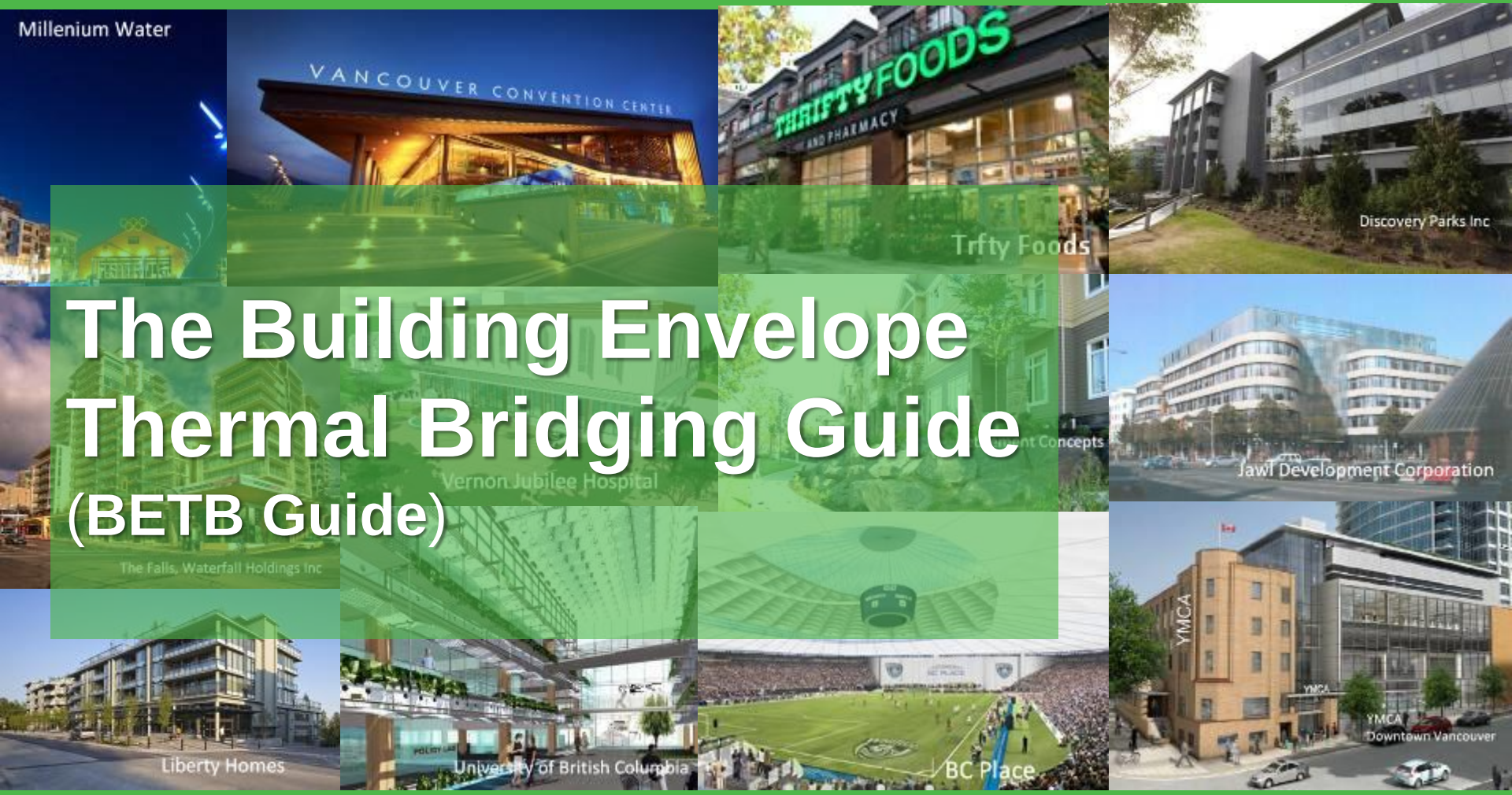

The Building Envelope Thermal Bridging Guide (BETB Guide)

September 2014, BCBEC Conference

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Power Smart Engineering

BC hydro powersmart

Agenda

- Overview of the Power Smart New Construction Program
- Introduction of Building Envelope Thermal Bridging Guide
- Overview of potential practical application of the guide to the building industry.
- Details regarding the public launch of the guide and download source.

