

Deep Energy Retrofits: Strategies for Gut Rehab or Full Occupancy Retrofits

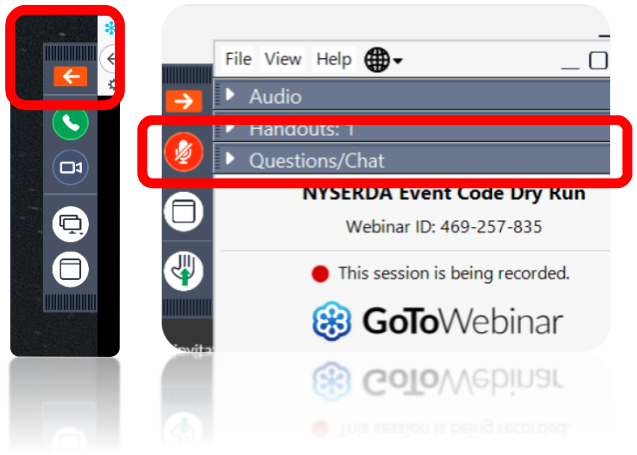
All attendees have been placed on mute.

Use the Question Section on the webinar control panel to ask a question at anytime during the presentation.

Q&A will take place at the end of each segment.

Webinar will be recorded and sent.

Webinar Overview



Since 1972, Steven Winter Associates, Inc. has been providing research, consulting, and advisory services to improve the built environment for private and public sector clients.

Our services include:

- Energy Conservation and Management
- Sustainability Consulting
- Green Building Certification
- Accessibility Consulting

We have over 125 staff across three office locations:
New York, NY | Washington, DC | Norwalk, CT

For more information, visit
www.swinter.com



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Upon Completion of Module

You will receive the following items via email:

- AIA Certificate of completion-can also be used for:
  - PHI Credits
  - NYS PE CEUs
- PDF of final presentation
- Link to the webinar recording



Steven Winter Associates, Inc.
Improving the Built Environment Since 1972

Provider #: J827

CONTINUING EDUCATION AIA

CERTIFICATE OF COMPLETION

THIS CERTIFICATE IS TO CERTIFY THAT
Katie Zoppo

PARTICIPATED IN
Module 1: Overview of PH/Net Zero Building Concepts, Techniques and Benefits

COURSE NUMBER
M1OOPHNZBCTAB

ON
February 11th, 2020

LOCATION
New Paltz, NY

EARNING
4 AIA CES Learning Unit/HSW

Lois B. Arena, PE
Director, Passive House Services
Steven Winter Associates, Inc.

Steven Winter Associates, Inc.
61 Washington Street
Norwalk, CT 06854
203.857.0200

If you need more details:

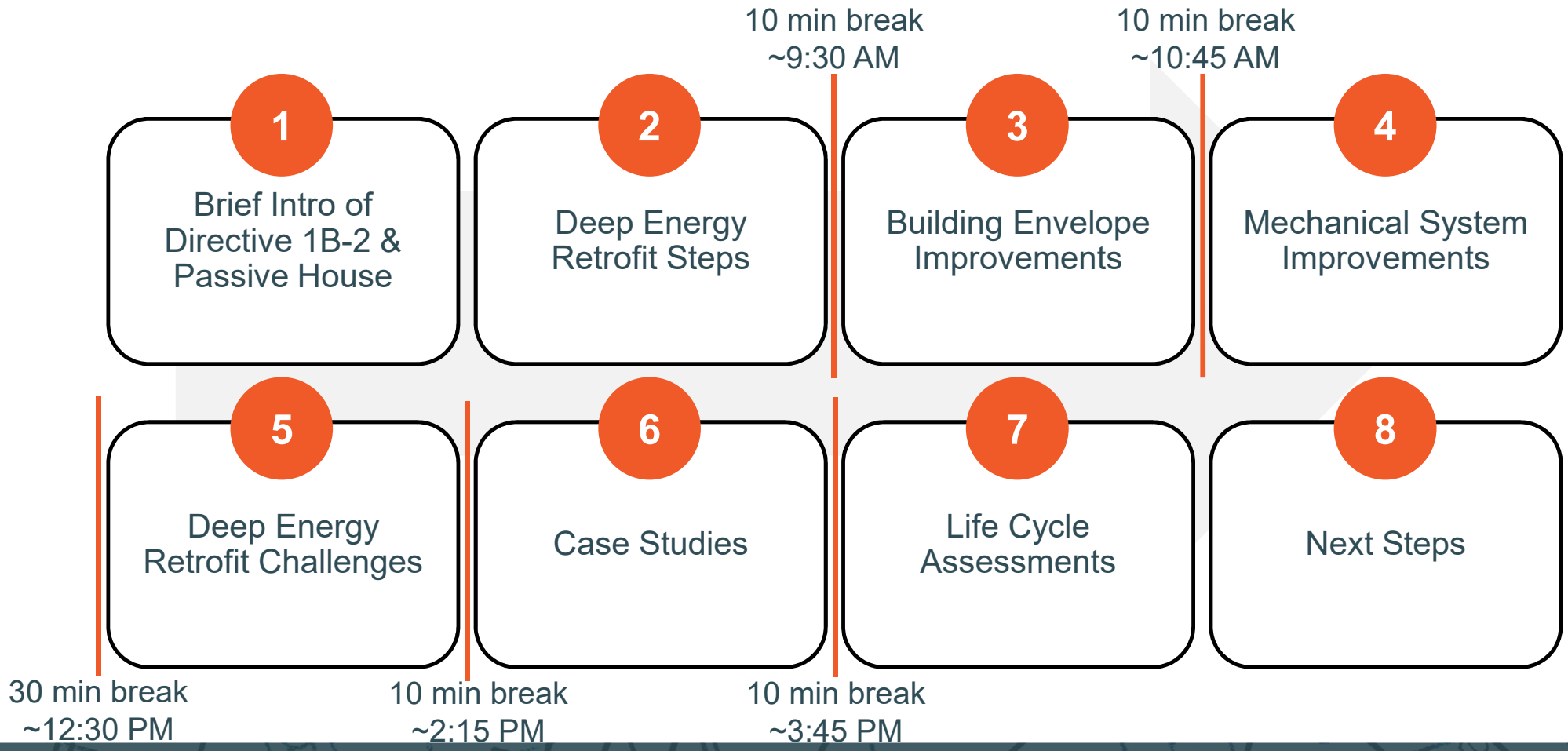
- Module 1: Overview of PH/Net Zero Concepts, Techniques & Benefits
- Module 2: Deep Dive into Construction Methods and High-Performance Products and Details
- Module 3: Deep Dive into Air Barrier Development & Implementation
- Module 4: Net Zero HVAC Strategies and Controls + DHW
- Module 5: Contracting for Passive House: Construction Documents and Bidding
- Module 6: Deep Energy Retrofits: Strategies for Gut Rehab or Full Occupancy Retrofits
- Module 7: Beyond Hydrofluorocarbons (HFCs): Refrigerant Management in Design, Construction, and Operations
- Module 8: Construction Manager/Subcontractor/Tradesperson Training: Classroom and Field Training

Learning Objectives

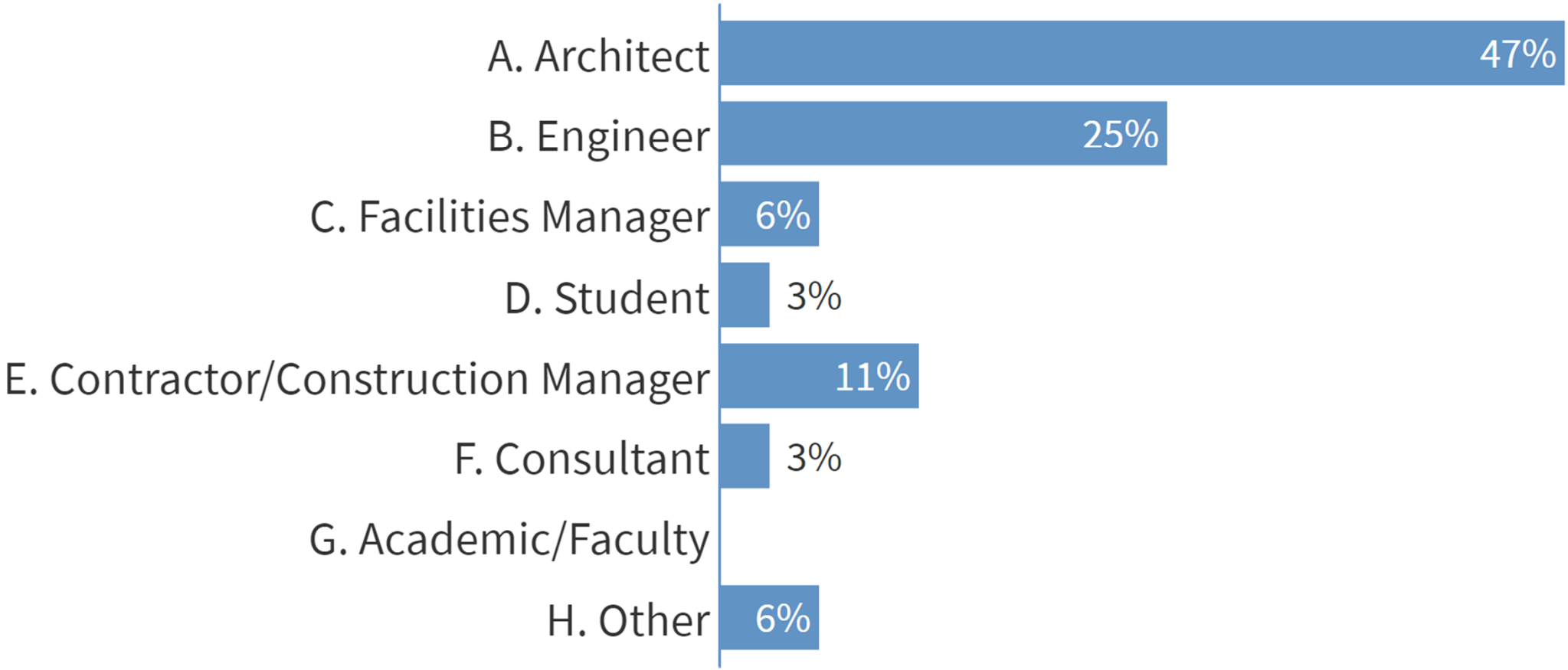


- **List** three reasons for providing balanced mechanical ventilation
- **Explain** why installing insulation on the exterior of the walls is preferred over interior insulation.
- **List** the main principles of Passive House/high performance design
- **Understand** how improving one system in a building affects occupant comfort, durability and energy performance.
- **Explain** the difference between life cycle analysis of a building retrofit and life cycle cost analysis

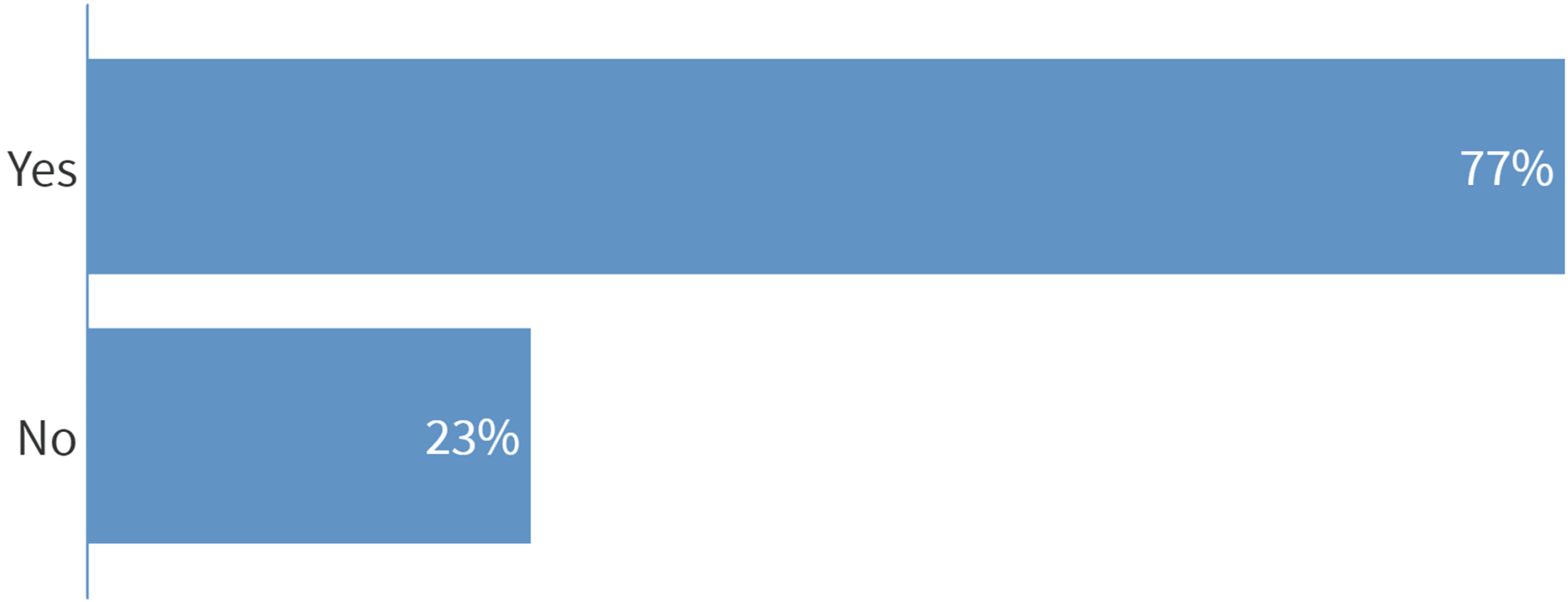
Overview of Presentation



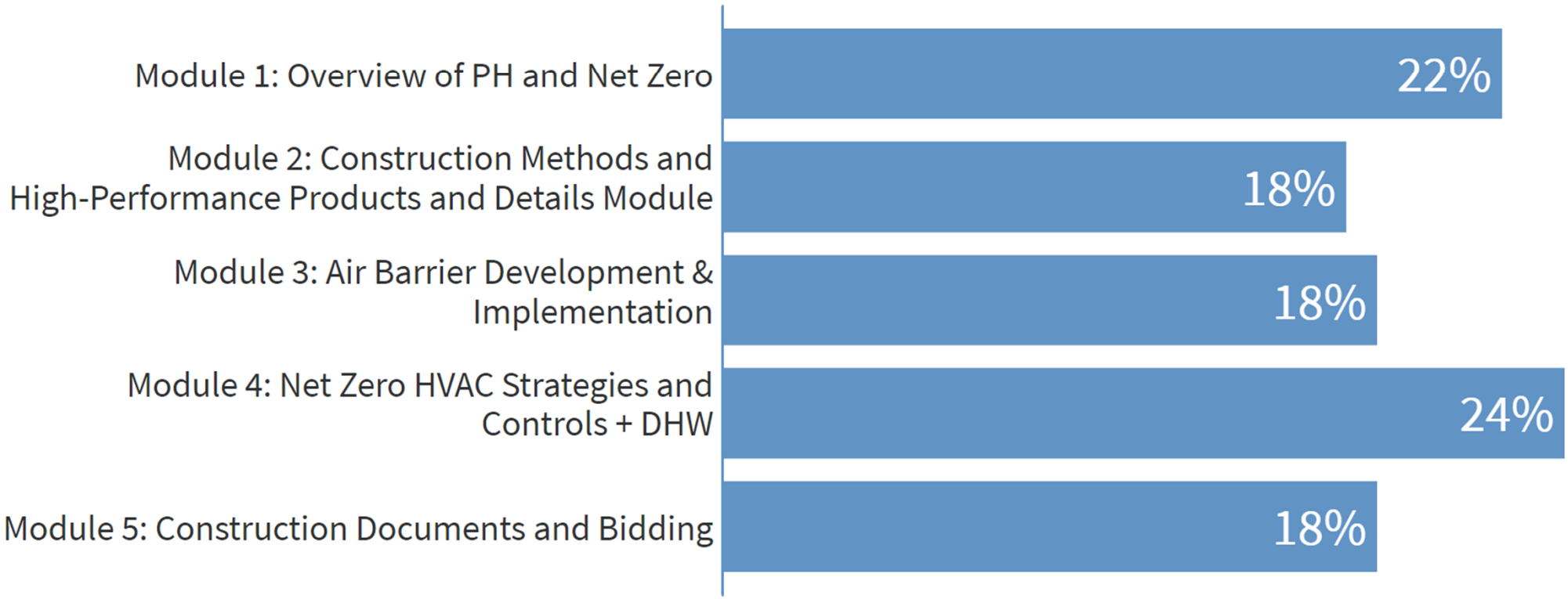
What is your profession?



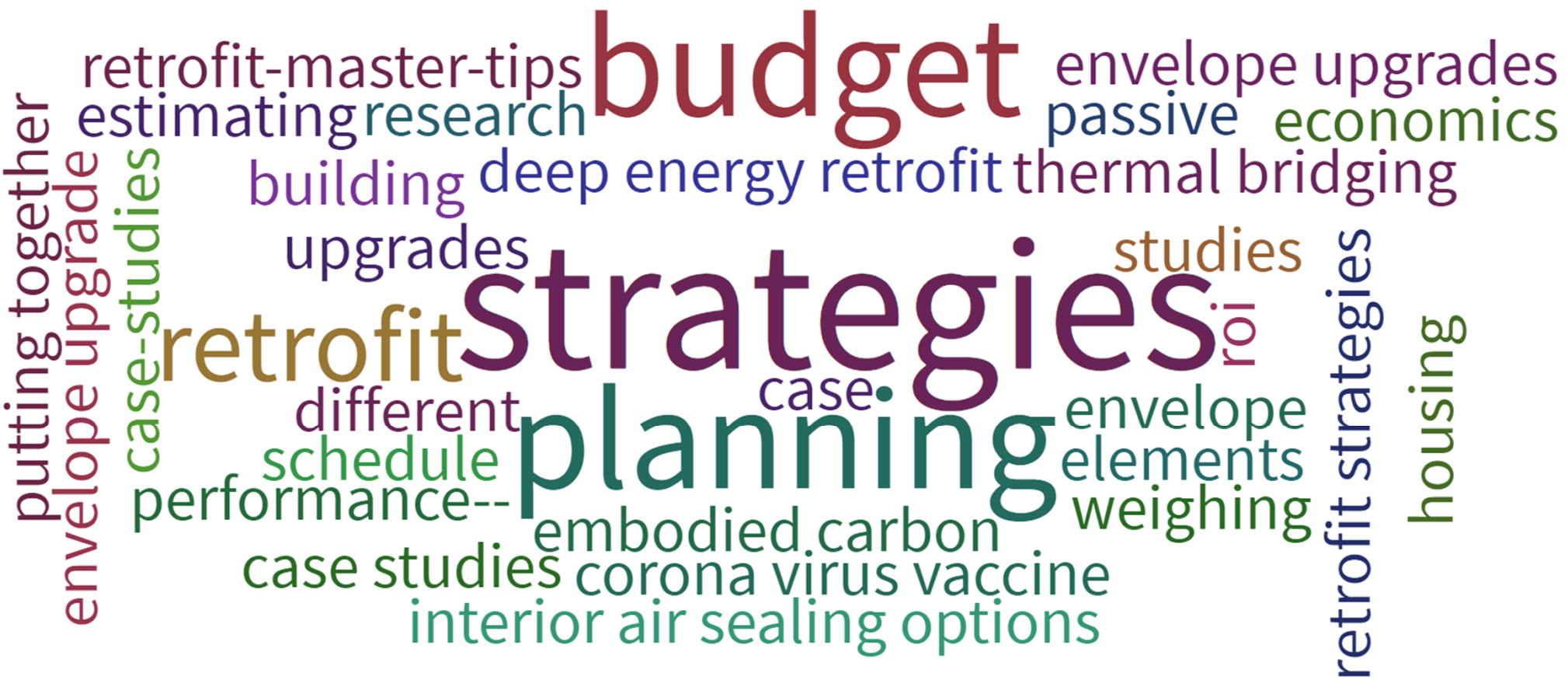
Have you attended at least one of the modules presented to date - Modules 1-5?



If you answered "Yes" to the previous question, which module did you attend?



What is the one thing you were hoping to learn about today?





Coykendall Science Building

Why we are here: **Directive 1B-2**

- 2018 Chancellor calls for all new buildings to be zero-net-carbon & deep energy retrofits for existing buildings
- 2018 SUCF issued Directive 1B-2
  - Purpose: define and identify goals for Net Zero Carbon (NZC) new buildings and Deep Energy Retrofits (DER) of existing buildings.
  - Function: outlines the project target goals and provides direction for project designs.
  - Metrics: Site Energy as the measure of performance and energy consumption.

Directive 1B-2: Setting Performance Targets

Current energy use should be determined from:

- existing metered building data.
- estimated using existing building or campus level utility invoices.
- estimated using benchmarking tools such as New Building's Institute's FirstView.
- existing ASHRAE Level 2 Energy Audits



Overview of SUNY New Paltz Buildings/Practices



Deep Energy Retrofits & Passive House Principles

What is EnerPHit?

- EnerPHit- retrofit version of the PH standard
- First and foremost, PH is a building standard
- Applies to new & existing buildings
- The most rigorous energy efficiency certification available
- Attention to insulation continuity and reduction of thermal bridges
- Emphasis on balanced ventilation

EnerPHit Standard

Compliance Pathways:

1. Component Method
   a) Prescribed envelope and ERV efficiencies
   b) Primary energy demand
      i. Either primary energy (PE) demand or primary energy renewables (PER) Demand
   c) Whole building air-tightness target
2. Performance Method
   a) Heating demand
   b) Cooling demand
   c) Primary energy demand
      i. Either primary energy (PE) demand or primary energy renewables (PER) Demand
   d) Whole building air-tightness target



Exemptions for EnerPHit

The limit values in Table 2 for the heat transfer coefficients of the exterior envelope building components may be exceeded if absolutely necessary based on one or more of the following compelling reasons:

- If required by the historical building preservation authorities
- If the cost-effectiveness of a required measure is no longer assured due to exceptional circumstances or additional requirements
- Due to legal requirements
- If implementation of the required standard of thermal insulation would result in unacceptable restriction of the use of the building or adjacent outer areas
- If special, additional requirements (e.g. fire safety) exist and there are no components available on the market that also comply with the EnerPHit criteria
- If the heat transfer coefficient (U-value) of windows is increased due to a high thermal transmittance (psi value) of the window installation offset to the insulation layer in a wall that has interior insulation
- If reliably damage-free construction is only possible with a smaller insulation thickness in the case of interior insulation
- If other compelling reasons relating to construction are present

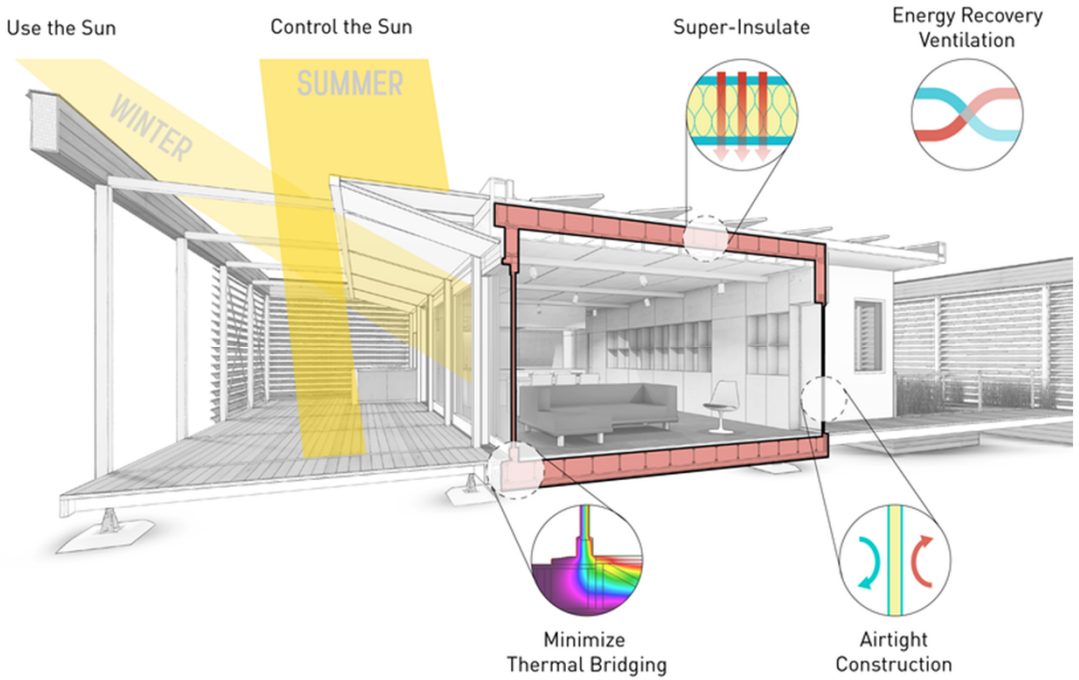
Goals of PH

- Building durability
- Energy $ reduction
- Optimal thermal comfort
- Superior indoor air quality
- Carbon emissions reductions



Passive House Principals

- Thermal insulation continuity
- Thermal bridge free construction
- Solar control
- Airtightness
- Balanced mechanical ventilation



The SURE House

Winner of the 2015 D.O.E. Solar Decathlon

www.surehouse.org

**For more on PH see Module 1*











How to Deeply Retrofit: General Guidance

How to Deeply Retrofit

Goal: provide the most comfortable building using the least energy

- We need buildings that are both efficient and effective
- Better ventilation might increase energy use
- Adding cooling will increase energy use
- But both essential in most typologies

In general, a deep energy retrofit:

- Targets source energy use reduction of at least 50%
- Touches every building system, including the envelope
- Is implemented through multiple projects, sequenced to maximize energy savings potential

How to Deeply Retrofit

Holistic framework, not disconnected steps

First . . .
- Reduce internal loads (plugs, appliances, lighting)
- Reduce external loads (airtight, well insulated, good windows)

Then . . .
- Ensure comfortable, healthy ventilation

Now that loads are reduced . . .
- Select high efficiency heating/cooling
- Ensure proper commissioning
- Enact strong operations & maintenance protocols

High Performance Heating & Cooling

- If possible, update systems after internal and external loads are reduced – may allow for smaller, simpler systems
- Take advantage of passive or free sources of heating & cooling (economizers, energy recovery, etc.)
- Take careful consideration of internal loads and peak demands – overheating will be a concern for some typologies
- Heat pump systems are a common solution



Reduce Internal Loads

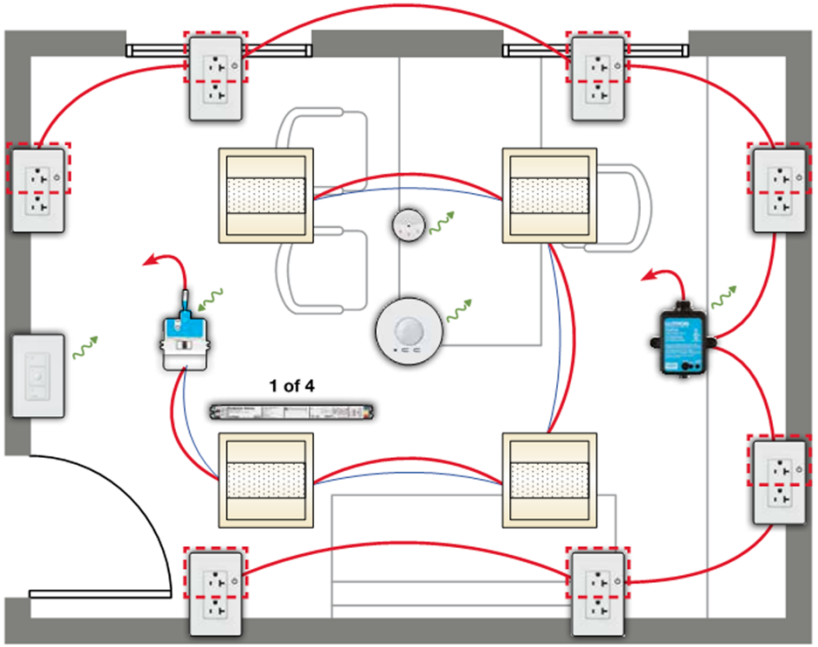
Internal Load Reduction Priorities

Lighting and Lighting Controls

- High efficacy fixtures
- Occupancy controls
- Daylighting control

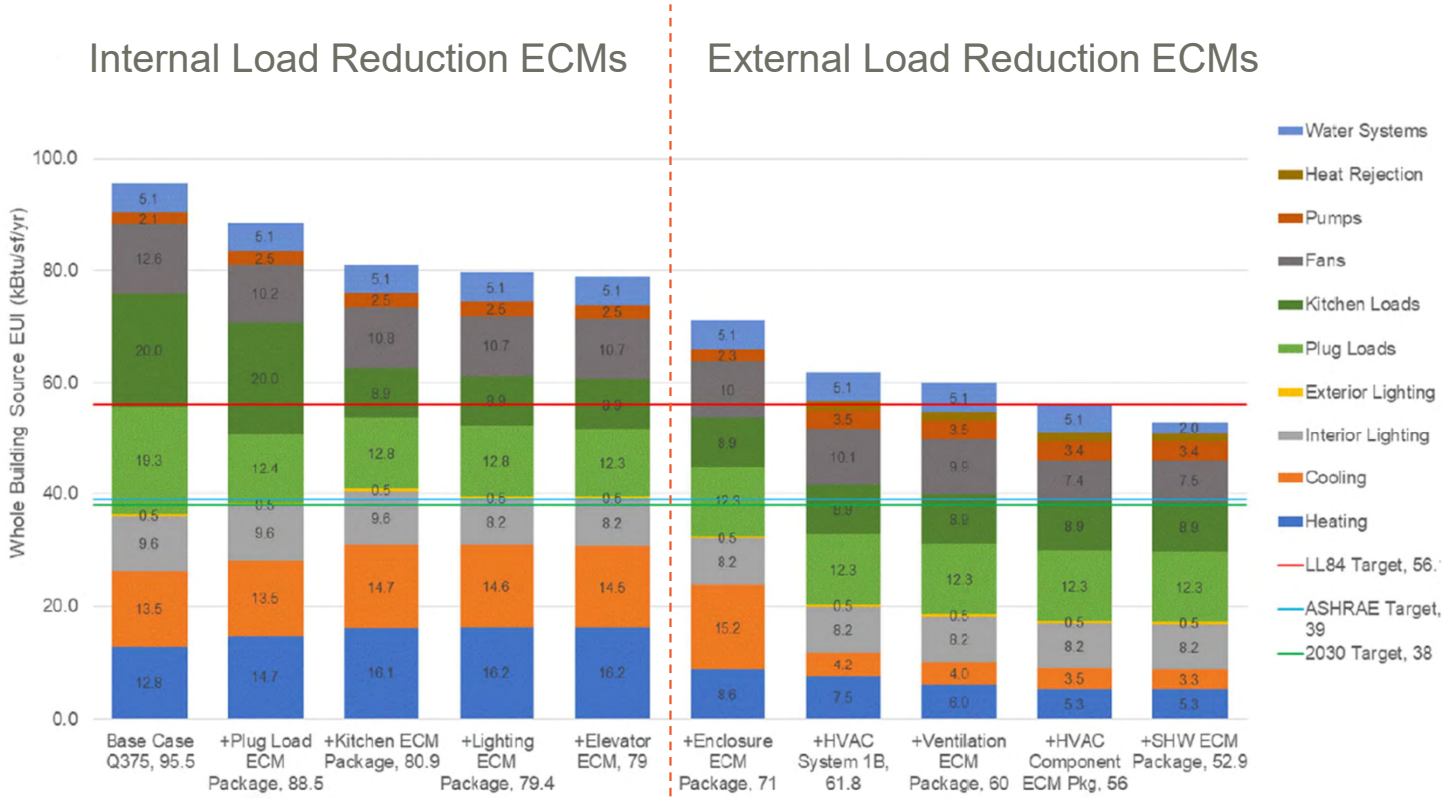
Appliances and Plug Loads

- ENERGY STAR / highest efficiency equipment
- Plug load controls and management



Stacked ECM Packages

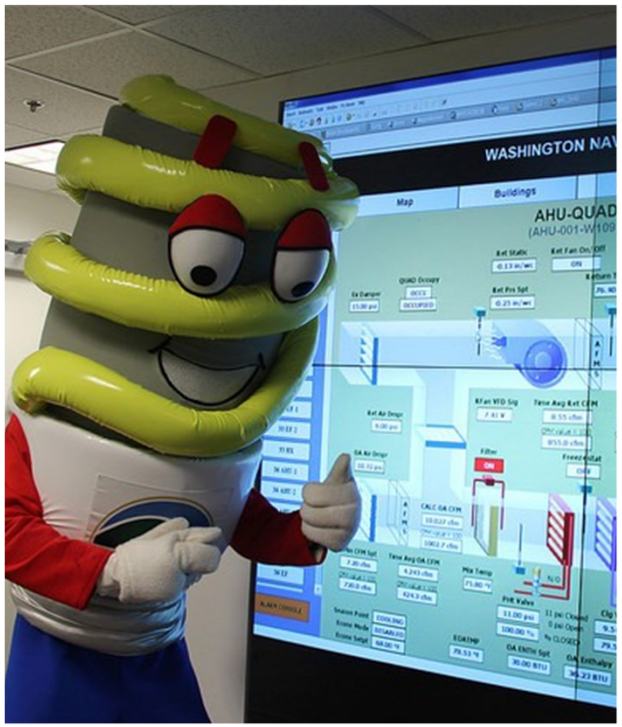
LL 31 Feasibility Study



From: NYC's Path to 2030 Local Law 31 of 2016 Feasibility Study. SWA, April 2018

High Performance Operations & Maintenance

- Proper staff training
- Accurate inventories & assessments
- Periodic retro-/re-commissioning
- Real time monitoring via computerized maintenance management system (CMMS)
- Streamline work through computerized monitoring
- Streamline procurement



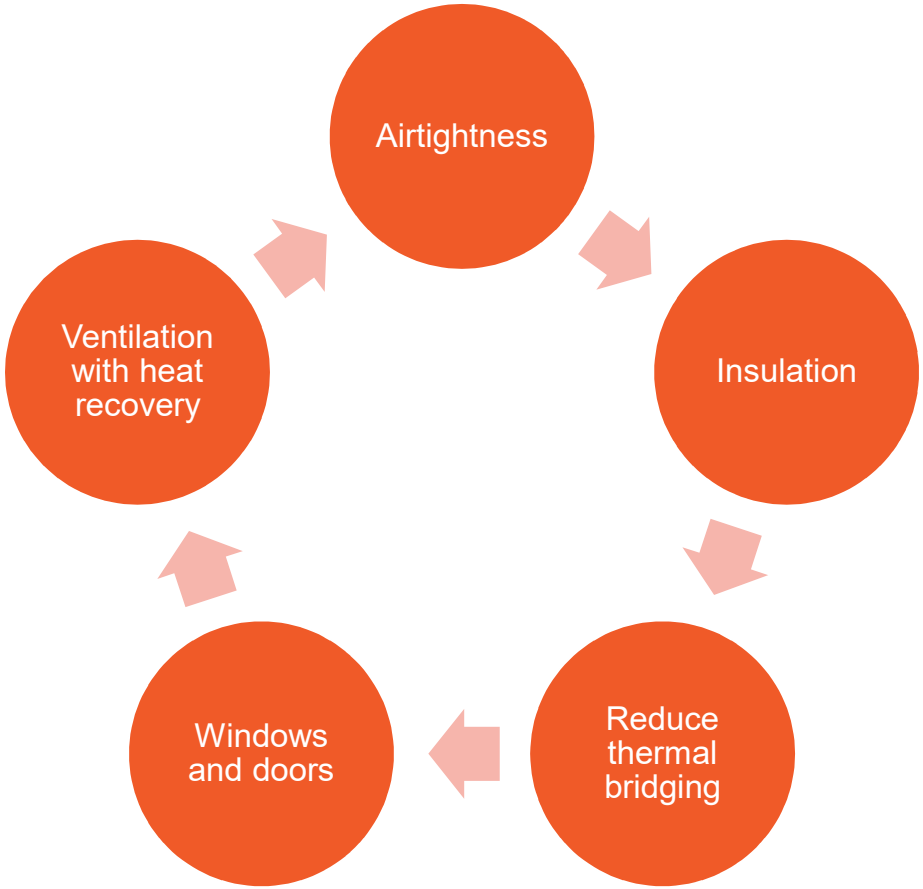
BRITE is the mascot of the Navy's shore energy program, managed by Navy Installations Command. (Source: U.S. Navy, Chatney Auger)

What are the biggest challenges beside cost when attempting a deep energy retrofit?



Reducing External Loads

Principles of External Load Reduction



Reducing External Loads: Airtightness

High Performance Building Principles

airtightness



Building Energy Exchange


airtightness
—
strategies &
components
photos: A2M Architecture
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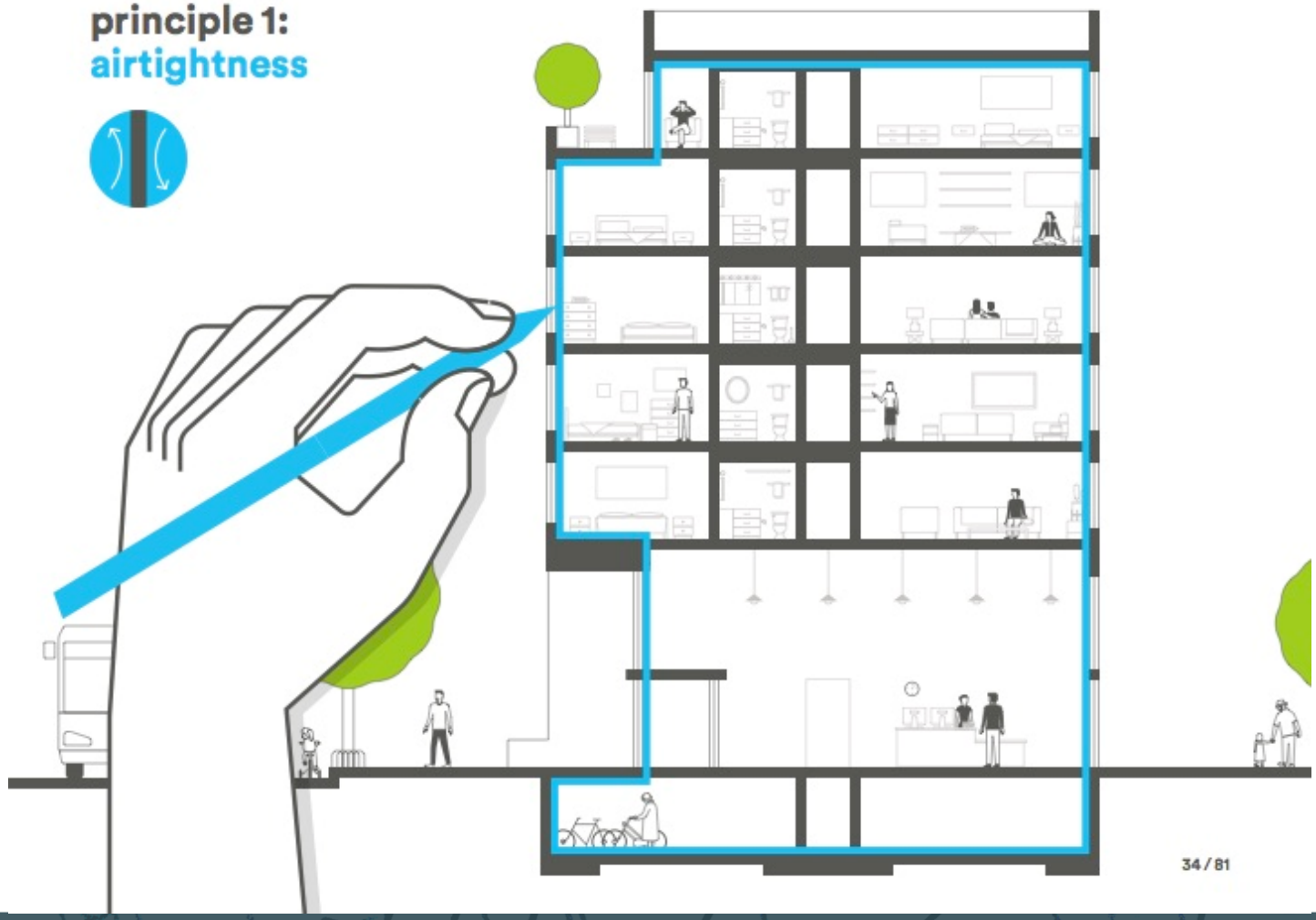
Common Gaps in Envelopes



Reduce drafts

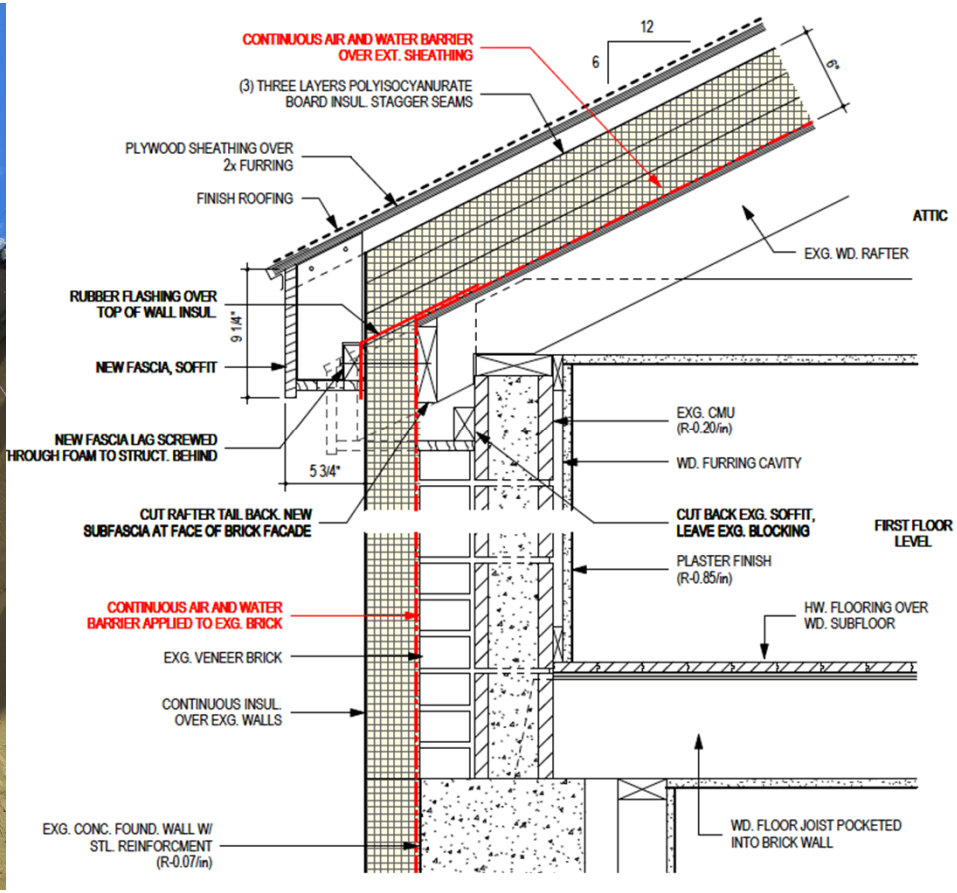


Stop ‘filtering’ air through cracks in the building envelope


principle 1:
airtightness
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Exterior Insulation and Air Barrier





Liquid Applied Air Barrier





Spray Applied Air Barrier





Tapes & Membranes Air Barrier



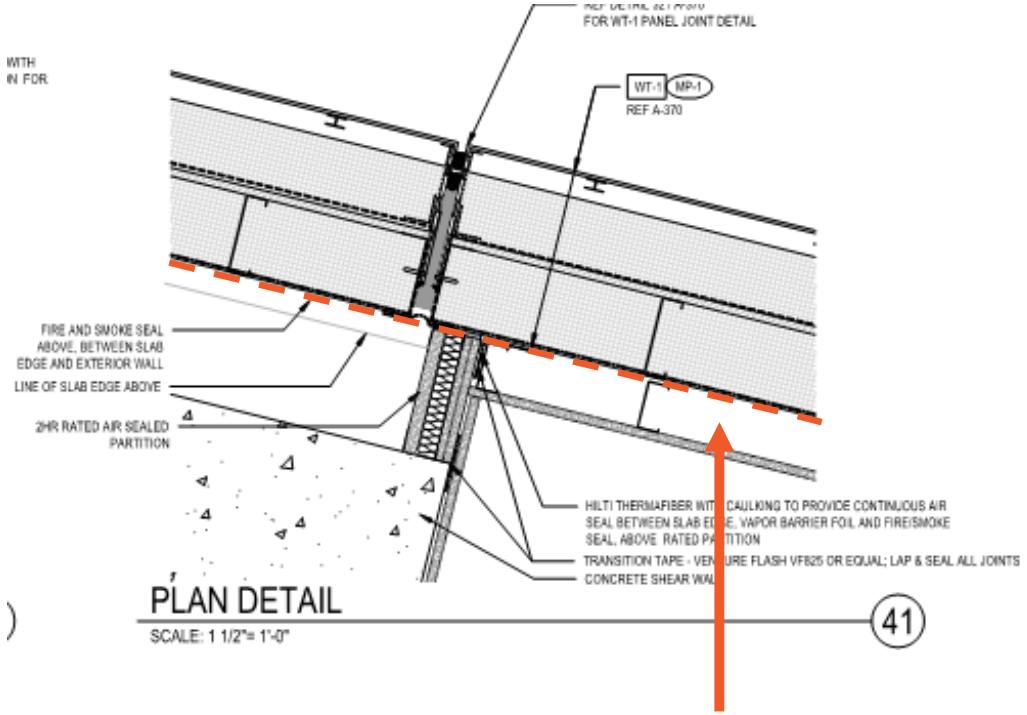


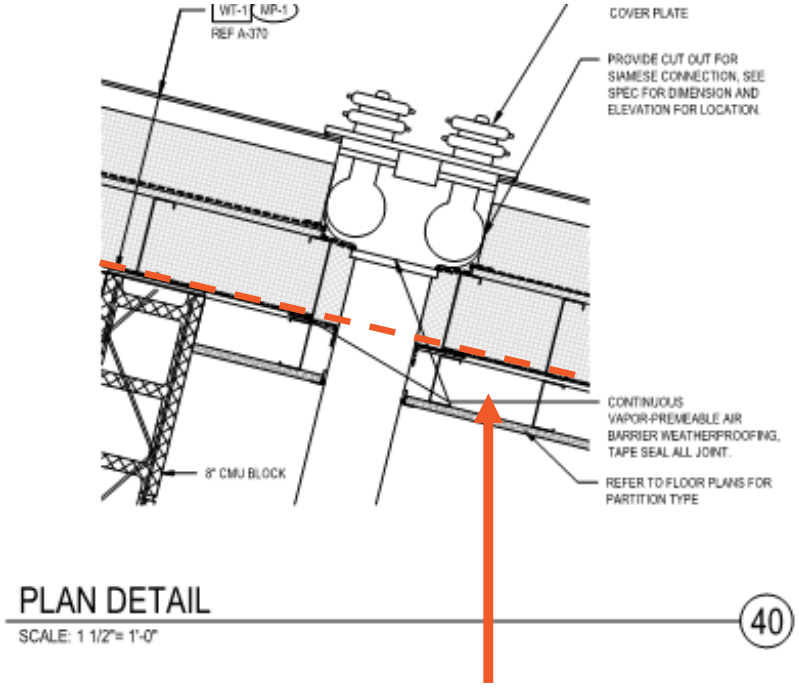
Penetrations (boots and tapes)



	**G-1**	**Vapor Permeable Gasket**	Incoming conduit & pipes Install in sequence!
	**T-1**	**Vapor Permeable/ Impermeable Tapes**	1. Windows & Door openings 2. Inside face of exterior wall in contact with vapor barrier 3. Inside face of exterior wall in contact with vapor barrier 4. Interior walls adjacent to hammerhead shear walls
	**V-1**	**Vapor Retarder**	Inside face of exterior wall

Service Cavities for Air Barrier Protection





Airtightness Testing

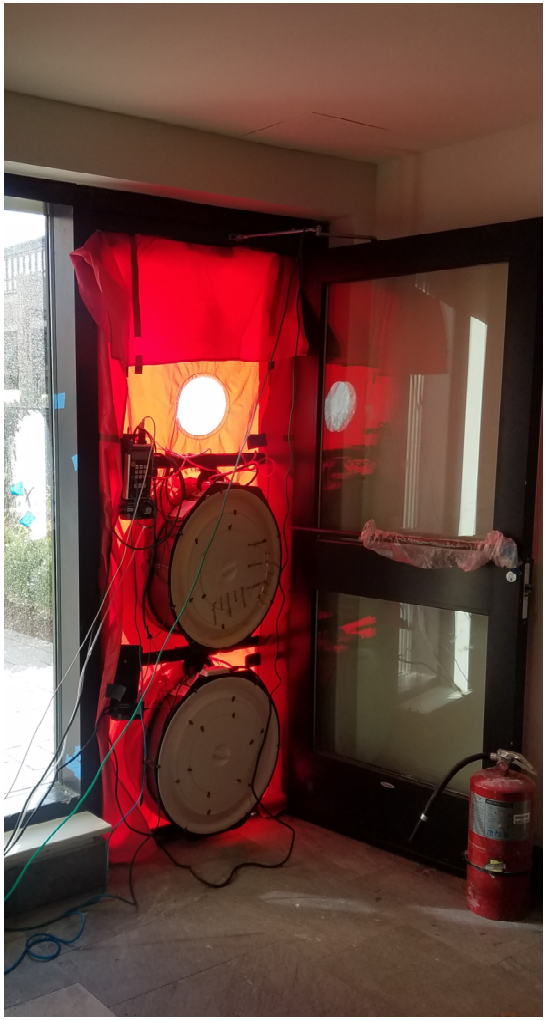
Steven Winter Associates, Inc.
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WHOLE BUILDING INFILTRATION TESTING PLAN

TO DETERMINE COMPLIANCE WITH PHIUS+ AIRTIGHTNESS REQUIREMENTS
AT BEACH GREEN DUNES PHASE II
45-19 ROCKAWAY BEACH BLVD., QUEENS, NY 11691
REV 1

APRIL 17, 2018
UPDATED 10/16/2019

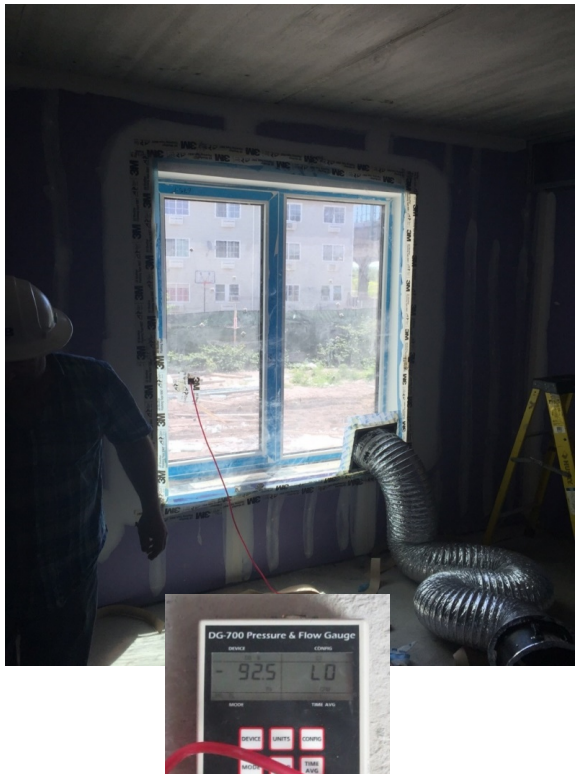




Testing Tools and Protocols

- Window mockup testing
- Interim guarded blower door testing
- Interim whole building test if schedule and sequencing allows
- Envelope compartmentalization and window testing
- Unique component testing
- Whole building blower door test

Window Mockup Test

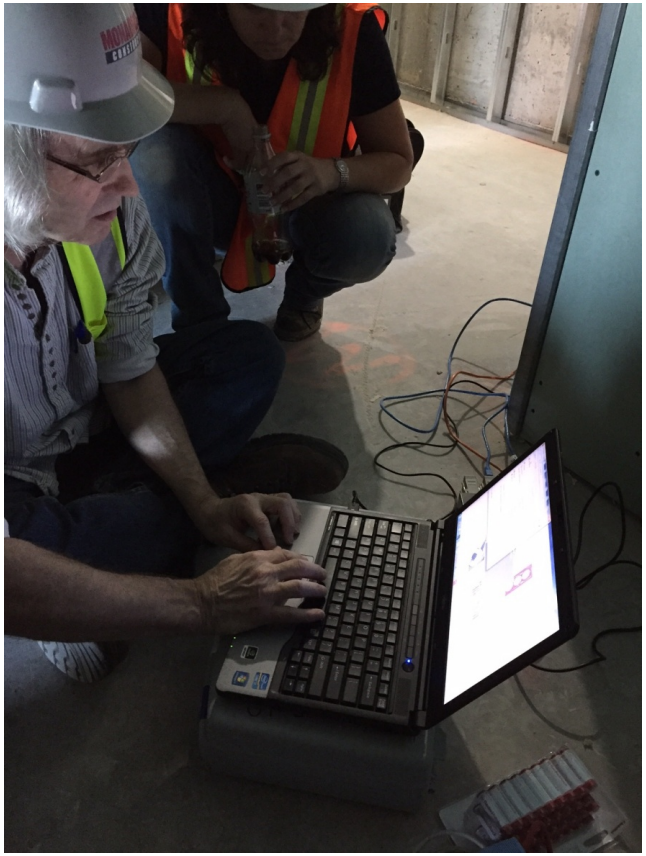




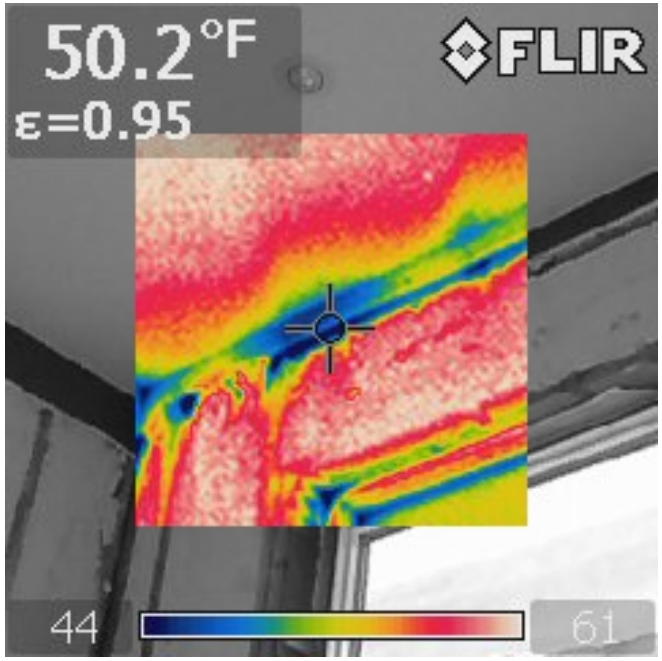
Guarded Blower Door Test



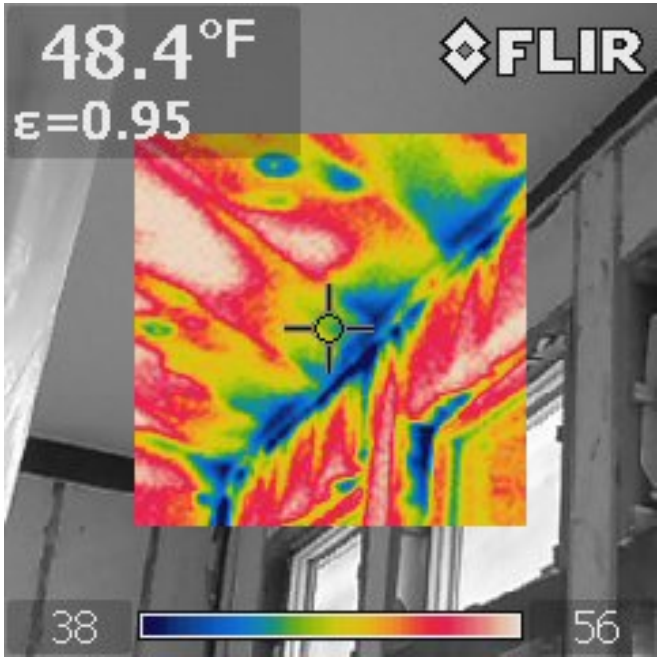




Blower Door Test: Diagnostics



before



during

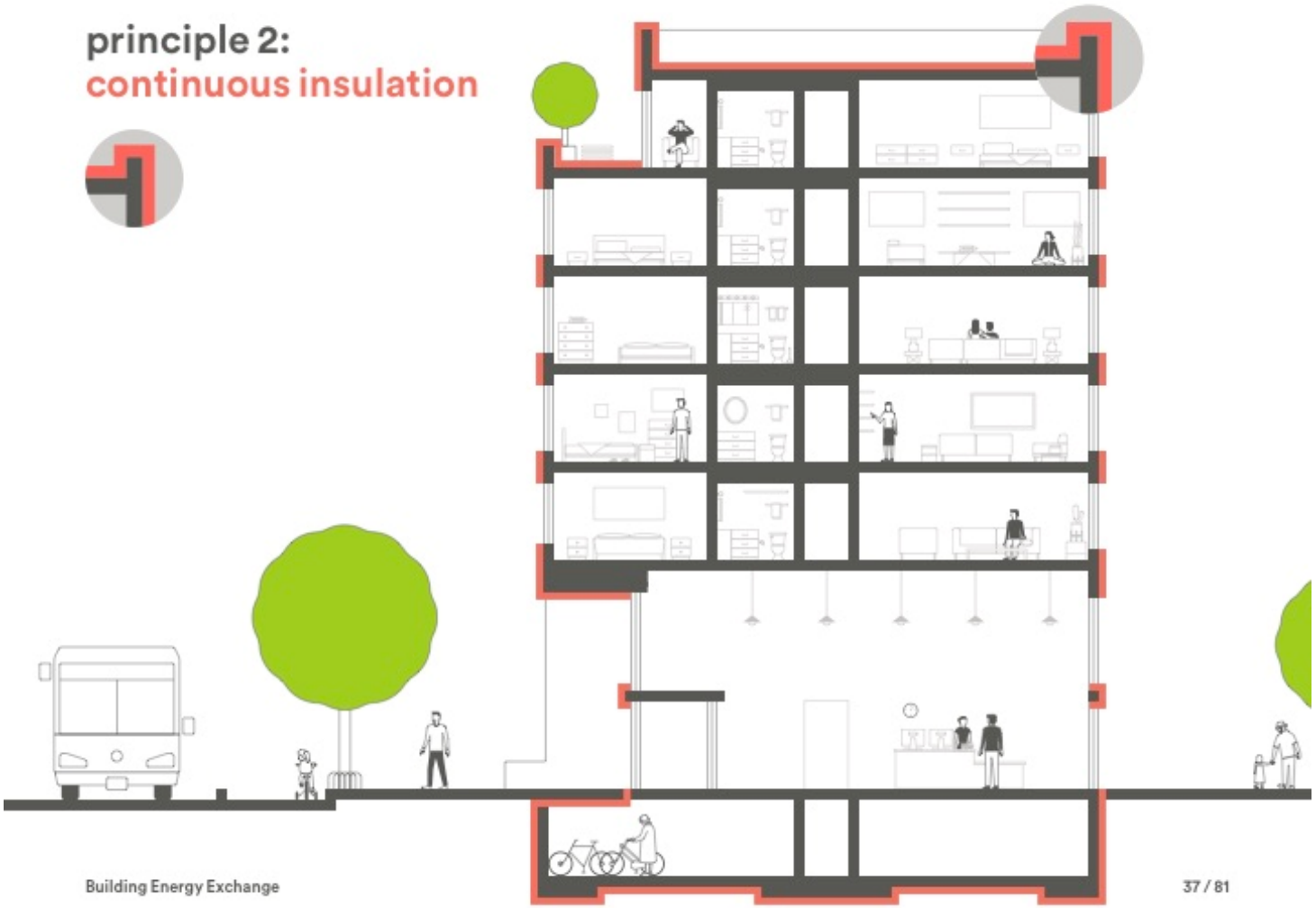
**For more on air barriers see Modules 2 & 3*

Questions?



