UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation into Induction versus Gas Stovetops:

A Triple Bottom Line Analysis

Adam Woods

Emily Beatty

Frans Kouwenhoven

Kjell Raemdonck

University of British Columbia

APSC 262

March 31, 2011

An Investigation into Induction versus Gas Stove Tops

A Triple Bottom Line Analysis

University of British Columbia
Pat Cramond
March 31st, 2011
APSC 262

Adam Woods
Emily Beatty
Frans Kouwenhoven
Kjell Raemdonck

ABSTRACT

The new Student Union Building being constructed at the University of British Columbia will have several new kitchens in order to cook for the growing population of students. A current decision of designers is whether to install traditional gas stove tops, or the newer, potentially more sustainable induction stove technology. This report compares the installation of these two different stove types according to the environmental, economic, and social pros and cons. Using data from the United States Department of Energy, several sources on both gas and induction stove tops, as well as local costs for natural gas and electricity, it was able to be determined that while induction stove tops are the more sustainable, healthy choice of stove top, they will cost more per annum to maintain in the new SUB and are potentially more difficult for cooks to use. Therefore, it is recommended that the designers of the new SUB proceed with installing both gas stoves and induction stoves in order to maintain a balance between the pros and cons.

Table of Contents

List of Illustrations

Glossary

Triple bottom line assessment: captures an expanded spectrum of values and criteria for measuring organizational (and societal) success: economic, ecological and social

Hob: refers to a cook top or hotplate, as distinguished from an oven.

List of Abbreviations

UBC – The University of British Columbia

SUB – Student Union Building

TBL – Triple bottom line

LEED - Leadership in Energy and Environmental Design

CO_2 – Carbon dioxide

CO – Carbon monoxide

WorkSafe – WorkSafe BC (Formally the Worker's Compensation Board of British Columbia)

EMF – Electro-magnetic Field

RF – Radio frequency

NO_2 – Nitrogen dioxide

1.0 Introduction

The University of British Columbia (UBC) is working towards becoming one of the most sustainable schools in Canada. Recently, it has been decided that a new Student Union Building (SUB) should be built in order to accommodate the University's growth in student population. It was determined that in order to improve UBC's image as a leader in sustainability, as well as for to address the growing environmental concerns the human population is facing, this building should be a Leadership in Energy and Environmental Design (LEED) Platinum certified building. In order to measure sustainability, a triple bottom line (TBL) assessment must be carried out for each aspect of a sustainable building. This is performed by an analysis of three categories: environmental, economic, and social. The focus of this report will be on the triple bottom line assessment of the choice in stove tops to be installed in the new SUB: Gas or induction.

Although stove tops do not have an immediately apparent impact on the environment, there are inherent impacts associated with the materials of construction and the sources of heating energy. For an induction stove, the source of energy is electricity, which in British Columbia is provided by hydropower. For the gas stoves, natural gas is used which has been known to lead to green house gas emissions. Natural gas itself also contributes to global warming when released into the atmosphere. The materials of construction for both stoves need to be recycled properly to prevent them from posing a threat to the environment.

Building a LEED platinum certified building typically comes at a higher monetary cost than a building which is not certified. The expenses in any large project are the predominant factors in determining what technologies are to be used. The price difference between gas and induction stoves depends largely on the quality of cook tops purchased. In general, though, induction stoves are much more expensive. However, the annual operating costs of induction stove tops are less than gas because they use electricity, which in British Columbia is cheaper than natural gas.

The third aspect of the triple bottom line assessment is the social aspect. This refers to the personal health and safety, as well as cooking preferences of the people working for the catering services in the new SUB. The biggest safety issue concerning stovetops is burns and scalds. This issue is avoided in induction stovetops because of the stovetops themselves do not heat up. Gas stoves have open flames being left on throughout the day, enabling burns to be a common injury in the kitchen. Personal preference and cooking style of each chef is important as well and may factor into the choice for the type of stoves to install. For example, if some chefs like lifting up the pans from the element, they may take some time to adjust to induction stovetops which may beep or turn off when the cooking vessel is removed from the cook top.

By researching the environmental, economic, and social aspects of the type of stove to be installed, an informed conclusion can be drawn about which is the best option for the kitchens in the new SUB at UBC.

2.0 Environmental Impacts

The potential environmental impacts of both gas and induction stoves are mainly caused by the materials of construction. However, the production impacts of the natural gas used in the gas stoves and the energy consumption of the overhead stove vents are also considered in this section.

2.1 Materials of Construction

A main environmental concern for both stove technologies is the materials used in the manufacturing of the stoves themselves, as well as the various cooking tools needed (which are very specific for an induction stove top).

2.1.1 Induction Stove Materials

An induction stove top is constructed with a copper coil used to produce the magnetic field required to heat the cooking vessels. The actual cooking surface where the pots are placed is composed of a ceramic glass material which does not conduct heat. Hence, the pots are heated directly by the magnetic field produced by the copper coils. The pots are generally made up of metals such as iron steels; essentially, they can be made of any material that is ferromagnetic (Wapedia , 2011). Materials such as aluminum and copper which are commonly used in professional cookware cannot be used (The Induction Site, 2010).

