MEMORANDUM

MORRISON HERSHFIELD

TO:	Patrick Enright, P.Eng.	ACTION BY:	N/A
FROM:	Christian Cianfrone, P.Eng.	FOR INFO OF:	City of Vancouver
PLEASE RESPOND BY:		PROJECT No.:	5160919
RE:	ZEN Target Testing	DATE:	September 7, 2016

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Morrison Hershfield has developed an energy model, reflective of a typical, high-rise Vancouver MURB, to test the energy use intensity (EUI), thermal energy demand intensity (TEDI), and greenhouse gas emission intensity (GHGI) targets that were developed as part of the City of Vancouver Zero Emission New (ZEN) Buildings Plan.

The parameters that were varied, in order to understand the sensitivity of certain design variables on the EUI, TEDI and GHGI targets, included:

- Wall to Floor Area Ratio (WFA from 0.4 to 1.0)
- Occupancy Density (from 150 to 400 ft^2 / person)
- Suite Ventilation Rates (from 40 to 100 cfm/suite)
- Corridor Ventilation Rates (from ASHRAE levels at 0.06 cfm/sq ft to 30cfm/suite door)
- Suite HRV effectiveness (from 60% to 90%)
- Window to wall ratio (WWR from 30% to 90%)
- Window U-Value (from 0.15 to 0.40 Btu/sq ft-F)
- Wall R-value (from 3 to 30)
- Inclusion of a fitness room, pool, or exterior fireplaces

The above parameters were assessed for their impact on EUI, TEDI, and GHGI. Detailed energy model inputs for the high-rise MURB can be found in Appendix A.

The data has been made available for assessment by the City of Vancouver, however, the following general observations were made, relative to a reference scenario that has meets the 2016 rezoning requirements at 0.60 WFA, 50% WWR, R-10, U-0.35, 40 cfm/suite, 60% HRVs, corridor ventilation at code rates and 275 sq ft/person occupancy density:

- Window to floor area (WFA) ratio can have a significant impact on the targets. For example, for the reference case noted above, WFA ranges between 0.4 and 1.0 show a range in TEDI between about 20 and 60 kWh/m^2/year, EUI between about 90 and 140 KWh/m^2/year and GHGI difference of about 1 kg/m^2. There would significant advantage to a simpler "box" geometry with large floor plate, which would reduce the WFA ratio down to 0.4, allowing a WWR of 60%, U-0.40 and R4 envelope. A WFA ratio above 0.6 would provide a disadvantage, though anything about 0.6 is rare and likely not to exceed 0.6 by very much.

- Occupant density has a significant impact both on ventilation rates and domestic hot water (DHW). More density means more suites, which increases overall ventilation in the building as the minimum ventilation rates are driven by occupancy rather than square footage. However, as noted in the point below, increase in ventilation can be managed through more efficient heat recovery ventilators. DHW load is driven by occupancy and forms a significant proportion of the EUI and almost all of the GHGI for this electrically heated building. Although the EUI could be overcome through a number of measures, GHGI could only be compensated by either a drastic reduction in load, more than is likely through low flow fixtures and/or drain water heat recovery, or a fuel switch. For example, an air source heat pump could preheat a portion of the DHW load to bring back down the GHGI. A potential administrative solution to this issue could be to reduce occupancy loads to 1 person for studio/micro suites instead of 2 people.

- Suite ventilation rates can have a large impact on TEDI and EUI, but can be compensated with higher heat recovery effectiveness. For example, if suite ventilation rates were increased to 100 cfm/suite from 40 cfm/suite in the reference case, a heat recovery effectiveness of 80% could compensate. While this may have some implications on the HRV size and space constraints in the suite, it is a readily available solution in the market. Another example of overcoming the increase in ventilation is to use triple glazing, which would also meet the 2016 rezoning requirement with 100 cfm/suite and 60% HRV effectiveness.

- Corridor ventilation rates vary widely in design, ranging from a relatively small code rate at 0.06 cfm/ft^2 of corridor area to as high as 30 cfm/suite to pressurize the corridors to limit odours between suites and overcome stack effect. Corridor MUA units also rarely include heat recovery. At the high end of 30 cfm/suite, a building would need to compensate to meet the required TEDI and EUI targets by increasing suite HRV effectiveness to 80%, have triple glazing, and improve its form factor by having a WFA ratio of 0.5 or lower. At 15 cfm/suite, the building could compensate by just having triple glazing or having 80% suite HRV effectiveness and a 40% WWR with double glazing. However, the only way to overcome the GHGI penalty caused by increasing the gas usage on the corridor make-up air unit for either the 15 or 30 cfm/suite ventilation options would be to fuel switch the make-up air unit to a heat pump unit or electric heating coil.

- The table below outlines the potential EUI, TEDI and GHGI impacts of fitness centres, pools and exterior fireplaces. Assumptions about the use and systems serving these areas is described in Appendix A. In general, fitness centres do not pose a major barrier to achieving the targets. Pools increase the TEDI by 1 kWh/m^2/year due to pool air handler heating load and the EUI by 3.4 kWh/m^2/year due to both pool air handler heating, dehumidification energy, and pool water heating. The increases in EUI and TEDI are both manageable with improvements to the envelope or ventilation systems, however, the increase in GHGI can only likely be overcome through additional DHW load reductions or corridor make-up air and/or DHW fuel switching. Exterior fireplaces have no impact on TEDI, but do impact EUI and GHGI emissions in a similar way as pools.

