

University Of Waterloo New
Student Residence
Waterloo, Ontario

Energy Strategy Report for
Zoning Bylaw Amendment

Prepared By:

Report Version 1.0

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LIMITING CONDITIONS

This report has been prepared for DSAI to explore opportunities to explore energy consumption and green house gas reduction opportunities as part of the Zoning Bylaw Amendment process. The analysis and the results presented show modelled performance metrics for several proposed building designs in comparison to the performance limits set out in the University of Waterloo Standard. The calculations are only applicable for determining relative system performance and compliance with program requirements and are not predictions of actual energy use or energy costs of the proposed design post construction.

Actual performance will differ from these calculations due to variations such as occupancy, building operation and maintenance, weather, energy uses not covered by energy standard, changes in energy rates between design of the building and occupancy, and precision of the calculation tool.

Executive Summary

Pratus Group has been contracted by DSAI to conduct the energy analysis for the proposed residential development located at 155 University Avenue in Waterloo, Ontario. The purpose of this analysis is to assess the building's energy performance as compared to a building designed to meet the minimum requirements of the University of Waterloo's Net Neutral Guideline. Additionally, as part of the Zoning Bylaw Amendment process, this analysis is meant to :

- o Explored opportunities to reduce energy consumption and greenhouse gas emissions in new construction;
- o Take advantage of existing or proposed energy infrastructure, energy capture and/or solar orientation; and/or,
- o Optimize the installation of future energy systems or infrastructure.

The project achieves the following metrics with the eight mechanical options analyzed:

Option	TEUI	GHGI	Scope 1	Scope 2	TEDI	CEDI	kW of PV Required
University of Waterloo Target	70	5	N/A	N/A	25	15	N/A
Traditional 4-Pipe Fan Coil	119	13	88%	12%	30	19	632
Central Air Source Heat Pump	106	9	79%	21%	30	19	465
Central Air Source Heat Pump 2-Pipe	105	9	79%	21%	30	16	448
Ground Source Heat Pump	97	8	76%	24%	30	19	347
Ground Source Heat Pump 2-Pipe	96	8	76%	24%	30	16	328
ASHP for DHW	101	8	77%	23%	30	19	392
ASHP for All	88	4	42%	58%	30	19	226
Traditional with Central ERV	120	12	85%	15%	24	19	646

1 PROJECT BACKGROUND

The proposed project located at 155 University Avenue in Waterloo, Ontario is a new mixed use student residence development in Waterloo, Ontario. The development consists of a twelve (12) storey building consisting of dormitories, common areas, amenities and ground floor classroom facilities. The total modeled floor area is 152,313 ft².

The building is heated and cooled via a 4-pipe fan coil system with a central heating and cooling plant. Three options for heating and cooling plants are analyzed as part of this study. The suites are provided with Energy Recovery Ventilators (ERVs). Common areas are ventilated with a Heat Recovery Unit with variable ventilation. Corridor pressurization is provided with a gas-fired and DX unit. The domestic hot water (DHW) heating is provided by separate water heaters and storage tanks.

The following emissions factors are used for the analysis:

- Scope 1 (on-site combustion) emissions factor: 176 kg/kWh
- Scope 2 (grid electricity) emissions factor: 29 kg/kWh

2 ENERGY MODELLING METHODOLOGY

The energy model at the permit level stage was developed based on the following information:

Permit level architectural, mechanical, and electrical drawings and specifications. The project was simulated using IES-VE 2022 building performance simulation software. IESVE is a sophisticated building energy simulation software allowing simulation of complex building systems including solar shading, daylighting, natural ventilation, and highly customizable HVAC systems.

For reference, a 3D rendering of the building in the software is shown in the figure below.

