Designing Quantum for Flexibility and Energy Efficiency

I2SL Annual Conference

Speakers

Bradford Crowley

Jonathan Friedan

ballinger

2025 Fall

Learning Objectives

Environmental Criteria for Quantum Research

Provide a basic understanding of quantum research and the range of environmental criteria required

Safety + Ventilation in Quantum Labs

Demonstrate the safety differences in quantum research compared with more typical wet laboratories and how this difference leads to various ventilation approaches

Energy Demands for Stable Environments

Review and understand the (tremendous) energy requirements needed to provide stable temperature and humidity for labs with high ventilation and heat loads

Designing Flexible, Efficient Quantum Labs

Show how flexibility and energy efficiency can be achieved in quantum lab design using a combination of house and supplemental systems

Speakers

Brad Crowley
PE, LEED AP
Principal

Ballinger

Jonathan Friedan
PE, LEED AP
Senior Principal

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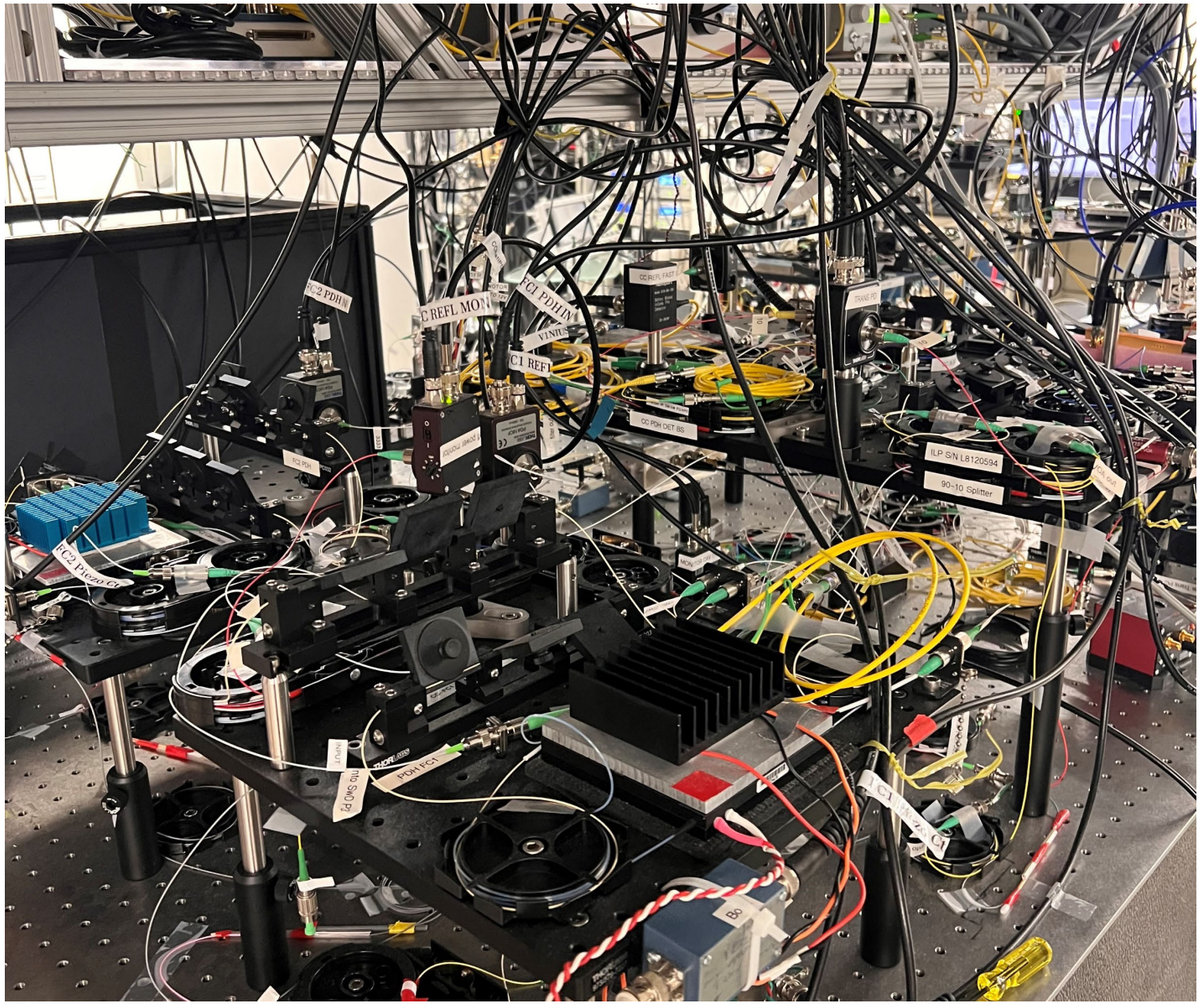
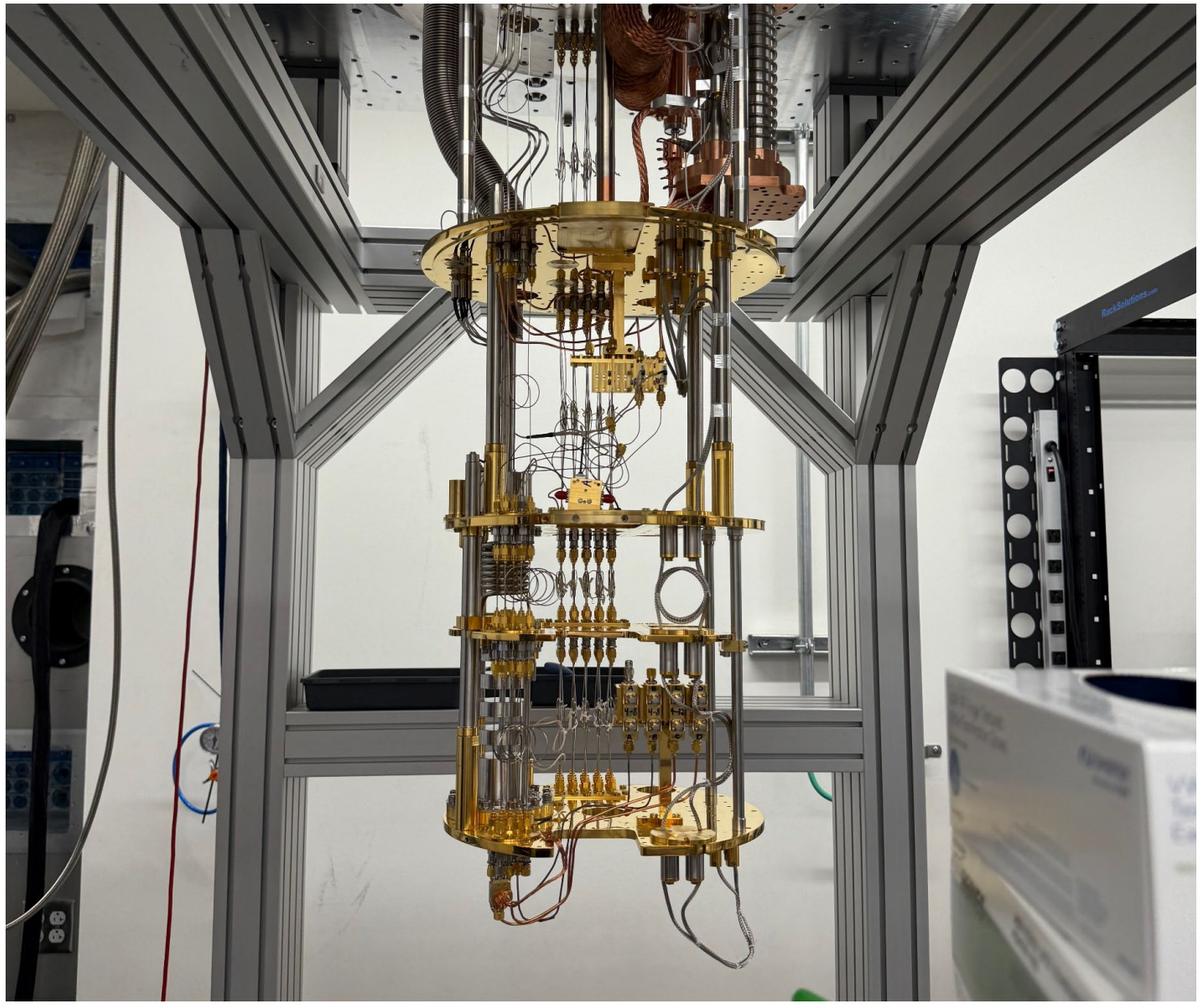
What is Quantum?





