AVALON ENERGY MANAGEMENT

A Division of Avalon Mechanical Consultants Ltd.

ENERGY STUDY
STUDENT UNION BUILDING
UNIVERSITY OF VICTORIA, B.C.

July 18, 2012

300-1245 Esquimalt Road
Victoria, B.C.
V9A 3P2
Tel: (250) 384-4128
Fax: (250) 384-4134
bob@avalonmechanical.com

LIST OF TABLES

APPENDICES (Provided Electronically)

Statement Concerning Liability

1 EXECUTIVE SUMMARY

1.1 Background of Project

With the support of BC Hydro's *Power Smart Program*, The UVic Student Union Building (SUB), and the university has initiated this investigation to identify and describe energy saving opportunities related to the facility; particularly their power, lighting, and HVAC systems.

This energy study consists of the following:

- a review of existing conditions,
- definition of potential improvements,
- estimations of energy cost avoidance resulting from these improvements,
- opinions of probable costs for the recommended bundle of improvements.

1.2 Precis of Project

UVic, in Victoria, BC, has commissioned this study to support their efforts to reduce energy costs and environmental footprint.

If

- all the recommended work were to be properly installed and operated, and
- the facility operating schedules remained constant, and
- no new loads were added, and
- energy pricing stayed constant.

then the anticipated energy savings for all the recommended measures would be as shown in Table 2.

Table 1 Total Potential Annual "Savings" Identified

	kWh/yr	GJ/yr	%	$
Electricity	292,784		23%	$24,552
Gas		2268	40%	$31,353
Maintenance				$3,765
Water				$0
Total				**$59,671**

Notes: 1. Opportunity savings are reduced maintenance requirements for in-house staff (primarily reduced light bulb changes due to longer life of proposed technologies).
2. Actual energy cost reductions (old energy costs minus new costs) will be less if energy rates rise, although actual savings should be greater.

The preliminary budget costs for implementing the recommendations are estimated at $340,000. These costs include engineering, implementation and project management, but not service tax. The HST/GST is extra. Construction costs reported herein are estimates and can differ significantly from tendered costs as a result of market conditions, absence of competition, inflation, or unforeseen complications.

The financial performance of the project is summarized as follows:

- the simple payback for the project is anticipated to be 5.1 years minus approx. 20% for utility incentives.

The recommendations contained in this report will result in additional benefits which include the following:

- replacement of equipment near the end of its life with new equipment,
- improved maintenance as a result of information available from the proposed DDC system upgrades,
- provision of improved documentation for facility systems,
- reduce greenhouse gas emissions by 119 tonnes of equivalent CO_2 per year.

Notes:

1. Effective HST (approx. 3.4%), carbon tax and carbon offsets are included in the savings of this main report.
2. Consumption saving discount for BC Hydro rate 1611 is assumed to be offset by transformer losses, and is not applied to the savings.
3. FortisBC has made an application to the BCUC to amalgamate natural gas prices throughout BC. This could result in a one-time reduction, followed by expected escalation. If this is approved, then the value of the gas savings would be reduced accordingly.
4. Similarly, changes in capital costs would affect the business case proportionately.
5. Opinions of lighting Maintenance savings are included, as the project will
   - replace old fluorescent lamps and ballasts;
   - replace incandescent with compact fluorescents that last 8 times longer;
   - add controls which reduce lamp/ballast burn hours, and
   - clean luminaires as part of the installation.
6. Opinions of added gas heating due to lighting and other power reductions is accounted for.
7. Opinions of added maintenance of new equipment are also accounted for.

1.3 Report Summary Table

Table 2 Bundle of Recommended Energy Options

		Electricity Consumption		Electricity Demand		Total Est.		Estim.	Estim	GHG	Estim.		Estim.	Simple	Pay back	Comments
	OPTION	Estim Savings kWh/yr	Estim Savings $/YR	Estim. Savings kW	Estim. Savings $	Electrical Savings $	Heating Penalty GJ	Fuel GJ Savings	Gas Saving $	tonne CO2 reduced	Other Savings $	Total Savings	Capital Cost $	Pay-Back (YR)	w/ Part 2 Saving	
5.1	Air sealing throughout	0	$0	0	$0	$0	0	170	$2,406	8	$0	$2,406	**$10,000**	4.2	**4.2**	
5.2	Wall-mount CO2 sensors for dampers	3,764	$325	0	$0	$325	0	9	$124	1	$0	$449	**$3,750**	8.4	**7.3**	AHU-2,10 & 13, see EF26 rec
5.3	S/A Duct CO2 sensors for dampers	0	$0	0	$0	$0	0	323	$4,578	16	$0	$4,578	**$20,000**	4.4	**4.4**	AHU-4,8,9,11,12
5.4	Shorten run times/optimum start	121,780	$10,514	0	$0	$10,514	0	593	$8,416	32	$0	$18,930	**$7,950**	0.4	**immed**	
5.4	Re-Cx SAT SWT Setpoints	0	$0	0	$0	$0	0	108	$1,532	5	$0	$1,532	**$4,000**	2.6	**2.6**	not req'd if Con.Op. to be done
5.4	Override timers for periods of low occupancy	0	$0	0	$0	$0	0	0	$0	0	$0	$0	**$1,500**	0.0	**na**	AHU-8,9,12/ No saving; supports schedules
5.5	Aerco upgrade of Kitchen exhaust / make-up	3,067	$265	0	$0	$265	0	459	$6,520	23	$0	$6,785	**$19,500**	2.9	**2.8**	EF9 plus bldg press sensor for AH6
5.6	Lighting	188,225	$16,251	35	$0	$16,251	-68	0	-$962	4	$3,790	$19,080	**$214,000**	11.2	**10.0**	
5.8	Upgrade theater exhaust fan to reduce SF hours	921	$80	0	$0	$80	0	283	$4,018	14	$0	$4,097	**$7,500**	1.8	**1.8**	EF26 noise reduces free cool
5.9	Local Mech Rm DHW Heat Pump	719	$62	-1	-$121	-$59	0	22	$310	1	-$25	$226	**$1,900**	8.4	**8.0**	Phase 1 - AH7 mech room
5.10	HP to replace AHU 1 10 ton AC	-25,692	-$2,218	-10	-$605	-$2,823	9	302	$4,411	14	$0	$1,587	**$20,000**	12.6	**14.6**	Incremental cost payback ~4yr
	Design Proj Management												**$29,900**			
	GRAND TOTALS	**292,784**	**$25,279**	**24**	**-$726**	**$24,552**	**-59**	**2,268**	**$31,353**	**119**	**$3,765**	**$59,671**	**$340,000**	**5.7**	**5.1**	

The term “**Consumption**” refers to the amount of energy used and metered.
The term **“Demand”** refers to the peak momentary electrical draw on the meter, from which the monthly demand penalty is calculated.

