Overview of Passive House & Net Zero Building Concepts, Techniques, & Benefits

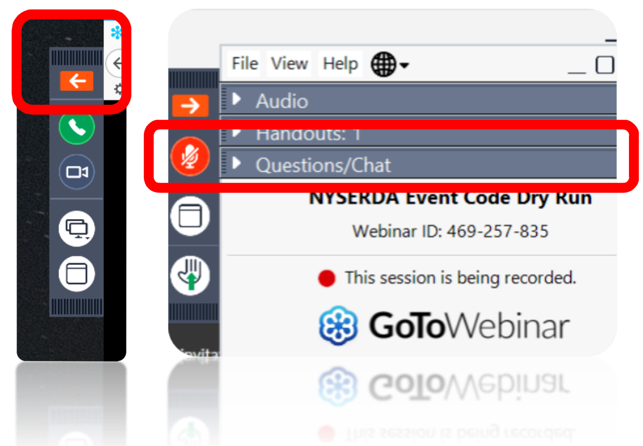
Webinar Overview

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 the presentation.

Webinar will be recorded and sent.



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CONTINUING EDUCATION AIA

Learning Objectives

Understand net zero carbon goals for SUNY

Name 3 challenges to meeting net zero performance

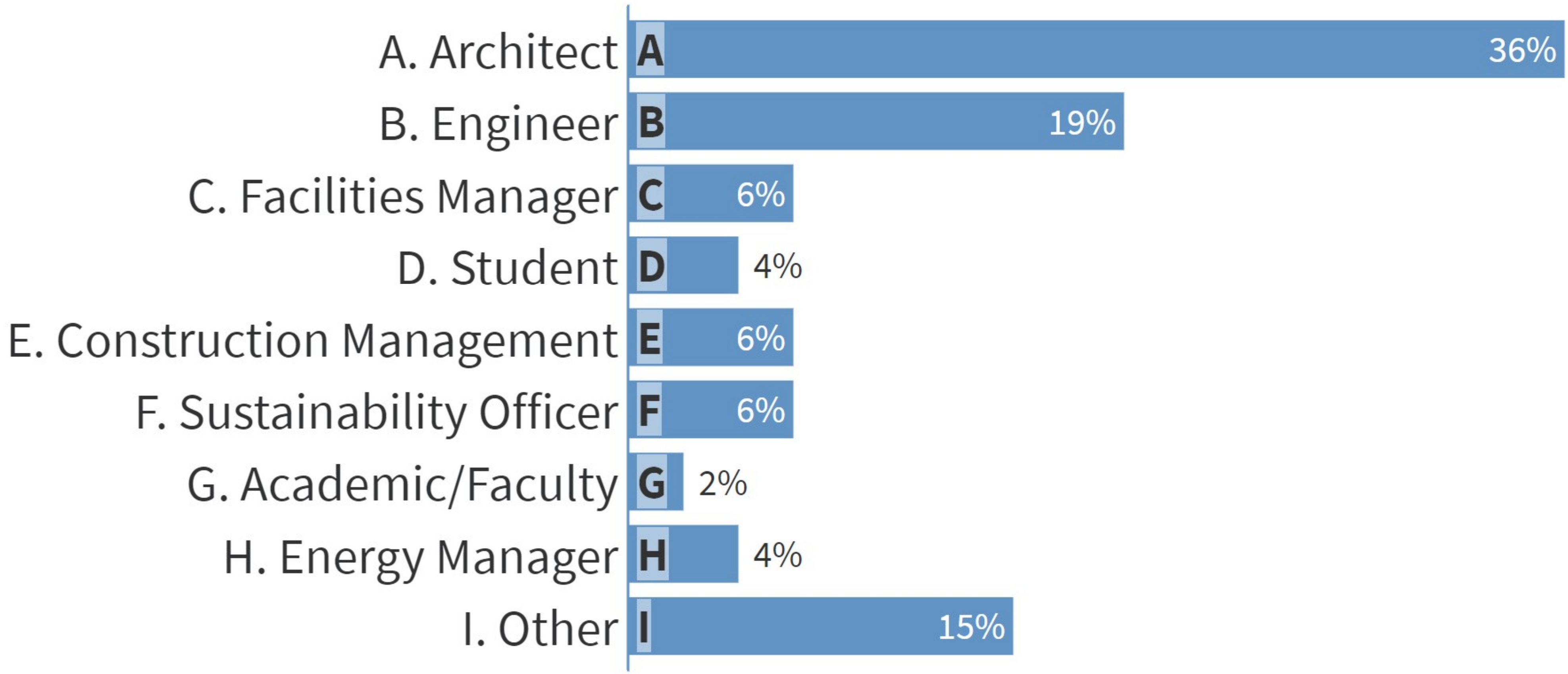
List principles common to Passive House standard & high performance construction

Provide 3 reasons why ventilation is important

Overview of Presentation

1. Introductions/House Keeping
2. SUNY's Directive 1B-2 & Where We're Starting From
3. Putting EUI Targets into Perspective
4. Passive House as a path to Net Zero
5. Solutions & Techniques
6. Deep Energy Retrofits
7. Integrated Project Management
8. Life Cycle Analysis

What is your profession?



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

Why we are here - Directive 1B-2

Coykendall Science Building

Directive 1B-2: Background

- 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.

Haggerty Administration Building

Directive 1B-2: Background

Design and construct highly energy efficient buildings which **significantly reduce energy consumed** below an energy code standard for new buildings or energy usage for an existing building.

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

Jacobson Faculty Tower

Directive 1B-2:

Setting Performance Targets: New Construction

New Building Performance goals:
Site Energy Use Intensity (EUI) limits

Classroom building	50 kBTU/ft2/year
Office building	50 kBTU/ft2/year
Laboratory building	150 kBTU/ft2/year
Residence Hall	32 kBTU/ft2/year

Directive 1B-2: Setting Performance Targets: DER

Deep Energy Retrofits of Existing Buildings → Full building major renovations or gut rehabilitations (single or multi-phased) → Some building types exceptions - i.e. historic buildings → A holistic building design approach and analysis is critical → Strong consideration should be given to combining replacement of multiple building systems

Smiley Art Building

Directive 1B-2: Setting Performance Targets

DER Performance goal:

- 50% reduction of the building's current annual site energy consumption.
- 25% reduction of the building's current annual site carbon consumption.

Sojourner Truth Library

Lenape Hall

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, which provide
  - system level energy use,
  - recommended energy conservation measures and
  - simple payback analysis.

Directive 1B-2: Setting Performance Targets: Partial Reno

- Partial Buildings Renovations or System/Component Replacements:

- Performance goal: - Include in project design all energy efficiency measures found to have a simple payback of 10 years or less.

Esopus Hall

Directive 1B-2: Setting Performance Targets: Partial Reno

- Evaluation and selection of new equipment and systems should take into consideration their contribution to the overall reduction of energy
- Holistic design and analysis approach is critical
- Where a less than optimum sequencing is needed, equipment selections must include turndown capability, ie:
  - chillers with multiple variable speed compressors or
  - multiple smaller condensing boilers.

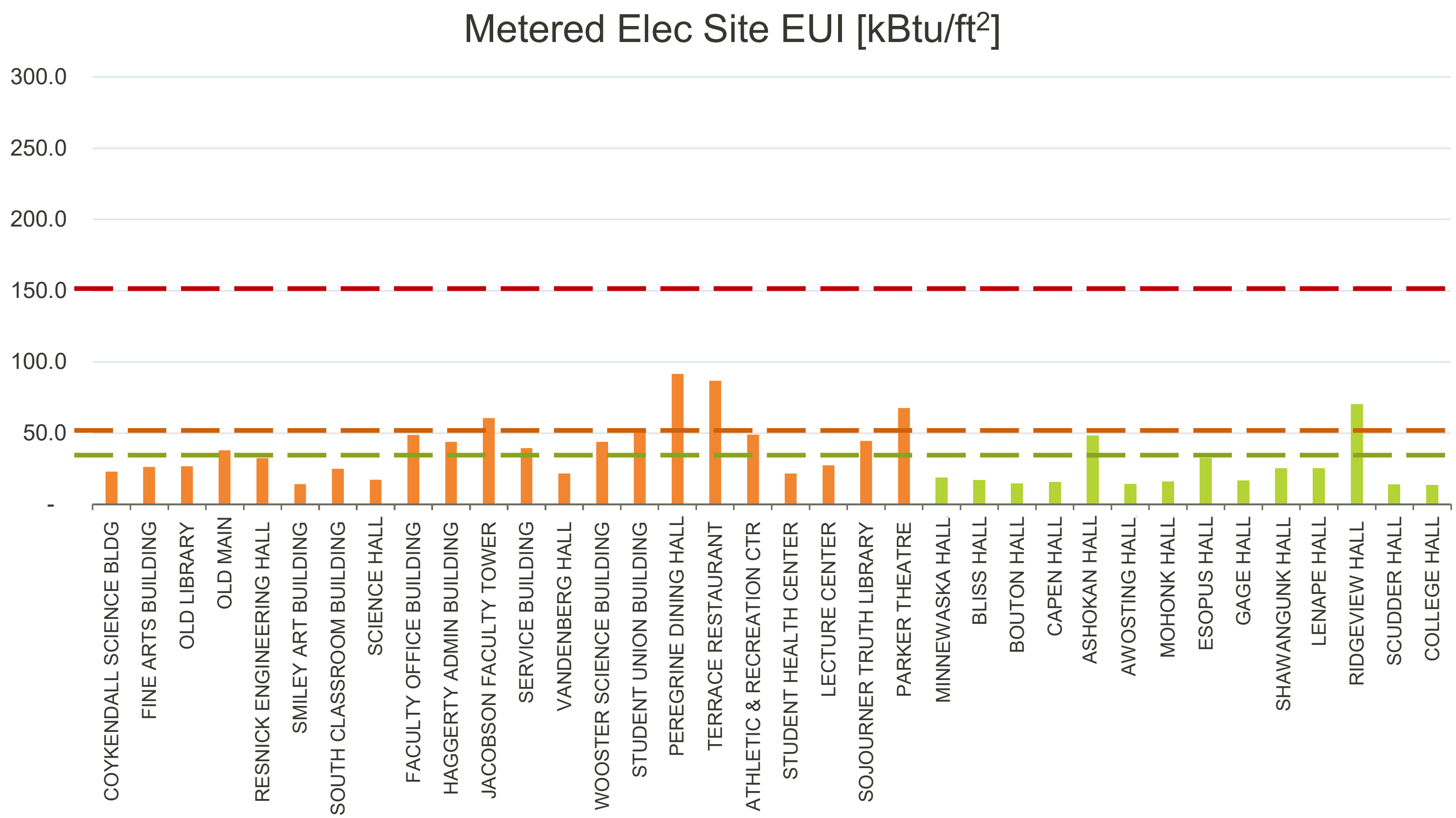
Bouton Hall

Overview of SUNY New Paltz Buildings/Practices

2018 Site EUI's for SUNY New Paltz: Electric

Target EUIs NC

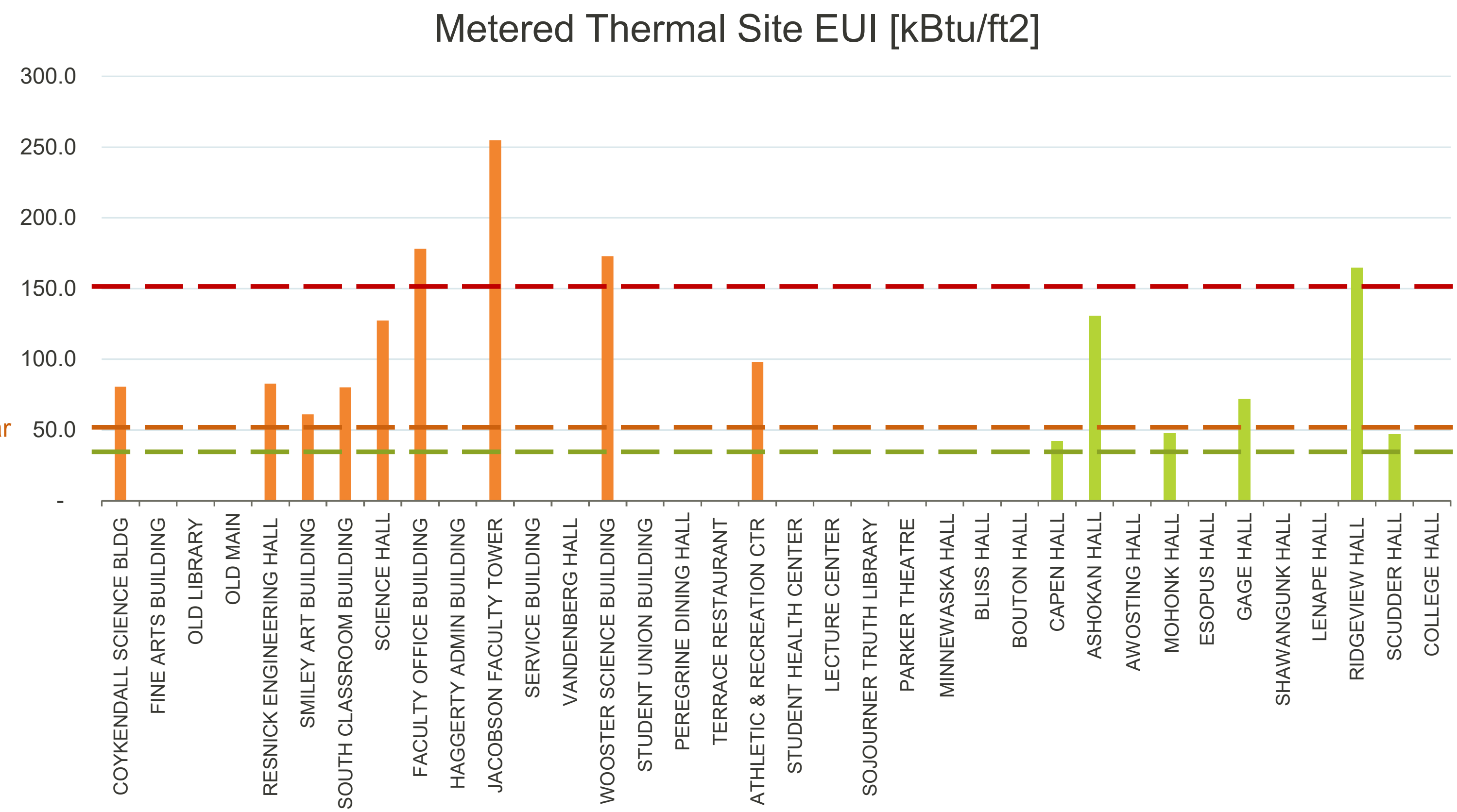
- Laboratory – 150 kBTU/ft2/year
- Classroom & Office – 50 kBTU/ft2/year
- Residence Hall – 32 kBTU/ft2/year



2018 Site EUI's for SUNY New Paltz: Thermal

Target EUIs NC

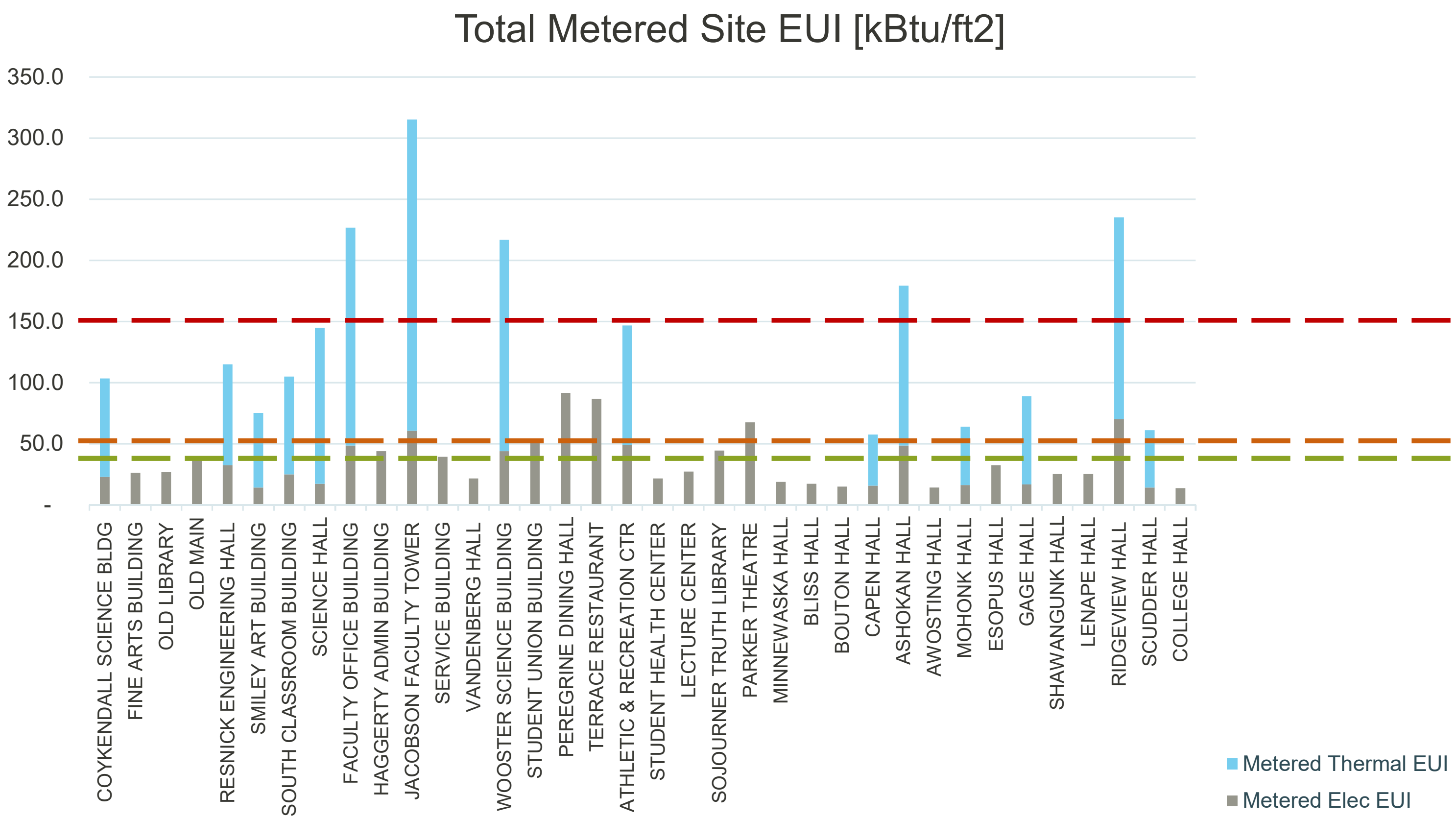
- Laboratory – 150 kBTU/ft2/year
- Classroom & Office – 50 kBTU/ft2/year
- Residence Hall – 32 kBTU/ft2/year



2018 Site EUI's for SUNY New Paltz: Total

Target EUIs NC

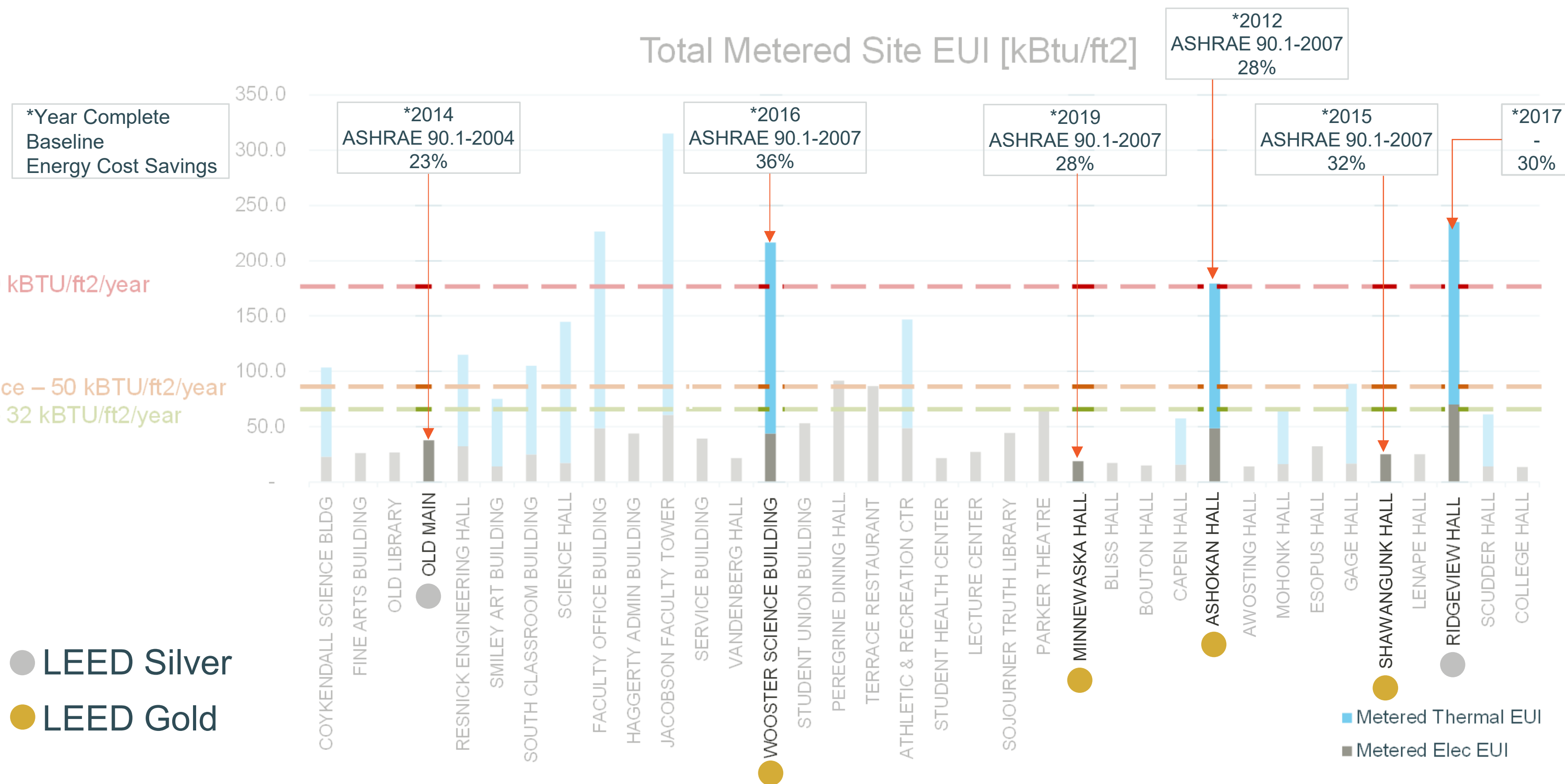
- Laboratory – 150 kBTU/ft2/year
- Classroom & Office – 50 kBTU/ft2/year
- Residence Hall – 32 kBTU/ft2/year



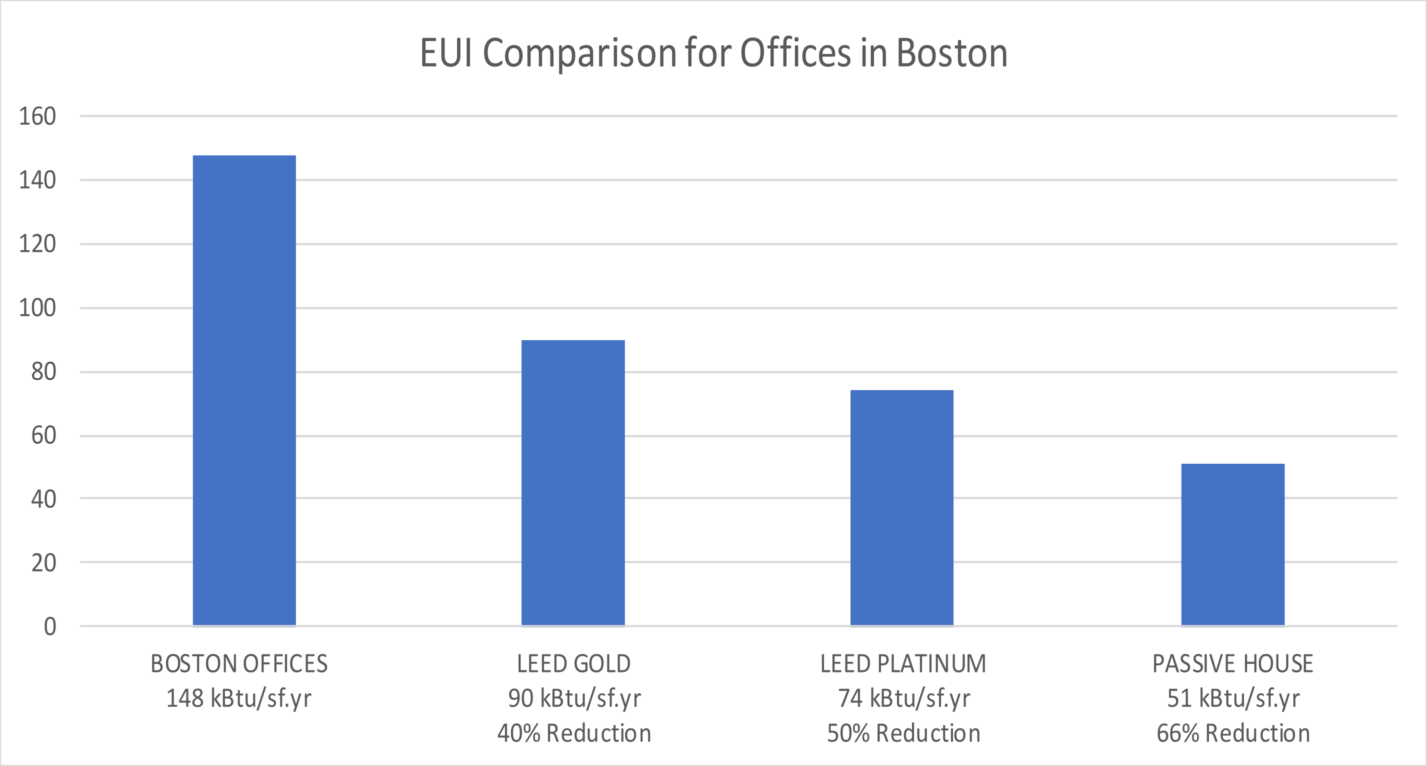
Comparison to site EUIs of existing LEED buildings

