Design and Coordination

The Potential Impacts of Design Decisions on the Building Thermal Performance

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Agenda and Presenters

1. BE thermal improvements at the different stages of design
2. Architectural features and their impacts
3. Roles and responsibilities
4. Insight into thermal performance of building envelope

Principal,
Architect AIBC

BOP Architects

Principal,
Building Envelope Specialist

Evoke Buildings

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BE thermal improvements at the different stages of design

PART 1

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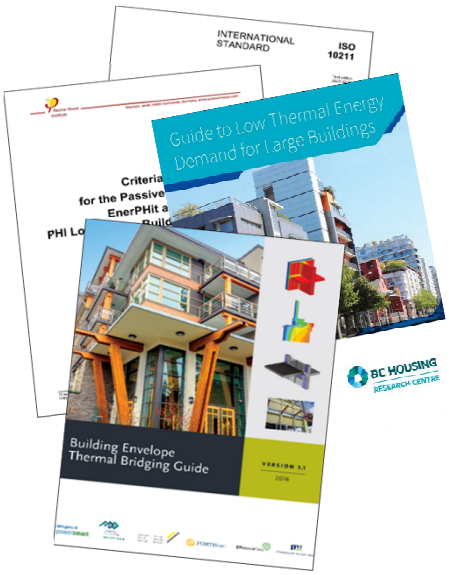
The References



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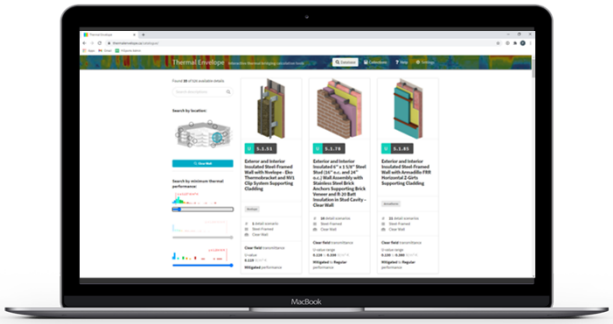
Thermal Envelope Web Application

- ✓ Search and compare details and assemblies
- ✓ Integrated thermal calculator
- ✓ Collaboration tools
- ✓ Educational resources



Demo – www.thermalenvelope.ca

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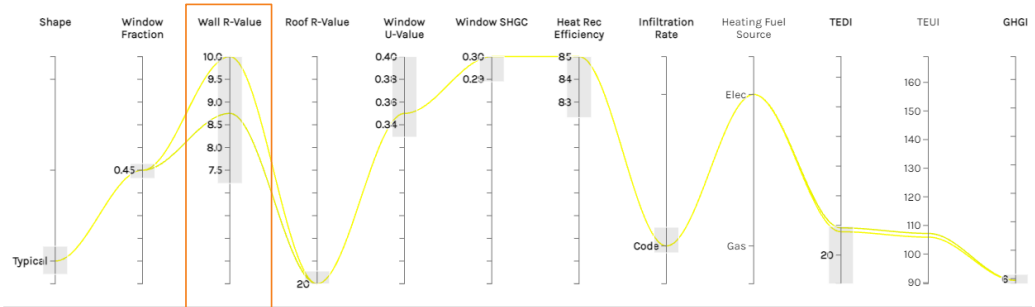
Building Pathfinder

PathFinder

Building Info

Climate Region: Vancouver

Building Type: High Rise Multi-Unit



Shape	Window Fraction	Wall R-Value	Roof R-Value	Window U-Value	Window SHGC	Heat Rec Efficiency	Infiltration Rate	Heating Fuel Source	TEDI	TEUI	GHGI
Typical	0.45	8.75	20	0.35	0.3	85	Code	Elec	29.17	107.21	5.89
Typical	0.45	10	20	0.35	0.3	85	Code	Elec	27.86	105.91	5.88

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The focus

BC Hydro powersmart | FORTIS BC

Enhanced Thermal Performance Spread Sheet **SI Units**

Scenario Description: Enter Scenario Name | Create New Worksheet | Copy to New Worksheet | Reset Current WorkSheet

Clear Field Area Method

Select Area Calculation (Choose One)	Area	Units
Sum of Active Clear Field Areas (Default)	0.00	m²
User Defined Area		

Overall Opaque Wall Thermal Performance Values

Base Building		Proposed Building	% Below Baseline
Opaque USI-Value (W/m²K)	Enter Base Building U-Value	Opaque USI-Value (W/m²K)	-
Effective RSI-Value (m²K/W)	-	Effective RSI-Value (m²K/W)	-

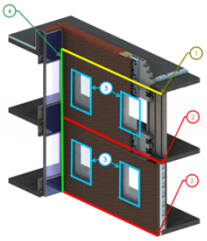
Proposed Building Entries — Totals: 0.0 | 0%

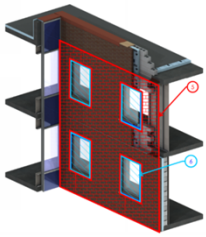
Add/Remove Detail	Transmittance Type	Include	Transmittance Description	Area, Length or Amount Takeoff	Units	Transmittance Value	Units	Source Reference	Heat Flow (W/K)	%Total Heat Flow
Add Clear Field	Clear Field	☑	Enter Description Here	Enter Area Here	m²	Enter Clear Field U-Value Here	W/m²K	Enter Source Here	-	-
Add Linear Interface Detail	Linear Interface Detail	☑	Enter Description Here	Enter Length Here	m	Enter Psi-Value Here	W/mK	Enter Source Here	-	-
Add Point Interface Detail	Point Interface Detail	☑	Enter Description Here	Enter Amount Here	#	Enter Chi-Value Here	W/K	Enter Source Here	-	-

$$U_T = \frac{\Sigma(\Psi \cdot L) + \Sigma(\chi)}{A_{Total}} + U_o$$

Where:

- U_T = total effective assembly thermal transmittance (Btu/hr·ft²·°F or W/m²K)
- U_o = clear field thermal transmittance (Btu/hr·ft²·°F or W/m²K)
- A_{total} = the total opaque wall area (ft² or m²)
- Ψ = heat flow from linear thermal bridge (Btu/hr·ft °F or W/mK)
- L = length of linear thermal bridge, i.e. slab width (ft or m)
- χ = heat flow from point thermal bridge (Btu/hr· °F or W/K)





1. Parapet Length
2. Slab Lengths
3. Wall to Window Transition Lengths
4. Corner Length
5. Opaque Brick Wall Area
6. Glazing Area

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"If you want to make an easy job seem mighty hard, just keep putting off doing it"

- Olin Miller

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Tip #1 – Plan your take-offs

- ✓ Confirm with the Energy Modeler if there are sections of the building that need to be modeled differently
- ✓ Identify some architectural features which could potentially be replaced
- ✓ Set yourself up to be able the copy your “base” worksheet – this may mean splitting a same assembly or detail in 2
- ✓ Be consistent with the methodology – e.g. balcony between glazing

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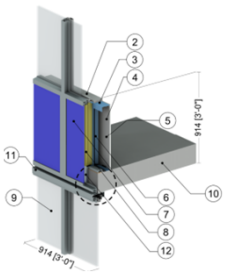
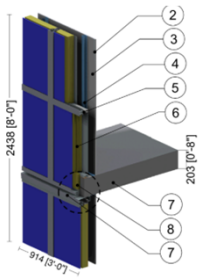
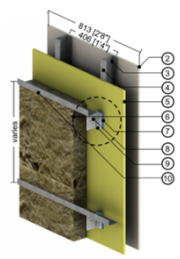
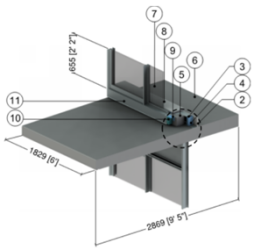
Basic design

