THE WORLD'S LARGEST PASSIVE HOUSE BUILDING

Cornell Tech NYC Campus Residential Building

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PARTNERSHIP: HUDSON COMPANIES AND RELATED COMPANIES

Seven Buildings on Roosevelt Island

Riverwalk 7:
25.5% better than ASHRAE 90.1–2007
LEED Silver and NYSERDA ENERGY STAR anticipated

THE HUDSON COMPANIES: GREEN LEADERSHIP

Third + Bond

LEED Platinum and ENERGY STAR labels
Completed 2011

Gateway Elton Street Phases I, II, III

Largest Residential PV Installation in NYS
3 phase multi-building mid-rise development
LEED for Homes Gold or better expected
Plan to exceed NYSERDA's energy-efficiency standard

RELATED: SINCE 2008 BUILDS GREEN EXCLUSIVELY

LEED Silver or Better

Completed:

14 projects, 6.4M SF, $3.7B

1 LEED Platinum

5 LEED Gold

8 LEED Silver

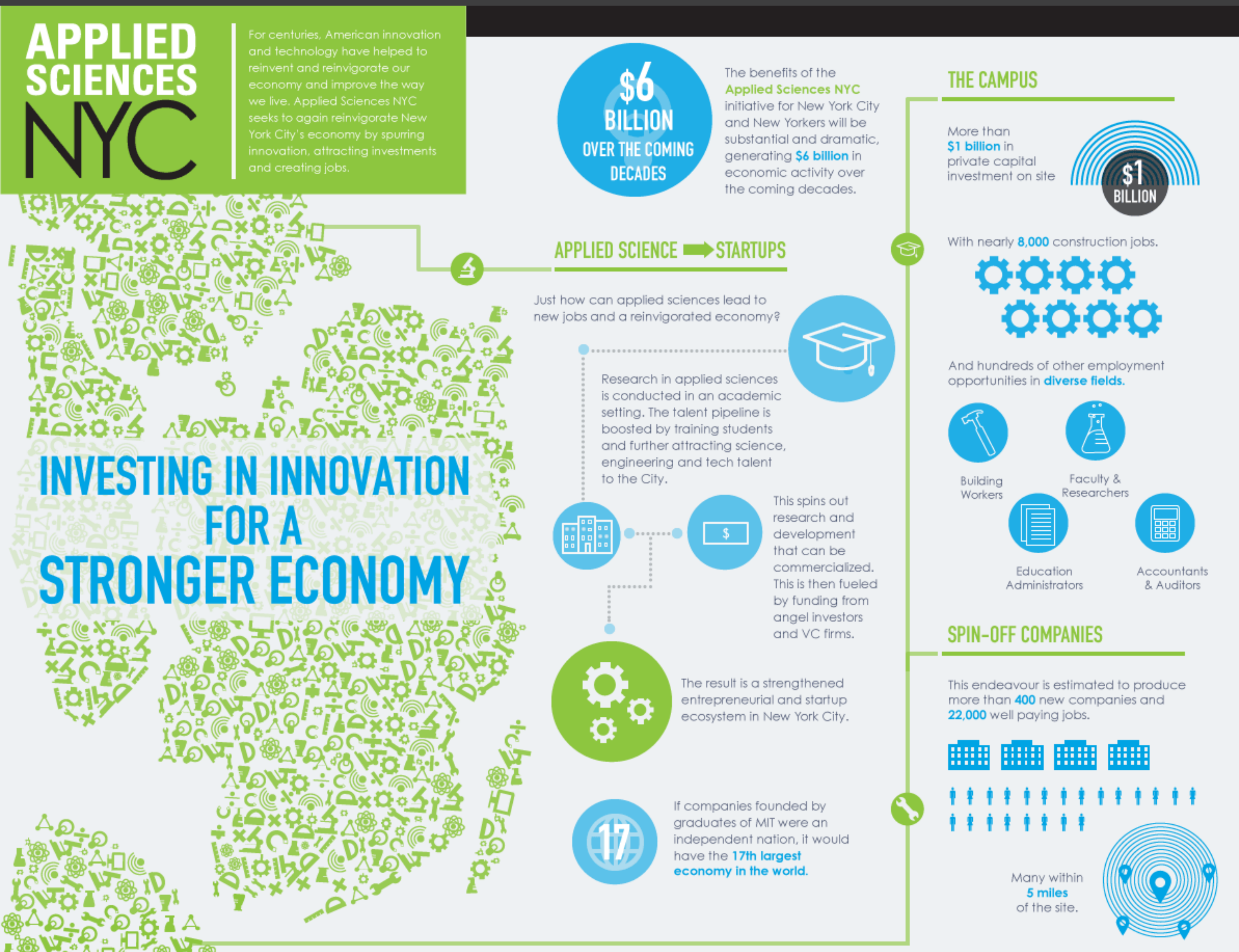
Underway:

32 projects, 14.5M SF, $10B

3 LEED Neighborhood Developments

Tribeca Green, NYC
Completed: 2004
LEED NC Gold

HANDEL ARCHITECTS: MIXED-USE HIGH-RISE DESIGNERS



December 2010

City launches "Applied Sciences NYC."

October 2011

Responses received from universities around the world.

Technion - Israel Institute of Technology President Peretz Lavie, Cornell President David Skorton, Mayor Michael Bloomberg

Bloomberg hands over 12-acre plot for Cornell campus on Roosevelt Island

The Cornell Tech 'Genius School' under the Queensboro Bridge will 'ensure that New York City businesses play a major role in determining how technology shapes our future,' the outgoing New York City mayor says.

BY JENNIFER FERMINO Follow / NEW YORK DAILY NEWS / Friday, December 20, 2013, 1:13 AM

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BART MICHIELS

Outgoing Mayor Bloomberg handed over a 12-acre plot to Cornell at a City Hall ceremony Thursday that will pave the way for a Cornell Tech 'Genius School' on Roosevelt Island.

RELATED STORIES

- Cornell tech campus takes shape
- Mike charts the future
- Engineering NYC's future

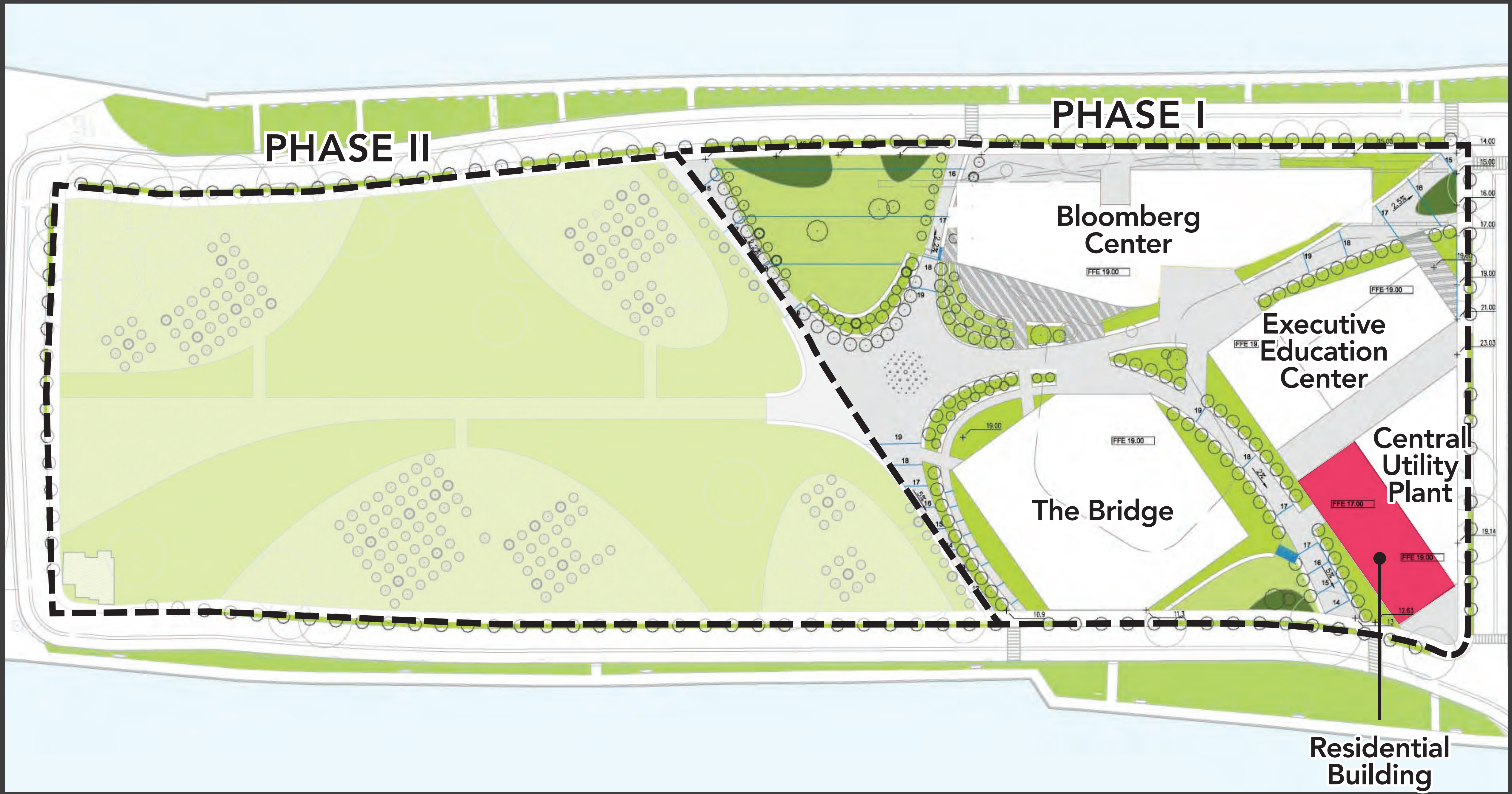
It was a finishing touch on one of Mayor Bloomberg's signature legacy projects — the Cornell Tech "Genius School."

Bloomberg on Thursday formally handed over 12 acres of city land to Cornell at a City Hall ceremony, paving the way for construction of the 2 million-square-foot campus on Roosevelt Island.

NOVEMBER 2012

Cornell issues an RFP for the Phase 1 Residential Tower.

- Sustainable design
- Competitive rents
- Design Excellence



PROJECT GOALS

1 Better Living Quality

- Improve indoor air quality and comfort
- Provide acoustic separation from the surrounding environment
- Allow individual control of heating & cooling

2 Save the Planet

- Reduce energy consumption
- Reduce Greenhouse Gas (GHG) emissions
- Reduce dependance on fossil fuels

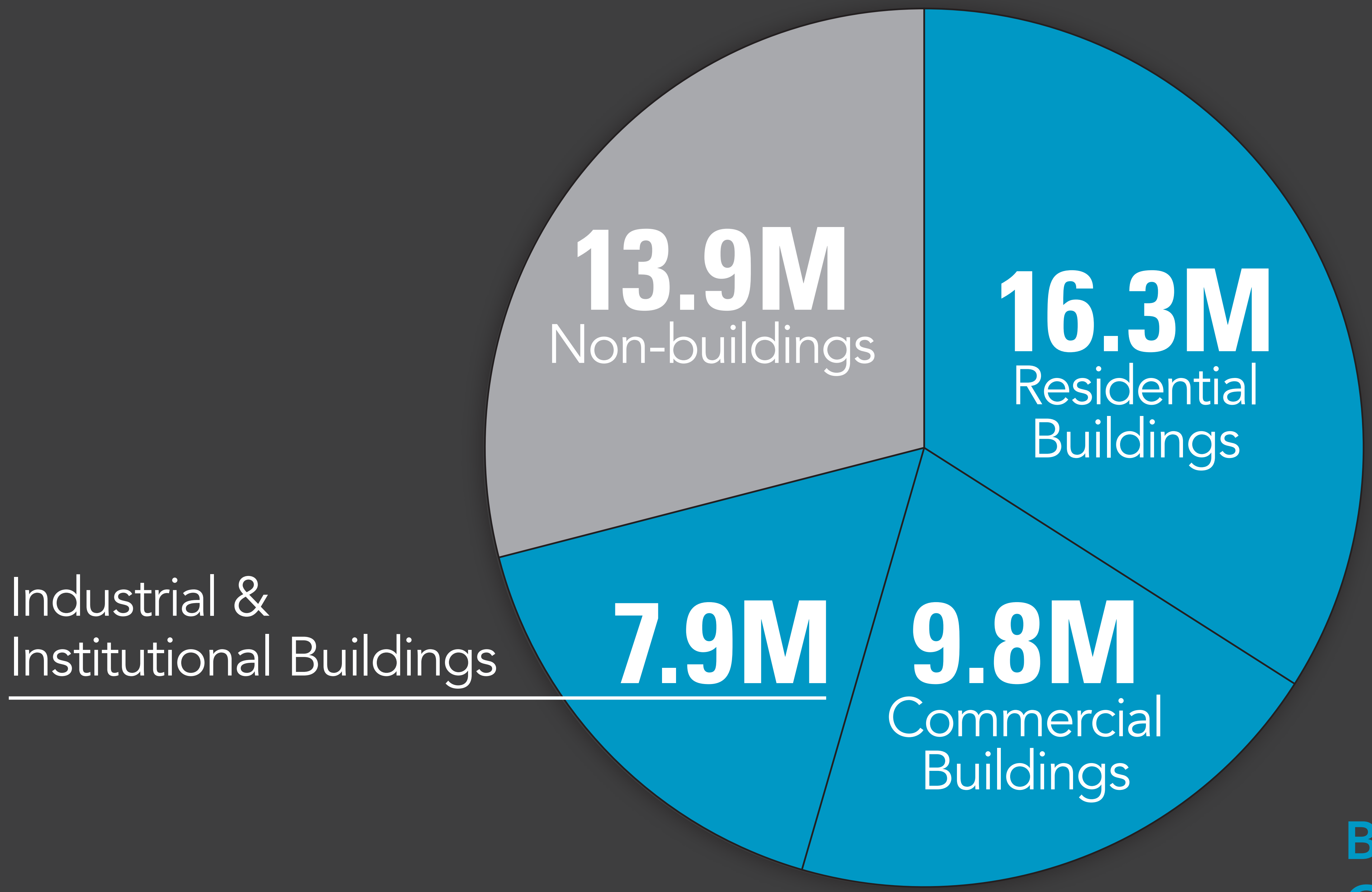
3 Elevate the University

- Position University at the forefront of innovation

4 Save Money

- Provide housing that is affordable to the community
- Reduce energy costs for users

GREENHOUSE GAS EMISSIONS IN NEW YORK CITY (2014 = 47.9 MILLION TONS CO2)



BUILDINGS = 71% GREENHOUSE GAS EMISSIONS

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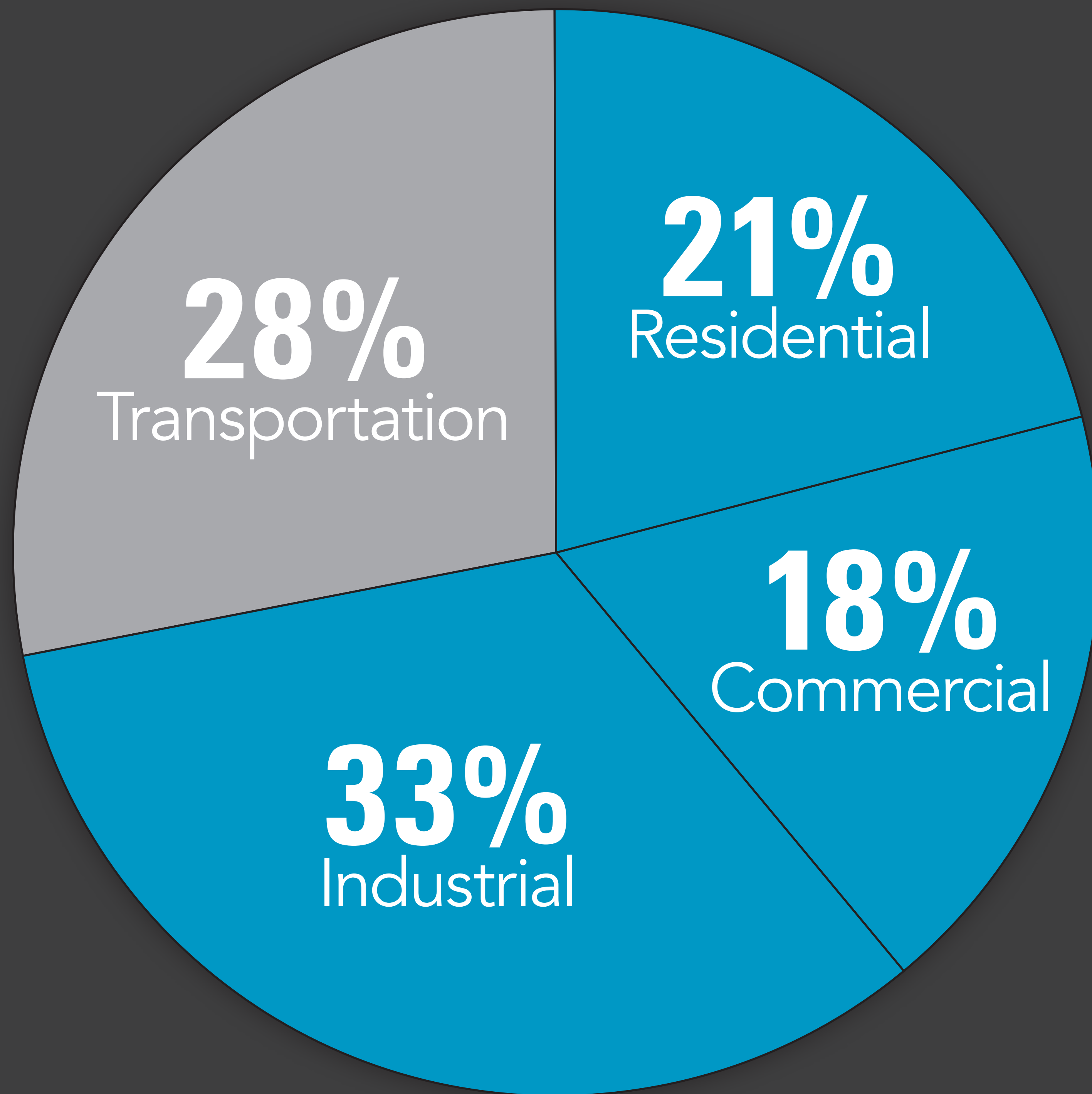
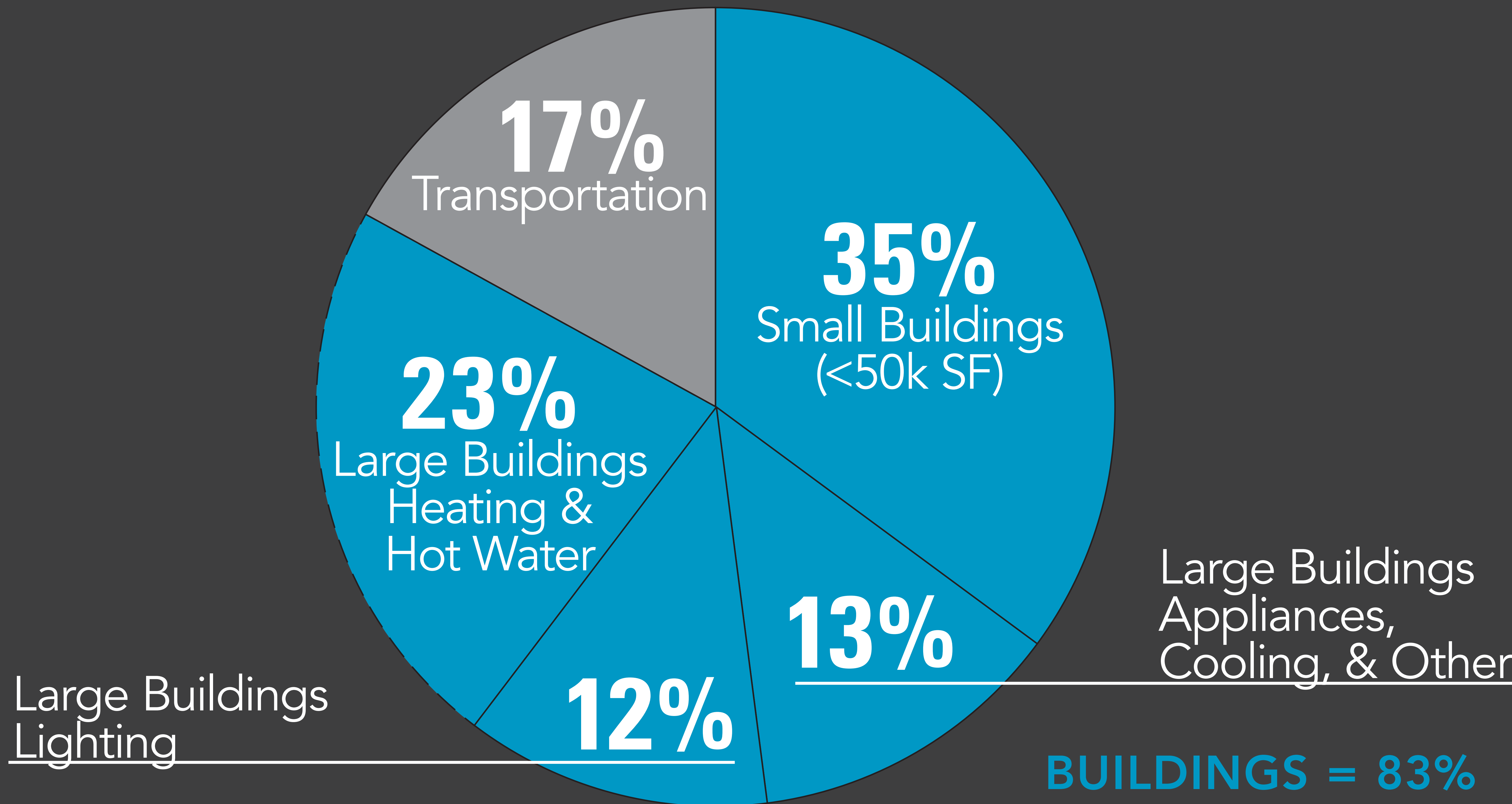
SHARES OF U.S. PRIMARY ENERGY CONSUMPTION (2006)



ENERGY CONSUMPTION IN NEW YORK CITY (2011)



BUILDINGS = 83% TOTAL SOURCE ENERGY

DOING RADICALLY MORE WITH RADICALLY LESS

Median Energy Use of All NYC Buildings over 200,000 sq. ft.:
140.8 pEUI kBTU/SF per year

Energy Use of Passive House Buildings:
38.1 pEUI kBTU/SF per year
370% Improvement

Buildings = 83% Total Source Energy in New York City
Designing to Passive House = 775.9 MMBtu (77.5 %) reduction

DOING RADICALLY MORE WITH RADICALLY LESS

Greenhouse Gas Emissions of All NYC Buildings:
38 Million Tons per year

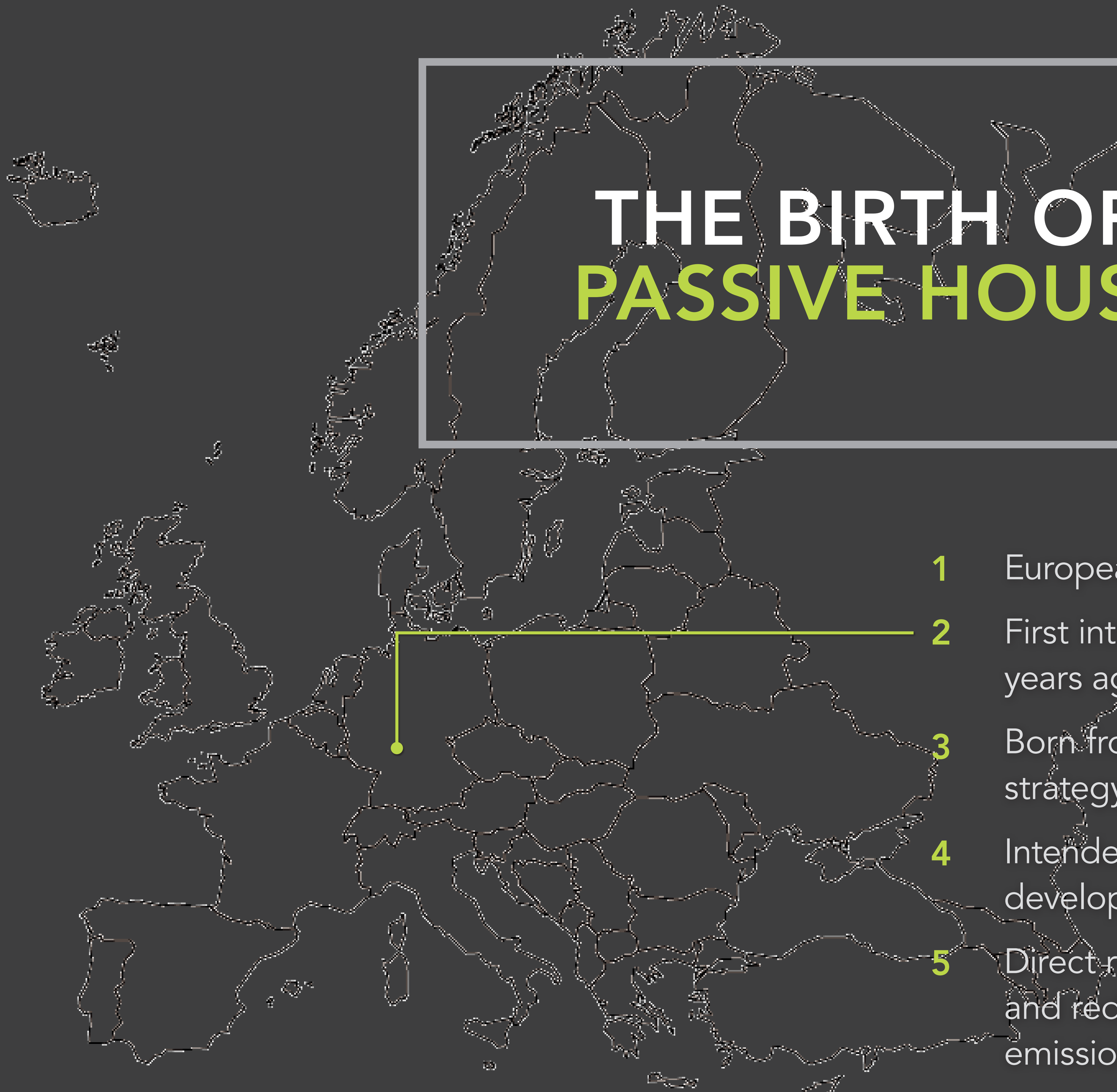
Designing to Passive House:
24.8 Million Tons CO_2 reduction
52% reduction

WHAT IS PASSIVE HOUSE?

Maximize your gains, minimize your losses

1. The most rigorous energy efficiency standard in the world
2. Based on absolute energy use, not enhancement over code
3. Focus attention on enclosure - insulation continuity and elimination of thermal bridging and air leakage
4. An emphasis on balanced filtered fresh air
5. Building maintains constant temperature allowing for a drastically reduced heating and/or cooling load

THE BIRTH OF PASSIVE HOUSE



1. European response to climate change
2. First introduced in Darmstadt, Germany over 25 years ago
3. Born from a need for an energy independent strategy
4. Intended to change the face of low energy developments and architecture
5. Direct response to stopping global warming and reducing Green House Gas (GHG) emissions

PASSIVE HOUSE AT A DIFFERENT SCALE

Allgemeine Angaben, Germany - Current Tallest Residential Passive House Building

- 16-Stories
- 140 units
- 91,200 sq.ft.

