UBC Social Ecological Economic Development Studies (SEEDS) Student Report

Promoting Sustainable Behaviour Change in an Older Building: Towards a more energy efficient future

Stephanie Demmers

University of British Columbia

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Promoting Sustainable Behaviour Change in an Older Building: *Towards a more energy efficient future*

By: Stephanie Demmers

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Executive Summary

This report provides an analysis and evaluation of effective communication strategies in promoting sustainable behaviour and the best places to implement them, specifically in regards to energy efficiency, in an older building: the UBC Geography building. Methods of analysis in this report include case studies and literature review which address communications strategies, minor retrofitting options, the installation of passive infrared (PIR) sensors and implementation costs.

The results of the literature analysed shows that the best way to approach the promotion of sustainable behaviour is a combination of communication strategies with minor retrofitting and PIR sensors. This, therefore, is the recommendation to the Geography Sustainability Committee in order to see the biggest reduction in energy efficiency consumption within the department.

- Install PIR sensors that detect body heat and turn off or turn down heating and lighting systems based on occupancy.
- Minor retrofitting options: daylight harvesting blinds, double pane windows, minimisation of drafty-ness under around door and window frames

This report has data limitations when it comes to cost analyses, especially without being guided by any economic limit. So to address this, the report looks at providing the most economically friendly options for retrofitting and a PIR cost analysis provided by Energex Inc.

Introduction

The goal, in collaboration with UBC SEEDS and the Geography Sustainability Committee is to seek effective communications strategies that will promote positive behaviour change (in regards to energy efficiency) within an older building (the UBC Geography Building).

This report looks at three different communications strategies and attempts to identify where they would be most useful within the UBC Geography building.

The communications strategies introduced and evaluated will include user centred design (UCD) which addresses the theory that "by understanding the user, it becomes possible to use design to effectively nudge users towards more sustainable product use".[1] Another strategy is "Eco-feedback": the idea that by making the user more informed about the impact of their decisions, they can make a more knowledgeable decision about their own behaviour change. The last is behaviour steering (or scripting) which focuses on creating and designing products in a manner that encourages users to behave in a certain way. In other words, making it harder, or putting obstacles in the way of unsustainable action while simultaneously promoting the easier, more sustainable route.

The three strategies: UCD, Eco-feedback, and Behaviour Steering/Scripting will be described in a more comprehensive manner, and then outlined by success in a given situation (or "change" opportunity). In other words, recommendations will be given as to when each communication strategy would or would not be appropriately used, and how all, either separately or collectively could be used most effectively.

In addition to communications strategies, this report will analyse a couple of case-studies in other instances where people looked to achieve the same goal (promote sustainable behaviour change) or outlined what their research proved is least efficient in

[1] Strategic Direction (2008)

an older building, given the Geography building was built in 1925.

Case studies of others who either looked at implementation of communications strategies or where to implement more sustainable methods will be evaluated and based on their findings, used to avoid their mistakes or to make sure to address their positive suggestions.

The analysis of these case studies will result in a series of recommendations to supplement the communications strategies: where in the (old) Geography building should have the most focus when it comes to sustainable changes. All of the compiled research will then be used to provide a plan for the Geography Sustainability Committee as to where their energy should be focused and why.

The recommendations given will not only include the use of communications strategies, but as well their combination with the installation of passive infrared sensors (PIR) and minor retrofitting options. Lastly, a cost analysis will be done to determine the cost of installing PIR sensors and minor retrofitting options.

Communications Strategies

User-centred Design

User-centred design for sustainable behaviour

By understanding the user it will be more effective to shift people towards more sustainable behaviour and product use. An article in *Strategic Direction* explains how focus has to shift to the user, in other words, the user has the ability to control the energy use of the product, and therefore products should be created with this in mind making overall user-product interaction more sustainable.[2] In order to do this

[2] Strategic Direction (2008)

effectively users' consumption patterns and everyday habits need to be known.[3] The goal of UCD is to improve the quality of interaction between the user and the product.[4] The use phase of a product tends to have the most immediate impact on the life-cycle of any product, this is partly determined by user behaviour, but can be influenced to a more sustainable future by user design.[5] This strategy is important to the usability aspects of PIR sensors and daylight harvesting blinds: the easier they are to use, the more likely they are to be used.

