FAÇADE TECTONICS

2021-05-06

Energy Modeling Best Practices and Why Facades Matter – Processes

Steve Kemp, M.A.Sc., P.Eng., LEED®
Fellow, Principal RDH Building Science

Historical Overview

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John Straube's mom,
not Steve Kemp's mom

Mom's Rules of Building Science

- "Close the window / door / fridge"
  - Airtightness matters
- "Wear a hat"
  - Overhangs = Sunshade, rain shelter
- "Don't tuck your pants into your boots"
  - Drainage and shingling
- "Wear your jacket, sweater, mittens"
    - Insulate on the outside

From Envelope is King, to it's the HVAC stupid and back again

- My early career
  - It's all about the envelope
  - Heating and cooling loads are imposed primarily by the envelope, so let's start there!
- It didn't take me long to find…
  - HVAC design and specifications are terrible
  - Fix the stupid things that we're doing!
- Today… Great envelopes enables great HVAC

What climate are these buildings experiencing?

Denver

Edmonton

Honolulu

Toronto

Los Angeles

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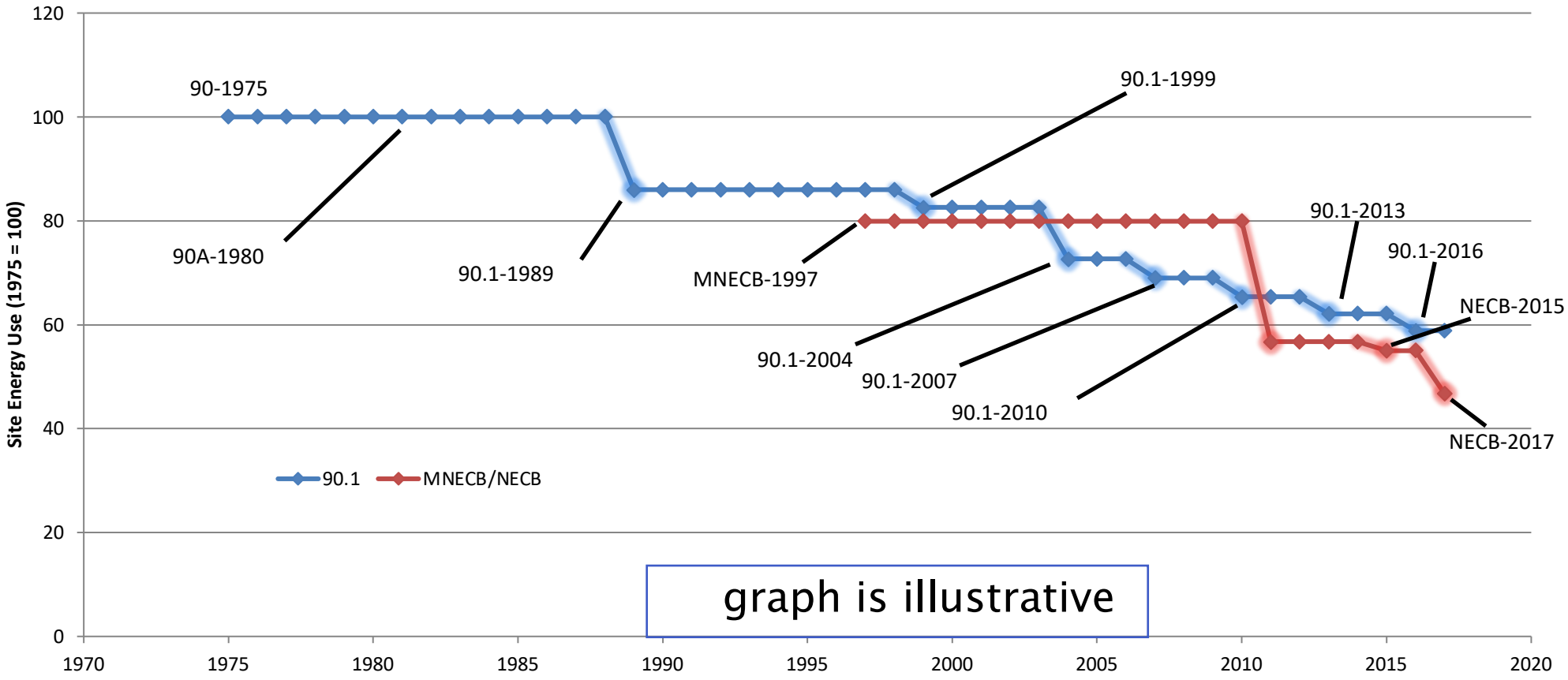
History of Energy Codes (Non-Part 9) in Canada