Target EUIs NC

- Laboratory – 150 kBTU/ft2/year
- Classroom & Office – 50 kBTU/ft2/year
- Residence Hall – 32 kBTU/ft2/year



Comparison to site EUIs of LEED buildings



Barriers to Adoption

Barriers to Adoption

Putting Net Zero Goals Into Perspective

Let's Talk EUI

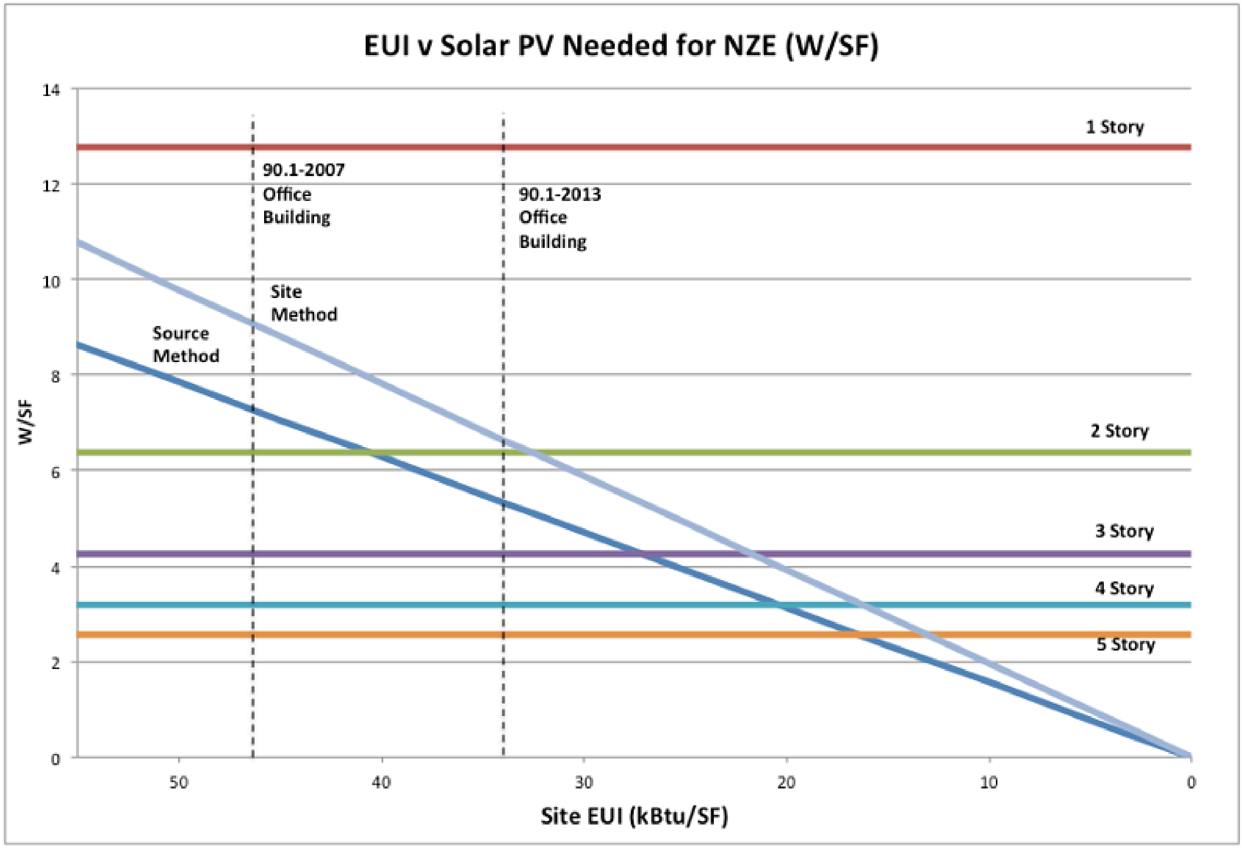
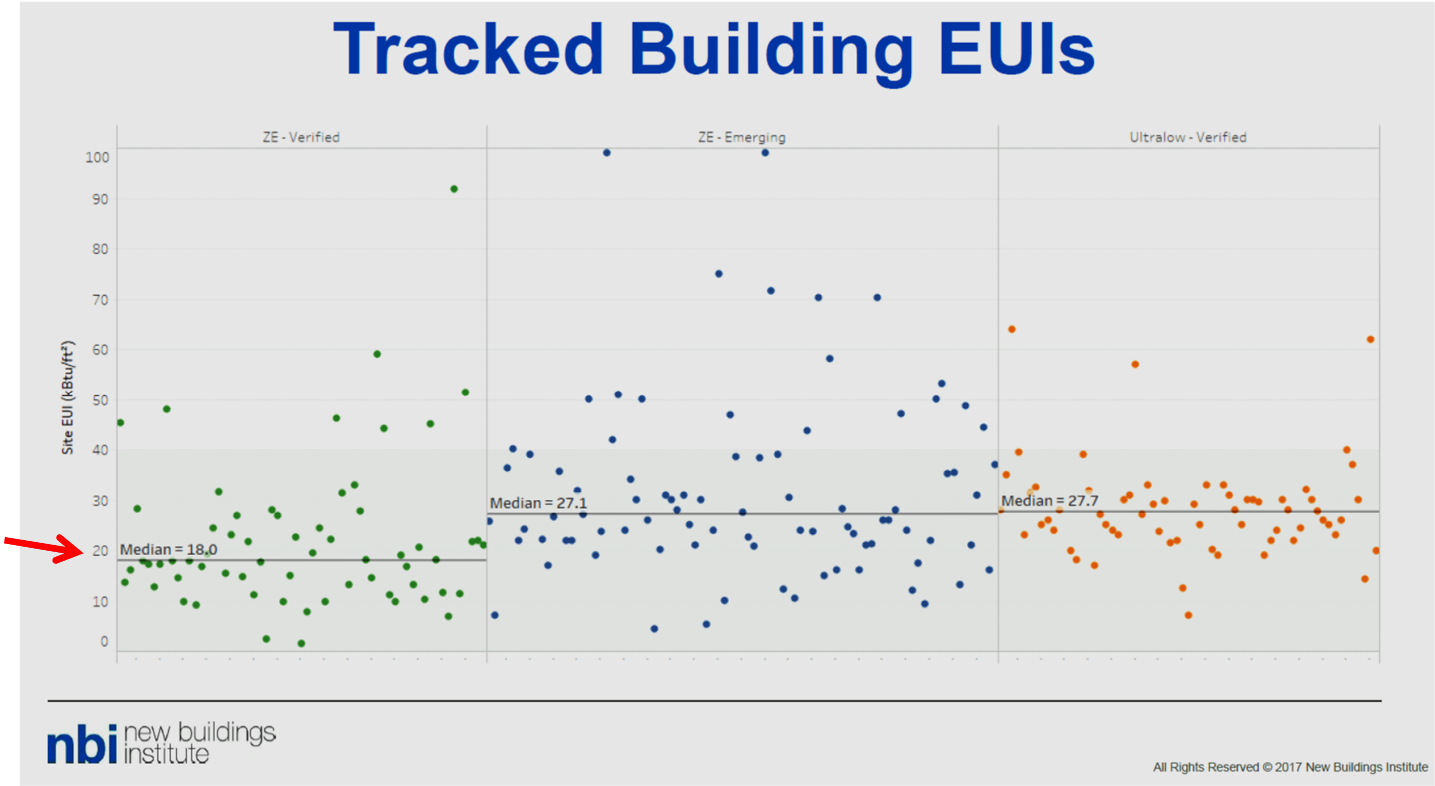


Image: Joshua Radoff

Zero Energy Building EUIs



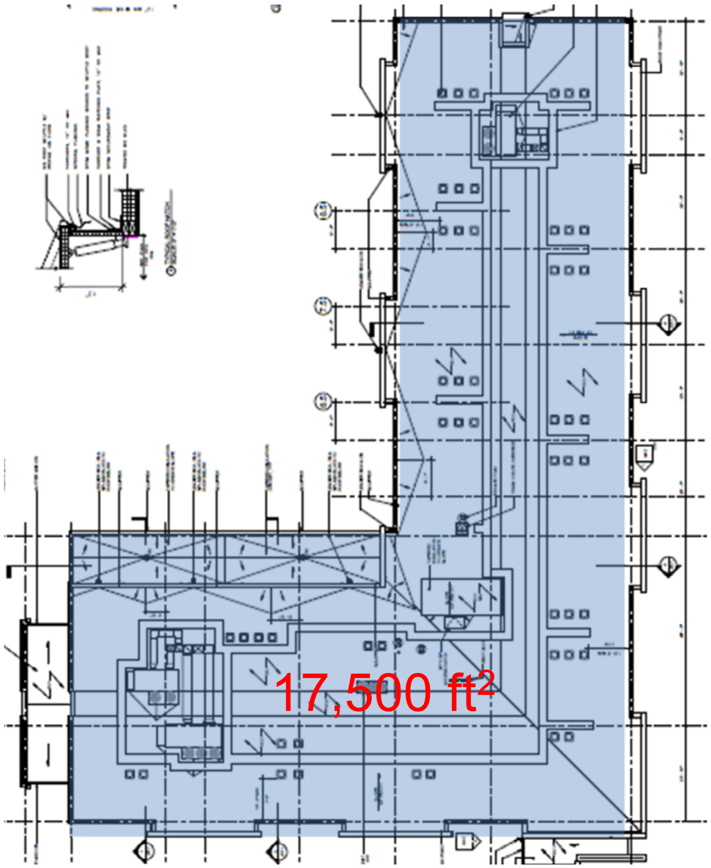
St. John Neumann

- 3 Stories, 50 senior apartments, 1 Bed
- 51,000 ft2 gross,17,500 ft2 roof
- EUI – 25 kBtu/ft2

St John Neumann

- 25 kBtu/ft^2 = 375,000 kWh
- PV array needed = 300 kW
- Roof area needed =18,000 ft^2 @ 20W/ft^2

- NZ is possible, but further reductions are needed



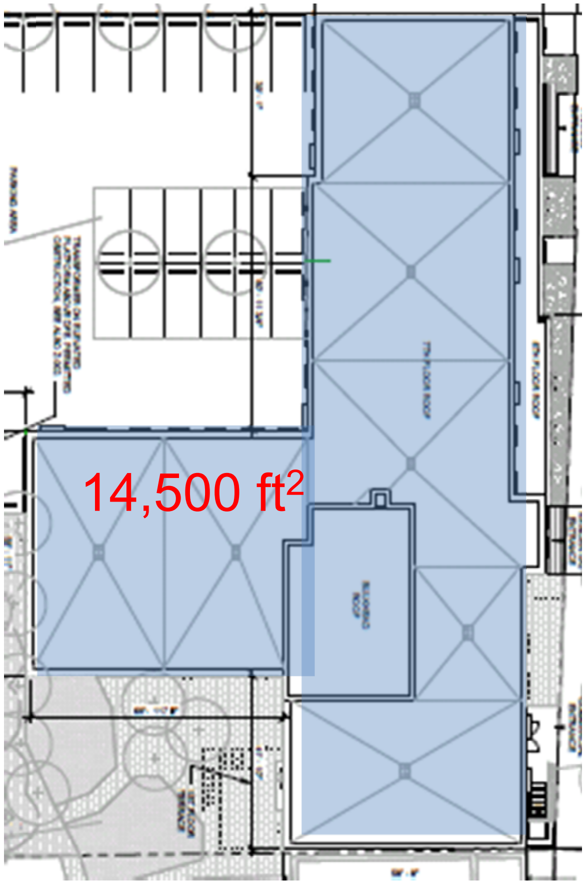
Beach Green North II

- 8 Stories, 130 apartments, range of sizes,
- 116,000 ft2 gross, 14,500 ft2 roof
- EUI – 26 kBtu/ft2

Beach Green North II

- 26 kBtu/ft2 = 885,000 kWh
- PV array needed = 650 kW
- Roof area needed =32,500 ft^2 @ 20W/ft^2

- NZ is not possible w/ current design
- Would need to reduce EUI to 12 kBtu/ft2



425 Grand Concourse

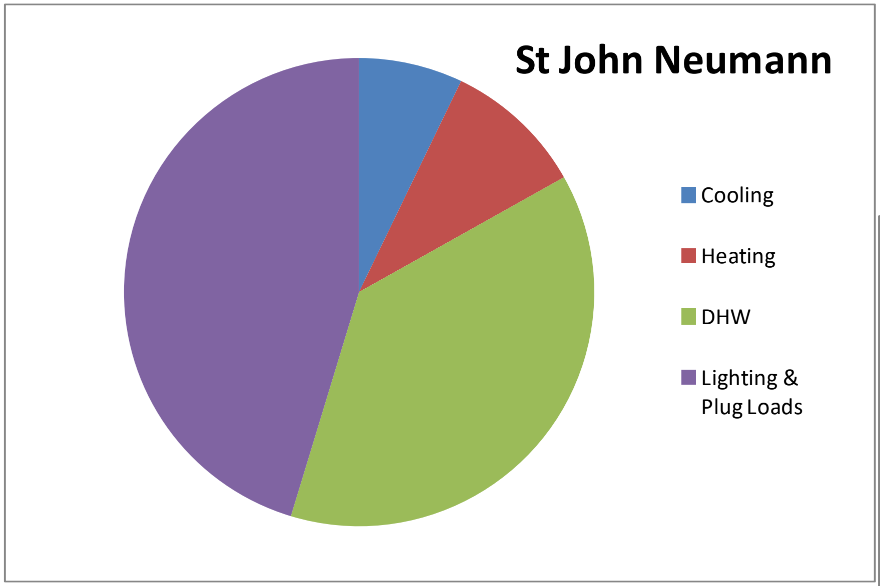
- 25 Stories, 290 units
- 260,000 ft^2 gross
- Roof area:10,474 ft^2
- EUI – 22.5 kBtu/ft2

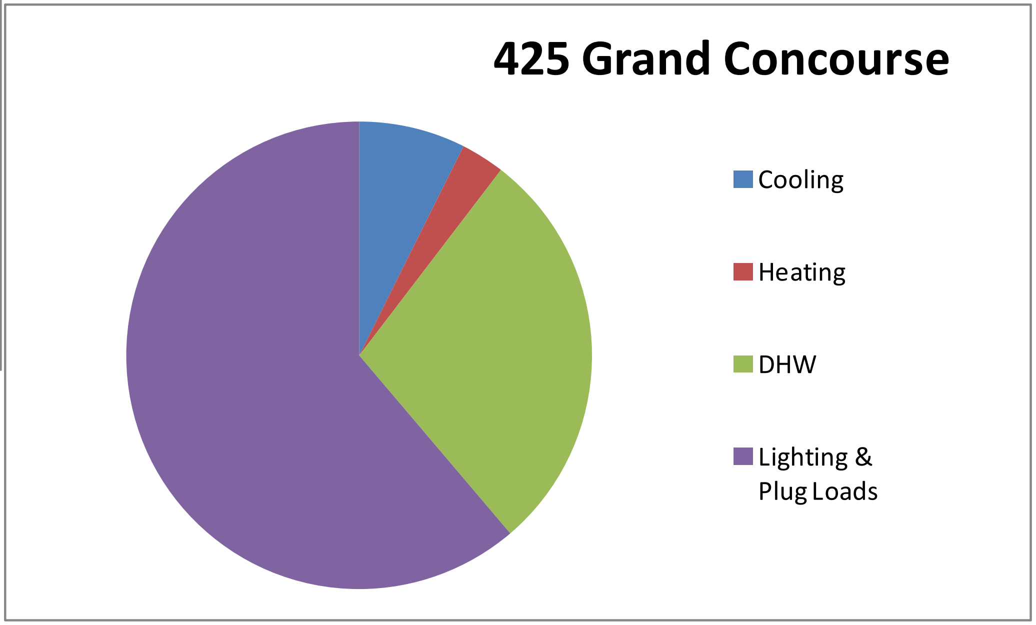
425 Grand Concourse

- 22.5 kBtu/ft2 = 1,700,000 kWh
- PV array needed = 1,400 kW
- Roof area needed =70,000 ft^2 @ 20W/ft^2

- NZ is not possible w/ on site renewables
- Would need to reduce EUI to 12 kBtu/ft2

MF Buildings & EUI Breakdown





Challenges of the Urban Environment

Shade

Ownership

Roof Conditions

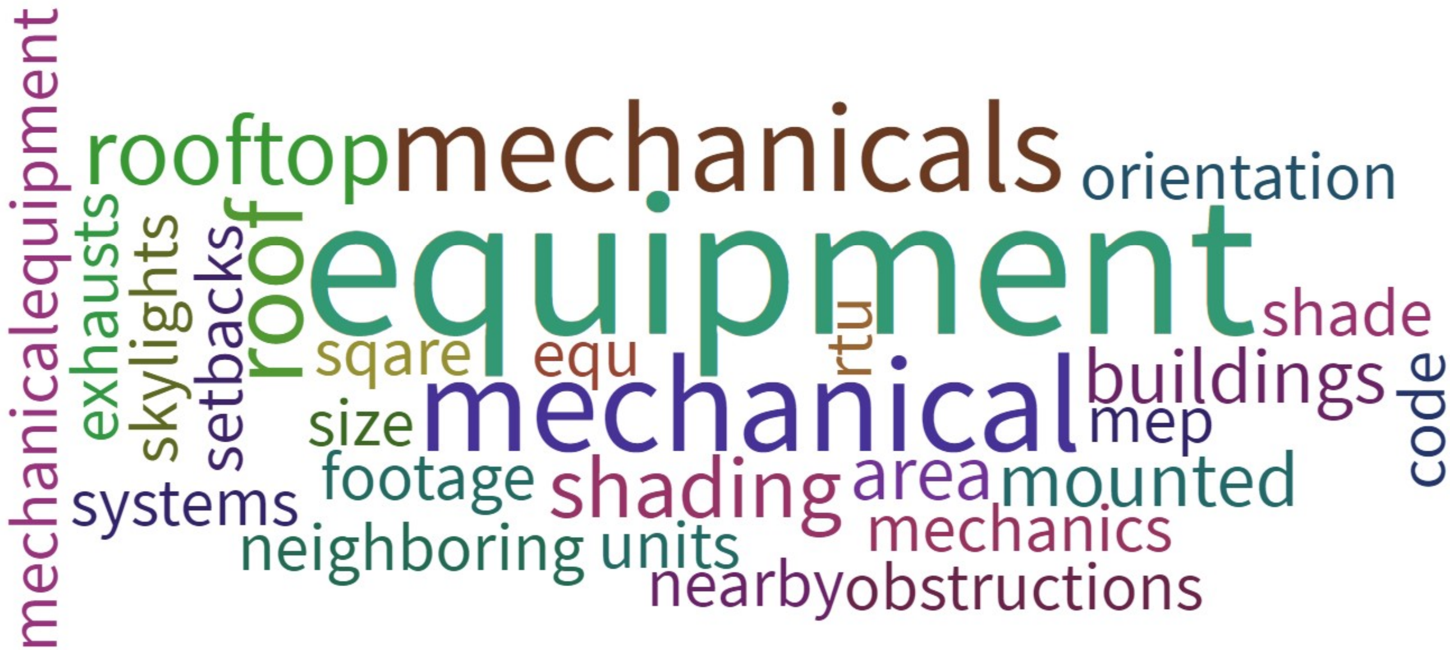
Roof Layout

- Racking types:

- Key considerations:
  1. Sun access
  2. Rooftop equipment
  3. Fire access pathways
  4. Regulatory restrictions

Above how many stories does getting to zero with roof mounted PV become next to impossible?

Name something that restricts the amount of roof-mounted PV that can be installed or its effectiveness .



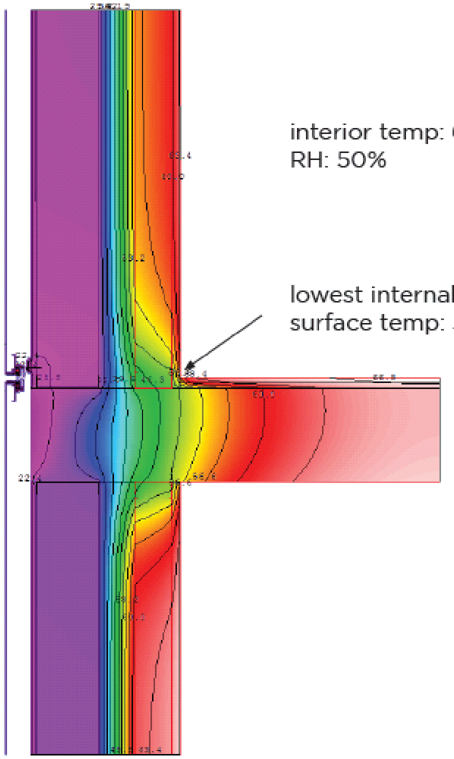
Getting to Zero with Passive House

What is Passive House (PH)?

- First and foremost, PH is a building standard
- Applies to New & Existing buildings
- The most rigorous energy efficiency certification available
- Performance-based approach
- Attention to insulation continuity and reduction of thermal bridges
- Emphasis on balanced ventilation

Comfort Criteria

- Interior surface temperatures should not deviate by more than 7.6°F from the average operative temperature on the inside;
- the surface temperature must not be lower than 55.4°F or greater than 132°F at any point;
- the surface temperature of the floor must be between 66°F and 81°F.