New Construction Program

Comprehensive Offer

Whole Building Design

- 50,000 kWh/year minimum savings
- Building as a complete and integrated system
- Up to 100% modeling funding & capital incentives

System Design

- 50,000 kWh/year minimum savings
- Focus on specific systems

Energy Efficient Lighting Design

- 10,000 kWh/year minimum savings
- Lighting design to maximize efficiency and exceed applicable building codes

New Construction Program

Education

Comprehensive Offer	New Construction Market
Streamlined Process	Simpler and Faster Application Process
Energy Study Funding	Up to 100% Funding Alignment with LEED-NC & Fortis BC
Tiered Incentives	To support the implementation of EE Measures
Recognition	Project and Customer Recognition
Education	Industry Workshops, Conferences and Studies

New Construction Program

Education

Comprehensive Offer

New Construction Market

Streamlined Process

Simpler and Faster Application Process

2010 POWER SMART FORUM
BUILDING THE GREEN ECONOMY

Funding
with LEED

Tiered Incentives

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Recognition

CASCADIA GREEN BUILDING COUNCIL

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Education

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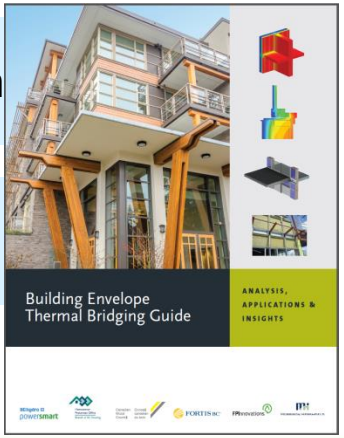


New Construction Program

Energy Modeling Challenges

Lack of:

- Communication/coordination with design team members.
- Continuous training and education that could increase accuracy and overall modeling quality.
- Credible technical resources that reduce an “educated guess” approach in modeling.

Building envelope modeling is a good example…

BETB Guide
Primary Objective

Initiated and project managed by BC Hydro Power Smart, project sponsors include HPO, Fortis BC, FP Innovations and Canadian Wood Council.

Primary objective of this guide is to address the obstacles currently confronting our industry, with regard to thermal bridging by:

1.Providing a catalogue of the thermal performance of common envelope assemblies and interface details in BC.

2.Providing information that makes it easier for industry to comprehensively consider thermal bridging in building codes and bylaws, design, and whole building energy simulations.

3.Examining the costs associated with improving the thermal performance of opaque building envelope assemblies and interface details, and forecasting the energy impact for several building types and BC climates.

4.Evaluating the cost effectiveness of improving the building envelope through more thermally efficient assemblies, interface details, and increasing insulation levels.

BETB Guide
Target Audiences

The target audiences for this guide are broad:

- committees for energy standards, policy and government,
- utilities,
- architects,
- energy modellers,
- building envelope consultants,
- mechanical designers,
- developers and contractors,
- manufacturers and trade organizations.

BETB Guide Sections

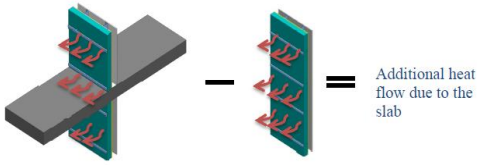
The guide is broken up into three stand-alone main sections:

- **Part 1:** Building Envelope Thermal Analysis (BETA) Guide
- **Part 2**: Energy Savings and Cost Benefit Analysis
- **Part 3**: Significance, Insights and Next Steps
- **Appendices A to E**

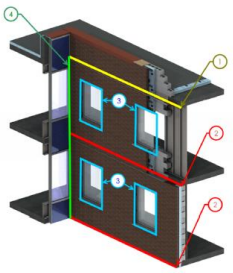
Each section begins with an overview, highlighting important information for the various target audiences, a summary of analysis completed in preparation of each section and a discussion of how to use the information in practice.