Basis: Recent Quantum Experience

University of Maryland, College Park
Stanley R. Zupnik Hall

185,300 SF
Engineering

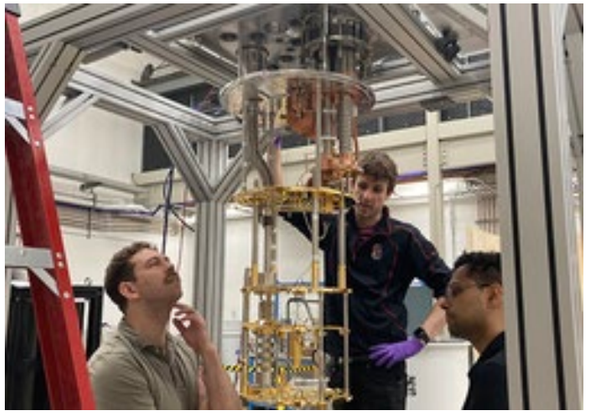
University of Maryland, College Park
Chemistry Research Building

105,000 SF
Chemistry

Yale University
Upper Science Hill Development

410,000 SF
Purpose-built for quantum physics
and material science

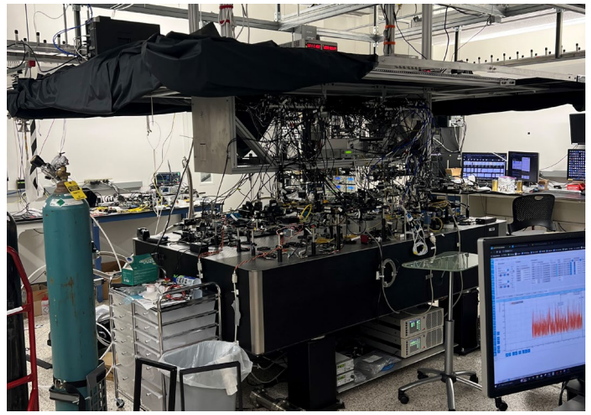
Quantum Laboratory Infrastructure



Dilution Refrigeration / Cryogens

Chemical Use

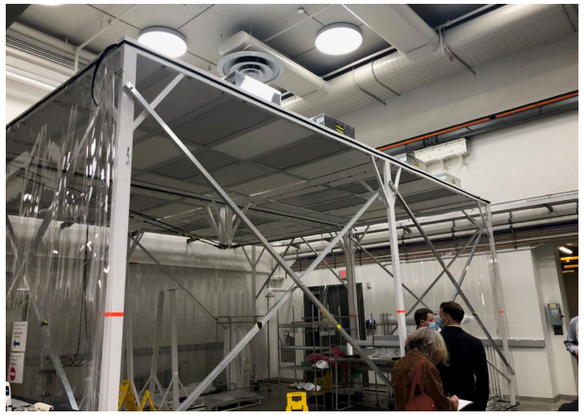
Power / Sensible Cooling Load



Temperature / Humidity

Process Cooling Water

Vibration, Noise, & Air Distribution



