An Investigation into Low-Wattage Convection Heaters

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ABSTRACT

During the cold winter time, UBC buildings must provide a warm environment to staff, students, and faculties. However, individual thermal comfort differs in age, metabolic rate, gender, and many other factors. Personal heaters are commonly used in offices and workplaces to address the problem. A typical convection heater needs 1500 W to operate, which is equal to fifteen 100 W light bulbs operating at the same time in a single room. Nevertheless, these heaters can overload the power grid, trip the breaker, and confuse the building HVAC sensors which will trigger cooling system, causing more discomfort among the personnel.

A triple bottom line analysis is used to evaluate the environmental impact, social acceptance, and economic profit of an energy efficient convection heater model. The primary investigation includes the market field trip, scholar journal, sustainability survey, and product reviews by UBC members, which were used to determine the heater model. Survey results and user feedback showed that UBC members care about campus sustainability and are willing to try efficient convection heaters. Supplementary investigation such as online research, online product review, and manufacturing background information will help further understand the sustainability of the product. The manufacturer of the suggested heater model was found to be very self-sustainable. Almost no ground or water pollution was produced in the process.

This project focuses on the efficient convection heaters available in Vancouver. As the result, a heater model that is energy efficient, safe, quality ensured, user friendly, and economic profitable should be recommended to future workplace use. It was concluded that the suggested convection heater with temperature control would fit the requirement above. A trade-in program could be done in the future to improve the campus sustainability.

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We would like to thank Carmen Raiche, the administrative assistant, for buying the heater for us.

Special thanks to the unknown carpenters who made the wooden stand so that the heater could be tested.

Special thanks to the staff and faculty in one of the Kaiser building offices for helping to distribute our survey.

We are grateful to Carol Jaegar for testing the heater for us.

Lastly, we would like to extend a word of thanks to the other heater and blanket groups for their collaborative efforts in distributing the surveys.

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1.0 INTRODUCTION

This report is an investigation of the proposal to replace current heaters in UBC buildings with low-wattage convection heaters through a triple bottom line analysis. The triple bottom line is a measure of sustainability that looks at the social, economic, and environmental impacts. One low-wattage convection heater model, the Econo-Heat Wall Panel heater, a.k.a. eHeater, is used as a representative for low-wattage convection heaters in general. Social impacts are measured by conducting surveys of UBC staff that use heaters, while economic and environmental impacts are measured by looking at the specifications of the eHeater. After analysis of these impacts, recommendations are given in the conclusion of this report regarding the proposal to replace current heaters.

2.0 BACKGROUND

This section underlines the prevalent problems with current personal heater usage, as well as the proposed project to remedy it.

2.1 PROBLEM

In UBC buildings, many occupants use personal heaters to stay warm during cool weather. This has an effect on the demand and consumption of energy performance, depending on the heater used. Most convection heaters will draw 1500 W, or watts, of power, which comprises almost one percent of the power provided by most buildings. In addition to potentially overloading the circuit, the use of heaters may trigger the building's cooling system due to higher temperatures, which defeats the purpose.

2.2 SOLUTION

To satisfy the need for personal thermal comfort while minimizing energy consumption, it is necessary to investigate energy-efficient personal heaters. These efficient heaters could replace current heaters, which reduces both energy and electricity costs. This project proposes heater replacement for free; the purchasing costs would be reimbursed by the savings in electricity.

There are several groups in this project and several groups in a similar project, the latter of which investigates blankets for replacing personal heaters. The former project considers three heater models: radiant panel, radiant carpet, and low-wattage convection heater. These are to be compared to a conventional 1500W convection heater for a triple bottom line analysis. In this report, the low-wattage convection heater is examined.

A convection heater works by circulating the air and using a heated surface to warm up the air as it moves through the heater. Unlike radiant heaters, which use infrared radiation to provide heat to solid bodies and objects, convection heaters provide heat to the air, which keeps the area warmer for longer periods of time. Low-wattage convection heaters use less power than the typical convection heater at the expense of heating a smaller space.

