An Investigation into Personal Heaters

University of British Columbia

APSC 262

May 04, 2015

An Investigation into Personal Heaters

University of British Columbia
APSC 262 Impact of Technology on Society
Paul Winkelman
April 9, 2015

Abstract

This report presents an extensive assessment on the selection of an optimal personal office heater to serve as a replacement for the current heaters that are used by the UBC staff. UBC is proposing a potential 'trade-in' program, which individuals could exchange their current heaters for a more economically, socially and environmentally acceptable model at free of charge. UBC would recoup the cost of providing the new heater through reduced expenditures on electricity. As indicated by the stakeholder, the expected payback period on this project is approximately 2 years. All of the available heater models on the market have been investigated, the report reveals the most optimal model by conducting the triple bottom line assessment on fan forced heater, ceramic heater, infrared heater, and radiant oil heater. The method of research includes both primary and secondary data. Majority of primary data used came from communication with Project Coordinator while peer-reviewed journals and online customer reviews are used as the secondary source.

One of the key assumptions for selecting an energy-efficient heater model is that the economic analysis, financial model, and energy cost saving were evaluated on 600 hours of operation per year. Through analysis, the LifeSmart Life Pro., a 400 watts infrared heater, is determined to be the best economic choice. In terms of environmental aspect, there is a great reduction of carbon dioxide production when comparing the conventional 1500W model, currently in use, to the 400W model in our recommendation. For social aspects, individuals' thermal comfort can be satisfied, resulting in potential increase in productivity. Moreover, this initiative will also educate the staff to become energy aware. Based on the triple bottom line analysis, the recommendation for UBC is to select The LifeSmart Life Pro.

Table of Contents

List of Illustrations

List of Figures

List of Tables

Glossary

CO_2	A naturally occurring chemical compound is composed of two oxygen atoms each covalently double bonded to a single carbon atom; Leading cause for the green house effect
BTU	The amount of heat required to increase the temperature of a pint of water (which weighs exactly 16 ounces) by one degree Fahrenheit
kWh	Unit of energy equivalent to one kilowatt (1 kW) of power expended for one hour
Payback Period	Period of time required to recoup the funds expended in an investment, or to reach the break-even point
FFH	Fan Forced Heater
CH	Ceramic Heater
IH	Infrared Heater
ROH	Radiant Oil Heater

1.0 Introduction

94% of US and Canadian office workers agree that the number 1 complaint is that it is “too cold”. A study done by the American Society of Heating, Refrigerating and Air Conditioning Engineers Inc. shows that 34% of the complaints occur during winter months where summer is a close second at 29%. Occupants deal with thermal discomfort by using personal fans (66%), supplemental clothing (64%), personal heaters (60%), blocking or redirecting vents (56%) or adjusting the thermostat (51%). [1]

