

Economizers: Design, Performance, and Commissioning Issues

What Economizers Are and Why We Use Them



Instructor:

- David Sellers
- Senior Engineer
- Facility Dynamics Engineering
- February 7, 2017

Class Material Location

- The slides and other supporting information for the class can be found at:
 - <http://www.av8rdas.com/pacific-energy-center-classes1.html>
 - They will be there until the next class, at which time they will be relocated down the page under the class title.
- 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

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Learning Objectives

After completing this course you should be able to:

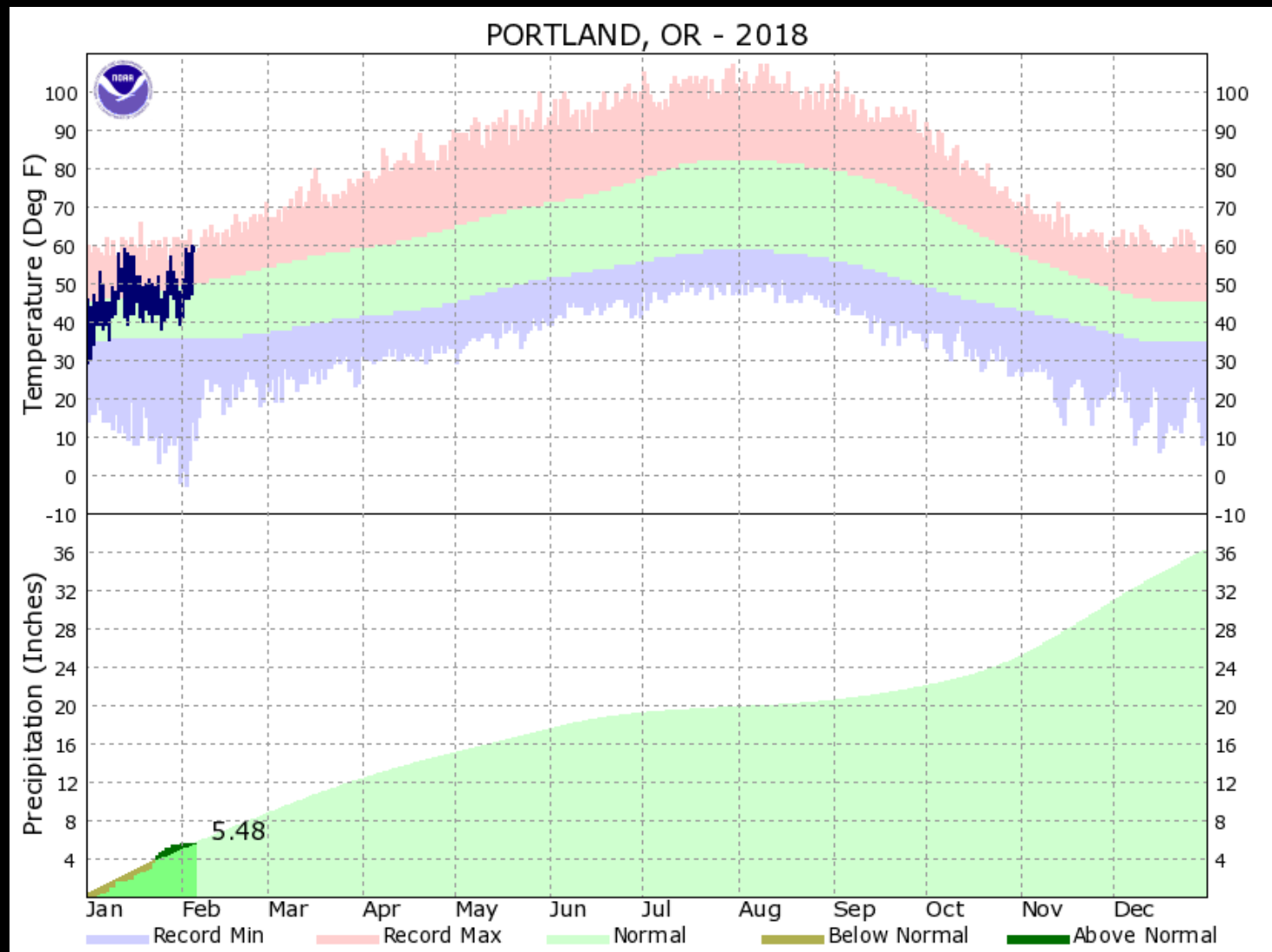
1. Identify an economizer process, both water side and air side
2. Understand the difference between an integrated and non-integrated economizer cycle
3. Recognize some of the design and operating challenges associated with applying an air side economizer
4. Be familiar with economizer field assessment techniques
5. Be familiar with critical economizer set points and control processes

What's In This Module?

- What is an economizer cycle and why do we use them
- Overview of the types of economizer processes
- Overview of the challenges associated with achieving a working economizer cycle
- The potential value economizer cycles can deliver
 - At the financial bottom line
 - At the sustainability bottom line

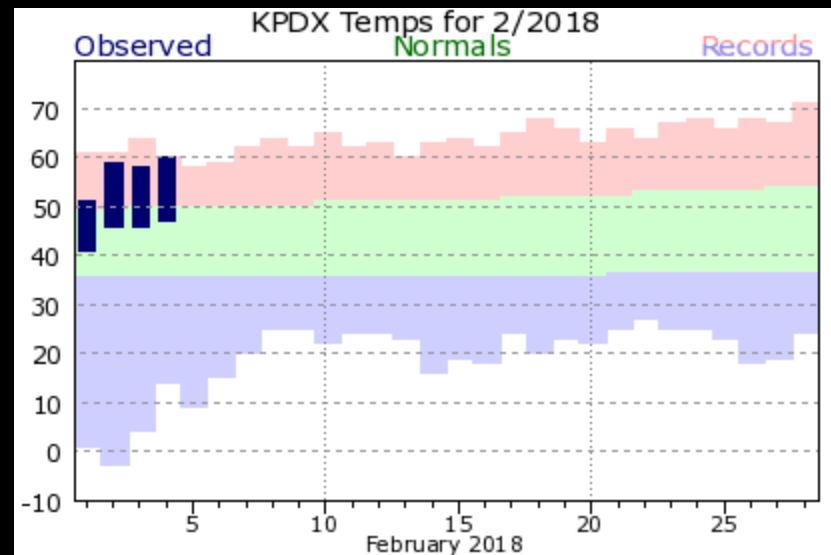
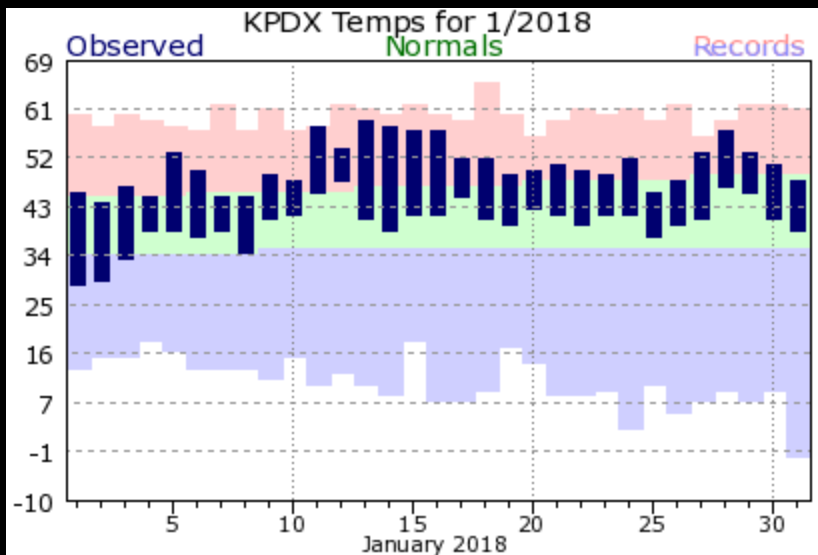
February 6, 2018

An Important Economizer Day in Portland, OR



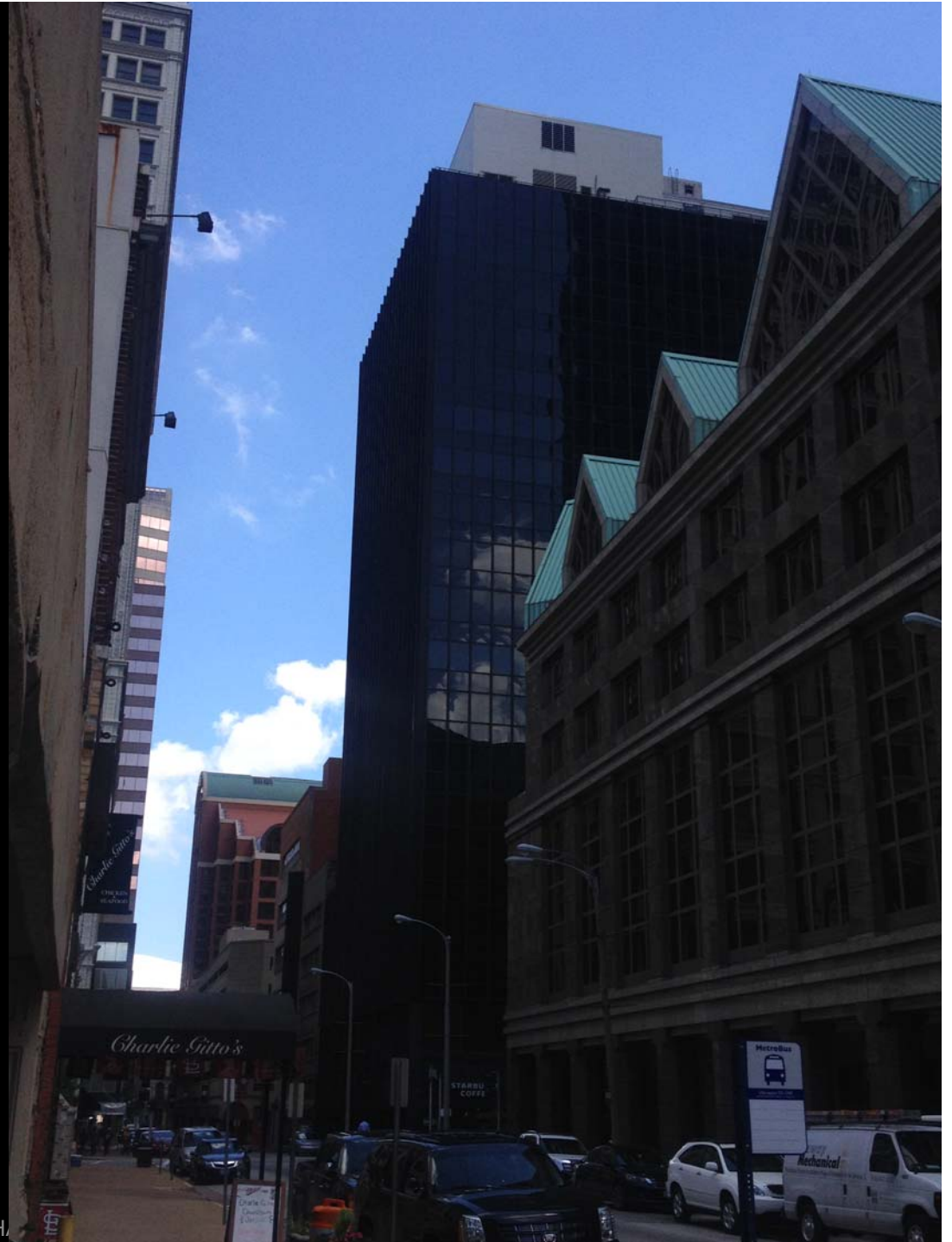
February 6, 2018

An Important Economizer Day in Portland, OR

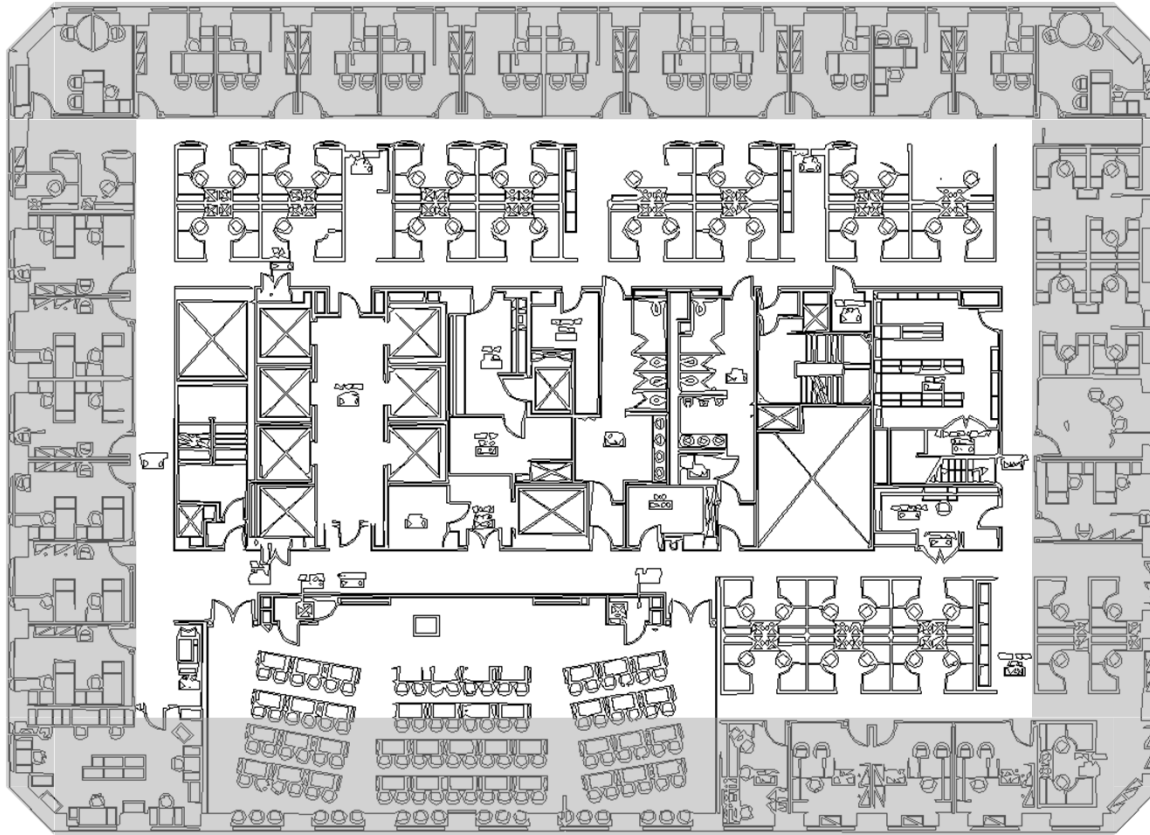


January 1977

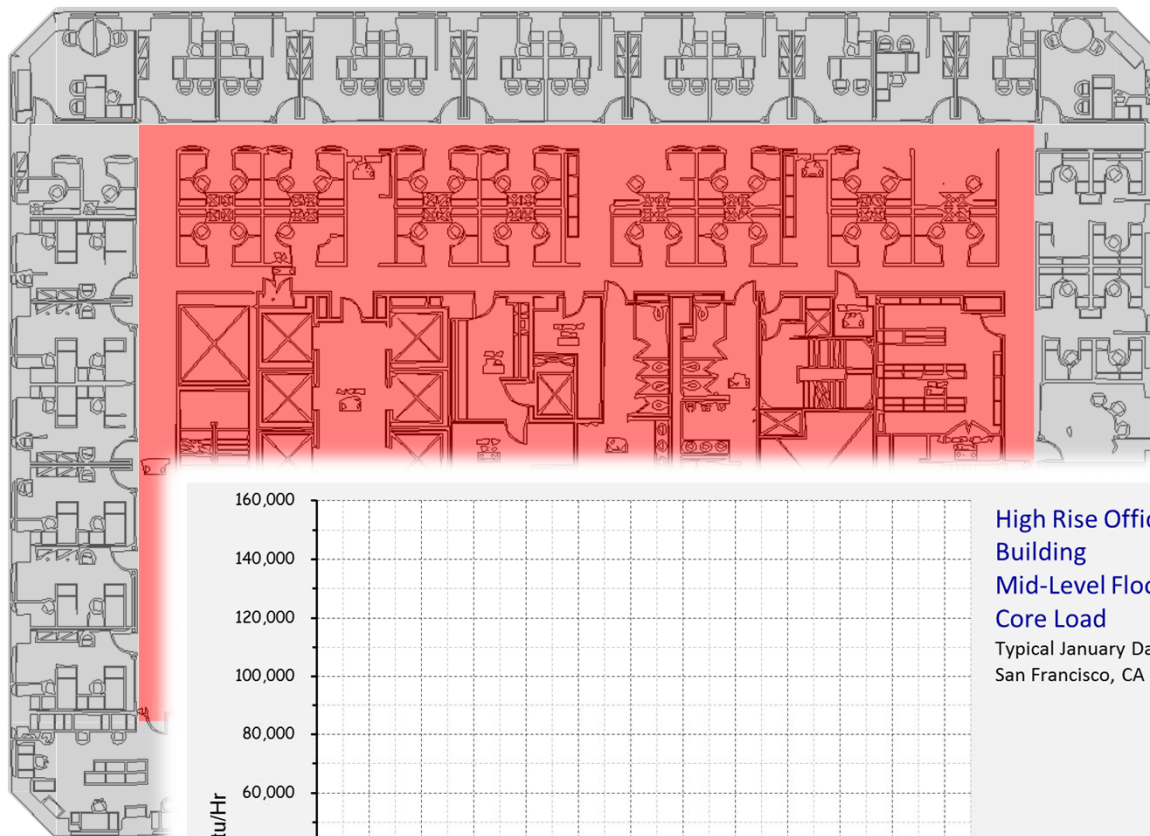
I Meet My First Economizer



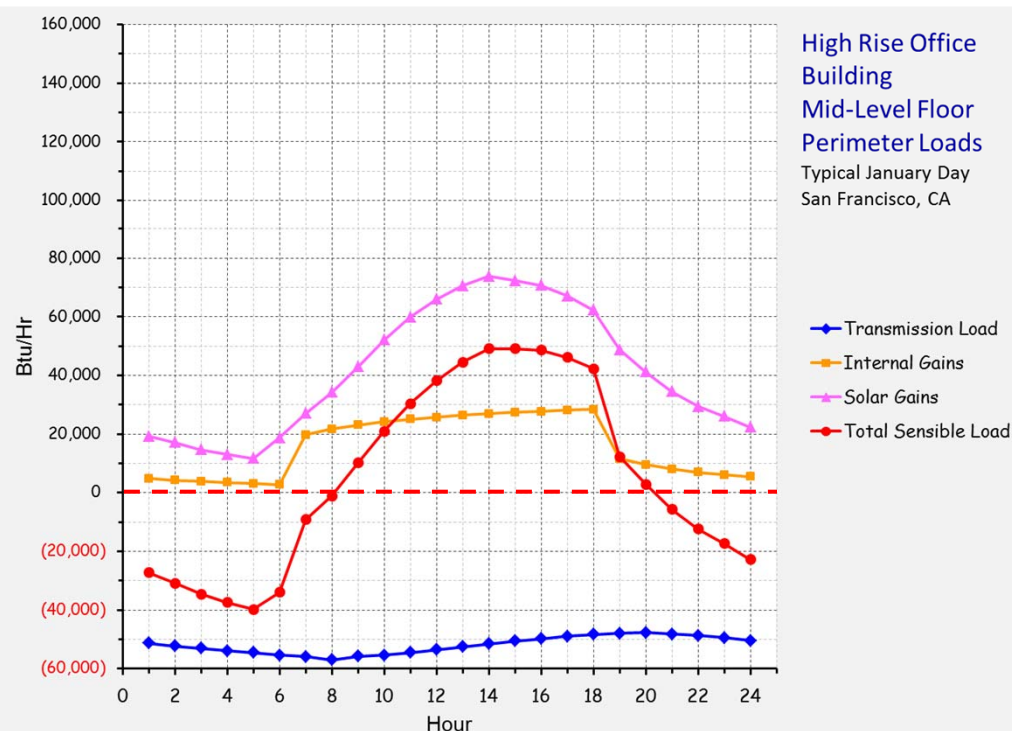
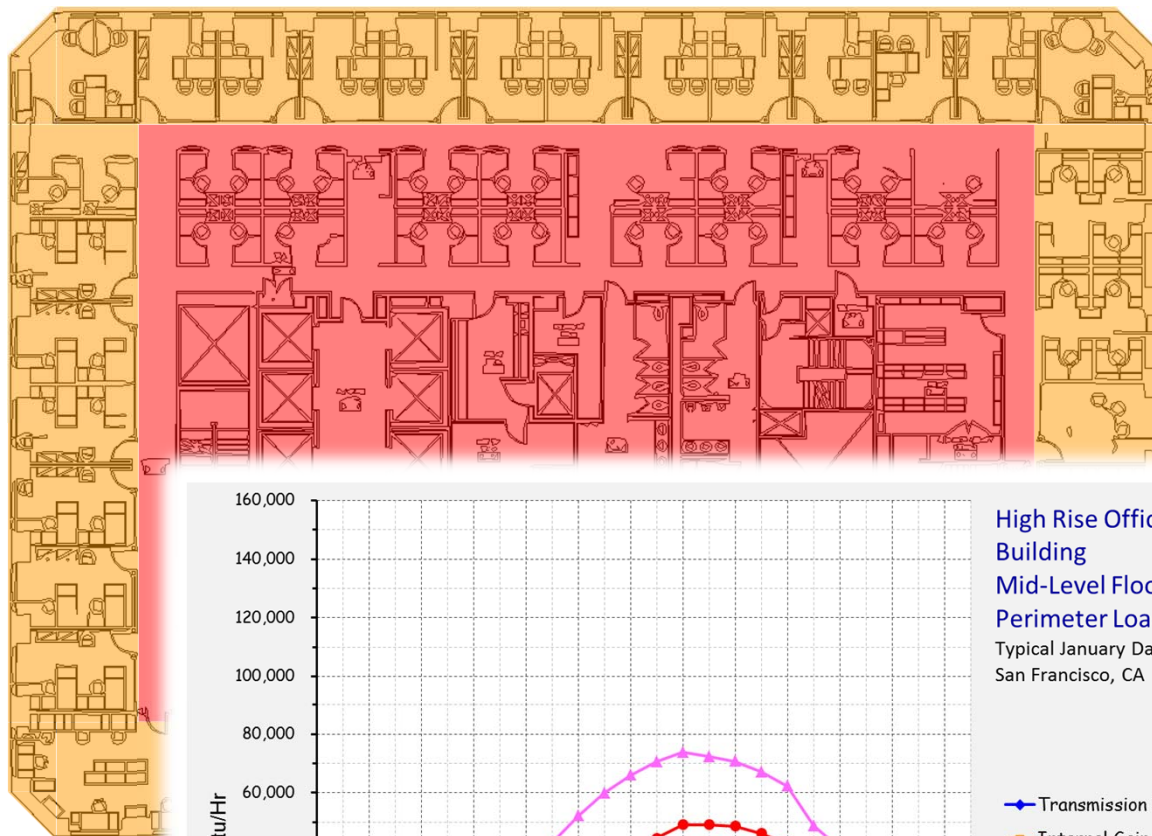
ECONOMIZERS; WH



