A Technical and Behavioural Energy Efficiency Assessment of McGill Cafeteria Operations at Bishop Mountain Hall and Royal Victoria College

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Abstract

McGill Food and Dining Services (MFDS) have, over the past three years, progressed as a leader in sustainable practices at McGill University. Increased expectations for sustainable management have pushed Executive Chef Oliver deVolpi to assess energy efficiency at the Bishop Mountain Hall (BMH) and Royal

Victoria College (RVC) cafeterias. This project aims to determine which technical and behavioural modifications should be made in the Royal Victoria College (RVC) and Bishop Mountain Hall (BMH) cafeterias in order to increase energy efficiency. Two key aspects determining energy consumption were addressed: the required energy input of the appliances and the frequency and manner of appliance usage. The technical approach assessed the sustainability of energy sources, including natural gas, electricity, and steam. The behavioural approach identified necessary improvements in mealtimes, the operation and availability of appliances, and staff practices. Using this data and appliance specification data, priority lists of suggested appliance replacements were made.

Keywords: Energy efficiency, sustainable building, energy efficient appliances, school cafeterias, energy analysis, university dining.

1. Executive Summary

McGill Food and Dining Services (MFDS) have, over the past three years, progressed as a leader in sustainable practices at McGill University. Increased expectations for sustainable management have pushed Executive Chef Oliver deVolpi to assess energy efficiency at the Bishop Mountain Hall (BMH) and Royal Victoria College (RVC) cafeterias. This project aims to determine which technical and behavioural modifications should be made in the Royal Victoria College (RVC) and Bishop Mountain Hall (BMH) cafeterias in order to increase energy efficiency.

Two key aspects determining energy consumption were addressed: the required energy input of the appliances and the frequency and manner of appliance usage. The latter aspect reflects the technical approach of the project, which is comprised of investigating the operations of the appliances, their efficiency, and options for alternate, more energy efficient appliances. The former reflects the behavioural approach, which is comprised of conducting observations and interviews to assess staff appliance usage and food preparation. The extensive research we conducted allowed us to provide costs and benefits of installing energy-efficient alternatives, as well as suggest alternative staff practices.

Recommendations were made for each type of appliance analysed. The technical approach assessed the sustainability of energy sources, including natural gas, electricity, and steam. Data on energy and cost savings of replacing particular appliances with high-efficiency units (Energy Star rated models) were provided. Using this data and appliance specification data, priority lists of suggested appliance replacements were made.

The behavioural approach identified necessary improvements in staff practices, which depended on factors such as the type of food being prepared, mealtimes, and the operation and availability of the appliances. Broad recommendations included completely turning off appliances (ones which are not in use for long periods of the day), and reducing preheat times for appliances such as

grills, griddles, and fryers. The most significant finding was the need to develop an atmosphere promoting energy efficiency through staff team support.

We hope that our recommendations facilitate the commitment of MFDS to sustainability.

2. Introduction: Project Issues in Broader Context

The focus of this report is to determine ways to increase energy efficiency in the McGill University cafeterias of Royal Victoria Hall and Bishop Mountain Hall. Our client, Executive Chef Oliver deVolpi from McGill Food and Dining Services (MFDS), has put forth this initiative. MFDS is a sector of McGill Student Life and Learning, which operates under a self-financing, mixed business model that includes self-operated locations which contract food providers (Rhodes 2011, MFDS 2012).

We realize there are greater consequences of this task and its implementation. The concept of energy efficiency goes far beyond the borders of the campus; environmental factors, national and provincial regulations, as well as university policies have all contributed to shaping our initiative. The findings in this report may be applied to the greater knowledge base of energy efficiency best practices in cafeteria and kitchen facilities.

In an era of rapid globalization and economic development, resource depletion and rising costs of energy have begun to limit our actions and behaviours. These limitations have made it essential for industries to operate under higher levels of efficiency. An industry that increases its energy efficiency will produce more outputs per unit of energy input (Bergstrom & Randall 2010), thus optimizing resource use and cutting down on operation costs. This sort of increase in energy efficiency can reduce negative impacts on the environment, particularly greenhouse gas (GHG) production and the destruction of ecosystems through resource exploitation.

Taking a more local perspective, the commercial food service industry in Canada accounts for 4% of commercial and institutional energy consumption (Natural Resources Canada 2010). Though this may be a small percentage on a national scale, the proportion of this industry's energy consumption in certain smaller environments, such as university campuses, is greater. With the exception of some medical facilities, dining facilities generally have the largest environmental footprint on university campuses (Elbaum 2010). In fact, commercial kitchens are typically found to use about five times more energy than any other part of a university campus (Conrad 2007). Thus, technical and behavioural modifications made to the operations of university cafeterias can have significant impacts on the overall energy consumption of the campus. Because these cafeterias are central hubs of student and staff activity, improvements in efficiency can optimize resource and energy use. (Elbaum 2010).

Governmental ministries have been quick to recognize the necessity for energy efficiency efforts in educational institutions. In 2006, Le Ministère de l'Éducation du Loisir et des Sport (MELS) of Quebec mandated the reduction of

energy intensity[1] consumption of post-secondary institutions in Quebec by 14% below 2002-03 figures by the 2010-11 academic year (McGill University 2010). McGill responded to this mandate by setting its own goal of achieving 12% reductions below 2002-03 levels by the 2010-11 year. However, by 2010, McGill had only achieved a 5.66% reduction (McGill University 2010). This failure to meet the targets outlined by McGill and the MELS was due to a few different factors. McGill's building areas, as well as student and staff populations, have been on the rise; square footage requiring heating and cooling had grown 13.2% since 2002 and most of this space is research-intensive facilities (McGill University 2010). The population at McGill had grown 10% since 2002 and is expected to grow another 3.7% in the next five years (McGill University 2010). Furthermore, the unit cost of energy has also been increasing, thus compounding the adverse effects of space and population growth on total university energy costs. For the past ten years, energy spending at McGill has been increasing at a rate of 2.8% per year (Appendix A: Figure 1) (McGill University 2010). This pattern of growth is unsustainable, and will drain the McGill's budget and resources if allowed to continue.

In response to increasing energy intensity on campus, McGill decided in 2010 to implement a five-year energy management plan, which outlined five key areas for improvement. The plan aimed to achieve a 14% energy intensity reduction by 2012-2013 (relative to 2002-03 figures) (McGill University 2010). The five areas of focus were the implementation of an energy management information system program (EMIS), a lighting and retrofit program, a building energy audit program, a building recommissioning program, and various energy conservation projects (McGill University 2010). The EMIS program was implemented to input metering, allowing for more accurate quantifying of the energy consumption of steam, electricity, and condensate (McGill University 2010). (As it had not been implemented yet, our project was not able to use any data from metering). The lighting and retrofit program was implemented to replace incandescent lighting with more technologically advanced fluorescent lighting, in the hopes of allowing for greater flexibility in illumination at different times during the day (McGill University 2010). The building energy audit program, which has already covered buildings such as Bronfman, Burnside Hall, and Rutherford Physics, aims to identify and "provide information on the most significant sources of energy consumption in [the] building, thereby ensuring that energy reduction investments are appropriately prioritized and planned" (McGill University 2010). However, the costs of audits for McGill run from $33,926 to $75,417 annually (McGill University 2010). Our project, though it does not depict itself as formal audit, is a zero-cost way to assess energy efficiency. The building recommissioning program aims to optimize the current automated control systems in McGill Buildings. McGill currently has an energy footprint of around $25.00/m^2, due to the intense use of many spaces and the inefficiency of some of the current ventilation systems (McGill University 2010).

The fifth section of the plan included energy conservation projects. Some examples of completed projects are the Otto-Maass retrofit, the Burnside Hall heat recovery project, and the new steam boiler for summer steam production (McGill University 2010). Other action plans for sustainability, such as MFDS's 'An Appetite

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[1] Energy intensity can be defined by the formula: GJ/$ of floor space (McGill Energy Project: MELS 2012).

for Sustainability', deal specifically with sustainable food purchasing (Rhodes 2011). This initiative takes into account changes that can be made in the amount of energy input used to provide food to students by changing the parameters of the life cycle of food procurement (Rhodes 2011). For example, by buying local foods, MFDS is able to cut down on transport costs, thus reducing energy consumed by the transport vehicles and total GHGs emitted. It is also important to note that in economics, demand drives supply, and the larger purchases made by an entity are, the greater the influence it has on what is demanded (Bergstrom and Randall 2010). MFDS can set an example for other university dining facilities since they are bulk food purchasers, and thus have purchasing power that can influence the decisions of suppliers.

Our project satisfies the goals of MFDS's strategic plan because it will add to the research and knowledge base needed to run more sustainable operations. It will also address the goal of making food service operations more sustainable by creating prioritized energy-savings suggestions, including appliance replacements and more time-appropriate use of appliances. The project will also assist in achieving financial sustainability so that the "premiums paid on local and sustainable food purchases are absorbed" (Rhodes 2011). Cost savings from increased efficiency will provide funds for more local and sustainable food purchases.

2.2 BMH and RVC: Historical and Current Conditions

The two cafeterias examined in this project are Bishop Mountain Hall (BMH) and Royal Victoria College (RVC) (Appendix C: Figures 1,2,3). The RVC cafeteria is connected to the RVC residence hall, so there is no distinction between the two areas in terms of energy billing. Within the last five years, the cafeteria in RVC was recently renovated and retrofitted with many new energy efficient appliances. The kitchen in RVC now has a new sensor-run heating, ventilation and air-conditioning (HVAC) system, which accounted for a significant amount of energy savings at RVC (deVolpi 2012). This is an especially important addition to a commercial kitchen because of the large discharges of heat and vapour from cooking activities. The appliances in RVC now all run on either electricity or gas, with the majority running on electricity (Appendix A: Figure 2). The RVC cafeteria was also retrofitted with a new lighting system, as well as a dishwasher (deVolpi 2012).

BMH is an independent dining hall, which serves the Upper Residence Halls of Molson, McConnell, and Gardiner. The majority of the building is a kitchen and dining space; there are also a few small offices in it. Thus, the energy billing for BMH is a fairly accurate representation of the energy consumption of its cafeteria operations. The cafeteria in BMH occupies two floors: the basement, where most of the food preparation occurs, and the second floor, where the food is served. BMH services around the same number of students as RVC (deVolpi 2012). However, the floor space at BMH is around twice the size of RVC's. It should be noted that increased floor space means an increase in area, which would need to be serviced by HVAC systems. BMH is older and less efficient than RVC (deVolpi 2012). Most of the appliances in BMH have not been updated in decades (deVolpi 2012). Though there are gas and electricity powered appliances in BMH, there are also many that run directly on steam. While there have been recent installations, most notably

energy efficient models of a walk-in fridge and walk-in freezer, appliance replacements in BMH will be a key focus of our analysis.

3. Research Question

Our project aims to determine which technical and behavioural modifications should be made in the Royal Victoria College (RVC) and Bishop Mountain Hall (BMH) cafeterias in order to increase energy efficiency.

