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Trends Analysis based on the Winning Projects of NZERBC Challenge

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Disclaimer

This report was produced as part of the UBC Sustainability Scholars Program, a partnership between the University of British Columbia and various local governments and organizations in support of providing graduate students with opportunities to do applied research on projects that advance sustainability across the region.

This project was conducted under the mentorship of Zero Emissions Building Exchange (ZEBx) staff. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of ZEBx or the University of British Columbia.

Acknowledgment

"**Be the change you wish to see in the world**", believed Mahatma Gandhi, an Indian leader, who lived in simplicity and employed non-violence throughout his life. Every small change in our way of life can have a massive impact on fighting global warming. Sustainable development is not an option, but a viable solution to the adverse effects of climate change on the planet.

I would like to acknowledge that the UBC Point Grey campus is on the traditional, ancestral, unceded territory of the xʷməθkʷəyə̓ m (Musqueam) First Nation. I am grateful for the opportunity to participate in the Sustainability Scholars Program and be part of an innovative and supportive cohort of Sustainability Scholars.
Secondly, I would like to thank the Zero Emissions Building Exchange (ZEBx) for allowing me to work with them in developing a trends study based on the winning projects of the NZERBC challenge which broadened my understanding of Building Sciences. I am especially pleased to work with Roberto Pecora, Director of Programs at ZEBx, whose mentoring and guidance furthered my interest in sustainable development. I am humbled by the support and kindness of Ms. Janani Gunasegaran Surender, Research Coordinator at ZEBx, for her timely directions in the evolution of this research work.

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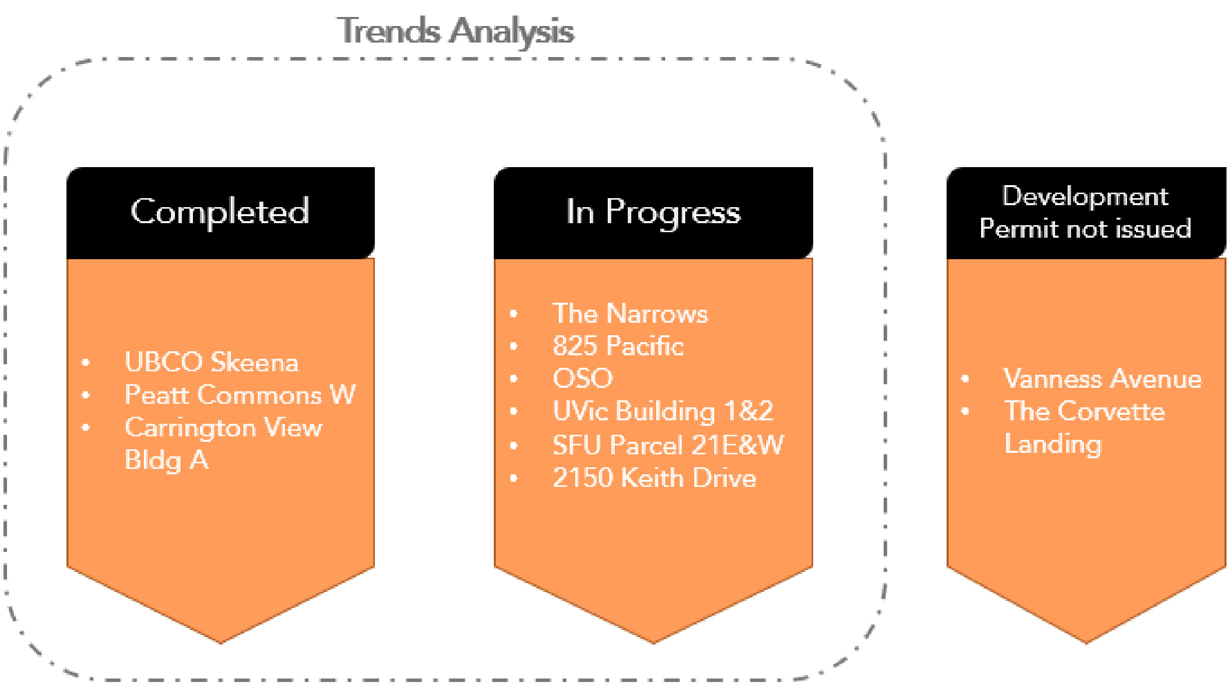
Introduction

The Government of Canada has committed to net zero emissions by 2050. British Columbia has set greenhouse gas (GHG) reduction targets, of reductions from 2007 levels of 40% by 2030, 60% by 2040, and 80% by 2050[1]. In order to meet these ambitious goals, the province initiated the CleanBC plan in 2018 with various strategies to meet the ambitious targets. As one of the paths to reduce emissions in the building sector, the Net-Zero Energy-Ready Challenge (NZERBC) was announced in late 2018 to make the new buildings more energy-efficient, less polluting, and more comfortable.

The NZER buildings are designed and built to be extremely efficient with minimal energy consumption and efficient energy technologies. Out of over 50 applications received, a juried competition resulted in the selection of 11 winning projects that represent the best examples of NZER buildings. These projects received up to $390,000 in incentives to help cover the estimated cost premiums associated with the design and construction of NZER buildings. ZEBx is developing case studies based on the 11 winning projects to showcase the best practices in the energy-saving improvements done in the buildings. This trend analysis report, prepared by the UBC sustainability scholar focuses on the trends in the architectural and mechanical features of the winning projects.

Winning Projects

Around 51 expressions were submitted to CleanBC for the challenge out of which 11 winning projects received construction NZER incentives. The winning projects and their progress is shown in the figure below:

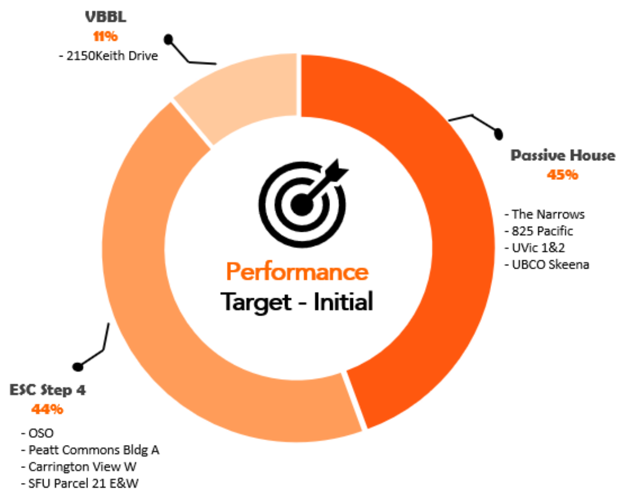


[1] Canada's Fourth Biennial Report on Climate Change – 2020
https://unfccc.int/sites/default/files/resource/br4_final_en.pdf

While 9 out of the 11 winning projects are either completed or in progress, the Vanness Avenue and the Corvette Landing projects are yet in their initial stages. As limited resources were available for these two projects, they are excluded from this trends analysis. The University of Victoria buildings 1 and 2 as well as SFU Parcel 21 E and W buildings have been considered as individual buildings in a few analysis categories as the energy calculations for these buildings were separated. In total, 9 out of 11 projects that could provide the building architectural and mechanical data are considered for the trends analysis.

