Design Decisions: Lasting Impacts on Lab Safety, Performance and Energy

Presented by

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B2Q

A Woman Business Enterprise (WBE)

Learning Objectives

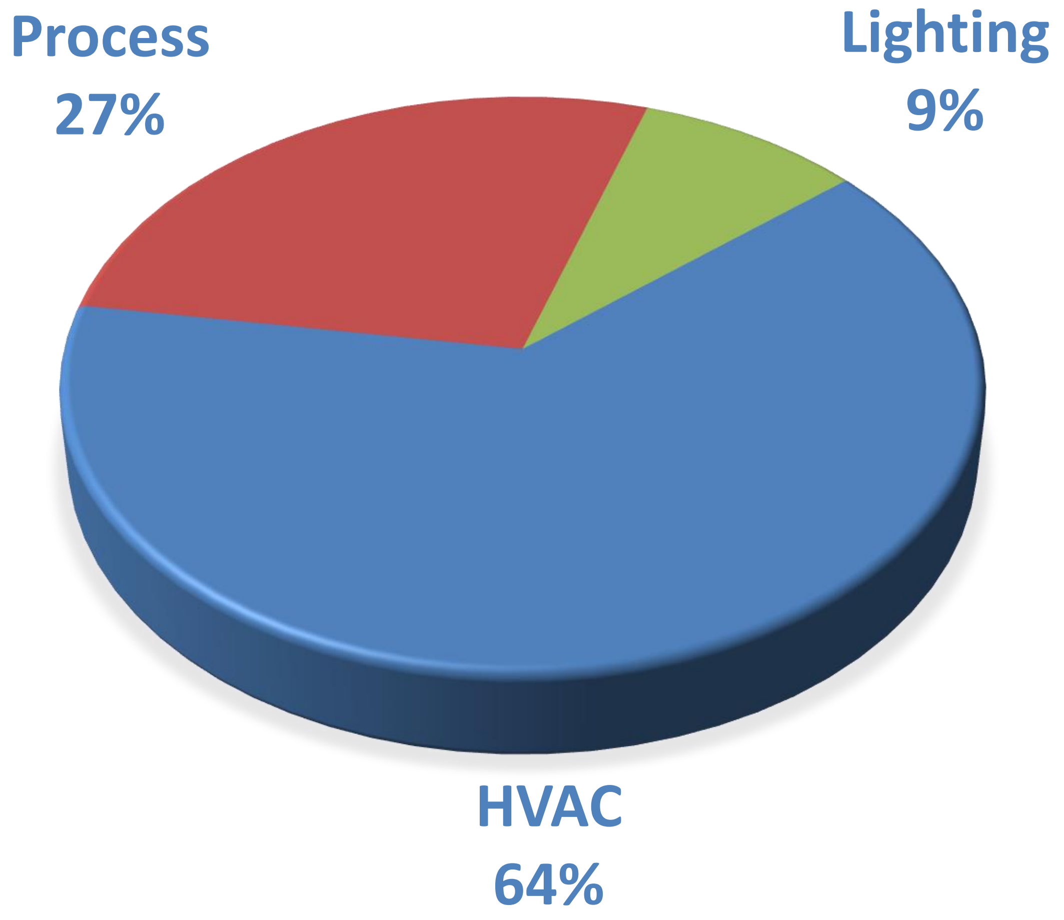
- Understand the decisions made during design and constructions and how they impact laboratory performance over the life of the building
- Review of common laboratory terminal device designs and understand the pros and cons with various options
- Analyze the energy impact of equipment choices over the life of the equipment/building
- Review other life-cycle impacts of other HVAC-related lab design decisions.

Why is this Important?

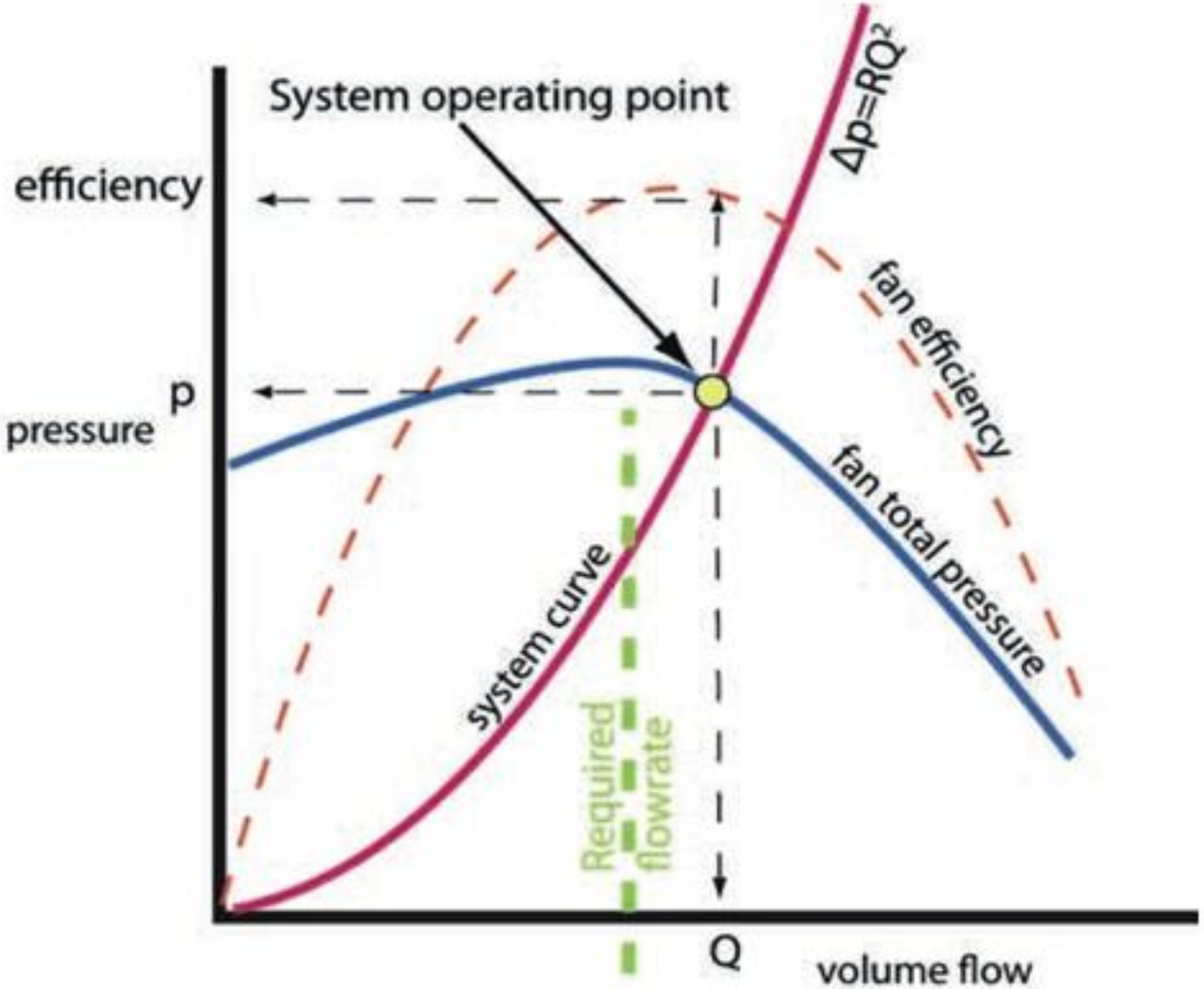
- Operating energy costs are expensive
  - Lab air is expensive
- Annual costs compound over time
- Do it right the first time – value engineering is a recipe for higher long-term energy and O&M, costs, and limited flexibility