Data Source: Combination of PNNL and phone a friends

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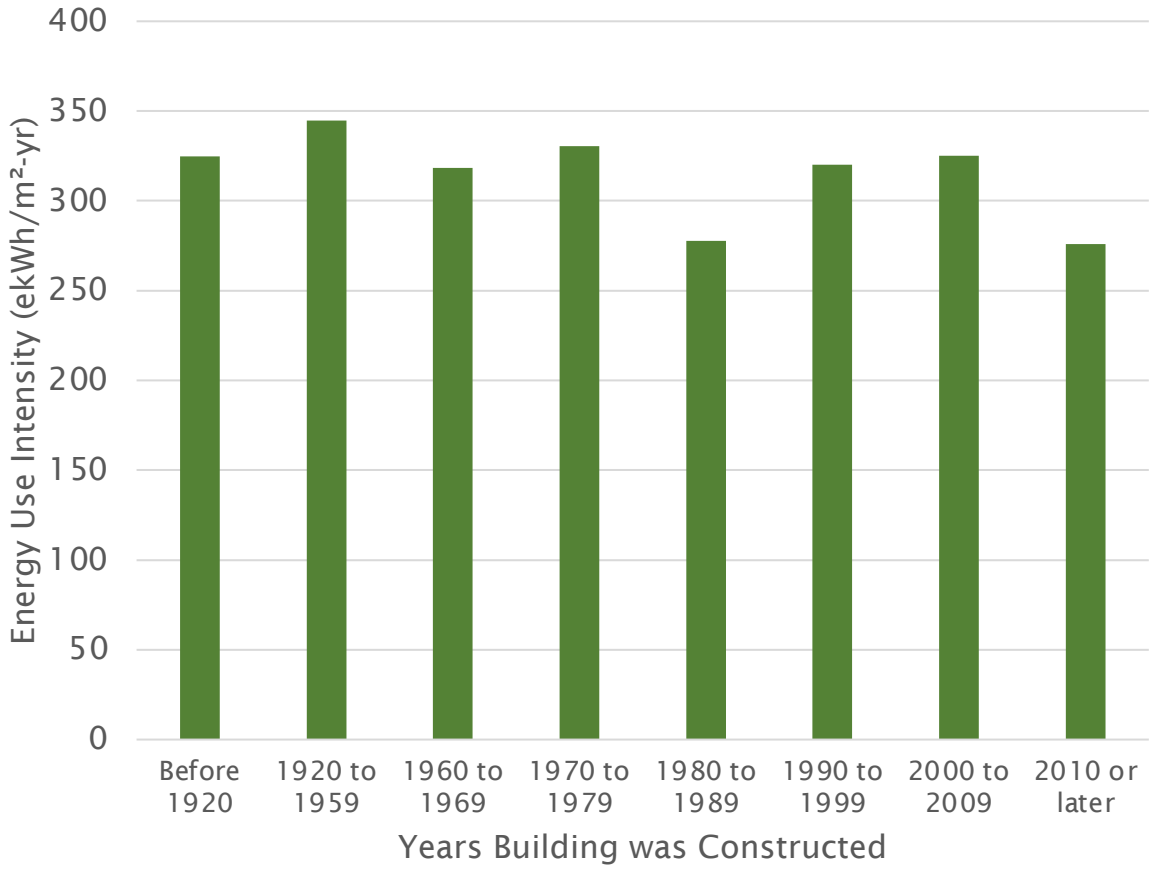
2014's *MEASURED* Energy Use of Canadian Buildings



Ref: Survey of Commercial and Institutional Energy Use – Buildings 2016, NRCAN

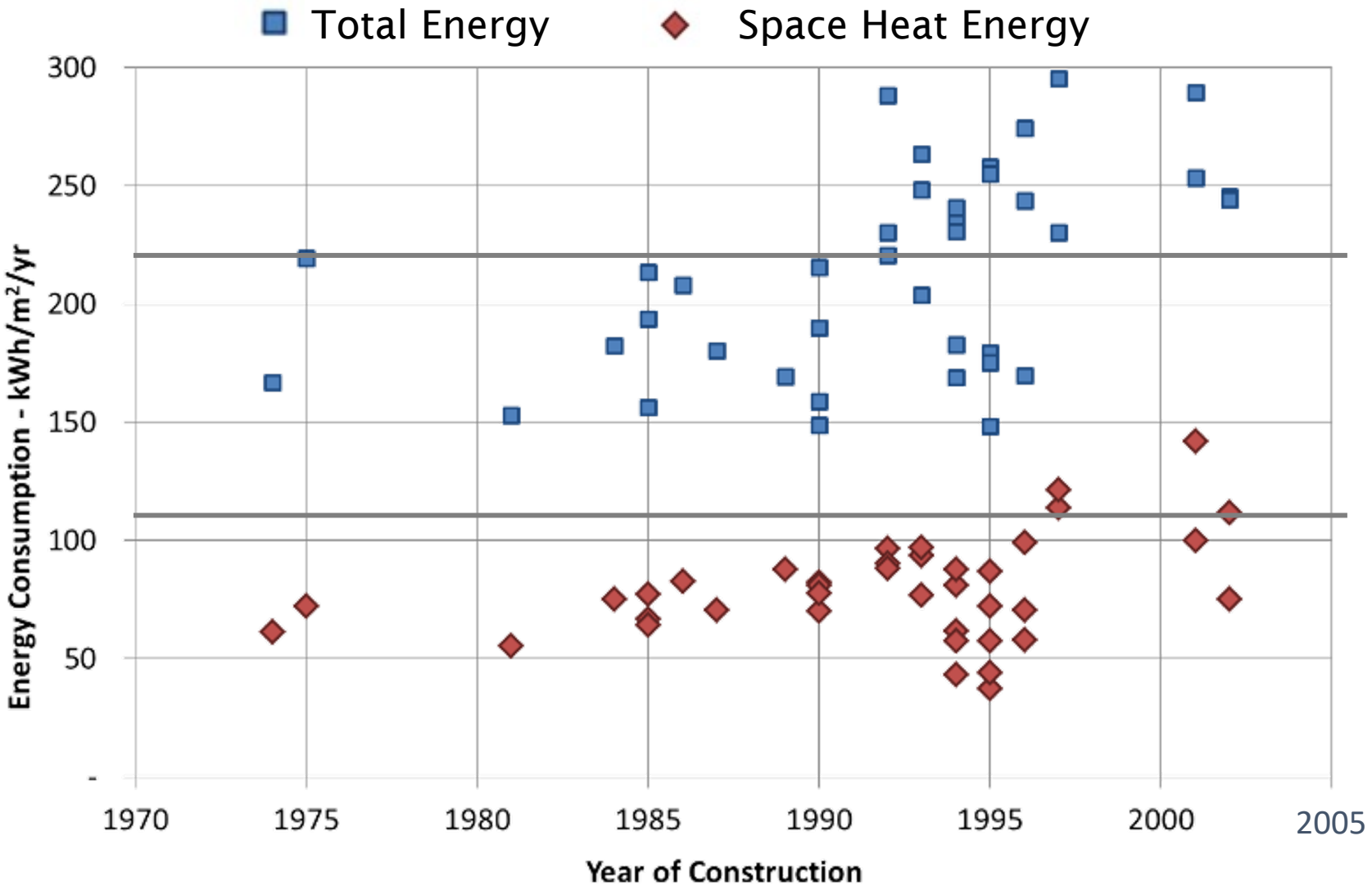
- Energy consumption is for year 2014
- Includes all building types
- Most older building have been renovated with newer HVAC
- Most older building have a "computer on every desktop"
- Why is this happening?
  - data does not come with explanation

