BUILDER INSIGHT

BC HOUSING
RESEARCH CENTRE

FACTS AND FIGURES

Construction timeline: November 2023 – late 2025

Construction budget: $54.9 M

Residential Units: 123

Site Area: 2,968 m^2, 31,945 ft^2

Total Gross Floor Area: 13,039 m^2, 140,334 ft^2

Net Floor Area: 10,446 m^2, 112,433 ft^2

Building Height: 22.64 m, 74.29 ft

Volume of Mass Timber: 1,194.67 m^3 of CLT

Annualized Whole Life Carbon Emissions: 7.8 $kgCO_2e/m^2$/year

Total Energy Use Intensity: 49 kWh/ m^2/year

PROJECT TEAM

Owner: More Than A Roof Housing Society

Land: Non-Market Housing Development & Operations

Architect: PUBLIC Architecture

General Contractor: Kindred Construction Ltd.

Owners BIM Consultant: Summit BIM

Design BIM Consultant: BIMOne

Construction BIM Consultant: Modelo Tech Studio

Structural Engineering: Wicke Herfst Maver Consulting Inc.

Mechanical and Electrical: Introba

Fire Suppression: Introba

Energy Modeling: Introba

Passive House Consultant: Introba

Embodied Carbon Modeling: Introba

Civil: Core Group Civil Consultants Ltd.

Landscape: Matthew Thomson Design Ltd.

Building Code: GHL Consultants Ltd.

Building Envelope: Morrison Hershfield

Acoustical: BKL Consultants Ltd.

Passive House Certification: Steven Winter Associates, Inc.

Elevator: GUNN Consultants

Project Management: CPA Development

Research Management: Scius Advisory

KEY STAKEHOLDERS

City of Vancouver
BC Housing
City of Vienna
Rüdiger Lainer + Partner

Bulletin No 7 | Vienna House

Sustainability and Resilience

Vienna House is a National Housing Strategy project that demonstrates sustainability and innovation in construction. The project will be Passive House certified. It is the first non-market multi-family housing project in B.C. to use Building Information Management (BIM). BIM was used throughout concept design, project delivery and facility management.

The seven-storey mass timber and lightwood frame hybrid building will provide 123 units ranging from studio to four bedrooms. It is an efficient mid-rise building type, with the potential for it to be recreated in B.C. and across Canada. The project has a counterpart housing project in the City of Vienna, Austria. This provides a unique opportunity to share knowledge and best practices in housing design. It will be subjected to acoustical and vibration testing prior to occupancy and will be monitored for ongoing environmental and structural performance.

Figure 1. Rendering of Vienna House from Stainsbury Ave. (source: PUBLIC Architecture).

This bulletin series describes innovative technologies and processes of the Vienna House project. Find them all in the BC Housing Research Centre Library.

These bulletins discuss the Vienna House project as construction is getting underway. Completion is expected in November 2025.

Sustainability and Resilience Objectives

The Vienna House team set forth objectives in a Project Charter to not only increase the supply of affordable housing, but to do so in a way that is sustainable and resilient (see Process Innovation insight). To address sustainability, Vienna House is designed as a Near Zero Emission Building. This will cut carbon emissions while increasing comfort for occupants. It will be Passive House certified, which is the equivalent to Step 4 of the BC Energy Step Code.

Resilience to extreme weather conditions is sometimes considered to be at odds with sustainable design, requiring more carbon-intensive materials or higher levels of available heating and cooling. Storms that deliver unprecedented wind and rainfall levels that cause damage to buildings and infrastructure are becoming more common. Between June 25 and July 1, 2021, British Columbia experienced the first "heat dome"– a high-pressure weather system that traps heat – causing record-high temperatures across the province reaching as high as 49.6 degrees C.

Research from the Pacific Climate Impacts Consortium (PCIC) predicts that temperatures and precipitation amounts in British Columbia will continue to rise in the coming years.[1] However, the extent of that change is unknown and is dependent upon the release of greenhouse gases (GHGs) and aerosols into the atmosphere. Modeling from PCIC indicates multiple scenarios are possible for rise in mean temperature in British Columbia (Figure 2). For the City of Vancouver, this results in the median number of days with temperatures higher than 30 degrees C per year rising. The median number of days was one in the 1990s and could rise to between six and 29 days by the 2050s. The number of nights per year with temperatures not dropping below 16°C could grow from six nights in the 1990s to 43 to 92 nights by the 2050s. The nighttime temperatures are especially concerning because buildings may not cool in the evenings as they have historically, and therefore will not have time to recover from the previous day's overheating. This can leave occupants more exposed to extreme heat and at risk to resulting illnesses. Residents with underlying health issues are particularly vulnerable.

