Alma Mater Society of the University of British Columbia New Student Union Energy Dashboard Project

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ALMA MATER SOCIETY OF THE UNIVERSITY OF BRITISH COLUMBIA NEW STUDENT UNION ENERGY DASHBOARD PROJECT

Building Dashboards and Sustainable Behaviour Changes

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GRS397: Directed Studies in Global Resource Systems
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Executive Summary

The Alma Mater Society of UBC (AMS) is currently in the construction phase of the New Student Union Building (SUB). The design for the building aims to achieve Leadership in Energy & Environmental Design (LEED) Platinum status, their highest green building rating. One required feature the society is looking to implement is a consumption feedback tool to engage occupants of the building through an energy dashboard. This report assesses techniques that should be utilized for energy dashboards to assist in promoting sustainable behaviours targeted by the AMS within the building.

Based on a literature review, I assessed several dashboard designs already available in the industry as well as the challenges faced by these interfaces. After, community based social marketing and digital communications strategies were identified as criteria for the design of the dashboard for the new AMS building. I then analyzed other factors of behaviour change needed to achieve objectives identified by the AMS that a typical building dashboard would not usually accommodate. As requested by the AMS, consultations with relevant stakeholders were held to establish a recommendation for the appropriate technologies needed to move forward.

The positive behavioural effects of existing energy dashboards dwindle over time (Hargreaves et al., 2010). Existing energy dashboards need additional motivators in order to establish sustainable behaviours in a building such as the New SUB. Effective communication is an important aspect of promoting sustainable behaviours and the building dashboard must adhere to digital communication strategies in addition to its role as a consumption feedback tool. However, studies show that sustainable behaviours are best motivated when one is immersed in a culture of environmental stewardship. The AMS must establish this culture within the building, in which energy dashboards will only play a part.

Due to the scope of the initial project, which focused on the design of the dashboard system, recommendations for establishing social norms are limited. I recommend that further study be conducted in this area to establish the best combination of communication and social programming within the New SUB.

Introduction

The Alma Mater Society (AMS) will be completing and opening the New Student Union Building in September 2015. A driving goal of the project has not only been to design and construct a sustainable building, but also to design operational processes and strategies that will improve sustainable social behaviours among building users. The AMS will be employing a Building Management System (BMS) that gathers data through meters to optimize building energy usage. The AMS has been pursuing development of a user-end dashboard that will display this information in order to engage users of the building in:

1. the sustainability features of the building;
2. campus-wide initiatives to reduce water and energy usage and waste production; and
3. campus-wide social behavioural changes.

Objectives of Project

- Identify best practices in operations and dashboard programming, social marketing strategies and sustainable behavior change
- Develop suitable and sustainable programming for the energy dashboard interface
- Develop materials for dashboard interface (design and layout)
- Develop a viable action plan to put forward to the AMS for approval, based on resources the AMS will have access to

As the project progressed, key stakeholders requested that the project to be more focused on the design and functionality of the dashboard and less on the dashboard content.

Background: Building Management Systems

In recent years, environmental sustainability has become an increasingly prominent element of the construction industry. Sustainability has been embedded by the AMS into the New SUB Project from the beginning. This manifests in, among other initiatives, the goal to achieve LEED (Leadership in Energy and Environmental Design) Platinum+ status, the highest green building rating, and implementing both operational and social sustainability measures for design, construction, operation and decommissioning of the building as stated in the New SUB Sustainability Charter (Alma Mater Society of UBC, 2011). As laid out by LEED requirements in the "Energy and Atmosphere" category, green building construction aims to achieve greater energy efficiency (United States Green Building Council, 2013). One method of achieving these goals is to employ an automated control system (Cooperman, Dieckmann, & Brodrick, 2012) – a building management system (BMS). An automated building management system gathers data from various meters in the building during its operation and responds to reduce energy usage and waste production as well as increase energy efficiency. In addition to controlling lighting, temperature and energy consumption (Cooperman, Dieckmann, & Brodrick, 2012; Johnson Controls, 2014; Schneider Electric, 2014), BMS systems can also track trends over time. Metrics to be tracked in the New Student Union Building include:

- Rain water catchment
- Water usage
- Electricity usage
- Natural gas usage
- Solar electricity generation

- Thermal comfort
- Carbon dioxide levels (determining indoor air quality)

(Michael Kingsmill, personal communication on March 21, 2014)

