UBC Social Ecological Economic Development Studies (SEEDS) Student Report

Totem Park pre-post renovation electrical energy analysis

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Table of Contents

List of Tables

List of Figures

Summary

For the six aoriginal houses in Totem Park Residence, Several Energy Conservation Measurements (ECMs) have been completed in the past ten years:

- In Kwakiutl House and Shuswap House, non-LED lighting system converted into full-LED lighting system.
- In all the six houses, washers were set to cold wash default.
- All the six houses took part in “Do It in The Dark” Program in 2011 to 2014.

After rough calculation, lighting system upgrade will reduce electricity consumption more than 40000KWh per year for each house, equal to approximately 1/3 of annually electricity per year. Washers cold wash default change will save approximately 30000KWh per year for each house.

From 2011 to 2014, the popular “Do It in The Dark” Program was acted as a strong incentive in Totem Park Residence every November. During the competition, the amount of electricity saving could be up to 30% in average compared to electricity consumption two weeks before the competition.

The purpose of this project was to implement building energy audits and quantify several completed energy conservation measures (ECMs) in Totem Park Residence, as well as recommend an alternative option to further reduce electricity consumption. If body motion sensors are installed in lights in front of elevators, in the hallway and lobby, more than 50000KWh electricity can be saved in one year.

1.0 Introduction

As a rapidly-growing and world-famous campus, UBC is always seeking its way to reduce energy consumption and greenhouse gas (GHG) emissions. The Residential Environmental Assessment Program (REAP) is a sustainability standard to measure the energy performance of a certain building, the method is developed by UBC.

To meet the requirement, there is a long list of checklist including:

- Sustainable Sites
- Water Efficiency
- Energy and Atmosphere
- Materials and Resources
- Construction
- Indoor Environmental Quality
- Innovation and Design Process

The REAP awards points also in this seven categories. The REAP Performance levels are: Gold, Gold Plus, Platinum and Platinum Plus. Nowadays, all UBC residential developers must apply a minimum REAP Gold standard to their projects.

REAP makes sure the housing built on campus uses at least 15% less energy than Canada's Model National Energy Code for Buildings. However, two new residence building built in Totem Park Residence (həm'ləsəm' House and q'ələχən House) are designed to use at least 30% less energy.

The six original houses in Totem Park Residence, including Haida House, Salish House, Nootka House, Dene House, Kwakiutl House and Shuswap House, all built in

1960s. At that time there was no quantitative regulation like REAP, to improve the six houses' performance, to achieve a more sustainable future. Several renovations have been completed in the six original houses in the past few years.

To reduce electrical energy consumption, lighting system upgrade and washer cold wash default change were completed in summer and spring of 2016, respectively. In addition, the well-known energy saving program, Do It in The Dark, also contributed a lot of electricity reduction in 2011 to 2014.

1.1 Purpose and Objectives

This project will focus on the six original buildings in the Totem Park: Haida house, Salish house, Nootka house, Dene house, Kwakiutl house and Shuswap house.

The purpose of this project is to inspect and analyze the electricity use in Totem Park, evaluate the energy conservation measurements which have been completed earlier this year, recommend more alternatives to reduce the amount of energy input into Totem Park without affecting the output performance negatively.

2.0 Project Background

To determine energy performance of a certain building, the process include:

- Analysis of metering data and energy bills
- Survey of the installed facility during a site visit
- Study of various of building drawings
- Understanding of the fluctuation in energy utility with weather and operating hour change
- Identify the concerns and needs for the residents inside the building

2.1 Building information

Totem Park Residence in UBC is a residence mostly for first and second year students, it is also a excellent place for new students come to UBC who want to enjoy the comforts of home. The Totem Park not only provides a perfect space for studying, but also has a relaxed and pleasant atmosphere for them to make new friends. Every student will always have someone to walk to class with, talk to, or have dinner with, all within a fun, safe and supportive environment. Each house at Totem Park is named in honor of the aborigines in British Columbia.

In Totem Park Residence, each house has six floors. All of them are mixed gender houses with single gender floor, except Shuswap, which allows women and men live in the same floor.

There are several features that makes Totem Park a comfortable and convenient residence for students to live in:

- Every house has elevators
- TV in the lounge and snacks in the kitchen
- Phone available in the outlet
- WiFi access everywhere in the houses
- Convenience store open till late at night
- Specified study area, dining room, fitness room, games room and musical practice room

The six buildings that will be assessed in this report are described below. Building areas were measured according to Google Map.

Address	2525 West Mall, Vancouver
Campus	Point Grey
Open Year	1964
Total Area	4423m^2
Construction Type	Concrete
Use	Residence

Table 1 Haida/Salish House description

Address	2525 West Mall, Vancouver
Campus	Point Grey
Open Year	1964
Total Area	4423m^2
Construction Type	Concrete

Use	Residence

Table 2 Nootka/Dene House description

Address	2525 West Mall, Vancouver
Campus	Point Grey
Open Year	1967
Total Area	4423m^2
Construction Type	Concrete
Use	Residence

Table 3 Kwakiutl/Shuswap House description

The majority of building space is mostly comprised of student rooms, each floor including 10 single rooms and 10 double unions. There are approximately 30 people live in one floor. Every floor has a public washroom and lounge. Laundry room is located in the basement for Haida/Salish House and Nootka/Dene House. For Kwakiutl/Shuswap House, there is a small laundry room located on every floor.

Table 4 shows the various electrical services delivered by purchased energy carriers in the buildings.

Service	Description	Metrics of Service Quantity
Clothes wash	Washer and dryer	Watt (W)
Food storage	Refrigerator	Temperature (℃)
Food cooking	Microwave oven	Temperature (℃)
Illumination	Lighting system	Watt (W)

Table 4 Energy Services Delivered

3.0 Electrical energy data analysis

All the electrical energy data is collected from ion.energy.ubc.ca. It is a website which records real time energy and steam/water information every 15 minutes. I choose the scope of work based on some facts as following.

- Electrical metering data for Haida house and Salish houses are not available until 10:45AM on August 31st, 2010.
- Electrical metering data for Nootka house, Dene house and Shuswap house are not available until 4:30PM on August 31st, 2010.
- Electrical metering data for Kwakiutl house is not available until 1:30PM on September 16th, 2015.
- Electrical metering data reset for five houses (except Kwakiutl House) at 2:30PM on January 25th, 2013.
- The metering data reading for Kwakiutl House is too low compared to other five houses, which does not make logic sense.

For annual electrical consumption analysis, I only take five houses (Haida, Salish, Nootka, Dene and Shuswap) into account in the range of 2011 to 2015.

For monthly electrical consumption analysis, in order to make comparison before and after the renovation, the time range is from October 2015 to November 2016.

3.1 Utility Rate

According to BC Hydro, most residential customers are charged under the Residential Conservation Rate. The following table shows the BC Hydro Residential

Conservation Rate structure.

Basic Charge	$0.2347 Per Day
Demand Charge	$0 per kW for first 35 kW. $5.72 per kW for next 115 kW. $10.97 per kW for remaining kW
Energy Charge	$0.1116 per kWh for first 14,800 kWh of your baseline. $0.0536 per kWh for remaining kWh up to baseline.

Table 5 BC Hydro LGS Rate Structure

Table 6 provides information of annually electricity consumption for each house, the data was collected from ion.energy.ubc.ca. The amount of electricity use had larger fluctuation in year 2014 and 2015.

(KWh)	2011	2012	2013	2014	2015
Haida	129405.85	119703.064	127267.76	123418.772	136429.006
Salish	125215.566	128026.321	129718.538	124372.16	143262.244
Nootka	125475.128	116578.029	113617.826	166012.279	122917.263
Dene	135699.347	127689.817	127616.892	61761.898	96895.202
Shuswap	134380.231	108487.397	134045.966	84641.342	150063.767
Total	650176.122	600484.628	632266.982	560206.451	649567.482

Table 6 Totem Park Residence Electrical Energy Consumption (2011-2015)

Electricity cost in Table 7 was calculated from the utility rate of BC Hydro.

	2011	2012	2013	2014	2015
Haida	$14527.3583	$13444.5274	$14288.7475	$13859.2004	$15311.1425
Salish	$14059.7226	$14373.4029	$14562.2543	$13965.5985	$16073.7319
Nootka	$14088.6897	$13095.7735	$12765.4148	$18612.6358	$13803.2320
Dene	$15229.7126	$14335.8490	$14327.7106	$6978.29331	$10899.1700
Shuswap	$15082.4992	$12192.8590	$15045.1953	$9531.63926	$16832.7819
Total	$72987.9827	$67442.4119	$70989.3226	$62947.3674	$72920.0584

Table 7 Totem Park Residence Electricity Cost (2011-2015)

3.2 Energy Use Intensity (EUI)

Energy use intensity (EUI) is the measurement used to evaluate a building's energy performance. It indicates the relationship between energy consumption and its size, expressed in GJ per m^2 per year.

