Airflow Optimization for Decarbonization and Energy Efficiency

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THRIVE BUILDINGS

AIRCUITY®
Accurate Ventilation for Healthy, Sustainable Buildings

Mega Trends for the Built Environment

Sustainability

- Efficiency First = Hard ROI's and just good business
- Life Cycle Approach
- Carbon reduction

Net Zero Buildings

- Net Zero designs are proliferating
- All Electric Buildings
- Eliminate the use of fossil fuels – i.e. Gas Reheat

Air quality > Safety and Compliance expectations

- Growing awareness of IAQ and its affect on health, safety and research outcomes
- Increasing compliance requirements

Why Corporations, Cities & Governments Care

NC Floods

Latest insurance trends tell the real story re: climate impact

Canadian Wildfires

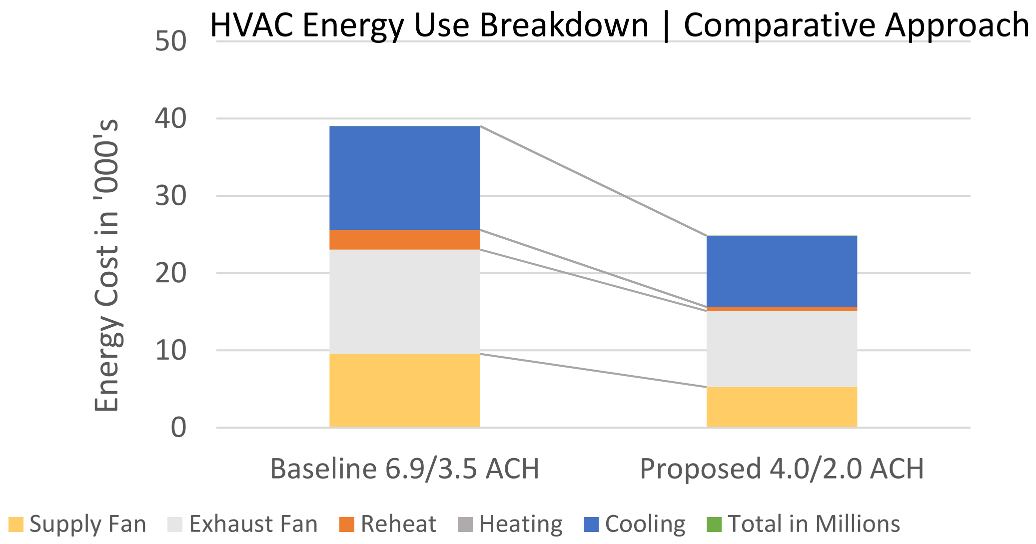
So….Why the Built Environment?

- >40% of CO2 Emissions from Buildings
- Eliminating all CO_2 emissions from the built environment by 2040 meets the **1.5°**Climate target.
- And >>> Emerging Massive Power Consumption of AI – Utilities need power!!

DEWA Net Zero HQ – Dubai

Smart Labs & Airflow Optimization Impact on EUI

- Typical new Lab space EUI = 100 - 115 range
- Typical new state-of-the-art Office EUI = 50 - 65 range
- Airflow Optimization = **decrease in EUI by roughly 30%** for the entire building*



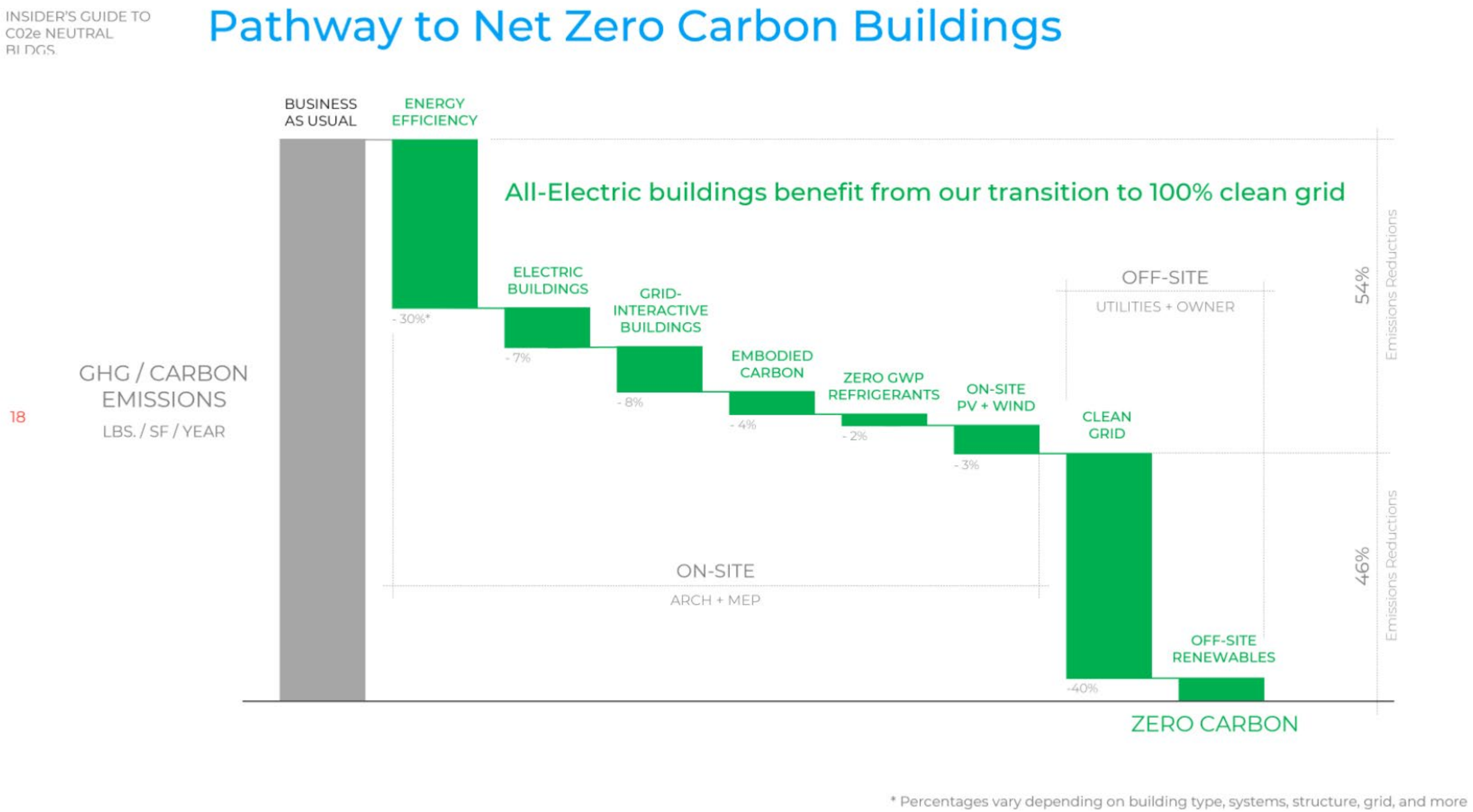
*Data is preliminary, based on laboratory buildings studied to date, data for specific EUIs at individual laboratory floors continues to be collected

Airflow Optimization & Smart Buildings

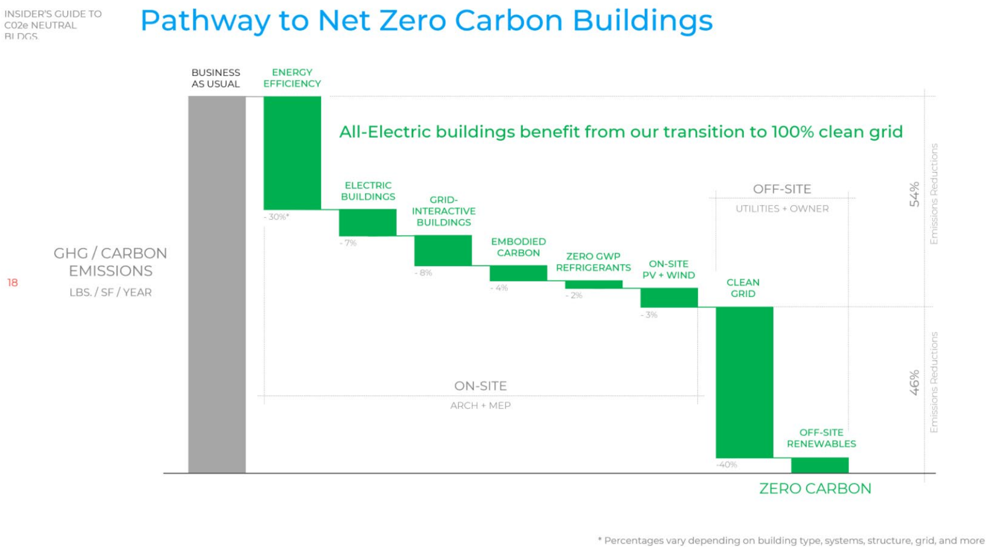
- Airflow Optimization is single best ECM for Critical Environments
- Impacts Heating, Cooling, Fan Power – Supply & Exhaust
- Address Deferred Maintenance
- Intelligence Provides Sustained Savings and Healthy, Safer Environments

Where is the Puck Going?