Project Name	Savings Metric	Electric Rate	Steam Rate	Heat Recovery
	$/cfm	$/kWh	$/Mlb	
NY College Science Center	$2.82	$0.05	$7.15	Yes
MA College Lab 1	$4.05	$0.10	$20.00	Yes
MA College Lab 2	$4.35	$0.10	$20.00	Yes
MA College Lab 3	$10.33	$0.10	$20.00	No

ANNUAL ENERGY COST BREAKDOWN



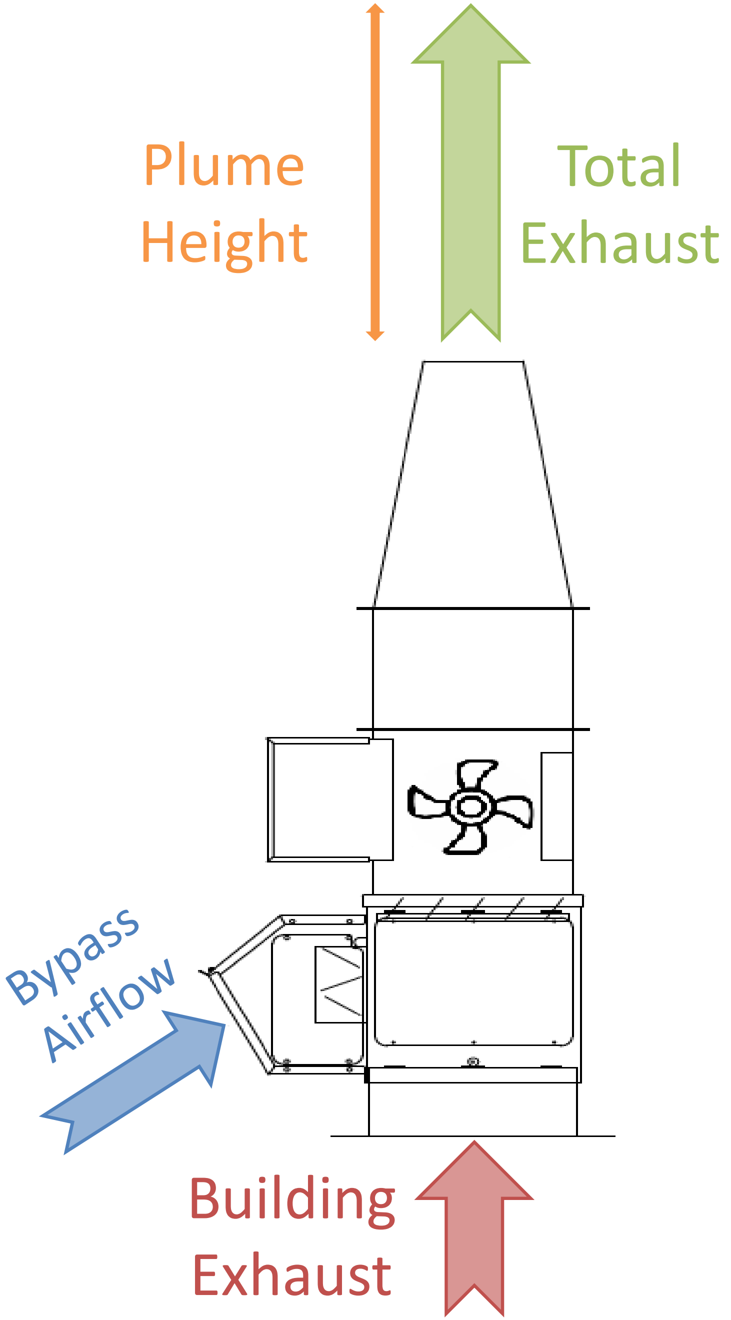
Fan Overview



$$BHP = \frac{Q \ * TSP}{\mu_{fan} \ * Fan\ Constant}$$

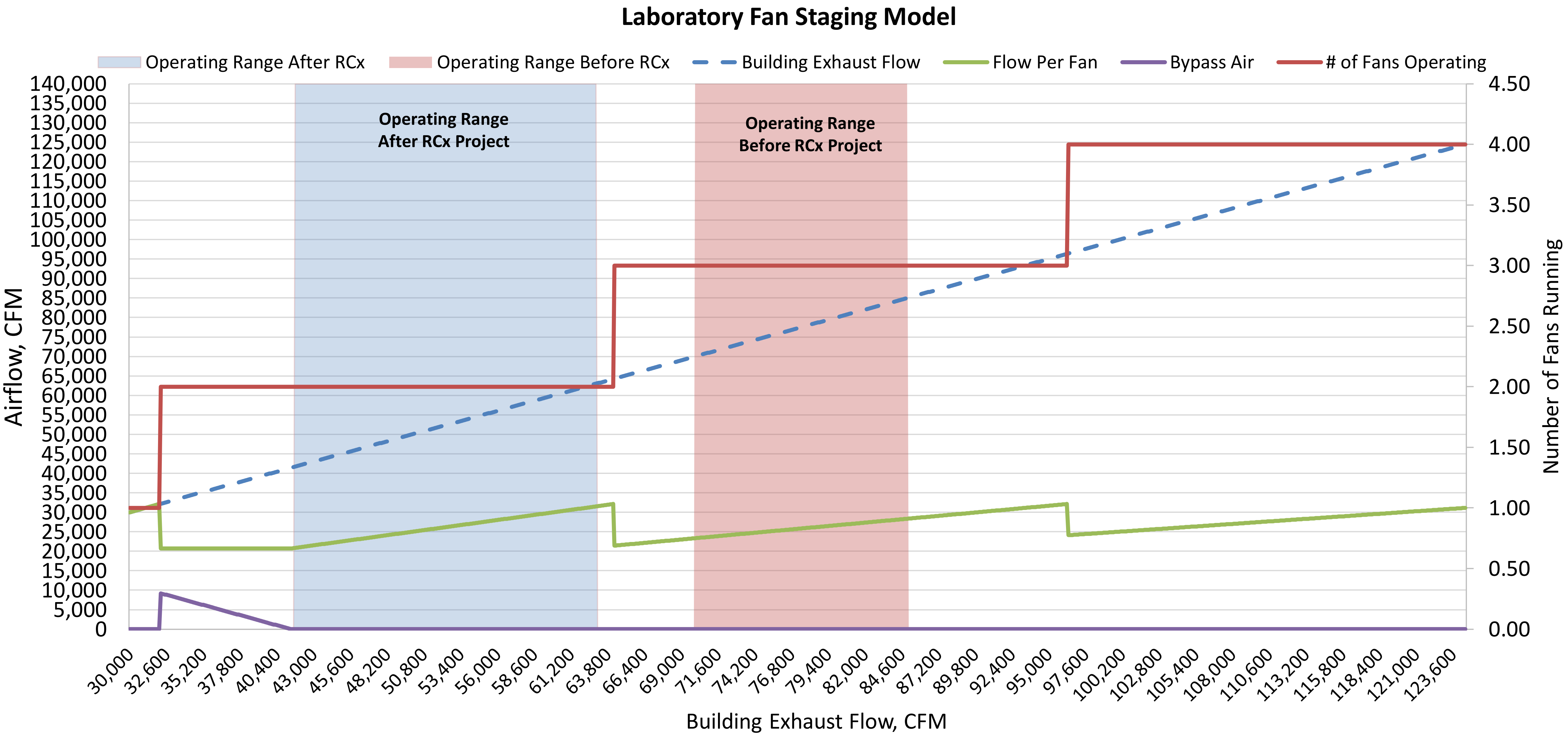
- Q = Airflow
- TSP = Total Static Pressure
- μ_{fan} = Fan efficiency