The materials mentioned above generally do not pose a direct threat to the environment during the manufacturing process; however, at the end of the stove's lifecycle they must be disposed of properly. The metals should be shipped to a metal smelting plant, where they can be melted and reused. The glass ceramic stove cover can be reduced down to its original state and be reused in glass ceramic tile production (e.g. for flooring). If these materials are disposed of in the proper ways, the environmental impact is minimal.

2.1.2 Gas Stove Materials

Gas stove materials generally consist of the surface grids and the gas dispensers around the cook top. These materials are much more challenging to recycle as there tends to be great discoloration on them due to the hot gas flames. Also, the cooking vessels used can be a much wider range of materials than those used for induction stoves – ranging from Teflon lined copper pots to aluminum pans. These would have to be disposed of properly if the switch from gas stove tops to induction were to be carried out. The Teflon lined pots and pans would have to be treated carefully, potentially having to go back to a cookware manufacturer who could reuse the materials in manufacturing.

2.2 Energy Consumption

Because natural gas is found in the ground mixed with various other fossil fuel compounds, it takes quite a bit of energy to refine it to its production purity. Of course, one could argue that the electricity needed to power the induction cookers also requires energy to be produced. However, as seen in Table 1 below, the efficiency of a gas stove (in converting input energy into cooking heat) is lower than that of an induction stove (which is referred to as 'Electric Smooth' in the table). Anytime more energy is needed, a greater global environmental impact is faced. Another note is that electricity in British Columbia is primarily generated by Hydropower, which is a technology that runs water through turbines which generate power. Hence it can be concluded that using an induction stove in the new SUB, which relies solely on electricity produced from water turbines, is the ‘greener’ technology.

Table 1: Energy Factors and Efficiencies for various Cook tops

Table 1.5 Baseline Cooktop Energy Factors and Cooking Efficiencies

	Energy Factor			Cooking
Product Class	Existing DOE	Proposed DOE	Recent	Efficiency
Electric Coil	73.7%	73.7%	73.7%	73.7%
Electric Smooth	74.2%	74.2%	74.2%	74.2%
Gas	21.4%	18.8%	15.6%	39.9%

(Lawrence Berkeley National Laboratory, 2001)

2.3 Natural Gas Effects

Natural gas is a fossil fuel and hence produces carbon dioxide (CO_2) when burned. CO_2 is the leading cause for anthropogenic global warming, which is an increasing environmental problem. Another issue with gas burning is that if it is not burned properly (not achieving full combustion which is shown by reaction R1), then Carbon Monoxide (CO) could be produced as well as CO_2; this mechanism is shown by reaction R2. CO is lethal for humans; hence, the release of such a gas in a confined space such as a kitchen could be lethal for its occupants. This is not an issue that would be encountered if induction stoves were used, as they rely solely on electricity.

$$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O \qquad \text{(R1)}$$

$$2\ CH_4 + 3\ O_2 \rightarrow 2\ CO + 4\ H_2O \qquad \text{(R2)}$$

Natural gas, on its own is detrimental for the environment if it is directly released because it has twenty five times more of an impact on global warming than CO_2 (Shindell et al, 2009). Direct releases could be caused by leaks in the pipes transporting the gas from the production plant into the SUB kitchens. Another cause of release could be if the fires in the stove do not light, allowing the natural gas to flow out into the kitchen area. These releases could be prevented if induction stove tops are used.

2.4 Stove Ventilation

A gas stove powered kitchen requires more ventilation than induction kitchens due to the gases emitted from the burning of natural gas, as well as the heat from the open flame. These ventilation units generally consume a lot of power. An induction stove requires much smaller ventilation units, as the need for such units is only when cooking smells, and limited heat needed to be removed from the cooking area.

3.0 Economics

The following section will detail the economic advantages and disadvantages the use of induction stove tops has over various other options being considered for use in the new SUB at the UBC. While the two main options for consideration are gas stove tops, currently being used in the existing SUB, and induction stove tops, a viable competitor to gas stove tops due to their fast response and control of the heat source, ease of cleaning, and ability to heat vessels which are not flat, there are other alternatives which may also be assessed as well – specifically halogen lamp elements and radiant elements. The precise areas which need to be looked at to assess the economics of various cook tops are as follows: How much does it cost to manufacture the stovetops? How much does it cost to obtain vessels, which will hold the food to be cooked for the various stovetops? Finally, how much does it cost, in either energy or natural gas, to use the stovetops? By answering these questions, one can make an educated decision on which cook top is appropriate for the budget the planners for the UBC's new SUB have in mind.