Within the context of this project, energy efficiency is defined as the 'optimal performance of food preparation with minimal use of energy, lowest possible costs of operational modifications and installations, and most effective procedure implementation'.[2] In the context of our project, 'lowest possible costs of installation' is represented in terms of cost savings from modifications and replacements of appliances. 'Most effective procedure implementation' is represented in our behavioural analysis and suggested best practices which can be implemented to streamline the food preparation process. Finally, 'optimal performance of food preparation with minimal use of energy' is represented in the integration of the technical and behavioural data, and the recommendations and prioritization of appliance replacements provided.

3.1 Working Definitions

Best Practices: A set of guidelines, ethics or ideas that represent the most efficient or prudent courses of action (Campus ERC 2007). Within the context of kitchen energy efficiency, they are cooking practices that prompt food to be cooked well and in a timely manner, using the lowest possible amount of energy.

Cooking Energy Efficiency (CEE): The ratio of energy absorbed by the food product to the total energy used by the appliance during cooking (Energy Star 2012).

Idle Energy Rate (IER): The rate of energy consumption while the appliance is maintaining or holding at a stabilized operating condition or temperature (Energy Star 2012).

Energy Input: The energy demand [of an appliance] of a particular energy source (i.e. electricity, natural gas, or steam) (Radovic). Energy input is used as one of the parameters for determining appliance energy efficiency.

4. Methodology

In our efforts to provide staff Best Practices and appliance modification or replacement recommendations, we looked to develop solutions using a methodology that is inclusive of all stakeholders and is holistic in nature. This has prompted us to use two distinct but complementary approaches, which we deemed were appropriate for a comprehensive analysis: a technical approach and a behavioural approach.

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[2] Definition was developed with the help of Indian Bureau of Energy Efficiency 2010.

4.1 Technical Approach

The technical aspects of energy efficiency were investigated by collecting and analysing data on existing cafeteria appliances, their sources of energy, and their energy consumption. The technical data collection methods are as follows:

   i.   A purposeful sampling method was used to collect data on existing cafeteria appliances in both BMH and RVC. The samples included all appliances that consumed significant amounts of energy, which were determined using researched literature. From the research, it was deducted that the sample should include ovens, steamers, griddles, grills, fryers, fridges, and freezers (Navigant 2009). Purposeful sampling allowed the focus to be on the appliances contributing the most to cafeteria energy consumption.

   ii.   Data from appliance labels was recorded wherever available. For unreadable or non-existent appliance labels, a description and image of the appliance were used to match the appliance as closely as possible to a model by the same manufacturer. Data of models were found using online publications of appliance specifications.

   iii.   Data or figures collected included number and type of doors (fridges only), energy source, location, manufacturer, model number, voltage, watts, amps, hertz, ounces of refrigerant, temperature or pressure setting, high and low pressure specifications, and status as an Energy-Star model, among others (Appendix B: Tables 2 & 3).

   iv.   Data was recorded in two separate spreadsheets: one for BMH, and one for RVC.

   v.   Floor plans of both cafeterias were created, and included all relevant appliances. Appliances were labelled according to the labels used in the spreadsheets.

   vi.   Energy-Star appliances, steam-run appliances, and fridges and freezers were subsequently excluded from comparative analysis.[3] All other appliances were analysed based on data collected from the behavioural research; information from staff interviews and observations of staff practices allowed us to determine the frequency of use of appliances. Hours of use were estimated and were recorded on a scale ranging from rarely used to very often used.

   vii.   Each category was as follows:
-    a.   Rarely: <5 hrs/week
-    b.   Sometimes: 5-20 hrs/week
-    c.   Often: >20- 35 hrs/week
-    d.   Very Often: >35 hrs/week

   viii.   Energy Input data was converted to a single unit (for comparison consistency), kilowatts (kW). Data often converted were British Thermal Units (BTUs) or Joules (J), often used for natural gas measurements.

   ix.   The frequency of use and energy input data for each appliance were then compiled as data points and plotted on a biaxial graph.

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[3] Justifications for these exclusions may be found in Sections 4.3.8 and 4.3.9.

x.   To determine priority of replacement, high-energy input and frequently-used appliances were noted as top priorities for replacement. Rarely-used appliances were examined for redundancies and possible removal.

xi.   Benefits and drawbacks of replacement of high-energy input and frequently-used appliances were charted based on factors including: cooking energy efficiency, improved idle energy rates and annual cost savings.

xii.   Finally, research and analysis of the energy sources of the appliances were completed along with the collection of data on building-specific and campus-wide energy usage.

4.2 Behavioural Approach

The behavioural aspects of energy efficiency were investigated by observing and analysing staff behaviour regarding the use of cafeteria appliances at RVC and BMH. Data on hourly usage of appliances were collected through formal interviews and later incorporated into the technical methodology. Furthermore, information on how staff operates the appliances was obtained by conducting numerous cafeteria observations and interviews at both cafeterias (Appendix D: Figure 1). The behavioural methodology is as follows:

i.   Observations of the kitchen were conducted during four periods of the day: opening, peak, non-peak, and closing hours, as appliance use differs throughout the working day. It is important to note that peak and non-peak hours vary between the cafeterias. Both cafeteria schedules assisted in determining these periods. The following types of observations were noted:

a.   When and how often particular appliances are used

b.   At which settings (e.g. temperature) the appliances are programmed/set to

c.   Whether an appliance is turned on when it is not in use

d.   Whether the use of the appliance suits its purpose well

ii.   Informal questions were posed to the staff during some of the observations in order to better understand their practices, and the rationale behind these practices.

iii.   Formal one-on-one interviews with staff members were conducted by members of our team. The aim was to conduct a more in-depth study of staff practices in the cafeterias. We interviewed 13 kitchen staff in total: six from BMH and seven from RVC. The staff interviewed included general helpers, counter staff, bakers, first cooks, second cooks, sous-chefs, and other kitchen staff who work on weekdays. The interview was completed using a series of 14 questions. Four were closed-ended questions, and 10 were open-ended questions. Closed-ended questions are easier to respond to and analyse, while still providing important data. Open-ended questions require the interviewee to answer a question in detail, which is beneficial as it provides clarification and further understanding of their reasoning. The interviews were conducted on Friday, November 16 at BMH from 10:00 a.m. to 1:00 p.m. by Carol, then 1:00 p.m. to 4:00 p.m. by Tal and Harriet. Interviews at RVC were conducted the following Monday, November 19 by Harriet from 9:30 a.m. to 10:30 a.m., Liz from 9:30 a.m. to 11:30 a.m., Tal and Carol from 11:30 a.m.

to 2:00 p.m., and Harriet from 3:30 p.m. to 4:30 p.m. Each of the interviews lasted approximately 20 to 40 minutes. The full interview form can be found in Appendix D: Figure 1. Examples of question topics include:

      a. Staff satisfaction with the performance of appliances
      b. Detailed accounts of the time, length, and frequency of use of specific appliances
      c. Suggestions for what could make their workspace more energy efficient
      d. Previous knowledge (if any) about energy efficiency

Subsequently, the data gathered from observations and interviews were studied in order to develop recommendations and suggestions of which best practices the staff at both cafeterias should implement. Data and information collected were compared to Best Practices found in the literature. Both observations and interviews were conducted to compensate for possible bias in the information collected in the interviews.

5. Analysis

5.1 Behavioural Results & Recommendations

Recommendations have been made for each type of appliance by comparing current staff practices to researched literature. A list of Best Practices for each type of appliance can be found in Appendix B: Table 4.

5.1.1 Grills

Staff that were informally spoken to said that the grill in RVC is on for over nine hours a day, from around 11:30 a.m. to 9:00 p.m. One interviewee explained that while the grill is not used for breakfast, it is turned on at 9:30 a.m. to prepare for the lunch-time peak, which begins at 11:00 a.m. This was clarified to be necessary due to the uncertainty of when a student may request a food item that must be cooked on the grill. The interviewee said it usually preheats for over an hour, and that the grill is always used at a high temperature setting despite the existence of a medium setting option. This statement was confirmed through observations. The interviewee also noted that the grill is cleaned about every hour to remove food scraps.

Based on these findings, we recommend that the grill be turned on no earlier than 10:30 a.m. at the medium setting because it was mentioned by the staff that it takes 10 to 15 minutes to preheat. The grill is then turned up to the high setting at 11:00 a.m., just before the lunchtime rush. Because of the uncertainty of when students will order food off the grill, it is understood that the grill cannot be turned down to a medium setting throughout the entire day. In accordance with Best Practices, the grill is cleaned an adequate number of times.

5.1.2 Griddles

There were four staff members interviewed that used the griddles—one from RVC and three from BMH. The griddles were observed at both cafeterias at various times of the day. Staff suggested that the griddles require preheating of 10 to 15 minutes at BMH, and 45 minutes at RVC. In BMH, there is a griddle in the upstairs serving area, and one in the basement kitchen. These griddles varied between being turned off, being left on occasionally, and always being left on, depending on the staff member. Two staff members indicated that both are cleaned after every use. However, another staff member said that the downstairs griddle is cleaned according to how busy the staff there is, while the upstairs griddle is cleaned after every use. There is one griddle in RVC, which is always on, and it is cleaned twice a day In BMH, the temperature setting of the griddles ranged from 350 °F to 450 °F, but were observed to be improperly calibrated. In RVC, the temperature of the griddle ranged from 300 °F to 350 °F depending on the food being cooked. RVC staff explained that when a lot of appliances that run on gas are being used at the same time, less gas will reach the griddle, so the griddle must consequently be turned up to a very high setting in order to effectively cook food. This may indicate the need for a future study of gas distribution. .

We recommend that the griddles be turned on only when needed, as they may use up a substantial amount of energy, especially depending on the size of the griddle. We also recommend preheating the griddles only as early as necessary. For the BMH griddles, we suggest calibrating the temperature setting more accurately in order to assure that energy is not wasted from unnecessarily high temperatures. We recommend cleaning the griddles at the end of every main mealtime at a minimum in order to maximize heat transfer (Campus ERC 2007).

5.1.3 Fridges & Freezers

There were five staff members interviewed from BMH and two from RVC who used the fridges and/or freezers. Observations confirmed that those who dealt with stocking the fridges and freezers opened them constantly during their shifts. All foods were covered or packaged in some way, although late food arrivals are occasionally left uncovered until the next day. Three out of five staff at BMH and all staff at RVC who used the fridges said they place warm and hot foods in the fridges and freezers very often. The fridges and freezers are usually packed to capacity in both cafeterias. All fridges use a defrost cycle system that is not regulated by staff. All interviewed staff mentioned they close the doors upon finishing using the fridge/freezer, but some mentioned that they occasionally notice others not closing the doors all the time. According to one interviewee, the gaskets are in bad condition at BMH. These faulty gaskets and poorly sealed doors contribute to the leaking of cool air from inside (Natural Resources Canada 2012). In RVC there is a beeping system installed in the walk-in fridges and freezers, which reminds staff if the door is open. Interviewees said that food items are usually thawed in fridges overnight, but if they are in a rush, food is defrosted in the sink with lukewarm running water.

