PRELIMINARY REFRIGERANT AND EMBODIED EMISSIONS REPORT

REZONING APPLICATION

1535, 1546, 1549, 1557 GRANT STREET MULTIFAMILY

VANCOUVER, BC

FOR STUART HOWARD ARCHITECTS

405 – 375 WEST 5TH AVENUE
VANCOUVER, BC V5Y 1J6

E3 ECO GROUP INC.

BUILDING BLOCKS OF SUSTAINABILITY

JULY 06, 2018

E3 Project Number - 02556

INTRODUCTION

This report presents the preliminary assumptions and results of the refrigerant and embodied emissions calculations conducted for the proposed multifamily development at 1535, 1546, 1549, 1557 Grant Street. Emissions calculations follow the requirements set out in the City of Vancouver Green Buildings Policy for Rezoning – Process and Requirements, amended April 28, 2017.

The currently proposed mechanical system for this project does not have heating or cooling equipment containing refrigerants of with total capacities summing greater than 35 kW. Therefore, the project is not required to report the life-cycle equivalent annual carbon dioxide emissions from refrigerants as per Section 6.1 of the policy. Refrigerant emissions were calculated for reference only, following the formula and supporting material provided in the Process and Requirements document section 6.1.

Embodied emissions of the building structure were calculated using a whole building Life Cycle Assessment (LCA) with the Athena Impact Estimator. The building geometry input was based on the architectural drawings dated May 23rd, 2018. Structural components have not yet been designed, and several assumptions have been made to describe the main assembly groups as they apply to this project. Envelope components have also been assumed based on descriptions of the principal assemblies and correlate with those applied in the ZEBP model.

The current Policy does not set an equivalent Greenhouse Gas (GHG) emissions limit or target, and as such the analysis can be interpreted as a starting point; an introduction to life cycle concepts and considerations as they apply to the construction of the building. The act of taking inventory and conducting an LCA is, in itself, a step towards net-zero carbon buildings in Vancouver. The LCA model will be updated with the design as it progresses and used to provide feedback to the design team as they make decisions with the primary objective to minimize the global warming potential of the structure, as well as monitor the impacts on other LCA measures. This process adds environmental metrics to the decision-making toolset available to the team, and provides a platform to discuss life cycle considerations such as materials sourcing, recycled materials and recyclability, product longevity, and effective use of materials.

This report has been prepared for Stuart Howard Architects Inc. and the results presented are specific to the specified LCA methodology and shall not be used for any purpose other than the Rezoning Application for the 1535, 1546, 1549, 1557 Grant Street multifamily project. Life cycle impacts reported are limited by the design information presently available and are subject to change as the design gains detail.

PROJECT DESCRIPTION

The Grant Street multifamily development consists of 6 storeys of residential space use with one level of below grade parking. The building provides two-storey townhomes on the first two levels, 1 bedroom, 2 bedroom and 3 bedroom suites on the levels above, and both indoor and outdoor amenity space on the 5th floor. The residential floor area is more than 50% of the total floor area.

The preliminary building envelope incorporates modest Fenestration and Door area to Wall area Ratios (FDWR) resulting in 30.6% overall. The structure assumes concrete construction below grade, and wood construction at the floors and the roofs. High performance envelope components are required to meet energy performance limits, and the current model includes triple-glazed vinyl windows, wood frame walls, thick insulation at roofs, and high efficiency details to minimize thermal bridging.

The proposed mechanical system for space heating is electric resistance baseboards with no mechanical cooling. The amenity and corridor supply air volume flow are cooled with Direct Expansion cooling. The gross capacity of refrigerant based equipment derived from the ZEBP energy simulation results is less than 35 kW, and therefore refrigerant emissions calculations are not required for this project, however they have been calculated for reference.

The calculations were conducted to satisfy the requirements Section 6 the City of Vancouver, Green Building Policy for Rezonings, amended February 2017.

The LCA will be used to help the design team identify which assembly groups present the greatest contribution to the Global Warming Potential (GWP) of the building, and work towards reducing the embodied emissions. The following components will be explored during the design with the objective of reducing embodied emissions:

- Exterior cladding types
- Insulation materials in the floors, walls, and roof
- Fenestration, frame materials, and gas layer
- Roofing materials

Metrics other than the GWP will also be monitored when comparing design decisions, to review how the reduction in GWP impacts environmental risks in other categories.

