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CT

The Sponsors of Energize Connecticut, and in partnership with Connecticut Passive House, are pleased to offer *Passive House Initiative* to support workforce development and help transform the energy efficiency and building construction industries in Connecticut.

CTPH
CONNECTICUT PASSIVE HOUSE

For more information, please visit EnergizeCT.com/passive-house
or email PassiveHouseTrainingCT@icf.com

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Take energy efficiency to a new level

Residential New Construction Passive House Multi-family buildings with five units or more

PASSIVE HOUSE INCENTIVE STRUCTURE FOR MULTI-FAMILY (5 UNITS OR MORE)

Incentive Timing	Activity	Incentive Amount	Max Incentive (Per Unit)	Max Incentive (Per Project)
Pre-Construction	Feasibility Study[1]	Up to 100% of Feasibility Study Costs	N/A	$5,000.00
	Energy Modeling[2]	75% of Energy Modeling Costs (Before 90% Design Drawings)	$500.00	$30,000.00
		50% of Energy Modeling Costs (90% Design/50% Construction)	$250.00	$15,000.00
Post Construction	Certification[3]	Up to 100% of Certification Costs	$1,500.00	$60,000.00

1. Feasibility Study will require documentation in the form of a Feasibility Study report and invoice from the Passive House Consultant
2. Incentives will only be awarded prior to 50% Construction Drawings for Passive House projects. No incentives will be granted after 50% Construction Drawing set.
3. Certification may be either through PHIUS, PHI, or EnerPHit certification offerings.

Next steps you can take...
Contact your Energy Efficiency Representative or

Go to EnergizeCT.com or call 1-877-WISE USE for more details.

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MULTI-FAMILY PASSIVE HOUSE

LESSONS LEARNED FROM THE FIRST GENERATION OF PROJECTS

Monte Paulsen | CPHC, PHI Building Certifier
Andrew Steingiser | RA, CPHC

RDH BUILDING SCIENCE
Making Buildings Better ™

Monte Paulsen

PHI accredited Building Certifier.

Leads the Passive House team at RDH.

Consulting for 7 million+ sf of Passive House.

A Pattern Language from Passive House:

- **Four part workshop**
- **Through Passive House Canada**

Co-Founder:

- **Passive House Canada**
- **PHPP Users Group and the Global Passive House Happy Hour**

Andrew Steingiser

Registered Architect in Massachusetts.

Certified Passive House Consultant (PHIUS).

Leads Passive House Consulting for RDH Boston.

Passive House MA Board of Directors.

Agenda

- **Local Requirements + Incentive Programs**
- **Architects + Engineers are Responsible for Adaptation**
- **Case Studies + Lessons Learned**
- **Cost + Timeline**
- **Q+A**

RDH

Making Buildings Better™

Making buildings better for 20+ Years

6 Million + SF of high-performance project experience

New Construction + Existing Buildings

300+ people

9 offices

Projects across North America

Focus on building science & building enclosures

Integrated Service Areas

- Building Enclosure Consulting

  [Panelization, Mass Timber, Deep Retrofit…]

- Energy + Sustainability

  [Including site verification]

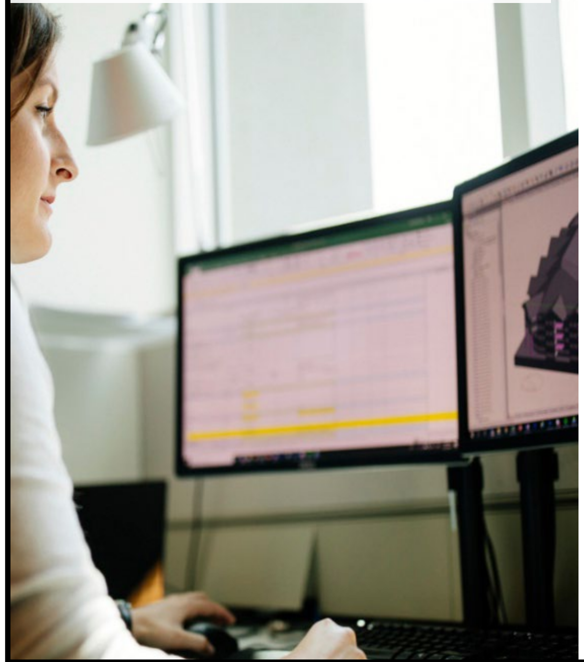
- Façade Consulting + Structural Engineering
- Maintenance + Capital Planning
- Material Science + Research
- Investigation + Litigation Support
- Building Enclosure Commissioning

We make buildings better through the integration of science, design and construction expertise

Asset Management

Building Enclosure

High Performance



Research

Early Phase Building Science

1. Switch the Design Process from Reactive to Proactive

2. Make the milestones match the metrics

3. Make the key decisions early with the whole team

4. Optimize the variables for what matters to the project [Performance, Cost, Carbon, Climate Resiliency…]

1. Design Process

2. Milestones to Match the Metrics

3. Early-Stage Key Decisions

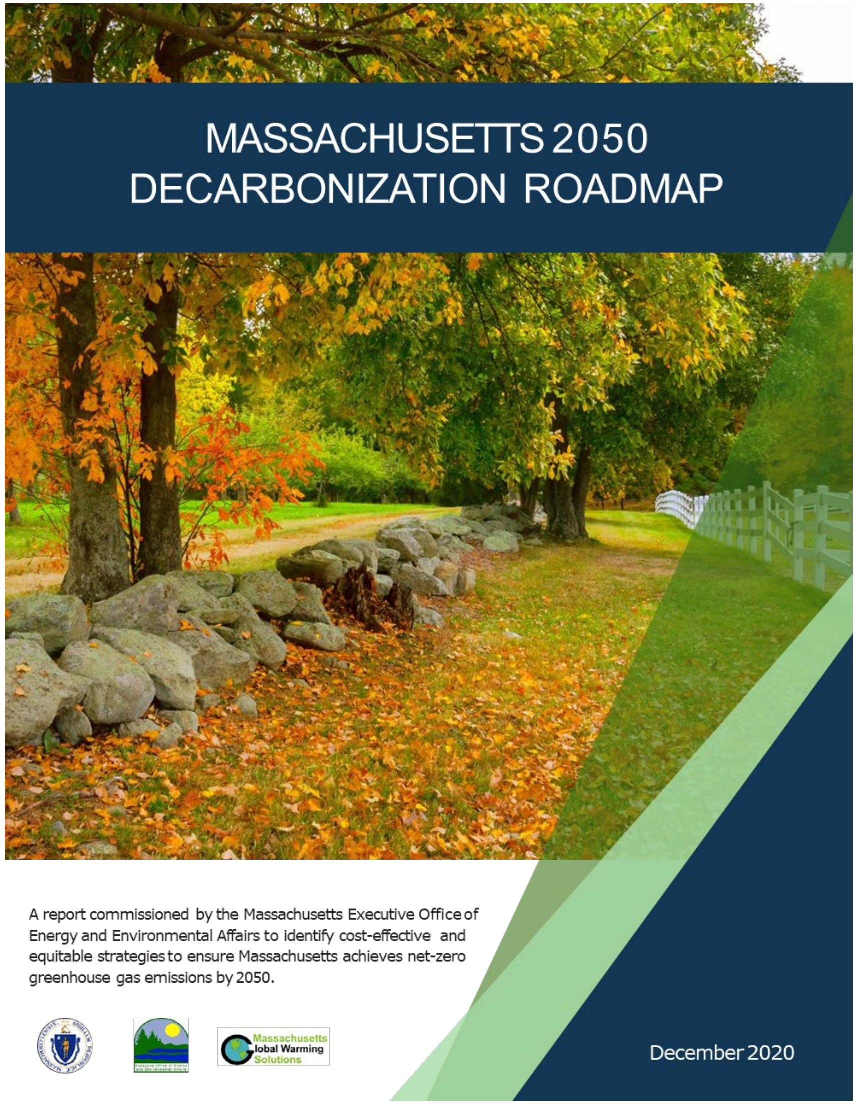
4. Optimize Decisions

LOCAL REQUIREMENTS + INCENTIVES

Decarbonization in MA

March 26, 2021 Governor Baker signed into law:

- 50% carbon emissions reduction by 2030
- 75% carbon emissions reduction by 2040
- Net Zero carbon emissions by 2050



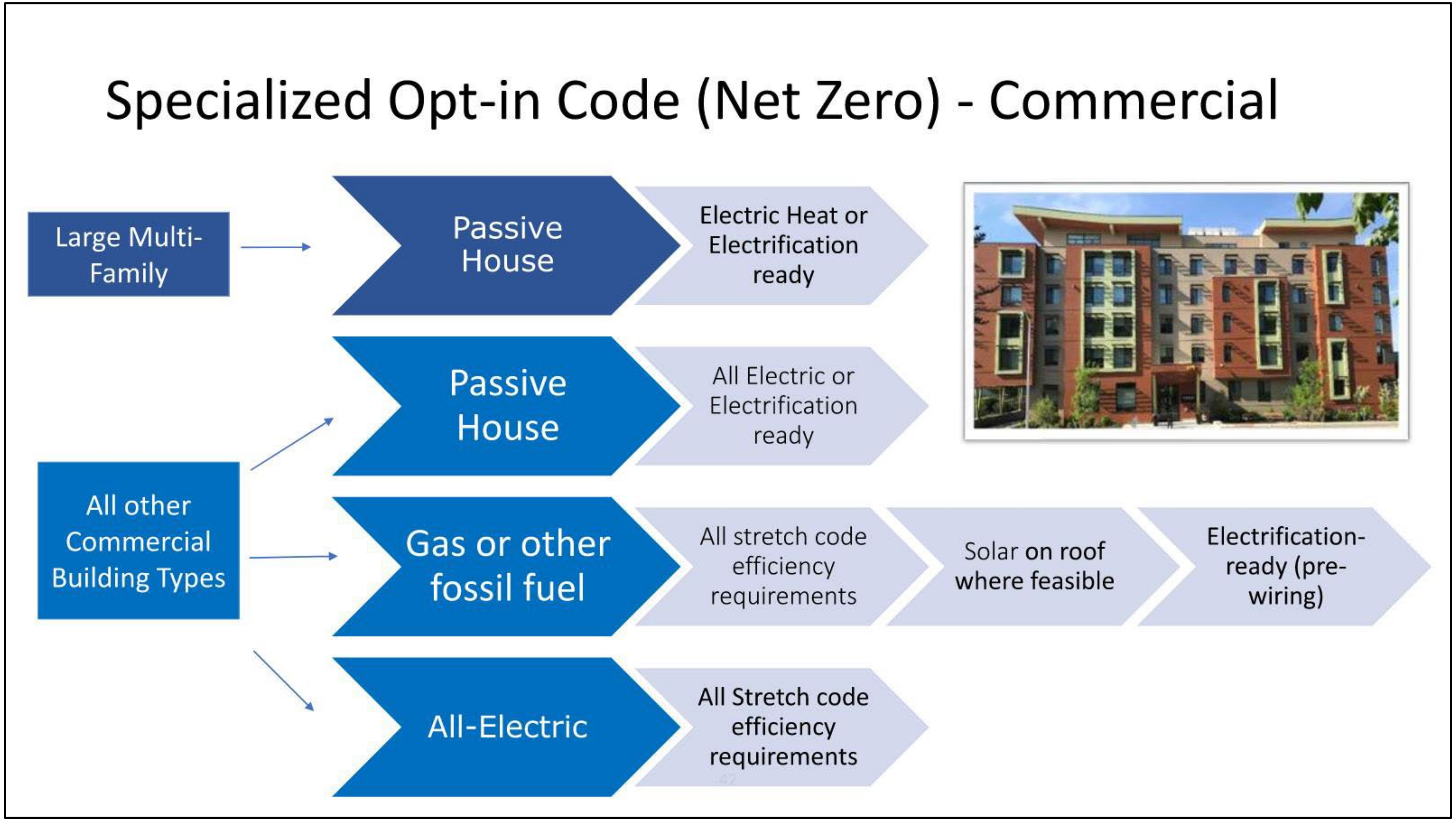
MASSACHUSETTS 2050
DECARBONIZATION ROADMAP

A report commissioned by the Massachusetts Executive Office of Energy and Environmental Affairs to identify cost-effective and equitable strategies to ensure Massachusetts achieves net-zero greenhouse gas emissions by 2050.

Massachusetts Global Warming Solutions

December 2020

Proposed Code in MA



Specialized Opt-in Code (Net Zero) - Commercial

Large Multi-Family → Passive House → Electric Heat or Electrification ready

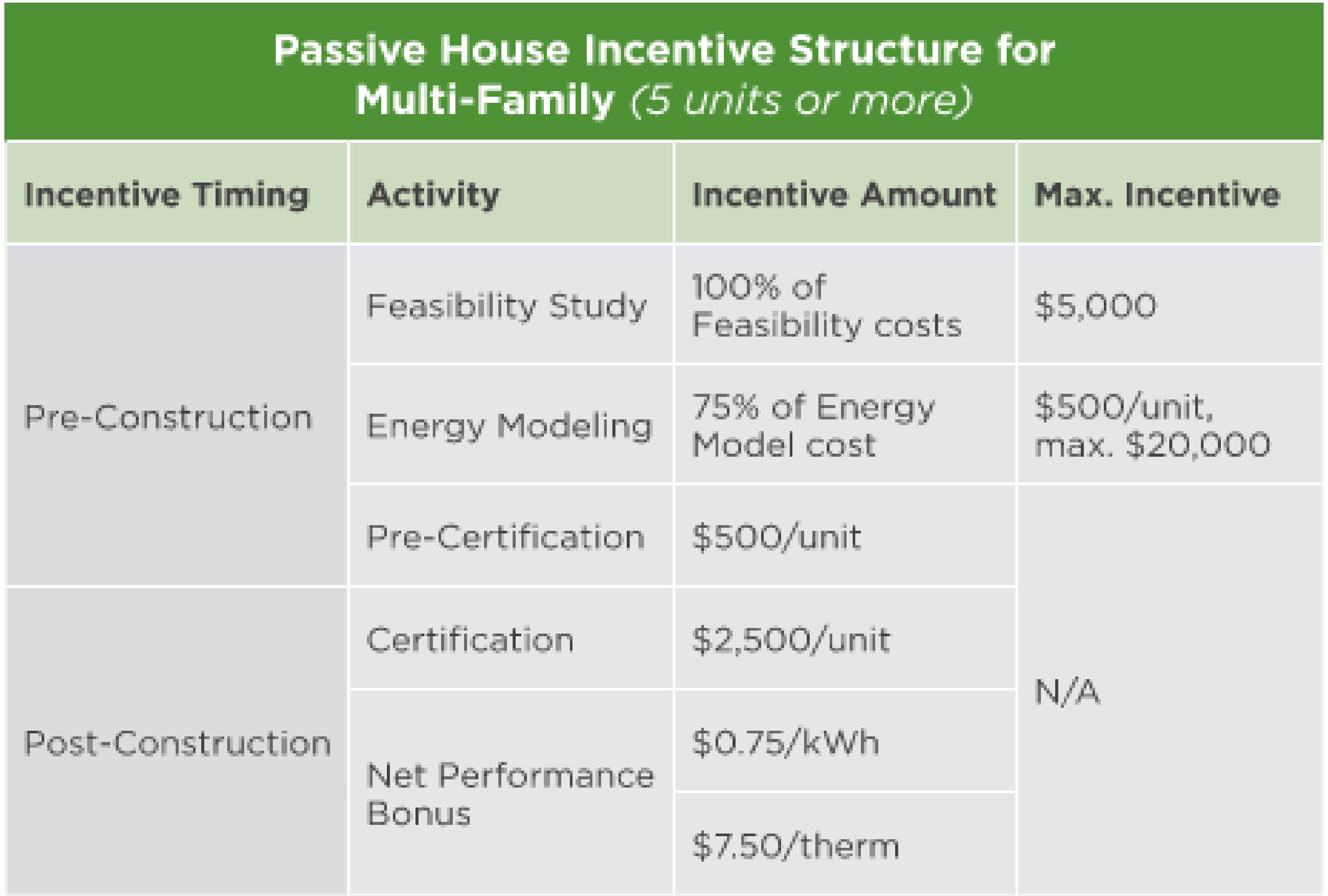
All other Commercial Building Types → Passive House → All Electric or Electrification ready

All other Commercial Building Types → Gas or other fossil fuel → All stretch code efficiency requirements → Solar on roof where feasible → Electrification-ready (pre-wiring)

All other Commercial Building Types → All-Electric → All Stretch code efficiency requirements

Source: DOER

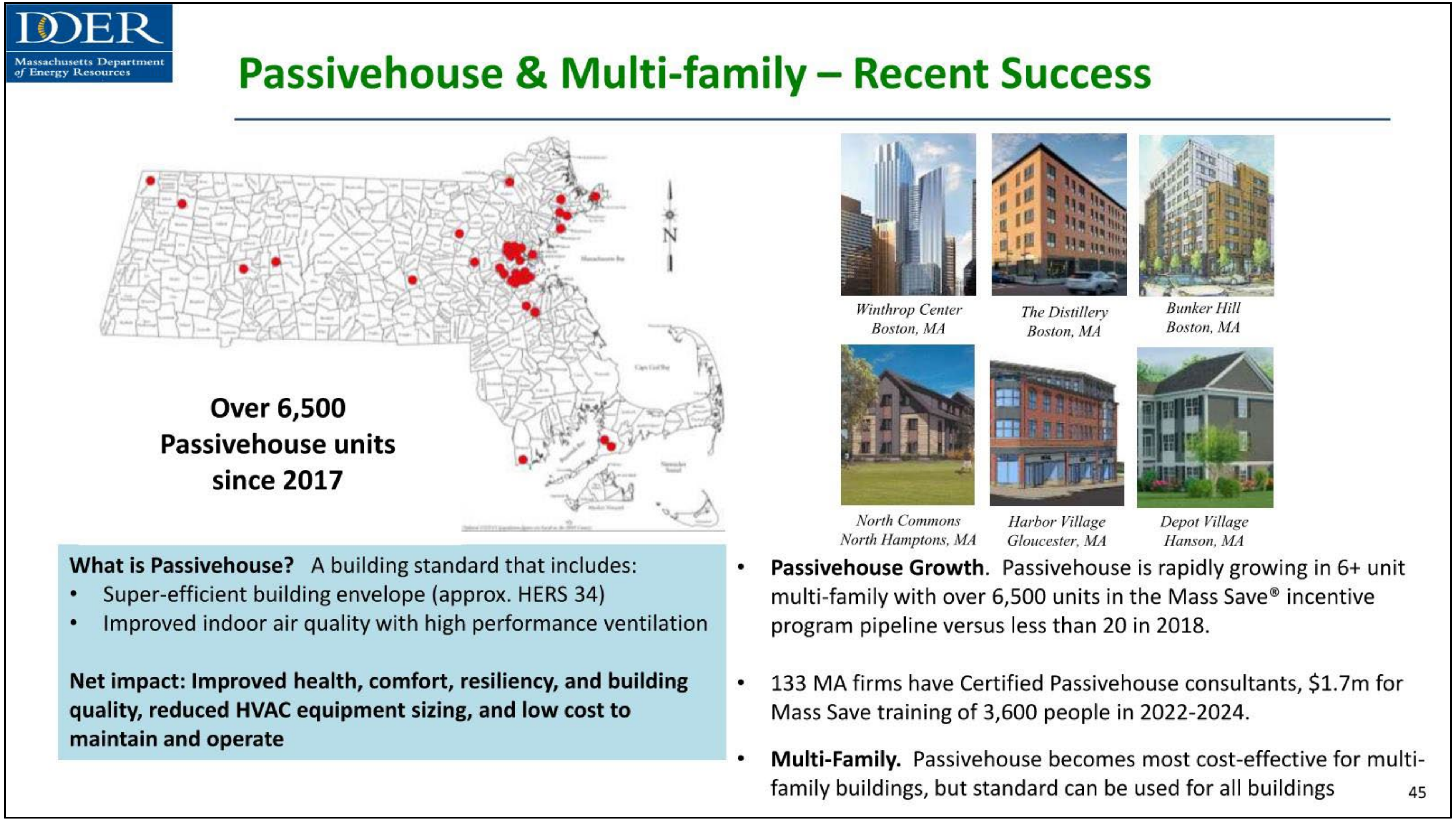
Incentives in MA



Passive House Incentive Structure for Multi-Family *(5 units or more)*

Incentive Timing	Activity	Incentive Amount	Max. Incentive
Pre-Construction	Feasibility Study	100% of Feasibility costs	$5,000
	Energy Modeling	75% of Energy Model cost	$500/unit, max. $20,000
	Pre-Certification	$500/unit	N/A
Post-Construction	Certification	$2,500/unit	
	Net Performance Bonus	$0.75/kWh	
		$7.50/therm	

Passive House in MA



DOER
Massachusetts Department of Energy Resources

Passivehouse & Multi-family – Recent Success

Over 6,500 Passivehouse units since 2017

Winthrop Center
Boston, MA

The Distillery
Boston, MA

Bunker Hill
Boston, MA

North Commons
North Hamptons, MA

Harbor Village
Gloucester, MA

Depot Village
Hanson, MA

What is Passivehouse? A building standard that includes:

- Super-efficient building envelope (approx. HERS 34)
- Improved indoor air quality with high performance ventilation

Net impact: Improved health, comfort, resiliency, and building quality, reduced HVAC equipment sizing, and low cost to maintain and operate

- **Passivehouse Growth.** Passivehouse is rapidly growing in 6+ unit multi-family with over 6,500 units in the Mass Save® incentive program pipeline versus less than 20 in 2018.
- 133 MA firms have Certified Passivehouse consultants, $1.7m for Mass Save training of 3,600 people in 2022-2024.
- **Multi-Family.** Passivehouse becomes most cost-effective for multi-family buildings, but standard can be used for all buildings

45

Source: DOER

Decarbonization in CT

March 26, 2021Governor Lamont signed law:

- 45% carbon reduction by 2030
  - Below 2001 levels

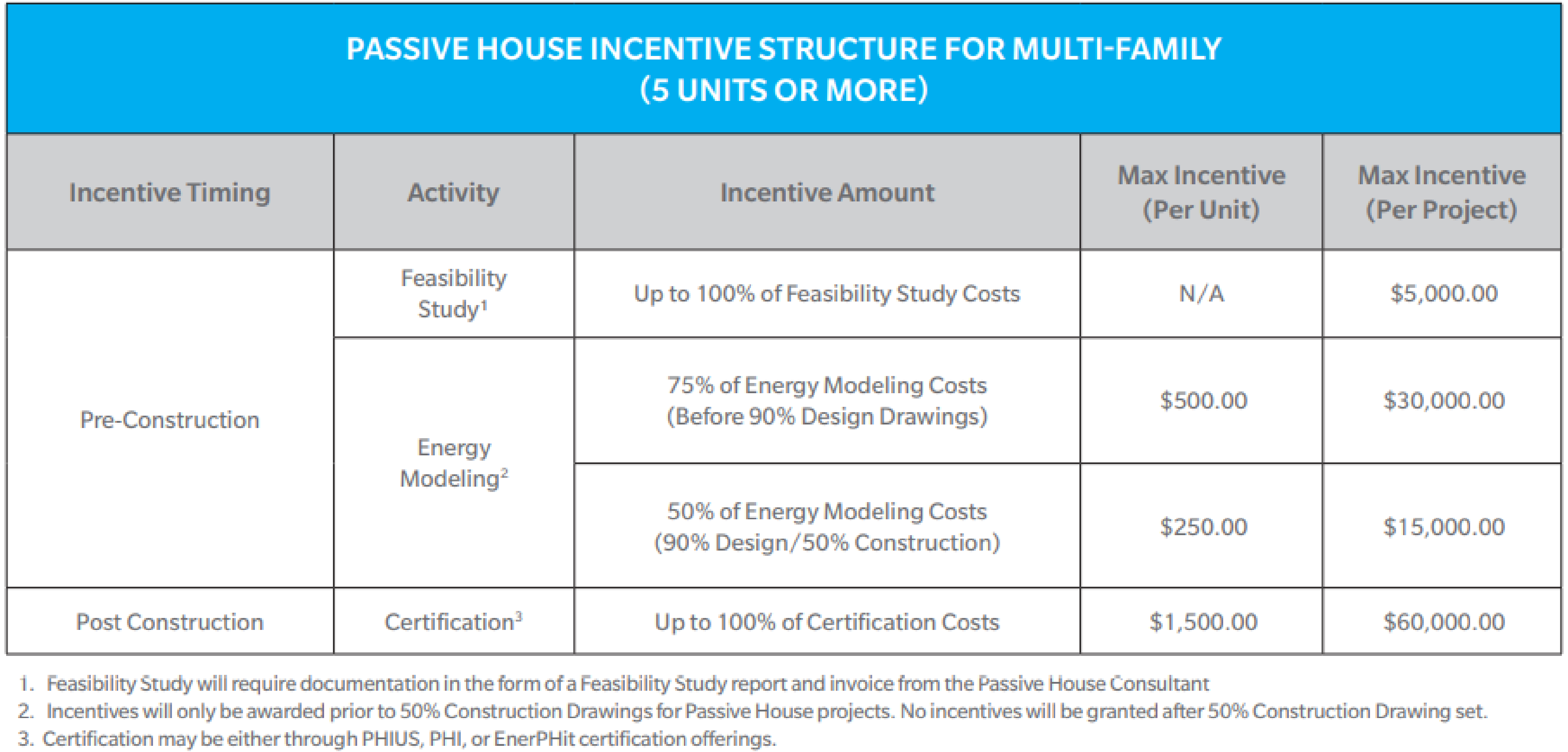
STATE OF CONNECTICUT
GOVERNOR NED LAMONT

12/16/2021

Governor Lamont Signs Executive Order Directing Connecticut State Agencies To Implement Actions That Reduce Carbon Emissions and Adapt to Climate Crisis

Provided by Connecticut Network - CT-N.com

Incentives in CT



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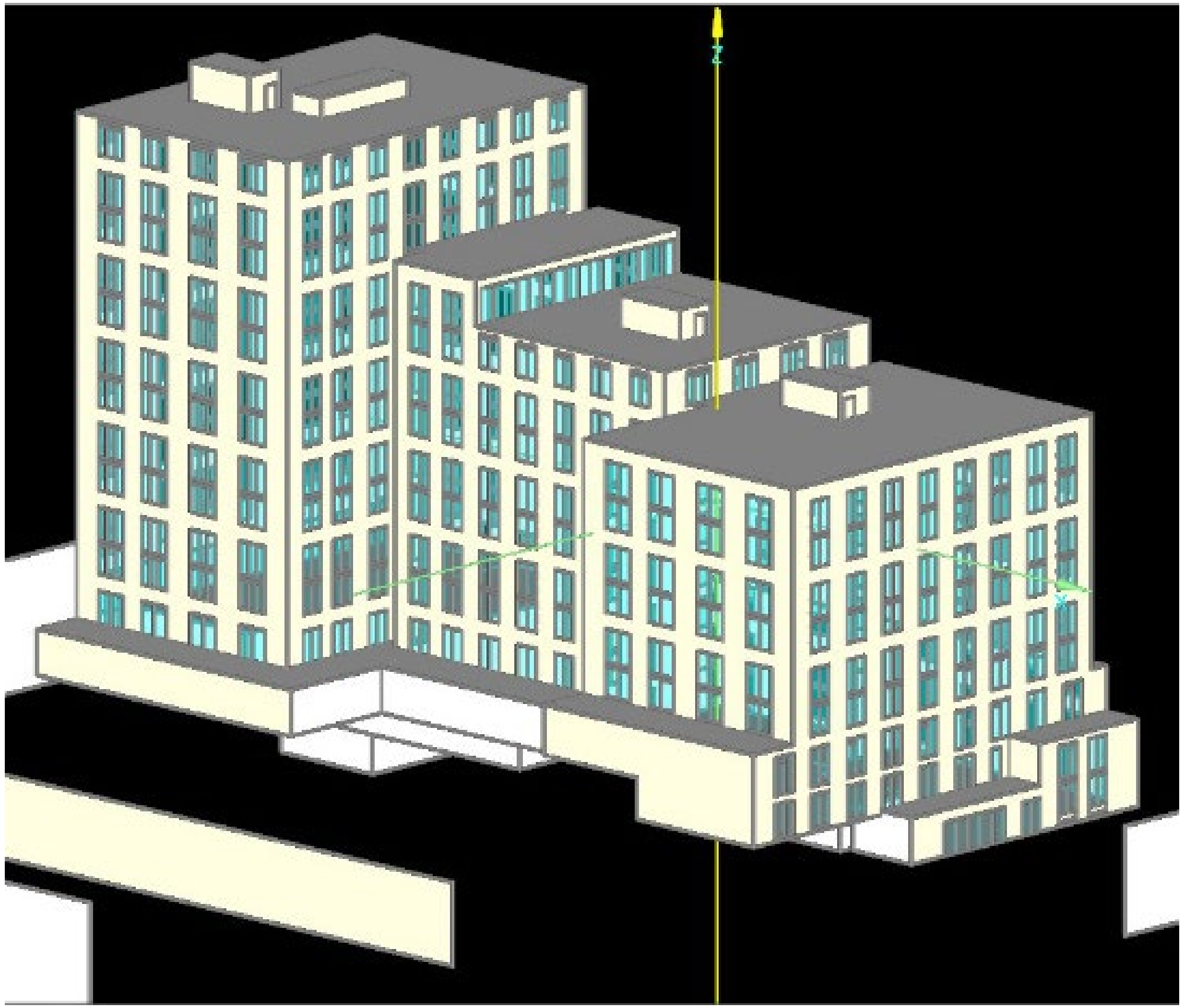
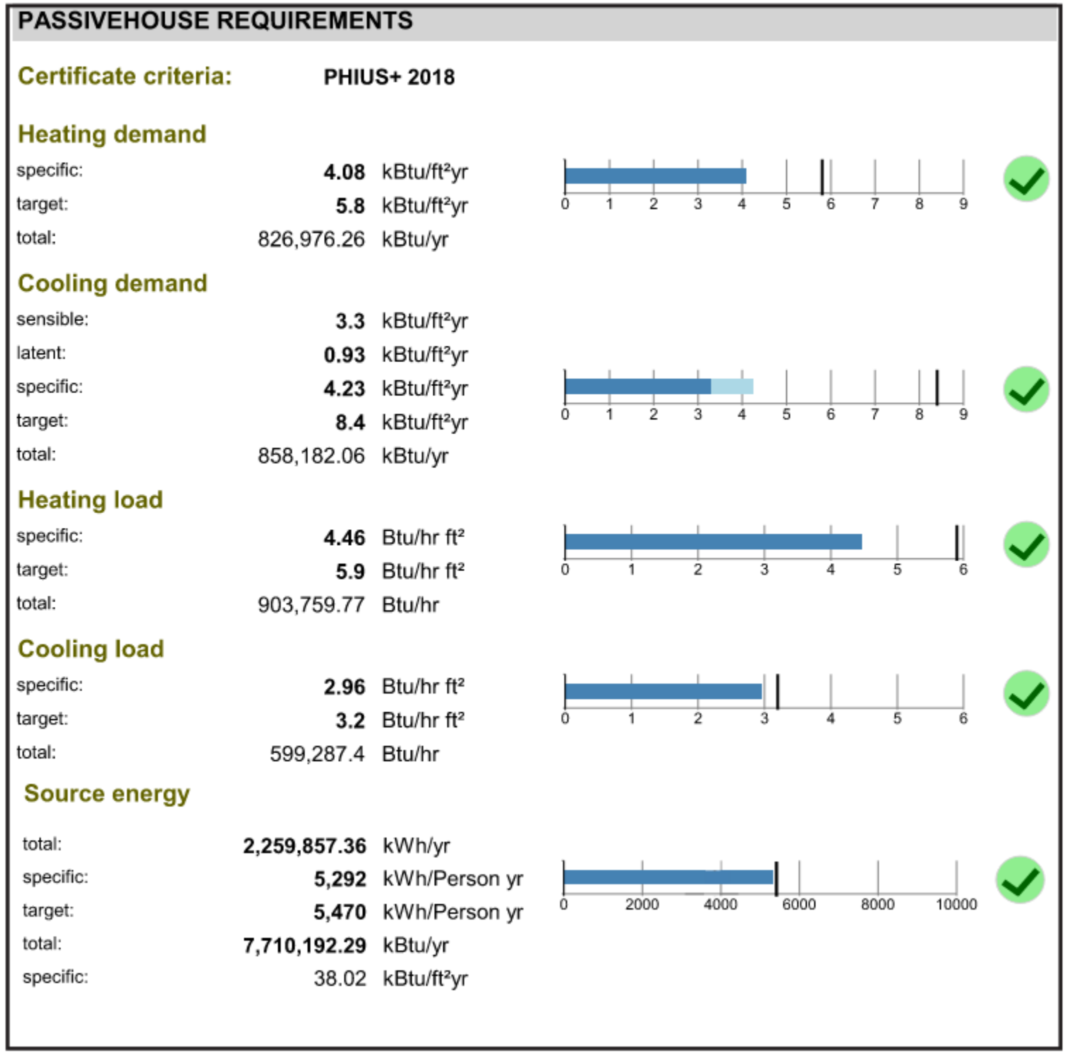
RDH Passive House Feasibility Studies





