An Investigation into Optimal Personal Heater – Radiant Panel

Hui Yang (Sunny) Li, Mariane Hans Alexandre, Steve Qiu

University of British Columbia

APSC 261

November 29, 2013

The University of British Columbia
APSC 261 – Technology and Society
Tutorial Instructor: Saloome Motavas

An Investigation into
Optimal Personal Heater – Radiant Panel

Submitted by:
Hui Yang (Sunny) Li
Mariane Hans Alexandre
Steve Qiu

November 29, 2013

ABSTRACT

This report provides an in-depth analysis on the selection of an optimal radiant panel office space heater to serve as a replacement for the current heaters that are used by the UBC staff. Available models in Great Vancouver were investigated using the triple bottom line analysis. UBC is planning on creating a trade-in program where employees can trade in their current heater for a more energy-efficient model for free, and the cost can be recouped from money saved from electricity bills. The preferred payback period to recoup these costs is under 2 years with the maximum limit at 5 years, as indicated by the project stakeholder, Lillian Zaremba (Climate & Energy Engineer, UBC Campus Sustainability). The methods of investigation for this project consisted of gathering both primary and secondary data. Primary data consists of a survey distributed to 24 participants and testing feedback form from three UBC staff who were selected for testing. The survey participants rated their interest in using a radiant panel at a score of 2.17 out of 4. Secondary sources include peer-reviewed journal articles and online articles.

Within the economic aspect of the triple bottom line, the purchase cost, payback period and energy cost savings were evaluated with the assumption that the heater was used for 600 hours per year. This analysis determined that the Cozy Legs (150W) was the best economical choice. The environmental aspect compared energy savings and CO2 emissions, where the two Cozy Legs models provided the most energy and carbon emission. For the social aspect, survey results show that the most important factors in heater selection are safety, low noise, quality, and comfort. The Cozy Legs heaters are safe, silent, and good quality. Testing feedback addresses the comfort level, with one tester providing positive feedback and two testers disliking it. These two testers have very cold offices and only warming their legs and feet was not enough. They require office heaters to heat up the entire room. The final recommendation for UBC is to only offer the Cozy Legs heater to those who require a little warmth in their offices. It is not recommended with people with large, cold offices. UBC can also consider extending its payback period limitation to over 5 years and test the Dayton (650W) model which can offer more heat, or consider other types such as convective heaters, which are designed to output more power.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

List of Figures

List of Tables

GLOSSARY

CO2	Carbon dioxide is a chemical compound composed of two oxygen atoms and a single carbon atom. It is the main cause of global warming.
Watt	The watt is a derived unit of power in the International System of Units used to measure the rate of energy conversion or transfer
kWh	The kilowatt hour is a unit of energy equal to 1000 watt-hours. The price for electricity in UBC is $0.0539/kWh.
Payback Period	The period of time required to recoup the funds expended in an investment.

1.0 INTRODUCTION

Managing a large building is a challenge, but making sure every occupant in the workspace is comfortable can prove to be more difficult. Poorly designed building structures and heating systems can lead to uneven heat distribution, causing discomfort in certain areas. Due to this problem, many UBC staff have personal heaters as a solution to meet their personal heating needs. However, there are many problems raised with the ceramic space heaters that are commonly used by UBC staff. These heaters increase the overall energy consumption and demand of the whole building, and may overload the electrical circuit. Therefore, investigation for an alternate more energy efficient model is required. UBC is planning on creating a trade-in program where employees can replace their current heater for the more efficient model for free, and the cost can be recouped from money saved from electrical bills by using these heaters.

In this project, four different models of radiant panel heater were investigated and the objective is to recommend the optimal personal heater for use in UBC office work spaces. A triple bottom line approach is used, which evaluates the economic, social and environmental aspects of the radiant panel heaters with the purpose of enhancing and advancing the sustainability initiatives of the UBC campus.