We recommend planning the stocking of fridges and freezers beforehand to minimize the number of times that they are opened. One effective method is to stock the foods that will be used in the front so that the length of time a door is kept open is reduced. This issue could also be addressed by stocking foods in a more

organized manner so that it does not take long to find particular foods. Items should always be covered before being placed in the fridge or freezer in order to increase cooling efficiency (Campus ERC 2007). This should either be arranged with the food delivery companies or faster packaging techniques should be developed. The gaskets in bad condition on the fridge and freezer doors in BMH should be replaced to make it easier to close the doors.. As the RVC staff indicated, there is an alarm system as a reminder that doors are left opened. We recommend that an alarm system be installed in more of the fridges and freezers in both cafeterias. Staff should always plan ahead and consider thawing food items in the fridges, rather than thawing them last minute using running water. Thawing more food in the fridge overnight will also aid in keeping the fridge cool (Food Safety and Inspection Service 2010).

5.1.4 Steam Kettles

We interviewed three staff members from BMH and one from RVC who dealt with steam kettles. According to staff, the steam kettles are never left operating while not in use. This was confirmed through observation. In BMH, only one steam kettle has a cover, but it is generally not used. In RVC, the covers are used only while the water is set to boil. None of the interviewed staff were aware of how often the kettles are flushed. The steam kettles are cleaned after every use at both cafeterias. The kettles at BMH undergo a full cleaning (including the removal of mineral deposits) once a year, and RVC staff were not aware of how often this was done for their steam kettles.

We recommend that the covers be used to speed up cooking times (Association for the Education of Young Children). Covers should be installed as additional parts on those steam kettles that do not already have them, and staff should be trained to use them in both cafeterias.

5.1.5 Fryers

There are three fryers at BMH and three at RVC. Two people from BMH and one from RVC were interviewed about these appliances. One interviewee said that fryers are left on between orders as they are uncertain about when students will request food from them. Furthermore, it takes about eight minutes to warm up the fryers. Another interviewee said that fryers are never on when they are not in use. The heat settings of the fryers are never adjusted. The oil in the fryers is replaced about once every ten to fourteen days. The baskets of the deep fryers are not often filled to capacity.

We recommend that meters for polar content, which measures oil quality, be installed in the fryers at BMH to make sure that the polar content does not go above 24% (replacing the oil every 10 to 14 days may not be as often as is necessary) (Gromicko and London 2012). The baskets of the deep fryer should be at capacity as often as possible. Fryers should be turned off when not in use, but otherwise adjusted to a lower temperature in between peak hours.

5.1.6 Warmers & Holders

There are two holders in BMH and four in RVC. At BMH, one of the holders is a steam bath that is set between 160 °F and 180 °F. The other one is a standard upright holder. RVC has an enclosed upright holder, which is set between 160 °F and 170 °F. The holders are on all day from opening to closing in both cafeterias, but are only actually filled and 'in use' for about three hours per day in BMH and RVC.

As there are several holders in either cafeteria, we recommend that only one or two holders be used until filled to capacity. Once the first holders are filled to capacity, others can be turned on for use. We also recommend that covers (where applicable) be used for all holders to reduce heat loss (Association for the Education of Young Children).

5.1.7 Ovens

Four out of the six staff members interviewed from BMH, and four out of seven staff at RVC use ovens. All of the staff interviewed that used ovens at BMH used the combination ovens very often, which is more than 35 hours for a five-day week. This indicates that the ovens are one of the most frequently-used appliances in the cafeteria. Staff said the convection oven was used occasionally as well. In RVC, two of the four staff interviewed use the combination ovens very often. Of the other two interviewed, one used the pizza oven and the other used the convection oven rarely (less than five hours per week).

Even though using convection ovens or the combination ovens on the convection setting is more energy efficient, the cafeteria staff prefer using the combination ovens on the combination setting (combining steam and convection) over the previous options (Natural Resources Canada 2012). Staff said that the combination ovens were set at temperatures between 225 °F to 465 °F with a median temperature of 375 °F, which was supported by our group observations. The combination setting was used an estimated 90% of the time, while the convectional heat setting was used the other 10%. The staff found that the third setting, the steam setting, was not preferable for the type of food being cooked in these ovens.

The ovens are filled to capacity depending on the menu and time of day, which was also confirmed through observation One cook explained that one type of entrée served for dinner cannot be cooked at the same time as the dinner period spans several hours; it would not be fresh for those who eat later. Thus, the cooking of some entrée meals in ovens is staggered. However, all interviewees said they tried to fill them to capacity if the menu and timing allowed for it.

All the cooks interviewed said they would open the oven doors multiple times, at least twice during a 20-minute cooking session. Cooks in RVC noted that with the new ovens, they did not have to open the doors as often because they have glass doors that allowed them to observe the food more easily. This decreases cooking time because less heat is lost to the surroundings, and more heat is available for the system to prepare the food (Natural Resources Canada 2012).

Oven cleaning is important because a clean oven can transfer heat more efficiently than one with excess food scraps left inside it (Natural Resources Canada 2012). Three of four BMH staff members interviewed believed that the ovens were cleaned two to three times a year. However, the RVC staff members interviewed did

not have uniform knowledge of the frequency of oven cleaning. Two out of four staff could not answer, while the other two guessed that cleaning happened twice a year.

The staff members noted that their usage varied. Three out of four staff from BMH use the ovens for about two hours at different times before 2:00 p.m. The fourth staff member said oven use varies based on the menu. At RVC, two cooks use the combination oven very often; one cook uses it for at least three hours in the morning, and the second cook uses it from 2:00 p.m. to 8:00 p.m. Two other staff members said they use the convection oven for two hours, and the pizza oven for at least one hour, depending on demand. At BMH, two of four of the staff interviewed said that the oven is never left on when not in use. One staff member said that it is sometimes left on while not in use, and another said that the combination oven was left on for most of the day. At RVC, three of four staff said that the oven is often left on when not in use, while one staff member disagreed. At BMH, no staff members said that they used the ovens to keep food warm. At RVC, one staff member said that the ovens were sometimes used to keep food warm. Again, the rest of the staff RVC staff interviewed disagreed with this point. No one was found to put food in the oven while the oven was in preheating mode.

We recommend using convection ovens (or the convection setting on the combination ovens) more often than the combination ovens (set on the combination setting). This shift would save energy and water (Campus ERC 2007). We recommend that the interior of the ovens be cleaned at least once a month and up to once a day in order to reduce food debris that could contribute to the reduction of heat transfer (Food Service Warehouse 2012). We also recommend loading the ovens to capacity, and even combining the various foods cooked into one oven, while maintaining a two-inch clearance space. Turning off an oven for several hours can save energy, but is not beneficial if turned off for less than an hour (Campus ERC 2007). We recommend that any new ovens purchased should have glass windows, which will help to reduce the number of times the oven door is opened and will reduce the amount of heat loss.

5.1.8 Stoves

Out of all the staff members interviewed, one from BMH and one from RVC interviewed used the stoves. During staff interviews and observations, it was noted that stoves are used mostly for vegetarian meals, sauces, and soups. The number of burners used ranged from one to three for about two hours a day. The stoves did not seem to be left on longer than necessary. Food is not left to steam after turning off the stove. For the most part, pot size is matched to the type or amount of food being prepared. It was not specified whether the pot size always matches burner size. Pressure cookers are not used in either cafeteria. Some pots are warped in shape and may not have full bottom-contact with the burners to achieve maximal heat transfer. When gas burners are set on high, the flames go much higher than just the bottom of the pans or pots. The gas burners are checked periodically, and the colour of the flames are checked. The flames are mostly blue, and occasionally white or orange.

We recommend ensuring the flames are not yellow or uneven in colour, as this indicates an unsatisfactory temperature of the flame. Burners should be cleaned regularly with a wire brush (Natural Resources Canada 2012). The cafeteria should consider purchasing a pressure cooker if the kitchen is not stocked with one already because pressure cookers use 50-75% less energy than standard pots (Natural Resources Canada 2012). We recommend reducing cooking times, especially with grains, lentils, and split peas, which can be cooked for three-quarters of the recommended cooking time. Additionally, a lid should be placed on the pot so that the food can continue to cook under the existing heat pressure, as food may need to sit and steam slightly longer past the recommended cooking time (Campus ERC 2007). We also recommend that when gas elements are set on high, flame tips should just touch the bottom of pots or pans rather than reaching higher than them. Any new pans purchased should be flat-bottomed and should match the burner size for maximum heat transfer. (Natural Resources Canada 2012).

5.1.9 Dishwasher

A staff member who works with the dishwasher was interviewed from each of BMH and RVC. At BMH, the dishwasher was said to be usually full to capacity. At RVC, the dishwasher was believed to be around 90% full when in operation. The dishwashers at both cafeterias run for approximately 12 hours, making us aware that their maintenance and use should be carefully watched in order to minimize energy losses. The dish-washing staff were not sure which settings the dishwashers were set to, and were unaware of whether a water softener was installed. Dishes were pre-rinsed before put in the dishwasher. The wash tank of the dishwasher at BMH was set to a temperature of 180 °F – 190 °F. However, the temperature of the hot water heater at BMH was observed to be at 140 °F and the shine wash was observed to be at 180 °F. Staff at RVC were not certain of the temperature settings. Additionally, staff at both BMH and RVC were unsure of whether the dishwasher has a booster heater. The dishwasher is cleaned twice every day at RVC; once after the lunch peak and once at the end of the night. The dishwasher at BMH is cleaned once every day.

We recommend that the wash tank of the dishwasher be set at a lower temperature: around 160 °F, in order to conserve heat (Campus ERC 2007). If the dishwasher has a "sanitizer" setting or booster heater, we advise that the temperature of the hot water tank be reduced to about 120 °F. This will significantly reduce water heating costs (Campus ERC 2007). We recommend scraping food off plates instead of pre-rinsing dishes before putting them in the dishwasher to save energy and water consumption. Soaking is generally suggested in cases of burnt or dried-on food. If dishes must be pre-rinsed, we advise the staff to use cold water instead of hot water (Campus ERC 2007). The RVC cleaning schedule fits the suggested frequency of cleaning. We recommend that the staff at BMH clean just as frequently to keep the appliance running more efficiently, and only run the dishwasher at full capacity.

From our observations, we noted that rotating rack toasters were using excessive energy, so we recommend that they be replaced with regular electric toasters, which consume less energy (Natural Resources Canada 2012). Furthermore, as a general rule, staff should know to unplug any small appliances that are not in use.

We recommend that staff refer to best practices guides and increase communication in order to avoid waste during food preparation activities. These best practices guidelines should be on display in the cafeteria to help guide the staff during their food preparation activities.

5.2 Creating a Culture of Sustainability within MFDS

In addition to suggesting technical and behavioural recommendations to increase energy efficiency, we conducted research on how to create a culture that promotes sustainability. This research will provide our client with the tools to create such an atmosphere to change the interactions between the cafeteria staff and students.

In the past few years, McGill University has taken many steps towards developing a sustainable future (Vision 2020 McGill). Through student and staff collaboration, McGill now has an Office of Sustainability, a Sustainability Policy, and a Sustainability Projects Fund (Vision 2020 McGill). This cooperation between students and staff members has created noticeable changes on campus (Vision 2020 McGill). To further such a collaborative and sustainable community within the RVC and BMH cafeterias, community-based social marketing techniques can be used.