Cornell Tech Residential

- 26 Stories
- 352 Units
- 272,500 sq.ft.
- 10,600 GSF/Floor
- 270' to Roof

NEW YORK STATE CLIMATE ACTION PLAN 2050

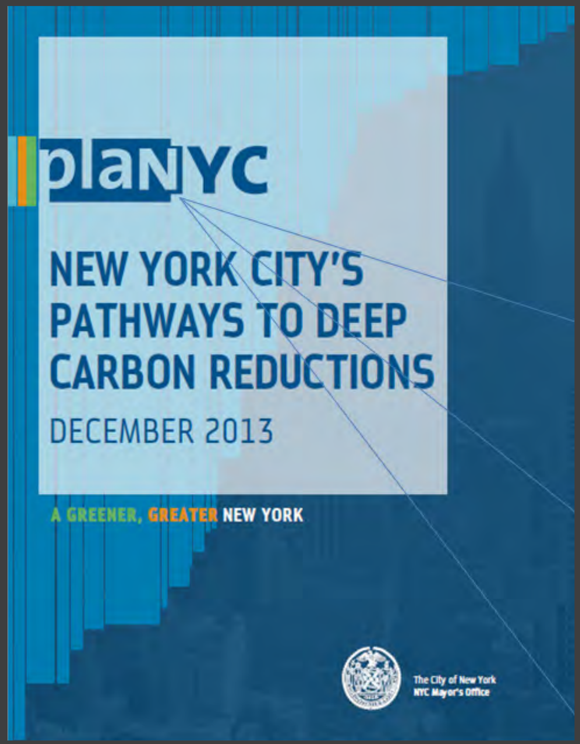
In Million Metric Tons of CO2/yr

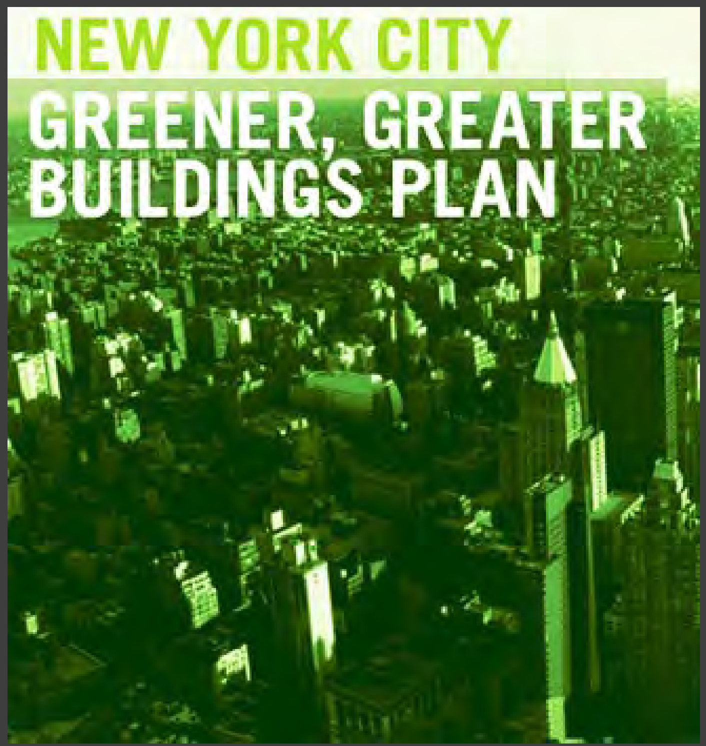
Sector	Case 1	Case 2	Case 3	Baseline	Notes
Residential	**0**	**0**	7.5	37.6/45.0	
Commercial	**0**	**0**	4.5	27.2/39.1	
Industrial	12.7	12.7	14.1	19.0/24.1	
Transport	20.1	20.1	51	88.3/126	
Electricity	10	13	24	49.2/83.3	
Other	12.3	12.3	12.3	28.8/43.0	
Total	**55.1**	**58.1**	**113.4**	**250.2/360.5**	**Goal – 55.4**

Source: Stokes, Gerald M., Brookhaven National Lab

INCREASING ENERGY STANDARDS

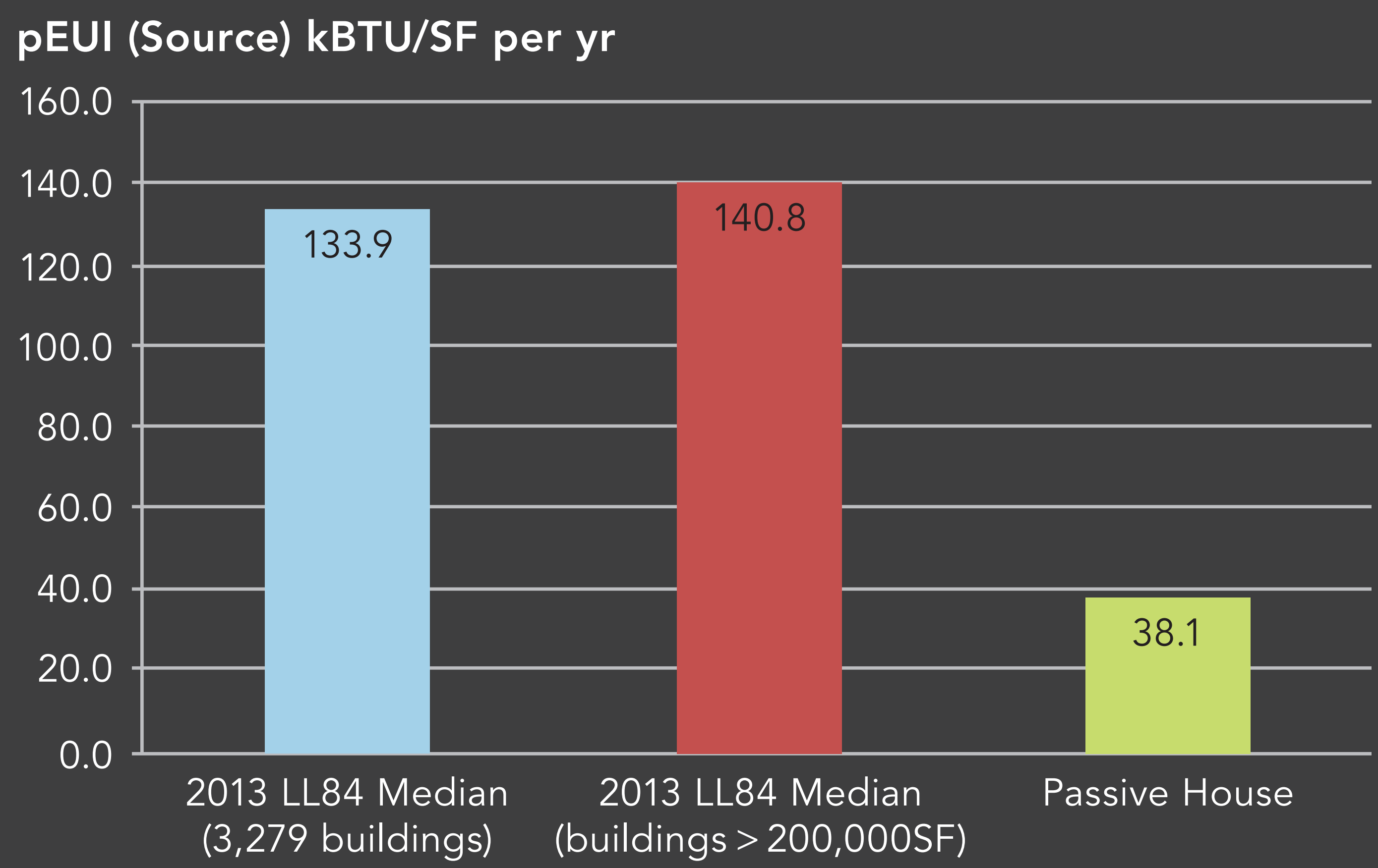
- To achieve 80% reduction in emissions by 2050, New York City must retrofit a large majority of today's existing buildings
- Convert onsite combustion of fossil fuels to renewable or low-carbon energy
- Construct new buildings 75% more efficiently than existing construction standards; and greatly improve the efficiency of appliances & electronics.





Sources: New York State Climate Action Council, Climate Action Plan Interim Report, November 2010

PASSIVE HOUSE PERFORMANCE CRITERIA



- **Overall Source Energy Used** 38 kBtu/ft² per year
- **Heating Energy Used** Max 4.75 kBtu/ft2 per year
- **Cooling Energy Used** Max 5.39 kBtu/ft2 per year
- **Air Changes per Hour (ACH) Through the Facade @ 50 Pascals of Pressure** 0.6 ACH - Very Tight Facade
- **Ventilation** Balanced supply and exhaust mechanical ventilation with energy recovery

INTEGRATION WITH OTHER CERTIFICATIONS

Many Passive House projects also pursue:

LEED Certification

- Green building certification program
- Save money and resources, have positive impact on health, and promote renewable, clean energy

ENERGY STAR v3

- Meet strict energy performance standards set by EPA
- Less expensive to operate and causes fewer greenhouse gas emissions

DOE Zero Energy Home Program

- Based on Energy Star
- Incorporates indoor air quality and moisture management principles

STRATEGIES TO ACHIEVE PASSIVE HOUSE CERTIFICATION

1 **Siting: Solar Orientation and Shading**
Maximize solar gains for winter, minimize gains for the summer.

2 **Compact Building Shape**
Low surface-to-volume ratio (<1)

3 **Enclosure**

Continuous Insulation
Create steady indoor temperatures that won't drop below 50 degrees without heating source

Thermal Bridge Free Construction
Minimize heat transfer/condensation/building deterioration

Airtightness
Tightly air seal building - limit air leakage. Minimize moisture diffusion into wall assembly.

4 **Balanced Ventilation with Heat Recovery**
Provide exceptional efficiency, indoor-air quality & comfort.

5 **Energy Efficient Appliances and Lighting**
Use energy efficient equipment, appliances and lighting.

6 **User Friendliness**
Manuals are given to residents, but operational use should be very similar to typical buildings

IMPLEMENTATION PROCESS

Owners

Architect

Engineers & Consultants

Accessibility, Code, Zoning, Landscape, Civil, Exterior Wall, Waterproofing, Structural, Mechanical, Electrical, Plumbing, Fire Protection, LEED, Elevator, Acoustical, Hardware, Security, Passive House

Passive House Consultant

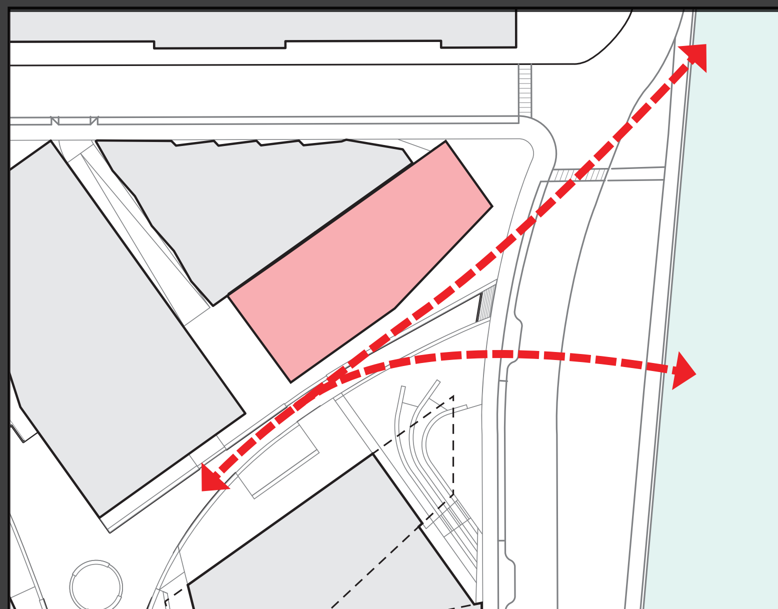
PHA
Passive House Academy certifies application

Local Certifying Body

PHI
Passive House Institute – Germany provides final certification

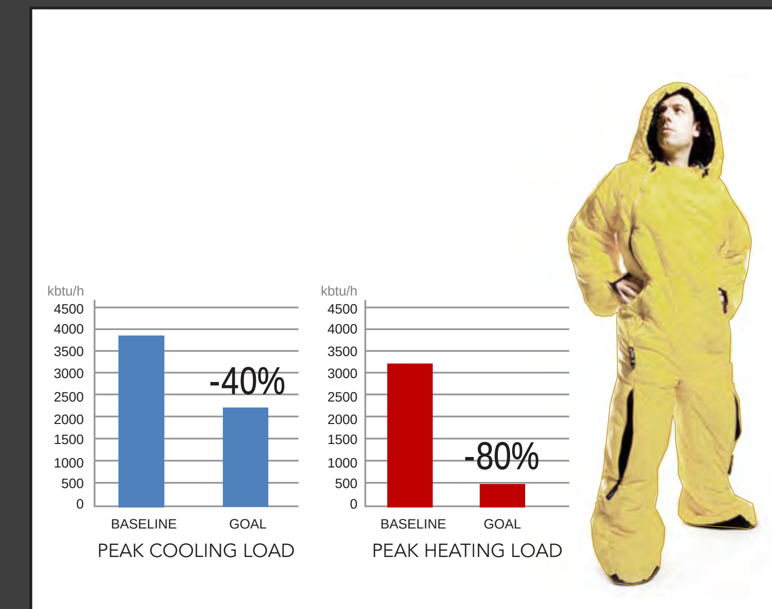
CERTIFICATION

SHAPING OUR APPROACH: MASTER PLAN PRINCIPLES

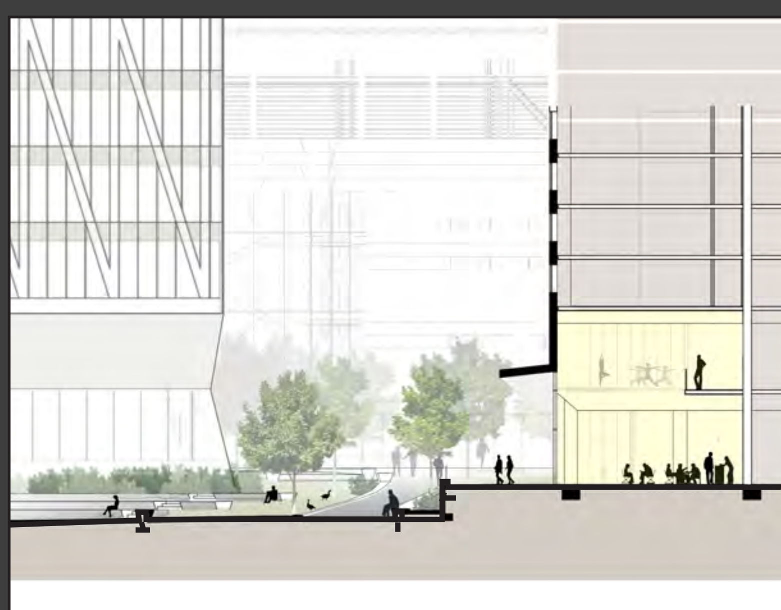


RIVER TO RIVER EXPERIENCE

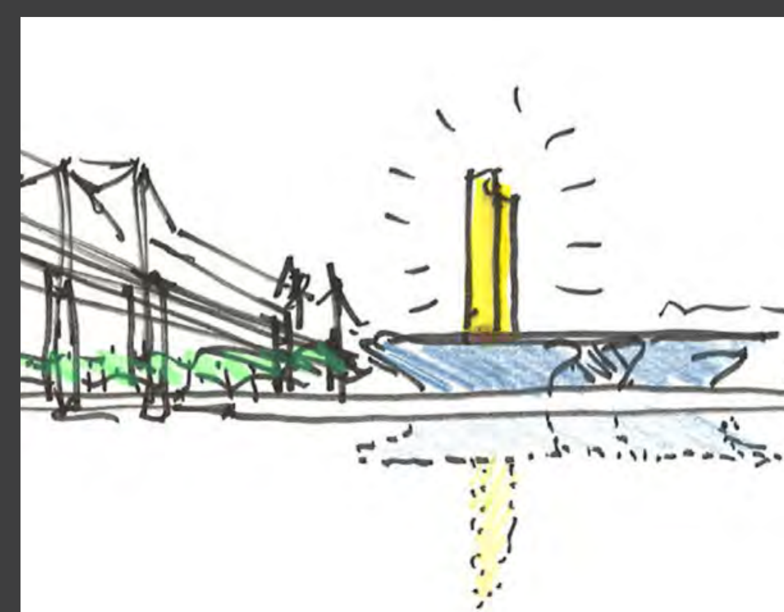
INDOORS AND OUTDOORS



OPTIMIZED PERFORMANCE



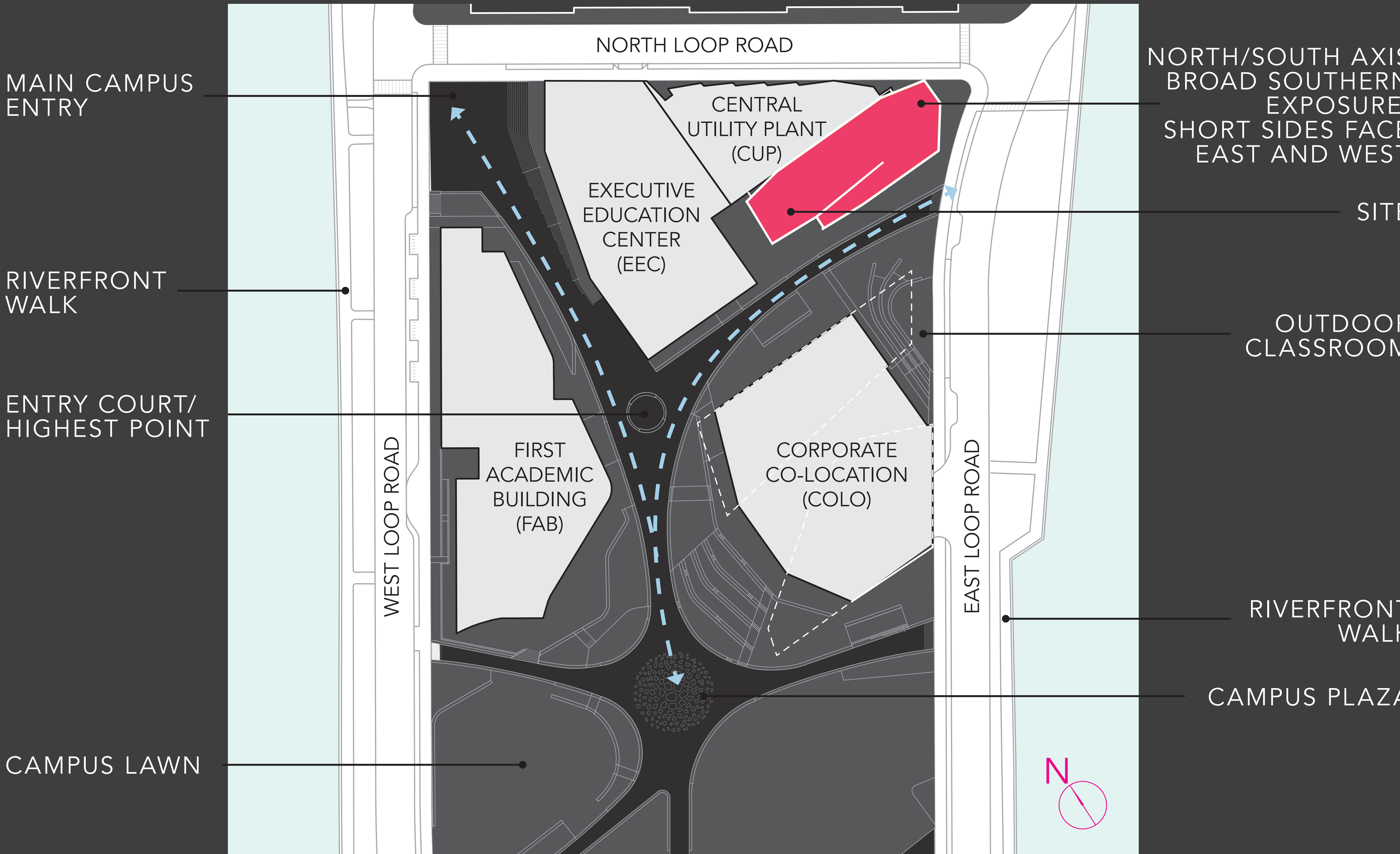
DIVERSE + ACTIVE OPEN SPACES



CAMPUS MARKER

LIVABLE + SUSTAINABLE CAMPUS

SITING



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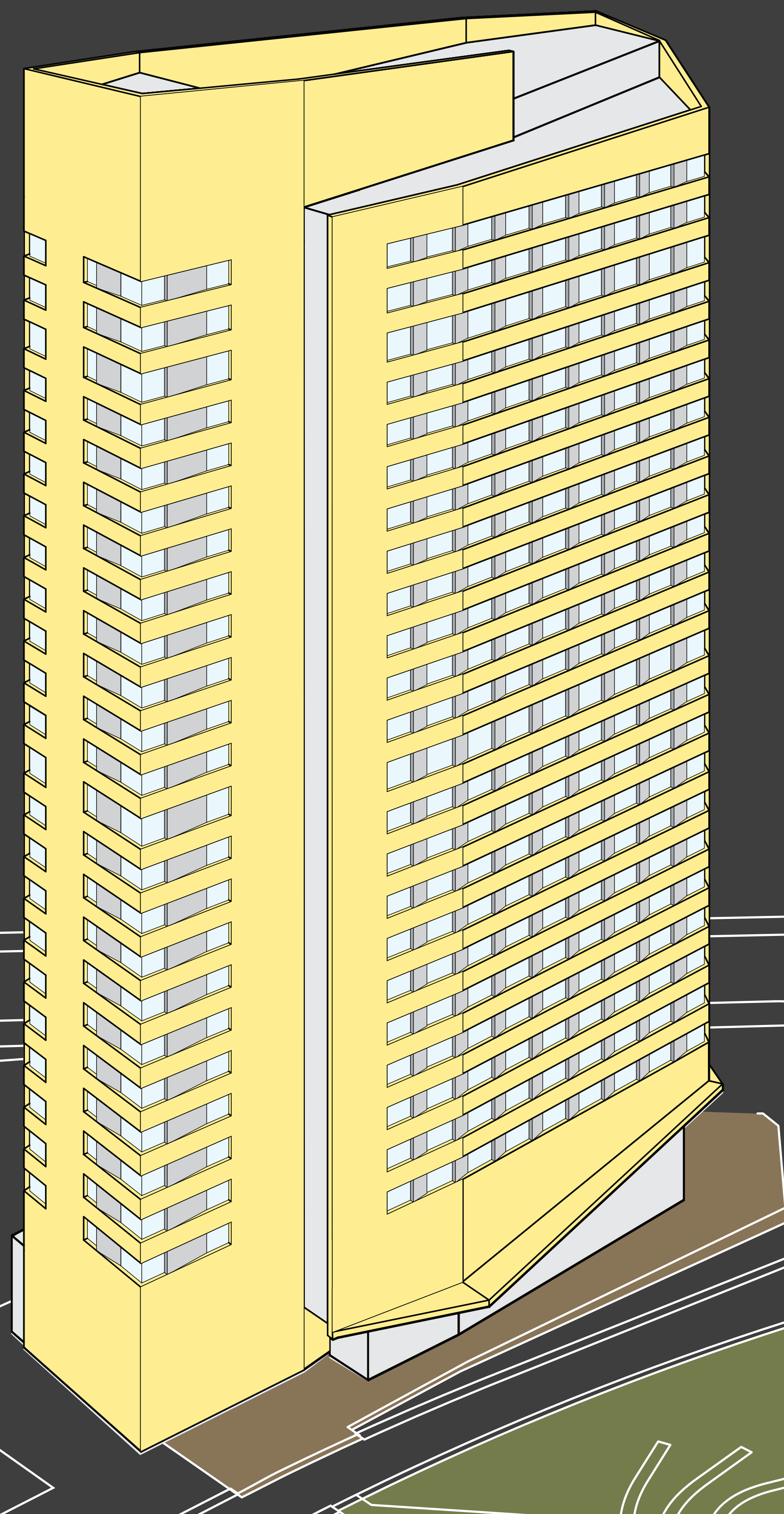
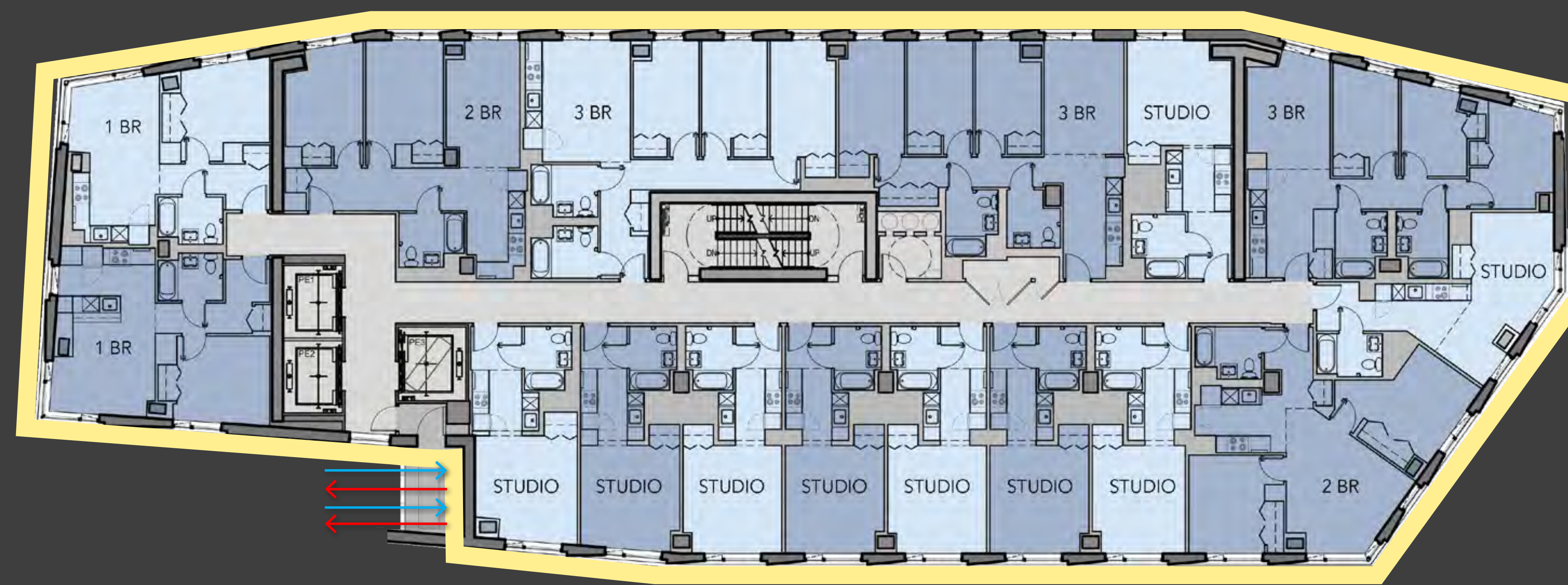
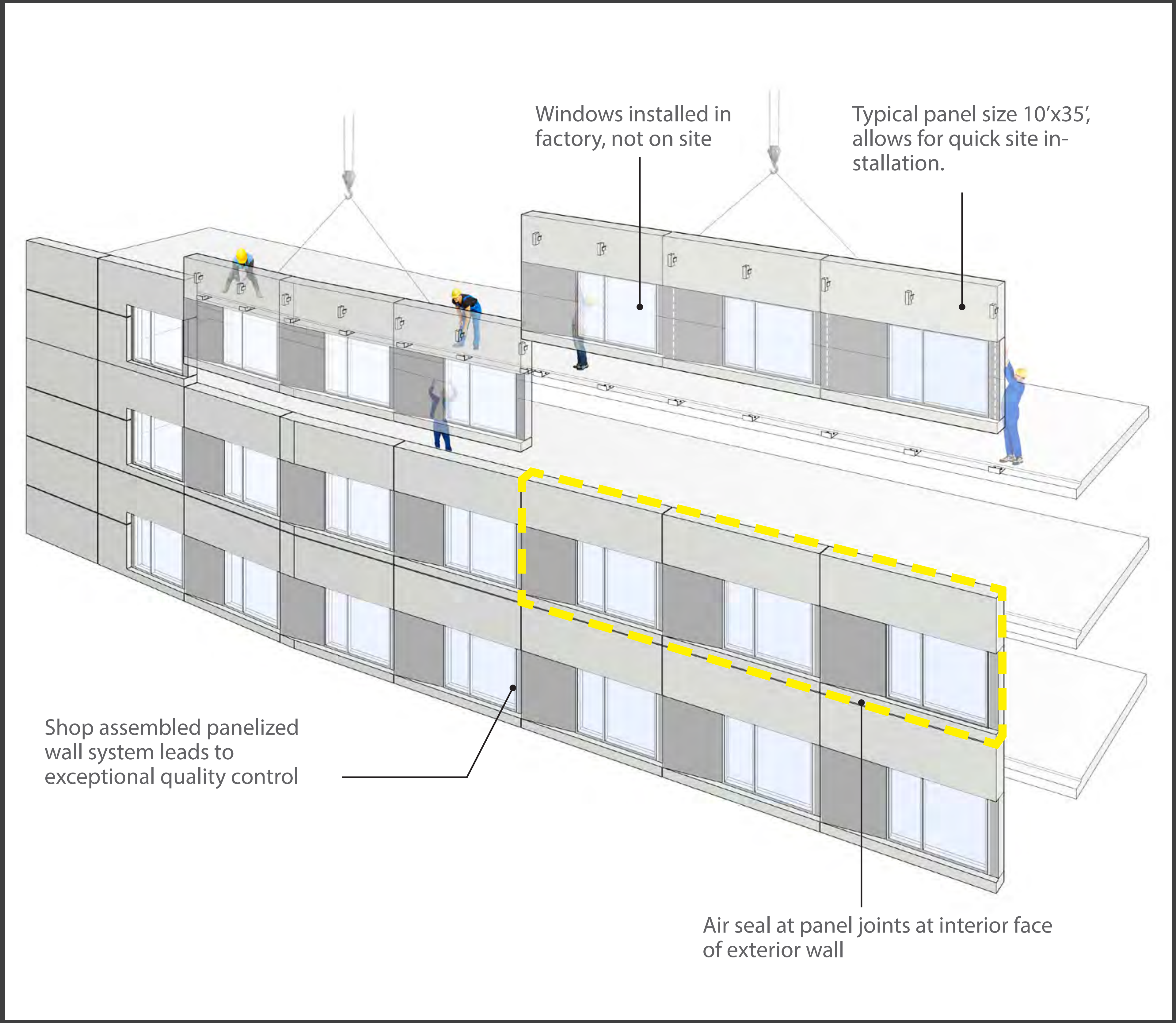
ENCLOSURE: THERMAL WRAP