Temperature Change in British Columbia
(vs. 1971–2000 baseline)

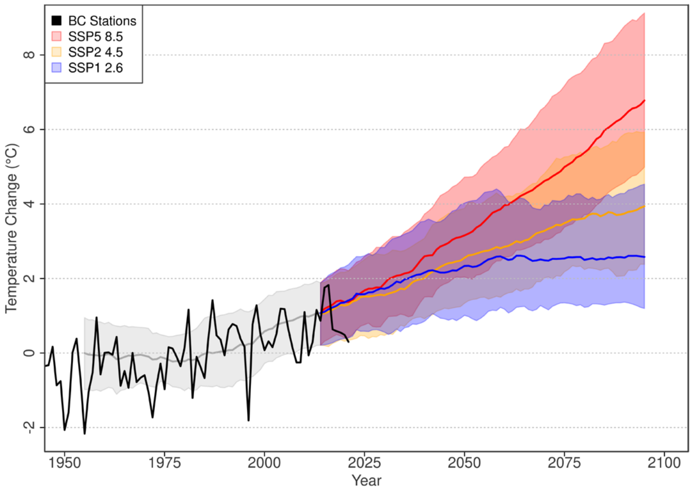

Figure 2. Projected change in mean air temperature in British Columbia (source: Pacific Climate Impacts Consortium).

Precipitation Change in British Columbia
(vs. 1981–2010 baseline)

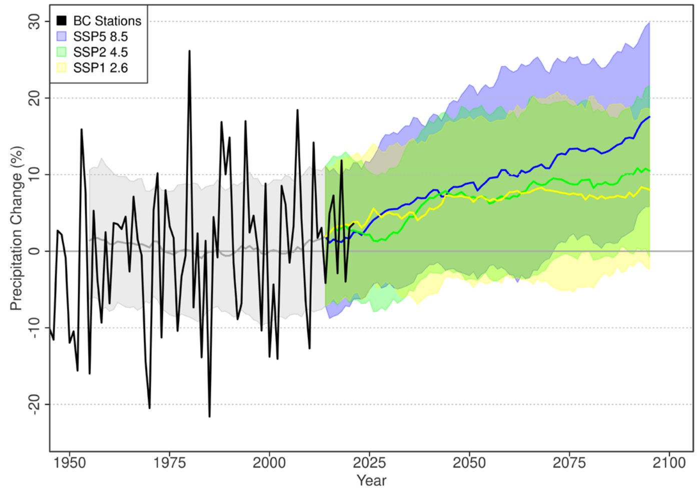

Figure 3. Projected change in total precipitation in British Columbia (source: Pacific Climate Impacts Consortium).

[1] pacificclimate.org/sites/default/files/publications/CityVan_rca_updated_120723.pdf

The predicted rise in precipitation modelled by PCIC (Figure 3) means that greater attention to stormwater mitigation plans and resilience to protect against flooding will become increasingly important. While annual snowpack could decrease between 45-84%, heavy rainfall could increase by 8-28% and occur 30% more frequently.

In addition to extreme temperatures and precipitation, the increasing prevalence of forest fires in British Columbia will continue to impact air quality, especially during dry, hot summer months when windows are often open for cooling. Closing windows to keep out smoke will also contribute to overheating.

Sustainable building practices will help limit the impact of the changing climate in the predictions. However, homes that are built now must be sufficiently resilient to provide a safe and comfortable space for residents during weather extremes, and do so in a way that does not contribute further to the problem. To do this, sustainability and resilience practices must work together to provide safe and comfortable housing.