SUMMARY OF KEY INPUTS AND ASSUMPTIONS

The inputs and results presented in this report are based on rudimentary design information available at this early stage of design. The LCA has been conducted on the entire structure. The modelled floor area for intensity results processing was input identical to the building energy model calculations for consistency, and is 2,982 m^2 excluding only the parking garage floor area.

Refrigerant Emissions

The refrigerant emissions were calculated with the following assumptions:

Global Warming Potential of Refrigerant
= HFC-410a, 1,890 $kgCO2_e$ per kg of refrigerant
Reference: Table B.1.6.1a

Refrigerant Charge
= Window air conditioner, heat pump, 10 year lifespan, 1.76 lbs per ton of capacity
Reference: LEED 2009 Credit 4 Table 2

Greatest of gross heating or cooling capacity
= 4.5 kW (1.3 tons), peak cooling demand at DX Coils plus NECB 2011 oversizing factor 10%
Reference: Rezoning Stage ZEBP energy model results

Embodied Emissions

The building geometry was derived from the drawing package dated May 23rd, 2018. The following list describes the assumptions applied in each assembly group, as they are designated by Athena Impact Estimator.

All concrete mixes and live loads have been assigned as per the default settings of Athena, and will be updated when design specific information becomes available.

The building information was input with a 60 year building lifespan and building height of 22.1 meters, as defined for Athena from the bottom of the lowest level of parking to the top of the building.

Foundations

Strip footings were assumed at the base of the perimeter walls, the base of the elevator shaft, and the base of the stairwells. The parking level slab on grade was input at 200 mm thickness. Column footings were also included with 7.6 m spacing across the floor surface area of the ground contact floor.

Beams and Columns

Beams and columns were input as LVL/PSL wood construction with the default dimensions assigned by Athena for 4.8 kPa live loads, 6.5 m average column spacing on an area basis as well as columns at perimeter walls at 6.5 m spacing.

Floors

Above grade floors were input as wood joist construction with no floor finishes (as per the City of Vancouver Process and Requirements document section 6.2.1.) The parking structure was input using the Athena component for parking structures, adjusted for the proposed parking floor area. The parking structure input accounts for 125 mm of mineral wool insulation at the parking ceiling. Exposed floors below residential spaces account for 220mm of mineral wool insulation.

Roofs

Roofs over fully conditioned spaces were input as wood joist construction with 250mm of XPS insulation, and a modified bitumen membrane roofing system. Where roofs are accessible the assembly also includes concrete tiles. The roof assembly at the parking garage was modelled with 125mm mineral wool insulation in spaces that would be semi-heated, such as the storage rooms below grade, or where conditioned space exists above.

Exterior Walls

The residential exterior wall assembly consists of a wood stud wall, 400mm o/c, with 140mm fibreglass batt insulation plus 25mm mineral wool continuous insulation, fiber cement siding, 13mm gypsum board, latex water based paint, and a 3mm polyethylene vapour barrier.

Fenestration is assigned at the walls assembly group in Athena, and the current model assumes triple pane glass, hard coated, with argon fill and vinyl clad wood frames.

Below grade walls were input as 200mm cast in place concrete with no insulation.

Project Extra Materials

Currently no extra materials have been applied in the model, but this category can be used to complement the assembly descriptions and account for other materials that were not captured in the other assembly groups, and may be used as the design develops.

Summary of Results

The refrigerant emissions calculations and reporting are not a requirement for this project because the currently proposed mechanical system uses refrigerant based equipment with a total capacity less than 35 kW. The calculations were conducted, following the City of Vancouver Process and Requirements document Section 6.1, for reference only. The results show:

Preliminary Refrigerant Emissions = 0.019 $kgCO2_e/m^2$

The global warming potential metrics of the proposed structure calculated with Athena Impact Estimator, as required by the City of Vancouver Policy for Rezonings, are:

Total life cycle embodied emissions (A to C) = 551,856 $kgCO2_e$

Total embodied emissions intensity = 185 $kgCO2_e/m^2$

Equivalent annual embodied emissions intensity = 3 $kgCO2_e/m^2$ per year

The Athena report for other LCA measures by life cycle stage are provided in Appendix A, and the resulting bill of materials is included in Appendix B.