3.1 Cost of Manufacturing

The cost of manufacturing a particular stove top affects not only the initial purchase price of the stove tops, but also the cost of replacing the stove tops after they have become unusable. In order to complete an analysis of these costs, we need to know the number of stovetops, which are to be purchased, as well as the average lifetime of the stovetops. However, since the average life expectancy of induction, electric and gas stovetops are all 19 years (Lawrence Berkeley National Laboratory, 2001) we can simply state the cost as the cost per 19 years.

For induction stovetops, as with most other electric stovetops, the average price of manufacturing can vary a considerable amount. This is because various manufacturers have different selling power based on their reputations and quality of products. Table 3.0 shows the total manufacturing cost for a variety of different stovetops, including both gas and induction. It is quite apparent from this table that induction stovetops will cost more to acquire than gas stove tops. However, from this table, one cannot determine how much more because it only provides the cost of manufacturing the stovetops, not the cost at which the UBC could acquire the stovetops.

Electric Cooktop, Coil Element

Energy Efficiency Level	Design No.	Design Options	Mat. Cost	Labor Cost	Tool. Cost	Ship. Cost	Ind. Cost	Total Incr.	Total Cost	Uncert
1	0	Baseline: Coil Element	41.44	6.91	0.00	0.00	20.72	-	69.06	30%
2,3	1	0 + Imp Contact Conductance	2.28	0.00	0.00	0.00	0.00	2.28	71.34	35%
4,5	2	1 + Reflective Surfaces	0.00	2.60	0.10	0.00	0.34	3.03	74.37	55%

Electric Cooktop, Smooth Element

Energy Efficiency Level	Design No.	Design Options	Mat. Cost	Labor Cost	Tool. Cost	Ship. Cost	Ind. Cost	Total Incr.	Total Cost	Uncert
1,2,3,4	0	Baseline: Solid Disk Element	55.88	8.31	0.00	0.00	24.94	-	89.14	5%
	1	0 + Halogen Lamp Element	99.59	16.60	0.00	0.00	49.80	165.98	255.12	10%
5	2	0 + Induction Element	168.96	28.16	0.00	0.00	84.48	281.60	370.74	50%
	3	0 + Radiant Element	28.89	4.81	0.00	0.00	14.44	48.14	137.28	55%

Gas Cooktop

Energy Efficiency Level	Design No.	Design Options	Mat. Cost	Labor Cost	Tool. Cost	Ship. Cost	Ind. Cost	Total Incr.	Total Cost	Uncert
	0	Baseline: Conventional	53.45	8.91	0.00	0.00	26.73	-	89.09	10%
1,2	1	0 + Electronic Ignition	12.06	0.00	0.00	0.00	0.00	12.06	101.15	5%
3,4	2	1 + Sealed Burners	20.00	0.00	0.00	0.00	0.00	20.00	121.15	20%
	3	2 + Reflective Surfaces	4.20	0.00	0.45	0.00	1.49	6.14	127.29	55%
5	4	3 + Thermostatic Burner	16.80	0.00	0.05	0.00	0.08	16.93	144.22	20%

(US Department of Energy)

Not only will the University have to cover the manufacturing cost, there will be a mark-up so that the manufacturer can make a profit. While purchasing a large number of stovetops might allow the designers of the new SUB to garner a discounted price, it is unsafe to assume that this will be the case. Thus, Table 3.1 provides a list of known North American manufacturers of induction stove tops, as well as the prices of the stovetops which they currently offer. The information for this table was gathered from The Induction Site, 2010. It is important to note that the new SUB will most likely require models on the higher end of the quality (and thus, price) scale due to the sheer volume of students and staff being cooked for each day.

Table 3: Cost of various commercial-grade induction stove hobs listed alphabetically by manufacturer

Company	**Model Number**	**Price (USD)**	**Cost/kW (USD/kW)**	**Notes**
Athena	6000	74.99	42	
	6015	149.9	42	
	6200	82.9	46	
	6050	149.95	46	
	6500	219.99	122	
	6530	265	88	
Buffet	1BTBHOF18	323	179	
	1BTBHOF16	176	110	
Cadco	BIR-1C	429.95	307	
Commercial Pro	CIN-10	258.75	144	
Cooktek	MCD2500	964.95	386	
	MCD2502S	1779.95	356	2 side by side elements
	MWDG2500	1369.95	548	build-in wok
	MC2500	1009.95	404	
	MC2502S	1779.95	356	2 side by side elements
	MWG2500	1369.95	548	countertop wok
	MC2500G	1199.95	480	

	MC2502SG	2359.95	472	2 side by side elements
	MW2500G	1699.95	680	countertop wok
Dito	601610	1839.95	613	2 front and back elements
	601613	2899	1035	
Diva de Provence	10CT	1850	514	
	10DI	1850	514	
Garland	GIU 1.8	1420		
	GIU 3.5	2377		
	GIU 5.0	2980		
	GIWOK 3.5	3713		
	GIWOK 5.0	4546		
Iwatani	DI-1800	825	458	
	IWA1800	409	227	
	IWA2500	650	260	
Spring	SR-181C	465		
	SR-261	976		
	SR-181R	656		
	SR-261R	976		
	SR-1262B-1	975		
	SR-650M	632		
Vollrath	59500	499.98	278	
	6950020	559.95	311	
	69520	999.95	345	