Mobilizing Building Adaptation and Resilience (MBAR)

The MBAR initiative at BC Housing helps building owners to identify and address the impacts of climate change and natural disasters on buildings and the people who reside in them. Expertise and resources are provided to assist with design considerations of air quality, chronic stressors[2], fire, flood, heat waves, power outages, seismic events, severe storms, and wildfires. The MBAR program runs pilot projects to support professional development for those who design, build, and renovate buildings to create more resilient homes that can withstand impacts of climate change.

As an early participant in this initiative, the Vienna House team worked with MBAR experts to identify natural hazards for the site based on 2050 climate data, opportunities for resilience, occupant essential needs and potential adaptation strategies. Additional information about these workshops is available in the Process Innovation insight.

Climate Considerations for Design

Choosing to design Vienna House to meet the Passive House standard addresses both sustainability and resilience concerns. Passive design offers thermal resiliency to temperature and humidity extremes due to ultra-low infiltration levels and superinsulation. It also delivers longer building durability by preventing condensation within the building envelope assemblies.

To meet performance limits defined by the Vancouver Building By-law, City of Vancouver Zero Emissions plans, and Path A of the City of Vancouver Green Buildings Policy for Rezoning, Vienna House is required to meet the following criteria:

Building Characteristic	Requirement	Vienna House Design
Space Heating Demand	≤ 15 kWh/(m²a)	14 kWh/(m²a)
Space Cooling & Dehumidification Demand	≤ 15 kWh/(m²a)	1 kWh/(m²a)
Frequency of Overheating (> 25°C)	≤ 10%	<1%
Airtightness	≤ 0.6 ACH50	0.6 ACH50
Primary Energy Renewable (PER)	≤ 72 kWh/(m²a)	68 kWh/(m²a)

[2] Chronic stressors include freeze-thaw cycles, wind-driven rain, wetting and drying, frost penetration, wind-driven abrasive materials, atmospheric chemical deposition on materials, broad-spectrum solar radiation, and ultraviolet (UV) radiation.

In addition, the Total Energy Use Intensity (TEUI) has been projected to use 49 kWh/m²/year, which works out to a Greenhouse Gas Intensity (GHGI) of 0.5 kg CO_2e/m²/year from building operations. By meeting these criteria, the building will be able to be certified as Passive House Classic. To model this performance, both current (2016) and future (2050) weather models were used.

Embodied Impacts

The City of Vancouver has recognized that the emissions from the operation of a building are only part of the total emissions triggered by the decision to develop housing. The other part are the impacts of upstream and downstream emissions during manufacturing, transportation, and eventual disposal of the building materials. These factors combined make up the 'embodied' emissions of the project. As a result, within the City of Vancouver, Life Cycle Assessments (LCAs) of a building's structure and enclosure are now required as part of the building code (Section 10.4).

To account for the emissions of Vienna House from construction to deconstruction, an LCA based on the data from the BIM model for the completed design was conducted in compliance with the City of Vancouver's Embodied Carbon Guidelines V1.0. The LCA indicated the structure and enclosure are responsible for 2,895 Tonnes of CO_2e, equal to 326 kgCO_2e per square meter.

However, the team recognizes that does not fully capture the full scope of Vienna House's embodied carbon impacts. A closer look to quantify the embodied carbon impacts of the mechanical, electrical, and plumbing (MEP) systems and landscaping is being done to account for this. Preliminary estimates indicate that Vienna House's MEP systems and the refrigerants contained within them are responsible for an additional 973 Tonnes of CO_2e. This value would be even higher if Vienna House was not a Passive House.

Wood, including prefabricated light wood frame walls and Cross Laminated Timber (CLT) floors (see Use of Wood, Prefabrication and Mass Timber insight) and other sustainable choices for materials were chosen to limit the embodied carbon emitted during the construction of Vienna House. While included separately from the LCA results mentioned above (per City of Vancouver's Embodied Carbon Guidelines V1.0), it is anticipated that the wood products within Vienna House will store 1,528 tonnes of CO_2e within the structure of the building for the life of the building – nearly cutting the overall reported emissions of the building in half.

