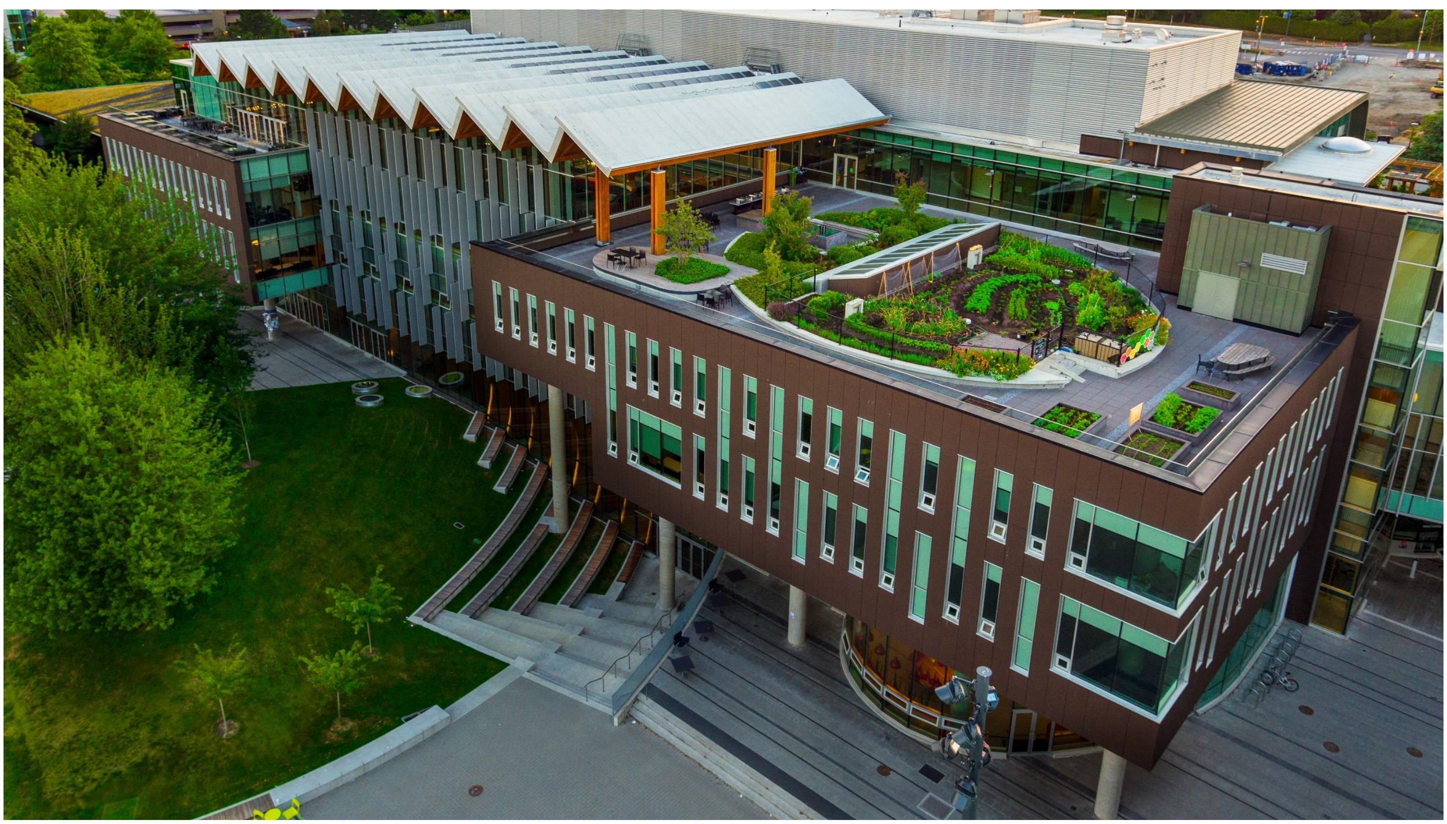
Energy & Water Services | Energy Conservation & Innovation
2023-02-13

UBC Energy Modeling Guidelines

Version 3.1 | 2023-02-13



THE UNIVERSITY OF BRITISH COLUMBIA

Contents

1. Introduction and Intent

These guidelines are intended to close the performance gap (the difference in modeled and observed energy performance) observed in 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.

In general, modelers for UBC buildings should 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.

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 produce a reasonably accurate prediction of energy consumption as well as to demonstrate compliance to energy and emissions targets. For UBC projects, the model uses assumptions (schedules, loads, etc.) that reflect actual expected operation of the building, and therefore can give a reasonably accurate prediction of operational energy consumption.

