UMass EH&S Lab Safety Coordinators
Lab Ventilation & Optimization

B2Q

EVERSOURCE ENERGY

UMass Amherst

- Design & Construction Management
- Physical Plant
- Research & Engagement
- Environmental Health & Safety

Introduction to B2Q

B2Q Associates is an independent consulting firm specializing in energy efficiency, commissioning, and advanced MEP and HVAC design for higher education, healthcare and industrial clients.

- Located in Andover, MA & Saratoga Springs, NY
- 16 Engineers (10 UMass Grads)
- Performing work on Campus since 2012
- Summary of Projects on Campus:
  - Over 40 energy & HVAC studies/investigations conducted
  - Turnkey HVAC & controls upgrades/optimization 10 buildings
  - Identified energy savings over 10 million kWh & 67 million lbs. of steam
  - B2Q Implemented savings of 6.4 million kWh & 39 million lbs. of steam
  - University Energy Cost Savings over $1.8 million annually
- Lab-specific work performed in GRC, Conte, ELab II, ISB, LSL North & South, PSB

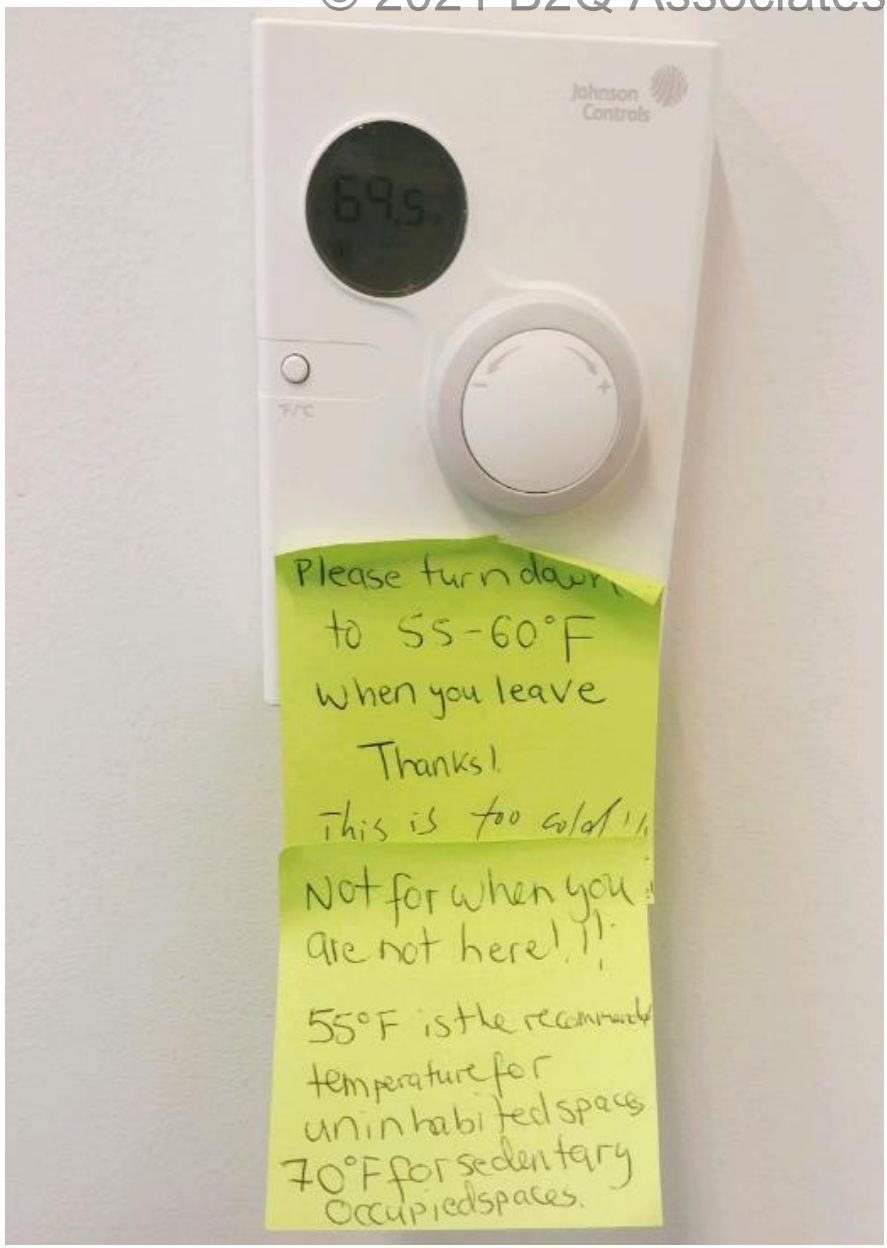
Why is Lab Ventilation Important?

- Primary objective of lab ventilation & lab ventilation controls is to provide a safe work environment by effectively removing contaminants from a lab and maintaining pressurization relative to adjacent spaces.

