

# Building Overheating and Air Quality: Considerations in New Construction

April 28, 2020



**BC HOUSING**



**CITY OF  
VANCOUVER**



**BCNPHA**  
BC Non-Profit Housing Association



## Additional webinars on overheating

Webinar	Date	Time
Building Overheating and Air Quality: Considerations in New Construction	April 28	9-10:30 AM PDT
Addressing Overheating in Buildings for Operational Staff	May 13	9-10:30 AM PDT
Retrofits for Overheating Buildings and Poor Indoor Air Quality	May 26	9-10:30 AM PDT

[bcnpha.ca/education/webinars/](https://bcnpha.ca/education/webinars/)



**BC HOUSING**




**BCNPHA**

BC Non-Profit Housing Association



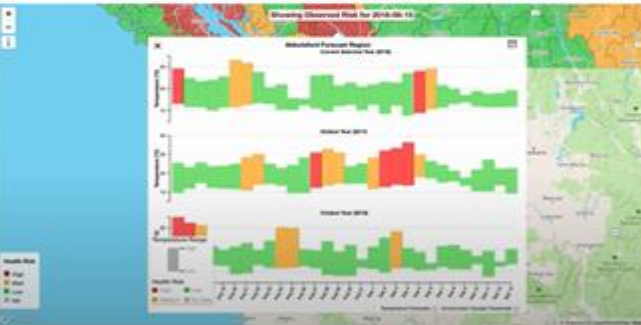
## Previous webinar: Health impacts of extreme heat and poor air quality

Preparing for Extreme Heat Poor Air Quality: 05-14-2019 Watch later




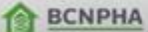
### BC Heat Impacts Prediction System


<https://maps.bccdc.ca/bchips>



Preparing for Extreme Heat and Poor Air Quality Events: Health Impacts

 BC HOUSING

 BCNPHA

 CITY OF VANCOUVER

[bcnpha.ca/courses/preparing-for-extreme-heat-and-poor-air-quality-events-health-impacts-webinar/](https://bcnpha.ca/courses/preparing-for-extreme-heat-and-poor-air-quality-events-health-impacts-webinar/)



**BC HOUSING**



**BCNPHA**

BC Non-Profit Housing Association

# Outline

1. Introduction	Welcome/logistics/introductions	Jackie Kanyuk, BCNPHA
2. Terminology, Context, Resources	<ul style="list-style-type: none"><li>• Designing for a changing climate</li><li>• Implications for housing in BC</li><li>• Introduction to resilient building design</li><li>• Overview of resources: MBAR &amp; Design Guide Supplement on Overheating &amp; Air Quality</li></ul>	Lisa Westerhoff, Integral Group
3. BC Housing Design Guidelines	<ul style="list-style-type: none"><li>• Overheating in housing</li><li>• 1st &amp; Clark MBAR case study, modelling for the future</li><li>• BC Housing Design Guidelines &amp; Construction Standards</li></ul>	Sadia Afrin, BC Housing
4. Passive & Active Design Strategies	<ul style="list-style-type: none"><li>• Passive Design Strategies</li><li>• Active Design Strategies</li></ul>	Chris Doel, Integral Group
5. Questions and Closing remarks	<ul style="list-style-type: none"><li>• Audience questions</li><li>• Closing remarks</li></ul>	Jackie Kanyuk, BCNPHA

# Resilient Housing for a Future Climate

**Lisa Westerhoff**

Principal

[lwesterhoff@integralgroup.com](mailto:lwesterhoff@integralgroup.com)



**INTEGRAL**  
CONSULTING ENGINEERING



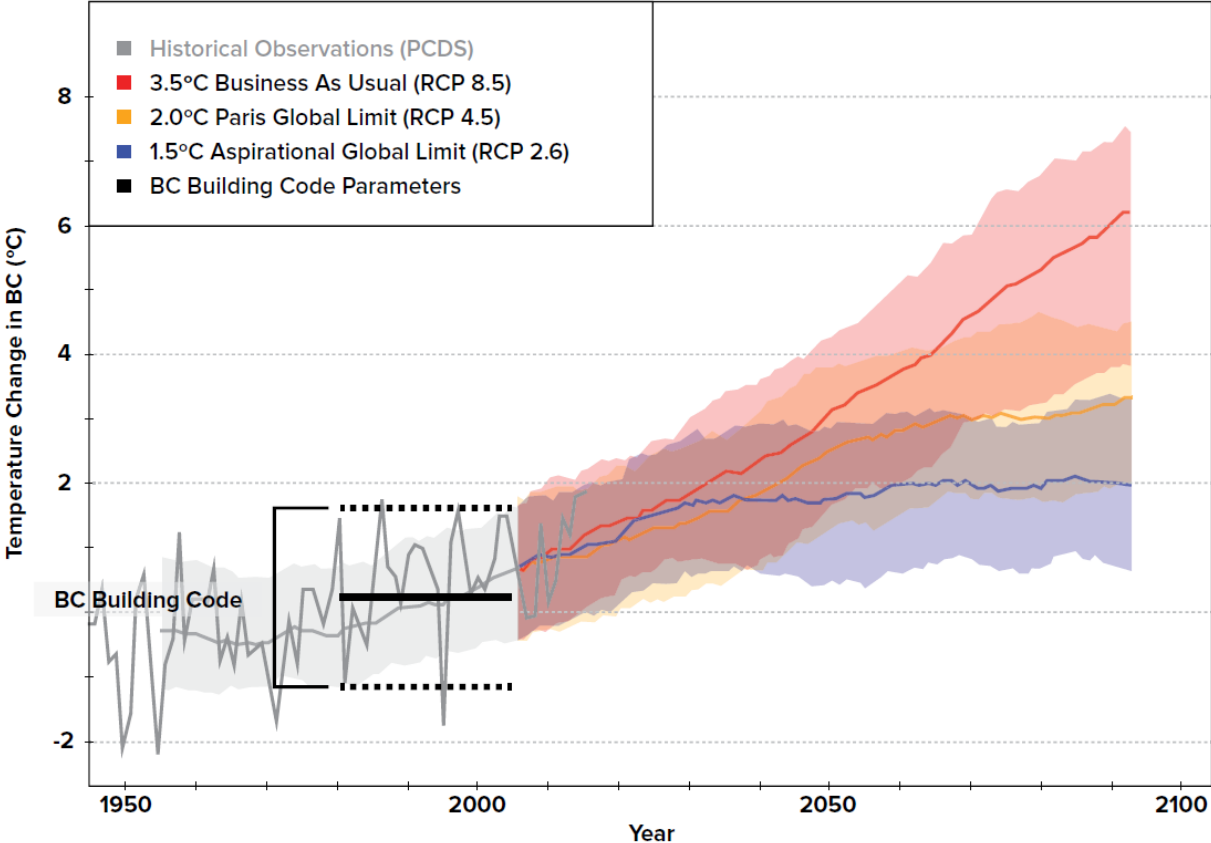
Image Courtesy of Perkins+Will

# Overview of Presentation

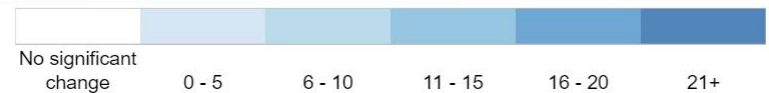
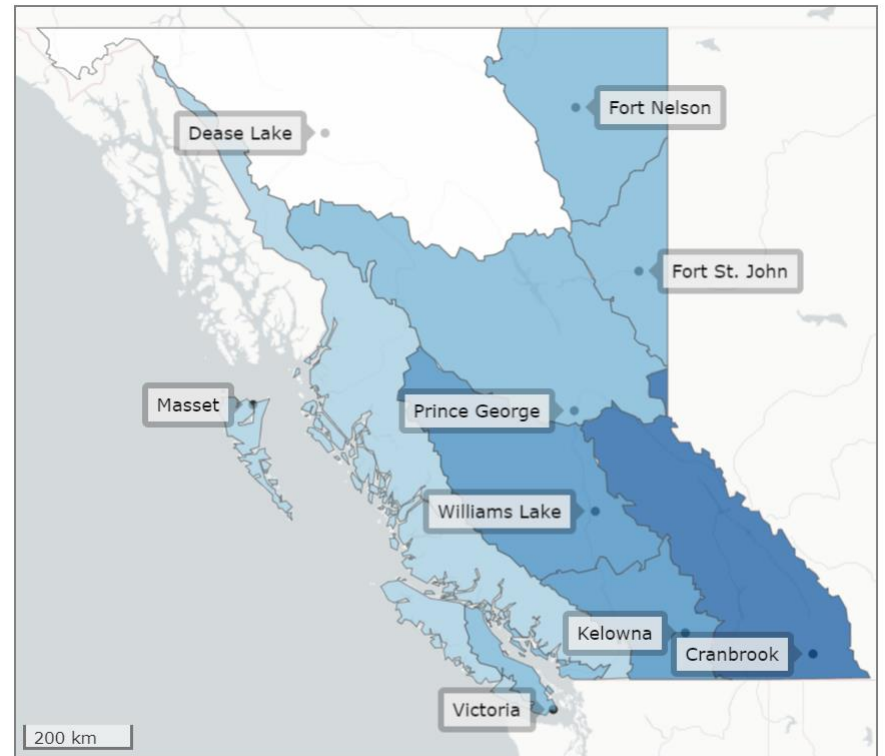
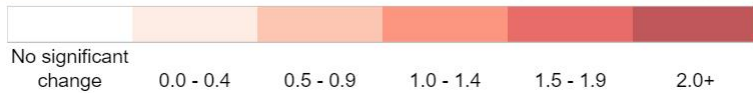
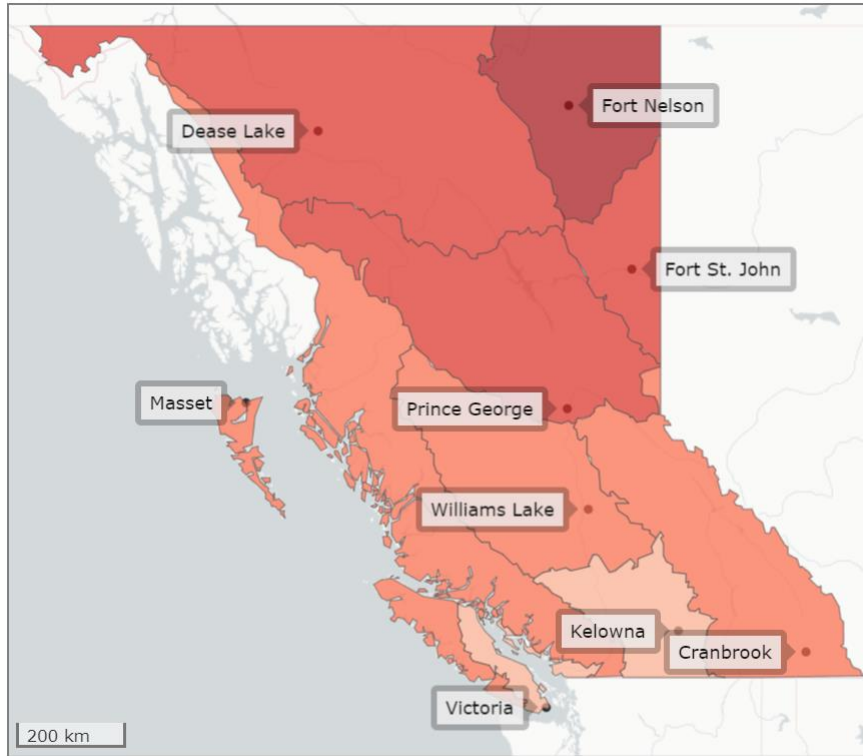
- Designing for a changing climate
- Implications for housing in BC
- Introduction to resilient building design
- Overview of resources