BETB Guide Sections

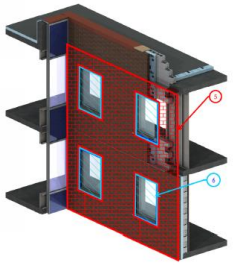
- **Part 1:** Building Envelope Thermal Analysis (BETA) Guide



Additional heat flow due to the slab



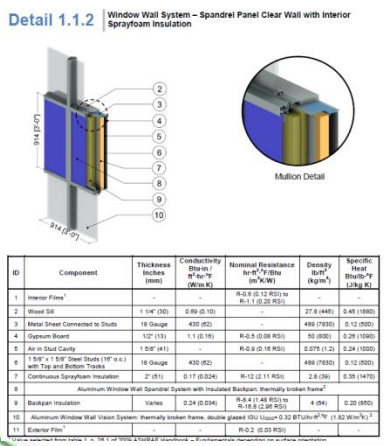
1. Parapet Length
2. Slab Lengths
3. Wall to Window Transition Lengths



4. Corner Length
5. Opaque Brick Wall Area
6. Glazing Area

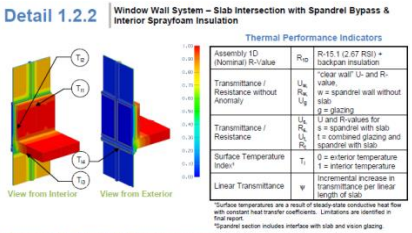
Step 1-2	Step 3	Step 4	Step 5		Step 6-7	
Transmittance Type		Quantity	Detail Ref.	Transmittance	Heat Flow (W/K)	% of Total Heat Flow
Concrete Wall	Clear Field	2987 m²	6.2.2	0.42 W/m²K	1254	16%
	Parapet	27 m	6.5.3	0.78 W/mK	21	<1%
	Exposed Floor Slab	1090 m	6.2.5	1.00 W/mK	1085	14%
	At Grade Transition	27 m	ISO-14863	0.75 W/mK	20	<1%
	Partition Wall	1315 m	6.2.2	0.67 W/mK	876	11%
Overall Concrete Wall U-value, BTU / hr ft² °F (W/m²K)					0.192 (1.09)	
Overall Concrete Wall R-value, hr ft² °F/ BTU (m²K/W)					5.2 (0.92)	
Window-wall Spandrel	Clear Field	1792 m²	1.1.1	1.07 W/m²K	1917	24%
	Parapet	82 m	1.3.2	0.72 W/mK	59	<1%
	Slab Bypass	1635 m	1.2.1	0.58 W/mK	945	12%
	Balcony Slab	1635 m	8.1.9	1.11 W/mK	1815	23%
	At Grade Transition	82 m	2.5.1 (est.)	0.86 W/mK	70	<1%
Overall Spandrel Wall U-value, BTU / hr ft² °F (W/m²K)					0.472 (2.68)	
Overall Spandrel Wall R-value, hr ft² °F/ BTU (m²K/W)					2.11 (0.37)	
Total (W/K)					8063	100%
Overall Opaque Wall U-value, BTU / hr ft² °F (W/m²K)					0.297 (1.68)	
Overall Opaque Wall R-value, hr ft² °F/ BTU (m²K/W)					3.4 (0.59)	

- **Appendix A:** Catalogue Material Data Sheets
- **Appendix B:** Catalogue Thermal Data Sheets