Community-based social marketing aims for behavioural change through direct communication and community level initiatives (Kennedy 2010). Social marketing is the application of traditional marketing techniques to inform the public about issues while aiming for particular behavioural changes (Kennedy 2010). To promote a more sustainable future, it is critical to understand how to encourage both individuals and organizations to adopt activities that promote sustainability. This type of marketing initiative emphasizes direct personal contact among community members and the removal of barriers (Natural Resources Canada 2009). Once the barriers are identified, marketers may then develop programs that address each of them (Natural Resources Canada 2009). Consequently, individuals and organizations will adopt more sustainable activities, creating more sustainable communities (Natural Resources Canada 2009).

Based on community-based social marketing and the expertise of Jonathan Glencross, co-founder of the McGill Food Systems Project, we recommend designing training sessions for the MFDS staff in community engagement and energy efficient cooking practices. We found that 85% of staff interviewed was interested in attending a training session about energy efficiency. We have decided to focus on an example of staff training that could be used to evoke behavioural changes. The following will outline an experimental model in the form of an energy reduction competition between staff-student teams at RVC and BMH.

Our goal through this competition is to build a culture of engagement between the staff and students while teaching energy reduction strategies. To begin this process, ENVR 401 student researchers would identify staff and students interested in acting as team leaders through the Residential Life office who would act as co-leaders of the team. The role of the team leaders is threefold: to recruit other staff and students to be part of teams in each cafeteria, to motivate the staff-student teams during the competition, and to provide feedback to the ENVR 401 team during the competition.

Once the teams are formed, the ENVR 401 group would facilitate training sessions on energy efficiency and Best Practices for the team leaders. The training would focus first on the greatest inefficiencies in the cafeterias or the tasks that are most easily modified. A specific methodology for evaluating behavioural change would be developed using information from this report and further input gathered from staff and students. We could potentially work with the McGill Energy Project to effectively meter electricity and gas consumption of appliances before, during, and after the competition. To maximize accountability and continuity, feedback to teams should be provided as often and in as much detail as possible during and after the competition. At the end of each competition, successful strategies and failed ones would be analysed by the participants.

For many of the suggested best practices to work, motivation coming from a level beyond the individual will also be necessary in order for the staff to feel that they are integral parts in a team that influences the McGill community. We therefore recommend integrating individual-level changes with a community initiative that promotes a culture of responsibility and sustainability.

5.3 Technical Analysis & Recommendations

5.3.1 Assessing Energy Sources: Electricity, Natural Gas, & Steam

Both cafeterias have three types of energy sources available to them: electricity, steam, and natural gas. However, BMH is the only cafeteria that relies on all three sources, while RVC relies only on electricity and gas (Appendix A: Figures 2, 3).

This section will first compare the energy consumption of each type of electrical and gas appliances. Secondly, the rates for each energy source will show the costs of running different appliances on both sources. Lastly, the environmental impacts of each source will be compared in terms of carbon dioxide (CO_2) gases produced. These evaluations will allow us to identify the energy source which best fits the appliance. It should be noted that most appliances on the market, excluding fridges, freezers, and warmers, are available as gas or electricity-run models.

5.3.2 Electricity & Natural Gas: Energy Efficiency

All types of appliances were found to have higher energy consumption as gas-run models compared to the energy consumption of electricity-run models. This is partially due to the fact that gas-run models tend to have higher idle energy consumption rates (Fisher 2002). However, in terms of the efficiency of basic energy transfer, natural gas is more efficient (CPS Energy 2012). This is because the gas itself releases heat quicker than electric heating elements and no energy is lost during conversion and transmission of the energy (CPS Energy 2012). To view the differences between the natural gas and electricity consumption for running various appliances (Energy Star 2012), see Appendix B: Table 5.

5.3.3 Electricity & Natural Gas: Costs

It is also important to compare price differences between natural gas and electricity, as this will inevitably affect the client's decisions when choosing a new appliance. Even though a particular appliance may be less energy efficient, differing operating costs can determine which one is more *cost* efficient. McGill is charged a rate of 0.0295$/kWh for electricity **(**McGill Energy Project: MELS 2012**)** and a rate of approximately 10.0463 $/GJ for natural gas (Gaz Métro 2012). These rates and the projected annual energy consumption from Appendix: Table 5 were used to estimate the annual cost. To view the differences between the costs of running appliances on natural gas and on electricity, see Appendix B: Table 6.

5.3.4 Electricity & Natural Gas: Impacts

McGill's electricity is provided by Hydro-Québec. Although considered a renewable resource, energy generated through water still impacts the environment. Hydroelectric reservoirs, many of which produce most of Quebec's electricity, cause the decomposition of flooded biomass, resulting in ecosystem damage and increases in GHG emissions (Hydro-Québec 2012). Hydro-Québec releases the equivalent of 2.04 g of CO2 for every GJ of energy consumed (McGill Energy Project: MELS 2012). McGill's natural gas is supplied by Gaz Métro, which receives its supply of gas from Alberta. The emissions related to the process of natural gas extraction contribute to the formation of acid rain and ground level ozone, both of which are linked to many health issues (Environment Canada 2007). Moreover, it is estimated that using a GJ of energy is equivalent to emitting 49,864.34 g of CO_2 (McGill Energy Project: MELS 2012). Though natural gas is more efficient with energy transfer, in this specific case, electricity may be the more sustainable source of energy because it comes from hydroelectric sources. See Appendix B: Table 7 for the different projected CO_2 emissions for appliances running on natural gas and electricity.

5.3.5 Electricity & Natural gas: Results & Recommendations

We analysed the energy consumption, costs, and environmental impacts of running appliances on natural gas versus electricity in order to recommend the best-suited energy source for kitchen appliances.

Considering the environmental impacts and projected GHG emissions of natural gas, we recommend appliances that operate with electricity. Electricity production by Hydro- Québec has been deduced to have the least negative impacts on the environment and considerably reduced emissions of GHGs compared to natural gas (Appendix B: Table 7). So, using electricity-run appliances contributes to the greater goal of protecting our natural resources and reducing our dependence on fossil fuels.

For all appliances, natural gas models consumed a higher amount of energy than the equivalent electricity-run model (Appendix B: Table 5). Also, the annual cost to run gas models was always higher than running electrical models (Appendix B: Table 6). As we realize that replacing all gas and steam-run appliances with electricity-run ones is not feasible in the short-term, we suggest that this become a long-term goal for the cafeterias. We also suggest that when the steam-run appliances

are eventually replaced, that electricity-run appliances are most heavily considered. The following sections show some of the findings of our research.

5.3.5.1 Fryers

All fryers in both BMH and RVC are open deep-fat fryers and run on natural gas, though electrical models exist on the market. A gas fryer consumes the equivalent of 47,774.98 kWh (172 GJ) annually, compared to 18,189 kWh for an electrical fryer, a 29,586 kWh difference. It costs $1191.40 more annually to run a fryer off natural gas than electricity.

5.3.5.2 Griddles

It was found that all of the griddles in BMH and RVC run on natural gas, with the exception of one electrical griddle in BMH. A gas griddle consumes the equivalent of 35,553.47 kWh (128 GJ) annually compared to 17,056 kWh for an electrical fryer, an 18,497 kWh difference. It costs $782.78 more annually to run a griddle natural gas than electricity.

5.3.5.3 Ovens

The majority of the ovens in both cafeterias were dependent on natural gas. A gas oven consumes the equivalent of 30,831.53 kWh (111 GJ) annually compared to 12,193 kWh for an electrical fryer, an 18,639 kWh difference. It costs $755.45 more annually to run an oven on natural gas than electricity.

5.3.5.4 Steam Kettles

All relevant steam kettles found in both cafeterias were dependent on natural gas. A gas-run steam kettle consumes an equivalence of 18,276.71 kWh (66 GJ) annually compared to 9,980 kWh for an electrical kettle, an 8,297 kWh difference. It costs $366.64 more annually to run a steam kettle on natural gas than electricity.

5.3.5.5 Steamers

All steamers found in the two cafeterias were dependent on natural gas. A gas steamer consumes an equivalence of 24,720.77 kWh (89 GJ) annually compared to 9,241 kWh consumed by an electrical steamer, a 15,480 kWh difference. It costs $366.64 more annually to run a steamer on natural gas than electricity.

5.3.6 Steam-Run Appliances

Several appliances in BMH currently run on steam, and the hot water that is provided to the building also comes from the steam lines. The demand for steam in the summer is much lower than during the school year, as the campus population is smaller and the residence halls are mostly not in operation. This requires an output of only 8,000-15,000 lbs/hour. However, as the minimal operating output of one

large boiler is 20,000-23,000 lbs/hour, all the extra steam produced is emitted into the air and wasted. By installing a smaller boiler, it is possible to tailor the amount of steam produced more closely to the actual demand, thus reducing wasted energy (MEP: Powerhouse 2012). However, this new boiler does not solve the problem of steam's inherent inefficiency.

The McGill powerhouse is one of the largest steam power plants in downtown Montreal and is located in the Ferrier building. It provides steam for many of the buildings in the downtown campus (MEP: Powerhouse 2012). BMH, in particular, relies on this steam network for energy to run many of the kitchen appliances. Before entering the powerhouse, the water must go through a purification process that includes water softening, gas removal, and sulfide treatments (MEP: Powerhouse 2012). This process is inherently inefficient; the intensive water purification steps, which would otherwise go toward purifying drinking water, are instead used during the production of steam. Furthermore, energy is lost as the three main boilers and the tunnel network that transports the steam around campus has an estimated leakage of 15-20% of total steam supply (MEP: Powerhouse 2012).

Steam production is also unsustainable because of the natural gas required. Most of the consumption of McGill's natural gas goes to running the boilers in the steam powerhouse, with smaller amounts contributing to gas appliances, activities in laboratories, and heating for several campus buildings (MEP: Natural Gas 2012). Due to the massive amounts of input necessary to create steam and the large amounts of wasted energy emitted in the form of steam arising from imprecise calculations of demand versus capacity, steam energy is very inefficient and environmentally unfriendly. As a result of these findings, we believe cafeterias should minimize their dependence on steam as an energy source. We recognize that this is a difficult and complex task, especially as the steam network is already in place. Replacing steam with another source of energy could prove to be costly. In the long run, however, replacement of the steam network at McGill will be necessary.

Steam-run technology, which dates back to the Industrial Revolution, is simply out-dated and inefficient. Steam must be maintained at very high temperatures, and many old steam pipes are poorly insulated, again, allowing for huge amounts of heat loss (UBC Sustainability 2012). When these steam pipes occasionally break down, there is no readily available hot water. This can potentially cause major problems in the BMH cafeteria, which serves hundreds of students.

Therefore, due to the evident inefficiency of steam-run technology, there will be no further analyses of steam-run appliances in BMH.

5.3.7 Energy Input versus Frequency of Use Analysis

Figures and results of appliance energy input vs. frequency of use are shown in Appendix A: Figures 4, 5 and Appendix B: Tables 1, 8, 9.