# Designing for the Past

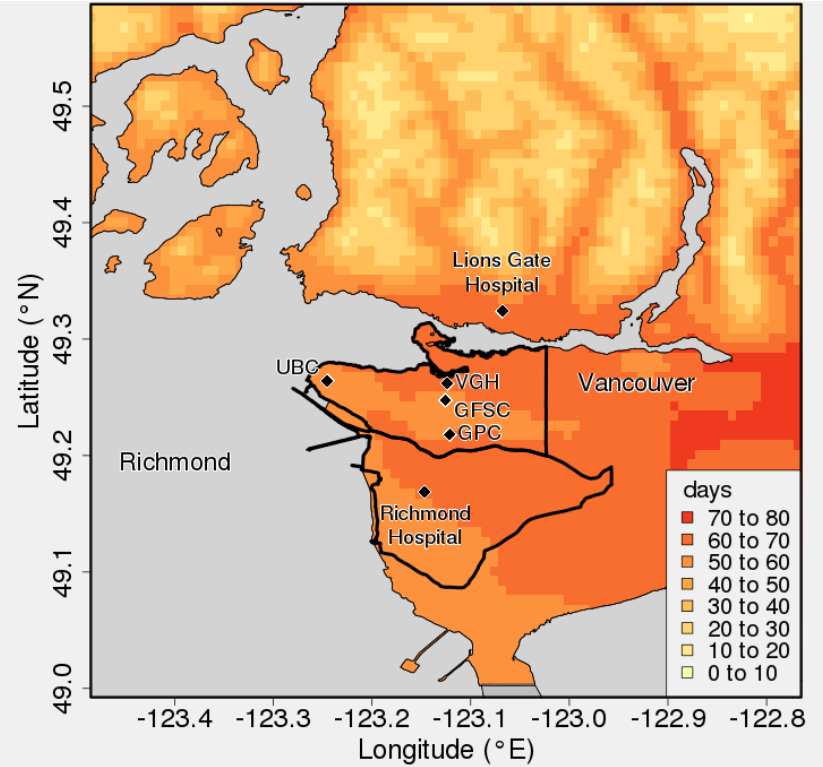
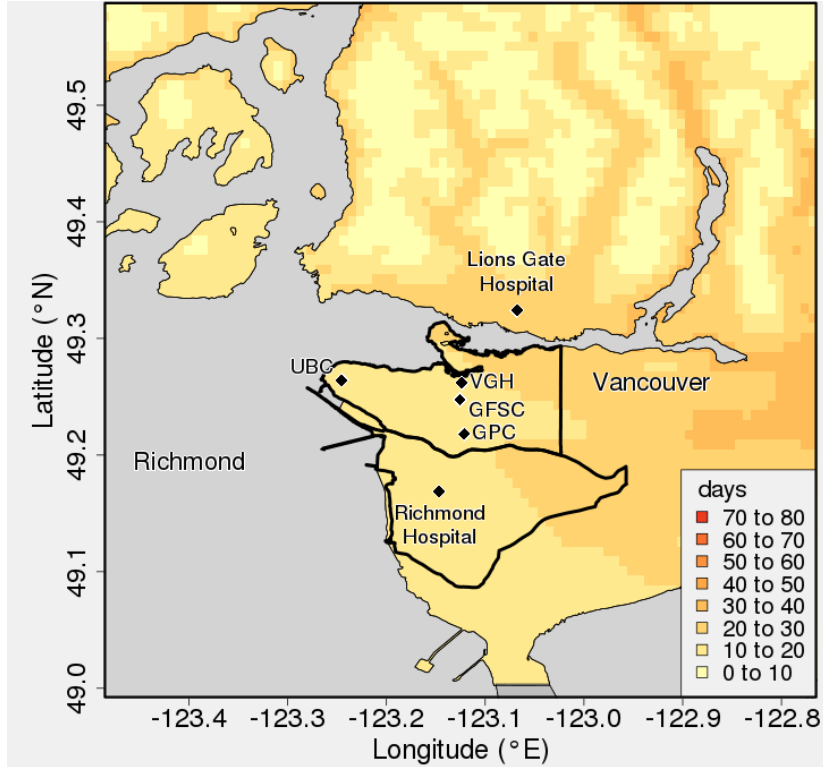


# Observed Changes, 1900-2013



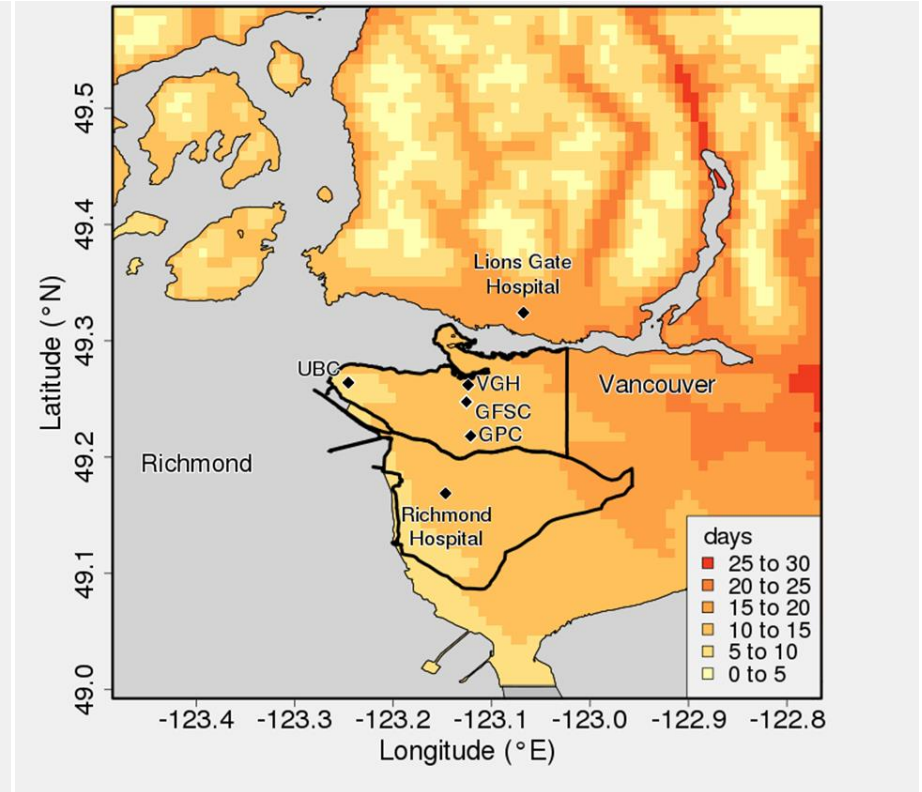


# Projected Increase in Number of Hot Days



**Days above 25°C:** 17 days for 1971 to 2000 □ 51 (36 to 69) days in 2050s

# Projected Increase in Number of VERY Hot Days



**Days above 30°C:** 2 days for 1971 to 2000 □ 12 (6 to 18) days in 2050s

# What Does This Mean for BC?

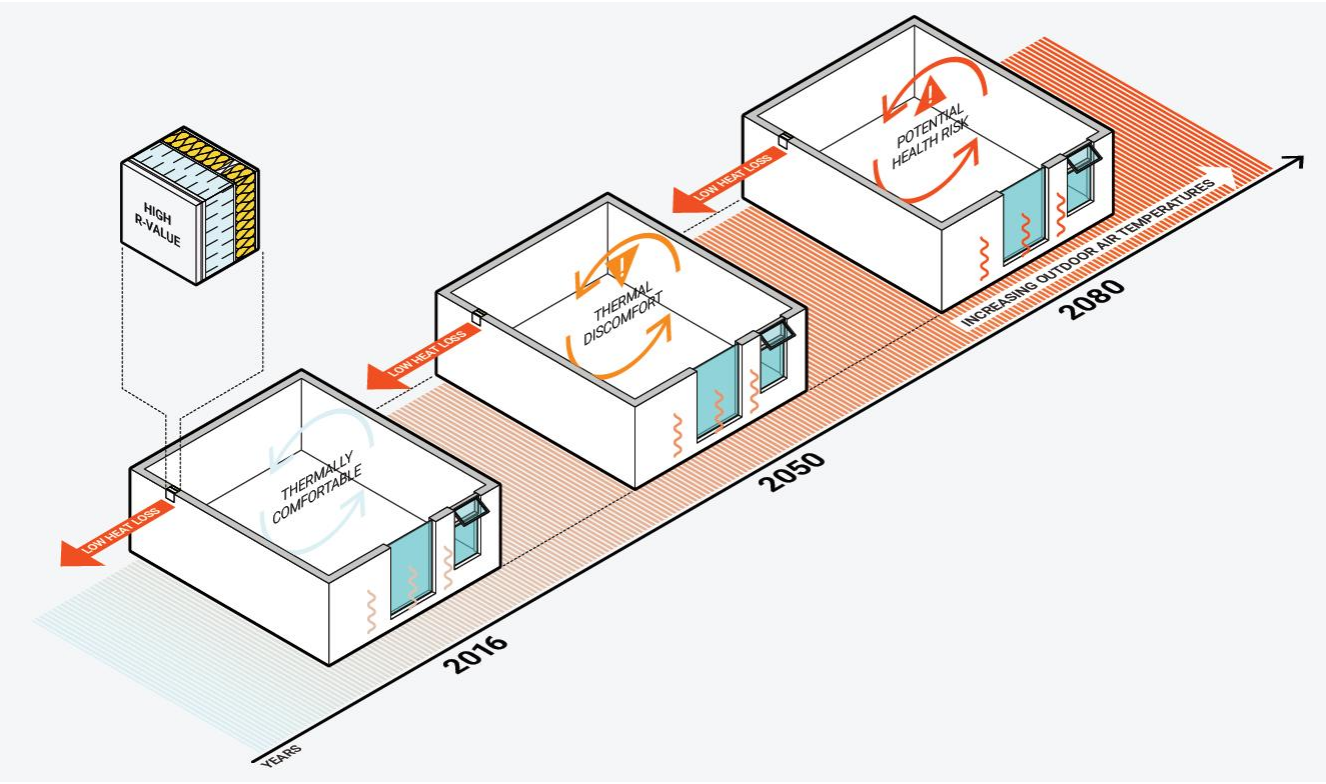
- **Vancouver Island**
  - Similar to Lower Mainland projections
- **Interior and Cariboo:**
  - Hotter and drier with a longer dry season and increased risk of wildfire
- **North:**
  - Increased precipitation in summer but with warmer temperatures

# Risks to Thermal Comfort

Buildings designed for today's climate will be unsuitable for tomorrow's

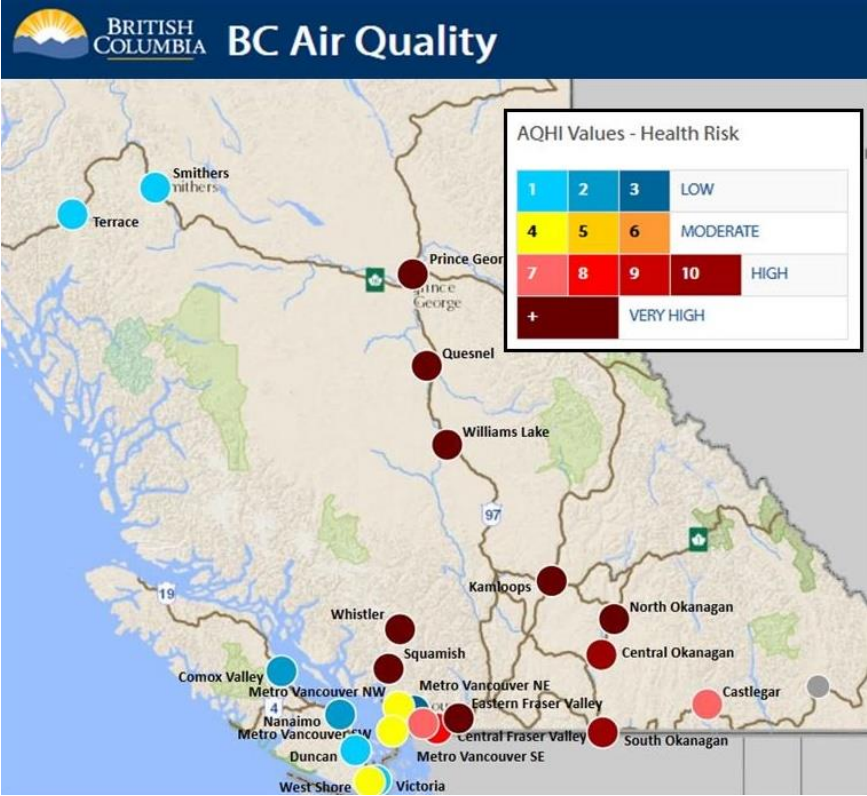
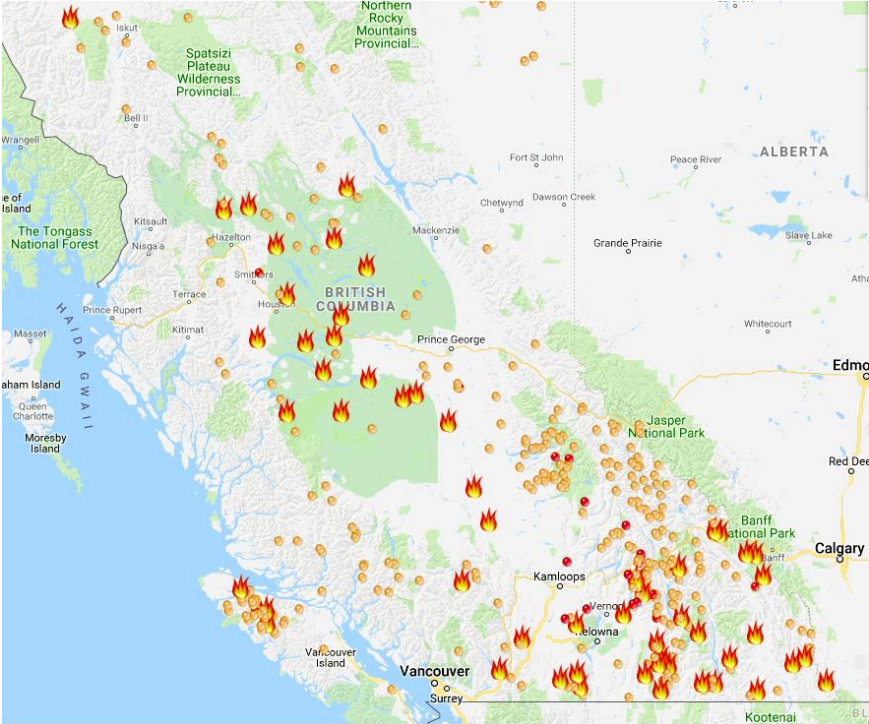
Impacts to **thermal comfort**

