placed their filters in the trash represent almost half of the respondents (48.1%, n = 38). It is possible that the lack of recycling containers or the lack of knowledge about the possibility of placing filters in recycling bins influence these results.

Approximately half of the respondents (53.6%, n = 52) place their coffee in the trash, which again indicates an opportunity for improvement. Recycling coffee cups and placing coffee grounds in the compost can greatly reduce an institution’s carbon footprint and reduce its waste outflow. These results can be partially explained again by the potential lack of education on recycling or the unavailability of recycling containers.

Several interesting conclusions can be made when measuring the survey responses on the number line. For example, though the Office of Student Services believes that they drink the most coffee, in reality they average 5th out of the six departments represented in calculated cups per day based on their answers to other survey questions. This is most likely because the difference between the 3rd and 5th most consumption is only 0.2 cups. If there were more respondents to the survey, it is likely that these relative rankings would change. However, the Vice President for Student Affairs and the Psychology departments were nearly correct with their views on coffee consumption. The Vice President for Student Affairs responses averaged the 2nd highest (1st overall in calculated cups per day) and Psychology responses averaged the lowest (also the lowest in calculated cups per day). Put together, these data show that Boston College faculty and staff are relatively aware of their coffee consumption habits. If given methods and information on how to make this consumption more sustainable and efficient, it is likely that there would be a strong response.
The ratings received to the second question regarding availability of coffee makers indicate that, overall, there is a general feeling of “need” for more coffee makers on campus. The ratings are all clustered between approximately 1.2 units of each other and are largely below the median answer of 3. Though the Psychology department drinks the lowest amount of cups of coffee per day, it was surprising that they felt the most negative about the availability of coffee brewers. As one of the largest undergraduate majors, Psychology also has one of the largest faculties that depend on the one brewer located in the departmental office. Despite this theoretical demand, the Psychology brewer was also one of the least used during the course of the research. This could indicate some other underlying factor is at play, for example, whether or not the department provides coffee for use in the brewer or if faculty is responsible to bring in their own coffee. In addition, the perceived lack of brewers could influence the miniscule amount of cups brewed for the department. The Vice President for Student Affairs responses might also be due to the fact that they are the only department measured that uses a filter-drip brewer. The constant sight of a partially full pot could influence the perception that coffee is readily available to faculty, students and staff.

While two thirds of the responses to the final question asked in Figure 2 were close to the median, there is still opportunity to improve. Part of the reason for the clustering of responses could be that faculty and staff, as employees of Boston College, are simply not aware of common practices at other universities. As such, they may assume that Boston College is approximately average. These results represent a need for more information regarding sustainable coffee consumption practices.

The final question posed on the survey, where respondents were given the opportunity to make statements regarding coffee sustainability, highlighted several needs that should be addressed by the Facilities Office and Boston College. For example, a focus on reusable containers should also be taken up by those in charge of departmental coffee. As has been observed in the prevalence of reusable plastic water bottles on campus, the shift from paper to reusable containers will largely be cultural and depend on the leadership shown at upper levels of the university. Secondly, because many respondents bemoaned the prevalence of disposable cups, there is a clear need for more education about disposal options. Some “disposable” coffee cups are actually recyclable, though it does not appear that faculty and staff are aware of this.
To continue, many of the other responses indicated that respondents were, in fact, aware of the waste produced during the process of brewing coffee. Whether it involved composting or the disposal of plastic packaging and cups, respondents had concerns over which methods were the best choices. To iterate the conclusions found for the first question in Figure 2, the faculty and staff are willing to question current practices and alter them to be more sustainable with their coffee consumption.

Lastly, one of the responses to this question may explain the low energy use of the coffee brewers in the Philosophy department. One respondent in that department stated “The coffee pod machines at work are awful and really limit the kind of coffee that we can make. I cannot understand why these were put into Stokes when it was built instead of regular drip coffee makers.” It is possible that this disdain for the coffee makers in this department has led to their non-use. This issue, regarding the brewer preferences, could be investigated more fully in the future.

Coffee Energy Audit Discussion

Results yielded by the quantitative energy audit reveal three major areas of inefficiency currently occurring within departmental coffee consumption, namely the use of machines beyond peak hours, the extensive energy lost idly over night, and the greater energy requirements of filter drip machines as opposed to single serve machines.

