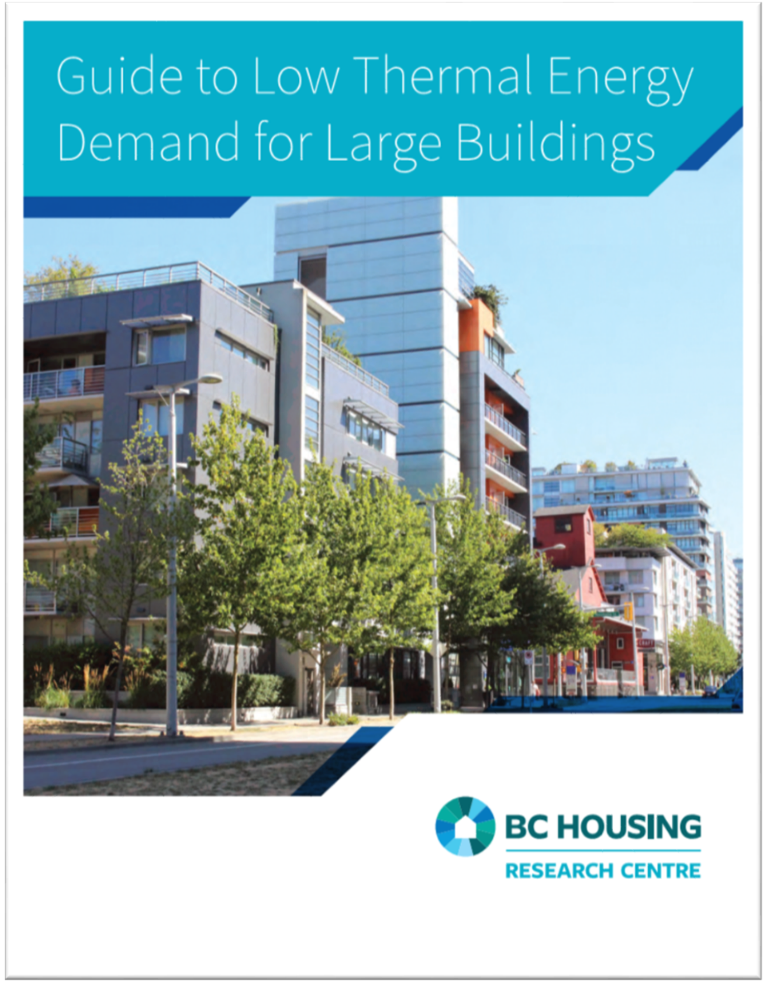
Morrison Hershfield

Guide to Low Thermal Energy Demand for Large Buildings

October 26, 2018

Aka the "Low TEDI Guide"

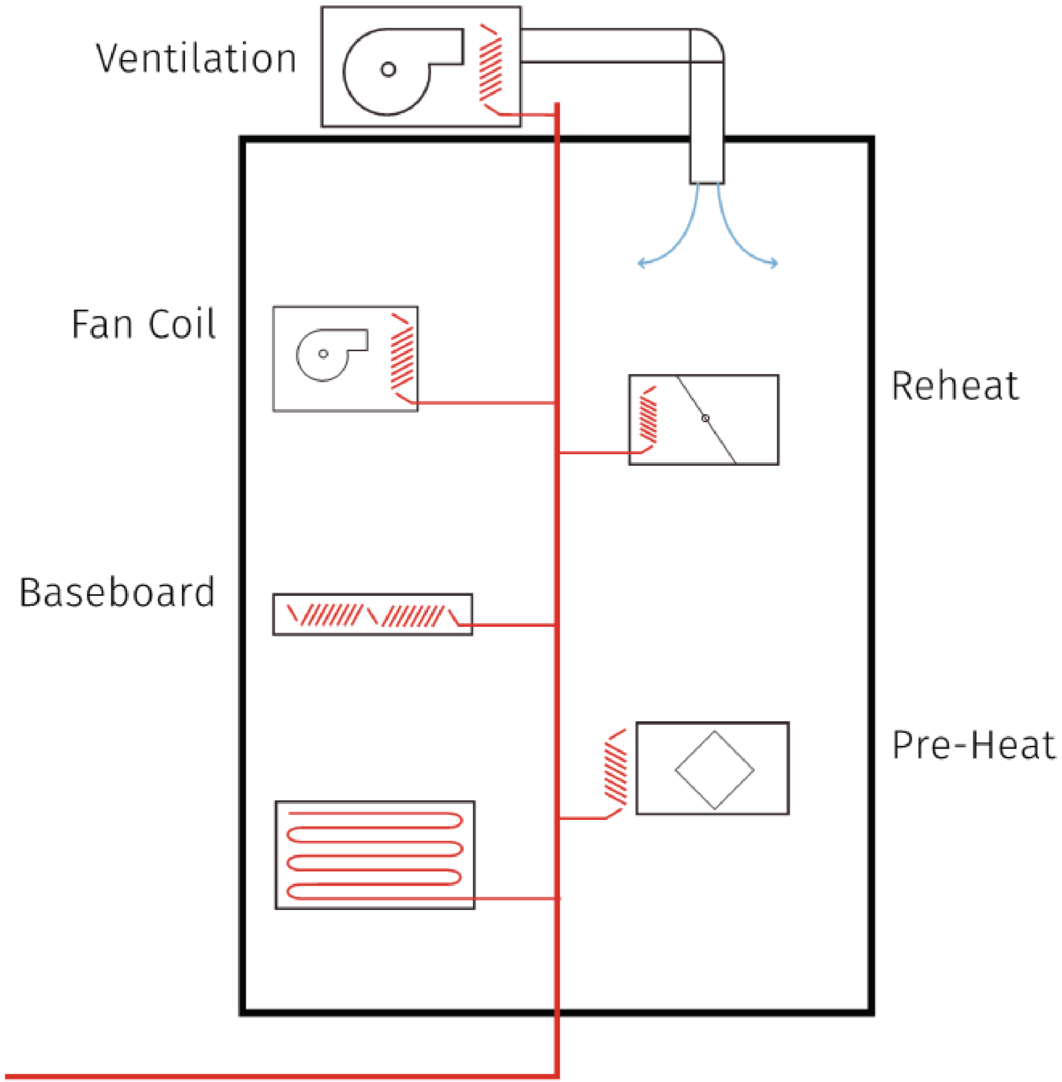


- Net Zero (Ready)
- Passive House

- Low is TEDI is 15 kWh/m^2/year
- Step 4 in BC Energy Step Code

- High-rise Residential

What is TEDI?



- Thermal Energy Demand Intensity
- Heating Load Per Unit Area
- Similar to Passive House Metric

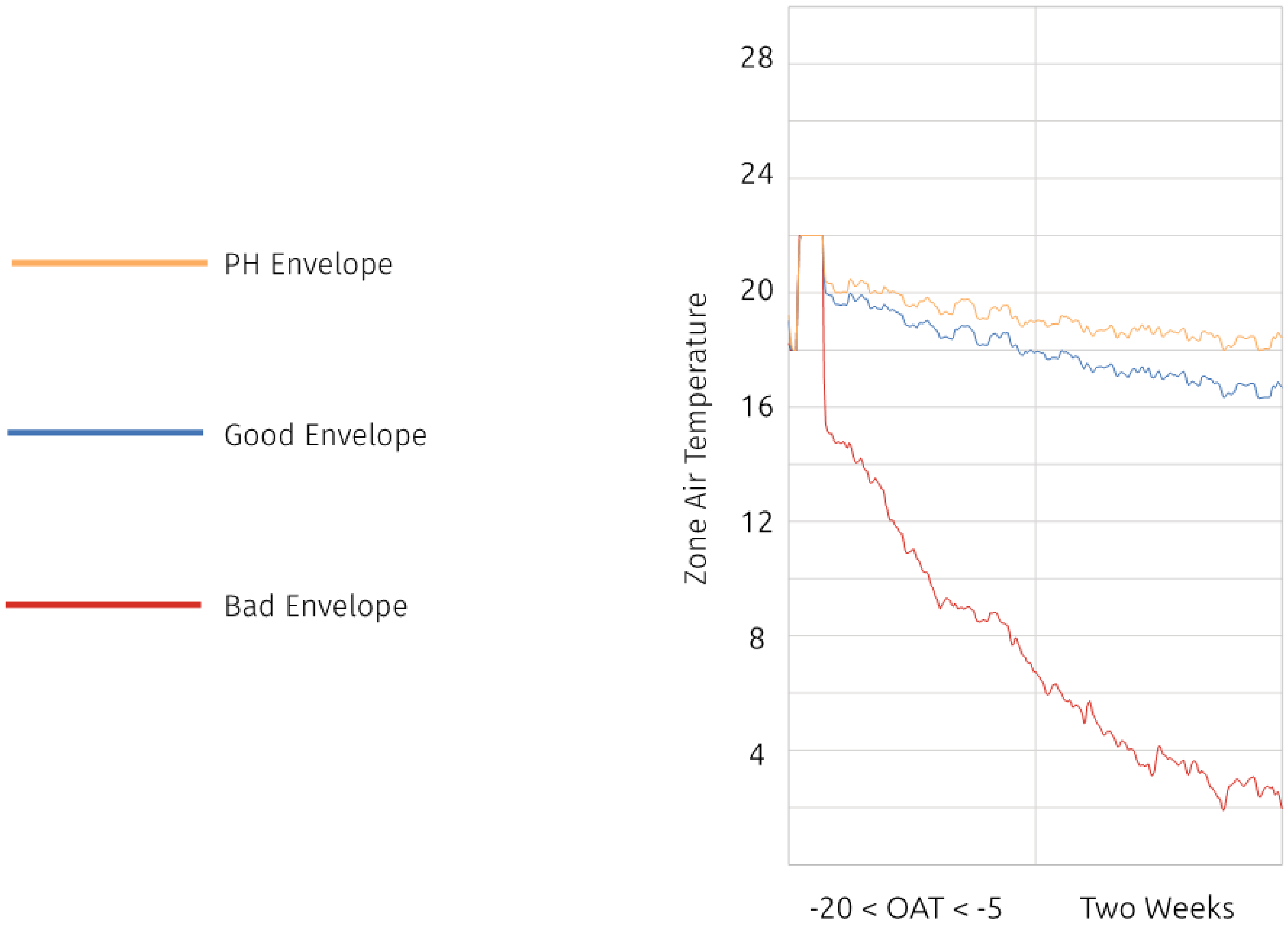
What is TEDI?

