BC Energy Step Code
Design Guide

March 2018

Version 1.0

British Columbia

BC Housing Research Centre

About this Guide

The BC Energy Step Code Design Guide is published by BC Housing in collaboration with BC Hydro, the City of Vancouver, the City of New Westminster, and the Province of BC. This guide provides information on the key strategies and approaches to meeting the Energy Step Code in mid- and high-rise (Part 3) wood-frame and noncombustible residential buildings within British Columbia. However, it is also a good resource for larger or more complex low-rise (Part 9) wood-frame residential buildings and buildings with other occupancies. The guide is intended to provide a clear and easy-to-read resource for a range of actors in British Columbia, including local governments, architects, and developers.

While the strategies outlined in the guide are designed to help buildings across the province meet the requirements of the Energy Step Code, they are also applicable to those seeking compliance with the City of Vancouver's Zero Emissions Building Plan. Additional information on strategies of particular relevance to designers working in Vancouver is provided at key points throughout the guide, and in Supplement S (pg 45).

Disclaimer

Acknowledgements

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SECTION 01.

Introduction to the BC Energy Step Code Design Guide

01 Introduction

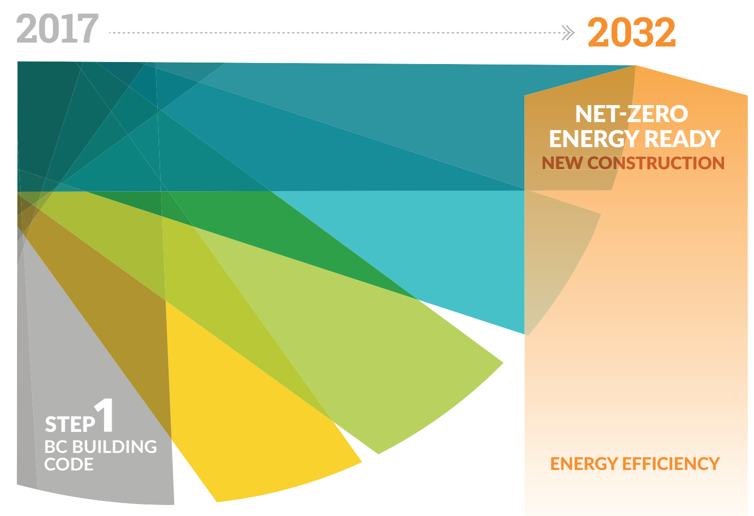
What is the BC Energy Step Code?

In April 2017, the Province of British Columbia adopted the BC Energy Step Code as a series of amendments to the Building Act and the Local Government Act. Local governments may now use the standard, if they wish, to incentivize or require a level of energy efficiency in new construction that goes above and beyond the requirements of the BC Building Code. Builders may also adopt the standard voluntarily.

The standard consists of a series of steps, representing increasing levels of energy-efficiency performance. By adopting one or more steps of the standard, local governments and builders can increase building performance requirements in their communities.

Local governments and builders may apply the BC Energy Step Code to new residential construction across the province. They may also apply the standard to multi-unit and commercial buildings in the Lower Mainland and on southern Vancouver Island.

The Province of British Columbia has set a goal that all new buildings must reach a "net-zero energy ready" level of efficiency by 2032. The BC Energy Step Code serves as a policy pathway and technical roadmap to reach that target. Please visit **www.energystepcode.ca** to read about the standard and access presentations and additional resources.



Additional References

The Energy Step Code Council, the Provincial Government, and third parties such as BC Housing have produced a series of publications and presentations to increase awareness and understanding of the BC Energy Step Code in local government and industry audiences. A few of these are listed below. For additional materials, visit www.energystepcode.ca

- PDF **Provincial Policy: Local Government Implementation of the BC Energy Step Code** (PDF 903KB)
  Office of Housing and Construction Standards, Province of British Columbia
  April 2017

- PDF **The Energy Step Code: A Best Practices Guide for Local Governments** (PDF 3.8MB)
  Building and Safety Standards Branch, Province of British Columbia, with the Energy Step Code Council
  September 2017

- PDF **Consumer Guide to High-Performance Homes** (PDF 540 KB)
  BC Housing
  April 2016

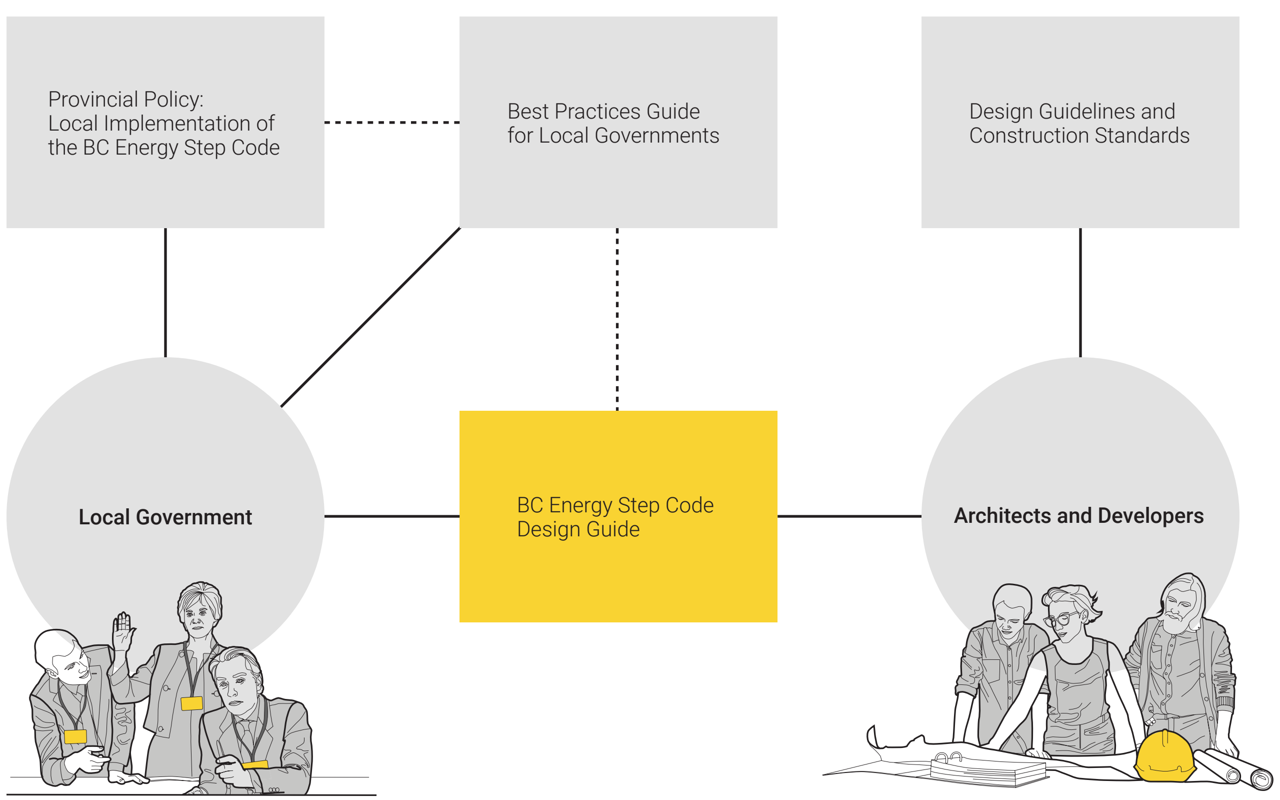
- PDF **BC Housing Design Guidelines and Construction Standards**
  BC Housing 2014
  Revised July 2017 to accommodate the BC Energy Step Code

- PDF **Guide to Low Thermal Energy Demand for Large Buildings**
  BC Housing
  February 2018

Why do we need a design guide?

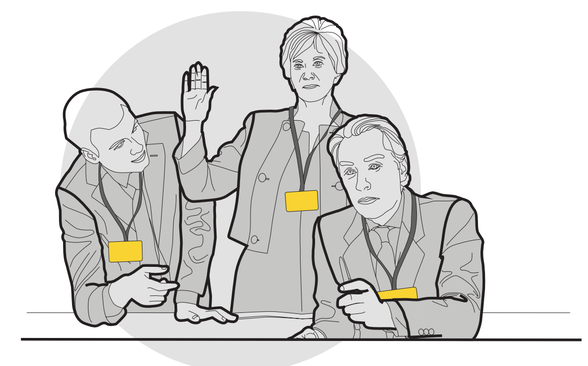
While increasing numbers of builders, developers, and architects are embracing high-performance construction practices, there is still considerable opportunity to grow awareness and capacity. The purpose of this guide is to provide an accessible resource to clearly illustrate a variety of techniques and strategies that industry can consider in meeting the BC Energy Step Code's performance requirements.

The guide will help local governments and industry understand the benefits and impacts of key design strategies necessary to achieve each step of the standard, including both mechanical and envelope strategies. It also offers a graphic explanation of more detailed implementation tactics related to heating, ventilation, and air-conditioning (HVAC) solutions and strategies.



Who is the guide for?

This guide is a resource for local governments, architects, and developers interested in pursuing the BC Energy Step Code.



LOCAL GOVERNMENT

British Columbia local governments, subject to the BC Building Code and covered by the Community Charter, may reference the BC Energy Step Code in their policies and bylaws.[1] Effective December 2017, Section 5 of the Building Act rendered all bylaws that referenced energy-performance programs other than the BC Energy Step Code to be unenforceable.

By adopting one or more steps of the standard, local governments will be able to improve the energy performance of the built environment in their communities, while contributing to occupant comfort, lowering utility bills, and reducing greenhouse gas (GHG) emissions. Local governments can choose to adopt any one or more steps of the standard, but should consider existing policies and market conditions in their communities when doing do.

Until 2020, the province is discouraging local governments from requiring Upper Steps on a community-wide basis, but Upper Steps may be used in connection with an incentive program. Higher steps of the BC Energy Step Code are expected to be adopted more widely as industry capacity increases and services and products for the design and construction of high-performance buildings become more readily available.

ARCHITECTS AND DEVELOPERS

Industry may voluntarily adopt the BC Energy Step Code as an alternate compliance path to meeting the minimum performance requirements of the BC Building Code.

Many developers already voluntarily adopt advanced performance standards to meet the growing demand for high-performance buildings. The consistent approach of the BC Energy Step Code allows industry to gradually build capacity and skills in a coordinated and predictable manner. This will help developers control costs and minimize disruption.

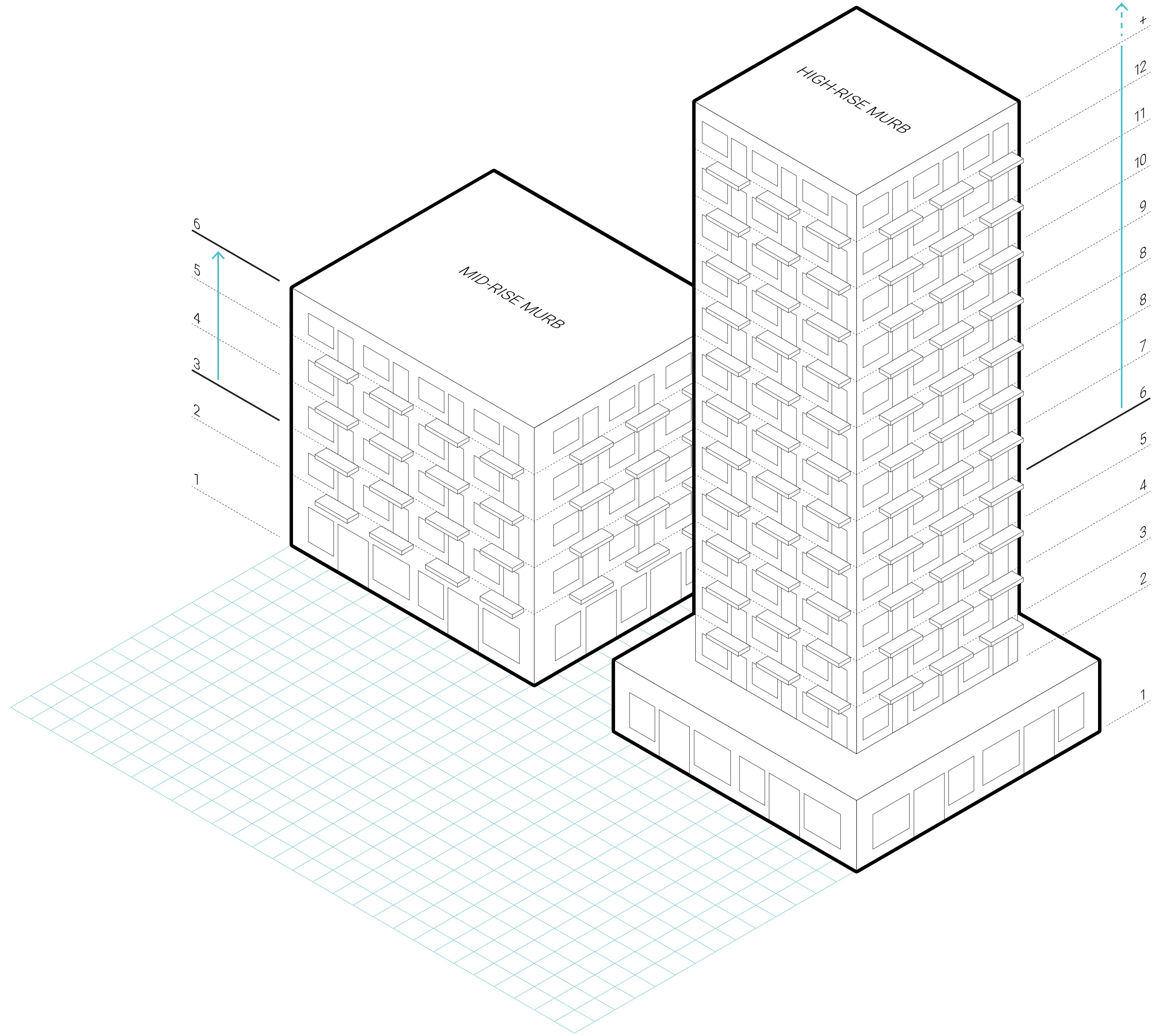
[1] At the time of this guide's production, the City of Vancouver had announced that, subject to Council approval, it would allow builders to reference the BC Energy Step Code as an alternate performance pathway to demonstrate compliance with its Zero Emissions Building Plan. For more information on Vancouver's Zero Emissions Building Plan, please see **Supplement S**.

What does the guide cover?

While the BC Energy Step Code applies to a number of Part 3 and Part 9 building types, this guide outlines key principles and strategies for meeting the Upper Steps of the BC Energy Step Code for two of B.C.'s primary Part 3 building types: High-Rise and Mid-Rise Multi-Unit Residential Buildings, or MURBs.

The principles, strategies, and technologies depicted in this guide are most relevant for construction in Climate Zones 4 and 5 (B.C.'s Lower Mainland, Vancouver Island, the southern Thompson-Okanagan/Kootenay region, and the southern coast), though several will also apply in higher Climate Zones. The guide is structured to take the reader from high-level strategies through a progression to greater levels of detail.

Several strategies included in the guide may be used or modified to meet the requirements of the City of Vancouver's Zero Emissions Building Plan. Callout boxes are used to indicate where the design strategies can be adapted to achieve the greenhouse gas emission reduction requirements in that plan. For more information on Vancouver's Zero Emissions Building Plan, please see Supplement S.



SECTION 02.

How to Use this Guide

02 How to Use this Guide

This guide outlines key design concepts that will meet the requirements of the BC Energy Step Code as it applies to High-Rise and Mid-Rise MURBs. It is intended as a quick reference for developers, architects, and local governments.

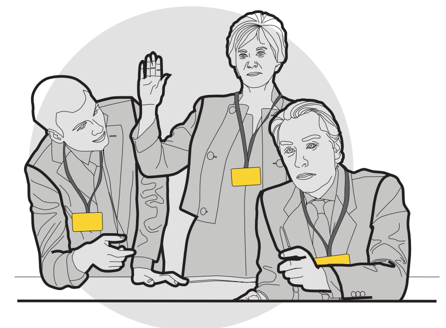
GO TO SECTION 03 FOR:
Overarching design principles necessary to meet BC Energy Step Code targets, and a diagram showing the importance of each design strategy in relation to the three key metrics of the BC Energy Step Code.

GO TO SECTION 04 FOR:
Detailed design strategies for High-Rise and Mid-Rise MURBs.

GO TO SECTION 05 FOR:
An overview of the benefits of energy efficient design.

GO TO APPENDIX A FOR:
A glossary of terms, and image sources.

GO TO SUPPLEMENT S FOR:
Strategies to reduce greenhouse gas emissions and to comply with the City of Vancouver's Zero Emissions Building Plan.



A Resource for Local Governments

Local governments should use this guide in two general ways: to inform policy design and development, and to review specific development applications to ensure proponents are complying with performance requirements.

Elected officials, policy-makers, community planners, and energy planners may wish to use this document to help establish guidelines for highly energy efficient urban form and development policies in official community plans and other documents. Local governments may wish to quickly adopt Lower Steps, while planning to adopt higher steps in the future. Consulting this and other BC Energy Step Code resources early will help inform policy development.

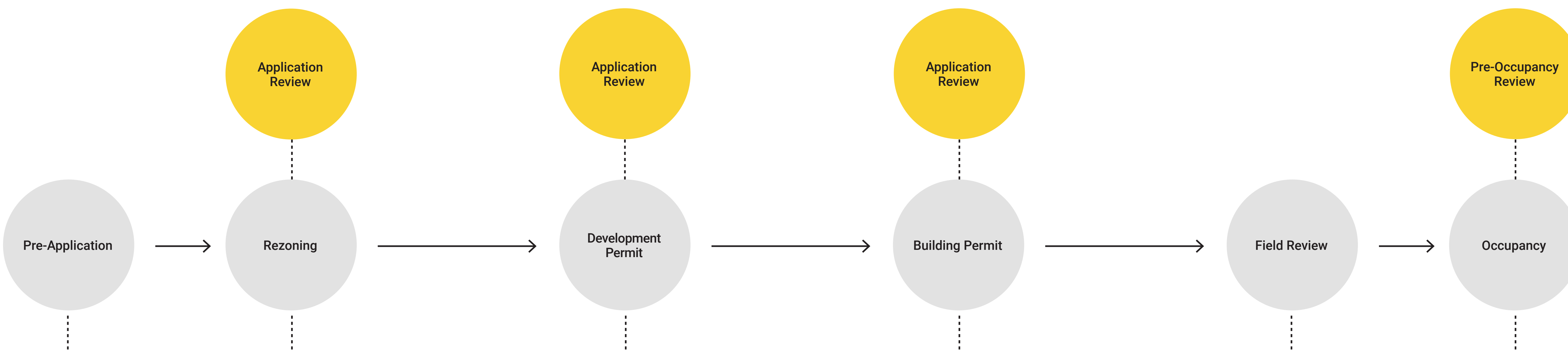
Community and energy planners should consult the guide when creating local area plans to determine how planned and proposed buildings will be impacted by the application of the BC Energy Step Code.

Area and energy planners should consult this guide when reviewing rezoning and development applications, to ensure proponents have applied the principles and strategies necessary to meet BC Energy Step Code performance targets.

A Resource for Architects and Developers

This Guide is designed to help architects and developers understand and use the key considerations and design strategies necessary to meet the BC Energy Step Code's performance targets. It offers clarity on the most cost-effective and straightforward strategies to reduce building energy demands and improve airtightness. As such, mechanical and envelope engineers may also find it helpful in their work.

While the guide provides some of the lowest cost strategies to meet the BC Energy Step Code, it is important to note that there are many ways of meeting the standard's performance targets. Practitioners can explore different design strategies, or **energy conservation measures**, for their ability to meet the TEDI, TEUI, and airtightness targets. These options should be considered early in the design process to ensure the final building complies with requirements.



