An Investigation into: Energy Monitoring

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ABSTRACT

The new AMS Student Union Building aims to act as a gathering place at the heart of the UBC-Vancouver campus, while reducing energy and materials consumed during building operation. This paper explores the methods and effects of monitoring electricity usage to help meet this goal. Currently, the University of British Columbia (UBC) uses a software system from Pulse Energy™ and sensors from Schneider Electric™ to monitor the total energy use of buildings across campus.

This paper presents two case studies that show how the presentation of energy consumption data induces behavioral change. By engaging occupants in metering programs, an attitude shift towards reduced reliance on energy and convenient consumption can be harvested and thus help the new SUB project reach its energy goals. If implemented effectively, metering systems will reveal areas of overuse or neglect to building managers allowing them to correct issues with building hardware or processes. By reducing the energy consumption of the building the annual cost of electricity will decline and the demand for an increase in energy production can be offset.

Implementing a sub-metering system can be difficult for existing buildings but the new SUB presents the opportunity to integrate a system into the building during construction/design stages. Pulse Energy™ estimates it would cost $45,000 for the software and hardware components necessary to add metering to 20 points in a building at an increasing cost of $2000 per point.

Based on this information this paper makes three recommendations.

1. We recommend that the goal to logically divide the building electrical layout be taken into account at design time so that sub-metering can be effectively implemented.

2. We recommend that further research be done on how the building should be electrically divided to be most useful to building managers.

3. We recommend that space be set aside for a public Pulse Energy™ dashboard display to engage building occupants.

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GLOSSARY

Sub metering – Breaking down electricity consumption into end use categories.
Current Transducer – Sensor that monitors current in an electrical line
BACnet – Communications protocol for building automation
ModBus – Serial communication protocol often used in building automation

ENERGY MONITORING

1.0 INTRODUCTION

The new AMS Student Union Building aims to provide more space for students and student services and act as a dynamic gathering place at the heart of the UBC Vancouver campus. Apart from its main objective the mynewsub.com website outlines ten other goals including the following statement on energy and sustainability.

"…the New SUB Project will aim to enhance… environmental sustainability by reducing the energy and materials consumed in the building and operation of the SUB." [1]

To ensure the SUB meets this goal, energy and consumable materials used in operation of the SUB should be monitored, recorded and presented in an effective manner which not only provides information, but encourages reductions in consumption.

Although metering is done on some buildings across campus, apart from monthly totals, the current SUB does not employ metering techniques. Lillian Zaremb, from the UBC sustainability office, has produced data showing 341,123kWh was consumed per month on average over the last 2 years.[2] Although sub-metering is not employed in any UBC buildings, the Sustainability office was able to produce a cross-campus estimated breakdown of end use electricity consumption.

End Use	End Use Percent
Lighting	30%
HVAC	40%
Plug Loads	15%
Research Equipment	10%
Heating	5%
Total	100%

Table 1 Breakdown of end use electricity consumption across campus.[2]

This paper explores the methods available for performing sub metering and analysis on an ongoing basis and outlines the triple bottom line effects of doing so.

2.0 EXISTING SYSTEMS

Currently the University of British Columbia uses Pulse™ to monitor energy use of buildings across campus. The electricity consumption of ten buildings on campus is currently being monitored by Pulse™. Steam consumption is monitored in seven buildings. This dashboard is available online with a user-friendly interface that allows viewers to compare current trends to typical trends. The website also allows one to look back by three months to view more long term trends. An example of this software can be seen in Figure 1 below.

Figure 1 Sample Electricity Consumption Data for Koerner Library

[3] Pulse Energy, "Koerner Library – UBC Energy Dashboard" [cited 2010 Nov 14], Available HTTP: http://my.pulseenergy.com/ubc/dashboard#/location/6

Administrative users have access to a separate interface which gives access to more than three months' worth of data and provides tools for granular analysis of the data. As students, we are not able to access this interface. This paper is written with the understanding that a main interface with more data exists.

Unfortunately the current UBC Student Union Building (SUB) is not one of the buildings currently being monitored by Pulse™; however it can be added to their network. Buildings

currently monitored by the pulse system using current transducers from Schneider Electric™ like the T1 Instrument Transformer shown in Figure 2. This current transducer is placed on the electrical input line to each building and wired into the Pulse™ acquisition hardware to provide continuous energy monitoring.

Figure 2 T1 Current Transducer manufactured by Schneider Electric

[4] Schneider Electric, "T1 Instrument Transformer" [cited 2010 Nov 28], Available HTTP: http://global.powerlogic.com/products/accessories/T1_instrument_transformer/default.aspx

Monitoring the main input line allows the software to quantify the total energy input into the building over time but does not give any indication where that energy is being used. To do so, sub metering would need to be employed which requires more points on the buildings electricity system to be monitored.

