Can we learn from the past?

Twenty-Seventh Westford Symposium on Building Science

EVOKE

What am I here to talk about?

With our eyes on the prize of ultimate sustainability, carbon emission reduction, are we too often focusing on the tree rather than the forest. We always think we can do it better than our predecessors, but sometimes we forget what they did, why and how they did it.

Don’t we all like to think we are 35?

Who am I anyway?

Vancouver

- Climate zone 4
- Lots of Rain November to April

- Building Envelope Specialist
- 27 years experience, 22 of which were with a multi-disciplinary North American firm.
- Managed the west coast building science department, from Edmonton to San Francisco
- But only practiced engineering in Vancouver and lower mainland
- Worked on all types of buildings, although now mostly institutional and multi residential NC
- About 5 years ago, I started Evoke Buildings with a few other mischiefs –that has allowed me to be more involved in project work again

Things I was told that still ring through today!

Some only have a little to do with building science:

1. Hire for attitude, you can teach the rest
2. You can make a mistake, but don't make it again
3. We are both advisors and gate keepers
4. It doesn't matter so much what you know if you cannot communicate it

But something that is more relevant to today's presentation

5. We have done that before.

The drainage cavity

Early publications

Rain penetration and its control

From National Research Council Canada

Download	View final version (PDF, 931 KiB)
DOI	https://doi.org/10.4224/40000854
Author	Garden, G. K.[1]
Affiliation	1. National Research Council of Canada
Format	Text, Issue
Physical description	4 p.
Subject	Rainscreen walls; rain penetration; walls; rain screens
Abstract	It is only recently that scientific studies have been undertaken to explain the mechanisms of rain penetration. Through better understanding of these mechanisms it should be possible to design and construct walls from which the problem is virtually eliminated.
Publication date	1963-09
Publisher	National Research Council of Canada. Division of Building Research
Series	Canadian Building Digest, no. CBD-40.

The drainage cavity

"As with capillary suction and gravity, water entry resulting from an air pressure difference can be controlled by the introduction of an air space in the joint or wall."

*[JS: Summary. While much of the article remains correct and relevant, the most jarring omission in the document is any mentioned of what today is as the fundamental concept of drained rain penetration control strategies: that is a "second-line of defense" or **drainage plane** / water resistant barrier integrated with flashing and weep holes…*

The drainage cavity timeline

Rainscreen cladding can be traced back hundreds of years in some form or another.

1950's
One of the US' first rainscreen buildings, Alcoa Building

1963 – The rain penetration and its controls (CBD-40)
Published and begins adoption

1998 – Barrett Commission
Commission of Inquiry into the Quality of Condominium Construction in B.C.

→ **Building Codes**

→ **Building Envelope Professionals (BEP)**

2000's
Rainscreen Principle brought to U.S. West Coast

1950 | 1960 | 1970 | 1980 | 1990 | 2000 | 2010 | 2020

1950's
Became more widely used in UK and Ireland

1960's
Research of rainwater penetration and adoption begins

1970's
Cavity in facades starts to be more widely used in Canada

1980's – 1990's
People forget about it...

EVOKE

The leaky condo crisis

Page A2 · The Review News Saturday, October 25, 1997

A billion-dollar nightmare

Fixing failed condos could cost $1 billion

CONDO CRISIS

Martin van den Hemel
staff reporter

It's an estimated billion-dollar problem that scientists warned of more than a decade ago.

Canada Mortgage and Housing Corporation's Jim White says researchers knew the use of wall designs common inside most failing condominiums on the West indicated that walls without rainscreens (a drainage cavity inside a wall that allows for penetrating water to exit a wall) will not hold up to the Lower Mainland's wet weather. Not only are these walls flawed, they are destined to fail, he says.

But most of the failed three-storey wood-frame condos, which are rotting, have no rainscreens in their walls, he says.

First in a three-part series

You can't admit you were wrong then by

Not my photos, from RDH Presentation

In B.C. alone an estimated **$4 billion** in damage has occurred to over **900 buildings** and **31,000 individual housing units** built between the late 1980s and early 2000s, establishing it as the most extensive and most costly reconstruction of housing stock in Canadian history.[1]

Similar infiltration problems have been reported in highrise buildings and schools, as well as in other climatic zones in Ontario and Nova Scotia,[2] in the United States,[3] and New Zealand.[4]

WIKIPEDIA HTTPS://EN.WIKIPEDIA.ORG/WIKI/LEAKY_CONDO_CRISIS

Contributing factors

The evidence suggests that significant building envelope failures in British Columbia since the early 1980s ... is a result of numerous factors, including

- design features inappropriate for our climate
- a reliance on face-sealed wall systems
- a fundamental lack of awareness regarding the principles of enclosure design suitable for our climate;
- a lack of meaningful inspection at critical stages of construction;
- and a regulatory system which was unable to understand that failures were occurring and to redress them.

Not my photos, from image search

SOURCE: BARRETT COMMISSION INQUIRY INTO THE QUALITY OF CONDOMINIUM CONSTRUCTION IN BRITISH COLUMBIA

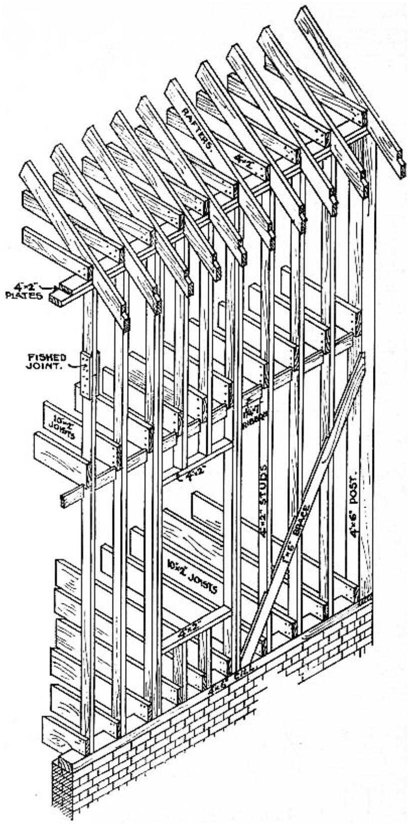
History repeating itself?

- Trades appear to be losing collective knowledge – many old timer retired during Covid, less mentorship and lots of turnover.
- More construction needed than people to build it
- VE being necessary for project to go ahead
- Many new material flooding the market, new assemblies being used
- That buildable space and its exemption still pushing design in the wrong direction

EVOKE

Better Insulation

Evolution of Insulation



1950

1950's
Framing cavity filled with news paper, animal wool or sawdust

1960

1970

1970's
The Oil Crisis of 1973 led to improvement in both material and technics

1980's – 1990's
Increase in insulation thickness without much consideration for thermal bridges