Developers should review this guide while acquiring land and calculating a project's proforma analysis. It is important to begin to explore different possibilities regarding the overall massing, orientation, and unit density of a prospective project at this stage, as all have implications for energy performance.

Prior to submitting a rezoning application, **developers, architects, and engineers** should use this guide to consider the key design strategies that will reach a given performance step. While designs are rarely final at the rezoning stage, massing, orientation, and fenestration should be identified as early as possible, along with broad mechanical, ventilation, and envelope strategies. Local government staff and design panels may review applications to ensure the proponent has considered BC Energy Step Code requirements.

At the development permit stage, **designers** will be required to use energy modelling to confirm that the proposed development meets the relevant community's BC Energy Step Code performance targets, and that any concerns identified at the rezoning stage have been addressed.

Final project design documentation is required for the application of a building permit. By this stage, all design strategies will be final, and the required whole-building energy model will demonstrate that the proponent's chosen approaches will meet the performance targets.

Building officials will require **architects and engineers** to review the project while it is under construction, to ensure it substantially conforms with the requirements of the BC Energy Step Code.

Prior to issuing an occupancy permit, local government officials may check that letters of assurance have been completed, and that the coordinating registered professional has signed off on all design strategies needed to achieve the targeted step of the BC Energy Step Code. Developers must also ensure that a post-construction airtightness test is conducted, and that the results of the airtightness test are included in determining the final energy performance of the building.

SECTION 03.

Designing for the BC Energy Step Code

03.1 Primary Objective

Communities and developers can reduce the impact of new buildings on the built environment by embracing energy-reducing design techniques. Buildings currently account for approximately 22% of the energy consumed in the Province of British Columbia, and 12% of the greenhouse gas emissions released into the atmosphere. The BC Energy Step Code has been designed to create a stepped approach to reducing building energy consumption, while controlling costs and improving occupant comfort — particularly at the Upper Steps.

While there are countless possible combinations of energy conservation measures that can be used to reduce building energy consumption, the strategies and principles outlined below will yield significant results.

BC ENERGY STEP CODE

Primary Objective	Performance Metrics	Key Strategies	
Reducing the impact of the built environment through the use of thoughtful design techniques that minimize building energy consumption.	The BC Energy Step Code requires buildings to achieve specific levels of performance in three key metrics:	Design strategies for achieving Step Code required performance targets in each of the three metrics.	
	Thermal Energy Demand Intensity (TEDI)	Minimizing Heat Losses Through Simplified Massing	Reducing Thermal Bridging
	Total Energy Use Intensity (TEUI)	Minimizing Heat Losses Through Orientation	Increasing Airtightness
	Airtightness	Considering Unit Density	Using Compartmentalization
		Optimizing Fenestration	Using Heat Recovery In Ventilation
		Increasing Building R-Values	Separate Heating And Cooling From Ventilation

VANCOUVER'S ZERO EMISSIONS BUILDING PLAN (ZEBP)

In addition to limits on heat loss and energy use, the City of Vancouver sets limits on greenhouse gases (GHG) to further target reductions in emissions.

Primary Objective	Performance Metric	Key Strategy
Minimizing GHG emissions	Greenhouse Gas Intensity (GHGI)	Select Low-Carbon Mechanical Systems (See Supplement S, pg 45.)

03.2 Performance Metrics

The BC Energy Step Code specifies levels of performance in Thermal Energy Demand Intensity (TEDI), Total Energy Use Intensity (TEUI), and airtightness. (See the Glossary of Terms for an explanation of each.) The key principles for achieving good performance in each of the three metrics are outlined below.

BC ENERGY STEP CODE

TEDI

Thermal Energy Demand Intensity is a measure of the total heating energy necessary to maintain a comfortable indoor temperature over the course of a year, measured and expressed in $kWh/m^2/year$. The metric considers both passive gains (e.g. incoming solar radiation, heat generated by indoor appliances) and losses (e.g. heat losses through the building envelope), as well as any energy needed to mechanically heat a building or warm incoming ventilation air.

To achieve a TEDI target, professionals must maximize gains and minimize losses as much as possible, and reduce reliance on mechanical systems.

Strategies for achieving TEDI targets:

- *Minimize heat loss*
- *Consider occupant and unit density*
- *Optimize fenestration*
- *Increase building R-values*
- *Reduce thermal bridging*
- *Increase airtightness*
- *Recover heat during ventilation*

TEUI

Total Energy Use Intensity is a measure of the total amount of energy a building uses over the course of a year, per unit of building area. The metric considers all energy used in a building, including plug loads (e.g. lighting, appliances) and process loads (e.g. elevators, mechanical systems, fans). Like TEDI, TEUI is measured and expressed in $kWh/m^2/year$.

Strategies for achieving TEUI targets:

- *Consider occupant and unit density*
- *Optimize fenestration*
- *Increase airtightness*
- *Recover heat during ventilation*
- *Separate heating and cooling from ventilation*

Airtightness

In Part 3 buildings, professionals measure ***airtightness*** using the Normalized Air Leakage Rate, which tracks the rate at which air leaks through the envelope. The air leakage rate is measured per unit of envelope area and expressed as $L/s \cdot m^2$ at 75 Pascals pressure differential.

Strategies for increasing airtightness include:

- *Designing buildings with a more compact massing to reduce the number of corners*
- *Limiting building-envelope penetrations*
- *Paying careful attention to detailing at interfaces*
- *Ensuring strict adherence to construction practices*

VANCOUVER'S ZEBP

GHGI

The City of Vancouver has authority over its own building code, and has instituted its own step code-like provisions described in the Zero Emissions Building Plan. In addition to setting targets for TEUI and TEDI, the plan also sets thresholds for performance in ***greenhouse gas intensity (GHGI)***.

GHGI is a measure of the emissions intensity of a building's emissions, measured and expressed in tonnes or kilograms of carbon dioxide equivalent per unit area over the course of a year (kg $CO^2/m^2/year$).

For more information, go to Supplement S, pg 45.

03.3 Achieving the BC Energy Step Code

The strategies presented in this guide represent the lowest cost strategies to achieve Steps 2, 3, and 4 of the BC Energy Step Code in Climate Zone 4, as determined by the 2017 BC Step Code Metrics Study. However, this is only one set of strategies that can be used to achieve the performance targets in the BC Energy Step Code. There are many different possible combinations of measures that can be taken to achieve the same level of performance, depending on the nature and goals of the project. Designers should use energy models to explore the different trade-offs between strategies and identify the appropriate set of architectural, envelope, and mechanical strategies for their project.

This chart presents a summary of the kinds of measures required to meet each step of the BC Energy Step Code.

Higher Performance

Step 1

Step 1 is often referred to as "enhanced compliance", because it simply requires builders to demonstrate that they have achieved the energy-efficiency requirements of the existing BC Building Code. In a Step 1 project, builders must supply officials with an energy model to demonstrate that their design will meet the code requirements. Upon substantial completion, a builder must also submit the results of an airtightness test. He or she would ideally do so before installing drywall or other interior surfaces, to allow opportunities to address leaks.

Step 2

Builders can achieve Step 2 using conventional practices and widely available materials. However, they will need to improve the building's overall airtightness and use additional measures. For example, they should:

- Design for a lower overall window-to-wall ratio (e.g. 40% WWR)
- Require higher building R-values (e.g. minimum effective R-10 for walls and effective R-20 for roofs)
- Improve window performance (e.g. double- and triple-glazed windows with lower U-values)
- Improve heat-recovery efficiency (e.g. 60%)

Step 3

To comply with the requirements of Step 3, designers will use many of the Step 2 strategies noted here. However, they will also begin to take a more integrated approach. To reach Step 3, they might also:

- Consider sealing off individual building units and uses from one another to improve airtightness, a practice known as compartmentalization
- Reduce thermal bridging

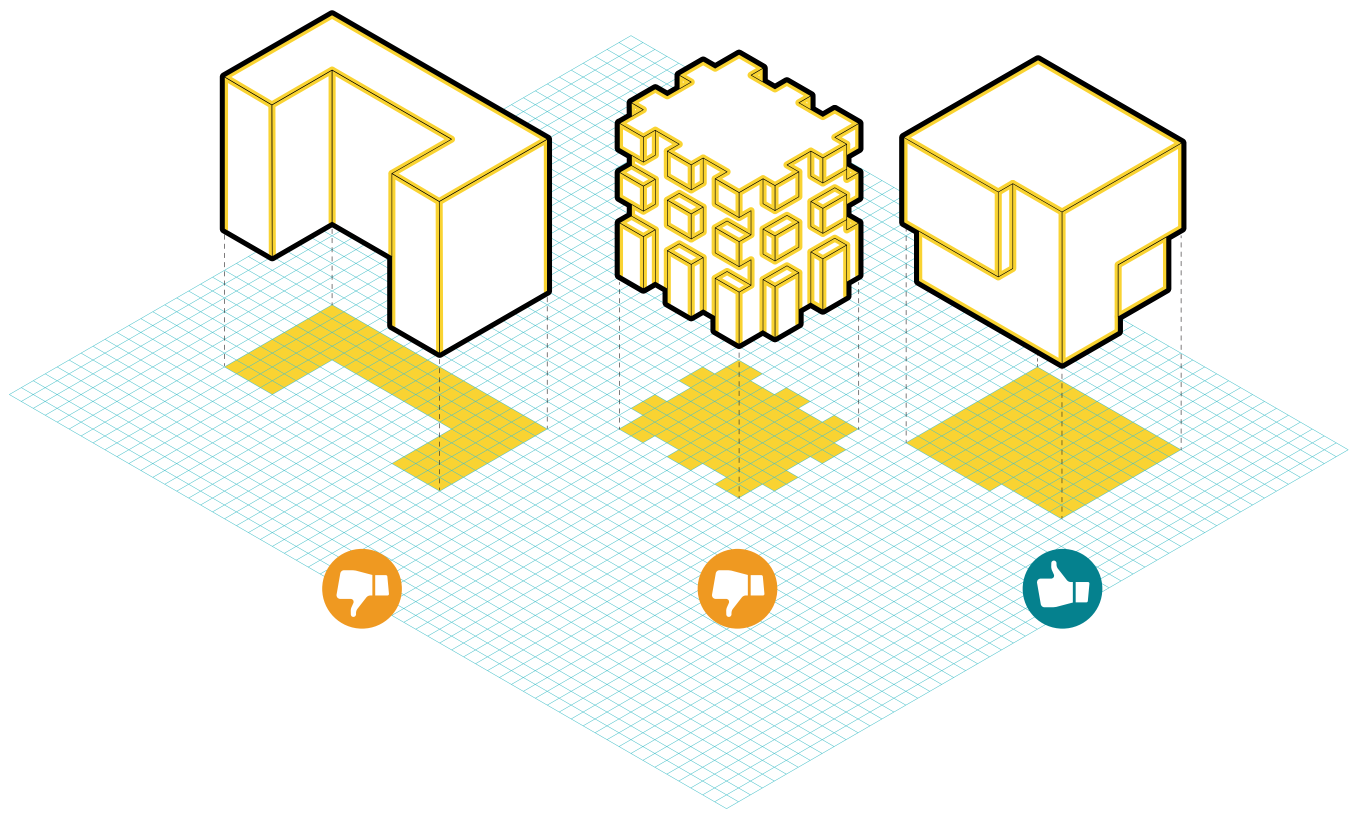
Step 4

Designers wishing to achieve Step 4's more rigorous energy efficiency and airtightness requirements will need to reconsider multiple practices and systems. Although they can achieve this level of performance using wall systems applicable to the Lower Steps, they will want to consider the building envelope first. Designers should look to the strategies we suggest for Step 3 and also:

- Specify very high levels of heat recovery efficiency (e.g. at least 80%)
- Source triple-glazed windows with high performance frames and reduce frame elements
- Eliminate all significant thermal bridges

03.41 Minimize Heat Loss through Simplified Massing and Orientation

Two key factors that should be considered early in the design process are the proposed building's massing and its orientation. Massing refers to a building's overall shape, form, and size. Orientation refers to the alignment of a building's principal axis. (See page 16 for Orientation).



Simpler Form

A building's massing can influence the achievement of TEDI performance targets: the more complex a building shape, the greater the number of opportunities for heat loss through the envelope. A building with several complex junctions and corners will lose far more heat through the envelope than a building that has been designed as a simple, solid form, such as a cube or rectangle. Compact buildings also reduce the total number of exterior walls — where heat is lost — as well as the number of ledges and other horizontal surfaces where accumulations of moisture can degrade the building envelope.

Lower VFAR

Massing can also be thought of in terms of a building's vertical surface area to floor area ratio (VFAR). A lower VFAR decreases overall heat loss potential, because vertical surfaces (walls) tend to have lower R-values than horizontal ones (floors and roofs). Higher VFAR values are often a function of the building's floor plate size, as well as the level of articulation, or the complexity its overall form.

Larger Floor Plate

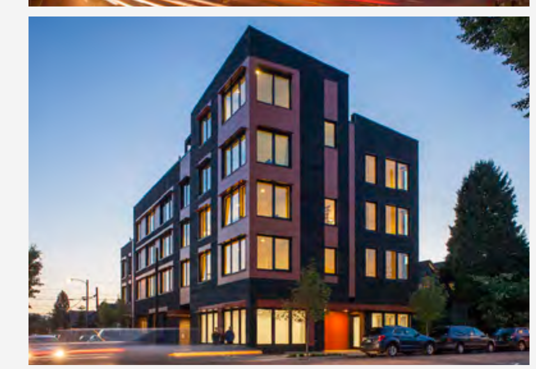
In general, smaller and narrower floor plates make TEDI performance targets harder to achieve. Increasing a building's floor plate size and simplifying its external shape and form both help improve a building project's ability to meet the BC Energy Step Code targets.

CASE STUDIES

A High-Performance Building Need Not Be Boring

A building doesn't need a lot of bells and whistles to be attractive. Design professionals can use a wide variety of strategies — such as exterior colours or textures — to create visually interesting buildings that maintain a compact building form.

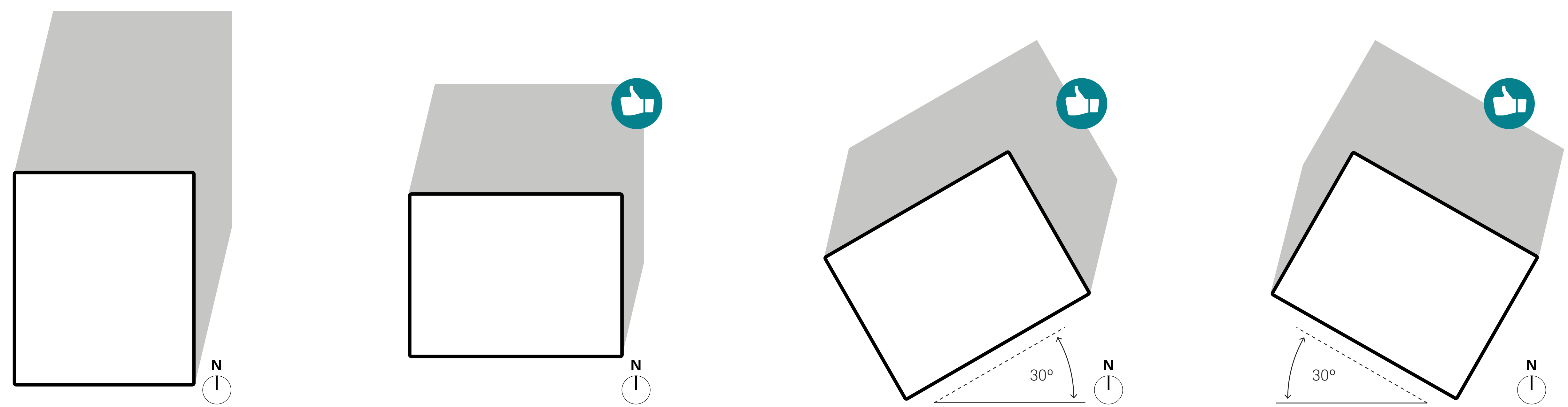
Top *The Spot, Vancouver, B.C.*
Bottom *Kiln Apartments, Portland, OR*



KEY TAKEAWAY

Reduce the complexity of the building facade, and increase the floor plate as much as possible to reduce the potential for heat loss through the envelope.

Most important metric(s) to consider: TEDI, Airtightness



Professionals who orient their buildings to maximize solar-gain potential from the south can reduce heating demands by as much as 30 to 40%. While this strategy does not minimize heat losses per se, it does take advantage of passive heat gains that can provide a benefit when reaching for a TEDI target.

Take Advantage of Natural Light

Thoughtful building orientation can also help designers reach TEUI targets, by taking advantage of natural light to reduce lighting loads.

Maximize Solar Gains

To maximize the potential for solar gains, designers should orient a proposed building's longest facade as close to due south as possible. Ideally, the south-facing facade should be within 30 degrees of due south. While many sites are constrained by existing adjacent buildings and street grids, opportunities may exist to orient upper floors to the south.

Avoid Overheating !

At the same time, designers taking advantage of solar gain must be careful to avoid overheating in the summer months, by specifying the use of thermally-broken external shading (see Exterior Shading callout).

KEY TAKEAWAY

Orient the longest facade of the building towards south as much as possible. Shade south-facing facades to mitigate the risk of overheating.

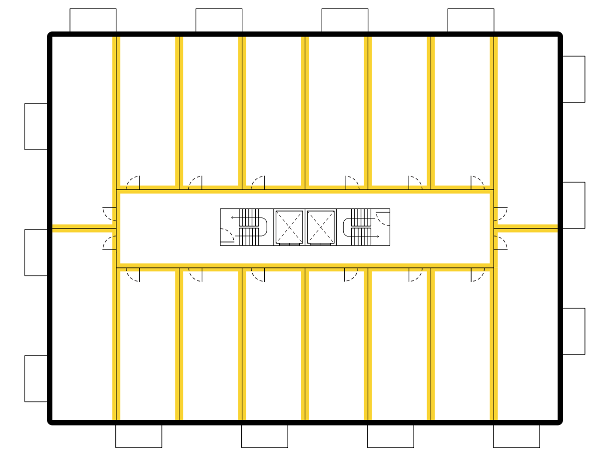
Most important metric(s) to consider TEDI TEUI

03.42 Consider Unit Density

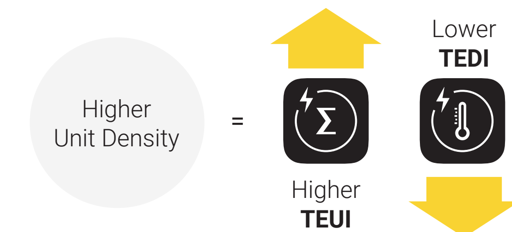
Occupant and unit density significantly influence a proposed building's TEDI and TEUI performance.

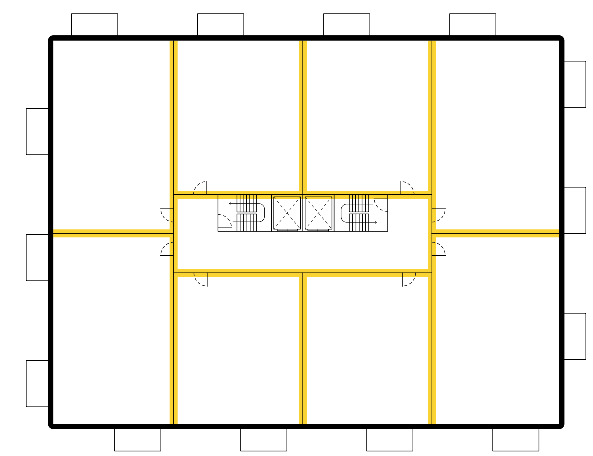
Higher occupant density can make it easier to achieve a TEDI target, while pushing a TEUI objective farther out of reach. This is because a building's occupants drive plug loads, as more people switch on more appliances, and turn on hot-water faucets. As such, the higher a building's occupancy, the more difficult it may be to achieve a specified TEUI. While this trend can be inhibited by poor ventilation, designers should nevertheless look for opportunities to reduce hot-water demand when planning high-occupancy buildings.