WSP: Path to Zero Starts with Energy Efficiency !!!



Here is Why!!



Efficiency Delivers a 5X Return on Investment in total cost to Net Zero

A Top 10 Life Sciences Firm

"Eliminating GHG emissions by 2040 requires moving away from fossil fuels (Scope 1) and procuring 100% renewable electricity. To make electric heating possible and reduce costs, buildings must first reduce the heating loads via optimized ventilation and energy recovery."

FY21 U.S. Region Capital Project – Lab Air Optimization[1]

Lab air quality is continuously monitored via centralized sampling platform and ventilation adjusted accordingly.

GREFP Sustainability Program Priorities

1. **Prioritize occupant** health, comfort, and productivity

2. **Target high impact** interventions to support sustainability goals

3. **Invest in long-term** opportunities, owned facilities, and hub sites

1. Lab air optimization is a program to improve occupant health and safety through air quality monitoring.
2. Project significantly reduces Scope 1 and Scope 2 greenhouse gas emissions and water consumption.
3. Optimizing ventilation rates is a first step towards a transition away from fossil fuels (natural gas).

$3.2 Million
Total Cost

$1 Million
Utility Rebate

$900,000
Annual OpEx Savings

2.4 years
Simple Payback

2,000 MTCDE
GHG Savings

3,000,000 Gallons
Water Savings

6% from FY19
GHG Reduction

4% from FY19
Water Use Reduction

Flinders University
Health and Medical Research Building

- Ten story research facility, which houses more than 600 staff
  - Labs & vivaria

- First medical institute in the world to earn a ‘platinum’ rating from WiredScore for its cutting-edge digital capabilities

- Aiming to achieve WELL & LEED Gold certification

Flinders University
Health and Medical Research Building

- Monitoring & Controlling:
  - **40** vivarium spaces
  - **60** wet labs (900 benches!)
- ROI:
  - **1.9 years** for vivarium
  - **4.1 years** for wet lab
- Rightsized HVAC system delivered significant savings!

New Construction and Existing Facilities

Targeting Highest Saving Buildings & Systems

- Labs, vivariums, cleanrooms, exhaust systems, high variable occupancy spaces
- Decarbonization + Energy ROI + Implementation Speed + Lowered Cost of Electrification

Design Optimization Expertise

- Dynamically controlling airflow requirements
- Expertise in multiple ECMs (Aircuity, fume hood controls, VFDs, etc.)
- Looking at the future: Efficiency + Clean Energy + Electrification

Turnkey & Comprehensive Solutions

- Most owner's portfolio are existing facilities
- Consistent design, installation, integration
- Rebate management

Results:

Over 1,000 Systems Installed
25 Years of DCV & IAQ Excellence
w/ Sustained Performance

LBS CO_2 REDUCED	SQFT INSTALLED IN	GLOBAL REACH	SENSORS CALIBRATED	DIVERSE MARKETS
16	>100	17	9,000+	1/2
Billion	Million	Countries	Per Year	More than half of all sqft monitored is non-lab

Delivering Retrofit: Thrive Buildings

A specialty design-build firm for decarbonizing the life science industry's most challenging and energy intensive buildings.

IMPACTFUL CARBON REDUCTION

INNOVATIVE TECHNOLOGY DELIVERY

EXECUTION RISK ELIMINATED

Problem Statement –
Built Environment Lacks Critical Environment Solution for Existing Buildings

Critical Environments are typically defined as:

- Mission Critical
- Involving unique and more complex HVAC and Control systems
- Having highest carbon footprint & energy intensities per Sq Ft (5 to 15 X Office Space)

Challenges:

1. Involve diverse constituents with varying information and performance requirements
    - (EH&S, Quality, Energy Efficiency, Facilities, Users – Head Vet, Infectious control)
2. Legacy vendors (BMS, Manufacturers etc.) are myopic; bringing equipment sales mentality to a multi faceted complex systems problem
3. Complexity and Lack of Expertise
4. Lacking integration of disparate systems (Facility BMS, EH&S, Compliance / Quality, etc.)
5. Poor Life Cycle cost solutions

Over a Decade of Insight, Across 100's of Clients

Clients

- "To much work"
- "UCI can… but we can't fund"
- "Deferred maintenance"
- "Getting stakeholder alignment"
- "Need data – many & various BMS difficulties"
- "pilot" a project…then loss of momentum"
    - Turnover, loss of champion, etc.
- "Commissioning of systems"
- "Upkeep"

Providers

- Disparate views and capabilities
- BMS vendor lock / data hording
- New construction mindset vs. OD retrofit
- Program vs. project DNA
- Regional ability w/ varied and complex national requirements
- Ability to share risk with client
- Ability to understand and work across constituent groups (Sustainability, EHS, Engineering, Facilities, Finance)

The Solution

Create a company leveraging 15+ years of 'Smart Labs' experience to NOW deliver through a proven, turnkey and Managed Services Program focused on all constituent requirements.

Program Results:

- Innovative technology
- Operational & Energy Efficiency
- Dramatic Carbon Footprint Reduction
- Safer Facilities / Reduced Risk
- Quality Compliance
- Built in Intelligence

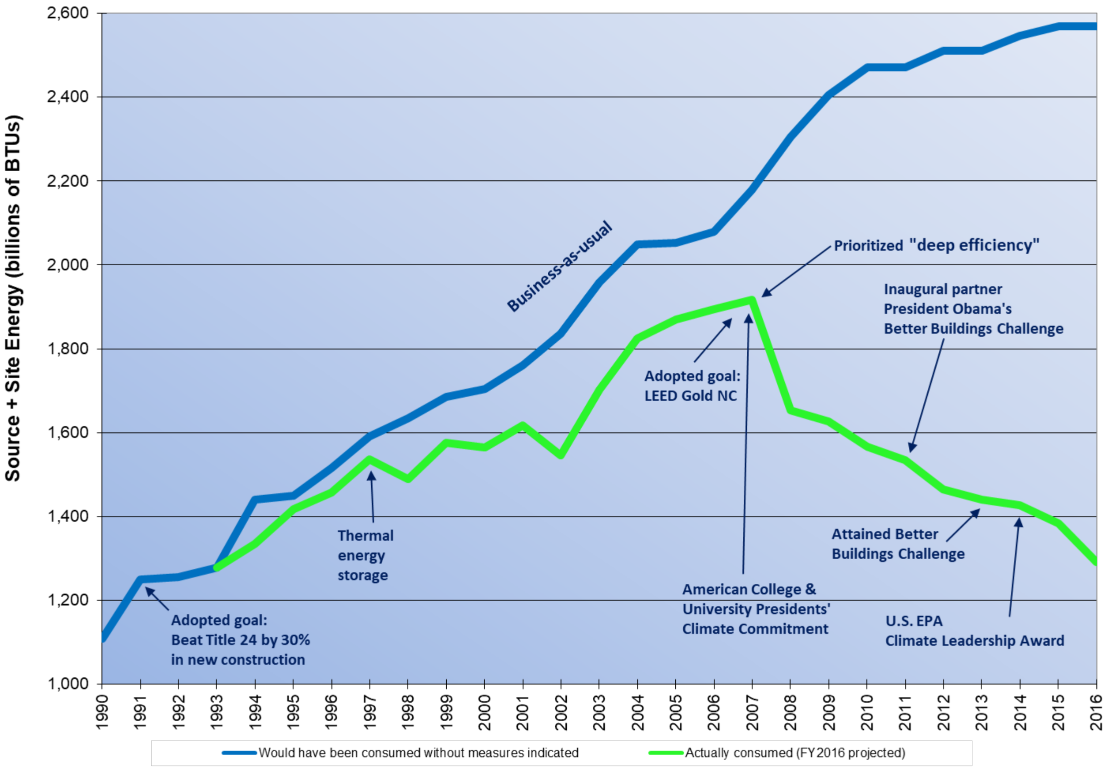
Benefits:

- System vs. component performance
- Dramatically reduced operating costs
- Sustainability Achievement
- Reduced Insurance Cost
- Insightful real time data
- Sustained performance

Foundational Learning: UCI Smart Labs Program

Concept

- “Put the right amount of energy where and when needed”
- Start with “efficiency first” to maximize lifecycle benefits
- Focus on biggest energy users - labs
- Involve all parties / constituents
- Program approach
  - Funding
  - NC & retrofit
  - Master specification



