BUILDING INNOVATION
Conference

Deep Green, Net Zero, Market Rate

How ASHRAE'S New Global Headquarters Renovation Achieved All Three

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ASHRAE is:

American Society of Heating, Refrigerating and Air-Conditioning Engineers

Professional Organization supporting engineers, contractors, manufacturers, and others in industry.

57,000 members in 132 countries, Headquartered in Atlanta, GA since 2010

A diverse industry leader dedicated to advancing the arts and sciences of HVACR, to creating standards and guidelines involving building systems, energy efficiency, indoor air quality, and to promoting a sustainable world.

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Project Background:

ASHRAE made a commitment to sell their existing property in late 2018.

Design Team was hired Feb. 2019

CM was hired April 2019

Project had to be completed October 2020.

ASHRAE had a commitment to renovate an existing office building from the 1970's/1980's.

PROJECT ‘MUST HAVE’ CRITERIA

Safety – safe work environment and construction

Affordable – to be constructed within the available budget.

Exceed the requirements of ASHRAE Standards 90.1-2016 (Energy Efficiency), 62.1-2016 (IAQ), 55-2017 (Thermal Comfort)

Meet acoustic requirements of “Sounds Matter”, produced by GSA. Office space to also exceed the acoustic requirements listed in the latest ASHRAE HVAC Applications Handbook by 3 to 5 NC/RNC

Net Zero Energy, Building EQ rating 100

PROJECT ‘HIGHLY DESIRABLE’ CRITERIA

Exceed the requirements of ASHRAE Standard 189.1-2017 (High Performance Buildings)

A maximum energy consumption of 21.4 kBtu/SF/yr.

Limit maximum daytime plug load to 0.5 W/SF

Deliver Outside Air at a value of at least 1.3 times the requirements of Std. 62.1 OA (Air Quality) to regularly occupied areas and use Demand Controlled Ventilation (DCV) for high occupancy spaces

Achieve Spatial Daylighting Autonomy (SDA) which assures the vast majority of occupants have a generous level of daylighting in their work space 55% of the time

Achieve Resiliency at a level established by ASHRAE.

Achieve a Plug Load < 0.4 w/sf

Achieve a demand side EUI < 15 kBtu/SF/yr

PATH TO NET ZERO

Seek to reduce the load demand as much as possible.

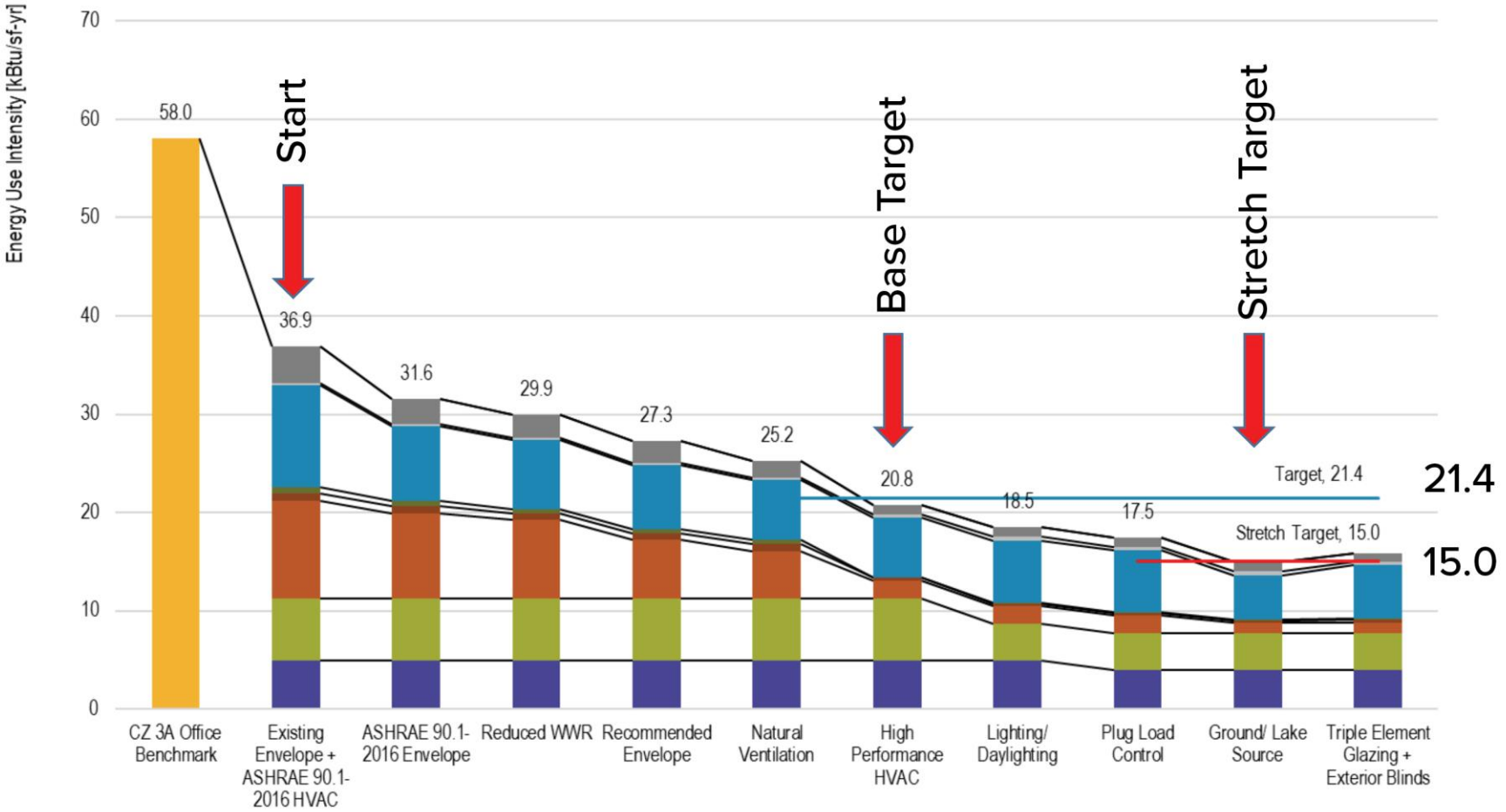
Our general design approach was:

- Create a high performance exterior envelope
- Utilize a high efficiency HVAC system
- Provide for long term program flexibility
- Run analytics throughout the process to check and re-check
- Right-size the PV array and backup.

During construction - constant monitoring and testing

Post occupancy - constant monitoring and adjusting

ENERGY USAGE INTENSITY (EUI) - REDUCING DEMAND



Baseline EUI used:
36.9

Base Target EUI:
21.4

Stretch Target EUI:
15

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RIGHT STEPS IN THE RIGHT ORDER

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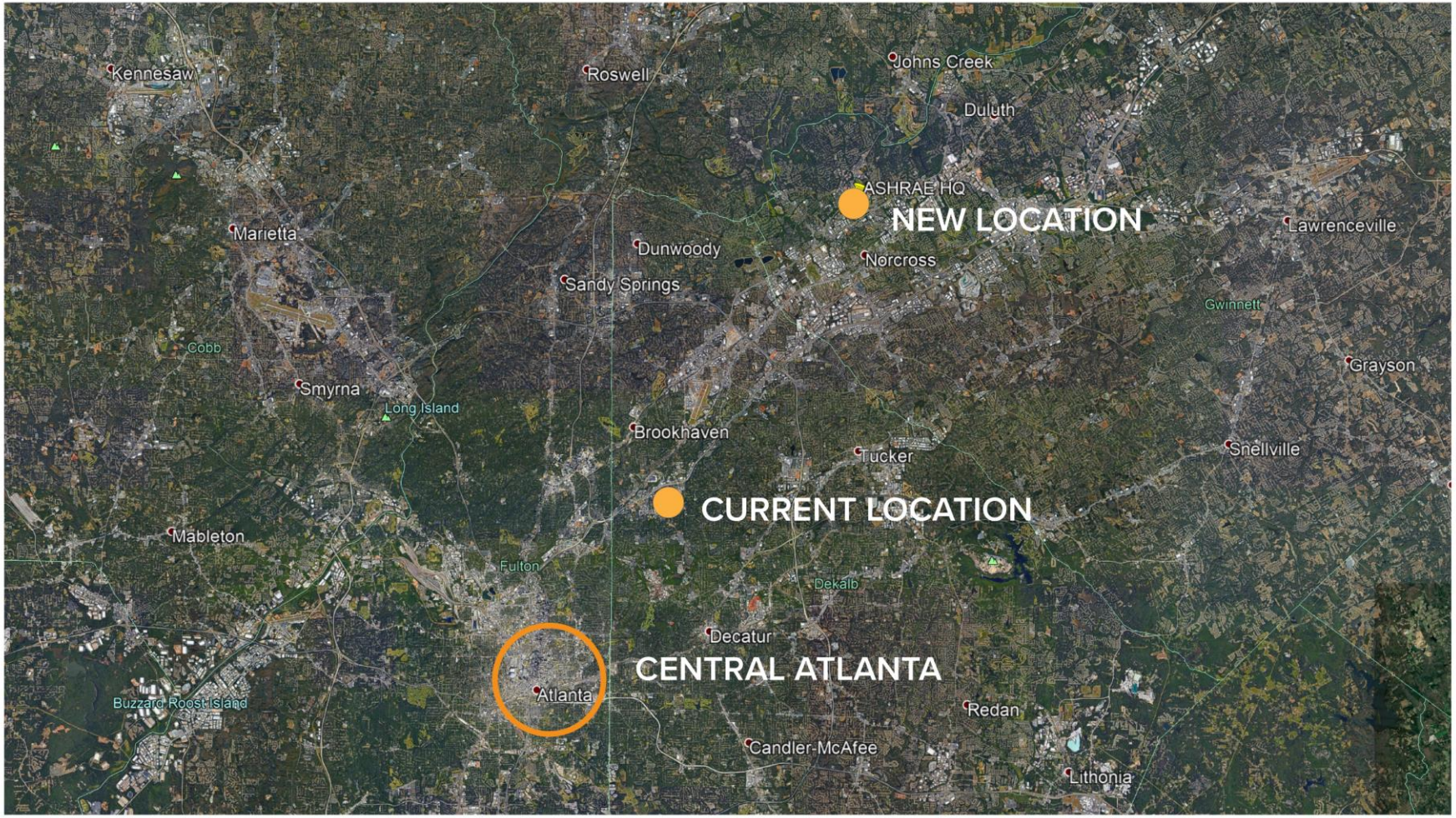
HQ LOCATION - OLD AND NEW