Eco-feedback

The concept of eco-feedback is important when looking at user-centred designs. Eco-feedback is the idea that by presenting more information about the user's impact, they can actually make an informed decision of whether or not to change their behaviour.[6] In other words, eco-feedback presents the user with information on the (in)efficiency of their behaviour.[7] With this information (and the knowledge of their personal consumption), the idea is that people are not only informed when making a decision but are more likely to shift their behaviour towards more sustainable use. The concepts of user-centred design and eco-feedback are integral components of PIR sensors, as the sensors can provide consumption level readings which can be presented to the energy consumer, and can be used more effectively based on usability.

Behaviour Steering/Scripting

Behaviour steering is creating and designing products in a manner that encourages users to behave in a certain way.[8]

[3] Selvefors et al (2011)
[4] Wever et al (2008)
[5] Ibid
[6] Strategic Direction (2008)
[7] Wever et al (2008)
[8] Strategic Direction (2008)

Sustainable Behaviour Steering

The object of behaviour steering is to create obstacles to unsustainable product use, or to make sustainable behaviour so easy it is hardly given any extra thought.[9] Behaviour steering as a strategy is used in PIR sensors and in retrofitting options by forcing people to act more sustainably without putting in additional effort.

Strategies – Case Studies & Literature

***WEVER et al. (2008)* -** *User-centred design for sustainable behaviour*

In this case study Milieu Centraal, a Dutch non-profit, gave participants of one of their campaigns the opportunity to use an energy-meter for 3 weeks free of charge, on the condition they would pass the meter along to another family after their time elapsed. A problem arose, where many users found that the meter was too complex, which triggered Milieu Centraal to collaborate with Delft University of Technology to create a better design based on usability. In addition, due to product language and abbreviations people found it hard to use, not to mention that it had to be plugged into a wall socket, of which many were too close to other object to house the device, or so close to the floor that people had to lay on the floor to get a reading. In the end a new product was created that was more accessible to the user, and simpler and less time consuming to use. This study emphasizes the importance of user-centred design and usability and accessibility when looking at PIR sensors.

***Jain et al (2012)* -** *Assessing eco-feedback interface usage and design to drive energy efficiency in buildings*

[9] Strategic Direction (2008)

A case study was done where a user interface was created where people could logon to view their energy usage over time and their consumption compared to the building average. A points system was used to either reward or penalize the users based on their usage. The test building was a multi-story residential building on the campus of Columbia University. Their findings were that the users who decreased their consumption logged on to the interface nearly twice as much as those who increased their consumption. In this case, the users' logins were used as a mechanism of eco-feedback; eco-feedback proved to have an impact on the users' consumption based on frequency of interface use. This case study proves that the more one is presented with information based on their energy consumption; the more likely they are to address and change their consumption in a sustainable manner.

Lilley (2009) - *Design for sustainable behaviour: strategies and perceptions*

In this article Lilley discusses the how eco-feedback can be used to provide "tangible aural, visual, or tactile signs as a reminder to inform users of resource use." Lilley puts this strategy in the" power in decision-making 'guiding' zone", in other words eco-feedback guides the user towards the possibility of change. The author indicates that what then maintains this change is behaviour steering which "encourages users to behave in ways prescribed by the designer through the embedded affordances and constraints." Lilley attributes importance towards the use of these two strategies in succession in this manner so as to implant the idea of change and then maintain change by making it easier to be sustainable than unsustainable.

Focus of change

As stated in the introduction, this report will focus on changes in regards to energy efficiency. The areas of focus will be on retrofitting in regards to PIR sensors and limiting and recovery methods for heat loss, and daylight availability.

Passive infrared sensors (PIR sensors) are becoming an increasingly more popular method of measuring energy efficiency. The most common way PIR sensors are used is in motion detection systems. These can be used to determine when to turn off a lighting or HVAC system based on motion or lack thereof. Less common, but becoming more popular are PIR sensors which measure the heat flux of a black body, in other words, it measures an individual's body heat so that when they leave a room and that heat is no longer detected, HVAC systems can be turned down or lighting systems turned off until such time someone returns to the room.

According to the U.S. Environmental Protection Agency PIR sensors can have up to a 50% energy savings in offices and 30% to 90% savings in restrooms.[10] PIR sensors are most effective in smaller places with few obstacles, such as an office space.[11] If used in larger areas, more sensors would have to be placed around the room to get the same accuracy. Presently, such sensors can be found in the Geography building in the men's washroom urinals to control the flushing mechanisms; ideally these would become more common practice throughout the Geography building.