Energy Star-rated appliances were left out of this analysis as they already meet the energy standards of the Government of Canada (Natural Resources Canada 2011). Energy Star-rated models are government approved and recognized as energy-efficient appliances. They are defined by meeting minimum CEE, as well as maximum IER (Natural Resources Canada 2011).

Steam-run appliances are also excluded from this analysis.[4]

All of the following recommendations were formulated using the collected specification data and behavioural data as well as the costs and savings of various appliances from Natural Resources Canada (Energy Star 2012). Natural Resources Canada makes assumptions of $9.02/GJ for natural gas and $0.12/kWh for electricity (Energy Star 2012). These figures were adjusted to reflect, as closely as possible, the rates applied to McGill.

Because McGill is under the D1 General Distribution Service in the Southern Zone **(**Gaz Métro 2009)**,** figures of the Natural Gas Supply Price ($3.48/GJ or 13.186¢/m^3) and Compressor Fuel Price (0.462¢/m^3) from December 1, 2012 were used to calculate estimated natural gas prices per unit energy (Gaz Métro 2009). This calculation was done by adding these figures to Gaz Métro transportation (6.927 ¢/m^3), load-balancing (4.652 ¢/m^3), distribution (11.924 ¢/m^3), and inventory-related adjustment (0.915 ¢/m^3) prices (Gaz Métro 2009). The calculated natural gas rate was 38.066 ¢/m^3 or $10.046/GJ.

The electricity rate paid by McGill to Hydro Quebec (as a large user) is 0.0295$/kWh. Calculations were made as follows:

  i. *Gas-run Appliances:* Estimated Operating Cost x (($10.046/GJ) / ($9.02/GJ)) = Adjusted Estimated Operating Cost
  ii. *Electricity-run Appliances:* Estimated Operating Cost / (($0.12/kWh) / ($0.0295/kWh)) = Adjusted Estimated Operating Cost

Appliances not included in the appliance savings figures include full ranges and steam kettles. Ranges vary widely in type, and steam kettles are not presently made for Energy-Star standards. Alternate sources were used to make replacement cost-benefit analyses.

Using the Priority Appliances tables (Appendix B: Tables 8, 9) and the Appliance Savings figures (Appendix B: Table 12), we examined the high-energy input and very often-used appliances to determine the costs and benefits of their replacement. Our recommendations for replacements are based on the energy and cost benefits of installing Energy Star-rated appliances. The particular factors that are examined are energy savings, cost savings, and costs of replacement.

5.3.7.1 BMH Appliance Analysis & Recommendations

  i. Fy123 (Gas fryers) have the highest energy input, 58.57 kW, and are used sometimes (~15hrs/wk). Replacement with an Energy Star model is about $2,944, with annual cost savings of $535.69 and annual energy savings of 53 GJ/yr (14,722 kWh/yr).
  ii. Gd1 (Gas griddle) has an energy input of 43.34 kW and are used often (~25hrs/wk). Replacement with an Energy Star model is about $1,560, with annual cost savings of $158.15 and annual energy savings of 16 GJ/yr (4,444 kWh/yr).

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[4] see Section 4.3.6. for justification for the exclusion of steam

iii.   R1 (Range with 1 griddle, 2 burners, and oven) has an energy input 45.1 kW of and is used rarely (2-3 hrs/wk). Energy Star data is not available for ranges.

iv.   O6 (Gas combination oven) has an energy input of 33.68 kW and is used very often (>35hrs/wk). As combination ovens are excluded from Energy Star products, exact figures are not available (Energy Star 2011). However, figures for gas ovens will be used for comparison. Replacement with an Energy Star model is about $1,550, with annual cost savings of $324.09 and annual energy savings of 32 GJ/yr (8,888 kWh/yr).

v.   Gd2 (Electric flat griddle) has an energy input of 14.3 kW and is used very often (>35hrs/wk). Replacement with an Energy Star model is about $850, with annual cost savings of $80.88 and annual energy savings of 2,595 kWh/yr.

vi.   W1 (Electric warmer) has an energy input of 1.1 kW and is used very often (>35hrs/wk). Replacement with an Energy Star model is about $3,569, with annual cost savings of $261.32 and annual energy savings of 8,382 kWh/yr.

Appliances ordered from the greatest to lowest energy savings: Fy123, O6, W1, Gd1, Gd2. It is clear that the costs of replacement may affect the follow-through of these recommendations. Appliances ordered from greatest to lowest replacement cost: W1, Fy123, Gd1, O6, Gd2. For BMH, we recommend prioritizing according to energy savings and frequency of use. We recommend, in order of priority, the replacements of O6, W1, Fy123, Gd2, and Gd1. Recommendations for R1 will be continued in Section 4.3.8 (rarely-used appliances).

5.3.7.2 RVC Appliance Analysis & Recommendations

i.   R1 (Gas range with 4 burners) has an energy input of 49.78 kW, and is used sometimes (10-15hrs/wk). As ranges are excluded from Energy Star standards, exact figures are not available (Energy Star 2011).

ii.   SK1 (Gas steam kettle) has an energy input of 49.78 kW, and is used often (20-25hrs/wk). Energy Star data is not available for steam kettles.

iii.   Gd1 (Gas griddle) has an energy input of 43.34 kW, and is used very often (>35 hrs/wk). Replacement with an Energy Star model is about $1,560, with annual cost savings of $158.15 and annual energy savings of 16 GJ/yr (4,444 kWh/yr).

iv.   SK2 (Gas steam kettle) has an energy input of 49.78 kW, and is used sometimes (~10 hrs/wk). Energy Star data is not available for steam kettles.

v.   S1 (Gas steamer) has an energy input of 36.61 kW, and is used very often (>35 hrs/wk). Replacement with an Energy Star model is about $7,256, with annual cost savings of $209.58 and annual energy savings of 50 GJ/yr (13,889 kWh/yr).

vi.   O3 (Gas combination oven) has an energy input of 33.68 kW and is used very often (~45hrs/wk). As combination ovens are excluded from Energy Star products, exact figures are not available (Energy Star 2011). However, figures for gas ovens will be used for comparison. Replacement with an Energy Star model is about $1,550, with annual cost savings of $324.09 and annual energy savings of 32 GJ/yr (8,888 kWh/yr).

vii.   G1 (Gas grill) has an energy input of 26.35 kW and is used very often
         (>35hrs/wk). Replacement with an Energy Star model is about $1,560, with
         annual cost savings of $158.15 and annual energy savings of 16 GJ/yr (4,444
         kWh/yr).

viii.   W2 (Electric warmer) has an energy input of 2.8kW and is used very often
         (>35hrs/wk). Replacement with an Energy Star model is about $3,569, with
         annual cost savings of $261.32 and annual energy savings of 8,382 kWh/yr.

ix.   W1 (Electric warmer) has an energy input of 1.1kW and is used very often
         (>35hrs/wk). Replacement with an Energy Star model is about $3,569, with
         annual cost savings of $261.32 and annual energy savings of 8,382 kWh/yr.

Appliances ordered from the greatest to lowest energy savings: S1, W2/W1, O3, G1/Gd1. It is clear that the costs of replacement may affect the follow through of these recommendations. Appliances ordered from greatest to lowest replacement cost: S1, W2/W1, Gd1/G1, O3. For BMH, we recommend prioritizing according to energy savings and frequency of use. We recommend, in order of priority, the replacements of S1, W2/W1, O3, and G1/Gd1. Though data is not available for SK1 and SK2, as they require high energy inputs and are used often and sometimes respectively, modified behavioural changes should be made to increase use efficiency (see Section 4.1.4.). Furthermore, modification changes such as adding lids, which can reduce simmer energy use by 60%, should be made (Fisher 2002). Also, as figures for R1 are not available, we recommend modified behavioural changes to increase use efficiency (see Section 4.1.8.).

5.3.8 Rarely-Used Appliances

Rarely-used appliances are examined individually. As they are used so infrequently, it is important to assess their necessity in the cafeterias. Energy savings can be made if operations carried out on these appliances can be done using other already available appliances in the cafeterias. Rarely-used appliances in BMH include: R1, O4, O5.

R1 is a high-energy input and rarely-used appliance. It has a griddle, two burners, and an oven. BMH is already equipped with a functioning griddle, which is used significantly more often than the small surface area provided by the R1 griddle. Furthermore, the R1 oven is rarely used as there are many other available ovens, including both convection and combination ovens in BMH. Though the burners have been found to be rarely used as well, it is possible that their functions are specific to cooking particular foods, oatmeal for example. While we suggest the removal of R1 due to its high energy input and low frequency of use, we recognize the role of a burner. Further assessment by the client is necessary to make conclusive judgments.

O4 and O5 are currently part of a range which includes Gd1. The removal of O4 and O5 would thus require the removal of Gd1 one as well. Because R1 was recommend for removal, this leaves Gd1 as the only griddle in the basement kitchen of BMH. What we recommend is the installation of an Energy-Star rated griddle in place of the current range which includes O4, O5, and Gd1. This would be beneficial because other existing ovens, such as the combination oven, O6, may replace the functions of O4 and O5.

Rarely-used appliances in RVC included: Fy3, O5, O6, O7.

Fy3 is one of 3 fryers in RVC, and is used the least. It is recommended that it be removed, and that its functions be replaced by the existing fryers, Fy1 and Fy2. With management of cooking times and estimations of food loads for a particular period of the day, Fy1 and Fy2 may be used efficiently and successfully even without Fy3.

O5 and O6 are also part of a range which includes Gd1. Because Gd1 is used frequently and has been installed recently, we recognize that the removal of O5 and O6 would be unreasoned. We therefore strongly urge that the use of these ovens be regulated and that best practices be followed closely (Appendix B: Table 4).

O7 is a salamander, which is primarily used for browning large dishes. It would be beneficial to remove it and use existing ovens to perform this function instead. Moreover, the browning of dishes contributes primarily to the visual appeal of food, and not necessarily to improvement in its taste.

After considering existing appliances in the cafeterias - ones that may replace some of the functions of these rarely-used appliances - we gather that they may be removed without much impact on overall food preparation.

5.3.9 Fridges & Freezers

Our recommendations for fridges and freezers are not based on energy consumption rates, but on observations only. Estimates of energy consumption of these appliances depend on how often their compressors operate. The role of a compressor is to maintain a constant temperature in the fridge or freezer. As compressor operation is highly variable, depending on how often and for how long the fridge or freezer is opened, only rudimentary estimates can be made. Furthermore, as fridges contribute to only about 6% of electricity consumption in a kitchen (Energy Star 2009), mass replacements of non-Energy Star fridges may not improve energy efficiency significantly in comparison to other options for appliance replacements presented in this report.

We do suggest, however, that particular modifications to the walk-in fridges and freezers be made. It is beneficial to add strip curtains to the walk-ins, as they can save about $784.59/yr of operational costs (based on McGill's rate of $0.0295/kWh) (Energy Star 2009). It is also noted that WF2, WF3, WFr2, and WF4 in BMH have not been updated in over 30 years.

