UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation into Induction Stovetops versus Gas Stovetops

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Abstract

Although gas stovetop has been the dominant cooking appliance in the past few decades, they can no longer satisfy the current society's sustainability standards. Induction stovetop on the other hand is a great sustainable alternative. The focus of this report is a detailed triple-bottom line assessment between gas and induction stovetops that the new Student Union Building at the University of British Columbia will be choosing. To demonstrate validity, information presented in this report is based on library research and expert interviews.

The triple-bottom line assessment between the gas and induction stovetops features a combination of environmental, economical, and social analysis. Induction stovetop is environmentally sustainable as it produces no greenhouse gas emission, consumes less energy and eliminates ecological footprint. Economically, the induction stovetop costs 10% less than its gas counterpart. Finally, induction stovetop is socially sustainable since it has negligible side effects, and does not put its users in danger of gas leakage and heat exposure.

The advantages of the induction stovetop allow the new UBC Student Union Building to function as a more sustainable unit. As a result, the new SUB can better serve students and teachers providing a more enjoyable experience during their time at UBC.

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Introduction

The purpose of this report is to provide an in-depth analysis on the usage of induction stovetops versus gas stovetops in the New SUB which is scheduled to be completed in September 2014. The new SUB aims to become an icon of sustainable design and be certified as a LEED Platinum building. To achieve this ambitious goal, the new SUB must reduce resource usage such as energy and water consumption in a variety of ways.

The food and beverage department in the new SUB will undoubtedly be one of the biggest users of energy and water. Therefore a great way to reduce overall energy consumption of the new SUB would involve reducing the energy consumption of the food and beverage department. A main source of energy consumption is cooking. In order to constantly serve a large student population, stovetops remain turned on for the entire hours of operation of the new SUB. Reducing the energy consumption of stovetops will significantly reduce the overall energy consumption of the new SUB.

This report will provide perform a triple-bottom-line assessment on the usage of induction stovetops versus gas stovetops comparing and discussing the advantages and disadvantages of each technology. A triple-bottom-line assessment evaluates the economical, social and environmental impacts of the product in question. A comparison done using a triple-bottom-line assessment can more accurately predict the overall cost of a product and help stakeholders determine the best product for the job.

1 What is an Induction Stovetop

The induction technology itself is not a new one. It was first discovered by Michael Faraday in 1831. However, it was not until the 1970s when European companies started developing induction cooking systems in an attempt to create cleaner and more energy efficient cooking systems (TCL, 2011). The technology behind an induction stovetop is quite simple. An induction cooking element is a powerful magnet which generates an electromagnetic field when current flows through. This electromagnetic field penetrates the magnetic material above the cooking element generating a loop current within the material. Heat is then generated by the resistances present throughout the entire magnetic material after encountering the loop current (Induction Cooking : How it works, 2010). Here, the magnetic material is typically the pan or pot that is being used to cook. It is important to note that during induction cooking, the heat is generated directly by the pan or pot itself rather than the cooking element.

Figure 1 – Induction Stovetop

<http://purecontemporary.blogs.com/photos/uncategorized/melting_chocolate.jpg>

2 What is a Gas Stovetop

The first gas stoves were invented in the 1820s, but were restricted to be used in experiments. It was not until the 1880s when the gas stovetops achieved commercial success. The technology behind the gas stovetop is also very simple. Gas stovetops are connected to natural gas lines that supply the natural gas. When the switch is turned on, this natural gas is released to combine and mix with the air. This mixture is then ignited with a spark from the stovetop (Bellis, 1997). Cooks generally favour gas stovetops because they are able to control the temperature by simple looking at the strength of the flames.

Figure 2 – Gas Stovetop

< http://fivebeegas.com/images/natural_gas_stove.jpg>

3 Gas Stovetop – An environmental assessment

To provide a complete environmental assessment for gas stovetops, several important topics will be discussed and analyzed thoroughly below. These topics include ecological footprint, energy consumption, and emission.

3.1 Ecological footprint

Natural gas production often occurs in remote and pristine areas. The development of these areas will have large impact on the area's wildlife and environment. For example, geologists that explore the area for natural gas will disturb vegetation. If an area is deemed suitable for natural gas production, it will often require clearing and leveling of the area. This can potentially remove any forests present in the area and ruin wildlife habitat. This can in some cases cause wildlife species to become extinct. In addition, production of natural gas will produce large quantities of contaminated water and if improperly handled will cause further damage to sea life and animals including human living near large bodies of water (U.S. Energy Information Administration).

