OVERVIEW

00 Project
01 Baseline
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05 Systems
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ASHRAE future global headquarters
Renovating a 67,000 ft² 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/ft²/yr
Before renewable energy. Aspirational target 15 kBtu/ft²/yr
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

- Existing Building Constructions
- ASHRAE Project Requirements

Target Maximum 21.4 EUI
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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
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 > 70°F | Outdoor Air Temp < 81°F

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

Daytime Ventilation / 60% RH Limit

19%-28%
Hrs in Comfort Range

Daytime Ventilation / No RH Limit

27%-40%
Hrs in Comfort Range

Day & Night Ventilation / No RH Limit

42%-56%
Hrs in Comfort Range
ONSITE RENEWABLES

12,000-14,000 ft² rooftop PV area
Assuming ~50% of 28,000 ft² roof available for PV array

210-260 kWp 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/ft²/yr potential EUI offset
Assuming 68,000 ft² floor area for EUI calculations
PATH TO NET ZERO ENERGY

Target Maximum 21.4 EUI

NZE Target 17 EUI

EUI kBtu/ft²/yr

EXISTING BUILDING CONSTRUCTIONS
ASHRAE PROJECT REQUIREMENTS
RECOMMENDED CONSTRUCTIONS

- FANS
- PUMPS
- COOLING
- HOT WATER
- HEATING
- LIGHTING
- PLUG LOADS
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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
PATH TO NET ZERO ENERGY

- NZE Target 17 EUI

- EXISTING BUILDING CONSTRUCTIONS: 36 EUI/ft²/yr
- ASHRAE PROJECT REQUIREMENTS: 30 EUI/ft²/yr
- RECOMMENDED CONSTRUCTIONS: 25 EUI/ft²/yr
- PROGRAM LAYOUT COMFORT CRITERIA: 22 EUI/ft²/yr

- Fans, Pumps, Cooling, Hot Water, Heating, Lighting, Plug Loads

- Safety factor: 20%
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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
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
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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
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
DOAS distribution

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
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.
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.
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 ~72°F (n=29)

After Fan Install
and air conditioning failure, Indoor temperature ~80°F (n=28)

Air Speeds
~40-150 fpm

82% comfortable
89% comfortable

too warm comfortably warm comfortable cool too cool

want more 11%
air movement: no change 78%
want less 11%
ASHRAE HQ NZE
Renovation

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