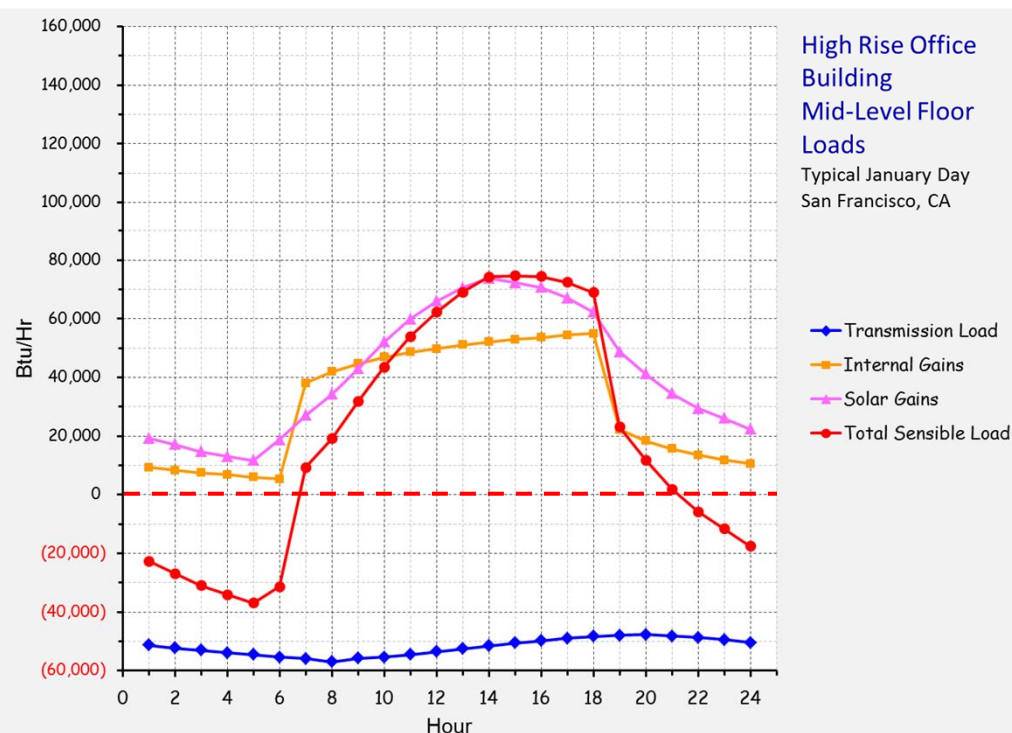
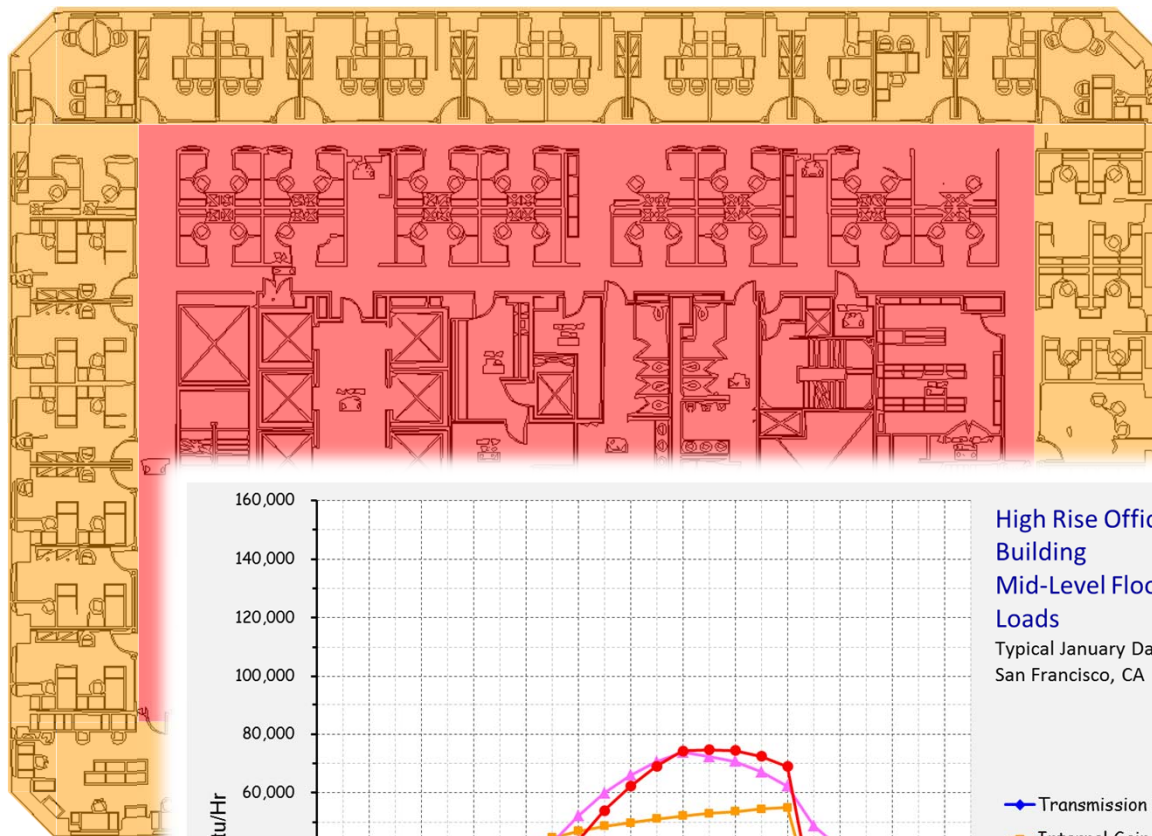
- Perimeter zones are a buffer between the core zones and the ambient environment
- If the perimeter is under control, then the uncontrolled environment has no impact on the controlled environment in the core
 - No ambient temperature impact
 - Minimal solar impact



- Most day to day processes in most buildings generate heat and/or moisture
 - People
 - Lights
 - Equipment
 - Food processing
 - Product manufacturing
- As a result, core zones generally require cooling even if it is cold outside



- Most day to day processes in most buildings generate heat and/or moisture
 - People
 - Lights
 - Equipment
 - Food processing
 - Product manufacturing
- As a result, core zones generally require cooling even if it is cold outside
- Perimeter zones may also require cooling on a sunny day even though it's cold outside

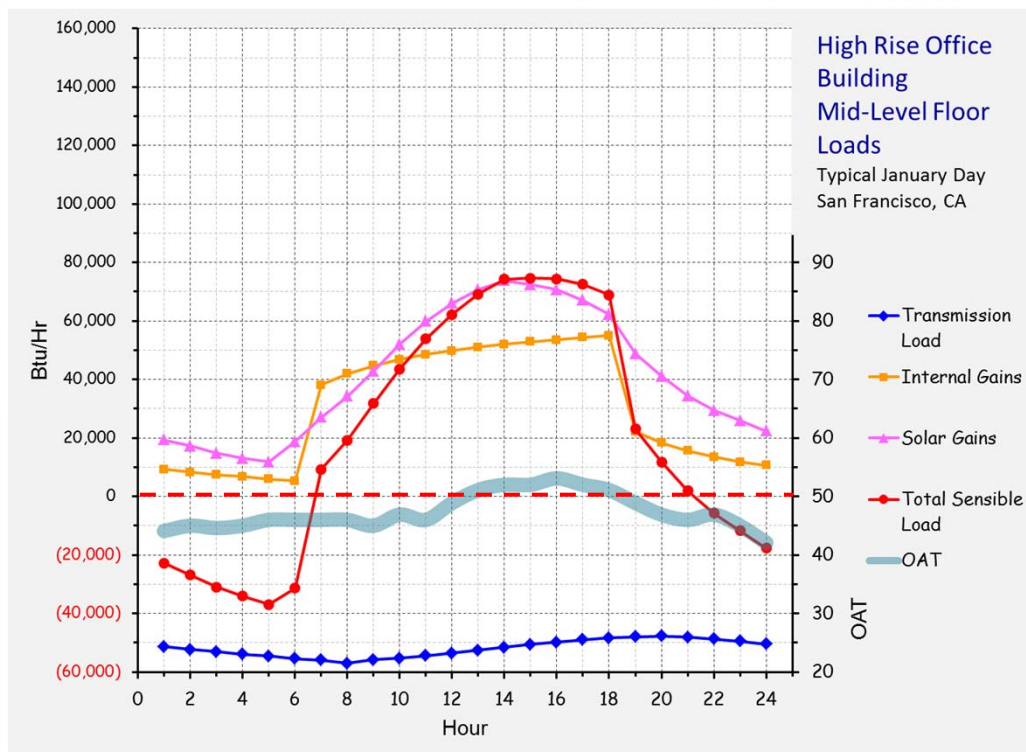
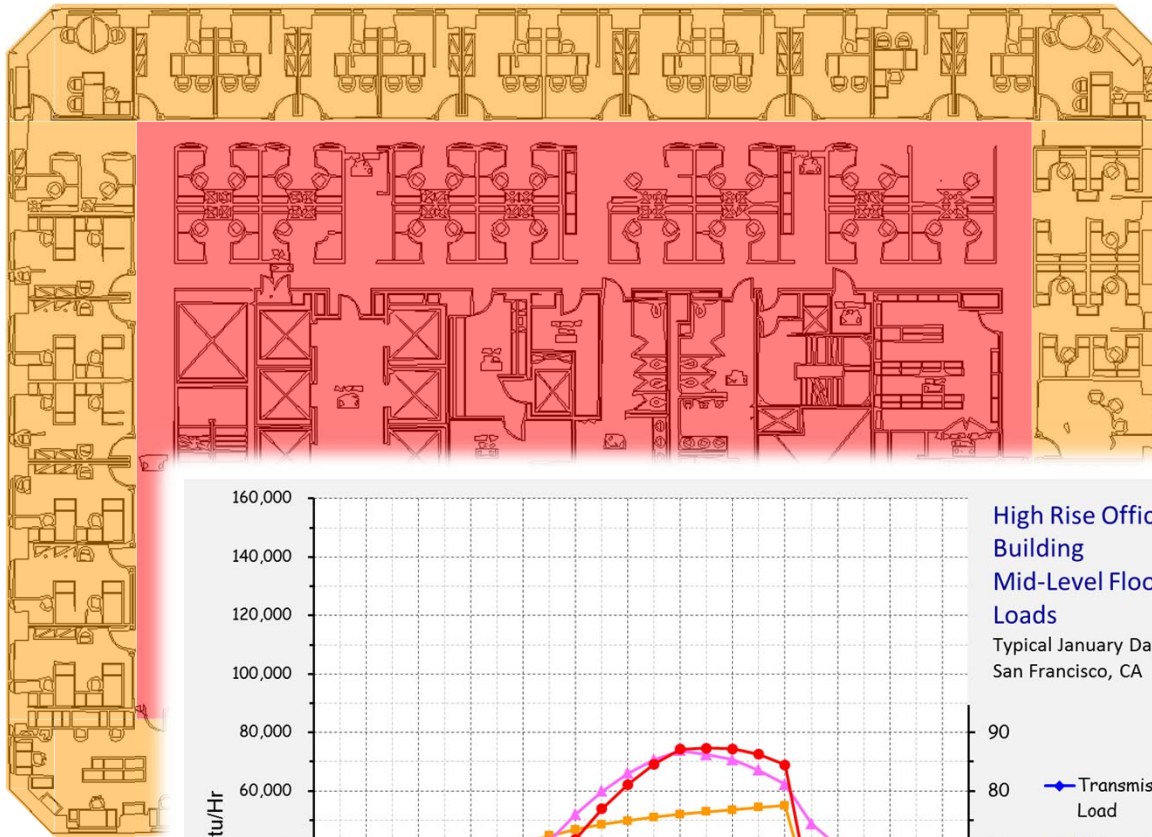


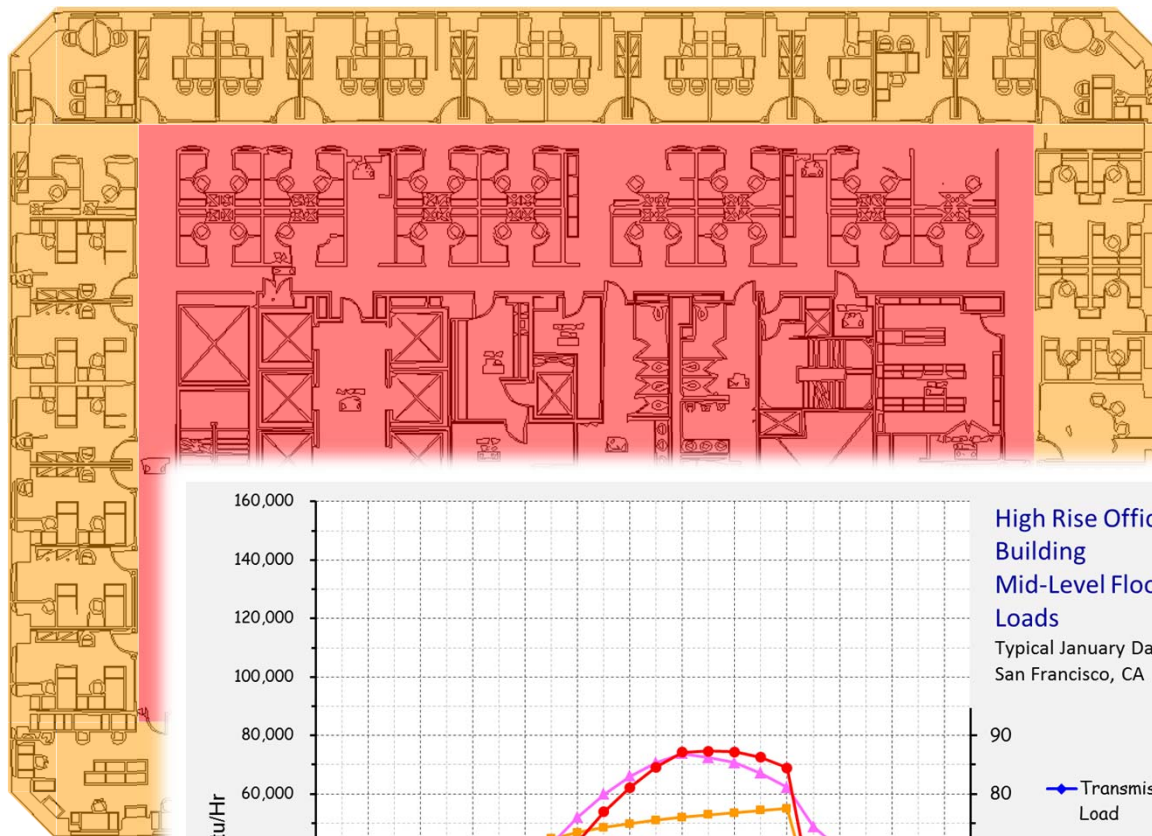
The Bottom Line is that a Modern, Complex Building Represents a Year Round **Cooling** Requirement Even if it is **Cold** Outside

- *At \$.15/kWh, it will cost about \$15 per day to cool this floor on a day when it is 40°F outside*
- *There are 39 similar floors in this building*

Here's an Idea:

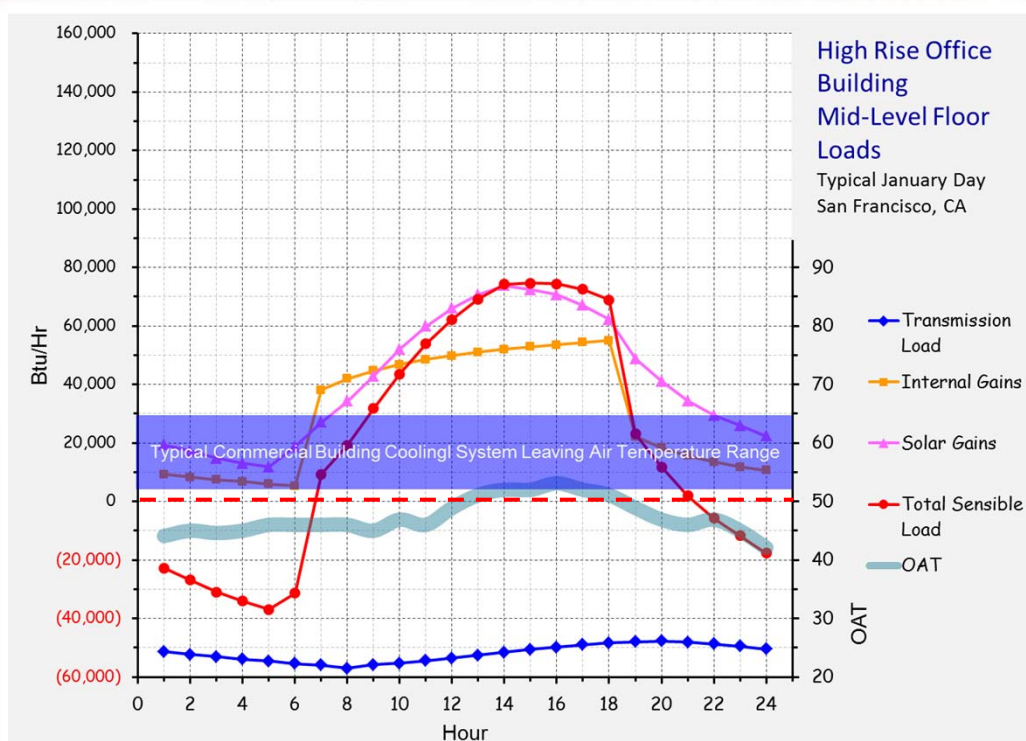
Use the Cold Outdoor Air to Cool the Building Instead of Running Refrigeration Machinery





