



Decarbonization Dilemmas: Deliberating Difficult Decisions in Laboratory Design

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Learning Objectives



- Understand the potential tradeoffs when developing decarbonization and sustainability goals
- Assess how your facilities can efficiently mitigate environmental impacts while prioritizing occupant safety and cost effectiveness
- Understand how the design phase of new construction or retrofit projects can make a difference in decarbonizing your buildings
- Harnessing the experience that industry professionals have gained from recent decarbonization efforts and moving forward



INTRODUCTION



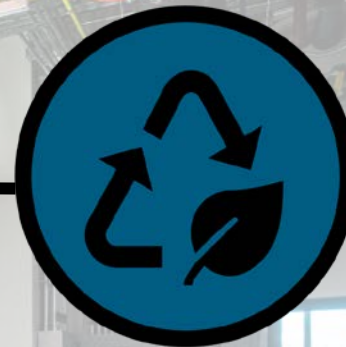
HEAT RECOVERY



DILEMMAS IN EXISTING LABS



NEW BUILDING DESIGN



OPTIONS FOR TERMINAL UNITS



USER'S ROLE



CONCLUSION

Introduction



- **WHY?**

- **Decarbonization is Happening!**

- **The Trade-Offs**

- **What to Expect in this Session...**

Why?



Why are we looking at decarbonization in labs?



Joe DeNero / NREL

- Laboratories typically consume **3 to 10** times more energy than similarly sized commercial buildings¹
- U.S. life sciences laboratory/R&D has grown by **47%** over the past five years to 182 million sq. ft.²
- A record **40 million sq. ft. of new construction** currently underway

¹ Smart Labs Toolkit 2024

² CBRE 2023

Decarbonization is Happening!

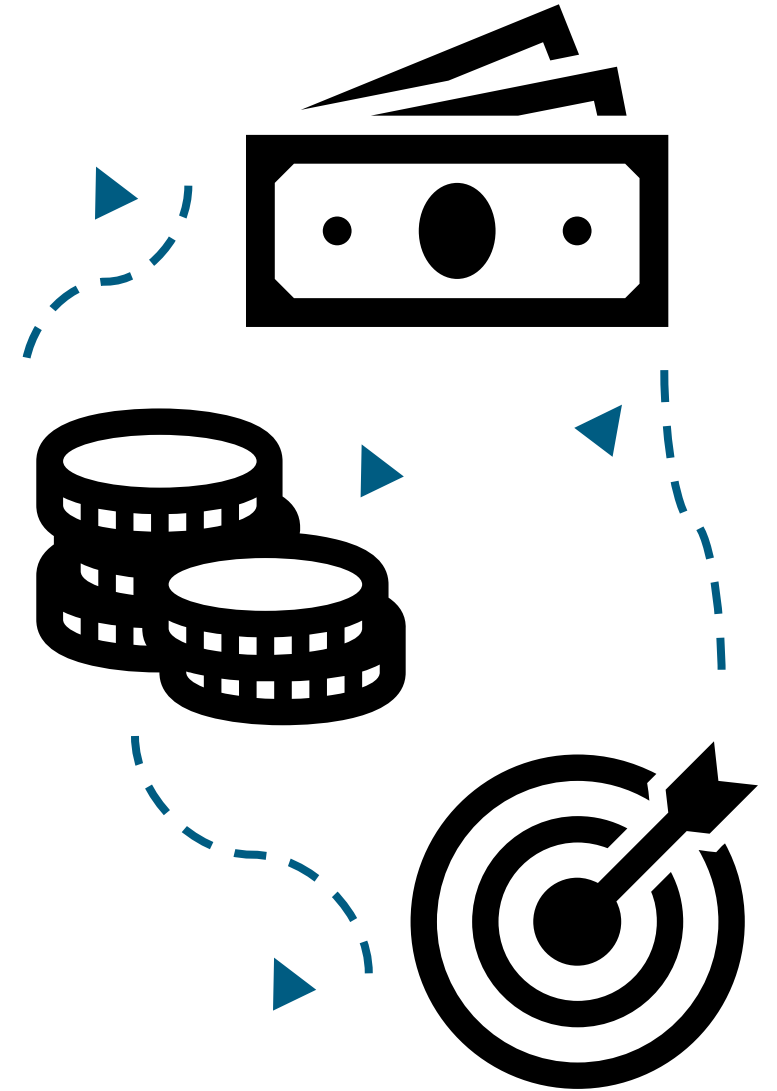


- Focus on **deploying** energy efficiency and renewable energy solutions, not just testing them
- Moving from goals to **implementing** real decarbonization strategies
- **Utilizing data** to measure emissions reductions and ensure targets are being met
- Harness the **experience** from industry professionals to move forward



What are the Trade-Offs?

- What's feasible?
- What's cost effective?
- What are the project's goals?



What to Expect in this Session?

- Go over scenario
- Insight from presenters
- Discussion from the room
- Questions from the audience



Werner Slocum / NREL

Heat Recovery – Get Creative

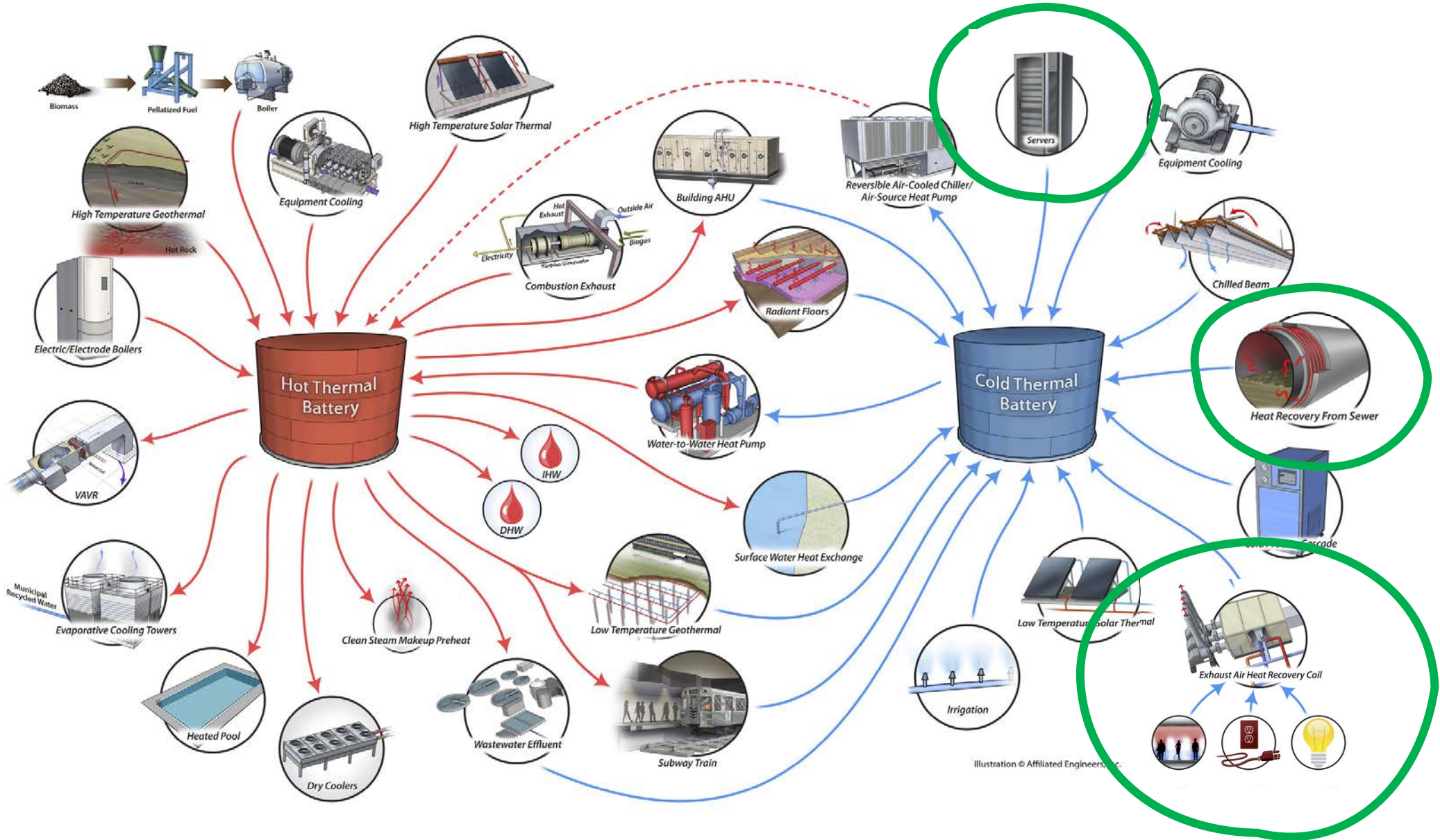


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Heat Recovery – Laboratory Exhaust

Illustration © Affiliated Engineers, Inc.