The details of the options are presented in section 5 of the report. They are generally arranged in order of likely implementation (best ROI) as follows:

- Load reduction options (e.g., wall insulation).
- Distribution upgrade options (e.g., pipe insulation).
- Plant upgrade options (e.g., new heat pumps).

Within the above framework, we generally present the waste-reduction options (e.g., running equipment less) before the efficiency increase options (e.g., replacement of equipment). This ordering facilitates the calculation of savings for the overall bundle of options to be implemented. The bundle has been adjusted so that the savings associated with each line item takes the reductions of the previous items into account; this avoids double counting of savings. Payback with Part 2 Savings allows for the benefit of the new BC Hydro Conservation Rate bonus savings that accrue over the first 3 years after implementation. Hydro and Fortis incentives should shorten the paybacks further.

2 CUSTOMER INFORMATION

The University of Victoria
3800 Finnerty Road Saanich, BC, V8W 2Y2,
Contact:
Cathie Patrick
Project Officer | Capital Development
Facilities Management | University of Victoria
p. 250 472 5421 | c. 250 516 2922
email: cpatrick@uvic.ca | web: www.uvic.ca/fmgt

Table 3 SUB Overview

Facilities	
Meters	**Hydro Meters:** UVIC Main Campus is bulk metered by BC Hydro The building is sub-metered by the Owner's Schneider meter **Gas Meters:** Fortis gas meter for cooking and process. Heat from the central high temperature campus loop is sub-metered by the Owner's meter.
Types of facilities	Pub/restaurant, theatre, meeting space, radio station and office.
Key line of business	University student union building.
Environmental issues	GHG emissions, recycling, water usage.
Stakeholders	City of Victoria, Saanich, faculty, staff, management, clients, Province

3 DESCRIPTION OF FACILITY, HARDWARE & SYSTEMS

3.1 SUB Overview

The University of Victoria (UVic) maintains 75,940 ft^2 of public and university space in its on-campus Student Union Building. The building was originally built in 1963. Facility details are presented below.

3.2 SUB Building Descriptions

3.2.1 Architectural Systems

The building is a large concrete and steel structure.

3.2.2 Occupancy Patterns

The fall and spring semesters see greater occupancy than the summer. There are conference/meeting bookings that vary, and a Pub and movie theatre which see use thoughout the year. The building also contains 12 month offices, a radio station and a student newspaper. See table **Table 10 Proposed DDC Annual and Weekly Occupancy Schedules** for greater detail.

3.3 SUB Mechanical Systems

3.3.1 Description of Mechanical Systems

The building is heated, via a district heating loop that supplies the majority of the UVIC campus, through a primary heat exchanger. There is a mixing valve to schedule the building heating loop and a secondary heat exchanger to heat the DHW and there are 14 AHU's.

The predominant AHU configuration is as follows:

- Supply and return fans
- DX cooling coil (on 5 units)
- Heating coil
- Constant volume air
- Mixing damper
- Reheat coils
- Reliable DDC control.

Two units have run-around glycol loop heat reclaim.
There is one large commercial grease hood in the main kitchen and three smaller grease hoods in the food court area.

DHW is normally provided via a shell and tube heat exchanger with the high temperature central loop as the heat source. There was a temporary electric tank system in place during our site visits.

3.3.2 Equipment Inventory & Energy

An inventory of the mechanical system was compiled, and is the basis for the energy simulation table in section Energy Accounting System & Analysis 3.7.

Equipment run times were determined in consultation with UVIC Facilities Management.

3.4 SUB Controls System

3.4.1 Description of Controls System

The primary control system is direct digital. Control panels are from Reliable Controls.

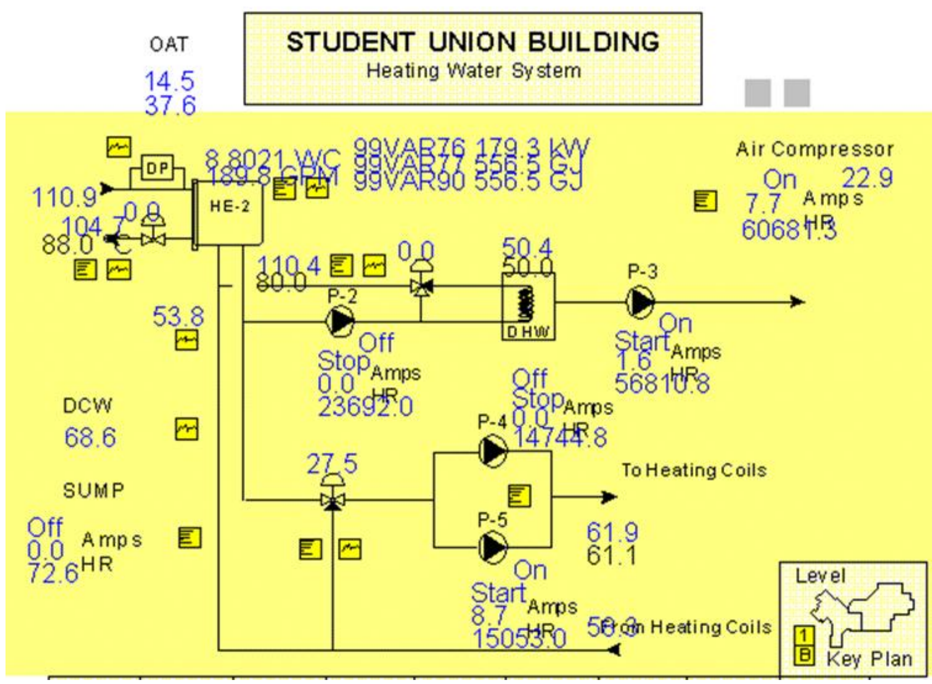
Supply Fans:

The hours of occupied run times appear to be long, and 7 days a week. There are no holiday schedules.

The systems do not employ optimum start routines. There is no demand ventilation control (CO2) in these areas of highly variable occupancy.

Heating:

The primary supply water temperature is approximately 110 deg.C, and the secondary temperature is controlled via a valve and plate heat exchanger to 80 deg C. There is a mixing valve resetting the heating loop between 80 and 40 deg C based on outdoor air temperature. It would be possible to lower this in the summer season when the only load is DHW.