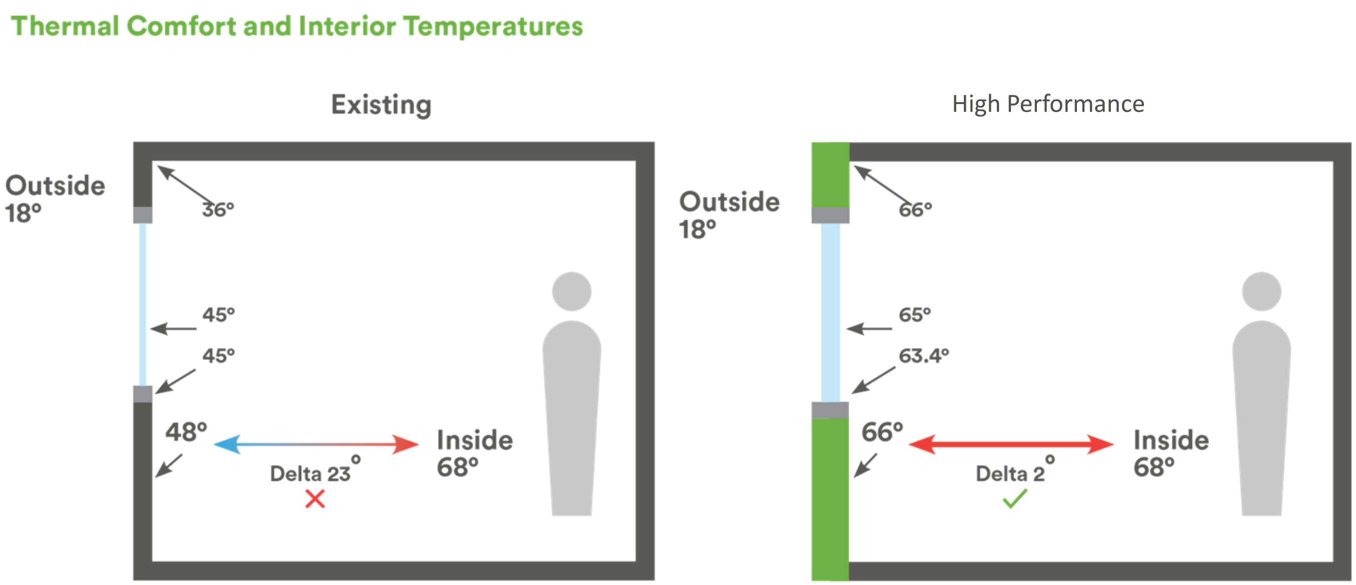


A-11 Option 2
At risk for condensation

Goals of PH

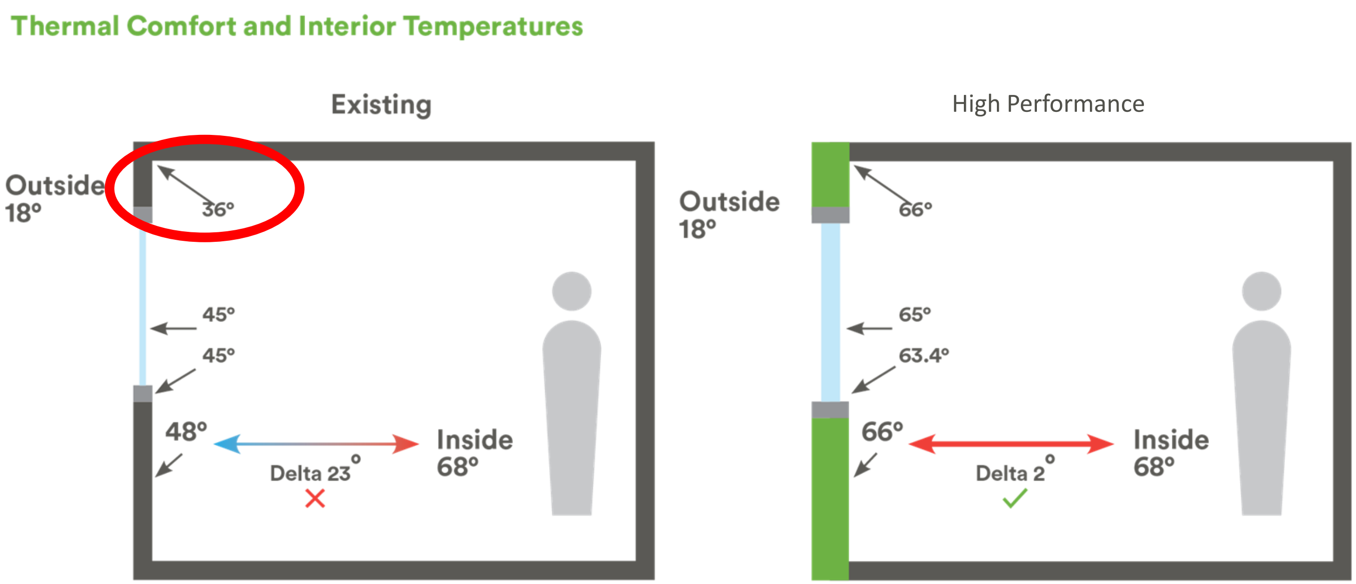
- Building durability
- Energy $ reduction
- Optimal thermal comfort
- Superior indoor air quality
- Carbon emissions reductions

Comfort



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

Comfort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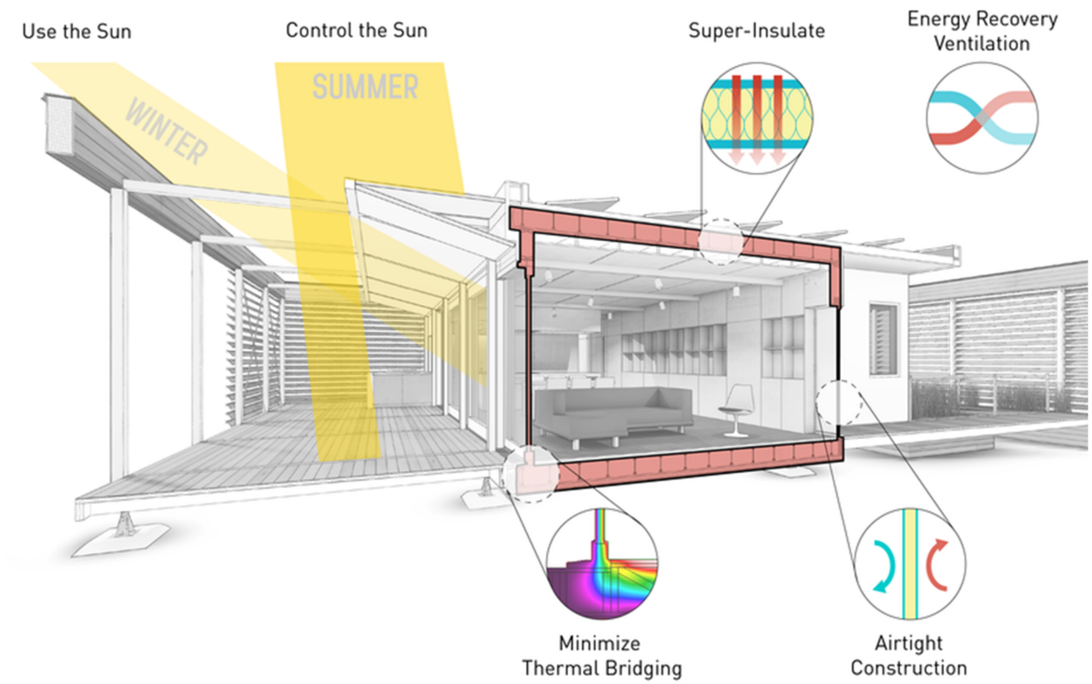
Delta 23°
High Performance
Outside
18°
66°
65°
63.4°
66°
Inside
68°
Delta 2°

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







PH Performance Criteria: New Construction

Criteria	Threshold
Space heating/cooling demand	4.75[1] $kBtu/ft^2$ yr
Whole building energy demand	38.0 $kBtu/ft^2$ yr
Air infiltration	0.6 ACH@50
Frequency of overheating[2]	<10%

← Source

[1]Cooling demand varies depending on climate and density
[2]Applicable if no mechanical cooling is present

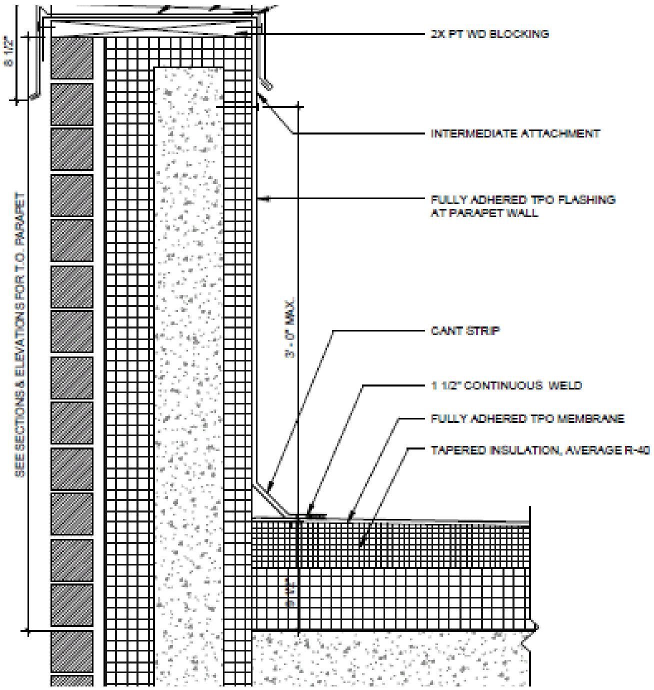
38 kBtu/ft2 Source Energy ≈ 21 $kBtu/ft^2$ Site Energy (assuming 30% gas)

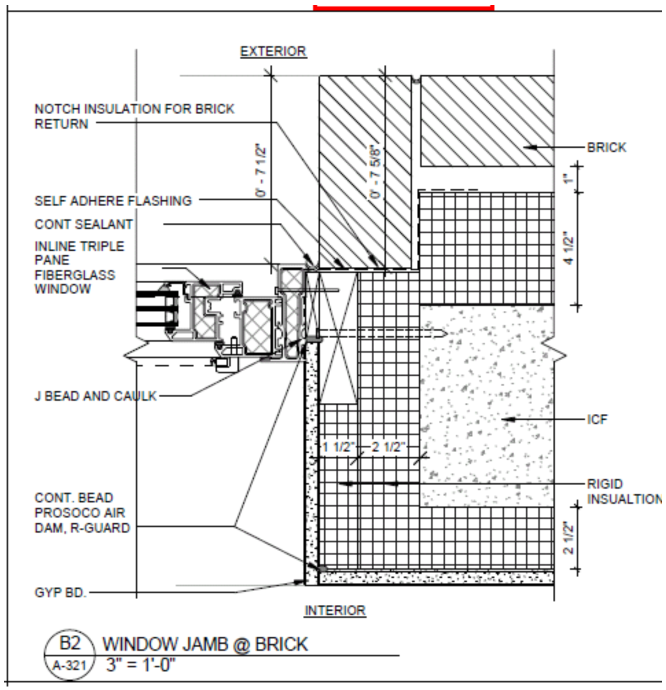
EnerPHit Standard

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

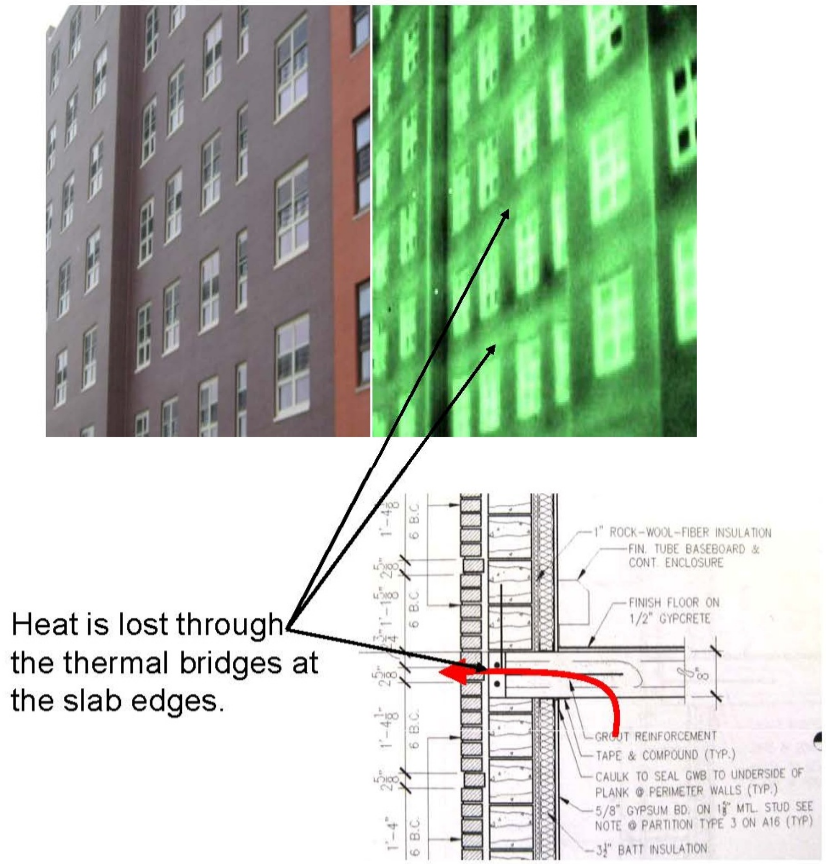
Continuous Insulation





Thermal Bridge Free Design

- All typical details must be reviewed and modeled by PH consultant
- Too much thermal bridging can result in condensation and comfort issues
- This can completely undermine the exterior insulation of the building if not handled

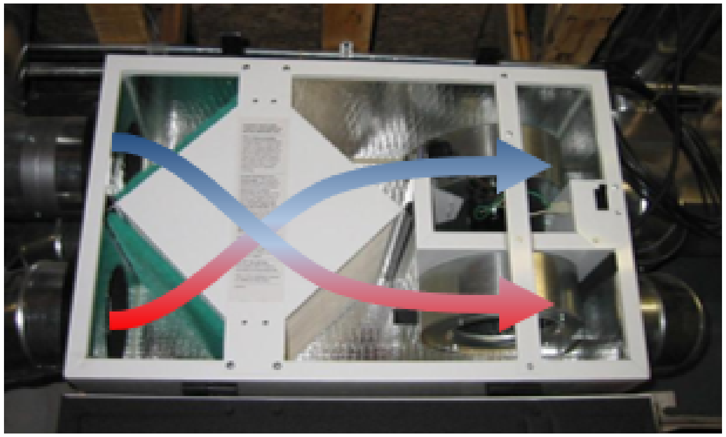


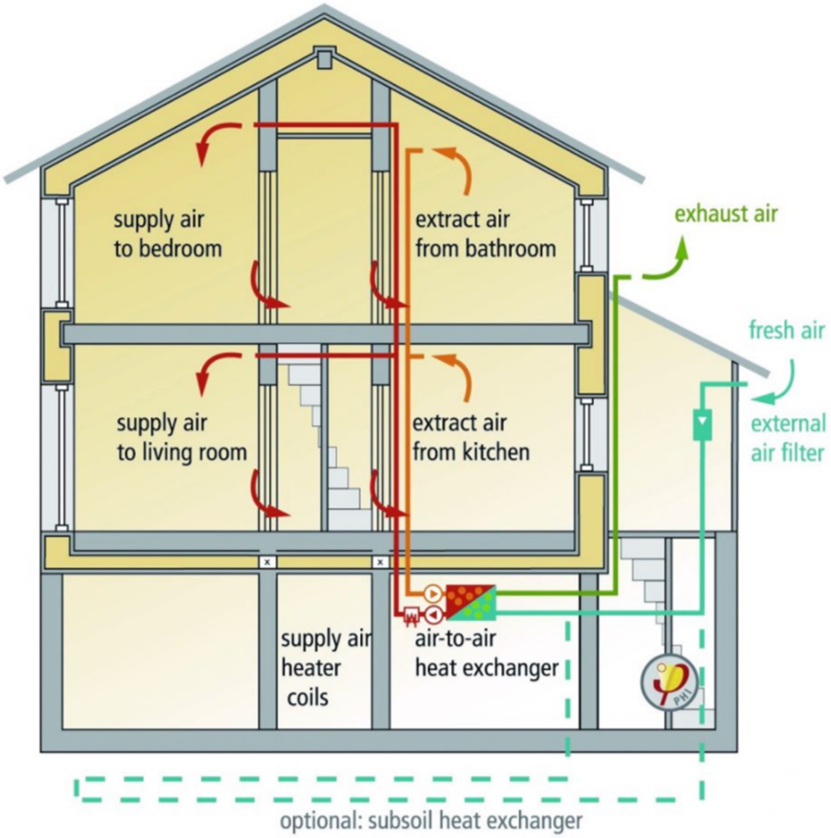
Air-Tightness

- Requirement: < 0.6 ACH@50
- What does this mean?
  - @50 refers to 50 pascals pressure difference between indoors and out during a blower door test, ≈ 20mph wind on all sides of house
  - 0.6 ACH@50 ≈ 5 times tighter than ENERGY STAR®

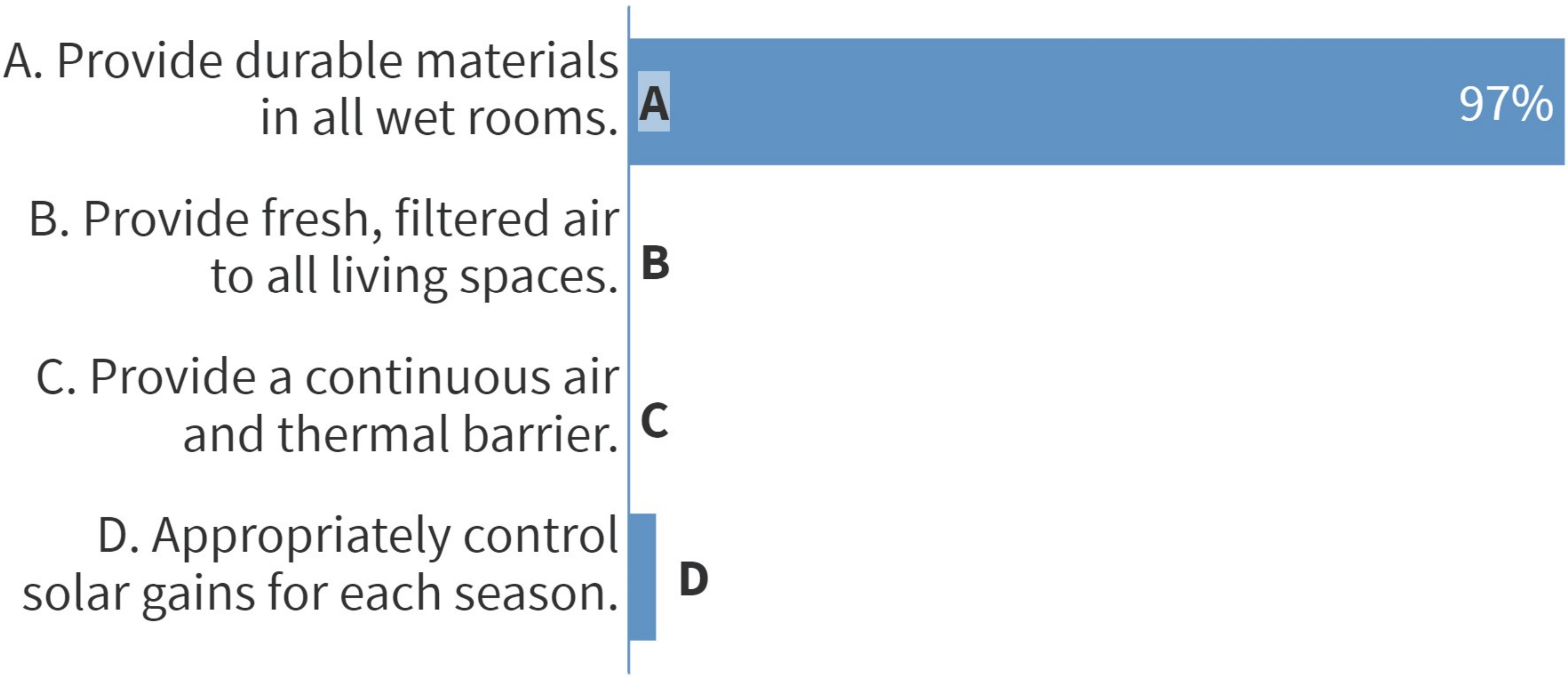
Balanced Ventilation and Heat/Energy Recovery

- Provide fresh, filtered air 24 hours a day
- Heat exchanger +75% Efficient
- Highly insulated and air-sealed ductwork





Which of the following is NOT a PH principle?



Solutions & Techniques

15 Minute Break

Thermal Boundary

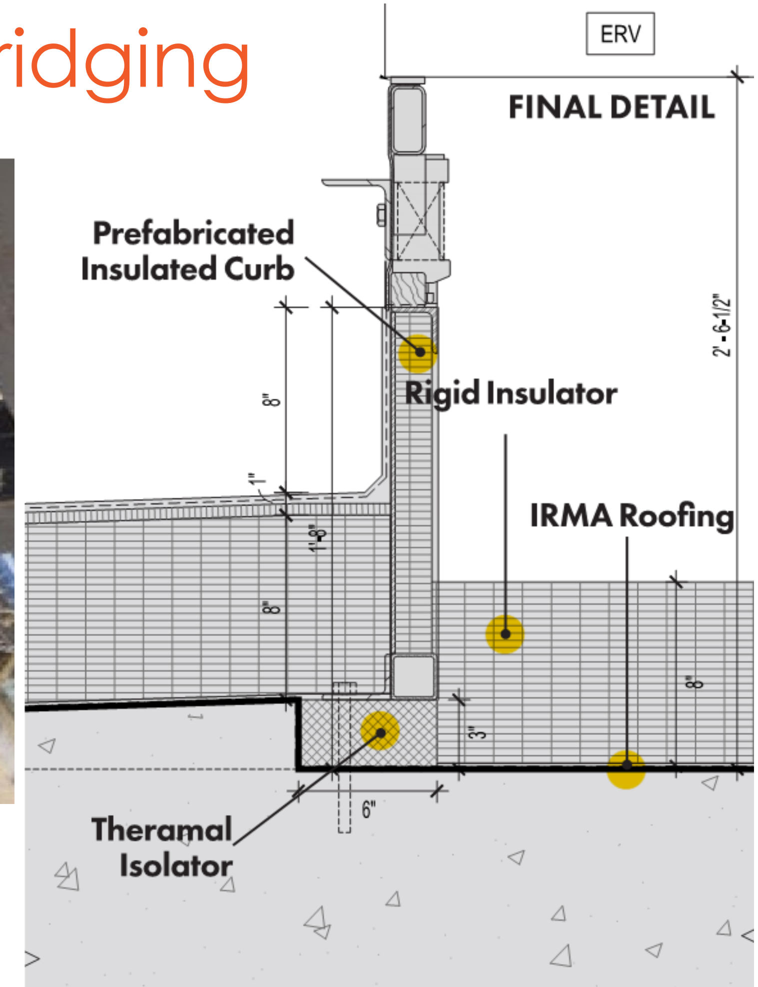
. . . a plane where insulation exists to prevent thermal transmission through the building shell.

- Factors affecting performance:
  - Location of insulation in the building shell
  - Type of insulation
  - Amount of insulation (thickness and ft^2)
  - Quality of installation (good, fair, poor)
  - Is insulation protected from wind-washing?
  - Is insulation protected from moisture?

Factors That Reduce Insulation Performance

- Penetrations
- Compression (refer to manufacturer's compression charts)
- "Fluffing", especially blown fiberglass
- Voids and gaps, inconsistent coverage
- Moisture
- Not in contact with the surface it is insulating

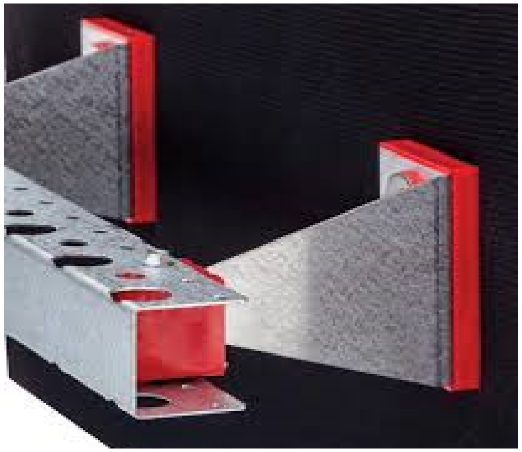
Eliminate/Mitigate Thermal Bridging



Evaluating Different Envelopes

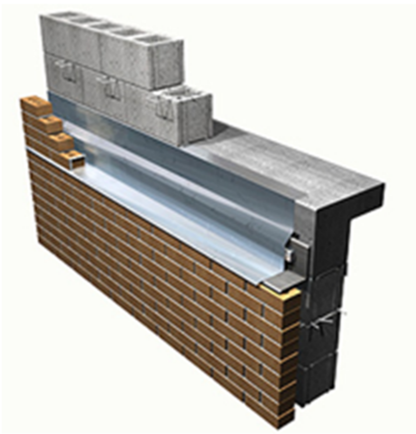
Stainless Steel Clips
Thermal Efficiency
63% Steel Backup
74% CMU Backup

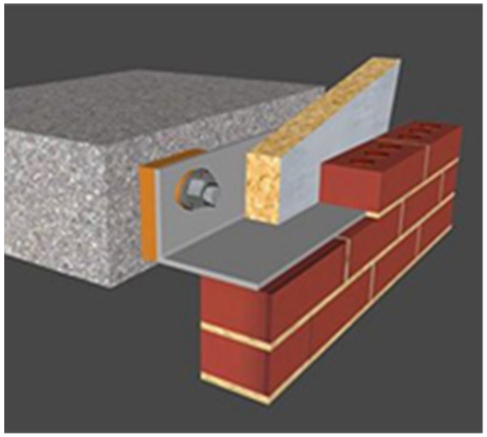
Fiberglass Clips
Thermal Efficiency
64% for Steel Backup
79% for CMU backup



Thermal Stop Clips
Thermal Efficiency
67% for Steel Backup
80% for CMU Backup

Evaluating Different Envelopes



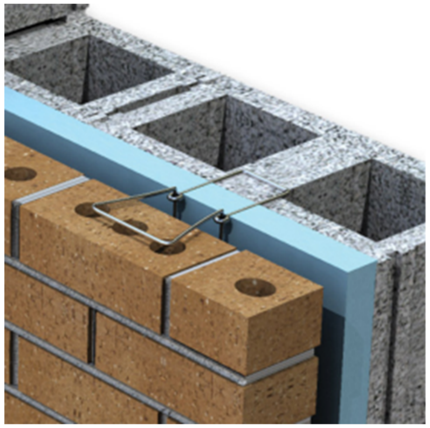


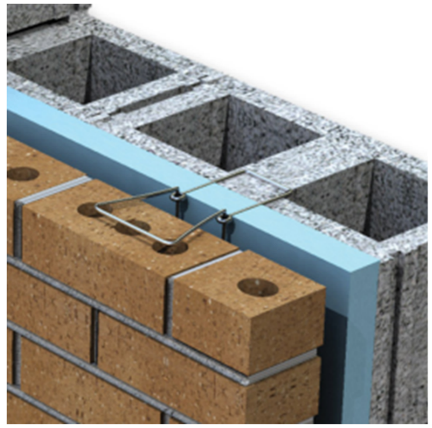
Typical Shelf Angle
Thermal Efficiency
55% Steel Backup
67% CMU Backup

Stand-off Angle
Thermal Efficiency
72% Steel Backup
81% CMU Backup

Angle with 1” Thermal Break
Thermal Efficiency
80% Steel Backup
86% CMU Backup

Evaluating Different Envelopes





Galvanized Steel Brick Ties
Thermal Efficiency
75% Steel Backup
84% CMU Backup

Stainless Steel Brick Ties
Thermal Efficiency
87% Steel Backup
93% CMU Backup

Thermal Break Brick Ties
Thermal Efficiency
88% Steel Backup
94% CMU Backup

High Performance Walls Guide

CLADDING ATTACHMENT SYSTEMS AND THEIR IMPACT ON CONTINUOUS EXTERIOR INSULATION EFFICIENCY

Document Summary: This document is meant to serve as a guide for designers and builders to compare the thermal performance of different cladding attachment systems. The first section is a catalogue of products, split into brick veneer and cladding finish systems. The second section presents thermal modeling results of these systems from a study conducted by Steven Winter Associates (SWA).

Thermal Efficiency: percentage of continuous insulation R-value that is effective.

- **100%** thermal efficiency = continuous insulation without thermal bridging
- **20%** thermal efficiency = continuous insulation derated to 20% of installed R-value

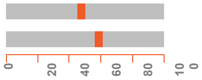
For Cladding Finish Systems: Clips

Galvanized Metal Clips

Description

These clips are usually galvanized steel and are used to support rainscreen and panel cladding systems.

Thermal efficiency per SWA: **46-59%**



46% for Steel backup
59% for CMU backup

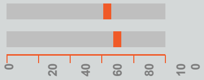
Standard Product

Stainless Steel Clips

Description

Replacing galvanized steel clips with stainless steel ones can greatly reduce the thermal conductivity.