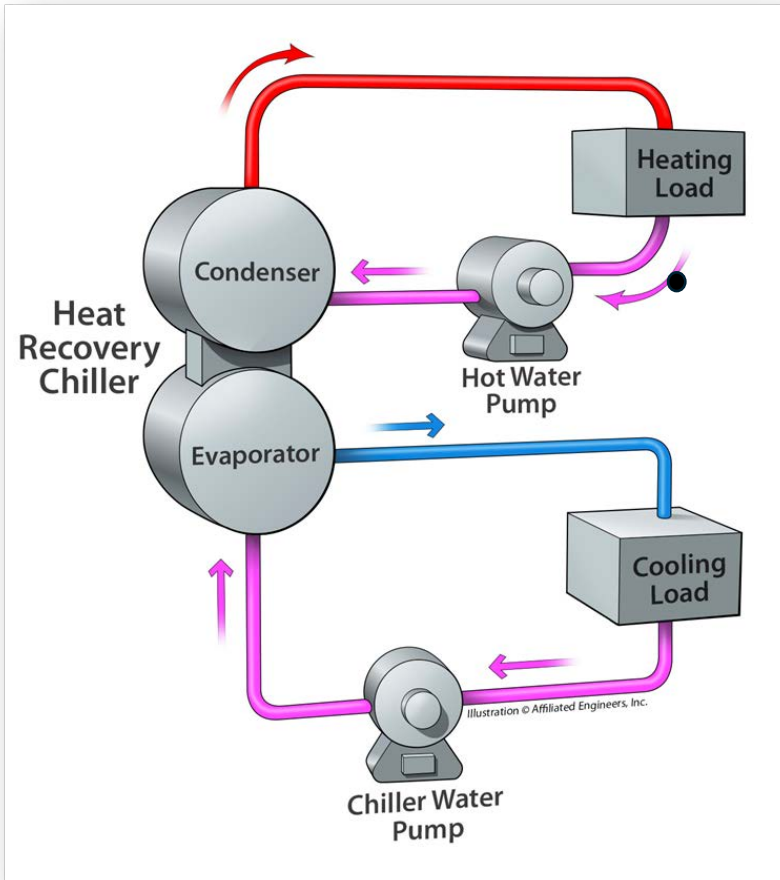
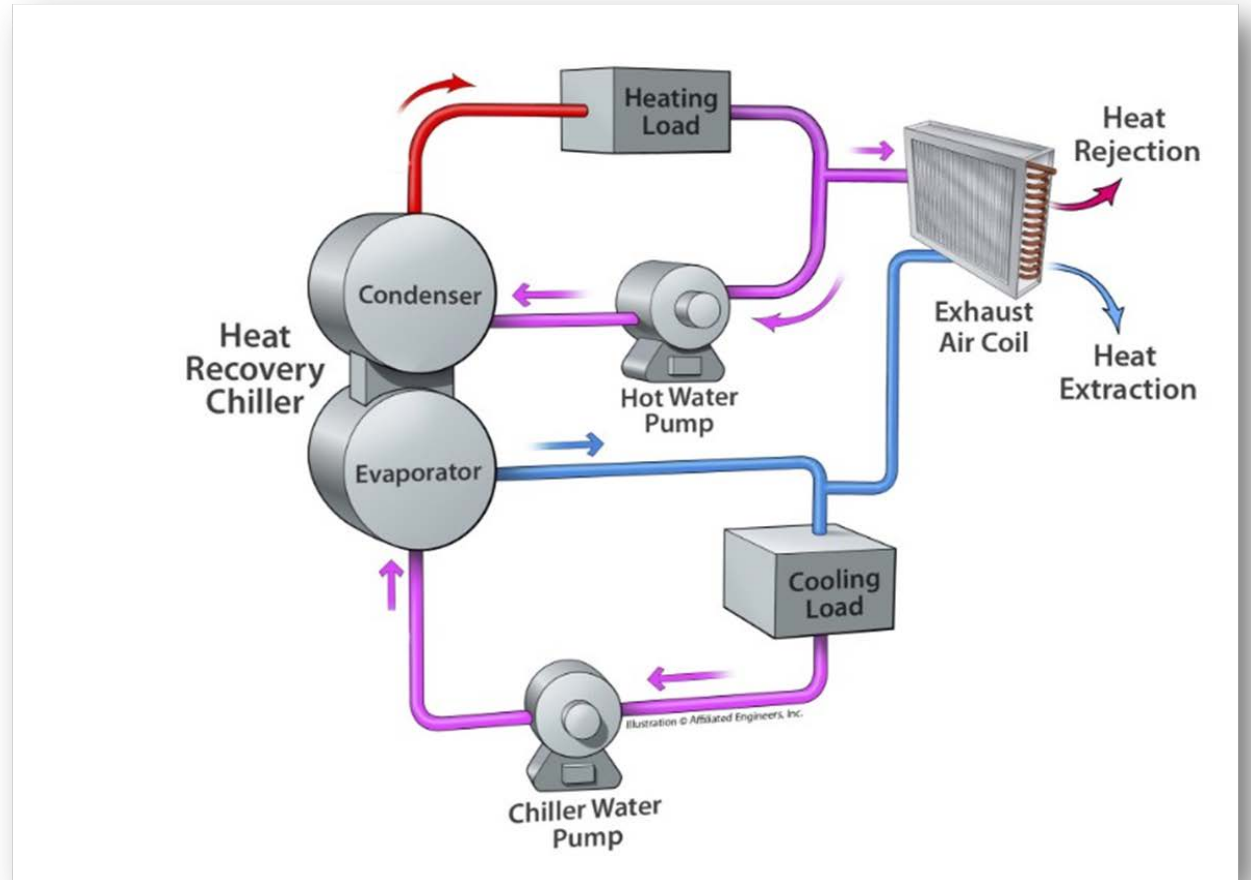


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Heat Recovery from Wastewater

- Use wastewater to generate clean energy for heating and cooling
- Grinding system plus heat exchanger
- Double-benefit for the wastewater treatment plant

? Any other unique sources for heating and cooling?



Rachel Romero / NREL

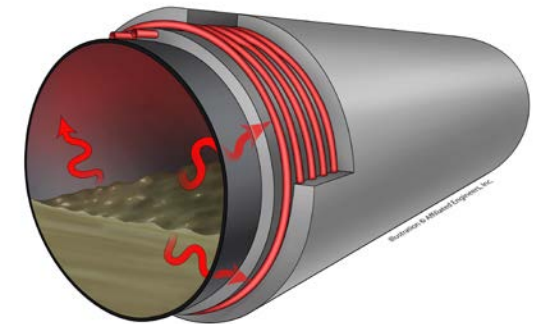


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High Performance Computing



- High Performance Computing, Data Centers, Supercomputers, etc.
- Emergence of liquid-cooled technologies
- Opportunity of Load Size



