Designing Mixed-Use Recreational Facilities to Meet TEDI, TEUI, GHGI, and Thermal Comfort Targets

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Abstract

The new BC Energy Step Code and Green Building Policy for Rezoning has made designing buildings in Vancouver, Canada an increasingly difficult task. The Code and Policy mandates that buildings must either meet select 3rd-party certifications (e.g. Passive House) or stringent Total Energy Use Intensity (TEUI), Thermal Energy Demand Intensity (TEDI), and Greenhouse Gas Intensity (GHGI) targets. Furthermore, there are thermal comfort requirements for passively cooled buildings. In our work, we analysed design solutions for a mixed-use recreational facility that includes a pool, gym, multipurpose, and residential spaces. We performed studies utilizing parametric simulations and Passive House concepts to optimize the building's envelope, operation, and heat recovery system to achieve its TEDI targets. With a natural ventilation study, we identified overheated spaces and analysed measures to address the problem. This paper presents the study results and recommended design solutions for the mixed-use recreational facility to achieve its performance targets.

Introduction

Designing buildings in Vancouver, Canada, has become an increasing difficult task due to the new British Columbia (BC) Energy Step Code (Government of British Columiba, 2019) and City of Vancouver's (CoV) Green Building Rezoning Policy (City of Vancouver, 2018b). Both new Code and Policy are part of the Greenest City 2020 Action Plan (City of Vancouver, 2015). The goal for green buildings is to "lead the world in green building design and construction" with the targets of reducing energy use and GHG emissions by 20% (compared to 2007 levels) and by requiring all buildings constructed in 2020 and after to be carbon neutral.

Any new building in Vancouver may potentially have to meet both the Code and Rezoning Policy depending on location and building type. Performance targets include TEUI, TEDI, and GHGI.

Building energy analysis plays an increasingly important role in the design process as the design teams must adapt to the seemingly everchanging performance requirements for new buildings. The following sections summarizes the requirements of the BC Energy Step Code and CoV's Green Building Rezoning Policy.

BC Energy Step Code & VBBL

The BC Energy Step Code is an optional compliance path in the BC Building Code (Province of British Columbia, 2018) that local governments in the province may use to incentivize or require a level of energy efficiency in new construction that goes above and beyond the requirements of the BC Building Code.

As a part of the Vancouver's Zero Emissions Building Plan, the CoV has chosen to adopt the Step Code into the Vancouver Building By-law (VBBL). The current TEUI, TEDI and GHGI are found in Section 10.2.2.5 of the VBBL.

City of Vancouver's Green Buildings Policy for Rezoning

The Green Buildings Policy for Rezoning offers two paths: Near Zero Emissions Buildings or Low Emissions Green Buildings. Near Zero Emissions Buildings requires the project to meet and apply for Passive House certification or a similar net zero standard. Alternatively, the Low Emissions Green Buildings involves the following building performance requirements: 1) LEED Gold Certification and 2) Performance Limits on the TEUI, TEDI, and GHGI. Currently, the policy has two sets of performance limits, those for buildings connected to a City-recognized Low Carbon Energy System and those not connected (Table 1), which is the most common.

Table 1. Performance Limits for Buildings not Connected to a City-recognized Low Carbon Energy System.

Building Type	TEUI (kWh/m^2)	TEDI (kWh/m^2)	GHGI ($kgCO_2/m^2$)
Residential Low-Rise	100	15	5
Residential High-Rise	120	30	6
Office	100	27	3
Retail	170	21	3
Hotel	170	25	8
All Other Buildings	EUI 35% better than Building By-law energy efficiency requirement		

Vancouver Energy Modelling Guidelines

Both Policy and Code reference the Vancouver Energy Modelling Guidelines, which provides additional modelling guidance and thermal comfort requirements.

Mixed-Use Buildings

For mixed-use buildings, the TEUI, TEDI, and GHGI limits are a combined area weighted average of the performance limits for each building type. The portions of the building that have a TEDI target must also meet their combined TEDI target (City of Vancouver, 2018a).

Passive Cooled Buildings

As an effect of climate change, overheating in the summer has become an urgent concern for residential buildings in Vancouver that do not have a mechanical cooling system. In order to address this, there are additional requirements for passively cooled buildings in the City of Vancouver Energy Modelling Guidelines (City of Vancouver, 2018a). The overheating hours in all space must demonstrate that the interior dry bulb temperatures of occupied spaces do not exceed the 80% Acceptability Limits for passively cooled spaces for more than 200 hours per year for any zone.