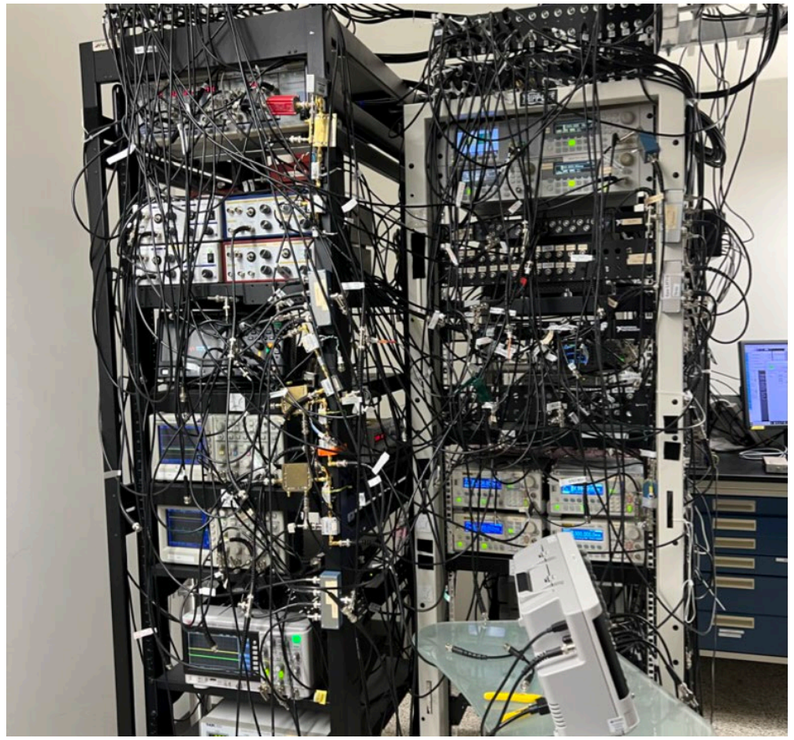
Air Filtration (HEPA)

Pressurization

Drivers of Design / Focus Areas

Ventilation

How much ventilation air is required for quantum?



High Equipment Loads

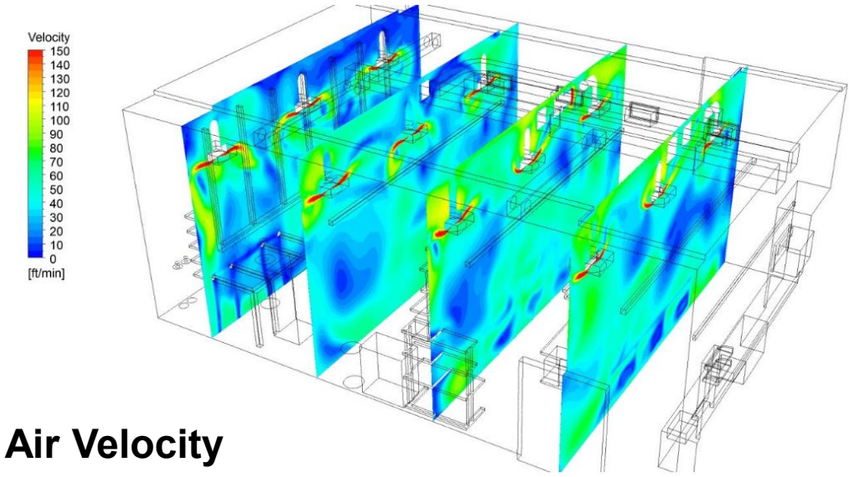
How do laboratory equipment loads drive design and energy?

Temperature & Humidity

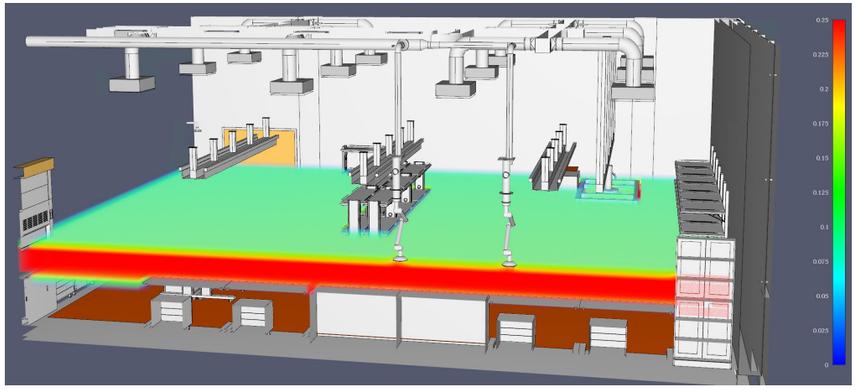
What are the impacts on energy due to the environmental criteria (temperature and humidity)?

How much ventilation air is required for quantum?

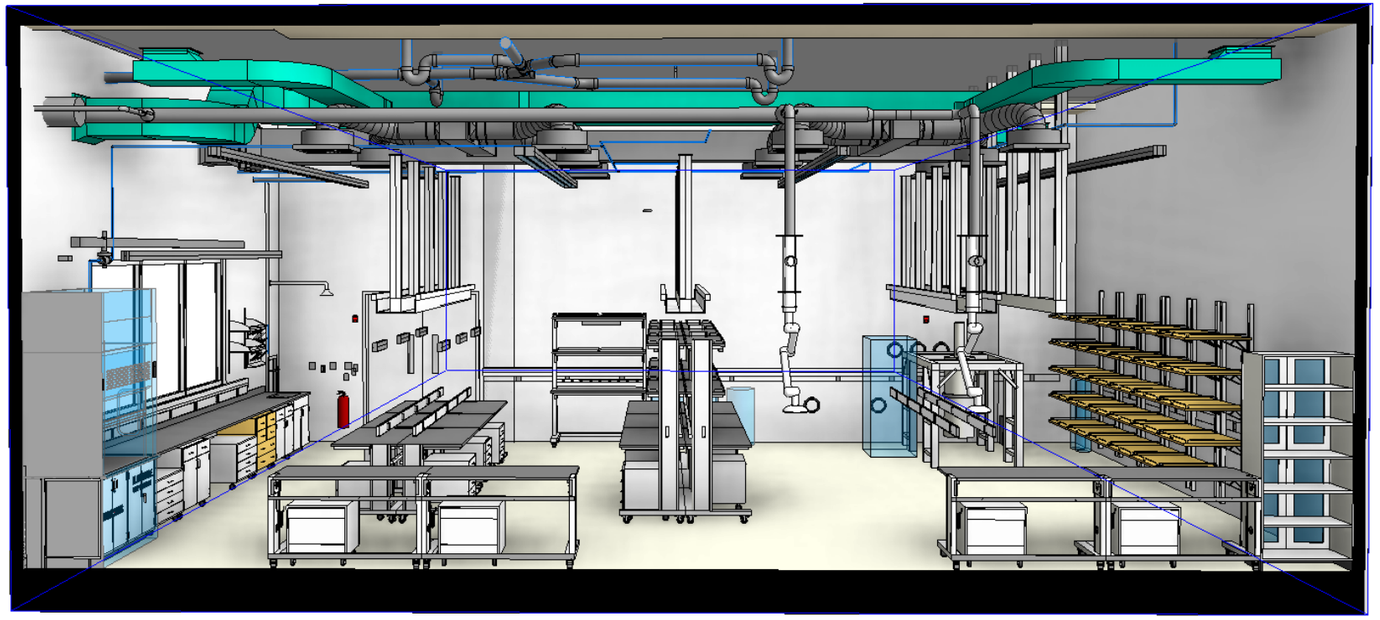
CFD to inform minimum ACH large, high-ceiling rooms promote dilution