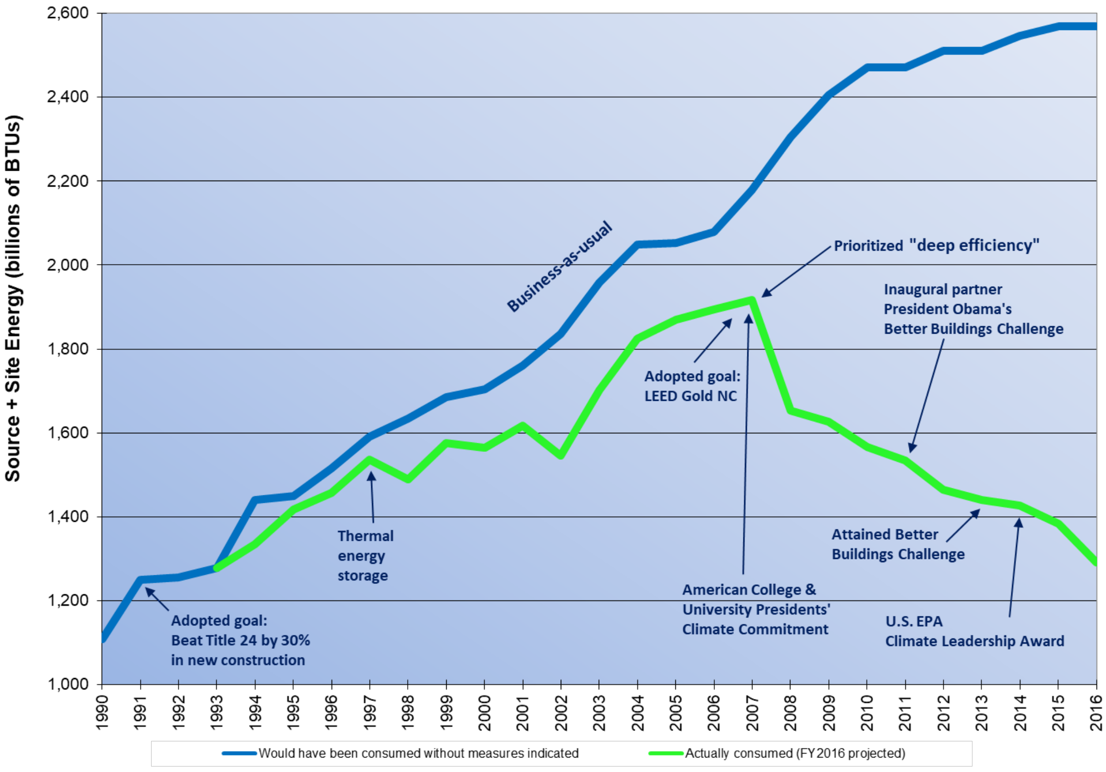
Foundation: UCI Smart Labs Program

Compelling Results over 15 yrs

- ✓ 60%+ energy savings
- ✓ Improved safety
- ✓ 15+ years documented success
- ✓ Co-benefits > $100 M

Adoption

- So WHY have less than 5% of the market adopted this systematically?



Thrive is a Turnkey Smart Labs Provider

A managed solution for delivering sustained Critical Environment performance.

PROGRAM LEVEL ENGAGEMENT

- Portfolio review
- Funding
- Stakeholder Engagement
- Rebate landscape
- DM needs
- BMS landscape

EFFICIENCY FIRST

- Enabling technology
- Funded with good ROI
- Maximize decarb
- Minimize cost to net zero

DEFERRED MAINTENANCE

- Leverage savings
- Reduce operational cost
- Address & improve safety

INDEPENDENT DATA LAYER

- Pre-commissioning
- Fault detection
- Allows for A.I. optimization
- Removes vendor lock
- Sustained safety & savings

HEALTH & SAFETY

- Real time capture of events
- Reinforce best practices
- Optimized airflow (as needed)

Recipe

1. Start with a program mindset
    - Involve various constituents
    - Master guide-spec mentality
    - Funding alignment
2. Efficiency first for optimized cost to Net Zero
3. Address challenges head-on: DM, data, engineering, commissioning
4. "Eat the Carrots" – maximize utility rebates
5. Embed IDL for futureproofing & data independence:
    - Sustained operational and energy efficiencies
    - AI, analytics and reporting

Enabling Technology

Proven, Reliable… Not Another Deferred Maintenance Headache

DBC Technology 'Must Haves'

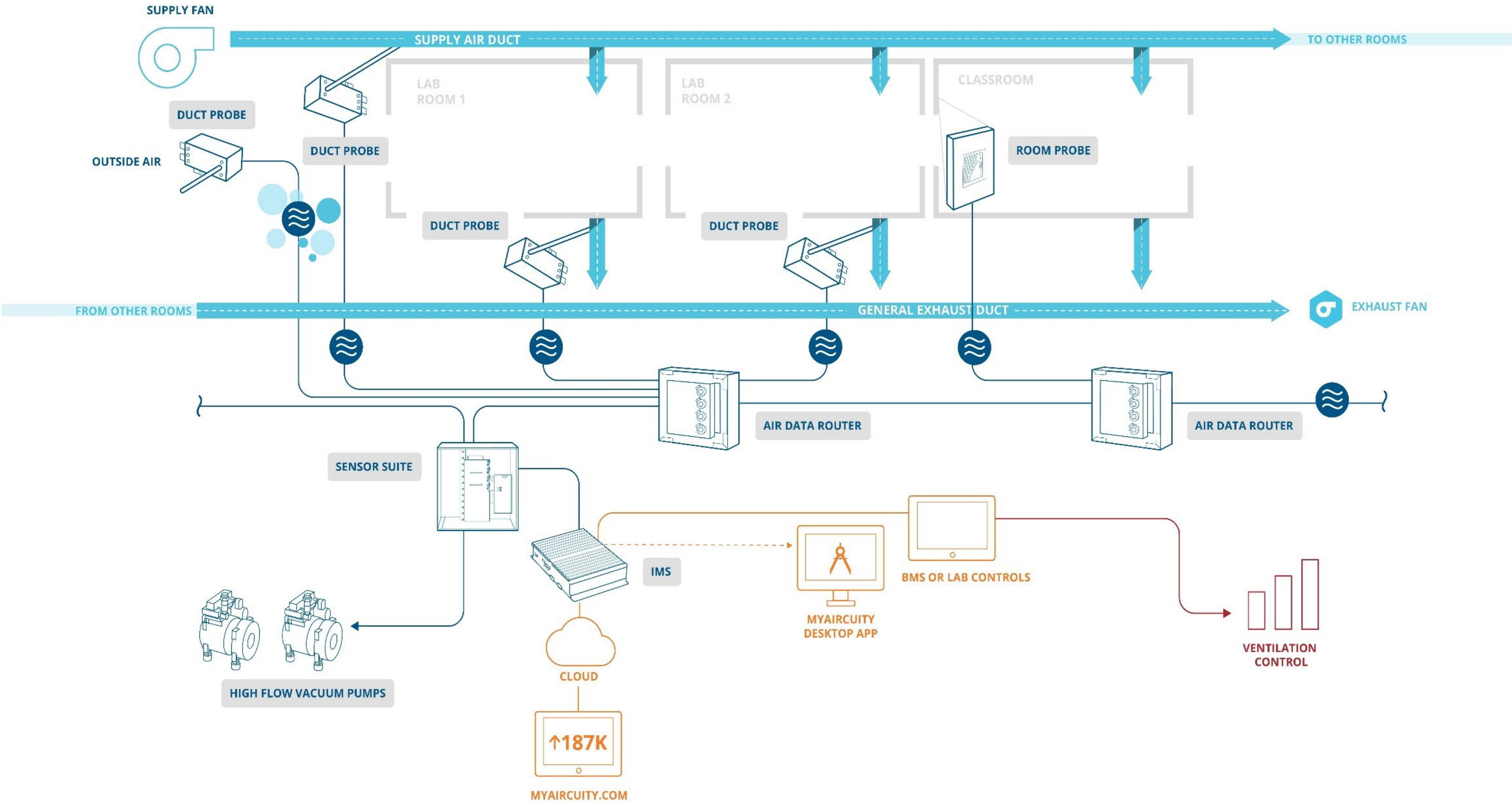
1. **Patented Microduct Tubing**
    - Chemically inert & electrically conductive
    - Plenum UL rated
2. **Differential Measurement Control Signal**
    - i.e. Particles from OA – i.e. wildfires
    - High Select command from all measurements (VOC's, Particles)
3. **NIST Traceable Sensors with Pressure Compensation**
    - National Institute Standards Testing
    - Pressure compensation is a must for accuracy
4. **Photo Ionization Detector - 10.6 eV**
    - EH&S requirement
5. **Known Air Sample Volumes**
    - Pump draws a know quantity of air sample

Multiplexed Sensor Approach

Centralized sensors measure multiplexed air samples with patented tubing +

- Cost effective
- Higher quality sensors
- Greater accuracy
- Easier to maintain
- Differential measurement to outside air
- Each sensor is recycled (vs. discarded) and can be individually calibrated

Airflow Optimization Platform Overview



Typical Sustainability Statement – MSU

“Our Facilities Operations and Planning group is leading the effort to seek new and innovative ways for the University / Organization to meet its sustainability goals through conservation, reducing, reuse and recycling programs and reducing their energy consumption in an effort to decarbonize our operations by 2030” -MSU

MSU is committed to reducing greenhouse gas emissions by 50% by 2030 from our 2010 baseline and achieving climate neutrality by 2050.