PASSIVEHOUSE REQUIREMENTS

Certificate criteria: PHIUS+ 2018

Heating demand ✓

specific:	**4.08**	kBtu/ft²yr
target:	**5.8**	kBtu/ft²yr
total:	826,976.26	kBtu/yr

Cooling demand ✓

sensible:	**3.3**	kBtu/ft²yr
latent:	**0.93**	kBtu/ft²yr
specific:	**4.23**	kBtu/ft²yr
target:	**8.4**	kBtu/ft²yr
total:	858,182.06	kBtu/yr

Heating load ✓

specific:	**4.46**	Btu/hr ft²
target:	**5.9**	Btu/hr ft²
total:	903,759.77	Btu/hr

Cooling load ✓

specific:	**2.96**	Btu/hr ft²
target:	**3.2**	Btu/hr ft²
total:	599,287.4	Btu/hr

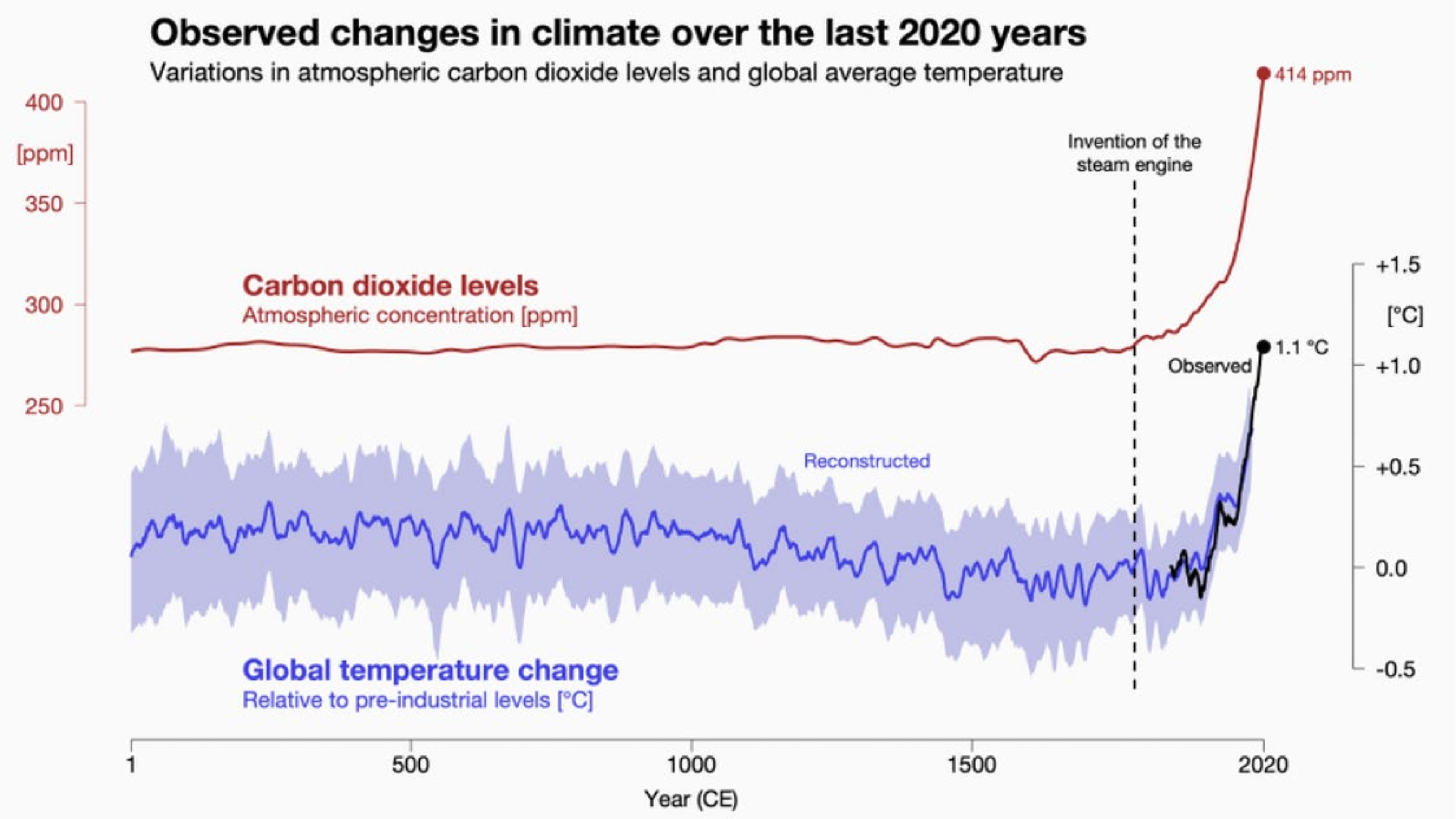
Source energy ✓

total:	**2,259,857.36**	kWh/yr
specific:	**5,292**	kWh/Person yr
target:	**5,470**	kWh/Person yr
total:	**7,710,192.29**	kBtu/yr
specific:	38.02	kBtu/ft²yr

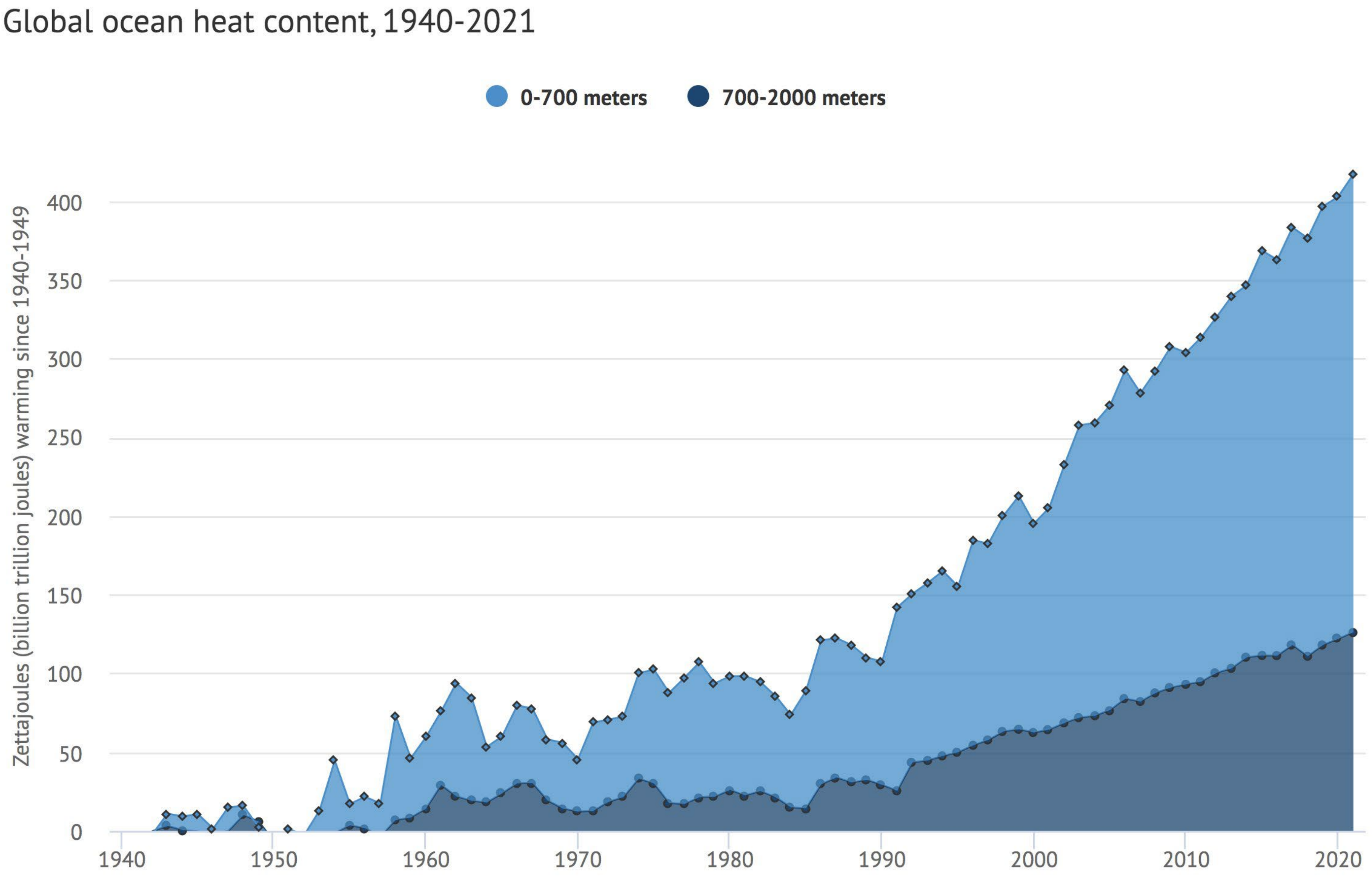
Note: Source Energy does not include any offsets from renewable energy sources.

ARCHITECTS + ENGINEERS ARE RESPONSIBLE FOR ADAPTATION

Carbon Emissions and Global Temperature

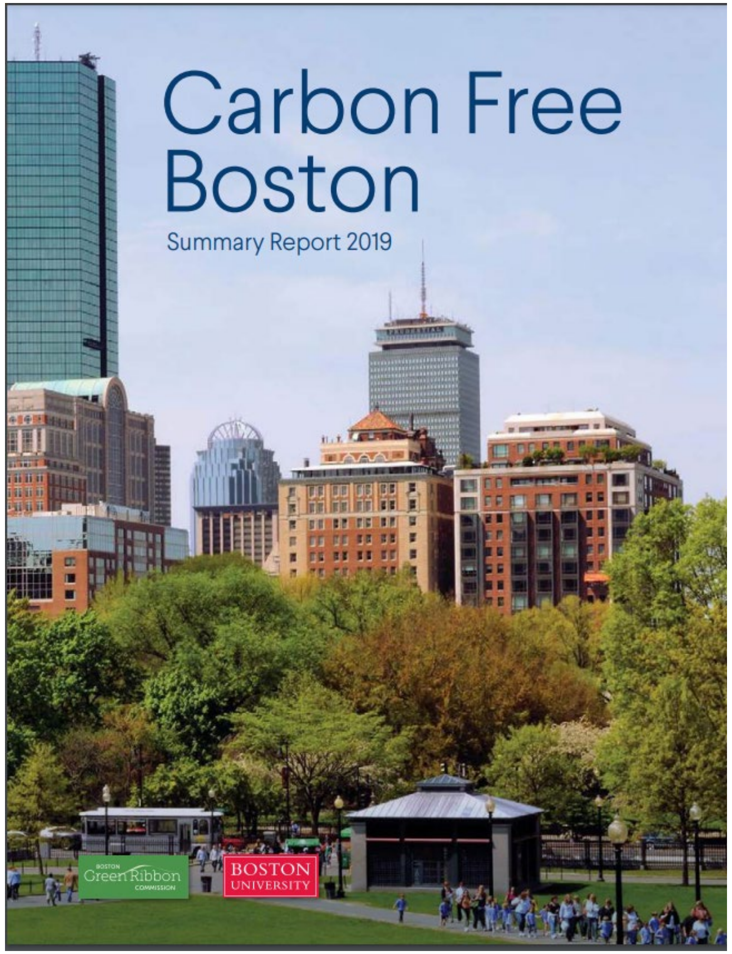


Oceans absorbing 90% of the heat for now



Ocean Warming Continues through 2021 despite La Niña Conditions. *Adv. Atmos. Sci.* (2022).

The Information is Out There

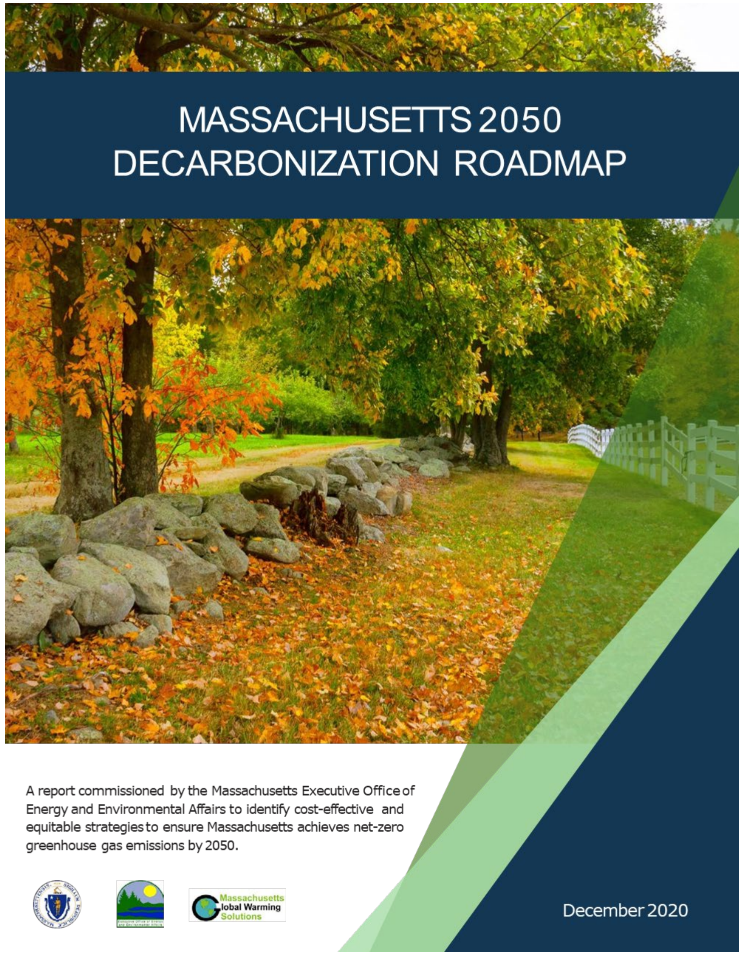


Carbon Free Boston

Summary Report 2019

Boston Green Ribbon Commission

Boston University



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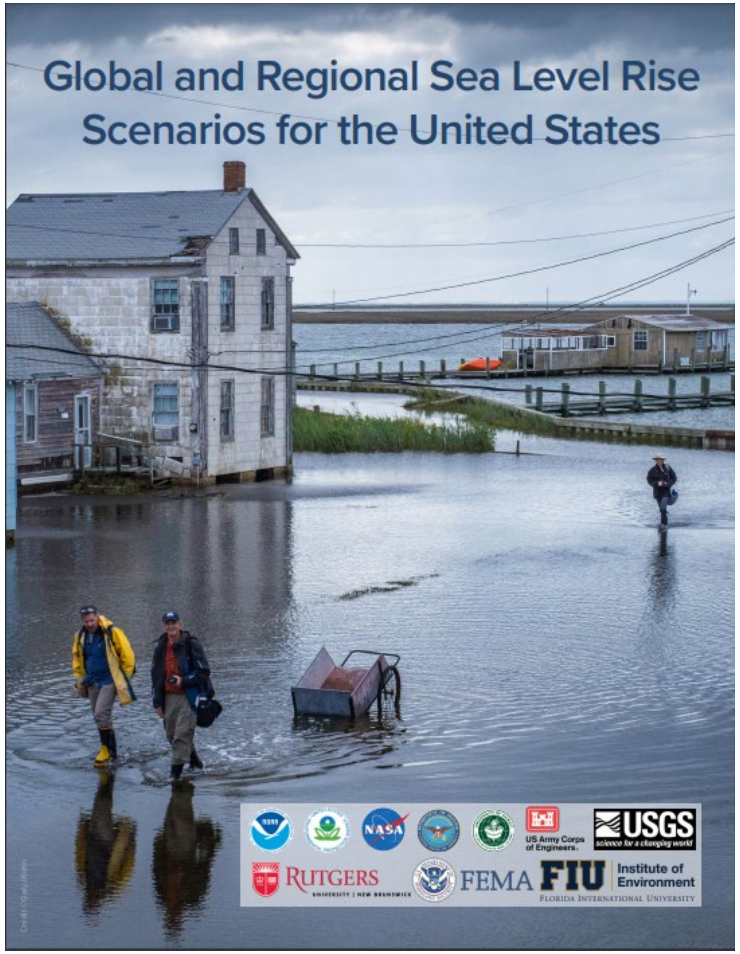


Global and Regional Sea Level Rise Scenarios for the United States

NASA

US Army Corps of Engineers

USGS science for a changing world

Rutgers University | New Brunswick

FEMA

FIU Institute of Environment Florida International University

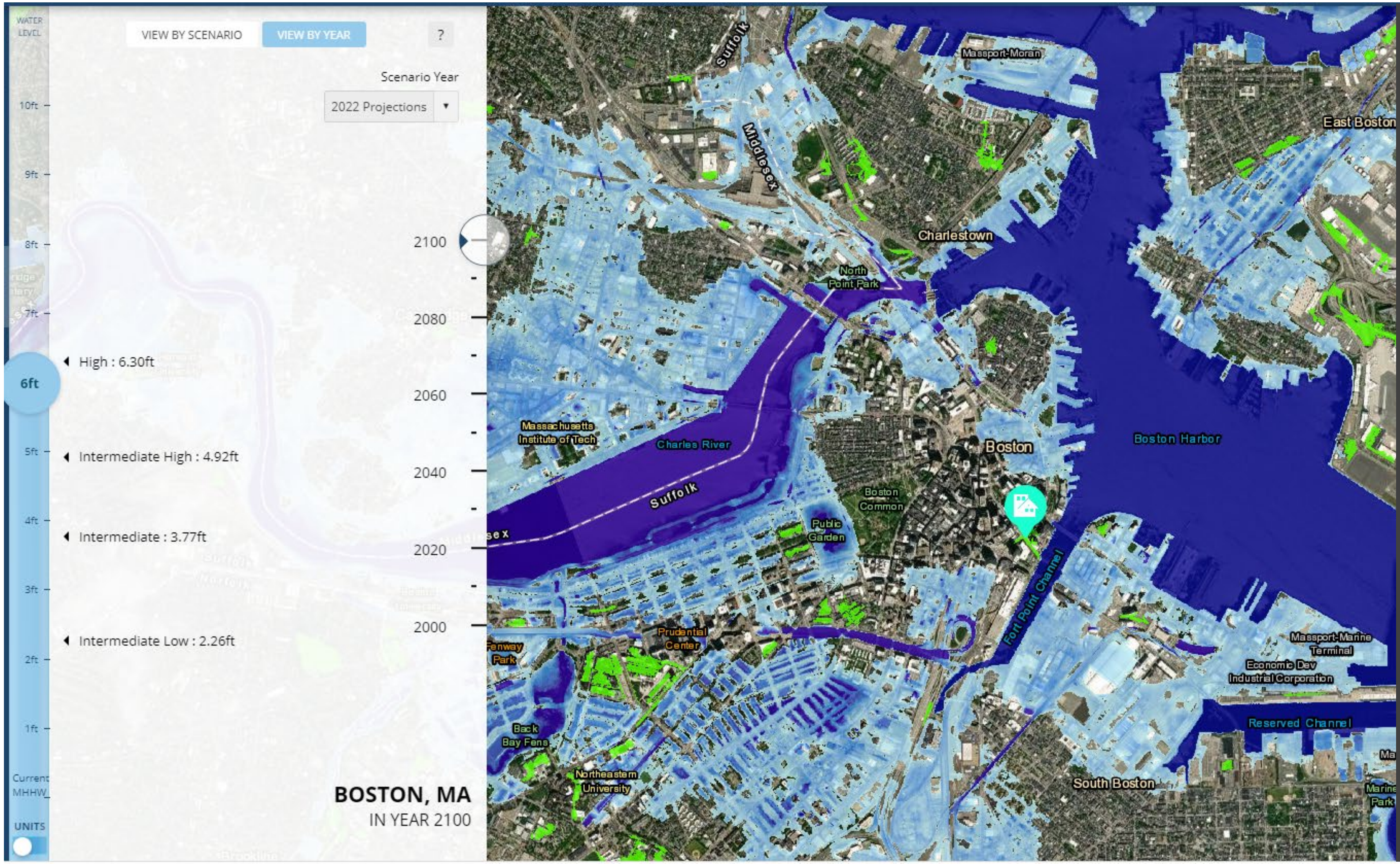
The Information is Out There

- 2/3 of Boston’s GHG emissions come from Buildings

Transitions Needed for Decarbonization:

- Electrification of space and water heating
- Invest in building envelope to drive down costs to consumers and the grid
- Use decarbonized energy sources

Resiliency + Emissions



Scenario Year: 2022 Projections

High : 6.30ft

Intermediate High : 4.92ft

Intermediate : 3.77ft

Intermediate Low : 2.26ft

BOSTON, MA
IN YEAR 2100

Emissions Matter

Current and future emissions matter.

About 2 feet of sea level rise along the U.S. coastline is increasingly likely between 2020 and 2100 because of emissions to date.

Failing to curb future emissions could cause an additional 1.5 - 5 feet of rise for a total of 3.5 - 7 feet by the end of this century.

Source: NOAA

Our Locality + Circumstances

Boston, 2018

Our Locality + Circumstances

CT Coast, 2012

Source: CT Post

Standard of Care

The Architect shall perform its services consistent with the professional skill and care ordinarily provided by architects practicing in the same or similar locality under the same or similar circumstances. The Architect shall perform its services as expeditiously as is consistent with such professional skill and care and the orderly progress of the Project.

Every Building Needs a Plan

- Plan to adapt to flooding, overheating, poor air quality.
- Plan to reduce greenhouse gas emissions to zero.
- Plan to strategize response for future carbon penalties.
- Plan to prepare for Natural Gas bans and retrofit mandates.
- Plan to tackle these costly mandates in affordable steps over time.

Mitigation?