Joe DelNero / NREL

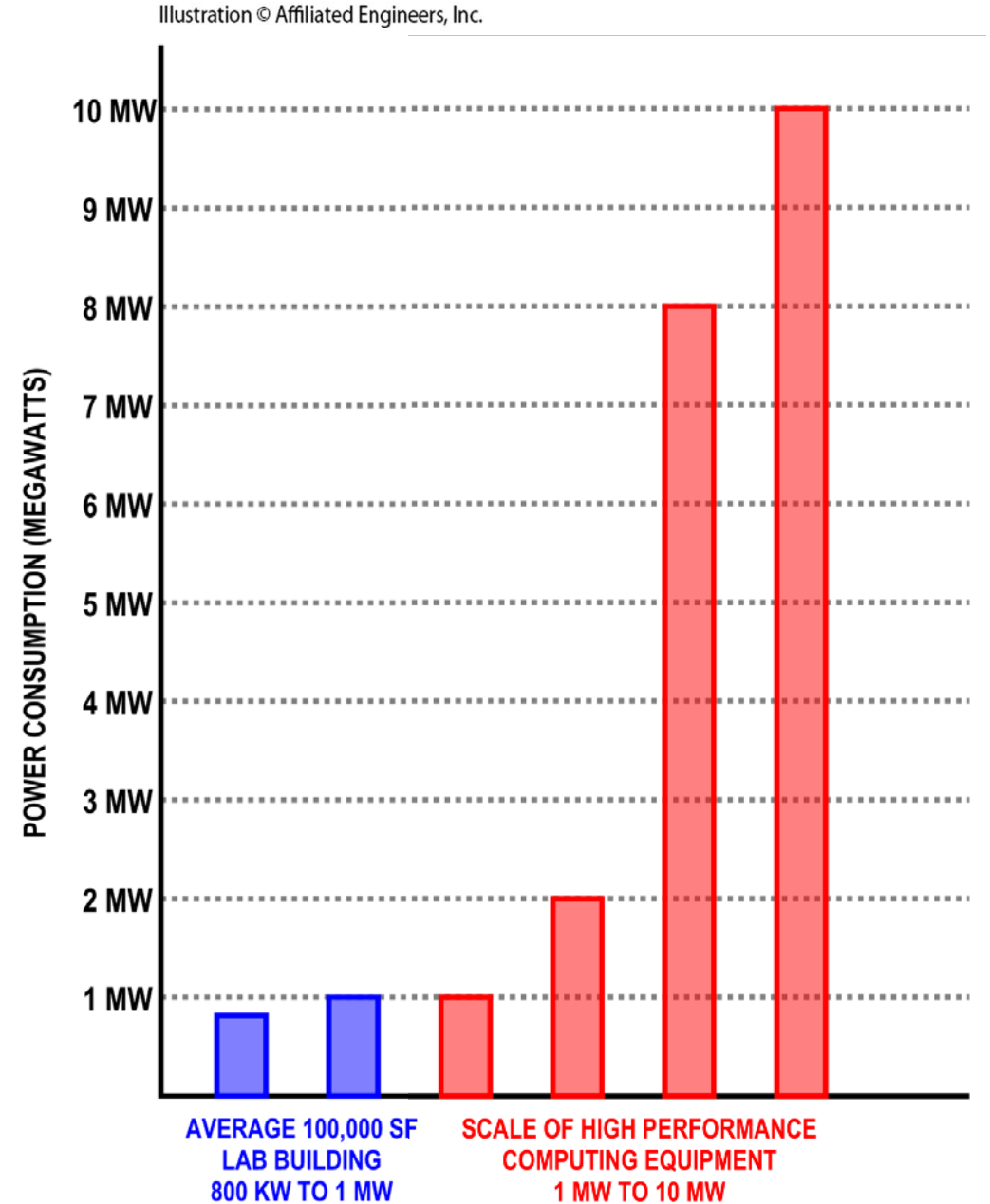
HPC – Load Size

Dilemmas Associated With:

Equipment Operation

Equipment Location

Cooling Loop Temperatures



HPC – Equipment Operation

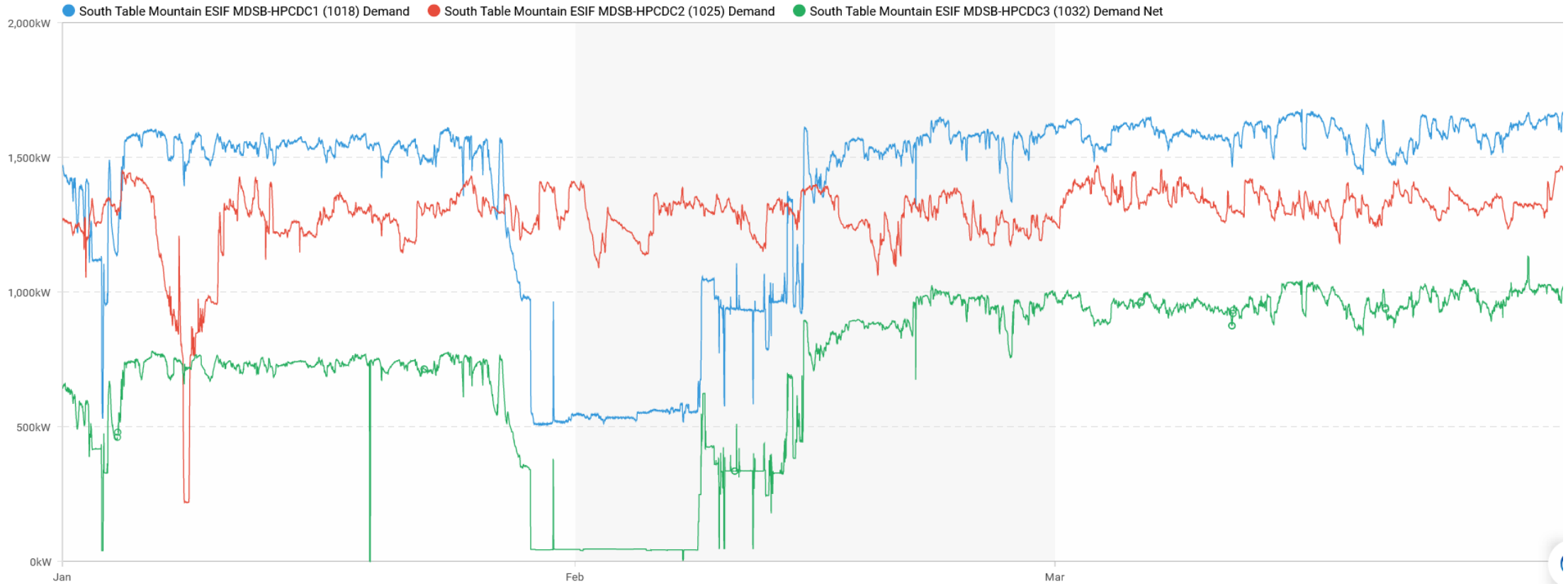


Photo Credit: NREL

HPC – Equipment Location

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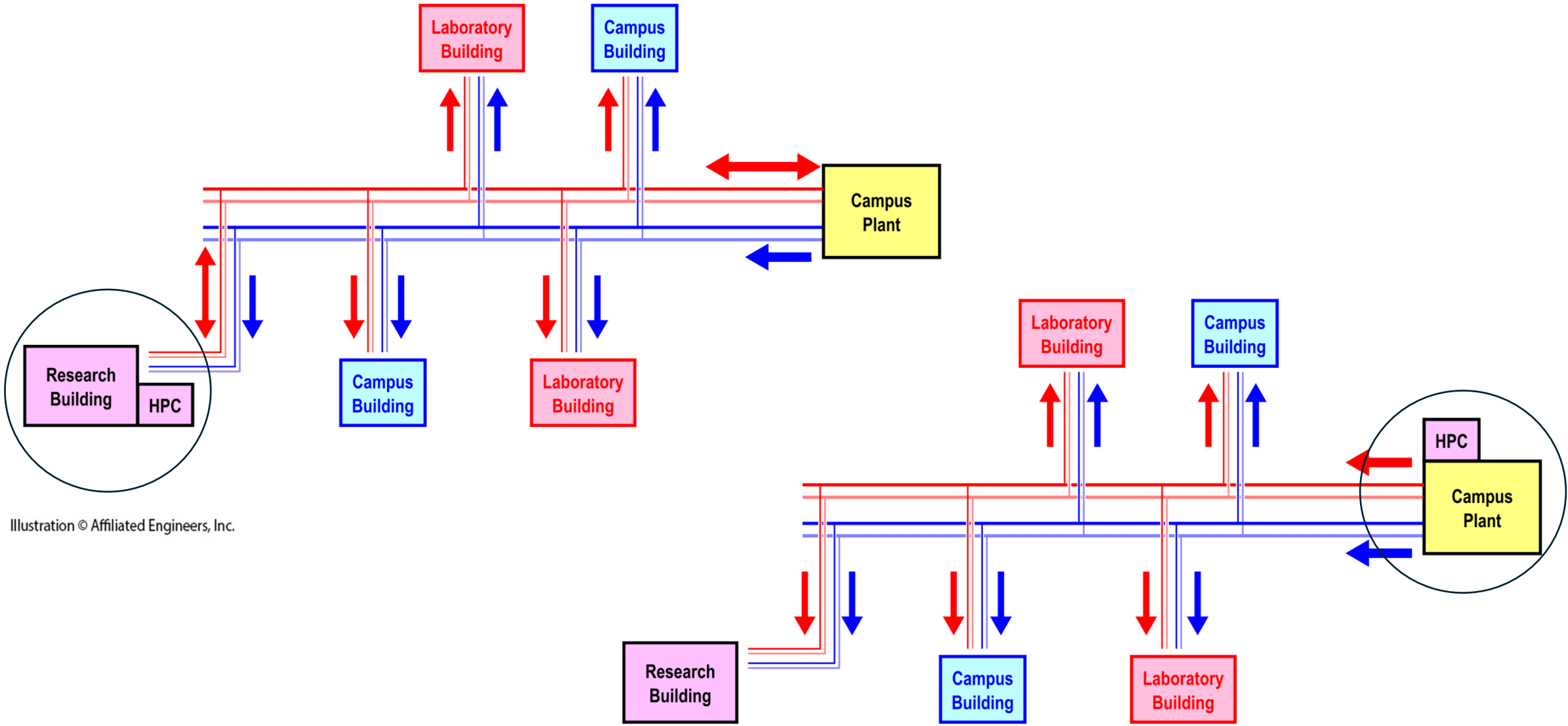


