Air Handling Systems: Design, Performance and Commissioning Issues

Introduction

Presented By:
David Sellers
Senior Engineer, Facility Dynamics Engineering

Class Material Location

The slides and other supporting information for the class can be found at:

https://www.av8rdas.com/pacific-energy-center-design-performance-and-commissioning-issues-classes.html#Current

They will be there until the next class, at which time they will be relocated down the page.

About using my spreadsheets and other resources:

- They are my tools vs. tools I developed to be used by others
- Use at your own risk; I provide them as a resource for you to use as a starting point
- You still need to understand how it works and fix it if it doesn’t work for you

Get Connected with My Poll Everywhere

Via text messaging

Step 1

Text DAVIDSELLERS022 to 22333 (the hyphen gets inserted automatically on some phones)

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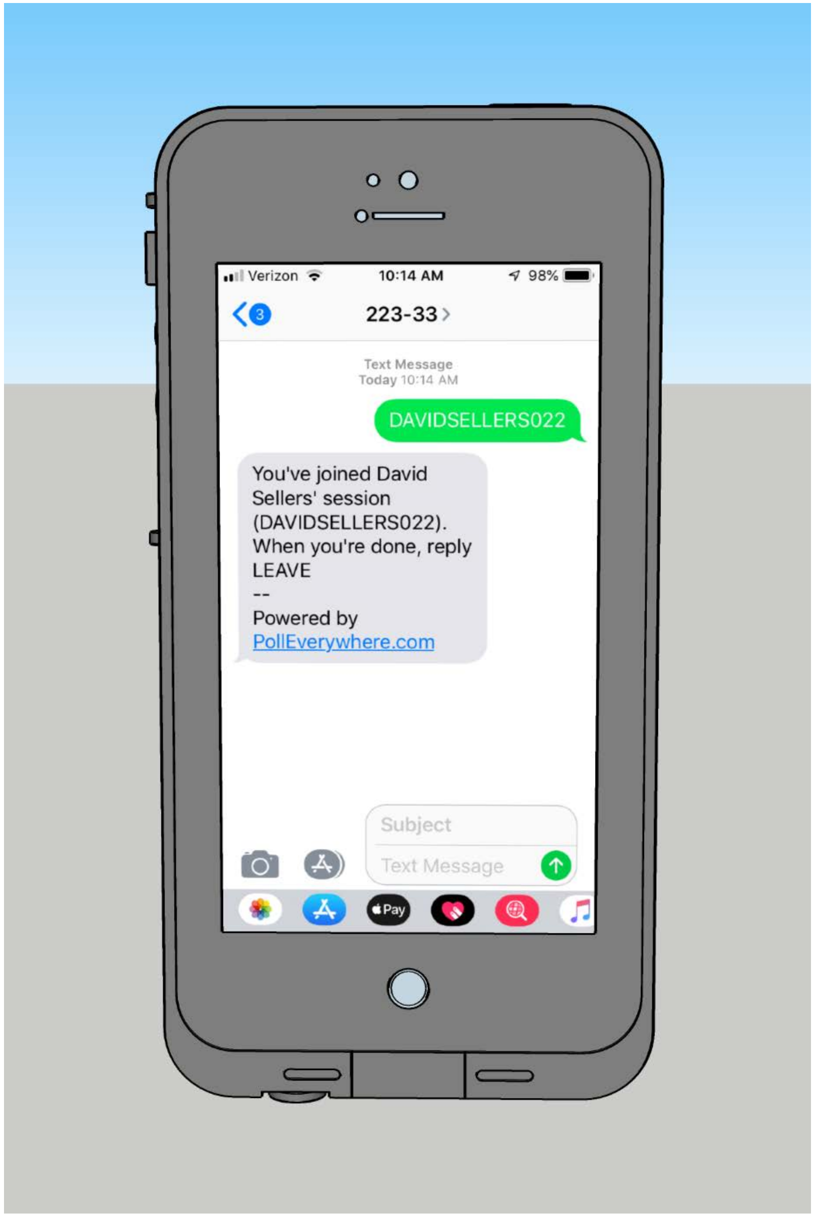
Via text messaging

Step 2

Receive confirmation that you have joined the session



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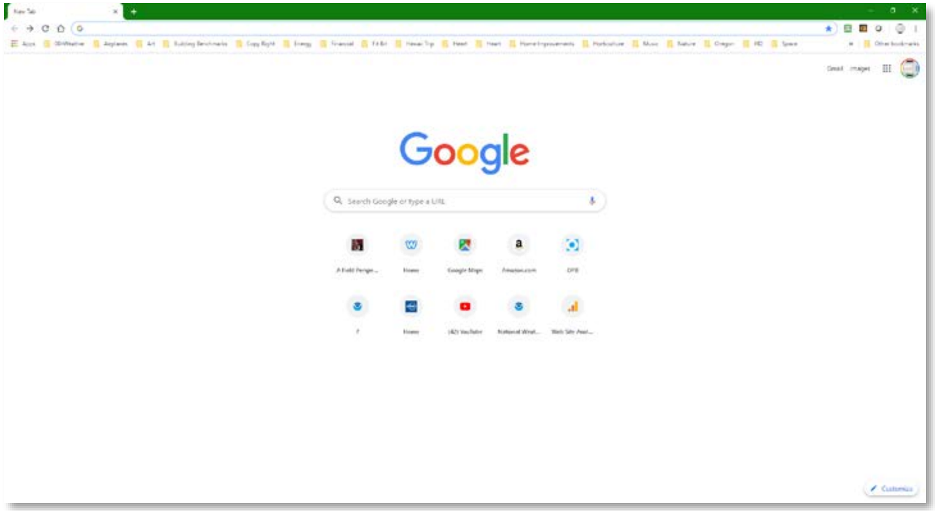

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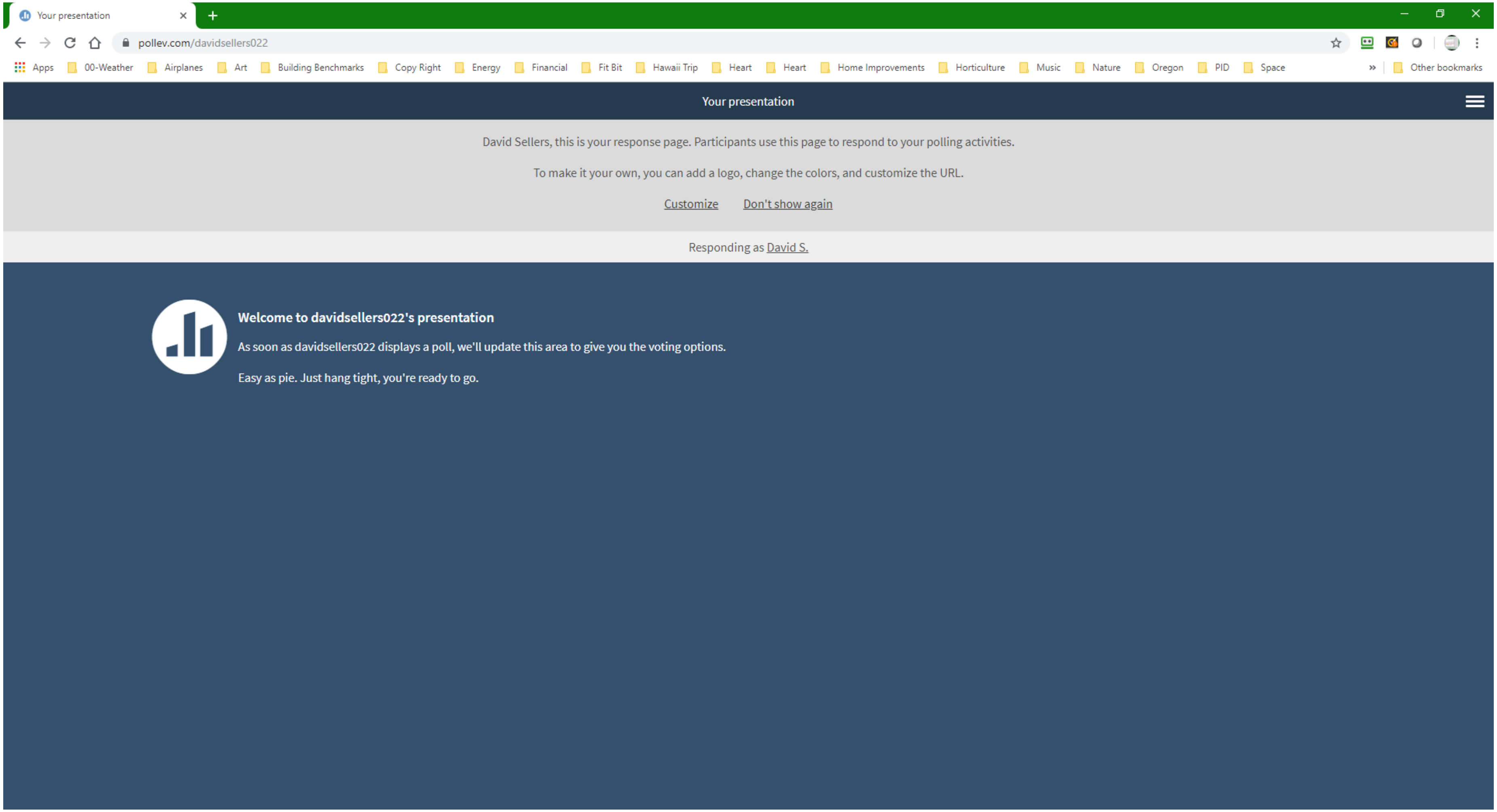

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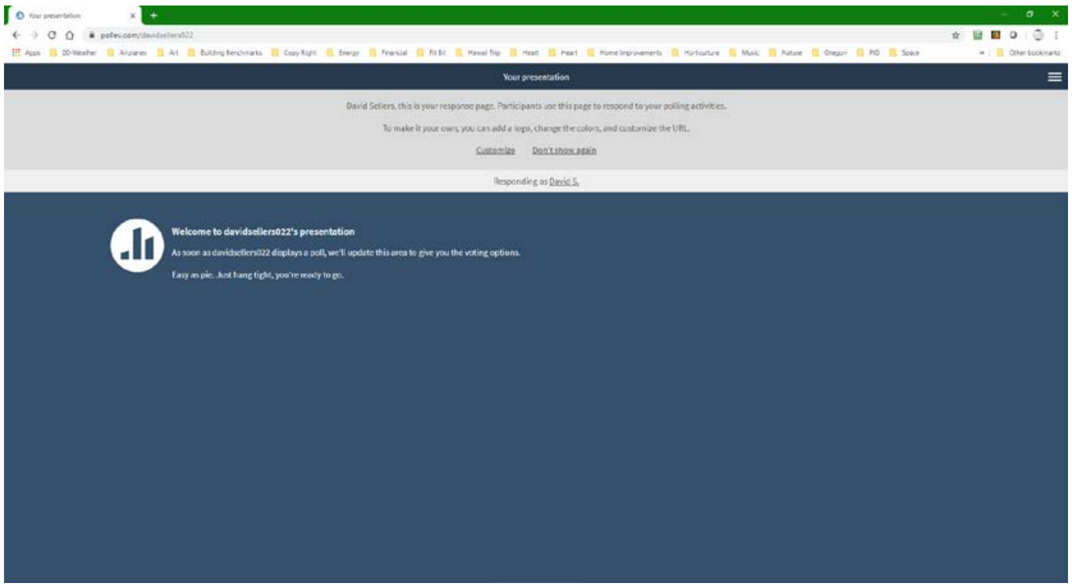

Via web browser or text messaging

Step 3

Wait for a poll question to come up

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Learning Objectives

After completing this course you should be able to:

1. Identify common components in a typical air handling system
2. Recognize the interactive nature of the various components in an air handling process with each other and the utility systems serving the process
3. Understand how to apply common HVAC relationships to evaluate typical air handling system energy and power metrics
4. Learn how to use a psychrometric chart and psychrometric principles to analyze an air handling process.
5. Learn to identify common performance and resource utilization opportunities for air handling systems including economizer evaluation techniques and best life cycle cost-based filter operation strategies

Agenda

1. Introduction
2. Key Fundamental Concepts
   a) Fans
   b) Ducts and Distribution
   c) HVAC processes
3. Exploring a Typical AHU
   a) Schematically
   b) SketchUp Model
4. Applying a Psych Chart
5. Scoping an Air Handling System

How many folks spent some time with the items in the pre-class preparation materials? Select all of the answer(s) that apply to you.