3.0 METHODOLOGY

In preparation for experimental testing and user feedback, surveys were distributed to various buildings. To determine the best heater model, product research was conducted.

3.1 SURVEY

A sustainability survey was collaboratively composed by several heater and blanket groups to be distributed among different buildings on UBC campus. To get subjective and complete results, the survey included questions regarding energy conservation awareness, personal thermal comfort in workplace, and current solutions to personal thermal comfort. It was refined by stakeholder to suit the style and content in workplace. The survey is included in Appendix A for reference. A total number of fifty surveys were distributed in the Kaiser, MacLeod, and Buchanan buildings. Participants majorly consisted of faculty with some staff members in these buildings. The surveys were collected and analyzed using an Excel spreadsheet, and major results regarding the convection heater were put into charts for direct impression and analysis. The survey spreadsheet is included in Appendix B.

3.2 PRODUCT RESEARCH

Online product research was conducted before going to local retailers. A few convection heater models were found within the Vancouver area. These models were examined carefully in-store, and after discussion, the Econo-Heat Wall Panel Heater, or eHeater, was decided to be purchased and tested. It was also noted that these convection heaters either need hardwire installation or wall mounting. The AMS Sustainability office sponsored the model, and the stakeholder found a carpenter who could make a wooden test stand for the heater. This wooden stand enabled the heater could be tested without having to mount the heater on the wall. The heater on the stand is shown in Figure 1 and Figure 2 below.

Figure 1: Front view of the eHeater on the wooden stand.

Figure 2: Side-view of the eHeater on the wooden stand.

Survey results showed there were personnel in Kaiser using personal heaters. The suggested heater model was delivered to them to test out for a few days. Short interviews were arranged to get their short-term using feedback. The interview results were collected as primary data for analyzing the convection heater.

Online product investigation was also conducted to find relevant user feedback and manufacturing background information. Scholarly journals were reviewed to learn about personal thermal comfort.

4.0 RESULTS

Out of approximately fifty participants in the survey, about seventy-seven percent care about energy conservation in the workplace. Safety, noise, and temperature control were the top three factors that people considered when buying personal heaters. The peak heater usage months were November, December, January, and February, typically the coldest months of the year. The average heater usage time was 3.5 hours per person per day. In general, an efficient convection heater as a replacement for a typical 1500 W heater was considered acceptable by the participants. The survey result charts are included in Appendix B.

The in-store investigation showed that a few convection heater models were available. These models included: a wattage adjusting model, a low wattage baseboard model, and a tested 400 W model. The wattage adjusting model allows the user to switch between 750 W and 1500 W of energy consumption. The low wattage baseboard model needs hardwire installation and provides heat for a small area of about 80 square feet. In the end, a 400 W model, the Econo-Heat Wall Panel Heater, was then selected to be purchased and tested. Online product background research provided information about the manufacture of the eHeater.

5.0 ANALYSIS

Using the results of the survey along with manufacturing information, user reviews, and product specification, a triple bottom line analysis was conducted on the eHeater.

5.1 ECONOMIC IMPACT

In the economic impact analysis, the costs of using the eHeater and the survey results are used to calculate the payback period.

5.1.1 COSTS

The cost of the eHeater that was chosen is $99. Meanwhile, the cost of installation is negligible. An installation kit is supplied and most people can install the heater in 20 minutes or less.

5.1.2 PAYBACK PERIOD

Energy savings were calculated using the UBC electricity rate. This was given by the stakeholder as $0.0539/kWh. For a typical 1500 W heater, the cost of use for eight hours is:

$$= \$0.0539/kWh \times 1.5kW \times 8h = \$0.6468$$

The cost of using an eHeater for eight hours is:

$$= \$0.0539/kWh \times 0.4kW \times 8h = \$0.17248$$

This gives **a payback period per heater** of:

$$= \$99 / (\$0.0539/kWh \times (1.5\text{-}0.4)\ kW) = 1670 \text{ hours per heater.}$$

For UBC to fund a project, it is preferred that the payback period is two years at the most. Assuming that every eHeater is used for eight hours per day, for twenty days per month (counting only weekdays), and for five months per year (November to March), the payback period would be a little over two years (10.4 months) which is an idealized scenario.

