Energy Savings & Greenhouse Gas (GHG) Reductions through behavior change programs

July 2016

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Executive Summary

Behavior Change Program has been one of the most powerful tools to achieve significant energy savings in any organisation or institution. To meet the goals of Climate Action Plan 2020, UBC has defined potential areas for implementation of behavior change programs as one of the initiatives that would deepen the sustainability culture on campus. To develop an effective behavior change program, creating an energy model that would unravel GHG reductions as well as associated energy savings was the first step to march ahead in this direction. Hence, regular weekly meetings have been conducted from February-2016 to May-2016 with all the stake holders of the project in order to come up with a model that would act as a guide while forming a strategy for campus wide behavior change programs.

Student Residences, Offices and Labs are the primary locations where this study was targeted. Members of SEEDS, Sustainability & Engineering, Green Labs, Building Engineers, Risk Management Services (RMS) and Energy & Water Services (EWS) have been kind enough to co-operate and provide necessary data/information for the advancement of this energy model at various stages. Detailed Recommendations are given at the end of every section of the report that would assist in aligning the planning and implementation of the behavior change program in near future.

Following are the highlights:

	Annual Savings						
	Potential Areas	Opportunities	Criteria	Energy Savings (GJ)	GHG Reductions (kg CO2e)	Energy Cost ($)	Water Cost ($)
Student Residences	Student Residence Showers	Encouraging the students to reduce the shower time	If students reduce shower time by 5 mins	22,850	1,260,564	$ 346,813	$ 113,721
Student Residences	Student Residence Laundry	Encouraging the students to switch to cold water wash	If students switch to cold water wash by 40% from hot or warm or water wash	302	15,000	$ 4,576	
Buildings	Offices	Encouraging occupants to adjust to a reduced base temperature	If base temperature is reduced by 1 degree in 'Office dominated' spaces for a total area of 46,089 sq.m	9,100	10,893	$ 74,623	
Labs	VAV Fumehood Labs	Shut the Sash - Energy Savings by reducing the fume hood sash heights	If methodology is same as previous competitions	16,609	683,374	$ 165,666	

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1 Introduction

While UBC is committed towards reducing its greenhouse gas emissions on campus, the Climate Action Plan 2020 has further presented an opportunity for all the stakeholders of our innovative institution to expand the engagement of students/staff/faculty into several promising sustainable programs. Energy savings & GHG reductions through behavior change opportunities has been identified as one of the potential initiatives while tackling ways to meet the challenging energy goals of CAP 2020.

Labs, offices, classrooms and student residences are potential areas on campus where behavior change programs can be driven to save energy and reduce the respective green house emissions. The energy analysis was developed into a spreadsheet that contains assumptions which can be manipulated/varied to calculate the actual savings for the respective behavior change program. This study does not indicate the level of behavior change that is achievable. The assumptions and calculations are explained for each area. The recommendations are given keeping in mind the realistic implementation of individual programs for labs, offices and student residences in near future in order to achieve maximum energy savings.

