An Investigation into Blankets to Replace Personal Heaters in Offices

Charlie Zhang, Kevin Shen, Pouya Memar

University of British Columbia

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Pouya Memar

Charlie Zhang

Kevin Shen

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Dr. Carla Paterson

Acknowledgements

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ABSTRACT

This report investigates the possibility of replacing heaters in offices at UBC with blankets for warmth. Often occupants use personal heaters to keep warm during cold months, as it is very challenging for all occupants in a building to reach optimal thermal comfort at all times. The triple bottom line method was used to compare the environmental, economic, and social aspects of heater and blanket usage. To evaluate the economic impact of heaters, the cost of operating a heater was calculated and compared with the cost of purchasing and maintenance of blankets to determine the payback period. The environmental aspect of the project was investigated by considering the carbon emissions of heater usage and washing and drying of blankets. A survey was distributed at one of the buildings at UBC where it is known that occupants use personal heaters for warmth. It was found that there are advantages in switching from heaters to blankets with respect to economics and environment, however occupants are resistant to the idea of using blankets for warmth.

Finally, in the conclusion section recommendations are made to purchase more efficient and environmentally friendly heaters to replace the heaters that occupants are currently using, as well as to educate the people who are using heaters about the environmental and economic disadvantages of heaters.

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GLOSSARY

kWh	A unit of energy equivalent to one kilowatt (1kW) of power expended per hour.
Polyester (PET)	A category of organic polymers with useful properties, such as durability, wrinkle resistance and high colour retention.
Payback period	The length of time required for the blankets to recover its initial outlay in terms of savings.
Acrylic (fibre)	A lightweight, soft, and warm fibre with a wool-like feel that can mimic other fibres such as cotton.
Ceramic heater	A space heater that passes electricity through a high resistance wires embedded in ceramic plates to produce heat.

1.0 Introduction

Balancing internal temperature is one of the most important functions performed by the human body. A healthy body is able to produce anywhere between 80 and over 1000 Watts of heat depending on the activity, from sleeping or rigorous exercise (Fung, 2002). If there is excess heat in the body, it is dissipated to the surroundings by conduction, convection, radiation, or evaporation (Saville, 1999). The goal of this is to maintain a constant temperature of 37 ℃. It has been shown that a drop in temperature as small as 2 ℃ will induce violent shaking and poor coordination and at the other end, if the body retains more heat than it expels, the person can become fatigued and stressed (Fung, 2002). As such, there is tremendous interest in thermal comfort giving rise to modern technologies such as air conditioning, and complex heating systems in buildings.

2.0 Background Information

It is extremely challenging to design a building in which all occupants feel comfortable with the temperature in the building. This may be due some spaces in the building being warmer or colder than others or it may be due to fundamental physiological differences between individuals. It is known that office workers in numerous buildings at UBC use personal heaters for warmth. The demand of these heaters can be high and when running at maximum power, they can draw as much as 1% of the total power of the building. Using the triple bottom line methodology, this report attempts to investigate the possibility of replacing personal heaters with blankets in offices at UBC. The environmental, social and economic aspects of this switch will be considered to

reach a conclusion. In addition, three different blanket types will compared against one another using the triple bottom line methodology to find out if there are any significant advantages among different blanket types.

3.0 Methodology

In order to conduct this investigation, both primary and secondary data was collected. The primary data was used mainly in evaluating the social aspect of the investigation and it was collected by distributing a survey to office workers at the Engineering Student Services and the Applied Science Dean's Office, both located at the Kaiser building. The secondary data came from research through the UBC Library and Google. There was a considerable body of literature pertaining to human thermal comfort, which was used in the Introduction, but finding information about heaters and blankets were more challenging than originally anticipated. It was necessary to search for peer-reviewed articles about the life cycles of blankets and heaters, gas emissions and environmental impacts of producing blankets and heaters, and recycling of blankets and heaters. Librarian Ms. Ursula Ellis attempted to search through the UBC databases, but she too had difficulty finding relevant information pertaining to the requested information. As such, the focus was directed to energy consumption of heaters and the energy cost of maintaining blankets (washing and drying) as the main indicators for evaluating environmental impact.