(Source: The Induction Site, 2010)

The average cost of one of these stovetops can be calculated to be $1060 US. However, as mentioned before, UBC would most likely require stove hobs on the higher end of the price range for the new SUB. The average cost of the Cooktek, Dito, Diva de Provence, and Garland units is $1760 US per stovetop. Assuming the new SUB will require 40 stove tops in order to cover about 10 cooking ranges, this works out to an expected cost of $70 400 US. As aforementioned, this cost can be expected to be incurred every 19 years.

Comparatively, a top of the line, 6 burner, gas stove range can cost about $3449, or $575 per stove top (Universal Appliance and Kitchen Center, 2011). Again, consider that the new SUB will require approximately 40 stovetops. The cost of purchasing all new gas stoves would be $23 000 US. This cost would be incurred every 19 years, on average, in order to replace broken/unusable units.

The cost difference between purchasing 40 top of the line induction stove tops, and 40 top of the line gas stove tops works out to $47 400 ($70 400 - $23 000), a price difference of $1185 per stove top every 19 years. Annually, this works out to a difference of $2494.74.

3.2 Cost of Cooking Vessels

Unlike gas stovetops, which can heat any cooking vessel due to the fact that they apply heat directly to the surface of the vessel, induction stovetops require that the vessels be made out of ferromagnetic materials. Many commercial kitchens use either aluminum or copper pots and pans which will not work with induction stoves. Typical use of induction stoves will require either cast iron or clad stainless steel vessels.

Comparing costs of sets from the same manufacturer is the most reliable way to obtain a comprehension of the price difference. Mauviel, a French producer of cookware since 1830, produces both copper and stainless steel cooking sets (Mauviel, 2011). Their

5 piece M'heritage copper cookware set with stainless steel coating sells for $805.00 US ($161.00/piece). On the other hand, Mauviel's 5 piece M'cook stainless steel cookware set sells for $490.00 US ($98.00/piece). Calphalon, an alternative cookware supplier which sells both copper and stainless steel cooking sets, offers a 10-piece Tri-Ply copper cookware set for $449.95 US ($45.00/piece) (Calphalon, 2011). Meanwhile, they sell their 13-piece Tri-Play stainless steel set for $399.95 US ($30.77/piece).

Assuming that the new sub will need 80 pieces of cookware for the new kitchen, one can expect to pay between $2460 and $7840 for stainless steel cookware depending on the quality. However, if one wanted to stock with the best gas stove cookware, one could expect to pay between $3600 and $12880. It is important to note, though, that stainless steel cookware would work on either gas or induction stove tops. Since the designers of the new SUB would most likely wish to minimize costs where possible, the cost of cooking vessels would probably be the same, no matter the choice in heating methods.

3.3 Cost of Running

The cost of running a stovetop is the total amount of money spent on the energy required to utilize the stovetops. For induction stove stops, this is the amount spent on electricity. For gas stove tops, this is the amount spent on natural gas.

The amount that would be spent in a year for either stovetop can be calculated by looking at the average energy consumption of the stovetop, located in table 3.2, and multiplying it by the price per kWh. This will give us the average cost per year.

Table ES.2 Energy Consumption for Cooking Products[1]

Product Class	Baseline	1	2	3	4	5
	Energy Efficiency Level					
Cooktops						
Electric Coil (kWh/yr)	234.7	234.7	225.2	225.2	222.9	222.9
Electric Smooth (kWh/yr)	233.4	233.4	233.4	233.4	233.4	206.4
Gas (kBtu/yr)	3373	3373	3373	1323	1323	1256
Ovens						
Electric Standard (kWh/yr)	274.9	263.2	251.8	248.0	169.6	162.4
Electric Self-Cleaning (kWh/yr)	303.7	303.7	303.7	303.7	220.0	213.7
Gas Standard (kBtu/yr)[2]	2982	2982	2982	1524	1438	1359
Gas Self-Cleaning (kBtu/yr)[3]	1659	1659	1659	1659	1659	1358
Microwave Ovens (kWh/yr)	143.2	143.2	143.2	143.2	143.2	132.4

[1] Energy consumption values based on most recent annual useful cooking energy output values

[2] Values include electrical secondary cooking energy consumption; electrical energy consumption converted to kBtu with a factor of 3.412 kBtu/kWh

[3] Values include electrical secondary, clock, and self-cleaning cooking energy consumption; electrical energy consumption converted to kBtu with a factor of 3.412 kBtu/kWh

(Technical Support Document for Residential Cooking Products)

The figures in table 3.2 are for residential stoves, each with 4 hobs and assuming an average of about an hour of use a day. However, the difference in price between gas and induction stoves scales linearly so one need only scale by the difference in consumption between the presented figures and known data for the commercial product one wishes to install. By scaling these figures by a factor of 10, assuming that the stoves in the new SUB will be on for approximately 10 hours a day, we can arrive at a closer estimate to the actual running cost of these new stoves.