2.0 BACKGROUND ON RADIANT HEATING

Radiant panel heaters work by heating a metal plate, usually made of aluminum, and radiating this heat off in the direction that is perpendicular to the surface of the heater [1]. Therefore, the best positions to place such heaters are parallel to and directly facing the surface area that is to be heated. Research have shown that in a sample office room, the optimal positions to place these heaters are one on the wall facing the windows, and another on the wall close to the windows [2]. In this study, it was found that radiant heating solutions can save up to 39.7% of energy per day compared to convective heaters, and provide better comfort to office employees [2]. The benefits of radiant panel heaters compared to other types of heating solutions are that extra humidification for the room is not necessary, and air infiltration heat loss is reduced [3]. This is because radiant heat does not modify air moisture content, so users will not feel the dryness caused by other types of heaters [3].

3.0 METHODS OF INVESTIGATION

The investigation for this project consisted of analyzing both primary and secondary sources to collect data. For the Primary Sources of data, the three following approaches were taken:

- Distribute surveys to the UBC staff and Faculty regarding their perspective on office heaters - 24 participants;
- KiloWatt Meter for power measurement;
- Conduct tests with UBC staff to evaluate the performance of the new heater - 3 people.

The survey is a standardized survey for all the electric heater and blanket groups to distribute to all UBC staff in selected buildings. The survey is for both people who do and do not currently use space heaters. A total of 24 participants were surveyed. Each group was in charge of different buildings and the buildings that this group was responsible for are the two Campus and Community Planning (C&CP) buildings as well as Buchanan Tower. The KiloWatt Meter was used to measure the power output of the heater and verify it with the marketed values. The procedure for testing is have three UBC staff who currently use ceramic heaters and ask them to try the suggested replacement heater. The testing staff will then be provided with a feedback form where they will be able to compare and evaluate the performance of the new radiant panel heater compared to their current heater.

For the secondary sources of data, research was performed on peer-reviewed academic journal articles and books related to similar projects done in the past and on radiant panel heating. From these articles insight was gained on how radiant panel heating works compared to ceramic heaters as well as its current common applications [1][2][3]. Additionally, online catalogs of home electronics stores such as Acklands Grainger and Home Depot were also used to assess and analyze the different radiant panel heaters available on the market today. This research was supported by performing additional readings of online articles and reviews of these heaters.

4.0 ECONOMIC ASPECT

In this project, the purchase cost, payback period and energy cost savings were taken into consideration when evaluating the economic aspect. This is a very important analysis because it determines whether a model will meet the cost savings specifications to be considered for testing. The recommendations given to the teams to find an optimal radiant panel heater from the project stakeholder, Lillian Zaremba (Climate & Energy Engineer, Campus Sustainability), were also taken into consideration.

4.1 PURCHASE COST

For the purpose of this project, four portable radiant panel models were investigated at stores in Great Vancouver. These four models are INDUS-TOOL Cozy Legs (100W), INDUS-TOOL Cozy Legs (150W), QMARK (170W), and DAYTON (650W). The purchase cost (taxes included) of these models were last checked on November 4, 2013 and shown in Table 1.

Radiant Panel Heaters	Purchase cost	Store
INDUS-TOOL Cozy Legs Radiant Heating Panel (100 W)	$ 60.69 [4]	Global Industrial
INDUS-TOOL Cozy Legs Flat Panel Heater (150 W)	$ 67.66 [5]	The Home Depot
QMARK Electric Flat Panel Radiant Heater (170 W)	$ 148.88 [6]	Grainger
DAYTON Heater Radiant Flat Panel (650 W)	$ 181.59 [7]	Acklands Grainger

Table 1: The purchase cost of each radiant panel heater.

4.2 PAYBACK PERIOD

For the purposes of this study, as informed by the project stakeholder, it was assumed that the replacement heater would be provided free of charge to the user. UBC would recoup the cost of providing new heaters through saving electrical bills as a result of using these heaters.