According to Natural Resource Canada, a building's EUI is calculated as follows:

EUI =total energy consumed in one year (GJ) / total floor space of the building (m^2)

Table 8 converted electricity consumption in Table 6 from KWh to GJ.

(GJ)	2011	2012	2013	2014	2015
Haida	465.8611	430.9310	458.1639	444.3076	491.1444
Salish	450.7760	460.8948	466.9867	447.7398	515.7441
Nootka	451.7105	419.6809	409.0242	597.6442	442.5021
Dene	488.5176	459.6833	459.4208	222.3428	348.8227
Shuswap	483.7688	390.5546	482.5655	304.7088	540.2296
Total	2340.6340	2161.7447	2276.1611	2016.7432	2338.4429

Table 8 Totem Park Residence electricity consumption expressed in GJ

The six house is like a duplicate of each other, they have the same gross area of 4423m^2. The bar chart below shows the EUI for every house.

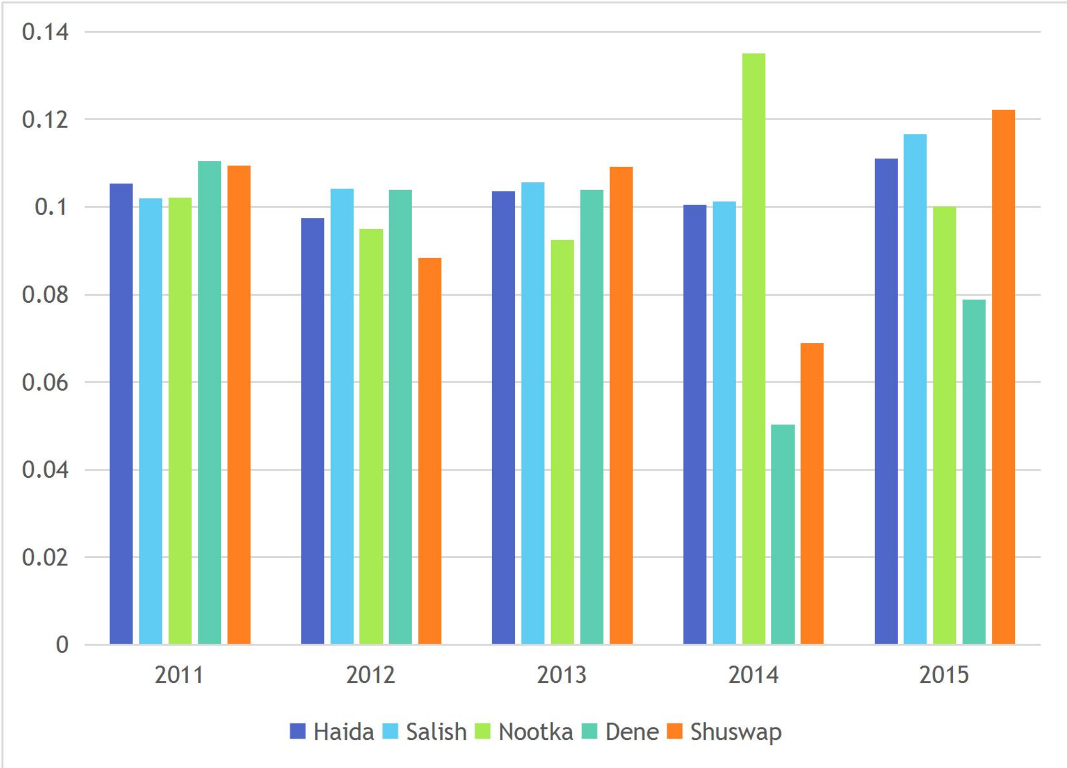

Figure 1 Totem Park Residence EUI Comparison

ENERGY STAR® PortfolioManager® Technical Reference

Broad Category	Primary Function	Further Breakdown (where needed)	Source EUI (GJ/m²)	Site EUI (GJ/m²)	Reference Data Source – Peer Group Comparison
Healthcare	Ambulatory Surgical Center		1.50	1.02	CIBEUS – Out Patient Care
	Hospital	Hospital (General Medical & Surgical)* / Other / Specialty Hospital	3.12	2.30	SCIEU – Hospitals
	Medical Office*		1.46	0.98	SCIEU – Medical Offices
	Outpatient Rehabilitation / Physical Therapy		1.50	1.02	CIBEUS – Out Patient Care
	Residential Care Facility*		1.94	1.12	SCIEU - Nursing and Residential Care
	Senior Care Community*		1.94	1.12	SCIEU - Nursing and Residential Care
	Urgent Care / Clinic / Other Outpatient		1.50	1.02	CIBEUS – Out Patient Care
Lodging / Residential	Barracks		2.05	1.45	CIBEUS – Accommodation
	Hotel		1.75	1.12	SCIEU – Hotel and Motel
	Multifamily Housing		N/A	N/A	NA
	Prison / Incarceration		1.74	1.28	CIBEUS – Public Order and Safety
	Residence Hall / Dormitory		2.05	1.45	CIBEUS – Accommodation
	Residential Care Facility*		1.94	1.12	SCIEU – Nursing and Residential Care
	Senior Care Community*		1.94	1.12	SCIEU – Nursing and Residential Care
	Single Family Home		N/A	N/A	NA
	Other – Lodging / Residential		1.75	1.12	SCIEU – Hotel and Motel
Manufacturing / Industrial	Manufacturing / Industrial Plant		N/A	N/A	NA
Mixed Use	Mixed Use Property		1.23	0.90	SCIEU – Other
Office	Medical Office*		1.46	0.98	SCIEU – Medical Offices
	Office*		1.31	0.91	SCIEU – Offices

March 2016 Canadian National Median Values Page 4

Figure 2 Canadian EUI by Property Type (Natural Resource Canada)

High-density multi-family Building Energy Performance Index (BEPI) is the most suitable one to compare with Totem Park Residence. BEPI=1.12 was taken from Natural Resources Canada from their energy use database for residential houses in British Columbia, The data is updated by March 2016.

As we can see from Figure 1, the largest EUI is observed in 2014 for Nootka House (EUI=0.14). The BEPI is much higher than any of the five houses from 2011 to 2015, which means that buildings in Totem park are already pretty energy-efficient.

The conclusion can be also drawn from the REAP rating system. As shown in Figure 3, Totem Park Residence was already rated as Gold level in 2011.

UBC VANCOUVER GREEN BUILDING DIRECTORY

Updated November 2015

a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

Building	Address	Rating System	Version	Level	Certification Status	Occupancy Date	Certification Date	GSM	GSF
Academy	5728 Berton Ave	REAP	v2.1	Gold	Certified	2014	2014	14,159	152,351
Axis	6090 Iona Dr	REAP	v2.1	Gold	Certified	2013	2013	9.656	103,899
Binning Tower	3355 Binning Rd	REAP	v2.1	Gold	Registered			19,259	207,307
Clements Green	6268 Eagles Dr	REAP	v1	Silver	Certified	2006	2006	6,915	74,405
Coast	6093 Iona Dr	REAP	v1	Bronze	Certified	2009	2009	11,552	124,296
Dahlia & Magnolia House (Faculty & Staff Housing)	3515 & 3565 Wesbrook Mall	REAP	v2.1	Gold	Certified	2012	2012	5,524	59,439
Fraser Hall	2550 Wesbrook Mall	REAP	v1	Bronze	Certified	2006	2006	3,810	41,000
Granite Terrace	3233 Wesbrook Mall	REAP	v2	Gold	Certified	2009	2009	7,184	77,302
Greenwood Commons	2660 Wesbrook Mall	REAP	v1	Bronze	Certified	2007	2007	5,948	64,000
Keenleyside	5788 Birney Ave	REAP	v2	Bronze	Certified	2008	2008	7,993	86,000
Larkspur House (Faculty & Staff Housing)	3428 Wesbrook Mall	REAP	v2	Silver	Certified	2009	2009	4,881	52,524
Laureates	5628 & 5638 Birney Ave	REAP	v2.1	Gold	Registered	2015		22,381	240,817
Legacy	6353 Larkin Dr	REAP	v1	Silver	Certified	2007	2007	7,435	80,000
MBA House	3385 Wesbrook Mall	REAP	v2	Silver	Certified	2009	2010	3,577	38,484
Mews	3333 Wesbrook Mall	REAP	v2	Gold	Certified	2011	2014	7,807	84,000
Pacific	5928 Birney Ave	REAP	v2	Gold	Certified	2010	2010	7,802	83,950
Pathways	5777 & 5779 Birney Ave	REAP	v2	Gold	Certified	2008	2008	11,668	125,549
Prodigy	6038 Grey Ave & 3462 Ross Dr	REAP	v2.1	Gold	Registered			17,150	184,534
Sage	5728 Berton Ave	REAP	v2	Silver	Certified	2011	2013	13,011	140,000
Sail	5981 & 5983 Gray Ave	REAP	v2.1	Platinum	Certified	2013	2013	14,540	156,450
Sitka	5868 Agronomy Rd	REAP	v2.1	Gold	Registered	2012		N/A	N/A
Spirit	3478 Wesbrook Mall	REAP	v2	Gold	Certified	2010	2011	5,261	[illegible]
Stirling House	6080 Iona Dr	REAP	v1	Bronze	Certified	2008	2008	4,785	51,488
Tapestry (Senior Residence)	3338 & 3382 Wesbrook Mall	REAP	v2	Silver	Certified	2010	2010	15,799	170,000
Totem Park In-Fill (Student Residence)	2525 West Mall	REAP	v2.1	Gold	Registered	2011		16,914	182,000
Ultima	3479 Wesbrook Mall	REAP	v2.1	Gold	Certified	2011	2011	5,111	54,993
University Boulevard - Site B	N/A	REAP	v3	Gold	Registered			7,283	78,368
Vista Point	5828 Thunderbird Blvd	REAP	v2.1	Gold	Registered	2013		8,963	96,442
Webber House (Faculty & Staff Housing)	N/A	REAP	v3	Gold	Registered			4,233	45,547
The Wesbrook	5838 Berton Ave	REAP	v2	Silver	Certified	2009	2009	12,844	138,199
Wesbrook Place (Faculty & Staff Housing)	N/A	REAP	v3	Gold	Registered			15,322	164,861
Wesbrook Village Supermarket & Office Building	5923 & 5945 Berton Ave & 3233 Wesbrook Mall	REAP	v2	Gold	Certified	2009	2009	3,106	33,418
Yu	5955 Birney Ave	REAP	v2.1	Gold	Certified	2012	2014	9,758	105,000