The primary intent of this document is to provide consistent guidance and accurate major assumptions (schedules, plug loads, etc.) for models produced for LEED certification and for showing compliance to UBC's energy and emissions targets. Hourly schedule and plug load data given in this document are based on analysis of data obtained from energy meters or Wi-Fi occupancy data in UBC buildings. While every building is different and has different operation, the hope is that 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 LEEDv4 projects, modelers may use the NECB Alternative Compliance Path (ACP) if desired (see UBC LEEDv4 Implementation Guide).

All new buildings at UBC must achieve LEED Gold Certification (C+CP, 2018) and achieve a minimum of 10 Optimize Energy Performance credits (UBC, 2016; UBC, 2022). Refer to the UBC's Implementation Guides for LEEDv4 and v4.1 for a list of mandatory credits and guidance on credit compliance. In addition, buildings must achieve target EUI, TEDI, GHGI, 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 Appendix B – Utility Rates 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 biomass (at the Bioenergy Research Demonstration Facility) producing heat from waste wood.

GHGI – Greenhouse Gas Intensity. Total GHG emissions from the building normalized by building area. This shall be calculated using the average monthly emission factor of the DES (see Appendix B – Utility Rates).

Monthly Average Emission Factor – The amount of emissions associated with the DES for each month of the year. The value fluctuates based on the ratios of thermal energy delivered by natural gas and biomass each month. In summer months, the DES emission factor is low because the biomass plant is able to satisfy the full heating load of the DES. In winter months, the natural gas boilers are required to meet the high thermal demand, resulting in a higher emission factor.

Monthly Marginal Emission Factor – The emission factor of the fuel source being used for peaking in a given month. For example, in winter, the natural gas boilers are required to satisfy the peaking load; therefore, any load added to the DES in winter would be satisfied by the natural gas peaking boilers, resulting in a high emission factor.

1.4. Renewable Energy

Refer to UBC LEEDv4 and v4.1 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 2016 file is reasonably accurate at representing 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 YVR produced by PCIC. These files are a morphed version of the CWEC weather files.

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 (YVR)	https://www.pacificclimate.org/data/weather-files

The table below highlights some of the similarities and differences between the CWEC 2016 weather data for YVR vs actual observed UBC weather and future shifted PCIC weather files.

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

				PCIC Weather Files (YVR, Vancouver)		
	Metric	UBC Weather (2017-2022 avg)	CWEC 2016 (Vancouver)	2020s	2050s	2080s
Heating Season	HDDs (18°C)	2716	2853	2406	2137	1545
	Min Temp	-6.7	-5.6	-4.1	-3.8	-0.5
	Hours below 0°C	152	250	107	76	4
Cooling Season	CDDs (18°C)	160	98	178	432	526
	Max Temp	31.7	27.0	29.6	33.4	33.6
	Hours above 25°C	98	32	81	460	569

Also note that the actual number of degree days fluctuate year-to-year. For example, 2020 was a mild summer with 115 CDDs compared to 2021 when there was 206 CDDs.

1.6. District Energy

Refer to UBC LEEDv4 and v4.1 Implementation Guide for info on how to treat the UBC district energy system in the LEED energy model.

1.7. Reporting Requirements

Refer to ASHRAE 90.1 Appendix G for a list of recommended documentation to accompany energy models (G1.4 in 90.1-2010; G1.3 in 90.1-2016).

Energy modeling results shall be presented using the following metrics at a minimum in the energy modeling report:

1.7.1. UBC Compliance Results

Metric	UBC Target*	Baseline Model	Proposed Model
TEUI ($kWh/m^2/yr$)			
TEDI ($kWh/m^2/yr$)			
GHGI ($kgCO_2e/m^2/yr$)**			
DHW ($kWh/m^2/yr$)			

*use values from Owner's Project Requirements document.
**calculate using average monthly GHG rates of DES. See Appendix B – Utility Rates.

1.7.2. Additional metrics to report for Student Housing projects

For Student Housing projects, results shall be presented normalized **by bed** (in addition to the metrics above) as per the table below:

Metric	UBC Target*	Baseline Model	Proposed Model
TEUI (kWh/bed/yr)			
GHGI ($kgCO_2e$/bed/yr)**			

*use values from Owner's Project Requirements document.
**calculate using average monthly GHG rates of DES. See Appendix B – Utility Rates.