On the flip side, the higher a given building's occupancy, the greater the potential for passive internal heat gains. Those appliances and all that hot water — and even the warmth generated by human bodies — all help passively heat buildings. As such, in cooler months, higher occupancy can also reduce a building's heating requirements. Designers should therefore carefully consider expected occupant and unit densities when calculating TEDI and TEUI.

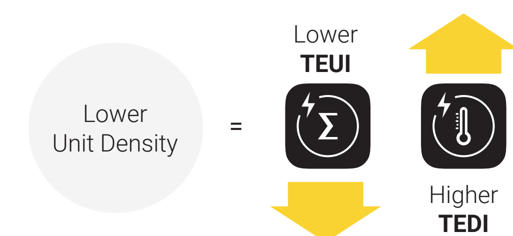


Higher density buildings will achieve TEDI targets more easily as a result of higher rates of passive heating, but can experience challenges in achieving TEUI targets.





Lower density buildings experience the opposite, and have greater ease in achieving TEUI due to a lower overall demand for energy.



KEY TAKEAWAY

Consider trade-offs between TEDI and TEUI carefully in building energy modelling.

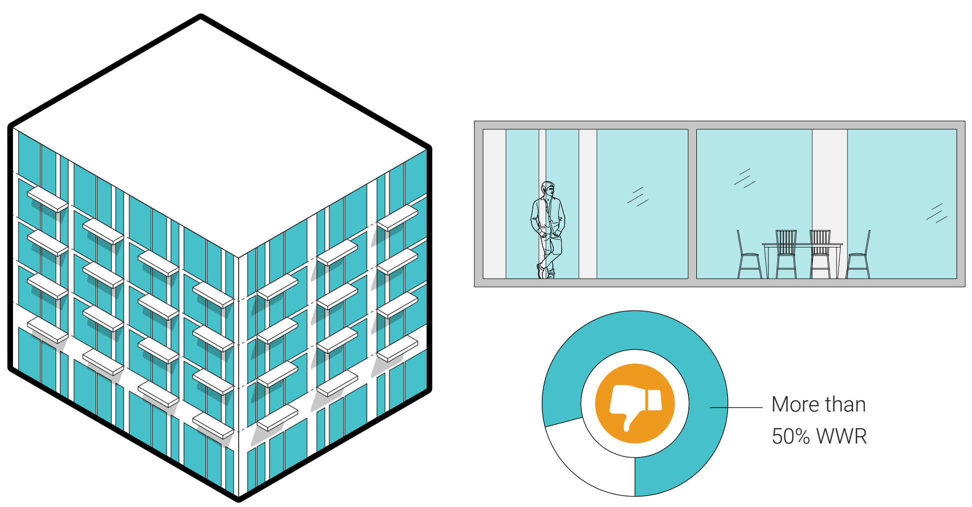
Most important metric(s) to consider TEDI TEUI

03.43 Optimize Fenestration

Fenestration refers to the number, size, and placement of windows on a building's facades. Size and placement are key factors when considering passive heat gains and daylighting.

Window-to-Wall Ratio (WWR)

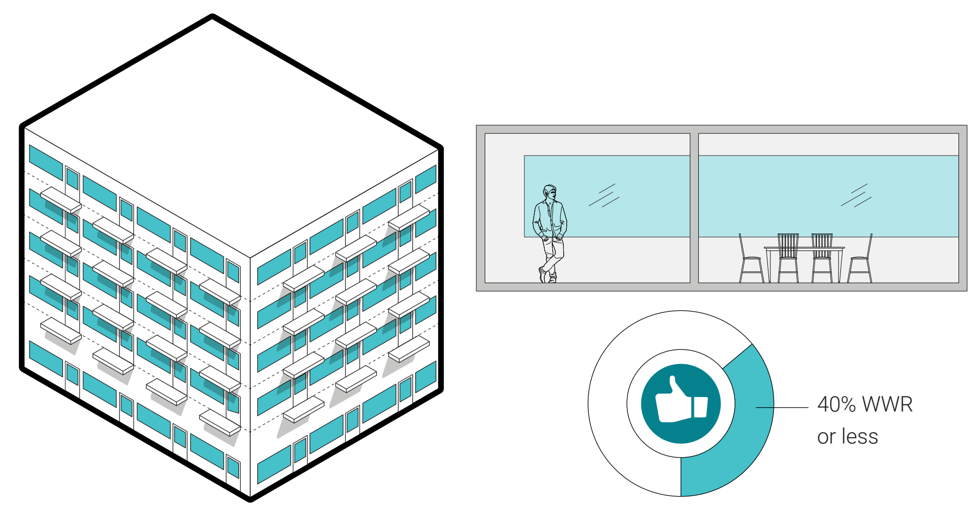
When compared with opaque walls, windows offer low thermal resistance. As such, a lower window-to-wall ratio (WWR) reduces heat gain and loss through the envelope by increasing the area of insulated wall. As a rule of thumb, designers working to comply with the Lower Steps of the BC Energy Step Code should target no more than a 50% WWR. Buildings intended to meet Upper Steps should target a WWR of less than 40%.



While many building designs emphasize much larger WWR (e.g. floor-to-ceiling windows), larger windows can provide harsh light at certain times of the day.

Orientation and Site Specific Considerations

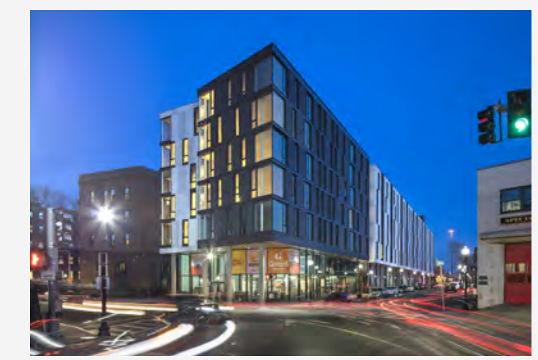
Designers should also consider the direction the building's windows will face, as well as site-specific considerations, such as shading from nearby buildings. Buildings with a high WWR on the southern elevation will maximize their solar gains in the cooler winter months when the sun is lower in the sky. As north-facing windows have the lowest potential for solar gains, WWR on north facades should be more modest if possible. Abundant glazing on south and west facades will support solar heat gains during the winter months.

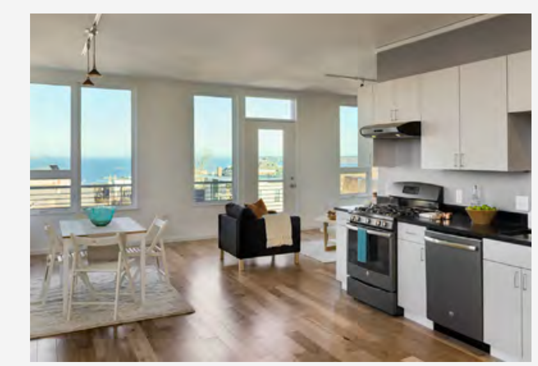


Reducing the size of windows can actually help to improve occupants' comfort by reducing glare and providing a more comfortable indoor temperature, without requiring any additional indoor lighting or losing the potential for views.

Designers should specify lower window sills to sit 24 inches or more above the floor helps to reduce unnecessary solar radiation at foot-level, while still allowing light and views while occupants are sitting or standing.

Top *Cornerstone Apartments, Vancouver, B.C.*
Middle *Girard, 600 Harrison Ave, Boston, MA*
Bottom *Marquis Lofts, Portland, ME*





KEY TAKEAWAY

Target a 40% window-to-wall ratio (WWR)

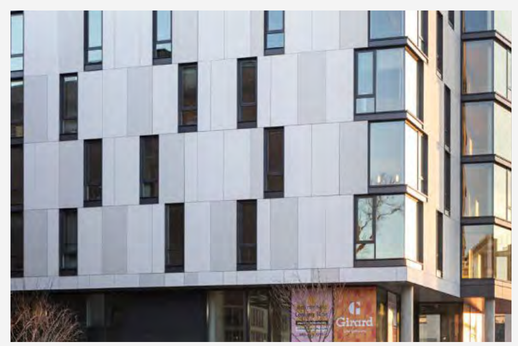
Most important metric(s) to consider TEDI

CASE STUDIES

How to Cut the Rays When They Aren't Wanted

Exterior shading devices can be used to block unwanted solar gains and keep indoor temperatures comfortable in the summer months. These will become even more important as B.C.'s climate warms, and the number of days of extremely high temperatures we experience over the course of a summer rises. Designers can use solar shading devices such as louvres, overhangs, eaves, and balconies to improve occupant comfort, as well as programmable motorized shades placed on the exterior of a building. On lower floors, deciduous trees can provide shade in summer months.

In some cases, designers may also use horizontal shading devices as "light shelves" to direct light deeper into building interiors, reducing the need for artificial illumination.

NORTH FACING

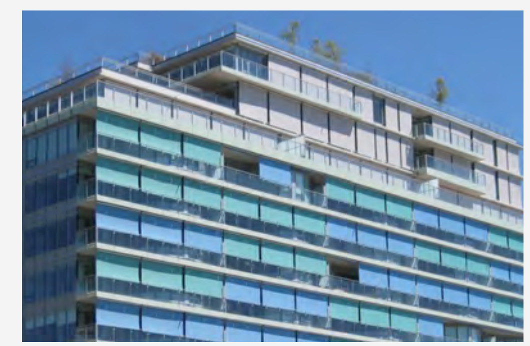
Shading devices aren't necessary on north-facing facades, but designers can reduce the WWR to reduce heat losses through the envelope.

Reference *Girard, 600 Harrison Ave, Boston, MA*


EAST/WEST FACING

Designers can use vertical fins to block incoming summer sun on western elevations.

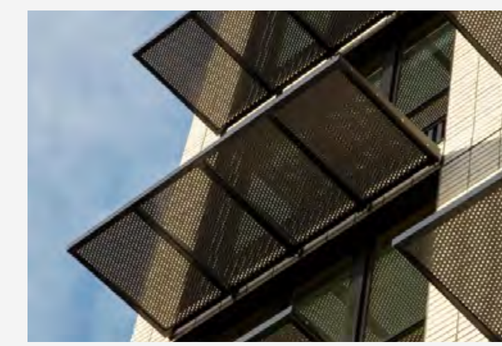
Reference *The Spot, Vancouver, B.C.*

WEST FACING

Programmable motorized shades can be placed on the outside of a building to shade interiors when necessary. Shades automatically extend or retract according to the amount of incoming solar radiation.

Reference *181 W 1st Ave, Vancouver, B.C.*

SOUTH FACING

Designers should place shading devices along a building's southern elevation to block incoming solar radiation in the summer, while welcoming solar gains from lower winter sunlight.

Reference *Muse Apartments, Portland, OR*

KEY TAKEAWAY

Use external shading devices to minimize unwanted solar gains.

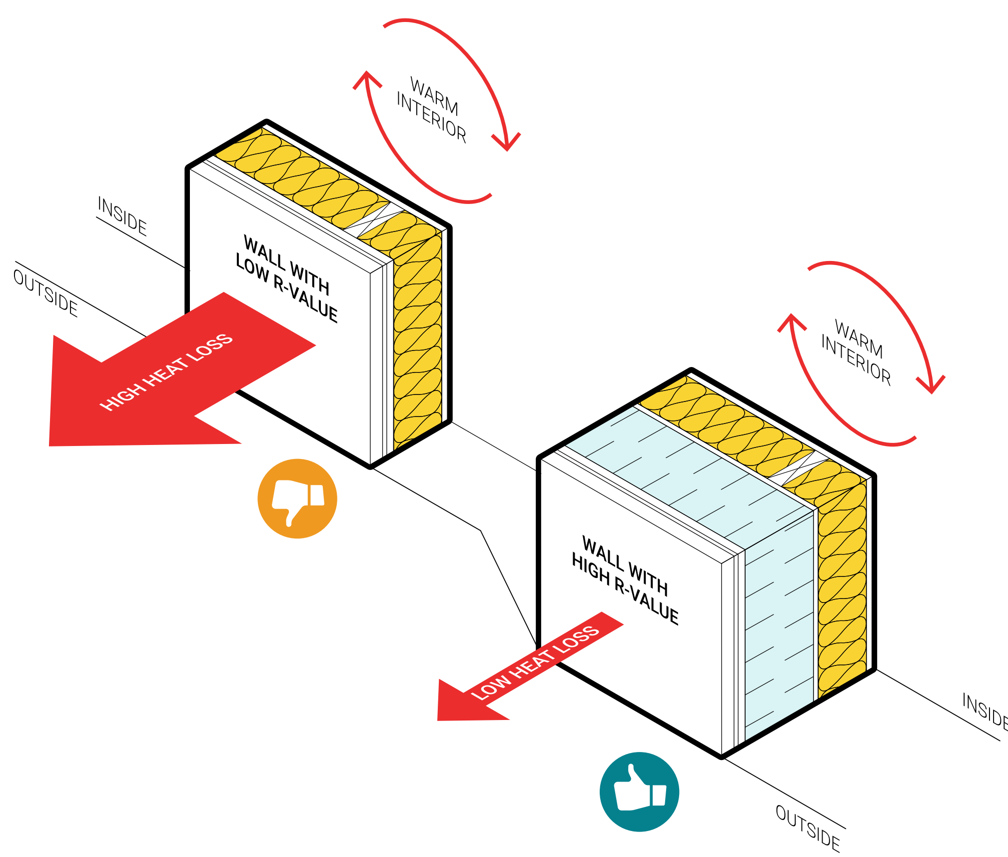
03.44 Increase Building R-Values

R-values indicate an envelope's thermal resistance, or its ability to prevent heat from moving from one side to the other. The higher the R-value, the better the envelope is in terms of its insulating effectiveness. By selecting building-envelope components with higher R-values, designers can improve a building's thermal performance and help reach TEDI targets. Higher R-values also help to improve occupant comfort by keeping building interiors warmer in the winter, and cooler in the summer.

R-values depend on many variables, including a given wall system's insulation type, thickness, and overall density. However, there are two different ways to measure and present a given material's R-value. Nominal R-values indicate the insulating effectiveness of the material itself, while effective R-values convey its performance in conjunction with framing members and/or other materials. Designers should carefully select envelope systems for their effective R-values, and to minimize or even eliminate thermal bridges.

As window areas (glazing) offer lower thermal resistance than opaque wall assemblies, designs that feature a lower WWR and high-performance windows will also improve overall envelope performance. Professionals typically evaluate window performance in terms of U-value — a measure of how well a given window allows heat to pass through. U-values are the inverse of R-values. As such, the lower the U-value, the better a window's performance.

In general, wall systems that are scalable with respect to their insulation allow greater flexibility in balancing glazing and wall performance throughout the design process. These primarily include wall systems that can easily accommodate more insulation without substantially changing their cost or form. When selecting a window system, designers should consider the composition and arrangement of framing elements. Low-conductivity frames and fewer framing elements can help to reduce the potential heat loss through the windows.



CASE STUDIES

Is everyone comfortable?

Higher performance wall and window systems improve a building's energy efficiency, but they can also greatly improve the comfort of its occupants by maintaining a more consistent and comfortable indoor temperature.

Image *Kiln Apartments suite, Portland, OR*

KEY TAKEAWAY

Select envelope systems with high effective R-values. Select windows with low U-values.

Most important metric(s) to consider TEDI

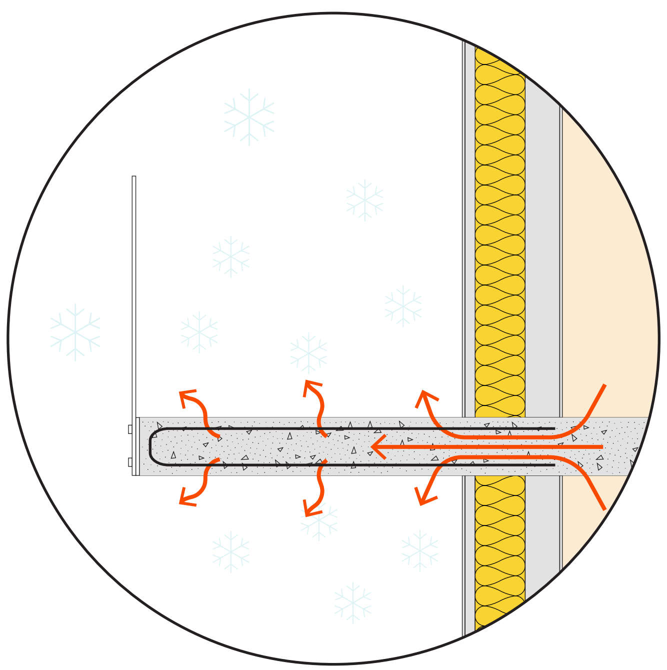
03.45 Reduce Thermal Bridging

A thermal bridge refers to an area in a building's envelope that interrupts the building's continuous insulation layer, causing heat to escape the interior of the building to the outside.

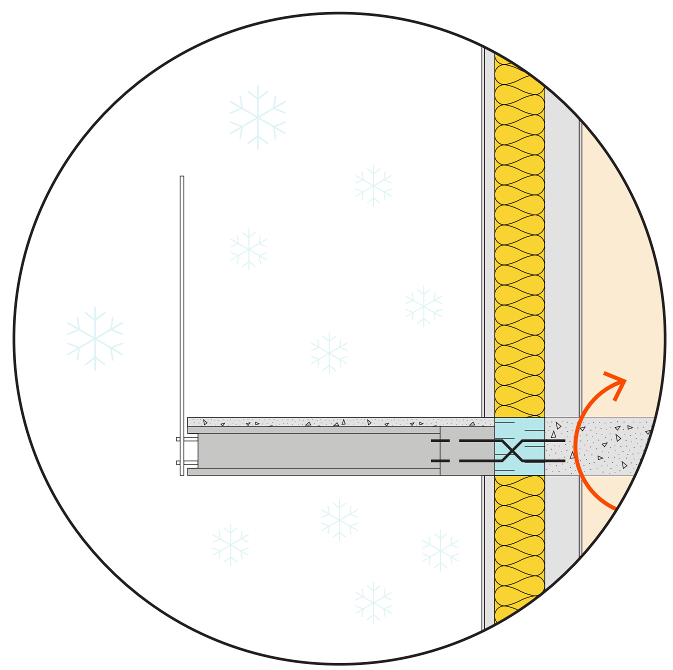
Examples of thermal bridges include concrete balconies and beams that run from the building's interior to exterior. To prevent excessive heat loss, designers should avoid or "break" these thermal bridges with insulating materials, or specify thermally broken building products.

Designers can mitigate thermal bridging by choosing a compact building design that reduces articulations and junctions. They should also require continuous insulation around floor edges, and position window frames in line with building insulation. Doing so will minimize heat loss through the frame-to-wall connection.

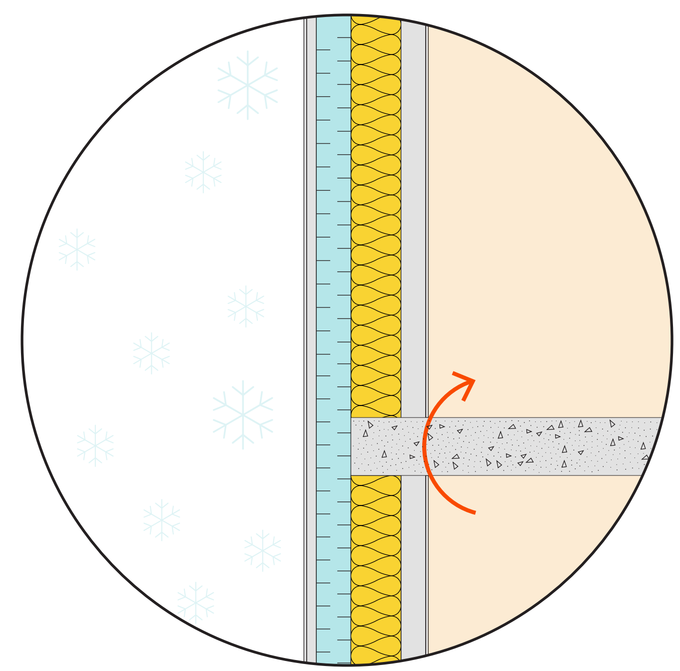
Professionals should avoid slabs that extend the floor plate beyond the heated building envelope, and choose thermally broken balconies in situations where balconies are required.