Scenario	**TEDI** (kWh/m^2)	**EUI** (kWh/m^2)	**GHG** (kgCO_2e/m^2)
2016 RZ Reference Case	32.6	98.5	5.7
+ Fitness Centre	33.1	99.4	5.8
+ Pool	33.6	101.9	6.3
+ Exterior Fireplaces	32.6	107.6	7.4

Appendix A

Table A-1: Model Input

Characteristic	High Rise MURB Archetype
Weather	Vancouver CWEC
Software	EnergyPlus v8.5
Building Area	28,560 m^2 (excluding parkade) 3,300 m^2 parkade
Operating Hours	NECB Schedule G occupancy, lighting and plug loads. Parkade and Corridor lights always on, Parking exhaust 4h/day, Suite exhaust 2h/day
Occupancy	100 m^2/person corridors Varied: 13.95 m^2/person (150 ft^2/person) suites, 667 suites 25.54 m^2/person (275 ft^2/person) suites, 364 suites 37.21 m^2/person (400 ft^2/person) suites, 250 suites Unit occupancy assumes 2 people per suite + 1 person per additional bedroom in each suite, 50% 1 bedroom suites, 25% each two and three bedroom suites.
Plug & Process Loads	1 W/m^2 corridor 5 W/m^2 suite 43.8 MWh annual Elevator Load (5 kW continuous load) Parking Exhaust Load, 4h/day, 0.5 W/cfm fans, 0.73 cfm/ft^2 (3.7 L/s/m^2), 12.9 kW total Suite Exhaust Load, 2h/day, 0.5 W/cfm fans, 150 cfm/suite (70.8 L/s/suite), 18.75 kW to 50.0 kW Varies with Occupancy Density
Optional Fitness Facility	100 m^2 (1,080 ft^2) area RTU with DX Cooling, Gas furnace 10 L/s/person plus 0.3 L/s/m^2 Outdoor Air NECB B Schedules for occupancy, ventilation **Total Energy End Uses:** 78 kWh Cooling Electricity 22,015 kWh Heating Gas 2,305 kWh Fan Electricity **Additional Building End Use Intensity:** 0.85 kWh/m^2 EUI 0.52 kWh/m^2 TEDI 0.14 $kgCO_2e/m^2$ GHG

Characteristic	High Rise MURB Archetype
Optional Pool	28°C, 60% RH setpoint, Dectron system DX Cooling, Gas Furnace, Condensing Water Boiler 150 ft^2 pool, no cover, 100 m^2 (1,080 ft^2) room area 2.4 L/s/m^2 Outdoor Air 1,600 W Latent Load NECB B Schedules for occupancy, ventilation **Total Energy End Uses:** 1,121 kWh Dehumidification Electricity 40,925 kWh Air Heating Gas 53,246 kWh Water Heating Gas 3,391 kWh Fan and Pump Electricity **Additional Building End Use Intensity:** 3.43 kWh/m^2 EUI 0.99 kWh/m^2 TEDI 0.61 $kgCO_2e/m^2$ GHG
Optional Exterior Gas Fireplaces	250 Suites 10 kW/suite, 2h/week **Total Energy End Uses:** 260,000 kWh Gas **Additional Building End Use Intensity:** 9.10 kWh/m^2 EUI 1.68 $kgCO_2e/m^2$ GHG
Outdoor Air	Varied: 40 to 100 cfm/suite Suite Ventilation 0.3L/s/m^2 or 15 to 30 cfm/suite Corridor Ventilation Also Varies with Occupancy Density
Wall R-Value	Varied, R-3 to R-30
Roof R-Value	R-30
Window U-Value	Varied: U-0.40 to U-0.15 SHGC 0.3
Window Area %	Varied: 30% to 70%
Wall to Floor Area Ratio	Varied: 0.4 to 1.0 Represents different floor plate sizes, shapes, and geometric complexity
Shading	Yes, Balconies
Interior Lighting	5 W/m^2 suite 7.1 W/m^2 corridor 2 W/m^2 parking
Exterior Lighting	5 kW allowance modeled
HVAC Systems	Suite Electric Baseboards and HRVs Corridor Gas-Fired MUA with DX Coils and Electric Baseboards
Supply and Ventilation Air	Constant ventilation air supplied directly to zones through HRVs and corridor MUA.

Characteristic	High Rise MURB Archetype
Heat Recovery	Suite HRV only Varied 60% to 90% effective
Fans	0.48 W/cfm for HRVs, MUA
Cooling	None
Heating	Electric Baseboards, 100% seasonal eff. Corridor Gas Coil, 80% nominal eff., 71% seasonal eff.
Pumps	72 ft head, DHW pumps
DHW	0.0013 L/s/person peak flow plus 20% savings for low flow fixtures 240 W/person total peak DHW demand Varies with Occupancy Density Condensing Gas Boiler, 95% seasonal eff.