In reality, heater usage is not as extensive. The survey results show that a single heater is used for 3.5 hours per day on average. If each weekday is equally likely to be a cool day, it can still be assumed that a heater would be used for roughly twenty days per month. This means that a heater is used for 70 hours per month. The sample data for monthly heater usage shows that an average of 7.7 heaters is used every month for twelve months per year. Therefore, there are roughly 539 hours of heating per month, or 6468 hours of heating per year. The cost savings are then $383.50 per year. In this sample, the number of heaters is assumed to be 21, as there are 21 heaters used in January (typically the coldest month). This means the total purchasing cost is $2079. As the calculations for the number of heaters involve a percentage (7.7/21 heaters), this can be

generalized to the population of people who use heaters. Thus, **the payback period as extrapolated from the survey** is:

= ($99 × 21) / ($0.05929/h × 6468 h/yr.) = 5.42 yr.

It should be noted that the three buildings surveyed typically do not have heating problems. In colder or less heat evenly distributed buildings, it is probable that personal heaters would be used for longer periods of time for a greater portion of the year.

5.1.3 MAINTENANCE

The eHeater is covered by a 3-year warranty. After examining many personal heaters, it was estimated that the average warranty is about one year. Therefore, switching to the eHeater would lengthen the warranty time and reduce the user maintenance required. The eHeater is also easy to install and contains few parts; it is, for all intents and purposes, a ceramic board. For disposal, the heater can easily be given to an electronics expert for reuse.

5.2 ENVIRONMENTAL IMPACT

The environmental impact analysis mainly considers the energy consumption when using the heater, as well as the manufacturing process for considering the impact of the materials used.

5.2.1 ENERGY CONSUMPTION

The typical convection heater uses 1500W, while the eHeater uses 400W. This means eHeater covers approximately 120 square feet for normal winters, or 90 square feet for very cold winters.

When the eHeater was tested using a kilowatt meter, the power measured was a steady 380W, even when left on for five hours. The eHeater can be used for at least three hours before the energy consumption equals the energy consumption of a typical 1500W heater that is used for one hour. Despite having the benefit of lower energy consumption, this heater does not have a temperature adjuster, so it can only be used at 400W, or not at all. Therefore, if the user only wants a portion of the heat supplied, the rest of the heat is wasted, possibly making this heater less efficient than a regular heater that contains a temperature adjuster.

If the eHeater is compared to a heater that automatically shuts off when it reaches a certain temperature, the lower power consumption of the eHeater should still be better. Further tests could be conducted to see the exact amount of time for which a heater with a thermostat operates, but if the heater with the thermostat is assumed to operate for only half the time the eHeater operates, then the eHeater is still more energy efficient. An upgraded version of the eHeater is available with an adjustable thermostat and timer that can set the temperature to a specific temperature, but this will cost an extra $60.

5.2.2 MANUFACTURING PROCESS

According to the Econo-Heat specifications, not only is the eHeater environmental friendly, but the manufacturing process also has minimal environmental impact. The efficiency in the production of the eHeater was increased in 2010, with dust pollution kept at a minimum and noise pollution blocked by soundproof enclosures. Currently, there is no ground or water pollution in the manufacturing process. The eHeater is made of fiber cement with about fifteen percent of it composed of wood pulp. The heater is packaged inside a fully recyclable cardboard box and has recyclable plastic parts.

5.3 SOCIAL IMPACT

When looking at the social impact, it is necessary to consider the safety and user-friendliness of the heater, in addition to the global impacts.

5.3.1 SAFETY

Safety was the top concern of users. The US Consumer Product Safety Commission estimated that there are 25,000 residential fires caused by space heaters every year, causing approximately 300 deaths and 6,000 injuries. However, the Econo-Heat Company claims that the eHeater is non-flammable and non-combustible.
According to the Econo-Heat website, the panel heater is made of a non-metal material and has no exposed elements. It will also not tip over while mounted on the wall. Despite this, it has a surface temperature of about 70-90°C and can easily inflict burn injuries. Most children at the age of two years or older will possess the “pain reflex” necessary to avoid these injuries, but it is strongly advised that young children are constantly supervised while the panel heater is in use.