There were pre-class preparation materials? This is news to me!

Watched the "What are HVAC Loads and Processes?" RCxU video or was already familiar with the concepts.

Watched the "HVAC Fundamentals: Air Side Systems?" RCxU video or was already familiar with the concepts.

Watched the "Introduction to System Diagrams Part 1 and 2?" videos or was already familiar with the concepts.

Read the "A Free Electronic Psych Chart and How to Use It to Plot Basic HVAC Processes" blog post.

Read the "Retrocommissioning Findings: Scoping a Dental Clinic VAV Reheat System–Part 1" blog post.

SketchUp and Electronic Psych Chart

How many people downloaded SketchUp and plan to work along with me during the interactive exercises vs. just watching me navigate through the model and responding to my questions?

How many people downloaded the free electronic psych chart and are planning to use it to work with me in the interactive exercises vs. just watching me use it and responding to my questions?

Are there any questions you would like to address that came up during your self study effort?

In a few words, what to you hope to gain by attending this class?

Start the presentation to see live content. For screen share software, share the entire screen. Get help at **pollev.com/app**

Are there any specific air handling system related topics you want to have covered in this class?

Start the presentation to see live content. For screen share software, share the entire screen. Get help at **pollev.com/app**

Why a Class on Air Handling Equipment?

Just about every building has at least one fan

Air handling can account for 30-40% of a buildings energy consumption

PIER* research indicates significant fan energy savings potential by simply applying best practices

- 10 – 15% in for small commercial buildings
- $0.12 per square foot for large commercial buildings

**Public Interest Efficiency Research*

How Fans Use Power and Energy

$$bhp = \left(\frac{Flow \times Static}{6{,}356 \times \eta_{Fan}} \right)$$

Where :

bhp = Brake horse power into the fan drive shaft

$Flow$ = Flow rate in cubic feet per minute

$Static$ = Fan static in inches water column

$6{,}356$ = A units conversion constant

η_{Fan} = Fan efficiency

Calculating Power Into the Motor

$$kW = \left(\frac{Flow_{cfm} \times Static_{in.w.c.}}{6{,}356 \times \eta_{Fan} \times \eta_{Belts} \times \eta_{Motor} \times \eta_{VSD}} \right) \times .746$$

Where:

kW = Input to the system to produce the flow and static pressure.

Flow = Flow rate in cubic feet per minute. Generally speaking, we try to use a field measurement for this. If that is not available we will use a value from a tab report. Lacking that we will use a design metric from the original drawings or an equipment submittal.

Static = The fan static pressure in inches water column. Since fan static as defined by AMCA is difficult to measure in the field, we usually try to derive this number from the fan curve using two other feild measurements like flow and fan speed or flow and power. Lacking those measurements we will use a value derived from a TAB report or the design value.

6,356 = A units conversion constant that is good for air at approximately 0 - 2,000 $feet_{msl}$ and between -40°F and 120°F.

η_{Fan} = Fan static efficiency. We usually try to get this number from the fan curve or from the fan's rated brake horse power (bhp), flow and static. Lacking that, we will make a geometrically similar fan selection (same flow rate, static, wheel diameter, wheel type, and speed) using manufacturer's software and use that efficiency.

η_{Motor} = Motor efficiency. We usually try to get the motor performance curve and select the efficiency from the curve for the bhp that the fan wheel is extracting from it. If we can't get the motor curve, we use a similar motor selected from MotorMaster^{TM} International. In all cases we adjust the efficiency for the motor operating point vs. using the motor's rated nameplate efficiency.

η_{VSD} = Variable speed drive efficiency. Where possible, we try to get the manufacturer's data for this. But this data is difficult to obtain and not consistent in its development. Lacking manufacture specific data, we use generic data as published by the Department of Energy on their Industrial Best Practices web site.

.746 = Horsepower to kW conversion constant.

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$.746$ = Horsepower to kW conversion constant.

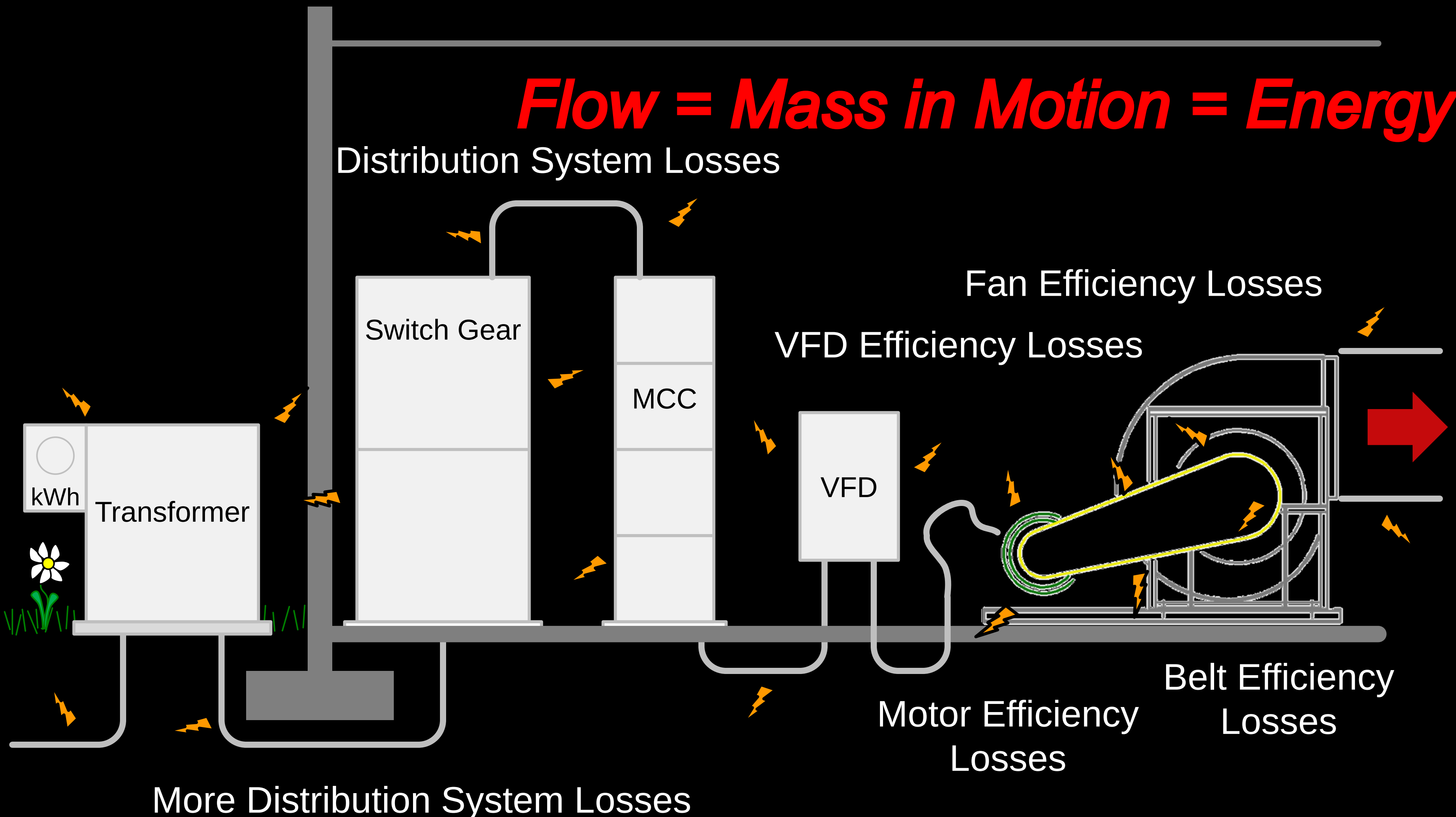
Energy = Power Applied Over Time

1 horsepower used for one hour = 1 horsepower-hour

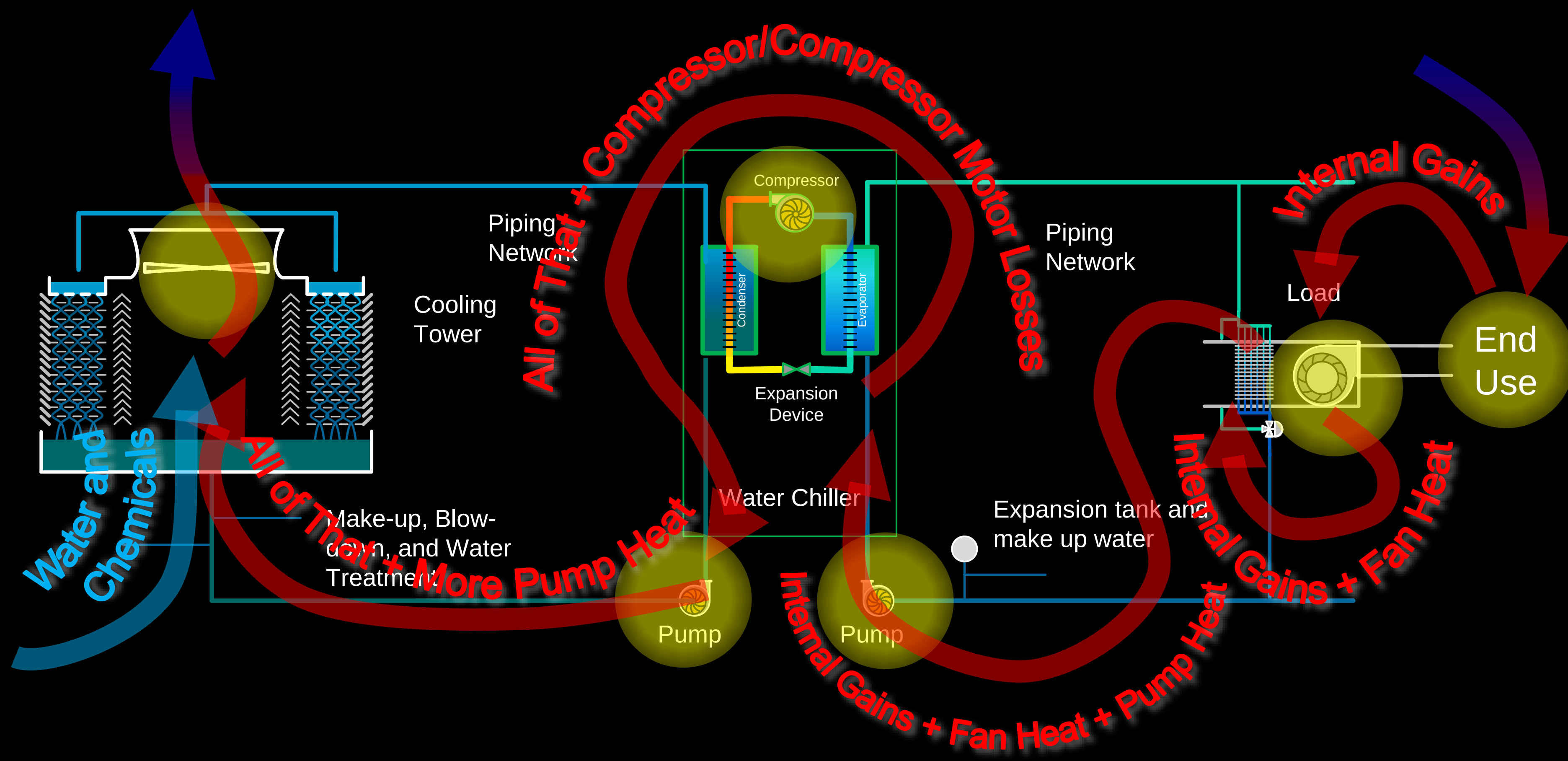
1 kilowatt used for one hour = one kilowatt-hour