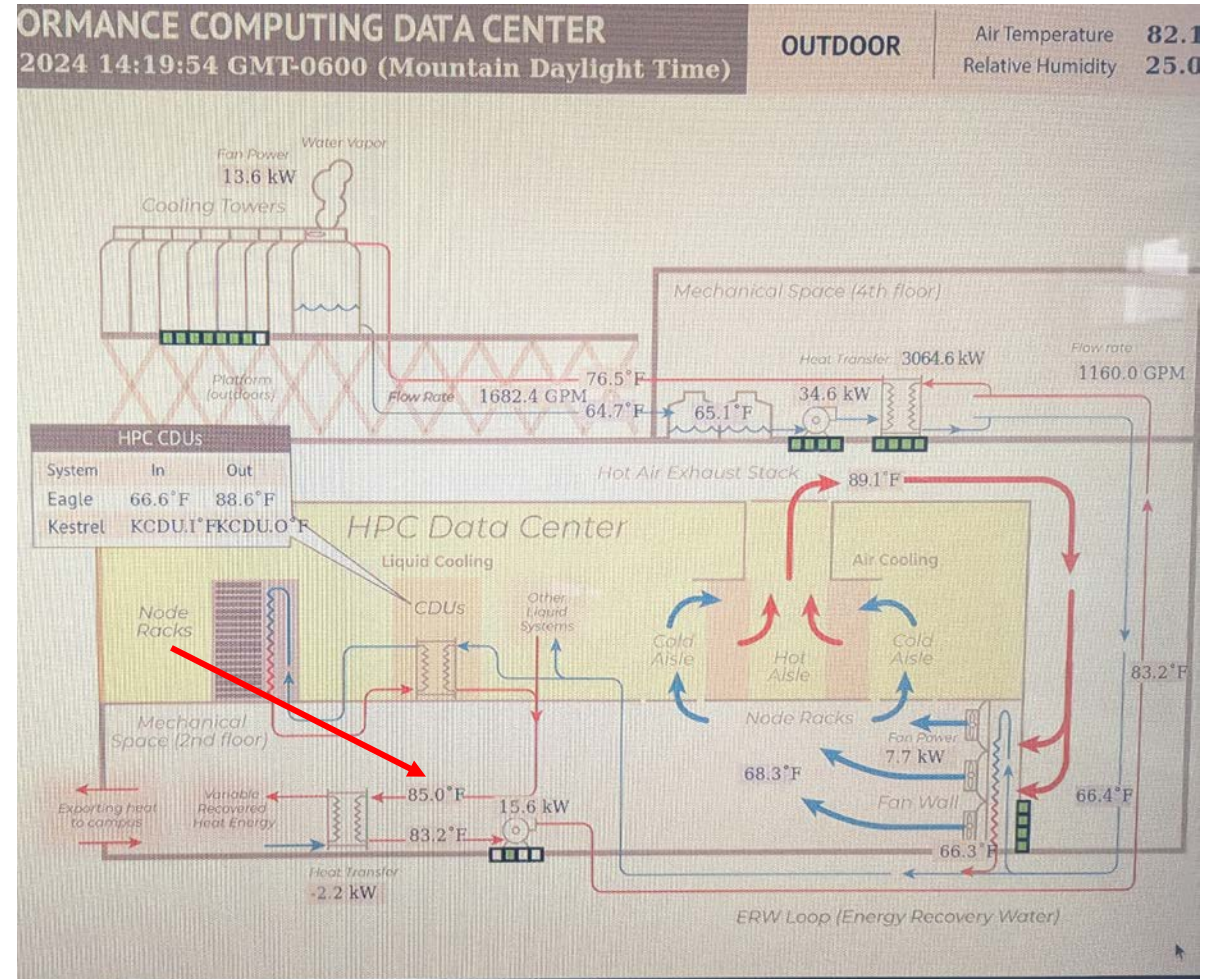
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HPC – Cooling Loop Temperatures

- Delta T
- Changing Technology

? Has anyone had a success with HPC heat recovery for labs?



Dilemmas in Existing Labs

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Dilemma 1
Ventilation Effectiveness

C&EN- American Chemical Society



Dilemma 2
Upgrading Existing Labs

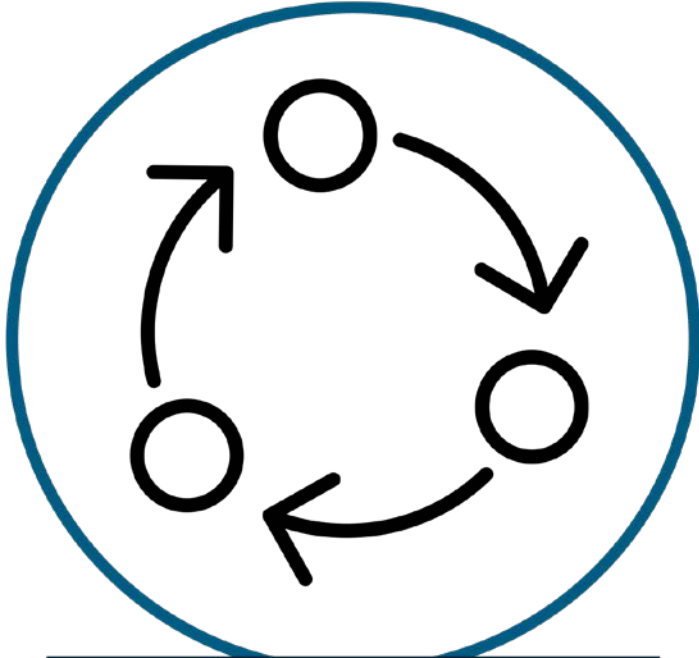
Brent Nelson/ NREL



Dilemma 3
Challenges with Costs

Adobe Stock

Ventilation Effectiveness



Process and
Evaluation



Safe Operations



Engineering
Design



Process and Evaluation

Laboratory Ventilation Risk Assessment (LVRA)

- Method to provide ventilation designers and laboratory safety personnel with a **systematic, effective process to assess risk.**

Assessment Categories	
✓	Type of hazards and procedures
✓	Generation characteristics of hazard
✓	Quantity of materials used or generated
✓	Frequency and duration of hazard generation
✓	Containment by exposure control devices



Risk Level	Description
0	Negligible
1	Low
2	Moderate
3	High
4	Extreme



ASHRAE-Recommended Minimum Room Flows



Safe Operations



- Setbacks
 - When, where, why, and how
- Safety decisions
- Green chemistry options