The eHeater lacks a thermostat and therefore does not shut off automatically when the temperature of the room becomes too hot. This causes inconvenience and raises safety concerns for users.

The eHeater does not contain materials that are dangerous to health because it is made of asbestos-free fibre-cement, unlike regular manufactured fibre-cement. It does not dry up the air in the room to heat it up, like other heaters do.

5.3.2 COMFORT

According to reviews on Amazon.com and Home Depot.com, the eHeater is pleasantly aesthetic and makes virtually no noise. The thermal comfort provided is satisfactory given the size and power of the heater. Moreover, the eHeater does not produce unpleasant odors.

5.3.3 EASE OF INSTALLATION

A convection heater draws in cold air from the floor of the room and circulates the warm air around the whole room. Therefore, as room features affect the efficiency of the eHeater, choosing a proper location is essential. The eHeater is not recommended to be installed in a room with inadequate insulation or numerous windows, in a floor plan with open access to other rooms, or near a stairway or an exterior doorway. However, the problem of inadequate insulation can be solved by adding a reflective thermal shield.

The eHeater is a wall-mounted heater, but the installation is simple. The eHeater can be quickly installed by drilling four holes on either soft or hard walls. Clear instructions and installation kit are provided by Econo-Heat. As previously mentioned, installation requires twenty minutes or less.

5.3.4 LABOUR STANDARDS

The eHeater is made in South Africa, which creates job opportunities there and can stimulate South Africa's economic growth. In September 2012, the Econo-Heat Company won first place in all three categories: innovation, job creation and sustainability, at the South African Industrial Development Corporation Business Partners competition.

6.0 CONCLUSION

It is recommended that the heater model chosen by UBC is one of two options: buy an advanced version of the Econo-Heat Wall Panel Heater that has an integrated thermometer and temperature adjustment system, or buy the regular Econo-Heat Wall Panel Heater in addition to a thermostat for an additional $11.

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APPENDIX A - SURVEY

Thank you for taking the time to fill out this survey. This survey is being conducted as part of an APSC 261 class project to learn more about workplace attitudes toward thermal comfort and use of products including heaters and blankets. The results have the potential to contribute to energy efficiency and conservation in UBC buildings.

Please circle your choice of answer for each question below.

1. I care about energy conservation in my workplace.

   I care very much – 1 2 3 4 5 – I care not at all

2. I would guess that a portable heater uses as much electricity as:

   A) 1 x 100 W lightbulb B) 15 x 100 W lightbulbs C) 50 x 100 W lightbulbs D) I don't know

3. To keep warm in my workplace, I currently do the following: *(select all that apply)*

   A) Drink a hot beverage
   B) Wear warmer clothes
   C) Put on additional layers
   D) Use a blanket on my lap
   E) Use a shawl/throw around my shoulders
   F) Close door(s)
   G) Close window(s)
   H) Close blinds or curtains
   I) Get up and walk around
   J) Turn on an electric heater
   K) Turn up the thermostat
   L) Call UBC Building Operations
   M) Other _____

If you answered (J) above, please answer the following 3 questions.

3.1 My current personal heater most closely resembles: *(please circle one)*

A) 
B) 
C) 
D) 

3.2 I typically need to use my personal heater in these months: *(circle all that apply)*

Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

3.3 When I use my personal heater, I typically turn it on for (approx.) _____ hours per day

4. Please rank the following factors in terms of importance when choosing a thermal comfort product such as a heater or blanket, *1 being most important and 6 being least important.*

   Appearance ___ Comfort ___ Ease of use ___ Price ___ Quality ___ Safety ___

5. Please rank the following features in terms of importance when selecting a personal electric heater for use in the workplace, *1 being most important and 5 being least important.*