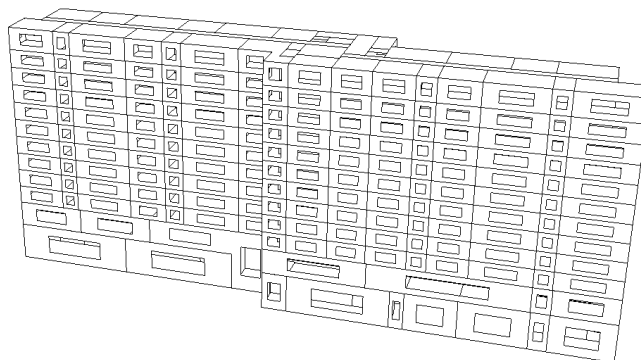


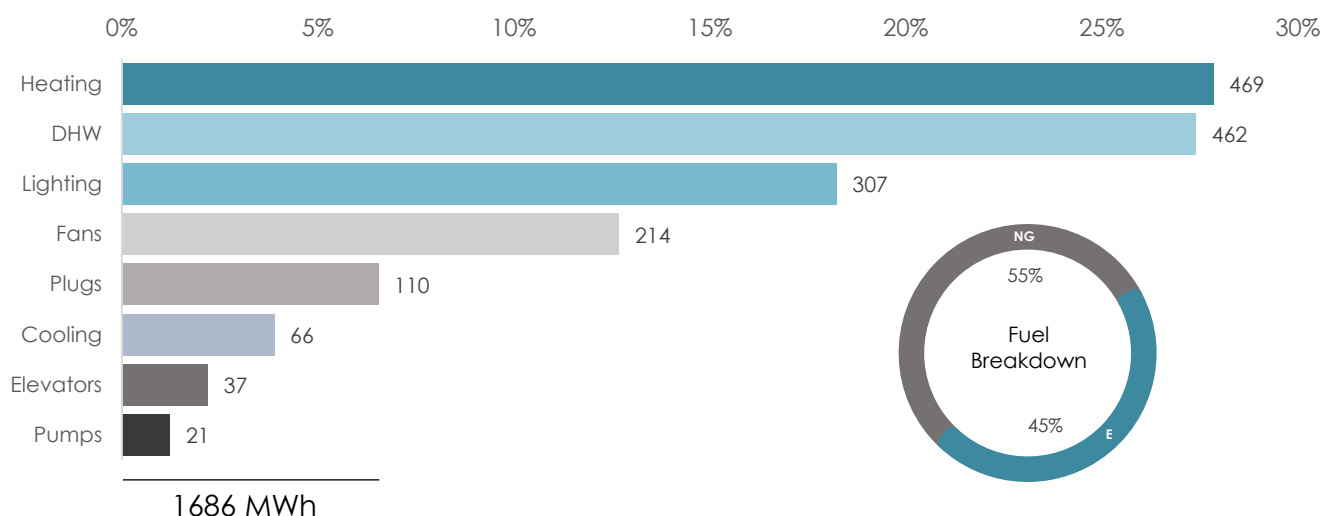
Figure 1: 3D Rendering Images of Energy Model

3 SUMMARY OF KEY INPUT PARAMETERS

The Appendix A provides the building characteristics for proposed and reference building.

4 ENERGY MODELING RESULTS – Traditional 4-Pipe Fan Coil

The energy consumption of the building with a traditional 4-Pipe Fan Coil HVAC system is summarized below.



In addition to the reference and proposed energy models, two other mechanical plan options were analyzed. The measures are summarized in Table 1.

Option	TEUI	GHGI	TEDI	CEDI
University of Waterloo Target	70	5	25	15
Traditional 4-Pipe Fan Coil: Gas-fired boilers and air-cooled chiller	119	13	30	19
Central Air Source Heat Pump: Central Air-Source Heat Pumps working down to 14 F. COP of 2.7 F at 47 F and COP of 1.7 at 14 F. Corridor MUA in this scenario includes hydronic coils.	106	9	30	19
Central Air Source Heat Pump 2-Pipe: Same as above but operating in cooling between June 1 st and September 15 th ; heating mode otherwise.	105	9	30	16
Ground Source Heat Pump: Central water-to-water heat pumps connected to ground source heat exchangers delivering hot and cold water through the building. Average COP of 3.0. Corridor MUA in this scenario includes hydronic coils.	97	8	30	19

Ground Source Heat Pump 2-Pipe: Same as above but operating in cooling between June 1 st and September 15 th ; heating mode otherwise.	96	8	30	16
DHW Air Source Heat Pump: Air-Source Heat Pumps working down to 14 F. COP of 2.7 F at 47 F and COP of 1.7 at 14 F for DHW, gas supplementary heating. Traditional 4-Pipe Fan Coil System for heating/cooling.	101	8	30	19
Central Air Source Heat Pump for DHW and HVAC: Central Air-Source Heat Pumps working down to 14 F. COP of 2.7 F at 47 F and COP of 1.7 at 14 F. ASHP supplies DHW with gas supplementary heating. Corridor MUA in this scenario includes hydronic coils.	88	4	30	19
Traditional 4-Pipe Fan Coil with Central ERV: Gas-fired boilers and air-cooled chiller, ventilation provided by central ERV with 14,000 cfm to all residence rooms.	120	12	24	19

Table 1: Summary of Options

The proposed options are achieving high levels of energy efficiency. However, they are not currently meeting the University of Waterloo's targets. To meet the targets, the following changes can be considered:

- Reduce corridor fresh air flow.
- Reduce kitchen exhaust, provide recirculating units or include heat pipe heat recovery if appropriate.