Risk of **overheating**





# Wildfires and Air Quality Advisories



# Wildfire Smoke and Air Quality

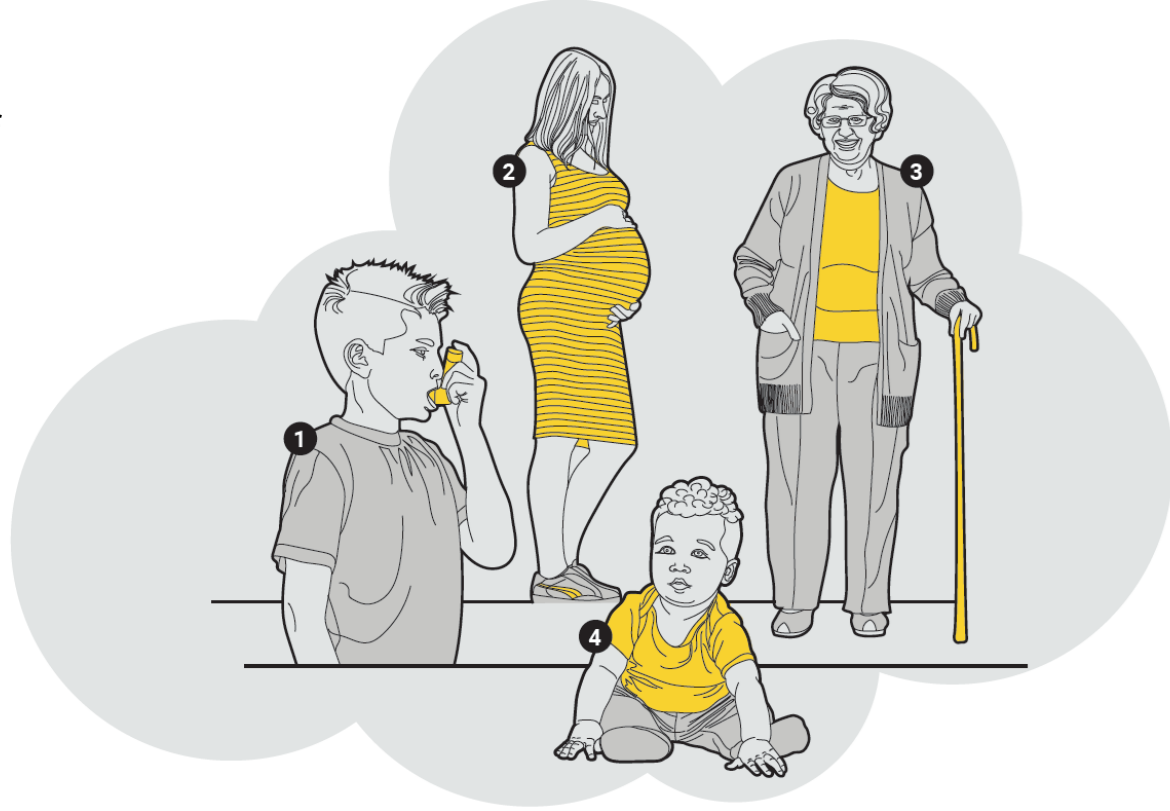
- Wildfire smoke can compound with existing sources of air pollution, including emissions from cars and industry
- Pollen is also anticipated to increase with extended growing season



# Impacts to Occupants

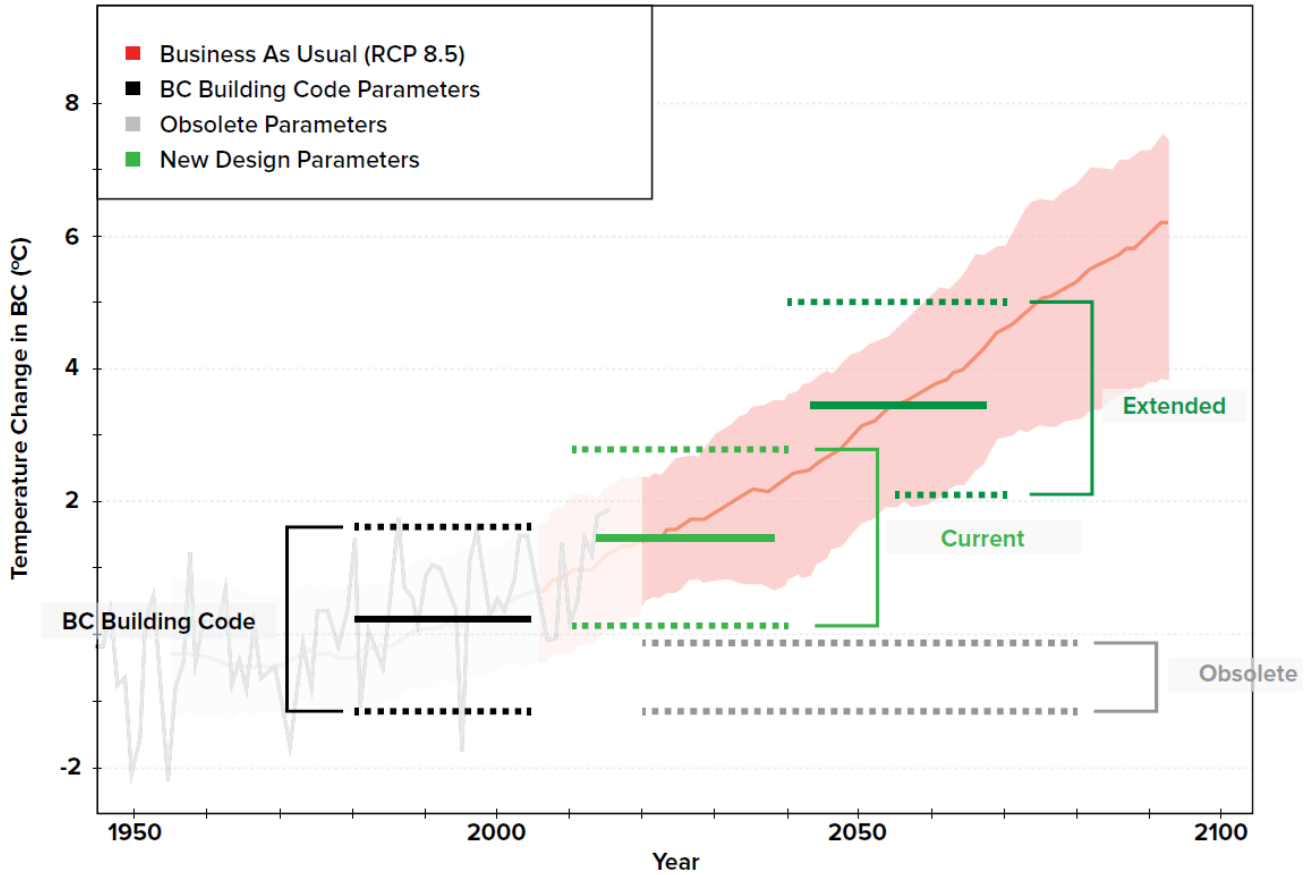
**Low-income households** already bear a disproportionate burden of disease

- Face **higher exposure** (e.g. urban heat island effect)
- **More sensitive** to heat-related illness and death (e.g. older populations, people with pre-existing health conditions)
- **Fewer resources** to draw on to cope





# Designing for the Future



# Adaptation & Resilience

Climate **resilience** or climate **adaptation** is the ability to anticipate, prepare for, and respond to hazardous events, trends, or disturbances related to climate

(and take advantage of opportunities)



# Resilient Housing



## Designed and managed to:

- Reduce vulnerability to climate-related risks
- Enhance personal safety
- Promote social connectedness
- Maintain affordability for residents
- Enhance resilience through the broader community



# Cost-Benefit of Climate Change Adaptation

## Estimates of \$ spent in preparation vs. \$ saved in costs (at community scale):

- Global Commission on Adaptation: **\$1 spent = \$4 saved**
- Federation of Canadian Municipalities: **\$1 spent = \$6 saved**
- Economist: **\$1 spent = \$5 saved**



# Integrating Climate Change Responses

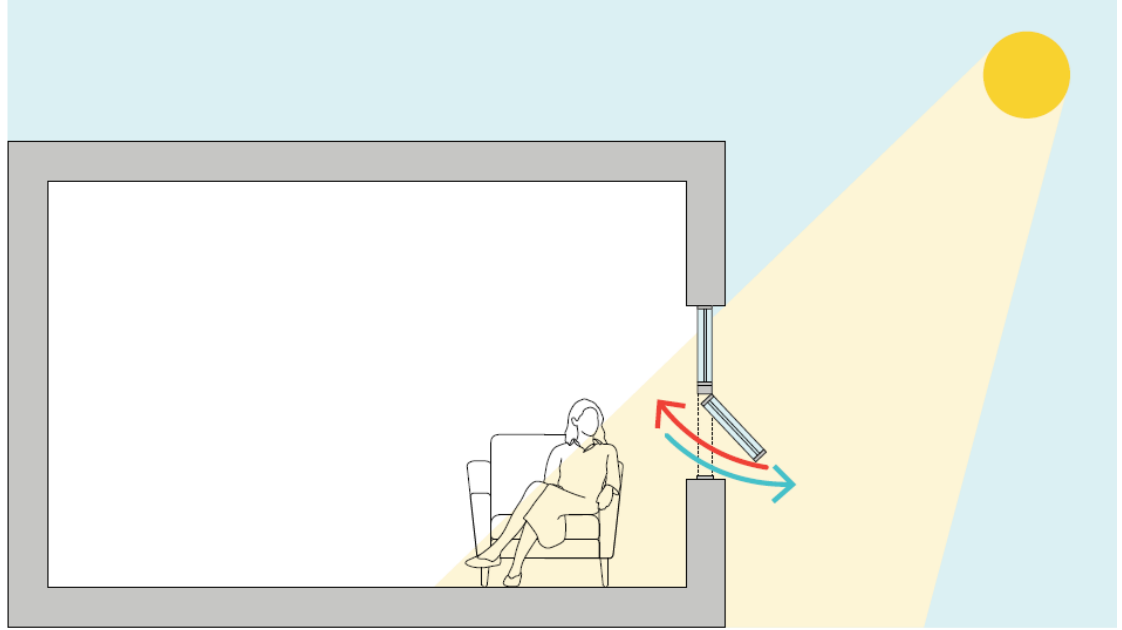
Improved energy efficiency

+

Improved thermal comfort

+

Improved indoor air  
quality



# The MBAR Project



## Mobilizing Building Adaptation and Resilience (MBAR)

- Multi-year, multi-stakeholder knowledge and capacity building project
- Representing over 30 organizations, agencies, and industry partners



# Resilient Building Primers



Housing Assistance ▾ Projects & Partners ▾ Licensing & Consumer Services ▾

Home / Research Centre / Research Library / Residential Design & Construction Guides / Mobilizing Building Adaptation and Resilience (MBAR)

## Mobilizing Building Adaptation and Resilience (MBAR)

Mobilizing Building Adaptation and Resilience (MBAR) is a multi-year, multi-stakeholder knowledge and capacity building project led by BC Housing, with participation and contribution from over 30 organizations, including national, provincial, and local agencies; and industry partners.