3.1 Social

To investigate the social aspect, all the teams working on the heater project assisted in preparing a survey, which was submitted to the project stakeholder, Lillian Zaremba, who made adjustments and approved the survey. By using the same survey, consistency was ensured and it became possible for different teams to collaborate. The surveys were distributed at the Kaiser building, which is known to be cold and occupants have reported using personal heaters. In total, 16 office workers completed the surveys. To increase the sample size, results were shared with another team consisting of Wilson To, Chun-Ju Chen, and Martin Eccleston. They distributed their surveys at the Frank Forward Building. By combining results, the sample size for this report grew to 22 completed surveys, which provided a more accurate picture of people's perception toward energy usage, thermal comfort, various methods to keep warm and the possibility of blankets replacing heaters. In order to thoroughly investigate blanket preference, an application for funding from AMS Sustainability was put forth and subsequently approved for $400. The initial goal was to compare four different blanket types, but ultimately three types were purchased and analyzed in this report. The reasons for the exclusion of the fourth blanket are discussed in section 3.2. The three blanket types purchased were fleece, heavy-knit and a double-sided (knit/polyester) blanket. The blankets were given to the Sustainability Office at the end of the project.

3.2 Economic

Each office worker purchases personal heaters individually, but blankets would be purchased by UBC. As such, the main indicators are the cost of purchasing blankets and the annual cost of electricity usage by all the heaters at UBC. To calculate a value for the annual cost of operating

heaters, it was necessary to make certain assumptions. It was assumed that a typical ceramic heater consumes 1500 kW when running at maximum power and it operates for 5 hours per day, 5 days a week, and for 24 weeks. The 24 weeks represent the coldest months of the year. Knowing UBC's electricity rate ($0.0539 kWh), the annual cost of running a typical heater was calculated. Knowing the approximate number of office workers at UBC who have reported using a heater, an approximate annual cost of running all the heaters at UBC was determined. Although the main goal of this project was to compare personal heaters with blankets, it was also interesting to examine whether blanket type was important in office workers' decision to replace their heaters with blankets. As mentioned in the previous section, the initial goal was two purchase four blankets, fleece, heavy-knit, double-sided, as well as silk/polyester, hereafter referred to as silk. The silk blanket posed a challenge due to its elevated cost and its strict requirement to be dry-cleaned. Considering these two factors and given that small-sized silk blankets are difficult to find in the local department stores (Wal-Mart and Sears) led to the exclusion of this blanket from analysis in this report. The three blankets and the materials from which they are constructed are listed in the table below.

Blanket type	**Material**
Fleece	100% Polyester (PET)
Heavy-knit	100% Acrylic
Double-sided	Cotton (60%) & Acrylic (40%) on one side, 100% polyester on the other side

Table 1 - List of various blanket types and materials in them.

3.3 Environmental

To assess the environmental impact of blankets, the electricity to maintain the blankets was calculated. Here, maintenance of blankets refers to washing and drying. If occupants are to switch to blankets, it was assumed that the building would be responsible for cleaning the blankets. According to the estimates provided by Lillian Zaremba, there are approximately 769 personal heaters being used by office workers in various buildings at UBC. The exact same assumptions made for heaters were made for blankets as well. This means blankets would be required for 24 weeks out of the year. Considering the environment in which blankets would be used, it is reasonable to assume that they could be washed on a bi-weekly basis (12 times annually). In order to calculate the energy cost associated with washing the blankets, it was necessary to know the energy consumption of a typical front load washer. For this, a GE front load washer was considered for analysis ("GE ENERGY STAR," n.d.). This washer is capable of washing 0.1 m^3 of fabric during each wash cycle and each cycle consumes 1.2 kWh assuming the washer operates for 30 minutes. In addition to the energy of washing, there is also a need to consider the energy consumed for drying the blankets. According to the GE website, a dryer consumes 4.2 kW of energy per drying cycle assuming that the dryer operates for 50 minutes ("GE 7.8 cu. ft.," n.d.). Each dryer is capable of drying 0.22 m^3 of fabric during each cycle. The other assumptions were identical to the washing cycle in that the dryer is used only when the washer is used, which means that the dryer is operated 12 times annually. The total annual electricity required to wash and dry the blankets was determined. The results of the analysis are outlined in section 4.1.3 and 4.2.3.