Estimated Heating System Efficiency

GJ Gas to Central Boilers	100%
Instantaneous Combustion Efficiency	85%
Seasonal Efficiency	74%
Line loss	69%
	69%

Cooling:

The following areas are cooled by D/X systems: Retail, Radio Station, Newspaper, Lower North Wing. There is a good deal of refrigeration associated with the food services.

DHW:

There is a large tube and shell type heat exchanger generating and storing DHW at 50 deg C.

3.5 SUB Electrical Systems

The building's 208 3 phase power is provided from the campus mains Transformer #1. Exterior lighting is generally 600/347 volt; interior lighting is generally 208/120 volt. Lighting is described in the Appendix "A".

3.6 SUB Process System

3.6.1 Description of the Process Systems

There is a movie theatre, radio station, and food outlets including the following:

Table 4 SUB Food Service Meals per Day

FOOD OUTLET	MEALS/DAY
Main kitchen	146
Bean There	103
Health Food Bar	93
Grill	36
	378

The main kitchen uses reusable dishes and cutlery;

Food Court outlets use both disposable are recyclable products.

3.6.2 Equipment Inventory with Energy

A detailed equipment inventory was compiled to produce the energy simulations for the facility. The inventory is contained in Appendix "B".

3.7 Energy Accounting System & Analysis

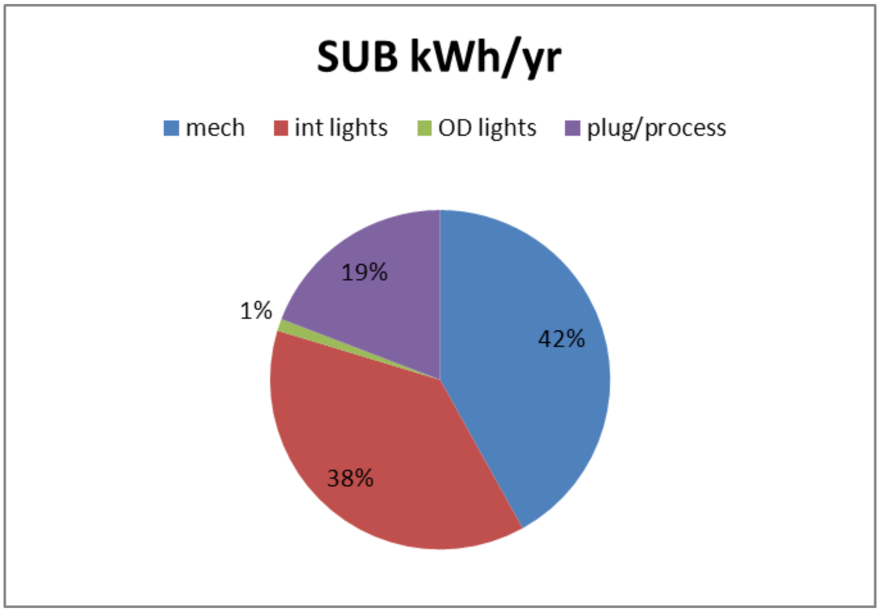
Table 5 SUB Energy Performance Indices

ENERGY	Floor Area (sq ft)	kWh/yr	MJ/sm.yr
10/11 Hydro	75,940	1,256,000	641
10/11 Gas		355,556	181
10/11 Heat	75,940	1,611,111	822
	75,940	**3,222,667**	**1,644**

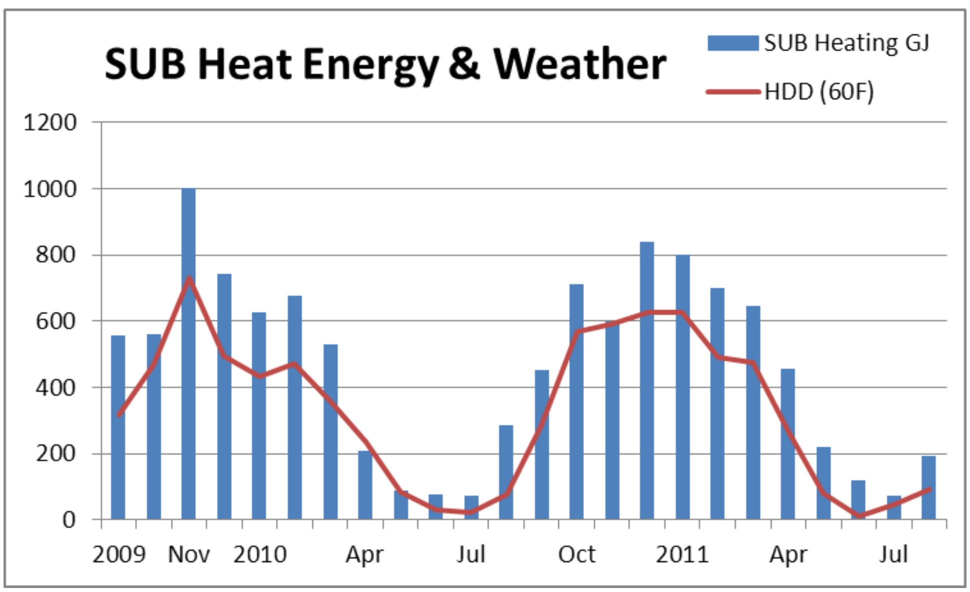
COST	Power Factor Charge	Total Charge	$/SM
10/11 Hydro	0	$87,920	$12.46
10/11 Gas	NA	$18,240	$2.58
10/11 Heat		$82,650	$11.71
		$188,810	**$26.75**

Table 6 SUB Hydro Consumption

HYDRO kWh	SUB ION Meter	GSC ION Meter	SUB - GSC = SUB Actual
JULY 1/09 to JUNE 30/10	1,454,495	161,553	1,292,942
JULY 1/10 to JUNE 30/11	1,411,753	155,822	1,255,931
Note : GSC is sub-metered from SUB therefore SUB actual is Grad Student Centre ION meter less SUB ION meter.			
Note : Year = 365 days			

