UBC Energy Modeling Guidelines

Version 2.0 | 2020-09-17

THE UNIVERSITY OF BRITISH COLUMBIA

Contents

1. Introduction and Intent

In general, modelers for UBC buildings shall follow the City of Vancouver (CoV) Energy Modelling Guidelines v2.0 (City of Vancouver, 2018) with the exceptions noted in this document. The section numbers and titles in this document are aligned with the CoV guidelines to facilitate cross reference between the UBC and CoV guidelines.

These guidelines are intended to close the performance gap observed on several UBC buildings. Over the past 10 years, UBC has observed that buildings use an average of 60% more energy than the proposed LEED energy model. Part of this gap is due to shortfalls in the commissioning process – and UBC is actively piloting new commissioning strategies on new buildings – and part is due to energy model accuracy. UBC understands, however, that calibrated energy models are a very specialized type of model that are used for energy prediction with a different methodology than a compliance model. Understanding this, these guidelines provide major assumptions that can be used to improve the accuracy of compliance energy models.

The fundamental difference between the UBC and CoV guidelines is that the CoV guidelines are intended as a code compliance tool. They impose a set of standardized assumptions – such as schedules – to ensure all buildings of a given archetype can be compared against each other, and be compared against energy and emissions targets. For UBC models, the intent is to have a reasonably accurate prediction of energy consumption as well as demonstrate compliance to energy targets. For UBC projects, the model uses assumptions (schedules, loads, etc.) that reflect actual operation of the building, and therefore can give a reasonably accurate prediction of operational energy consumption.

The primary focus of this document is to provide accurate major assumptions (schedules, plug loads, etc.) that affect the accuracy of energy models. To this end, several studies were conducted at UBC to determine hourly load profiles and peak energy use for plug loads and service hot water in various building archetypes. Hourly schedule and plug load data given in this document are based on analysis of data obtained energy meters or Wi-Fi occupancy data in UBC buildings. While every building is different and has different operation, these guidelines give modelers reasonably accurate data to use for new projects.

NECB Part 8 and ASHRAE 90.1 are both acceptable modeling approaches. For LEED projects, modelers may use the NECB Alternative Compliance Path (ACP) if desired (see UBC LEEDv4 Implementation Guide).

All new buildings at UBC must achieve LEEDv4 Gold Certification (C+CP, 2018) and achieve a minimum of 10 Optimize Energy Performance credits (UBC, 2016). Refer to the UBC LEEDv4 Implementation Guide for a list of mandatory credits and guidance on credit compliance. In addition, buildings must achieve target EUI, TEDI, and DHW usage intensity outlined in the UBC Green Building Action Plan.

1.1. Guidelines are Additional to Energy Code Modelling Rules

(refer to CoV Energy Modeling Guidelines v2.0)

1.2. Modelled vs Actual Results

(refer to CoV Energy Modeling Guidelines v2.0)

1.3. Definitions

(refer to CoV Energy Modeling Guidelines v2.0 with the following additions)

Refer to UBC LEEDv4 Implementation Guide Appendix H for GHG intensities of fuels used on campus.

PCIC - Pacific Climate Impacts Consortium, University of Victoria. PCIC has produced future weather files for hospitals in Southwest BC. The files are based on CWEC files typically used for Vancouver, but morphed to align with predicted climate models. See Section 1.5 for more info on weather files.

ADES – Academic District Energy System. UBC's primary district energy system used to heat most buildings at UBC. The ADES is heated by a mix of natural gas boilers (at the Campus Energy Centre) and a biomass gasification process (at the Bioenergy Research Demonstration Facility) producing heat from waste wood.

1.4. Renewable Energy

Refer to UBC LEEDv4 Implementation Guide for guidance on renewable energy for UBC buildings.

1.5. Weather File

UBC is in Climate Zone 4C as per ASHRAE 90.1-2016.

Modelers shall use the CWEC 2016 weather file for Vancouver International Airport as per the CoV Guidelines. Note that "…the CWEC 2016 are derived from up to 30 years of data through 2014" (Crawley & Lawrie, 2019), and therefore don't include some of the extremes in weather observed in Vancouver over the past several years. The table below highlights some of the differences between actual weather data and Vancouver CWEC 2016 weather data. It has been observed that the CWEC file reasonably accurately represents winter months, but shows milder summers than have been observed at UBC in recent years.