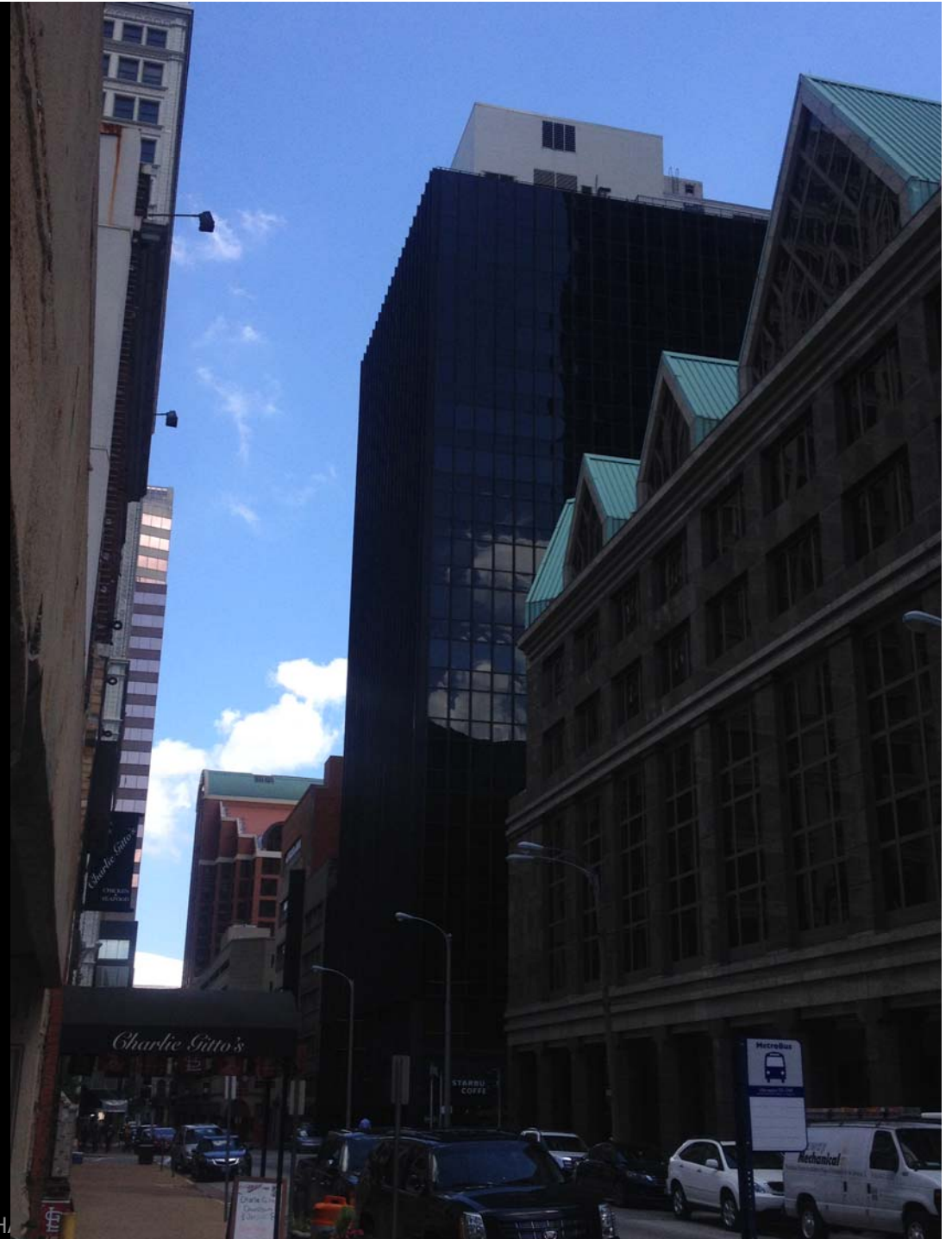
Here's an Idea:

*Use the **Cold** Outdoor Air to **Cool** the Building Instead of Running Refrigeration Machinery*

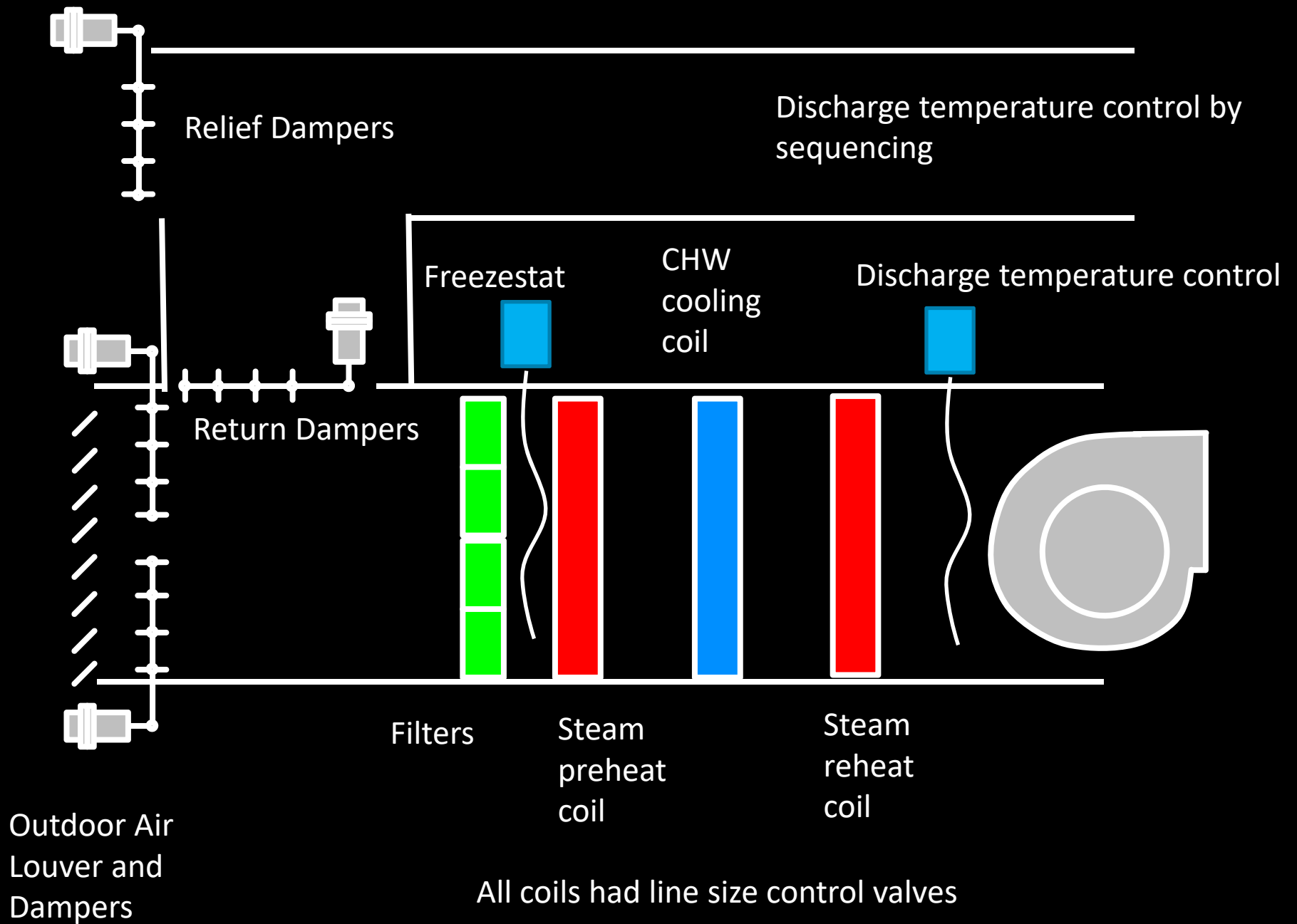


January 1977
I Meet My First
Economizer

What I Saw



ECONOMIZERS; WH



“Economizers” and “Cold Outdoor Air” You Can’t Have One Without the Other

Airside Economizers

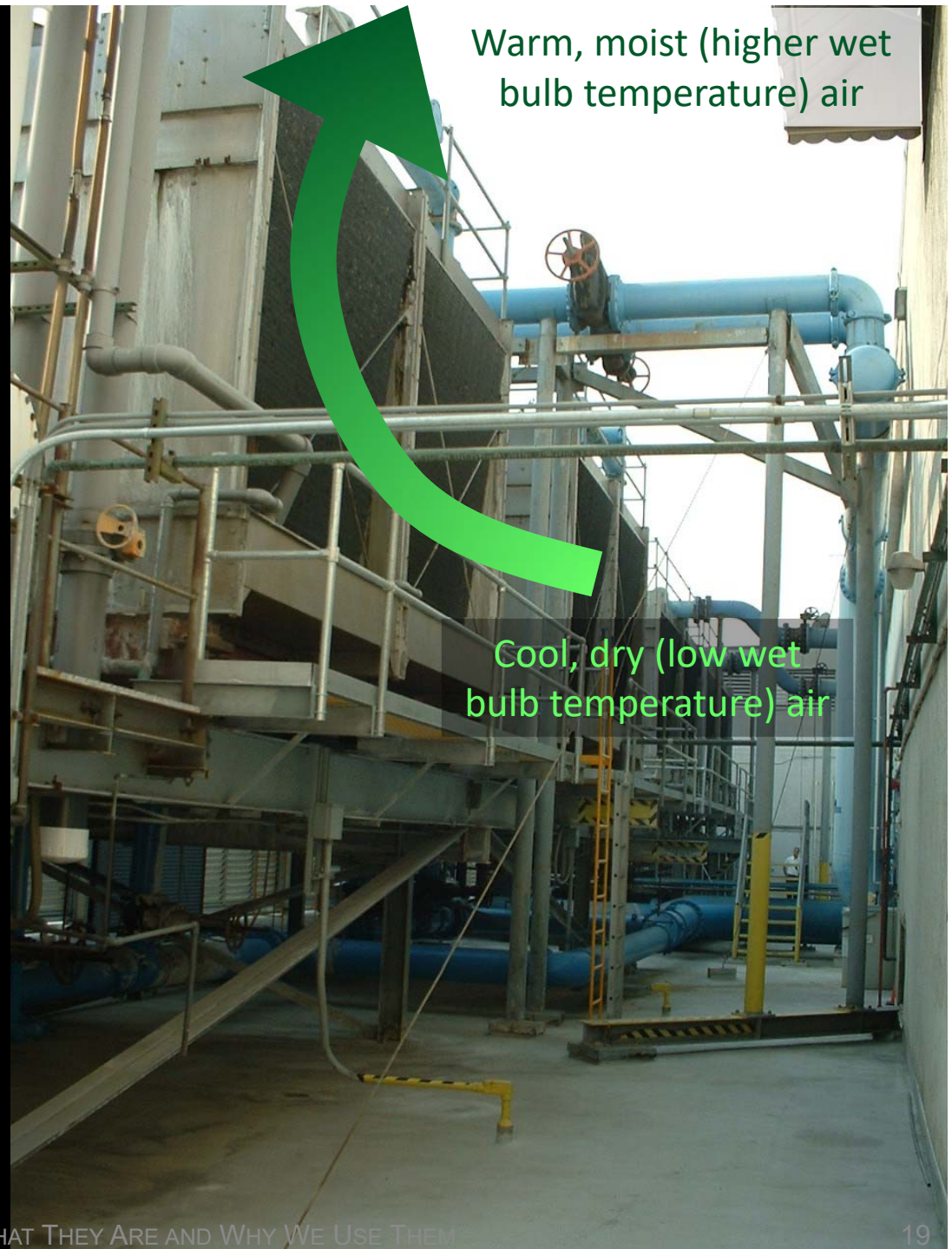
- Mix **warm return** air with **cold outdoor air** to control **supply air** temperature
- Use air handling system for distribution mechanism



“Economizers” and “Cold Outdoor Air” You Can’t Have One Without the Other

Waterside Economizers

- Leverage evaporative cooling ability of dry outdoor air (low wet bulb temperatures) to evaporatively cool water and minimize mechanical cooling



“Economizers” and “Outdoor Air” You Can’t Have One Without the Other

Waterside Economizers

- Run cooling towers to make chilled water directly (45-55°F supply temperature versus 65-85°F)



“Economizers” and “Outdoor Air” You Can’t Have One Without the Other

Waterside Economizers

- Run cooling towers to make chilled water directly (45-55°F supply temperature versus 65-85°F)
- Plate and frame heat exchanger transfers cooling to the chilled water system



“Economizers” and “Outdoor Air”

You Can't Have One
Without the Other

Waterside Economizers

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“Economizers” and “Outdoor Air” You Can’t Have One Without the Other

Waterside Economizers

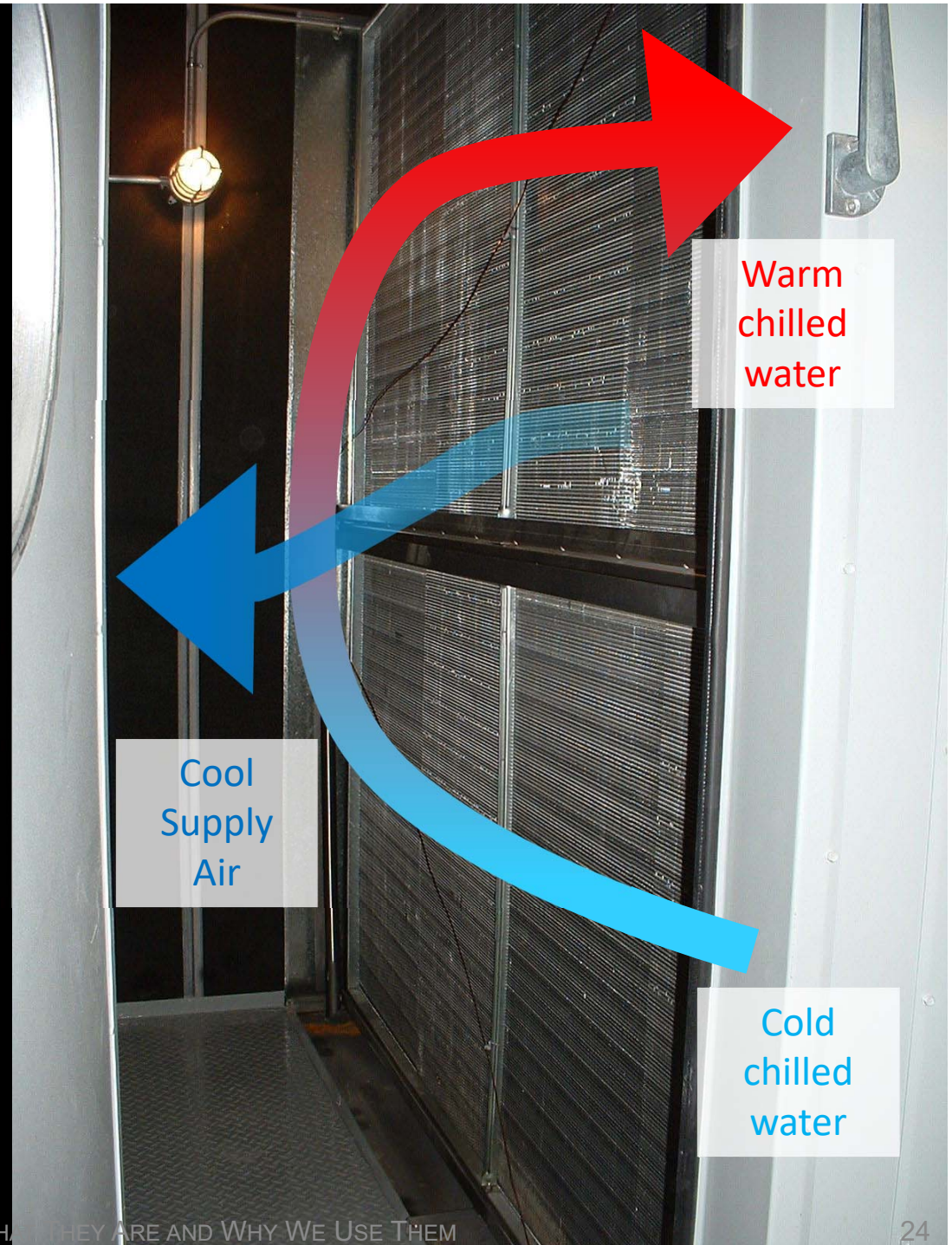
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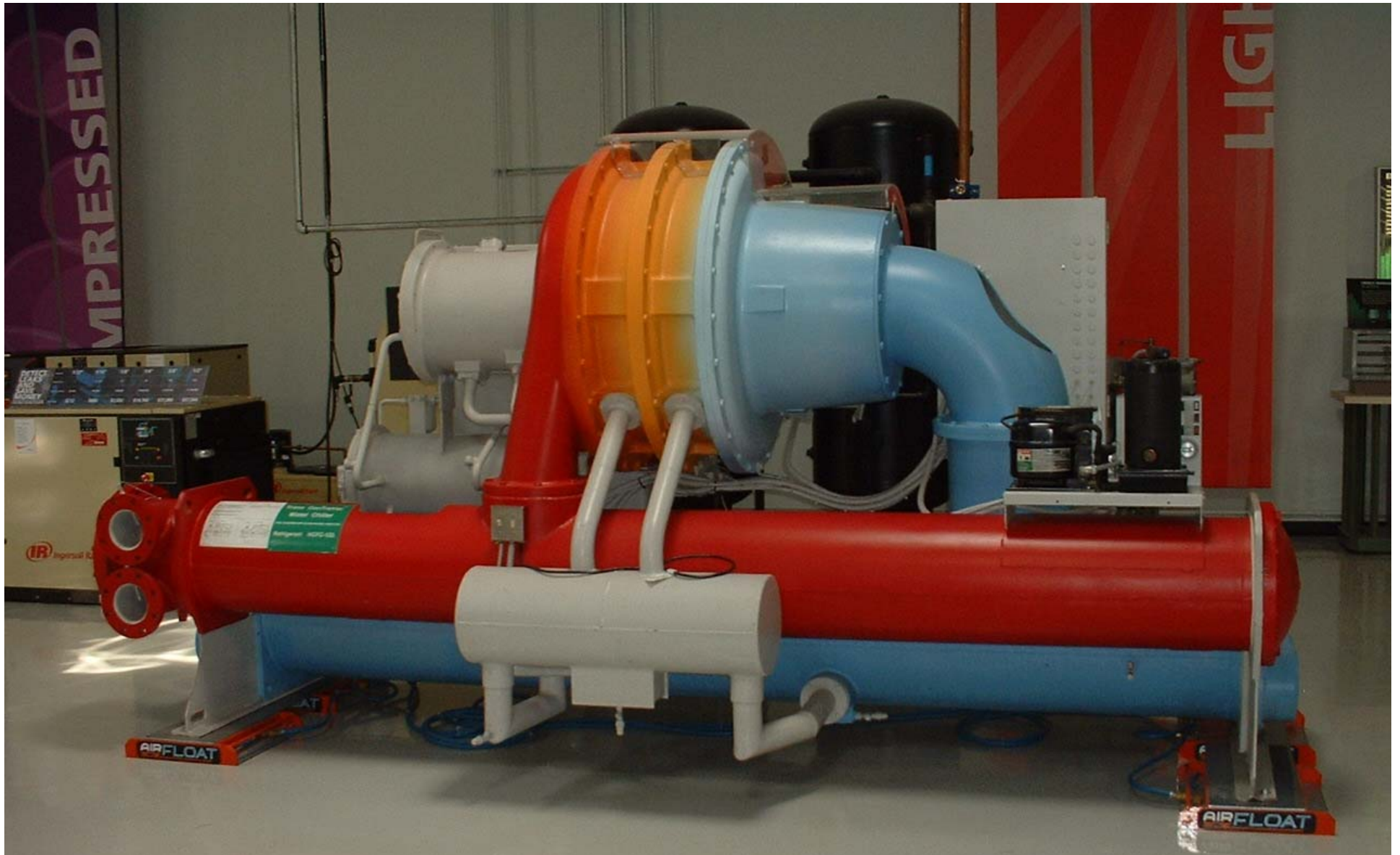