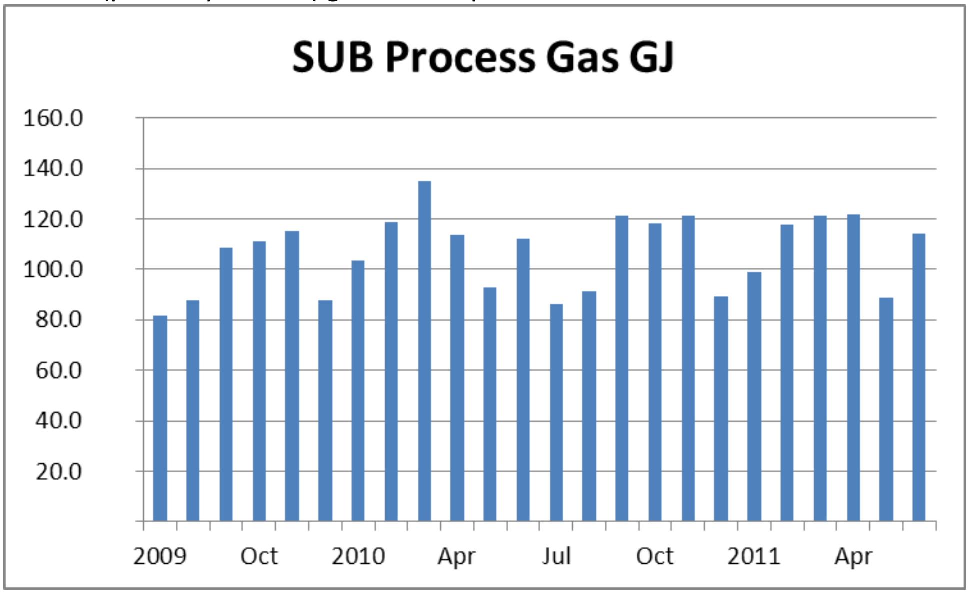


The heating energy use from the campus high temperature water mains was recorded as follows:



Irregularities of 2009 and ‘10 seem to be stabilizing in 2011. DHW use cannot be determined from summer use because SUB is busier during the school year.

Process (primarily kitchen) gas use is reported as follows:



3.7.1 Reconciliation of Bills & Simulations

Table 7 Hydro End-Use kWh/yr Breakdown 10/11

Mechanical	581,243
Int lights	523,051
OD lights	15,840
Plug/process	265,790
	1,385,924
Actual (2 yr avg)	1,274,437
sim/act	**109%**

4 ENERGY CONSERVATION OPPORTUNITIES

4.1 Integrated Design Process Proposed

This report is an Energy Study prepared for the Owner, and is not intended to be a design document. Detailed scopes of work, sizing, code references, commissioning requirements, quality assurance measures, etc. have yet to be developed.

It is anticipated that the UVic will engage a design team to implement the project. The goal is to identify and consider designs, through multi-disciplinary coordination, that

- meet the Owner's project requirements,
- carefully reflect the preliminary objectives of this energy study, including its implicit and explicit requirements as approved by external funding agencies such as BC Hydro,
- maximise efficiency,
- minimize materials,
- use low impact installation techniques,
- result in minimal ongoing maintenance, and
- optimize the environmental and economic performance of the facility.

5 ENERGY CONSERVATION OPPORTUNITIES

5.1 Air Sealing Throughout

5.1.1 Description

The recommendation involves having a member of the in-house maintenance staff (or a contractor) inspect the building during windy winter days to identify areas of excessive air infiltration. This should be done with a "smoke pencil" or some other non-toxic identifier. The Federal Building Energy Technology Transfer Program document entitled *Air Sealing Homes for Energy Conservation* (catalogue # M92-6/1984E) is an excellent resource for selecting product types and identifying risks.

The most effective sealing will often be done at the top floor ceiling (around top floor light fixtures, plumbing stacks, etc.) or in the basement/ground floor (foundation sills, duct or conduit penetrations, etc.). Special care should be taken in selection of non-toxic sealants, and sealants rated properly where surfaces are subject to high temperatures. V-seal and door sweeps can be applied to doors, and new fin-seal can be applied to windows.

5.1.2 Affected Area(s)

Perimeter of the building.

5.1.3 Opinion of Probable Schedule

1 year

5.1.4 Estimated Service Life

2 to 10 years

5.1.5 Opinion of Probable Annual Energy Savings, Cost and Payback

Refer to **Table 2 Bundle of Recommended Energy Options** on page 6.

5.1.6 Description of Energy Analysis

This estimate is rough and is based upon educated impressions of the building envelope, and a high evaluation of the staff's technical abilities and conscientiousness. Paybacks range from 3 to 9 years.

5.1.7 UVIC Operational Resources Required

Contractor coordination, or in-house staff hours.

5.1.8 Synergy

Comfort should increase due to the reduction of drafts.

Please note that the only other envelope option reviewed was Low E window film for approximately 1350 sq ft of single pane windows. A 20 year payback was projected for a $20,000 cost. The payback, even with further consideration for Fortis incentives, is near the life expectancy of the film, and the project was not recommended.

5.2 Demand Controlled Ventilation For Single Room Zones

5.2.1 Description

For AHUs that serve a single room, there is an opportunity to reduce AHU runtimes to only when needed. One or two wall-mounted carbon dioxide ($C0_2$) sensor(s) would be installed in the room. If the room's temperature and CO_2 concentrations were both within desired values, then the fan, cooling and heating could be disabled. When this occurs during occupied or rented hours (for example during set up when very few people are present, or during prolonged breaks, or simply when the rooms are lightly occupied) the fan could be duty cycled to come on for 5 minutes every half hour. A push-button over-ride could also provide 30 minutes of fan runtime. Short cycling of motors to be prevented. When the fans are called to operate due to CO_2 level or temperature, the outside air (O/A) dampers will control to the "high select" of the MAT and CO2 software controllers to minimize the intake of unnecessary cold outdoor air during heating.

In heating operation, the DDC system would modulate the air handling unit outside air (O/A) dampers towards their closed position as occupants leave the building (and the measured S/A carbon dioxide (CO_2) concentration falls). This would reduce unnecessary outdoor air intake during heating mode, and save heating energy.

5.2.2 Affected Area(s)

AHUs serving single zone booked meeting rooms are:

Table 8 Proposed Wall Mount CO2 Rooms

	Rooms Served
AHU 2	Multi-purpose
AHU 10	Multi-purpose
AHU 13	Cinecenta

5.2.3 Opinion of Probable Schedule

1 year

5.2.4 Estimated Service Life

5 years

5.2.5 Opinion of Probable Annual Energy Savings, Cost and Payback

Refer to **Table 2 Bundle of Recommended Energy Options** on page 6.

5.2.6 Description of Energy Analysis

See Appendix "C" for probable savings associated with

- Minor reduction of fan runtime
- Reduction in minimum ventilation during the heating season.