- ✓ Regular double glazed thermally broken aluminum window-wall vison glazing
- ✓ Horizontal and vertical spandrel sections
- ✓ Steel Stud walls with 4” of exterior insulation
- ✓ Cantilevered concrete balconies









+ Glazing transitions
  - Vision to cladding
  - Spandrel to cladding

+ Parapets
+ Base of Walls
+ Corners

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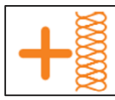
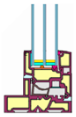
The improvements (first level – clear walls)



✓More insulation → More outside and within steel studs
Spray foam inboard of WW spandrel

✓Thermal bridging mitigation → Better clips

✓Increased air-tightness



✓Better windows and glass → More efficient WW (improved spandrel and by-pass detail)

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Thermal performance

Base – effective R 3.6

Improvements through opaque clear walls	Effective R Value
More (5”) and dual insulation (R12), same clips	3.7
Better clips and more exterior insulation (6”)	3.7
Spray foam inside WW (instead of more insulation at walls)	4.5
More efficient window wall	4.7
Efficient window wall with spray foam	5.0
Better walls, more efficient window wall and Spray foam	5.2

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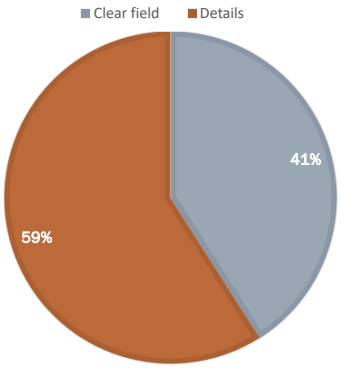
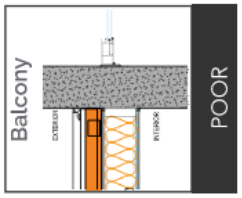
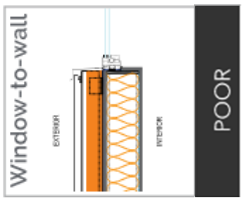
Tip #2 – Start with items that have an impact*



34%
% Contribution to Overall Heatflow



17%
% Contribution to Overall Heatflow



* Don't sweat the small stuff, unless you are targeting very high level of energy performance such as passive house and step 4

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Next level of improvements

More outside and within steel studs
Spray foam inboard of WW spandrel

Better clips, balcony thermal breaks, and window transitions

More efficient Window Wall

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Thermal performance

Base – effective R 3.6

Base with the best opaque walls– effective R 5.2

Same results but one of these improvement is much costlier than the other

Improvements through details and opaque clear walls	Effective R Value
Thermal breaks (TB) at balconies	4.2
Better window transition (WT) details	4.1
Both TB and WT	5.0
Better window transition details with better walls and efficient window wall (No TB or SF)	5.6
Better window transition details with better walls, efficient window wall and TB (No SF)	6.8
Better window transition details with better walls and efficient window wall with SF and TB	7.6

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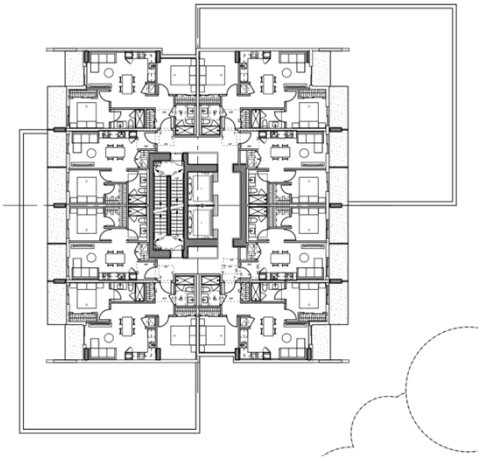
Tip #3 – Make the right design decisions early on



- ✓ Reduce the amount of balconies slabs coming though
- ✓ Use more thermally efficient assemblies than window wall (especially at and around slabs)
- ✓ Be strategic about your windows sizes as to reduce the length of transition details

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Thermal performance

Base – effective R 3.6

Base with the best opaque walls– effective R 5.2

With all the bells and whistles– effective R 7.6

Improvements through opaque clear walls	Effective R Value
Replace good portion of spandrel with base cladding	3.8
Replace with base cladding and improved window transitions	5.2
Replace with better cladding and improved window transitions	5.9
Reduce balconies by 50% (back to base building, slab covered with spandrel by-pass)	4.4
Replace with better cladding including improved window transition and reduced balconies	7.7

Some of these measures are actually cost savings

Some of these measures are actually cost savings

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Tip #4 – Cost is always part of the equation

Remember that:

- ✓ Reducing balconies is actually a cost savings
- ✓ Detailing the windows to reduce thermal bridging is +/- cost neutral
- Changing window configuration is free

Has cost implications:

- Thermal breaks
- Spray foam inboard of spandrel
- ✓ Replacing window spandrel with cladding
- ✓ Improving the window- wall frame performance

R7.7 → R8.75

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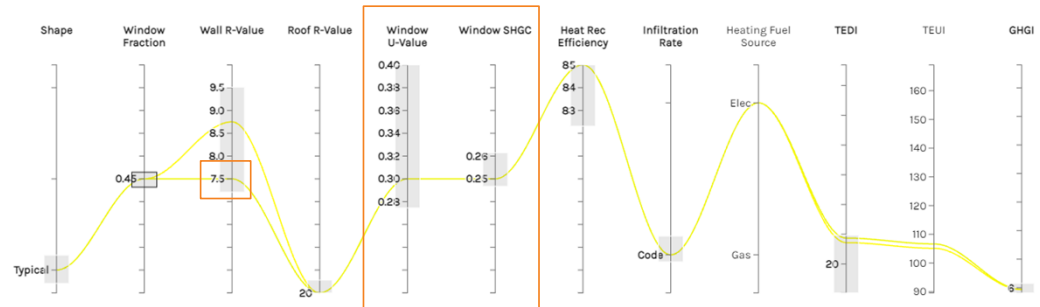
Building Pathfinder

PathFinder

Building Info

Climate Region: Vancouver

Building Type: High Rise Multi-Unit



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Typical	0.45	8.75	20	0.3	0.25	85	Code	Elec	27.18	105.12	5.87

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Questions

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Architectural Features and their Impacts

PART 2

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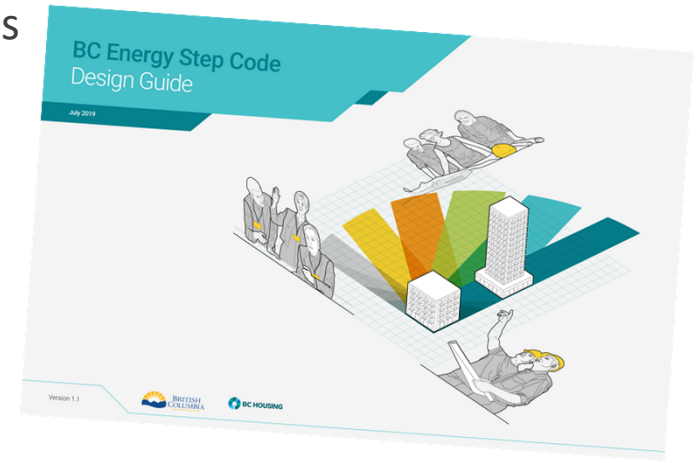
Features and Considerations

