UBC Social Ecological Economic Development Studies (SEEDS) Student Report

Investigation of Induction Stovetops for Use in the New SUB

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APSC 262

April 4, 2011

Abstract

The induction stovetop is a fairly new innovation that is becoming more commonplace in both residential kitchens and commercial establishments. It presents numerous advantages over its conventional gas and electric counterparts, but there are also some drawbacks that need to be considered, such as high initial cost and lack of widespread familiarity. Numerous studies have been performed to test the efficiency and safety of all types of stovetops. Furthermore, there is both scholarly and informal information available regarding other criteria for comparison, including environmental effects, social impact, and economical evaluation. This paper presents a triple-bottom-line evaluation of the numerous perspectives on induction cooking and its alternatives, with a view for commercial establishment usage in the new Student Union Building (SUB) at UBC. Induction cooking was found to comparable or better than its alternatives in all three areas of our triple-bottom-line assessment; thus, we recommend it for use in the new SUB.

Keywords: Triple-bottom-line, induction, Student Union Building

Table of Contents

List of Illustrations

Glossary

Joule Heating – atomic energization of a material by electromagnetic induced current to increase thermal energy in the material.

Eddy Current – Current induced in an electrical conductor by a magnetic field that is moving relative to the conductor, or varying with time.

List of Abbreviations

Abbreviation	Full Name
AC	Alternating Current (in electrical power sources)
BTU	British Thermal Unit (of Energy, 1 BTU = 1055 Joules)
PG&E	Pacific Gas & Electric Company

1.0 Introduction

Induction cooking involves using an electromagnetic field to generate eddy currents in a metal. The metal then heats through resistance, which is known as Joule heating (Renseas, 2008). The field is generated by passing a high-frequency AC current through an electromagnet. In order to enhance the effectiveness of heat transfer, special cookware is often used. This cookware typically takes the form of a multi-ply base, with one layer specially designed to generate heat through induction, and the other layers designed to transfer that heat to the food being cooked and to resist corrosion (Ulam, 1987).

Induction is a fairly new technology in comparison to it alternatives, gas and electric stovetops. Gas is the standard for most homes and commercial kitchens. Its benefits include widespread familiarity and availability, with disadvantages emerging in safety and efficiency. Electric stovetops (infrared and contact heating) have some of the safety and energy benefits of induction, but they take a long time to heat up, are more difficult to adjust, and have surfaces that are hot to the touch, unlike induction.

2.0 Alternatives

Gas stovetop technology has been in existence for a long time, and the efficiency of its burners has practically been maximized. However, one way to make a gas range more economical is to increase its efficiency. While it's hard to improve the efficiency of the burners themselves, there has been some research into new cookware that uses fins on the bottom to greatly enhance heat transfer and thus the efficiency of the system. In tests performed at the PG&E Food Service Technology Center, they found these pots increased the efficiency of low-efficiency stoves from around 25% to over 40%, and of high-efficiency stoves from 30% to over 60% (Sorensen and Zabrowski, 2009). While this is impressive, efficiencies of induction are generally in the 80-90% range. Thus, a further analysis of the sources of energy for both types of stoves must be performed, and is outlined in further detail in subsequent sections of this report.

Electric stovetops, which heat through contact or infrared light, were billed as an improvement over gas ranges when they first came out. There is not a wealth of scholarly literature available on the merits of this type of stove. The general consensus is that while they are more efficient than gas, they still lack the efficiency of induction. Furthermore, they present dangers of a hot surface with little indication of heat (i.e. flame), take longer to heat up, and are less adjustable. These fundamental disadvantages of electric stovetops make their implementation in the new SUB less desirable than both gas and induction. Therefore, the remainder of this report will investigate and compare only induction and gas alternatives.