The New SUB will feature projects implemented by previous Social Ecological Economic Development Studies (SEEDS) students and AMS staff. These include a single scale that measures building waste from four streams (compostable materials destined for UBC's in-vessel composter, recyclable plastics, recyclable paper, solid waste) implementing a campus-wide reusable container program (Eco-to-Go) and an in-house biodigester. Due to these unique features, the AMS has stipulated that several operational metrics must be monitored:

- "Green Discount" given to those who bring their own containers
- Eco-to-Go program container purchases
- Data collected from four waste streams leaving the building measured in kg
- Compostable materials diverted to in-house biodigester measured in kg

Methodology

This report is based on a literature review sourced from peer-reviewed sources as well as publications from industry professionals. In addition, I interviewed various stakeholders including AMS Designer Michael Kingsmill, UBC Campus Sustainability Climate and Energy Engineer Lillian Zaremba, UBC Digital Information Channels Communications Coordinator Jamil Rhajiak and UBC Land and Food Systems Multimedia Developer Duncan McHugh in order to gain insight on the current technologies, strategies and limitations of similar projects on campus.

Providing information is not enough to change behaviour

Trends and analyses produced by BMS systems are fed into interactive dashboards that allow users of the building to "view current and historical real-time energy consumption/production data" (Lucid Design, 2012). This system can be applied to achieve LEED's Occupant Engagement and Behaviour Change credit. The credit is earned through three components: providing consumption feedback to building occupants; empowering occupants with data through engagement activities, and monitoring the data to observe the performance of occupant behaviour change (USGBC, 2014).

Industry dashboard software (Lucid Design, Pulse Energy, Schneider Electric, Honeywell, et cetera) provide platforms for feedback to users regarding their utility consumption. In "Curiosity to cupboard: Self reported disengagement with energy use feedback over time," Snow et al. (2013) note that although there is widespread evidence that eco-feedback provides positive behavioural reactions, the effectiveness of feedback devices differ over time. In their study, Snow et al. (2013) interviewed users of a simple feedback device that displayed their energy consumption and indicated when consumption was higher than average. Although participants that owned feedback devices had all initially been interested, many noted that the device "failed to maintain [their] interests" over time, in particular because these devices did not provide users with new information. Secondly, the study states that although these devices informed users about their energy consumption and users were indeed motivated to perform actions to save money, the devices "failed to motivate pro-environmental behaviour" (Snow et al, 2013). In other words, users did not perform the requisite energy saving actions to achieve those goals despite an incentive to do so. Similarly, in "Making energy visible: A qualitative field study of how householders interact with feedback from smart energy monitors," Hargreaves et

al. (2010) compared user engagement with three different types of devices over time. Their study found that, overall, the “least common behaviour effect” was motivating changes to consumption in other areas of their own life, or encouraging others to reduce their energy consumption (Hargreaves et al, 2010). This suggests that the information-deficit model (an assumption where increased feedback increases awareness or knowledge leads to changes in energy-use behaviour and therefore a decrease in consumption) posited by Wilhite and Ling (1995) may not actually promote sustainable behaviour changes and that information provision may not be the determinant that promotes social behavioral change.

Findings

Designing for Sustainable Behavioural Change: Building Dashboards

a. Location and Aesthetic Appeal

As identified above, a key issue with dashboard and feedback devices is their ability to hold user interest over time. In Hargreaves et al. (2010), there were significantly higher levels of interest among users for two of the three commercial devices that were tested because of two factors: 1) the company insisted that the monitor be placed in a prominent location within the house and 2) the company devices were perceived as having better aesthetic design and coloured graphics. This is supported by Snow et al. (2013), who found "highly visual and playful" eco-feedback prototypes were well received." The findings from these studies are supported by various other industry reports. The University of British Columbia's "Content Guidelines for Digital Signage" (2011) lists "signage screen locations," "relevance and accessibility of the information," and "design and aesthetic integrity" as criteria for a clear communications strategy. The support for appealing graphics is echoed in other studies such as Tractinsky et al.'s "What is beautiful is usable" (2000). Their findings indicate that there is a strong relationship between initial user "perceptions of interface aesthetics and their perceptions of the system's usability." This is supported by research in social psychology and consumer behaviour that suggest, "a design's aesthetics may improve users' mood and their overall evaluations of the system" (Tractinsky et al., 2000). Therefore, current graphic and web design trends should be incorporated into the dashboard's design. This will increase the perceived usefulness of the dashboard and ensure a higher probability of engagement by building users.