6. Conclusion

6.1 Key Findings

Two key aspects determining energy consumption were addressed: the required energy input of the appliances, and the frequency and staff usage of the appliances. The technical approach investigated the operations of the appliances, their efficiency, and options for alternate, more energy-efficient appliances. The behavioural approach conducted observations and interviews to assess staff practices of the use of appliances and the preparation of food. Extensive research conducted

allowed us to provide the costs and benefits of installing energy-efficient alternatives, as well as suggest alternative staff practices.

The most significant finding was the need to develop a culture of sustainability, encompassing education, participation, and energy efficiency through staff team support. Although the student staff undergoes the same turnover rate as the students using the cafeterias every three to four years, the permanent staff play a key role in maintaining the techniques and practices used in the cafeterias. Interviews with these employees provided insight on energy-efficient practices that could be incorporated into the cafeteria operations. In working with staff and including them in research and the decision-making process, a greater sense of participation and transparency was felt. It was found that employees were open to having training sessions on how to operate in more energy-efficient manners. This is a promising finding, as it may instigate a community of acceptance for the implementation of Best Practices, and potentially even a development in sustainable norms and values followed in the cafeterias.

The technical approach assessed the sustainability of energy sources including natural gas, electricity, and steam. Using this data and appliance specification data, priority lists of suggested appliance replacements were made. Our key findings were the need to switch from reliance on steam to reliance on gas and electricity. Furthermore, where the options are feasible, we see it fit to invest in electricity-run models rather than natural gas-run models. We found that most appliances that needed high energy inputs and were very frequently used were not Energy Star-rated models, and that many were very out-dated models. Our prioritized recommendations for replacements may be found in Appendix B: Tables 8, 9.

6.2 Limitations

During the first month of our project, we met with various stakeholders working on the sustainability movement on campus in order to design the scope and feasibility of our project. This included addressing which aspects of the life-cycle of energy we should focus on. We first met with our client, Chef deVolpi, and stakeholder David Balcombe (see Appendix B: Table 10). After dealing with many projects that focus on food systems (which are continually being assessed by McGill Food Systems Project and McGill's Office of Sustainability), the clients preferred to focus on the aspect of energy use within the constraints of the cafeteria setting. This was further emphasized in our meetings with Maria Mazzotta and Elana Evans (see Appendix B: Table 10). Subsequently, it was decided that addressing the full life-cycle analysis of the food served in the cafeterias was not feasible due to the time constraints of the project. Instead, we decided to focus on aspects of energy use in the cafeterias that could be reduced with technical and behavioural modifications.

After meeting with stakeholders Jerome Conraud (Energy and Utilities Management team), and Marc-Etienne Brunet (see Appendix B: Table 10), it was determined that an extensive energy audit of all appliances would not be possible. Professional firms may have advantages in completing comprehensive energy-efficiency assessments or audits within shorter time periods. As students who are not trained as professionals in the field, we carry only fundamental knowledge in the

execution and format of formal energy assessments and audits. Furthermore, energy-efficiency assessments often require metering instruments (for example, temporary energy meters on appliances) in order to measure energy consumption. These apparatuses are quite costly (Powershift 2012). As this project is not supported financially, purchases of such equipment were not possible. This led us to our decision to approach this project using a user-interface perspective. Jerome Conraud also informed us of McGill Residences Facilities and Buildings Operations' plan to complete a full energy audit of McGill cafeterias within the next two years.

Our group had discussed including the water usage in the cafeterias as part of our scope, and this was brought up with Jerome Conraud as well. He informed us that there are no water meters used within McGill, and that access to billing data is very difficult to obtain. Additionally, our client wanted us to focus on energy consumption over water usage.

One of the main criticisms of our project was that energy consumption in the cafeterias is highly dependent upon the menu. We understand that due to differences in the weekly menus, there will be differences in the amount of energy used per day in order to prepare dishes. However, due to time constraints and lack of influence over food purchasing, we did not investigate this aspect of energy efficiency.

Our team also met with David Gray-Donald (see Appendix B: Table 10) to determine whether an analysis of the food waste produced by the cafeterias would be feasible. We were informed that Big Hannah, the industrial composter on campus, is already running at full capacity, and the only way that composting capacity could increase was if macerators were successfully installed in the cafeterias. He further informed us that this had already been attempted last year, but that the macerators did not end up being suitable. We therefore concluded that it was not practical to include food waste in our scope.

The technical analysis relied on energy data for old appliances, which was in some cases not available. These appliances are expected to have labels that state various energy figures. However, some of these labels are physically inaccessible, missing, or illegible. There is no equipment list available for either cafeteria, which hindered our ability to verify all existing appliances. We compiled a list of all the relevant appliances in the cafeterias, concentrating on appliances chosen according to energy consumption. This appliance list was a useful asset to us, particularly for the technical analysis, and may be found in Appendix B: Tables 2 and 3**.**

Another limitation was the inability to use energy bills for electricity and gas as a measurement of energy usage. Electricity bills for McGill are based on the energy usage of entire buildings and are not broken down by areas within the buildings. Furthermore, gas bills are not available for public viewing (Conraud Sept. 27th, 2012). Thus, we were unable to use billing as an analytical tool in our procedure.

A large component of our behavioural analysis relied on interviews with the cafeteria staff. We interviewed thirteen staff in total from both of the cafeterias. Without a full census of all staff, it was difficult to make definite conclusions of each staff member's use of appliances. Staff observation, completed several times by each member of the project group in both cafeterias, supplemented the interviews as a method of estimating the frequency of the use of the appliances.

6.3 Future Studies & Research

There is constantly room for improvement, especially for projects focusing on sustainability. In determining the scope of our project, we realized early on that there were many aspects of energy efficiency within MFDS that we were not able to assess. It is therefore important to look at potential projects that may be conducted in order to address other energy efficiency and sustainability matters.

Jerome Conraud is already working on an energy audit to be completed by an external agency, in addition to implementing meters for both energy and water consumption at McGill. For the future it is important to be able to monitor energy use within the institutional setting. The maps of the cafeterias and the appliance lists (see Appendix B: Table 2, 3) may be helpful in the implementation of meters. Furthermore, these documents may be accessible to students interested in doing applied student research through the McGill Energy Project.

Future ENVR 401 projects, or even prospective internship positions with MFDS or SPF projects, can look at the life-cycle of food within the cafeterias. In the past, MFDS has worked with ENVR 401 groups to look at sustainable seafood options and sourcing options for poultry and tomatoes in Quebec. However, addressing all of the food served has not been carried out yet. MFDS has also collaborated with students in research groups through the Office of Sustainability, resulting in significant developments in sustainability like the creation of the McGill Food Systems Project.

Food waste and composting at McGill cafeterias is also a potential undertaking. As previously discussed, the compost facilities are already filled to capacity from pre-consumer food waste alone, leaving no room for post-consumer food waste. Once proper macerators are installed, post-consumer food waste may also be added to the composting process. An exciting feature of food waste and composting initiatives is that there are many ways to get involved. According to our client, informative eco-stations are to be installed. In these stations, students, staff, faculty, and the administration can learn about and take part in composting. Furthermore, these stations will always be in constant need of enhancement and personalization. Other project ideas include competitions between campus cafeterias to determine which cafeteria produces the least amount of waste (see Section 4.2: Creating a Culture of Sustainability within MFDS).

Continuing to build a connection between staff, supervisors, and students is important when working towards a culture of sustainability at McGill. Community-building initiatives of this kind are in constant progress. The results of this report will add to the knowledge base of best practices and energy efficiency at McGill University. We hope it contributes to the greater awareness of sustainability in McGill dining facilities and that it provides a platform from which future projects on different aspects of energy efficiency can be conducted.

6.4 Final Statements

In light of expectations for improvements in overall sustainable management, we have conducted this project with the hopes that our technical and behavioural recommendations will properly address the matter of energy efficiency in the BMH and RVC cafeterias.

We believe that, in following through with many of these recommendations, the prospective cost savings and premiums will allow MFDS to purchase even more local and sustainable foods. Most importantly, in the way that both approaches in the methodology were necessary for a comprehensive study, it is important to continue to take on the same holistic approach towards sustainability while taking into consideration social and economic aspects. We hope this report adds to the knowledge base of best practices and energy efficiency at McGill University. We hope it contributes to the greater awareness of sustainability in McGill dining facilities and that it provides a platform from which future projects on different aspects energy efficiency can be conducted.

We would like to thank our client, Executive Chef Oliver deVolpi, for providing us with the means to carry out this project.

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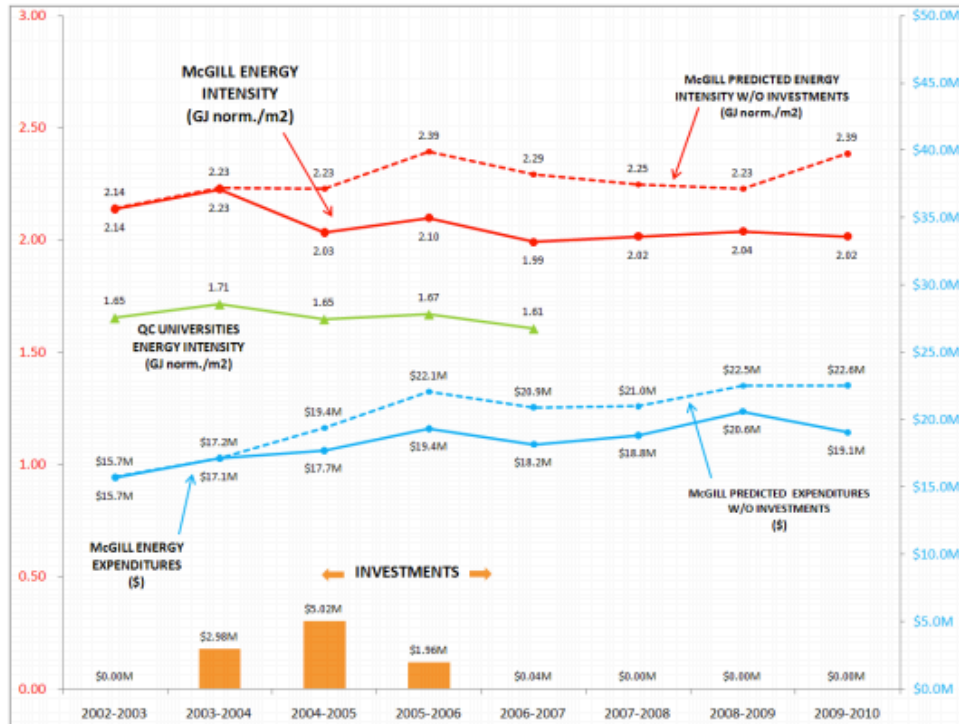
Appendix A: Graphs