HQ LOCATION - 180 TECHNOLOGY PARKWAY

ACCESSIBILITY - CAR, BUS, BIKE

GAS EASEMENT

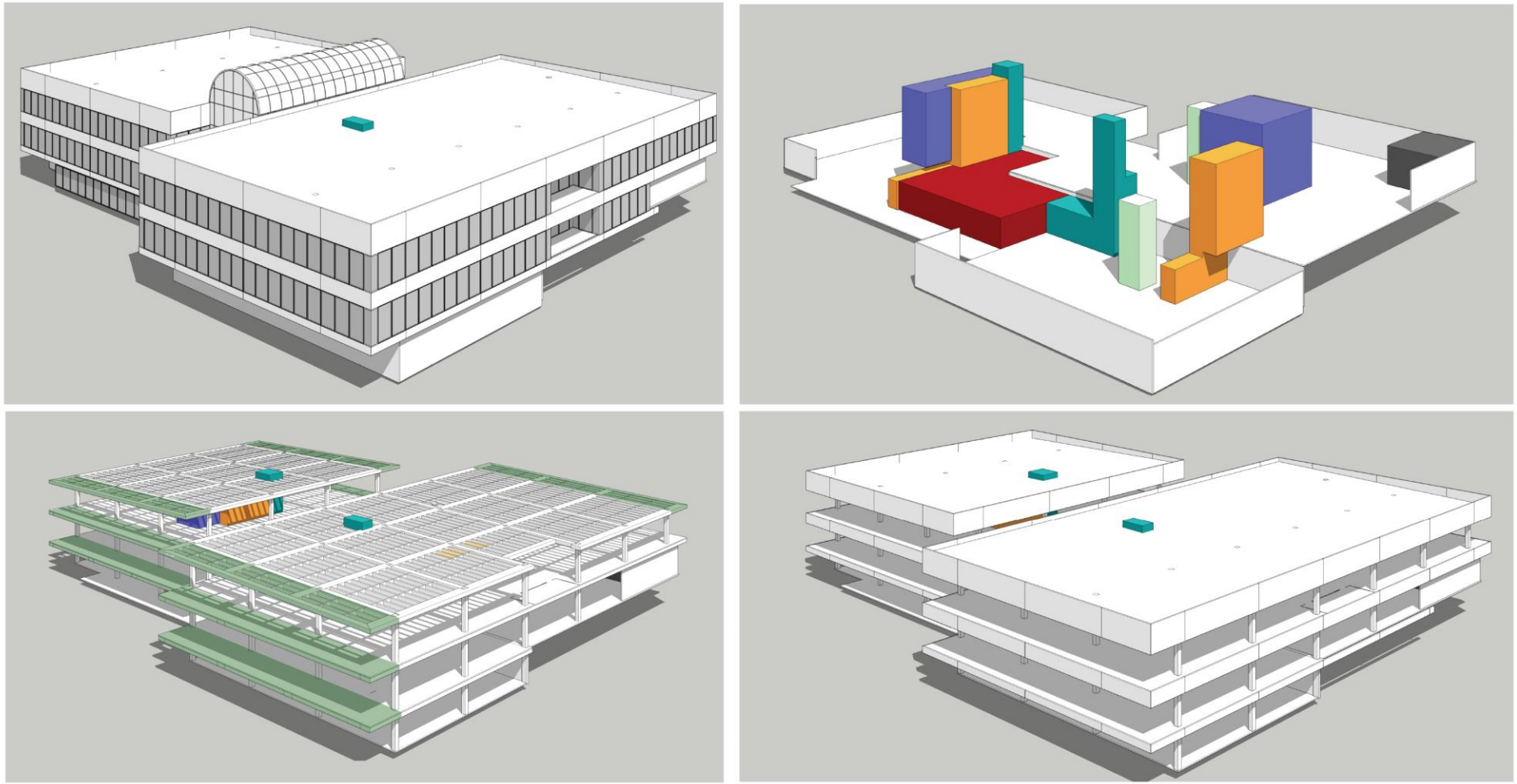
LAKE

TREE CANOPY

EXISTING STRUCTURE

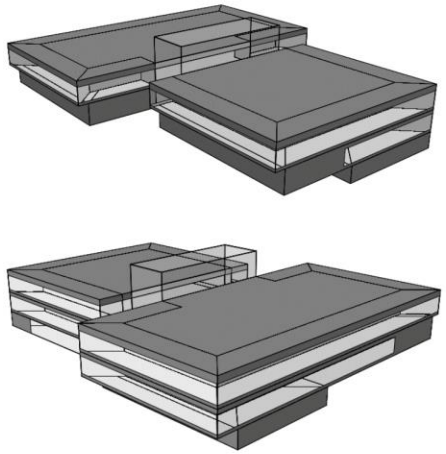
180 Technology Parkway, Peachtree Corners, GA
Site is 10.7 ac., 64,300 sq. ft. building over 2.5 stories
Built in mid to late 1970's - purchased in 2018

EXISTING BUILDING



ENERGY MODEL INPUT ASSUMPTIONS

General Parameters	
Project / Building	ASHRAE HQ
Occupancy	Office
Location	Altanta, GA
Weather File	Atlanta, GA
Climate Zone	ASHRAE 3A



Envelope	Existing	90.1-2016	Recommended
Wall Assembly	U-0.3 (R-3.0)	U-0.122 (R-8.0)	**U-0.058 (R-17)**
Roof Assembly	U0.047 (R-21)	U-0.039 (R-25)	**U-0.028 (R-35)**
Window Assembly	U-0.59 SHGC-0.52	U-0.45 SHGC-0.25	**U-0.40 SHGC-0.25**
Window to Wall Ratio	~50%	40%	**40%**
External Shade Depth	N/A	N/A	**1'** (to be further optimized for visual, thermal comfort)
Infiltration	0.0448 cfm/ft²	0.0448 cfm/ft²	**0.0112 cfm/ft²**

HVAC System Parameters			
System Description	VAV PFP Boxes	-	-
Total Static Pressure	Supply/Exhaust	in	4" / 1"
Fan Min Turn Down	-	%	10%
Ventilation Airflow	-	cfm	8,317
Total Airflow Capacity (Existing)	-	cfm	72,861
Total Airflow Capacity (ASHRAE 90.1-2016)	-	cfm	54,061
Demand Control Ventilation	None	-	-
Airside Economizer	Dry-bulb High Limit	°F	65°F
Airside Heat Recovery	Sensible Eff / Latent Eff	%	50% / 50%
Cooling Coil	DX Cooling Coil	EER	9.5
Heating Coil	Electric Resistance	%	100%
Reheat Coil	Electric Resistance	%	100%
Supply Air Temperature	-	°F	55°F
Supply Air Control	Warmest Zone Reset	°F	10°F
Domestic Hot Water			
System Description	Electric Resistance	-	-
DHW System Efficiency	-	%	98%
DHW Supply Water Temperature	-	°F	140°F
DHW Delta-T Water Temperature	-	°F	30°F

Space Type Inputs				Internal Load Parameters							Thermal Zone Parameters				
Space Type	Area [SF]	Area in Model [%]	# People	Area/person [SF/Person]	People/Area [Person/SF]	Lighting [W/SF]	Eqp Load [W/SF]	DHW [gal/hr/p]	DHW [gpm]	OA Rate [CFM/SF]	OA Rate [CFM/P]	OA Rate [CFM]	TStat Clg [deg F]	TStat Htg [deg F]	Clg Setback [deg F]	Htg Setback [deg F]
Office	65,914	97%	132	500	0.0020	0.637	0.5	0.18	0.4	0.078	6.5	5,998	75	70	80	60
Atrium	1,885	3%	283	6.67	0.1499	0.390	0.5	0	0.0	0.078	6.5	1,984	75	70	80	60
Lobby	318	0%	48	6.67	0.1499	0.585	0.5	0	0.0	0.078	6.5	335	75	70	80	60
TOTAL	68,117		462	147	0.0068	0.6	0.5		0.4			8,317				

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CLIMATE PROFILE - REGION 3A

Annual Air & Ground Temperature Profiles

Key Climate Factors: Atlanta Georgia

Key Climate Design Drivers

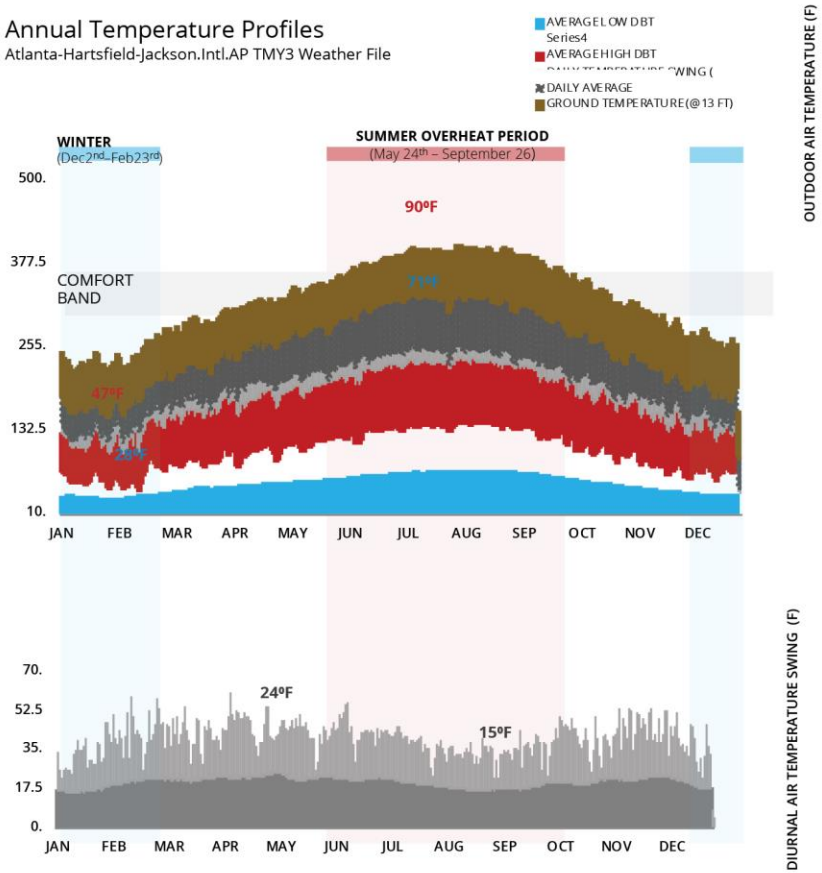
- **Summer:** May to September (Avg. OA>70ºF)
  - Extreme Hot Week Period: Jul 6 - Jul 12, Maximum Temp= 98.06F (36.7C). Future climate to be accounted for.
  - Exterior shading beneficial May-September to minimize unwanted summertime solar gains and enable low-energy passive cooling strategies.

- **Winter**: December to February (Avg. OA< 50ºF)
  - Extreme Cold Week Period : Jan 6 to Jan 12, Minimum Temp= 8.96F (-12.8C)
  - Leverage passive solar gains through south-facing façade fenestration to offset supplemental heating requirements.

- **Diurnal Swing**: Average Diurnal swing between 15-24ºF suggests an opportunity to leverage thermal mass to reduce peak indoor temperatures, reduce cooling energy, and improve occupant thermal comfort.

- **Ground and Water Temperatures:** Relatively stable ground (and Lake) temperatures suggest a potential heat source and sink for the HVAC system.

Rainfall: 30 yr avg - 49" per year



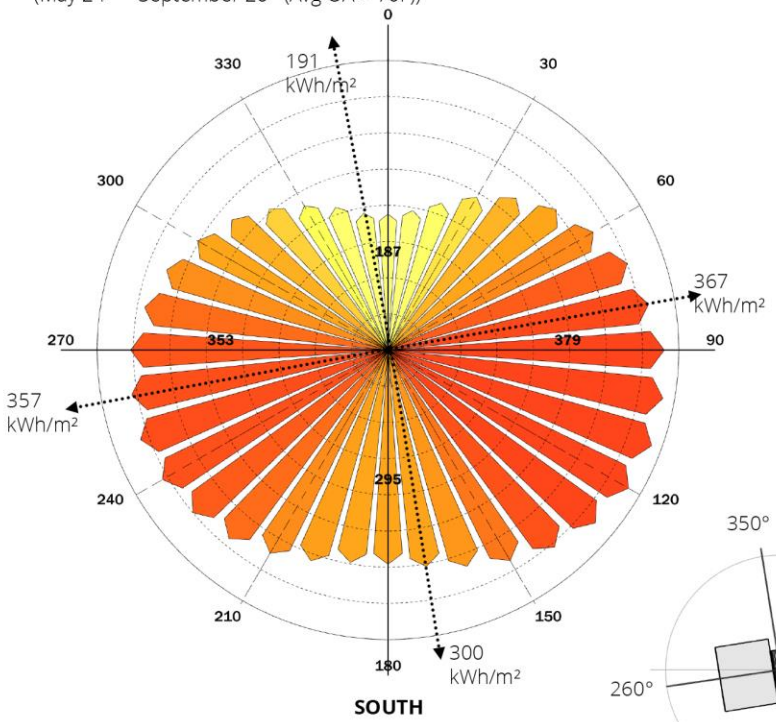
Incident Solar Radiation - SUMMER

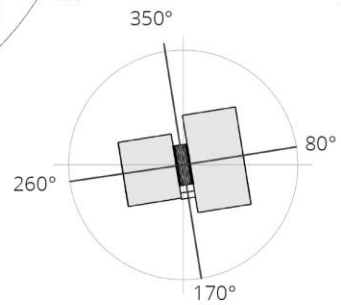
Key Climate Factors: Atlanta Georgia

CUMULATIVE SEASONAL INSOLATION BY ORIENTATION (KWH/M²)

SUMMER INCIDENT SOLAR RADIATION BY FAÇADE ORIENTATION

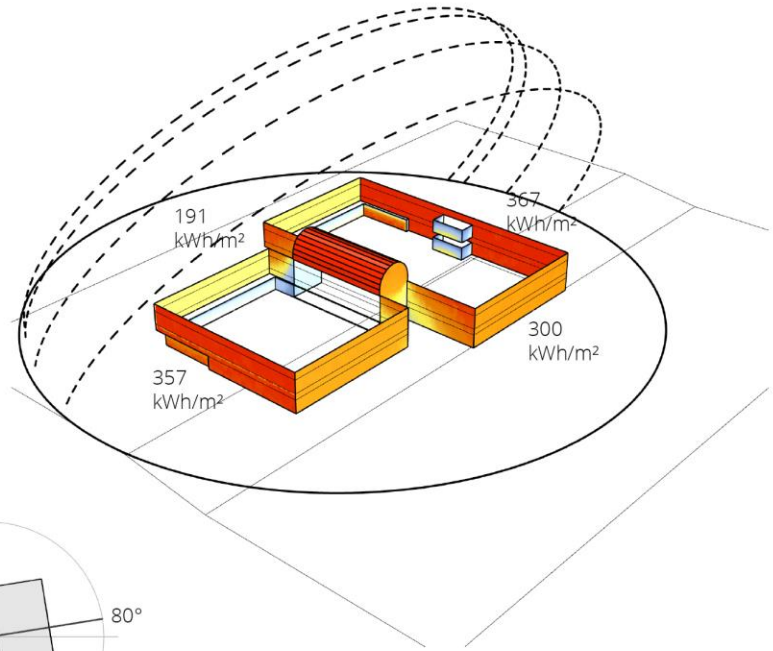
(May 24th –September 26th (Avg OA > 70F))





SUMMER INCIDENT SOLAR RADIATION - BASELINE

(May 24th –September 26th (Avg OA > 70F))