Balcony with high thermal bridging



Thermally broken balcony



Continuous insulation

ADDITIONAL RESOURCES

Software tools and resources such as **BC Hydro's Building Envelope Thermal Bridging Guide** are useful in identifying and mitigating thermal bridging.

KEY TAKEAWAY

Break all thermal bridges with insulating materials.

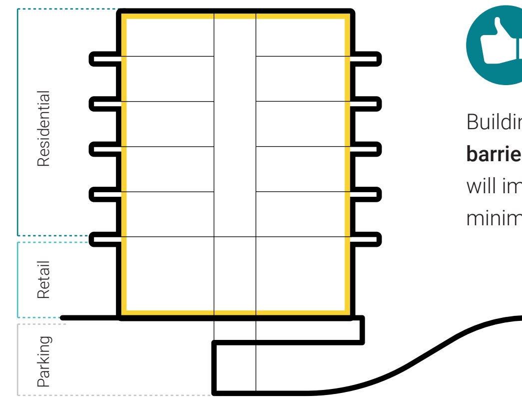
Most important metric(s) to consider TEDI

03.46 Increase Airtightness

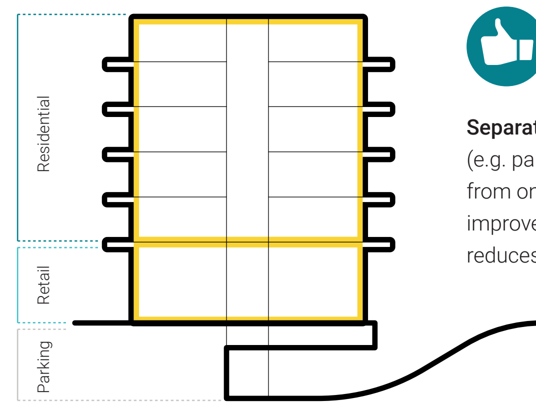
Buildings designed for a compact shape, form, and size not only improve thermal performance, but can improve airtightness as well. Complex forms with more corners have a greater overall potential for air leakage through the building envelope.

Designers should create an airtightness plan to detail the installation of a continuous air barrier, and clearly indicate it on section drawings.

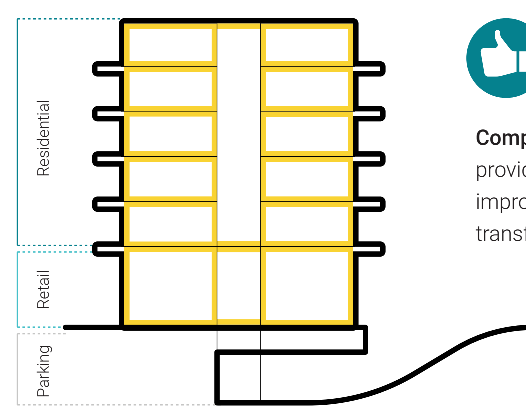
Designers might also consider a compartmentalization strategy to improve a proposed project's airtightness. **Compartmentalization** refers to the practice of isolating individual suites or units in a building from one another, such that they are individually ventilated. The approach minimizes transfer of air — and therefore smoke, smells, and contaminants — from adjacent units or spaces. It also helps to mitigate the "stack effect" in taller buildings.



Buildings with a **continuous air barrie**r around the entire facade will improve airtightness and minimize heat losses



Separating building uses (e.g. parking, retail, residential) from one another further improves airtightness and reduces the stack effect



Compartmentalizing individual units provides the highest level of airtightness and improve occupant comfort by reducing the transfer of noise and smells between units

ADDITIONAL RESOURCES

The Illustrated Guide to Achieving Airtight Buildings, published jointly by BC Housing, BC Hydro, and the City of Vancouver, offers additional resources on how to create effective air barriers.

KEY TAKEAWAY

Install a continuous air barrier to minimize heat losses through the building envelope. Seal off residential units from each other and from other building uses.

Most important metric(s) to consider Airtightness

03.47 Recover Heat During Ventilation

Typical Ventilation

Historically, MURBs have been ventilated using a centralized pressurized corridor system, in which positively pressurized corridors on each floor force air into individual units through gaps under entrance doors. While it is still common in some areas, this approach has been found to be inefficient in effectively or evenly distributing air throughout the building. Leakage along the distribution system ductwork wastes large amounts of energy, and leads to inadequate ventilation across a building's units. As of 2012, the BCBC also began requiring the provision of ventilation to individual rooms within a unit, making this approach less feasible.

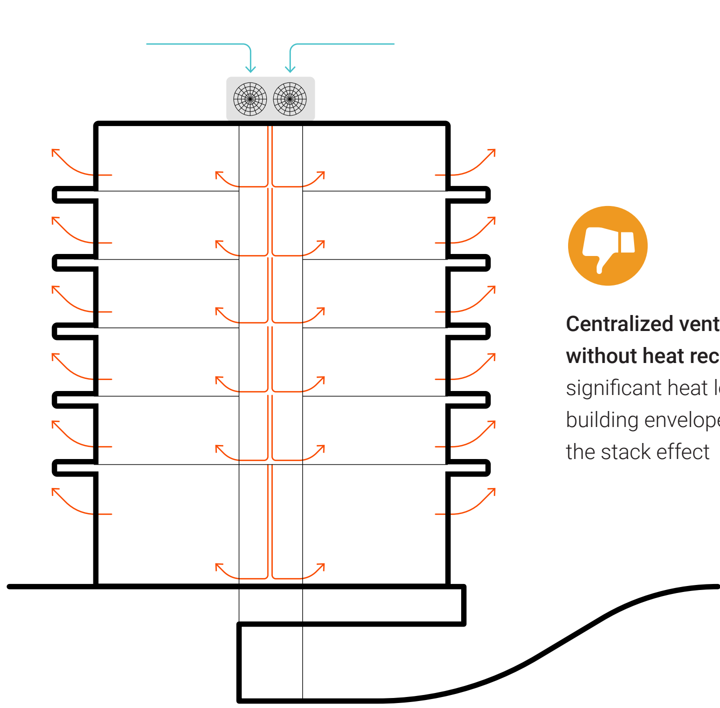
Compartmentalized Ventilation

In contrast, the compartmentalization of unit ventilation helps to control the overall flow of air in a building, reducing overall energy demand and improving the health and comfort of unit occupants.

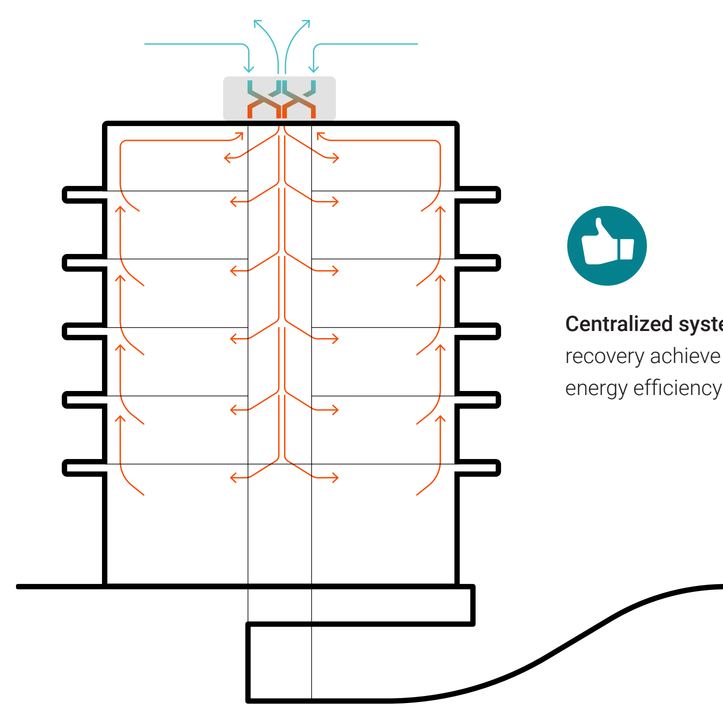
Designers working to meet the performance targets of the BC Energy Step Code should specify high-efficiency heat recovery ventilators (HRV) for either the whole building or at the suite level. Buildings will not likely achieve the Upper Steps of the code without some kind of highly efficient heat recovery.

Heat Recovery

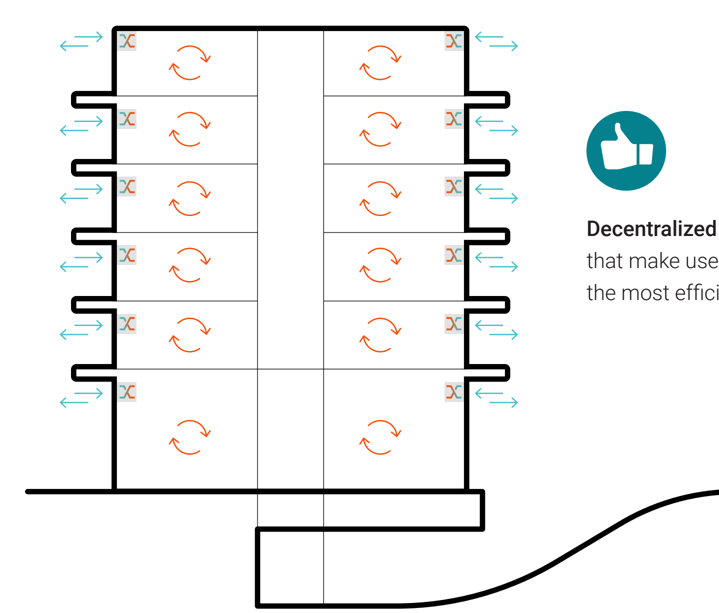
With HRVs, designers can limit centralized, conditioned ventilation to corridors and common areas only, reducing energy that is often wasted through redundant heating. These systems also provide a direct source of fresh air to individual suites, reducing the transfer of smoke, smells, and sounds between units and improving air quality. They minimize heat loss in ventilation, improving a building's overall TEDI and TEUI.



Centralized ventilation systems without heat recovery can lead to significant heat losses through the building envelope, and can increase the stack effect



Centralized systems that use heat recovery achieve higher levels of energy efficiency



Decentralized ventilation systems that make use of heat recovery are the most efficient

KEY TAKEAWAY

Use a heat recovery ventilation system at whole building or individual unit scales to reduce heat losses.

Most important metric(s) to consider TEDI

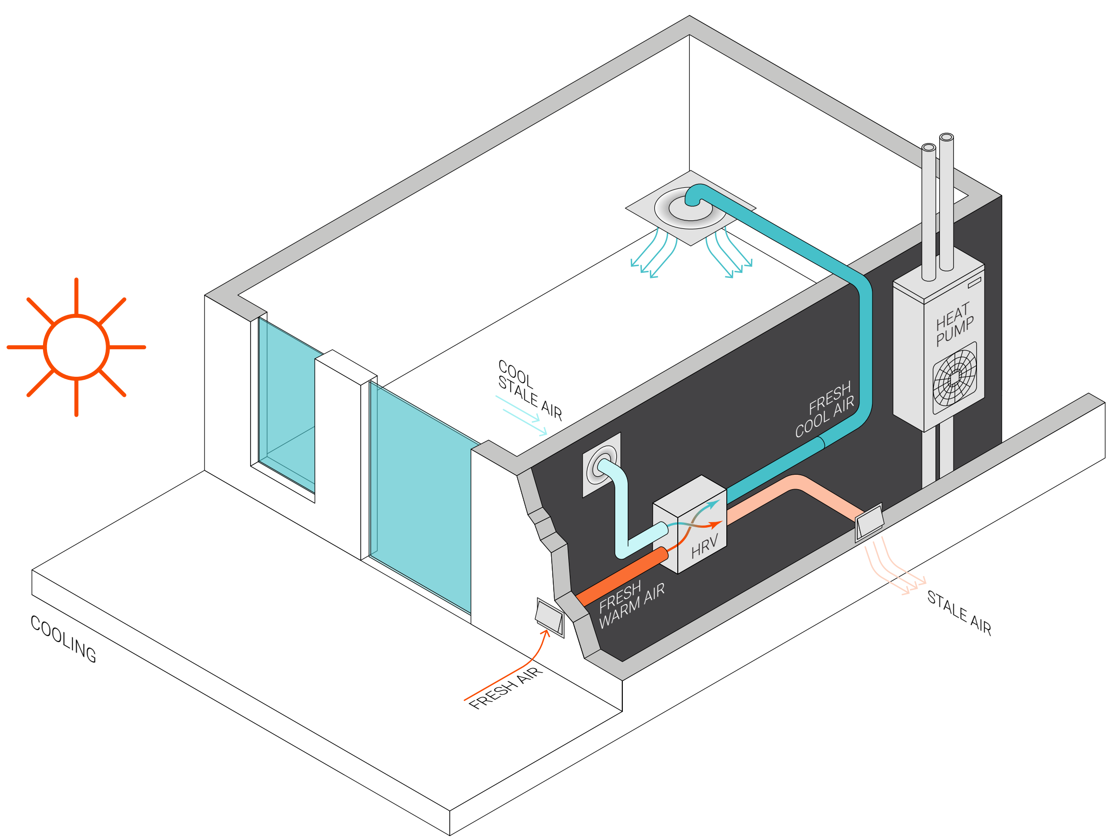
03.48 Separate Heating and Cooling from Ventilation

To achieve TEUI targets, designers should separate heating and cooling systems from ventilation systems. In addition to the ventilation strategies noted in Section 03.47, designers striving to achieve TEUI targets should consider high-efficiency mechanical systems. This separation allows for continuous ventilation, regardless of whether a suite requires heating.

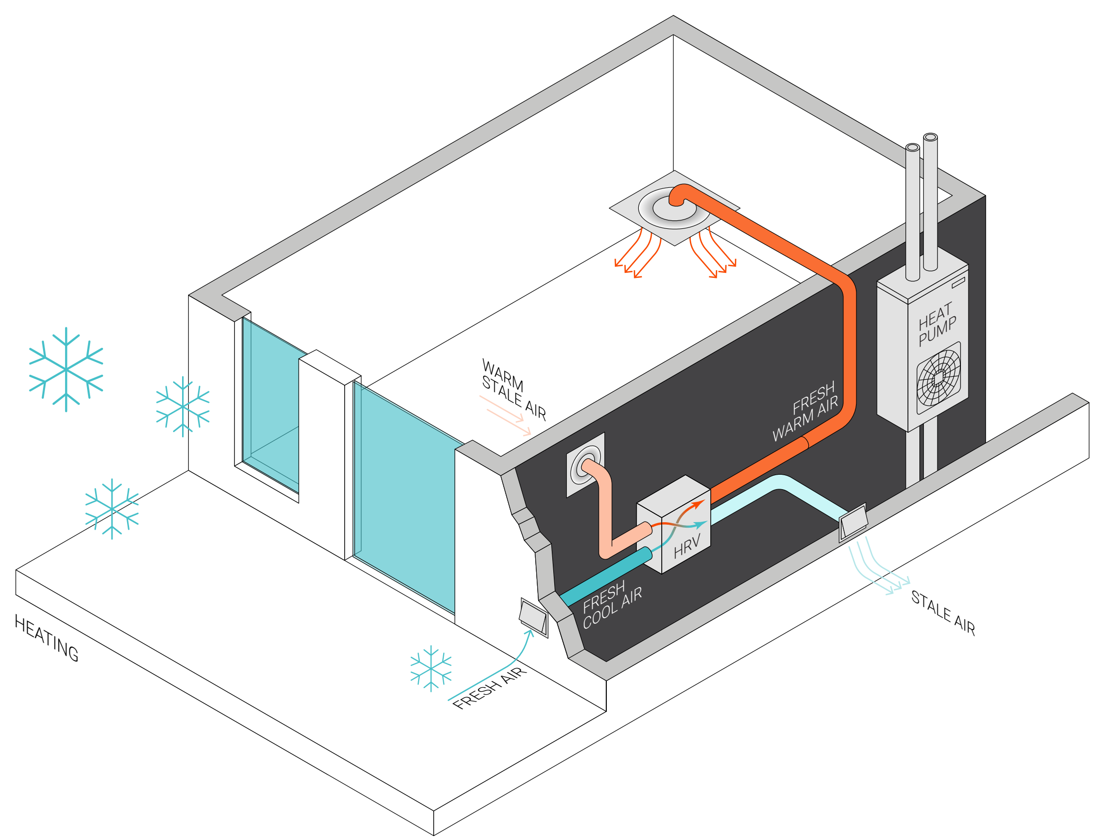
Of all mechanical space-conditioning systems, heat pumps generally do the most effective job of lowering TEUI scores. Options include geo-exchange, air-source, and variant refrigerant flow (VRF) systems. Systems that connect to district energy systems also tend to incorporate some type of heat pump.

Beyond improving a building's TEUI, heat pumps often offer the added benefit of providing occupants with air-conditioning in the summer months. However, prior to selecting mechanical systems, designers should take an envelope-first approach to reducing energy demand as much as possible.

Heat pump technologies are desirable in that they can also provide cooling in summer months



Heat pumps can efficiently provide heat to buildings in cooler months



Selecting Low-Carbon Mechanical Systems for the City of Vancouver's Zero Emissions Building Plan (ZEBP)

The selection of mechanical strategies is of central importance to the achievement of GHGI performance targets in the City of Vancouver ZEBP. See Supplement S (page 45) for more details on the City of Vancouver's ZEBP.