Efficiency – Case Studies & Literature

Silvestre-Blanes & Pérez-Lloréns (2011) - *Energy efficiency improvements through surveillance applications in industrial buildings*

Silvestre-Blanes and Pérez-Lloréns write an article about the efficiency of presence sensors as methods to increasing energy efficiency. Inefficient use and poor installation of presence sensors can in fact increase energy consumption instead of reducing it. For optimal efficiency the installation and functioning of energy efficiency systems must be kept simple, and should be of the plug and play type, not requiring complex parameter

[10] Wilson (2007)
[11] Ibid

setting operations. As well, for systems such as this to be successful and to improve energy optimisation, it is necessary to know the occupancy patterns of the particular location. That being said, the authors mention that issues with motion detecting presence sensors occur often with inactivity (eg. someone sitting in the same position for a long time could look like inactivity). The findings were that the system was cost effective, but unless installed on both sides of corridors and other rooms, the system was still not 100% effective in detecting movement. From this, it can be determined that likely there is a more effectual method of monitoring energy efficiency through behaviour scripting, especially one that looks at HVAC in addition to lighting systems.

Hartungi & Jiang (2012) - *Energy efficiency and conservation in an office building: a case study*

Hartungi and Jiang claim that energy efficiency technology has the potential to reduce carbon emissions by 60% or more. The article and case study are geared towards constructing new energy efficient buildings, yet multiple methods in the article could easily be applied to making an old building more energy efficient. One instance of this is the use of daylight and how important it can be to lessening level of lighting use, in addition to having automatic controlled blinds/window coverings that will cover the windows during the appropriate hours depending on season (either maximizing heat capabilities in winter, or deterring too much sunlight due to overheating in the summer). Other suggestions for a more energy efficient building include: a ventilation system with good high heat recovery system, air tightness to minimise uncontrolled air leakage, space heating, improving the control and monitored of heating, lighting and ventilation systems (sensors). Evidently, an important aspect of any of these changes is looking at level of energy conservation versus operation and installation costs, keeping in mind many changes could last for an incredibly long duration of the operational life of the building. Daylight harvesting and minor thermal insulation efforts will be included in the cost analysis.

Carlos & Carvacho (2010)- *Retrofit Measures in old elementary school buildings towards energy efficiency*

This is a case study is on a thermal retrofit of a Portuguese elementary school. The building had a very poor thermal performance; the end result through to retrofitting application was a 52% reduction in heating energy needs. The case study mainly focused on the exterior of the school, which can have an enormous (in this case 52%) impact of energy consumption. By essentially insulating a large portion of the building (double glass windows, plaster layering of walls, rock wool blanketed roofing and flooring) can decrease heat loss and increase efficiency. Evidently this option would be fairly expensive, but for an older building to run more efficiently such cost consuming changes would likely be necessary at some point. This article is used in reference to minor thermal retrofitting options.

Lubbehusen & Thornsbury (2012) - *How to Make a 155 Year Old Building a High Performance Building*

In this case study they make an over 150 year old building a high performance building by looking at energy efficiency (lighting systems, heat loss [insulating], and energy modeling) In addition to the (more expensive) exterior retrofitting that was done. For the lighting system they found that presence sensors would be the most effective, turning off after not detecting motion for 20 minutes. The authors indicate that when using occupancy sensors it is best to look at the use of the room to even determine if the device will have an opportunity to go into standby mode. As well, the authors discuss using LED lighting fixtures in the majority of the rooms, though this would be an option better served after the current light bulbs burn out. Lastly, Lubbehusen and Thornsbury indicate that all the areas with natural daylight available had daylight harvesting sensors installed to automatically control the lighting levels. Overall, this article emphasizes the importance, in an older building, to control levels of energy consumption, by insulating and thermo-fitting an older building in order to keep the heat in. As well, the use of sensors for daylight harvesting and heating and lighting consumption control. As this article focuses on specific methods of making an old building high performance it is ideal for any changes in the 88 year old Geography building.

Cost Analysis

Energex Inc. is a company that sells and installs PIR energy sensors which sense body heat to determine occupancy. They were kind enough to make available their distributor price list and Okanagan College student housing analysis available for this report. The cost of the necessary parts (Energy Management Unit: $55.20 & Wall Mounted Occupancy Sensor: $39.20) is: $94.40.[12] According to the Okanagan College analysis the cost of a system unit installed is $ 318. Looking at the Okanagan student housing analysis, Energex determines that the payback period (for 212 units is 4.62 years, with a total cost of $39,410.62 ($67,416.00 for installed costs minus $28,005.38 of estimated Fortis BC rebates).[13] These systems would have to be installed in rooms that have their own thermostats. Given the decrease in energy costs versus the installation costs, looking at repayment at about 4.62 years, these PIR sensors are surprisingly affordable and would (after the given time period) actually provide profit for the department. When looking at PIR sensors, not many cost analyses on campuses are readily available, making the information provided by Energex important but not 100% reliable for the Geography Building. The numbers provided could vary greatly depending on window size, insulation and building efficiency. Therefore, it can be assumed that by increasing the efficiency of the building by completing small retrofitting changes to daylight harvesting and airtightness the cost of the sensors would be paid off more quickly.