Figure 3 REAP Certified Buildings (UBC Sustainability)

One possible reason is that Totem Park is residence mainly for first-year student, they spend most of their time in classrooms and social activities. Another reason is, because of the limitation of metering data collection, I failed to take cafe, grill bar and convenient store in Totem Park Residence into account.

3.3 Electricity Consumption

Following is a table showing electricity consumption from October 2015 to November 2016. Data for Kwakiutl House is not included.

Monthly total(KWh)	Haida	Salish	Nootka	Dene	Shuswap
2015-10	14950.394	15310.469	13245.163	10552.959	17091.173
2015-11	15022.658	15202.59	13710.756	10855.18	17022.926
2015-12	11737.194	12198.934	10684.66	8586.255	13383.273
2016-01	12165.463	11864.491	12351.675	10284.405	16005.335
2016-02	9210.34	8300.591	10800.211	9679.515	15183.806
2016-03	9899.891	9001.912	12033.675	10301.431	16384.629
2016-04	9103.411	8255.816	11523.889	9415.641	14754.87
2016-05	5034.566	5683.534	3853.17	2411.436	9683.881
2016-06	5229.576	6469.078	4304.844	1907.394	9909.948
2016-07	7961.17	7679.318	6752.29	4350.377	8403.247
2016-08	6825.798	7706.01	6425.169	3855.229	8195.562
2016-09	13048.133	13888.191	11238.701	9423.875	11209.645
2016-10	14670.284	15534.482	12263.945	10741.48	12410.987
2016-11	14302.092	14956.099	12226.404	10799.807	12134.306

Table 9 Totem Park Residence Monthly Electrical Energy Consumption (2015-2016)

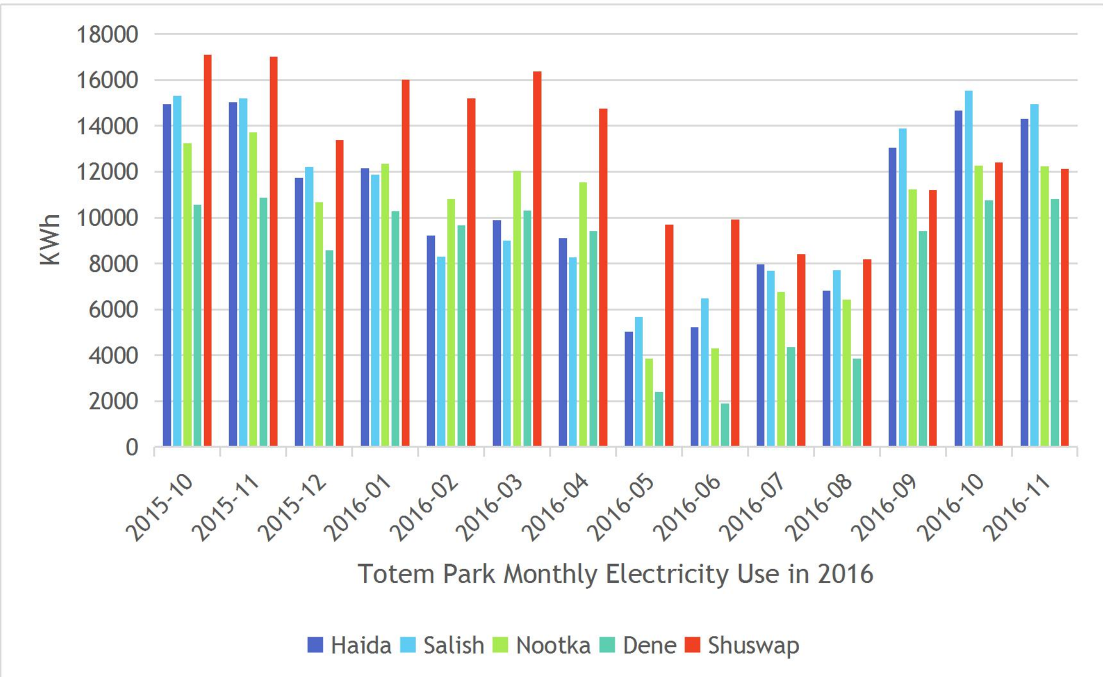

Figure 4 Totem Park Residence Monthly Electrical Energy Consumption Comparison

Electricity consumption reach its bottom in the summer time, since there is much less student stay at school during the summer break.

According to the energy engineer of Totem Park, in September, at the beginning of fall semester, the building office will split some single rooms for two people, a sharply increase in electrical energy consumption should be observed, which is shown in Figure 2.

3.4 CUSUM Analysis

Cumulative Sum (CUSUM) is an analysis method which can compare the actual energy performance with model predicted energy performance.

The method used to establish the baseline is to measure how the seasonal temperature change affect electricity consumption.

Monthly heating degree days (HDDs) data in 2015 are collected from Environment Canada website. The building temperature set point is 15°C.

Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
281.6	201.6	203.6	169.4	56.0	15.7	6.1	9.0	58.4	105.4	285.4	296.4

Table 10 Monthly HDDs in Vancouver in 2015

3.4.1 Haida House

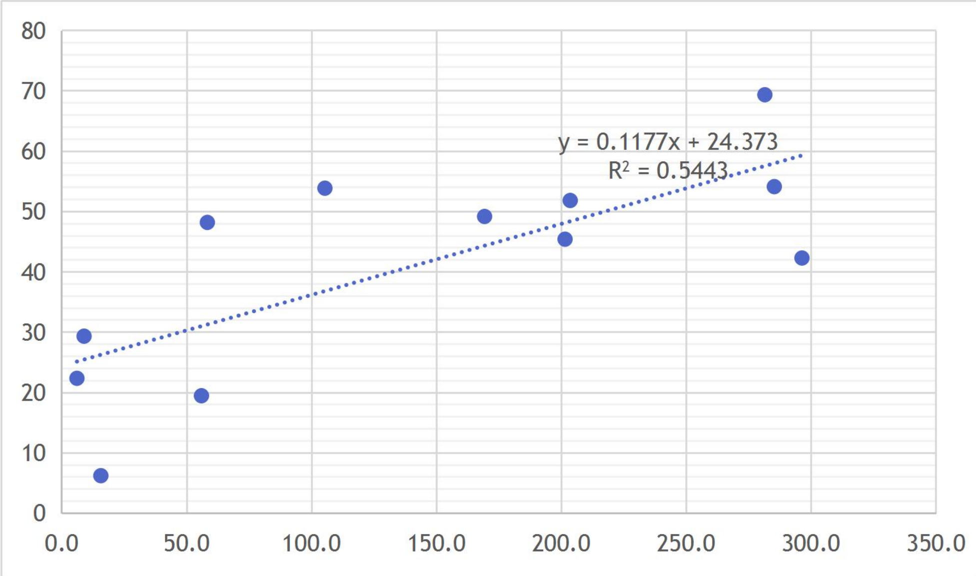

Figure 5 Haida House: Monthly Electricity Consumption as a Function of Monthly HDDs in 2015