- The amount of heat needed to
  - offset the heat loss Through the Building Envelope
  - Condition the ventilation air
- **TEDI requires Energy Simulations**
- TEDI is Impacted by
  - Exterior surface area
  - Building Envelope Thermal Transmittance
  - Airtightness
  - Solar Radiation
  - Internal Gains
  - Heat Recovery
  - Ventilation

Net Zero Policies with TEDI

		Toronto	Vancouver	British Columbia	CaGBC
		Zero Emissions Building Framework	*Zero Emissions Building Plan*	*B.C. Energy Step Code*	*Zero Carbon Building Standard*
kWh/m^2 (kBTU/sf)	EUI	↘ 75 (24)	↘ 100 (32)	↘ 100 (32)	
	TEDI	↘ 15 (5)	↘ 15 (5)	↘ 15 (5)	C.Z: 4, 5, 6, 7, 8 TEDI: 30, 32, 34, 36, 40
$kgCO_2/m^2$	GHG	↘ 5	↘ 0	n/a	0

Low TEDI Helps Meet Many Objectives



- Reduce Energy Consumption
- Reduce Greenhouse Gas emissions
- Increase Resiliency
- Passive Survivability

- Not Prescriptive
- Less Levers and Trade-off
- Less subject to Operation Error
- Maintain Livable Conditions in Power Outages

What's in the Low TEDI Guide?

1. Overview

2. Thermal Bridging Calculations
3. Ventilation Heat Recovery

4. Whole Building Energy
5. Design and Construction

6. Future Horizons

Chapter 2: Thermal Transmittance

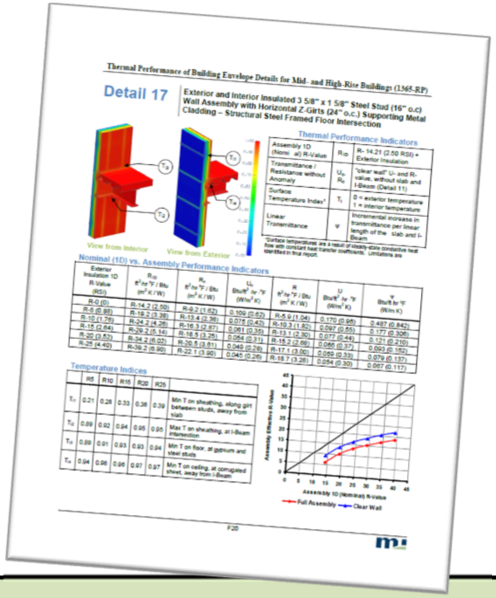
- Awareness of how Thermal Transmittance is Calculated
- Insight for Comparing Details from Different Sources

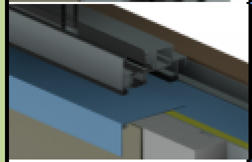
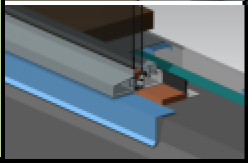
- **ISO Standard 10211**
- ISO Standard 14683
- BETB Guide
- Passive House Institute Standard (PHI)

- Window to Wall Interface Demands the most attention
- When 2D is OK and 3D is Recommended
- What parameters can be Overlooked
- **Quality of the Detail Matters the Most!**

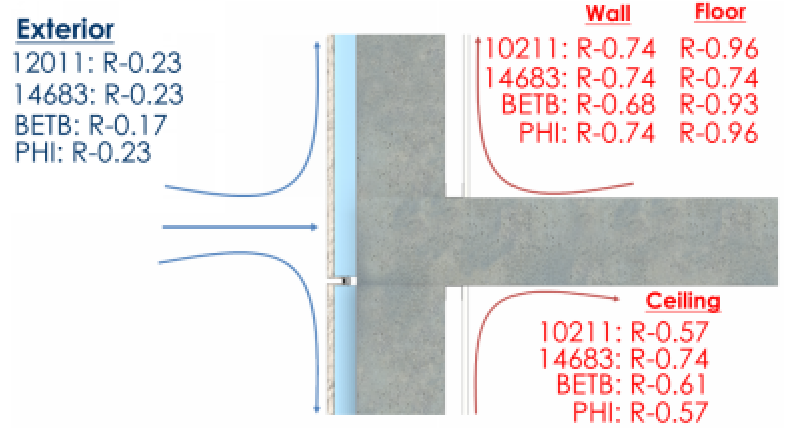
Thermal Transmittance

±5%	Numerical simulations of specific details
±5-20%	Generic details from a catalogue
±5-20%	Manual calculations
+50%	Default values



Glazing Transitions	Performance Category		Description and Examples	Linear Transmittance Btu/hr ft F	Linear Transmittance W/m K
		Efficient	**Well aligned glazing without conductive bypasses** Examples: wall insulation is aligned with the glazing thermal break. Flashing does not bypass the thermal break.	0.12	0.2
		Regular	**Misaligned glazing and minor conductive bypasses** Examples: wall insulation is not continuous to thermal break and framing bypasses the thermal insulation at glazing interface.	0.20	0.35
		Poor	**Un-insulated and conductive bypasses** Examples: metal closures connected to structural framing. Un-insulated concrete opening (wall insulation ends at edge of opening).	0.29	0.5

Overview of Impacts

<table>
<tr><th colspan="2">Procedure or Parameter</th><th>Impact on Thermal Transmittance</th></tr>
<tr><td>Boundary Temperature</td><td>
</td><td>No impact for steady-state calculations when using constant material properties.</td></tr>
<tr><td>Air Films</td><td>
</td><td>Less than 2% impact on clear field U-value and linear transmittances for insulated assemblies > R-5 (RSI-0.88).</td></tr>
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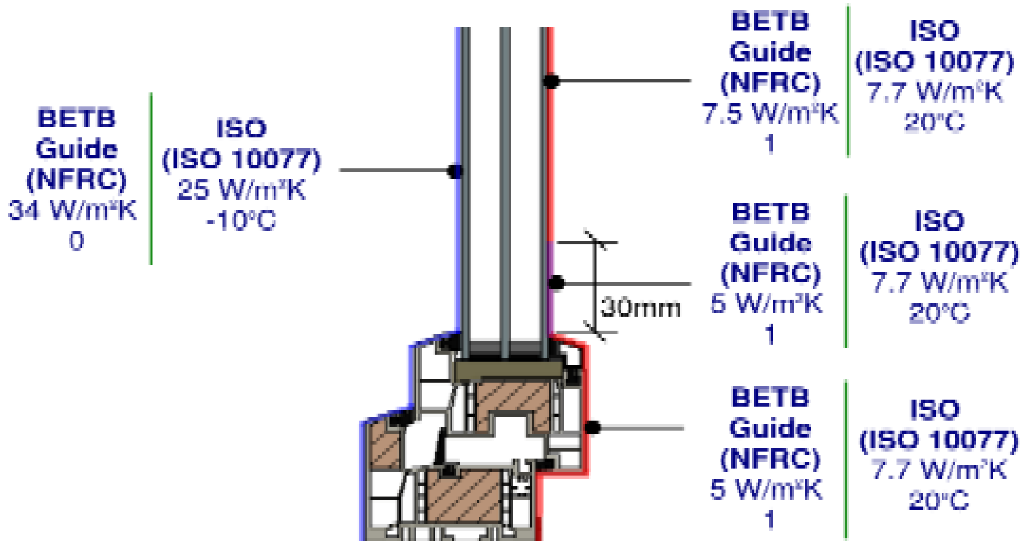
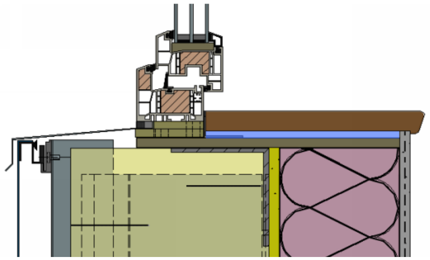
Window to Wall Interfaces

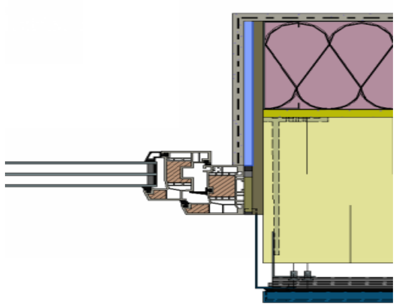


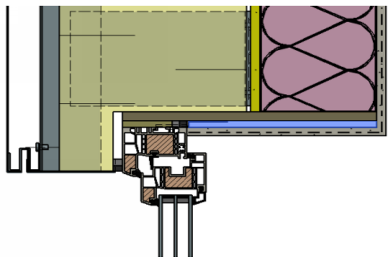
Glazing Air Films for PHI and BETB

Linear Transmittance (W/m K)

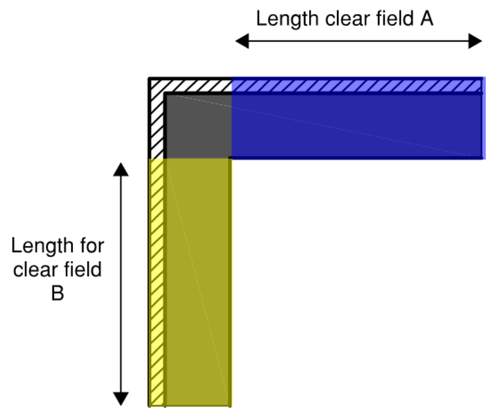
	BETB Guide	ISO
Head	0.047	0.038
Jamb	0.109	0.096
Sill	0.099	0.088