3.2 Energy Consumption

Gas stovetops transfer only about 40% of the input energy to the pan. This means 60% of the input energy is lost as heat to the surroundings (Schultheiss, 2008).

3.3 Emission

Natural gas contains mainly methane which is a very potent greenhouse gas (GHG). This is often released into the atmosphere during the transportation, processing and storage of natural gas. In the United States, this accounts for 3% of the total GHG emissions. When natural gas is burned, it releases GHGs such as CO_2, CO, NO and NO_2. Although these gases are not as potent as methane, they still contribute to the overall GHG emissions around the world due to the large quantities produced. For example, 117 pounds of carbon dioxide are produced per million Btu equivalent of natural gas (U.S. Energy Information Administration).

3.4 Other Considerations

Natural gas is a depleting natural resource. As of 2007 natural gas contributes to 23% of the world's primary source of energy production. In North America, Natural gas production is in a rapid decline. Currently, the United States needs to import about 17% of its natural gas from countries like Canada and Trinidad (Korpela, 2007). Depleting this valuable resource can potentially halt or severely impede technological advancements and progress. Therefore, every attempt should be made to reduce the usage of non renewable resources such as natural gas.

4 Induction Stovetop – An environmental assessment

To provide a complete environmental assessment for induction stovetops, several important topics will be discussed and analyzed thoroughly below. These topics include ecological footprint, energy consumption, and emission.

4.1 Ecological Footprint

Induction stovetops use electricity as its source of energy. The electricity used in British Columbia, Canada is generated and served by BC Hydro which uses water to generate electricity. The process of generating and delivering electricity does not leave noticeable traces of ecological footprint (BC Hydro, 2006). However, developing and building new dam and sites for hydroelectricity generation will most certainly have an effect on the forest and wildlife in that area. For example, building dams would require forest removal which will disturb the wildlife habitat in that area.

4.2 Energy Consumption

Induction stovetops transfer about 90% of the input energy to the pan. This means only 10% of the input energy is lost as heat to the surroundings (Schultheiss, 2008). This high efficiency is achieved due to the basic technology behind induction stovetops where the heat is generated by the pan and not the heating element itself.

4.3 Emission

Since induction stovetops uses electricity as its source of energy, there is no combustion and therefore no emission. Any possible sources of emission would come from the generation of electricity. In British Columbia, there are no coal-burning power generation plants (Coal-Fired Plants in Canada, 2011). Most of the electricity is through hydro generation, where the only source of emission would occur from the operation of such plants.

4.4 Other Considerations

Induction stovetops mainly make use of electricity. Electricity itself is a renewable resource and is therefore more favorable to use as opposed to other non renewable resources. Also, British Columbia possess an abundant and varied supply of clean and affordable electricity therefore implying that using electricity as the source for energy in British Columbia is the smartest and cheapest choice (Government of British Columbia).

In summary, induction stovetops causes less ecological footprint, consumes less energy and have negligible emission. It is the better choice in an environmental point of view when compared against gas stovetops.

5 Gas Stovetop – An Economical Assessment on its Energy Consumption

In order to calculate the energy consumption and energy cost of using gas stovetops, various assumptions are made: 1) there will be 30 stovetops operating daily in the new Student Union Building; and 2) the new Student Union Building's cafeteria will operate on average 11 hours per business day (Monday to Friday) and 8 hours per weekend (Saturday to Sunday).

Typical commercially used gas stovetop has 5 individual burners and together their rated energy consumption is 35,000 BTU. Also, as the major natural gas supplier in BC, FortisBC Energy Inc. (Formally known as Terasen Gas) charges UBC under *Rate Schedule 7* at an $880 basic monthly charge (FortisBC Energy, 2011). In addition, $6.405 is charged per Gigajoule of energy delivered. With these figures in mind, the approximate energy costs each month are calculated below.