b. User Experience: Compelling, Compact, Guided Content

A dashboard designed with an objective of user engagement must use the interface and information presented to stay “relevant to different users” (Juice Analytics, 2009). This begins with controlling how “compelling content” ((Shneiderman, 2004) is accessed by users. Marketing studies and UX (user-experience) design professionals state that data should reveal first the information that “deserves attention” and is the most important for all users to understand (Juice Analytics, 2009; Patterntry, 2010; McKenzie-Mohr, 2000). Information should by grouped into clear and concise portions that can be “gradually revealed” to display greater detail (Juice Analytics, 2009). Visual cues and prompts should “guide” the user to explore the more detailed information that is selected by building staff. These user-experience methods are in line with research that supports digital storytelling (use of visuals, photography and text) as a tool for engaging a broad range of audiences, particularly students (Sadik, 2008; Barrett, 2007).

(Adapted from Juice Analytics, 2009)

User-experience considerations:

- Location of attention (top left is most observed)
- Grids
- White space
- Colour theory (the meanings behind colours; colours appropriate for displaying data)
- Typography
- Chart type

c) Peer Network: Competition, Cooperation

Several studies have shown that more energy is conserved more greatly when feedback devices compare an individual's consumption with that of their peers or the average consumer. In Snow et al. (2013), the ability to compare energy consumption with those of similar age or families of similar size was noted as a desirable function. This is supported by Chen et al.'s (2012) study, "Modeling building occupant network energy consumption decision-making: The interplay between network structure and conservation" where they note that in "tighter [... and] denser networks," the sharing of peer energy consumption data can "improve energy saving behaviour" (2011). Hargreaves et al. (2010) echo this in their study, where they found that energy consumption is a "social and collective [...] process." However, household dashboards can promote both senses of "empowerment or disempowerment," when individuals discuss energy reduction strategies with household members or when results invoke feelings of "anxiety and even guilt." The sharing of peer networks may not result in significant energy use reduction. Snow et al. (2013) notes that the effect of peer sharing is polarizing–some desire the comparison while others do not. Existing energy dashboards compare campus buildings to one another. For example, UBC's Pulse Energy Dashboard (2014) can compare statistics between

residences. However, comparison to other buildings may not accurately reflect the meaning of "peer" in a social community that is unique to a building such as the New SUB. It is neither a residence nor an academic building. This report will later discuss how the dashboard should utilize the meaning of "peer" within the New SUB as a means to cultivate behavioural change while utilizing the energy dashboard.

d) Calls to Action

> *"I probably used it more when we first got it [... but then] you develop habits to switch things off and keep the lights off–and then you don't need to look at it so much"*

(Participant feedback, Hargreaves et al., 2010).

Most user interactions with an energy dashboard tend to follow a pattern: at first exposure, users are more willing to change their behaviour as prompted. However, as illustrated in the feedback quoted above, users lose interest in performing positive behaviours as time moves on (Snow et al., 2013). Due to the nature of the New SUB, frequent user turnover will ensure there will likely always be many individuals in "discovery" phase, but likely many more in the "maintenance" phase, so strategies in communication must appeal to this second type. Similarly, McKenzie-Mohr's (2000) "Quick Reference: Community Based Social Marketing" notes that humans tend to forget to take actions that "support sustainability" and that "prompts" are effective aids to incite sustainable actions. In dashboard design, Juice Analytics (2009) states that dashboards must answer the question "what do I do with this information?" and therefore, should display "actionable information." Criteria for clear call to actions include:

- Noticeable prompts, "visually prominent"
- Self-explanatory, common interpretation

- Presented close to where the action is to be taken

(McKenzie-Mohr, 2000; Juice Analytics, 2009)

Discussion

The AMS hopes to improve energy efficient behaviours in addition to other sustainable behaviours, such as improving waste diversion, lowering sales of bottled water, and encouraging use of public transportation. When it comes to sustainable actions, studies have shown that even though an individual may agree that environmental sustainability is important, these opinions do not necessarily lead to sustainable actions (Cross et al, 2010; Owens and Driffill, 2008; Simcock et al, 2013). What these studies point out is that providing information or changing attitude cannot guarantee sustainable behaviour change. So what can change behaviour?