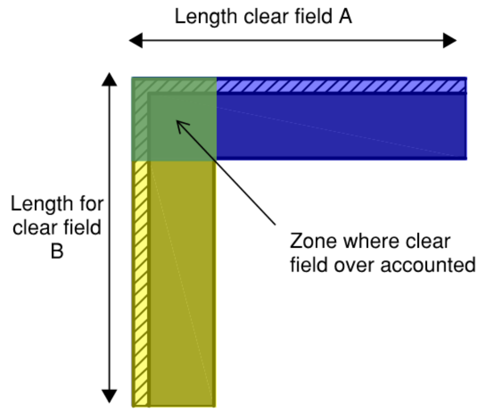


Interior versus Exterior Dimensions



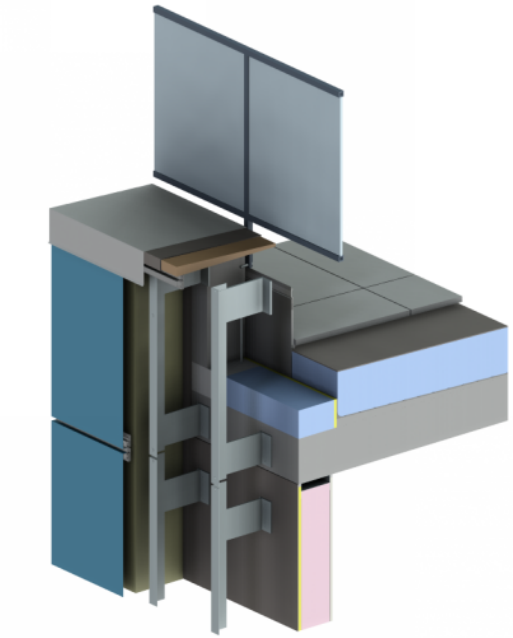
Linear transmittance calculated with interior dimensions

$\Psi_{interior}$: 0.15 W/mK
(0.087 Btu/hr·ft·°F)



Linear transmittance calculated with exterior dimensions

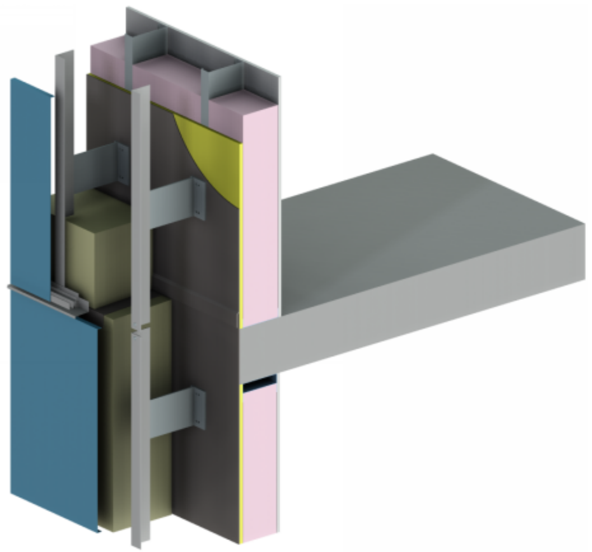
$\Psi_{exterior}$: -0.05 W/mK
(-0.029 Btu/hr·ft·°F)



Wall to Roof Transition

$\Psi_{interior}$: 0.171 W/mK
(0.099 Btu/hr·ft·°F)

$\Psi_{exterior}$: 0.061 W/mK
(0.035 Btu/hr·ft·°F)

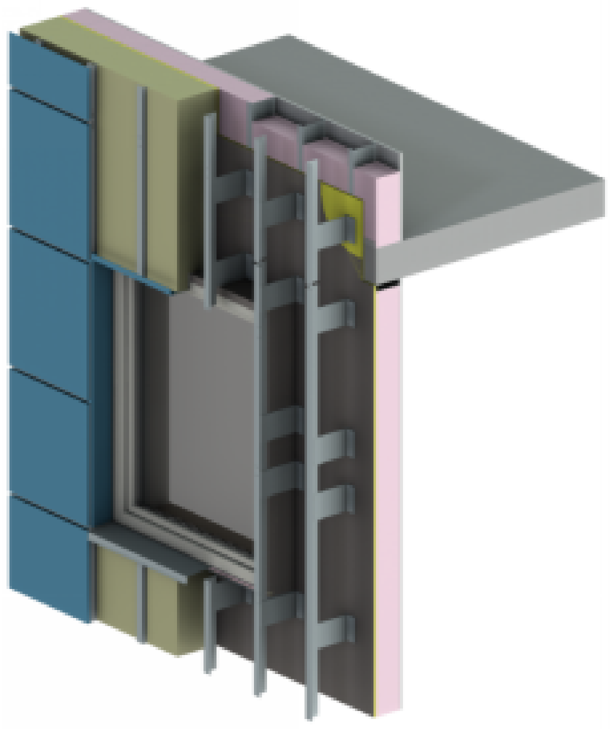


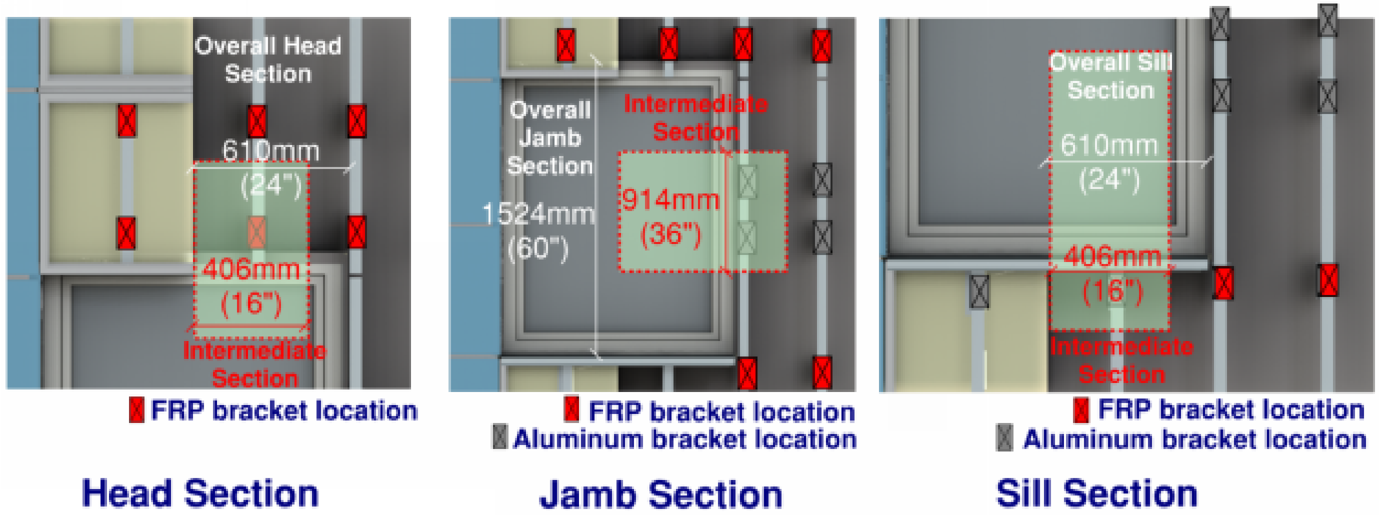
Intermediate Floor Slab

$\Psi_{interior}$: 0.015 W/mK
(0.008 Btu/hr·ft·°F)

$\Psi_{exterior}$: 0.015 W/mK
(0.008 Btu/hr·ft·°F)

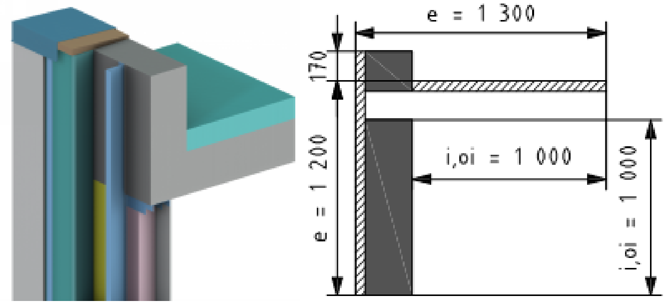
GEOMETRY AND SIMPLIFICATIONS





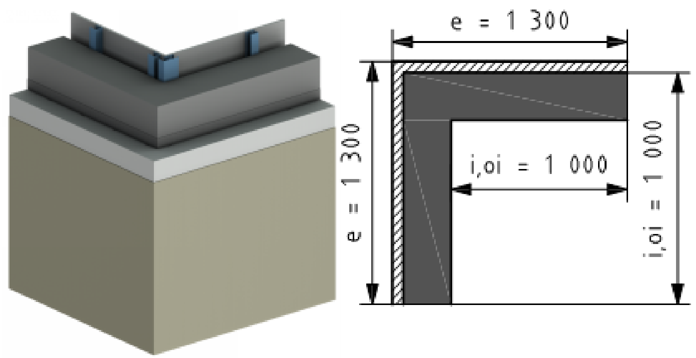
When is 2D OK?