To calculate the payback period* of each product, the following assumptions were made according to Vancouver's climate when considering the usage of the heaters among UBC staff:

- 5 hours per day
- 5 days per week
- Oct. 15 to Apr. 15 (exclude two weeks holidays) for a total of 24 weeks

In one year, the total hours that one heater is used is 5 x 5 x 24 = 600 h. To calculate the cost spent per year with one heater, the following equation is used:

$$Cost\ per\ year = Wattage\ (kW)\ \text{x}\ Hours\ Used\ per\ year\ (h/year)\ \text{x}\ Electricity\ Rate\ \left(\frac{\$}{kWh}\right)$$

UBC's electricity rate is \$0.0539/kWh [8]. The calculations of each model found can be checked in the following table:

Calculation of the electricity cost of each heater	Cost per year
Ceramic model (1500 W) C = 1.5kW x 600h x \$0.0539/kWh = \$48.51	\$ 48.51
INDUS-TOOL Cozy Legs Radiant Heating Panel (100 W) C = 0.1kW x 600h x \$0.0539/kWh = \$3.23	\$ 3.23
INDUS-TOOLCozy Legs Flat Panel Heater (150 W) C = 0.15kW x 600h x \$0.0539/kWh = \$4.85	\$ 4.85
QMARK Electric Flat Panel Radiant Heater (170 W) C = 0.17kW x 600h x \$0.0539/kWh = \$5.50	\$ 5.50
DAYTON Heater Radiant Flat Panel (650 W) C = 0.65kW x 600h x \$0.0539/kWh = \$21.02	\$ 21.02

Table 2: Calculation of the electricity cost of each heater

Knowing how much money UBC can save per year if employees could trade in their current ceramic heater for one of the radiant panel models is essential for choosing the model. It is needed to calculate the difference in energy cost between the two models. Table 3 can provide this information.

Radiant Panel Heaters	Difference in cost per year
INDUS-TOOL Cozy Legs Radiant Heating Panel (100 W)	48.51 - 3.23 = $ 45.28
INDUS-TOOL Cozy Legs Flat Panel Heater (150 W)	48.51 - 4.85 = $ 43.66
QMARK Electric Flat Panel Radiant Heater (170 W)	48.51 - 5.50 = $ 43.01
DAYTON Heater Radiant Flat Panel (650 W)	48.51 - 21.02 = $ 27.49

Table 3: Difference in cost between the ceramic heater and the radiant models.

The payback period of each product will be its cost of purchasing divided by the energy saved by using each radiant panel model that has been compared. This information is shown in Table 4. The payback period is closely related to the power of each product. The bigger its value, the more energy it consumes and longer the time UBC will recoup the money spent on purchasing.

Radiant Panel Heaters	Payback Period
Indus-Tool Cozy Legs Radiant Heating Panel (100 W)	60.69 / 45.28 = 1.34 year
Indus-Tool Cozy Legs Flat Panel Heater (150 W)	67.66 / 43.66 = 1.55 year
QMARK Electric Flat Panel Radiant Heater (170 W)	148.88 / 43.01 = 3.46 year
DAYTON Heater Radiant Flat Panel (650 W)	181.59 / 27.49 = 6.60 year

Table 4: Payback period of each radiant panel model.

4.3 ENERGY COST SAVINGS

To calculate the energy cost savings, it is important to take into consideration the total of employees using personal heaters. According to Campus Sustainability Department, there are approximately 1,000 users at UBC. The differences in cost between each radiant panel and the ceramic model have been calculated before, so what is needed it to expand it for 1,000 heaters.

Radiant Panel Heaters	Energy Cost Savings per year
INDUS-TOOL "Cozy Legs" Radiant Heating Panel (100 W)	45.28 x 1,000 = $ 45,280.00
INDUS-TOOL "Cozy Legs" Flat Panel Heater (150 W)	43.66 x 1,000 = $ 43,660.00
QMARK Electric Flat Panel Radiant Heater (170 W)	43.01 x 1,000 = $ 43,010.00
DAYTON Heater Radiant Flat Panel (650 W)	27.49 x 1,000 = $ 27,490.00

Table 5: Energy Cost Savings per year

Another recommendation from the project stakeholder Lillian Zaremba was that a payback period of 2 years or less is desired to fund a project. It can possibly be up to 5 years, although 2 years is preferred. By taking into consideration the payback period of each product, its power and the energy cost savings, it was decided that the model that was going to be tested was Cozy Legs (150W). The DAYTON model (650W) exceeds the payback period constraint at 6.6 years. Cozy Legs (100W)'s power was too low compared to the other options, so it might not be able to provide enough heat. Both Cozy Legs (150W) and QMARK (170W) have similar power ratings but they differ significantly in their cost and payback period, with the QMARK at a higher price. There are the reasons why Cozy Legs (150W) was picked as the best economical choice. It will take approximately one year, six months and eighteen days for UBC to recoup the money spent to purchase the heaters and allows for electricity savings of $43,660.00 per year. A picture of the Cozy Legs (150W) heater is shown in Figure 1 below.