1.7.3.Energy End-Use Breakdown

In addition to the table below, it is recommended that end-use energy results be presented graphically with a **stacked-bar chart** indicating the contribution of each end-use to overall EUI.

	Component EUI (kWh/m²/yr)		Energy Cost ($/yr)	
End-Use	**Baseline Model (ASHRAE 90.1-XXXX*)**	**Proposed Model**	**Baseline Model (ASHRAE 90.1-XXXX*)**	**Proposed Model**
Heating (DES)**				
Heating (Elec)				
Cooling				
DHW				
Fans & Pumps				
Lighting				
Misc.				
TOTAL				

*reference the version of ASHRAE 90.1 used for the baseline model.
**calculate using average monthly costs of DES. See Appendix B – Utility Rates.

1.7.4.LEED Model Results

	Energy Consumption		Energy Cost	
Metric	**Baseline Model (ASHRAE 90.1-XXXX*)**	**Proposed Model**	**Baseline Model (ASHRAE 90.1-XXXX*)**	**Proposed Model**
DES (kWh)**				
Electricity (kWh)				
Gas (kWh)				
TOTAL (kWh)				
Savings (kWh)				
% reduction				

*reference the version of ASHRAE 90.1 used for the baseline model.
**calculate using average monthly costs of DES. See Appendix B – Utility Rates.

1.7.5. Specific Requirements for LEED v4.1

For projects applying to LEED v4.1, design teams shall show the calculation from ASHRAE 90.1-2016 section 4.2.1.1 and show how modeled PCI compares to PCI_t:

$$PCI_t = [BBUEC + (BPF \times BBREC)]/BBP$$

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. For schedules not provided in this guideline, it should be obtained through:

1. Building occupant, based on how they anticipate using the facility.
2. ASHRAE 90.1-2013 User's Manual schedules (assumptions in models used to produce energy and GHGI targets were based on assumptions in ASHRAE 90.1).
3. NECB schedules.

Table 3 – Peak Load Densities for UBC Space Types

Space Type	Occupant Density	Receptacle Power Density	Service Hot Water Quantities	Elevators
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	BC Hydro Energy Modeling Guidelines section 5.8 Elevators
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			

* Low usage for dorms without kitchens; Medium usage for dorms with kitchens

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.

Space Type	Schedule
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
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. Space-specific heating and cooling set points can be found in UBC technical guideline 20 00 30 Indoor Thermal Environment section 2.2.

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.

2.1.1.Fume Hoods

Fume hood operation varies from lab to lab based on the type of research in the lab, number of researchers, and individual lab user habits. The following schedules were assembled based on measured sash positions for various labs in two facilities. These values were used to establish EUI/GHGI targets for lab buildings.

Fume hood volume flow rates should be based on actual design data. For preliminary models where fume hoods are not sized, assume the following flow rates:

Table 6 – fume hood assumptions for lab spaces.

Facility Archetype	Fume Hood Density*	Max/Min Airflow	Sash Positions (occupied)	Sash Positions (unoccupied)	Fume Hood width
Science/Lab Building (low fume hood density)	24m / 1000m²	500 / 125 cfm	60% closed; 40% open	80% closed; 20% open	6'
Lab Building (high fume hood density)	49m / 1000m²	900 / 250 cfm	60% closed; 40% open	80% closed; 20% open	4'

* For use in preliminary models when actual fume hood density is not known. Actual fume hood density should be used for final models.

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 2021 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 Table 6 and 7 in ASHRAE Fundamentals 2021 Chapter 18.

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 and leaving water temp = 50°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 2021 Chapter 16.

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 (minimum requirement of UBC Technical Guidelines Section 07 25 00 Weather Barriers). 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 ignore the TEDI and TEUI adjustment procedure in the CoV Energy Modelling Guidelines for corridor pressurization used for restricting the transfer of odors between suites. UBC's energy and emissions targets were set without including this adjustment, so it should not be included in energy models. 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.

When using a contaminant monitoring system, assume 4ACH occupied / 2ACH unoccupied ventilation rate. The fume hood ventilation rate may override these values in high density labs.

Modelers should assume the following occupancy schedule for lab spaces:

Table 7 – Occupancy Schedule and ACH for Lab Spaces.

Days	Occupied hours	Occupied / Unoccupied ACH* (no contaminant monitoring)	Occupied / Unoccupied ACH* (with contaminant monitoring)
Monday-Friday	7AM-10PM	8ACH / 4ACH	4ACH / 2ACH
Saturday-Sunday	7AM-6PM	8ACH / 4ACH	4ACH / 2ACH

* ACH to be overridden by fume hood demand requirements.