1. Massing and Orientation
2. Unit Density
3. Fenestration
4. Wall Systems
5. Airtightness and HVAC



Link

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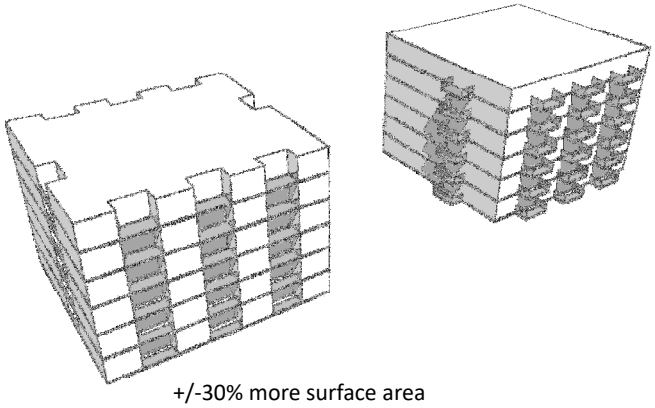
1. Massing and Orientation

Considerations:

1. Orientation of facades
2. Corners
3. Surface area
4. Surroundings



+/-30% more surface area
36 corners vs. 4

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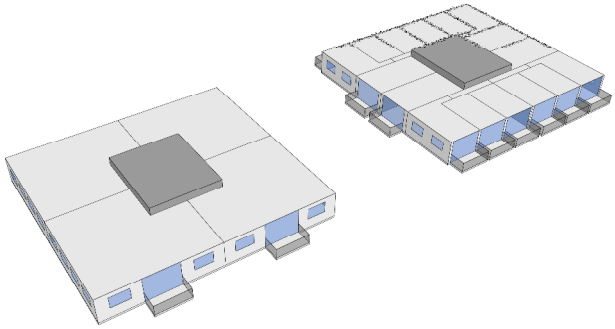
2. Unit Density

Considerations:

1. TEDI vs. TEUI
2. Internal loads
3. Vision glazing
4. Balconies
5. Different uses in one building & Different standards may be Modelled differently (like the example)



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3. Fenestration

Considerations:

1. Window to wall ratio
2. Marketing and AHJs
3. Comfort
4. Construction efficiency
5. Aesthetics/Concept

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3. Fenestration

- ❑ Upstands
- ❑ Privacy
- ❑ Views
- ❑ Solar Orientation

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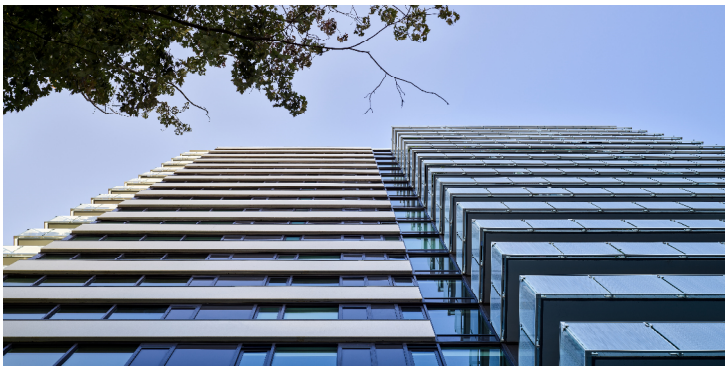
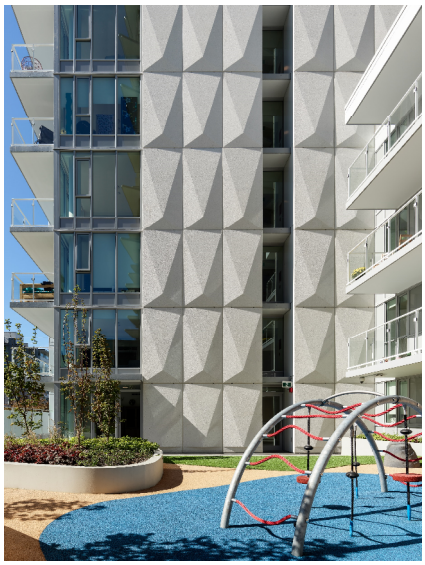
3. Fenestration

- ❑ Upstands
- ❑ Views
- ❑ Privacy
- ❑ Solar Orientation





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4. Wall Systems

Envelope Criteria -

- ☐ Availability (# of bidders, shipping)
- ☐ Cost
- ☐ Slab edge detail
- ☐ FSR/Area impact
- ☐ Installation –Framed, Window wall/curtain wall type
- ☐ Moisture management –closing the building & protecting unfinished construction
- ☐ Airtightness (a system vs. combination of parts)
- ☐ Transportation and element sizes
- ☐ Thermal performance & thickness limitations
- ☐ Ability to handle
- ☐ Crane time / scaffolding
- ☐ Compatibility with other systems (vents, windows, etc)
- ☐ Fire
- ☐ Acoustics
- ☐ Maintenance/service life/durability
- ☐ Aesthetics

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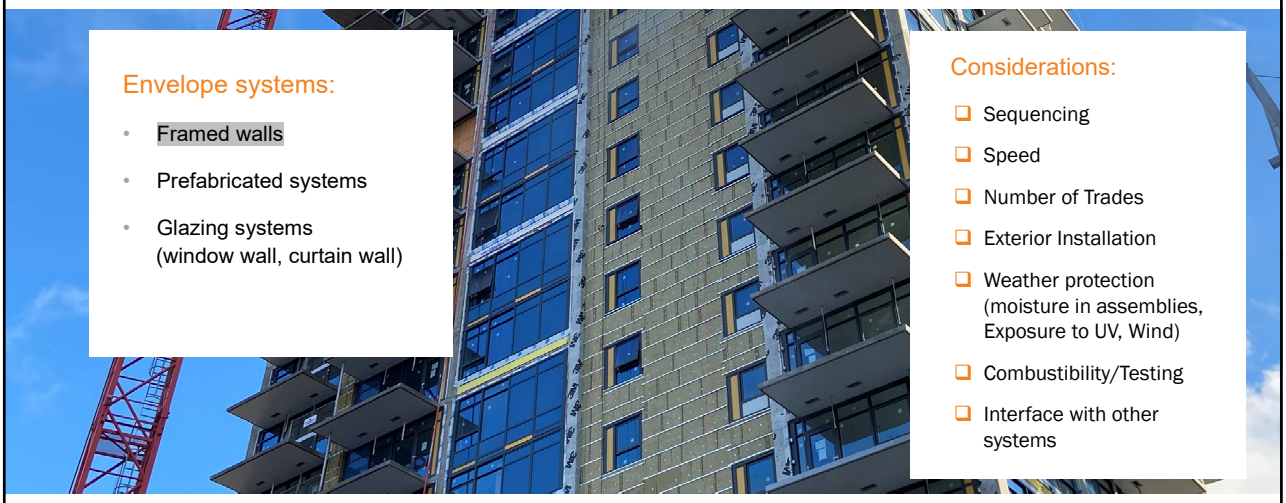
4. Wall Systems



Envelope systems:

- Framed walls
- Prefabricated systems
- Glazing systems (window wall, curtain wall)

Considerations:

- ❑ Sequencing
- ❑ Speed
- ❑ Number of Trades
- ❑ Exterior Installation
- ❑ Weather protection (moisture in assemblies, Exposure to UV, Wind)
- ❑ Combustibility/Testing
- ❑ Interface with other systems

CLEAR FIELD RANGE: R16-

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4. Wall Systems

Envelope systems:

- Framed walls
- Prefabricated systems
- Glazing systems (window wall, curtain wall)

Considerations:

- ❑ Sequencing
- ❑ Speed
- ❑ Number of Trades
- ❑ Handling of systems
- ❑ Crane time; Scaffolding; Stages
- ❑ Weather protection (moisture in assemblies, Exposure to UV, Wind)
- ❑ Combustibility/Testing