ID	Component	Thickness Inches (mm)	Conductivity Btu-in / ft²-hr-°F (W/m K)	Nominal Resistance hr-ft²-°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb-°F (J/kg K)
1	Interior Finish[1]	-	-	R-0.6 (0.12 RSI) to R-1.1 (0.20 RSI)	-	-
2	Wood Sill	1 1/4" (30)	0.69 (0.10)	-	27.6 (445)	0.45 (1880)
3	Metal Sheet Connected to Studs	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
5	Air in Stud Cavity	1 5/8" (41)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
6	1 5/8" x 1 5/8" Steel Studs (16" o.c.) with Top and Bottom Tracks	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
7	Continuous Sprayfoam Insulation	2" (51)	0.17 (0.024)	R-12 (2.1 RSI)	2.8 (39)	0.35 (1470)
8	Aluminum Window Wall Spandrel System with Insulated Backpan; thermally broken frame[2]					
9	Backpan Insulation	Varies	0.24 (0.034)	R-8.4 (1.48 RSI) to R-16.8 (2.96 RSI)	4 (64)	0.20 (850)
10	Aluminum Window Wall Vision System; thermally broken frame, double glazed IGU U_{IGU}= 0.32 BTU/hr-ft²-°F (1.82 W/m²K)[3]					
11	Exterior Film[4]	-	-	R-0.2 (0.03 RSI)	-	-

Description of Detail (Thermal Anomaly)	Construction Type	Wall Assembly Description	Detailed Description	Reference	1D Insulation	Thermal Transmittance Btu / hr ft² F	Thermal Transmittance W/ m² K
Spandrel Section	Curtain-Wall	Conventional curtain-wall Spandrel	Conventional Curtain-wall Spandrel with no Interior Stud Cavity Insulation	2.1.1	R-5	0.238	1.35
					R-15	0.210	1.19
					R-25	0.202	1.15
Spandrel Section	Curtain-Wall	Conventional curtain-wall Spandrel with interior Insulation	Conventional Curtain-wall Spandrel with Interior Spray Foam Insulation	2.1.2	R-5	0.122	0.69
					R-15	0.113	0.64
					R-25	0.110	0.63
Spandrel Section	Curtain-Wall	Conventional curtain-wall Spandrel with AIM Application	Conventional Curtain-wall Spandrel with AIM Application	2.1.4, 2.16 & 2.1.8	Varies	0.095 to 0.163	0.54 to 0.93
Spandrel Section	Curtain-Wall	Conventional curtain-wall Spandrel with AIM Application	Conventional Curtain-wall Spandrel with AIM Application and Intermediate Mullion	2.1.10	Varies	0.163 to 0.217	0.92 to 1.23
Section		Unitized curtain-wall	Unitized Curtain-wall Spandrel with no		R-8.4	0.157	0.89



Assembly 1D (Nominal) R-Value	R_{1D}	R-15.1 (2.67 RSI) + backpan insulation
Transmittance / Resistance without Anomaly	U_w R_w U_g	"clear wall" U- and R-value w = spandrel wall without slab g = glazing
Transmittance / Resistance	U_s R_s U_t R_t	U and R-values for s = spandrel with slab t = combined glazing and spandrel with slab
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per linear length of slab

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.
[2]Spandrel section includes interface with slab and vision glazing.

Backpan Insulation 1D R_{1D}-Value (RSI)	R_{1D} ft² hr °F / Btu (m² K /W)	R_s ft² hr °F / Btu (m² K /W)	U_s Btu/ft² hr °F (W/m² K)
R-8.4 (1.48)	R-23.5 (4.15)	R-9.0 (1.59)	0.111 (0.63)
R-12.6 (2.22)	R-27.7 (4.89)	R-9.8 (1.72)	0.102 (0.58)
R-16.8 (2.96)	R-31.9 (5.63)	R-10.4 (1.82)	0.097 (0.55)

$U_{frame\ in\ glass}$ Btu/ft² hr °F (W/m² K)	U_g Btu/ft² hr °F (W/m² K)
0.321 (1.82)	0.408 (2.32)

Backpan Insulation 1D R_{1D}-Value (RSI)	R_s ft² hr °F / Btu (m² K /W)	U_t Btu/ft² hr °F (W/m² K)	ψ Btu/ft hr °F (W/m K)
R-8.4 (1.48)	R-2.9 (0.51)	0.344 (1.95)	0.377 (0.652)
R-12.6 (2.22)	R-2.9 (0.52)	0.340 (1.93)	0.376 (0.651)
R-16.8 (2.96)	R-3.0 (0.52)	0.339 (1.92)	0.380 (0.658)