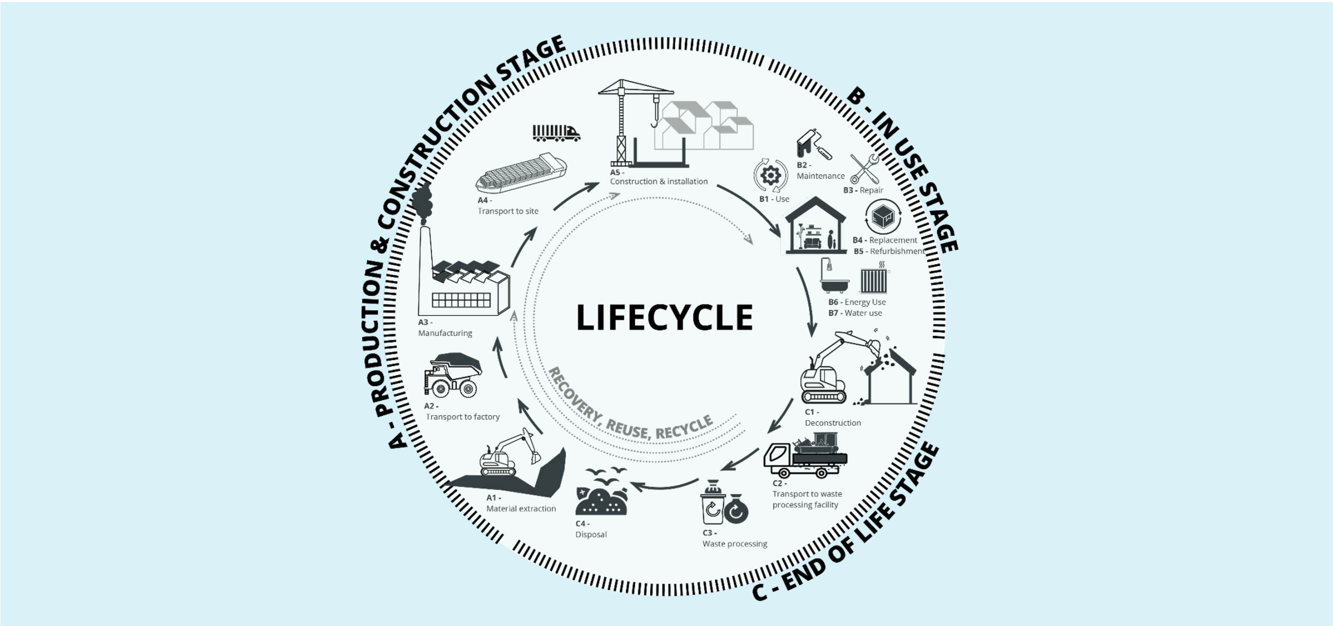

Figure 4. Stages of a Building's Life Cycle per the EN15978 Standard (source: Introba).

Whole Life Carbon

The Vienna House team has also worked to think in terms of the Whole Life Carbon impact of the building (thinking about Operational & Embodied emissions holistically), which is anticipated to be 466 $kgCO_2e$ per square meter over the next 60 years (7.8 $kgCO_2e/m^2/yr$). This is well below that of comparable new buildings in the Province. Even built to a "Strong" level of performance under the new Zero Carbon Step Code, comparable buildings emit around 704 $kgCO_2e$ per square meter. Vienna House is also far below buildings built only a decade ago, estimated to be around 2070 $kgCO_2e$ per square meter.

Acoustics

Vienna House is located on a lot that borders the curves of the SkyTrain elevated rapid-transit rail line to the north and Victoria Drive to the west in a non-rectangular fashion. The SkyTrain operates from 5:00am to 1:30am and expected noise levels on the north side of the building are 72 – 74 dB. Victoria Drive, a busy arterial road, is expected to produce noise levels that also exceed 70dB.

The unusual shape of the site offered an opportunity to design the building with a courtyard, which would allow for the acoustical challenges to be addressed without compromising access to daylight and ventilation for all the units. Units above, and at, the courtyard level have windows to both the exterior of the building and into the courtyard. This provides energy-saving passive cross ventilation when windows are open. Acoustic modeling indicates the courtyard could be 20 dB quieter than the SkyTrain side of the building (Figure 5). Even if the windows facing the SkyTrain or Victoria Drive are closed, the courtyard windows can remain open with noise levels around 53 dB.