KEY TAKEAWAY

Separate heating and cooling systems from ventilation systems

Most important metric(s) to consider TEDI

03.5 Summary of Key Strategies

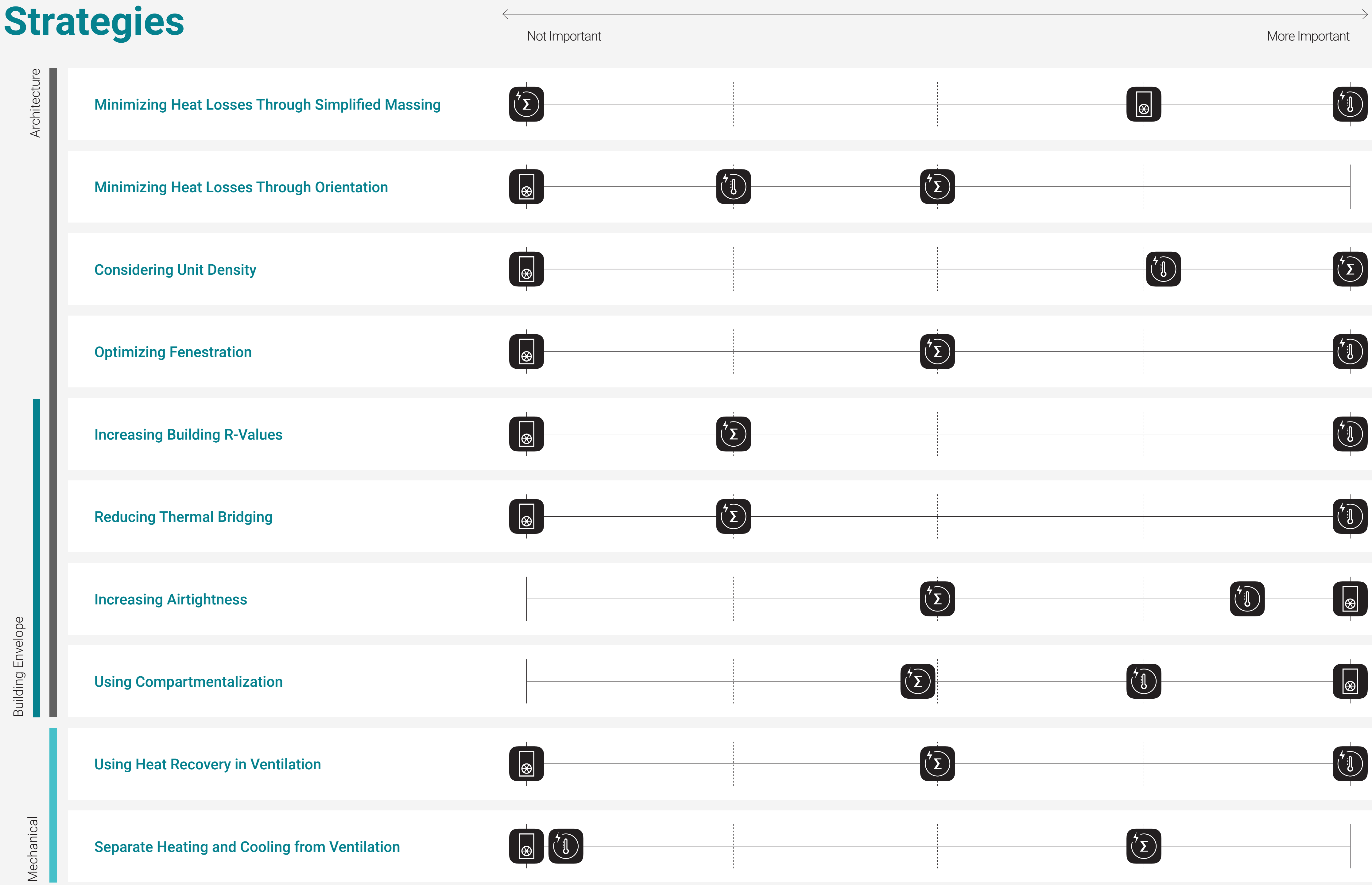
While certain design strategies will help meet a single BC Energy Step Code performance target (e.g. TEDI), others will help accomplish all three. Practitioners should consider these core strategies — addressing building shape, orientation, and envelope, as well as mechanical and ventilation systems — early in the design process. Proponents must retain the services of an energy modeler at the design and permitting stages. To ensure overall compliance, designers should rely on hourly energy modelling tools.

Diagram Description

The figure to the right shows the importance of each design strategy in relation to the three key metrics of the BC Energy Step Code (TEDI, TEUI, and airtightness). To explore the impact of different design decisions interactively, visit the **Building Pathfinder website**.

LEGEND

- TEDI
- TEUI
- Airtightness
- Architecture
- Building Envelope
- Mechanical



SECTION 04.

Design Strategies for High-Rise and Mid-Rise MURBs

04.1 Introduction

This section presents details on the key design strategies necessary for designers of MURBs to meet the BC Energy Step Code.

High-Rise MURB

In this guide, High-Rise MURB refers to multi-unit residential buildings of six storeys or higher, designed and built using concrete construction techniques. Such buildings often consist of one to two storeys of commercial space at grade, with up to several dozen setback storeys of residential units above. Exclusively residential high-rise MURBs often include common areas such a lobbies and shared-use facilities, such as gyms and common rooms, alongside or in addition to ground-level suites.

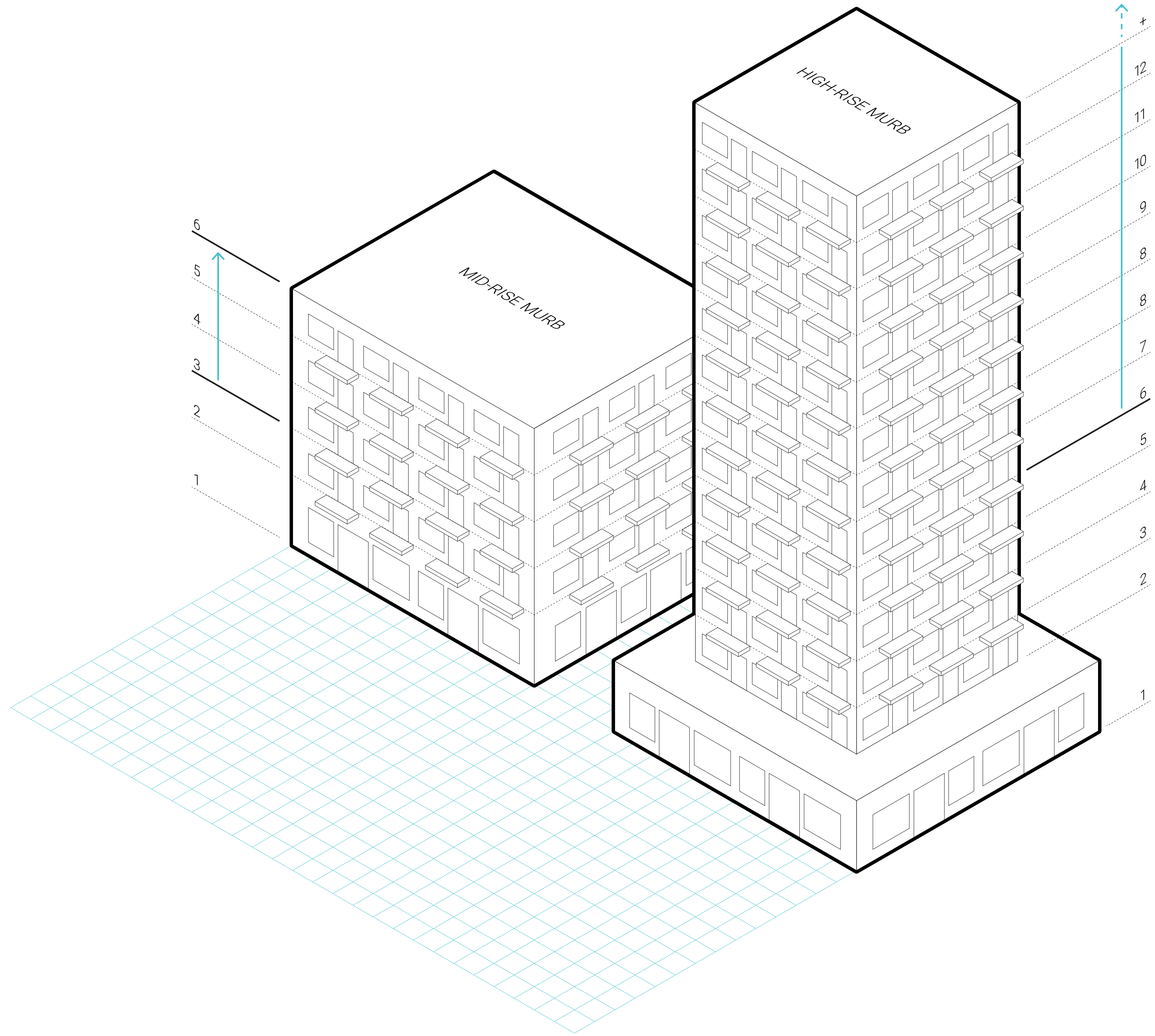
Mid-Rise MURB

Mid-Rise MURB refers to multi-unit residential buildings of three to six storeys, and designed and built using wood-frame construction techniques. Mid-rise MURBs can be configured with a concrete first storey and wood construction above. While many mid-rise MURBs are purely residential, others can host small businesses in the first and second storeys.

Key Design Strategies

The strategies presented in this section represent some of the lowest cost design solutions to meet TEDI, TEUI, and airtightness performance targets in the province's Lower Mainland (Climate Zone 4). However, it bears repeating that designers can turn to nearly endless combinations of energy conservation measures to meet BC Energy Step Code requirements. Site conditions, the owners' performance requirements, and many other factors impact a given design's potential to meet BC Energy Step Code requirements.

As such, designers should consider a variety of strategies to determine the best response to meet their specific needs. Hourly energy modelling tools will prove invaluable in doing so.



04.2a Building Massing: High-Rise MURB

The design of high-rise residential towers is often constrained by existing site conditions, including the size of the lot and its orientation with respect to the existing street grid. However, designers can take measures to improve a proposed building's ability to meet the BC Energy Step Code's TEDI targets.

Lower VFAR

High-rise residential towers designed with a lower vertical surface area to floor area ratio (**VFAR**) have a lower overall potential for heat loss through the building envelope. Towers with smaller, narrower floor plates tend to lose more heat through the building envelope. In tower forms, any floor plate of 600m² (6,500ft²) or less can be considered to be a "smaller" floor plate. As cities often emphasize smaller floor plates to help maximize daylight to the street, building designers will need to strive for a balance between municipal requirements and a building's energy performance.

Simpler Form

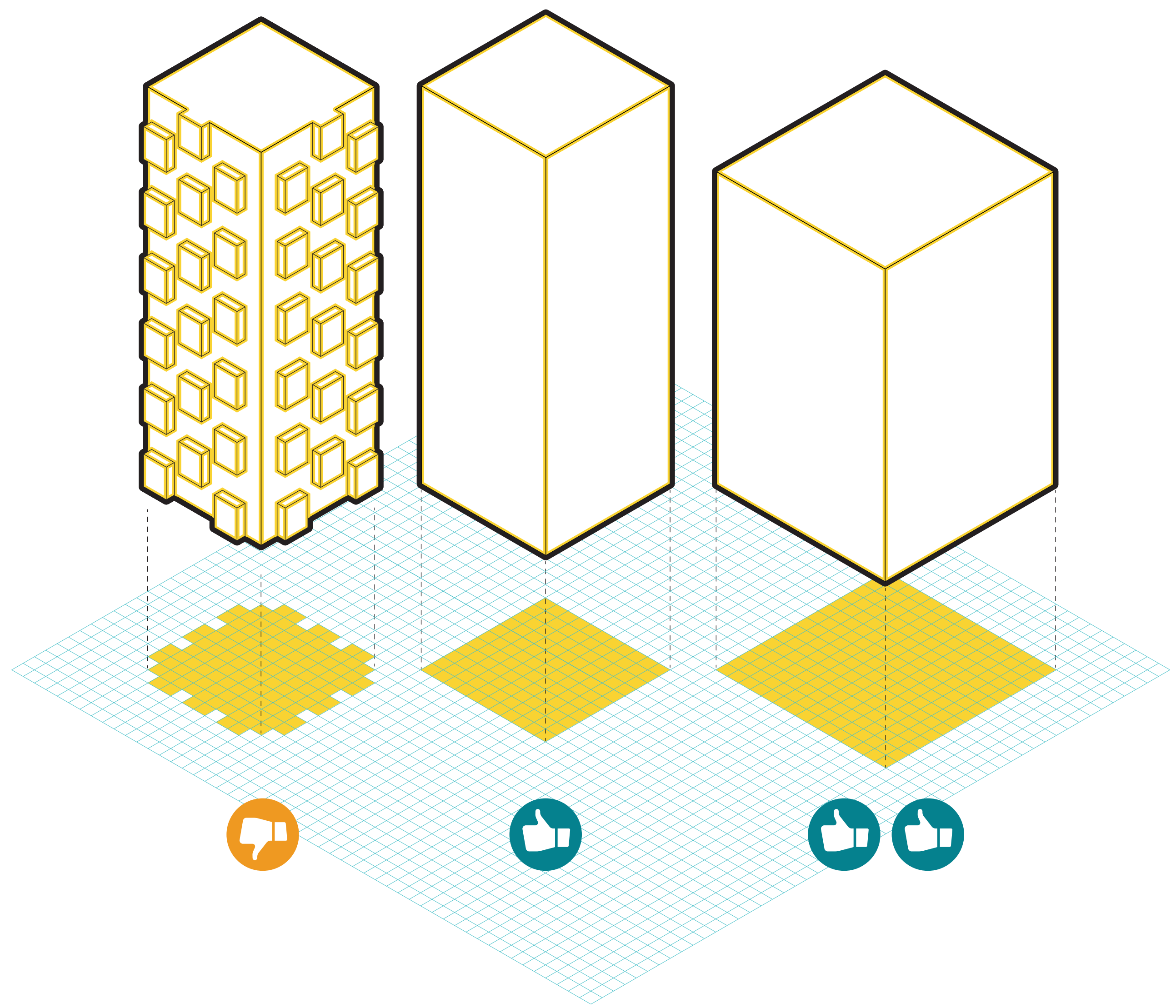
Heat loss through the building envelope is also influenced by the complexity of the building's shape, or **massing**. High-rise MURBs tend to have simpler forms than low- or mid-rise residential buildings. Nonetheless, designers should still work to minimize the number of junctions, indents, and intersections in the building envelope.

Optimized Orientation

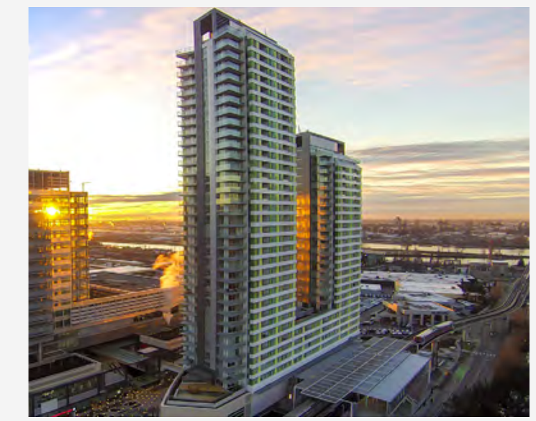
Finally, high-rise MURBs that are designed in such a way that incoming solar gains are maximized in the winter will reduce heating requirements in the wintertime, helping to achieve TEDI performance targets. The **orientation** of residential towers should allow the longest facade of the building to align with due south as much as possible, while ensuring precautions are taken to address the potential for overheating (see Fenestration and Shading). While orientation is often highly constrained by existing street grids and other considerations, high-rise MURB can be designed in such a way that the building's podium aligns with the grid, and the tower is oriented to align towards south.

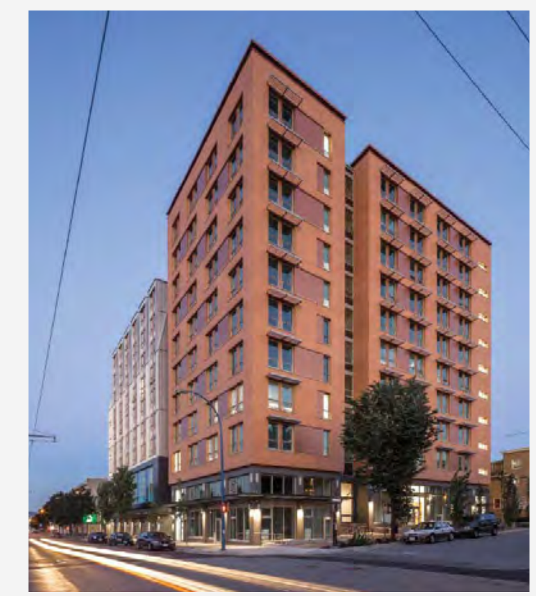
A building with several complex junctions and corners will lose far more heat through the envelope than a building that has been designed as a simple, solid form (e.g. cube, rectangle)

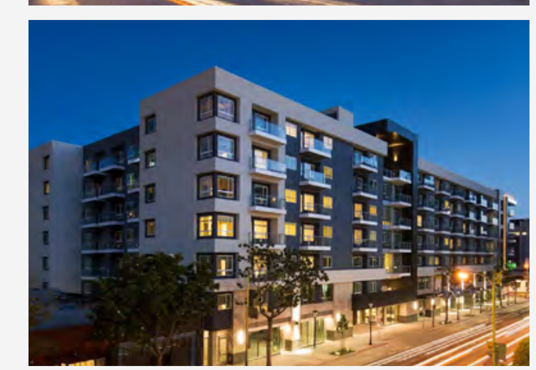
Complexity of shape and size of floor plate both impact Step Code targets



Top *Marine Gateway, Vancouver, B.C.*
Middle *Budzey Building, Vancouver, B.C.*
Bottom *Olympic by Windsor, Los Angeles, CA*



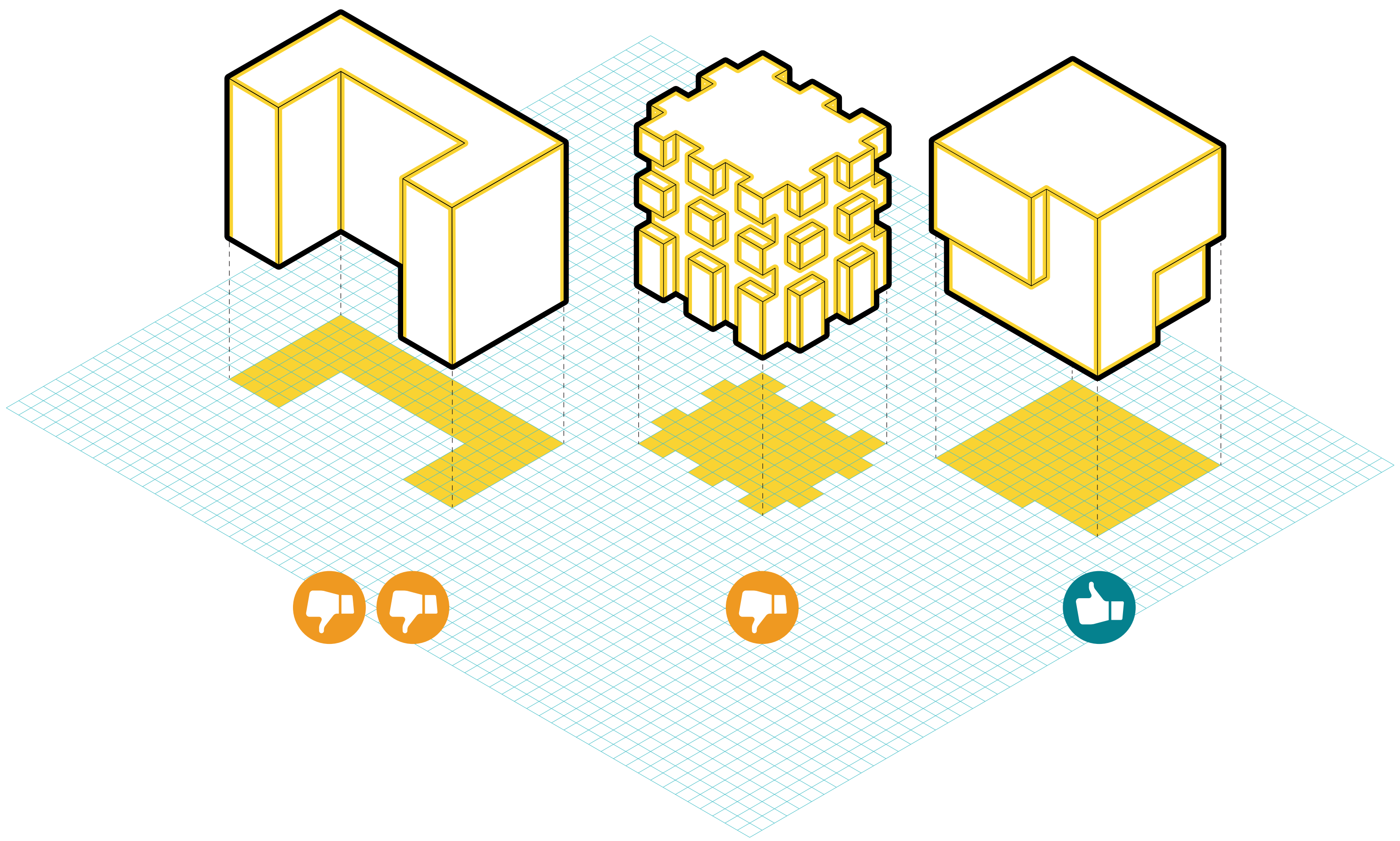




Most important metric(s) to consider: TEDI, Airtightness

04.2b Building Massing: Mid-Rise MURB

Mid-rise residential buildings are usually the most constrained by existing site conditions, setback requirements and lot size, and the existing street grid. However, designers can begin to consider the massing and proportions of the building's design early on to improve its ability to meet the BC Energy Step Code's TEDI targets.