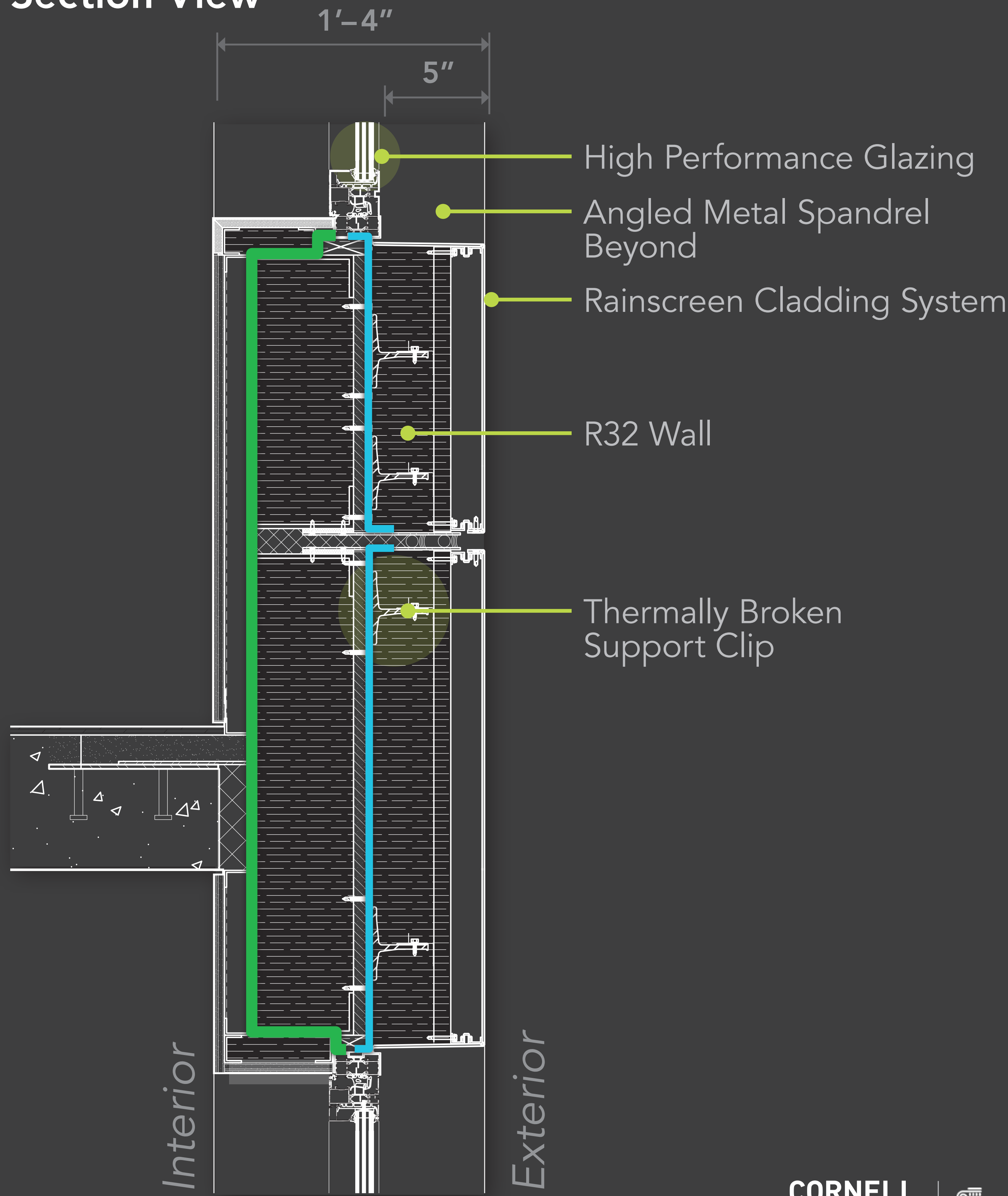
PANEL SYSTEM



Prefabricated metal wall panel installation

EXTERIOR WALL DETAIL

Section View

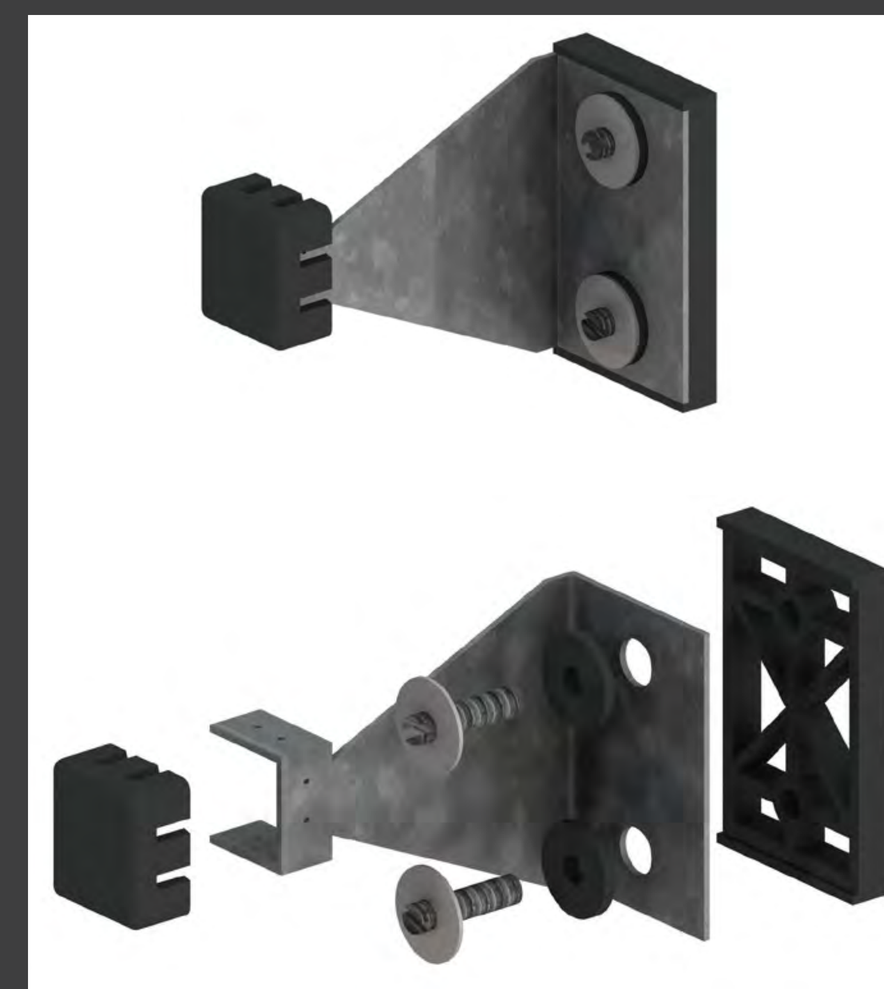


Insulation

Continuous Vapor Barrier

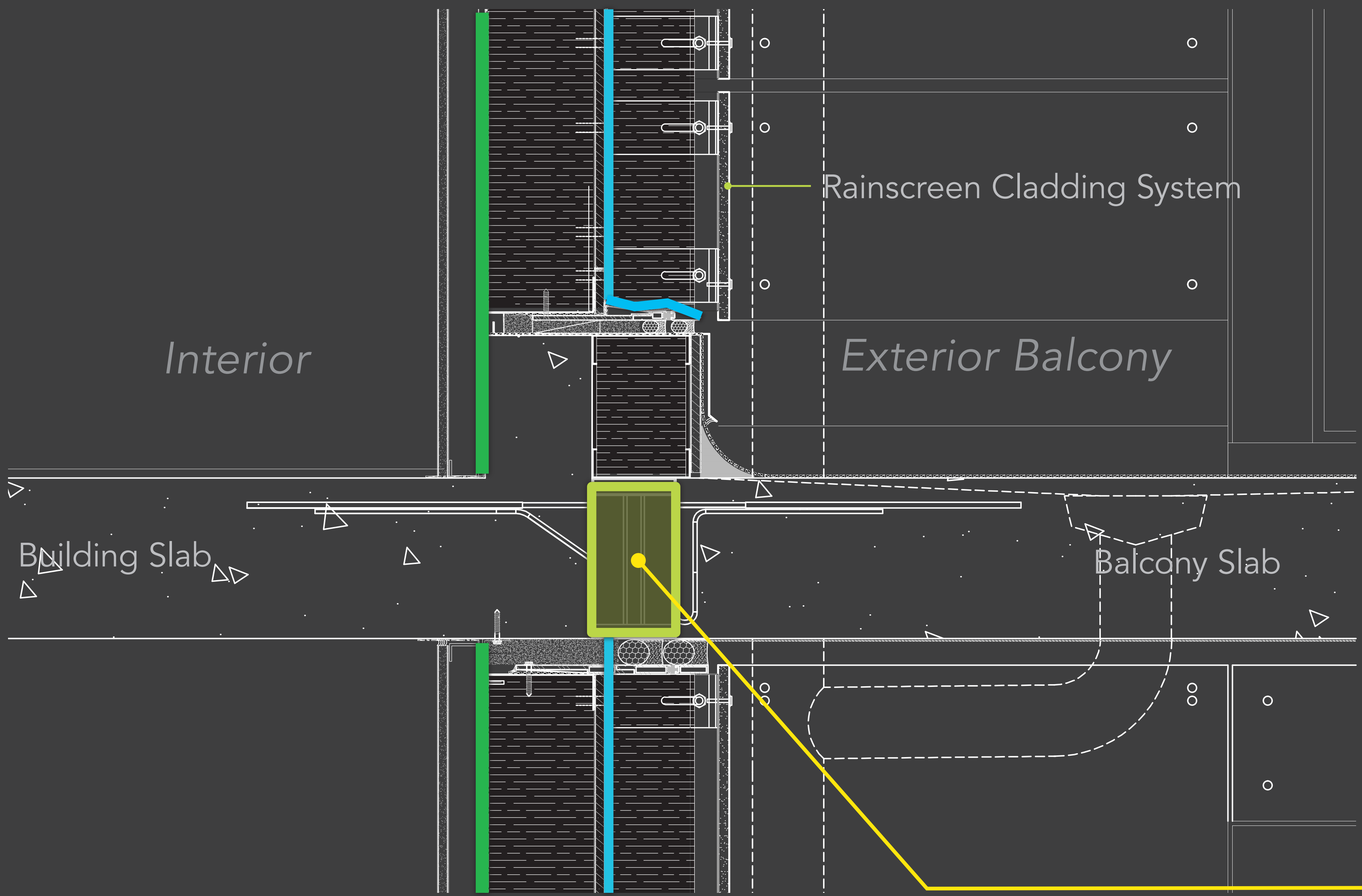
Continuous Air/Water Barrier

- Thermally broken construction
- Airtight envelope: 0.6 ACH@50pa
- Window-to-wall ratio calibrated to maximize performance



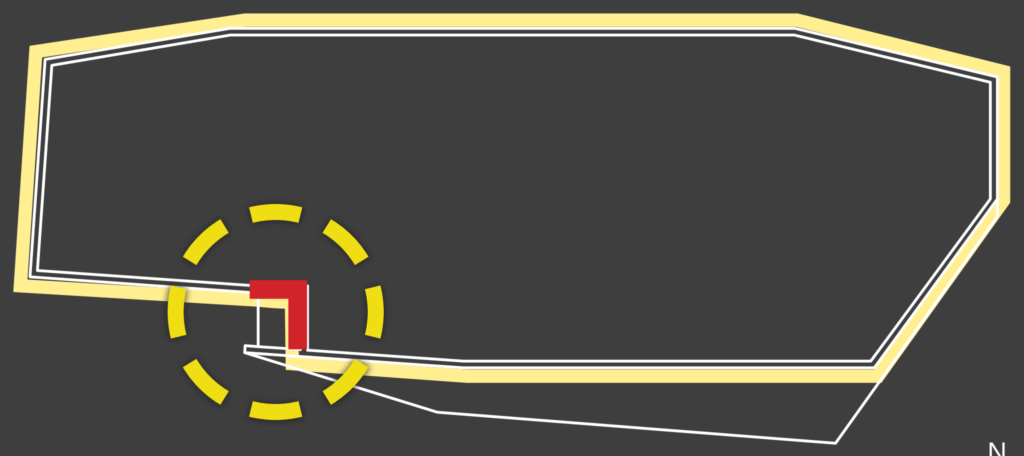
ThermaBracket Assembly with Isolators

BUILDING BALCONY DETAIL - CONCRETE TO CONCRETE THERMAL SEPARATION



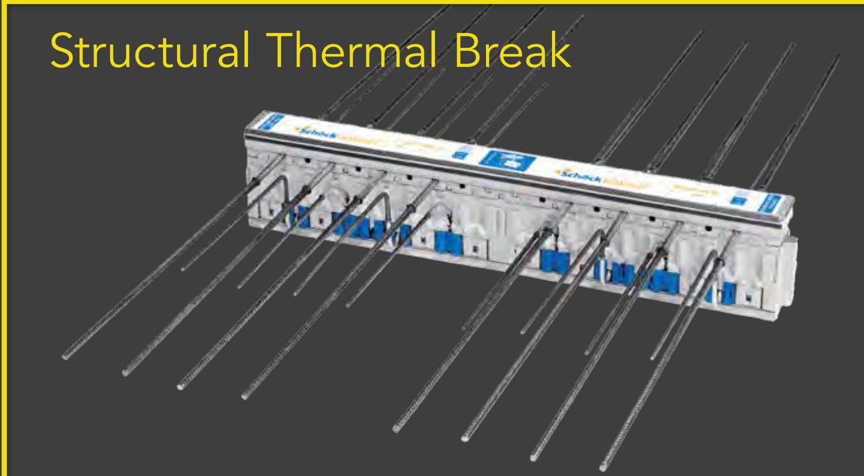
Section Detail

Insulation
Continuous Air/Water Barrier
Continuous Vapor Barrier

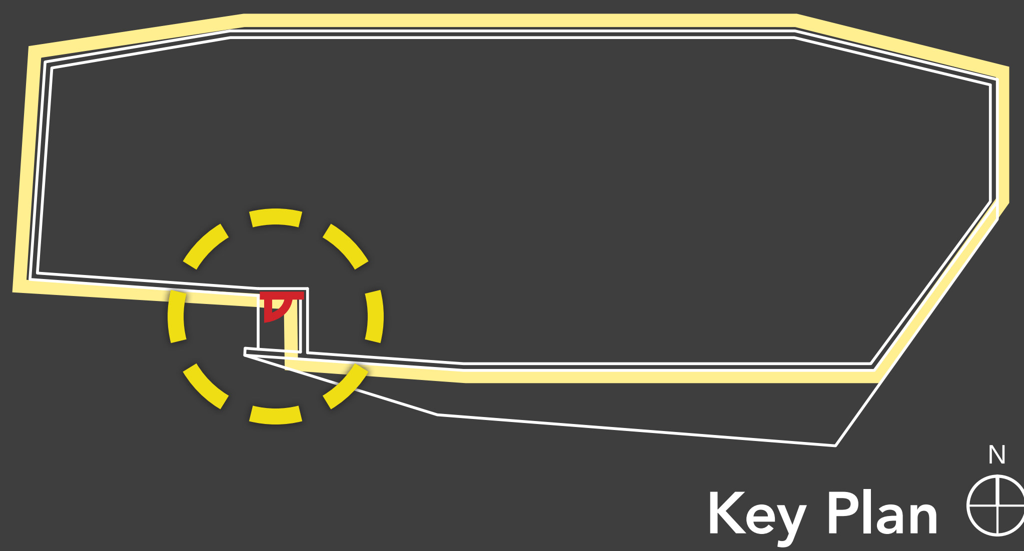


Key Plan

Structural Thermal Break

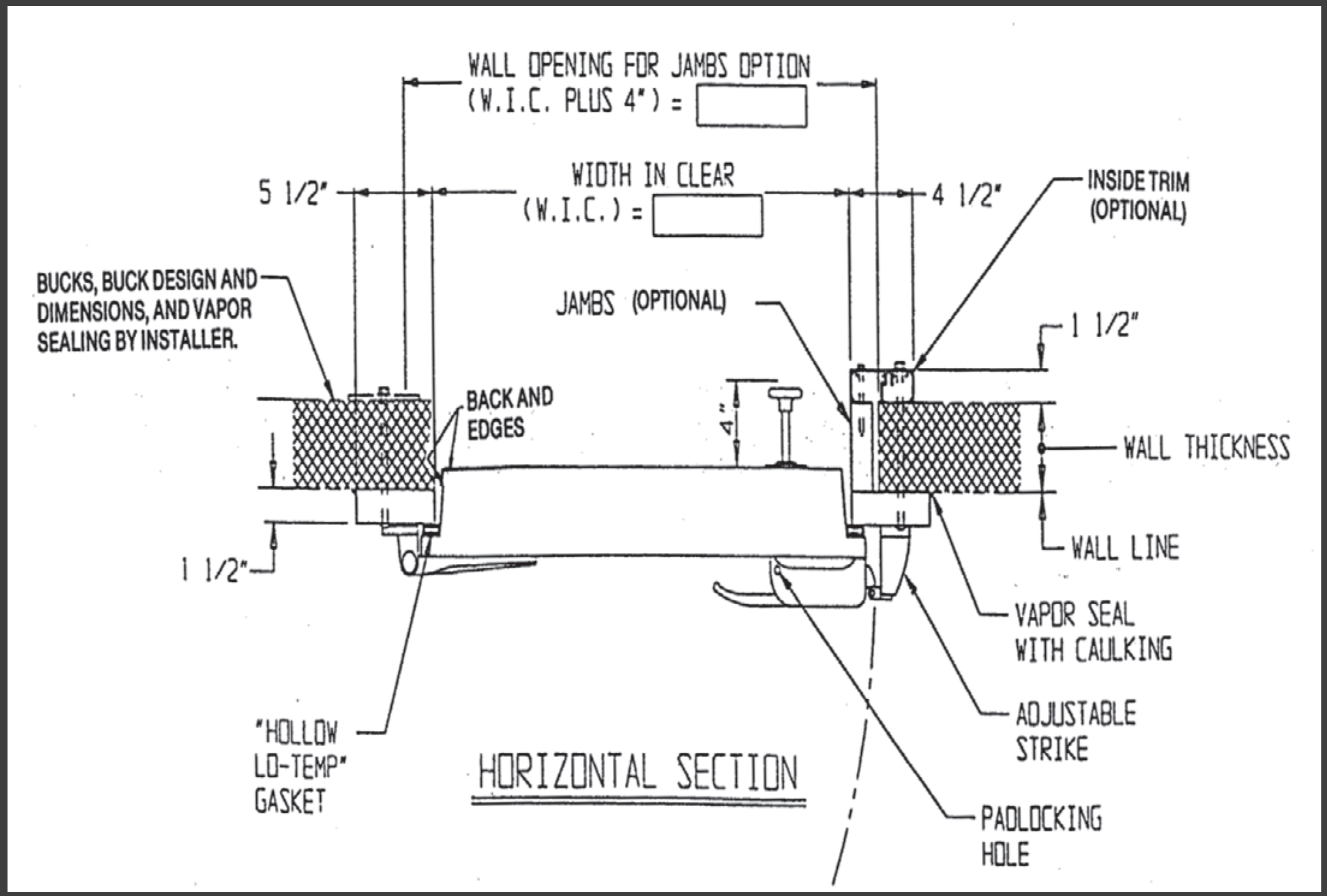


BUILDING BALCONY - THERMALLY INSULATED DOOR

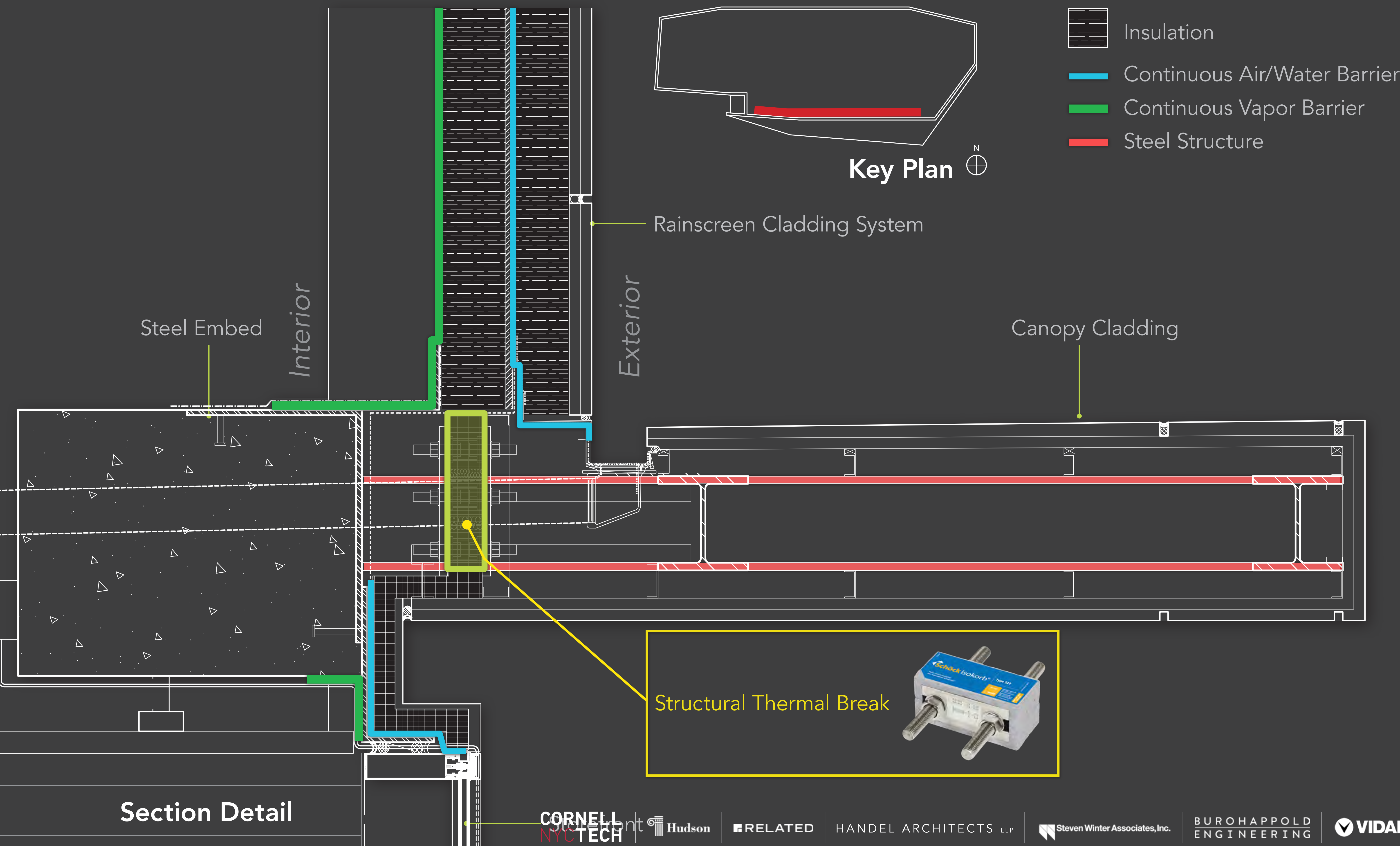


Key Plan

Insulation R value is 32 at 40°F.