R_s ft² hr °F / Btu (m² K /W)	U_t Btu/ft² hr °F (W/m² K)
R-4.2 (0.74)	0.228 (1.29)
R-4.4 (0.77)	0.228 (1.29)
R-4.5 (0.79)	0.223 (1.27)

	R8.4	R12.6	R16.8	
T_{11}	0.73	0.74	0.75	Min T in stud cavity, on spray/foam in line with vertical frame
T_{12}	0.93	0.93	0.94	Max T on spray/foam, in line with center of backpan
T_{13}	0.51	0.51	0.51	Min T on interior glazing, at corner of deflection header
T_{14}	0.53	0.53	0.53	Min T on slab, at deflection header, in line with vertical frame

BETB Guide Sections

- **Part 2:** Energy Savings and Cost Benefit Analysis

2.2.2 Building Archetypes and Modeling Variables

Whole building energy analysis was performed on eight archetype buildings, each representing a different building sector. The characteristics of the archetype buildings were selected based on current BC design and construction practice. The eight archetype buildings that were analyzed are detailed in Appendix C and listed below:

- High-Rise Multi-unit Residential
- Low-Rise Multi-unit Residential
- Hotel / Motel
- Institutional
- Secondary School
- Commercial Office
- Community/Recreation Centre
- Non-Food Retail

Each archetype building was analyzed for two glazing ratios, which varied by sector and three climates representing the major climate zones in the province. The climates modeled were:

Vancouver	Summerland	Prince George
Lower Mainland BC, Cool-Marine Climate Zone	*Interior BC, Cool-Dry Climate Zone*	*Northern BC, Very Cold Climate Zone*

The thermal resistance of the wall was varied for each archetype building, glazing ratio and climate zone while all other parameters of the building were kept constant. In general, the R-values input into the model for the walls ranged from R2.5 to R20. The thermal mass of building materials was also considered and that analysis, along with more detailed modeling parameters, is provided in Appendix C.

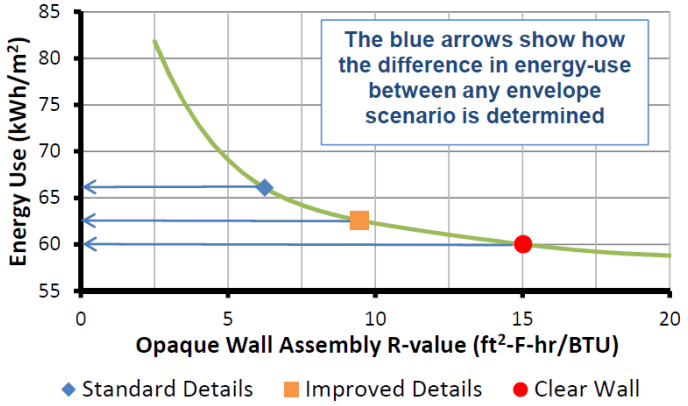
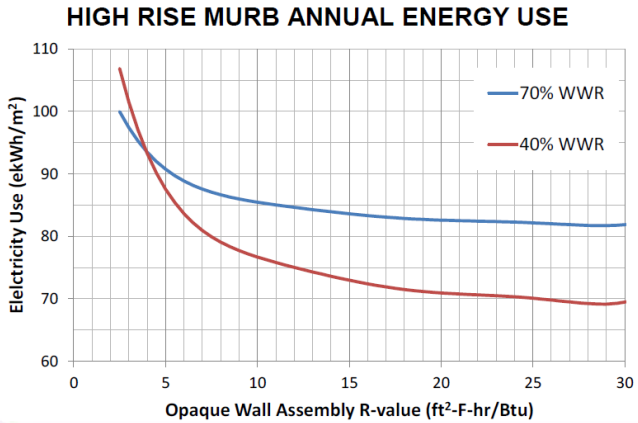