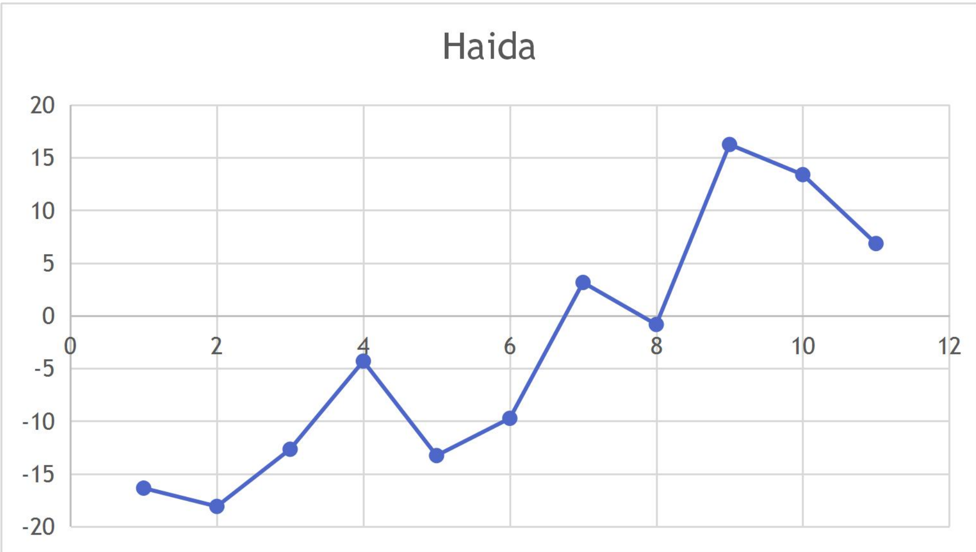

Figure 6 Haida House: CUSUM Energy Performance Model in 2016

The trend line shows a increase throughout the year, which is the worst case in the prediction, which means electricity consumption will increase next year.

3.4.2 Salish House

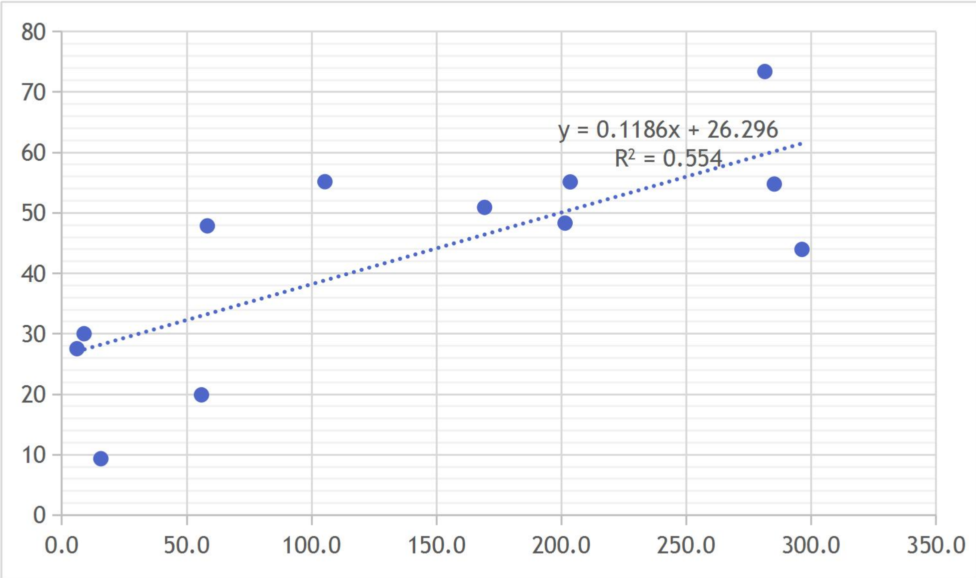

Figure 7 Salish House: Monthly Electricity Consumption as a Function of Monthly HDDs in 2015

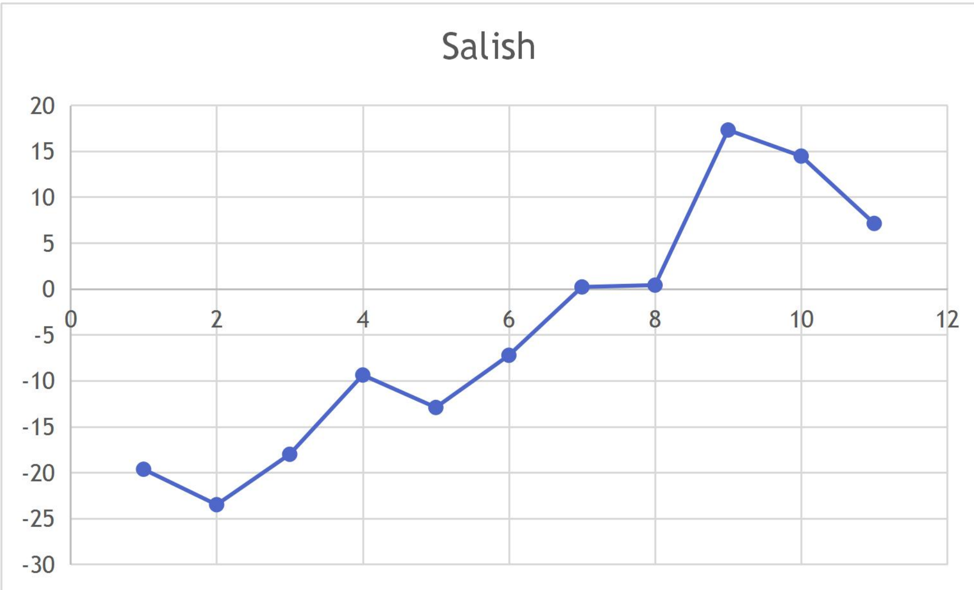

Figure 8 Salish House: CUSUM Energy Performance Model in 2016

The model for Salish house is similar to Haida house.

3.4.3 Dene House

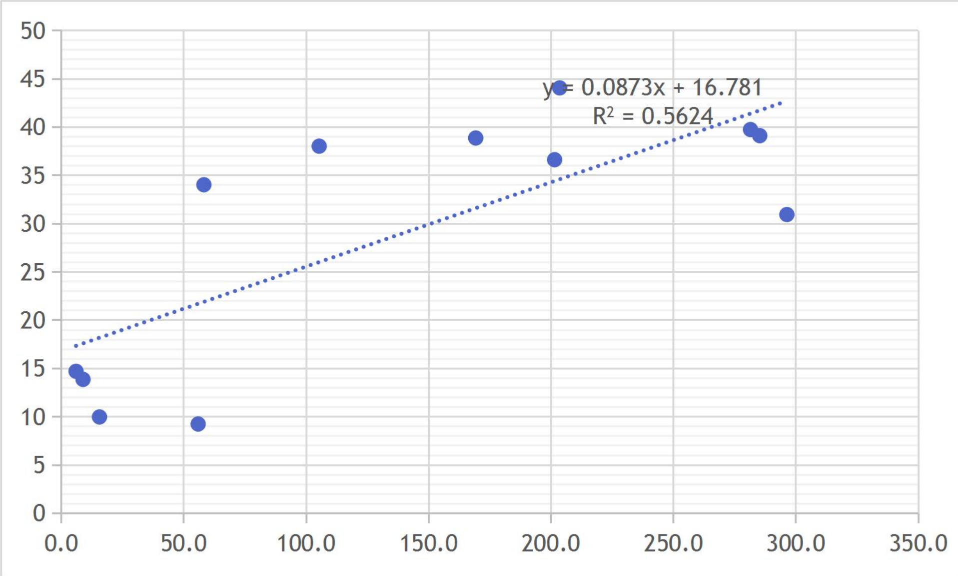

Figure 9 Dene House: Monthly Electricity Consumption as a Function of Monthly HDDs in 2015

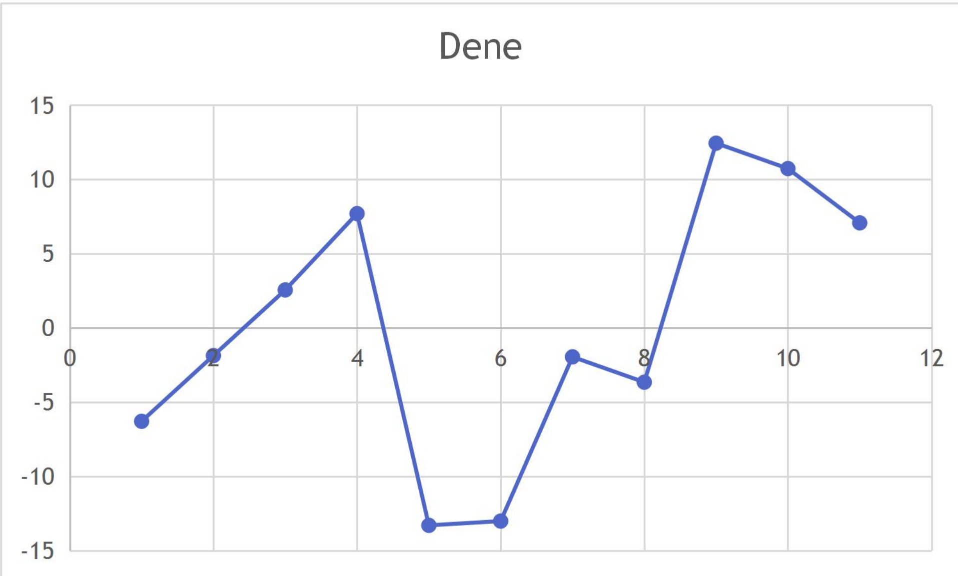

Figure 10 Dene House: CUSUM Energy Performance Model in 2016

The trend line shows the strongest fit among all the five buildings (R^2=0.5624). There is a marked decrease during the summer break and increase in September. September is the beginning of fall semester, which will bring lots of new students to Totem Park. Although it has no trend for decreasing next year, this model should be the most reasonable one.