Source: wolfehousebuildigmovers.com

Source: NY Times

CASE STUDIES

Wheaton College, Pine Hall

SGA
Architect

45,000 gsf
Building Area

$21.5m Construction Cost

$466.00
Cost/SF

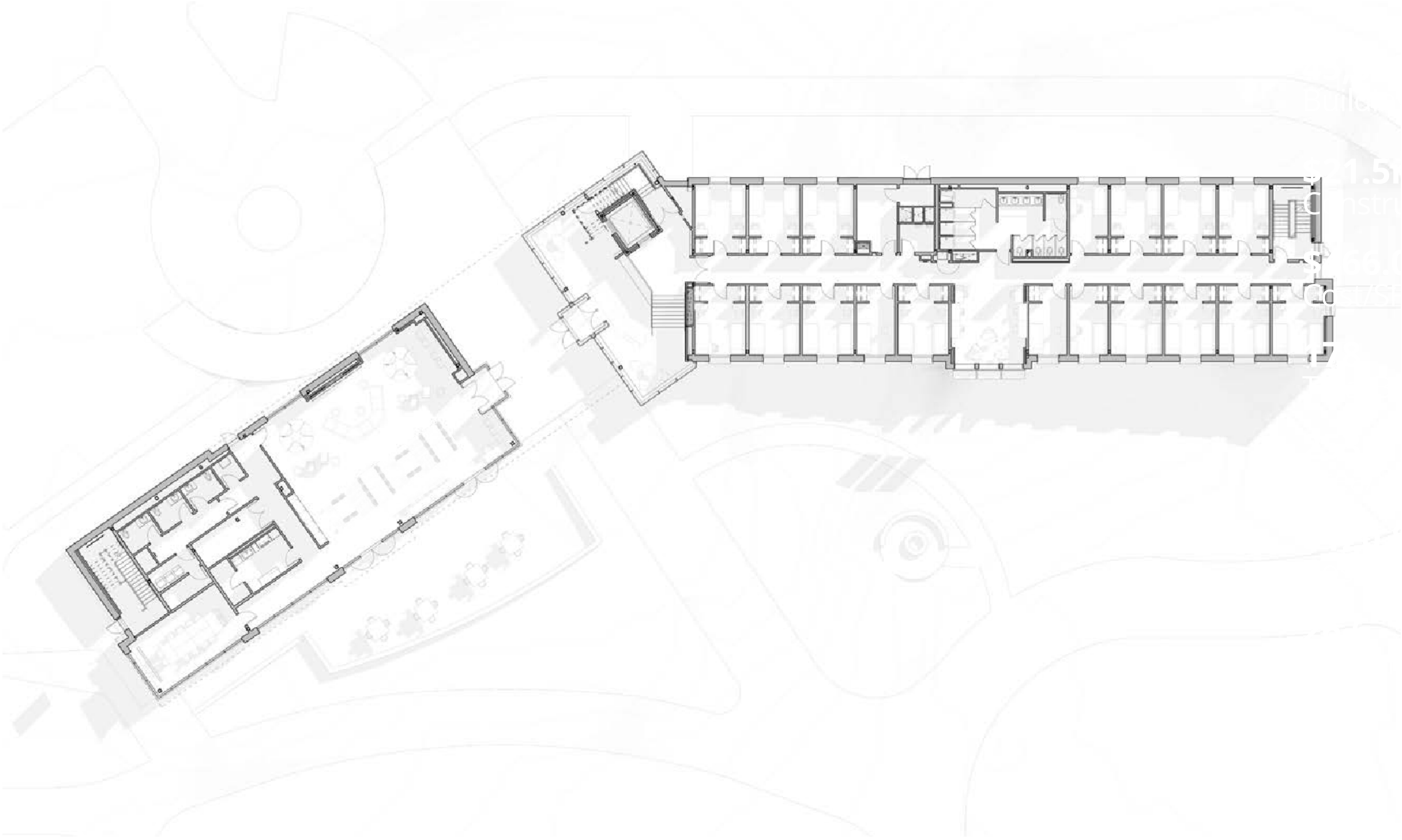
178
Total Beds

253 sf/bed
Area/Student

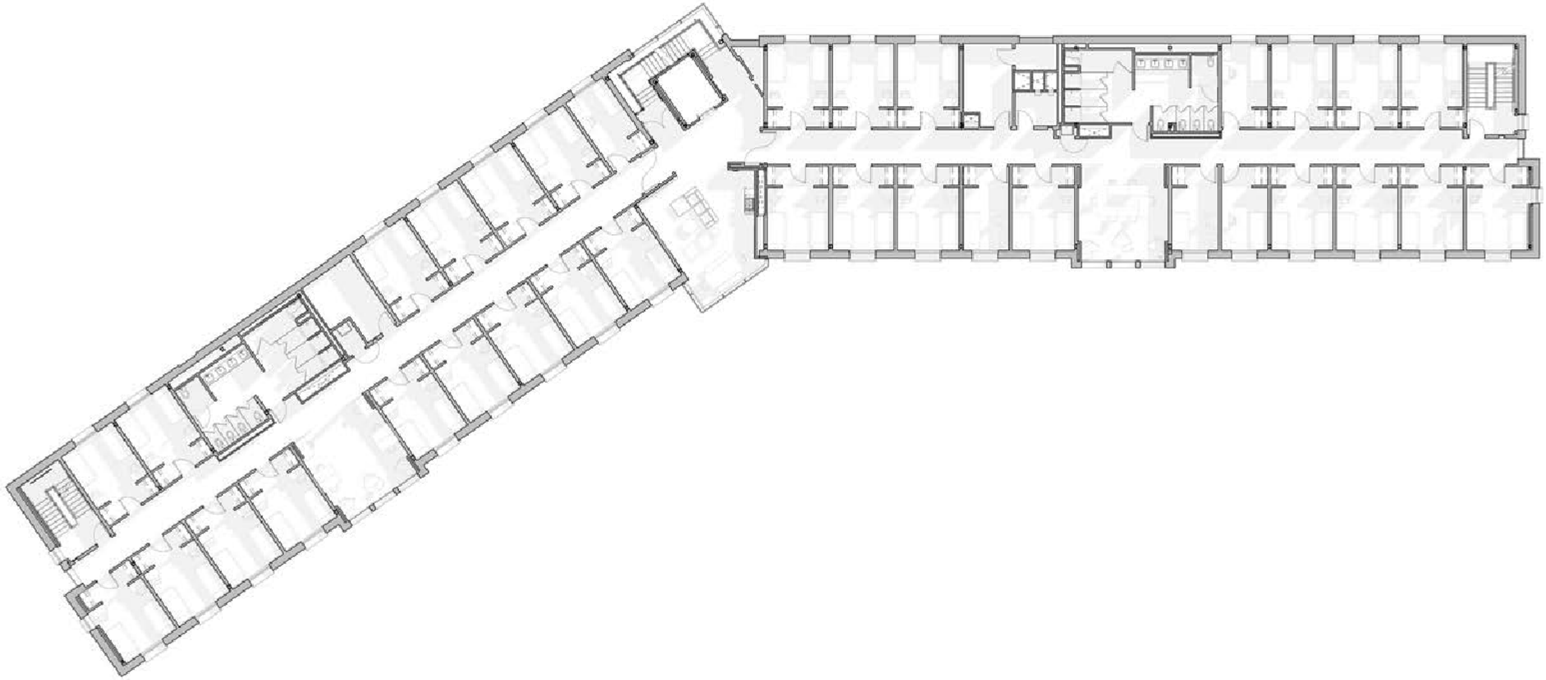
$120,800
Cost/Bed

26.6
Design EUI

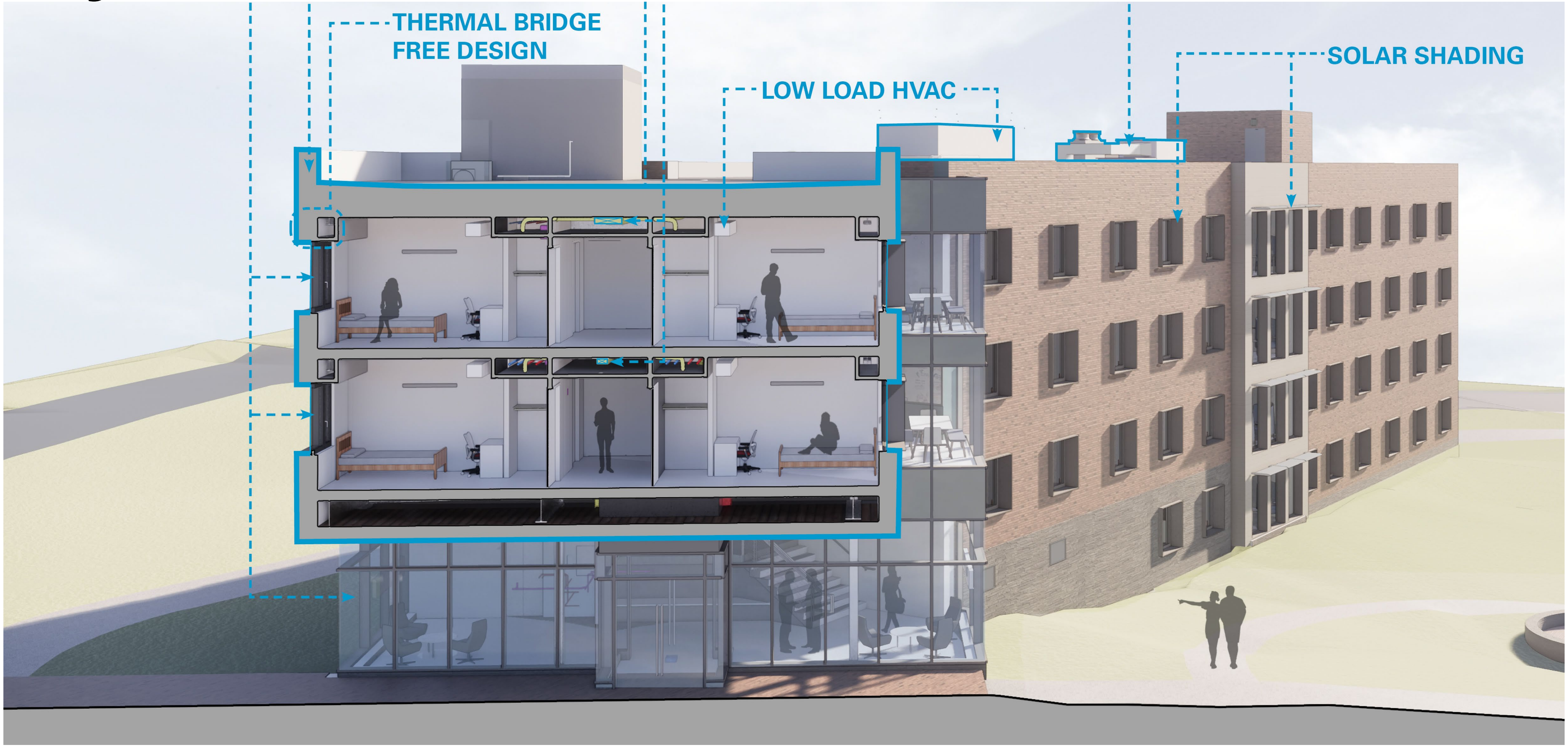
Wheaton College, Pine Hall



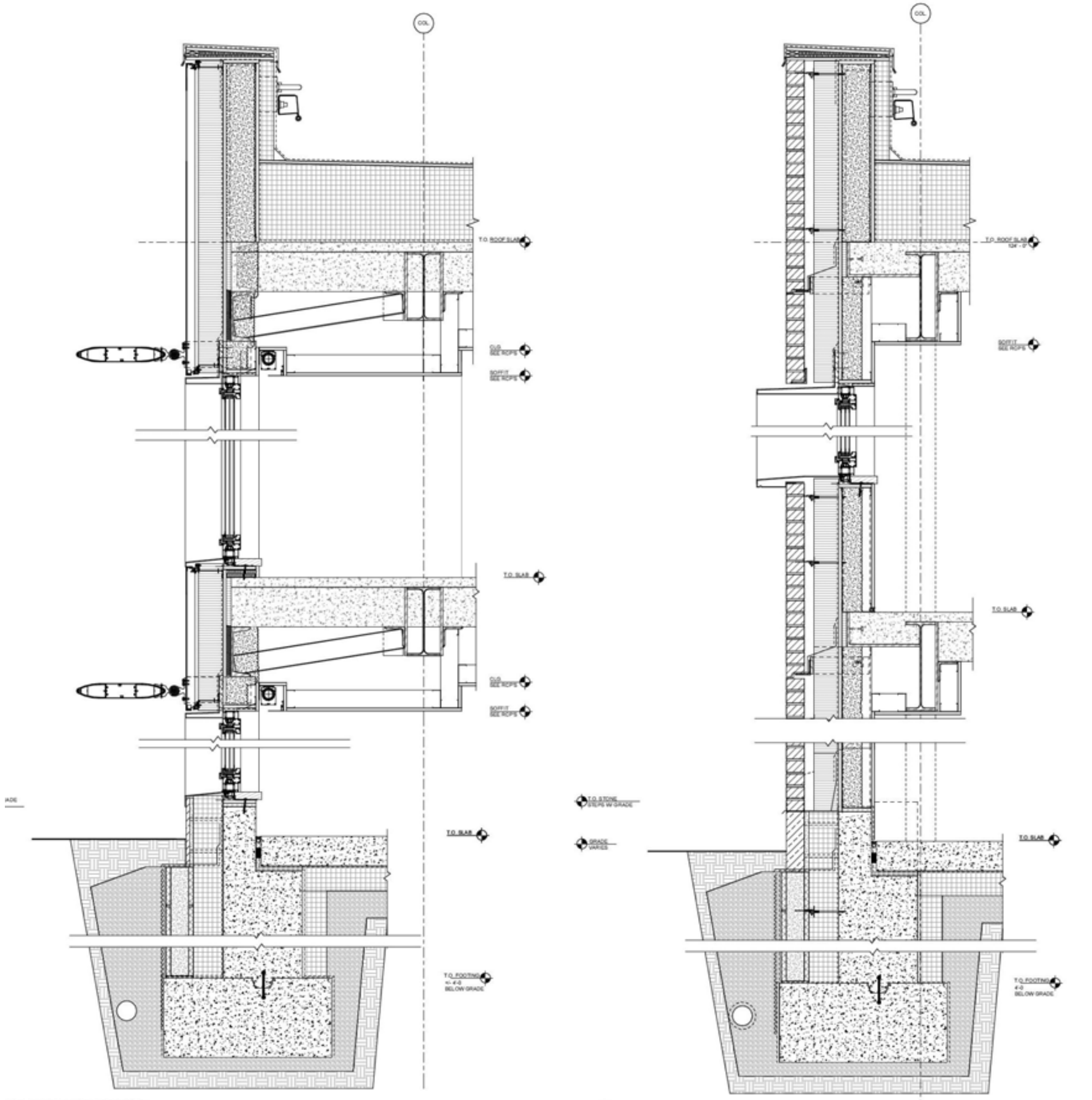
Wheaton College, Pine Hall



Layout Mechanical First/ Centralized ERV



Brise Soleil



Williams College, Garfield House

SGA
Architect

16,500 gsf
Building Area

$9.5m Construction Cost

$575.00
Cost/SF

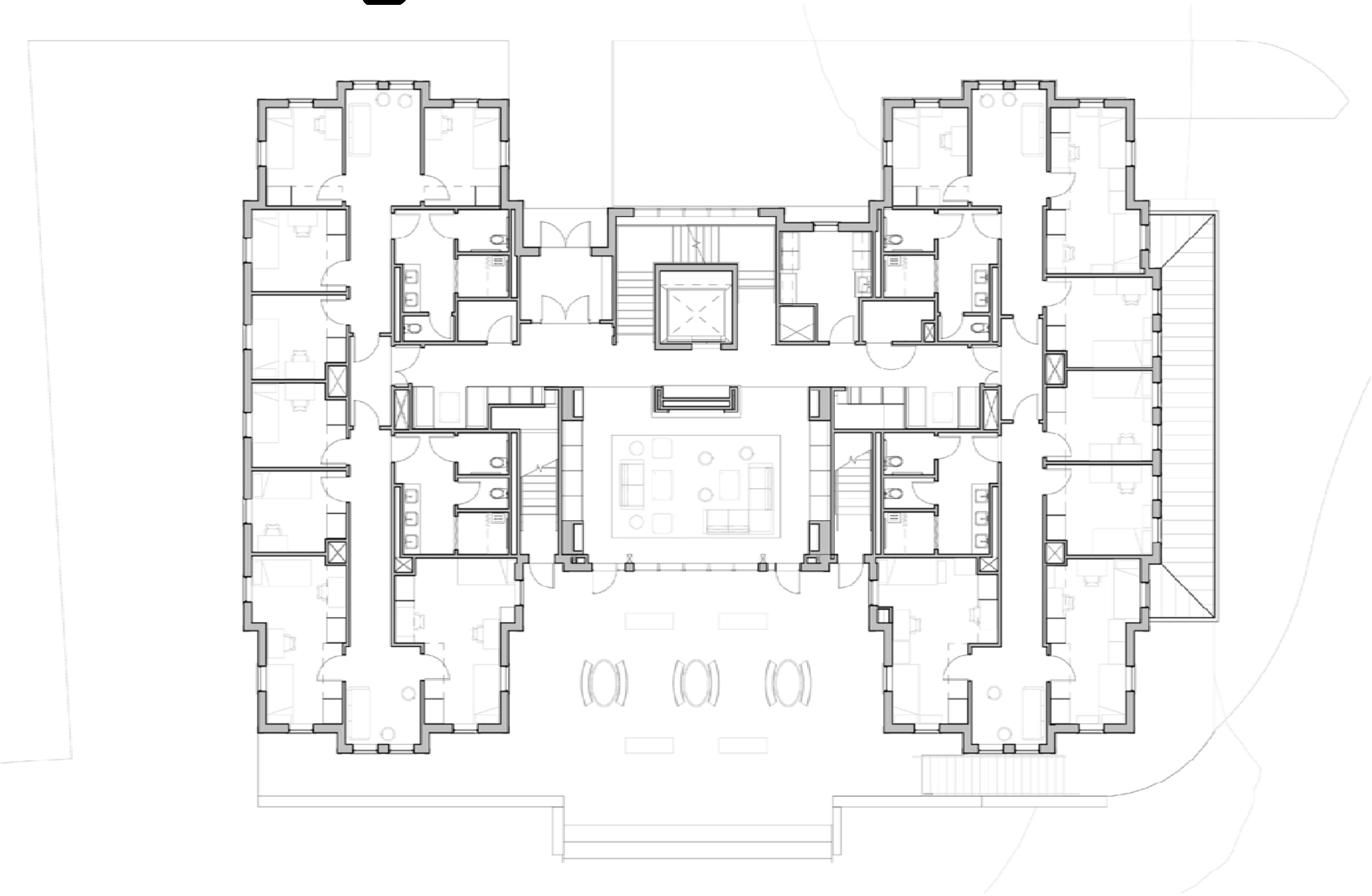
40
Total Beds

413 sf/bed
Area/Student

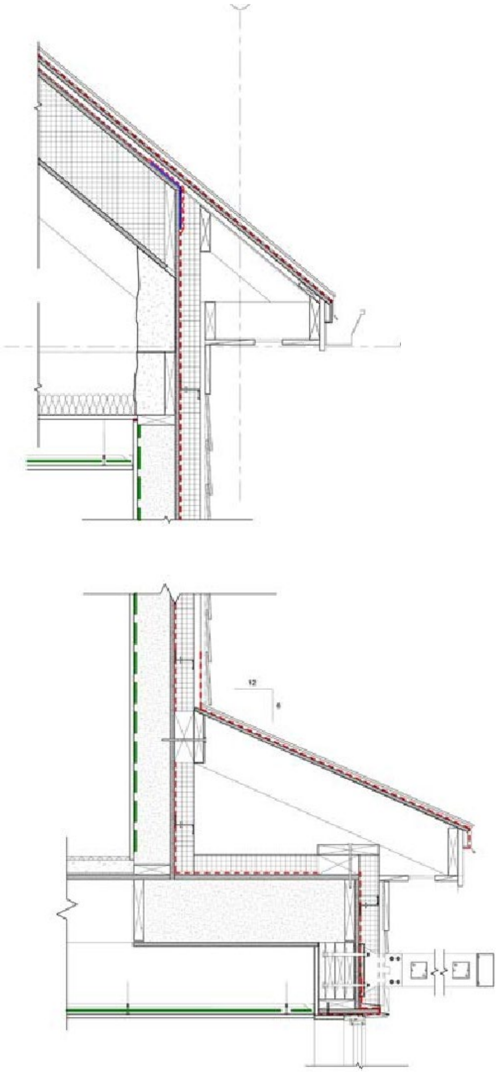
$237,500
Cost/Bed

28.2l
Design EUI

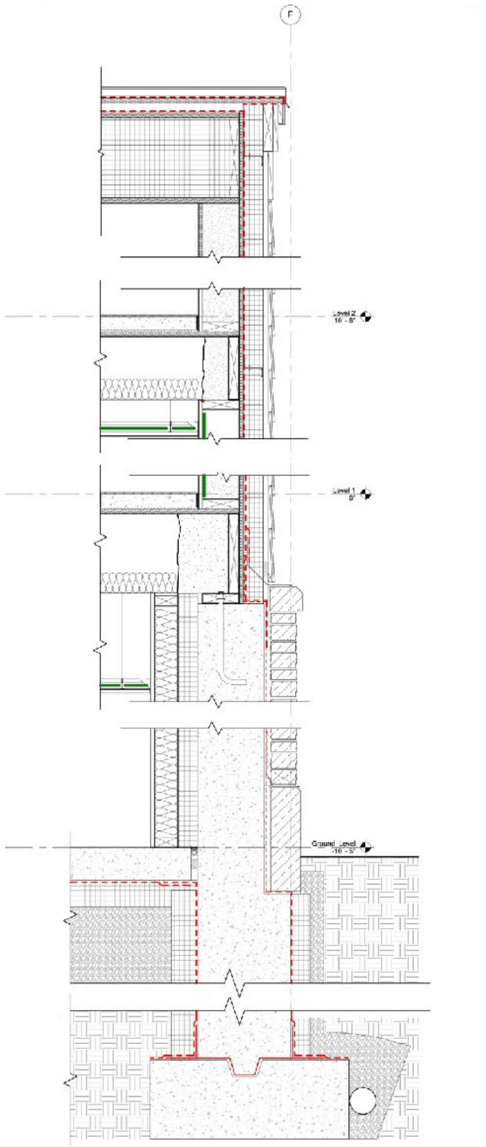
Williams College, Garfield House



Williams College, Garfield House

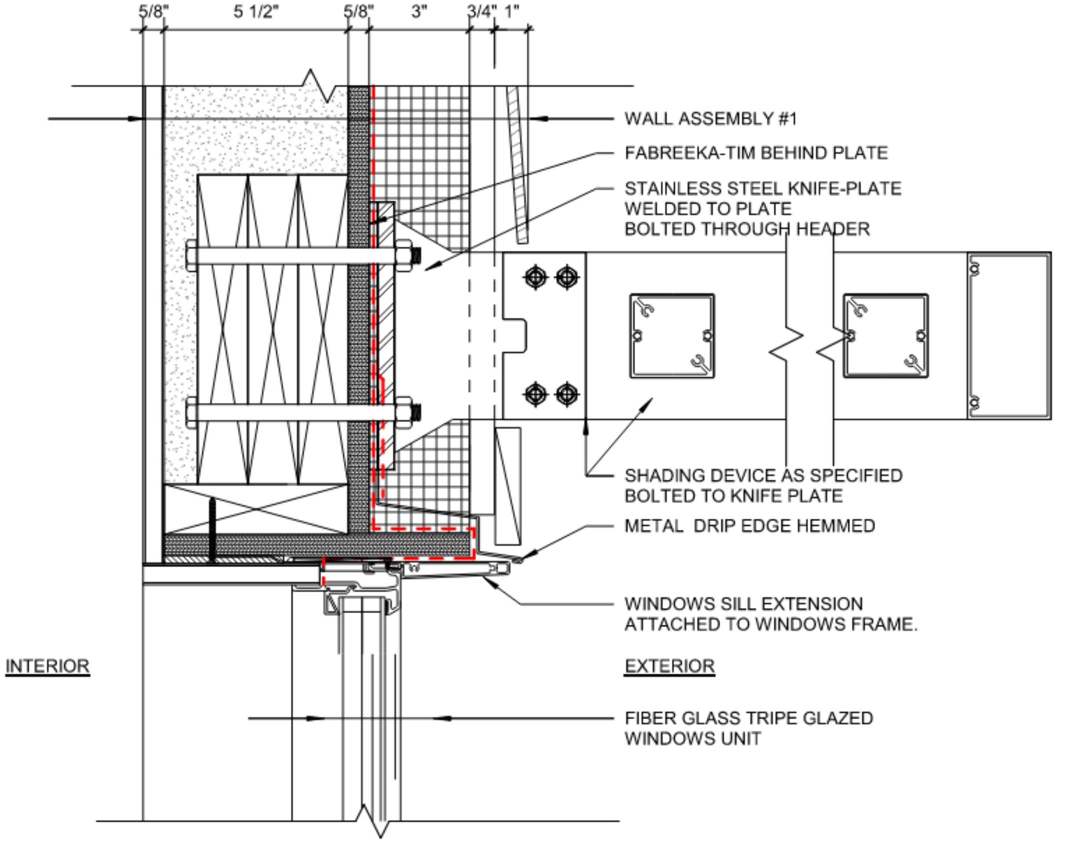


4 ROOF AT BAY
1 1/2" = 1'-0"



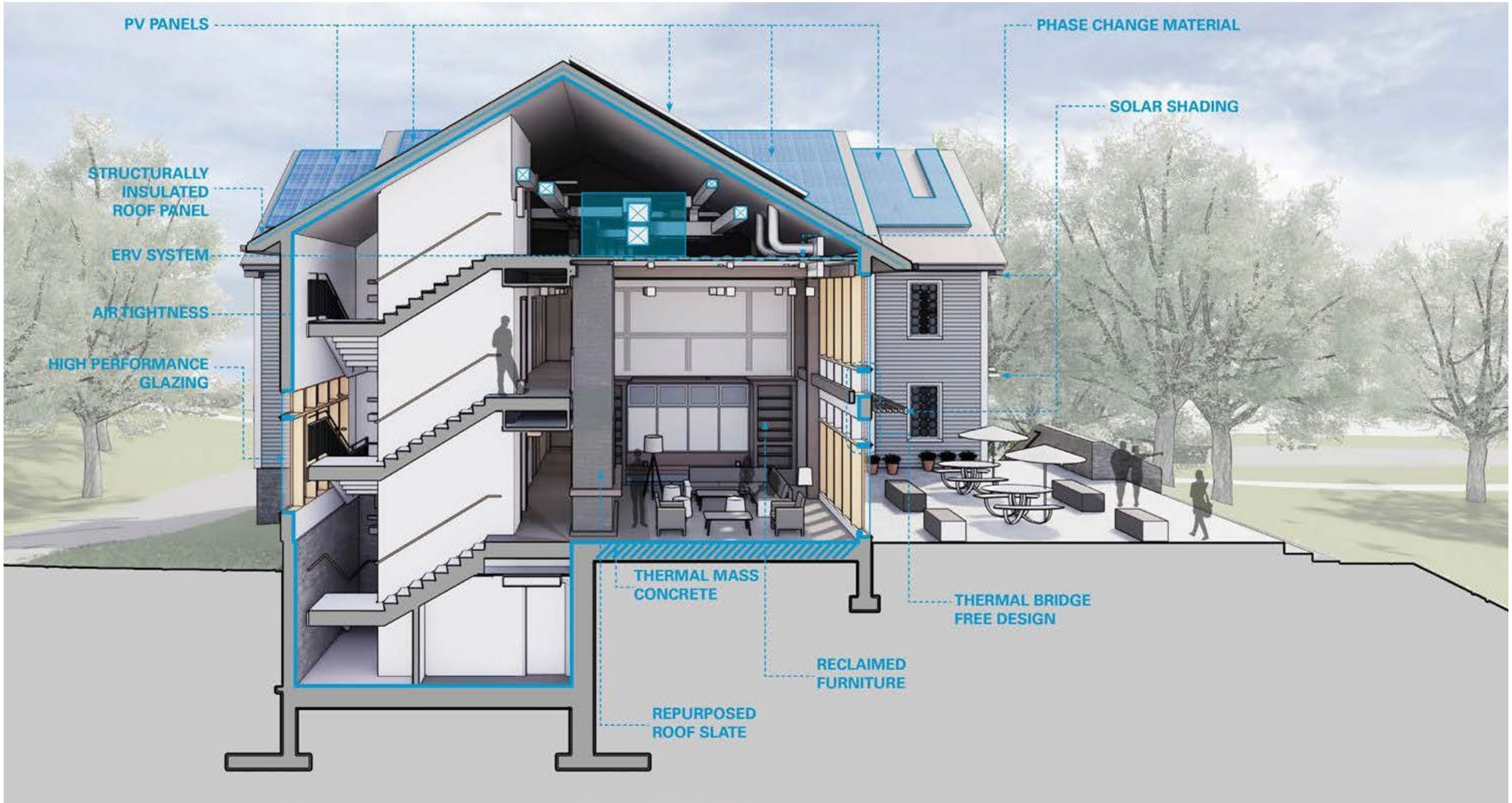
1 EXTERIOR WALL - FULL HEIGHT FOUNDATION
1 1/2" = 1'-0"