Reducing External Loads: Continuous Insulation

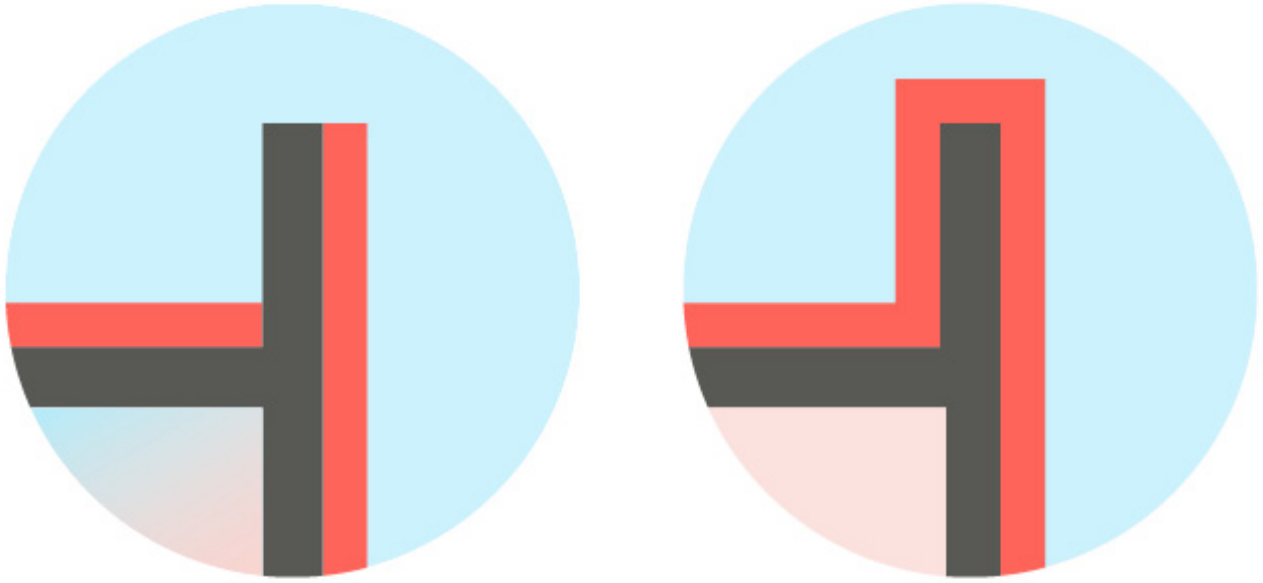
principle 2:
continuous insulation



Building Energy Exchange

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principle 2:
continuous insulation



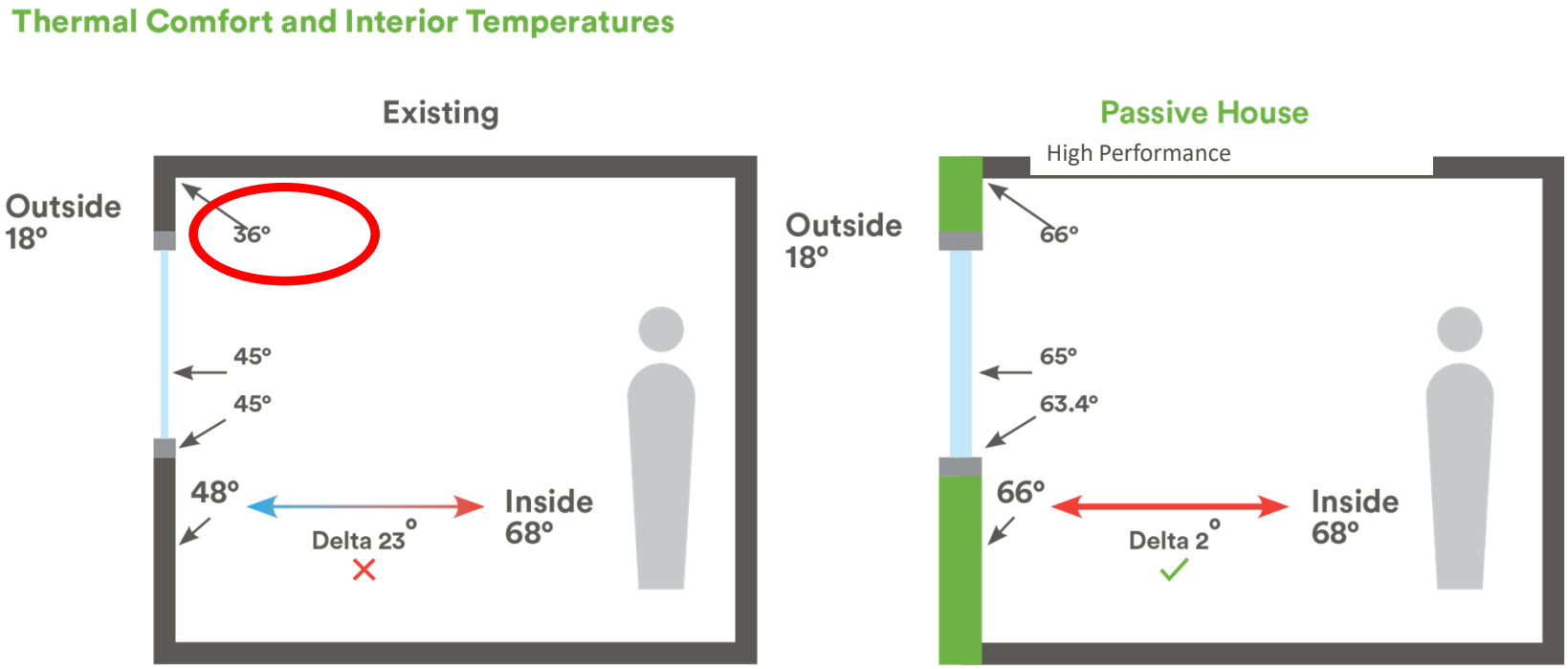
Conventional Construction

High Performance Construction

Condensation Fosters Mold



Comfort

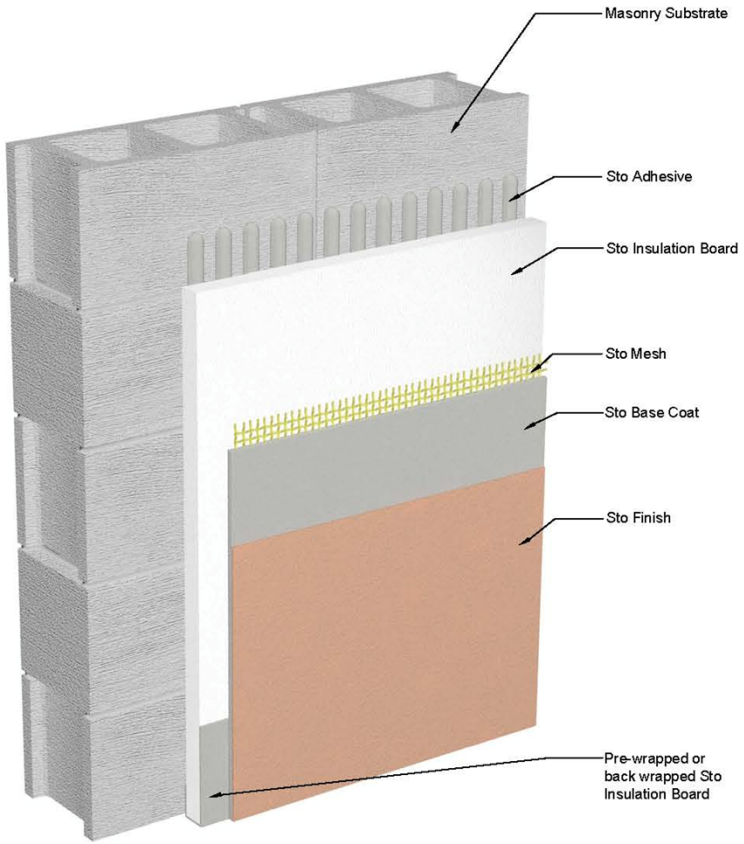

Thermal Comfort and Interior Temperatures
Existing
Outside
18°
36°
45°
45°
48°
Delta 23°
Inside
68°
Passive House
High Performance
Outside
18°
66°
65°
63.4°
66°
Delta 2°
Inside
68°

Exterior Insulation - EIFS

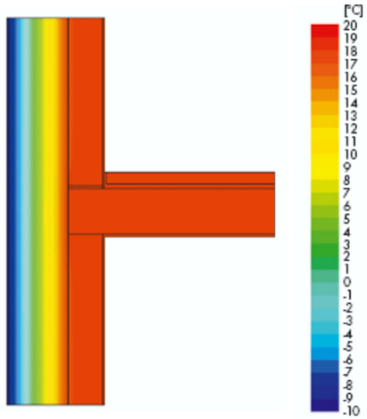




Exterior Insulation - EIFS







Exterior Insulation - EIFS

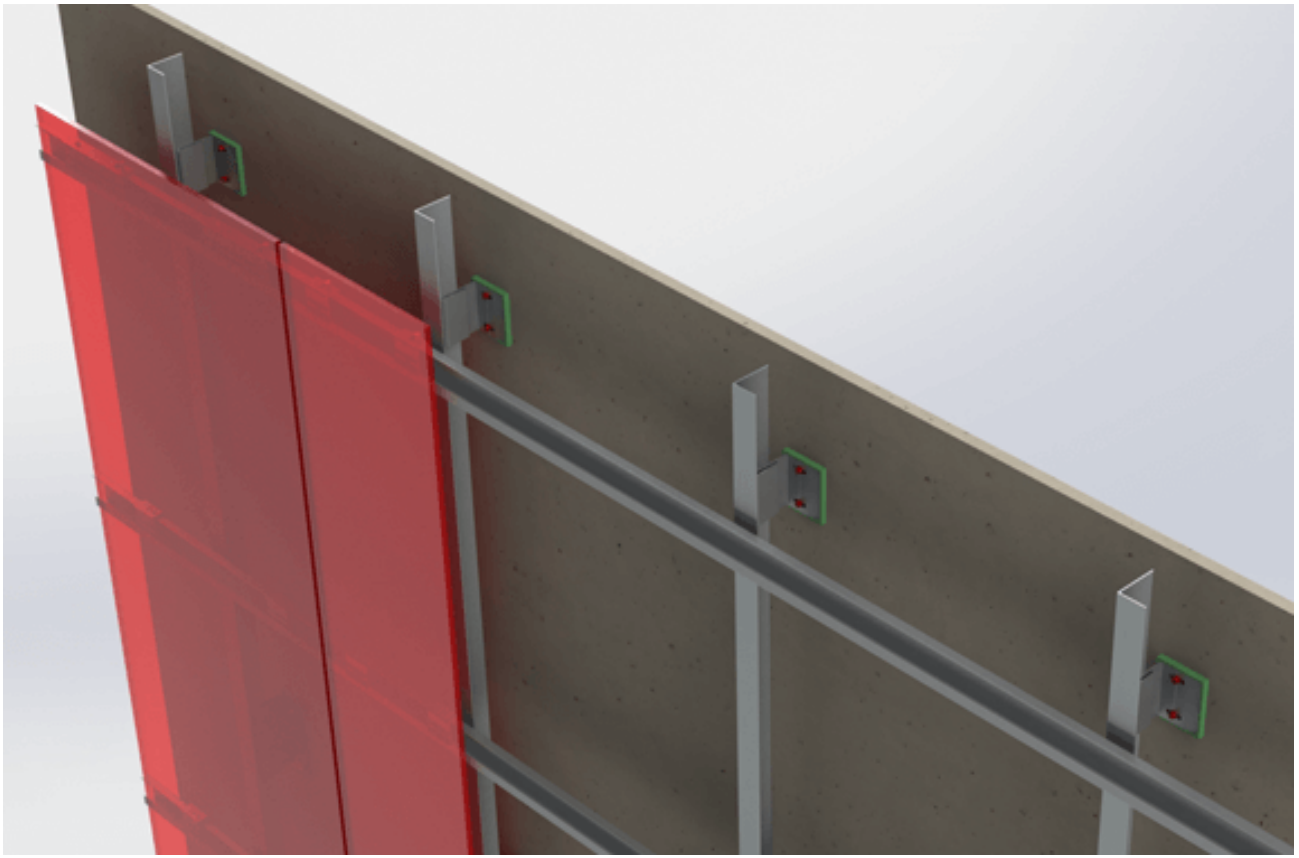




Exterior Insulation - Rainscreen







Source: Cascadia and Nvelope

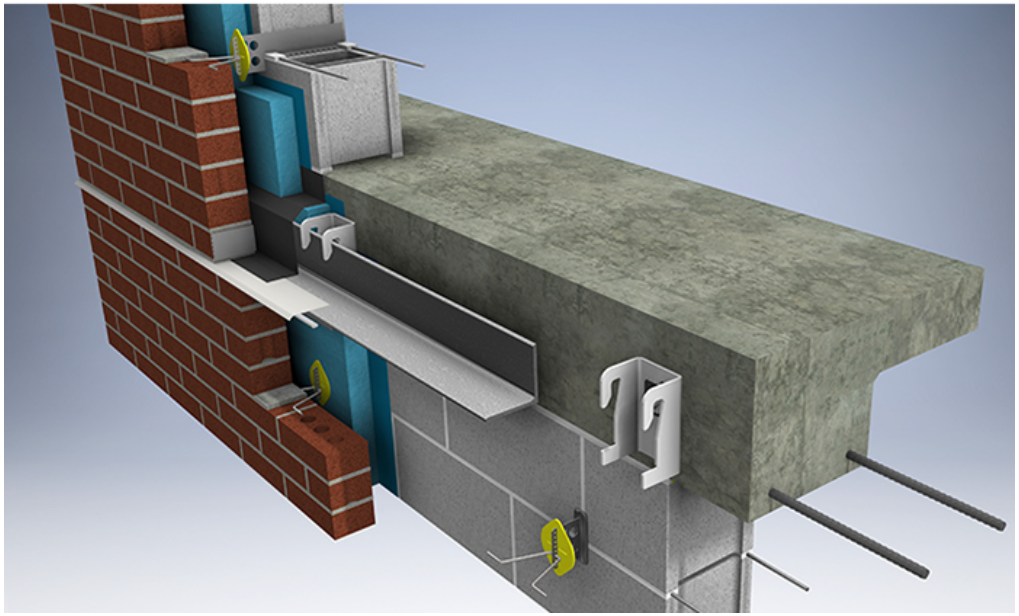
Exterior Insulation - Rainscreen

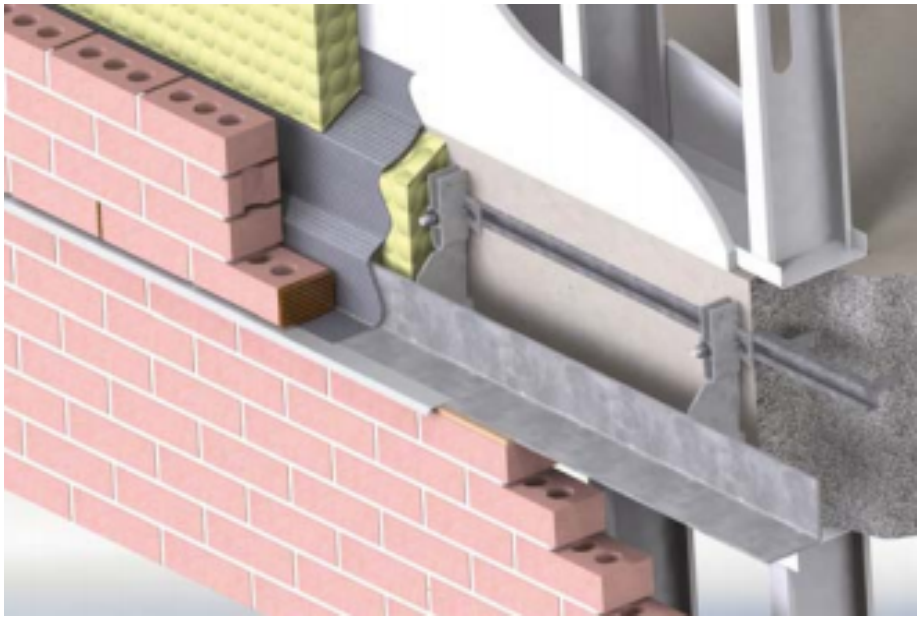






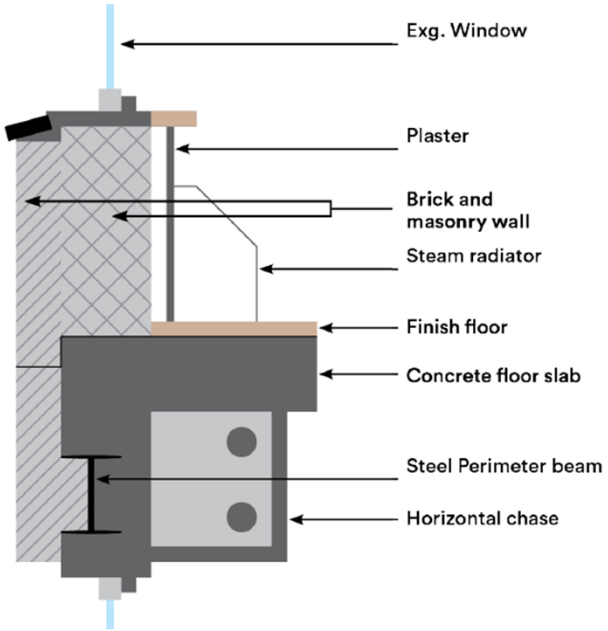
Mitigating Thermal Bridging



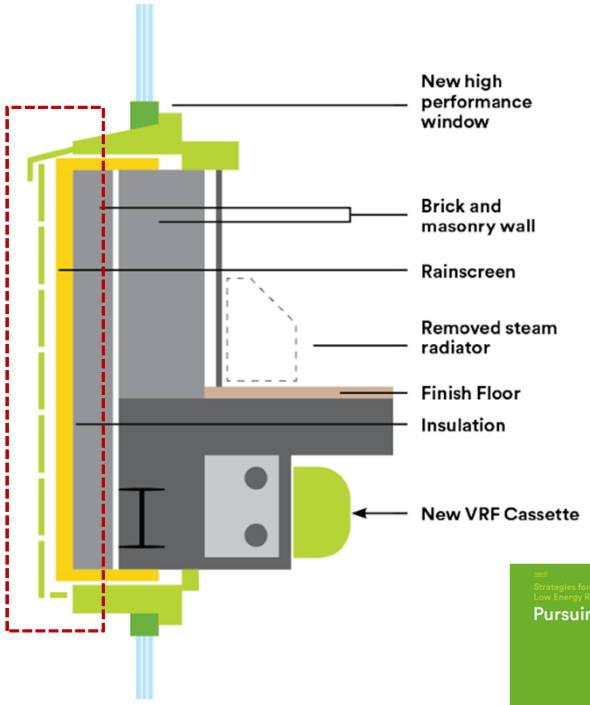


Source: Fero and Halfen

Energy Demand



Upgraded Building

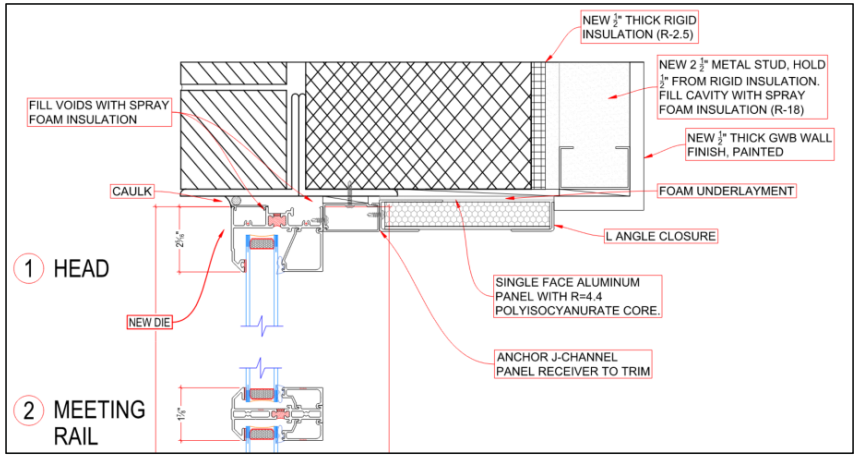




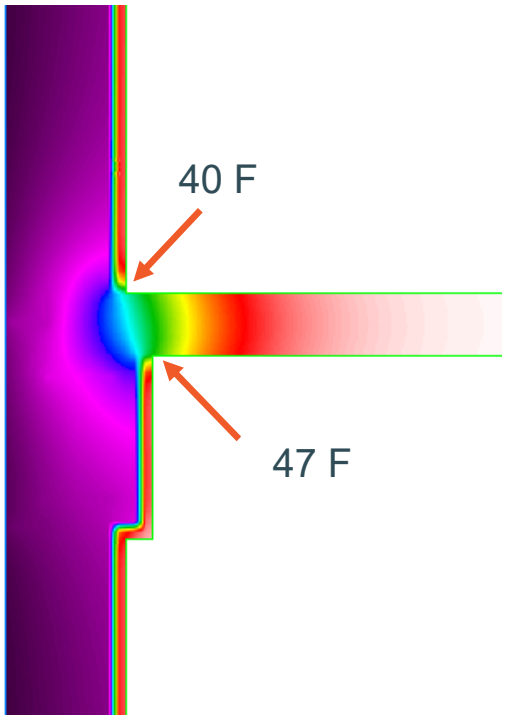
Connect air barrier/insulation to window frames



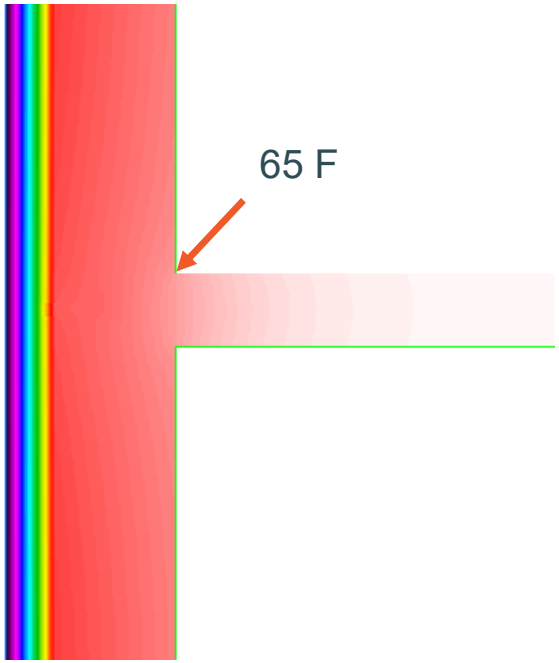




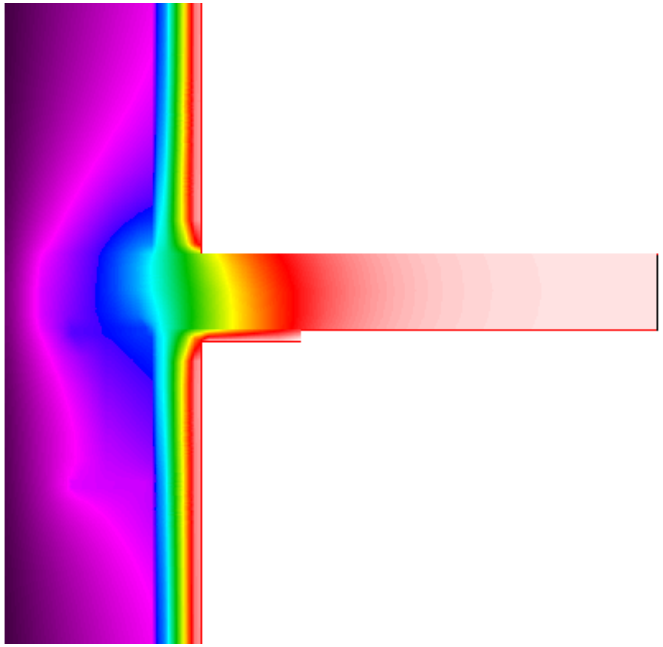
Interior Insulation

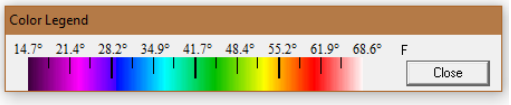


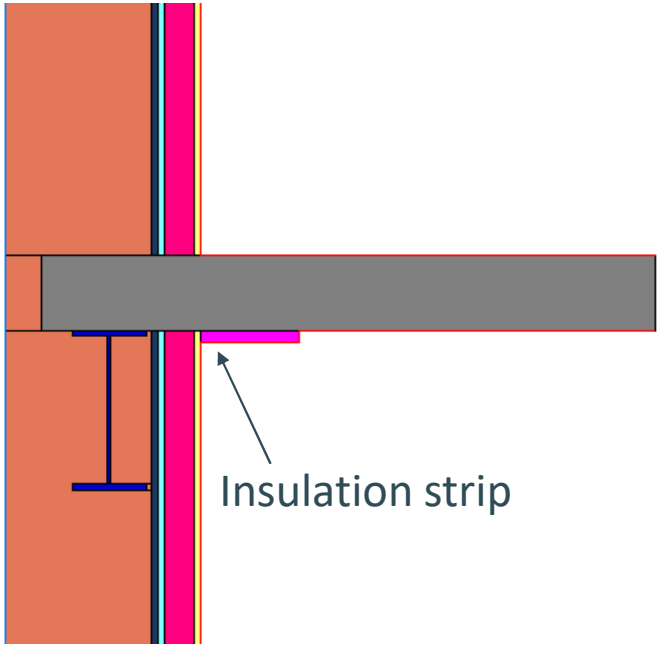
Exterior Insulation



Floors & Walls as Thermal Bridges







Floors & Walls as Thermal Bridges



Source: BLDGtyp


example project
—
23 Park Place, Brooklyn
photo: Sam McAfee e. Fentrend. 23 Park Place designed by Fete Nature Architecture, PLLC
Building Energy Exchange
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Beware Unintended Consequences

1. Blocking the flow of **thermal energy** has consequences; some good, and some bad.

2. **Drying requires energy**, so blocking the flow of thermal energy also reduces drying potential

3. Understand the mechanisms or wetting and drying. Begin with a review of **moisture management** and **air-barrier completeness**, and resolve any specific issues.

Moisture Management

- Bulk Moisture Control
- Moisture Vapor Control
- Relative Humidity and Condensation
- Vapor Retarders: What, Where, Why
- Air-barriers, infiltration, & moisture transport

Water is the enemy!



Building Enclosure Components

- Thermal Insulation:
  - Slows the transfer of thermal energy (heat)
- Air Barrier:
  - Slows the movement of air through an assembly
- Water Resistive Barrier
  - Part of the assembly that protects the enclosure from water penetration
- Drainage Plane:
  - Provides a predicable path for shedding water
- Vapor Retarder:
  - Slows the rate of vapor diffusion

Making Decisions



WUFI: Heat and Moisture Transiency

Project Name 25 WEST 4TH ST
Date 03/18/ 2019

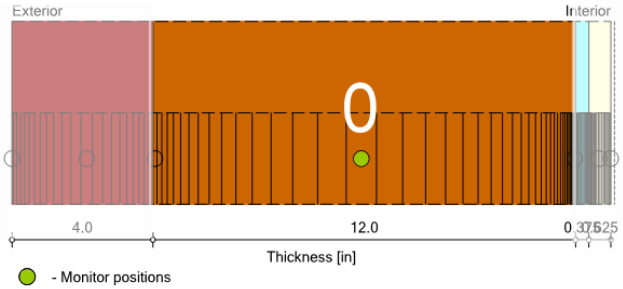
MS - 01

25 WEST 4TH_ Existing exterior wall assembly MS - 01
NO Insulation

Boundary Conditions

Exterior (left side) New York, NY; cold year

Interior (right side) 70o F with fluctuation of 5o F; and 35% RH with a 10% amplitude



Materials:

- *Buff Matt Clay Brick - old	4.0 in
- Brick (old)	12.0 in
- Air Layer 10 mm; without additional moisture capacity	0.375 in
- Interior Plaster (Gypsum Plaster)	0.625 in

Total Thickness: 17.0 in
R-Value: 6.79 h ft² °F/Btu

Temperature/ Relative Humidity @ monitor position (■ temperature/ ■ relative humidity)

the walls has a tendency to drying



Temperature/ Dew-point @ monitor position(■ temperature / ■ dew point)

the dew point temperature remains below the actual temperature in the three year period



Questions?



10 Minute Break

Reducing External Loads: Thermal Bridge Free

principle 3:
thermal bridge free construction



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Thermal Bridges

Part of the building envelope where the otherwise uniform thermal resistance is significantly reduced by:



full or partial penetration of the insulating layers by materials with a different thermal conductivity



and/or a change in thickness of the insulating layers

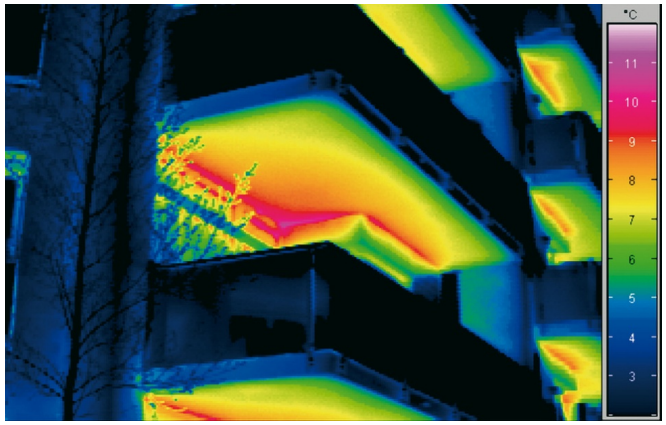


and/or
a difference between internal and external areas, such as occurs at wall/floor/ceiling junctions.

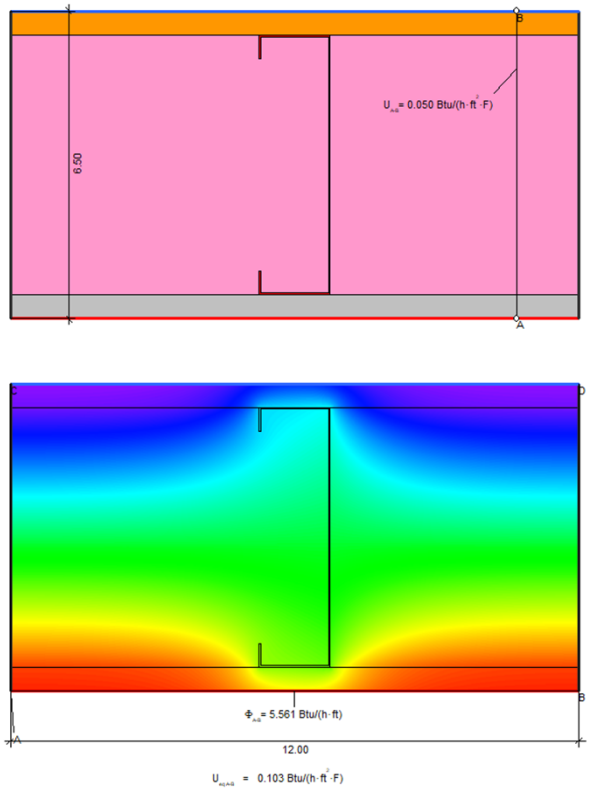
Condensation Fosters Mold



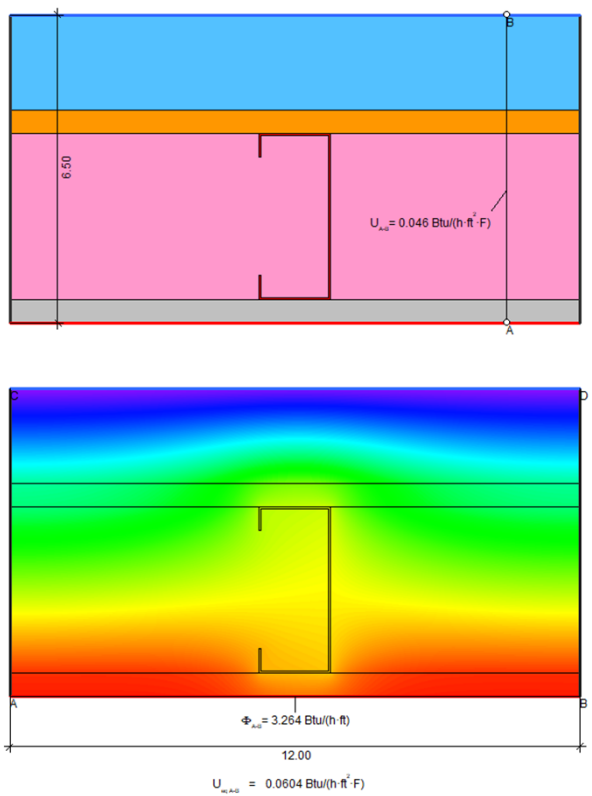




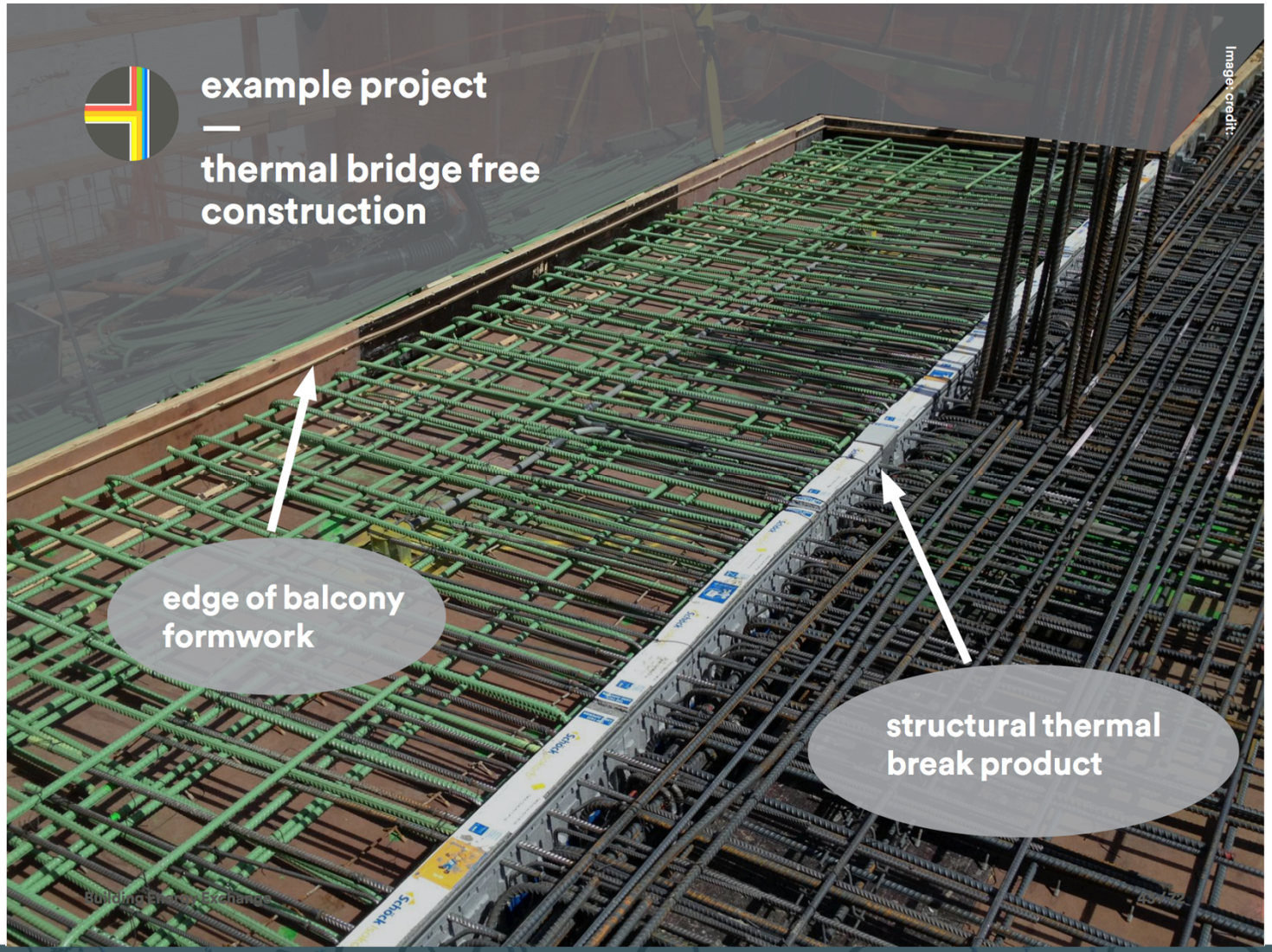
Steel stud wall, insulated cavity:
Nominal R-value: R-20.0
Actual R-value (incl. framing): R-9.7



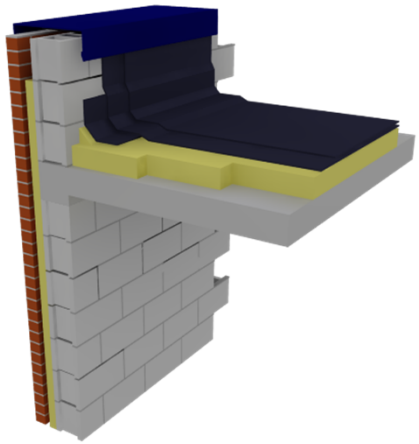
Steel stud wall + Continuous Exterior:
Nominal R-value: R-21.7
Actual R-value (incl. framing): R-16.6



Source: BLDGtyp

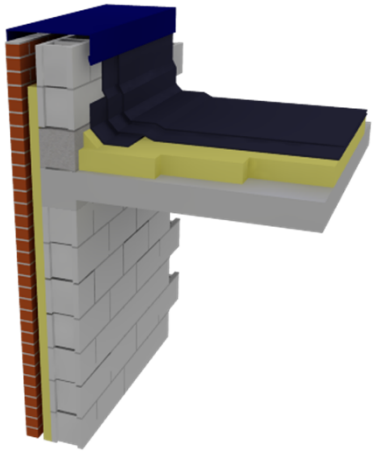

example project
—
thermal bridge free construction
edge of balcony formwork
structural thermal break product
Image credit:

Typical detail – poor thermal bridge



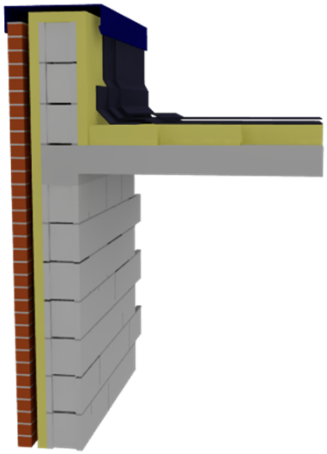
0.247 BTU/hr.ft.ºF

Option 1: Insert thermal break



0.010 BTU/hr.ft.ºF

Option 2: Wrap the parapet



0.039 BTU/hr.ft.ºF

Reducing External Loads:
High Performance Windows & Doors

principle 4:
high-performance windows and doors

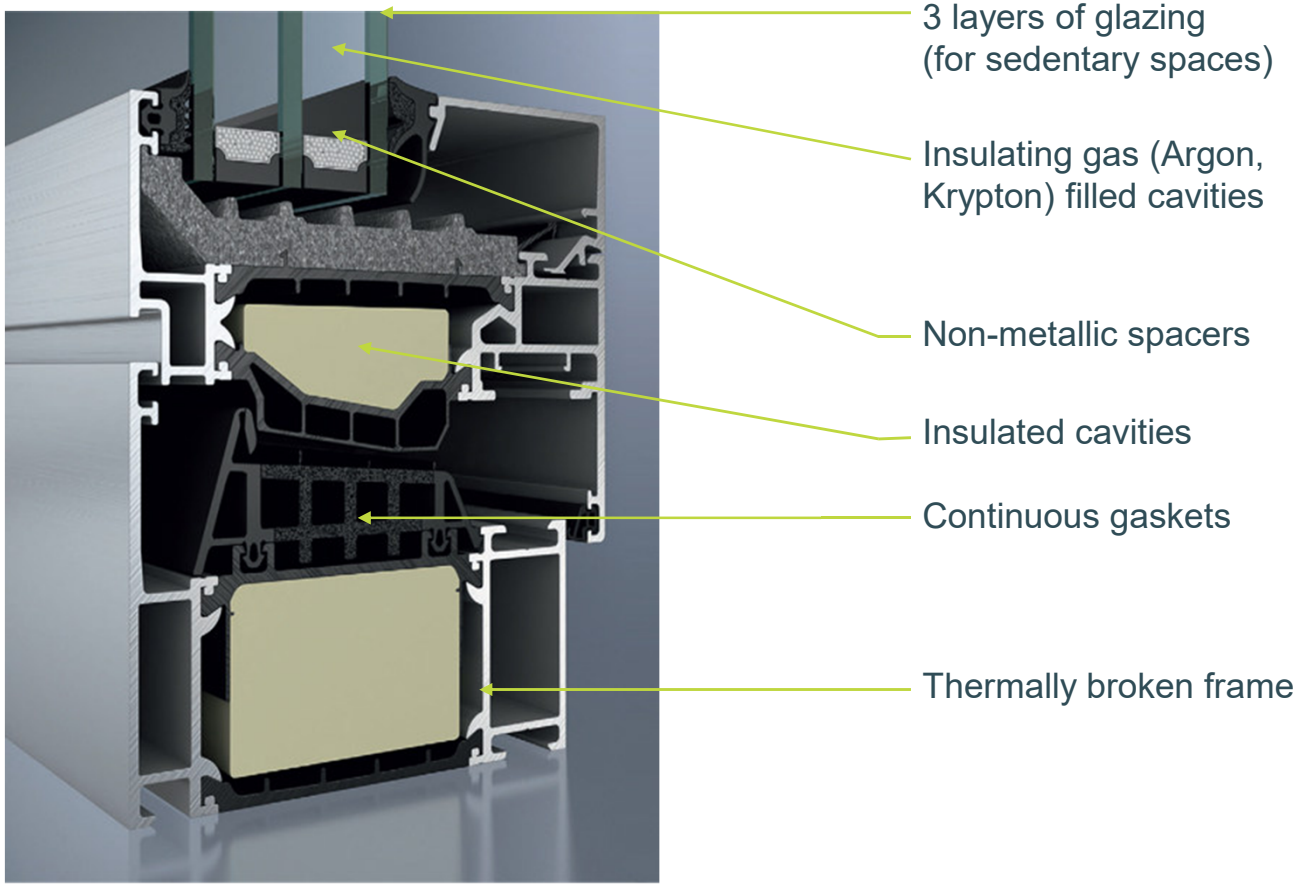


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photo: Ken Levenson, 475 High Performance Building Supply
Building Energy Exchange
475

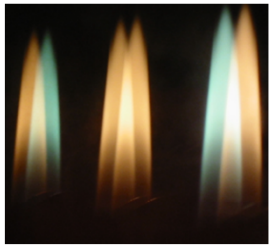
High Performance Windows

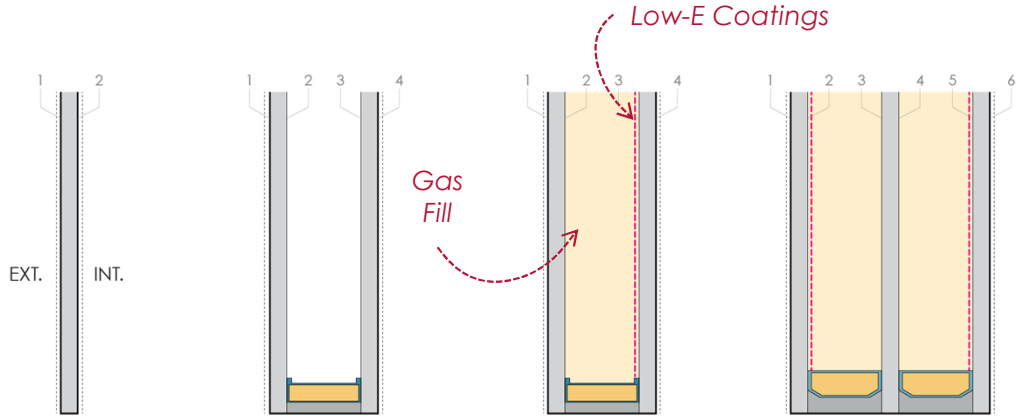


Source: Schuco AWS 90.SI+

Glazing Performance

Coating position, quick test



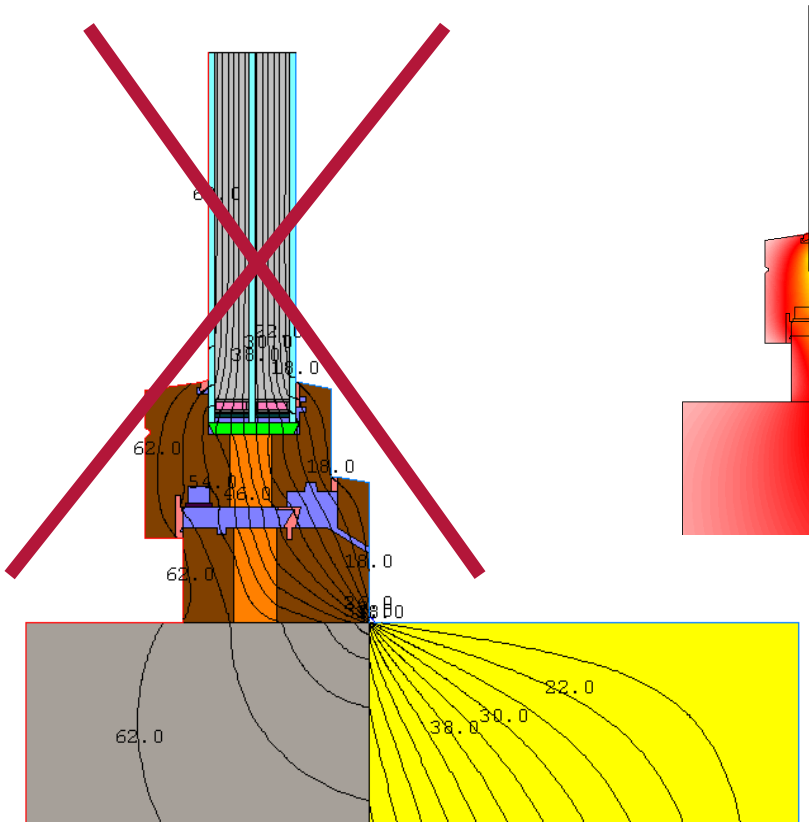


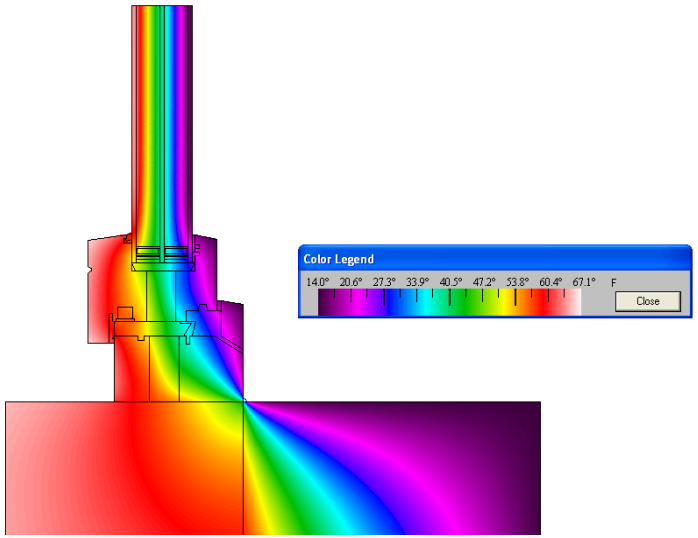
Glazing	Single	Double with air fill + Aluminum Spacers	Double Low-E with gas fill + Aluminum spacers	Triple Low-E with gas fill + Plastic Spacers
U-Value	1.00	0.50	0.18 – 0.28	0.09 – 0.14
Int. Surface Temp*	29 °F	48 °F	60 °F	64 °F
SHGC	85%	75%	50 - 70%	40 - 60%

*With Exterior at 14°F, Interior at 68°F

Source: Passipedia.org

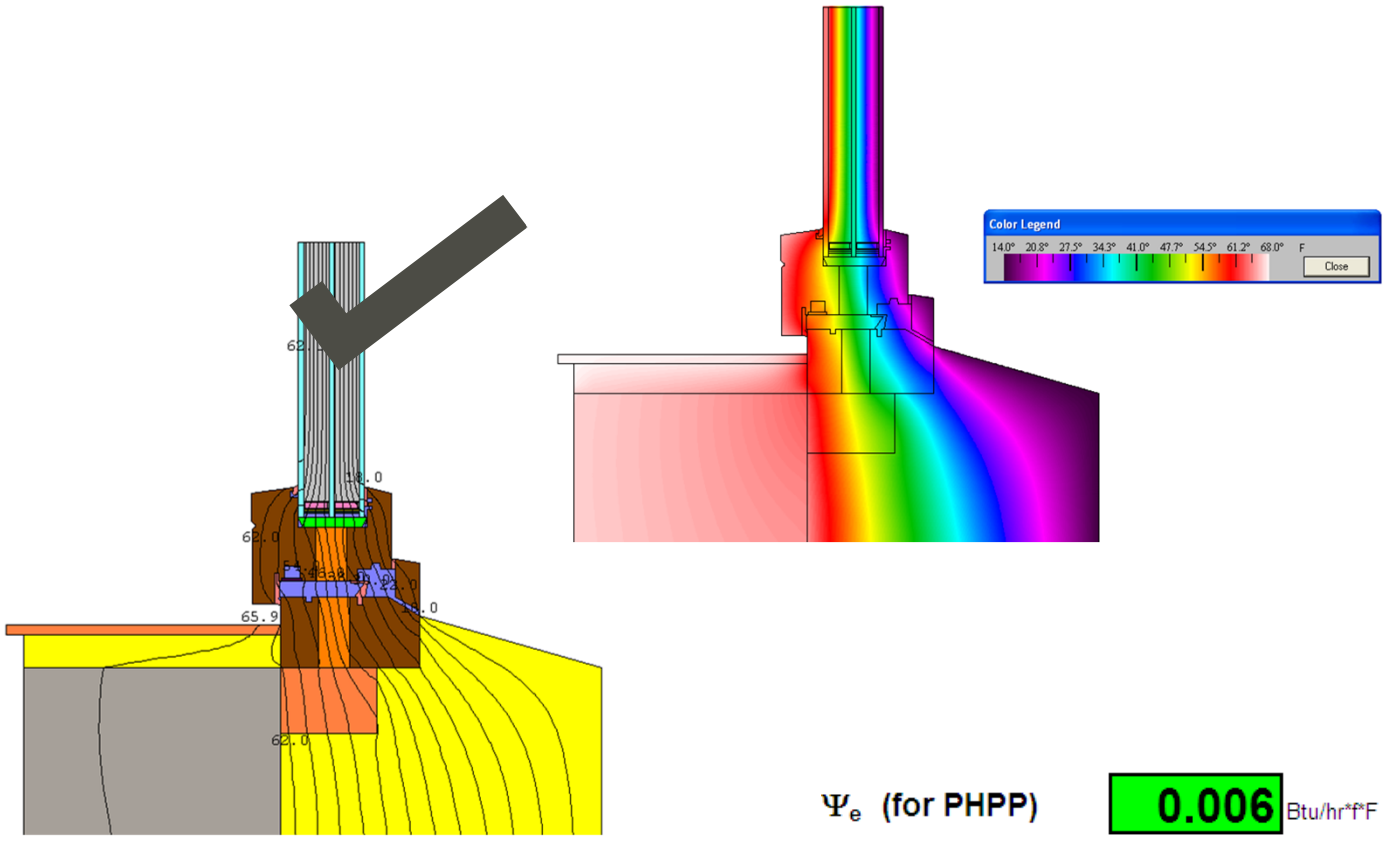
Window Position Relative to Insulation





Ψ_e (for PHPP) **0.108** Btu/hr*f*F

Window Position Relative to Insulation

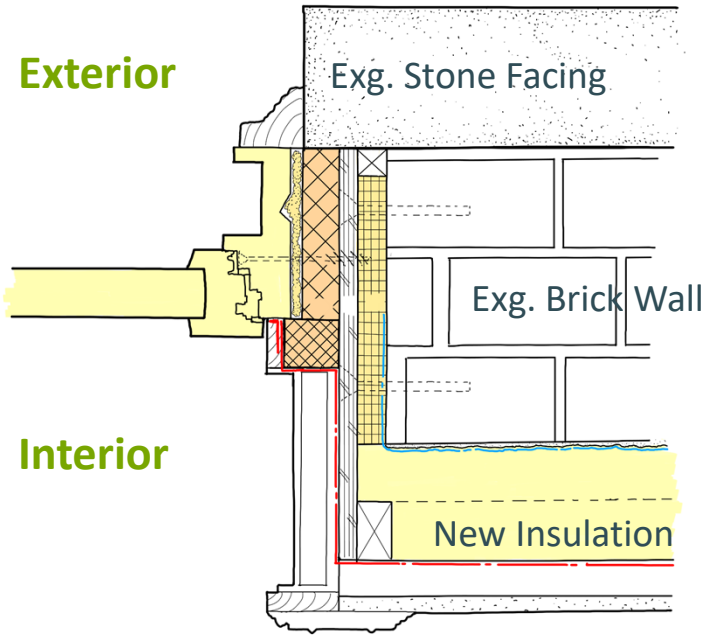


Ψ_e (for PHPP) **0.006** Btu/hr*f*F

High Performance + Historically Appropriate



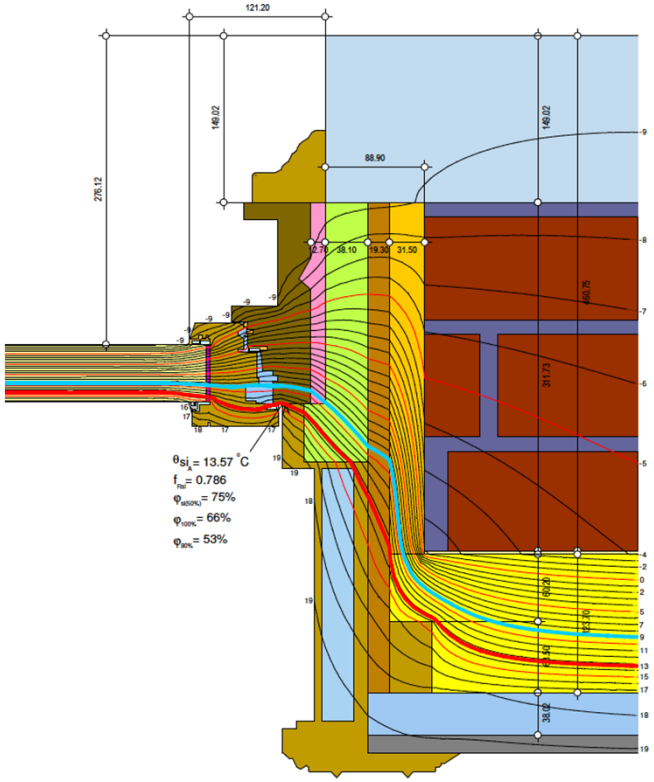
Source: BLDGtyp



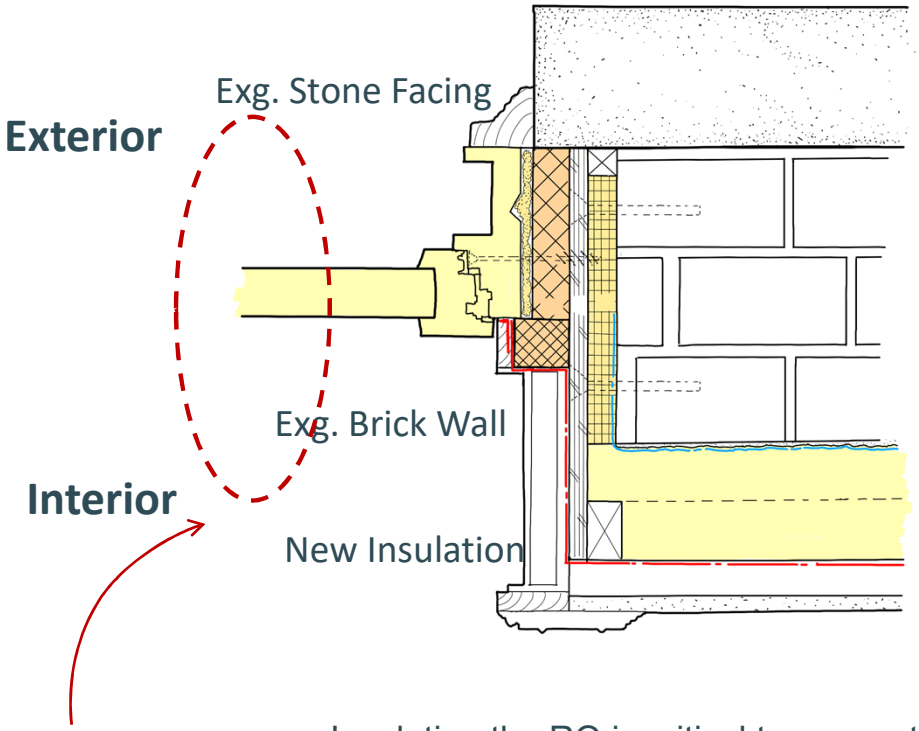
Insulating Rough Openings

Issues:

- Decrease in glazing area – light & air requirements
- Historic properties – can't change exterior look



Source: BLDGtyp



Insulating the RO is critical to connect the window to the insulation layer

High Performance Windows

Market trends - 2015

- 16 window suppliers in US
- Mostly residential
- Mostly expensive

Today



- 100+ window suppliers
- All sectors served
- All frame materials
- Regional component make up
- Wide cost options


example project
—
Kanaai Bellevue, Belgium
photo: A2M Architects
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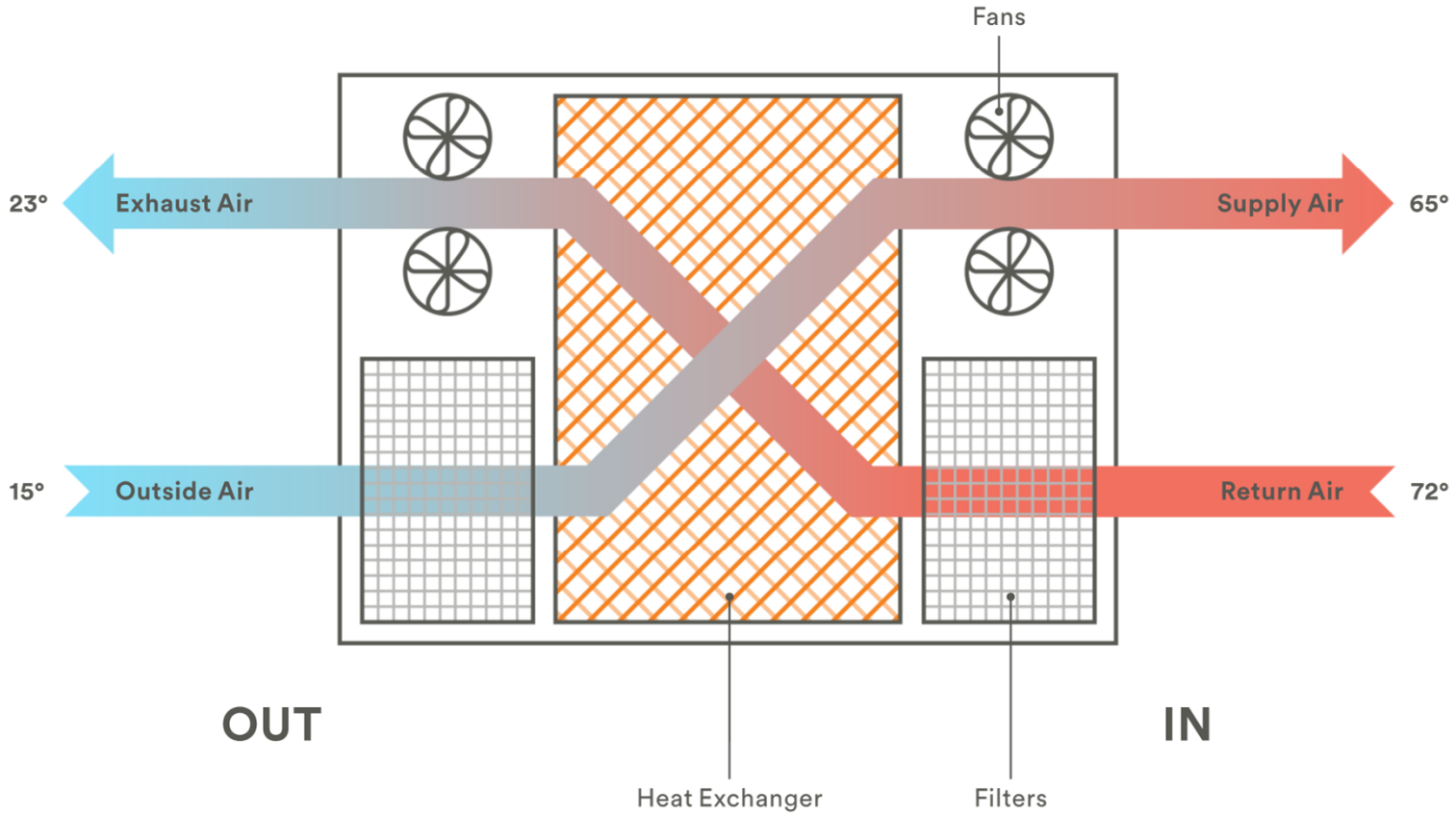
Questions?



High Performance Systems: Ventilation


principle 5:
balanced ventilation +
energy recovery
exhaust
supply
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principle 5:
balanced ventilation + energy recovery



Why Ventilate?