2018's *MEASURED* Energy Use of Canadian MURBs

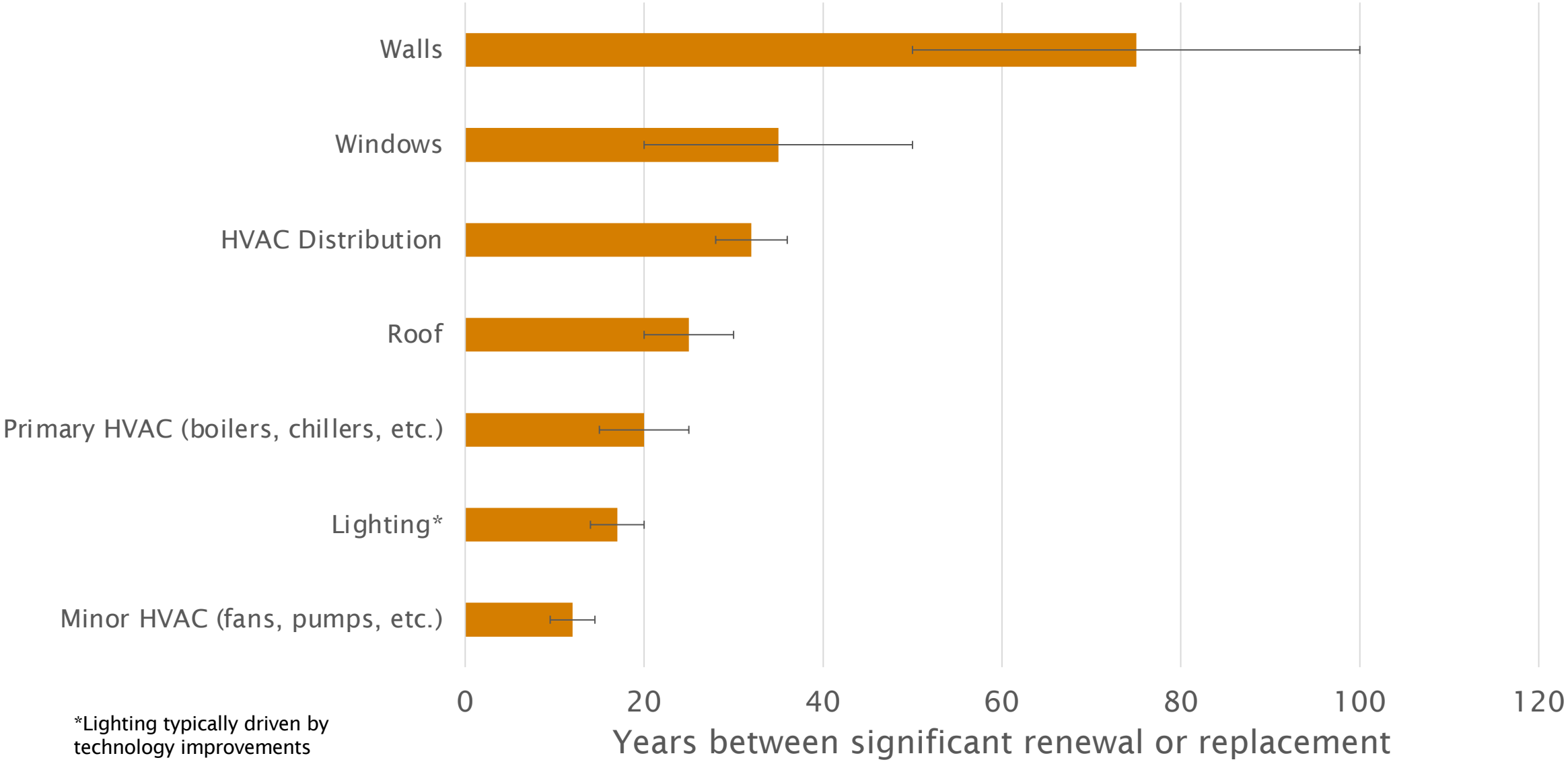
- Energy consumption is for year 2018
- Includes only MURBs
- Most older building have been renovated with newer HVAC
- Most older building have more modern energy efficient appliances
- Why is this happening?
  - data does not come with explanation

Ref: Survey of Energy Consumption of Multi-Unit Residential Buildings (SECMURBs) 2018, NRCan