Thermal efficiency per SWA: **63-74%**



63% for Steel backup
74% for CMU backup

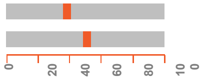
Example Products:
A-Clip. MFSSCHAN

Aluminum Clips

Description

Aluminum clips are light weight and strong. They are a more elastic and non corrosive alternative to traditional metal clips.

Thermal efficiency per SWA: **38-52%**



38% for Steel backup
52% for CMU backup

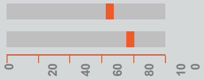
Example Products:
Alpha Brackets

Fiberglass Clips

Description

Fiberglass clips have a much lower thermal transmittance coefficient than any metal equivalent.

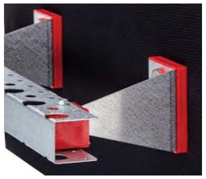
Thermal efficiency per SWA: **64-79%**



64% for Steel backup
79% for CMU backup

Example Products:
Cascada Clip

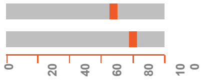
Thermal Stop Clips



Description

This clip has a plastic thermal stop at the base and head to help mitigate thermal bridging.

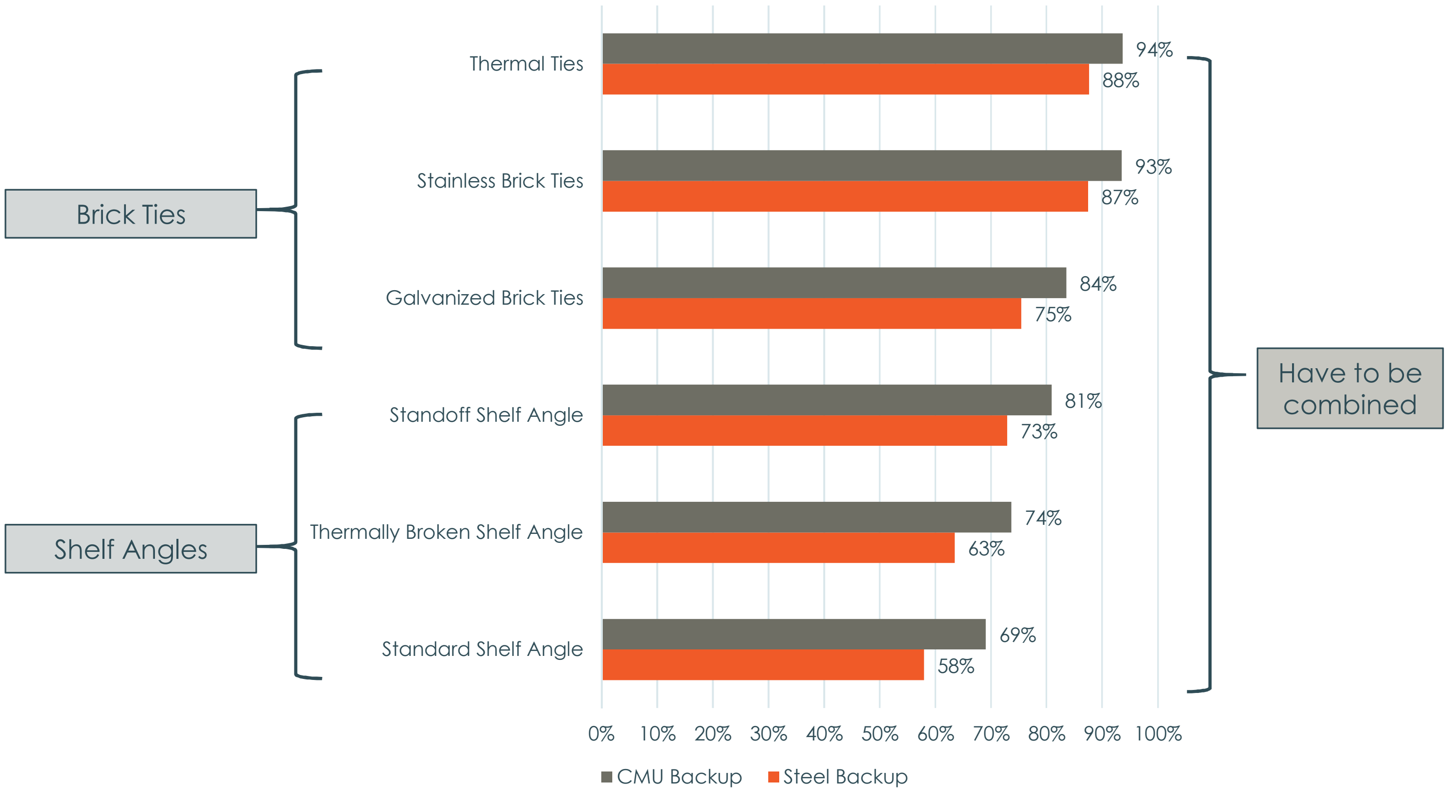
Thermal efficiency per SWA: **67-80%**



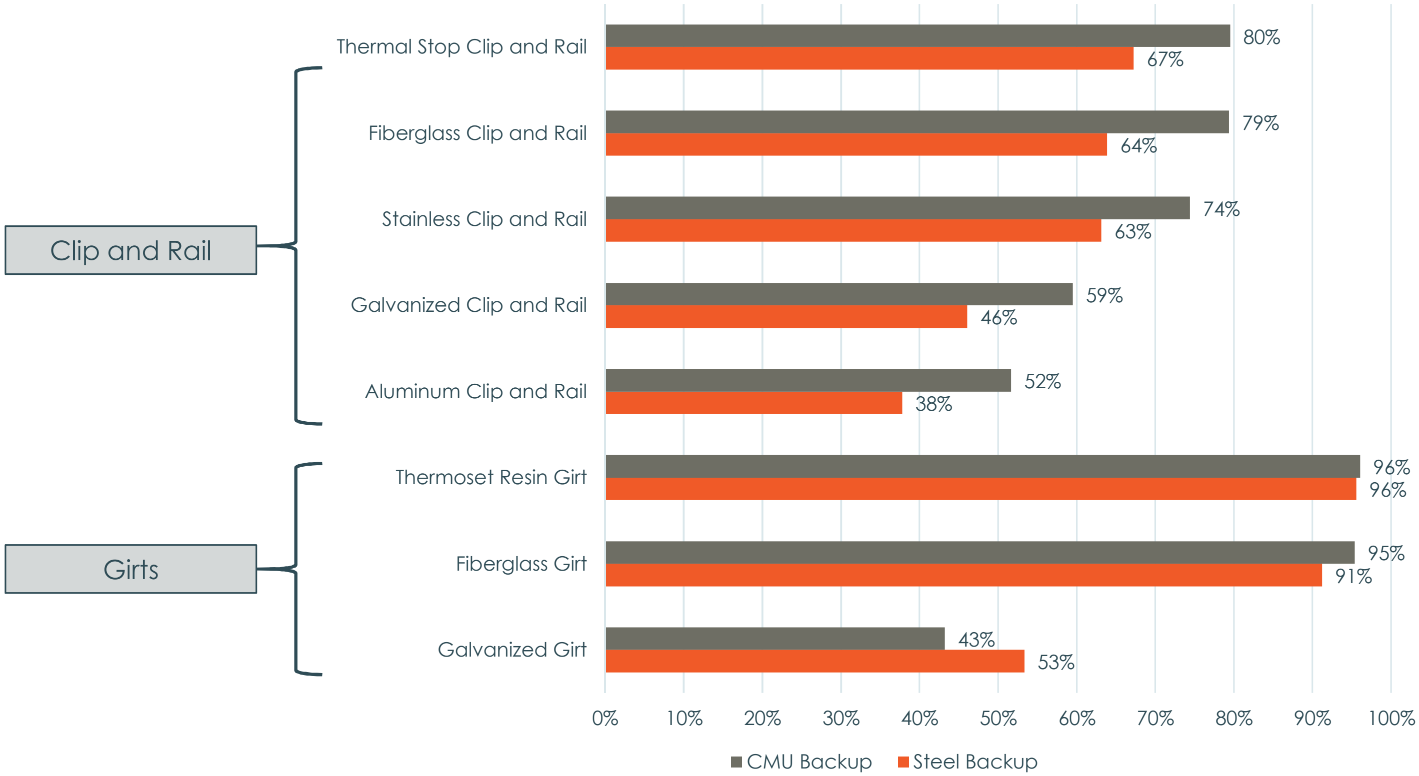
67% for Steel backup
80% for CMU backup

Example Products:
Pos-I-Tie Thermal Clip, Nvelope NV1 Thermal Clip

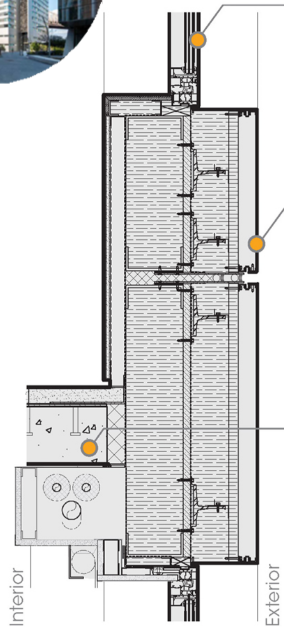
Results: Brick Veneer



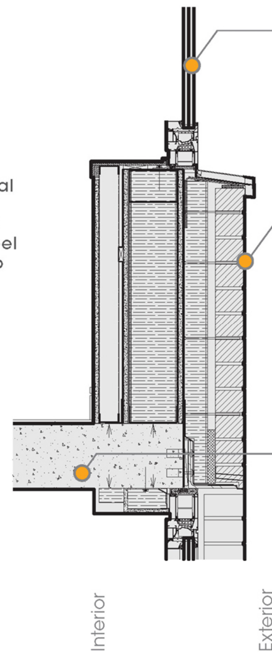
Results: Panel Cladding



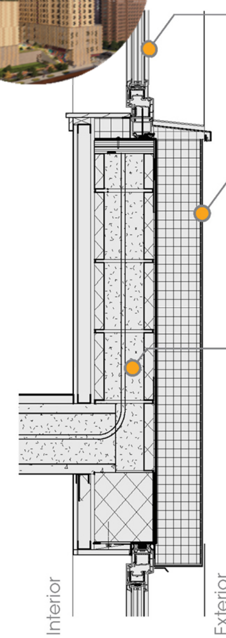
EXTERIOR WALL SECTION COMPARISON



The House

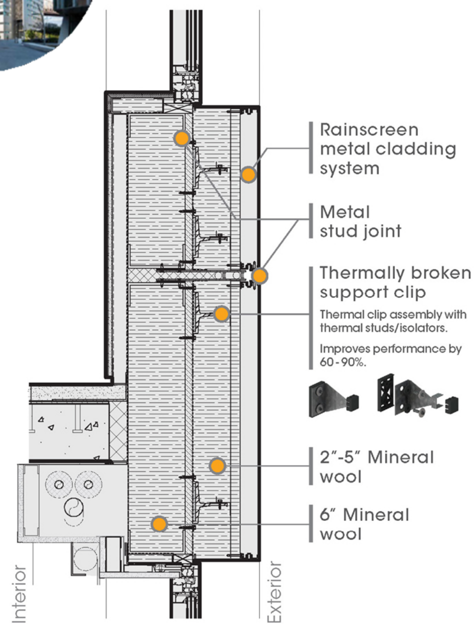


Sendero Verde Bldg. A

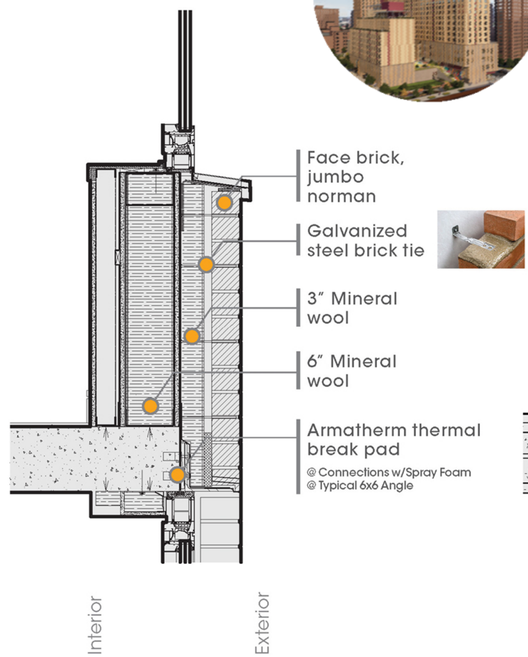


Sendero Verde Bldg. B

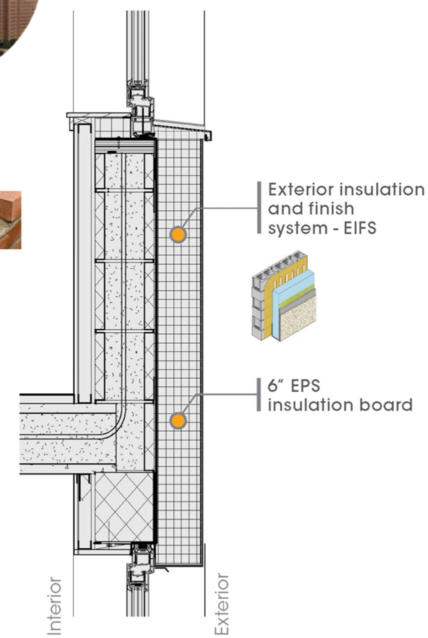
EXTERIOR WALL SECTION COMPARISON



The House
R Value: R-19

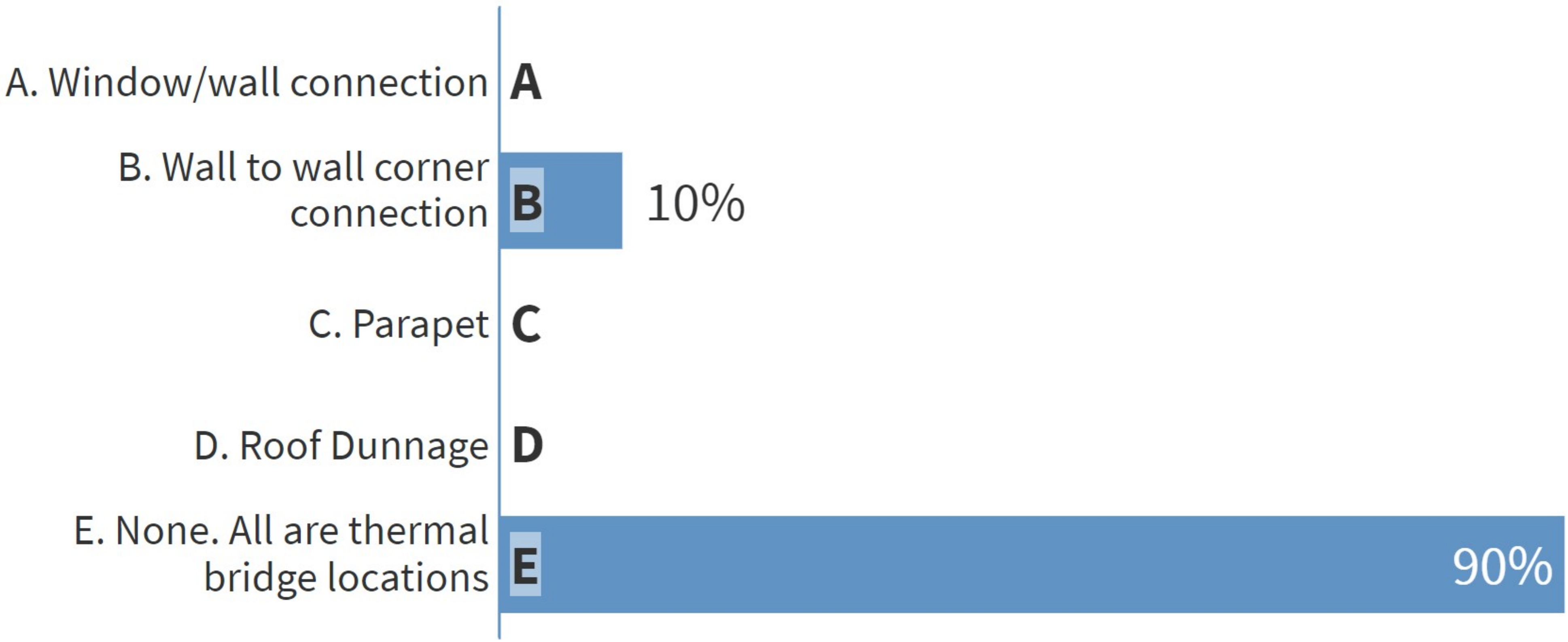


Sendero A
R Value: R-24



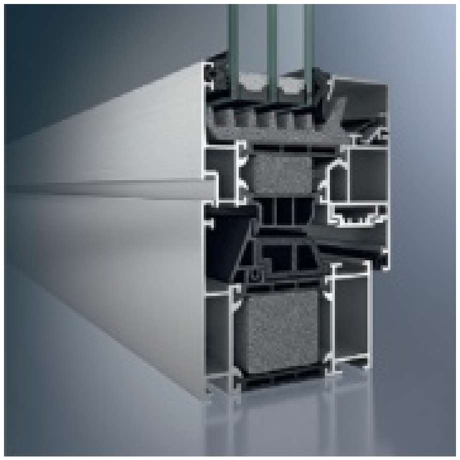
Sendero B
R Value: R-25

Which one of these is not a location where thermal bridges typically occur?



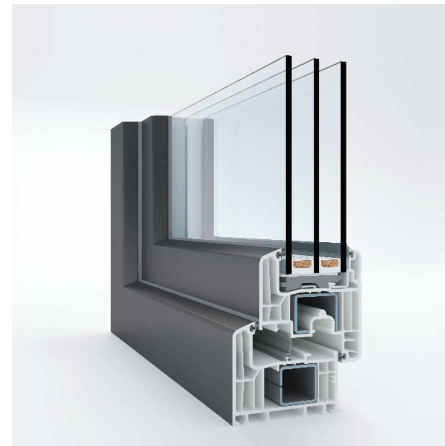
High Performance Windows

Evaluating Different Windows



Thermally Broken Aluminum
U-value:~.14
U-Frame: ~.211
Greatest Structural Capacity
$$$

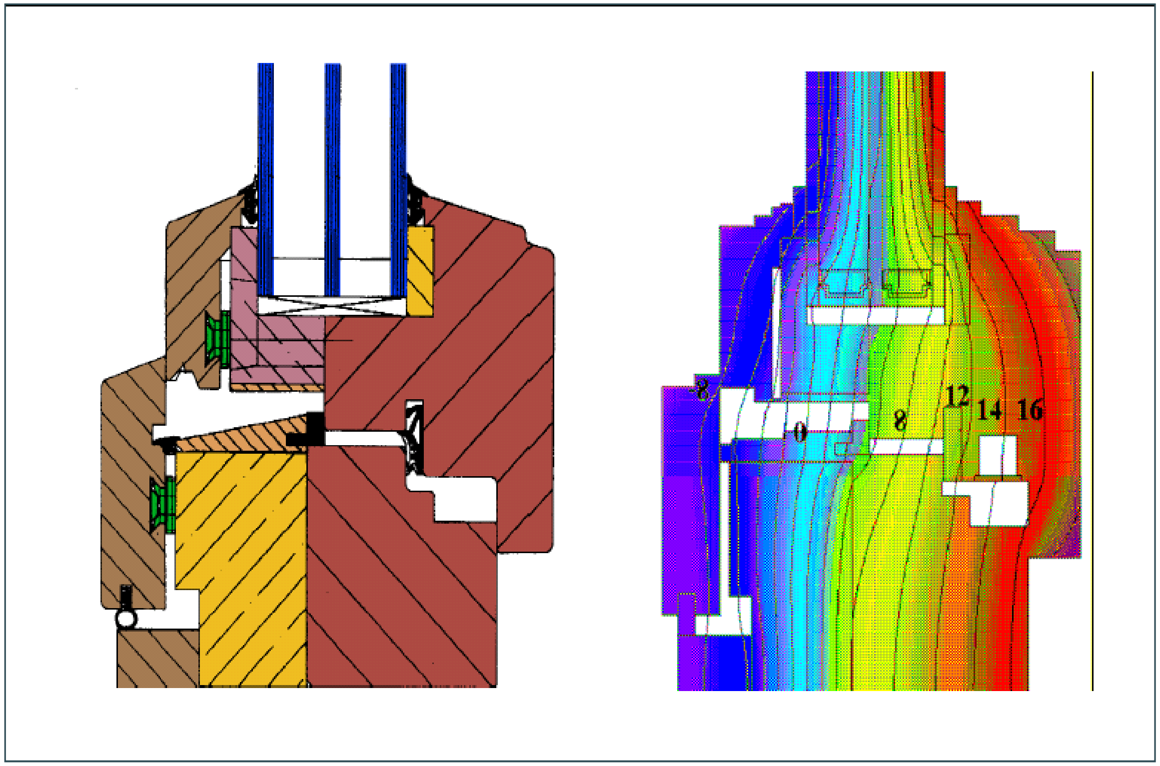
Fiberglass
U-value: ~.17
U-Frame: ~.2
$$



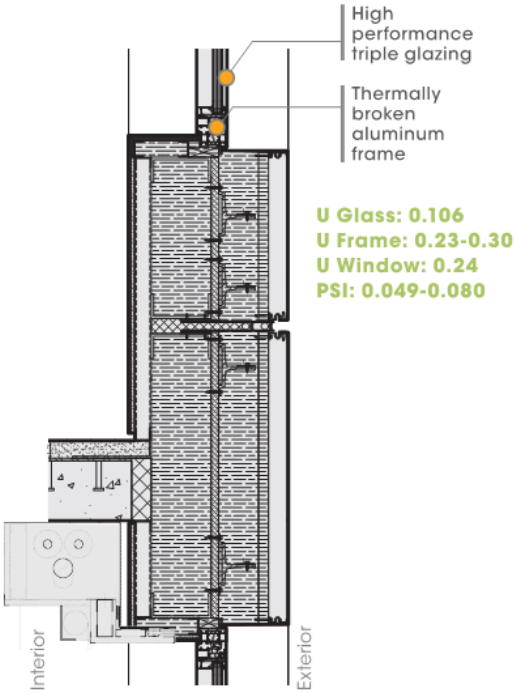
uPVC
U-value: ~.12
U-Frame:~.167
Reinforced with Steel
$

PH Windows

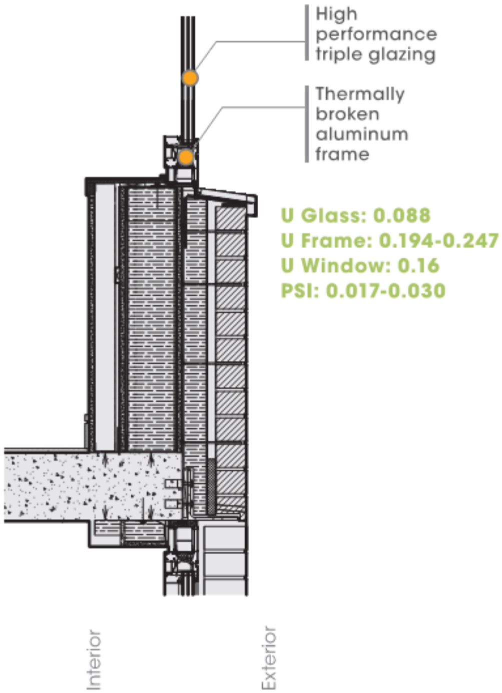
- Window install detailing is extremely important
- Must meet comfort criteria – sort of
- Flashing details can ruin install



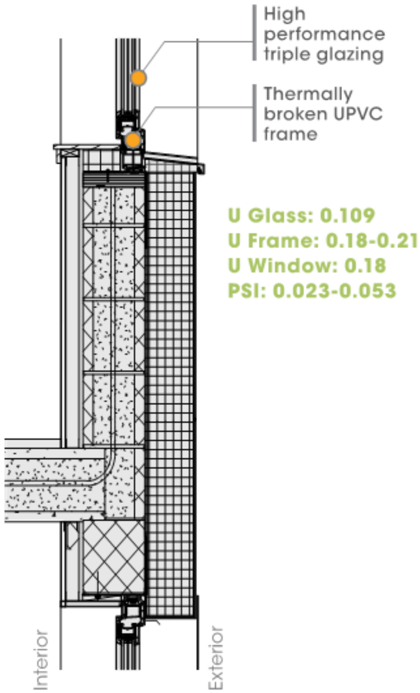
Exterior Wall Comparison: Window Install



The House



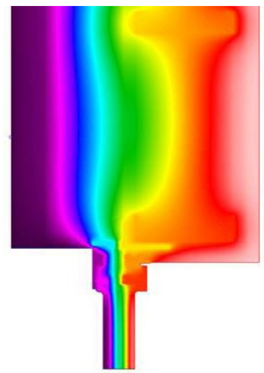
Sendero A



Sendero B

Exterior Wall Comparison: Window Install

Therm Models



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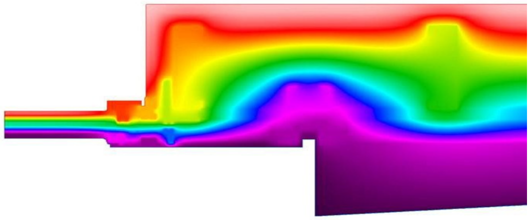
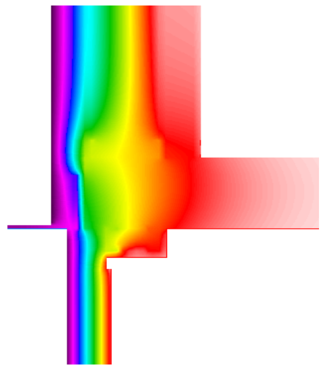


