ASHRAE HQ NZE Renovation

INTEGRAL | ELEMENTA

HOUSER WALKER ARCHITECTURE
MCLENNAN DESIGN
ASHRAE

OVERVIEW

OVERVIEW

CHALLENGE

ASHRAE future global headquarters

Renovating a 67,000 ft^2 building from 1978 near Atlanta, GA

Demonstrate a replicable process

For retrofitting a mid-century building

Achieve net-zero energy performance

While providing an exceptional workplace

Target maximum EUI 21.4 kBtu/ft^2/yr

Before renewable energy. Aspirational target 15 kBtu/ft^2/yr

VISION

Showcase for latest technology

Destination venue for industry visitors

Superior efficiency

While providing a healthy and comfortable environment

Represent sustainability values

That ASHRAE has long held

Have a net-zero energy operation

And a zero-carbon footprint

PRINCIPLES

Climate and place inform design

Envelope tailored to task and orientation

Daylight as primary lighting source

Minimal reliance on electric lighting

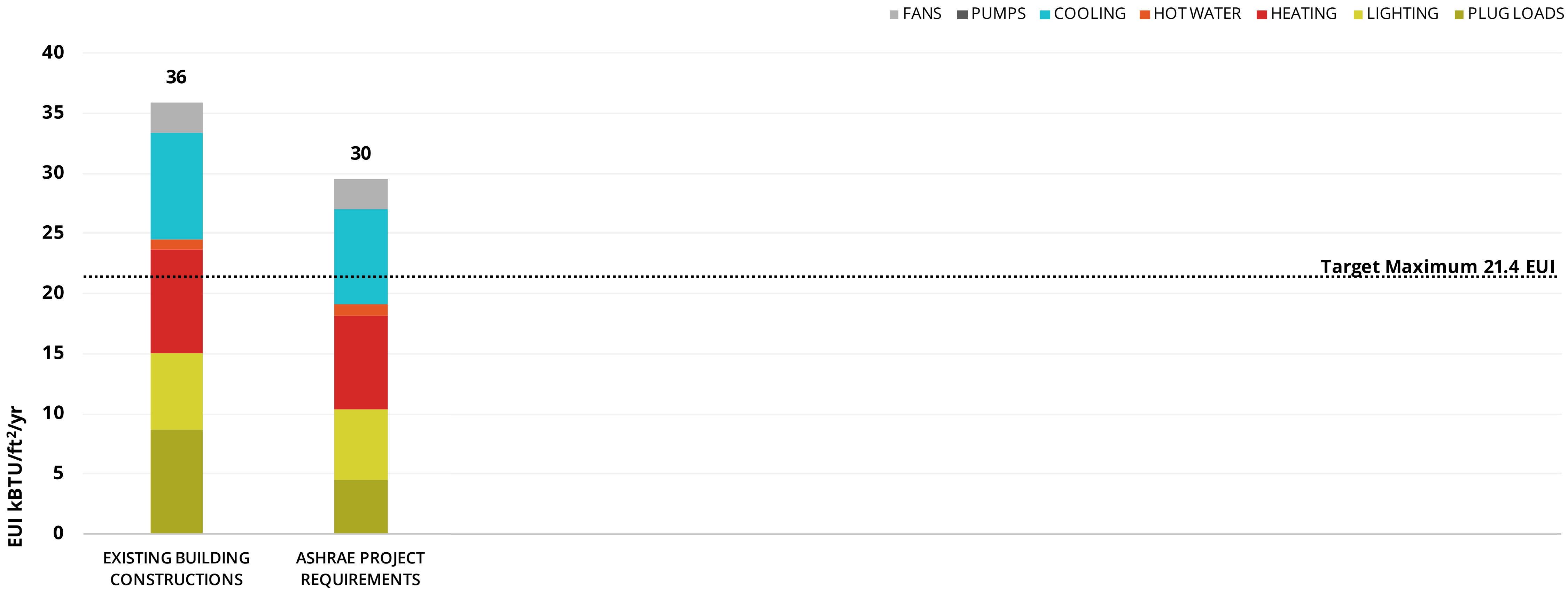
Expanded thermal comfort range

Natural ventilation when appropriate

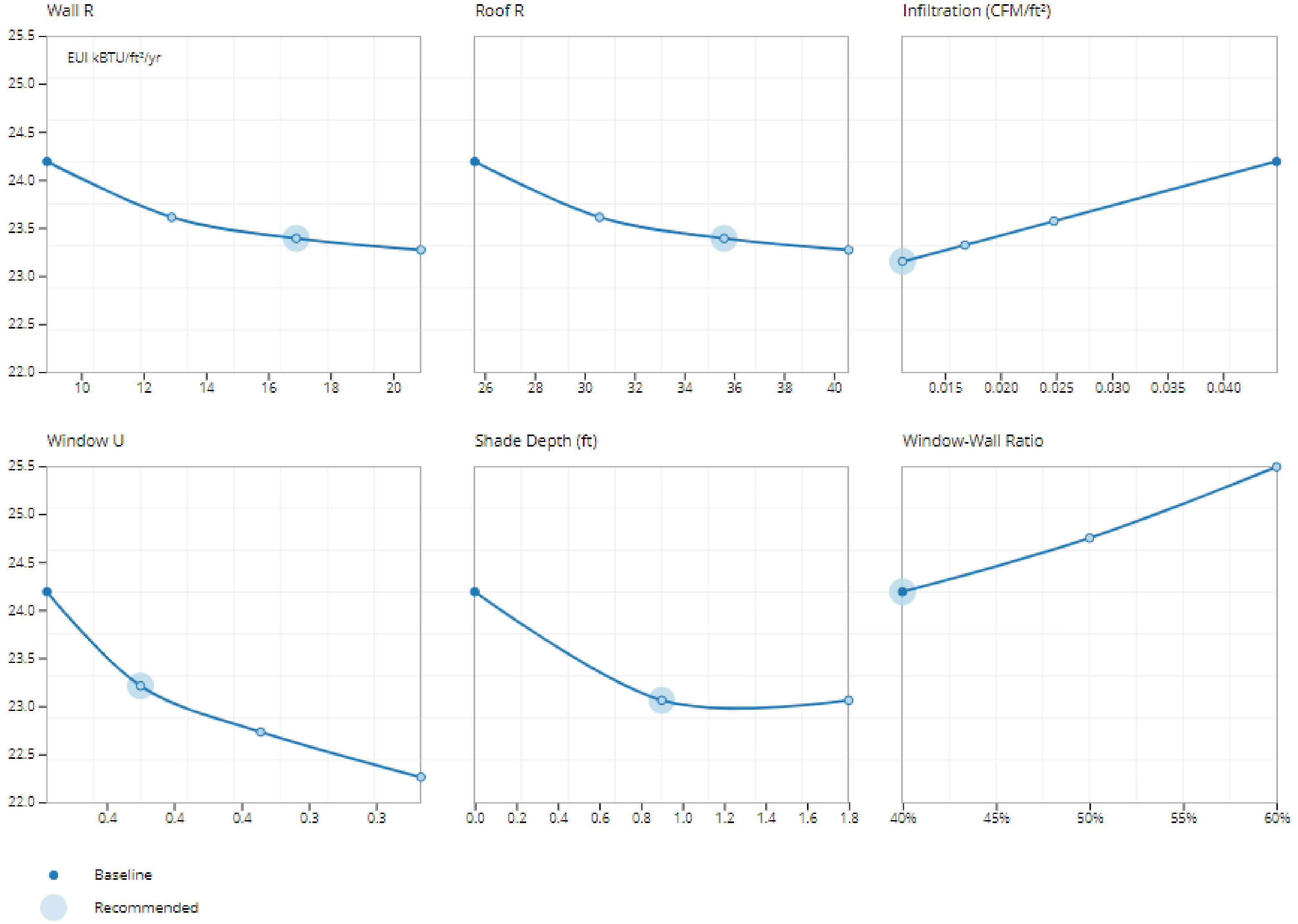
Low energy use systems

Spaces zoned thermally and acoustically

PATH TO NET ZERO ENERGY



SENSITIVITY ANALYSIS



Evaluate a series of envelope measures

To understand the sensitivity of individual characteristics

X-axes show incremental improvement

In the specific studied parameter over baseline values

Y-axes show associated impact

of improvement on annual energy use intensity

R-17 walls, R-35 roof, U-0.4 windows

Targets based in diminishing returns

PARAMETRIC STUDY

Parallel coordinates plot

To better understand the effect of different parameters

Left axes each represent a parameter

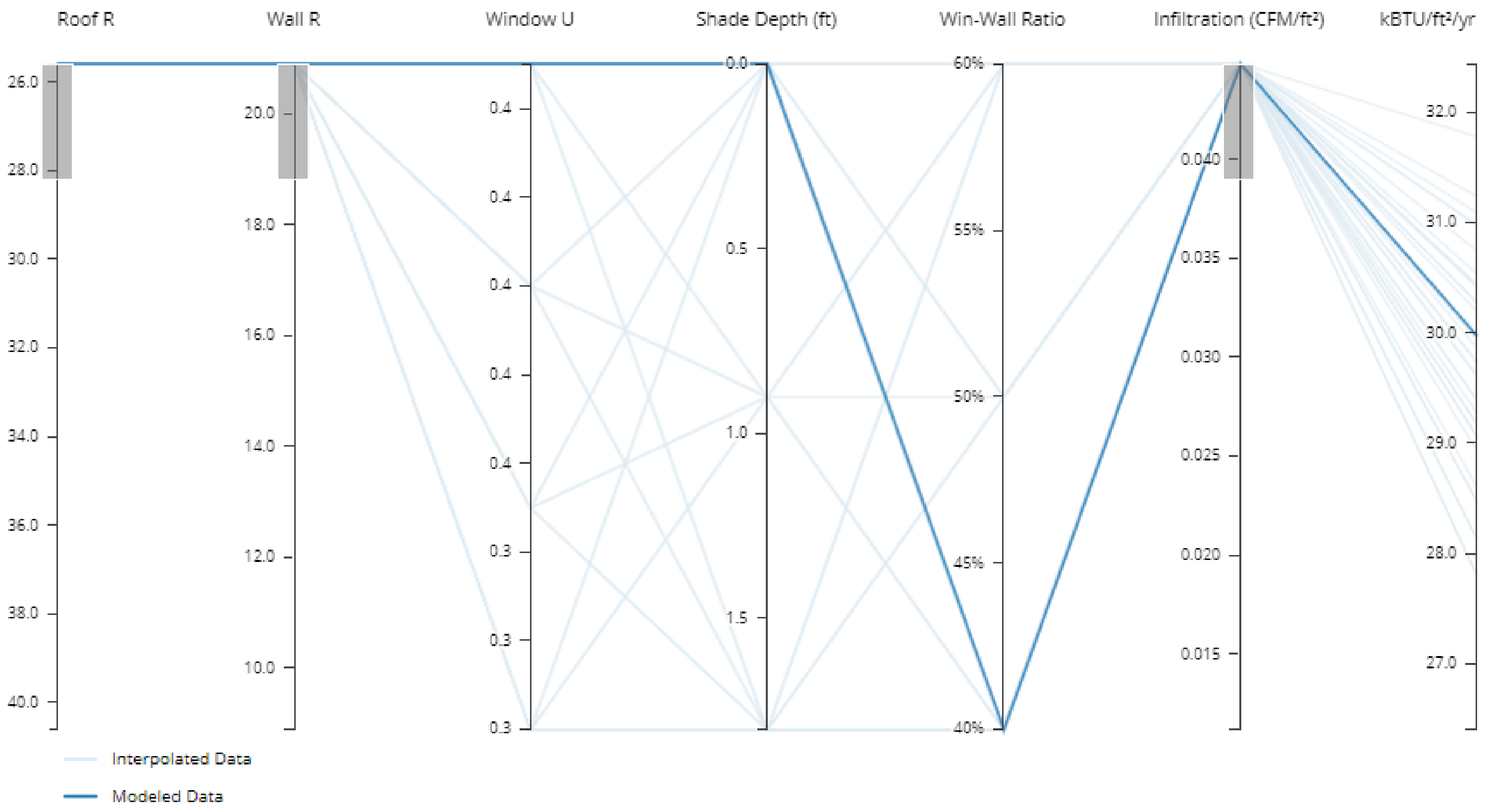
And the different evaluated properties

Right axis presents energy use intensity

Resulting from the selected parameter combination(s)