Energy Performance Targets

Winning projects are targeting more stringent goals such as the Passive House standard, BC Energy step code Step 4, and Vancouver Building By-Law. While 5 projects each target Passive house and BC ESC Step 4, 2150 Keith Drive aims to achieve VBBL along with satisfying the demands of LEED Gold Certification. The various requirements of the energy targets can be seen below:



Passive House	
Heating Demand	Max. **15 KWh/m²a**
Cooling Demand	Max **10 KWh/m²a**
Total Primary Energy Demand(PE)	Max. **120 KWh/m²a**
Primary Energy Renewable (PER)	Max. **60 KWh/m²a**

BC Step Code 4	
Thermal Energy Demand Intensity (TEDI)	Max. **15 KWh/m²a**
Total Energy Use Intensity (TEUI)	Max. **100 KWh/m²a**

VBBL*	
Thermal Energy Demand Intensity (TEDI)	Max. **30 KWh/m²a**
Total Energy Use Intensity (TEUI)	Max. **130.2 KWh/m²a**
GHGI	**7 kgCO₂e/m²a**

*Keith Drive project targets VBBL along with LEED Gold certification. Since criteria for VBBL stringent than LEED Gold, the latter is neglected.

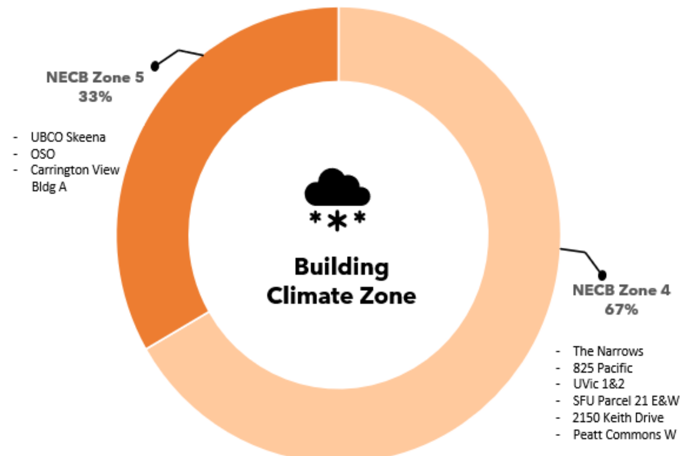
- SFU Parcel 21 E&W buildings initially targeted the Passive House Standard but changed to ESC Step 4 they posed difficulties to meet the Primary Energy Renewable (PER) of the Passive House standards.
- Majority of energy step code projects are residential buildings and half of the Passive house buildings are student residences.
- While comparing the various limit of each standard, it is observed that the Passive House standard is difficult to attain compared to others. Irrespective of heating demands and energy intensity requirements, all the projects are intending to have an airtightness < 0.6 ACH.

- It's worth noting that 2150 Keith Drive as it achieves the VBBL conditions, also has satisfied the LEED Gold certification criteria for GHGI emission limits. The TEUI of 2150 Keith Drive is altered a bit to account for the commercial unit on its ground level.
- Passive house standard Institute has adjusted the PER requirements of UBC Skeena from 60 to 72 KWh/m^{2}a to account for high density in student residences as opposed to a typical multi-unit residential building.

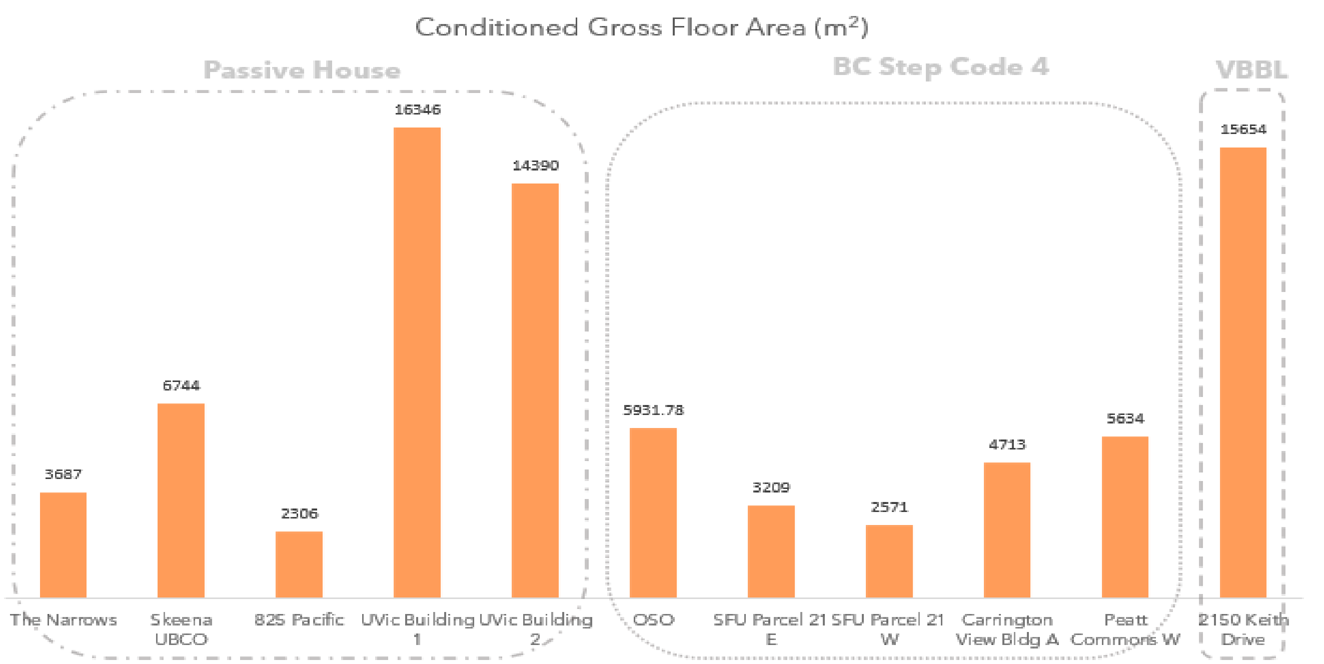
All these project developers were mindful of the energy aspects of the architectural and mechanical features for their Part 3 building.