CLIMATE PROFILE

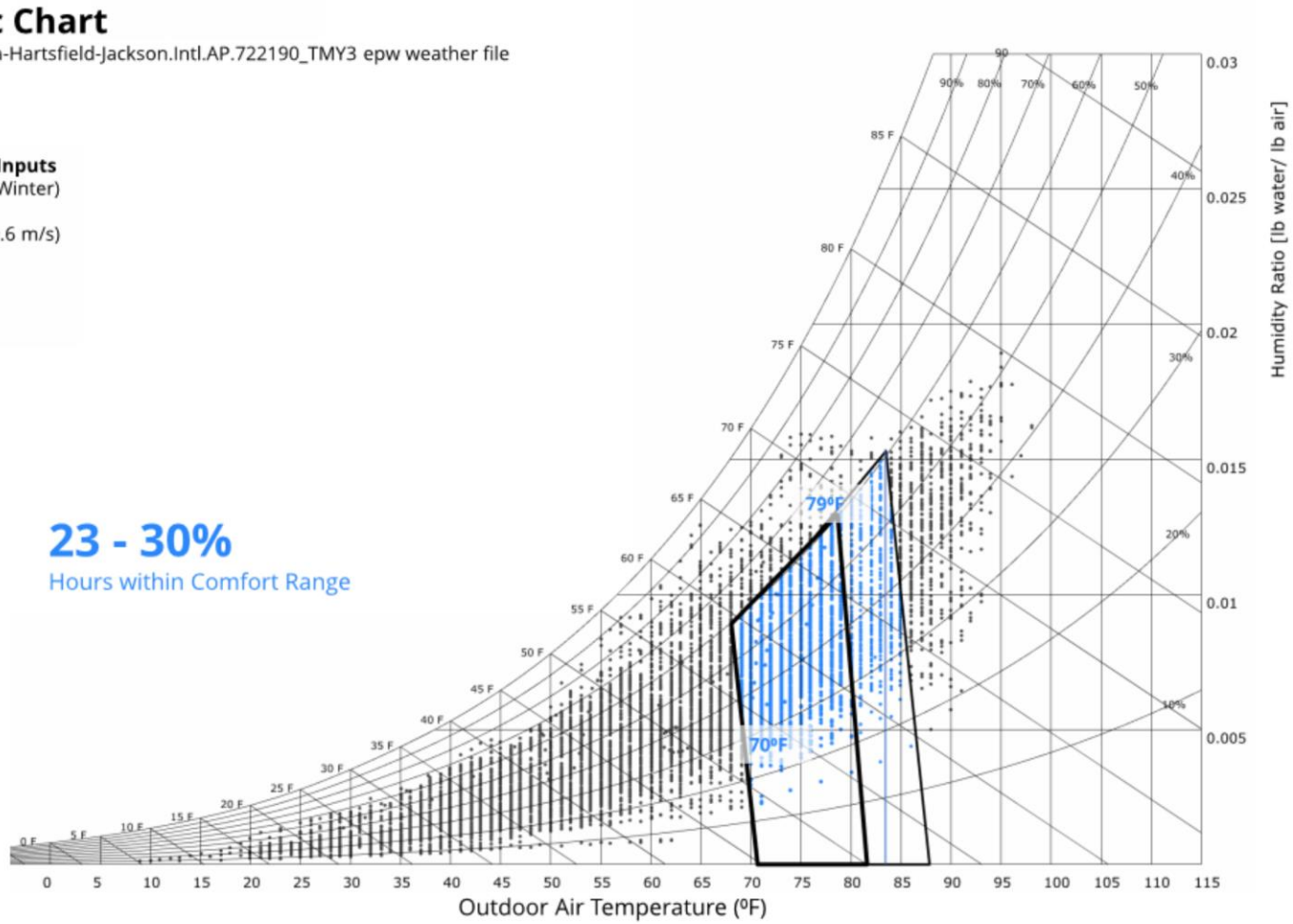
Psychrometric Chart

Key Climate Factors: Atlanta-Hartsfield-Jackson.Intl.AP.722190_TMY3 epw weather file

ASHRAE- 55 PMV Method Inputs

- Clo: 0.61-1.0 (Summer/ Winter)
- Met: 1.1 (Typing)
- Air Speed: 0 -118 fpm (0.6 m/s)

- RH Upper Limit: 60%



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ENVELOPE ASSUMPTIONS - SENSITIVITY ANALYSIS

Preliminary envelope performance targets based on point of diminishing Energy Use Intensity (EUI) savings shown at right:

Parameter	Existing Performance	ASHRAE 90.1-2016	Recommended
Wall Assembly	U-0.3 (R-3.0)	U-0.122 (R-8.0)	**U-0.058 (R-17)**
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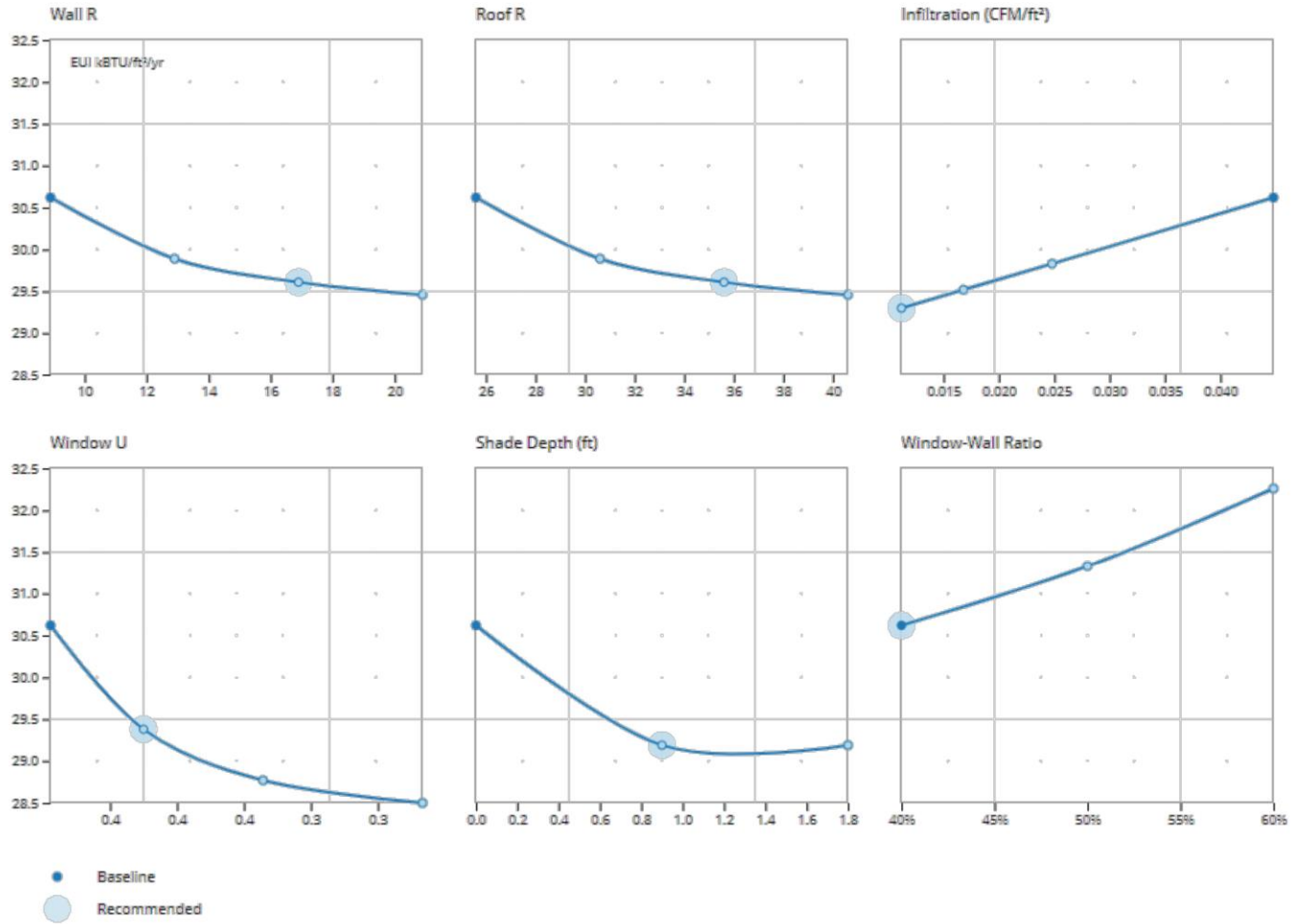
Window to Wall Ratio	~50%	40%	**40%**
External Shade Depth	N/A	N/A	**1'** (to be further optimized for visual, thermal comfort)
Infiltration	0.025 cfm/ft^2	0.045 cfm/ft^2	**0.011 cfm/ft^2**

ASHRAE NZE AEDG recommends R-15.6 wall for Climate Zone 3!



ENVELOPE ANALYSIS ASSUMPTIONS

Envelope	Existing	90.1-2016	**Recommended**
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System Description	Electric Resistance	-	-
DHW System Efficiency	-	%	98%
DHW Supply Water Temperature	-	ºF	140ºF
DHW Delta-T Water Temperature	-	ºF	30ºF

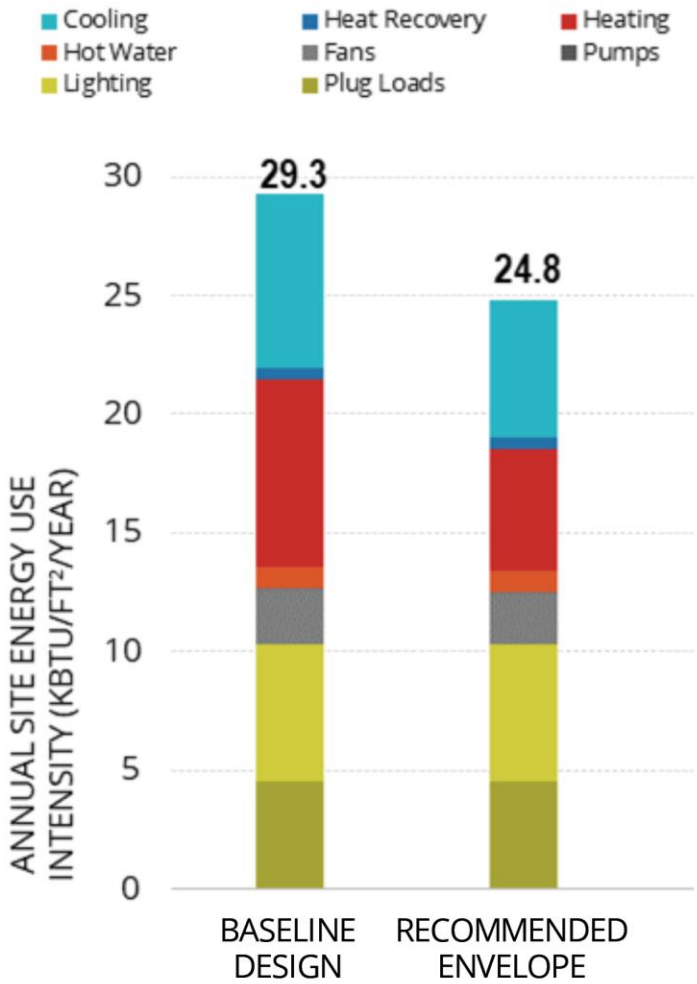
ENVELOPE CONSIDERATIONS

Air Infiltration - set ASHRAE's highest target:
- .11 envelope leakage ratio (ELR75) or
- 7,122 cubic feet per minute (CFM75).

Existing infiltration was equal to a 100sf opening

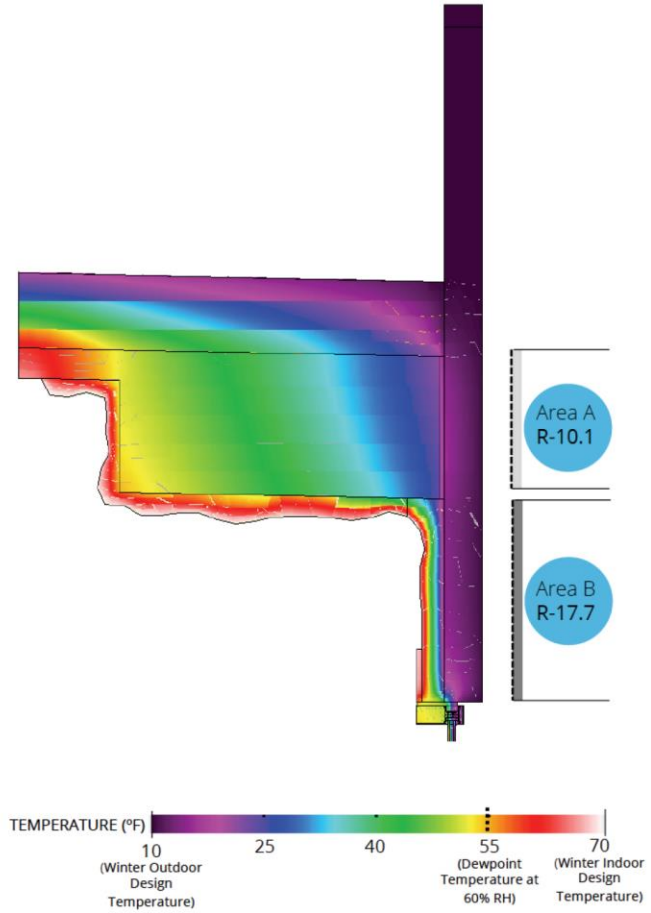
Insulation optimization, especially at the roof.
- Where was the optimal R-Value for each part of the exterior envelope?

Important to achieve daylight autonomy goals, as well as maximize the thermal efficiency of the wall.
- Properly sizing the Window to Wall Ratios (WWR)
- Solar shading and control devices.
- Ambient lighting for the upper level - clerestory or skylights.