BUILDING CANOPY DETAIL - STEEL TO STEEL THERMAL SEPARATION



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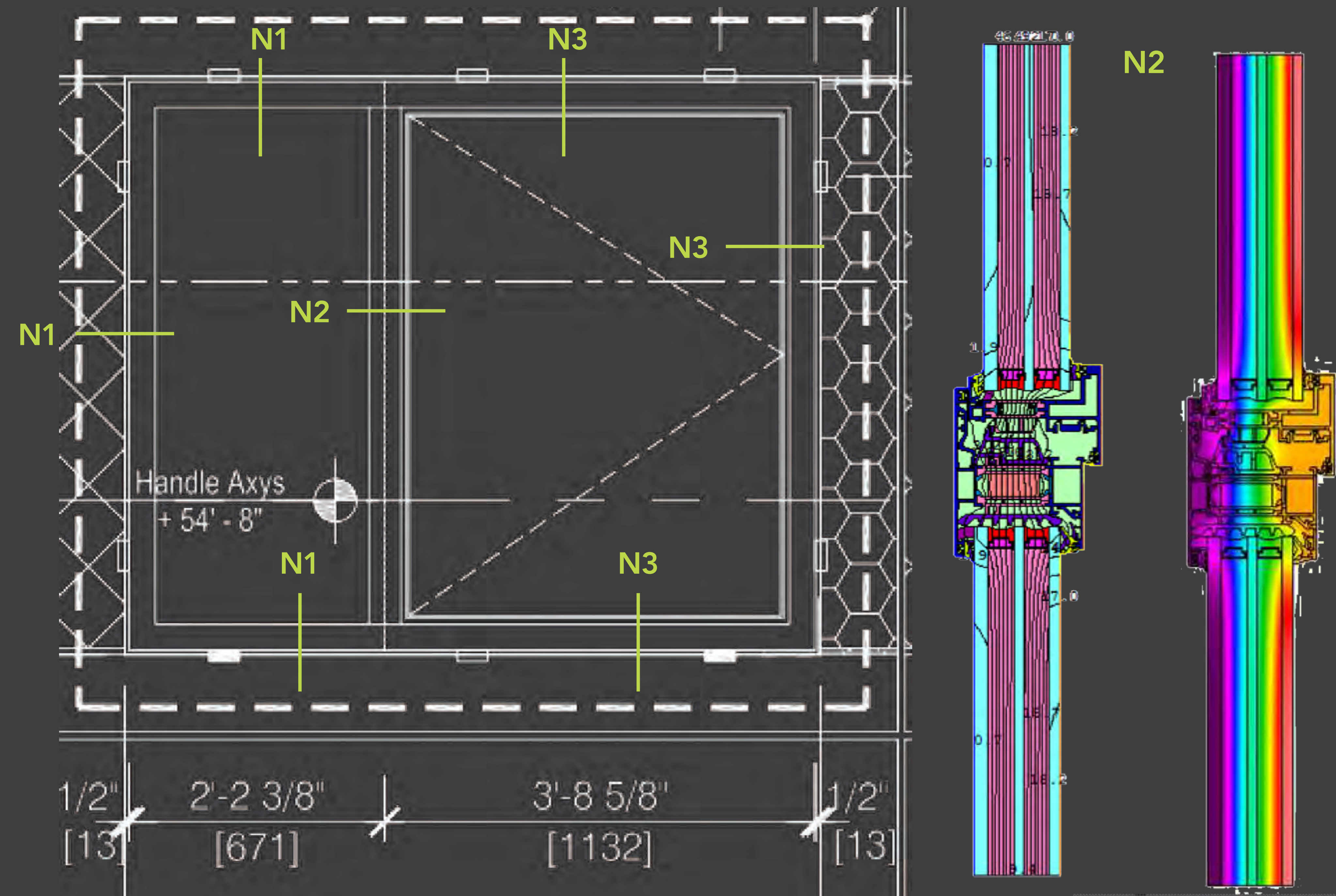
WINDOWS

- **EN vs. NFRC**
  - » The centre-of-glazing U-value (Ug), according to standard EN 673.
  - » The frame U-value (Uf), calculated with THERM, according EN ISO 10077-2
  - » The linear thermal transmittance through the glass edge (Ψ-value)
- **Unit conversion US to Metric**
- **Condensation analysis**
- **Third party analysis**



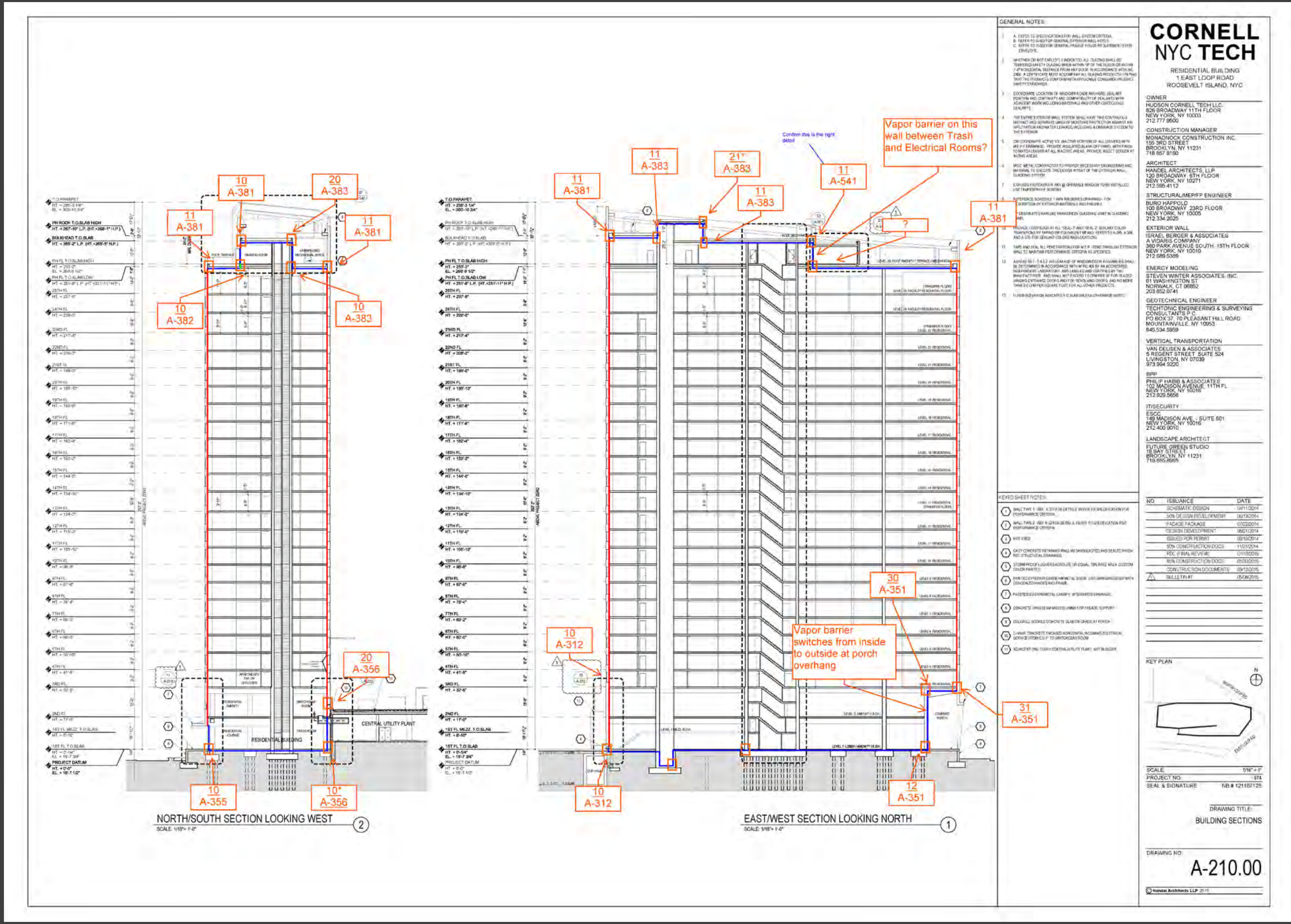
WINDOW + FRAME

Standard metal frame and window is .45

	Frame U-Value		Average Overall U-Value	
	Calculated Value (Average)	Target Value	Calculated Value (Average)	Target Value
Window Type A	0.28 Btu/h·ft²·F (1.59 W/m²K)	0.28 Btu/h·ft²·F (1.59 W/m²K)	0.18 Btu/h·ft²·F (1.05 W/m²K)	0.20 Btu/h·ft²·F (1.14 W/m²K)
Window Type B	0.27 Btu/h·ft²·F (1.51 W/m²K)	0.28 Btu/h·ft²·F (1.59 W/m²K)	0.16 Btu/h·ft²·F (0.93 W/m²K)	0.20 Btu/h·ft²·F (1.14 W/m²K)
Window Type C	0.26 Btu/h·ft²·F (1.50 W/m²K)	0.28 Btu/h·ft²·F (1.59 W/m²K)	0.17 Btu/h·ft²·F (0.96 W/m²K)	0.20 Btu/h·ft²·F (1.14 W/m²K)

Condensation Risk (T_e=0°F; T_i=70°F; R.H.=30%)	$T_{s,\ min}$ = 50.2°F (10.1°C)	T_{dp} = 37.0°F (2.8°C)
Condensation Risk (T_e=18°F; T_i=68°F; R.H.=50%)	$T_{s,\ min}$ = 54.0°F (12.2°C)	T_{dp} = 48.7°F (9.3°C)

AIR SEALING - CONTINUITY OF AIR BARRIER



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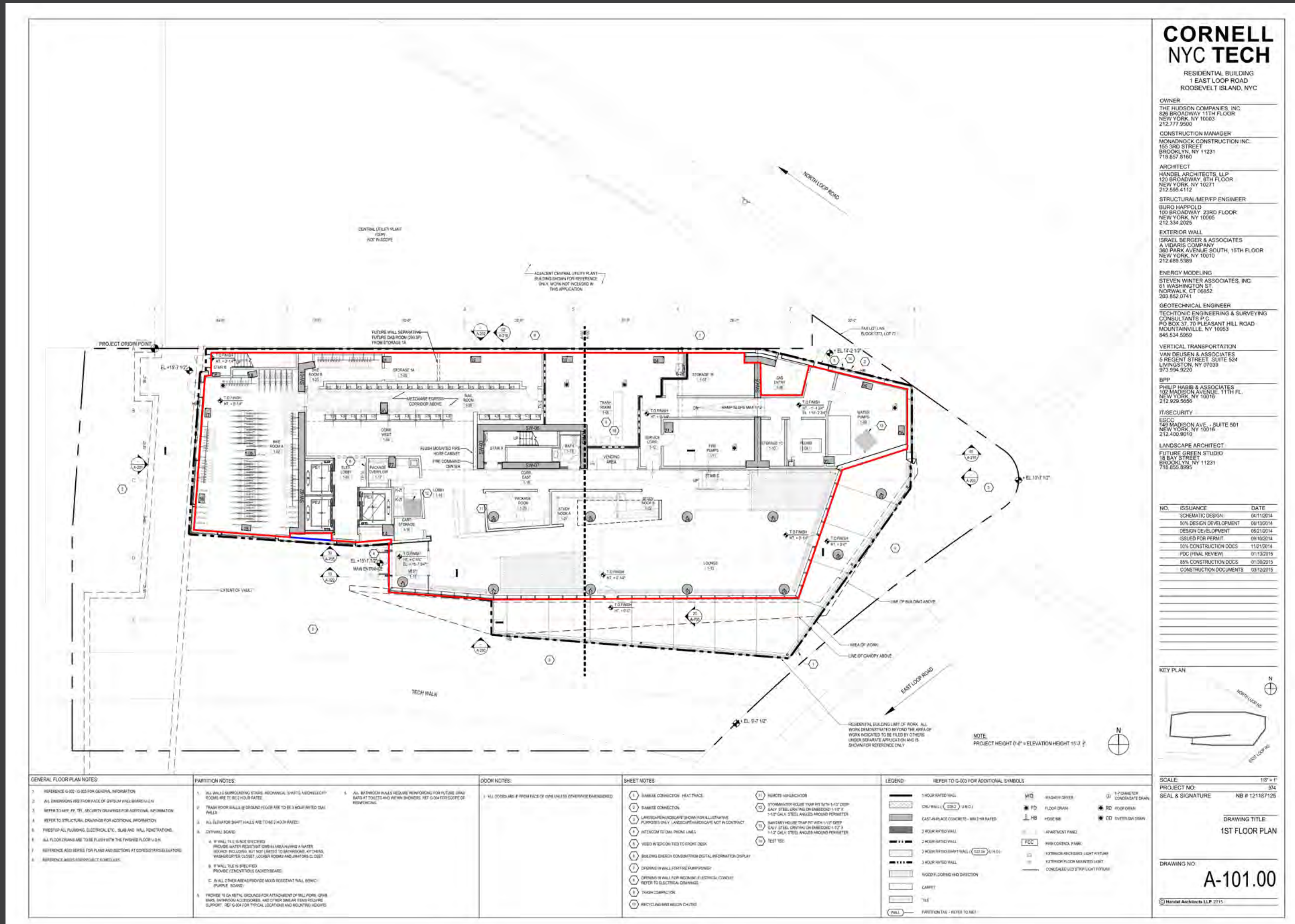
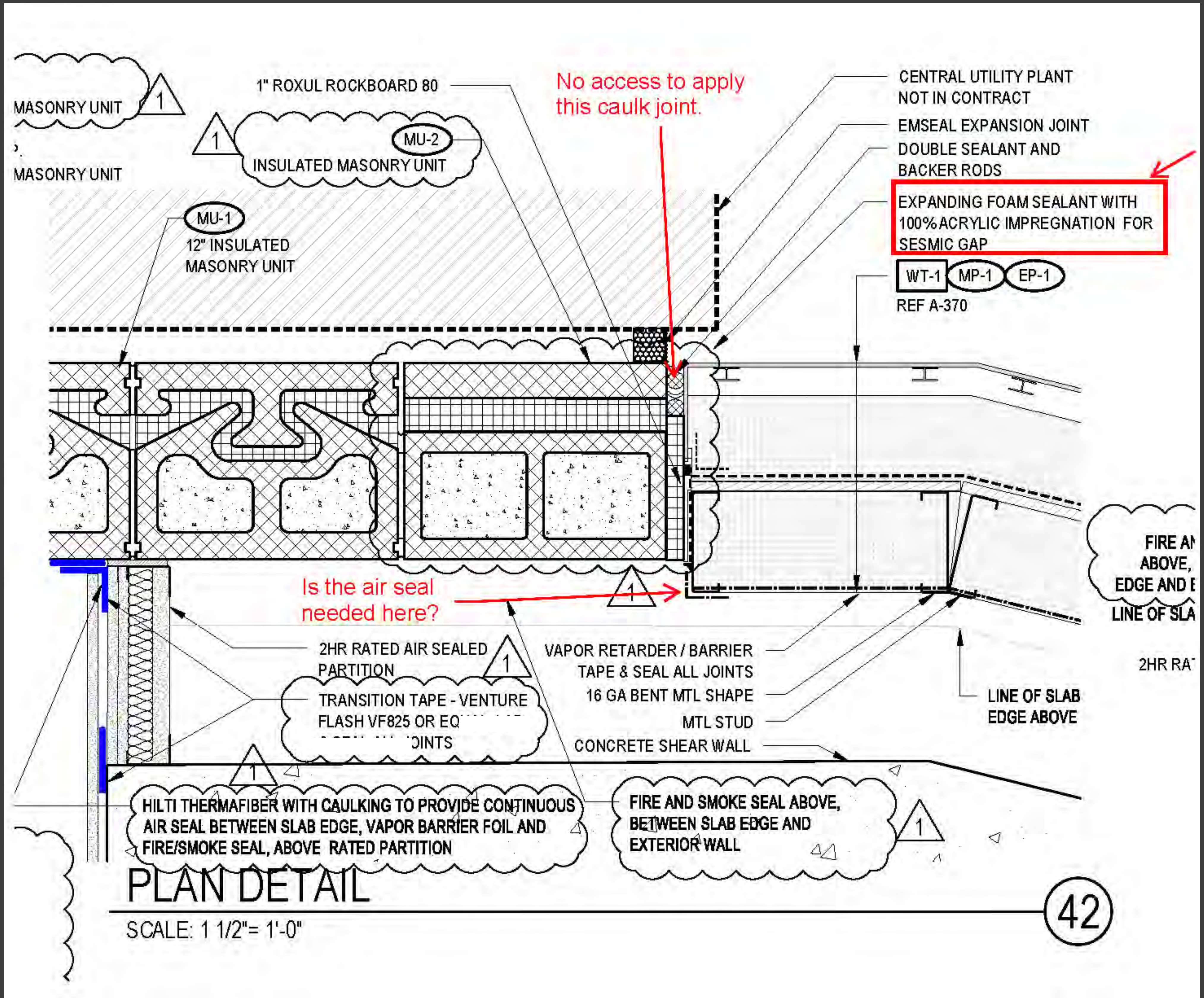
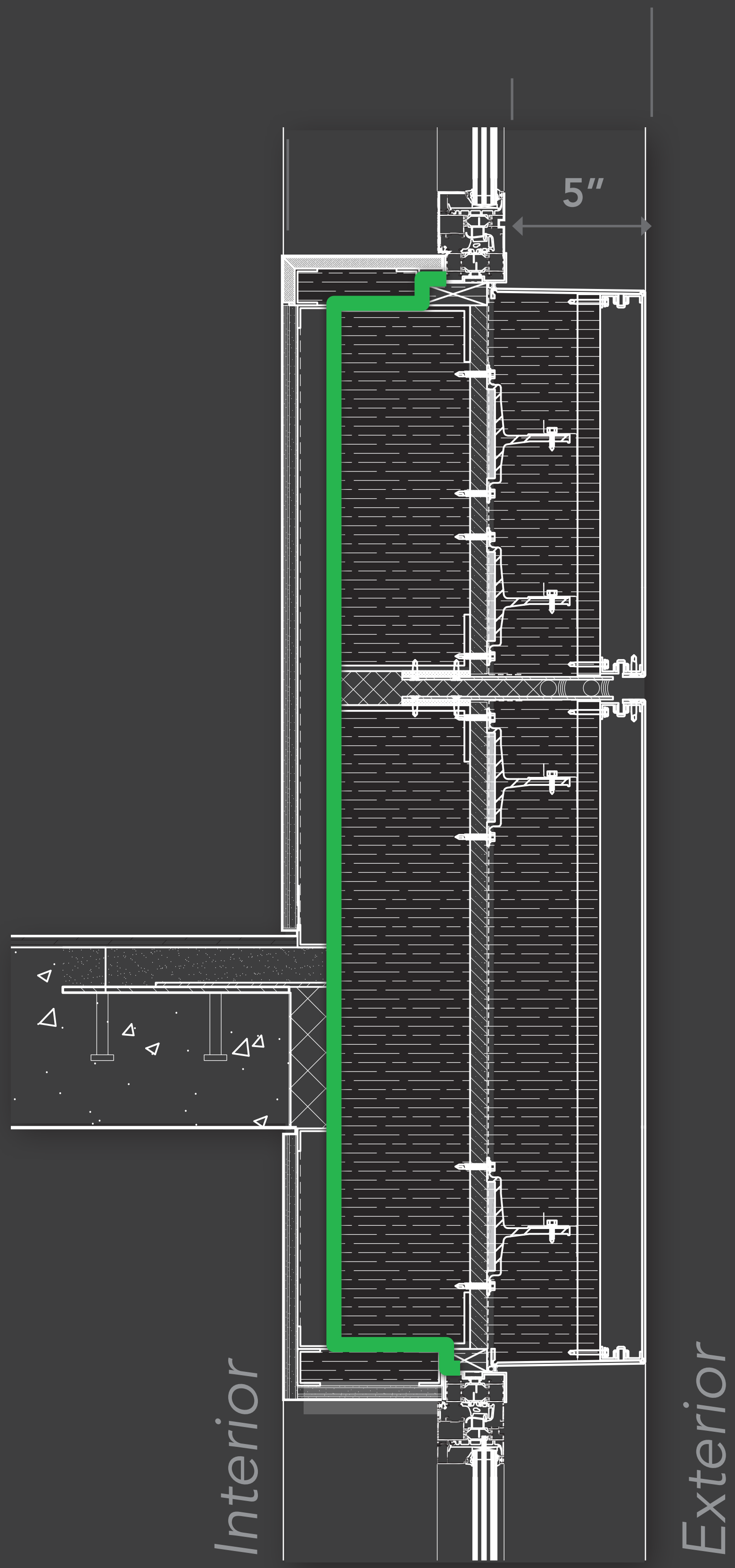


AIR SEALING - ITERATIVE PROCESS



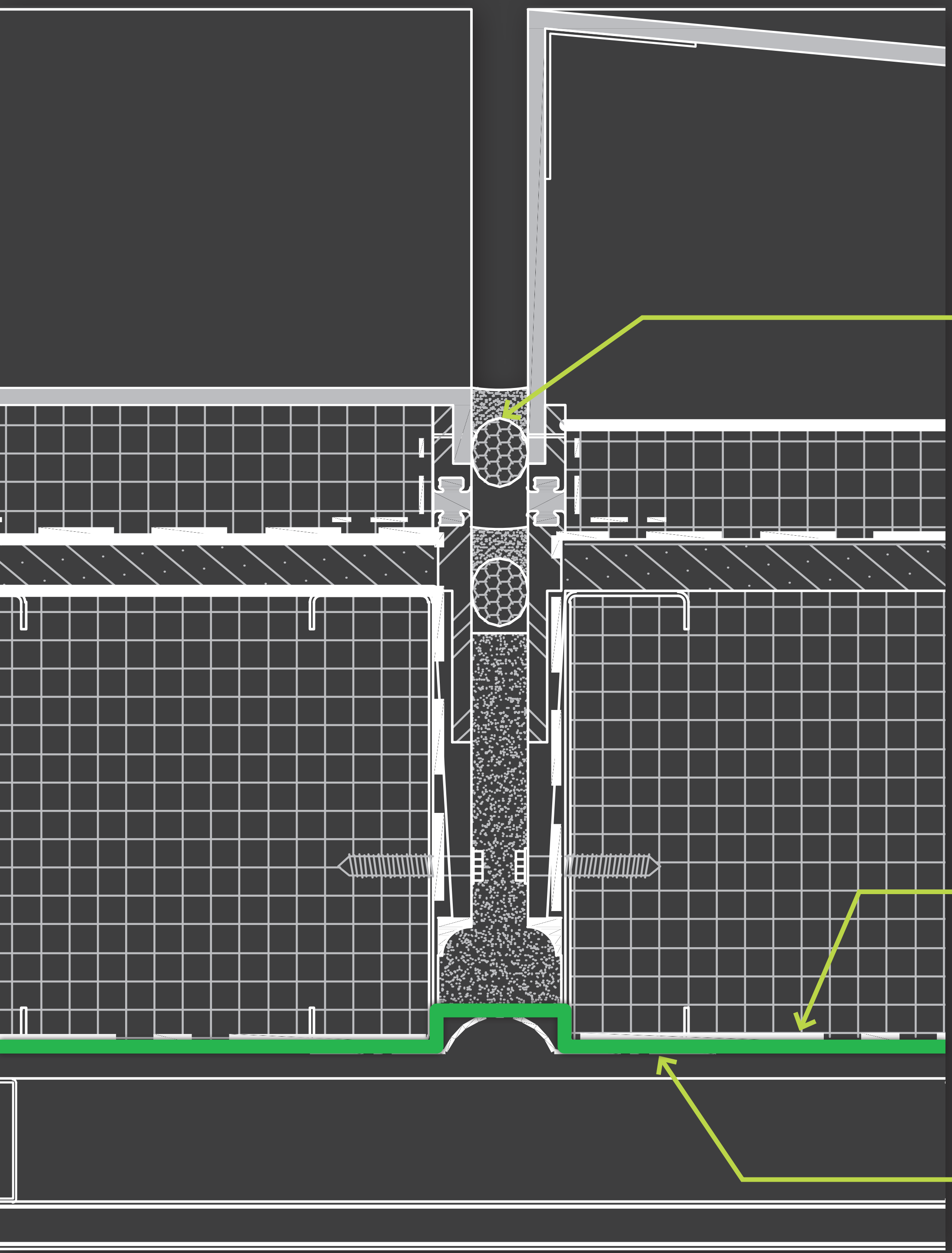
AIR SEALING - AT INSIDE FACE OF EXTERIOR WALL



- Smart vapor retarder on interior installed in the shop
- Taped to interior face of window and studs
- Overlaps at panel joints - held back at factory and connected in field
- Panel joints taped in the field - bypassing slab edge

AIR SEALING - ENLARGED PANEL JOINT DETAIL

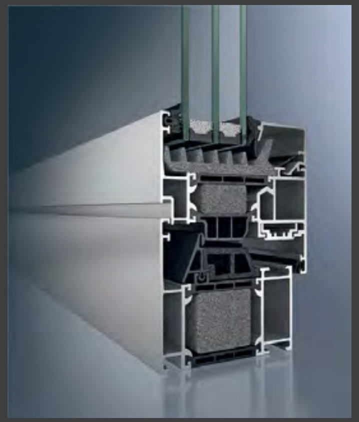
Exterior



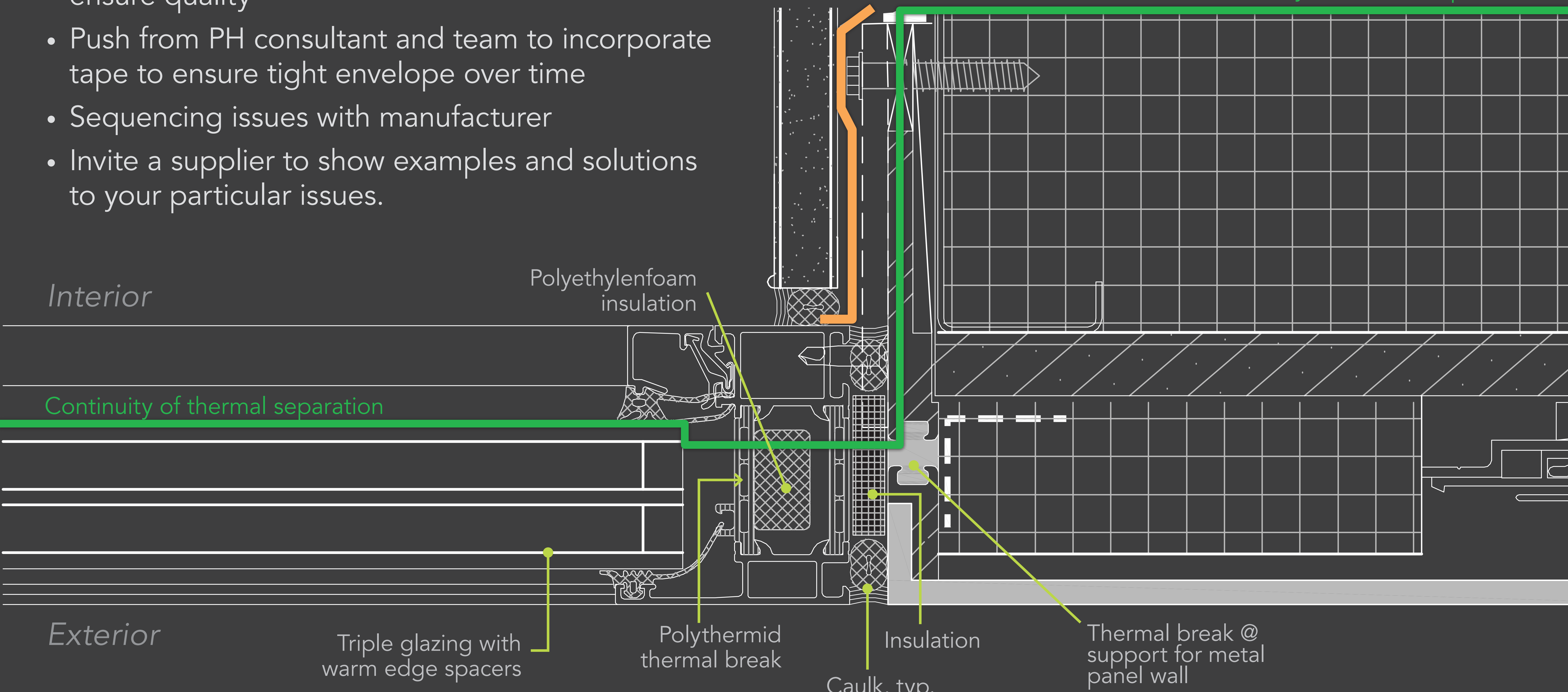
Interior

- Problem for Passive House blower door testing: caulking not complete until façade is completely installed. Therefore, there is no way to verify tightness during construction.
- Interior vapor retarder will be used to determine compliance for air sealing during construction, therefore, continuity is critical.

AIR SEALING - TYPICAL WINDOW



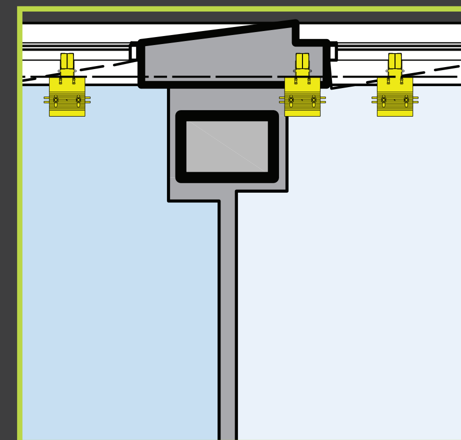
- Façade consultant and contractor – caulk is what was proven and usually done.
- Tape not accepted – too hard to work with and ensure quality
- Push from PH consultant and team to incorporate tape to ensure tight envelope over time
- Sequencing issues with manufacturer
- Invite a supplier to show examples and solutions to your particular issues.