Pollutant	Effects
Water vapor	Below 30% RH: dryness, discomfort. Above 60% RH: Discomfort, mold/mildew growth.
Carbon Dioxide (CO_2)	Build up in poorly ventilated spaces leads to sleepiness, indicator of air quality
Dust, pollen	Often an allergen or irritant.
Volatile Organic Compounds (VOCs)	Often toxic chemicals found in paint, adhesives, cleaning products That “new car smell” can give you cancer
Carbon Monoxide (CO)	A product of combustion (furnaces, boilers, etc.) 100 ppm = headaches, 800 ppm = severe effects Over 1,600 ppm is fatal after 2 hours.
Radon	Natural, regional problem that can lead to cancer

Moist indoor air leaking out through cracks encounters cold surfaces, and the moisture condenses





Condensation may even occur on cold interior surfaces if the assembly is poorly insulated. (even if at just one point)

Material Selection

Construction materials have major health impacts

- Avoid “red list” materials (put the onus on the vendors)
- Specify recycled materials (countertops made from waste glass)
- Specify rapidly renewable materials (Bamboo rather than hardwoods)
- Reduce construction waste, divert from landfill



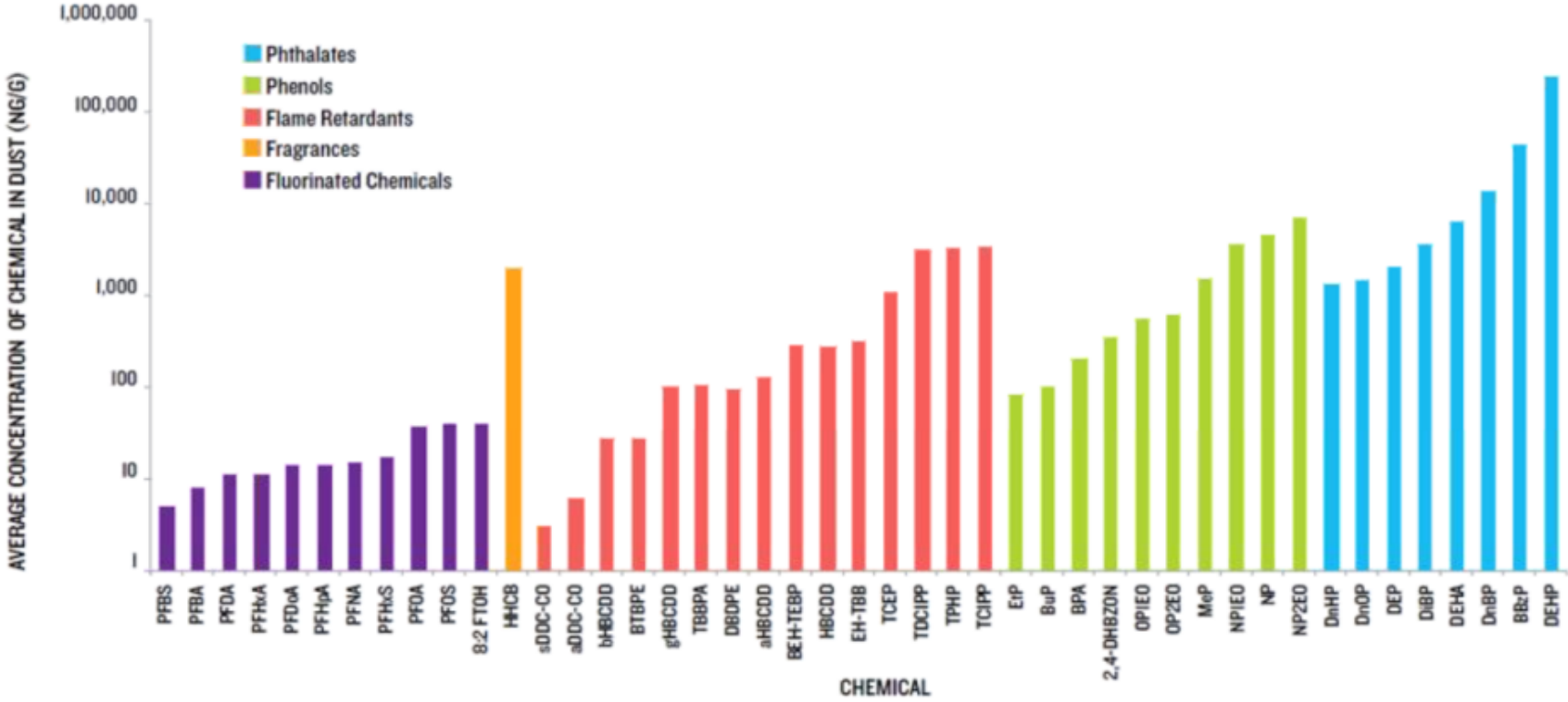
Source: Havelock Wool Insulation

Avoid Chemicals of Concern

- Asbestos
- Cadmium
- Chlorinated Polyethylene & Chlorosulfonated Polyethlene
- Chlorofluorocarbons (CFCs)
- Chloroprene (Neoprene)
- Formaldehyde (added)
- Halogenated Flame Retardants
- Hydrochlorofluorocarbons (HCFCs)
- Lead (added)
- Mercury
- Petrochemical Fertilizers and Pesticides
- Phthalates
- Polyvinyl Chloride (PVC)
- Wood treatments with Creosote, Arsenic or Pentachlorophenol

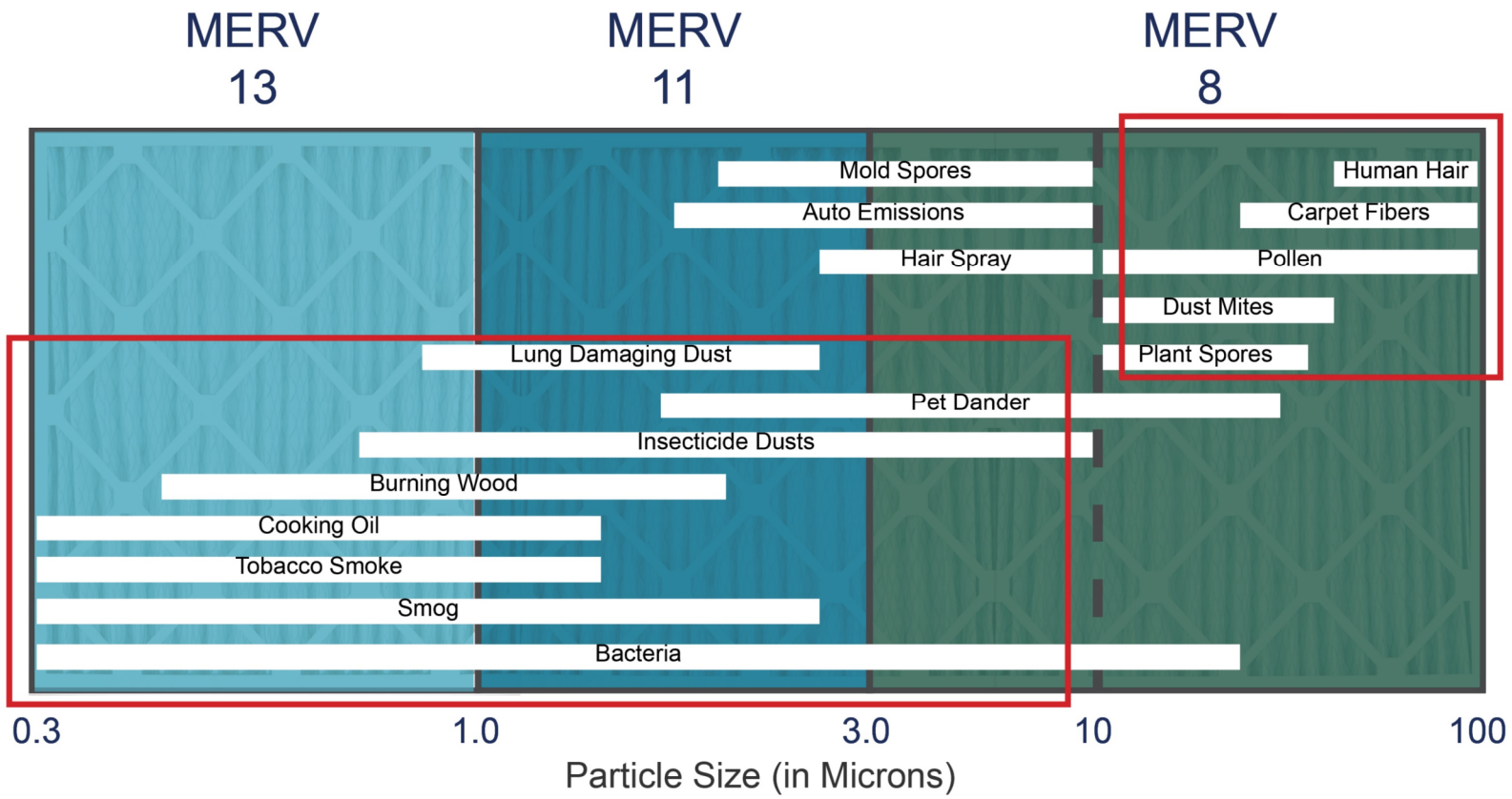


Dust is Not Just Dirt



Average (geometric mean) dust levels in nanograms of chemical per gram of dust for the 45 chemicals reported in at least three data sets. The average concentration of DEHP is about 45,000 times higher than PFBS.

Solutions


MERV 13
MERV 11
MERV 8
Mold Spores
Auto Emissions
Hair Spray
Lung Damaging Dust
Pet Dander
Insecticide Dusts
Burning Wood
Cooking Oil
Tobacco Smoke
Smog
Bacteria
Human Hair
Carpet Fibers
Pollen
Dust Mites
Plant Spores
0.3
1.0
3.0
10
100
Particle Size (in Microns)

Ventilation Systems

None
- Common in small buildings
- Relies on operable windows

Exhaust only
- Typical for most small to medium buildings
- Air extracted from baths, kitchens
- Relies on exterior infiltration
- Depressurizes building

Supply only
- Uncommon
- Fresh air to living spaces only
- Pressurizes building, increases exfiltration

Balanced
- Equal amounts of supply & exhaust
- Minimal reliance on infiltration
- Pressure balanced

Balanced with Heat Recovery
- Best of all
- Optimal for high performance buildings/retrofits
- Relies on tight envelope
- Energy and health outcomes improved

Ventilation Operations

Intermittent

- Fans activated by occupancy/event (cooking, showering)
- Often on countdown timer

Cycling

- Fans cycle on/off on a timer
- Higher flow rate leads to larger ductwork
- Not recommended for high performance projects

Oscillating

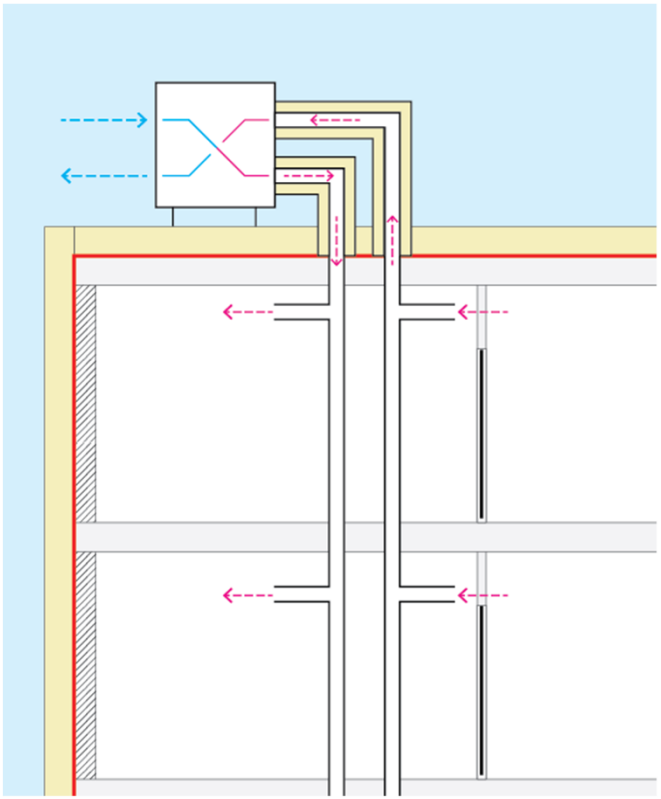
- Fans (in pairs) alternate air flow according to timer
- Can include regenerative heat recovery

Continuous

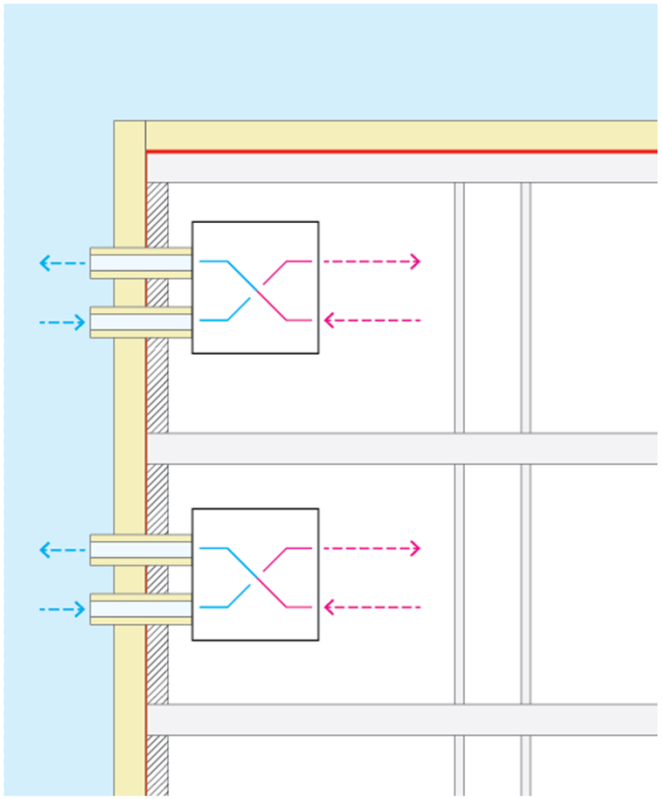
- Fans run continuously at variable speeds
- Lower duct size
- Optimal for high performance


energy recovery ventilation
—
strategies & components
photo: Curtis + Giinsberg Architects; Beach Green Dune Apartments
photo: Shoeck
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Centralized:
One main ventilator unit for the entire building



Decentralized:
Multiple ventilators distributed throughout the building



Source: BLDGtyp: Candela Lofts

Ventilation Controls are Critical

Controls will be based on use.

Recommend:

- Occupancy controls (common areas/lobbies)
- Timers for offices
- CO2/humidity sensors for active spaces & assembly rooms w/ high occupancy periods

Ventilation Controls are Critical

- ASHRAE 62.1Flow Rates are based on max capacity, too high during normal operation
- Controls should be based on use
- Recommend:
  - Occupancy controls (common areas/lobbies)
  - Timers for offices
  - CO2/humidity sensors for active spaces & assembly rooms w/ high occupancy periods

Retrofit Context – Savings Estimation

- Energy audit measurements of air flow rates at a sampling of grilles and rooftop fans
  - **Measurements at grilles show airflow serving unit**
- Measurement at roof shows total airflow for riser, including leakage



Retrofit Context – Construction Phase



- Scope the existing system, look for holes, blockages, problems
- Clean the ductwork
- Aeroseal, balance
- Replace roof fans with ECM/adjustable



Duct Tightness

- Clean the risers first
- Mastic is not enough in large systems
- Aeroseal gets leakage down
- Duct-to-interior wall transitions must be sealed

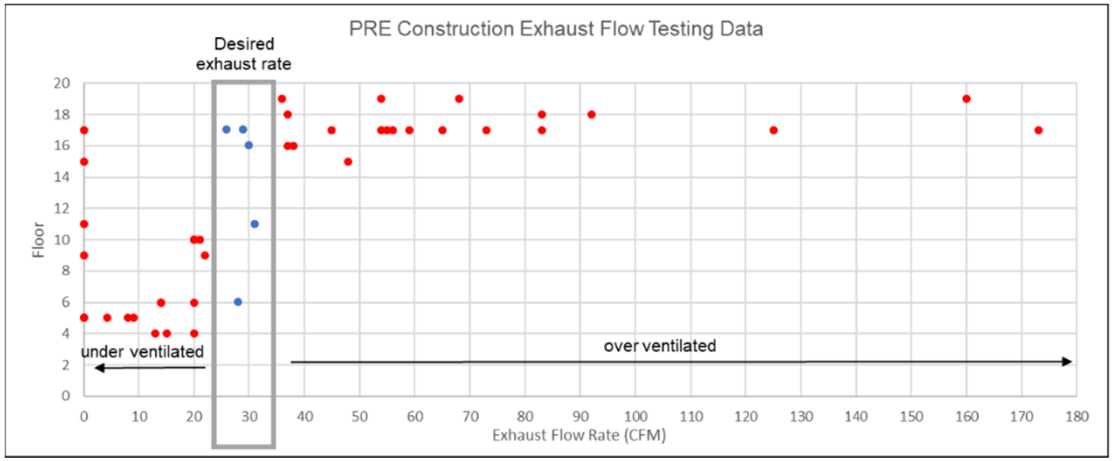
Ventilation Balancing

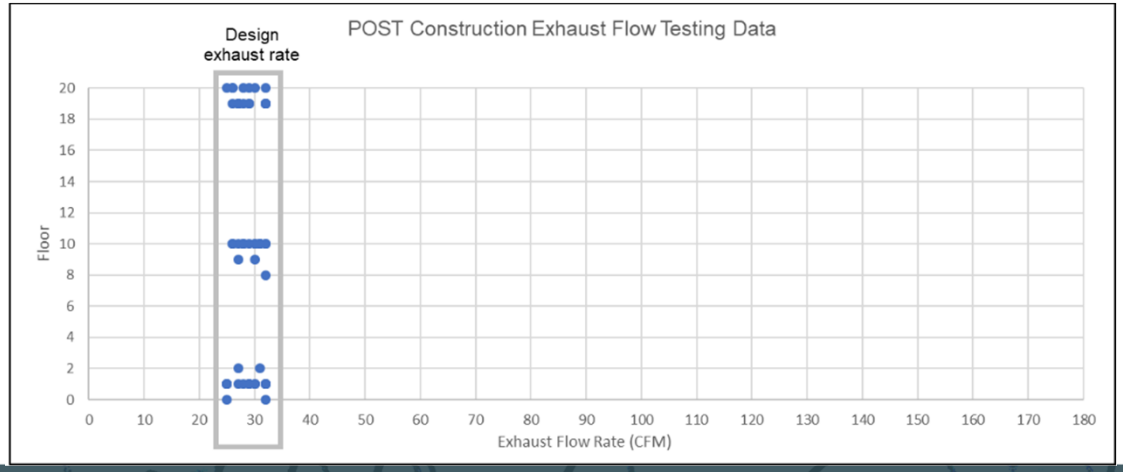
Two critical components needed:

1. CAR dampers auto-balance
   - Tall buildings see stack effect
   - All buildings see seasonal pressure changes
   - Windy days push/pull
2. Superior duct air sealing
   - Mastic is not enough in large systems
   - Aeroseal gets leakage down
   - Duct-to-interior wall transitions must be sealed



Case Study: 300 Unit Occupied Residence





High Performance Systems: Heating

Maximize Heating & Cooling System Efficiency

- Design for reduced fan and pump energy
- Favor water/refrigerant over air systems
- Separate ventilation from heating/cooling
- Select high efficiency fans and pumps
- Utilize variable flow/speed controls



Directive 1B-2: Background



- In the case of insufficient project funding, the design goal will be to design the building as NZC “capable” where: the design achieves the energy use intensity (EUI) limit using HVAC equipment and systems that can be electrically powered from renewable energy sources.
- **Note**: Heat pumps are not renewable resources

Takeaway – electrification is desired therefore heat pumps for heating/cooling & DHW are recommended

Resnick Engineering Hall

Heating + Cooling Options

	Hydronic		VRF	
Type	Boiler/Cooling Tower + Radiant panels	Water Source Heat Pump	Air Cooled Heat Pump	Water Cooled Heat Pump
EER	3	14	11-14	15
First Cost	$$$$	$$$$	$$$	$$$$$
Maintenance cost	$$	$	$$$	$$$$





Terminology

Air-Source

Takes heat from air, pushes it into air or water. Commonly moves heat in/out of a building.

Water-Source

Terminal units take heat from (and rejects heat to) a water loop in the building. Moves heat around a building.

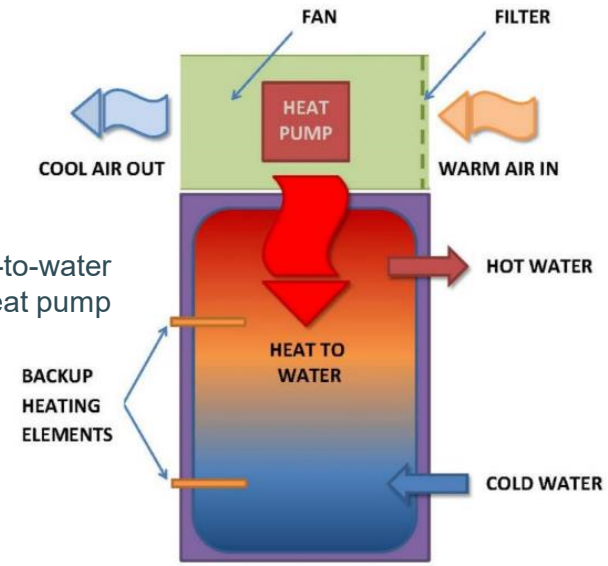
Ground-Source

Takes heat from (and rejects heat to) the ground via a water loop. Moves heat in/out of a building.

Inverter, inverter-driven

Variable-speed compressor.

Smart Electrification: Air Source Heat Pump 101



Example air-to-water heat pump



Example air-to-air heat pump

- Heat is harvested from air or water and pushed into air or water
- Electric compressors and valves move heat-laden refrigerant from one place to another
- Refrigerant is evaporated and condensed to absorb and release heat

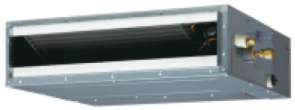
Terminology

Mini-Split

Split and mini (<1.5 tons or so)

Ducted (compact) or Ductless

Usually 1:1



OR







Terminology

Multi-Split (multi-port, multi-zone, not VRF)

- One outdoor unit
- 2+ indoor units
- Ducted, Ductless, or mix
- 1.5 – 4 tons typ.



Images from Mitsubishi

Terminology

VRF (variable refrigerant flow)

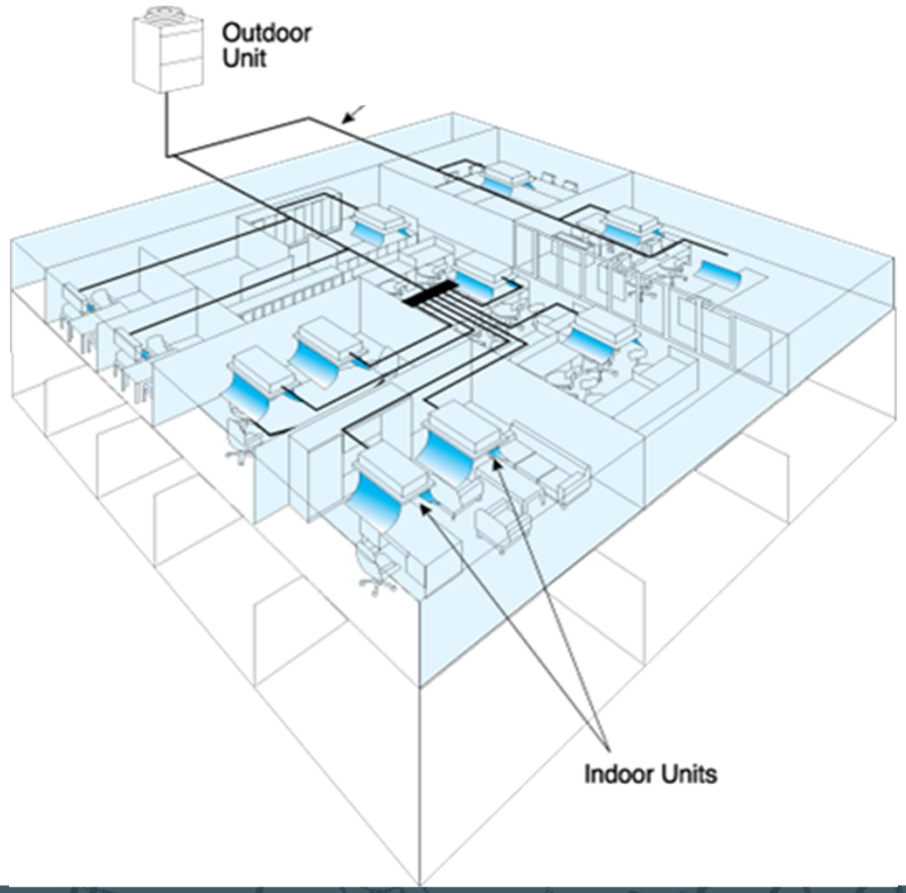
- Modular outdoor units, ~6-12 tons typ.
- Many indoor units, many types
- Exp. valves at indoor fan coils





Images from Mitsubishi

VRF



Performance

+ Heat recovery option allows for simultaneous heating and cooling

Design

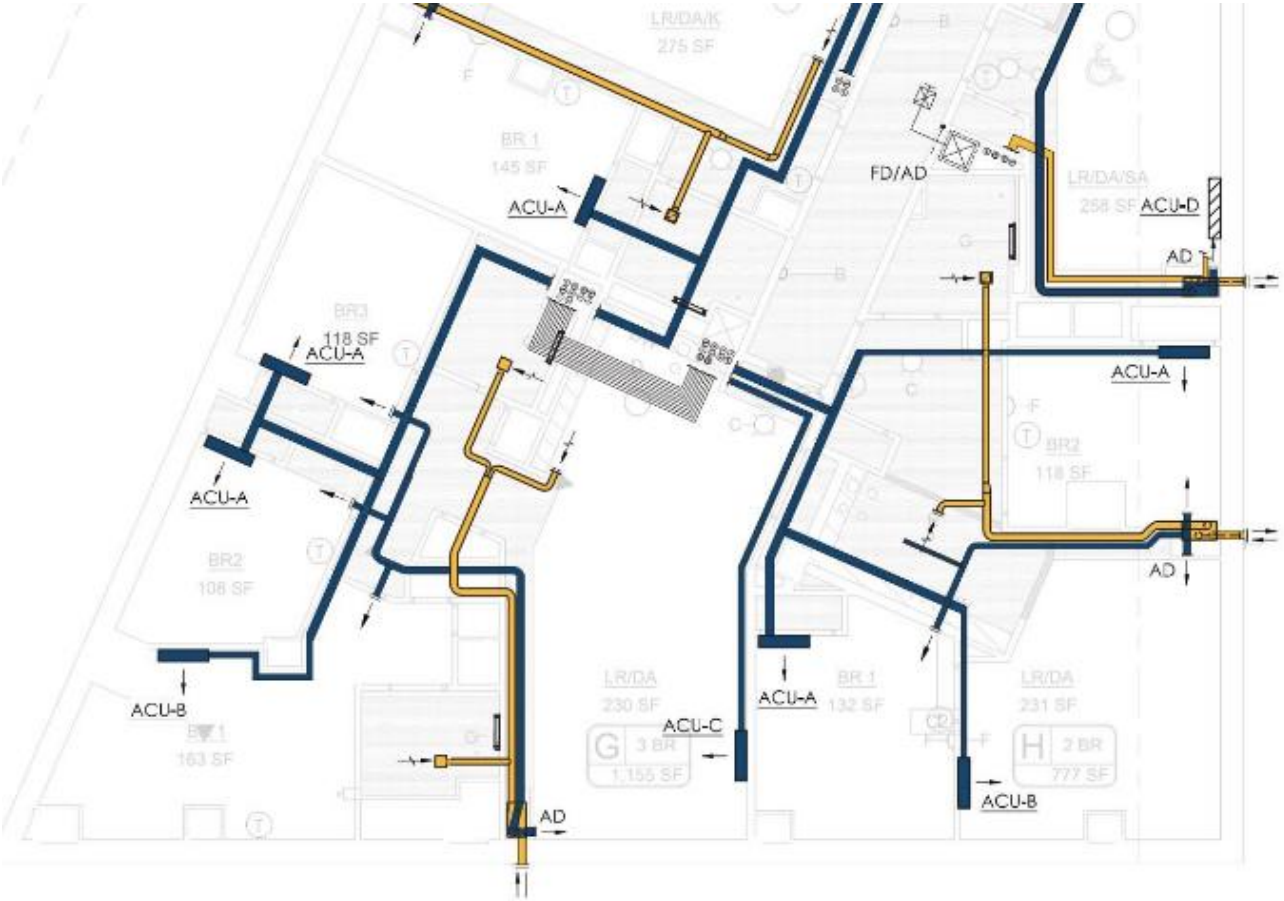
- Extra piping required

<u>Wall Units</u>

+ No additional ceiling space required
- Additional power for individual unit per room one unit per room

<u>Ducted Units</u>

- Requires additional ceiling space
- Required sealing of ducts



Issues

- Higher cost
- Smallest unit 4,500 BTU, could really use a 2,000 BTU unit
- How you have tenants pay for cooling and owner pay for heating?
- Changing filters

Heating Upgrades
Best: Heat Pump Considerations

- Refrigerant volume limits
- Unique operations & maintenance
- Refrigeration management
- Familiarity of staff w/ codes
- Cost of heat recovery
- Height of runs to condensers
- Minimum Capacity

Centralized VRF Schematic



Practical Retrofit Considerations

Unitary

- Need to locate outdoor units
- More total refrigerant/condensate lines, but smaller systems. Easier to run soft tubing line sets out to a unitary ODU on a balcony.
- More installers and servicers available

Central

- Fewer outdoor units needed
- Consolidated refrigerant lines, but greater refrigerant volume. Vertical risers with braised or press fit piping, more invasive installation work
- Requires more Cx and oversight

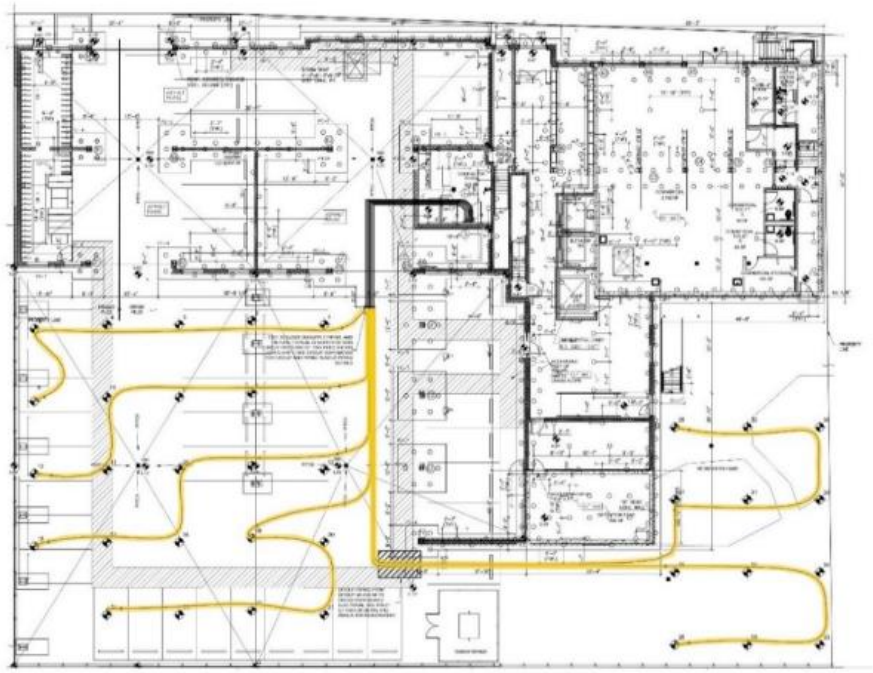
Why low temp?

- Heat pumps have limited operating ranges and efficient ranges
  - Refrigerant is a big limiter
- Assume <110F water produced on the coldest days



AERMEC NRK AIR TO WATER HEAT PUMP (OUTDOOR UNIT)

Low Temp Hydronic / Water Source Heat Pump



Performance

+ Low temperature heating water = minimal distribution loss, more efficient central plant options
- Pumping energy for water loops

Design

+ Flexibility in terminal units (floor units, ceiling mounted, vertical units in cabinets)
+ No chiller required, cooling tower only
+ Simultaneous heating and cooling



Ground Source Heat Pumps

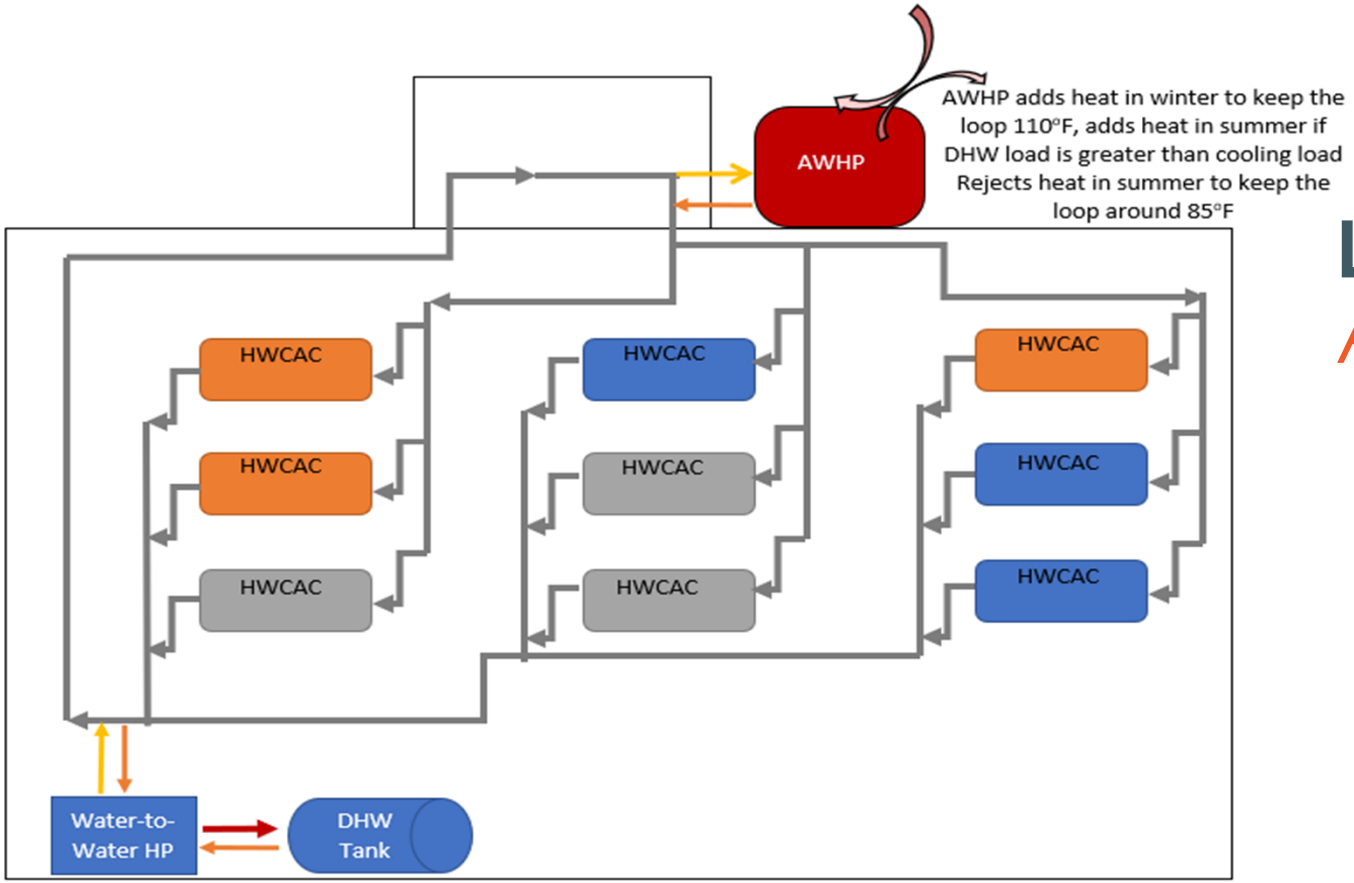
- Potential source for high efficiency heating and cooling
- Ground is typically consistent temperature
- Can be with electric heat pump or gas (rare)

Low Temperature Hydronic Architecture

- *What can and what should be done today for future-proofing*
- Hydronic loop heated by air-to-water heat pumps (AWHPs)
- Terminal units accepting low/moderate temperature ranges (above 70F for cooling, below 110F for heating)
- Heat rejection either accomplished by AWHPs or by cooling tower

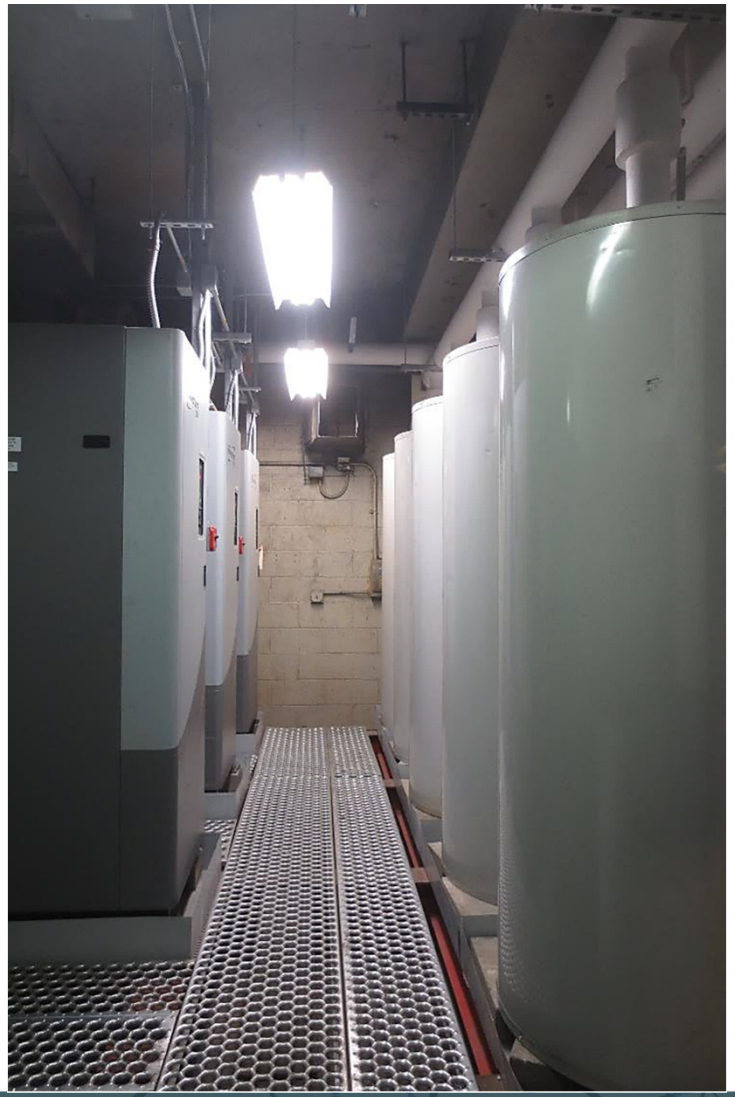


Low Temp Architecture



Future - compatible

- A low temp loop can be heated well by a condensing boiler today
- Selecting low-temp terminal units and leaving futures for AWHP connections makes it “easy” to electrify later
- Roof space
- Plumbing chases
- Futures and valves
- Electrical capacity where possible



Central Plants in NYS

- There are at least 20 central plants serving district systems in NY, most are at colleges/universities
- Goals: **heat recovery** across multiple building types, electrification
- Typical process: study loads, evaluate remaining lifetime for major equipment, reduce loads, get off steam, move towards lower operating temperatures, improve plant efficiency, bring in renewables

SUNY New Paltz

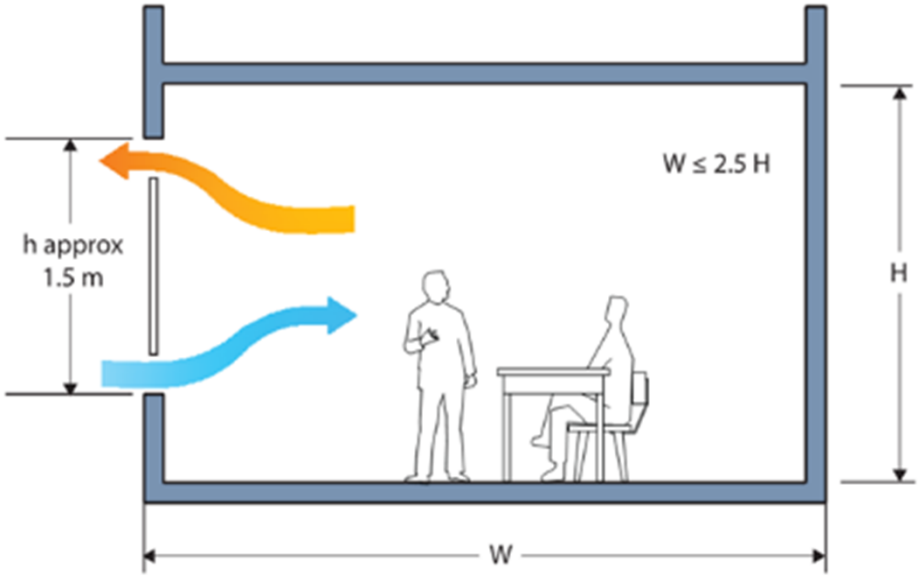
- Develop a long term plan
  - Leverage district loop?
  - Building systems conversions?
  - Addition of geothermal system?
  - Role of renewables and heat recovery?



10 Minute Break

High Performance Systems: Cooling

Passive Cooling
Take advantage of natural ventilation



- Study stack effect potential
- Consider security, outdoor air quality, noise
- Ensure occupants will manage systems

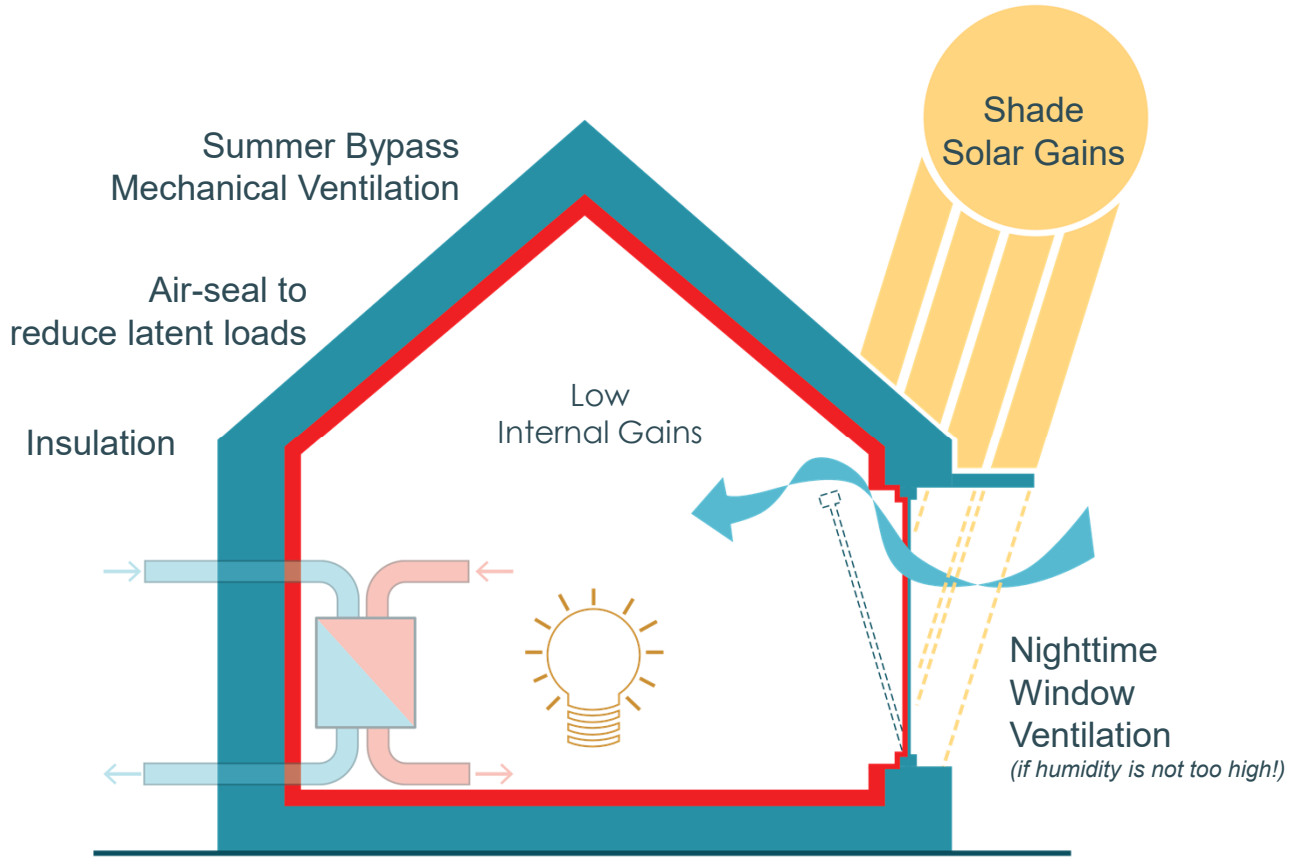
Peak Cooling Load



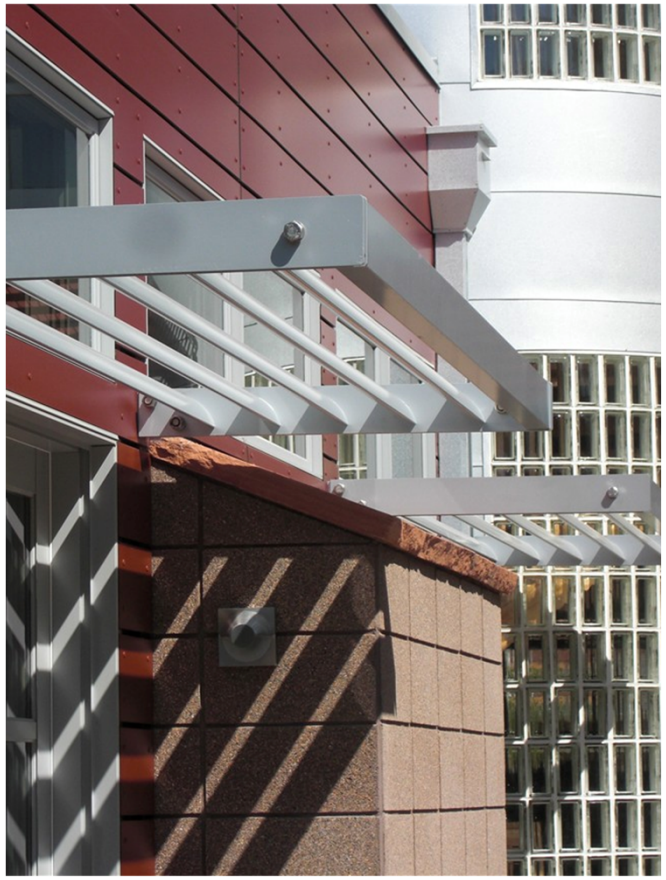
For cooling, the design process is similar to that for heating, but with more focus on:

- Window size and orientation
- Shading requirements
- Operable window ventilation
- Humidity control

Peak Sensible & Latent Cooling Loads



Sensible Cooling ($P_{C\text{-}SENSIBLE}$)



When possible, take advantage of passive cooling techniques:

Shading (outside of the glass is by far the best). May be movable, or fixed (but check influence on heating demand, too!)

Natural ventilation – including night-flush ventilation

Internal heat gain reduction (esp. lights)

Thermal mass

Moisture Sources



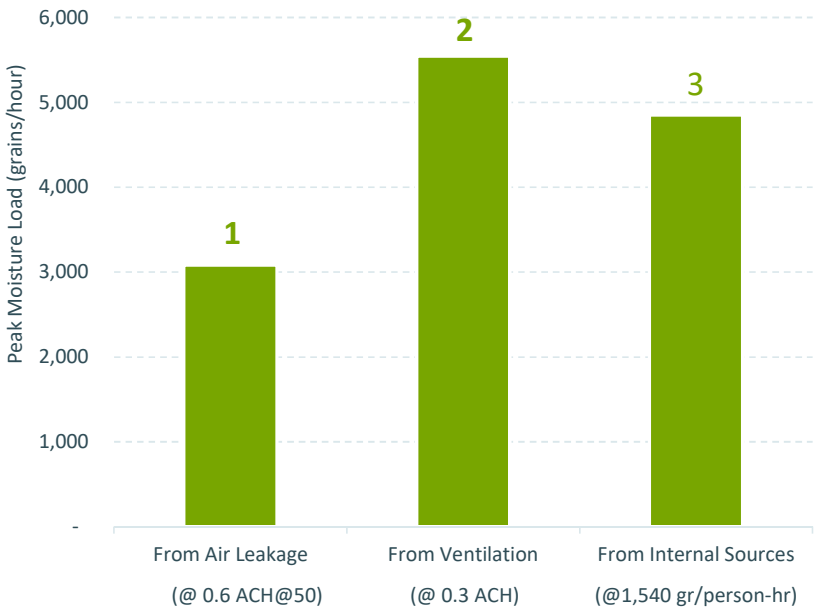
Moisture Sources considered in Peak Cooling Load Calculation:

1. **Unintentional Infiltration**
   Air leaks in the building envelope
   Window and door operation

2. **Intentional Ventilation**
   HRV / ERV / Enthalpy wheel
   Natural ventilation

3. **Internally Generated**
   Cooking
   Showering/bathing
   House plants
   Human activity
   Clothes washing/drying
   Dishwashing

Managing Moisture Loads -
Focus on each source of moisture



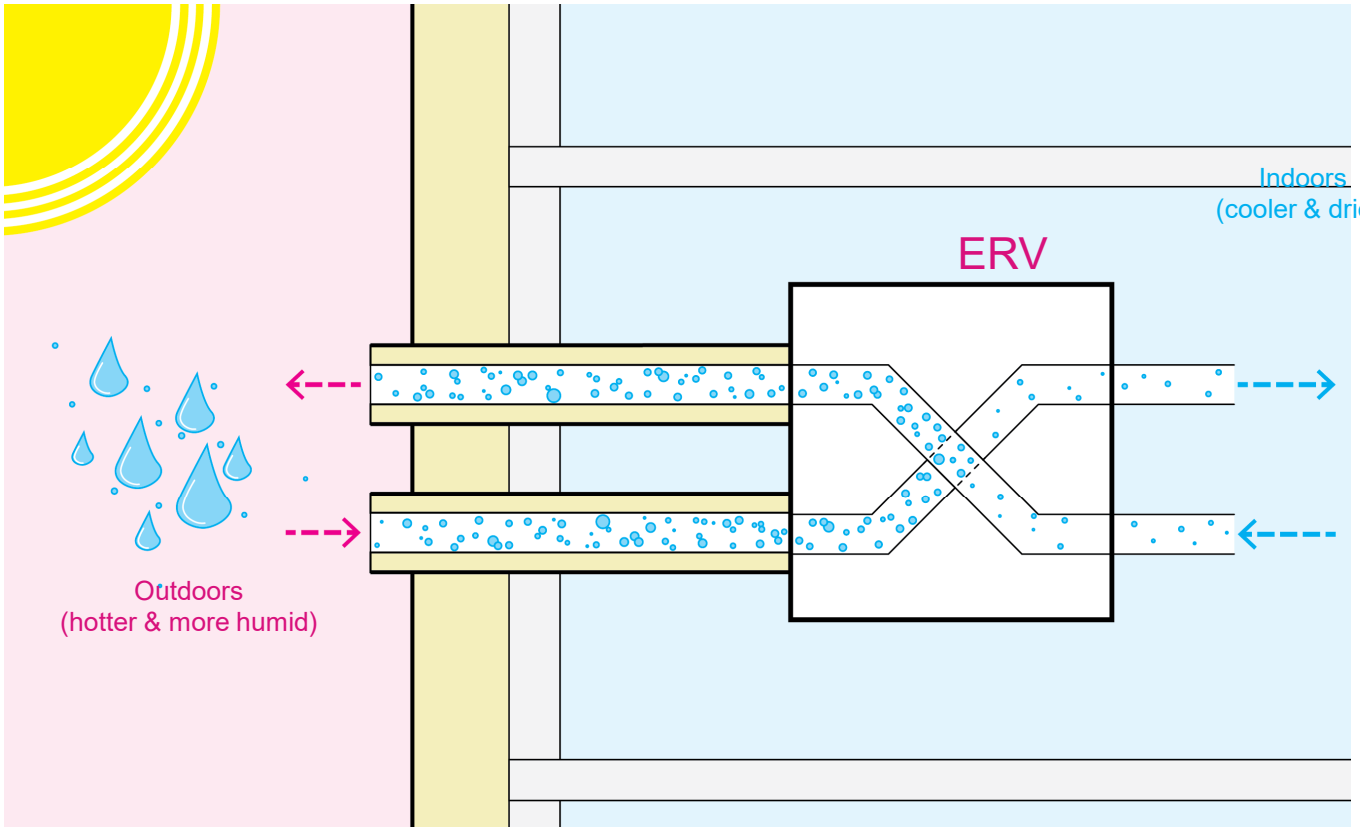
BDGTYP: Mayers House. 2016

Mitigation strategies

1. Make building more airtight
2. ERV with high efficiency recovery
3. Simply must accommodate

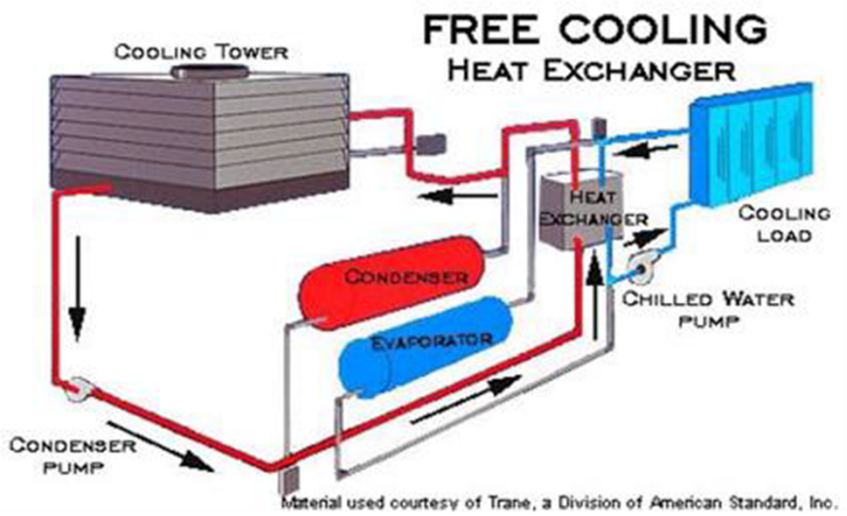
- Climate determines moisture
- Efficient cooling equipment critical
- Proper sizing critical! (Oversized cooling eq. poor at removing humidity)

ERV & Humidity



Note: the reverse of this process is also true which is why in winter an ERV can help to maintain higher indoor RH levels even when the outdoor air is low RH.

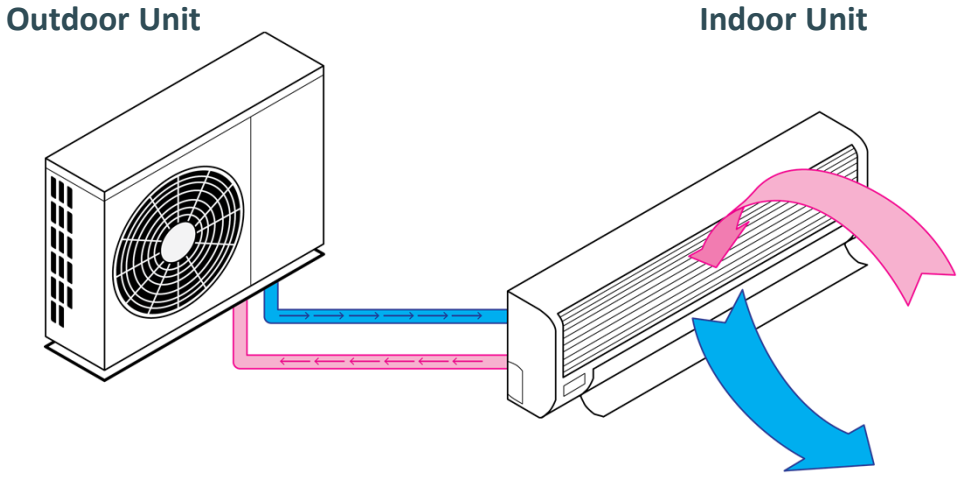
Free Cooling



Take advantage of low outdoor temps

- Match to cooling dominated occupancies
- Air- and Water-side economizers

Heat Pump Heating + Cooling



Can be used for **heating and cooling**, for many types of buildings. They do not GENERATE heat, but instead use the refrigeration cycle to MOVE (pump) heat.

- Very efficient
- Multiple /Variable capacities
- Single and multi-zone
- Can dehumidify in summer
- Usually run on electricity

High Performance Systems: DHW



Electrifying DHW

- Efficient electric DHW is analogous to heat pump heating – it is NOT just a replacement of a gas boiler with an electric one.
  - This section touches on many differences

Heat Pumps – Smaller Scale / Indoor Systems







- Many indoor options readily available in US market
- Must get the design right!









Large Scale / Outdoor HPWH

- Commercial grade for modular engineered solutions
- Little to no market penetration in the USA in multifamily
- Widely used in Asia and Europe for DHW
- In USA, used in commercial/industrial applications

Large Scale HPWH

Down to -4F R-410A Up to 150F	Down to 40F R-410A Up to 150F	Ambient Temp Refrigerant Max H_2O Supply	Down to 10F R-410A Up to 150F	Down to 14F R-744 Up to 194F
				

Other Challenges

- Finding space outdoors
- Very few outdoor use options in the US market today (Sanden's 15 MBH only CO2)
- Balance of system upgrades required
  - Electrical service to roof, plumbing penetrations/ties ins, pumps
- Potential rooftop installation trouble with larger units – small halls, door openings + large components

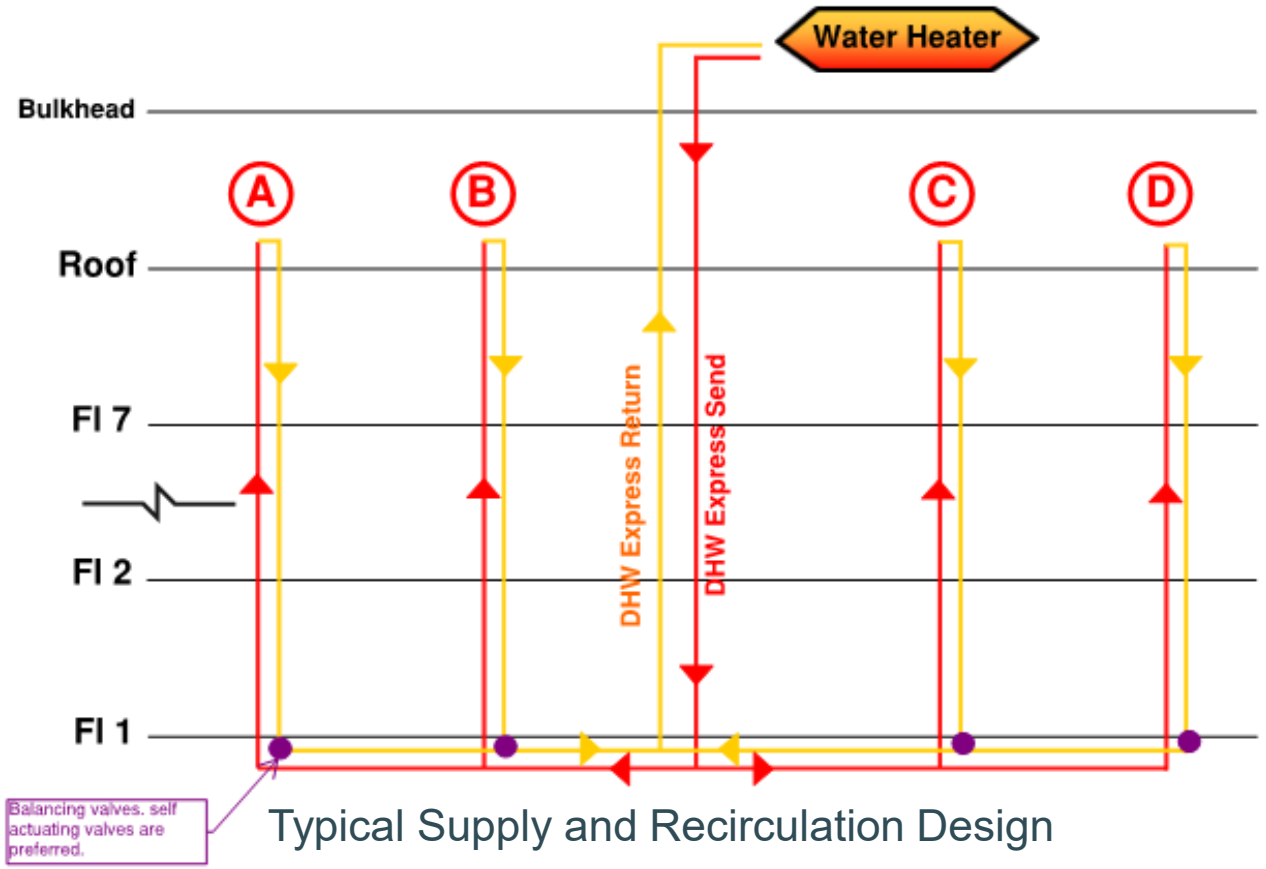






Domestic Hot Water Electrification Summary

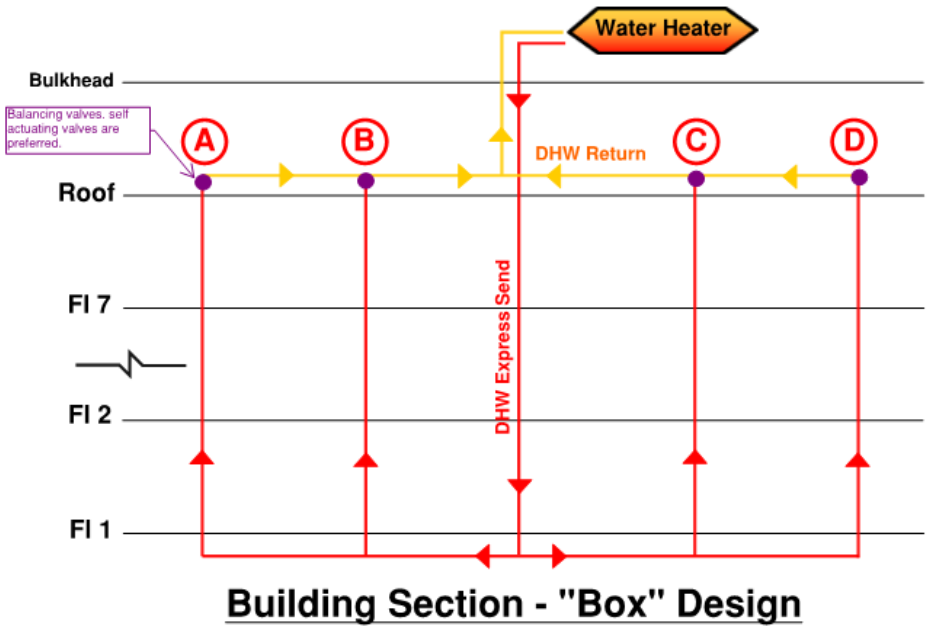
- Efficient electrification of DHW is needed
- It gets very cold outside, central plants need high temperature water
- CO2 is a good fit, but very few options on the market in US (many elsewhere)
- R-410a and R-134a options (slightly) more common
- Plant design and sizing requires thought – not 1 for 1 replacement of boilers



Typical Supply and Recirculation Design

Designing Optimized Recirculation

Design Optimization – Central Recirculation



Building Section - "Box" Design

- Will reduce distribution piping by ~40%.
  - Pumping energy ↓
  - Material costs ↓
  - DHW heating costs ↓
- Balancing critical
  - Thermostatic balancing valves help
- May impact floor to floor heights

Water –
Water efficiency is a critical component of sustainability



Basic Measures

- Select high efficiency fixtures
- Limit landscape that requires irrigation
- Collect rainwater
- Consider greywater systems

Water -
Large building systems offer opportunities to save



Advanced Measures

- High efficiency cooling tower operation
- Submeter tenants/floors/ high-use equipment
- Grey water/Rain water re-use
- Water Sense labeled equipment
- District steam condensate re-use
- Water filtration

Questions?