1.1 Potential Areas:

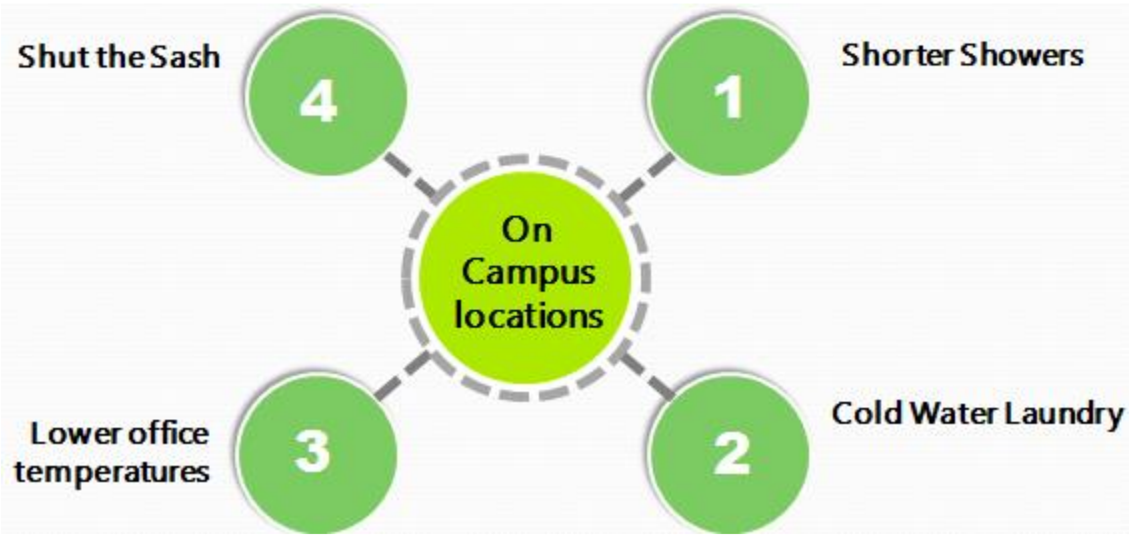


Figure 1 - Potential Areas for Energy Savings

In order to foster the sustainability culture and maximise the efficiency of Behavior-change opportunities, the following areas (each with individual agendas for energy savings) were shortlisted during the initial set of meetings with all the stakeholders of the program:

1) Student Residences(Showers) - Reducing the shower time.

2) Student Residences (Laundry) - Switching to cold water laundry.

3) Offices - Lowering the baseline temperatures.

4) Labs (VAV fume hoods)- Shut the Sash.

2 Reducing shower time:

2.1 Assumptions & Recommendations:

1) Type of shower head and flow rate:

A: 'Symmons Temptrol 2' type of shower head with a capacity of 2.5 gpm is assumed to be installed inside all the student residences.

R: Individual surveys should be carried out at every student residence to identify the type of shower head and its respective capacity. The spreadsheet has provision of introducing a mix of various types of shower heads which would deliver a weighted average value. The results are linked to the inputs and would change accordingly.

2) Occupancy:

A: Student Housing has shared that there is 100% occupancy for 10,000 beds between the months of September to April at student residences inside UBC campus and 35% occupancy between May to August. The total number of showers round the year to calculate the baseline are calculated on the basis of these numbers for occupancy.

R: The occupancy during the summer months could vary and the occupancy rate of 35% can be refined after further confirmation with Student Housing.

3) Baseline frequency of showers round the year:

A: The Do it in the Dark campaign 2012 report was referred to for the frequencies of shower duration among students. These percentages (of frequencies) combined with the occupancy rates are converted to calculate the total number of showers round the year at all the student residences. This formed the baseline for energy analysis.

R: These frequencies were extracted from surveys in the literature and then introduced in the Do it in the Dark campaign report. Residence advisors can create a questionnaire asking the residents about their shower usage patterns and duration or measurement devices could be provided such as shower timers or on-shower meters. These numbers can be used to calculate the shower duration frequencies and simply introduce in the spreadsheet to refine the energy saving numbers.

2.2 Methodology:

Year round 'Occupancy' of on campus residences and the 'Frequency' of shower durations by students are two critical factors that are imperative to form a baseline and estimate the anticipated energy savings.

The occupancy data received from the Risk Management Services is converted into average total number of showers on campus by making a that on an average *one person has his/her shower once per day.*

Shower durations	Frequency of showers
<5mins	13%
10 mins	43%
15 mins	28%
20 mins	13%

Table 1 - Frequency of shower duration

The total number of showers are then quantified into energy use as per the 'frequency' of the shower usage (Planning, 2012). From every category, 5 mins are reduced and the existing as well as future energy use is calculated to further extract the final values.