External Shading

External solar shades will be added to the south and west elevations of the building to help provide occupants with thermal and visual comfort in the summer months by controlling solar radiation. Passive cooling in this manner requires no energy to operate and will provide better resiliency in the event of power outages. Effective exterior shading can reduce the cooling load, the size and capital cost for mechanical cooling systems, and overall building energy use.

Exterior shading blocks or reduces solar energy before it passes through the glazing. This type of solution for windows can provide over five times more solar protection

Figure 5. Results of acoustic modeling of courtyard design (source: PUBLIC Architecture).

than a typical white interior roller blind. Adjustable exterior window shades, or shutters, are commonly available in the European market as an alternative to active cooling. In Vienna, Austria, they are promoted with subsidies available for retrofit installations in existing multi-unit residential buildings.

A variety of solar shading options were analyzed by the architects. Those selected are similar to the ones depicted in Figure 7. These Spanish style roller blinds are easy to maintain and provide near total sun protection when in the closed position, providing 50% coverage for south-facing surfaces. They are installed on the exterior of the windows and are manually adjusted by the occupant, providing them with a degree of control over the temperature of their units.

As discussed below, thermal comfort analysis found that exterior Spanish style blinds are a simple, effective and affordable means of minimizing solar gains and affording flexibility to occupants, while still allowing natural ventilation beneath the blinds.

Mechanical Systems

Resilience is an important consideration in the mechanical systems design goals, which are to provide optimum thermal and acoustical comfort, and a high level of indoor air quality for building occupants. Space heating is provided by electrical baseboard heaters. It is supplemented by heating the minimum rate ventilation air at the central energy recovery ventilators (ERVs). This process uses the same refrigerant coils used for summer month cooling.

Active cooling systems are designed to complement available natural ventilation. Outside air is supplied to each residential unit at a boosted ventilation rate. This air is cooled within central ERVs using cooling coils served by variable refrigerant flow (VRF) outdoor units. Outdoor air for all units is provided by two central ground floor mounted ERVs, one serving north facing units and one serving south facing units. Both ERVs utilize a cross-flow core heat exchanger to pre-heat/cool the supply air as needed.

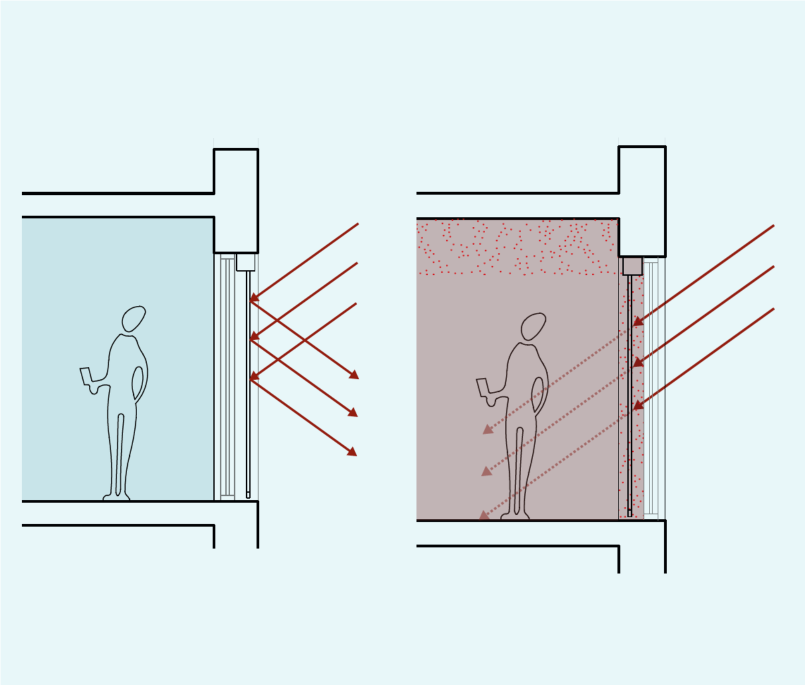

Figure 6. Comparison of solar radiation with exterior vs. interior shading (source: PUBLIC Architecture).