Our Work

In our work, we have developed a process for finding cost-effective design solutions for retrofit or new construction projects (Chan et al., 2018). Our process is designed to clearly identify the tasks of the energy modeller as well as the inputs and deliverables for each task. It is also designed to provide sufficient data and recommendations to inform decision makers of the best design measures or combination of measures to implement. This process builds upon the use of parametric simulations to optimize design by adding financial analysis and a user-friendly and interactive interface to analyse the parametric results.

This paper presents the design methodology for a new construction project in the CoV. Namely, we show what performance targets the building is required to meet and how to use energy analysis as a tool to come up with an optimized design to meet those targets. Using a more complex building type such as a mixed-use recreational facility as an example, we will present the analysis methodology and results of choosing the best energy efficient features for a new building in the CoV.

Methodology

The purpose of this analysis is to find design solutions for this mixed-use recreational building to meet the building performance targets of the Green Buildings Policy for Rezoning and VBBL. The following sections outline our approach to finding design solutions. Additional iterations of this analysis or further investigation of specific design measures may be required as the design evolves.

Building Energy Model

An energy model of the proposed design is created based on the architectural, mechanical, and electrical drawings/documentation of the proposed design.

Heating and Cooling Load Analysis

The heating and cooling load breakdown of the proposed design was analysed in order to determine the key energy consumers. This analysis gives us a good understanding of where we can potentially improve the building design with the aim of meeting the performance limits.

Design Measure Selection

The number of design upgrade measures imaginable are countless; however, many of them do not pass an initial viability test. To establish a list of plausible measures, we have implemented a selection strategy based on professional judgement and experience, proven technology, ease of maintenance, capital investment, and energy impact on the building's largest energy consumers.

Design Measure Evaluation

A stand-alone energy model can be used to evaluate more complex EEMs (e.g. pool control optimization) or a parametric simulation study can be used for simpler EEMs (e.g. envelope, lighting, HVAC).

Energy Model Analysis

The design measure is implemented into proposed design energy model and their impact is evaluated via the change in simulation results.

Parametric Design Analysis

Parametric Design Analysis (PDA) provides a review of the interactive effects of multiple measures implemented simultaneously. This enables the design team to estimate the impact of all individual design decisions on the overall building energy performance.

Potential Design Options are created by combining all the different design parameters that are conceivable for the project. This means that many design iterations (e.g. envelope performance, HVAC system, lighting design) are created and combined in various permutations.

The parametric simulations generate a very large number of results data as they efficiently perform hundreds or thousands of full individual energy models. To be able to analyse the data and draw conclusions, the data is presented using the parallel coordinates tool. The tool presents the data in an interactive way, where sets of parameters can be chosen to view an outcome of interest.

Using the tool, Design Options (i.e. measure bundles) are selected based on the ability of a combination of individual measures to meet the project objectives (e.g. EUI, TEDI or GHGI targets). The power of the parallel coordinates tool lies in the ability to select the target outcome in the interactive data set and get, as a result, all the Design Options that would meet the performance targets.

Results

The building analysed in this study is a recreational facility with a residential tower. It is located in Vancouver, Canada. The recreation building is a 14-storey building with a conditioned floor area of approximately 13,220 m^2. The building accommodates several space types such gymnasium, pool, fitness area, office, conference room, restroom, locker room, stairwell, lobby, corridors, residential suite, as well as other spaces to provide service to the building such as storage room, electrical and IT server room, and mechanical room.

The following sections show the analysis performed to find design solutions for achieving the performance targets (i.e. TEDI, TEUI, GHGI) and thermal comfort requirements of the Green Building Rezoning Policy, which has more stringent targets than the VBBL.

Preliminary Energy Model

A preliminary energy analysis was performed in (Chan et al., 2019) to find design solutions that achieve the performance targets. A variety of energy efficient measures (EEM) were investigated. Figure 1 to 3 shows the TEUI, GHGI, and TEUI savings for each EEM based on the preliminary design energy model.

Figure 1: EEM TEUI Savings.

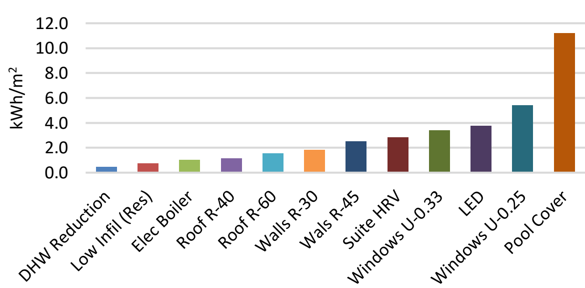


Figure 2: EEM GHGI Savings.