MEASURED Energy Consumption Trends - BC MURBs



Typical Building Renewal Cycles



*Lighting typically driven by technology improvements

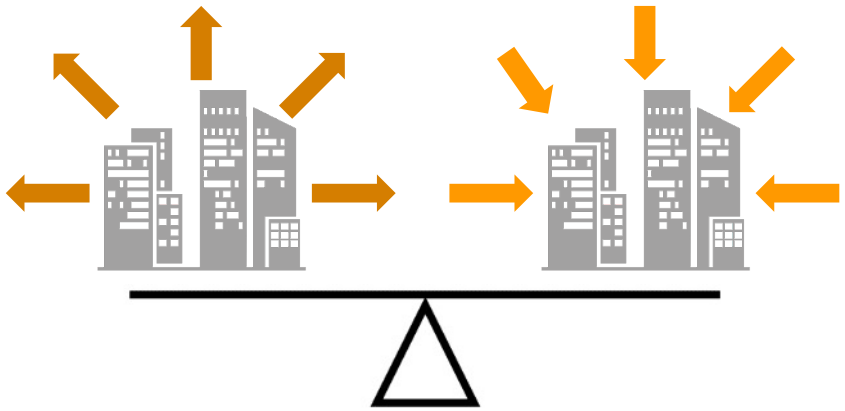
New Energy Performance Metrics:

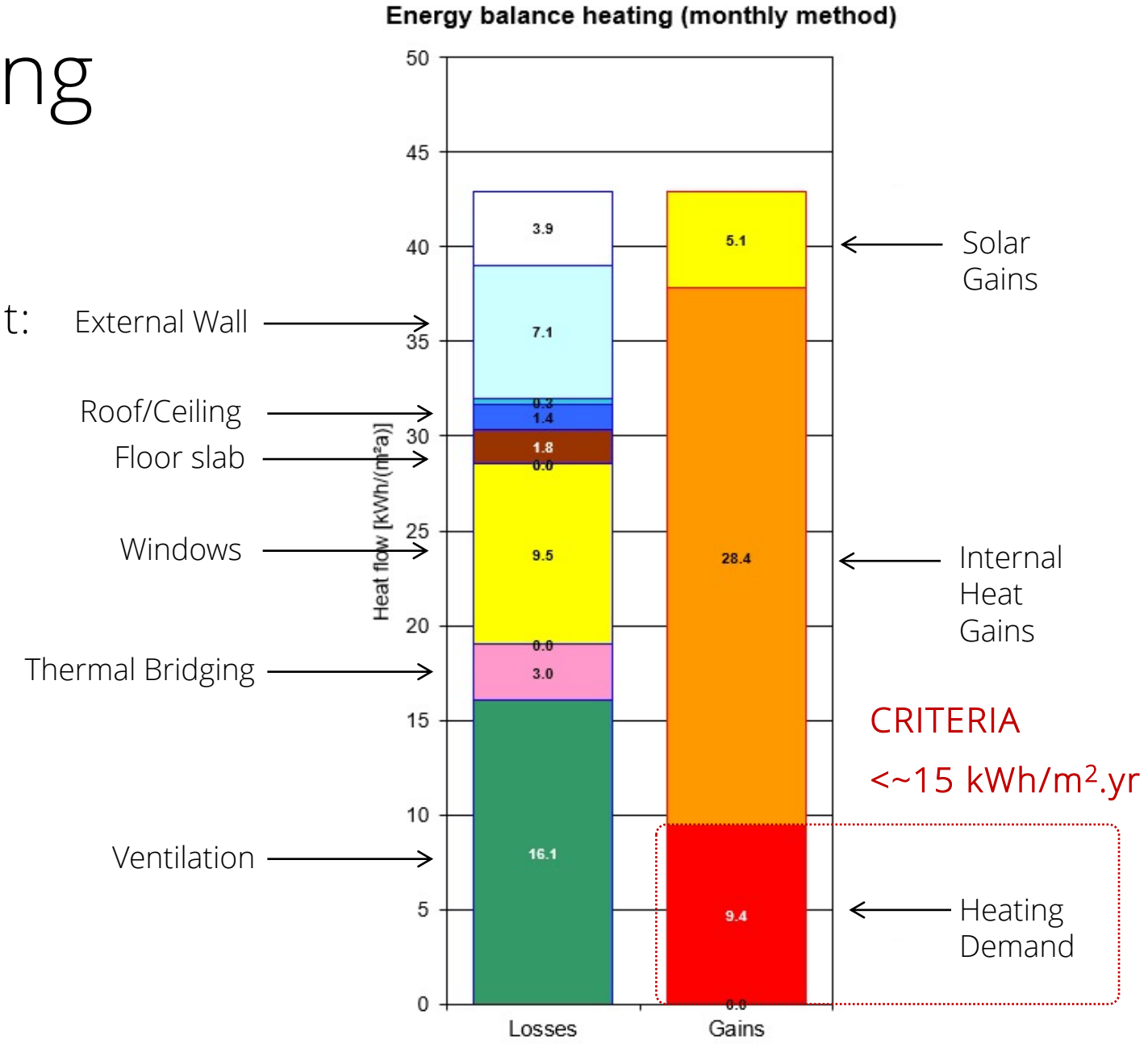
- Annual Space Heating Demand or Heating Load
- Annual Total Energy Use Intensity
- Greenhouse Gas Emission Intensity

Space Heating/Cooling

To maintain a comfortable environment:

Σ Heat Loss = Σ Heat Gains

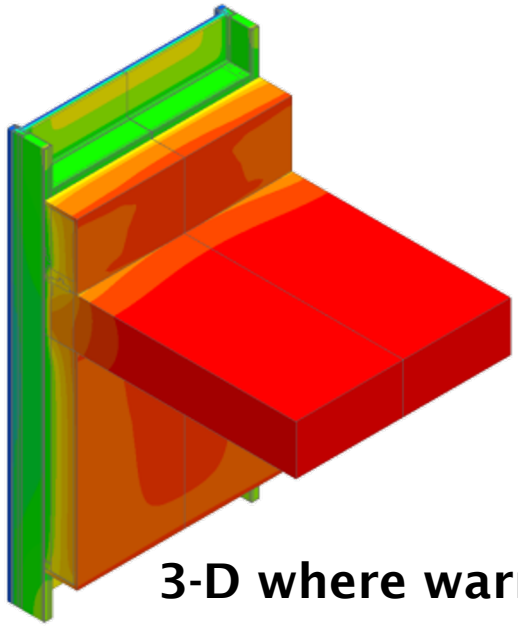




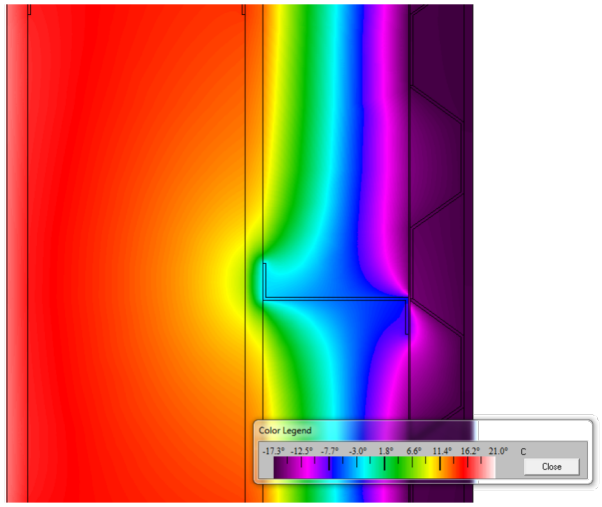
Graph: PHPP Energy Balance – UBC Okanagan PHPP by RDH

Thermal Demand Details – Thermal Bridging

→ Thermal bridging assessment is required



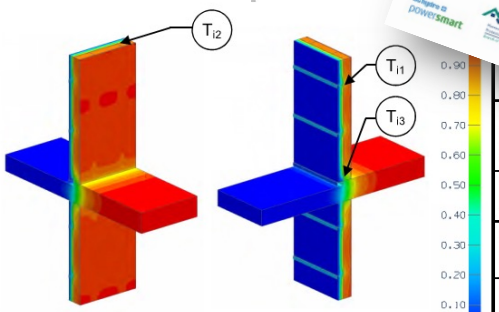
3-D where warranted



2-D evaluation

Published values

Detail 5.2.4 Exterior Insulat… with Horizonta… Uninsulated C…



View from Interior View from Exterior

Transmittance / Resistance without Anomaly	R_o	…nd R-…slab
Transmittance / Resistance	U, R	U- and R-values for overall assembly
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.

Nominal (1D) vs. Assembly Performance Indicators

Exterior Insulation 1D R-Value (RSI)	R_{1D} $ft^2 \cdot hr \cdot °F$ / Btu (m^2 K / W)	R_o $ft^2 \cdot hr \cdot °F$ / Btu (m^2 K / W)	U_o Btu/ft^2 ·hr ·°F (W/m^2 K)	R $ft^2 \cdot hr \cdot °F$ / Btu (m^2 K / W)	U Btu/ft^2 ·hr ·°F (W/m^2 K)	ψ Btu/ft hr °F (W/m K)
R-15 (2.64)	R-18.2 (3.20)	R-11.3 (1.99)	0.088 (0.50)	R-6.8 (1.19)	0.148 (0.84)	0.584 (1.011)

Temperature Indices

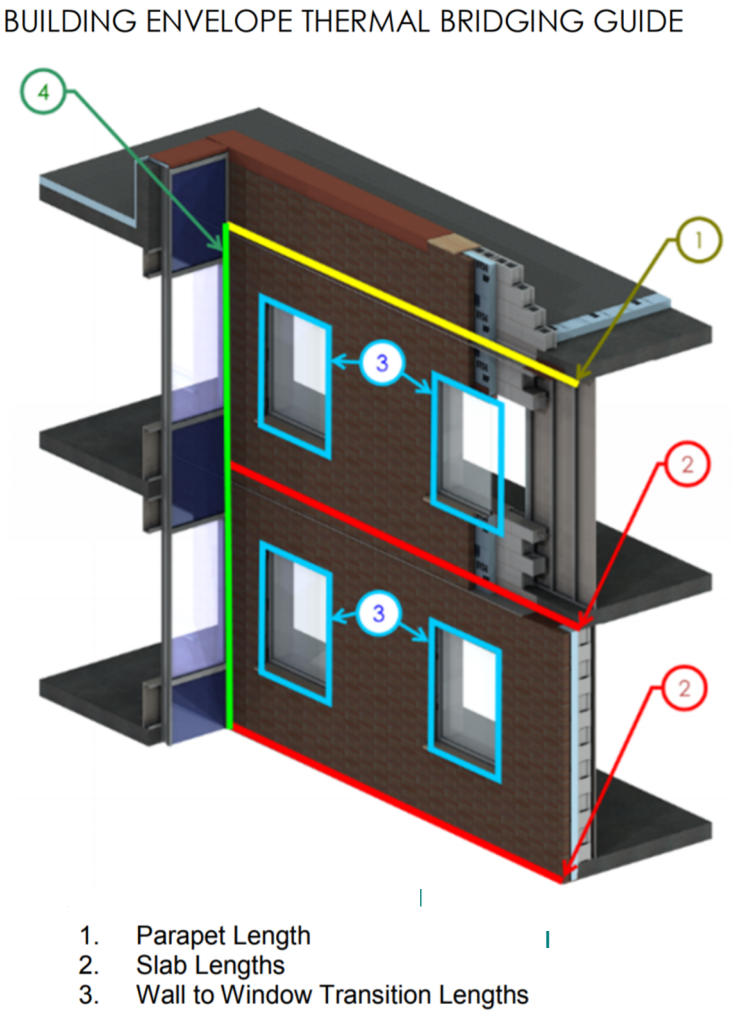
T_{i1}	0.71	Min T on sheathing away from slab, between studs at girts
T_{i2}	0.86	Max T on sheathing away from slab, between girts at studs
T_{i3}	0.45	Min T on slab exposed to interior air, at sheathing between studs