Another drawback to the current implementation of the public Pulse dashboard is that it limits the public's ability to view data more than 3 months old. In addition, you are not able to specify a custom time frame for the charts since the end of the chart is fixed at the current date. This prevents a user from viewing data specific to a past day or week.

The benefit of this technology is that the display is clear and simple; it is comprehensive and visually appealing. All of the functions are simple to use and interactive. It is easy to quickly pick up on trends such as low energy demand on weekends and high energy demand on weekdays

Additional perks of this site is it allows comparison between buildings by both total usage and as a ratio normalizing against square footage. It also shows comparisons to well know energy consumers such as the Eiffel Tower. There are also “Energy Saving Tips” and a “Green Features” section where one can find out more information on how to save energy.

3.0 TRIPLE BOTTOM LINE

The proposed solution for energy monitoring for the new UBC SUB is solely focused on the ability to sub-meter electricity use and use the acquired data as a feedback loop for students and building managers. This monitoring will have an impact in economic, social and ecological areas. The goal is to ensure that all three see positive shifts/benefits, should a monitoring system be installed.

a. INCREASED AWARENESS (SOCIAL)

By implementing electricity monitoring systems building managers and users will be faced with the data of electricity use. As many case studies show there is evidence of changes in attitude and practices involving energy use. One such case is that of a Quebec home where the hot water tank was the highest user of electricity followed by the refrigerator [5]. Simply by knowing what uses the most energy empowers individuals to do something about this. Another simple change to the home in Quebec was during a renovation; the front door was changed from wood to an insulated steel door. Upon inspection of the electricity data there was a decrease in use [5]. These positive impacts can be seen by users thus encouraging them to continue making green choices.

The goal of having a sustainable SUB should be to harvest a shift in attitudes toward reduced reliance on energy and convenient consumption. By displaying dashboards of the energy use in the new SUB passers-by can see what is really going on in the building. By

seeing this sort of system an individual is more likely to go back home and think about their personal consumption. By triggering this thought the individual is now challenged to think about one's own lifestyle and hopefully when faced with a choice to reduce one's reliance or consumption the image of the SUB's display monitor comes back to mind.

It is very important for there to be a feedback loop for building users to be able to relate to. If someone cannot see the effect they have why should they change? Providing a monitoring system is the beginning of this feedback loop. The challenge is still there to engage the users to first of all care about their energy use. According to a Pulse™ case study on the implementation of their product for the government of British Columbia

The Pulse™ Dashboard was a key part of a recent campaign to encourage staff to turn off lights at lunchtime. During the campaign, the Dashboard gave staff real-time feedback about their energy conservation efforts and allowed them to compare their results to colleagues on other floors of the building. The campaign week led to a 35% energy savings by staff using the daylight dimming system [6].

In addition to monitoring it is also beneficial to encourage these "occupant engagement programs [6]". This helps to ensure there is an effort to make improvements. The reward for the occupants is when they are able to see the benefits in the monitoring, thus the completion of the feedback loop.

For the renewable energy sources in the SUB there would be the opportunity to display how effective these innovative solutions are to the overall energy use of the SUB. It would enable people to see how the renewable energy is benefitting the SUB and prove it is not just an experiment with no real effect. Upon seeing the potential for these technologies people will recognize their validity. During an Applied Science 261 lecture Dan Hajdukovic explained how most people today expect convenience, for example when one flicks the light switch the light just appears and they do not care where it comes from. The same is true for garbage collection and water supply [7]. This attitude is a large factor in overuse. People do not see the effect they have and therefore abuse the resources

that appear to be endless. With this monitoring system people can start to recognise that there is money being wasted and energy being consumed.

A simple survey was sent out to numerous people, some students (mostly engineering), some professors and other SUB users. The results from the survey can be found in the Appendix. The purpose was to estimate people's interest in energy monitoring and whether or not they felt it would be an effective way to encourage people to change their habits. There were various written responses that are not shown in the Appendix, however some were negative but more were optimistically positive, believing that by displaying the energy uses of the SUB will encourage students to think about their impact at home. The most important feedback from this survey was that 81% of people said that they would be interested in the information that would be available; if a display monitor available, 15% of people would view it every time going to the SUB, 26% every other time going to the SUB and 34% would rarely look at it. This is a total of 75% of people who would be looking at the monitor at some point. In the comments there was some concern that one would look at it then not bother again, others seemed to believe it would be of lasting interest. In conclusion this survey shows that the majority of people believe that monitoring the SUB's energy use is a positive idea that will have beneficial results.

b. IMPROVED PERFORMANCE (ECONOMIC/ECOLOGICAL)

According to a study that approaches climate change by proposing that using seven existing technologies, the first suggested methods are under the category of "Efficiency and Conservation". Each solution is expected to be a wedge in cutting out emissions. Under the "Efficiency and Conservation" category the third suggested wedge is to have "More Efficient Buildings". According to this study it is possible to reduce building emissions by 25% simply by using known/proven technology already in use [8]. By having an energy monitoring system this will assist the new SUB to see where there is continued room for growth and more savings.

