PASSIVEHOUSE CANADA

Build better.
Feel better.

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85 Suite Mixed Use Market Rental Housing

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Officially opened

February 6, 2018

by the

Mayor of Vancouver

1. Outline of the Project
2. Envelope Details
3. Air Tightness Testing
4. Building Systems
5. Field Monitoring and Results
6. Energy Performance

Make Building Envelopes Great Again

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Basic Envelope Specifications

- **Walls:** U 0.104 (~ R35)
- **Roof:** U 0.075 (~ R45)
- **Floor:** U 0.171 (~ R25)
- **Windows:** Ug 0.70 W/(m2 K) (~ R8)
- **Thermal Bridge Free Detailing**
- **Fresh Air with high efficiency Heat Recovery (85%)**
- **Air Tightness .6 Ach/hr @50 Pa**

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Design PH Model

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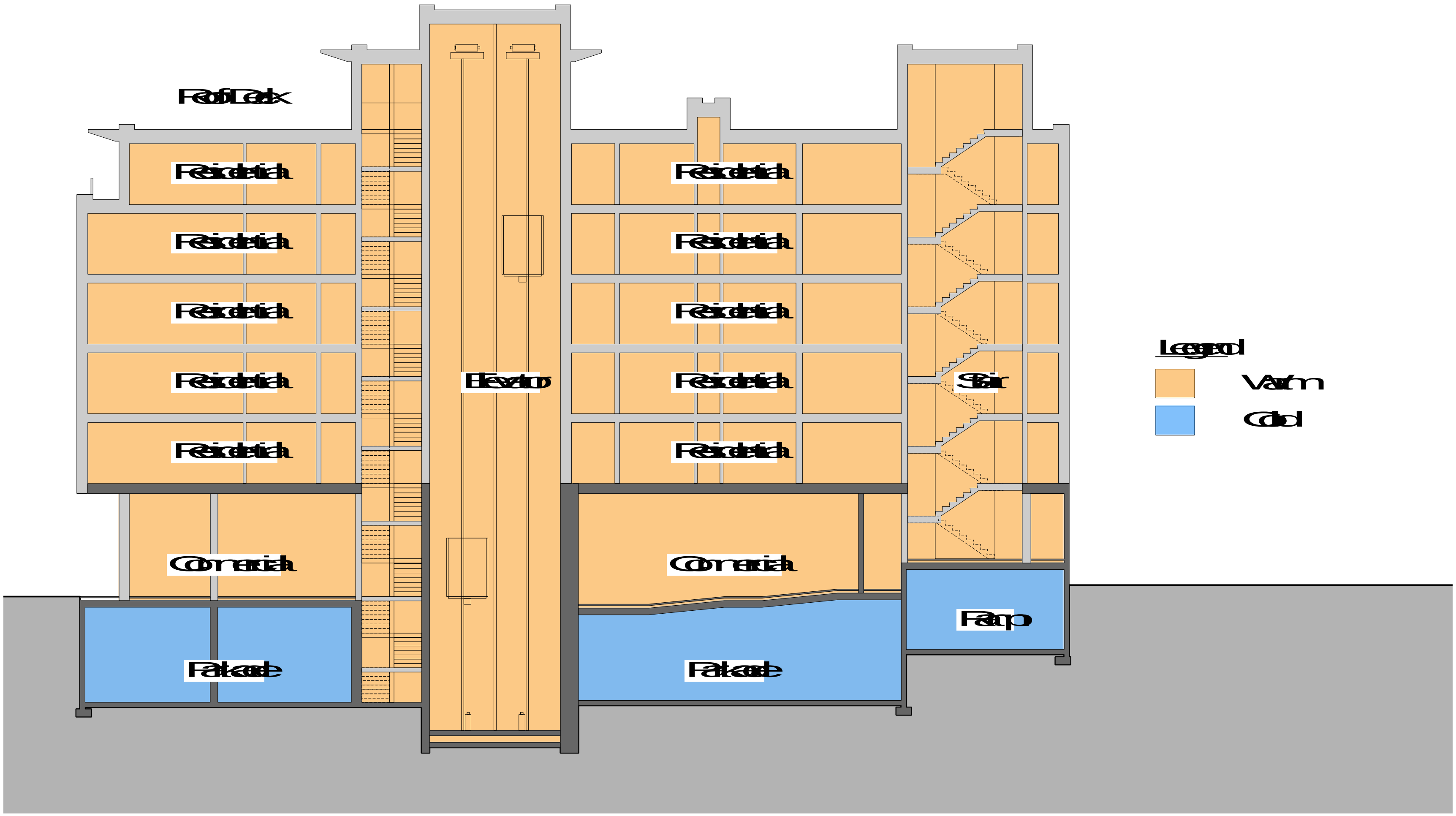
Typical Section



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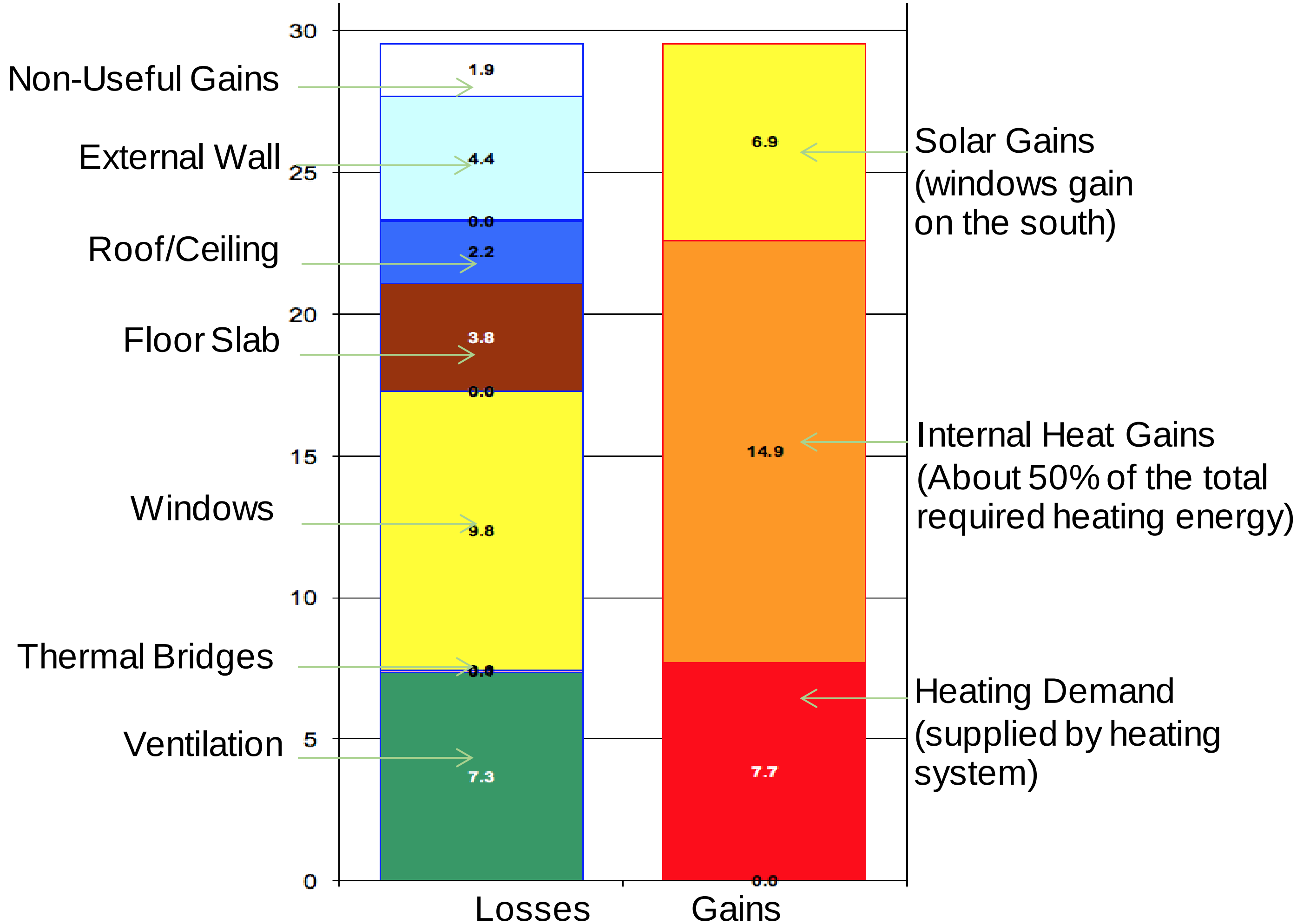
Annual Heating Energy Balance



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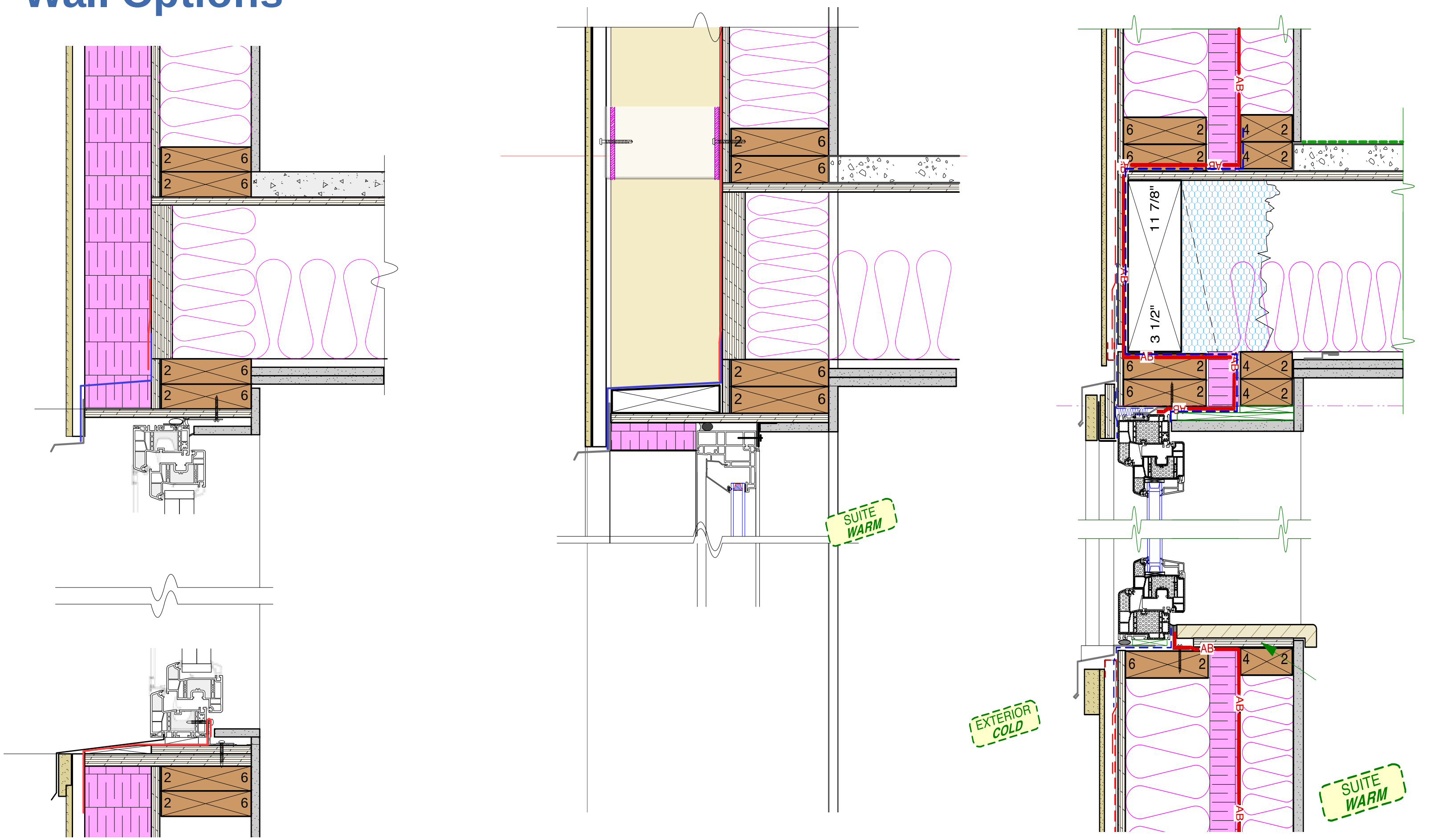
Construction Options

- **Walls**
  - Exterior insulated with rigid foam
  - Exterior insulated with Roxul and girts
  - Interior insulated
- **Concrete Floors**
  - Insulate above
  - Insulate below and deal with thermal bridging
  - combination

Wall Options

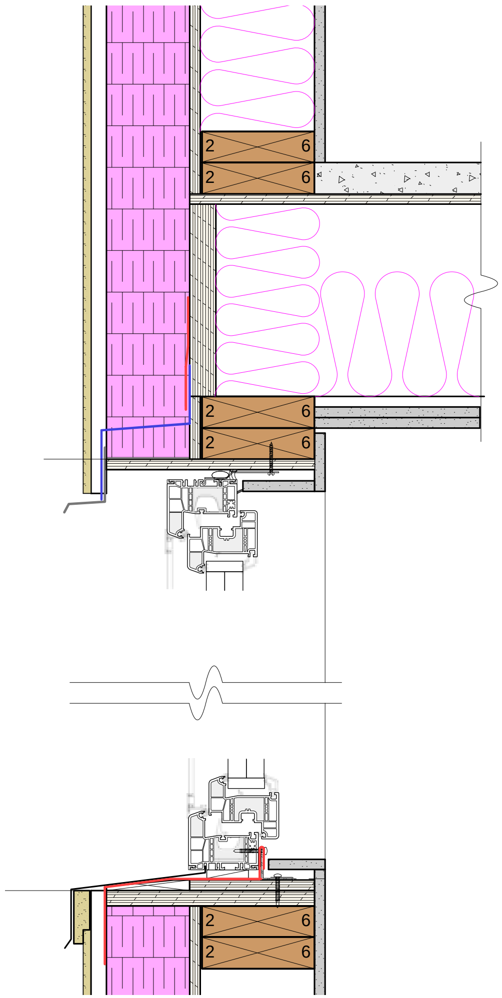


EPS Exterior Insulated **Roxul Exterior Insulated** **Interior Insulated**

Wall Options: EPS Exterior Insulated

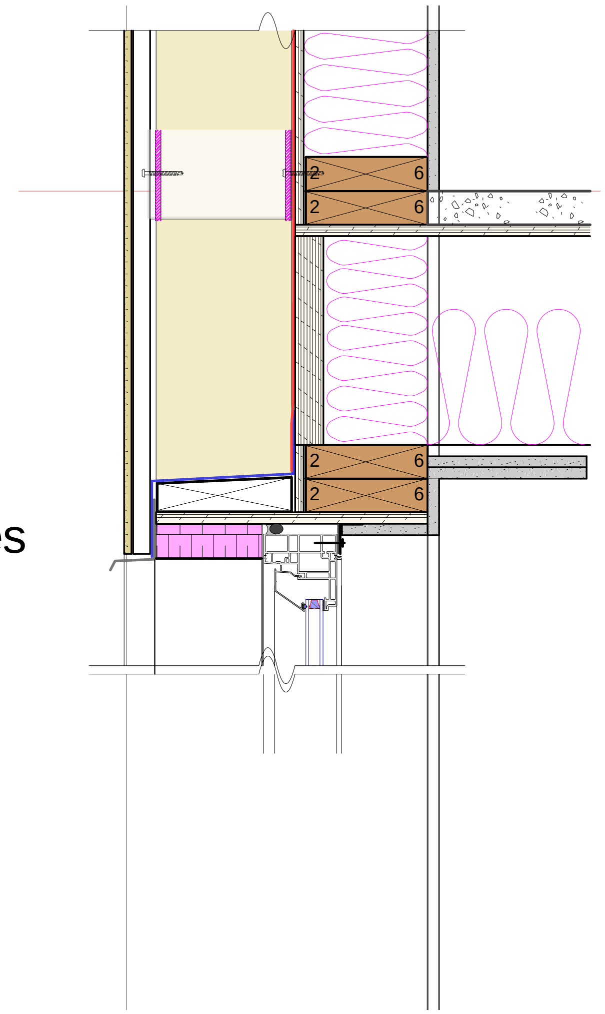
- **Advantages**
  - Interior trades progress in a typical manner
  - Cost effective
- **Disadvantages**
  - Fire spread
  - Long screw paths to the wood studs
  - Difficult to hang heavier claddings
  - Some concerns over drying potential for wood
  - Where is the moisture barrier?

    On surface of the sheathing / On exterior side of the insulation?



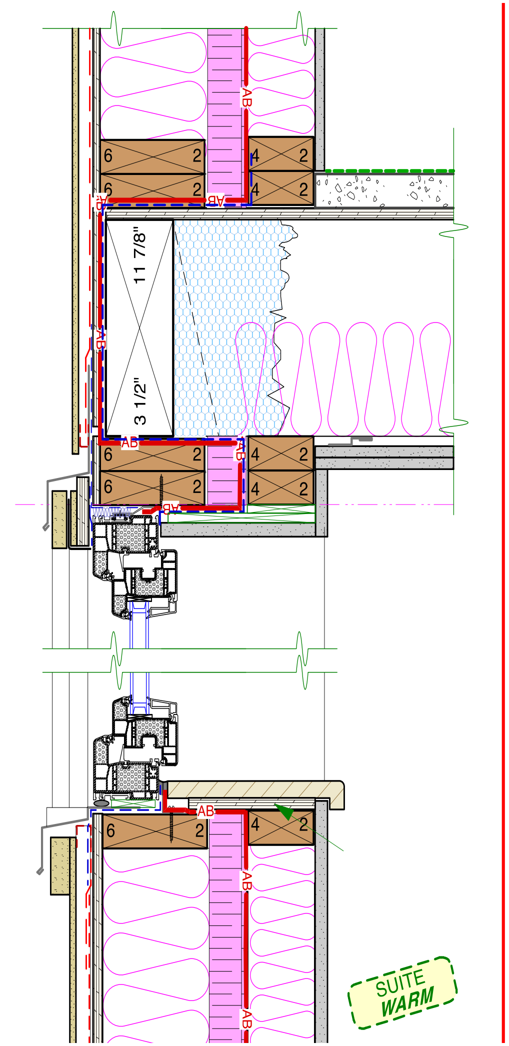
Wall Options: Roxul Exterior Insulated

- **Advantages**
  - Best Building Science for drying
- **Disadvantages**
  - Cost
  - Installation in wet weather
  - Not common knowledge for wood frame trades
  - Window details more complex
  - Difficult to install sunshades and handrails



Wall Options: Interior Insulated

- **Advantages**
  - Most of the air sealing is one trade working in dry conditions
  - Fairly conventionally framed
  - Conventional siding installation
  - Better for the wall on the property line
- **Disadvantages**
  - Interior wall awaits install of exterior moisture barrier for drying
  - Wiring will commence before the exterior wall is ready



Wall System Mock-ups

Wall System Mock-ups

Insulating on top of the cold concrete floors is very useful to deal with thermal bridging.

We used plywood over the top but concrete can be used as we did in the commercial areas.

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Framing– stage 1

Air Barrier – stage 1

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Framing– stage 2

Air Barrier – stage 2

Framing – stage 3

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Framing– stage 4

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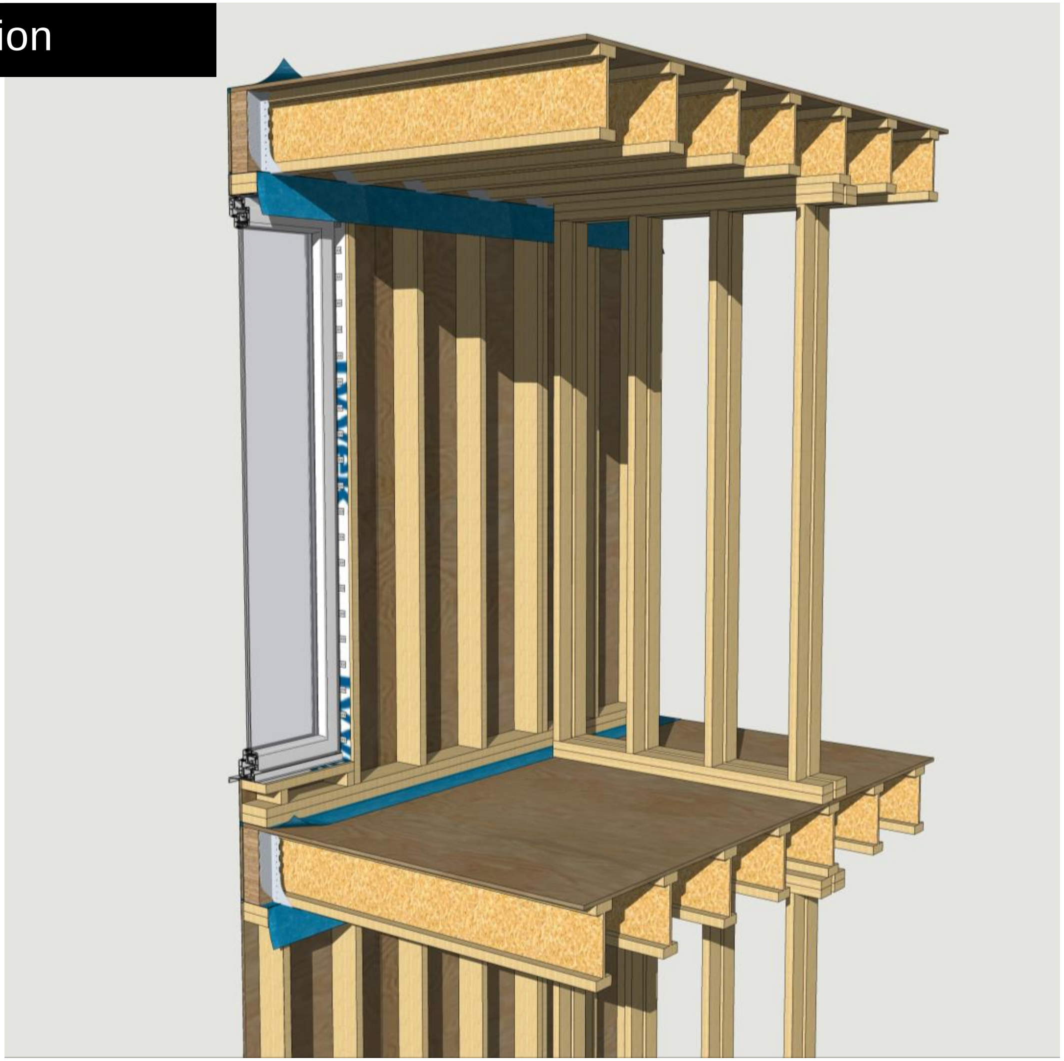
Window Installation