4.0 Discussion

The discussion section considers the social, economic, and environmental aspects of the project starting with heaters and blankets and continuing with comparing different blanket types in a similar fashion.

4.1 Heater vs. Blanket

The discussion continues in the sub-sections below with the comparison of heater and blankets.

4.1.1 Social

The social aspect of this investigation is particularly important because it requires individuals to change the way they have kept warm for a more environmentally friendly and less expensive alternative. The data collected for this part of the project came mainly from the surveys from office workers in the Kaiser and Frank Forward building. The purpose of the survey was to examine if occupants are aware of the energy usage of a typical heater and to examine their willingness to replace their personal heater for a blanket if it were provided free of charge. 68% of the individuals who completed the survey claimed that they care about energy conservation at their workplace. 32% said they were somewhat indifferent, but 0% said that they do not care at all. With respect to their heaters, 32% correctly identified the correct amount of energy used to run a heater, 45% claimed they did not know and 23% underestimated the value. In total 68% did not know the answer. Closing windows (64%), drinking a hot beverage (59%), and turning on a personal heater (64%) among the popular responses to the methods that occupants used to keep warm. 0% indicated that they use blankets on their lap to stay warm.

When asked whether they would consider using a blanket or throw to keep warm, the responses are summarized in the following table.

Would you be willing to use a blanket or throw to keep warm?	
Definitely	5%
Maybe	23%
Probably not	14%
Definitely not	50%

Table 2 - Responses to the question of whether blankets can be used to keep warm in offices.

64% of the respondents had an unfavourable view of using blankets to keep warm. Some respondent commented that blankets usage at the office is not possible because their job requires standing up and walking around frequently and claimed that having a blanket on their shoulder or lap would frustrate them and in turn impede their productivity. Respondents consistently ranked safety and comfort above cost and appearance when asked about thermal comfort. This coupled with the unfavourable responses to blanket usage indicate that people view blankets as ineffective and not feasible, not due to aesthetics, but in terms of their effectiveness to provide thermal comfort in an office environment, which requires them to frequently stand up and walk around.

4.1.2 Economic

To operate a heater, a continuous source of electricity is required. UBC's cost of electricity is $0.0539 kWh. The payback period was the main indicator used to evaluate the economics of replacing heaters with blankets. Ideally, UBC would like a payback period of two years or less.

Knowing a rough estimate for the total number of heaters being used at UBC, and assumptions made about their usage, the annual cost of operating personal heaters was calculated. The bar graph below shows the annual cumulative cost of operating heaters in comparison to the annual cost of maintaining blankets. It can easily be concluded that even when considering the cost of washing and drying the blankets, they still have a payback period of less than two years, making them the better choice for the economic consideration of this investigation.