Designing for Sustainable Behaviour Change: fostering a culture of sustainable behaviour

Community-based social marketing shows that clearly communicated and tangible actions will increase the likelihood of positive behaviour being adopted (McKenzie-Mohr, 2000). However, the most effective interventions for behaviours "involve combinations of mass-media messages, household- and behavior-specific information, and communication through individuals' social networks and communities" (Dietz et al, 2009; McKenzie-Mohr, 2000). The role of an energy dashboard is merely a tool of communication that provides information. The interface may use the most effective strategies, but without combining it with strategies that engage the social environment it is embedded in, the dashboard alone will not achieve the AMS's goals for

sustainable behavioural changes in the long-term. Sustainable behaviour change can manifest within a building when effective communication is combined with social engagement.

Substantial research in social science and behaviour change agrees that “the actions of individuals are powerfully shaped by the observations of others” (Markowitz & Shariff, 2012). Social norms play an important role in shaping how new and regular users behave within a community. In a study of UBC’s Centre of Interactive Research on Sustainability (CIRS) and the effectiveness of the building's design on food disposal, Wu et al. (2013) found that the environmental focus of CIRS "leads both to feeling and behaving in a more environmentally conscious manner." This idea is supported by other studies which have shown that setting behavioural expectations within a community motivates positive behaviour changes (Markowitz and Shariff, 2012; McKenzie-Mohr, 2000; Cross et al, 2010). In Schelly et al.'s (2011) “Reducing Energy Consumption and Creating a Conservation Culture in Organizations: A Case Study of One Public School District”, energy conservation success at Rocky Mountain High School was attributed in part to "feeling like their efforts make a difference" and "having the opportunity for responsibility and decision-making."

To ensure sustainable behaviour changes in its student users, the New SUB must foster the creation of a community where sustainable behaviours are social norms. The building is a place where users should feel ownership, expectation, and responsibility over conservation initiatives. To achieve their objectives targeting behaviour change, the AMS must design social initiatives and programs within the building to create a culture of acting sustainably. Once in place, trends that are observed through the building monitoring system can then be used as a means of tracking the effectiveness of social initiatives within the building.

Flexibility and personalization within the system built

In designing the building dashboard, the criteria mentioned above imply the need for flexibility. Aesthetic appeal, selective content and clear calls to action will change over time to suit the trends observed. The dashboard must be designed to accommodate change and be easy enough for AMS staff to customize content and content design on a regular basis.

Dashboard project is a living lab

There is currently a lack of studies conducted about green buildings as unique as the New SUB. Studies have focused mostly on private households, student residences, or buildings that see little turnover in audience. The New SUB will be a lively, ever-changing environment that will experience large changes in users throughout the useful life of the building as well as through the summer and winter terms. As such, the building dashboard and requisite social programming should be treated as a living laboratory to test new strategies that target user behaviour. This is also an opportunity for the AMS to provide on-going student-led opportunities. Disciplines that could conduct studies related to the dashboard include marketing, communications, psychology, land and food systems, computer science and engineering.

Recommendations

1) **A well-established company should be contracted to develop the building monitoring system. The AMS should stipulate that the company partner with computer science students to develop the energy dashboard interface**

Traditionally, the company that would implement that building monitoring system would also create the user-end dashboard using their own software. Meters on the building will send data to the campus-wide server (ION), which will store the data from all buildings on campus (from here, the AMS can consider backing up this data on their own servers). The data from this server has two destinations: the building management system and the building dashboard. In a discussion with Jamil Rhajiak, Communications Coordinator with UBC's Digital Information Channels, it was recommended that the AMS consider creating a website to host the energy dashboard. A website can be accessible via computer, tablet or mobile phone and should be easily connected to screens that would be located in the New SUB. If created by a student, the AMS could retain the code year-after-year and be able to change and improve upon the methods used to communicate with building users. Student written code would provide an opportunity for student contributions to the AMS, as well as reduce costs to the society. If the company were to write the code, the AMS will likely have to pay annual fees to retain their services and pay additional lump sums to change the code. I recommend a combination between the BMS provider and the student programmer. The BMS provider, which will already have expertise in developing management systems, can implement their existing software that controls the energy usages in the building – a feat that might be outside the capability of a student programmer.

2) Consider creating a student staff position for the behaviour interventions required within the building

Given that the dashboard and social interventions will require regular updates to its design, calls to action and selected content, the creation of a staff position in charge of monitoring and updating the dashboard is recommended.

3) Sample layouts of suggested actions implemented:

Below are layouts of the potential web interface that I have created using Adobe InDesign. They incorporate the findings outlined in this report. Larger versions can be seen in Appendix III.