What’s the effect of Aircuity on lab safety?

An EHS Perspective on Use of Demand Control Ventilation

Dave Erickson, Senior Industrial Hygienist
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Presentation Outline

- ACH Setpoints for DCV
- Aircuity DCV Control and Monitoring for Research Labs
- Case Studies of DCV Monitoring in Research Labs
- Vivarium Monitoring
- Sash Management in Research Labs
- The Future
- Acknowledgements

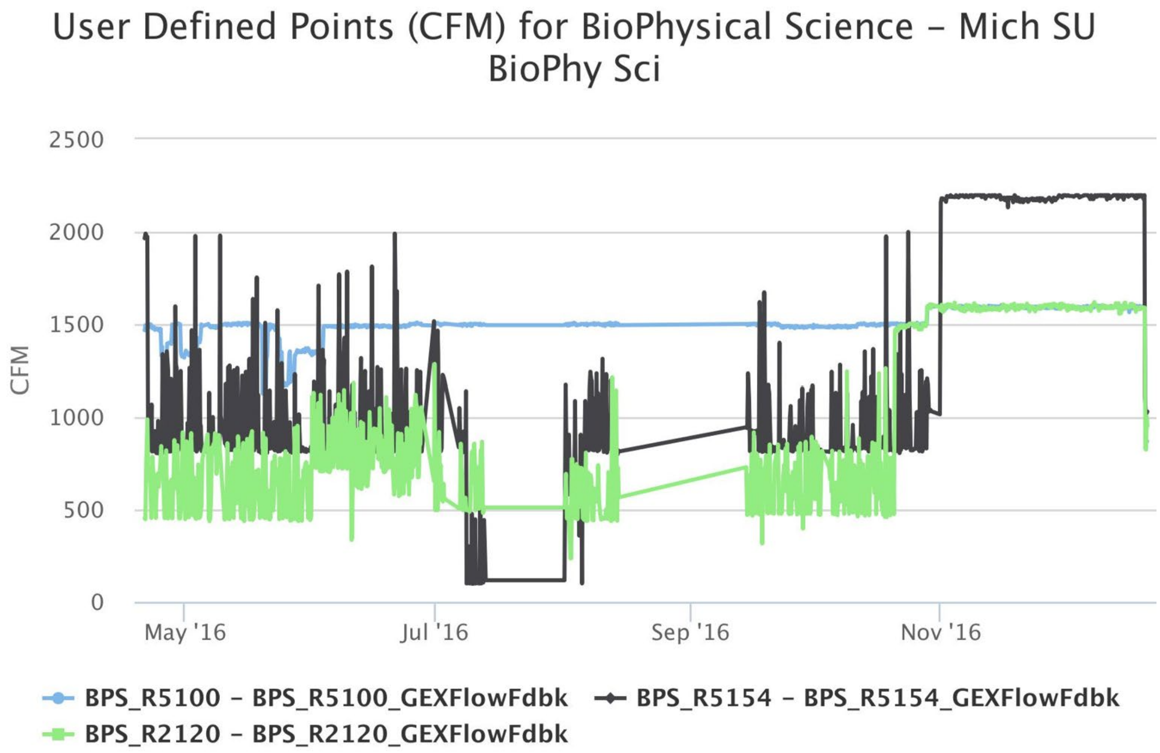
MSU ACH Setpoint Overview

- Risk assessment needed to set ACH, Control Banding
- Biomedical, biochemistry, plant science
  - 6 ACH without DCV
  - 4 ACH with DCV, 4 ACH unoccupied
- Proposed 4 ACH with DCV, 2 ACH unoccupied in a new building
- High hood density will drive higher ACH
- ANSI Z9.5-2022 Generic assignment of air change rates is not appropriate
- But where do you start?

Purge Buttons

- Why Purge buttons?
- Aircuity DCV is a sample draw system
- Air samples taken every 15 mins
- Allows users to react to a spill
- Place near main lab exits
- Use Bump Proof design
- Light stack in hallway
- Can get left on, must check

Purge Button left on.



Aircuity DCV Control and Monitoring for Research Labs

On-Campus MSU Aircuity Installations

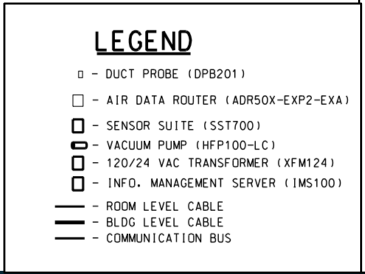
Building	New Install/ Retrofit	DCV/ Monitoring	Year Installed	SST Quantity	Room Count	Total Sq. Ft.
Anthony Hall	Retrofit	DCV	2012	5	84	150,779
Biochemistry	Retrofit	DCV	2011	2	29	43,722
Bioengineering	New Install	DCV	2013	5	108	145,135
BPS	Retrofit	DCV	2013	4	70	66,947
Broad Art Museum	New Install	Monitoring	2010	1	14	32,653
Clinical Center	Retrofit	Monitoring	2013	1	16	4,000
Food Science	Retrofit	DCV	2008	2	31	24,704
ISTB	New Install	DCV	2017	5	101	34,481
MPS	New Install	DCV	2010	1	19	22,043

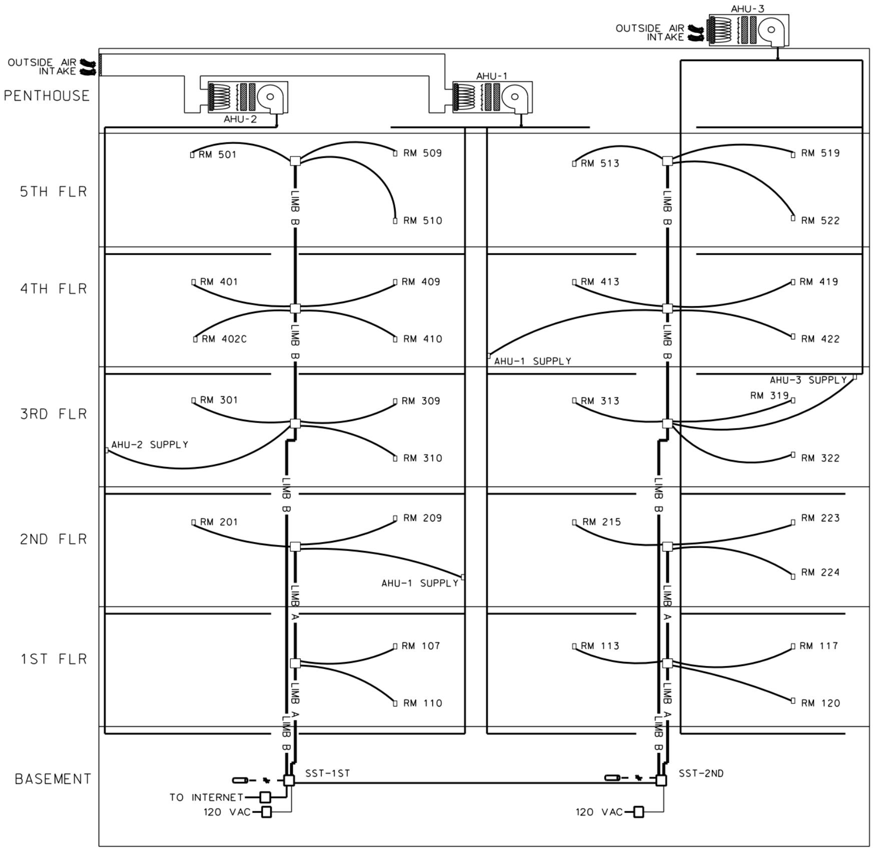
Off-Campus MSU Aircuity Installations

Building	New Install/ Retrofit	DCV/ Monitoring	Year Installed	SST Quantity	Room Count	Total Sq. Ft.
GRRC	New Install	DCV	New Install	4	100	30,000
Secchia Center	New Install	Monitoring	New Install	2	34	