The global warming potential by assembly group is presented in the following Figure 1.

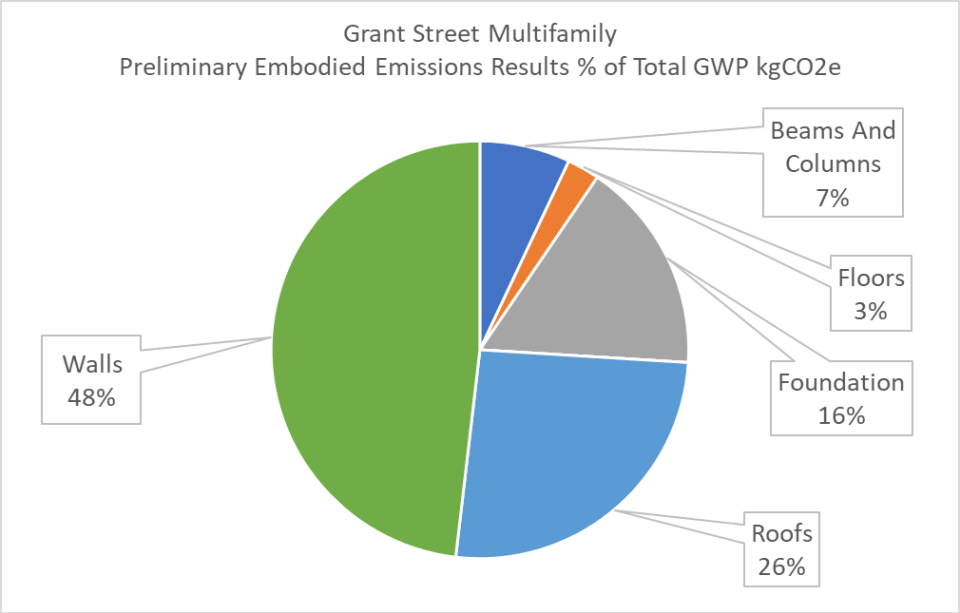

Figure 1 Global Warming Potential by Assembly Group

The results show that the walls and windows have the greatest embodied emissions of the building model, followed by the roofs, foundations, beams and columns, and finally the floors.

The assemblies with the greatest impact present the greatest opportunity to reduce embodied emissions. As the design develops, the LCA model will be used to compare design options and provide the design team with feedback regarding the environmental impact of various construction materials, with the overall goal of reducing embodied emissions, while monitoring other environmental measures as well.

Though not required by the City of Vancouver Policy, it is interesting to compare the LCA results with the energy model results for the GHGI, also in $kgCO2_e/m^2$ per year. The preliminary energy model results show a GHGI of 1.0 $kgCO2_e/m^2$ per year. The results indicate that the annual embodied emissions of the building structure are roughly three times the annual operating energy use emissions, over the 60 year LCA lifespan.

Closure

The LCA results presented in this report are based on rudimentary design information and the model includes many assumptions. As the design gains detail, the model inputs will be adjusted and used to

provide feedback to the design team with respect to the environmental impact of various architectural and structural design decisions.

We trust the enclosed provides helpful information for the design team and for the rezoning application submission. If any additional information is required, please do not hesitate to contact E3 Eco Group.