1 kW used for 1 h = 1 kWh

A Bigger Perspective on Delivering Mass in Motion



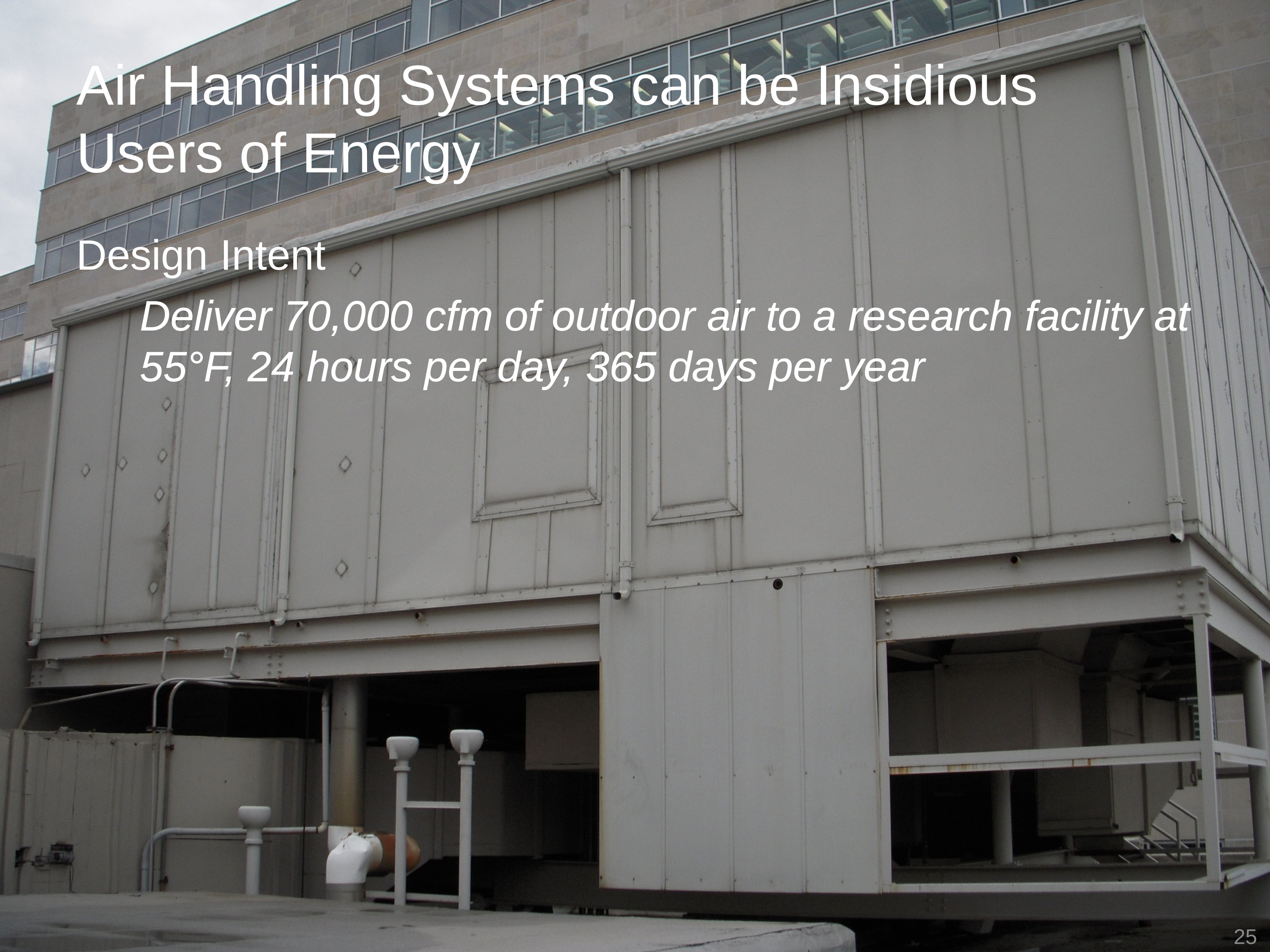
A Bigger Perspective on Delivering Mass in Motion



Fans;

Only One of Many Terms in the Air Handling Resource Consumption Equation

Air Handling Systems can be Insidious Users of Energy

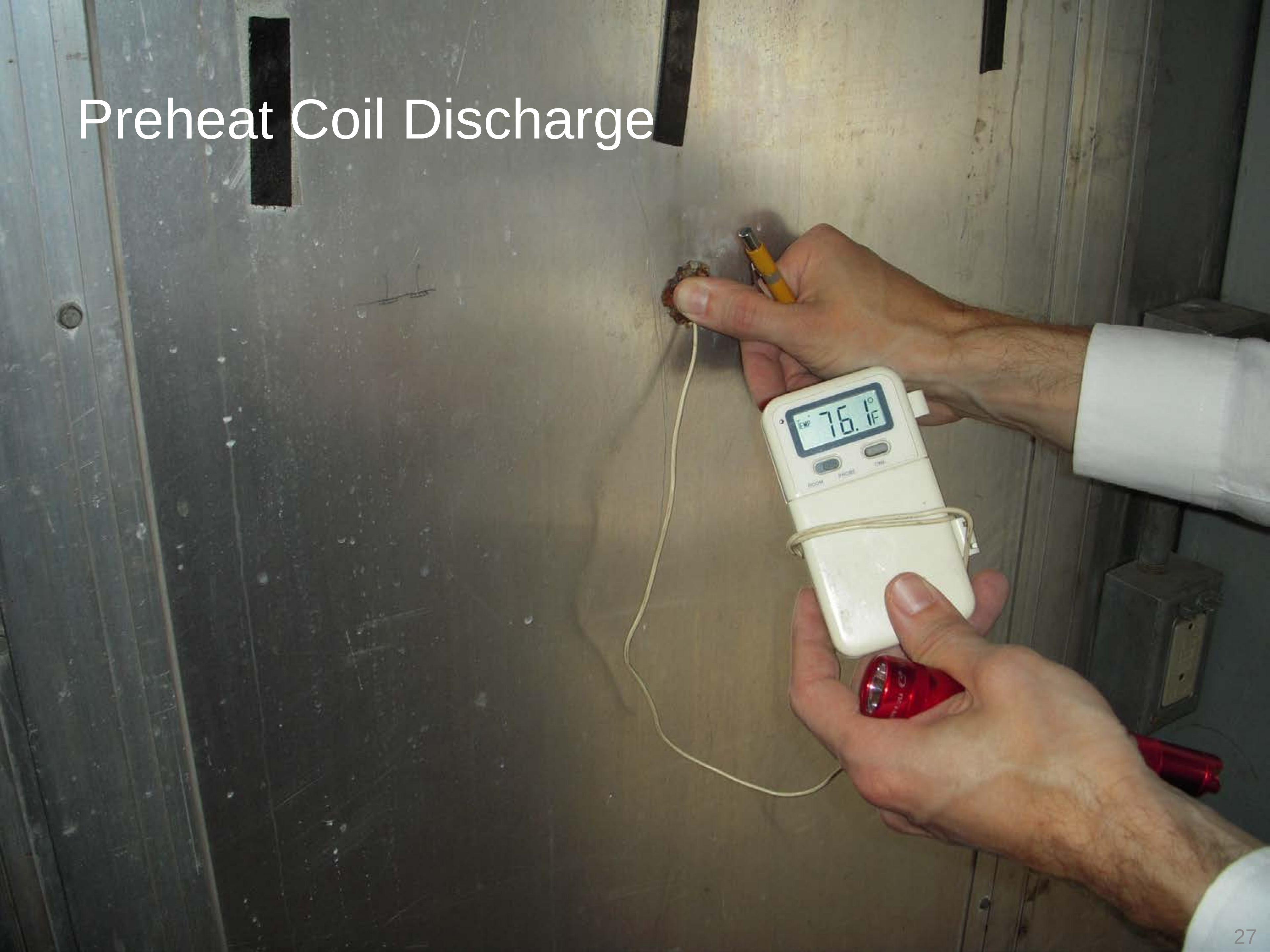


Design Intent

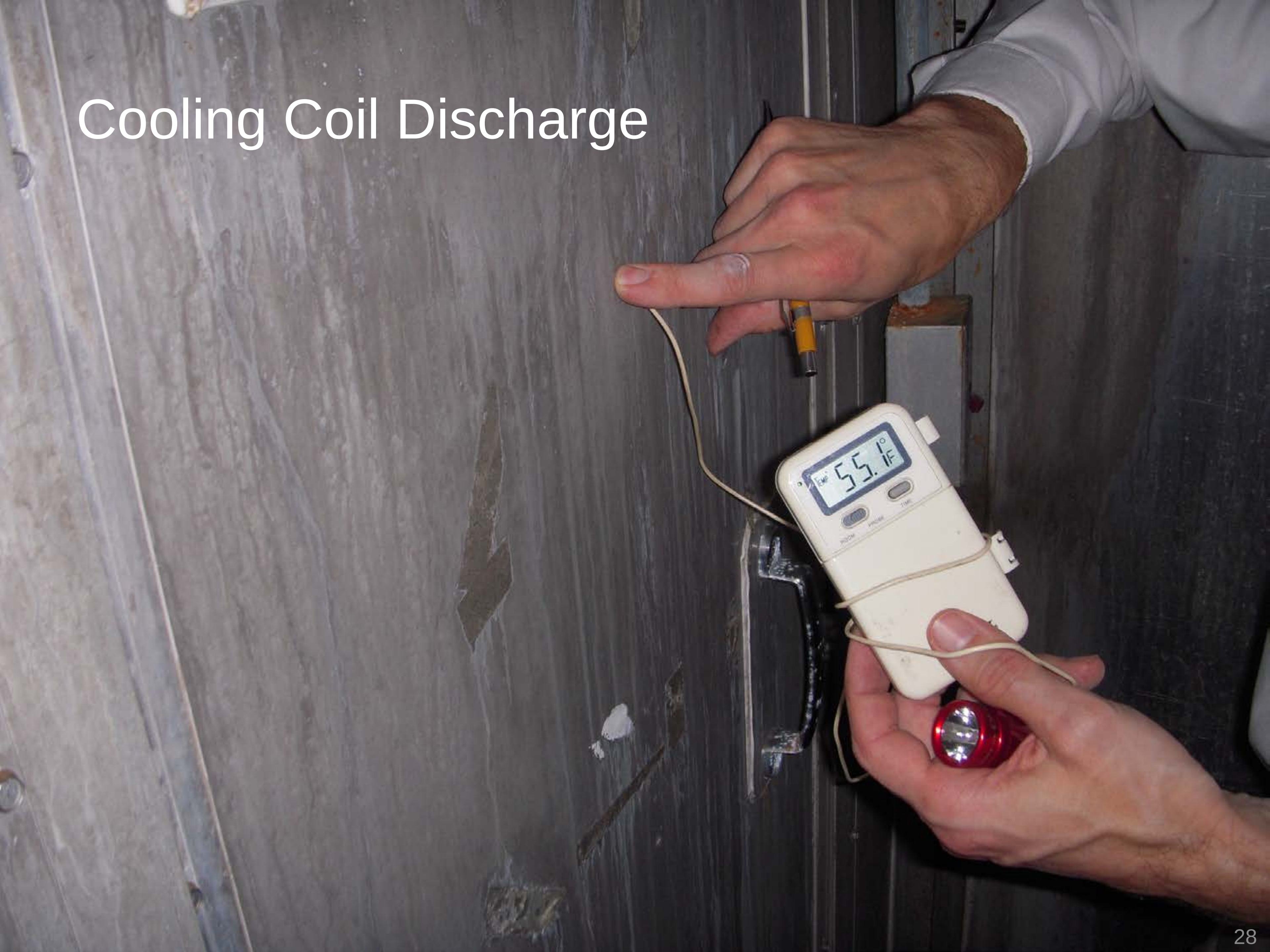
Deliver 70,000 cfm of outdoor air to a research facility at 55°F, 24 hours per day, 365 days per year