Exhaust Fan: Bypass Dampers

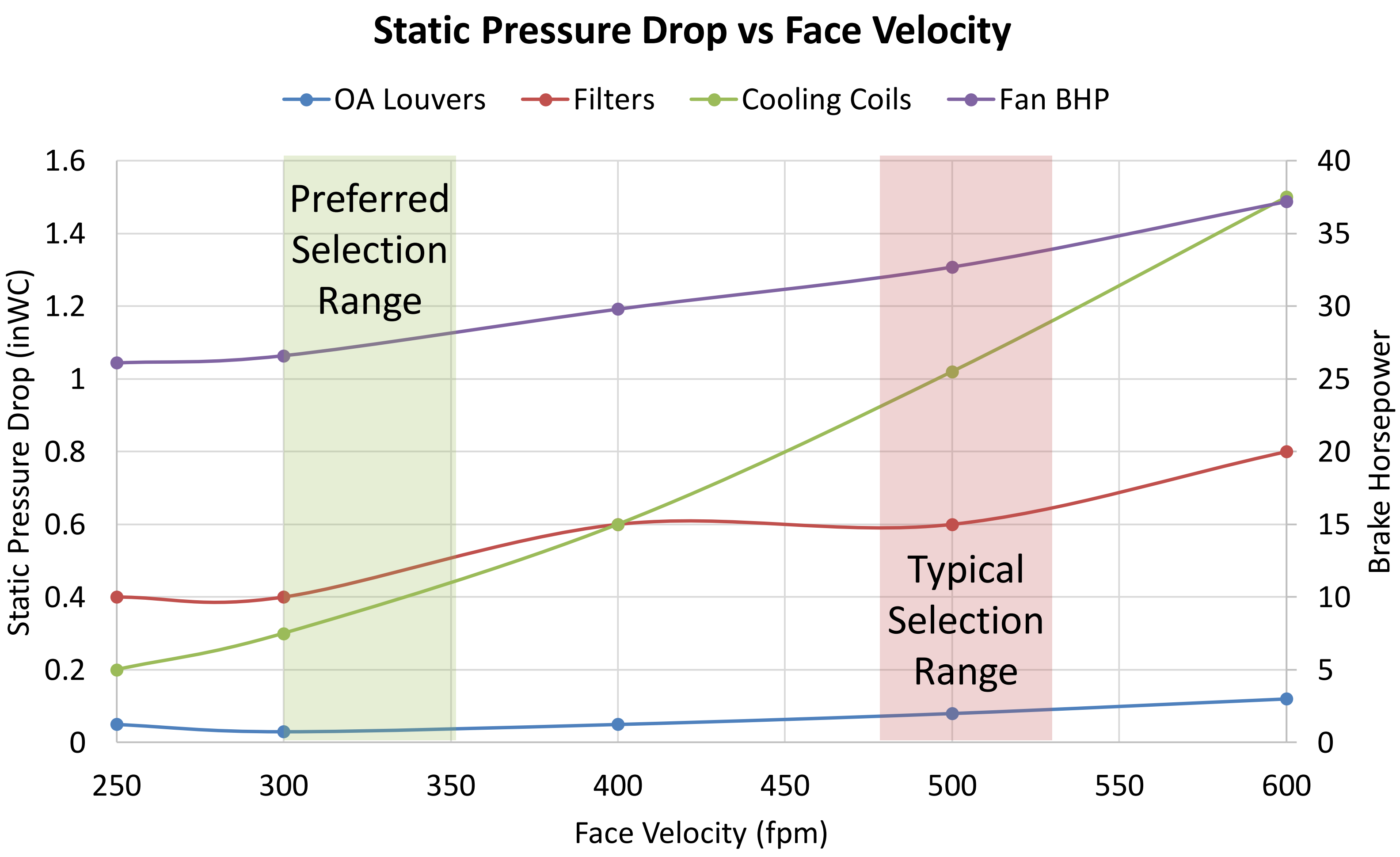


Lower Bypass Airflow → Lower Fan Airflow → Lower Energy Cost

Exhaust Fan: Bypass Damper



AHU Coil Sizing



Lower Face Velocity

Better Coil Performance

Lower Static Pressure

Lower Brake Horsepower

Energy Savings

AHU Coil Sizing: Economics

- Design Conditions: 42,000 cfm AHU
- Sized the casing, coils and filter bank for a 65,000 cfm AHU
- Observed a 34% reduction in brake horsepower