Brise Soleil

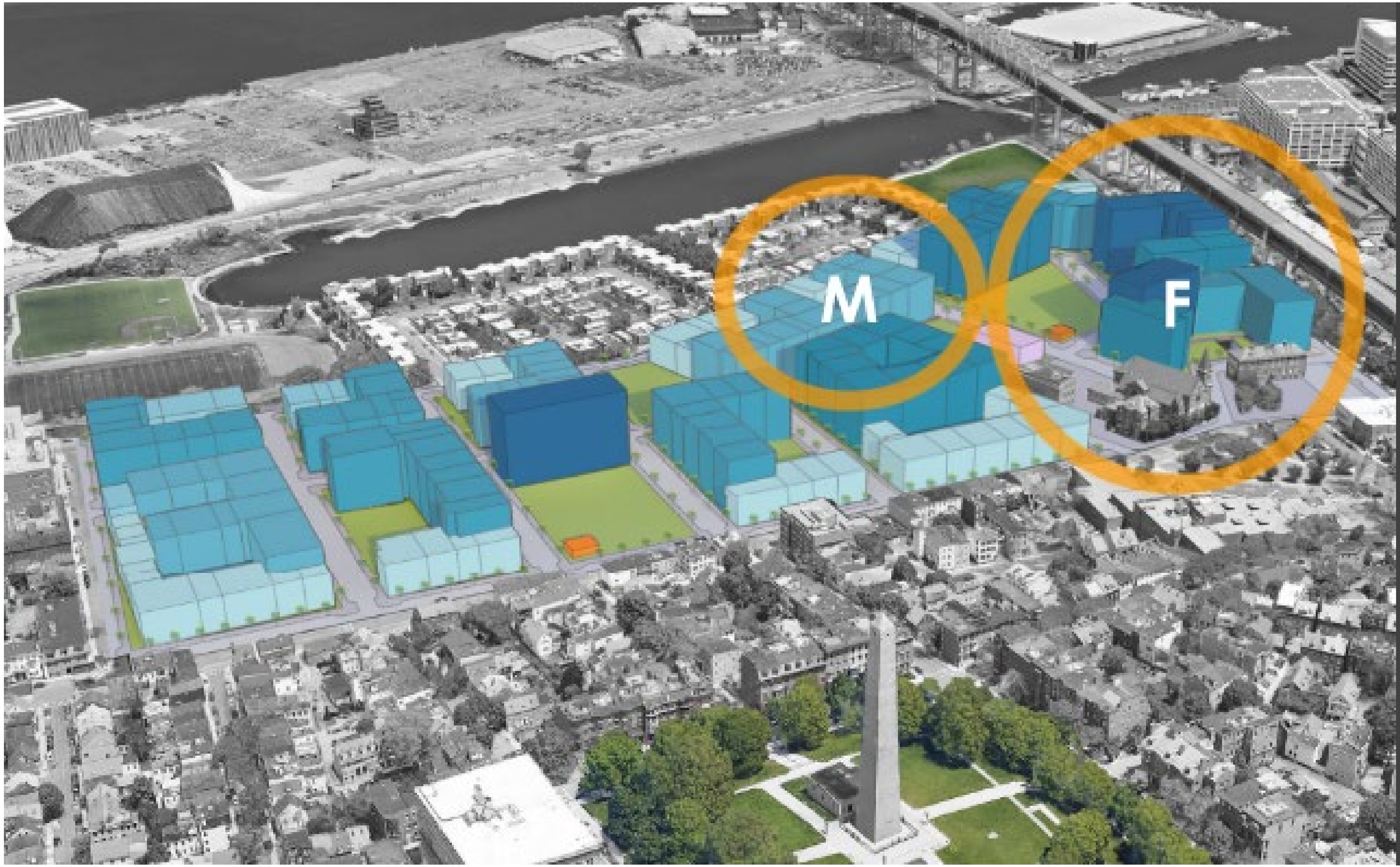


2 WINDOW HEAD SHADING DETAIL, TYP.
3" = 1'-0"

Other lessons



Bunker Hill Housing



27 Acres
Site

3,287,000 SF
Housing

2,699
Units

Bunker Hill, Building M

Stantec
Architect

Leggat McCall
Client

93,320 gsf
Building Area

102
Units

Bunker Hill, Building F

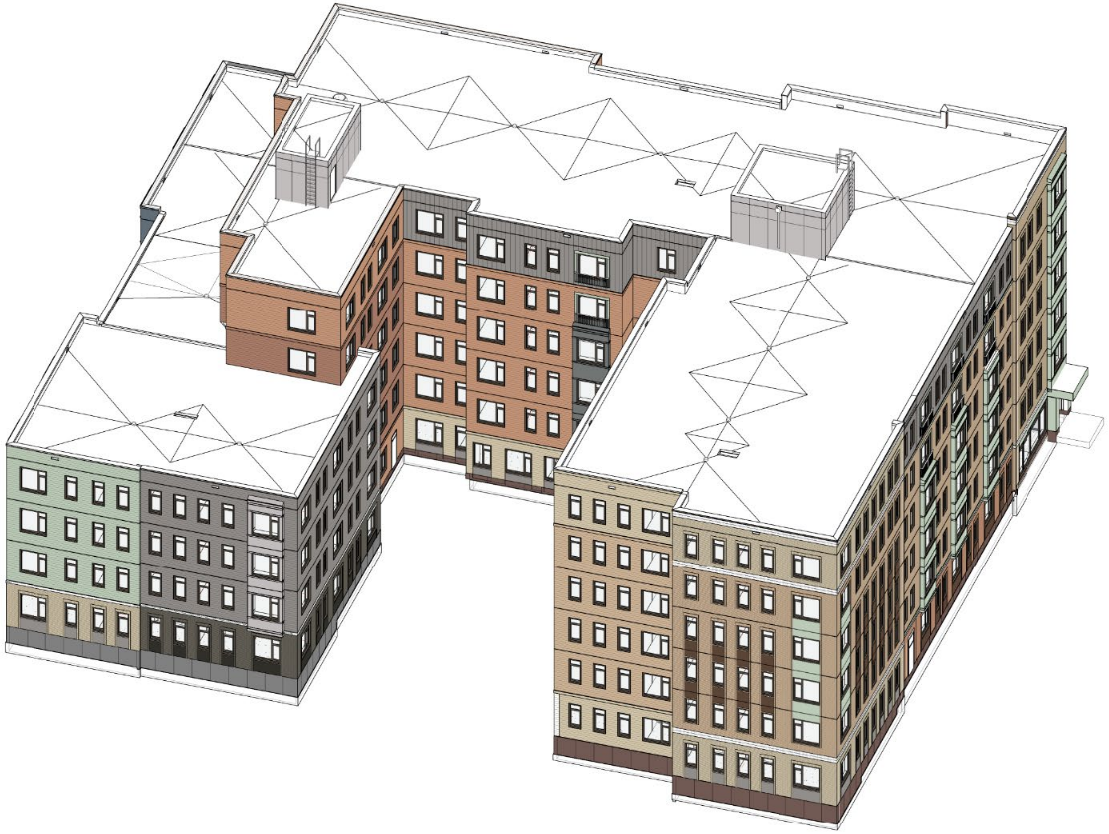
Stantec
Architect

Leggat McCall
Client

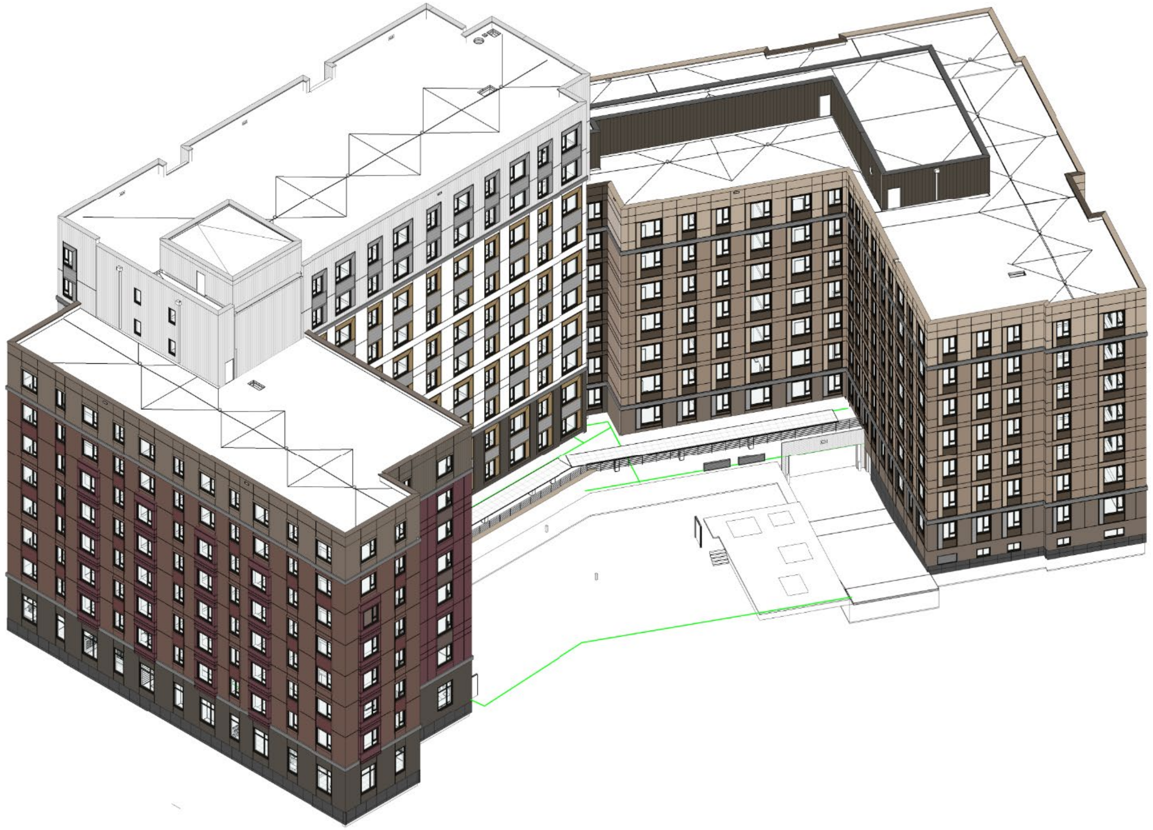
191,131 gsf
Building Area

249
Units

Compact Form, Low Window/Wall Ratio



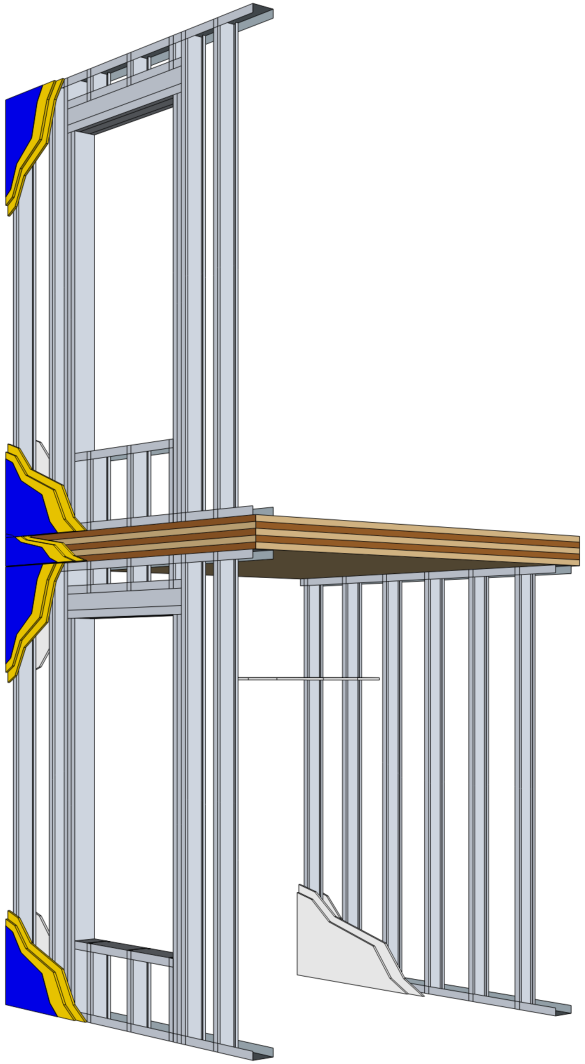
Building M

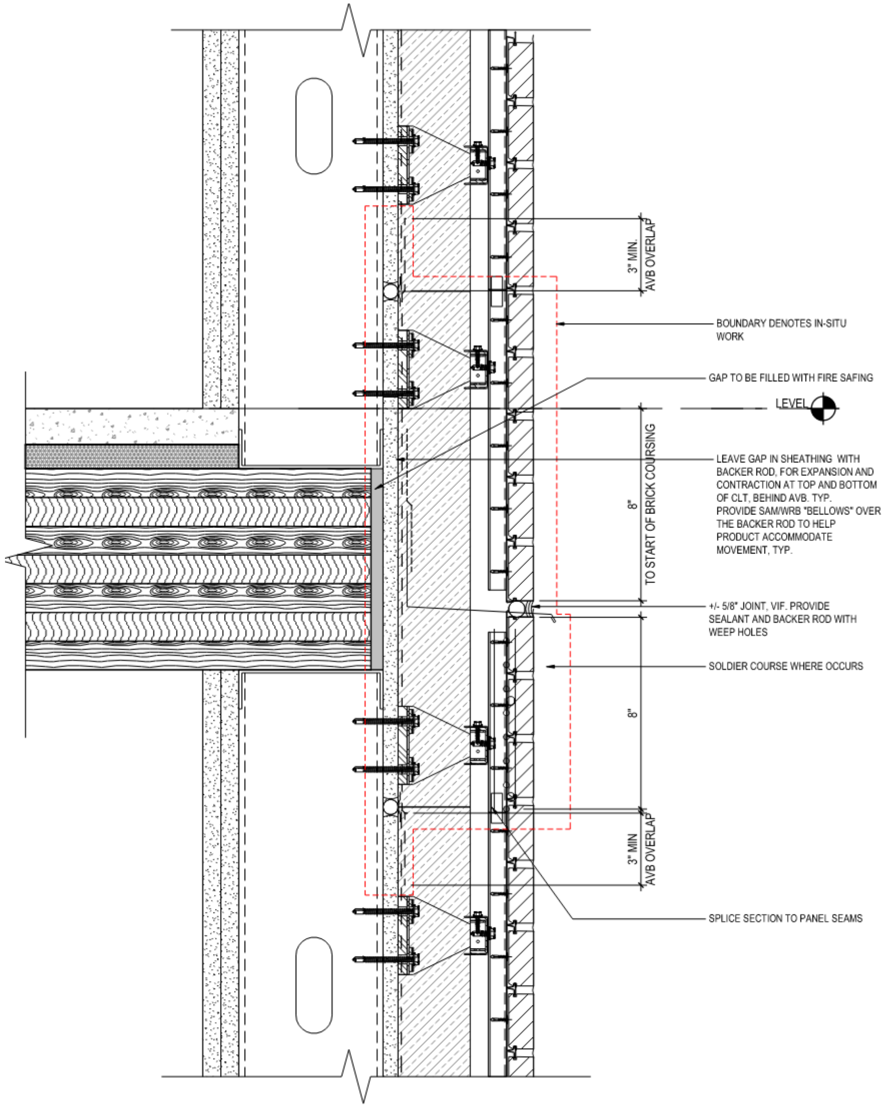


Building F

Images: Stantec

Standing Panels

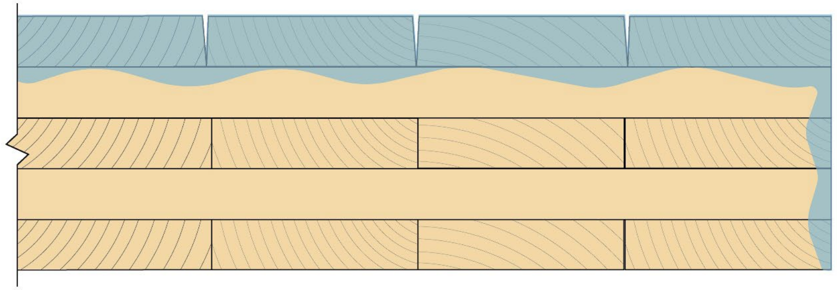




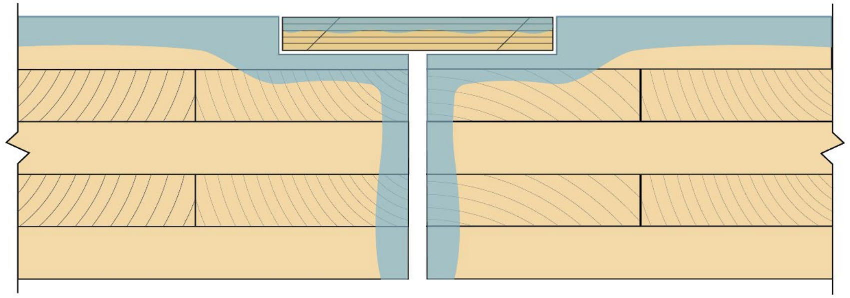
Images: Stantec

Mass Timber Moisture Risks

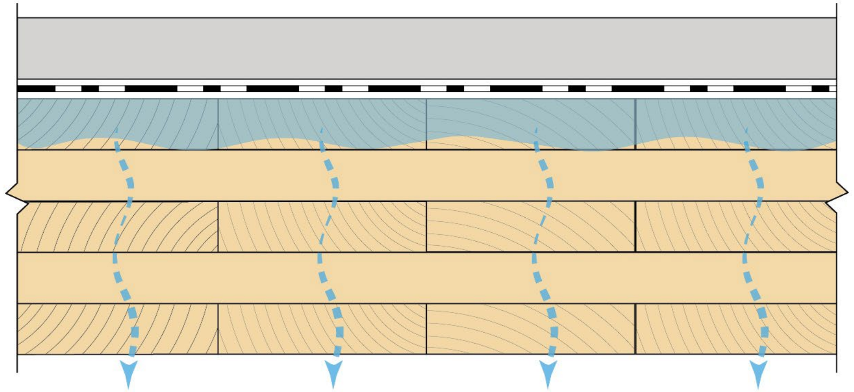
Mass timber components



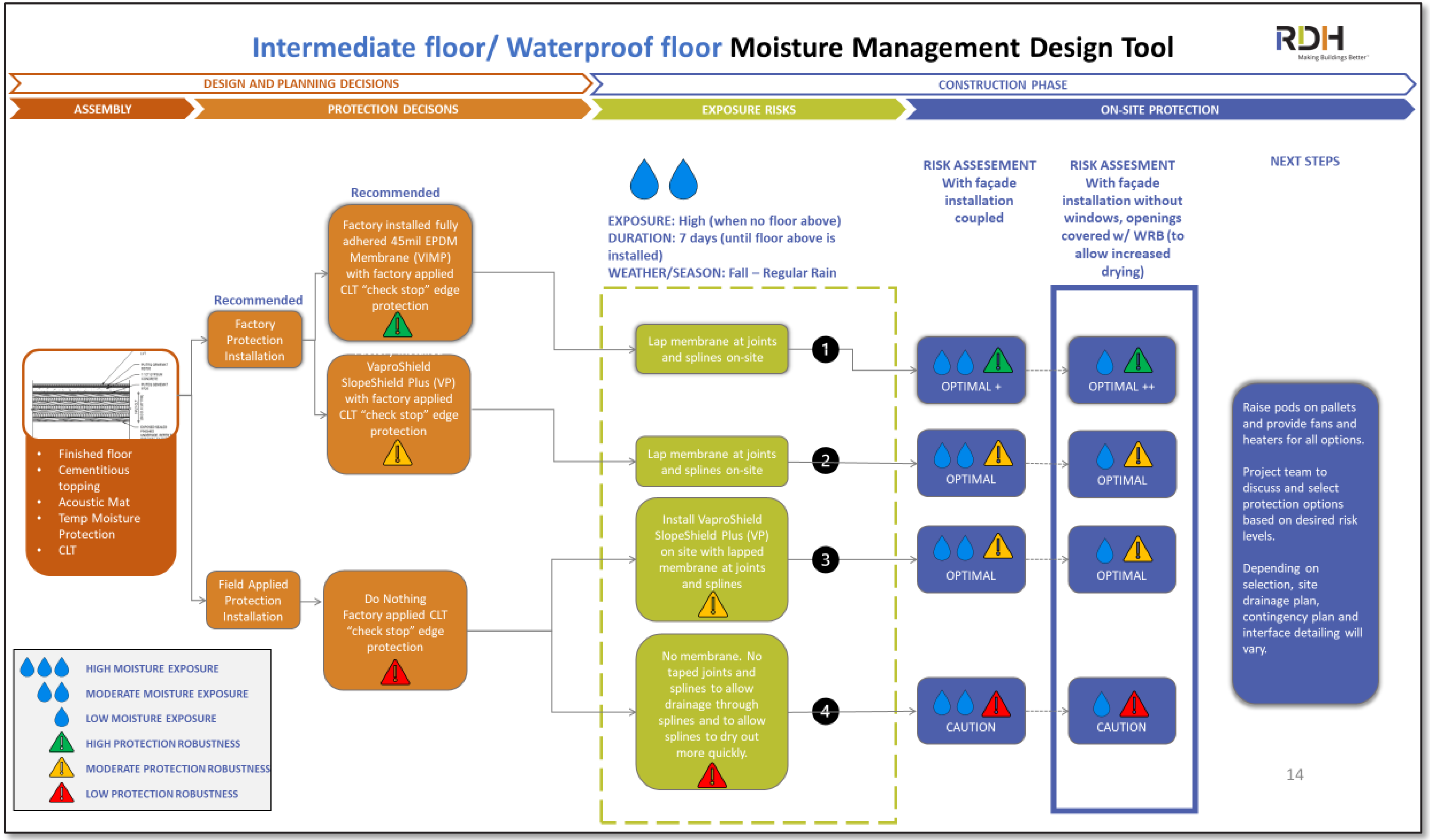
Mass timber connections



Mass timber assemblies



Mass Timber Moisture Management



Intermediate floor/ Waterproof floor Moisture Management Design Tool

RDH
Making Buildings Better

DESIGN AND PLANNING DECISIONS

CONSTRUCTION PHASE

ASSEMBLY

PROTECTION DECISONS

EXPOSURE RISKS

ON-SITE PROTECTION

- Finished floor
- Cementitious topping
- Acoustic Mat
- Temp Moisture Protection
- CLT

Recommended
Factory Protection Installation

Recommended
Factory installed fully adhered 45mil EPDM Membrane (VIMP) with factory applied CLT "check stop" edge protection ⚠

VaproShield SlopeShield Plus (VP) with factory applied CLT "check stop" edge protection ⚠

Field Applied Protection Installation

Do Nothing Factory applied CLT "check stop" edge protection ⚠

💧💧

EXPOSURE: High (when no floor above)
DURATION: 7 days (until floor above is installed)
WEATHER/SEASON: Fall – Regular Rain

Lap membrane at joints and splines on-site ❶

Lap membrane at joints and splines on-site ❷

Install VaproShield SlopeShield Plus (VP) on site with lapped membrane at joints and splines ⚠ ❸

No membrane. No taped joints and splines to allow drainage through splines and to allow splines to dry out more quickly. ⚠ ❹

	RISK ASSESEMENT With façade installation coupled	RISK ASSESMENT With façade installation without windows, openings covered w/ WRB (to allow increased drying)
1	💧💧⚠ OPTIMAL +	💧⚠ OPTIMAL ++
2	💧💧⚠ OPTIMAL	💧⚠ OPTIMAL
3	💧💧⚠ OPTIMAL	💧⚠ OPTIMAL
4	💧💧⚠ CAUTION	💧⚠ CAUTION

NEXT STEPS

Raise pods on pallets and provide fans and heaters for all options.

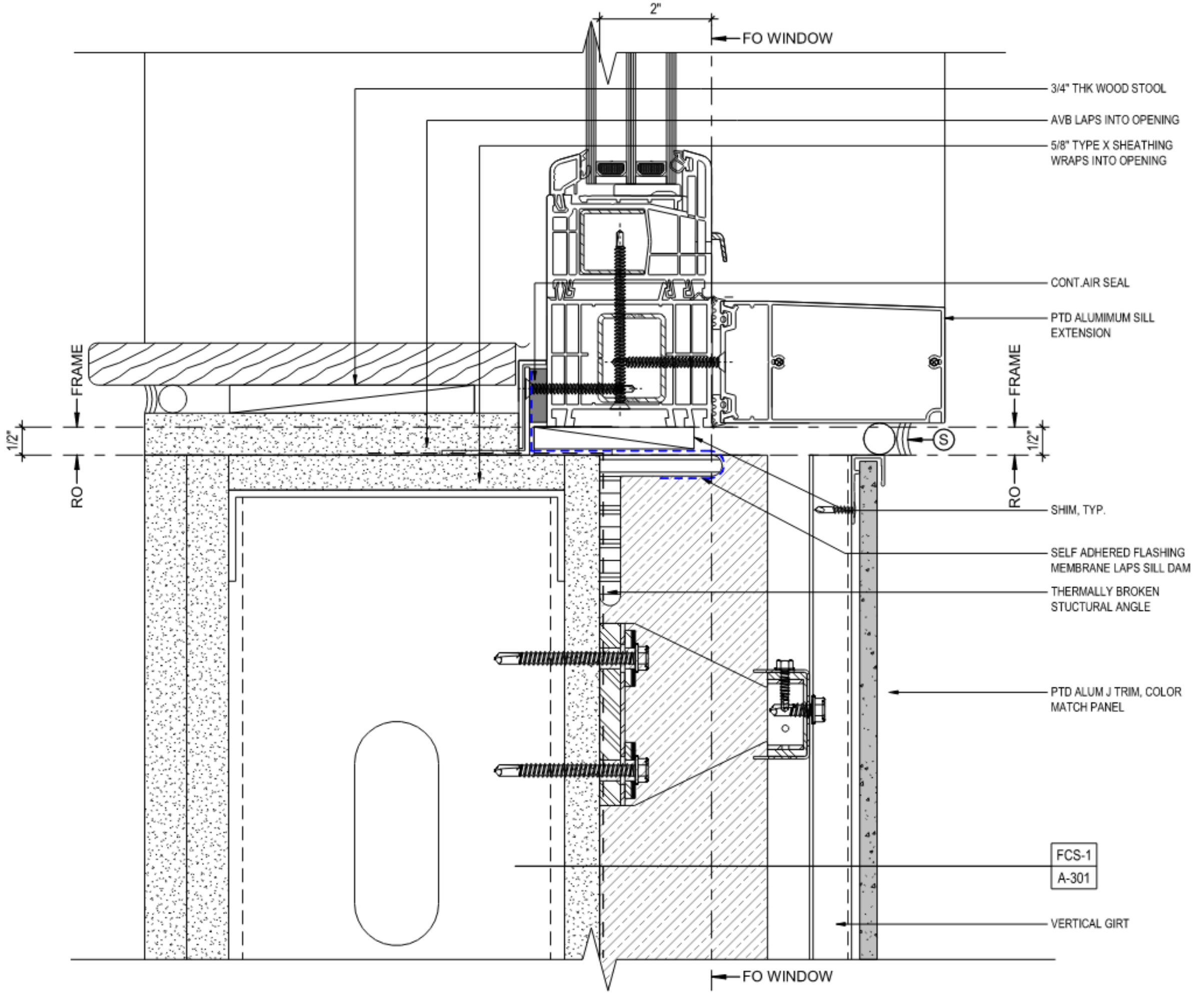
Project team to discuss and select protection options based on desired risk levels.

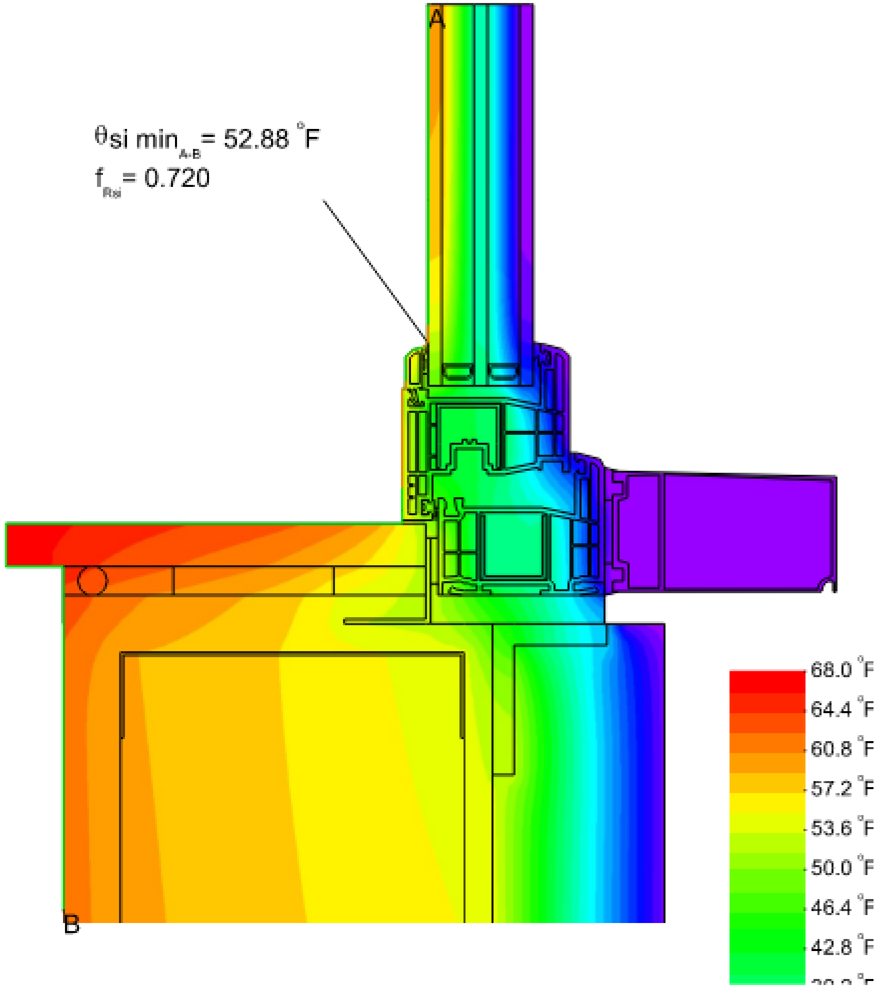
Depending on selection, site drainage plan, contingency plan and interface detailing will vary.

💧💧💧	HIGH MOISTURE EXPOSURE
💧💧	MODERATE MOISTURE EXPOSURE
💧	LOW MOISTURE EXPOSURE
⚠	HIGH PROTECTION ROBUSTNESS
⚠	MODERATE PROTECTION ROBUSTNESS
⚠	LOW PROTECTION ROBUSTNESS

14

Windows with Purpose





Architect: Stantec

Bakers Place, Madison WI

Michael Green Architecture/ Angus Young
Architect

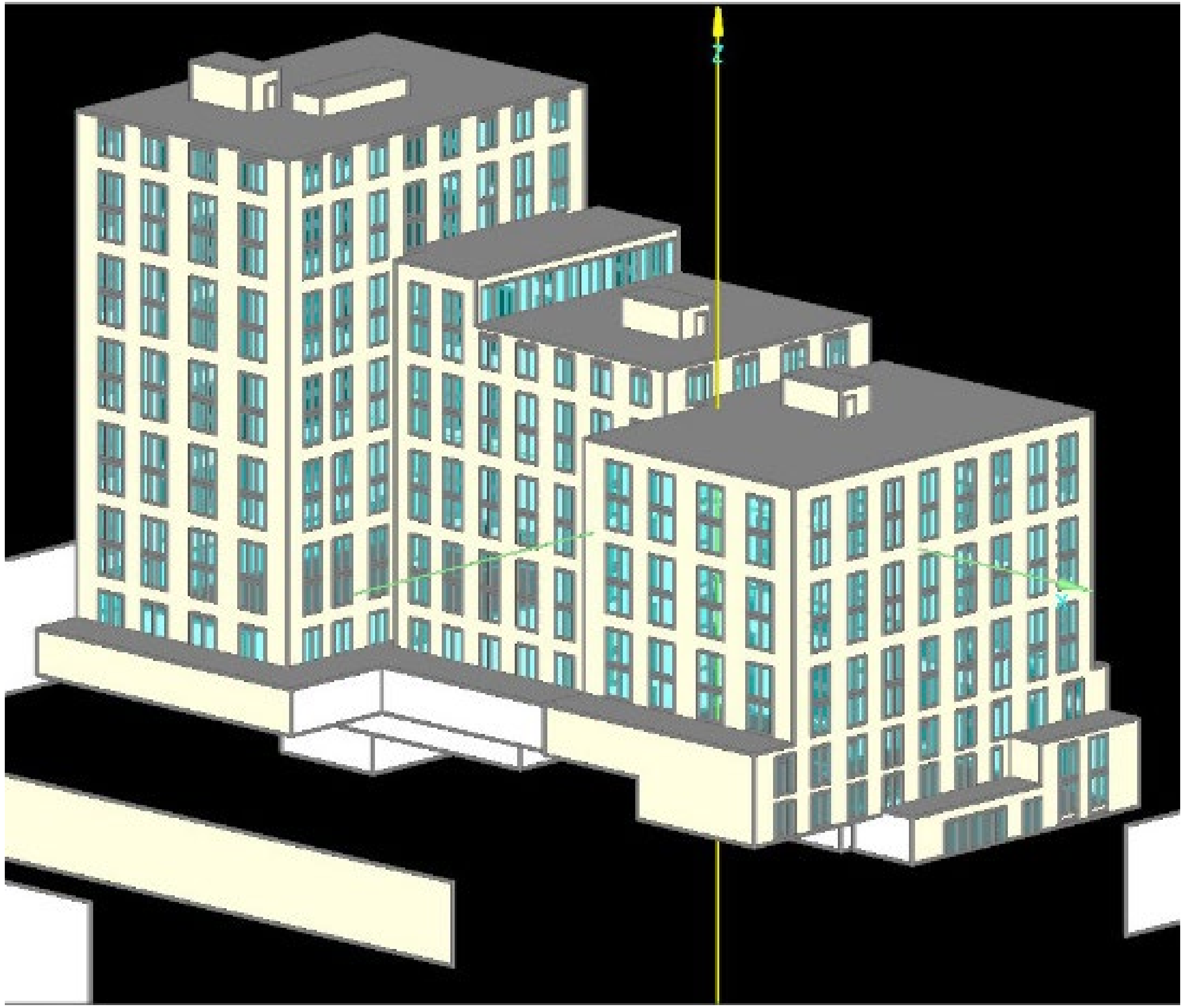
The Neutral Project
Client

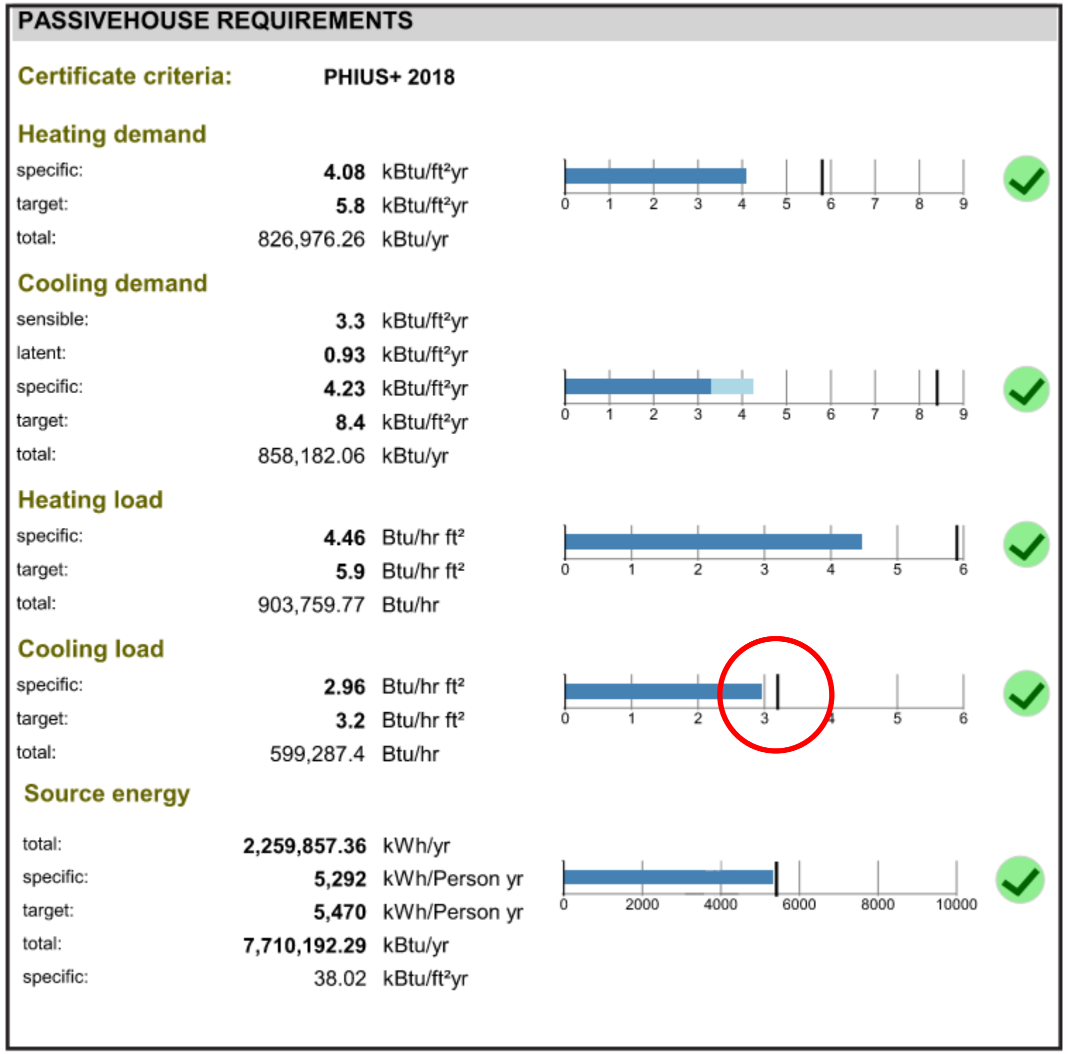
287,832 gsf
Building Area

23.84
Site EUI

Bakers Place, Madison WI

PHIUS Targets





PASSIVEHOUSE REQUIREMENTS

Certificate criteria: **PHIUS+ 2018**

Heating demand ✓

specific:	**4.08**	kBtu/ft²yr
target:	**5.8**	kBtu/ft²yr
total:	826,976.26	kBtu/yr

Cooling demand ✓

sensible:	**3.3**	kBtu/ft²yr
latent:	**0.93**	kBtu/ft²yr
specific:	**4.23**	kBtu/ft²yr
target:	**8.4**	kBtu/ft²yr
total:	858,182.06	kBtu/yr

Heating load ✓

specific:	**4.46**	Btu/hr ft²
target:	**5.9**	Btu/hr ft²
total:	903,759.77	Btu/hr

Cooling load ✓

specific:	**2.96**	Btu/hr ft²
target:	**3.2**	Btu/hr ft²
total:	599,287.4	Btu/hr

Source energy ✓

total:	**2,259,857.36**	kWh/yr
specific:	**5,292**	kWh/Person yr
target:	**5,470**	kWh/Person yr
total:	**7,710,192.29**	kBtu/yr
specific:	38.02	kBtu/ft²yr

Note: Source Energy does not include any offsets from renewable energy sources.