Assuming operating hour per month for 30 stovetops is:

$$
\begin{aligned}
&Total\ Hours\ of\ Operation \\
&\qquad = (22\ Days \times 11\ Hours + 8\ Days \times 8\ Hours) \times 30\ Stovetops \\
&\qquad = 9180\ Hours\ per\ Month
\end{aligned}
$$

And the average energy consumption per hour is:

$$
\begin{aligned}
&Average\ Energy\ Consumption \\
&\qquad = 35000\ BTU\ per\ 5\ Stovetop\ Unit \\
&\qquad = 0.0369\ GJ\ per\ 5\ Stovetop\ Unit \\
&\qquad = 0.00739\ GJ\ per\ Stovetop\ Unit \\
&\qquad = 67.8402\ GJ\ per\ 30\ Stovetop\ Unit
\end{aligned}
$$

Therefore, the average energy cost per 30 Stovetops per month is:

$$\begin{aligned} &\textit{Average Cost per Month} \\ &\qquad = 67.8402GJ \times (\$1.073 + \$5.332) + \$800 \\ &\qquad = \$1234.25\ \textit{per Month} \end{aligned}$$

From the above calculations, the cost of energy each month is approximately $1234.25. In the long run, 30 gas stovetops will cost approximately $20K in a year, $80K in 5 years and as much as $220K in 15 years.

6 Induction Stovetop – An Economical Assessment on its Energy Consumption

In most cases, in the lifetime of a stovetop, an induction stovetop is approximately 10% more efficient than its gas counterpart (Sains, 2002). Although induction stovetops do require an almost 50% more principal than a gas stovetop, in the long run, it is still a better choice. In the following section, a more detailed economical assessment of using the induction stovetop is presented.

In order to calculate the cost of using induction stovetops, various assumptions are made: 1) there will be 30 stovetops operating daily in the new Student Union Building; and 2) the new Student Union Building's cafeteria will operate on average 11 hours per business day (Monday to Friday) and 8 hours per weekend (Saturday to Sunday).

As mentioned above, a commercial 5-buner induction stovetop unit typically costs approximately $1800. The power consumption for each unit is typically 1800 Watts, which is approximately 3.5 KW-Hour. As the major supplier of electricity in British Columbia, BC Hydro charges the new SUB under *Rate Schedule 1823* (BC Hydro, 2008) for commercial users at $0.3271/KW-Hr. With these figures in mind, we calculate the approximate monthly cost of using 30 induction stovetops at the new Student Union Building cafeteria.

Assuming operating hour per month for 30 stovetops is:

$$\begin{aligned} &\mathit{Total\ Hours\ of\ Operation} \\ &\qquad = (22\ \mathit{Days} \times 11\ \mathit{Hours} + 8\ \mathit{Days} \times 8\ \mathit{Hours}) \times 30\ \mathit{Stovetops} \\ &\qquad = 9180\ \mathit{Hours\ per\ Month} \end{aligned}$$

And the average energy consumption per stovetop per hour is:

$$\begin{aligned}&Average\ Energy\ Consumption\\&\qquad = 1800\ Watts\ per\ 5\ Stovetop\ Unit = 0.36\ KW \cdot Hour\end{aligned}$$

Therefore, the average energy cost per 30 Stovetops per month is:

$$\begin{aligned}&Average\ Cost\ per\ Month\\&\qquad = 9180 \times 0.36 \times \$0.3271\\&\qquad = \$1081\ per\ Month\end{aligned}$$

From the above calculations, the cost of energy each month is approximately $1081. This is $153.25 less than that of the gas stovetop. Although each induction stovetop costs over $1800, in the long run, the savings on energy puts the induction stovetop at a much better choice. I.e. see figure 3 below.