MSU Biochemistry Aircuity Diagram

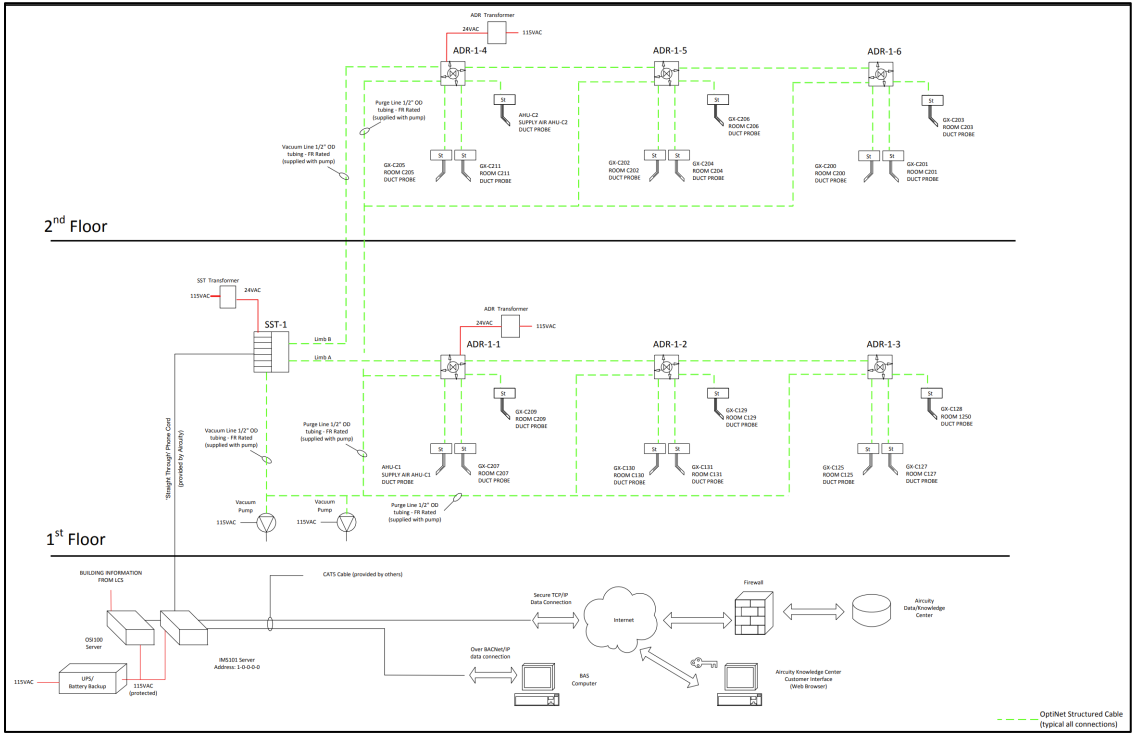
- Retrofitted in 2011 for DCV
- 2 SSTs that cover 29 rooms over 5 floors





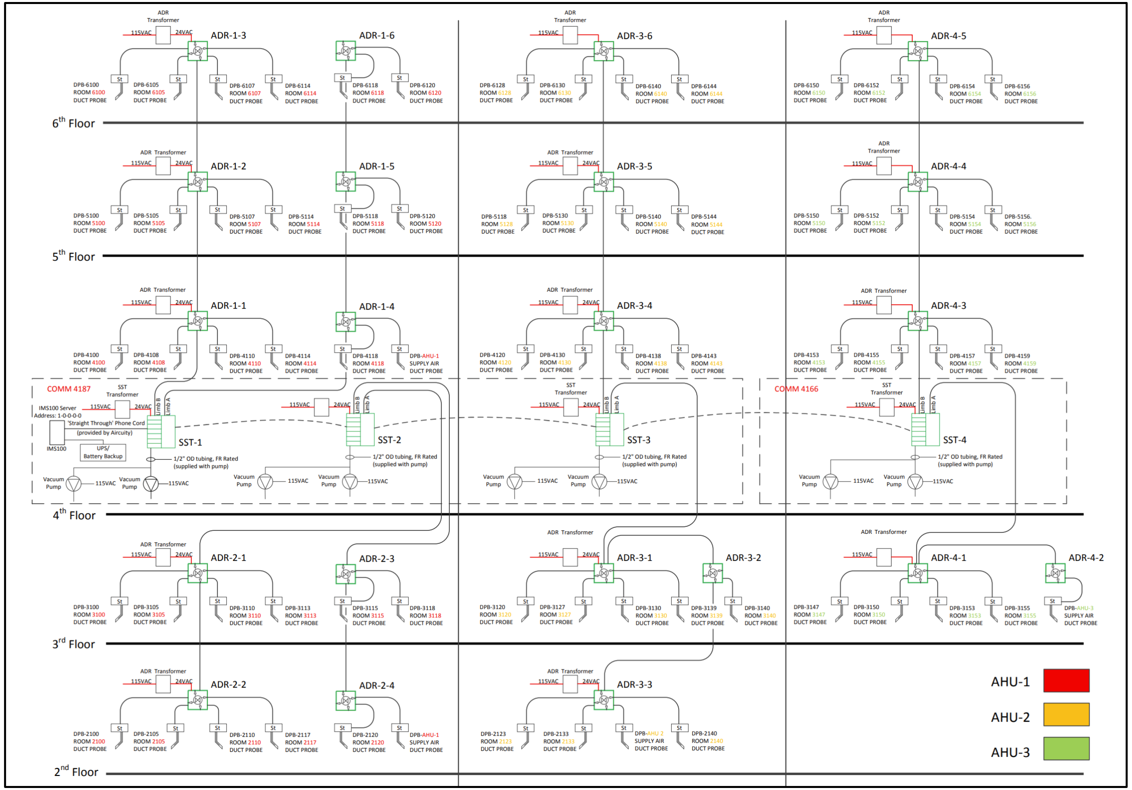
MSU Clinical Center – C Wing Aircuity Diagram

- Retrofitted in 2013 for vivarium monitoring
- 1 SST that cover 16 rooms over 2 floors



MSU Biomedical Physical Sciences Aircuity Diagram

- Retrofitted in 2013 for DCV
- 4 SSTs that cover 70 rooms over 5 floors



MSU Vivarium Monitoring

- Vivariums typically use 10x the energy of office space
- Significant energy savings possible
- Animal Room environment vs cage microenvironment
- MSU has 3 vivariums with Aircuity-monitoring only

In a vivarium Aircuity can monitor for:

- Carbon Dioxide
- Carbon Monoxide
- Temperature
- TVOCs (solvents and other volatile organic compounds)
- Ammonia
- Differential Pressure *
- Particles – PM2.5
- Dewpoint

New Construction Buildings - Proposed DCV

Plant Environmental Science Building

Henry Ford Health MSU Research Building 1

Engineering Design and Innovation Center

Case Studies of DCV Monitoring in Research Labs

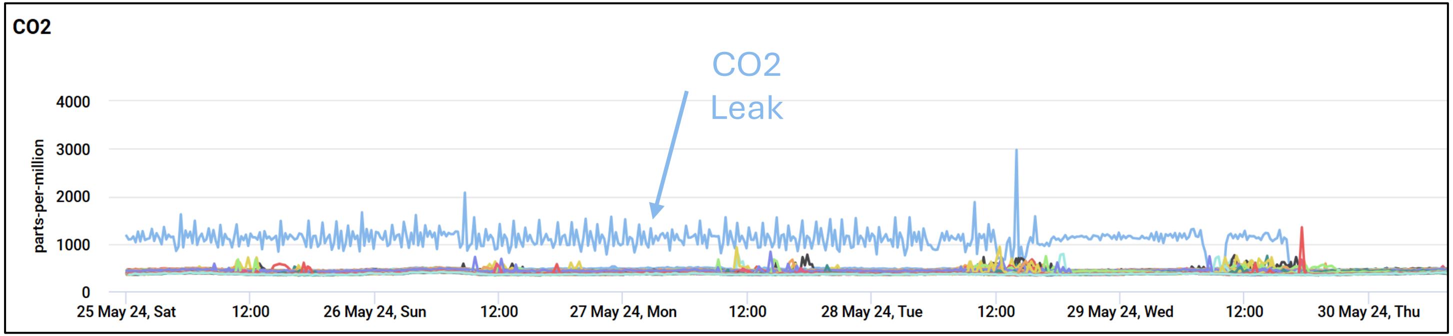
Aircuity enhances environmental monitoring and safety in research settings

Aircuity has proven to be an invaluable resource for MSU EHS to support researchers in several key areas:

- Monitoring and Safety Oversight:
  - MyAircuity provides daily reports on rooms exceeding threshold activity, enabling timely interventions and ensuring a safe, healthy research environment
- Reducing Exposure and Improving Researcher Health:
  - Increased ventilation in response to air contamination (DCV) reduces exposure to harmful substances and supports researchers' long-term health

Detection of CO_2 Leaks

- Aircuity can be used to identify leaks
- This feature enables researchers to address issues promptly, maintaining a safe and stable environment for their work
- Notification at 1500 ppm CO_2