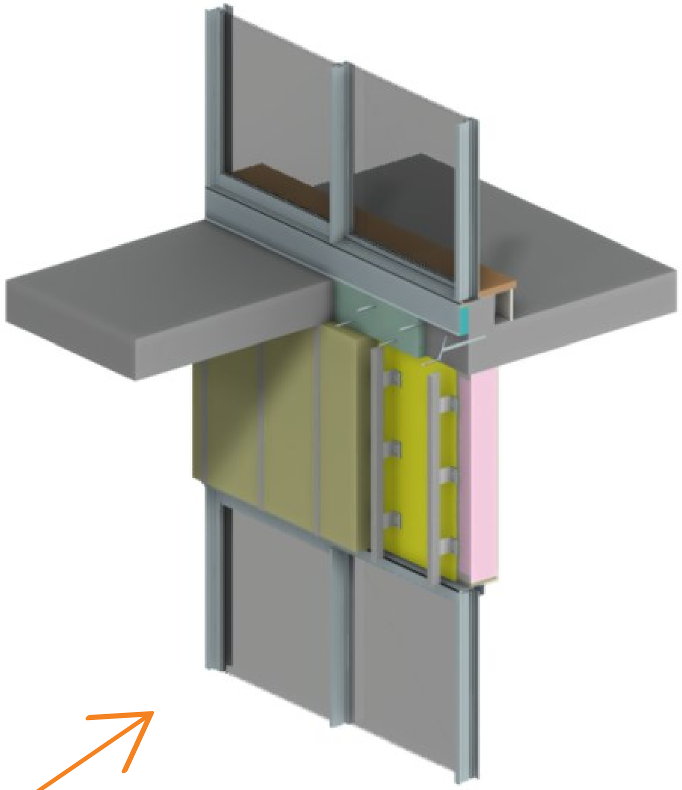
1980

1990

2000

2000's - 2010's
Development of tool to better evaluate thermal bridging

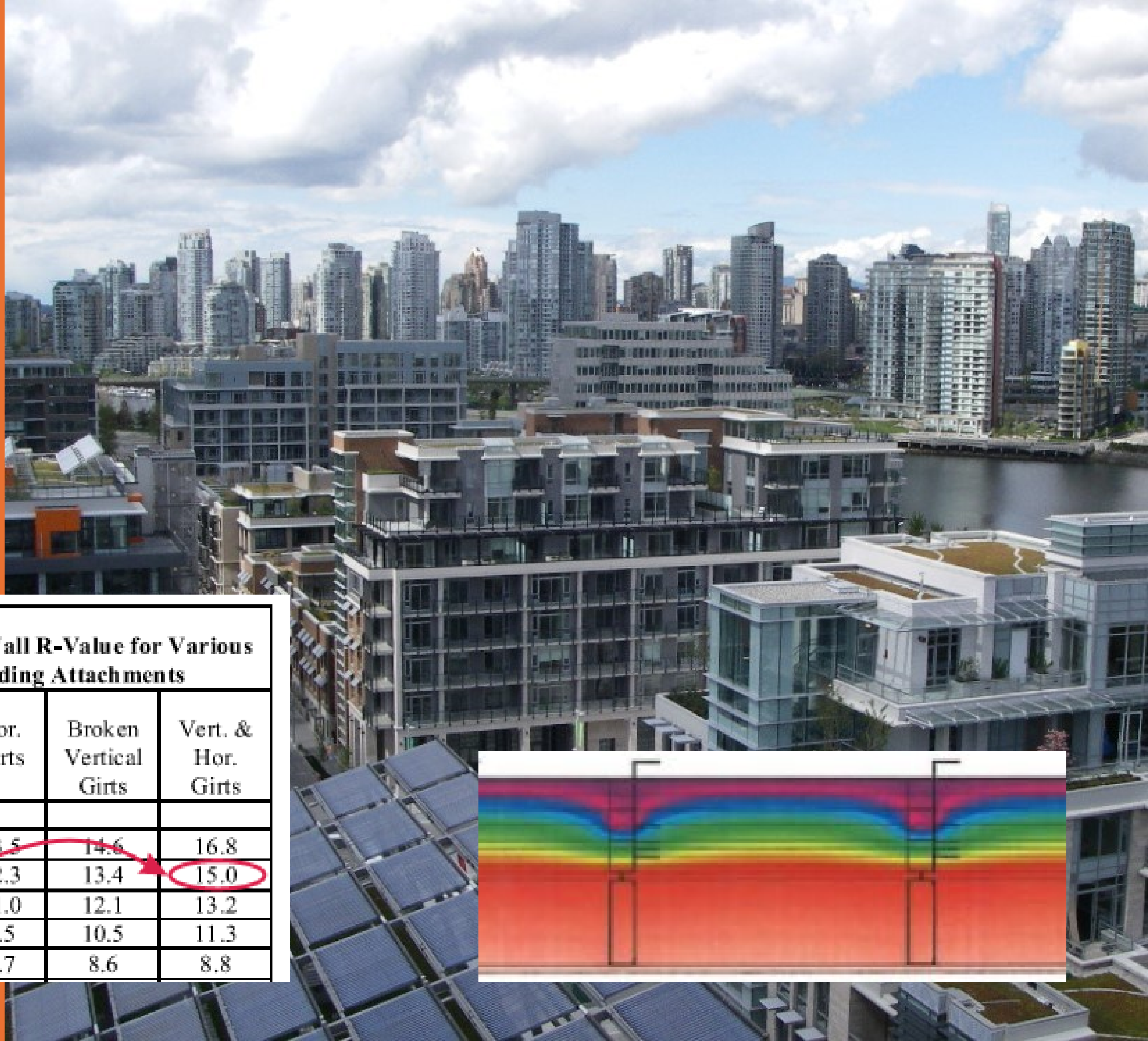
2010



The beginning

Before 2010 Winter Olympics

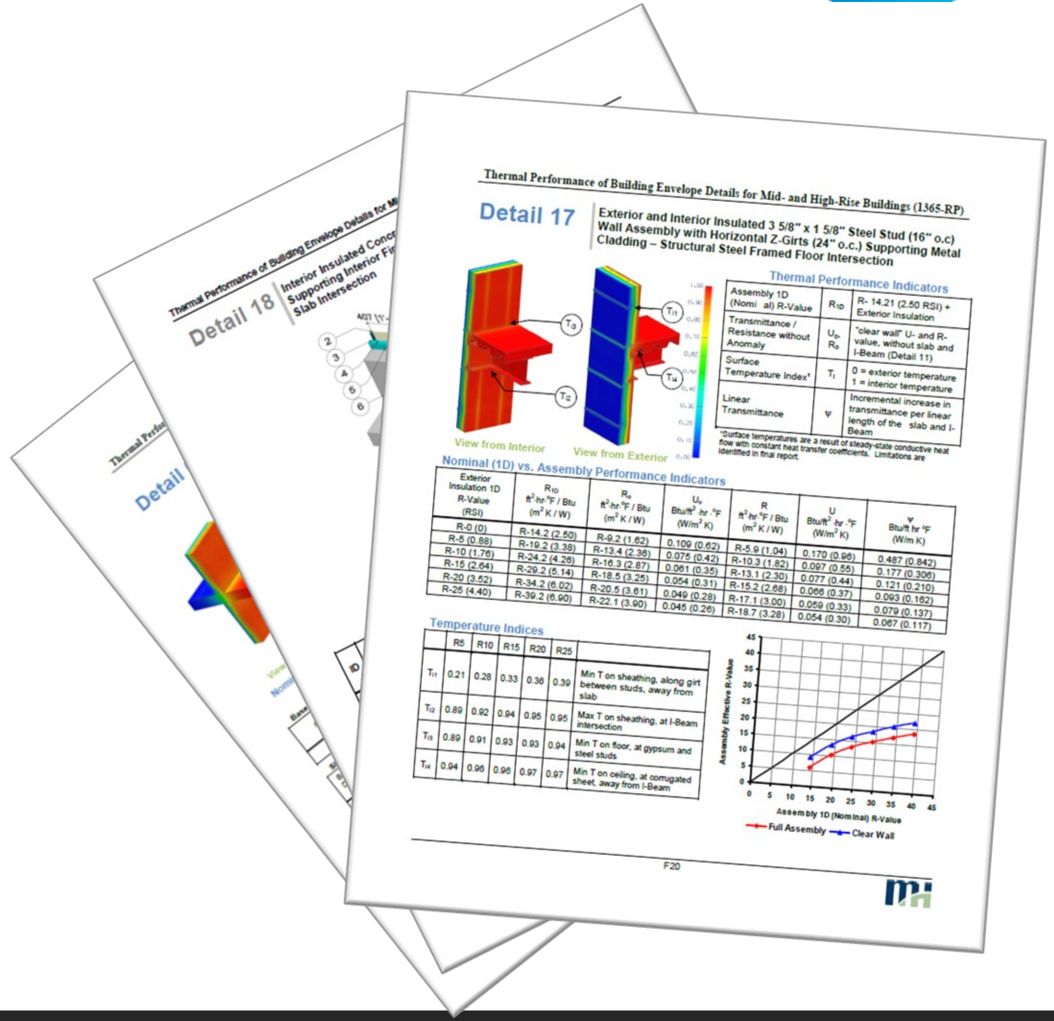
Nominal Wall R-Value	Insulation Thickness (Inches)			Effective Wall R-Value for Various Cladding Attachments			
	Mineral Wool	EXPS	Spray foam	Vert. Girts	Hor. Girts	Broken Vertical Girts	Vert. & Hor. Girts
33.1	7.0	5.9	4.9	10.6			
28.9	6.0	5.0	4.2	9.8	13.5	14.6	16.8
24.7	5.0	4.2	3.5	9.0	12.3	13.4	15.0
20.5	4.0	3.4	2.8	8.2	11.0	12.1	13.2
16.3	3.0	2.5	2.1	7.3	9.5	10.5	11.3
12.1	2.0	1.7	1.4	6.1	7.7	8.6	8.8



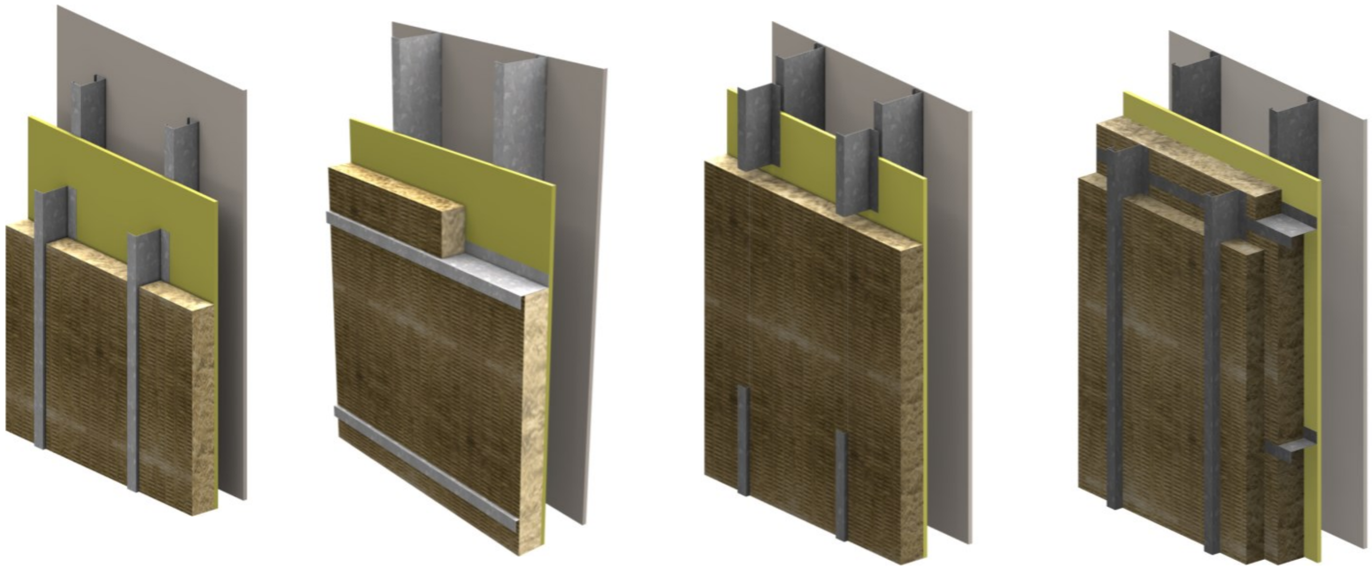
ASHRAE 1365 (2011)

Bedrock of the BETB Guide

- Validation of procedures and software to measured data
- Borrowed a methodology from Europe and applied to North American Practice
- Raised awareness in North American of the impact of thermal bridging
- Demonstrated the value of 3D detail database for interface details



From concept to practice



MORRISON HERSHFIELD

SOLUTIONS[MH]

BUILDINGS

Thermal Bridging in Exterior Insulated Steel Stud Assemblies

Volume 2011, Issue 2

With a continued focus of sustainable and energy efficient building design, more attention is being paid to the thermal performance of building enclosure assemblies. Providing a higher level of thermal resistance in the building enclosure may seem as straightforward as just adding insulation, but when building with conductive elements like steel, achieving higher thermal performance levels can be elusive.

When cladding is attached to back up steel stud walls, the attachments bypass the exterior insulation. These attachments, usually made of steel, can create significant heat flow paths. While there are some systems that minimize the bridging effect, many of the common attachment methods are not very efficient from a thermal perspective.

The Questions

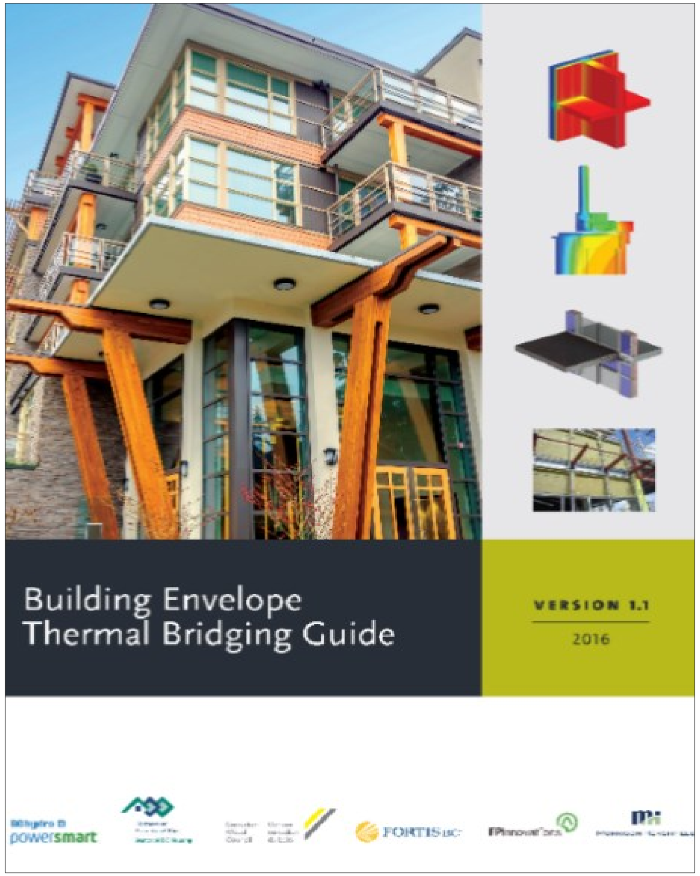
Building energy standards, such as ASHRAE 90.1, force recognition of the impact of thermal bridging. Table A3.3 in ASHRAE 90.1 provides effective assembly U values for stud walls that consider the effects of the steel studs through the stud cavity. These values, however, are for assemblies with different levels of continuous insulation outboard of the studs (basically assuming you have the full nominal value of the exterior insulation). The table does not provide guidance in addressing the thermal impact of the cladding support elements passing through the exterior insulation. This raises some critical questions:

1. **What are the effective R- and U-values of your steel stud assembly walls and do they meet code requirements?**

2. **What is the difference in thermal performance of different cladding attachment arrangements?**

SOLUTIONS MH Volume 2011, Issue 2

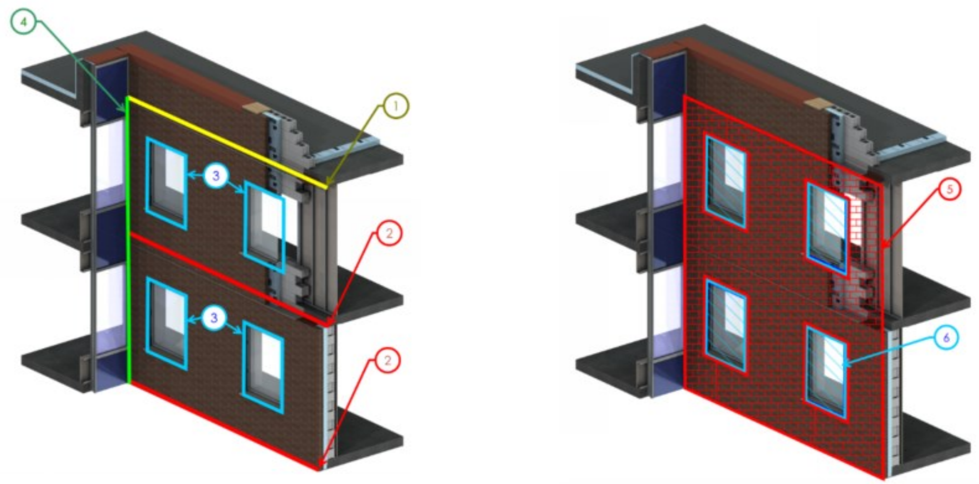
The thermal bridging guide



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

Where:

- U_T = total effective assembly thermal transmittance (Btu/hr·ft^2·°F or W/m^{2}K)
- U_o = clear field thermal transmittance (Btu/hr·ft^2·°F or W/m^{2}K)
- A_{total} = the total opaque wall area (ft^2 or m^2)
- 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)



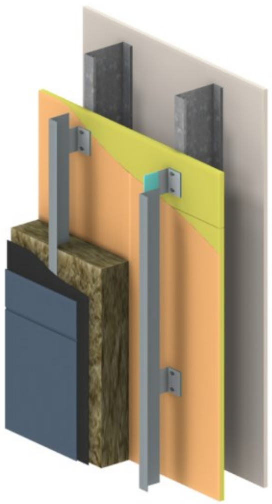
1. Parapet Length
2. Slab Lengths
3. Wall to Window Transition Lengths
4. Corner Length
5. Opaque Brick Wall Area
6. Glazing Area

BETB Guide and Thermal Bridging

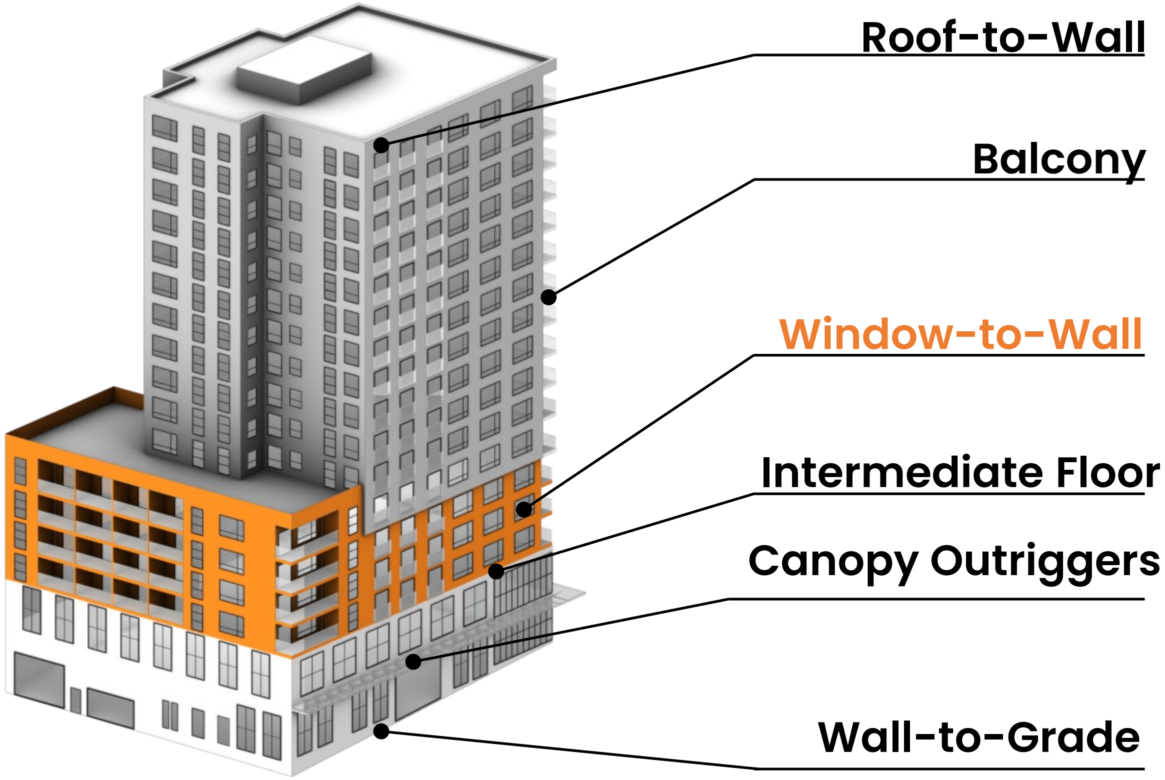
Details 30-70 % of Total heat loss

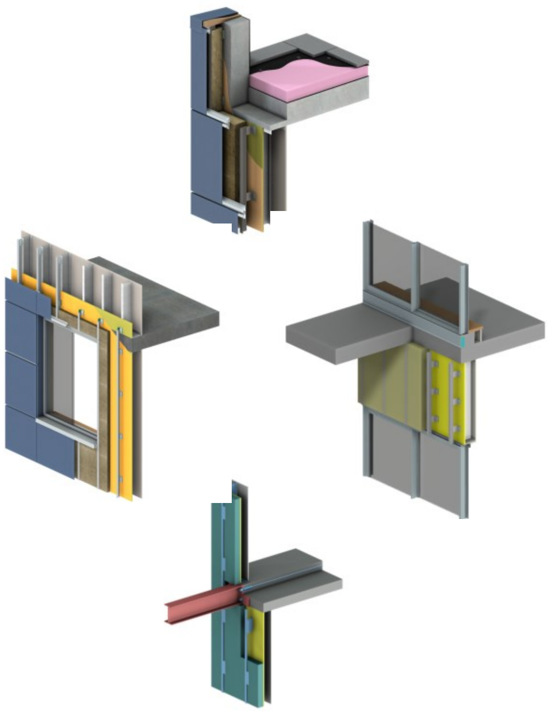
Window perimeter is often the largest contributor to heat loss