Building Climate Zone

- Two-third of the projects are located in the NECB Zone 4 (Metro Vancouver and Victoria).
- UBCO Skeena though located in the Okanagan region, working on successfully Passive house standard status.
- Peatt Commons W is a residential rental building that can be influenced by the higher Window-to-Wall ratio and an opportunity to liaise the energy consumption to the individual suites



Gross Floor Area

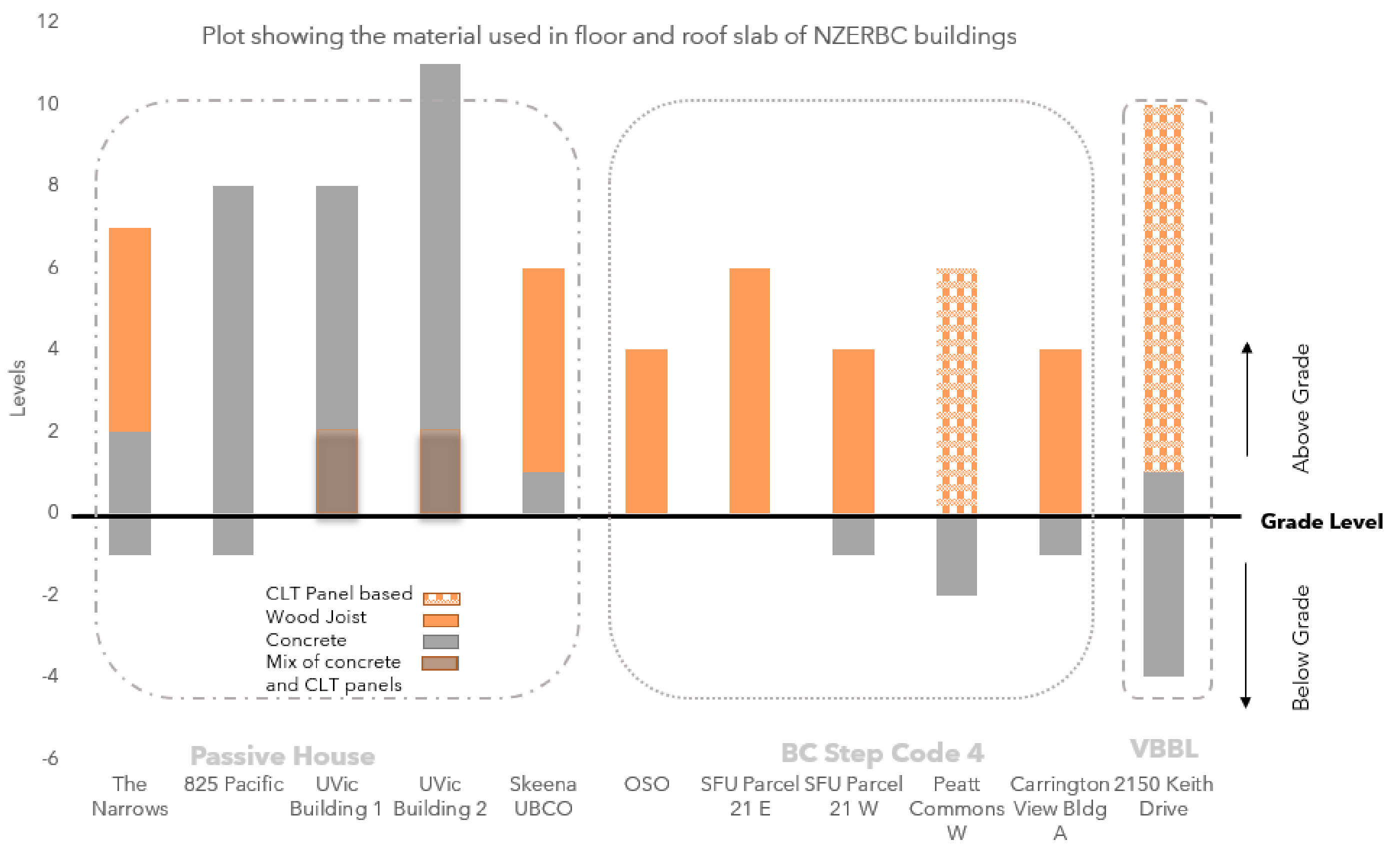


Gross Floor Area indicates all usable area including the wall thickness but excludes the unconditioned areas such as parking and basement.

The above plot is illustrative of the size of the NZERBC winning projects. The area shown here is the conditioned GFA which is the total usable area including the wall thickness but excluding the unconditional areas such as parking and basement.

- UVic buildings and 2150 Keith Drive has the largest GFA with more than 15000 m^2 whereas 825 Pacific Street and SFU Parcel 21 are the compact ones. Though the data set is small, significantly, the GFA of step 4 targeting buildings is less than 6000 m^2.
- Simplifying the form of the building helps achieve ESC Step 4 and is instrumental in reducing the TEDI of the building. Complex the form, greater chance of heat loss through envelope detailing in joints, corners, and intersections.
- The simple repetitive floor plan is adopted by residential projects such as UBCO Skeena, Carrington View Bldg A, Peatt Commons W, and OSO namely limiting their thermal demand.
- The designers for all the projects have been mindful of placing the longer façade towards the South to increase the passive solar heat gain during summer thereby reducing the heating demand.
- The 2150 Keith Drive project is designed with a long narrow south-facing facade with a curtain wall, reducing the heating demand and the lighting requirement. The building uses cross bracings that also act as external shading, to limit the solar heat gain during the summer months.