Kelsey Townsend / NREL

Engineering Design

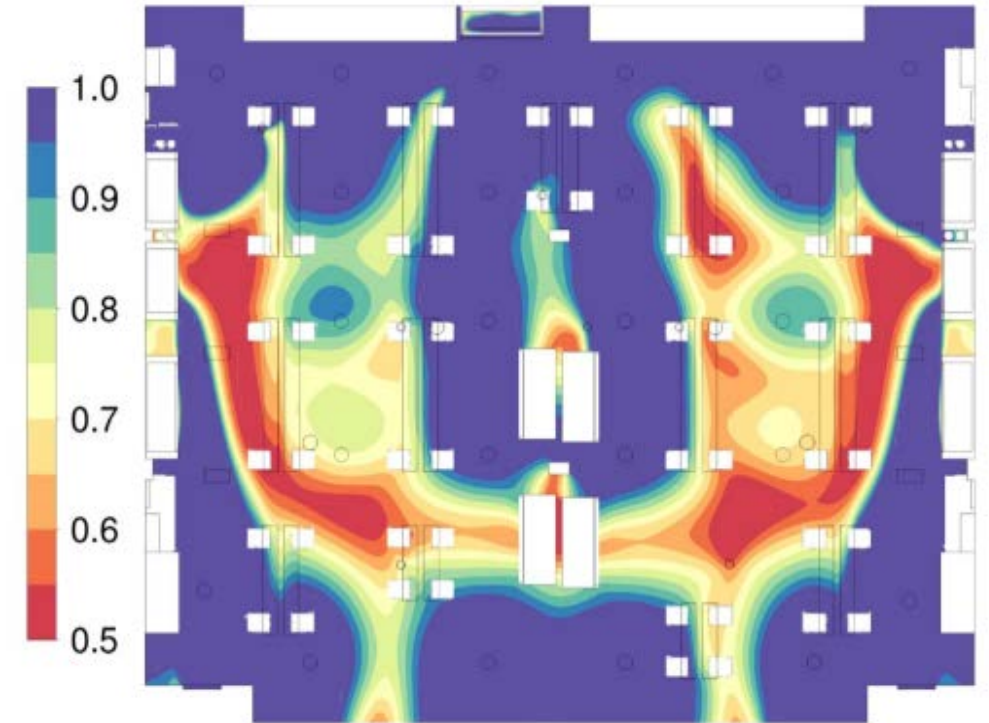
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- Fume hoods/exposure control devices
- Ventilation design
 - CAV and VAV
 - Diffuser placement and design



What evolutions and choices in engineering design, operations, and equipment are you seeing?



Air change effectiveness

Photo from AnSight LLC

Difficulty of Upgrading Existing Lab

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Plant level

Joe DelNero / NREL



Terminal Level

Joe DelNero / NREL

Plant Level

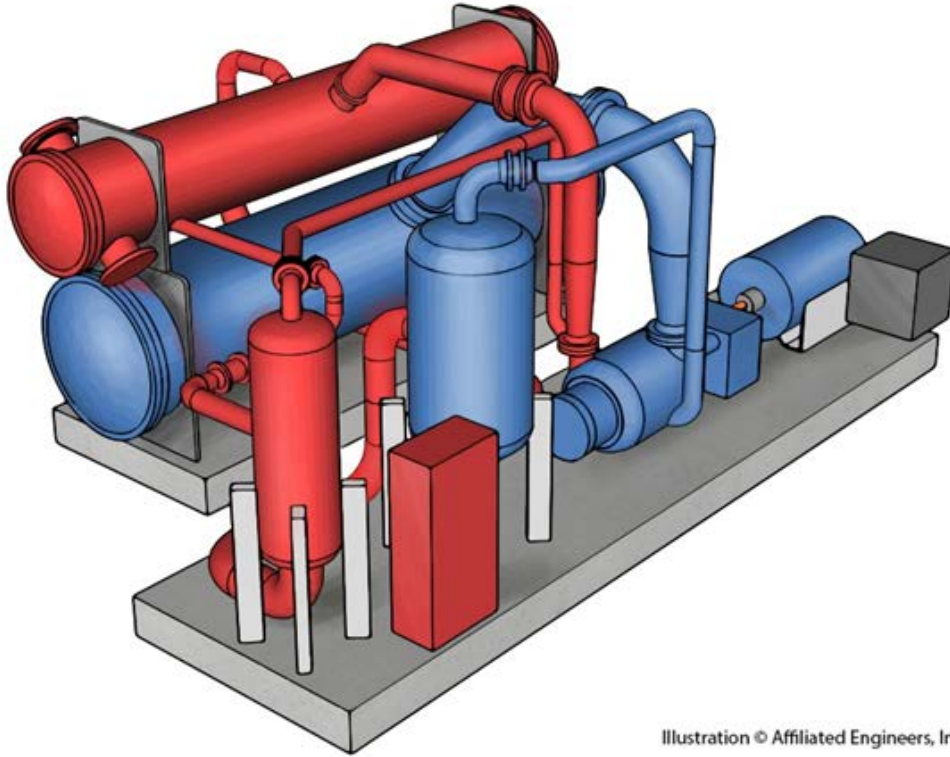
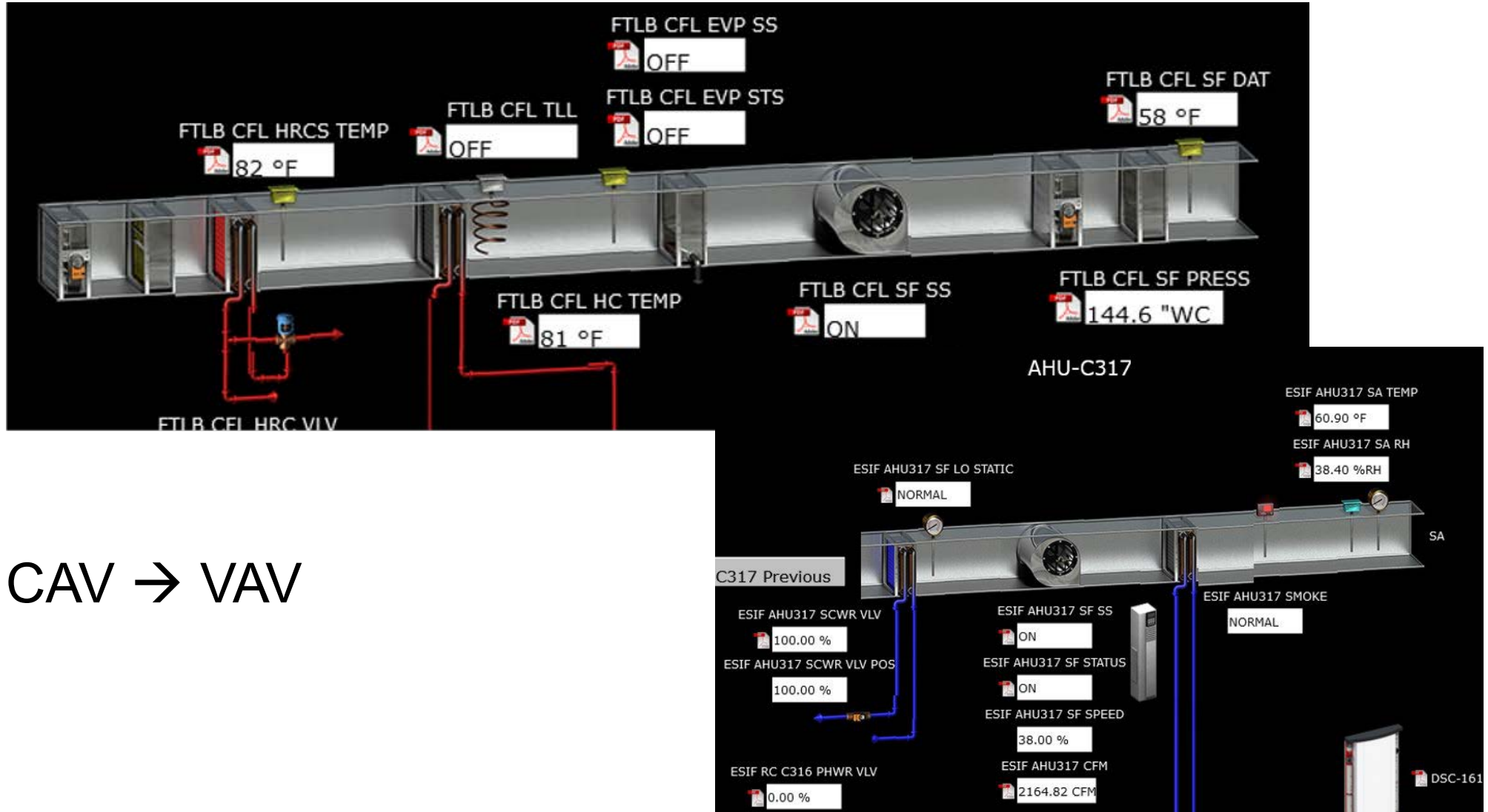


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How to plug in a heat recovery chiller into existing hydronic systems?