Simpler Form

The complexity of the building's shape, or massing, significantly influences heat loss through the building envelope. Traditionally, mid-rise MURB designers design multiple junctions and articulations in the envelope to enhance visual interest and/or assimilate the building into the urban landscape. However, the fewer such junctions, indents, and intersections, the easier time a designer will have reaching TEDI and airtightness targets. Designers should aim to reduce the overall complexity of the building's shape by replacing complex envelope designs with simpler, compact forms.

Maximize Solar Gains

Mid-rise MURB designers should seek to maximize solar gains in the winter to reduce heating requirements; doing so will help achieve TEDI performance targets. This is often challenging given existing site conditions, but may be a consideration for upper floors. Designers must also be careful to avoid overheating.

CASE STUDIES

Compact Charisma

Building designers can make use of different colours and textures to enhance the visual interest of a building while keeping its form simple and compact.

Top *Cornerstone, Vancouver, B.C.*
Bottom *Kiln Apartments, Portland, OR*

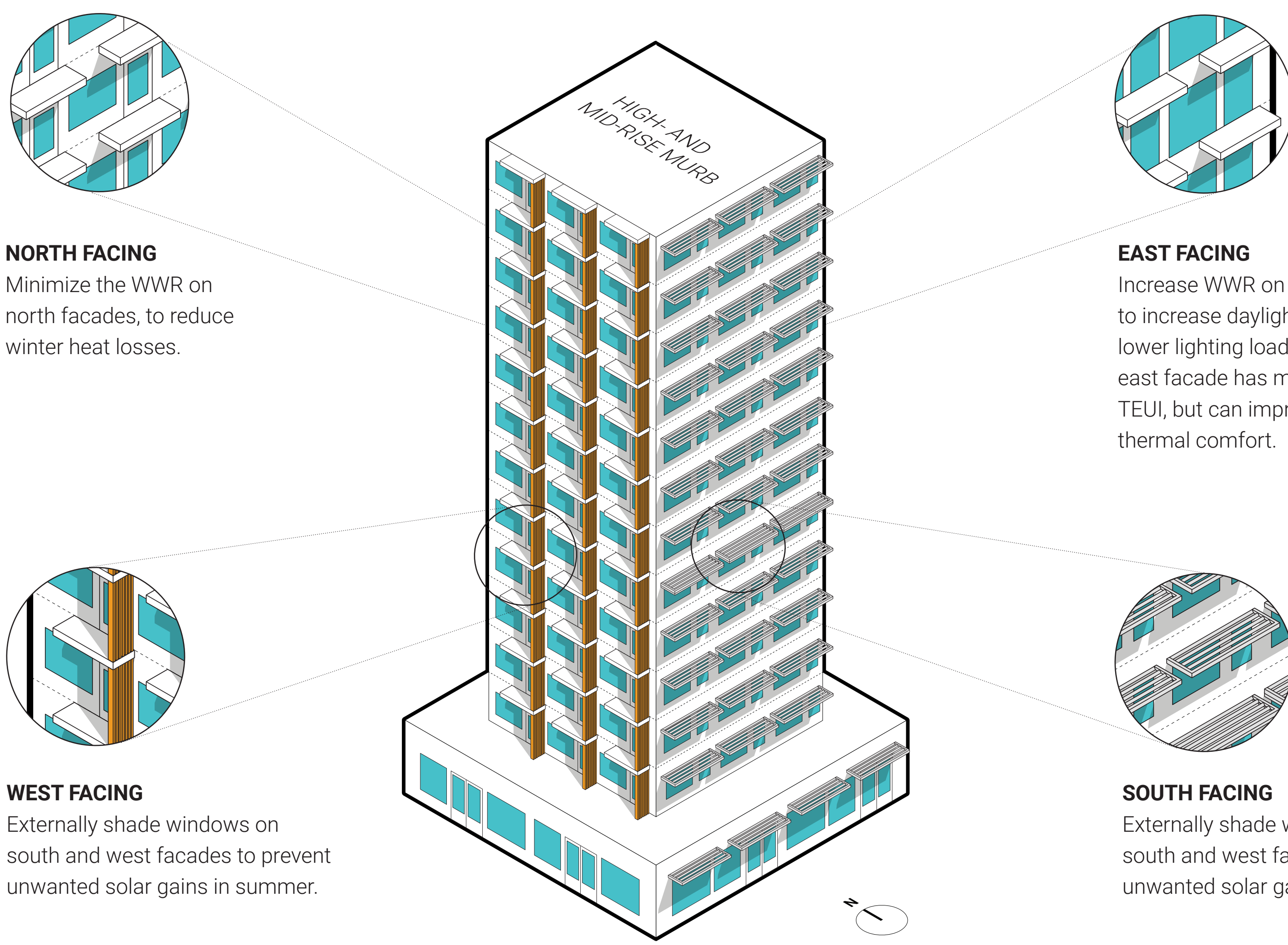
Most important metric(s) to consider TEDI Airtightness

04.3 Fenestration and Shading

The size and placement of windows can influence a MURB's TEDI and TEUI performance. To reduce a building's TEDI, windows should be placed in such a way as to optimize incoming solar gains in the winter, and minimize solar gains in the summer. Careful placement of windows can also improve cross-ventilation, support daylighting, and reduce the need for artificial lighting, all lowering total energy demand.

Strategies to address these issues include increasing sill heights, and ensuring that operable windows are on multiple facades or walls wherever possible. Moving corridors and elevators to the north side of a building can also help to minimize areas that require glazing and daylight access.

Designers can also consider existing adjacent buildings and trees in a shading strategy, so long as they recognize that neither strategy may be permanent. (Adjacent trees and buildings are subject to change!)

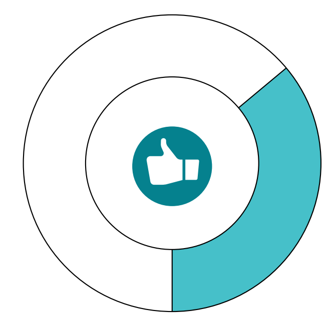


NORTH FACING
Minimize the WWR on north facades, to reduce winter heat losses.

EAST FACING
Increase WWR on east facades, to increase daylighting potential and lower lighting loads. Shading on the east facade has minimal impact on TEUI, but can improve occupants' thermal comfort.

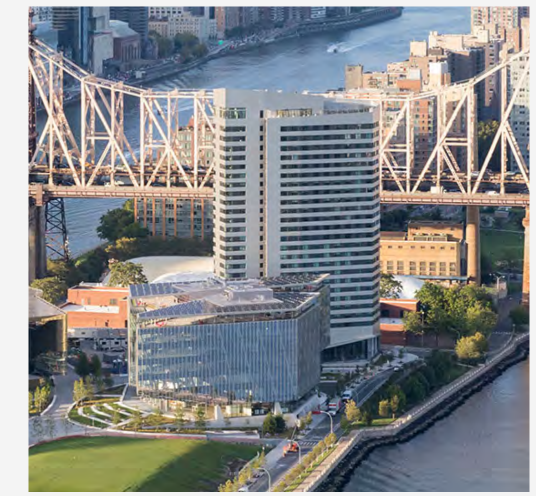
WEST FACING
Externally shade windows on south and west facades to prevent unwanted solar gains in summer.

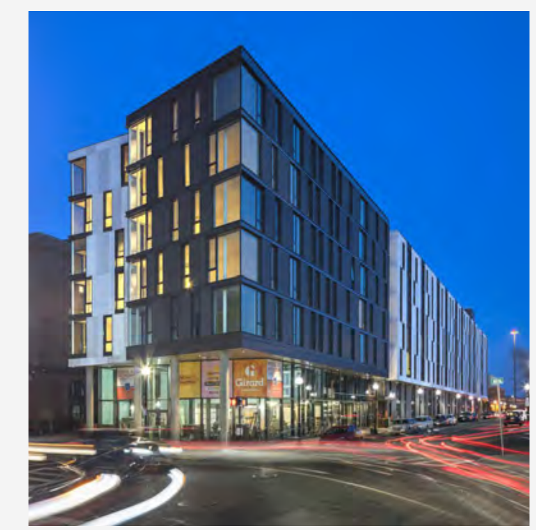
SOUTH FACING
Externally shade windows on south and west facades to prevent unwanted solar gains in summer.



OVERALL WWR
40% or less

Top *Cornell Tech Residential, NYC*
Middle *Girard, 600 Harrison Ave, Boston, MA*
Bottom *Cornerstone, Vancouver, B.C.*





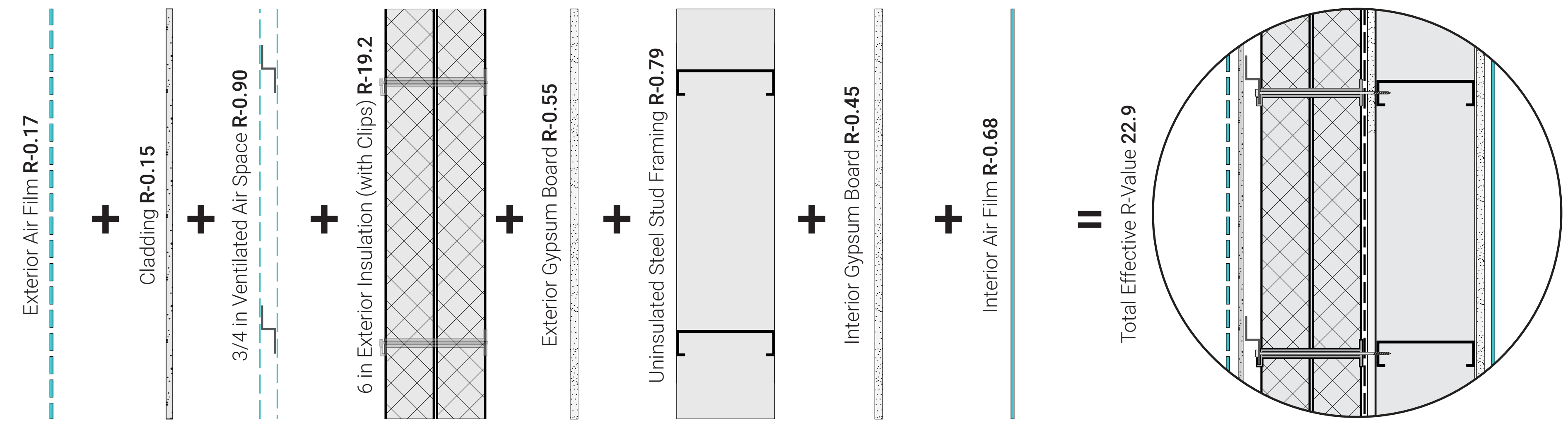
Most important metric(s) to consider TEDI

04.4a Wall R-Values: High-Rise MURB

To improve the ability to meet the TEDI performance targets for all steps of the BC Energy Step Code, designers should select wall systems with a minimum value of R-10 effective, and consider roof designs with a minimum value of R-20 effective.

Historically, window wall systems have not achieved high R-values and, as a result, do not typically achieve the higher levels of performance that steel stud and exterior insulation or concrete panel systems can achieve. That said, there are a small number of high-performance window wall systems that are currently on the market in B.C. that can be designed and installed to achieve insulation levels capable of achieving Steps 2 and 3.

Wall systems that exhibit the most favourable characteristics for achieving better building performance include concrete assemblies with exterior insulation, concrete sandwich panes, and steel-stud with exterior insulation wall systems.



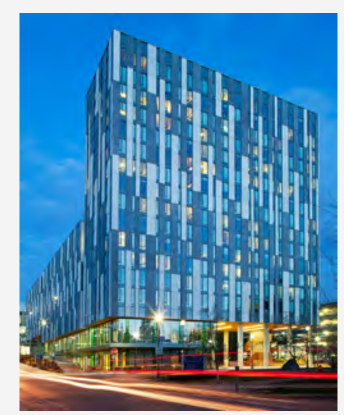
Concrete Assemblies with Exterior Insulation

Cast-in-place concrete wall assemblies are common on high-rise MURBs. In this approach, cladding and exterior insulation is attached to the concrete wall with intermittent thermally efficient clips. A continuous layer of insulation around the entire envelope is necessary to achieve higher levels of thermal performance and minimize thermal bridging.

Above
Terrace 459, Chicago, IL

Concrete Sandwich Panels

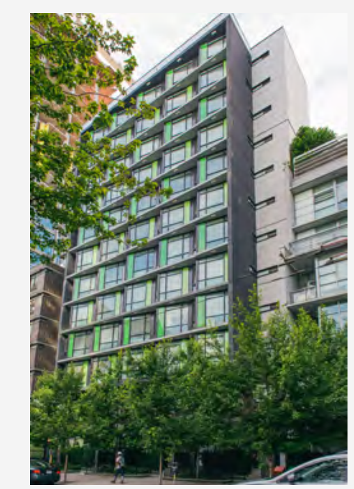
In this approach, insulation is sandwiched between two layers of pre-cast reinforced concrete panels. Sandwich panels offer higher levels of thermal performance than solid pre-cast panels, as the sandwiched layer provides for continuous insulation. They also achieve good levels of airtightness.



Above
Ponderosa Commons, Vancouver, B.C.

Steel-Stud with Exterior Insulation

Steel stud wall assemblies are commonly used in High-Rise MURB construction. In this approach, cladding and exterior insulation is attached to the steel stud wall with intermittent thermally efficient clips. Steel stud walls can either be built on-site, or made as prefabricated panels off-site and lifted into place. A continuous layer of insulation around the entire envelope is necessary to achieve higher levels of thermal performance and minimize thermal bridging.



Above
Mclaren House, Vancouver, B.C.

Fire Safety All exterior wall assembly materials must be non-combustible.

Most important metric(s) to consider TEDI

04.4b Wall R-Values: Mid-Rise MURB

Mid-rise MURB designers can improve TEDI performance by selecting wall and roof systems that offer a minimum effective R-20 insulation value. Mid-rise MURBs are commonly constructed using either wood-frame or concrete wall assemblies. Wood-frame construction typically achieves higher thermal performance than concrete wall systems, because the thermal conductivity of wood is lower than that of concrete and steel. Mid-rise MURB designers seeking BC Energy Step Code compliance will want to consider four major wall approaches:

Wood-Stud with Split Insulation

This conventional construction method achieves high thermal performance with standard 2x4 or 2x6 studs. Crews install insulation within the stud cavities, and also apply a continuous layer of rigid or semi-rigid insulation to the building's exterior.

Above
Riverport Flats, Richmond, B.C.

Deep Wood-Stud Assemblies

Designers can achieve higher thermal performance with deeper stud walls (e.g., 2x8, 2x10, 2x12, or I-joists), and/or double stud framing with an interior service wall. Contractors then fill these deeper stud cavities with mineral-fibre batt insulation, blown-in fibrous insulation, or spray-foam insulation.

Above
Orchards at Orenco, Portland, OR

Steel-Stud with Exterior Insulation

Steel-stud wall assemblies are commonly used in MURB construction. In this approach, cladding and exterior insulation is attached to the steel stud wall with intermittent thermally efficient clips. Steel-stud walls can either be built on-site, or made as prefabricated panels off-site and lifted into place. A continuous layer of insulation around the entire envelope is necessary to achieve higher levels of thermal performance and minimize thermal bridging.

Above
Richardson Apartments, Portland, OR

Concrete Assemblies with Exterior Insulation

Exterior insulated concrete walls score well on durability and thermal performance. Designers choosing this option can minimize thermal bridging through the exterior insulation by carefully selecting cladding attachments and ensuring interface details are thermally improved.

Above
Knickerbocker Commons Passive House, NY

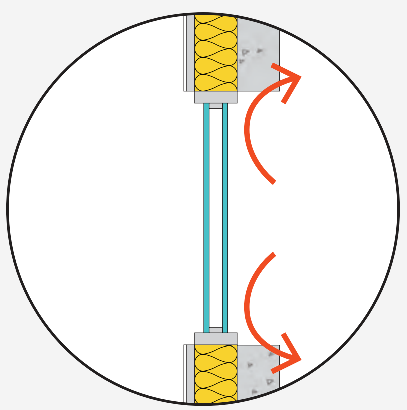
Most important metric(s) to consider TEDI

04.5 Window U-Values

The U-value of the glazing selected for use in building design will have a significant impact on the ability of the building to achieve the performance targets of the BC Energy Step Code. In general, energy modelling will reveal the level of window performance needed to meet a given step's TEDI target.

Select the Right Windows:

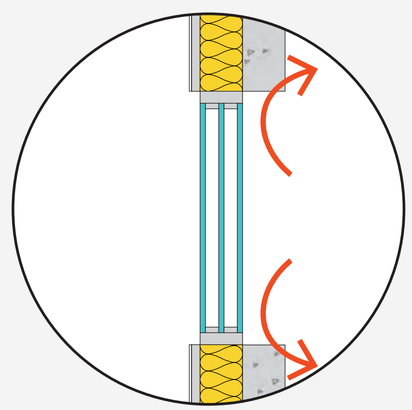
For Designers Targeting Step 2 or Step 3:
Select Double Pane Windows



High-Rise MURBs
Designers targeting Step 2 or Step 3 should consider the use of double pane windows with a **maximum U-value of USI-2.5.**

Mid-Rise MURBs
Designers targeting Step 2 or Step 3 should consider the use of double pane windows with a **maximum U-value of USI-2.5.**

For Designers Targeting Step 4:
Select Triple Pane Windows



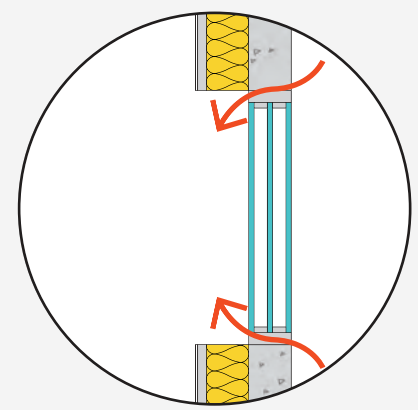
High-Rise MURBs
Designers aiming for Step 4 will want to investigate the use of triple pane windows with a **maximum U-value of USI-1.6.**

Mid-Rise MURBs
Designers aiming for Step 4 should consider the use of double or triple pane windows with a **maximum U-value of USI-2.0.**

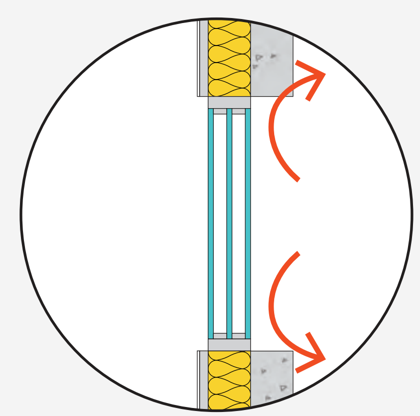
In mid-rise MURBs, designers can also reduce thermal bridging by specifying window frame materials, such as vinyl or fibreglass, which offer lower thermal conductivity.

Reduce the Number of Opportunities for Thermal Bridges to Occur:

Align Windows with Insulation

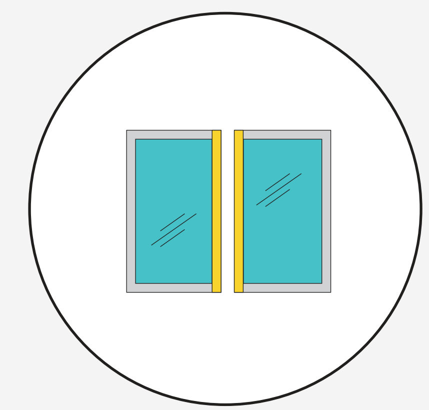


Windows frames that are out of line with the building's insulation layer increase the chances of heat loss through the envelope.