Air Velocity



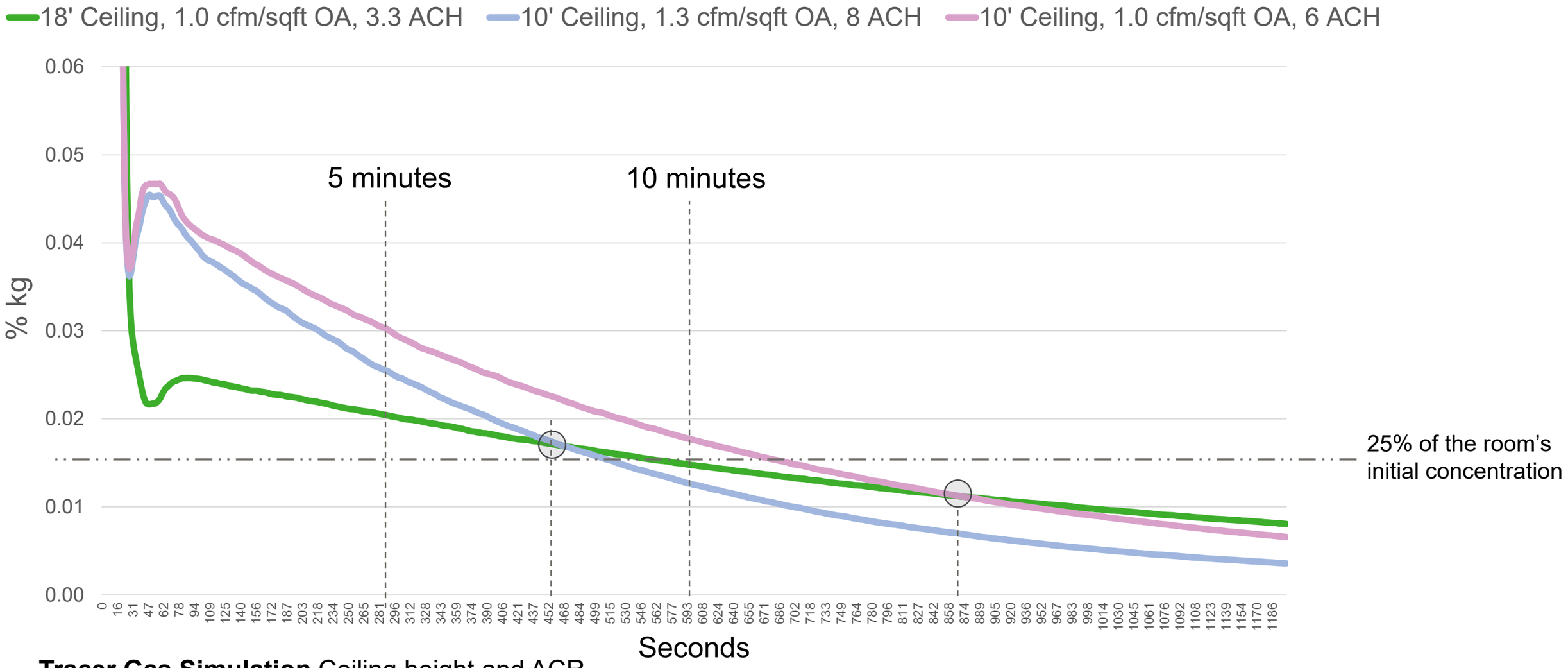
Tracer Gas Simulation Starting Condition



Laboratory

How much ventilation air is required for quantum?

CFD to inform minimum ACH large, high-ceiling rooms promote dilution

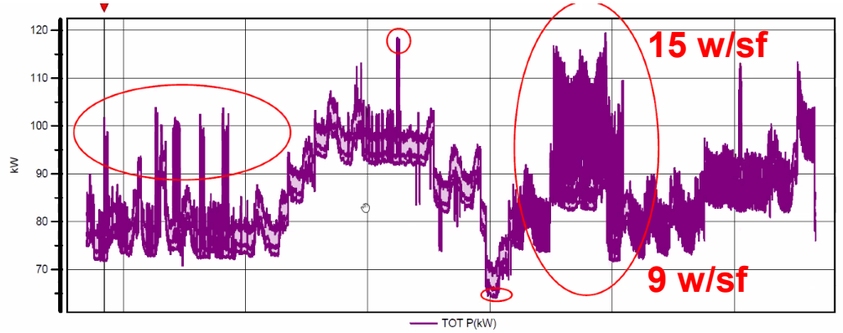


Tracer Gas Simulation Ceiling height and ACR

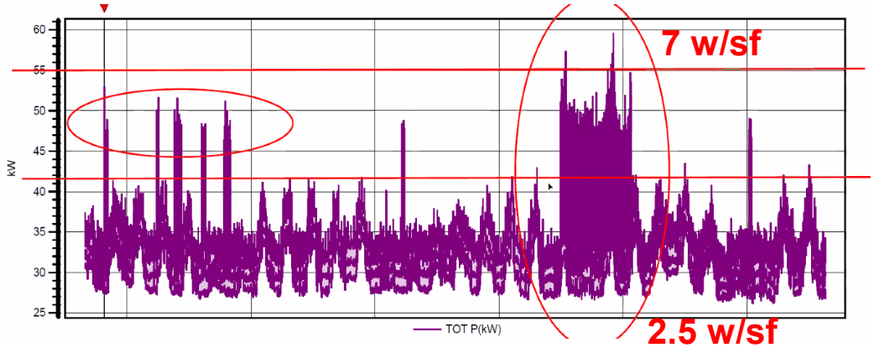
How do laboratory equipment loads drive design & energy?