When conducting thermal comfort modeling, modelers shall use the 2050s future climate files for UBC produced by PCIC. These files are a morphed version of the CWEC weather files (with geographic offset from the YVR weather station and accounting for future climatic conditions based on climate models).

Table 1 – Weather Files to Use for Simulation

Simulation	Weather File	Data Source
Annual energy consumption (LEED and UBC energy compliance)	CWEC 2016 Vancouver International Airport	http://climate.onebuilding.org/
Thermal Comfort (see Section 4.1)	PCIC 2050s (UBC)	Contact UBC Energy & Water Services for the file.

The table below highlights some of the similarities and differences between the CWEC 2016 weather data for YVR vs actual observed UBC weather and PCIC 2020s predicted weather.

Table 2 – Comparison of measured UBC weather data vs CWEC 2016 YVR and predicted future weather data.

				PCIC Weather Files (UBC, Vancouver)		
	Metric	**UBC Weather (2014-2018 avg)**	**CWEC 2016 (Vancouver)**	**2020s**	**2050s**	**2080s**
Heating Season	HDDs (18°C)	2584	2853	1997	1769	1198
	Min Temp	-4.2	-5.6	-4.5	-4.0	-1.3
	Hours below 0°C	159	250	161	149	12
Cooling Season	CDDs (18°C)	153	98	203	501	618
	Max Temp	30.0	27.0	33.7	38.0	38.1
	Hours above 25°C	78.9	32	80	415	588

Also note that the degree days fluctuate year-to-year. For example, 2017 was a cold year with 2831 HDDs compared to 2015 where there were only 2382 HDDs.

1.6. District Energy

Refer to UBC LEEDv4 Implementation Guide for info on how to treat the UBC district energy system in the LEED energy model.

2. Standardized Assumptions

2.1. Schedules

The building program or UBC project team should be consulted for the load/occupant density and schedule data, as this will best inform how the facility will operate. If information on occupancy, schedule, and load assumptions are not available from the UBC project team, then assumptions from Table 3 and 4 shall be used. These schedules have been stipulated as they best represent observed data from current UBC buildings. Where a large discrepancy was found between ASHRAE/NECB and observed data, a custom value or schedule is provided (as referenced in Appendix A) based on UBC meter and WiFi data. Where ASHRAE does not have info, NECB is referenced. The same order should be followed for reference space types not covered in this guideline.

Table 3 – Peak Load Densities for UBC Space Types

Space Type	Occupant Density	Receptacle Power Density	Service Hot Water Quantities
Laboratories	From space programming requirements (if available), otherwise use ASHRAE assumptions that best fit the intended laboratory space use.	20 W/m² in laboratory spaces, 400W/m² for freezer farms	NECB 2011 Table A-8.4.3.3.(1)B
Offices	ASHRAE 90.1-2013 User's Manual – Table G-C		
Student Residences	BC Hydro Energy Modeling Guidelines section 5.6 Plug Loads		0.001L/s/person
Retail	ASHRAE 90.1-2013 User's Manual – Table G-C		

Table 4 –Hourly Schedules for UBC Space Types.

Space Type	Schedule
Laboratories	ASHRAE 90.1-2013 User's Manual – Table G-M, except:
Lighting	Appendix A – A.1.1
Laboratory Equipment	On 24/7 – see Section 2.2 for equipment load densities for labs.
Plug Loads	Appendix A – A.1.1
SHW	NECB 2011 Table A-8.4.3.2(1)A
Nighttime Setback	See UBC Technical Guidelines 23 05 00
Occupancy	ASHRAE 90.1-2013 User's Manual – Table G-M
Offices	ASHRAE 90.1-2013 User's Manual – Table G-G
Student Residences	
Lighting	BC Hydro Energy Modeling Guidelines section 5.6 Plug Loads
Receptacle	BC Hydro Energy Modeling Guidelines section 5.6 Plug Loads

Space Type	Schedule
SHW	Appendix A – A.2.1
Occupancy	NECB 2011 Table A-8.4.3.2.(1)G
Retail	ASHRAE 90.1-2013 User's Manual – Table G-J

Thermostat setpoints shall operate as per Table 5 below for all space types.