Energy and surrogate model results

Lighter lines are results from statistical surrogate models



ENERGY USE CHARACTERIZATION

Breakdown of energy by end use

To identify opportunities to improve overall performance

Windows largest heat loss component

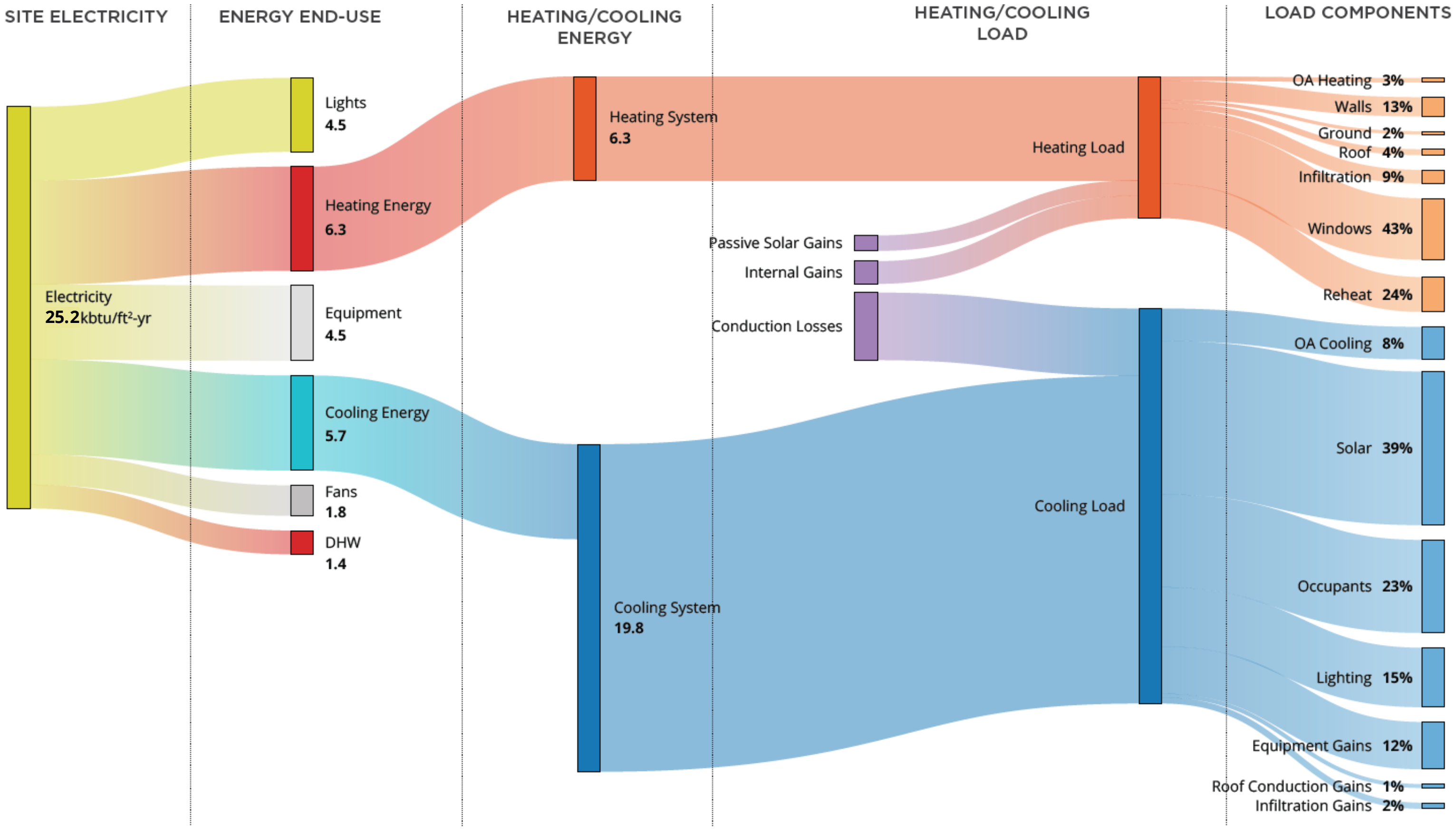
Heating ~25% of total energy use

Solar gains largest cooling component

Cooling ~25% of total energy use

Fenestration offers largest opportunity

By further reducing conductive losses and solar gains



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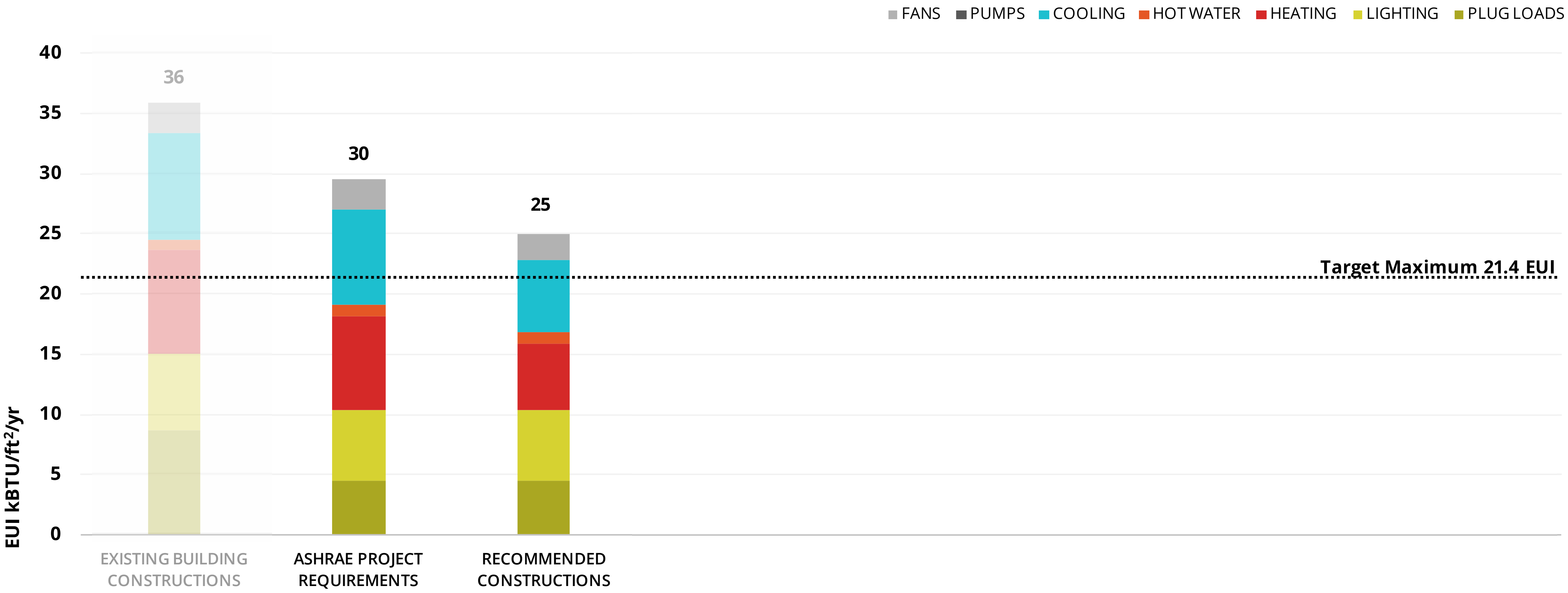


OVERVIEW

SOLAR ORIENTATION

Summer: May to September

Extreme hot period: Jul 6-12 | Max Temp 98°F (37°C)

Winter: December to February

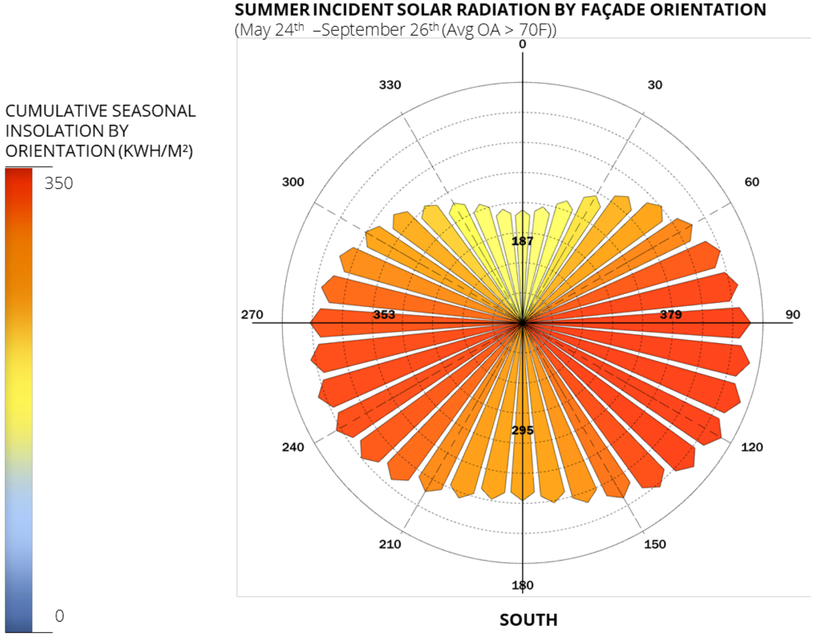
Extreme cold period: Jan 6-12 | Min Temp 9°F (-13°C)

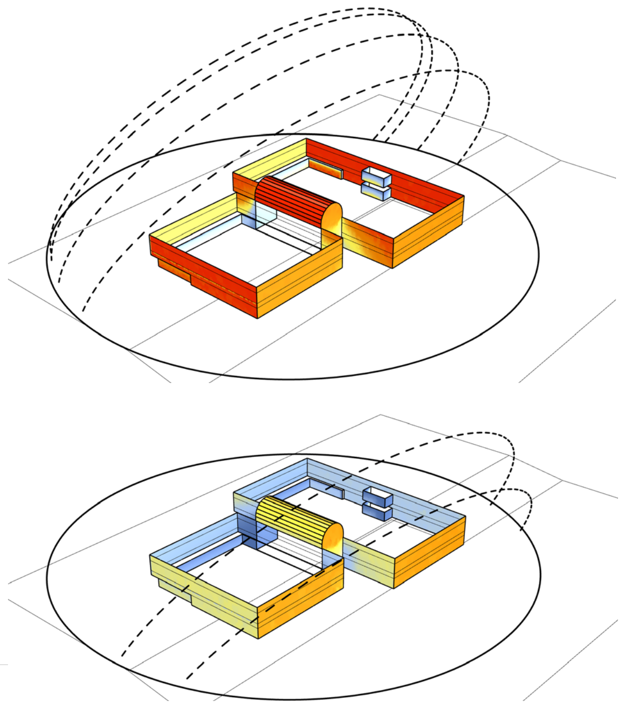
Orientations to avoid: East/West

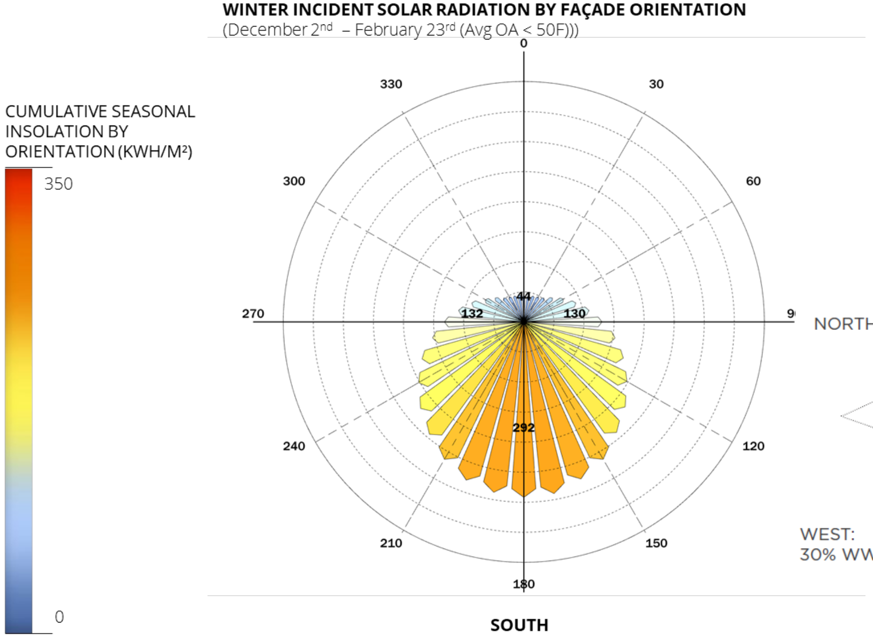
High summer solar exposure | Low solar angles

Windows to orient: North/South

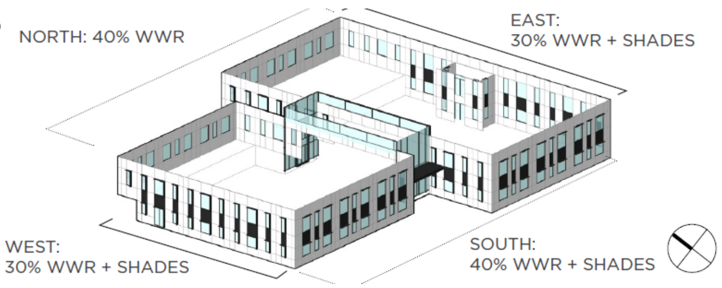
Passive winter gains | Controllable summer exposure