3.4.4 Nootka House

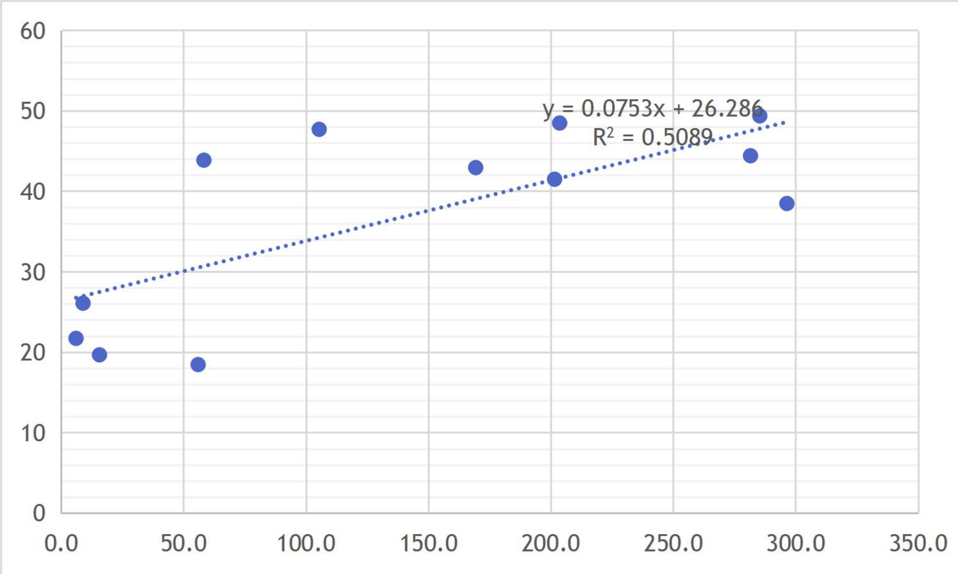

Figure 11 Nootka House: Monthly Electricity Consumption as a Function of Monthly HDDs in 2015

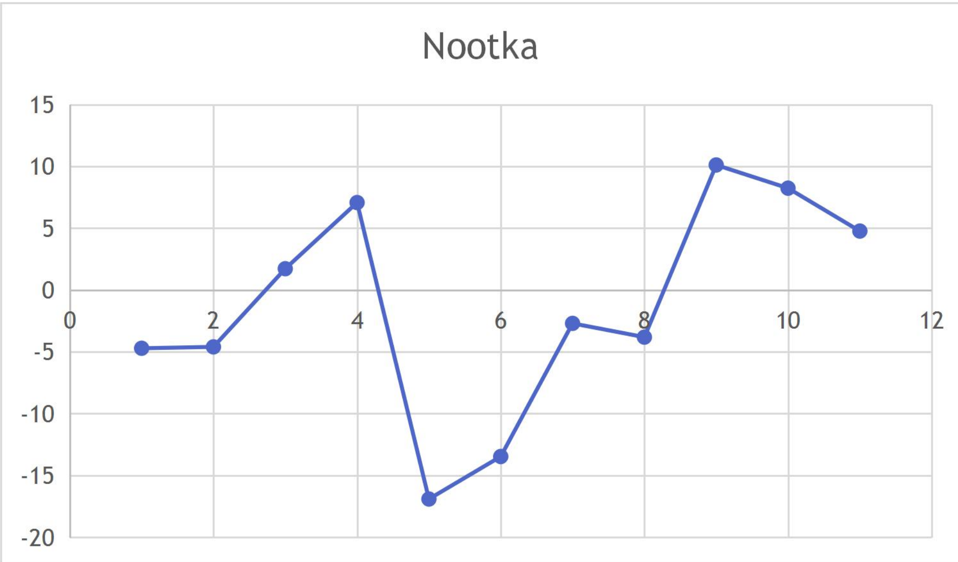

Figure 12 Nootka House: CUSUM Energy Performance Model in 2016

The model for Nootka house is similar to Dene house.

3.4.5 Shuswap House

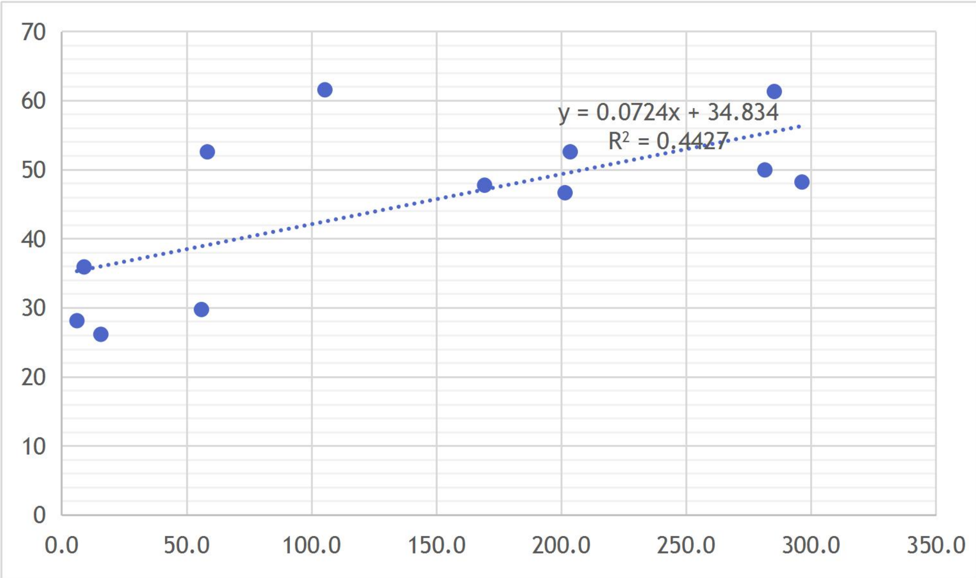

Figure 13 Shuswap House: Monthly Electricity Consumption as a Function of Monthly HDDs in 2015

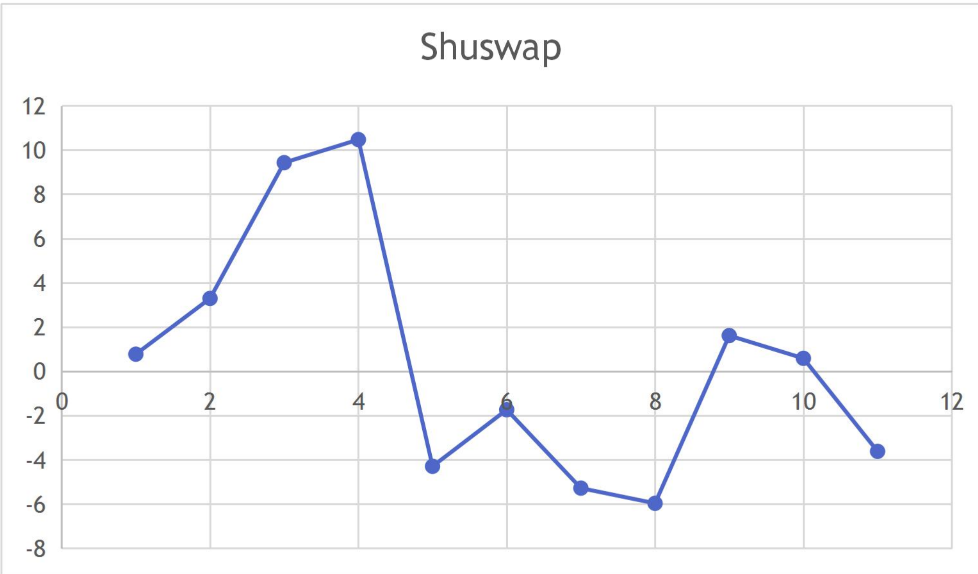

Figure 14 Shuswap House: CUSUM Energy Performance Model in 2016

The trend line shows the weakest fit for the data spread (R^2=0.4427) among the five buildings, which means use the equation to predict electricity use is not quite reliable. However, this is the only model that has a trend in electricity consumption decrease for next year.

4.0 Energy Conservation Measurements (ECMs)

There were several renovations completed in Totem Park Residence in the past few years. Listed in Table 11.