Daylight harvesting blinds can be easily purchased and installation costs would depend on the labourer, the lowest priced system that was found was the LightLouver Daylighting System at a cost of $2.47 per square foot compared at anywhere from $8.00-$17.00 per square foot for other systems.[14] Other options for minor retrofitting

[12] Energex Distributor Price List (2013)
[13] Energex (2010)
[14] LightLouver LLC (2013)

options could include double pane windows being installed ($300-500 per unit depending on window quality)[15]

Findings

Through the research done in this report the findings were that which approach to use depends on the product and its context and therefore a combination of strategies and methods would prove most effective.[16] The communication strategies represented here are with the intention to make change happen with minimal effort put in to convincing energy consumers to change their own behaviour and rather making sustainable behaviour so easy, or thoughtless that it would be more difficult to avoid it than to do it. These strategies embody a "do it yourself" manner which leaves little room for error, and minimal dependence on others. User centred design is important when considering change, making a product revolve around how, when and why a product is used is important to the implementation of eco-feedback and behaviour steering strategies, not to mention the physical construction (and usability) of PIR sensors and retrofitting changes. In other words, usability of a product must be considered when determining which changes to make. Eco-feedback, behaviour steering and PIR sensors are effective in encouraging people to use systems more efficiently or forcing systems to be used more efficiently while making it easier to be more sustainable than unsustainable. Retrofitting and behaviour steering (via PIR sensors, daylight harvesting blinds, double pane windows) might take some minor investment capital, but in total, the costs would be paid back in less than a decade, while simultaneously promoting and forcing peoples' behaviour to shift towards more sustainable action. Overall, this report determines that strategies which force consumers' behaviour to change (UCD, behaviour steering, PIR sensors and retrofitting) and present them with knowledge of their consumption levels (eco-feedback and PIR sensors) are most effective in facilitating a successful sustainable behaviour change environment.

[15] Homewyse (2013)
[16] Wever et al (2008)

Recommendations

- Install PIR sensors that detect body heat and turn off or turn down heating and lighting systems based on occupancy.

These devices can be used as eco-feedback mechanisms that inform people of their consumption levels implanting the idea of consumption levels and ultimately more sustainable behaviour in general into their minds. These devices must be purchased with usability in mind, and therefore will incorporate the user-centred design strategy.

- Minor retrofitting options: daylight harvesting blinds, double pane windows, minimisation of drafty-ness under around door and window frames

For optimal use the PIR sensors must be combined with, at least, minor retrofitting. The intention would be to minimise drafty-ness and make areas, with and without sensors more airtight by insulating areas that lack air tightness. This would maximise HVAC system efficiency by allowing the heat in a given area to remain in that area, where it does exist in the Geography building.

Both of these recommendations use the introduced communications strategies, as the PIR sensors and retrofitting changes should be made based on decisions revolving around user-centred designs and product usability. The PIR sensor readings can be presented to the energy consumers within the building; this is a method of eco-feedback

Future Work and Limitations

The biggest limitation to this report is the cost analysis completed due to the fact that cost examples were only given for one company or scenario. Future work should be done to look at costs, types and usability of the same products (PIR sensors, daylight harvesting blinds, double paned windows) through additional companies than those referenced here.

The strategies referenced in this report were limited in scope to more forceful behaviour change options. Future work could be done to supplement these strategies to determine ways of altering one's thinking surrounding the environment and sustainability with the end goal of making people more geared towards sustainable behaviour and action.

It would be ideal for these changes and other retrofitting changes to be presented to UBC and the Geography department through the current and ongoing renovations on the building so as to take advantage of the ability to incorporate these recommendations in to the initial design and usability of the renovations taking place. As well, other major retrofitting options should be considered, depending on the remaining life cycle of building.

Overall, given the limited scope of this report, costs of installation and implementation of strategies and retrofitting changes should be researched in a more comprehensive manner or trialed by the Geography Building on a limited scale basis.

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