### Project Objectives

Through facilitating and piloting sustainable and resilient design and renovation of buildings, the Mobilizing Building Adaptation and Resilience (MBAR) project aims to stabilize communities in a natural disaster. MBAR will help building owners and occupants better protect their investments and adapt to anticipated climate change stresses (higher precipitation, warmer summers, fire-related air pollution) and assist them in preparing for future climate change stresses by providing them with the tools and resources they need to do so.

### HEAT WAVES

**Risks to Buildings, Occupant Safety & Environment**

- Overheating beyond typical comfort conditions
- Electrical system overload due to increased energy usage associated with ventilation and air conditioning systems
- Potential utility service interruption due to increased energy usage
- Increased lighting and communications connectivity
- Risk of heat exhaustion or loss of life due to overheating, dehydration or hyperthermia
- Decreased outdoor and indoor air quality due to smog and associated risk to human health

Design Strategies	Strategy	Cost	Impact	Alignment
Design Strategies	Conduct simulations to explore the thermal performance of individual suites and the building as a whole, focusing on window to wall ratio, window to floor area ratio, window thermal performance and solar heat gain coefficient, wall thermal performance, airtightness, natural ventilation, stack effect and solar orientation	\$	***	⊕
	Use current climatic data for the modelling of thermal performance of the building and individual suites	\$	**	⊕
	Increase thermal mass performance of horizontal and vertical surfaces through the inclusion of exposed concrete floor slabs, exposed brick walls, natural stone tile, avoid carpeting and suspended ceilings	\$\$\$	***	⊕
	Take advantage of thermal masses to allow for night-purging of heat from passive gains	\$	***	⊕
	Identify facades with highest potential for solar heat gains and optimize glazing accordingly (e.g. reduce ratio of glazing)	\$	***	⊕
	Design horizontal and vertical external shading and external operable awnings to reduce incoming solar heat gains along south, east, and west facades	\$\$	***	⊕
	Use high performance insulation and glazing, including higher solar heat gain coefficient fenestration, and low-e coatings to reduce the rate of heat transfer through building structures, and reduce heating and cooling loads	\$	***	⊕
	Include operable windows throughout floorplan layout and common corridors to assist cross ventilation and night-purging of internal heat	\$	**	⊕
	Incorporate operable windows in common corridors wherever security concerns do not pose a risk	\$	**	⊕
	Locate entry spaces in a north-facing area with operable windows (and high ceilings) to act as a cooling refuge area. Design for additional cooling capacity, connect to back-up power, and finish floors with exposed concrete or natural tile	\$	***	⊕
Site Strategies	Identify and incorporate opportunities for cross ventilation during floorplan development to increase air flow without dependence on mechanical systems	\$	***	⊕
	Use shading devices and/or add shading or vegetation to reduce the heat island effect	\$	**	⊕
	Place deciduous vegetation along south, east and west facades to reduce solar heat gains	\$	**	⊕
	Install outdoor water features connected to a gravity-fed source in a location easily accessible to building occupants	\$	**	⊕
	Use high albedo or "cool" roofing materials or vegetated roof systems to reduce internal heat gains	\$	**	⊕
	Use light-coloured building materials to reduce envelope surface temperatures	\$	**	⊕
	Include passive and mixed-mode ventilation strategies to cool internal spaces without dependence on active cooling systems	\$\$\$	***	⊕
	Investigate opportunities to use solar energy technologies to power cooling systems or utilities	\$\$\$	**	⊕
	Use high-efficiency lighting, equipment and appliances to reduce internal heat gains	\$	**	⊕
	Use equipment and furniture with air circulation and temperature control in mind	\$	**	⊕

### HEAT WAVES

**Heat waves are prolonged periods of abnormally hot weather that are often paired with high humidity in maritime climates such as the Pacific Northwest. What is considered a heat wave depends on the degree to which temperature exceed the normal temperature range for the area and season. Heat waves can be particularly intense in urban environments, as the number of heat-absorbing structures and buildings can act to increase overall temperature in what is known as the urban heat island effect. Heat waves are projected to increase in frequency and intensity as a result of climate change, and are projected to have adverse impacts on human health and well-being as risks of overheating increase. Building designers and operators should consider a range of strategies to reduce impacts to health and comfort of building occupants.**

Design Strategies	Strategy	Cost	Impact	Alignment			
Design Strategies	Use high-efficiency lighting, equipment and appliances to reduce internal heat gains	\$	**	⊕			
	Use equipment and furniture with air circulation and temperature control in mind	\$	**	⊕			
	Ensure a minimum of 72 hours of fuel storage (natural gas) for power to refuge area and key services, including building pumps, fans, emergency lighting, and security systems	\$\$\$	***	⊕			
	Establish operations and maintenance procedures and building management systems (BMS) to determine the level of cooling required in extreme heat events	\$	**	⊕			
	Ensure common areas' operable windows are opened at night to allow for circulation	\$	**	⊕			
	Establish agreements on practices to keep cool, including closing windows after noon and opening them at night	\$	**	⊕			
	Ensure building operators and occupants understand how to use thermal mass to mitigate temperature swings and optimize comfort	\$	**	⊕			
	Develop training programs to help staff to be able to identify symptoms of heat stress and associated health complications	\$	**	⊕			
	Power Outages	Air Quality	Fire at the Urban Interface	Relative Cost/ Cost Premium	Relative Impact		
	Severe Storms	Seismic Events	Low	Medium	High	Low	Medium

**Community Benefits**

- Consider the following strategies to help improve the resilience of the community overall:
  - Provide resilient potable water supply in the design to allow for universally accessible drinking water
  - Design amenity rooms to act as cooling centres/refuge areas for at-risk community members (e.g. seniors) and a central location for emergency support and services
  - Ensure refuge areas are designed to foster social connection, mental health, and overall cultural safety
  - Increase tree canopy to help lower local temperatures and provide shading for community members
  - Include public information in building common areas to educate on the common symptoms of health impacts from extreme heat
  - Incorporate greywater recycling and rainwater cisterns for irrigation and plant drought tolerant species to conserve water during heat waves

**Potential Design Conflicts**

- Take care and ensure resilient strategies do not exacerbate vulnerability and other risks
- Passive ventilation strategies that help cool buildings with fresh outdoor air can conflict with strategies used to reduce the impact of poor air quality advisories. Ensure buildings have back-up cooling and ventilation systems that allow for mechanical ventilation when necessary
- Increasing the thermal performance of vertical and horizontal surfaces through the use of concrete floor slabs may pose a risk to seismic resilience overall. Ensure concrete structures are appropriately designed to withstand seismic events.
- Ensure any vegetation used to shade building interiors are planted with fire risk in mind.

**Additional Resources**

- City of Vancouver: Extreme Heat Cool Buildings, A Review of Alternatives to Traditional Air Conditioning
- Government of British Columbia: Current Air Quality Data Map - Air Quality Health Index
- Bureau de planification du Québec: Reducing the Urban Heat Island Effect



# The BC Energy Step Code Design Guide Supplement



LOCAL GOVERNMENT

## BC Energy Step Code Design Guide

A publication of the BC Energy Step Code Council  
and the Building and Safety Standards Branch

January 2018



## BC Energy Step Code Design Guide Supplement S3 on Overheating and Air Quality

June 2019

Version 1.0



ARCHITECTS AND DEVELOPERS



IMAGINE | PERFORM | ACCELERATE | SUSTAIN

SUPPLEMENT S3  
Version 1.0





# Thank you!

**Lisa Westerhoff**

Principal

[lwesterhoff@integralgroup.com](mailto:lwesterhoff@integralgroup.com)



**INTEGRAL**  
CONSULTING ENGINEERING



Image Courtesy of Perkins+Will

# BC Housing Addressing Overheating in New Construction

Sadia Afrin, Sr. Manager - Construction Standards

# Who We Serve

---





We work with about 800 housing providers and help more than 104,000 households in 200 communities across British Columbia

---

# Affordable Housing Portfolio



Low-mid rise - Smither's Passive House, Smither



High rise - Karis Place, Vancouver



Low rise - Hart Haven, Prince George



Mid-high rise  
BC Hydro, Fort St. John

# Climate Change and Overheating

---



# Overheating in Housing Projects

- Warmer summer
- Buildings becoming more air-tight
- Heavily insulated to retain heat
- Uncontrolled solar gain through windows/glazing
- Conventional timber frame construction
- People, appliances, lighting
- Inadequate or poorly controlled ventilation
- Orientation
- Exposed thermal mass

35°C - Danger of heat stress

28°C - Hot

25°C - Warm

21°C - Average house temperature



BC HOUSING



## BC Housing Project: 1<sup>st</sup> and Clark, Vancouver

---

---

- 97 residential units, 51 withdrawal management beds, 20 transition bed and a Social enterprise for indigenous residents
- DP submission May/2019, Construction starts Aug/2020



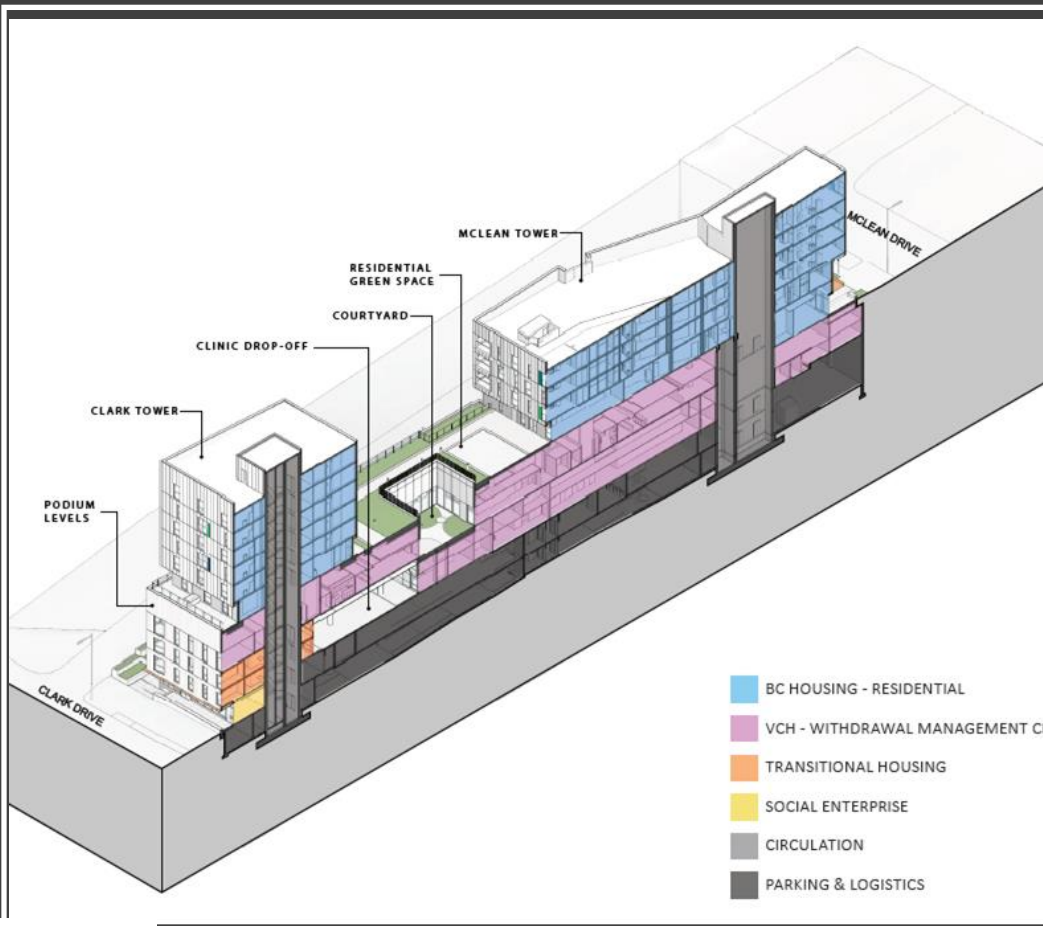
## 1<sup>st</sup> and Clark

---

---

### Passive Strategies

- Massing
- Site and Orientation
- Landscape
- Space Planning
- Wall/window Ratio
- Window Design
- ASHRAE 55 – Thermal Comfort