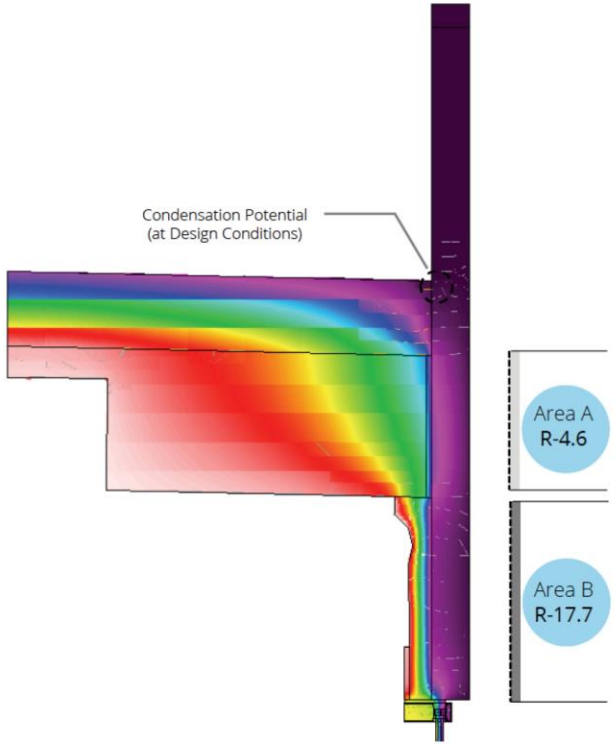


HIGH PERFORMANCE ENVELOPE: AIR INFILTRATION & THERMAL

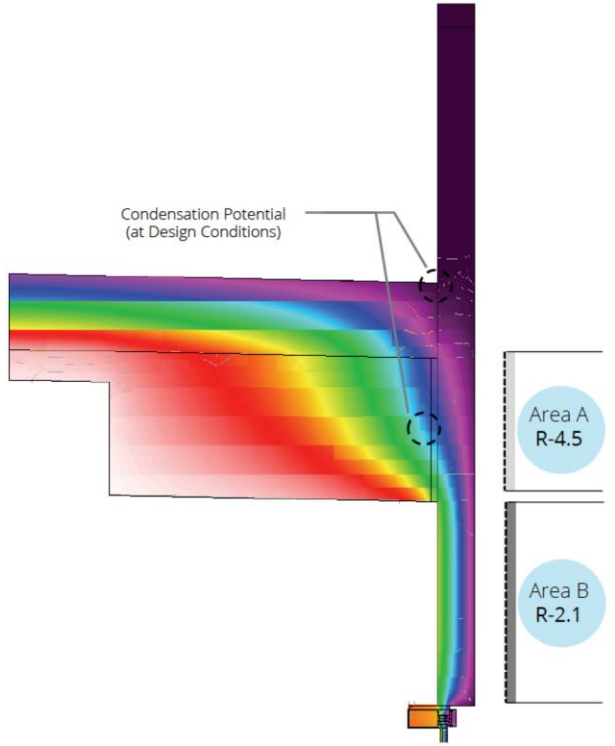
Option 1: Proposed Insulated Slab



Option 2: Partially Insulated Slab Underside

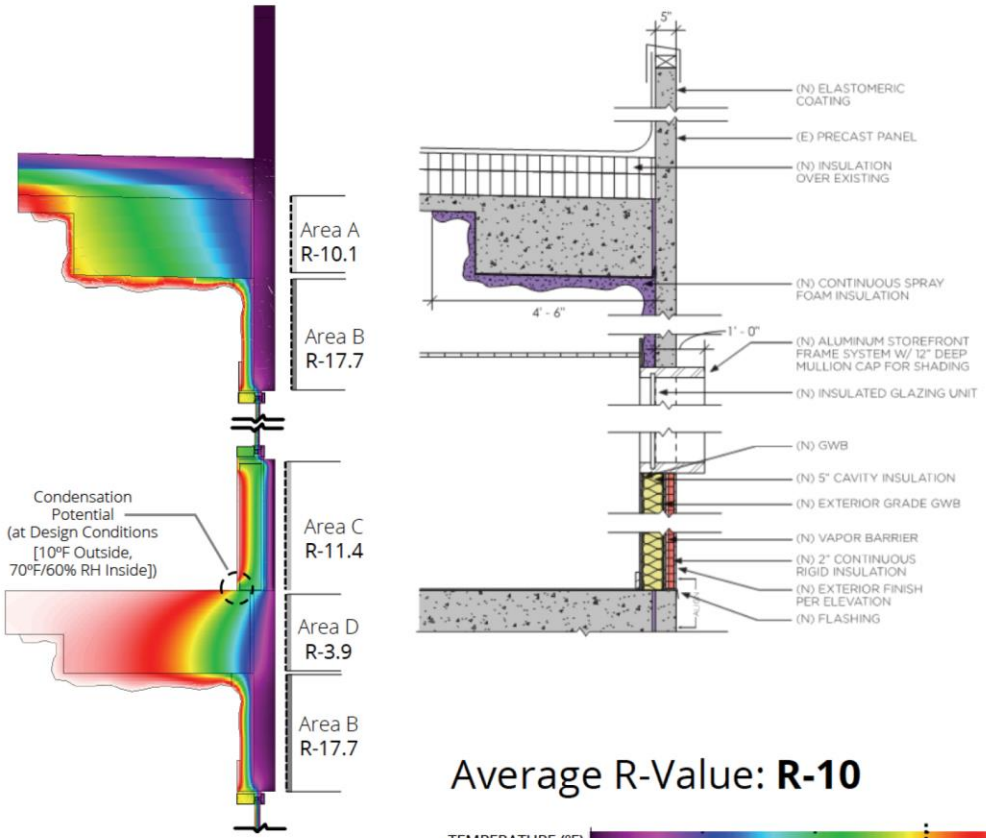


Baseline (Uninsulated Existing Condition)

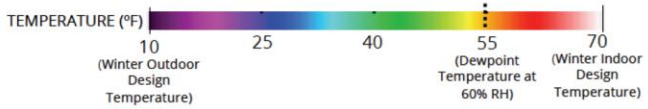


HIGH PERFORMANCE ENVELOPE: AIR INFILTRATION & THERMAL

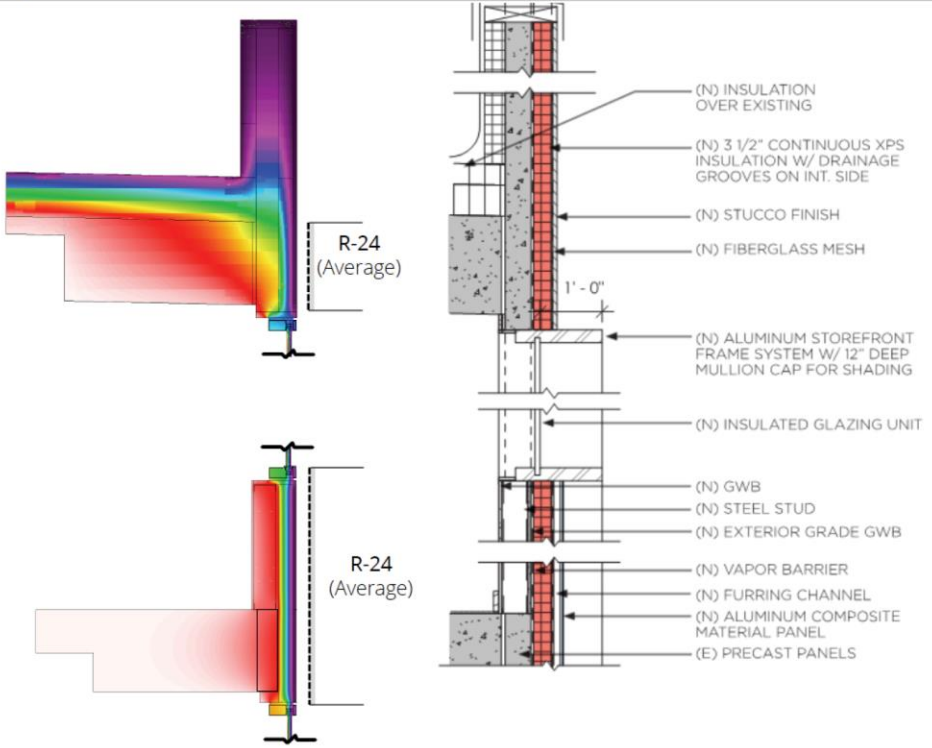
Option A: Insulate From Interior, Maintain Precast