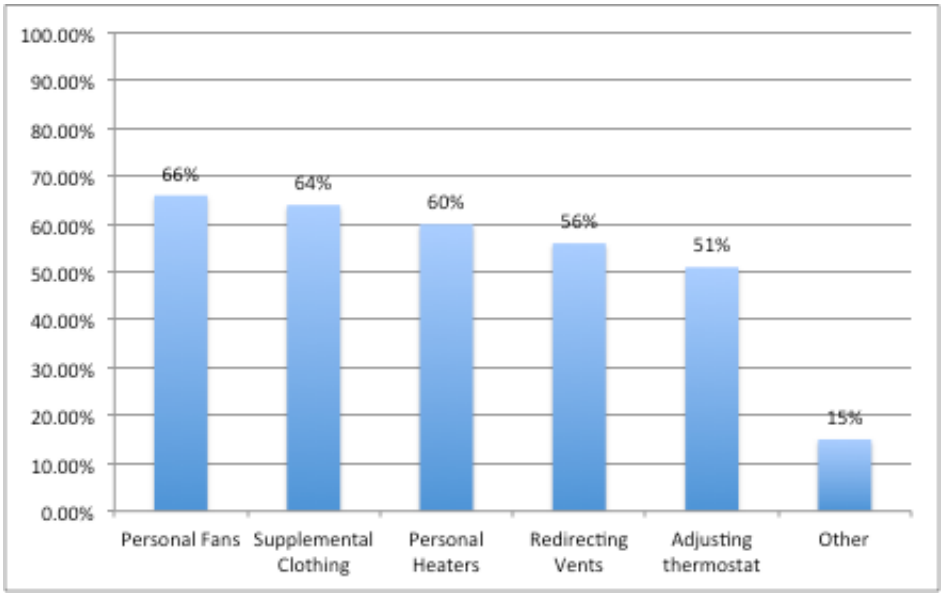

Figure 1. How Occupants adjust to thermal discomfort
Source: IFMA, retrieved from ASHRAE Journal

Central controlled heating and cooling are not efficient enough to accommodate everyone’s personal preferences. Large complex heating systems tend to have varying heat distribution causing hot and cold spots throughout a building. Occupants of a UBC building have overcome this problem by supplementing thermal discomfort with energy draining ceramic heaters. The addition of the ceramic personal heaters has increased the overall power consumption of the building. UBC is currently assessing a trade-in program where building occupants can replace their current ceramic heater for an energy efficient model.

The cost of the new heaters would be recovered from money saved on their electrical bill.

This project investigates different personal heaters, important criteria when choosing a heater and a purchasing model based on power consumption and heater unit price. The objective is to recommend a personal heater that will impact the stakeholders economically, socially and environmentally.

2.0 Methods of Research

The majority of primary data used in this investigation came from email communication with the Project Coordinator about specific operating conditions of the project.

Homedepot.com, Homehardware.ca, Rona.ca and other major online home hardware retailers provided a list of personal heaters that are readily available. In addition, these online retailers provided specifications, prices, shipping and customer reviews.

Peer-Reviewed Journals from the UBC Library Database provided this project statistical data on personal heaters and power consumption. This is the basis on which the project built its arguments. The project is also supplemented with journals and papers discovered through power search engines such as Google and Amazon.ca.

3.0 Personal Heaters

As part of the study, four different types of heaters, which are readily available through major home hardware retailers, were reviewed: Fan Forced, Ceramic, Infrared and Radiant Oil Heaters. The following sections are an analysis of the pros and cons of these four types of heaters along with an overview of its price and specifications.

3.1 Fan Forced Heater (FFH)

This type of heater uses a large diameter fan to force air over an electrical heating source as well as to also prevent overheating. The main heating source is a coiled wire frame that is installed behind the fan blades. The hot air is blown into the surrounding area and a circulation of warm air is created in the room. [2]

Advantages

- Low cost
- Quick and even distribution of heat
- Ideal for office or workshop environments

Disadvantages

- Potential fire hazard
- Low airflow temperature
- Large Size
- Noisy Operation
- Energy lost to fan operation

FFH Model #	**Price**	**Power Cons (KW)**	**Heating Rating (BTU/hour)**	**Area Covered (Sq Foot)**
HFH131TG	$24.99	1500	4096	100
EH1-00360-46	$199.99	1500	5120	300
KB2407-1-T-B1	$599.99	7500 kWh/year	25590	n/a

Table 1. FFH Models with Specifications at Low, Med and High Price Points

3.2 Ceramic Heater (CH)

Ceramic heaters are equipped with a ceramic and aluminum coil as its heating source. To prevent overheating, a small fan housing is usually used to cool the heating source. The heating coil dissipates heat around the heater and thus creates naturally induced convection currents between hot and cold air. The air circulation then distributes the heat around the room. [2]

Advantages

- Powerful in small areas
- Heating element starts up quickly
- High airflow temperatures around 120° C
- Coil is durable and capable of reaching high temperatures
- Low noise

Disadvantages

- Higher relative cost to FFH heaters
- Slow distribution of heat

CH Model #	Price	Power Cons (KW)	Heating Rating (BTU/hour)	Area Covered (Sq Foot)
754200	$24.97	1500	5120	300
760000	$99.99	1500	5120	300
CUH05B31T	$226.41	5040	17203	400