By being more conscious of energy use and keeping a focus on reduction there will be both economic and ecological benefits. For example, the reduced emissions all the way

back to the source of the electricity. Here in British Columbia we are fortunate to have hydroelectric dams. As the province grows the demand for electricity will grow. Should BC Hydro be forced to build a new dam due to increase in demand, this would cause large volumes of greenhouse gasses to be released into the atmosphere while flooding the reservoir. Although reducing energy use in British Columbia does not appear to be overly beneficial due to the use of hydro, if everyone consumes less we will have a smaller environmental affect. The best way to help this is to reduce the dependence on externally generated electricity. By reducing the amount of energy consumed, there is a greater ability to offset that consumption with renewable energy production, thus reducing the SUB's dependence on externally generated electricity and reducing the SUB's ecological footprint.

This reduction of electricity use is done by revealing the areas of overuse or neglect by building users through the sub-monitoring system. If there are any abnormal operating conditions there is the possibility to catch these instances quickly and deal with them rather than having them continue operating undetected. In addition to the benefits of reducing the energy use, this directly correlates to saving money. When there is less electricity being used less money needs to be paid.

4.0 HARDWARE RECOMMENDATIONS FOR THE NEW SUB

Implementing a sub-monitoring system in an existing building can be difficult. To make for an effective system, monitoring points should be chosen to match a logical electrical division in the building such as division between rooms, floors, or major systems such as HVAC and lighting. Existing buildings are rarely wired with this in mind as any given electrical line could be serving multiple different rooms, floors or system types, thus those ideal points rarely exist. Furthermore, the geometry of the building's construction may make it impossible to access and mount current transducers at ideal points in the electrical layout.

Fortunately, in the case of the new SUB project, the monitoring system can be developed in parallel with the electrical layout in order to avoid these two issues. We recommend that the goal

to logically divide the building electrical layout be taken into account during design stages so that sub-metering can be effective and easy for users to understand.

Most new buildings the size of the new SUB, are already equipped with building automation networks such as BACnet or ModBus. These networks allow for communication between building automation and control systems for HVAC, lighting and access control but can also be interfaced with the Pulse™ system. Current transducers can be placed at key points in the electrical layout and interfaced with nearby BACnet or ModBus modules. Doing so would decrease the cost of implementing the sub-metering system by merging it with the building automation system.

According to Damir Hot, a sales associate at Pulse Energy™,the average hardware cost for a sub-metering system varies from $1500 to $2000 per point monitored.[9] This includes the transducer cost from a company like Schneider Electric and nominal signal network costs. Hardware can be purchased through Pulse, as a product reseller, or through companies directly. Software costs for sub-metering with the Pulse™ system range from $2000 for smaller systems to $8000 for larger systems with 100's of inputs [9]. A building with 20 points of monitoring would cost around $5000 bringing the total estimated cost to $45,000, which does not include the cost of an existing building network.

In the survey of 47 potential UBC SUB users, only 15 (32%) were aware that UBC *does* local energy metering on campus buildings already, while 81% were interested in looking at the data. As described earlier, it is beneficial to lead occupant engagement programs [5]. We recommend that space be set aside for a public Pulse™ dashboard display. This display could be a television set or projector system. It would display easily understood energy information and rotate through several different views, a feature that the dashboard software currently allows. The display should be set up in a heavily trafficked area of the SUB in order to induce the social awareness described earlier in this paper.

5.0 CONCLUSIONS

The recommendations of this paper are to consider the presence of a sub-monitoring system as the electrical layout is designed, implement a sub metering system using existing building networks and expand the reach of the Pulse™ dashboard to a public area using a television or projector. Pulse™ was the only system considered in this report because UBC has already invested in their software and hardware systems; however the same triple bottom analysis would apply to any system capable of sub metering and dashboard presentation.

Implementing this solution will positively affect all three aspects of the triple bottom line simultaneously. People will be able to see the electricity use; they will be able to compare trends and will be challenged to improve their performance. From this there will be a reduced reliance on externally generated electricity, thus reducing the SUB's ecological footprint and at the same time save money doing it by reducing the bill to BC Hydro.

This paper does not fully explore the implementation of the sub metering system. Further research should be conducted as to how the building should be electrically divided to give building managers meaningful data and how to effectively present that data to educate students on electricity use.