The Edison, Milwaukee WI

Michael Green Architecture/ Angus Young
Architect

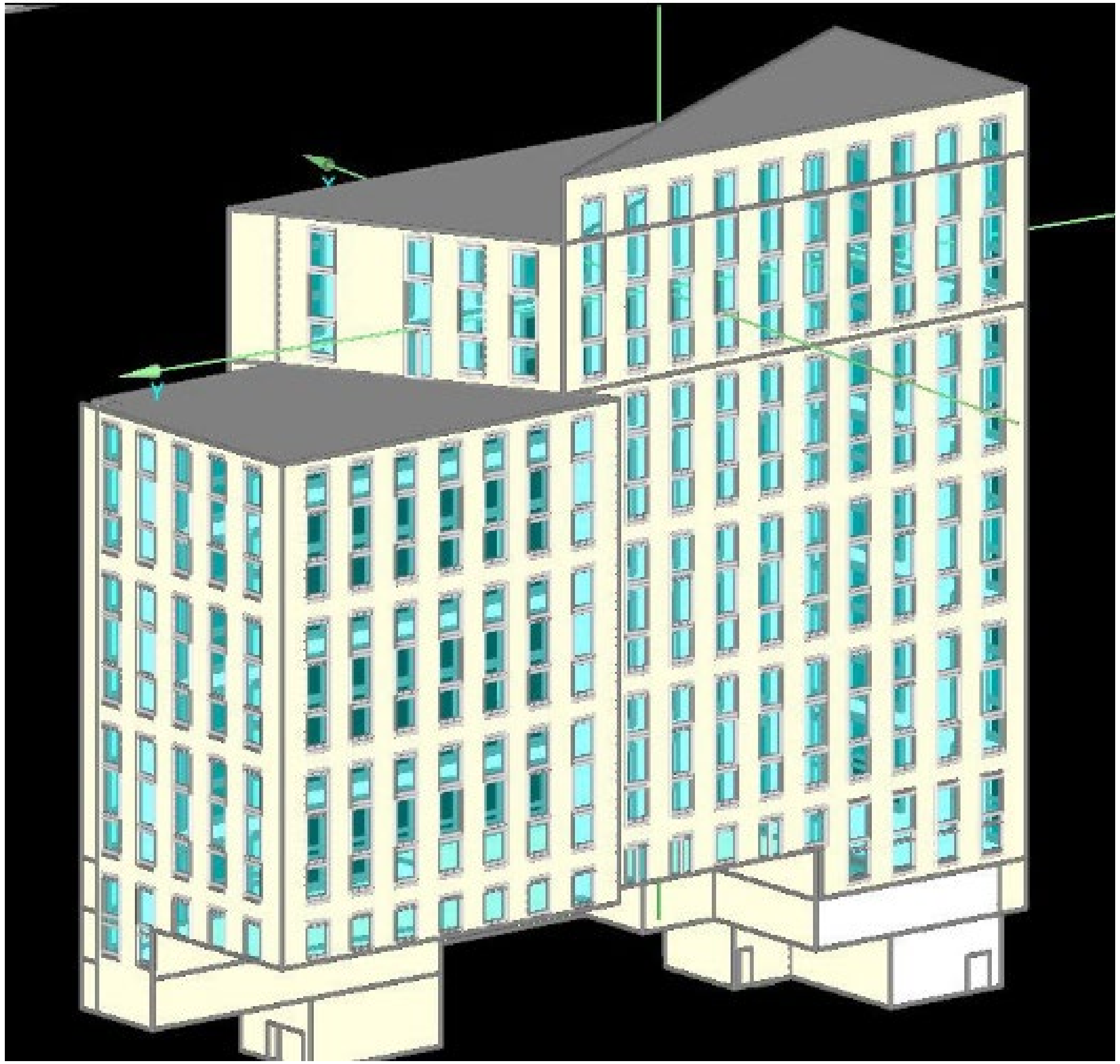
The Neutral Project
Client

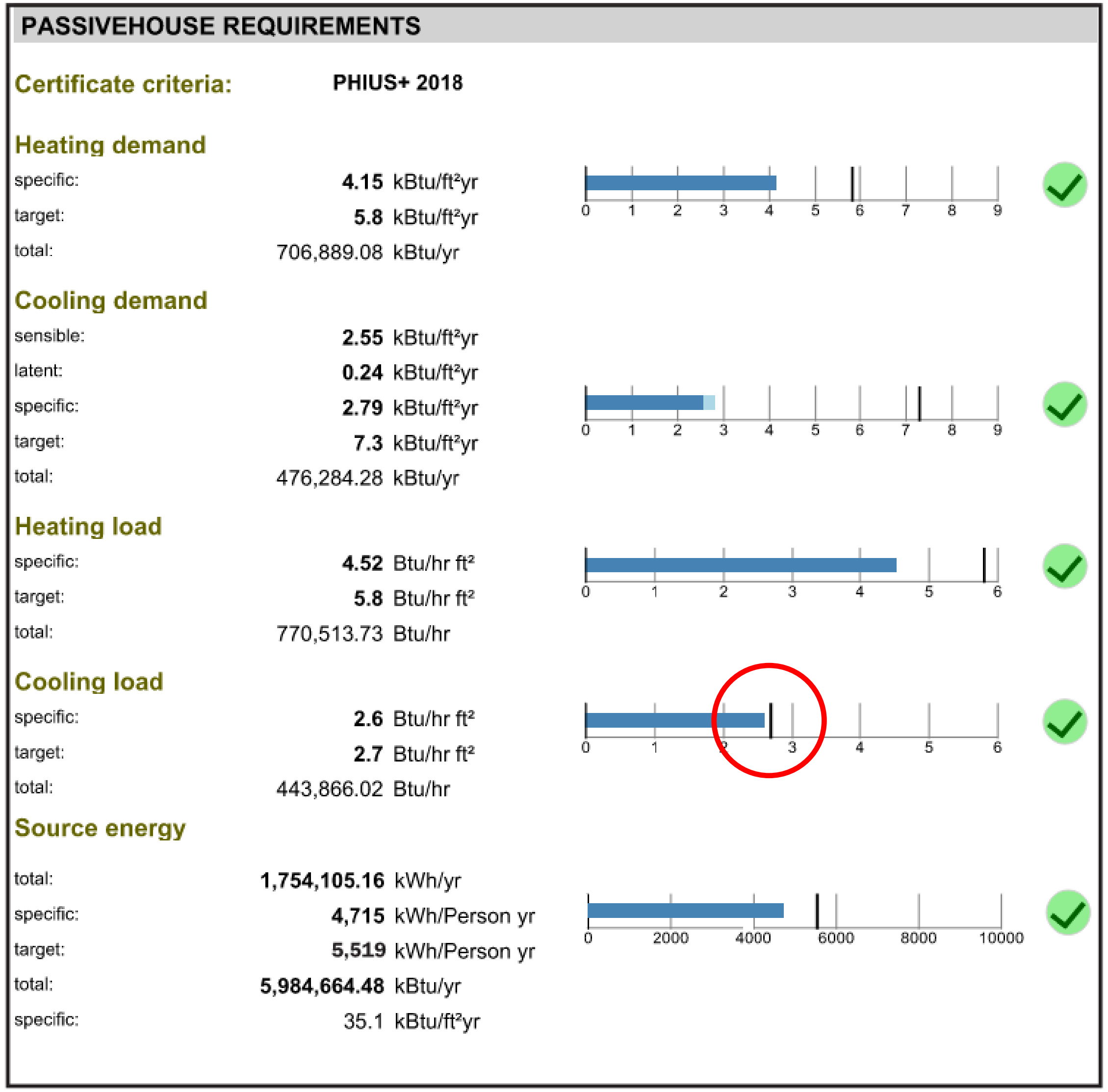
252,950 gsf
Building Area

24.06
Site EUI

The Edison, Milwaukee WI

PHIUS Targets





PASSIVEHOUSE REQUIREMENTS

Certificate criteria: **PHIUS+ 2018**

Heating demand

specific: **4.15** kBtu/ft^{2}yr ✓
target: **5.8** kBtu/ft^{2}yr
total: 706,889.08 kBtu/yr

Cooling demand

sensible: **2.55** kBtu/ft^{2}yr
latent: **0.24** kBtu/ft^{2}yr
specific: **2.79** kBtu/ft^{2}yr ✓
target: **7.3** kBtu/ft^{2}yr
total: 476,284.28 kBtu/yr

Heating load

specific: **4.52** Btu/hr ft^2 ✓
target: **5.8** Btu/hr ft^2
total: 770,513.73 Btu/hr

Cooling load

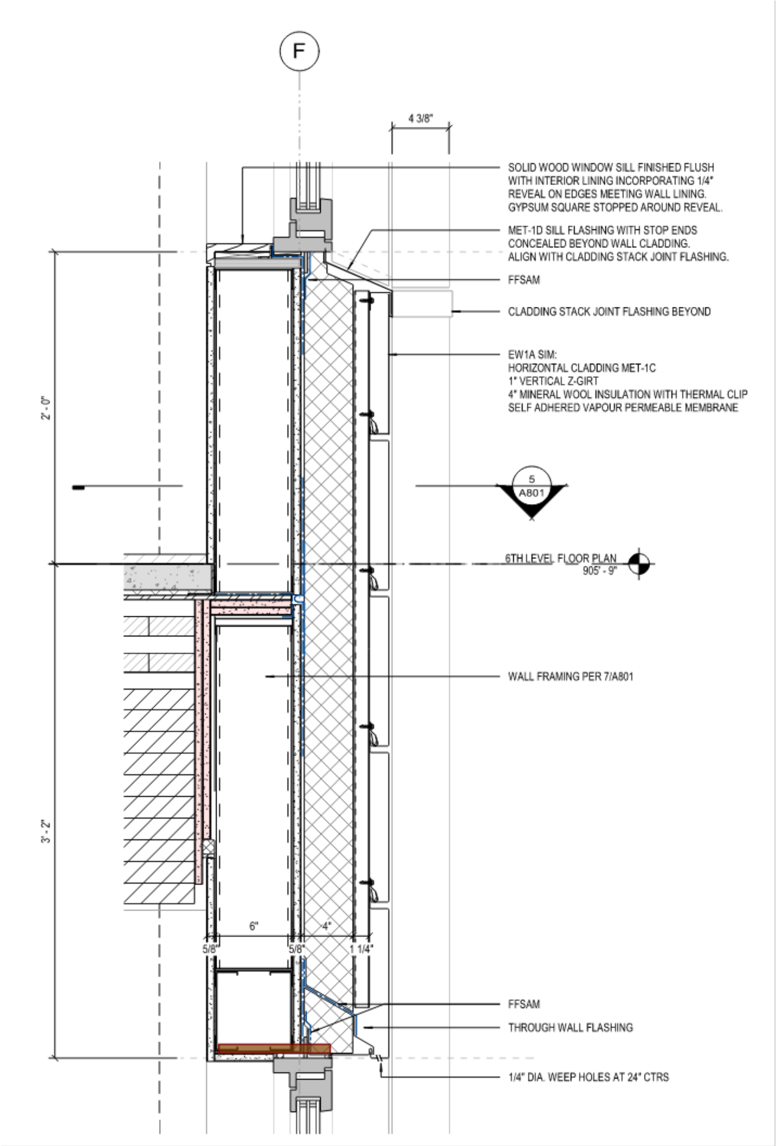
specific: **2.6** Btu/hr ft^2 ✓
target: **2.7** Btu/hr ft^2
total: 443,866.02 Btu/hr

Source energy

total: **1,754,105.16** kWh/yr
specific: **4,715** kWh/Person yr ✓
target: **5,519** kWh/Person yr
total: **5,984,664.48** kBtu/yr
specific: 35.1 kBtu/ft^{2}yr

Note: Source Energy does not include any offsets from renewable energy sources.

Hanging Panels



What I learned the hard way from my first multi-family Passive House

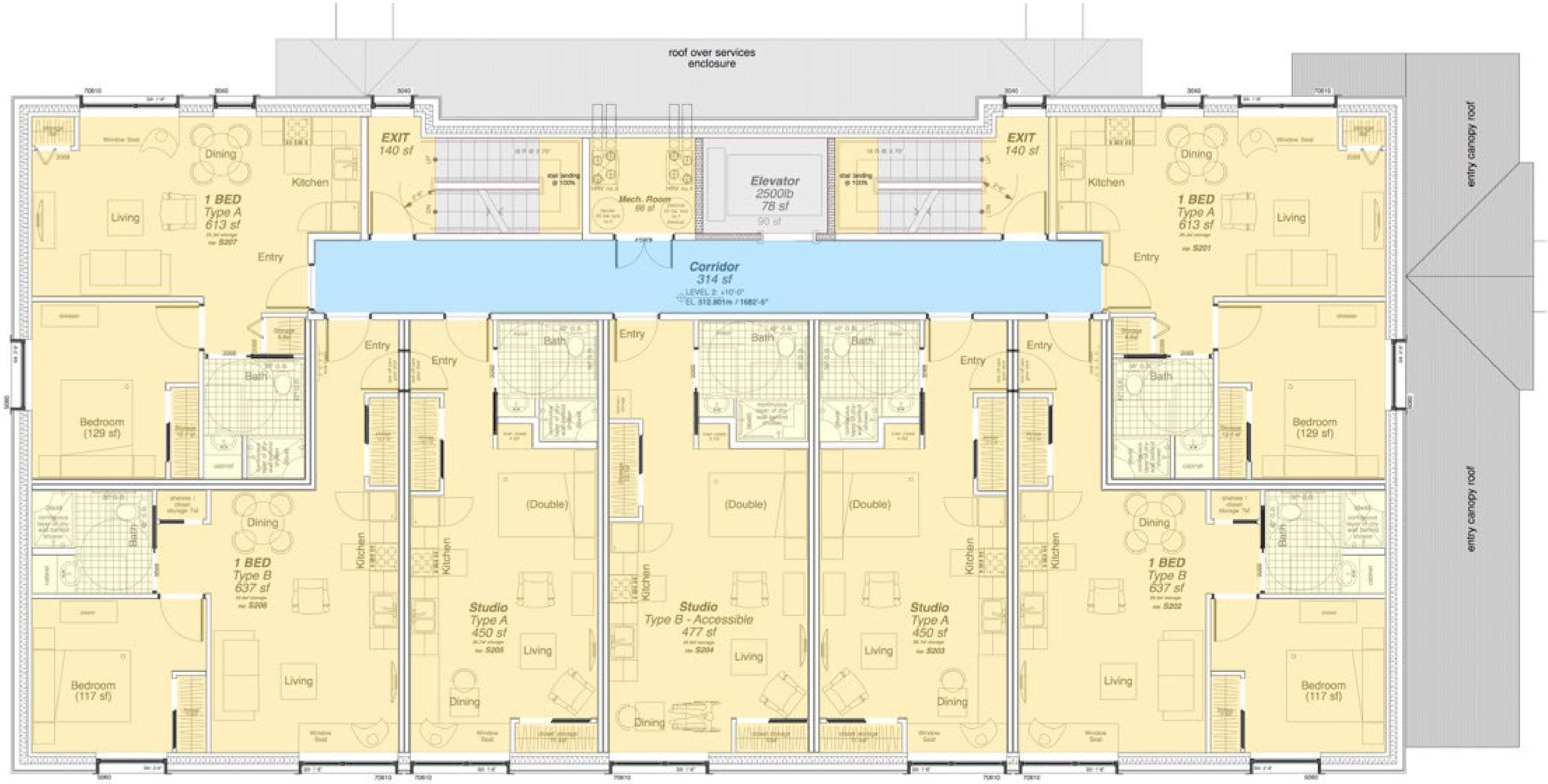
Monte Paulsen
Passive House Specialist
RDH Building Science

mpaulsen@rdh.com

Harding Heights
Smithers, B.C.

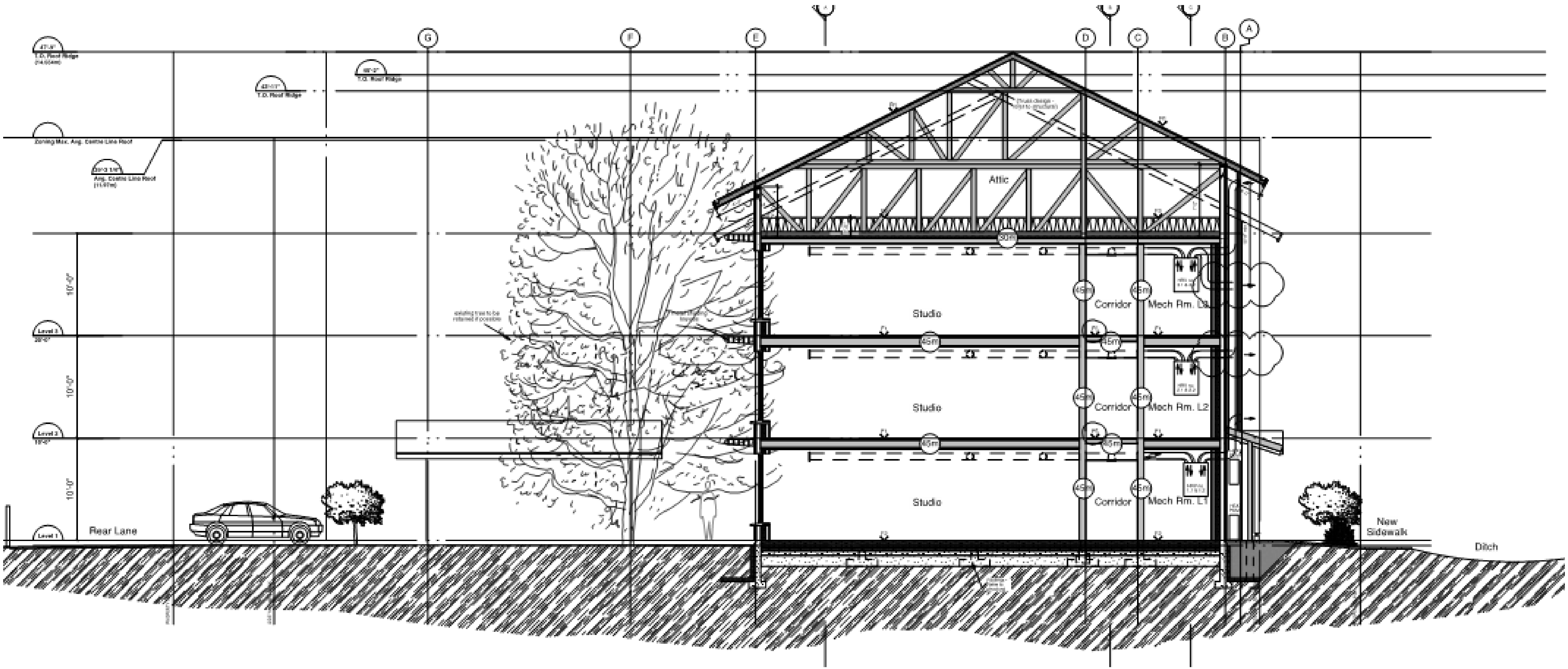
Cornerstone Architects
Yellowridge Construction
Smith + Anderson
RDH Building Science

Cold climate
Seniors Housing
19 small suites



Designed to be capable of either modular or on-site construction

Harding Heights



Harding Heights

Harding Heights
Mechanical Systems

VENTILATION

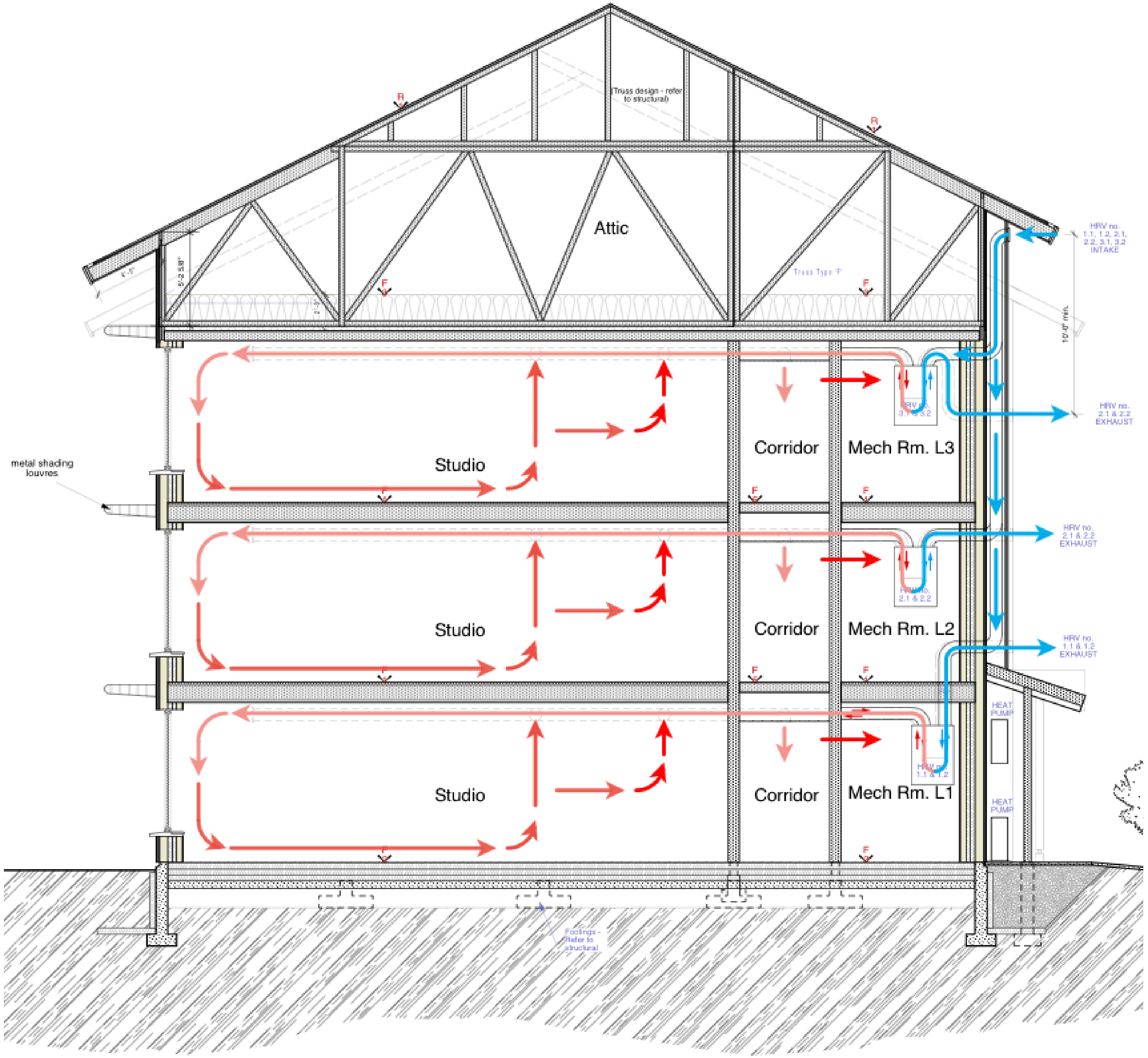
- → Two HRVs per floor
- → Each serves 3-4 suites

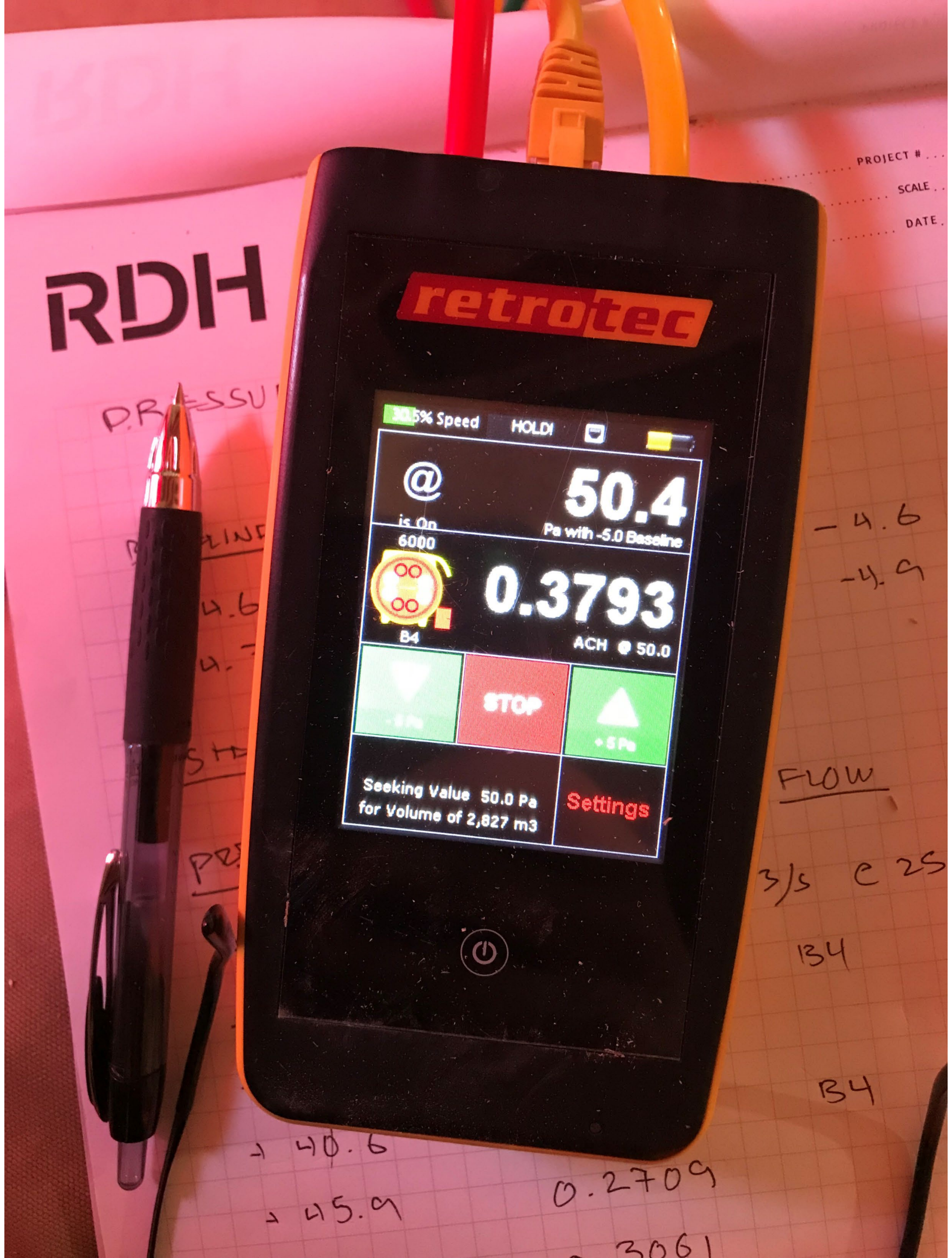
DHW

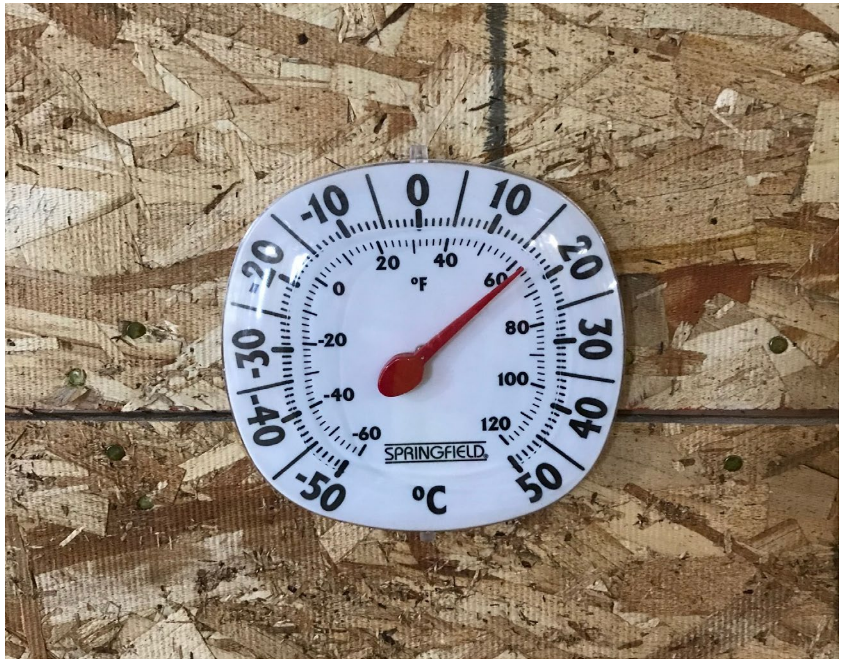
- → Three Sanden C02 systems
- → Storage in AC back-up tanks

HEAT

- → AC baseboards

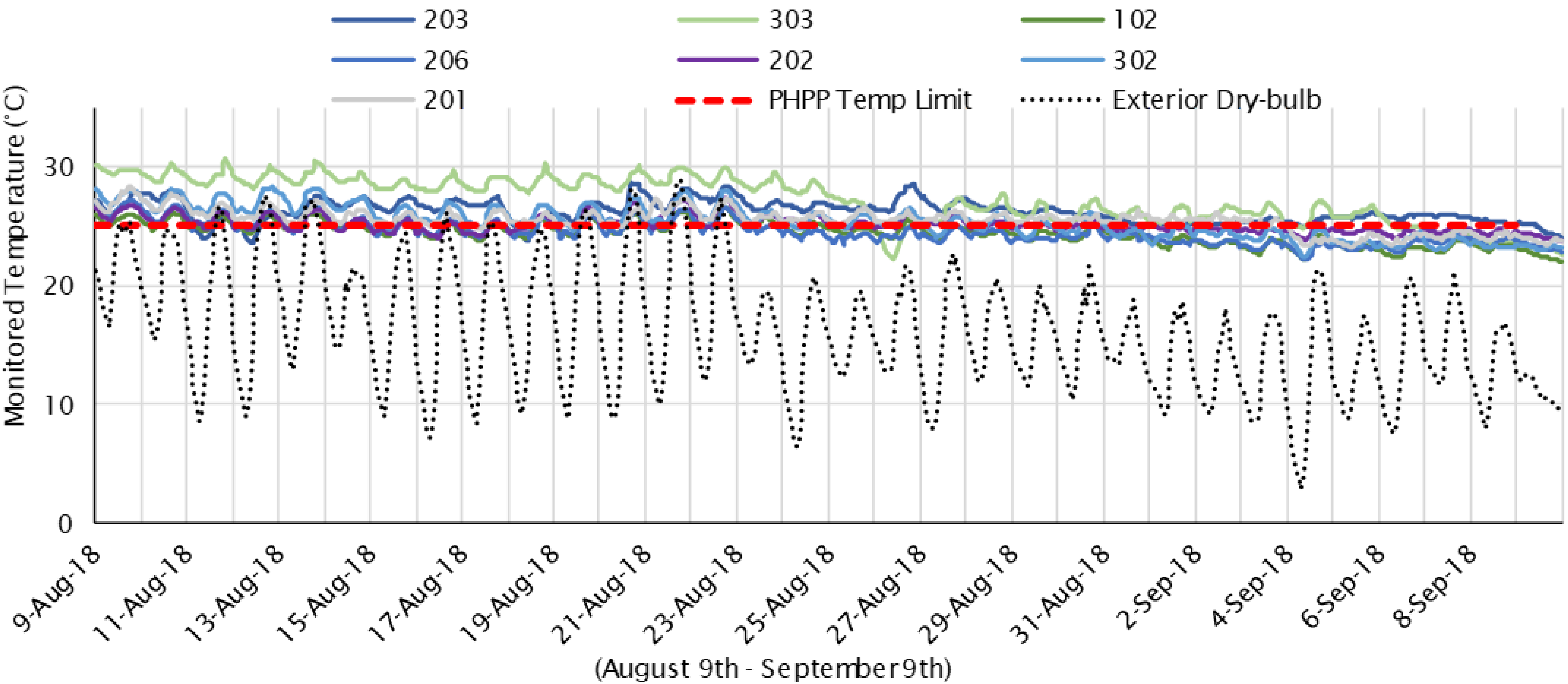



RDH
retrotec
30.5% Speed
HOLD!
@
is On
50.4
Pa with -5.0 Baseline
6000
B4
0.3793
ACH @ 50.0
STOP
+5 Pa
Seeking Value 50.0 Pa
for Volume of 2,827 m3
Settings
PROJECT #
SCALE
DATE
-4.6
-4.9
FLOW
B4
B4
0.2709


°F
°C
SPRINGFIELD


201

July 2018: Mayor cuts ribbon, seniors move in, big smiles until…



Aug-Sept 2018 temperatures in Harding Heights

Seven factors that contributed to overheating

- **No operable exterior shading**
- Fixed shading inadequate
- Tree removed
- Glazing substitution
- Insect screen substitution
- Warm ducts = No night flush
- Weather warmer than predicted

→ Operable exterior shades would have kept the building comfortable even if the other seven mistakes had persisted.