Figure 1: Heater chosen: INDUS-TOOL Cozy Legs Flat Panel Heater (150W). Retrieved from http://www.cozyproducts.com/cozy-legs-products-27.php?page_id=57

5.0 ENVIRONMENTAL ASPECT

The second Triple Bottom Line assessment requires the product to be reviewed from a sustainability perspective. In this report two main environmental factors of using office heaters will be assessed to determine the best heating choice – energy demand consumption and user control over efficiency.

5.1 ENERGY DEMAND AND CONSUMPTION

Currently, a single space heater in the office can demand up to 1% of the total building's power and can overload an electrical circuit [8]. As Figure 2 shows, the World Energy consumption in 2008 was 505 quadrillion Btu, and this will only steadily increase into 2035. The U.S. Department of Energy's report in 2001 stated that the use of radiant panel heating energy technology in residential heating systems has provided cumulative energy savings of 1.45 trillion Btu[9], avoided almost $1.9 million dollars in electricity costs, and reduced CO_2* emissions by as much as 97000 tons through the year 2000.

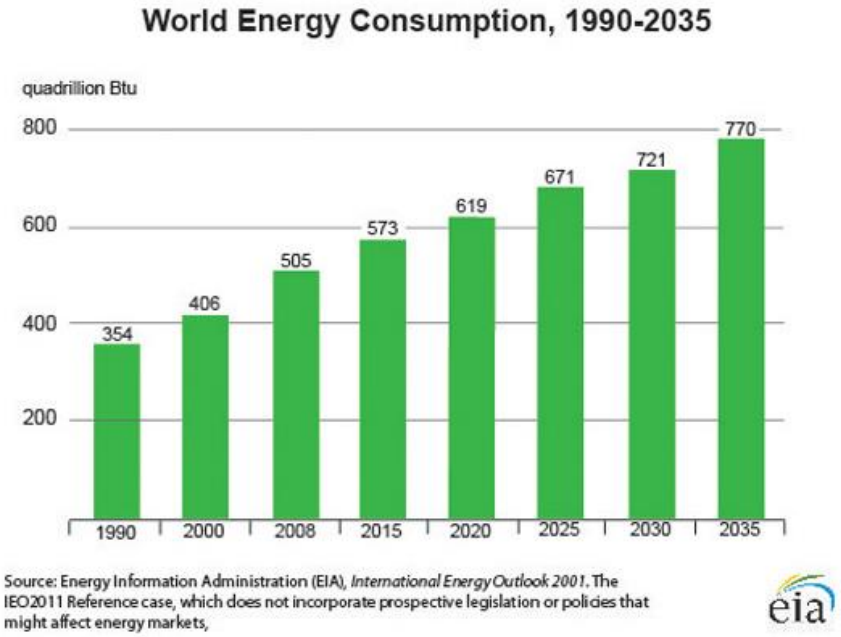

Figure 2. World Energy Consumption from 1990 – 2035. Image Retrieved from http://www.cozyproducts.com/heating-cost-calculator-pages-251.php.

When this radiant panel heating technology is applied to office space heaters, the Cozy Legs manufacturer's website shows that if 10 regular 1500W regular office heaters are replaced by ten 150W Cozy Legs heaters, the total electricity costs can be cut by over 90% [10]. This is shown in Figure 3. Additionally, the CO_2 emissions can be reduced by a total of 14.57 tons per year [10]. Compared to the annual CO_2 emission of 5.1 metric tons from a passenger vehicle [11], this is equivalent to almost to the total emissions from 3 passenger cars per year. Table 6 shows the total amount of energy that will be saved for UBC with 1000 units of each heater model per year by replacing the current heaters. Being the heaters with one of the lowest power rating out of the four models being studied, the two Cozy Legs (100W) & (150W) will be the heaters that provides the most waste reduction and energy savings.