30% - 40% **WWR+SHADES** Based on Orientation



NATURAL VENTILATION

Natural ventilation alternates

Daytime | Night purge | RH limits

605 hours with 60% RH high limit

Indoor Air Temp > 70ºF | Outdoor Air Temp < 81ºF

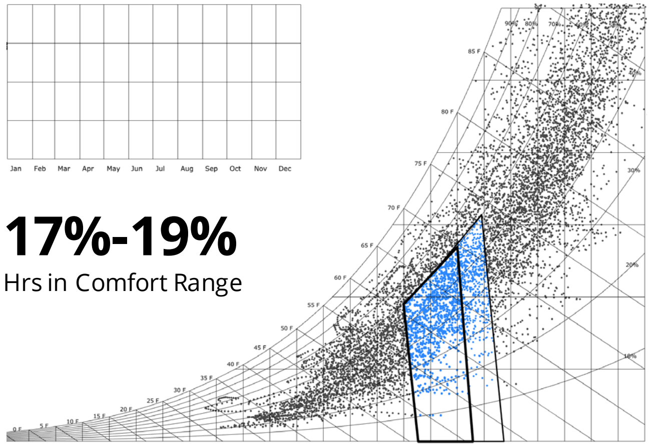
1264 hours without RH limit

Daytime operation only

3043 hours with night purge

Fan assisted nighttime economizer operation

No Natural Ventilation

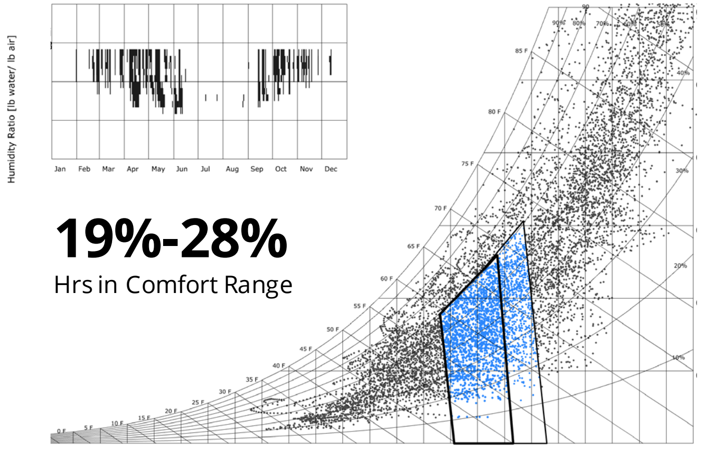


17%-19%

Hrs in Comfort Range

Indoor Operative Temperature

Daytime Ventilation / 60% RH Limit

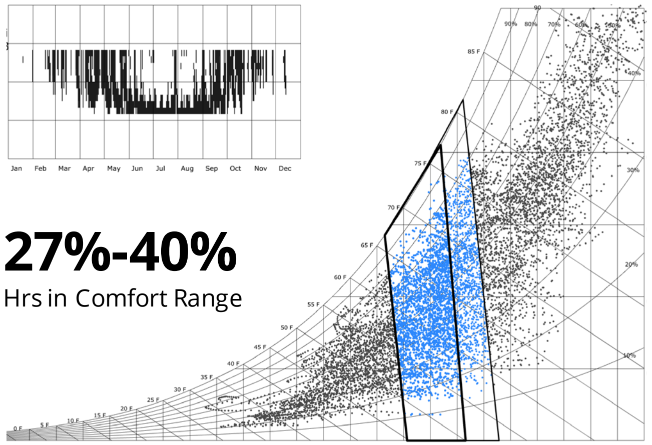


19%-28%

Hrs in Comfort Range

Indoor Operative Temperature

Daytime Ventilation / No RH Limit

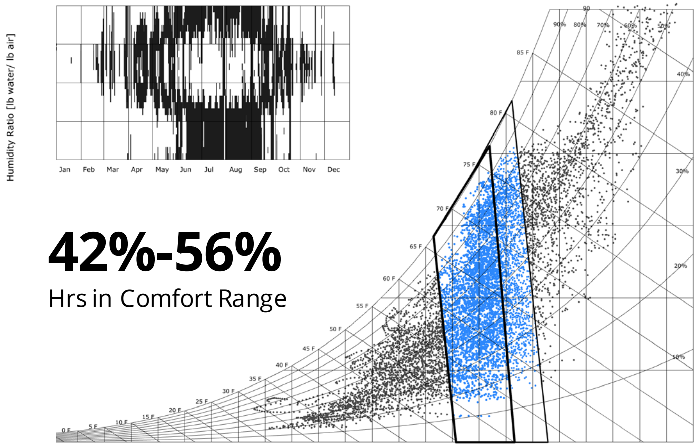


27%-40%

Hrs in Comfort Range

Indoor Operative Temperature

Day & Night Ventilation / No RH Limit



42%-56%

Hrs in Comfort Range

Indoor Operative Temperature

ONSITE RENEWABLES

12,000-14,000 ft^2 rooftop PV area

Assuming ~50% of 28,000 ft^2 roof available for PV array

210-260 kW$_p$ PV system capacity

Assuming 19.5% PV module efficiency

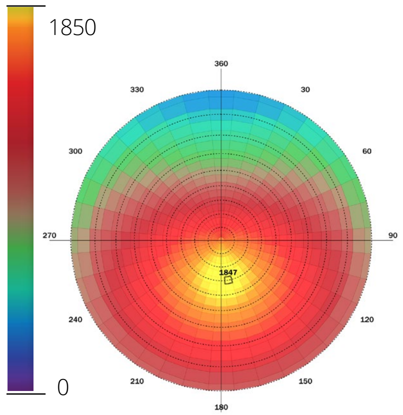
290-341 MWh annual energy generation

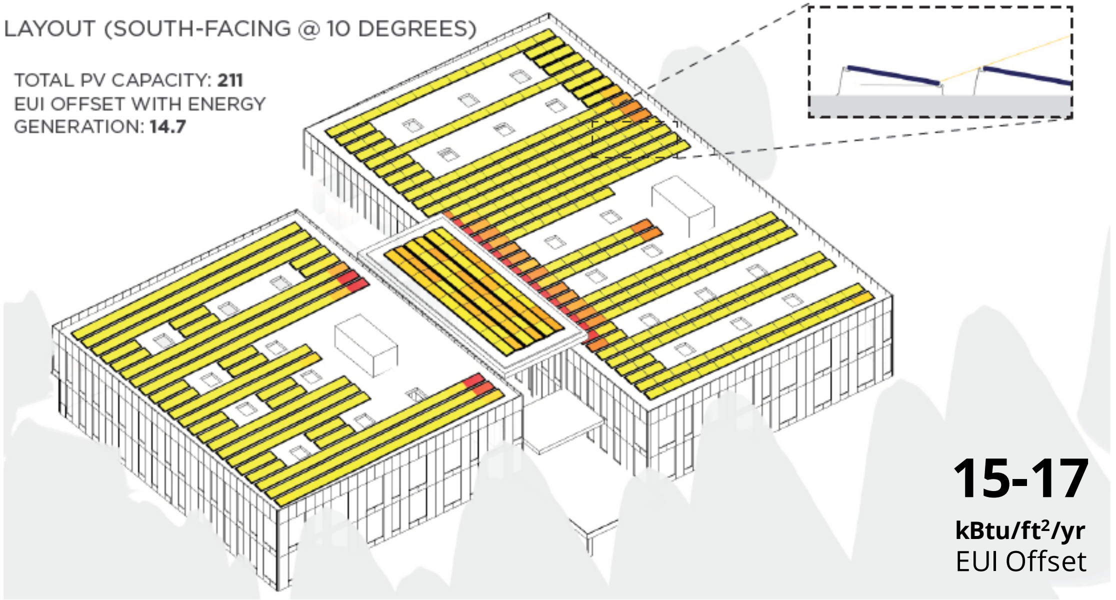
Assuming 15% inverter losses, 4% system losses

15-17 kBtu/ft^2/yr potential EUI offset

Assuming 68,000 ft^2 floor area for EUI calculations

PV CONFIGURATION 1: SINGLE-TILT LAYOUT (SOUTH-FACING @ 10 DEGREES)

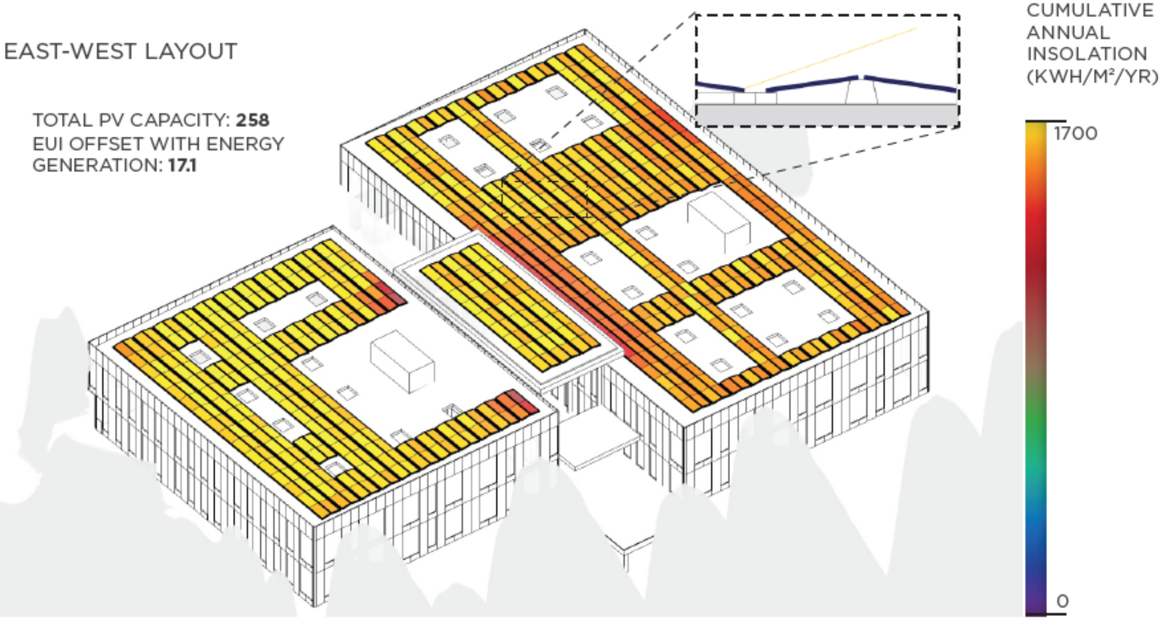




15-17
kBtu/ft^2/yr
EUI Offset

PV CONFIGURATION 2: DUAL-TILT, EAST-WEST LAYOUT

Annual Insolation	(kWh/ m2/yr)	1,615
Array Altitude	Degrees	5
Array Azimuth	Degrees	80/260
PV Panel Efficiency	(%)	19.5%
System Losses	(%)	15%
Inverter Losses	(%)	4%
PV Panel Area	(m2)	1,323
Roof Utilization	(%)	49%
# 405W Panels*		638
DC System Size	(kW)	258
Annual PV Energy	(kWh)	341,000
Annual PV Generation Potential (EUI**)	(kBtu/ ft2/yr)	17.1
Annual PV Generation Per m² Panel	kWh/m²	258