2.3 Results

Energy Savings - **22,850 GJ.**

GHG reductions - **1,260 kg CO_2e**[1]**.**

Energy Cost Savings - **$346,813.**

Water Cost Savings - **$113,721.**

[1] Emission factors are cited from http://www2.gov.bc.ca/assets/gov/environment/climate-change/policy-legislation-and-responses/carbon-neutral-government/measure-page/2014_bc_best_practices_methodology_for_quantifying_greenhouse_gas_emissions.pdf

2.4 Additional Recommendation:

The results for this section are based on 5 mins reduction in shower time. Once the latest data on usage frequencies is available from residence advisors, the reduction in shower time can be more than 5 mins too depending on achievable savings. Currently, 5 mins reduction time is deemed achievable for all students living on campus.

3 Cold Water Laundry

3.1 Assumptions & Recommendations

1) Machine usage and estimated number of washes:

A : Machine usage data of Totem Nootka and Walter Gage was provided by Student Housing. These percentages have been averaged and further used for calculation. The estimated number of washes were cited from the Do it in the Dark campaign 2012 report. It is assumed that every student does his/her laundry twice a month. The machine usage combined with estimated number of washes delivers the total number of hot, warm and cold washes respectively.

R: The machine usage data can be updated once Student Housing supplies the data for all the student residences. A constant contact needs to maintained with the team for this data. A survey in each of the buildings could render realistic information about the average number of washes. The results are linked to the inputs and would change accordingly.

3.2 Methodology

The Hot, Warm and Cold water temperatures were cited from various studies published in the literature.[2] The 'Occupancy' and 'frequency' of hot, warm and cold water wash was given by Student Housing. The total average number of washes was calculated by assuming that on an average, one person does his/her laundry twice a month.[3] The total number of washes in each category is tabulated and further expanded by estimating different scenarios of **'switching to cold water wash'.** For eg. Ranging from 10% to 40% switching from HOT and WARM water wash to COLD water wash.

		Hot	Warm	Cold
Residences	Walter Gage	5%	41%	54%
	Totem Nootka	10%	47%	43%
	Average	**8%**	**44%**	**49%**

Table 2 - Hot, Warm and Cold Water wash percent use

Energy Savings and GHG reductions in every scenario are then calculated for rendering the final values.

[2] http://www.clean-organized-family-home.com/laundry-temperature.html#sthash.bbcynbX3.dpbs
[3] The Do it in the Dark 2012 report mentions that most of the students wash their clothes 1-3 times per month. Usage frequencies best suited for on campus laundry usage were not available.

3.3 Results

Energy Savings - **300 GJ.**

GHG reductions - **15,000 kg CO_2e.**

Energy Cost Savings - **$4,576.** [4]

3.4 Additional Recommendation

1) The type and model of washers in individual residences is still not known. The model assumed in the calculations is the one used in Thunderbird residence and has been considered for campus wide calculations. This data can be extracted from the residence mangers/ advisors and incorporated into the spreadsheet for more realistic energy saving values.

2) The results for this section are developed from a range of 10% - 40% switching to cold water wash (from hot and warm water wash). Once the machine usage values are available for all the residences, a minimum of 20% switching can certainly be targeted to achieve sizeable energy savings and then further expand to achieve higher percentages.

[4] These values are estimated for 40% of HOT and WARM water washes switching to COLD water wash in the future. This estimation can elaborated for higher percentages too if deemed realistic.

4 Lower office temperatures

4.1 Assumptions and Recommendations :

1) Reduction in office temperature:

A: It is assumed that a delta of 1 degree reduction in baseline temperature would be comfortable for the all the office & classroom area occupants inside office dominated buildings shortlisted for calculations.

R: The number of complaints by occupants with respect to change in temperature can be assessed for all the potential office dominated spaces on campus. Also, in areas where the set point temperature is already low, it could be checked if further lowering the baseline temperature is acceptable. The delta of temperature change (reduction by 1 or 2 degrees) can then be decided and brought into effect through behavior change programs. The results on spreadsheet are designed to change as per the change in delta of temperature.