The survey data represented in Figure 1 demonstrate that the rate of coffee consumption peaks between 7 and 8am, after which it continuously declines. This suggests that the majority of institutional coffee machines are utilized only in the early morning, after which they sit expending energy but not being used until the next peak of consumption in the early afternoon. A similar inefficiency is suggested by the amount of energy expended over night. As demonstrated by the calculation below, 75.4% of the total energy is used over the nighttime hours. This represents a massive opportunity for energy savings.

\[
\frac{\text{(average night kWh)}}{\text{(average day kWh) + (average night kWh)}} \times 100 = \frac{1.295}{0.4229 + 1.295} \times 100 = 75.4\%
\]

Another major area of inefficiency made apparent by the results is the use of filter drip machines as opposed to single serve machines. Daily average energy use was shown to be 0.756 kWh and 0.385 kWh, respectively. This means that filter drip machines require 1.96x more
energy than single serve on account of their need to continually heat the coffee. Although there was no way for this report to quantify exactly how many of this type of brewer are currently in use in campus facilities, national data suggests that they are the dominant technology type currently in the market (Bush, 2011). Even if this trend is not represented within the facilities of Boston College, we can assume that the exact number is somewhere between the percentage found in literature (55%) and that found in our random sample of departments and offices (12.5%). Considering the substantial difference between the technology types, this range of percentages represents a significant area of inefficiency that is easily targetable through recommendations.

**Calculating Brewing Energy Cost and Potential Savings**

Through the data established with the meter readings and survey results, Boston College’s environmental impact and energy cost can be estimated for the course of the academic year. Results given in Table 6 are limited to the academic year because during the summer months and weekends, it is reasonable to assume coffee consumption habits would change. Without the large influx of undergraduates, faculty and staff will have largely different routines and habits than those observed during the study period.

**Table 6.** Energy cost and environmental impact of coffee brewers in Boston College’s Undergraduate College of Arts and Sciences during academic year.¹

<table>
<thead>
<tr>
<th>Total # departments</th>
<th>39</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average divisional energy during 8-hour day (kWh)</td>
<td>0.4229</td>
</tr>
<tr>
<td>Average divisional overnight energy use (kWh)</td>
<td>1.295</td>
</tr>
<tr>
<td><strong>Daily combined energy usage (kWh) (all depts)</strong></td>
<td>67.00</td>
</tr>
<tr>
<td><strong>Academic Year Energy total (kWh)</strong></td>
<td>12060.1</td>
</tr>
<tr>
<td><strong>Cost of electricity: Feb 2014</strong>²</td>
<td>$0.173</td>
</tr>
<tr>
<td><strong>Cost of electricity: Feb 2015</strong>³</td>
<td>$0.225</td>
</tr>
<tr>
<td><strong>Academic Year Energy Cost (2014)</strong></td>
<td>$2086.40</td>
</tr>
<tr>
<td><strong>Academic Year Energy Cost (2015)</strong></td>
<td>$2713.52</td>
</tr>
<tr>
<td><strong>CO₂ tons/academic year</strong>⁴</td>
<td>1.8711</td>
</tr>
</tbody>
</table>

---

¹ Assumes an academic year to be equivalent to 180 days.
⁴ Assumes 6.89551x10⁻⁴ metric tons CO₂/kWh (U.S. EPA, 2014)
Based off these calculations, the cost of electricity specifically used to brew coffee ranges from $2086.40 to $2713.52 during the academic year in this undergraduate school. The College of Arts and Sciences was chosen for this calculation because it is the home of the departments studied. Again, these figures only apply to the academic year. While brewers are still used and plugged in during the summer months and weekends, it cannot be assumed they are used with the same frequency observed during the study period. Finally, the CO₂ calculation does not include emissions produced during the production and transportation of the coffee itself from the farms, usually located thousands of miles away, to Boston. As a result of these qualifying factors, these monetary and emission figures are conservative.

The findings in Table 6 are intriguing in the sense that they attempt to quantify the amount of energy used specifically by coffee makers. By putting a dollar sign next to these values, it is much easier to see the economic value of making efficient and sustainable choices with coffee makers. The most valuable insight gained from this calculation is that 75.4% of the coffee brewer energy comes from overnight use. This finding represents an immense opportunity for savings for Boston College Facilities. Furthermore, this figure can be used to estimate the amount of potential energy savings for the entire year. In Table 7, the economic and environmental impact of coffee brewers is estimated for the entirety of Boston College faculty and staff during the daylight hours.
Table 7. Estimated cost of energy and environmental impact of coffee brewers for all Boston College faculty and staff.