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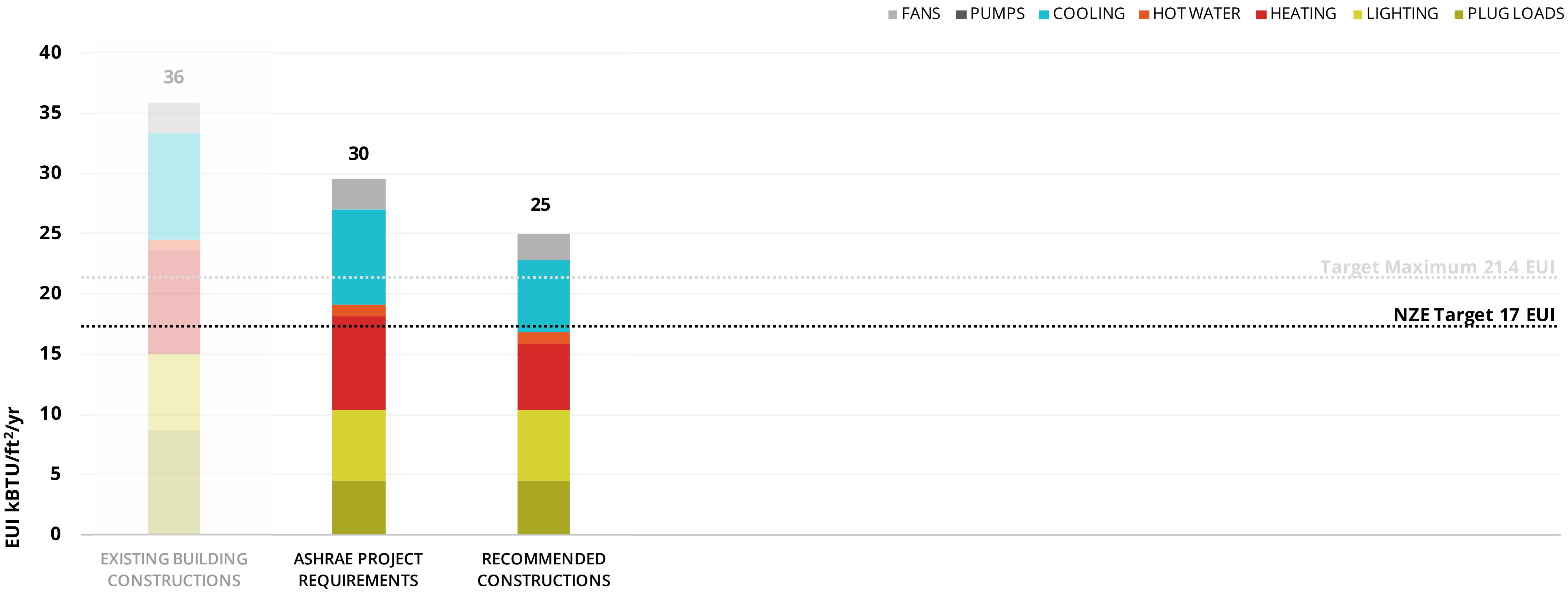


OVERVIEW

PROGRAM ORGANIZATION

First principles approach

Adapted to accommodate program criteria flexibility

A - Mixed

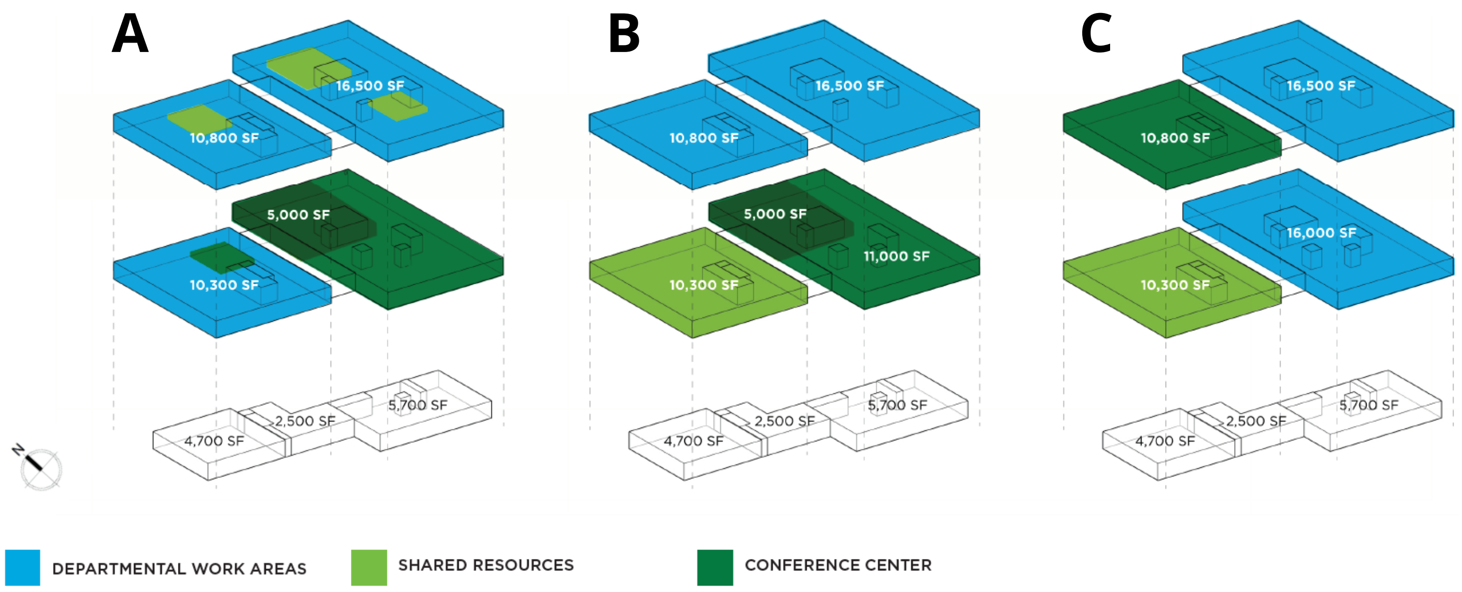
Good inter-department workflow

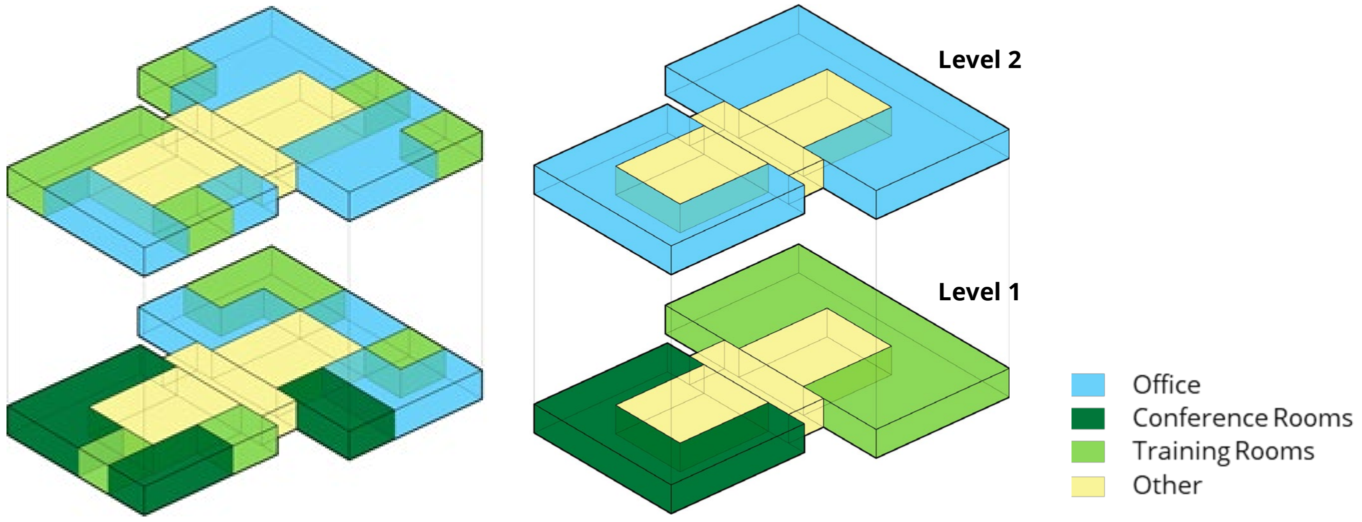
B - Stratified ✓

Best daylight | All staff on one level | Good thermal zoning

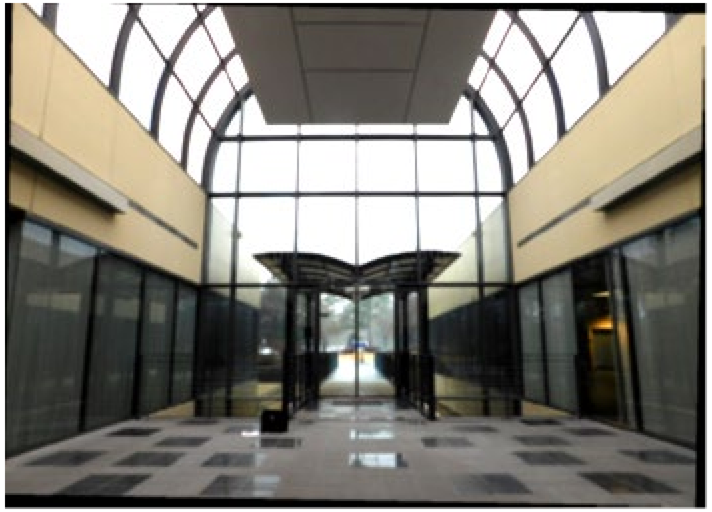
C - Stacked

Good thermal zoning | Better proportion of program areas





ATRIUM ENCLOSURE



Existing atrium is a greenhouse

Example of exactly what not to do

New opaque roof

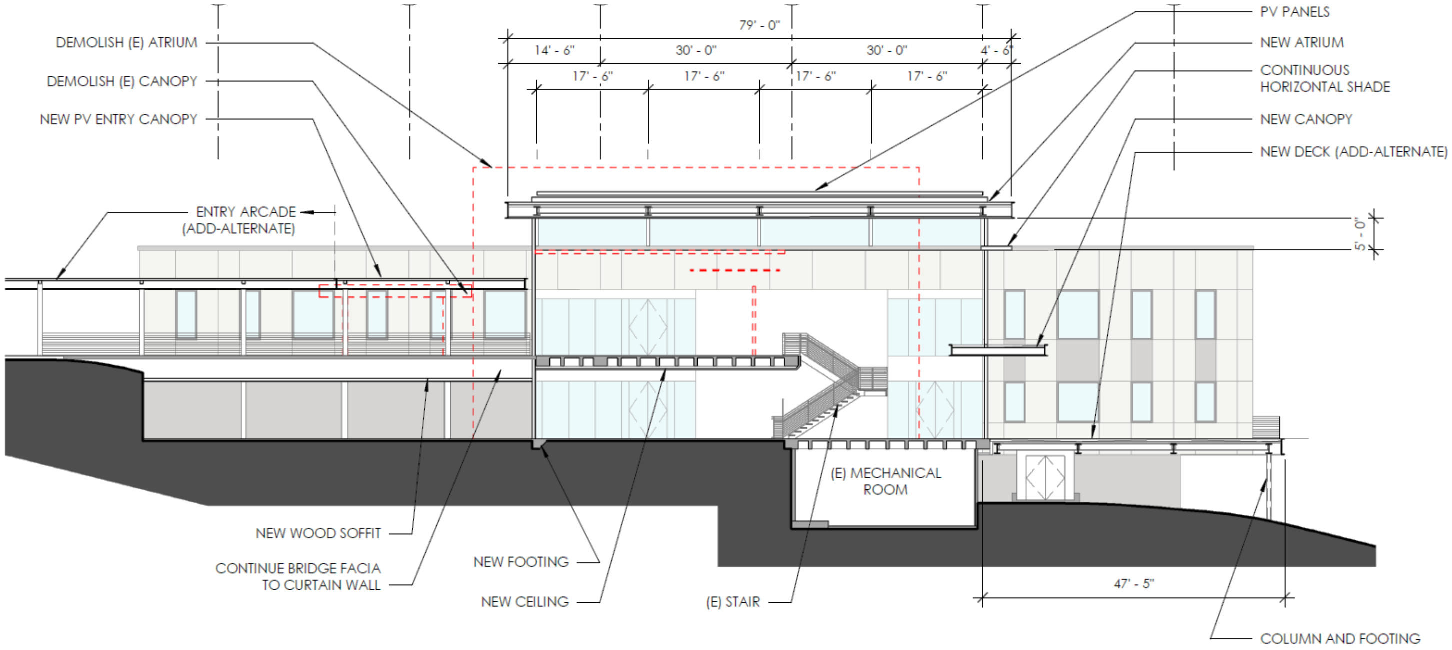
Provide area for additional photovoltaic panels

Deep shading on south

For optimal solar control

Insulated interior glass walls

Atrium to act as a thermal interstitial zone



EXPANDED COMFORT RANGE

Separate sensible load control

Hydronic radiant or chilled beam systems

Remove heat using convection

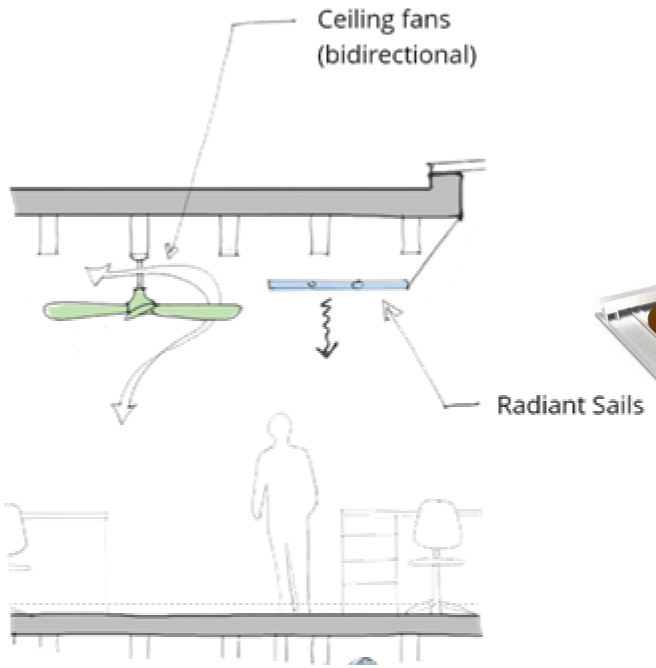
Using ceiling fans and natural ventilation