Insulation– stage 1

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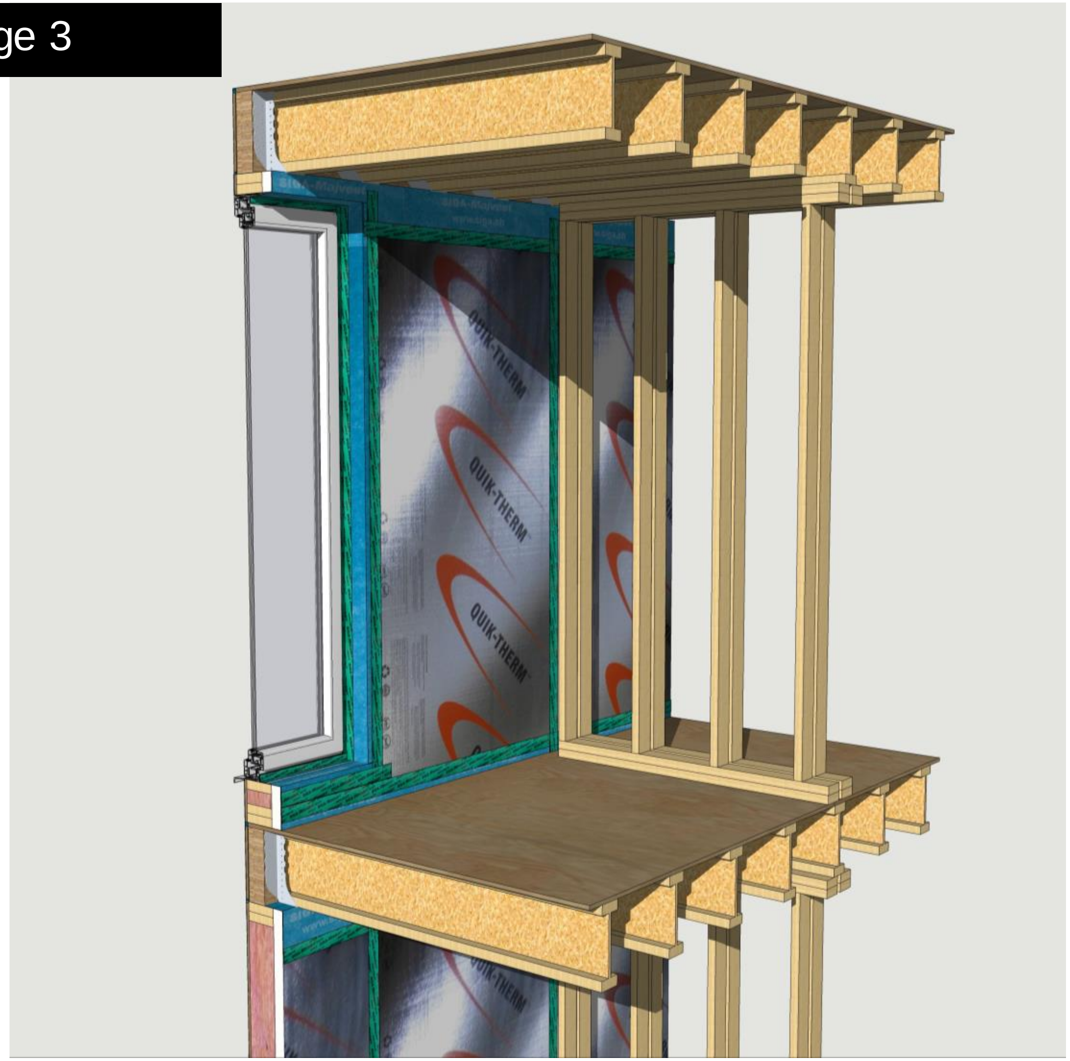
Air Barrier – stage 3



Framing – final

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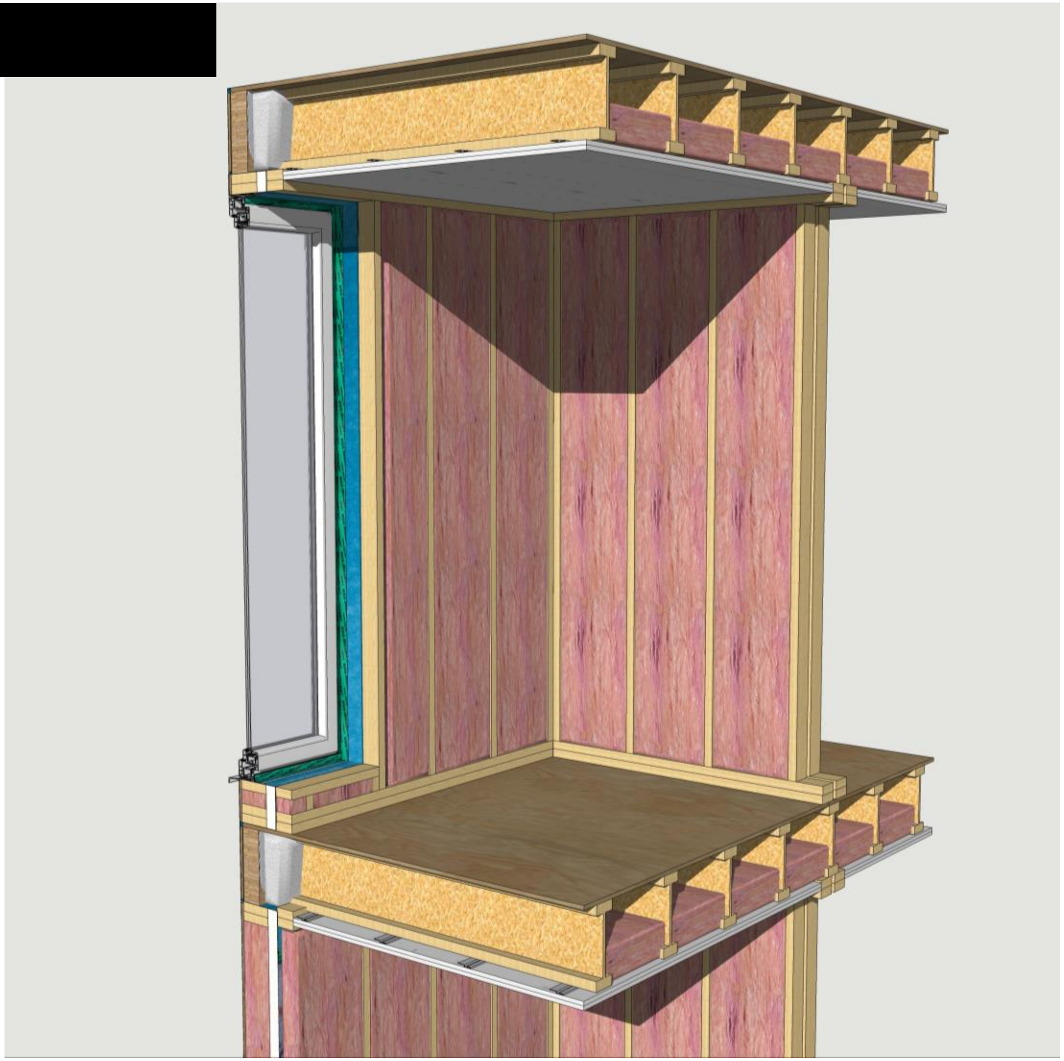
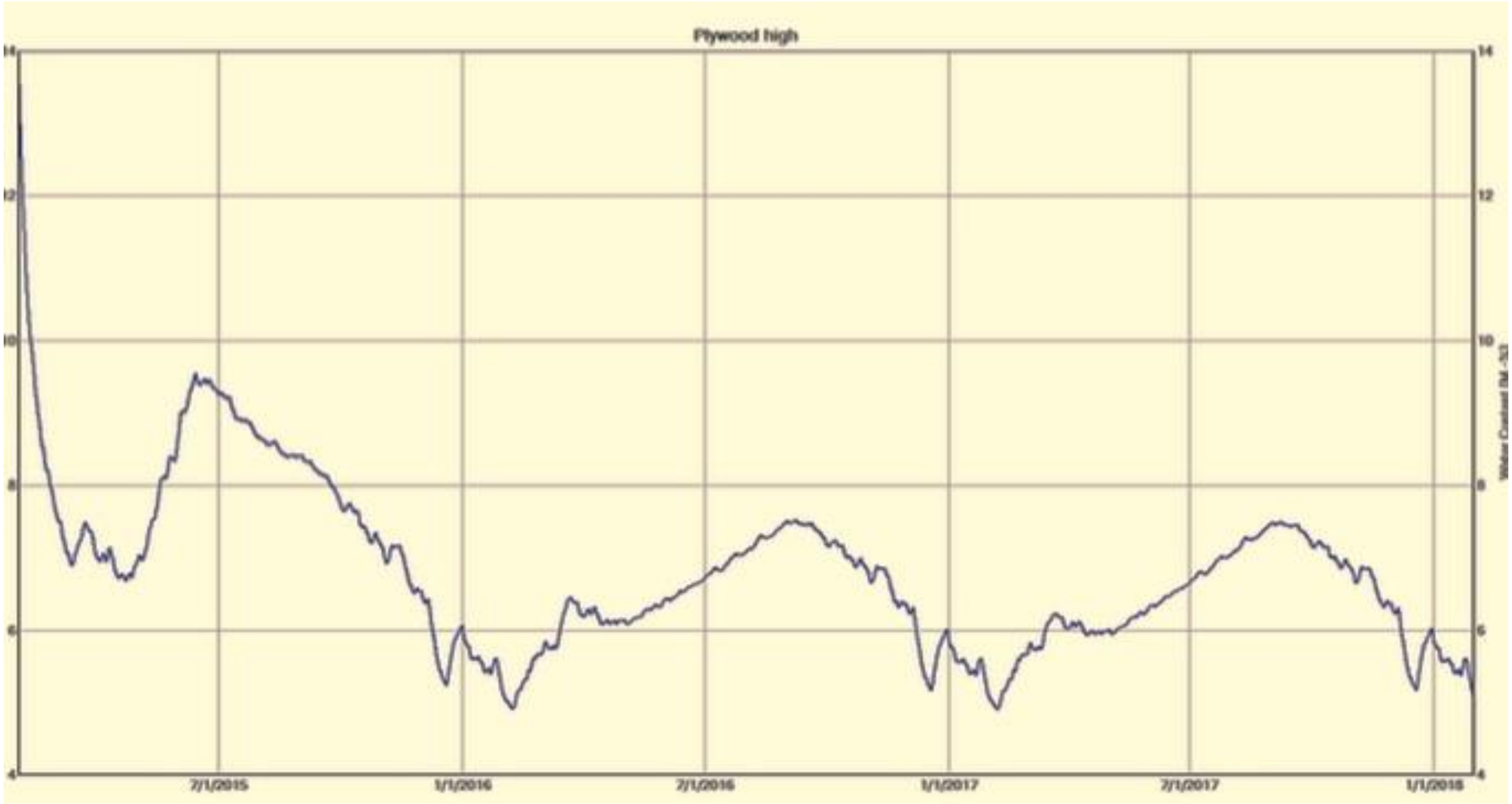
Insulation – final



WUFI analysis showed the walls will remain dry over time



Water Content:

Time:

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Exterior showing air barrier material wrapping the outside of the floors

Exterior Wall

Polymer faced Taped EPS used as the Air Barrier.

The product has been tested with portions of the polymer removed and it still performs as an air barrier.

Installation Details – Taping the Air Barrier

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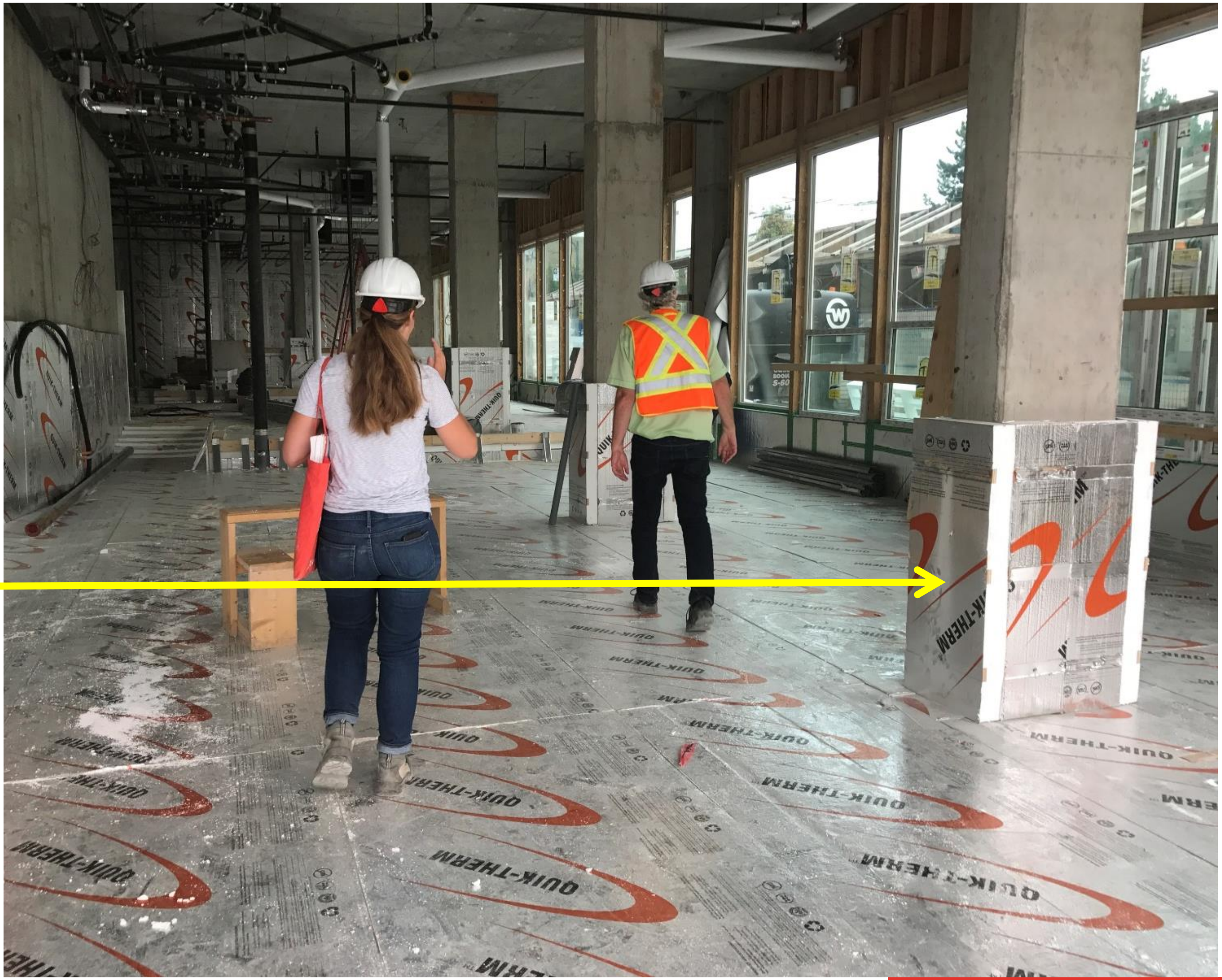
Commercial Floor over Parkade



Thermal Bridge Insulation Extension

Windows

Euroline ThermoPlus was the only locally made Passive House certified window

- Window U-values below 0.8 W/(m2.K)
  (<0.141BTU/ft2.F or >R 7.1)
- Multi-point locking for air seal
- Consideration of orientation and shading

Window Installation

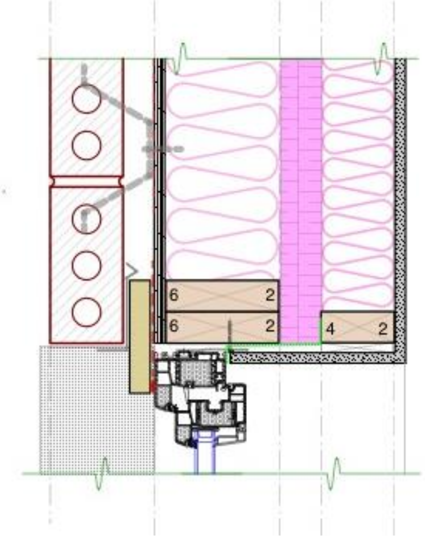
- Best thermal performance about the middle of the wall
- This project installs window at the outside face to align with the moisture barrier and takes an energy use penalty

Outboard Position:

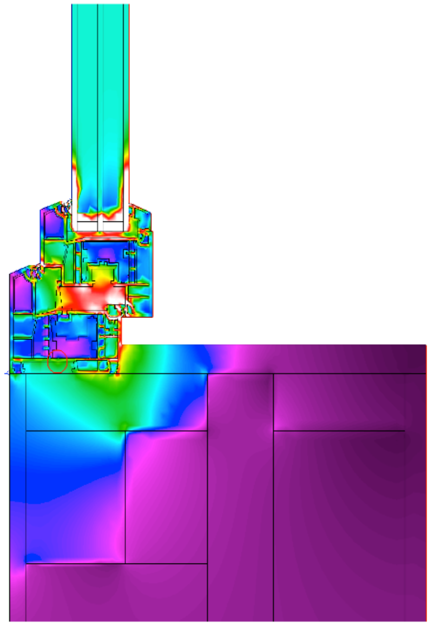
- Outboard works well with outboard moisture barrier
- Conventional for Trades

Details:

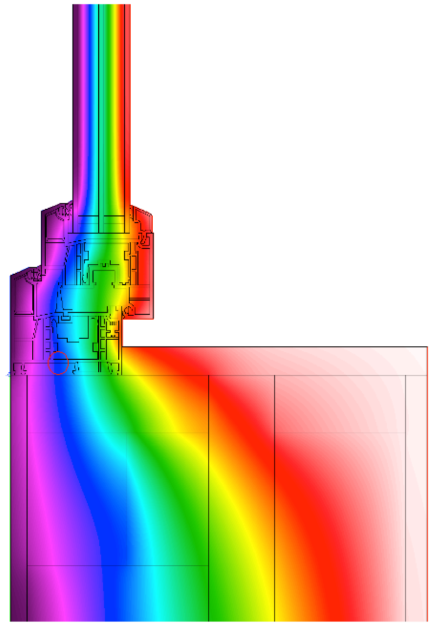
- Tie-ins to moisture layer
- Tie-ins to air barrier
- Over insulation to reduce frame losses is typical in cold climates



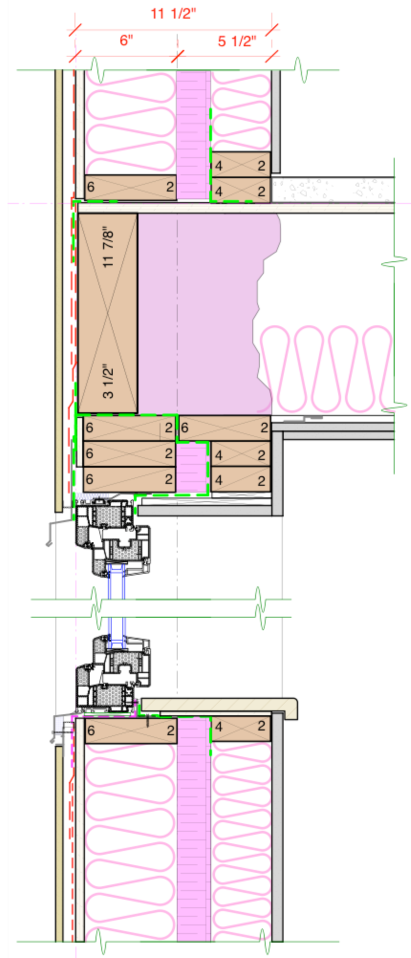
WINDOW junction



THERM Colour Flux Magnitude



THERM Colour Infrared



Junction Detail

- The Therm model shows a large offset in the temperature contours.
- It is better thermal practice to minimize the offset
- Thermal bridging performance input to PHPP – Ψ value as part of every window

Windows

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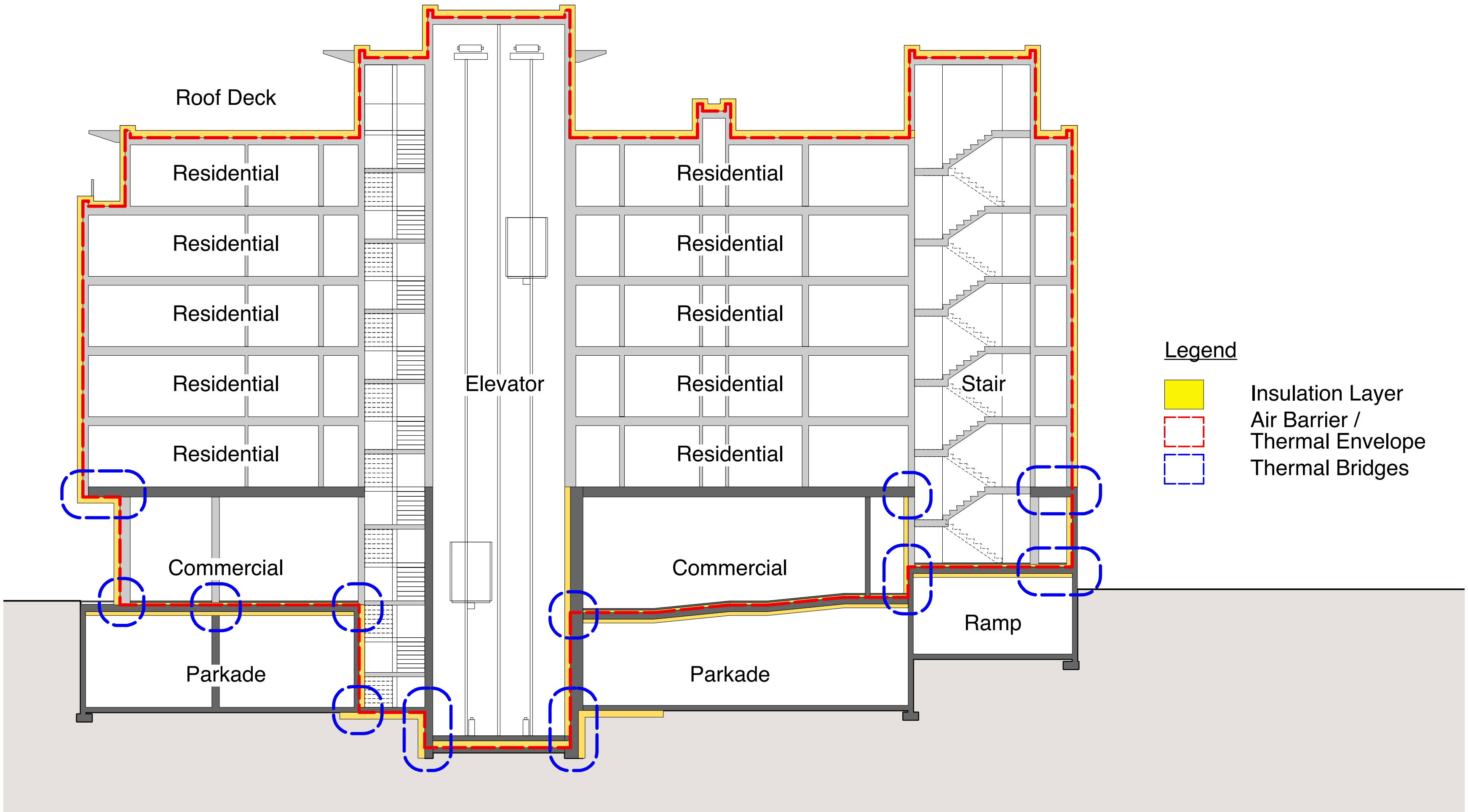
Thermal Bridges