Temperature at Outdoor Air Intake

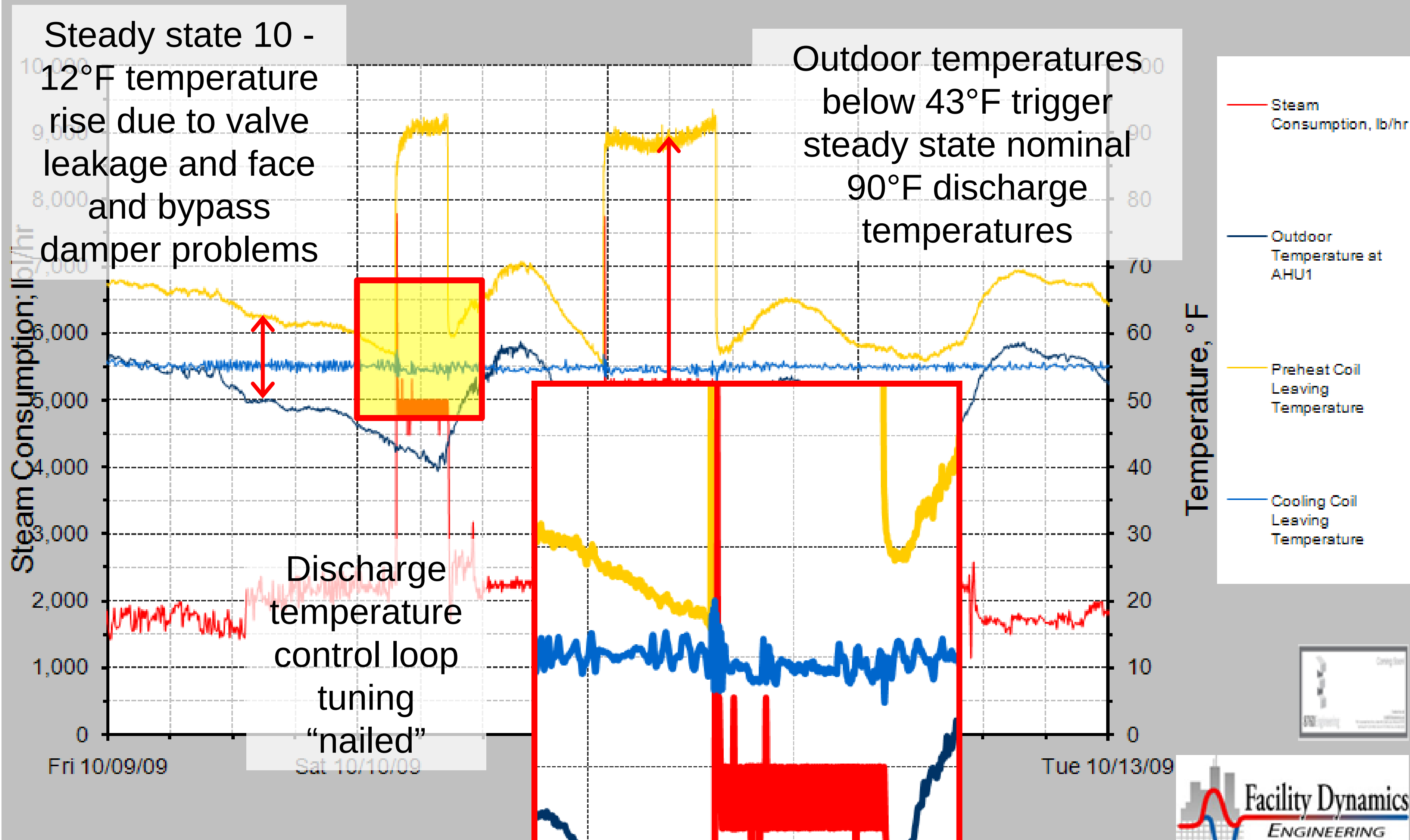
Preheat Coil Discharge



Cooling Coil Discharge



Steam Load from Condensate Pump Operation



Facility Dynamics Engineering

Meanwhile, the Research Environment is Just Fine

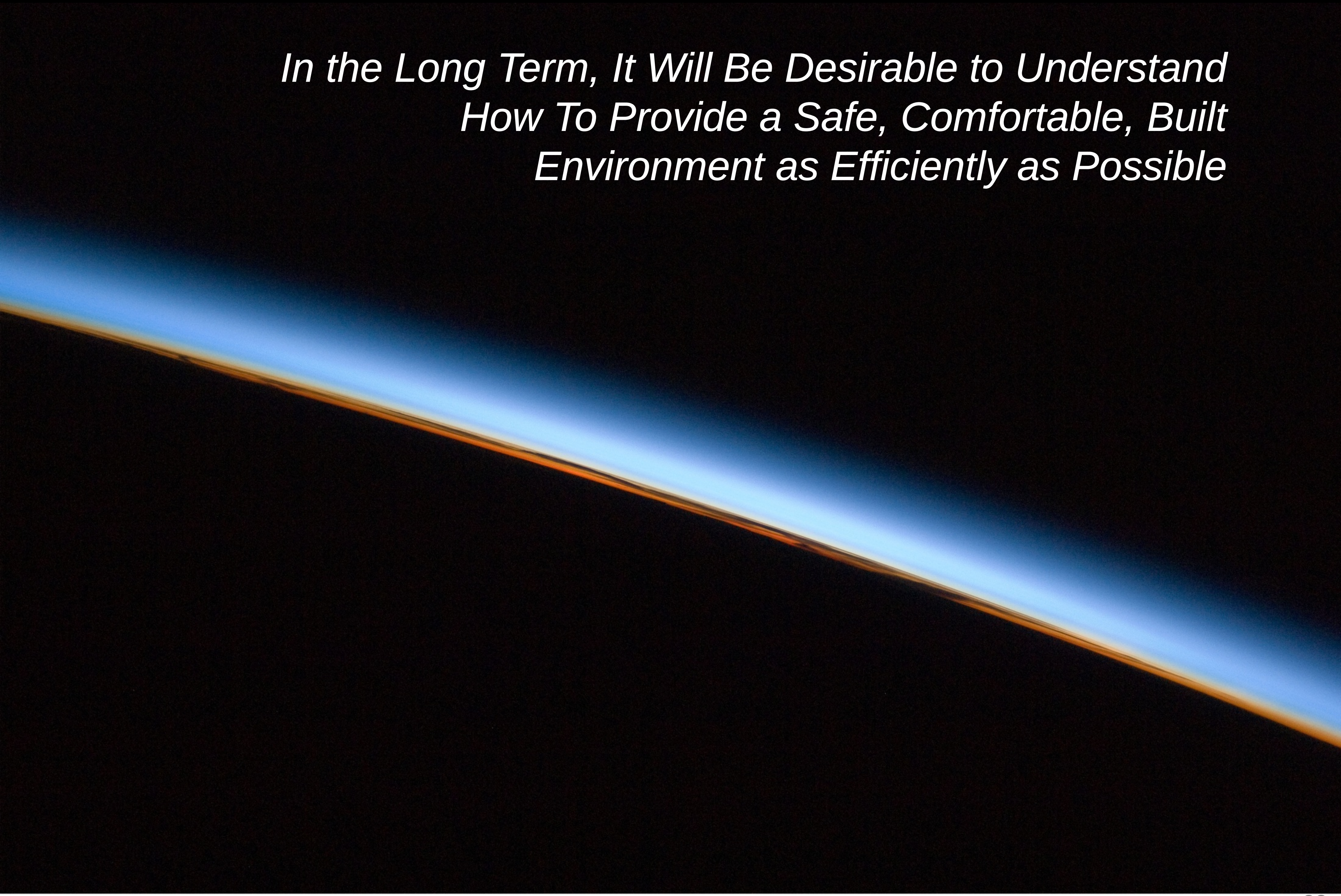
Energy is Not the Only Resource Consumed by Air Handling Equipment

There could easily be at least one 24" x 24" filter for every 2,000 – 4,000 square feet of building space

CBECS 1999 data says there is about 58,800,000,000 square feet of commercial building space

Of Course, There's a Reason for Doing This

In the Long Term, It Will Be Desirable to Understand How To Provide a Safe, Comfortable, Built Environment as Efficiently as Possible