Maintain operative temperatures

Use higher air temperature setpoints

Higher chilled water temperature

Allow improved energy efficiency at plant



+

OR

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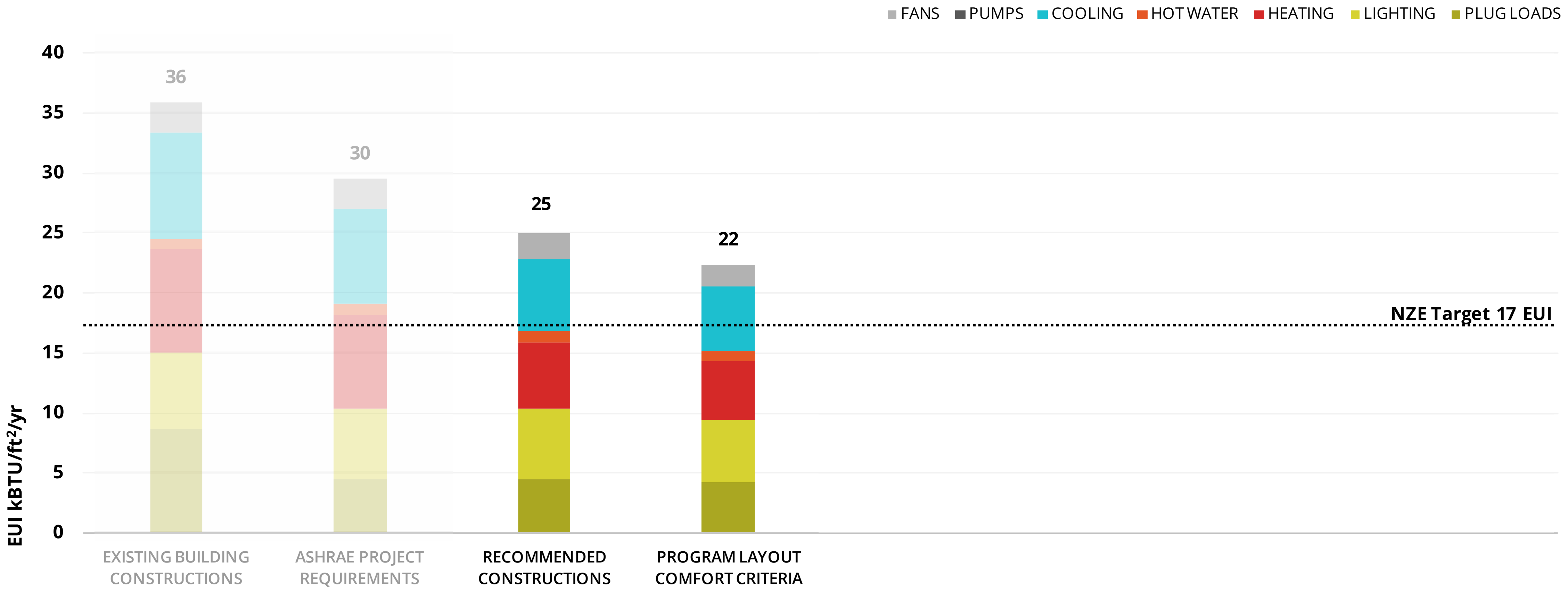
PATH TO NET ZERO ENERGY



OVERVIEW

FENESTRATION CONFIGURATION

Several window option studies

Location and sizes with respect to interior planning

IGUs in aluminum frame

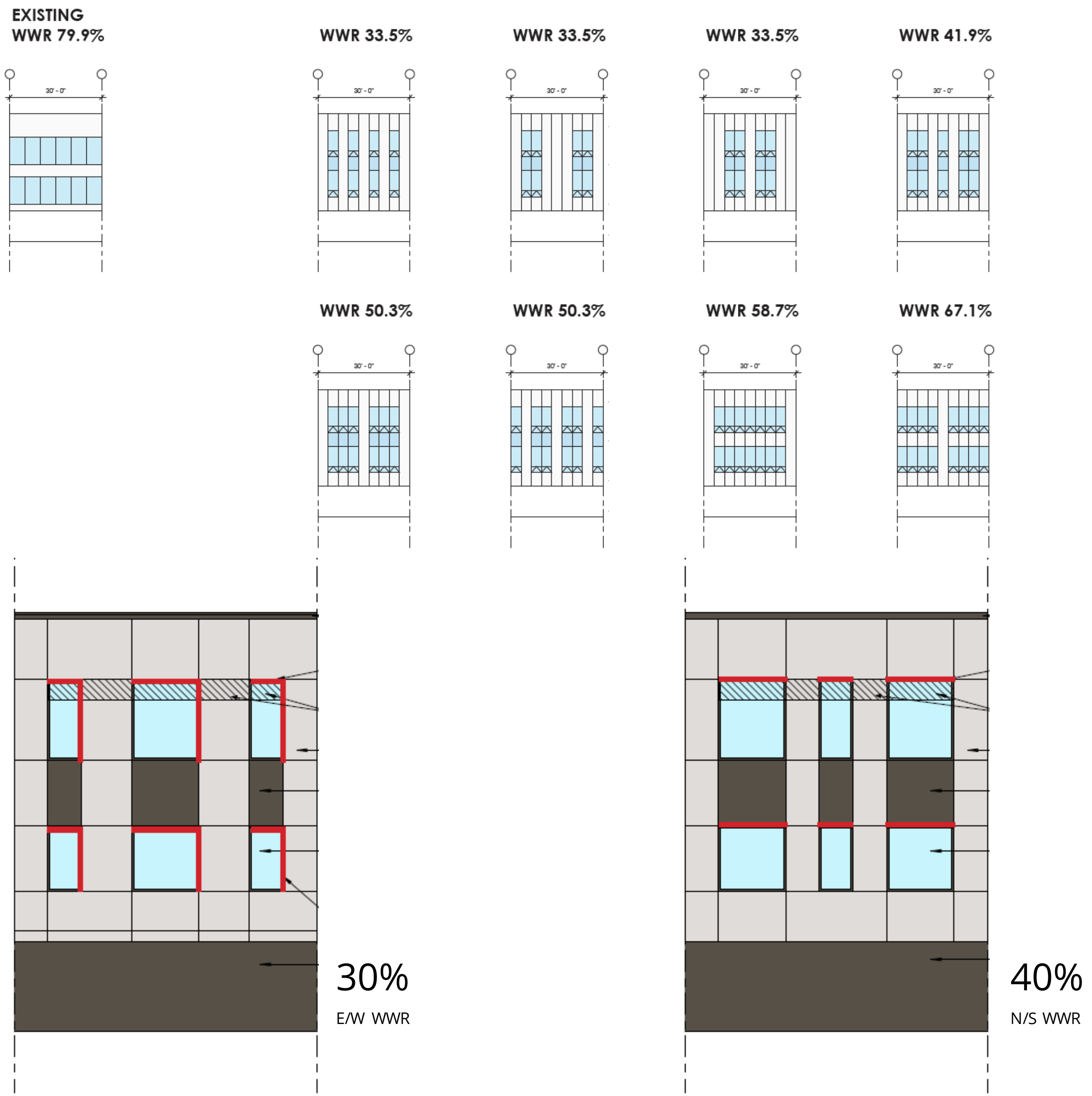
Strategically designed to leave existing precast panels in place

Tuned to desired area ratios

30% on east and west | 40% on north and south

Exterior shading devices

Horizontal and vertical on east and west | Horizontal on south



SKYLIGHTS AND DAYLIGHT

Cloud ceilings over workstations

Host ceiling fans and radiant panels

Skylights over circulation zones

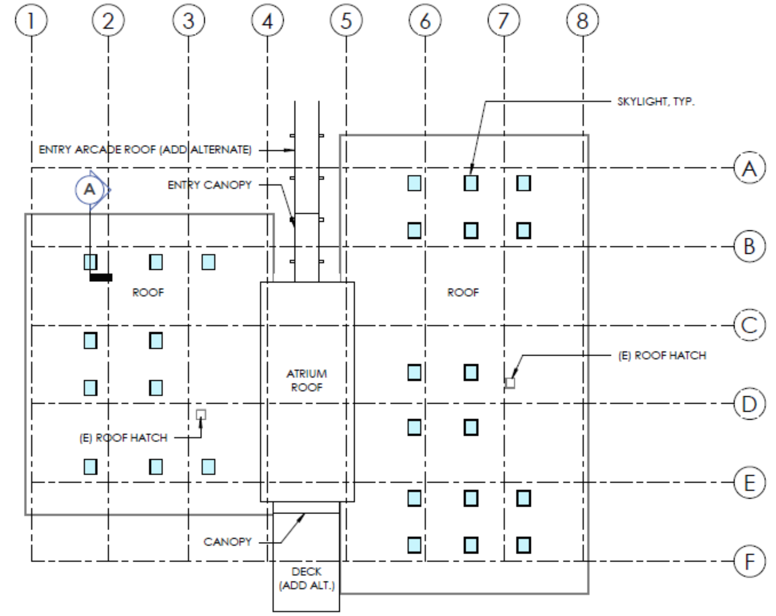
More ideal than having skylights directly over a workstation

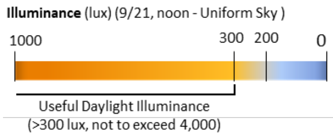
Closed offices to be glass enclosed

Allow borrowed light to permeate with little obstruction

Centralized restrooms and storage

Opaque areas clustered in the center of floorplate

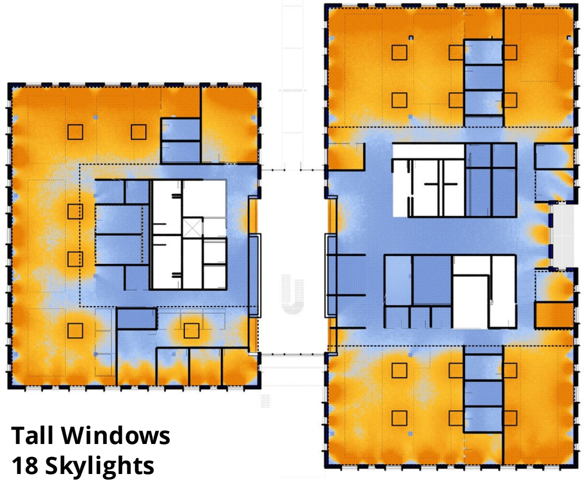




Short Windows
No Skylights

36%

Percentage of regularly occupied workspaces with useful daylight illuminance (>300 lux)

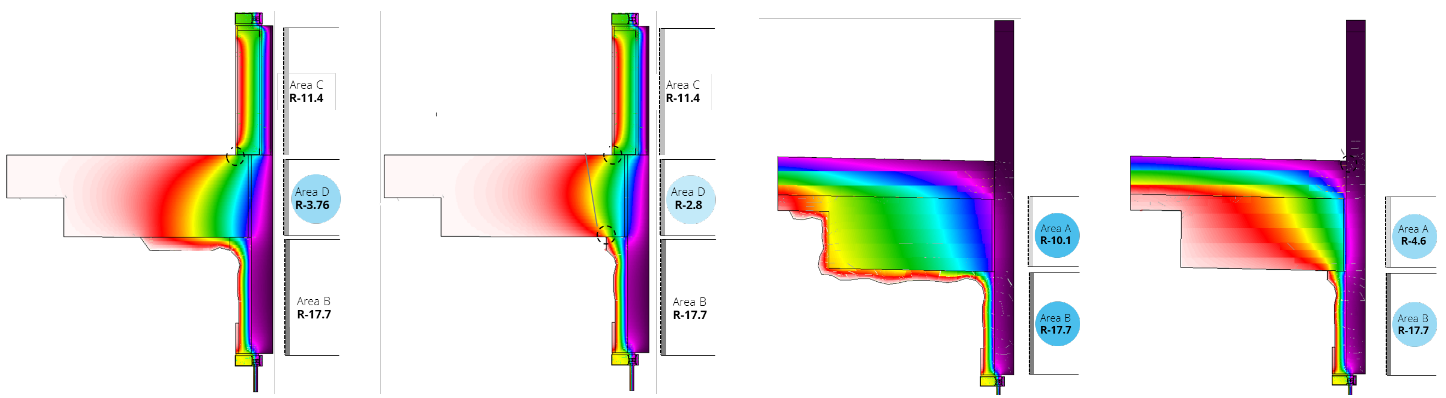


Tall Windows
18 Skylights

67%

Percentage of regularly occupied workspaces with useful daylight illuminance (>300 lux)