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Appendix A: Athena Results by Life Cycle Stage

		PRODUCT (A1 to A3)			CONSTRUCTION PROCESS (A4 & A5)			USE (B2, B4 & B6)				END OF LIFE (C1 to C4)			BEYOND BUILDING LIFE (D)			TOTAL EFFECTS	
LCA Measures	**Unit**	Manufacturing	Transport	**Total**	Construction-Installation Process	Transport	**Total**	Replacement Manufacturing	Replacement Transport	Operational Energy Use Total	**Total**	De-construction, Demolition, Disposal & Waste Processing	Transport	**Total**	BBL Material	BBL Transport	**Total**	**A to C**	**A to D**
Global Warming Potential	kg CO2 eq	4.11E+05	3.08E+03	**4.14E+05**	3.36E+04	1.97E+04	**5.33E+04**	5.21E+04	2.30E+03	0.00E+00	**5.44E+04**	2.19E+04	8.49E+03	**3.04E+04**	-1.52E+05	0.00E+00	**-1.52E+05**	**5.52E+05**	**3.99E+05**
Acidification Potential	kg SO2 eq	2.17E+03	3.21E+01	**2.20E+03**	2.38E+02	2.11E+02	**4.49E+02**	4.20E+02	2.37E+01	0.00E+00	**4.44E+02**	3.05E+02	8.17E+01	**3.87E+02**	3.72E+01	0.00E+00	**3.72E+01**	**3.48E+03**	**3.52E+03**
HH Particulate	kg PM2.5 eq	4.46E+02	1.64E+00	**4.47E+02**	1.71E+01	1.03E+01	**2.74E+01**	9.73E+01	1.25E+00	0.00E+00	**9.86E+01**	1.05E+01	4.52E+00	**1.50E+01**	1.63E+01	0.00E+00	**1.63E+01**	**5.88E+02**	**6.05E+02**
Eutrophication Potential	kg N eq	1.89E+02	1.99E+00	**1.91E+02**	1.63E+01	1.31E+01	**2.94E+01**	1.40E+01	1.47E+00	0.00E+00	**1.55E+01**	1.90E+01	5.07E+00	**2.41E+01**	1.91E+00	0.00E+00	**1.91E+00**	**2.60E+02**	**2.62E+02**
Ozone Depletion Potential	kg CFC-11 eq	5.33E-03	1.12E-07	**5.33E-03**	2.37E-04	7.15E-07	**2.38E-04**	1.10E-03	8.50E-08	0.00E+00	**1.10E-03**	9.46E-07	2.96E-07	**1.24E-06**	0.00E+00	0.00E+00	**0.00E+00**	**6.67E-03**	**6.67E-03**

Smog Potential	kg O3 eq	3.11E+04	1.02E+03	**3.22E+04**	5.92E+03	6.74E+03	**1.27E+04**	3.06E+03	7.51E+02	0.00E+00	**3.81E+03**	1.01E+04	2.58E+03	**1.27E+04**	3.76E+02	0.00E+00	**3.76E+02**	**6.13E+04**	**6.17E+04**
Total Primary Energy	MJ	5.49E+06	4.48E+04	**5.54E+06**	4.31E+05	2.84E+05	**7.15E+05**	1.74E+06	3.35E+04	0.00E+00	**1.77E+06**	3.27E+05	1.24E+05	**4.51E+05**	7.44E+04	0.00E+00	**7.44E+04**	**8.48E+06**	**8.55E+06**
Non-Renewable Energy	MJ	4.51E+06	4.48E+04	**4.56E+06**	3.90E+05	2.84E+05	**6.74E+05**	1.51E+06	3.35E+04	0.00E+00	**1.55E+06**	3.23E+05	1.24E+05	**4.47E+05**	7.44E+04	0.00E+00	**7.44E+04**	**7.22E+06**	**7.30E+06**
Fossil Fuel Consumption	MJ	4.04E+06	4.47E+04	**4.08E+06**	3.78E+05	2.83E+05	**6.61E+05**	1.51E+06	3.34E+04	0.00E+00	**1.54E+06**	3.22E+05	1.24E+05	**4.46E+05**	1.49E+05	0.00E+00	**1.49E+05**	**6.74E+06**	**6.89E+06**