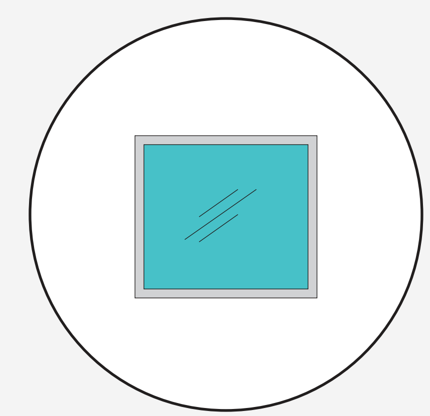


Place windows in line with the building's insulation layer to minimize heat losses.

Reduce Framing Elements by Having Fewer, Larger Windows



The greater the number of window framing elements, the greater the opportunities for thermal bridging.



Minimize the number of framing elements to reduce heat losses through the building envelope.

Wherever possible, window design should emphasize fewer, larger windows in lieu of a greater number of smaller windows.

04.6 Thermal Bridges

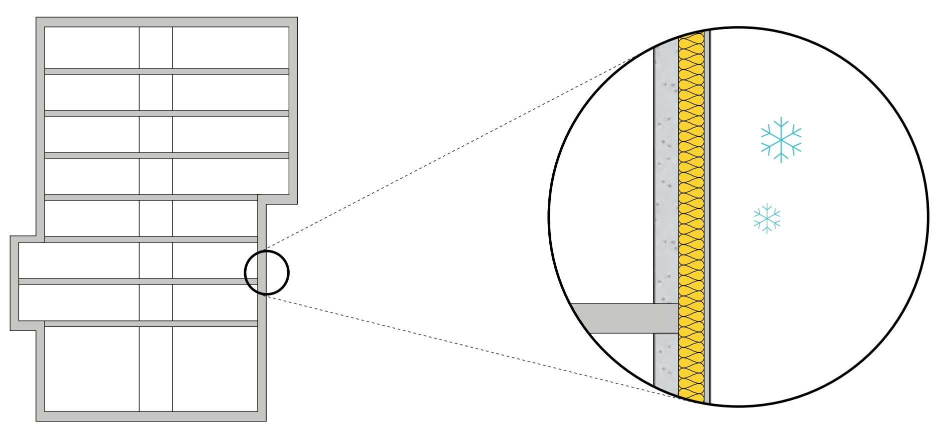
MURB designers will be required to identify and minimize instances of thermal bridging in building designs. This can be accomplished in three ways:

Compact Massing

First, building massing should be as compact as possible in order to minimize the number of junctions and articulations in the building facade.

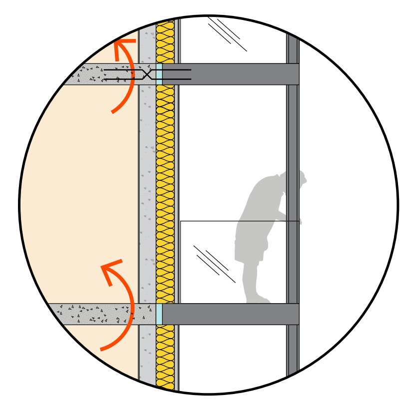
Continuous Insulation

Second, continuous insulation should be placed across the entire building envelope to create a barrier between structural materials and the building exterior.

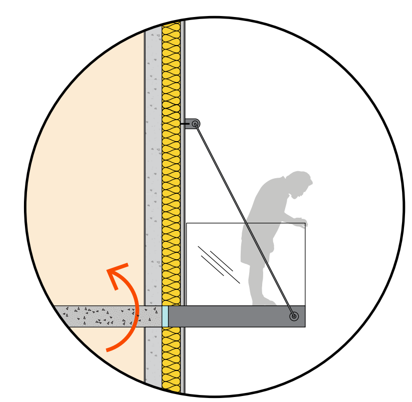


Mounted Balconies

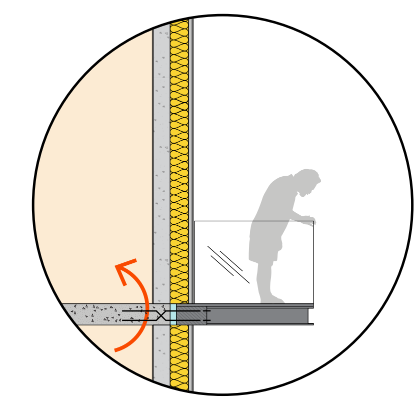
Third, building designs that cantilever floor slabs to form balconies without a thermal break should be avoided. Instead, designers should mount balconies so that they do not create thermal bridges. New methods of mounting balconies are becoming more available, and include:



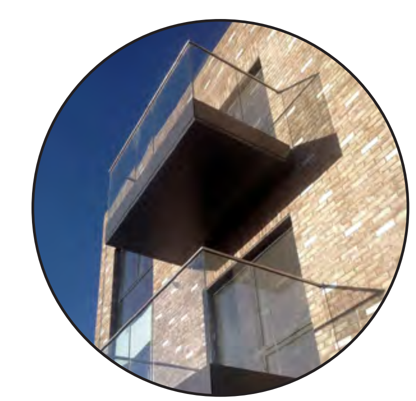
Exterior supported balconies (or self-supporting balconies) are supported from below. This allows the size of the tie-backs that connect the balcony to the building to be minimized, reducing thermal bridging.



Exterior hung balconies (or suspended balconies) are attached to the building by tension cables. These allows for continuous insulation across the building envelope.



Thermally-broken balconies use lower-conductivity materials (such as stainless steel) to attach the balcony to the building, reducing heat losses through the envelope.



Mid-rise MURBs that make use of wood-frame construction methods will have less of an issue with thermal bridging, because wood materials exhibit lower thermal conductivity overall. However, the key strategies for reducing incidences of thermal bridging are the same as those used for high-rise MURBs.

Most important metric(s) to consider TEDI

04.7 Airtightness

Designers should target a level of airtightness corresponding to the required step of the BC Energy Step Code.

Minimum Requirements

While there are no prescriptive airtightness targets associated with any of the Steps for Part 3 buildings, designers should use the airtightness value recommended in the **City of Vancouver Energy Modelling Guidelines**, as referenced by the BC Building Code, in the initial energy modelling. The value represents a target air leakage rate of **2.0 L/s m² at 75 Pascals and translates to a design infiltration rate of approximately 0.00025 m³/s m².** On-site testing is required to determine the as-built building airtightness, and the energy model must be updated. If the tested values differ from the initial airtightness value assumed, it may impact the building's ability to achieve Step Code performance targets.

Findings reported in the 2017 BC Step Code Metrics Research report have shown that targeting a higher level of airtightness is one of the most cost effective energy conservation measures. This translates into a design infiltration rate of 0.0001 m³/s m².

Step 4 Requirements

Designers seeking to comply with Step 4 should target an airtightness level on par with that permitted by the Passive House standard. This requirement varies with building geometry, but translates into a design infiltration rate close to 0.00001 m³/s m².

Compact building massing and a high-quality building envelope are two key design strategies that contribute to an improved level of airtightness. Designers should plan air barriers that will remain intact through minor repairs or occupant upgrades. For example, a resident hanging a picture on a wall should not be able to puncture an air barrier.

Compartmentalization

Designers seeking to meet the improved airtightness requirements of the Upper Steps should consider compartmentalization. MURB designers can significantly improve airtightness by sealing off and separating each individual unit.

Top *Kiln Apartments, Portland OR*
Bottom *100 Pike, Seattle, WA*

Below *Cornell Tech Residential, NYC*

Most important metric(s) to consider Airtightness

04.8 Ventilation Systems

Ventilation is important to the achievement of BC Energy Step Code performance targets. Designers must plan to route direct ducting into each room within a dwelling unit. The conventional approach of simply providing exhaust ventilation in bathroom and kitchen areas will not meet BC Energy Step Code requirements. Similarly, corridor-pressurization ventilation strategies will not likely meet the standard's performance targets.

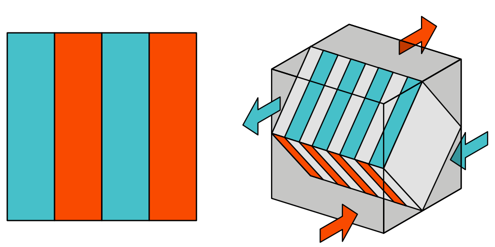
Designers targeting any level of the BC Energy Step Code are advised to use heat recovery ventilation (HRV), because it significantly reduces heat losses by recovering the heat energy from ventilation air before it is expelled from the building. Designers seeking to achieve Upper Steps should consider higher efficiency HRV systems. A minimum of 60% HRV efficiency should be considered for designs targeting Steps 2 and 3, while those aiming for Step 4 should seek minimum efficiencies of 80%.

The efficiency of an HRV is determined by the efficiency of the ventilation equipment, and the quality of its installation. A wide range of high efficiency HRV systems exist for larger buildings, including those that use thermal wheels.

For more compact residential applications, designers should investigate three forms of high-efficiency HRV technology:

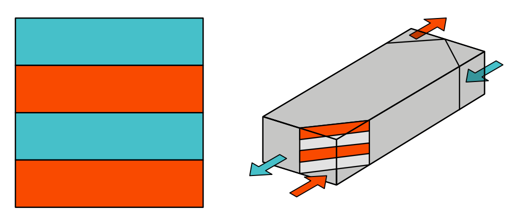
Vertical Flat Panel HRV

These represent some of the least costly HRV systems



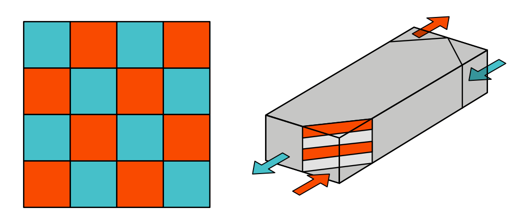
Horizontal Flat Panel HRV

These can be more expensive than vertical flat panel systems, but achieve higher levels of performance



Cellular HRV

Although these are not yet widely available and can be even more costly, they offer the highest available performance



DESIGNERS TARGETING STEP 3
Both the vertical and horizontal flat panel systems will achieve performance targets.

DESIGNERS TARGETING STEP 4
Designs using only a cellular-based technology will achieve the required levels of efficiency.

! The size of the HRV's core also has an influence on the level of the system's efficiency. Larger cores tend to achieve higher efficiencies.

! In high humidity environments, Energy Recovery Ventilation (ERV) Systems can be used in place of HRV systems. See **BC Housing's Heat Recovery Ventilation Guide for Multi-Unit Residential Buildings** for more details.

As noted, an HRV's design and installation impacts its effectiveness. Designers should be careful to avoid short circuiting and circuitous routing:

SHORT CIRCUITING refers to a design in which ventilation air enters and leaves a space or duct before it has a chance to mix well enough with room air to adequately dilute pollutants and replace stale air. In MURB construction, short circuiting occurs as a result of the placement of the ventilation supply too close to the ventilation exhaust.

CIRCUITOUS ROUTING occurs when too many corners and complex runs are placed within the duct work. This requires an increase in fan power to properly ventilate a space, which in turn reduces the overall effectiveness of the ventilation design. Direct duct routes make the most of fan power and improves the overall efficiency of the system.

While these two issues are some of the most problematic when designing ventilation systems, other issues such as improper sizing or excessively long duct runs can present problems. Designers should carefully review the ventilation design with the project's mechanical designer and contractor. All ducts should be insulated to improve the overall efficiency of the system. It is also recommended that special attention be paid to the location where the ducting meets the envelope to prevent thermal bridging.

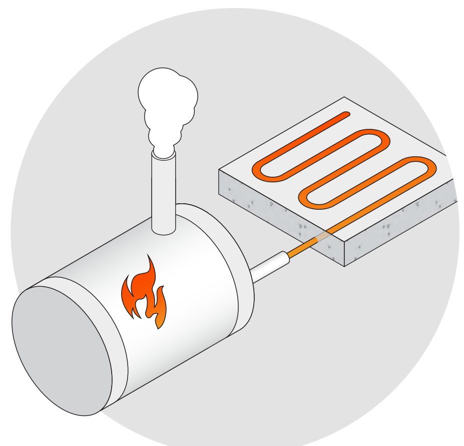
Most important metric(s) to consider TEDI

04.9 Mechanical Systems

Mechanical systems for MURBs can take four major forms:

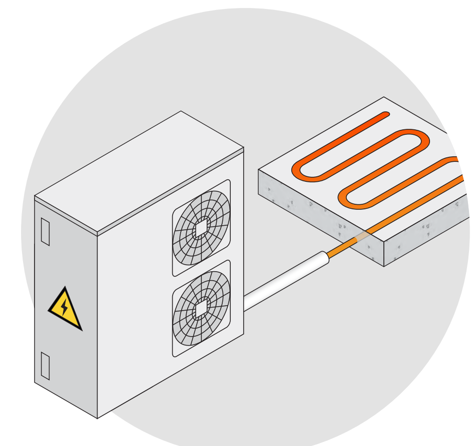
Hydronic* Delivery Using Natural Gas

These systems use a central natural gas boiler to heat and provide domestic hot water to units. They are generally among the lowest cost systems to install and operate, because they reliably handle large loads using relatively low-cost natural gas. While other systems may require some redundancy, boilers typically do not.



Hydronic* Delivery Using Electricity

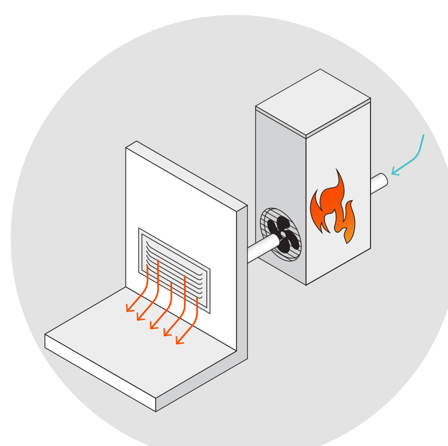
These systems use some form of heat pump to generate heat, including air-source, geo-exchange, and most district energy systems. They tend to be the most efficient of the available options. They also provide cooling, making them popular with occupants. Heat pump systems will struggle to deliver heating to large buildings when outdoor temperatures are below freezing.



* "Hydronic" refers to the practice of using a water-based medium to distribute heat throughout a building. Hydronic systems can use either radiators, in-floor systems, and in some cases, in-ceiling systems.

Forced Air

Forced air systems driven by a two or four-pipe fan coil are also used to heat and cool MURB units. Mechanical engineers must combine these systems with either a centralized or suite-level heat recovery ventilation system to achieve the desired level of efficiency. However, designers should note that suite-level heat recovery requires more ducting space and can therefore be challenging in buildings with low floor-to-ceiling heights.

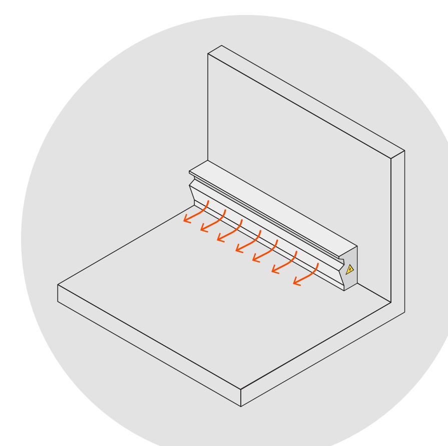


Electric Baseboards

Electric baseboard heaters are often the cheapest and most flexible systems to install. Given the low carbon intensity of electricity in most parts of British Columbia, they are also very climate-friendly to use.

The current cost differential between electricity and natural gas can make these systems more expensive to operate. They are typically not used for common areas, and require an additional solution to heat domestic hot water.

Given their higher operating costs, baseboards work best in buildings that have low heating demands.



Preventing Overheating in High-Rise MURBs

If not considered carefully, the use of highly efficient building envelopes can be at risk of overheating in the summer months.

To prevent the risk of overheating, designs should consider specifying:

- *Electrically powered mechanical cooling systems*
- *Shading devices on southern and western elevations*
- *Natural ventilation and cooling strategies, such as operable windows*

Need to Comply with the City of Vancouver's Zero Emissions Building Plan?

Hydronic delivery and electric baseboard systems are low-carbon mechanical systems that will also conform to the City of Vancouver's Zero Emissions Building Plan, as natural gas based systems typically yield the highest carbon intensity. However, gas-based systems can be selected where designers pursue a higher step than they are required to under the Plan.

Most important metric(s) to consider TEDI

04.10a The High-Performance High-Rise MURB Checklist

☐ **Massing and Orientation**

Focus on simple, compact forms that minimize the number of junctions and articulations. Wherever possible, target a low VFAR to reduce envelope heat loss.

☐ **Unit Density**

Higher occupant and unit densities (i.e. buildings with many small one-bedroom and/or bachelor units) make TEDI targets easier to achieve, but make TEUI targets more difficult. Consider these trade-offs early in the design process.

☐ **Fenestration and Shading**

Aim for an overall WWR of 40%. Use thermally broken external shading devices on south and west facades to reduce risk of summer overheating.

☐ **Wall and Window Systems**

Select wall systems with a minimum effective R-10 insulation value; for roof systems, look for those rated to a minimum effective R-20. To meet the performance requirements of the Upper Steps, designers will need to specify triple-pane, high performance windows.

☐ **Thermal Bridges**

Specify continuous insulation to minimize envelope heat loss, and thermally broken balconies.

☐ **Airtightness**

Create an airtightness plan to detail the installation of a continuous air barrier, and clearly indicate it on section drawings. Consider sealing off building uses and units from one another, an approach known as compartmentalization.

☐ **Heat Recovery**

Use heat-recovery strategies to improve system efficiency and occupant comfort. Carefully configure HRV systems and ensure they are properly installed and provide fresh air to all rooms.

☐ **Mechanical Systems**

Specify highly energy efficient mechanical systems. Consider using electricity-based systems that reduce greenhouse gas emissions when designing for a zero emissions building.

04.10b The High-Performance Mid-Rise MURB Checklist

Massing and Orientation

Focus on simple, compact forms that minimize the number of junctions and articulations. Where site conditions support, designers should attempt to maximize solar gains to reduce wintertime heating requirements.

Unit Density

Higher occupant and unit densities (i.e. buildings with many small one-bedroom and/or bachelor units) make TEDI targets easier to achieve, but make TEUI targets more difficult. Consider these trade-offs early in the design process.

Fenestration and Shading

Aim for an overall WWR of 40%. Use thermally broken external shading devices on south and west facades to reduce risk of summer overheating.

Wall and Window Systems

Select wall and roof systems with a minimum effective R-20 insulation value. Specify double- or triple-paned windows to meet the BC Energy Step Code performance targets. Units should use minimal framing elements wherever possible, and utilize low-conductivity framing materials such as vinyl and fibreglass.

Thermal Bridges

Specify continuous insulation to minimize envelope heat loss, and thermally broken balconies.

Airtightness

Create an airtightness plan to detail the installation of a continuous air barrier, and clearly indicate it on section drawings. Consider sealing off building uses and units from one another, an approach known as compartmentalization.