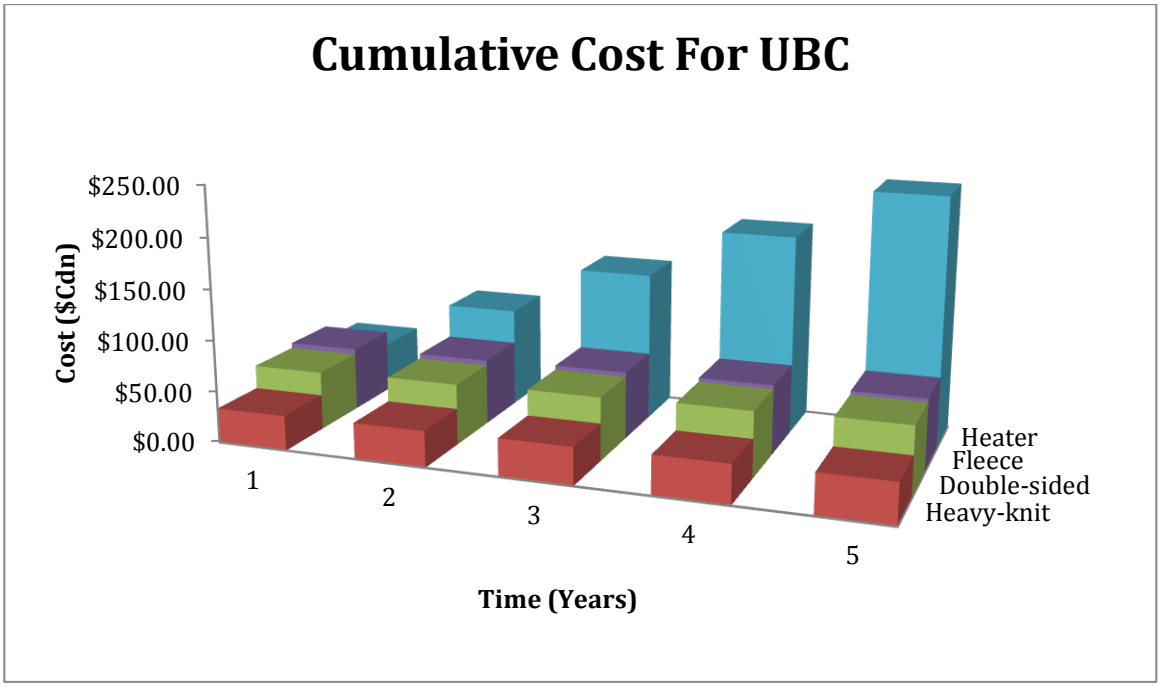

Figure 1 - Annual cumulative cost of blankets vs. heaters.

4.1.3 Environmental

Different blanket types have different volumes and hence only a set number of a particular blanket type can be washed during each cycle. This means that the larger a blanket is, the more cycles are required to wash all the blankets of that type. The following table outlines blanket

types, their respective volumes and the number of cycles of washing required to wash all the blankets of that particular type.

Blanket type	Volume (m^3)	# of washes required
Fleece	0.017	128
Heavy-knit	0.010	86
Double-sided	0.020	157

Table 3 - The number of cycles required to wash all blankets of each type.

The table below outlines the energy consumption associated with washing each blanket type on an annual basis. The following formula was used to calculate the annual energy cost:

$$\begin{aligned} &\#\ of\ cleaning\ sessions\ per\ year\ \times\ \#\ of\ washes\ per\ session \\ &\times\ Energy\ used\ per\ wash\ (in\ kWh) \\ &=\ Annual\ Energy\ Consumption\ (in\ kWh) \end{aligned}$$

Blanket type	Number of wash cycles required	Number of times blanket is to be washed annually	Energy consumed per cycle of wash in kWh	Annual Energy Consumption in kWh for washing
Fleece	128	12	1.2	1843
Heavy-knit	86	12	1.2	1238
Double-sided	157	12	1.2	2261

Table 4 - Annual energy consumption of washing blankets.

The table below outlines the number of drying cycles required for the drying machine to operate to be able to dry 769 blankets of each type.

Blanket type	Volume (m^3)	# of drying cycles required
Fleece	0.017	64
Heavy-knit	0.010	35
Double-sided	0.020	70

Table 5 – Number of drying cycles required based on volume.