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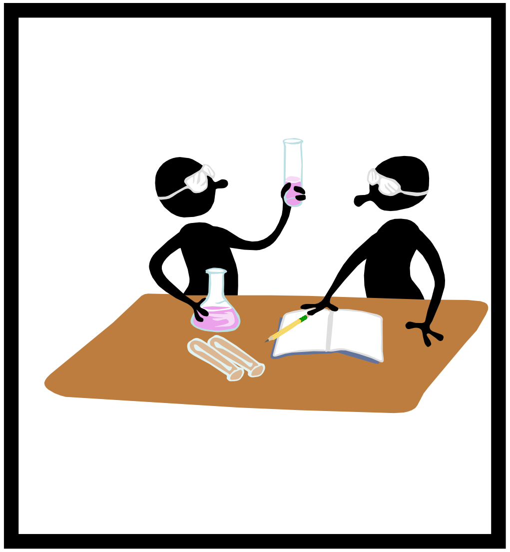
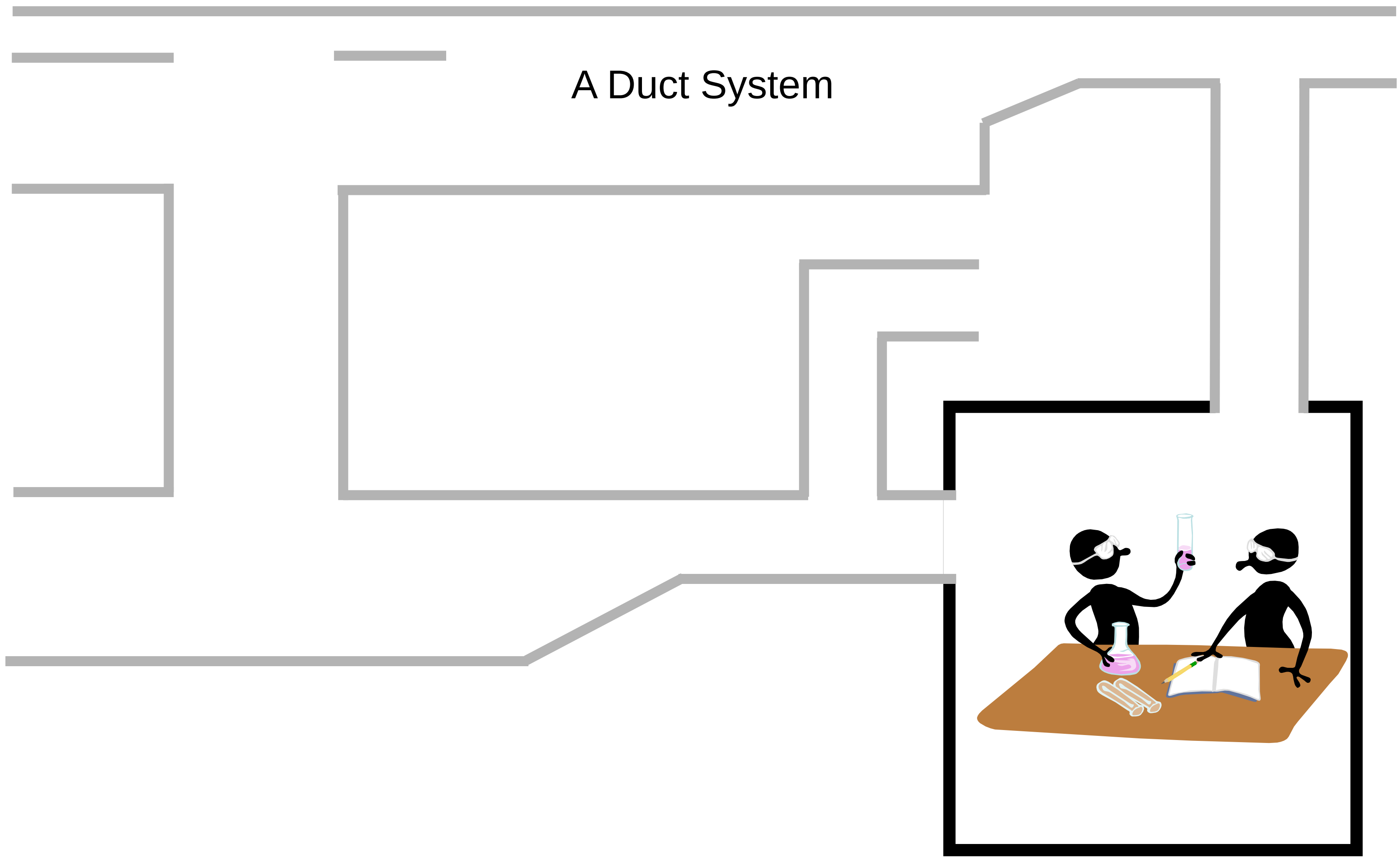
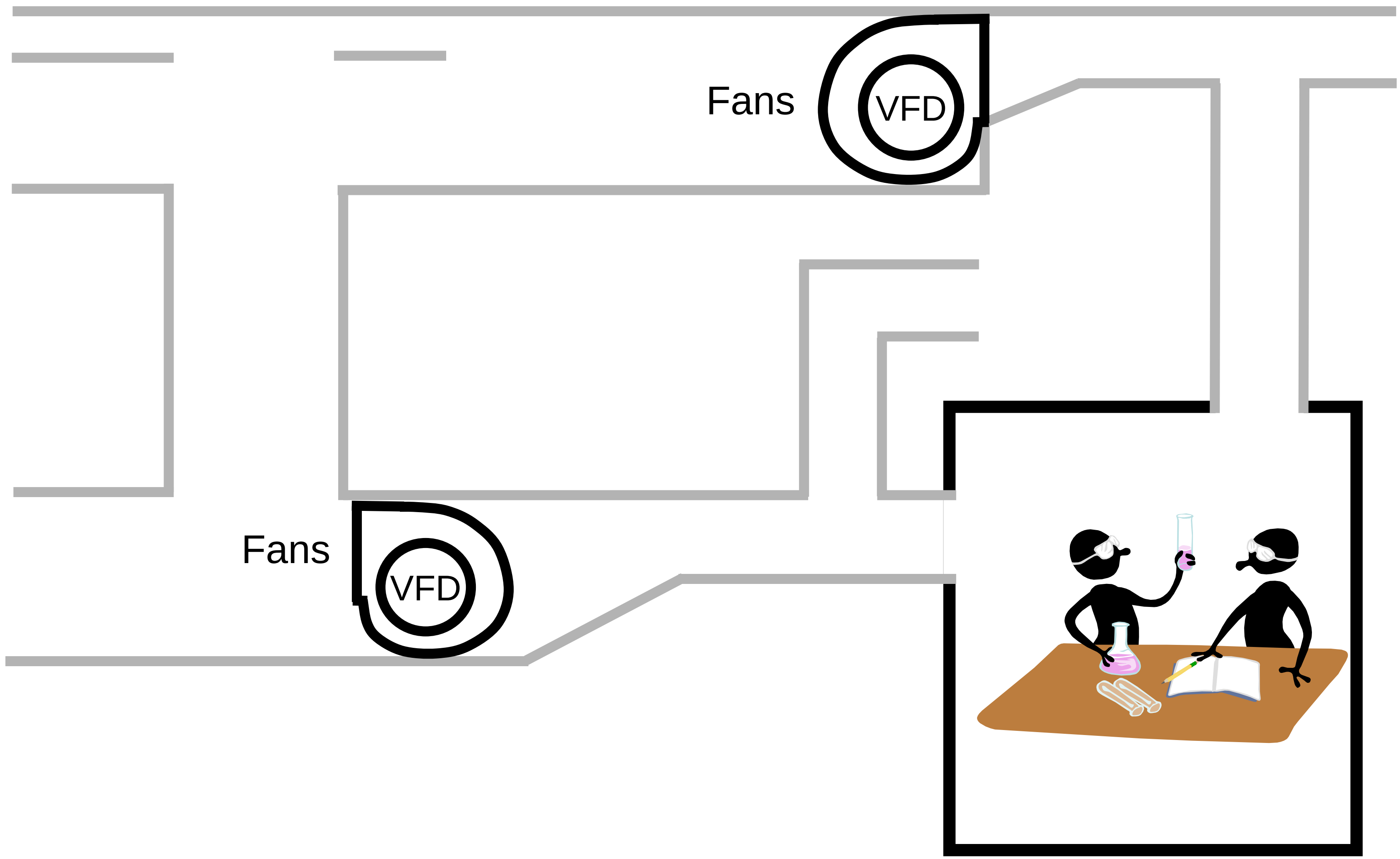
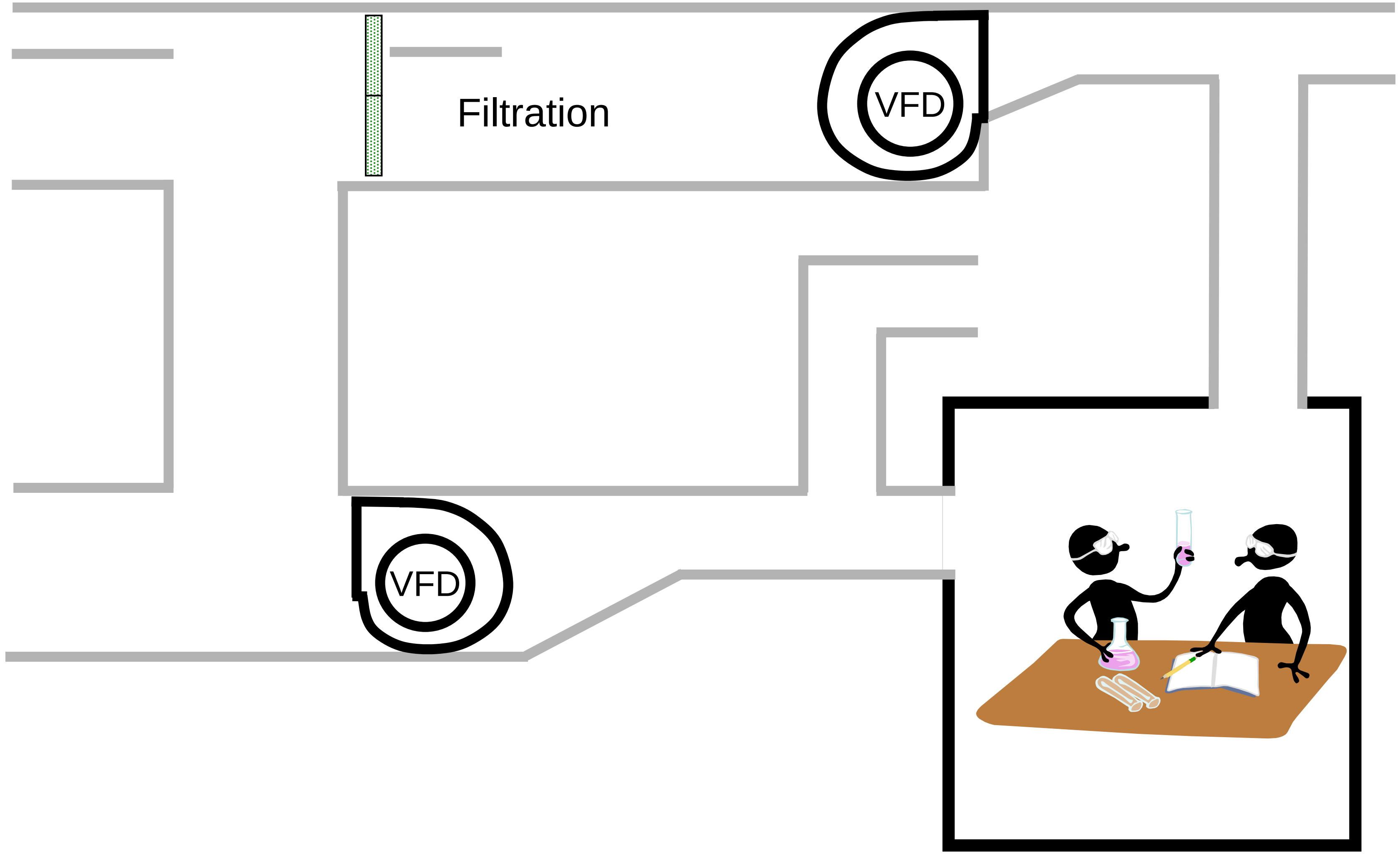
A Load to Serve for Starters