ECMs	Time	Location
“Do it In The Dark” program	Nov 1st-19th, 2010	All six houses
	Nov 7th-25th, 2011	
	Nov 5th-23rd, 2012	
	Nov 4th-15th,2013	
Lighting system Upgrade	Summer 2016	Kwakiutl/Shuswap house
Washer Cold Wash Default Change	Spring 2016	All six houses

Table 11 Completed ECMs in Totem Park Residence

The calculation and analysis of ECMs is based on the facts:

- Electricity in Vancouver is $0.1012 per KWh. (BC Hydro)
- The GHG emission factor is 30g/KWh equivalent for electricity consumption. (Environment Canada)
- There are approximately 30 students per floor in the houses. (Building administrator)
- Compared to non-LED lighting system, LED lights can save labor cost $200 in 4 years per light. (Energy engineer of Totem Park Residence)

4.1 Energy Saving Programs - “Do It in The Dark”

“Do It in The Dark” is an exciting three-week energy conservation competition in

North America among universities. Began in 2010, every year, over a two to three week period in November, residence students from different houses try to save as much energy as they can, in order to gain the highest score and win the competition. There are several recommended energy saving action during the competition:

- Turning out lights in common areas and residence rooms when no one is there
- Unplugging electronic devices while not using them
- Washing clothes in cold water and hang them to dry
- Taking short shower
- Reducing heater temperature
- Walking more on stairs instead of taking elevators

There will also be some activities and resources to promote such behaviors. From 2010 to 2013, the competition attracted most of the students in Totem Park to participate, made great contribution in saving energy and protecting environment.

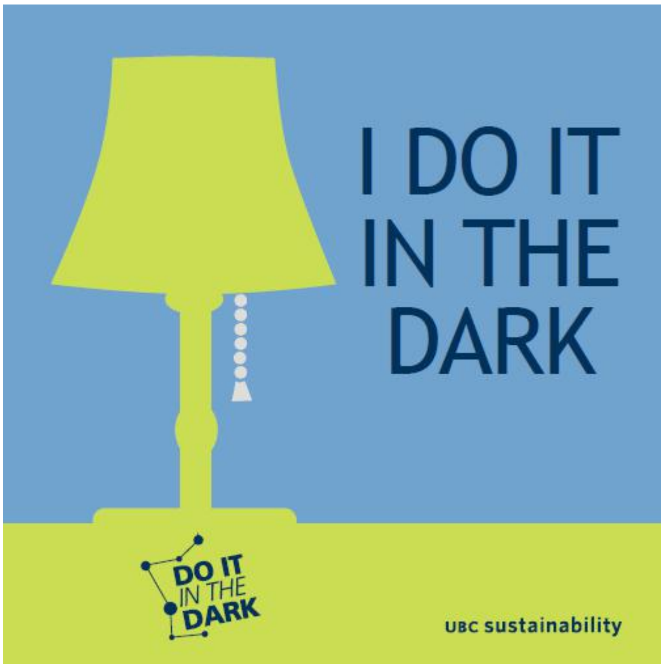

Figure 15 Stickers used during “Do It in The Dark” Program

The measured impact of this campaign for the Totem Park Residence, which has real-time energy meters installed at the residence house level. Energy reduction was determined by the percentage reduction below the baseline measurements. The measurements baseline was taken a week before the competition. Since there was no advertisements until the beginning of the competition, the baseline could be regarded as the typical electrical consumption in normal times.

“Dine in The Dark” was considered to be the most successful activity, students had their dinner together in the dining room with a LED candle on every Monday during the competition.

4.1.1 2010 Competition

The competition in 2010 achieved a total electrical reduction of 9431KWh over the three-week time period in six houses of Totem Park. Average 17.4% reduction of the baseline. Haida House won the first place with a electrical reduction of 24.1%.

4.1.2 2011 Competition

In 2011, Totem Park competed against 20 other BC university residences. Totem Park placed first in the Energy Reduction category. Haida House led the way, with an overall energy reduction of 27.6%.

4.1.3 2012 Competition

For 2012, the competition took place only at UBC. The competition achieved an average electrical savings of 23.1% across the six measured residence houses at the Totem Park residence. Haida House won yet again for reducing their overall energy consumption by 30.2%.

4.1.4 2013 Competition

In 2013, students had the chance to monitor Totem Park’s real-time energy consumption via the Lucid Energy dashboard. The competition achieved an average energy savings of 15% across the six measured residence houses at the Totem Park residence complex, with the winning house reducing energy consumption by 21.2%.

4.2 Washer Cold Wash Default Change

Salish House and Haida House share a laundry room which located on the underground floor, which has 10 washers in total for students in the two houses. Nootka House and Dene House are the same cases.

For Shuswap House and Kwakiutl House, a small laundry room is located on every floor, each laundry room has one washer inside.

There is also a washer for the housekeeper. The housekeeper indicated that she seldom uses the washer in her room, we assumed that the electrical consumption of the washer in housekeeper's room can be neglected.

	Location	quantity	Capacity
Haida and Salish House	Laundry Room in the basement	10	4.2 ft^3
Nootka and Dene House	Laundry Room in the basement	10	4.2 ft^3
Kwakiutl House	Laundry Room on every floor	6	4.2 ft^3
Shuswap House	Laundry Room on every floor	6	4.2 ft^3
Housekeepers	Bedroom	1	4.2 ft^3

Table 12 Washer Location, Quantity and Capacity

In the Spring 2016, all the washers in the Totem Park were set to cold wash default. Each washer is considered to run full wash cycle 5 times a day. Warm water wash temperature is 100 ^{o}F, cold wash temperature is 60 ^{o}F according to Figure 15.

Figure 16 Washers used in Totem Park Residence

Cold Water

The Cold Wash is ideal for delicate items. Although its cleaning abilities are not as great as hot or warm water, it is useful for colors that bleed easily and for sensitive fabrics.

The Cold Rinse is optional in every cycle and is the most beneficial for fabrics. **Cold rinses reduce wrinkling and color fading. In addition, cold rinses will save money and energy.**

NOTE: In wash temperatures colder than 16°C (60°F), detergents do not dissolve well. This may cause ineffective cleaning, or lint and residue to form.

NOTE: Always follow manufacturer's care labels.

Wash Temperature Guide

Water Temperature	Use	Comments
BOOSTED HOT (select models only) (approximately 60°C [140°F])	• Sturdy whites and colorfast items • Work clothes • Heavily soiled items • Diapers	• Best cleaning for heavily soiled items • Best for sanitizing
HOT (approximately 49°C [120°F] or as determined by outside hot water supply)	• Sturdy whites and colorfast items • Work clothes • Soiled items • Diapers	• Best cleaning for soiled items • Good for sanitizing
WARM (approximately 38°C [100° F])	• Rinsing of some items (OPTIONAL) • Light and moderately soiled items • Non-colorfast or dark colors • Permanent press • Silks, woolens, nylon, acrylic	• Reduces wrinkling in permanent press fabrics • Less fading • Reduces shrinking in knits
COLD (approximately 16°C [60° F])	• Rinsing of most items • Non-colorfast fabrics • Extra delicate clothing	• Saves energy • Reduces color fading • Reduces wrinkling • Reduces shrinking

Energy

You can save energy when washing by following a few guidelines:

1. Heating water accounts for the greatest energy expense when washing. Save on heating water by using warm or cold washes as well as cold rinses.
2. Wash full loads, but do not overload.

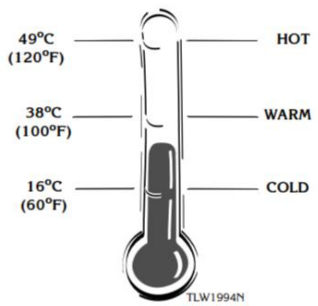

Figure 17 Wash Temperature Guide of Alliance Laundry Systems

4.2.1 Predicted electrical energy saving

For each washer in one full wash cycle,

electricity saving = $Cm（T_2 - T_1）= C \times V \times \rho \times (T_2 - T_1) = 11199988.8J = 11.2MJ$

$C = 4200 J / kg \cdot K$

$V = 0.12 m^3$

$\rho = 10^3 kg / m^3$

$T_1 = 60^o F = 288.7056 K$

$T_2 = 100^oF = 310.9278K$

Six houses in one day,

total electricity saving $= 11.2MJ \times 5 \times (10 + 10 + 6 \times 2) = 1792MJ = 497.78KWh$

Yearly Energy Saving: $497.78KWh \times 365 = 181690KWh$

4.2.2 Economics

Capital cost : \$0

In Vancouver, electricity charge rate $= \$0.1012 / KWh$

Yearly electrical energy saving $= \$0.1012 \times 181690KWh = \$18387.028$

Payback year: 0

4.2.3 GHG impacts

GHG emission factor $= 30gCO_2 / KWh$

Total GHG emission reduction $= 30g / KWh \times 181690KWh = 5450.7kg$

4.3 Lighting system upgrade

Only Kwakiutl and Shuswap completed the full LED lighting system upgrade in summer 2016. Compared to non-LED lighting system, LED lighting system is absolutely more environmental friendly, the reduction in lumen output can be considered negligible and its efficiency can be improved by frequently cleaning lens and fixture. It is anticipated that an LED bulbs have a longer lifetime than non-LED bulbs. The calculation is not include bathrooms lighting system upgrade, which has been done earlier.