Figure 1: Energy Conservation at McGill and corresponding costs and investments from 2002-2009 (McGill 2010).
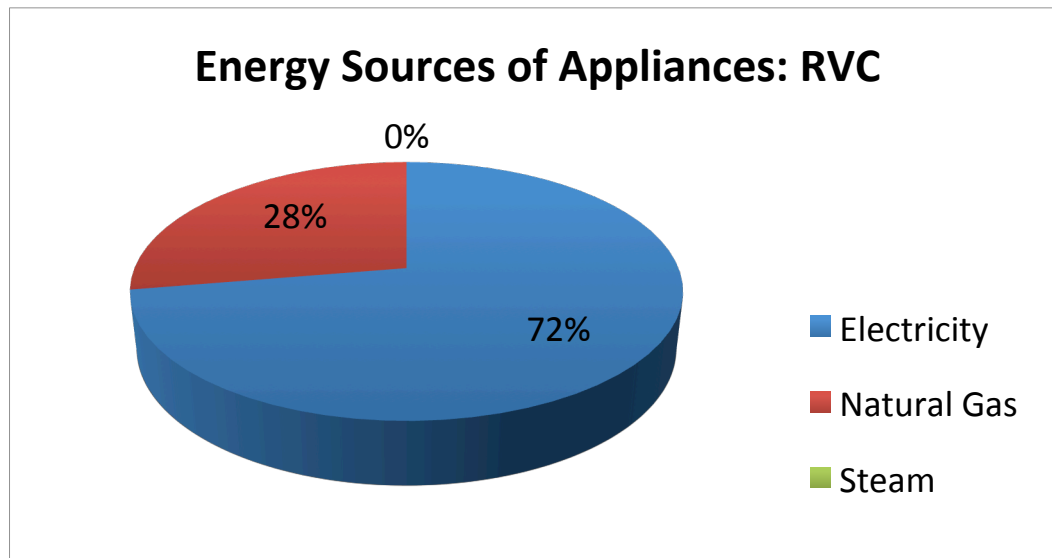

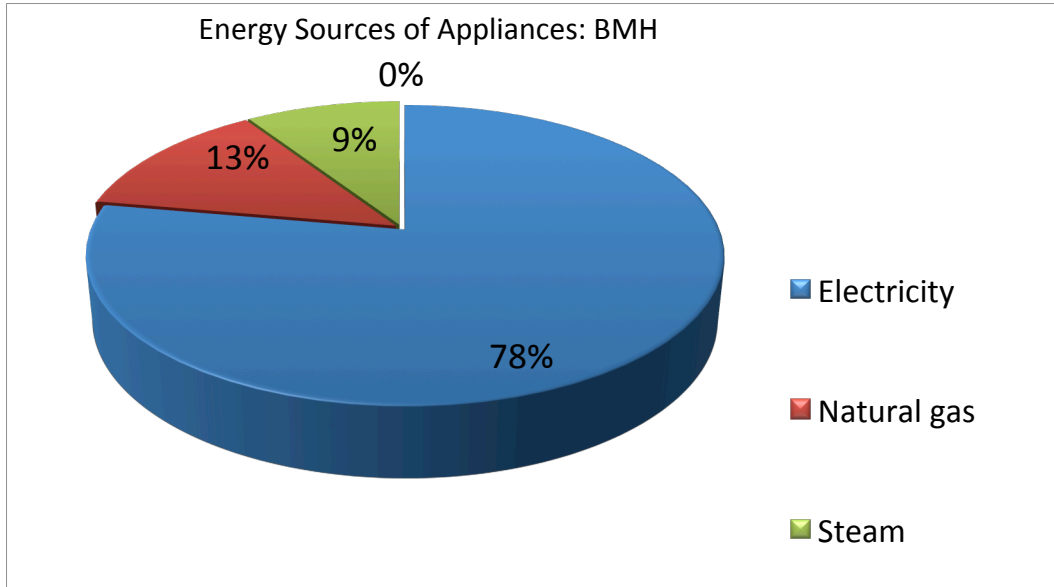**Figure 2:** Pie-Chart: distribution of energy input by source: RVC

Figure 3: Graph of energy input vs. frequency of use: BMH
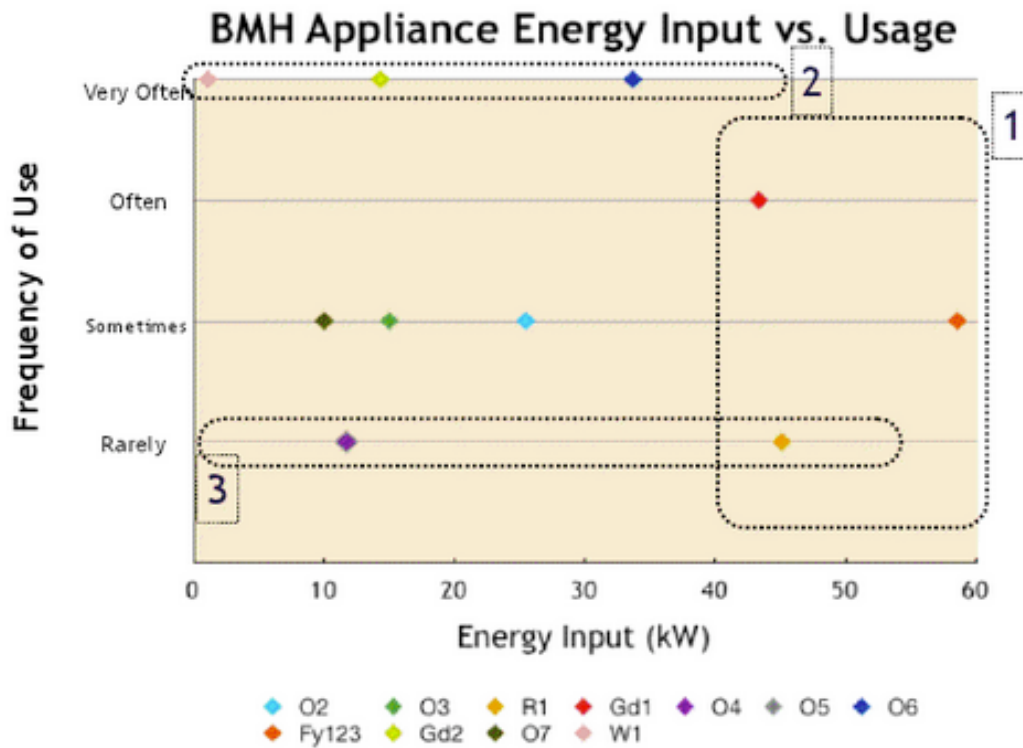

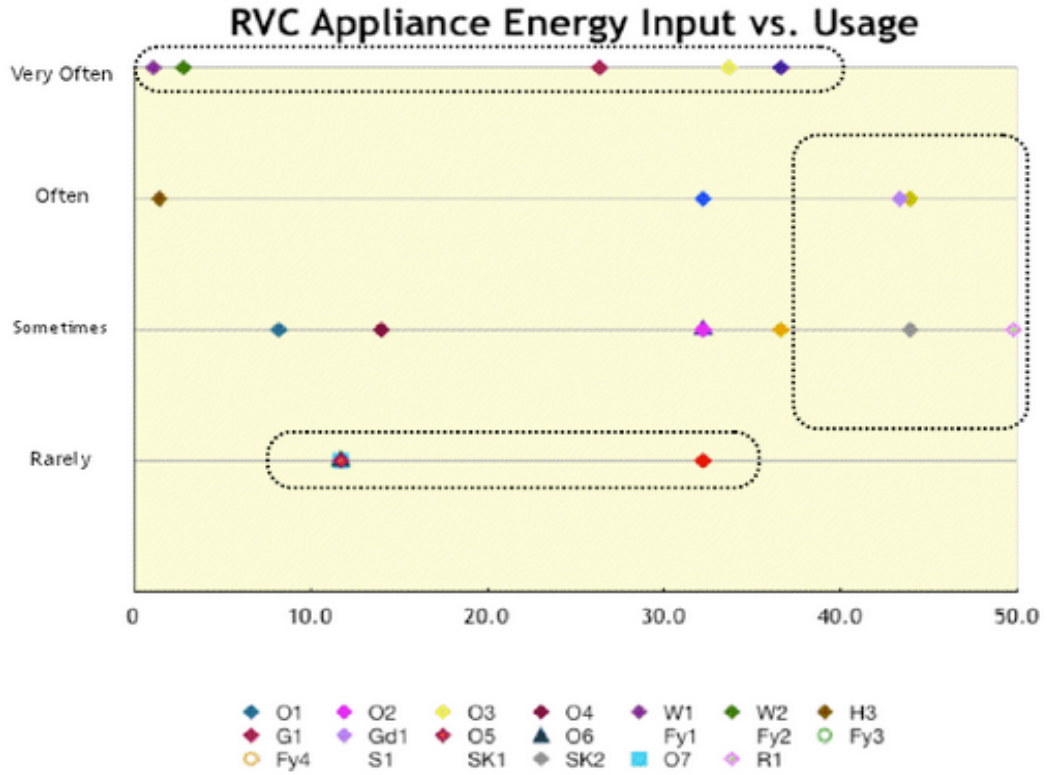**Figure 4:** Pie Chart: distribution of energy input by source: BMH

Figure 5: Graph of energy input vs. frequency of use: RVC

Appendix B: Tables

Tables and additional data can be provided upon request.

Table 1: Frequency of use: BMH and RVC

Table 2: Appliance list with specifications: RVC

Table 3: Appliance list with specifications: BMH

Table 4: Best practices

Table 5: Appliance energy consumption: Natural Gas vs. Electricity

Table 6: Cost ($) of running appliances: Natural Gas vs. Electricity

Table 7: Carbon Dioxide emissions: Natural Gas vs. Electricity

Table 8: Prioritized list of replacements: BMH

Table 9: Prioritized list of replacements: RVC

Table 10: List of stakeholders

Table 11: Annual energy savings calculations

Table 12: Appliance Savings Figures (Energy Star 2012)