Clear Field Assembly



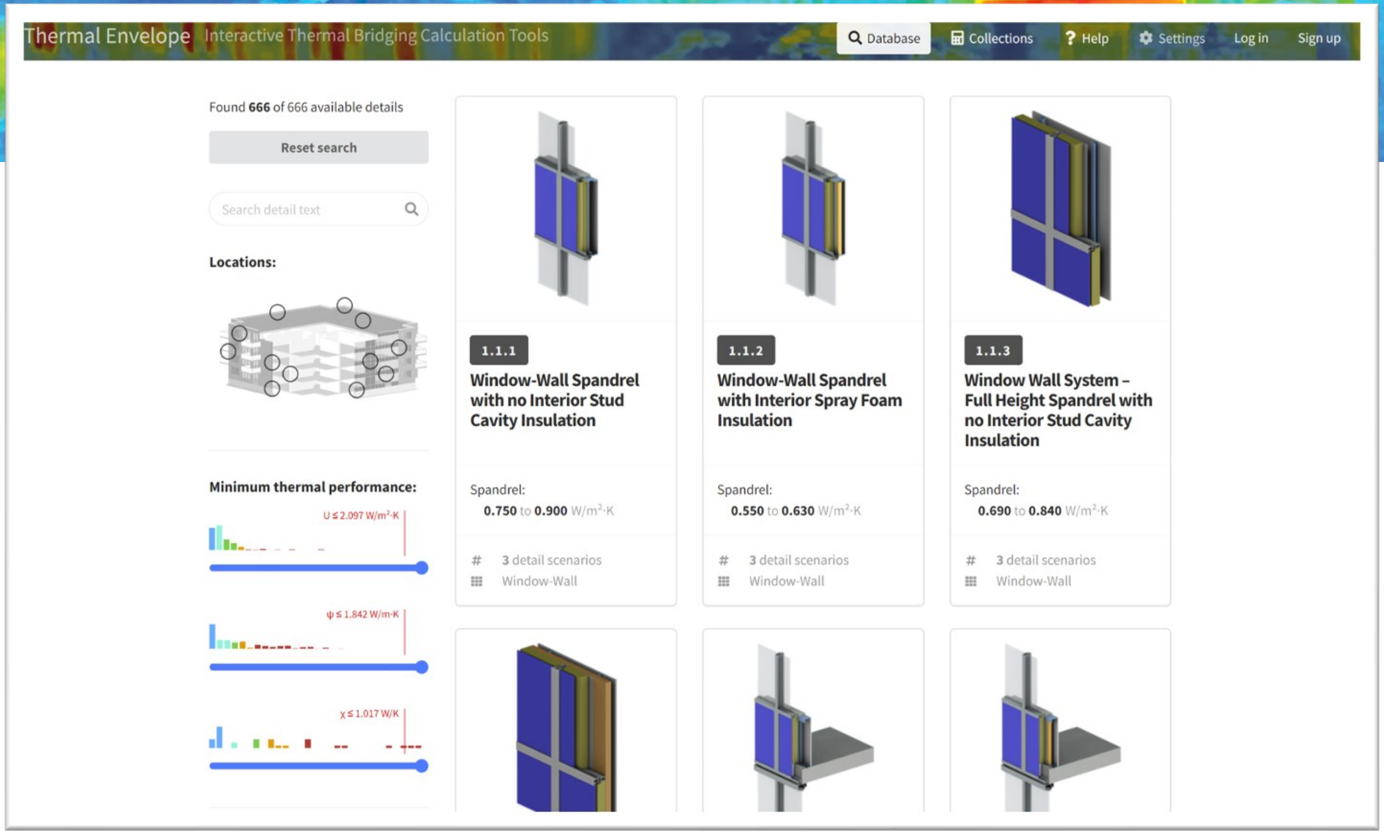
Interface Details





Thermal Envelope

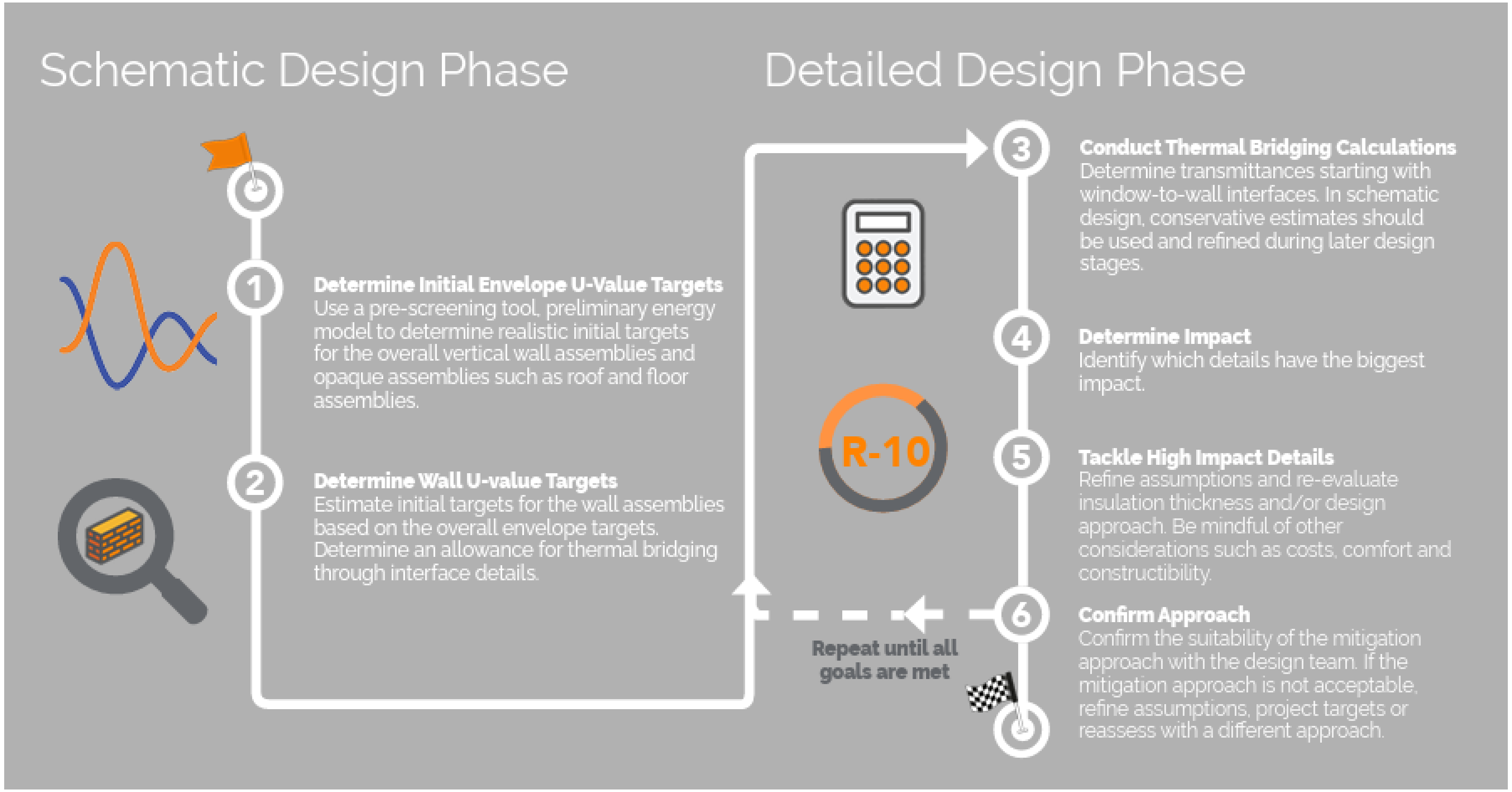
Interactive Thermal Bridging Calculation Tools



- Significant database of thermal data
- Integrated thermal calculator
- Reports and collaboration tools
- Educational resources

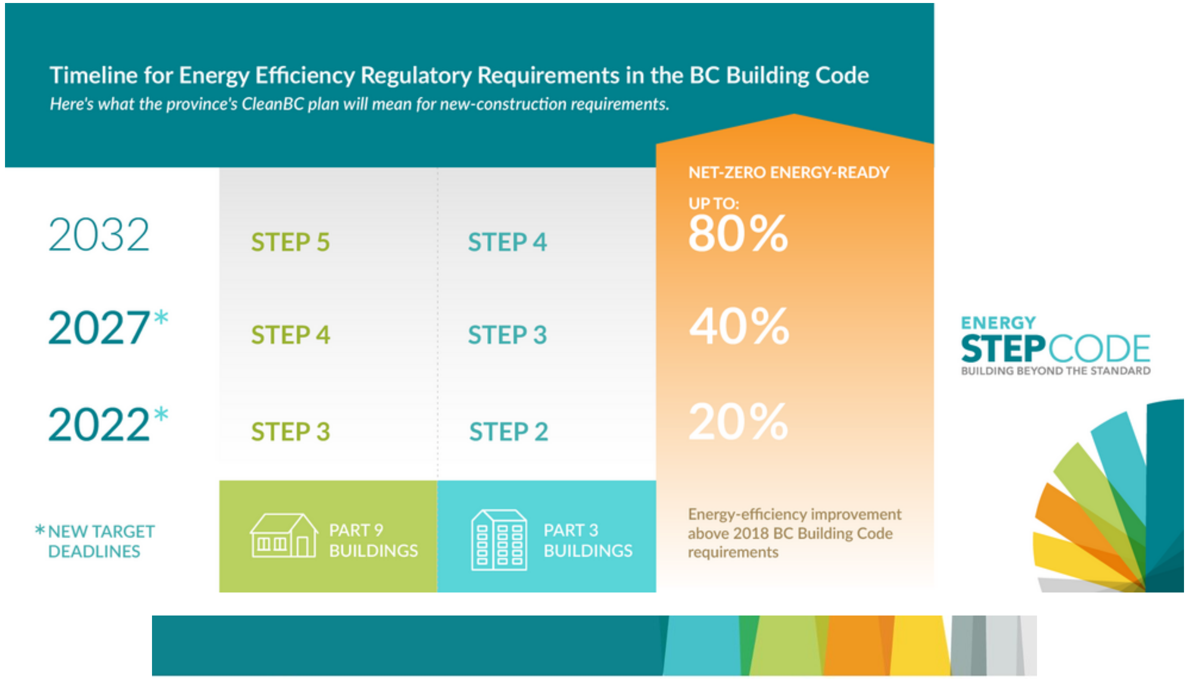
www.thermalenvelope.ca

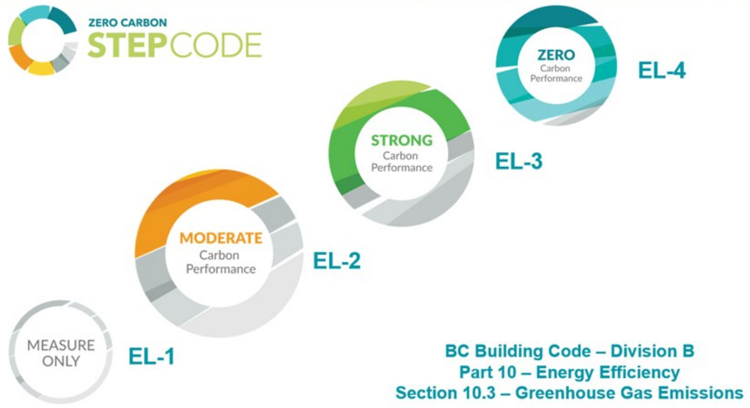
Better tools, Better results



All in the same boat, no surprise

Charting the path ahead





TEUI – Total Energy Use Intensity

All energy uses in the building

TEDI – Thermal Energy Demand Intensity

Annual heating load in the building

Building envelope performance

Ventilation system performance

GHGI – Greenhouse Gas Emissions Intensity

From operations

That leaves the question…

Is net zero ready an achievable target for an entire industry?

EVOKE

Whole Building Air Tightness

Building air tightness

Image : Saskatchewan Research Council

1950

1960

1970

1970's
The Oil Crisis of 1973 led to more efficient homes, including air leakage testing

1980's
R2000 home start being built

1980

1986
First north American Code adoption

1990

1990-2000's
Status quo

2000

2010

2010's
New code requiring whole building air tightness testing

The Saskatchewan Conservation House

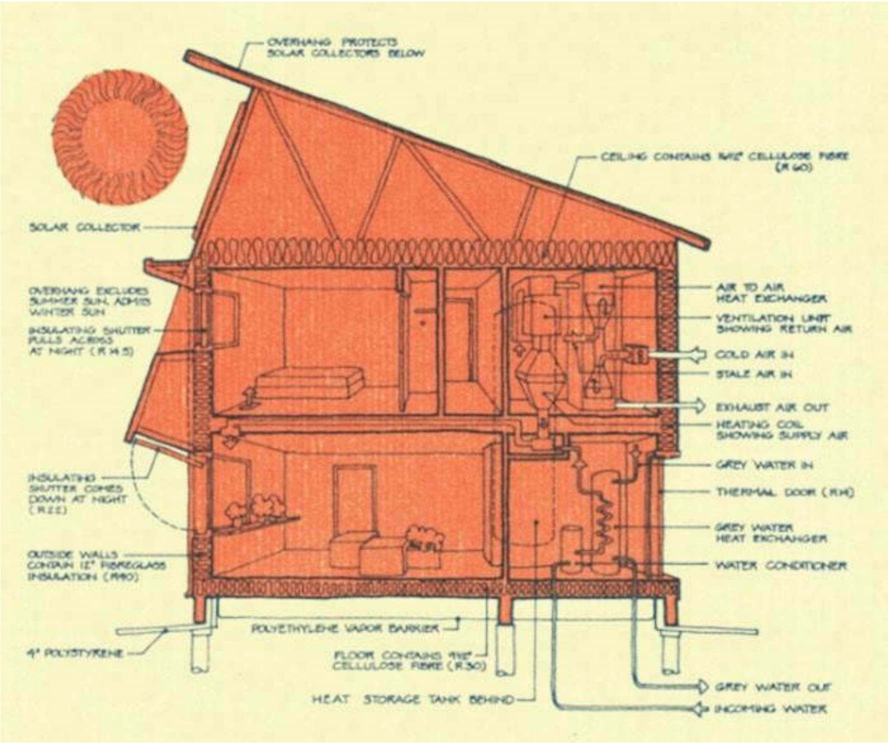
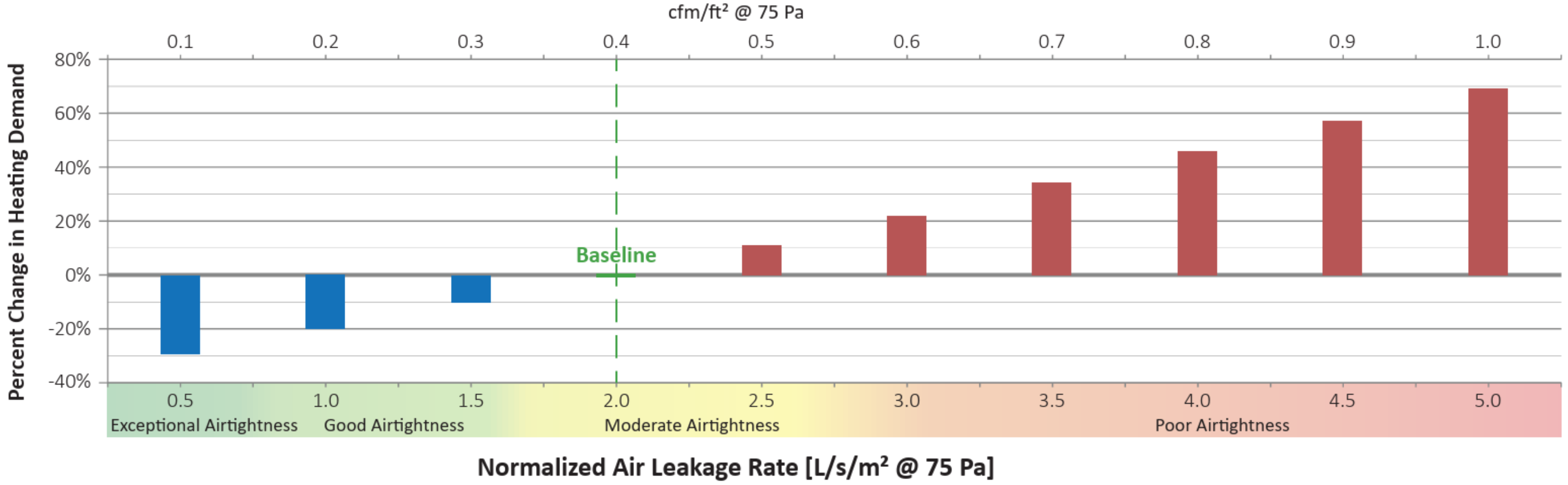