Concrete Parapet



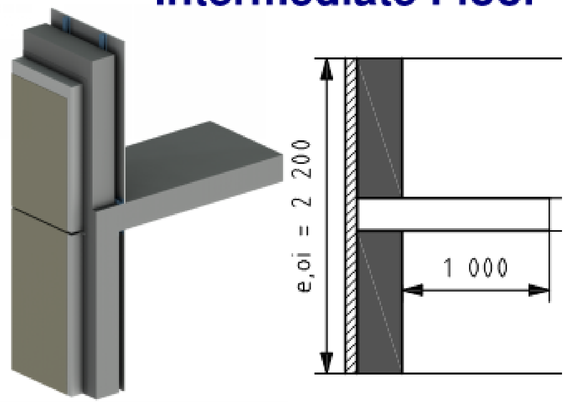
$\Psi_i = 0.785$ W/mK $\Psi_i = 0.80$ W/mK

Outside Corner



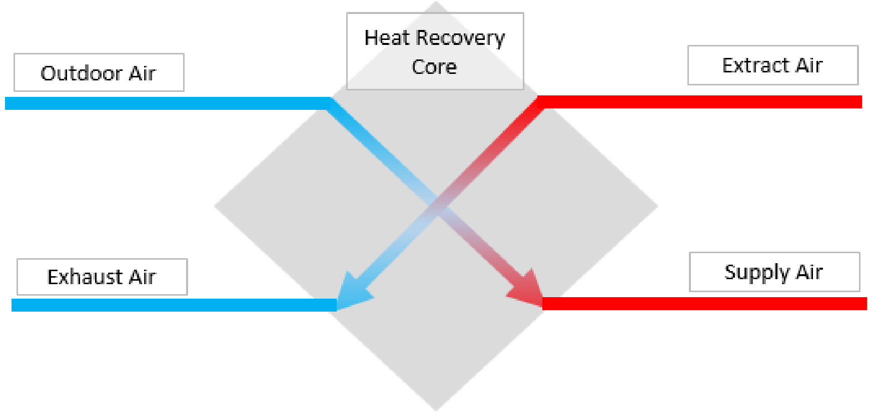
$\Psi_i = 0.15$ W/mK $\Psi_i = 0.15$ W/mK

Intermediate Floor



$\Psi_i = 0.02$ W/mK $\Psi_i = 0.00$ W/mK

Chapter 3: Heat Recovery Ventilators

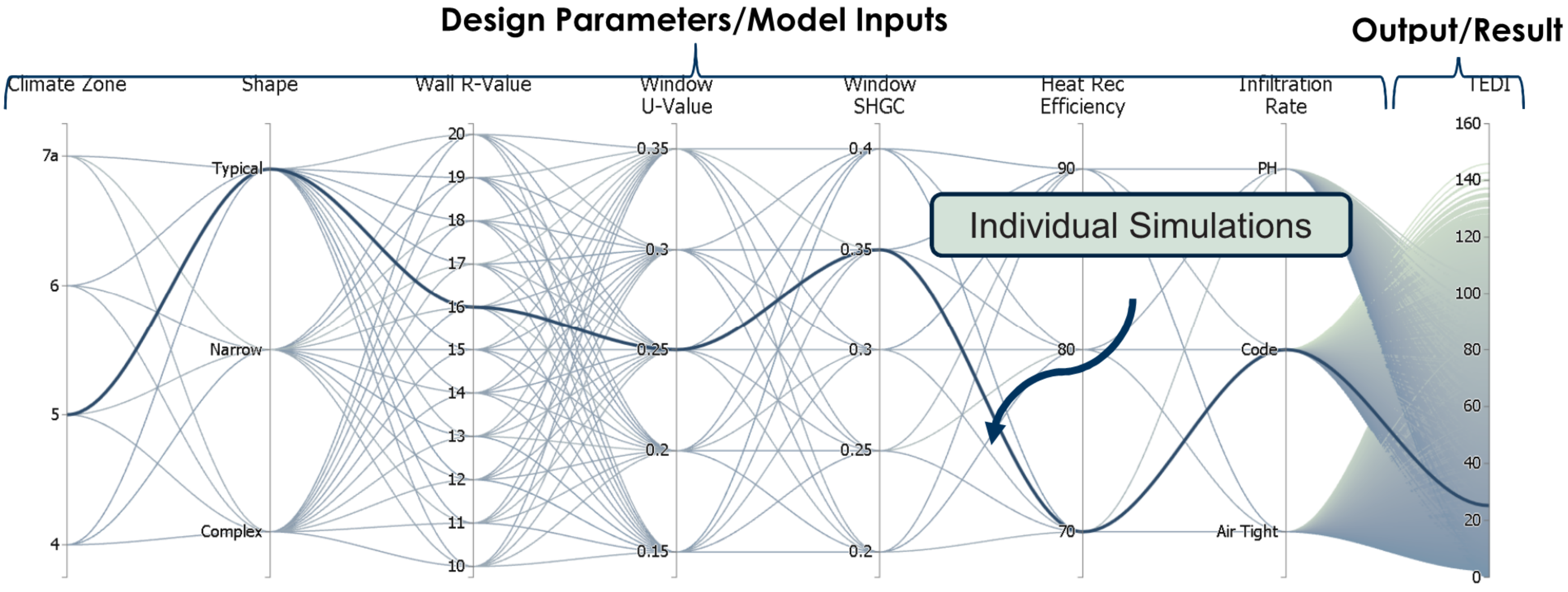


- HRV's Critical to Low TEDI Buildings
- Focusing on Protocol Differences is not Productive

- Available Data or Project Requirements often Fixed
- A Capable Modeler can Accurately Model Energy Impact

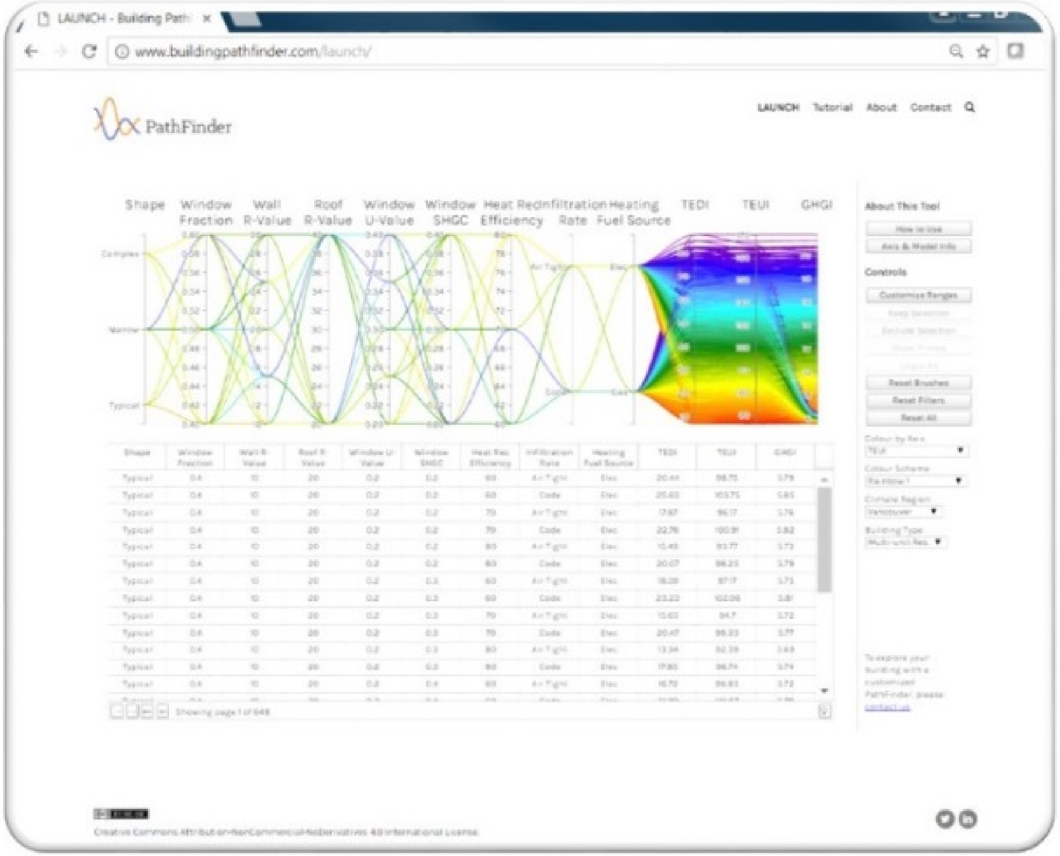
- Main difference is treatment of Fan Power
- Understand the Available Metrics and Software
- HVI Standard is the easiest to use in Canadian Context

Chapter 4: Whole Building Context



- TEDI is not Alone – Don't Forget EUI
- Other loads become increasingly important as TEDI Decreases
- There are many Paths to Low TEDI Buildings

BuildingPathfinder.com



Many Paths, but Common Characteristics

Design + Performance

- Optimize Building Shape (VRAF)
- Low window to Wall Ratios
- Internal Gains
- Overheating
- Orientation and Solar Heat Gain
- **Minimized Thermal Bridges**
- **Highly Insulated Walls**
- **High Performance Glazing**
- **Airtight Assemblies**
- HRVs