**1<sup>st</sup> and Clark**

---

**Vancouver CWEC 2016 weather  
file**

**Energy Modelling Guidelines  
version 2.0**

- R13 concrete / R16 wood walls
- Operable windows
- In suite HRVs
- - LED lighting
- - Low flow fixtures

**Step Code 3**

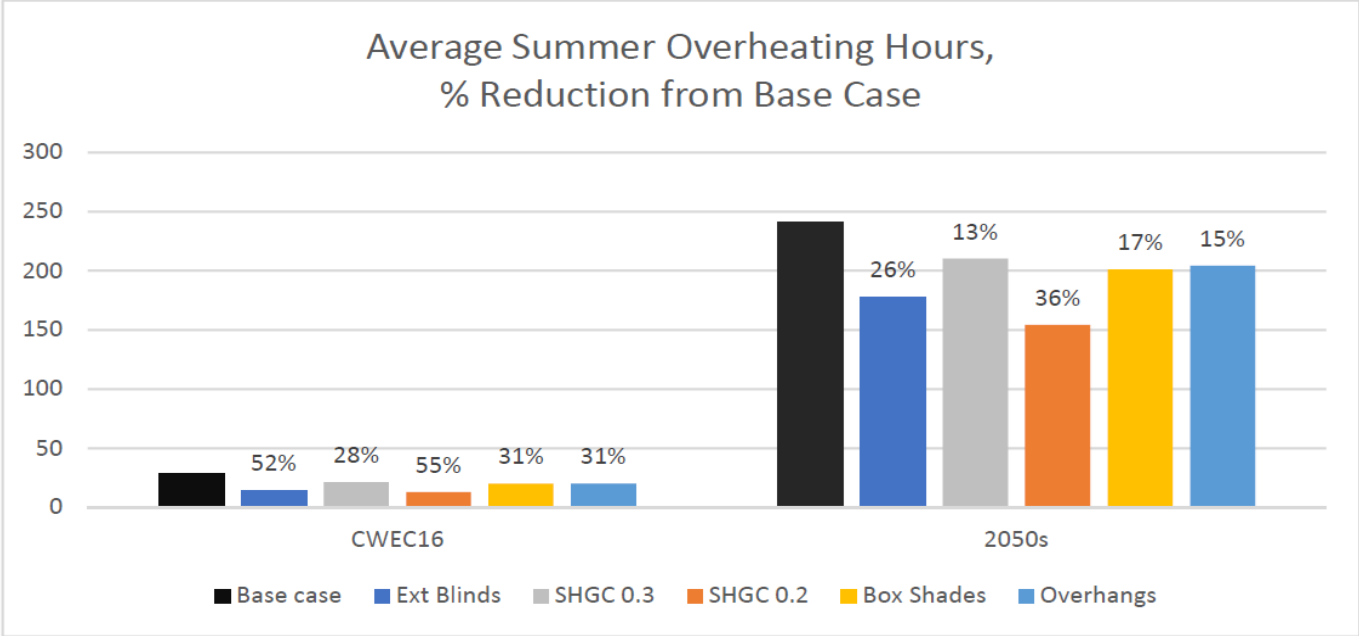
# Simulation to Future Projected Data

## A. Future Weather

Location: Vancouver	CWEC	CWEC 2016	2020s	2050s	2080s
<i>January</i>	3.2	<b>4.2</b>	5.7	5.5	9.1
<i>February</i>	5.1	<b>5.1</b>	6.9	6.6	10.3
<i>March</i>	6.1	<b>6.9</b>	8.9	9	12.3
<i>April</i>	8.7	<b>9.5</b>	11.6	12	14.7
<i>May</i>	11.8	<b>12.4</b>	14.6	15.6	17.4
<i>June</i>	15.1	<b>15.4</b>	17.3	19.4	20.5
<i>July</i>	17.0	<b>17.9</b>	19.6	22.8	23.4
<i>August</i>	17.1	<b>18</b>	19.2	22.6	23.3
<i>September</i>	13.8	<b>15.5</b>	16.3	19.3	19.9
<i>October</i>	9.8	<b>10.2</b>	10.7	12.9	13.6
<i>November</i>	5.3	<b>5.9</b>	6.5	8.1	9.6
<i>December</i>	3.6	<b>3.9</b>	5	5.7	8.1

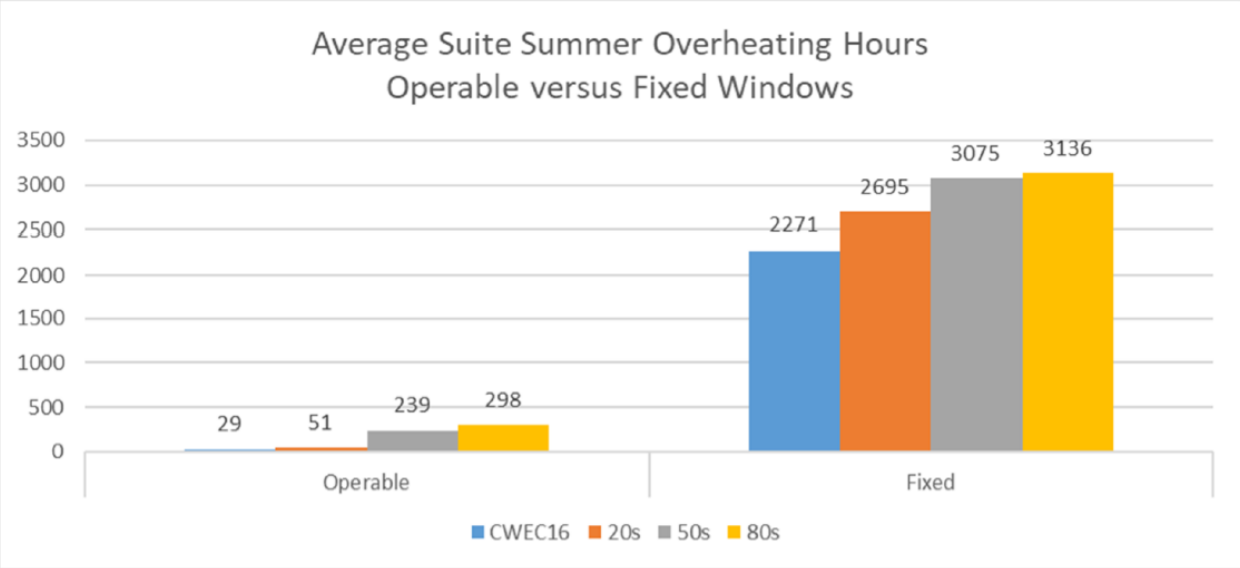
# B. Overheating Mitigation Strategies

## 1. Passive Cooling



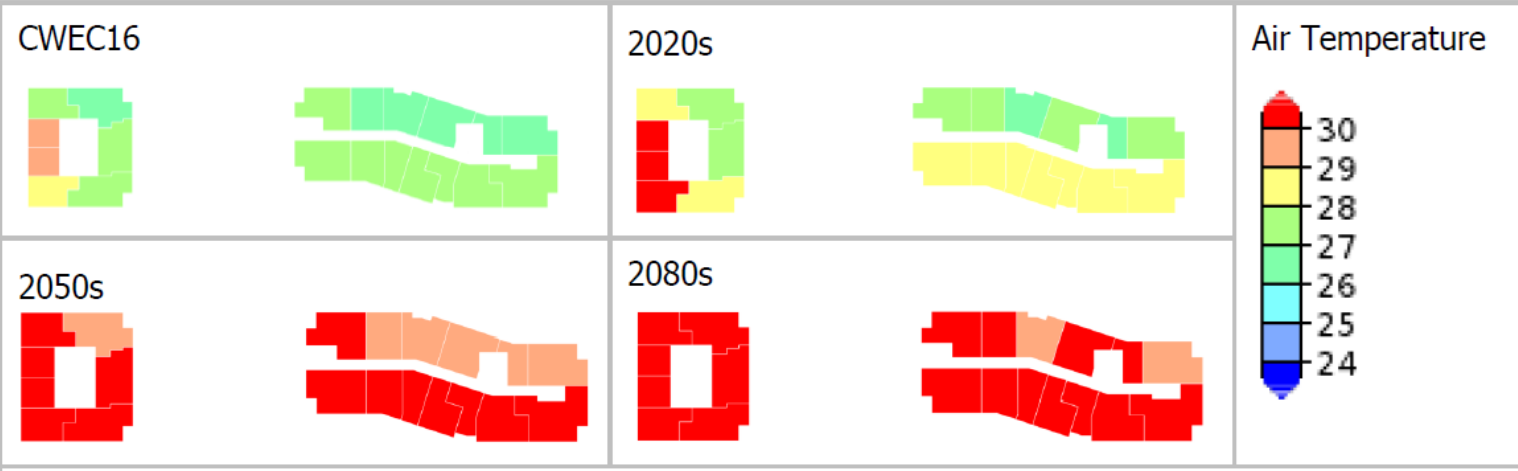
# B. Overheating Mitigation Strategies

## 2. Operable Windows



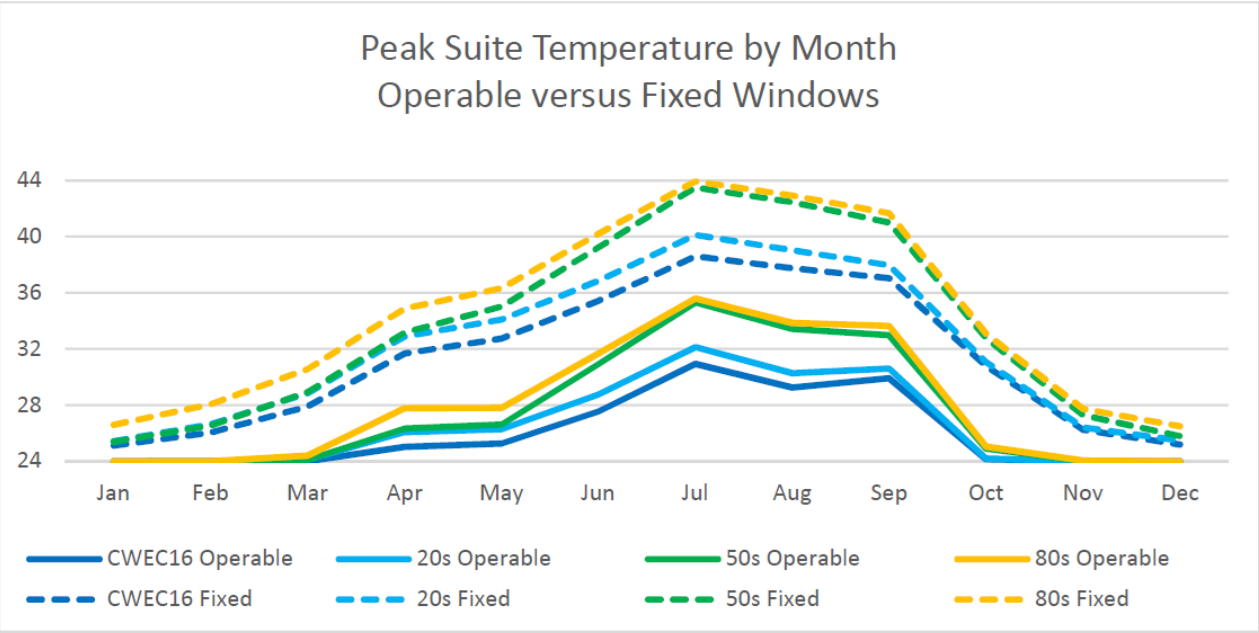
# C. Evaluating Comfort

## 1. In-suite Temperature (North)



# C. Evaluating Comfort

## 2. Operable Windows



# 1<sup>st</sup> and Clark: MBAR

---

## Considerations in Design

- Passive cooling strategies:
  - glazing with good solar control
  - operable windows
- HVAC Design (Partial cooling):
  - central heat recovery air handling w/DX cooling
  - Ventilation rates
  - MERV-13 filters





## LESSONS LEARNED

- . Microclimate
- . Effectiveness of Passive approach
- . Active Mechanical Cooling (Full/Partial)



## Moving Forward

- All Amenity, Program and Office areas w/Full Mechanical Cooling
- Overheating Hours < **20 hours** of the 80% acceptability limits ASHRAE Standard 55
- Residential units in Interior w/Full mechanical cooling
- SHGC of Windows **0.27 – 0.33 with VT > 60%**
- Ventilation inside units design in compliance with **Section 9.32**
- Prescribed Ventilation rates
- Partial mechanical cooling provided by central or semi-central Energy Recovery Ventilators (ERVs).