5.2.7 Operational Resources Required

UVic will have to monitor calibration alarms. Reduced runtime is expected to offset the maintenance caused by the added motor cycling.

5.2.8 Synergy

This recommendation provides a powerful tool when dealing with indoor air quality problems or concerns.

5.3 Demand Controlled Ventilation for AHU's Which Serve More than 1 Zone

5.3.1 Description

A single carbon dioxide ($C0_2$) sensor, configured to measure both supply and outdoor air CO_2 concentrations, is recommended in the supply air ducting of each AHU.

In heating operation, the DDC system would modulate the air handling unit outside air (O/A) dampers towards their closed position as occupants leave the building (and the measured S/A carbon dioxide (CO_2) concentration falls). This would reduce unnecessary outdoor air intake during heating mode, and save heating gas.
The S/A $C0_2$ set point would be selected to satisfy the ventilation loads in the most densely occupied zone under usual conditions. The outdoor air dampers would be DDC controlled to limit the maximum supply CO_2 concentration level of about 200 to 300 ppm above outdoor level (depending on the design occupant density).

This arrangement offers the following benefits over space or return carbon dioxide sensor locations:

- Sensor malfunction can be alarmed when outdoor air readings fall outside normal range;
- Reading error is reduced as drift is largely cancelled out – both concentrations used in the

calculation are measured by the same sensor;

- Outdoor air CO_2 concentration is measured rather than assumed. This should increase the accuracy of control;
- Return CO_2 set points are not useful when more than one room or space is served by the system.

ASHRAE Standard, 62.1-2004, recommends that ventilation rates be maintained at a minimum of 0.06 cfm/sq.ft. Damper leakage is expected to provide this level of ventilation.

5.3.2 Affected Area(s)

Systems were selected based on outdoor ventilation rates, occupancy profiles, weekly operating schedules supply air temperature reset schedules and, ultimately, energy savings potential. One would think that there would be a number of good candidates for this strategy in the building, but most the minimum O/A damper settings seem to be quite low, leaving little opportunity for savings. There are zones where the indoor air quality is suspect due to the low damper settings. The ventilation of the building requires further study, but there is an argument for applying S/A CO_2 sensors to the following AHUs:

Table 9 Proposed Duct Mount CO2 Sensors

AHU-4	Pub Supply
SF-8	Student Newspaper
SF-9	Lower Floor N. Wing
SF-11	N. Wing Offices
SF-12	Upper Floor

5.3.3 Opinion of Probable Schedule

1 year

5.3.4 Estimated Service Life

5 years

5.3.5 Opinion of Probable Annual Energy Savings, Cost and Payback

Refer to **Table 2 Bundle of Recommended Energy Options** on page 6.

5.3.6 Description of Energy Analysis

Please see Appendix "D".

5.3.7 Operational Resources Required

UVic will have to monitor calibration alarms.

5.3.8 Synergy

This recommendation provides a powerful tool when dealing with indoor air quality problems or concerns.

5.4 DDC Re-Commissioning

5.4.1 Description

Our review of the Reliable DDC system identified several areas were minor changes could provide substantial energy savings.

1 Shorten system run times to match occupancy.

2 Shut down systems not needed on holidays if possible. See Appendix "E" for detailed schedules determined in consultation with Al Bishop Support and Administrative Services Division Manager for the SUB. Schedules are summarized as follows:

Table 10 Proposed DDC Annual and Weekly Occupancy Schedules

AREA		MAY 1 to AUG 31	SEP 1 to APR 30
AHU-1	Retail	800 to 2000 Mon to Fri	800 to 2000 Mon to Sat
AHU-2	Multi-purpose Area	notify Facilities each week	notify
AHU-3	Entrance Lounge	unocc mode w CO2	1000 to 2000 Mon to Fri; notify for weekend
AHU-4	Pub Supply	1100 to 100 Mon to Fri	1100 to 100 Mon to Sat
AHU-5	Concourse West and South	700 to 2200 Mon to Sat	700 to 2200 - 7 day/wk
AHU-6	Concourse East	600 to 2100 Mon to Fri	600 to 2100 Mon to Fri
SF-7	Radio Station	600 to 2100 7d/wk	600 to 2100 7d/wk
SF-8	Student Newspaper	900 to 1600 Mon to Fri	100 to 1700, Mon to Fri
SF-9	Lower Floor N. Wing	700 to 2200 Mon to Sat	700 to 2200 7 day/wk
SF-10	Multi-purpose Area	notify Facilities each week	notify
SF-11	N. Wing Offices	700 to 2100 Mon to Sat	700 to 2100 Mon to Sat
SF-12	Upper Floor	800 to 1800 Mon to Fri	800 to 1800 Mon to Fri
EXSF-13	Theartre	1800 to 2400 7d/wk	1800 to 2400 7d/wk (notify for events)

The practice of extending occupied hours results in fewer complaints to Facilities about space temperature, but it is generally agreed that the cost of heating large buildings for a few after-hour workers is unjustified, and not in keeping with the intent of UVIC's Energy and GHG Policy. It is hoped that the UVIC's Sustainability Plan will garner support for a new conservation ethic where students, faculty and staff will gladly wear sweaters and take other measures to end unnecessary after-hours heating.

Table 11 Proposed AHU Operation Sequences

Mode	Time	Operation
Warmup	Early morning on normally occupied days.	Warm Up: Initiated by optimum start program. Mixing dampers remain in full re-circulation position. Fan or pump runs continuously until RT-Avg heating set point is reached.
Pre-cool	Early morning on normally occupied days.	Summer Pre-cool - Supply fan runs from 4:00 am with mixing dampers in full outdoor position until pre-cool RT_Avg set cooling set point (23C) temperature is obtained or outdoor air temp > 20C.
Fully Occupied	Occupied days.	Supply fan runs continuously. Occupied temperature conditions are maintained. Minimum ventilation rate is maintained at least.
Unoccupied	After hours on normal occupied days, weekends, holidays, etc.	UNOCCUPIED: Unit off and zones under setback set points; UNOCCUPIED HEAT: Units cycled to maintain avg space heating temperature at set point (17C). Mixing dampers remain in full re-circulation position. Fan off when RT_avg > 18C. Alarm if any space < 14C and enable unit. UNOCCUPIED COOL: free cooling is required if avg space temperature at set point (2C). No mechanical cooling is provided in this mode. Ensure that all zone heating is off before unoccupied cooling is enabled. Fan off when RT_Avg < 23C

Annual schedules were missing in all cases. The following is the list of days where the vast majority of zones could be in unoccupied mode:

Table 12 Annual Statutory Holidays

Holiday	Stat's
Labour day	0
Thanksgiving	1
Remembrance Day	1
Xmas	9
Family Day	1
Good Friday	1
Easter Monday	1
Victoria Day	1
BC Day	1
Canada Day	1
per year	**17**

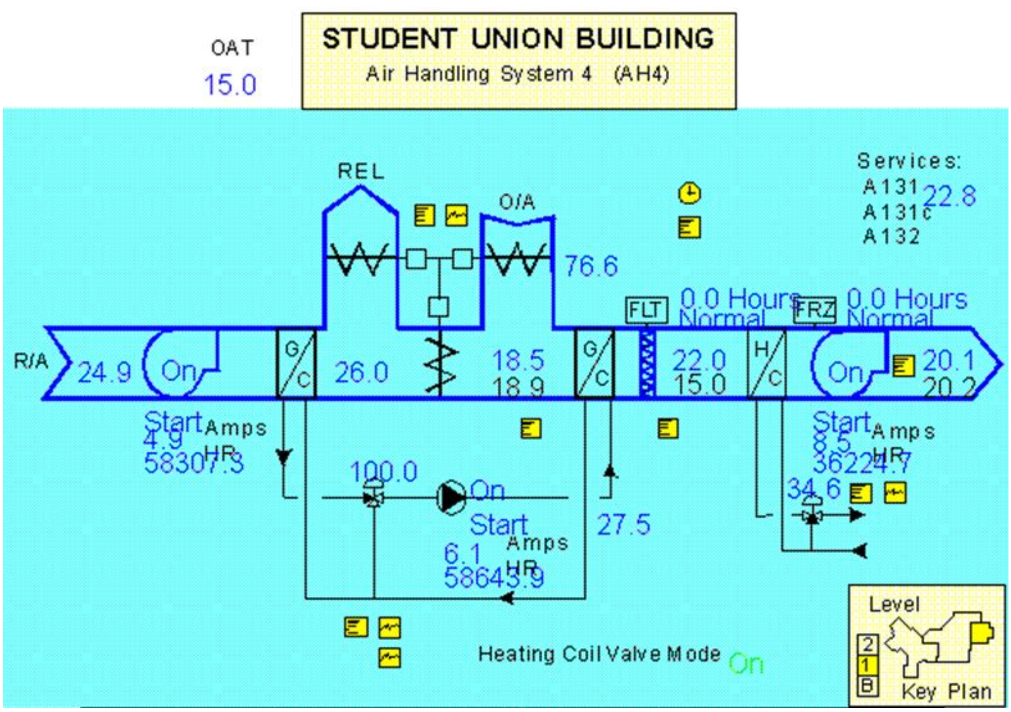
The possibility of DDC room temp sensors with occupancy override buttons should be considered for AHUs 8,9 and 12. The feature would trigger 3 hours of full HVAC operation in a zone if someone requires it during unoccupied hours.

3 Revise fan supply air temperature setpoints to maximize free cooling and minimize reheat. Incorporate space demand (use the average of the highest 50% RTs rather than RTmax) into set point calc, and use one common software controller (0 to 46% for heating; 54 to 100% for free cooling then mechanical cooling). As found conditions are as follows:

Table 13 As-found SAT-SP Approaches

AHU	AREA	CHARACTERISTICS	SAT_SP	COMMENTS
1	Retail	SF,RF, HC, **AC**, **CV**, RA, MAT, **ReHt**	constant 13 C	overcools (wastes heat)
2	Multi-purpose	SF,RF, HC, **CV**, RA, MAT, **ReHt**	constant 17 C	overcools in winter, overheats in summer
3	Vertigo	HR,SF,RF, HC, **CV**, RA, MAT, **ReHt**	constant 15 C	overcools in winter, overheats in summer; HR=15
4	Pub	HR, SF,RF, HC, **CV**, RA, MAT, **ReHt**	43 - RTA131rt	often overheats; HR will be on almost all year, regardless of sun, occupancy, etc.
5	Concourse W	SF, HC, **CV**, RA, MAT, **ReHt**	constant 16 C	overcools in winter, overheats in summer
6	Concourse E	SF, HC, **CV**, RA, MAT, **ReHt; Kitch MU**	OA reset 16 to 23	sun and occupancy not accounted for
7	Radio	SF,RF, HC, **AC**, **CV**, RA, MAT, **ReHt**, **Plenum**	36-MaxRT	may over-cool
8	Martlet	SF,RF, HC, **AC**, **CV**, RA, MAT, **ReHt**	40-RTavg	may overcool
9	Lower N Offices	SF,RF, HC, **AC**, **CV**, RA, MAT, **ReHt**	57 - 2*RTavg	probably overcools
10	Multi-purpose	SF,RF, HC, **CV**, RA, MAT	OA reset	sun and occupancy not accounted for
11	N Offices	SF,RF, HC, **CV**, RA, MAT, **ReHt**	OA reset	sun and occupancy not accounted for
12	Main & 2 Offices	SF,RF, HC, **CV**, RA, MAT	41-MaxRT	may overcools
13	Theatre	SF,RF, HC, **CV**, RA, MAT	RT controller	as-found pre-purge mode is excessive

The following is as example of simultaneous and cooling heating (glycol pump on, and final HCV = 35%; Economizer = 77%):