Climate Zone 5 Examples

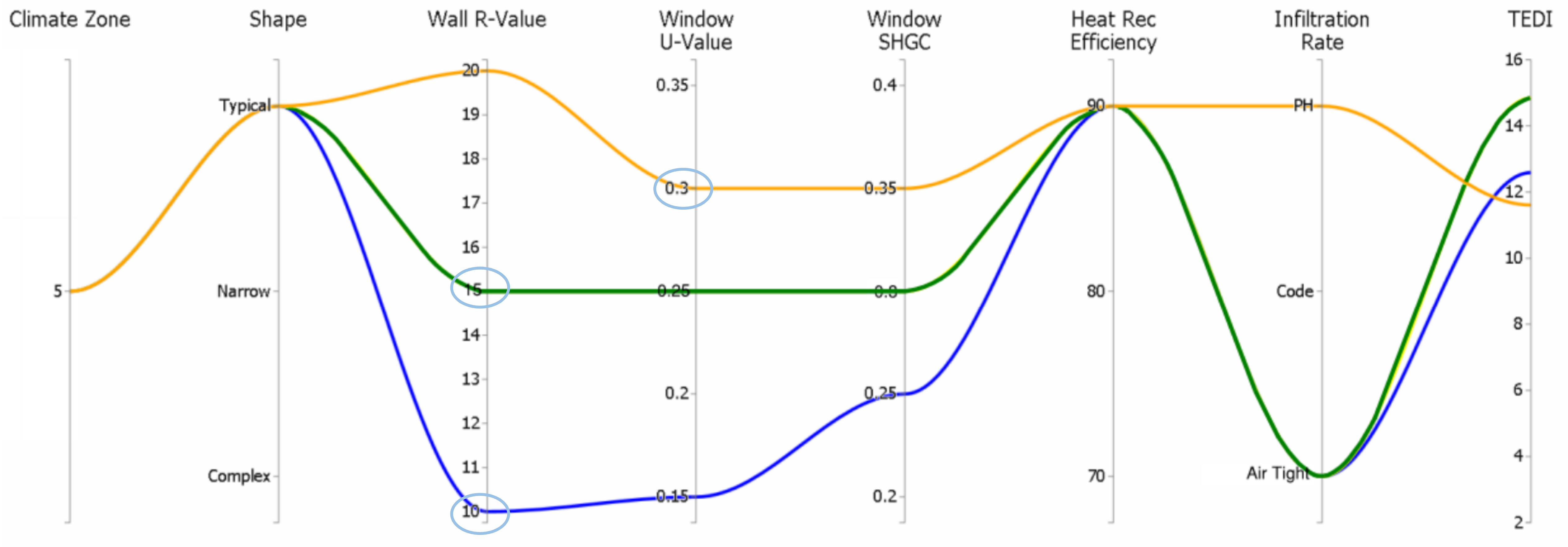


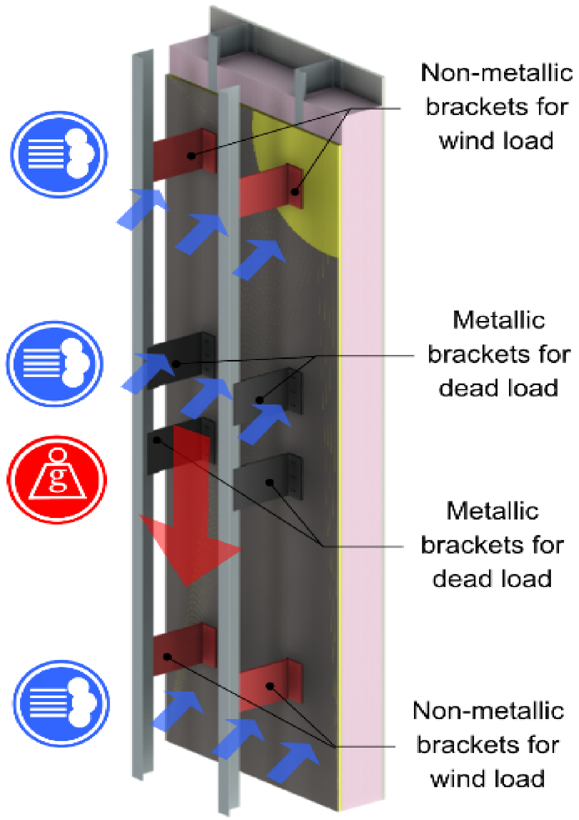
Figure 4.10: Example Paths to Low Energy Buildings in Climate Zone 5

Chapter 5: Design and Construction

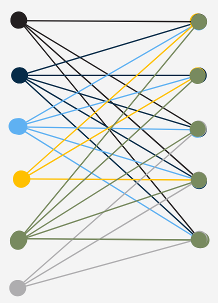
Design Principles

- Fire Protection and Combustibility
- Environmental Separation
- Structural Support
- Durability
- Constructability

More than Thicker Walls and Extra Insulation



Design Specification
Insulation type
Cladding type
Glazing type
Cladding attachment
Window detailing
Insulation placement

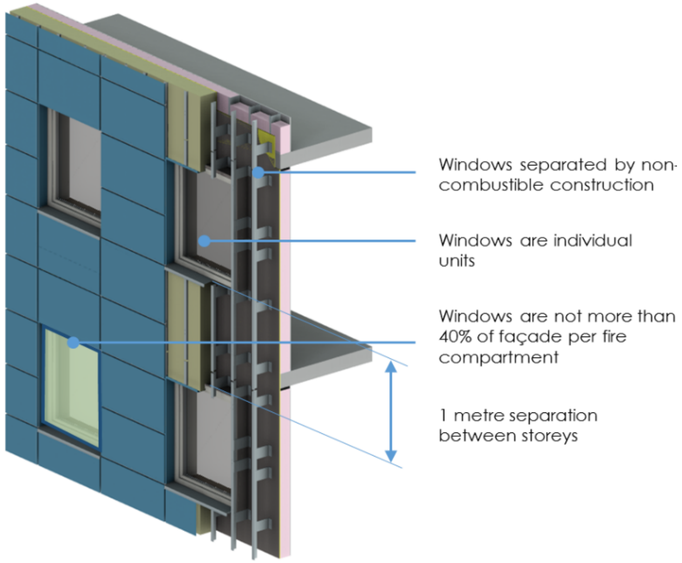


Requirement
Fire Protection
Structural Support
Environmental Separation
Durability
Constructability

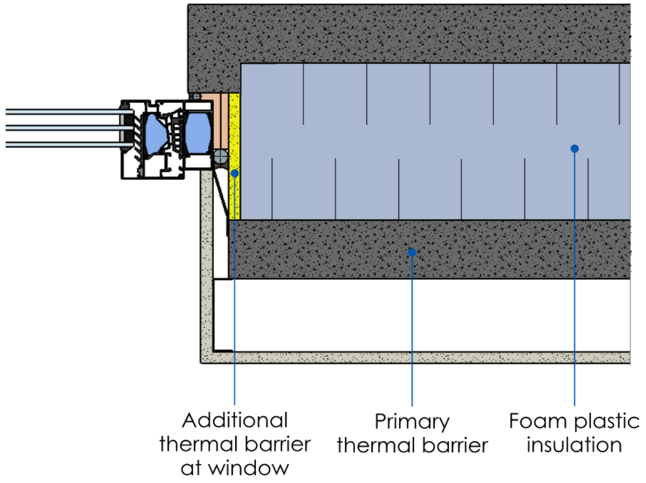
- Deviation from conventional practice is required, but it is in everyone's best interest to minimize disruption and build on local practice
- Success will come from a holistic viewpoint to design specifications and project requirements
- More effort will be required, by everyone, until new norms are established
- Importing technology from Europe is not necessary

Fire Protection and Combustibility

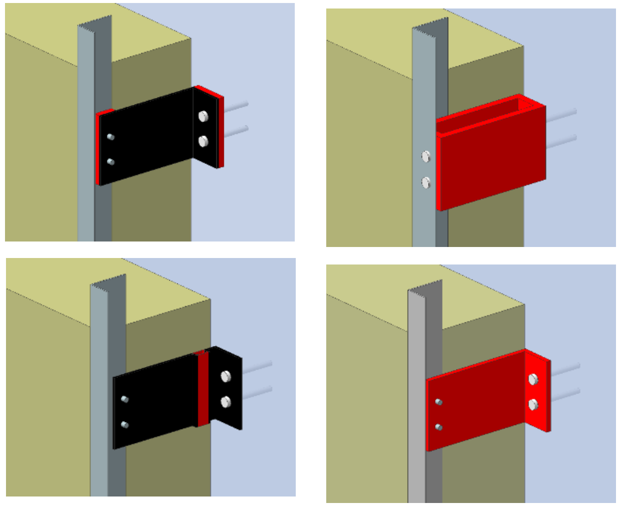
Combustible Window Frames



Foam Plastic Insulation



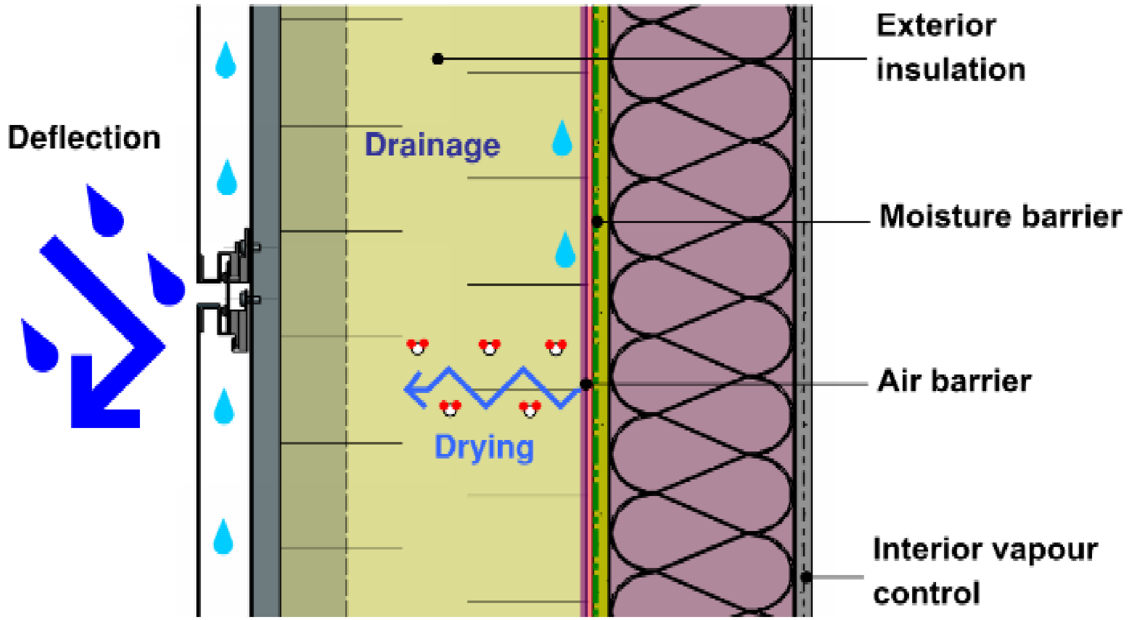
Non-metallic Cladding Attachments



Significant differentiator and challenge for high-rise MURBs

- Many components relied upon to reduce thermal bridging and minimize wall thickness have combustible components