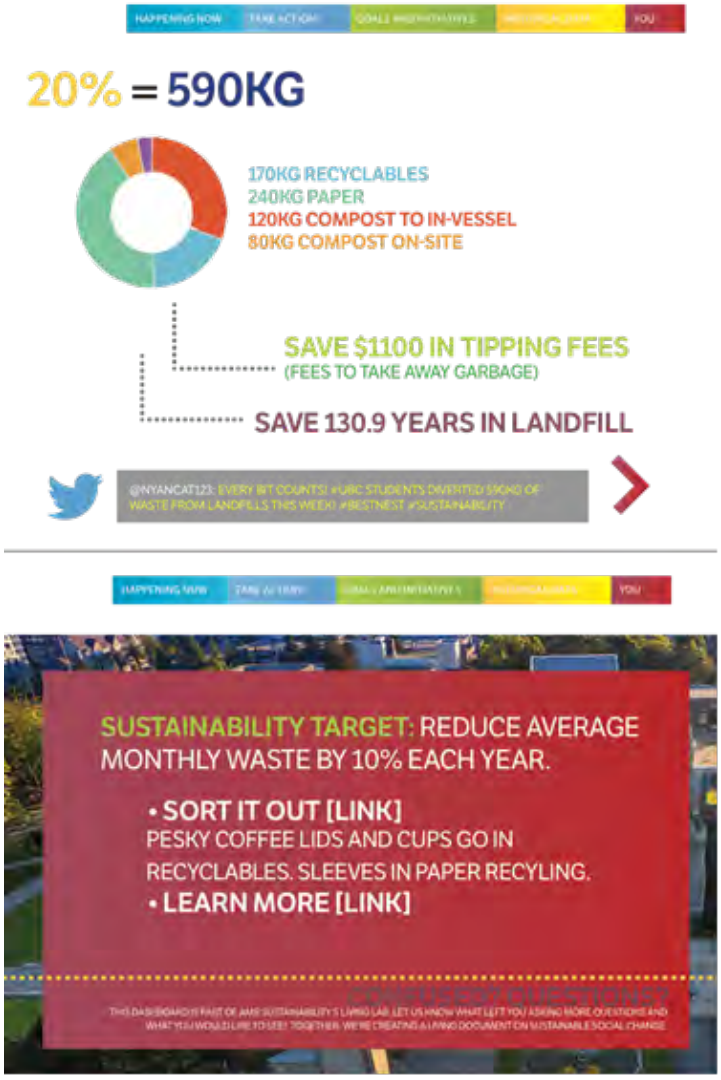
Seen below:

Sample Layout 1 (top) and 2 (bottom)—Front Pages

Seen below:

Sample Layout 3 (top) — Detailed Metrics and Social Media

Sample 4 (bottom) — Community Calls to Action



Sample Layouts 1-4 are possible designs for the dashboard interface. It is a web layout, accessible on multiple platforms. The home page (Samples 1 and 2) states a key metric that can be rotated so that each refresh brings up one of three to four key metrics for the week. Clicking the page slides the module right. This slide reveals more detail about the metric (see Sample Layout 3). In Sample 3, there is a social cue that can encourage students to share this metric via social media platforms. Clicking on the page slides to reveal Sample 4, where there are calls to

action connected to a community goal. Here, it invites users to learn more, give feedback on the dashboard system or explore other parts of the website.

There is a navigation panel on top of all pages. The “Happening Now” tab lays the other three to four key metrics in the system that can be explored. Under “Take Action”, there should be calls to action that can be taken immediately within the building. “Goals and Initiatives” connects users with the goals, initiatives and history of AMS Sustainability in the New SUB. “Historical Data” would allow students to access all data available from the server that is tracked but not highlighted for the week. The “You” section connects users with on campus resources regarding sustainability.

4) Suggested Timeline:

Month	Tasks
January – March 2015	Contact BMS providers with proposed course of action, identify/recruit a Computer Science course and student
April 2015 – July 2015	Building opens, BMS begins tracking metrics, dashboard website will be in development
July to August 2015	Website troubleshooting, enough data will have accumulated in order to display meaningful selective data
September 2015 or January 2016	Dashboard user-end will come online in the building

Appendices

I. Establishing a culture of acting sustainably: sample actions

This is a compiled list of successful actions drawn from studies mentioned in the report. They are purposely framed in the context of the New SUB.