Table 2. CH Models with Specifications at Low, Med and High Price Points

3.3 Infrared Heaters (IH)

The infrared heater (a.k.a. heat lamp) emits long-wave infrared radiation that is then converted into heat energy when it strikes a solid nearby object. No heat energy is absorbed by the air and therefore the heating process is unaffected by air drafts. In addition, typical infrared heaters have no moving parts so they can produce heat efficiently, quickly, and silently. [3]

Advantages

- No moving parts
- Direct transfer of heat
- Durable components
- Silent operation
- High safety ratings
- Provides unidirectional heating

Disadvantages

- Limited heating range
- Not ideal for large spaces
- Exposing to a large amount of infrared radiation over an extended period of time can result in eye and skin diseases.

IH Model #	**Price**	**Power Cons (KW)**	**Heating Rating (BTU/hour)**	**Area Covered (Sq Foot)**
JHS500G	$24.99	500	1707	200
L-HOM4-NS12	$99.00	1650	5120	1200
UK-15	$349.00	1500	5120	n/a

Table 3. IH Models with Specifications at Low, Med and High Price Points

3.4 Radiant Oil Heaters (ROH)

The radiant oil heater operates similar to a central heating radiator, heating the room by natural air convection. When the heater is on, it uses a heating element to first warm up the oil that is sealed inside an oil tank, then releases that heat to the surrounding air. The oil tank acts like a heat sink. The thermal energy inside the oil tank is picked up by the air currents and distributes the heat by convection. [2]

Advantages

- Slow to cool off - continues to generate some heat after turning off
- Low noise

Disadvantages

- Slow to heat up
- Not safe for contact at high temperature settings
- Large, heavy, and bulky
- Regular oil maintenance is needed
- Dependent on ambient air currents [2]

ROH Model #	Price	Power Cons (KW)	Heating Rating (BTU/hour)	Area Covered (Sq Foot)
H6003	$37.97	1500	2389	150
TRD0715T	$89.99	1500	5120	350
FHP0750T	$159.99	756	2560	75

Table 4. ROH Models with Specifications at Low, Med and High Price Points

4.0 Financial Model

According to project stakeholder, UBC intends to implement a replacement plan for the models of personal space heaters currently in use at UBC at no cost to the users. The cost of replacement heaters would be ideally recuperated within the payback period of 2 years on the savings earned on electrical bills as a result of switching to personal space heaters with a lesser power consumption.

Several assumed factors, provided by the stakeholder, can be used to determine the maximum price for a model to satisfy the payback criteria.

- 750 units to be replaced
- Current units are all 1500W models
- Units are operated for
    - 5 hours a day
    - 5 days a week
    - 24 weeks during winter
- UBC pays $0.06/kWh

The data shows that a single heater unit is operated for 600 hours per year. To find the total cost that UBC spends in electricity due to heaters, the following formula is used:

Cost per year ($) = Wattage (kW) x Hours per year (hr/yr) x Total units x Rate of electricity ($/kWh)

Following this, the maximum price per heater can be calculated as the difference of their costs per year to the current cost per year, divided by the number of units, and doubled to account for the 2 year payback period. The formula for determining the maximum price of a heater is thus:

Max. price per heater ($) = 2 x (Wattage$_{Current\ Heater}$ - Wattage$_{New\ Heater}$) x (Hours per year x Rate of electricity)

For any heater model with a power consumption that falls under this maximum price, UBC will be able to satisfy the payback criteria of 2 years, assuming that 750 units are purchased in bulk, and will also produce excess savings depending on how far below it is. *(Refer to **Figure 2** below)* However, if a heater model surpasses this maximum price threshold, UBC will be unable to subsidize the cost of the heaters in 2 years but may be able to do so in a greater number of years. For a greater number of years, the condition is only satisfied if the wattage of the new heaters is less than the current 1500W models.