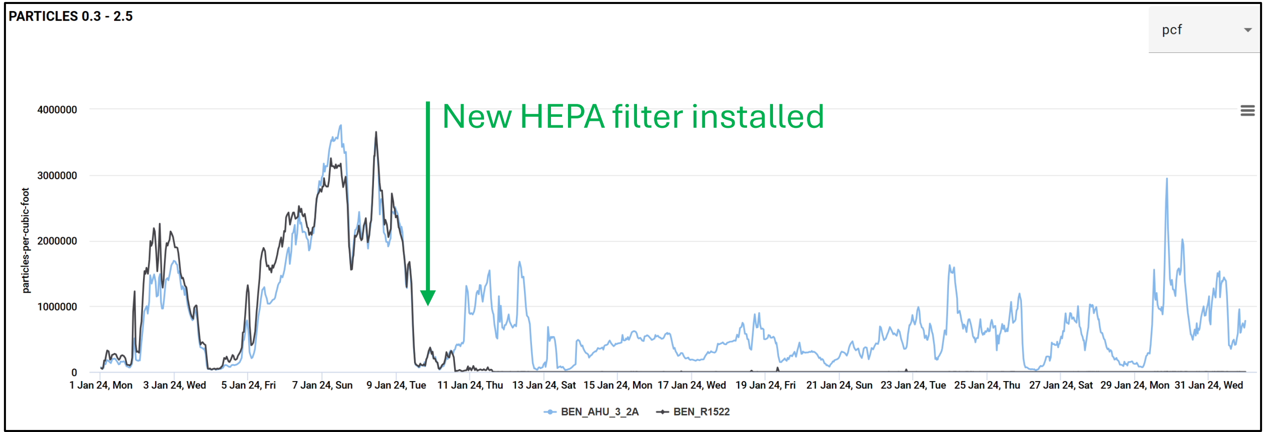


Example of a CO_2 leak found using Aircuity

Clean room monitoring

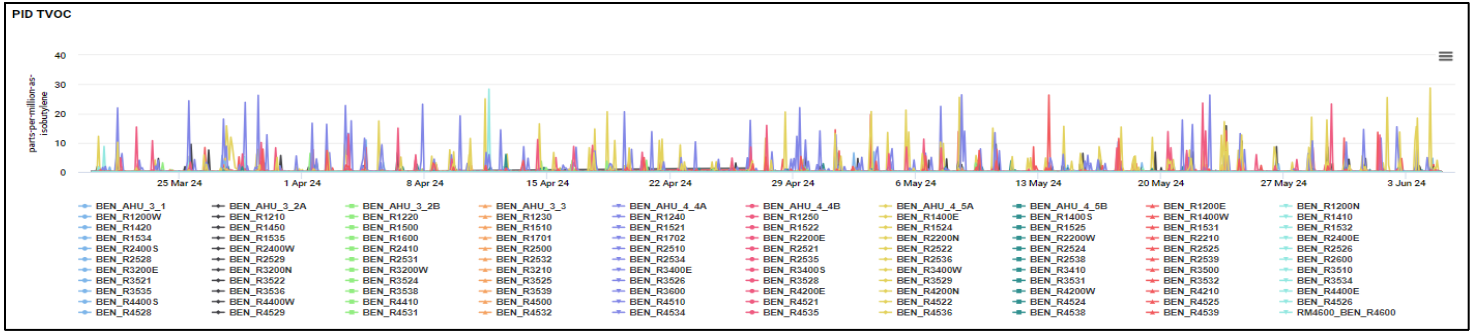
- A new instrument required a clean room
- EHS compared particle count data from Aircuity with DustTrak meter results before and after the installation of new HEPA filters and confirmed that the clean room met necessary standards

This assurance provided peace of mind and ensured that the environment was suitable for sensitive experiments

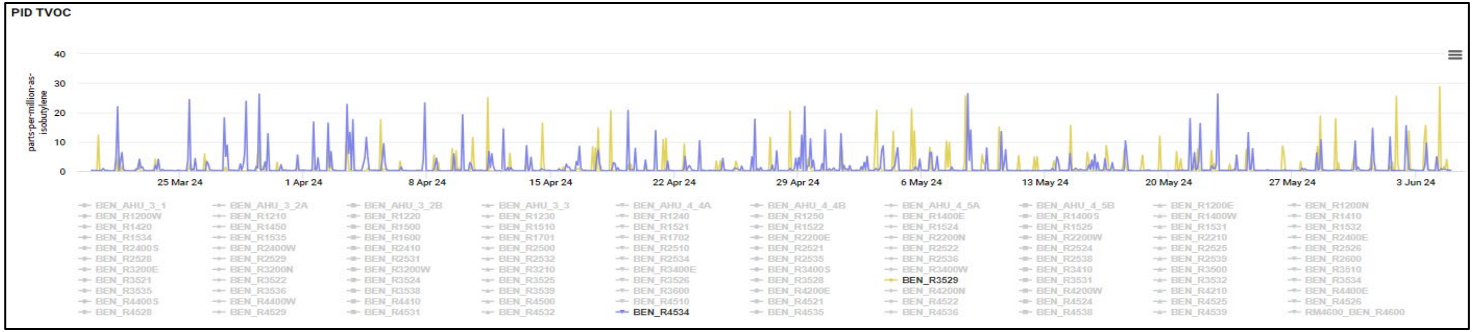


TVOC hotspots found with Aircuity

TVOC counts for Bioengineering are consistently high



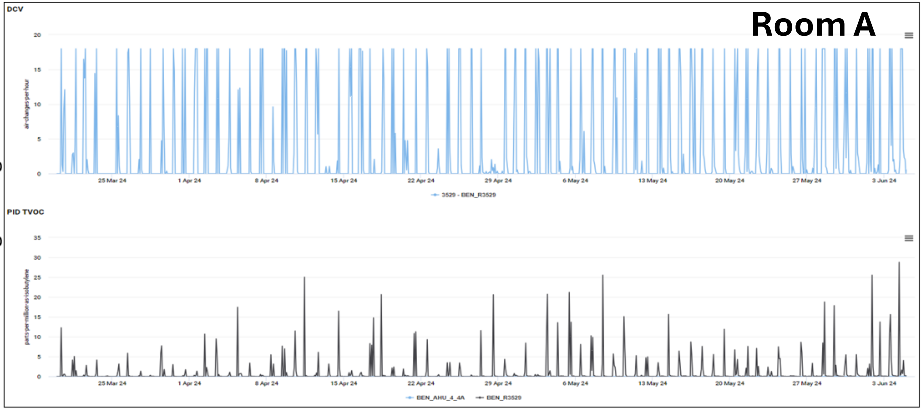
When all other rooms are removed, it is apparent that most of the high counts come from just two rooms

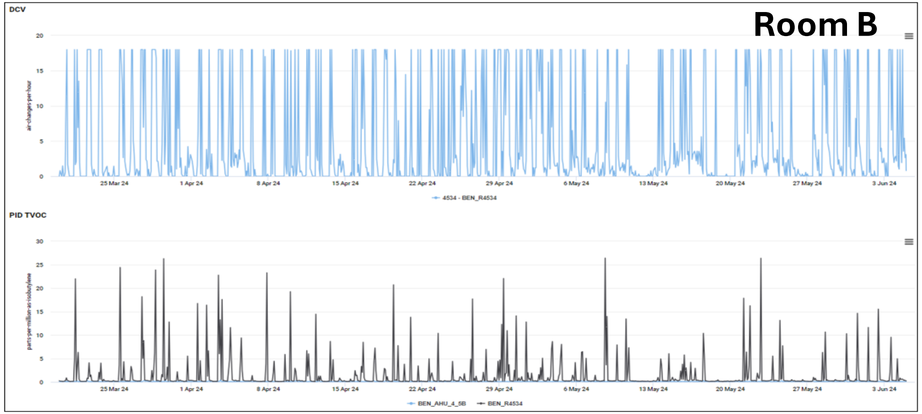


High TVOC hotspot investigation

- Due to the continued increase in TVOC activity, the air change rate is consistently increasing to accommodate

- Researchers from both labs were badged with dosimeters, and the results showed insignificant individual VOC exposure
    - The high VOC counts are spread out between multiple researchers since these rooms have high foot traffic