All wet labs and dry labs (where temperature changes can adversely impact research experiments) shall use constant occupied hours setpoints with no nighttime setback.

Table 5 – Thermostat set points for occupied spaces.

	Heating	Cooling
Occupied Hours	21°C +/- 1°C	25°C +/- 1°C
Night Time Setback	17°C	26°C

Buildings with slab heating or cooling systems should **not** be modeled with night time setback due to the slow response time of the slab.

2.2. Internal Gains and Domestic Hot Water

2.2.1. Laboratories

Internal loads of large laboratory process equipment (usually indicated by a dedicated room for the process, e.g. MRI's, Helium Compressors, NMRs, Mass Spectrometers, Laser Microscopes, large sterilizers, cage washing process equipment) shall be modelled as separate additional electrical loads and subsequent heat gains taken into account in the energy model. Most equipment should be assumed to run at full load during occupied hours, unless directed otherwise from the building occupant.

Laboratory internal gains are highly dependent on the processes within the building. It is recommended that specialized equipment for laboratories and hours of operation be obtained from the following sources (in order of most to least reliable):

1. From the building occupant – preferably in the form of an equipment list indicating electrical power consumption and heat output for each device.

2. Equipment heat outputs listed in ASHRAE Fundamentals 2013 handbook Chapter 18 Table 7.

3. Assume heat output equivalent to electrical power consumption and follow the same usage schedule.

4. If average power consumption is unknown, heat output should be estimated as 50% of equipment nameplate rated power, as per ASHRAE Fundamentals 2013 page 18.10.

Freezer Rooms

Special attention should be given to rooms used to house low-temperature freezers, as these rooms tend to get filled beyond what the cooling system was intended to handle, and therefore overheat. For this reason, it is recommended that modelers assume **400W/m²** for smaller freezer rooms – this is the average value calculated in a selection of rooms in a building at UBC ranging in size from 15-30m².

Since freezers are on constantly, heat output should be equivalent to the 400W/m² power consumption indicated above, applied continuously.

2.2.2. Student Housing

Service Hot Water (SHW)

Consumption = **0.001 L/s/person** at peak flow rate, modified by the schedule in Appendix A. The consumption rate and schedule are based on meter data from two new residences at UBC.

Assume entering water temp = 5°C

2.3. Other Loads

(refer to CoV Energy Modeling Guidelines v2.0)

2.4. Infiltration

A study conducted by RDH found that building airtightness is considerably better in jurisdictions where airtightness testing is required (ex. State of Washington) (RDH, 2015). Designing to the ASHRAE 90.1-2016 requirement of 2.0 L/s/m² does not ensure that airtightness will be achieved, similar to how mechanical systems don't perform as designed if not commissioned. Further information on building airtightness can be found in ASHRAE 90.1-2016 section 5.4.3 and ASHRAE Fundamentals 2017 Chapter 16.

UBC Technical Guidelines Section 07 25 00 Weather Barriers requires airtightness testing on all new buildings, with a maximum leakage rate of 2.0 L/s per m² of total enclosure (including slab on grade, walls, roofs, below grade walls) when tested at 75Pa. Where no specific air leakage target is defined by the project team, energy modelers are to assume the building will have an air leakage of 2.0 L/s/m² when tested at 75 Pa. Modelers are to follow the procedure in ASHRAE 90.1-2016 section C3.5.5.3 (also in CoV Energy Modelling Guidelines v2.0 section 2.4) to convert this value to a model infiltration rate which shall be the modeled as continuous.

2.4.1. Accounting for Airtightness Testing

For buildings where there is an airtightness target, modelers may use the target airtightness for the building. Once the airtightness test is completed, designers will then rerun the model with an infiltration rate *based on the results of the pressure test*. This step will be completed after construction, at which time the energy model can be updated prior to LEED document submission to CaGBC.

2.5. Ventilation

Modeled ventilation rates and schedule must conform to design documents.

