HVAC Option 1: All-Air TZHP System
TZHP – Thermodynamically Zoned Heat Pumps

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
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
All-Air TZHP vs. Hydronic System

Path to NZE Recap

NZE Target 21.4 kBTU/ft²/yr

Stretch Target 15.0 kBTU/ft²/yr

Option 1: All-Air TZHP System

Option 2: Hydronic System
Potential Night-flush Impact

Passive Night Flush

- HVAC fans operating
  - 10PM - 5AM, April – September
  - 55°F < OAT < 70°F
- Highly thermally massive concrete slabs pre-cool office spaces
- Strategy reduces EUI by 0.1 kBtu/sf
  - Reduced cooling EUI
  - Fan EUI penalty for nighttime fan operation
Potential Night-flush Impact

- HVAC fans and cooling coils operating
  - 10PM - 5AM, April – September
  - 55°F < SAT < 70°F
- Active cooling engaged at night (nighttime COP > daytime COP)
- Strategy increases EUI by 0.6 kBtu/sf
  - Cooling EUI penalty (cannot provide enough pre-cooling to overcome daytime cooling needs)
  - Fan EUI penalty for nighttime fan operation
Atrium Impact

ANNUAL SITE ENERGY USE

ASHRAE 90.1-2016 Baseline
Recommended Envelope
Stratified Program
Optimized All-Air System
Passive Night Flush
Active Night Flush
Atrium Intervention
DOAS + CHW
TUS + ASHP
Passive Night Flush
Active Night Flush
Atrium Intervention

FANS PUMPS COOLING HOT WATER HEATING LIGHTING PLUG LOADS

Atrium Intervention

- Atrium model updated to match current proposed design
  - Reduced atrium height
  - Reduce atrium glazing
  - Additional overhangs
- Atrium peak load reduced by more than 50%
- Overall EUI reduced by 1-2 kBtu/sf
Life Cycle Cost Analysis (LCCA): HVAC Options A & B

OPTION 1 - ALL-AIR SYSTEM (TZHP):
- First Cost $1,856,000
- Replacement Cost $281,500 every 15 years
- Maintenance $28,600 per year

- Life-Cycle Cash Flow (NPV): **$5,179,476** ($1,032,241 less money spent than Option 2 over a 30 year period)

OPTION 2 - HYDRONIC SYSTEM:
- First Cost $2,913,000;
- Replacement Cost $322,700 once at 25 years;
- Maintenance $41,200 per year

- Life-Cycle Cash Flow (NPV): **$6,211,718** ($1,032,241 more money spent than Option 1 over a 30 year period)