Electrical Metering Recorded Data

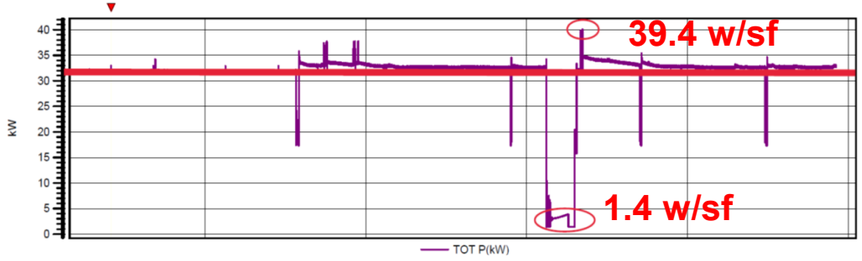
4th Floor Labs (Diversified amongst multiple labs)

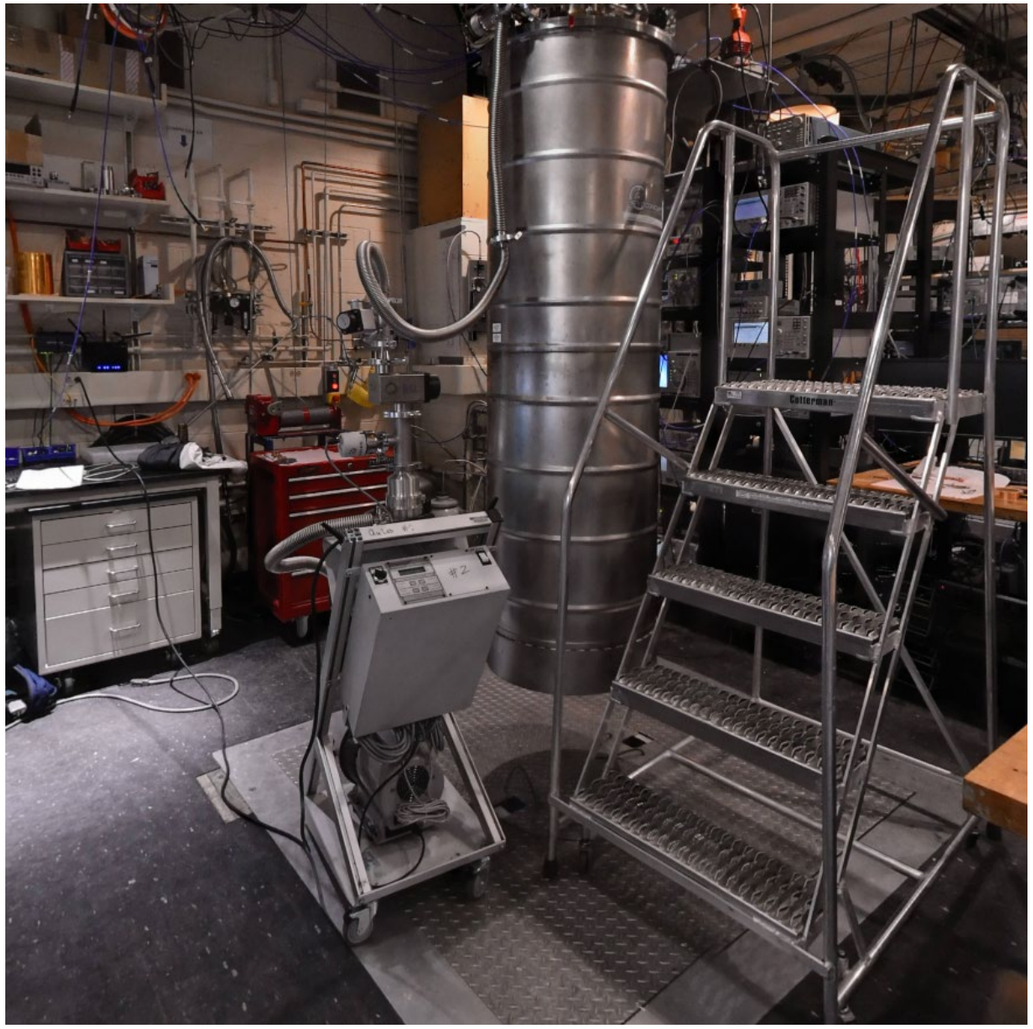


3rd Floor Labs (Diversified amongst multiple labs)



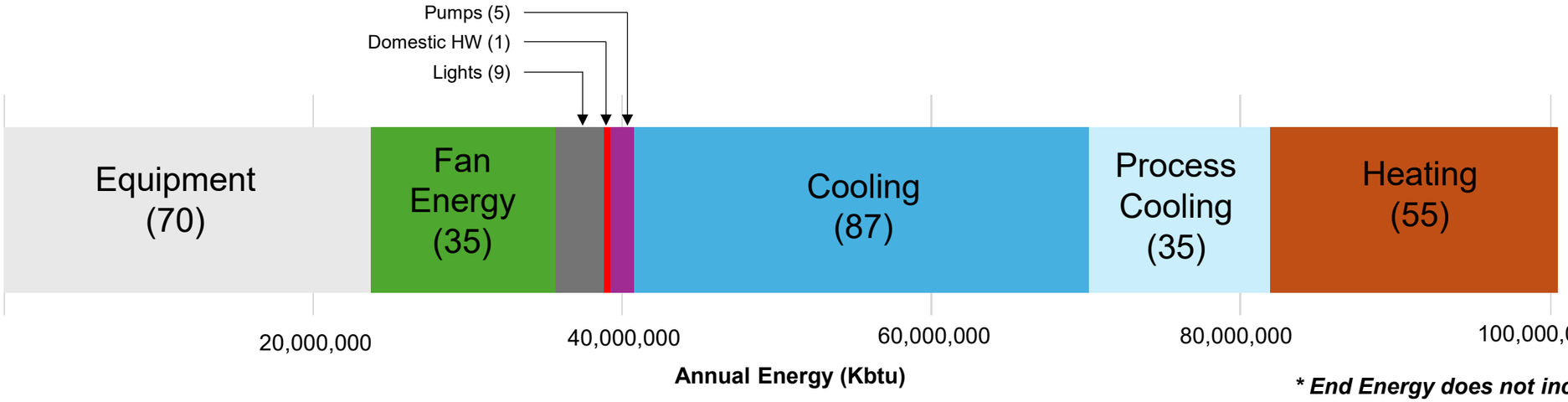
Cryo-coolers for Helium Liquefier





How do laboratory equipment loads drive design & energy?