Figure 2.1: Annual Electrical Energy for a 40% Glazed High-Rise MURB in Vancouver, Heated with Electric Baseboards

- **Appendix C:** Energy Modeling Analysis and Results



BETB Guide Sections

- **Part 3:** Significance, Insights and Next Steps

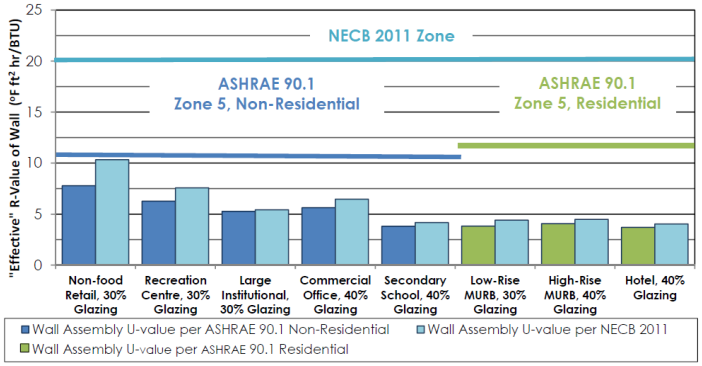


Figure 3.4: "Effective" R-value for the 30% to 40% Glazing Archetype Buildings with Concrete Walls and Common Details

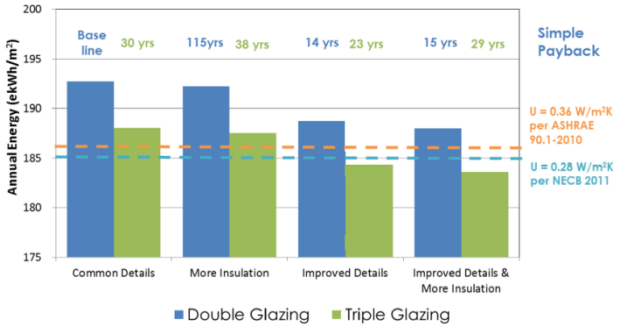


Figure 3.7: Comparison of Annual Energy Use and Simple Payback for High-Rise MURB with 40% Glazing in Vancouver

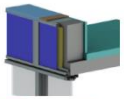
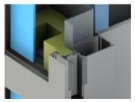
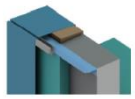
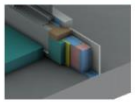
- **Appendix D:** Construction Costs
- **Appendix E:** Cost Benefit Analysis

Table D.1: Glazing System Assembly Costs (Imperial)

ID	Assembly Category	Detailed Description	Detail Reference	Cost ($/ft²)					
				Insulation Level† for Low and Mid-Rise Applications			Insulation Level† for High-Rise Applications		
				1	2	3	1	2	3
1	Window-wall	doubled glazed with insulated slab bypass	1.2.1	52[1]	52.4[2]	52.7[3]	53.7[1]	53.8[2]	54.1[3]
2	Window-wall	doubled glazed with insulated slab bypass and interior foam insulation	1.2.2	52.6[1]	52.7[2]	53.0[3]	54.6[1]	54.7[2]	55.0[3]
3	Window-wall sliding door	double glazed and thermally broken	8.1.6	58.8[1]	59.0[2]	59.3[3]	60.0[1]	60.1[2]	60.5[3]
4	Conventional curtain-wall	doubled glazed with insulated metal backpan	2.1.1	88.2[4]	88.3[5]	89.8[6]	90.7[4]	90.8[5]	92.3[6]
5	Conventional curtain-wall	doubled glazed with insulated metal backpan and interior foam insulation	2.1.2	97.7[4]	97.9[5]	99.5[6]	97.2[4]	97.4[5]	98.1[6]
6	Unitized curtain-wall (i.e. modular system with stacked joint)	doubled glazed with insulated metal backpan	3.2.1	102.1[4]	102.2[5]	103.9[6]	104.9[4]	105.1[5]	106.8[6]
7	Unitized curtain-wall (i.e. modular system with stacked joint)	doubled glazed with insulated metal backpan and interior foam insulation	3.2.2	104.4[4]	104.6[5]	106.2[6]	105.9[4]	106.1[5]	107.8[6]
8	High performance curtain-wall	doubled glazed with insulated metal backpan	4.2.1	97.4[4]	97.6[5]	99.2[6]	98.7[4]	98.8[5]	100.4[6]
9	High performance curtain-wall	doubled glazed with insulated metal backpan and interior foam insulation	4.2.2	102.9[4]	103.0[5]	104.7[6]	106.0[4]	106.2[5]	107.9[6]