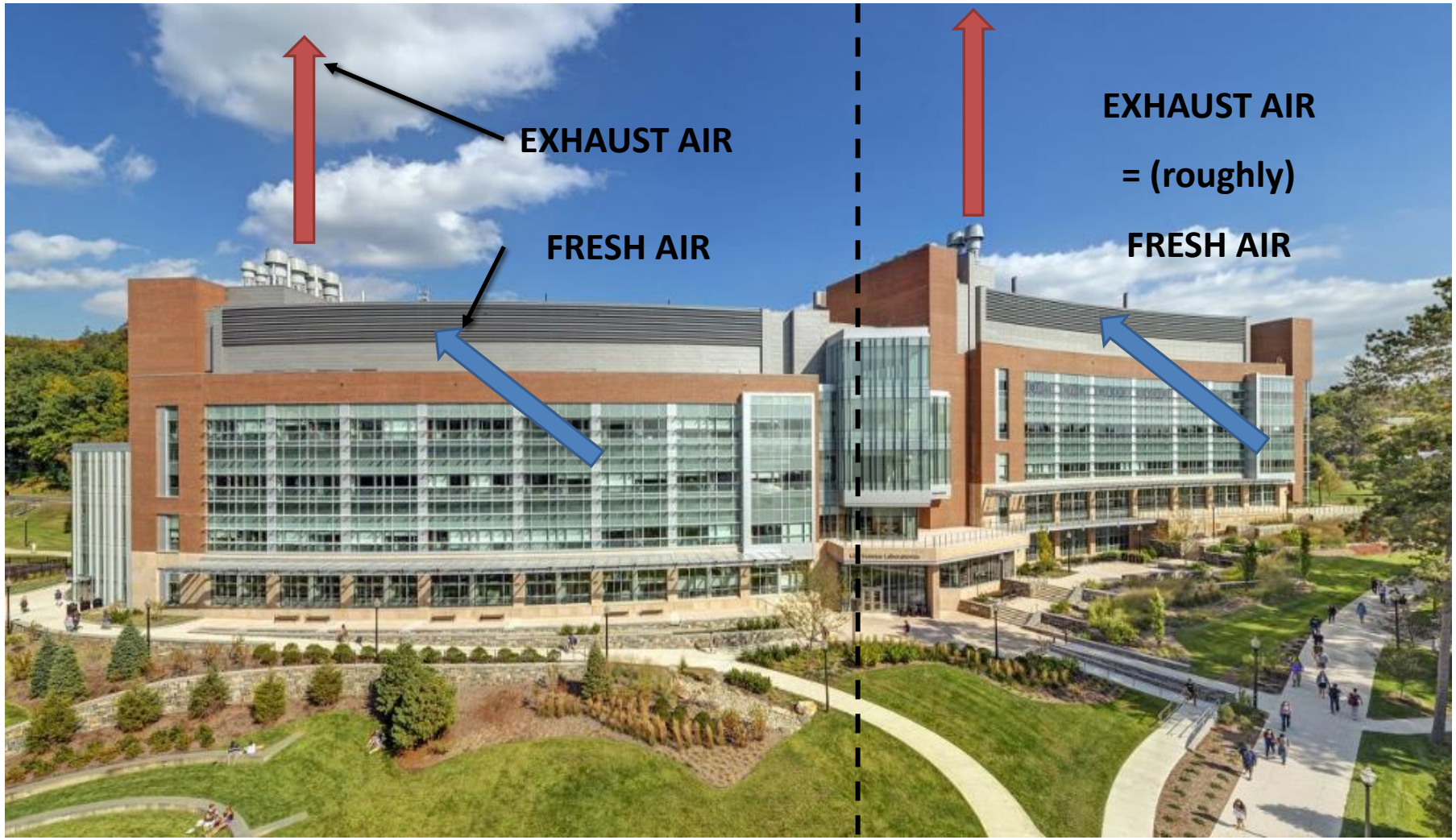
- Provide comfortable working environment for occupants.
  - Temperature, Relative Humidity, Noise
  - Maintain Consistency of Environments

- Lab ventilation is extremely expensive!
  - 100% outdoor air
  - High energy demand day & night

Building	Savings Metric ($/CFM)
UMass LSL	$4.05
UMass ISB	$4.35
UMass Elab II	$10.33

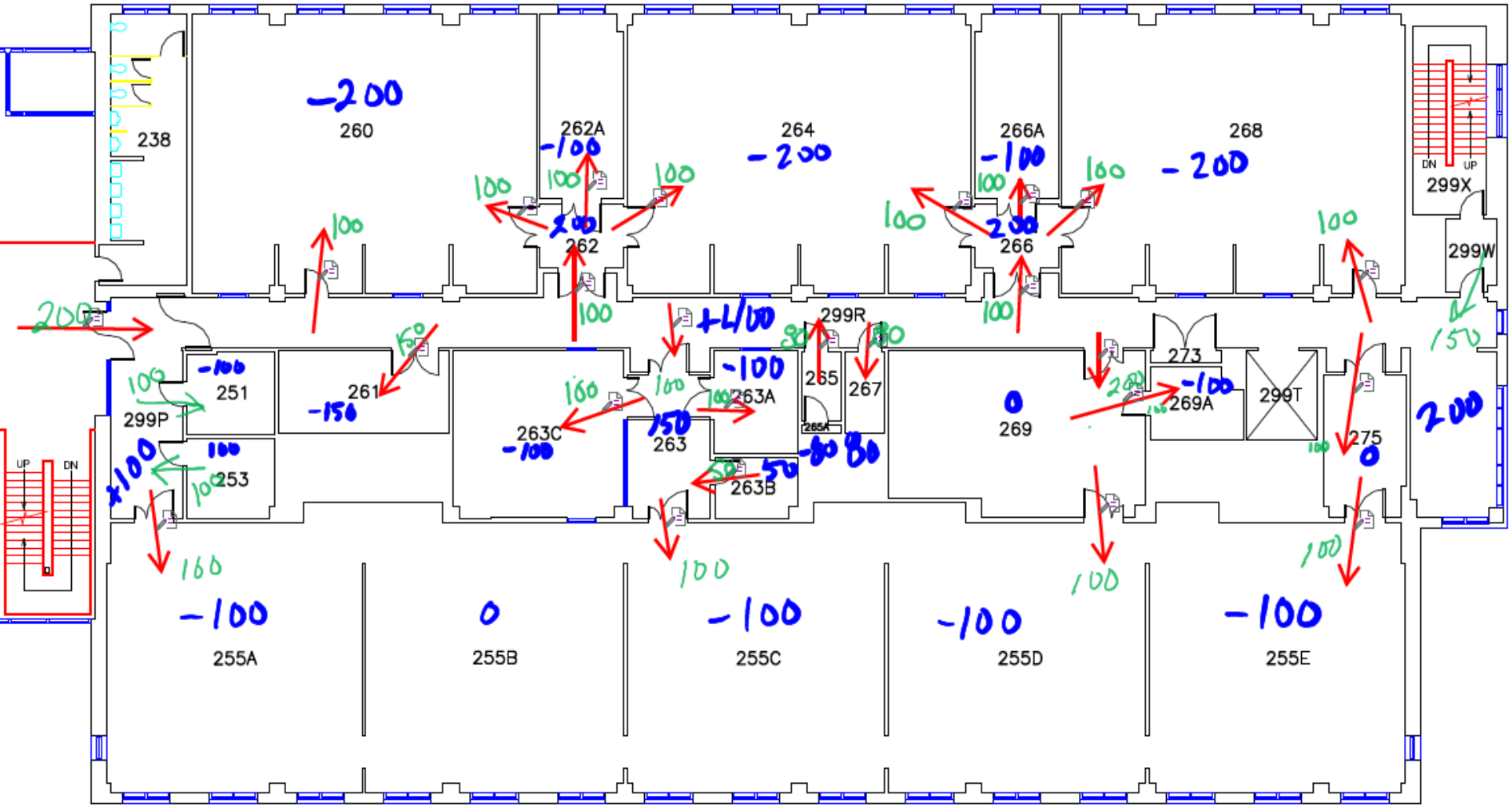


How Does Ventilation Work in a Lab Building?