30 Minute Break

Deep Energy Retrofit Challenges

Deep Retrofit Challenges



New Construction



Retrofits

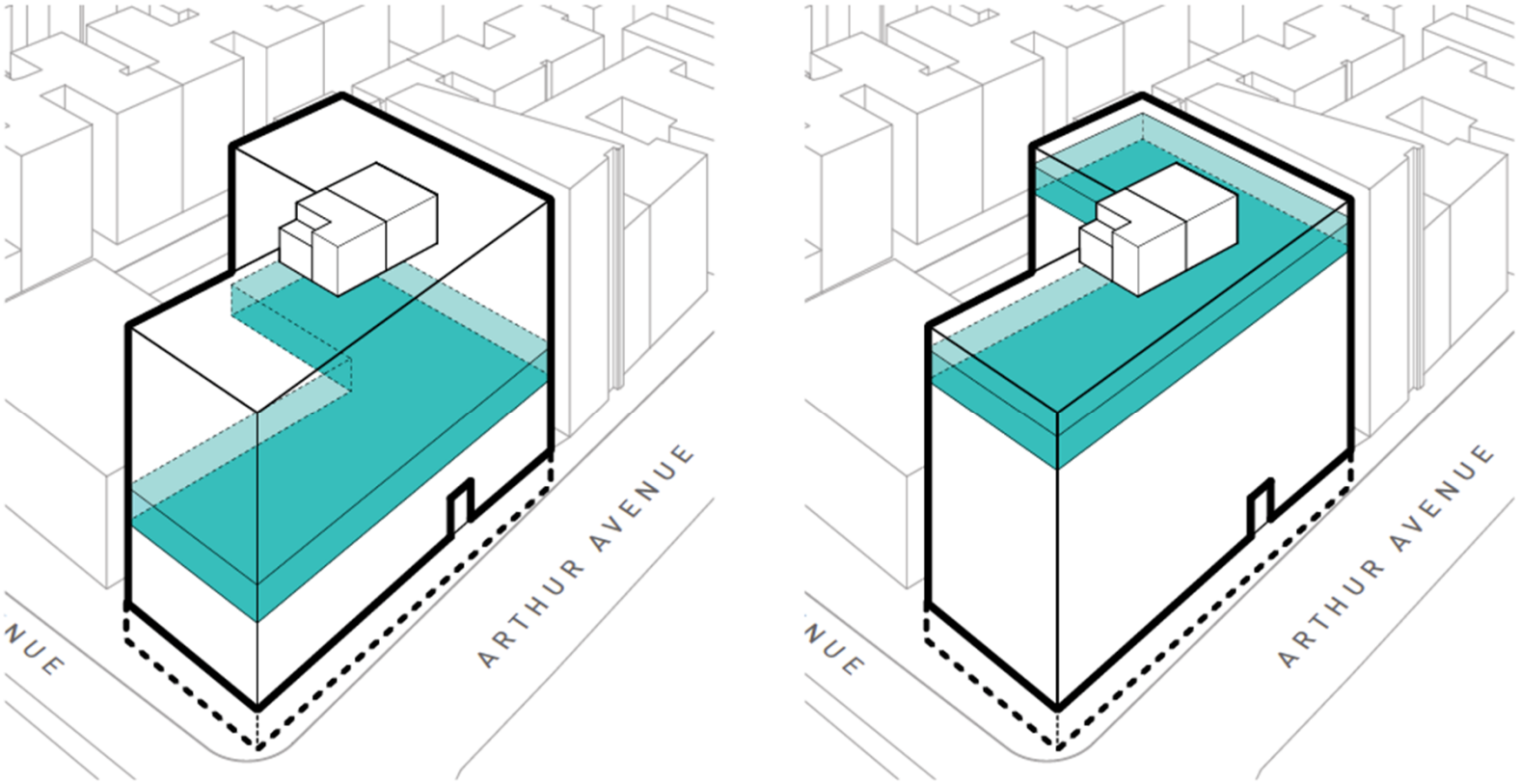
- Airtightness: existing penetrations, limited access
- Space: for insulation, ventilation systems
- Incremental work: continuous occupancy the norm
- Openings: window positions and size not optimal
- Historic fabric: can severely limit options

Retrofit Scenarios: Complete Retrofit (Single Shot)

Favor Single, Comprehensive Projects

- 15-20% less expensive
  (general conditions, startup costs, less repetitive)
- Enjoys scheduling efficiencies
  (overlapping trades, freedom of movement)
- Avoid in-situ disruption
  (work isn't in occupied buildings)

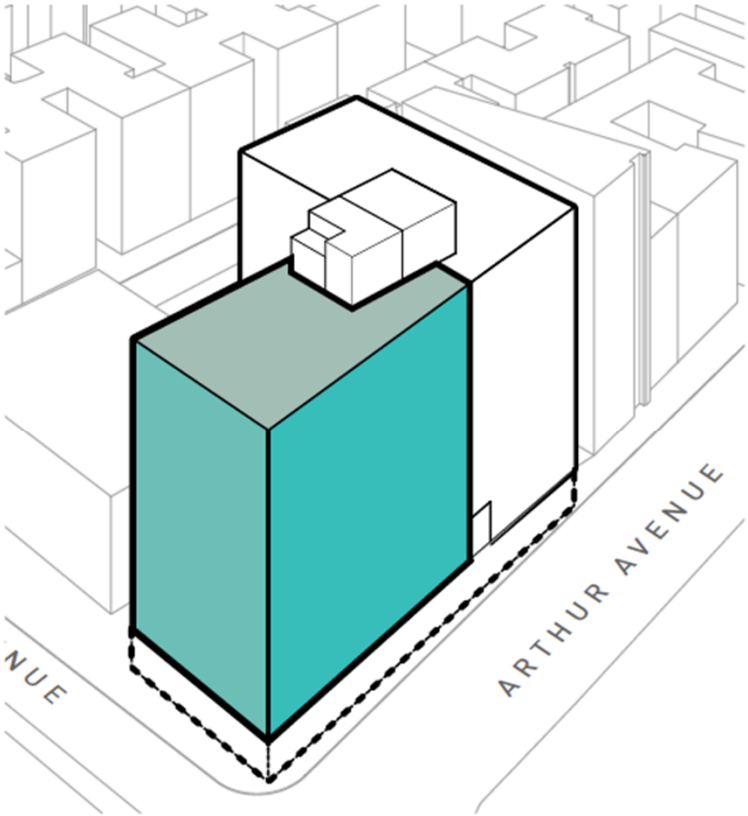
Phasing Options – floor by floor

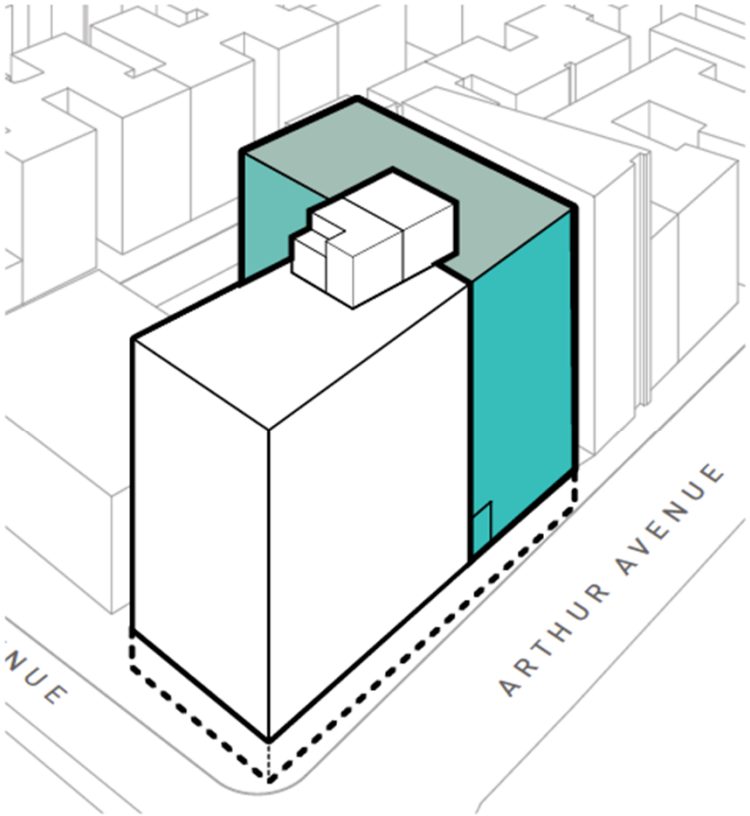


Floor-by-floor tenant phasing diagram

Building Energy Exchange

Phasing Options – phase by wing





Two-zone tenant phasing diagram
Building Energy Exchange

Phasing Considerations

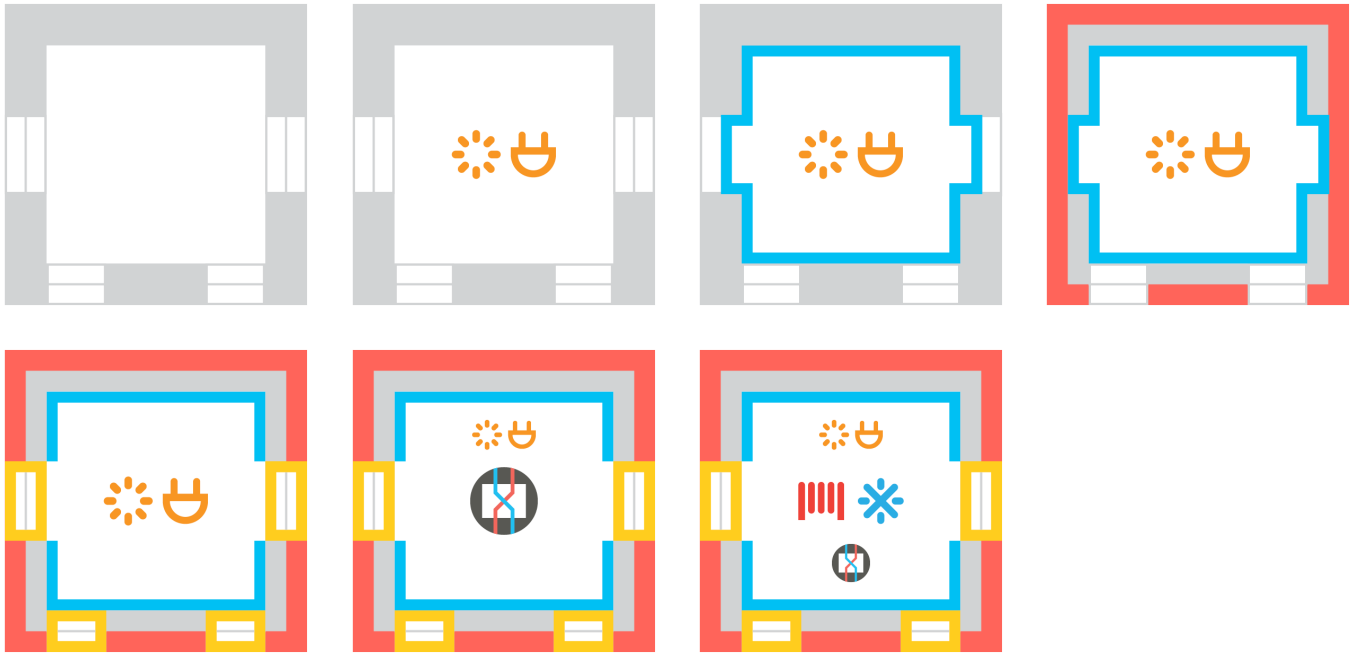
Order of staged improvements depends on:

- End of equipment life
- Comfort, durability issues
- Acoustic qualities
- Indoor air quality

A deep retrofit touches every part of a building

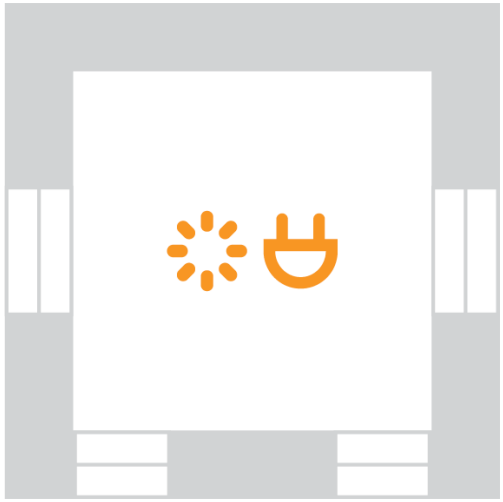
- For example: window replacement improves airtightness, so ventilation upgrades required to improve humidity, air quality

Retrofit Stages



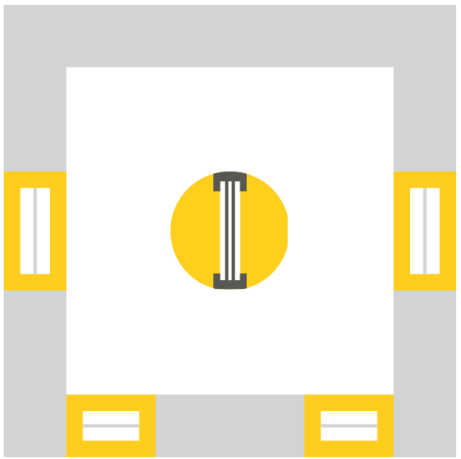
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Plug Loads



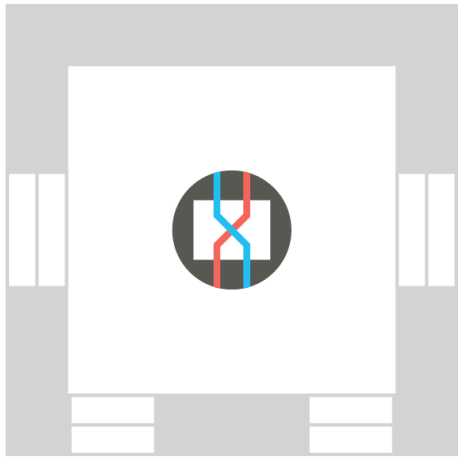
- Very few phasing issues and provides many benefits if conducted early in the retrofit process.
- Cooling demands and loads will be reduced immediately.
- Any cooling equipment can be decreased in size.
- There is the potential for increased short cycling of the cooling equipment which could result in less humidity control

Windows



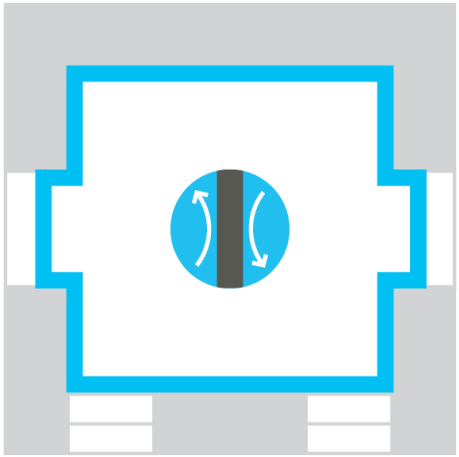
- High performance windows not compatible with window AC units
- High performance windows significantly improve the air tightness
  - Exhaust only systems may not provide adequate fresh air
  - Evaluate ventilation strategy against window upgrade impacts
- High performance windows can result in overheating
  - Common in steam heating buildings (typically already oversized)
  - Mitigation strategies affording better occupant control may be needed

Ventilation



- Typically, the earlier the upgrade the better.
  - Can reduce both heating and cooling loads and
  - Provides better indoor air quality
- Central ERV coupled with a dX coil for dehumidification improves humidity control
- Changes require extensive interior construction, often very disruptive

Air Sealing



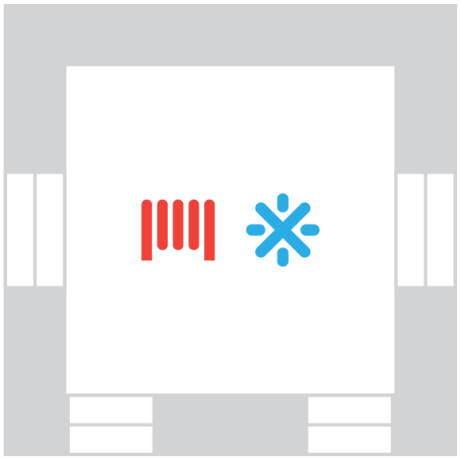
- Improvements will reduce fresh air infiltration
  - Challenge for exhaust only systems
  - Challenge for poorly balanced systems
- Pair ventilation improvements with air sealing where possible
- Improves comfort and acoustic environment
- Improves air quality, reduces particulates
- Reduces potential for condensation inside

Insulation



- Exterior repairs ideal time to increase insulation
- Can result in overheating
  - Especially steam heating buildings
  - Additional controls may be necessary until heating system is replaced
- Ventilation should definitely be upgrade before the air sealing and insulation
- Ideal to replace windows with insulation improvements
  - Even if windows not at end of life
  - Far easier coordination of drainage, air tightness and vapor control
  - Capital costs greatly reduced
- Interior insulation improvements are highly disruptive
- Roofs:
  - Not typically subject to phasing
  - Special conditions critical (door thresholds, parapet heights)
  - Context often limits options

Heating/Cooling



- H/C system replacement after envelope improvements
  - Allows proper sizing of equipment
  - Increased temperature and humidity control results in greater comfort
  - Reduced potential for moisture problems
- Consider exterior supply & return lines when applying exterior insulation
- PTAC openings can often be used for new units
- Identify chases for interior runs of supply & return lines

Deep Energy Retrofit Sequencing

Your Building's Ideal Sequence

This chart can help facilitate discussions on the timing of upgrades to your building and visualize the potential relationships between measures. Major building systems are designated for replacement based on the approximate end of useful life of the equipment. Your building's owner, management, and energy auditors can work together to adjust the timing of these and all other measures in your building.

		Within 5 years	5-9 years	10-14 years	15-19 years
Existing Building System Optimization					
Lights/Appliances	Common area efficiency and controls upgrade				
Air Sealing	Common area air sealing				
Space Heating	Optimized heat distribution				
Ventilation	Seal and balance existing ductwork				
On Site Generation	On-site and/or community solar electricity supply				
Tenant Turnover					
Lights/Appliances	Improved tenant space lighting efficiency/controls				
Lights/Appliances	Improved tenant space plug load efficiency/controls				
Air Sealing	Tenant space air sealing				
Space Heating	Room by room heat control				
Dom. Hot Water	Low flow fixtures				
Existing Building System End of Life					
Space Heating	Package 2: low temp hydronic conversion				
Space Cooling	Package 2: water cooled DX and cooling tower				
Ventilation	Install energy recovery for centralized equipment				
Dom. Hot Water	Air-water heat pump				
Exterior Walls	Package 4: Increased wall insulation				
Windows	Install triple-pane low-emissivity windows				
Roof	Maximize roof insulation				

Building Energy Exchange

Case Studies: Residential

Pursuing Passive



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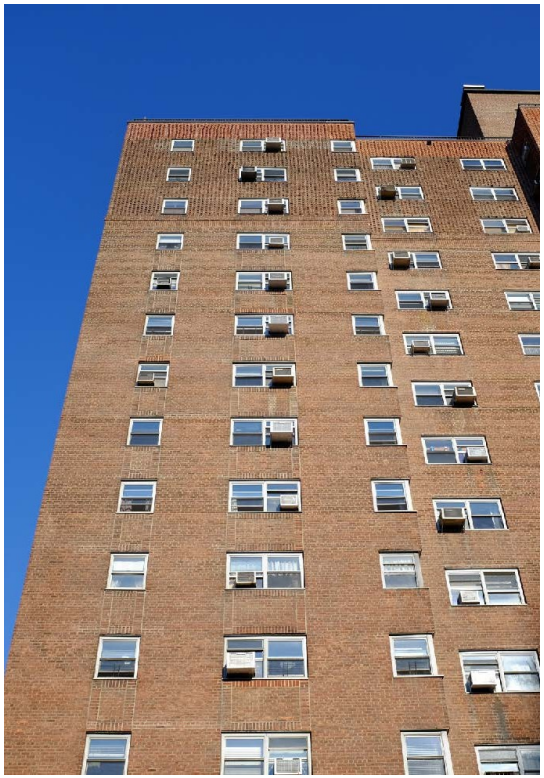
Passive House Institute

Steven Winter Associates, Inc.

- Actual building
- Fully occupied
- Typical challenges
- Tall “looks like NYC”
- Post war
- Market rate

- Focus: phasing/benefits
- Focus: Break inertia dominated decision making

Subject Building



be-exchange.org

- 15 floors + cellar
- 163 units
- Gross: 123,000 sq.ft.
- Treated:100,500 sq.ft. (82%)

Costs:

- rentals: $50/sf avg
- sales: $850/sf avg

- Built 1950
- 21% W to W ratio
- Converted to co-op 1980
- Doorman/Super
- Laundry/Fitness
- Common roof deck

Systems



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Envelope
- No insulation
- 21% window to wall ratio

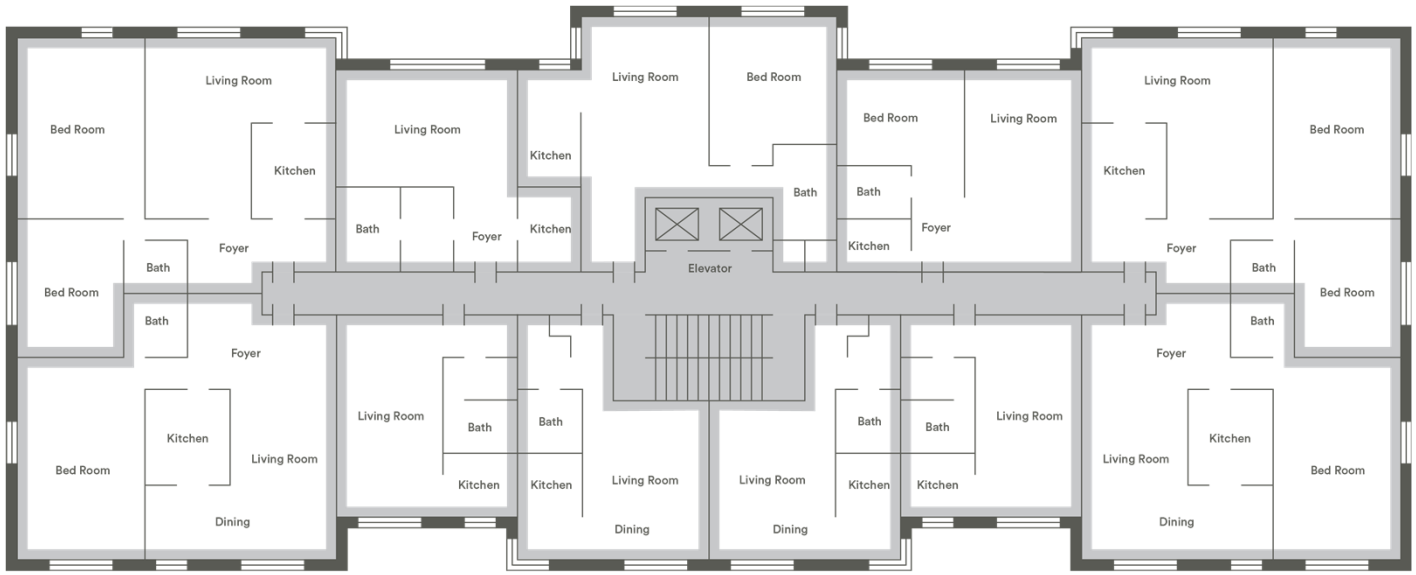
Heating
- 2-pipe steam
- fin-tube radiators

Ventilation
- Exhaust only
- Bath/kitchen separated

Cooling
- window units only

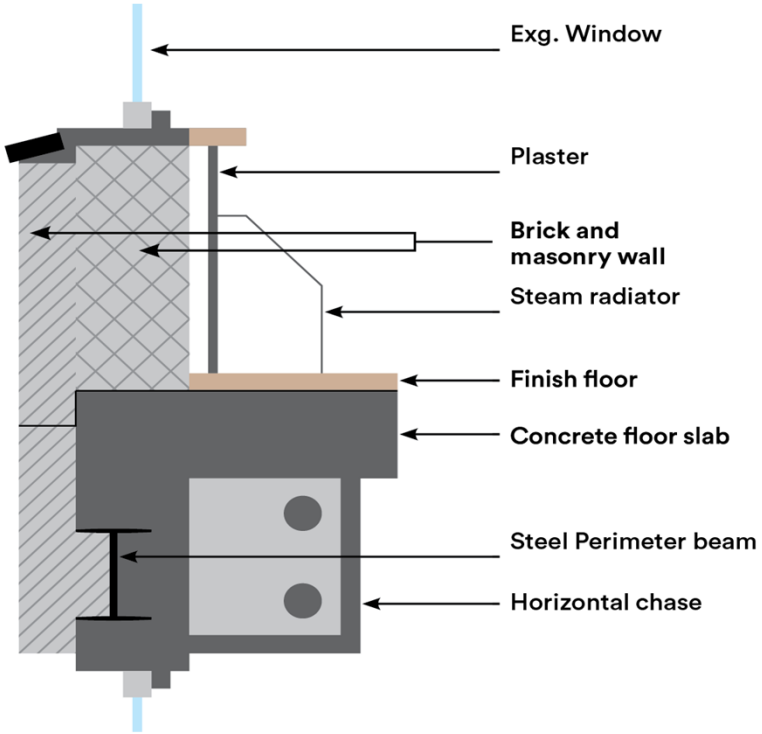
DHW
- Steam heat exchanger

Floor Plan



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Wall Section



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Interiors



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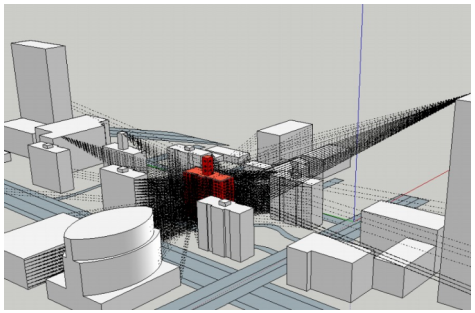
AC



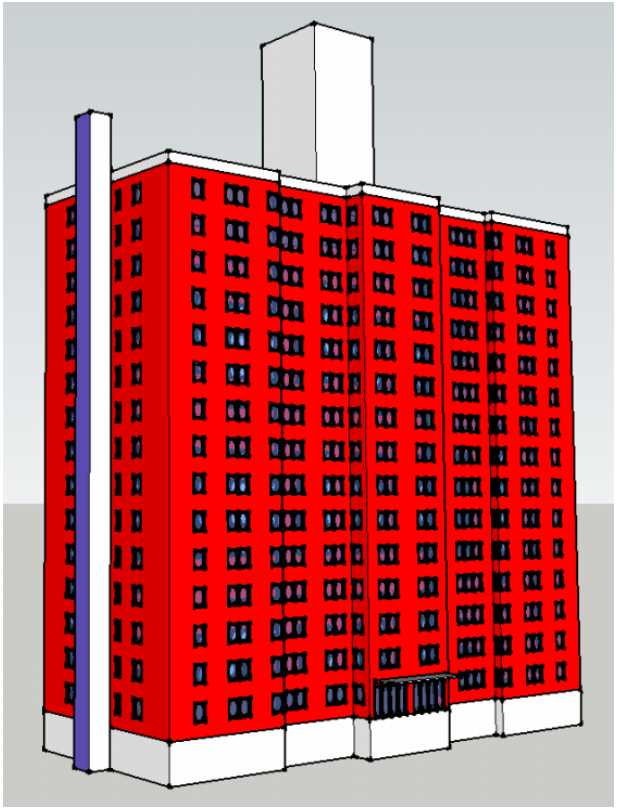


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Process - Energy Modeling

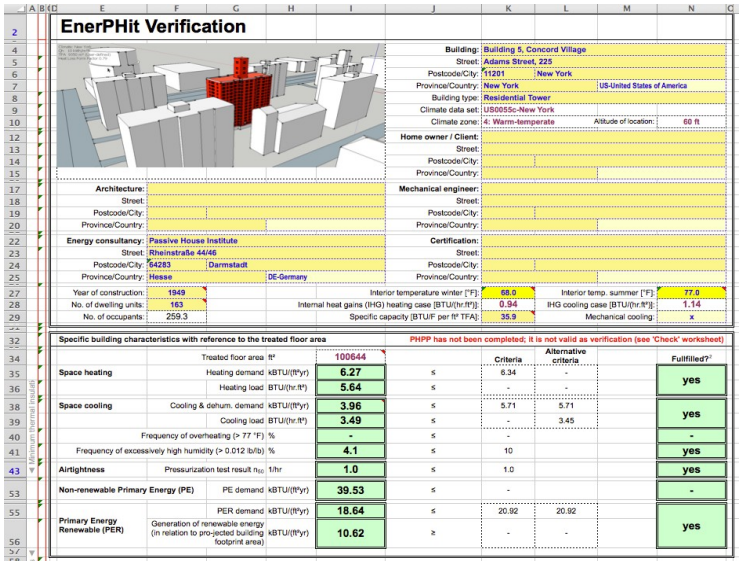


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- DesignPH + PHPP
  - physical elements
  - schedules
  - loads
- Calibrate to existing
- Model thermal bridging
- Calculate PH criteria

Process - strategies



EnerPHit Verification

Building:	Building 5, Concord Village
Street:	Adams Street, 225
Postcode/City:	11201 New York
Province/Country:	New York US-United States of America
Building type:	Residential Tower
Climate data set:	US0055c-New York
Climate zone:	4: Warm-temperate Altitude of location: 60 ft
Home owner / Client:	
Architecture:	
Mechanical engineer:	
Energy consultancy:	Passive House Institute
Certification:	
Street:	Rheinstraße 44/46
Postcode/City:	64283 Darmstadt
Province/Country:	Hesse DE-Germany
Year of construction:	1949
No. of dwelling units:	163
No. of occupants:	259.3
Interior temperature winter [°F]:	68.0
Internal heat gains (IHG) heating case [BTU/(hr.ft²)]:	0.94
Specific capacity [BTU/F per ft² TFA]:	35.9
Interior temp. summer [°F]:	77.0
IHG cooling case [BTU/(hr.ft²)]:	1.14
Mechanical cooling:	x

Specific building characteristics with reference to the treated floor area — PHPP has not been completed; it is not valid as verification (see 'Check' worksheet)

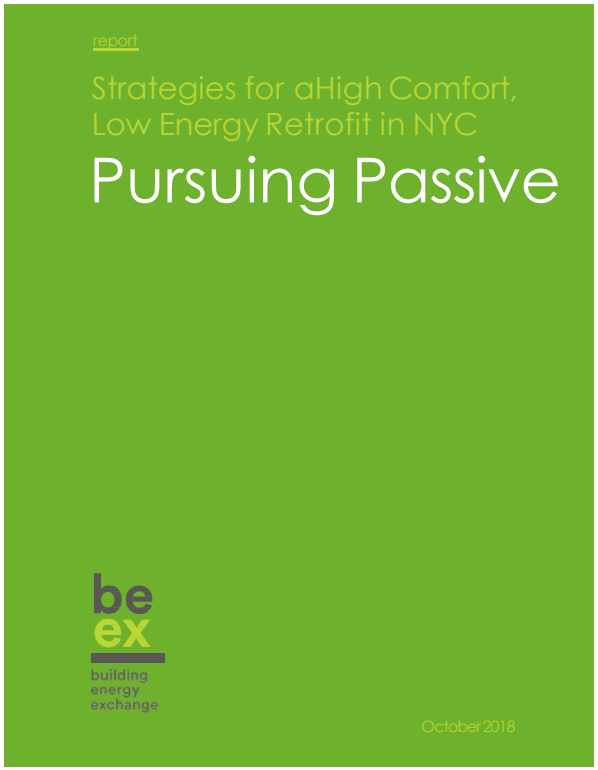
					Criteria	Alternative criteria	Fulfilled?
	Treated floor area	ft²	100644				
Space heating	Heating demand	kBTU/(ft²yr)	6.27	≤	6.34	-	yes
	Heating load	BTU/(hr.ft²)	5.64	≤	-	-	
Space cooling	Cooling & dehum. demand	kBTU/(ft²yr)	3.96	≤	5.71	5.71	yes
	Cooling load	BTU/(hr.ft²)	3.49	≤	-	3.45	
	Frequency of overheating (> 77 °F)	%	-	≤	-		-
	Frequency of excessively high humidity (> 0.012 lb/lb)	%	4.1	≤	10		yes
Airtightness	Pressurization test result n_{50}	1/hr	1.0	≤	1.0		yes
Non-renewable Primary Energy (PE)	PE demand	kBTU/(ft²yr)	39.53	≤	-		-
Primary Energy Renewable (PER)	PER demand	kBTU/(ft²yr)	18.64	≤	20.92	20.92	yes
	Generation of renewable energy (in relation to projected building footprint area)	kBTU/(ft²yr)	10.62	≥	-	-	

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Process - Options/benefits

- Analyze strategies
  - envelope
  - heating/cooling
  - ventilation
- research products/systems
- phasing options
- outline benefits
- costs/financing

Retrofit Strategies



Envelope

- Windows - replace
- Insulation - add
- Airtightness - add

Ventilation

- Refurbish/add balanced system, with recovery

Heating/Cooling

- Replace steam/window units with VRF

DHW

- Upgrade heat exchanger to high efficiency boiler

Lighting/Equipment

- LEDs
- EnergyStar

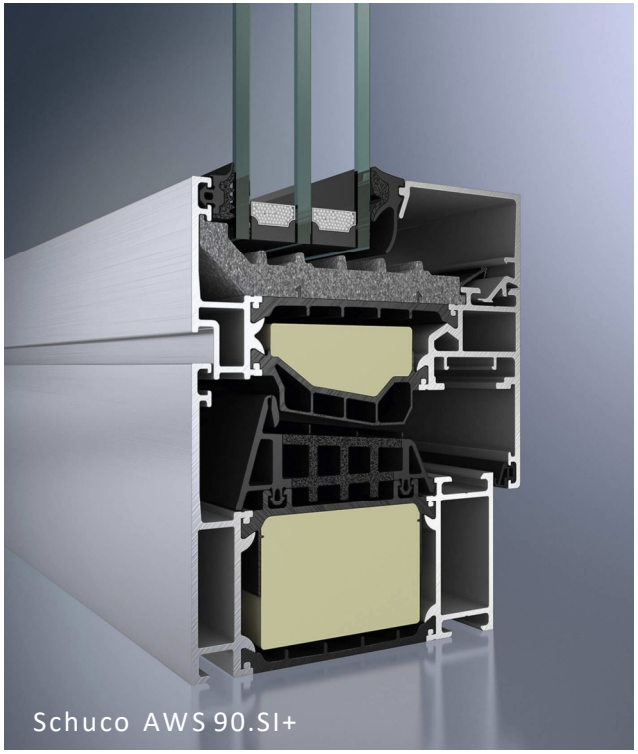
Existing - Windows



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- Old, double hung
- No thermal break
- 1/4” glazing spacer
- “Permanent” window AC units
- Est. U = 0.8

Envelope - Windows



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- 858 window units
- Winter design temp/comfort criteria drives window spec
- 14.4 deg F. —> U = 0.18
- 0.144 unit selected
- Available frame profiles a major issue
- Analysis of window position required
- Retrofit specific windows needed

PH Window U-value	0.18*
Existing U-value	0.8
Delta	5X
Code U-value	.55**
Delta	3.4X

*Assumes carefully detailed installation that mitigates thermal bridging at window perimeter. (A poorer installation would require a more stringent U value.)

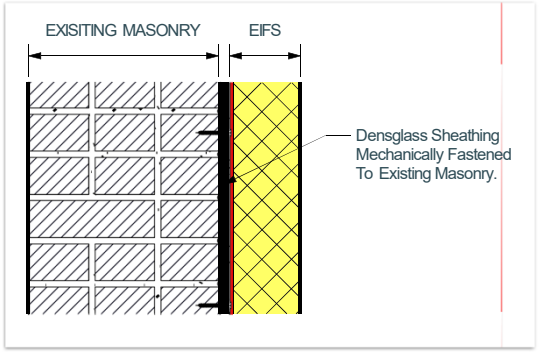
**Code U values do not take installation conditions into account.

Envelope - EIFS



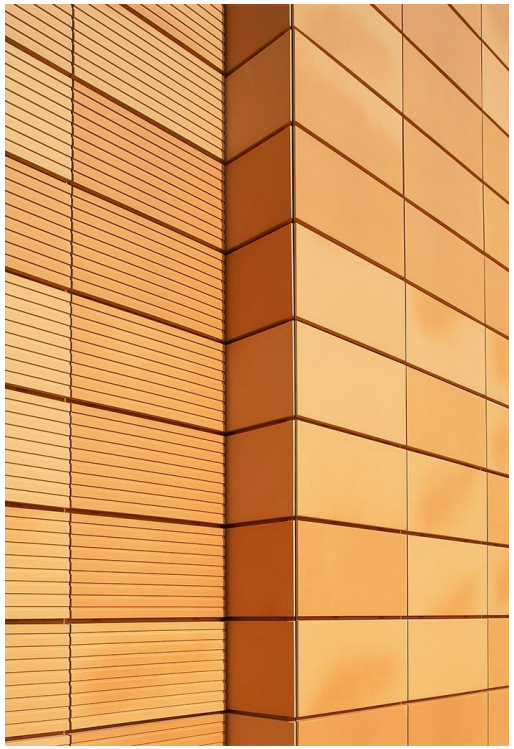


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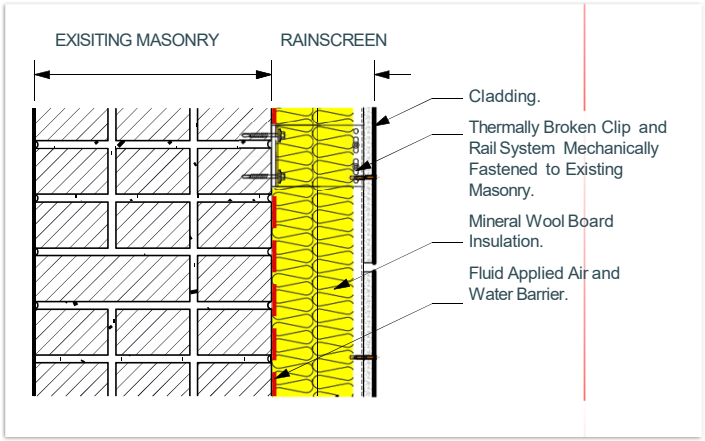


- 2” EIFS (+4” for exterior VRF piping)
- Adhesive = air barrier
- Recycled wood fiber / mineral wool available
- Avoid EPS/XPS
- Failure potential is real

Envelope - rainscreen



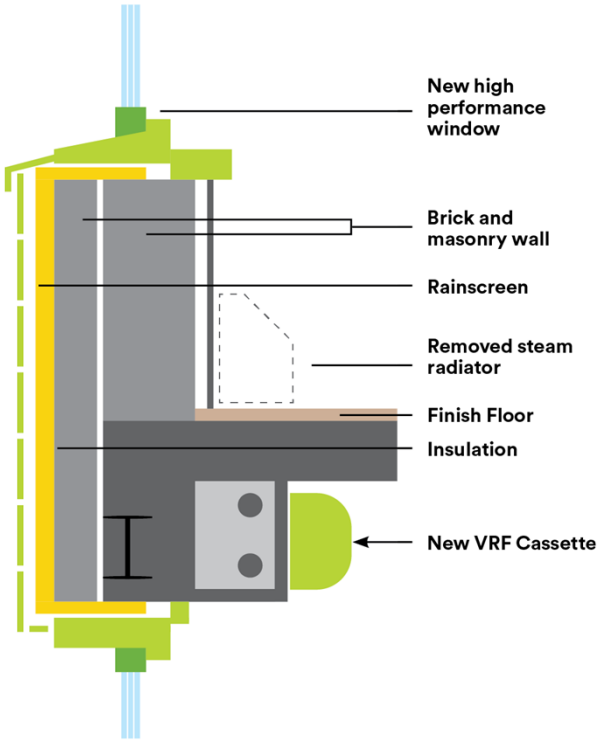
be-exchange.org



- Clean aesthetic
- “Like” masonry
- Expensive
- Increases asset value
- Long term durability
- Limits LL11/FISP work

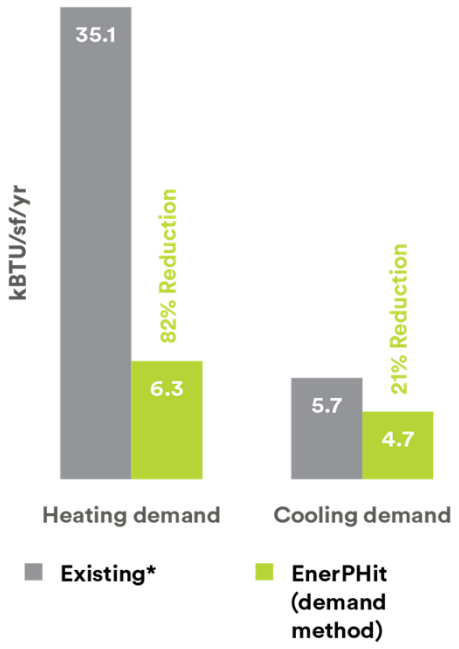
Envelope - outcomes

Proposed Wall Section

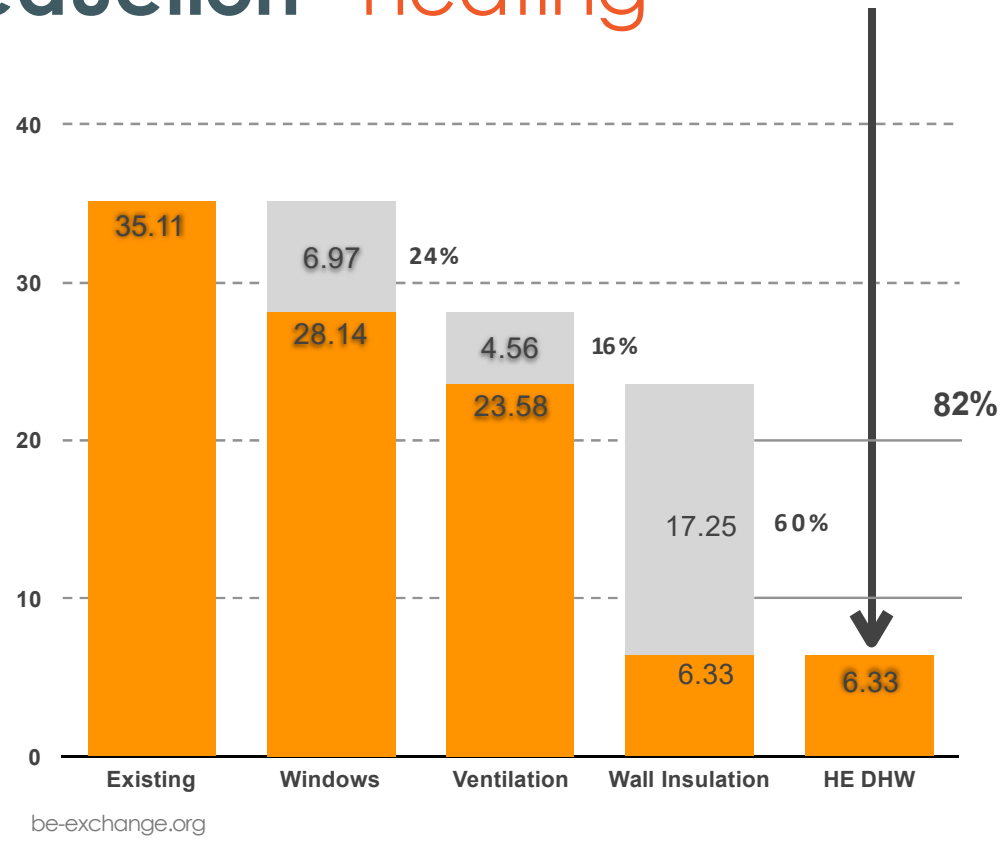


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Heating and Cooling Reductions



Demand Reduction - heating



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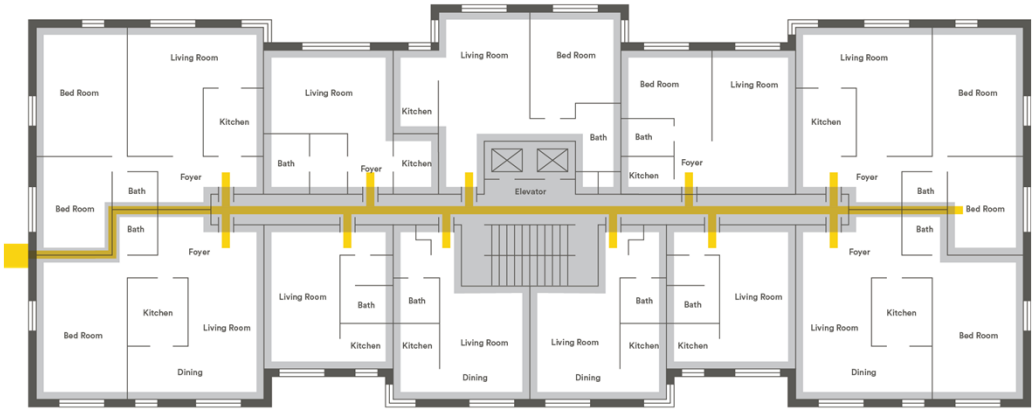
Retrofit - H + C + DHW Matrix

CURRENT		GOOD	BETTER	BETTER YET
Steam	HEATING	upgrade control valves (risers and rads)	VRF conversion	HE PTACs (EU spec)
Window AC	COOLING	HE windowunits (winter removal)		
Exhaust only	VENTILATION	thru-wall units/apt (exg. exhaust = intermittent)	thru-wall units/apt (exhaust = ducted/apt)	Centralized ERV (use exg. risers)
Steam HX	HOT WATER	Pump/insulation upgrades	HE Boiler	Air to Water Heat Pump

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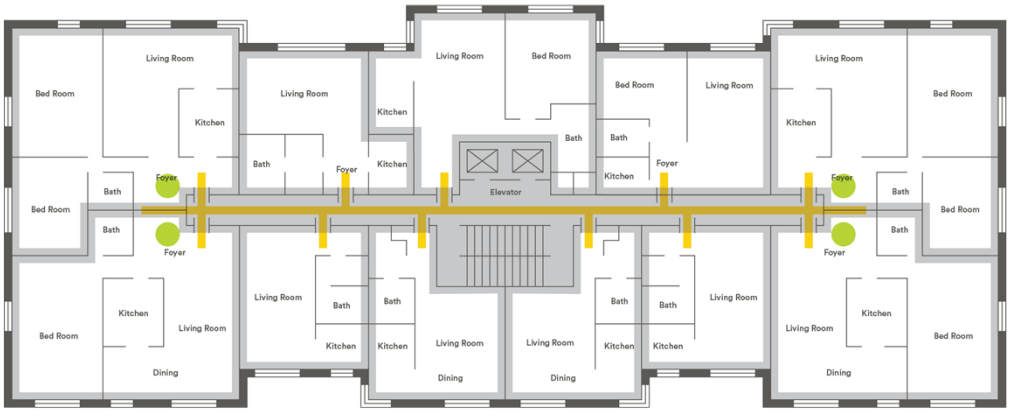
VRF - roads not taken

Distributed VRF Diagram



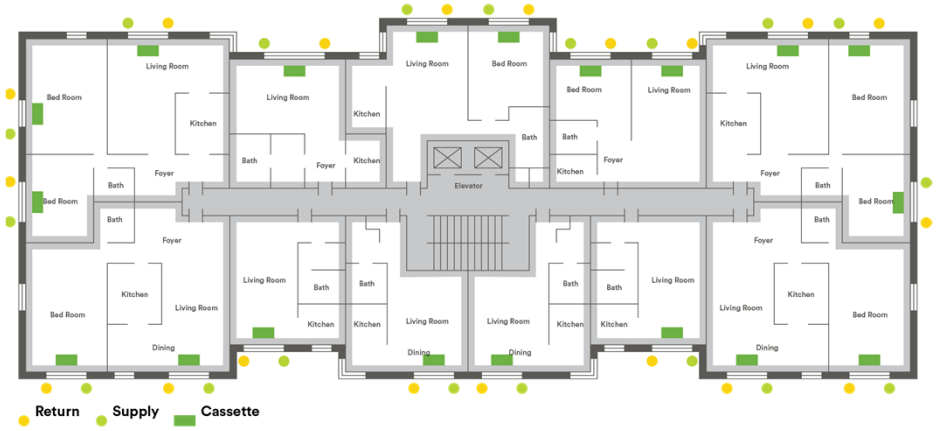
be-exchange.org

Centralized VRF, Option 2: New Central Shafts



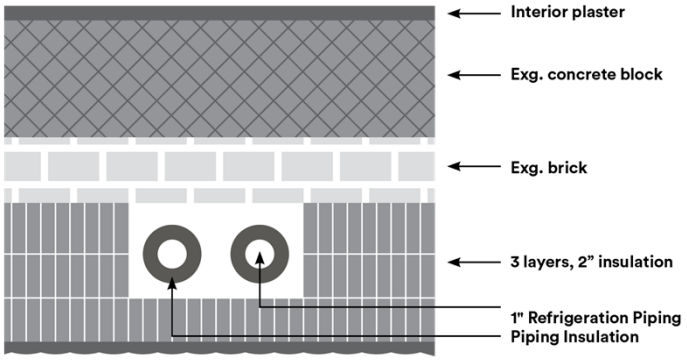
VRF - rooftop units + exterior risers





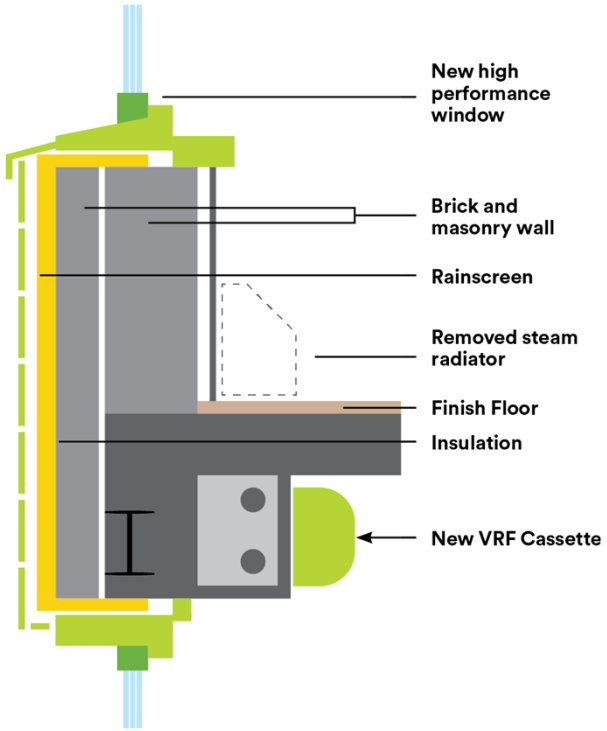
- Rooftop condensing units + risers on exterior facade
- Covered by EIFS / rainscreen
- Risers serve stacks of floors (1 thru 7, 8 thru 15)
- No crossovers (to avoid increases in depth)
- Supply one side of each stack, return on the other
- Feeds rooftop condensing units

VRF - rooftop units + exterior risers



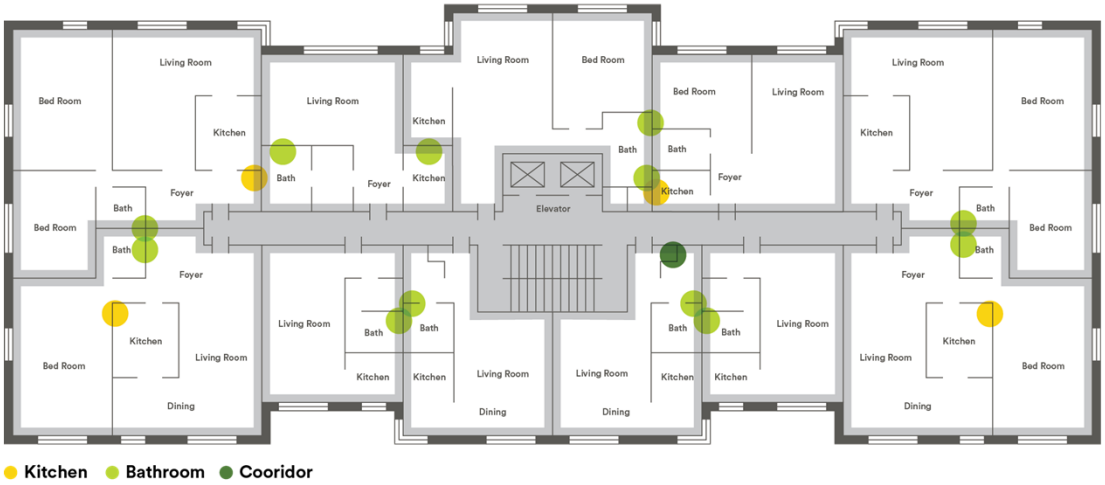


be-exchange.org



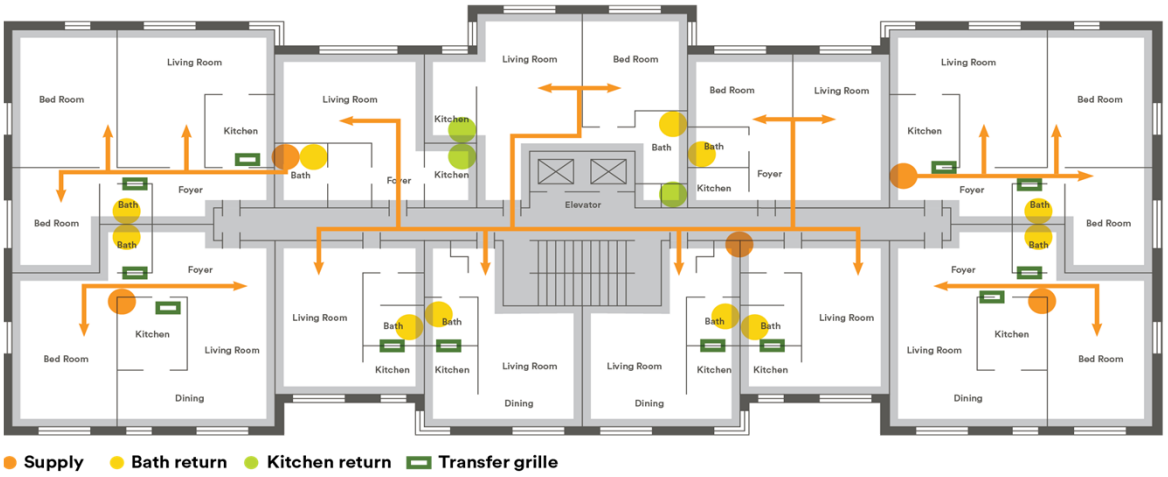
- Cassettes replace radiators
- Less tenant disruption
- Simpler phasing
- Increases exterior insulation

Existing Ventilation



- Exhaust only
- Kitchen/bath/corridor (1 fan per)
- Merely adequate outcomes

Proposed Ventilation





- Convert to balanced system
- Rooftops ERVs serve new supply
- Transfer grilles to connect spaces

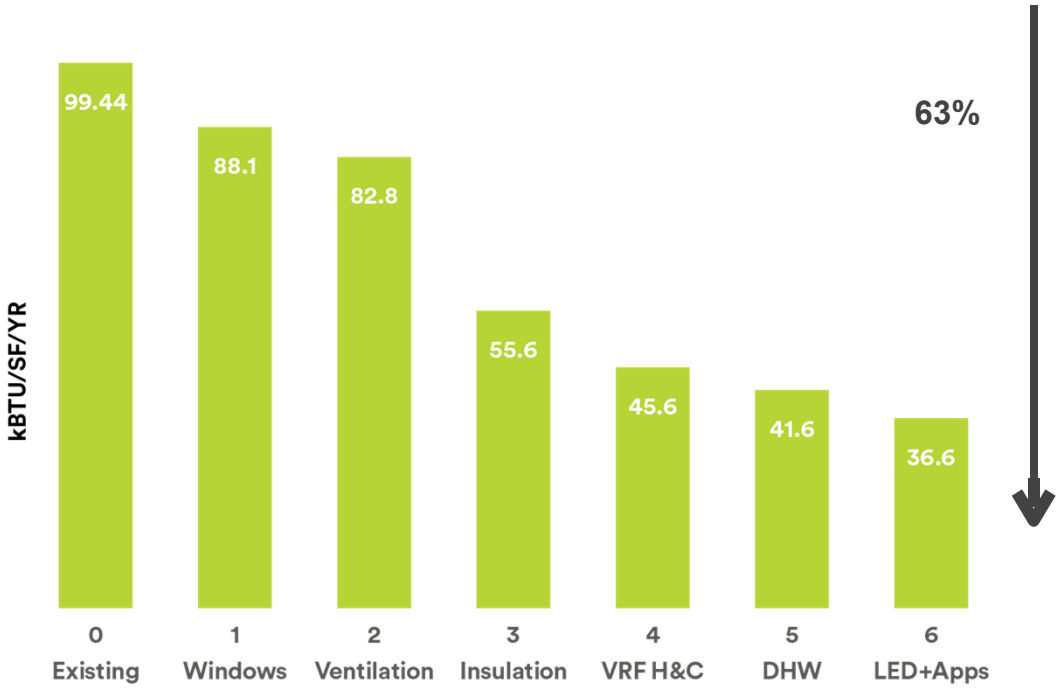
Phasing

PHASE	YR		
1	0	ENVELOPE 1	Windows + Roof insulation+ Airtightness (shafts, etc)
2	4	VENTILATION	Balanced ERV system+ Exhaust upgrades
3	8	ENVELOPE 2	Wall insulation + Airtightness (walls)
4	12	HEATING/COOLING	VRF system
5	16	HOT WATER	High efficiency boiler
6	-	PLUGS/LTG/APPS	Energy star appliances, Elevator upgrades

Phasing - optional

PHASE	YR		
1	0	INSULATION & VENTILATION	Wall/Roof insulation + Airtightness Balanced ERV system + Exhaust upgrades
2	4	WINDOWS & HEATING/ COOLING	Window replacement, VRF system
3	8	HOT WATER	High efficiency boiler
4	-	PLUGS/LTG/APPS	Energy star appliances, Elevator upgrades