Criteria	Sample actions
Set Behavourial Expectations	• Marketing the building as a hub of sustainability, include this language in all descriptions of the building • Set sustainability as an expected course of action • Permeate building with clear, actionable expectations (such as achievements monitored by the BMS system, occupants using reusable containers, etc).
Create Social Norms	• Regularly demonstrate that peers are performing sustainable actions (ex. play videos/ads on digital signage to promote positive behaviours) • Use highly regarded individuals such as the UBC mascot • Communicate how well peers within the building are performing sustainable actions (ex. "Today, Blue Chip customers saved 40lbs of paper cups from the landfill! Remember to bring your own cup")
Efficacy, responsibility	• Include users in decision making processes. ex. “We used 5% less energy this month compared to previous weeks, saving $20. Where should that money go? Vote now.) • Note: the vote would take place on the dashboard website and should be multiple choice. The choices should contribute back to sustainability initiatives in the building such as purchasing more equipment for the rooftop garden.

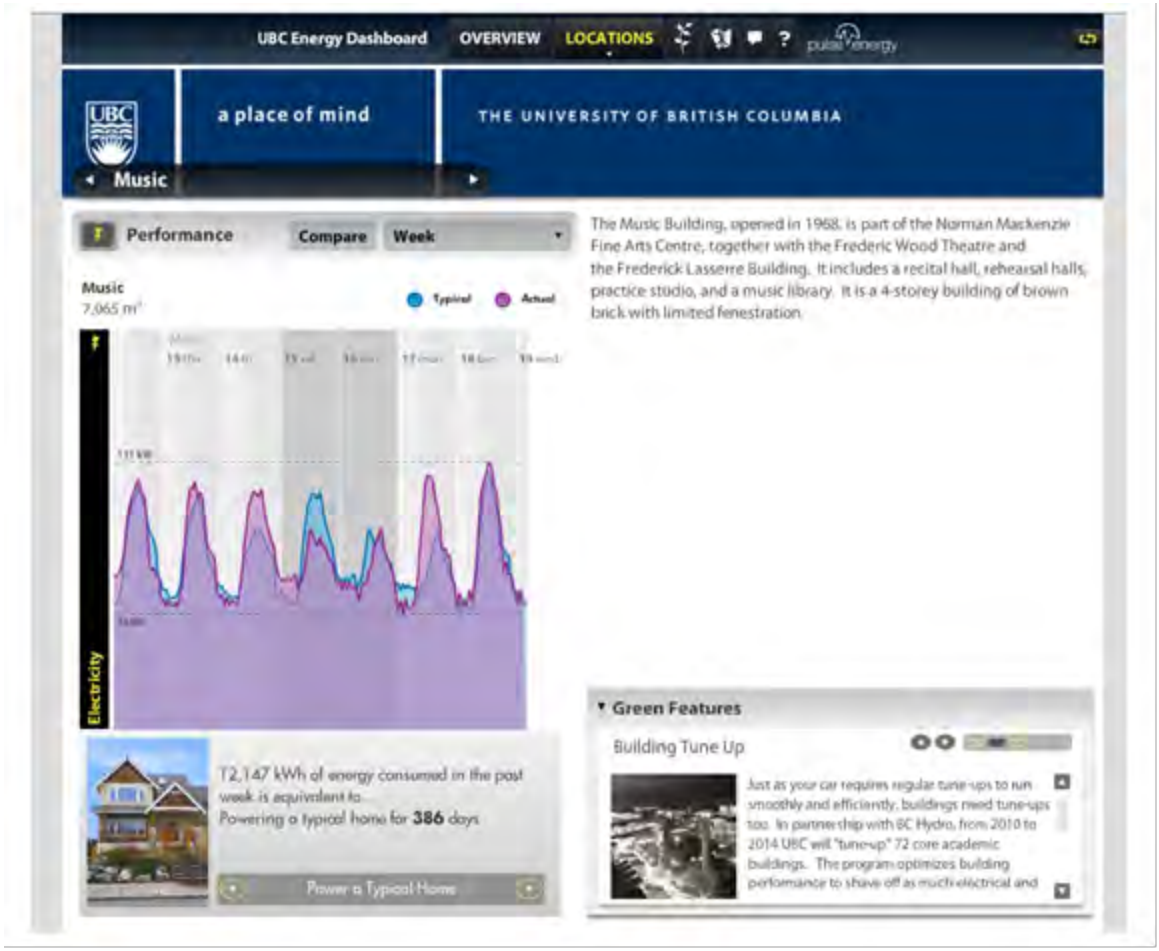
II. Existing Energy Dashboards versus Proposed Dashboard

This is a comparison between two energy dashboards common in post-secondary institutions compared to the proposed energy dashboard. They were evaluated on the criteria identified in the report.