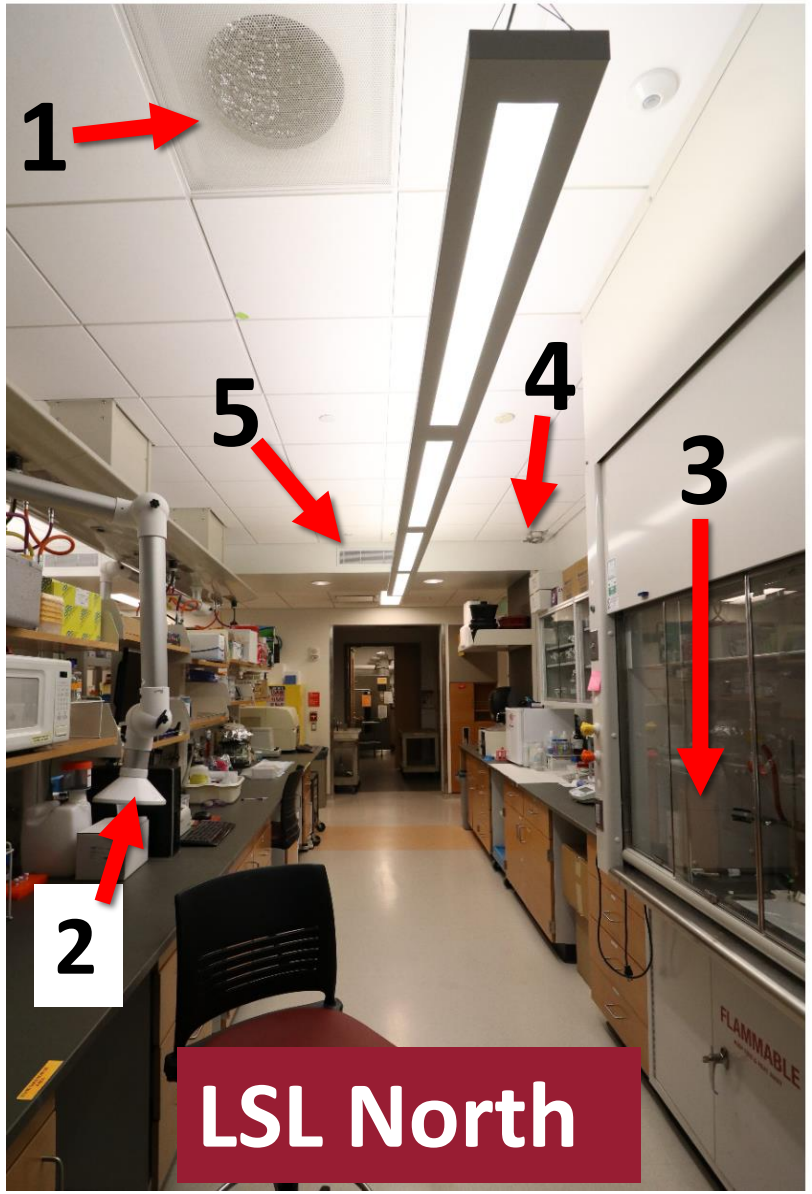
- Lab air exhausted from top of building
- Fresh outdoor air brought in at a lower elevation.
- In general, the fresh outdoor air entering the building equals the exhaust air leaving.

Lab Pressure Cascades & Airflow Balance

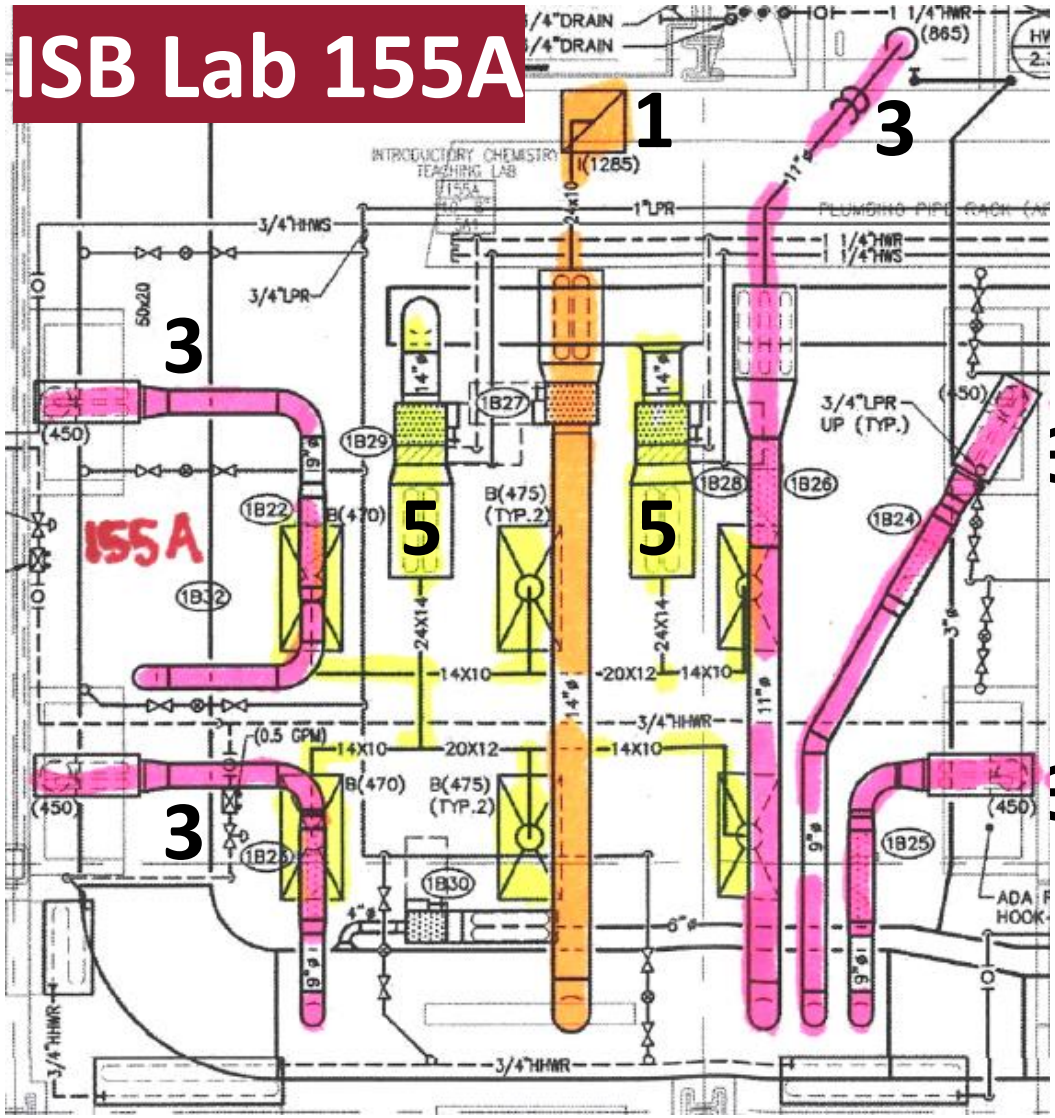


- Air “cascades” from non-lab to lab zones.
- Generally, labs are negative to surrounding areas.
  - There are exceptions
- Supply air is brought into labs to maintain pressurization
- Supply air is brought into non-labs to “make-up” for lab negativity.