The price of electricity in British Columbia was calculated from BC Hydro's website (BC Hydro, 2011). Since we were unsure of the actual electric output that would be required, we simply took an average of $0.06 / KW. The price of natural gas in British Columbia was calculated from Fortis' website (Fortis BC, 2011). Again, since we were unsure of the actual gas output that would be required, we simply assumed that it would be more than 2000 GJ annually and selected Rate 3 which gives a total cost of

\$7.856 / GJ or \$0.0082885 / kBtu. Using table 3.2 as well as table 3.0 to determine the energy efficiency levels of induction stoves and the standard gas stoves, the average costs per year were calculated as follows:

*Cost of Induction Stove (Efficiency level 5) = 206.4 kWh/yr * \$0.06/kW = \$12.384 per range.*

*Cost of Gas Stove (Efficiency level 1) = 3373 Btu/yr * \$0.0082885 = \$27.957 per range.*

Assuming the same number of ranges that was assumed above (10), we can calculate a very rough approximation to the running cost of new stoves which the new SUB will incur on an annual basis:

*Total running cost of induction stoves (10 ranges) = \$12.384 * 10 = \$123.84*

*Total running cost of gas stoves (10 ranges) = \$27.957 * 10 = \$279.57*

Thus, by utilizing induction stoves over gas stoves, the new SUB will save an average of \$155.73 annually. When scaled by the factor of 10 mentioned above (due to the number of hours of use of a commercial stove compared to residential), we reach a total of \$1557.30 annually in savings.

3.4 Conclusion on the Economics of Induction Stoves

The annual costs incurred by installing induction stove tops in the new SUB versus the annual costs incurred by installing gas stove tops is the sum of the difference in purchasing costs, maintenance costs and running costs. Due to the current prices of quality induction hobs, induction stovetops will cost approximately \$937.44 more annually than gas-stove tops. However, this is largely due to the preference to have top of the line induction hobs. If the new SUB were to install lower quality induction hobs, it is quite reasonable to think that the annual prices would be very similar between induction and gas.

4.0 Social

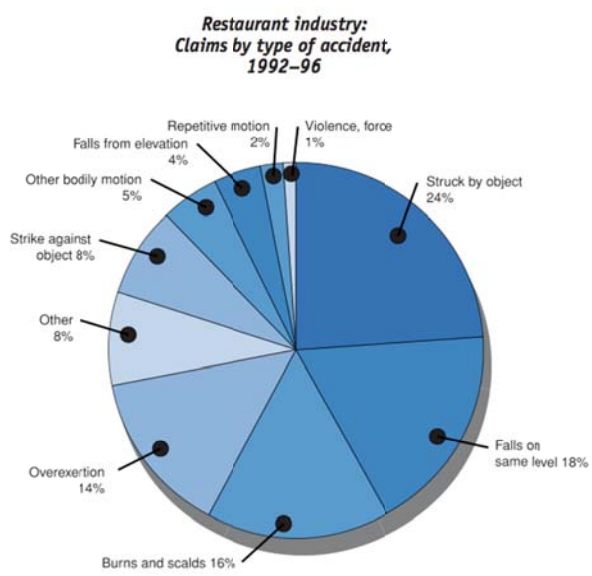
When considering the potential social benefits and drawbacks of the implementation of induction stovetops versus standard gas burner stoves in the new SUB, several aspects have to be examined and deliberated. The most paramount of these aspects is the health and safety of the catering staff that will be operating these products on a daily basis. As well, other social impacts of the implementation of these two technologies will also be attributed to the personal preference and comfort of the staff.

4.1 Health and Safety

As stated above, when considering the advantages and disadvantages of the use of induction stovetops rather than gas stovetops, health and safety is of paramount importance. Outlined below are some of the potential health and safety concerns with the use of both induction and gas stoves. This includes: Fire and heat, radiation, and others.

4.1.1 Fire and Heat Risk

According to the WorkSafe BC (WorkSafe), "About 8,900 workers in the hotel and restaurant industries are injured on the job every year in British Columbia". Out of these injuries, "sixteen percent of all accidents in restaurants from 1992 to 1996 were burns and scalds"



Source: WorkSafe BC, 1998, p.27

(WorkSafe, 1998, p.7). This is the third largest cause of injury within this industry. These are injuries that can be directly related to the operation of commercial kitchen equipment, such as induction and gas stovetops, as well as other equipment such as ovens. In fact, twenty percent of burns and scalds are caused by direct contact with such heating and cooking equipment, while an additional 70 percent is caused by secondary contact with hot fat, grease, oil, and other food products (Worksafe, 1998, p.27).