The table below outlines the energy consumption associated with drying each blanket type on an annual basis. The following formula was used to calculate the annual energy cost:

$$\begin{aligned} &\#\ of\ cleaning\ sessions\ per\ year\ \times\ \#\ of\ drying\ cycles\ per\ session \\ &\times\ Energy\ used\ per\ drying\ cycle\ (in\ kWh) \\ &= Annual\ Energy\ Consumption\ (in\ kWh) \end{aligned}$$

Blanket type	Number of drying cycles required	Number of times blanket is to be dried annually	Energy consumed per cycle of drying in kWh	Annual Energy Consumption in kWh for drying
Fleece	64	12	4.2	3226
Heavy-knit	35	12	4.2	1764
Double-sided	70	12	4.2	3528

Table 6 - Annual energy consumption of drying blankets.

Below is a table shows the annual energy consumed for washing and drying the three blanket types.

Blanket type	Annual Energy Consumption in kWh for washing	Annual Energy Consumption in kWh for drying	Total Annual Energy Consumption in kWh
Fleece	1843	3226	5069
Heavy-knit	1238	1764	3002
Double-sided	2261	3528	5789

Table 7 - Annual energy consumed to wash and dry blankets.

The graph below is a visual comparison of the total energy consumed to operate heaters and the anticipated energy consumption of washing and drying all the blankets at UBC.

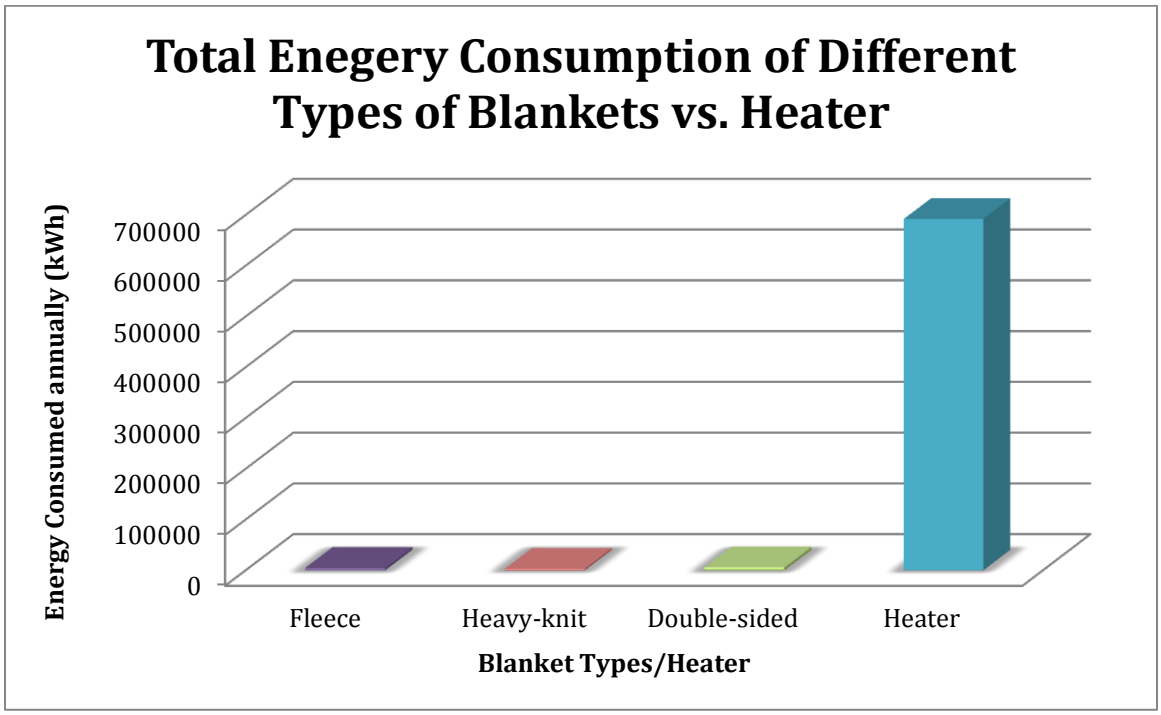

Figure 2 - Side by side comparison of energy consumption of heaters and blankets.