3.0 Environmental Assessment

The first portion of the triple-bottom-line assessment will analyze the environmental impacts of gas versus induction stoves. Through a life-cycle analysis of the two systems, no distinct difference in the longevity of the cooking surface or cookware was found. One notable danger of induction stovetops is their capacity to rapidly melt aluminum foil, which could bond to the cooking surface if accidentally placed on top of a running hob (Heldman). However, the cooking surface can be replaced without replacing all of the operational electronics. Efficiency analysis suggested that gas stoves generally transfer about 30% of input power to the food being cooked, or up to 60% with special finned cookware. Induction, however, commonly tests between 82 and 85% heating efficiency (Sorensen and Zabrowski, 2009), and some manufacturers claim up to 90% (The Middleby Corporation, 2010). However, when comparing the environmental impacts of both stovetops, the efficiency of the entire system – from the initial energy source through to food preparation – needs to be considered since the new SUB will only be providing 5% of the electrical power demand via renewable photovoltaic cells (UBC AMS, 2010).

In the case of gas stoves, natural gas is recovered either from natural gas liquid deposits or as a by-product of oil recovery in some reserves. Since no energy conversion takes place during gas recovery, the only upstream energy losses in the gas stove system occur during transportation of the natural gas via pipeline. In a pipeline efficiency analysis, Williams suggested that only 2-3% of fuel energy is lost in pipeline transport to overcome friction (Bowden, 2010). If gas stoves achieve 30-60% heating efficiency, then total gas stove system efficiency falls between 29% and

58%. On the other hand, induction stoves require electrical input energy, which must be generated from another energy source. Electrical generation is typically only 45% efficient (Green Energy Efficient Homes, 2010). An additional 8% upstream loss occurs due to electrical resistance during transportation and transformation. Electricity transmission is 93-94% efficient (Bowden, 2010) whereas transformers are typically 99% efficient (Saint, 2008). Once electricity reaches the induction stove, 80-90% of the electrical energy is delivered to the food, giving a total system efficiency of 33-37%. The preceding system efficiency analysis is summarized in Table 1 below.

Table 1: System Efficiency Analysis Summary

System	**Production**	**Transportation**	**Cooking**	**Total System Efficiency**
Gas	100%	97%	30% - 60%	29% - 58%
Induction	45%	92%	80% - 90%	33% - 37%

As seen in Table 1, induction stovetops are competitive with their traditional gas counterparts from a system efficiency standpoint, but if finned cookware is used in a gas application, induction stoves may be the less efficient alternative. An important note in this comparison is that the primary source of electricity in BC is hydroelectric power. Since hydroelectric generation is a renewable process, the energy loss due to production can be ignored because water is a renewable resource that replenishes itself regularly. This tips our recommendation towards induction, especially because the highest system efficiency for gas is based on finned cookware, which still has low availability and uncertain reliability.

4.0 Economical Assessment

The second part of the triple-bottom-line assessment will evaluate the initial and operational costs for gas and induction stoves for an economical comparison of the two alternatives. As seen in Figure 1, a commercial restaurant report from Sustainable Foodservice Consulting suggests that almost 25% of a restaurant's electricity bill (the green area) comes from food preparation alone.