Criteria	**UBC Pulse Energy Dashboard** (Pulse Energy, 2014)	**Oberlin College Lucid Design Dashboard (Lucid Design, 2014)**	**Proposed**	**Recommendations**
Aesthetic Appeal	• Figure I (below) • Not eye-catching • Graphs are lackluster, though clear	• Figure II (below) • Pleasing colours and fonts • Large visual is eye-catching	• Sample Layout 1 and Sample Layout 2 • Eye catching visuals • Modern/trendy colours	• Ensure recent design trends are reflected in dashboard display
Guided Content	• There isn't a clear hierarchy of information • Does answer the question of "why is this important" by comparing the energy use to a comprehendible scale (household energy) • Too much data upfront, distracts from the message • Detailed content is available	• There is a hierarchy of information • Does not place the importance of this information front and centre • Too much data upfront, distracts from the message • Detailed content is available	• Most important information is displayed first • Detail is revealed in the process • Detailed content is available	• Content is revealed, guided • Most important information is revealed first • At first glance, important information is digestible (easy to understand)
Peer Networks	• Compares data to other buildings on campus	• Compares data to other buildings on campus	• Data is fed to central server and can be compared to other buildings • Comparisons are drawn to actions of peers within the building	• Emphasize the sustainable actions of peers and leaders within the building and community (staff, students, mascots, et cetera)

Criteria	**UBC Pulse Energy Dashboard** (Pulse Energy, 2014)	**Oberlin College Lucid Design Dashboard (Lucid Design, 2014)**	**Proposed**	**Recommendations**
Calls to Action	• No clear call to action	• No clear call to action	• Call to action follows the relevant data • Actions can be performed within the building or on campus • Actions are easy to understand	• Easily understandable call to action that can be performed immediately
Flexibility/Accessibility from other platforms	• Company is somewhat flexible with customizing the dashboard • Dashboard uses Flash, which cannot be enabled on many phones and tablets	• The company is inflexible on the design of the dashboard. All dashboards have the same design. • Dashboard uses Flash, which cannot be enabled on many phones and tablets • Dashboard is slow to load	• If the AMS holds ownership over a website's coding, it can be modified when needed • Websites can be more easily accessed by phones and tablets when designed without Flash	• Ability to program appropriate messaging is key

Figure I.



(UBC Pulse Energy Dashboard, retrieved on November 19, 2014)