Floor and Roofing Material

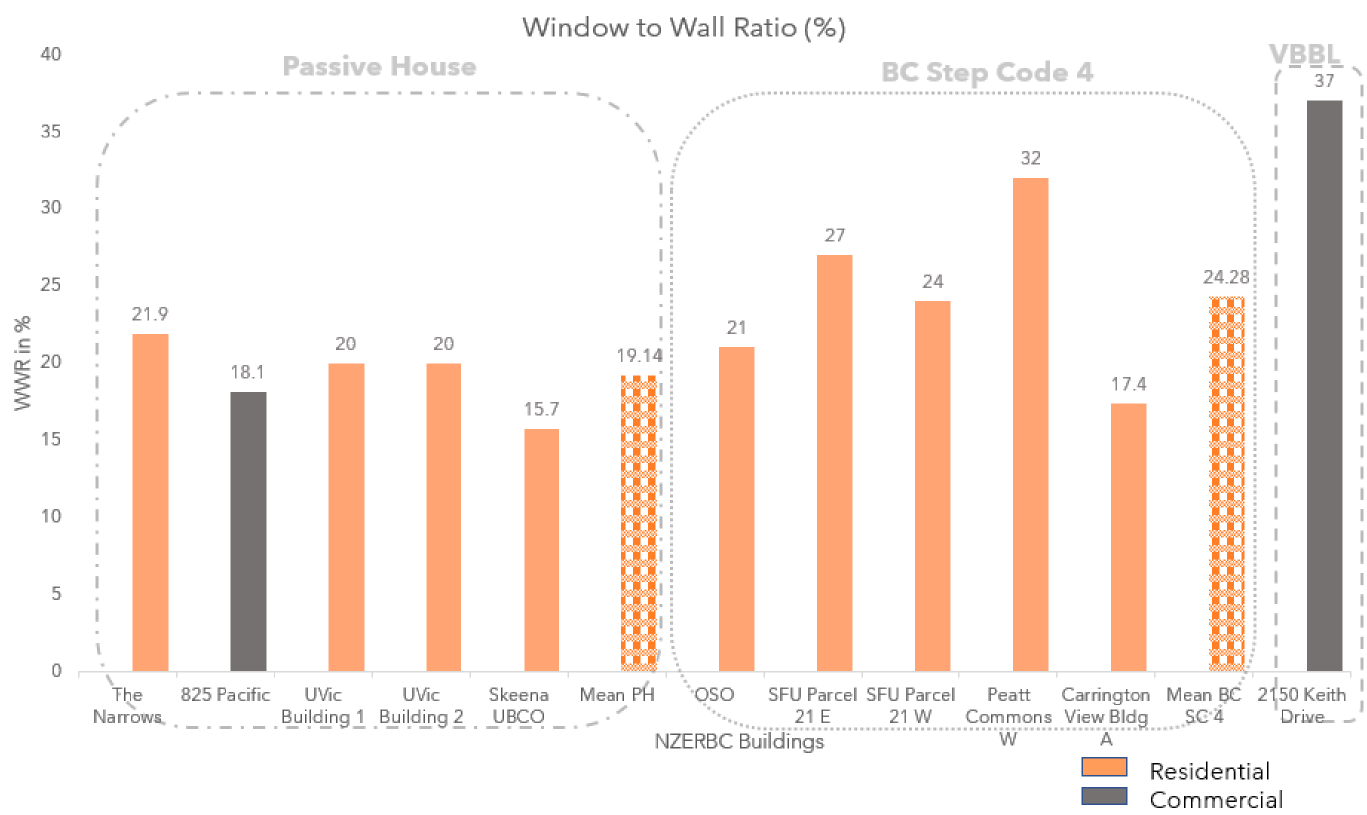


The above interpretation gives a high-level overview of the material in the building as it shows the materials used in the floors and roof slabs excluding the materials in vertical facades and columns. Wood is a common choice of building material, as well as the CLT panels, which are prefabricated and also decrease construction time and cost. The grade level represents the elevation at which there is the main entrance for the building irrespective of the slopes in the plot area or design.

- All these buildings have their grade-level flooring and basements (if applicable) as concrete slabs.
- The UVic Buildings use concrete for their superstructure since it is a preferable choice of material for the building height and the complex load distribution between the podium and tower levels.

- While 825 Pacific Street and UVic buildings use concrete as their exclusive choice of construction material, Narrows, UBCO Skeena, and 2150 Keith Drive restrict the use of concrete to the lower floor levels.
- OSO, SFU Parcel 21, and Carrington view Bldg A has got 100% wood-based floors in their superstructure.
- Peatt commons W and 2150 Keith drive use CLT panels to ease up the construction process and reduce the waste produced at the site.