Image : Passipedia

There were four main stages to the process:

STAGE 1	Finding a way to measure where the leakages of energy happen in houses.
STAGE 2	Finding a way to minimize the waste of energy (and the building of the Saskatchewan Conservation House).
STAGE 3	Going out and teaching others how to build and retrofit houses to an acceptable energy standard.
STAGE 4	Developing software to design energy-efficient homes (and the development of the HOTCAN computer model).

Getting an idea of performance



Heating energy demand changes due to improved airtightness

The chart below shows the effect of airtightness on heating energy demand for an example archetype six-storey, 4,700 m^2 wood-frame, multi-unit residential building in Climate Zone 4 (southwest B.C.) with the following energy efficient design characteristics:

- Effective RSI-4.4 (R-25) walls and USI-1.53 (U-0.27) windows
- Heat recovery ventilation (60% efficient)
- Drain water heat recovery and low-flow fixtures
- LED lighting and occupancy sensors in corridors

Air tightness over time

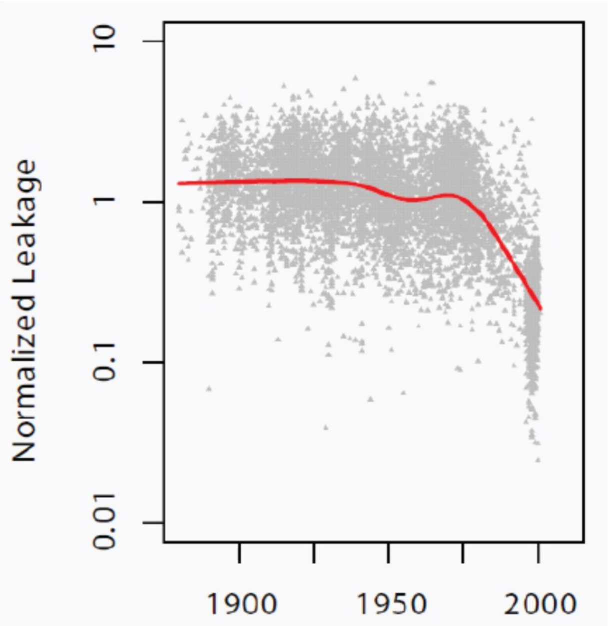


Image : RDH presentation

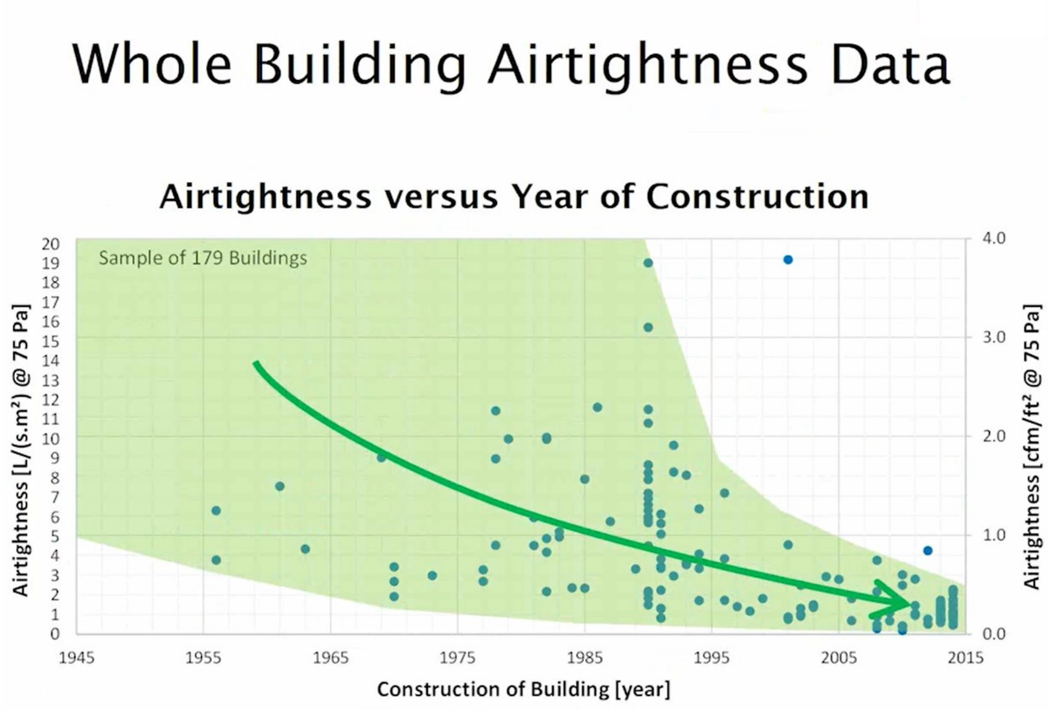
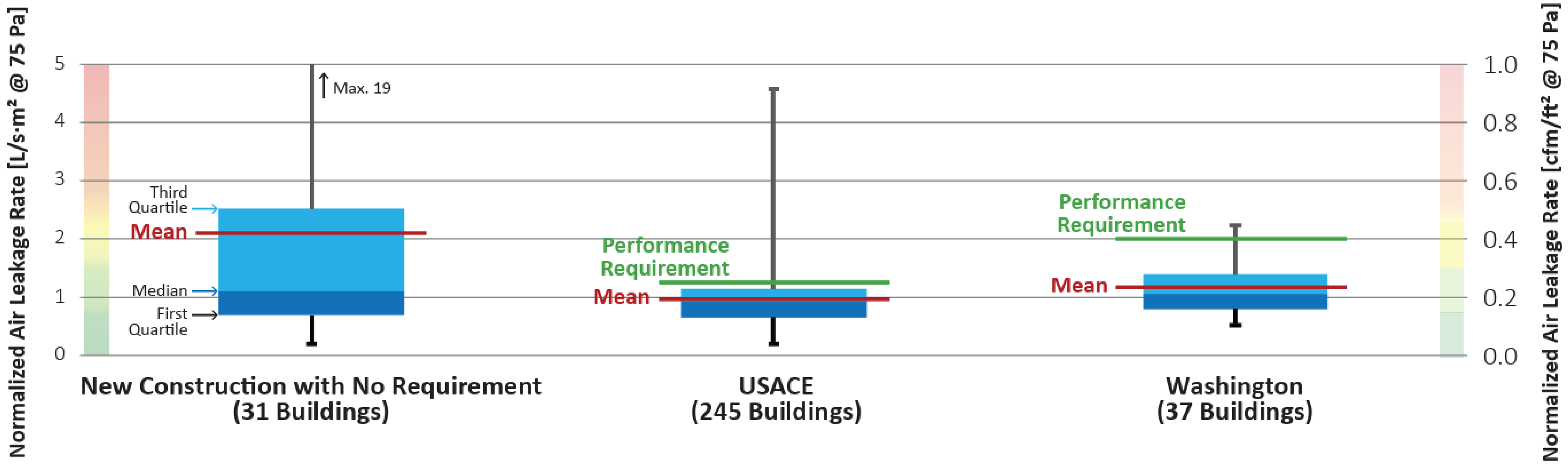


Image : RDH presentation

Tested buildings

Image : Retrotech website

Impact of mandatory testing



Distribution of test results for each set of buildings in different jurisdictions

That brings yet another question

If you are not testing, are you really getting what you are expecting?

The first 5 takeaways

1. Patience is in order, it can take a long time for a concept to become practice
2. Legislation or codification is important to affect long lasting change
3. Need for tools and training, and a define path to implementation
4. Measurement and verification is key to obtaining the desired results
5. History has a tendency to repeat itself, let's not let it

EVOKE

Present day

Where are we standing today?

Image : Nested Living

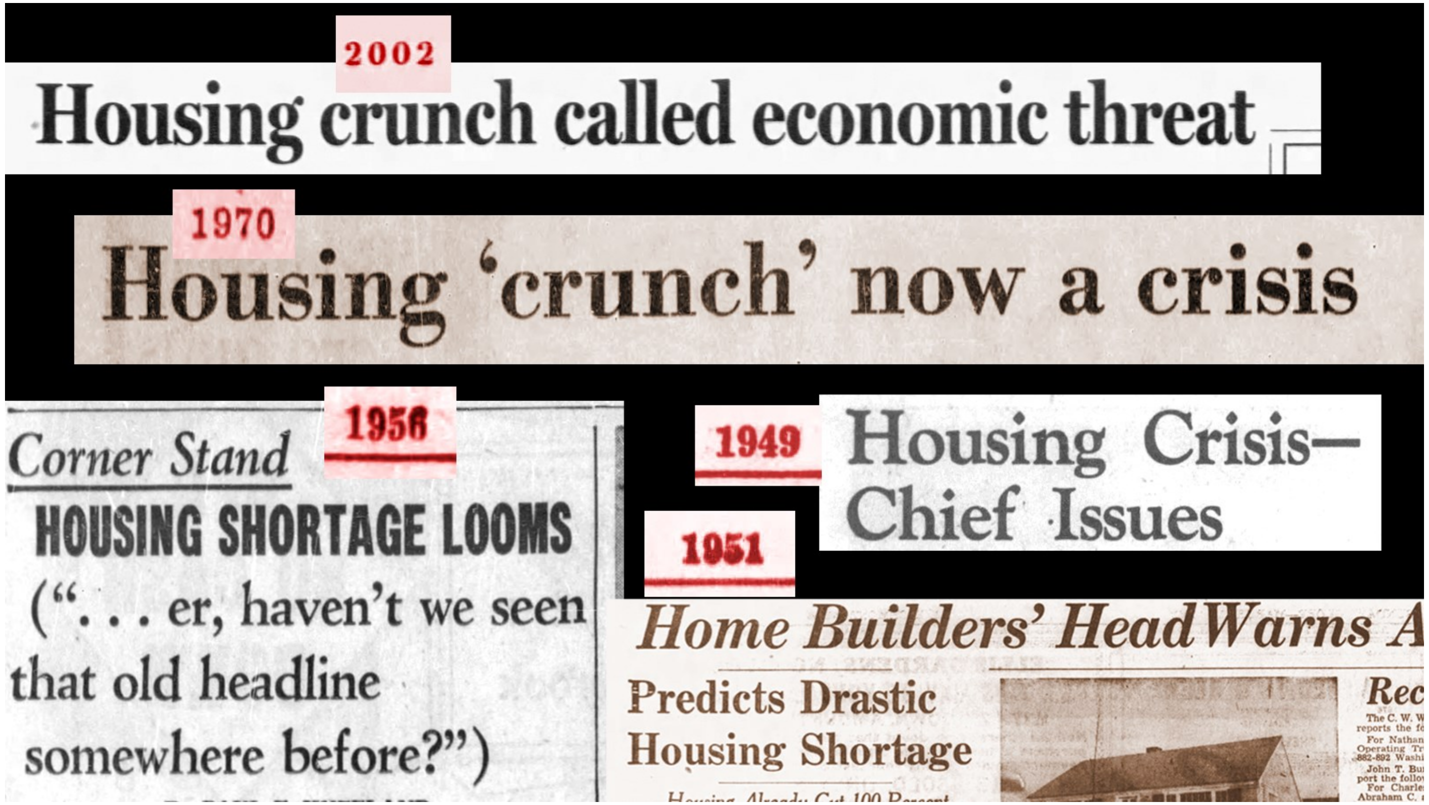


Image : Boston Globe

There's already a lot to Think and Talk About!