End Energy Component Annual EUI (kBtu/sf) Breakdown



**** End Energy does not include thermal efficiencies in creating cooling or heating***

Building EUI

How do laboratory equipment loads drive design & energy?

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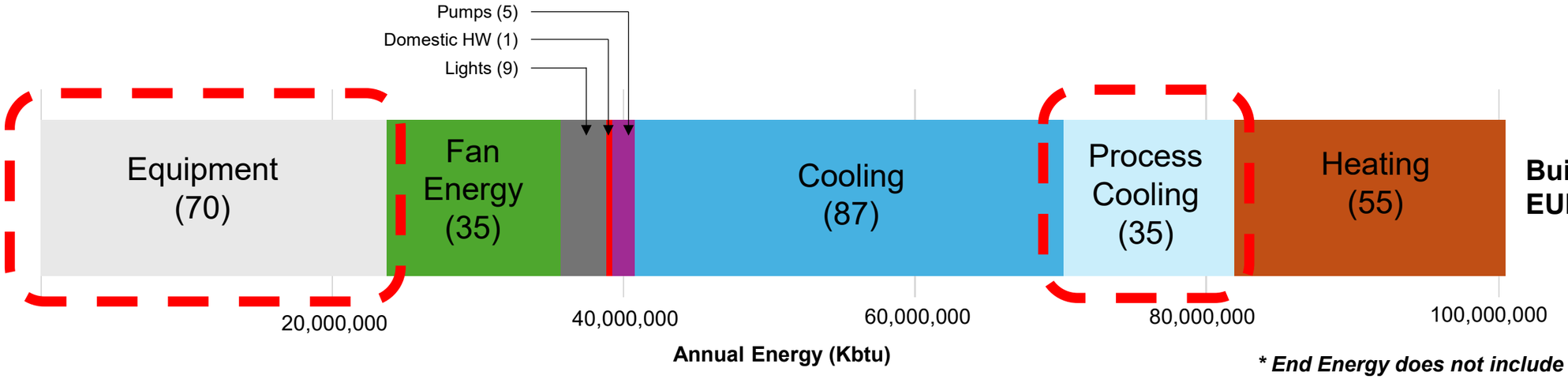

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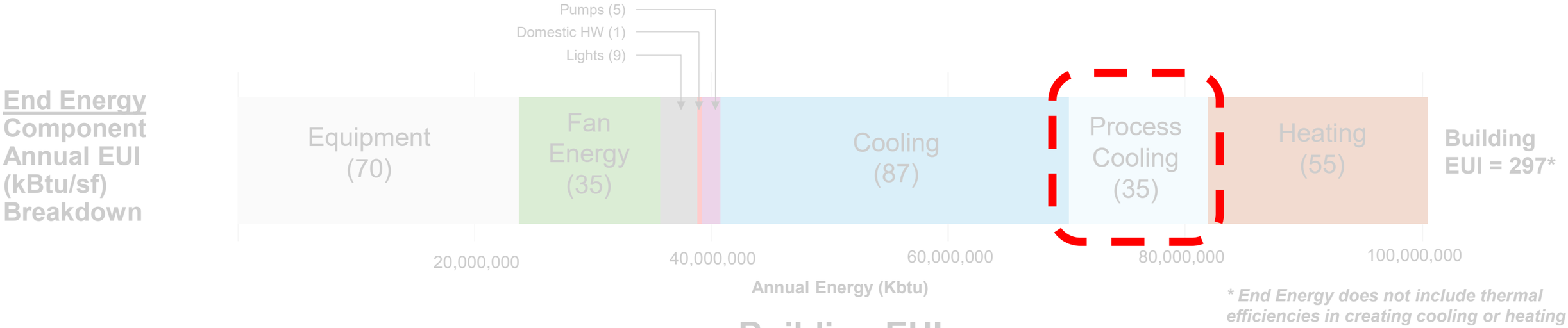
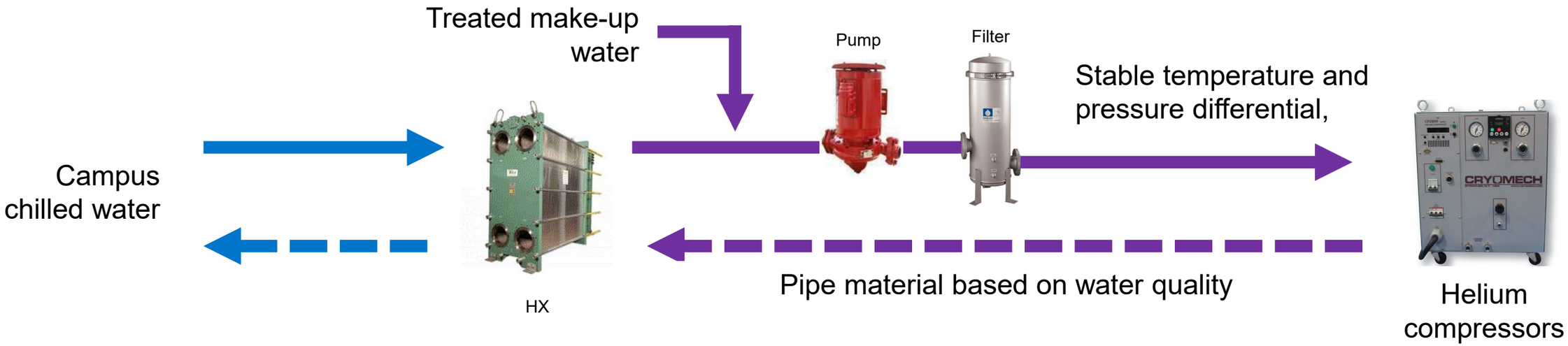
Building EUI

How do laboratory equipment loads drive design & energy?





Process Water Diagram – Direct use w/out independent process chillers

What are the impacts on energy due to the environmental criteria (temperature / humidity)?