According to the building administrator, lights in the lobby and hallway, as well as in front of the elevators keep open all day.

Lights in the student units, laundry rooms and floor lounges are controlled manually.

Lights in the ground-floor lounges have sensors. Lights in front of elevators, in the hallway and lobby keep open for 24 hours.

Only students who live in the double units have table lamps, students in the single rooms has to bring their own lamps.

Working time assumption are based on the dialogue with house administrator.

Lighting system in Kwakiutl/Shuswap house：

Location	Quantity	Old system	Upgraded system	Working time per day
All bedrooms	240	26W non-LED	12 inch LED Flush Mount 12W 1100 lumens 3000k	10
Bedroom desks	120	29W non-LED	LED 15W Glass T8 3500k 48 inch	8
Ground-floor lounge	21	39W non-LED	12 inch LED Flush Mount 12W 1100 lumens 3000k	12
Laundry rooms	6	29W non-LED	LED 15W Glass T8 3500k 48 inch	10
In front elevators	12	29W non-LED	LED 15W Glass T8 3500k 48 inch	24
Hallways	84	15W non-LED	LED 8W T8 3500k 24inch	24

Lobby	54	39W non-LED	12 inch LED Flush Mount 12W 1100 lumens 3000k	24
Floor lounge	12	26W non-LED	12 inch LED Flush Mount 12W 1100 lumens 3000k	12

Table 13 Lighting System in Kwakiutl/Shuswap House

4.3.1 Predicted electrical energy Saving

Old system electricity consumption:

All bedrooms $240 \times 26W \times 10hours \times 365 = 22776KWh$

Bedroom desks $120 \times 29W \times 8\text{hours} \times 365 = 10161.6KWh$

Ground-floor lounges $21 \times 39W \times 12\text{hours} \times 365 = 3587.22KWh$

Laundry rooms $6 \times 29W \times 10\text{hours} \times 365 = 635.1KWh$

In front elevators $12 \times 29W \times 24\text{hours} \times 365 = 3048.48KWh$

Hallways $84 \times 15W \times 24\text{huors} \times 365 = 11037.6KWh$

Lobby $54 \times 39W \times 24hours \times 365 = 18448.56KWh$

Floor lounges $12 \times 26W \times 12\text{hours} \times 365 = 1366.56KWh$

Total $71061.12KWh$

Upgraded LED system:

All bedrooms $240 \times 12W \times 10hours \times 365 = 10512KWh$

Bedroom desks $120 \times 15W \times 8\text{hours} \times 365 = 5256KWh$

Ground-floor lounges $21 \times 12W \times 12\text{hours} \times 365 = 1103.76KWh$

Laundry rooms $6 \times 15W \times 10\text{hours} \times 365 = 328.5KWh$

In front elevators	$12 \times 15W \times 24\text{hours} \times 365 = 1576.8KWh$
Hallways	$84 \times 8W \times 24\text{huors} \times 365 = 5886.72KWh$
Lobby	$54 \times 12W \times 24hours \times 365 = 5676.48KWh$
Floor lounges	$12 \times 12W \times 12\text{hours} \times 365 = 630.72KWh$
Total	$30970.98KWh$

Saving $= 71061.12KWh - 30970.98KWh = 40090.14KWh$

For two houses, total saving $= 40090.14KWh \times 2 = 80180.28KWh$

4.3.2 Economics

Upgraded system	Quantity	Price	Total cost
12 inch LED Flush Mount 12W 1100 lumens 3000k	327	\$8.5	\$2779.5
LED 15W Glass T8 3500k 48 inch	138	\$15	\$2070
LED 8W T8 3500k 24inch	84	\$8	\$672
High electronic blasts	549	\$30	\$16470

Table 14 Upgraded Lighting System Capital Cost

Capital cost for each house: \$21991.5

For per LED light, saving in labor cost $= \$50 / year$

Yearly labor saving $= \$50 \times 549 = \$27450$

In Vancouver, electricity charge rate $= \$0.1012 / KWh$

Yearly electrical energy saving $= \$0.1012 \times 40090.14KWh = \$4057.12$

Payback year $= \$21991.5 \div (\$27450 + \$4057.12) = 0.70 years$

4.3.3 GHG impacts

GHG emission factor $= 30gCO_2 / KWh$

GHG emission reduction $= 30g / KWh \times 40090.14KWh = 1202.70kg$

For two houses, total GHG emission reduction $= 2 \times 1202.70kg = 2405.40kg$

5.0 Discussion

1. Energy saving program is quite efficient in a limited period of time. It attracted thousands of students to participate in and reduced 15% to 30% of energy compared to the baseline. The competition with other schools was an incentive for students to act and contribute to save energy. Students had the access to real-time electrical energy consumption, I think it was an effective strategy to encourage students taking actions to contribute more.

However, the competition did not continue in 2014, 2015 and 2016. One of the possible reason should be the time period. The competition happened every November. November is cold and rainy in Vancouver. Hand wash clothes in cold water is torture for students, hang clothes to dry is difficult to achieve. In addition, if lower the heater temperature in bedrooms, students have to wear warm clothes inside the room, which is not comfortable and convenient for them.

To solve those problems, I suggest the competition take place in summer time. Students can hand wash clothes in cold water and hang them to dry. Some of the students can even take cold water showers to save energy. Furthermore, we can also encourage students to go out and have more outdoor activities, not only make more friends, but also strengthen their bodies.

2. After the completion of the full LED upgrade in Kwakiutl House and Shuswap House, there is a fact that: Kwakiutl House lighting work requests is 3 since renovations August 2016, compared to 16 of Nootka House lighting work Requests during the same time period. Except energy saving, technology renovation also has a huge potential in worker demand.

With an estimated annual saving of more than 40000KWh electricity and more than 1200kg GHG emission reduction for each house, we should conduct the upgrade in the other houses as soon as possible.

3. As shown in the table below,

	Oct& Nov 2015	Oct& Nov 2016	Reduction
Haida house	29973.052KWh	28972.376KWh	3.33%
Salish house	30513.059KWh	30491.472KWh	0.07%
Nootka house	26955.919KWh	24490.349KWh	9.14%
Dene house	21408.139KWh	21541.287KWh	-0.62%
Shuswap house	34114.099KWh	24545.293KWh	28.0%

Table 15 Electrical energy reduction in 2016 compared to 2015

Right after the washer cold wash default change, there is no significant decrease in electrical energy metering data. As the payback year is hard to estimate in the case, the most savings in energy may yet to be seen as years 2 and 3 after renovation should be most telling.

6.0 Recommendation measurements

After the site visit of Shuswap House and Nootka House, talking to one of the house administrator, an alternative energy saving measurements was evaluated. The cases are presented below.

6.1 Sensor installing on lighting system

The option is to install sensors to the existing lights in the lobby, hallway and in front elevators. Although it is dark in the building in the daytime, it is not necessary to keep the lights on since students have classes and other activities. Most of the time those areas are empty. Light sensor is an infrared technology based automatic motion sensor switch, automatically turn ON/OFF while detected people come or left. It is a perfect solution for electrical energy saving.

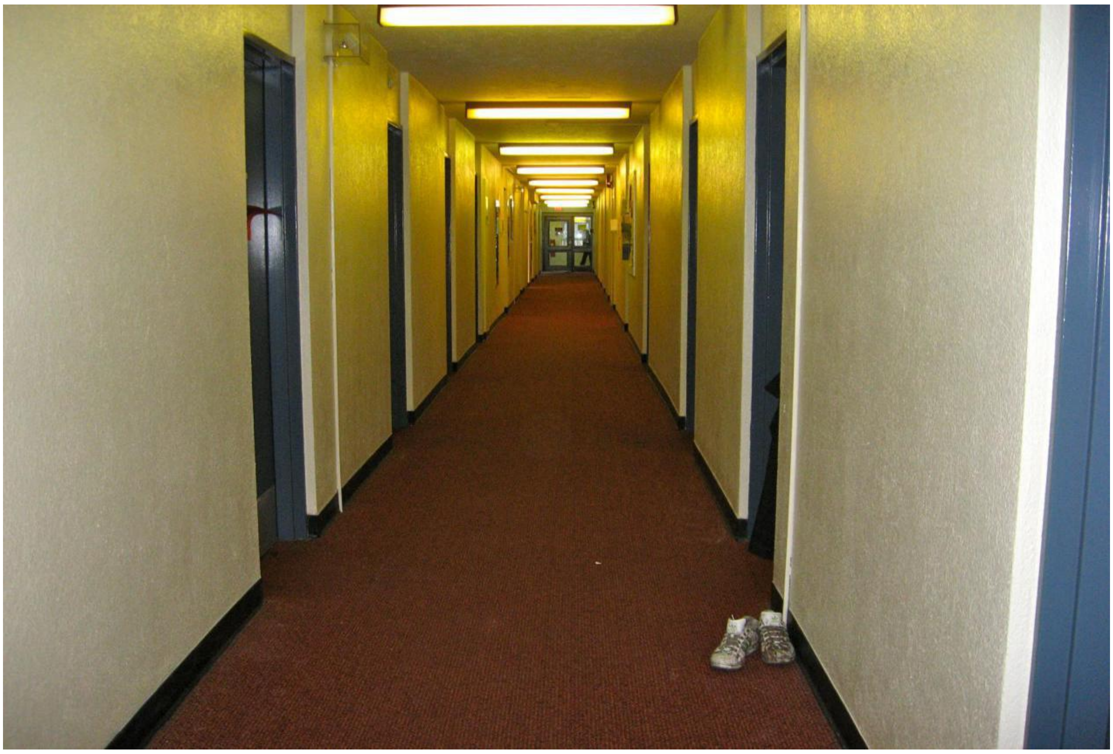

Figure 18 Insufficient lights usage during daytime in Shuswap House

Sensors can not only save electricity, but also extend the lifetime of lights. In the long term, maintenance cost is also reduced.