Language matters: R-values

- **Nominal R-value (or installed)** - rated R-value of the insulation in its installed condition

- **Assembly R-value (or centre-of-cavity)** - Nominal R-value + thermal resistance of other layers , assuming the assembly is 1D
- **Clear-wall R-value R_{cw}** - **Assembly R-value** + two-dimensional effect of standard repetitive thermal bridging (z-girts, steel studs, …)

- **Whole Wall R-value R_{ww}** – **Clear-wall R-value** + transitional thermal bridges (window to wall, slab edges, wall to roof, balconies, etc.



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Graphics: RDH Building Science Inc.

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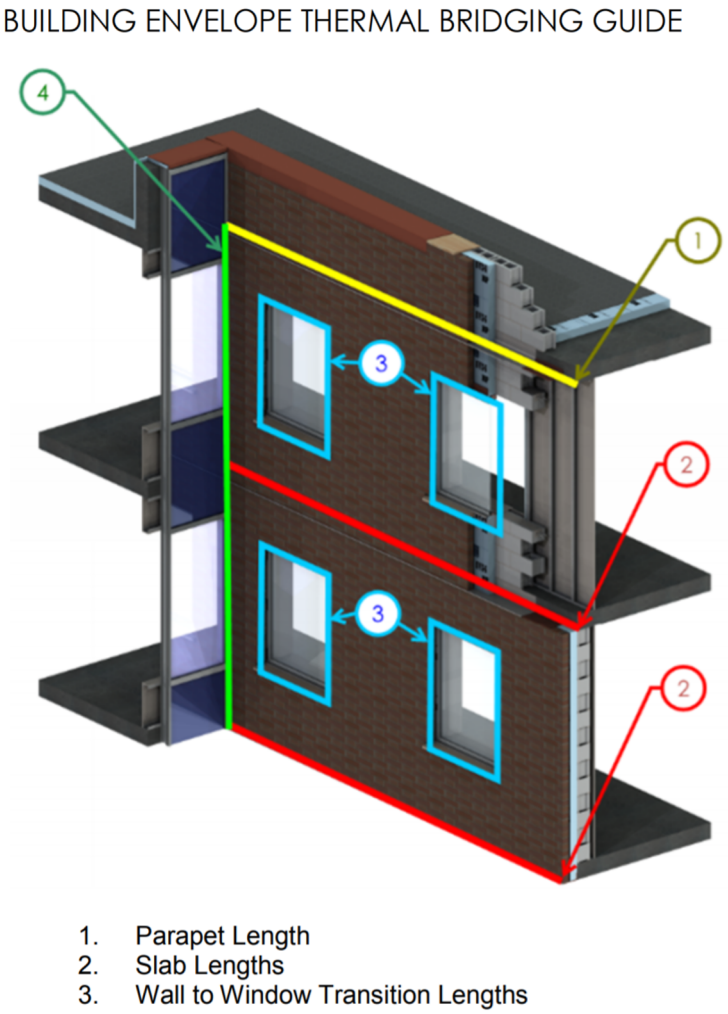
- Overall Effective Window + Wall R-value $R_{overall}$ – **Whole Wall R-value R_{ww}** + Windows.