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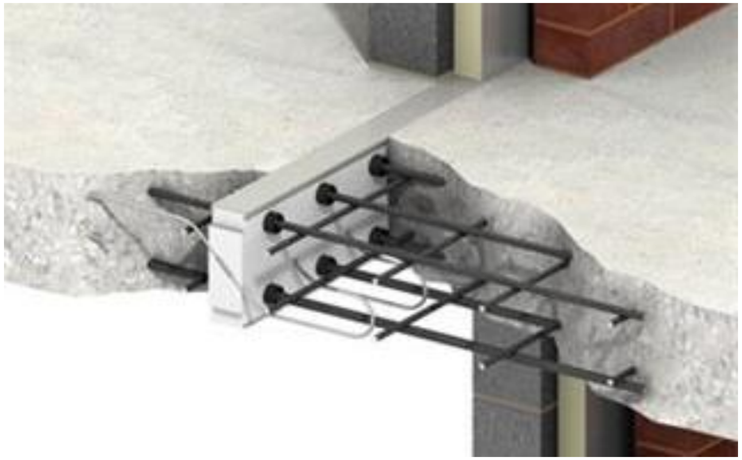
Thermal Bridges- Concrete Slabs

Concrete thermal break options:

- Concrete to Concrete thermal break connectors
- Concrete to Steel (eg. canopies) thermal break connectors
- Extended insulation installation up or down columns and shear walls



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Thermal

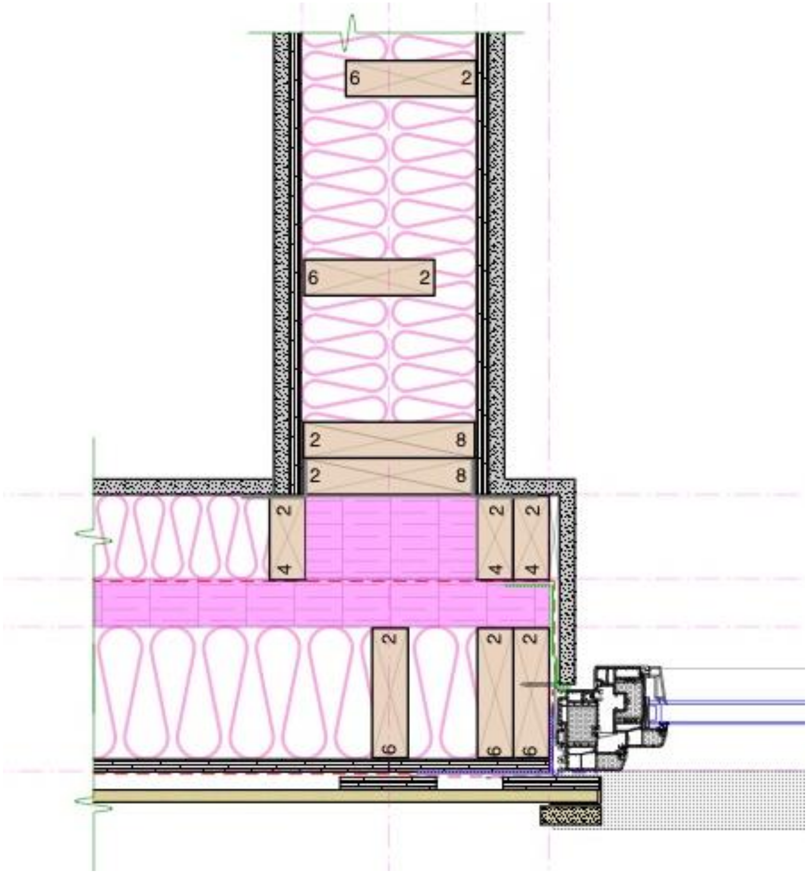
Bridges

At

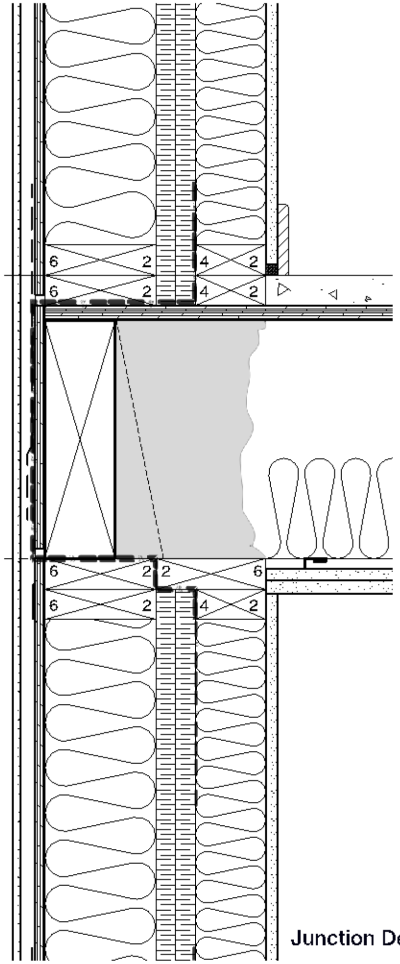
Canopy

Thermal Bridge Details

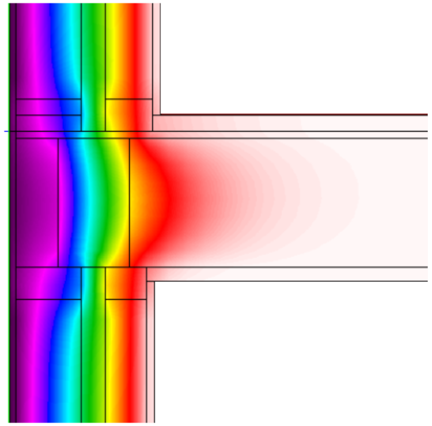
- Plan view of the Party Wall at the Exterior Wall

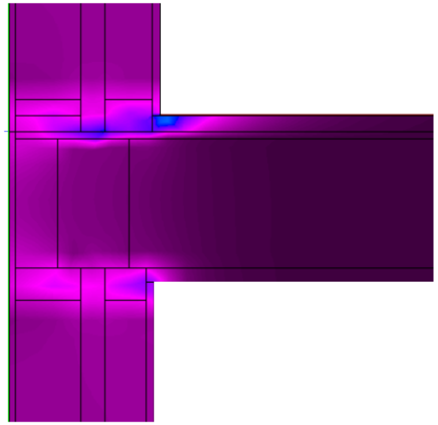


FLOOR line junction

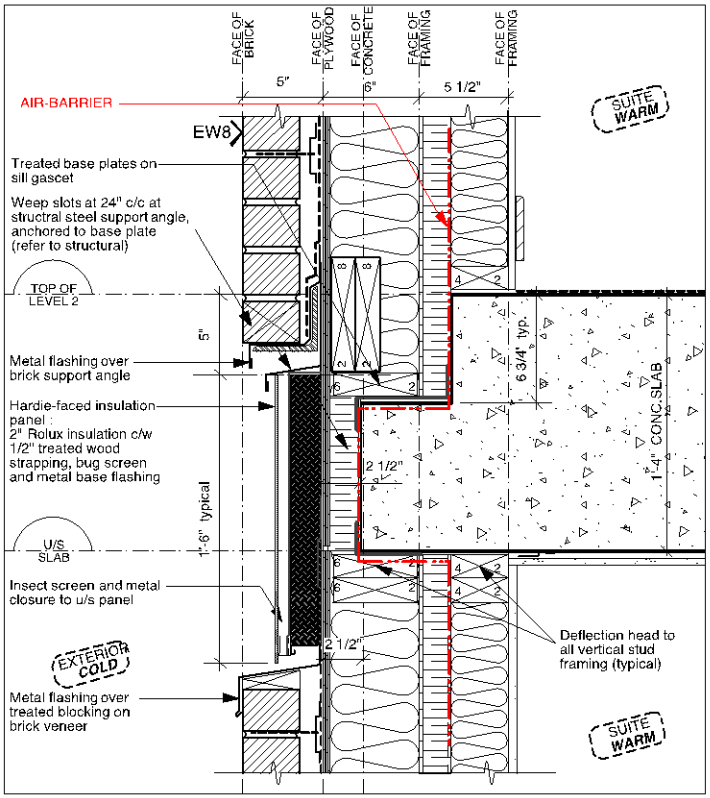


Junction Detail

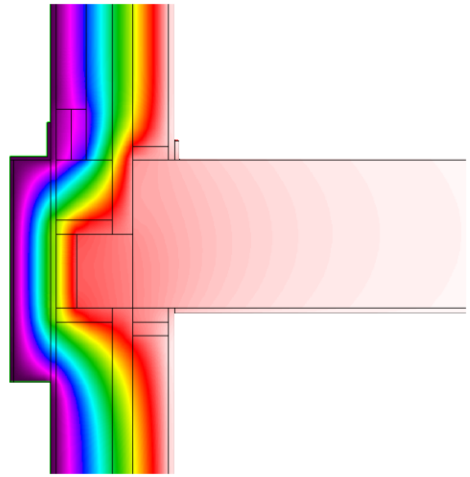

THERM Colour Infrared


THERM Colour Flux Magnitude

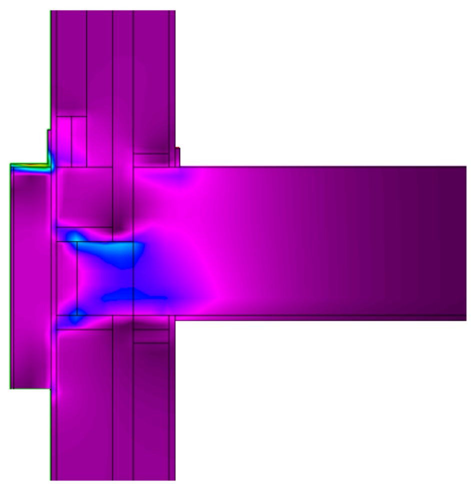
SLAB edge junction



Junction Detail



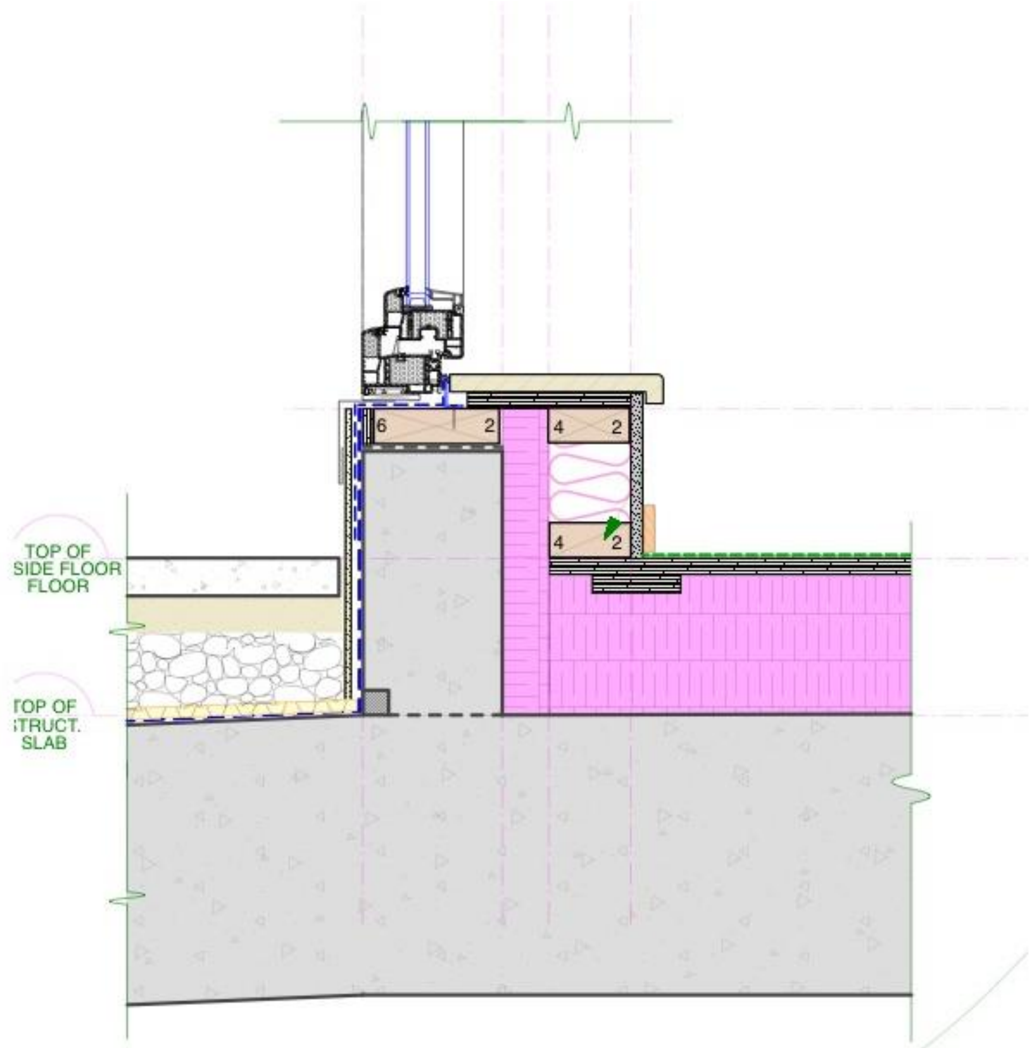
THERM Colour Infrared



THERM Colour Flux Magnitude

Thermal Bridge Details

- Edge of Cold Concrete Slab at Window

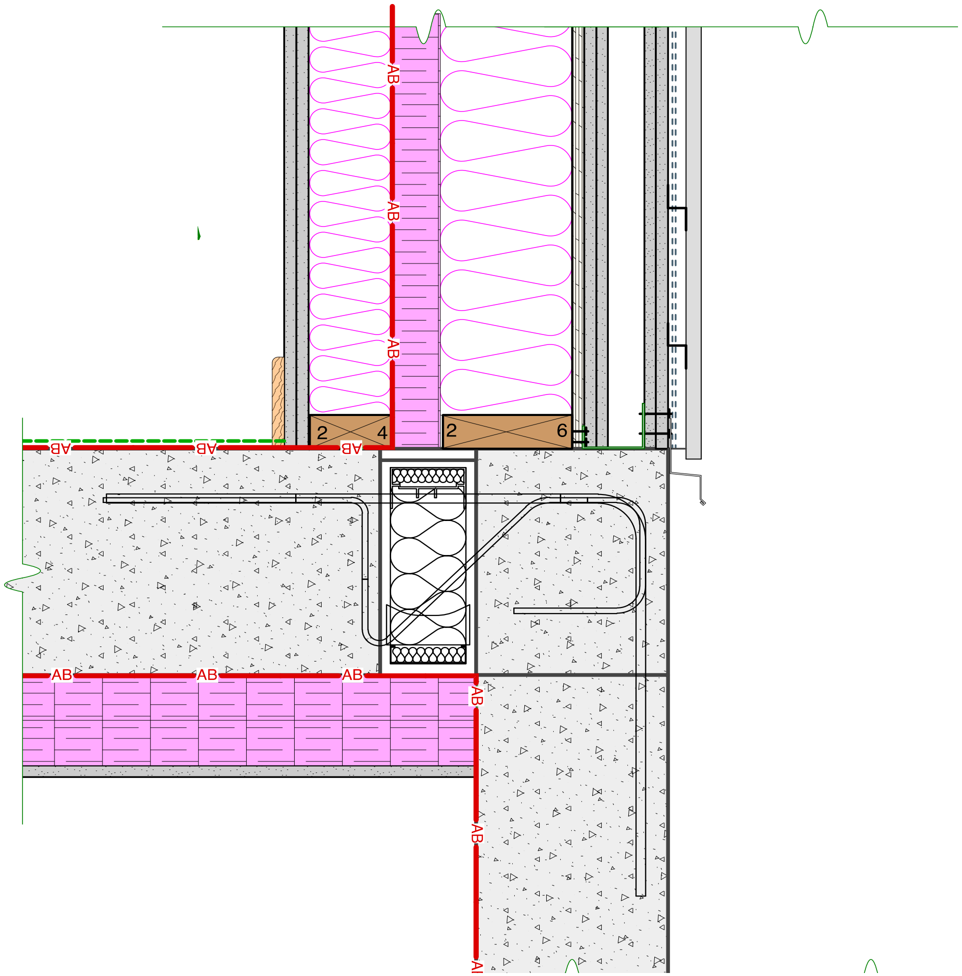


Thermal Bridge Details

- Cold Ground Floor at Planter

Thermal Bridge Details

- Isocorp at Exterior Property Line Wall

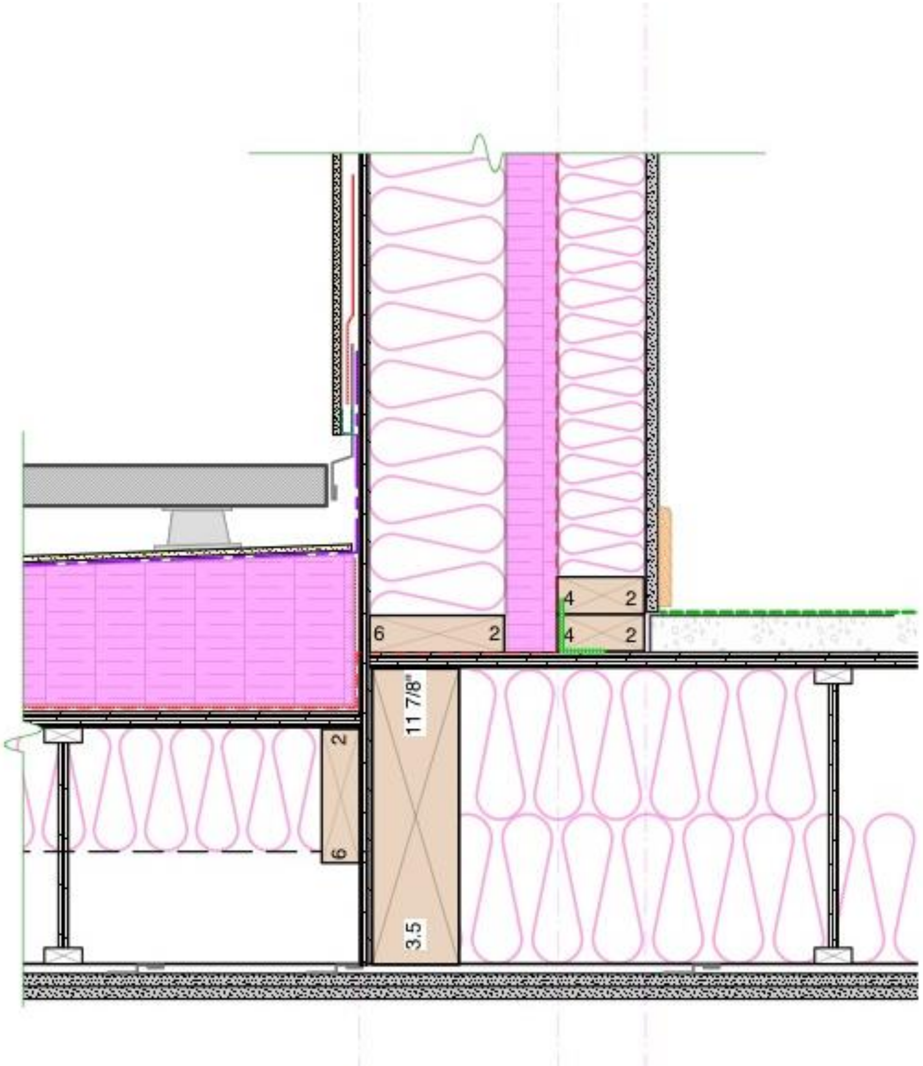


Thermal Bridge Details

- Insulation extending 4' into the warm space at shear walls to reduce the thermal bridge effects

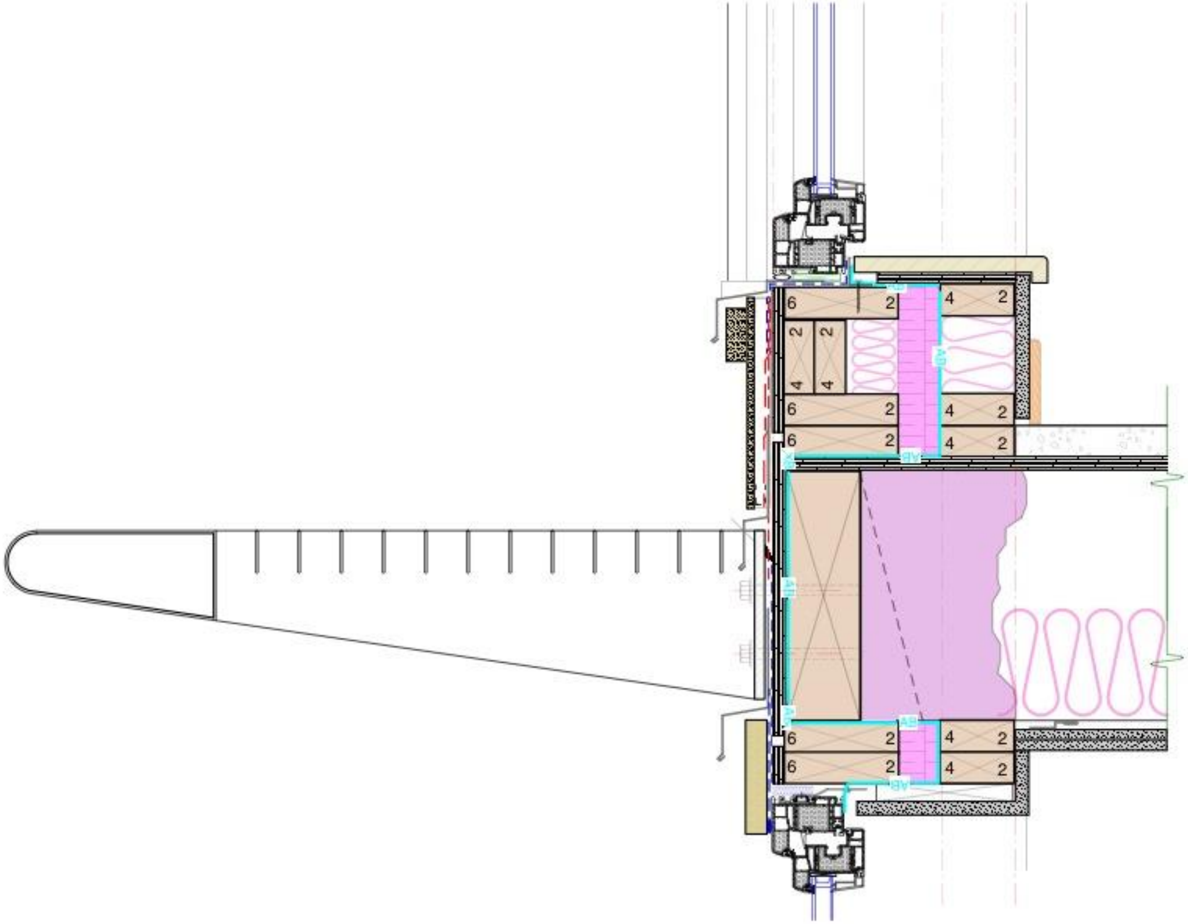
Thermal Bridge Details

- Transition to Balcony over Warm Space



Thermal Bridge Details

- Sunshade Detail



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Sunshades

Thermal Bridge Details

Wood Thermal Breaks at Steel supporting Brick

Slots in Elevator Lobby Floor

Formwork Thermal Bridge

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Air Tightness Test:

- Depressurization test @ 50 Pa
- Pressurization Test @ 50 Pa
- Result is the average
- Windows, doors and hardware causing leaks

0.29 Ach/hr

Q50 = [0.63 m3/(h/m2)]

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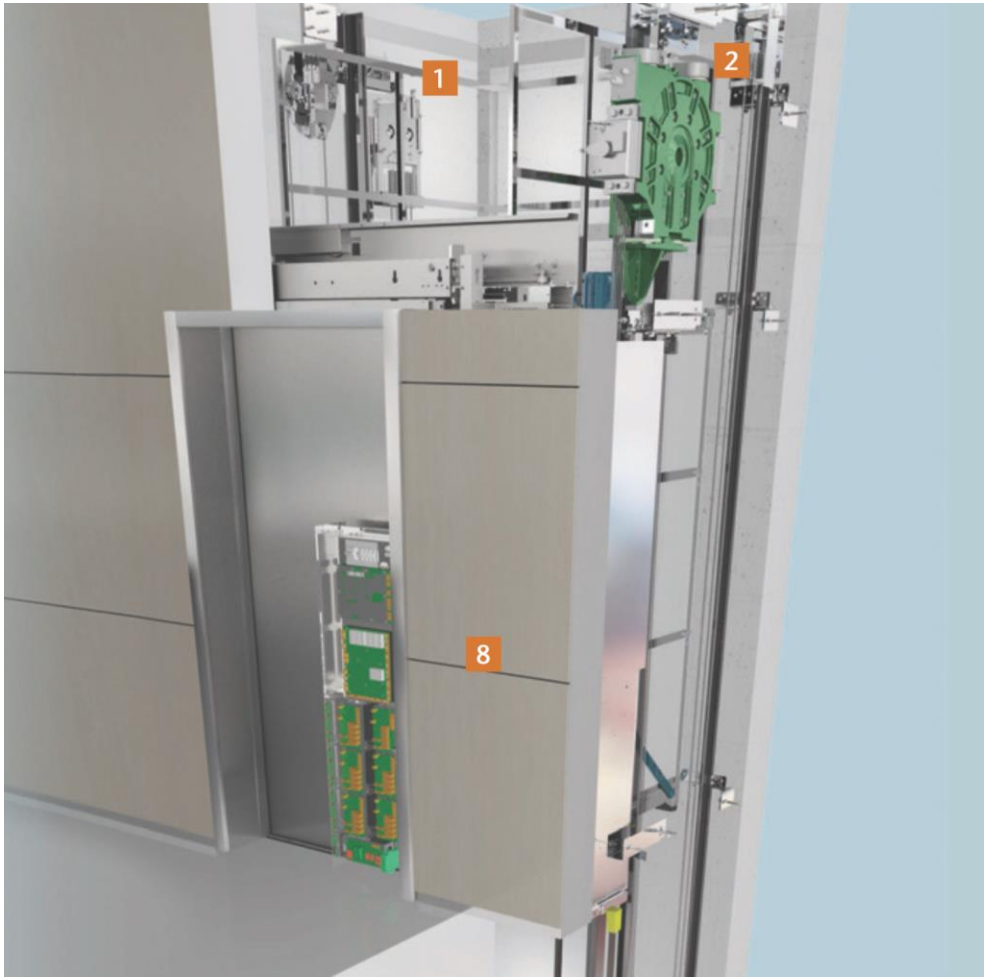
Elevator

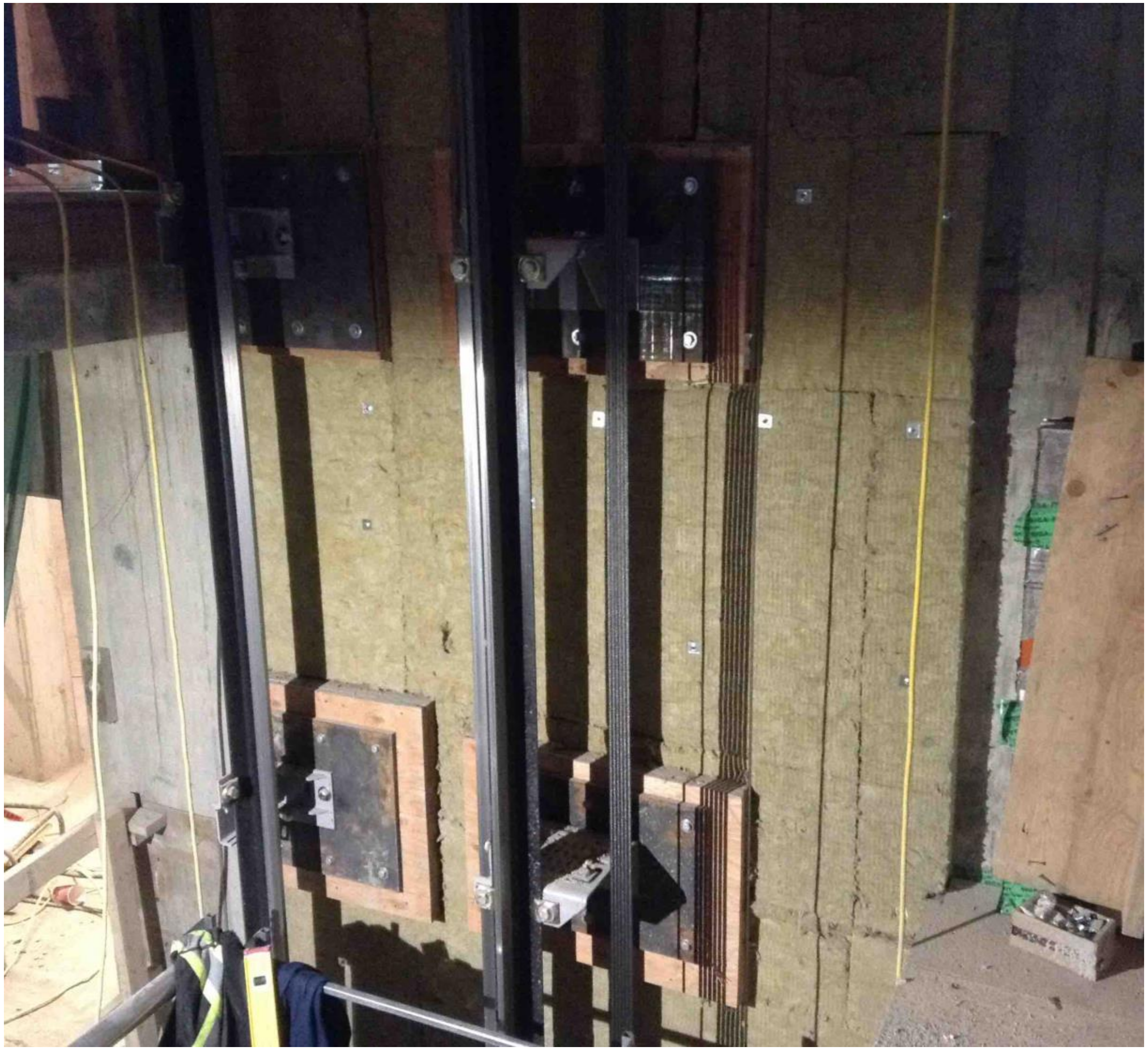
- Low Standby Power Consumption
- Efficient Motors
- Regenerative Braking



Elevator

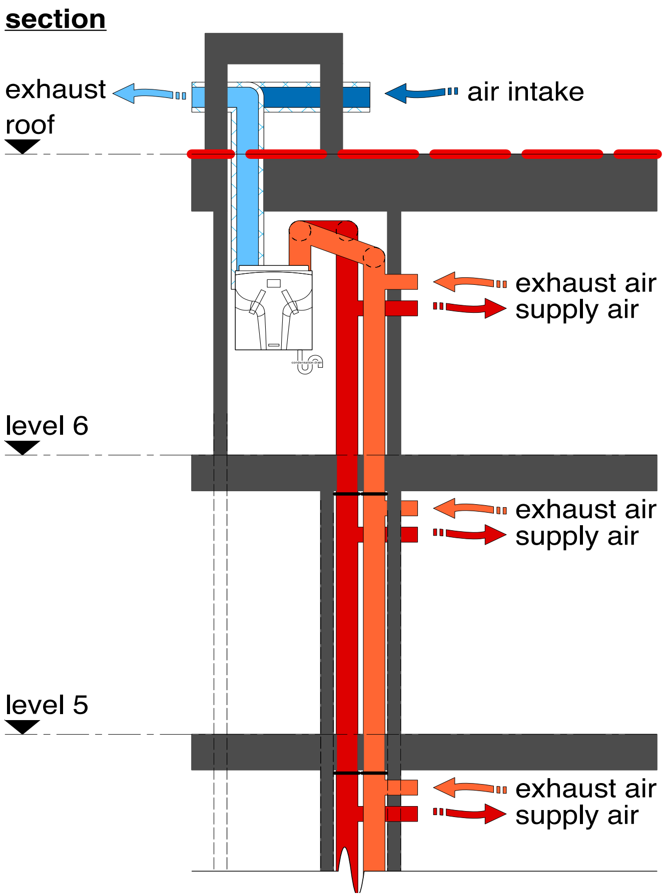
Elevator shaft insulated inside with Rockwool at the parkade.

All components thermally isolated with 4” blocks of wood



Ventilation

- Heat Recovery ventilation is essential with efficiencies in the order of 80-90%
- We looked at 4 ideas
- Central system
- Distributed system by unit
- Distributed system by room
- Semi-central system



Semi Central Ventilation System

- Zehnder ComfoAir 550
- 90% heat recovery
- Located off the common corridor to facilitate maintenance

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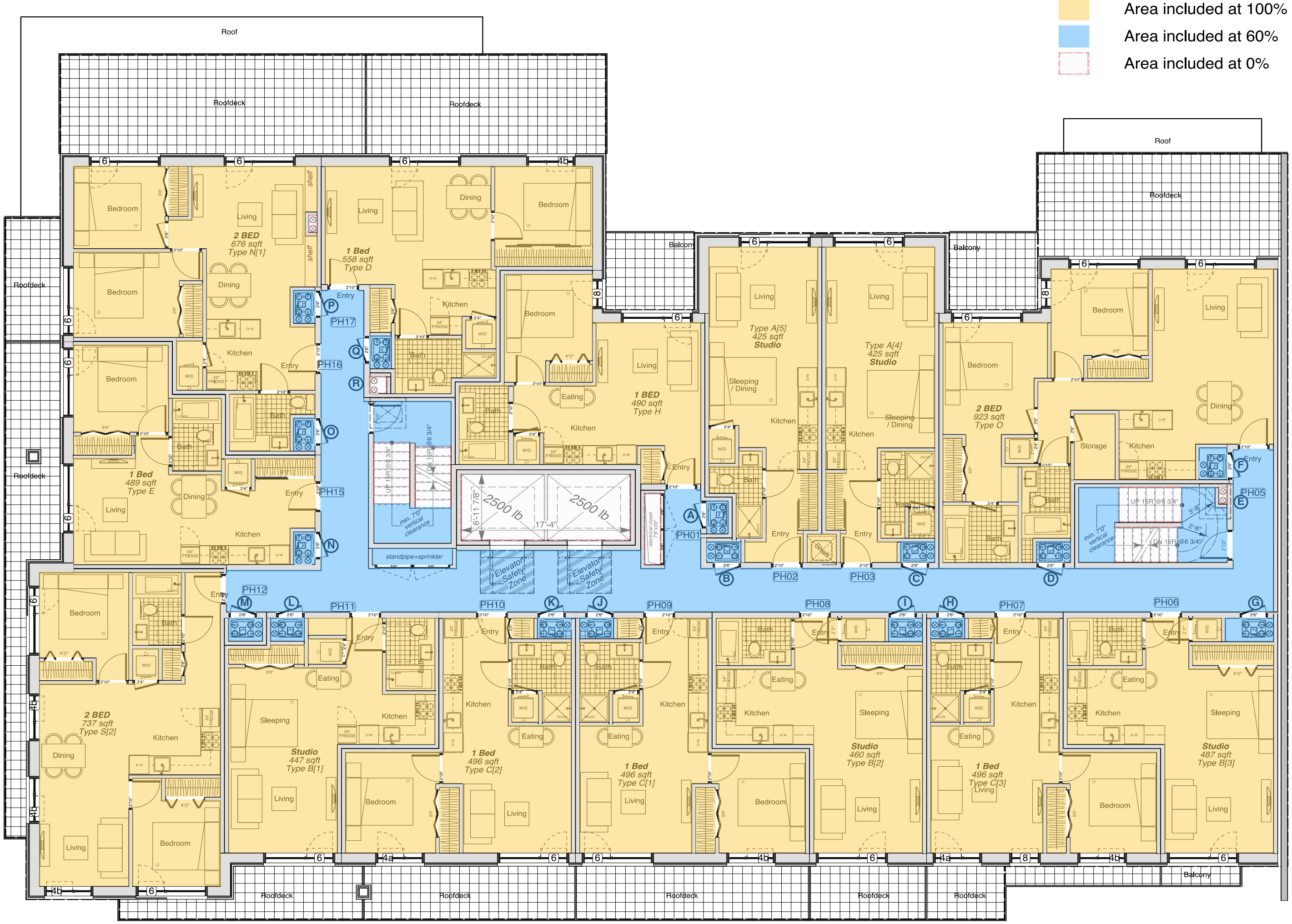
HRV Strategy – Level 6 Plan

Legend

- Area included at 100%
- Area included at 60%
- Area included at 0%



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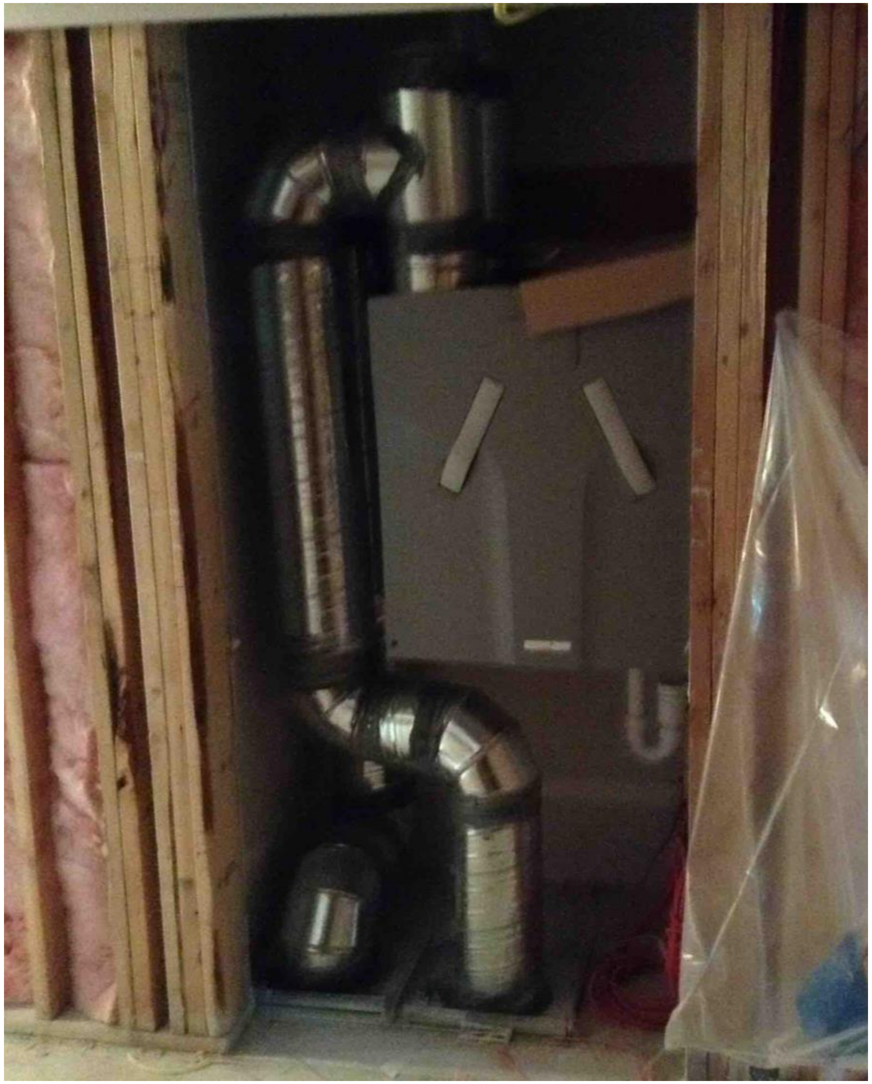
HRV Strategy

HRV Closet

Fire damper access from hall



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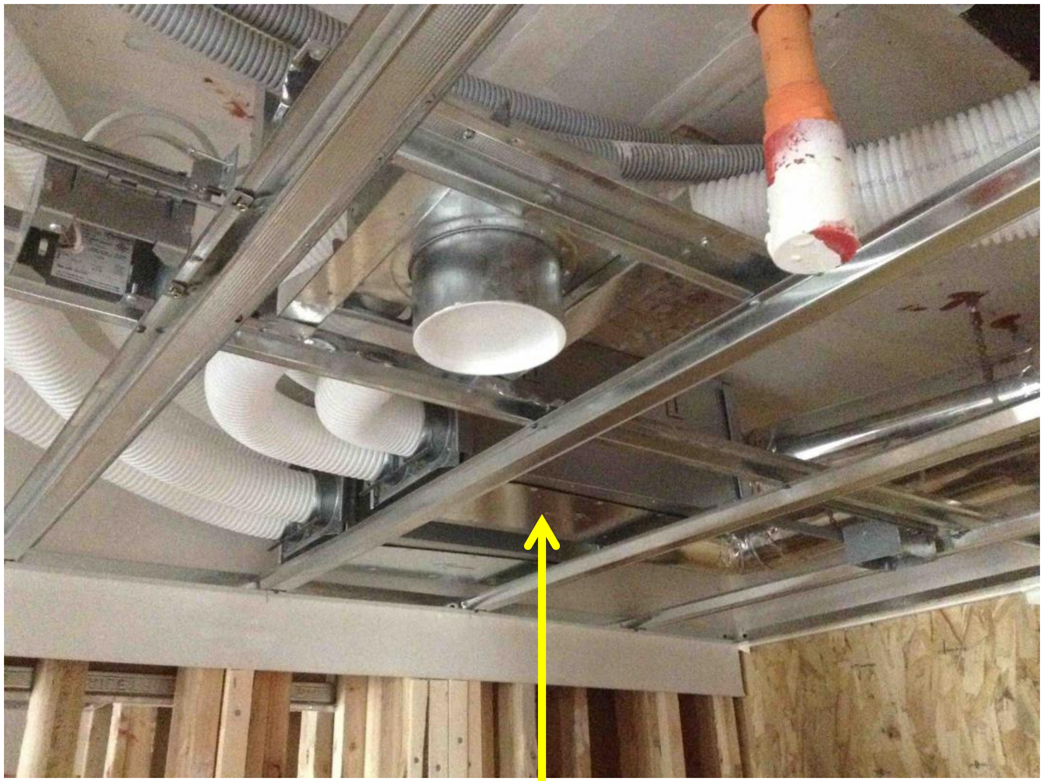
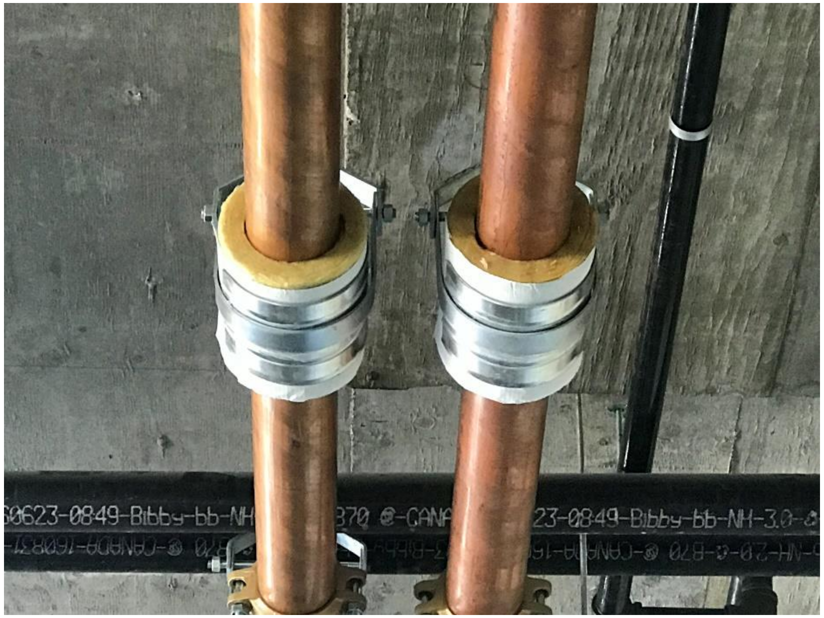
Suite Air Distribution

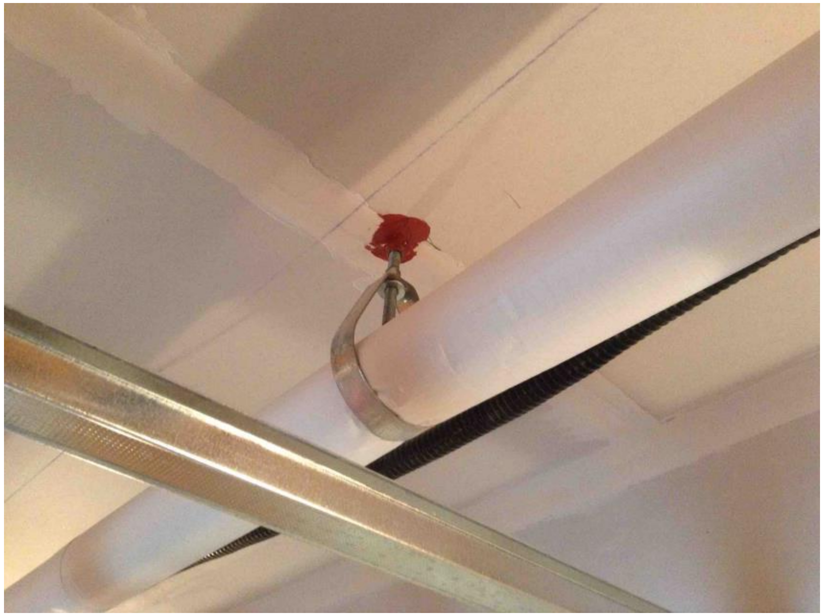


Silencer

Hot Water Strategy

- 95% Efficiency Gas Fired Hot Water Generation
- Minimized Hot water Recirculation lengths
- Well insulated and detailed hot water circulation





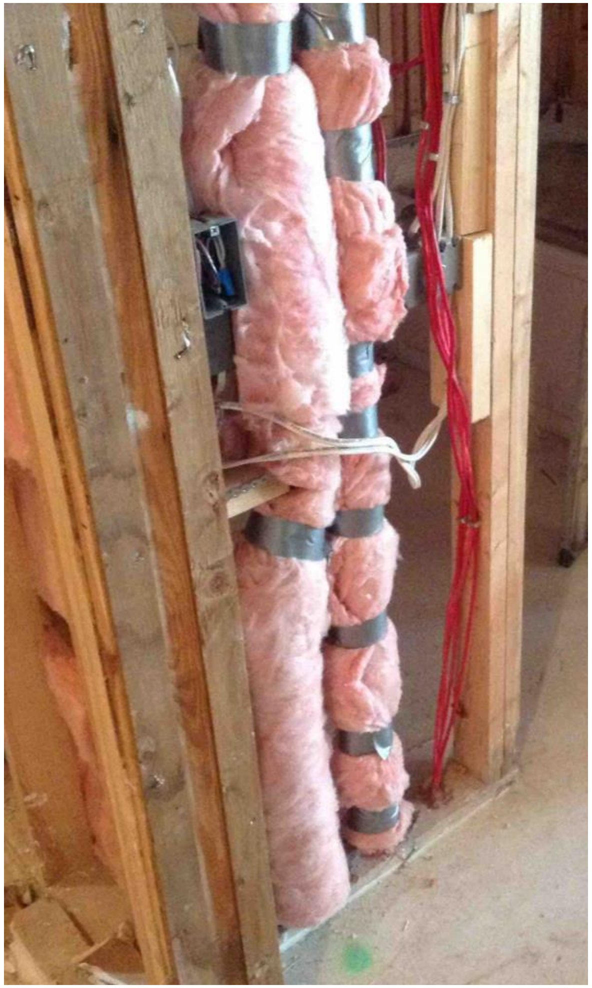
Hot Water Strategy

Plumbing Vents can cause significant losses though convection.