WALL AND ROOF INSULATION



Two-dimensional heat transfer model

LBNL THERM platform

Assess options for wall assembly

Target wall R value | Condensation potential

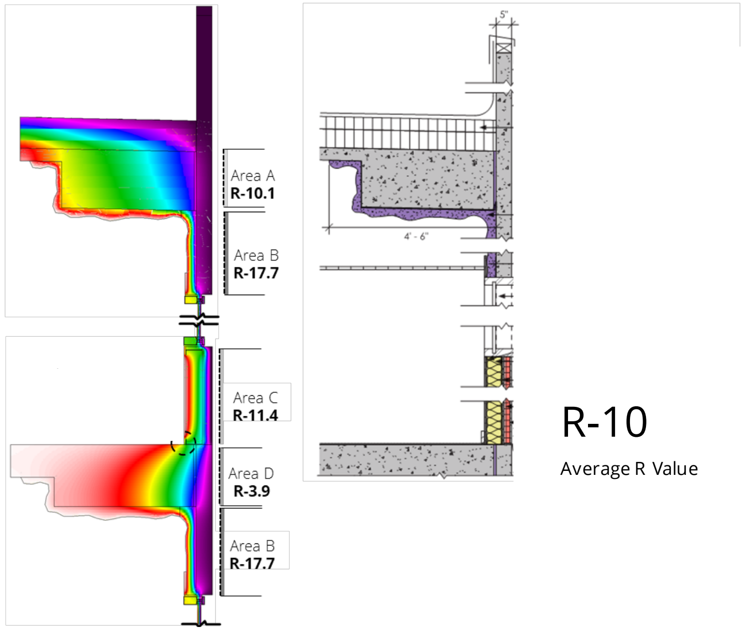
3.5" XPS added to interior: R-10

Thermal bridging | Condensation risk | Not recommended

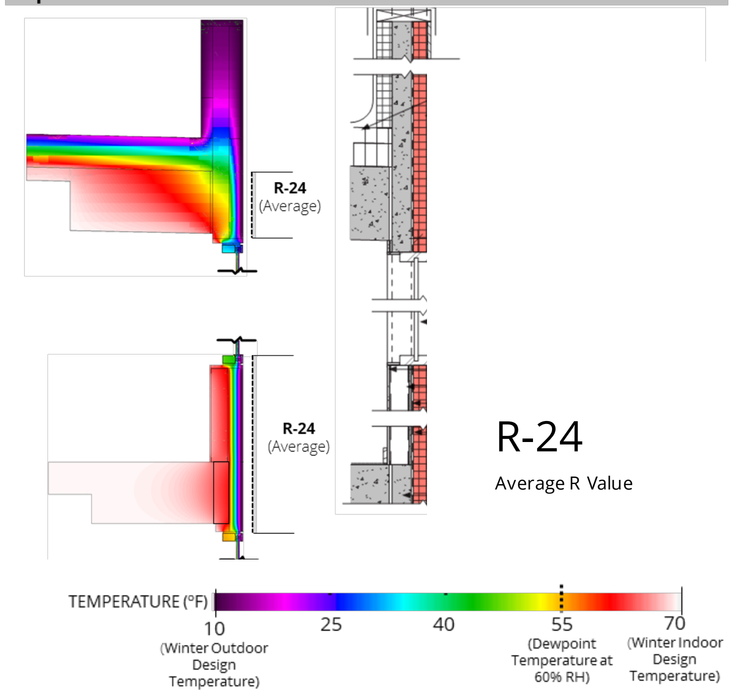
3.5" XPS added to exterior: R-24

Exceeds target| Recommended

Option A: Insulate From Interior, Maintain Precast



Option C & D: Continuous Exterior Insulation Over Precast



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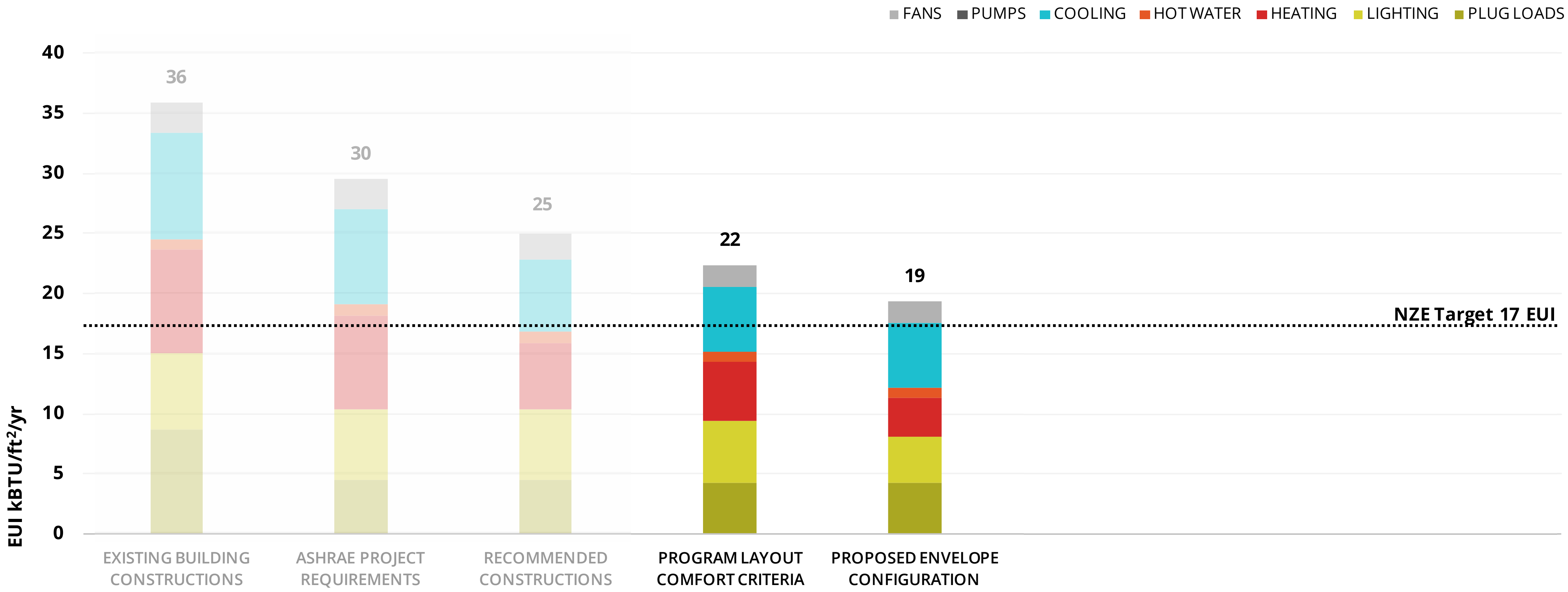


OVERVIEW

HVAC CONCEPT OVERVIEW

Demand more from the building envelope

Both thermally and tightness – Architect

Demand more from the building occupants

In terms of plug loads and day lighting – Owner

Utilize high efficiency systems

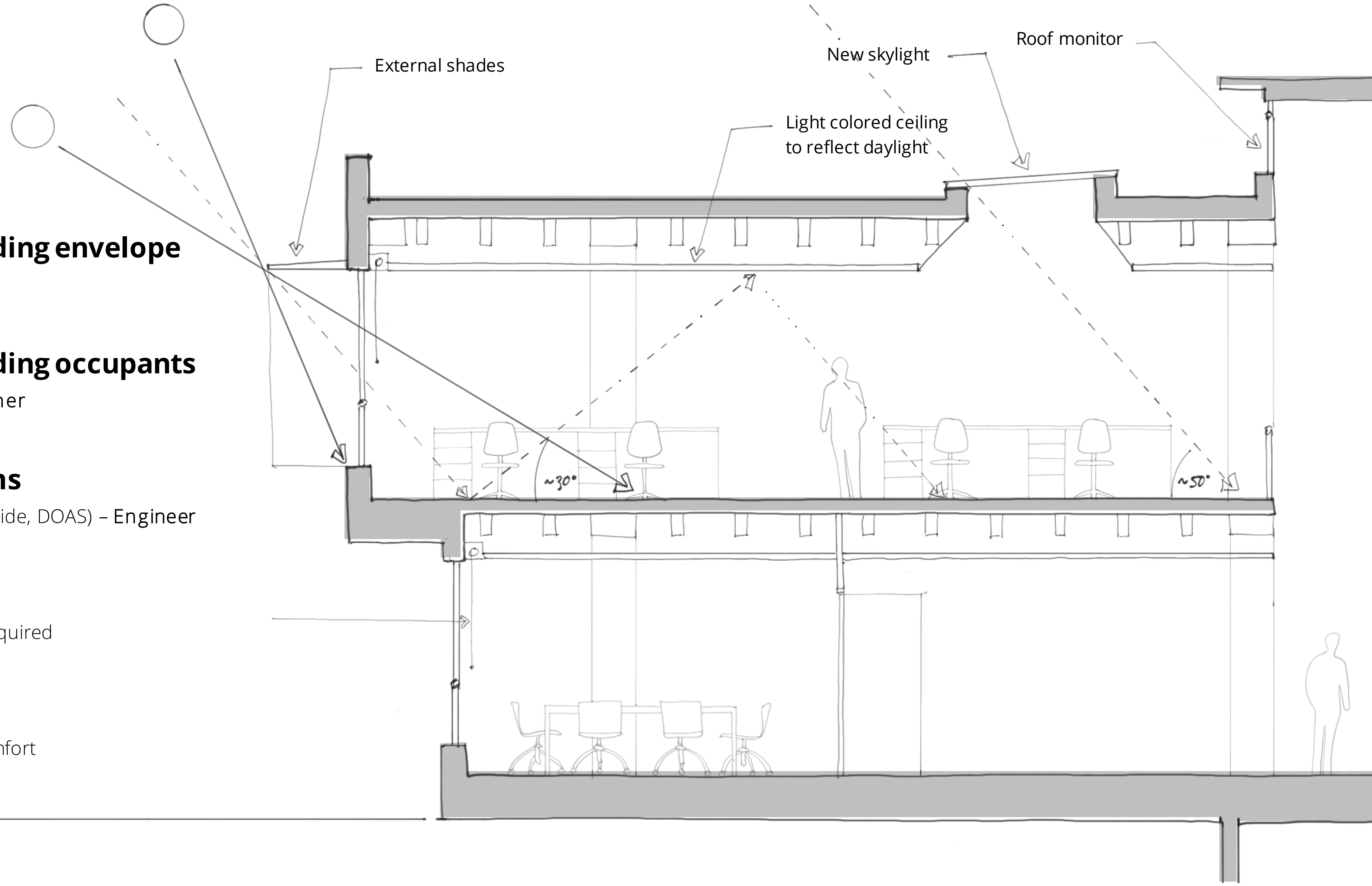
To reduce energy demands (hydronic vs. airside, DOAS) – Engineer