Average R-Value: **R-10**

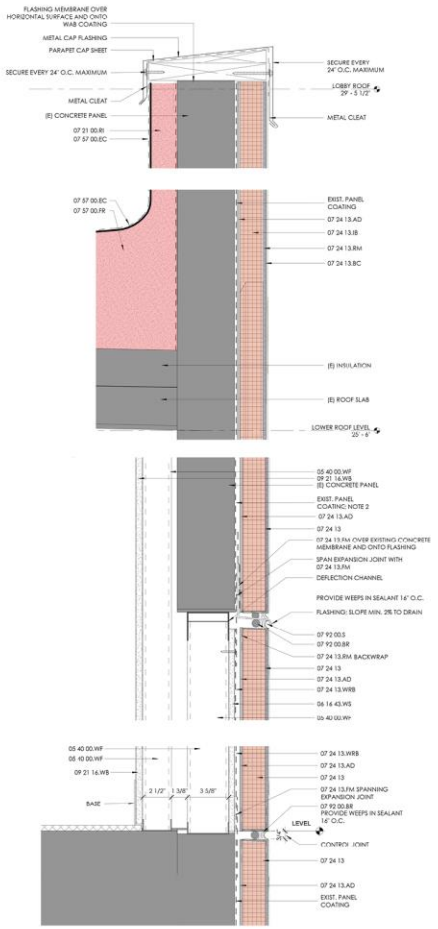


Option B: Continuous Exterior Insulation Over Precast

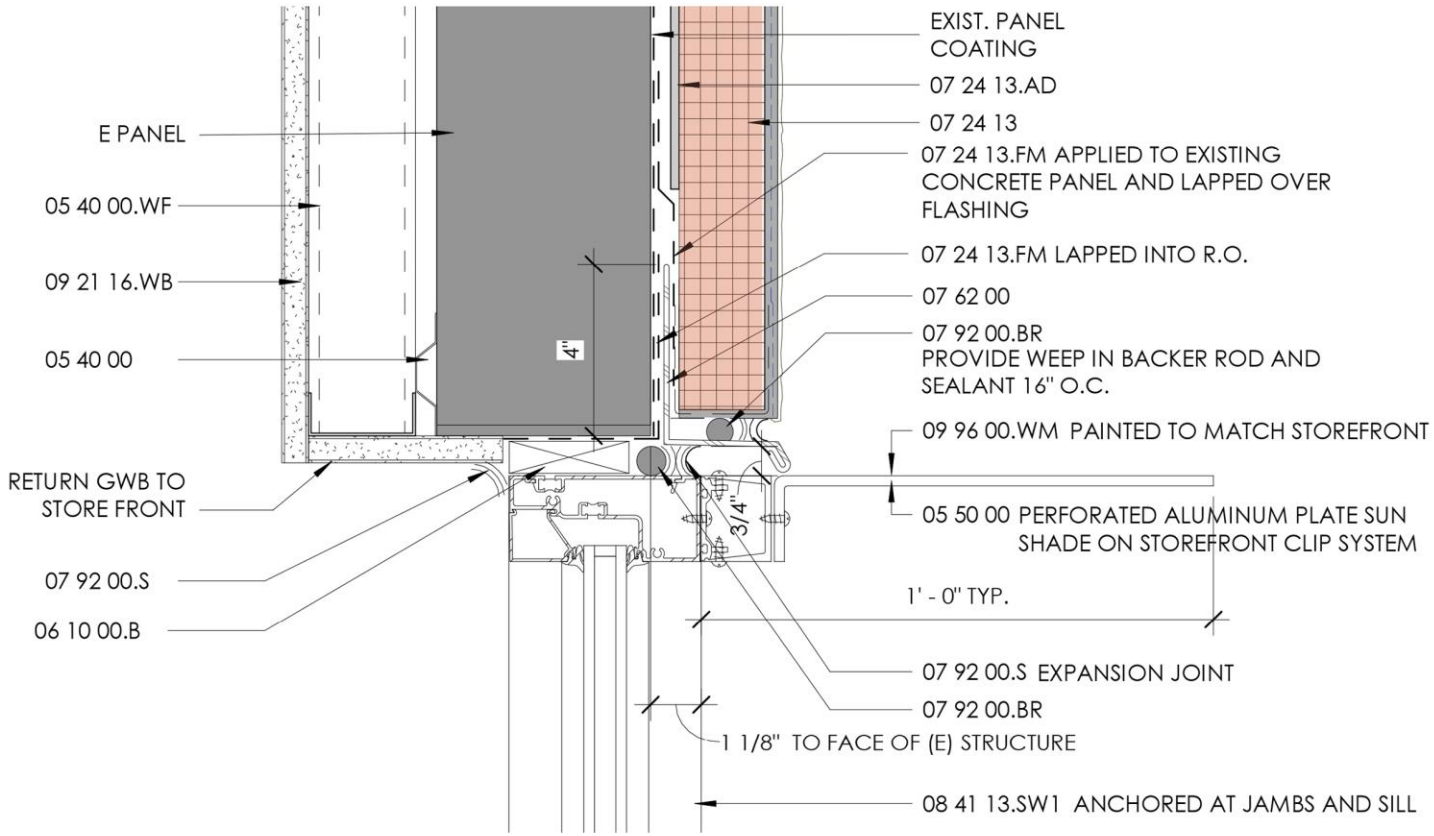


Average R-Value: **R-24**

HIGH PERFORMANCE ENVELOPE: AIR INFILTRATION & THERMAL



SECTION AT TYPICAL WALL



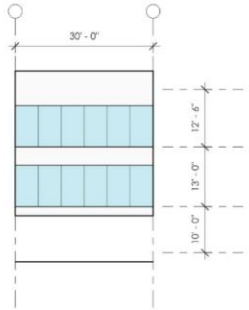
DETAIL AT TYPICAL WINDOW

HIGH PERFORMANCE ENVELOPE: DAYLIGHT

East and West

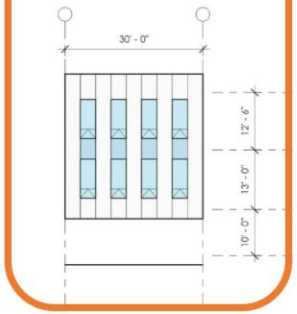
North and South

EXISTING
WWR 79.9%

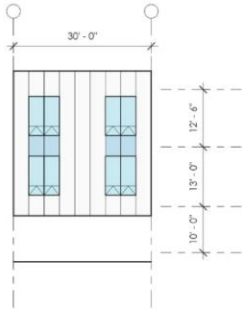


Optimo Panel Widths: 24, 30, 36, 40
Karrier Panel Widths: 24, 30, 36, 40, 42

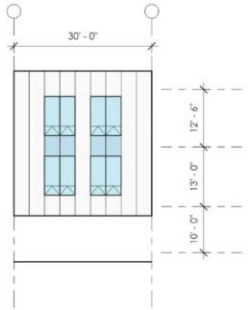
WWR 33.5%



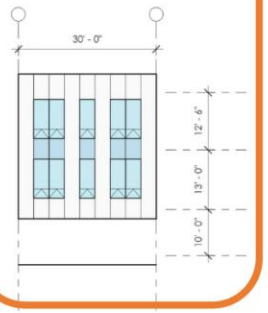
WWR 33.5%



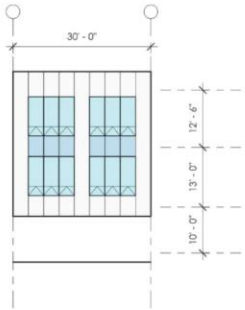
WWR 33.5%



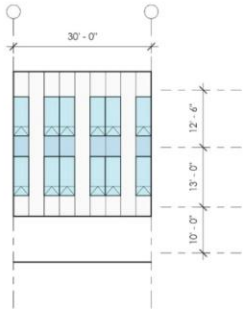
WWR 41.9%



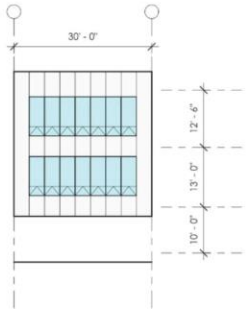
WWR 50.3%



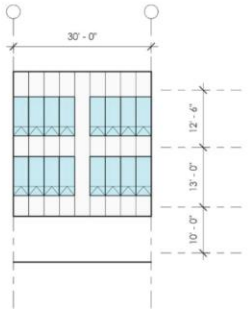
WWR 50.3%



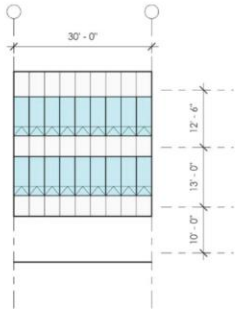
WWR 58.7%



WWR 67.1%



WWR 75.4%

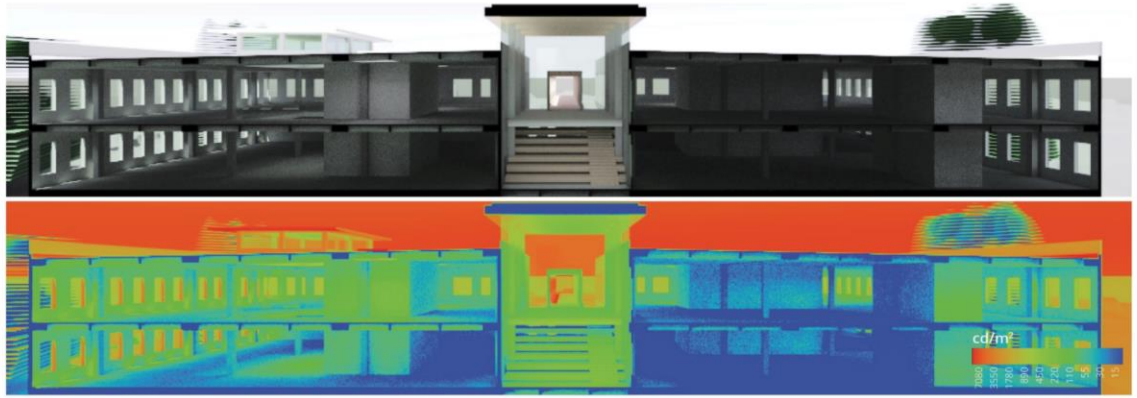


HIGH PERFORMANCE ENVELOPE: DAYLIGHTING - FINAL MODEL

40% WWR N & S, 30% WWR E & W + EXISTING WINDOW HEAD + NEW SILL + LIMITED SKYLIGHTS

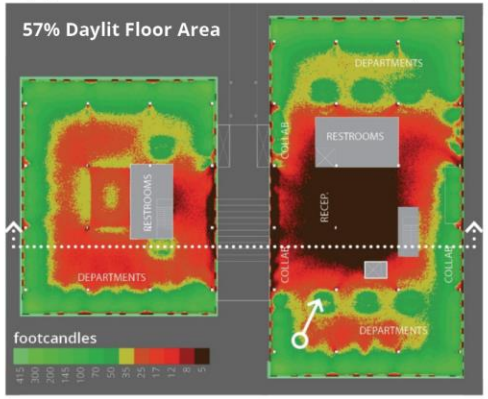
DAYLIGHT PATTERNS

Section View and Falsecolor Luminance Map, Equinox at 12pm, Clear Sky with Sun

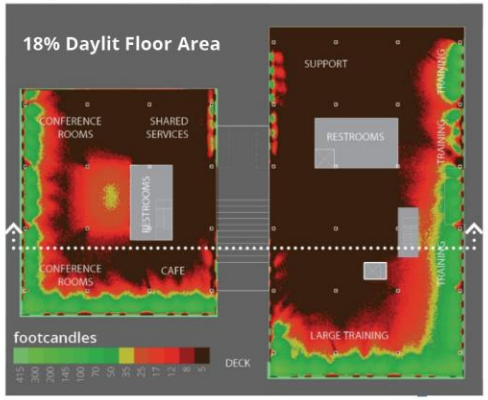


Perspective View and Falsecolor Luminance Map, Equinox at 12pm, Clear Sky with Sun

Daylight Illuminance, Uniform Overcast Sky – Top Floor



Daylight Illuminance, Uniform Overcast Sky – Mid Floor

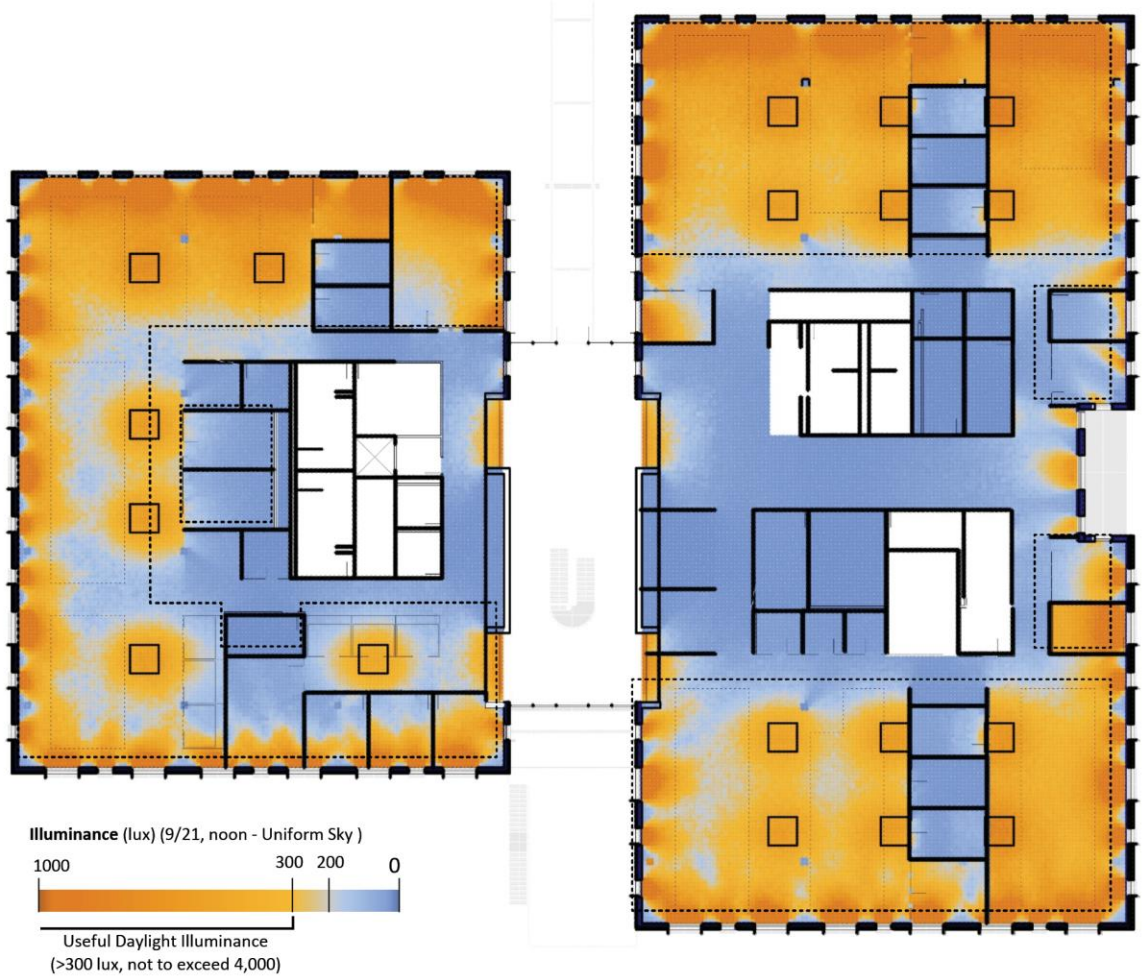


HIGH PERFORMANCE ENVELOPE: FINAL DAYLIGHTING ANALYSIS

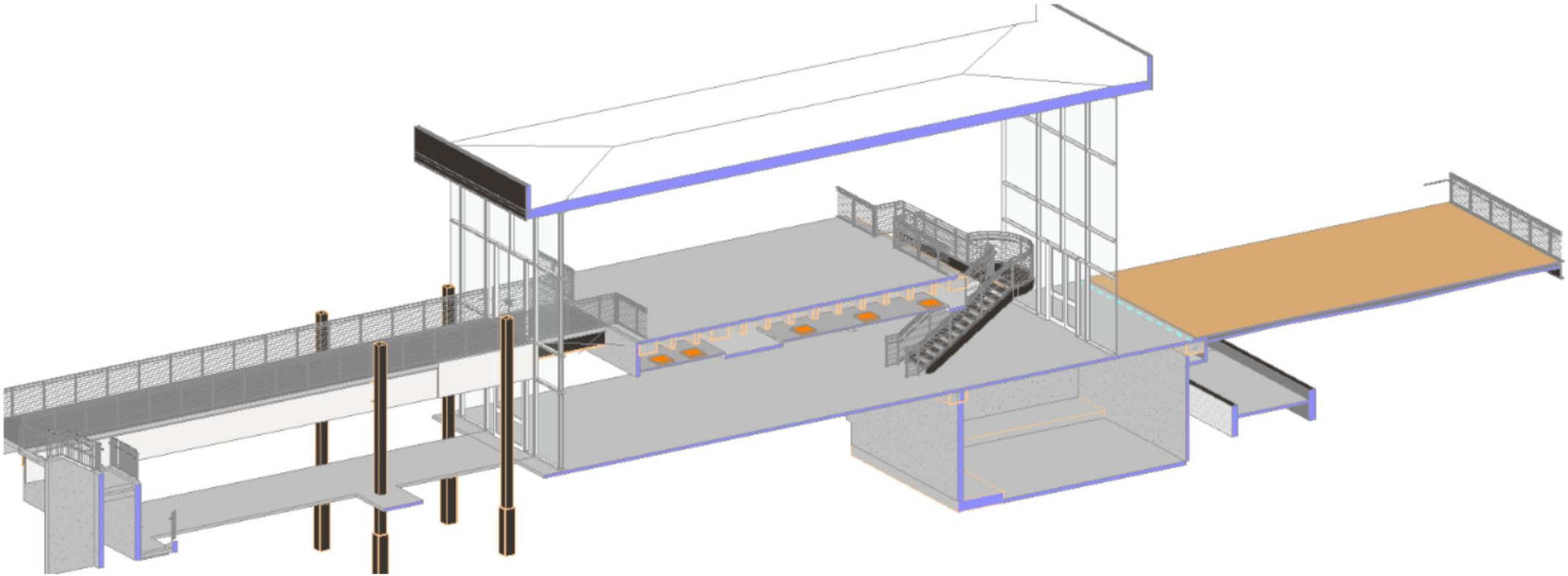
Short Windows, 18 Skylights

57%

Percentage of regularly occupied work spaces on the upper level with useful daylight illuminance (>300 lux) at the work plane