“Economizers” and “Outdoor Air” You Can’t Have One Without the Other

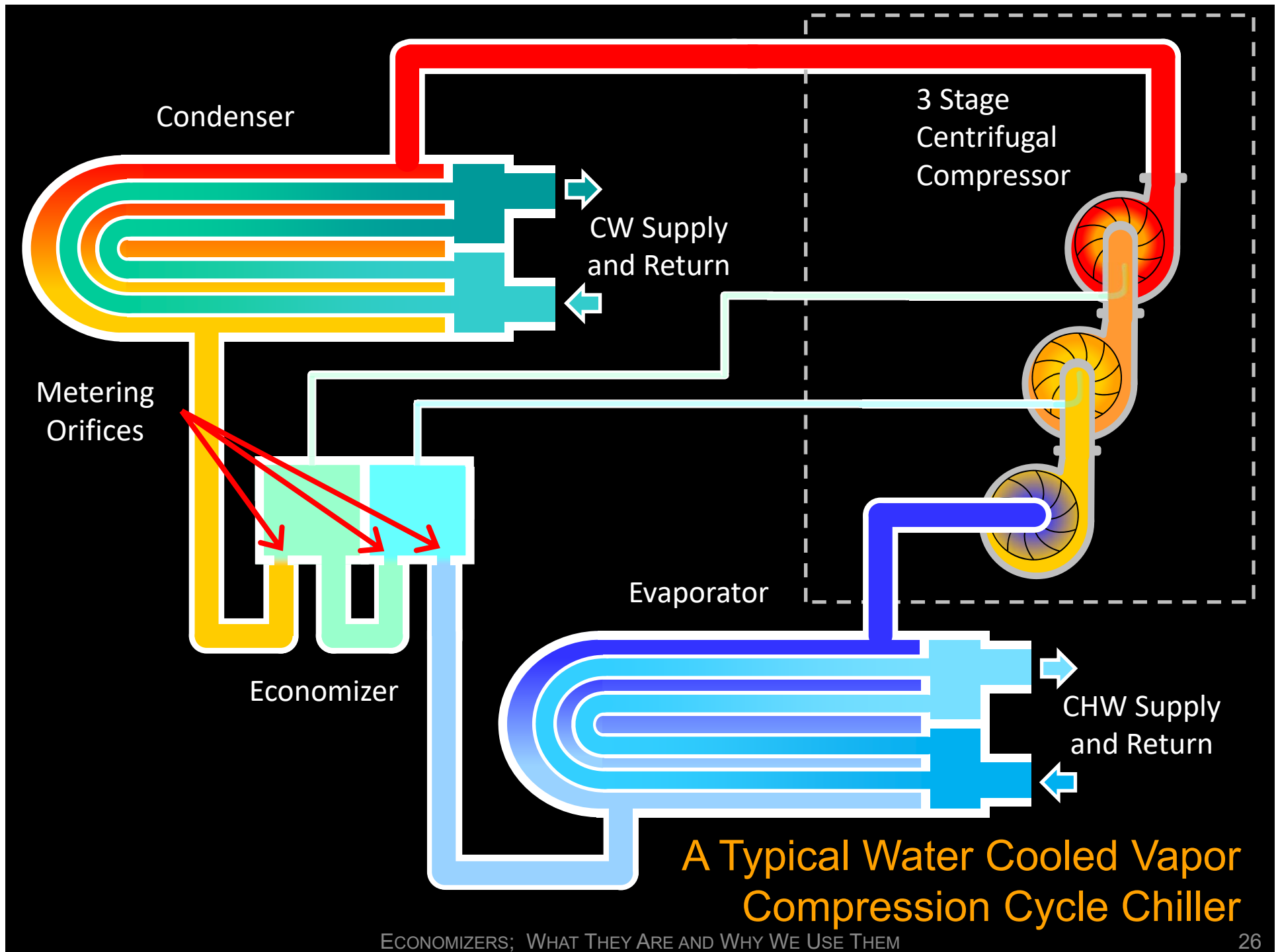
Waterside Economizers

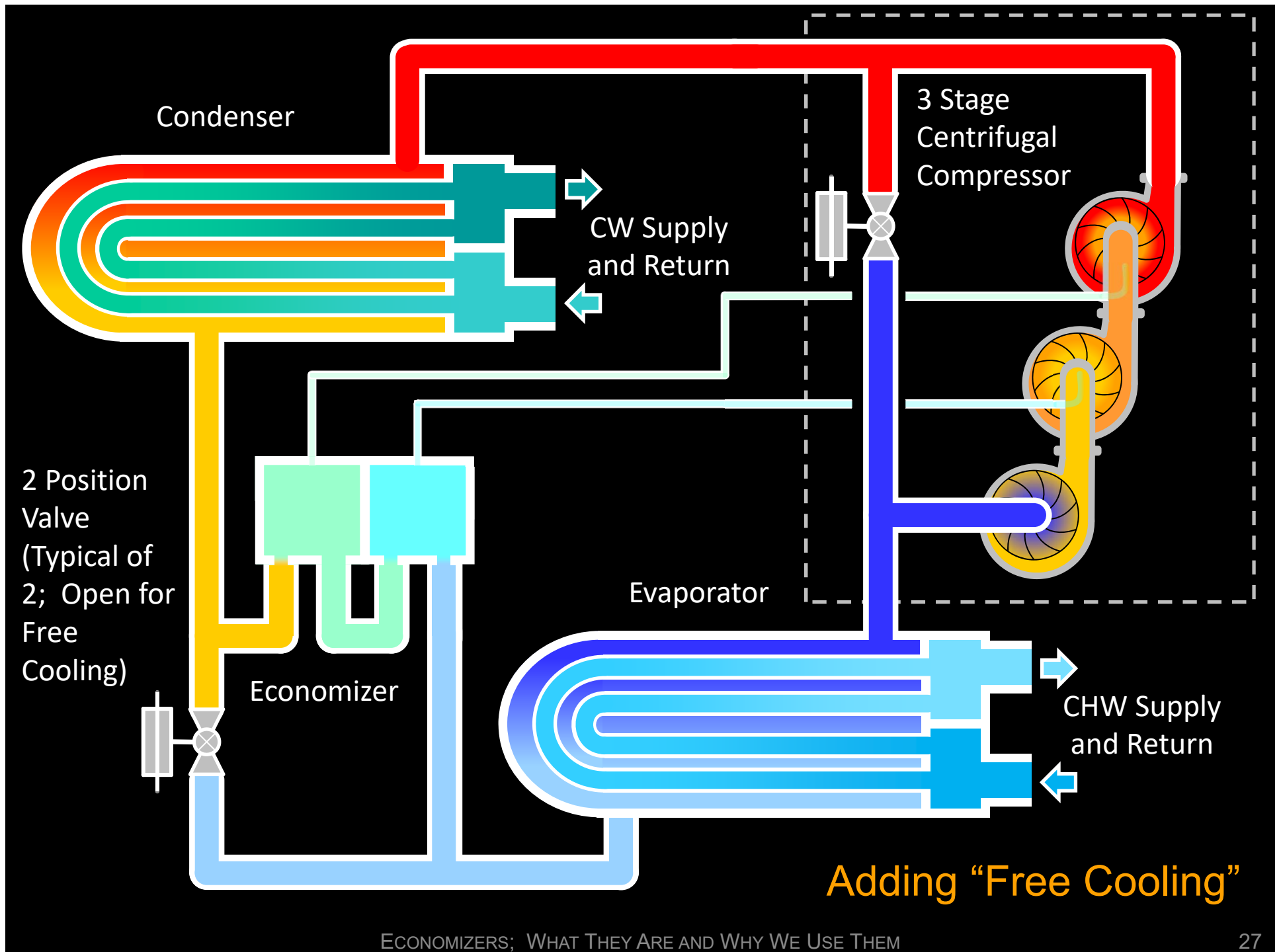
- Run cooling towers to make chilled water directly (45-55°F supply temperature versus 65-85°F)
- Plate and frame heat exchanger transfers cooling to the chilled water system
- Use chilled water and air handling systems for distribution

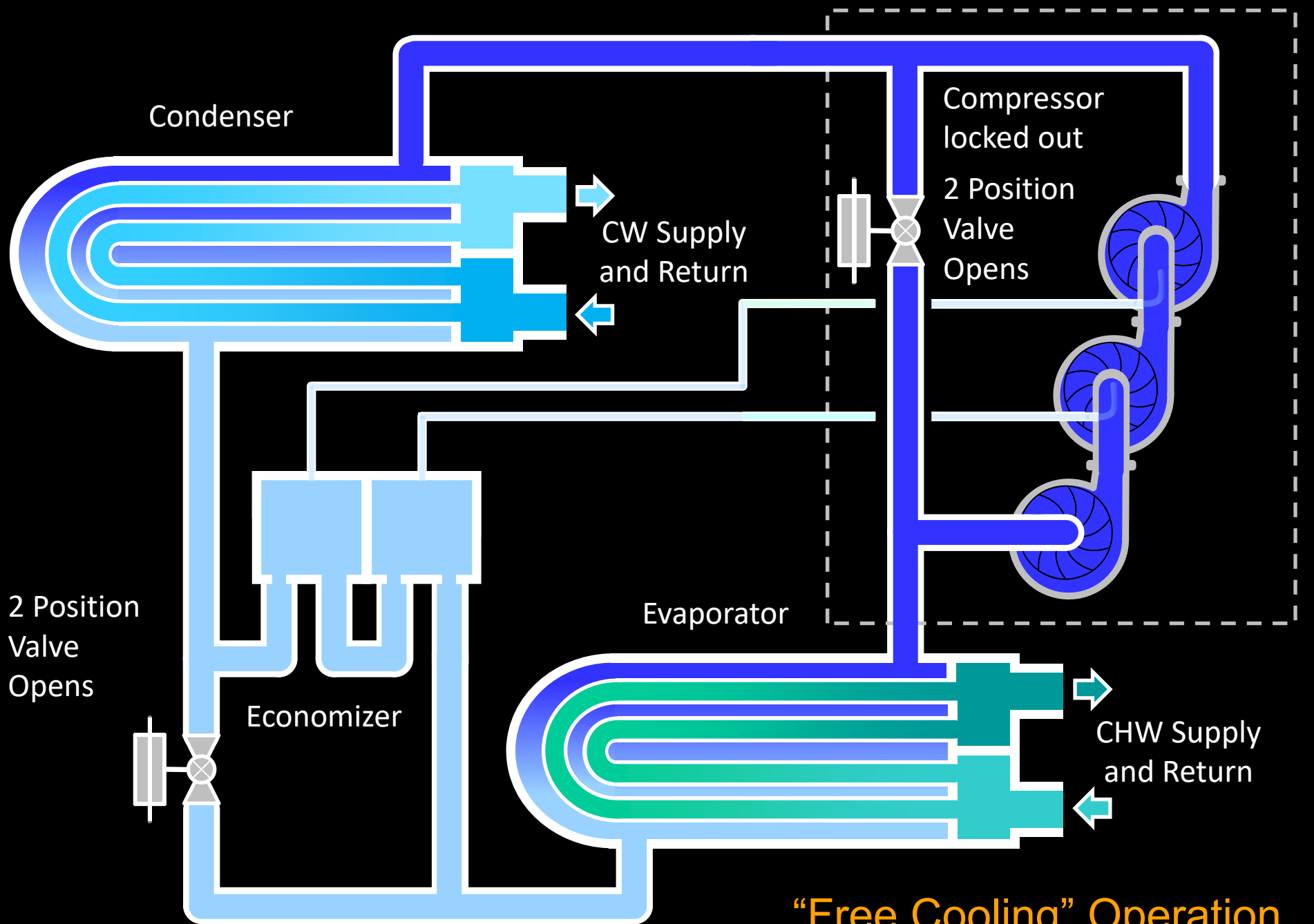




Free Cooling;
An Option Available on Many Centrifugal Chillers

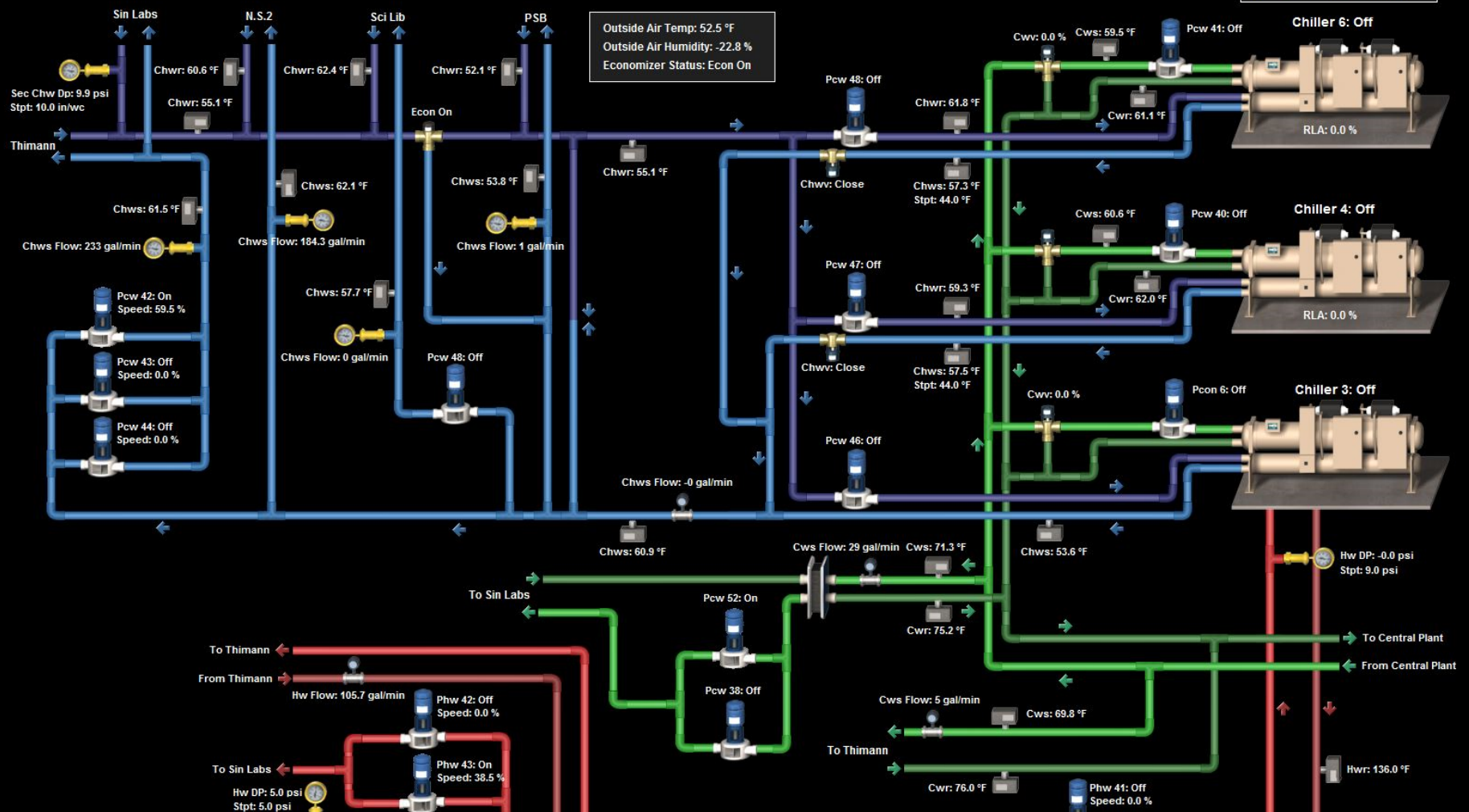


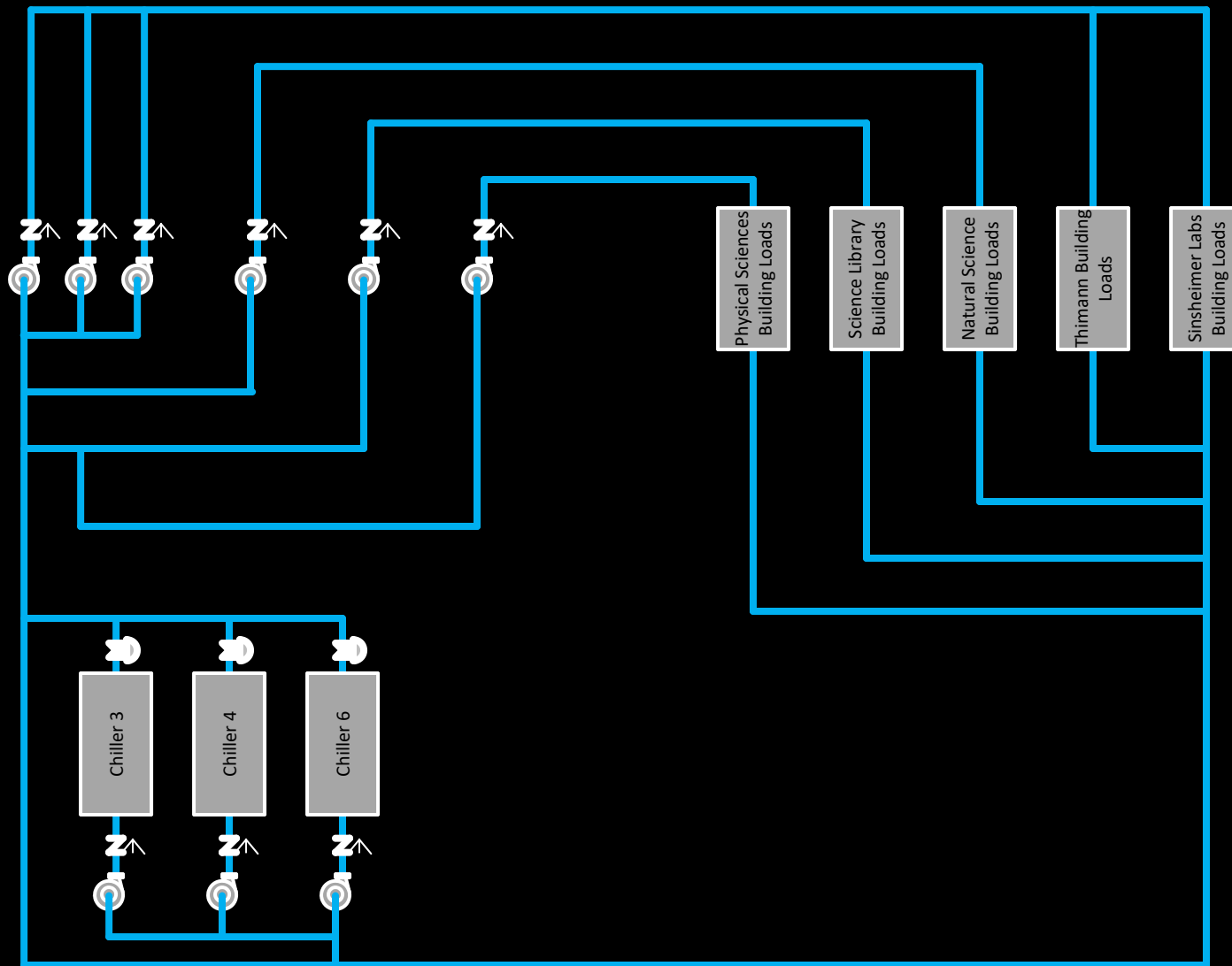




“Free Cooling” Operation


```
EF_10_HiSpeed_Command: Off
EF_10_LoSpeed_Command: On
```





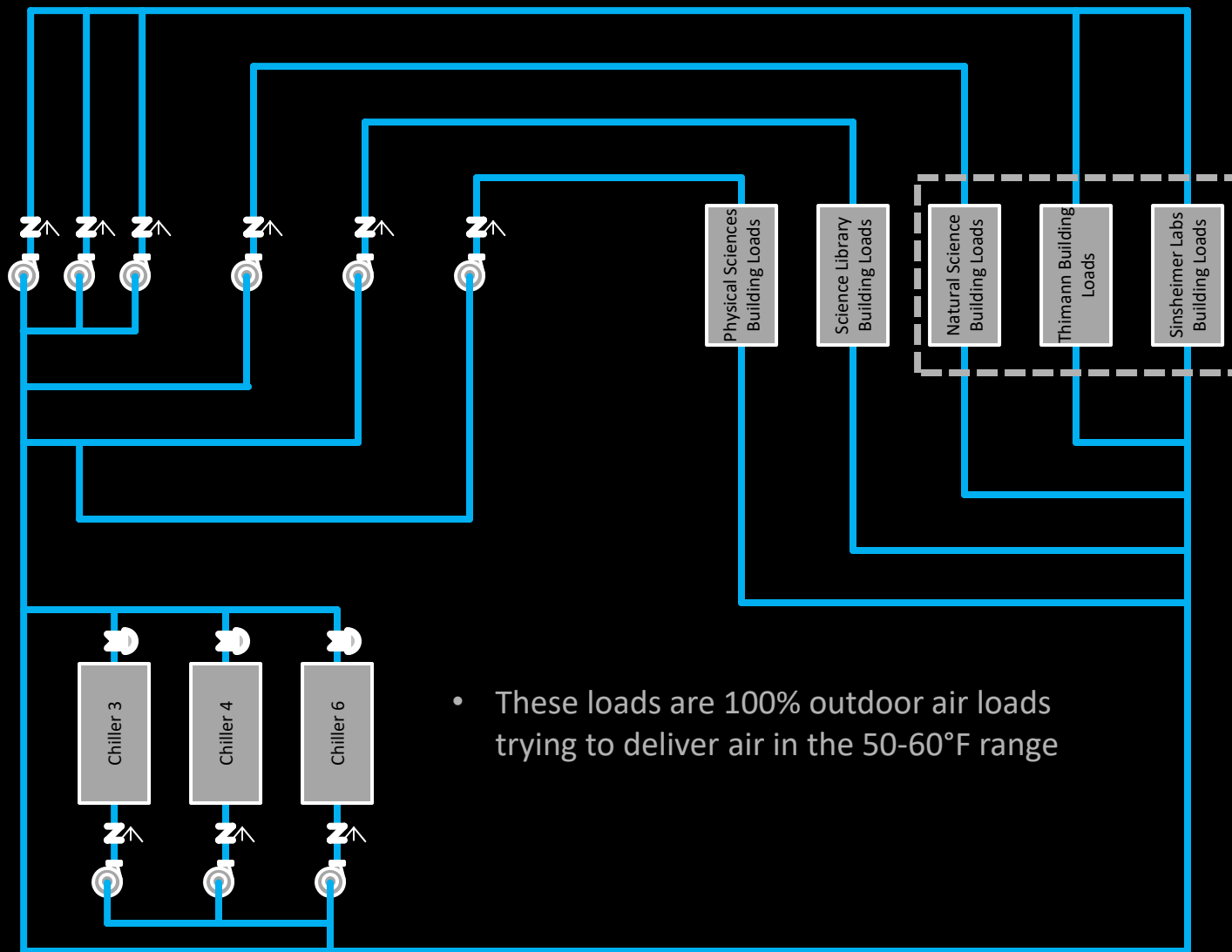
The Untangled System Diagram

UC Santa Cruz

Pre-Wet Economizer System

2016-01-29

Drawn By : DS



- These loads are 100% outdoor air loads trying to deliver air in the 50-60°F range