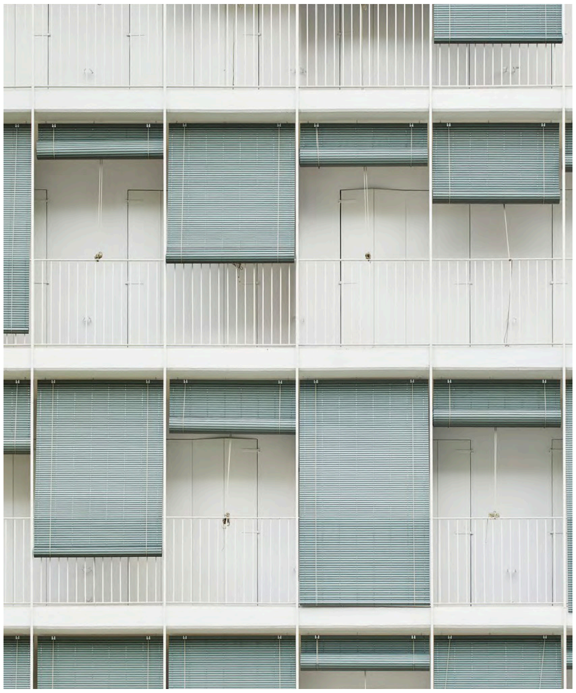

Figure 7. Spanish-style roller blinds similar to those selected for Vienna House (source: PUBLIC Architecture)

Ventilation is distributed to the units from the ERVs with primary ductwork runs feeding multiple supply and exhaust shafts to distribution ductwork in each unit. Air is extracted from the units by the ERVs to maximise energy recovery and to meet the Passive House targets. To support this ventilation design strategy, recirculating kitchen cooker hoods and heat-pump/condensing in-unit clothes dryers have been specified for each unit.

Mixed Mode Ventilation and Cooling

One of the key features of the Vienna House mechanical design is the 'mixed mode' ventilation and cooling system, which combines both mechanical ventilation (MV) and natural ventilation (NV) during warmer months of the year, offering the resiliency of multiple options for cooling instead of a mechanical-only system. Benefits of this system include:

- Redundancy and resilience for events including blackouts, forest-fires and heat waves,
- Direct outdoor air from both active and passive strategies results in greater ventilation rates. This minimizes airborne contaminants and CO_2, improving health and productivity,
- Using NV generates significant cooling and fan energy savings and helps to achieve Passive House targets,
- As the climate becomes warmer and more cooling-dominant, NV occupies a greater proportion of ventilation and cooling hours.

In line with Passive House philosophy, MV will provide minimal levels of cooling until there is demand for 'boost' ventilation for air quality or cooling within a residential unit. Each occupant has the option to open windows to supplement the MV. On mild or warm summer days, the NV provides additional airflow and generates additional comfort, as well as a valuable connection to outdoors. On the hottest days of the year, when external temperatures exceed 26°C, it is recommended for the occupant to close the windows and rely on the MV tempered air only. During a wildfire event, windows will also remain closed to ensure all supply air is filtered.

Thermal Comfort Analysis

The intent of a thermal comfort analysis is to ensure that the mechanical ventilation and NV strategies can meet thermal comfort targets for a 2050 future weather file and are appropriately sized. A well-designed mixed mode

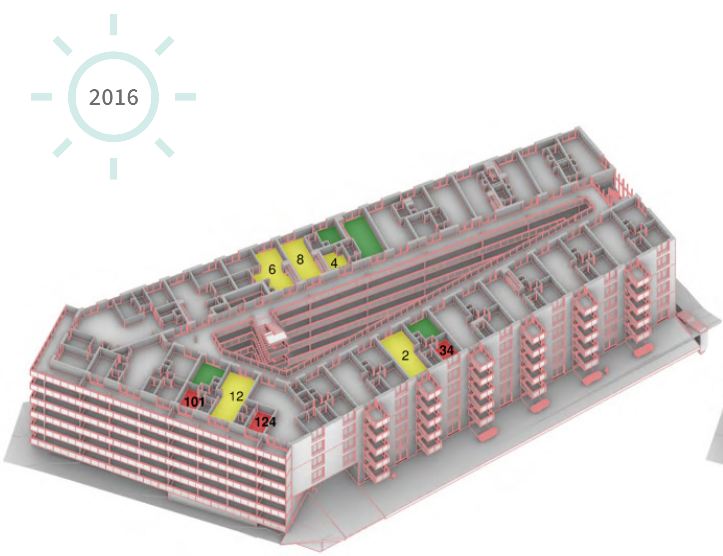

Figure 8. Overheating hours in 2016 with use of exterior blinds, closed windows, and minimal tempered air (source: Introba).