Energy Use Reductions by Phase



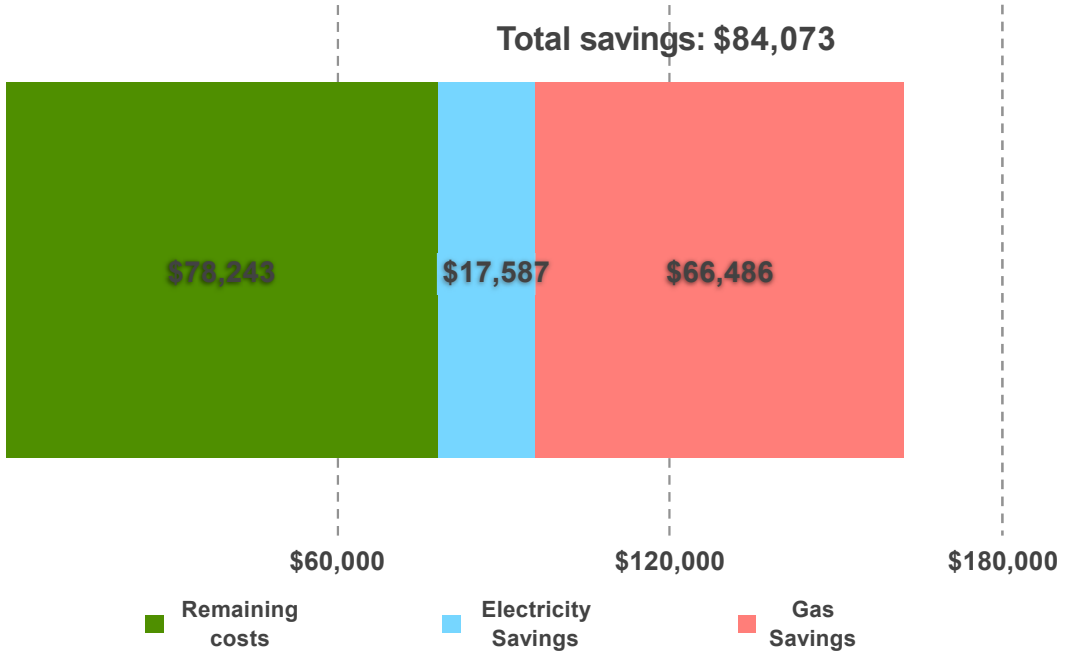
Energy Cost Reductions by Phase

	Electricity			Gas			
	kBTU/SF/YR	kWh/YR	$/YR*	kBTU/SF/YR	therms/YR	$/YR**	total ($)
Existing Utility Costs	11	396429	$79,286	64.29	79077	$83,031	$162,316
Utility Cost Savings by Phases							
1 Windows	0	0	$0	10.23	12583	$13,212	$13,212
2 Ventilation	-0.68	-24507	$4,901	6.51	8007	$8,408	$3,506
3 Ext. Insul.	0.21	7568	$1,514	24.36	29963	$31,461	$32,975
4 VRF	0.82	29552	$5,910	7.13	8770	$9,208	$15,119
5 DHW	0.15	5406	$1,081	3.25	3998	$4,197	$5,279
6 Plugs/Appliances	1.94	69916	$13,983	0	0	$0	$13,983
Totals	2.44		$17,587	51.48		$66,486	$84,073

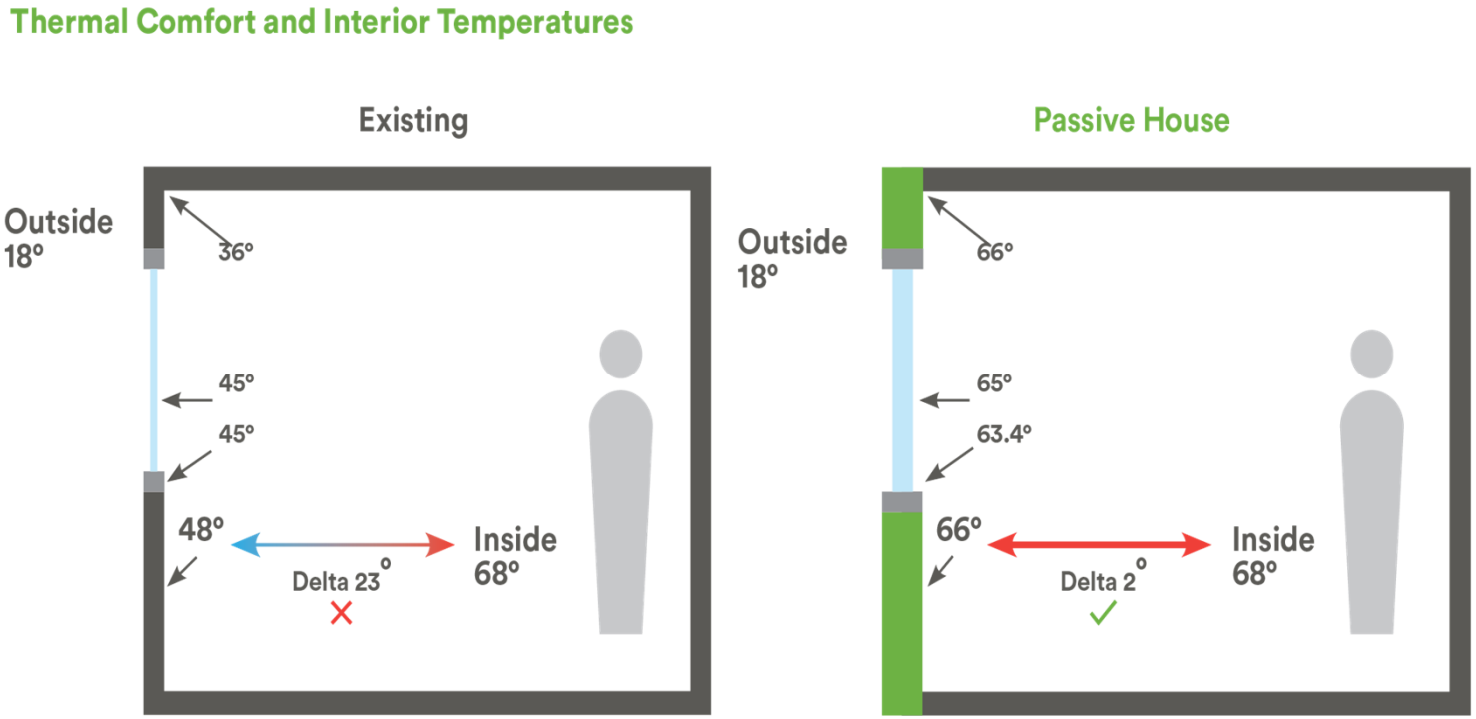
* Cost kWh $0.20

** Cost therms $1.05

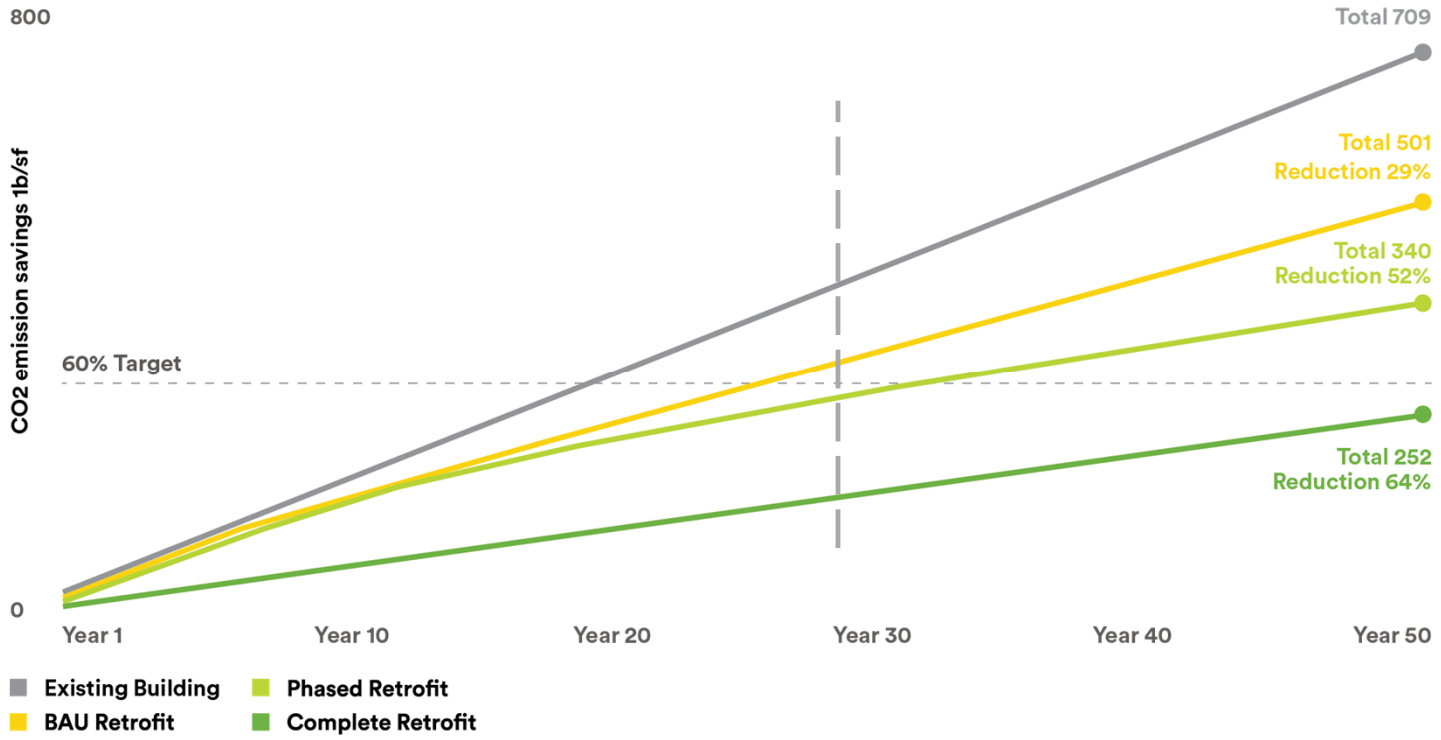
Utility Cost Savings



Comfort


Thermal Comfort and Interior Temperatures
Existing
Outside
18°
36°
45°
45°
48°
Delta 23°
Inside
68°
Passive House
Outside
18°
66°
65°
63.4°
66°
Delta 2°
Inside
68°

Retrofit Scenario Comparisons



Retrofit Costs by Phase

Phase	Est. Cost ($)	Alternates	BAU Costs
Windows/Roof insulation	$4,494,000	-	-$652,000
Ventilation (balanced ERV + exhaust refurb)	$1,447,000	-	-$324,000
Exterior insulation + airtightness	$2,528,000		-$1,150,000
Alt: Exterior rainscreen + airtightness		$1,191,000	
Install VRF system (remove steam/PTACS)	$3,071,000		-$1,261,000
Alt: Install HP Packaged H/C units (remove steam/PTACS)		-$1,054,000	
Replace DHW boiler	$250,000	-	-$250,000
Total costs, phased			
General Conditions reduced (if single phase project)	$1,655,000 (B)		
Total, alternates (net)		$137,000 (C)	
Total offset costs			$3,636,000 (D)
Total costs, single project			
Net costs, phased			$8,154,000 (A-D)
Net costs, single project			
+ Alternates, single project		$10,272,000 (A-B+C)	
+ Alternates, multiple phases		$11,928,000 (A+C)	
Optimal Project (net, future)		$6,635,000 (A-B-D+C)	

Includes:

- Insurance (4%)
- Overhead (2%)
- Fee (8%)
- Contingency (10%)

- $82/sf
- $62,000/unit)

- $53/sf
- $40,000/unit

Questions?



10 Minute Break

NYU Master Plan Evaluation

- Evaluate different dormitories for EnerPHit Compliance
  - 1920's Historic Building
  - 1986 Apartment Style Dorm
- Evaluate Existing utility bills
- Model buildings As-Is and compare to EnerPHit levels of efficiency
- Make recommendations for equipment and materials
- Evaluate cost/benefit payback

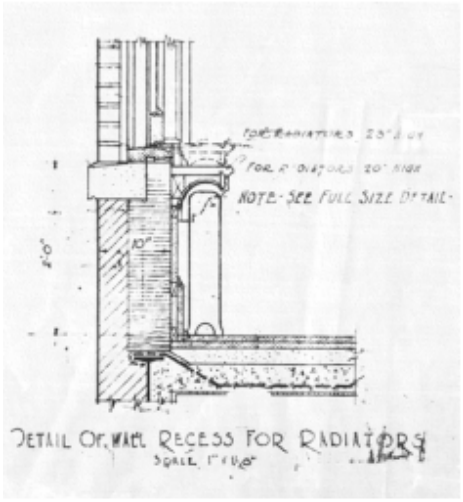


Project Example: NYU-Rubin Hall Dormitory

- NYU-Rubin Hall: SWA/EnerPHit study
- 150’ tall,16 story hotel/apartment building built in Greenwich Village in 1925
- Purchased by NYU in 1964 for use as a dormitory residence.
- EnerPHit study assessed three packages for upgrades including simple payback for each

EnerPHit Study: Rubin Hall - Interior Insulation Proposed



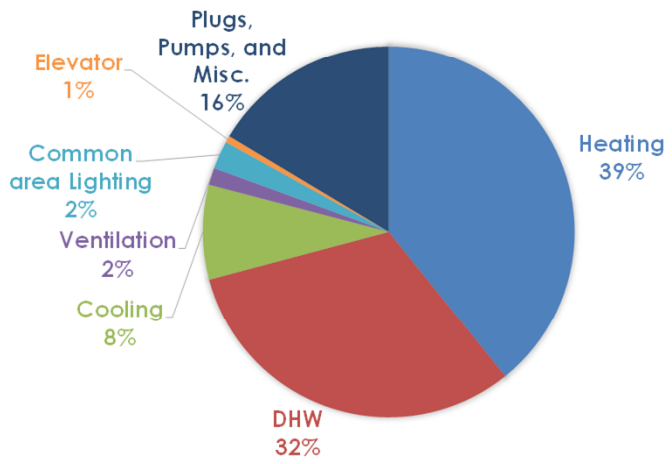


WALL SECTION DETAIL DATED 1948

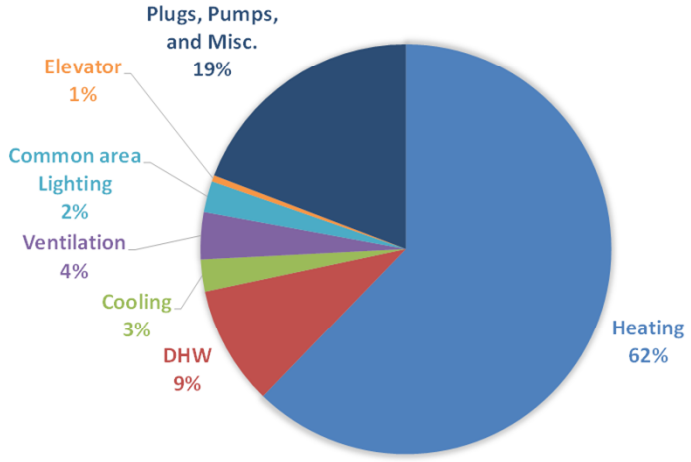
- Rubin Hall – 1925 Historic Bldg
- Uninsulated Walls: 4” face brick + 8” Terracotta
- Metal, Single Pane Windows

As Built Utility Analysis

Carlyle Utility Data (15 min)



Rubin Hall Utility Data (15 min)



RH: Wall Assembly Recommendations

	1.5” Polyiso +2.5” Mineral Wool	**2.5” Closed Cell**
Benefits	Provides interior continuous insulation, air-barrier and dewpoint control layer. R-10 without additional mineral wool	Provides interior continuous insulation, air-barrier and dewpoint control layer. Thinner wall assembly. Even coverage is easily achieved
Issues	Thicker wall assembly - 4.5" and loss of square footage Install quality is important Can be labor intensive	Objections to spray foam and off gassing. Cost of material is higher, but labor to install may not be.

EnerPHit Study: Rubin Hall - Interior Insulation Proposed

Project Name NYU Student Housing Energy Master Plan
Date 11/30/2018

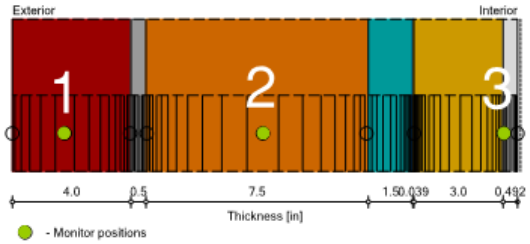
Option R - EW - 01

Rubin Hall_ Typical exterior wall assembly + polyiso + mineral wool

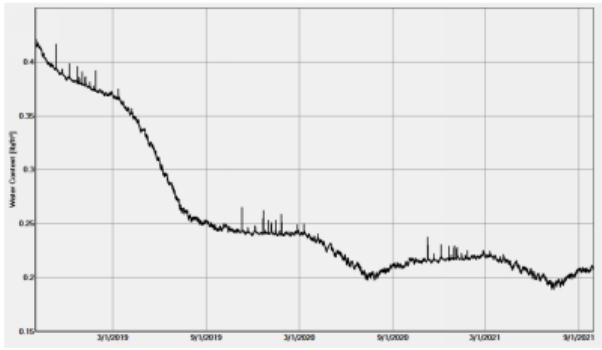
Boundary Conditions

Exterior (left side) New York, NY; cold year

Interior (right side) 70o F with fluctuation of 5o F; and 45% RH with a 10% amplitude



Total Water Content in the Wall Assembly



Materials:

- *Buff Matt Clay Brick - old	4.0 in
- Masonry Cement Mortar - Type N	0.5 in
- Brick (old)	7.5 in
- Polyisocyanurate Insulation	1.5 in
- vapor retarder (0.1perm)	0.039 in
- Roxul ComfortBatt	3.0 in
- Interior Gypsum Board	0.492 in

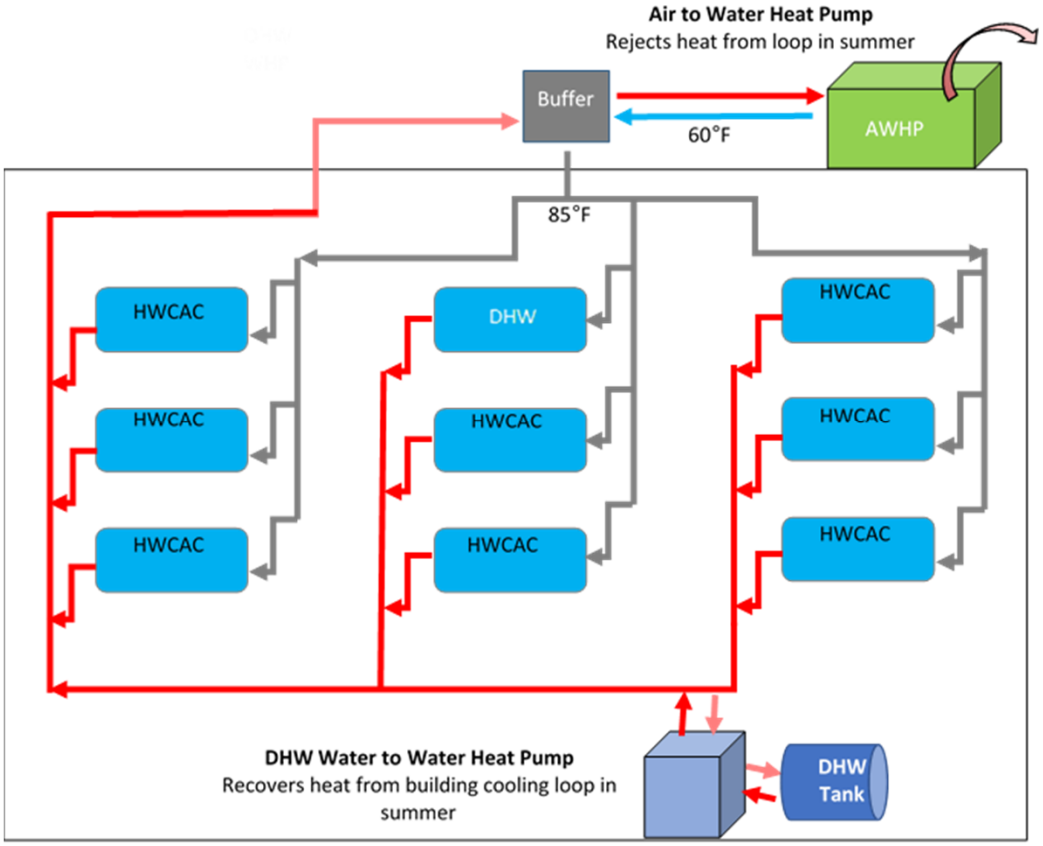
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STEVEN WINTER ASSOCIATES, INC

Heating and Cooling System Comparison

	Hydronic Loop with HWCACs	VRF System
Pros	• Minimal distribution losses • Long distribution lifetime (40 – 50 years) • Simultaneous heating and cooling • Waste heat Recovery during cooling season for DHW • Ability to switch out HPs for CO2 based HP units as technology becomes more available	• Simultaneous heating and cooling • Quiet • Flexibility in terminal unit output
Cons	• Larger rooftop footprint than VRF units • Rooftop structural considerations • Pumping energy • Phasing challenges	• Potential for refrigerant leakage / IAQ • Refrigerant phase out and piping lifetime (~20 years) • Rooftop structural considerations

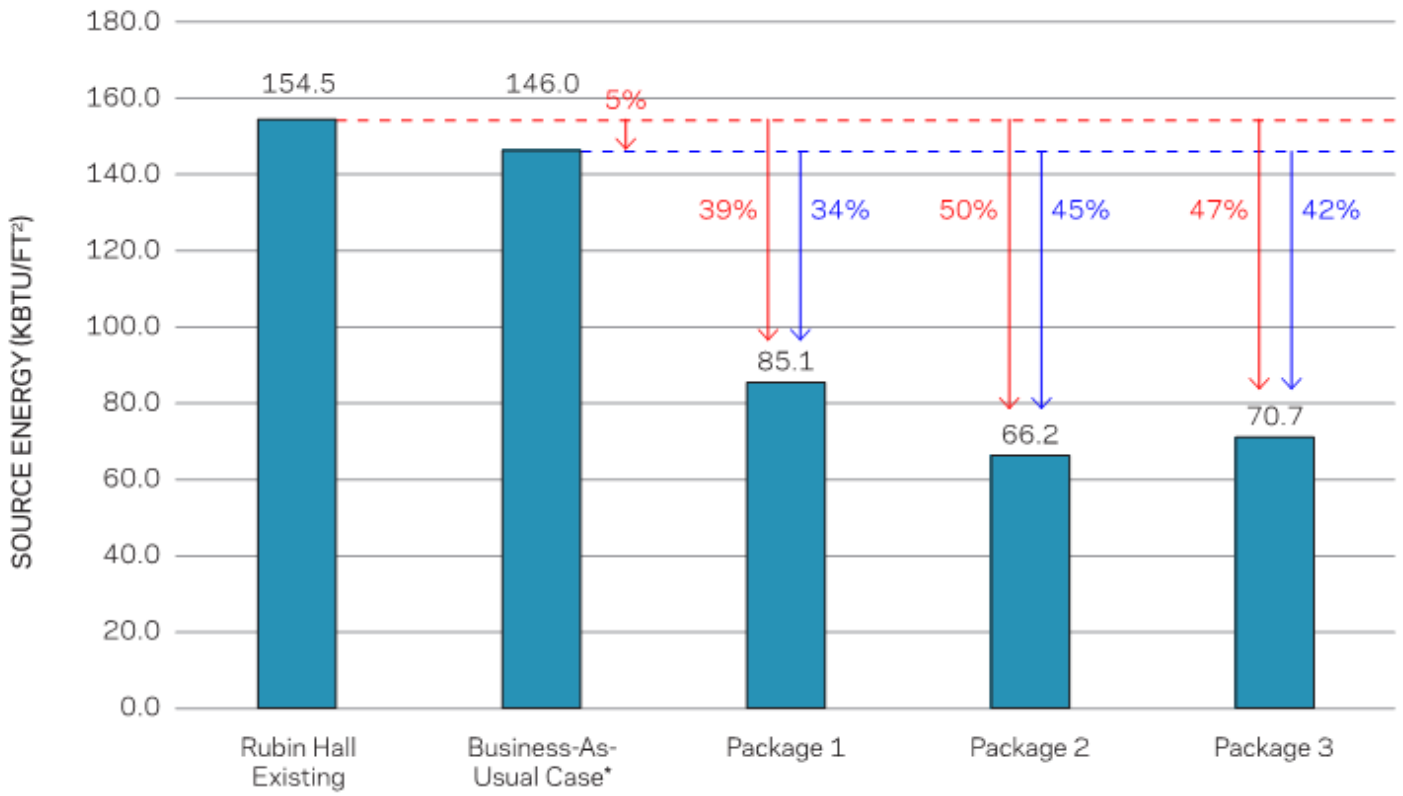
Hydronic Loop with HWCACs: Cooling-Mode



NYU - Rubin Hall Dormitory

	Baseline	Package 1	Package 2	Package 3
2.5” interior polyiso insulation	X	X		
Double pane windows/insulated frames	X	X		
Upgrade doors	X			
Water source Heat Pump/ Boiler upgrade	X			
Fan upgrade/new ventilation ductwork	X			
Common Area Lighting Improvements	X	X	X	X
Reduced air leakage to 1.0 ACH @50		X	X	X
VRF heating/cooling		X	X	
Distribution improvements, air to water heat pump		X	X	X
Balanced Vent w/ ERVs		X	X	X
1.5” poliso & 3” mineral wool			X	X
Triple pane windows/ insulated frames			X	X
Plug load improvements			X	X
Low temp Hydronic heating/cooling				X
Distribution improvements, water source heat pump				X

Total Source EUI of each ECM for Rubin Hall

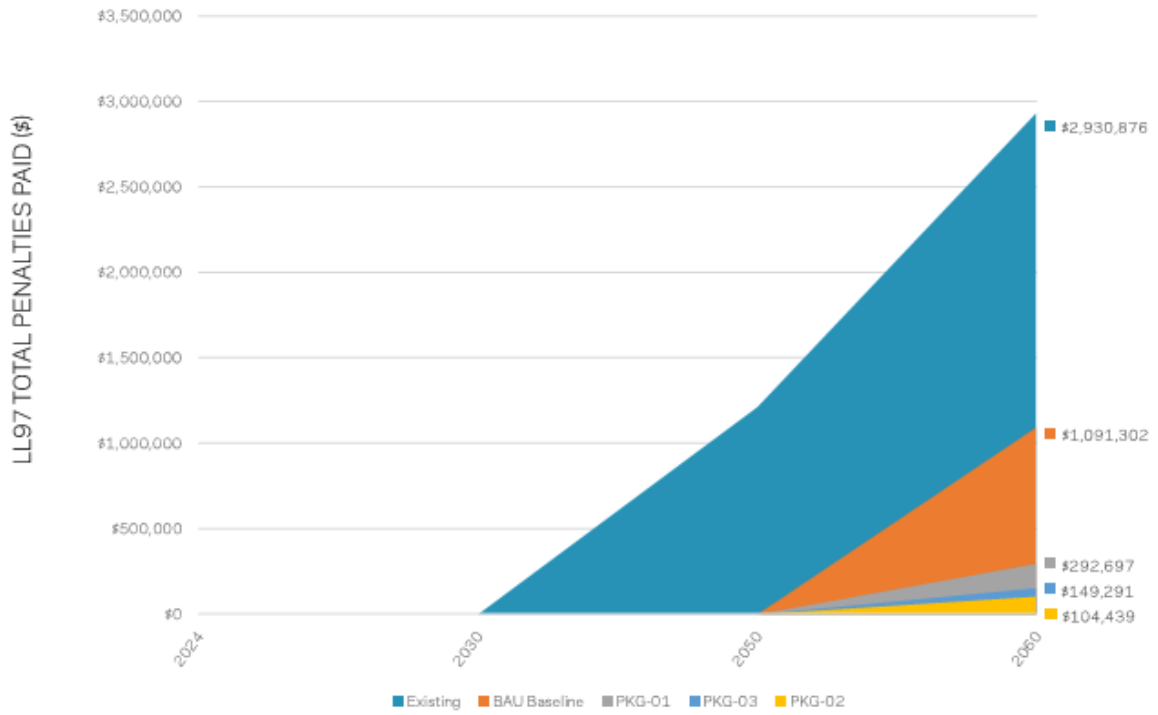


* Estimated based on savings observed at Brittany Hall

Costs, Savings, and Simple Payback by Package

PACKAGE	TOTAL ENERGY COSTS $ / yr	TOTAL ENERGY COST SAVED $ / yr	MARGINAL ENERGY COST SAVED $	DIRECT COST (W/ 20% DETAILING) $	FINAL COST W/ CONTINGENCIES $	MARGINAL COST W/ CONT. $	SIMPLE PAYBACK W/ CONT. Years	SIMPLE PAYBACK WW/O CONT. Years
Business-As-Usual	$265,500	$12,500	$0	$10,297,000	$19,157,500	$0	0.0	0.0
R-PKG - 01	$178,500	$99,000	$86,500	$12,750,500	$23,722,500	$4,565,000	52.6	23.6
R-PKG - 02	$137,500	$140,500	$128,000	$13,538,000	$25,188,000	$6,030,500	47.1	21.1
R-PKG - 03	$147,000	$130,500	$118,000	$13,579,500	$25,264,500	$6,107,000	51.7	23.1

Expected Penalties due to Local Law 97 Climate Mobilization Act



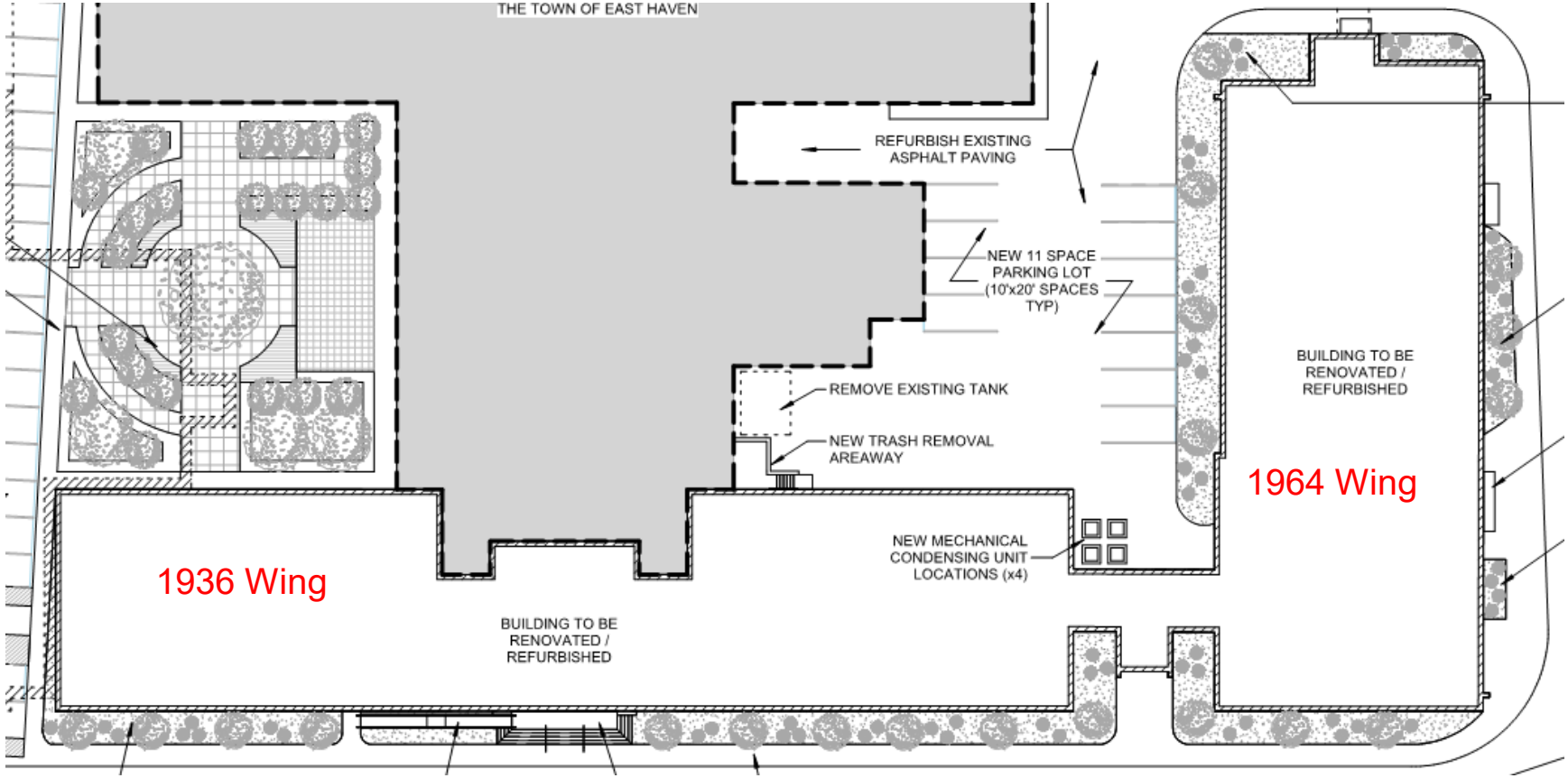
- All upgrade packages comply with LL97 until 2050 where penalties are realized

200 Tyler Street – Historic Retrofit

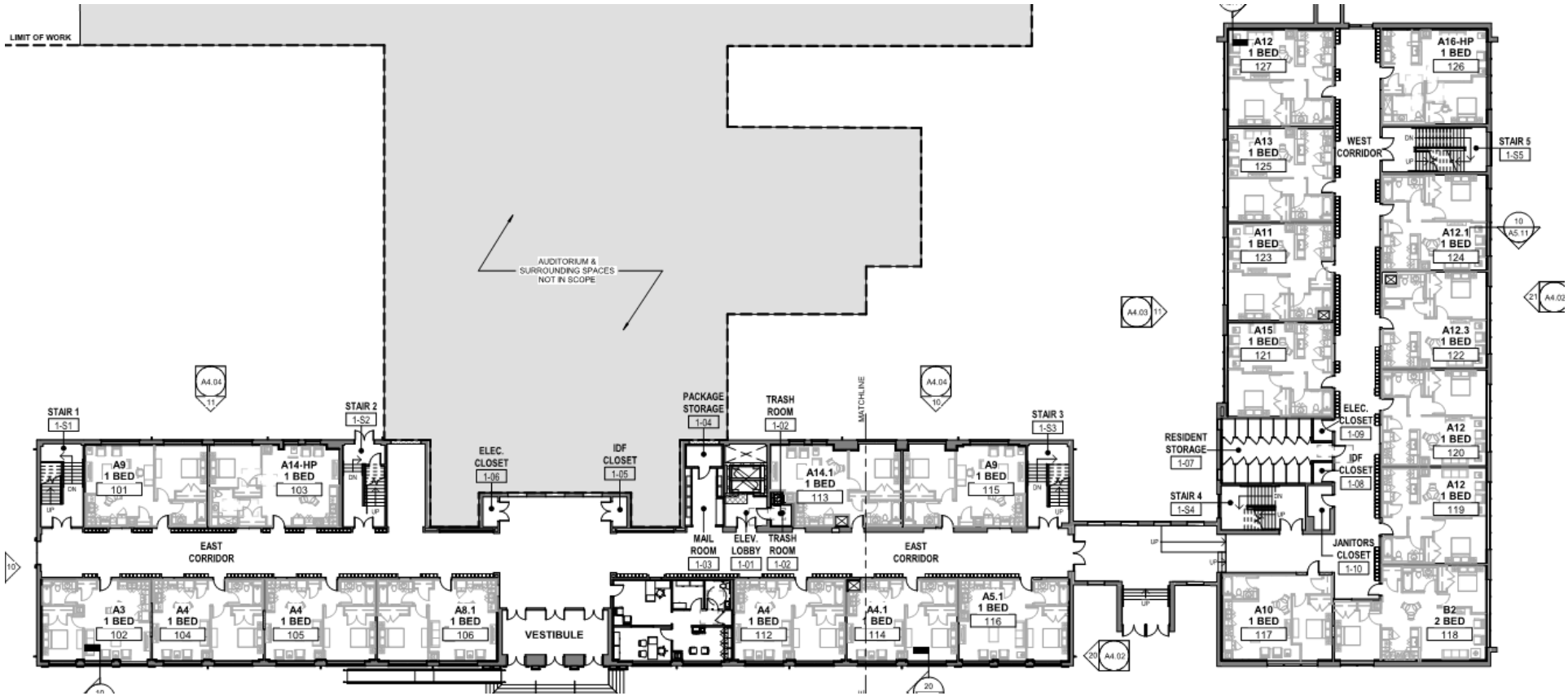
PROJECT SCOPE & SPECS	
Developer / Owner:	WinnCompanies
Architect:	The Architectural Team, Inc.
Project Services:	Passive Certification Services; Energy & Thermal Bridge Modeling; Testing & Verification
Building Size:	65,000 sf, 4 stories
Certification: **Incentive Programs:**	Passive House Institute - EnerPHit
Funding:	2017 CHFA 9% LIHTC Program
Primary Energy Conservation Measures:	Projected savings of 60-70% whole building energy demand
SWA Contact:	Lois Arena (larena@swinter.com)



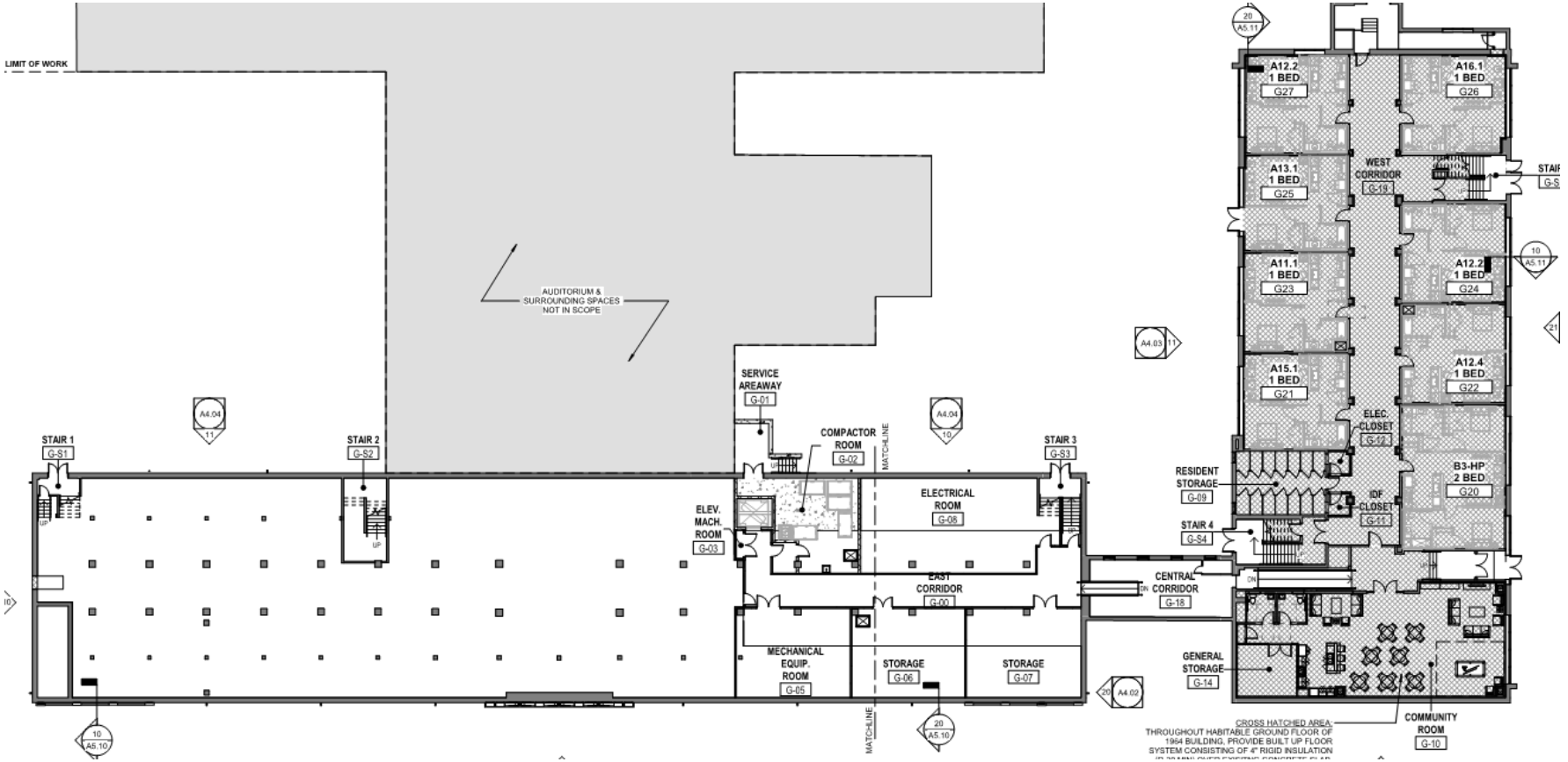
Site Plan


THE TOWN OF EAST HAVEN
REFURBISH EXISTING ASPHALT PAVING
NEW 11 SPACE PARKING LOT (10'x20' SPACES TYP)
REMOVE EXISTING TANK
NEW TRASH REMOVAL AREAWAY
BUILDING TO BE RENOVATED / REFURBISHED
1964 Wing
NEW MECHANICAL CONDENSING UNIT LOCATIONS (x4)
1936 Wing
BUILDING TO BE RENOVATED / REFURBISHED

Typical Floor



1964 Wing – ½ story below 1936 Wing



Historic Requirements: What We Can't DO

- Triple pane windows
- PH frames
- Change the exterior
- Change some of the interior surfaces not in the apartments
- Eliminate any doors

Exemptions for EnerPHit

The limit values in Table 2 for the heat transfer coefficients of the exterior envelope building components may be exceeded if absolutely necessary based on one or more of the following compelling reasons:

- *If required by the historical building preservation authorities*
- If the cost-effectiveness of a required measure is no longer assured due to exceptional circumstances or additional requirements
- Due to legal requirements
- If implementation of the required standard of thermal insulation would result in unacceptable restriction of the use of the building or adjacent outer areas
- *If special, additional requirements (e.g. fire safety) exist and there are no components available on the market that also comply with the EnerPHit criteria*
- *If the heat transfer coefficient (U-value) of windows is increased due to a high thermal transmittance (psi value) of the window installation offset to the insulation layer in a wall that has interior insulation*
- If reliably damage-free construction is only possible with a smaller insulation thickness in the case of interior insulation
- If other compelling reasons relating to construction are present

Comfort Analysis

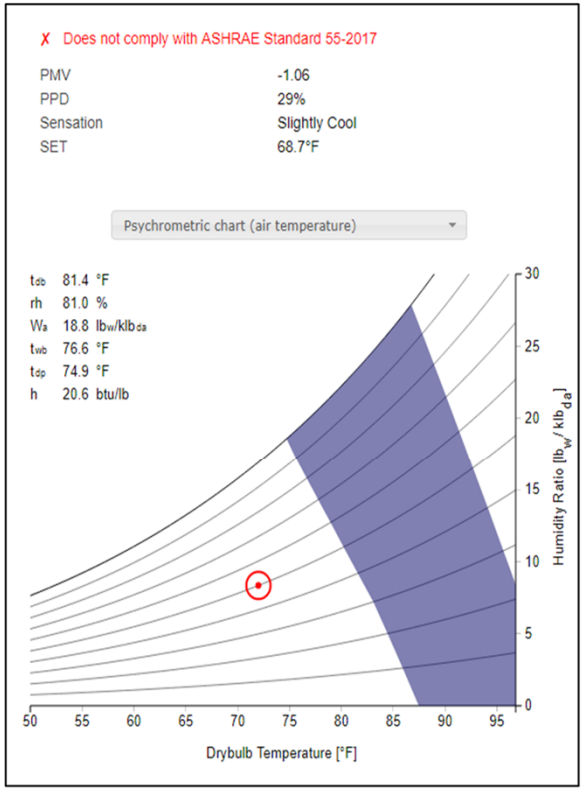


Figure 1. Current conditions result in situation outside of the ASHRAE 55 comfort zone.

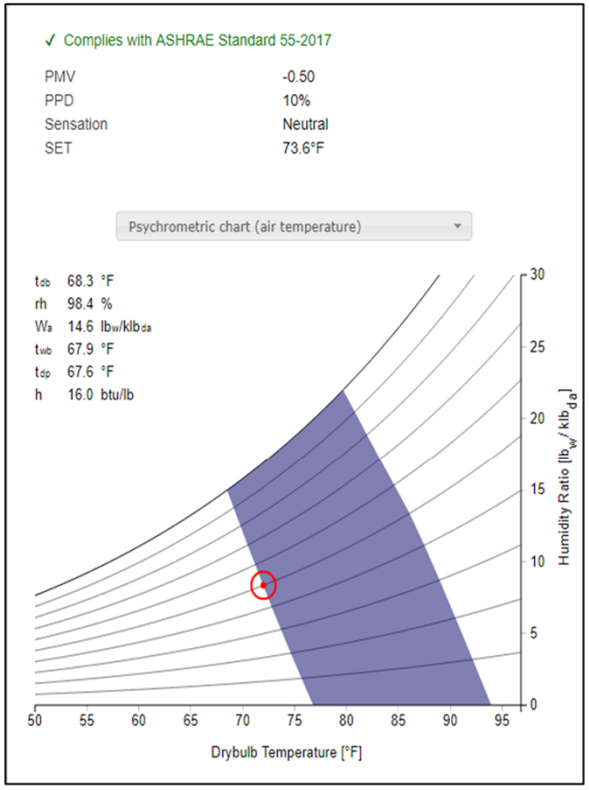
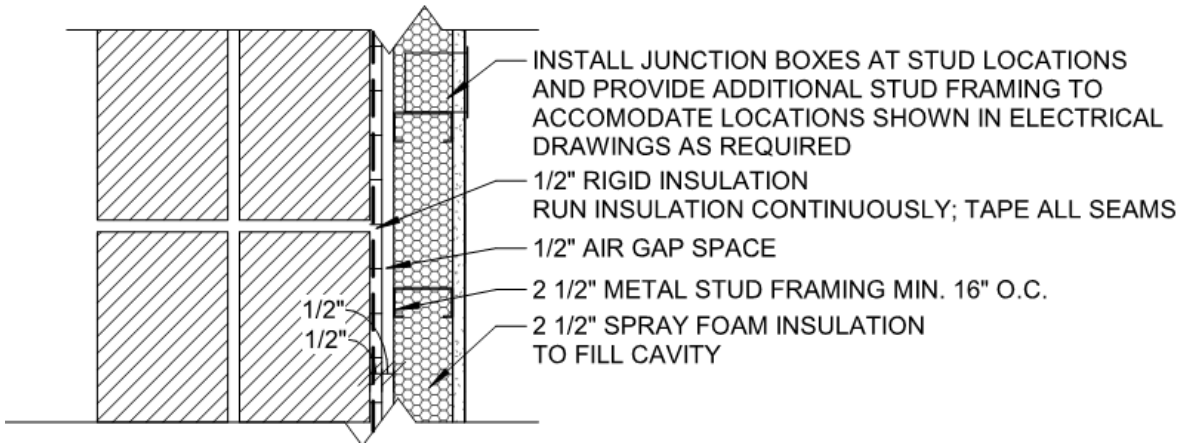
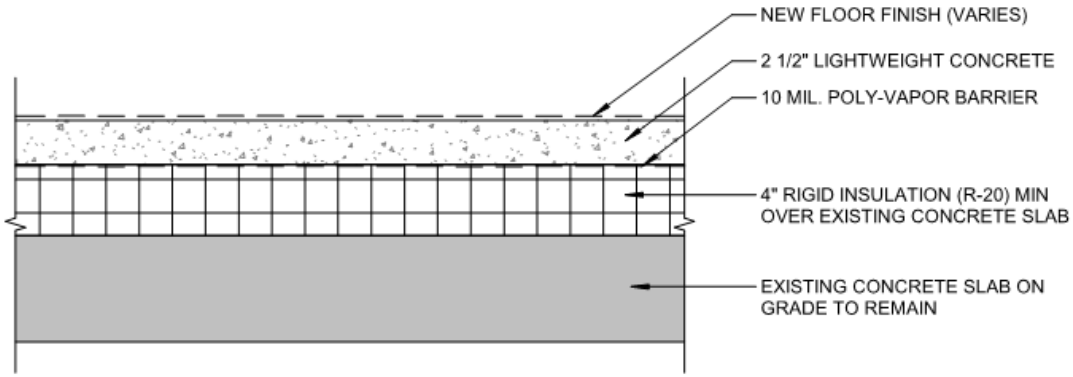


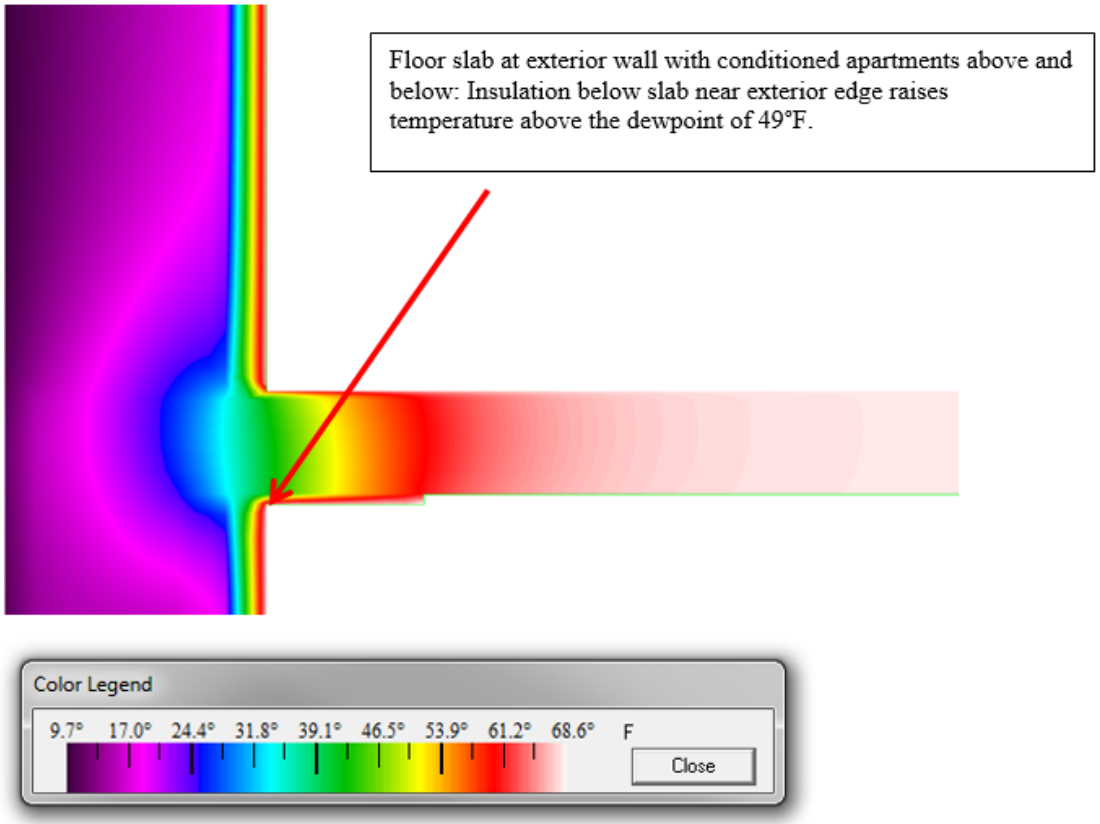
Figure 2. With the exterior walls insulated, the space falls within the ASHRAE 55 comfort zone.

Typical Wall Both Wings & Bsmnt Slab in '64 Wing





Condensation Analysis

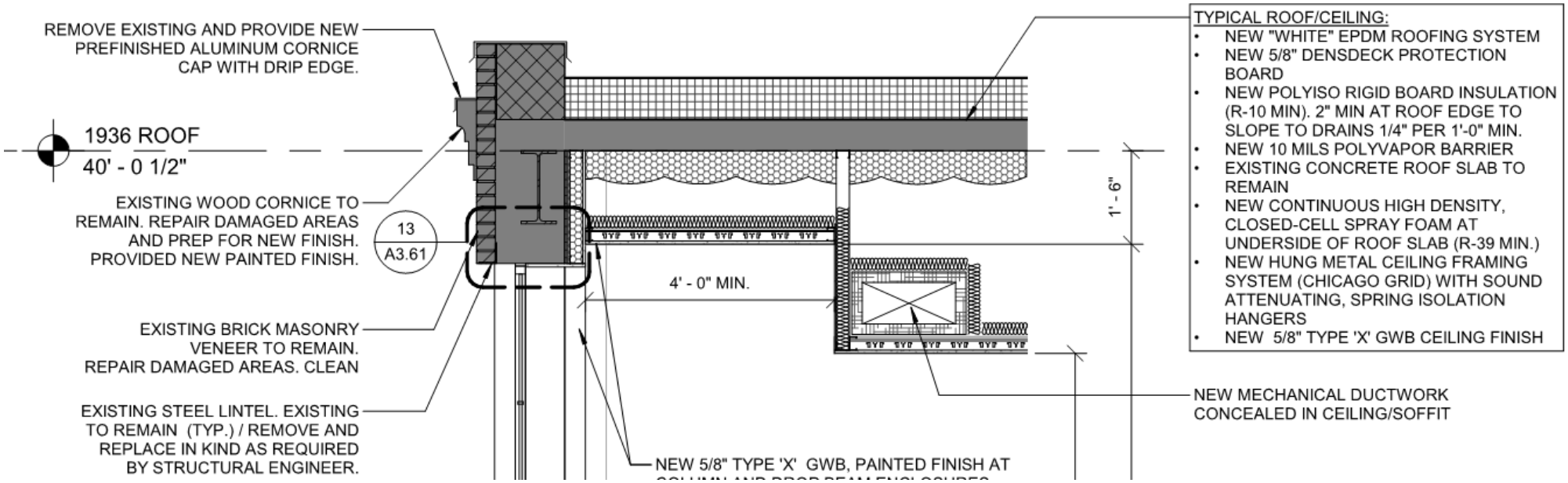


Wall Insulation Being Installed

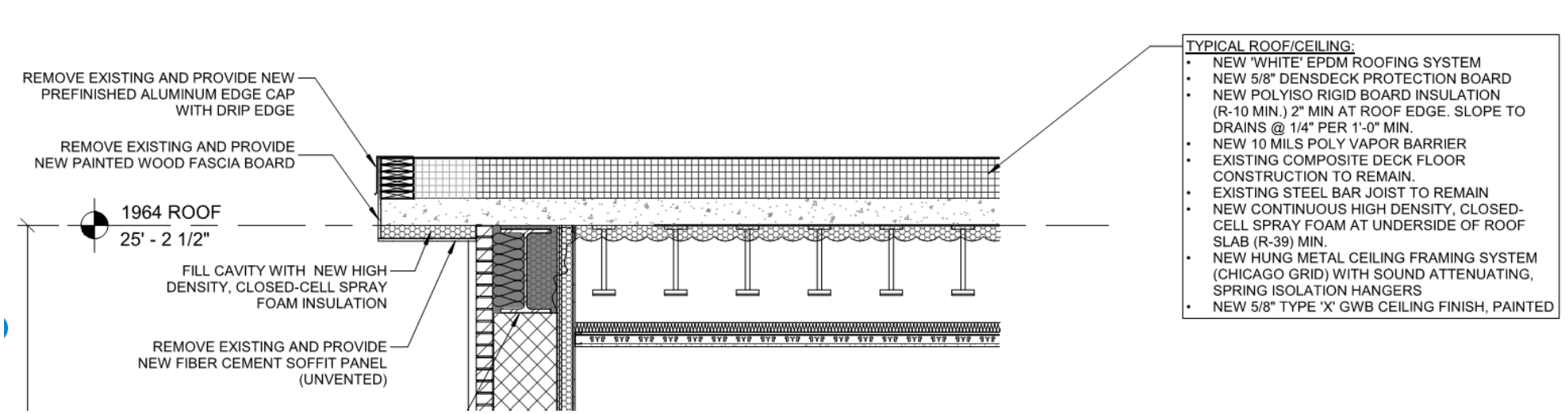




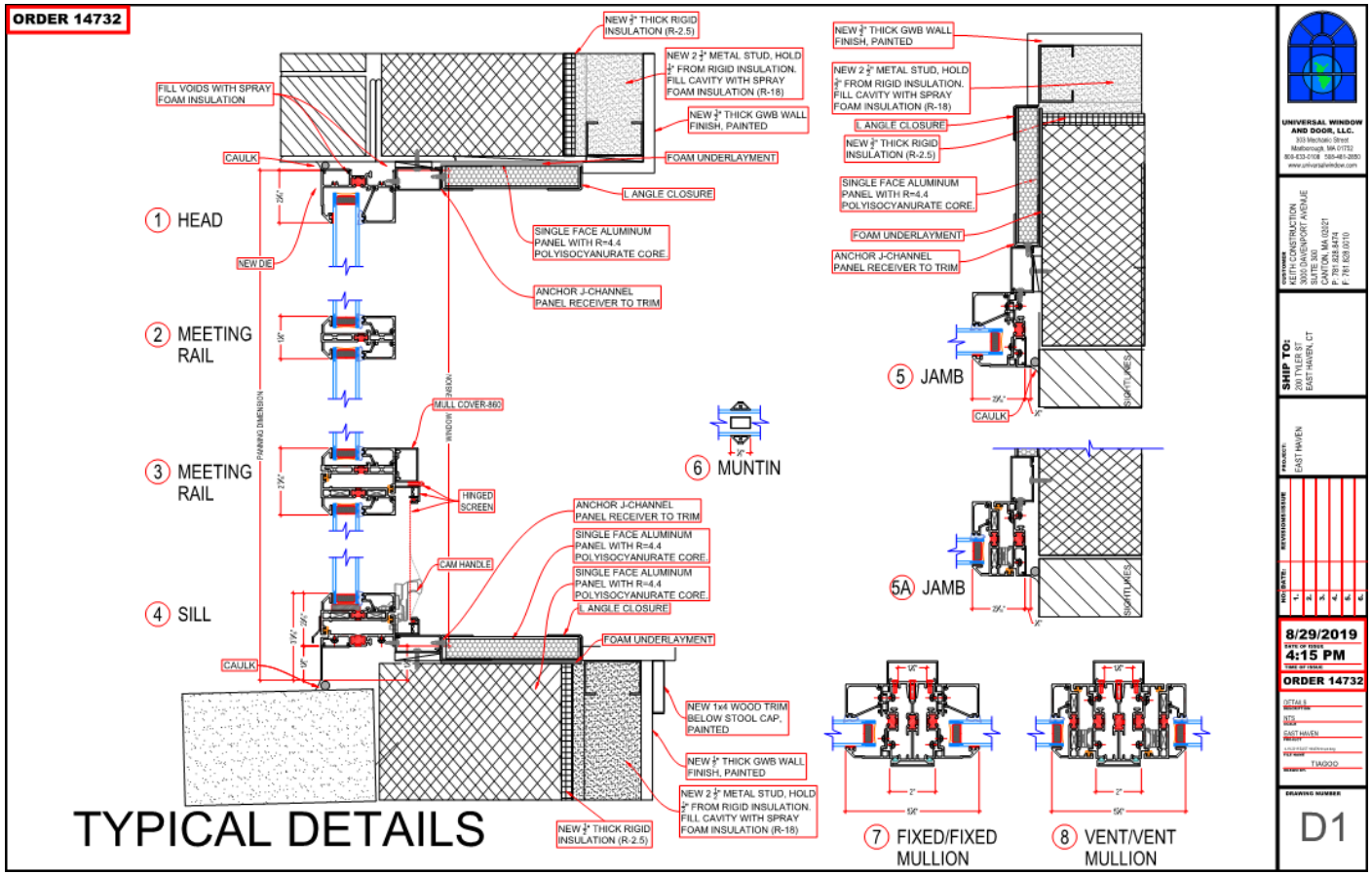
Typical Roof in ’36 Wing



Typical Roof in ’64 Wing



Punched Window Details



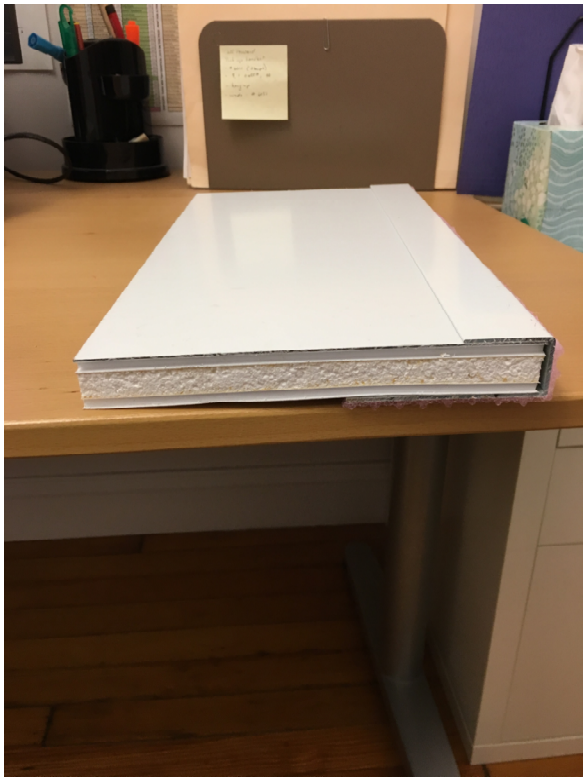
Punched Window Conditions

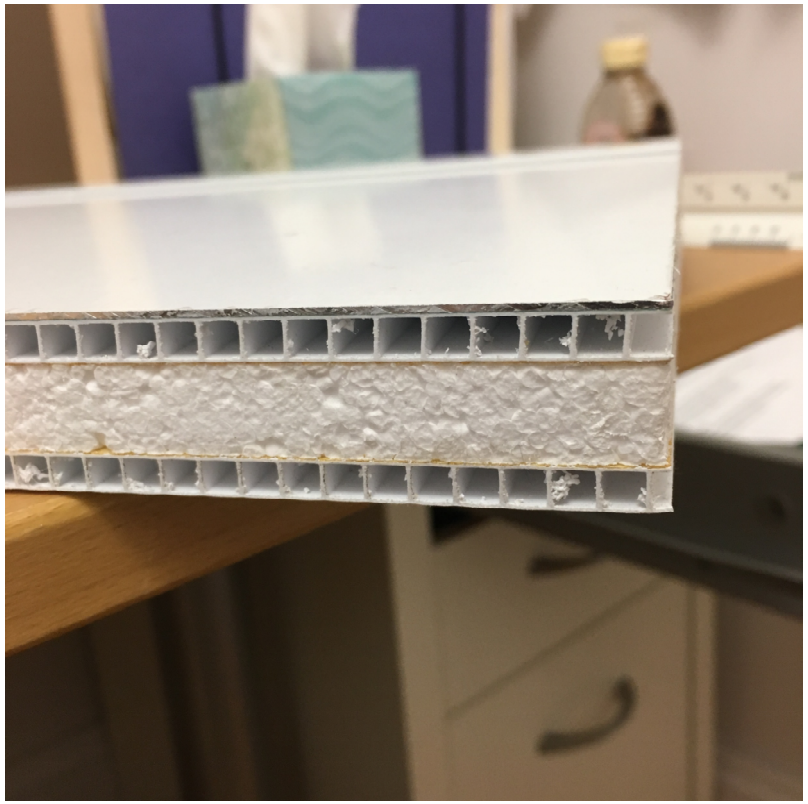






Custom Window Surround





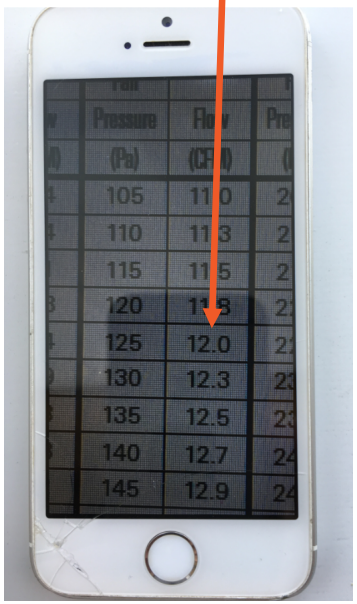


Punched Window Mock-up







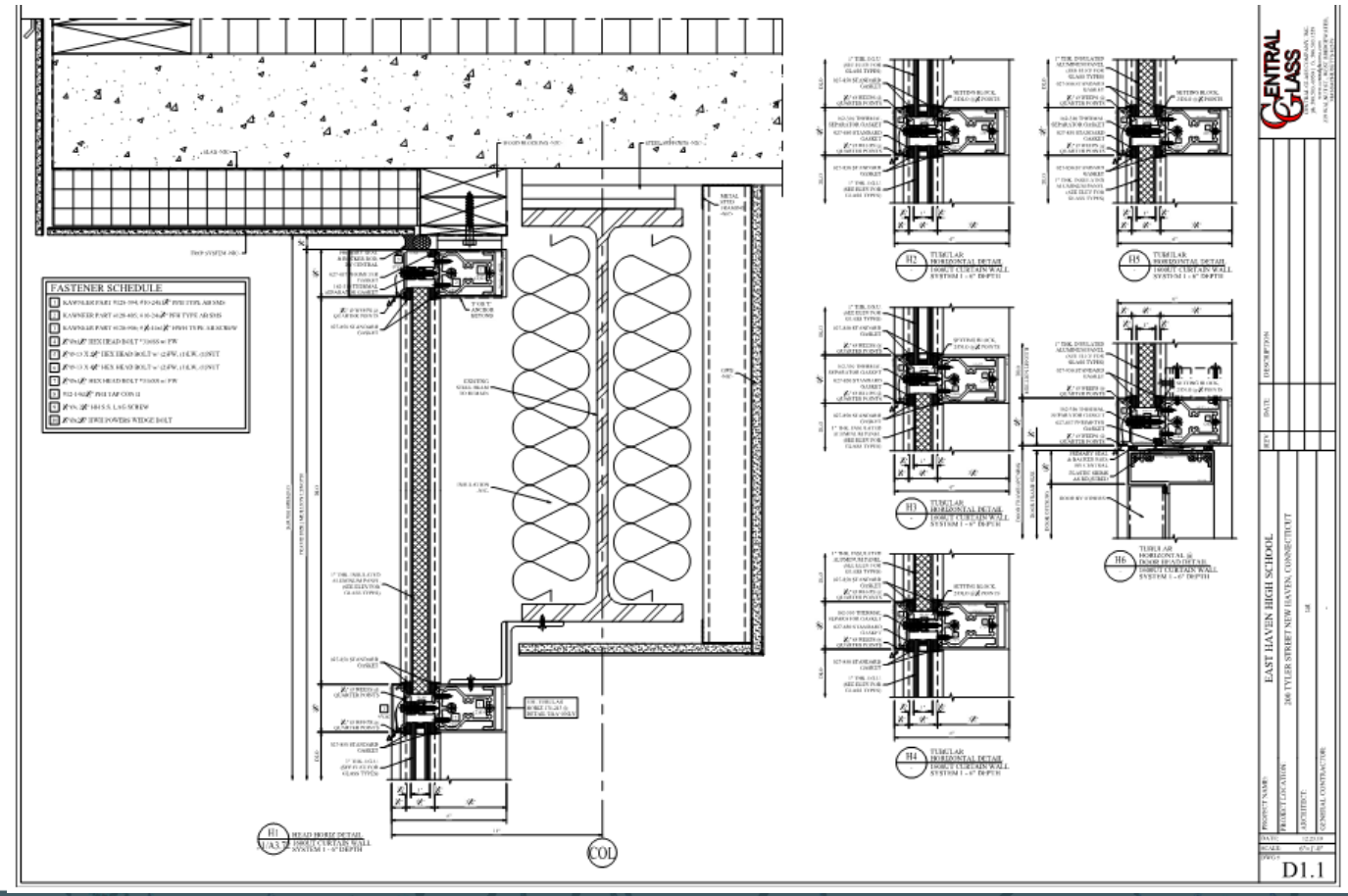


Curtain Wall in ’64 Wing





Curtain Wall Shop Drawings



Curtain Wall Conditions in ’64 Wing







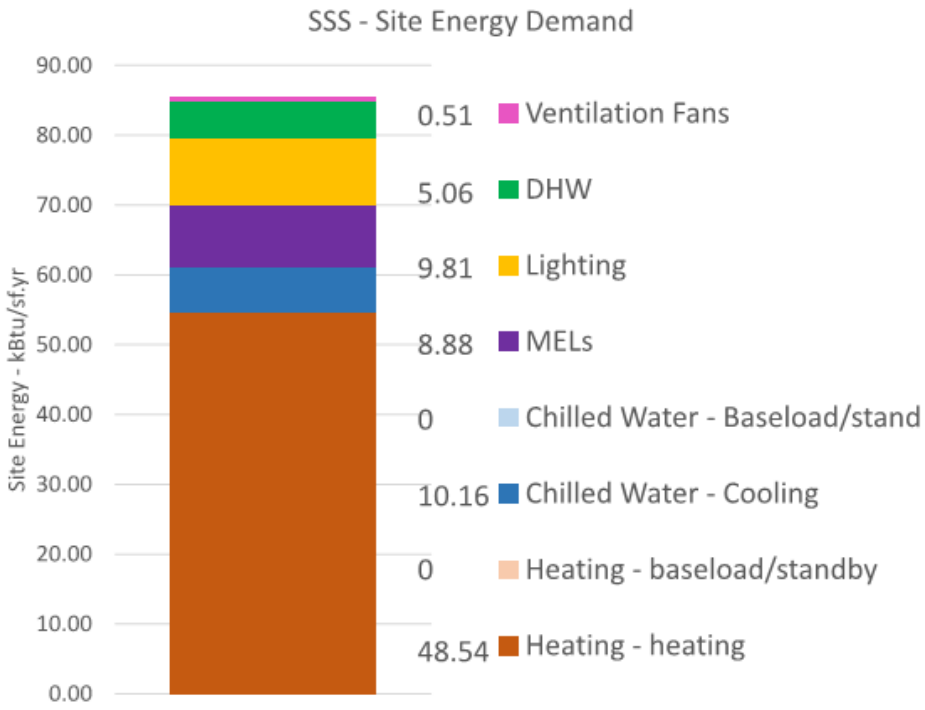
Questions?