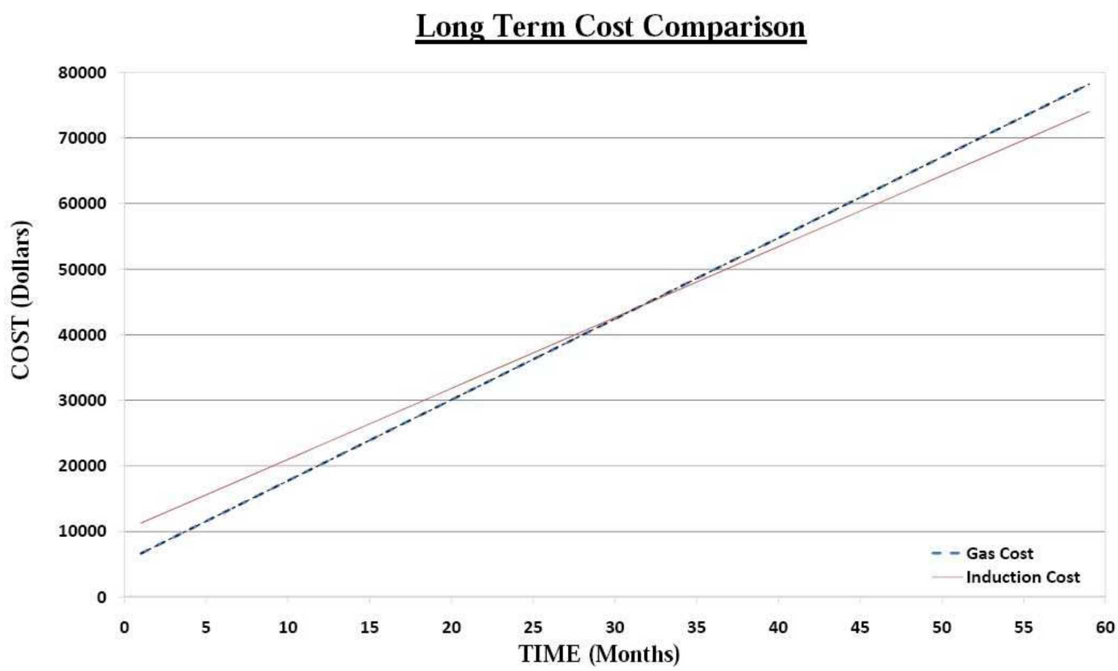

Figure 3 - Long Term Cost Comparison between Gas and Induction Stovetops

Looking at the long term cost, it takes only 3 years for the total cost of using induction stovetop to be cheaper than using gas stovetop in the new SUB. In fact, looking at table 1 below, since each stovetop can last 10 to 15 years, UBC could save $22740 per stovetop in 15 years, and as much as $600K in total from energy alone.

	Energy Cost	
Time (Years)	**Gas Cost ($ CND)**	**Electricity Cost ($ CND)**
1	20208	23172
2	35016	36144
3	**49824**	**49116**
5	79440	75060
8	123864	113976
12	183096	165864
15	227520	204780

Table 1 - Cost between Gas and Induction Stovetops over 15 Years

7 Gas Stovetop – A Social Assessment

One of the most important factors to consider when assessing the social impact of gas stovetops is the health concerns that affect the stakeholders. In order to fully address these concerns, the side effects of gas stovetops are analyzed and then compared against induction stovetops, conclusions are then drawn based on these results and recommendations are given.

7.1 Side effects of Gas Stovetops

The gas stovetops operate using the transfer of thermo energy, this method of operation results in the fact that heat are dissipated into its surroundings as conductors cannot be made to be 100% efficient. Three distinct parameters are used when assessing the effects of heat on the working environment: ambient dry-bulb temperature, WBGT (wet-bulb globe temperature), and radiant heat Index.

i. Ambient Dry-Bulb Temperature is defined as the temperature of air measured by a thermometer freely exposed to the air but shielded from radiation and moisture (Nall, 2004).

ii. Wet-bulb globe temperature is a composite temperature used to estimate the effect of temperature, humidity, and solar radiation on humans (Nall, 2004).

iii. Radiant Heat Index is an index that combines air temperature and relative humidity in an attempt to determine the human-perceived equivalent temperature.

In an experiment conducted by Hiroe Matsuzuki, Makoto Ayabe, Yasuo Haruyama, Akihiko Seo, Shizuo Katamoto, Akiyoshi Ito and Takashi Muto (2006), 12 healthy men are asked to perform mock cooking, once in front of gas stovetops, and once in front of induction stovetops. Physiological responses, body weight, oxygen uptake, heart rate, blood pressure, and body temperature were measured, before and after the experiments. In this experiment, it was found that ambient dry-bulb temperature, wet bulb globe temperature, and radiant heat index increased significantly in front of gas stovetop, but slightly increased in front of induction stovetop (Matsuzuki, et al., 2006). Further research have also shown long-term exposure to natural gas will have significant severe effect on the respiratory health; respiratory symptoms such as asthma are likely to develop (Rea, 1994).