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of faculty and staff</td>
<td>3267</td>
</tr>
<tr>
<td>Coffee-drinking fac/staff</td>
<td>1764.18</td>
</tr>
<tr>
<td>Fac/staff that drink department coffee</td>
<td>664.43</td>
</tr>
<tr>
<td># cups of coffee</td>
<td>450.19</td>
</tr>
<tr>
<td>Weighted Average cups per person in department</td>
<td>0.6775</td>
</tr>
<tr>
<td>Average energy per cup</td>
<td>0.17</td>
</tr>
<tr>
<td>Daily energy use (kWh)</td>
<td>76.533</td>
</tr>
<tr>
<td>Academic year energy use (kWh)</td>
<td>13776.03</td>
</tr>
<tr>
<td>Cost of electricity: Feb 2014</td>
<td>$0.173</td>
</tr>
<tr>
<td>Cost of electricity: Feb 2015</td>
<td>$0.225</td>
</tr>
<tr>
<td>Academic year energy cost (2014)</td>
<td>$2383.25</td>
</tr>
<tr>
<td>Academic year energy cost (2015)</td>
<td>$3099.61</td>
</tr>
<tr>
<td>CO₂ tons/year</td>
<td>9.4993</td>
</tr>
</tbody>
</table>

However, based off the findings that daytime energy use represents only 19.75% of overall energy, and assuming that the cups being calculated here are being made during the workday hours, the total energy cost and environmental impact can be calculated, as seen below.

\[
\frac{\$2383.25}{x} = \frac{24.6\%}{100\%} \quad x = \$9683.94
\]
\[
\frac{\$3099.61}{x} = \frac{24.6\%}{100\%} \quad x = \$12600.03
\]
\[
\frac{9.50 \text{ metric tons CO}_2}{x} = \frac{24.6\%}{100\%} \quad x = 38.61 \text{ metric tons}
\]

---

5 BCOIR, 2013
6 Assumes 54% coffee drinkers (HPSH, 2015)
7 Of coffee-drinking survey respondents, approximately 41.4% (n=29) stated they drink coffee in their department.
8 Calculated by taking the survey response for number of cups per day, assuming 41.4% were brewed in department. Weighted average by number of responses to survey.
9 Simmerman, 2013
12 Assumes $6.89551 \times 10^{-4}$ metric tons CO₂/kWh (U.S. EPA, 2014)
According to these calculations, Boston College, as an institution, pays approximately $9,600 to $12,600 on energy alone during the academic year to run coffee makers. With so much money being spent on the convenience of having a coffee maker in the department, it underlines the necessity for efficiency measures. Furthermore, 38.61 metric tons of CO\textsubscript{2} are emitted into the atmosphere due to this energy use. Below, potential energy savings are calculated using average energy costs from both 2014 and 2015.

Potential Savings:
\begin{align*}
\text{(Using 2014 Numbers)} & \quad 9683.94 - 2383.25 = 7300.69 \\
\text{(Using 2015 Numbers)} & \quad 12600.03 - 3099.60 = 9500.43 \\
\text{(CO}_2) & \quad 38.61 - 9.50 = 29.11 \text{ metric tons CO}_2
\end{align*}

When represented this way, the benefits of turning off coffee brewers during the nighttime hours are much more obvious. This change has the potential to decrease spending on energy by $7,300 to $9,500. Furthermore, the amount of CO\textsubscript{2} emissions saved would be the equivalent of removing approximately 6 cars from the road for an entire year (U.S. EPA, 2014). Once again, these figures are conservative and the actual energy savings are likely much higher.

**Limits of Interpretation**

The survey's sample size of 90 respondents was fairly small, and accuracy could have been improved if it were larger. While it was sizable enough to reasonably extrapolate to the rest of Boston College faculty, it is probably not large enough to make assertions about the coffee consumption habits of faculty at all universities. Therefore, the relevance of this data is targeted at improving knowledge of energy usage specifically at Boston College.