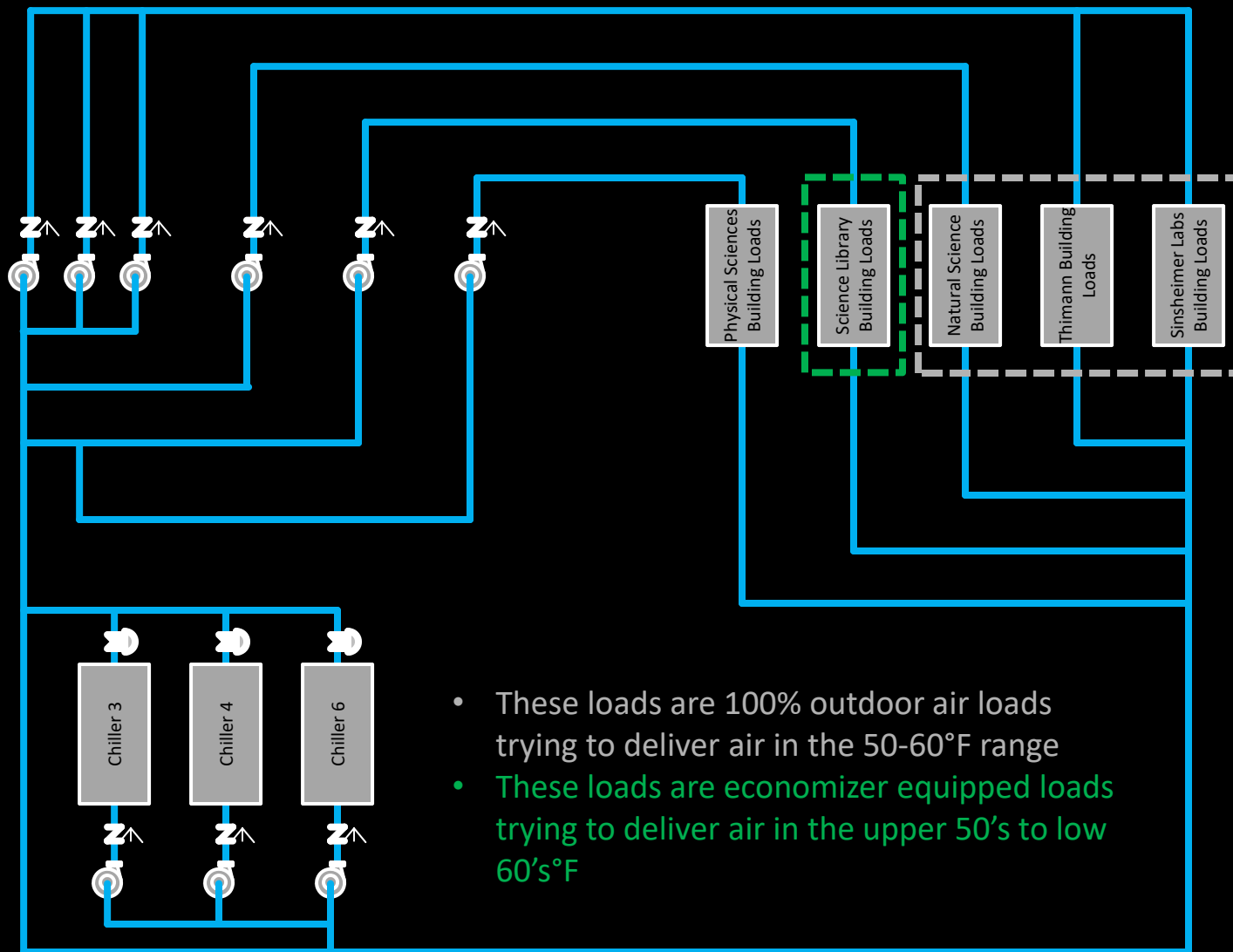
The Original Plant Configuration

UC Santa Cruz

Pre-Wet Economizer System

2016-01-29

Drawn By : DS



The Original Plant Configuration

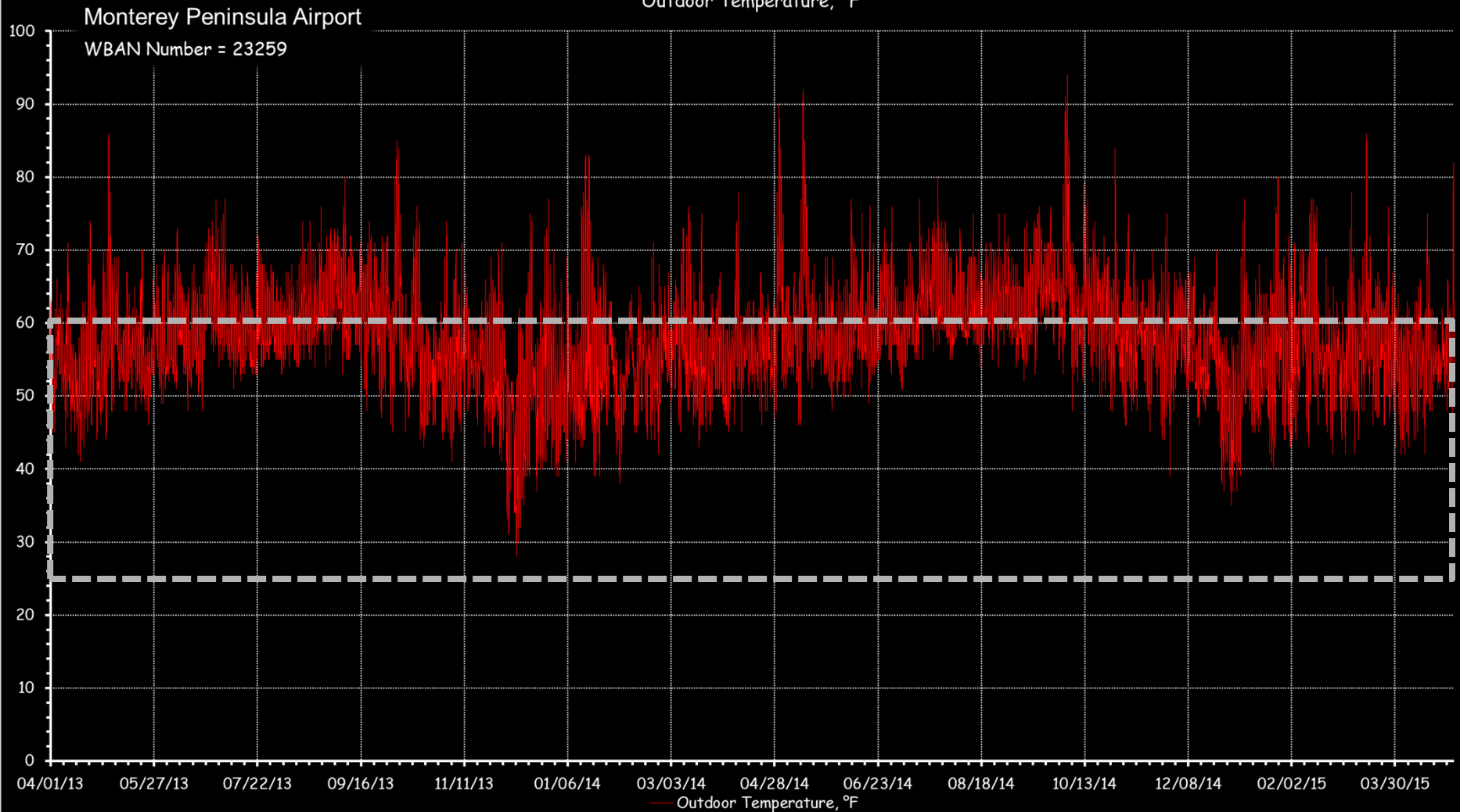
UC Santa Cruz

Pre-Wet Economizer System

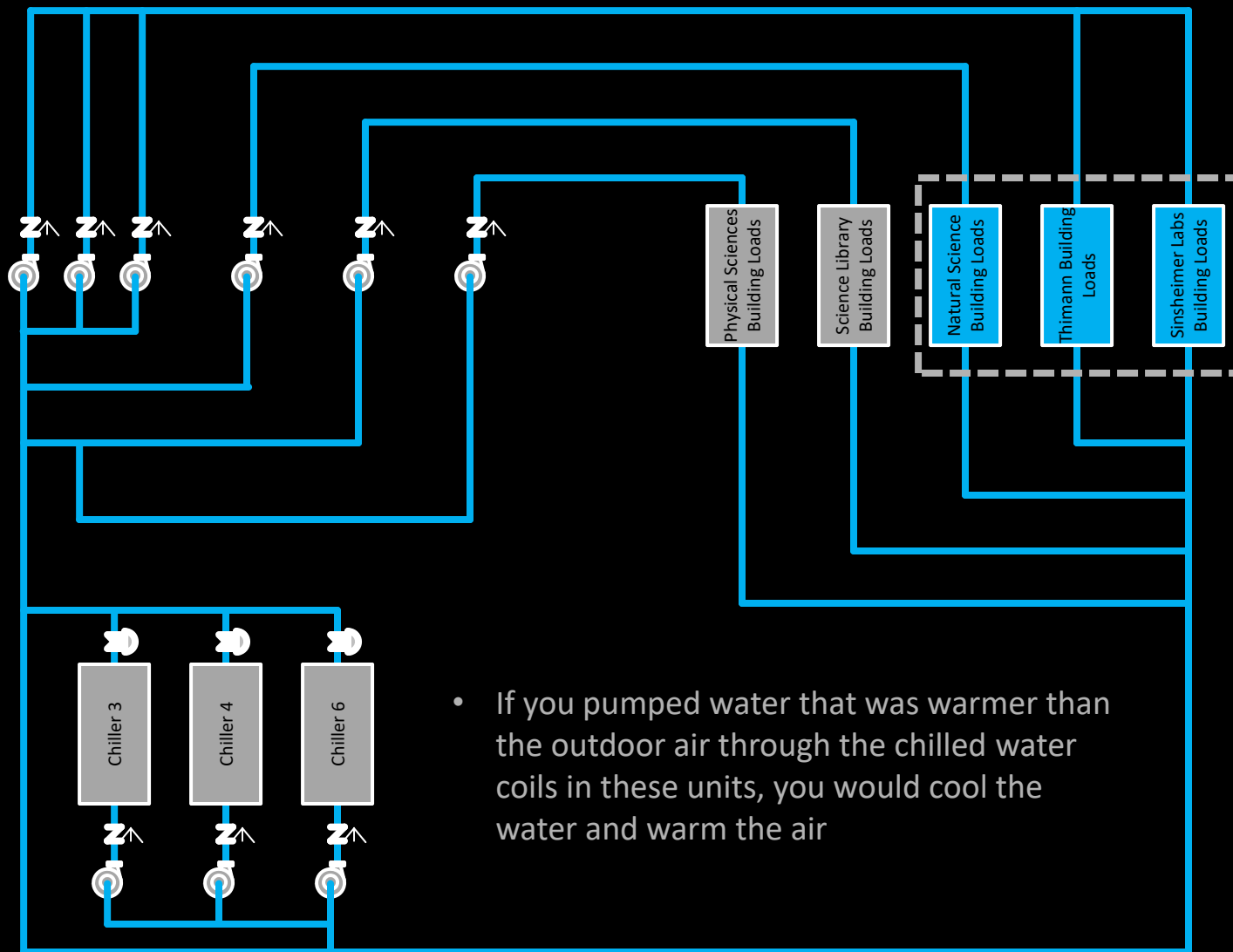
2016-01-29

Drawn By : DS

Outdoor Temperature, °F



There Are A Lot of Hours When 100% Outdoor Air Systems
Delivering 50-60°F Air will Need Preheat



- If you pumped water that was warmer than the outdoor air through the chilled water coils in these units, you would cool the water and warm the air

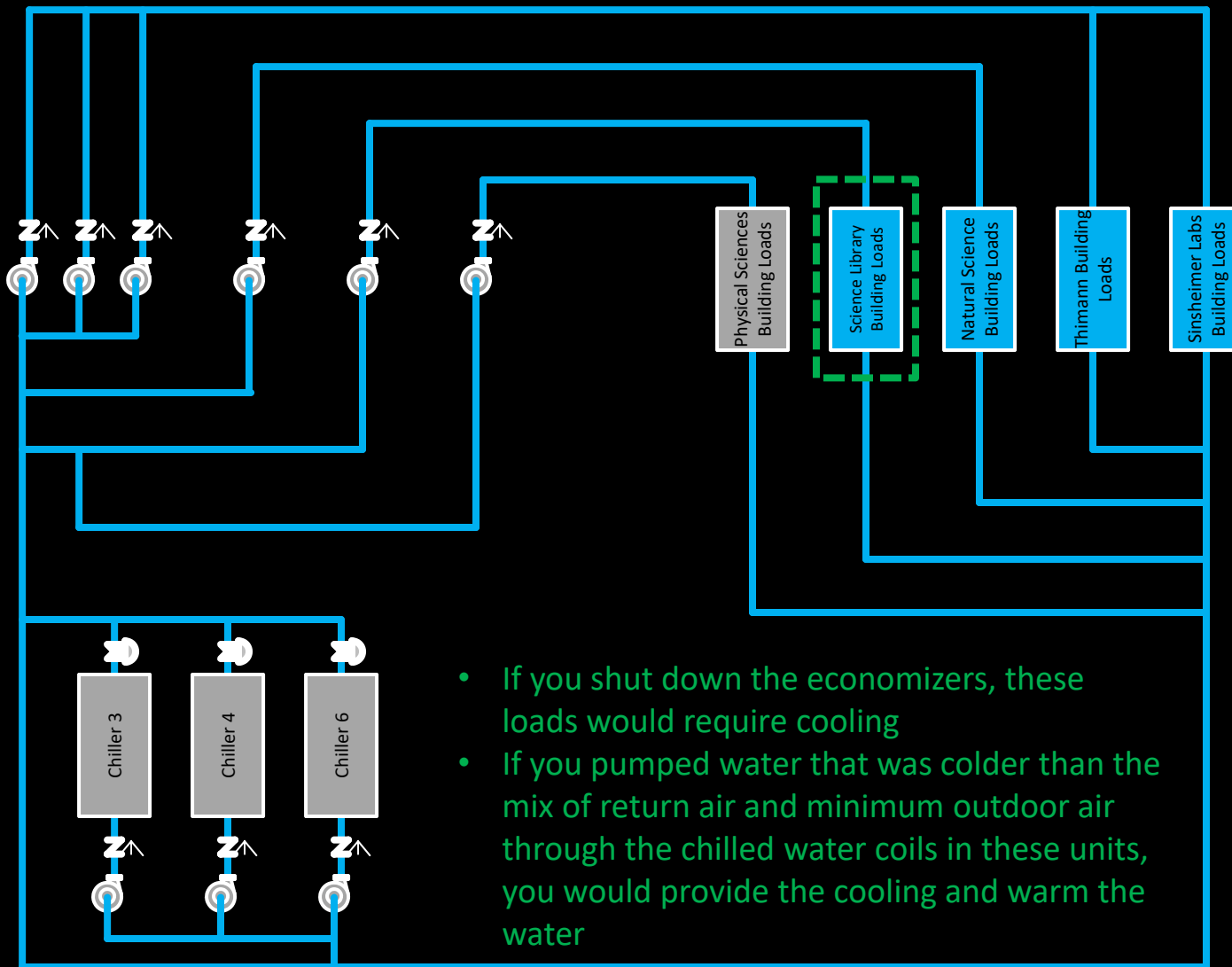
The Original Plant Configuration

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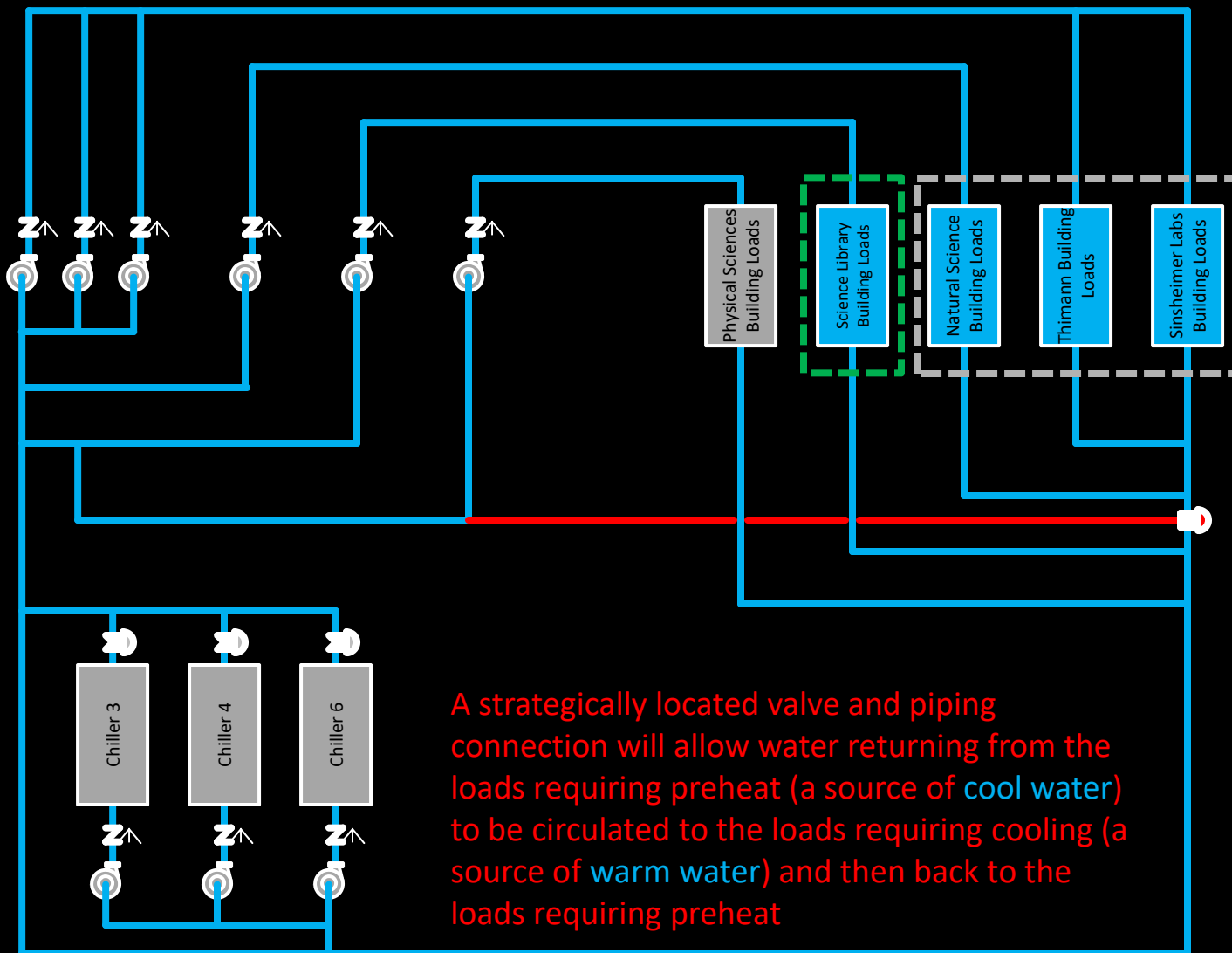
The Original Plant Configuration