  - Possibly select a smaller fan motor
- Annual Savings of **108,000 kWh or $13,000** (in New England)
- Note: This is NOT upsizing the AHU fan – just the components

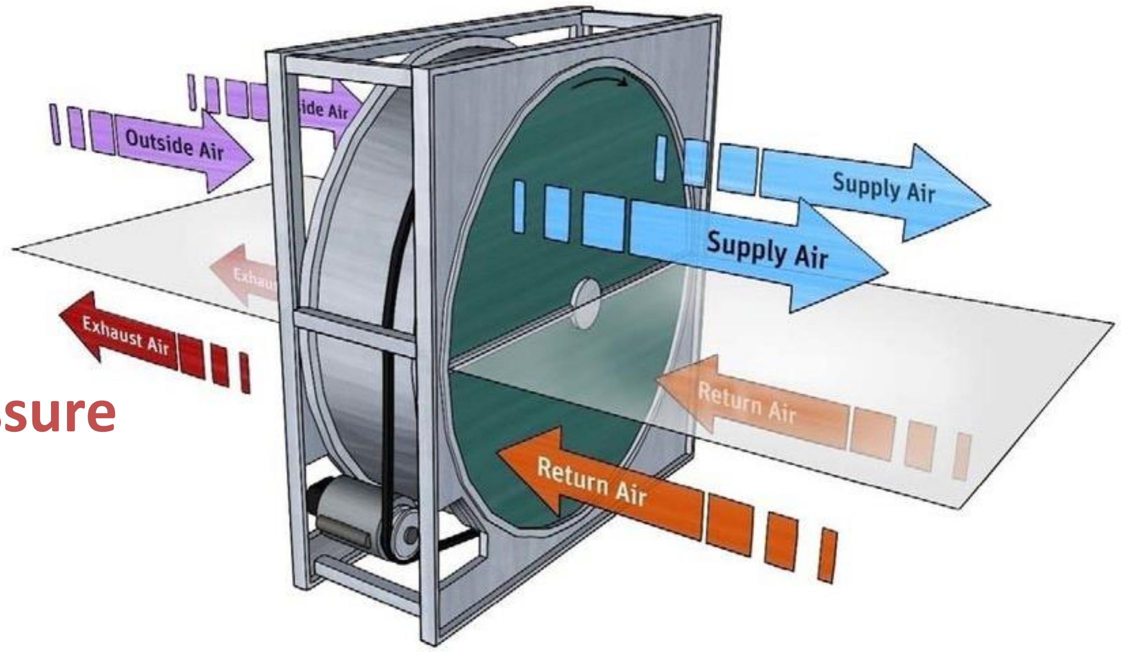
Heat Wheels

Pros

- Better heat transfer & effectiveness
- Latent and sensible heat recovery

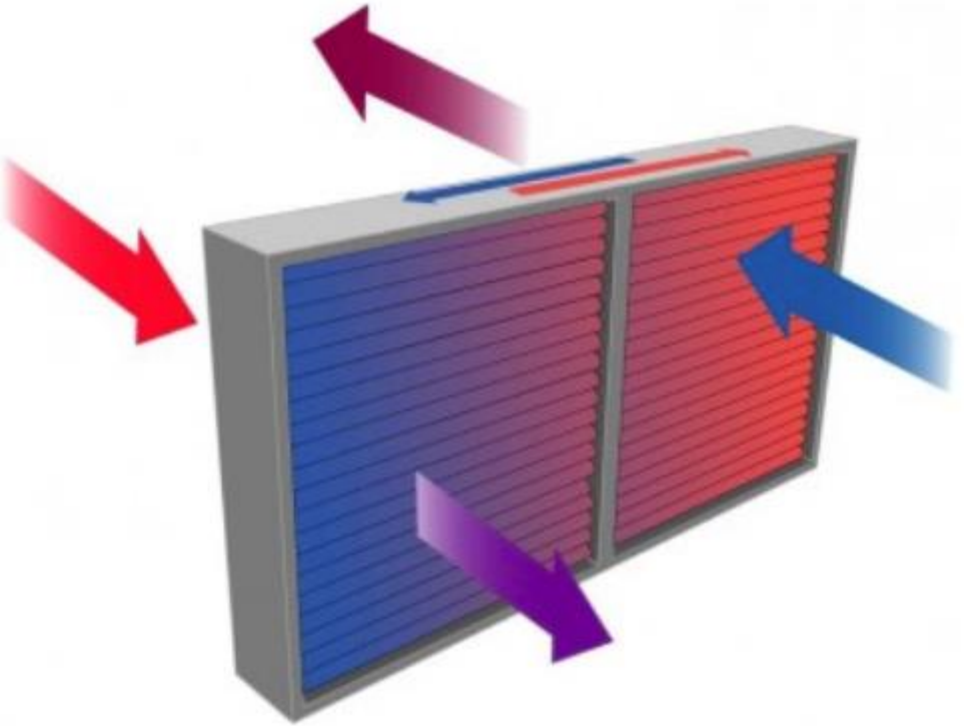
Cons

- Higher risk of contamination
- Purge Airflow
- Higher static pressure drop
- Minimum wheel speed