Terminal Level




CAV → VAV

Photos by NREL

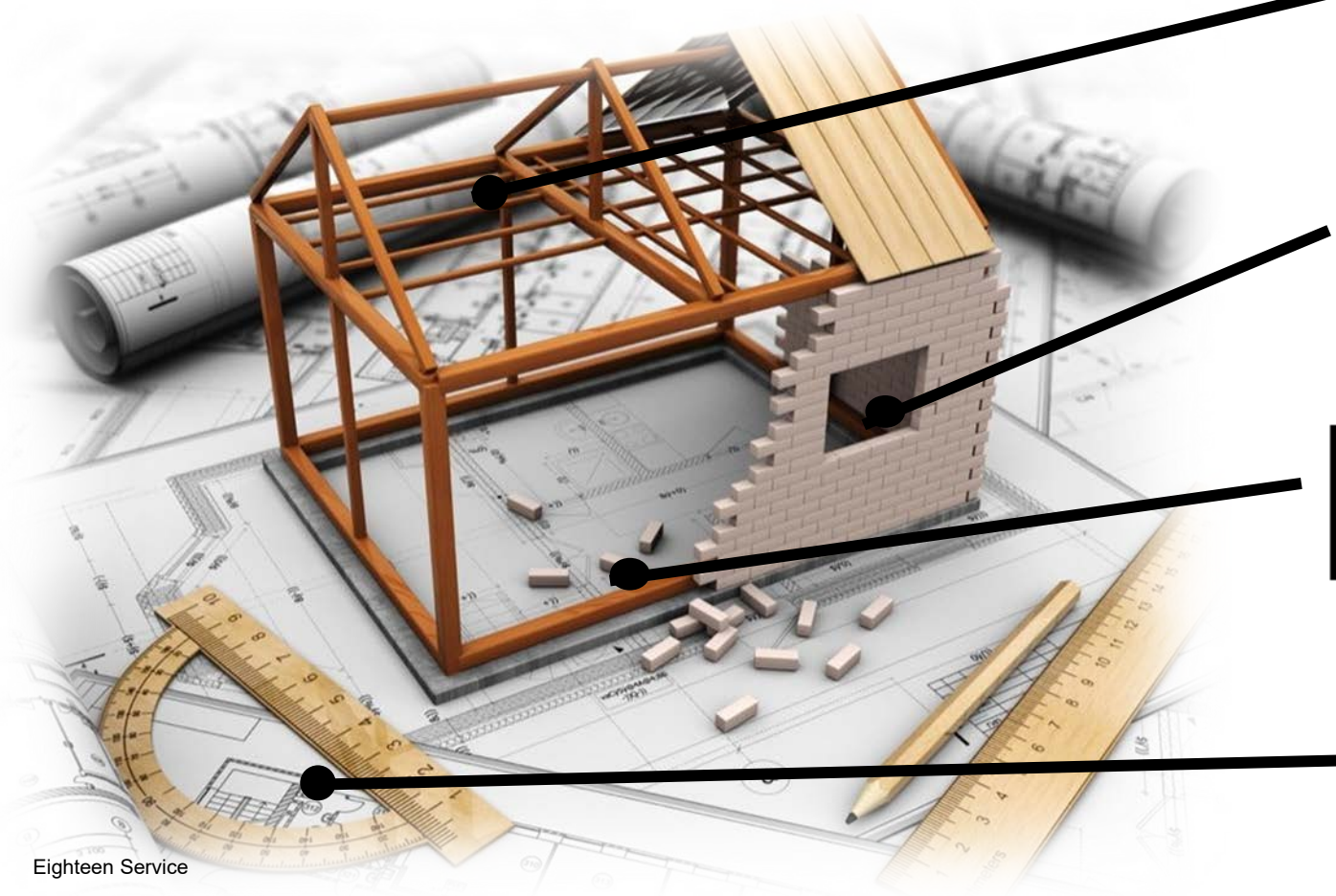
Challenges with Costs

- Utility incentives
- ESPC options
- Deferred maintenance vs upgrading



 What interesting financial tools or solutions are you using to reduce or reach zero carbon emissions your labs?

New Building Design



Optimizing Heat Recovery Potential

A Case Study

Setting Realistic Goals

Mechanical System Design

Eighteen Service

Optimizing Heat Recovery Potential

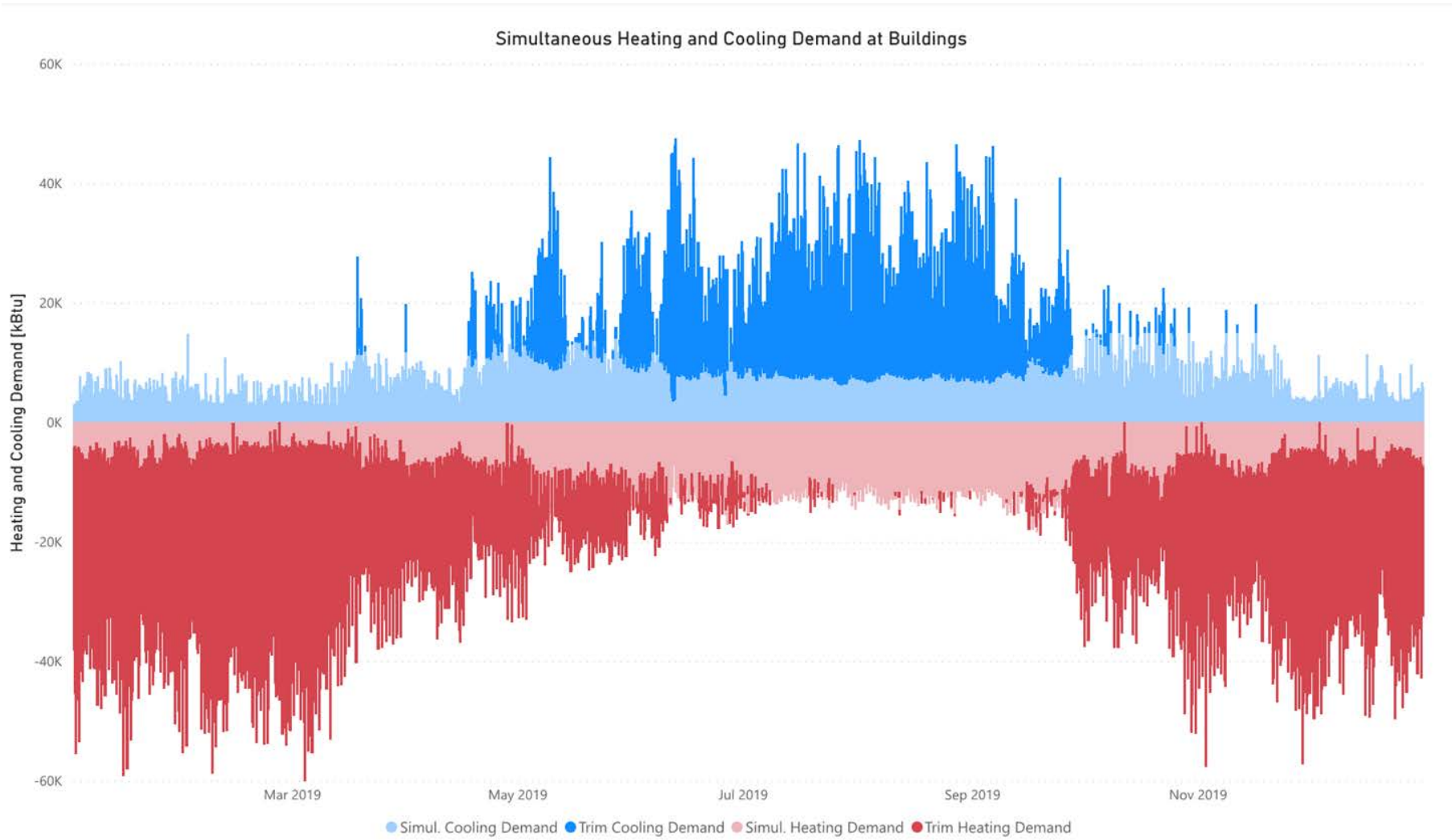


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Optimizing Heat Recovery Potential



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PowerBI Tool Credits: Hugo Bodik and Sam Gebremeskel

Case Study

- A Smart Labs partner conducted CFD analysis to better understand the ventilation effectiveness in their new construction laboratory building
- Found that window-to-wall ratio may be more important than they anticipated
- Significant glazing area had lower air change effectiveness and inadequate mixing compared to the space without a facade
- Additional heating required in the laboratory beyond minimum ventilation requirements