**Recommendations**

The findings of this study have demonstrated that:

1. Filter-drip machines expend 1.96x more energy than single serve machines
2. 75.4\% of energy is expended while machines are idle over night
3. Peak coffee consumption occurs between 7am and 9am
4. Faculty and staff currently lack proper receptacles for coffee waste
5. Many departments have more than one communal machine, resulting in many individual coffee makers
Based upon these major findings. We suggest that Boston College take the following steps in order to improve the efficiency of coffee consumption in campus facilities:

1. Where economically feasible, switch from filter-drip to single serving coffee machines
2. Unplug machines at the end of the work day
3. Turn off machines after peak hours in the morning
4. Implement composting for coffee grounds and filters for those departments using filter-drip machines or, for those using single serving machines, implement reusable capsules or pods
5. Where there are multiple departmental coffee machines, consolidate into one central maker

Error

Data may be skewed on account of participant bias. Volunteers are inherently more likely to participate in a survey regarding their habits. This may explain why such a high percentage of the survey participants were coffee-drinkers. This could have had the impact of collecting data from those who are more enthusiastic about the subject, and therefore create biased trends associated with those groups. However, because the survey was explicitly stated as anonymous and names were not collected, these data cannot be interpreted for the Boston College community.

Further Studies

This study was inherently limited based off resources available and time constraints. Therefore, future investigations should use these finding as a basis to investigate this topic further. Such studies should analyze coffee consumption at the student level within Boston College dining halls. Further, because the cultivation of coffee beans contributes to 55% of the overall emissions of a coffee’s life cycle, future investigations should analyze the sourcing, production, and transportation of various coffee brands (Brommer, 2011).

It would be useful to measure the per-cup energy usage and subsequently calculate the number of cups consumed per department. These data would help determine efficiency of certain
machines, although this can be indicated by energy usage alone. Integrating such data with the respondents’ answers on how sustainable they believe their office or department to be could be relevant from a social science perspective.

There is also a lack of clarity of faculty opinion on which types of coffee makers should be available in offices. This could be further researched by instituting another survey with more direct questions regarding preferred coffee makers, and it could help incentivize Boston College administration to respond to employee wishes. In addition, more research could be performed into how educated the faculty is about options for recycling and sustainability at Boston College. This survey asked that basic question, but did not further explore it. This could be done by asking respondents if they are aware of certain sustainability measures being taken at the university, and it improve education of faculty about outlets for recycling and conserving.
Acknowledgements

The researchers would like to thank their Professor, Tara Pisani-Gareau for the opportunity to perform this research and for her guidance during its execution. An additional “thank you” goes to Bruce Dixon with the Facilities Department for his role as a mentor in this project and his provision of the Kill-A-Watt meters. Finally, the researchers owe gratitude for the representatives of the four academic departments and four offices, which volunteered to participate in this research, replied to emails, forwarded the survey, and dealt with hourly intrusions by the research team to take meter readings.

Works Cited


Appendix

1. Online Survey

An Assessment and Audit of Coffee Consumption Habits and Related Energy Usage at Boston College
A survey of coffee consumption habits at Boston College
* Required

Consent Form
Why have I been asked to take part in the study?
- Because you are at least 18 years of age
- Because you are a part of the Boston College faculty
- Because you might have an interest in sharing your coffee habits

What do I do first?
- Before agreeing, please read this form of consent.
- Please ask any questions that you may have before completing.

What is the Study about?
- Energy usage related to the consumption of coffee at Boston College

Who will take part in the Study?
- Each Academic Department at Boston College will be asked to take part.

If I agree to take part, what will I be asked to do?
1. Answer a 12 question survey, which should take about 5-10 minutes.
2. If you do not wish to answer a question, you can choose to skip it.

What are the risks to being in the study?:
- The potential distress involved with examining one’s own coffee consumption habits.
- This study may include risks not known at this time.

What are the benefits to being in the study?
- The ability to share and examine one’s own coffee consumption habits.
- The ability to share ideas on possible improvements for sustainability.
How will things I say be kept private?
- The records of this study will be kept in a private online database.
- In any type of report we may write, we will not include your name or anyone else’s.
- Research records will be kept in a locked file.
- Research records will be destroyed within 3 years.
- Access to the research records will be limited to the researcher, and also sponsors, funders, regulators, and the University IRB may have to review the research records.

What if I choose to not take part or leave the study?
- Taking part in the study is voluntary.
- If you choose not to take part, it will not affect your present or future relations with the University.
- You will not be penalized or lose benefits for not taking part.
- You are free to stop the survey and leave the study at any time, for whatever reason.
- You will not be penalized or lose benefits if you stop taking part in the study.

Will I be asked to leave the Study?
- You may not be able to take the survey if the researchers have stopped taking in data.
- We ask that you follow the directions the best you can.
- If you do not feel comfortable answering questions or it is not in your interest to take it, you may be asked not to take the survey.