CLEAR FIELD RANGE: R16-

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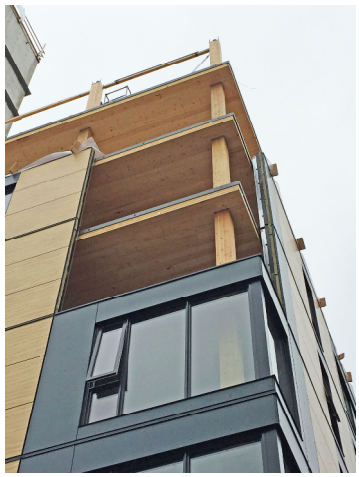
4. Wall Systems



Considerations:

- Speed
- Better quality control
- Handling of systems
- Transportation/storage
- Crane time
- Combustibility/Testing

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4. Wall Systems

Envelope systems:

- Framed walls
- Prefabricated systems:
- Glazing systems (window wall, curtain wall)

Considerations:

- Sequencing
- Speed
- Handling of systems
- Crane time
- Installation below overhangs
- Combustibility of insulation
- Connections and air seals
- Weight

CLEAR FIELD RANGE: R18-

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4. Wall Systems

Considerations:

- Sequencing
- Speed
- Handling of systems
- Crane time
- Installation below overhangs
- Combustibility of insulation
- Connections and air seals
- Weight

CLEAR FIELD RANGE: R18-

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4. Wall Systems

Envelope systems:

- Framed walls
- Prefabricated systems
- Glazing systems (window wall, curtain wall)

CLEAR FIELD RANGE: R3-

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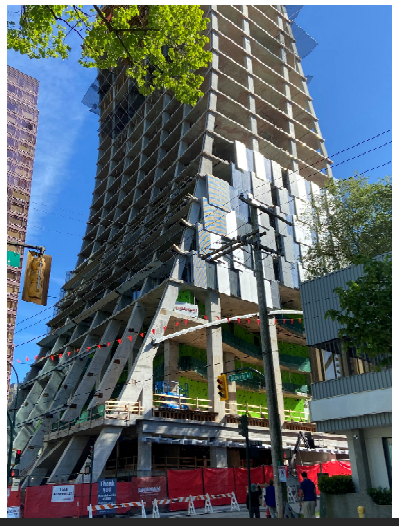
4. Wall Systems

Considerations:

- Slab edge
- Fire/acoustic separation
- Panel weight
- Installed outside/inside the floor



CLEAR FIELD RANGE: R3-

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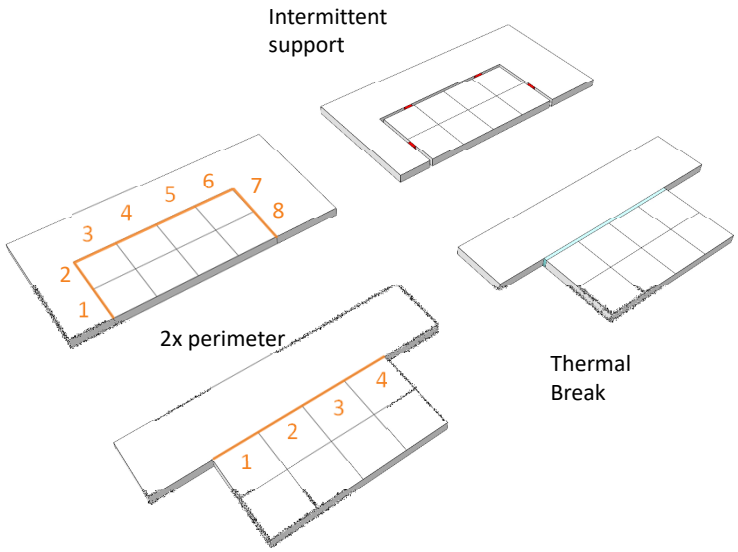
4. Wall Systems

Thermal bridging:

- Balconies
- Structure
- Eyebrows
- Structural connections (canopies, sun-shades, etc)
- Details (curbs, jambs, etc)



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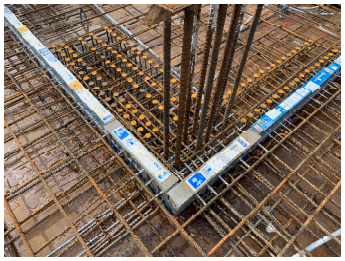
4. Wall Systems

Thermally broken balconies:

- Ducting
- Details
- Cost/linear quantity



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OR …

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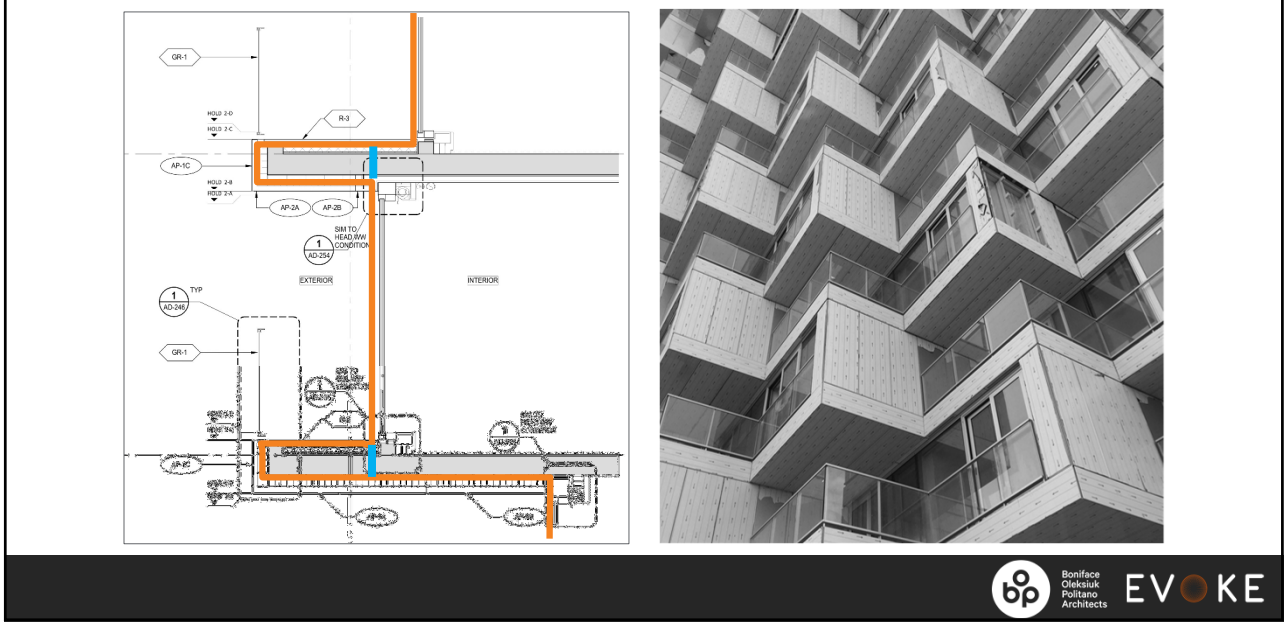
Full Wrap



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4. Wall Systems

- Control through orientation and amount of glazing
- External Shading
- Comfort/overheating
- Thermal bridging
- Complexity
- shgc

