Can Program Flexibility and Energy Efficiency Coexist?

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Learning Objectives

- Learn about the challenges associated with designing an energy efficient lab where program flexibility is key
- Understand the importance of tenant engagement in efficient design and operation of labs
- Approach towards analyzing and selecting appropriate mechanical systems for buildings with program uncertainties
- Learn about how existing tenant occupied lab buildings perform
System Selection Parameters
Impact of Functional, Operational, and Climatic Parameters

Functional Parameters
- Internal Loads
- Ventilation Requirements
- Exhaust Requirements

Operational Parameters
- Low Usage
- Typical Usage
- High Usage

Climatic Parameters
- Hot Climate
- Mild Climate
- Cold Climate
1. Decoupling offers Max Savings for High Usage Load Driven Labs in Hot Climates
2. Decoupling without Water Side Economizer may be a Penalty for Mild & Cold Climates
3. Vent Rate Reduction offers no savings in Load Driven High Usage All-Air Labs
4. Decoupling and Vent Rate Reduction offer large savings for High Load & Usage Labs
5. Vent Rate Reduction offers substantial savings for Ventilation Driven Labs
**System Selection Parameters**
Impact of Functional, Operational, and Climatic Parameters

**Functional Parameters**
- Internal Loads
- Ventilation Requirements
- Exhaust Requirements

**Operational Parameters**
- Low Usage
- Typical Usage
- High Usage

**Climatic Parameters**
- Hot Climate
- Mild Climate
- Cold Climate

Both Function and Operational parameters become variables for core and shell lab buildings.
Comparison at the beginning of the calibration process of an existing lab building in North East
Findings From Measured Data – Example 1

Profiles after removing supply air temperature reset
Lowering the plug loads helped improve the RSME values.
Facilities had to reset the SAT reset to constant SAT to address humidity issues. This resulted in significant heating energy increase.
Lower SAT without reset also limits the heat recovery effectiveness.
Efficient Dehumidification and SAT Reset
Strategy 1: Dual wheel system
Efficient Dehumidification and SAT Reset

Strategy 2: Wrap-around coil
Decoupling with Room Neutral Air Supply

- There is a large diversity in laboratory equipment usage
- Equipment are getting more efficient
- Laboratory use may change over time

Above factors can change the laboratory from being “Load Driven” during design to “Ventilation Driven” during operation

Decoupling with room neutral air supply can provide the required flexibility and eliminate the need for reheat

System Options:
- DOAS with Fan Coil Units
- 4-pipe VAV
Air Flow Reduction

1. Ventilation rates driven by cooling loads and air change requirement.

2. Chilled beams eliminate airside cooling loads.

3. Air quality sensing enables reduction in minimum air change rate.

4. Sensor-based fume hood controls minimize fume hood exhaust; high fume hood use drives ventilation during peak occupancy hours.
Core and Shell Labs Energy Efficiency Measures

High Performance Case
- High performance envelope
- All LED lighting in common areas
- Low pressure drop fans system design and local FCU's with EC motors
- Low flow plumbing fixtures
- Enhanced energy recovery system
- Dual wheel/wrap around coil at DOAS for efficient dehumidification
- High performance central plant (condensing boilers, chillers with WSE)
- Variable speed laboratory exhaust fan controls
Core and Shell Labs Energy Efficiency Measures

Exemplary Case (Requires Tenant Participation)

- LPD reduction in tenant offices/labs
- Energy Star appliances
- Decoupled system configuration (CB/FCUs or 4-pipe VAV)
- Air-quality sensing to reduce background ventilation rate
- Low flow fume hoods and automatic fume hood control for labs
Maximizing heat recovery is key for achieving a low energy labs. Plant level measures such as heat recovery chillers and thermal energy storage can help maximize energy savings.
Importance of Sensitivity Studies
System Selection Parameters

Sensitivity Study

Table 3: Energy Performance of Proposed Design compared against EEM 1 – All Air VAV