Right size equipment

Based on these demands – accountability required

Provide flexible and systems

Which provide exemplary environmental comfort



OPTIMIZED CONDITIONING

DOAS + Packaged ASHPs

Operable windows & Atrium exhaust | Ceiling fans

Night-flush Economizer

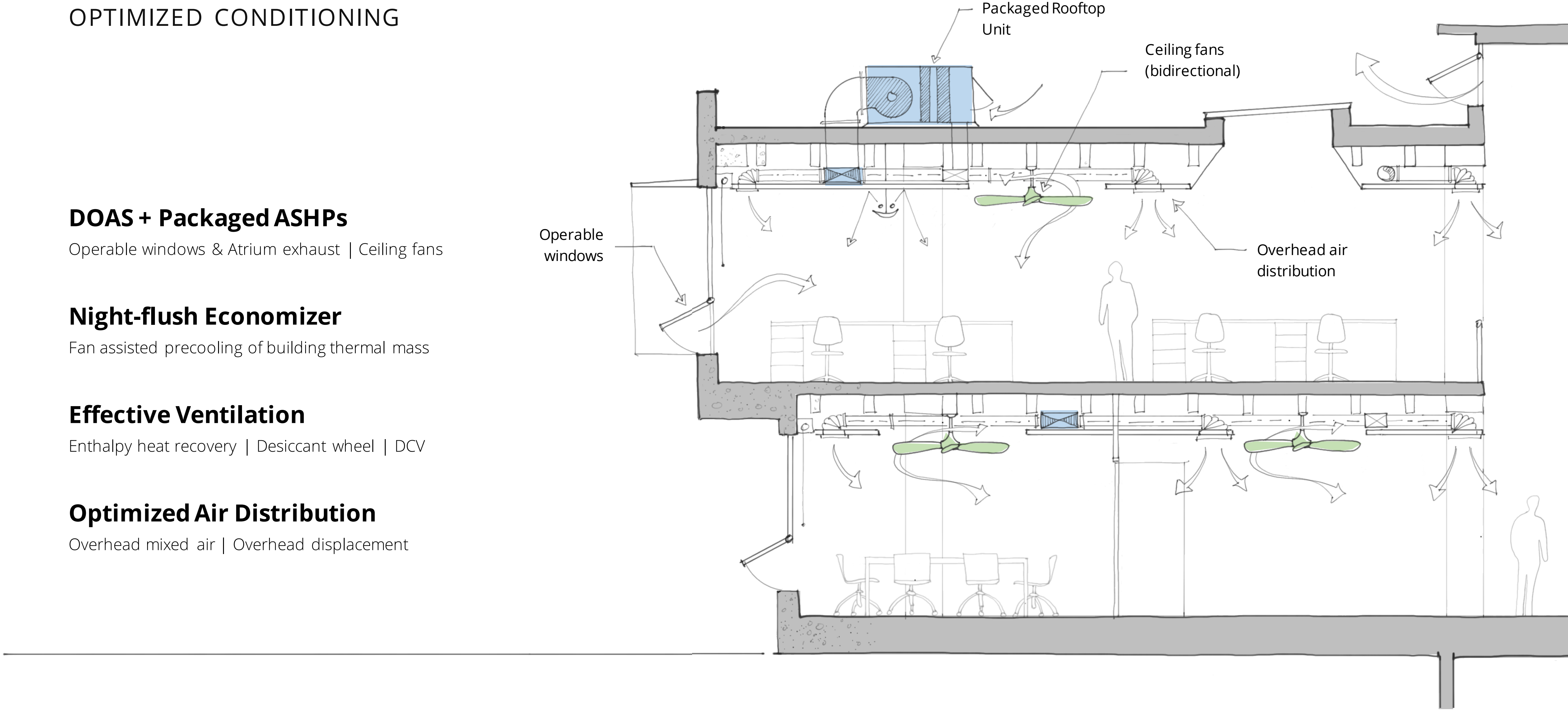
Fan assisted precooling of building thermal mass

Effective Ventilation

Enthalpy heat recovery | Desiccant wheel | DCV

Optimized Air Distribution

Overhead mixed air | Overhead displacement



DECOUPLED SYSTEMS

DOAS + Hydronic Terminal Units

Chilled beams | Radiant ceiling panels | DOAS boxes

Dedicated Outside Air System

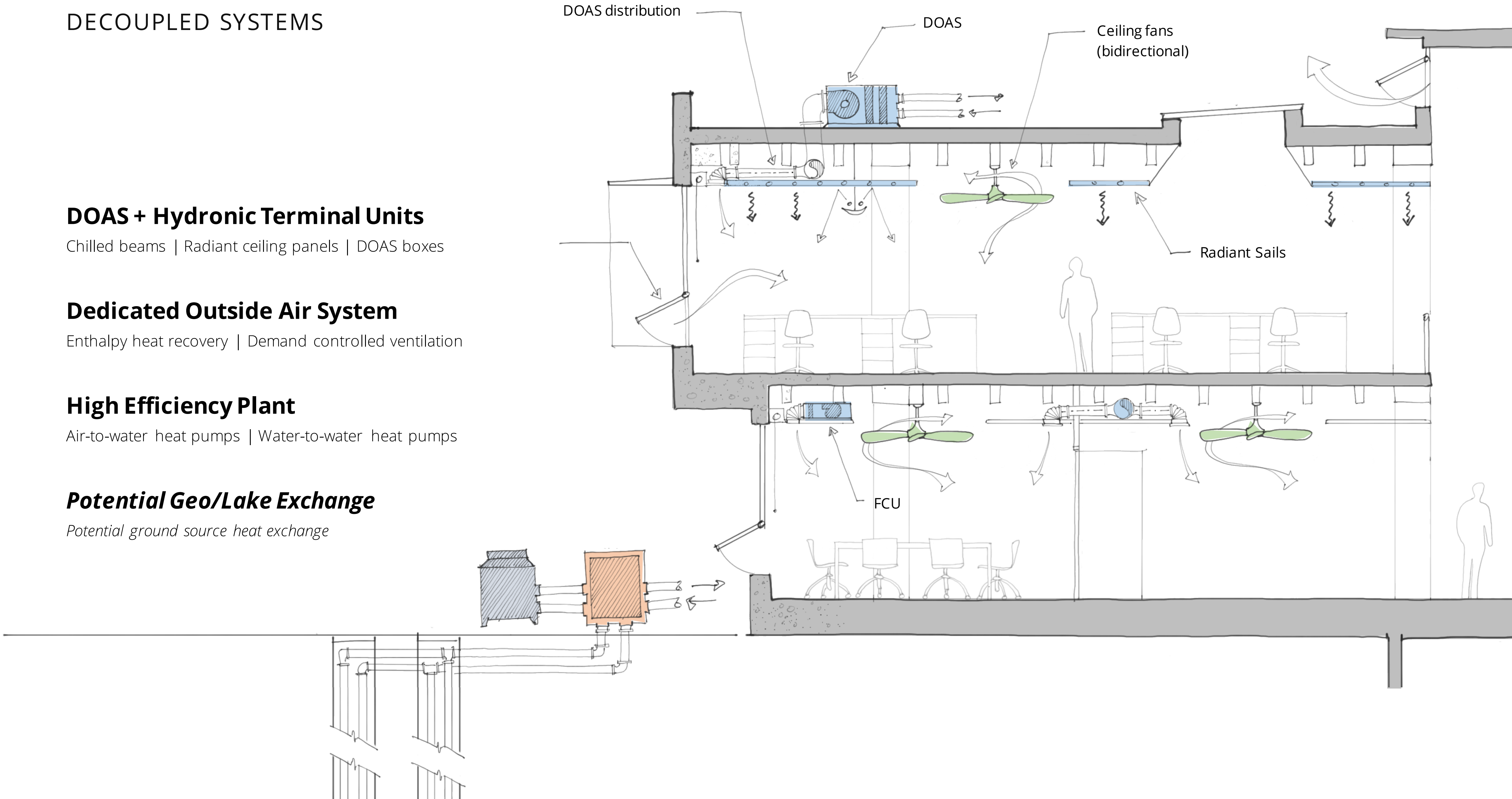
Enthalpy heat recovery | Demand controlled ventilation

High Efficiency Plant

Air-to-water heat pumps | Water-to-water heat pumps

Potential Geo/Lake Exchange

Potential ground source heat exchange



RESULTING SYSTEM NEEDS

Radiant
Hydronic Systems reduce energy

Smaller, modular control
Control valves and ceiling fans vs VAV terminal units and ductwork

Simultaneous heating and cooling
Heat Pump and/or heat recovery machines

Decouple temperature from humidity
DOAS recover energy whenever possible

SYSTEM OVERVIEW

Overhead Radiant Panels
For heating/cooling at exterior zones, cooling only at interior zones

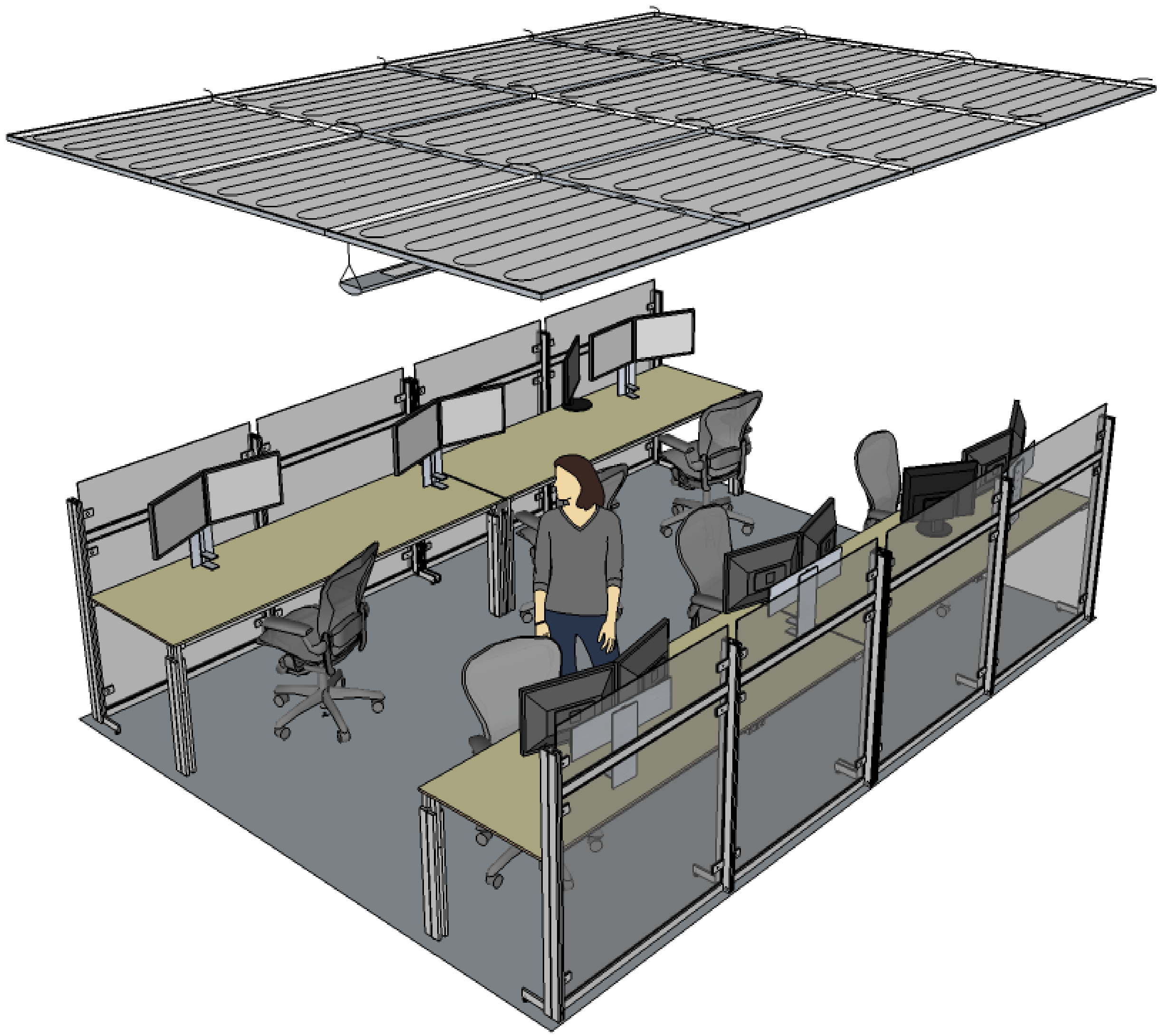
Outdoor Air-cooled Modular Heat Pump
Staged Pumping

Water Source Heat Pump
For transient or potentially humid spaces utilize CHWR

Air Cooled DOAS
Decoupled from waterside systems

Ceiling Fans
To induce cooling and improve environmental comfort

OVERHEAD RADIANT SYSTEMS



Radiant Panels

Form clouds above the occupied spaces

All heating and cooling

In these spaces are provided by the panels.

Ventilation is cool/neutral temperature air

Delivered directly to the space and not directly responsible for temperature control within the zone.

OVERHEAD RADIANT SYSTEMS

Areas between the clouds are open

To structure above and provide access for other trades mounted in the ceiling plane. No direct drilling.

Rigid piping in exposed areas

For aesthetic reasons. Insulation on supply piping only.
Panel support system is required.