The trend line in **Figure 2** can be shown to follow: Maximum price = 7.2*(Wattage) - 7.2

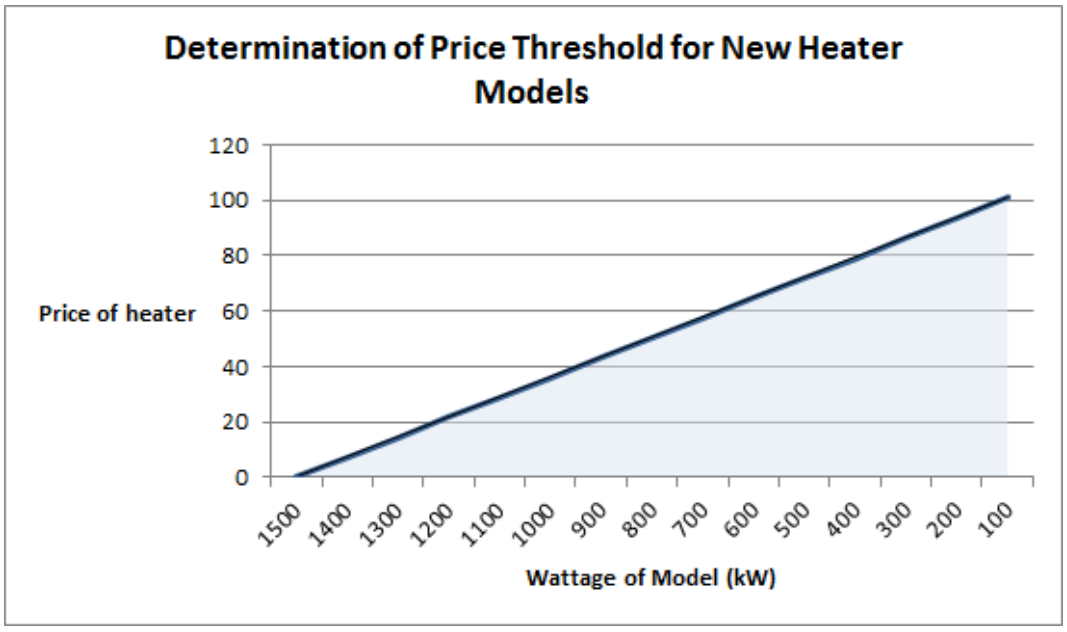

Figure 2. Graphical representation of the price threshold when considering new heater models. The shaded area below the line represents prices of heaters that can satisfy the payback criteria for the given heater model.

The data can be applied to subsequently calculate the 2 year savings for selecting any model heater.

Savings per X Years = X(Original Cost per Year ($) - New Cost per Year($)) - Price of 750 Units*

The equations given above for Cost per Year can be applied here. For reference, the personal space heaters at UBC contribute approximately $40 500/year in electrical fees.

5.0 Recommendation

5.1 Financial Consideration of Heater Models

It is vital to consider the purchasing aspects of the heaters since one of UBC's primary criteria for selecting a heater is that it can produce savings on electrical bills within 2 years.

Industry standards for power consumption are 1500 W for Ceramic, Fan Forced and Radiant Oil Heaters. There is no room for savings in power costs, as these heaters do not offer models at a lower power consumption rate and are not viable options. However, Radiant heaters are offered at lower power ratings.

The formulas and findings in the section above can be applied to potential replacement candidates:

Heater	**Wattage (W)**	**Maximum Price to Satisfy Payback Criteria (W)**	**Heater's Price ($)**	**Calculated Savings in Payback Period ($)**
Lifesmart Life Pro Series	400	$79.20	$39.97	$29422.50
Optimus 400-Watt to 800-Watt	400	$79.20	$28.99	$37657.50
	800	$50.40	$28.99	$16057.50

Table 5. Shows the two models in consideration for UBC's replacement of personal space heaters and their forecasted savings over 2 years, if they are to be implemented. Calculations here assume there will be 750 units.

This motor has two modes of operation. For the purposes of the calculation, they will be treated separately, assuming that the motor either runs in 400W mode or 800W mode for its entirety of operation.