Energy Use Modeling

End Use Energy (kBtu/ft²)

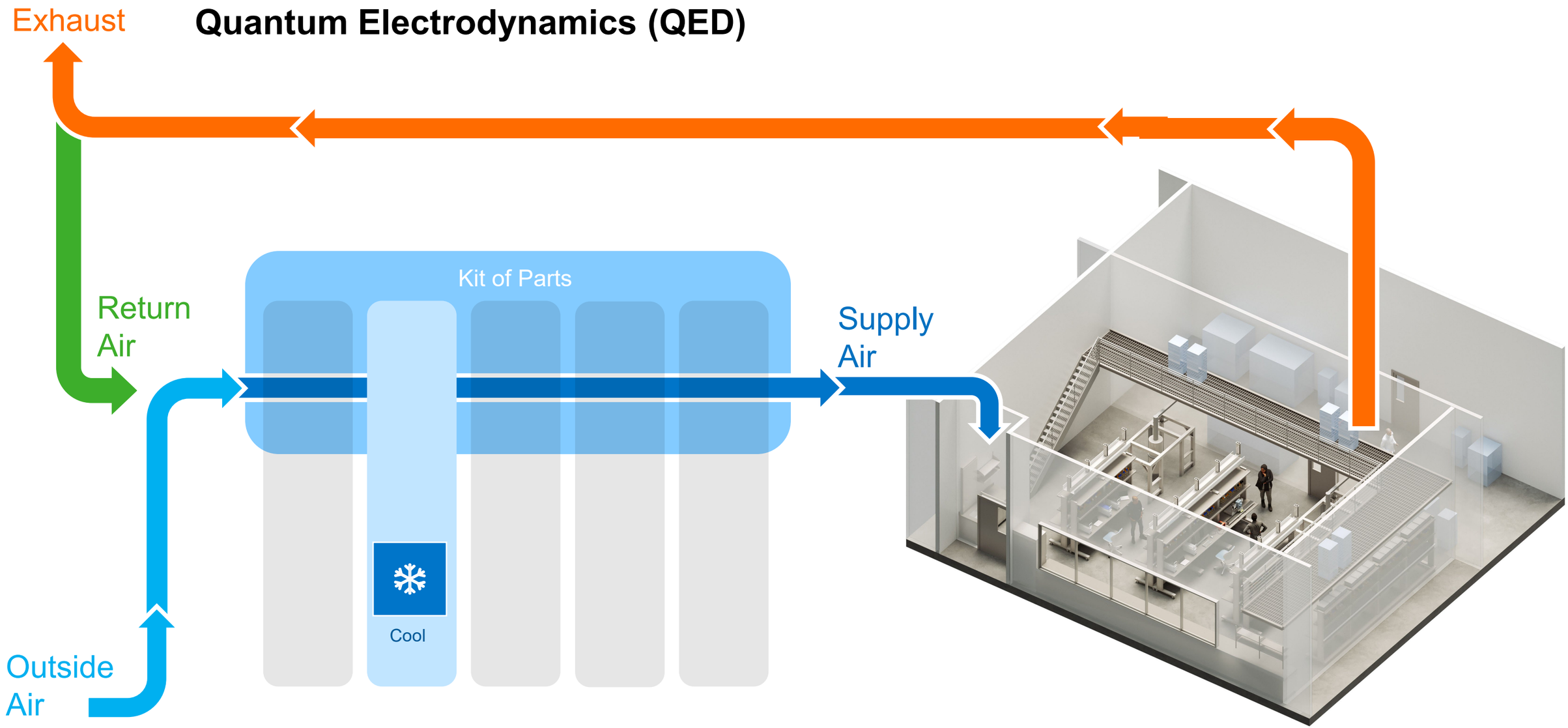
	Enhanced Lab Grade 30% - 50% RH	**Specialized Lab Grade** 40% RH +/- 3%
Lighting	12	12
Equipment	206	206
Fan	47	42
Heating/Humidification	72	204
Cooling	159	290
Total	**495**	**754**
Site Energy **H.COP = 3 C.COP = 6**	**315**	**376**

Standard Lab Grade
Temperature: 72°F
+/- 4°F Range
RH: 30 – 50% Variable

Enhanced Lab Grade
Temperature: 72°F
+/- 2°F Range
RH: 30 – 50% Variable

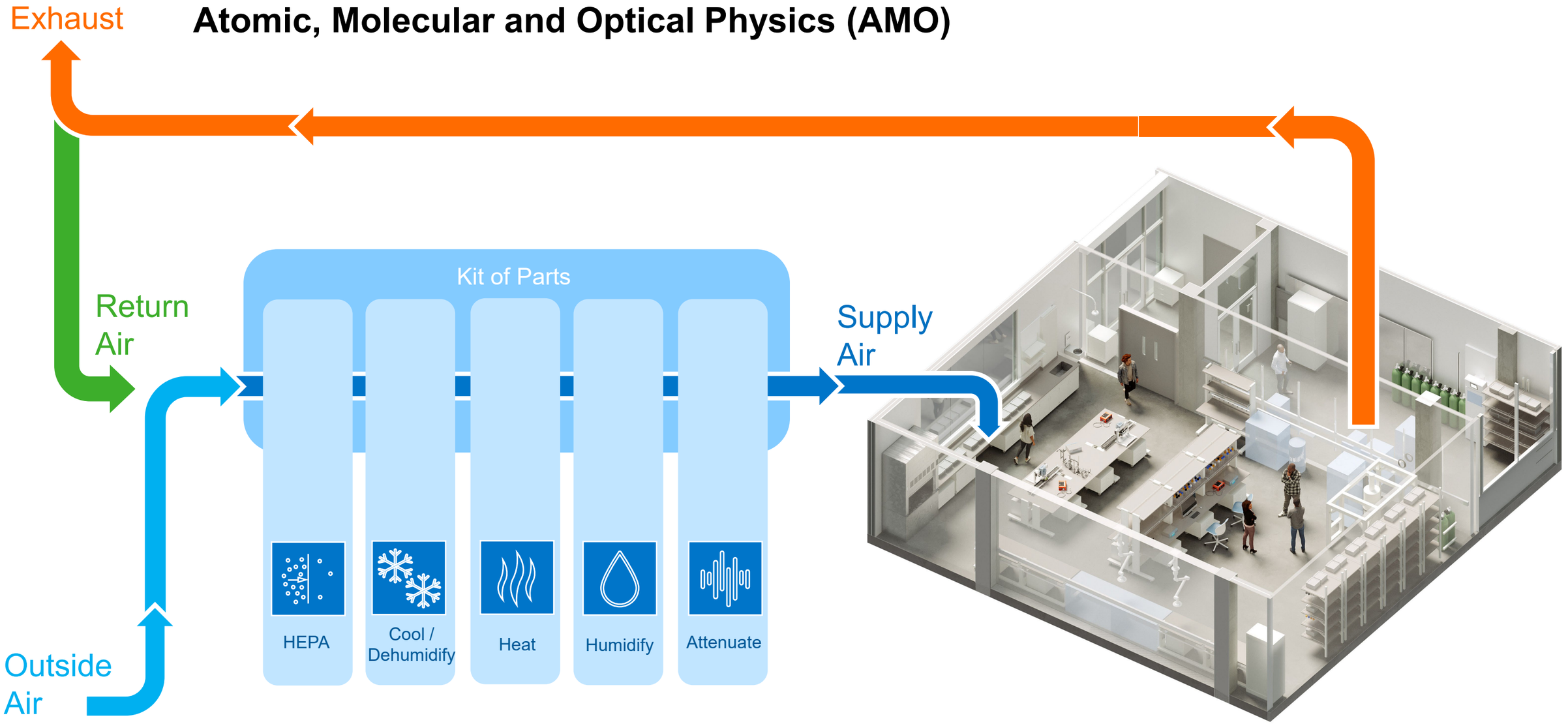
Specialized Lab Grade
Temperature: 72°F
+/- 1°F Range
RH: 40 – 45% Fixed
(+/- 3%)