JAMB

The House



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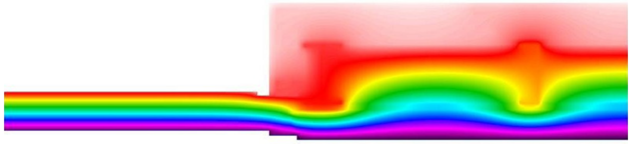
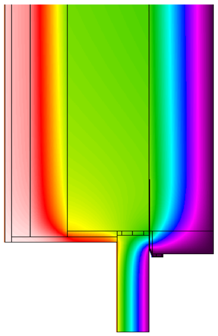


JAMB

Sendero A



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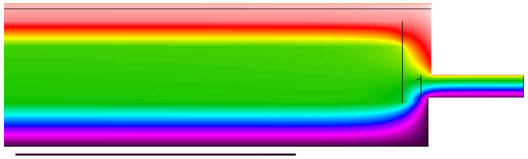


JAMB

Sendero B

High Performance Mechanical Systems: Ventilation

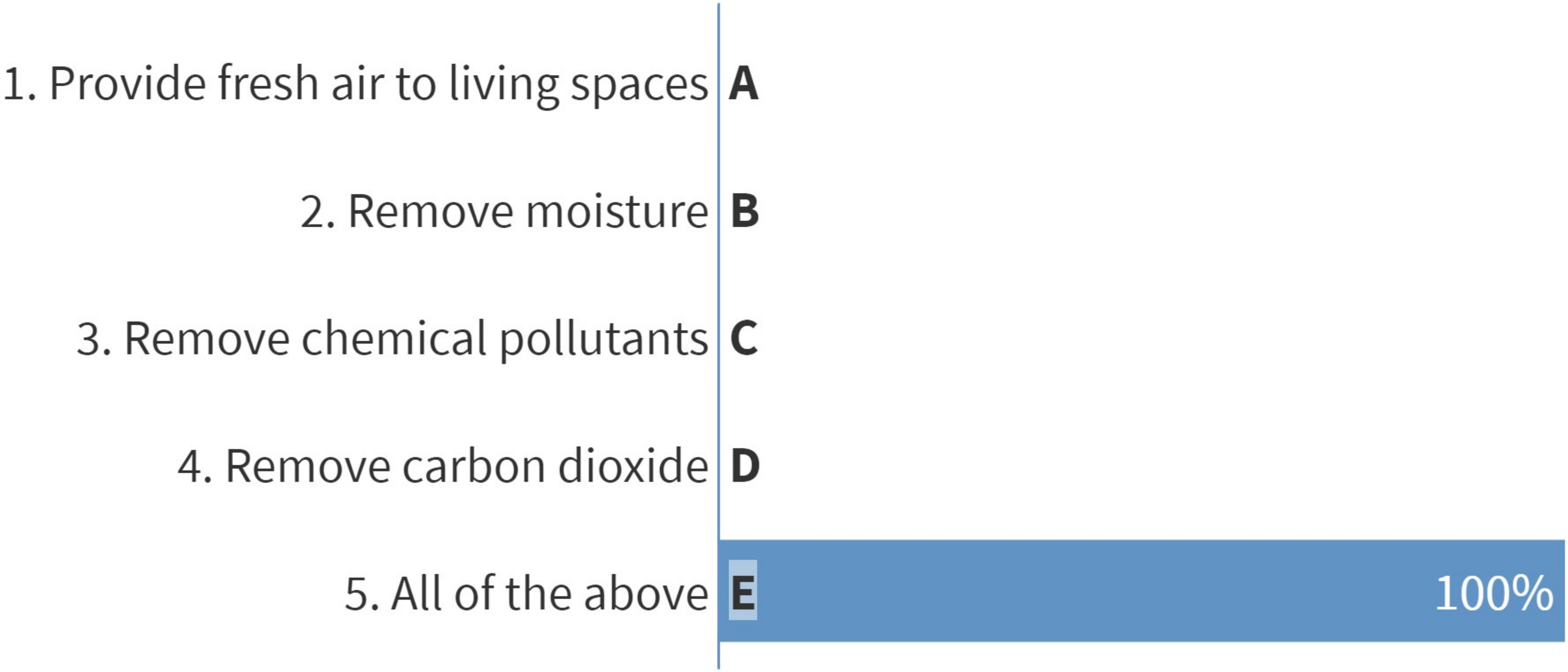
Certification Program Requirements

- Passive House, Indoor airPLUS, LEED, etc. have ventilation – related requirements
- Major points in some programs:
  - Heat recovery
  - MEASURED performance (TAB)
  - >code minimum flow rates
  - Minimum system efficiency
  - Duct sealing/testing
  - Kitchen recirculation / charcoal filters

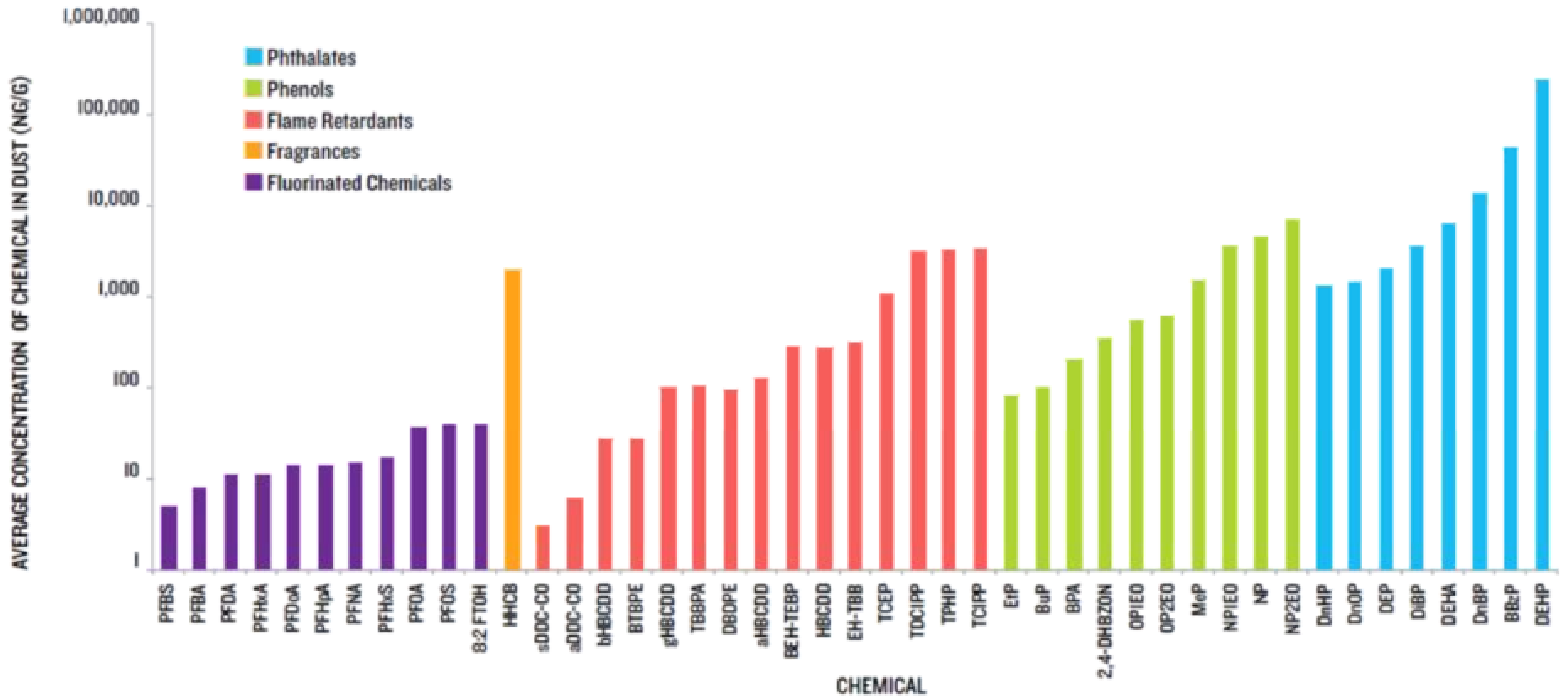
Why ventilate?

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

We ventilate to:

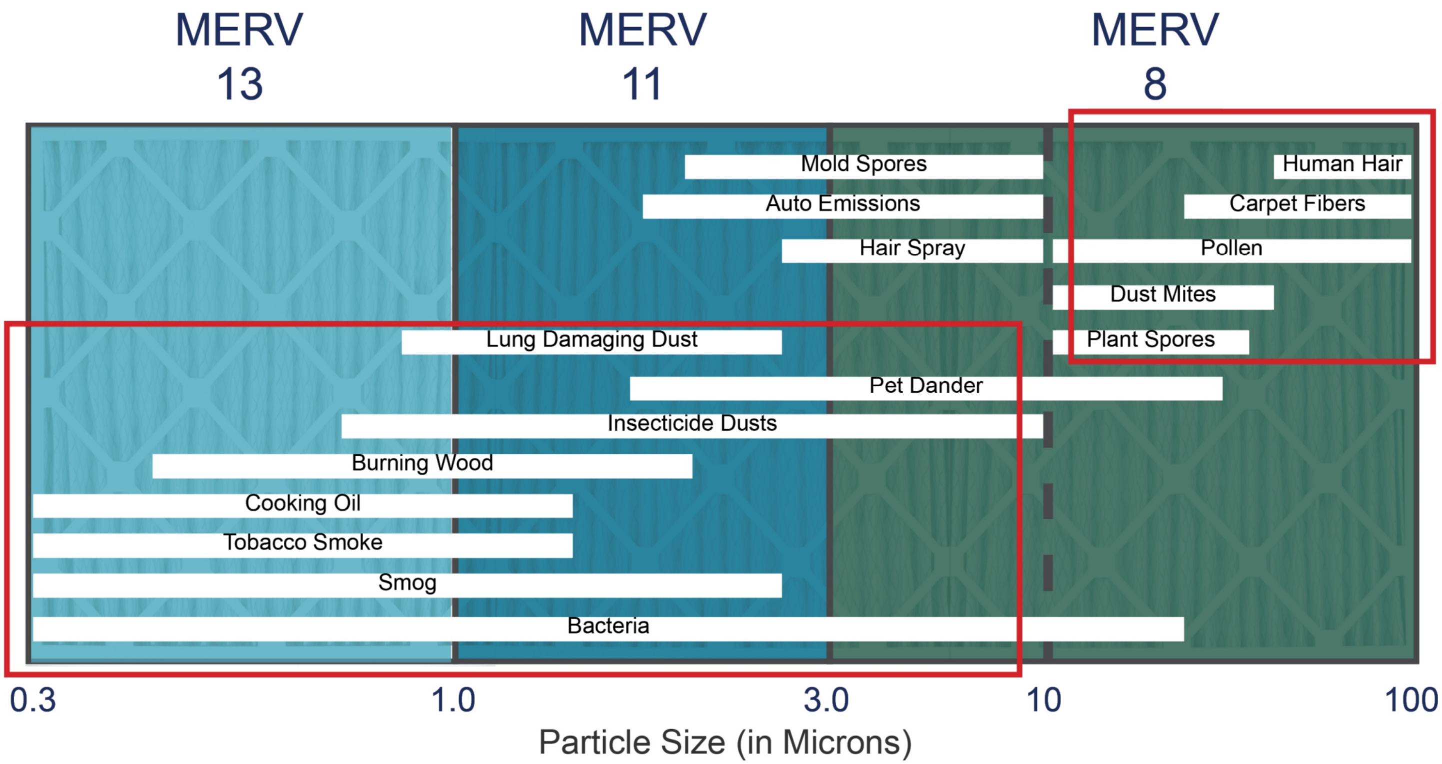


Dust is not just dirt



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.

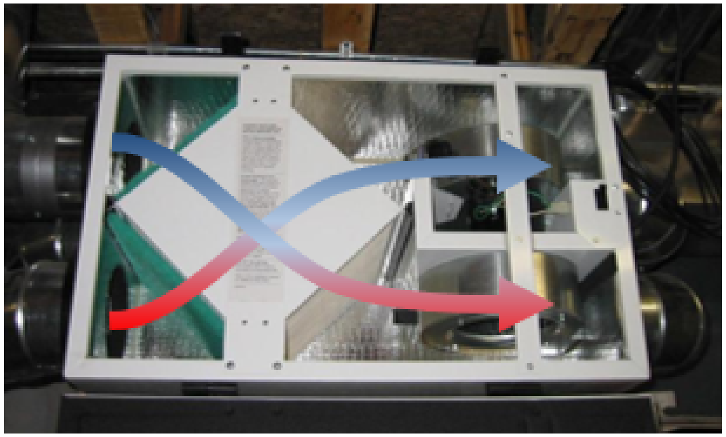
Solutions

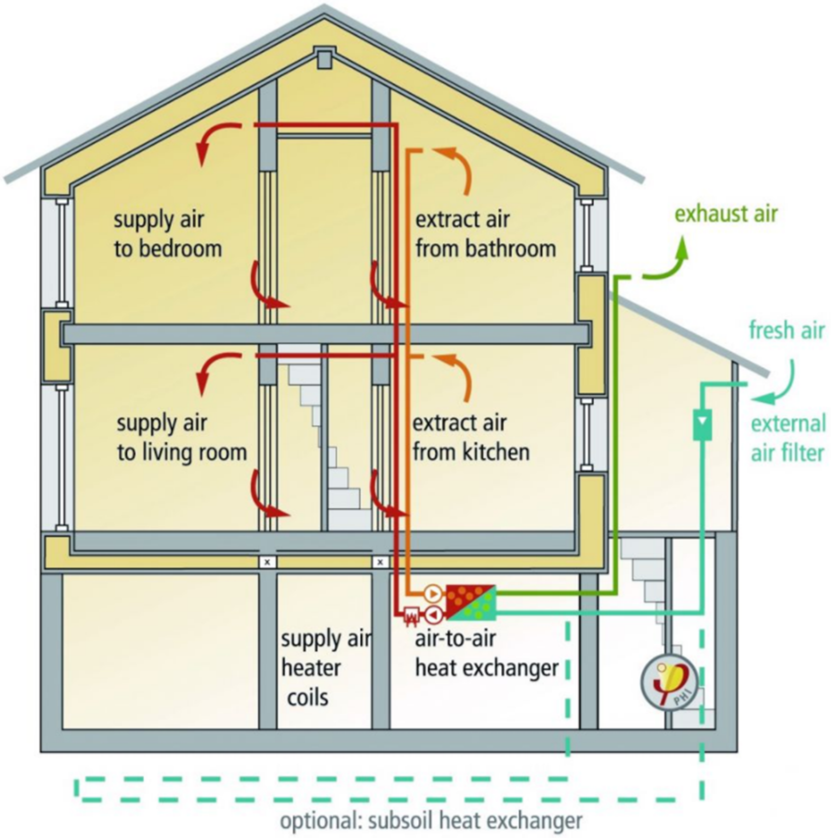


MERV 13
MERV 11
MERV 8
Mold Spores
Auto Emissions
Hair Spray
Human Hair
Carpet Fibers
Pollen
Dust Mites
Plant Spores
Lung Damaging Dust
Pet Dander
Insecticide Dusts
Burning Wood
Cooking Oil
Tobacco Smoke
Smog
Bacteria
0.3
1.0
3.0
10
100
Particle Size (in Microns)

Balanced Ventilation and Heat/Energy Recovery

- Provide fresh, filtered air 24 hours a day
- Heat exchanger +75% Efficient
- Highly insulated and air-sealed ductwork



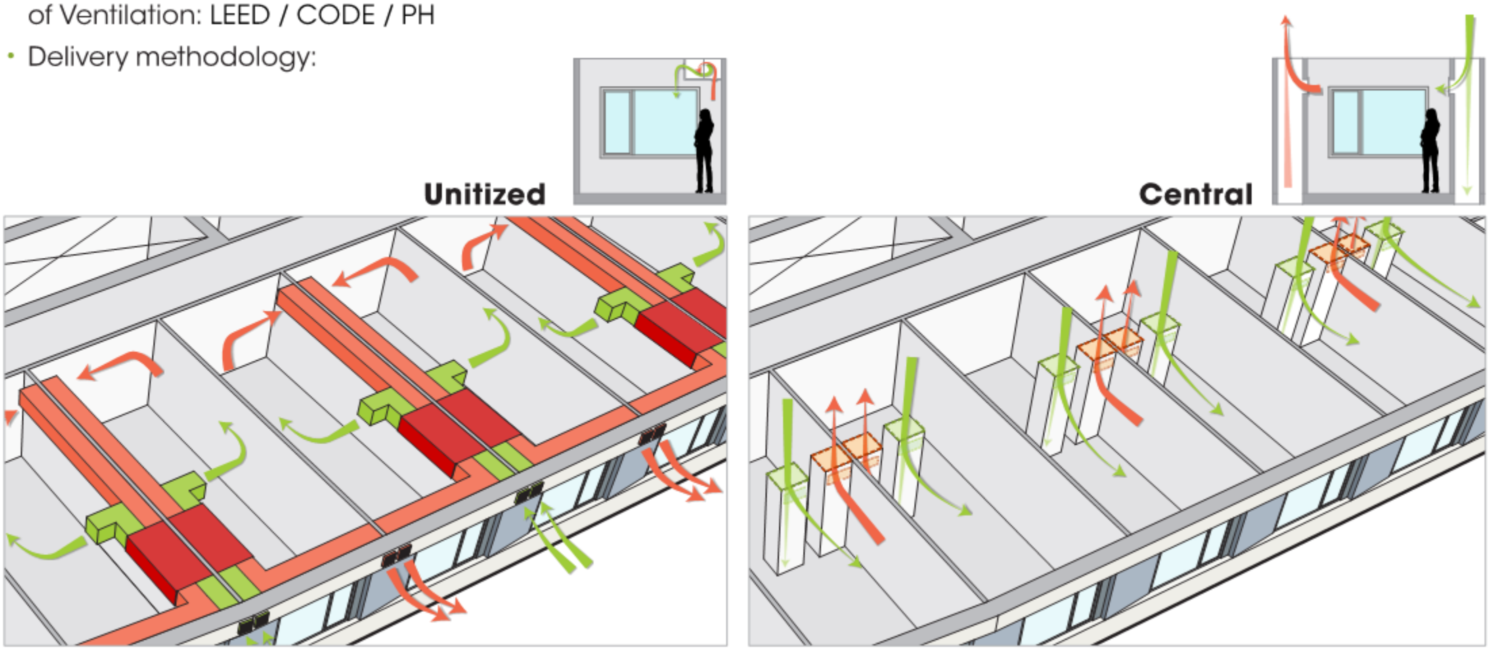


Balanced Ventilation and Heat/Energy Recovery

Balanced Ventilation with Heat Recovery

- All bedrooms and living rooms require supply air, balanced within 10% of exhaust
- Conflict in codes regarding amount of Ventilation: LEED / CODE / PH
- Delivery methodology:

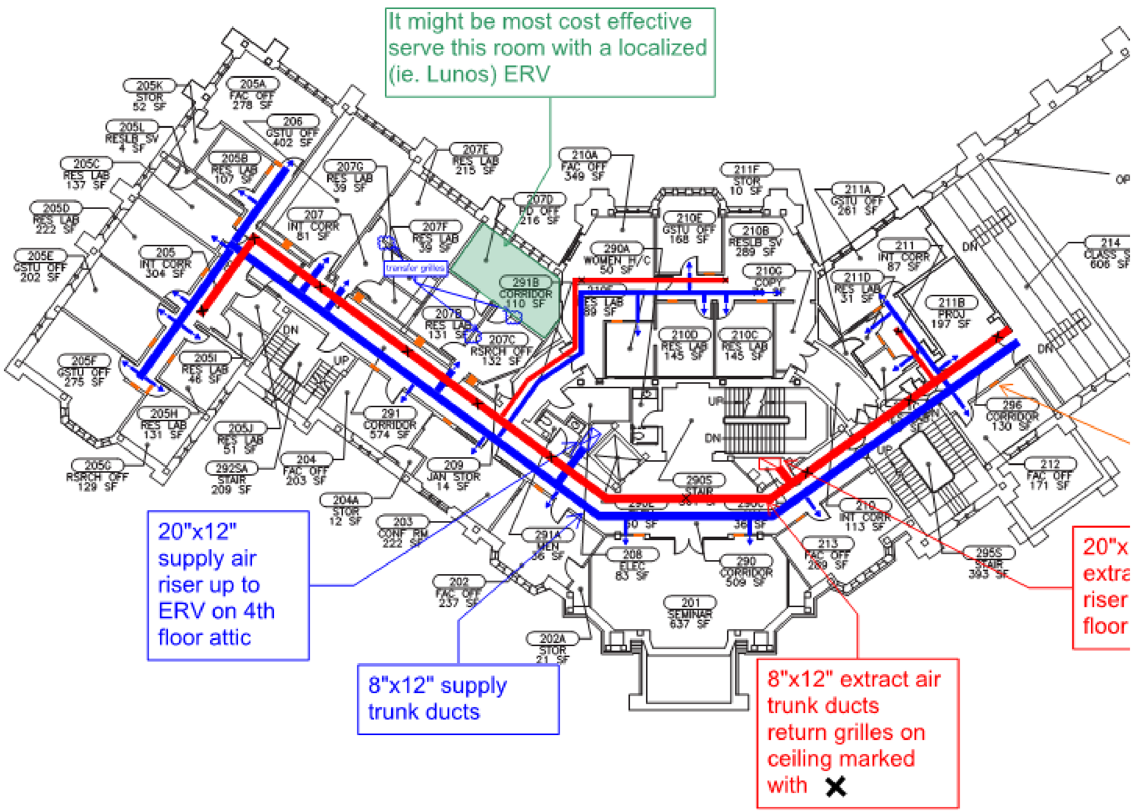
Exhaust Air
Fresh Air
ERV



Balanced Ventilation and Heat/Energy Recovery

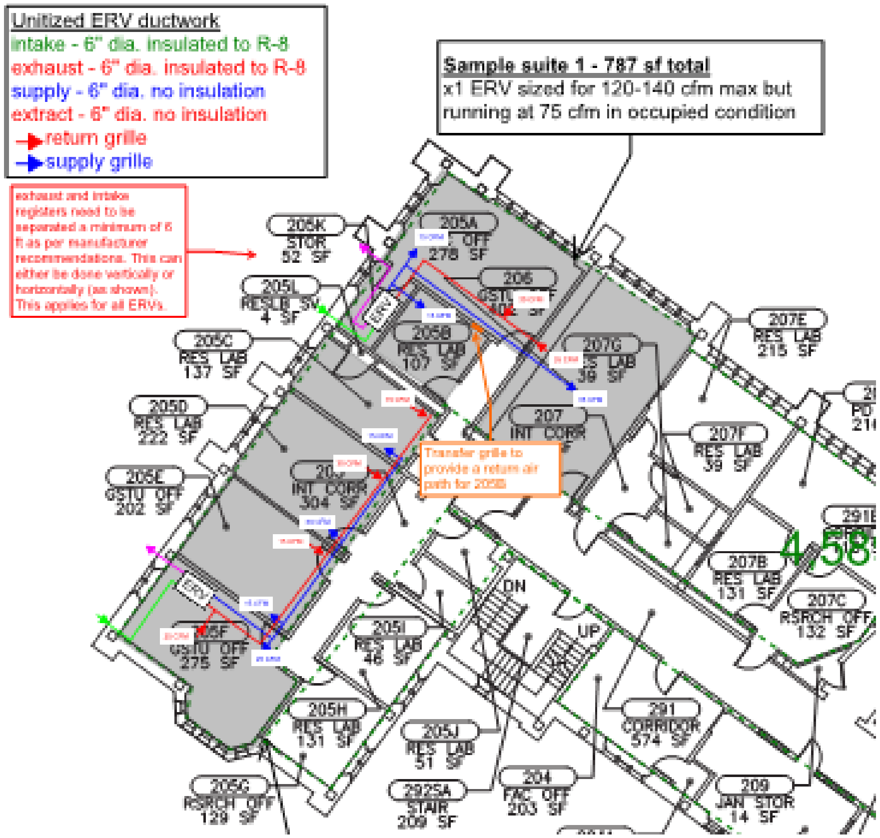
	Individual	Central
Pros	• Resident pays bill • No floor slab & roof penetrations • Boost flow more easily achievable in apartments • Better heat recovery efficiency, in general	• Less horizontal ductwork, lower ceiling heights possible • Significantly reduced maintenance • No thru wall penetrations • Easier to precondition supply air
Cons	• 2 through wall penetrations per apartment • Ceiling height issues with duct runs • Loss of floor space if ceiling space unavailable • Filters must be changed 3x/year • Individual units and exterior grilles must be accessible for cleaning & maintenance • UL approved units not readily available • Preheater recommended in cold climates • Conditioning supply air more difficult	• Owner pays bill • Floor space reduction due to vertical shafts • Large floor slab & roof penetrations • Fire rated shafts & dampers needed • Little to no control for individual apartment boost • Balancing is more challenging