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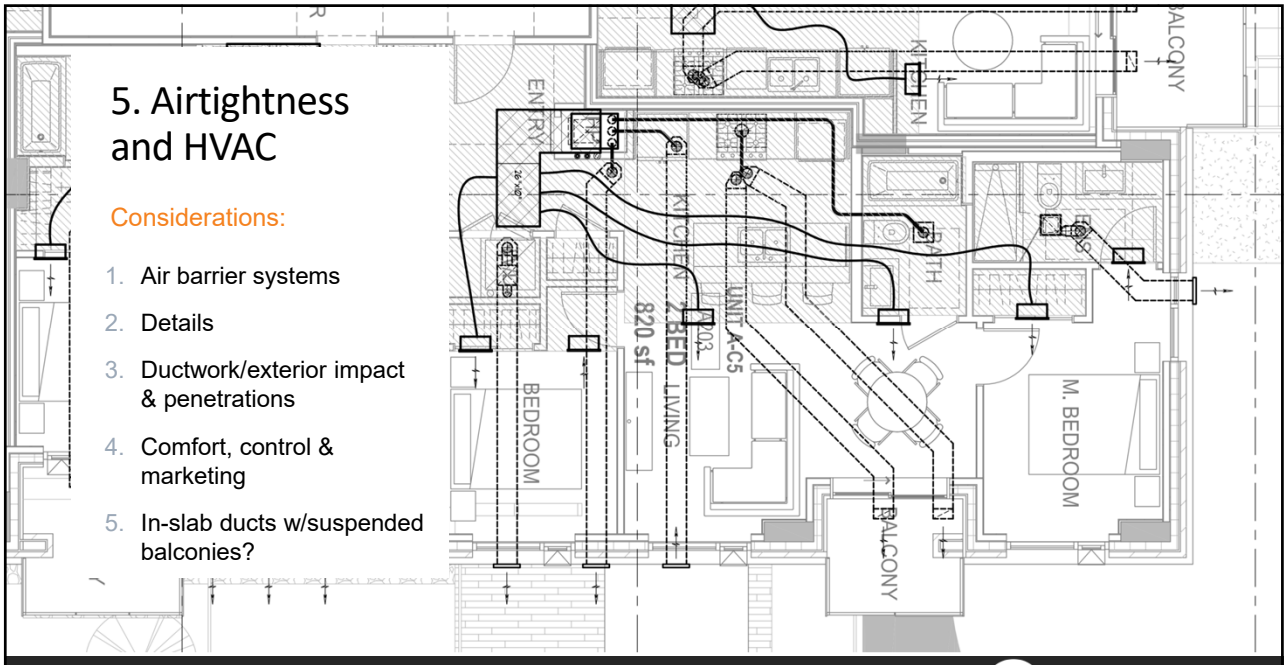
5. Airtightness and HVAC

Considerations:

1. Air barrier systems
2. Details
3. Ductwork/exterior impact & penetrations
4. Comfort, control & marketing
5. In-slab ducts w/suspended balconies?



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Roles and Responsibilities

PART 3

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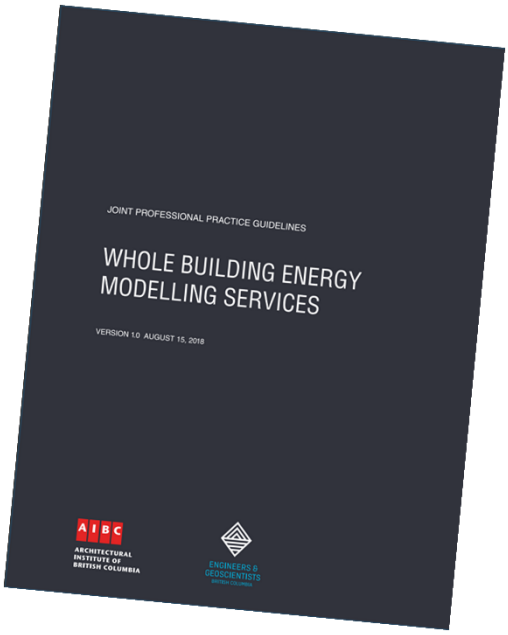
Reference

Whole Building Energy Modelling Services
Joint Professional Guidelines

Deals with:

- Qualifications
- Roles and Responsibilities
- Quality Assurance etc.

Link



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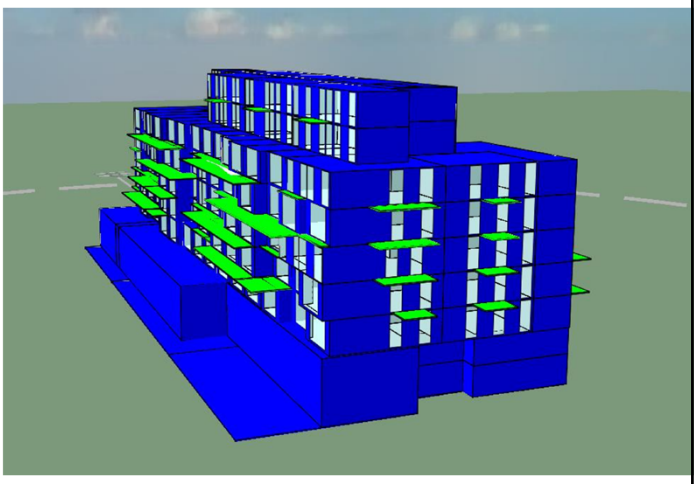
Energy Modelling Services Team

- OWNER/CLIENT
- **THE COORDINATOR**
- DESIGN TEAM
- **QUALIFIED MODELLER (QM)**
- **ENERGY MODELLING SUPERVISOR (EMS)**
- BUILDER CONSTRUCTOR



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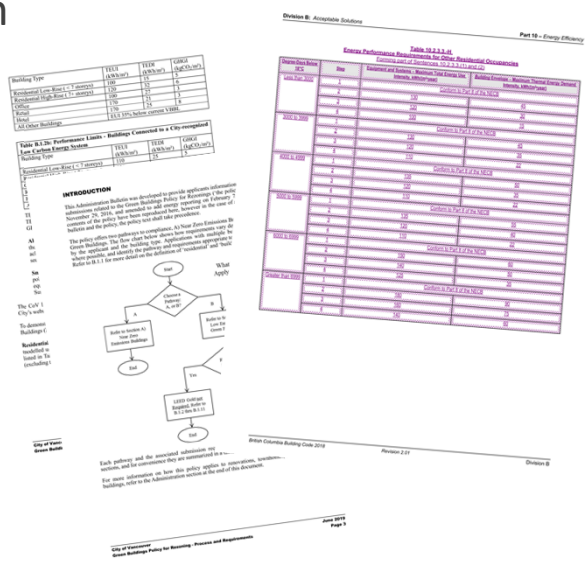
Energy Modelling Services Team

THE COORDINATOR

The architect or engineer responsible for coordinating the work that is represented by the energy model.

For design projects, the Coordinator is the Coordinating Registered Professional (CRP) per BCBC definition.