From the statistics obtained from WorkSafe, we can conclude that the use of stoves contributes to a large percentage of injuries in the restaurant and hotel industry. One of the potential advantages of induction stovetops is the absence of an open flame in contrast to that of a gas stovetop. The open flame burners of gas stoves can easily catch employees' sleeves and other garments on fire if exposed for any amount of time. In addition, the grates above burners can remain dangerously hot for an extended period of time after the burner is turned off. In comparison, the use of induction stoves requires no open flames and the elements cool almost instantly after being shut off. The risk of burns and scalds then could potentially be mitigated in the design of the new SUB by the implementation of induction stovetops.

However, as indicated before, a large proportion of burns and scalds are attributed to contact with hot fat, grease, oil and other food products during the cooking process. This cause of injury would not be directly reduced by the use of induction stoves, as the risk of working with hot food and oil would be considered identical between induction and gas stoves.

4.1.2 Radiation Risk

“Induction cooking units work by generating a field of electromagnetic energy. Concerns have been expressed about whether such fields (from induction cookers, microwave ovens, cell phones, or any of a variety of other sources)…might be a potential health hazard” (The Induction Site, 2010). Most notable of these risks is the potential complications with implanted cardiac devices (“pacemakers”). In an article discussing this risk, authors Werner Irnich and Alan D. Bernstein conclude that, “Patients are at risk if the implant is unipolar and left-sided, if they stand as close as possible to the induction cook top, and if the pot is not concentric with the induction coil” (1998). Therefore, in order to reduce risk to current and future SUB employees, employees should be required to state whether they have an implanted cardiac device if induction stove technology is to be put into operation in the new SUB.

Another concern for the employees health is the excessive exposure to the electromagnetic field produced by the induction stovetop. However, in accordance with the European Commission Directorate-General of Health and Consumer Protection’s article on the possible effects of electromagnetic fields (EMF), radio frequency fields (RF) and microwave radiation on human health, occasional exposure to EMF’s comparable to that of induction stovetops are not a conclusive health risk (1998). As well, due to the fact that induction elements are only turned on during the cooking process, “you're not going to *get* any nontrivial radiation from an induction cooker unless you spend an awful long time well within one foot of a running element” (The Induction Site, 2010).

4.1.3 Nitrogen Dioxide Risk

As with the risk attributed with the induction stovetop from electromagnetic radiation, gas stovetops do have a potential hazard caused by by-products of the combustion reaction. One of these by-products is nitrogen dioxide (NO_2). “Indoor sources of nitrogen dioxide include gas stoves, gas heaters, and smoking. Due to the fact that these sources are not always well ventilated during use, any nitrogen dioxide generated is trapped indoors, causing higher levels than outdoors” (Garrett et al., 1998). In the same article it is stated that, “Gas stove exposure was a significant risk factor for respiratory symptoms” and that there is a “significant adverse effect of gas stove exposure on respiratory health in children” (Garrett et al., 1998). This is especially true with children with asthma as the asthma makes them more susceptible to the effects of gas-stove exposure because of underlying airway hyper responsiveness. It even goes so far as to suggest “alternative methods of cooking should be used by families with young children, particularly children with asthma. Appropriate ventilation of all indoor combustion appliances, including gas stoves, is strongly recommended”.

On the other hand, in a separate paper, it is concluded that “Among adults with asthma, there was no apparent impact of gas stove use on pulmonary function or respiratory symptoms” (Eisner, 2003). In addition, these negative effects of respiratory irritants, such as nitrogen oxide, can be easily lessened by the use of proper ventilation in the kitchens of the new SUB.

4.2 Personal Preference

In addition to the health and safety of the staff that will be operating these cook tops in the new SUB, it is also important that we respect their personal preference with the different cooking methods, as well as their comfort level. Due to difference in cooking methods, there are differing restrictions on how staff can use both these technologies. Outlined below are some of these restrictions, as well as some of their advantages and opinions from different chefs.

4.2.1 Control and Responsiveness

"Before induction, good cooks, including *all* professionals, overwhelmingly preferred gas to all other forms of electric cooking for one reason: the substantial "inertia" in ordinary electric cookers. When you adjust the heat setting, the element (coil, halogen heater, etc…) only slowly starts to increase or decrease its temperature. With gas, when you adjust the element setting, the energy flow adjusts instantly" (The Induction Site, 2010)**.** The same can be said about induction stovetops, as you can quickly and easily adjust the cooking temperature to the desired level. It can even be argued that induction stovetops are even quicker at responding to temperature change as the grates on gas stoves heat and cool at a slower rate than induction hobs do (ChefTalk, 2007).

4.2.2 Heat and Noise

When considering the overall comfort of staff working in a commercial kitchen comparable to the one that will be located at the new SUB, some of the primary factors to consider are the heat and noise levels. When operating an induction stovetop, in comparison to a gas stovetop, there is much less heat energy released to the surrounding area of the kitchen. “Of course the cooking vessel and the food itself will radiate some of their heat into the cooking area, but compared to gas or other forms of electrically powered cooking, induction makes for a *much* cooler kitchen” (The Induction Site, 2010). In addition, it is standard practice in a commercial kitchen to keep the gas burners running throughout the day, constantly heating the air in the kitchen. However, with an induction stove the elements are only activated after a pot or pan is placed on the heating element.