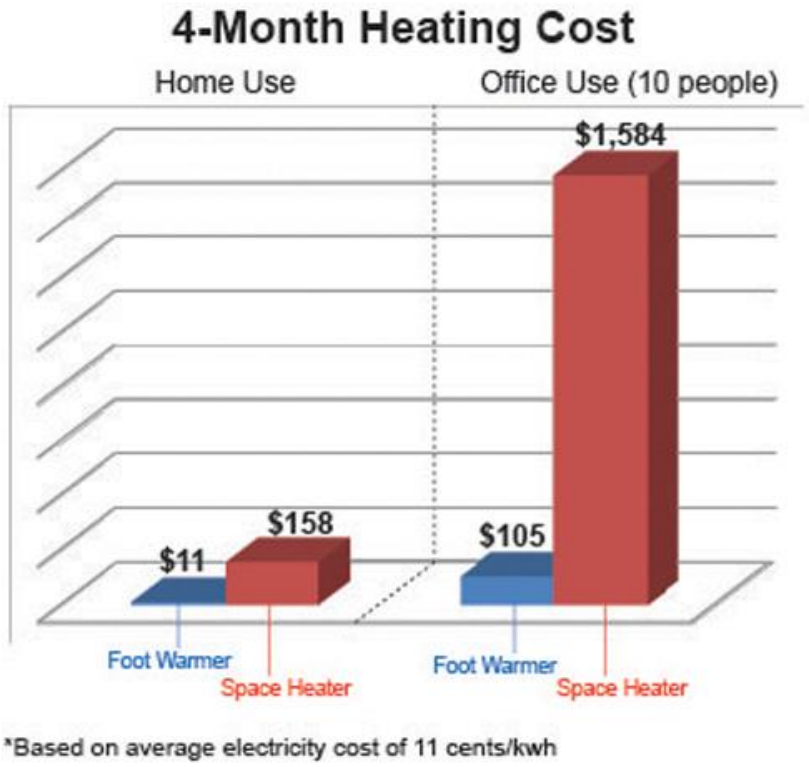

Figure 3. A 4-month electricity cost comparison between 10 regular office heaters and 10 Cozy Products heaters. Image Retrieved from http://www.cozyproducts.com/heating-cost-calculator-pages-251.php.

Calculation of the energy consumption of 1000 heaters	Energy Consumption per Year	Energy Saved per Year
Ceramic model (1500W) C = 1.5kW x 600h x 1000 = 900000kWh	900000kWh	--
INDUS-TOOL Cozy Legs Radiant Heating Panel (100W) C = 0.1kW x 600h x 1000 = 60000kWh	60000kWh	840000kWh
INDUS-TOOL Cozy Legs Flat Panel Heater (150W) C = 0.15kW x 600h x 1000 = 90000kWh	90000kWh	810000kWh
QMARK Electric Flat Panel Radiant Heater (170W) C = 0.17kW x 600h x 1000 = 102000kWh	102000kWh	798000kWh
DAYTON Heater Radiant Flat Panel (650W) C = 0.65kW x 600h x 1000 = 390000kWh	390000kWh	510000kWh

Table 6. Comparison of amount of energy saved for 1,000 heaters of each model per year.

5.2 ENERGY EFFICIENCY SETTINGS AND CONTROLLABILITY

One sustainable goal related to the space heater would be to maximize energy efficiency, which can be achieved with some features added to the product. Some examples of such desired features would be multiple settings to control the heat level output, or have a mechanism to measure the temperature of the heater and ensure that no more unnecessary power is supplied after the heater reaches a certain temperature.

According to the product descriptions of the radiant panel heaters on Ackland Grainger and Home Depot's online shopping websites, all four models that were investigated for this project had only one heat level setting. This means that the heat level cannot be controlled, thus

reducing the controllability of the heater's energy efficiency. Since all four models do not have this feature, this was not regarded as a major factor when choosing our final heater.