Individual Lab Ventilation



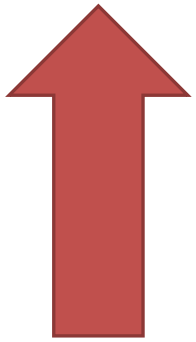
1. General Exhaust
2. Snorkel Exhaust
3. Fume Hoods
4. Slide Gate Dampers
5. Supply Air



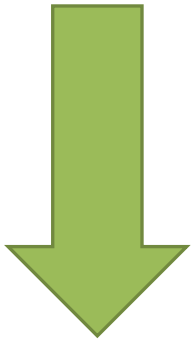
Individual Lab Ventilation

- Lab ventilation is generally measured in air change rates (ACH) or how many times the volume of air in a lab zone is exchanged in an hour

$$Air\ Change\ Rate\ (ACH) = \frac{Total\ Exhaust\ Airflow\ \left(\frac{ft^3}{min}\right) x\ 60\ \frac{min}{hour}}{Gross\ Lab\ Volume\ (ft^3) - Furniture\ Volume\ (ft^3)}$$



Higher ACH is typical for more hazardous lab zones and occupied periods

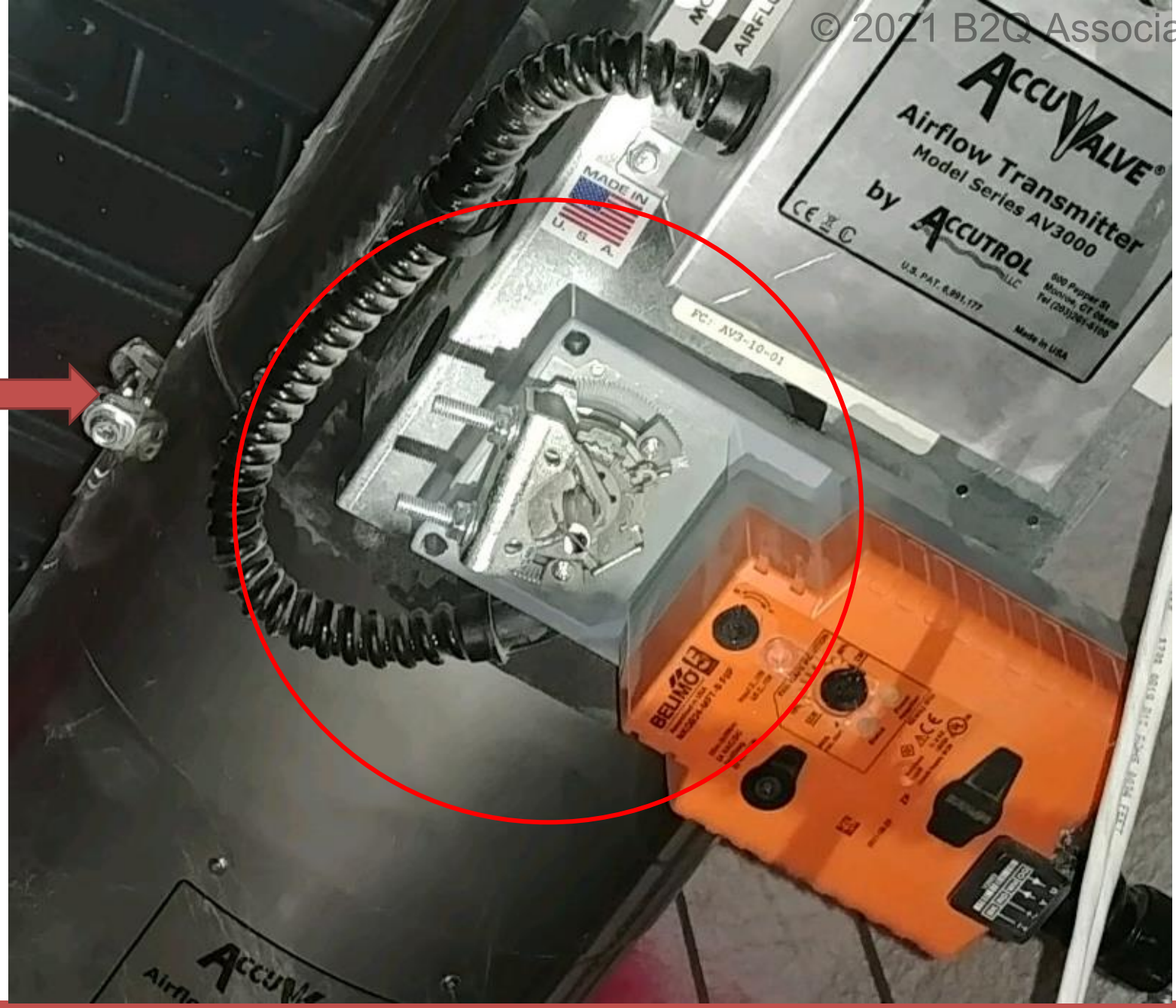


Lower ACH is typical for less hazardous lab zones and unoccupied periods

- Safe and effective lab ventilation is more than just ACH – distribution, layout, velocity, airflow patterns, etc. matter.

Potential Issues

- Labs over ventilating or under ventilating
- Exposure due to improper fume hood control
- Improper room balance
- Stratification or concentrations
- Equipment or diffuser interference – Physical constraints



What is the Opportunity & Where does B2Q fit in?