Case Studies: Office

Yale




SSS - Site Energy Demand
Site Energy - kBtu/sf.yr
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.51 Ventilation Fans
5.06 DHW
9.81 Lighting
8.88 MELs
0 Chilled Water - Baseload/stand
10.16 Chilled Water - Cooling
0 Heating - baseload/standby
48.54 Heating - heating

Retrofitting for the Future at Yale University



Yale Sustainability Plan 2025

Includes a goal of university carbon neutrality by 2050



Passive House → steep carbon reductions

EnerPHit = Passive House Institute's retrofit standard



Goal: conduct a deep energy retrofit / EnerPHit feasibility study for Sheffield Sterling Strathcona Hall.



Apply major takeaways and principles from this study to all buildings on campus

Sheffield Sterling Strathcona Hall

- Yale - New Haven, CT
- Built in 1931
- Two 4 story wings + a central 11 story tower
- Primarily student and faculty offices
- Has one lecture hall



ICTION PHOTO, 1931

Windows



IMAGE 11: TYPICAL RESTORED PODIUM WINDOWS
(EXTERIOR VIEW)



IMAGE 12: TYPICAL RESTORED PODIUM WINDOWS
(INTERIOR VIEW)

Open Air Wells and Chimneys



IMAGE 9: SHAFT IS OPEN AT THE TOP OF THE TOWER



IMAGE 10: OPEN AIR WELL IS COVERED WITH A METAL GRATE

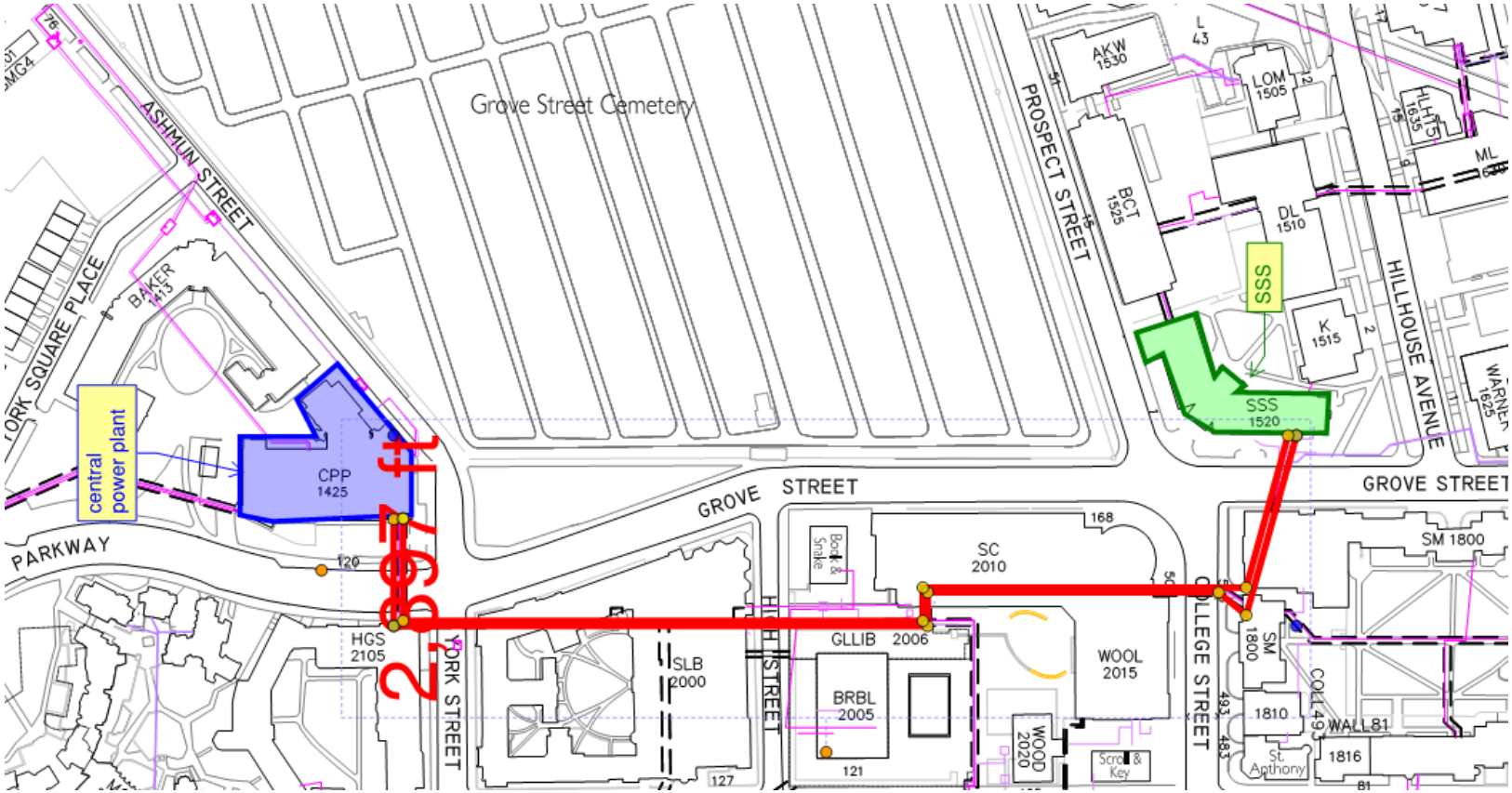
Heating and Cooling



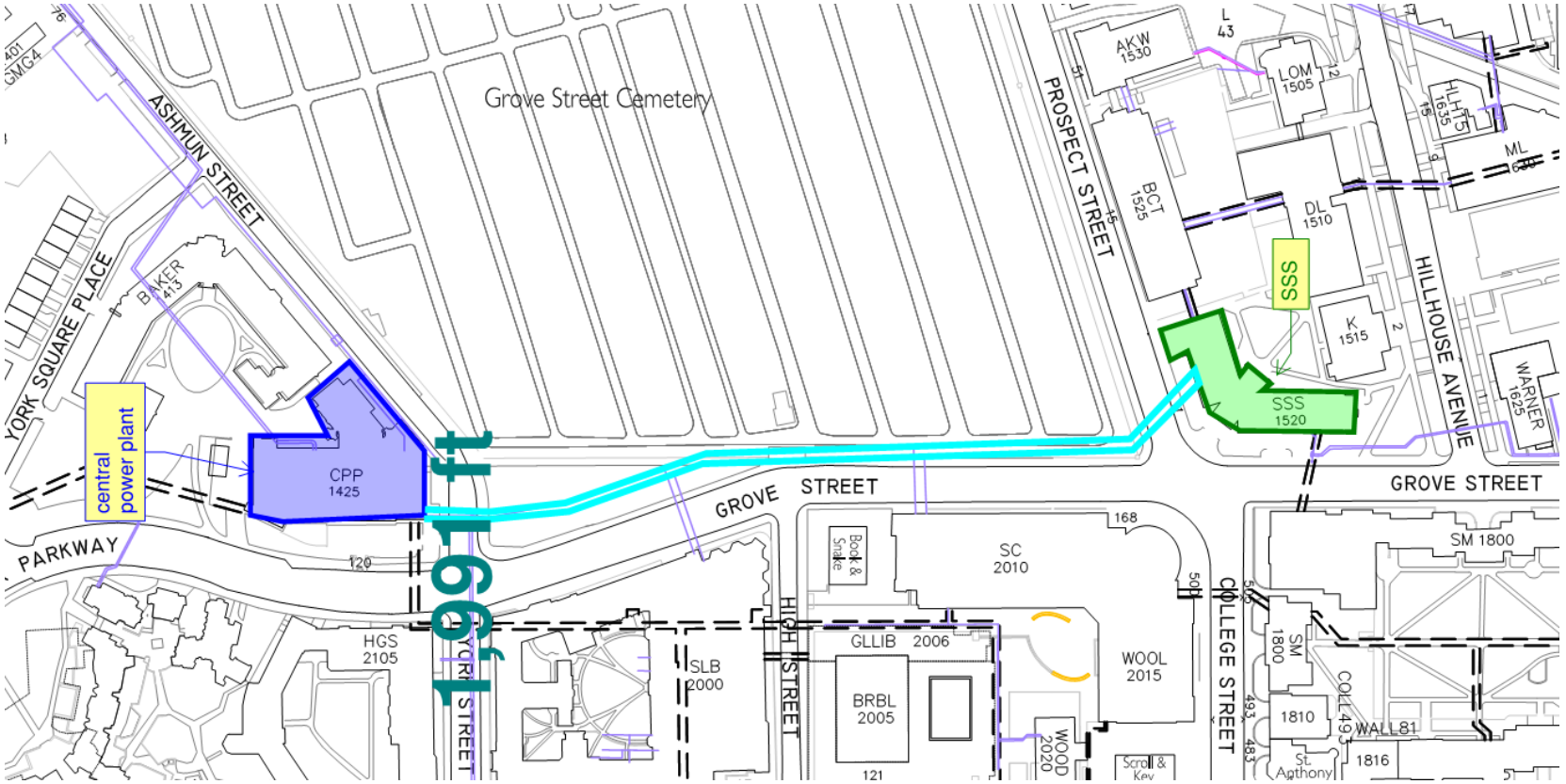
EXAMPLE OF LOCALIZED A/C UNIT LOCATED IN ROOM 403



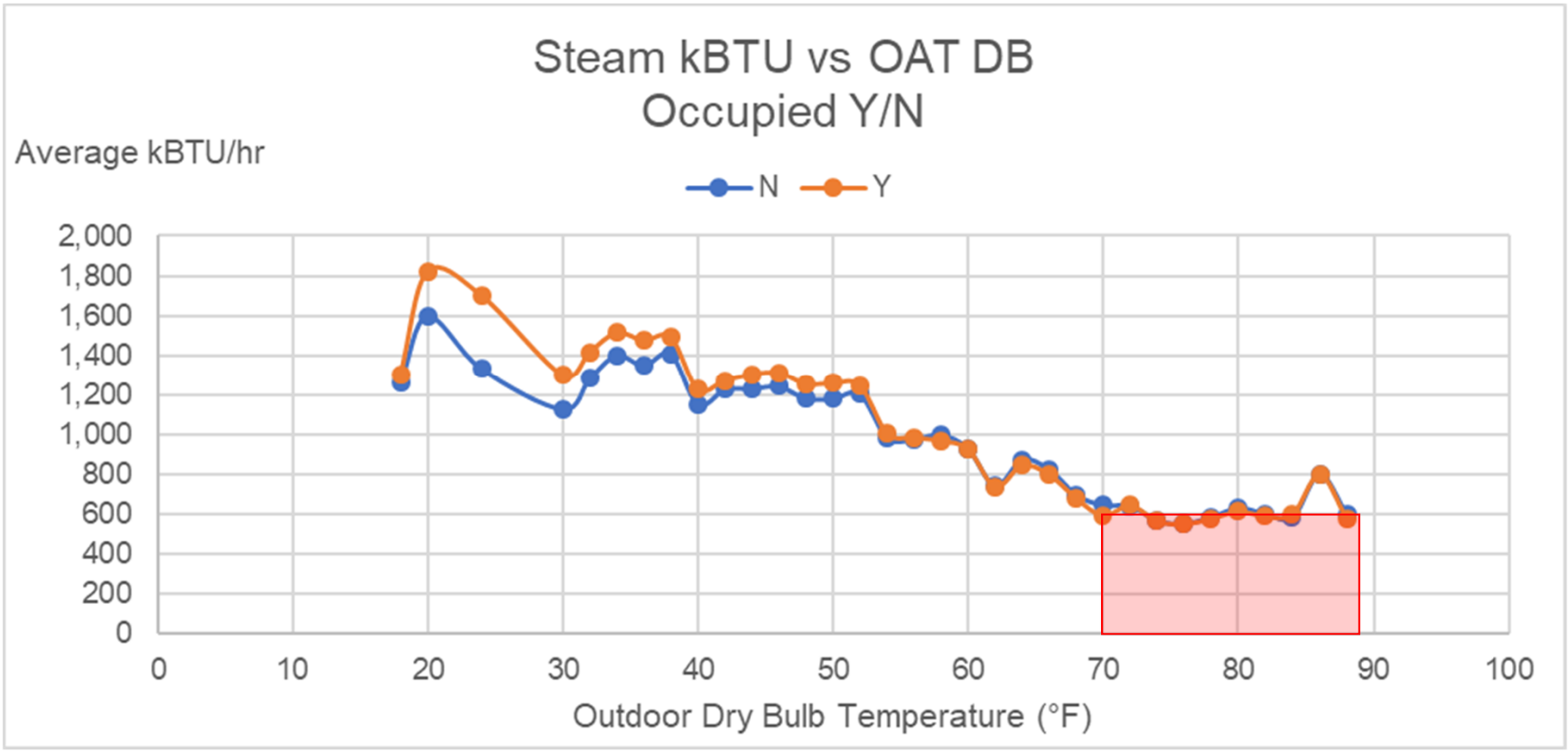
Mechanical – Steam Distribution Piping



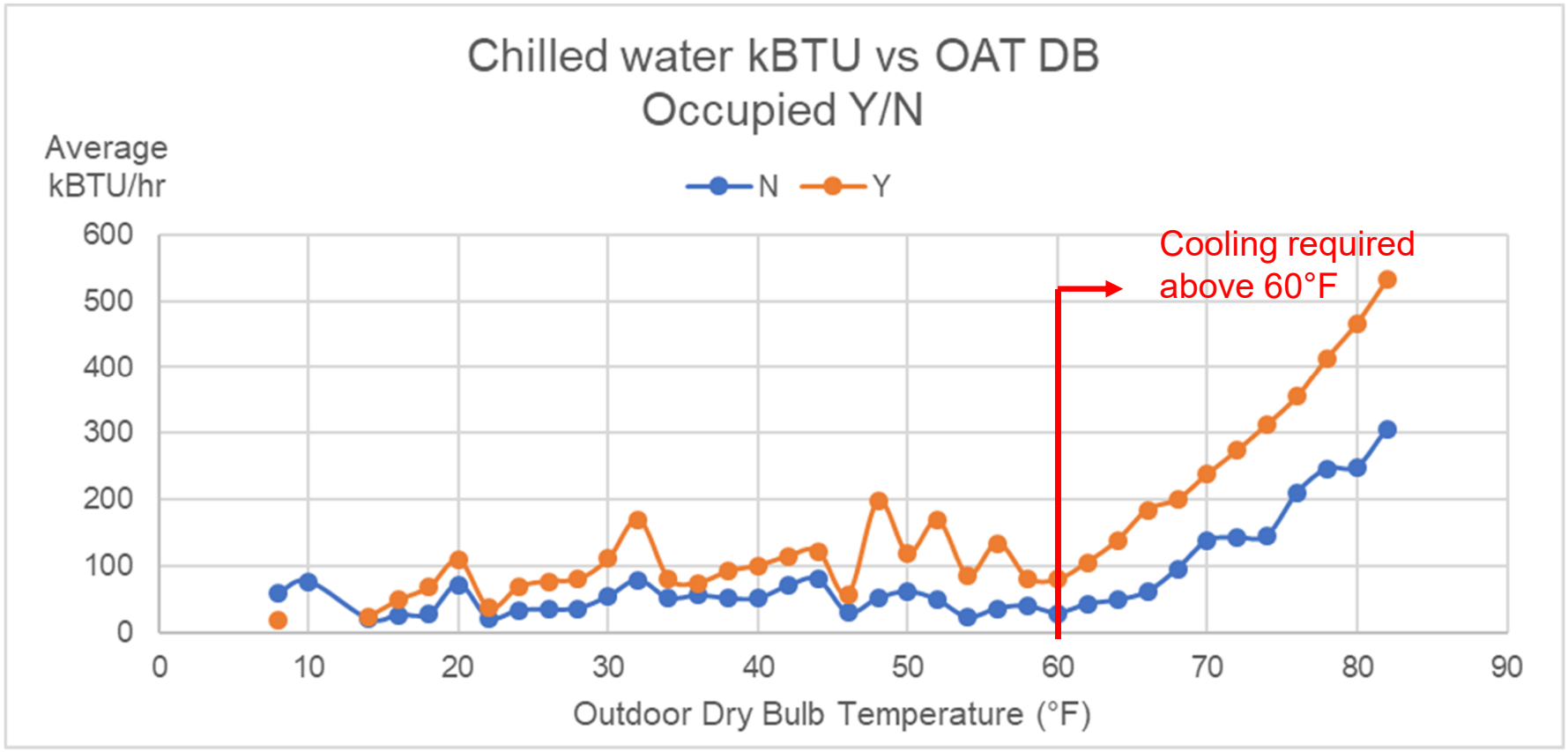
Mechanical – Chilled Water Distribution Piping



Utility Analysis & Model Calibration: Steam



Utility Analysis & Model Calibration: Chilled Water



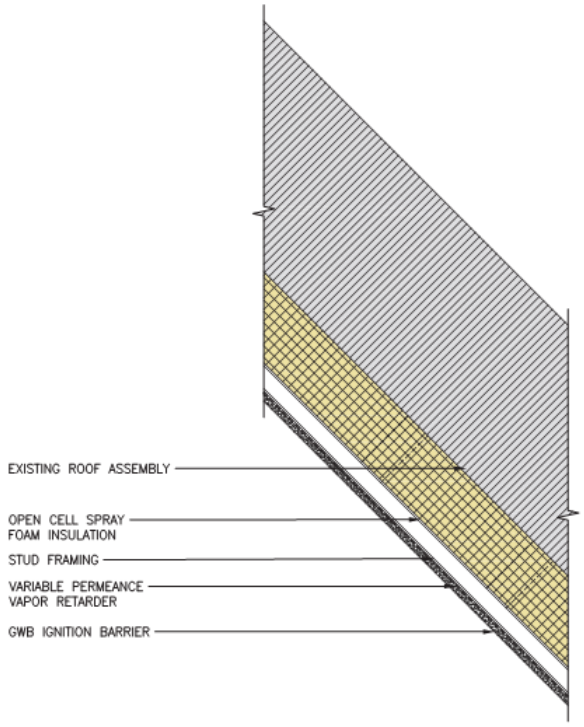
Lighting and Plug Load Reductions

1. LIGHTING
   - ECM-L-01 Occupancy sensors in all spaces, including bi-level lighting controls in main corridors and stairwells
   - ECM-L-03 / 04 LED Interior and Exterior Lighting

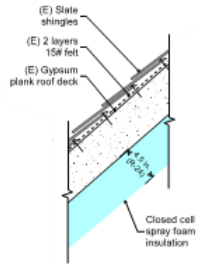
2. PLUG LOADS
   - ECM-PL-01 Replace Desktops with Thin Clients
     - Approx 20% of the University is on "Thin Clients." This % is expected to grow.
   - ECM-PL-02 Eliminate personal HVAC devices
   - ECM-PL-03 Upgrade to Energy Star Refrigerators
   - ECM-PL-04 Eliminate Personal Refrigerators
   - ECM-PL-05 / 06 Reduce Printers & Copiers
     - Yale is also deploying software to reduce paper and energy usage.
   - ECM-PL-07 Energy Star Servers
     - Most central servers are already Energy Star.
   - ECM-PL-08 Eliminate Servers on Site
   - ECM-PL-09 Heat Pump Server Room Cooling
   - ECM-PL-10 Smart Outlets



Roof Insulation



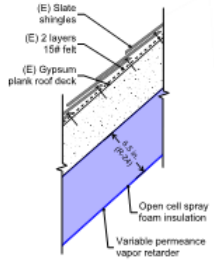
ECM-R-02 OPEN-CELL SPRAY-FOAM INSULATION TO UNDERSIDE OF EXISTING ROOF ASSEMBLY



CLOSED CELL SPRAY FOAM

- We modeled the assembly with R-24 or R-36 closed cell spray foam. Results below are for the north facing case with R-24 closed cell spray foam insulation (Results for R-36 insulation show ~2% higher RH in the gypsum deck).
- Temperature at underside of gypsum deck falls below interior air dew point for roughly 3 months during winter (insulation introduces freeze-thaw cycles).
- Relative humidity within gypsum deck exceeds 80% for approximately 6 months (peaks at 85%RH).

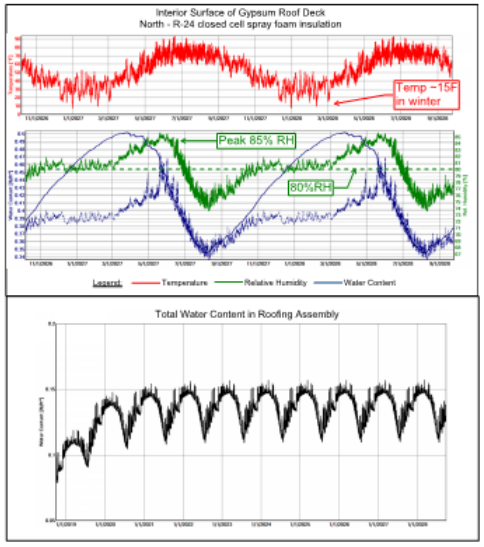
High potential for moisture accumulation and condensation

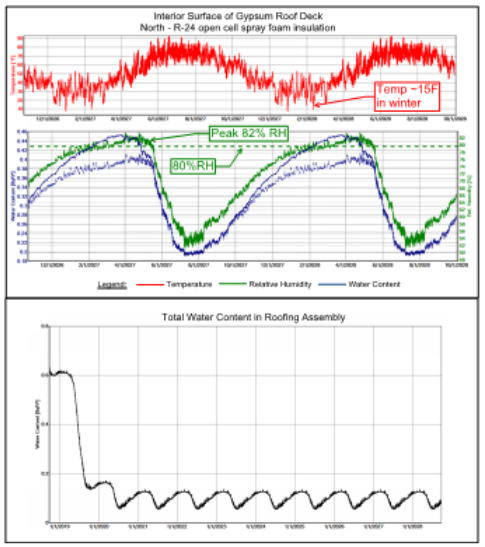


OPEN CELL SPRAY FOAM + VARIABLE VAPOR PERMEANCE MEMBRANE

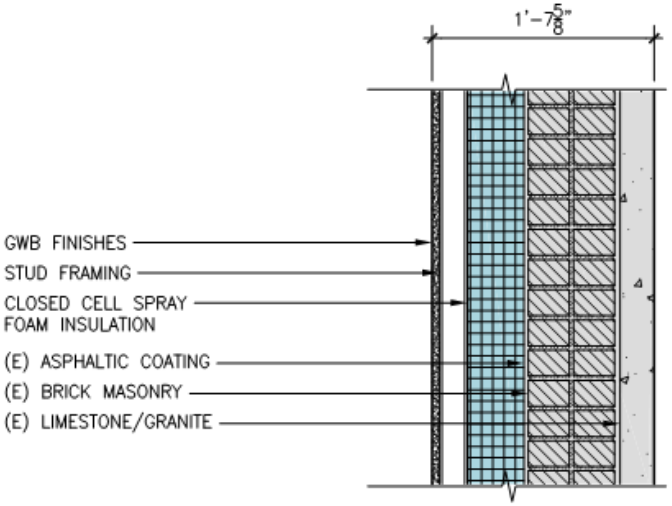
- We modeled the assembly with R-24 open cell spray foam and a variable vapor permeance membrane.
- Temperature at underside of gypsum deck falls below interior air dew point for roughly 3 months during winter (insulation introduces freeze-thaw cycles).
- Relative humidity within gypsum deck exceeds 80% for approximately 3 months (peaks at 82%RH).

High potential for moisture accumulation and condensation

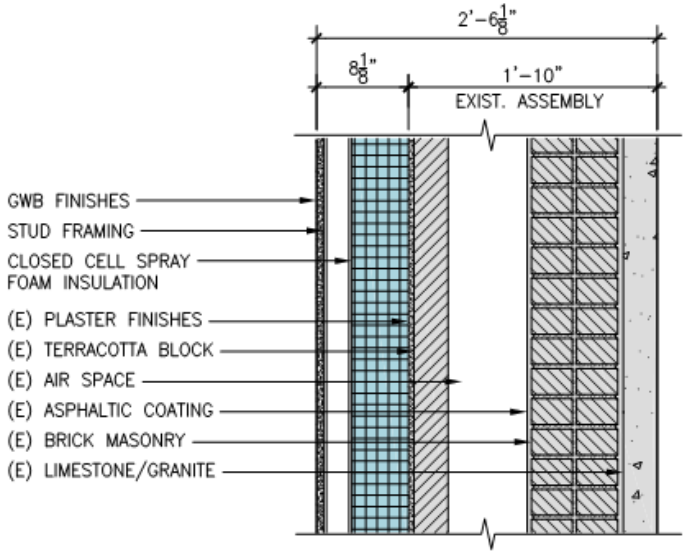




Wall Insulation



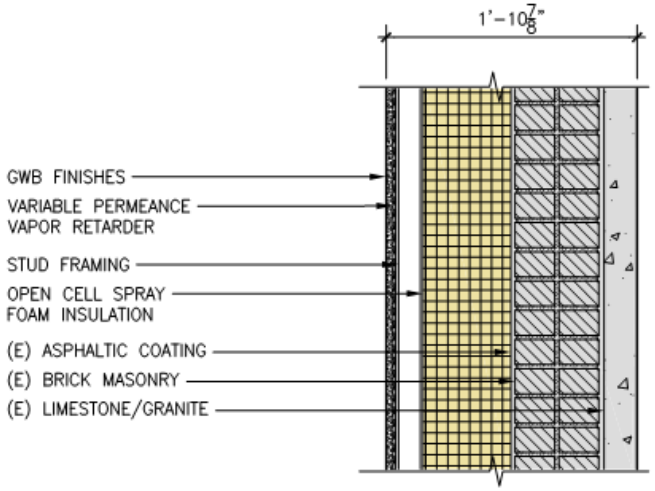
ECM-EW-01: CLOSED-CELL SPRAY-FOAM INBOARD OF EXISTING BRICK MASONRY



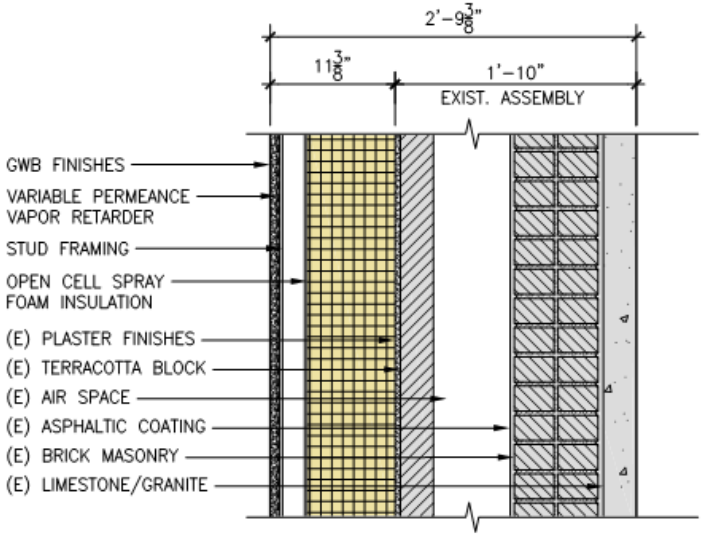
ECM-EW-02: CLOSED-CELL SPRAY-FOAM INBOARD OF EXISTING PLASTER FINISHES

Source: FXCollaborative

Wall Insulation



ECM-EW-03: OPEN-CELL SPRAY-FOAM INBOARD OF EXISTING BRICK MASONRY



ECM-EW-04: OPEN-CELL SPRAY-FOAM INBOARD OF EXISTING PLASTER FINISHES

Source: FXCollaborative

Wall Insulation: Moisture Analysis

Graph Notes:

- We modeled the wall assembly facing north and south. Graphs show the north facing cases as these were the worst-case for temperatures and brick saturation.

- Models assume no bulk water leakage through the assembly.

- % Saturation is the amount of water vapor that is adsorbed into brick compared to the maximum it can hold, expressed as a percent.

- 10 yr simulation performed, but only last year of data shown is for clarity.

Legend:

- Existing
- Closed Cell (R-24) Installed Directly onto brick (no terra cotta, plaster or air gap)
- Closed Cell (R-30) Installed Directly onto brick (no terra cotta, plaster or air gap)
- Closed Cell (R-24) Installed over terra cotta and plaster (air gap remains)
- Closed Cell (R-30) Installed over terra cotta and plaster (air gap remains)
- Open Cell w/VVR (R-24) Installed directly onto brick (no terra cotta, plaster or air gap)
- Open Cell w/VVR (R-24) Installed over terra cotta and plaster (air gap remains)

Overall Findings:

1. Percent saturation and moisture storage capacity depends highly on specific hygroscopic properties of brick, which are unknown. We estimated properties for this study based on historic masonry materials in WUFI's database, but recommend testing material samples for an actual project. For example, if critical saturation is 2% or higher, then these models show all options are viable.
   - Another option to consider is to measure the existing moisture content of the brick and calibrate models to those conditions.

2. Existing interior brick is warmer than dew point and does not experience freezing temperatures in winter. Adding spray foam insulation blocks interior heat, introduces freeze-thaw cycles, and lowers surface temperature below dew point. Since spray foam can shrink, interior air may reach cold brick surface and condense.

3. Open cell is more vapor permeable than closed cell, so saturation is not as high. The variable permeance vapor retarder helps prevent outward vapor drive during winter, while allowing summertime drying to the interior.

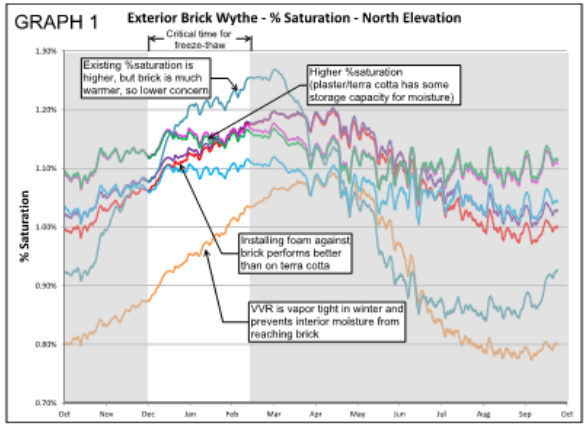
Recommendations:

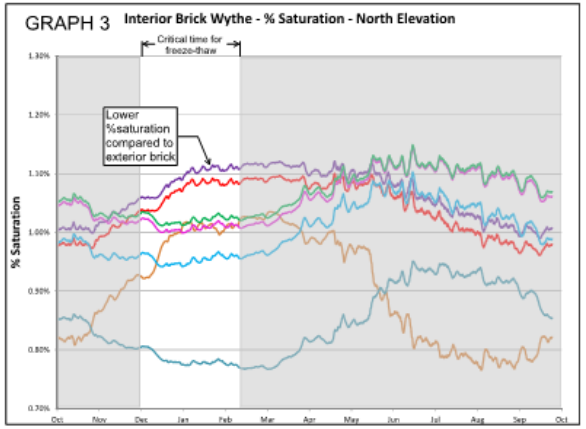
1. Test brick samples to obtain material properties - confirm critical saturation point for brick.

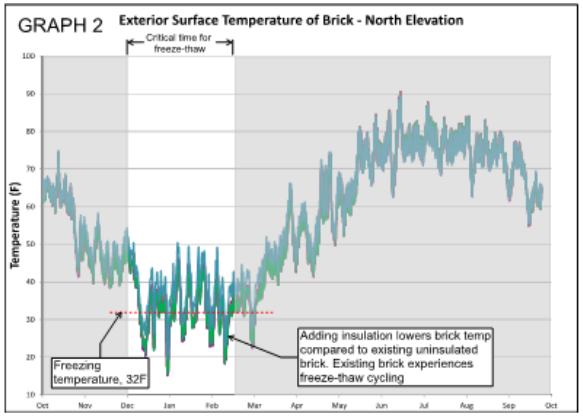
2. Perform hygrothermal analysis to confirm brick saturation levels that are lower than critical saturation point.

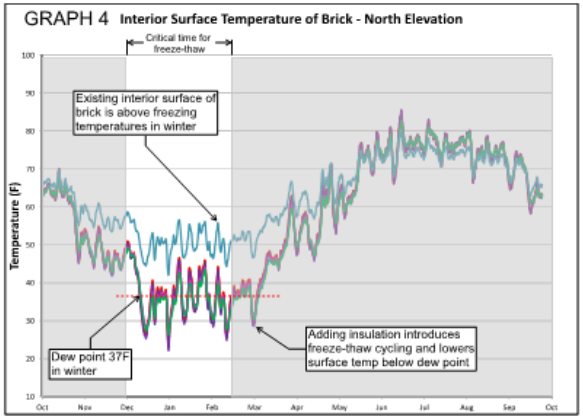
3. Install spray foam directly against the brick. If air gap remains, high risk for air flow/condensation in the cold cavity, but also for pipes to freeze. With spray foam directly against brick, provide an interior service cavity to limit penetrations through spray foam and variable vapor permeance membrane.

4. For the purpose of EnerPHit study, we recommend proceeding with open cell spray foam insulation with a variable permeance vapor retarder installed directly against the brick (i.e., remove terra cotta and interior plaster).









Wall Insulation: Moisture Analysis

Overall Findings:

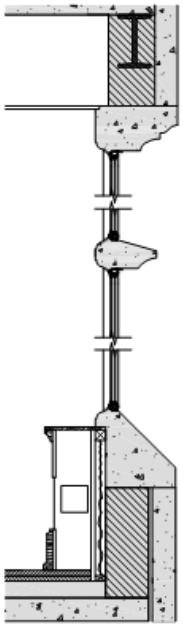
1. Percent saturation and moisture storage capacity depends highly on specific hygroscopic properties of brick, which are unknown. We estimated properties for this study based on historic masonry materials in WUFI's database, but recommend testing material samples for an actual project. For example, if critical saturation is 2% or higher, then these models show all options are viable.
   - Another option to consider is to measure the existing moisture content of the brick and calibrate models to those conditions.

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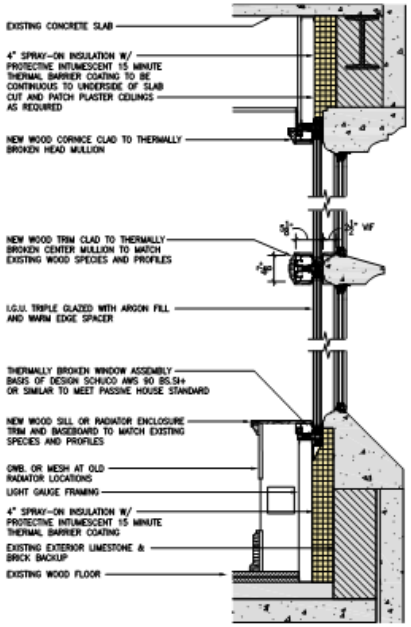
3. Open cell is more vapor permeable than closed cell, so saturation is not as high. The variable permeance vapor retarder helps prevent outward vapor drive during winter, while allowing summertime drying to the interior.

Window Recommendations

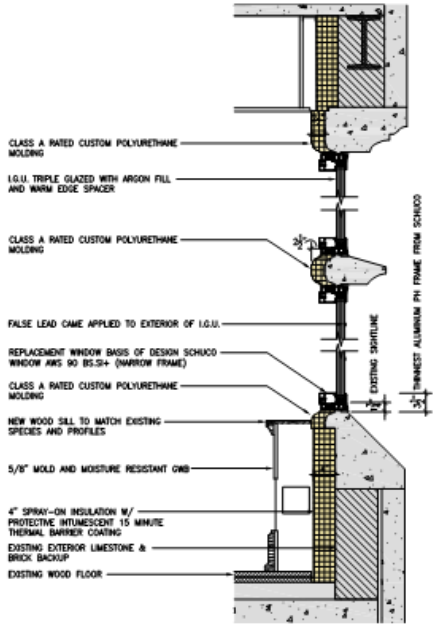
PODIUM WINDOW ECMs



EXISTING
SINGLE GLAZED
WITH STORM



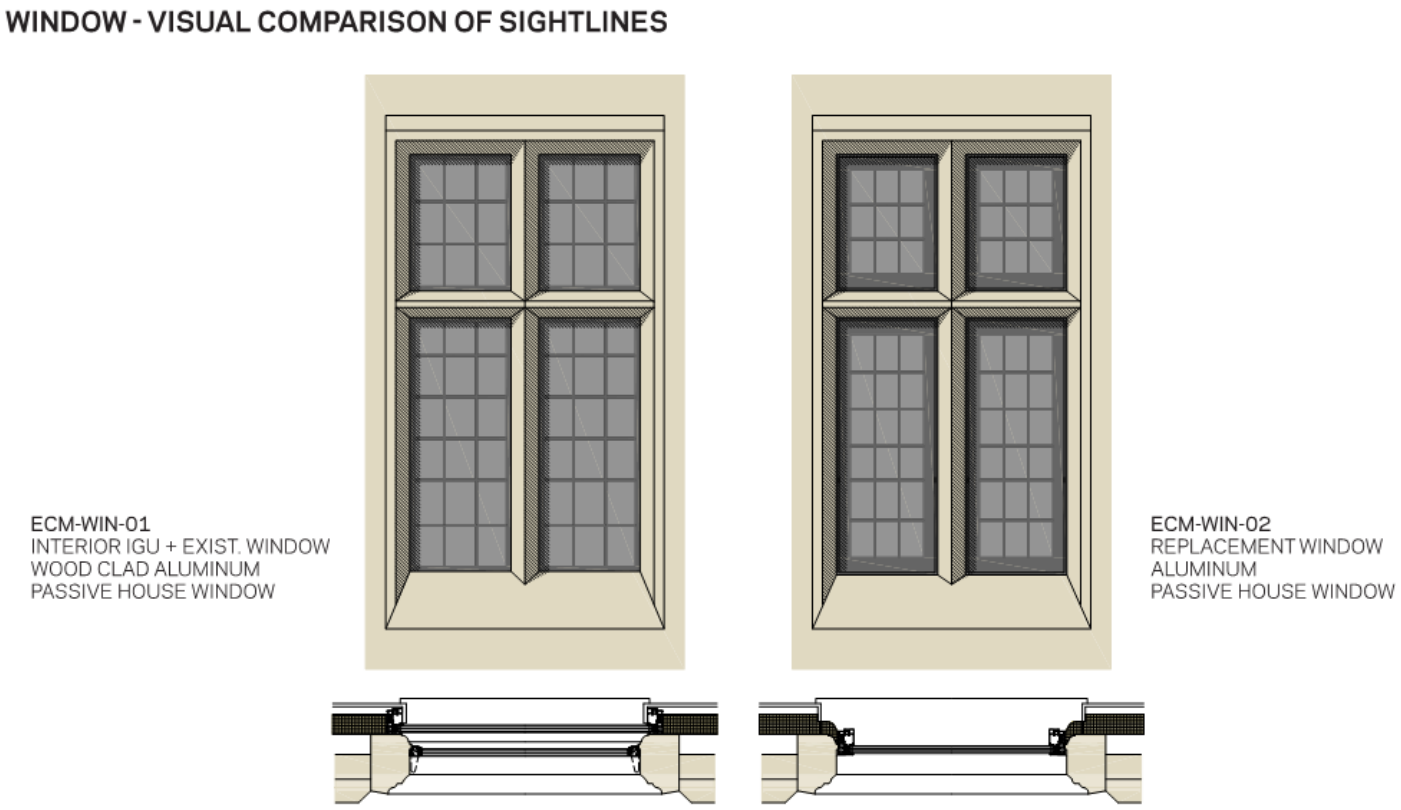
ECM-WIN-01
INTERIOR IGU + EXISTING WINDOW
WOOD CLAD ALUMINUM PASSIVE HOSUE



ECM-WIN-02
REPLACEMENT WINDOW
ALUMINUM PASSIVE HOUSE

Source: FXCollaborative

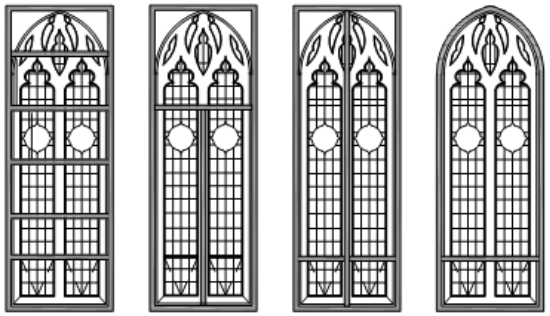
Window Recommendations



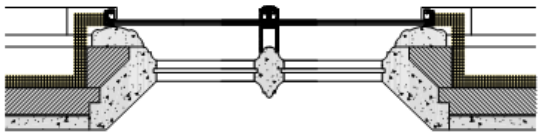
Source: FXCollaborative

Window Recommendations

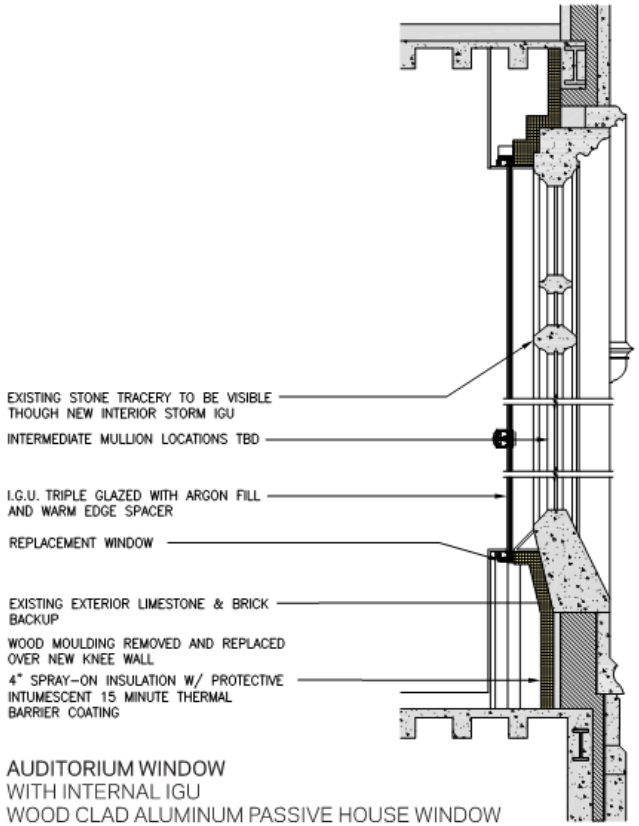
WINDOW - AUDITORIUM



ELEVATION SUBDIVISION STRATEGIES



PLAN DIAGRAM



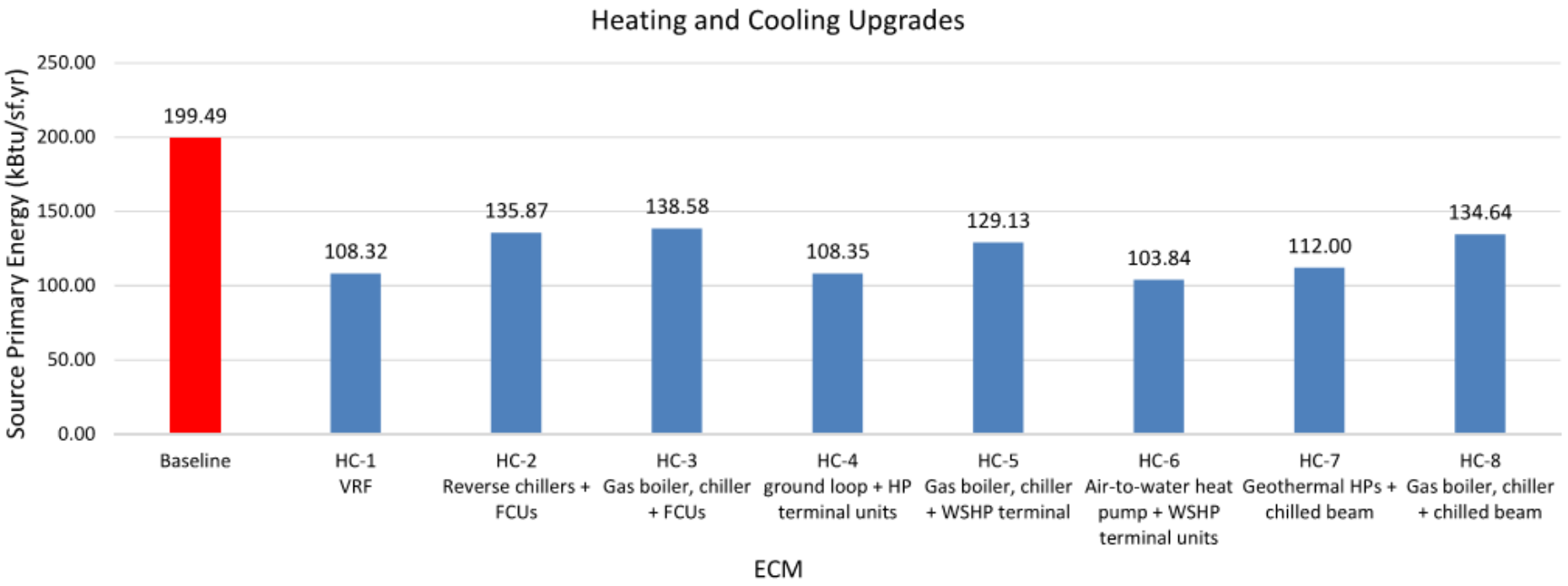
AUDITORIUM WINDOW
WITH INTERNAL IGU
WOOD CLAD ALUMINUM PASSIVE HOUSE WINDOW

Source: FXCollaborative

HVAC Options

Heating and Cooling Legend: Good Moderate Fair	Impact on PHPP Model	Impact on Carbon Reduction	Aesthetics	Occupant Disruption	Occupant Comfort / Noise	Constructability	Flexibility of Design	Equipment Durability	Condensation Potential / Interior Humidity Control	Code / Fire
Option 1: Add Variable Refrigerant Flow System (VRF) (ECM-HC-1)	🟢	🟢	🟡	🟡	🟢	🟢	🟢	🔴	🟢	🟡
Option 2: Switch steam radiators to fan coil units and use reverse cycle chillers (ECM-HC-2)	🟢	🟢	🟡	🔴	🟢	🟡	🟡	🟢	🟢	🟢
Option 3: Add water sourced heat pumps in interior spaces w/ ground-source water loop (ECM-HC-3)	🟢	🟢	🟡	🟡	🟡	🟡	🟢	🟢	🟢	🟢

HVAC Options: Estimated Savings



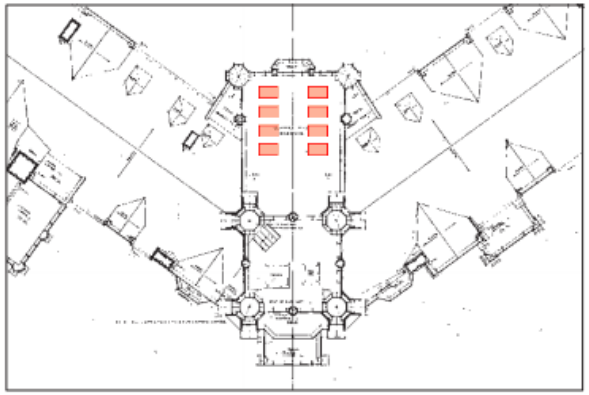
HVAC Option 1

VRF AIR SOURCE HEAT PUMPS — VRF TERMINAL UNITS — DECENTRAL

IMPLEMENTATION:



ROOF PART PLAN:



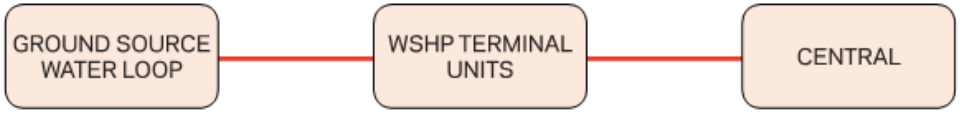
PROS:

- BEST FOR PHASING
- MULTIPLE OPTIONS FOR TERMINAL UNITS
- PERIMETER HEATING CAN BE MAINTAINED DURING RETROFIT
- MOST SIZING OPTIONS, UNITS AS SMALL AS 1/3 TON
- HEAT RECOVERY WOULD ALLOW FOR SIMULTANEOUS HEATING AND COOLING

CONS:

- MORE DIFFICULT TO MODIFY / EXPAND IN FUTURE RENOVATIONS
- FILTERS IN EACH ROOM
- CODE RESTRICTIONS ON REFRIGERANT QUANTITY AND PIPING LOCATIONS
- HEAT RECOVERY REQUIRES ADDITIONAL REFRIGERANT LINES
- REFRIGERANT TYPES BECOMING OBSOLETE WITH NEW POLICIES
- IF EQUIPMENT NEEDS REPLACEMENT, REFRIGERANT MAY NEED TO BE CHANGED
- WOULD NEED TO RUN ELECTRICAL (220V) TO ALL TERMINAL UNITS

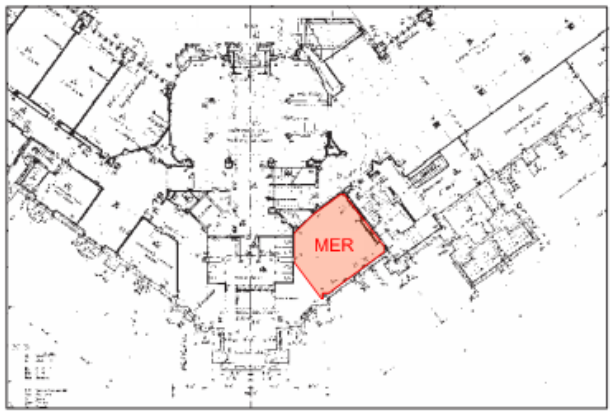
HVAC Option 2



IMPLEMENTATION:



BASEMENT PART PLAN:



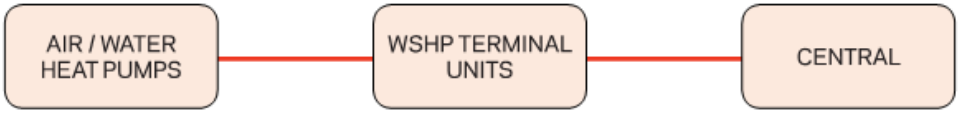
PROS:

- SECOND-BEST EUI REDUCTION
- FLEXIBILITY IN TERMINAL UNITS (FLOOR UNITS, CEILING MOUNTED, VERTICAL UNITS IN CABINETS)
- IMPROVED COLD WEATHER PERFORMANCE SINCE HEAT PUMP IS INSIDE
- POTENTIAL FOR "FREE" SHOULDER SEASON OPERATION
- NO EQUIPMENT VISIBLE ON EXTERIOR
- SINGLE PIPE WATER LOOP THROUGH BUILDING

CONS:

- WELL QUANTITY AND VIABILITY STILL T.B.D.
- REQUIRES HIGH INITIAL COST
- PHASING IS CHALLENGING
- PUMPING ENERGY FOR WATER LOOPS
- LOCAL HEAT PUMPS MAY BE NOISIER THAN OTHER OPTIONS
- REFRIGERANT IN CENTRAL AND LOCAL HEAT PUMPS
- FILTERS IN EACH ROOM
- WOULD NEED TO RUN ELECTRICAL (220V) TO ALL TERMINAL UNITS

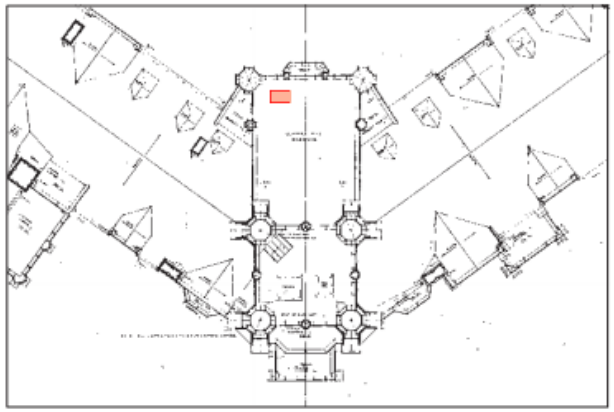
HVAC Option 3



IMPLEMENTATION:



ROOF PART PLAN:



PROS:

- BEST EUI REDUCTION
- FLEXIBILITY IN TERMINAL UNITS (FLOOR UNITS, CEILING MOUNTED, VERTICAL UNITS IN CABINETS)
- POTENTIAL FOR "FREE" SHOULDER SEASON OPERATION
- REQUIRES THE LEAST PHYSICAL SPACE: ONE 4'X6' EXTERIOR HEAT PUMP
- SINGLE PIPE WATER LOOP THROUGH BUILDING

CONS:

- LOCAL HEAT PUMPS MAY BE NOISIER THAN OTHER OPERATIONS
- PHASING IS CHALLENGING
- WOULD NEED TO RUN ELECTRICAL (220V) TO ALL TERMINAL UNITS"
- REFRIGERANT IN CENTRAL AND LOCAL HEAT PUMPS
- FILTERS IN EACH ROOM