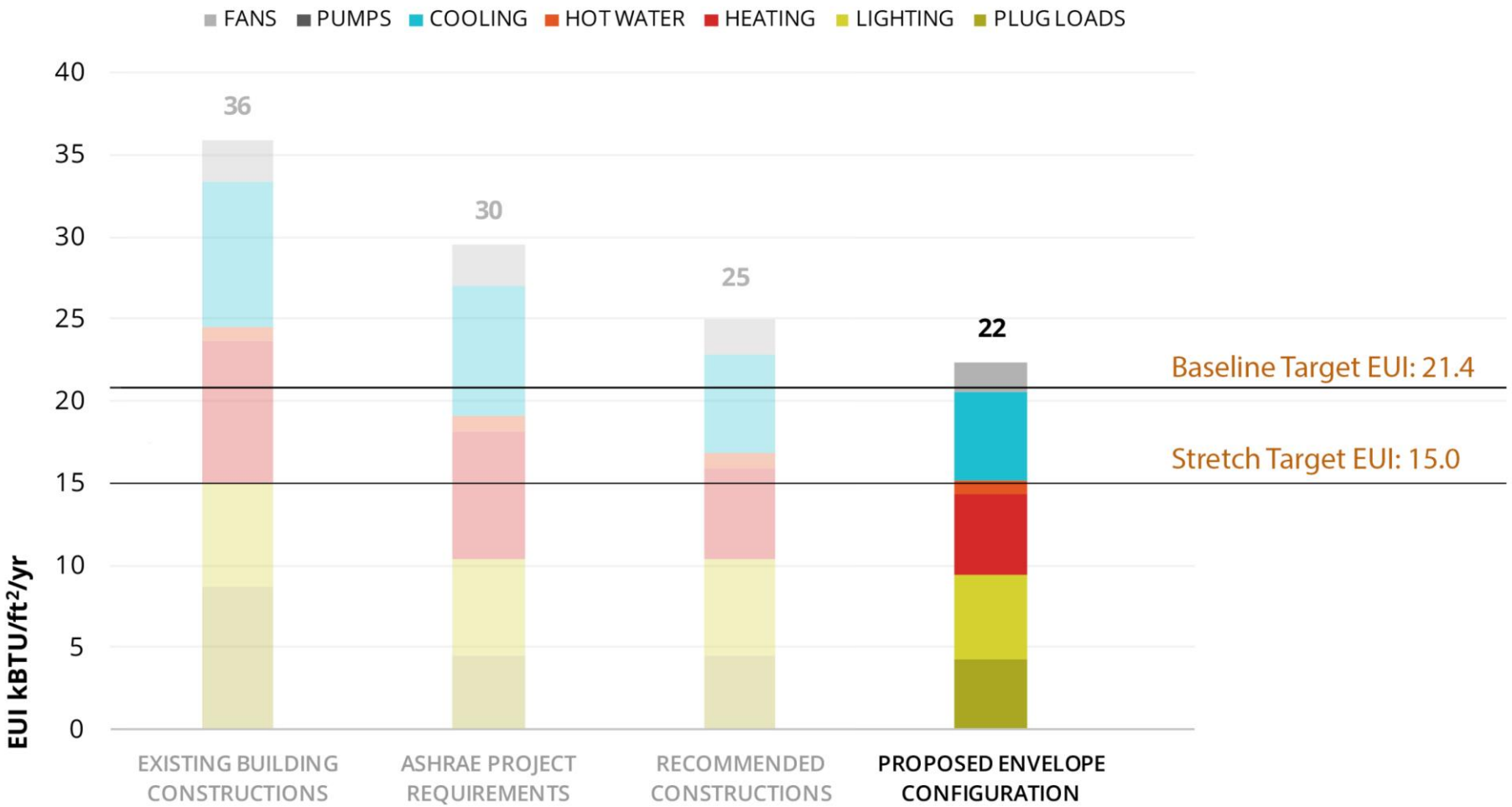
HIGH PERFORMANCE ENVELOPE: “LIGHTLY TEMPERED” ATRIUM



HIGH PERFORMANCE ENVELOPE: SUMMARY

Air Infiltration Rates:	.11 envelope leakage ratio (ELR75) or 7,122 cubic feet per minute (CFM75)
Window Wall Ratios:	29% on East/West walls ; 38% on North/South walls
Daylight Autonomy:	57% overall
Exterior Cladding:	EIFS with 3.5” of R5 insulation over existing. R17 overall
Window Performance:	U- 0.4; SHGC - 0.25; overhang/shade depth - 12” optimal
Skylights:	18 skylights on top floor
Roof:	R 39 total - adding approximately 4” new insulation.

HIGH PERFORMANCE ENVELOPE: EUI IMPACTS



BUILDING INNOVATION
Conference

RIGHT STEPS IN THE RIGHT ORDER

Baseline Analysis
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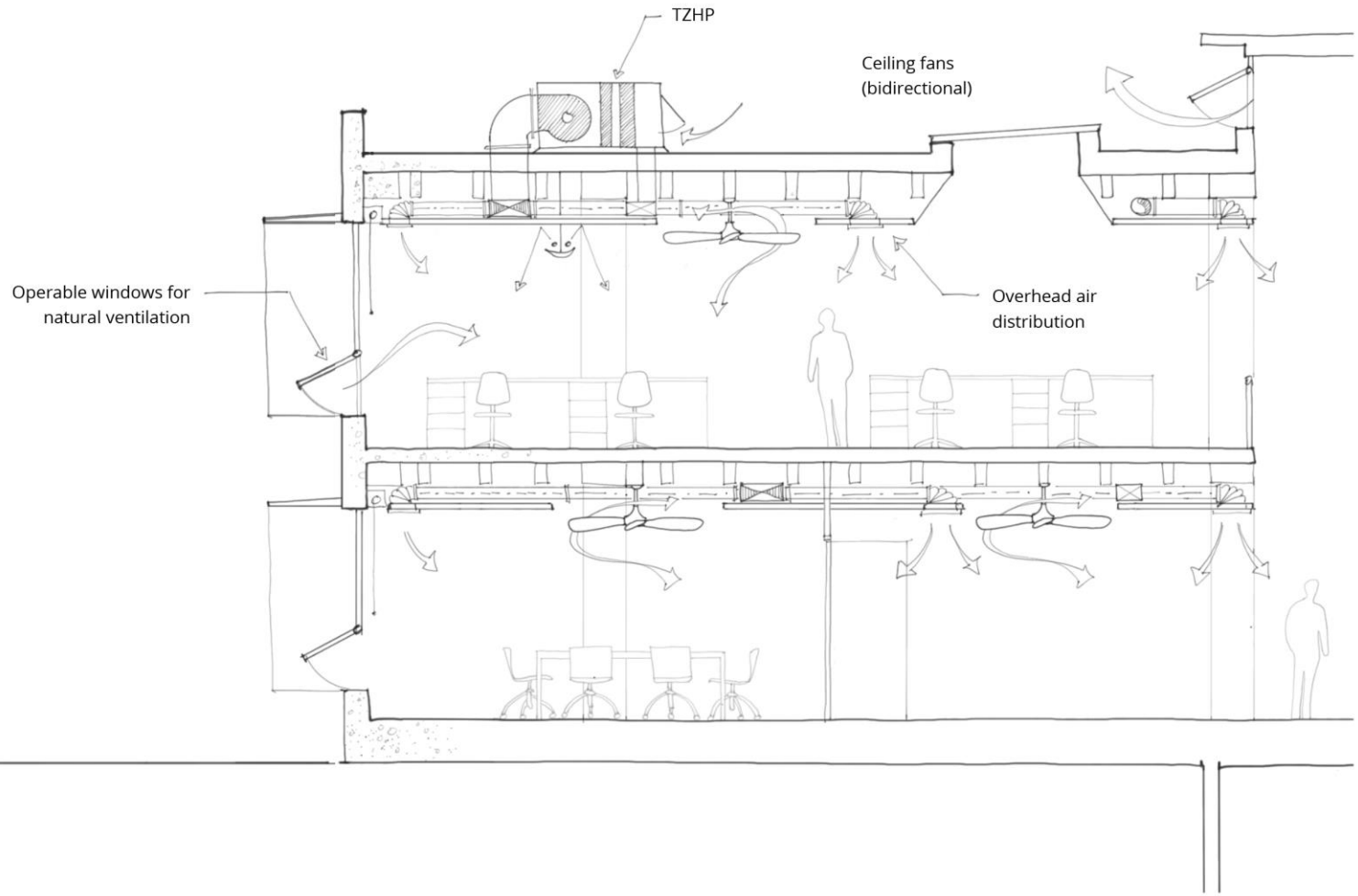
HVAC OPTION 1 - ALL AIR TZHP SYSTEM

System Type
Rooftop Packaged Thermodynamically Zoned ASHPs with DOAS, enthalpy heat recovery, DCV, and a desiccant wheel

Air Distribution Options
Overhead, Mixed Air

Mixed-Mode Ventilation
Operable windows and atrium exhaust
Ceiling fans with reverse control

Night-Flush / Airside Economizer
Fan-assisted night flush



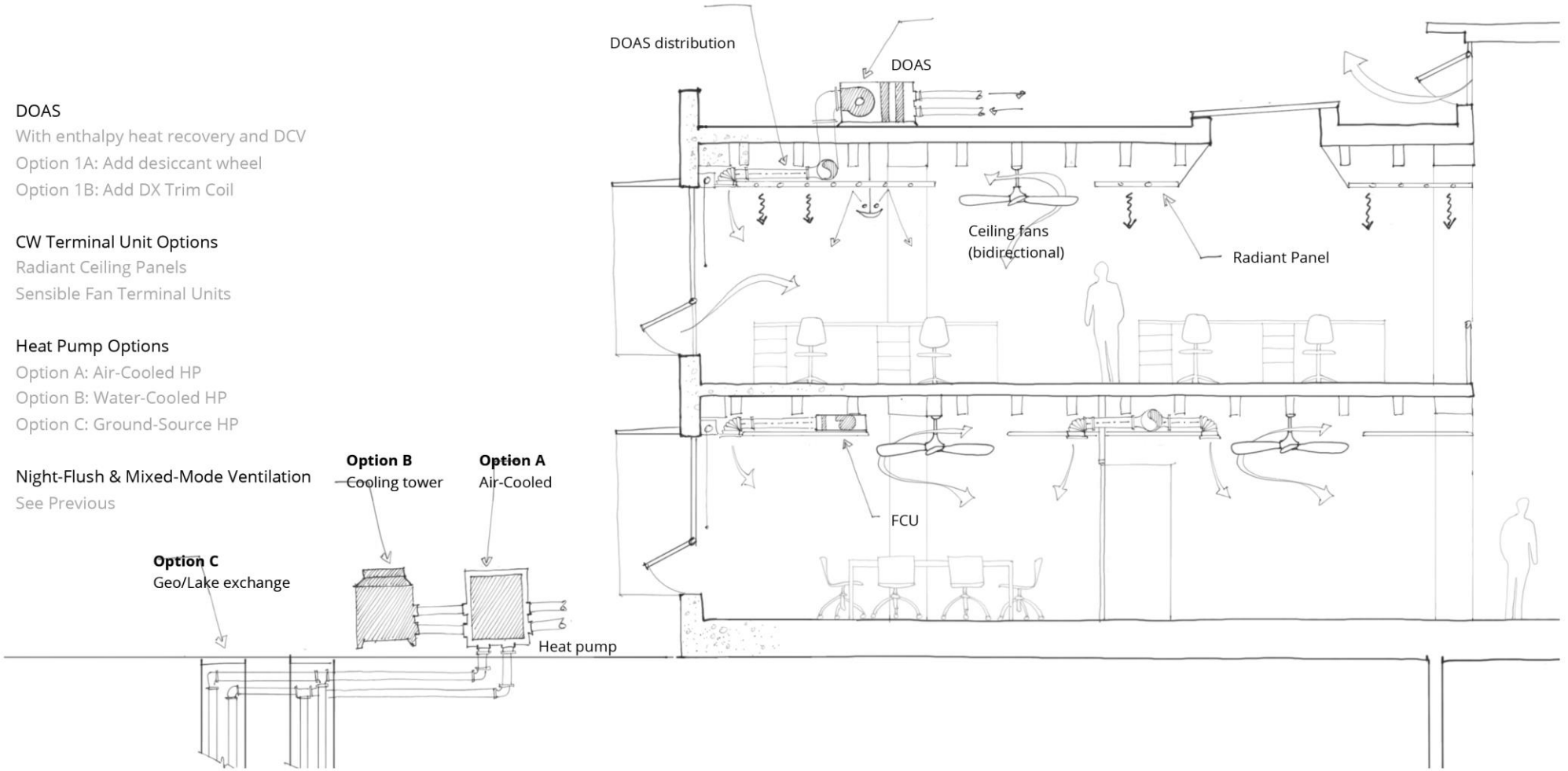
HVAC OPTION 2 - HYDRONIC SYSTEM

DOAS
With enthalpy heat recovery and DCV
Option 1A: Add desiccant wheel
Option 1B: Add DX Trim Coil