AIR SEALING - ACCESS AT FACADE COLUMNS AND SHEAR WALLS

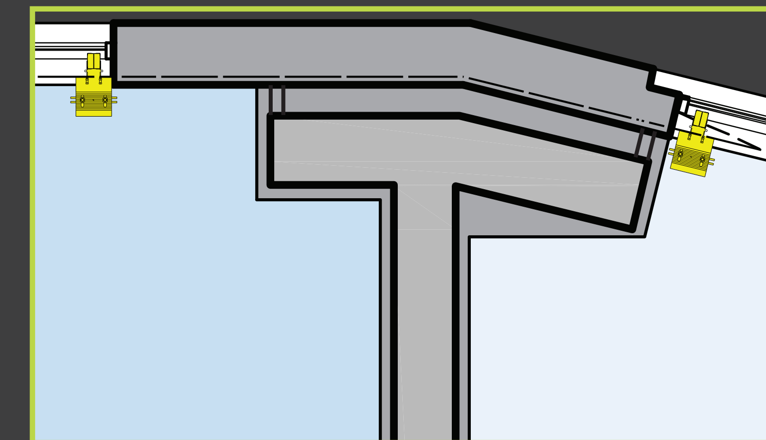
TYPICAL COLUMN DETAIL

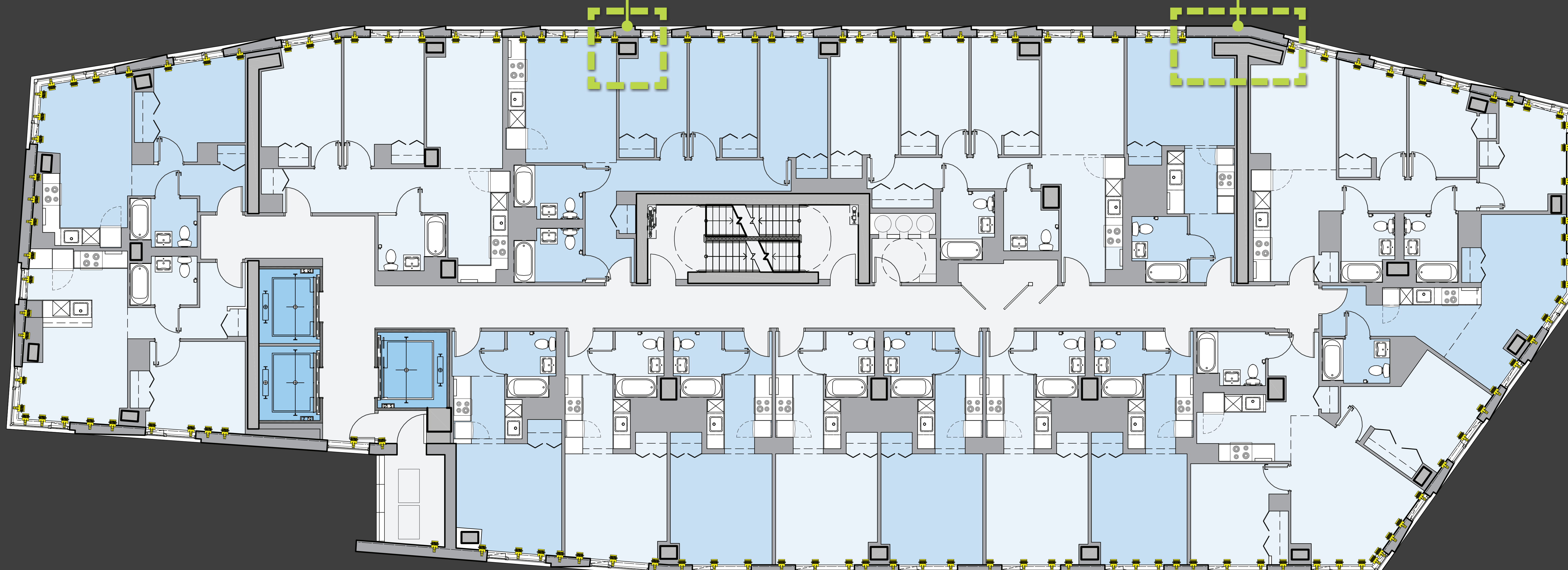
17 PER FLOOR



SHEAR WALL

CONDITION





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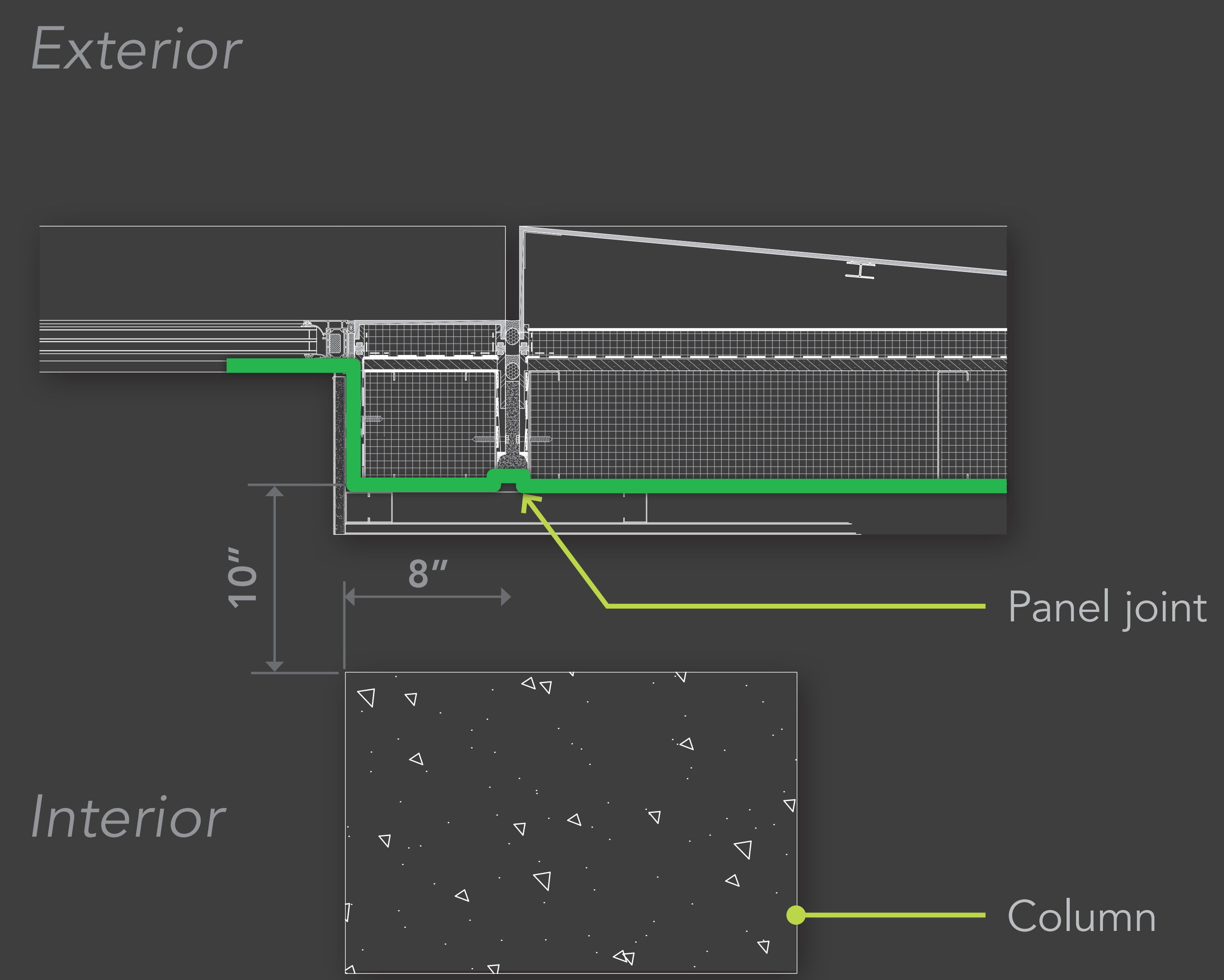
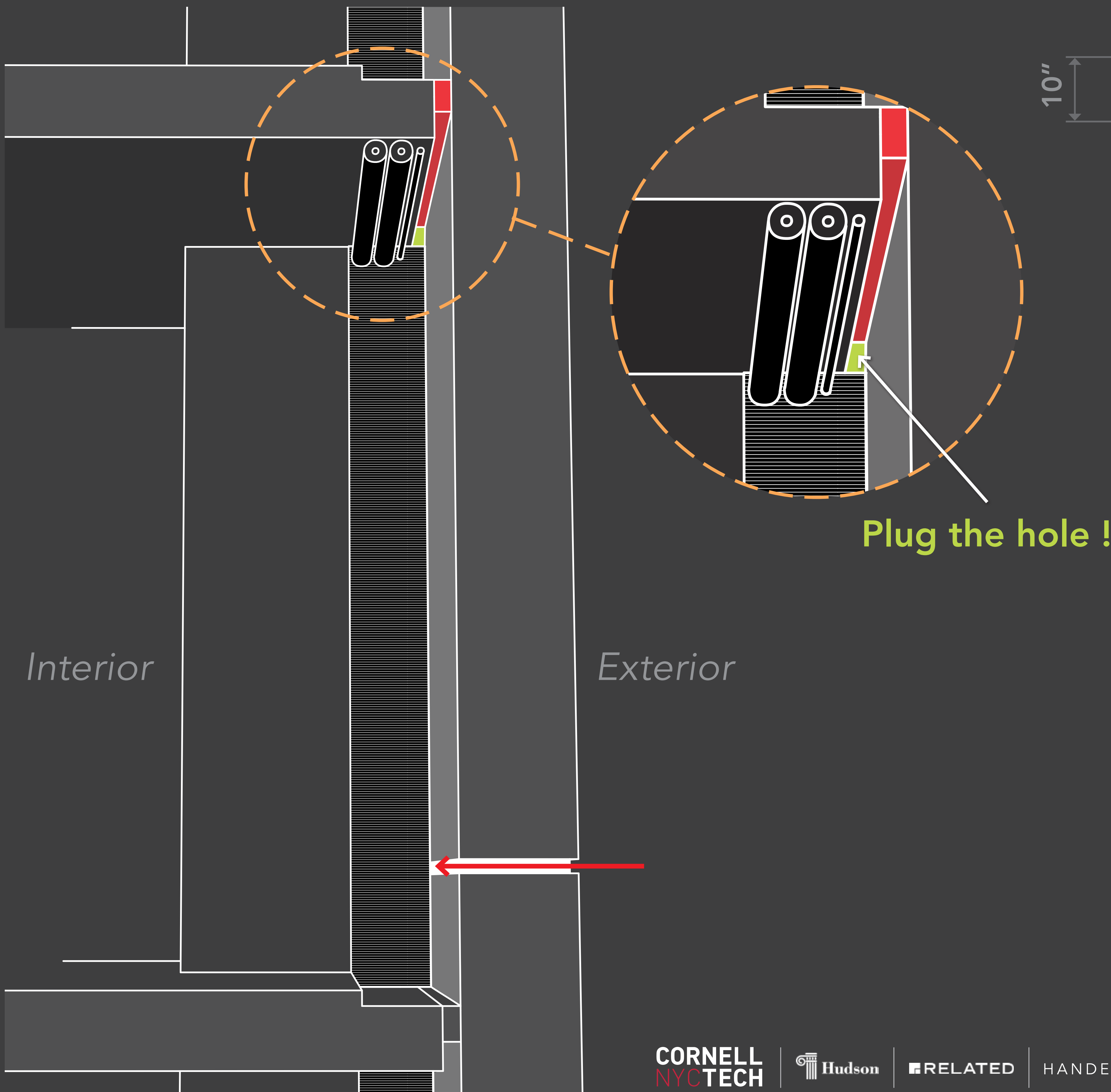
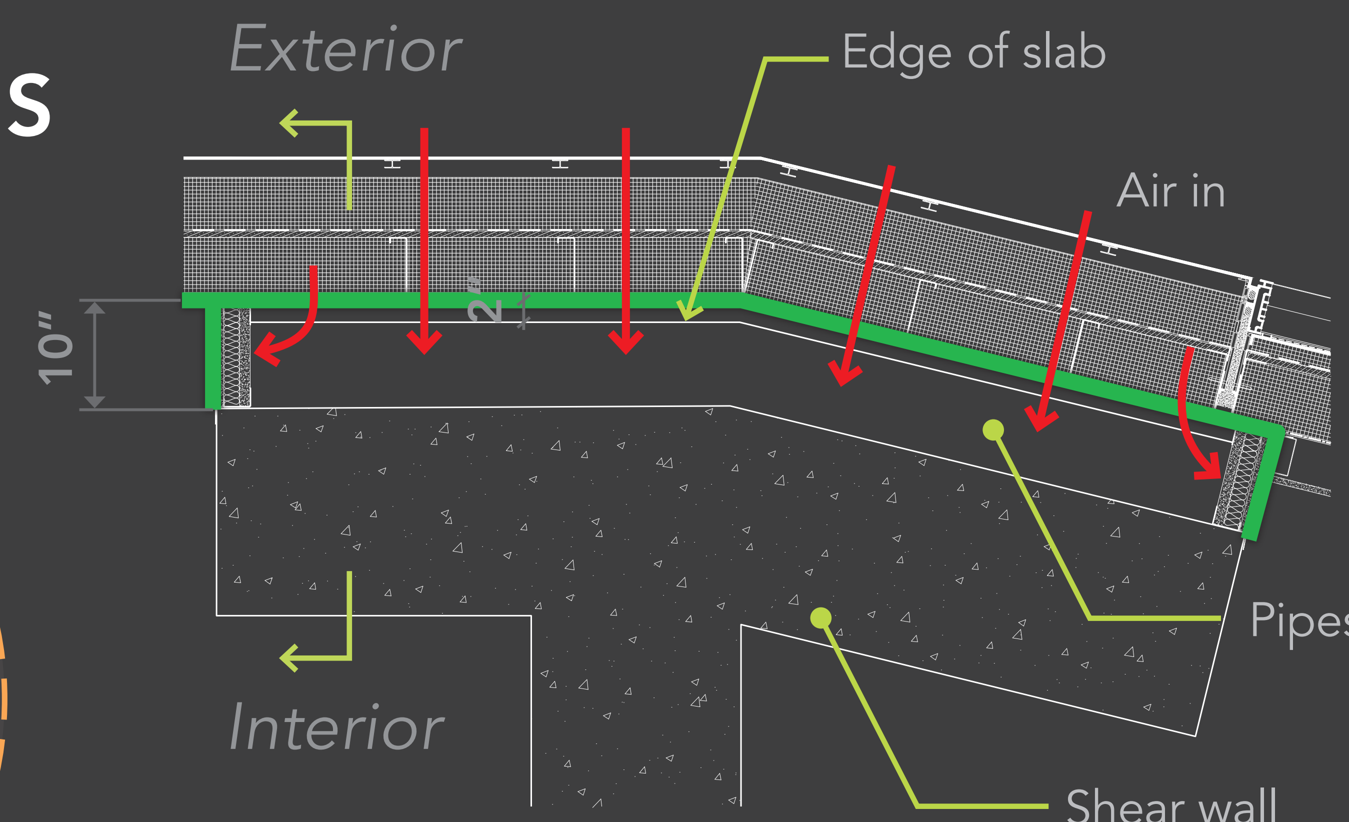
AIR SEALING - ACCESS AT FACADE COLUMNS

- Allow for access at columns
- Columns set back 10"
- Max horizontal distance to panel joint = 8"
- Coordinate with facade design