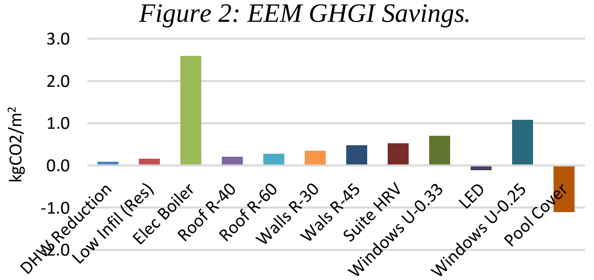
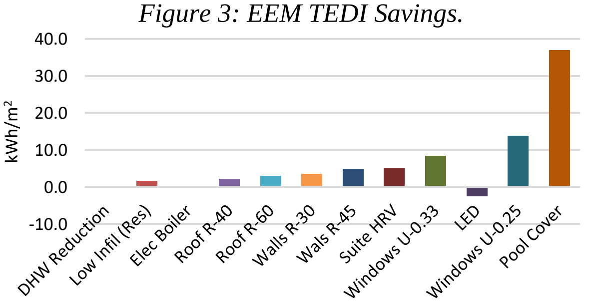


Figure 3: EEM TEDI Savings.



Building Energy Model

Based on the TEUI, TEDI, GHGI, financial, and feasibility considerations, the design team incorporated some EEMs from the preliminary study into the current design. Additional geometric changes were also incorporated, which has increased the conditioned building area.

The energy model was updated to reflect the geometry and key design features of the current proposed design (Table 2). Figure 4 shows a 3D rendering of the energy model. IES Virtual Environment (Integrated Environmental Solutions Limited, 2019) is the software used to model this building.

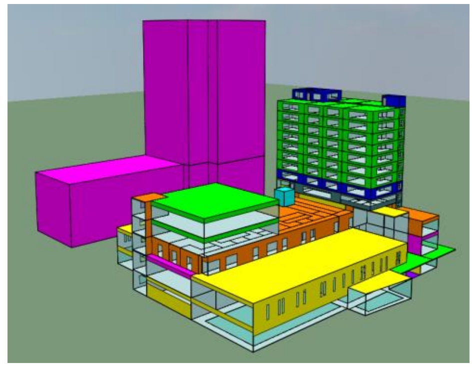


Figure 4. IESVE Model of the Proposed Design.

Table 2. Key Features of the Proposed Design.

Component	Proposed Design
Envelope	Roof: R-20.8 (RSI 3.7) Recreation Ext. Walls: R-7.3 (RSI 1.3) Residential Ext. Walls: R-5 (RSI 0.9) Windows: U-0.35 (USI 2.0)
Lighting	Fitness: 0.50 W/ft^2 (5.4 W/m^2) Gym: 0.82 W/ft^2 (8.8 W/m^2) Multipurpose: 1.07 (11.5 W/m^2) Pool: 1.70 W/ft^2 (18.3 W/m^2) Offices: 0.93 W/ft^2 (10.0 W/m^2) Residential: 0.49 W/ft^2 (5.0 W/m^2)
HVAC: Central System	Recreation heating/cooling: heat recovery chiller and backup gas-fired boiler Residential heating: gas-fired boiler
HVAC: Zone Level	Recreation: VAV with reheat Residential: hydronic baseboards
Heat Recovery	Recreation: heat recovery chiller, central HRV Residential: suite HRV

Building Energy Use

Figure 5 show the energy use breakdown of the proposed design. The TEUI of the building is 279 kWh/m^2. The largest contributors to the TEUI are electric heating and cooling, interior fans, and interior lighting. The GHGI is 13 etonnes kgCO$_2$/m^2. The TEDI for whole building and residential spaces are 246 kWh/m^2 and 29 kWh/m^2, respectively.