Based on **Table 5** shown above, the Lifesmart model falls between the high and low modes of operation of the Optimus model. If it is assumed that the Optimus model operates with equal times in both modes, the Optimus model provides fewer saving at $26 857.50.

The Optimus model can accommodate two different temperature settings for greater control of temperature. However, if the heater is operated at 800 W the cost savings are greatly reduced. Even if it operates in both modes for an equal amount of time, the LifeSmart Model produces a greater cost savings of $2 565. The life cycle of a personal heater is approximately 20 years [4] and can accumulate approximately $51 300 over its lifetime more than its counterpart.

5.2 Benefits of Infrared Heaters

Infrared heating solutions were found to reduce power consumption by 39.7% compared to convective heaters such as Fan Forced Heaters [5]. Infrared heating systems can be comfortable at temperatures 6°F to 8°F lower than other heater types. In addition, infrared heaters do not alter the ambient moisture content. Conventional heaters reduce moisture content in the air causing dry skin and irritation. It also promotes infiltration of cold air from outside [6].

Infrared Heaters are unidirectional and are not affected by air drafts. Occupants can use this heater with control of the area they are heating. This allows for greater control of the ambient temperature.

5.3 Workplace Culture

Education plays a big role in reducing power consumption. If upper management promotes energy saving behaviors, it can greatly influence employees to follow. Outside-In Day is a week during winter where employees are recommended to wear winter clothing inside, as Central Heating would be turned off for that week. This is a teaching opportunity to show that supplemental clothing is a viable option for staying warm inside. Another promotional idea for upper management would be to implement lenient dress codes to allow employees to use blankets and wear jackets during work.

5.4 Final Recommendation

Lifesmart Life Pro Series is the personal heater to choose. Its infrared capabilities allow for lower power consumption at 400 W. Although the Optimus costs less, it can use more power and significantly reduces its overall power savings over time. The Lifesmart Life Pro will recover its costs within the first year of implementing the project. Lifesmart features benefits such as temperature control and an over heat safety switch.

Lifesmart is 3.75 in x 6.5 in x 5 in making it ideal for compact spaces such as underneath a desk. It makes storing easier and does not take up as much space in the office. Infrared heaters are also known to be silent as to not bother the building occupants while they are working.

6.0 Triple Bottom Line Impacts

6.1 Social

The most important aspect in addressing the issue of personal thermal comfort is level of happiness. Employees who are made comfortable and happy are said to have an increase in productivity by 12% [7]. By empowering the occupants with the ability to change their ambient environment provides the employees sense of control. “High levels of perceived control are associated with increases in job satisfaction, commitment, involvement, performance and motivation, and with low levels of physical symptoms, emotional distress, and absenteeism.”[8] These positive improvements at work will also improve life at home. In addition to overall work satisfaction, this initiative will also educate everyone apart of this program to become energy aware. As employees become more aware, these energy saving habits will be transferred to their personal lives as well. Therefore, this project will have a Triple Bottom Line impact at home and at work.

6.2 Economic

UBC can accrue savings of $29 422.50 a year by choosing the LifeSmart Life Pro. In addition, UBC can save up to $29 745 in energy savings per year. The project will make recover the costs from energy savings in the first year. Personal Heaters are durable machines. If personal heaters are well maintained, they could last up to 20 years [4]. Analyzing the total life cycle of the Optimus Infrared Heater, this project can accumulate up to $468 000 (adjusted for inflation at 2.4%) in energy cost savings. With BC Hydro announcing to increase rates 28% over the next five years, it can potentially save more money in the near future.

6.3 Environmental

The calculated CO_2 production per kWh of energy is 125g/kWh [9]. There is a great reduction of CO_2 production when comparing the 1500W model to the 400W model in our recommendation. From the figure below, the lower powered

infrared model reduces CO_2 emissions by 96.7% assuming that 750 units are being powered for 600 hours/year. The figure below is a graphical comparison of CO_2 emissions using two different heater models.