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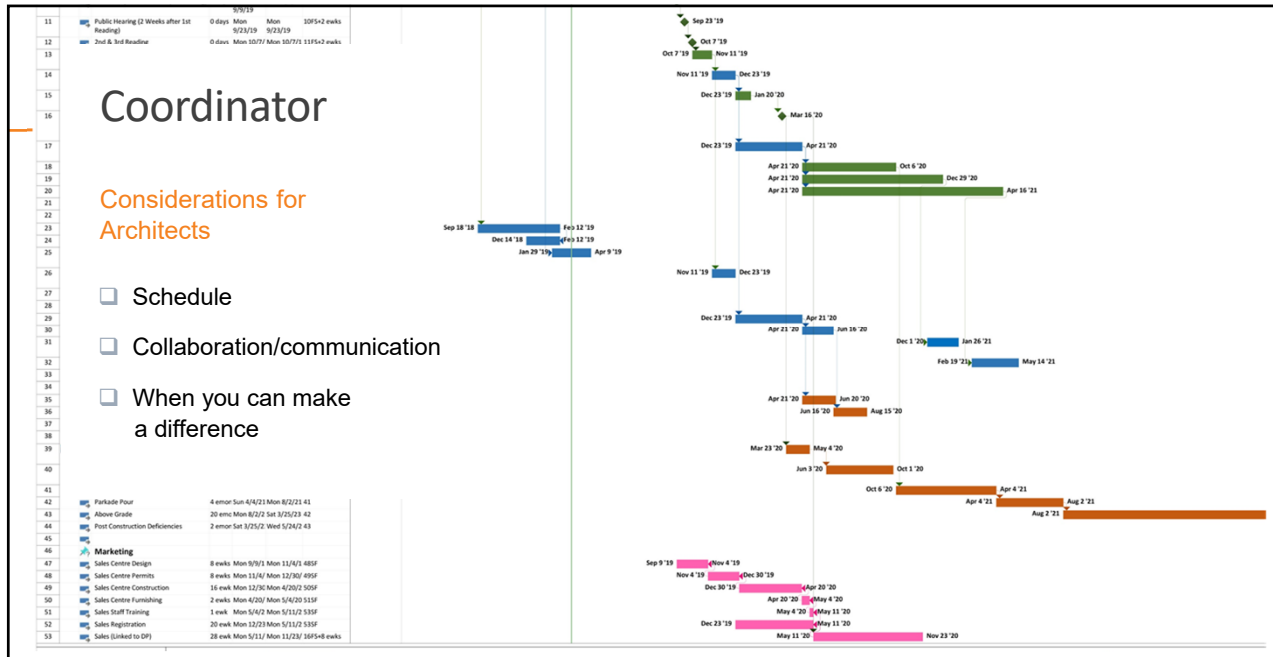
Coordinator

Considerations for Architects

- ❑ Schedule
- ❑ Collaboration/communication
- ❑ When you can make a difference



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Energy Modelling Services Team

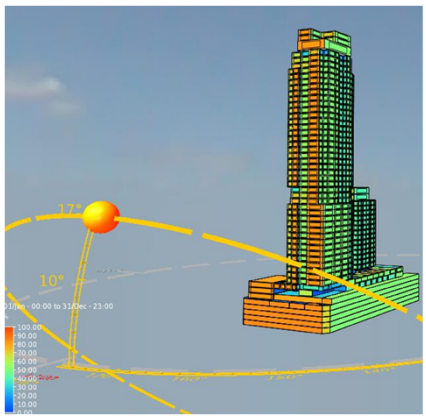
QM + EMS

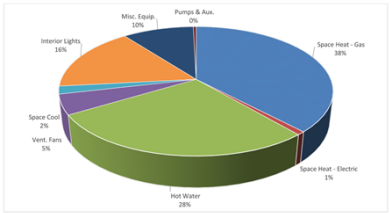
QM QUALIFIED MODELLER

Person responsible for Building Energy Modelling and analysis, who through education, training and experience, is competent in simulation, science and systems that pertain to building energy performance. A Qualified Modeller may or may not be an architect or engineer.

EMS ENERGY MODEL SUPERVISOR

An architect or engineer directly supervising a Qualified Modeller





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Roles

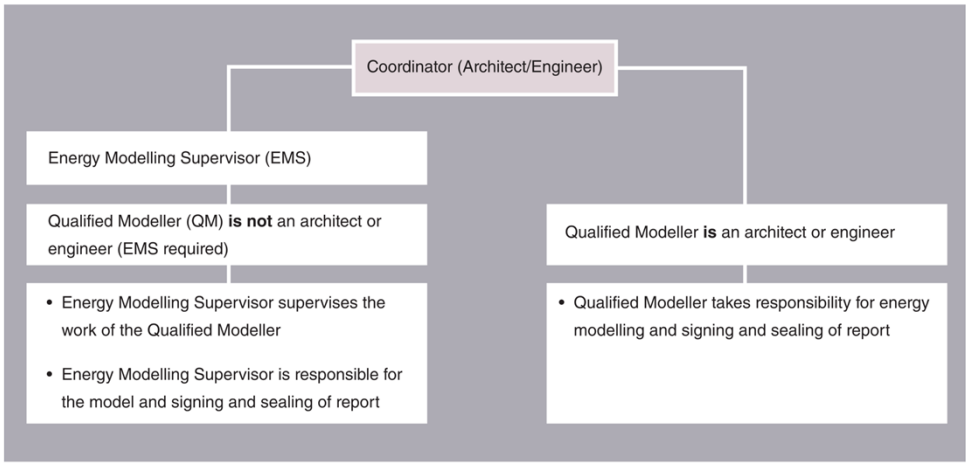

FIGURE 5-1 OF PROFESSIONAL PRACTICE GUIDELINES

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Role of the Building Envelope Professional

Building modelling needs to consider all applicable building functions including the anticipated use and space conditions, the enclosure, mechanical, electrical, lighting, process, etc. Like with any work, professionals must be knowledgeable in the area they practice.

The guideline references the building enclosure professional as a potential sub consultant. It is often the case that a building envelope or enclosure professional will assist with the heat transfer calculation for enclosure components and assemblies.

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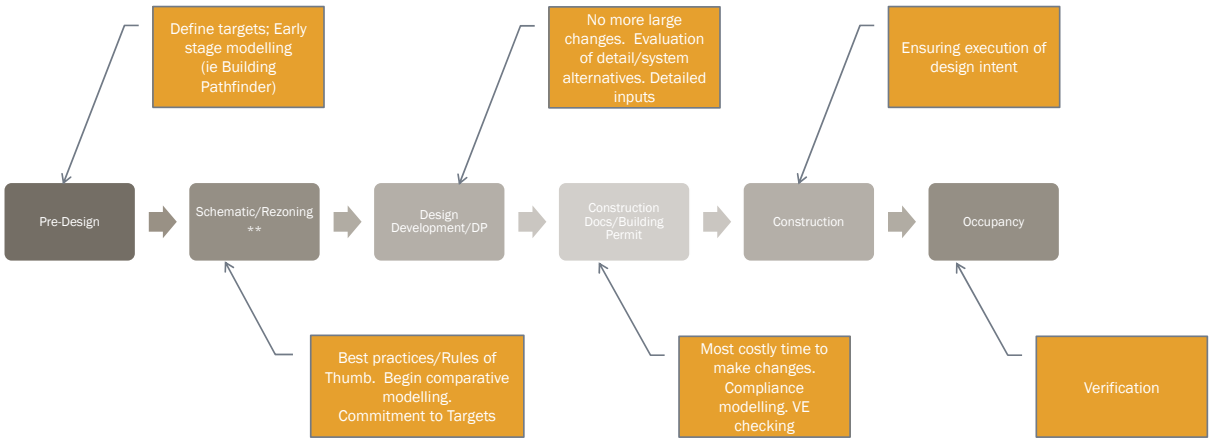
Stages of the project & The Model



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Insights into Thermal Performance of Building Envelope

PART 4

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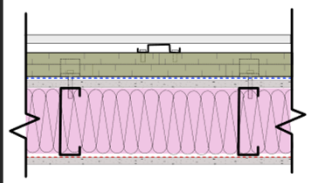
How to Mitigate

Example Thermal Bridging Scenarios for Mid-Rise Residential Building

This example will be part of the ZEBx Thermal Bridging Playbook that is currently in development

www.zebx.org



1. Panel cladding
2. R12.8 (3") of Exterior Insulation with aluminum bracket and rail system
3. Exterior sheathing with moisture control layer
4. Steel-framed wall with R-20 Fiberglass Batt
5. Gypsum board with interior vapour control