Induction itself is a nearly noiseless process; the electromagnetic fields are generated by electronic equipment, which is virtually silent (The Induction Site, 2010). As well, the same can be said for gas stoves, which do not produce much noise directly. In spite of this, as acknowledged above, gas stoves in commercial kitchens are typically left on throughout the day producing a large amount of heat, which then must be ventilated. A hood-fan overtop the gas range is the conventional form of ventilation in commercial kitchens. Some hood fans can be considerably loud and cause discomfort, even making communication amongst staff more difficult. In the use of induction stoves, hood-fans would not be required to be operating throughout the day, but only when a cooking element is activated.

4.2.3 Cleanliness

In general, “induction cook tops are much, much easier to clean than gas cook tops, as they are flat, seam free, and remain cool” (ChowHound, 2008).

Additionally, according to one chef on a cooking blog, “pots and pans are easier to clean when using induction stovetops as the sides and top edge will be exposed to comparably less heat” (ChowHound, 2008). Dissimilarly, with the use of gas cook tops, the combustion reaction creates “byproducts that are vaporized, but eventually condense on a surface somewhere in the vicinity of the cook top. Electrical cooking of any kind (such as induction) eliminates such byproducts” (The Induction Site, 2010). As a result of the reasons listed above, it can be concluded that if cleanliness is a priority for the new SUB design team, and a preference of the staff, induction stoves should be recommended.

4.2.4 Familiarity

For years the standard for chefs in commercial kitchens has been the gas range. Induction stovetops are a relatively new technology, especially in the context of commercial kitchens and some restrictions come with their use. One example of these differences is that you “pick up your pan while cooking, a lot of induction burners will either beep at you, or they will shut off after a few seconds without a pan”(ChowHound, 2008). Another restriction is that of the use of cooking vessels of extreme sizes (very small or large), as the induction element can only operate with vessels of a particular size (The Induction Site, 2010). Hence, due to the numerous points stated above, it can be concluded that gas stoves have the benefit of versatility.

5.0 Conclusion and Recommendations

In the new Student Union Building, planned to be built by the University of British Columbia, there is debate about which type of industrial stove top should be used in the kitchens: Gas or induction. Throughout this report we have discussed the triple bottom line of environmental, economic, and social concerns, enabling us to outline the pros and cons of each stove top.

5.1 Environmental

Through researching the environmental impact of using stove tops, we were able to show that induction stoves are more energy efficient and use produce harmful substances. The disposal of the gas stoves in existing SUB when they reach the end of their life time is one of the biggest concerns to the environment. Recycling gas stoves has been shown to be harder than recycling induction stoves due to the discolouration and the wider range of cooking materials. In the future, when disposing of the stoves, if the SUB invests in new induction stove tops, the recycling of materials will be much easier.

The less energy the stove tops require, the less the process of making that energy will be required. Therefore, using more efficient stove tops is a more sustainable option. Induction stoves have a 73.3% efficiency rate and use electricity as their source of power. In British Columbia, electricity is made by hydroelectric dams - a very green source of energy. On the other hand, gas stoves use natural gas and are also not very efficient (only 39.9% efficiency rate). Thus, induction stoves require less energy and are better for the environment in this regard.

Finally, natural gas has 25 times more of an impact on global warming than CO_2. If improperly combusted, this could pose serious environmental and health concerns.

5.2 Economic

In determining which stovetops should be installed in the new SUB, the decision of which type to invest in, gas or induction, may come down to the price difference. Induction stove tops are a relatively new technology and are more expensive to purchase because of the lack of companies producing them. Gas stoves, though, have been the number one preference in commercial cooking for a long time and are easily found for competitive prices. Also, they are able to accommodate any type of cookware a chef wishes to use. Induction stoves are compatible only with certain types of cooking material. Depending on the type of material requested for the cookware for each given stove, either stove top may be more expensive than the other.

The running costs of each type of stovetop are different because of the type of energy each use. Gas stoves use natural gas, which is more expensive than electricity. This would make the annual cost of running gas stoves greater than induction stoves. Also, in a commercial kitchen, it is common to see the gas stoves turned on in the morning and left on all day; whereas, some induction stoves have an indicator to turn off the element if it is not being used. This would save energy throughout the day. For these reasons, gas stoves cost more than twice the amount of money to run than induction stove tops.

In the end, because induction stovetops are still a new technology and cost more to purchase, gas stovetops will still be less expensive in the long run.