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<th></th>
<th>Energy Cost Savings of Proposed Design</th>
<th>Fume Hood Usage</th>
<th>50% Lower Usage</th>
<th>Proposed Design</th>
<th>50% Higher Usage</th>
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<td>Lab Equipment Usage</td>
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<td>1.6%</td>
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Table 4: Energy Performance of Proposed Design compared against EEM 1 – All Air VAV

<table>
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<th>HVAC Cost Savings of Proposed Design</th>
<th>Fume Hood Exhaust Diversity Factors</th>
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<th>Proposed Design</th>
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VAV Vs. Chilled Beams
System Selection Parameters

Sensitivity Study

- Net present value is optimum when the TES is sized between 6000-8000 ton-hr for Case 1 and Case 3.
- For Case 2 a 5000 - 6000 ton-hr capacity TES yields an optimum net present value.
System Selection Parameters
Sensitivity Study

UTILIZATION GRAPH (COGENERATION PLANT)

Cogeneration Sizing
System Selection Parameters

Sensitivity Study

Floor-by-Floor Vs Central Chilled Water Plant

FLOOR-BY-FLOOR WATER COOLED DX AHU WITH CENTRAL CONDENSER WATER LOOP

WORST CASE ASHRAE BASELINE BEST CASE

-12% 0% 16%

- NO CONDENSER WATER TEMPERATURE TEMPERATURE
- FAULTY ISOLATION VALUES
- LOWER EFFICIENCY DX UNIT

- WATER-SIDE ECONOMIZER
- HIGH PERFORMANCE VARIABLE SPEED DX
- CW PUMP STATIC PRESSURE RESET

FLOOR-BY-FLOOR CHW AHU WITH CENTRAL WATER COOLED CHILLED WATER PLANT

WORST CASE ASHRAE BASELINE BEST CASE

-37% 0% 23%

- OVERSIZED CHILLERS WITHOUT VSD
- CONSTANT SPEED CHILLED WATER PUMP OPERATION
- NO CHILLED WATER TEMPERATURE RESET

- WATER-SIDE ECONOMIZER
- HIGH PERFORMANCE MODULAR CHILLERS
- PUMP STATIC PRESSURE RESET

Floor-by-Floor Vs Central Chilled Water Plant
Setting EUI targets
Dry Lab vs. Intensive Wet Lab

Site EUI
100 kBtu/sf
200 kBtu/sf
300 kBtu/sf

DRY LAB

Exemplary EUI: 116 kBtu/sf/yr
High-Performance EUI: 145 kBtu/sf/yr
Base Case EUI: 173 kBtu/sf/yr

DRY + WET LAB

Exemplary EUI: 131 kBtu/sf/yr
High-Performance EUI: 165 kBtu/sf/yr
Base Case EUI: 198 kBtu/sf/yr

WET LAB

Exemplary EUI: 172 kBtu/sf/yr
High-Performance EUI: 217 kBtu/sf/yr
Base Case EUI: 200 kBtu/sf/yr
Conclusion

Can program flexibility and energy efficiency co-exist? – Yes!

- It requires an integrated design process with involvement of all key stakeholders early in the design.
- In core and shell buildings, Tenant involvement is key in achieving low energy laboratory buildings. Rethinking laboratory system ownership models and tenant leasing agreements are important.
- Reducing heating and reheat is one of the most important part of the building energy efficiency puzzle specially in cold climates. Tackling reheat efficiently is important to achieve goals like all-electric building/Carbon Neutrality/Net Zero Energy etc.
- Providing room neutral air supply with localized cooling and heating using FCUs/4-pipe VAV (in all or select areas) can significantly reduce both reheat and outside air heating energy.
- Operational uncertainties should be taken into account during the design process to design and operate building requiring flexibility efficiently.
- Sensitivity studies are critical for system sizing and selection for buildings where functional and operational parameters are variables/unknows.
- Shared lab spaces, space planning to improve effectiveness of passive and flexible modular labs, are key in designing energy efficient flexible labs.
Questions?
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