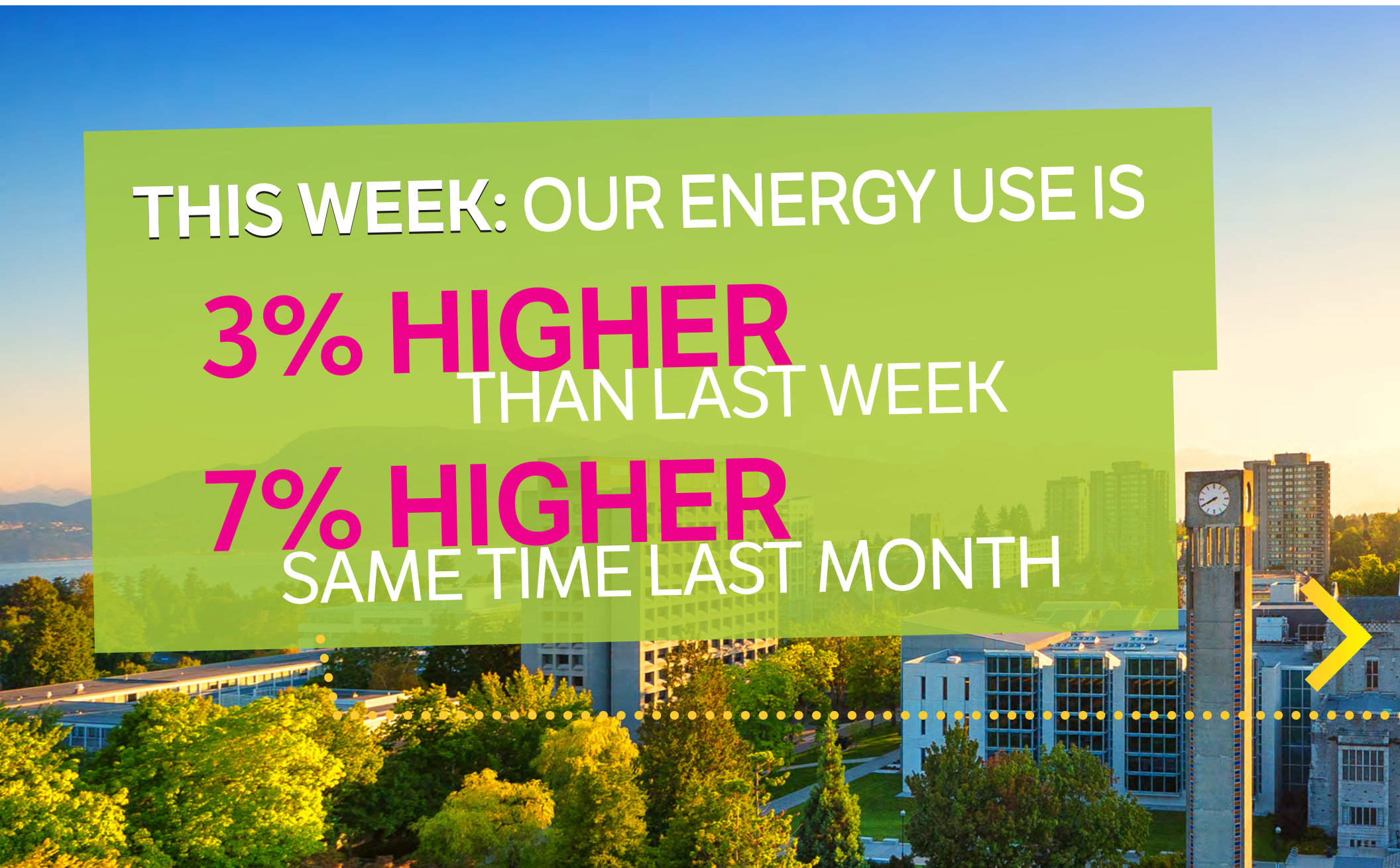
Figure II.

(Oberlin College Lucid Energy Dashboard, retrieved on November 9, 2014)

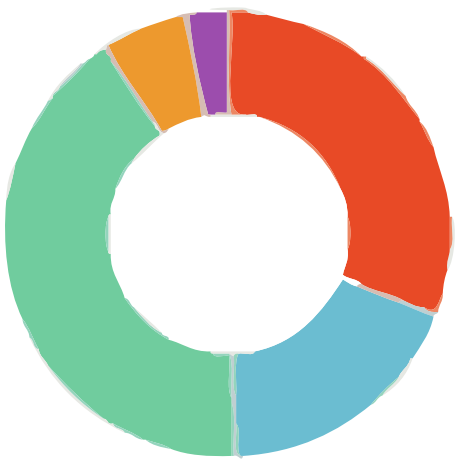
III. Larger Sample Layouts

See below.

HAPPENING NOW | TAKE ACTION! | GOALS AND INITIATIVES | HISTORICAL DATA | YOU



20% = 590KG



170KG RECYCLABLES
240KG PAPER
120KG COMPOST TO IN-VESSEL
80KG COMPOST ON-SITE

SAVE $1100 IN TIPPING FEES
(FEES TO TAKE AWAY GARBAGE)

SAVE 130.9 YEARS IN LANDFILL

@NYANCAT123: EVERY BIT COUNTS! #UBC STUDENTS DIVERTED 590KG OF WASTE FROM LANDFILLS THIS WEEK! #BESTNEST #SUSTAINABILITY

HAPPENING NOW | TAKE ACTION! | GOALS AND INITIATIVES | HISTORICAL DATA | YOU

SUSTAINABILITY TARGET: REDUCE AVERAGE MONTHLY WASTE BY 10% EACH YEAR.

- **SORT IT OUT [LINK]**
  PESKY COFFEE LIDS AND CUPS GO IN RECYCLABLES. SLEEVES IN PAPER RECYLING.
- **SHARE WITH FRIENDS [SOCIAL]**
- **LEARN MORE [LINK]**

CONFUSED? QUESTIONS?

THIS DASHBOARD IS PART OF AMS SUSTAINABILITY'S LIVING LAB. LET US KNOW WHAT LEFT YOU ASKING MORE QUESTIONS AND WHAT YOU WOULD LIKE TO SEE! TOGETHER, WE'RE CREATING A LIVING DOCUMENT ON SUSTAINABLE SOCIAL CHANGE.

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