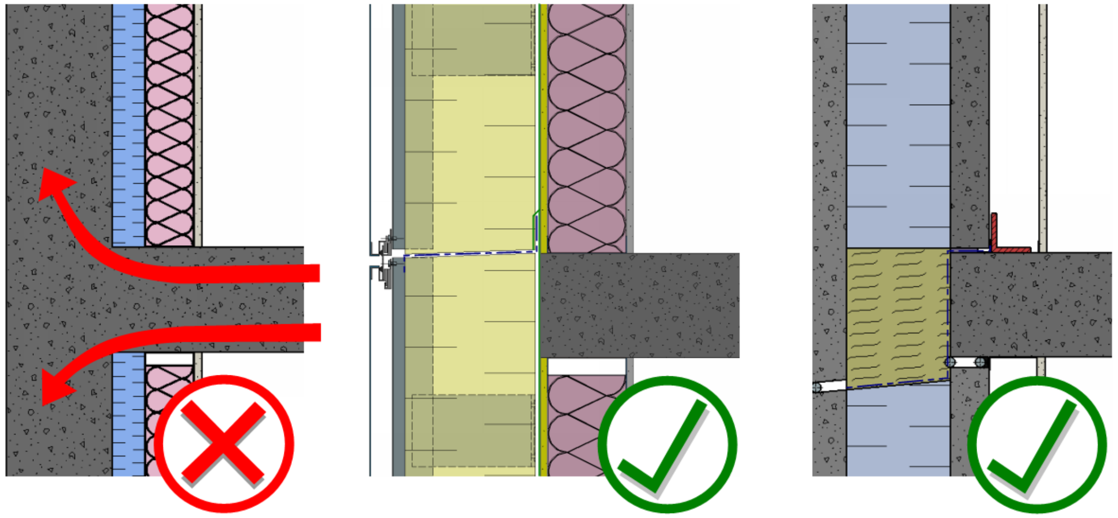
Environmental Separation and Durability



Same Minimum Requirements

- Less energy transfer
- Less forgiveness

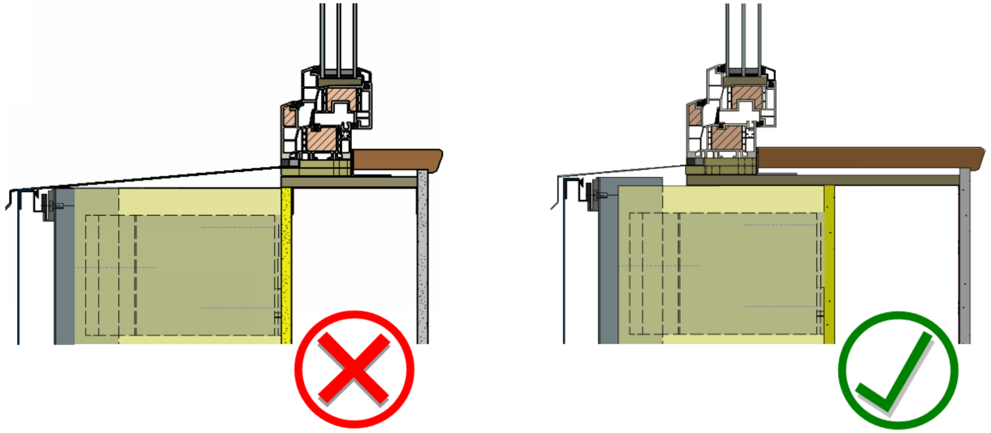
Structural Support



Interior insulated concrete

Exterior insulated walls

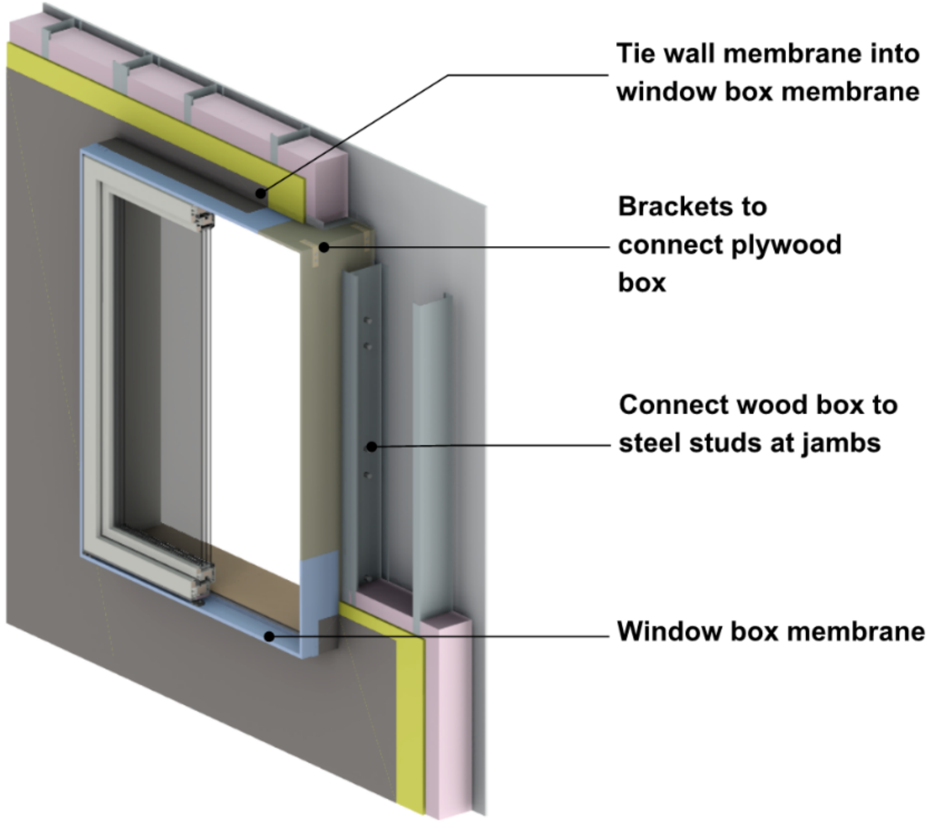
Precast concrete panels



Some easy and efficient designs are non-starters

- More complex connections, such as required for balconies or overhangs
- More accommodation in structural design for other requirements, such as
  - Cladding attachments with combustible components
  - Thermal breaks
  - Continuity of the thermal insulation across the structure
  - Windows positioned outboard of the structure

CONSTRUCTABILITY

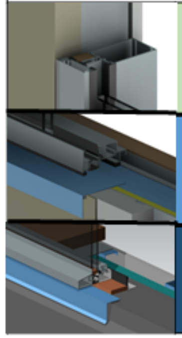


CRITICAL TO QUALITY AND COST CONTROL

- FAMILIARITY AND AVAILABILITY
- ENGINEERING AND TESTING FOR JURISDICTION
- SITE-BUILT VERSUS PRE-FABRICATED
- FIELD REVIEW AND TESTING
- SEQUENCING AND EXTERIOR ACCESS
- CRANE USE

Expectations for Thermal Bridging

BETB V1.1



Performance Category	Linear Transmittance	
	Btu / hr ft F	W / m K
Efficient	0.12	0.2
Regular	0.20	0.35
Poor	0.29	0.5

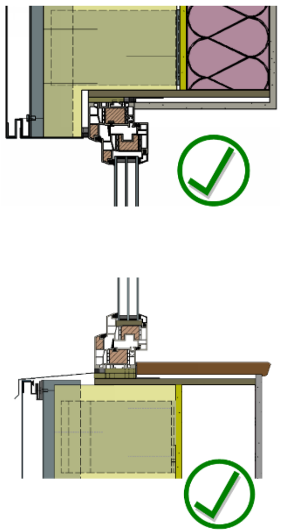
Low TEDI Guide

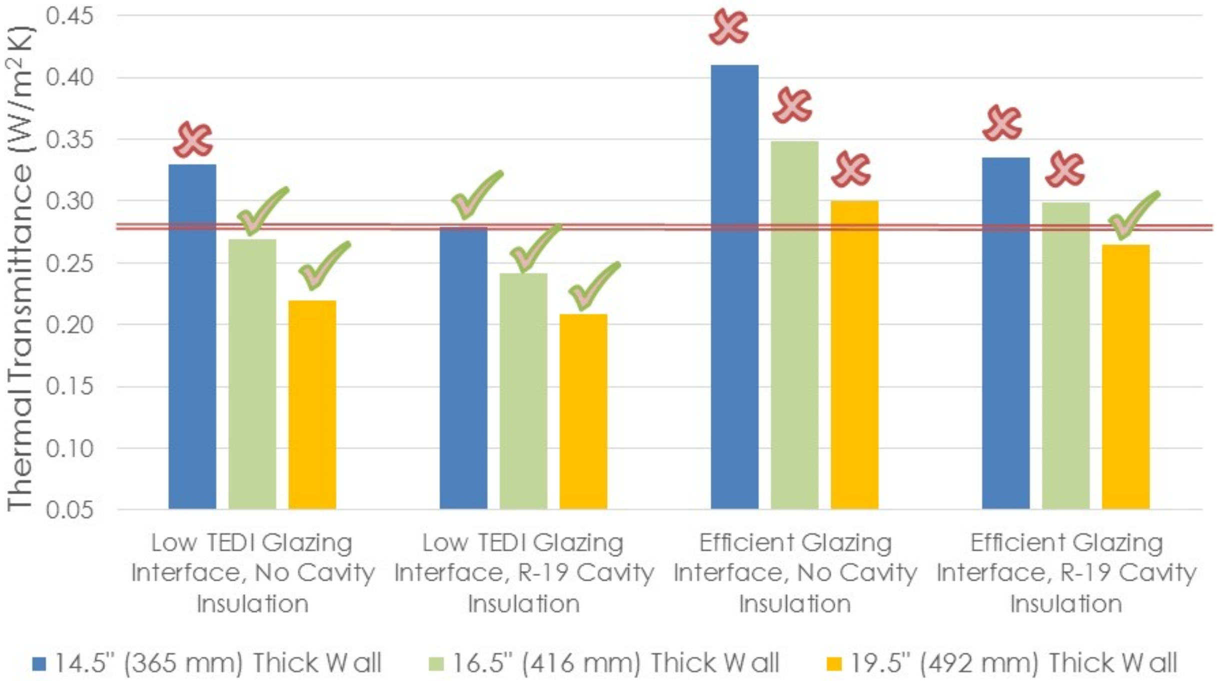
Performance Category	Linear Transmittance	
	Btu / hr ft F	W / m K
Thermal Bridge Free	0.01	0.01
Efficient	0.06	0.1
Mitigated	0.12	0.2
Moderate	0.17	0.3
Regular	0.23	0.4
Poor	0.58	1.0

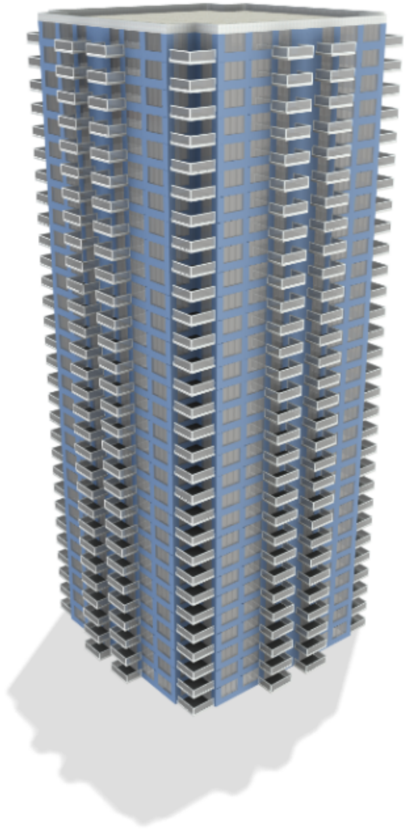
Low TEDI is difficult without high thermal quality details

- Small differences in detailing can be significant
- The wall to window interface demands the greatest attention for thermal transmittance calculations because of the potential variation in values and overall impact

Examples







- Expectations for Interface Details
- Impact of Balconies
- Impact of Glazing Size

Resources

Thermal.ly

Buildingpathfinder.com

Step Code Design Guide

THANK YOU!