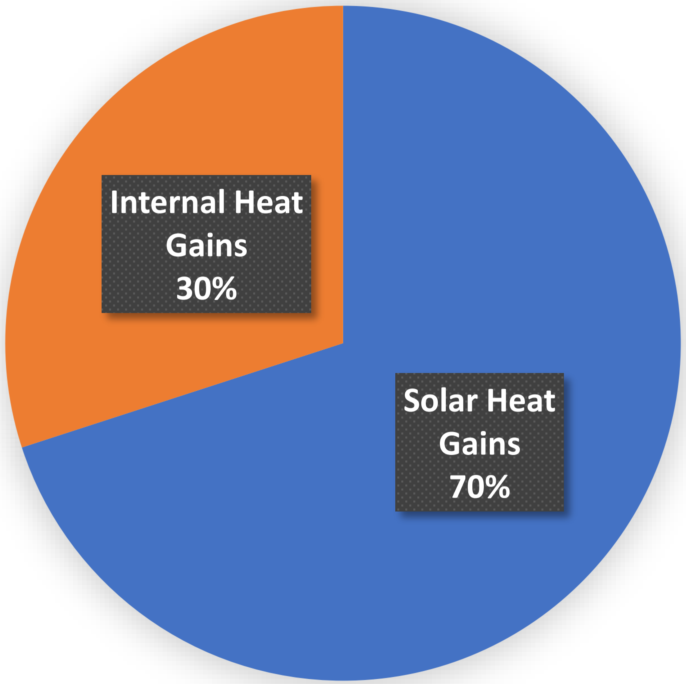
Seven factors that contributed to overheating

- No operable exterior shading
- **Fixed shading inadequate**
- Tree removed
- Glazing substitution
- Insect screen substitution
- Warm ducts = No night flush
- Weather warmer than predicted

Seven factors that contributed to overheating

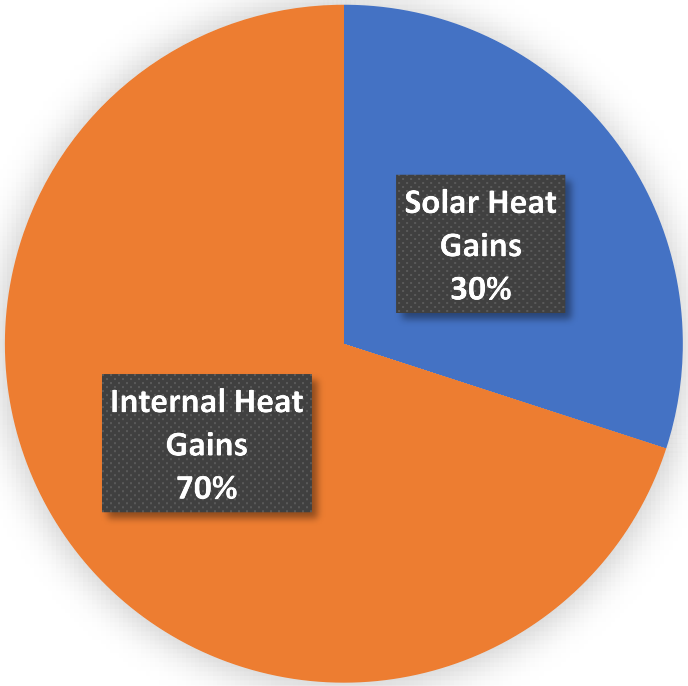
- No operable exterior shading
- Fixed shading inadequate
- **Tree removed**
- Glazing substitution
- Insect screen substitution
- Warm ducts = No night flush
- Weather warmer than predicted

Lesson: Multi-family buildings need exterior shading



Small Building

Solar Heat Gains

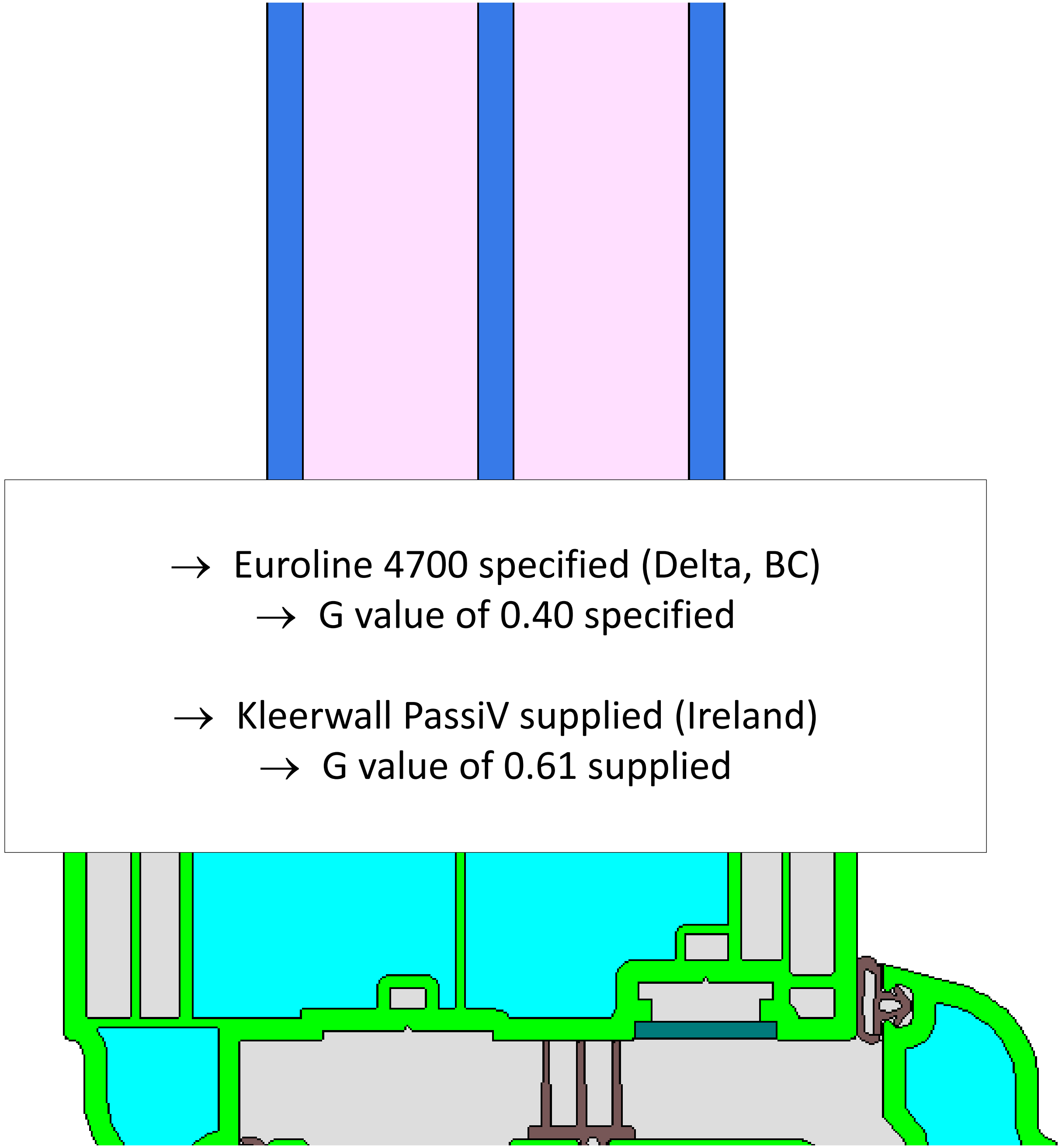


Large Building

Internal Heat Gains

Seven factors that contributed to overheating

- No operable exterior shading
- Fixed shading inadequate
- Tree removed
- **Glazing substitution**
- Insect screen substitution
- Warm ducts = No night flush
- Weather warmer than predicted



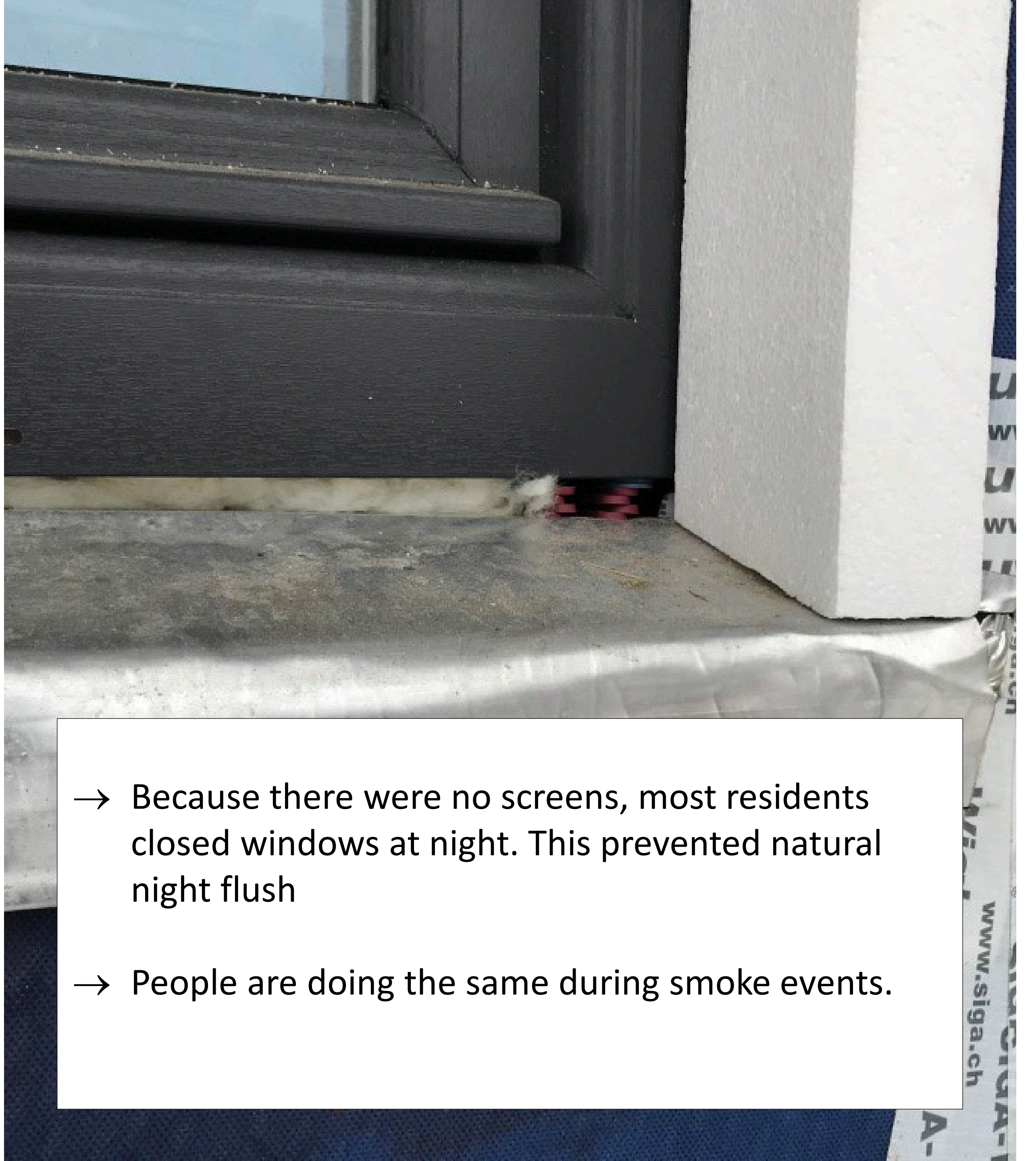
→ Euroline 4700 specified (Delta, BC)
→ G value of 0.40 specified

→ Kleerwall PassiV supplied (Ireland)
→ G value of 0.61 supplied


68% 10 hours/day
68% 10 hours/day
40% 10 hours/day
40% 10 hours/day
40% 10 hours/day
40% 10 hours/day

Seven factors that contributed to overheating

- No operable exterior shading
- Fixed shading inadequate
- Tree removed
- Glazing substitution
- **Insect screen substitution**
- Warm ducts = No night flush
- Weather warmer than predicted



→ Because there were no screens, most residents closed windows at night. This prevented natural night flush

→ People are doing the same during smoke events.

Seven factors that contributed to overheating

- No operable exterior shading
- Fixed shading inadequate
- Tree removed
- Glazing substitution
- Insect screen substitution
- **DHW tanks warmed ducts**
- Weather warmer than predicted

Seven factors that contributed to overheating

- No operable exterior shading
- Fixed shading inadequate
- Tree removed
- Glazing substitution
- Insect screen substitution
- Warm ducts = No night flush
- **Weather warmer than predicted**

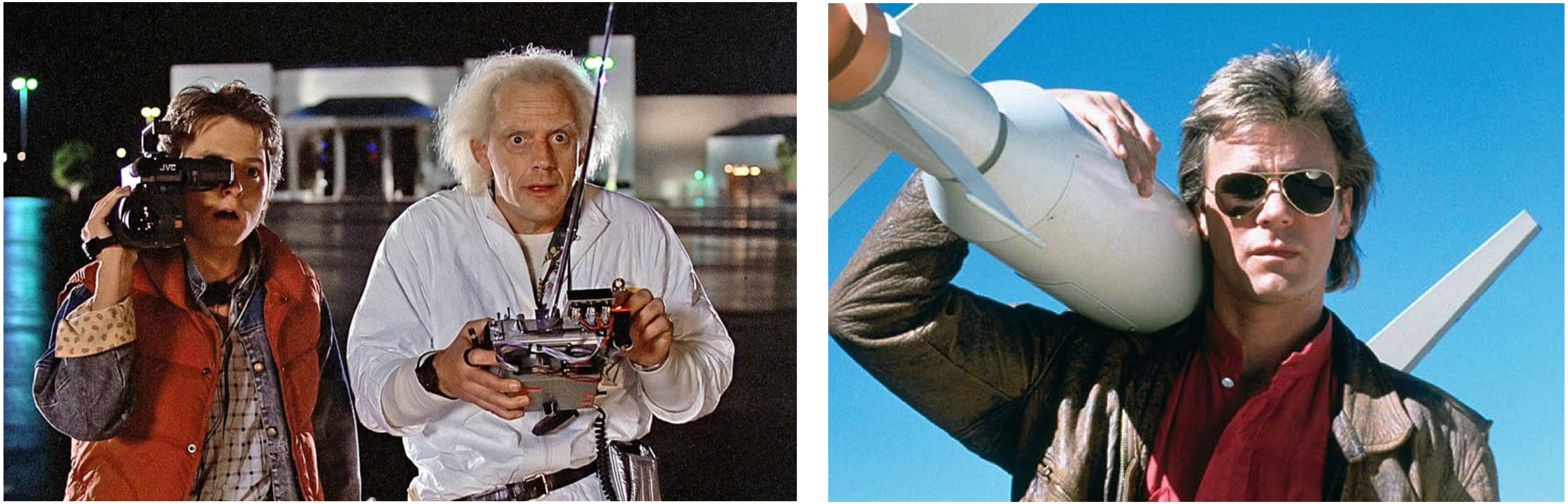
The 30-year average August temperature for Smithers is 14.2°C

In 2018, August averaged

16.4°C

→ August 2017: **17.0°C**
→ August 2016: **16.0°C**
→ August 2015: **13.9°C**
→ August 2014: **15.5°C**
→ August 2013: **16.4°C**
→ August 2012: **14.5°C**
→ August 2011: **12.6°C**
→ August 2010: **15.0°C**

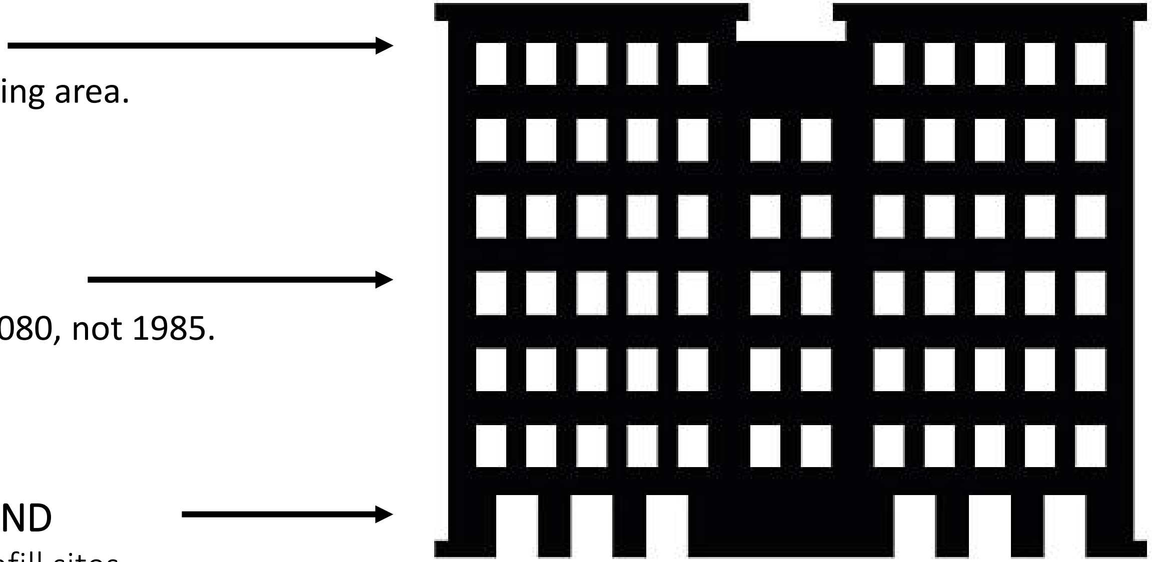
The midpoint of most 30-year climate files is 1985.
Care to guess what the top movie & show were that year?



Are we designing Passive House & Step Four buildings for a Marty McFly climate?

Lesson: Six factors that affect summer comfort

OUTSIDE *the* BUILDING

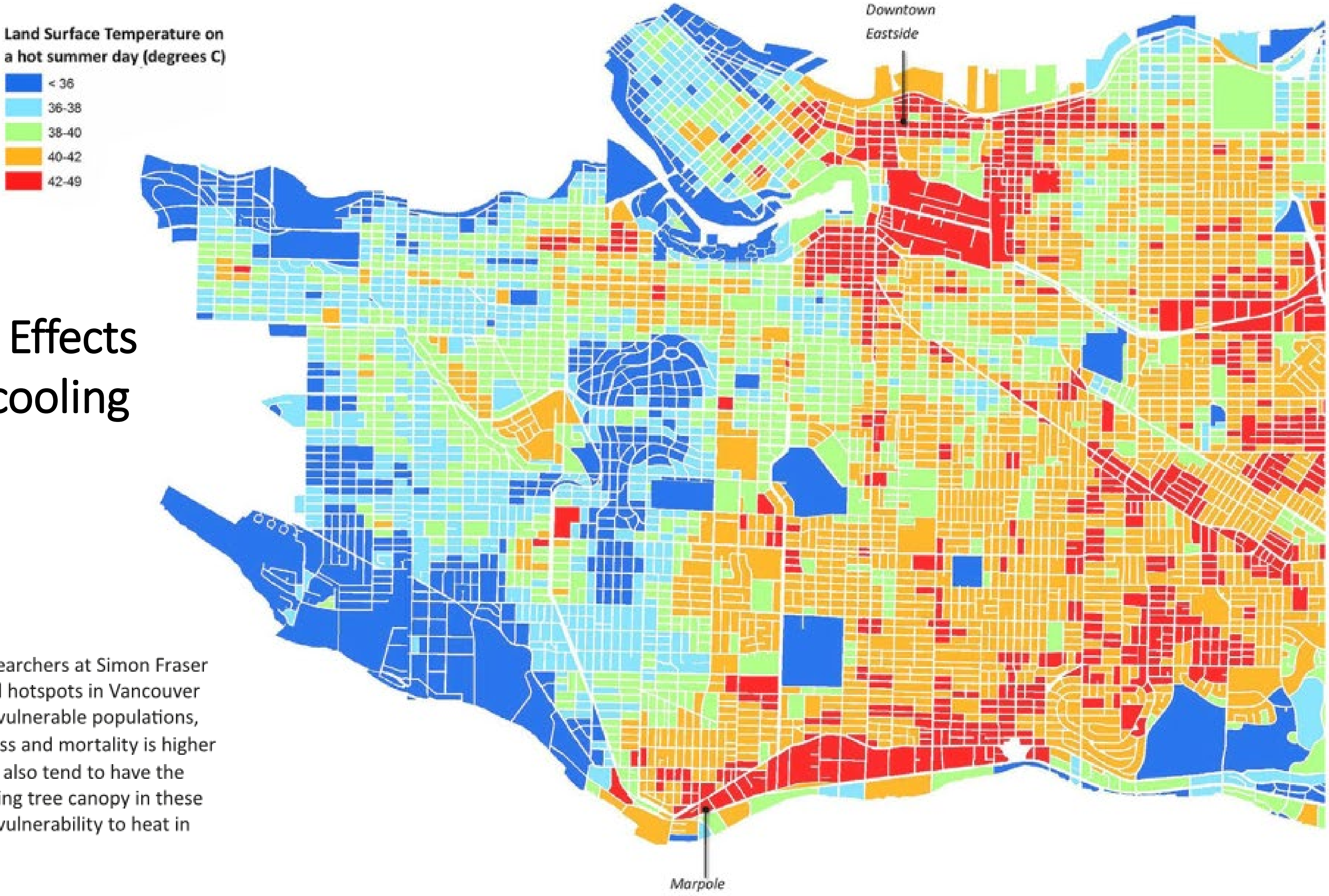


SOLAR GAIN
Shading, SHGC, glazing area.

TEMPERATURE
Model for 2050 & 2080, not 1985.

URBAN HEAT ISLAND
Most multiunit on infill sites.
Effects greater than climate change.

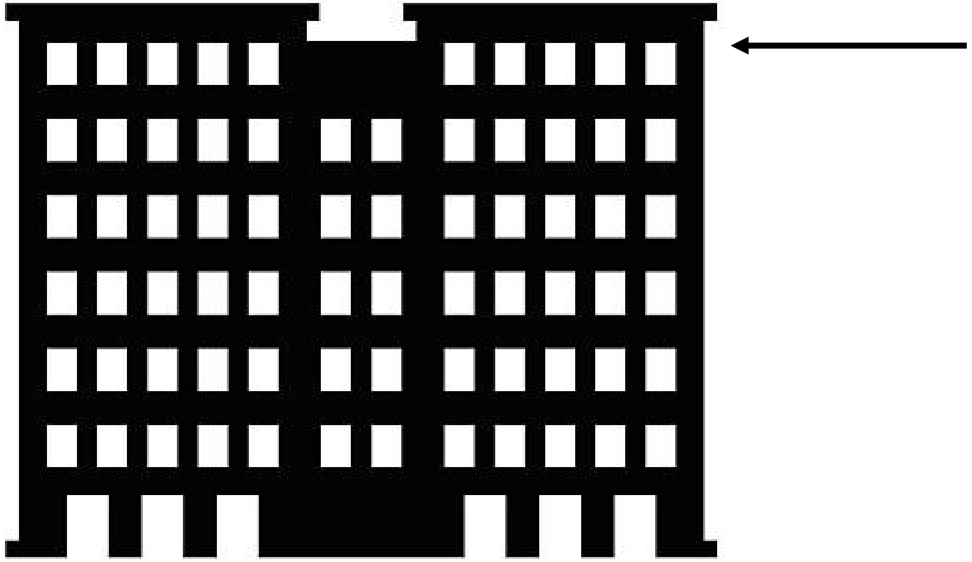
Heat Island Effects limit night cooling



Urban heat mapping by researchers at Simon Fraser University identified several hotspots in Vancouver where, when coupled with vulnerable populations, the risk of heat-related illness and mortality is higher [14]. The city's hottest areas also tend to have the lowest tree canopy. Increasing tree canopy in these areas is one way to reduce vulnerability to heat in these locations.

Source: Urban Forest Strategy, 2018 Update, City of Vancouver.

Lesson: Six factors that affect summer comfort



OUTSIDE *the* BUILDING

INSIDE *the* BUILDING

SOLAR GAIN
Shading, SHGC, glazing area.

TEMPERATURE
Model for 2050 & 2080, not 1985.

URBAN HEAT ISLAND
Most multiunit on infill sites.
Effects greater than climate change.

OCCUPANT DENSITY
Small units produce higher
IHG/m2 than large units.

Occupant density is a key consideration in social housing

24 RESIDENTS

21 refrigerators. 30+ televisions. 20 computers.
60 meals per day? 20 showers?

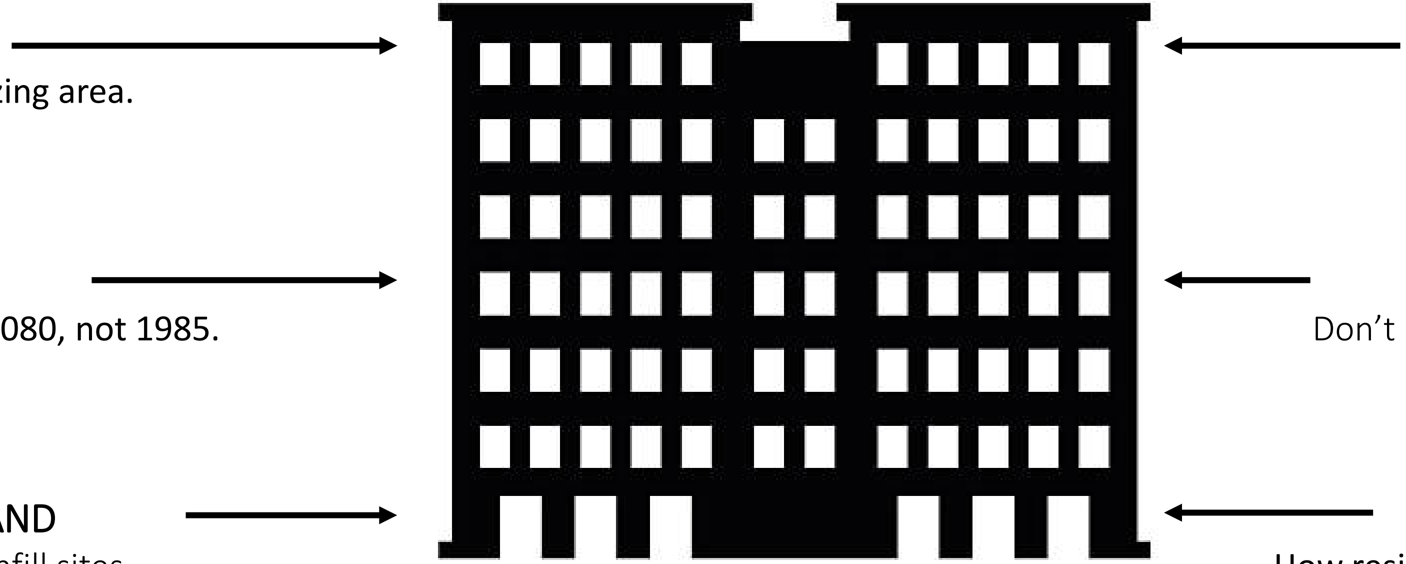
4 RESIDENTS

2 refrigerators? 5 televisions? 4 computers?
Two meals per day? Four showers?

Lesson: Six factors that affect summer comfort

OUTSIDE *the* BUILDING

INSIDE *the* BUILDING



SOLAR GAIN
Shading, SHGC, glazing area.

TEMPERATURE
Model for 2050 & 2080, not 1985.