The best solution is to install air admittance valves.

In the Heights we ended up insulating all the vent stacks as the we were not aware of the need until part way through construction.

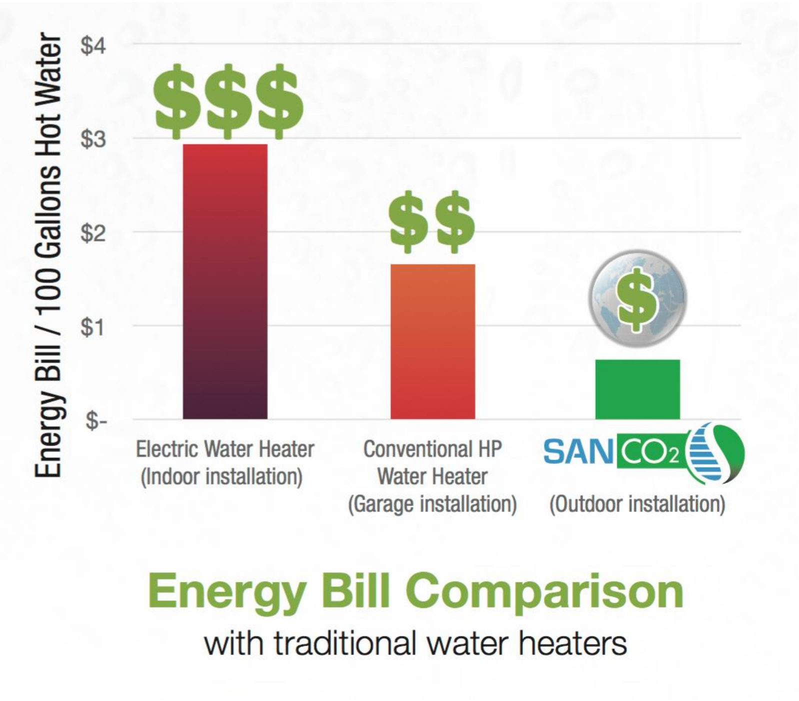
Insulated Hot Water Header



Insulated Plumbing Vents

New Hot Water Strategy

- **Sanden CO2 Based Heat Pumps**



Appliances

Dryers are heat pump type and not vented to the exterior.

Range hoods are recirculating type with a low Sone Rating and charcoal filters.

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Objectives, Major Monitoring Items

- To provide *in-situ* performance data on
  - Environment (T, RH, CO_2) in 7 suites (S, N, W)
  - Durability performance of exterior walls (S, N, W) and roof (1 roof, 1 roof deck)
  - Vertical movement of exterior/interior walls below a roof/roof deck
- Measurements aimed to show general trends

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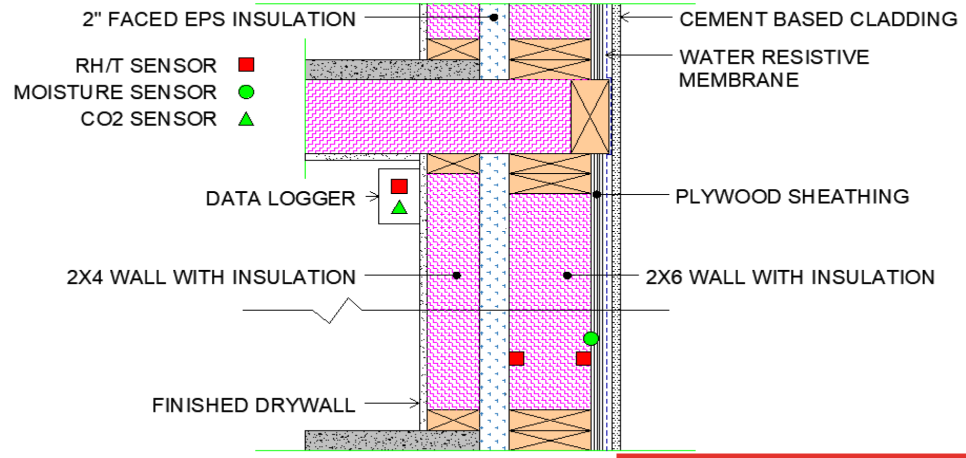
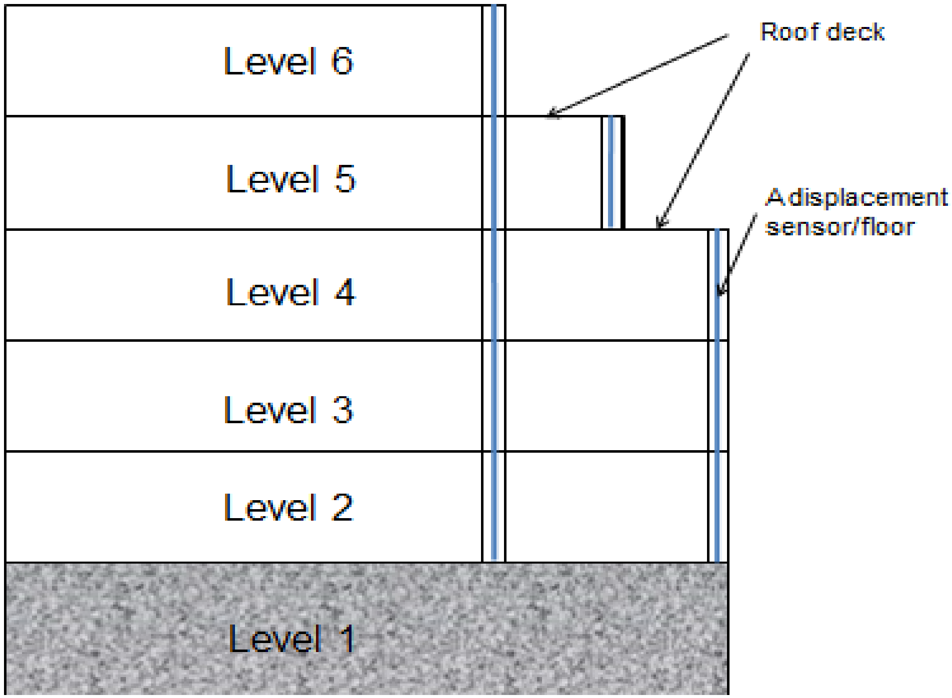
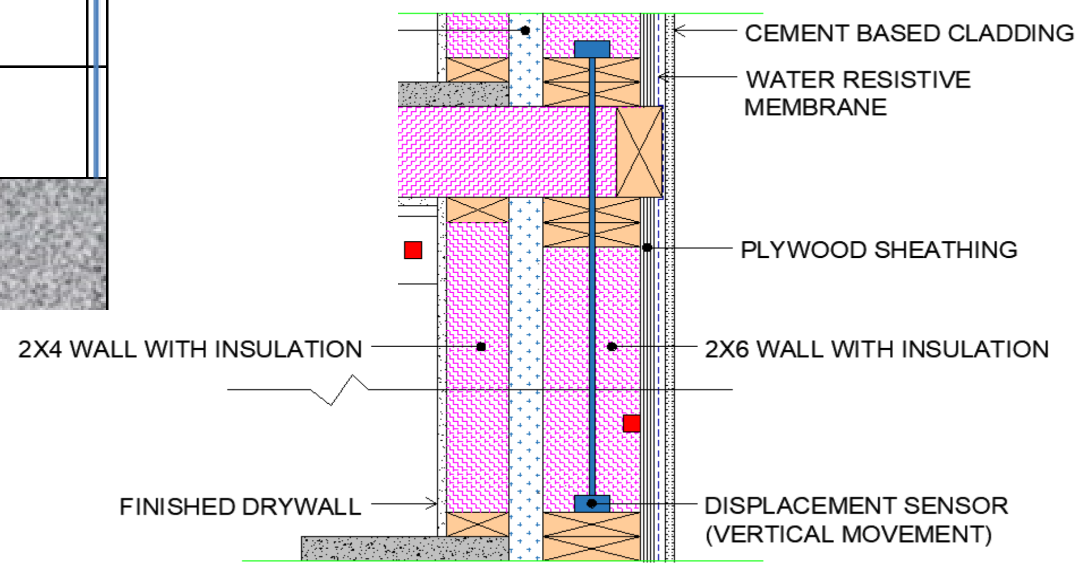
Instrumentation: Indoors and Envelope

Location in building	Sensors installed
South-facing wall and indoors, on floors 2, 4, and 6 North-facing wall and indoors, on floors 2, 4, and 6 West-facing wall and indoors, on floor 4	RH/T at plywood, foam sheathing, and indoors
	Moisture sensor in plywood sheathing, stud
	Indoor CO_2
Roof deck, on floor 4 Roof, on floor 6	RH/T at roof/wall sheathing
	Moisture sensor in roof/wall sheathing



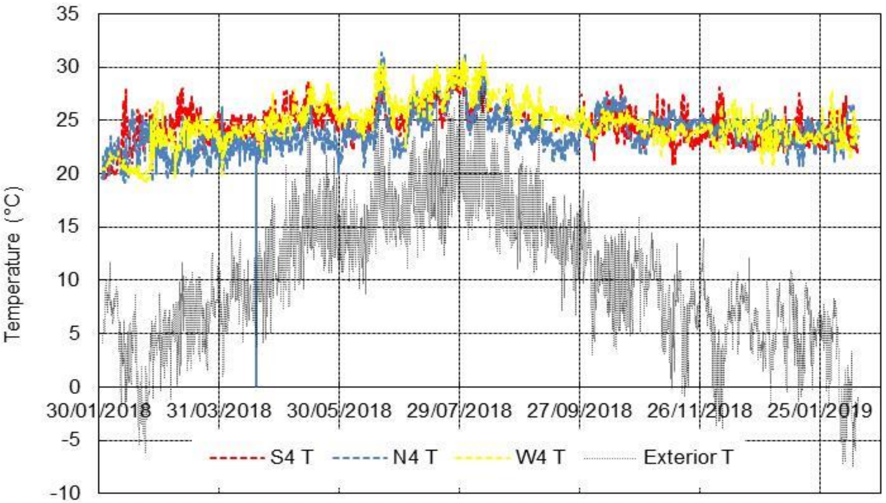
Instrumentation: Vertical Movement





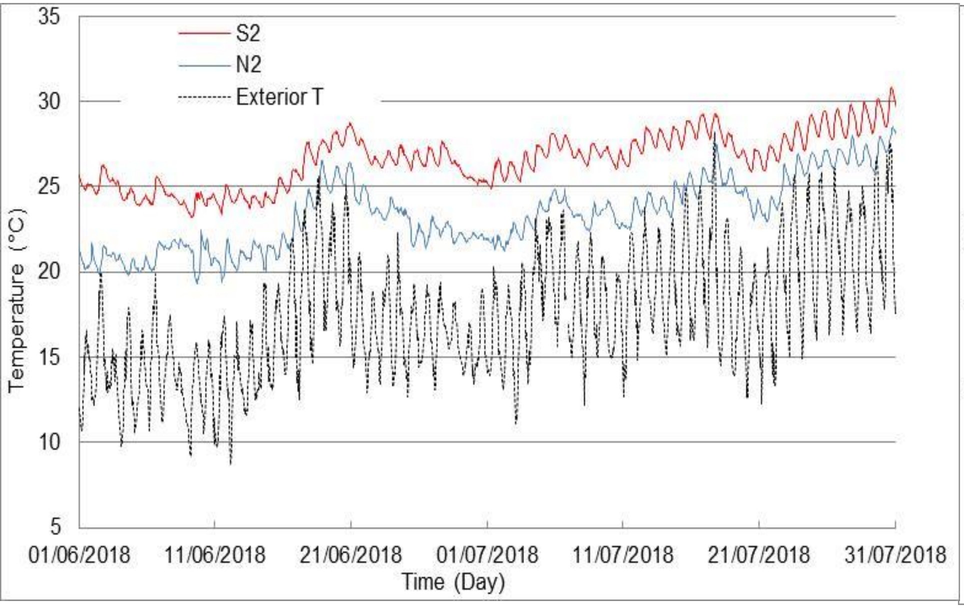
Indoor Temperature

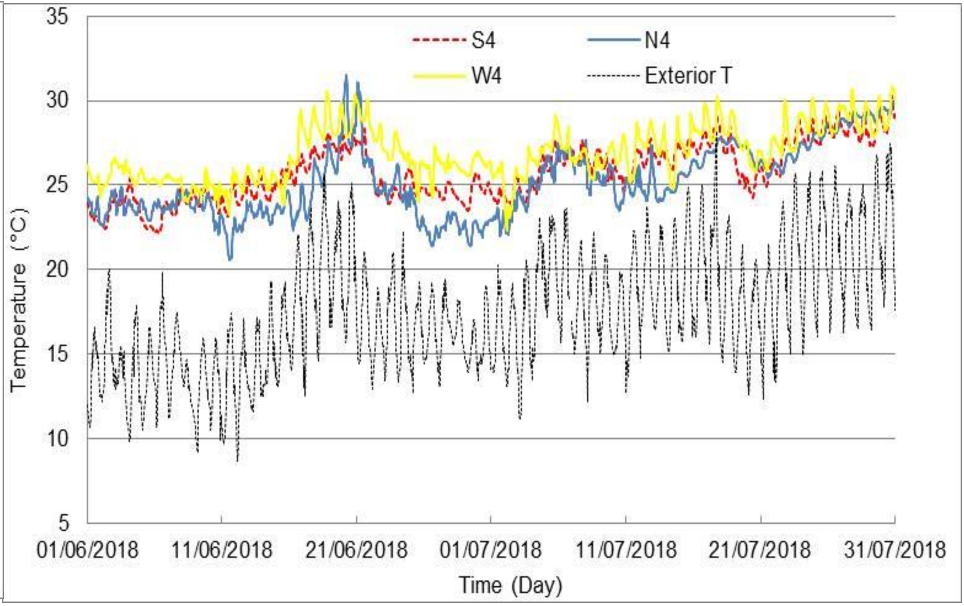
- Winter: overall 20-25°C
  - South-facing and west-facing suites showed higher indoor T
  - Often exceeded 28°C in south-facing suites in Feb. and Mar.
- Summer: slightly higher, sometimes exceeded 30°C



Indoor Temperature

- Overheating criterion
  - Passive House: no more than 10% of hours should exceed 25°C in a given year





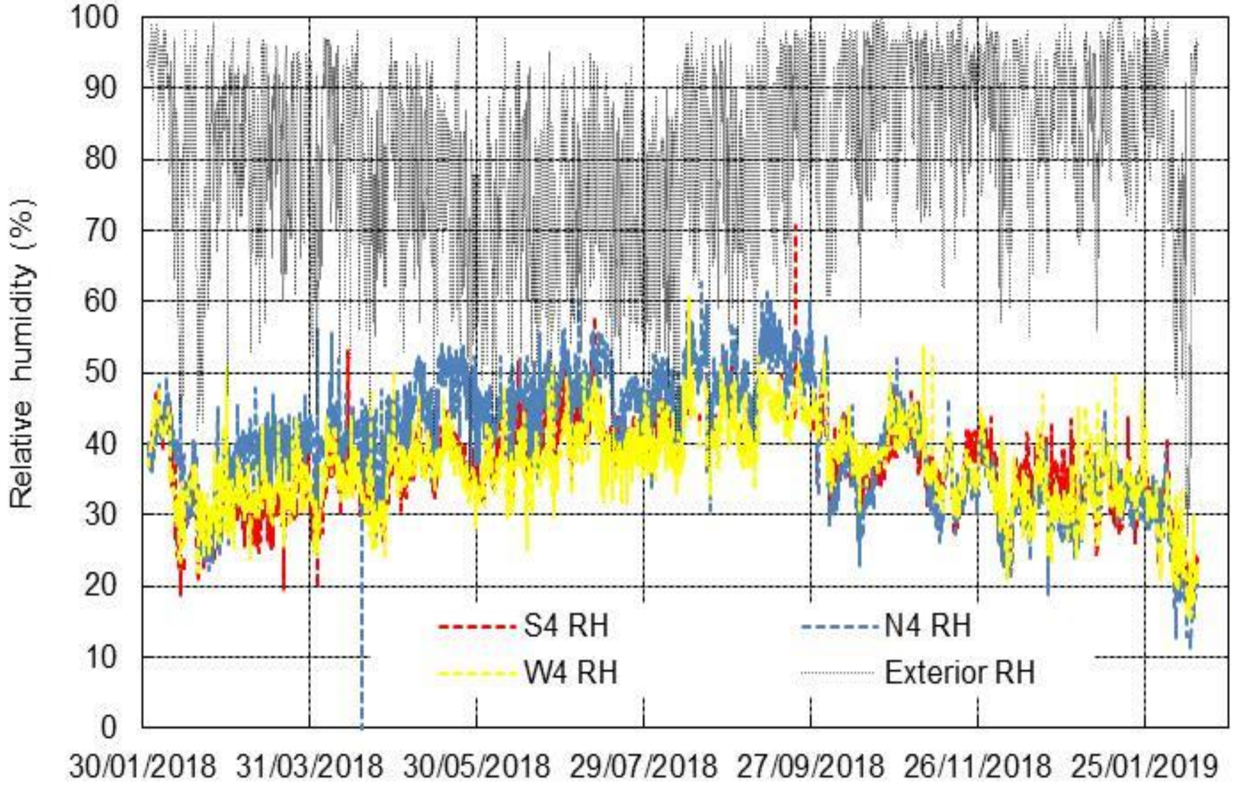
Indoor Temperature

- Six out of seven suites showed overheating
  - Based on measurements from Feb 2018-Jan 2019

Suite	Percentage of hourly T > 25°C (%)
S2	35
N2	8
S4	38
N4	22
W4	42
S6	15
N6	29
Exterior	0.77

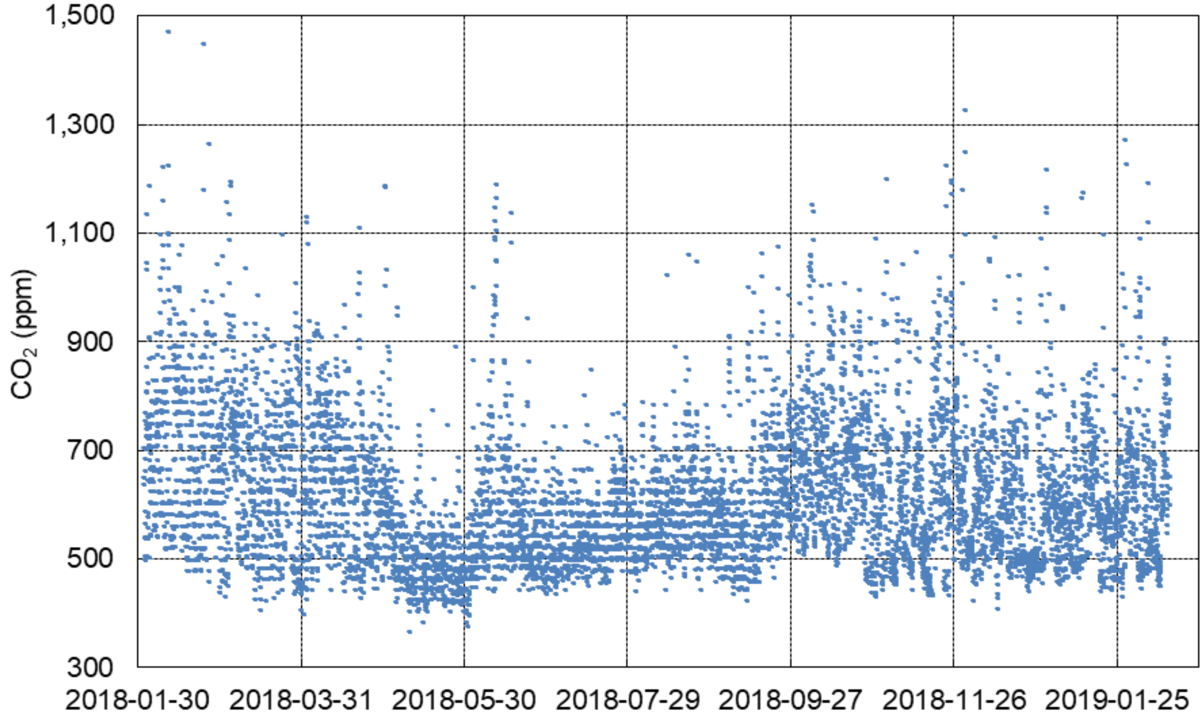
Indoor Humidity

- Winter: 25-45%; summer: 35-55%
  - RH tended to be slightly higher in north-facing suites



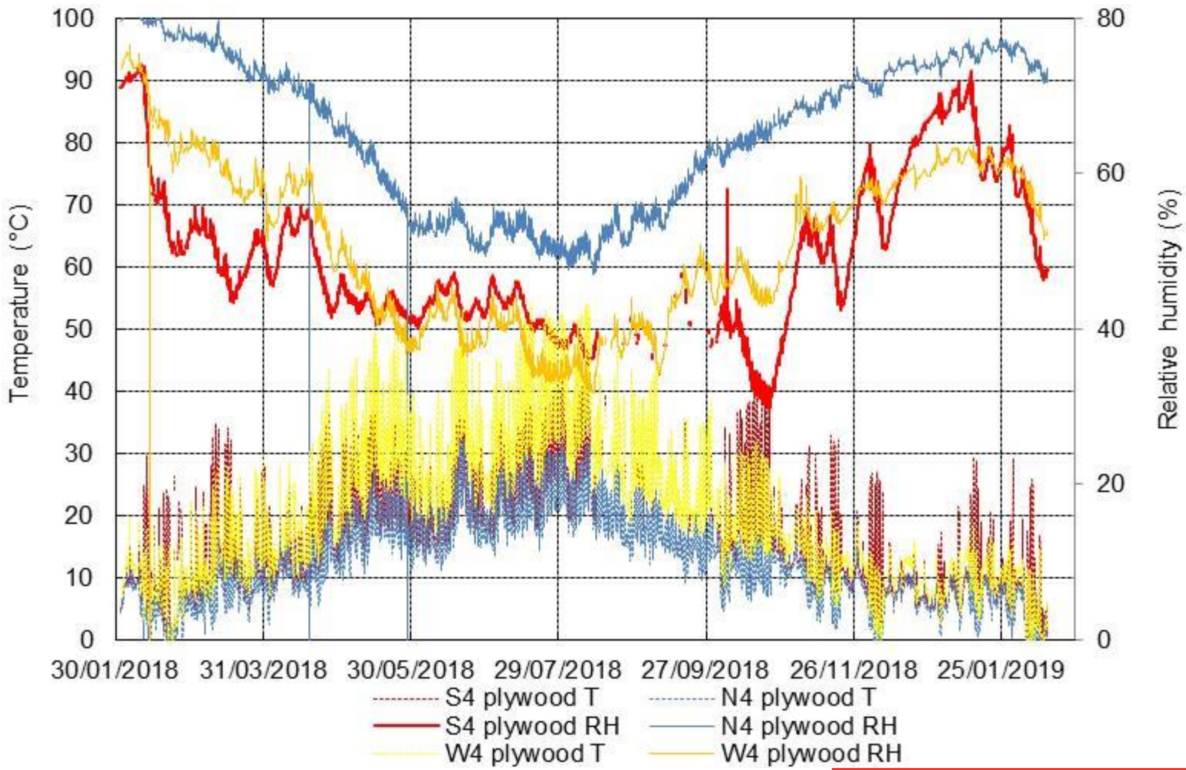
Indoor CO_2

- Measurements in living rooms of 7 suites
- Majority of hourly CO_2 below 1000 ppm
  - A commonly acceptable level