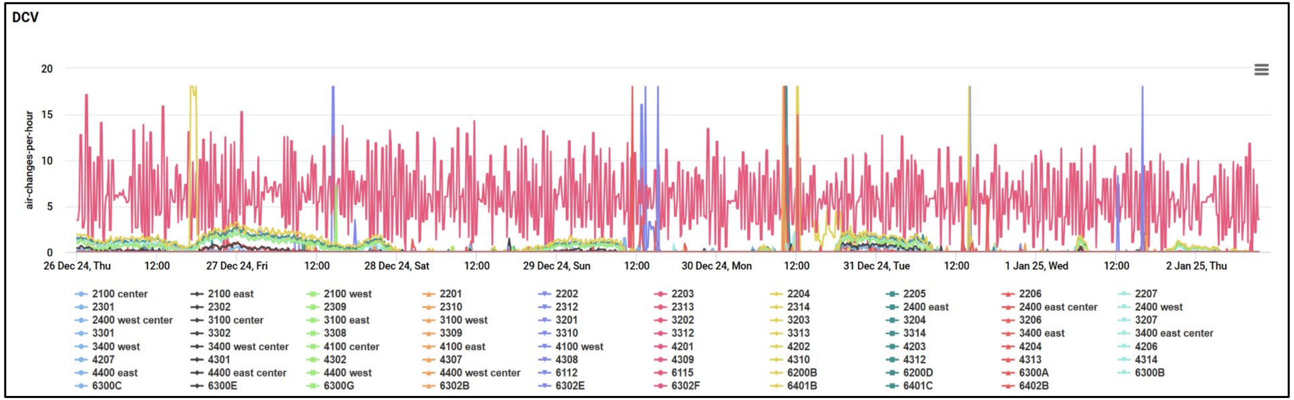


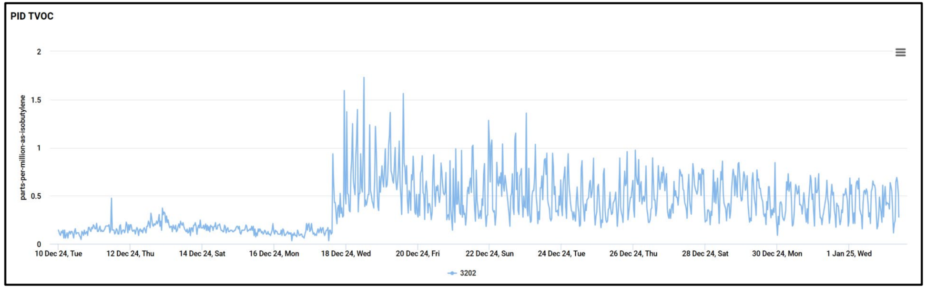


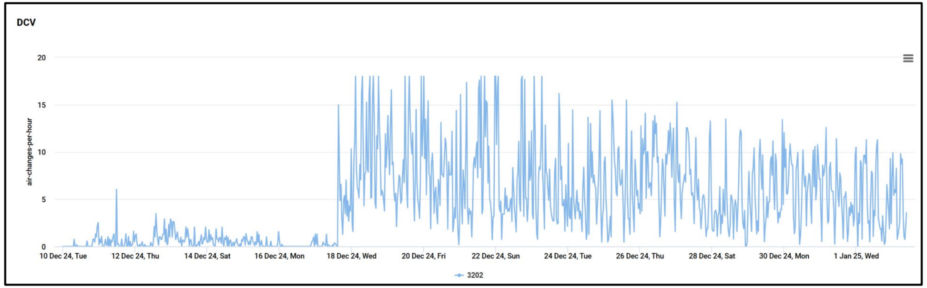
The ventilation is adequate in

GRRC – High DCV in histology lab

- DCV for a histology lab at GRRC become extremely sporadic
- Further investigation showed an increase in PID activity on 12/17/24





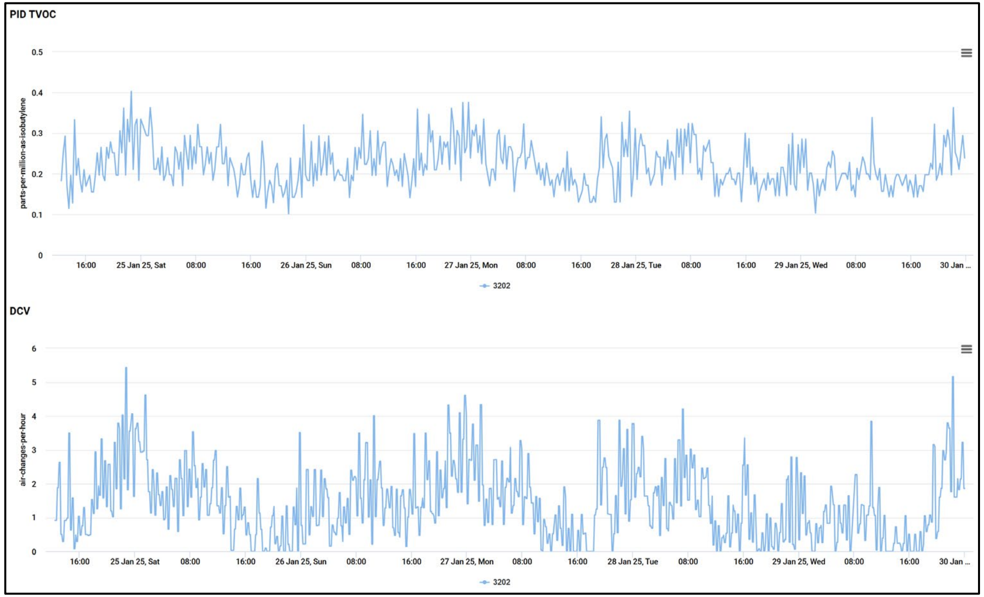


GRRC – High DCV in Histology Lab *investigation*

Vent for a tissue processor was not placed correctly in the fume hood

GRRC – High DCV in histology lab *solved*

The vent was placed further into the fume hood, and the TVOC levels and DCV returned to normal



Sash Management in Research Labs

Sash management of FHs

BACKGROUND

- Best practice is to keep a fume hood (FH) closed when not in use
- How often do labs comply? How can we convince labs to comply? What are the best practices for encouraging people to comply?
- Ways to control sash closures
  - ISTB – ZPS on FHs (if no one is present, reduces cfm)
  - Bioengineering – ZPS on FHs (beeps if room light is off)
  - GRRC – ZPS on FHs (if no one is present, reduces cfm)
  - Biochemistry – hook sash sensor to room light switch
  - Automatic sash closers

- An investigation using Aircuity conducted on 3 buildings

Determining how often FHs are left open overnight

Analysis using Aircuity

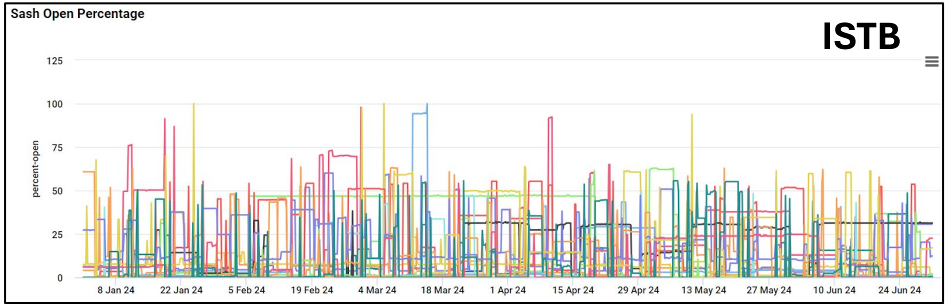
The average percentage in which a hood sash was left at greater than 10% open overnight in each building, was quantified from Jan–June 2024

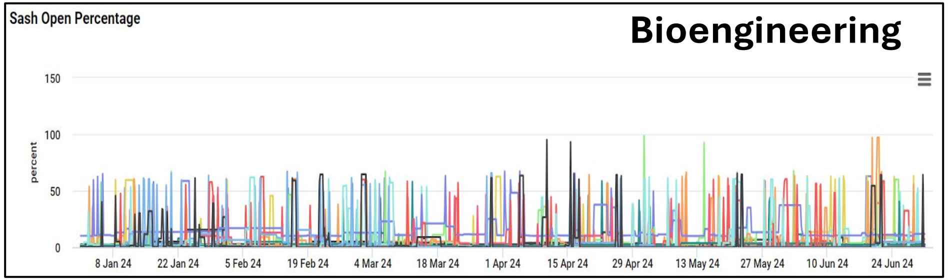
RESULTS

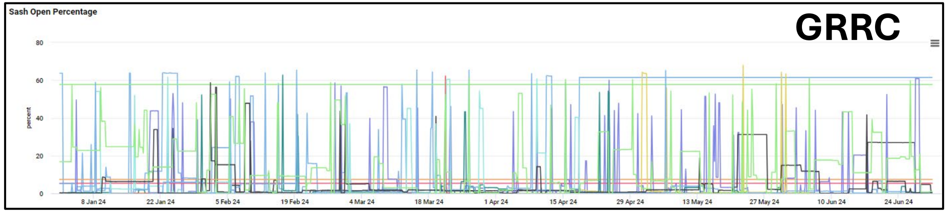
ISTB 27%

Bioengineering 5%

GRRC 18%

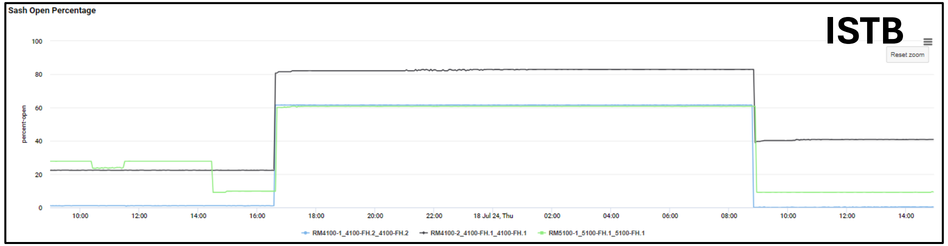


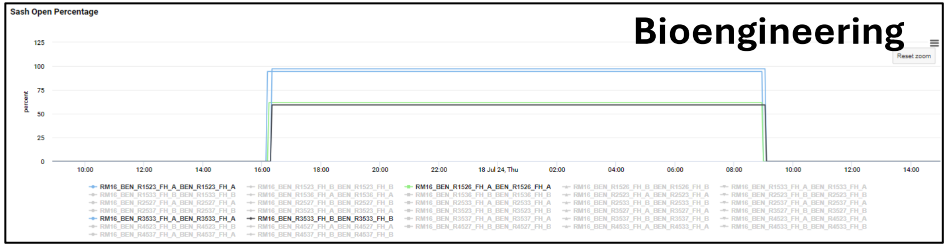




Testing the reliability of Aircuity data in determining sash open percentage

- FHs were chosen at random and left open overnight in ISTB and Bioengineering
  - The hoods were opened to either 50% or 100% around 4 pm
  - The hoods were then closed around 9 am the next day