8 Induction Stovetop – A Social Assessment

8.1 Side Effects of Induction Stovetops

In order for an induction stove to be effective, two contradicting requirements must be met: the magnetic field must be strong enough to achieve good performance, while the leakage field must be kept below the safety limit (Scorretti, Siauve, & Burais, 2007). This is often hard to achieve as leakage field is proportional to the magnetic field generated, as a result, a good balance must be found for an ideal induction stove. It is then not surprising that the leakage fields are evaluated and its effects analyzed for the purpose of health safety.

8.1.1 Cellular Genotoxicity

In order to fully comprehend the side effects of induction stovetops, the effects of electromagnetic radiation on human tissues are to be analyzed. Genotoxocity refers to deleterious actions on a cell's genetic material that affect the cell's integrity (Smith, 1996). It is a common effect associated with radiations. In an experiment conducted by Junji Miyakoshi, Emi Horiuchi, Takehisa Nakahara, and Tomonori Sakurai (2007) found that exposure to magnetic flux density of 532 $\pm$ 20 uT for 2 hours caused minimum change in the cell's mutation frequency, and neither single nor double strand DNA breaks were observed. It is worth mention that the magnetic flux density applied in this experiment is 85 times greater than the admitted safety limit that exists in most commercial induction stovetops.

8.1.2 Dosimetry of Induced Currents

Since now the effect of magnetic radiation is understood, it is then necessary to find the actual amount of radiation emitted in commercial induction stovetops. The dosimetry, or the measurement of radiation dosage into the human body is a direct indicator of the potential side effects of induction stoves. In order to quantify the actual amount of electromagnetic radiation emitted by induction stovetops and analyze its effect, a measuring system must be implemented such that numerical values can be obtained and analyzed. In an experiment conducted by Riccardo Scorretti, Nicolas Siauve, Noel Burais (2007), the average magnetic flux density absorbed by the user at 30cm away is 5.9 uT, which is below the admitted safety limit of 6.25 uT.

As the above researches have shown, the effects of magnetic radiation caused by induction stovetops are negligible even at 85 times greater than the admitted safety level, while gas stovetops poses many major health threats to both the working environment and its users. It is then safe to conclude that induction stovetops are a better choice in terms of their impact on the stakeholders' health.

Conclusions

In this report, both the induction stovetops and gas stovetops are pitted against each other, and their advantages and disadvantages are compared and analyzed. The stovetop of choice becomes very clear after the triple-bottom line assessment. Induction stovetops are the clear-cut winner in all three categories as shown in the triple-bottom line assessment.

Environmentally speaking, the induction stovetops are more efficient than its gas stovetop counterparts, saving approximately 10% energy over its life time. The gas stovetops use natural gas which is a source of contamination for the environment, while the induction stovetops use electricity which could be generated in a renewable and sustainable manner. Moreover, gas stovetops emit gases such as CO, NO, and NO_2, which in large doses could become a serious health threat. On the other hand, induction stovetops produce no significant combustion by-products.

From an economical perspective, the induction stovetops have a steeper initial cost, but the cost of maintenance is lower. Gas stovetops on the other hand are cheaper to set up, however, the high cost of natural gas and maintenance make it the less desirable choice in the long run. After a detailed calculation, it is found that the high initial cost of induction stovetops will break even after 30 months of operation, and after that, they will end up saving more money than gas stovetops.

In the social aspect of the assessment, the main focus is on potential health concerns that both induction stovetops and gas stovetops pose on the stakeholders. Two problems had to be addressed in the analysis of induction stovetops: the amount of electromagnetic radiation that induction stovetops emit, and the effects of these radiations. It is found that the actual radiation absorbed by the users does not exceed the admitted safety level of 6.25 uT. Moreover, electromagnetic radiation has minimum effects on human tissue even at 85 times the admitted safety level. This means that induction stove has negligible impacts on the users in terms of health concerns. Gas stovetops however, are found to have negative effects on respiratory health. They also emit large amount of heat into their surroundings, which make a harsher working environment.

In summary, after a detailed assessment on the environmental, economical and social impacts of both induction stovetops and gas stovetops, it is recommended that induction stovetops be used in the new SUB building as this will leave less ecological footprints, save more money and impose minimum health threats on the users. Induction stovetops are definitely the cookware of the future, and with the goal of LEED platinum certification in mind, the new SUB building should beyond any doubt consider induction stovetops as its top candidate.

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