Ventilation: Centralized Strategy



TYPICAL CENTRAL DUCTWORK STRATEGY

Ventilation: Decentralized Strategy



Ventilation Controls are Critical

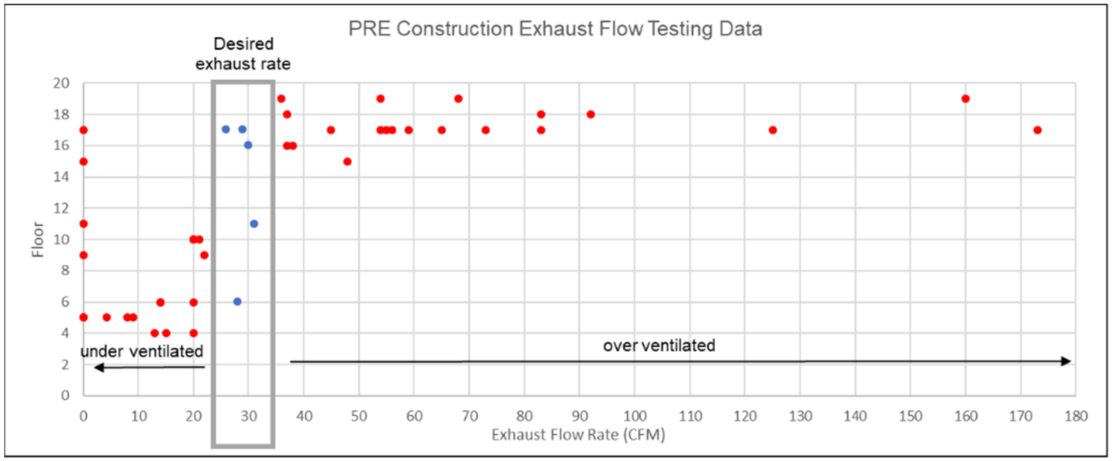
- ASHRAE 62.1Flow Rates are based on max capacity, too high during normal operation
- Controls should be based on use
- Recommend:
  - Occupancy controls (common areas/lobbies)
  - Timers for offices
  - CO2/humidity sensors for active spaces & assembly rooms w/ high occupancy periods

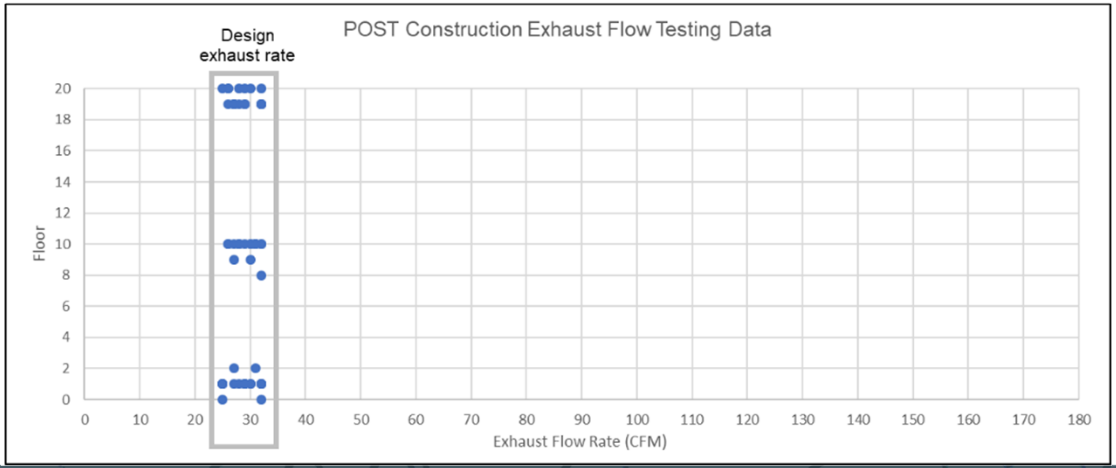
Ventilation Balancing

- 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





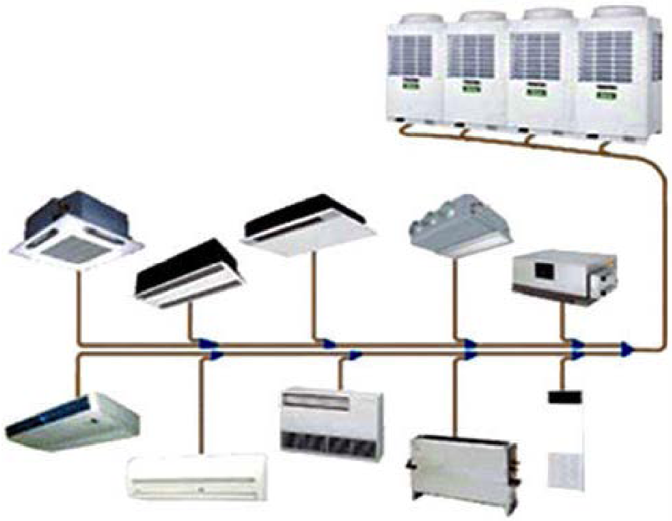
High Performance Systems: Heating & Cooling

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	$$$	$$	$$$$	$$$$$
Maintenance cost	$$	$	$$$	$$$$

Heating Upgrades: Heat Pumps

- All refrigerant systems
- High efficiency
- Electrification option
- Cold climate performance
- Provides heating and cooling
- Multitude of options for terminal units
- VRFs can provide simultaneous heating and cooling



Heating Upgrades: Heat Pumps

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

Centralized VRF Schematic

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

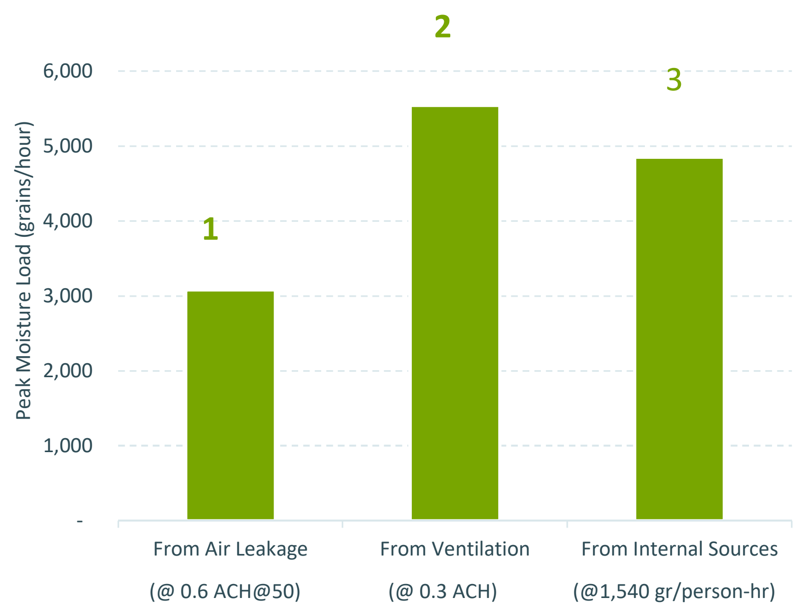
2. **Intentional Ventilation**
   HRV / ERV / Enthalpy wheel
   Natural ventilation

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

Managing Moisture Loads
Focus on each source of moisture

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

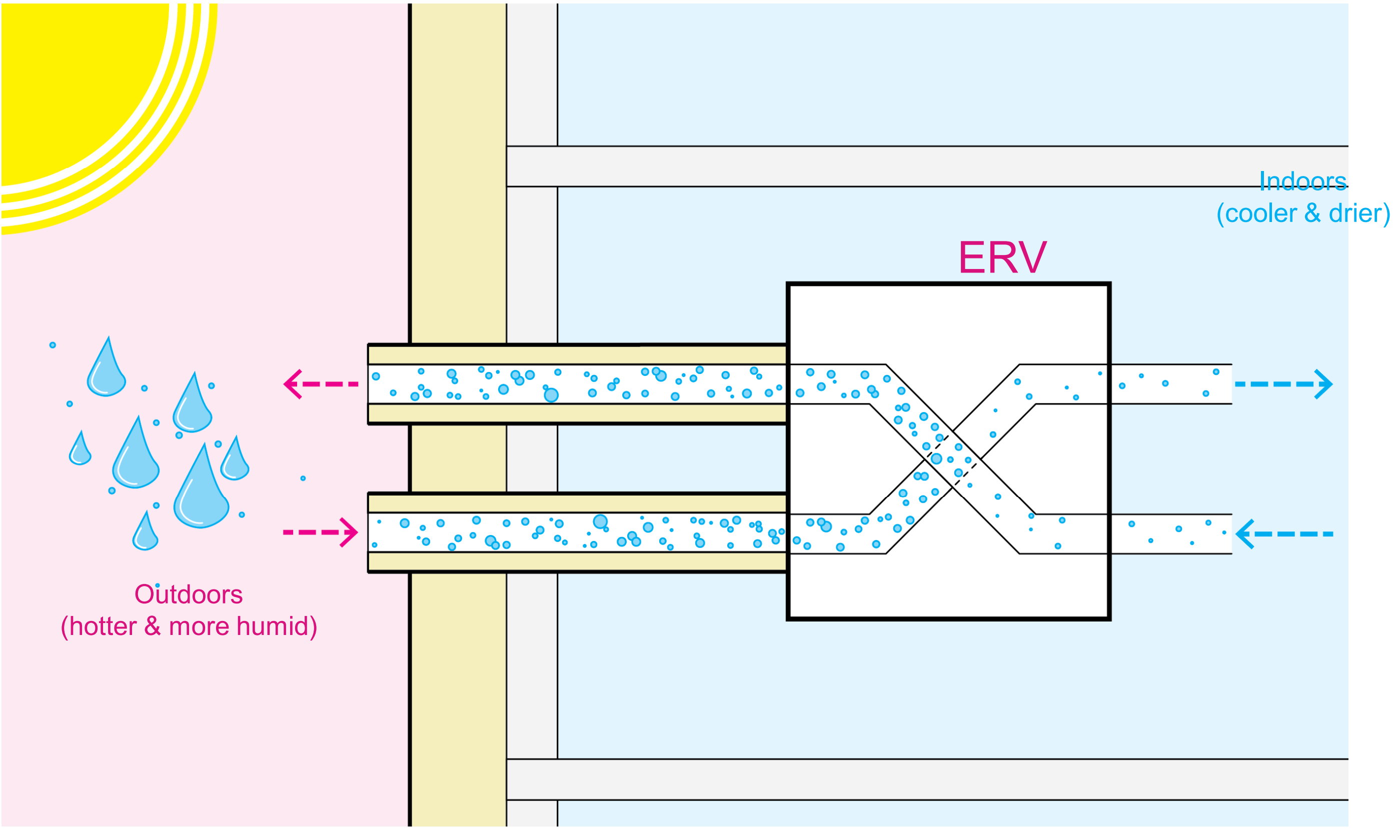
- Climate determines moisture
- Efficient cooling equipment critical
- Proper sizing critical! (Oversized cooling eq. poor at removing humidity)



BDGTYP: Mayers House. 2016

ERV & Humidity

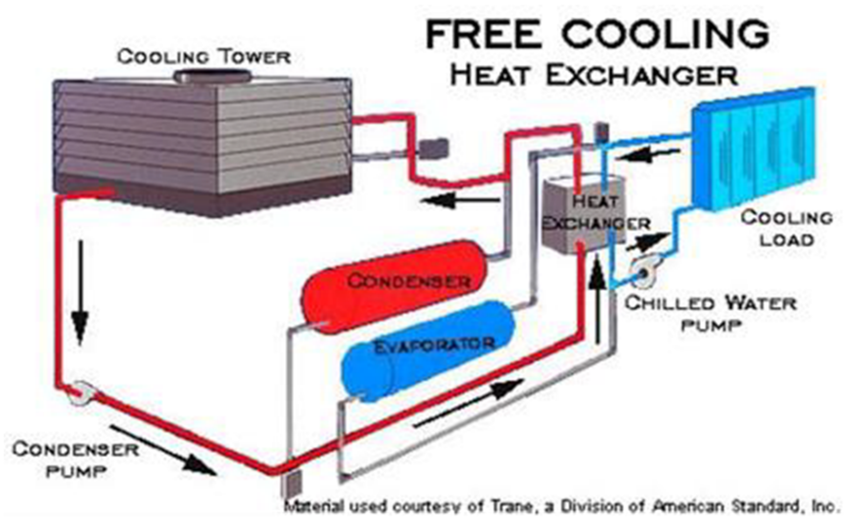
Note: the reverse of this process is also true which is why in winter an ERV can help to maintain higher indoor RH levels even when the outdoor air is low RH.



Free Cooling

Take advantage of low outdoor temps

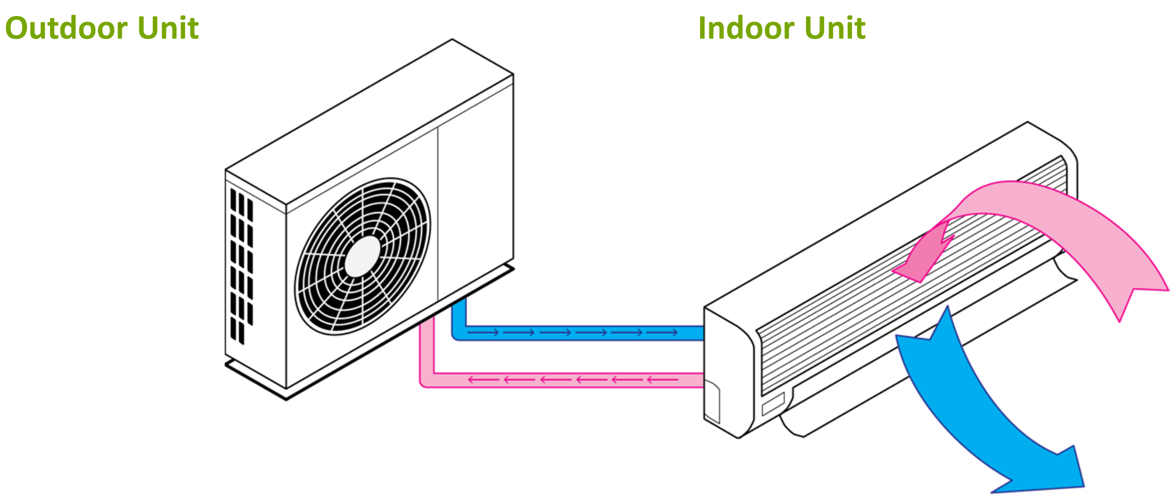
- Match to cooling dominated occupancies
- Air- and Water-side economizers



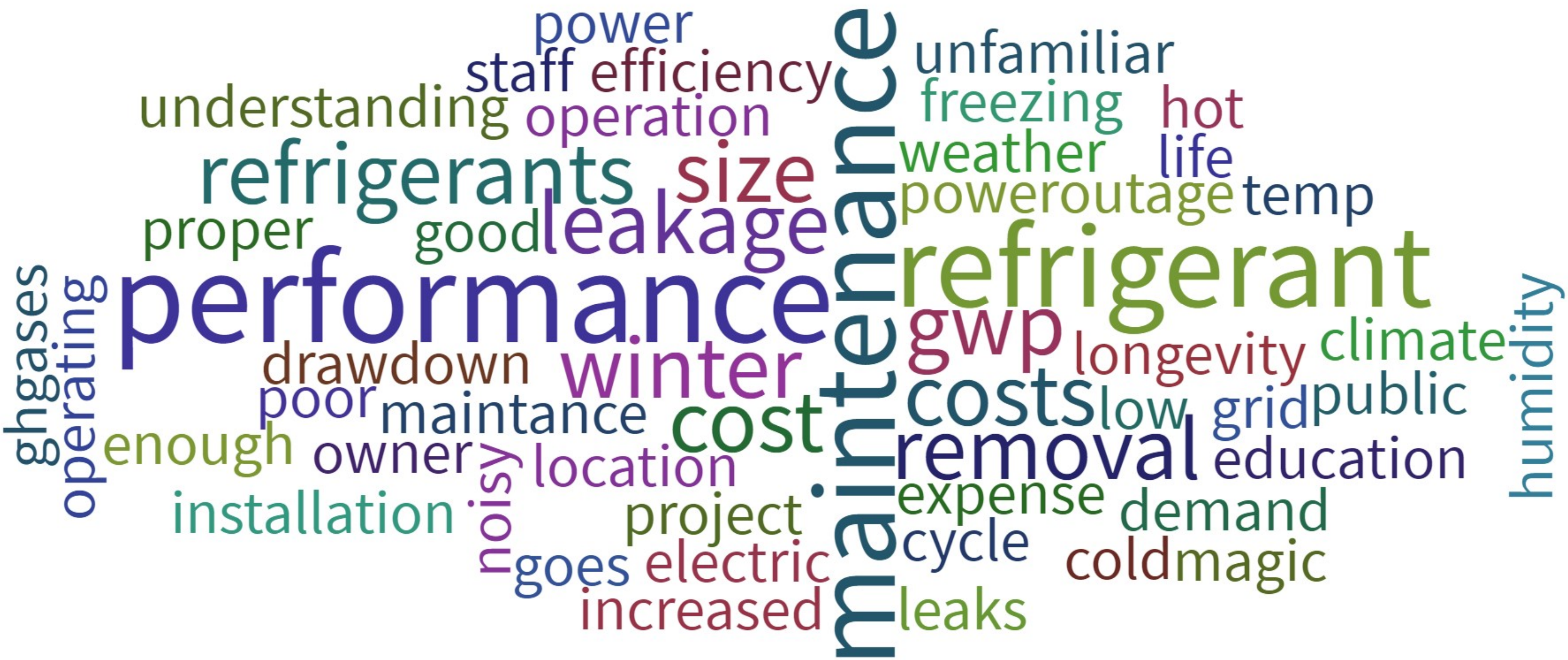
Heat Pump Heating + Cooling

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



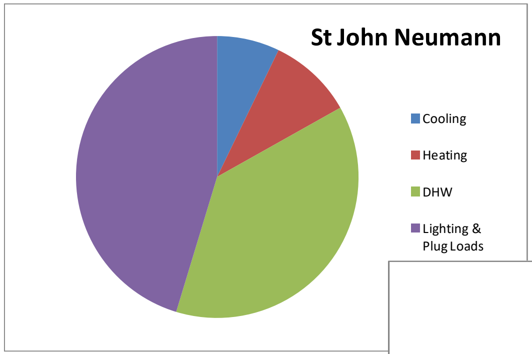
My concern with heat pumps is:

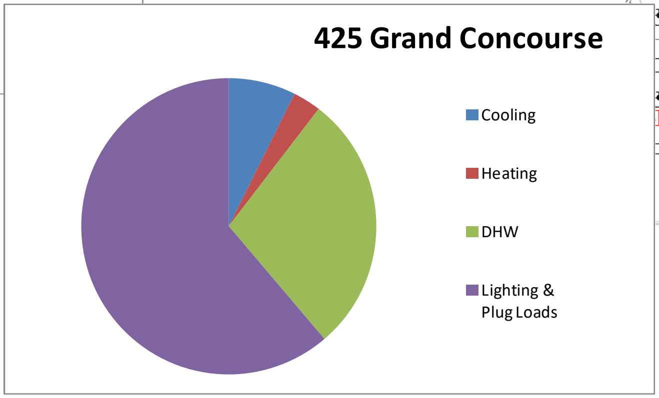


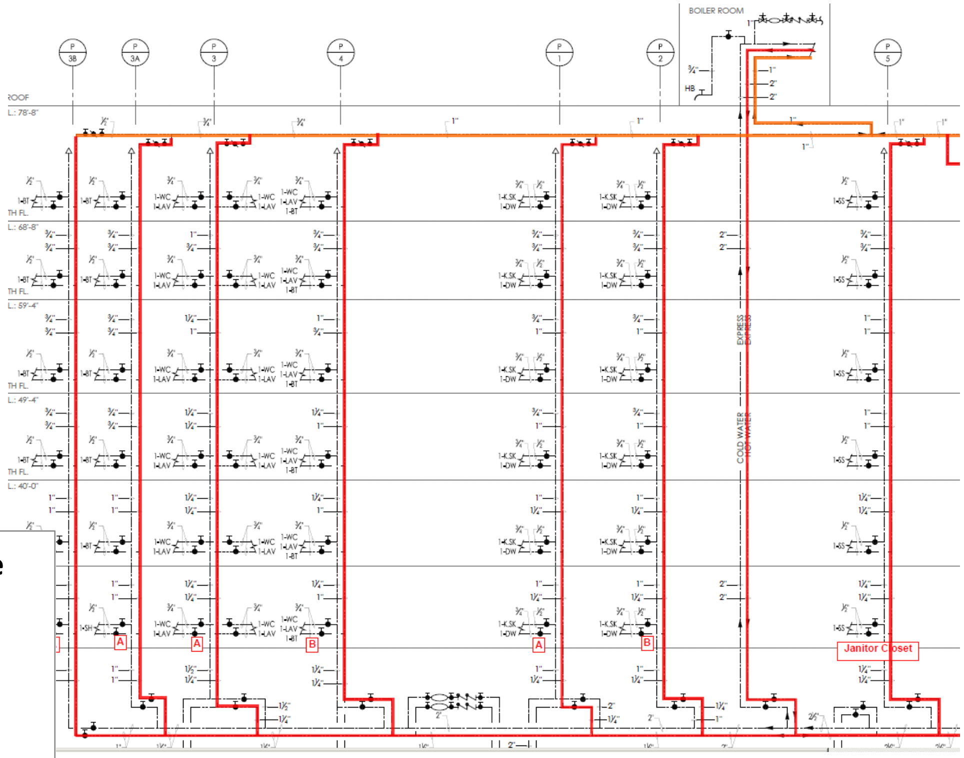
High Performance Systems: DHW

Central Recirculation

- Distribution system losses are significant

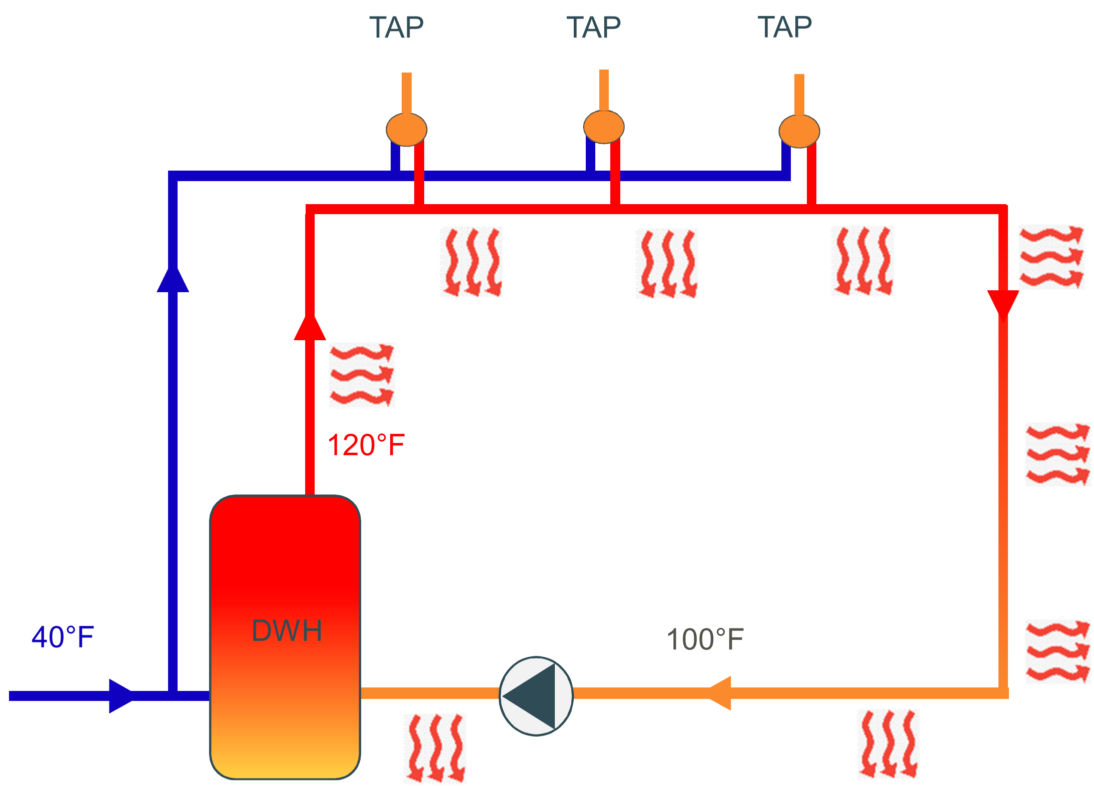






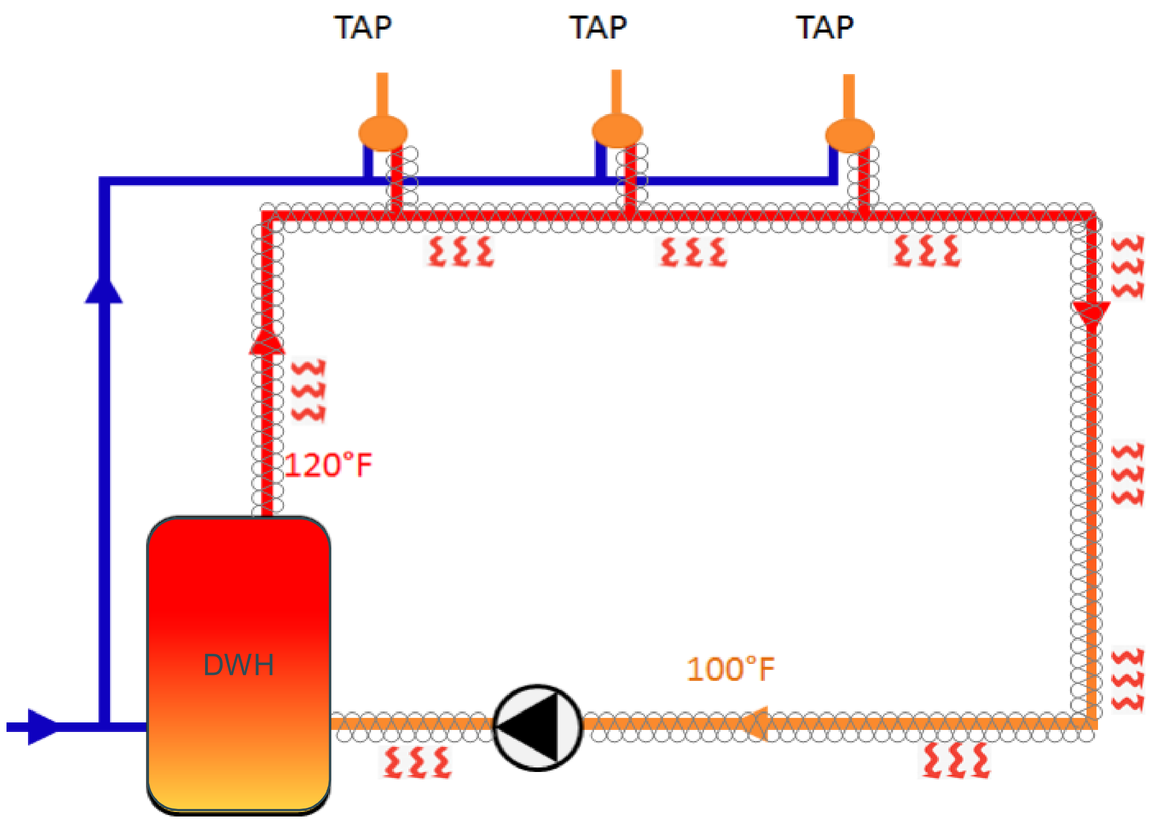
Central Recirculation

- Losses affect
  - DHW demand
  - Cooling demand
  - Overall source energy demand