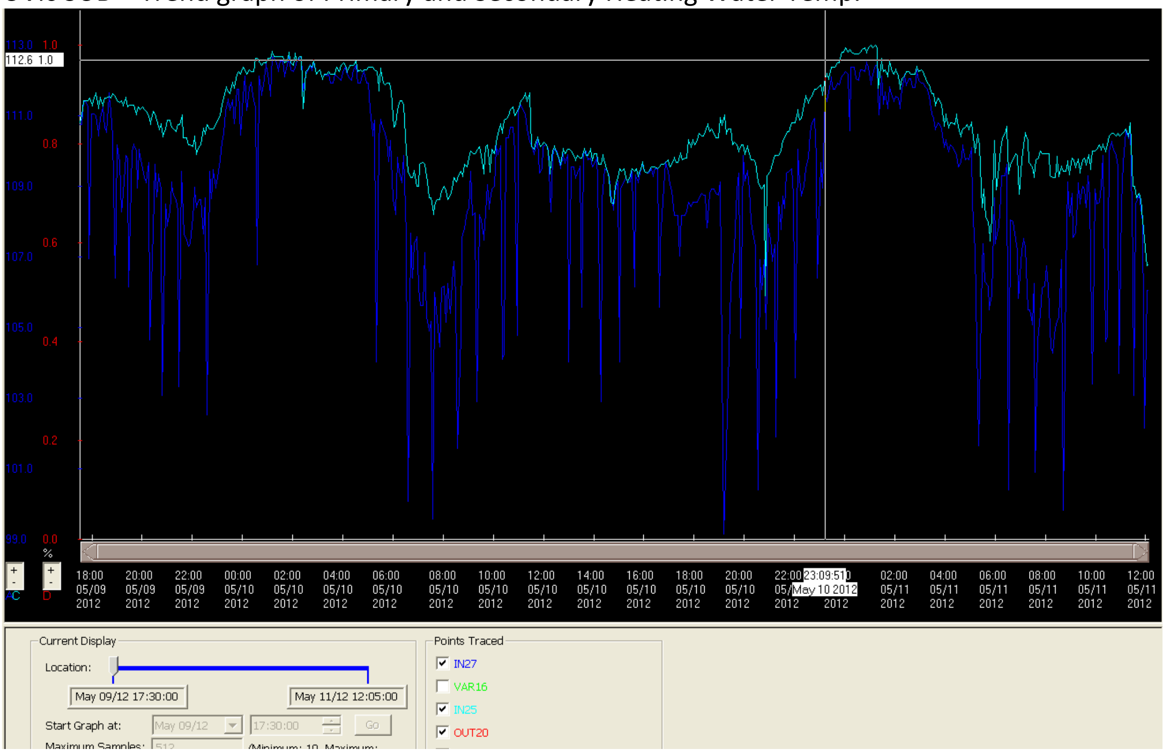


4 Using a "cold day" point lock out heating above the building balance point.

5 AHU 3 and 4 glycol heat reclaim pumps found on in July. Re-program in conjunction with SAT set points, and institute warm day lockout.

6 The primary (campus loop) supply water temperature is high all year. Control valve on the primary side of the HX appears to be leaking by as the secondary was 110 deg with the CV shut and 99-var 19 (primary flow) was reading 219.6 gpm. It appears that the secondary SWT set point is fixed at 80 deg. Tertiary has OA reset which could possibly be adjusted once the AHU SAT set points are adjusted.

UVic SUB – Trend graph of Primary and Secondary Heating Water Temp.



7 Control air compressor only serves terminal heating controls, so could possibly be disabled June through Sept.

8 Pending decisions on BC Hydro's *Continuous Optimization Program*, joint DDC Re-commissioning by Facilities, the Energy Consultant and Contractor's DDC Technician is recommended for all energy systems. The following tasks are recommended:

a) Eliminate incorrect sensor scale ranges, and review sensor calibration.
b) Review Outdoor Air minimum positions for ventilation. Also ensure that OA temperature sensors are reporting the correct OA temperature.
c) Test heating water valves for leakage when closed.
d) Outputs which are in manual mode shall be placed into auto where possible. A monthly report of manual points is recommended.
e) Check for areas which do not have unoccupied set backs. Review all unoccupied Rm Temp trends to verify that setbacks are being achieved.
f) Experiment with temperature and pressure set points. More investigation will be put into lowering heating set points on mornings of warm days (so boiler heat is not injected into

the space, and then absorbed by the A/C) – a temperature prediction strategy.

g) Apply for BC Hydro's Continuous Optimisation Program so a smart power meters can be installed to record and graph electrical demand and consumption, and so that the DDC systems automatically employ load shedding, by raising summer space temp set points, and lowering winter space temp set points in electrically heated areas.

h) Set up more trend logs and log sheets (e.g., all reheat valves on each AHU) to make it easier to evaluate system performance.

i) Implement the following strategies, where applicable and practical:

Table 14 DDC Recommissioning Strategy Checklist

1) Fan systems	annual and weekly schedule
	optimal start
	supply air temperature reset
	supply air pressure reset
	demand ventilation control
	HCV to 100% during NSB (to shorten run time)
	close OAD during morning warm-up
2) Hot water distribution	optimal start
	pump lock-out on warm day
	supply water temperature reset
	variable flow control
3) Chilled water distrib.	N/A
4) Boiler plant	lock-out on warm day
	sequencing to maximize efficiency
	optimal stop of primary hot water
5) D/X Cooling	lock-out on cold day
6) Miscellaneous	circulation pump control

5.4.2 Affected Area(s)

See above

5.4.3 Opinion of Probable Schedule

1 year

5.4.4 Estimated Service Life

5 years, barring possible software or hardware upgrades.

5.4.5 Opinion of Probable Annual Energy Savings, Cost and Payback

Refer to **Table 2 Bundle of Recommended Energy Options** on page 6.

5.4.6 Description of Energy Analysis

Gas savings are estimated at 3% of supplied campus heat, after accounting for other savings. Hydro savings are calculated in detail in Appendix "F".

5.4.7 UVIC Operational Resources Required

The installation of more sophisticated sequences will be less effective if the on-site operator is not familiar with them and/or does not support them. It is recommended that the Controls Technician implement, monitor and tune the strategies as seasons and occupancy change, and that he identifies and fixes problems as they occur. The recommendation involves regular periods of this person's time, at least until the controls have been recommissioned and are operating satisfactorily.

5.4.8 Synergy

Less equipment run time should result in less maintenance and longer equipment life.

5.5 Kitchen Grease Hood Demand Controlled Ventilation

5.5.1 Description

There is an opportunity to save fan energy, and heated make-up air, through the installation of a demand ventilation control system such as the Aerco Kitchen Demand Control Ventilation system. This system is promoted by BC Hydro Power Smart, and is applicable to the main kitchen.

Fan Energy:

The relationship between slowing down a fan's speed and saving power falls under the fan affinity laws. Savings are in proportion to the cube of the fan speed; e.g., reduce a fan's speed by 10% and you reduce the power used by approximately 28%.

The proposed system is estimated to be running the fans at an average fan speed of around 65% when in demand mode. During full cooking and any smoke or steam generation would the system ever go to 100%.

Heating Energy:

The control strategy insures that the make-up fan speed is reduced simultaneously with the exhaust fans, thus requiring less air to be heated to the discharge temperature set point.

The East Concourse area would be provided with a DDC building pressure sensor to assist with make-up air control, and allow the AHU6 outdoor air reductions during heating mode when the grease hood is at low speed, or off.

5.5.2 Affected Area(s):

The main kitchen

5.5.3 Opinion of Probable Schedule:

Dependant upon funding and project priorities.