However, in terms of temperature control, according to the Cozy Products company's website, the Cozy Legs (150W) radiant panel heater has a built-in thermostat to monitor its temperature [12]. When the Kilowatt meter was used to test the power output of this heater, the initial power level was read to be around 149-150W, which matches the marketed power output of 150W. Over time as the heater slowly heats up, the meter reading decreases slowly to around 140W and slightly fluctuates. This observation could be due to less power being used after the heater has already heated up, indicating that it is very energy conservative, putting it at an advantage compared to other radiant panel models.

6.0 SOCIAL ASPECT

Safety, comfort, practicality, ease of use, quality, and testing performance are some key elements that contribute to the social aspect of triple bottom line. Primary data was collected through a survey and also a feedback form from 3 UBC employees that currently use the ceramic heater. The following sections provide statistical analysis regarding social concerns towards heaters, especially the radiant panel. The analysis discusses specific features and reveals the most recent thoughts about personal heaters on UBC campus.

6.1 FACTORS AND FEATURES

Some important factors that people take into consideration when purchasing space heaters are: comfort, price, safety, ease of use, appearance and quality. In addition to these factors, office workers also look for features such as low noise, auto shut-off, temperature control, safety and maximum heat output.

UBC staff's relative preferences to these factors are shown in Figure 4, with a ranking of 1 being the most important and 6 the least important. Individuals rank quality (2.5), comfort (2.61) and safety (2.64) as their main concerns when they purchase a heater. Ease of use (3.09) might be considered as well, although price (4.14) and appearance (4.91) do not seem to be relevant to them due to the high rank received.

Rank	Factors	Average Ranking
1	Quality	2.50
2	Comfort	2.61
3	Safety	2.64
4	Ease of Use	3.09
5	Price	4.14
6	Appearance	4.91

Figure 4 - Average Ranking of Importance of Different Factors when Choosing Personal Heaters.

By analyzing the most important features for UBC staff, it is possible to notice in Figure 5 that safety (2.13), low noise (2.39) and temperature control (2.48) are the most desirable features. Auto shut-off (3.09) and maximum heat output (3.86) are not their first choice when choosing a heater. A rank of 1 in Figure 5 means the most important feature, while a rank of 5 corresponds to the least important feature.

Rank	Features	Average Ranking
1	Safety	2.13
2	Noise	2.39
3	Temperature Control	2.48
4	Auto Shut-off	3.09
5	Max Heat Output	3.86

Figure 5 - Average Ranking of Importance of Different Features when Choosing Personal Heaters.

Both analysis indicate that the major interests are: quality, comfort, low noise, safety and temperature control. The Cozy Legs (150W) meets three out of the five requirements. The product has good quality and it is extremely safe, due to the fact that it has very good heat and electrical insulation, non flammable or combustible. This heater has received the ETL List Mark, ETL Zero-Clearance Rating, and TUV certificates.[13] Having ETL List Mark and ETL Zero-Clearance Rating indicates that this electrical product meets North American standard and can be place near flammable and combustible materials without being a fire hazard. TUV Certification verifies the quality of the product, showing that the products were tested thoroughly. Additionally, the product has a low chance of causing burn injuries, can operate with little to no noise, and is very portable, being easy to carry around and mountable on walls.

The unmet requirements are comfort and temperature control. The Cozy Legs (150W) and all the other radiant panel models do not have settings and controllability over its temperature due to its low power and heat output compared to other types of heaters, but the product has a built-in thermostat to monitor its temperature, according to Company's website [12] . According to Nicol and Humphreys (2012) [14], having the right temperature is one of the most important aspect of a building, but even with the right temperature, not all people will be

satisfied because it is a personal preference. This is one reason UBC staff use heaters, with the other reason being that some offices are really cold due to old and poorly designed heating systems. Consequently, they have to use heaters to warm up their entire room. Therefore, the Cozy Legs (150W) does not meet the comfort requirements because it is just designed to warm the feet and legs.