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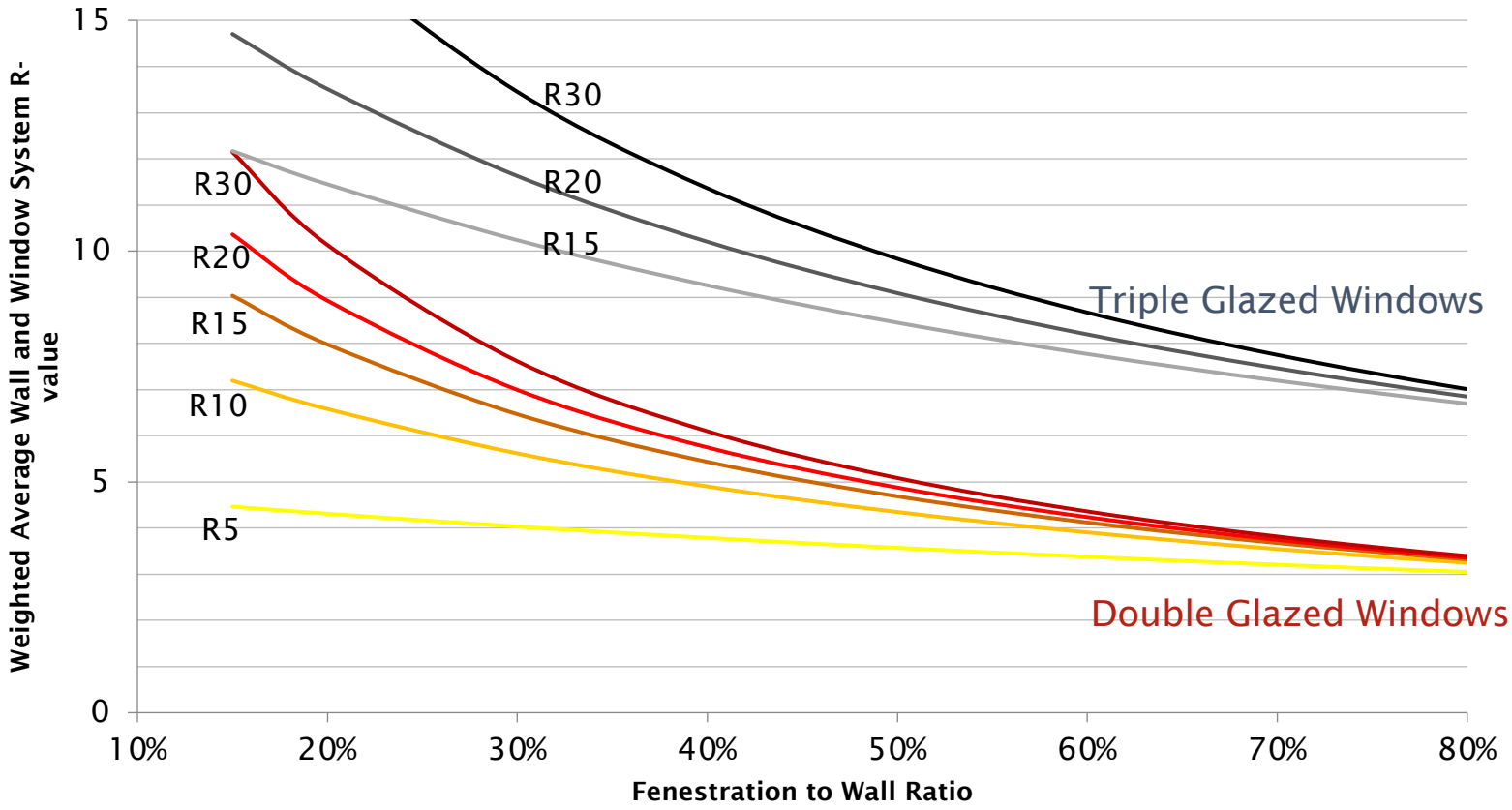
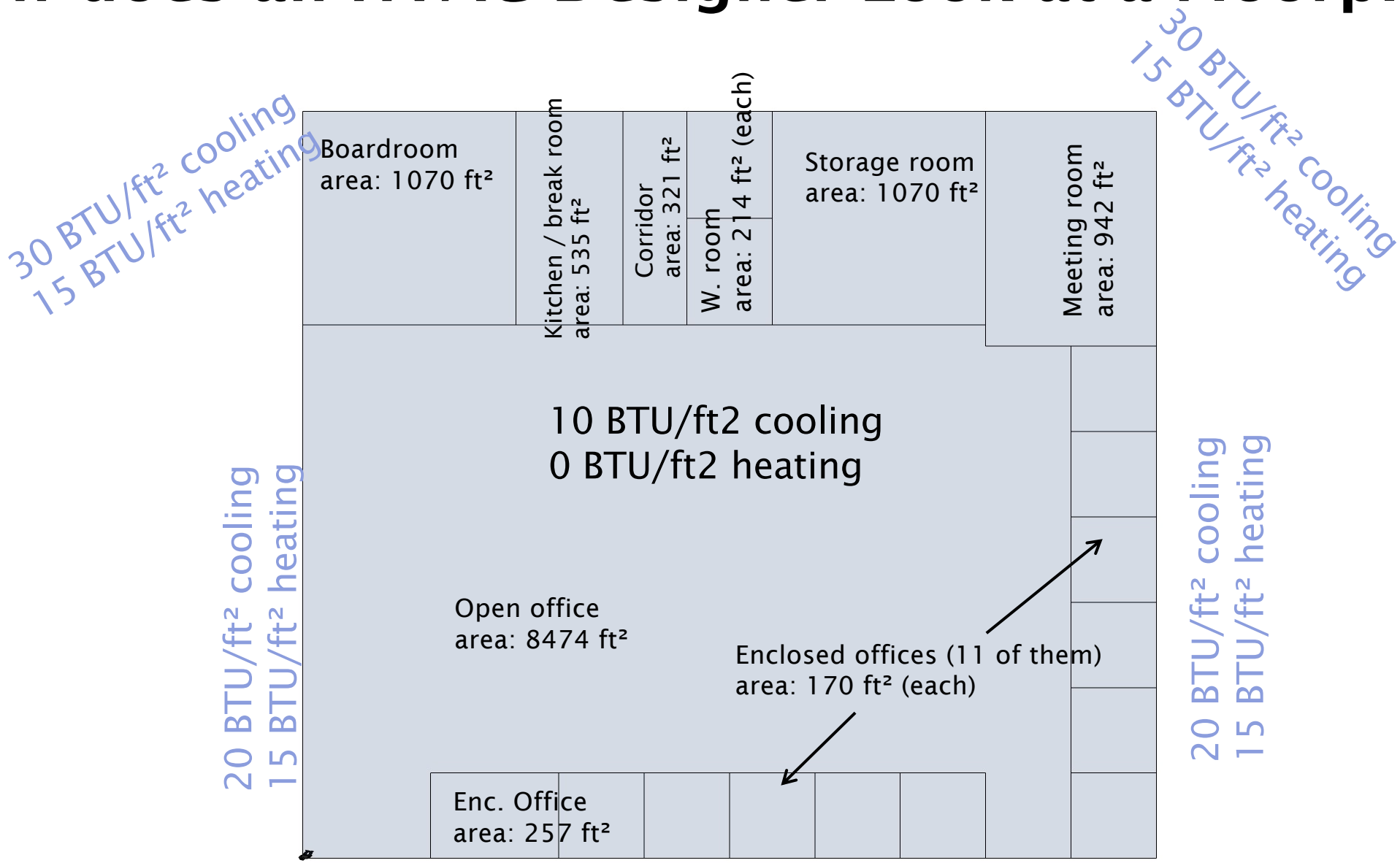
Graphics: RDH Building Science Inc.