CW Terminal Unit Options
Radiant Ceiling Panels
Sensible Fan Terminal Units

Heat Pump Options
Option A: Air-Cooled HP
Option B: Water-Cooled HP
Option C: Ground-Source HP

Night-Flush & Mixed-Mode Ventilation
See Previous



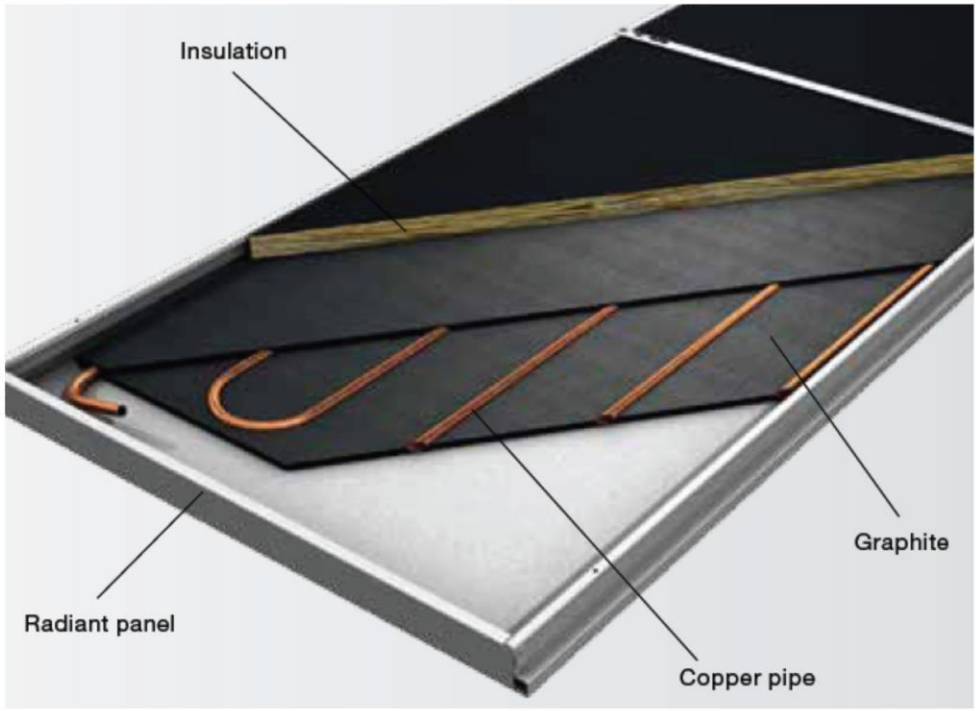
HYDRONIC OVERHEAD PANELS

Panels contain a multi-pass single circuit coil.

Panels may be piped in series (up to 64 square feet of active panel)

Quick disconnects for hoses allow for ease of installation and replacement.

Piping to the panels will be PEX tubing concealed above the cloud/array.

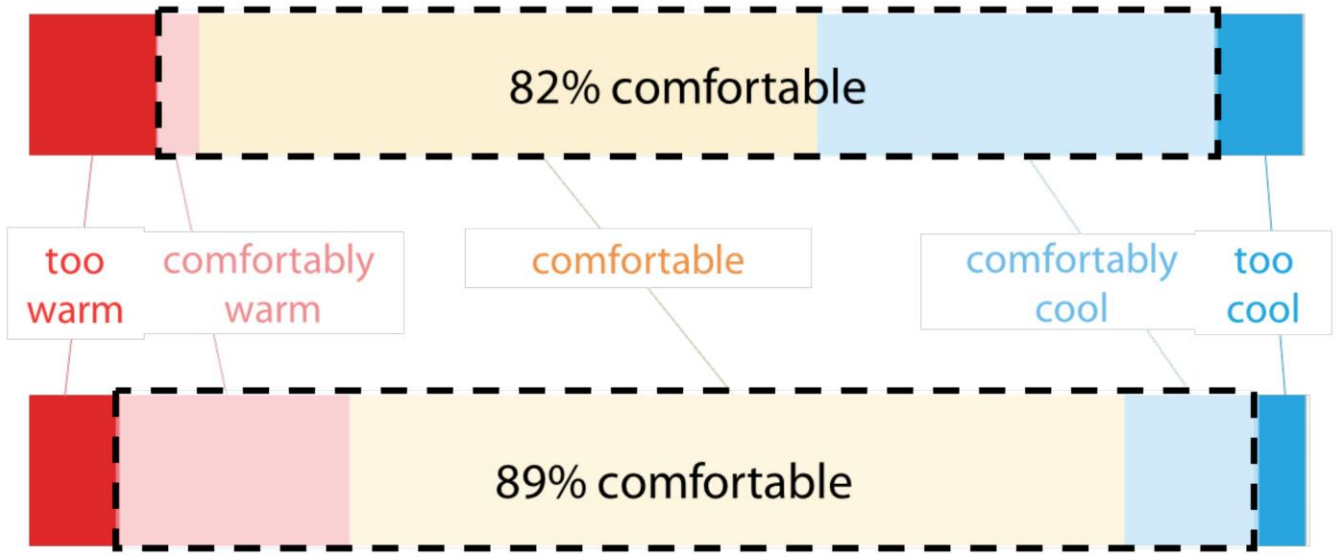


ASHRAE HYDRONIC SYSTEM OVERVIEW - CEILING FANS

Before fan install

Indoor temperature ~ 72 °F

(n = 29)



After fan install

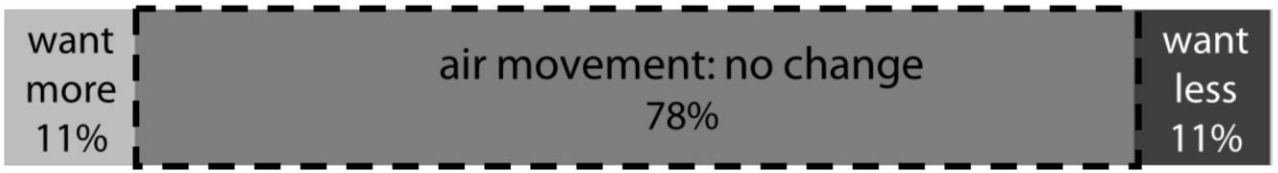
and air conditioning failure

Indoor temperature ~ 80 °F

(n = 28)

Air speeds

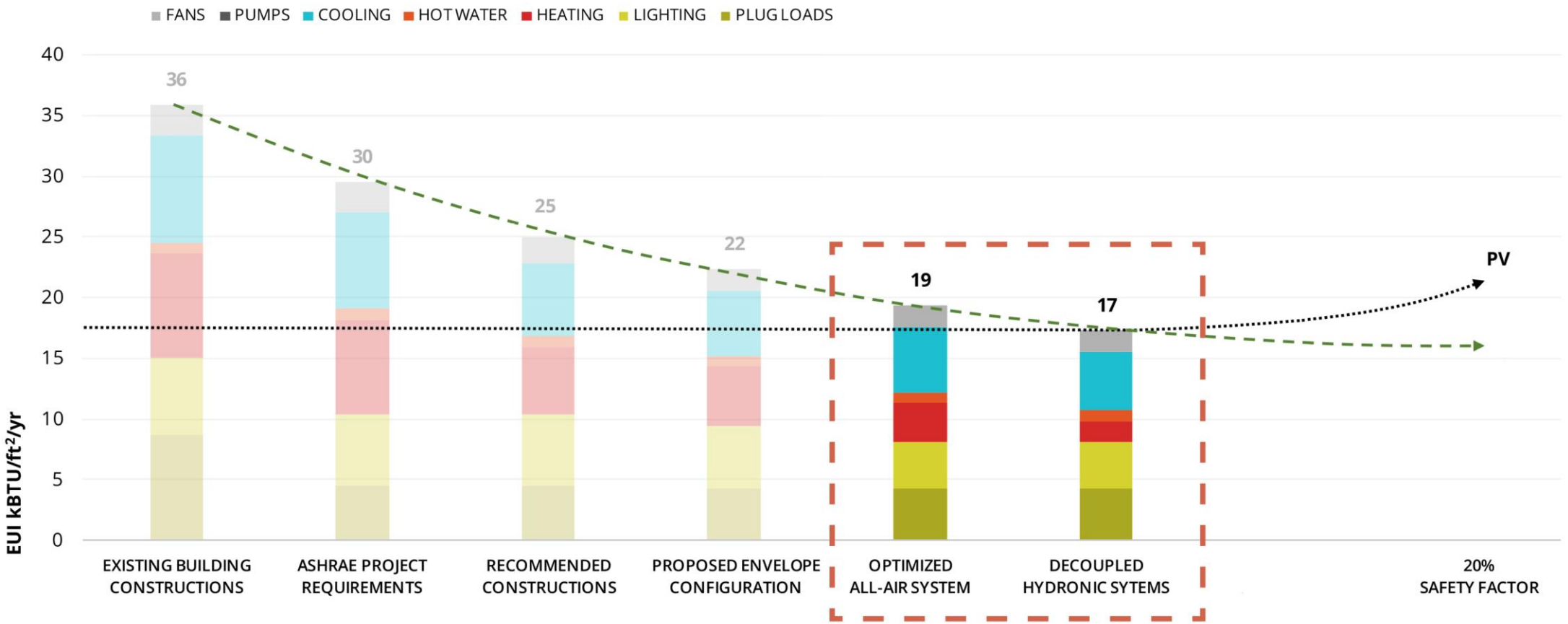
~40 – 150 fpm



HYDRONIC SYSTEM INFRASTRUCTURE

HYDRONIC SYSTEM INSTALLATION

HVACR SYSTEMS - EUI IMPACTS



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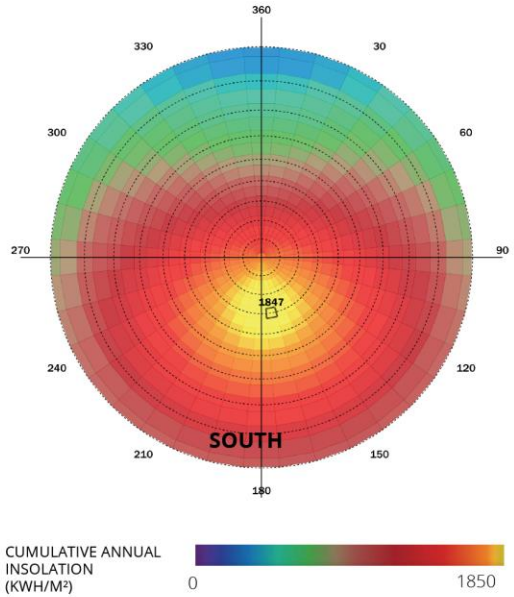
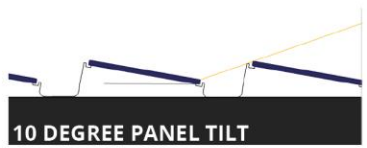
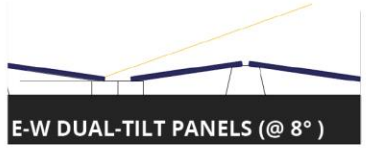
ENERGY GENERATION - PHOTOVOLTAICS

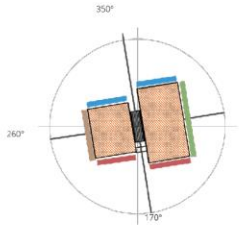
Rooftop Photovoltaic (PV) Generation Potential

Key Climate Factors: Atlanta Georgia







	Option 1	Option 2	Option 3
Annual Insolation (kWh/m2)	1847	1787	1657 (West-Facing) / 1632 (East)
PV Panel Efficiency (%)	19%	19%	19%
System Losses (%)	15%	15%	15%
Inverter Losses (%)	4%	4%	4%
PV Panel Area (55-68% Roof Utilization*) (m2)	620 -713	884 -1,078	1,178 -1,430
DC System Size (kW)	118 -136	168 -205	224 -272
Annual PV Generation Potential (kWh/yr)	180,000 - 207,000	248,000 - 299,000	304,000 - 365,000
Annual PV Generation Potential (EUI**) (kBtu/ft2/yr)	**9 -10**	**12 -15**	**15 -18**
Schematic Layout				

* Total roof area used for PV panel area estimate = 27,017 ft2 (2,510 m2)