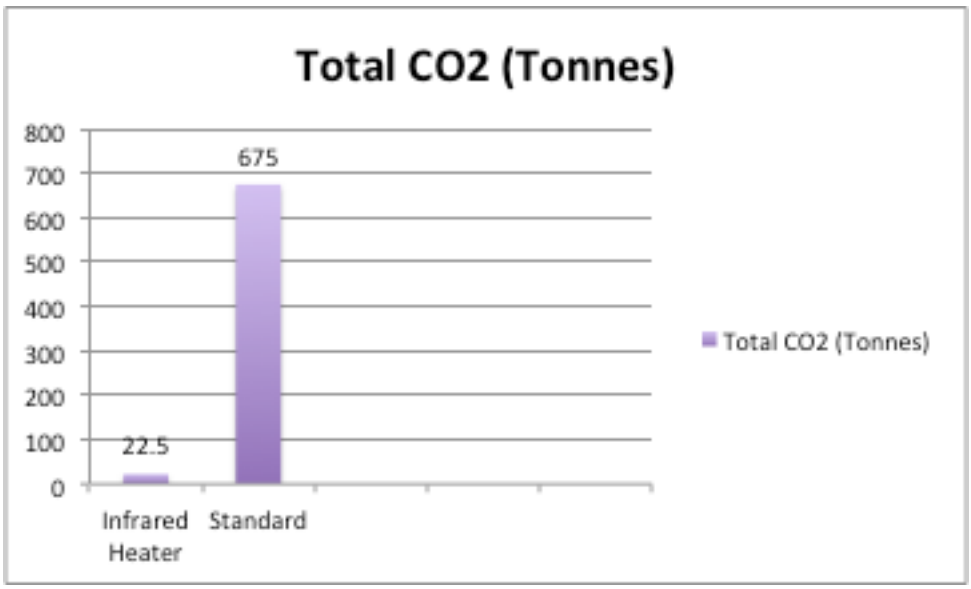

Figure 3. Comparison of CO_2 emissions

If measures are not taken to reduce CO_2 emissions, it is projected to grow over the next 5 years to 862 Mt. However, if measures currently in place are taken and no further CO_2 emission reduction practices are introduced, it is projected to grow 734 Mt. The Canadian goal is to reach 612 Mt per year by 2020 [10]. This goal can be achieved by starting at a fundamental level of purchasing lower powered personal heaters. Below is a chart projecting CO_2 emissions.