Appendix B: Athena Results Bill of Materials Report

Material	Unit	Total Quantity	Columns & Beams	Floors	Foundations	Roofs	Walls	Project Extra Materials	Mass Value	Mass Unit
#15 Organic Felt	m2	7,519.8492	0.0000	52.9303	0.0000	3,904.1393	3,562.7796	0.0000	5.4879	Tonnes
#30 Organic Felt	m2	1,143.2946	0.0000	0.0000	0.0000	1,143.2946	0.0000	0.0000	1.6454	Tonnes
1/2" Moisture Resistant Gypsum Board	m2	659.2300	0.0000	0.0000	0.0000	659.2300	0.0000	0.0000	5.9397	Tonnes
1/2" Glass Mat Gypsum Panel	m2	1,203.1800	0.0000	0.0000	0.0000	0.0000	1,203.1800	0.0000	11.9075	Tonnes
3 mil Polyethylene	m2	1,160.3030	0.0000	0.0000	0.0000	0.0000	1,160.3030	0.0000	0.0870	Tonnes
Blown Cellulose	m2 (25mm)	629.7432	0.0000	0.0000	0.0000	629.7432	0.0000	0.0000	0.4030	Tonnes
Concrete Benchmark 3000 psi	m3	904.4343	0.0000	0.0000	267.5662	187.4895	449.3786	0.0000	2,074.2024	Tonnes
Concrete Tile	m2	450.6840	0.0000	0.0000	0.0000	450.6840	0.0000	0.0000	35.1534	Tonnes
Extruded Polystyrene	m2 (25mm)	6,139.1522	0.0000	0.0000	0.0000	6,139.1522	0.0000	0.0000	7.5512	Tonnes
FG Batt R20	m2 (25mm)	6,224.0561	0.0000	0.0000	0.0000	0.0000	6,224.0561	0.0000	1.6764	Tonnes
Fiber Cement	m2	1,465.2660	0.0000	21.4500	0.0000	0.0000	1,443.8160	0.0000	20.5035	Tonnes
Galvanized Sheet	Tonnes	1.7673	0.0000	1.0537	0.0000	0.7136	0.0000	0.0000	1.7673	Tonnes
Laminated Veneer Lumber	m3	234.6870	234.6870	0.0000	0.0000	0.0000	0.0000	0.0000	127.8806	Tonnes
Modified Bitumen membrane	kg	15,132.1538	0.0000	0.0000	0.0000	15,132.1538	0.0000	0.0000	15.1322	Tonnes

MW Batt R11-15	m2 (25mm)	1,128.3769	0.0000	0.0000	0.0000	0.0000	1,128.3769	0.0000	1.4680	Tonnes
MW Batt R20	m2 (25mm)	3,398.3317	0.0000	0.0000	0.0000	3,398.3317	0.0000	0.0000	4.4903	Tonnes
MW Batt R30	m2 (25mm)	145.3060	0.0000	145.3060	0.0000	0.0000	0.0000	0.0000	0.1723	Tonnes
Nails	Tonnes	1.4342	0.0000	0.4903	0.0000	0.5237	0.4202	0.0000	1.4342	Tonnes
Rebar, Rod, Light Sections	Tonnes	33.7855	0.0000	0.0000	1.6852	16.1461	15.9542	0.0000	33.7855	Tonnes
Roofing Asphalt	kg	13,305.2341	0.0000	0.0000	0.0000	13,305.2341	0.0000	0.0000	13.3052	Tonnes
Screws Nuts & Bolts	Tonnes	0.4985	0.0000	0.0000	0.0000	0.0000	0.4985	0.0000	0.4985	Tonnes
Small Dimension Softwood Lumber, kiln-dried	m3	54.1777	0.0000	20.0129	0.0000	7.7120	26.4528	0.0000	24.1275	Tonnes
Softwood Plywood	m2 (9mm)	8,327.9195	0.0000	5,637.0557	0.0000	1,163.3593	1,527.5045	0.0000	39.3410	Tonnes
Triple Glazed Hard Coated Argon	m2	830.0813	0.0000	0.0000	0.0000	0.0000	830.0813	0.0000	20.6908	Tonnes
Vinyl Clad Wood Window Frame	kg	11,168.1436	0.0000	0.0000	0.0000	0.0000	11,168.1436	0.0000	11.1681	Tonnes
Water Based Latex Paint	L	3,129.1144	0.0000	23.0724	0.0000	0.0000	3,106.0420	0.0000	2.3468	Tonnes
Welded Wire Mesh / Ladder Wire	Tonnes	0.5973	0.0000	0.0000	0.5973	0.0000	0.0000	0.0000	0.5973	Tonnes