UC Santa Cruz

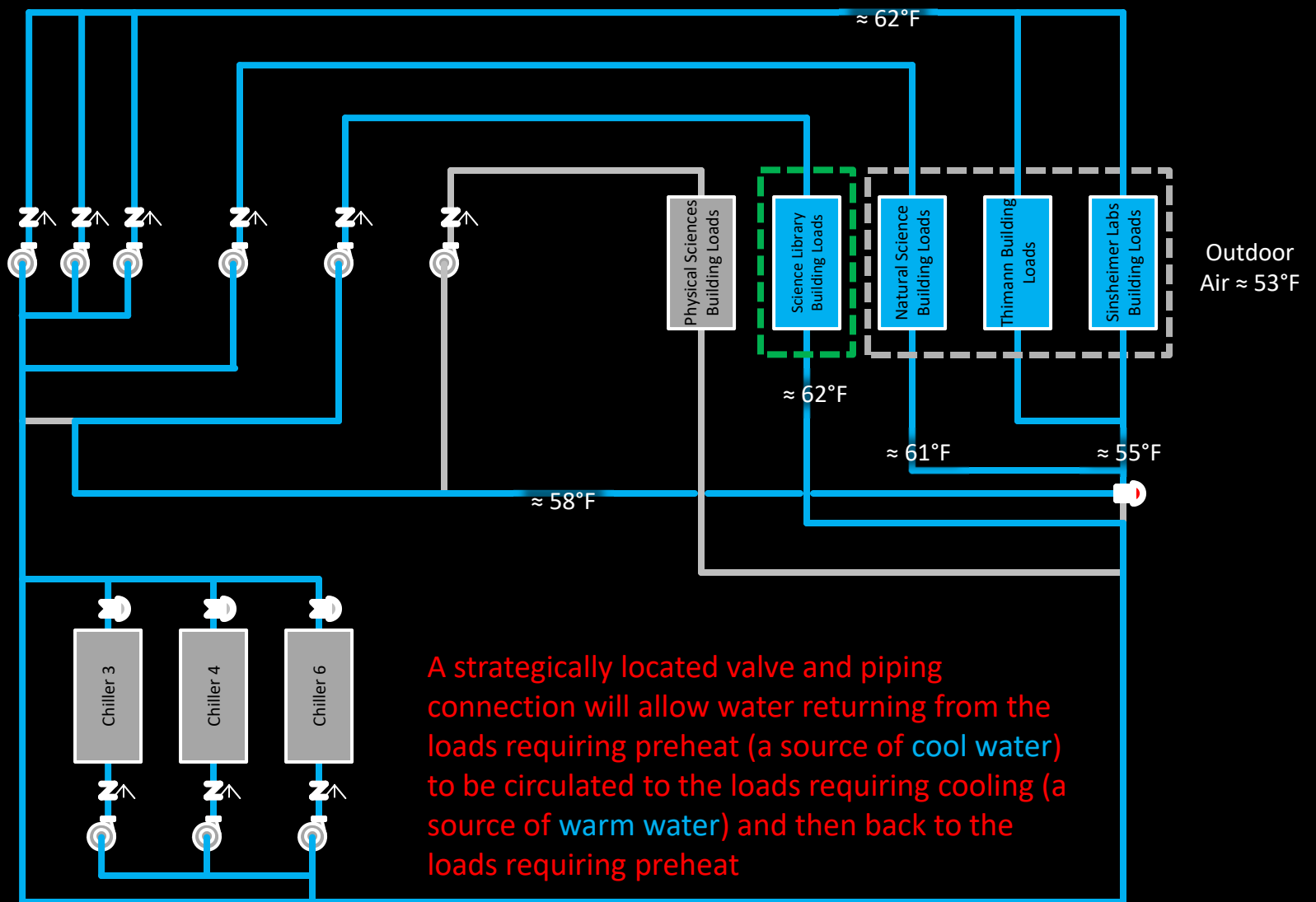
Pre-Wet Economizer System

2016-01-29

Drawn By : DS



The Modification to Make the Wet Economizer



The Wet Economizer in Operation

Free Cooling; It's Not Totally Free

For Airside Economizers

- Properly sized dampers = Pressure drop
 - Pressure drop = Energy

$$bhp = \left(\frac{cfm \times static}{6,356 \times \eta_{fan_{static}}} \right)$$

- Relief fans may be required
- Filters may load up faster

For Waterside Economizers

- Pumps have to run
- Cooling tower fans have to run
- Water will be evaporated in the cooling towers
- Make up water will need to be treated to manage water chemistry

“Economizers” and “Outdoor Air” You Can’t Have One Without the Other

Waterside Economizers

- Optional approach but not mandated
- Can also have operational difficulties
- See Cool Tools for good information on design and operation

www.TaylorEngineering.com

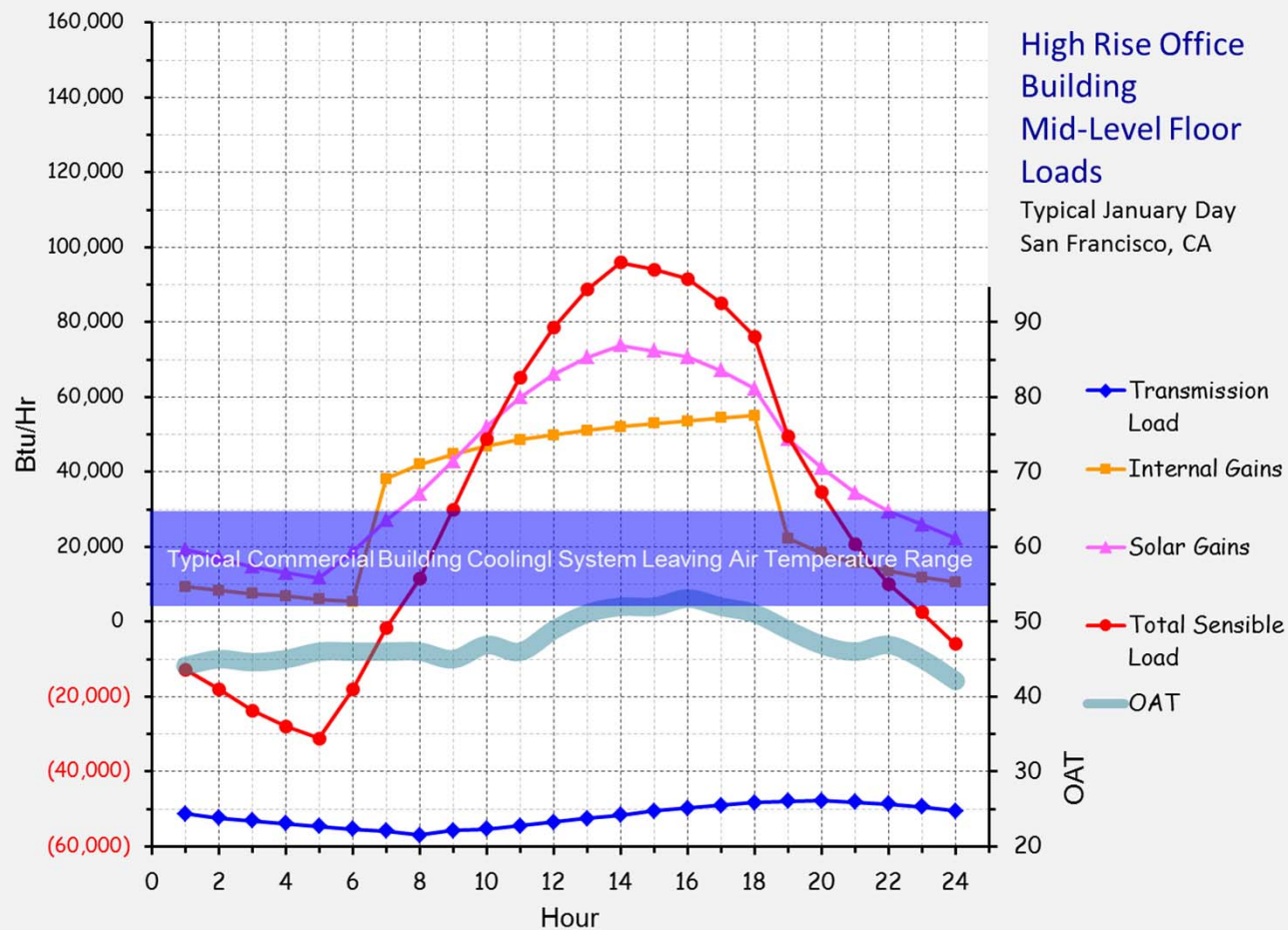
Under Publications, Design
Guides and Tools

Airside Economizers

- Title 24 requirement for most air handling systems
- Our focus for today
- Resources to follow!

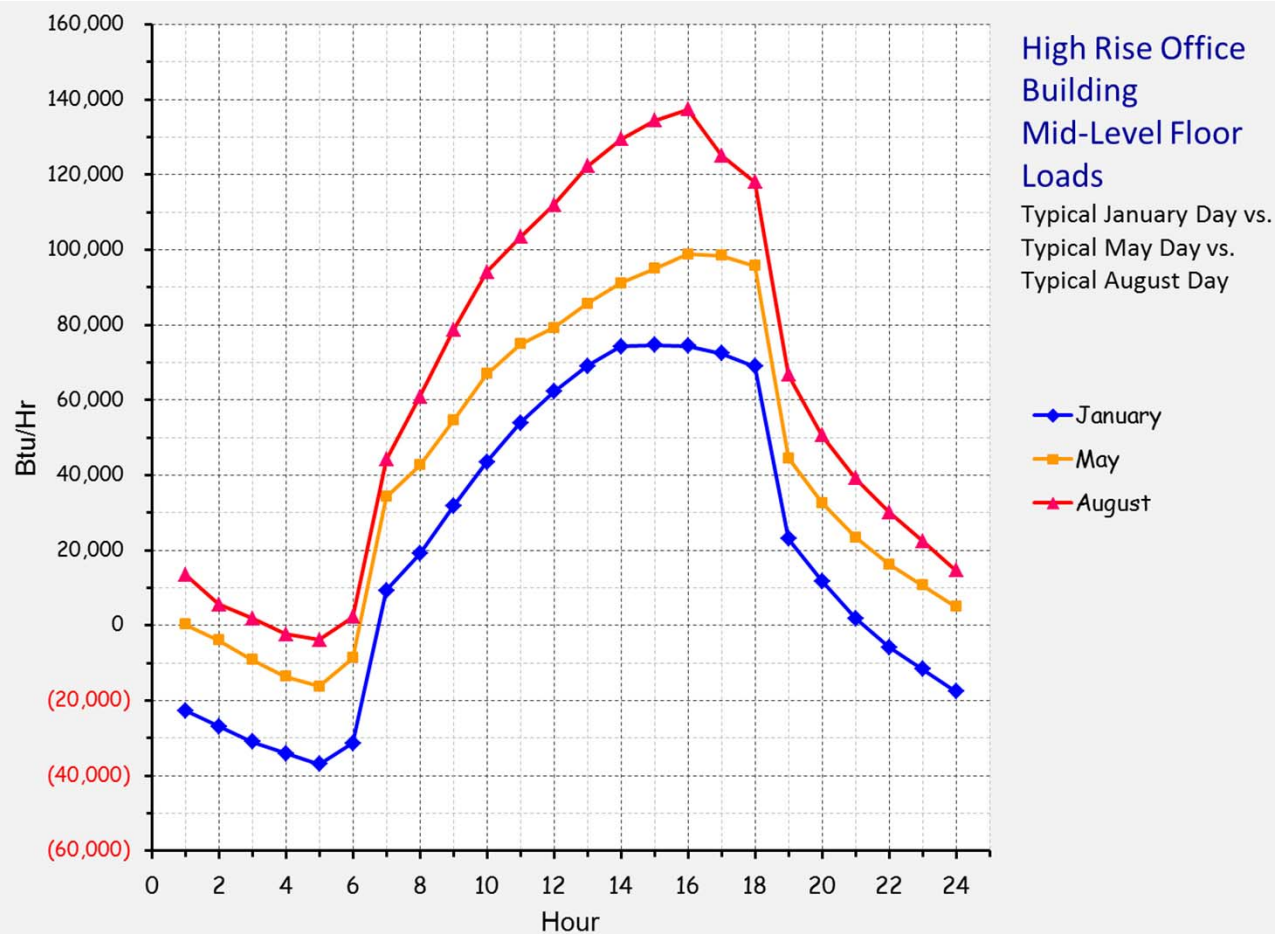
Cool the Building with Cool Outdoor Air

Simple in Concept; Challenging in Reality



Cool the Building with Cool Outdoor Air

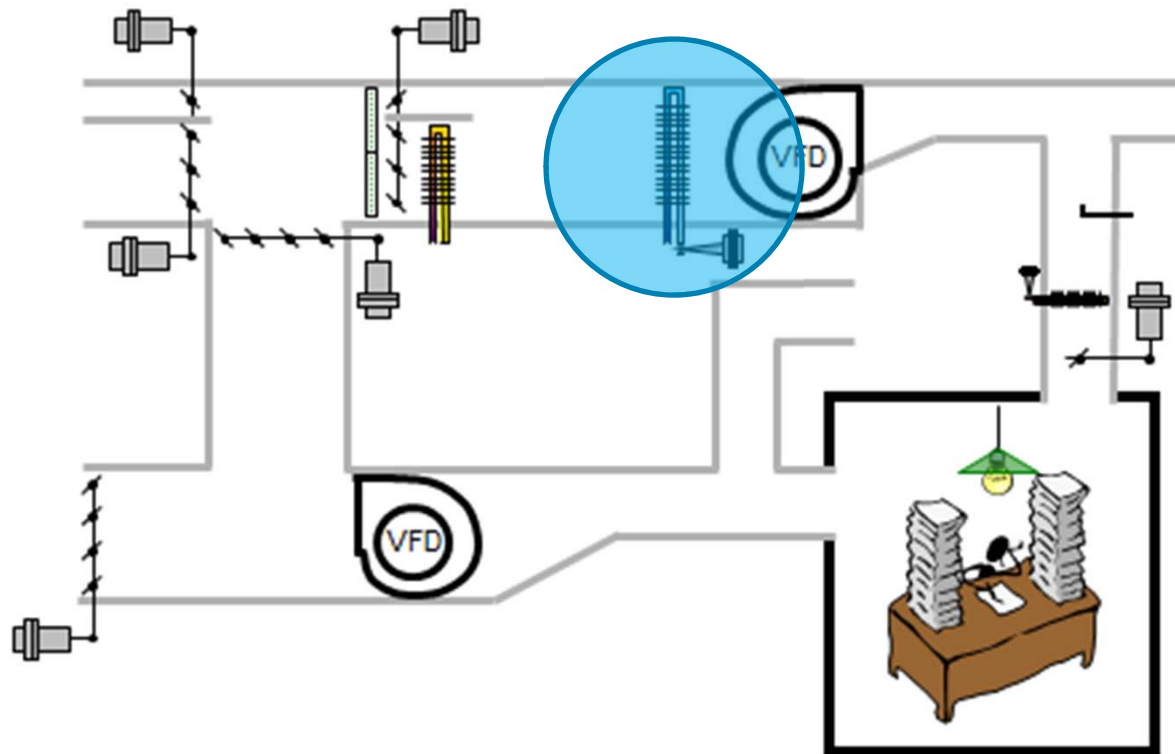
Simple in Concept; Challenging in Reality



The Cooling Requirements Vary with Time of Day and Time of Year

Cool the Building with Cool Outdoor Air

Simple in Concept; Challenging in Reality

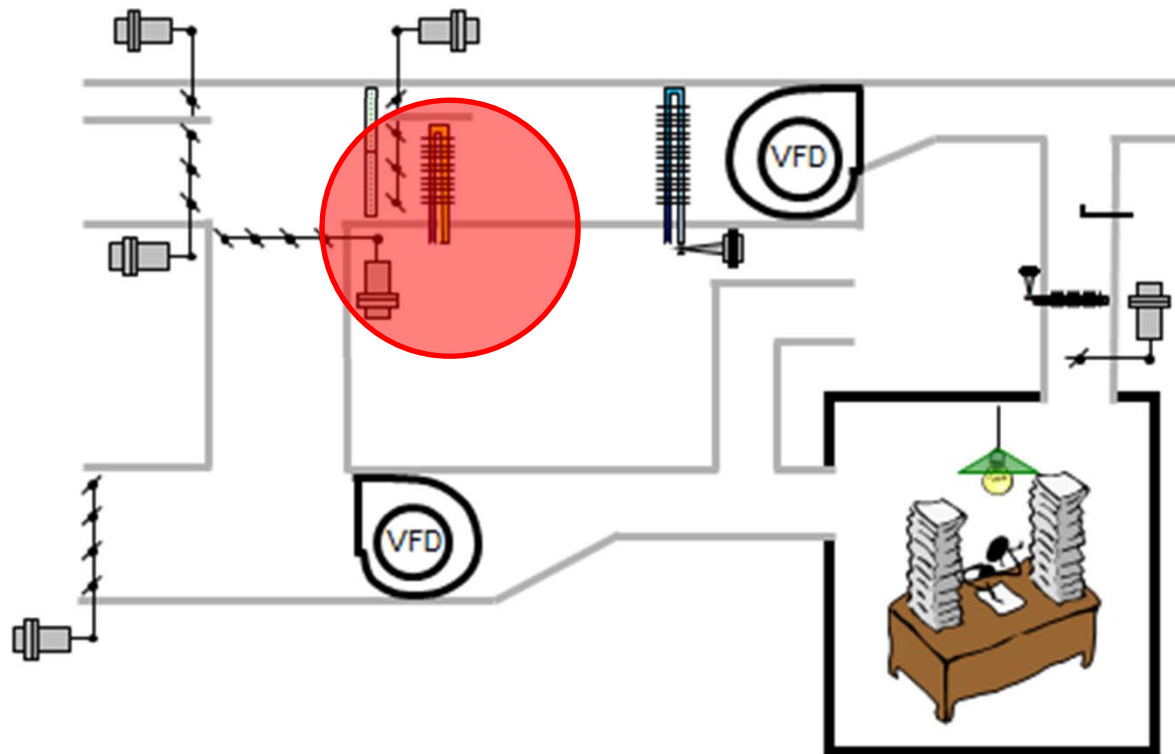


Economizers are a Cooling Process that must be Integrated with:

- Other cooling processes

Cool the Building with Cool Outdoor Air

Simple in Concept; Challenging in Reality

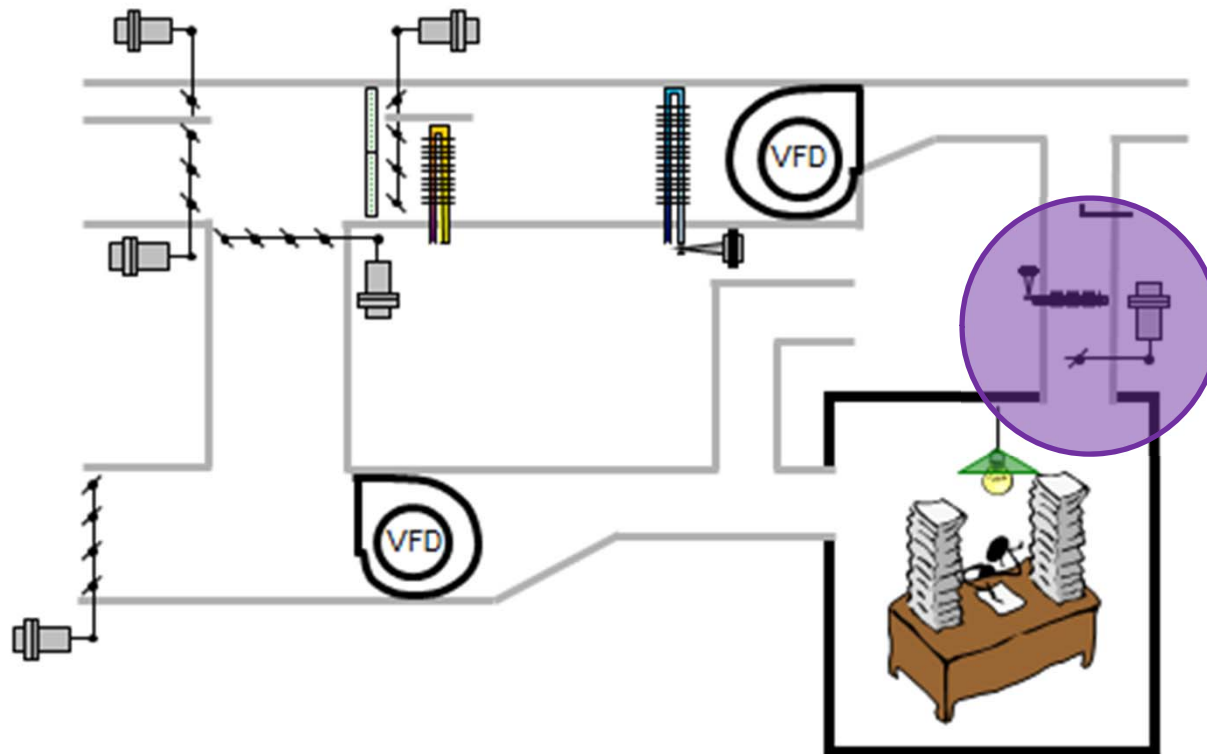


Economizers are a Cooling Process that must be Integrated with:

- Other cooling processes
- Preheat processes

Cool the Building with Cool Outdoor Air

Simple in Concept; Challenging in Reality

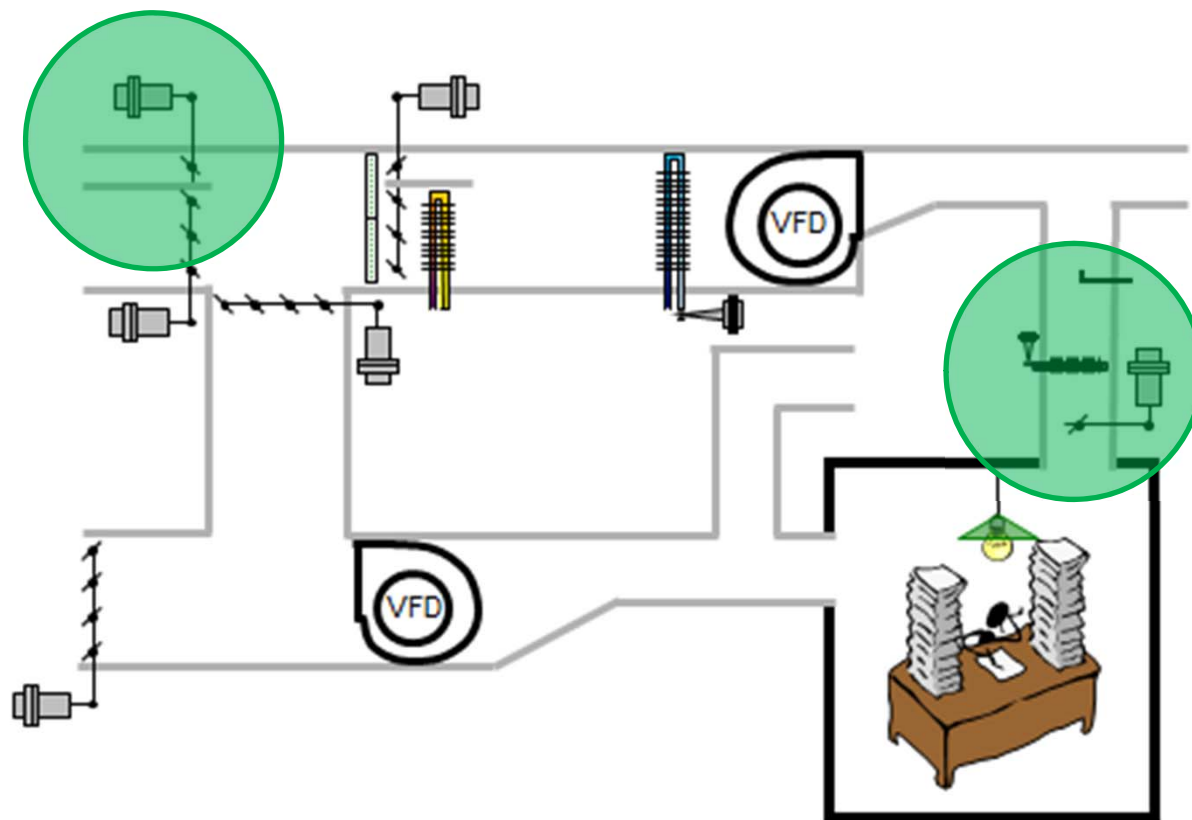


Economizers are a Cooling Process that must be Integrated with:

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- Preheat processes
- Zone control processes

Cool the Building with Cool Outdoor Air

Simple in Concept; Challenging in Reality

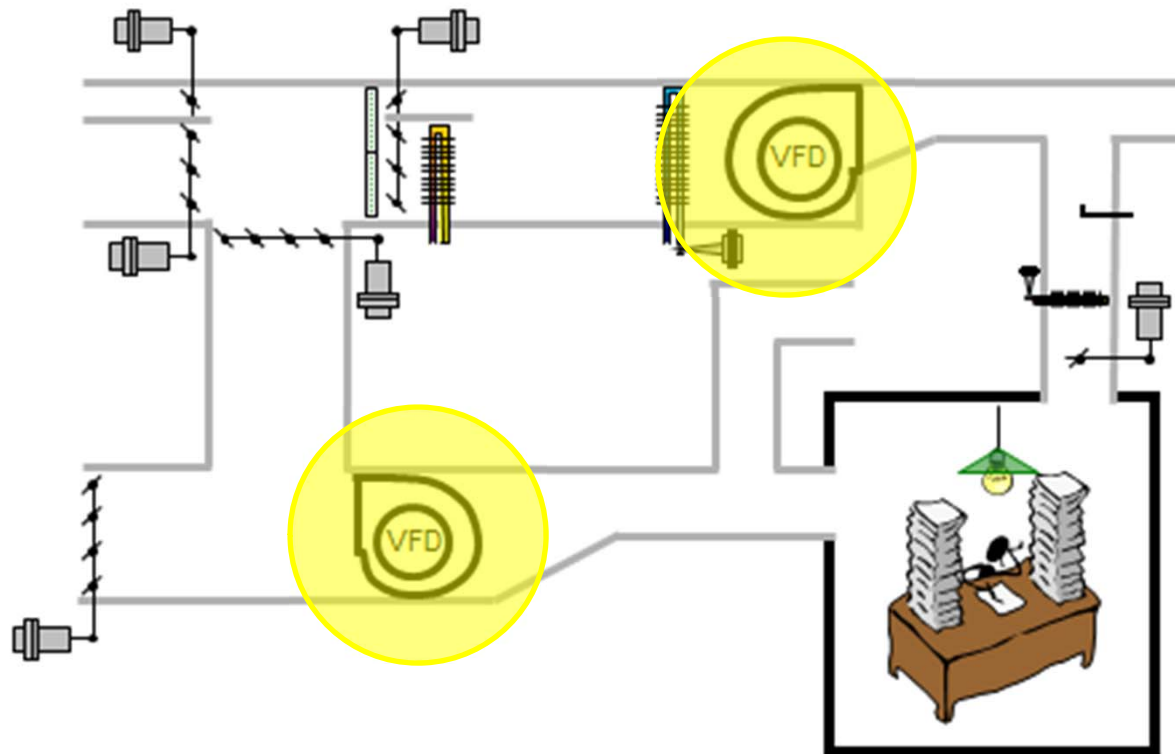


Economizers are a Cooling Process that must be Integrated with:

- Other cooling processes
- Preheat processes
- Zone control processes
- Ventilation processes

Cool the Building with Cool Outdoor Air

Simple in Concept; Challenging in Reality



Economizers are a Cooling Process that must be Integrated with:

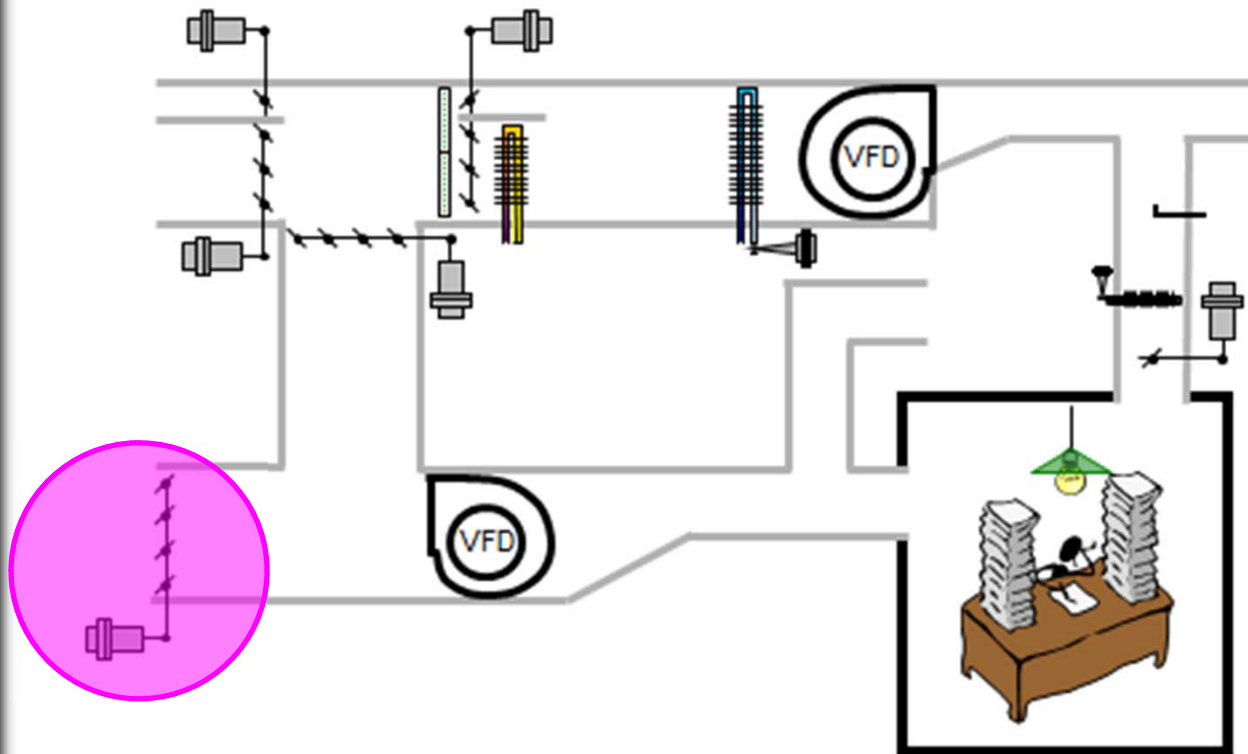
- Other cooling processes
- Preheat processes
- Zone control processes
- Ventilation processes
- Flow control processes

Cool the Building with Cool Outdoor Air

Simple in Concept; Challenging in Reality

Economizers are a Cooling Process that must be Integrated with:

- Other cooling processes
- Preheat processes
- Zone control processes
- Ventilation processes
- Flow control processes
- Pressure control processes



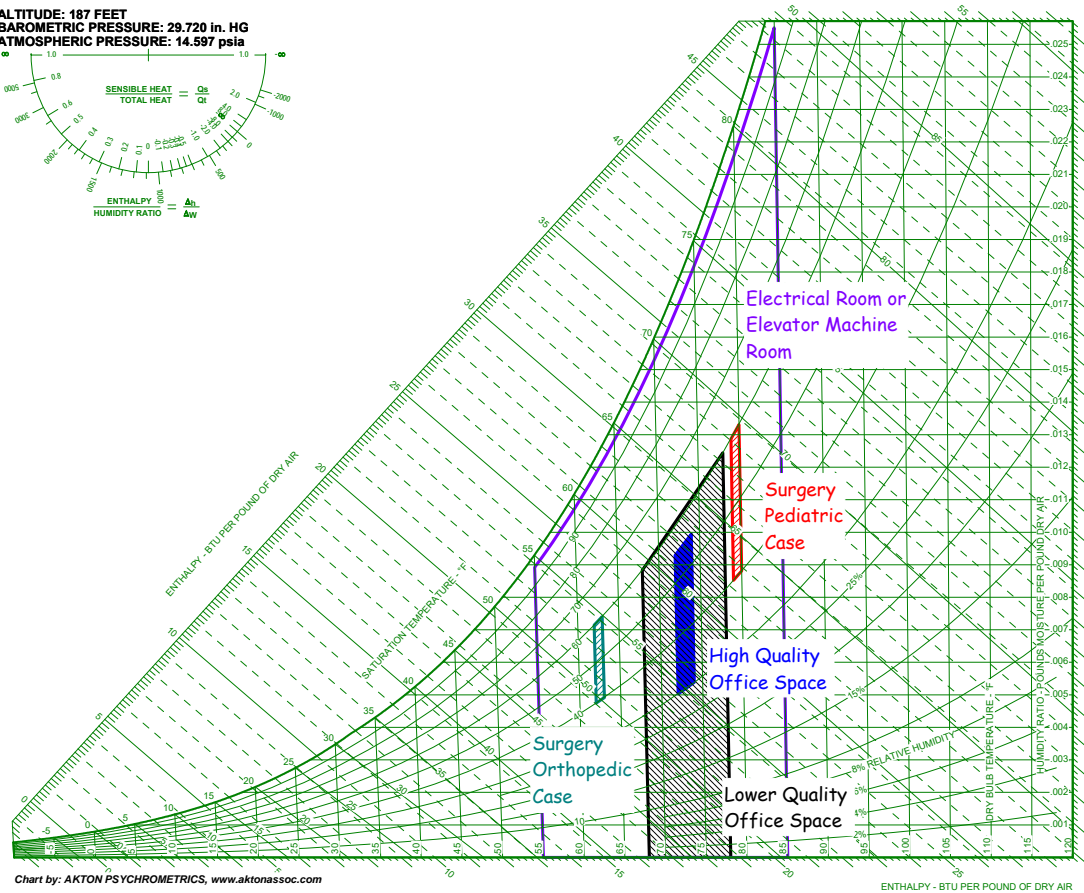
Cool the Building with Cool Outdoor Air

Simple in Concept; Challenging in Reality

ALTITUDE: 187 FEET
BAROMETRIC PRESSURE: 29.720 in. HG
ATMOSPHERIC PRESSURE: 14.597 psia

SENSIBLE HEAT
TOTAL HEAT = $\frac{Q_s}{Q_t}$

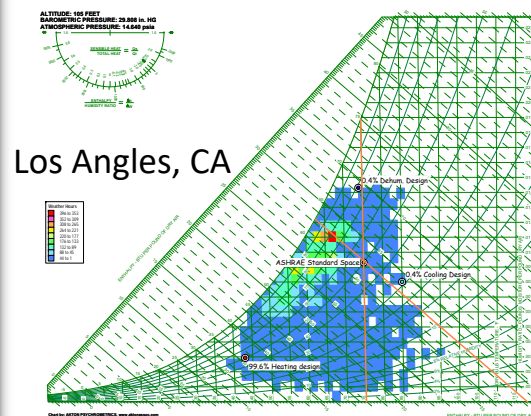
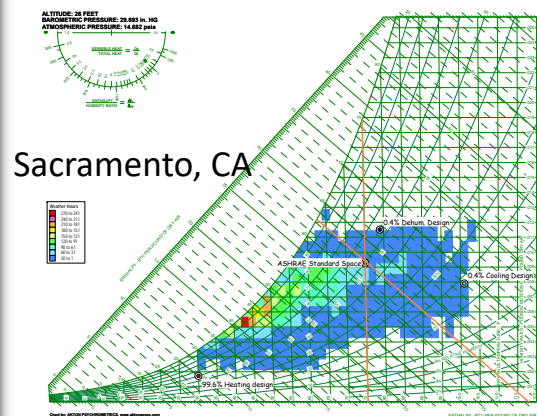
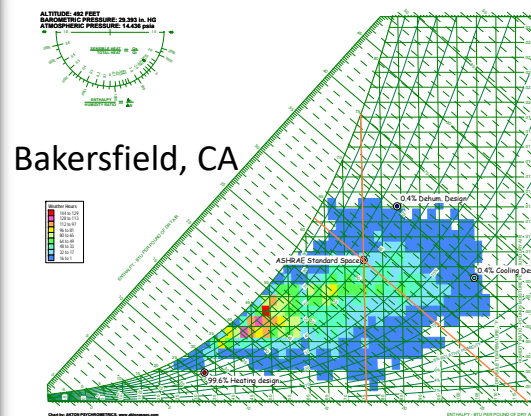
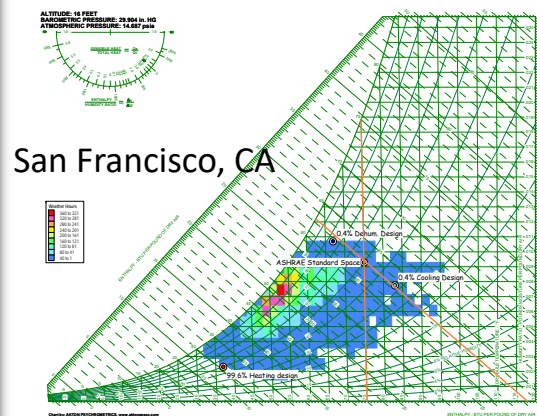
ENTHALPY
HUMIDITY RATIO = $\frac{h}{W}$



The Suitability of Outdoor Air for Cooling Varies with the Application

Cool the Building with Cool Outdoor Air

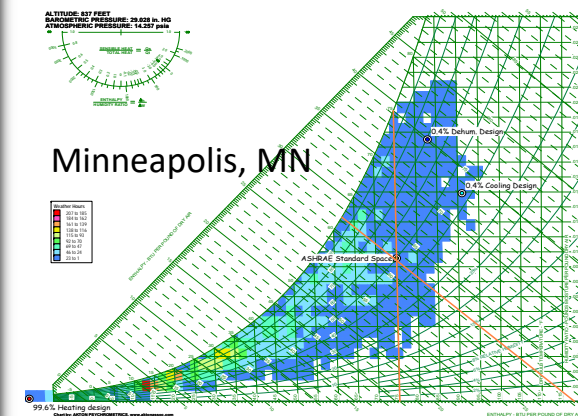
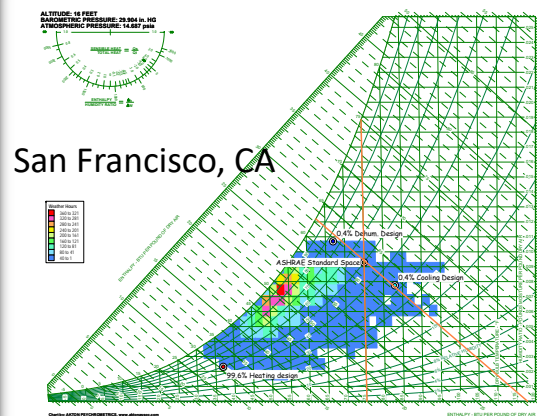
Simple in Concept; Challenging in Reality



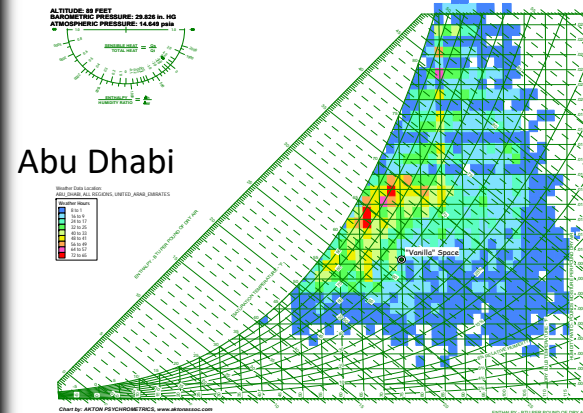
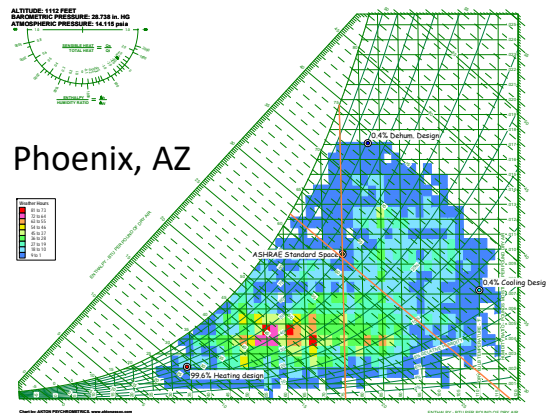
The Cooling Requirements Vary with Location as Dues the Suitability of Outdoor Air for Cooling

Cool the Building with Cool Outdoor Air

Simple in Concept; Challenging in Reality

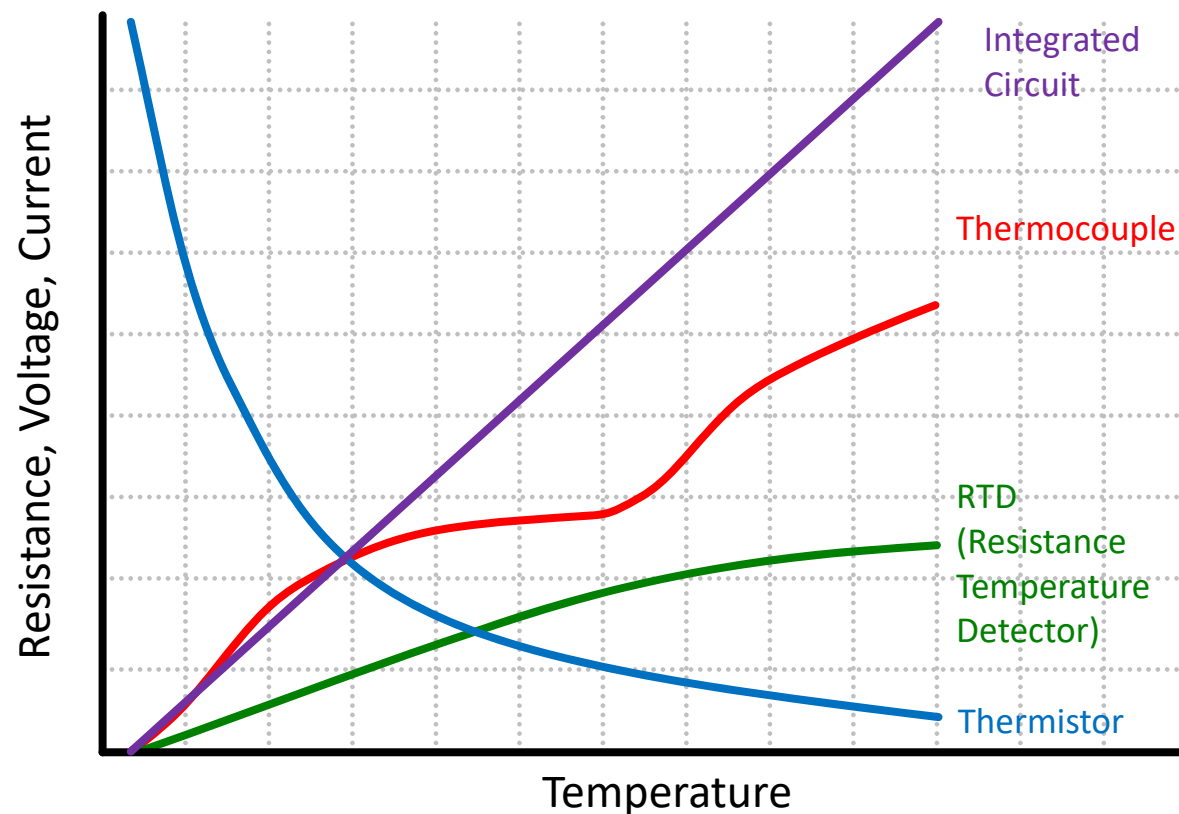


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Cool the Building with Cool Outdoor Air