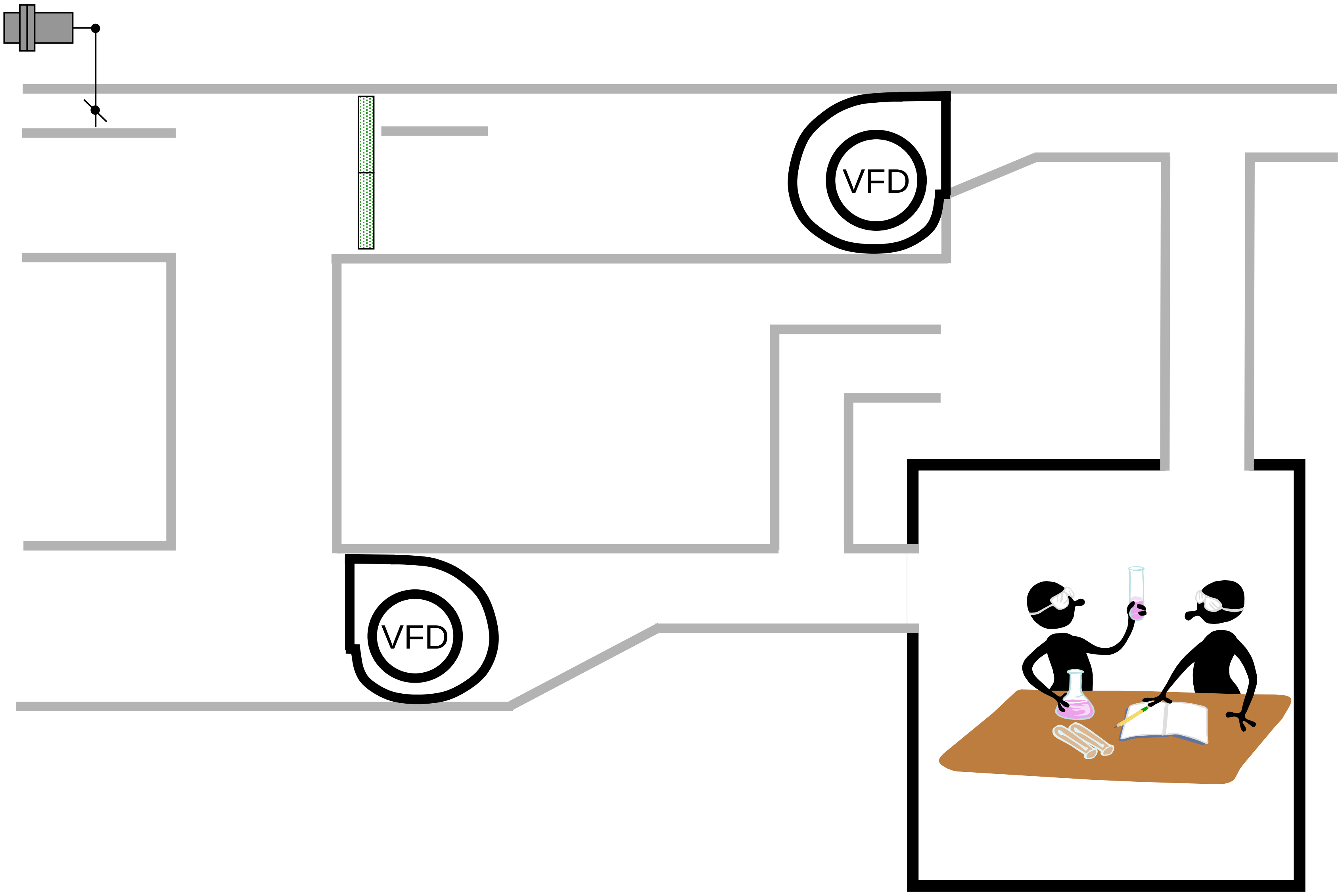
A Duct System

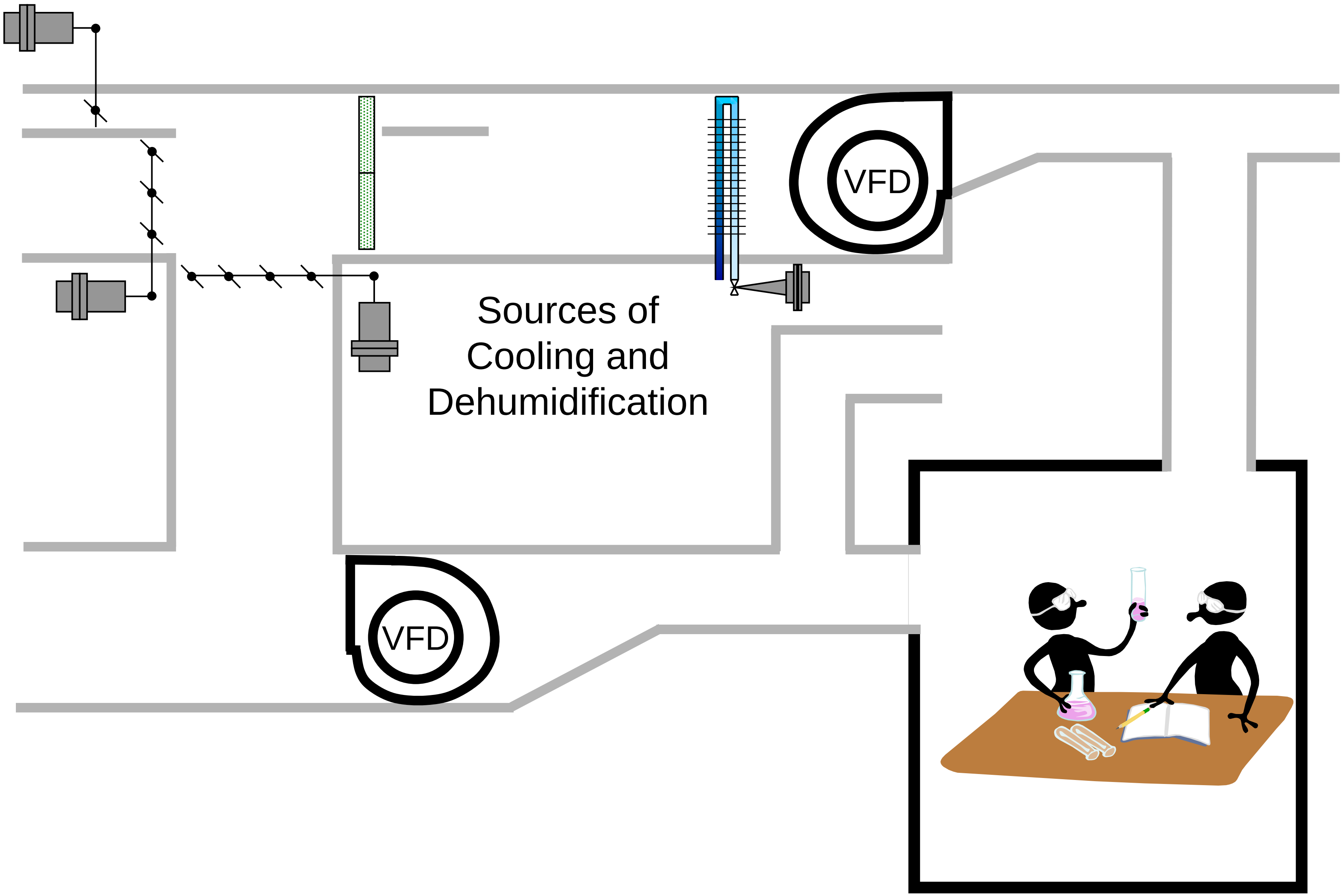


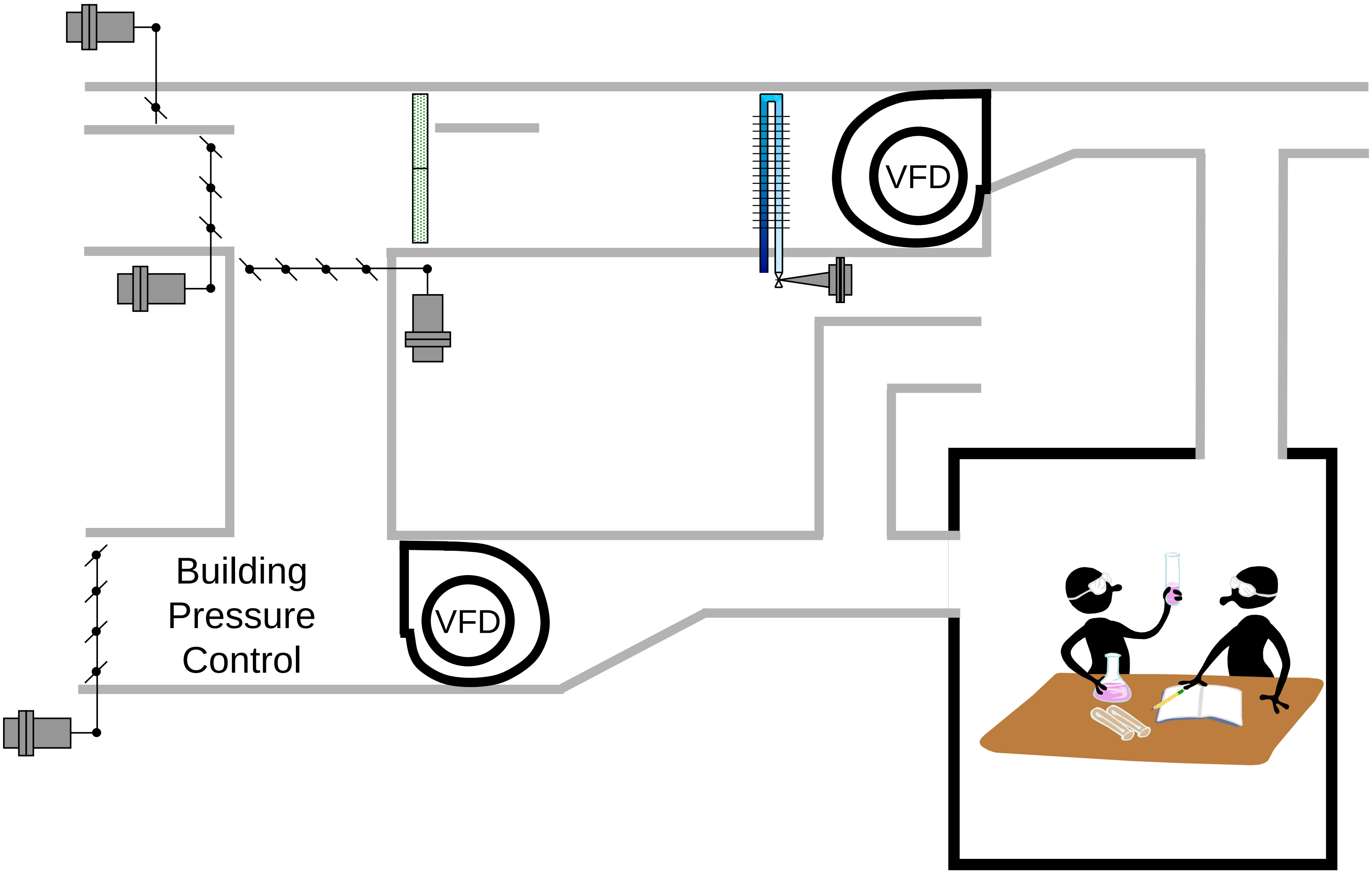

Fans
VFD
Fans
VFD

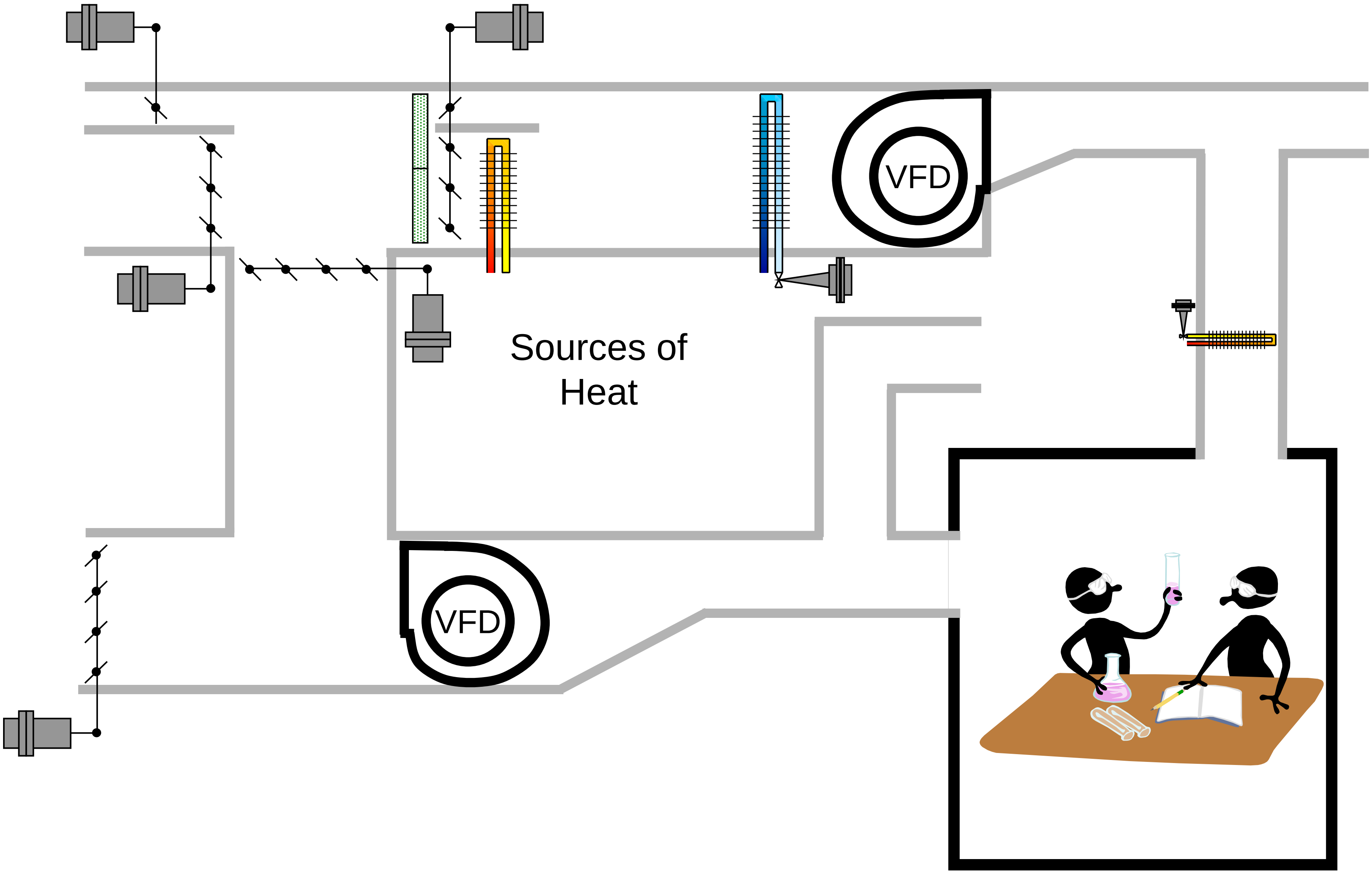

Filtration
VFD
VFD

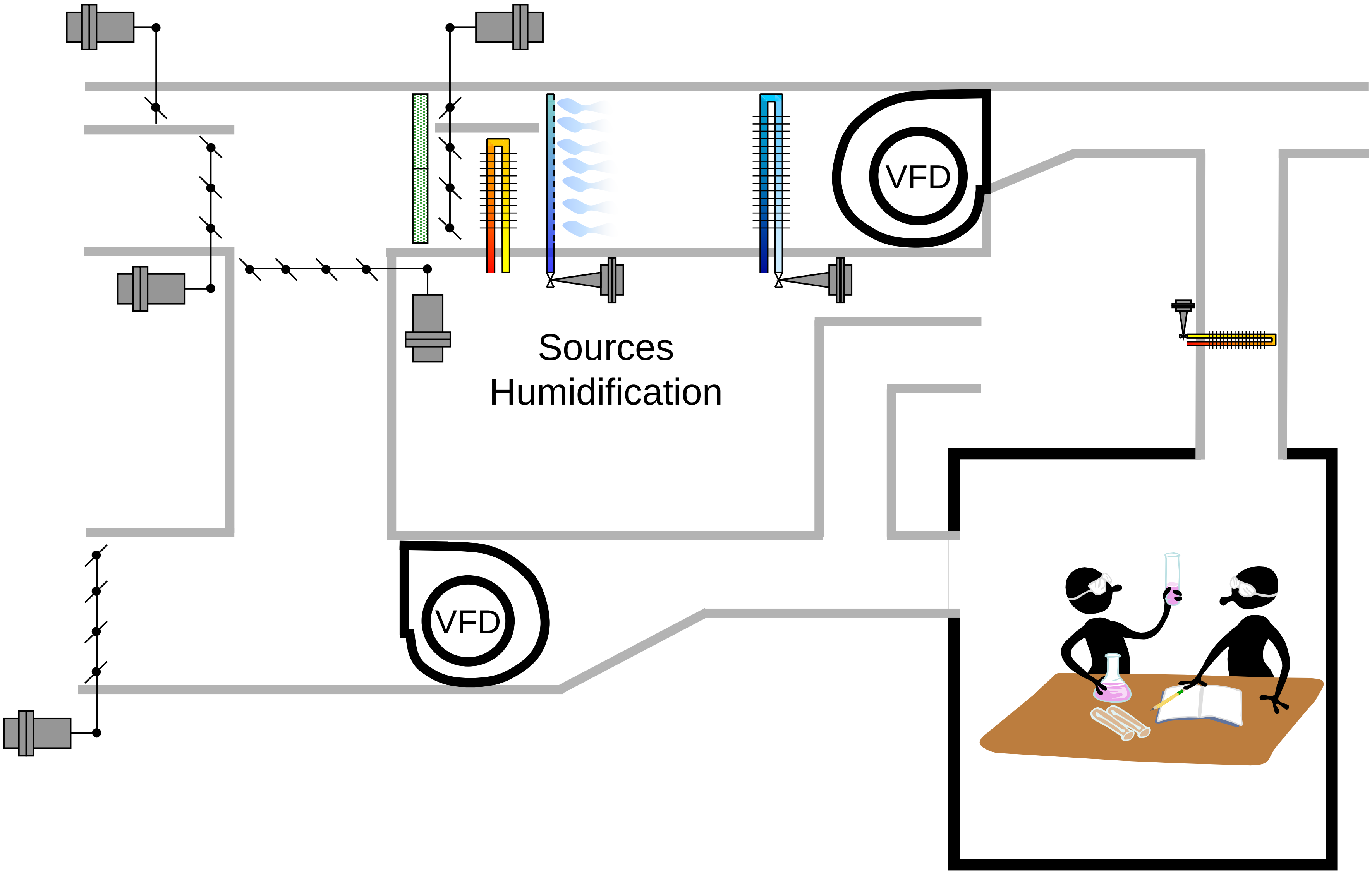
Ventilation

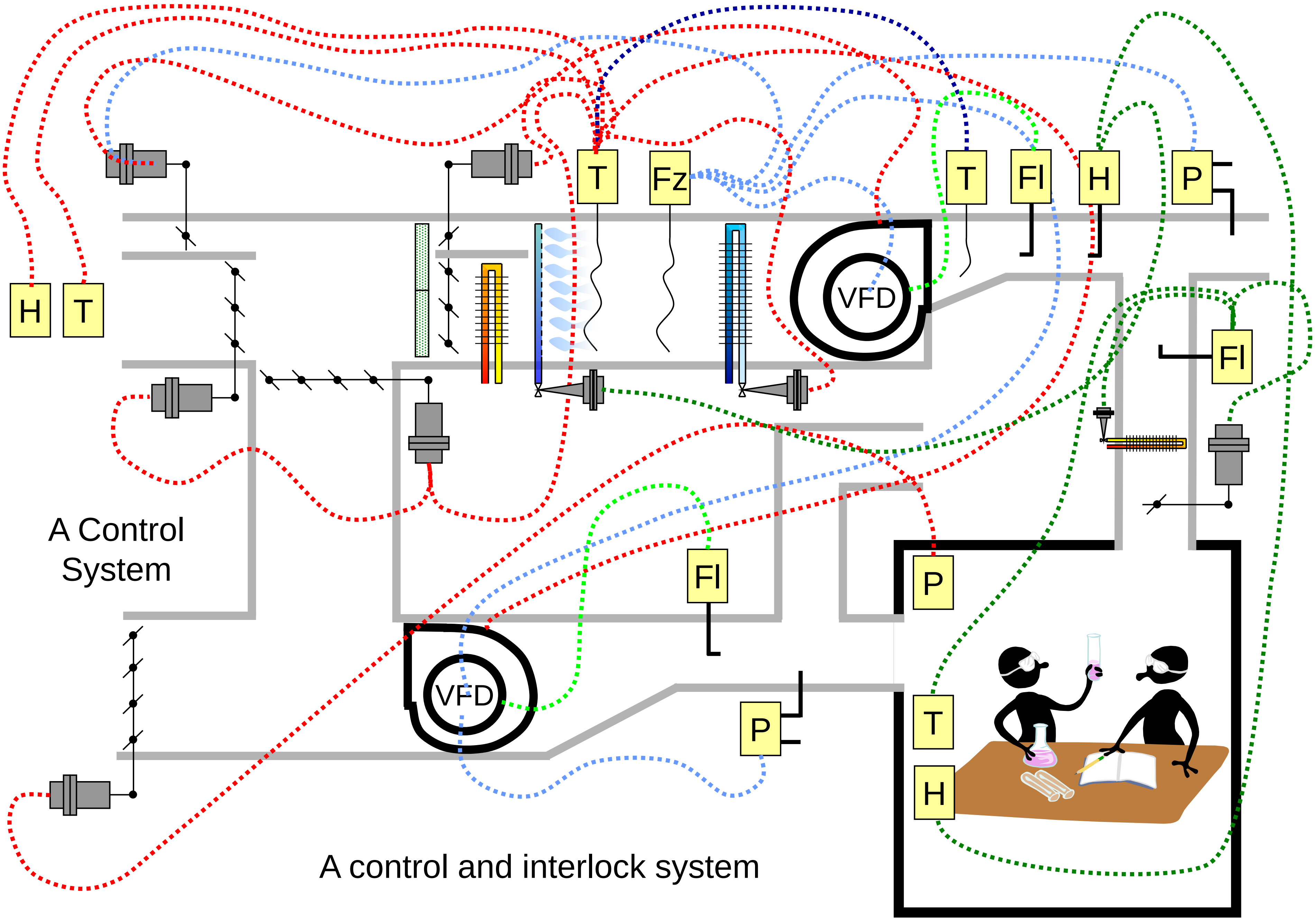



VFD
Sources of
Cooling and
Dehumidification
VFD


VFD
Building
Pressure
Control
VFD


VFD
Sources of Heat
VFD


VFD
Sources
Humidification
VFD



A control and interlock system

Another Important Relationship

$$N_{Config_{Sys}} = \left[\left(\sum_{All} HVAC\ Engineers \right)^2 \times K_{Climate} \times K_{BuildingType} \right] + \frac{\partial Y_{Earth-Moon}}{\partial Z_{Sun-Saturn}}$$

Where :

$N_{Config_{Sys}}$ = The number of potential HVAC system configurations

Another Important Relationship

$$N_{Config_{Sys}} = \left[\left(\sum_{All} HVAC\ Engineers \right)^2 \times K_{Climate} \times K_{BuildingType} \right] + \frac{\partial Y_{Earth-Moon}}{\partial Z_{Sun-Saturn}}$$

Where :