- Re-design lab ventilation to match current lab use, chemical inventory, & updated codes
- Optimize / update lab ventilation control strategies through re-commissioning
- Repair/replace failed controls/HVAC hardware – actuators, sensors, occupancy
- Applies to new and old buildings.
  - Failing equipment (~2% / year observed) & facility operator overrides
  - Codes, standards, guidelines updated since design
  - Lab use has changed or is not as intended during design
  - Commissioning not performed or not well-executed
  - Controls may be outdated or new technology is available
  - Policy change – energy conscious movements and practices
- B2Q helps UMass identify the opportunity, estimate savings and costs, and implement changes

The Big Picture

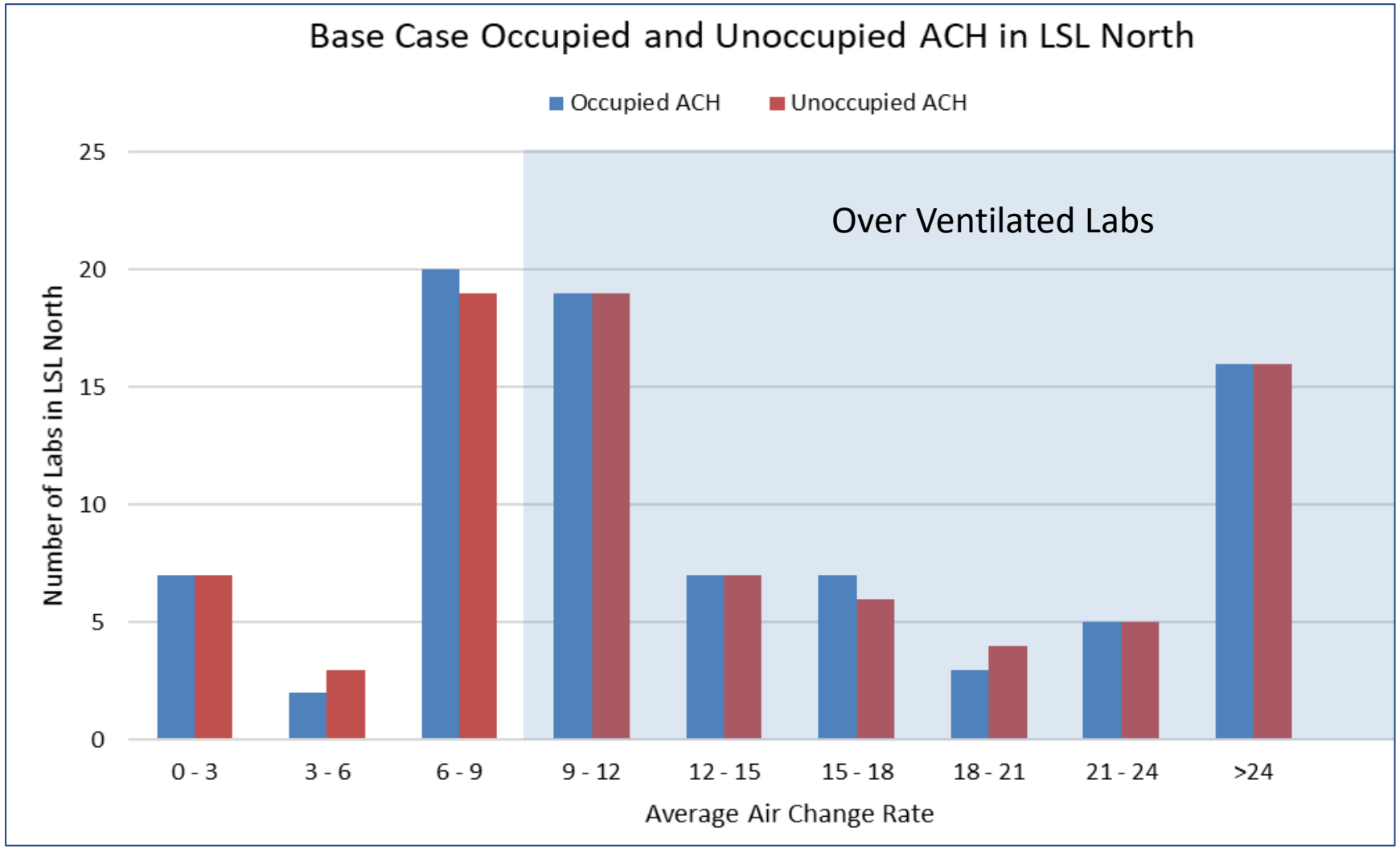
1
- Baseline Buildings & Labs
  - "What is the building doing now"
- Determine the opportunity

2
- Work with EH&S to determine safe ventilation & other factors
- Evaluate energy savings and project economics

3
- Implement Changes
- Measure and Verify results (12 months)

LSL North - Site Energy Use Intensity Information					
Building Area (ft^2)			180,000		
Annual Energy Use		Use Intensity	Annual Cost	Average Bill Rate	Cost Intensity
Electric Energy					
kWh	MMBtu	kBtu/ft^2	$	$/kWh	$/$ft^2$
5,053,920	17,244	95.8	$505,392	$0.10	$2.81
Steam Energy					
Mlbs	MMBtu	kBtu/ft^2	$	$/Mlb	$/$ft^2$
17,149	16,206	90.0	$342,980	$20.00	$1.91
Chilled Water Energy					
kWh	MMBtu	kBtu/ft^2	$	$/kWh	$/$ft^2$
612,597	2,090	11.6	$61,260	$0.10	$0.34
Total Energy					
MMBtu		kBtu/ft^2	$	$/MMBtu	$/$ft^2$
35,540		197.4	$909,632	$25.59	$5.05

Lab Baseline



- Download building operating data & evaluate operation
- Determine base case lab ventilation during occupied and unoccupied operation
- Identify over ventilated labs and under ventilated labs
- Identify the opportunities that exist – for LSL North:
  - Occupancy control – little change between occ/unocc
  - Generally over ventilated

Areas for Improvement in Labs

- **Lab Ventilation (ACH)**
  - Is ventilation too high or low?
- **Fume Hood Operation**
  - Variable Volume
  - Face Velocity Control
  - Minimum Flow Setpoint
  - Are sashes being left open?
- **Occupancy Control**
  - Do lab controls respond to occupancy?
- **Lab Pressurization & Make Up Air**
  - Are labs positive or too negative?
  - Is make-up air lacking?