Although only electricity metering has been explored here, similar metering systems can be applied to energy and materials such as steam, natural gas, recycling, compost and garbage. The environmental impacts of these resources differ from electricity but the social feedback loop generated by presenting metering information remains the same. Research should be done to explore the methods of metering in these areas.

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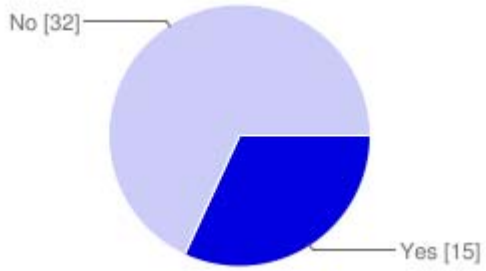
APPENDIX

1.0 SURVEY RESULTS

47 responses

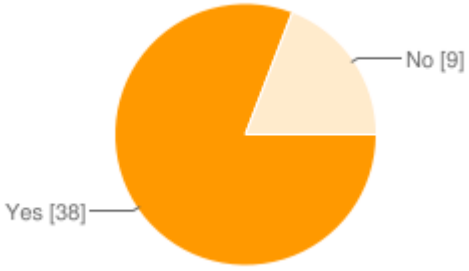
Summary

Are you aware of any energy monitoring systems for energy consumption in buildings on campus at UBC?



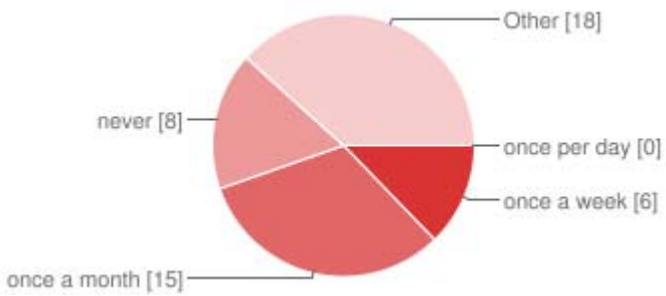
Yes	**15**	32%
No	**32**	68%

If there were a monitoring system in place to show the energy use in buildings would you be interested in looking at it?



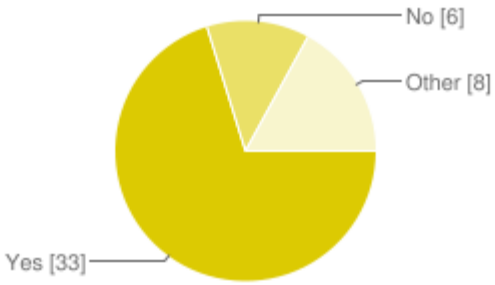
Yes	**38**	81%
No	**9**	19%

If there were a monitoring system would how often would you visit this site or view the data?



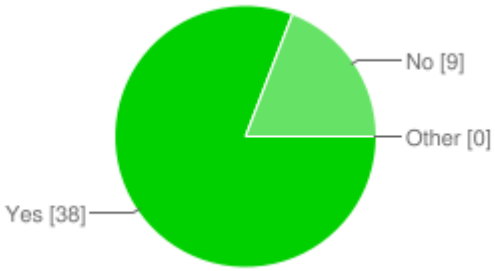
once per day	**0**	0%
once a week	**6**	13%
once a month	**15**	32%
never	**8**	17%
Other	**18**	38%

Do you think that monitoring a building's energy use would be beneficial to reduce energy use?



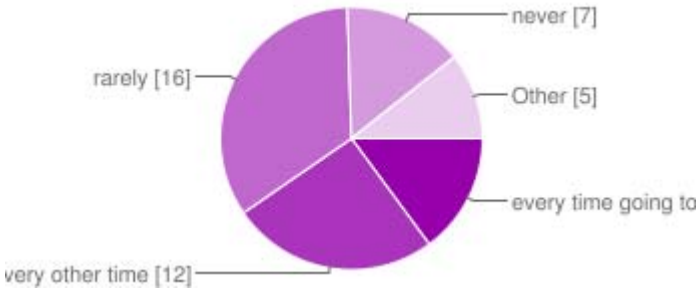
Yes	**33**	70%
No	**6**	13%
Other	**8**	17%

If there were a display monitor set up in a common area in the new SUB displaying the energy uses would you be interested in this information?



Yes	**38**	81%
No	**9**	19%
Other	**0**	0%

How often would you purposely go look at the display monitor if there were one in the new SUB?



every time going to the sub	**7**	15%
every other time	**12**	26%
rarely	**16**	34%
never	**7**	15%
Other	**5**	11%

Please share why you think monitoring the new SUB's energy use is a good thing or bad thing.

Answers varied