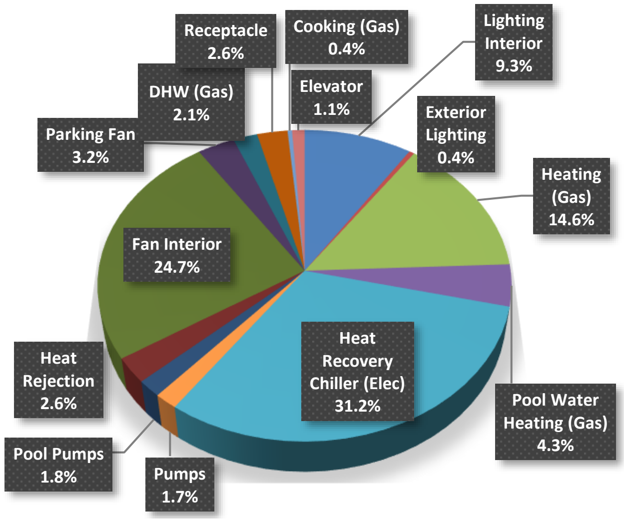


Figure 5. Energy Use Breakdown.

CoV Performance Limits for Mixed Use Buildings

This building has both residential areas and non-residential areas, so it falls under the requirements for mixed-use buildings. This means that the TEUI, TEDI, and GHGI limits are a combined area weighted average of the recreational spaces and residential tower limits. The residential tower also must meet the TEDI requirement for "Residential High Rise".

The recreational spaces of this building falls under the "All Other Buildings". Therefore, the performance limits of those spaces are determined based on the VBBL energy efficiency requirements at the time of the rezoning application (i.e. ASHRAE 90.1-2010 or NECB 2011). An ASHRAE 90.1-2010 baseline model was created to determine the TEUI, TEDI, and GHGI targets for the recreational spaces. This baseline model only contains recreational facility space types. The TEUI performance limit for the recreational space types is 35% lower than the baseline model TEUI. The TEDI and GHGI performance limits are the baseline model TEDI and GHGI.

Table 3 show the performance limits and proposed design metrics for the residential spaces, recreational spaces, and whole building. The proposed design is meeting the TEUI and GHGI requirements, but not the TEDI requirements.

Table 3. Performance Limits and Values for the Building.

Metric	Performance Limits	Proposed Design
TEUI (kWh/m^2)	367	279
GHGI (kgCO$_2$/m^2)	70	13
TEDI (kWh/m^2)	201 (Building) 30 (Residential)	246 (Building) 29 (Residential)

The following sections show a more focused attempt (than the preliminary study) at finding design solutions to meet the TEDI requirement, optimize the envelope design of the residential tower, and ensure that the thermal comfort requirements are met.

Heating & Cooling Load Analysis

A significant portion of the heating and cooling load is attributed to the pool space in the building. Significant energy is used to heat the pool water, as well as condition and dehumidify the space. Figure 6 shows a breakdown of the heating load in the building. 58% of the heating load is from heating the pool water and space heating for the pool area. The space heating load of the building directly relates to the TEDI and GHGI.

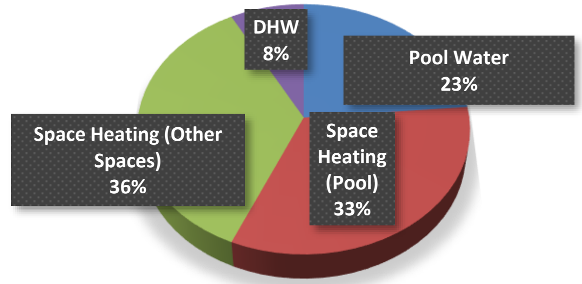


Figure 6. Heating Load Breakdown.

The pool space has such a high thermal demand because it is a large space with high air change requirements (i.e. 6 air changes per hour) and a high heating setpoint of 28°C. Currently, evaporation makes up 76% of the total pool water load. The high evaporative losses to the pool space result in a high dehumidification load and, consequently, a significant reheat load. The building TEDI can be improved with additional heat recovery, improved envelope performance, and/or a reduction of the dehumidification load.

Figure 7 shows the breakdown of the building's cooling load. As expected, the largest cooling load is the dehumidification and space cooling for the pool. This shows that there is a significant of heat recovery potential from cooling, where the heat rejected from cooling can be used for heating. The high cooling load affects the TEUI and GHGI of the building.

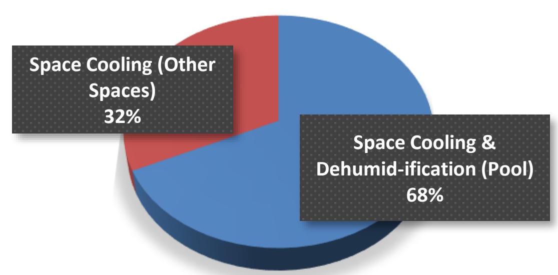


Figure 7. Cooling Load Breakdown.