A considerable difference was found in the annual energy usage, measured in kWh, of blankets in comparison to heaters. The energy consumed to run all the personal heaters at UBC is about 692,000 kWh, which is almost 120 times more than the energy consumed to wash and dry all the double-sided blankets. Moreover, all blanket types are easily recyclable. PET, the main chemical in the fleece blanket is easily broken down in a simple industrial reaction, the products of which may be used to synthesize new PET, or even be used in the production of other materials (Bartolome *et al*., 2012). Both acrylic ("Recycled Cotton," n.d.) and cotton ("Acrylic Waste,"

n.d.) can also easily be recycled to produce materials of the same kind. So in this category, blankets are identified to be the more environmentally friendly option by a large margin.

4.2 Blanket vs. Blanket

The discussion continues in the sub-sections below with comparison of the three different blanket types.

4.2.1 Social

To evaluate the social aspect of different blankets, their preference was examined according to the survey responses. On the survey, the respondents were asked to rank blankets according to preference. 1 indicated most preferred, and 4 least preferred. To analyze the results, a point system was implemented. Blankets were assigned a score between 1 and 4 depending on the ranking they received in the survey. 4 points were assigned to the most favoured blanket and 1 point to the least favoured blanket.

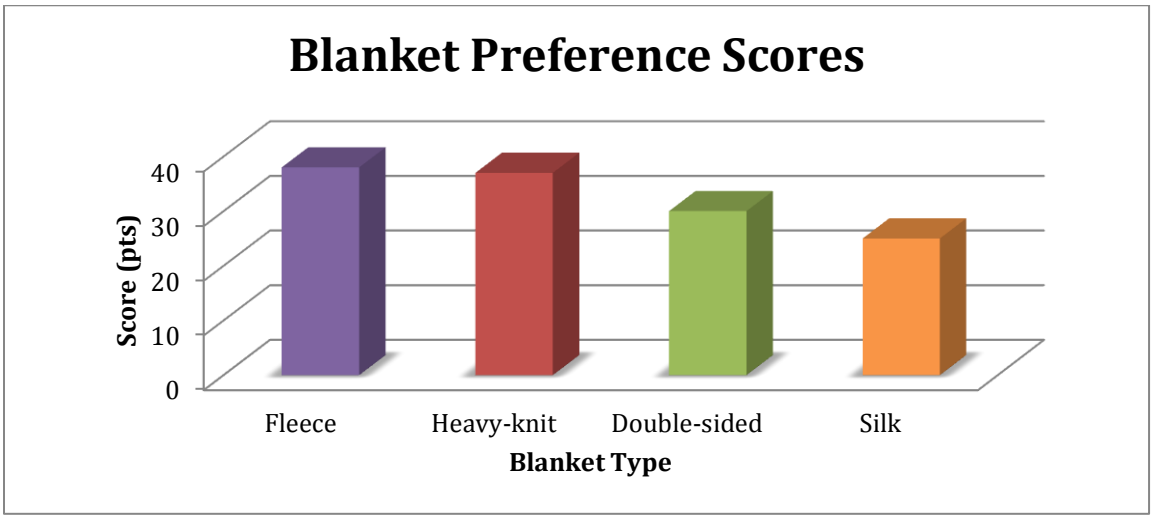

Figure 3 - Preference scores for each blanket type.

Of the 22 respondents, 13 responded. The results, shown in the graph above, indicate that there is a slight preference for fleece and heavy-knit blankets in comparison to the double-sided and silk. The silk blanket is included in the graph only because it was present on the survey, but as explained in the previous sections, it was excluded from further analysis. Three individuals at the Kaiser building tried the blankets and all three preferred the double-sided and the heavy-knit blankets, however due to this small sample size it was not possible to draw any tangible conclusions from their feedback. Hence, analysis was done purely based on the ranking provided on the surveys.

4.2.2 Economic

The cost of purchasing blankets along with the cost of washing and drying each blanket type was determined. The results are presented in the table below. Considering these figures, the preferred choice among the blankets with respect to economics is the heavy-knit blanket.