Heat Pipes

Cons — Pros



Cons

- Lower heat transfer & effectiveness
- Sensible heat recovery only - no latent

Pros

- Lower risk of contamination
- Lower static pressure drop
- No purge airflow
- Ability to fully bypass airflow

Heat Pipe vs Heat Wheels: Economics

Heat Wheel

Winter Recovery

3,280 Mlbs

Summer Recovery

14,026 kWh

Additional Fan Energy

-34,412 kWh

Heat Wheel Annual Cost Savings

$11,217

$10/Mlb
$0.10/kWh

Heat Pipe

Winter Recovery

1,950 Mlbs

Summer Recovery

2,425 kWh

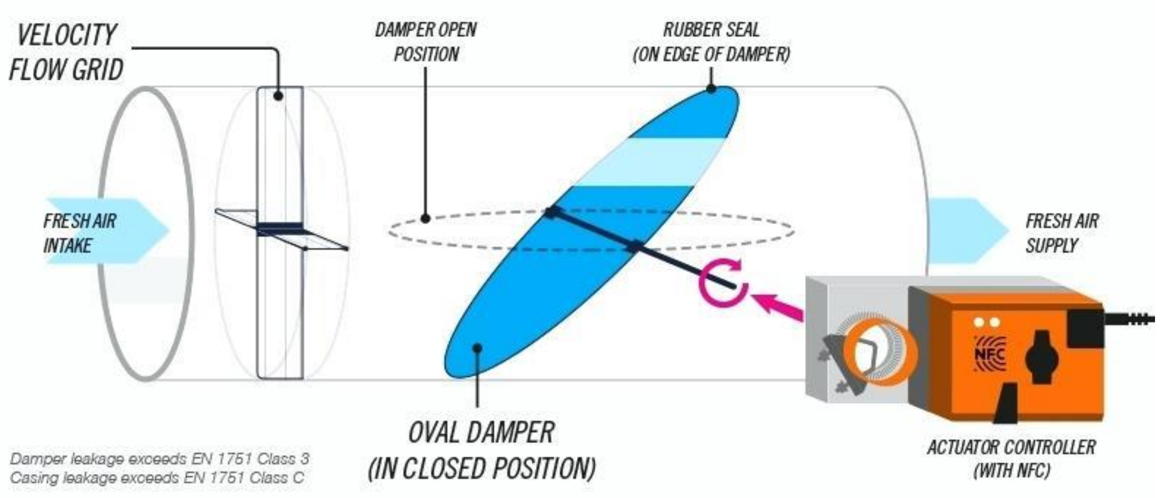
Additional Fan Energy

0 kWh

VAVs vs Air Valves

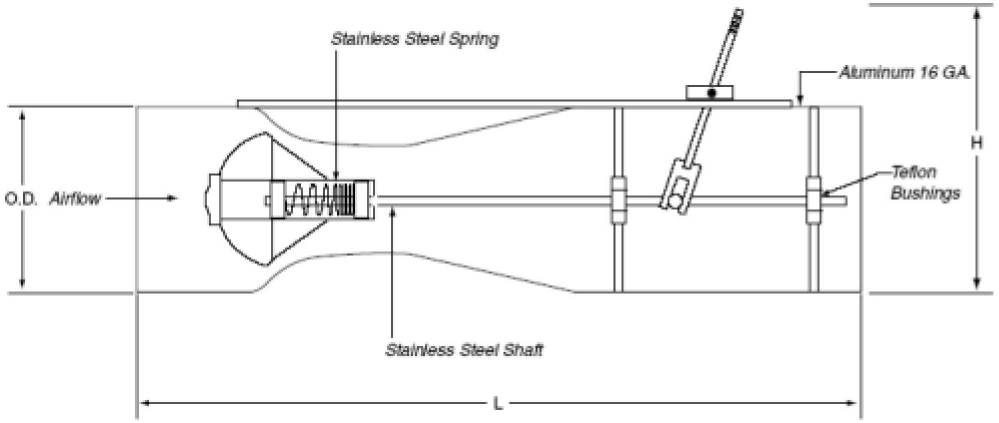
VAV BOX

- Relatively inexpensive
- Commonly used - easy to engineer, install, integrate to control system & repair
- Poor turndown & less accurate flow measurement
- Do not working well with fast-acting actuators
- Turbulent airflow at low end of operating range



AIR VALVE

- Higher initial cost
- Less frequently used – more difficult control integration, heavier than VAVs, not as easy to repair
- Excellent turndown and control and accurate airflow measurement through entire range
- Work great with fast-acting controls
- Better laminar flow through control range



VAVs vs Air Valves: Economic Impact

For a lab building with 600 devices:

Turndown Impacts

- 200 devices x 125 cfm/device = 25,000 cfm
- At $4.00/cfm → $100,000 /year

Flow Accuracy Impacts

- 150 devices x 50 cfm/device = 7,500 cfm
- At $4.00/cfm → $30,000 /year

Maintenance Impacts

- 3%/year failure rate = 18 devices/year
- 18 devices/yr x $1,000 /device = $18,000 /yr

Total Cost Savings:

- $100,000+$30,000+$18,000 = **$148,000 /yr**

Incremental Cost of Air Valves

- 600 devices x $2,000 /device = $1,200,000

Project Payback

- $1,200,000 / $148,000 = **8 year payback**
- Gross benefit over 20 year life
  - ($148,000 x 20 years) - $1,200,000
  - **$1,760,000 in savings**

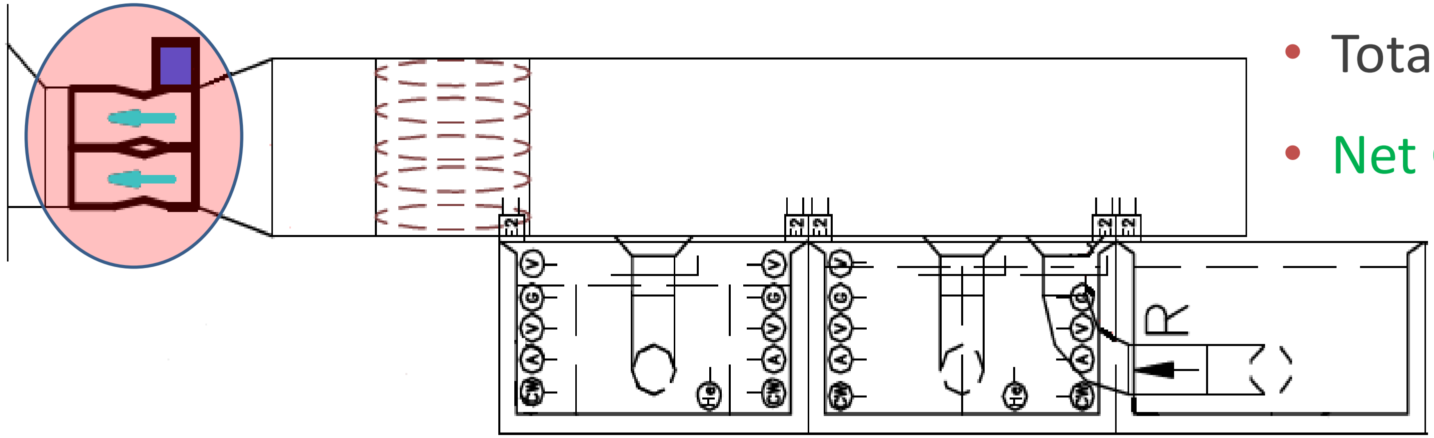
Oversized Terminal Devices

- Terminal devices (VAVs/Air Valves) should be sized in the middle of their operating range
  - Ability to change airflow setpoint based on lab service change
- University lab building example:
  - 29% of airflow setpoints higher than required due to terminal device mins
- Additional airflow savings potential if boxes were properly sized
  - 1,700 cfm
  - $7,100 per year of avoided energy costs
  - $107,000 of savings over the life of the equipment (15 years)
  - 175 valves/VAVs at $75 /device = $13,125 of additional construction costs

Terminal Devices: Shared Controllers

Original Design Intent

- One airflow controller for three fume hoods
  - Each hood is constant volume @ 400 cfm
- At $4.00/cfm → $4,800 /year
- Cost of one air valve & controls = $5,000
- Total cost over 20-year life = $101,000