TEDI Reduction Analysis

This section presents the analysis and results of design solutions to meet the CoV's building performance targets Namely, we investigated design measures that would enable the building to achieve the whole building TEDI target of 201 kWh/m^2. We also explored opportunities to improve the aesthetic of the residential tower envelope while meeting the residential TEDI target of 30 kWh/m^2. The following three categories of measures were investigated: 1) recreation facility, 2) pool space, and 3) residential tower.

Recreation Facility TEDI Reduction Measures

The measures in this category is specific to the recreation facility only. Since the recreation facility accounts for 65% of the building, these measures will have the greatest impact on the building TEDI value. The aim of these measures is to minimize the heat loss and recover energy wherever possible. The following measures were investigated:

Decreasing Window Area

The window-to-wall ratio (WWR) of the proposed design is 57%. Heat loss through the windows significantly contribute to the building's TEDI value; however, daylighting is also important to occupant experience and capture solar gains. The proposed measure must strike a balance between those factors. Therefore, we proposed an optimized window design that results in a WWR of 40%.

Addition of Pool Cover

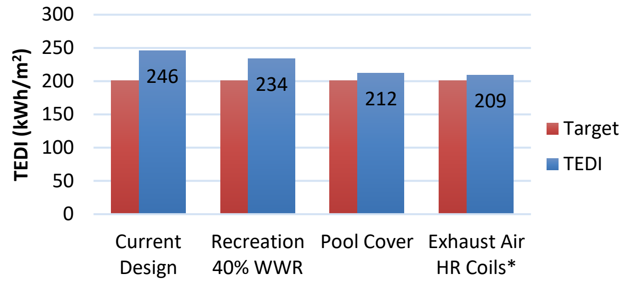
Pool covers are an effective way of decreasing pool water evaporation losses. This, in turns, decreases the latent heat gain to space, dehumidification load, and reheat required after dehumidification. A pool cover was modelled by reducing the latent heat gain to the pool space by 90%. Less heating would reduce the TEDI. The drawback to this measure is that it can be expensive to implement as it requires the purchase of the cover system, maintenance of the system, additional training of the pool staff, and extra work time every day to deploy the cover.

Exhaust Air Heat Recovery

In order to maximize on the heat recovered from the exhaust air, heat reclaim coils are proposed to be added after the air-to-air heat recovery device. Cooling coils were modelled at the exhaust air duct with a cooling setpoint of 13°C and turns on when the outside air is below 16°C (i.e. heating season) Since this does not reduce heating load of the building, it does not technically reduce the TEDI. Strictly speaking, only the effect of ventilation heat recovery devices is included in the TEDI. However, one can argue that, in both cases, heat is extracted from the exhaust air stream and is put back into the building, either directly into the air or via heating coils. Therefore, we believe that the effect of exhaust heat recovery coils should be included in the TEDI. This alternative way of calculating TEDI will be confirmed with the City of Vancouver upon submission of the rezoning application.

Impact of Measures

Figure 8 shows the estimated impact of the proposed measures on the building's TEDI value. All three measures reduce the TEDI significantly but none of them individually are enough to meet the TEDI target. Therefore, we recommend that at least two of the measure be implemented into the design.



*Includes heat recovered from exhaust air heat recovery coils

Figure 8. Recreation Facility: Design Measure Impact on TEDI.

Pool Space TEDI Reduction Measures

These measures focus reduction heating loads in the pool area. The dehumidification process cools the incoming outdoor air to a low temperature, which needs to be reheated before it's supplied to the space. Therefore, if more dehumidification is needed, more reheat is also needed, which increases the building TEDI. In this analysis, we have investigated Passive House design concepts that were applied in the Bambados Pool design (BINE Information Service, 2016; Grove-smith & Krick, 2009) to lower the dehumidification load in the proposed design.

Condensation Issues in the Winter

The pool space is dehumidified to a relative humidity setpoint to avoid condensation at the windows during winter. This occurs when warm humid air is in contact with a cold surface. This is especially concern at the inner corner of the window frame, which is the coldest part of the window (Figure 9).

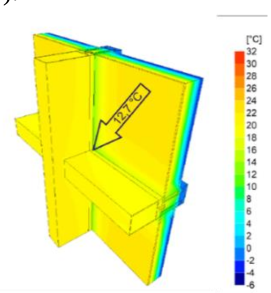


Figure 9 Coldest Point of the Window

The dewpoint temperature (i.e. the temperature at which water condensates) is dependent on the surface temperature and the relative humidity of the air. At a particular surface temperature, there is a maximum relative humidity the air can be before it condensates. If the surface temperature is higher, the maximum relative humidity can also be higher. Therefore, we proposed to lower the dehumidification needed by increasing the inside surface temperature.