Blanket type	Purchasing cost including tax ($)	Washing/drying energy consumption (kWh)	Washing/drying cost ($)	Total cost ($)
Fleece	61.60	5069	273.22	334.82
Heavy-knit	33.60	3002	161.81	195.41
Double-sided	56.00	5789	312.03	368.03

Table 8 - Total cost of washing and drying blankets.

The graph below represents the annual cost of maintaining the three blanket types in a more visual manner.

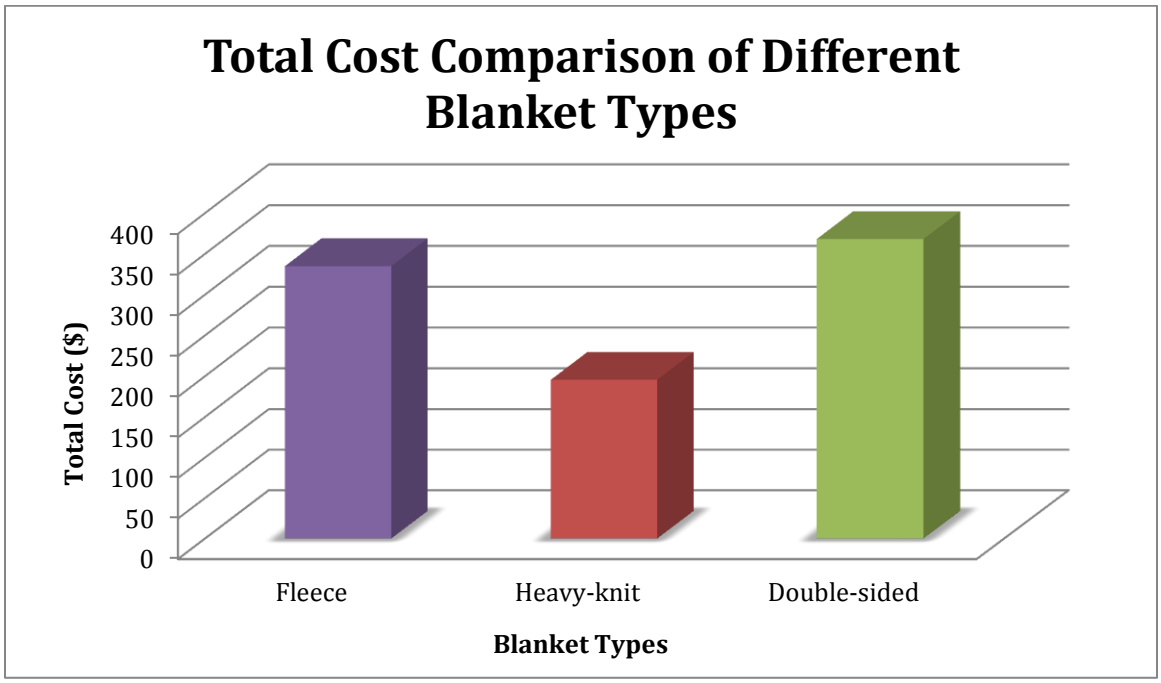

Figure 4 - Annual cost comparison of different blanket types.

4.2.3 Environmental

The annual energy consumption associated with washing the three blanket types is shown on the following graph. The indicators used to measure the environmental impact of blankets were the energy consumed by washing and drying the blankets for one year. Given its relatively larger size, the double-sided blanket consumes more energy on an annual basis. As discussed in section 4.1.3, the required energy to operate heaters is considerably larger than that of the blankets. As such, it is concluded that the difference in energy consumption among the different blankets is negligible.