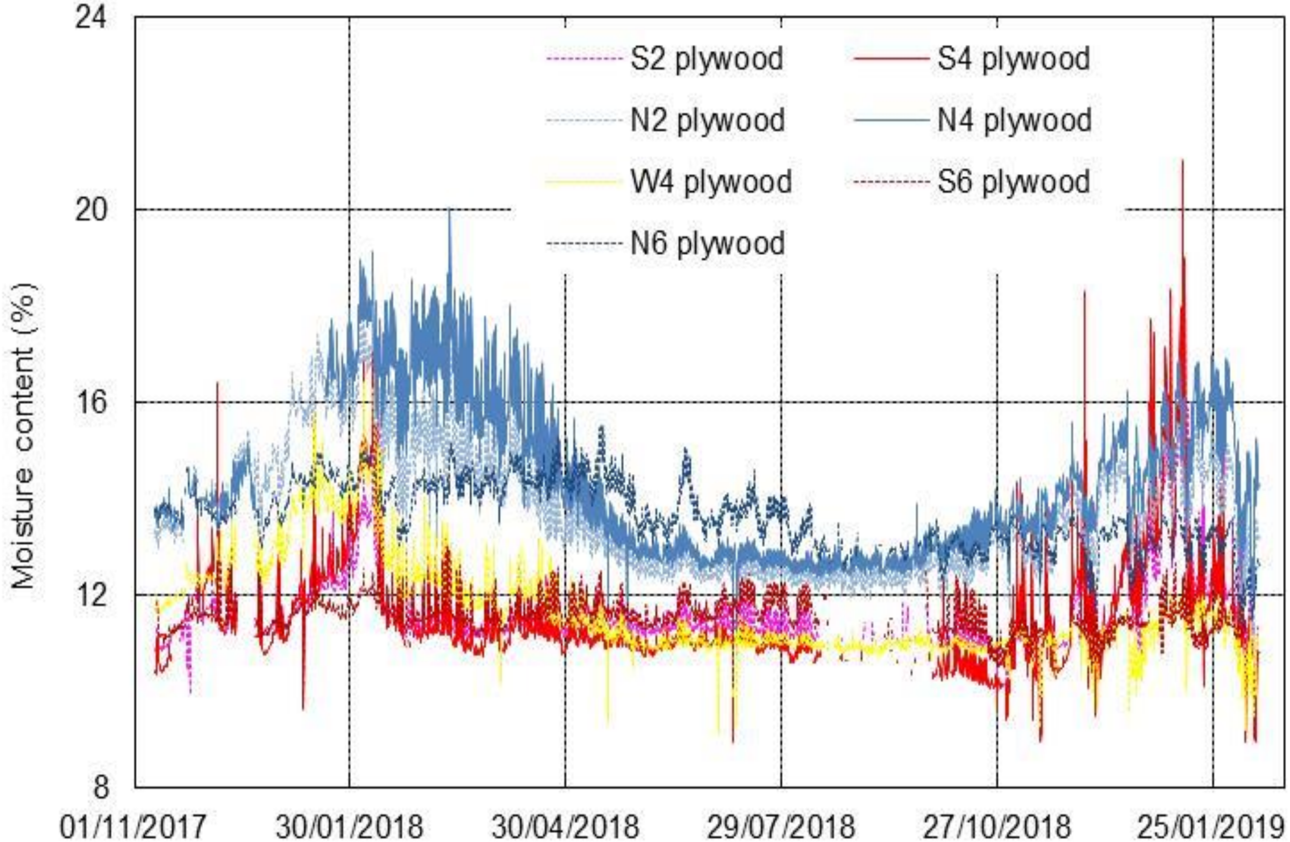
Envelope Performance: RH at Sheathing

- North walls showed lower T and higher RH at exterior sheathing
- RH below 80% throughout the year



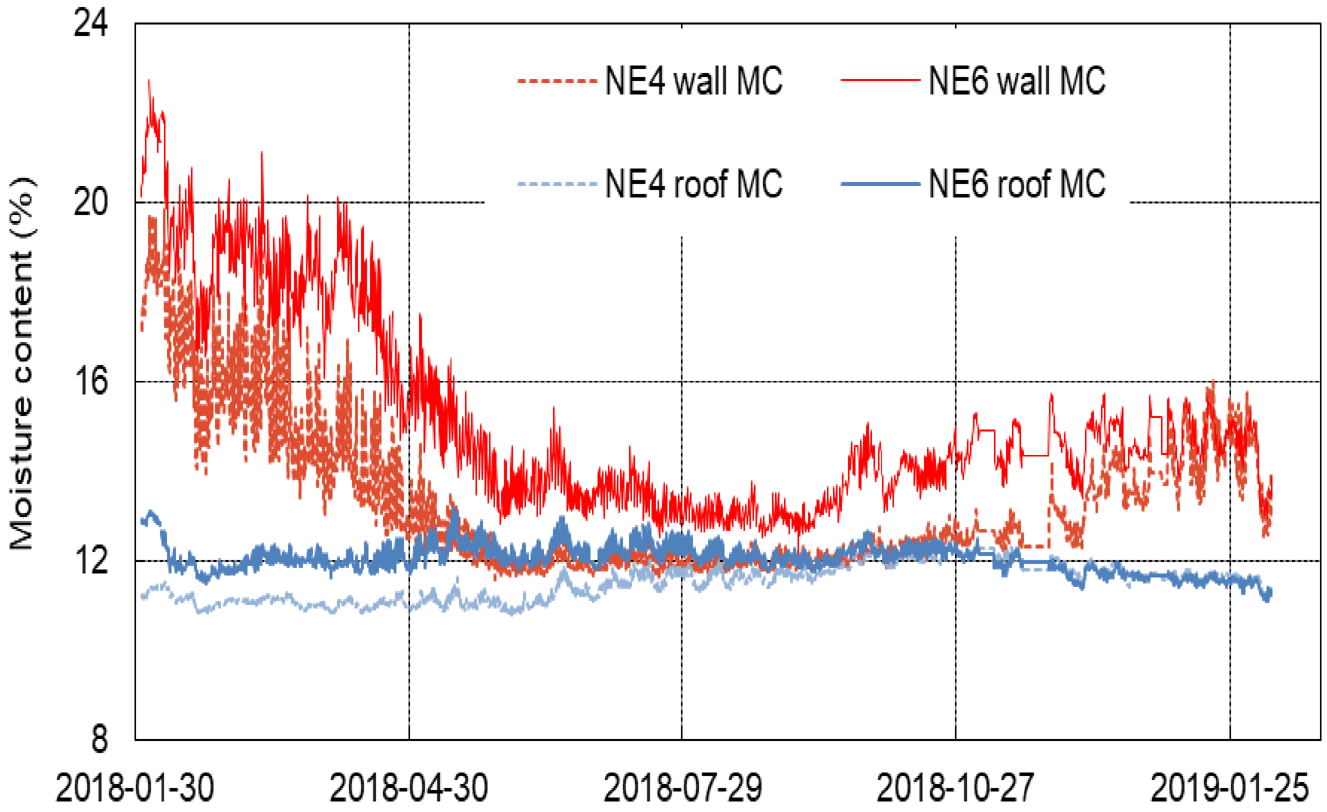
Envelope Performance: MC of Sheathing

- MC of wall plywood sheathing below 16% in second winter



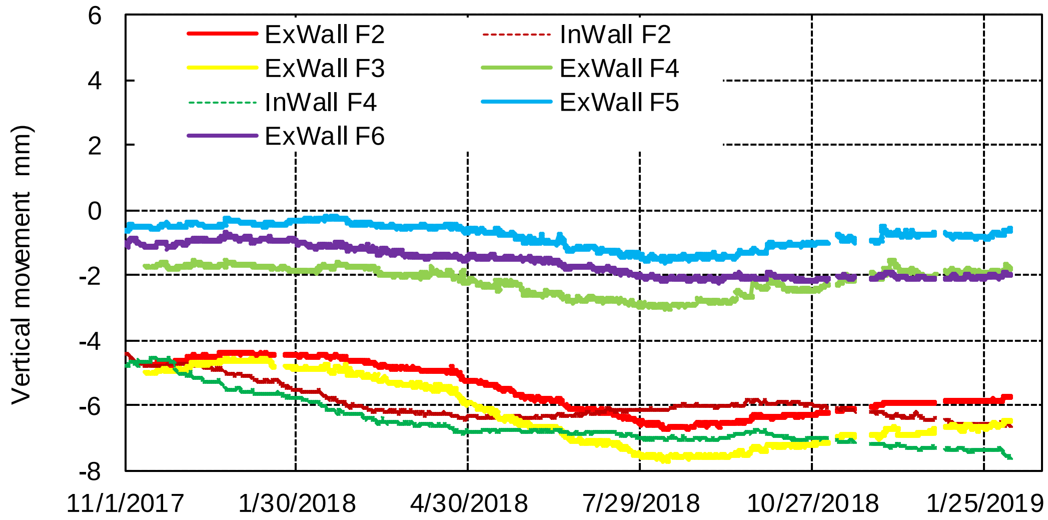
Envelope Performance: MC of Sheathing

- MC of roof plywood lower by 2-4%
  - With thick rigid insulation installed above



Vertical Movement

- Shortening/floor: 1-8 mm after 1 year in service
  - Lower floors settle more than higher floors
  - Interior walls tend to settle more



Wall location	Floor 2 (mm)	Floor 3 (mm)	Floor 4 (mm)	Floor 5 (mm)	Floor 6 (mm)
Exterior wall	5.7	6.5	1.8	0.56	1.97
Interior wall	6.6	-	7.6	-	

Conclusions/Implications for Future Design

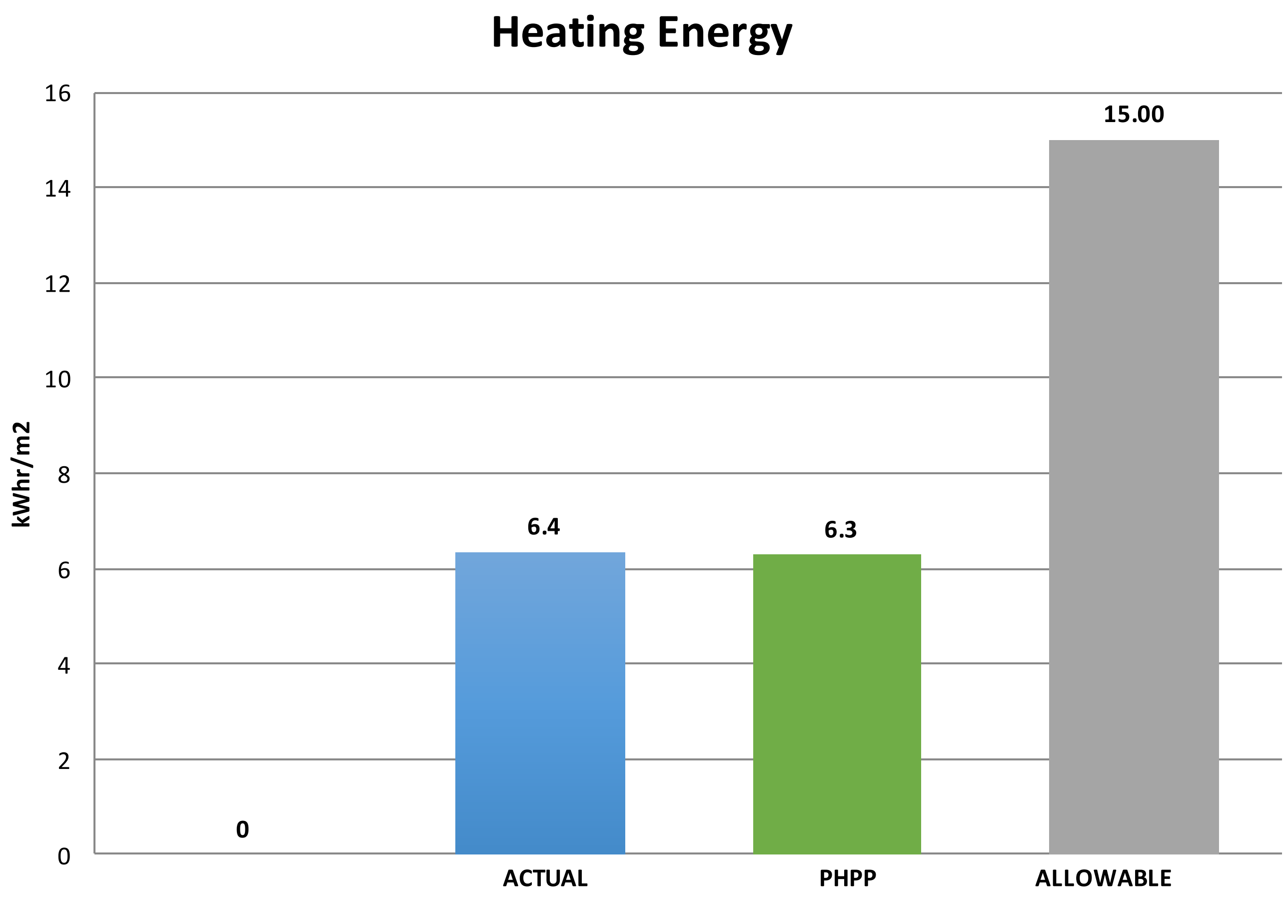
- Overheating appeared to be a large issue; effective measures required
- Indoor CO_2 mostly acceptable, indicating good ventilation
- Measured MC and RH suggested exterior wall should have reasonably durable performance in service
- Comparing wall vs. roof indicated exterior insulation provided a good environmental separation
- Differential vertical movement existed between exterior/interior walls, in line with previous field results

1. Outline of the Project
2. Envelope Details
3. Air Tightness Testing
4. Building Systems
5. Field Monitoring and Results
6. **Energy Performance**

Heating Energy

Heating Energy at the Heights appears to be near that predicted by the PHPP and well below the 15kWhr established by the Passive House Standard.

Average Canadian Buildings can be 150 kWhr/m2

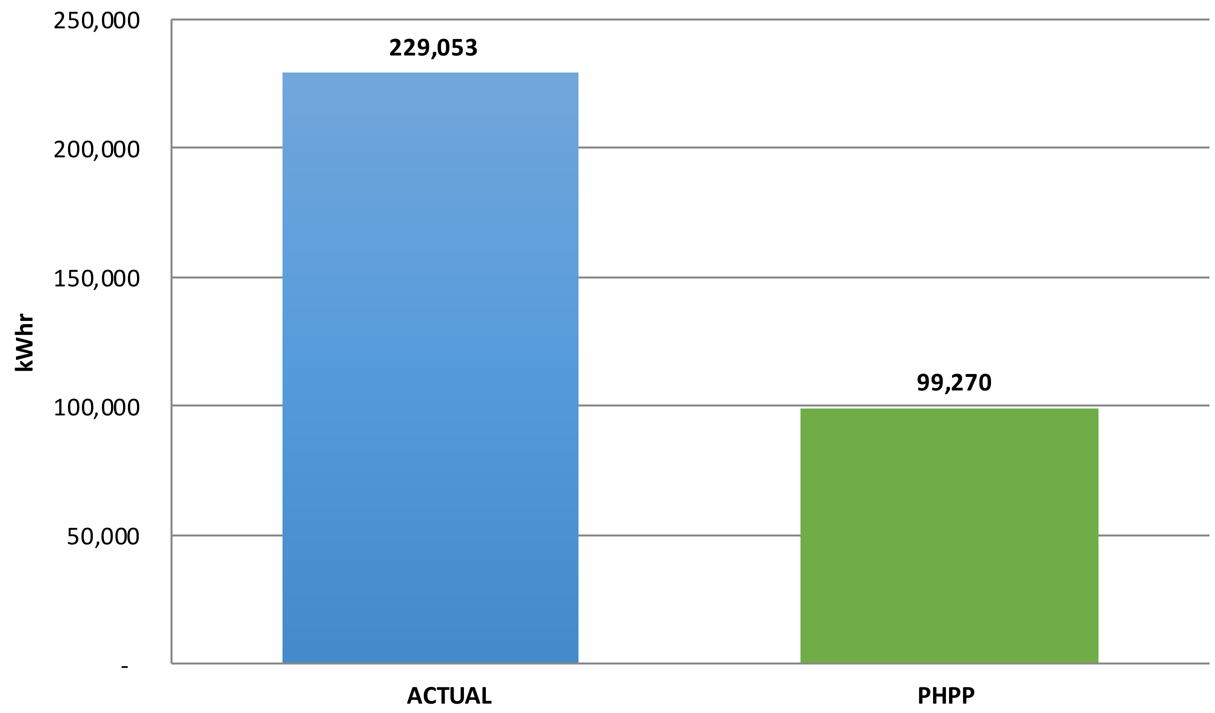


Suite Electricity Consumption

The Electrical Plug Loads in each suite are significantly higher than the loads predicted by the Passive House Planning Package.

These loads end up as heat inside the building envelope

Total Suite Energy (net calculation):

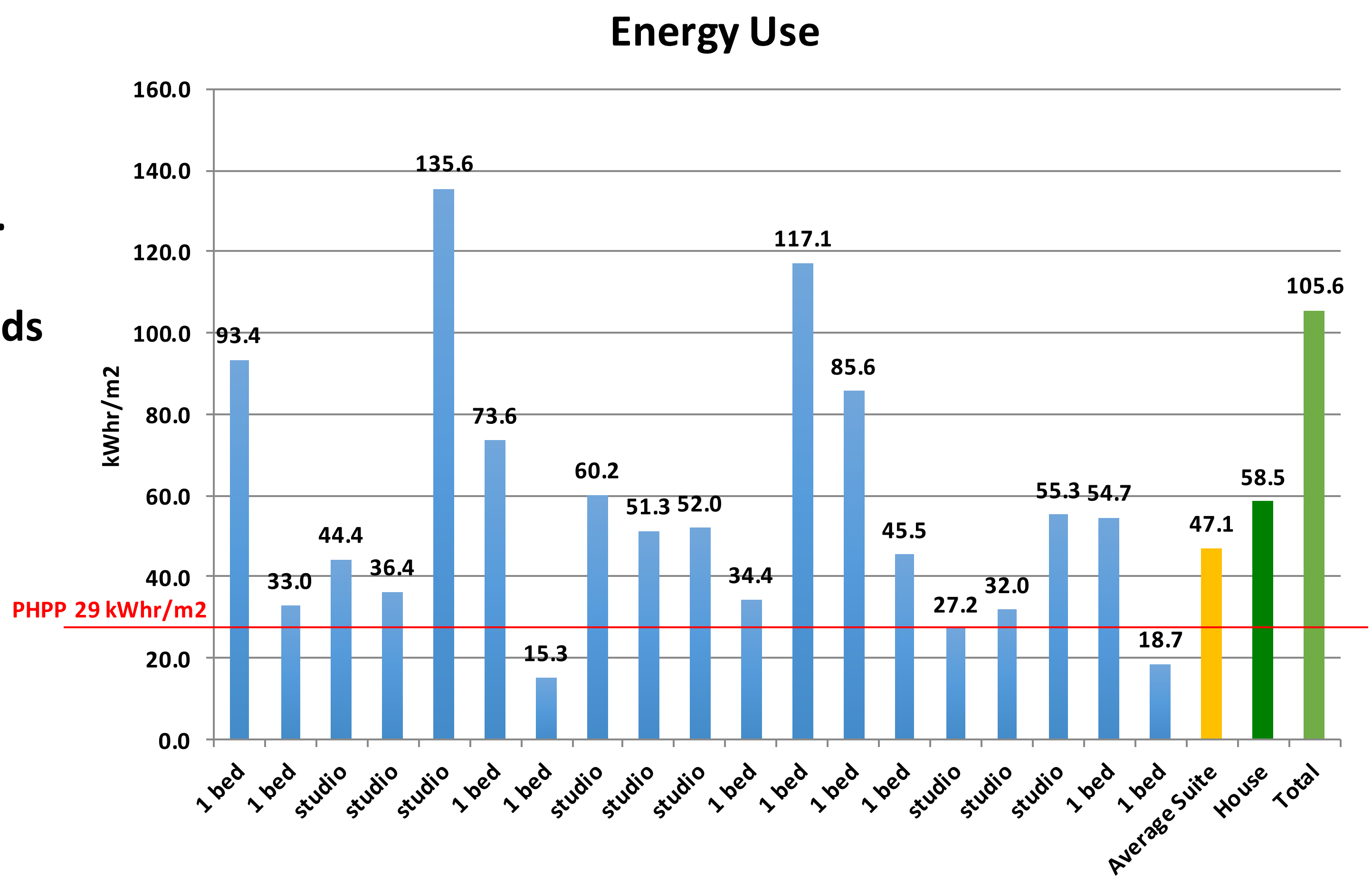


Energy Use Typical Suite Distribution (not the Heights)

Energy Use in by individuals can vary a great deal.