2) Occupant density and Ventilation rates:

A: Since the exact occupancy numbers for the shortlisted buildings were not available, ASHRAE standard occupant densities for offices (20 people/100m^2) and classrooms (150 people/100 m^2) were considered for calculations.

R: The exact occupancy details can be extracted for all the buildings along with ventilation rates for individual office spaces on campus to come up with best possible energy savings.

3) Baseline area:

A: A total of 11 buildings were shortlisted for office dominated spaces above a gross area of 5,000 sq.m. The uniformity of energy savings and GHG reductions over a larger area renders consistent values and also helps to create a scalable unit (eg. GJ/1000m^2) for estimating savings over other office dominated spaces on campus.

R: Apart from analyzing the delta for temperature reduction, occupancy and ventilation rates, the same 11 buildings can be used as a baseline reference for future calculations and estimation.

4.2 Methodology:

11 office dominated spaces above 5000sq.m were shortlisted for the energy calculations. In order to estimate the energy savings and GHG reductions, it was critical to know the occupant densities as well as ventilation rates. The ASHRAE Standard 62-2001 gave a mechanical ventilation rate of $36m^3/s$ and the literature review transpired the density values to 20 people/$100m^2$ for offices and 150 people/$100m^2$.

Once the savings due to a delta of 1 degree reduction in temperature was known, the total occupancy of the shortlisted buildings was found with the help of % office areas in the master list.

Energy savings and GHG reductions were then calculated for all the 11 buildings and a scalable number was developed that can be used for estimating the savings for all other buildings on campus.

4.3 Results

Total Area (sq.m)	46,089	1000[5]
Energy savings (GJ/yr)	9,100	197
GHG reductions (kg CO2)	502,000	10,893
Energy cost ($)	103,437	1,619

4.4 Additional Recommendation

This is an intensive work that would require time and efforts for an energy professional in order to successfully implement a realistic behavior change program for offices. Hence, compilation of building data from various sources like individual building engineers, Student Housing, RMS, EWS etc. by a single point of contact will be of great use to drive this initiative in a timely and effective manner.

[5] Scalable unit for all other office spaces on campus.

5 Shut the Sash

5.1 Assumptions and Recommendations

1) Number of VAV fume hoods:

A: Both the old and new master list of fume hoods were scrutinized for filtering the Variable Air Volume (VAV) type of fume hoods. There are 54 new fume hoods that were found in the new RMS list and have not been a part of the STS program post 2015. Also, there are 41 VAVs that were present before 2015 inside various labs but never participated in STS. The savings have been estimated for a total of 95 fume hoods (54+41).

R: Telephonic conversations, meetings and gradual discussions with experts from Prism Engineering, members of Risk Management Services and Green Labs program have revealed that a detailed identification process needs to be implemented to identify only those VAV fume hoods that have higher potential of energy savings through behavior change programs.

5.2 Methodology

The analysis and summary of STS from 2012-2015 has been tabulated from the Green Labs Management proposal where the values for electricity savings per fume hood, steam savings per fume hood and total energy savings per fume hoods are listed.

Since STS was implemented in 2012-2013 for a set of 3 buildings and from 2014-2015 for a new set of 3 buildings, an average of the highest and the lowest number from 2012 and 2014 has been considered to calculate the energy savings for a total of 95 fume hoods. The actual savings would deviate slightly once the exact number of potential VAV fume hoods is identified.

The GHG reductions have been calculated separately for electricity and steam and then an equivalent number has been quantified for total savings.

5.3 Results

Total Energy Savings - **16,608 eGJ**.

Total Energy Cost Savings - **$165,000**.

GHG reductions - **683,373 kg CO_2e**.

5.4 Additional Recommendation:

1) One of the barriers while working on Shut the Sash was the barrier of time. The program has been in place for a while and has been channeled by experts from the industry as well as previous staff members/ volunteers/engineers at UBC. Acting as a point of convergence to gather critical data on labs ,fume hoods, understanding the masters fume hoods list and engaging into discussions with all the stake holders led to the revision of all the past documents. However, in order to broaden the scope of Shut the Sash program and re-

start it all over the campus with maximum impact, it is necessary to involve a professional who knows the background of this work and can accelerate it from the stage where this analysis came to a halt. This will avoid duplication of efforts and save precious time.