SSS – EnerPHit Design Recommendations
Phasing Considerations



1. SUITE



2. FLOOR

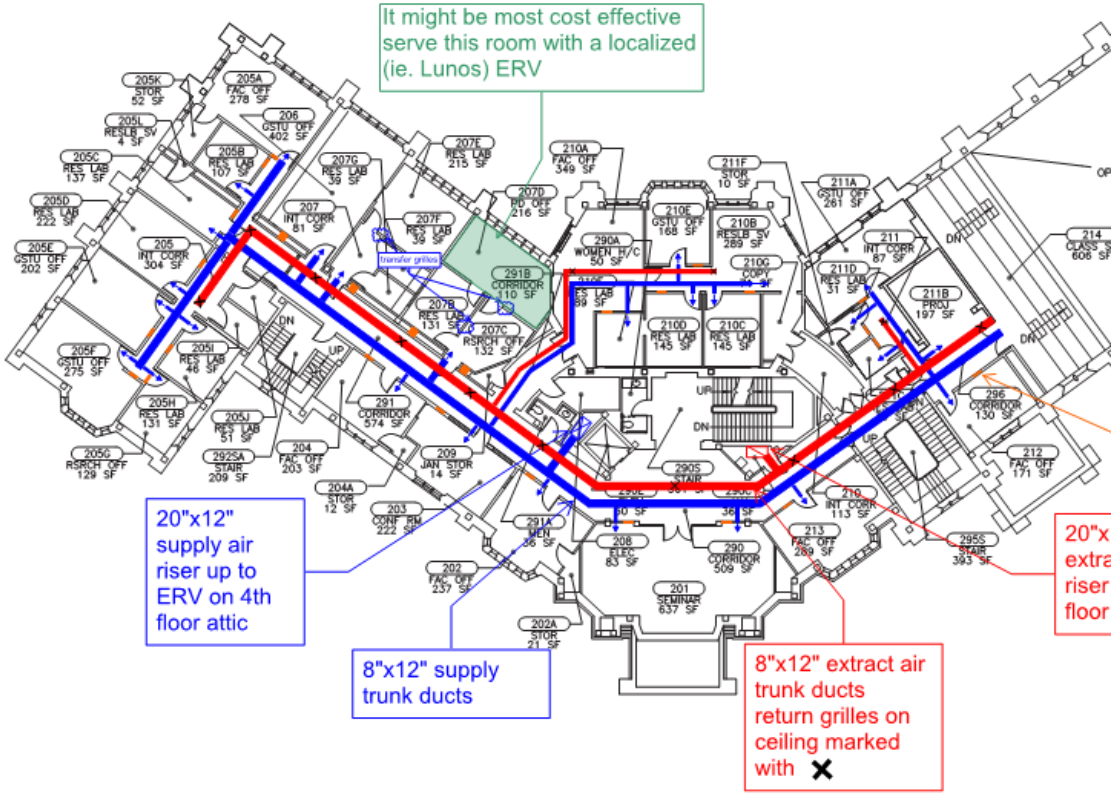


3. WING

Ventilation Options

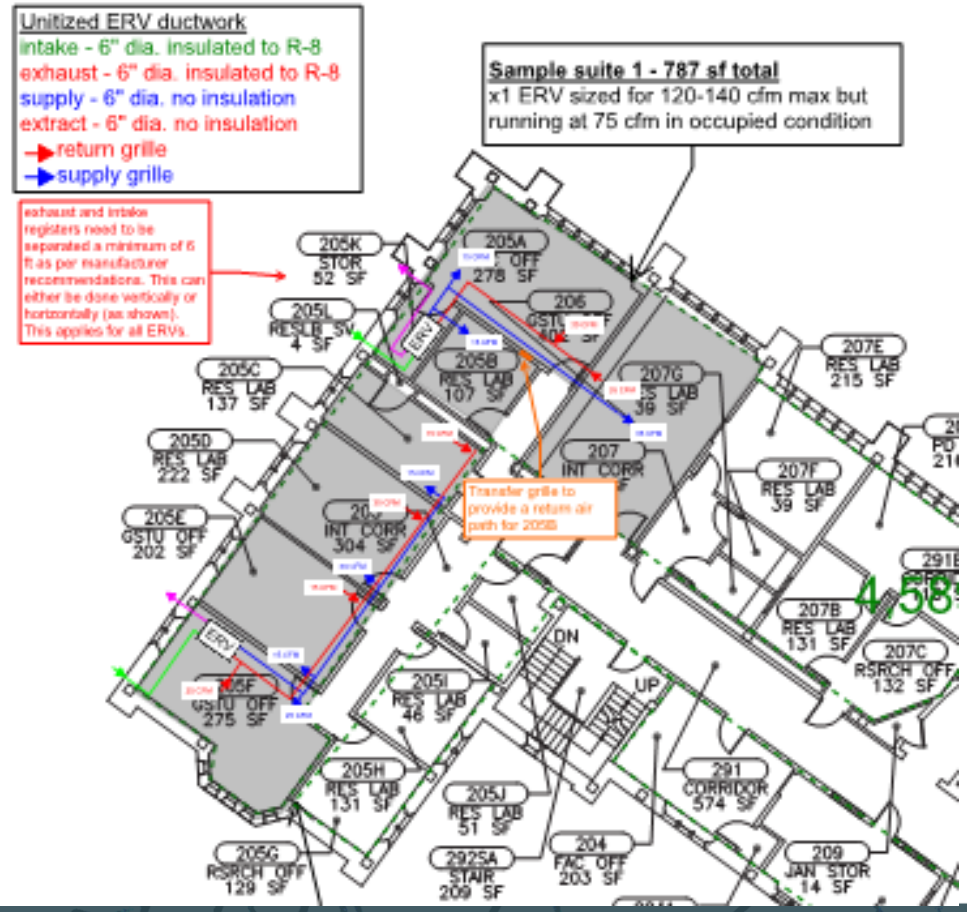
Ventilation Legend: Good Moderate Fair	Impact on PHPP Model	Impact on Carbon Reduction	Aesthetics	Occupant Disruption	Occupant Comfort / Noise	Constructability	Flexibility of Design	Equipment Durability	Condensation Potential / Interior Humidity Control	Code / Fire
Option 1: Add semi-centralized energy recovery ventilators (ECM-V-1)	●	●	●	●	●	●	●	●	●	●
Option 2: Add de-centralized energy recovery ventilators (ECM-V-2)	●	●	●	●	●	●	●	●	●	●
Option 3: Use Lunos de-centralized ERV for tower spaces and offices where ductwork is challenging to run (ECM-V-3)	●	●	●	●	●	●	●	●	●	●
Option 4: Add CO2 controls for demand control ventilation (ECM-V-4)	●	●	●	●	●	●	●	●	●	●

Ventilation: Centralized Strategy



TYPICAL CENTRAL DUCTWORK STRATEGY

Ventilation: Decentralized Strategy



BAU vs. EnerPHit

TYPICAL COMPREHENSIVE RETROFIT

- New HVAC – VAV system w/ campus steam & CW
- Window Replacement – Code Compliant
- Interior Lighting – LED w/ Occ Sensors
- Exterior Lighting – LED
- Interior Partitions, Doors, Millwork
- Interior Ceilings
- Interior Finishes
- Restroom Renovation
- Elevator Upgrades
- Sprinkler Install / Upgrade
- Electrical Upgrades – Service / Distribution
- IT and AV Systems

EnerPhit COMPREHENSIVE RETROFIT

- New HVAC – Heat Pump
- Window Upgrade
- Interior Lighting – LED w/ Occ Sensors
- Exterior Lighting – LED
- Interior Partitions, Doors, Millwork
- Interior Ceilings
- Interior Finishes
- Restroom Renovation
- Elevator Upgrades
- Sprinkler Install / Upgrade
- Electrical Upgrades – Service / Distribution
- IT and AV Systems
- Exterior Wall Insulation
- Roof Insulation
- Sub-grade Insulation

BAU vs. EnerPHit

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- Electrical Upgrades - Service / Distribution
- IT and AV Systems
- Exterior Wall Insulation
- Roof Insulation
- Sub-grade Insulation

EnerPHit Estimate

1.	**Insulation**	
	Roof	$ 1.0 M
	Exterior Walls	$ 2.9 M
	Cellar	$ 0.2 M
2.	**Windows**	
	Interior IGU	$ 2.0 M
3.	**HVAC**	
	Ground-Source (or AWHP) + WHSP	$ 2.6 M
	(Phased Alt: VRF)	*($ 1.6 M)*
	Central ERV's	$ 0.5 M
	(Phased Alt: Local ERV)	*($ 1.8 M)*
4.	**Load Reduction**	
	Lighting	$ 1.1 M
	Equipment / Computer / IT	$ 0.1 M
5.	**Other Measures**	
	Doors, Chimneys & Shafts	$ 0.1 M
	Domestic Hot Water	$ 0.1 M



PHFA

PENNSYLVANIA HOUSING FINANCE AGENCY

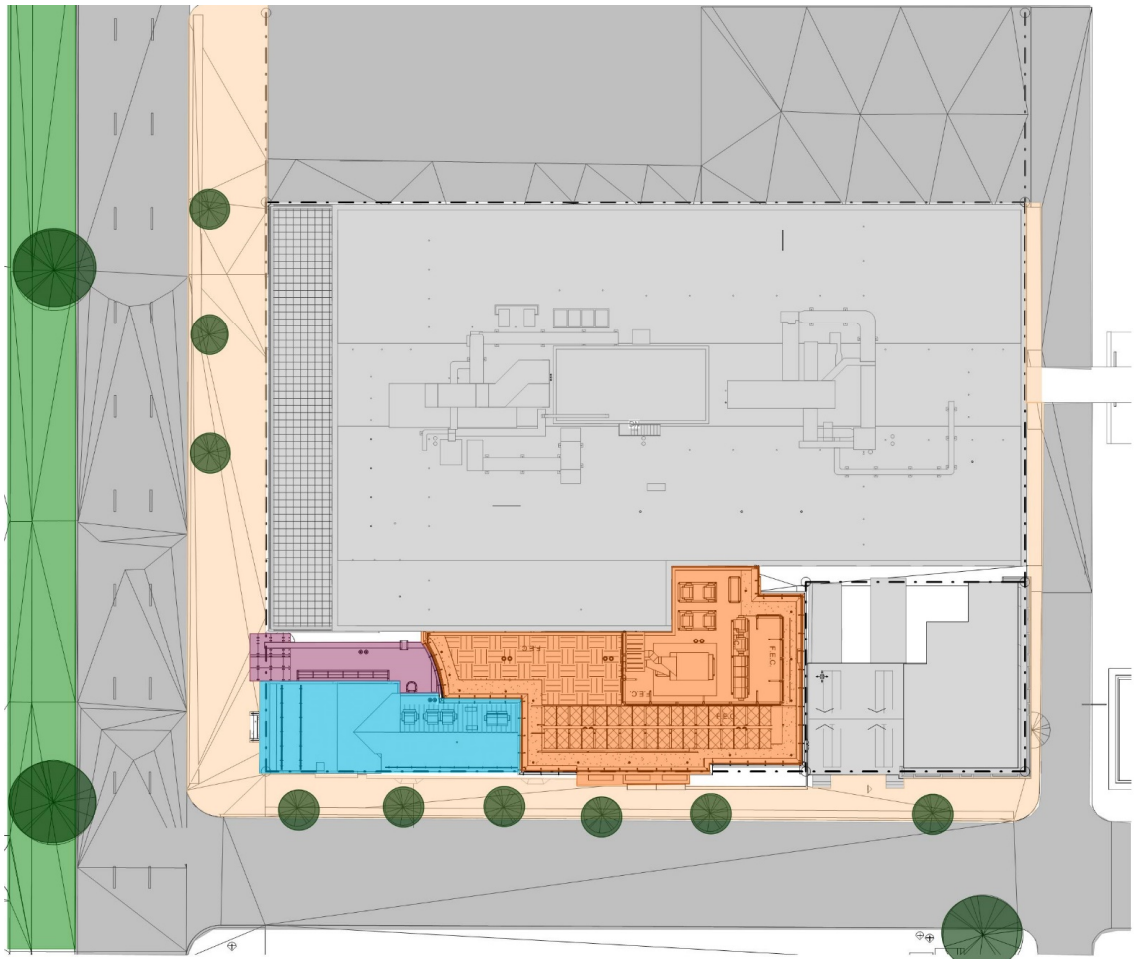
MURRAY ASSOCIATES ARCHITECTS, P.C.



HOW THEY GOT HERE…

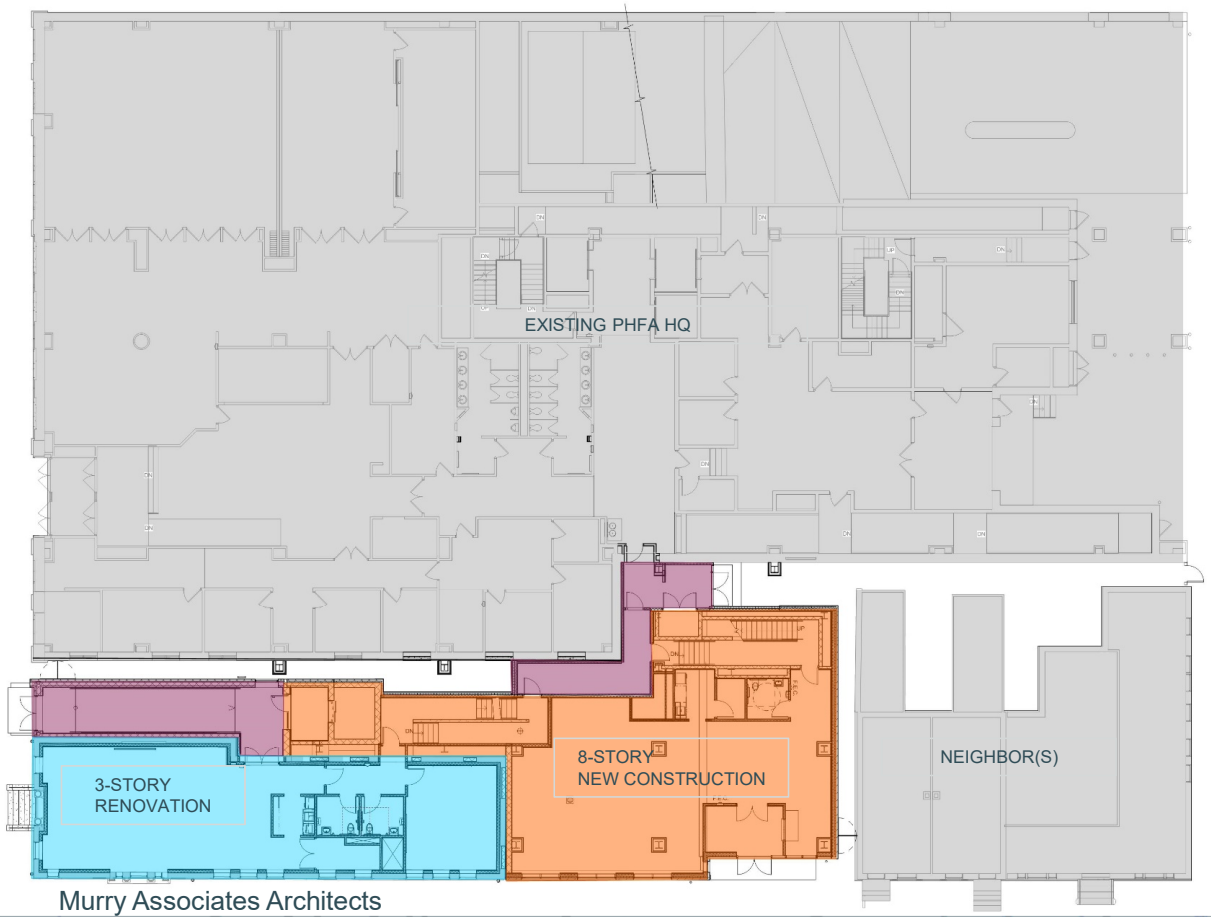
- A schematic design was already planning phases when the PHFA newly incentivized multifamily program was fully implemented.
- PHFA Technical Service Division were engaged with a passive house consultant as the passive house multifamily designs were arriving at PHFA for design criteria review.
- The stars and planets aligned themselves in one moment. “Could we do it?”

Site Plan



Murry Associates Architects

Ground Floor Plan

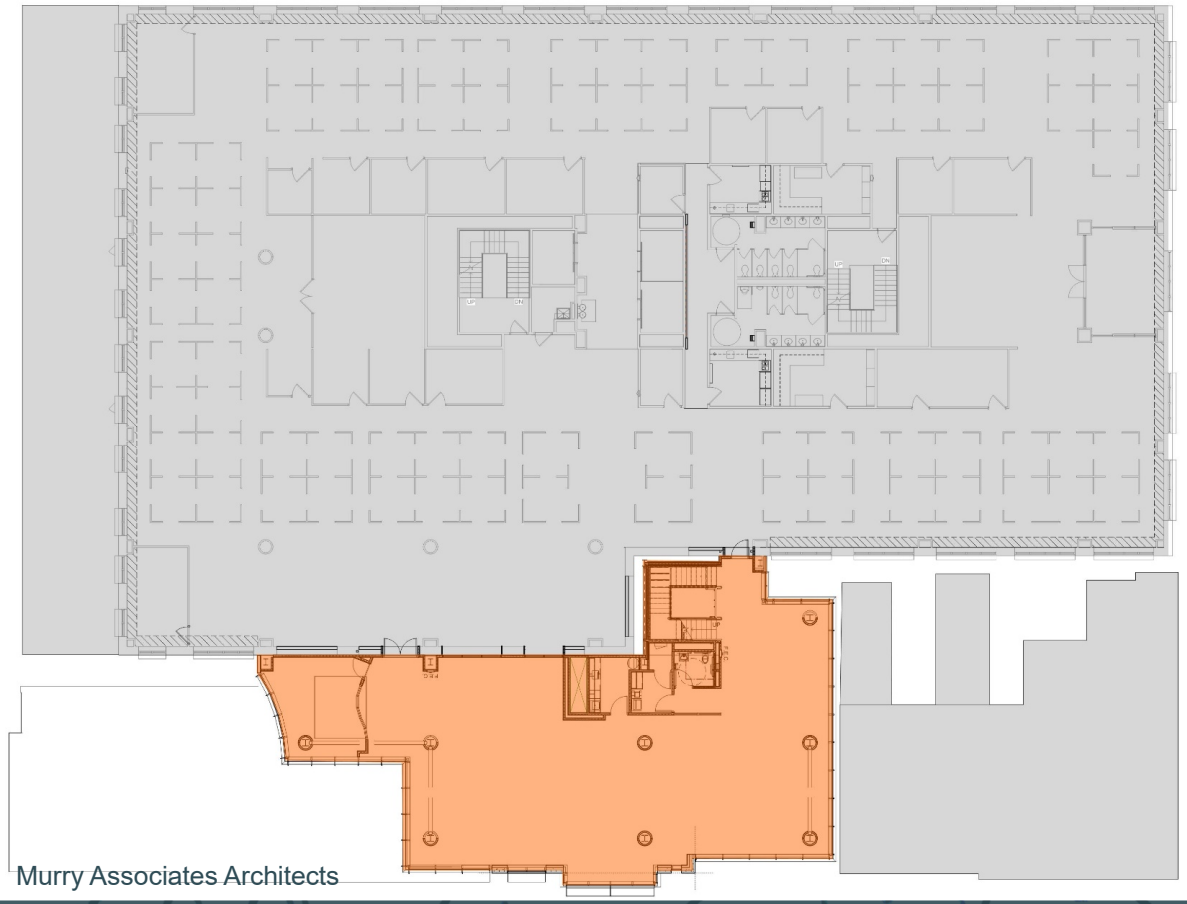


Murry Associates Architects

3rd Floor Plan

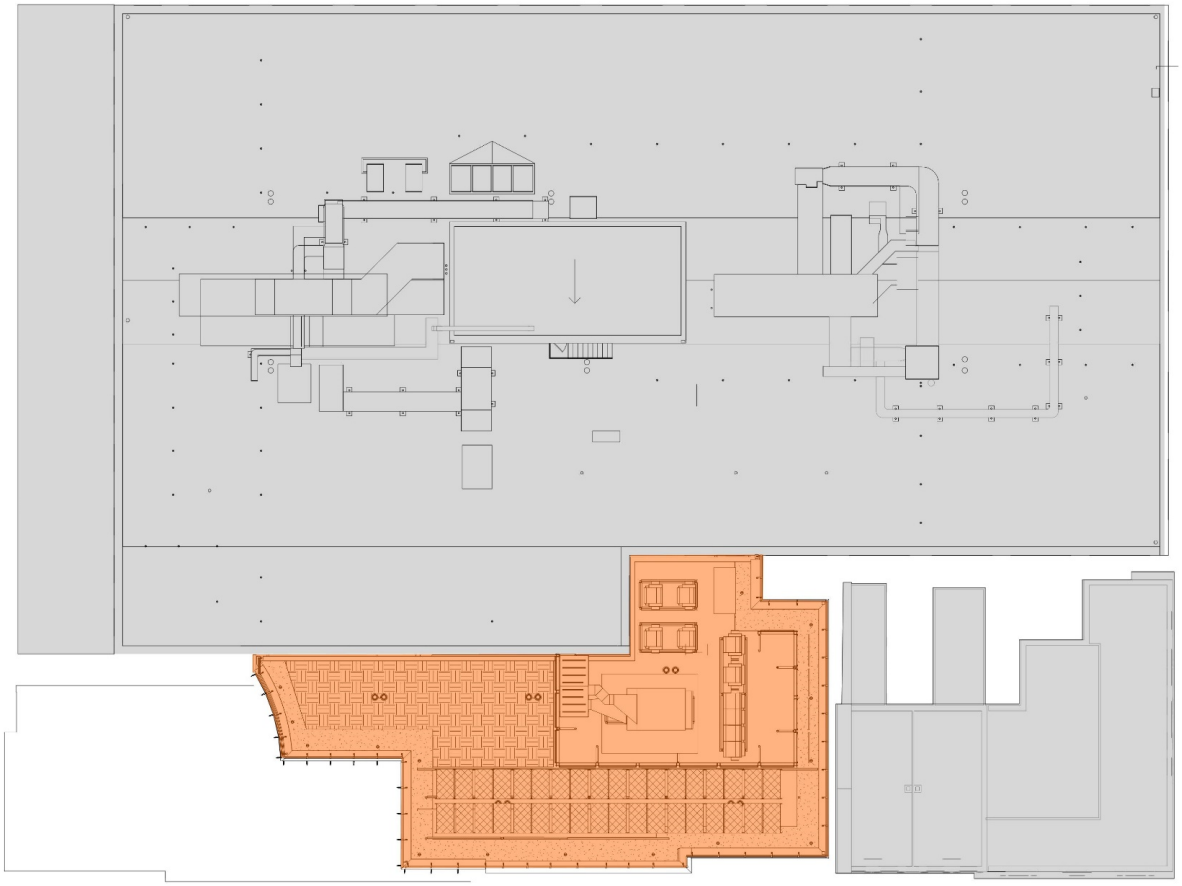


5th - 7th Floor Plan



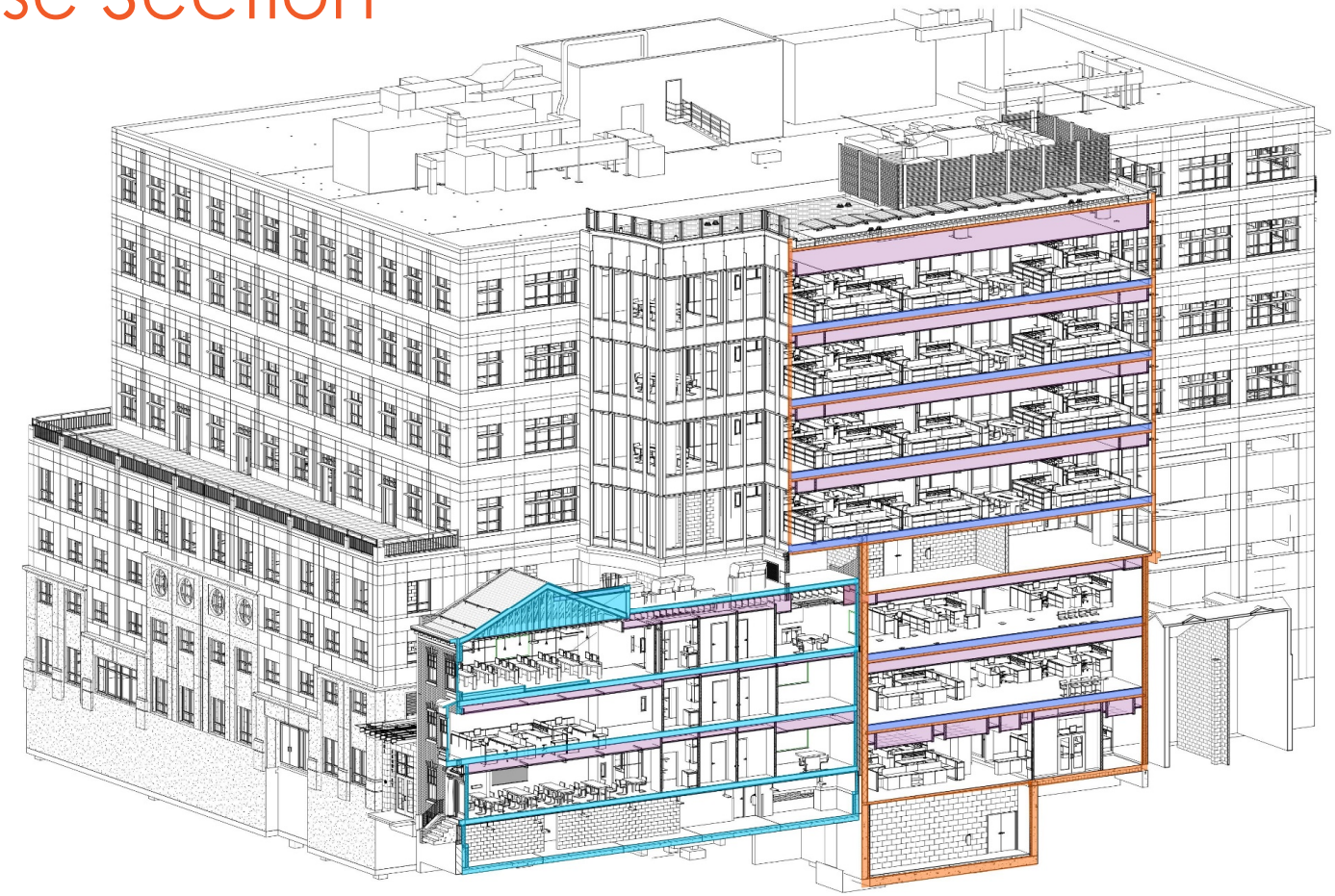
Murry Associates Architects

Roof Plan



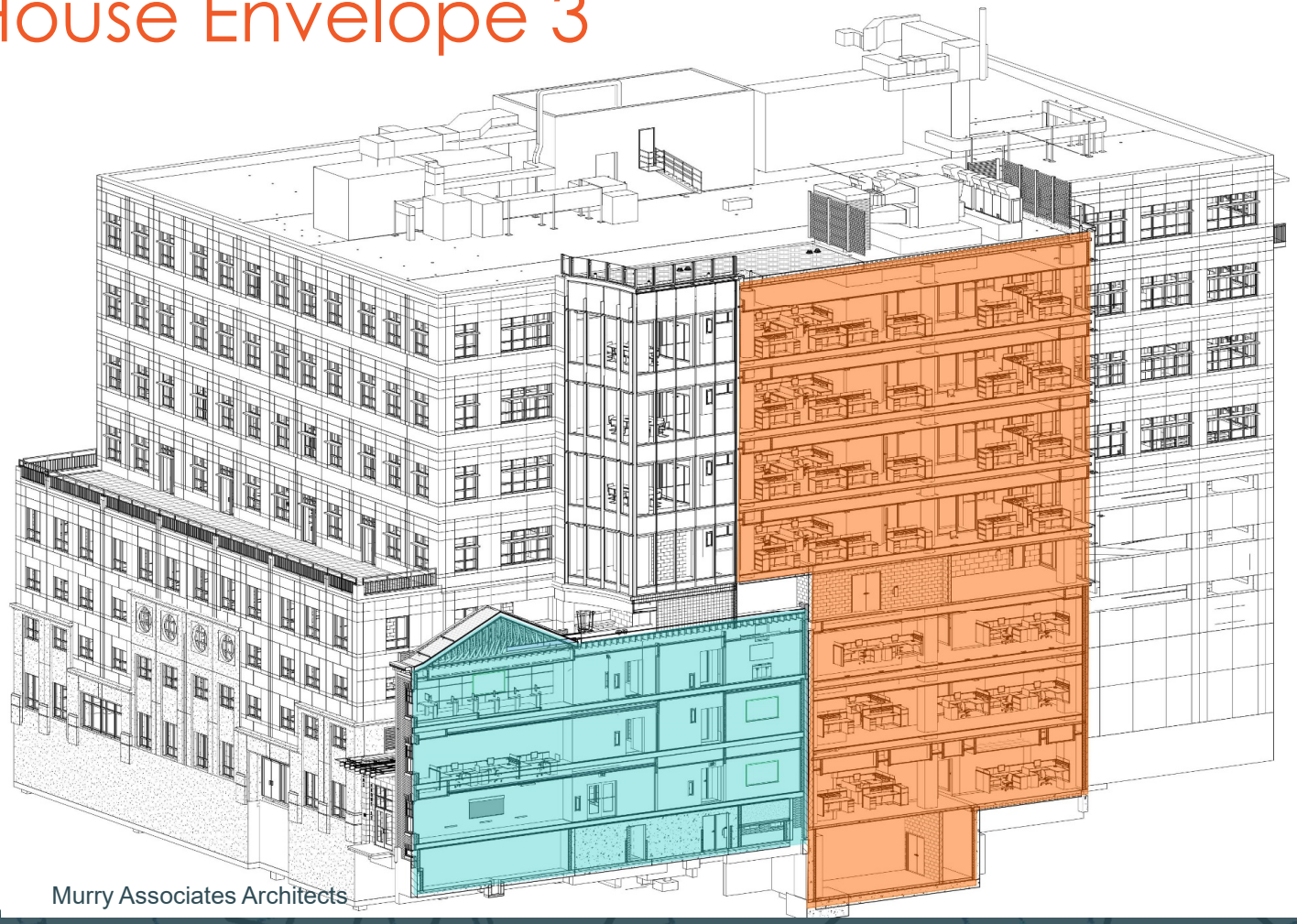
Murry Associates Architects

PassiveHouse Section



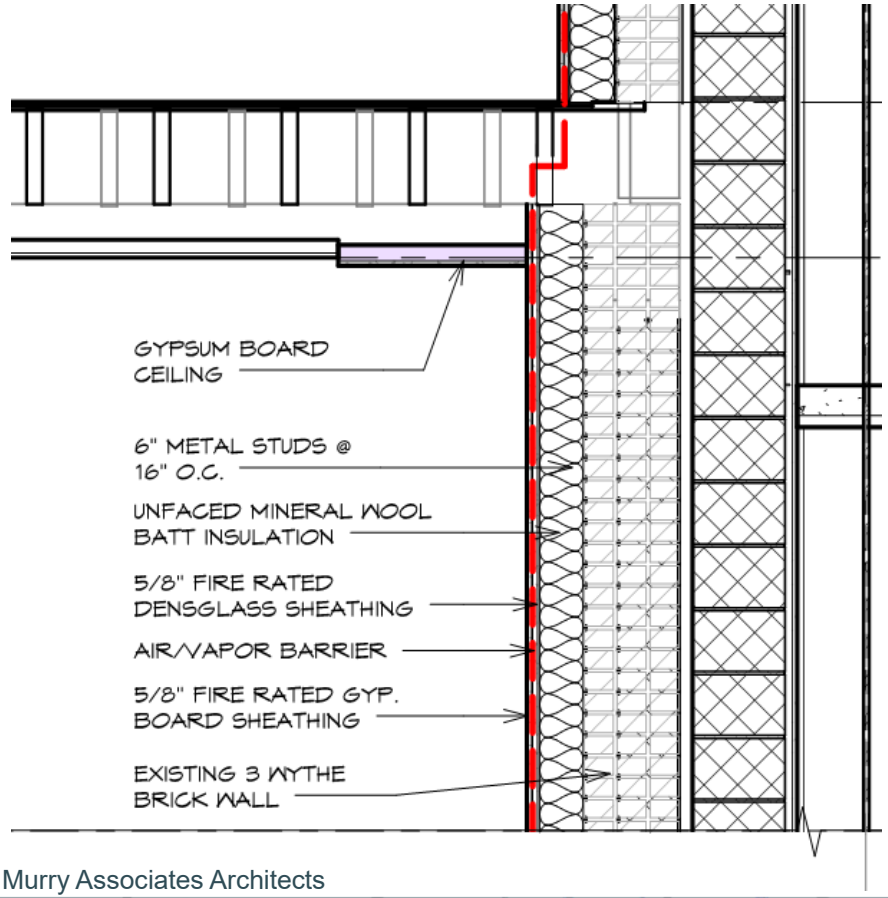
Murry Associates Architects

PassiveHouse Envelope 3



Murry Associates Architects

Existing Building Wall Section



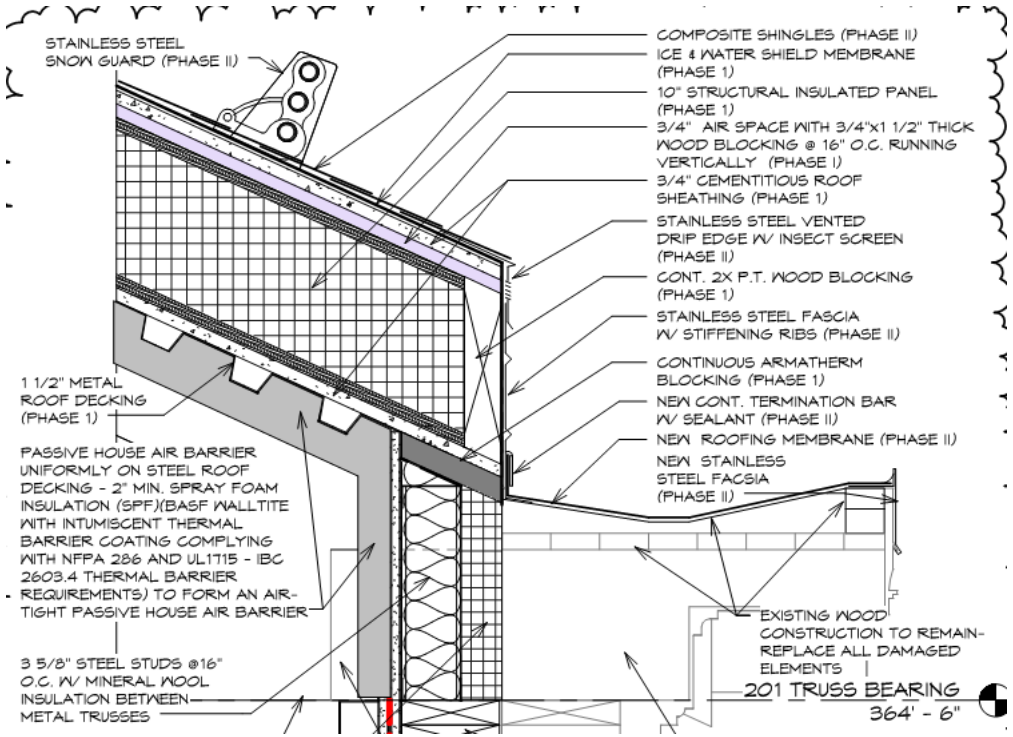
Murry Associates Architects

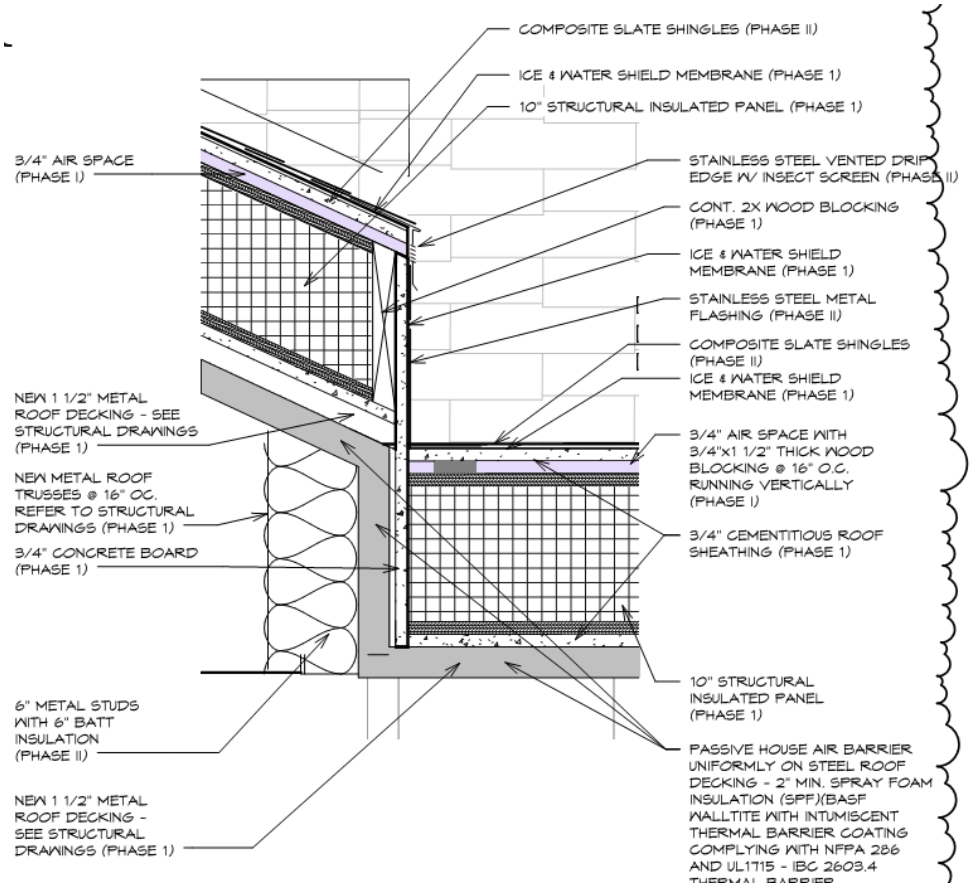
Existing Building Wall Insulation & Air Barrier





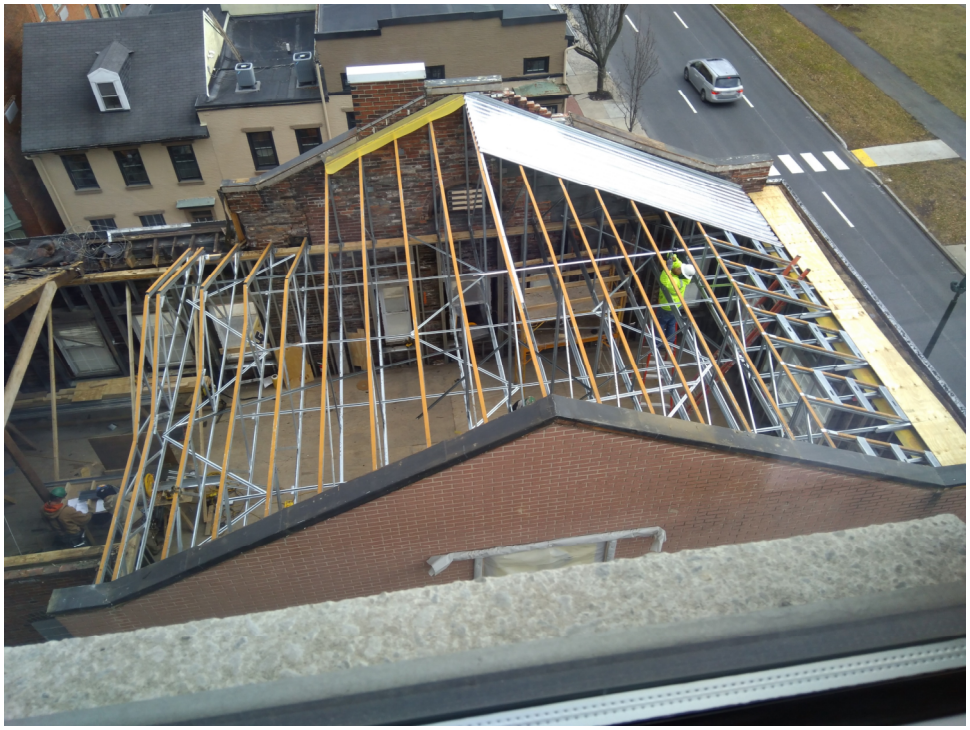
Existing Building Roof Details





Murry Associates Architects

New Roof Getting Installed





Existing Building Wall Insulation & Air Barrier



PHFA Office Addition: Finished Product





Questions?



10 Minute Break

Case Studies: Hotel

Pirelli Building

New Haven, CT



1970-1988

Armstrong Rubber

Offices →

Development labs →



1988-2003

Pirelli (tire company) bought and sold building

Vacant →

Vacant →



2003 – 2019

IKEA owned

Vacant →

Vacant →



Pirelli Building Retrofit (New Haven, CT)

- Owner / Architect – Becker & Becker
- Re-developing to be all electric, net zero hotel and conference space
- Registered as a historic building
- Pursuing:
  - Net Zero
  - LEED Platinum
  - EnerPHit
  - Energy Star
  - UI Incentives
- **Main Driver: Owner wants to do it!**
- Just finished Design Development

Net Zero – Energy Production

- Total annual production ≈ 510,000 kWh/yr
  - ~130 kW on roof (30%)
  - ~290 kW on carport canopies (70%)



Net Zero – Energy Consumption

- Goal < 510,000 kWh/yr
  - **Equates to a site EUI < 18.0 kBtu/sf.yr**
- Currently evaluating how we get there…

KEY CONSIDERATIONS

- Limiting commercial kitchen energy use
- Limiting common area lighting energy
- Predicting annual average occupancy rates
- Ventilation controls
- High efficiency heat recovery on ventilation
- Electrification of domestic hot water (in addition to space heating)
- Passive House level enclosure

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Limiting Commercial Kitchen Energy Use

- **Coordinate** the following **assumptions** with kitchen designer
  - All electric possible?
  - Can we get away with only Type **II** hoods?
  - Heat recovery limitations on ventilation air
  - List of proposed equipment and electrical power draw
  - How long will each piece of equipment run for?

Limiting Commercial Kitchen Energy Use

- **Coordinate** the following **assumptions** with kitchen designer
  - All electric possible? **Yes**
  - Can we get away with only Type **II** hoods? **No, need Type I hoods**
  - Heat recovery limitations on ventilation air **Glycol loop (max SRE ≈ 30%)**
  - List of proposed equipment and electrical power draw
  - How long will each piece of equipment run for?

  Initial Pirelli estimates

  Proposed scenario = 301,000 kWh/yr (site EUI - 9.9 kBtu/sf.yr) !!

  Improved scenario = 150,000 kWh/yr (site EUI – 4.9 kBtu/sf.yr)
    - *Eliminating the one electric fryer*
    - *Cutting electric kettles (qty. 2) time of use from 12 to 2 hrs/day.*

Net Zero – Energy Consumption

- Goal < 510,000 kWh/yr
  - **Equates to a site EUI < 18.0 kBtu/sf.yr**
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- Limiting commercial kitchen energy use
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Electrification of DHW

- **Load reduction measures**
  - Low flow fixtures
  - Efficient recirculation pipe layout
  - Drain water heat recovery on shower drains
- **Efficient heating strategy**
  - 4 air-sourced heat pump water heaters (located indoors)
  - 700 gallons of DHW storage
- Initial energy estimate = 48,000 kWh/yr (site EUI – 1.6 kBtu/sf.yr)

Net Zero – Energy Consumption

- Goal < 510,000 kWh/yr
  - **Equates to a site EUI < 18.0 kBtu/sf.yr**
- Currently evaluating how we get there…

KEY CONSIDERATIONS

- Limiting commercial kitchen energy use
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Passive House Level Enclosure

Exploratory site visit







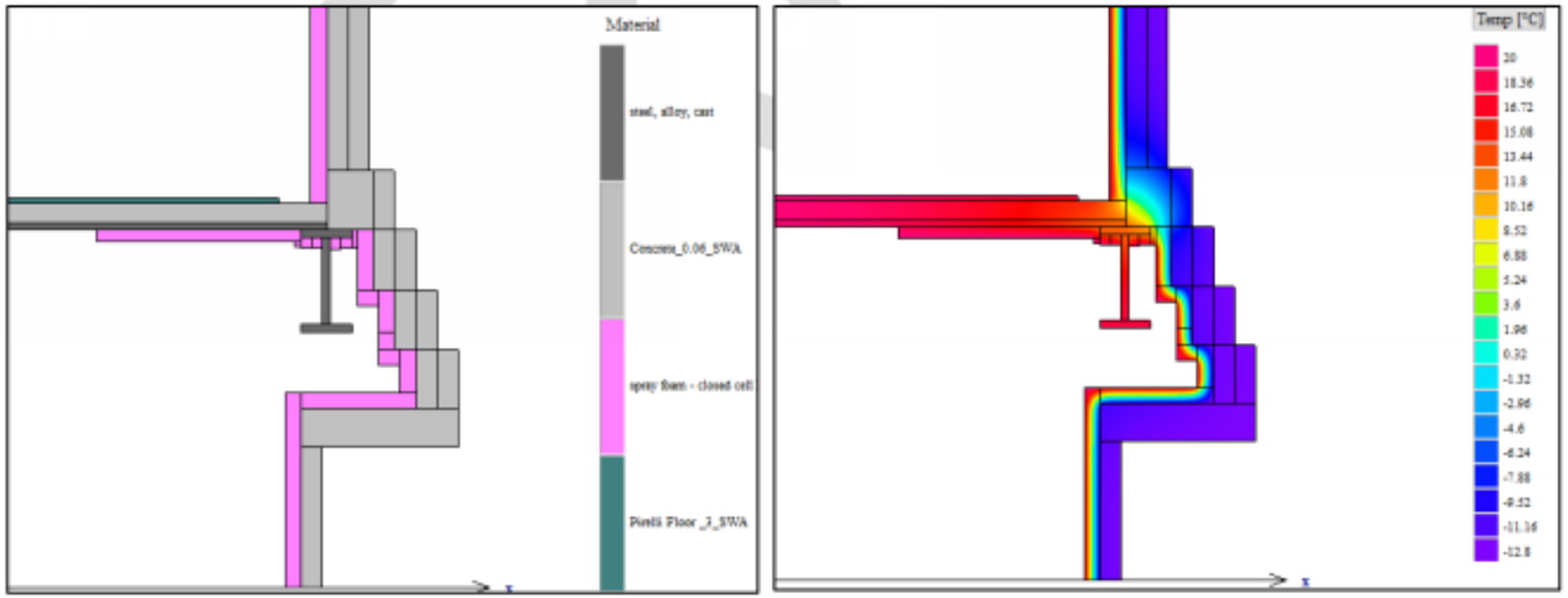
Passive House Level Enclosure

- **Can only insulate on interior. What is right amount of R-value?**
- R-21 to comply w/ EnerPHit
- Ongoing WUFI modeling to ensure no long-term issues
- Proposing a low GWP blowing agent closed cell spray foam (R-6.3 /in)

Passive House Level Enclosure

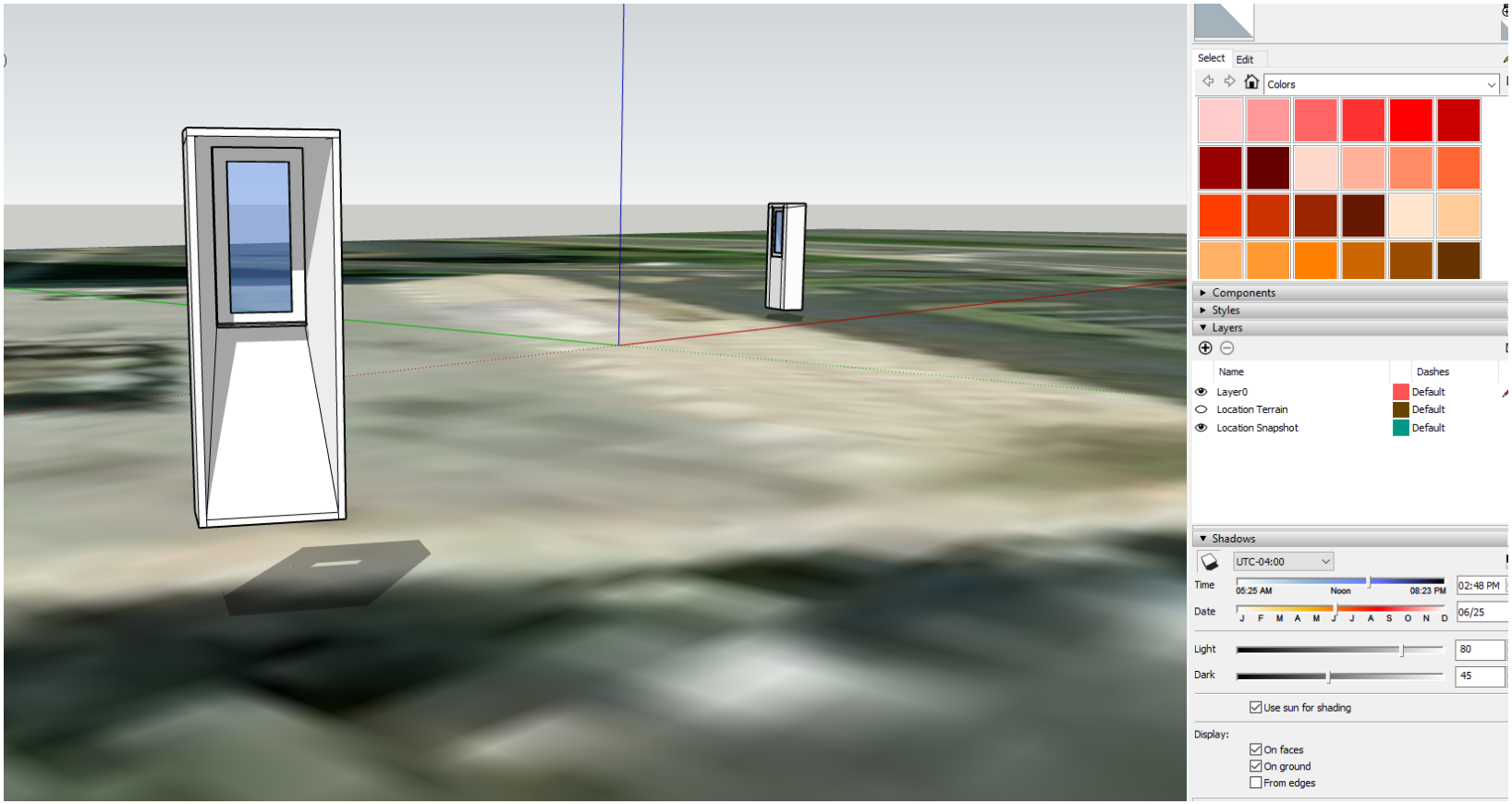


- **Typical slab edge thermal bridge**
- Condition modeled in 3D thermal modeling software



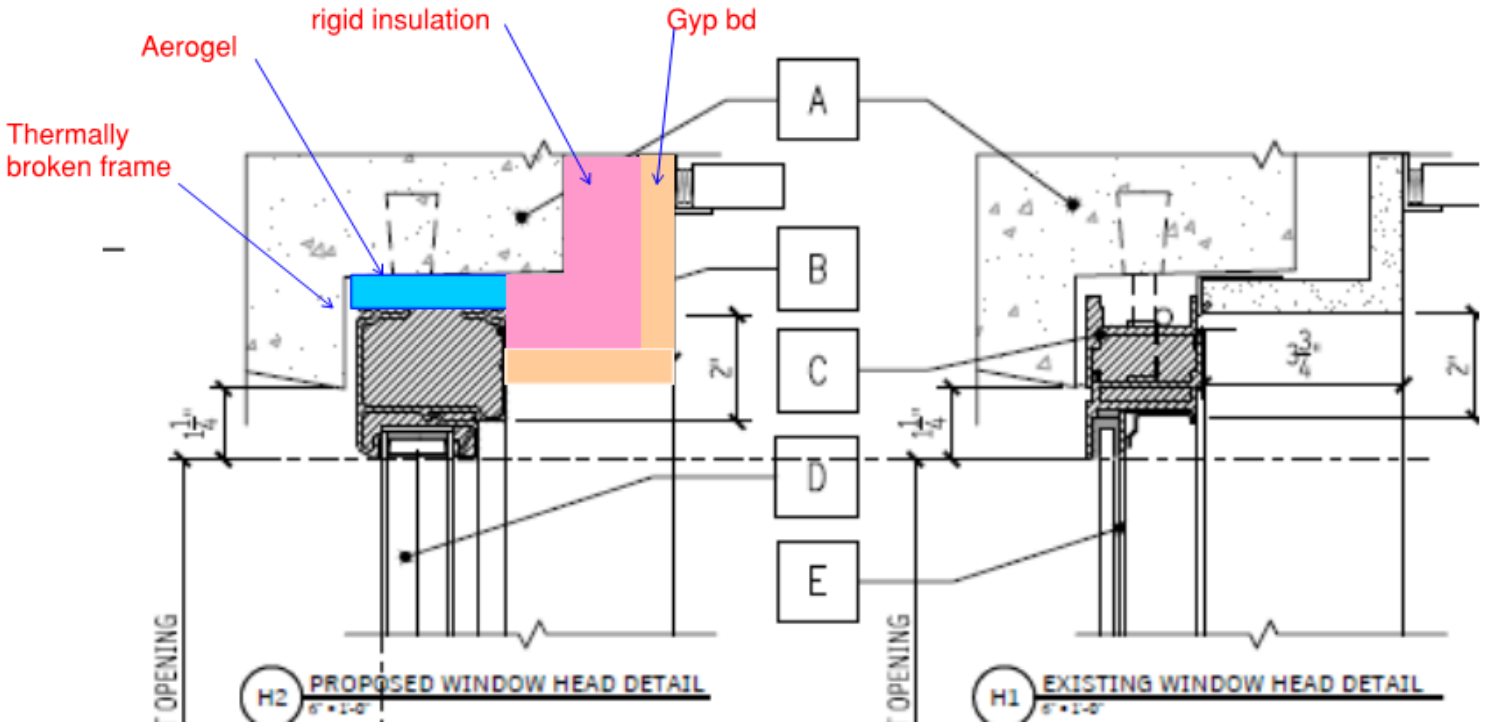
Passive House Level Enclosure

- **Windows**
- Shading Analysis in Sketchup / DesignPH



Passive House Level Enclosure

- **Windows**
- Triple pane
- Metal / uPVC / fiberglass (TBD)



Net Zero – Energy Consumption

- Goal < 510,000 kWh/yr
  - **Equates to a site EUI < 18.0 kBtu/sf.yr**
- Currently evaluating how we get there…

KEY CONSIDERATIONS

- Limiting commercial kitchen energy use
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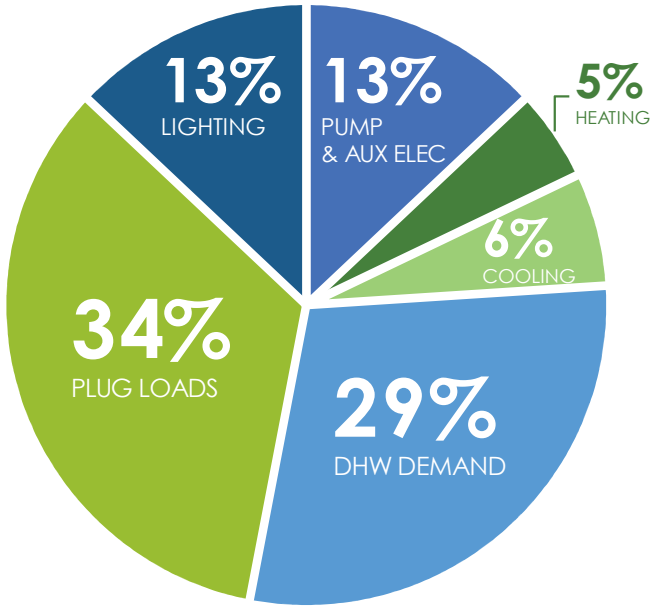
Sri Lanka EnerPHit Industrial Building