Overall Effective Window + Wall R-value

Not as a modeling or performance metric, but as a language between HVAC design and Architect



How does an HVAC Designer Look at a Floorplan?



Example Peak Heating Loads – Toronto

Toronto Office Tower
R-4 spandrel,
60% WWR of U-0.40

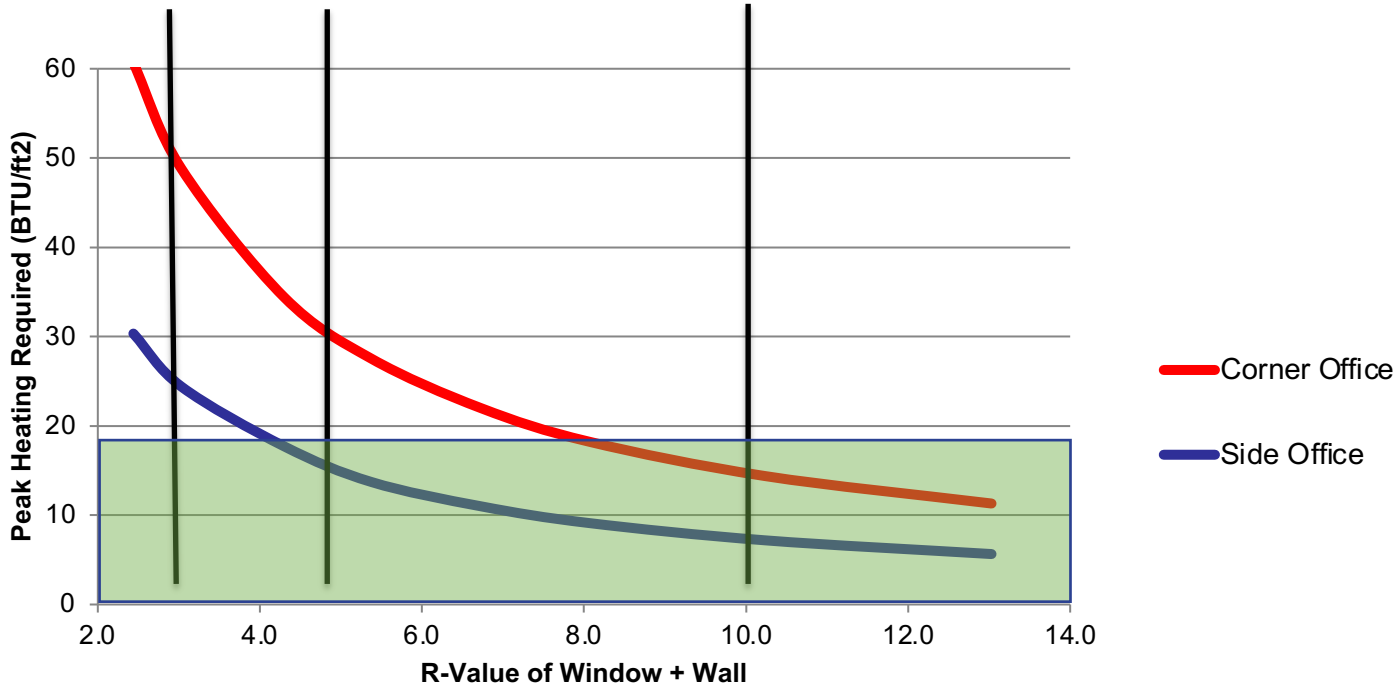
SB-10
R-18 wall
40% WWR of U-0.45

What I want
R-18 Walls,
40% WWR of U-0.16

Typ. Limit of 180F Baseboard

Typ. Limit of Infloor Radiant

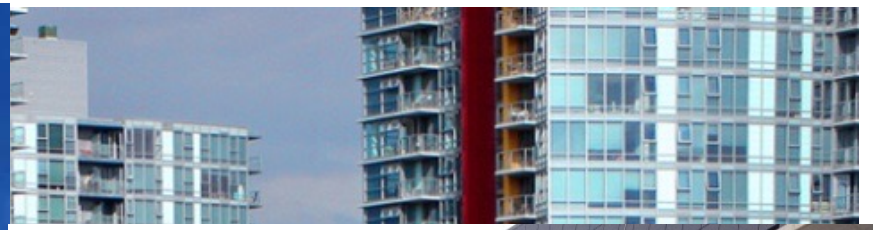
Typ. Cost Effective VRF Heat Pumps



Some summary

- Granular and Absolute Energy Targets (Budgets) are changing the conversation
- I know longer need to spend time making the reference building worse to meet an energy goal
- Language matters:
  - Batter ways to define Wall R-values, improving the accuracy of our models. ‘
  - Annual thermal demand (TEDI), a passive design metric
  - Should buildings and the language they reflect back to us and respond to their local climate?
- Architects and Engineers need to have a common language / tool set to identify synergistic performance goals
- Many low energy heating/cooling designs have capacity limitations
- Great envelopes enables great HVAC

New / Old Paradigm Shift



ENERGY MODELING BEST PRACTICES AND WHY FACADES MATTER – PROCESSES

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