Assumptions: Natural gas at $10.046/GJ; Electricity at $0.0295/kWh; Water at $2.20/m³; 45.4 kg (100 lb.) daily food load (where applicable).
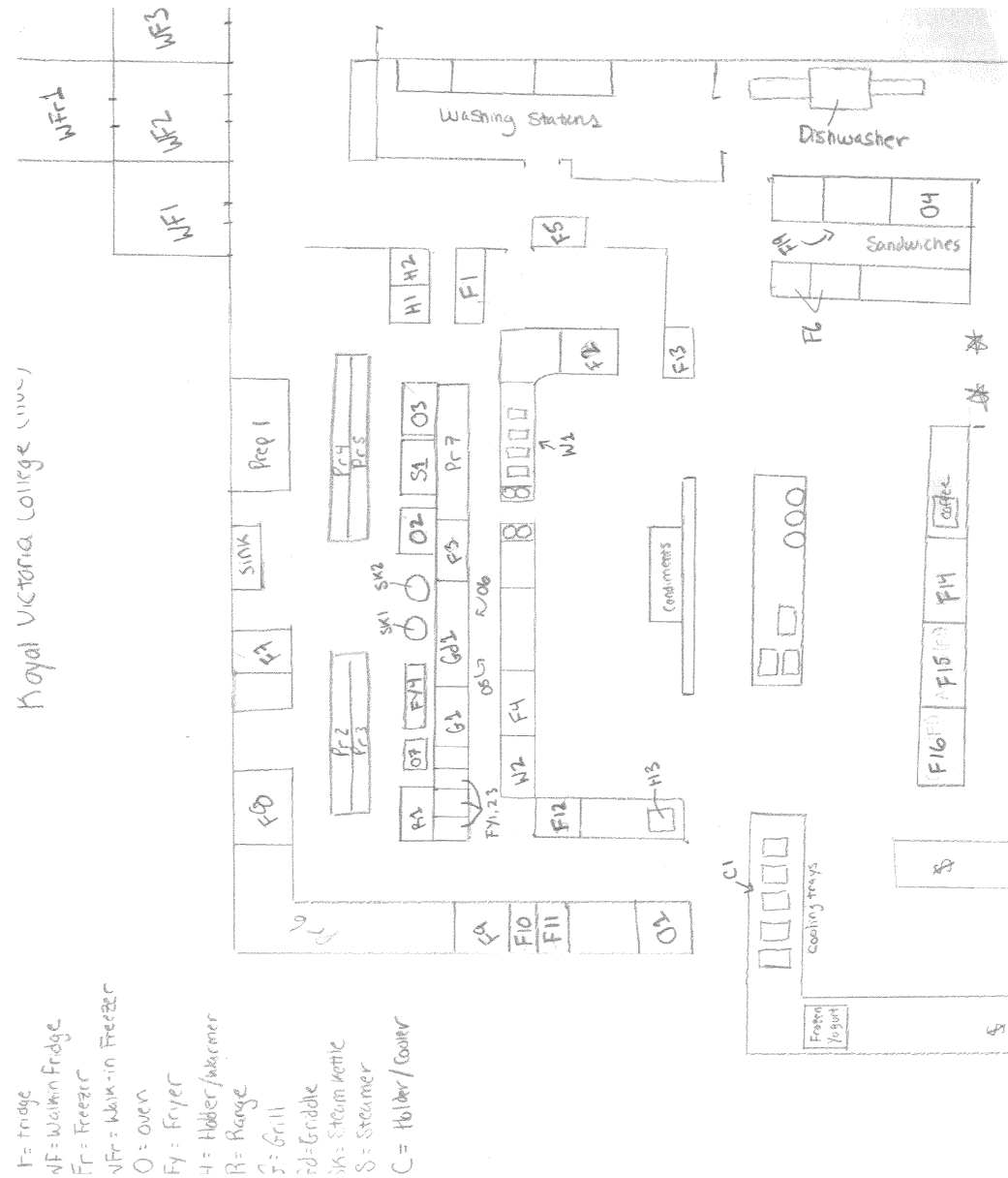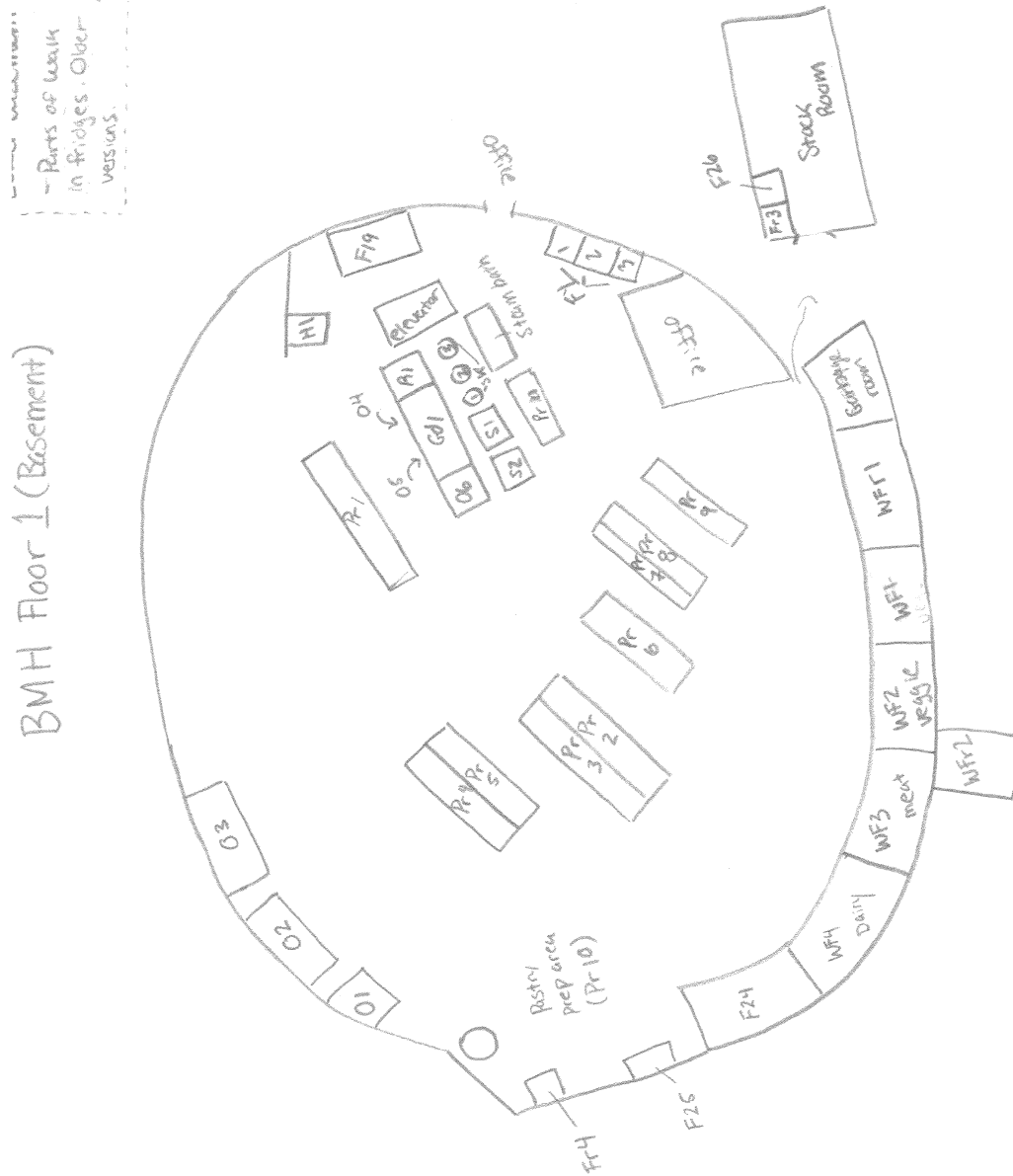
Appendix C: Tables

Figure 1: Map of RVC

Figure 2: Map of BMH: Basement kitchen

Figure 3: Map of BMH: Main Cafeteria & kitchen

Appendix D: Other Documentation

MFDS Staff Interview

1. Where do you work?

☐ BMH
☐ RVC
☐ Both
☐ Other

2. What is your position?

☐ General helpers
☐ Counter

Kitchen staff
☐ Baker
☐ First cook
☐ 2nd cook
☐ cook's helpers
☐ casual kitchen

Student
☐ Counter
☐ Dish
☐ Driver
☐ Other

3. Average weekly hours (including weekends)
☐ <10
☐ 10-20
☐ 20-30
☐ 30-40
☐ >40

4. Which time of day do you usually work at? (specify peak hours for each cafeteria)
☐ opening hours
☐ peak times
☐ non-peak times
☐ closing hours

5. What station(s) do you work at? What are your main tasks?

6. According to your estimations, how often and how long do you use the main equipment (specified by technical analysis) in your area?

_____

7. What do you know about energy efficiency?

_____

8. Which changes (if any) can be made in relation to your practices and use of appliances to save energy?

_____

9. During the time of a normal work period, would you be interested in attending a staff training session about energy efficiency?

      ☐   yes
      ☐   no

Why or why not?

_____

10. Do you work with or use any appliances that are broken or/and inefficient?

_____

11. What are you satisfied and not satisfied with in relation to the equipment that you work with?

_____

12. Are you satisfied with the current location of your equipment in relation to your working space?

_____

13. Do you think there are kitchen practices (related to staff behavior) that could be changed to be more efficient?

_____

14. Do you have any other questions or concerns about the energy efficiency project conducted by students from the environmental research course?

Figure 1: Interview Form for MFDS Staff

McGill

Research Ethics Board
Faculty of Agricultural and Environmental Sciences

McGill University
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Tel: (514) 398-8716
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www.mcgill.ca/macdonald/research/compliance/human/

Certificate of Ethical Acceptability
Research Involving Humans

REB File #: 989-1112

Project Title: *"Energy-wise dining at McGill"*

Principal Investigators: H. Kim, E. Marsh, Maidaziosmanovic, T. Cantor, K. Wright, C. Zastavniouk C. Secules

Department: School of Environment
Course: ENVR401
Supervisor: Raja Sengupta

Status: Undergraduate Students

Funding Agency and Title: n/a

This project was reviewed and approved by

Expedited Review ___ ✓ ___
Full Review _____

Elias Georges, Chair
REB, Faculty of Agricultural and Environmental Sciences

Approval Period: November 8, 2012 to November 7, 2013

This project was reviewed and approved in accordance with the requirements of the McGill University Policy on the Ethical Conduct of Research Involving Human Subjects and with the Tri-Council Policy Statement: Ethical Conduct For Research Involving Humans

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*All research involving human subjects requires review on an annual basis. A Request for Renewal form should be submitted at least one month before the above expiry date.
*If a project has been completed or terminated and ethics approval is no longer required, a Final Report form must be submitted.
*Should any modification or other unanticipated development occur before the next required review, the REB must be informed and any modification can't be initiated until approval is received.
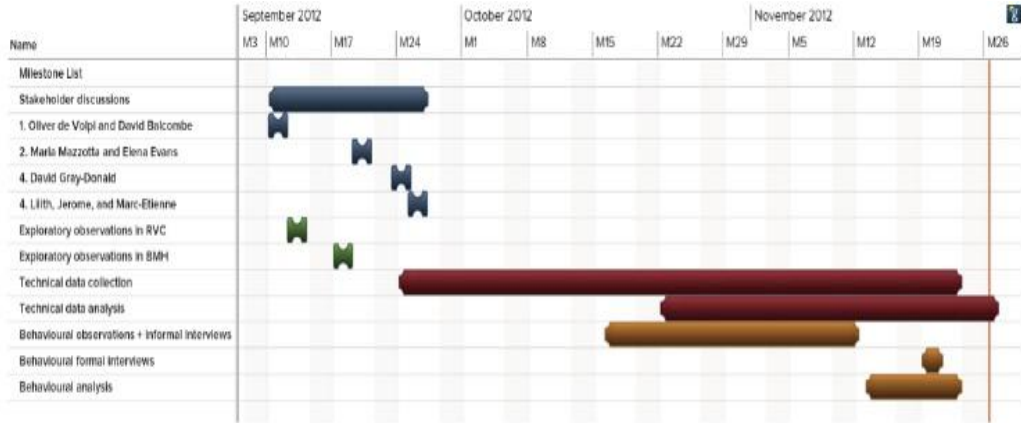
Figure 2: Ethics Approval

Figure 3: Gantt Chart