†For insulation level notes see Table D.7: Insulation Level Notes

D.9.1: Incremental cost per length for modifying standard details

Detail Reference		Modification to Standard Detail	Additional Cost $/ft	Additional Cost $/m
	1.3.2	Add insulation to interior and exterior face of parapet	53	174
	2.3.2	Add insulation along mullion edge	2.5	8
	5.5.6	Add 3" mineral wool insulation on the exterior face of parapet	14.50	48
	8.1.11	Add 3" XPS insulation on the exterior face of steel stud curb	9	29
				

BETB Guide
Practical Applications and Benefits

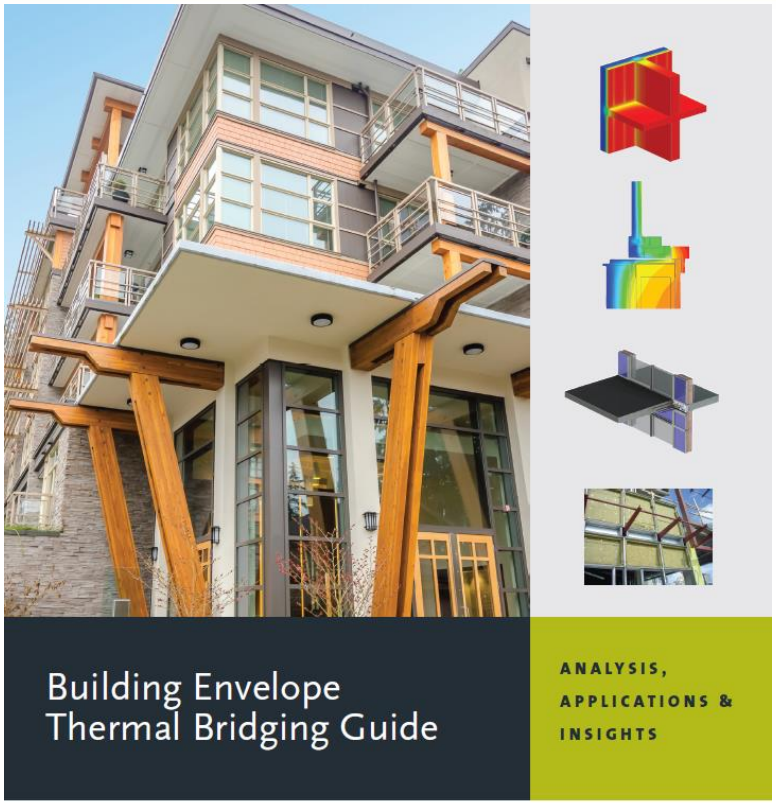
Practical Applications:

- As of January 1st, 2015, City of Vancouver will require effective R-value reporting for code compliance purposes.
- Use of the guide will become a mandatory requirement for the BC Hydro New Construction Program (after some additional technical training sessions).

Benefits:

- Modelers and architects will be able to more quickly, accurately and easily account for the building envelope thermal performance in their modeling and design practices.
- All this will support Power Smart's goal to help transform the BC marketplace to the point where new buildings are designed and built to the highest standards of energy efficiency.

BETB Guide
Public Launch and Download



- **Public launch:**

October 16th (9am – 12pm) at UBC Robson Square.

- **Register at:**

www.hpo.bc.ca/building-envelope-thermal-bridgingguide

- **Download from:**

Power Smart New Construction Program website:

http://bchydro.com/thermalguide

September, 2014

BC hydro powersmart