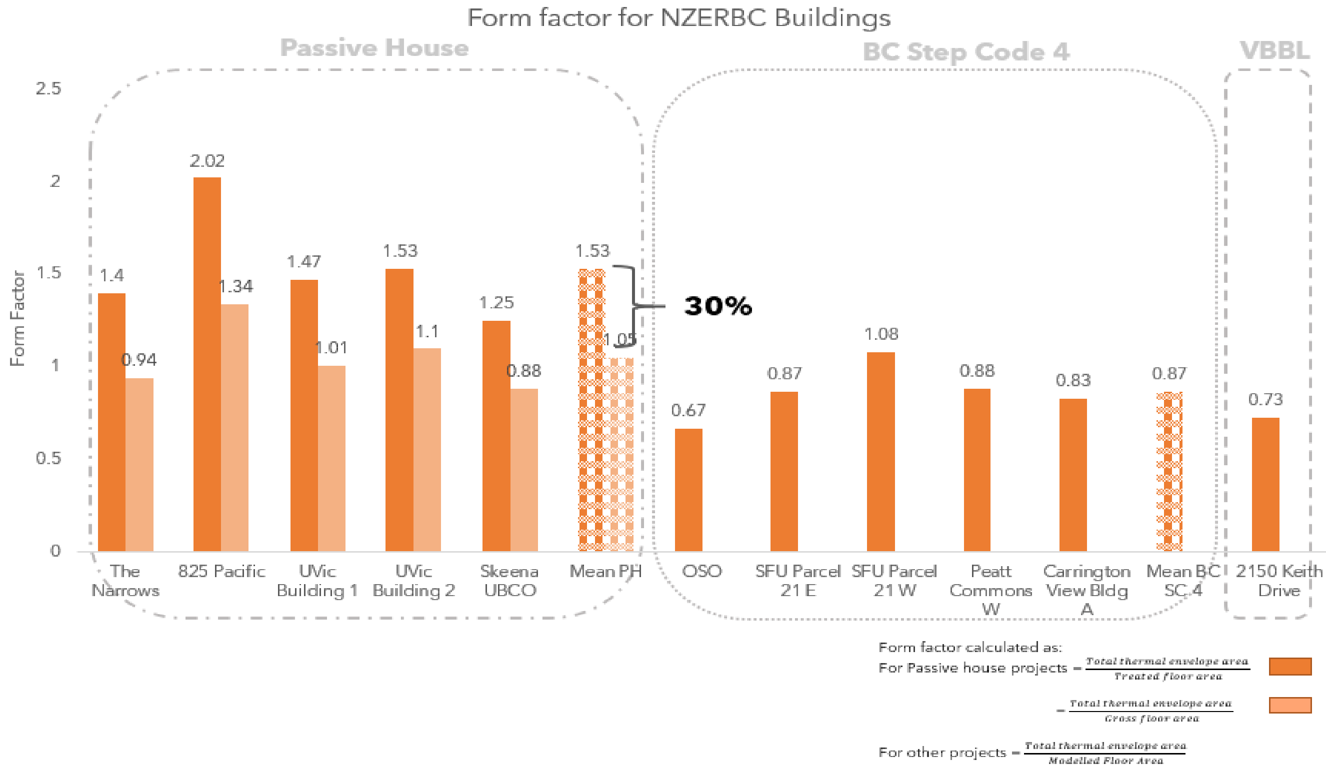
Wall to Window Ratio



Collectively, all the buildings have maintained a Window-to-wall ratio of less than 40% which is ideal according to the BC Energy step code recommendations for Part 3 buildings. The WWR for all the passive house buildings lies around 20%, as a strategy to achieve low heating demand.

- Office complexes usually have higher WWR. Among the commercial buildings, the 2150 Keith Drive has the highest WWR of 37% while the 825 Pacific Street building has only an 18% WWR. The reduced WWR in 825 Pacific Street could have been a method used to achieve the stringent target of the Passive House standard.
- Though Peatt Commons W and the Carrington View Bldg Aare residential buildings targeting the Energy Step code, there is a huge difference in the WWR. This may be because Peatt Commons W has large windows and balconies in their apartments, unlike the Carrington view Bldg A that has opted for smaller windows.
- Analyzing between the student residences, SFU Parcel 21 has a large window area.

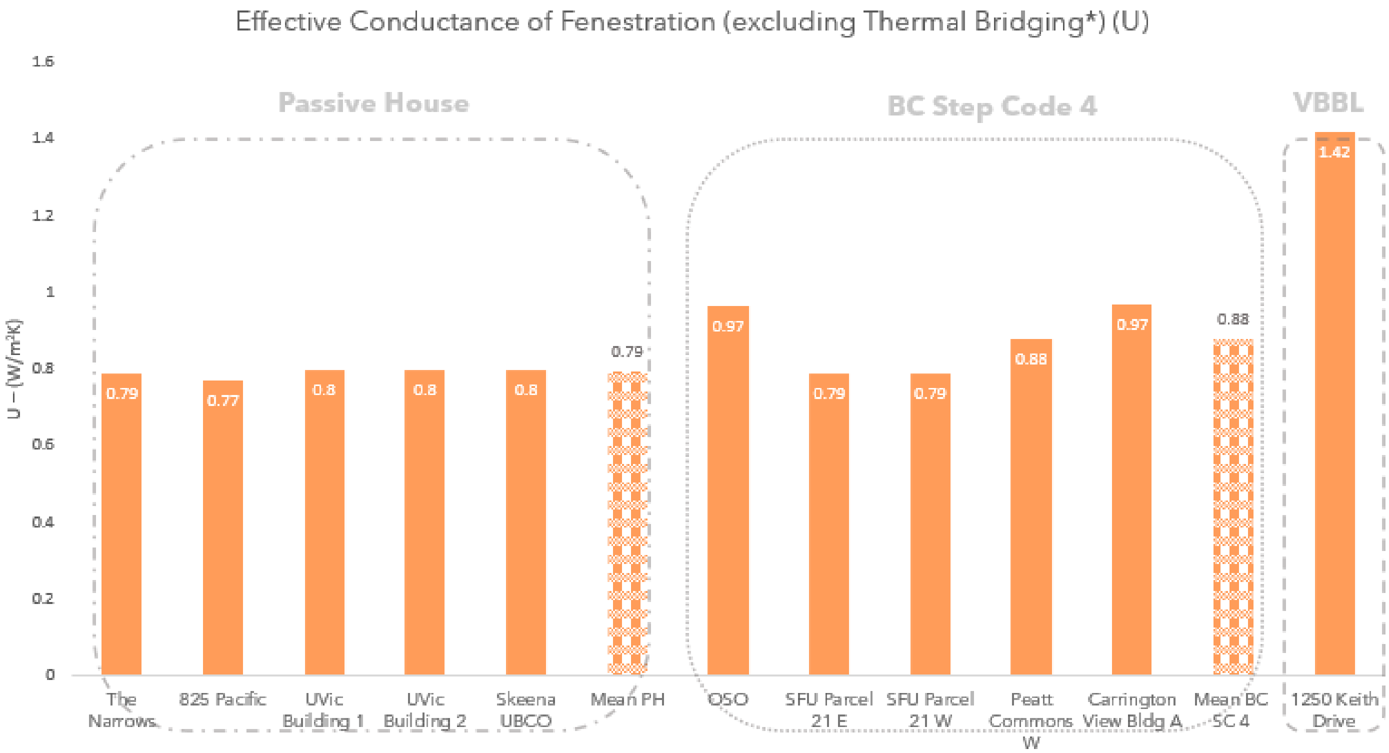
Form Factor



The Form factor is a ratio It is important to note that the form factor is calculated in different ways for the Passive House Standard and the Energy Step Code targets. The form factor for the Passive House projects is calculated as Total thermal envelope area divided by Treated Floor Area (TFA). TFA for Passive House standard building is calculated as the measure of the internal building area excluding the wall thickness along with PE factors. The second bar next to the Passive House projects denotes the form factor calculated using the Gross Floor Area (GFA). For all the other buildings, the form factor is formulated by using the thermal envelope area and the GFA.

- On average, there is a 30% increase in form factor calculated using the GFA over the TFA
- Against the common perception that the form factor of Energy Step code buildings is larger than the Passive House projects, the Passive House standard buildings in the NZERBC projects have a higher form factor than that of the ESC step 4 buildings. This may be because, in this small data set, the vertical height of PH buildings is higher compared to its floor area. For example, 825 Pacific has a GFA of around 2300 sqm but is 21 m tall.
- Though there is no pattern identified in the form factor of step code and VBBL buildings, the average value is less than 1.