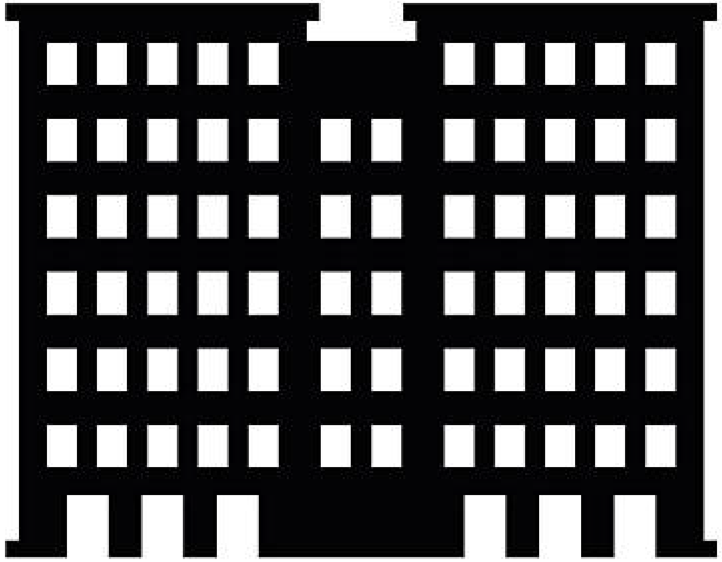
URBAN HEAT ISLAND
Most multiunit on infill sites.
Effects greater than climate change.

OCCUPANT DENSITY
Small units produce higher IHG/m2 than large units.

DHW HEAT LOSS
Don't put DHW in same room as HRV.
Shorten DHW runs.

LIFESTYLE VARIATION
How residents live and play affects IHGs significantly.

Lesson: Six factors that affect summer comfort



OUTSIDE *the* BUILDING

SOLAR GAIN
Shading, SHGC, glazing area.

TEMPERATURE
Model for 2050 & 2080, not 1985.

URBAN HEAT ISLAND
Most multiunit on infill sites.
Effects greater than climate change.

INSIDE *the* BUILDING

OCCUPANT DENSITY
Small units produce higher
IHG/m2 than large units.

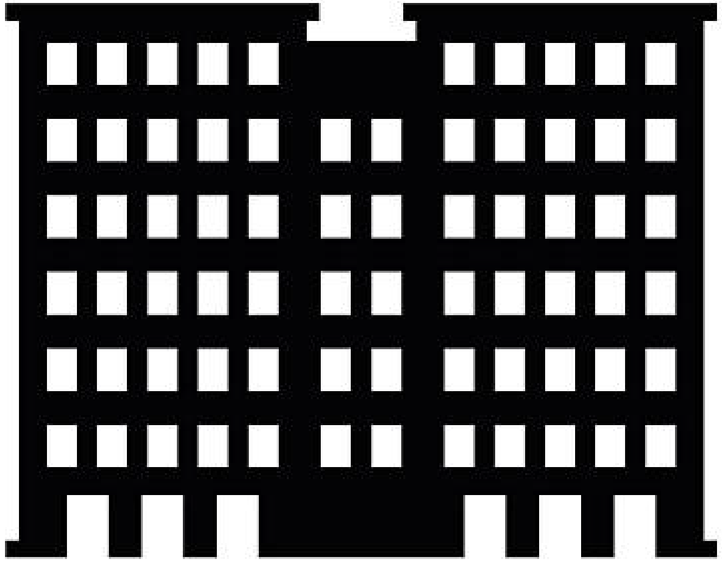
DHW HEAT LOSS
Don’t put DHW in same room as HRV.
Shorten DHW runs.

LIFESTYLE VARIATION
How residents live and play affects IHGs
significantly.

Most summer comfort modelling ignores four of these

OUTSIDE *the* BUILDING

INSIDE *the* BUILDING



SOLAR GAIN
Shading, SHGC, glazing area.

TEMPERATURE
Model for 2050 & 2080, not 1985.

URBAN HEAT ISLAND
Most multiunit on infill sites.
Effects greater than climate change.

OCCUPANT DENSITY
Small units produce higher
IHG/m2 than large units.

SYSTEM HEAT LOSS
Don’t put DHW in same room as HRV.
Shorten DHW runs.

LIFESTYLE VARIATION
How residents live and play affects IHGs significantly.

We would like to discuss revising the criteria

Skeena Residence at University of British Columbia in the Okanagan (UBCO)

Skeena Residence

> Public Architecture

> AME Group

> RDH Building Science

Challenge

> High exhaust rate in laundry room required make-up air and a separate air tightness zone

Challenge

> Lack of point-of-delivery inspection resulted in some windows being replaced

Whistler Housing Authority

1075 Nelson

- > WKK Architecture (Tom Wright)
- > IBI Group
- > Integral Group
- > RDH Building Science

“A Passive House that does not look like a Passive House”

> Hanging panels with pre-installed windows

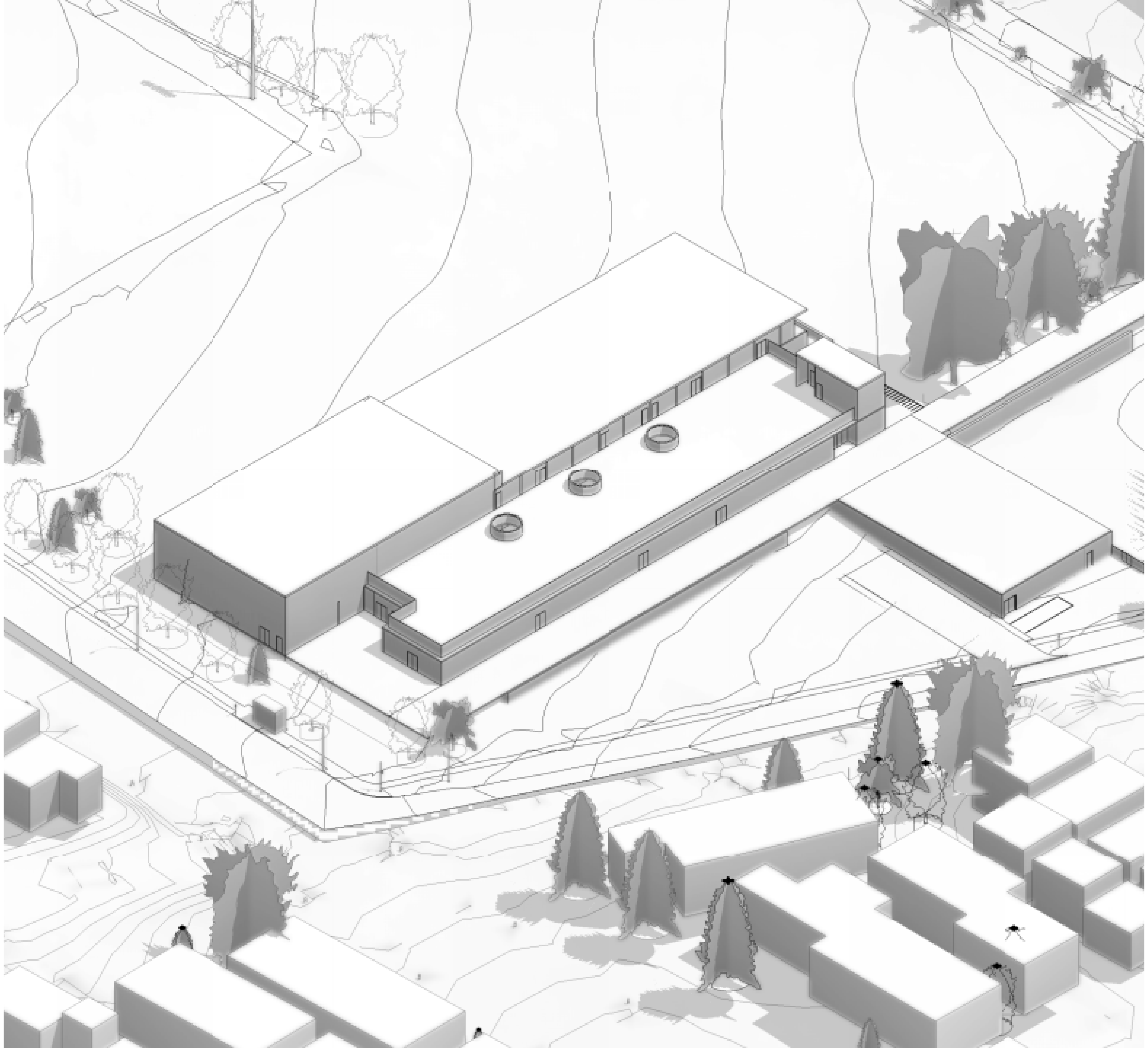
> Large Swegon HRVs in pairs.

> The tallest planned Passive house on Earth


1075 Nelson UDP Dry Run

Marpole Community Center

- > City of Vancouver
- > Diamond Schmitt
- > Integral Group
- > RDH Building Science



We’re discussing underground parking

Parkades represent the largest share of embodied carbon in a mass-timber building.

The cars that park in these underground spaces also contain embodied carbon, and their use releases operational carbon.

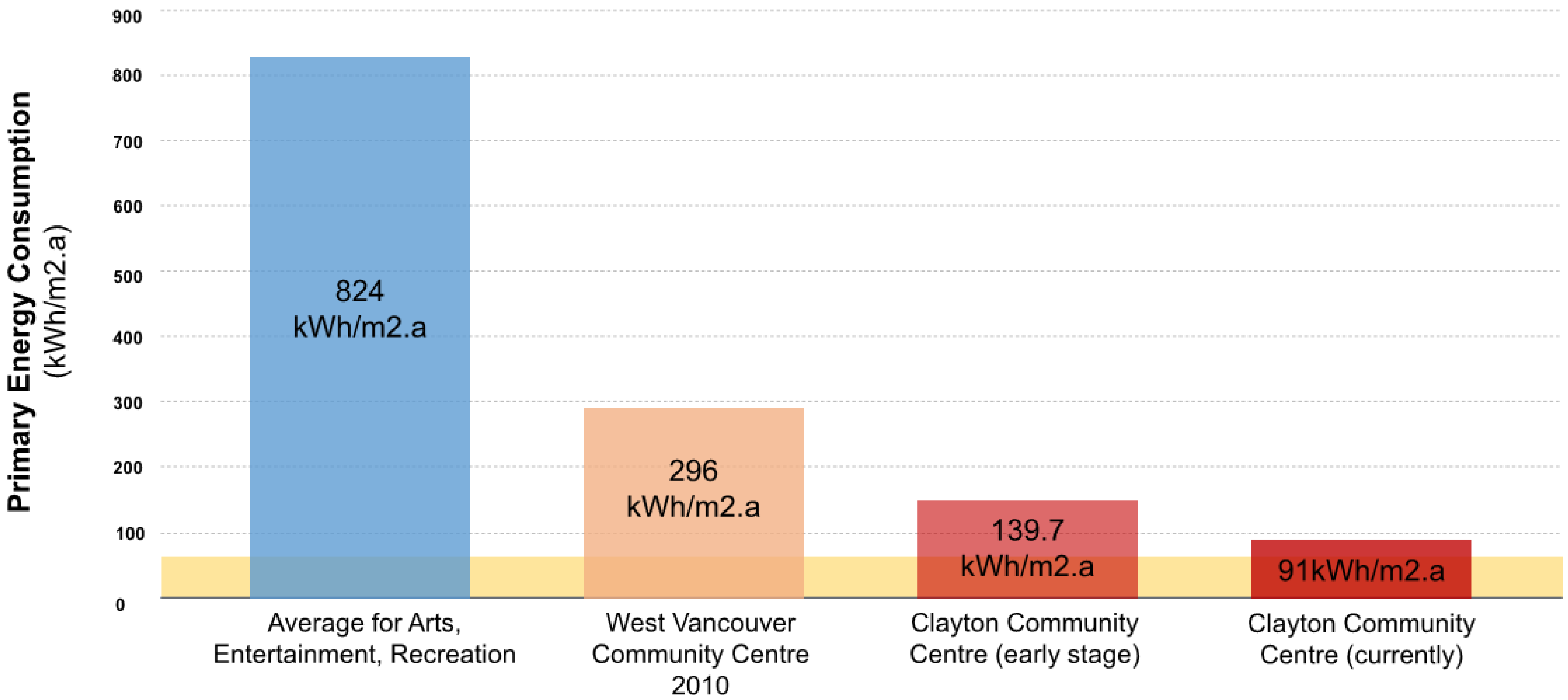
Negotiating with municipalities to reduce the size of parkades—or eliminate them altogether—may be the largest step any team can take to reduce emissions.

We’re discussing Internal Heat Gains

What are the Internal Heat Gains of a basketball game?

Of a typical workout?

We’re discussing Primary Energy



Vancouver Art Gallery

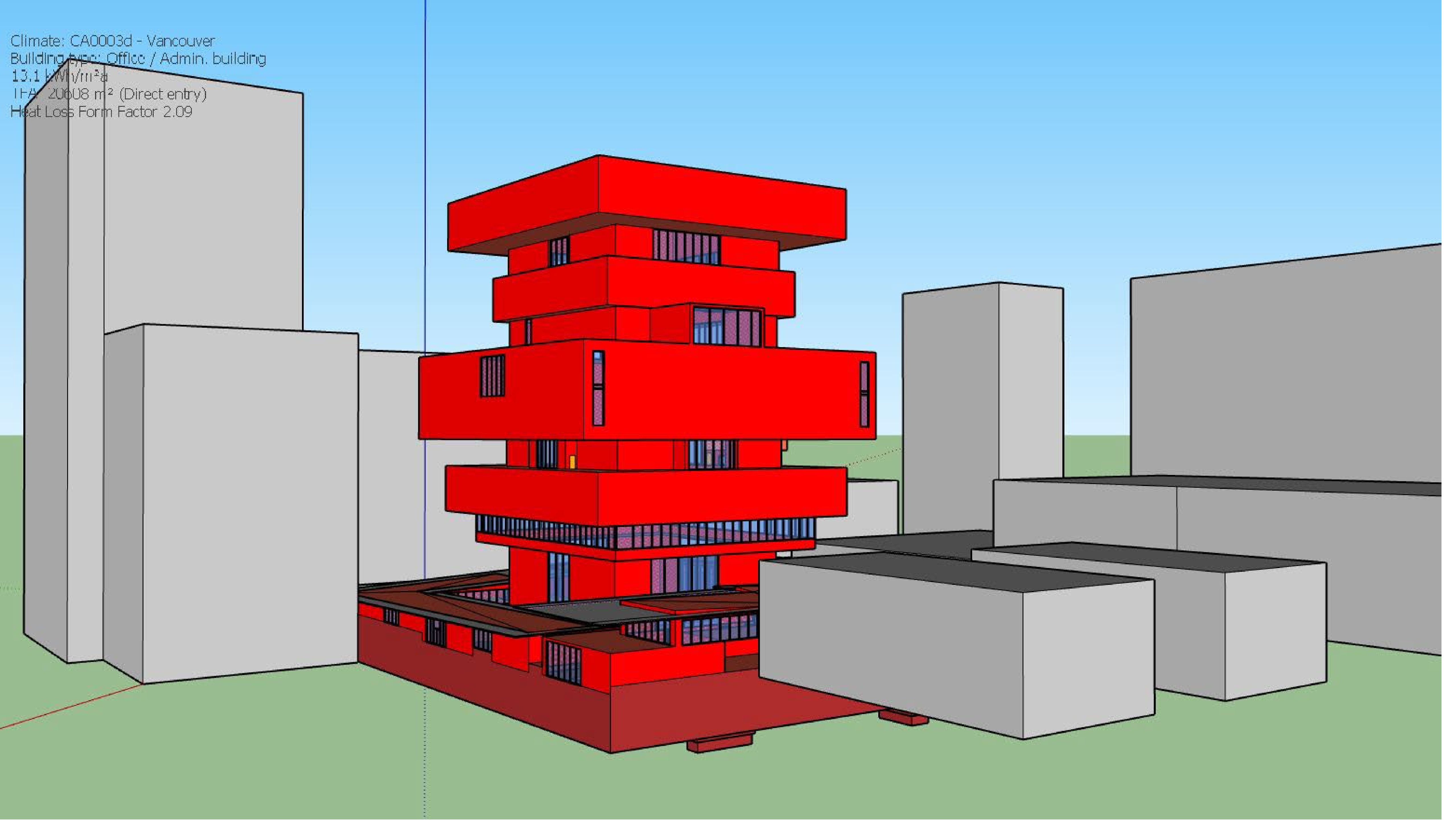
> Herzog & De Meuron

> Perkins + Will

> Integral Group

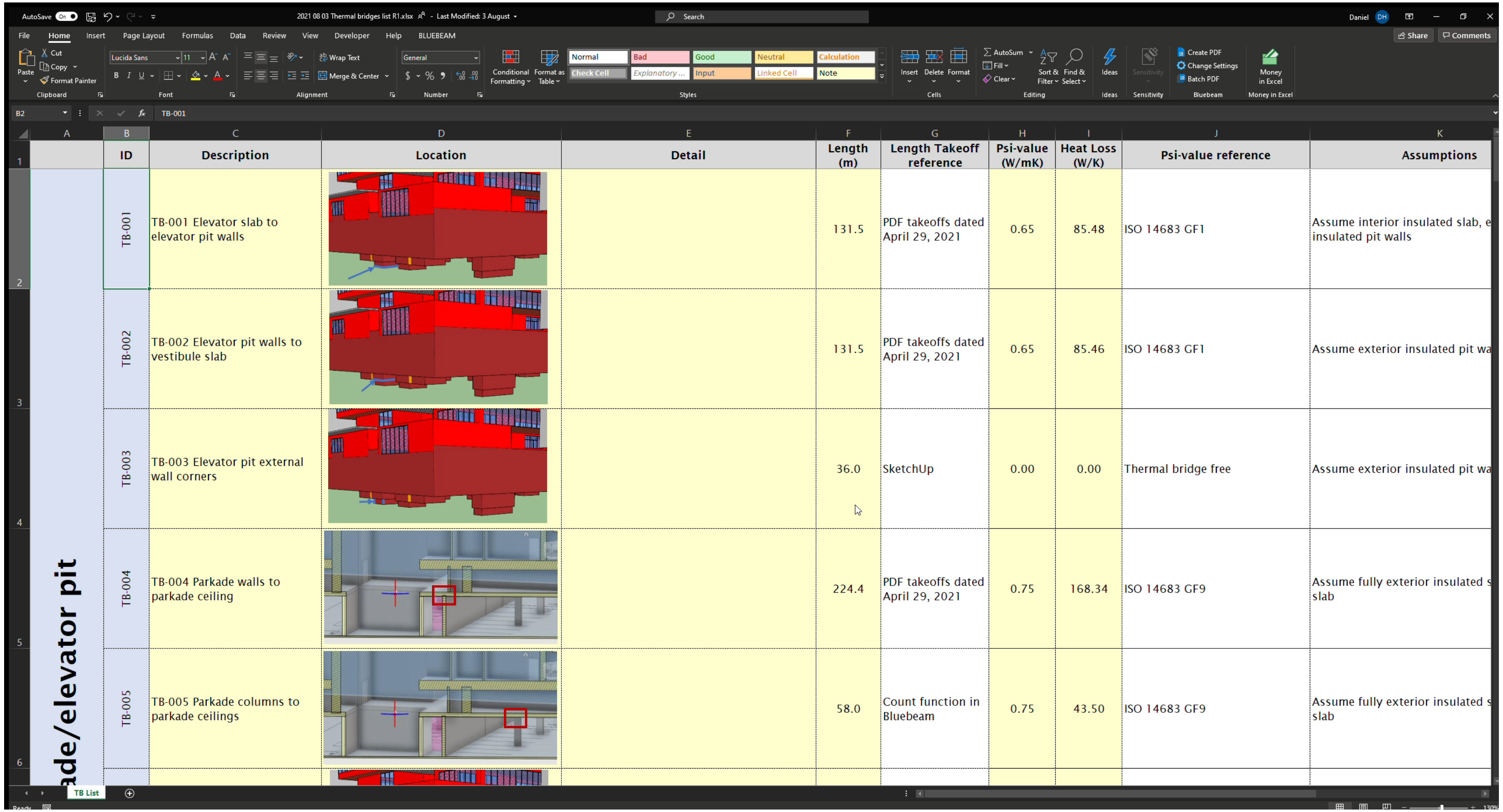
> RDH Building Science


QUEEN ELIZABETH



```
Climate: CA0003d - Vancouver
Building type: Office / Admin. building
13.1 kWh/m²a
TFA: 20608 m² (Direct entry)
Heat Loss Form Factor 2.09
```

RDH has modelled more than 100 details for this project

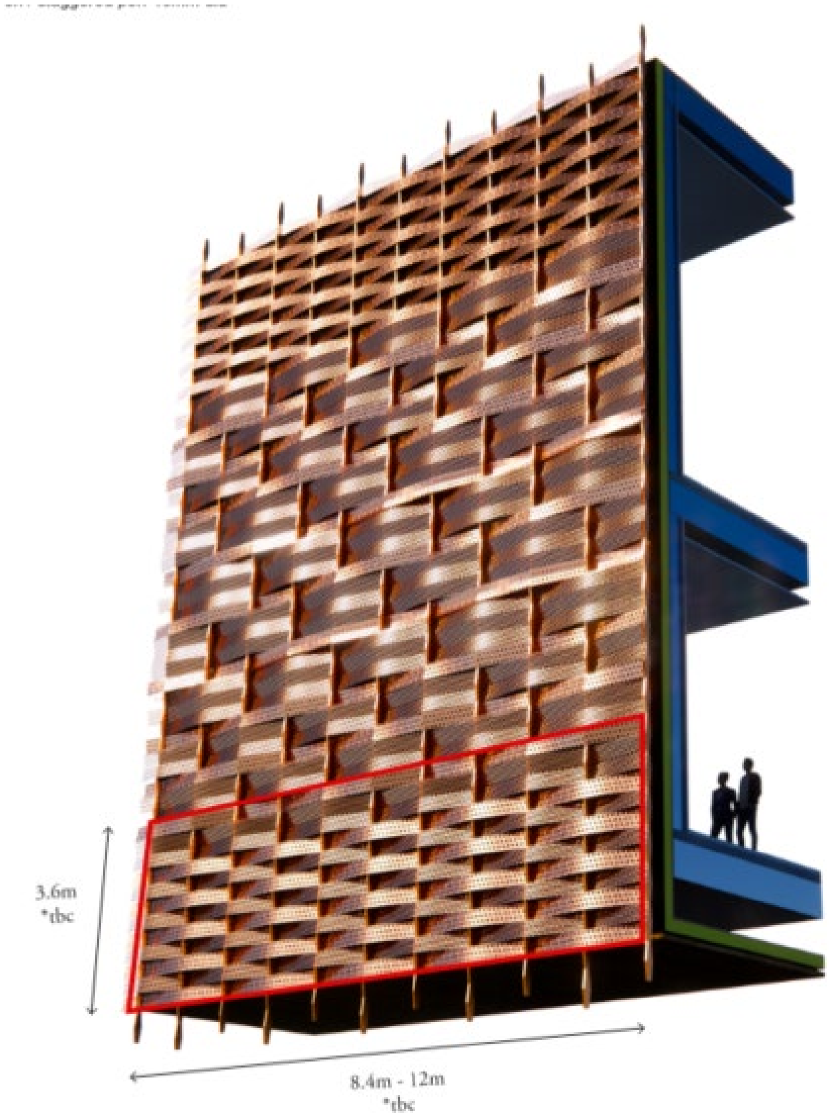


	A	B	C	D	E	F	G	H	I	J	K
1		ID	Description	Location	Detail	Length (m)	Length Takeoff reference	Psi-value (W/mK)	Heat Loss (W/K)	Psi-value reference	Assumptions
2	ade/elevator pit	TB-001	TB-001 Elevator slab to elevator pit walls			131.5	PDF takeoffs dated April 29, 2021	0.65	85.48	ISO 14683 GF1	Assume interior insulated slab, e insulated pit walls
3		TB-002	TB-002 Elevator pit walls to vestibule slab			131.5	PDF takeoffs dated April 29, 2021	0.65	85.46	ISO 14683 GF1	Assume exterior insulated pit wa
4		TB-003	TB-003 Elevator pit external wall corners			36.0	SketchUp	0.00	0.00	Thermal bridge free	Assume exterior insulated pit wa
5		TB-004	TB-004 Parkade walls to parkade ceiling			224.4	PDF takeoffs dated April 29, 2021	0.75	168.34	ISO 14683 GF9	Assume fully exterior insulated s slab
6		TB-005	TB-005 Parkade columns to parkade ceilings			58.0	Count function in Bluebeam	0.75	43.50	ISO 14683 GF9	Assume fully exterior insulated s slab

Vancouver Art Gallery

> Mass Timber & Concrete structure
> Never-before cladding approach
> Complicated program: Restaurants, daycare, studios, workshops.
> Must achieve 50% humidity 24/7/365

> But we are not alone…



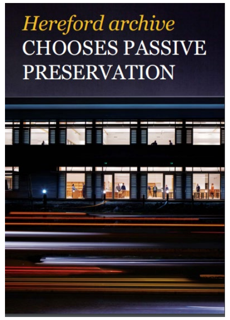
Three precedents for the new VAG…

1. Hereford Archive and Record Centre

- First repository designed to the new standard for archival materials storage, PD 5454
- First Passive House Archive in the UK (2015)

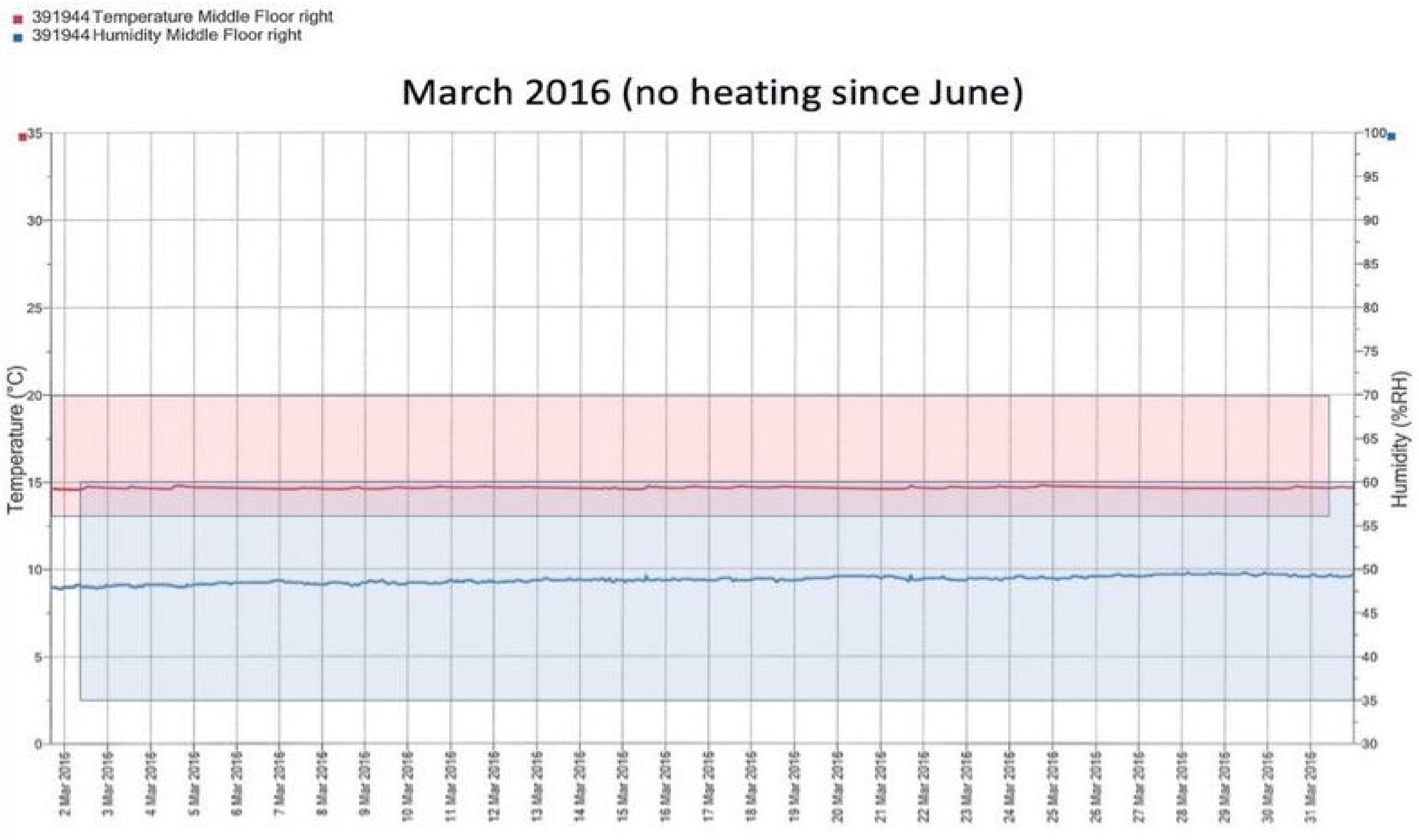
Hereford Archive and Record Centre

https://www.elementalsolutions.co.uk/wp-content/uploads/2012/08/Hereford-PH-Iss-10.pdf



Hereford archive
CHOOSES PASSIVE
PRESERVATION

Hereford Archive and Record Centre



15°C

50% RH

2. Museum of Bavarian History

- → Regensburg, Germany
- → 7,712 m^2 (83,000 s.f.)
- → 300,000 visitors/year
- → Opened 2019