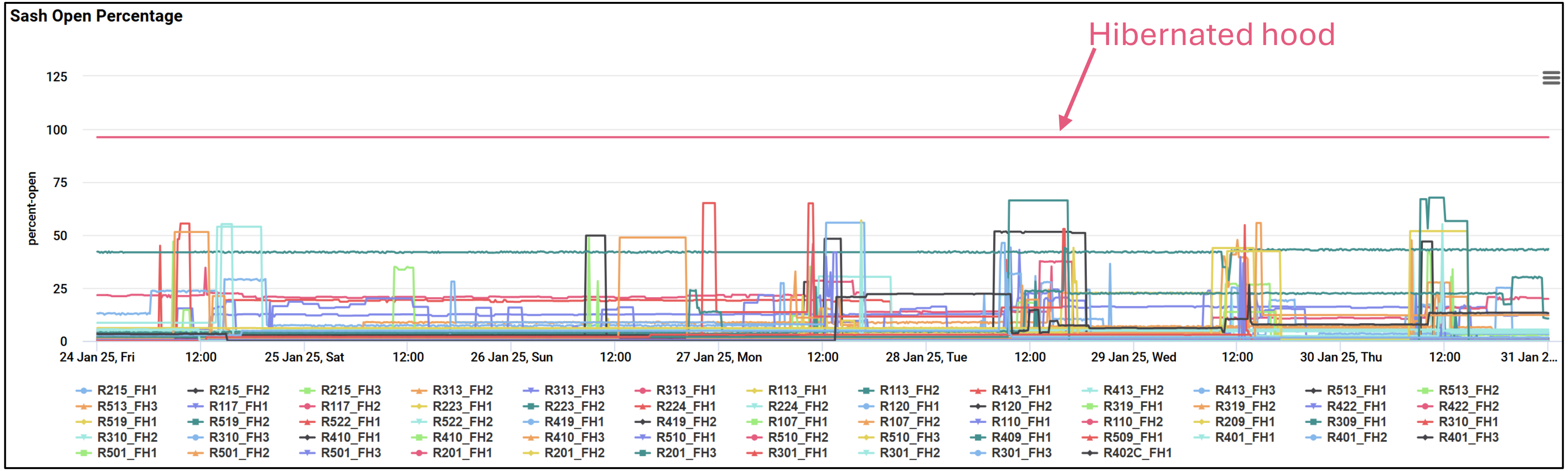




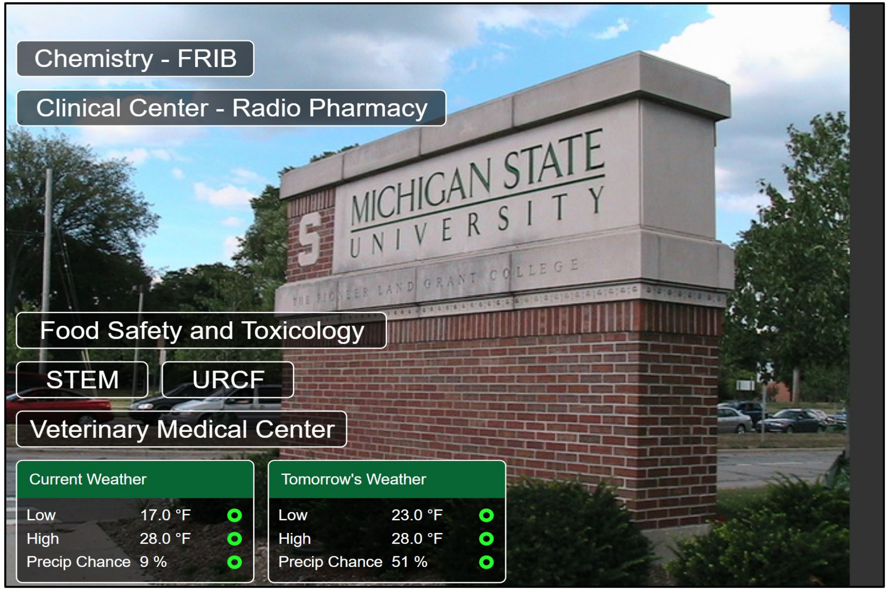
Aircuity accurately represented the sash position of the hoods tested

Biochemistry FH sash openings

- Data from Aircuity shows most of the hoods are closed after use, or left open under 25%
- Sash sensor connect to lab light switch



STEM lab monitoring with Phoenix Vision Dashboard



Phoenix Vision Dashboard – STEM FH sash monitoring

The dashboard gives real-time data for each fume hood

Phoenix Vision Dashboard – STEM ACH monitoring

The dashboard gives the current ACH values for each monitored room

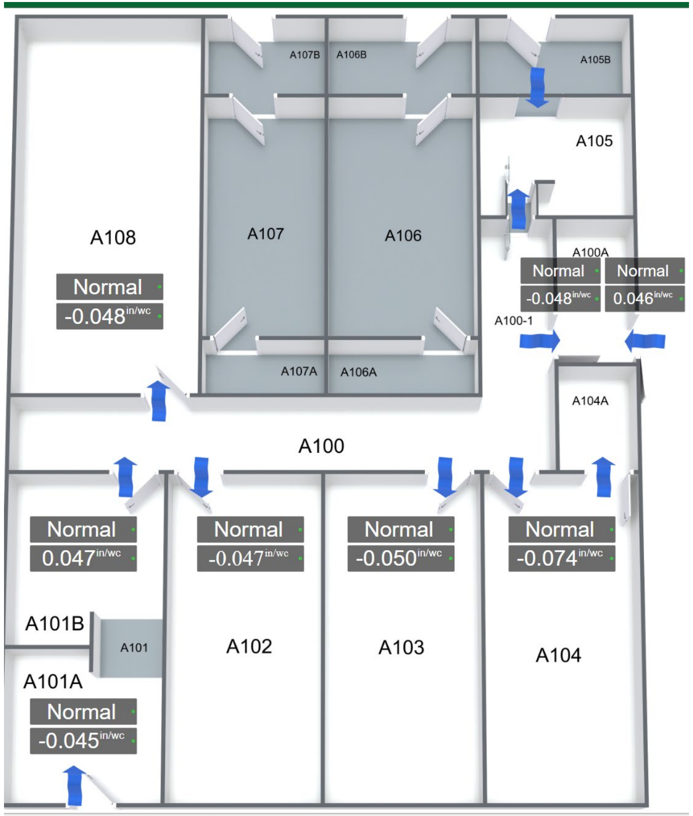
1st Floor Air Change Rates per Hour	
1001	6.0
1002	6.0
1004	6.0
1008	6.0
1017	6.0
1019	5.9
1020	6.0
1025AA	6.0

2nd Floor Air Change Rates per Hour	
2001	6.0
2002	6.0
2004	5.9
2009	6.0
2010	6.0
2016	6.0
2017	5.9
2019	6.0
2019A	11.8
2020	6.0

3rd Floor Air Change Rates per Hour	
3001	6.0
3002	6.0
3004	14.9
3011	6.0
3020	6.0

Phoenix Vision Dashboard – Pressure Profile in a BSL3

1st Floor Air Change Rates per Hour		
A100	13.0	
A100A	15.1	
A101	10.0	
A102	19.0	
A103	13.8	
A104	22.0	
A105	42.6	
A108	10.4	



The Future!

Conferences

- International Institute for Sustainable Labs (I2SL)
    - April – I2SL Education Week
    - October – I2SL Conference
    - Labs 2 Zero
- Safe Labs
- Gorden Sharp, I2SL President

I2SL International Institute for Sustainable Laboratories

Labs2Zero

Acknowledgements

MSU Core DCV Team

Dave Erickson, Industrial Hygienist EHS

Elyssa Cox, Laboratory Performance Analyst, EHS & IPF

Andrew Arras, Building Performance Analyst, IPF

Conclusions - Airflow Optimization Makes Sense

Airflow Optimization is an Efficiency First Approach

- ✓ Ability to Deploy Immediately
- ✓ Pays for itself in two important ways – Energy and Future Measures
- ✓ Airflow used to fund deferred maintenance

Financial Impact is Considerable

- ✓ Simple Paybacks of 1-4 years
- ✓ Strongly Positive NPV and IRR
- ✓ 5X return when considering the future cost of electrification

Story is Interesting and Innovative

- ✓ Using dynamic IAQ data to drive energy efficiency
- ✓ Puts UM right at the intersection of Sustainability and Healthy Buildings