Fenestration



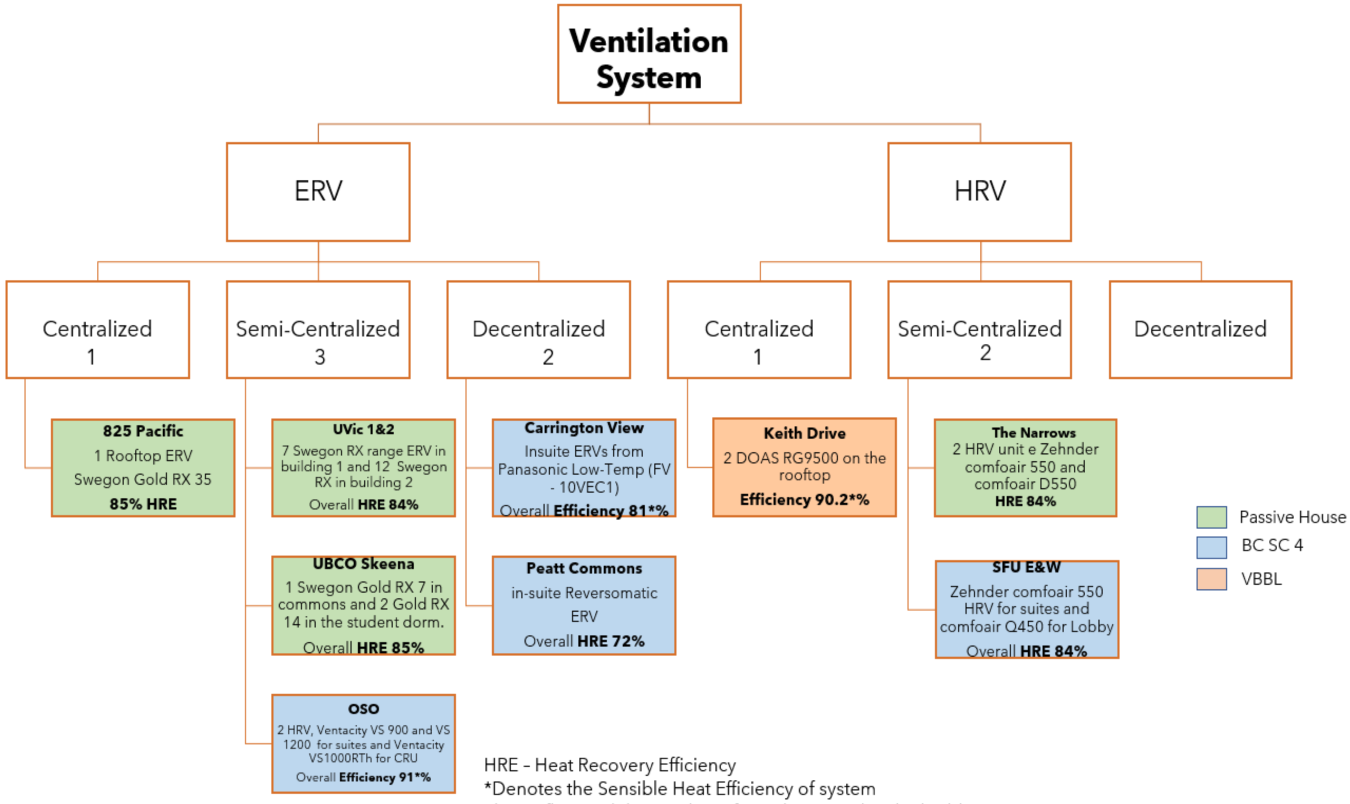
* Thermal bridging effects between the window and the surrounding wall is not included.

In the above plot, Effective conductance of the window assembly is considered to analyze the performance in heat transfer into the building. The effect of thermal bridging between the windows and the surrounding walls is excluded but the heat losses between the components of the windows are included.

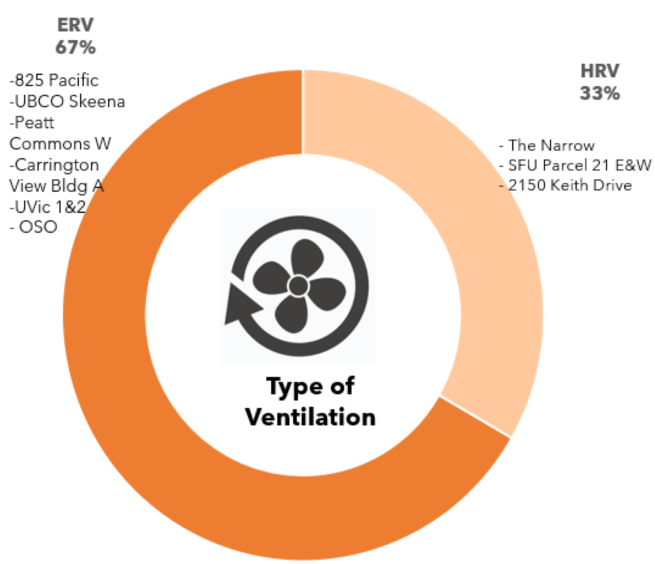
- 2150 Keith Drive is an office complex with a large window wall façade has got a higher conductance value compared to others.
- All the passive house standard projects have got more or less a conductance of 0.8 which is a standard value for Passive House Standard buildings.
- Energy step code buildings have got a varied range of U values but 0.88 W/m2K is the overall average, which is higher than that of passive house standard projects.

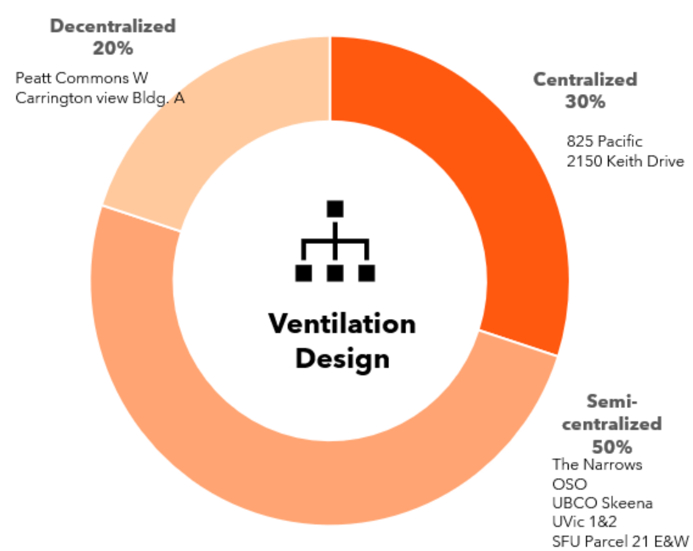
Ventilation System

The chart on the next page shows a hierarchy chart of the ventilation units in the buildings. Projects are broadly classified based upon the choice between Heat Recovery Ventilator (HRV) and Energy Recovery Ventilator (ERV). Based on the system design, they are then classified as centralized, semi-centralized, and decentralized.