Heat Recovery

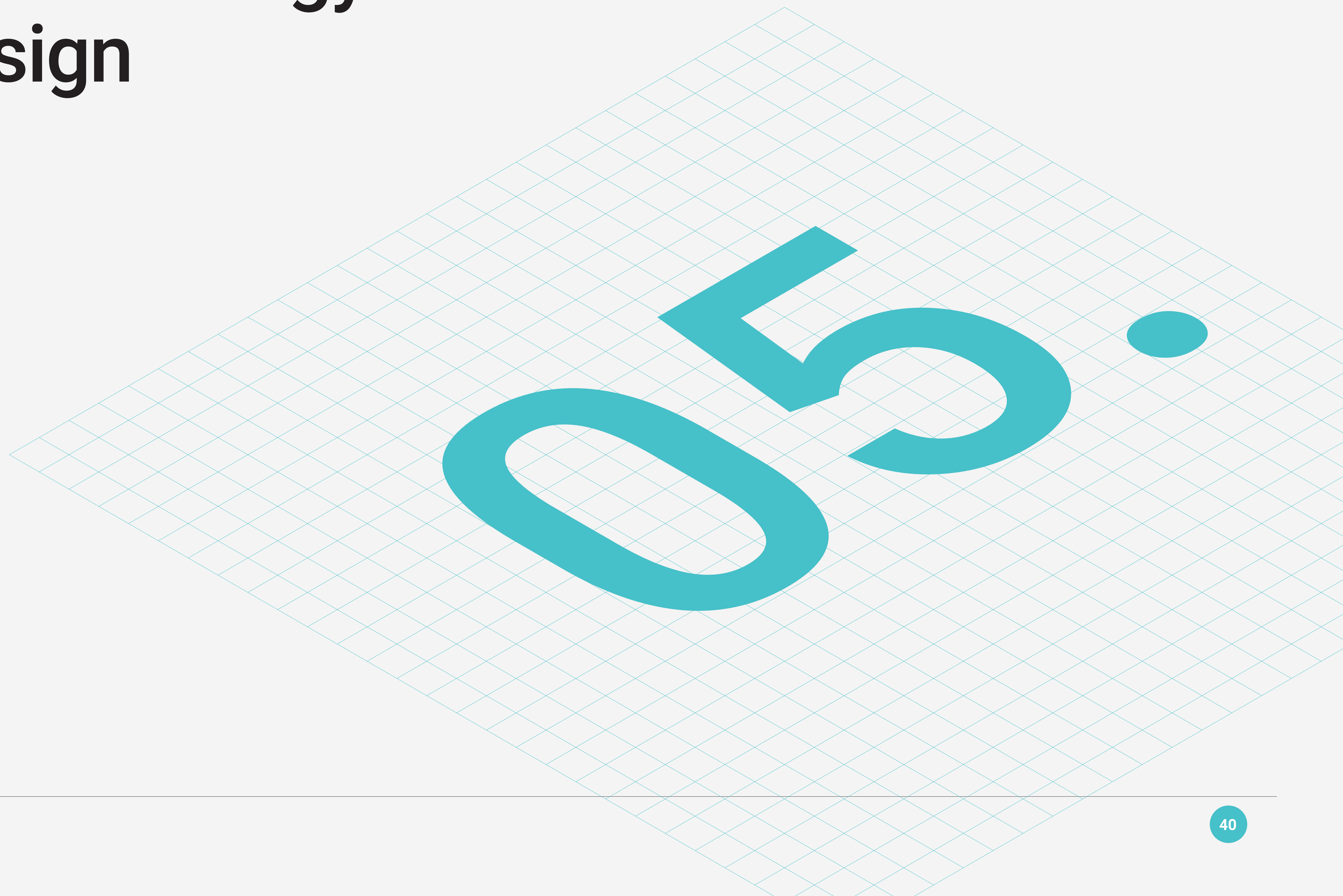
Use heat-recovery strategies to improve system efficiency and occupant comfort. Carefully configure HRV systems and ensure they are properly installed and provide fresh air to all rooms.

Mechanical Systems

Specify highly energy efficient mechanical systems. Consider using electricity-based systems that reduce greenhouse gas emissions when designing for a zero emissions building.

SECTION 05.

The Benefits of Energy Efficient Design



05.0 The Benefits of Energy Efficient Design

Improve Health and Comfort

The strategies outlined in this guide can yield healthier and more comfortable buildings.

HIGH-PERFORMANCE BUILDINGS:

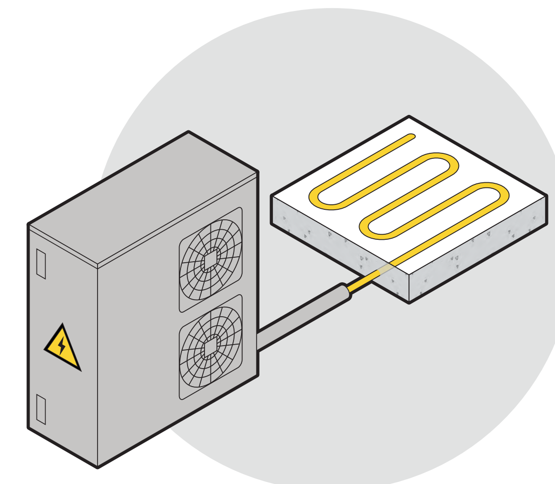
- Eliminate transfer of smells, fumes, and smoke between units by sealing them off from one another.
- Improve occupant health by supplying abundant fresh air and removing stale air.
- Reduce noise from other units and the outside via thicker, better insulated walls.
- Improve comfort by reducing heat loss through the envelope.

Reduce Costs

High-performance buildings help owners and occupants save money by lowering the amount of energy needed to provide a comfortable indoor temperature. They do so through improved insulation levels and more efficient mechanical systems. Buildings with thicker, higher-quality envelopes also tend to last longer, which lessens the need for costly repairs and upgrades over time.

Provide Consistency to the Industry

The standard provides a clear set of steps and a shared "language" on energy efficiency between local governments. It serves as a clear roadmap to 2032, when all new construction must be built to a net-zero-energy-ready level of performance. Its staggered approach gives the industry the time it needs to upgrade skills, adopt new techniques, and identify new products and suppliers.



Achieve Better Performance with Today's Technologies

The strategies outlined in this guide draw on technologies and practice that are already used across B.C. From building envelope systems to mechanical strategies, high-performance buildings can be achieved using familiar products.

Reduce Greenhouse Gas Emissions

Although the BC Energy Step Code does not explicitly target greenhouse gas emissions by reducing energy demand, it will lower emissions in jurisdictions where natural gas is used for heat. Buildings that rely on electrical systems such as air-source heat pumps will help reduce carbon emissions, contributing to the province's overall climate goals.

Appendix

A1 Glossary of Terms

AIR-SOURCE HEAT PUMP A highly energy efficient heat pump-based system that uses low-grade heat from the ambient air and uses it as a source of heat to condition building interiors.

AIRTIGHTNESS The measure of an envelope's resistance to the leakage of air in or out of a building.

ARTICULATION An approach to building design that uses joints between different sections of a building's form such that they stand out individually. Highly articulated buildings have several transition points that create opportunities for thermal bridging to occur.

BCBC British Columbia Building Code

BUILDING ENVELOPE (ENCLOSURE) The elements that make up the outer shell of a building that separate indoor from outdoor spaces. A building's envelope prevents or controls the entry of heat, water, air, noise, and light from entering or leaving.

BUILDING FORM See massing.

CLIMATE ZONE A region of the country defined by its average temperature (based on heating degree days) and moisture. Climate zones in British Columbia range from Climate Zone 4 in Vancouver to Climate Zone 8 in the far north.

COMPACT FORM A building form that is characterized by a low surface-to-volume ratio.

COMPARTMENTALIZATION The isolation of individual suites or units in a building from one another such that they are individually ventilated.

CONDUCTIVITY A measure of a material's ability to conduct heat.

COOLING DEGREE DAYS The total number of days per year that the average outdoor temperature is above a certain threshold as to require cooling.

CONDITIONED SPACE Any space within a building in which the temperature is controlled to limit variation in response to the exterior ambient temperature by the provision, either directly or indirectly, of heating or cooling over substantial portions of the year.

DAYLIGHTING The practice of placing windows or other openings in the building envelope to allow the use of natural light and reduce the need for artificial lighting.

EFFECTIVE R-VALUE A measure of an envelope's thermal resistance, considering the effectiveness of the insulation when it is used in combination with other building materials, such as framing members.

ENERGY EFFICIENCY A measure of the effectiveness of energy use. A building with high energy efficiency requires less energy to perform the same tasks (e.g. heating, cooling, ventilation, etc.) as a building with lower energy efficiency.

ENERGY PLANNER In this guide, a broad category of energy-related local government positions, including energy managers, energy advisors, community energy managers, sustainability coordinators, and sustainability planners.

ENERGY RECOVERY VENTILATION (ERV) A ventilation device that captures the energy from stale air as it leaves a building and uses the warmth to temper or pre-heat incoming fresh supply air before circulating it to occupants. It also captures some of the humidity in the air to help temper indoor climates — in summer, humidity is removed from incoming air prior to being injected into a building; in the winter, the reverse process occurs.

ENVELOPE See building envelope.

FACADE The exterior face of a building.

FENESTRATION The placement or arrangement of windows on a building, including their general size and number.

GEOEXCHANGE A heat pump-based heating and cooling system that uses low-grade heat stored in the ground to condition interior building spaces.

GEOMETRIC THERMAL BRIDGE A thermal bridge that occurs where two planes meet, such as at a corner.

GREENHOUSE GAS INTENSITY (GHGI) A measure of the emissions intensity of a building's emissions, measured and expressed in tonnes or kilograms of carbon dioxide equivalent per square metre per year ($CO_2e/m^2/year$).

GLAZING Windows on a building.

HEATING DEGREE DAYS The total number of days per year that the average outdoor temperature is below a certain threshold as to require heating.

HEAT RECOVERY VENTILATOR (HRV) A ventilation device that captures heat from stale exhaust air as it leaves a building and uses the warmth to temper or pre-heat incoming fresh supply air before circulating it to occupants.

HIGH-RISE MURB A multi-unit residential building of six storeys or higher, and designed and built using concrete construction techniques.

HYDRONIC The practice of using a water-based medium to distribute heat throughout a building. Hydronic systems can use either radiators, in-floor systems, and in some cases, in-ceiling systems.

HVAC Heating, Ventilation, and Air-Conditioning, (usually refers to equipment).

MASSING A building's general shape and size.

MURB Multi-Unit Residential Building

NATURAL VENTILATION The process of intentionally exchanging air in a building to replace stale air with fresh air from the building exterior, using non-mechanical means such as stack effect, cross ventilation, design elements, and operable windows.

PART 3 BUILDING A building over three storeys in height or over 600 square metres in footprint. Part 3 also includes some buildings of three storeys or less in height or under 600 square metres in area that are of a specific use. This includes larger buildings intended for residential, commercial or medium-to-low hazard industrial activities, as well as buildings intended for public gatherings, residential care, detention, or high-hazard industrial activities.

PART 9 BUILDING A building three storeys and under in height and with a footprint of 600 square metres or less. Part 9 buildings include small buildings intended for residential, commercial or residential, commercial or medium-to-low hazard industrial activities.

R-VALUE The capacity of an insulating material to resist heat flow, or its ability to prevent heat from moving from one side to the other. The higher the R-value, the greater the material's insulating properties. R-values can be expressed in $h \cdot ft^2 \cdot °F/Btu$ (RSI units $K \cdot m^2/W$). U-value is the inverse of R-value.

SOLAR HEAT GAIN The increase in thermal energy in a building as it absorbs incoming solar radiation.

STACK EFFECT A phenomenon that occurs in taller buildings, this pressure differential between the interior and exterior drives the movement of interior air. In cooler months, it often creates positive pressure, which forces warmer air out of the enclosure at the upper portions of walls and the building, and draws cooler air into lower portions.

THERMAL ENERGY DEMAND INTENSITY (TEDI) A measure of the total heating energy necessary to maintain a comfortable indoor temperature over the course of a year, expressed in kilowatt hours per square metre per year ($kWh/m^2/year$).

TOTAL ENERGY USE INTENSITY (TEUI) A measure of the total amount of energy used by a building over the course of a year, per unit of building area, measured and expressed in kilowatt hours per square metre per year ($kWh/m^2/year$). TEUI encompasses all energy used in a building, including plug loads (e.g. lighting, appliances) and process loads (e.g. elevators, mechanical systems, and fans).

THERMAL BRIDGING The transfer of heat through materials and structures that interrupt the building's continuous insulation layer, causing heat to escape the interior of the building to the outside air. Thermal bridges lower overall building energy efficiency.

THERMAL BREAK The placement of a material of low conductivity (such as insulation) to prevent the transfer of heat through a building envelope.

U-VALUE A measure of how well a building element conducts heat. The lower the U-value, the greater the material's insulating properties. U-values are expressed in SI units of $W/(m^2K)$ and U.S. units of $BTU/(hr\ °F\ ft^2)$. U value is the inverse of R value.

VENTILATION The process of introducing fresh air to replace stale air in a building by mechanical or natural means.

VFAR A building's vertical surface area to floor area ratio. A building's VFAR influences a building's heating energy use, as buildings in B.C. lose the most heat through their vertical surface areas.

VFR Variable Refrigerant Flow, or a highly energy efficient refrigerant-based heating and cooling technology.

WWR Window-to-wall ratio, or the percentage of a building's facade that is made up of glazing.

A2 Image Sources

PAGE 15
The Spot, Vancouver, B.C.
Source http://www.tcpm.ca/wp/portfolio/the-spot-at-12th-and-cambie/

Kiln Apartments, Portland, OR
Source http://kilnpdx.com/

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Cornerstone Apartments, Vancouver, B.C.
Source http://www.cornerarch.com/passive-house/

Girard, 600 Harrison Ave, Boston, MA
Source http://www.equityapartments.com/boston/south-end/girard-apartments

Marquis Lofts, Portland, ME
Source http://www.wright-ryan.com/blog/portfolio/marquis-lofts/

PAGE 19
Girard, 600 Harrison Ave, Boston, MA
Source https://www.utiledesign.com/work/girard-at-600-harrison-avenue/

The Spot, Vancouver, B.C.
Source http://www.tcpm.ca/wp/portfolio/the-spot-at-12th-and-cambie/

181 W 1st Ave, Olympic Village, Vancouver, B.C.
Source http://www.condoinvancouver.ca/181-west-1st

Muse Apartments, Portland, OR
Source http://www.gbdarchitects.com/portfolio-item/muse-apartments/#

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Kiln Apartments, Portland, OR
Source http://kilnpdx.com/

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Marine Gateway, Vancouver, B.C.
Source http://marinegatewaycondo.com/2016/07/marine-gateway-sale-prices-match-downtown-vancouver/

Budzey Building, Vancouver, B.C.
Source http://www.sabmagazine.com/blog/2016/06/08/2016-regional-quebec-winner/

Olympic by Windsor, Los Angeles, CA
Source https://www.olympicbywindsor.com/

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Cornerstone Apartments, Vancouver, B.C.
Source http://www.cornerarch.com/passive-house/

Kiln Apartments, Portland, OR
Source http://kilnpdx.com/

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Cornell Tech Residential, NYC
Source https://www.burohappold.com/projects/the-house-at-cornell-tech/

Girard, 600 Harrison Ave, Boston, MA
Source http://www.sabmagazine.com/blog/2016/06/08/2016-regional-quebec-winner/

Cornerstone Apartments, Vancouver, B.C.
Source http://www.cornerarch.com/passive-house/

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Terrace 459, Chicago, IL
Source http://www.holstenchicago.com/communities/terrace459.html

Ponderosa Commons, Vancouver, B.C.
Source http://www.garibaldiglass.com/items/ubc-ponderosa-commons/

Mclaren House, Vancouver, B.C.
Source http://www.streetohome.org/project/howe-street/

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Riverport Flats, Richmond, B.C.
Source https://riverportflats.com/

Orchards at Orenco, Portland, OR
Source http://www.housingfinance.com/developments/oregon-passive-house-project-lowers-residents-expenses_o

Richardson Apartments, Portland, OR
Source https://www.archdaily.com/211129/richardson-apartments-david-baker-partners

Knickerbocker Commons Passive House, NY
Source http://blog.eima.com/eifs-in-the-spotlight-knickerbocker-commons/

PAGE 34
Exterior supported balconies
Source http://www.wright-ryan.com/blog/portfolio/marquis-lofts/

Exterior hung balconies
Source http://www.gbdarchitects.com/portfolio-item/landing-drive/

Thermally-broken balconies
Source https://kirhammond.files.wordpress.com/2015/05/balcony-photo-for-schock.jpg

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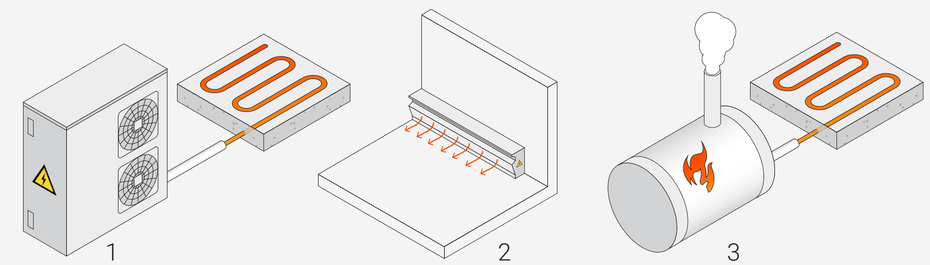
Kiln Apartments, Portland, OR
Source http://kilnpdx.com/

100 Pike, Seattle, WA
Source http://www.cascadebuilt.com/project/thirteenandpike/

Cornell Tech Residential, NYC
Source https://www.burohappold.com/projects/the-house-at-cornell-tech/

Supplement

S1 Complying with the City of Vancouver's Zero Emissions Building Plan



Hydronic delivery[1] and electric baseboard[2] systems are low-carbon mechanical systems that will conform to the City of Vancouver's Zero Emissions Building Plan. However, gas-based[3] systems can be selected where designers pursue a higher step than they are required to under the Plan.

Reducing GHG Emissions

The City of Vancouver has authority over its own building code, and has instituted its own step code-like provisions described in the Zero Emissions Building Plan (ZEBP). In addition to setting targets for TEUI and TEDI, the ZEBP sets thresholds for performance in greenhouse gas intensity (GHGI). GHGI is a measure of the emissions intensity of a building's emissions, measured and expressed in tonnes or kilograms of carbon dioxide equivalent per unit area over the course of a year (kg CO^2/m^2/year).

Selecting a Low-Carbon Mechanical System

The addition of a GHGI threshold requires building designers to consider not only the quantity of energy that a building will demand, but the source of that energy. As such, the selection of mechanical strategies is of central importance to the achievement of GHGI performance targets in the City of Vancouver's ZEBP. One of the easiest ways to achieve the GHGI targets in the ZEBP is to select a mechanical system that runs on the low-carbon electricity available in British Columbia. Heat pumps and electric resistance (e.g. baseboards) heating systems are readily available systems that can provide heat cost effectively, while reducing emissions. In some cases, buildings can also connect to a low-carbon district energy system.

Conversely, the selection of mechanical strategies that rely on energy sources with higher carbon intensities will render the achievement of GHGI targets more difficult. Due to their higher emissions intensity, designs that incorporate natural gas-based systems may not be able to meet the City of Vancouver's GHGI targets. While natural gas can still be used when necessary (e.g. for hot water heating), designers looking to lower GHGI should try to minimize the combustion of natural gas in the building wherever possible.

Reducing Global Warming

In addition to GHGI, designers should also consider assessing the global warming potential (GWP) of any refrigerants that may be used, as reporting the GWP of refrigerants is a requirement of the City of Vancouver's Green Buildings Policy for Rezoning.

S2
Summary of Key Strategies: Vancouver's Zero Emissions Building Plan

The design strategies necessary to met the Step Code (p. 25) are also applicable to designers seeking compliance with the City of Vancouver's Zero Emission Building Plan (ZEBP).

While certain design strategies will help meet a single performance target (e.g. TEDI), others will help accomplish a number of different targets, including GHGI. Practitioners should consider these core strategies — addressing building shape, orientation, and envelope, as well as mechanical and ventilation systems — early in the design process. Proponents must retain the services of an energy modeler at the design and permitting stages. To ensure overall compliance, designers should rely on hourly energy modelling tools.

Diagram Description

The figure to the right shows the importance of each design strategy in relation to the three key metrics of the BC Energy Step Code (TEDI, TEUI, and airtightness), as well as for their emissions reduction potential (GHGI) under the ZEBP.

The impact of each design strategy on GHGI depicted here assumes the use of a natural gas-based system. To explore the impact of different design decisions interactively, visit the **Building Pathfinder website**.

LEGEND

- TEDI
- TEUI
- Airtightness
- GHGI
- Architecture
- Building Envelope
- Mechanical