R -21 clear wall assembly

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How to Mitigate

Scenario 1: Unmitigated Thermal Bridging

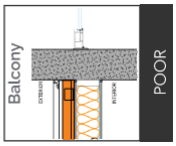
Proportion of heat flow related to interface details

Effective R-value

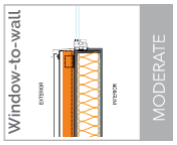
Clear field Wall Assembly R-21

Overall R-8.8

18% % Contribution to Overall Heatflow



23% % Contribution to Overall Heatflow



Two details contribute to 40% of the heat flow

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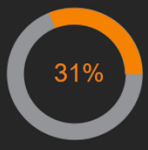
How to Mitigate

Scenario 2: Mitigated Thermal Bridging



Proportion of heat flow related to interface details

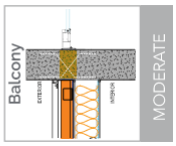
Effective R-value

Clear field Wall Assembly R-21

Overall R-14.5

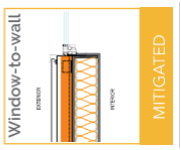
6% % Contribution to Overall Heatflow

↓66% Reduction from Scenario 01



12% % Contribution to Overall Heatflow

↓48% Reduction from Scenario 01



Same two details are reduced to 18% of the heat flow

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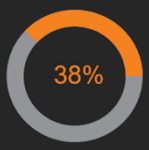
How to Mitigate

Scenario 3:

Mitigated + Insulation



Proportion of heat flow related to interface details

Effective R-value

Clear field Wall Assembly	R-30
Overall	R-18.5

Same details with more insulation.
Interface details contribute to higher percentage of heat flow

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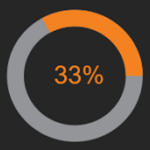
How to Mitigate

Scenario 4: Efficient Details + Insulation



Proportion of heat flow related to interface details

Effective R-value

Clear field Wall Assembly	R-30
Overall	R-19.9

Higher expectations for thermal quality are needed for an overall effective R-values greater than R-20 (3.5 RSI)

Thermal Quality	Linear Transmittance	
	BTU/hr ft F	W/ M K
Thermal Bridge Free	0.01	0.01
Efficient	0.06	0.1
Mitigated	0.12	0.2
Moderate	0.17	0.3
Low / Poor	Greater than 0.23	Greater than 0.3

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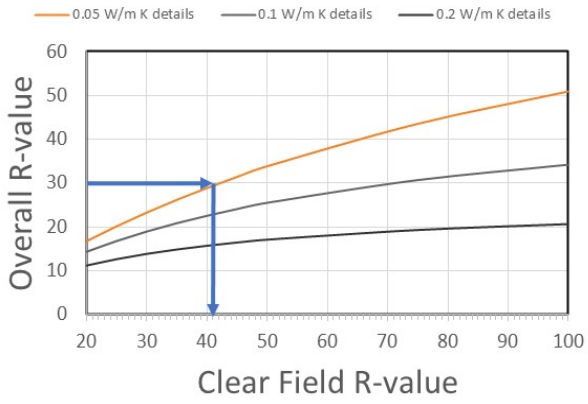
Diminishing Returns

More Insulation and High Thermal Quality Details are required for High Expectations of Overall R-value



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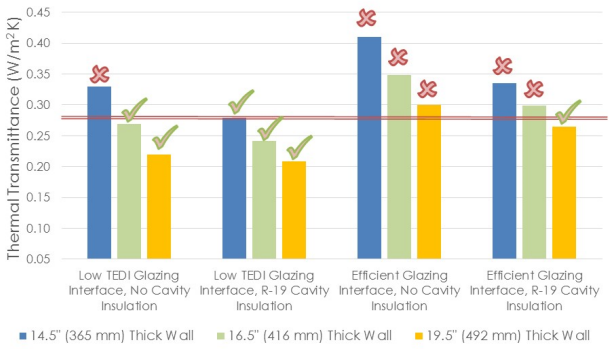
Window-to-Wall Interface

Impact on Wall Thickness

- 0.1 W/m K versus 0.05 W/m K for window-to-wall interface
- 5, 7, or 10 inches of exterior insulation

Source: Chapter 6, Guide to Low Thermal Energy Demand for Large Buildings, BC Housing



Impact of window-to-wall interface transmittance on wall thickness for a target of 0.28 w/m²K (R-20 effective)

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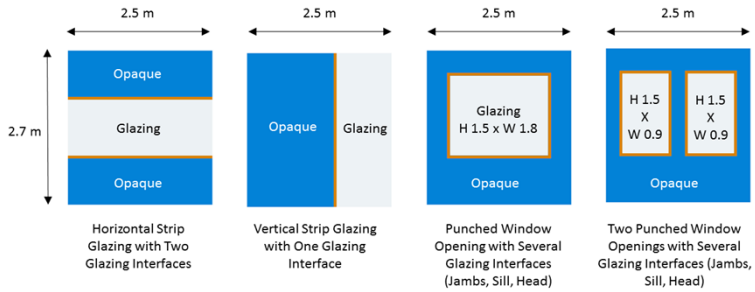
Glazing Configuration



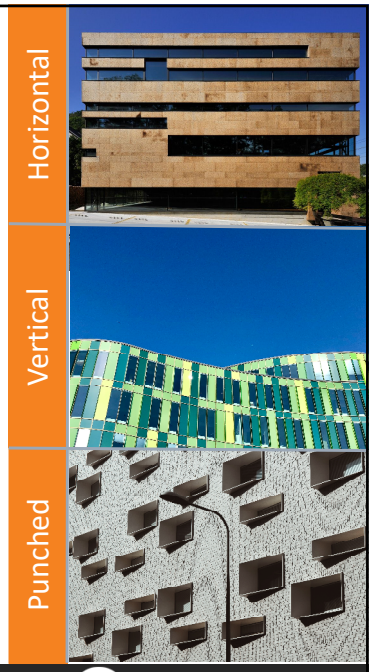
Horizontal Strip Glazing with Two Glazing Interfaces

Vertical Strip Glazing with One Glazing Interface

Punched Window Opening with Several Glazing Interfaces (Jambs, Sill, Head)

Two Punched Window Openings with Several Glazing Interfaces (Jambs, Sill, Head)

	Horizontal Strip Glazing	Vertical Strip Glazing	Punched Window Opening	Two Punched Window Openings
Interface Length (m)	5	2.7	6.6	9.6
Effective R-Value	10.2	12.2	9.2	7.8



Source: Chapter 4, Guide to Low Thermal Energy Demand for Large Buildings, BC Housing

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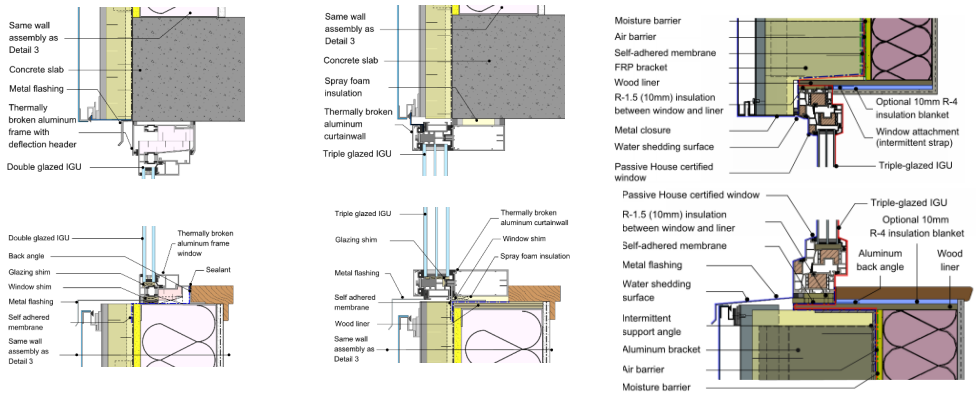
Window Detailing