2.5.1. Ventilation Rates

(refer to CoV Energy Modeling Guidelines v2.0)

2.5.2. Corridor Pressurization in MURBs

Modelers are to follow the TEDI and TEUI adjustment procedure in the CoV Energy Modelling Guidelines for corridor pressurization used for restricting the transfer of odors between suites. Note that corridor pressurization is not intended for suite ventilation, and suites must be ventilated directly – studies have shown that corridor ventilation is an unreliable as a means of ventilating suites (Montgomery & Ricketts, 2015)

2.5.3. Demand control ventilation

Refer to CoV Energy Modeling Guidelines v2.0 with the following exception:

According to ASHRAE 62.1-2010 sentence 6.2.7.1.2, minimum O/A rate shall be equal to the building area calculated ventilation rate $V_{bz} = R_a \times A_z$. However, minimum damper positions on air handling equipment are typically set at a certain arbitrary position – often 10% or 20% – rather than a position determined by ventilation calculations. Note that this is damper *position*, not O/A fraction. Observations of select UBC buildings have shown that actual O/A fraction is marginally lower than the O/A damper position. For UBC buildings using DCV control, modelers are to assign **10%** as the minimum O/A fraction.

2.5.4. Laboratories

According to UBC Technical Guideline Section 23 05 00 HVAC – General Requirements sentence 2.2.23, wet labs are to be designed for 8ACH during occupied hours, with a nighttime setback of 4ACH permitted with motion detection. Nighttime setback is activated based on occupancy sensor feedback. Generally, modelers should assume 8 ACH from 7AM to 11PM in all lab spaces.

2.6. Other Considerations

(refer to CoV Energy Modeling Guidelines v2.0)

2.7. Projects Not Sub-Metering Hot Water for Space Heating

This section is to be ignored for UBC projects, as the CoV requirement refers to MURBs rather than the typical core UBC building.

3. Calculating Envelope Heat Loss

3.1. Opaque Assemblies

(refer to CoV Energy Modeling Guidelines v2.0)

3.2. Fenestration and Doors

(refer to CoV Energy Modeling Guidelines v2.0)

Modeled windows must include the effect of thermal bridging. In addition to the methods mentioned in the CoV Energy Modelling Guidelines, the following are acceptable methods for obtaining window u-values:

- Frameplus online tool
- NFRC rated values from manufacturer
- Energy Star published values
- Morrison Hershfield Thermal Bridging Guide

4. Passively Cooled Buildings

There are several buildings on campus that overheat in the summer; and with summers projected to get hotter (Metro Vancouver, 2016), it is important to demonstrate thermal comfort in new buildings, particularly those that are passively cooled. As per ASHRAE Standard 55, thermal comfort is the result of the combination of several parameters – not simply ambient dry bulb temperature, which is often the only metric controlled by building HVAC systems. Additionally, thermal comfort also depends on acclimatization – the recent historical trend in outdoor temperatures.

Further, it should be demonstrated that passive cooling strategies will be effective for the foreseeable future. For this reason, all thermal comfort analysis shall be conducted using the PCIC 2050s UBC weather file.

4.1. Thermal Comfort Modeling

As per UBC Technical Guidelines Section 20 00 30 Indoor Thermal Environment, designers are encouraged to employ passive cooling strategies in new buildings. Where thermal comfort cannot be attained in a building by using passive means, active cooling systems will be permitted through variance submission.

Whether using passive or active cooling systems, modelers must show that buildings will achieve reasonable thermal comfort throughout the expected life of the building. The energy model shall be run using the PCIC **2050s** weather file for UBC for the months of May-September inclusive, tracking indoor temperatures in occupied zones for all hours. Modelers must then show that the maximum temperatures in the simulation do not exceed the limitations prescribed in UBC TG Section 20 00 30.

4.2. Climate Ready Requirements

Refer to UBC's Climate Ready Requirements for requirements of thermal comfort modelling for future climate conditions.

5. Mixed Use and Other Building Types

5.1. Mixed-Use Buildings

See below for UBC's energy and water usage targets. The following table has been reproduced from Table 4 in the UBC Green Building Action Plan.

Table 6 – energy targets for building archetypes. Source: UBC Green Building Action Plan Table 4.