HRE – Heat Recovery Efficiency
*Denotes the Sensible Heat Efficiency of system
The air flow and the number of ventilator used in the building differs for one another

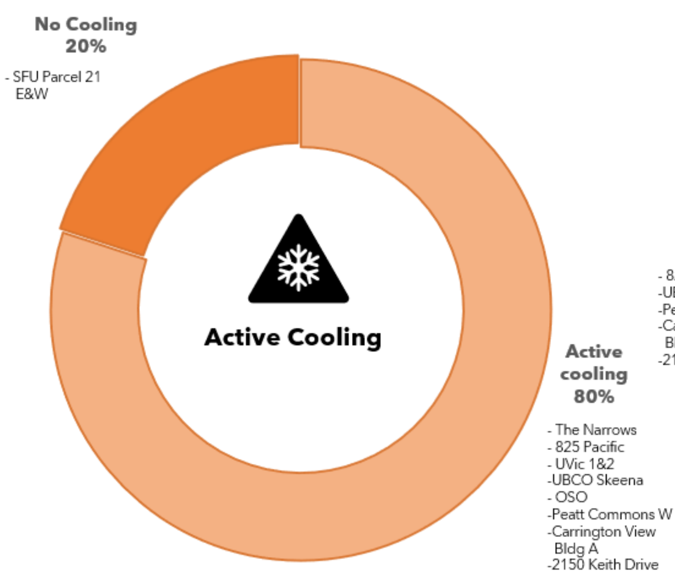


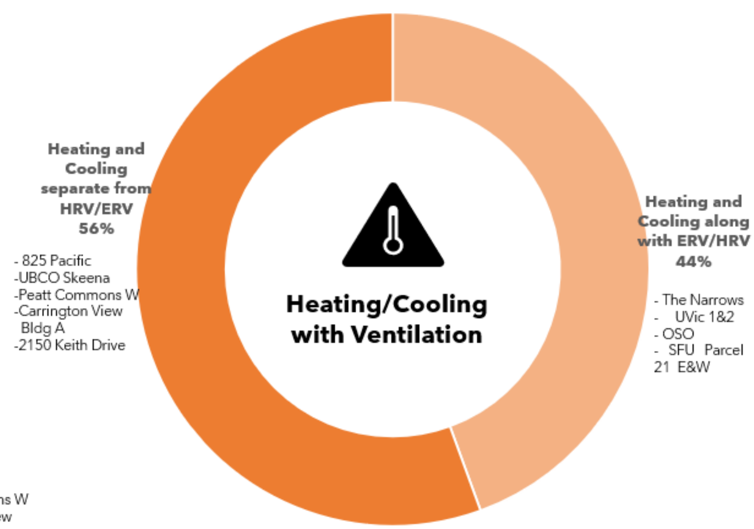


The choice of HRV or ERV is highly influenced by the climate zone of these buildings.

- The NECB zone 4 buildings in the Vancouver region choose the HRV system, while the buildings in the Zone 5 region have chosen ERV. This is due to the greater variability in humidity throughout the year.
- The 825 Pacific Street building is in Vancouver and has preferred to use the ERV system.
- In terms of the system design, 5 out of the 9 projects are designed with a semi-centralized system while the others have chosen between the centralized and the decentralized system.
- Decentralized systems have been the ideal choice for residential buildings like Peatt Commons W and Carrington View to make tenants aware of their energy consumption.
- The Commercial buildings, the 2150 Keith Drive, and the 825 Pacific Street opted for a centralized system.
- As the Narrows and the OSO have commercial use in the lower levels, these buildings have opted to use a semi-centralized system.
- All the student residences have compartmentalized the building and provided a semi-centralized ventilation system.