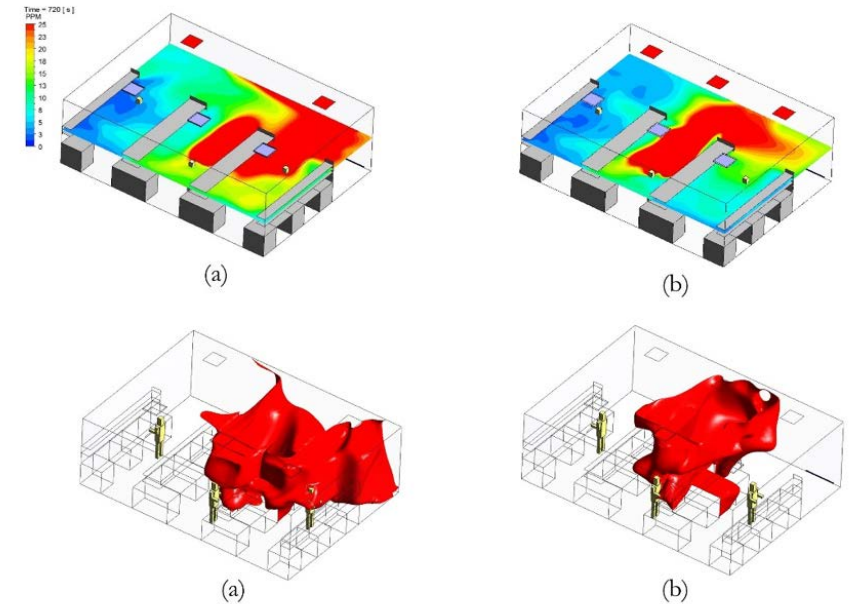


Photo Credit: AnSight LLC

Computational Fluid Dynamics (CFD)
Analysis

Setting Realistic Goals with Decarbonization

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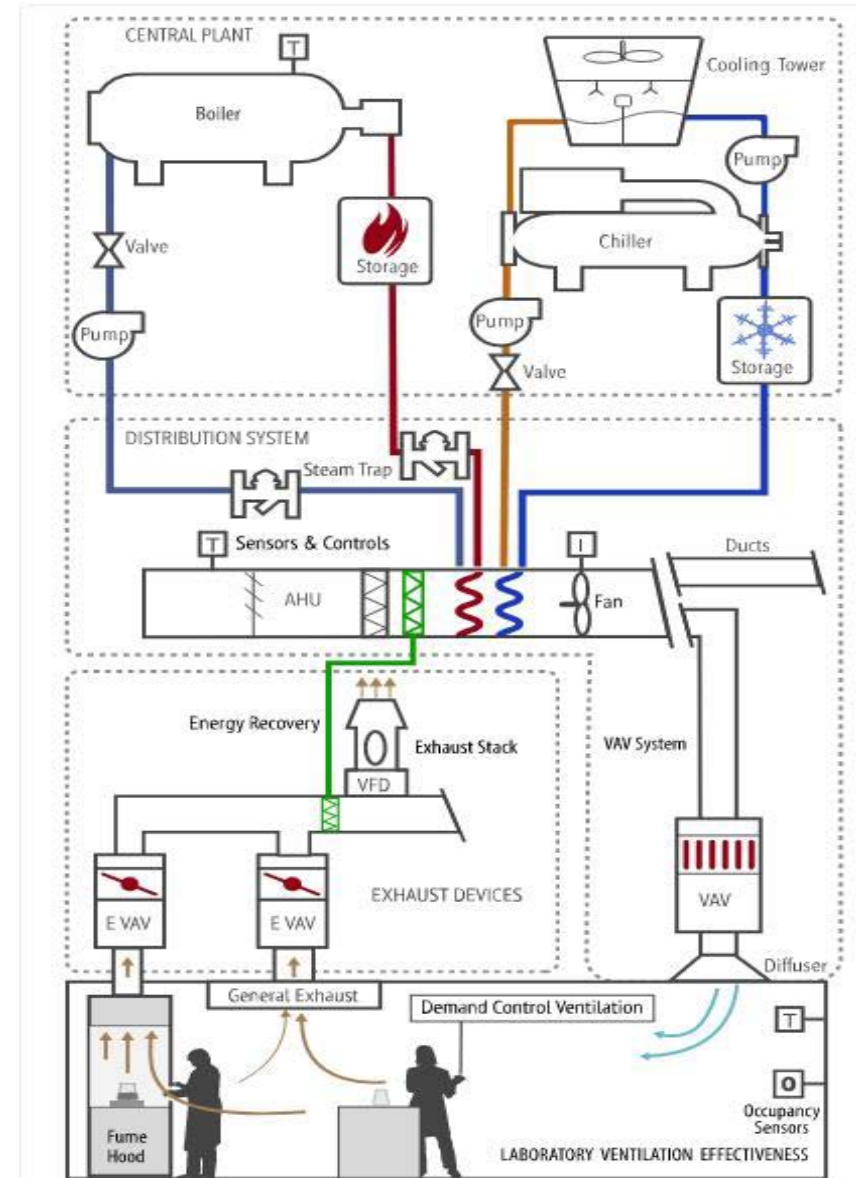
- Efficient design
- Appropriate costing and scoping for goals up front
- Funding tied to decarb goals



Joshua Bauer and Bryan Bechtold / NREL

Mechanical System Design

What are your **decarbonization** strategies for new building designs?



Options for Terminal Units

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Active Chilled Beams

U.S. Boiler Company

A photograph showing a white, rectangular active chilled beam terminal unit mounted on a ceiling. The unit is angled downwards, and its internal components, including a fan and a coil, are visible. The background shows a modern building with large glass windows.



Air-Source Heat Pump

Molly Rettig / NREL

A photograph of four outdoor air-source heat pump units installed on a concrete pad. The units are arranged in a 2x2 grid. Each unit has a large circular fan grille. The background shows a building with a wooden structure and a large vent.



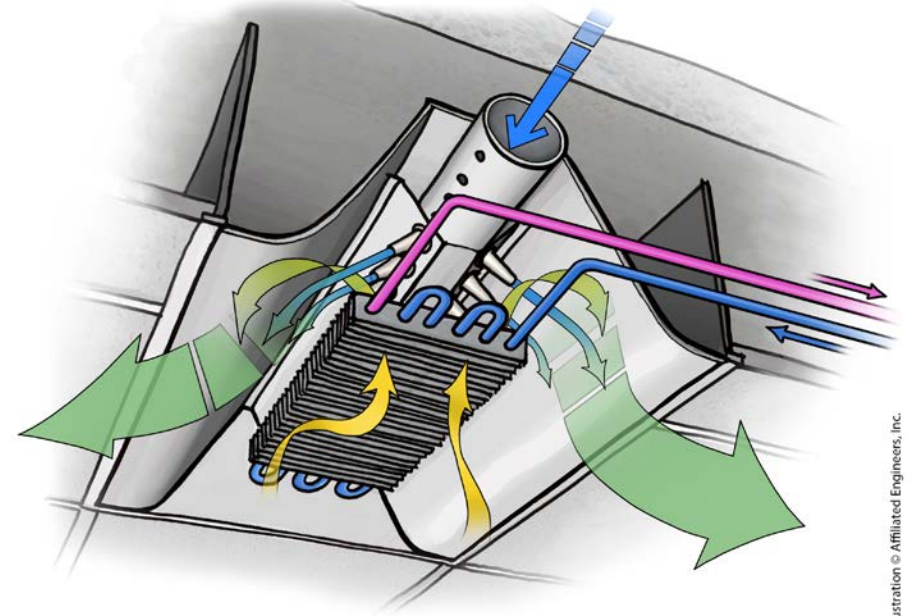
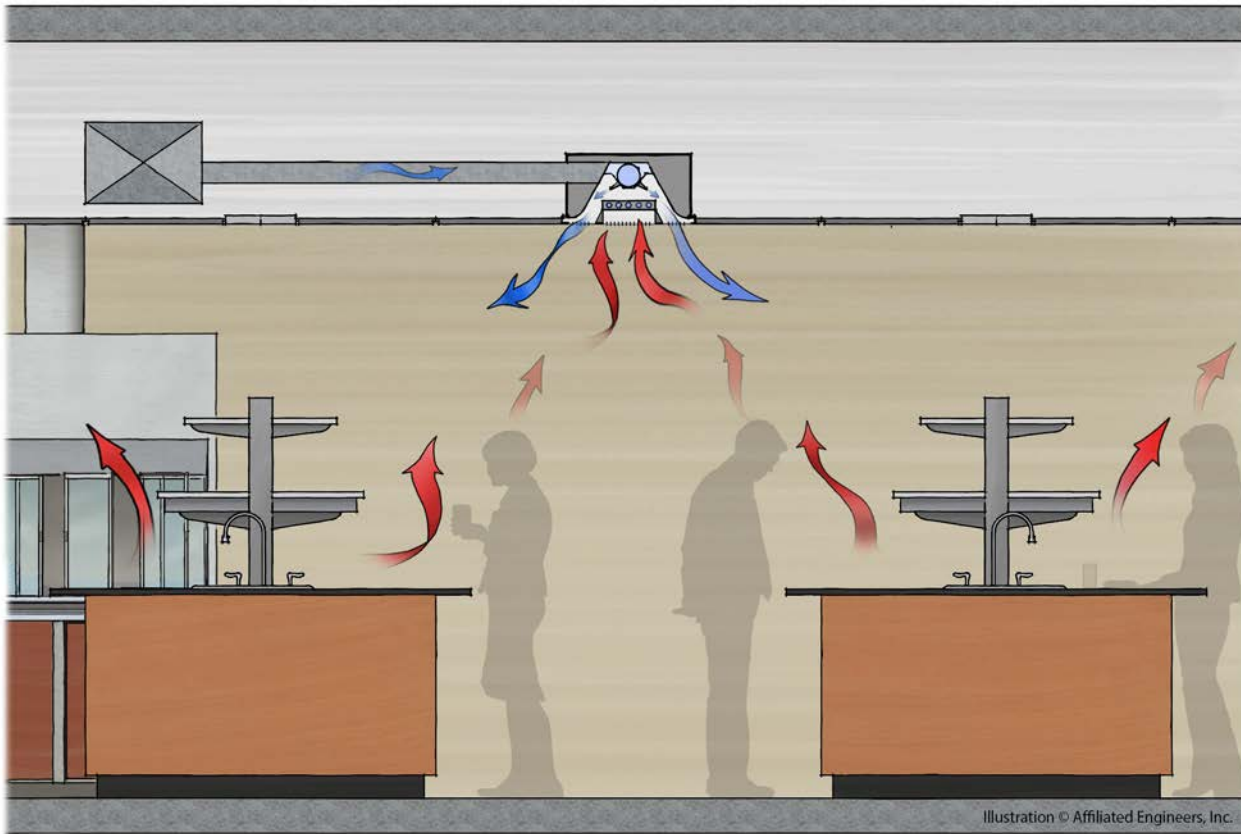
High Bay Lab Spaces