2) Identification of potential fume hoods and estimating the energy savings through the analysis sheet would require an energy engineer to study the drawings/documents for all the fume hoods and permanently identify the same. Once these conditions are fulfilled, the current energy analysis sheet can be used to formulate the savings and design the program.

6 References

Planning, C. a. (2012). *Do it in the Dark Summary Report*. Vancouver.

NRDC (2004) *Energy Down the Drain*, Natural Resource Defence Council

Shove, E et al. (2008) *Behavioural change and water efficiency*. Presented at a workshop in London. ESRC Society Today.

WRc. (2007) UC7325: *Analysis of shower event data captured using Identiflow*. WRc.

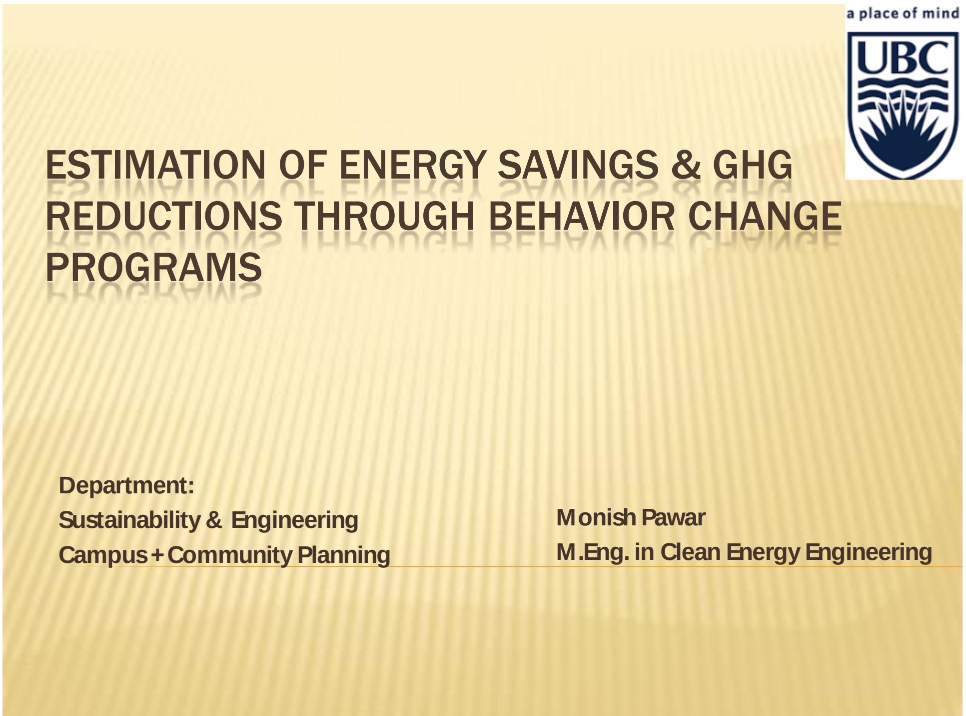
CLG and Defra (2006). *Water efficiency in new buildings – a consultation document.*

UBC (2013): *Campus Sustainability Engagement Strategy.*

Prsim-UBC (2015): *Energy Behavior Opportunity Assessment*

7 Appendix

A) Link to the powerpoint presentation: (Kindly double click below)



B) Ventilation Rates for Offices

Reference-IP-20 - Ventilation rates in offices - mechanical and natural.pdf

C) ASHRAE Standard 62-2001

Ashrae ventilation guideline .pdf

D) Shower head studies

Efficiency of shower heads and toilets.pdf

E) Water benefits and conservation

WATER CONSERVATION & ENERGY USE_Ontario.pdf