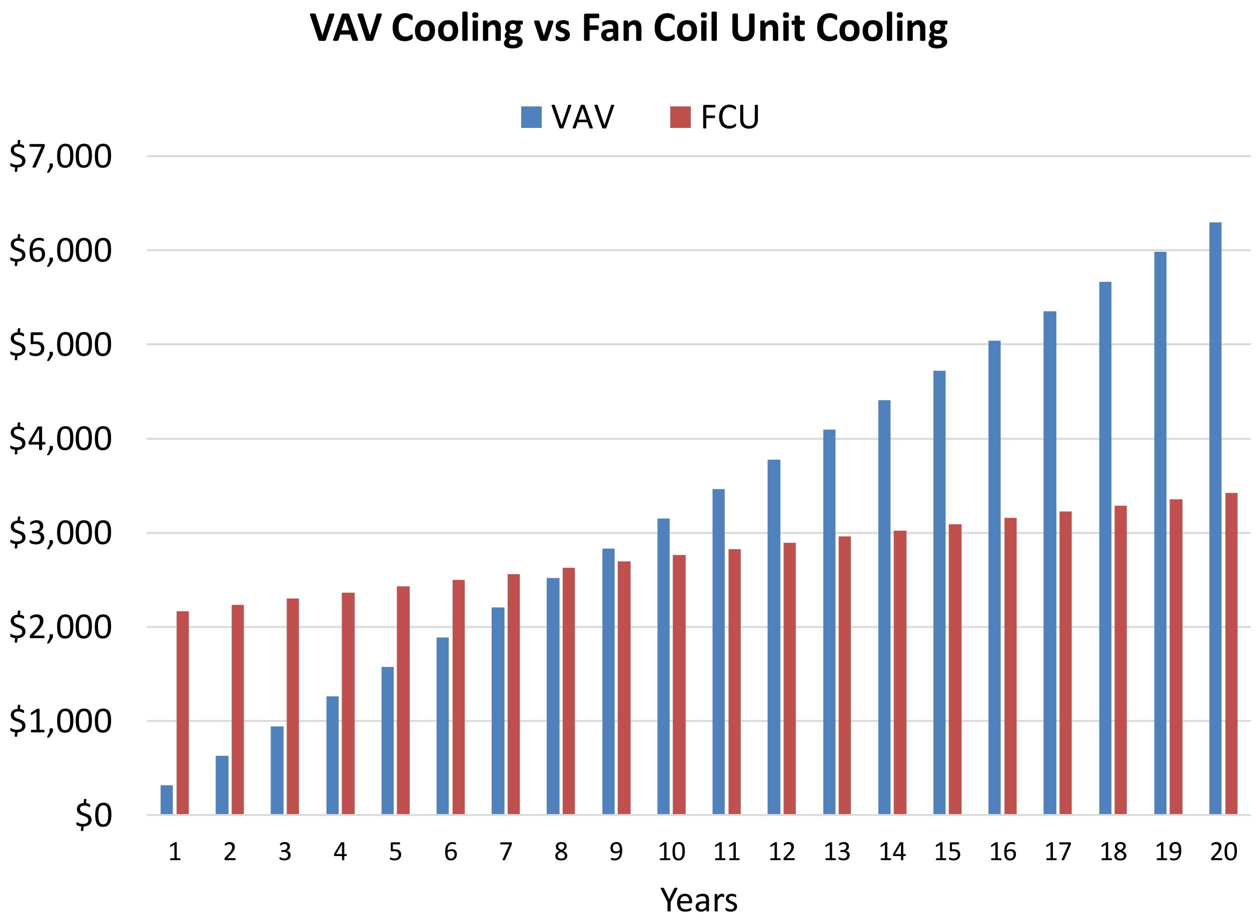
Proposed Design

- One airflow controller for each fume hoods
  - Each hood is variable volume @ 175 cfm (average)
- At $4.00/cfm → $2,100 /year
- Annual savings = $2,700 /year
- Two additional air valves & controls = $10,000
- Simple payback = $10,000 / $2,700/yr = **3.7 yrs**
- Total cost over 20-year life = $57,000
- Net Cost Savings: **$44,000**

VAV Cooling vs FCU Cooling

VAVs	FCUs
• VAV increases airflow from AHU • 100% outside air • Exhaust air increases and causes supply to track up; maintaining pressurization airflow offset • No additional installation cost	• Recirculating fan (EC motor) pushes air through local coil • Secondary pumping provides chilled water • Exhaust airflow does not increase • Higher additional installation cost

VAV Cooling vs FCU Cooling: Economics

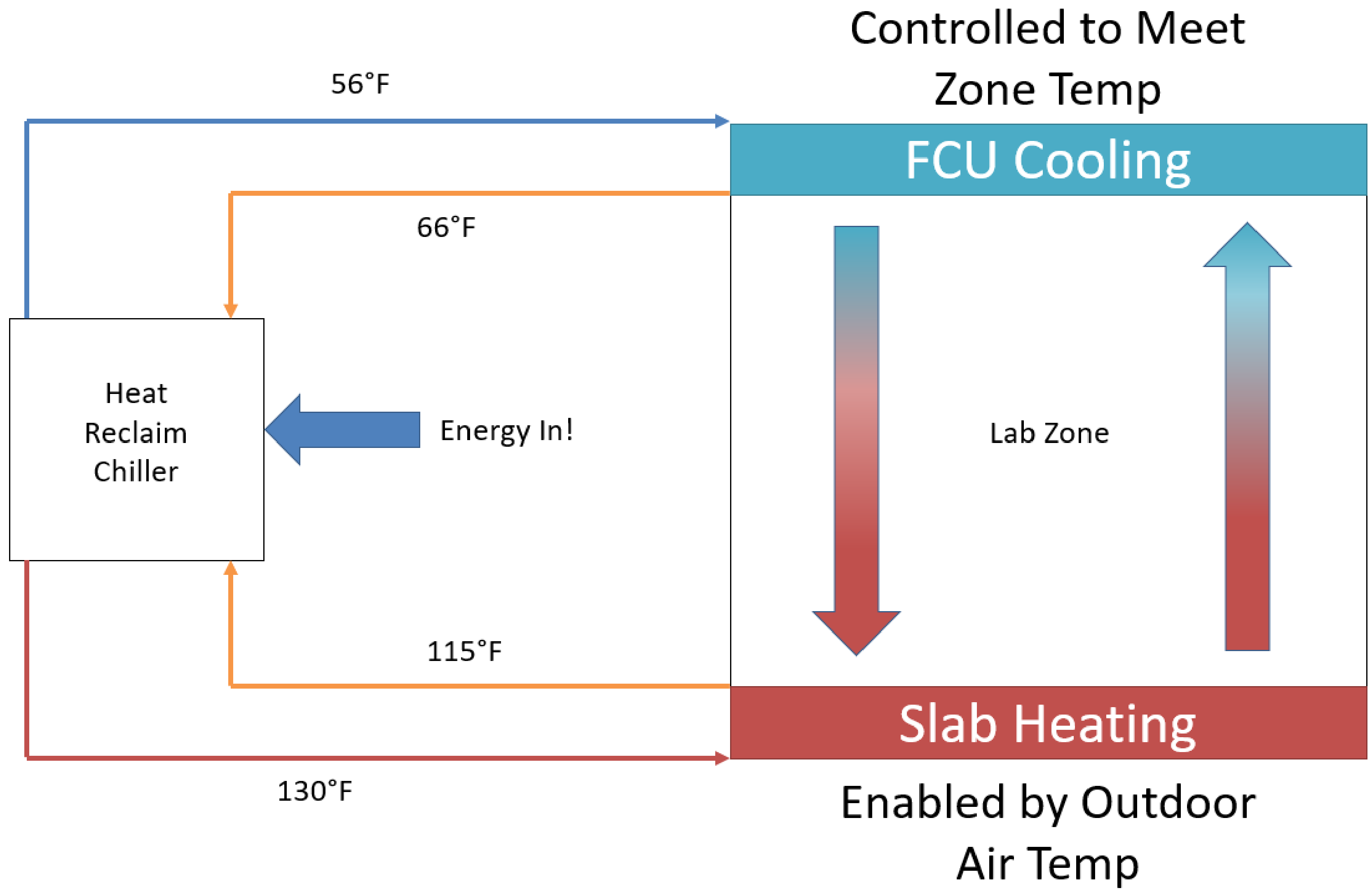


VAV Cooling vs FCU Cooling	VAV	FCU
Cooling Season Hours:	2,895	2,895
Average Annual Cost of Cooling Energy:	$315	$66
Incremental Equipment Installation Cost:	$0	$2,100
Assumed Building Life (Years):	20	20
Total Life Installation & Energy Cost:	$6,298	$3,420
Equipment Simple Payback:	**8.4**	
Life Cost Savings for One Device:	**$2,878**	
Life Cost Savings for Building*:	**$431,655**	