All the energy ends up as heat in the building

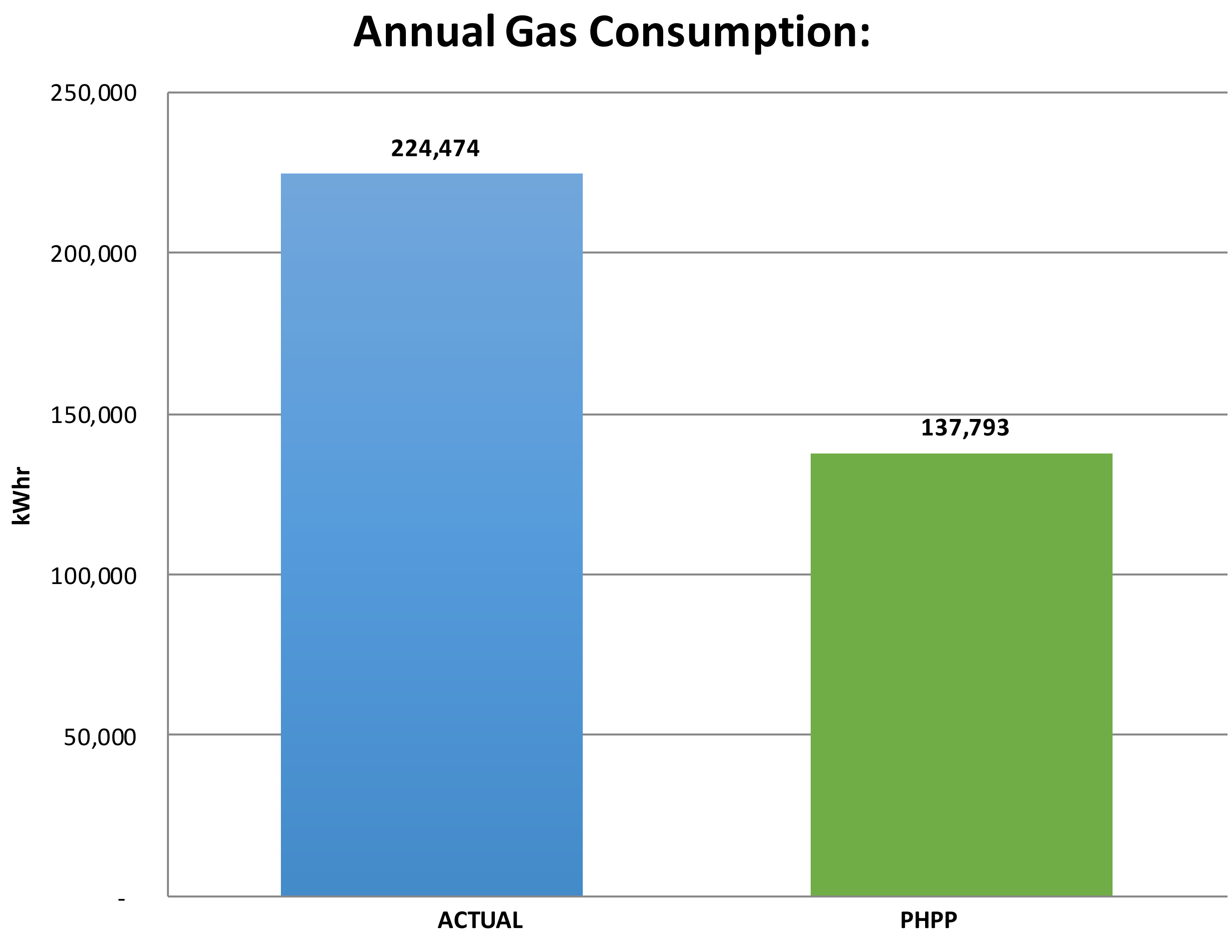
PHPP models 29 kWhr/m2 as the default value for The Heights



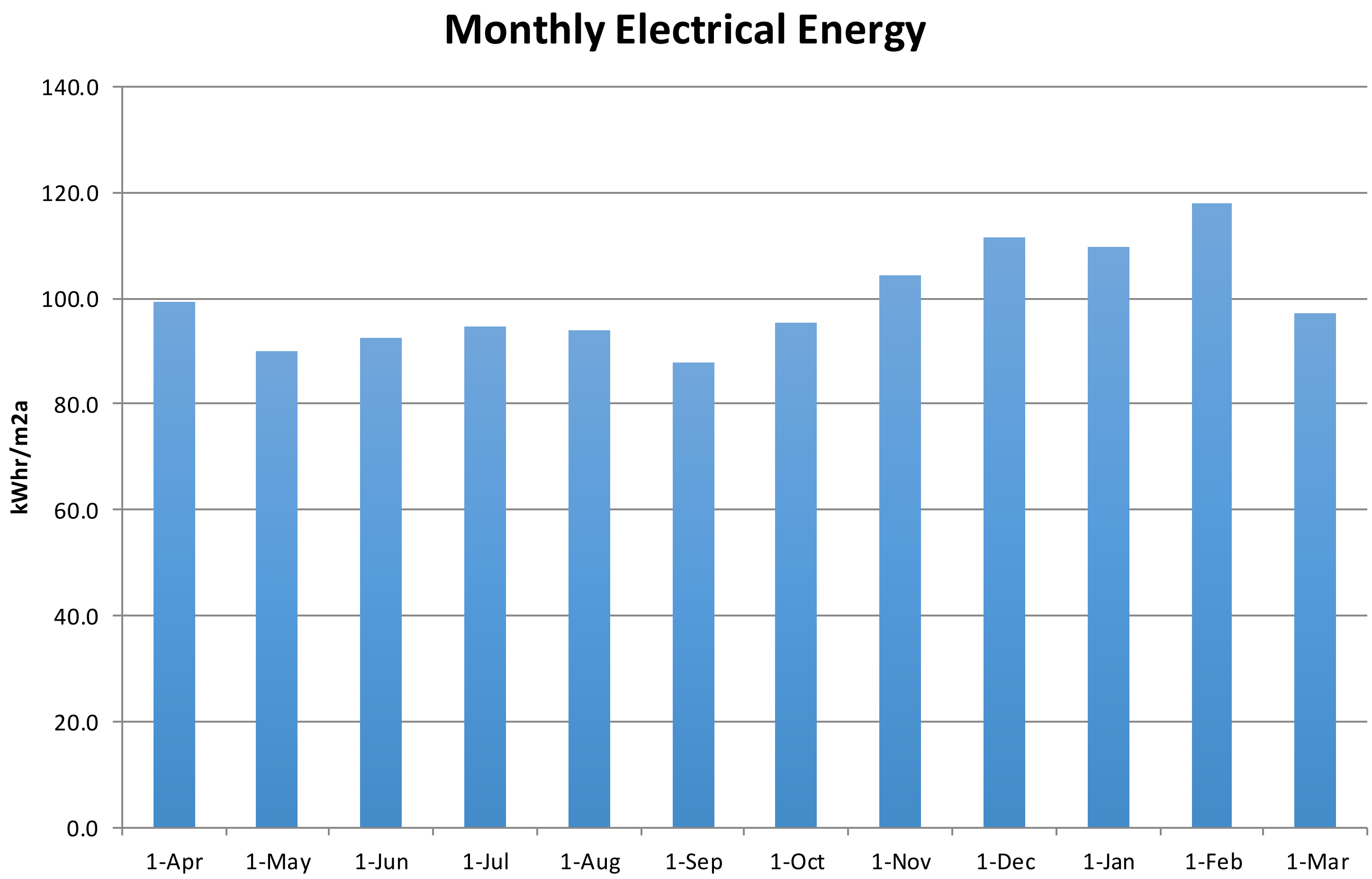
Hot Water Energy

Hot water energy is significantly higher than predicted by PHPP.

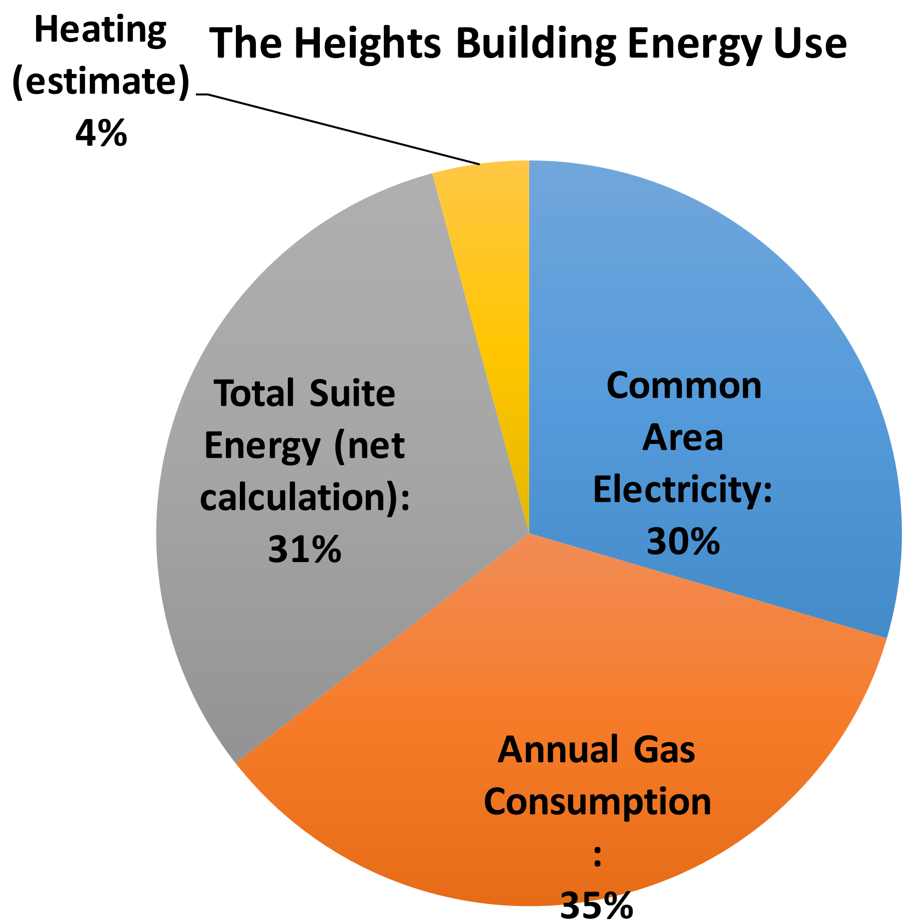
Some of this extra energy will remain in the building contributing to overheating.



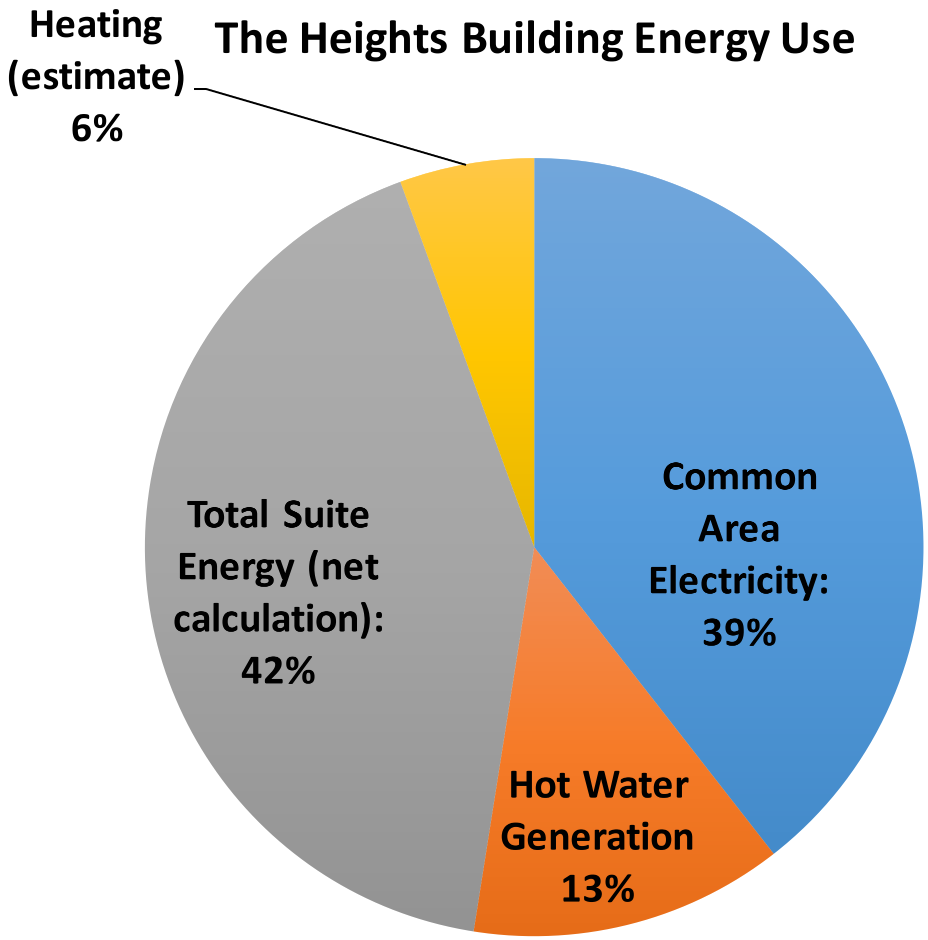
Electrical Energy Use in The Heights



Energy Use in The Heights

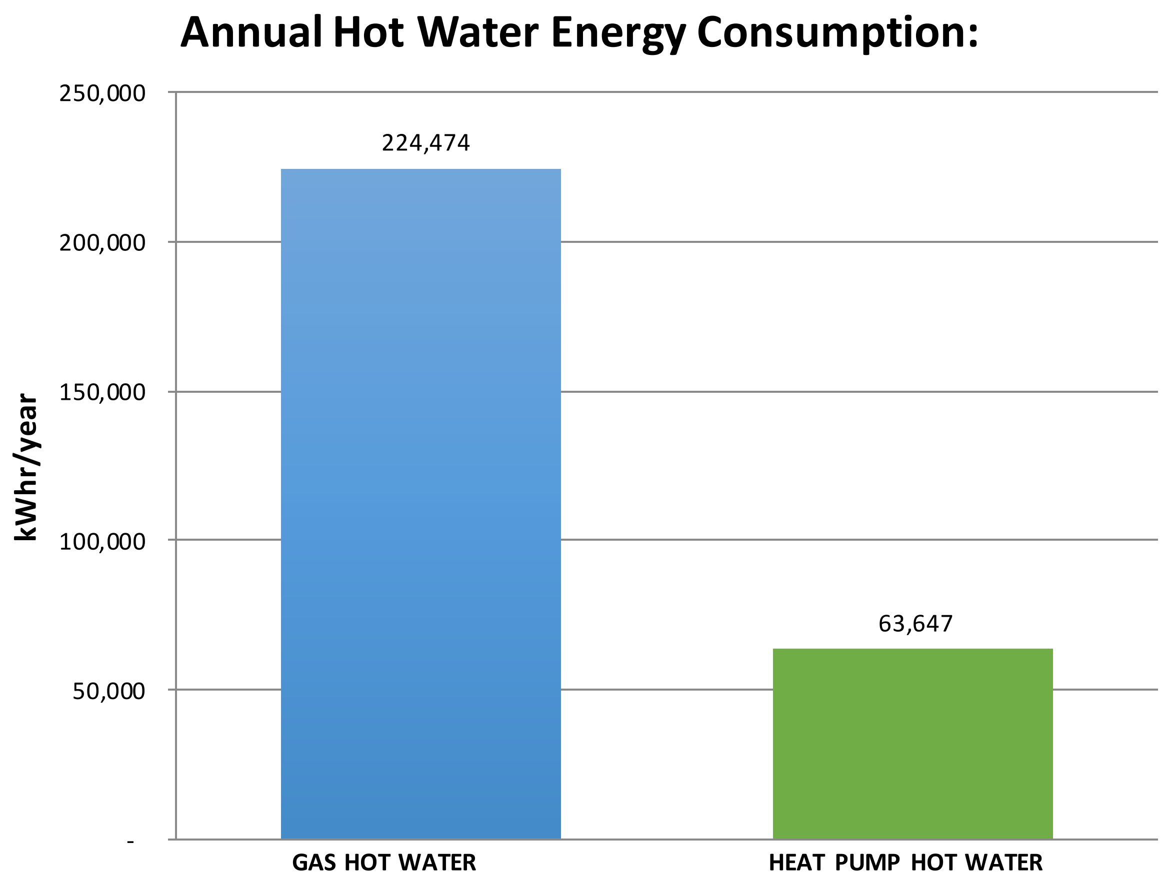


Energy Distribution if Hot Water Generation is converted to Sanden Heat Pumps



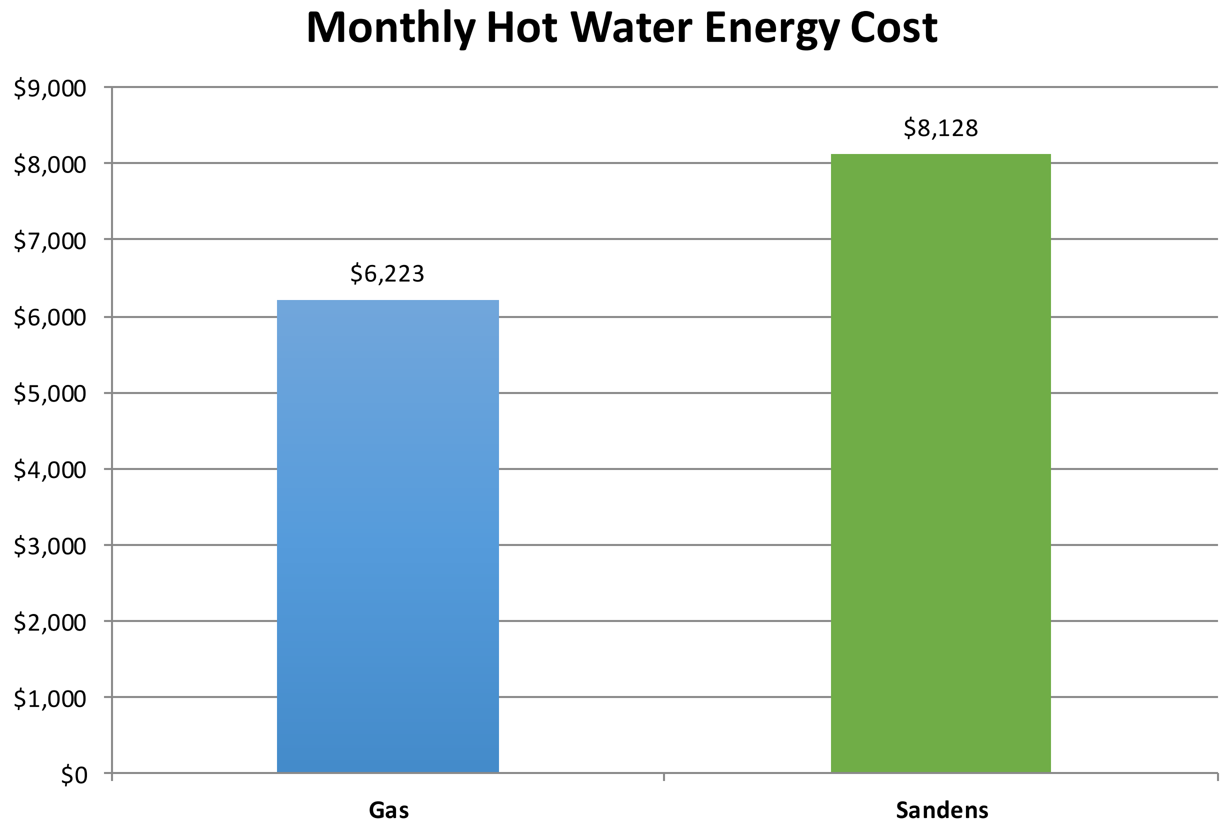
Hot Water Energy

The efficiency of a Heat pump for hot water drastically reduces Greenhouse Gas Emissions in a clean electrical grid or in preparation for renewable energy

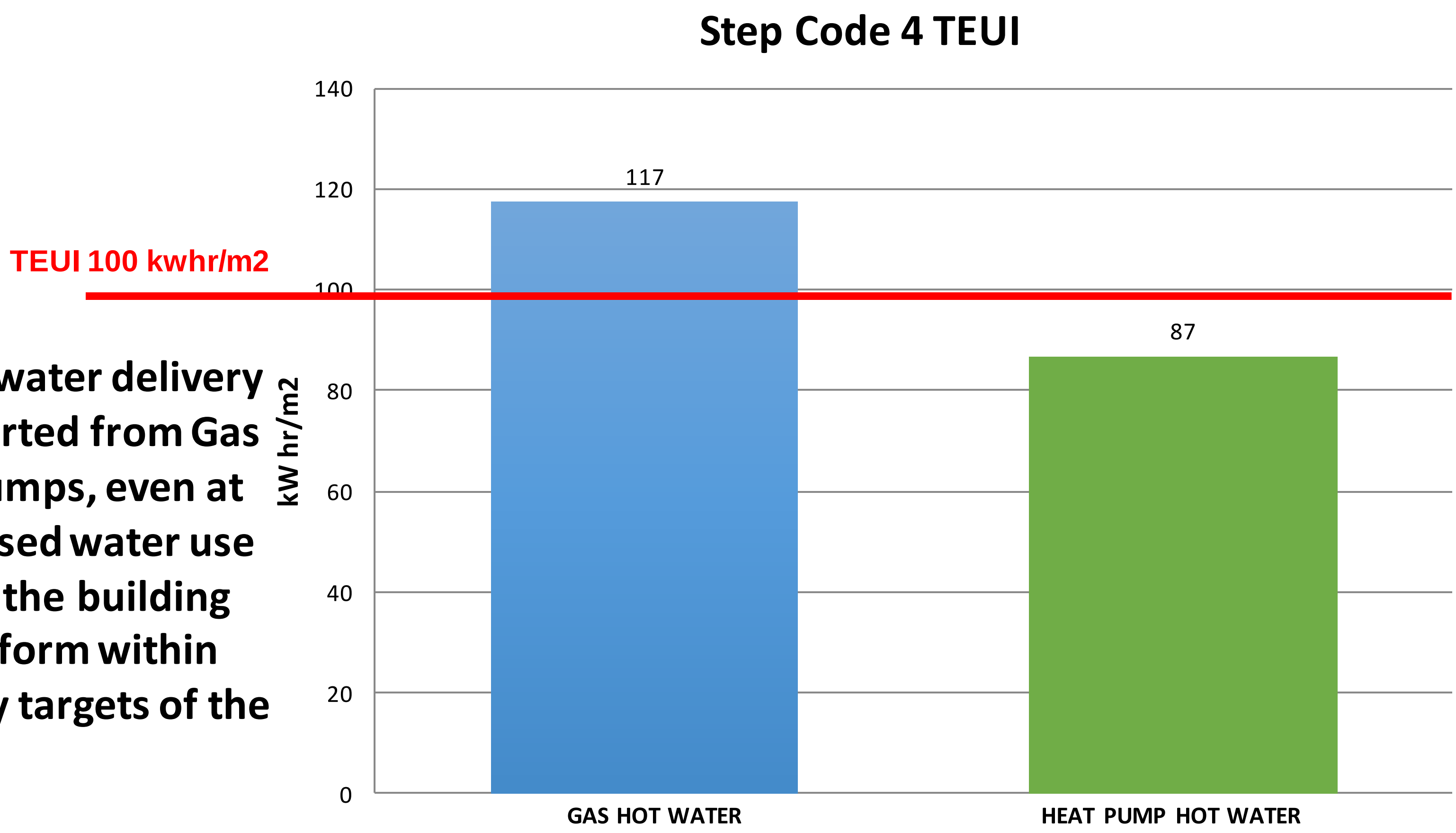


Hot Water Energy

At the current price of gas even generating hot water with electricity using a heat pump with a COP of 3.35 still costs more to operate.