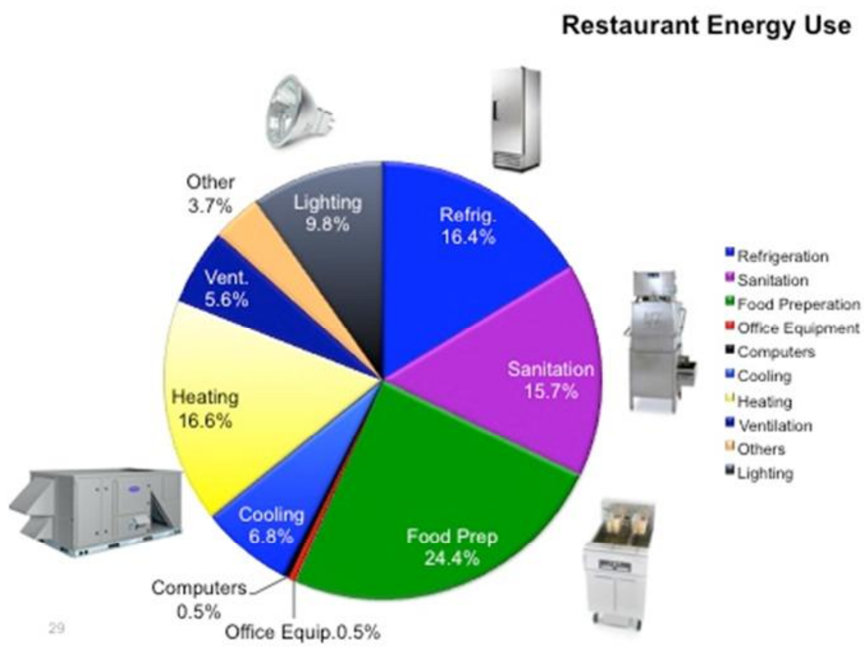

Figure 1: Restaurant Energy Use Breakdown

(Sustainable Foodservice Consulting, 2011)

If the new SUB kitchen and cafeteria are modeled as commercial restaurants, then Figure 1 suggests that a marginal cost savings from increased energy efficiency in food preparation will lead to the largest total cost savings for the new SUB compared to any other category. Thus, it is extremely important to minimize operating cost of the cooking equipment used in the new SUB.

Because technical reports and other technical information regarding an existing commercial application of induction cookware are extremely rare if not non-existent, a relative analysis was conducted for the initial and operating cost comparison between gas and induction stovetops. The initial cost of a single induction stovetop unit was found to be about $2100 while gas stoves generally cost $1000 (Green Energy Efficient Homes, 2010). However, sustainable cookware manufacturers such as the Middleby Corporation claim that the operating cost for an induction stovetop can be half that of a traditional gas stove. (The Middleby Corporation, 2010). Additional research confirmed that induction stovetops can operate at roughly half the cost of their gas counterparts. As of April 1, 2010, BC Hydro charges 4-6 cents per kilowatt-hour for commercial clients (BC Hydro, 2011) while a single induction stove typically operates at about 3 kilowatts (The Middleby Corporation, 2010). Typical gas consumption for a single gas stove is 70 000 BTU/hr (Engineering ToolBox, 2011), and the price of natural gas is 6 cents per 1000 BTU's (Sze, 2006). Thus, the relative operating costs from the preceding figures are 0.18 per hour for an induction stovetop and $0.42 per hour for gas. This brief economic comparison suggests that in a long-term application such as the new SUB, yearly operational cost savings from the use of induction stoves are likely to far outweigh the initial cost savings associated with the implementation of gas alternatives.

5.0 Social Assessment

This section of the report will focus on the social aspects of induction stoves versus their gas counterparts. This social breakdown will assess safety, workplace comfort, emissions and their impact on worker health, and limitations of the appliances in operation.

5.1 Safety

One of the most promising social benefits of using an induction stove over a gas stove is that the induction stove is much safer. The method of heat input, as described above, relies on basically using the pot as a traditional stove element - directly exciting the molecules via an electromagnetic field rather than using a flame. If one were to put a non-ferrous material in between the element and the pot, it would not be affected by the field that is heating the vessel above. The same action on a gas stove would be most unadvisable.

There is also a fear with gas stoves that a leak of fuel, whether it is due to a pipe leak or negligence to spark the burner when it is in an “on” position, can lead to a major explosion. Of course, safeguards such as tagging gas with an unpleasant sulphuric odour can help prevent a leak from becoming catastrophic. It is possible to keep a gas stovetop ignited while a pot is not on the element, but many induction stoves have sensors that detect a ferrous pot above the cooking area (The Induction Site, 2010). If one does not exist, or it is insufficient in size to be a true cooking vessel, the element does not create a field. This feature is especially effective for an industrial cooking application, where burners are left on all day, because the ranges draw less power when they are not creating a field to heat the pot when it is not there.