	Student Housing			High-Intensity Science Building			Low-Intensity Science Building			Office, Classroom, and/or Library		
	TEDI	DHW	EUI	TEDI	DHW	EUI	TEDI	DHW	EUI	TEDI	DHW	EUI
Current	40	30	130	65	15	380	45	15	200	40	5	140
2020	30	30	120	55	15	370	35	15	190	30	5	130
2025	20	30	110	45	15	360	25	15	180	20	5	120
2030	15	30	95	35	15	350	15	15	170	15	5	115

The TEDI, DHW, and EUI targets for a multi-use building are determined by UBC Sustainability & Engineering based on an area weighted calculation using floor areas and the values above.

5.2. Other Building Types

Specific energy targets will be developed in collaboration with UBC Sustainability & Engineering based on the project's tier level as determined by UBC's Building Tier System.

6. References and Resources

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Appendix A – Schedules

The schedules in this section were compiled using metered data from UBC buildings and are considered to be an accurate representation of how typical UBC buildings are operated.

For space types that are not covered in this section, standard ASHRAE schedules should be used (found in ASHRAE 90.1-2013 User's Manual Appendix G). If schedules aren't in ASHRAE 90.1, they may be in NECB 2015 Part 8.

A.1. Laboratories

Designers should use the schedules found in ASHRAE 90.1-2013 User's Manual – Table G-M, except for the following:

A.1.1. Lighting & Receptacle Schedules

Table A.1.1 – Lighting & Receptacle Schedules

Hour	Lighting			Receptacle		
	Wk	Sat	Sun	Wk	Sat	Sun
1	20%	20%	20%	20%	20%	20%
2	20%	20%	20%	20%	20%	20%
3	20%	20%	20%	20%	20%	20%
4	20%	20%	20%	20%	20%	20%
5	20%	20%	20%	20%	20%	20%
6	20%	20%	20%	20%	20%	20%
7	30%	20%	20%	20%	30%	30%
8	50%	20%	20%	30%	30%	30%
9	90%	40%	40%	40%	40%	40%
10	90%	40%	40%	50%	40%	40%
11	90%	40%	40%	50%	40%	40%
12	90%	40%	40%	50%	40%	40%
13	80%	20%	20%	40%	30%	30%
14	90%	20%	20%	50%	30%	30%
15	90%	20%	20%	50%	30%	30%
16	90%	20%	20%	50%	30%	30%
17	90%	20%	20%	50%	30%	30%
18	90%	20%	20%	40%	20%	20%
19	50%	20%	20%	30%	20%	20%
20	50%	20%	20%	30%	20%	20%
21	30%	20%	20%	20%	20%	20%
22	30%	20%	20%	20%	20%	20%
23	20%	20%	20%	20%	20%	20%
24	20%	20%	20%	20%	20%	20%

Lighting Schedule Notes:

The above lighting schedule is simply the ASHRAE schedule modified to have a minimum of 20%. This is based on meter data from a lab on campus that showed lighting levels dropping to 23% of max overnight.

This schedule includes emergency lighting.

A.1.2. Service Hot Water

Use NECB 2011 Table A-8.4.3.2.(1)A (no ASHRAE schedule for lab SHW).

A.1.3. Night Time Setback

Refer to Technical Guidelines TG 23 05 00 for night time setback strategy

A.2. Student Housing and Community Services (SHCS)

A.2.1. Service Hot Water Schedules

Table A.3.1 – Service Hot Water Schedules

Hour	SHW		
	Wk	Sat	Sun
1	77%	46%	53%
2	54%	42%	52%
3	40%	32%	40%
4	30%	25%	30%
5	22%	19%	22%
6	16%	15%	15%
7	18%	12%	16%
8	48%	15%	22%
9	100%	35%	37%
10	80%	52%	50%
11	62%	63%	64%
12	46%	68%	77%
13	40%	69%	79%
14	34%	64%	65%
15	31%	58%	52%
16	31%	44%	44%
17	32%	43%	49%
18	36%	47%	48%
19	37%	40%	45%
20	39%	45%	39%
21	45%	49%	39%
22	62%	56%	42%
23	75%	67%	47%
24	88%	71%	53%

SHW Schedule Notes:

SHW schedule shall be applied to a peak load calculated as **0.001 L/s/person** with **5°C EWT** and **50°C LWT.**