Quantum Electrodynamics (QED)



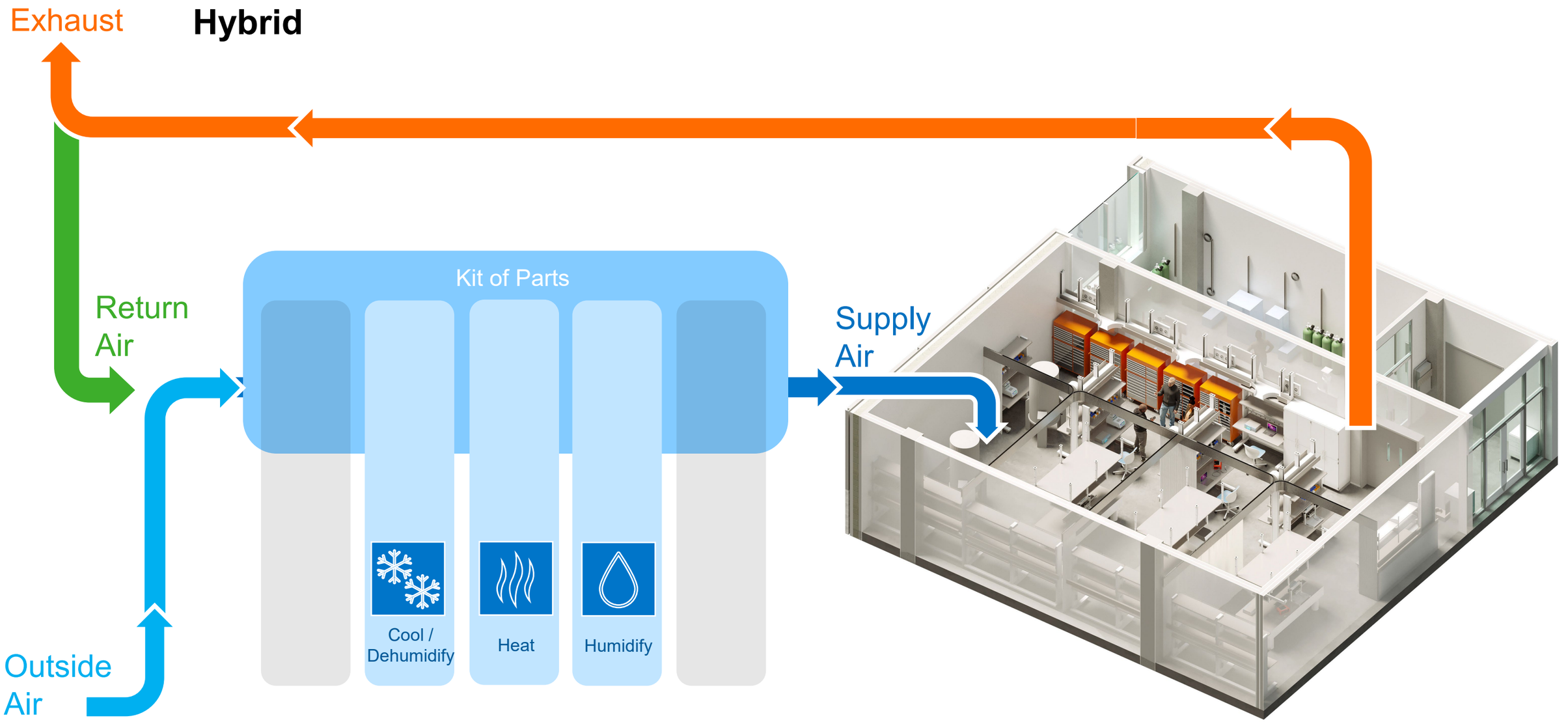
Temperature	72°F +/- 2°F	**Acoustics**	NC 40	**Air Cleanliness**	Standard
Humidity	30-50% RH	**Vibration**	VC-B		

Atomic, Molecular and Optical Physics (AMO)



Temperature	72°F +/- 1°F	**Acoustics**	NC 30	**Air Cleanliness**	Enhanced
Humidity	42% +/- 3% RH	**Vibration**	VC-E		

Hybrid



Temperature	72°F +/- 1°F	**Acoustics**	NC 40	**Air Cleanliness**	Standard
Humidity	42% +/- 3% RH	**Vibration**	VC-E		

Lessons Learned

Environmental Criteria for Quantum Research

- Range of temperature/humidity criteria.
- Design for flexibility to adapt with research

Safety + Ventilation in Quantum Labs

- Design for cryogens, more so than chemicals
- High ceilings help with dilution

Energy Demands for Stable Environments

- High power density – design for efficient cooling of equipment.
- Process cooling is key

Designing Flexible, Efficient Quantum Labs

- No two labs are identical
- Decouple ventilation from local environmental control.

Q&A

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