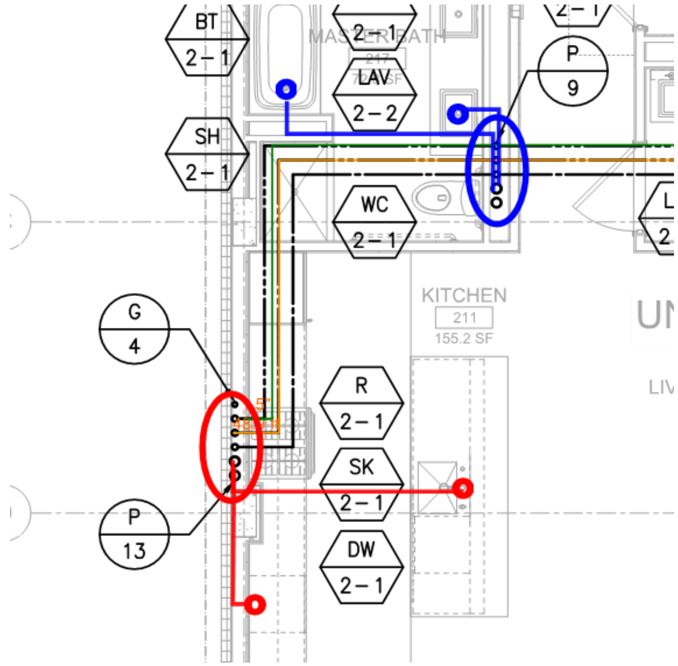
Central Recirculation: Insulation on Central Loop

- Results
  - DHW demand ↓
  - Cooling demand ↓
  - Overall source energy demand ↓

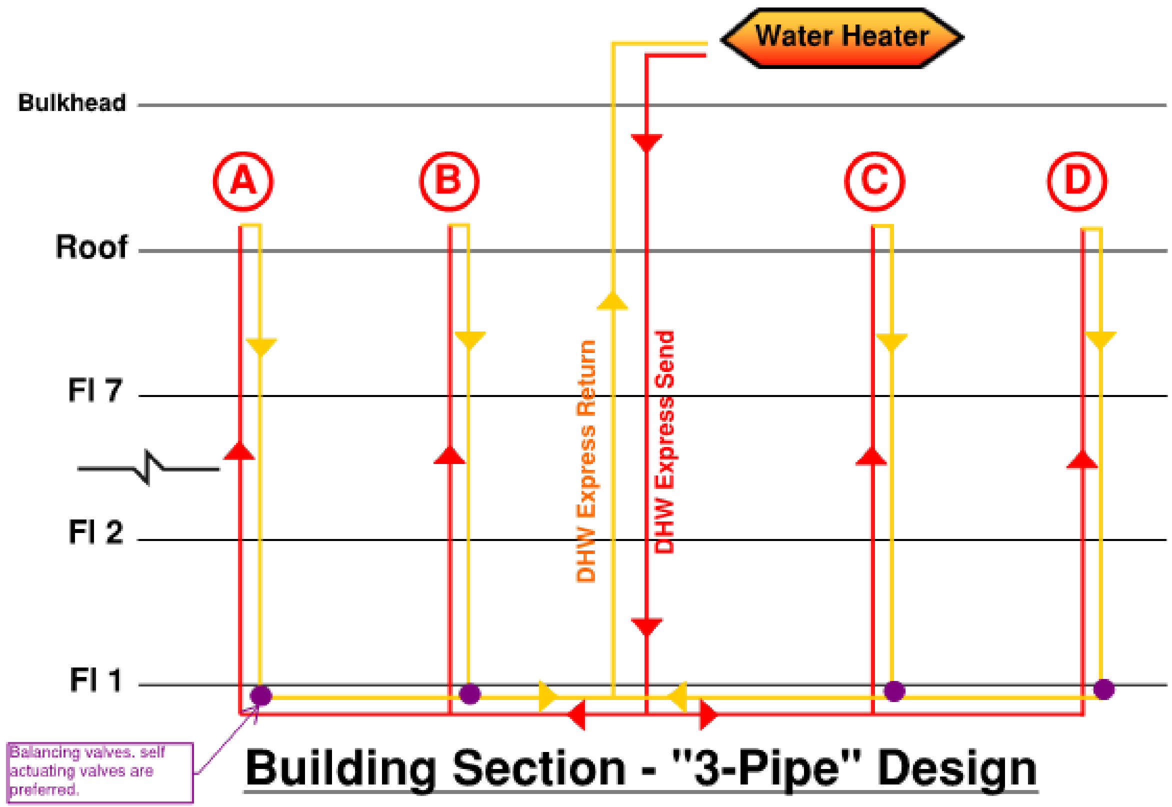


Design Optimization – Central Recirculation

- Distribution losses ~ **30% of DHW heating demand**
- Reduce risers
  - Cluster plumbing locations when feasible
  - Optimize HWR loop location – reduce runouts from riser to fixtures
- Insulation
  - Code required (NYS Energy Code 1” to 1.5”)



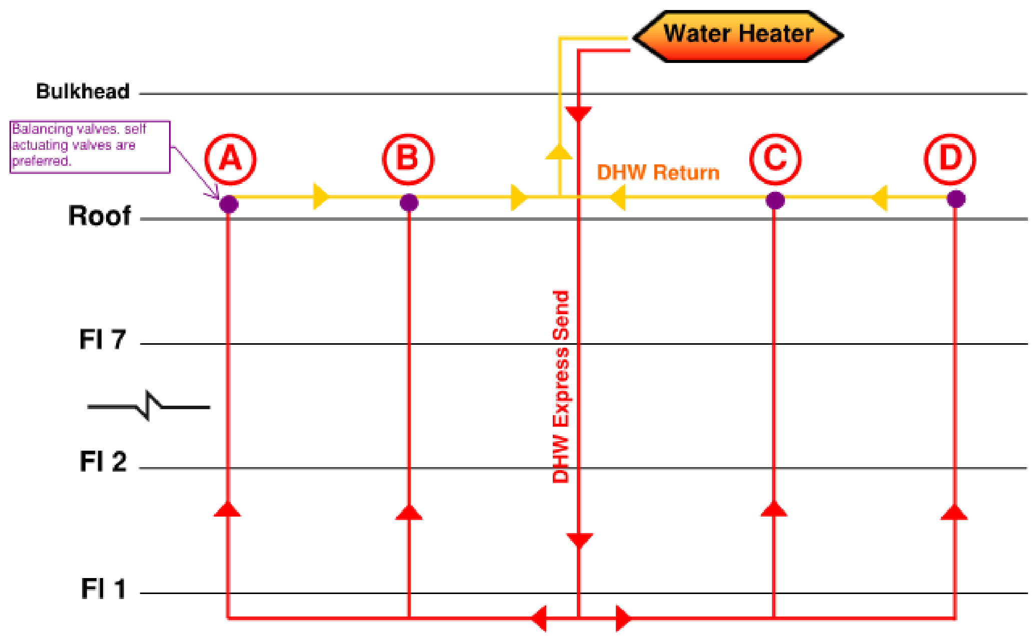
Design Optimization – Central Recirculation



Building Section - "3-Pipe" Design

Design Optimization – Central Recirculation

- 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



Building Section - "Box" Design

Central Recirculation Optimization: Case Study

- 37 story residential tower
- Switched from 3-pipe to box design
- Savings
  - 10,000 ft of recirc. piping
  - 18% reduction DHW heating
  - 16% reduction cooling

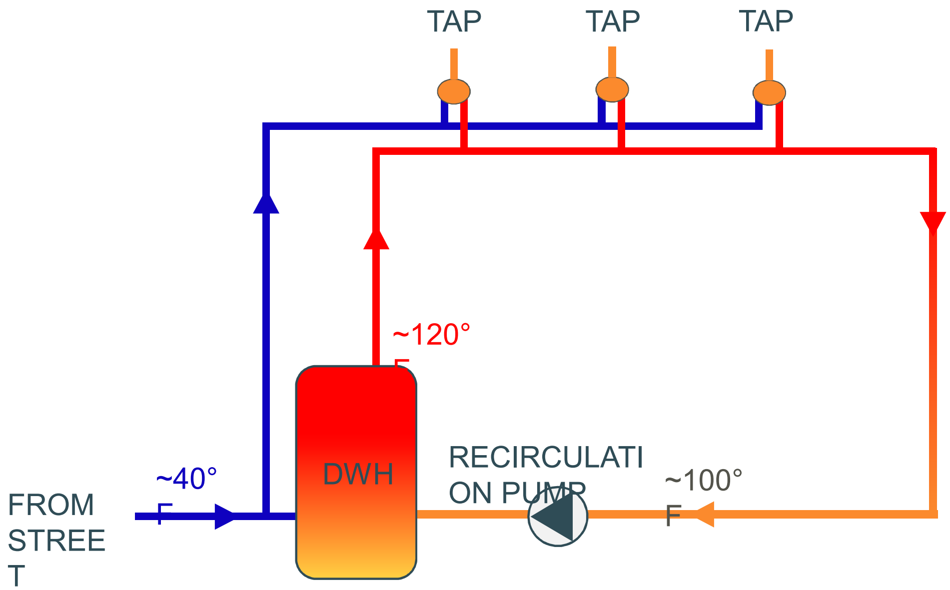
Typical Pump Roles

PUMPS SCHEDULE

DESIGNATION		SERVICE	MANUFACTURE/MODEL	G.P.M./CFH	MAX. CFH	MAX. T.D.H./P.S.I.	H.P (EA)	R.P.M.	VOLTS	PHASE	CYCLE	EFFICIENCY, %	BOOST "W.C.	MANUAL CONT'L.	STARTING STEPS	AUTO CONT'L.	PILOT LIGHT	PRESSURE GAUGE RANGE	METAL BASIN	CONCRETE PIT	CONTROL CENTER	LOCATION
PP-1 PP-2 PP-3	TRIPLEX DOMESTIC BOOSTER PUMP	DOMESTIC WATER SYSTEM	SYNCROFLO MODEL 250TRKB158VFD-GAF RKB40/12LV/4 (4-STAGES)	125 125 125	–	365' 365' 365'	25 25 25	3525 3525 3525	208 208 208	3 3 3	60 60 60	53 53 53	–	–	–	●	–	–	–	–	●	CELLAR
ESP-1	ELEVATOR SUMP PUMPS	ELEVATOR DRAINAGE	STANCOR OIL-MINDER SE-100	100	–	25	1	3500	208	3	60		–	–	–	●	–	–	–	●	●	ELEVATOR PIT CELLAR
ESP-2	ELEVATOR SUMP PUMPS	ELEVATOR DRAINAGE	STANCOR OIL-MINDER SE-50	50	–	25	.5	3500	115	1	60		–	–	–	●	–	–	–	●	●	ELEVATOR PIT CELLAR
ESP-3	ELEVATOR SUMP PUMPS	ELEVATOR DRAINAGE	STANCOR OIL-MINDER SE-50	50	–	25	.5	3500	115	1	60		–	–	–	●	–	–	–	●	●	ELEVATOR PIT CELLAR
SE-1 SE-2	DUPLEX SEWAGE EJECTOR PUMPS 48"x48" PIT x 6' DEPTH BELOW INVERT	SANITARY DRAINAGE	FLYGT MODEL NP3085-IMP453 WITH MIX FLUSH VALVE, SUB-RIG ASSEMBLY & "FLEETWAY" CONTROLLER	50 50	– –	25' 25'	1.5 1.5	1755 1755	208 208	3 3	60 60	77.3 77.3	–	–	–	●	–	–	–	●		CELLAR
STP-1	STORM WATER PUMP	STORM WATER	FLYGT MODEL CP3085VFD-IMP438	110	–	19	2.2	1730	208	3	60		–	–	–	●	–	–	–	–	–	CELLAR
HWRP-1 HWRP-2	RE-CIRCULATION PUMPS HIGH ZONE	DOMESTIC HOT WATER	BELL & GOSSETT SERIES 90-31S	41 41	–	20' 20'	.25	1750	120	1	60	–				●	–	–	–	–	–	MECH. ROOM – ROOF
HWRP-3 HWRP-4	RE-CIRCULATION PUMPS LOW ZONE	DOMESTIC HOT WATER	BELL & GOSSETT SERIES 90-31S	41 41	–	20' 20'	.25	1750	120	1	60	–				●	–	–	–	–	–	MECH. ROOM – ROOF
GBP-1	GAS BOOSTER PUMP	EMERGENCY GENERATOR	SPENCER MODEL GL-0244-1/2-R GASCUBE GAS BOOSTER SKID PACKAGE W/UPS	–	6360	–	.5	3500	208	1	60	–	7.5"	–	–	●	–	–	–	–	–	GAS ROOM GROUND
GBP-2	GAS BOOSTER PUMP	HOT WATER HEATERS	SPENCER GASCUBE MODEL GL-0231-1/2-R SKID PACKAGED GAS SYSTEM W/UPS	–	1500	–	.5	6500	208	1	60	–	6.5"	–	–	●	–	–	–	–	–	GAS ROOM GROUND

Hot Water Recirculation Pumps

- Used to ensure hot water at taps at all times
- Fractional HP
- Usually constant speed
- Options for controls
  - Limited in larger buildings



Lighting & Plug Loads

Internal Load Reduction Priorities

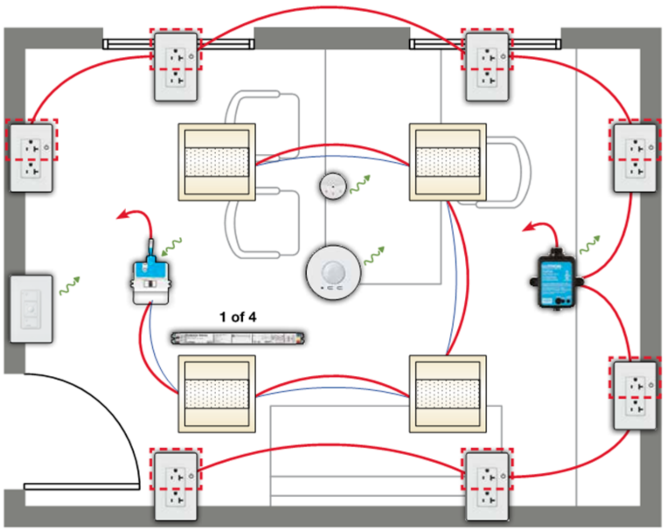
LL 31 Feasibility Study

Lighting and Lighting Controls

- High efficacy fixtures
- Occupancy controls
- Daylighting control

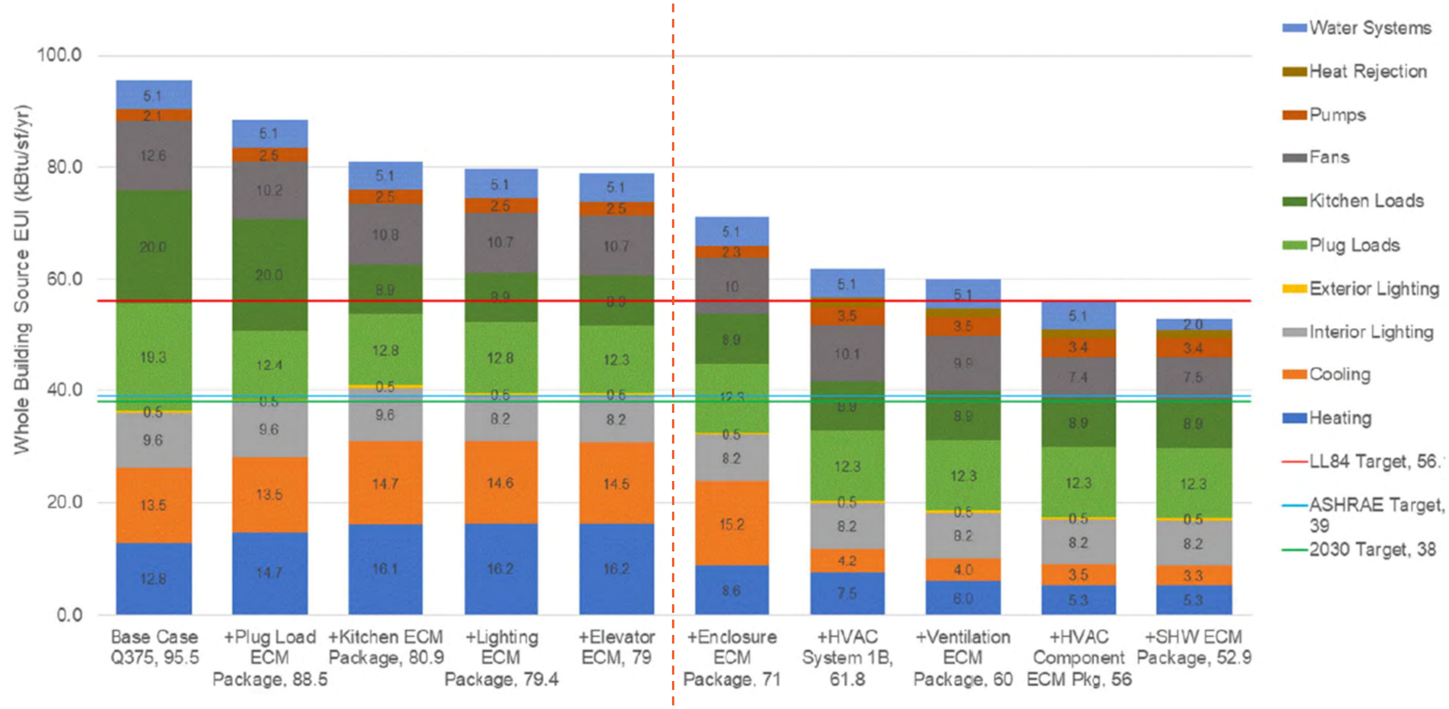
Appliances and Plug Loads

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



Stacked ECM Packages
LL 31 Feasibility Study

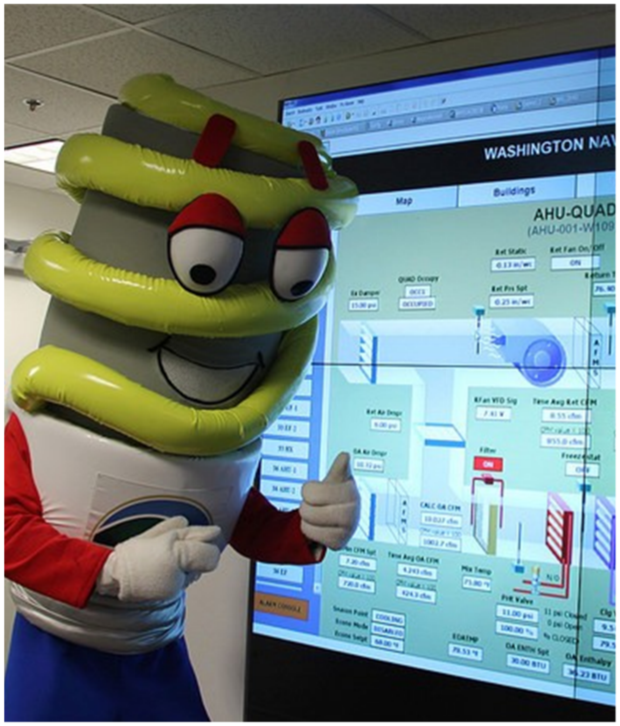
Internal Load Reduction ECMs External Load Reduction ECMs



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)

Deep Energy Retrofits

15 Minute Break

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

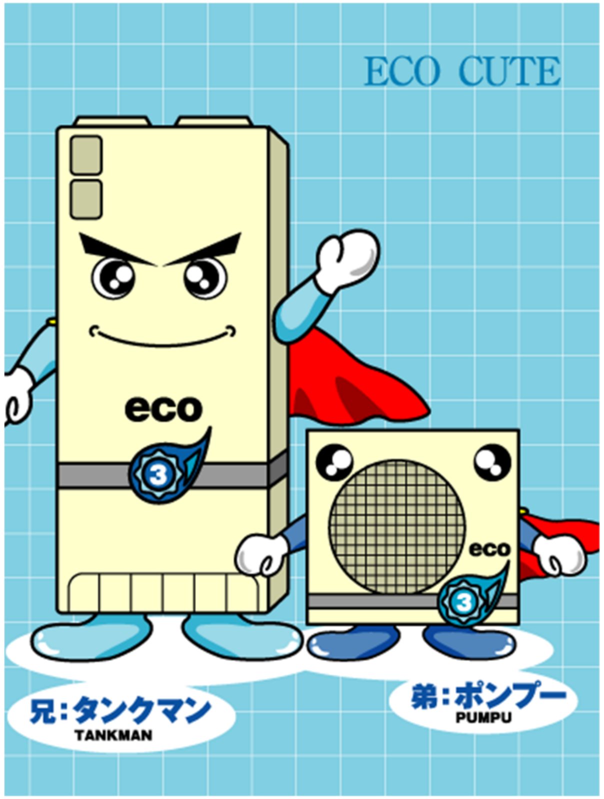
Now that loads are reduced . . .

- Select high efficiency heating/cooling
- Ensure proper commissioning
- Enact strong operations & maintenance protocols

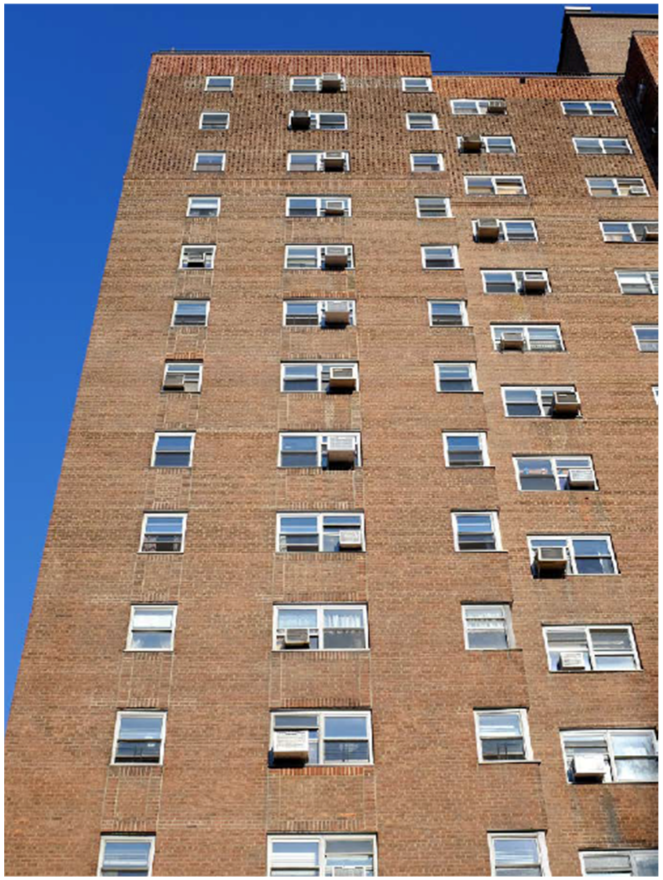
This approach is sometimes referred to as "Passive House" because it puts non-mechanical or "passive" measures first

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

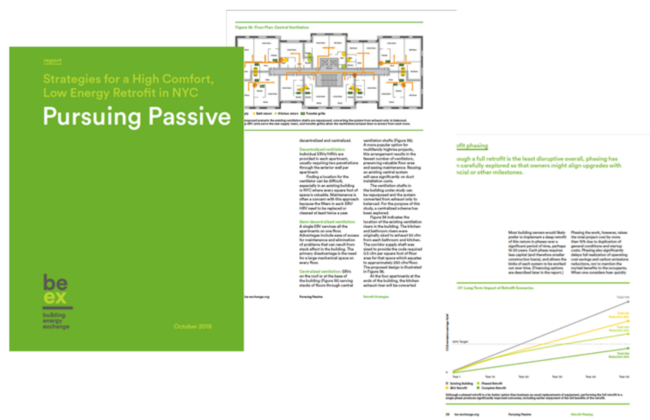


Relevant Study

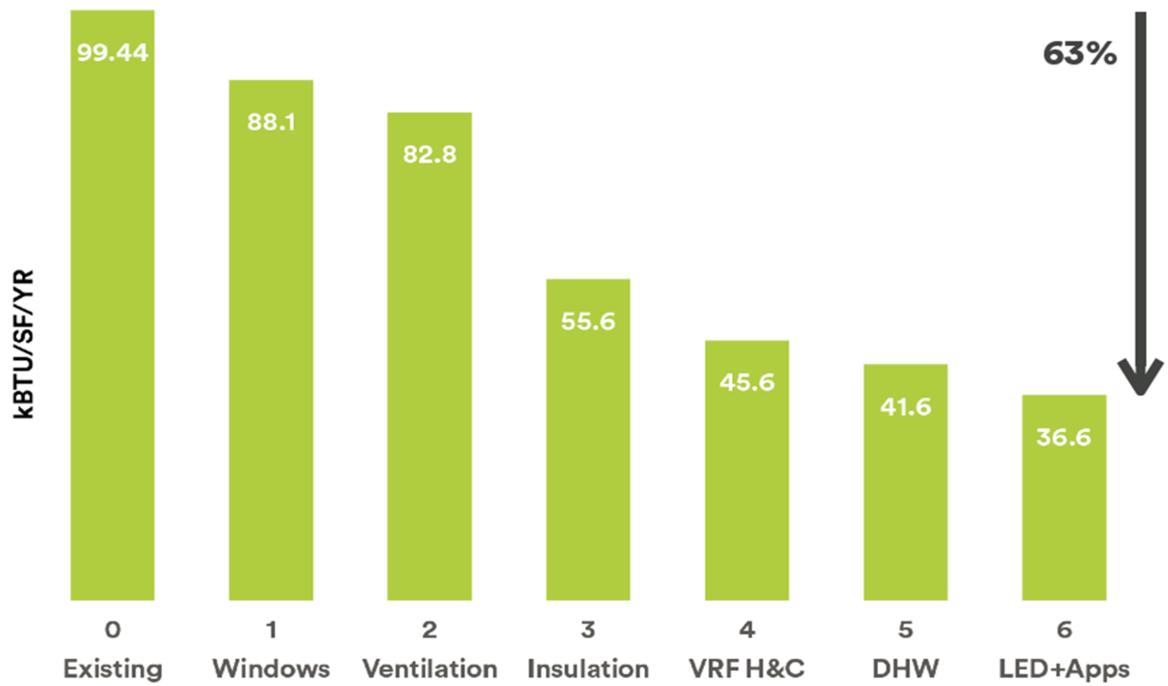


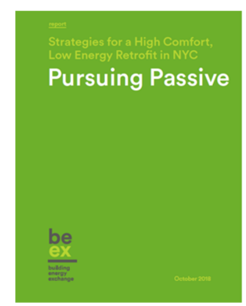
By:
Building Energy Exchange
Passive House Institute
Steven Winters Associates, Inc.