Tradeline Inc.

A photograph of a large, high-bay laboratory space. The room features a high ceiling with a yellow overhead crane. The floor is polished and reflective. There are metal railings and a staircase in the background. The space is well-lit with large windows on the side.

Active Chilled Beams

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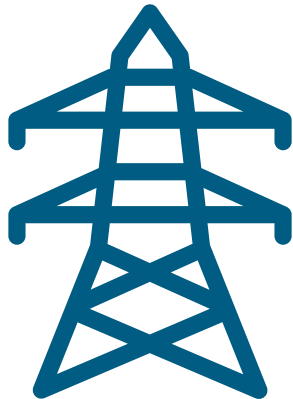


Air Source Heat Pumps

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Scope 1



Scope 2

- Deliver as much as three times more heat energy than the electrical energy it consumes
- Reduces scope 1 and scope 2 emissions when replacing gas-fired and electric resistance heaters

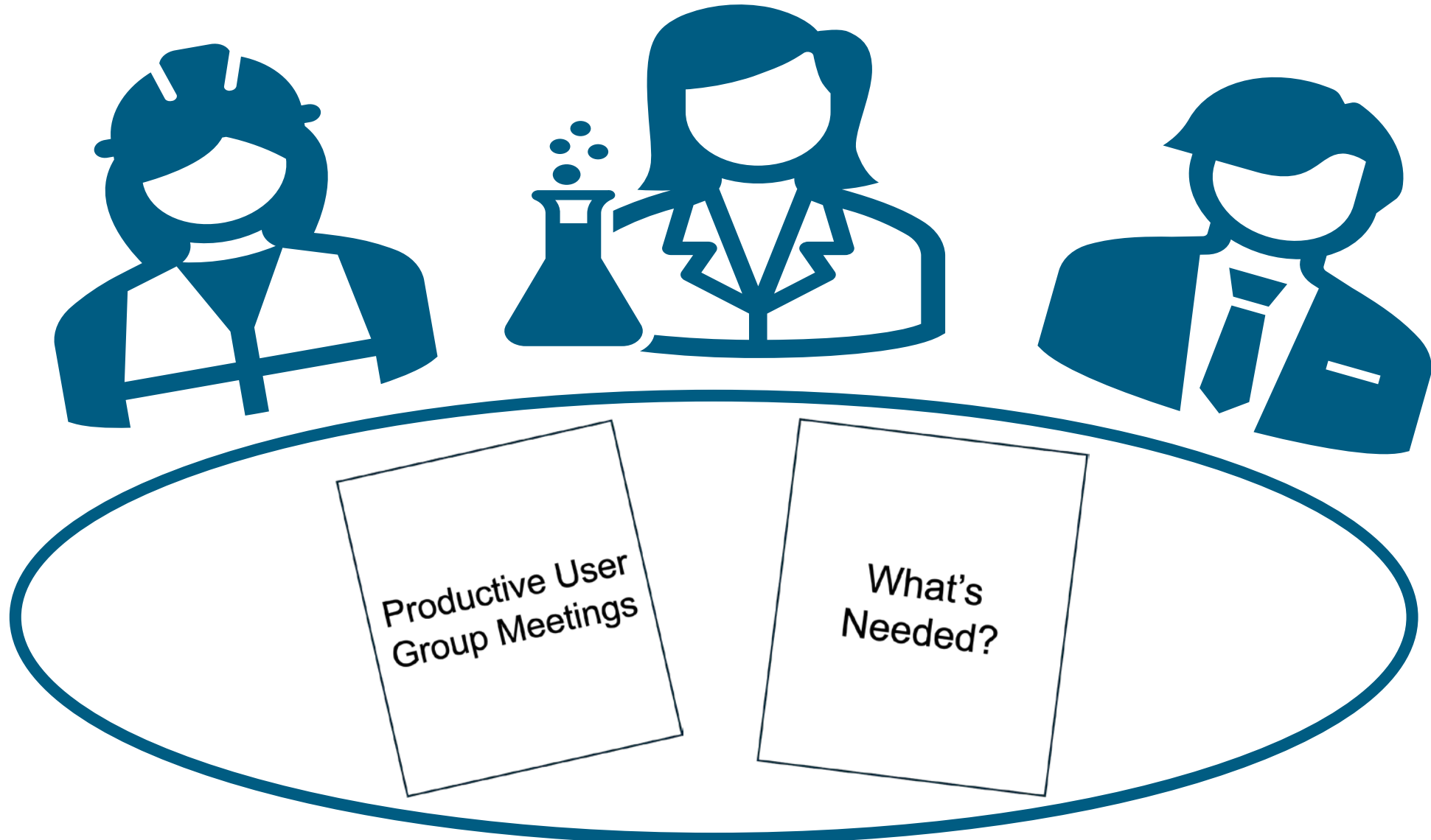
High-Bay Lab Spaces

- Admin Building 251
 - Air source heat pump (ASHP)
 - New electric boiler
- Structural Testing Laboratory (STL)
 - Infrared (IR) heaters with force air units
 - Variable refrigerant flow (VRF) system
- 2.5MW and 5MW Dynamometers
 - Infrared (IR) heaters with force air units



Photos by Josh Bauer and Bryan Bechtold

User's Role in Lab Building Design



Productive User Group Meetings

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- Get alignment on decarbonization goals
- Communicate expectations
- How does the design process work?
- Ask the right questions for their lab design
- EH&S involvement
- Avoid "sticker shocker" later in design/construction
- Design for the proper amount of future flexibility
- How to communicate design criteria in terms that everyone understands



Photo Credits: Affiliated Engineers, Inc.



What's Needed in the Lab

- Support researchers in understanding decarb goals
- Help lab users understand the impacts of their decisions
- Drivers for ventilation:
 - Temperature and humidity
 - Chemical choices and amounts
 - Occupancy levels and timing
-  Share an example of how researcher decisions affected decarbonization efforts



Dennis Schroeder/ NREL

Taking the Dilemma out of Decarbonization

- Many decarbonization solutions for labs

- Use data and tools to make better decisions

- Appropriately apply technological solutions through detailed analysis

- Operations are critical to an effective decarbonization plan

Go solve the decarb dilemmas!

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Credit:GIPHY

NREL/PR-3500-91520

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