5.3 Social

Health and safety of the working environment is a very large concern when deciding which stove tops to use. About 16 percent of injuries are from burns or scalds in kitchen workplaces, making it the third largest cause of injury in the cooking industry. Gas has an open flame and can be directly related to burns and scalds reported, whereas induction stove top elements are not heated. By using induction stove tops, there could be a decrease of accidents due to burns in the workplace.

Induction stove tops have been said to be unsafe due to the fact that the electromagnetic field emitted could disrupt implanted cardiac devices. Chefs with implanted cardiac devices should not work around induction stoves in the new SUB in order to ensure safety. On the other hand, Gas stoves can emit dangerous gasses into the working environment if the ventilation is not adequate enough. These gasses can cause respiratory irritants, as well as potential fatalities in the case of improper burning or inadequate ventilation.

Personal preference of the chefs revolves around topics such as heat, noise, cleanliness, and familiarity. With induction stove tops, the only heat emitted is from the food. Also, they are virtually silent and the flat surfaces make them very easy to clean. However, in some cases the cooking vessel must stay on the element to work or the element may turn off or beep. With gas stove tops, a lot of heat is emitted from the open flame. The ventilation required overtop of the stoves can also be very noisy. Also, it is much more difficult to clean a gas stove cook top than an induction stove top. However, gas stoves may enable cooks to have more variety in how they cook, by for example, tossing food by picking up the pan.

5.4 Closing Remarks

It has been shown that both gas and induction stove tops have pros and cons making them a better or worse choice for the LEED Platinum certified new SUB. It can be concluded that induction stoves are a more sustainable, environmentally friendly choice. However, they are more expensive than gas stoves. Induction stoves are also safer than gas stoves; although, this safety comes at the cost of familiarity for the SUB chefs. When taking all these factors into consideration, it is quite clear that induction stoves are a better choice for the new SUB to become as environmentally friendly as possible. However, we propose that a combination of induction and gas stoves be installed in order to both reduce costs and ensure that the chefs in the new SUB are able to prepare food in a way that is natural for them.

Bibliography

BC Hydro - Business Rates (2011). *BC Hydro - For Generations*. Retrieved from https://www.bchydro.com/youraccount/content/business_rates.jsp

Calphalon - Calphalon Official Website (2011), *Cookware, Bakeware, Electrics, Cooking Tools, and More*. Retrieved from http://www.calphalon.com/pages/home.aspx

Cheftalk (2007). *Induction cookers vs. Gas*. Message posted to http://www.cheftalk.com/forum/thread/29609/induction-cookers-vs-gas

Chowhound (2008). *Induction vs. Gas Stove* [moved from home cooking]. Message posted to http://chowhound.chow.com/topics/532644

Eisner, M.D. Blanc, P.D. (2003) Gas stove use and respiratory health among adults with asthma in NHANES III. *Occupational and Environmental Medicine,* 60(10), 759-764.

Fortis BC (2011). *Lower Mainland - Rate 3.* Retrieved from http://www.fortisbc.com/NaturalGas/Business/Rates/LowerMainland/Pages/LMRate3.aspx

Garrett M.H., Hooper M.A., Hooper B.M. and Abramson, M.J. (1998). Respiratory Symptoms in Children and Indoor Exposure to Nitrogen Dioxide and Gas Stoves. *American Journal of Respiratory and Critical Care Medecine*, 158(3), 891-895

The Induction Stove Site (2011). *What is Induction Cooking?* Retrieved from http://www.inductionstove.org/what-is.html

Lawrence Berkeley National Laboratory (2001). *Technical Support Document for Residential Cooking Products, Volume 2: Potential Impact of Alternative*

Efficiency Levels for Residential Cooking Products (EE-RM-S-97-700). Berkeley, CA: US Department of Energy, Office of Codes and Standards.

Mauviel (2011).: *Professional Copper and Stainless-steel Cookware from France*. Retrieved from http://www.mauvielusa.com

My New Sub, UBC AMS New Sub Project (2011). *100% Schematic Design Report.* Retrieved from http://mynewsub.com/files/100_percent_schematic_design_report.pdf

The Owlcroft Company (2010). *Induction Cooking: Pros and Cons.* Retrieved from http://theinductionsite.com/proandcon.shtml

Shindell, D. T.; Faluvegi, G.; Koch, D. M.; Schmidt, G. A.; Unger, N.; Bauer, S. E. (2009). *Improved Attribution of Climate Forcing to Emissions*. Science 326 (5953): 716.

Universal Appliance and Kitchen Center: Repair and Sales in Los Angeles (2011). *VGRT4826QWH Viking 48 Gas White Range Cook top , 6 Burners with Char-Grill.* Retrieved from http://www.universal akb.com/vgrt4826qwh.html?productid=vgrt4826qwh&channelid=NEXTA

Wapedia (2011). Induction Cooker. Retrieved from http://wapedia.mobi/en/Induction_cooker

WorkSafe BC (1998), *Preventing injuries to hotel and restaurant workers, focus report*. Retrieved from www.worksafebc.com/publications/reports/focus_reports/assets/pdf/focushotel.pdf