5.2 Workplace Comfort

To address workplace comfort, the ambient temperature of the cooking area will be considered first. With a gas stove, approximately 60% of the gas energy is lost during cooking, compared to about 15% of heat loss with an induction stovetop (The Induction Site, 2010). This energy is mostly lost through heat transfer to the surrounding kitchen, making temperatures higher. Even if a temperature regulation system is in place, the issue changes into one of space heating rather than one addressing workplace comfort levels. With higher temperatures in the kitchen, workers are less comfortable and more prone to stress (Kuse et al, 2000). If more temperature regulation needs to be done, this will result in more heating costs.

Another issue that can be traced to worker comfort is the unwanted cooking of non-organic materials and mishandled food in a burner. Resulting in odours, smoke, and possibly even a significant loss of material, the burning of these by-products can be avoided with an induction stove, as stated above in the safety discussion. These by-products, as well as the gas combustion products, result in vaporized material that is deposited on the surfaces around the cook-top in the form of stains and film (The Induction Site, 2010) (Kuse et al, 2000).

An induction stove may also produce noises if the cooking vessel contains materials referred to as “slugs”, which will cause vibrations (The Induction Site, 2010). Vibrations can also be caused by poorly designed lids and pot-bottoms, but most of these issues can be avoided by buying quality vessels. Listed below in section 5.3 are some ways the UBC SUB project will address some of these comfort issues.

5.3 Health Effects

A widely discussed issue relating to the competition between induction and gas is the harmful emissions from both technologies and their impact on worker health. The Scientific Committee on Toxicity, Ecotoxicity and the Environment (2001) and the Scientific Committee on Emerging and Newly Identified Health Risks (2006) discuss the health effects of “extremely low frequency electromagnetic fields”, referenced as “ELF magnetic fields”, that come from devices such as an induction stove. Both groups assess these fields and their possibility of being a carcinogen, causing childhood leukemia, causing breast cancer, causing DNA damage, resulting in hypersensitivity to radiation, and leading to many other diseases, but these impacts are deemed as negative or inconclusive by both. There are a number of possible health impacts discussed by the Scientific Committee on Emerging and Newly Identified Health Risks (2006), such as enhanced development of tumours, impedance of DNA repair, cell damage, and inhibition of certain breast cancer treatments. These claims are all noted as either unlikely but requiring further research, biased by other proven factors due to the scientific method implemented, or a combination thereof.

The impact of gas stoves on health has many conflicting claims like its induction-based counterpart. Burning gas results in hydrocarbons like carbon monoxide and other by-products. Without proper ventilation, carbon monoxide can be a serious issue. According to information from various studies, it appears that gas emissions have negligible impact on adult health, but seem to have more impact on children (Eisner and Blanc, 2003)(Jarvis, Chinn, Steme, Luczynska, and Burney, 1998) (Melia, Florey, Altman, and Swan, 1977). According to Melia, Florey, Altman, and Swan (1977) gas may increase prevalence of bronchitis, day and night cough, morning cough, chest colds, wheeze, and asthma in children. This study does not address the adult population, but one would expect there to be possible correlations with some workers. Gas stove byproducts apparently have no impact on chronic cough or phlegm production within a sample group of adults already with asthma, and might be related to a greater risk of other respiratory symptoms. These possible symptoms are not excluded in a 95% confidence interval, so there is not enough evidence to support the validity of this claim (Eisner and Blanc, 2003). Researchers Jarvis, Chinn, Steme, Luczynska, and Burney (1998) state that gas cooking in selected countries is associated with respiratory symptoms in females. As well, this article suggests that exposure to gas should be minimized, appliances should be properly maintained, and proper kitchen ventilation is encouraged.

Looking at the SUB 75% schematic, the plans call for negative pressure for odour control; commercial exhaust ventilators above any cooking equipment to vent grease, odours, humidity, and other cooking by-products; and the consideration of filters in the air systems (UBC AMS, 2010). All of these address some of the gas by-product and grease particulate issues, as well as the residue and odour problems discussed in section 5.2. The schematic also says that "equipment selected shall enable the operator to maintain or enhance accepted health standards," (UBC AMS, 2010). Though gas ranges are clearly adequate given the operating conditions and aforesaid plans, it is interesting to consider how to "enhance" the accepted health standards. Many measures seem to be in place to ensure the best health practices, but it might be more beneficial to implement induction ranges.