5 CONCLUSION

The current design of the University of Waterloo New Residence achieves high levels of energy performance. The project achieves the below metrics with the three mechanical options analyzed. There is an opportunity to improve the performance of the building and achieve the University of Waterloo Net Neutrality targets with further energy improvements.

The additional photovoltaic generation to meet the University of Waterloo TEUI target is also shown in right column of the summary table. Scope 1 emissions are direct greenhouse (GHG) emissions that occur from sources that are controlled or owned by the building (e.g., emissions associated with fuel combustion in boilers, furnaces, etc.). Scope 2 emissions are indirect GHG emissions associated with the purchase of electricity, steam, heat, or cooling.

Option	TEUI	GHGI	Scope 1	Scope 2	TEDI	CEDI	kW of PV Required
University of Waterloo Target	70	5	N/A	N/A	25	15	N/A
Traditional 4-Pipe Fan Coil	119	13	88%	12%	30	19	632
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We trust the foregoing provides the information required at this time.

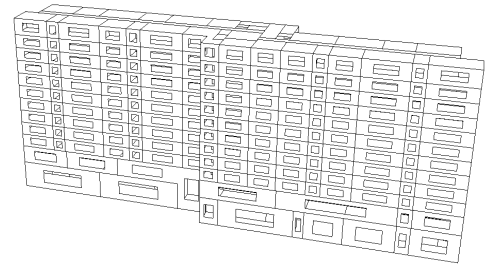
Appendix A

Summary of Inputs

SUMMARY OF KEY INPUT PARAMETERS

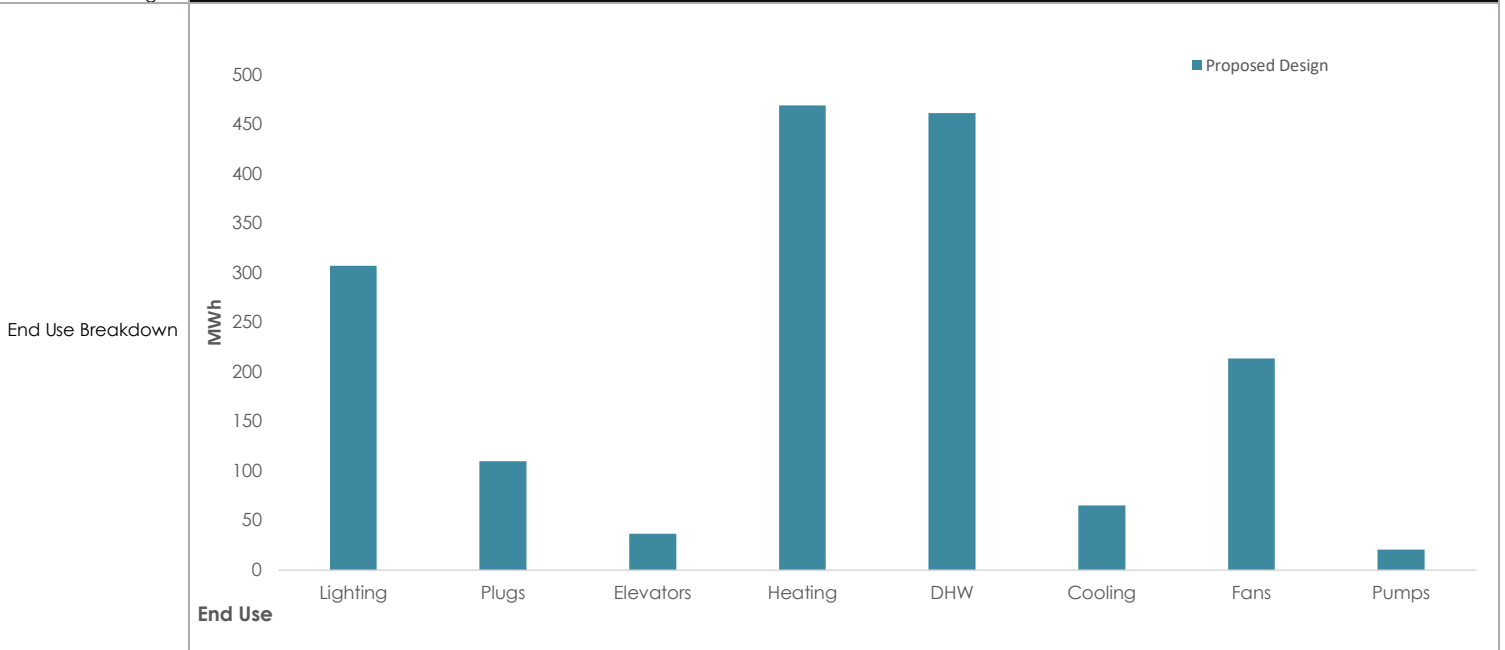
General

Building Name & Address	University of Waterloo Student Residence	
Location	Waterloo, Ontario	
Reference Building	NECB 2017	
Simulation Weather File	CAN_ON_ELORA-RCS_6142286_CWEC.epw	
Climate Zone	Zone 6	
Modeling Software	IESVE 2022 v3.0.0	
Building Area	Modelled Area	14,150 m ²
Number of Stories Above Ground	12-storey above ground, 2 amenity floors and 10 floors of residential	
Building Type	Student Residence	
Schedules	Dormitory	24/7 operation (As per NECB 2017 Operating Schedule G)



Overall Building Performance

	NECB 2017 Reference	Proposed Design
Energy Use (ekWh)	1502489 kWh	1685930 kWh
Energy Savings		-12.2%
Carbon Emissions	149034 kg of CO ₂ e	206158 kg of CO ₂ e
Emission Savings		-38.3%



Envelope Performance							
Opaque Envelope							
Wall Type	NECB 2017 Reference			Proposed Design			
	Description		R-IP	Description		R-IP	
Main Roof	NECB 2017 Table 3.2.2.2 (Zone 7): Roofs Maximum U Value: 0.024		R-41.1	Main Roof - Effective R-40.		R-40	
Walls Above grade	NECB 2017 Table 3.2.2.2 (Zone 7): Walls Maximum U Value: 0.037		R-27	•Metal or Brick finish •R15 interior + R35 exterior split insulated wall with thermally broken cladding attachment • Improved details around window to wall transitions, slab edge, corners • Thermally broken parapets • Continuity of insulation from wall to insulated footings		R-43.4 (overall effective accounting for all major sources of thermal bridging)	