Comparison of Actual Performance to the Step Code

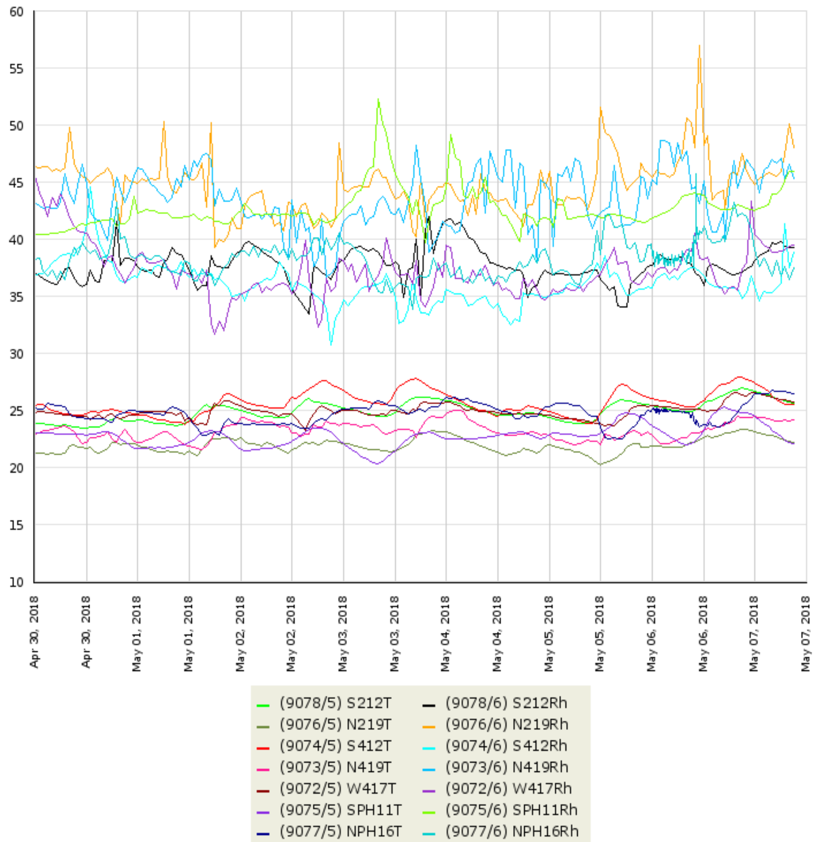


If the hot water delivery was converted from Gas to Heat Pumps, even at the increased water use measured the building would perform within the energy targets of the Step Code

Understand Thermal Comfort

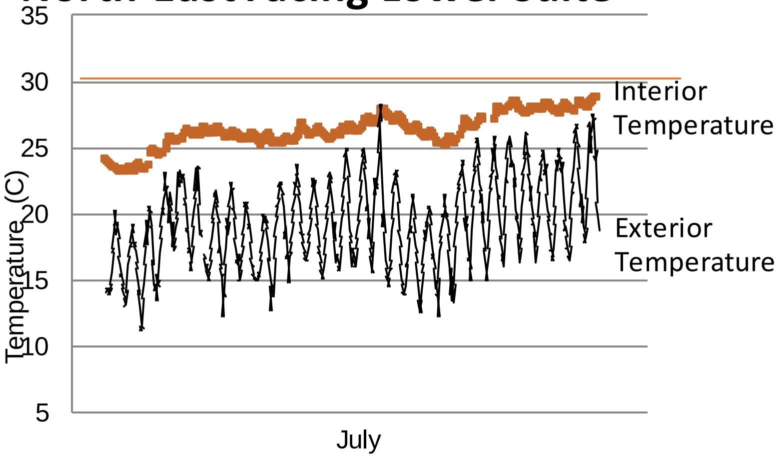
- Temperature sensors were provided in building to monitor thermal comfort conditions
  - Sensors were located at lower upper and penthouse levels along each major orientation
- Instances of overheating (interior temperatures over 25C) were recorded in all the spaces
- - North averaged +/-59% of July over 25C
- -North-East averaged +/-54% of July over 25C
- -South averaged +/-89% of July over 25C
- -West averaged +/-97% of July over 25C

All Suites Temperature and Humidity- May

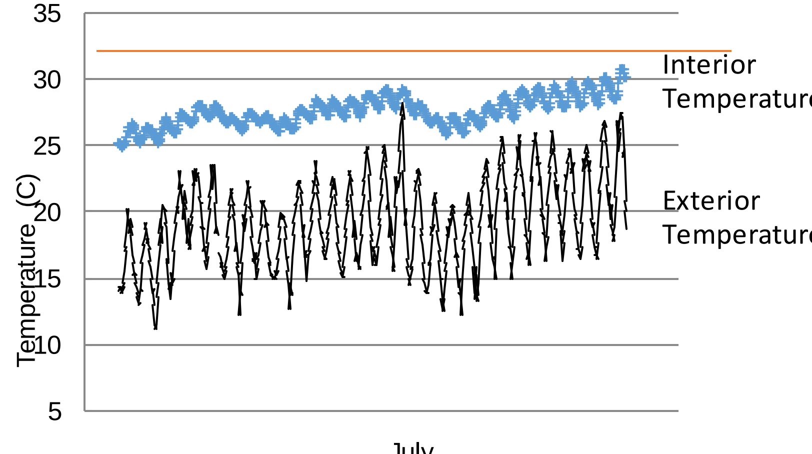


Understand Thermal Comfort

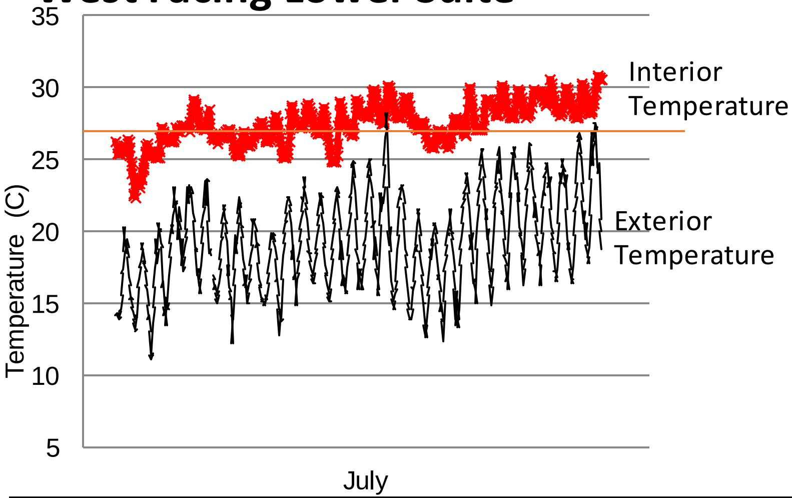
North-East Facing Lower Suite



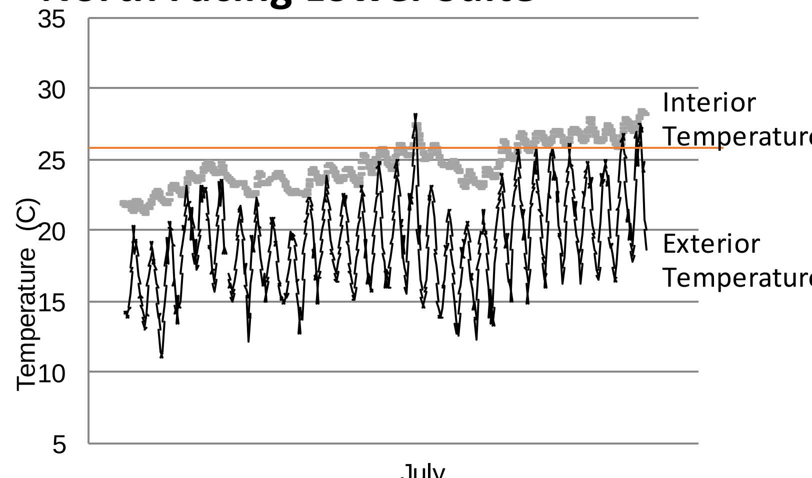
South Facing Lower Suite



West Facing Lower Suite



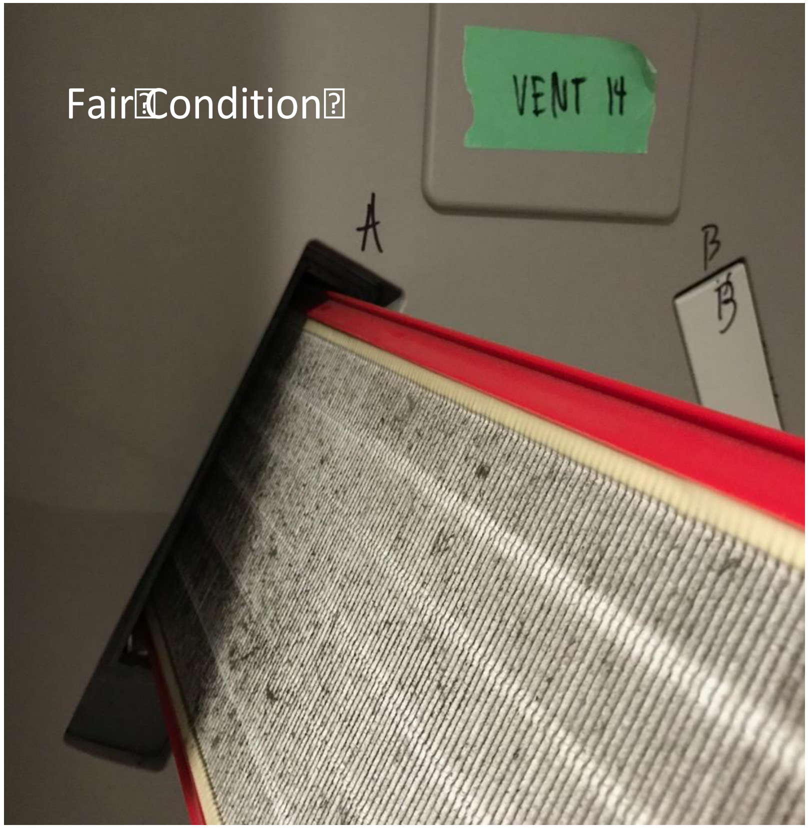
North Facing Lower Suite



Understand HRV Status

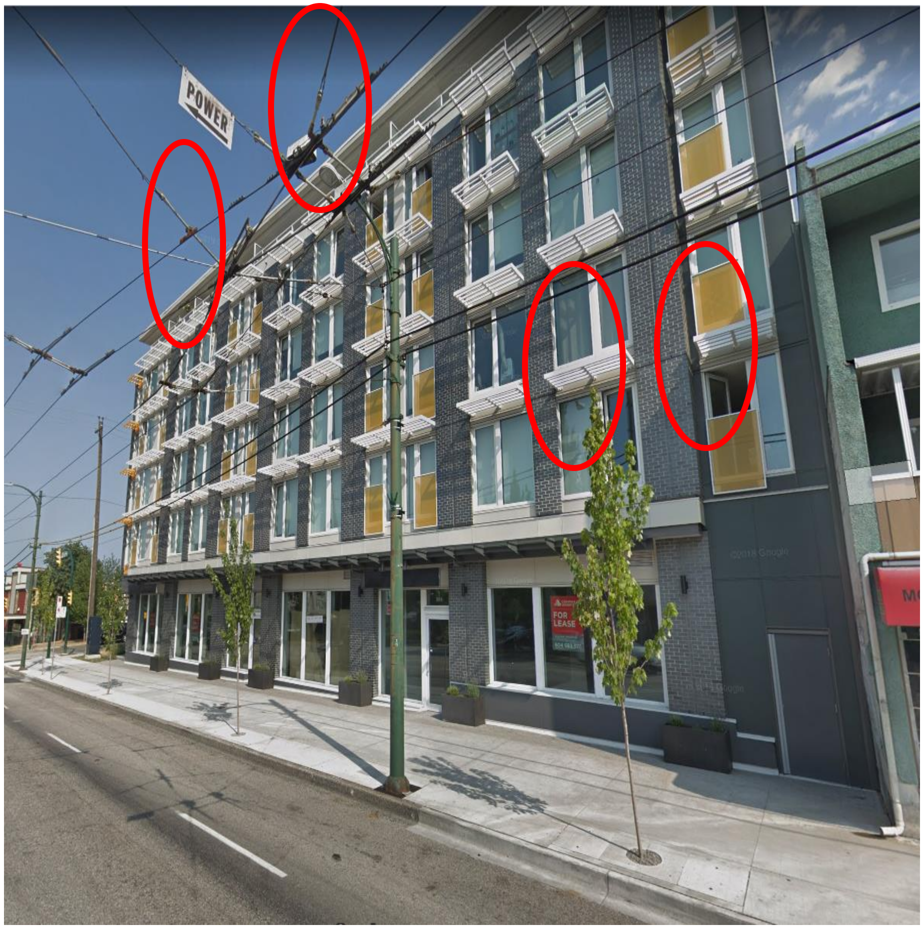
Replaced on August 03 2018
90-120 days

Condition September 12th 2018
40 days



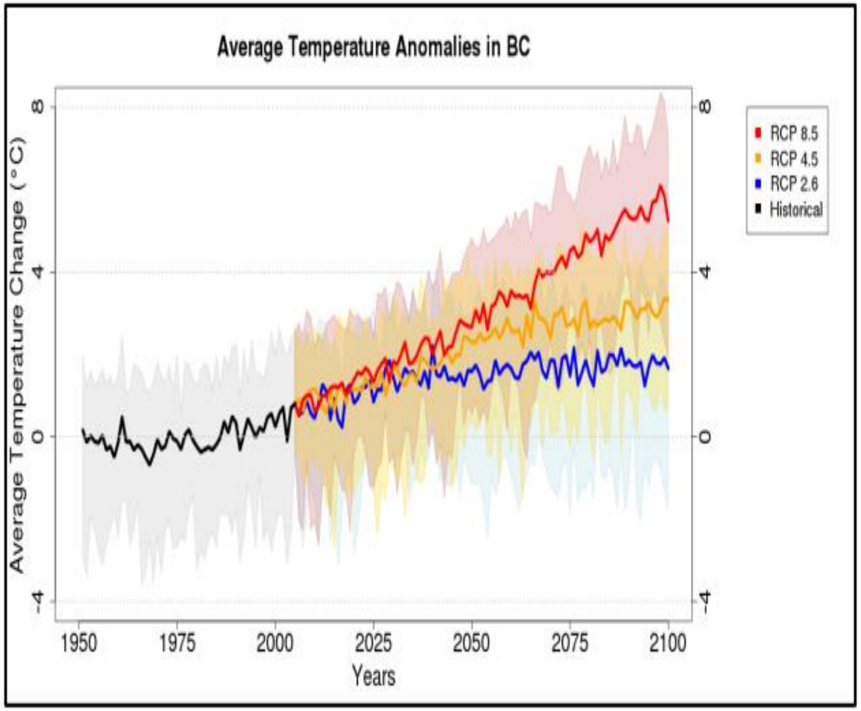
Planning for Thermal Comfort

- How is the building being used?
    - Are operable windows being maximized?
    - Are there more internal heat gains than anticipated?
    - What additional information could we be missing to help paint a clearer picture?
- Are the systems performing as designed?
    - Is the solar shading working as planned
    - Are the HRVs using their nighttime bypass mode properly?
    - Could boost mode be utilized to move more air into the space when advantageous?



Acting for Thermal Comfort

- What lessons are we taking away from the experience?
  - How important is the need for mechanical cooling?
    - Modelling for thermal comfort outside of PHPP
    - Considering PHPP Climate models and the climate change models
  - What sort of hand-off are we providing to tenants to better inform their behavior?
- How can we adapt the current system or design for adaptability in future projects?
  - HRVs being fit with a small cooling coil?



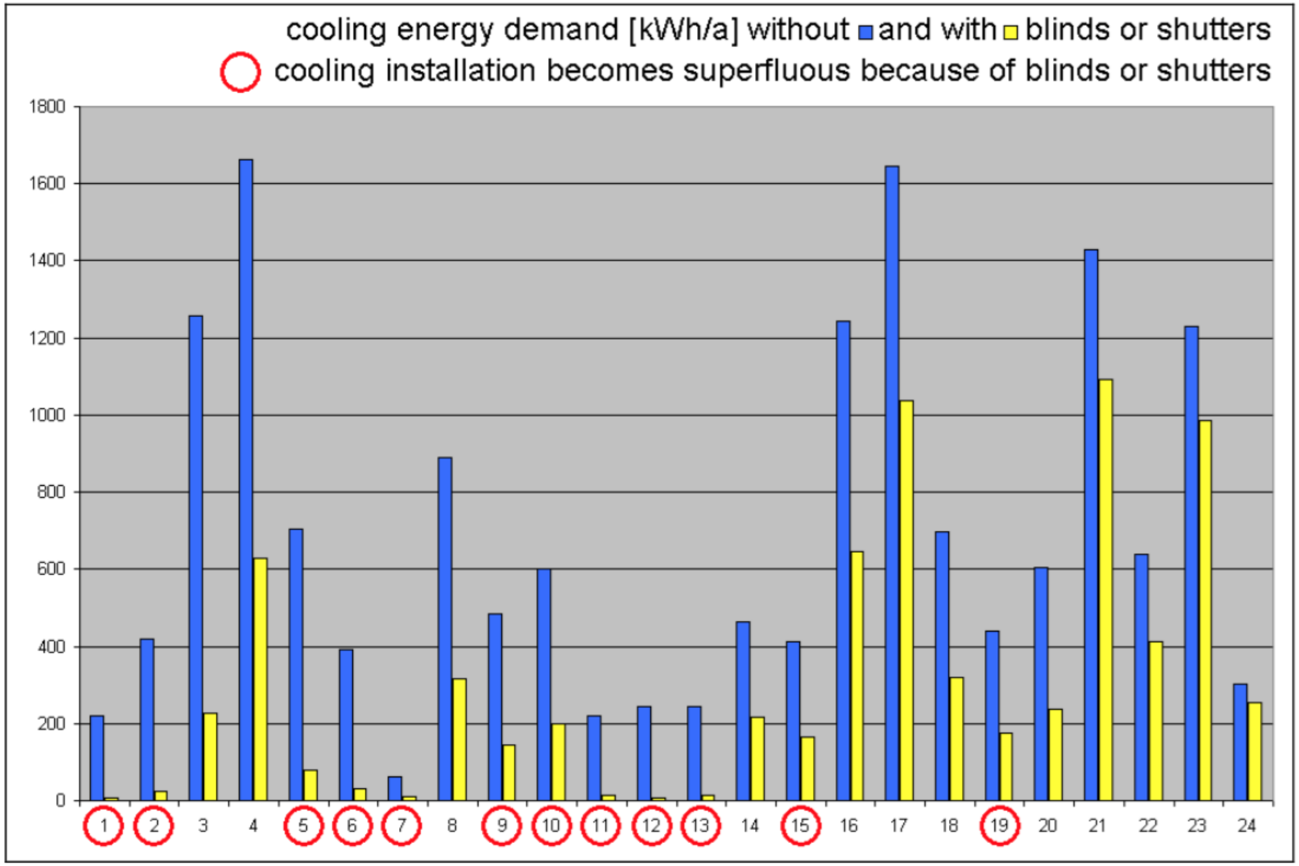
Planning Whole Building Energy Consumption

- DHW is the only use of natural gas in the building, therefor all additional energy consumption can be tied to it
    - Assuming heat loss as the constant DHW consumption was calculated
        - Estimated DHW consumption **50.07L/person/day**
        - PHPP modeled consumption was **25L/person/day**
- Occupant DHW consumption is likely the source of the additional gas consumption

388 Skeena Nat Gas TFA: 4201 m2 #of Occupants 122.9

Actual Energy Use							**Modeled Energy Use**		
Time Period			**Hot Water Energy Use**					**PHPP**	
Start	Finish	days	GJ	GJ/day	kWhr/day	kWhr/yr		kWhr/yr	
02-Feb	06-Mar	32	61.8	1.931	536.5	195,807			
06-Mar	05-Apr	30	71.4	2.380	661.1	241,306			
05-Apr	04-May	29	68.3	2.355	654.2	238,789	individual pipe loss	7,226	5%
04-May	04-Jun	31	62.5	2.016	560.0	204,413	recirculation loss	38,110	29%
04-Jun	04-Jul	30	63.6	2.120	588.9	214,945	tank loss	8,278	6%
							water use	77,790	59%
				2.161	600.1	219,052		131,404	100%
					Actual Energy Use		Modeled Energy Use		
					kwhr/m2	52	kwhr/m2	31.3	

Overheating Strategies



Exterior Shading is the most effective method of controlling overheating

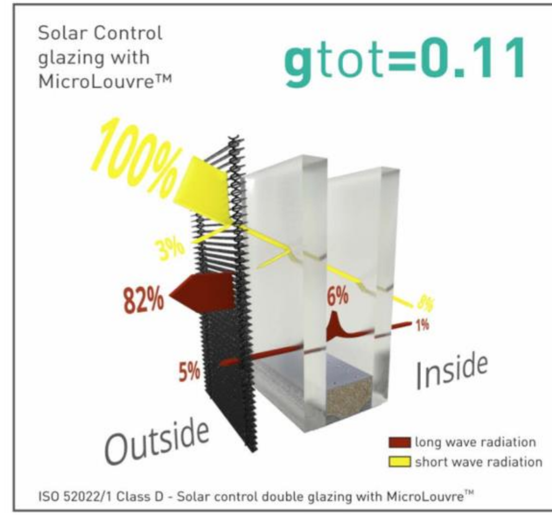
Overheating Strategies

Horizontal Louvres – Appropriately sized

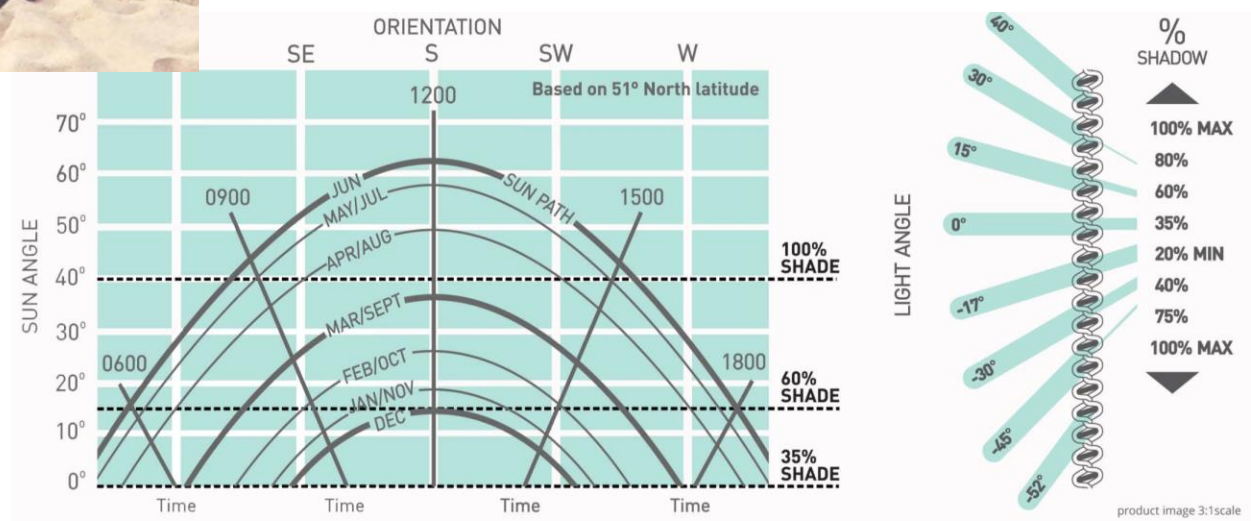
Overheating Strategies

External Automatic Deploying blinds

Overheating Strategies



Micro-Louvre Products



PASSIVEHOUSE CANADA

Build better.
Feel better.