Sill	0.28 W/m K	0.08 W/m K	0.08 W/m K
Head	0.53 W/m K	0.11 W/m K	0.04 W/m K

Source: Enclosure Solutions Thermal Bridging Guide by Owen Corning and Chapter 5, Guide to Low Thermal Energy Demand for Large Buildings , BC Housing

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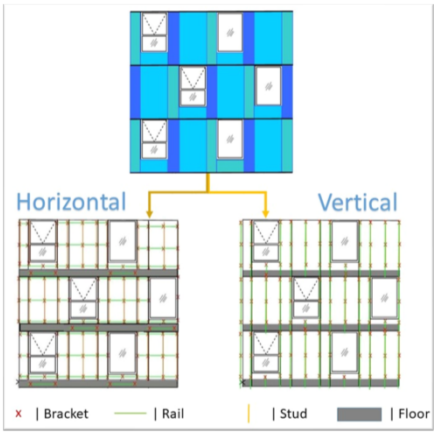
More Than Thermal Efficiency

Cladding Attachments

- Structural requirements, panel type and layout are import factors
- Less components is cost effective and results in higher R-value

Source: 2nd International Conference on New Horizons in Green Civil Engineering, Gretka et al. 2020



	Vertical Layout	Horizontal Layout	% Increase
Total Rail Length (ft)	347	223	-36%
Number of Clips	105	111	7%
Clear Field R-value	R-18.5	R-21.5	16%

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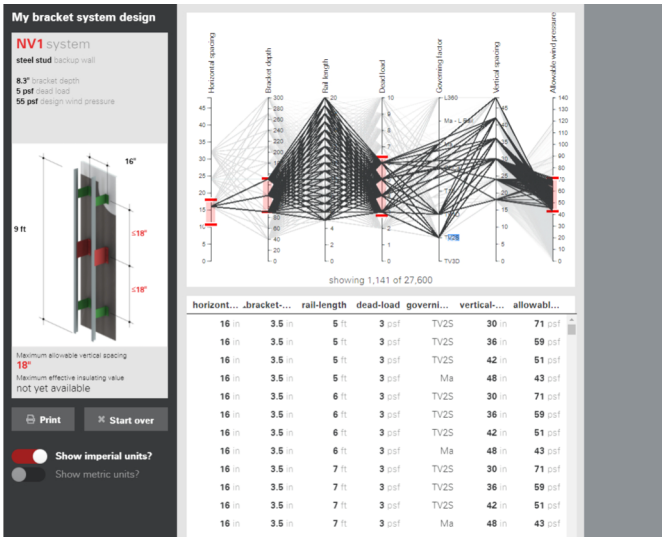
Design Assist Tools

- Explore the governing factors for a multitude of parameters
- Gain confidence in the spacing of the components at early design



Demo – www.sfsconstructionna.com/nvelope-designrx/

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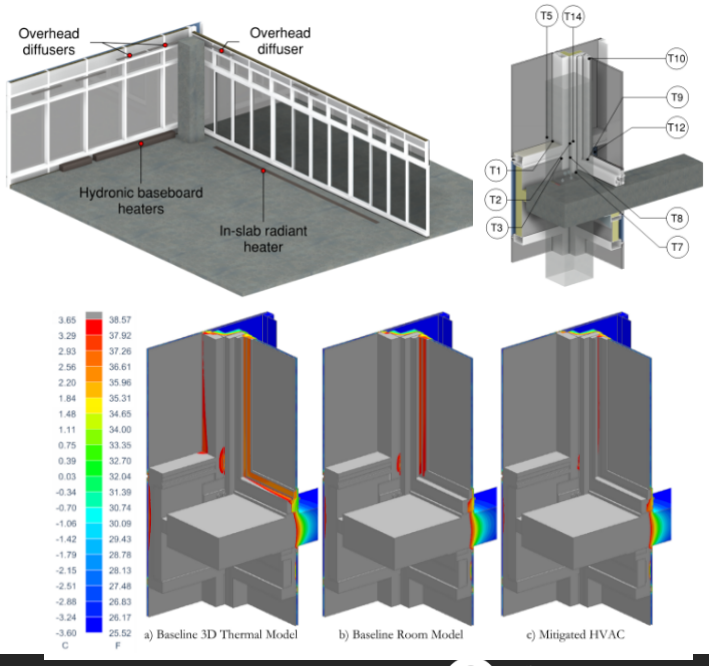
Condensation Risk

- 3D models are helpful for targeting areas of concerns
- Installation detail is important
- Data often not readily available
- Advanced room airflow analysis can help explore mitigation options – only do this if you have to



Source: Conference Proceedings for Buildings XIV: Thermal Performance of Exterior Envelopes of Whole Buildings, Almeida et al. 2009

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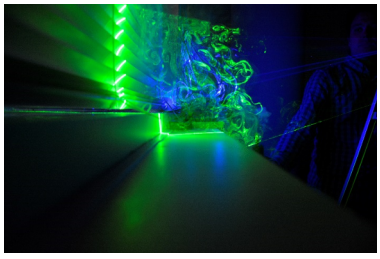
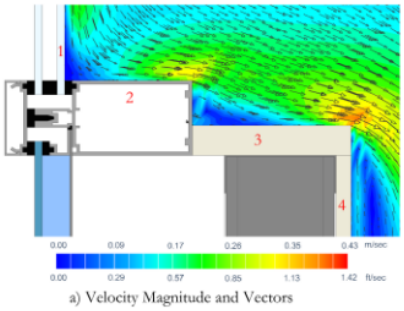
Thermal Comfort

- Avoid drafts and low mean radiant temperature
- Passive house tries to limit temperature deviation by 4.2°C
- The thermal comfort criteria can be more stringent than is needed for energy





Source: Conference Proceedings for Buildings XIV: Thermal Performance of Exterior Envelopes of Whole Buildings, Almeida et al. 2009

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Don't make it complicated

Comprehensive thermal bridging calculations will challenge the status, however

- Tools and resources are available
- Absolute certainty is not needed to make the right decisions
- Focus on what matters and follow the process

1

Use a pre-screening tool to determine target U-values for the opaque walls and glazing

www.buildingpathfinder.com

2

Estimate the insulation levels for the wall assemblies using an allowance for the interface details

$R_o = R/(1 - x)$

where
R_o = the clear field R-value
R = the overall effective R-value (step 1)
x = propoortion of heat flow for the interface details

Use x = 0.5 as a default so that migitgation of the interface details and optimization of the insulation levels is feasible during detail design

Optional

check assumpitons for typical details and quantities as outlined in the detailed design stage

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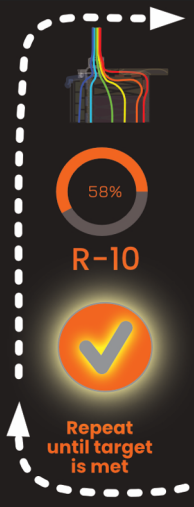
Detailed Design

Outline scenarios for several insulation and mitigation strategies

www.thermalenvelope.ca



Estimate transmittances
use broad expectations for the interface details. Focus on the window-to-wall interface

Determine Impact
Determine the details that have the biggest impact

Consider other factors
such as cost and comfort criteria

Tackle the high impact details
refine assumptions, revisit insulaiton levels, and target biggest offenders

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Questions

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