Floor - Slab on Grade	Floor Slab on Grade NECB 2017 Table 3.2.3.1 (Zone 7): R7.5 for 1.2 m horizontally with slab edge wrapped F-Factor = 0.510		F-0.510	R7.5 for 1.2 m horizontally with slab edge wrapped. F-Factor = 0.510		F-0.510	
Fenestration							
Aluminium framed Windows	NECB 2017 Table 3.2.2.3(Zone 7): All Fenestration		U-IP	0.335	Double Low-E or triple glazed windows with U-0.28 performance; conventional products, readily available in the market	U-IP	0.280
			SHGC	0.32		SHGC	0.32
Percentage Glazing	25.0%			25.0%			
Infiltration	1.0 lps/m2 @75 Pa of total above grade envelope surface area (roofs, exterior walls, and windows, exposed floors), as per University of Waterloo Net Neutral Guideline						

Mechanical Systems						
System Description	NECB 2017 Reference			Proposed Design		
	System 3 - Packaged Unitary Rooftop Heat Pump	Serving	Offices/Conference	4-Pipe Fan Coil with ERVs	Serving	Suites
		Description	Packaged unitary rooftop heat pump with DX cooling, constant volume fans and electric backup heat below 10 degC.		Description	4-Pipe Fan coil system with Energy Recovery Ventilator
		Efficiency	Heating COP = 3.30 Cooling COP = 3.22 ERV Effectiveness: 50%		Efficiency	Heating COP: N/A hydronic Cooling COP: N/A hydronic ERV Effectiveness: 80%/65%
		Fan Power	As per NECB 2017		Fan Power	FC Fan Power: 0.3 W/cfm ERV Fan Power: 40 W/ERV
System Description	System 3 - Packaged Unitary Rooftop Heat Pump	Serving	Commons Areas, Lab	4-Pipe Fan Coil with ERV	Serving	Common Areas
		Description	Packaged unitary rooftop heat pump with DX cooling, constant volume fans and electric backup heat below 10 degC.		Description	4-Pipe Fan coil system with Central Energy Recovery Ventilator. ERV is variable speed based on CO2 control. 5,000 cfm total outdoor air.
		Efficiency	Heating COP: 3.30 Cooling COP: 3.22 ERV Effectiveness: 50%		Efficiency	Heating COP: N/A hydronic Cooling COP: N/A hydronic ERV Effectiveness: 80%/65%
		Fan Power	As per NECB 2017		Fan Power	FC Fan Power: 0.3 W/cfm ERV Fan Power: 0.7 W/cfm
System Description	System 4 - Single-Zone Make-up Air Unit with Baseboard Heating	Serving	Industrial/ Warehouse	Gas and DX MUA	Serving	Corridors
		Description	Single zone gas-fired make-up air unit and hydronic baseboard heaters.		Description	2,000 cfm gas fired heat and DX cooling providing fresh air to corridors.
		Efficiency	Thermal efficiency = 80% ERV Effectiveness: 50%		Efficiency	Thermal efficiency = 80% ERV Effectiveness: 65%
		Fan Power	As per NECB 2017		Fan Power	0.7 W/cfm
	Electric Baseboard Heaters	Serving	Vestibules	Kitchens	Serving	Kitchens
		Description	Electric baseboard heater.		Description	Exhaust provided at 0.30 cfm/ft2, assumed operation for 4 hours/day. Make-up air heated with gas furnace.
		Efficiency	N/A		Efficiency	N/A
		Fan Power	As per NECB 2017		Fan Power	0.3 W/cfm