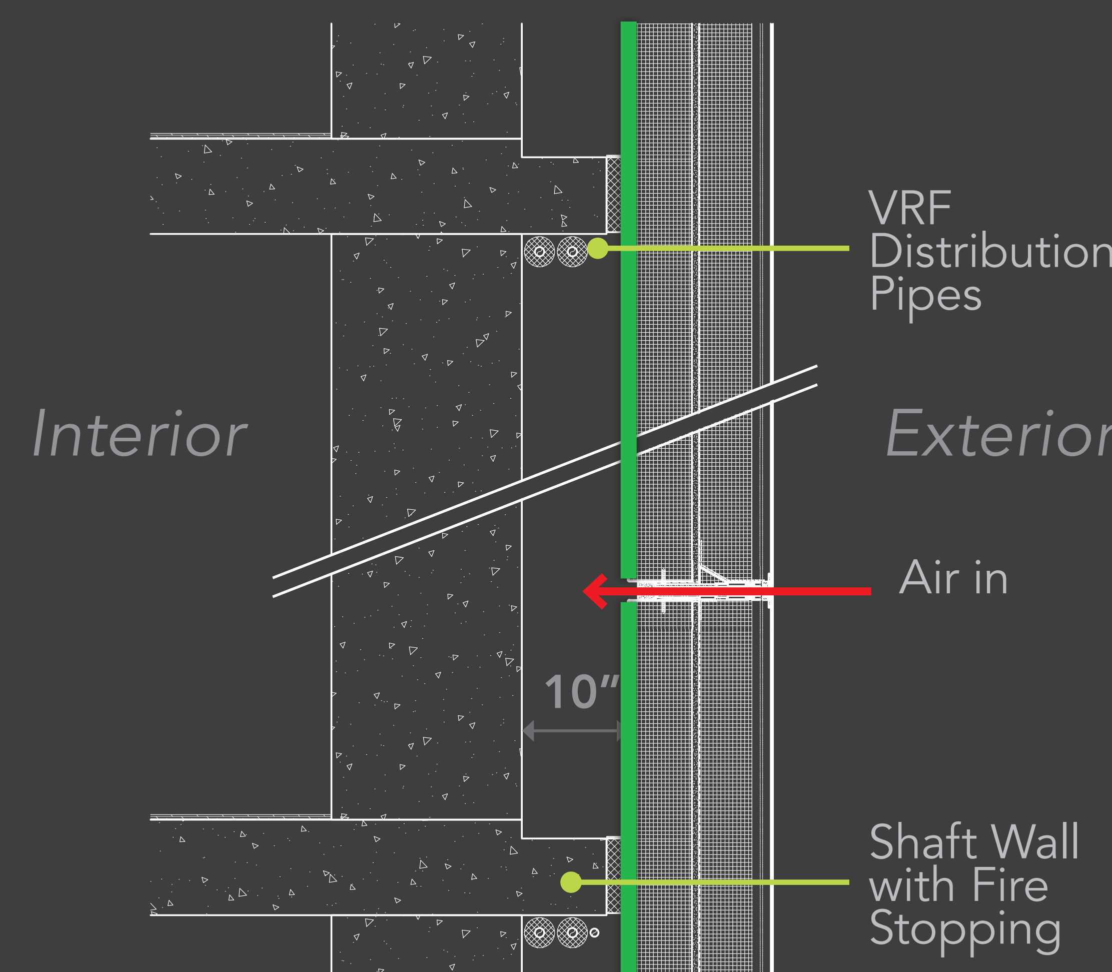


AIR SEALING - ACCESS AT SHEAR WALLS



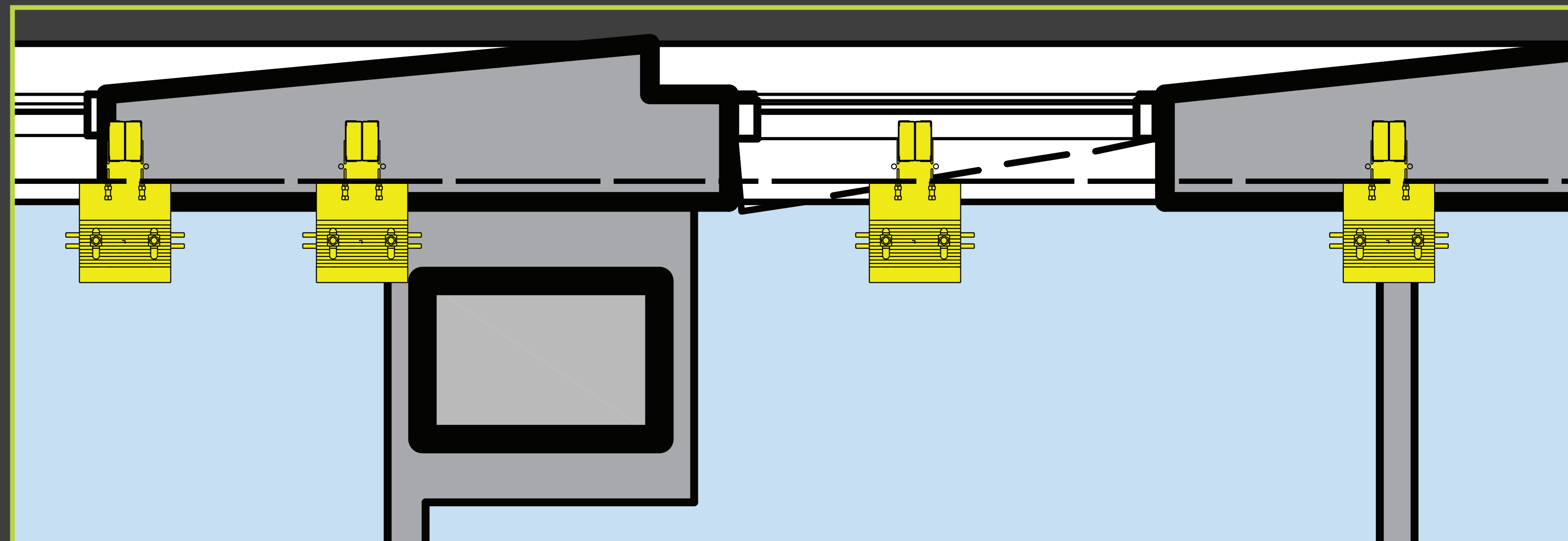


PLAN AT SHEAR WALL

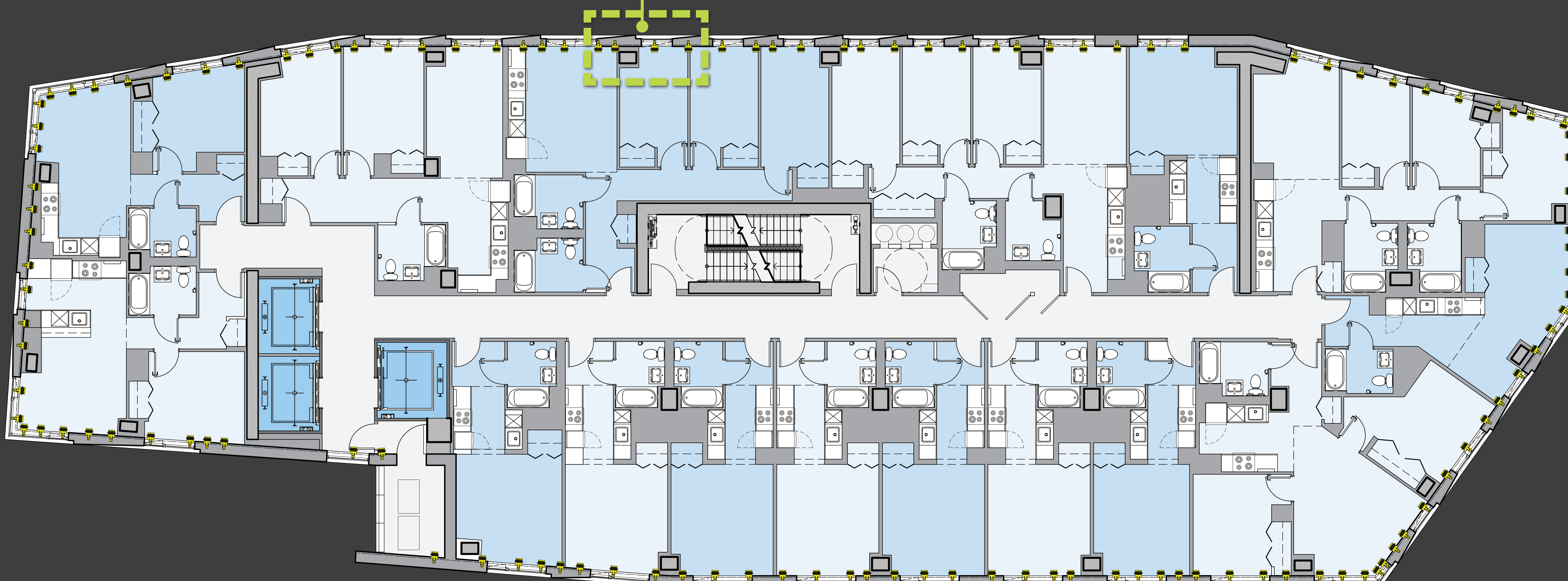


SECTION AT SHEAR WALL

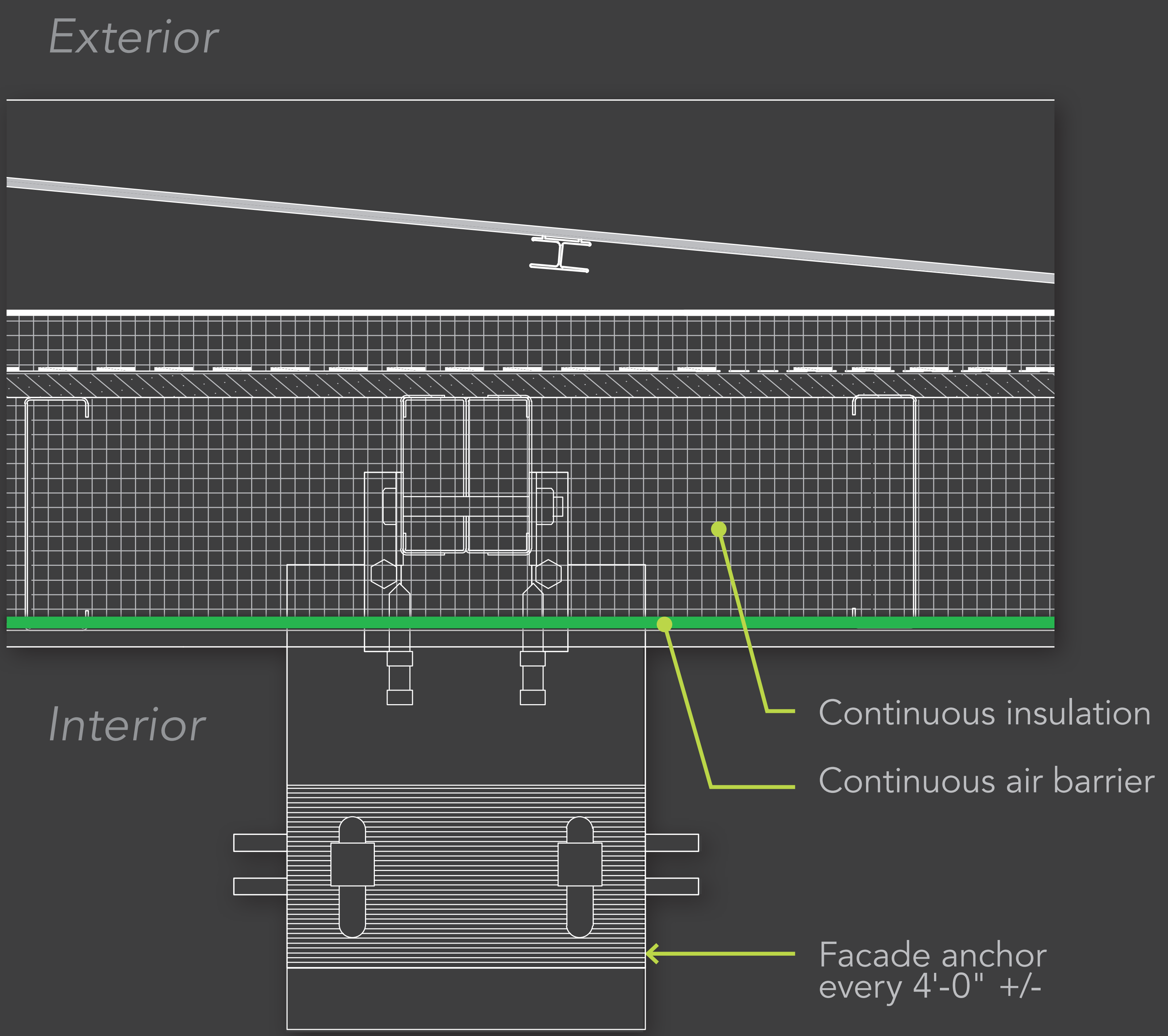
AIR SEALING - AT FACADE ANCHORS



- 123 Anchors Per Floor
- Over 3,000 Anchors Total

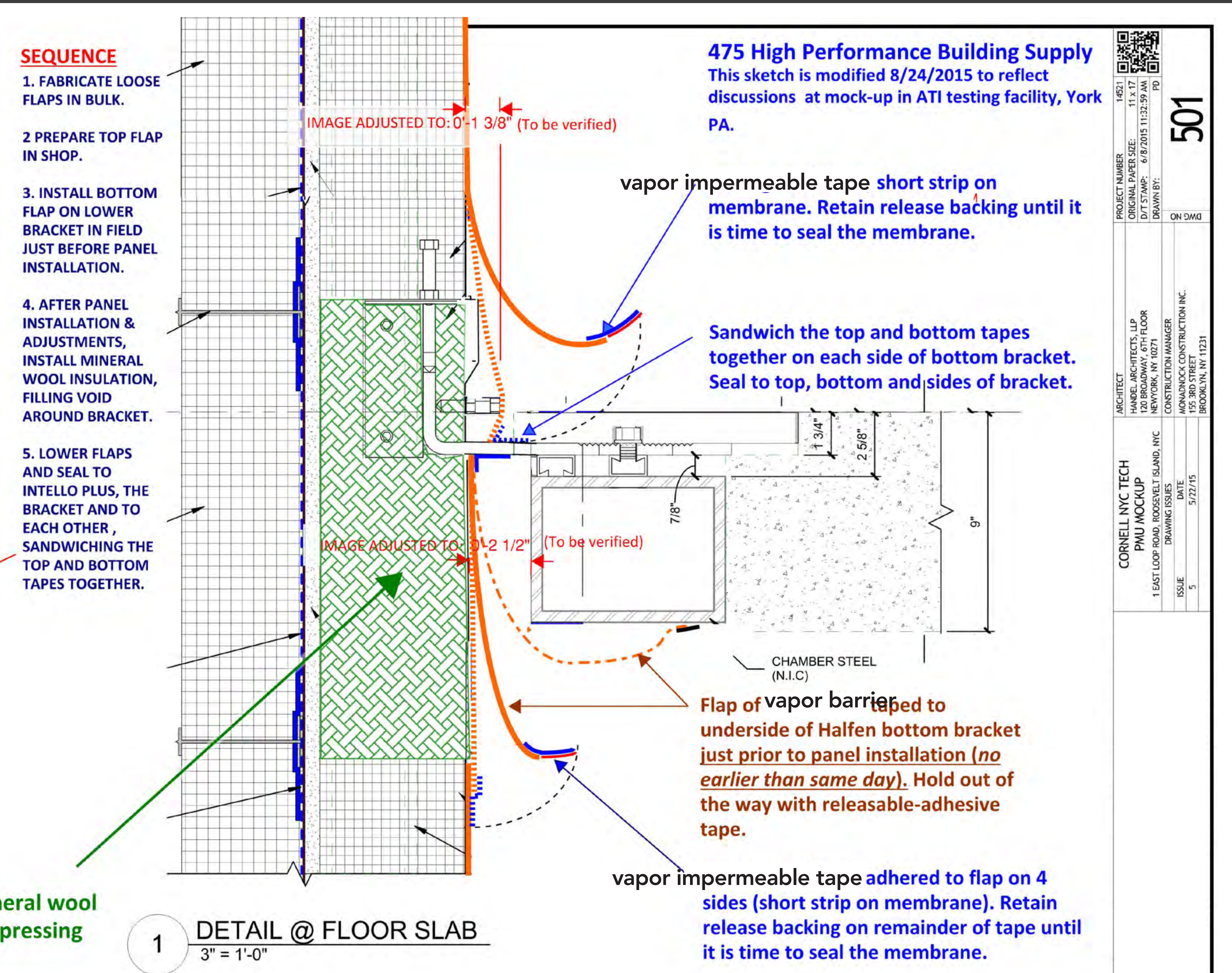


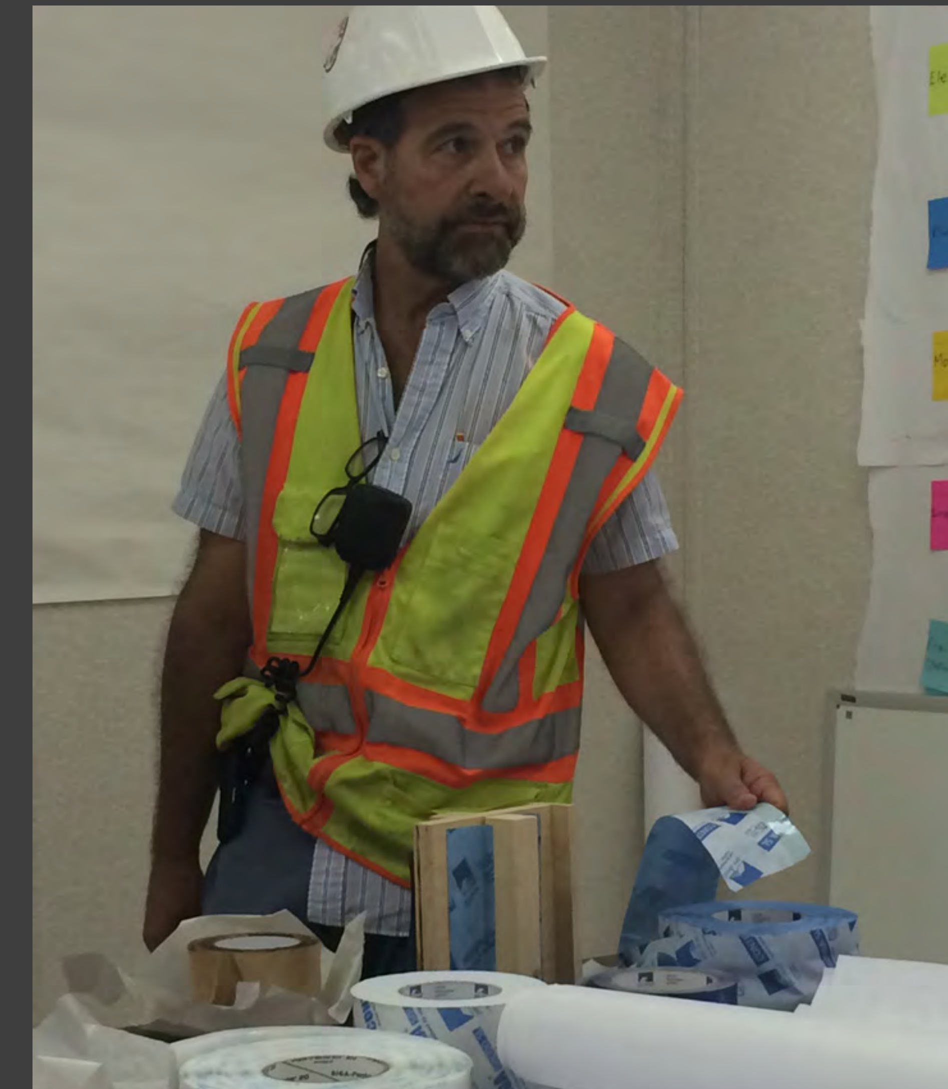
AIR SEALING - AT FACADE ANCHORS



PLAN AT FACADE ANCHOR

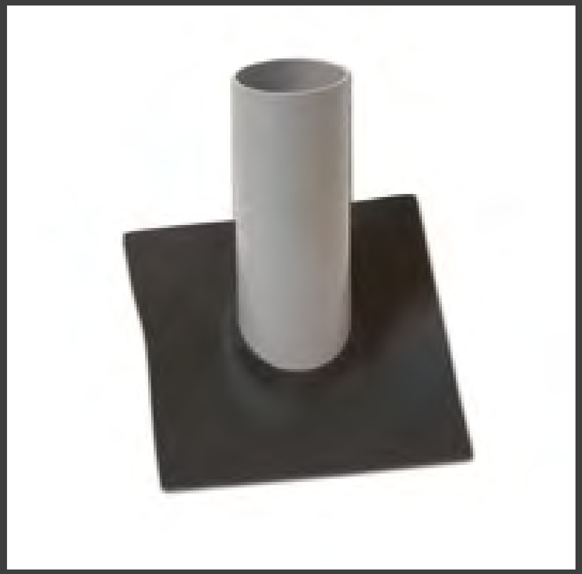
AIR SEALING - AT FACADE ANCHORS





- Construction method challenges
  - » Caulk: 20 years. Industry standard for keeping water out of buildings
  - » Tape: 100 years. Not yet proven in industry.
  - » Site Monitoring. QA/QC

AIR SEALING - MATERIALS



Schedule 4 | Tape Schedule

Tag	Description	Location
T-1	Vapor impermeable tape	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
T-2	Vapor impermeable tape	1. CMU block (Where no liquid applied membrane is present) 2. Inside face of exterior wall to 1st floor slab & 3rd floor slab in rooms over porch and unenclosed mechanical 3. Inside face of exterior wall to underside of roof slab (25th & 26th floors)
T-3	Vapor impermeable tape	1. CMU Block where the masonry has an liquid applied air barrier. A. Floor, ceiling and corner connections @ 1st and 2nd floor north wall. B. Transitions in the components around the porch area C. Transitions in the unenclosed mechanical area at the 2nd Floor

AIR SEALING - CONSTRUCTION MANAGEMENT COORDINATION

Trades Affected by PH Requirements

- **Exterior Sealing**
  - Exterior Panel Fabricator
  - Window Supplier
  - Carpenter
  - Mason
  - Caulker
- **Interior Sealing**
  - Mechanical
  - Electrical
  - Plumbing
- **Heating / Ventilation / Airside Contractor**

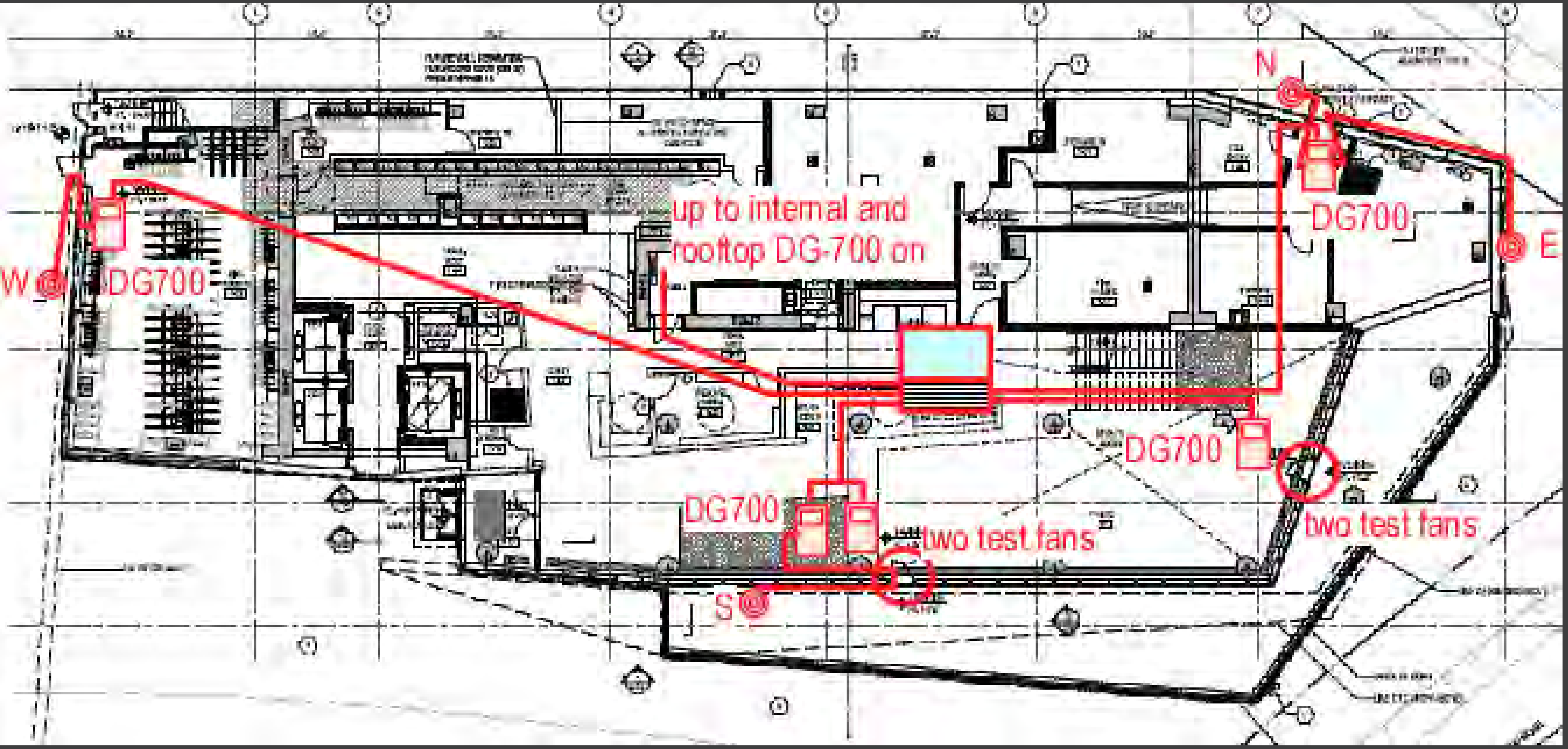
Control of Scope of Work

- Bid/Buy documents need to be sure to cover passive house requirements
- Not enough to say "follow spec"
- Contractors will exclude certain details/ requirements

AIR SEALING - AIR LEAKAGE TESTING

- On-going
- Various components to be tested along the way
- Full blower door tests not possible
- Mock-up indicates very tight façade
- Components that should be spot checked throughout construction
  - Slab/wall connection
  - Windows & store front
  - Doors to rooms outside the air barrier
  - Roof/Wall connections
  - Penetrations through the facade

AIR SEALING - BLOWER DOOR TEST



- Air Tightness Testing requirements for Passive House
- Large Building Test Procedures from RetroTec
- Ultimately need to create a plan for your particular building – can show Single family house vs. Cornell Resi images to make the point.

Test Configuration of Intentional Openings

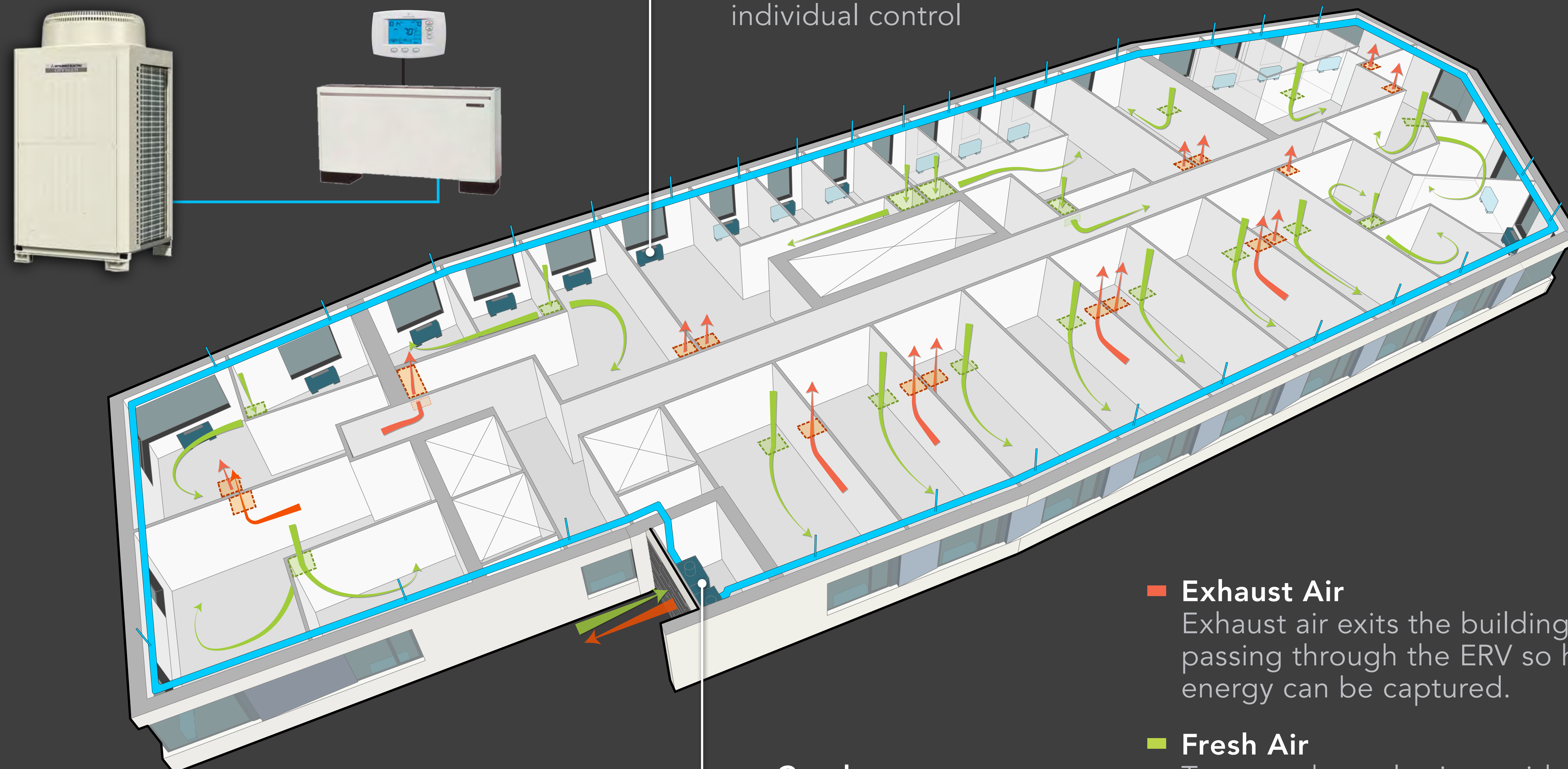
Intentional Openings	Test Status	Notes
Windows, doors, skylights and hatches in the bounding enclosure	Closed and latched	
Doors, hatches and operable windows inside the test enclosure	Open	
Fire Dampers	Remain as found	
Dryer Doors	Closed and latched	
AHU-1 (ERV OA) Penthouse roof 26th Floor	Fan off, dampers closed, sealed	Ventilation units run continuously, so dampers closed and sealed.

MOCK-UP TESTS

Pressure Sensor

Blower Door Test Set-up

HVAC SYSTEMS



Evaporator
Indoor unit for heating and cooling; individual control

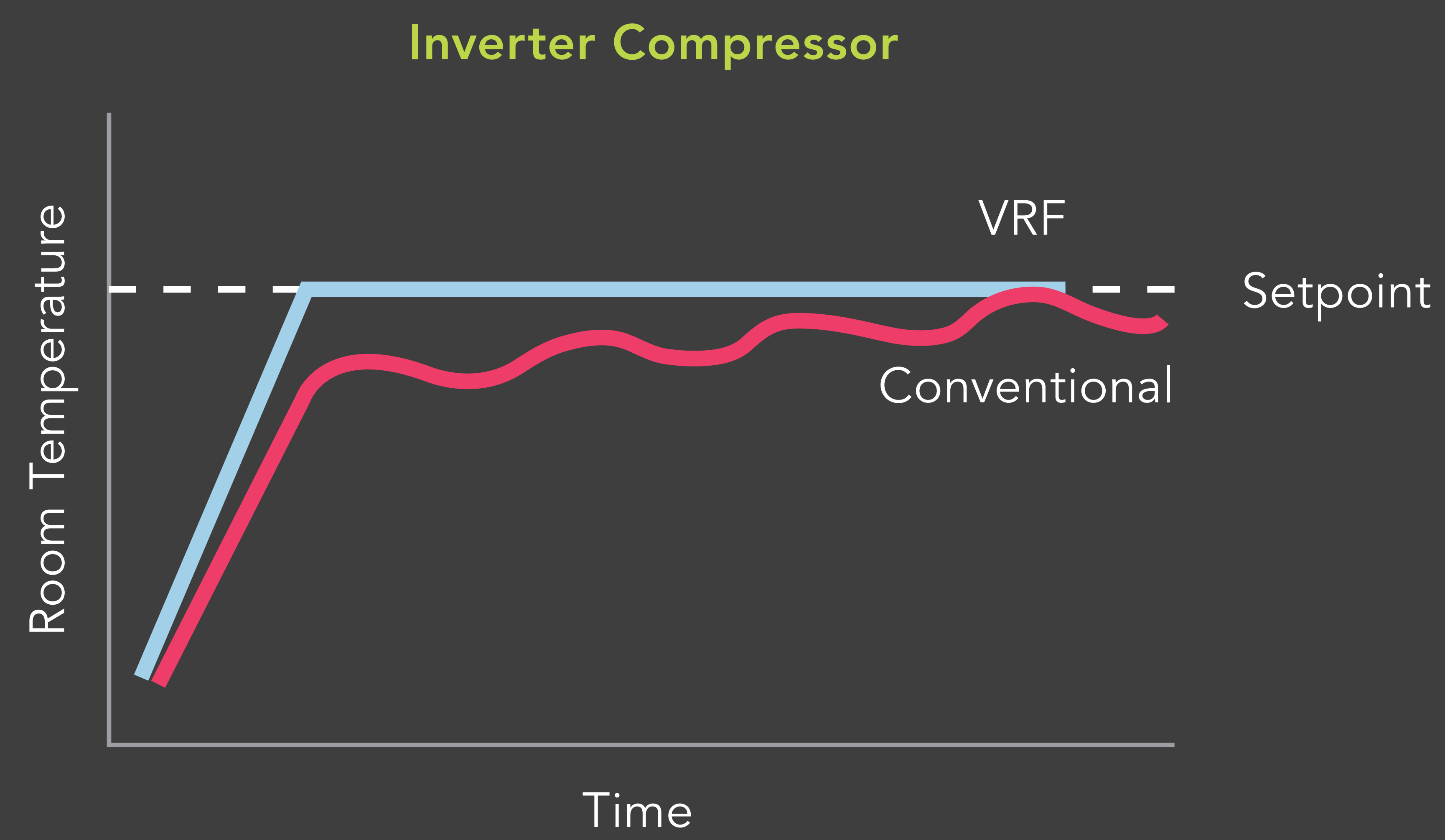
Condenser
Outdoor unit

Exhaust Air
Exhaust air exits the building after passing through the ERV so heat energy can be captured.

Fresh Air
Tempered supply air provided to all units in separate supply risers.

Refrigerant

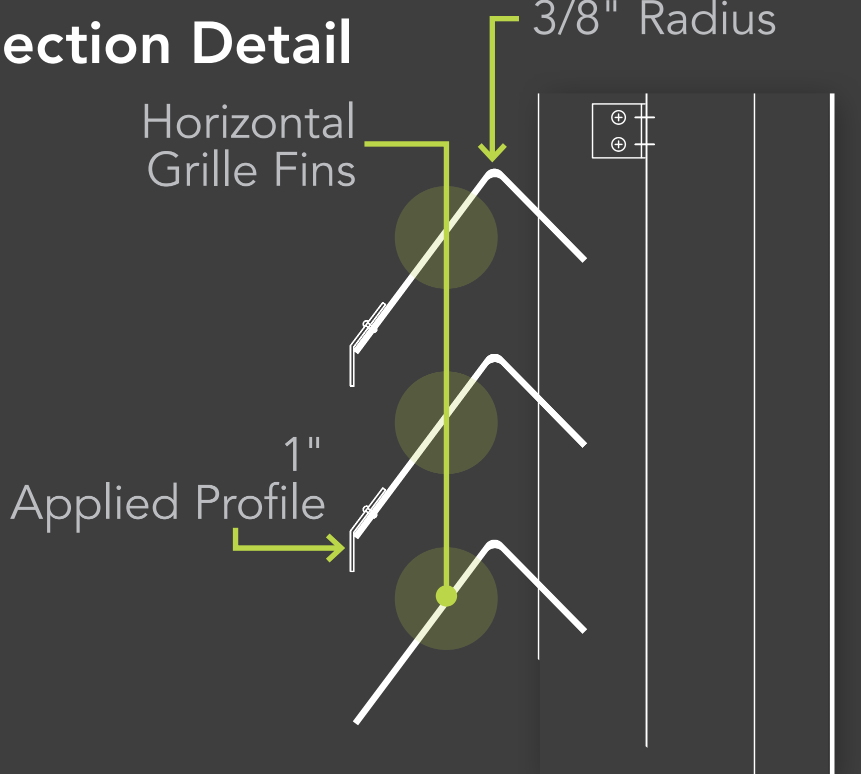
VRF TECHNOLOGY



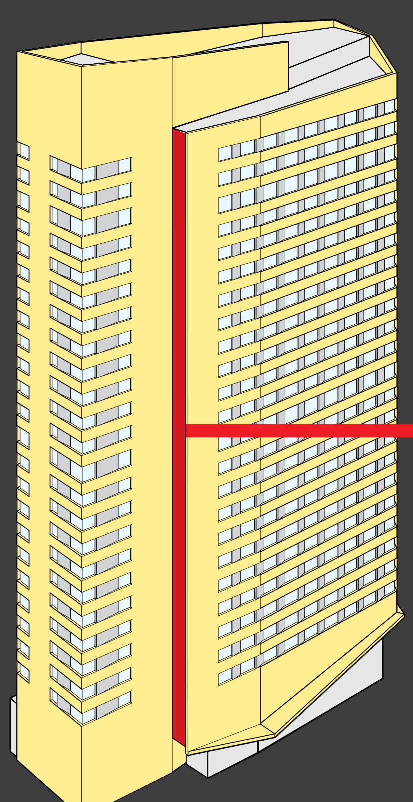
- Super efficient, highly variable, and very responsive
- Electric system: best energy efficiencies in the industry

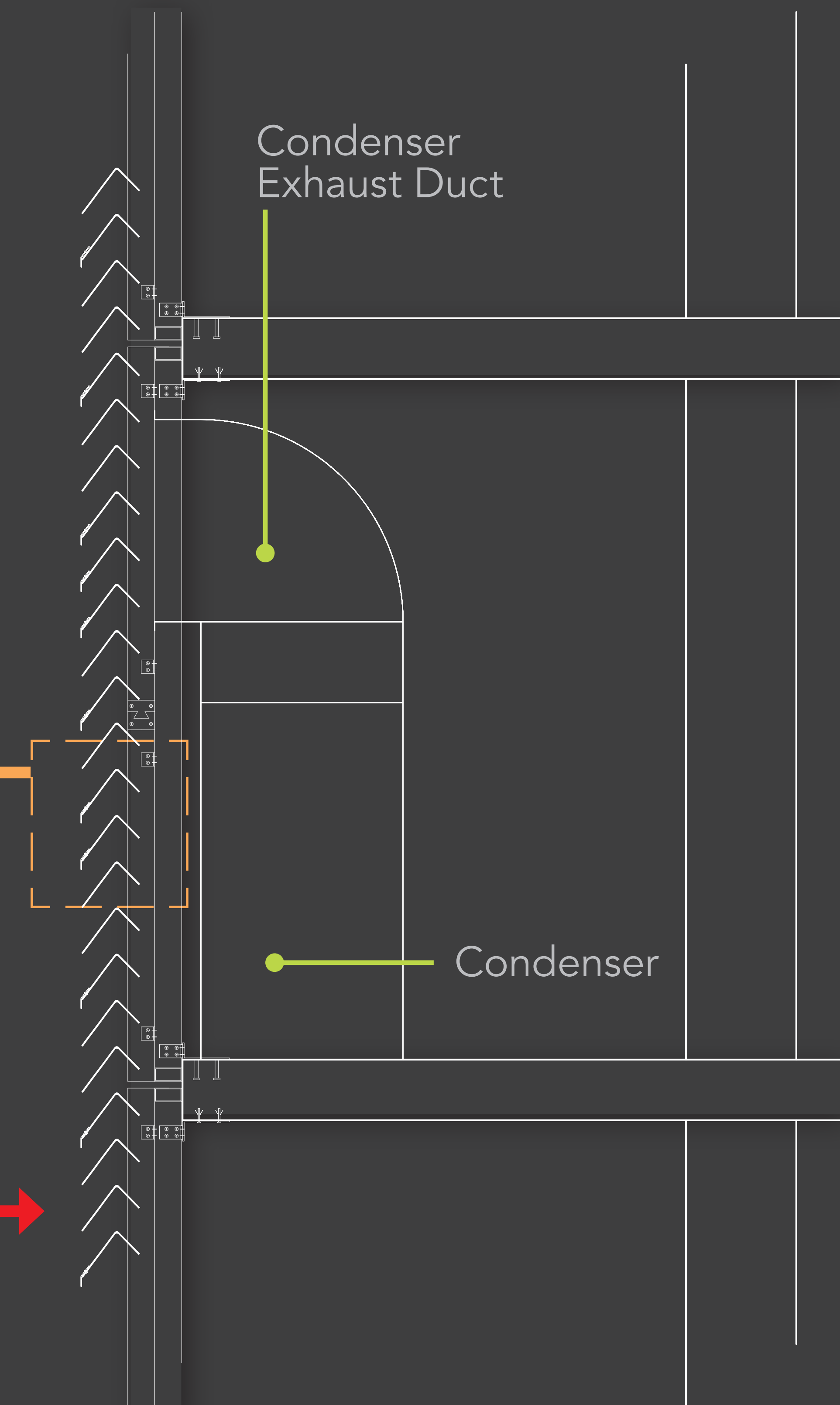
VERTICAL REVEAL GRILLE

Section Detail

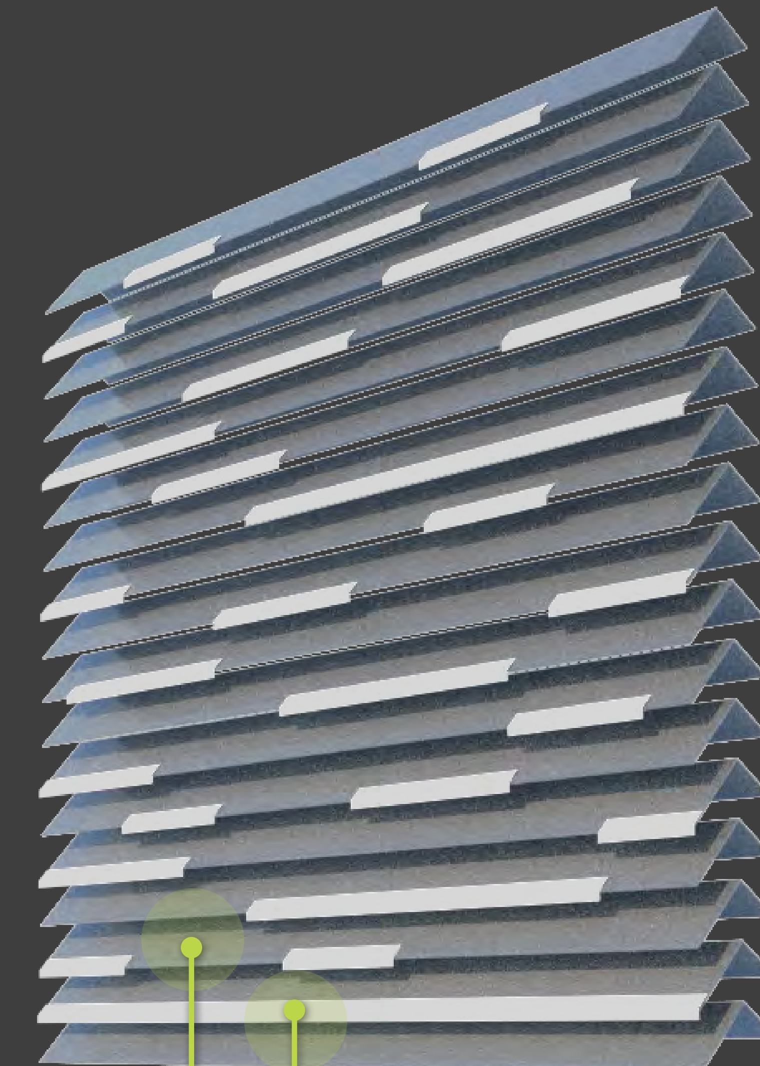


Total pressure drop required = 0.13 in H2O





Section Diagram



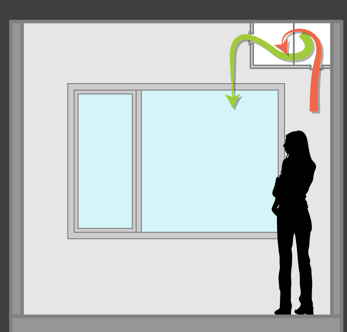
Applied Profile Paint
Warm champagne with metallic sparkle to match main wrap cladding material