Who can I contact if I have any questions?
- You can call Alexander Krowiak who is the researcher in charge of this study. His email is krowiaka@bc.edu.
- If you believe you may have suffered injury or harm from this research, contact Alexander Krowiak at krowiaka@bc.edu. He will tell you what to do next.
- If you have any questions about your rights as a person taking part in the study, you may call: Director, Office for Research Protections, BC at (617) 552-4778, or irb@bc.edu.

Will I get a copy of this consent form?
- If you would like a copy of this consent form please contact Alexander Krowiak at krowiaka@bc.edu.
- You will not receive a copy of this form unless it is requested.

Statement of Consent:
- I have read (or have had read to me) the contents of this consent form.
- I have been encouraged to ask questions.
- I have received answers to my questions.
- I give my consent to take part in this study.
- I have received (or will receive) a copy of this form.

Consent Form
- [ ] Check this box to indicate that you have read and agree with the statements in the consent form above and you give your consent to participate in this study.

Continue »
An Assessment and Audit of Coffee Consumption Habits and Related Energy Usage at Boston College

* Required

Boston College Faculty Coffee Energy Survey

On average, how many cups of coffee do you drink on a typical weekday? *
- 0
- 1
- 2
- 3
- 4
- 5
- More than 5

At what time do you typically make coffee? *
Please select all that apply
- 6:00 am - 7:00 am
- 7:00 am - 8:00 am
- 8:00 am - 9:00 am
- 9:00 am - 10:00 am
- 10:00 am - 11:00 am
- 11:00 am - 12:00 pm
- 12:00 pm - 1:00 pm
- 1:00 pm - 2:00 pm
- 2:00 pm - 3:00 pm
- 3:00 pm - 4:00 pm
- 4:00 pm - 5:00 pm
- 5:00 pm - 6:00 pm
- 6:00 pm - 7:00 pm
- 7:00 pm - 11:00 pm
- I do not make coffee.
Is the coffee you usually drink fair trade? *
- Yes
- No
- I don’t know

What type of coffee maker do you use?
- French Press
- Single Serve (Keurig)
- Automatic Drip Filter
- Espresso Machine
- I don’t know.

Where do you typically get your coffee from? *
- Department
- Dining hall
- Off-Campus (Restaurant, Home, etc)
- Department and outside
- Department and dining hall
- Dining hall and outside
- It depends on the day
- Other: 

What brand of coffee do you (or your department) use?

If applicable - do you recycle coffee filters?
- Yes
- No
- I don’t have access to coffee filters

What do you typically do with your waste related to coffee? *
Waste includes cups, lids, or any other disposable materials related to making or consuming coffee
- Recycle
- Compost
- Trash
- I don’t have access to the coffee waste
What do you do with the coffee grounds?
- Compost
- Trash
- I don't have access to coffee grounds

On a scale of 1-5, would you say your department drinks a lot of coffee? *
* Compared to other departments

1 2 3 4 5
Not a lot ☐ ☐ ☐ ☐ ☐ A lot

On a scale of 1-5, how would you rank the supply of coffee makers on campus to the need of the faculty, staff and student body? *
* Compared to the need of the faculty, staff, and student body

1 2 3 4 5
Not enough makers ☐ ☐ ☐ ☐ Too many makers

On a scale of 1-5, how sustainable do you think Boston College's coffee consumption practices are compared to other universities? *

1 2 3 4 5
Not sustainable ☐ ☐ ☐ ☐ Very sustainable

In your opinion, are there any improvements that Boston College could make to improve sustainability?
* Please relate to coffee if possible

Never submit passwords through Google Forms.
II. Types of Coffee Brewers in Different Departments and Offices

<table>
<thead>
<tr>
<th>Department/Office</th>
<th>Type of Coffee Machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philosophy/Theology</td>
<td>Single Serve</td>
</tr>
<tr>
<td>Psychology</td>
<td>Single Serve</td>
</tr>
<tr>
<td>Chemistry</td>
<td>Single Serve</td>
</tr>
<tr>
<td>Environmental Studies</td>
<td>Single Serve</td>
</tr>
<tr>
<td>Vice President for Student Affairs</td>
<td>Filter Drip</td>
</tr>
<tr>
<td>Student Services</td>
<td>Single Serve</td>
</tr>
<tr>
<td>Health Services</td>
<td>Single Serve</td>
</tr>
<tr>
<td>Facilities</td>
<td>Single Serve</td>
</tr>
</tbody>
</table>

III. Graphical Illustrations of Daily Results

![Graphical Illustration of Daily Results](image-url)
Day 2 measures - all locations

Day 3 - all locations