Indoor Design Temperature	Space Type	Heating (deg. F)		Cooling (deg. F)	
		Occupied	Unoccupied	Occupied	Unoccupied
	Suites	72	64.4	75	75
	Common Areas	71.6	64.4	75	75
		71.6	64.4	75.2	75.2
	Mechanical Room	64.4	64.4	NA	NA
	Corridor/Vestibule	64.4	64.4	NA	NA
	Warehouse	64.4	64.4	NA	NA
Heating/Cooling Supply Air Temperature	Heating	90°F			
	Cooling	55°F			

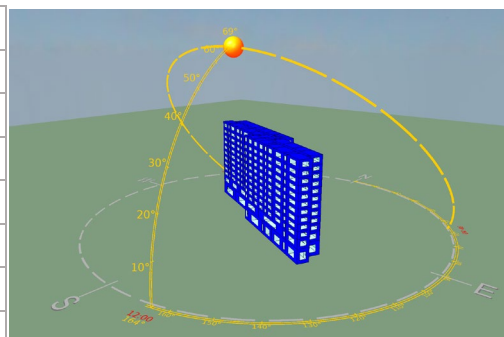


Figure 2: 3D Rendering with Solar Arc

Central Plant					
NECB 2017 Reference			Proposed Design		
Heating Plant	Description	Two modulating boilers serving hot water loops throughout the building.	Description	3x 1150 MBH high efficiency condensing boilers serving hot water loops throughout the building.	
	Efficiency	90% efficient (from 6.8.1-2017 SB-10) with 180 F supply and 130 F return temperatures for the loop. Pumping power matching proposed. Primary pumping loop configuration.	Efficiency	96% efficiency at rated condition, with 145 F supply and 130 F return temperatures for the loop. 19 W/gpm. Primary/secondary pumping loop configuration with VSD pumping.	
Cooling Plant	Description	One air-cooled chiller serving chilled water throughout the building.	Description	One air-cooled chiller with VSD operation serving chilled water throughout the building.	
	Efficiency	EER = 9.7 as per ASHRAE 90.1-2013 with 44 F supply and 55 F return temperatures for the loop. Pumping power matching proposed. Primary pumping loop configuration.	Efficiency	COP of 3.0 with 44 F supply and 56 F return temperatures for the loop. Pumping as per drawings with VSD. Primary pumping loop configuration.	
Domestic Hot Water	DHW Heater	Gas-fired DHW Heaters; Thermal efficiency = 93%	DHW Heater	Gas-fired DHW Heaters; Thermal efficiency = 96%	
	Fixture Type	As per NECB 2017	Fixture Type	Low flow fixtures as per below	
	Lavatory Faucet	1.9 LPM	Lavatory Faucet	1.9 LPM	
	Showerhead	7.6 LPM	Showerhead	5.7 LPM	
	Kitchen Faucet	5.7 LPM	Kitchen Faucet	3.8LPM	

Internal Loads			
Lighting Power Density (LPD)	Space Type	NECB 2017 Reference LPD W/ft²	Proposed Design LPD W/ft²
	Conference/Meeting/Multipurpose	1.07	1.07
	Corridors	0.66	0.66
	Classroom/Training	0.96	0.96
	Storage	0.63	0.63
	Dorm Room	0.48	0.48
	Restrooms	0.85	0.85
	Dining Area	0.63	0.63
	Loading Area	0.58	0.58
	Lounge	0.62	0.62
Lighting Controls	Same as NECB 2017 4.2.2		
Lighting Schedule	Corresponding to space type as per NECB 2015		
Process and Receptacle Loads	All Space Types	As per NECB Space type internal load (Table A-8.4.3.2. (2)-B)	
		18.6 kW x 3 annually modulated (As per BC Hydro modelling guide)	
Occupancy	NECB Defaults for space type		