Museum of Bavarian History

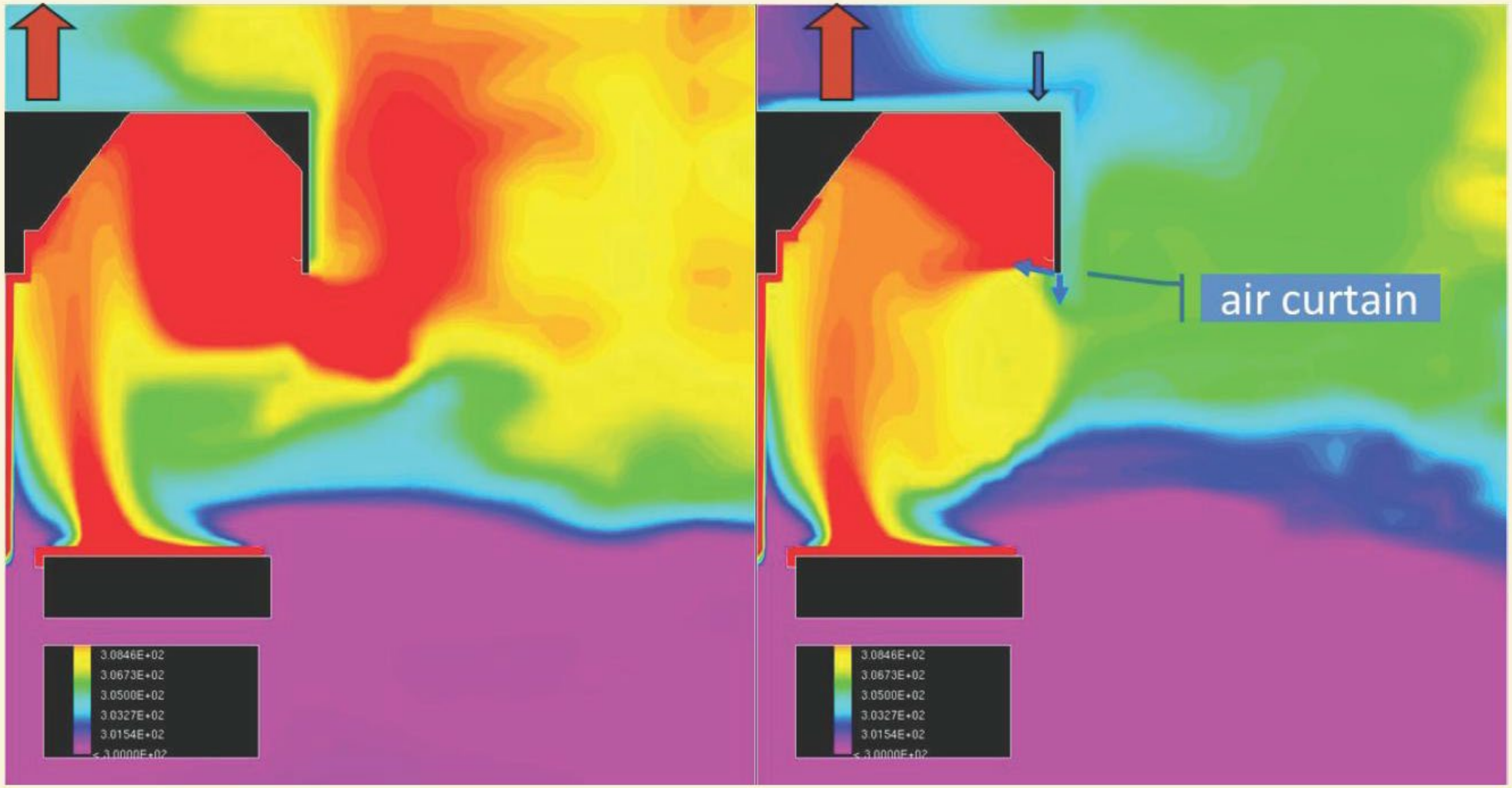
Museum of Bavarian History

Museum of Bavarian History

THE FRENCH LAUNDRY

Yountville, California

Air curtains improve capture efficiency



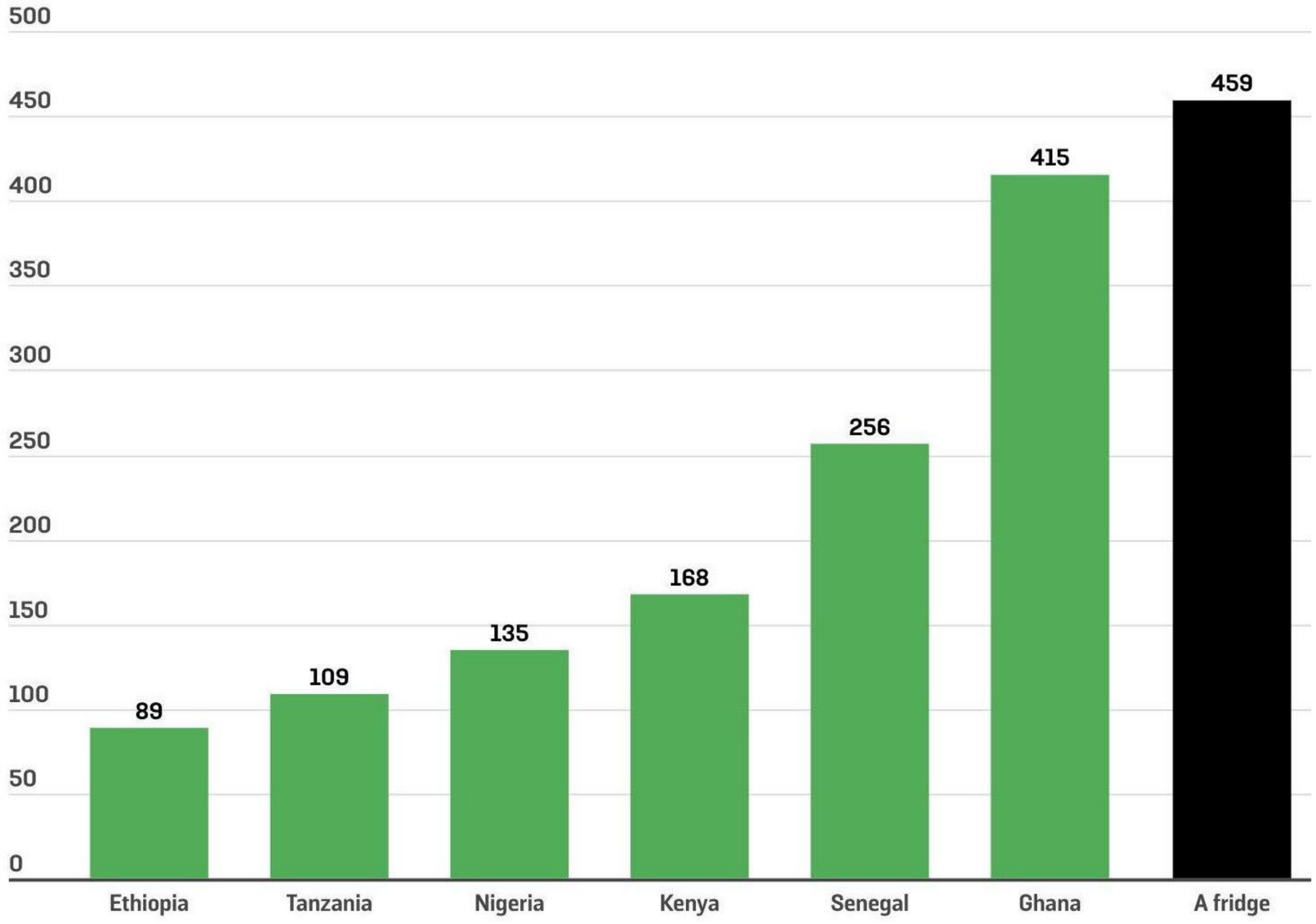
On the left – hood without air curtain spilling convective plume from hot appliance into the kitchen.
On the right – hood with activated air curtain operating at C&C airflow.

Closed coolers consume far less energy

Just to put refrigerator energy use in context…

Energy Use Per Person in Africa vs. a Typical American Refrigerator

Annual kilowatt-hours of electricity consumed per capita, 2017



SOURCE: INTERNATIONAL ENERGY AGENCY AND ENERGY FOR GROWTH HUB

3. Longfor Sunda Exhibition Hall

→ Gaobeidian, China

→ 1,484 m^2

→ Opened 2018


为何做被动房
WHY PASSIVE HOUSE

在被动房性能优秀的外保温包裹的情况下热量想要通过建筑围护结构传导很困难，但是通过边、角、连接点等细部节点传导则很容易，这种现象被称为热桥效应。采用无冷热桥的设计以及优化冷热桥细部节点是建筑节能最有效的方法之一。

Passive house employs continuous insulation throughout its entire envelope to block thermal conduction between indoor and outdoor. However in certain situations, thermal bridges exist in connecting areas such as joints, seams etc. A thermal-bridge-free or minimized planning is an effective method to reduce building heat loss.


Vancouver Artgallery
BOOKSHOP

COST+TIMELINE

I’ve been asked the same two questions about once a week for the past decade:

#1. How much more does it cost to build a multi-family building to the Passive House Standard?

#2. What does a Certified Passive House project do to your existing milestones and timeline?

CONSTRUCTION COST ANALYSIS
OF HIGH-PERFORMANCE
MULTI-UNIT RESIDENTIAL BUILDINGS
IN BRITISH COLUMBIA

JUNE 2021

zebx

→ The first seven projects in BC

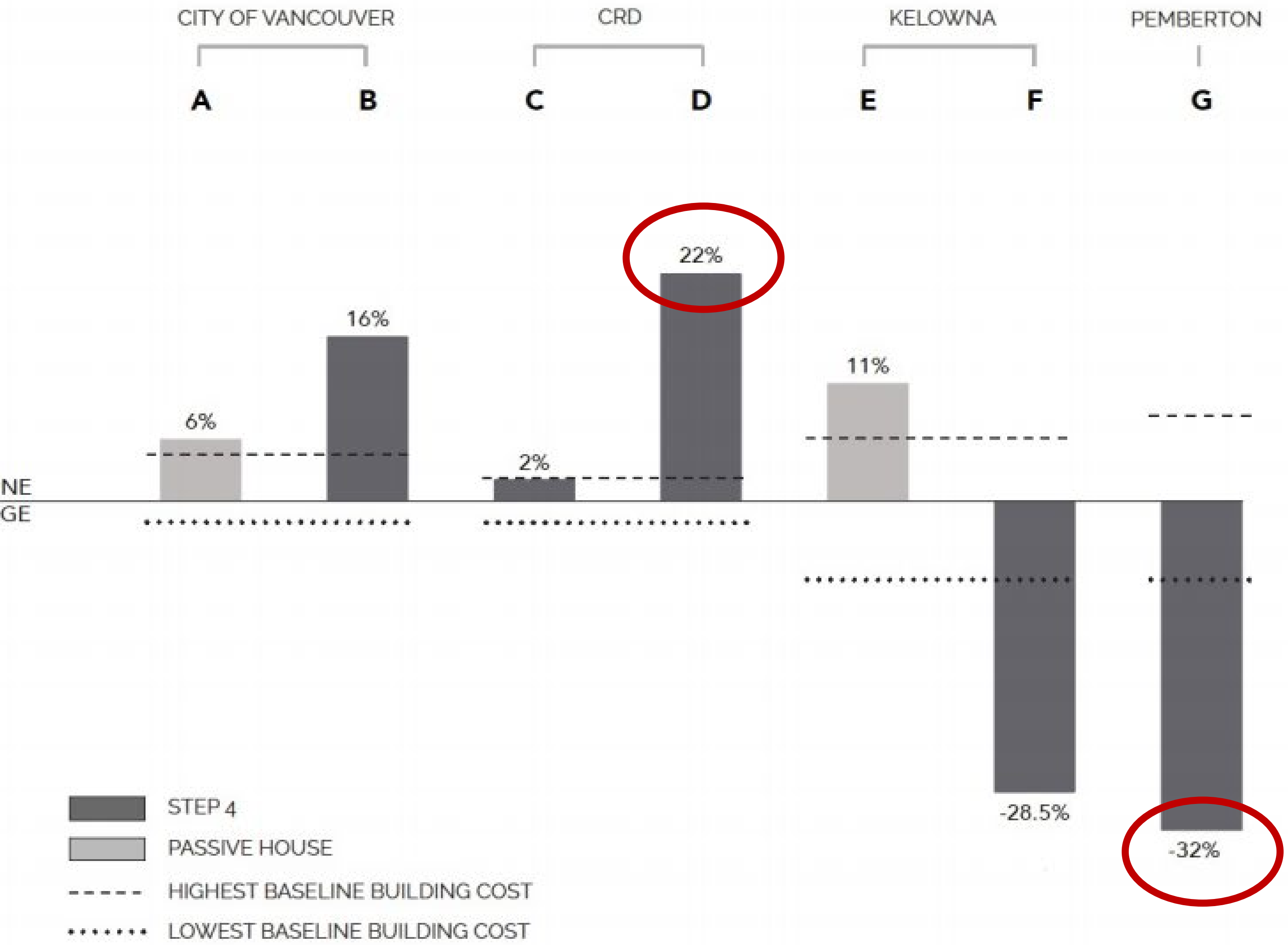
→ Passive House & Step Four

→ Three climate zones

→ We didn’t know what we were doing!

https://www.zebx.org/wp-content/uploads/2021/06/Cost-Analysis-of-High-performance-MURBBs.pdf

Overall Cost Comparison



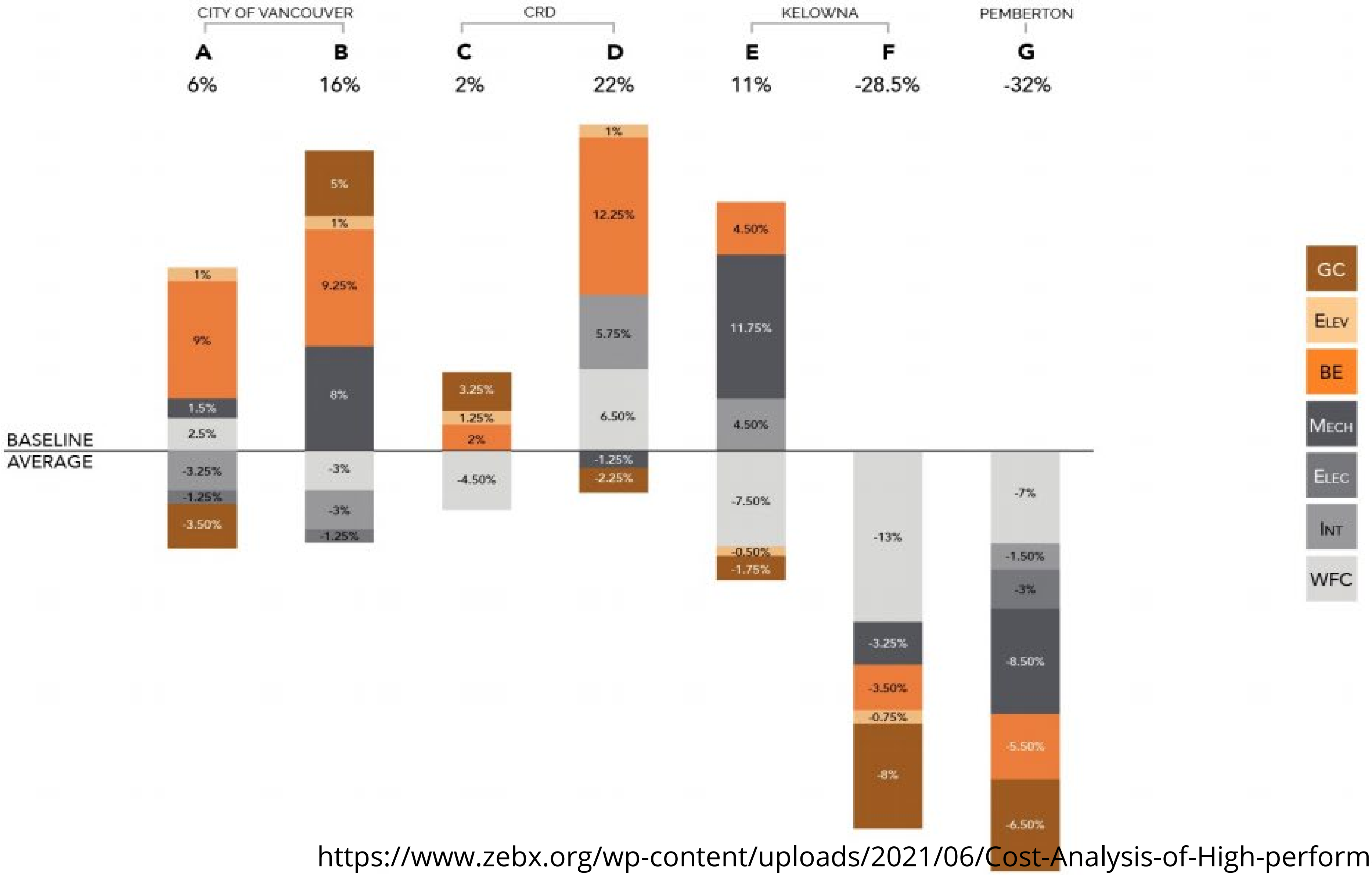

CONSTRUCTION COST ANALYSIS OF HIGH-PERFORMANCE MULTI-UNIT RESIDENTIAL BUILDINGS IN BRITISH COLUMBIA

JUNE 2021

zebx

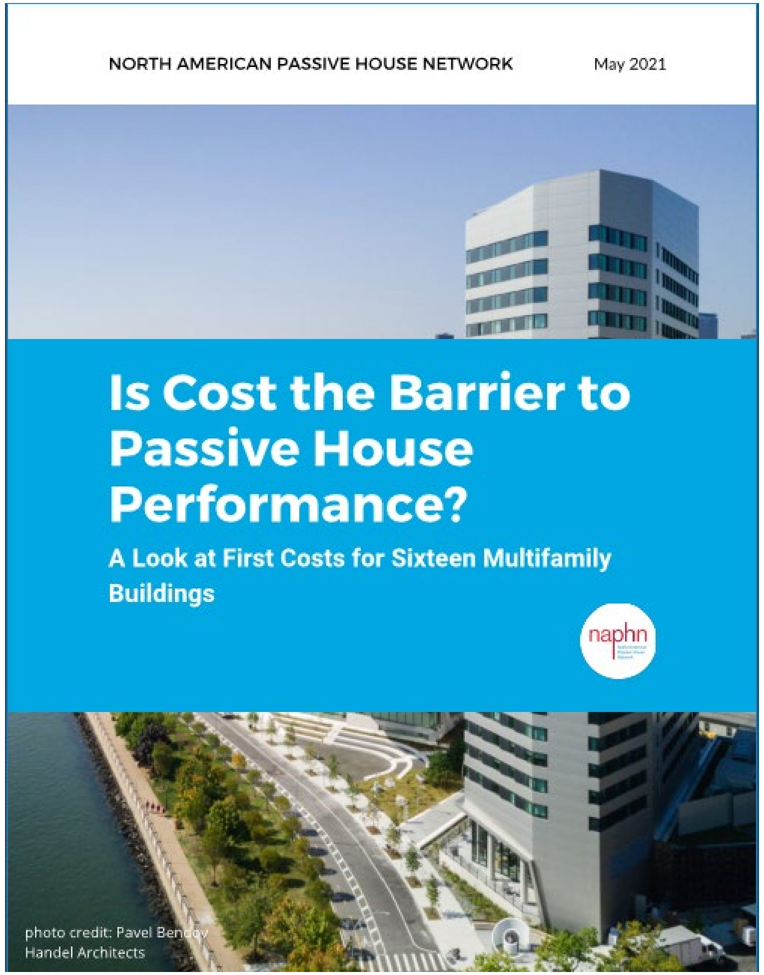
https://www.zebx.org/wp-content/uploads/2021/06/Cost-Analysis-of-High-performance-MURBBs.pdf

Overall Cost Comparison …. by System



https://www.zebx.org/wp-content/uploads/2021/06/Cost-Analysis-of-High-performance-MURBBs.pdf

Years later… Passive House Network survey



NORTH AMERICAN PASSIVE HOUSE NETWORK May 2021

Is Cost the Barrier to Passive House Performance?

A Look at First Costs for Sixteen Multifamily Buildings

naphn

photo credit: Pavel Bendov/
Handel Architects

“First costs between 1% and 8% over baseline.”

“The most obvious determinant of increased cost appears to be the experience of the project design team, and not the size of the building”

Today, costs are better managed

MASSACHUSETTS
CLEAN ENERGY
CENTER

Passive House Challenge (2019)

1.4 to 2.8%

Actual costs (not estimates) from 8 low and mid-rise PH projects around Massachusetts

CONSIGLI
Est. 1905

DOER Energy Code Analysis (2019)

1.9 to 2.9%

Detailed cost estimate by Consigli technical consultant

PHFA
PENNSYLVANIA HOUSING FINANCE AGENCY

Pennsylvania Housing Authority (2015-2018)

-1.1% less

Actual costs (not estimates) from 74 PH projects and 194 non-PH projects

Since 2019, Mass Save provides technical assistance, training and $3,000/unit in incentives for multi-family Passive House construction

Data & graphics from Massachusetts Department of Energy Resources

Today, costs are better managed

Cambridge Finch 1.4%

Old Colony 2.8%

North Commons 4%

Mattapan Station 2%

Kenzi 1%

Data & graphics from Massachusetts CEC

To save money, write a concise OPR

Write a concise Owner's Project Requirements document with specific objectives for adaptation, mitigation, and compliance.

Don't just list objectives in the OPR. Name cost-effective strategies that align with your value objectives for the project.

If you need to hire a consultant or work through a process to help you define objectives and name strategies, do it before you hire a table full of advisors.

Hire architects, engineer, and key consultants with a track record of delivering the objectives you have named. The best candidates will respond well to your OPR.

If your Step Four, Passive House, or all-electric project is their first such project, you will pay for their beginners mistakes.

To save money and drama, set specific milestones

Pre-Design

Schematic Design

Design Development

Construction Docs

Pre-Construction

Construction

Occupancy

Owner's Project Requirements

Hire experienced builder & consultants.

Set milestones that match your performance objectives.

Integrated Design Charette

First energy model sets targets (Include 20% buffer)

Identify ventilation strategy

Identify assembly strategy

Draw first the details that matter most

THERM models of key junctions

Identify windows & ventilation systems

Second energy model includes all details. (10% buffer)

Details & model to review.

Review specification for inconsistencies

PH training for site supervisors, identify air barrier supervisor

Meet to discuss VE process

Construction kickoff

Construction mock-ups, train site workers

Comprehensive QA/QC plans

Receive energy and embodied carbon approval.)

Site visits & testing

Enclosure reviews

Mechanical reviews

Ventilation commissioning

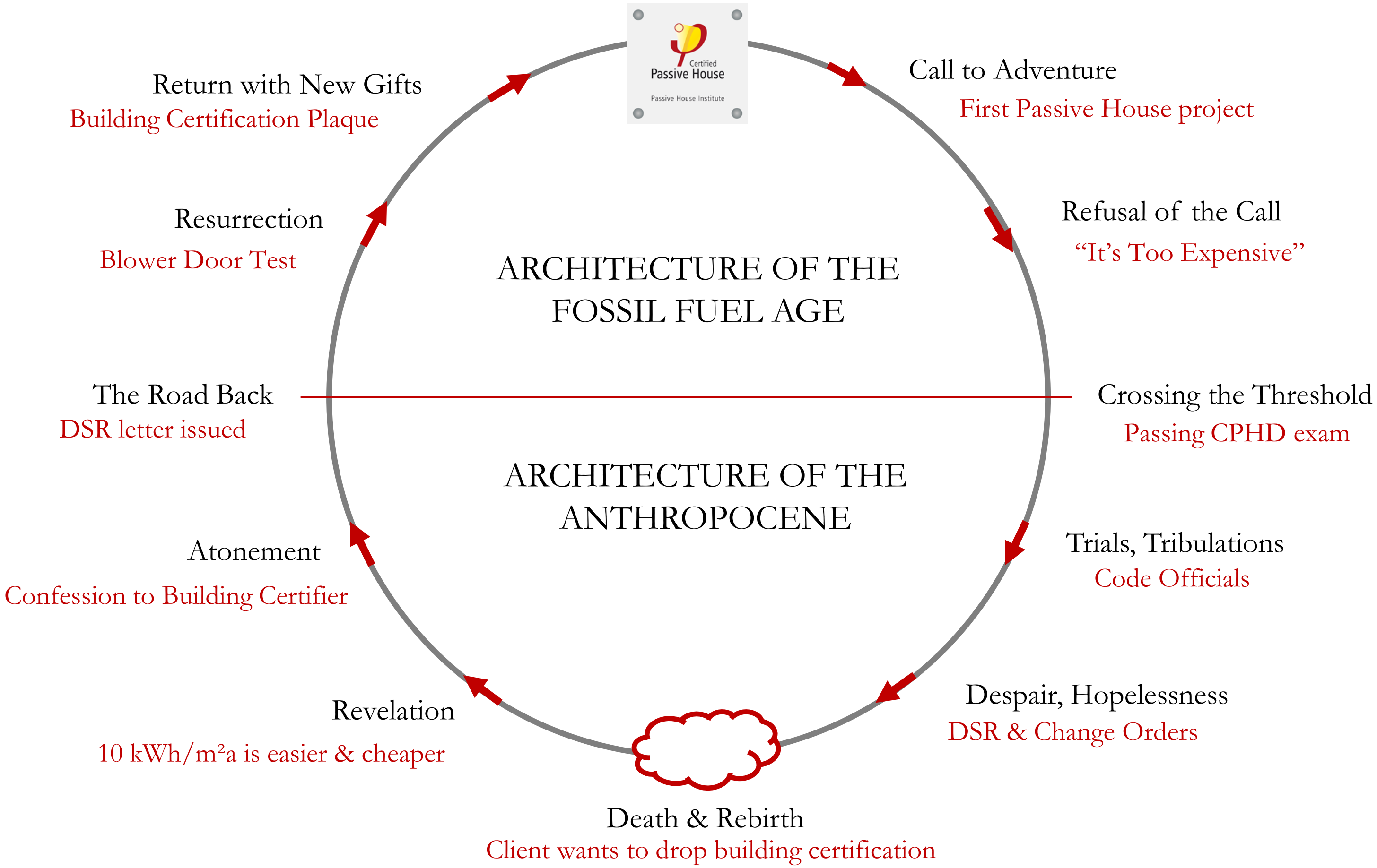
Air barrier testing

Final blower door tests

Training for residents & managers

Debrief on lessons learned

"There's your first Passive House. Then there's the rest."



ARCHITECTURE OF THE FOSSIL FUEL AGE

ARCHITECTURE OF THE ANTHROPOCENE

Call to Adventure
First Passive House project

Refusal of the Call
"It's Too Expensive"

Crossing the Threshold
Passing CPHD exam

Trials, Tribulations
Code Officials

Despair, Hopelessness
DSR & Change Orders

Death & Rebirth
Client wants to drop building certification

Revelation
10 kWh/m²a is easier & cheaper

Atonement
Confession to Building Certifier

The Road Back
DSR letter issued

Resurrection
Blower Door Test

Return with New Gifts
Building Certification Plaque

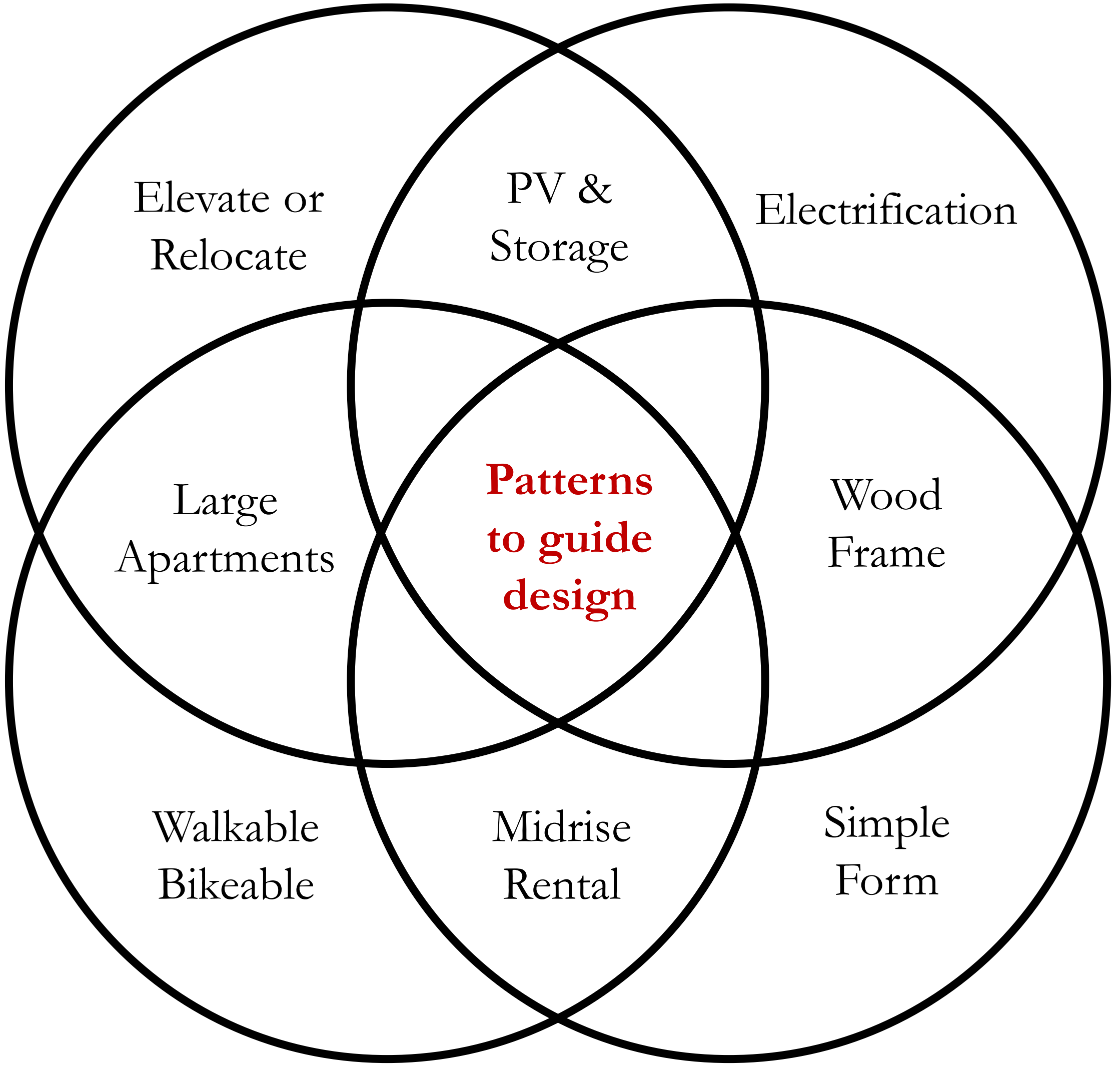
THESE ARE THE TRUE CONSTRAINTS

ADAPTATION

- Wildfire smoke
- Overheating
- Sea level rise
- Overland flooding
- Extreme storms
- Heat waves
- Pandemics

URBANIZATION

- Mass migration
- Urban populations
- Work at home
- Shelter in place
- Social isolation



Elevate or Relocate

PV & Storage

Electrification

Large Apartments

Patterns to guide design

Wood Frame

Walkable Bikeable

Midrise Rental

Simple Form

MITIGATION

- Embodied carbon
- Operational emissions
- Waste emissions
- Upstream emissions

AFFORDABILITY

- Homelessness
- Underhoused
- Land prices
- Resiliency
- Operation costs

Credit: Monte Paulsen, RDH Building Science

Please email comments to mpaulsen@rdh.com

Thank you.

Monte Paulsen | mpaulsen@rdh.com
Andrew Steingiser| asteingiser@rdh.com

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For more information, please visit EnergizeCT.com/passive-house or email PassiveHouseTrainingCT@icf.com