What are the drawbacks of greater heat recovery efficiency?

What is our maximum glazing ratio? What SHGC do we need for comfort versus energy?

What is a TEDI? **Do we really need triple glazing?** TEUI?

What is our building shape? **What effective R-value do we need for the opaque?**

How will the building be heated? Can you just tell me the answer?

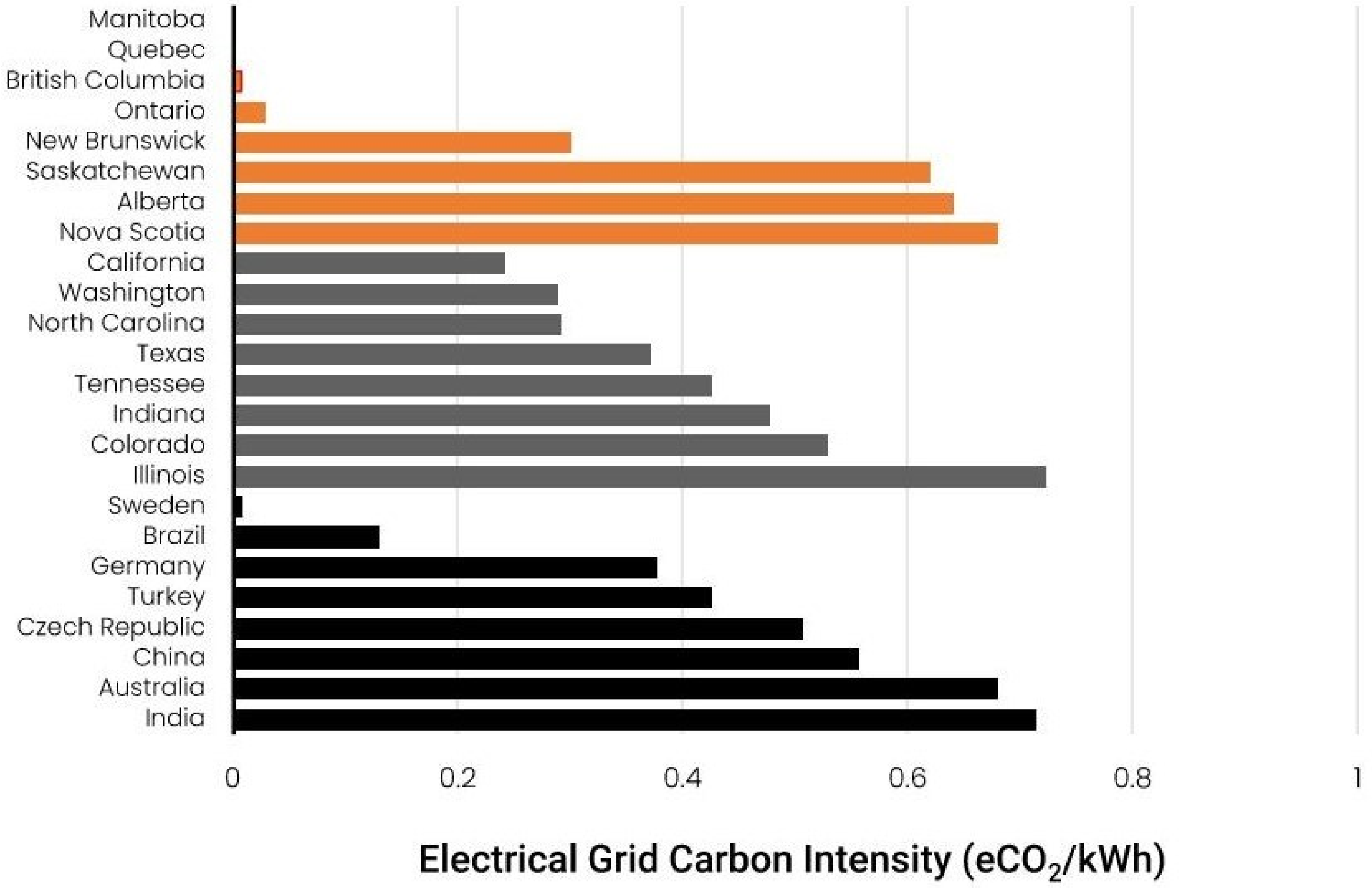
Can we achieve that level of air-tightness and take credit?

How can they still build like this?

Can I delete the exterior insulation to reduce embodied carbon?

Total Emission Reduction

- Electrification and energy efficiency both important for reducing GHG
- Impact of energy use reduction not as impactful in locations that have a lower carbon intensive power gird
- But still need to think about grid capacity



Efficiency Rule No. 1:

The best savings…

… is what you don't use in the first place.

What About “*THE PERFECT WALL*”?

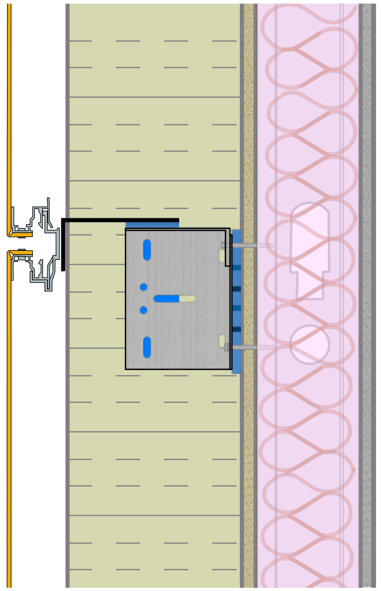
As wall thickness increases to meet higher energy performance requirements, it might be reasonable to look at hybrid walls

- Vapour-Permeable Membranes and intelligent vapour barriers
- Cladding Attachment Limitations

Don’t make stupid decision for the wrong reasons

This wall is 3” wider

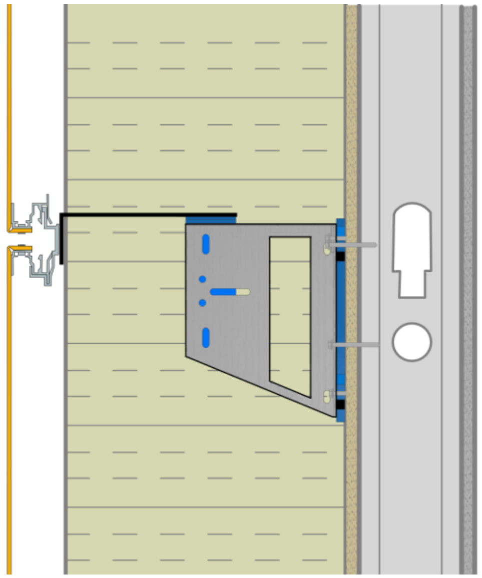
Split Insulated



5 inches of Mineral Wool

=

Exterior Insulated



8 inches of Mineral Wool

R-30 Effective Steel-Framed Wall Assembly

Needs a mention

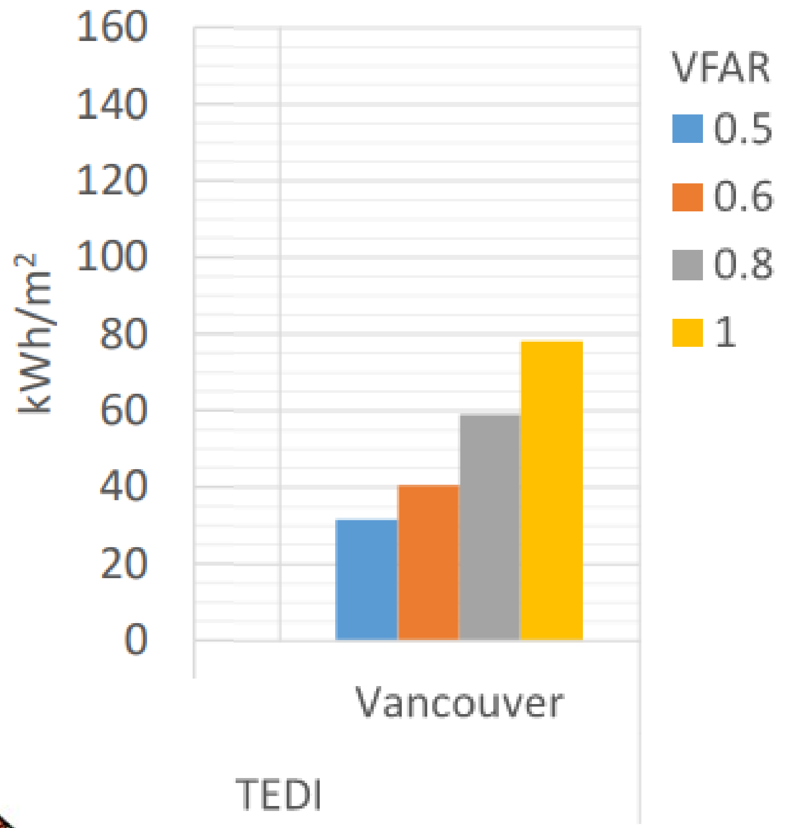
- Air tightness
- Heat recovery efficiency
- Window to wall ratio

Form Matters

Vertical Surface Area to Floor Area Ratio

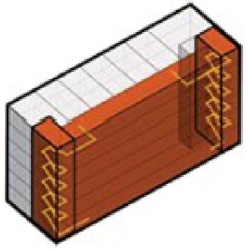
Table 4: VFAR for Example Building Shapes and Floor Plate Sizes

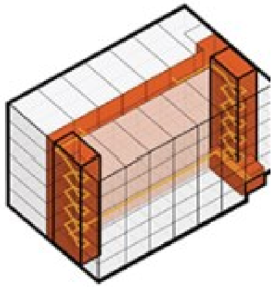
Floor Plate Size	Building Shapes		
	Square	Articulated	Narrow
600m^2	0.49 VFAR	0.59 VFAR	0.7 VFAR
400m^2	0.6 VFAR	0.72 VFAR	0.86 VFAR