An increase of an inner surface temperature from 16°C to 20°C could allow a rise of the relative humidity from 48%

to 62% at an interior temperature of 28ºC without reaching the dewpoint (Figure 10).

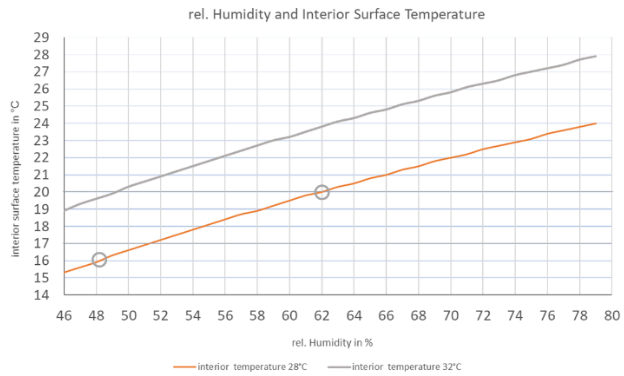


Figure 10. Maximum Relative Humidity and Interior Surface Temperature without Condensation

Technically, with a highly efficient window, the relative humidity in the space can set up to almost 80%; however, to prevent building envelope material damage the relative humidity is set to a maximum of 64 %.

One common way of increasing the inside surface temperature is to continuously blow warm air onto the inside surface of the windows. This results in additional heating and fan energy, which is not captured in the energy model. A more energy efficient way of achieving a warmer inside surface temperature is to have better insulated windows.

Pool Space Design Measures

In the proposed design, the air temperature setpoint for the pool space is 28ºC and the highest relative humidity setpoint is 47% with the proposed windows (U-0.35/USI 2.0). With a Passive House performance window (e.g. U-0.14/USI 0.8), the inside surface temperature is warmer and the relative humidity setpoint can be 64%. Therefore, we propose to implement the following measures for the proposed design:

1. **Passive house windows:** Interior surface temperature of window will be warmer; therefore, the space can have higher relative humidity setpoint
2. **Humidification setbacks at night:** Humidity setpoint is 58% during the day and increased to 64% during unoccupied times. This will act as a "pool cover" and lower evaporative losses of the pool water.
3. **Variable airflow:** Airflow can vary between 15%-100% of the maximum rate (i.e. 6 ACH) as long as it can maintain the temperature and relative humidity setpoints.

The design measure results in an estimated whole builidng TEDI value of 231 kWh/m^2. Furthermore, this measure will provide additional fan energy savings as the supply airflow rates would be lower and there is no longer the need for dedicated blowers for the windows.

Residential TEDI Reduction Measures

The measures in this category is specific to the residential tower only. In addition to the TEDI target for the whole building, there is TEDI requirement specific to the residential tower (i.e. 30 kWh/m^2). Currently the proposed design meets that target by achieving a TEDI value of 29 kWh/m^2; however, TEDI reduction measures were investigated to explore opportunities to increase the building window area on the east and west façade. Table 4 shows the various options investigated for the roof, external wall, windows, WWR, and heat recovery effectiveness. WWR for the south and north side is set to 30%.

Table 4. Residential: Design Measures.

Input Parameter	Options
Roof R-value (K·ft²/Btuh)	20, 30, 40 [RSI 3.5, 5.3, 7.0]
External Wall R-value (K·ft²/Btuh)	5, 7, 10, 15, 20 [RSI 0.9, 1.2, 1.8, 2.6, 3.5]
Window U-Value (Btuh/K·ft²)	0.25, 0.35, 0.45 [RSI 1.4, 2.0, 2.6]
West WWR (%)	30, 40, 50
East WWR (%)	30, 40, 50
Heat Recovery (% effective)	0, 75

Figure 11 shows a full set of results of every combination of EEMs investigated (i.e. 810 simulations). Each line represents one simulation. The first six axes starting from the left represent the input parameters that were varied in the analysis. The last axis on the right shows the resulting TEDI value of the simulation. A Design Option is a specific combination of measures. TEDI values for the Design Options range from 10 kWh/m^2 to 84 kWh/m^2.