5.5.4 Estimated Service Life:

Varying from 2 to 20 years

5.5.5 Opinion of Probable Annual Energy Savings, Cost and Payback

Refer to **Table 2 Bundle of Recommended Energy Options** on page 6.

5.5.6 Description of Energy Analysis:

See Appendix "G"

5.5.7 UVIC Operational Resources Required:

Project management and maintenance of a new speed drive.

5.5.8 Synergy

This project should improve winter comfort in the kitchen, and extend the fan lives.

5.6 Lighting

5.6.1 Description

Many lighting and lighting control retrofits have been described and paybacks have been estimated by Quantum Lighting. Details are contained in Appendix "A".

5.6.2 Affected Area(s):

The entire building

5.6.3 Opinion of Probable Schedule:

Dependant upon funding and project priorities.

5.6.4 Estimated Service Life:

Varying from 2 to 20 years

5.6.5 Opinion of Probable Annual Energy Savings, Cost and Payback

Refer to **Table 2 Bundle of Recommended Energy Options** on page 6. The summary differs from the appendix in that the summary includes the 25 cent/kW demand discount for rate 1211, and includes a penalty for additional heating required as a result of removed lighting wattage.

5.6.6 Description of Energy Analysis:

See Appendix "A".

5.6.7 UVIC Operational Resources Required:

Project management

5.6.8 Synergy

This project would reduce over-heating in summer, greatly reduce maintenance, simplify lighting replacements by reducing the great number of different types of lights, improve light quality and increase aesthetics in certain areas.

5.7 Mechanical Insulation

5.7.1 Description

UVic pipefitters could embark on a general campus program of insulating hot pipe components, accessories, fittings, heat exchangers, etc. This option is not included in the report costs and savings.

5.7.2 Affected Area(s)

Campus

5.7.3 Opinion of Probable Schedule

2 years

5.7.4 Estimated Service Life

15 years

5.7.5 Opinion of Probable Annual Energy Savings, Cost and Payback

A 6 year payback could be expected if the program was time-efficient.

5.7.6 Description of Energy Analysis

none

5.7.7 UVIC Operational Resources Required

Weeks for an in-house person, if the installation is done in-house.

5.7.8 Synergy

Over-heated mechanical rooms would be more comfortable, and cooling costs of adjacent spaces would be reduced.

5.8 Upgrade Theatre Exhaust Fan to Reduce AHU Run Time

5.8.1 Description

EF-26 (5500 CFM) serves the movie theatre. It is noisy, so it is seldom used during times of high occupancy. The recommendation involves the following:

- Installation of wall-mounted CO_2 sensors as per 5.2
- Provision of a new EF with proper sound attenuation and an adjustable speed drive
- A control strategy for cooling and ventilation whereby
  - The pre-cooling of the theatre regardless of cooling demand is ceased (see 5.4).
  - If space temperature is within acceptable limits, and CO_2 is less than 900 PPM, then fan is off, or on low speed.
  - As cooling or ventilation becomes required, first stage would be EF26 on, and speed would rise to meet set points as necessary.
  - EF26 Pre-cooling would only be done
    - after 3:00 pm when OA temp is between 19C and 23C, and Room Temp is greater than OAT, or
    - from 4:00 am on days where the previous day's OAT was >24C, until OAT exceeds Room temp.
  - As heating, ventilation or cooling demand passes set points, the AHU (4480 CFM) would be enabled. Short cycling would be prevented.

5.8.2 Affected Area(s)

Cinecenta (AHU13)

5.8.3 Opinion of Probable Schedule

1 year

5.8.4 Estimated Service Life

5 years

5.8.5 Opinion of Probable Annual Energy Savings, Cost and Payback

Refer to **Table 2 Bundle of Recommended Energy Options** on page 6.

5.8.6 Description of Energy Analysis

See Appendix "H" for probable savings associated with

- Minor reduction of fan runtime
- Reduction in minimum ventilation during the heating season.

5.8.7 Operational Resources Required

UVIC will have to monitor calibration alarms.

5.8.8 Synergy

This recommendation provides a powerful tool when dealing with indoor air quality problems or concerns.

5.9 Airside Heat Recovery to DHW & Cooling of Radio AHU Return Air

5.9.1 Description

Apparently the radio station has quite a high and persistent cooling load. It is served by SF-7, which has mechanical cooling. SF-7 return air is not ducted through the mechanical room, so there is an opportunity to use a small heat pump to reclaim some of this wasted heat into DHW preheat. Technology would be similar to Rheem model HP50RH
http://www.rheem.com/products/tank_water_heaters/hybrid_electric/
There is a large tube and shell type heat exchanger generating DHW at 50 deg C from the campus loop.

5.9.2 Affected Area(s):

SF-7 mechanical room

5.9.3 Opinion of Probable Schedule:

Dependant upon funding and project priorities.

5.9.4 Estimated Service Life:

12 years

5.9.5 Opinion of Probable Annual Energy Savings, Cost and Payback

Refer to **Table 2 Bundle of Recommended Energy Options** on page 6.

5.9.6 Description of Energy Analysis:

See Appendix "I" for probable savings

5.9.7 UVIC Operational Resources Required:

Project management and maintenance of the heat pump.

5.9.8 Synergy
This project would reduce over-heating in summer, and greatly improve working conditions in the mechanical rooms.

5.10 AHU-1 Heat Pump Conversion

5.10.1 Description
There is a 17 year old Haakon Pentak AHU1 (SAF: 5 HP; RAF 1.5 HP) with a 10T TTA120A300BA DX unit. The recommendation involves replacement of this old coil and condensing unit with a heat pump. A new reversing valve DDC controls point would be added, with new piping, sheet metal work, electrical and commissioning.

Controls would try to optimize the use of the heat pump, making the hydronic heating coil 2nd stage. All unoccupied heat would come from the heat pump.

5.10.2 Affected Area(s)
AHU-1 serves the retail areas.

5.10.3 Opinion of Probable Schedule
1 year

5.10.4 Estimated Service Life
12 years

5.10.5 Opinion of Probable Annual Energy Savings, Cost and Payback
Refer to **Table 2 Bundle of Recommended Energy Options** on page 6. The reported costs are total costs, although the unit is near the end of its useful life. Incremental costs (total cost – cost to replace old A/C) would result in a much faster payback.

5.10.6 Description of Energy Analysis
See Appendix “J”.

5.10.7 UVIC Operational Resources Required
Project management.

5.10.8 Synergy
GHG emission reduction.

APPENDICES ARE ELECTRONIC