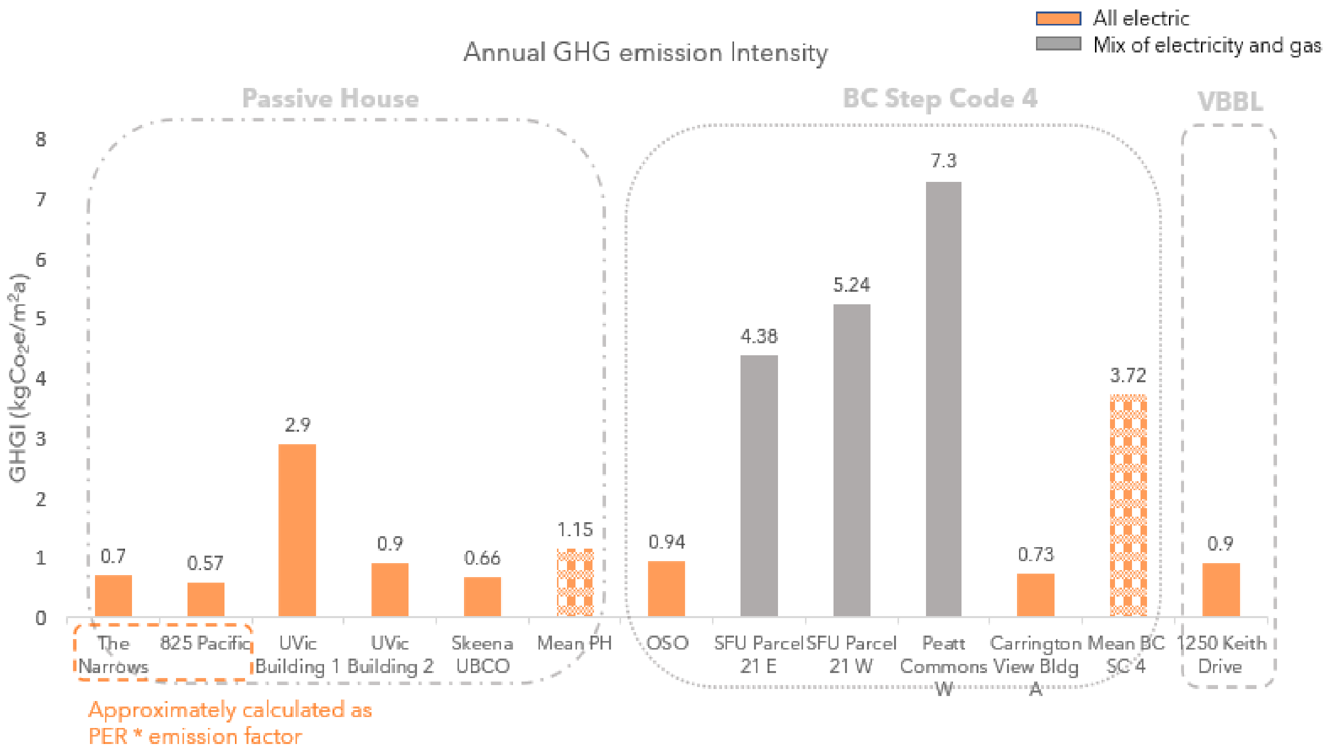
Heating and Cooling





- While looking at the heating and cooling, SFU Parcel 21 E & W is the only project out of the 9 projects that do not have active cooling.
- 5 projects have an independent heating cooling while 4 other projects have combined it with ventilation air.
- 2 Passive House projects opted for the integrated system while the 2 other Passive House projects preferred to have a separated heating/cooling and ventilation system. It could be concluded that no trend was observed behind the system preferences over the energy targets.

GHG Emission Intensity



This bar chart here presents one of the important comparison factors, GHG emission intensity. For almost all the projects GHGI is calculated by multiplying the total electricity and gas use in the building with its corresponding emission factors.

- The Narrows and the 825 Pacific Street buildings have a value of less than 1 KgCO2/m2a as they use the hydropower supply.
- The 2150 Keith Drive building has a lower GHGI value as the project targets a value of less than 7 KgCOe/m2 in order to meet the VBBL.
- The commercial kitchen on the podium level of the U Vic buildings contributes to their higher GHGI numbers.
- The step code buildings like the Peatt Commons W has a gas-powered condensing water heater system and a rooftop gas-fired makeup air unit, while the SFU Parcel 21 uses the district energy powered by gas boilers for the domestic hot water.

Future Directions

The following are some of the topics discussed but could not be explored for this trends analysis report:

- Comparison between the achieved airtightness of the buildings.
- Differentiating and analyzing the insulation levels of the different envelope elements of the building.
- Differentiating and analyzing the type of heating systems used in the buildings.
- Discrepancies in the internal heat gain assumptions between the ESC energy modeling and the PHPP

Conclusion

The 9 winning projects were studied and based on a few above discussed factors, the trends are seen among them and their significance is understood and presented.

References

1. BC Energy Step Code for Part 3 Buildings – September 2017
   https://energystepcode.ca/requirements/

2. ZEBx NZERBC case study series – Peatt Commons W – February 2021
   https://zebx.org/peatt-commons-west/

3. ZEBx NZERBC case study series – UBCO Skeena Residence
   https://zebx.org/skeena-residence/

4. Relevant Architectural, Mechanical and Energy Performance Reports of the 9 NZERBC Winning Projects.

Annexure

Mechanical Ventilation System

Sl.No	Building	Building Target	HRV/ERV system(s)	HRE (%)	Airflow rate (L/s)	Heat Exchanger type
1	The Narrows	**Passive house standard**	Centralized 2 HRV unit e Zehnder comfoair 550 and comfoair D550	**84%**	**30**	**Cross counterflow heat exchanger**
2	825 Pacific Street		Centralized in the rooftop – ERV Swegon Gold RX 35	**85%**	**1000-2083**	**Rotary**
3	UoV Building 1		Semi-centralized ERV systems 3 swegon RX 35 in the dining area 1 swegon RX 25 in kitchen 1 Swegon RX 20 in Tower – N 1 Swegon RX 35 in Tower – S & E each 1 Swegon RX 25 in Tower – W Total 8 ERV	**84%**	**3725** **1775** **1260** **2735** **1950**	**Rotary heat wheel**
4	UoV Building 2		Semi– Centralized 8 ERV in the podium level and 4 ERV on the tower, 1 per façade of the building (mostly Swegon RX model)	**84%**	**Varies from 300 - 3750**	**Rotary hot wheel**
5	UBCO Skeena		Semi– Centralized – 3 ERV located on the ground floor			
			ERV 3 - Swegon Gold RX 7 will serve the ground floor common spaces, vestibule and the two stairways	**86%**	**434**	**Rotary**
			ERV 1 & 2 Swegon Gold RX 14 will serve the student dorms, study lounges and floor lounges in above levels	**84%**	**1675**	**Rotary**
6	OSO	**BC SC 4**	Semi Centralized – 2 HRV for CRU at L1 and 1 HRV at L4 for suites			

			2 HRV in L1 HRV 3.1 Ventacity VS900 CMh HRV 3.2 Ventacity VS1200 CMh	**91.2*%** **90.6*%**	**94-425** **142 - 566**	**Counterflow Aluminum static plate**
			1 HRV in L4 Ventacity VS1000RTh	**84%**	**139-305**	**Counterflow Aluminum static plate**
7	SFU E		Decentralized HRV			
			Suite HRV – Zehnder comfoair 550 Lobby region – Zehnder comfoair Q450 HRV	**84%** **91%**	**156** **104**	**Cross counterflow heat exchanger** **Diamond heat exchanger**
8	SFU W		Decentralized HRV similar to the HRV of SFU E in suites and lobby along with Pavilion ERV Greenheck Minivent 750	**SAME AS ABOVE** **85%**	**400**	**Energy Wheel Tech.**
9	Peatt Commons		Decentralized in-suite Reversomatic ERV	**72%**	**30**	**Cross flow heat exchanger**
10	Carrington View Bldg A		Decentralized Insuite ERVs from Panasonic Low-Temp (FV - 10VEC1)	**81*%**	**25**	**Capillary Core exchanger**
11	2150 Keith Drive	**VBBL**	Centralized HRV – 2 DOAS RG9500 on the roof top	**90.2*%**	**4955**	**Dual Core Technology**

***Sensible Heat Efficiency of system**