$N_{Config_{Sys}}$ = The number of potential HVAC system configurations

$\sum_{All} HVAC\ Engineers$ = The number of HVAC engineers

$K_{Climate}$ = Climate coefficient; adjusts for the climate type at the system location

$K_{BuildingType}$ = Building type coefficient; adjusts for the building type that the system serves

$\frac{\partial Y_{Earth-Moon}}{\partial Z_{Sun-Saturn}}$ = Planetary alignment compensation factor

A Few of Many Common Air Handling System Configurations

Single Duct, Constant Volume, Single Zone

Single Duct, Constant Volume, Reheat

Single Duct, Constant Volume, Bypass VAV

Single Duct VAV and VAV with Reheat

Hybrid Constant and Variable Volume Systems

Constant Volume and Variable Volume Multizone

Texas Multizone

Three Deck Multizone

Dual Duct Constant Volume and Variable Volume

Dual Duct, Dual Conduit

Low Temperature Air

Natural Ventilation Cycle

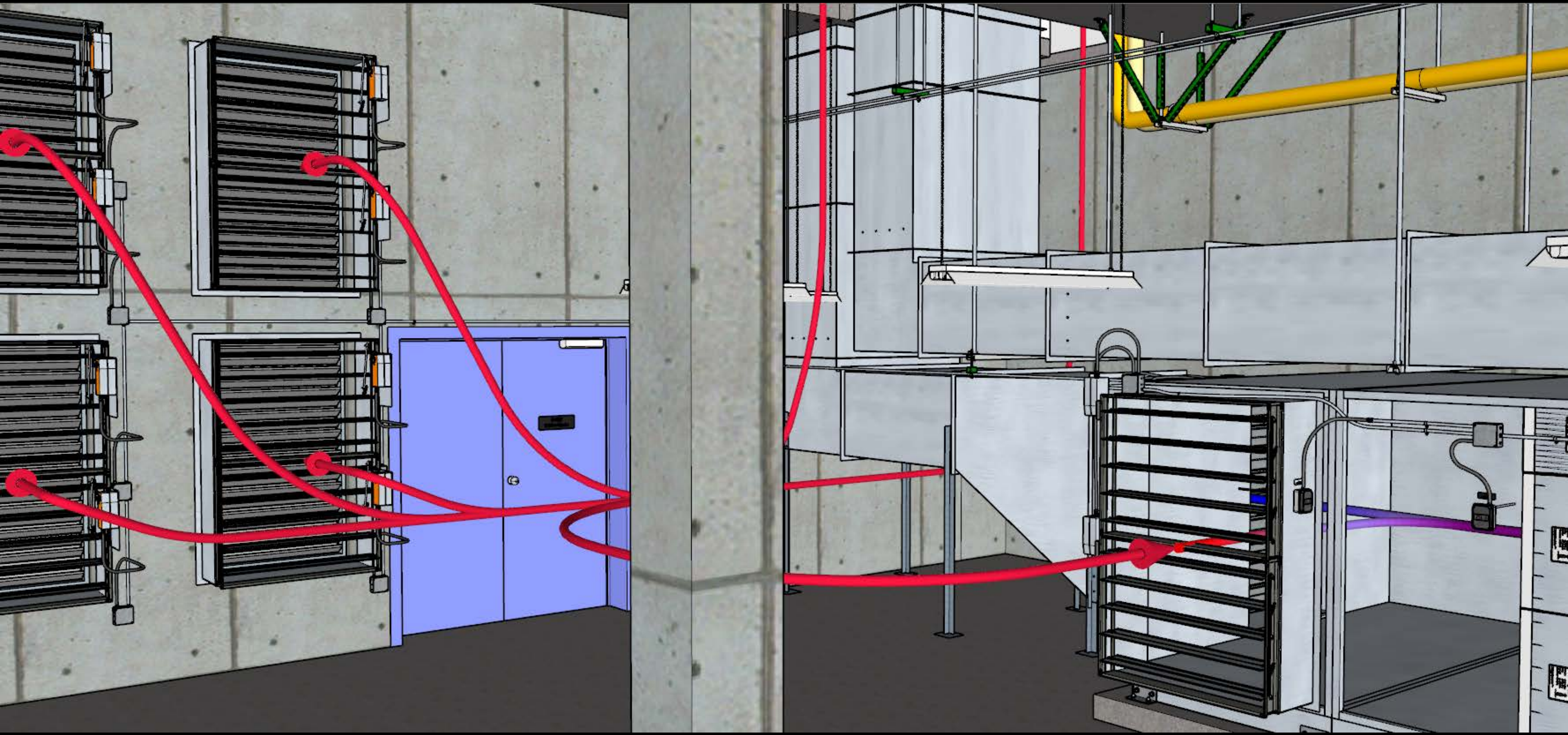
See the Control Design Guide for descriptions and standard point lists for these systems