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.

2.8. Operable Windows

It is impossible to predict how users will operate manual windows, and is a challenge to model actual air change rates as a result of opening windows. Therefore, the following assumptions shall be made with regard to operable windows and natural ventilation rates:

- Assume windows are operated optimally by users
- Assume the following air change rates when windows are open:
  - **0.5 ACH** without cross-flow
  - **1.0 ACH** with cross-flow

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
- Berkeley Lab WINDOW
- 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 YVR 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 shall be used.

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 YVR for the months of May-September inclusive, tracking indoor temperatures in occupied zones for all hours. Modelers must then show that the room 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, emissions, and water usage targets. The following table has been reproduced from the Institutional Energy Targets of the UBC Green Building Action Plan.

Table 8 – Energy and Emissions Targets for Building Archetypes.

	Student Residence		Office / Classroom		Science/Lab Building* (low FH density)		Lab Building* (high FH density)	
	2022	2025	2022	2025	2022	2025	2022	2025
GHGI ($kgCO_2e/m^2/yr$)	2.2	1.9	2.8	2.3	4.8	3.1	6.3	4.3
EUI ($kWh/m^2/yr$)	100	84	100	91	236	161	328	249
TEDI ($kWh/m^2/yr$)	24	16	23	15	N/A	N/A	N/A	N/A
DHW ($kWh/m^2/yr$)	27	27	N/A	N/A	N/A	N/A	N/A	N/A

*Lab building targets will be calculated based on the breakdown of space usage areas.

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, refer to the following resources in order of decreasing reliability:

1. Building occupant, as they will likely know how the building will be operated
2. Standard ASHRAE schedules in ASHRAE 90.1-2013 User's Manual Appendix G
3. 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, & Fume Hood Schedules

Table A.1.1 – Lighting & Receptacle Schedules

	Occupied / Unoccupied			Lighting			Receptacle			Fume Hoods (% of max flow) Low FH density			Fume Hoods (% of max flow) High FH density		
Hour	**Wk**	**Sat**	**Sun**	**Wk**	**Sat**	**Sun**	**Wk**	**Sat**	**Sun**	**Wk**	**Sat**	**Sun**	**Wk**	**Sat**	**Sun**
1	unocc	unocc	unocc	20%	20%	20%	20%	20%	20%	42%	42%	42%	40%	40%	40%
2	unocc	unocc	unocc	20%	20%	20%	20%	20%	20%	42%	42%	42%	40%	40%	40%
3	unocc	unocc	unocc	20%	20%	20%	20%	20%	20%	42%	42%	42%	40%	40%	40%
4	unocc	unocc	unocc	20%	20%	20%	20%	20%	20%	42%	42%	42%	40%	40%	40%
5	unocc	unocc	unocc	20%	20%	20%	20%	20%	20%	42%	42%	42%	40%	40%	40%
6	unocc	unocc	unocc	20%	20%	20%	20%	20%	20%	42%	42%	42%	40%	40%	40%
7	unocc	unocc	unocc	30%	20%	20%	20%	30%	30%	42%	42%	42%	40%	40%	40%
8	occ	occ	occ	50%	20%	20%	30%	30%	30%	57%	57%	57%	55%	55%	55%
9	occ	occ	occ	90%	40%	40%	40%	40%	40%	57%	57%	57%	55%	55%	55%
10	occ	occ	occ	90%	40%	40%	50%	40%	40%	57%	57%	57%	55%	55%	55%
11	occ	occ	occ	90%	40%	40%	50%	40%	40%	57%	57%	57%	55%	55%	55%
12	occ	occ	occ	90%	40%	40%	50%	40%	40%	57%	57%	57%	55%	55%	55%
13	occ	occ	occ	80%	20%	20%	40%	30%	30%	57%	57%	57%	55%	55%	55%
14	occ	occ	occ	90%	20%	20%	50%	30%	30%	57%	57%	57%	55%	55%	55%
15	occ	occ	occ	90%	20%	20%	50%	30%	30%	57%	57%	57%	55%	55%	55%
16	occ	occ	occ	90%	20%	20%	50%	30%	30%	57%	57%	57%	55%	55%	55%
17	occ	occ	occ	90%	20%	20%	50%	30%	30%	57%	57%	57%	55%	55%	55%
18	occ	occ	occ	90%	20%	20%	40%	20%	20%	57%	57%	57%	55%	55%	55%
19	occ	occ	occ	50%	20%	20%	30%	20%	20%	57%	57%	57%	55%	55%	55%
20	occ	unocc	unocc	50%	20%	20%	30%	20%	20%	57%	42%	42%	55%	55%	55%
21	occ	unocc	unocc	30%	20%	20%	20%	20%	20%	57%	42%	42%	55%	55%	55%
22	occ	unocc	unocc	30%	20%	20%	20%	20%	20%	57%	42%	42%	55%	55%	55%
23	unocc	unocc	unocc	20%	20%	20%	20%	20%	20%	42%	42%	42%	40%	40%	40%
24	unocc	unocc	unocc	20%	20%	20%	20%	20%	20%	42%	42%	42%	40%	40%	40%
EFLH				**3942 hrs/yr**			**2691 hrs/yr**			**4444 hrs/yr**			**4325 hrs/yr**		