* Assumes building has 150 supply devices

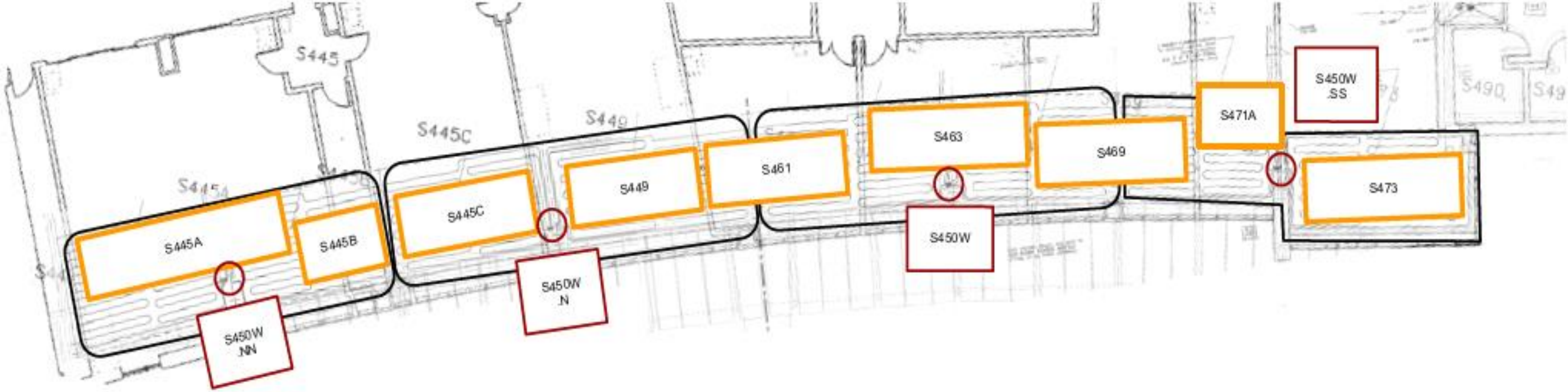
Note: Analysis was performed for a 12 inch VAV box and similar sized FCU

Simultaneous Heating & Cooling

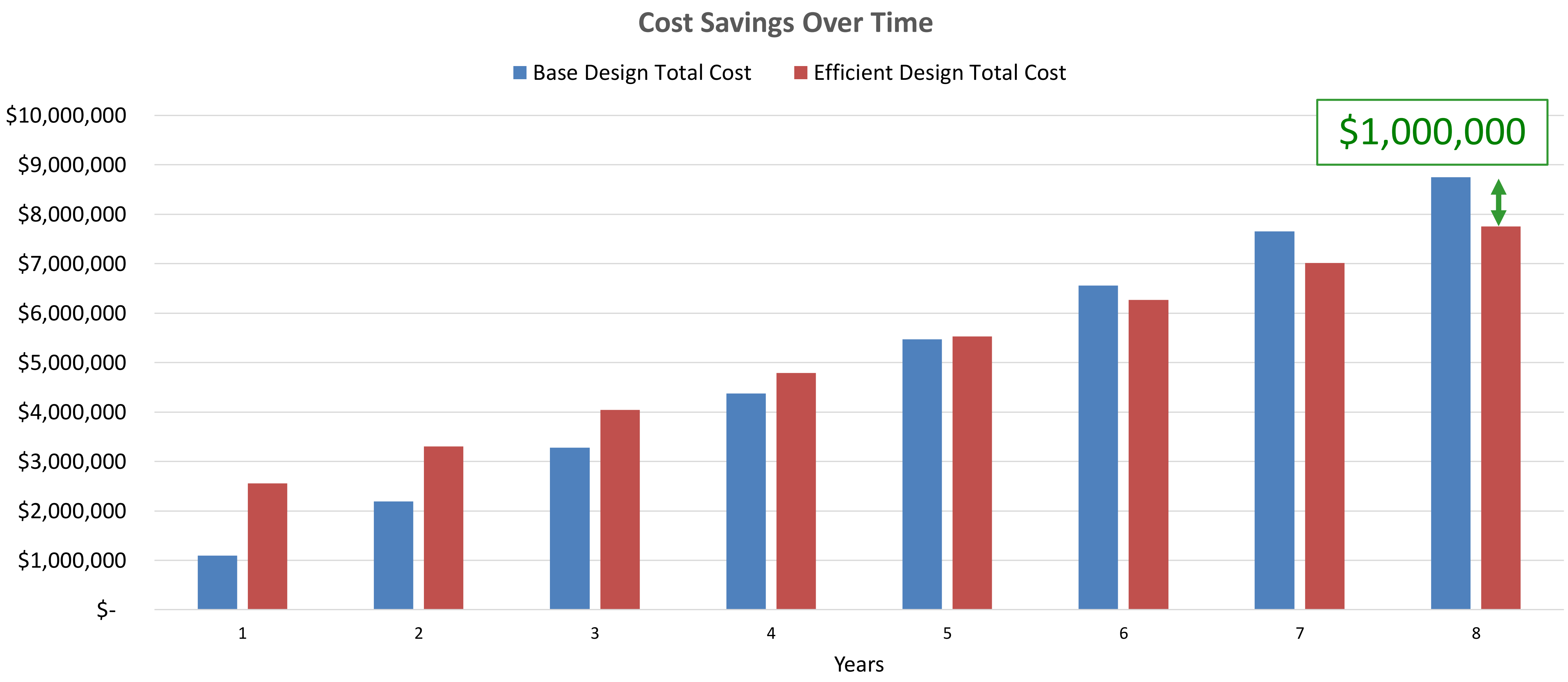


Future-Proofing

- Consider future building use when designing lab
  - Lab use and occupants change
- Example: Shell was built before the space was fit out
  - Radiant piping was placed when concrete was poured
  - During lab fit out, lab zones were built over multiple reheat zones



Conclusions



Questions?

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