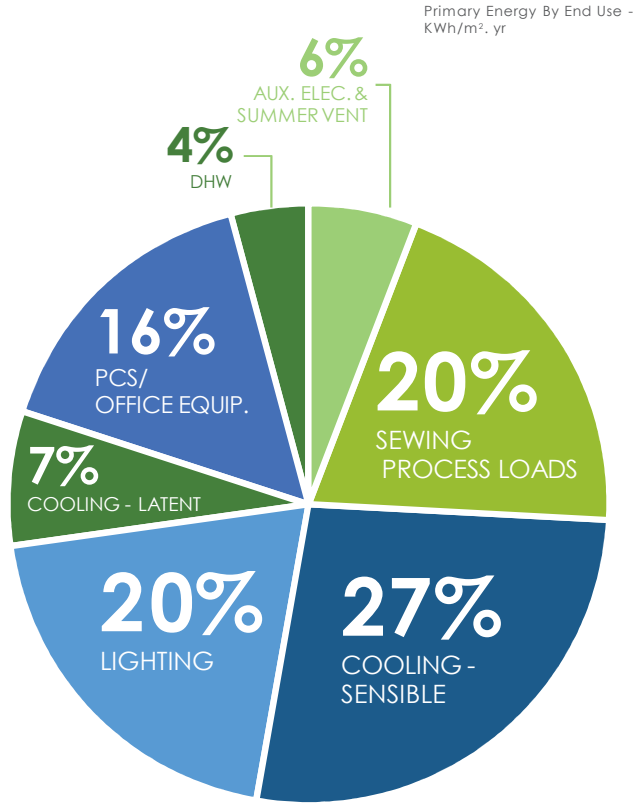
Sri-Lanka Factory Before



Residential vs Industrial:
Energy Use Distribution



PASSIVE HOUSE HIGH RISE: NYC



SRI Lanka Textile Factory

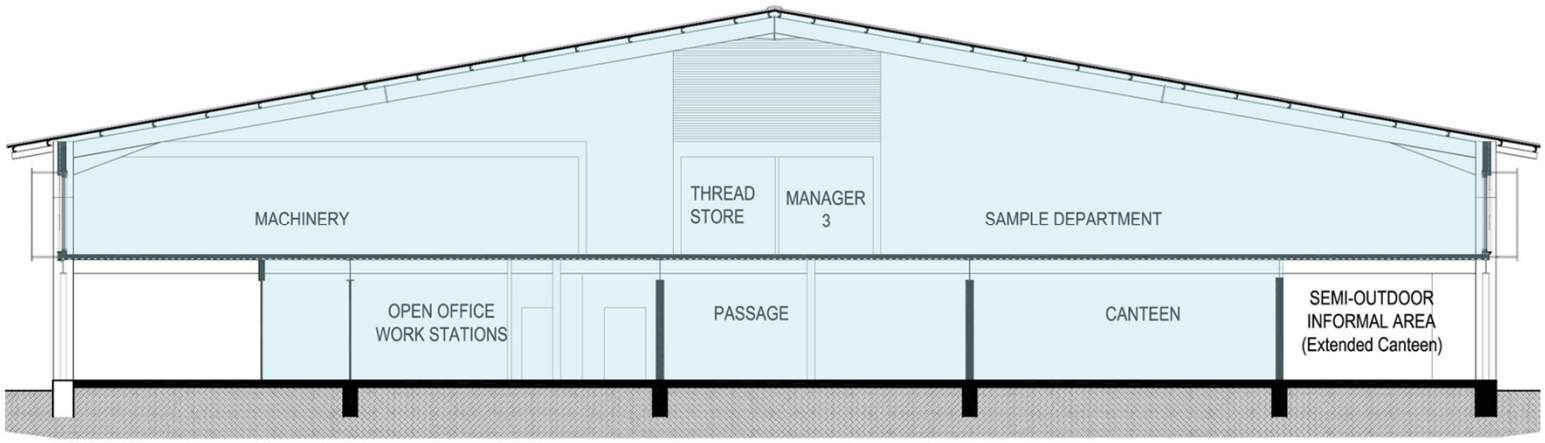
Sri-Lanka Factory Before



Sri-Lanka Factory Before

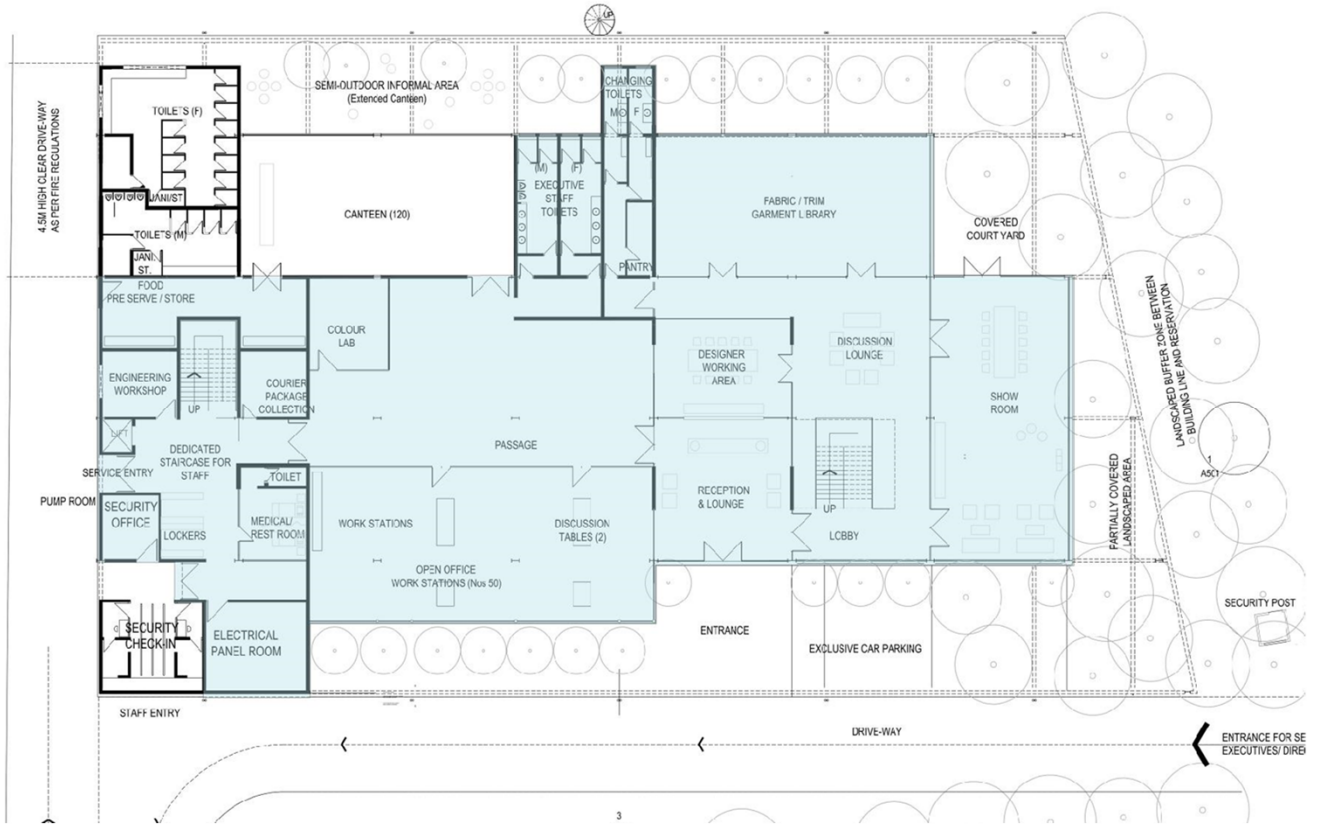


Sri-Lanka Factory Cross Section



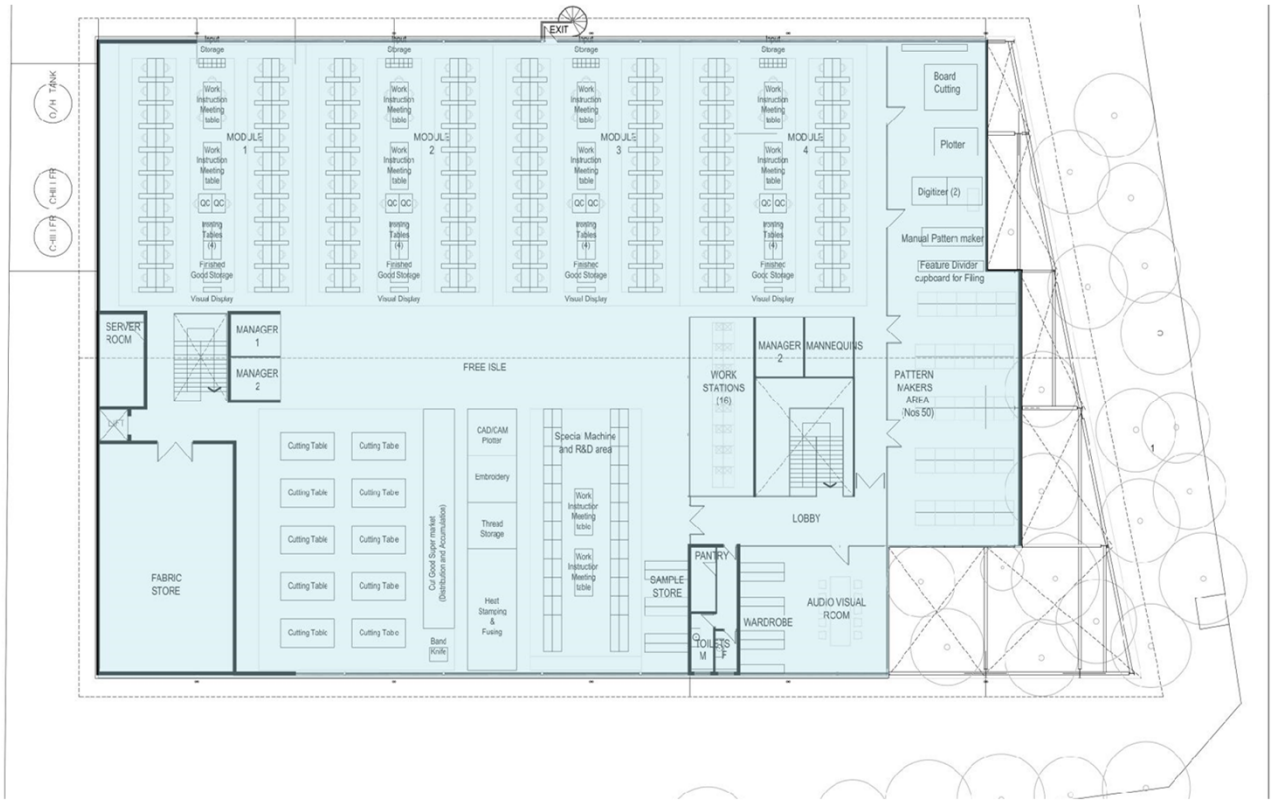
Source: JPDA

Sri-Lanka Factory 1st Floor Plan



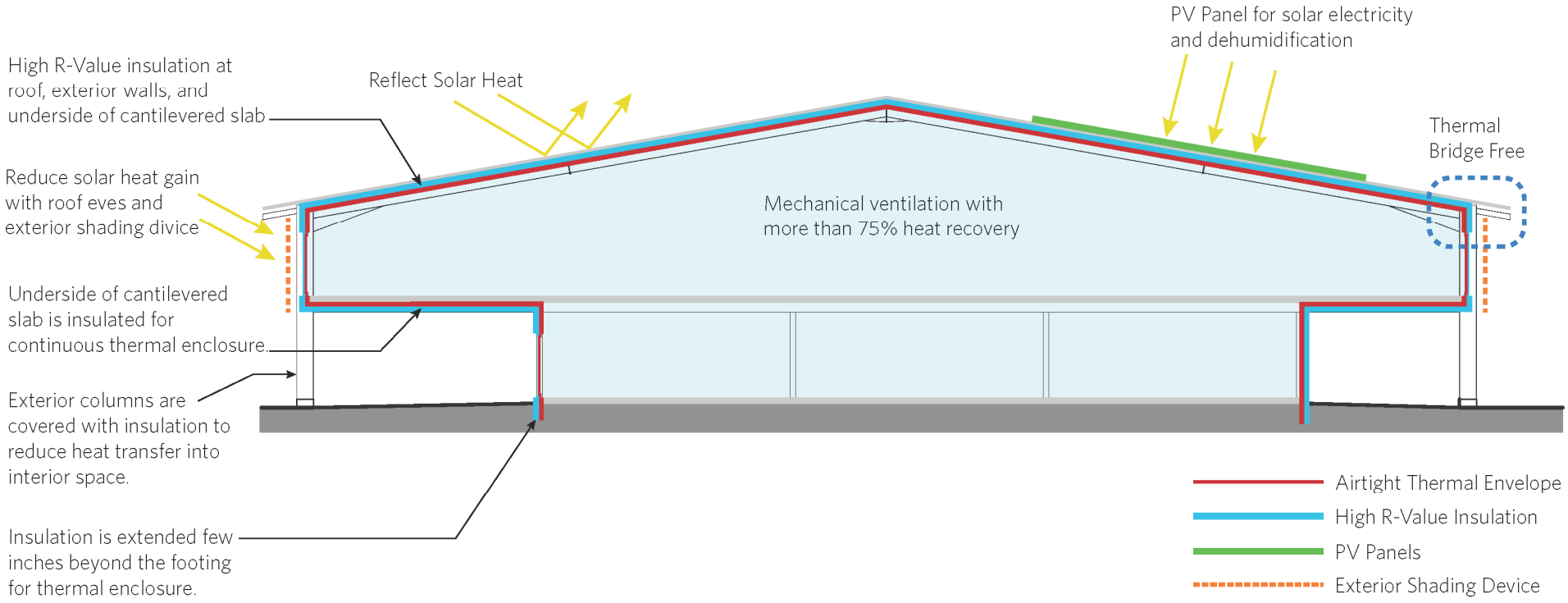
Source: JPDA

Sri-Lanka Factory 2nd Floor Plan

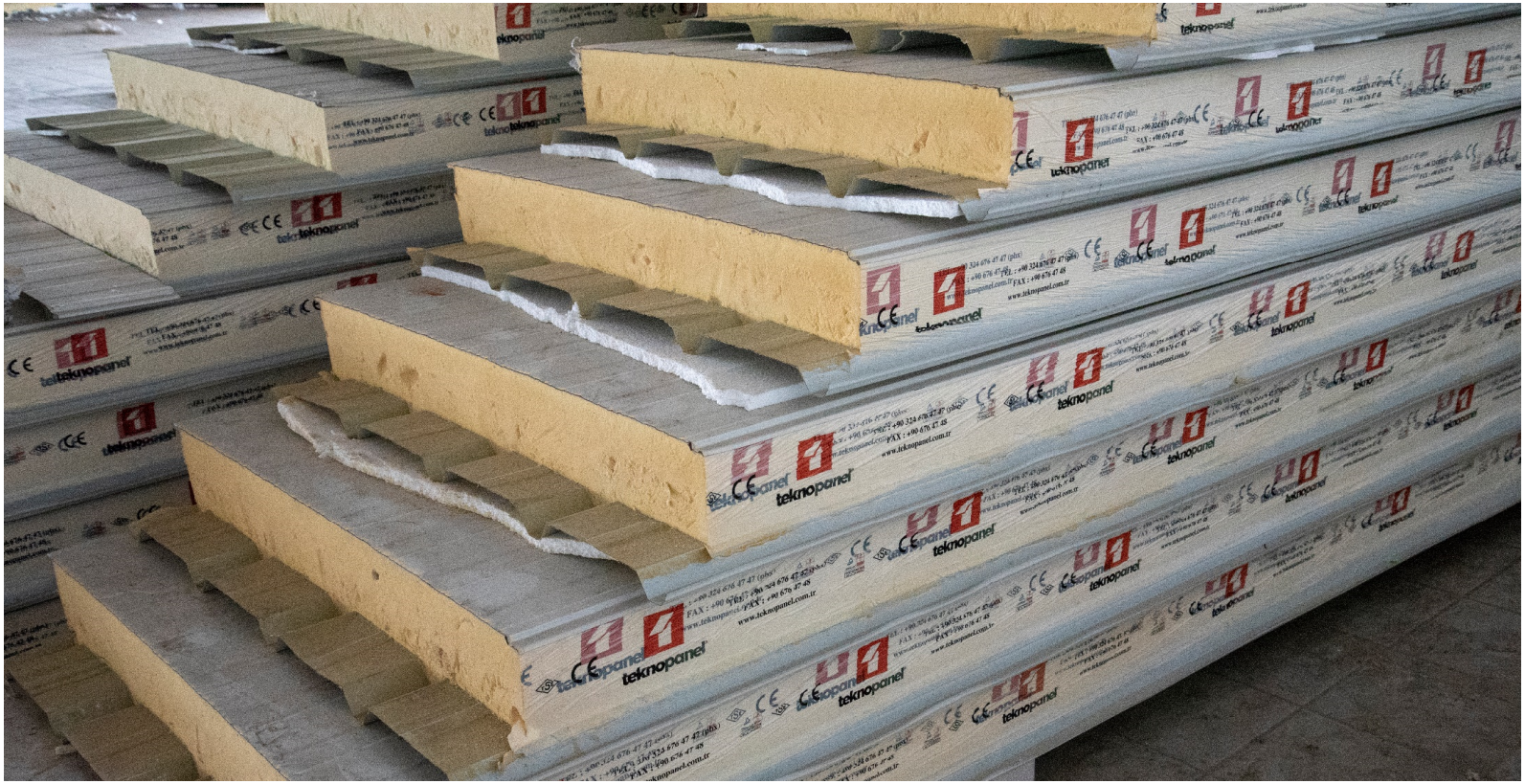


Source: JPDA

Sri-Lanka Factory: Envelope Improvements



Sri-Lanka Factory Roof Panels





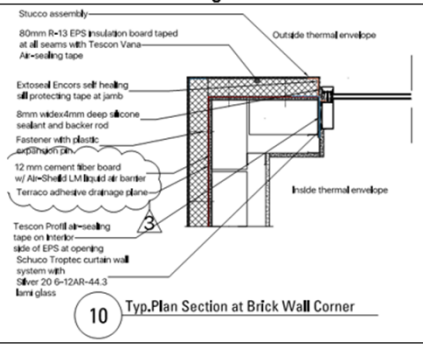
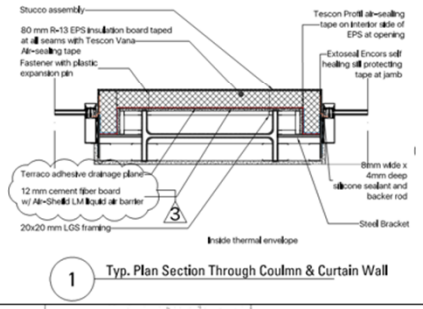
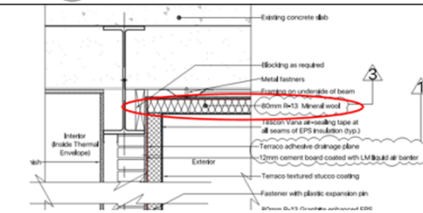




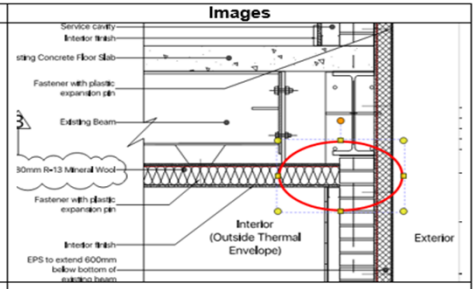
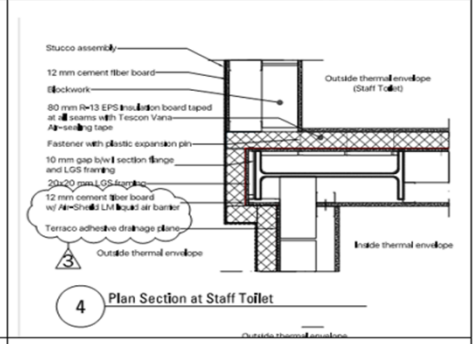
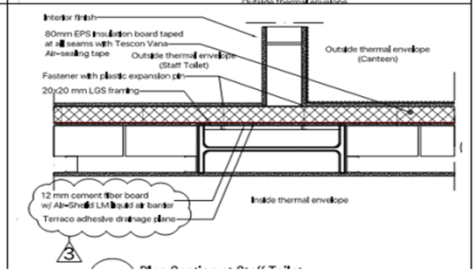




QA / QC: Typical Construction Checklists

Item #	Description	Images
13	**Items to be Inspected/Tested:** Typical brick wall corner condition **Action Required:** Visual Inspection, PH photo verification **Reinspection Required:** - **Construction Timeline:**	
14	**Items to be Inspected/Tested:** Typical steel collumn insulation and air barrier continuity **Action Required:** Visual Inspection, air leakage testing, PH photo verification **Reinspection Required:** - **Construction Timeline:**	
15	**Items to be Inspected/Tested:** Mineral wool insulation at underside of insulated 2nd floor slab **Action Required:** Visual Inspection, PH photo verification **Reinspection Required:** - **Construction Timeline:**	

QA / QC: Unique Construction Checklists

Item #	Description	Images
3	**Items to be Inspected/Tested:** Air barrier transition from cement board to brick wall **Action Required:** Visual Inspection, air leakage testing **Reinspection Required:** - **Construction Timeline:**	
4	**Items to be Inspected/Tested:** Insulation and air barrier continuity around corner I-beam condition at staff toilet **Action Required:** Visual Inspection, PH photo verification **Reinspection Required:** - **Construction Timeline:**	
5	**Items to be Inspected/Tested:** Insulation and air barrier continuity at flyby I-beam condition at staff toilet **Action Required:** Visual Inspection, PH photo verification **Reinspection Required:** - **Construction Timeline:**	

Interim Testing
& Inspections



Interim Testing
& Inspections



Planning the Site Visits

Final Whole Building Blower Door Test: Logistical Considerations

- Do we use our own equipment or try to rent equipment that is closer to the project site?
- If we use our own equipment, how can we get it to work on the local power supply?
- How do we get all the equipment there and back?
- What if some specialized piece of equipment doesn't work when we are there?





Testing Results

Test 1: Fail

- Air leakage most notably at steel purlin/roof connection

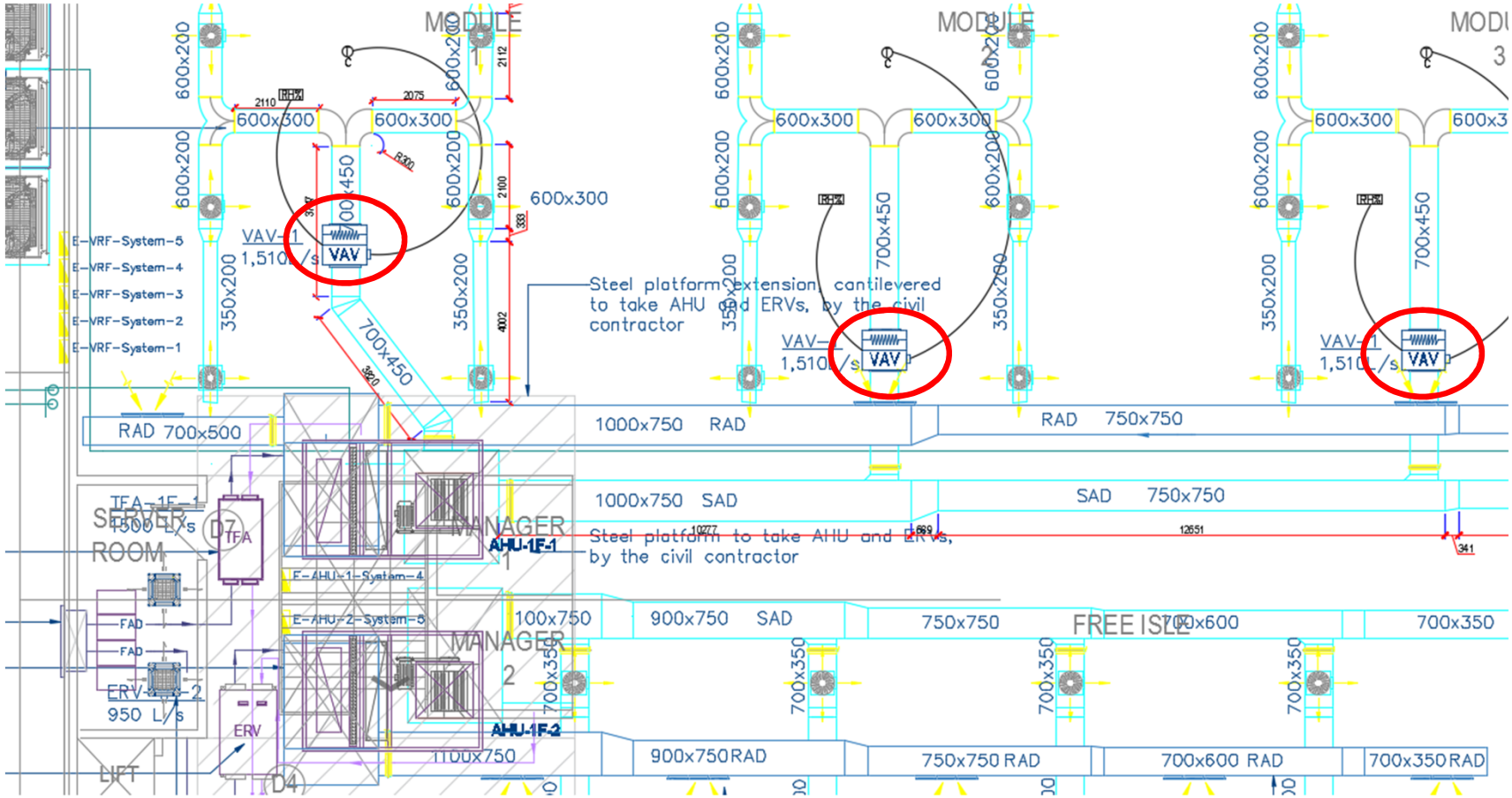




Test 2: Pass!!

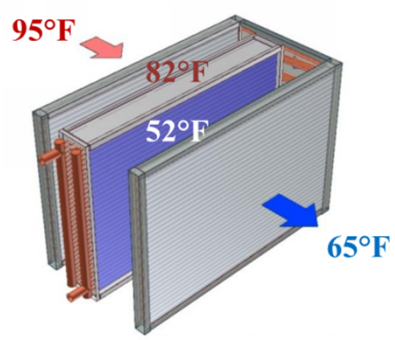
- Trip extended by a day to allow for additional air sealing
- All hands-on-deck effort with collaboration between the architect, contractors, and building owner/operator
- Air leakage was reduced from 85-99% at these locations!

Mechanical Equipment



Mechanical Equipment

- Additional Dehumidification Controls - Heat Pipes w/ Heat Recovery

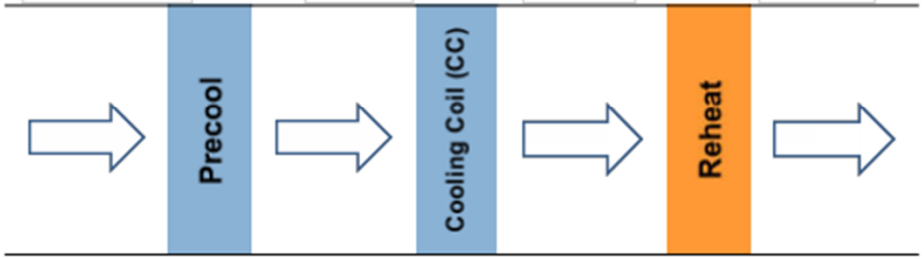


Air Properties

Air Type:Standard

Elevation: 0ft

	Outside Air	Returned Air	Mixed Air (Standard)	Precool Leaving	Reheat Entering	Reheat Leaving
SCFM	8,683		8,683			
DBT (°F)	79.00		79.00	68.66	54.12	64.52
WBT (°F)	67.82		67.82	64.49	53.84	57.95
RH(%)	56.7		56.7	80.3	98.3	67.8



Coil Performance

Pressure Drop (in. H2O)	0.21		0.21
Face Velocity (SFPM)	321.60		321.60
Temperature Gain/Loss(°F)	10.30		10.40
Sensible Effectiveness	41.57		41.81
Heat Transferred (BTU/h)	99,142	278,545	99,142
Condensation (lbs/hr)	0.0	128.3	

Heat Pipe Analysis

- **Electric Reheat Scenario**

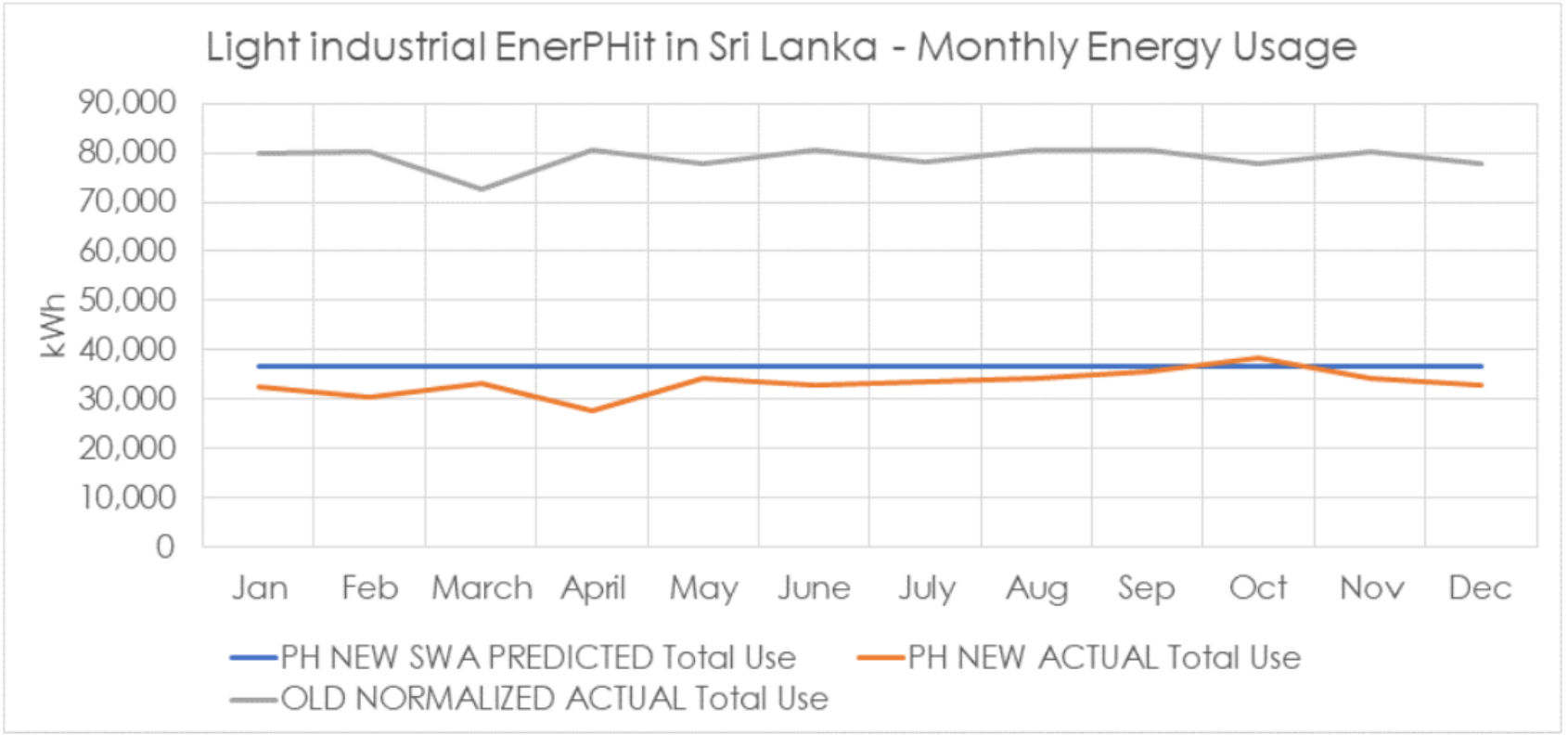
Specific building characteristics with reference to the treated floor area			
	Treated floor area	m²	3674.6
Space heating	Heating demand	kWh/(m²a)	0
	Heating load	W/m²	-
Space cooling	Cooling & dehum. demand	kWh/(m²a)	183.0
	Cooling load	W/m²	20.52
	Frequency of overheating (> 25 °C)	%	-
	Frequency excessively high humidity (> 12 g/kg)	%	0
Airtightness	Pressurization test result n_{50}	1/h	0.8
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	421
Primary Energy Renewable (PER)	PER demand	kWh/(m²a)	202
	Generation of renewable energy	kWh/(m²a)	19

- **Heat Pipe Scenario**

Specific building characteristics with reference to the treated floor area			
	Treated floor area	m²	3674.6
Space heating	Heating demand	kWh/(m²a)	0
	Heating load	W/m²	-
Space cooling	Cooling & dehum. demand	kWh/(m²a)	183.0
	Cooling load	W/m²	20.52
	Frequency of overheating (> 25 °C)	%	-
	Frequency excessively high humidity (> 12 g/kg)	%	0
Airtightness	Pressurization test result n_{50}	1/h	0.8
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	344
Primary Energy Renewable (PER)	PER demand	kWh/(m²a)	164
	Generation of renewable energy	kWh/(m²a)	19

- **108,625 kWh/yr savings x $0.075 /kWh**
- **$8,147 annual savings**

Utility Savings Year One



Completed Retrofit: 2017

Project Information

Client
Star Garment / Komar Brands

Passive House Designer
Jordan Parnass Digital Architecture

Energy Consultant
Steven Winter Associates

Quantity Surveying
475 High Performance Building Supply

Architect
Vinod Jayasingh Architects

Structural Engineering
URO Structural

HVAC Engineering
Chandana Dalugoda Consultants

Mechanical Engineering
K2 Consultants

Cost Consultant
Vform

General Contractor
Tritech Engineering & Civicon Engineering



Source: JPDA

Completed Retrofit: 2017



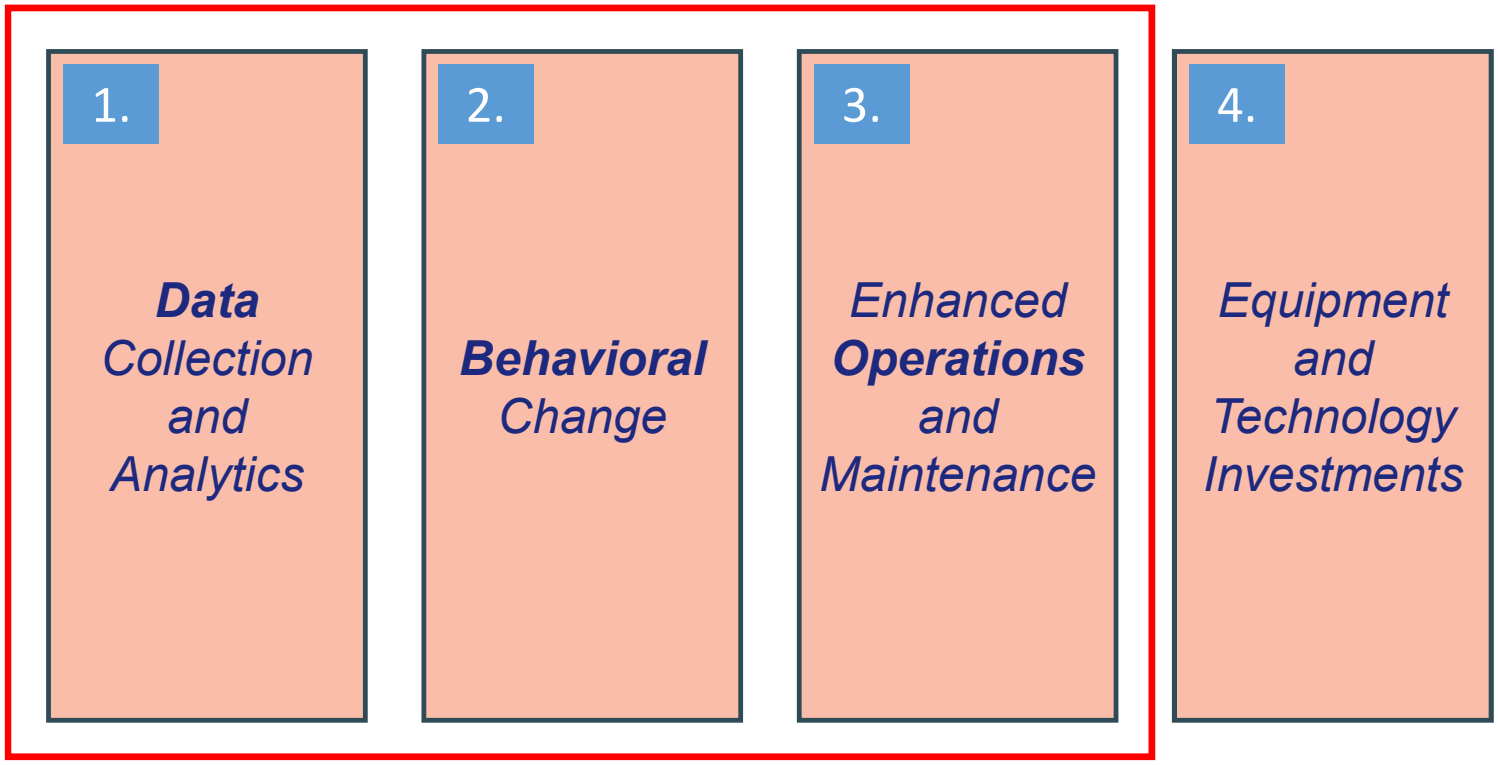
Questions?



10 Minute Break

High Performance Systems – Operations & Maintenance

DEM's Pillars of Energy Management



Proper Staff Training & Deployment

Preventative Maintenance Collaborative

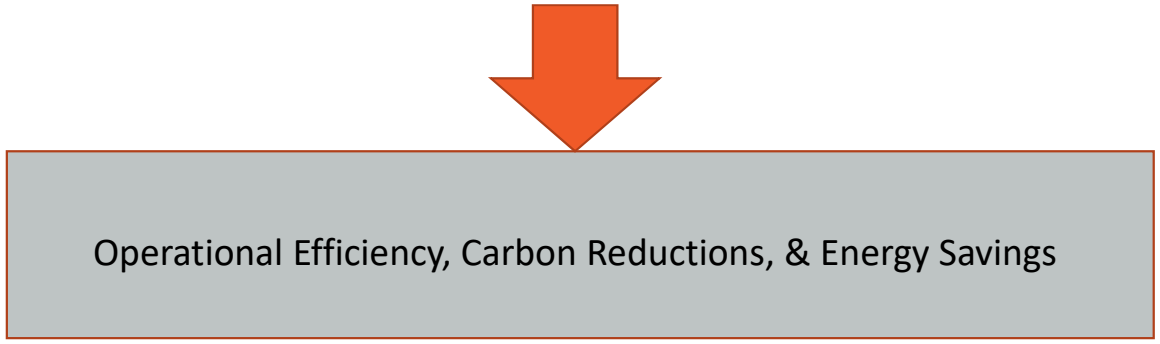
- Bring city buildings to a state of good repair
- Establish better building maintenance practices
- Prevent “run to fail” paradigm
- DCAS assisted preventative maintenance program development & technical expertise

Agency	Headcount Summary	PS	OTPS	Total
DPR	19	$ 1,974,932	$ 1,231,753	$ 3,206,685
DSNY	26	$ 2,444,816	$ 220,000	$ 2,664,816
DHS	12	$ 932,116	$ 350,000	$ 1,282,116
NYPD	23	$ 2,460,000	$ 410,000	$ 2,870,000
DCAS	26	$ 1,990,497	$ 1,054,255	$ 3,044,752
DOE	10	$ 1,018,683	$ 5,323,546	$ 6,342,229
DOHMH	10	$ 314,318	$ 762,215	$ 1,786,129
Total	**126**	**$ 11,135,362**	**$ 9,351,770**	**$ 21,196,727**

Asset Inventory & Facility Condition Assessments

Key Program Objectives

- Enhance critical O&M foundational elements: Accurate and comprehensive equipment inventory
- Create healthier building and workplace environments via the Building Management System Optimization Program
- Provide the data and tools to strategically manage and allocate available financial resources to address deferred maintenance needs.



Retro-Commissioning (RCx) – Remsen Yards

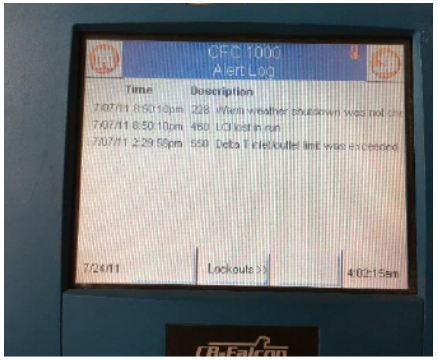


Photo 8: Boiler Control Panel showing alarm



Photo 3: Garage EF switch showing vegetation growing in the unit

Boilers

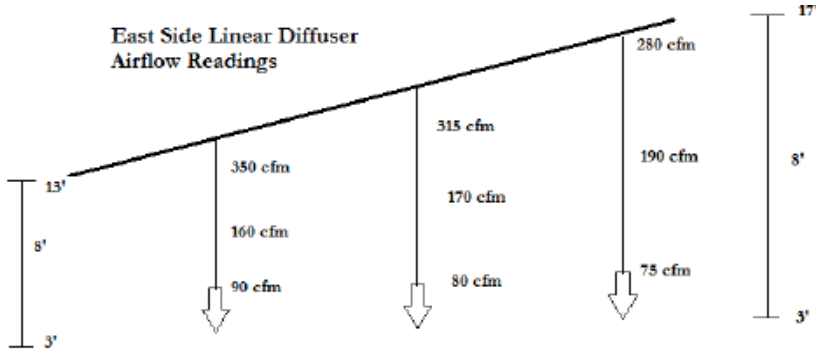
Boilers			1st Quarter		
Equipment	Component	Task	Jan	Feb	Mar
B-1	Boiler Vessel	Clean	X		
	Burner Combustion System	Clean	X		
	Condensate Neutralization	Clean, replace if needed	X		
	Ignition Electrode	Inspect, replace if needed	X		

Fans

Fans			1st Quarter			2nd Quarter		
Equipment	Component	Task	Jan	Feb	Mar	Apr	May	Jun
EF-4	Belt	Check belt for wear or tightness	X			X		
	Wheel/Housing	Clean wheel/housing for dust and oil						X
	Fasteners	Check for tightness	X			X		

Re-Commissioning – Mariner's Harbor

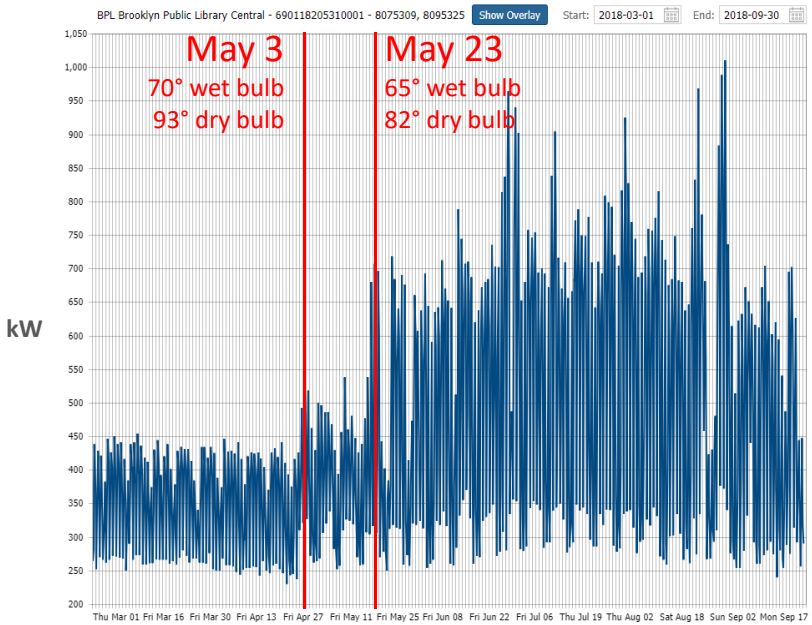




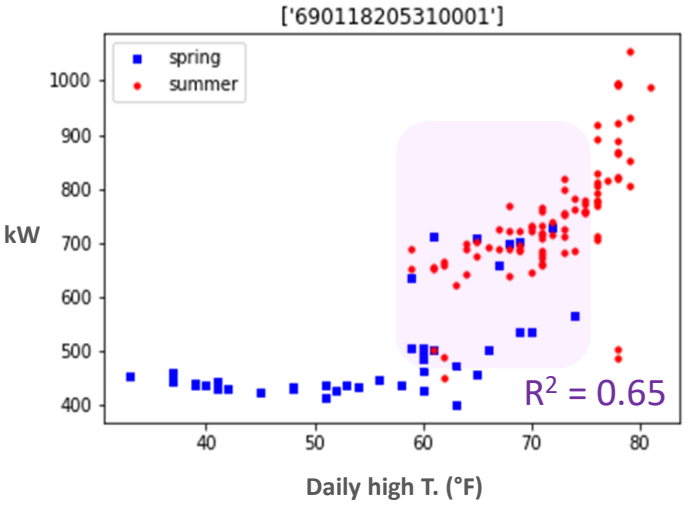
4.11 O&M PLAN ELEMENTS

Equipment Preventative Maintenance List	Annual Checks	Semi-Annual Checks	Quarterly Checks	Monthly Checks	Weekly Checks	Daily Checks	Total Labor Hours (Est.)
ACC-1	✓	✓	✓	✓	✓	TBD	TBD
ACC-2	✓	✓	✓	✓	✓	TBD	TBD
AC-1	✓	✓	✓	✓	✓	TBD	TBD
AC-2	✓	✓	✓	✓	✓	TBD	TBD
AC-3	✓	✓	✓	✓	✓	TBD	TBD
AC-4	✓	✓	✓	✓	✓	TBD	TBD
AC-5	✓	✓	✓	✓	✓	TBD	TBD
AC-6	✓	✓	✓	✓	✓	TBD	TBD
AC-7	✓	✓	✓	✓	✓	TBD	TBD
AC-8	✓	N/A	✓	N/A	N/A	TBD	TBD
ERV-1	✓	✓	✓	✓	✓	TBD	TBD
ERV-2	✓	✓	✓	✓	✓	TBD	TBD

Real Time Energy Metering - BPL Central Branch

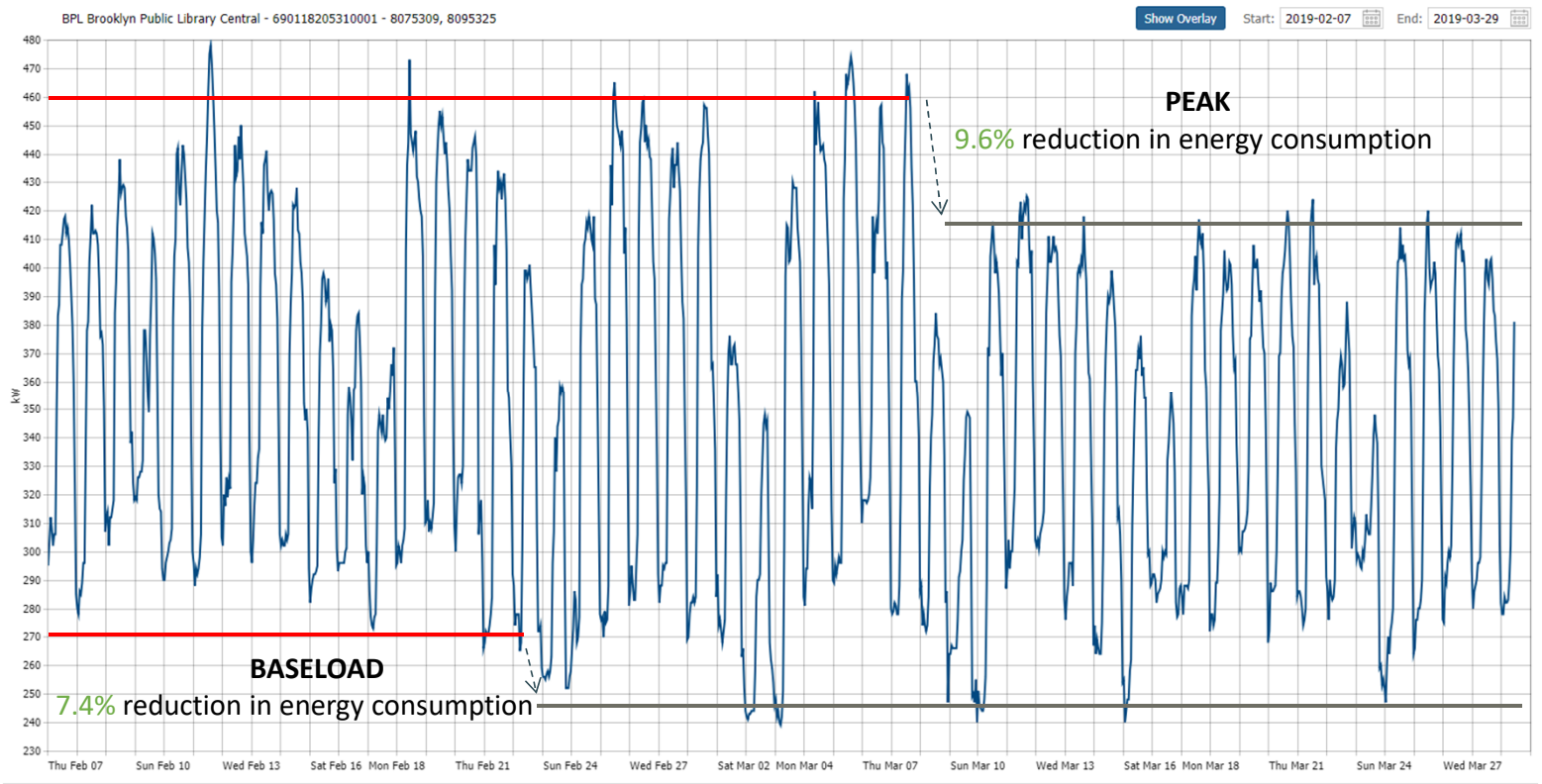


- Consumption increased after May 3rd, peak load spiked after May 23rd



- Major discrepancies noted in peak load at comparable outdoor temperatures

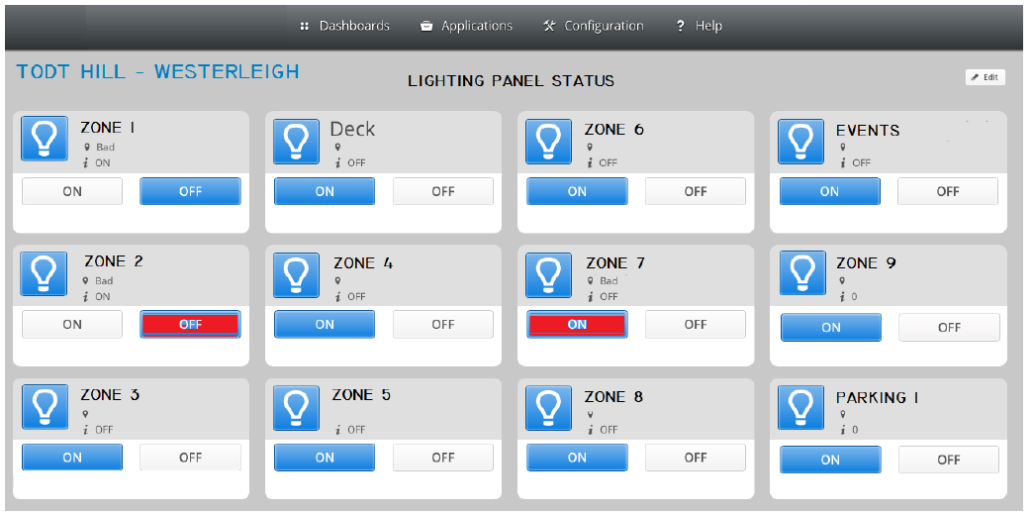
Real Time Energy Metering - BPL Central Branch

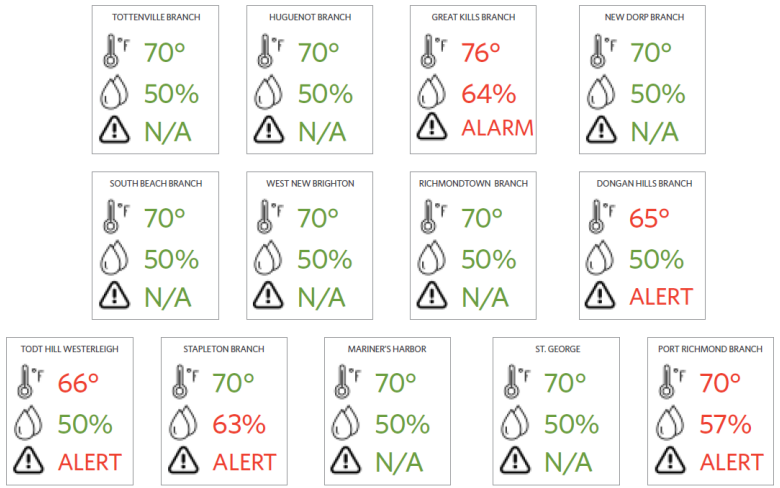


Computerized Maintenance & Monitoring Systems

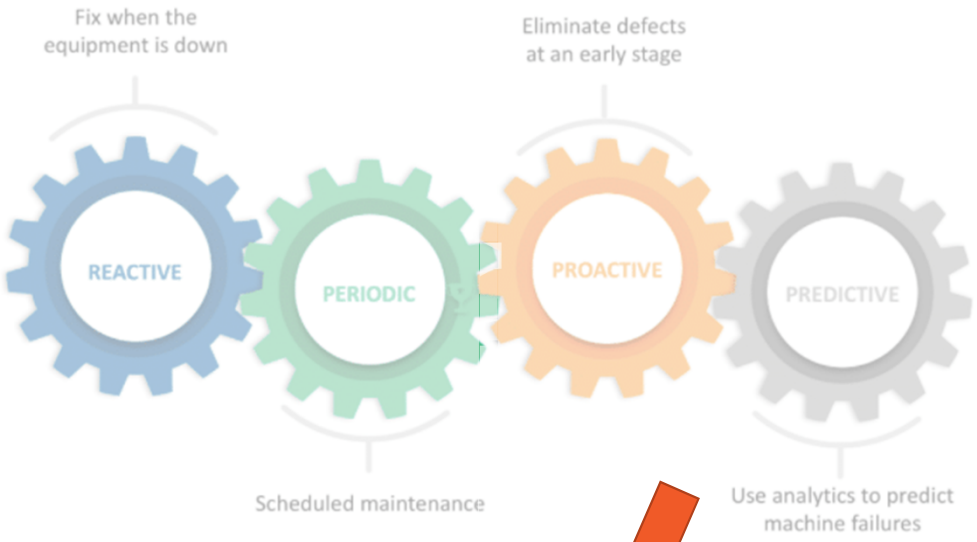


Building Management Systems





Future State of Operations & Maintenance



+ Ongoing Commissioning (OCx)

Questions?

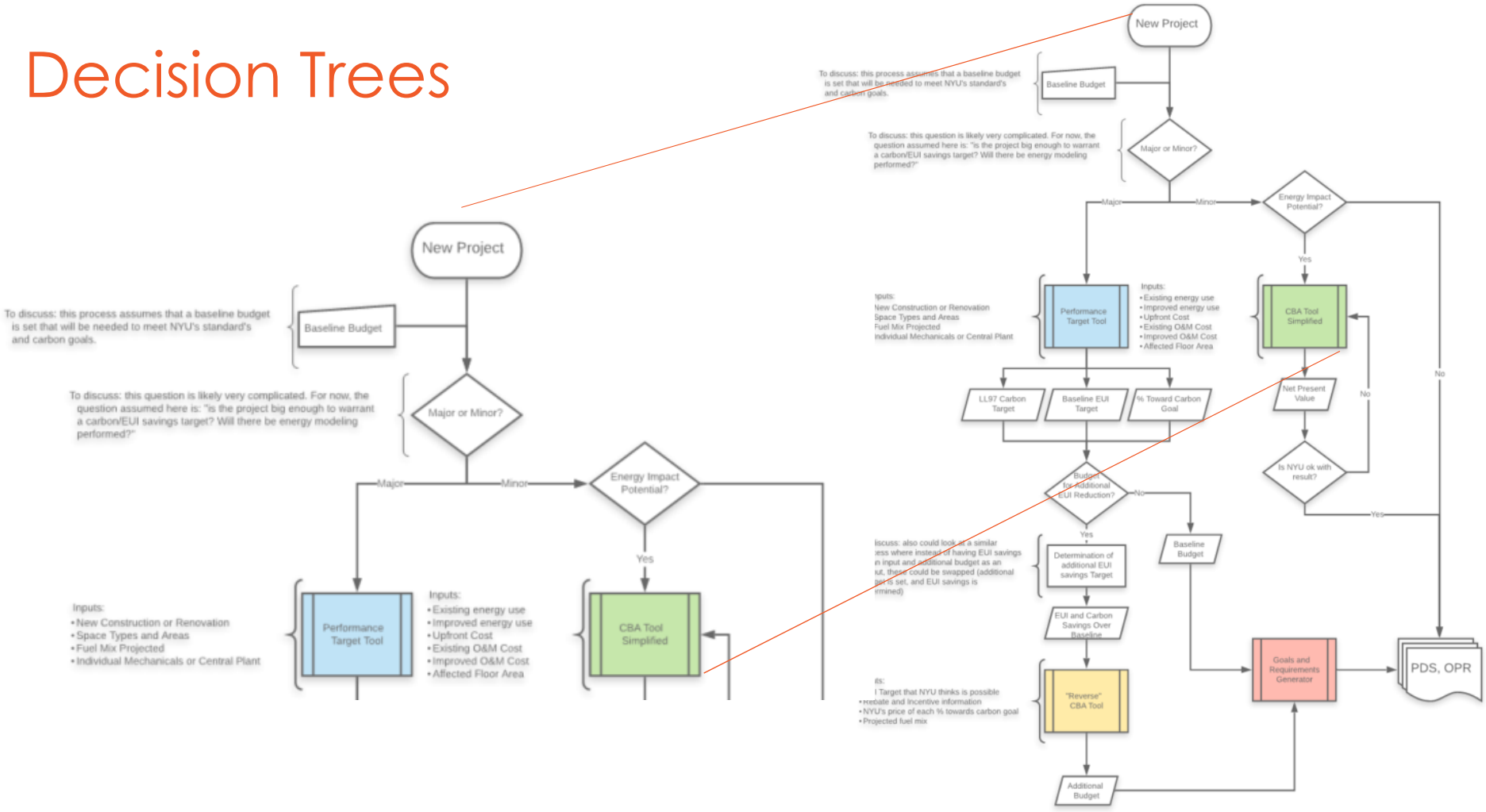


Next Steps

Tools & Document Synchronization

- Update/consolidate Standards & Owners Project Requirements (OPR)
- Update Specifications
- Create/identify Tools
  - Decision Trees
  - Cost/Benefit Calculators
  - Embodied Carbon Calculators
- Provide Guidance on Available Incentives/Financial Assistance

Decision Trees



Cost Benefit Analysis

- Excel based tool
- Help quantify the **financial benefit** of a particular Energy Conservation Measure (ECM) or package of ECMs
- Requires **costing information** and **energy modeling** inputs
- Will **standardize** how NYU uses energy modeling to inform decisions

Cost Benefit Analysis

- Inputs
  - energy cost savings,
  - ECM lifespan,
  - building lifespan, and
  - project financials.



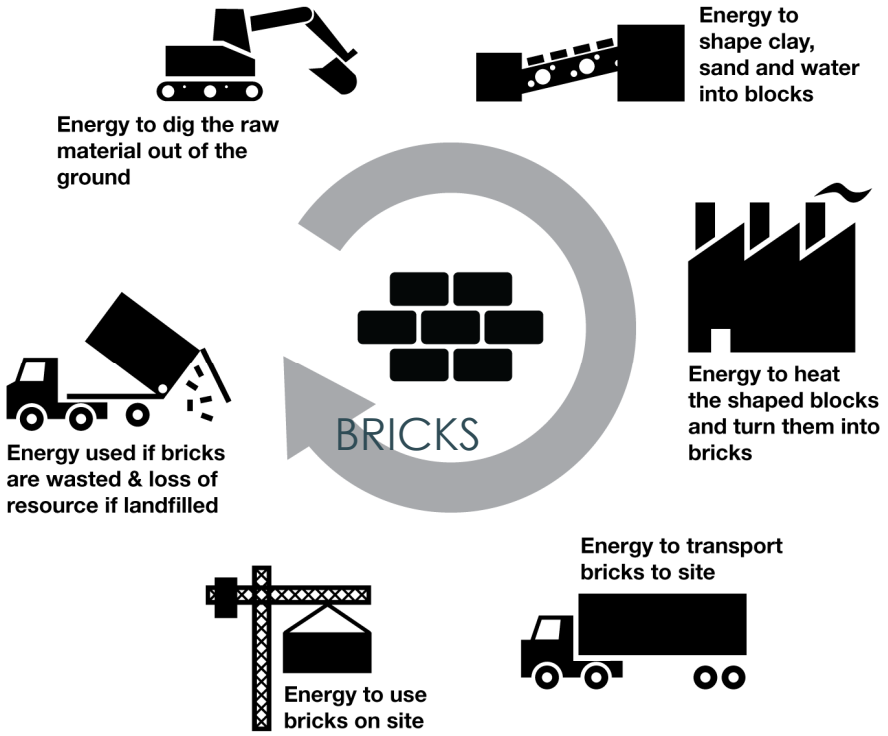
Cost Benefit Analysis

- Outputs
  - a. Simple Payback Period
  - b. Net Present Value
  - c. Annuity
  - d. Real Interest Rate
  - e. Residual Value
  - f. Cash Flow Diagrams

- CBA tool will accommodate various building types and sizes.

What is Embodied Carbon?

Embodied carbon refers to carbon dioxide emitted during the **manufacture**, **transport** and **construction** of building materials, together with end of life emissions.



Source: https://ccsbestpractice.org.uk/entries/embodied-carbon-poster/

Importance of Embodied Carbon?

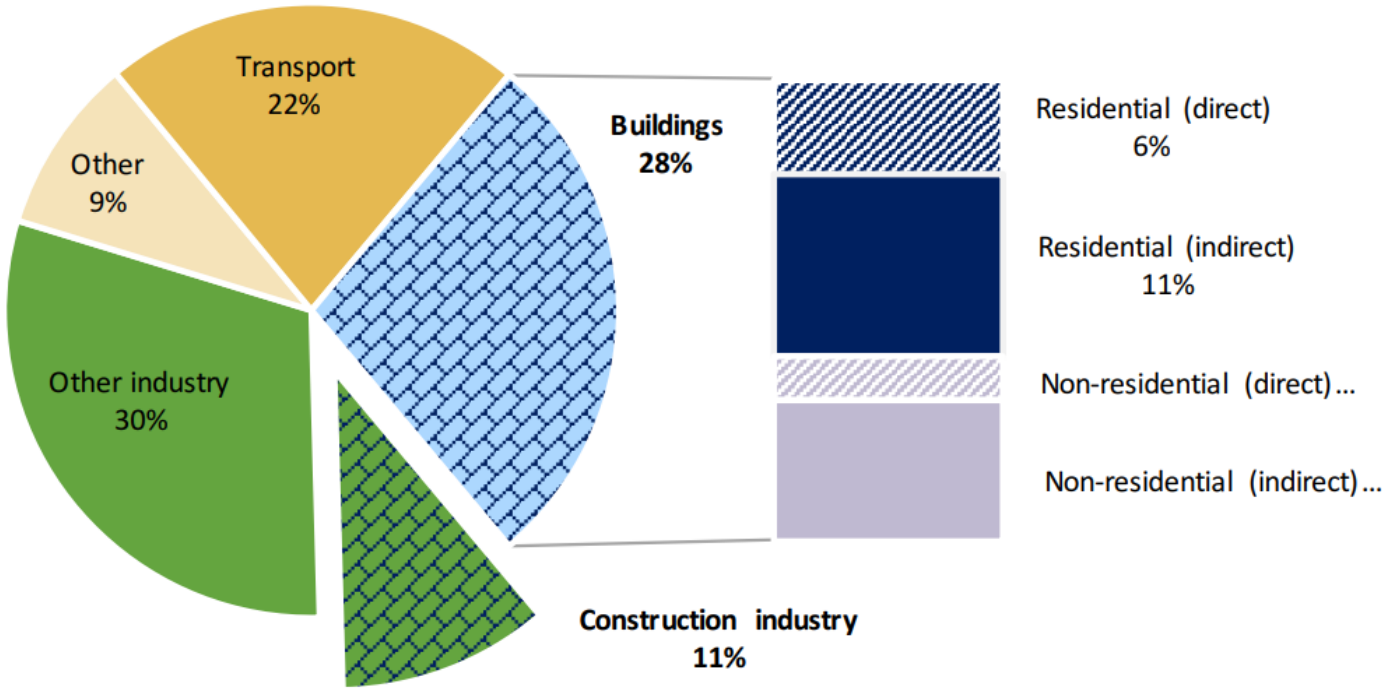
Embodied carbon can represent up to a **third of the whole life** carbon of a building.

With materials' carbon footprint making up as much as 20 percent of the total carbon emissions of a project during its full life cycle, there is a clear need for a focus on reducing the environmental impact of materials and products themselves.

Why Consider It?

Note: The "construction industry" is an estimate of the portion of the overall industry sector that applies to the manufacturing of materials for building construction, such as steel, cement and glass.

Share of global energy-related CO2 emissions by sector, 2015



Source: UN Environment Programme, 2017, Global Status Report 2017: Towards a zero-emission, efficient, and resilient buildings and construction sector. Pg 14

LCA

- One Click LCA
  - Life Cycle assessment tool: Automated whole life-cycle impact calculation including embodied carbon for entire project- **LCA**

	Baseline Building Value	Proposed Building Value	Units	Percent Reduction (%)
Global warming potential GHG	1,054,339.34	682,013.25	CO_2e	35.31
Stratospheric ozone depletion	0.04	0.03	kg CFC-11	25
Acidification of land and water	7,091.51	5,028.11	○ moles H ● kg SO_2	29.1
Eutrophication	1,935.29	1,402.84	● kg N ○ kg PO_4	27.51
Tropospheric ozone formation	78,973.21	54,822.57	● kg NOx ○ kg C_2H_4	30.58
Depletion of non-renewable energy resources	94,319,777.77	7,055,867.35	MJ	92.52
Number of measures with at least a 10% reduction				6

  - Example of an LCA using One Click for a childcare center in Washington, DC.

LCA Tools

- EC3
  - Looks at a “project’s overall embodied carbon emissions, enabling the specification and procurement of the low carbon options” (EC3). Product comparisons- **LCA**
  - Outputs include
    - Visualization of embodied carbon emissions w/ limits and targets
    - Material baselines and reduction targets
    - Material supply chains and embodied carbon data
    - Digitized Environmental Product Declarations (EPDs)

Discussion



Take our survey:

PollEv.com/swa335

Join Us for More Trainings!

- **Module 7**: Beyond Hydrofluorocarbons (HFCs): Refrigerant Management in Design, Construction, and Operations
- **Module 8**: Construction Manager/Subcontractor/Tradesperson Training: Classroom and Field Training

Register here: https://www.newpaltz.edu/sustainability/view-programs-and-progress/zero-net-carbon-training/workshop-schedule-registration--details/

Contact Us

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larena@swinter.com

203.857.0200 x 2140

www.swinter.com



Resources

- www.surehouse.org
- https://be-exchange.org/
- https://passipedia.org/
- https://www.aldes.us/airflow-zone-controls/car-ii
- https://www.youtube.com/watch?v=e6HTC_rOQOA
- https://www.buildingtransparency.org/en/