Duct distribution is only for ventilation

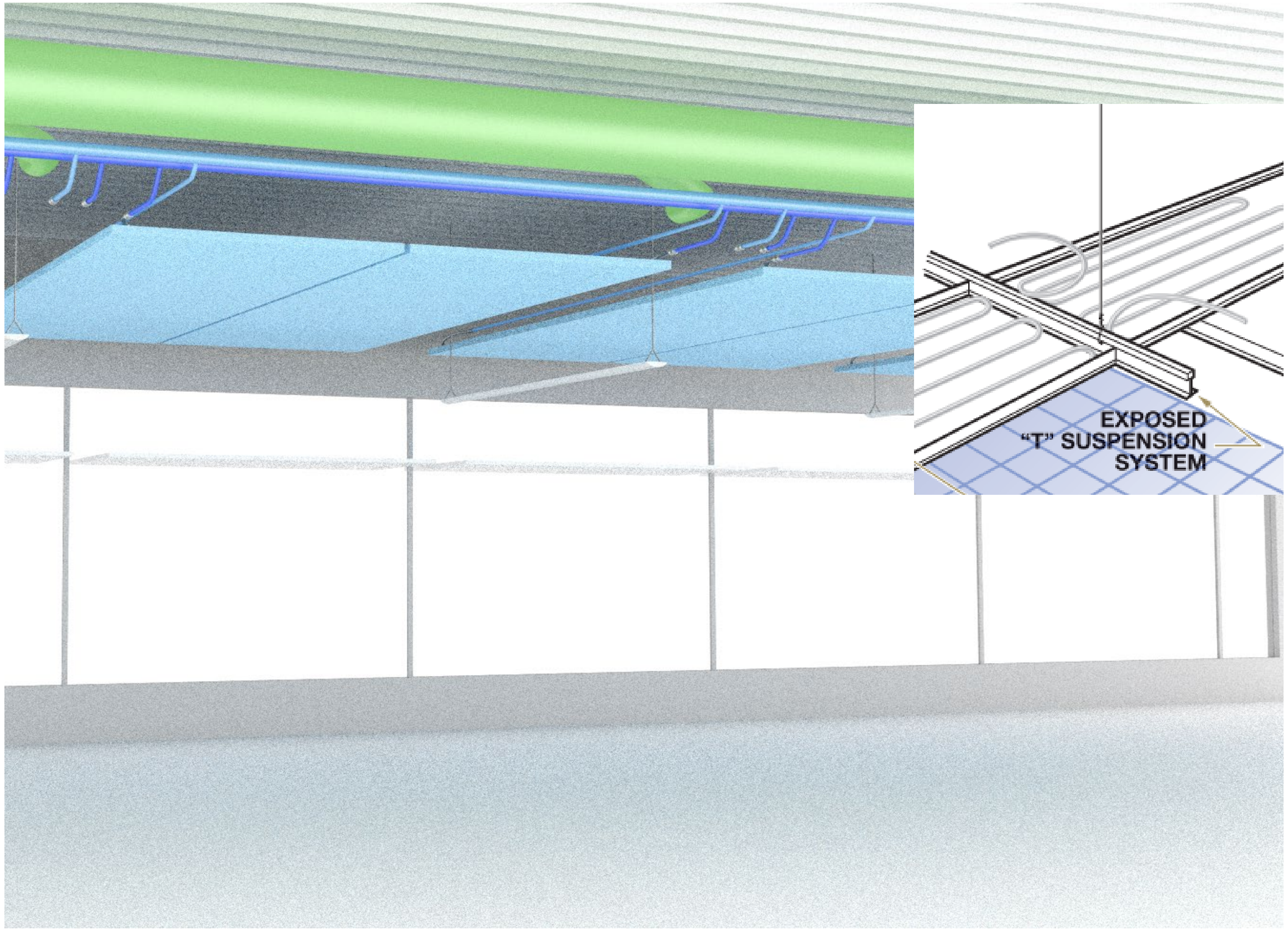
Quantities only (about 0.15 cfm/sf)

Air distribution is constant volume

Provided by Fabric Duct, reducing diffuser count and duct branches.

Ceiling fans throughout the space

Increase air mixing and induce capacity.



OVERHEAD RADIANT SYSTEMS

Panels contain multi-pass single circuit coil

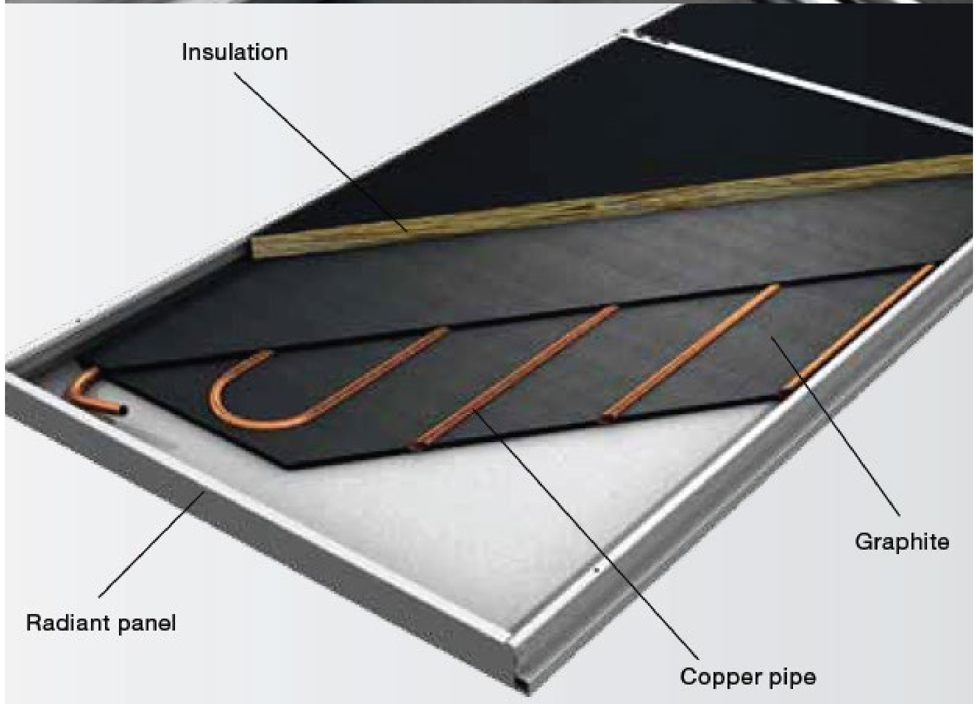
Panels may be piped in series (up to 64 square feet of active panel)

Quick disconnects for hoses

Allow for ease of installation and replacement.

Piping to the panels will be PEX tubing

Concealed above the cloud/array.



SUPPLEMENTAL CEILING FANS

Before Fan Install

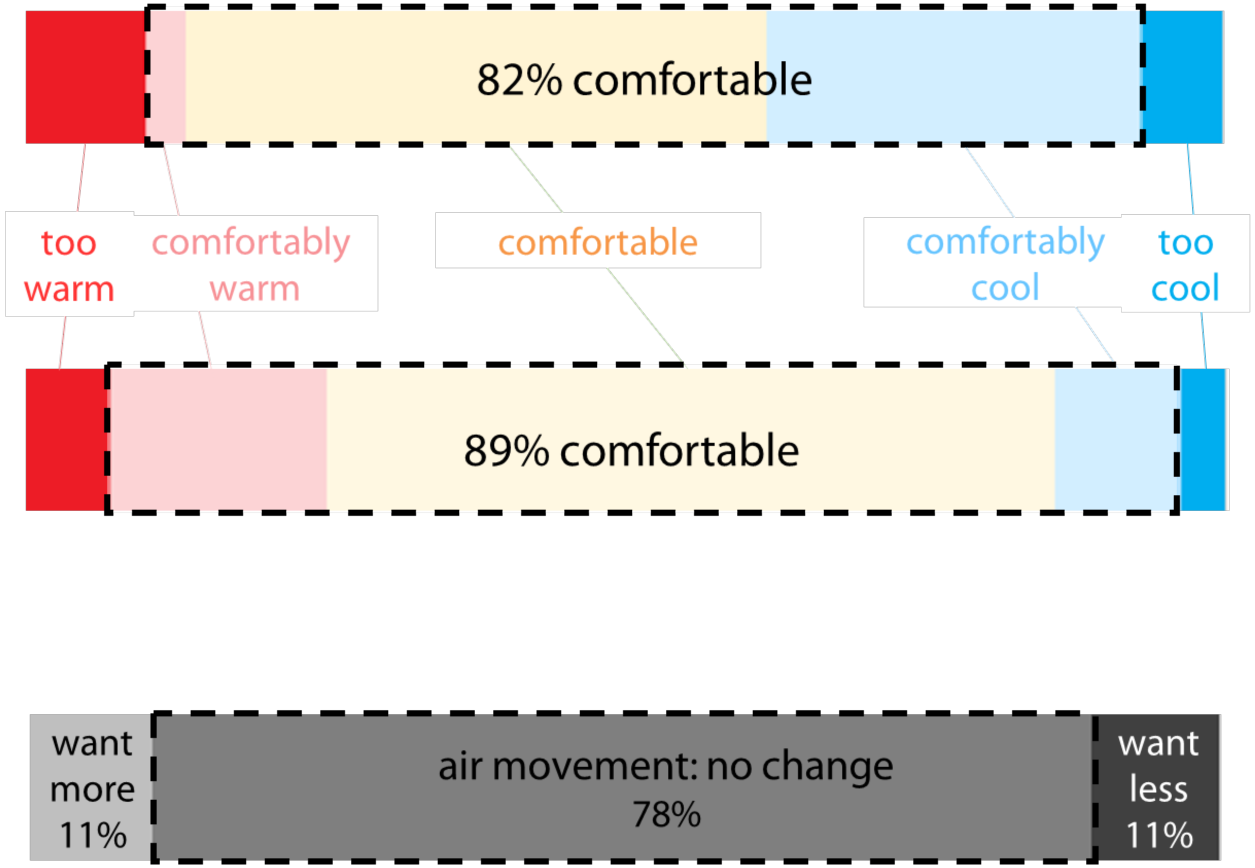
Indoor temperature ~72F (n=29)

After Fan Install

and air conditioning failure, Indoor temperature ~80F (n=28)

Air Speeds

~40-150 fpm



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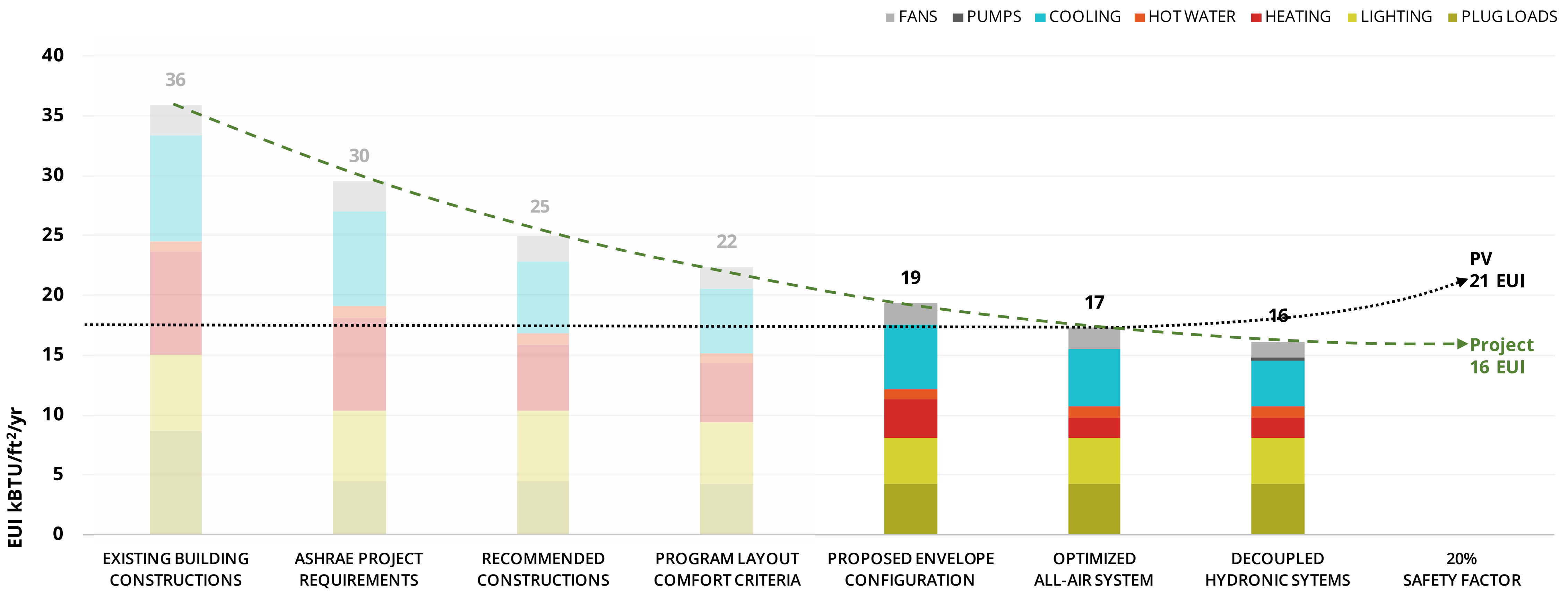

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