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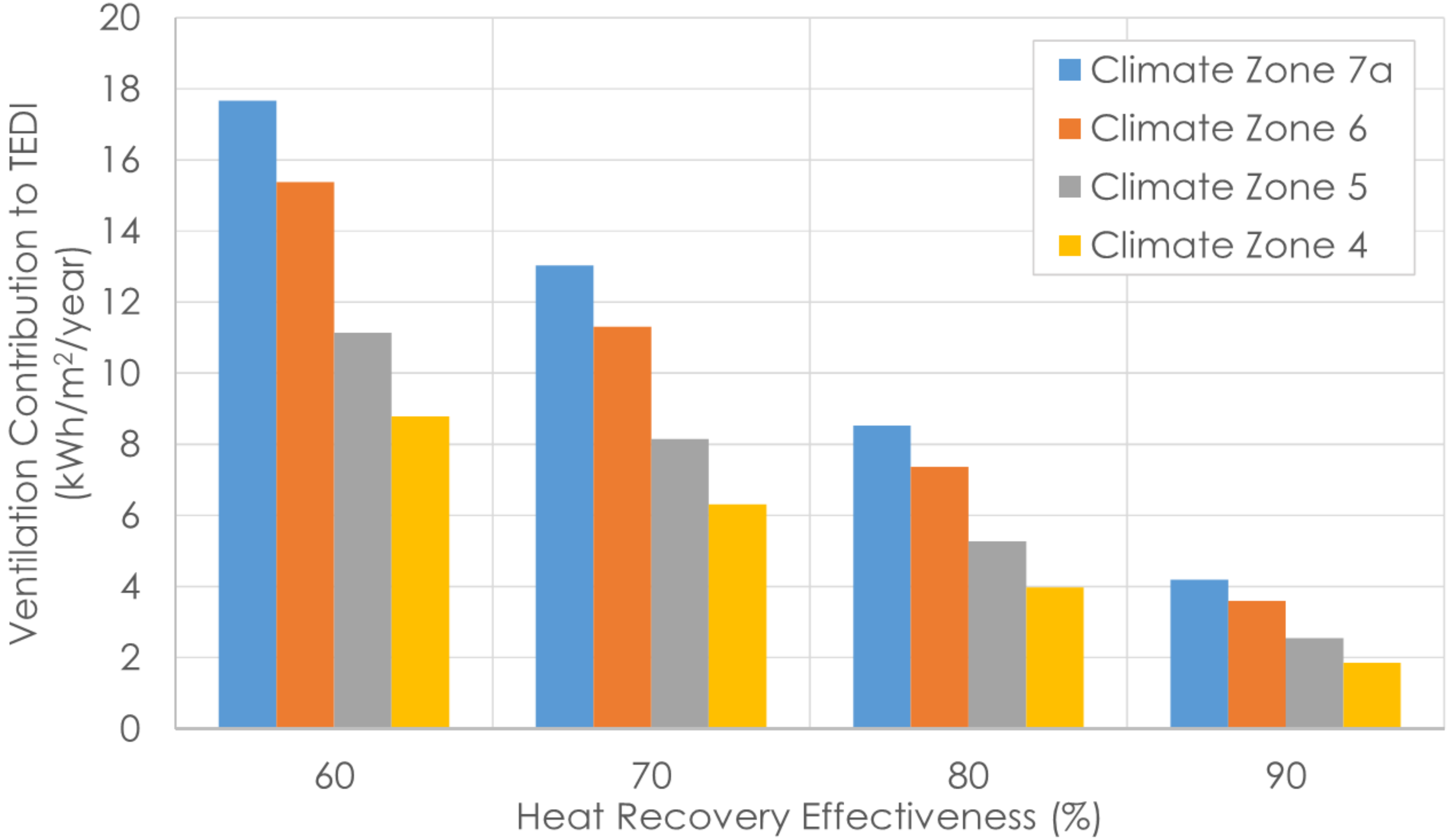
Strategy 2: High Efficiency Heat Recovery



STRATEGY 3: REDUCE HEAT LOSS

Table 4.2: Wall Thermal Transmittance for Conventional Assemblies and Details

Detail	Area or Length	Transmittance Value	Heat Flow (W/K)	Percent of Total Heat Flow (%)
Steel Stud Wall	5903 m^2	0.35 W/m^2K	2066	36.7%
Balcony Slab at Door	226 m^2	4.72 W/m^2K	1068	18.9%
Parapet at Wall	55 m	0.78 W/m K	43	0.8%
Parapet at Glazing	73 m	0.98 W/m K	72	1.3%
Intermediate Floor at Wall	616 m	0.20 W/m K	123	2.2%
Intermediate Floor at Balcony	778 m	1.06 W/m K	825	14.6%
Intermediate Floor at Glazing	1536 m	0.20 W/m K	307	5.5%
Window to Wall	5559 m	0.20 W/m K	1112	19.7%
Interior Wall Separation	988 m	0.20 W/m K	20	0.4%
			Overall Thermal Transmittance (W/m^2 K)	**0.92**
			Effective R-Value ($hr \cdot ft^2 \cdot F/BTU$)	**6.2**

Table 4.3: Wall Thermal Transmittance for Low TEDI Assemblies and Details

Detail	Area or Length	Transmittance Value	Heat Flow (W/K)	Percent of Total Heat Flow (%)
Wall with FRP Brackets	6129 m^2	0.142 W/m^2K	870	67.4%
Delta U for Aluminum Brackets	6129 m^2	0.041 W/m^2K	251	19.5%
Wall to Roof	128 m	0.171 W/m K	22	1.7%
Intermediate Floor	2930 m	0.003 W/m K	10	0.8%
Window to Wall	5559 m	0.024 W/m K	133	10.3%
Interior Wall Separation	988 m	0.003 W/m K	3	0.3%
			Overall Thermal Transmittance (W/m^2 K)	**0.21**
			Effective R-Value ($hr \cdot ft^2 \cdot F/BTU$)	**27.0**

STRATEGY 4: IMPROVE AIR TIGHTNESS

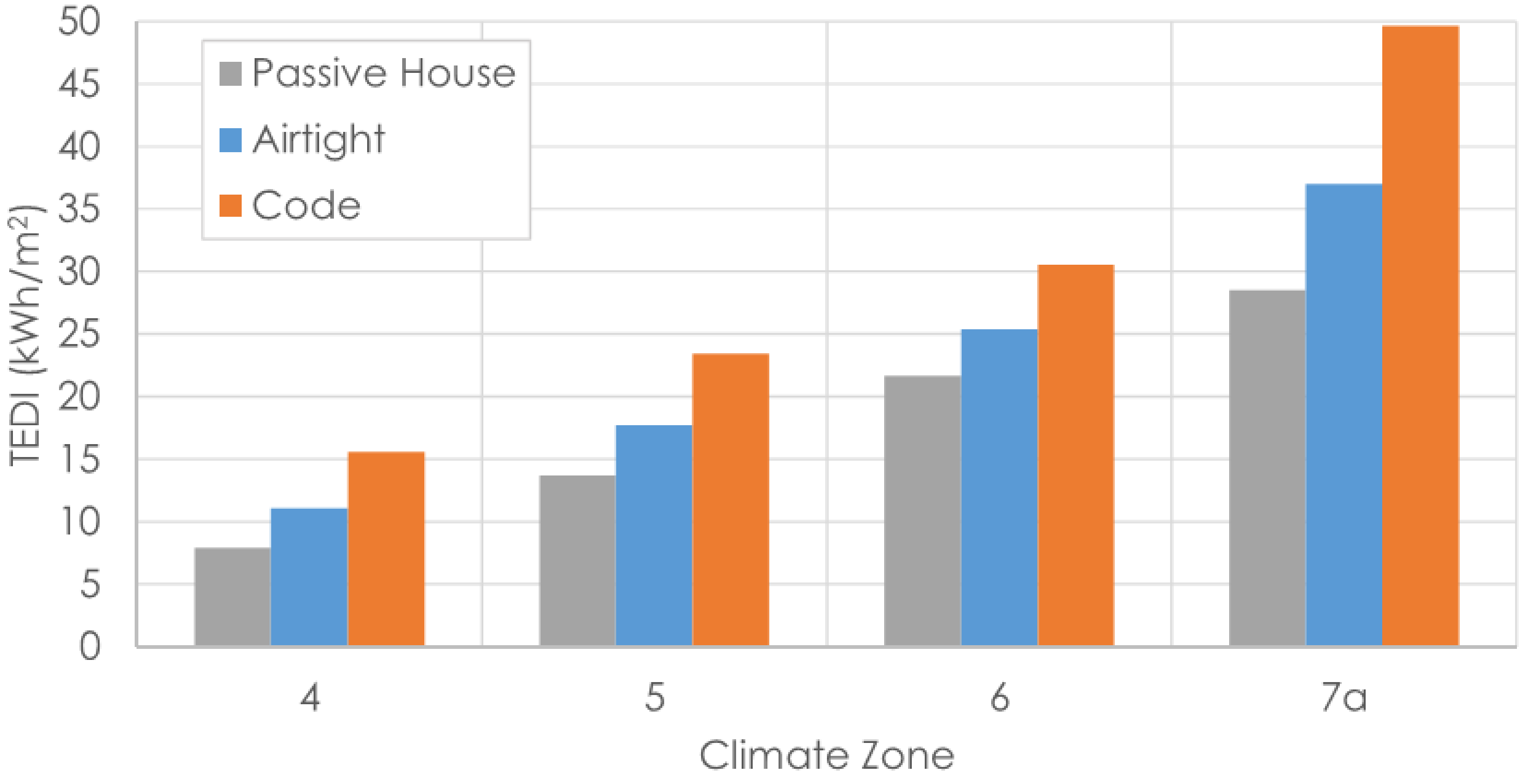


Figure 4.6: Impact of Air Infiltration on TEDI

"NET ZERO READY" HIGH RISE RESIDENTIAL

TEDI: 16 kWh/m²
(5 kBtu/sf)
EUI: 85 kWh/m²
(27 kBtu/sf)