   Auto-shutoff ___ Noise ___ Max. heat output ___ Safety ___ Temperature control ___

6. If a replacement product were provided free of charge, I would be willing to use the following instead of my current personal heater: *(select all that apply)*

Heated blanket A) Definitely B) Maybe C) Probably not D) Definitely not 	Efficient convection heater A) Definitely B) Maybe C) Probably not D) Definitely not 
Radiant panel heater (for legs) A) Definitely B) Maybe C) Probably not D) Definitely not 	Radiant carpet (for feet) A) Definitely B) Maybe C) Probably not D) Definitely not 
Blanket or throw (non-electric) A) Definitely B) Maybe C) Probably not D) Definitely not	

7. Please rank your preference for the following types of blankets for use at your desk, *1 being most preferred and 4 being least preferred.*

Fleece ___ 

Silk & polyester ___ 

Heavy knit ___ 

Double-sided knit/cotton ___ 

I am: Staff ___ Faculty ___ Graduate student ___

I work in: _____ (building name)

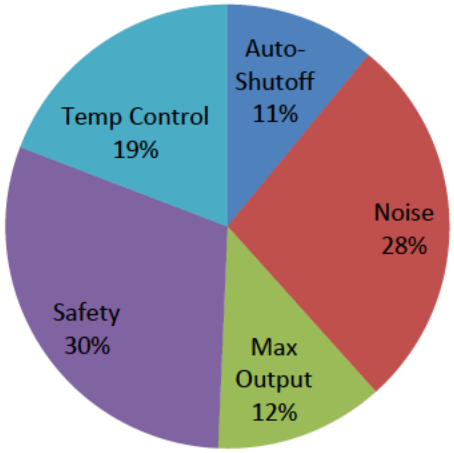
Comments:

Thank you! Please direct any questions to the staff sponsor for this project:
Lillian Zaremba, Climate and Energy Engineer, Campus Sustainability, 827-3441, lillian.zaremba@ubc.ca

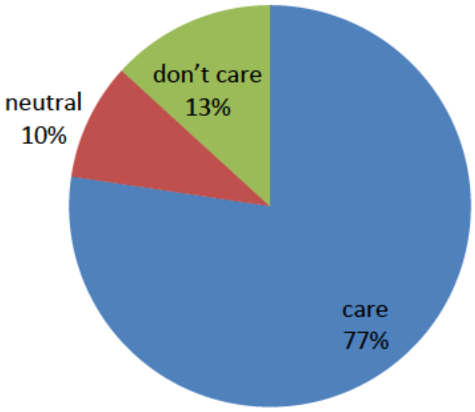
APPENDIX B - SURVEY RESULT SPREADSHEET

Q1	care	neutral	don't care								
	41	5	7								
Q2	A	B	C	D							
	1	17	9	17							
Q3	A	B	C	D	E	F	G	H	I	J	K
	30	40	25	5	10	5	31	5	11	15	4
L	Other										
8	1 (Large Oil Heater)										
Q3.1	A	B	C	D	Other						
	8	9	1	1	Radiant						
Q3.2	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	
	21	16	6	2	2	1	0	0	4	6	
Nov	Dec										
14	20										
Q3.3	average 3.5hrs per person per day										
Q4	Appearen	Comfort	Ease of Us	Price	Quality	Safety					
	1	23	23	13	28	19					
Q5	Auto-Shut	Noise	Max Outp	Safety	Temp Control						
	8	20	9	22	14						
	Heated Blanket					Radiant Panel					
Q6	A	B	C	D		A	B	C	D		
	3	11	5	17		4	13	10	9		
	Convenctional Heater					Radiant Carpet					
	A	B	C	D		A	B	C	D		
	12	16	1	6		2	14	8	11		
	Blanket or Throw										
	A	B	C	D							
	9	13	5	10							
Q7	Fleece	Silk	Heavy Kni	Double S.							
	19	4	11	3							

Important Factors when Buying Heater



Attitude towards Energy Conservation in Workplace



Number of Heaters Used in Each Month