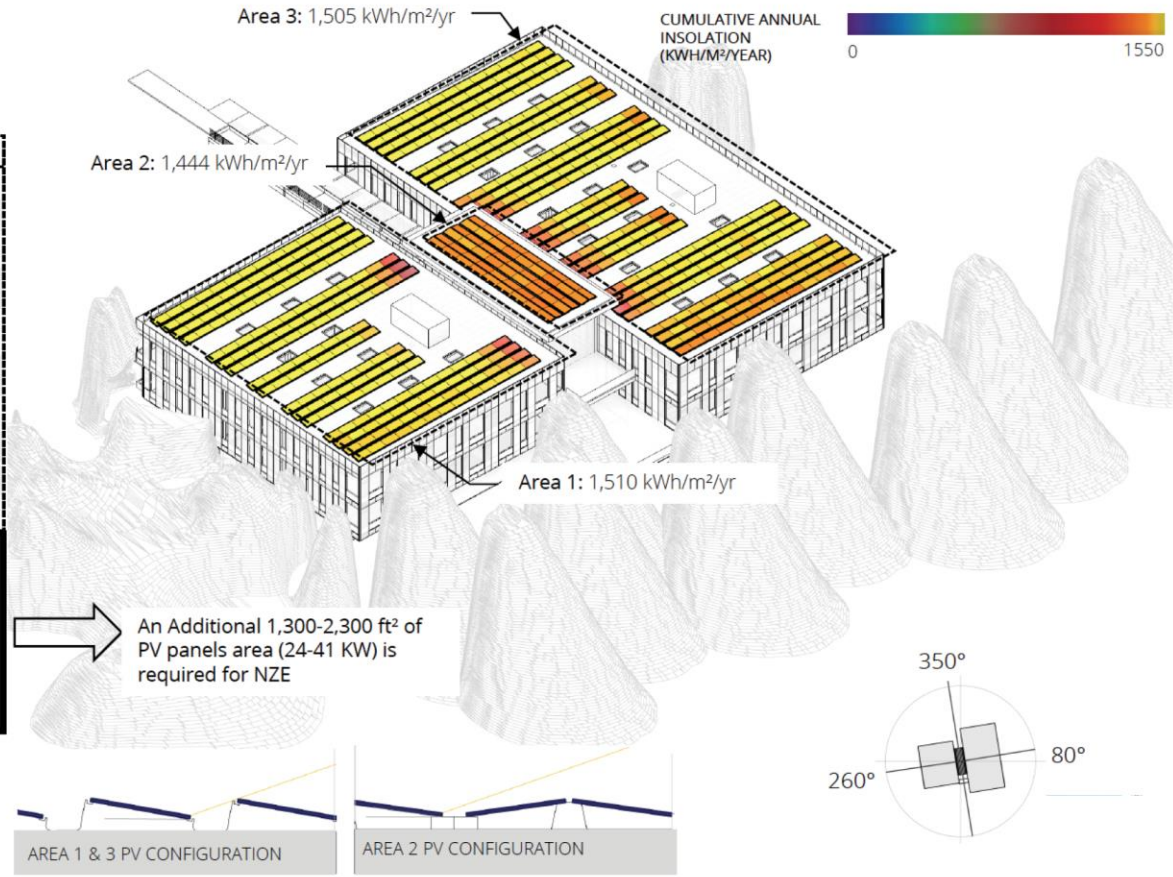
** Floor area used for EUI calculation: 68,118 ft2 (6,328 m2)

ENERGY GENERATION - PHOTOVOLTAICS

ROOFTOP PHOTOVOLTAIC (PV) ENERGY GENERATION POTENTIAL

		Area 1	Area 2	Area 3	Total
Annual Insolation	(kWh/m2)	1510	1444	1505	1,500
Array Tilt (Flat=0)	Degrees	10	8	10	8-10
Array Azimuth (S=180)	Degrees	170	80/260	170	Varies
PV Panel Efficiency	(%)	19.5%	19.5%	19.5%	19.5%
System Losses	(%)	15%	15%	15%	15%
Inverter Losses	(%)	4%	4%	4%	4%
PV Panel Area	(m2)	378	116	594	1,088
Roof Utilization	(%)	38%	60%	39%	40%
# 405W Panels*	#	183	54	295	532
DC System Size	(kW)	74	22	119	215
Annual Energy Generation Potential	(kWh/yr)	91,000	27,000	142,000	260,000
Annual EUI Offset (EUI**)	(kBtu/ft2/yr)	4.57	1.35	7.13	13.0
Annual Energy Generation Per Panel Area	(kWh/m²/yr)	241	233	239	239

* Based on LG NeON 2 (405W) Dimensions and Specifications
** Floor area used for EUI calculation: 68,000 ft2



System Provides 332KW of capacity; Utilization capped by utility at 250KW

PHOTOVOLTAICS INSTALLATION

BUILDING INNOVATION
Conference

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TESTING AND MONITORING DURING CONSTRUCTION

Infiltration Testing:

Air infiltration target- set ASHRAE's highest performance target:

.11 envelope leakage ratio (ELR75) or
7,122 cubic feet per minute (CFM75)

Air Infiltration final testing:

.34 envelope leakage ratio (ELR75) or
22,382 cubic feet per minute (CFM75)

Factors contributing to a higher rate:

Exterior doors were not completely installed - thresholds and seals were missing.
Biggest culprit was a valve in the DOAS units that under positive pressure is designed to open to the outside, to release the pressure. This was not fully understood and the valve was not able to be completely shut during testing.

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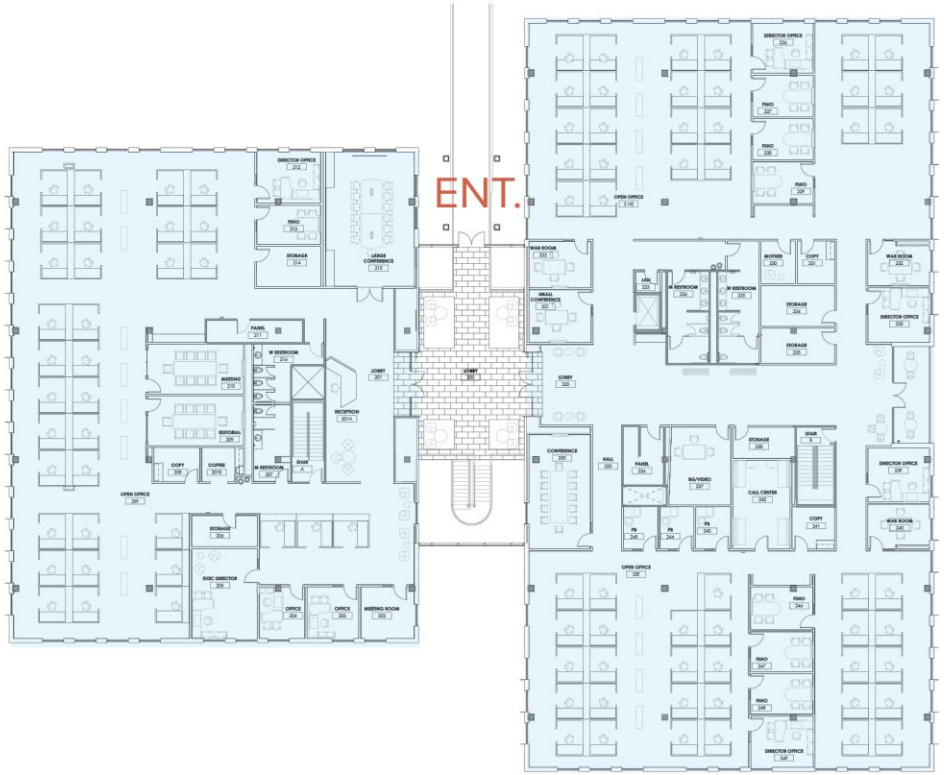
FINAL LAYOUT

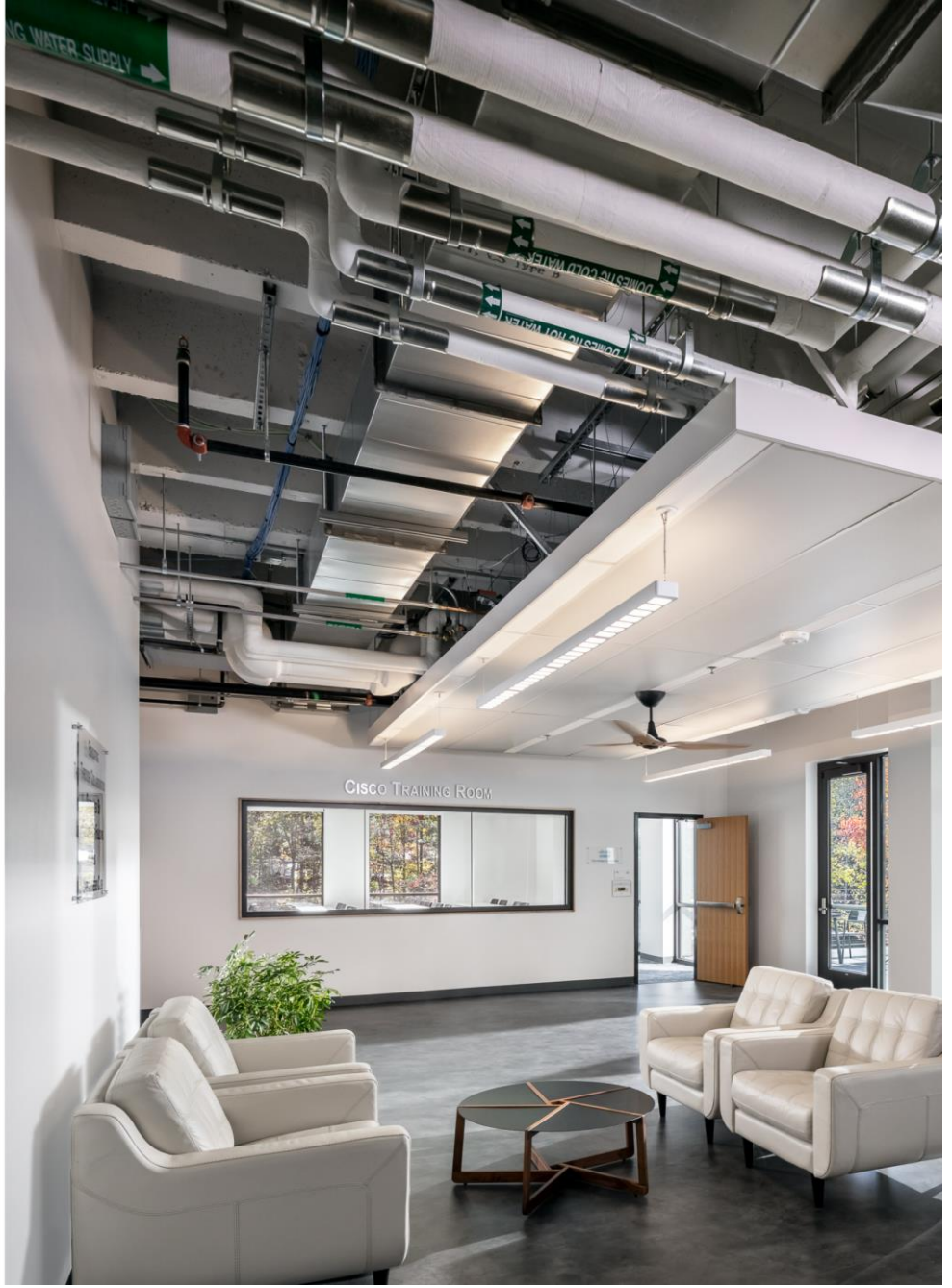


UPPER / ENTRY LEVEL
OFFICES / MAIN ENTRY

MIDDLE LEVEL
OFFICES / TRAINING CENTER


DAIKIN


ASHRAE
WELCOME


Cisco Training Room

CURRENT OPERATIONAL SUMMARY

Substantial Completion and Testing done December 2020.

Soft opening January 2021 (limited employees only - COVID related)

PV Array installed October 2021 and fully operational Dec. 2021.

Training and Tours began again in late 2021.

Staff is still largely remote working.

Building has been operating at closer to 18 EUI with this reduced demand.

POST-CONSTRUCTION OCCUPANCY AND OPERATIONS

NREL is doing a deep dive analysis of the building operations that will be published in 2023.

Building operations are lower than modeled for demand loading.

The PV array, which is 332KW, is capped for use at 250KW for the time being. This was a function of the local utility permitting process and not a part of the system or intent. This equates, roughly to a sub 18 EUI for consumption.

There are ongoing adjustments with some of the equipment and BAS. These have an incremental effect on the amount of energy used.

Building is still operating at roughly NZE - this is probably due to a lower demand load. ASHRAE is actively seeing if they can optimize the systems to get the energy consumption below the 250KV.

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LESSONS LEARNED

Process is key - right steps in the right order will improve results.

Know your local market - capabilities, capacity, pricing, etc.

Carefully examine existing building infrastructure early on.

Envelope improvement scope to meet EUI targets was more intensive than originally planned.

Testing sequences and challenges - especially air infiltration.

Integration - BAS, donated materials, existing furniture, etc.

Coordination = communication. Always.

PROJECT TEAM

ARCHITECTURE:	HOUSER WALKER ARCHITECTURE
ASSOCIATE ARCHITECT:	MCLENNAN DESIGN
MEPFP ENG:	INTEGRAL GROUP
STRUCTURAL ENG:	SHEAR STRUCTURAL
AV/IT/SECURITY:	TSAV
COST MODELING:	COSTING SERVICES GROUP
ACOUSTICS:	ACUSTICA
PROJECT MANAGMENT:	COLLINS | DARDEN
CONSTRUCTION MANAGER:	SKANSKA N.A.
COMMISSIONING:	THE EPSTEN GROUP
TESTING:	SK COLLABORATIVE

Thank you

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