A closed fume hood uses about 70% less energy than a fume hood with an open sash. … if the fume hood is variable volume, that is

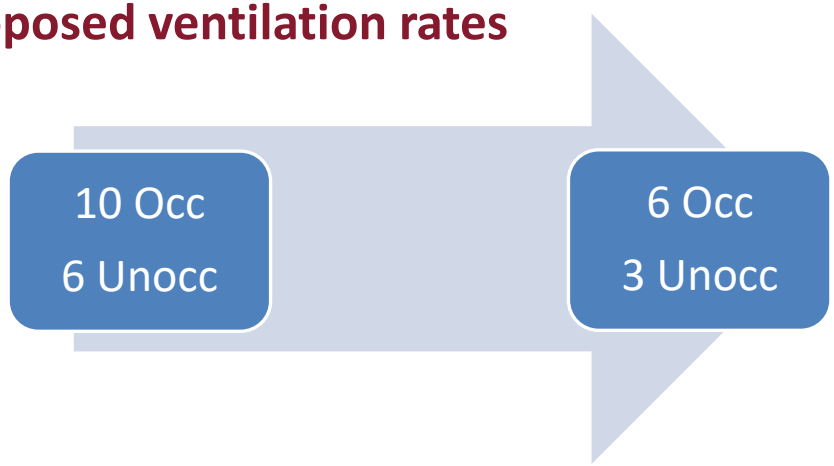
Working with EH&S / Lab PIs

- **Lab Ventilation (ACH)**
  - Is ventilation too high or low?
- **Fume Hood Operation**
  - Variable Volume
  - Face Velocity Control
  - Minimum Flow Setpoint
  - Are sashes being left open?
- **Occupancy Control**
  - Do lab controls respond to occupancy?
- **Lab Pressurization & Make Up Air**
  - Are labs positive or too negative?
  - Is make-up air lacking?

Walk through lab zones with EH&S to identify:

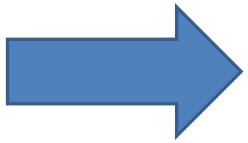
- **Lab housekeeping**
- **Chemical inventory**
- **Lab operations**
- **Gain understanding of lab occupancy patterns**
- **Take note of lab PI troubles or complaints**

Informs proposed ventilation rates



Working with EH&S / Lab PIs

- **Lab Ventilation (ACH)**
  - Is ventilation too high or low?
- **Fume Hood Operation**
  - Variable Volume
  - Face Velocity Control
  - Minimum Flow Setpoint
  - Are sashes being left open?
- **Occupancy Control**
  - Do lab controls respond to occupancy?
- **Lab Pressurization & Make Up Air**
  - Are labs positive or too negative?
  - Is make-up air lacking?

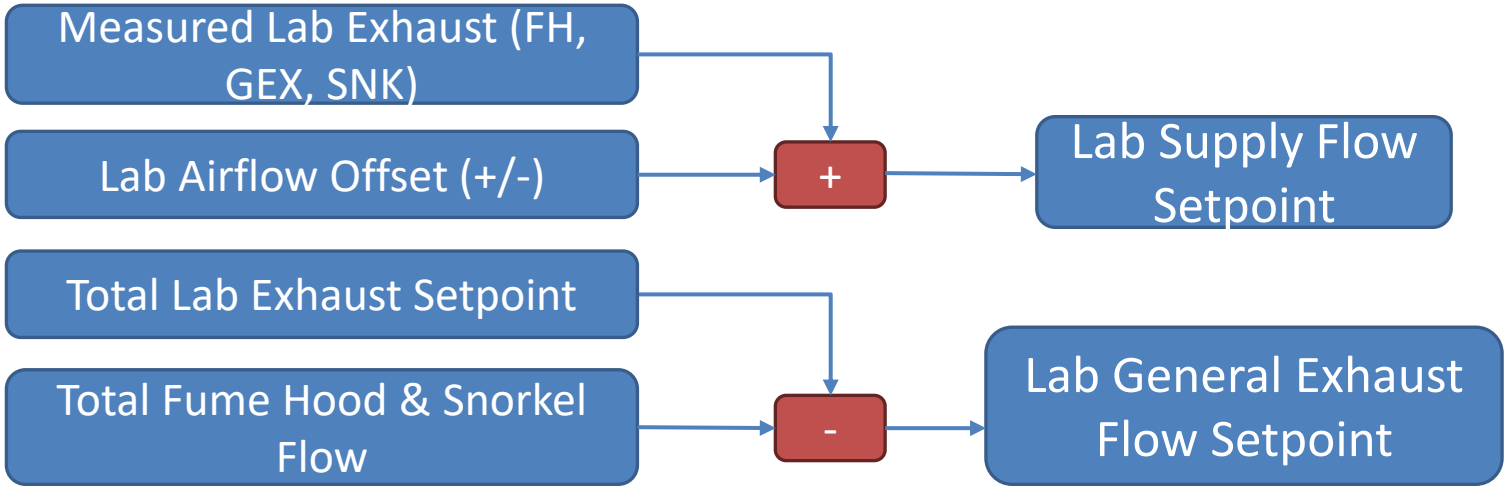


- **Variable Volume Control**
  - Constant volume fume hoods use same amount of exhaust air even with sash closed.
- **Face Velocity Control**
  - 100 fpm? 80 fpm? 40 fpm setbacks?
  - ASHRAE 110 notes 75-110 fpm acceptable
  - ASHRAE 110 Modified Testing
- **Minimum Flow Setpoint**
  - ANSI Z9.5 2012 notes as low as 10 cfm/ft^2
    - Was 25 cfm/ft^2 – code change
- **Culture & Behavior**
  - Are fume hood sashes being left open?
  - Chemistry / gas work being done on benches?