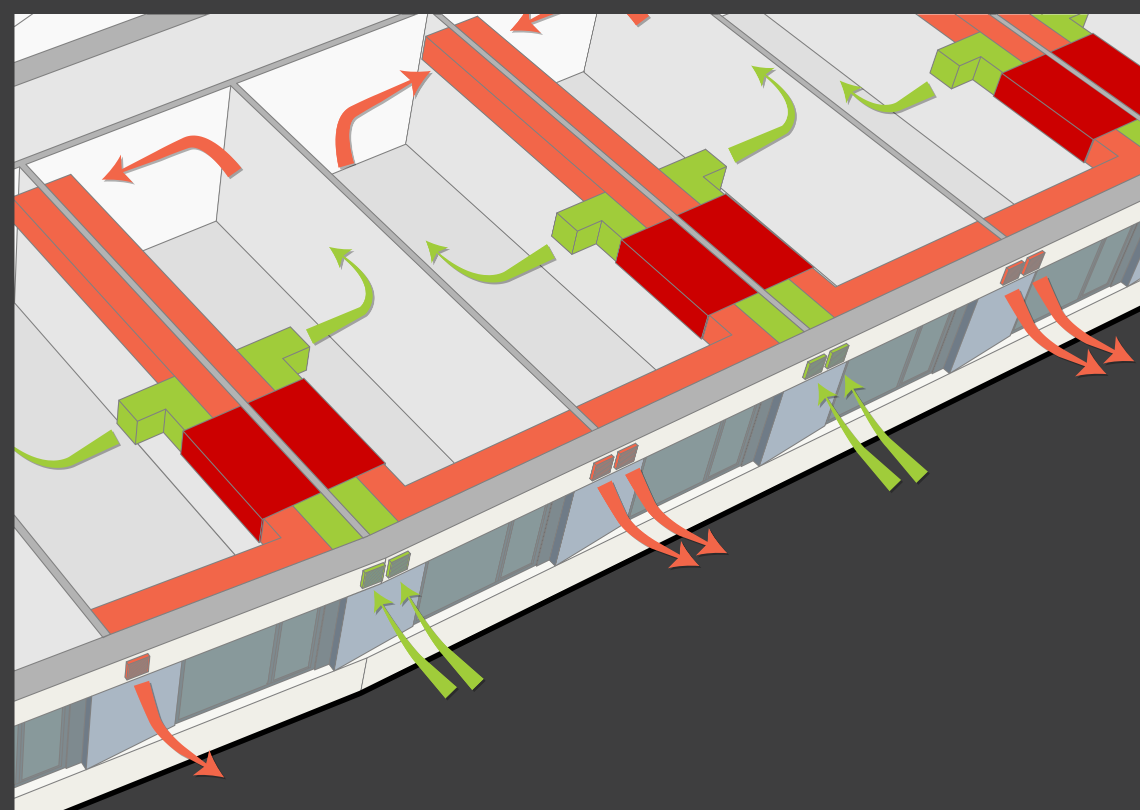
Horizontal Grille Fins Paint
Flat warm dark grey to match window frame color

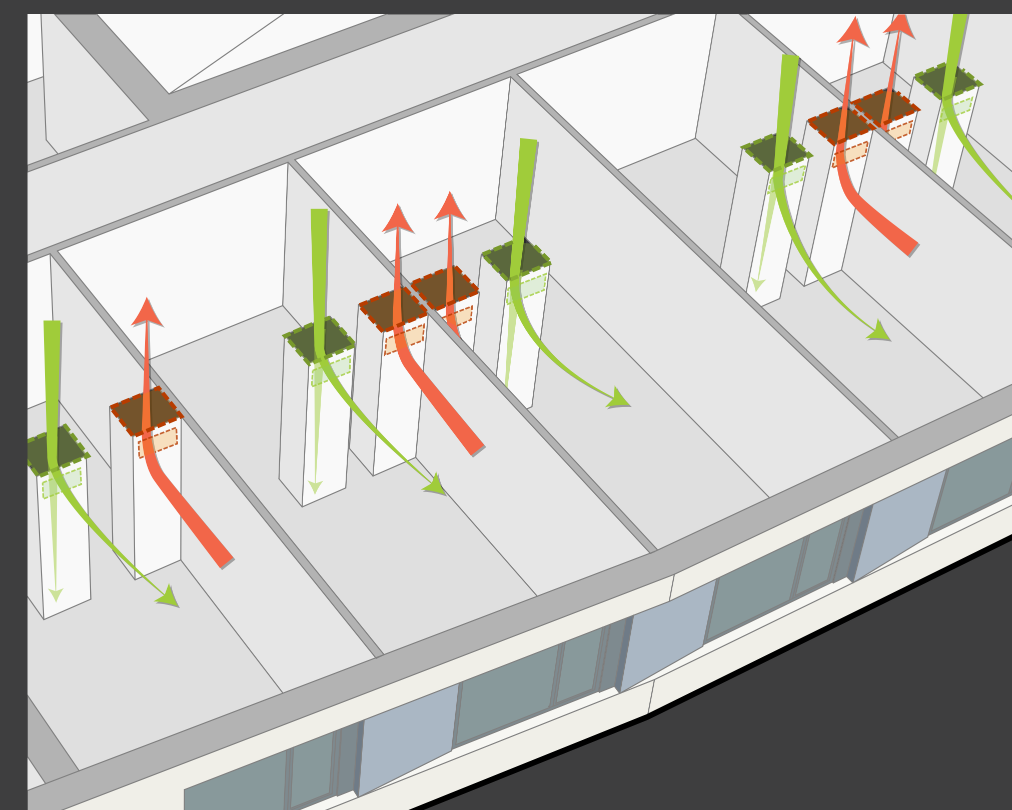
Grille Assembly

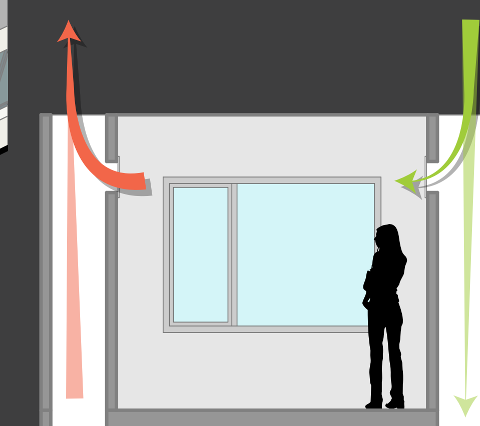
UNITIZED VS. CENTRAL VENTILATION SYSTEMS

- Exhaust Air
- Fresh Air
- ERV

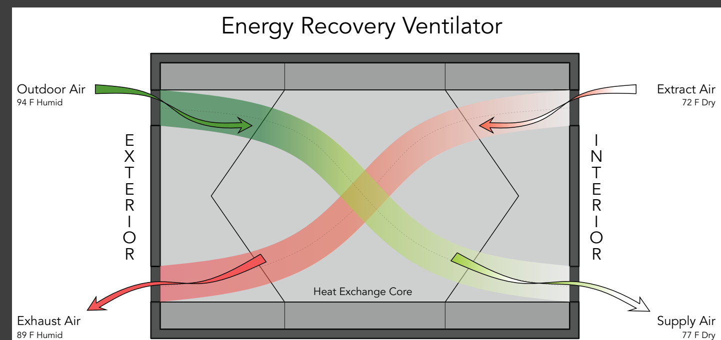




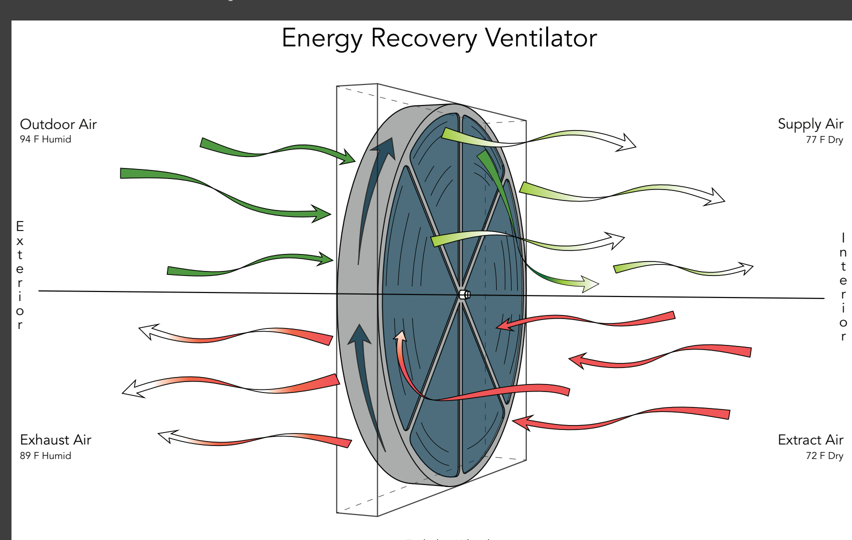


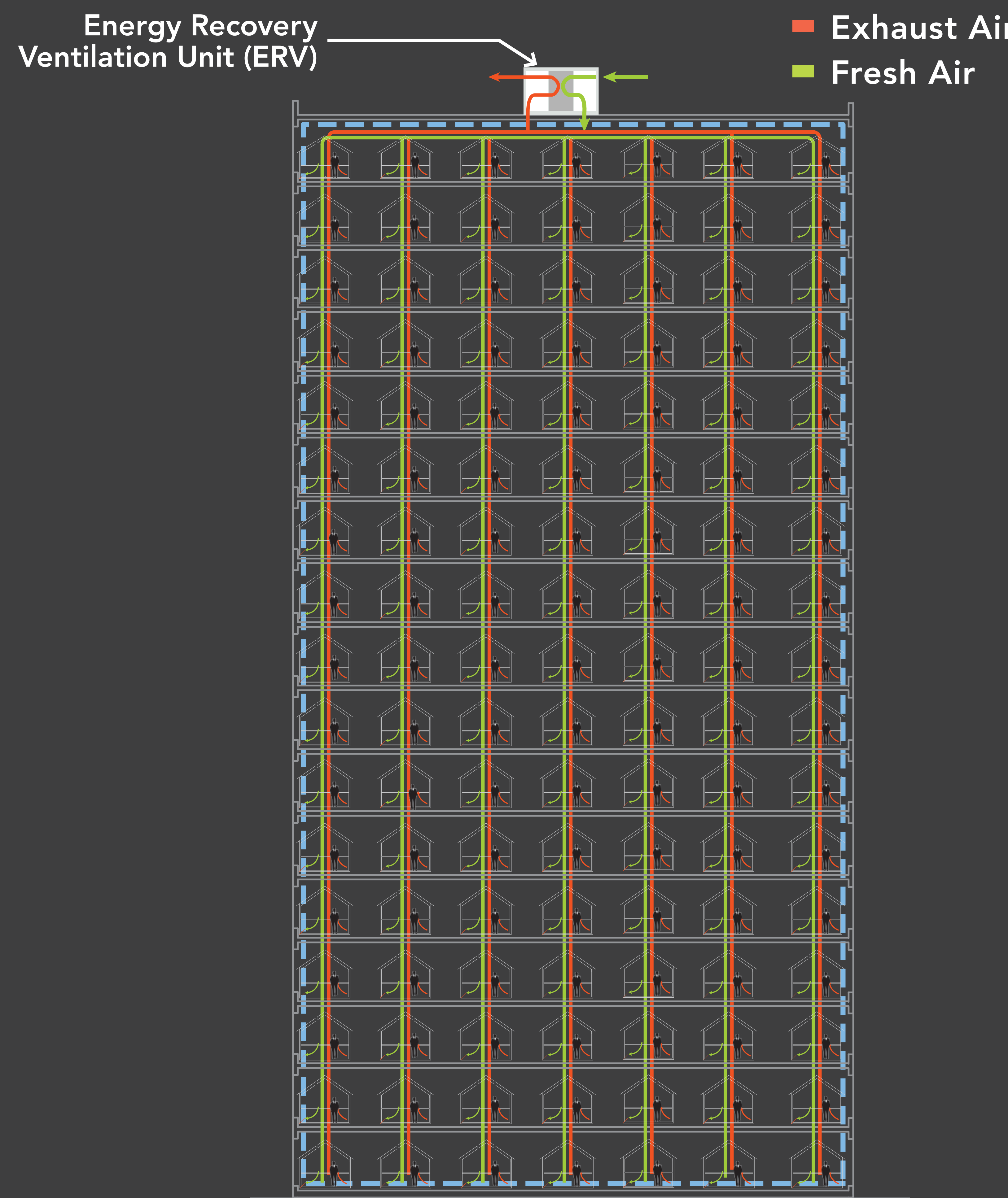


VENTILATION SYSTEM

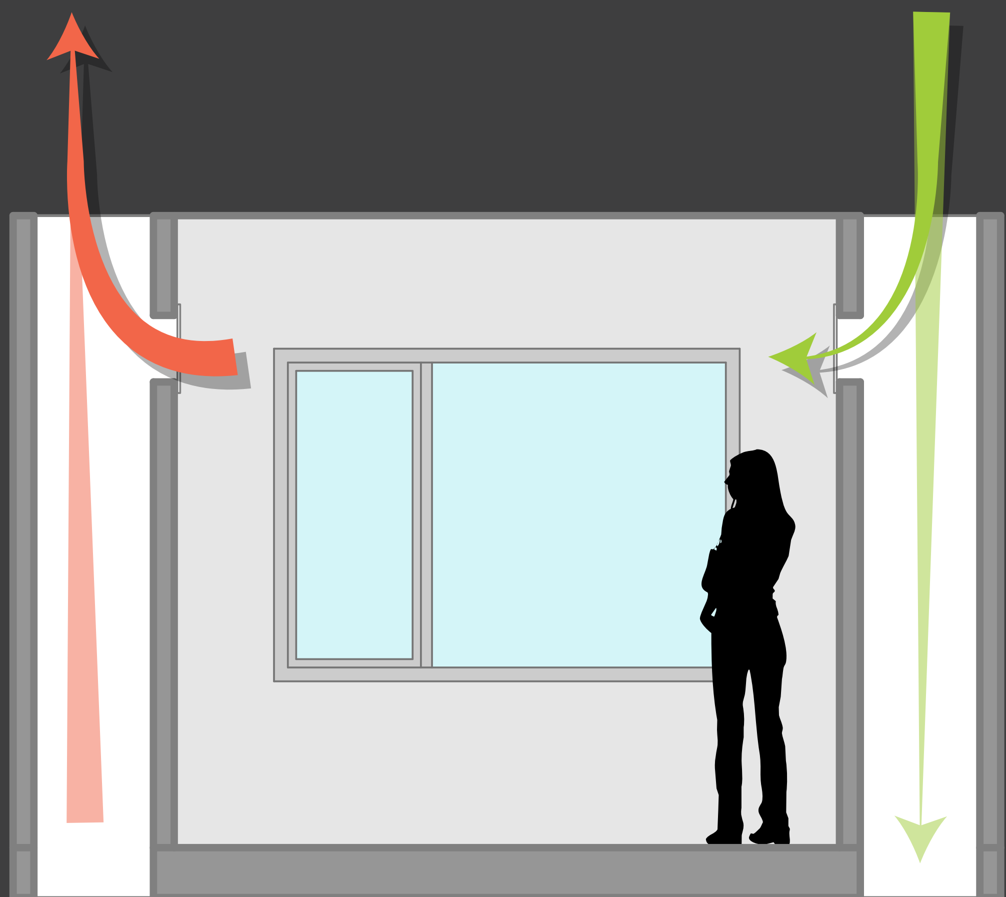


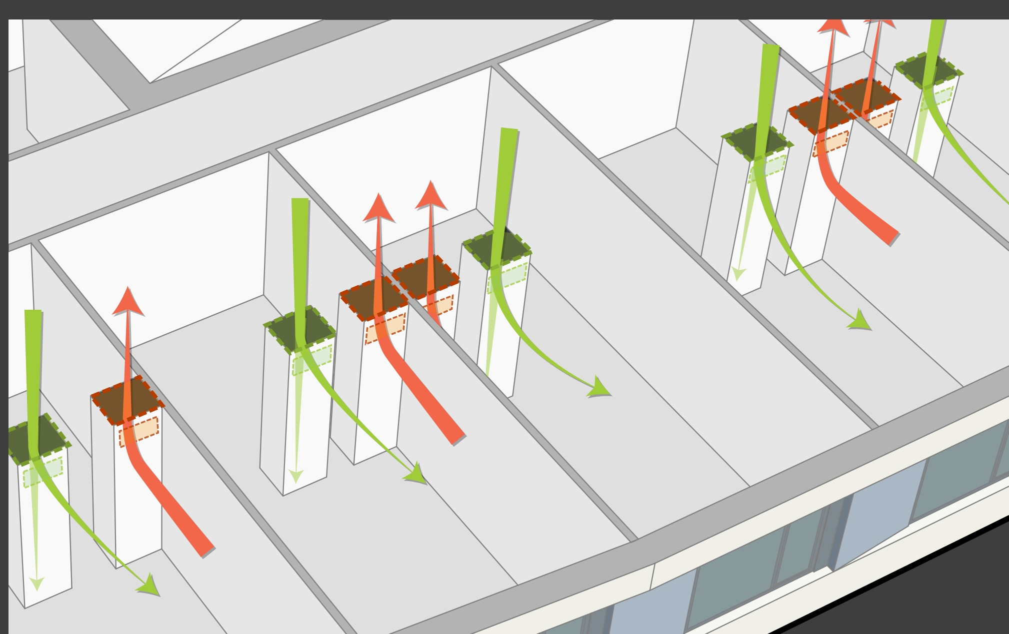
- ERV Unit to be air tight/Passive House Certified
  - Min 75% heat recovery efficiency
  - Include frost protection and humidity control
  - $\leq$ 35 decibels
- Utilize constant air regulating dampers to balance supply/exhaust flows to within 10% of one another
- Provide Average of 0.35 air changes/hour
- Flow rates approved by EPA and LEED for Homes
- Provide boost flow for localized humidity or pollutants
- System on emergency generator to provide fresh air in emergencies
- Timed options acceptable





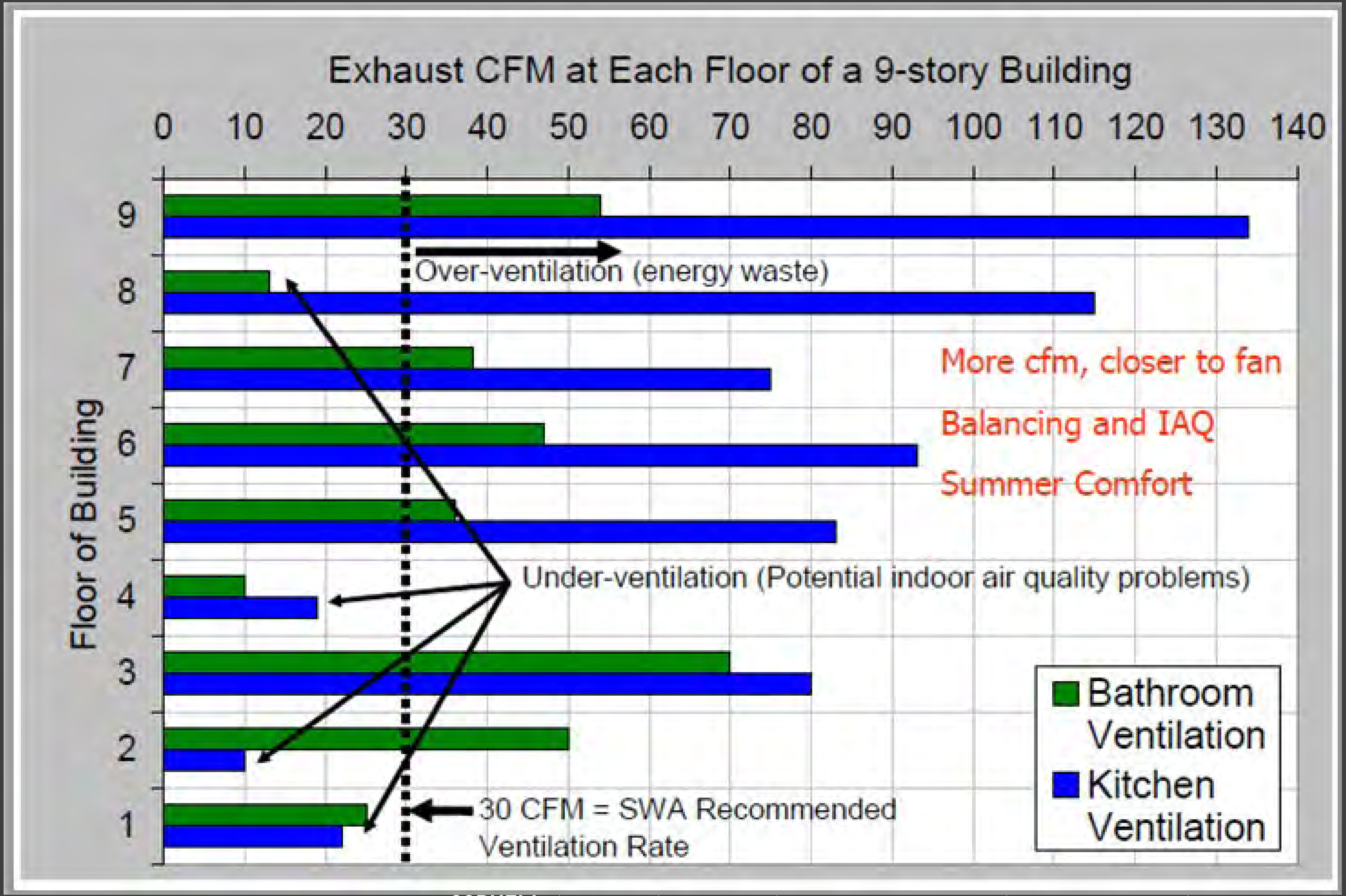
VENTILATION SYSTEMS



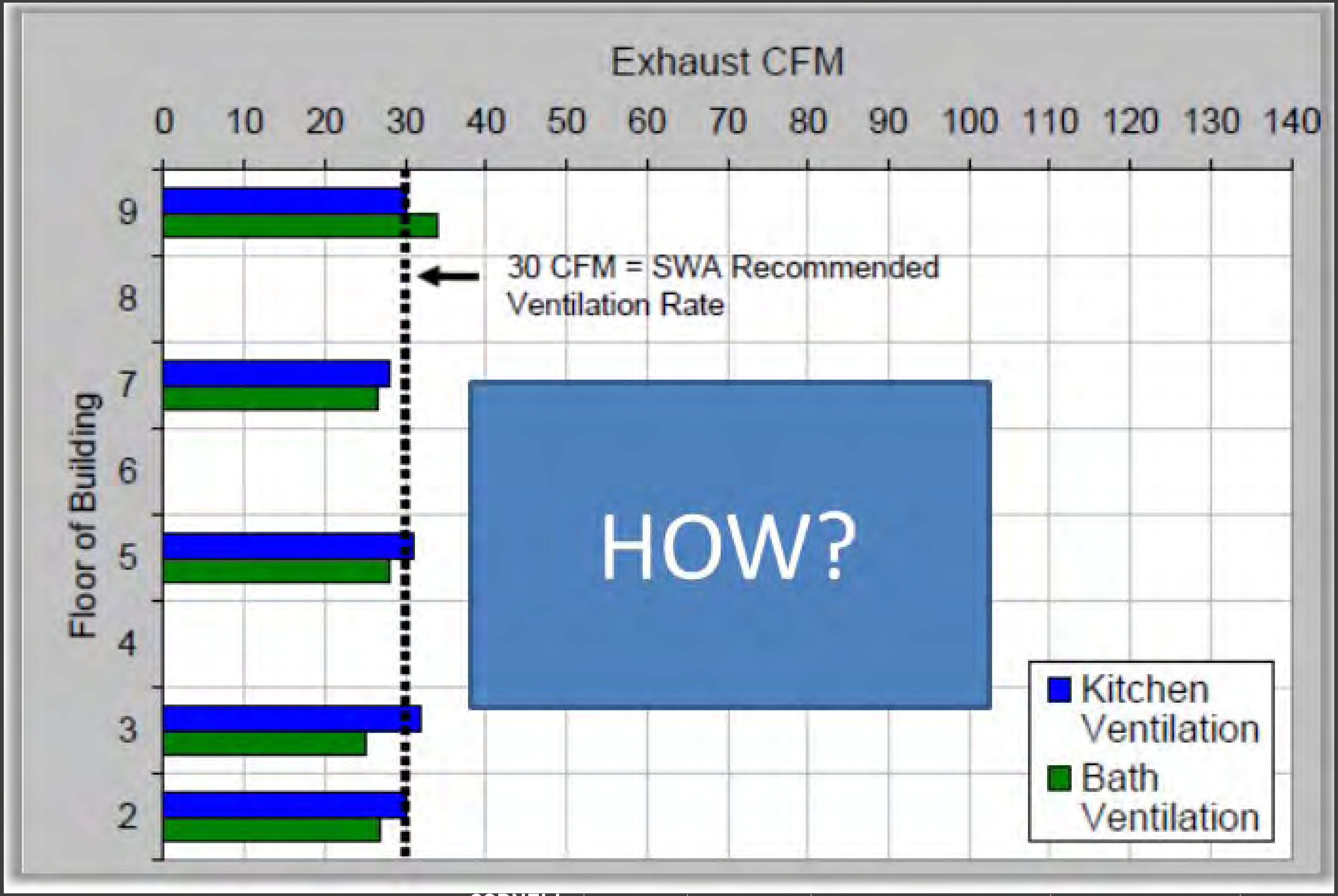


- As the building gets bigger ventilation has a bigger impact on energy
- As apartment size decreases ACH increases
- Central systems are easier to maintain, but less able to deal with variability
- This project:
    - Uses continuous ventilation
        - Average of 0.35 ACH
        - Kitchenettes = 10 CFM
        - Baths = 25 CFM
        - Supply = 10-20 CFM
    - Flow rates approved by EPA and LEED for Homes
    - ERVs connected to emergency generator