5.4 Limitations on the Ranges

One attribute that is prevalent in the selection of gas ranges by cooks is the range's apparent unique ability to be finely adjusted to fit the cooking parameters. The induction range actually has the same ability to be finely adjusted (Kuse et al, 2000). Since interviews with chefs about the adjustability of different ranges were not possible, a cooking site called "Seasoned Advice" was used – where cooks share recipes and equipment advice. A general consensus with cooks that have made the switch from gas to induction is that the controls are just as finely adjustable, but other issues surface. Problems with getting accustomed to arbitrary range of heating values (instead of relying on flame size), possibly non-linear heating adjustments, and touch screen controls are voiced (Seasoned Advice, 2010). Many people claim that the induction stovetop is faster at heating food than a gas one, perhaps due to the efficient energy transfer. This would result in shorter cooking times, and a more efficient kitchen.

For cooking applicability, there are a number of issues with induction ranges. One is the inability of the induction stovetop to char peppers and other food items you wish to insert into an open flame (The Induction Site, 2010). As well, one "Seasoned Advice" cook complains about the use of an induction element on with large pan – which will have cold spots on the outside because of the limited extent of the electromagnetic field (Seasoned Advice, 2010). Some brands do have ranges that are fully active on the top surface: adjusting their field to the size of the cookware on the surface (The Induction Site, 2010). This was an isolated incident, and no further information can be found on the limited vessel size topic. As the UBC SUB will probably invest in high quality ranges, this will be an unlikely problem.

Regarding limitations on equipment to be used with the ranges, as stated before, only ferrous materials can be used with an induction range. While gas stoves may damage the bottom of a pot over time with the flame, all (non-flammable) cooking vessels can be used on them. These special cooking materials are slightly more difficult to find, but it must be assumed that UBC will be able to find a reliable dealer for this problem, and many common vessels are applicable (The Induction Site, 2010) (Seasoned Advice, 2010).

A definite positive of using induction stovetops is their ability to be easily cleaned. Other heating methods require an interruption in the stove surface to integrate the cooking field, but an induction stovetop can be perfectly smooth (Kuse et al, 2000). All entries that reference cleaning at “Seasoned Advice” (2010) also address this easy ability to clean the induction range surface. As well, since grease, splatter, and burned food are much more prevalent on the surface and surrounding surfaces of the gas ranges, these issues compound the problem of cleaning.

On another note, no information could be found on how induction and gas stovetops are manufactured. One would assume that they both have equal likelihood, and a very low likelihood, that they are made unethically. Since they are, in practice, almost identical in practicality and applicability to the kitchens, they have no adverse social impacts in terms of amount of use and worker training.

6.0 Conclusion

It is clear that both gas and induction stoves have advantages and disadvantages associated with their use in residential and commercial applications. Gas stoves, the current standard for commercial kitchens, have undergone several decades of optimization and implementation, so they are widely available and most people are familiar with their function. On the other hand, induction stovetops address the main drawbacks of gas stoves, in that induction stovetops have extremely high heating efficiency, as well as instant cooling and a cool cooking surface. The main drawbacks of induction stovetops are the lack of familiarity in commercial applications, and large initial upfront cost.

The results of the triple-bottom-line assessment of induction stovetops for implementation in the new SUB suggest that induction stovetops are superior to gas stoves from both an economical and social point of view. In the long run, the lower operating cost of induction stoves will lead to cost savings despite the higher initial cost compared to gas. Socially, workplace safety is increased by the implementation of induction stoves due to cool cooking surface properties and reduction of the risk of gas leaks. Finally, environmental analysis suggested induction stoves are at least comparable to their gas counterparts from an energy efficiency point of view, or better if electricity to the new SUB is supplied mostly by renewable energy resources such as hydroelectricity. From these results, it is clear that induction stovetops are far superior to traditional gas stoves for implementation in the new SUB kitchen according to triple-bottom-line evaluation criteria.

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