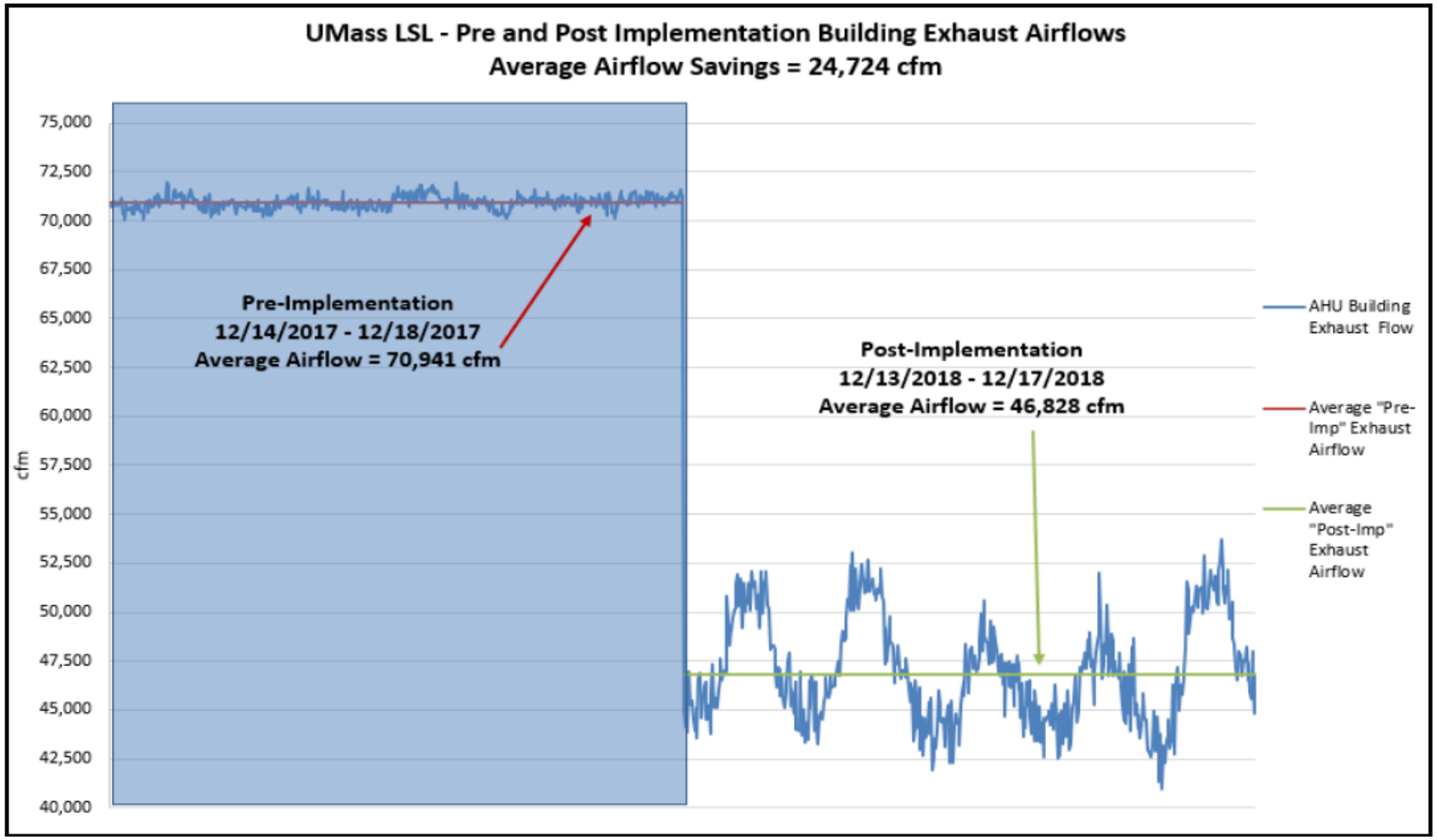
Evaluate & Implement

- Engineer new lab control sequences, setpoints and lab airflow offsets to control to new ACH.
  - **Setpoints and control sequences approved by EH&S** and Physical Plant.
  - Evaluate expected energy savings & implementation cost
- Example Net Room Volume = 11,813 ft^3 with a recommended 6 occupied ACH.

$$6\ ACH = \frac{Flow\ Rate(\frac{cu.ft}{min}) * 60\ (\frac{min}{hr})}{11{,}813\ (cu.ft)} = \frac{6 * 11{,}813}{60} = 1{,}181\ CFM\ (1968\ @\ 10\ ACH)$$



Commission, Measure & Verify



- Test new sequences and setpoints
- Monitor operation over 3-12 months
- Document savings for UMass & Utility
- Ensure that changes made have not been undone

Monitoring-Based Commissioning (MBCx)

- MBCx also known as Continuous Commissioning (CCx) or Real-time Energy Management (RTEM)
- Comprehensive approach to commissioning of new or existing buildings incorporating:
  - Allows facility operators and EH&S a “real time” view of lab and building operation.
  - Identifies potential faults, safety concerns and areas of potential waste energy and ranks by severity