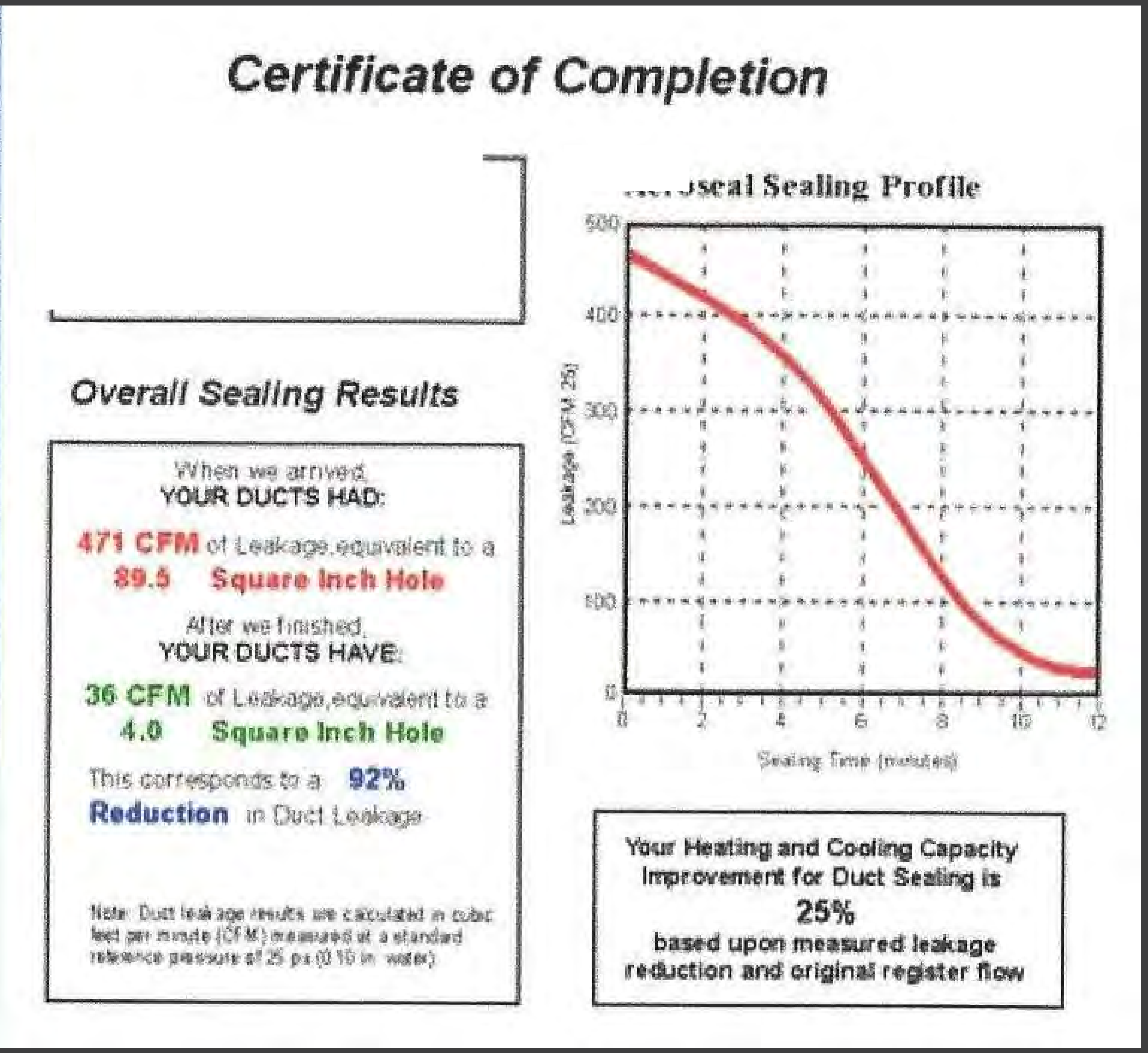
TYPICAL OVER-VENTILATED MULTIFAMILY BUILDING



SOLUTION: BALANCED SYSTEM WITH MINIMAL FLOW



AIR SEALING - DUCT SEALING



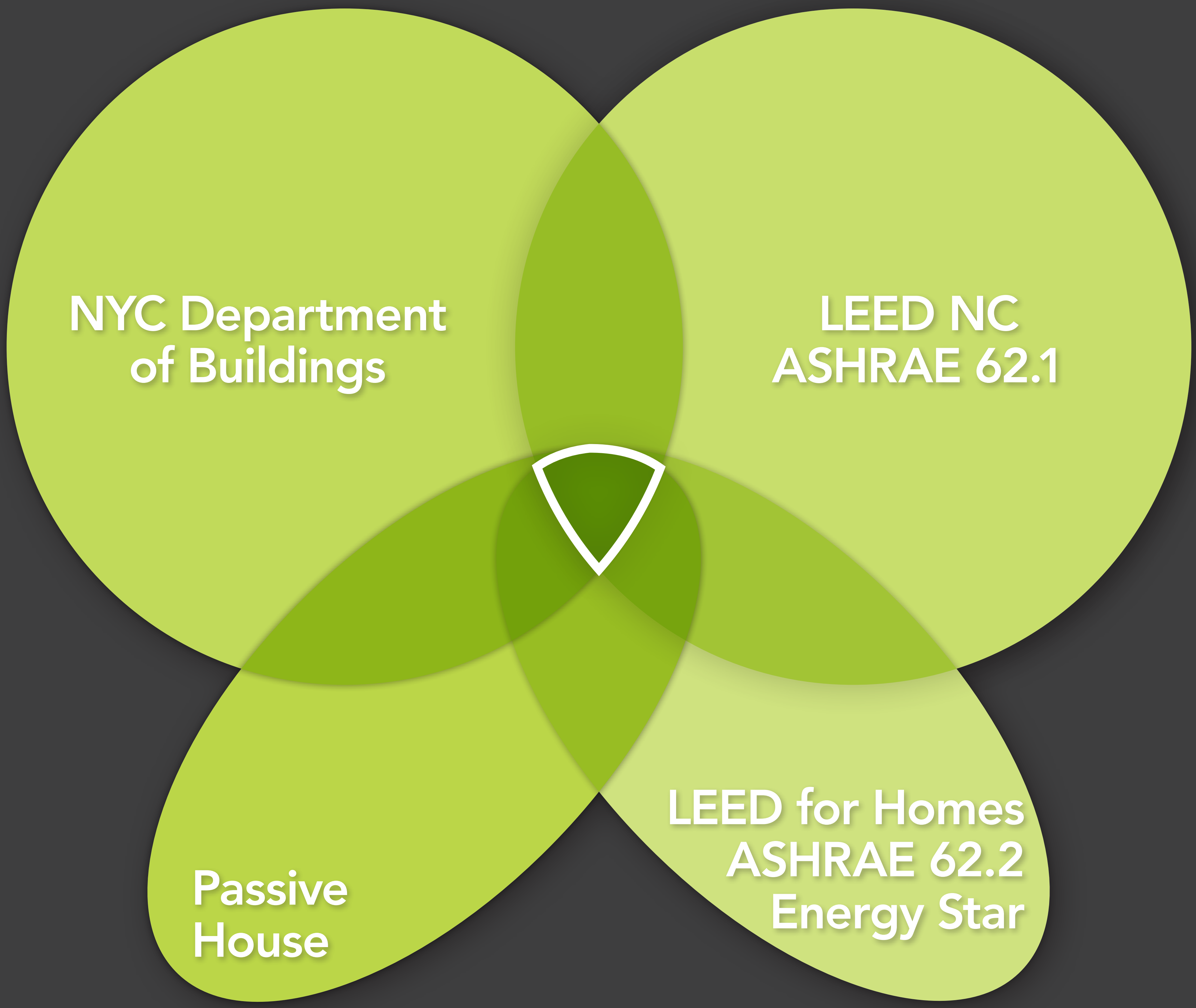
Automatic Balancing Dampers:

- Provide restriction in size of opening (increase static pressure)
- Dynamically self-adjust to changes in the system (automatic balancing)

Benefits:

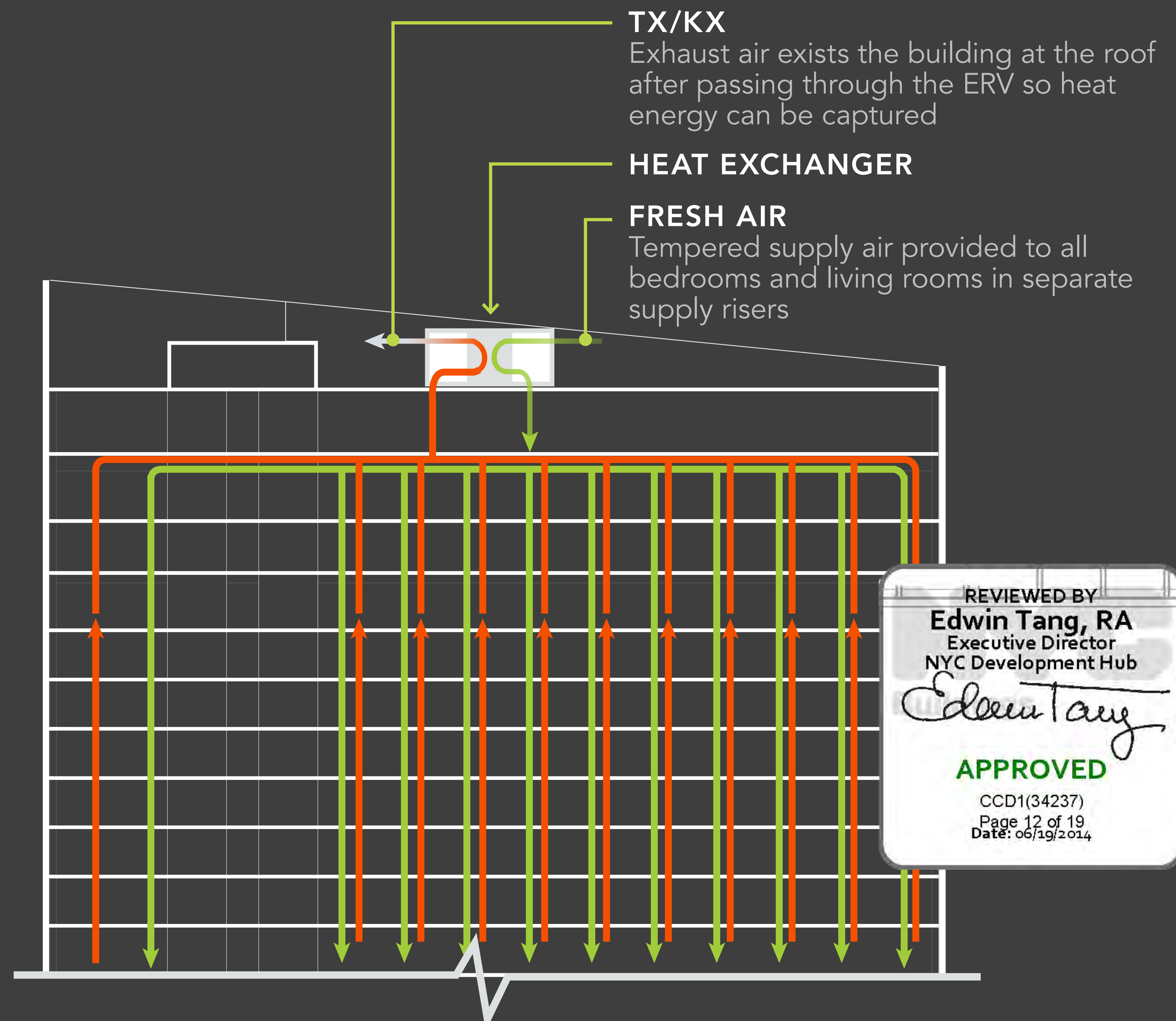
- Improves comfort
- Improves indoor air quality
- Increases life span of HVAC units
- Save money
- Reduces noise
- Protect the environment

OVERLAPPING OF CERTIFYING AGENCIES



CHANGE TO THE BUILDING CODE: MECHANICAL EXHAUST SYSTEM

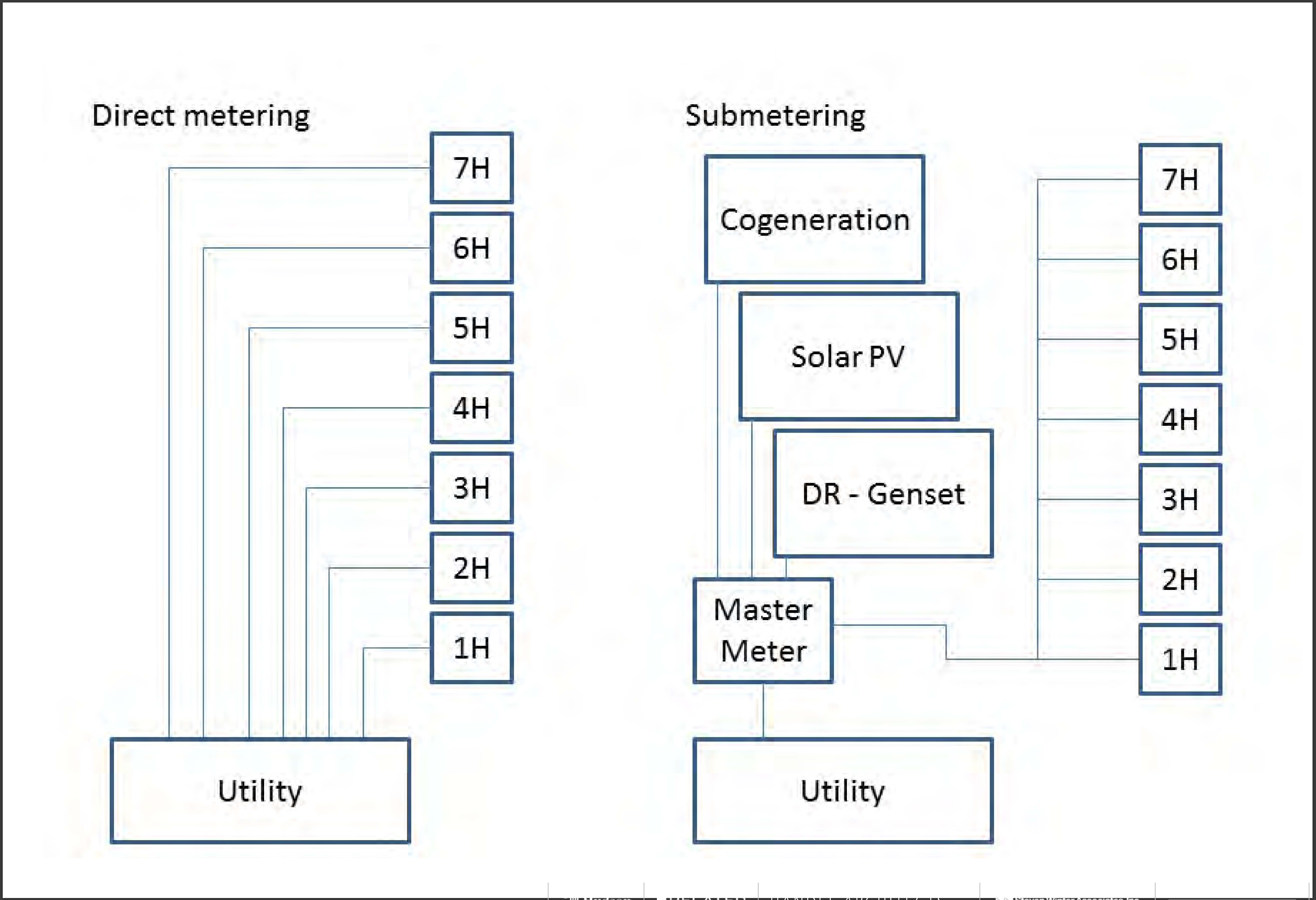
- Permission by DOB to combine toilet and kitchen exhaust from multiple apartments in vertical shafts, which is not typically allowed by NYC code.
- Necessary for proper balancing and operation of ERV



Section of the Code:

501.5.1. Single or combined mechanical exhaust systems from bath, toilet, urinal, locker, service sink closets and similar rooms shall be independent of all other exhaust systems, except as permitted in Section 401.5.2.

ELECTRIC SUBMETERING



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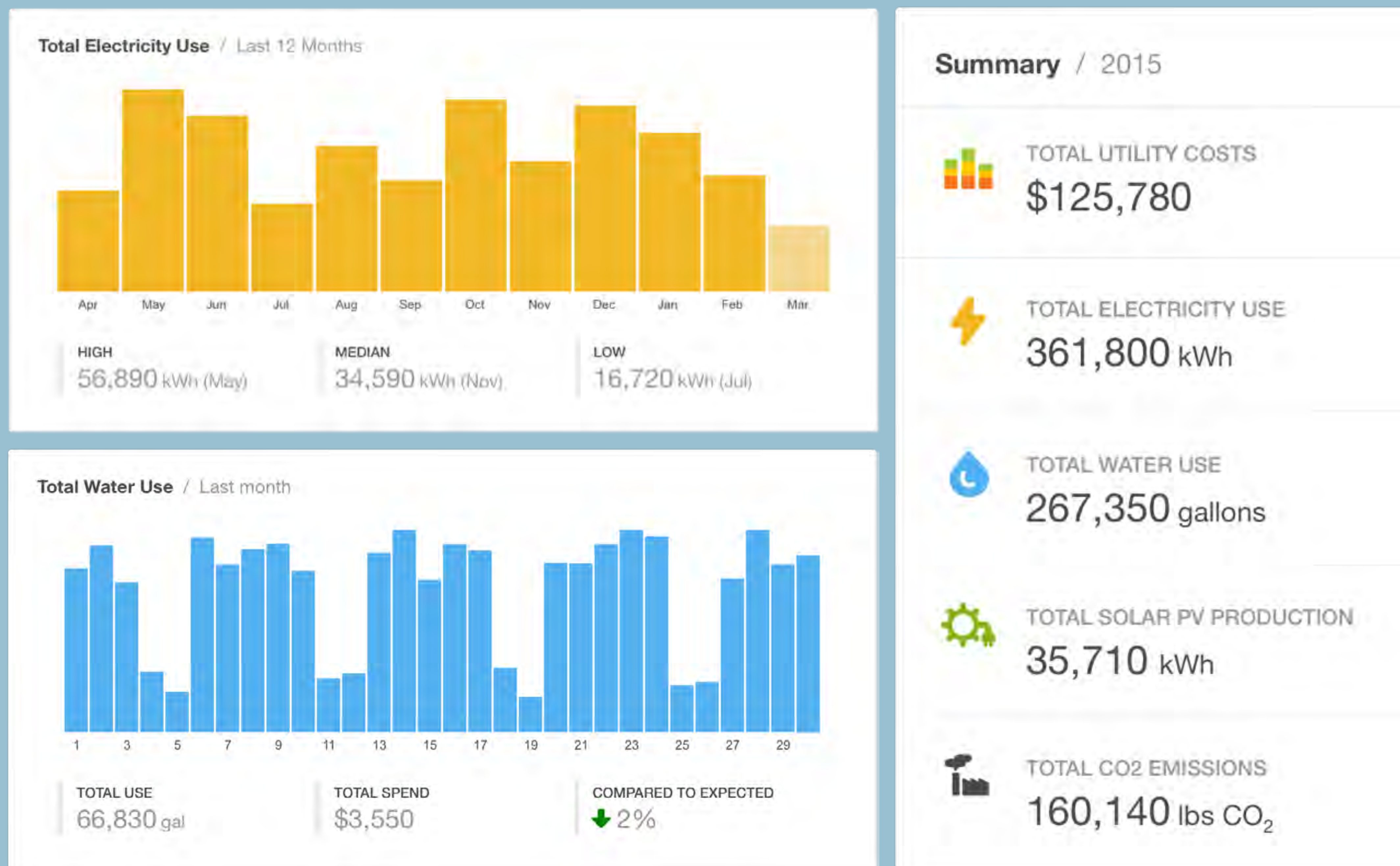

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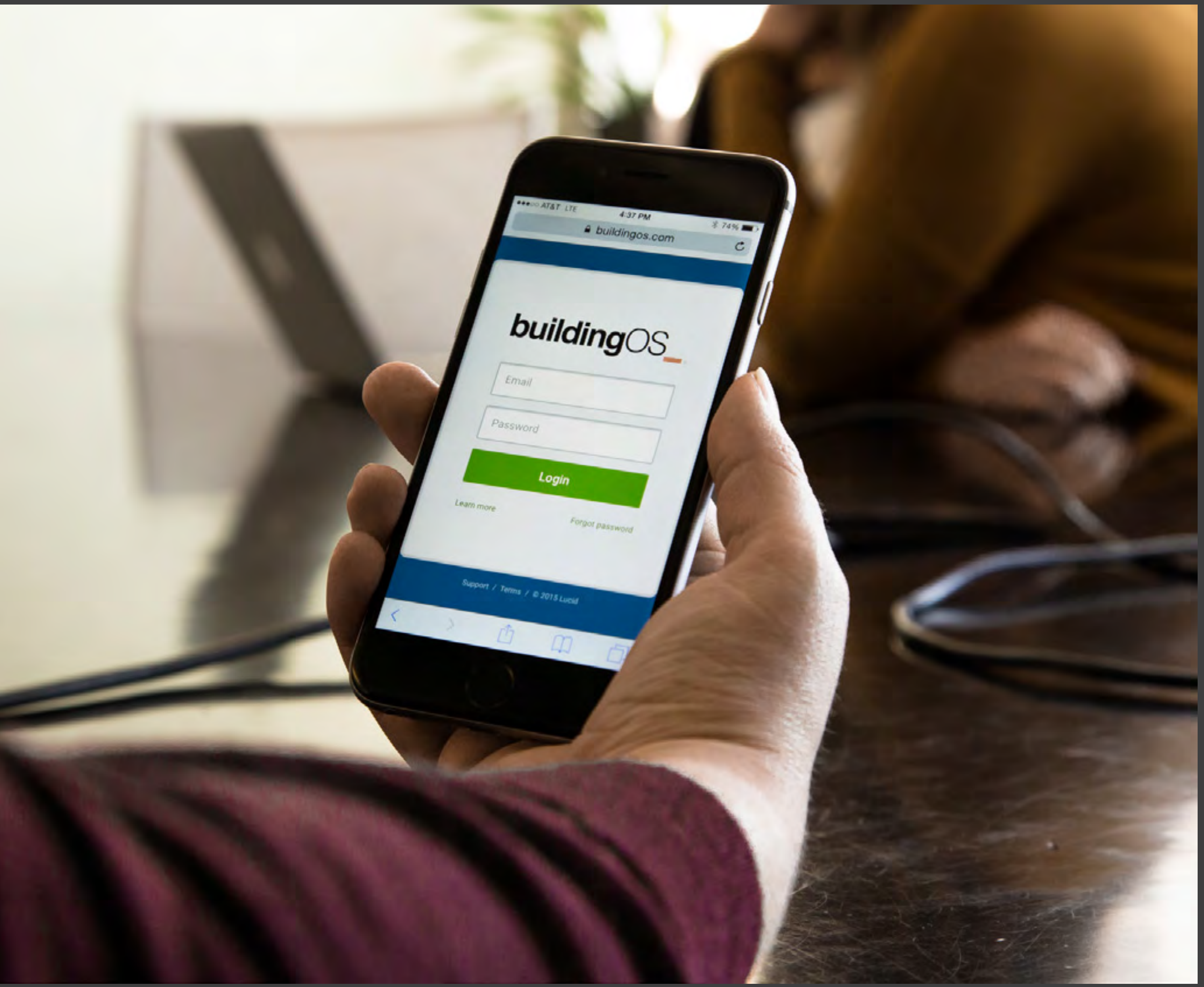

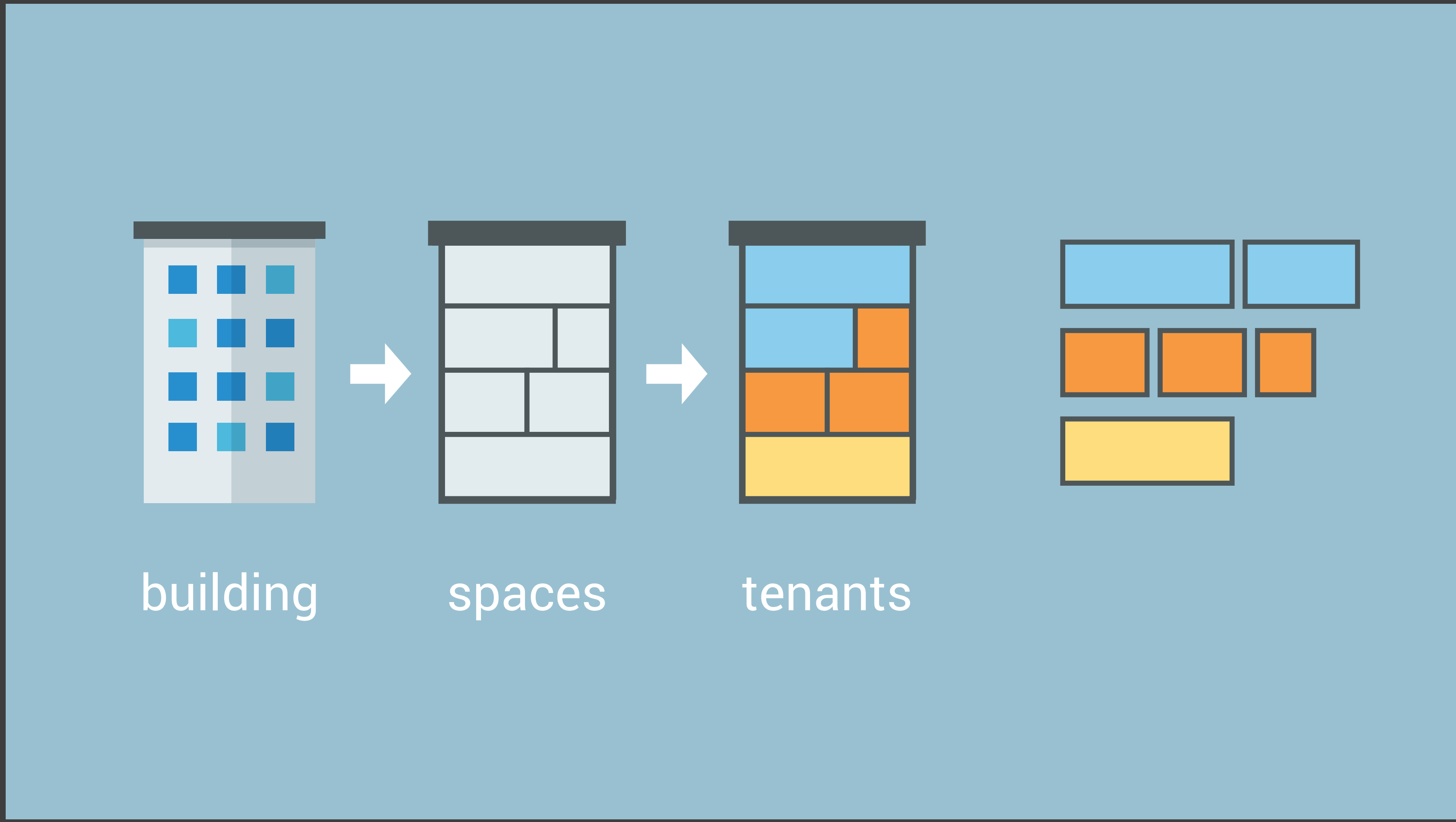

PASSIVE HOUSE MODEL REQUIREMENTS MET

Cornell

Specific building demands with reference to the treated floor area

		Value	Unit		Requirements	Fulfilled?*
	Treated floor area	189012	ft²			
Space heating	Heating demand	3.69	kBTU/(ft²yr)	78% of	4.75 kBTU/(ft²yr)	yes
	Heating load	4.13	BTU/(hr.ft²)	130% of	3.17 BTU/(hr.ft²)	-
Space cooling	Overall specif. space cooling demand	4.87	kBTU/(ft²yr)	90% of	5.39 kBTU/(ft²yr)	yes
	Cooling load	2.97	BTU/(hr.ft²)		-	-
	Frequency of overheating (> 77 °F)		%		-	-
Primary energy	Heating, cooling, dehumidification, DHW, auxiliary electricity, lighting, electrical appliances	37.4	kBTU/(ft²yr)	98% of	38.0 kBTU/(ft²yr)	yes
	DHW, space heating and auxiliary electricity	15.9	kBTU/(ft²yr)		-	-
	Specific primary energy reduction through solar electricity		kBTU/(ft²yr)		-	-
Airtightness	Pressurization test result n_{50}	0.6	1/h		0.6 1/h	yes

* empty field: data missing; '-': no requirement

Passive House?	yes

TIMELINE TO CERTIFICATION

Register Project

→ Project Approval

→ Develop Model

→ Model Approval

→ Construction Oversight

→ Blower Door Test

→ Power Usage Test

→ **CERTIFICATION**


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