Guidance for the Development of a Performance-Based Solution for Smoke Dampers

Our File Name: BCH Smoke Damper AS  
Our File Number: 200003  
Date of Guide: March 11, 2020 Revised March 15, 2020

Prepared for: BC Housing  
1701-4555 Kingsway  
Burnaby, BC  
V2H 4V8

Prepared by: Senex Consulting Ltd.  
202-1777 36th Street  
Delta, BC  
V4L 0A8  
www.senexco.com

# Mechanical Peer Review at Pre-BP Commissioning

A large, hand-drawn letter 'Q' in white chalk on a blackboard. The letter is filled with diagonal hatching lines.A large, hand-drawn ampersand (&) in white chalk on a blackboard. The symbol is filled with diagonal hatching lines.A large, hand-drawn letter 'A' in white chalk on a blackboard. The letter is filled with diagonal hatching lines.

**Sadia Afrin, Sr. Manager Construction Services**  
BC Housing Management Commission  
Email: [saafri@bchousing.org](mailto:saafri@bchousing.org)

# Resilient Housing for a Future Climate

## Passive and Active Systems

**Chris Doel** | Managing Principal  
cdoel@integralgroup.com



**INTEGRAL**  
CONSULTING ENGINEERING



# Overview of Presentation

- Overheating and Step Code Targets
- Passive Systems
- Active Systems



# A New Design Guide

## BC Energy Step Code Design Guide Supplement S3 on Overheating and Air Quality

June 2019



SUPPLEMENT S3  
Version 1.0



BRITISH  
COLUMBIA



BC HOUSING  
RESEARCH CENTRE

# HCMA

Architecture  
+ Design

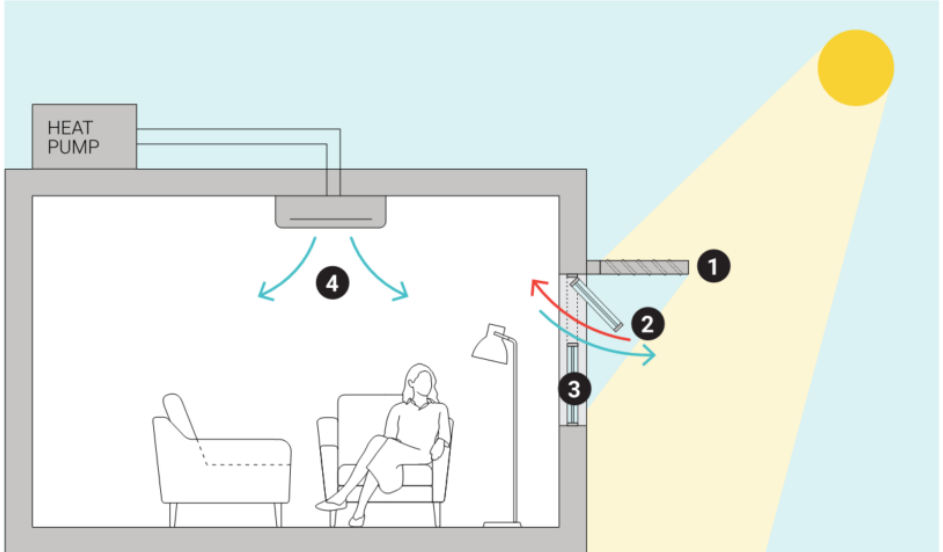


IMAGINE | PERFORM | ACCELERATE | SUSTAIN



BC HOUSING  
RESEARCH CENTRE

# Balancing Act



## ① Exterior

Lower risk of OVERHEATING



Higher TEDI

## ② Operable Windows

Lower risk of OVERHEATING



Higher risk of POOR IAQ

## ③ Low Solar heat gain glazing

Lower risk of OVERHEATING



Higher TEDI

## ④ Mechanical Cooling

Lower risk of OVERHEATING



Higher TEUI

Lower risk of POOR IAQ

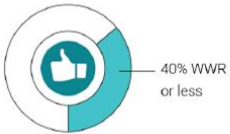
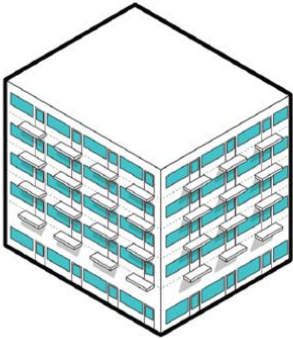
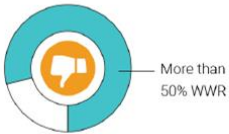
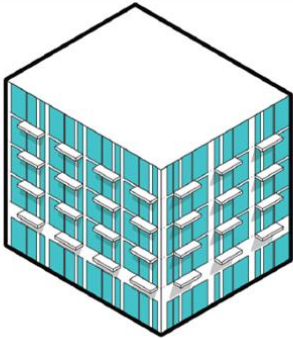
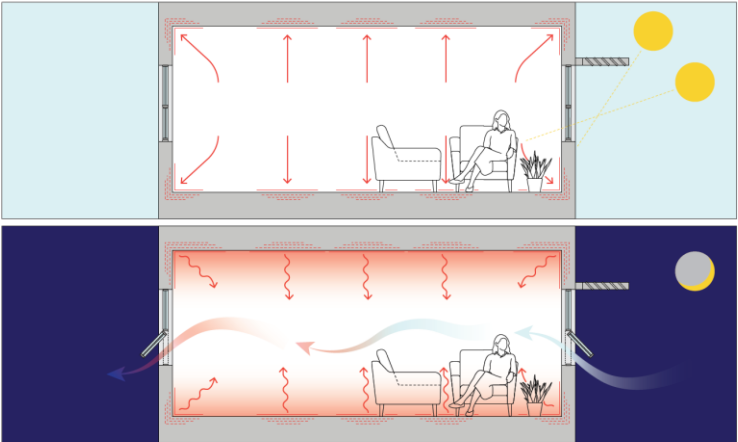




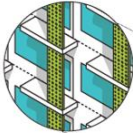
# Passive Systems



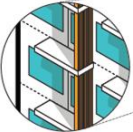
# Start Passively



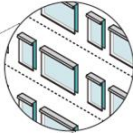
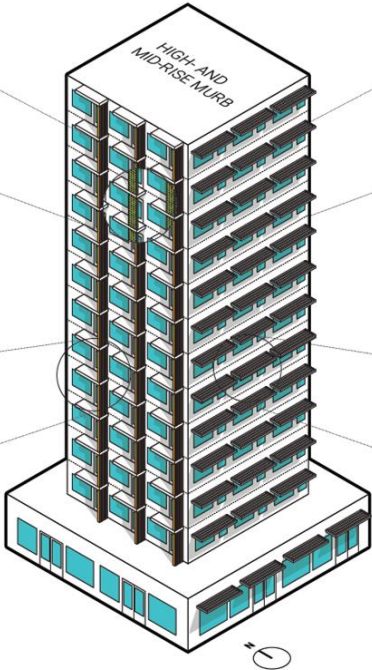
# Shade Incoming Solar Gains



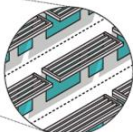
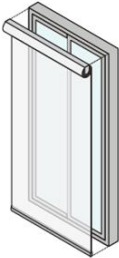
**PERFORATED SCREENS**  
mounted outside of a window or on a balcony can effectively block solar gains, but will also reduce passive heating potential in the winter and will obstruct some of the view.



**VERTICAL SHADES**  
can be effective on any orientation; however, they will reduce passive heating in the winter.



**SEMI-TRANSPARENT SHADES**  
can be used to block solar gains while allowing a view through to the outside.



**HORIZONTAL OVERHANGS**  
are best on the south façade as they block high angle summer sun while allowing low angle passive solar heating in winter.



Olympic Village



Hornby Island Fire Hall

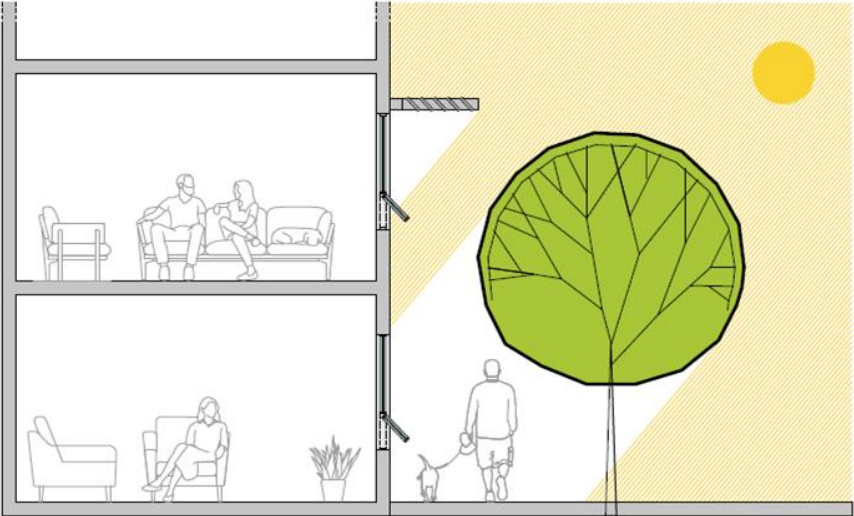


UBC Arts Student Centre

Image Credit: Leckie Studio Architecture + Design



# Shade Incoming Solar Gains



SUMMER (South/West Facing Facade)



# Shading Strategies

	Fixed External Shades	Manual Shades	Manual Shades	Vegetation	SHGC Selection	Window Coatings
Livability	👍👍	👍		👍👍		
Aesthetic	👍👍			👍👍		
No additional maintenance required					👍👍	👍👍
Controllability		👍👍	👍			
No increase in need for indoor lighting					👍*	
Glare Control	👍			👍	👍*	👍

LEGEND 👍 Good    👍👍 Better    \* Some SHGC reductions may impact visible light transmittance



Olympic Village



Hornby Island Fire Hall

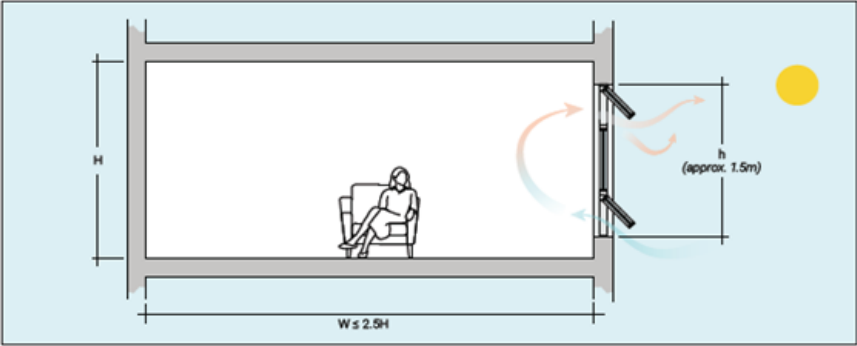
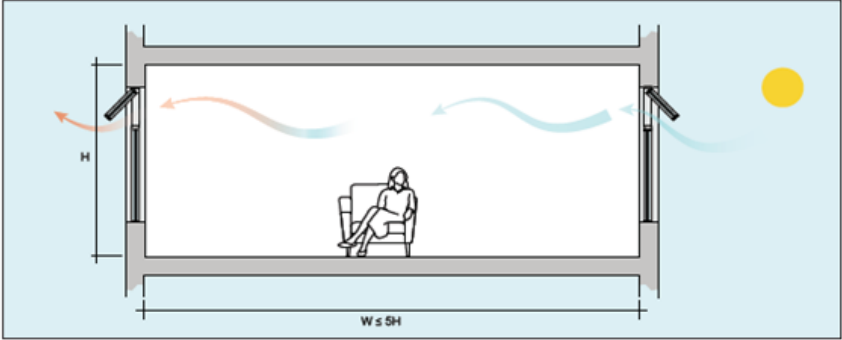
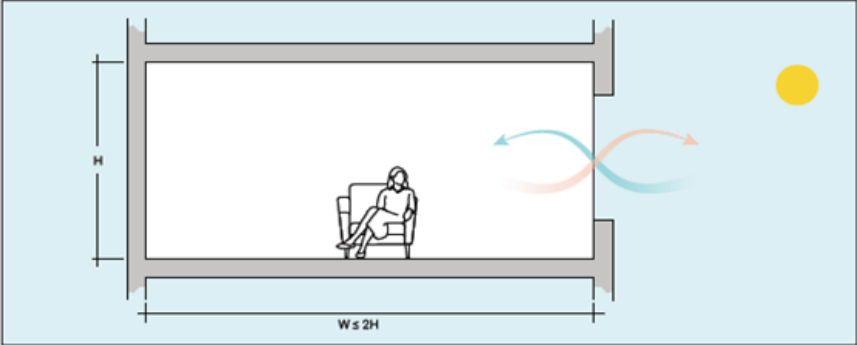