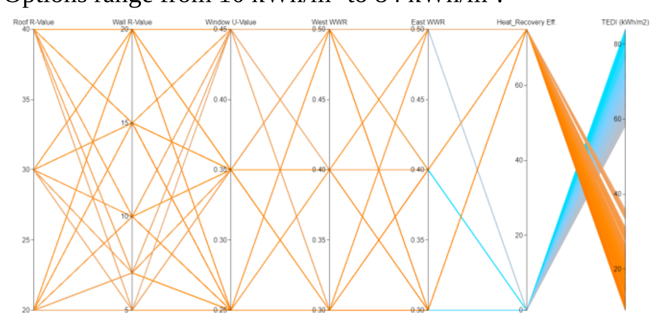


Figure 11. Parametric Design Analysis – All Results

Figure 12 shows the Design Options that meet the TEDI requirement for the residential tower (i.e. 30 kWh/m^2). From the selection options, we can see that heat recovery with a 75% effectiveness is critical to achieving the TEDI target.

Figure 13 shows the Design Options that meet the TEDI target and has the proposed roof and wall values (i.e. R-20 [RSI 3.5] and R-5 [RSI 0.9], respectively). This represents an ASHRAE 90.1-2010 code compliant roof and a typical metal framed external wall assembly with thermal bridging from balconies and other transitions considered. In this scenario, the window must have an overall U-value of U-

0.35 (e.g. a high performing double-glazed metal framed window). This is easily achievable in the design; therefore, the proposed design for the envelope is enough to achieve the TEDI target.

Figure 14 shows the case with the proposed envelope and the high WWR values. The resulting TEDI value is 29 kWh/m^2, which meets the target. This shows that the WWR on the east and west façade can be up 50% while still meeting the TEDI target.

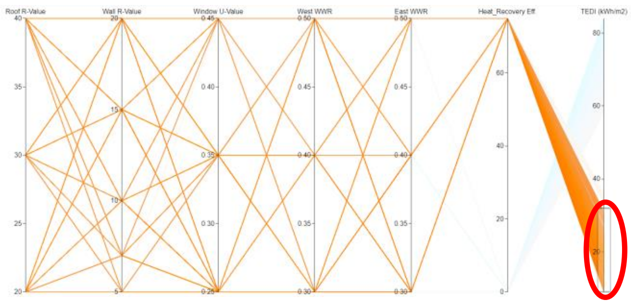


Figure 12. Design Options - Meets TEDI Requirement

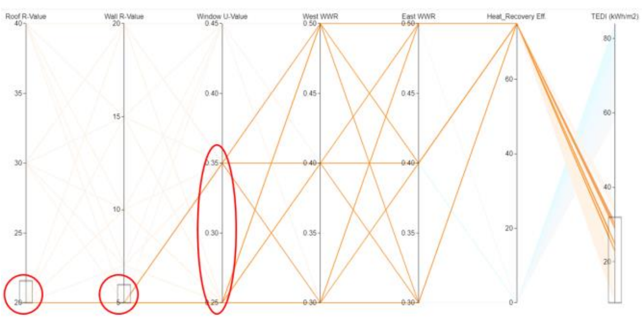


Figure 13. Design Options – Proposed Roof & Wall

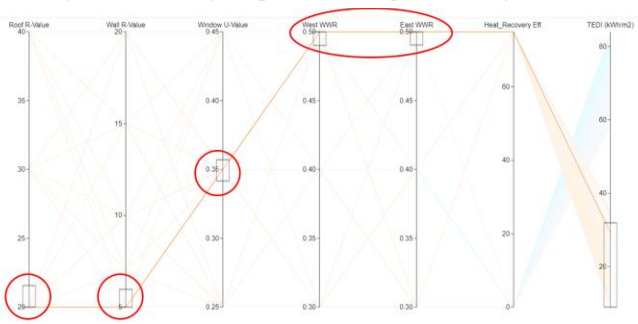


Figure 14. Design Options - Highest WWR

From this analysis, we conclude that:

1. To meet the residential TEDI target, HRV with effectiveness of 75% is required.
2. Acceptable Glazing Percentage:
   - Up to 50% WWR on east and west side
   - Up to 30% WWR on south and north
3. Proposed roof, wall, and window construction are acceptable.
4. Higher WWR values may be possible if thermal broken balconies are implemented.

Natural Ventilation Study

The residential tower does not have mechanical cooling and is designed to be passively cooled. A natural ventilation study has been performed to ensure that spaces in the residential tower are not overheating. In this study, natural ventilation is modelled in the energy model following the energy modelling guidelines of the CoV and NECB. MacroFlo (within IES) is used to define opening parameters and control strategy. A minimum and maximum outdoor air temperature band is set up when the windows are open based on the thermal comfort band. The overheating metric is set up based on the method in ASHRAE 55-2010 Section 5.3. It uses the local weather and assumed indoor air velocity to determine monthly overheating thresholds (i.e. 80% Acceptability Limits) using the adaptive comfort model. It tests the thresholds against the hourly indoor temperature for each scenario to get the overheating hours.