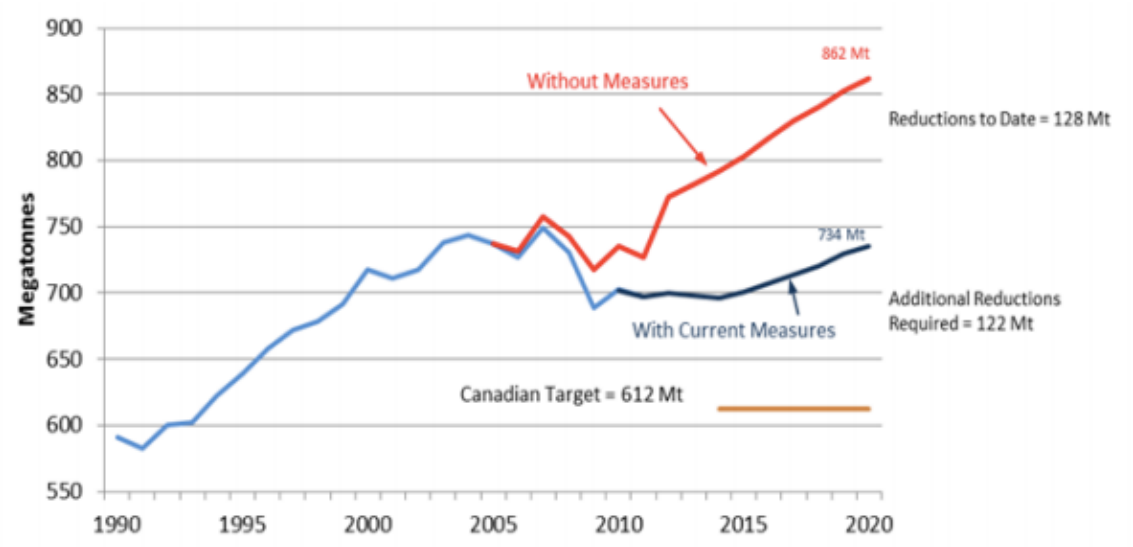

Figure 4. Projection of CO_2 emissions in Canada

Source: https://www.ec.gc.ca/ges-ghg/985F05FB-4744-4269-8C1A-D443F8A86814/1001-Canada%27s%20Emissions%20Trends%202013_e.pdf

7.0 Conclusion

As shown by the triple bottom line analysis, the infrared heater is a promising option when considering a sustainable personal heater to replace all the others in UBC. When people choosing heaters, their primary interests are: quality, safety, comfort and ability for temperature control. Infrared heaters are energy efficient, silent and unaffected by drafts which satisfy most of our interests. By using infrared heater, UBC can save significant amount of money with short payback time and reduce the amount of CO2 emission. Less energy usage means more sustainability, which not only save money but also help our society to become more environmental friendly. The models we recommend to use are called the LifeSmart Life Pro and Optimus. Infrared heating such as the LifeSmart Life Pro is capable of reducing power consumption by 39.7% compared to conventional heaters such as Fan Forced Heaters. The LifeSmart Model produces a greater cost saving by $2565 compare to Optimus per year. The life cycle of a personal heater is approximately 20 years and the saving can accumulate approximately $51,300 over its lifetime. However the Optimus model is capable of accommodating two different temperature settings for greater control of temperature. LifeSmart offers efficient heating, environmental friendly and capable of saving significant amount of money in a long term.

References

[1] ASHRAE (2009). Workers Still Too Hot or Cold, Winter Worst for Complaints. American Society of Heating Refrigerating and Air-Conditioning Engineers, 51(10), 6-6.

[2] Will Henry, (2015) Which is the Most Energy Efficient Space Heater? Retrieved from: http://gadgetboy.hubpages.com/hub/Which-is-the-Most-Energy-Efficient-Space-Heater-5-Reviews-Some-Tips

[3] Air & Water. (2014) Infrared Heaters: Pros and Cons. Retrieved February 25, 2015 from: http://www.air-n-water.com/infrared-heaters-pros-cons.htm

[4] Matulka, R. (2013, December 16). Energy Saver 101 Infographic: Home Heating. Retrieved April 7, 2015, from http://energy.gov/articles/energy-saver-101-infographic-home-heating

[5] Ali, A. H., & Morsy, M. G. (2010) Energy efficiency and indoor thermal perception: a comparative study between radiant panel and portable convective heaters. Energy Efficiency, 3(4), 283-301. Retrieved from: http://search.proquest.com.ezproxy.library.ubc.ca/docview/755540567

[6] Watson, R.D. (1992) Advantages of Radiant Heat. Retrieved from http://www.radiantec.com/why/technical-explanation.php

[7] Oswald*, A., Proto, E., & Sgroi, D. (2014). Happiness and Productivity. JOLE, 3(10).

[8] Sparks, Kate, Brian Faragher, and Cary L. Cooper, (2001), “Well-being and occupational health in the 21st century workplace,” Journal of Occuaptional and Organizational Psychology, 74(4).

[9] Aplin, S. (2014, January 3). Ontario electricity carbon spikes past 100 grams per kilowatt-hour: The Environmental Cost of the Perfect Storm of 2009. Retrieved April 3, 2015, from http://canadianenergyissues.com/2014/01/03/ontario-electricity-carbon-spikes-past-100-grams-per-kilowatt-hour-the-environmental-cost-of-the-perfect-storm-of-2009/

[10] Canada's Emission Trends. (2013, October 1). Retrieved April 8, 2015, from https://www.ec.gc.ca/ges-ghg/985F05FB-4744-4269-8C1A-D443F8A86814/1001-Canada's Emissions Trends 2013_e.pdf