UBC Arts Student Centre

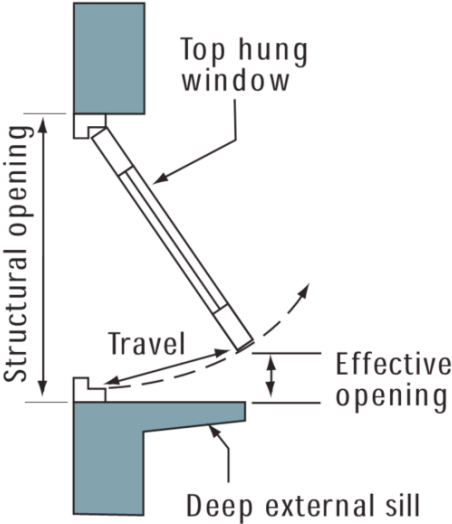
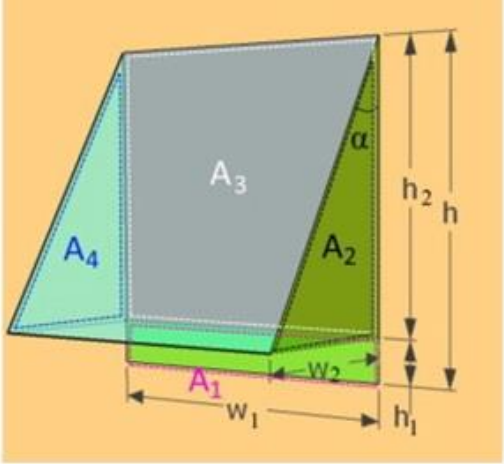
Image Credit: Leckie Studio Architecture + Design



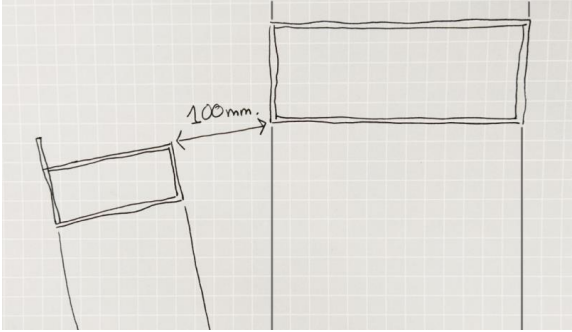
# Passive Cooling



# Openings - Size matters

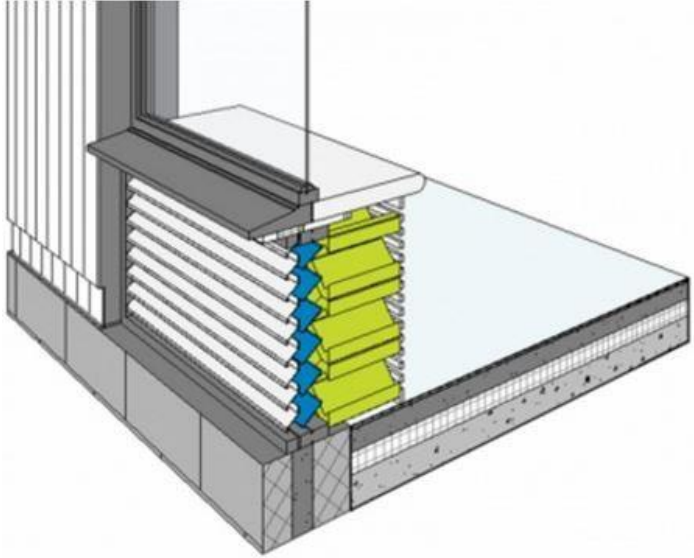


# Openings





# Acoustic Openings



# Ventilation Standards



**City of Vancouver** *Land Use and Development Policies and Guidelines*

**Planning, Urban Design and Sustainability Department**

453 West 12th Avenue, Vancouver, BC V5Y 1V4 | tel: 3-1-1, outside Vancouver 604.873.7000 | fax: 604.873.7100  
website: vancouver.ca | email: planning@vancouver.ca | app: VanConnect

## ENERGY MODELLING GUIDELINES

Version 2.0

Effective March 17, 2017  
Amended July 11, 2018

*(These guidelines are referenced in the Green Buildings Policy for Rezoning, amended by Council on November 29, 2016)*

The limits of thermal comfort:  
avoiding overheating in  
European buildings



TM52: 2013

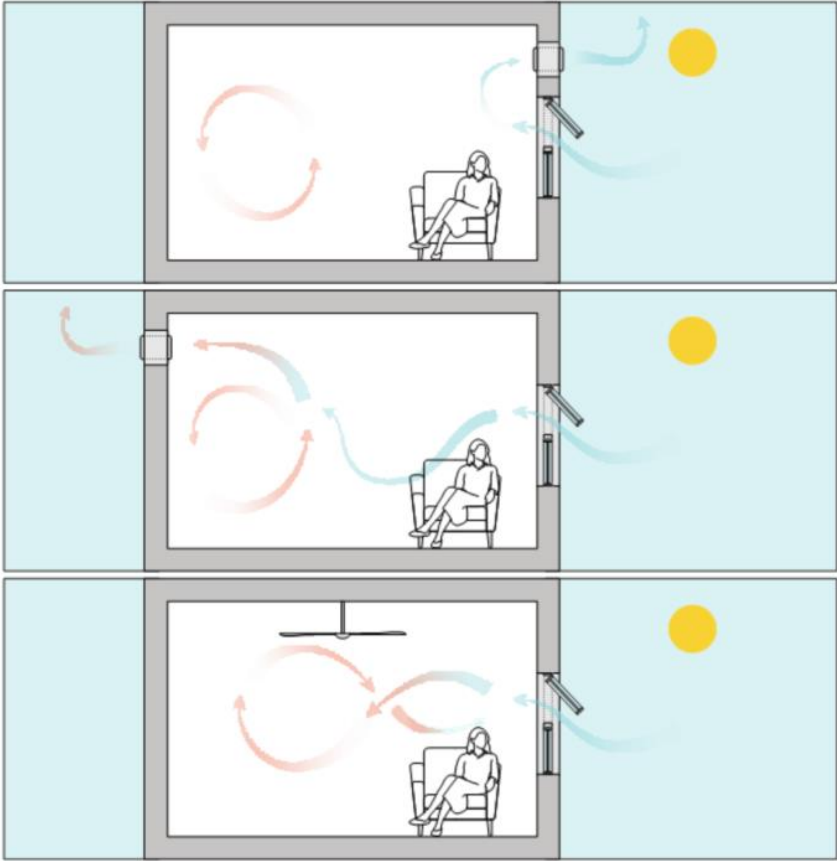
Design methodology for the  
assessment of overheating  
risk in homes



TM59: 2017



# Fan Assisted Passive Cooling

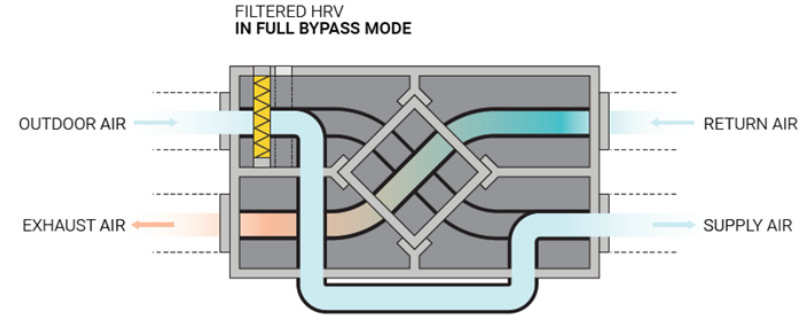
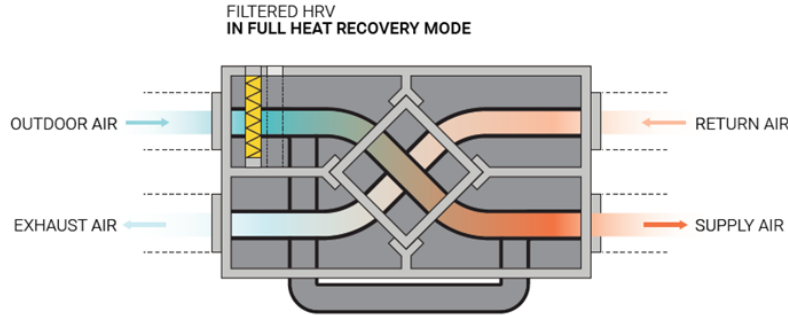


# Active Systems

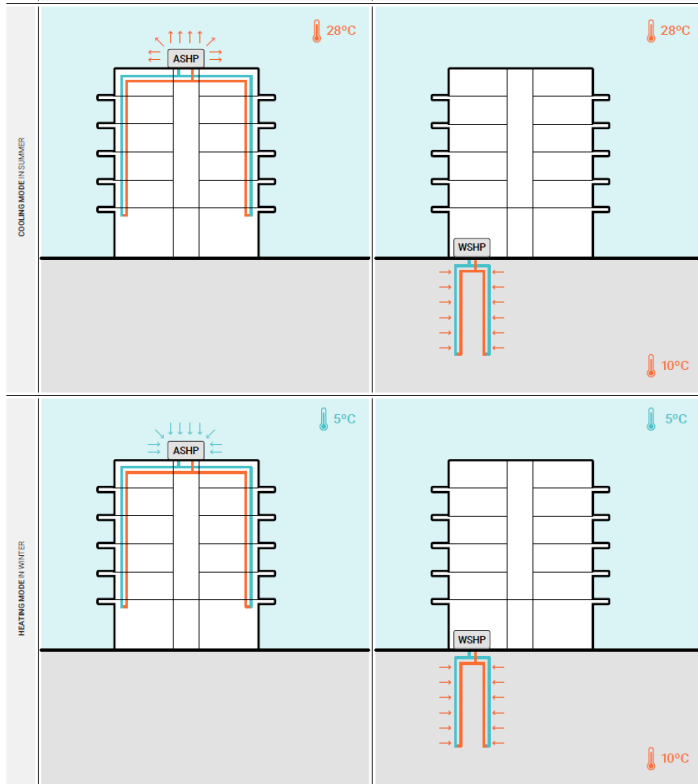


# Consider a Hybrid Cooling System

- Use a bypass in HRVs to reduce heat absorption from exhaust air
- Use supply or exhaust fans to move air
- Outfit central HRVs with a cooling coil



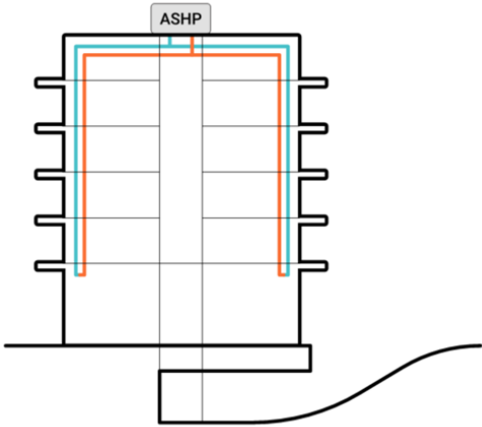
# Add Mechanical Cooling



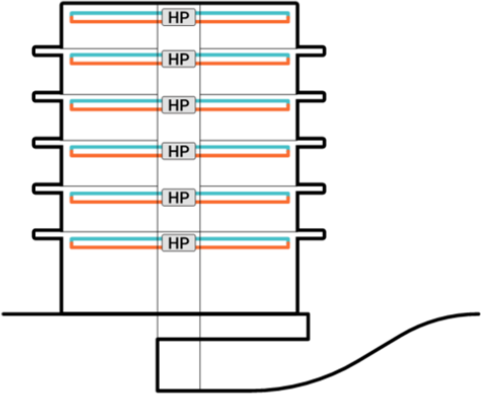
- Air and water heat pumps
- Central or distributed cooling
- VRF systems
- *Roughing in for future cooling*