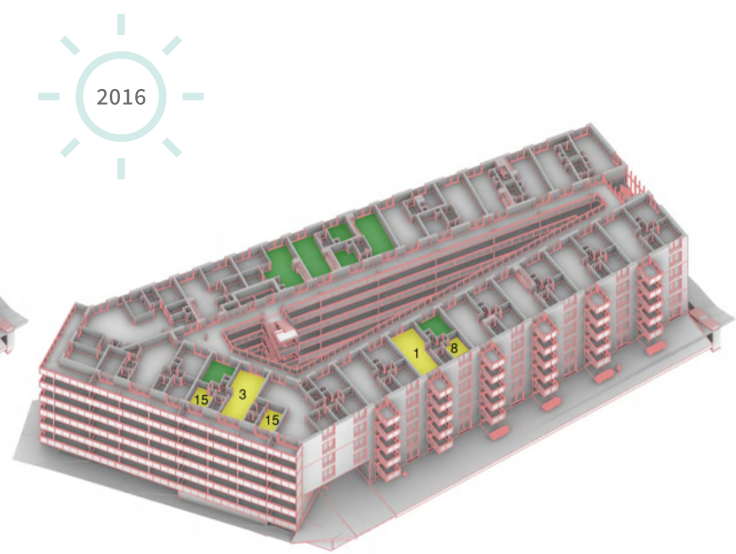

Figure 9. Overheating hours in 2016 with use of exterior blinds, natural ventilation, and minimal tempered air (source: Introba).

strategy has the potential to meet climate resilience goals with comparatively modest active mechanical systems.

The benchmark for compliance is ASHRAE 55 and, per Vancouver Building By-Law (VBBL) requirements, the thermal comfort threshold cannot be exceeded by more than 20 hours. This target applies for a 2016 weather file and is intentionally stringent in recognition of climate-vulnerable populations such as will be living in Vienna House.

The approach for Vienna House follows an adaptive comfort methodology. Occupants will acclimate to higher temperatures during warmer weather if there is a gradual change in temperature. Higher temperatures are tolerable provided they are limited in number and in magnitude across the warmer months.

The analysis was carried out by engineers at Introba using an IES Virtual Environment. They studied the mix of solar gain and the effects of heating similar to recent heat dome events and projected conditions for 2050. By providing robust airflow and blocking solar gains they were able to achieve a comfort level within design thresholds (limit of 20 hours) for the units expected to be most at risk for overheating.

Introba first examined using the exterior solar shading and low levels of tempered air (mechanically ventilated tempered air flow rate of 0.65 l/s/m^2, code minimum + 33% boost) supplied at 14°C but leaving the windows closed. This scenario results in excessive heating for the sixth-floor units facing southwest as shown in Figure 8. Opening the windows reduces this heating to below the design threshold when considering the 2016 climate model as shown in Figure 9.

However, when using the same configuration with the 2050 climate model, which is similar to recent heat dome conditions, the risk of overheating again exceeds the threshold as shown in Figure 10.

Increasing the mechanical ventilation rate to 0.95 l/s/m^2, equivalent to the code minimum plus 95% boost rate, when combined with the exterior blinds and natural ventilation, reduces the risk of overheating to fewer hours, in line with the adaptive comfort threshold (Figure 11).

The analysis showed that this higher boost rate achieved borderline comfort levels in current summers, even if an occupant chose to keep windows closed throughout warmer months of the year. It also showed the top floor performed worse than lower levels which achieved cooler