Survey participants were also asked to rate their interest to trade in their current heater for other models without any previous product testing. Higher ranking indicates higher preference. The average score for the radiant panel was 2.17 out of 4 as shown on Figure 6. Their first choice is the convective heater with a score of 3.14 out 4, and their last choice would be the radiant carpet with a score of 2.09 out of 4. The preference for the convective heater shows that staff is more interested in heaters that can provide more heat output to warm up the entire office.

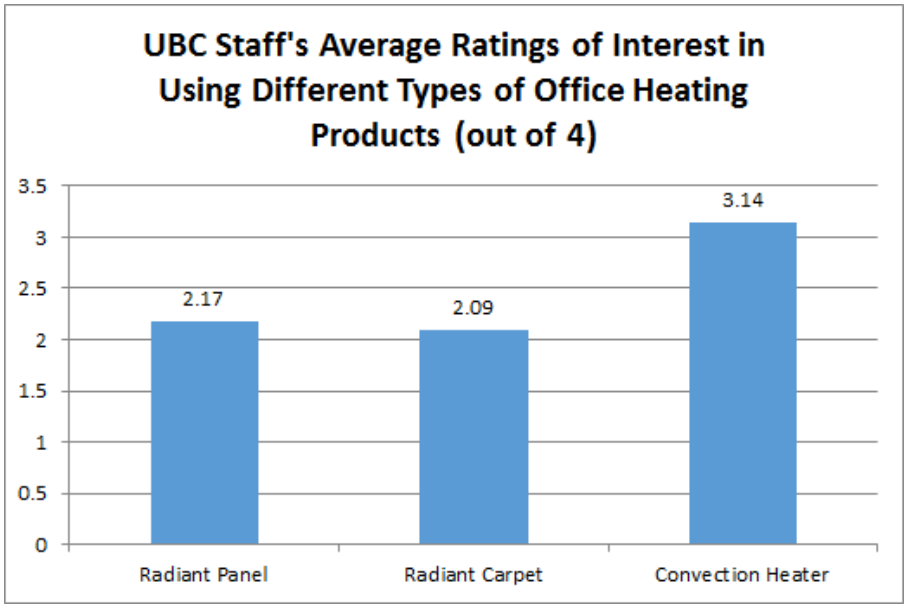

Figure 6. Comparison of UBC Staff's Average Ratings of Interest in Using Different Types of Heating Products out of a score of 4.

6.2 TESTING PERFORMANCE

Testing a product is one of the best ways to check its features and see whether or not it is a good choice for the target consumers. The Cozy Legs (150W) was tested by 3 UBC employees who have never had a previous experience with the radiant panel. When ranking the each

element, they had five choices: very bad, bad, neutral, good and very good. The feedback is shown in Table 7.

Testers	Tester 1	Tester 2	Tester 3
Comfort Level (warmth)	Bad	Very Bad	Good
Safety	Neutral	Neutral	Excellent
Portability	Bad	Neutral	Good
Overall Appearance	Neutral	Good	Good
Performance of the radiant heater compared to your current heater	Bad	Very Bad	Neutral
Would you choose the radiant panel and help save energy?	NO	NO	YES

Table 7 - Cozy Legs' (150W) feedback from testers

The testers agreed that Cozy Legs (150W) provides good appearance and safety level, but there is some disagreements regarding its portability. On average, the heaters' portability is neutral, although it is important to highlight that the model can be mounted on walls and it is generally placed under an office desk, with no need to be carried around. In general, the comfort level (warmth) and the radiant panel performance compared to current heater was bad, only one tester (33%) would go with the Cozy Legs (150W), and two testers (66%) would not choose the radiant panel to help save energy. The reason two testers answered no, is that they use a ceramic heater to warm up their entire office and the radiant panel cannot provide as much warmth as their original heaters. The Cozy Legs (150W) is a good choice for people who already have a good temperature in their offices, but would occasionally use the radiant panel to provide more comfortable in their feet and legs.