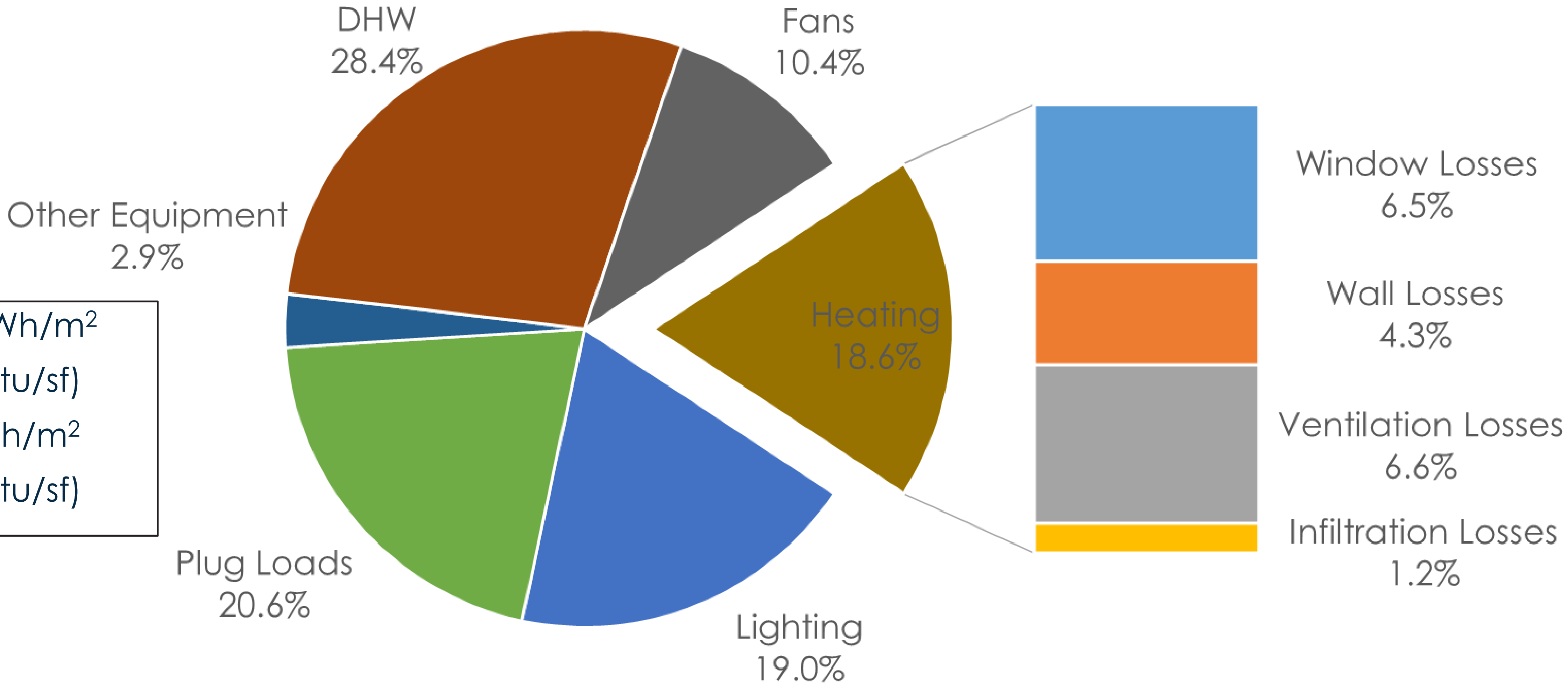


Figure 4.1: End-use Breakdown for a Low Energy MURB in Climate Zone 6

"NET ZERO READY" HIGH RISE RESIDENTIAL

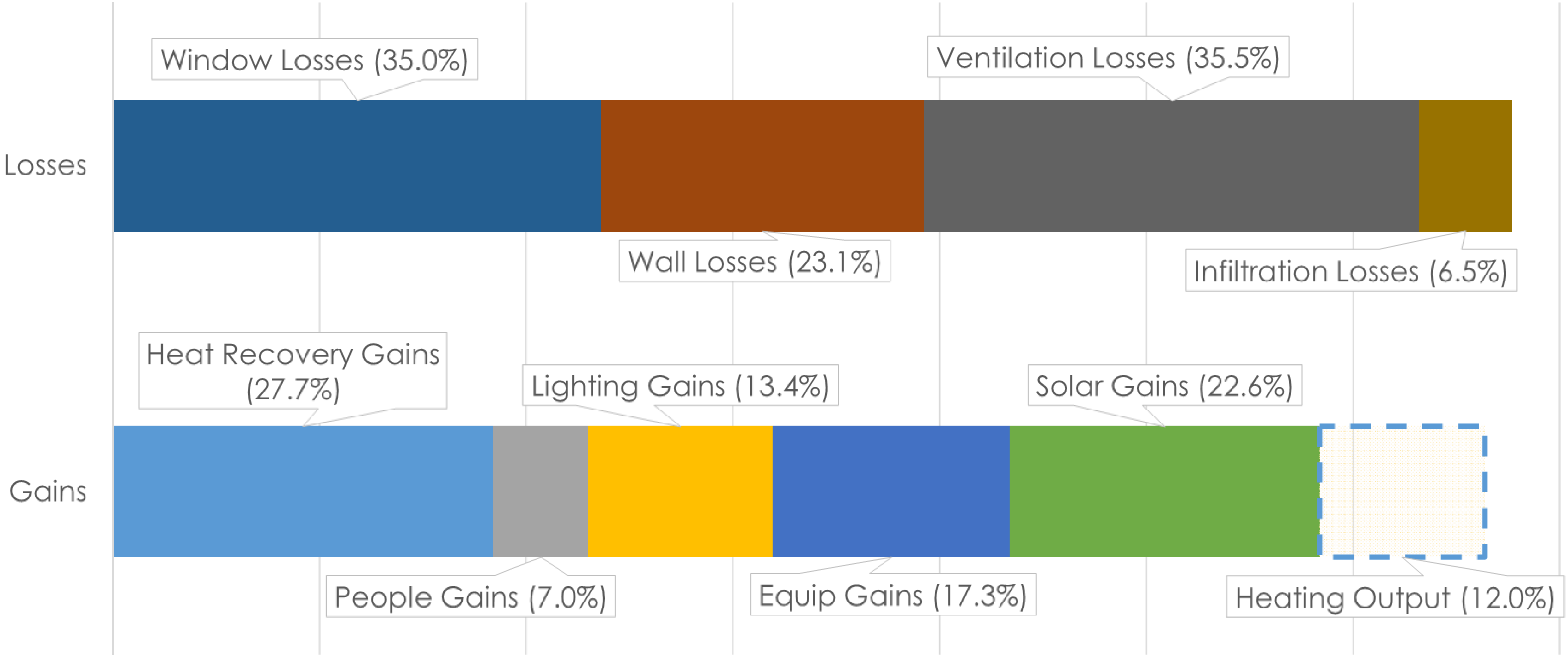
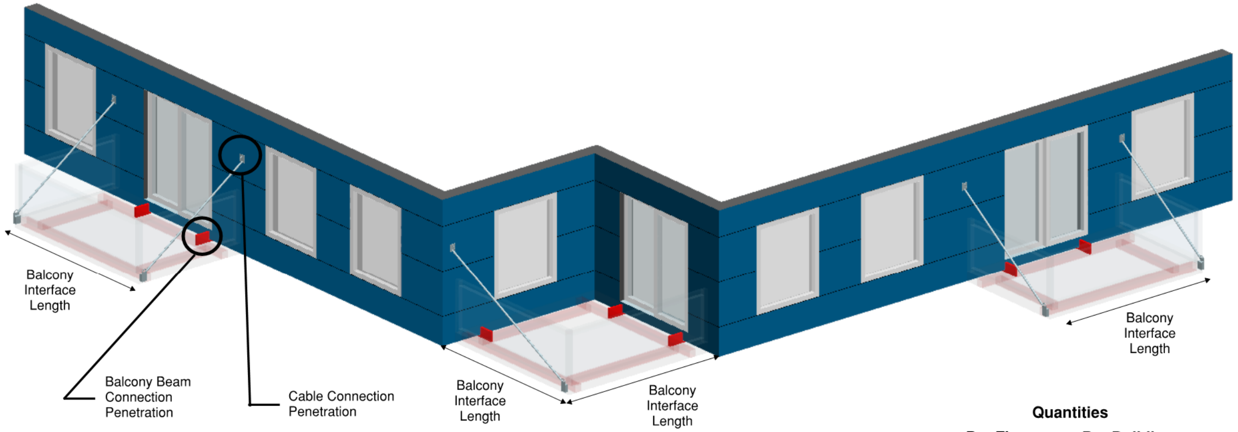


Figure 4.2: Example Breakdown of Heating Load Components

BALCONIES



Scenario	Detail	Quantity	Transmittance Value	Heat Flow (W/K)	% Total Heat Flow	Overall Transmittance
Intermittently Attached Balcony	Clear Field	7087 m²	0.142 W/m²K	1004	56%	**0.254 W/m²K (R-22 Effective)**
	Beam Connection	**812**	**0.271 W/K**	**220**	**12%**	
	Cable Connection	**580**	**0.147 W/K**	**85**	**5%**	
	Other Interfaces	-	-	488	27%	
Cantilevered Concrete Balcony	Clear Field	7087 m²	0.142 W/m²K	1004	36%	**0.390 W/m²K (R-15 Effective)**
	Balcony	**1414 m**	**0.9 W/m K**	**1273**	**46%**	
	Other Interfaces	-	-	488	18%	