Evaluated retrofit strategies for large multi-family masonry construction



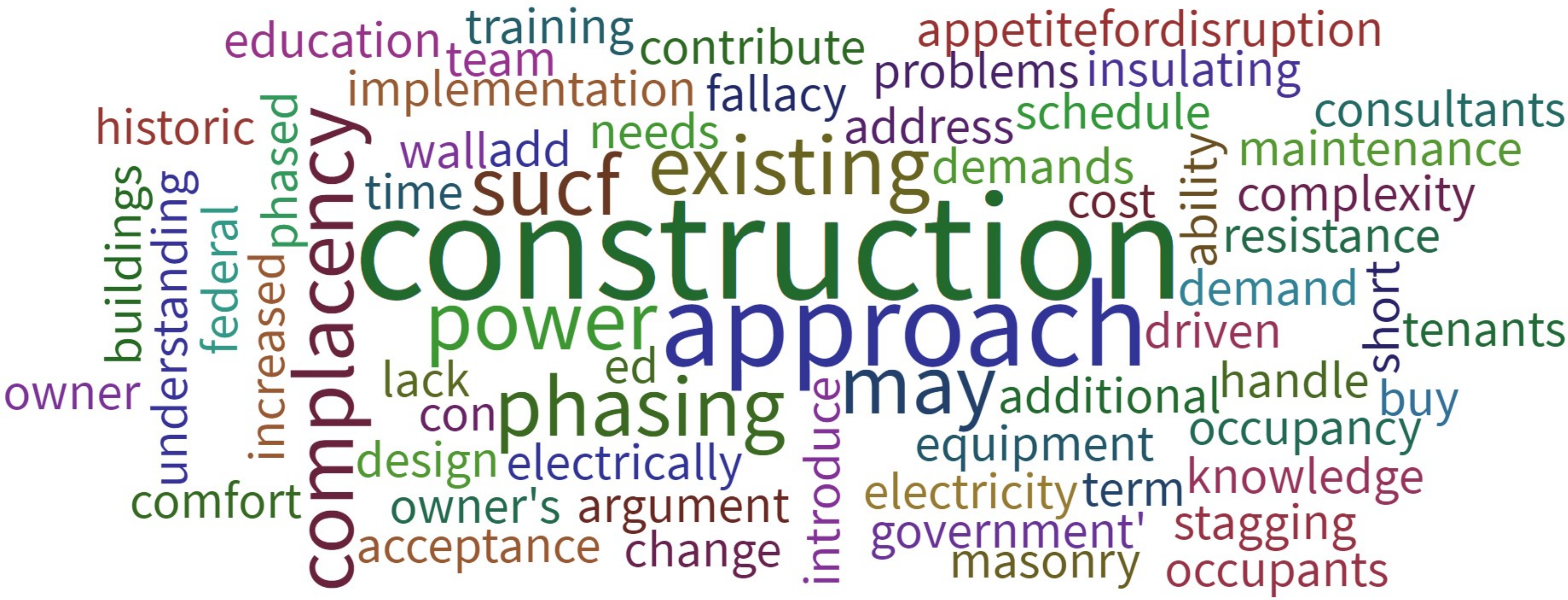
Total Energy Reductions





Deep Energy Retrofit Challenges

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



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

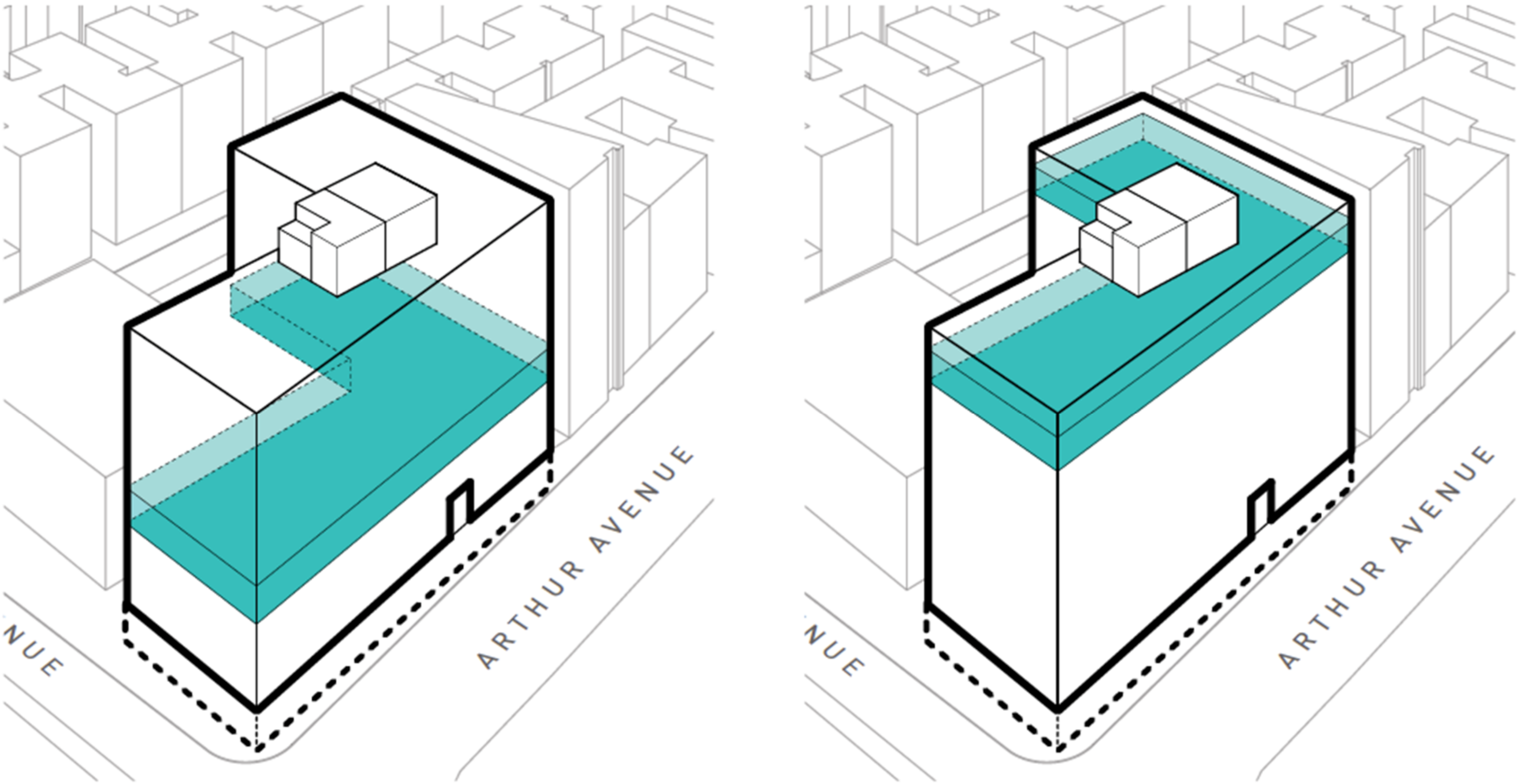
Retrofit Scenarios: Complete Retrofit (Single Shot)

- 15-20% less expensive
  (general conditions, startup costs, less repetitive)

- Enjoys scheduling efficiencies
  (overlapping trades, freedom of movement)

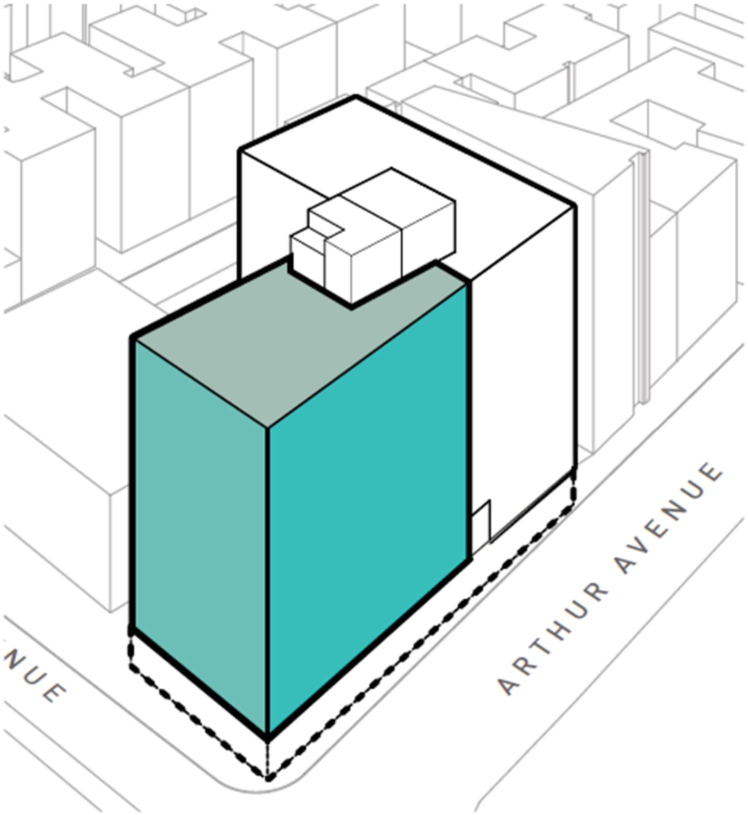
- Avoid in-situ disruption
  (work isn't in occupied buildings)

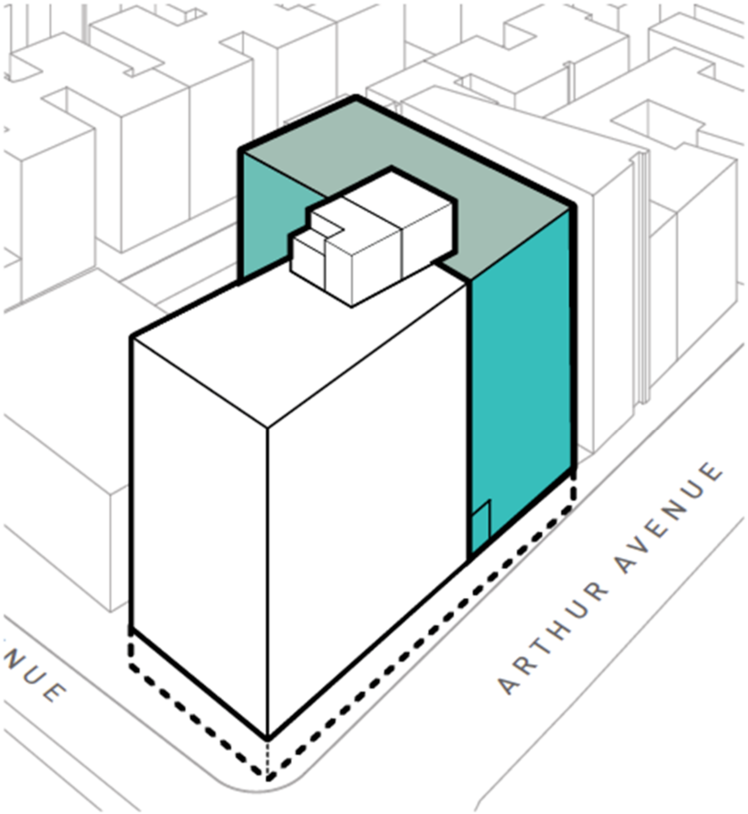
Phasing Options – floor by floor



Floor-by-floor tenant phasing diagram

Phasing Options – phase by wing





Two-zone tenant phasing diagram

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

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.

Existing Building System Optimization		Within 5 years	5-9 years	10-14 years	15-19 years
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				

Integrated Project Management

Writing Requests for Qualifications for design team and consultants

- Not absolutely necessary, but they should have to attend an informational meeting about what the project goals are and methods that will be employed to achieve them.
- Many projects succeed with first time PH team members if the owner & architect are committed.
- Should have some high performance or experience with other certification programs that require testing and commissioning.

Who should be included from the beginning

- Architect
- Owner
- PH Consultant
- Façade Consultant
- General Contractor
- MEP
- Structural

Pre-Construction

Pre Bid meeting

- HVAC
- Understand scope
- Sets clear expectations

Passive House QA/QC

PH Design Phase Process

50% SD: Two weeks

Preliminary energy model

100 % DD: Two weeks

- Detailed update to energy model
  - Critical THERM model(s)
  - Updated building geometry and shading
  - MEP systems
- PHPP Model Update Report
- 1st Model Submittal to PHI

50% CD: Two weeks for review

- Update Model
- Start THERM Modeling
- MEP Plan Review
- **Air Barrier Review**
- **QA/QC Inspection Checklists**
- **Blower Door Test Plan**
- PHPP Model Update Report

- **100% CD:** Two weeks for review

Finalize Tasks listed under 50% CDs

PH Construction Phase

Construction Phase:

- **Contractor Training**
- Site Inspections
- **Interim Testing**
- Submittal Review
- Attendance at Design Meetings & Additional Support
- Filing of common CCD1s related to PH and
- RFI reviews

Construction Completion:

- Whole building blower door tests
- Measurement of the ventilation system
- Verification of proper installation of the mechanical system
- Verification of fixtures & appliances
- Documentation & submission to certifying body

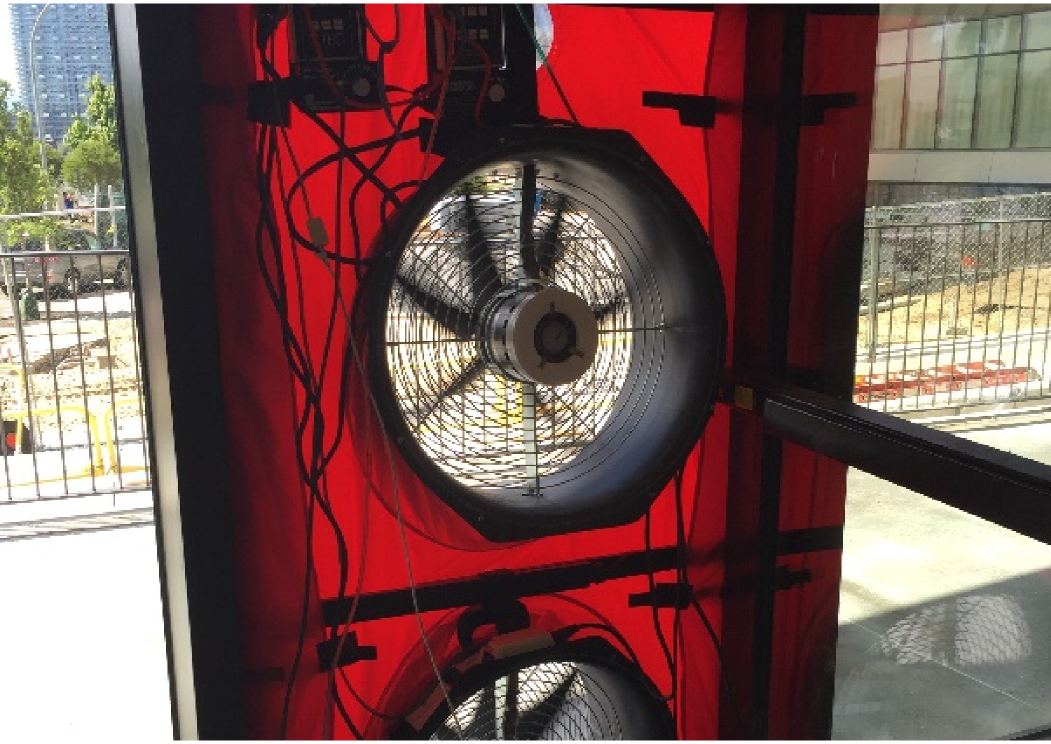
Interim Testing

- Window mockup testing
- Envelope and window testing
- Unique component testing
- Guarded blower door testing
- Whole building blower door test

Blower Door Testing

Basic Components

- Gauge (manometer)
- Shroud
- Frame
- Fan




Whole Building Blower Door Test

Life Cycle Analysis

Life Cycle Benefits of Passive House Buildings

- **Life Cycle Assessment (LCA):** Analysis of the environmental impact over the life of a building with a focus on embodied carbon.
  - Includes environmental impact of
    - Construction materials/transportation to site
    - Material replacement over time
    - Everyday equipment operation
    - Demolition

Life Cycle Cost Analysis of Passive House

- **Life Cycle Cost Analysis (LCCA):** Costs for building construction and operation compared to payback from energy savings over the life of an investment.
  - Takes into account
    - Initial construction costs
    - Maintenance labor/ replacement material costs
    - Everyday equipment operation costs
    - Additional costs**
    - Energy reduction savings
  - Fuel Escalation
  - Discount Rate of funding sources

Life Cycle Cost Analysis of Passive House

- Upfront capital costs: New Construction
  - Can be as low as 0% or as high as 12%
  - 3% to 5% increase in construction costs
- Ongoing maintenance costs
  - Highly complex systems?
  - More or fewer filter changes/units needing service?
  - Typically façade is more robust resulting in less decay, fewer comfort complaints
- Service Contracts
  - ERV fine tuning yearly
  - Refrigerant checks/charging

Life Cycle Cost Analysis of Passive House

- Does not consider Intangible benefits or GHGs

- Intangible Benefits
  - Comfort
  - Indoor air quality
  - Reduced noise levels
  - Reduced moisture-related problems
  - GHG reductions
  - Resilience

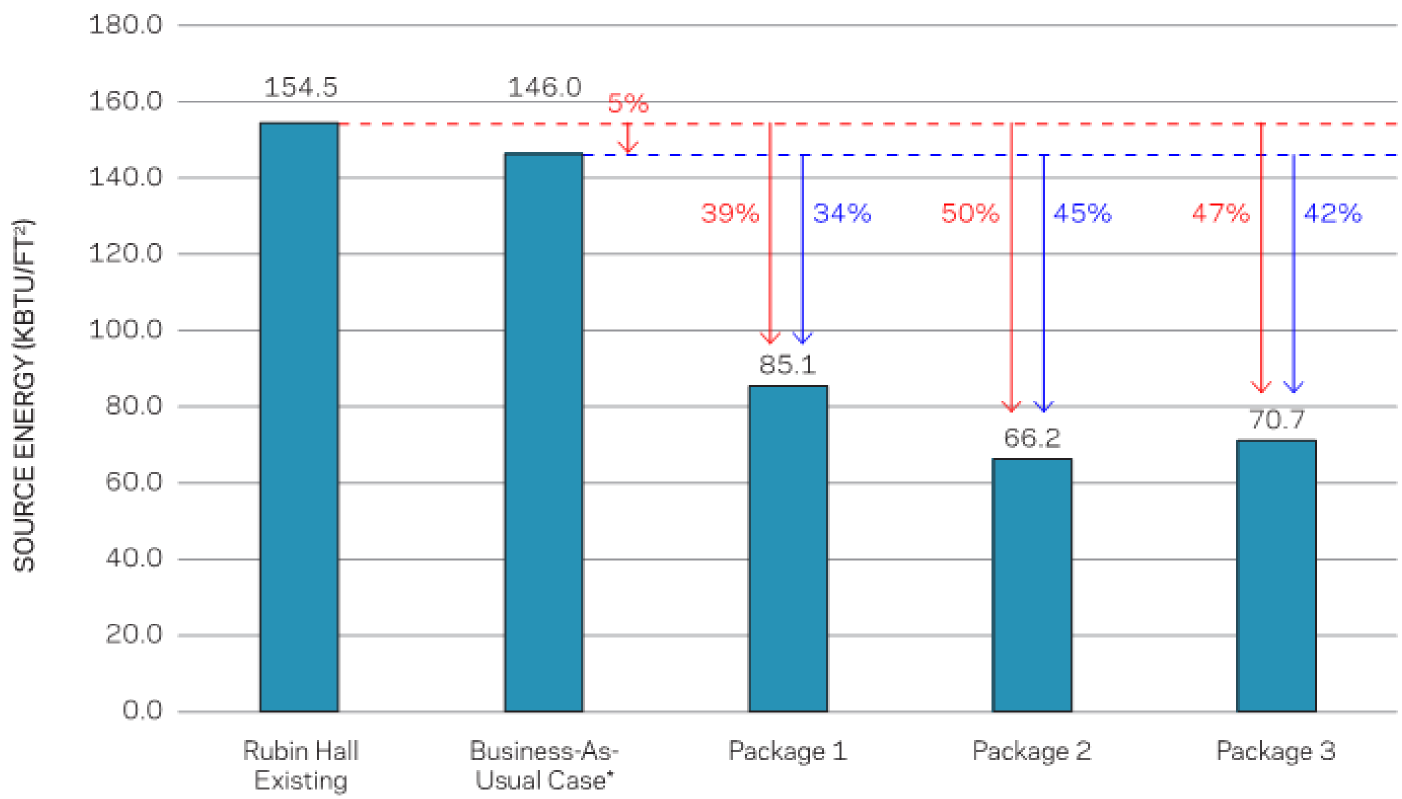
Project Example: NYU-Rubin Hall Dormitory

- 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

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

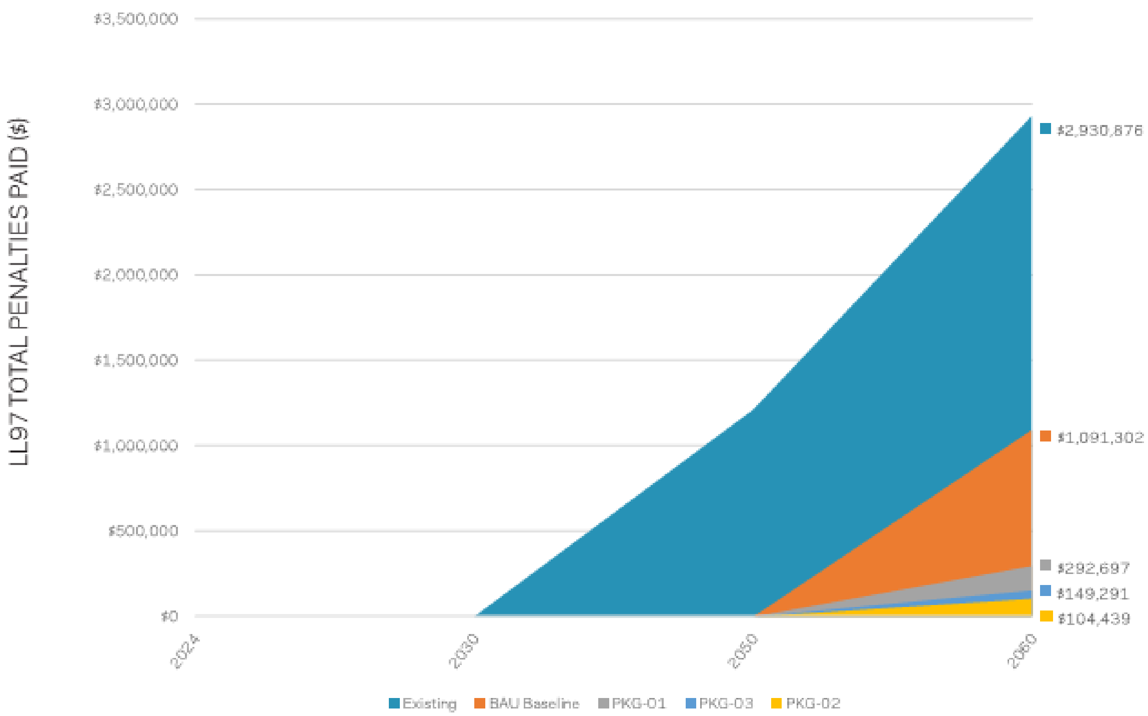


* Estimated based on savings observed at Brittany Hall

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

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Join Us for More Trainings!

- 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

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