DATA 87 of 87

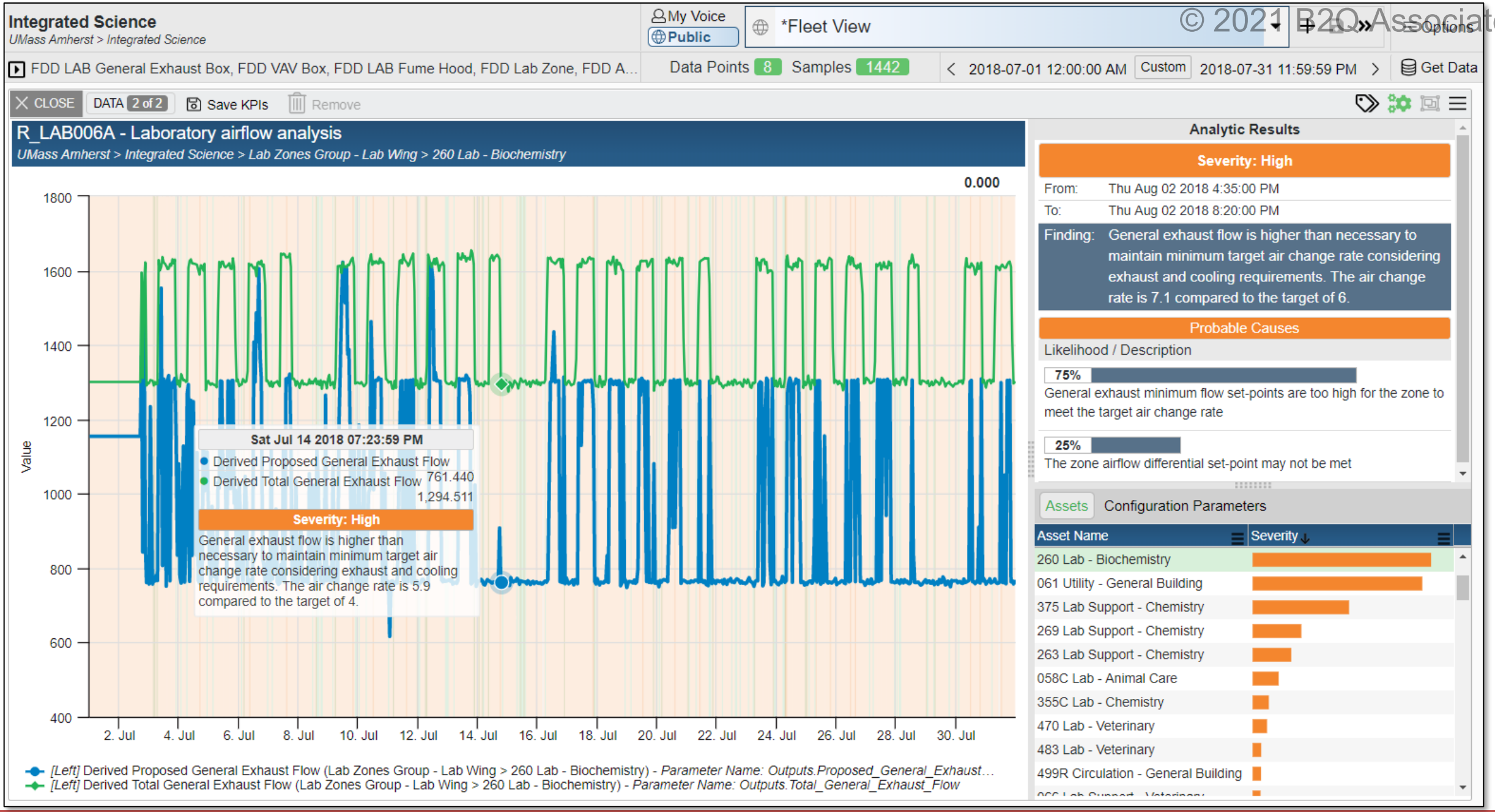
Historian KPI List

Name	Equipment	History	Value	UoM	Status
Face Velocity	230 NE Fume Hood > Hood Face		79.071	feet/minute	>75 fpm
Face Velocity	043 S Fume Hood > Hood Face		79.310	feet/minute	>75 fpm
Face Velocity	150 ENE Fume Hood > Hood Face		79.527	feet/minute	>75 fpm
Face Velocity	150 NW Fume Hood > Hood Face		79.854	feet/minute	>75 fpm
Face Velocity	021 N Fume Hood > Hood Face		79.967	feet/minute	>75 fpm
Face Velocity	240 SWSW Fume Hood > Hood Face		80.290	feet/minute	>75 fpm
Face Velocity	240 WSW Fume Hood > Hood Face		80.452	feet/minute	>75 fpm
Face Velocity	230 SE Fume Hood > Hood Face		81.906	feet/minute	>75 fpm
Face Velocity	240 NWNW Fume Hood > Hood Face				
Face Velocity	230 SSE Fume Hood > Hood Face				
Face Velocity	230 E Fume Hood > Hood Face				
Face Velocity	043 N Fume Hood > Hood Face				
Face Velocity	230 ENE Fume Hood > Hood Face				
Face Velocity	021 S Fume Hood > Hood Face				

DATA 50 of 50

Historian KPI List

Name	Equipment	History	Value	UoM
Derived Lab Air Change Rate	Zones > 023A Pump Chase		4.447	
Derived Lab Air Change Rate	Zones > 062 High Bay Lab		6.169	
Derived Lab Air Change Rate	Zones > 021 Wet Assembly		6.395	
Derived Lab Air Change Rate	Zones > 032 High Bay Lab		6.460	
Derived Lab Air Change Rate	Zones > 025 Dry Assembly		6.471	
Derived Lab Air Change Rate	Zones > 027 Optics Lab		6.494	
Derived Lab Air Change Rate	Zones > 068 High Bay Lab		6.508	
Derived Lab Air Change Rate	Zones > 064 High Bay Lab		6.510	
Derived Lab Air Change Rate	Zones > 028 High Bay Lab		6.515	
Derived Lab Air Change Rate	Zones > 066 High Bay Lab		6.535	
Derived Lab Air Change Rate	Zones > 033 Optics Lab		6.540	
Derived Lab Air Change Rate	Zones > 031 Optics Lab		6.540	
Derived Lab Air Change Rate	Zones > 070 High Bay Lab		6.550	



MBCx Results in PSB

- MBCx can be used to commission newly constructed labs to help the Owner take advantage of warranty periods.
- New building commissioning is usually performed through trend review and one time functional testing – MBCx monitors the building and systems through all hours of operation.
- At the end of the day – this technology allows for a safer, better functioning lab building from the start.

Tracking #	Description of Issue	FCX Analytic	Date of Resolution	Current Observed Operation / Set-points
5, 6, 9, 10, 11, 12	Lab zone airflow differential set-points not met. Some zones found with positive airflow offset when should be negative.	R_LAB006C	11/14/2018	Zones 039, 072: 50 cfm (positive) Zones 121, 221, 165, 264, 265: 100 cfm (negative) Zone 064: 50 cfm (negative)
16	Fume hood sashes left open overnight	R_LAB001C	11/9/2018	No fume hood sashes have been left open overnight above 30% position. Very limited instances where hood sashes remain above minimum for extended periods

Tracking #	Description	Details	Impact
1, 2, 3	Zone air change rate higher than design target; not due to cooling or fume hood ventilation demand	026 High Bay Lab: 10.2 ACH actual vs. 6.0 ACH design 024 Electronics Assembly: 11.7 ACH actual vs. 6.5 ACH design 072 High Bay Lab: 7.0 ACH actual vs. 6.0 ACH design	Energy
7, 8	Lab airflow differential set-point not met	166 High Hazard: -340 cfm actual vs. -100 cfm design 260C Cell Culture: -560 cfm actual vs. +100 cfm design	Energy Safety

Monitoring-Based Commissioning (MBCx)

- Helps EH&S & O&M staff maintain safe & efficient operating conditions.

Facilities Staff

- Informs on equipment and controls performance, at the equipment and lab level
- Identifies & prioritizes worst offenders with analytics specifically tailored to lab control sequences
- Quantifies potential savings for issues found, considering interactive nature of equipment within each lab
- Identifies likely causes and recommends corrective actions

Environmental Health & Safety

- Monitor air change rates, lab pressurization, and fume hood flows in real time, for any lab
- Notification of issues
- New tools for reporting lab HVAC and fume hood performance

Research Staff & PIs

- Improved transparency for safety
- High performing lab systems may attract research candidates

How can Lab Safety Coordinators Help?

- **Take note of the lab environment**
  - Is the lab overly cold or loud?
  - Are there lingering odors?
- **Keep an eye out for hazards in the lab & notify appropriate parties**
- **Encourage smart fume hood use and closing the sashes**
- **<u>Keep an open dialog with lab occupants and encourage them to ask questions.</u>**

A Woman Business Enterprise (WBE)

100 Burtt Rd. Ste. 212
Andover, MA 01810

Brad Newell – Project Manager
bnewell@b2qassociates.com
(603) 703-3932 (Cell)
(978) 447-5604 (Office)

Chris Schmidt – Vice President, Principal
cschmidt@b2qassociates.com
(603) 247-1575 (Cell)

Thank You!

Questions?