Floor to ceiling height matters

Single loaded VS Double loaded

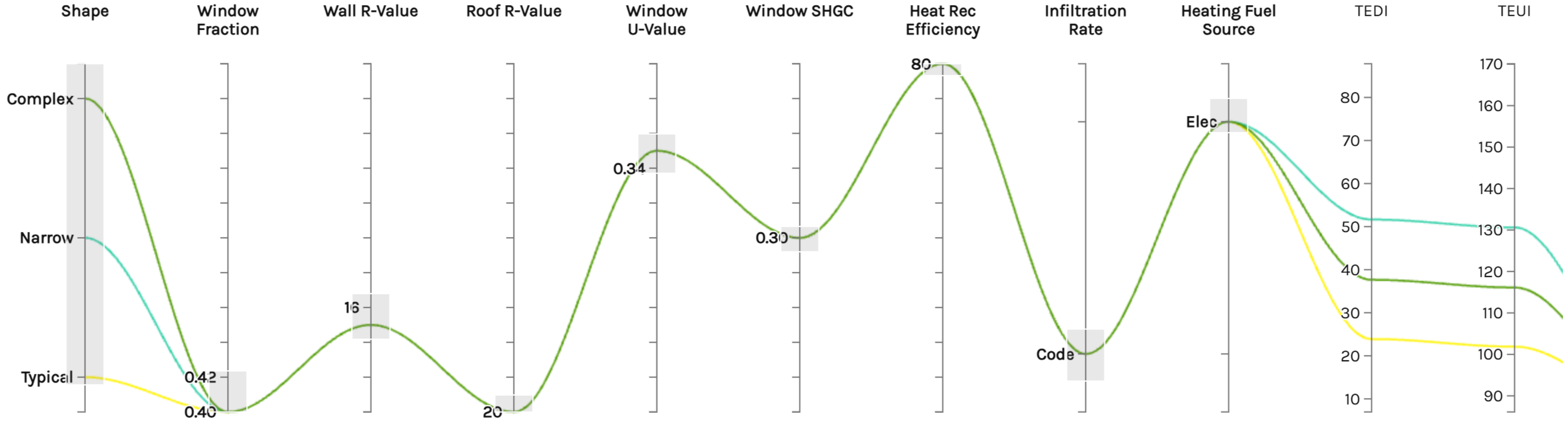

SINGLE-LOADED CORRIDOR


DOUBLE-LOADED CORRIDO

Getting an idea of performance

www.buildingpathfinder.com

PathFinder

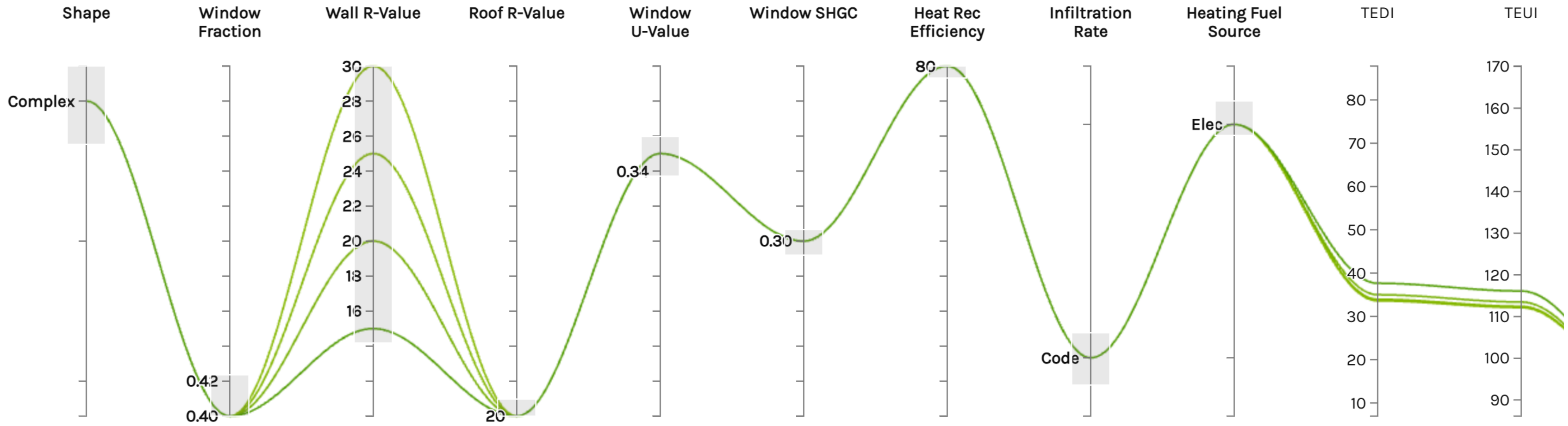


Shape	Window Fraction	Wall R-Value	Roof R-Value	Window U-Value	Window SHGC	Heat Rec Efficiency	Infiltration Rate	Heating Fuel Source	TEDI	TEUI
Typical	0.4	15	20	0.35	0.3	80	Code	Elec	23.89	101.86
Complex	0.4	15	20	0.35	0.3	80	Code	Elec	37.65	116.13
Narrow	0.4	15	20	0.35	0.3	80	Code	Elec	51.65	130.63

Getting an idea of performance

www.buildingpathfinder.com

PathFinder



Shape	Window Fraction	Wall R-Value	Roof R-Value	Window U-Value	Window SHGC	Heat Rec Efficiency	Infiltration Rate	Heating Fuel Source	TEDI	TEUI
Complex	0.4	15	20	0.35	0.3	80	Code	Elec	37.65	116.13
Complex	0.4	20	20	0.35	0.3	80	Code	Elec	35	113.5
Complex	0.4	25	20	0.35	0.3	80	Code	Elec	33.94	112.47
Complex	0.4	30	20	0.35	0.3	80	Code	Elec	33.58	112.16

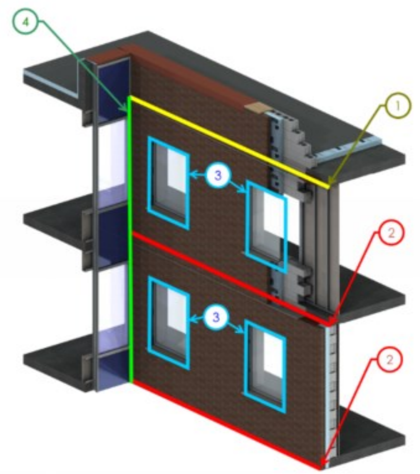
Not all buildings need to be iconic

Opaque Wall Uvalue

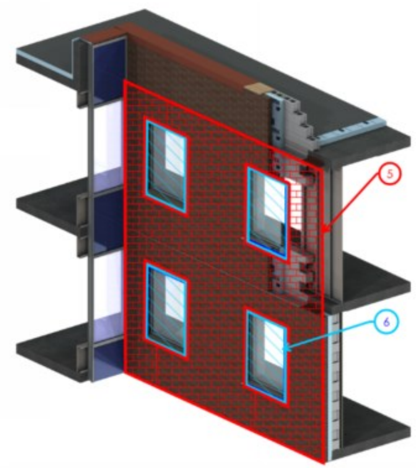
$$U_T = \frac{\Sigma(\Psi \cdot L) + \Sigma(\chi)}{A_{Total}} + U_o$$

Where:

U_T =	total effective assembly thermal transmittance (Btu/hr·ft^2·°F or W/m^{2}K)
U_o =	clear field thermal transmittance (Btu/hr·ft^2·°F or W/m^{2}K)
A_{total} =	the total opaque wall area (ft^2 or m^2)
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)



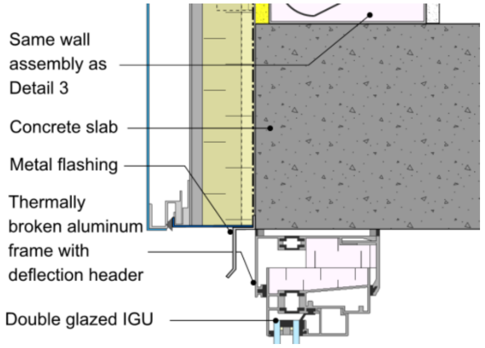
1. Parapet Length
2. Slab Lengths
3. Wall to Window Transition Lengths

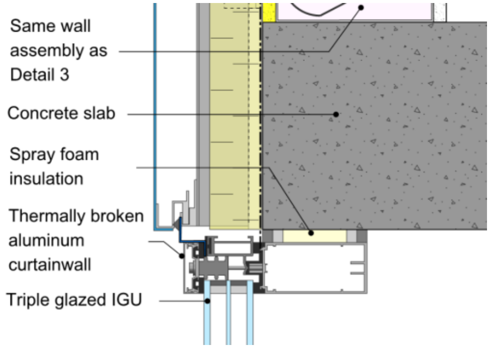


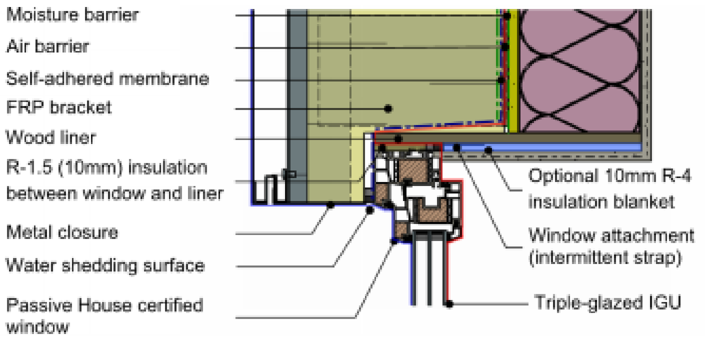
4. Corner Length
5. Opaque Brick Wall Area
6. Glazing Area