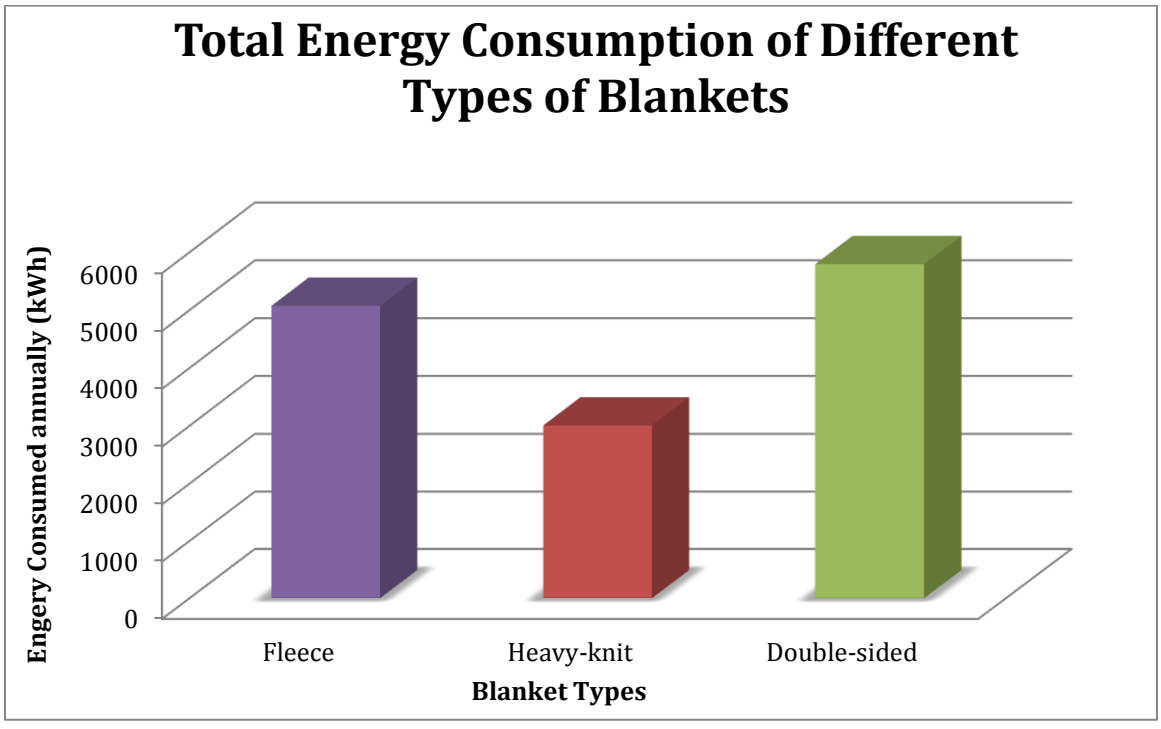

Figure 5 - Energy consumption of different blankets. The difference in energy is negligible.

5.0 Conclusion and recommendations

Considering the environmental and economic impact of switching from heaters to blankets, it is clear that blankets are the favoured choice. Interesting conclusions can be drawn from the social analysis of the report. It is evident that the majority of the respondents were conscious of energy consumption, however the majority were unaware of the energy consumed by heaters. It was also interesting to see how many respondents were opposed to switching from heaters to blankets. It is unknown whether the respondents' perception toward blankets would change if they learned about the impact of heaters on the environment. Although blankets are the better choice economically and environmentally, they are not a socially suitable choice. Therefore, after careful consideration, it was concluded that the switch from heaters to blankets is not feasible at this time. There are other issues that need to be resolved before a project such as this could be successfully implemented. How would UBC facilitate the washing of blankets? What would happen if blankets are damaged or lost? How many spare blankets should be purchased? How would buildings keep track of the blankets that are given out and would they be returned at the end of each day? Week? Questions remain about the possibility of replacing heaters with blankets. A better alternative to ceramic heaters could be to use low-energy radiant heaters, which are known to consume a fraction of the energy consumed by a typical ceramic heater, but are as effective in producing heat. They would decrease the demand for UBC to be involved and occupants would be satisfied if the same level of warmth could be provided.

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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