Figure 19 Selected Intelligent Light Body Motion Sensor

The 110V Infrared IR Sensor Module Intelligent Light Body Motion Sensor is ideal for LED lights no more than 50W, which is suitable for houses in Totem Park Residence. The induction distance is about 5-8 meters. Easy installation, simply replace existing switch, which can save lots of labor cost.

Totem Park Residence was not a high-volume area, as I visited two of the six buildings in the day time at weekdays, there are few people in the building and fewer people walk in public areas. I assume the working time reduced to 16 hours after the sensor installation.

In Kwakiutl House and Shuswap House:

Location	Quantity	Lighting
In front elevators	12	LED 15W Glass T8 3500k 48 inch
Lobby	54	12 inch LED Flush Mount 12W 1100 lumens 3000k
Hallway	84	LED 8W T8 3500k 24inch

In Haida House, Salish House, Dene House and Nootka House:

Location	Quantity	Lighting
In front elevators	12	29W non-LED
Lobby	54	39W non-LED
Hallway	84	15W non-LED

6.1.1 Predicted electrical energy saving

For Kwakiutl/huswap House:

In front elevators	$12 \times 15W \times (24-16)$ hours $\times 365 = 525.6KWh$
Lobby	$54 \times 12W \times (24-16)$ hours $\times 365 = 1892.16KWh$
Hallway	$84 \times 8W \times (24-16)\ hours \times 365 = 1962.24KWh$
Total	$4380KWh$

For Haida/Salish/Dene/Nootka House:

In front elevators	$12 \times 29W \times (24-16)$ hours $\times 365 = 1016.16KWh$
Lobby	$54 \times 39W \times (24-16)$ hours $\times 365 = 6149.52KWh$
Hallway	$84 \times 15W \times (24-16)\ hours \times 365 = 3679.2KWh$
Total	$10844.88KWh$

6.1.2 Economics

Capital cost=cost of sensors $= (12+54+84) \times \$18 = \$2700$

In Vancouver, electricity charge rate $= \$0.1012 / KWh$

For Kwakiutl/Shuswap House:

Yearly electricity saving $= \$0.1012 \times 4380 KWh = \$443.26$

In two houses, total electricity saving= $2 \times \$443.26 = \$886.52$

Payback year $= \$2700 \div \$443.26 = 6.09 years$

For Haida/Salish/Dene/Nootka House:

Yearly electrical energy saving $= \$0.1012 \times 10844.88 KWh = \$1097.50$

In four houses, total electricity saving $= 4 \times \$1097.50 = \$4390.0$

Payback year $= \$2700 \div \$1097.50 = 2.46 years$

6.1.3 GHG impacts

GHG emission factor $= 30 gCO_2 / KWh$

For Kwakiutl/Shuswap House:

GHG emission reduction $= 30 g / KWh \times 4380 KWh = 131.4 kg$

Total GHG emission reduction $= 2 \times 131.4 kg = 262.8 kg$

For Haida/Salish/Dene/Nootka House:

GHG emission reduction $= 30 g / KWh \times 10844.88 KWh = 325.35 kg$

Total GHG emission reduction = $4 \times 323.35 kg = 1293.4 kg$

In this case, we can also see the benefits of LED lighting system, with the same luminance, LED lights save a lot more electricity than non-LED lights. The system is also easy to operate and maintain.

6.2 Behavior Actions Encouragement

Except the energy saving competition which happens one time per year, there are also some strategies to change people's behaviors, including communication, prompts, incentives, commitment and social diffusion. The table below indicates strategies and some actions.

Strategies	Actions
Communication	Energy engineers give speech about the significance of energy conservation and proper measurements to students
Prompts	Use posters and stickers to remind students of saving energy
Incentives	Reward both students and staffs in the house which consume the least electrical energy in a certain period of time among the six houses
Commitment	Hold activities in the houses and use slogans to promote certain energy saving activities
Social diffusion	Choose the students who are prominent exponent to lead energy saving actions among students

Table 16 Strategies And Actions

Figure 20 Samples of Stickers and Posters

7.0 Sensitivity Analysis

7.1 Usage Intensity

In the analysis, the assumption of usage time for lights and washers are mostly based on common sense. The actual value will vary due depending on the house traffic and time period of the year. During the summer break and Christmas Festival, there is definitely less people in the house. Therefore, it is necessary to examine the sensitivity of the electrical energy consumption and the global warming impact with the usage of the washers as well as the lights.

7.2 Data Source

The next item to be examined is the data source. ion.energy.ubc.ca proveides the metering data for this report. As I mentioned in the energy analysis part, the data has several gaps and reset points in the last 6 years. If it is a huge gap, it is easy to find out and modify it. If the gap is small, such as a 5-minutes or 10-minitus data missing in a day, I may not notice it, thus cause inaccuracy.

7.3 Energy source

It was also assumed that the primary energy source is hydroelectricity for all the facilities and equipment in the building, thus I complete the estimation based on the information from BC Hydro website. The actual primary energy breakdown is not the same case. In British Columbia, 82.1% of the electrical energy comes from hydropower. It is noted that the analysis can change, however, it is a reasonable assumption to assume the primary energy source as hydropower as 82% of British Columbia's electricity comes from hydropower.

7.4 Experience uncertainty

Some of the facts I took into account in this report is according to the dialogue with energy engineer, house administrator and other staffs in school. It cannot be denied that most of the comments are based on their experience, lack of solid data support.

8.0 Recommendation

There are some limitations in conducting the energy analysis. Although the estimations, calculations and assumptions are acceptable, some further studies according to the followings are also recommended.

Less reliable data - Much lower reading were read at Kwakiutl House since the metering data for Kwakiutl House is available. Since Kwakiutl House and Shuswap House have pretty much the same amount of residences, the significant difference should not be observed. Also, Compared to other four houses, Shuswap House had a much higher reading before August in 2016, but relatively lower reading after that. It was indicated that the possible reason was the different construction year of different houses (1968 for Kwakiutl/Shuswap House, 1964 for Haida/Sailish/Nootka/Dene House). Moreover, the bills for electrical are lumped together for all of the houses in Totem. To further observe the building energy performance after implementing the ECMs, some further tracking and evaluations should be carried out. It is significant to find the department or people who really manage the energy usage, provides more information to determine the real energy usage data.

Insufficient data - The metering data is available from late 2010, which is limited for determining a baseline representing an average condition of electrical energy consumption. Therefore, the CUSUM model for electricity is different from what I expected (randomly for each house without a same trend). In addition, some specific data is missing in the product nameplates, and they are estimated based on similar nameplates from the product websites. In order to carry on the energy analysis of Totem Park Residence in the future, more historical data must be collected. The Totem Park Residence renovation construction was executed by Scott Construction Group, we can definitely find more details about facilities and equipment from the company.

Rough calculations - The economic analysis of ECMs is using simple calculation. For example, the conversions between present and future values are not taken into consideration for the determination of payback periods. Due to the difficulty in obtaining the cost of shipping, delivery, installation and maintenance, the Energy Engineer failed to provide me such information. I suggest related department (such as SHHS) keep the record and finish the documentation work every time after renovations for every building on campus for students' reference.

Water consumption analysis - Real-time water consumption metering is also available on ion.energy.ubc.ca. The analysis of water consumption for Totem Park Residence can be completed in the future.

Other renovations - There were also some other renovations took place in Totem Park Residence over the past 10 years, due to lack of historical metering data and facilities details, in this report, I failed to discuss them. It is also meaningful to analyze them and quantify the advantages. The renovations are listed below.

- Low flow fixtures piping upgrade

All six houses (Summer 2013)

- elevator motor/cab upgrades, new insulated roofs

Haida/Salish House (Summer 2012)

Nootka/Dene House (Summer 2013)

Kwakiutl/Shuswap House (Summer 2014)

- DES conversion

Haida/Salish/Nootka/Dene House (Summer 2013)

Kwakiutl/Shuswap House (Summer 2014)

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