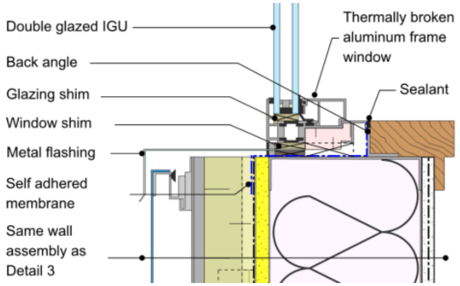
EVOKE

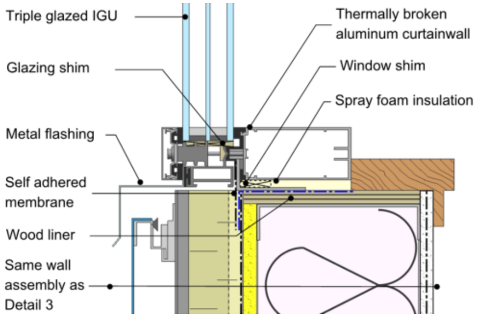
Window Frame & Detailing

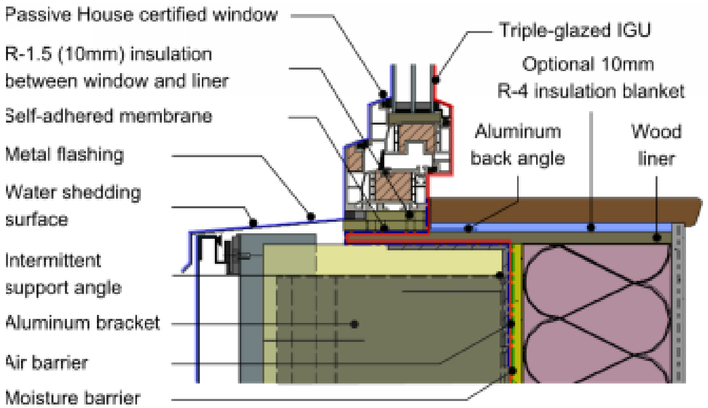






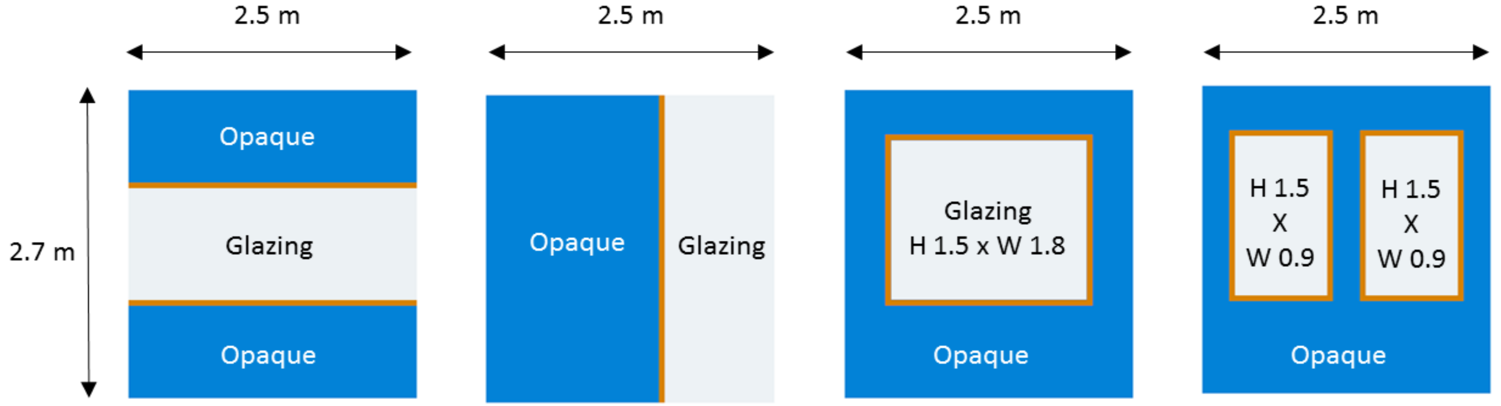






Sill	0.28 W/m K	0.08 W/m K	0.08 W/m K
Head	0.53 W/m K	0.11 W/m K	0.04 W/m K

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)

Wall Clear Field R16	Horizontal Strip Glazing	Vertical Strip Glazing	Punched Window Opening	Two Punched Window Openings
Interface Length (m)	5	2.7	6.6	9.6
Overall R-Value	10.2	12.2	9.2	7.8

Horizontal

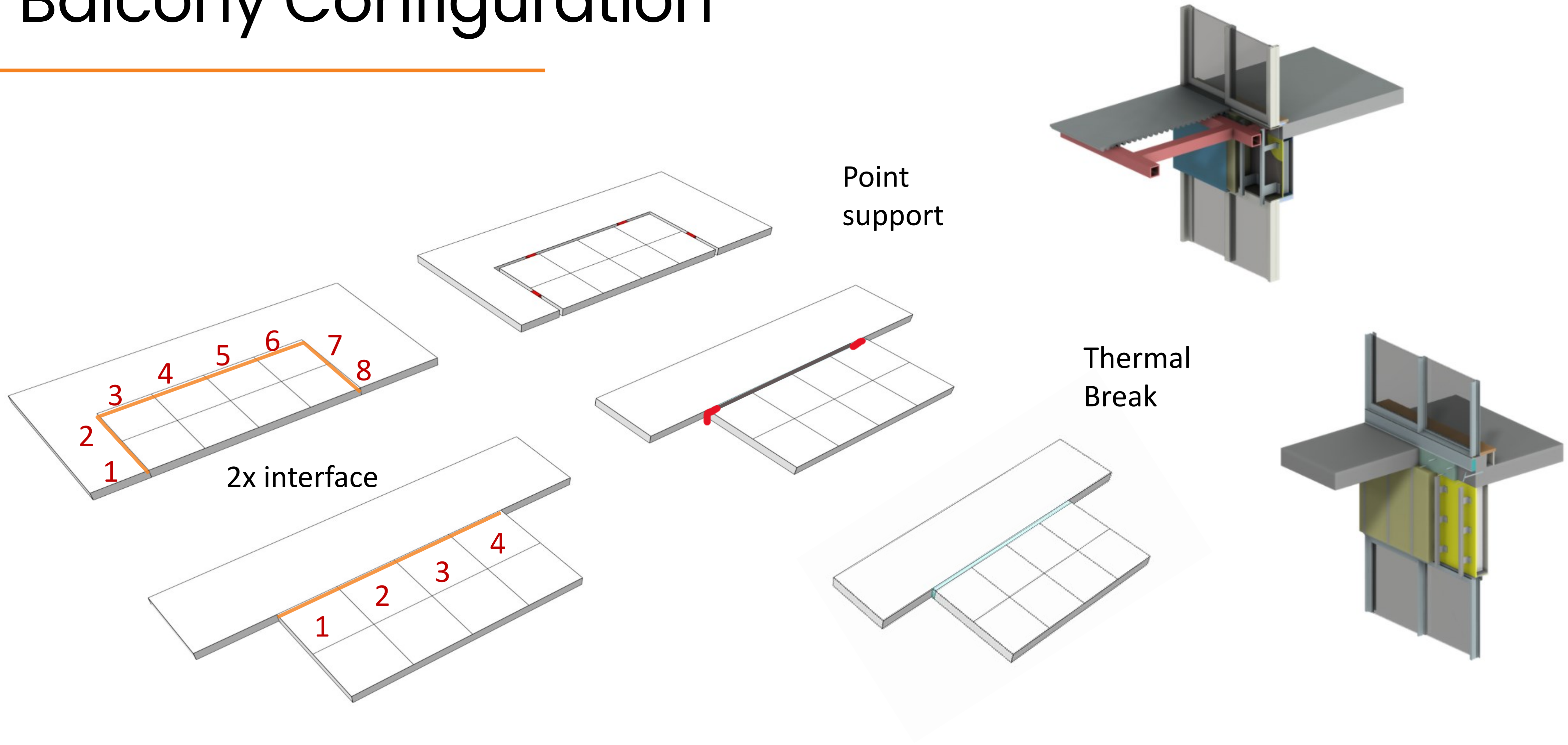
Vertical

Punched

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

EVOKE

Balcony Configuration

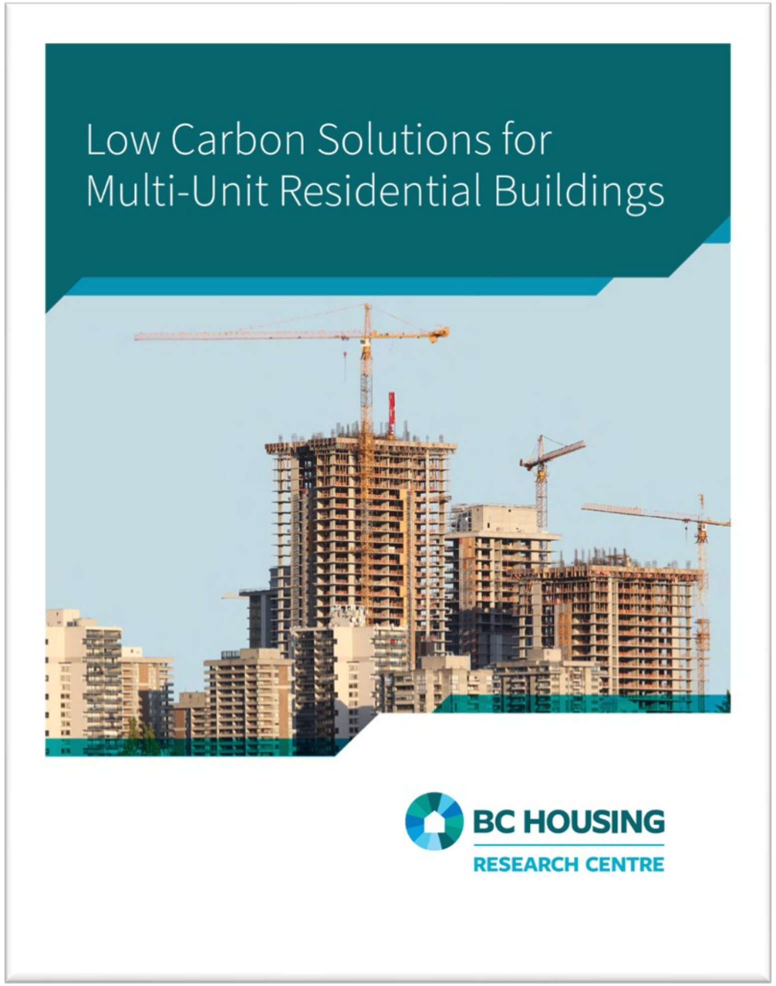


Source: Perkins + Wills: Thermally Broken Balcony Report

Low Carbon Study

Enclosure centric study

- Identify how embodied carbon can be meaningfully reduced for new construction and renewals for the full building lifecycle
- Provide guidance to aid decision making at the component and system level
- Highlight solutions that balance emissions with durability, cost, and occupant comfort



Link

The future

Image : The Scholarly Kitchen

The Good

- It can make your life easier

The Bad

- It can hallucinate , you still need judgement

The Ugly

- Will it diminish the need for entry level position?

THANK YOU

smercier@evokebuildigns.com

EVOKE

Pembina Reframed

- Cost effectiveness
- Resiliency & adaptability
- Health & Wellness
- Energy efficiency & carbon emissions





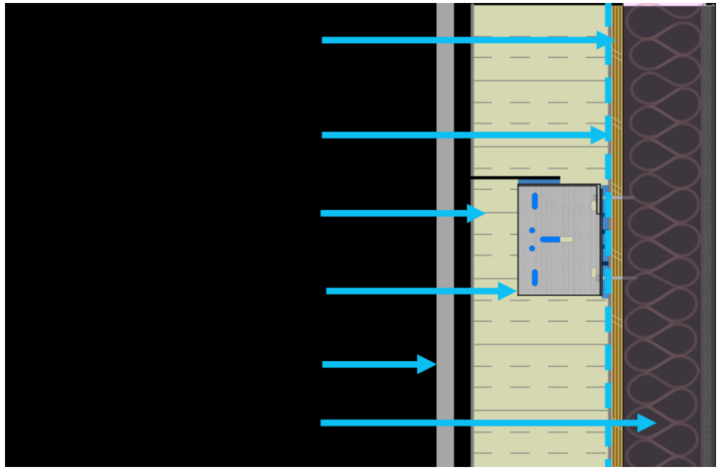

SOURCE: PEMBINA INSTITUTE

Le Chateau – DEEP retrofit

Rendering of intended retrofit

Balancing act

Conventional building envelope renewal



Best solution for market transformation