7.0 CONCLUSION AND RECOMMENDATIONS

As the triple bottom line analysis for the economic, environmental, and social aspects of these heaters show, the Cozy Legs (150W) model can greatly reduce the energy consumption and demand by 90%. This radiant panel heater is both an economical and environmentally feasible choice for UBC, at a value of $67.66 per unit with a payback period of 1.55 years. It also saves UBC up to a total of $43,660.00 on electricity costs and 840000kWh of energy from 1000 units per year. The social analysis indicates that the major interests of UBC staff when choosing heaters are: quality, comfort, low noise, safety and temperature control. The Cozy Legs (150W) provides little to no noise, it has good quality and it is also very safe, due to its effective heat and electrical insulation, non flammable or combustible. Although there is no temperature control, the product has a built-in thermostat to monitor its temperature, according to Company's website. Moreover, the Cozy Legs (150W) only provides comfort to the feet and legs, not for the entire room. Additionally, UBC staff also rated their interest in using a radiant panel heater at 2.17 out of 4 from the survey, and testing feedback indicated that 2 out of 3 testers would not choose this model, while one tester will. This is due to a large number of UBC staff currently work in big offices where their need for space heaters is to heat the entire room instead of just their body. The Cozy Legs heaters and most radiant panels are unfortunately not designed to do that due to their low power output.

The final recommendation for UBC is to offer the Cozy Legs (150W) heater only to those people who require a little warmth to be comfortable. UBC can also consider extending its payback period limitation to over 5 years and test the Dayton (650W) model. This model can offer UBC a 56% energy saving, but the payback period of 6.6 years is the only thing holding this product back from being considered as a serious candidate. Another recommendation for UBC is to take into consideration other types of heaters, such as the convection heaters, which are designed to output more power.

REFERENCES

[1] Atlantic Comfort (2013) *Electric Heaters Advanced.* Retrieved from: http://www.atlantic-comfort.com/our-products/electric-heaters/electric-heaters-advanced

[2] 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

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

[4] Global Industrial. (2013) *Indus-Tool Cozy Legs Radiant Heating Panel.* Retrieved from http://www.globalindustrial.ca/p/hvac/heaters/personal/radiant-heating-panel-with-stand-100w-at-120v?utm_source=ShopBot&utm_medium=cpc&utm_campaign=Personal-google_pr&infoParam.campaignId=T92

[5] Home Depot. (2013) *Cozy Products | Cozy Legs Flat Panel Heater*. Retrieved from http://www.homedepot.ca/product/cozy-legs-flat-panel-heater/839162

[6] Acklands Grainger. (2013) *Electric Flat Panel Radiant Heater.* Retrieved from: http://www.grainger.com/Grainger/QMARK-Electric-Flat-Panel-Heater-1DKW3

[7] Acklands Grainger. (2013) *DAYTON Heater Radiant Flat Panel.* Retrieved from: https://www.acklandsgrainger.com/AGIPortalWeb/WebSource/ProductDisplay/globalProductDetailDisplay.do?item_code=GGE1VNY1

[8] Richer,L., Zaremba, L., et al. (2013) *APSC 261/262 Sustainability Project - September 2013: Project Options*. UBC APSC 261 Course Material. Retrieved from http://connect.ubc.ca

[9] U.S. Department of Energy. (2001) *Direct Source to Object Radiant Heating Panels.* Retrieved from http://www.heatinggreen.com/docs/sshc.pdf

[10] Cozy Products. (2013) *Heating Cost Calculator.* Retrieved from http://www.cozyproducts.com/heating-cost-calculator-pages-251.php

[11] United States Environmental Protection Agency. (2011) *Greenhouse Emissions from a Typical Passenger Vehicle*. Retrieved from: http://www.epa.gov/OTAQ/climate/documents/420f11041.pdf

[12] Cozy Products (2013) *Cozy Legs - Flat Panel Radiant Heater.* Retrieved from http://www.cozyproducts.com/cozy-legs-products-27.php?page_id=57

[13] Cozy Products. (2013) *Space Heater Safety.* Retrieved from http://www.cozyproducts.com/space-heater-safety-pages-231.php

[14] Nicol, F., Humphreys, M. & Roaf, S. (2012). *Adaptive Thermal Comfort: Principles and Practice.* Winnepeg MB: Routledge. Retrieved from http://www.ubc.eblib.com.ezproxy.library.ubc.ca/patron/FullRecord.aspx?p=956913