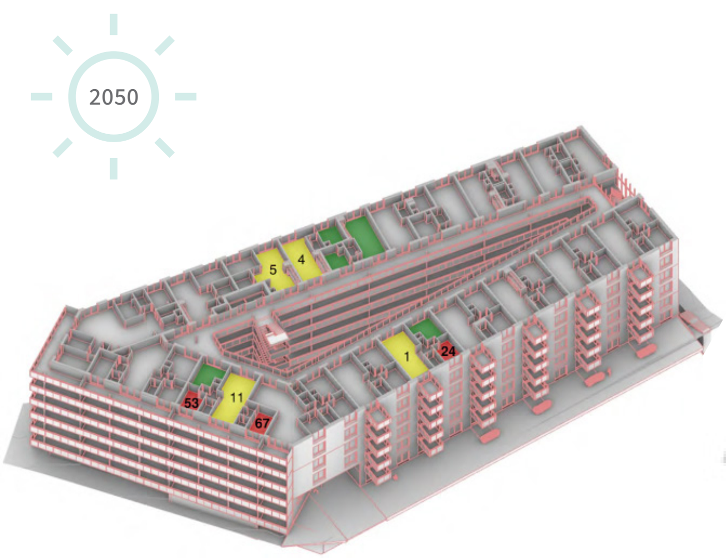

Figure 10. Overheating hours in 2050 with use of exterior blinds, natural ventilation, and minimal tempered air (source: Introba).

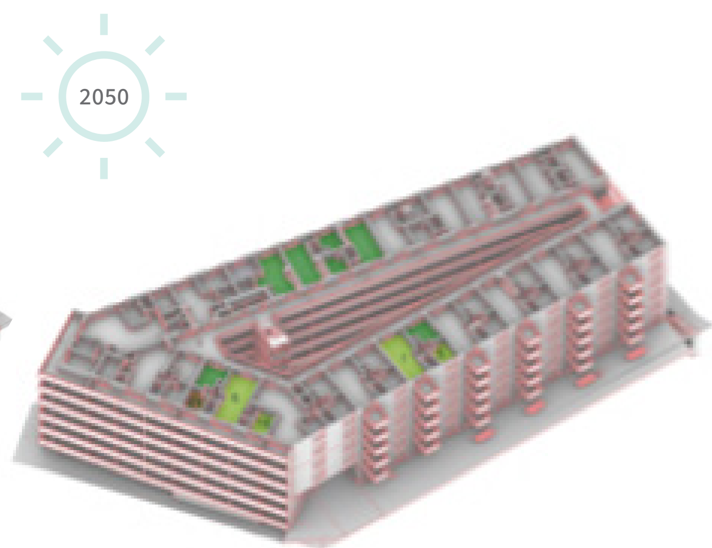

Figure 11. Overheating hours in 2050 with use of exterior blinds, natural ventilation, and increased tempered air (source: Introba).

temperatures. This ability to maintaining reasonably comfortable conditions while keeping the windows closed will provide more resilience if forest fire smoke during heat events degrades exterior air quality.

The mixed mode strategy is designed to meet thermal comfort compliance targets for a severe future weather year based on the 2050 climate model. The thermal comfort analysis was used to appropriately size the complementary passive and active mechanical systems. Appropriate use of natural ventilation and shading generates significant energy savings by offsetting the need for costly and carbon-intensive 'traditional' mechanical cooling systems.

Occupants of Vienna House will be able to adjust the shading, windows and cooling to provide a temperature within their comfort level, providing a healthier environment and the flexibility and resilience to adjust to a changing climate.

Additional Resilience through Design

Vienna House provides further resilience to a changing climate through the landscape design and stormwater management plan (see Landscaping and Public Realm insight). The courtyard has been designed with a blue-green roof technology that collects rainwater before it is slowly released into the city stormwater system. A portion of that water is retained for irrigation of plants in the courtyard. Additionally, a swale-like earthworks system along the southwest edge of the property has been proposed to create a lush biodiverse drainage course that could help slow, cool and filter rainwater, removing any street-born contaminants from Stainsbury Avenue and potentially, the adjacent streets.

NATIONAL HOUSING STRATEGY

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Acknowledgement

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About BC Housing Research Centre

BC Housing's Research Centre works in collaboration with housing sector partners to foster excellence in residential construction and find innovative solutions for affordable housing in British Columbia. Sharing leading-edge research, advances in building science, and new technologies encourages best practice. The Research Centre identifies and bridges research gaps to address homelessness, housing affordability, social housing challenges and the needs of distinct populations. Mobilizing knowledge and research expertise helps improve the quality of housing and leads to innovation and adoption of new construction techniques, Building Code changes, and enhanced education and training programs. Sign up to receive the latest news and updates from BC Housing's Research Centre at www.bchousing.org/subscribe.

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