www.peci.org/ftguide/csdg/CSDG.htm

Let’s Consider a Typical AHU Load

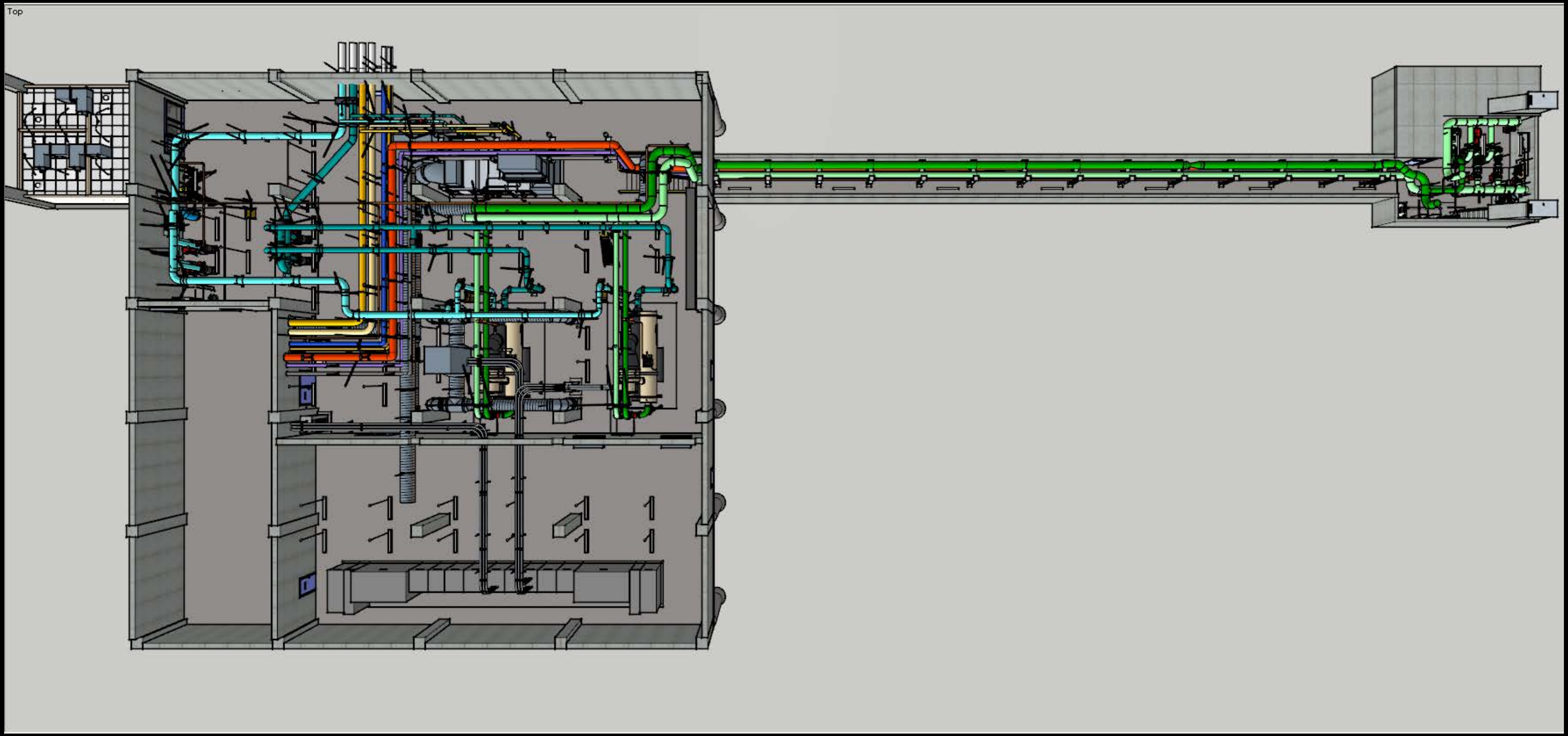
Discussion

Let's Trace the Path of Air and Energy Through an Air Handling System



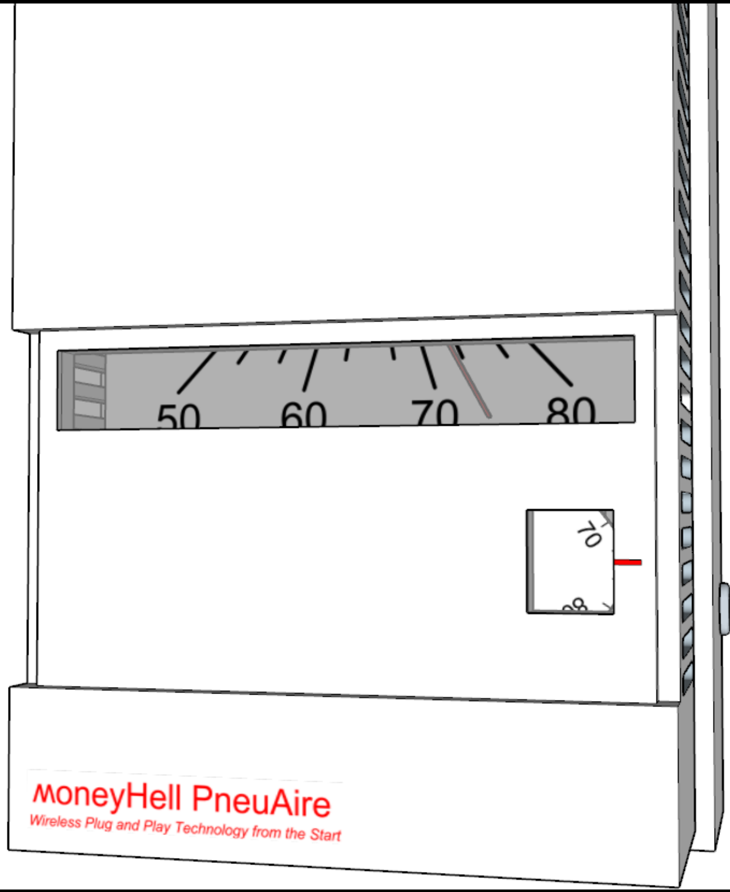
Discussion

Let's Follow the Energy All the Way Back to the Central Plant



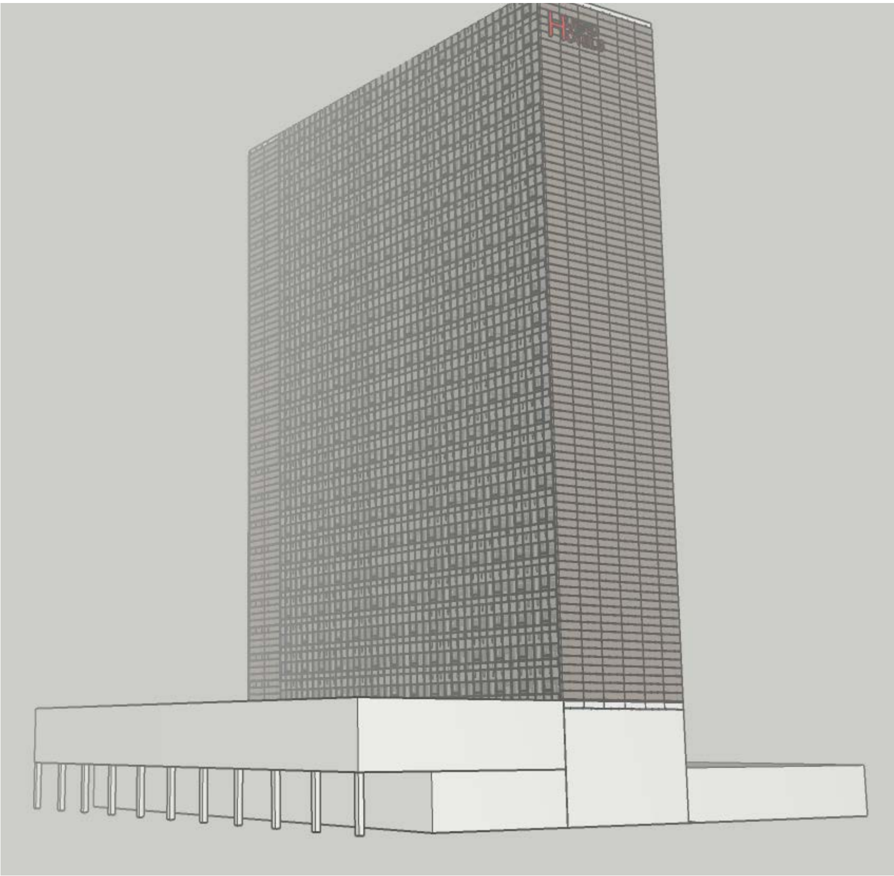
Discussion

Let's See if we can Figure Out the Conditions in the Ball Room from the Clues



Current Conditions

- Foggy
- Furnace running at home when you left
- Low 50’s °F through early afternoon, then clearing and sunny with a high of 68-70°F anticipated
- Hotel at 84% occupancy
- Major conference happening
  - Main ball room in use
  - Meeting rooms and Junior Ball Room in use
  - Spaces under control at design target of 72°F/50% RH
  - Ballroom MOA settings recently verified at 25%

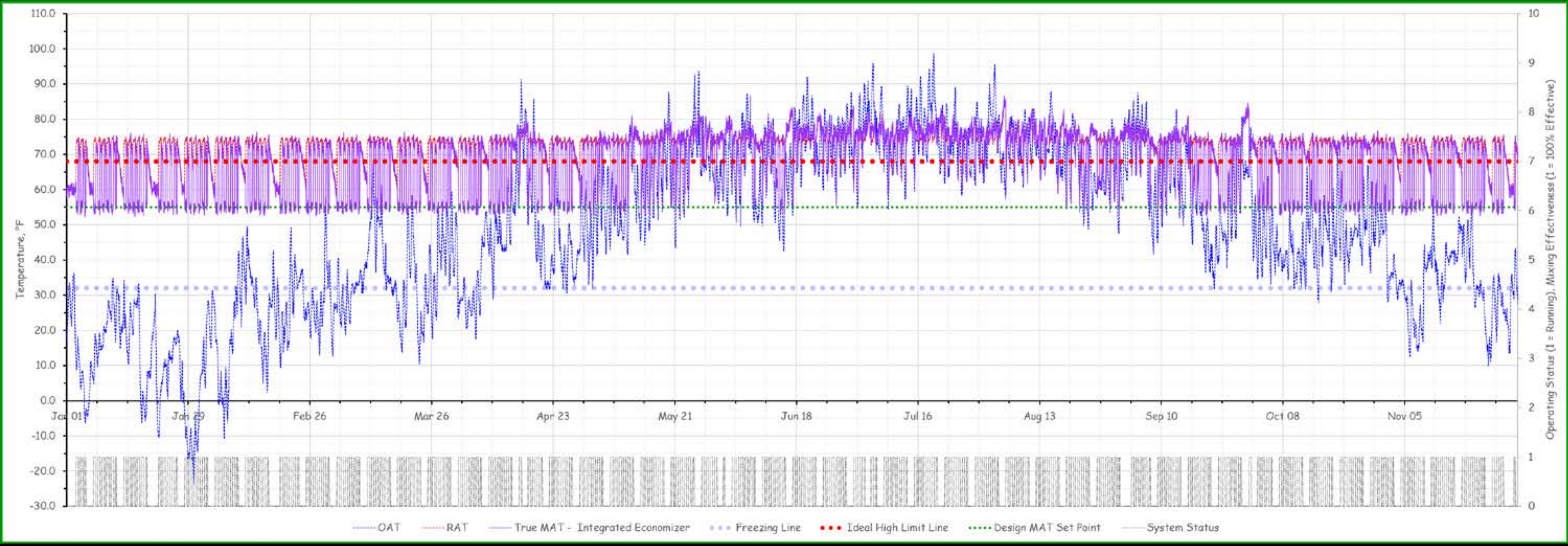


Discussion

Let’s Verify the Minimum Outdoor Air Percentage from the Available Information

Discussion

Let’s Discuss the Perfect Economizer



Discussion

Let’s Discuss Best Life Cycle Cost Filter Operation