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 (there is 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.2.1 – Service Hot Water Schedules

Hour	SHW		
	Wk	**Sat**	**Sun**
1	80%	50%	50%
2	50%	50%	40%
3	40%	40%	30%
4	30%	30%	30%
5	20%	20%	20%
6	20%	10%	20%
7	20%	20%	10%
8	50%	20%	10%
9	100%	40%	30%
10	80%	50%	50%
11	60%	60%	60%
12	50%	80%	70%
13	40%	80%	70%
14	30%	70%	60%
15	30%	50%	60%
16	30%	40%	40%
17	30%	50%	40%
18	40%	50%	50%
19	40%	40%	40%
20	40%	40%	50%
21	50%	40%	50%
22	60%	40%	60%
23	80%	50%	70%
24	80%	50%	70%
EFLH	**4119 hrs/yr**		

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.**

Appendix B – Utility Rates

B.1. Monthly DES Utility Rates

The following monthly utility rates apply to **core** buildings only.

The following monthly carbon intensity applies to all buildings connected to the ADES.

Table B.1 – Average monthly utility costs and emission factors

Utility	Average Cost ($/MWh)	Average Emission Factor (kgCO2e/MWh)*	Notes
Electricity	$69.64	10.67	Blended UBC rate, incl. carbon
DES blended	$29.81	60.0	Delivered Thermal Energy to Building including all upstream losses and effects.
DES monthly**			
January	$30.76	87	
February	$28.82	67	
March	$28.99	68	
April	$25.65	35	
May	$22.72	12.9	
June	$21.00	11.8	
July	$18.17	9.7	
August	$18.04	8.7	
September	$24.87	47	
October	$27.91	63	
November	$29.13	73	
December	$31.49	93	

* Note: DES emission factors vary year-to-year based on weather and actual operation of the DES. Values in this table are to be used for all compliance modeling, as these were the values used in establishing the GHGI targets. If needed, current actual emission factors can be obtained from UBC Energy & Water Services.
** Monthly DES emission factors shall be used when showing compliance to UBC GHGI targets.

B.2. Ancillaries Rates

The following utility rates apply to ancillary (athletics and student housing) buildings only.

Table B.2 – utility rates for ancillaries projects

Energy Source	Rate	Unit
DES	$90.00	/MWh
Electricity	$87.81	/MWh
Natural Gas	$14.06	/MWh

B.3. Carbon Intensity of Energy Sources

Table B.3 – carbon intensity of energy sources

Energy Source	Carbon Intensity	Unit
Electricity	10.67*	kgCO2e/MWh
Natural Gas	49.87	kgCO2e/GJ
Biomass	2.24	kgCO2e/GJ
RNG	0.29	kgCO2e/GJ
Diesel	70.62	kgCO2e/GJ

* Note: The BC Hydro grid emission factor fluctuates annually based on net imports/exports of electricity to/from neighboring grids. This value (10.67) is to be used for all compliance modeling, as this was the value used to establish GHGI targets for buildings.

B.4. Carbon Costs

Table B.4 – current and anticipated price of carbon

Year	Price of Carbon ($/tCO2e)	Carbon Offsets ($/tCO2e)	TOTAL Price of Carbon ($/tCO2e)
2022	$50	$25	**$75**
2023	$65	$25	**$90**
2024	$80	$25	**$105**
2025	$95	$25	**$120**
2026	$110	$25	**$135**
2027	$125	$25	**$150**
2028	$140	$25	**$165**
2029	$155	$25	**$180**
2030	$170	$25	**$195**
2030+	$170	$25	**$195**

Note that these carbon costs are included in the utility rates listed in section B.2.

If modeling years past 2030, contact UBC Energy & Water Services for future pricing methodology.