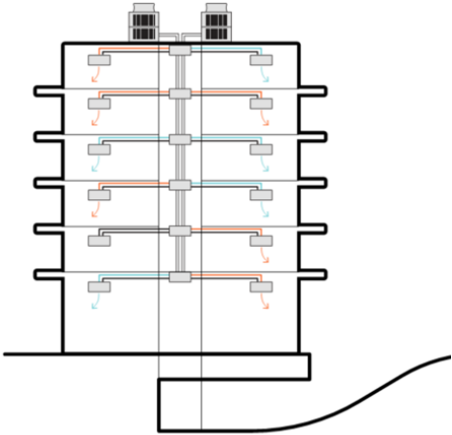
# Cooling Distribution



Central



Distributed  
Floor by Floor

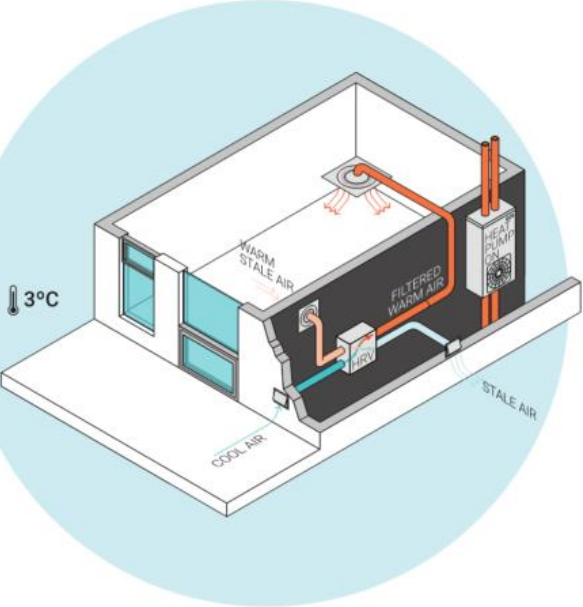


Distributed  
Space by Space

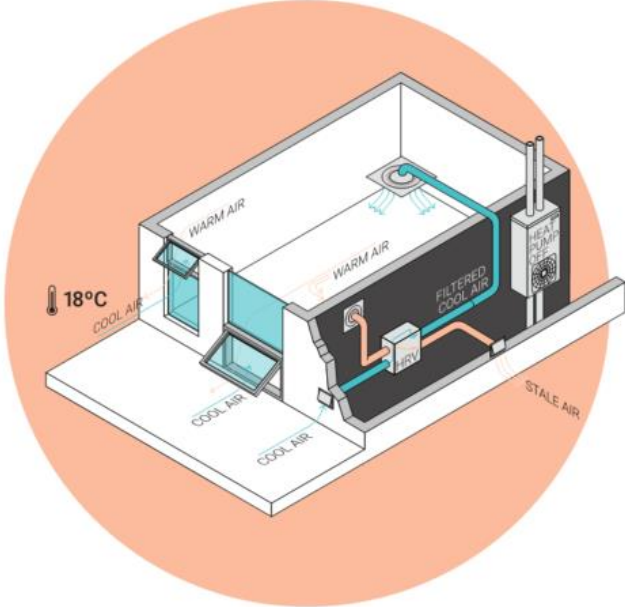


# Mix Your Modes

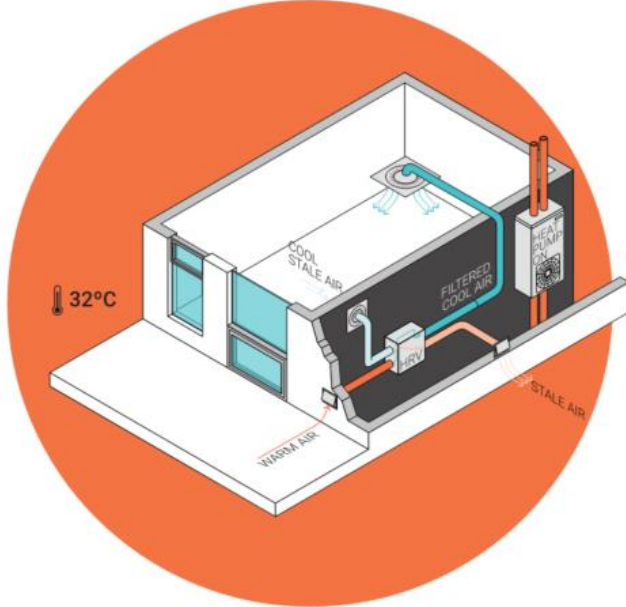
MECHANICAL HEATING  
DURING PEAK WINTER



PASSIVE AND MECHANICAL COOLING  
DURING SHOULDER SEASONS

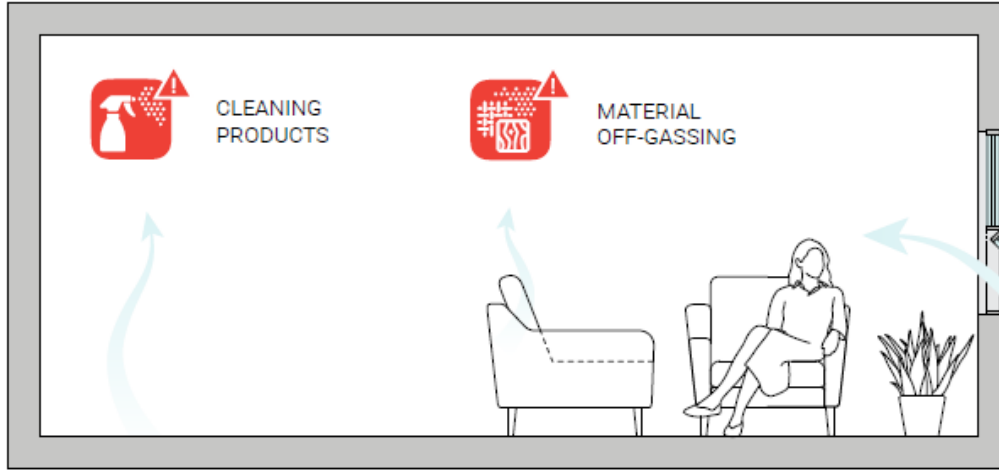


MECHANICAL COOLING  
DURING PEAK SUMMER











# Improve Indoor Air Quality



CONTEXTUAL OR SITUATIONAL FACTORS

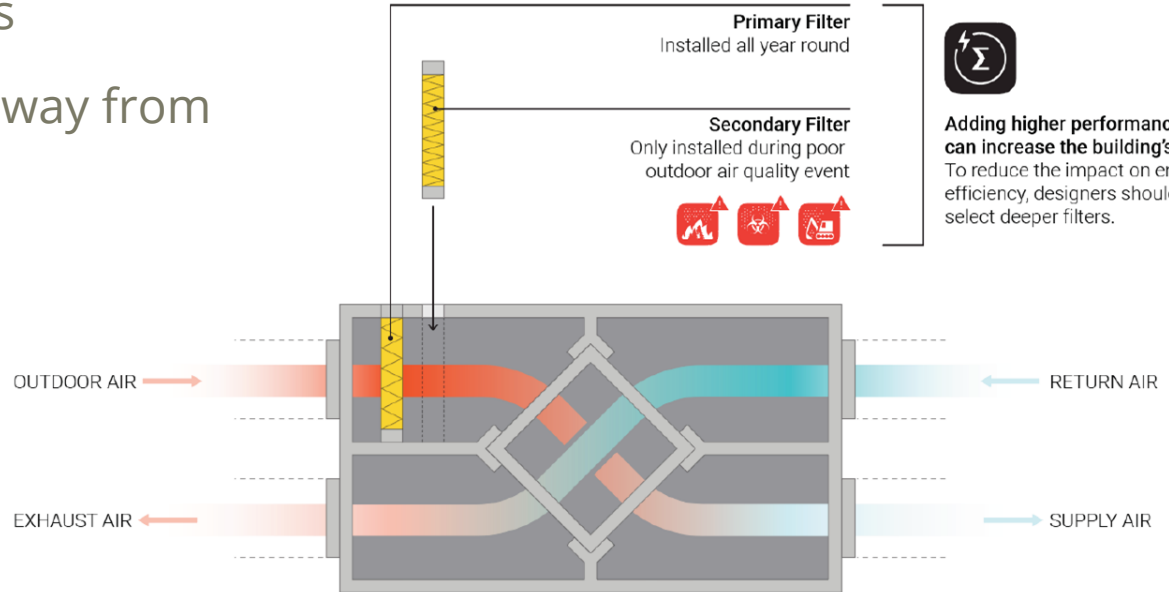
General Pollution	Poor Outdoor Air Quality Event
 TRAFFIC	 CONSTRUCTION
 INDUSTRY	 WILDFIRES
 NOISE	 HAZMAT EMERGENCIES

- Identify the number and intensity of local sources of air pollutants
- Refer to BCBC, LEED and WELL Standard

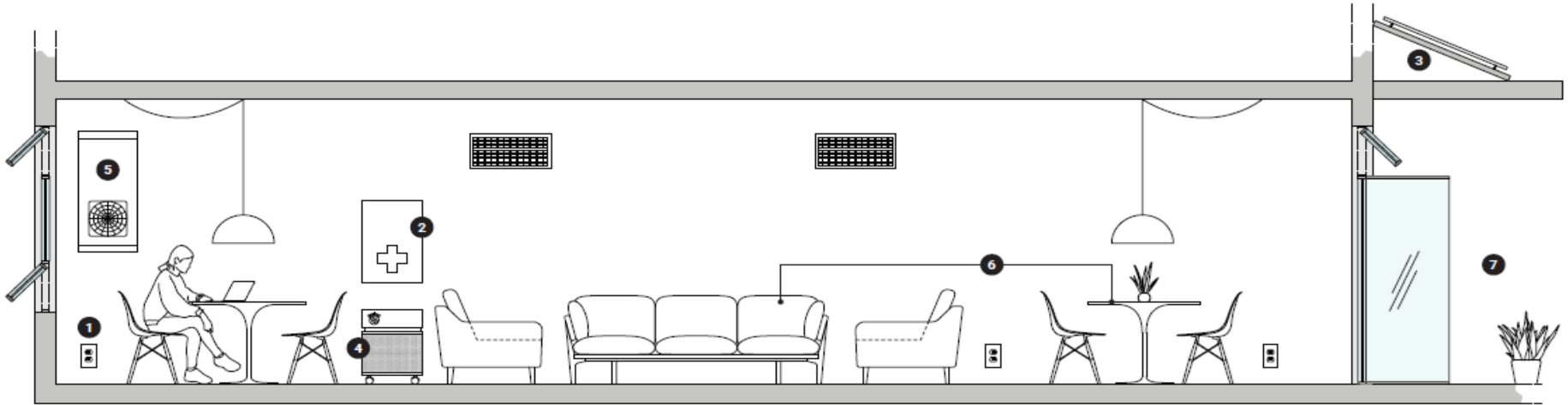


# Improve Indoor Air Quality

- Minimum MERV 13, or activated carbon for high VOCs
- Accommodate additional filters during AQ advisories
- Air intakes located away from pollution sources



# Provide a Refuge



1. Provide mechanical heating and cooling
2. Connect to a source of back-up power
3. Provide amenities and accessibility
4. Provide higher levels of filtration
5. Ensure emergency supplies are provided (food, water)
6. Provide both private and social areas
7. Allow access to outside green space



# Thank you!

**Chris Doel** | Managing Principal  
cdoel@integralgroup.com



**INTEGRAL**  
CONSULTING ENGINEERING





# Questions?



**BC HOUSING**



CITY OF

VANCOUVER



**BCNPHA**

BC Non-Profit Housing Association



Thank you for attending



**BC HOUSING**



CITY OF

VANCOUVER



**BCNPHA**

BC Non-Profit Housing Association



Contact:  
[energy@bcnpha.ca](mailto:energy@bcnpha.ca)



**BC HOUSING**



CITY OF  
**VANCOUVER**



**BCNPHA**  
BC Non-Profit Housing Association