Figure 15 shows air temperature of the warmest residential unit with and without natural ventilation. Without natural ventilation, the unit reaches temperatures of 38ºC in the summer and struggles to be below the 80% Acceptability Limits. However, with natural ventilation, the unit is significantly cooler and meets the thermal comfort requirements. Based on the simulation results, the temperature in every residential unit does not exceed the 80% Acceptability Limits for more than 200 hours.

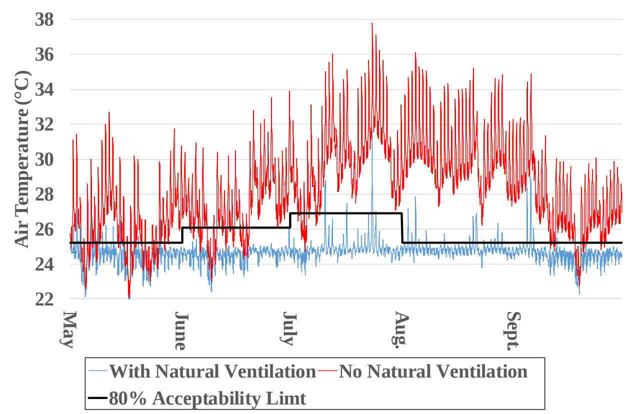


Figure 15. Air Temperature of Warmest Residential Unit.

However, for internal spaces with higher internal gains, such as the offices and multipurpose rooms, overheating is a problem. As it is hard to introduce natural ventilation into the internal spaces, a strategy of increasing the outdoor air ventilation rate in the summer is analysed to mitigate the overheating effect.

As presented in Table 5, overheating in the multipurpose room can be avoid if its outdoor air ventilation rate is doubled during the summer. Similarly, the ventilation rates in the office needs to increase by six times to avoid overheating. Although these high ventilation rates may not be comfortable for the occupants, a better arrangement of the supply air diffuser could potentially mitigate the problem. Alternatively, mechanical cooling can be implemented into the design for overheated spaces.

Table 5. Overheating Hours in Residential Tower.

	Overheating Hours		
Strategy	***Target***	***Office***	***Multipurpose***
ASHRAE 62.1 Ventilation Rate	*<200*	*1216*	*223*
2 x Ventilation Rate	*<200*	*920*	*110*
6 x Ventilation Rate	*<200*	*189*	*N/A*

Discussion

The new rezoning policy and BC Step Code requirements have significantly changed the building design practice in Vancouver, Canada. Before this policy, it was only required for the building design to with the ASHRAE 90.1 or NECB code. Either paths consist of relative comparisons to a "baseline" or "reference" building in terms of energy cost or energy savings. The new policy requires that the building design meet specific TEUI, TEDI and GHGI targets for residential, retail, hotel, and office buildings. New modelling guidelines (City of Vancouver, 2018) were also introduced by the City, which provide specific model inputs that are missing from the ASHRAE 90.1 or NECB modelling guidelines, as well as introduce thermal comfort requirements for passively cooled buildings.

These new performance targets have added a layer complexity to the design process. Every measure that is considered must be weighted in terms of energy, thermal demand, GHG emissions, and financial implications. For a complex building type like a mixed-use recreational building, there is an added challenge of meeting ASHRAE 90.1/NECB based relative targets for some building parts and fixed value targets for others (e.g. residential). Furthermore, there is the additional requirement of maintaining thermal comfort in passively cooled spaces. Hopefully, as the BC Step Code and Green Building Rezoning Policy evolves, we will have fixed targets for a greater variety of building types. This would make the analysis process more straightforward.

Conclusion

In this work, we have shown how to successfully use various whole building energy simulation tools to address an array of performance and thermal comfort requirements for designing a new mixed-use recreational facility.

For example, a heating and cooling load analysis can determine the key energy consumers and provide us with a good understanding of where we can potentially improve the building design. Parametric Design Analysis is a useful tool is determining which combination of EEMs are the best for the project by considering all metrics and ensuring that the optimal design can be achieved. Lastly, specialized stand-alone models can be used to investigated more complex EEMs such as pool control optimization or natural ventilation studies.

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