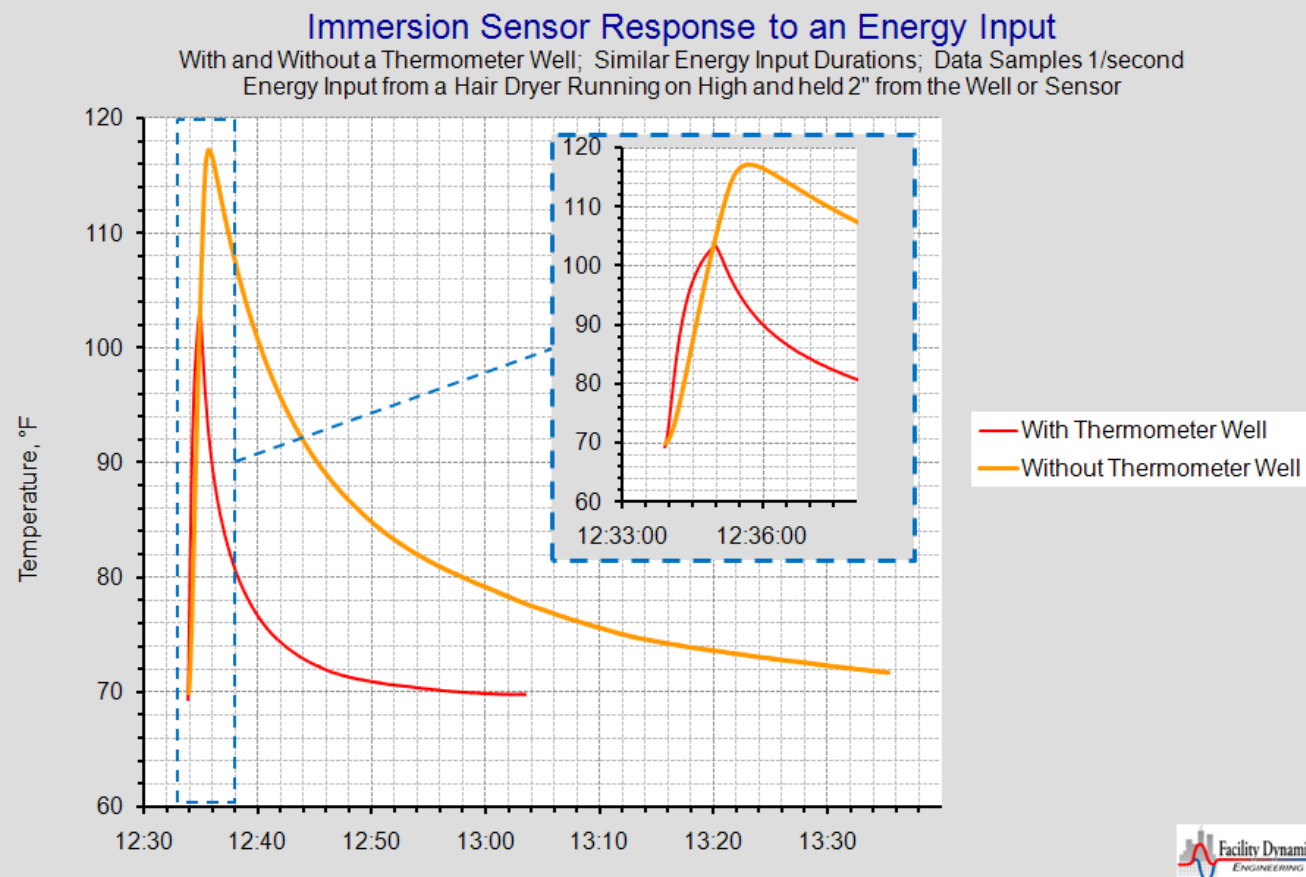
Simple in Concept; Challenging in Reality



The Sensors
Used to
Measure
Economizer
Parameters
Tend to be Non-
linear

Cool the Building with Cool Outdoor Air

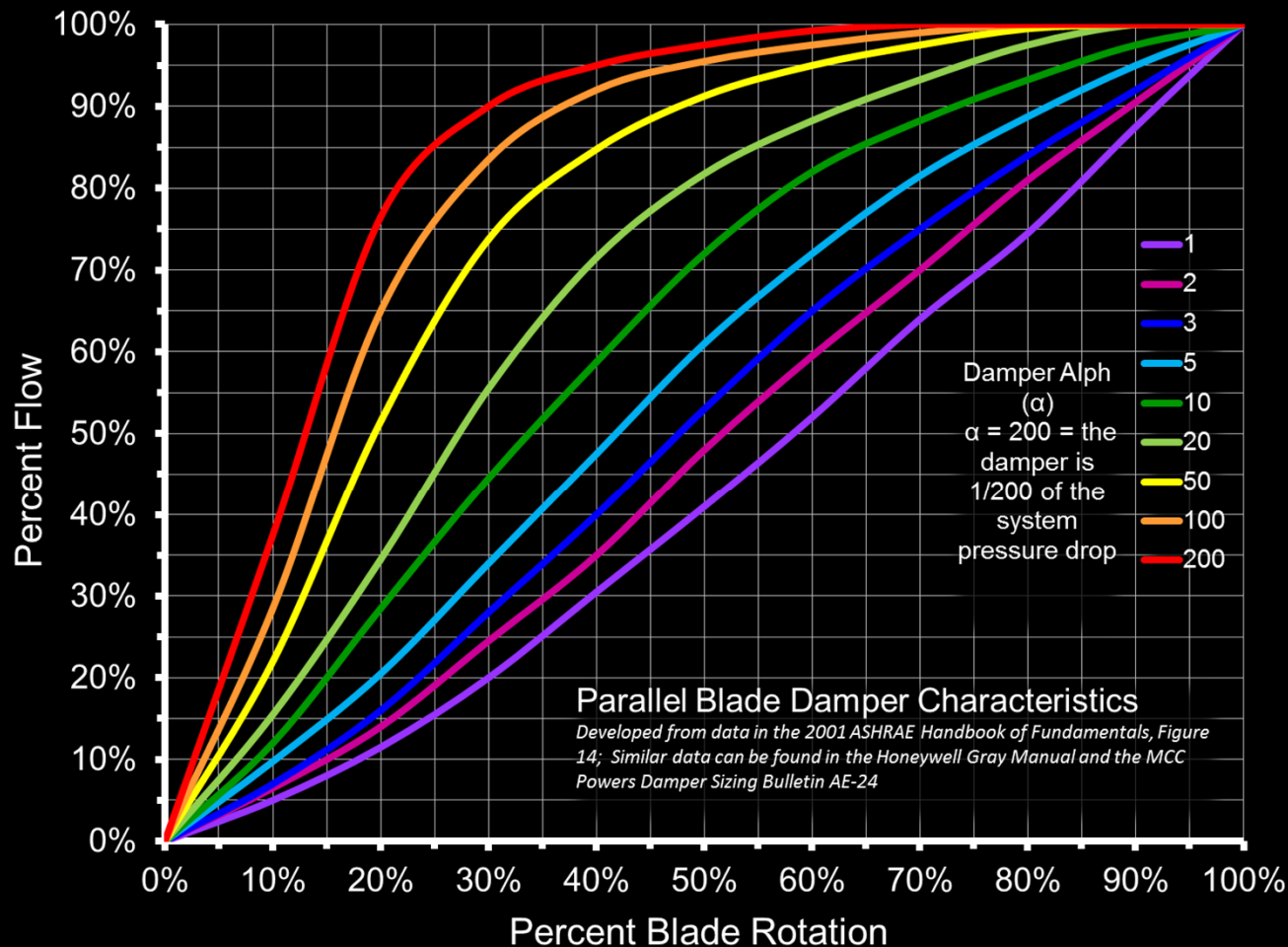
Simple in Concept; Challenging in Reality



The Sensors
Used to
Measure
Economizer
Parameters
Have Non-linear
Responses to a
Change

Cool the Building with Cool Outdoor Air

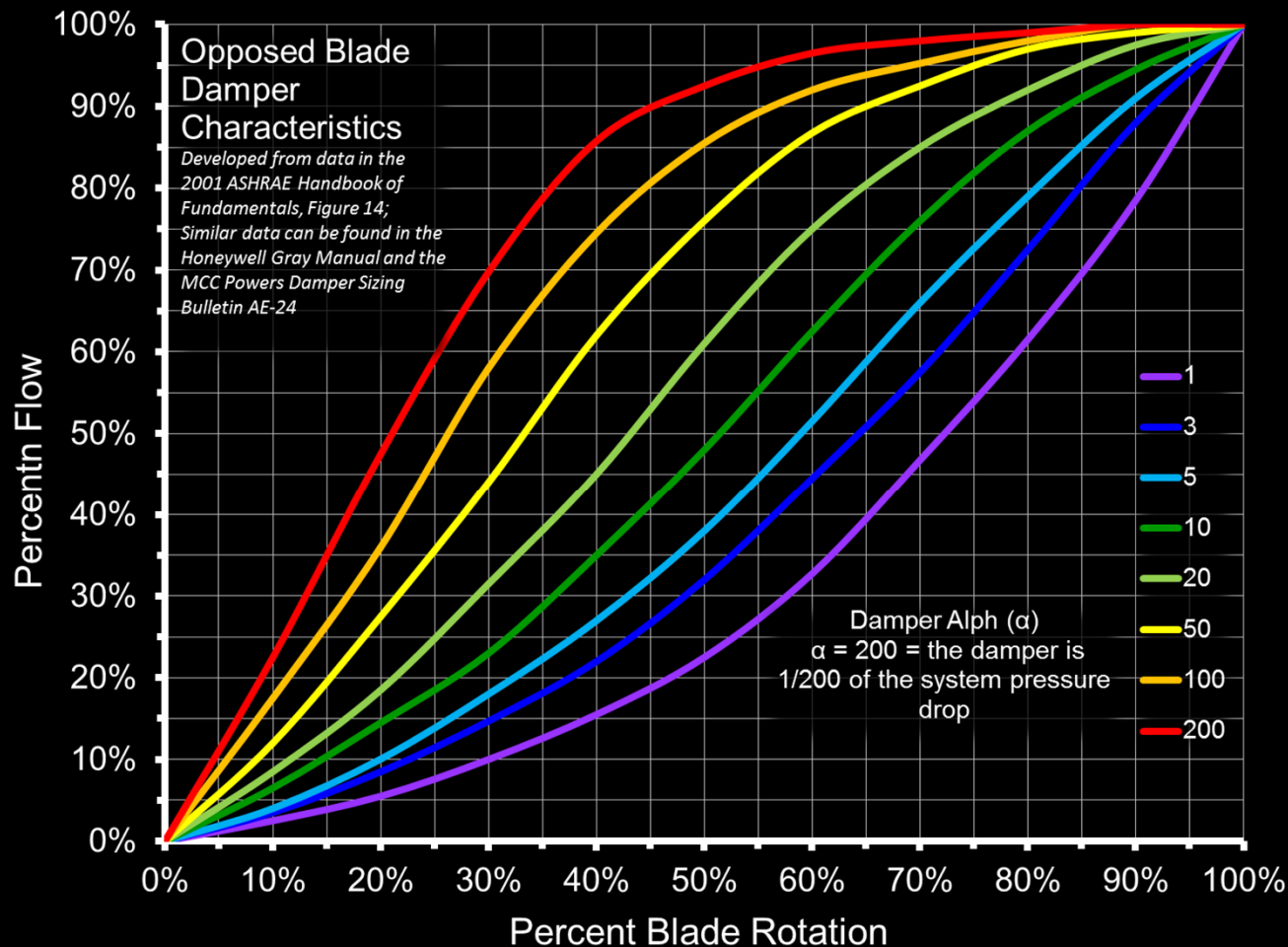
Simple in Concept; Challenging in Reality



The Final Control Elements Used to Control Economizers have Non-linear Characteristics

Cool the Building with Cool Outdoor Air

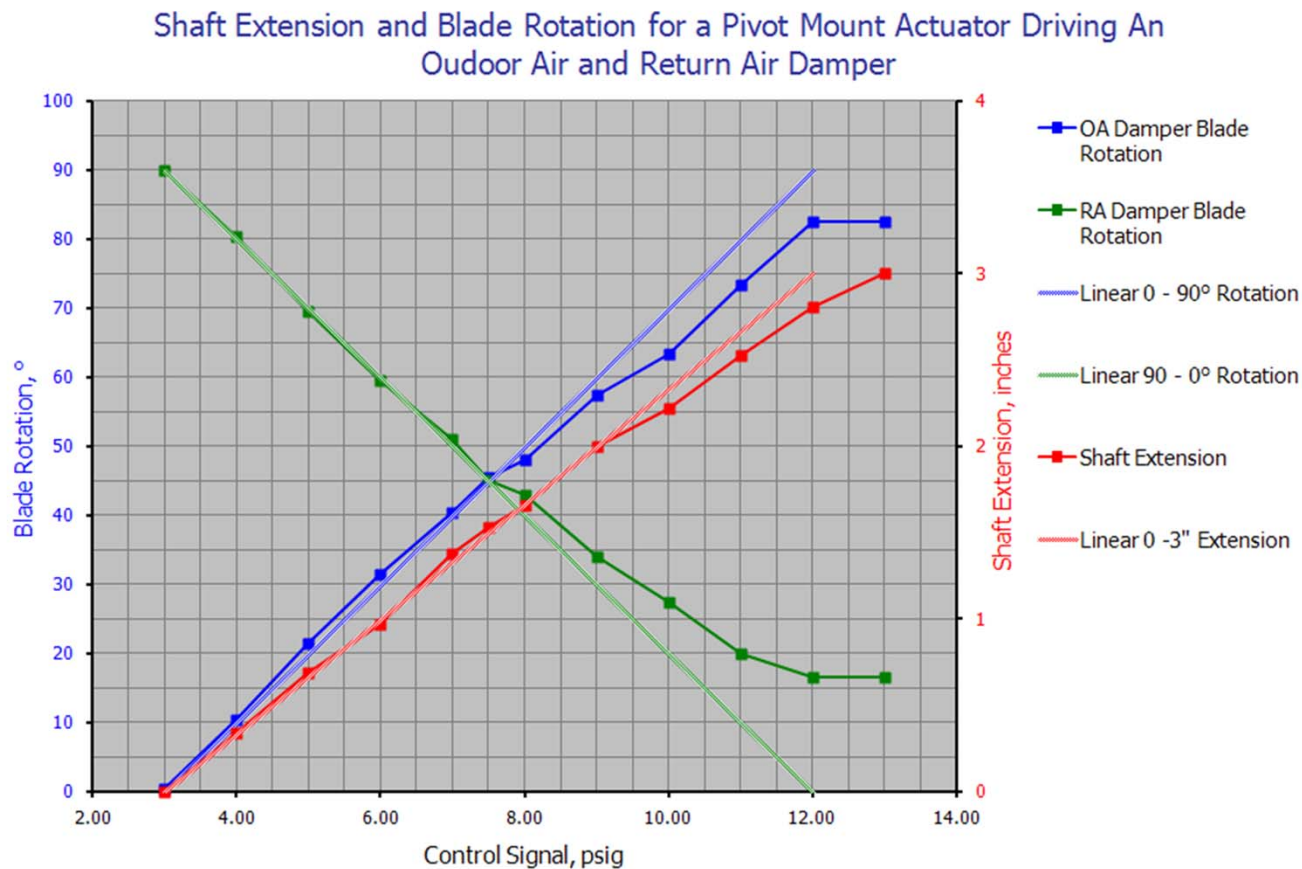
Simple in Concept; Challenging in Reality



The Final Control Elements Used to Control Economizers have Non-linear Characteristics

Cool the Building with Cool Outdoor Air

Simple in Concept; Challenging in Reality



The Linkage Systems Between the Actuators and Final Control Elements we Use with Economizers can be Non-linear

Cool the Building with Cool Outdoor Air

Simple in Concept; Challenging in Reality

Temperature Profile					
	24	24	24	24	24
24	69.4	69.8	70.1	69.9	69.9
24	69.6	69.2	69.4	69.2	69.9
24	68.7	68.9	68.9	68.7	69.6
24	68.7	68.9	68.3	68.9	69.6
Coldest			Hottest		
Minimum			Maximum		

The Temperature Distributions in the Mixing Plenum are Non-Uniform and Vary with Operating Conditions

Cool the Building with Cool Outdoor Air

Simple in Concept; Challenging in Reality

Velocity Profile					
	24	24	24	24	24
24	506	409	272	311	252
24	350	331	487	584	370
24	292	292	467	643	409
24	233	233	741	701	425
Slowest			Fastest		
Minimum			Maximum		

The Velocity Distributions and Related Mass Flow Rates in the Mixing Plenum are Non-Uniform and Vary with Operating Conditions

Cool the Building with Cool Outdoor Air

Simple in Concept; Challenging in Reality

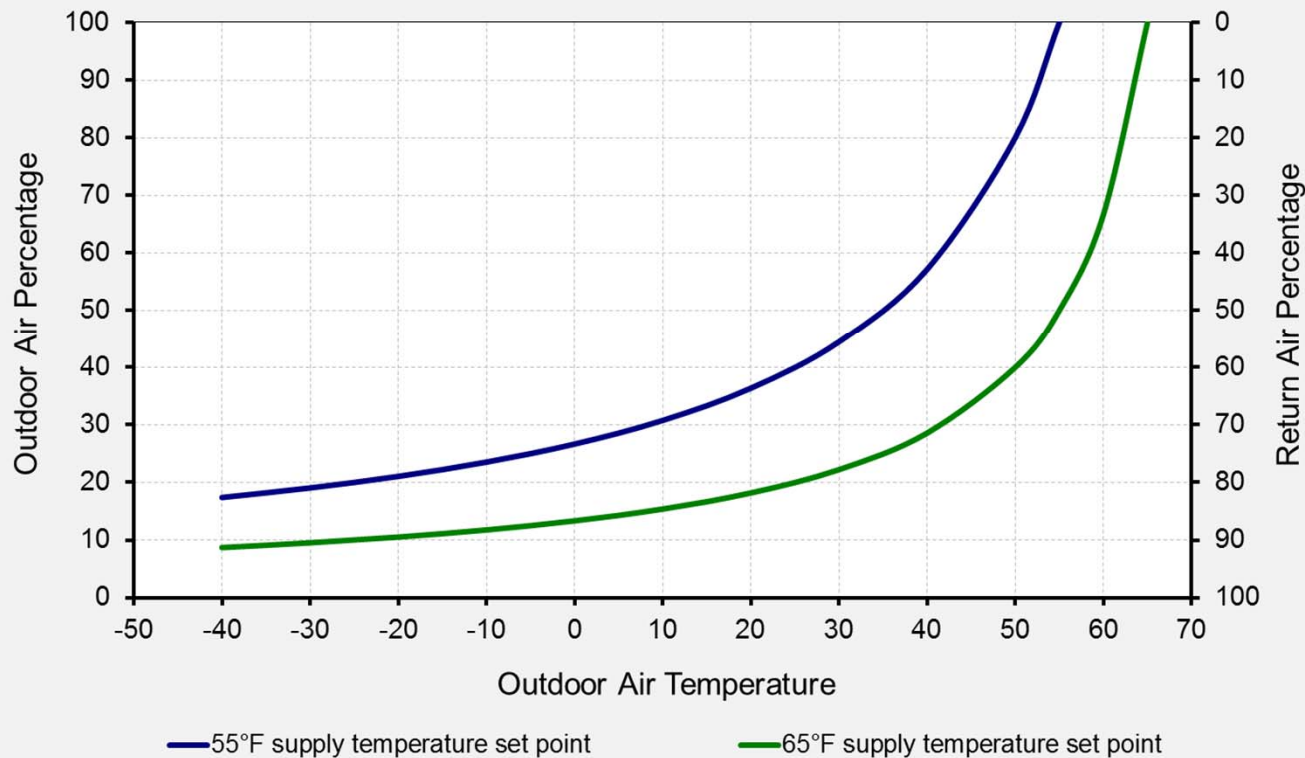


If the air is too cold, it can cause some problems

Cool the Building with Cool Outdoor Air

Simple in Concept; Challenging in Reality

Economizer Operating Curve



The Economizer Process Is Non-linear

Aside from those items, it should not be too hard to get an economizer to work

Why Focus a Class on Economizers?

PIER Economizer Research Results

Economizers show a high rate of failure in the study. Of the 215 units tested, 123 units were equipped with economizers. Of these, 30 units did not function, 36 units did not respond to the cold spray test, and an additional 13 displayed poor operation during the short-term monitoring period.

Why Focus on Economizers?

30 Simply not working

Why Focus on Economizers?

- 30 Simply not working
- + 36 No response to temperature change stimulus

Why Focus on Economizers?

- 30 Simply not working
- + 36 No response to temperature change stimulus
- + 13 Demonstrate very poor performance

Why Focus on Economizers?

- 30 Simply not working
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79 Failed Economizers

Why Focus on Economizers?

- 30 Simply not working
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79 Failed Economizers

79 Failed Economizers

Why Focus on Economizers?

- 30 Simply not working
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-

79 Failed Economizers

$$\frac{79 \text{ Failed Economizers}}{123 \text{ Tested Economizers}} =$$

Why Focus on Economizers?

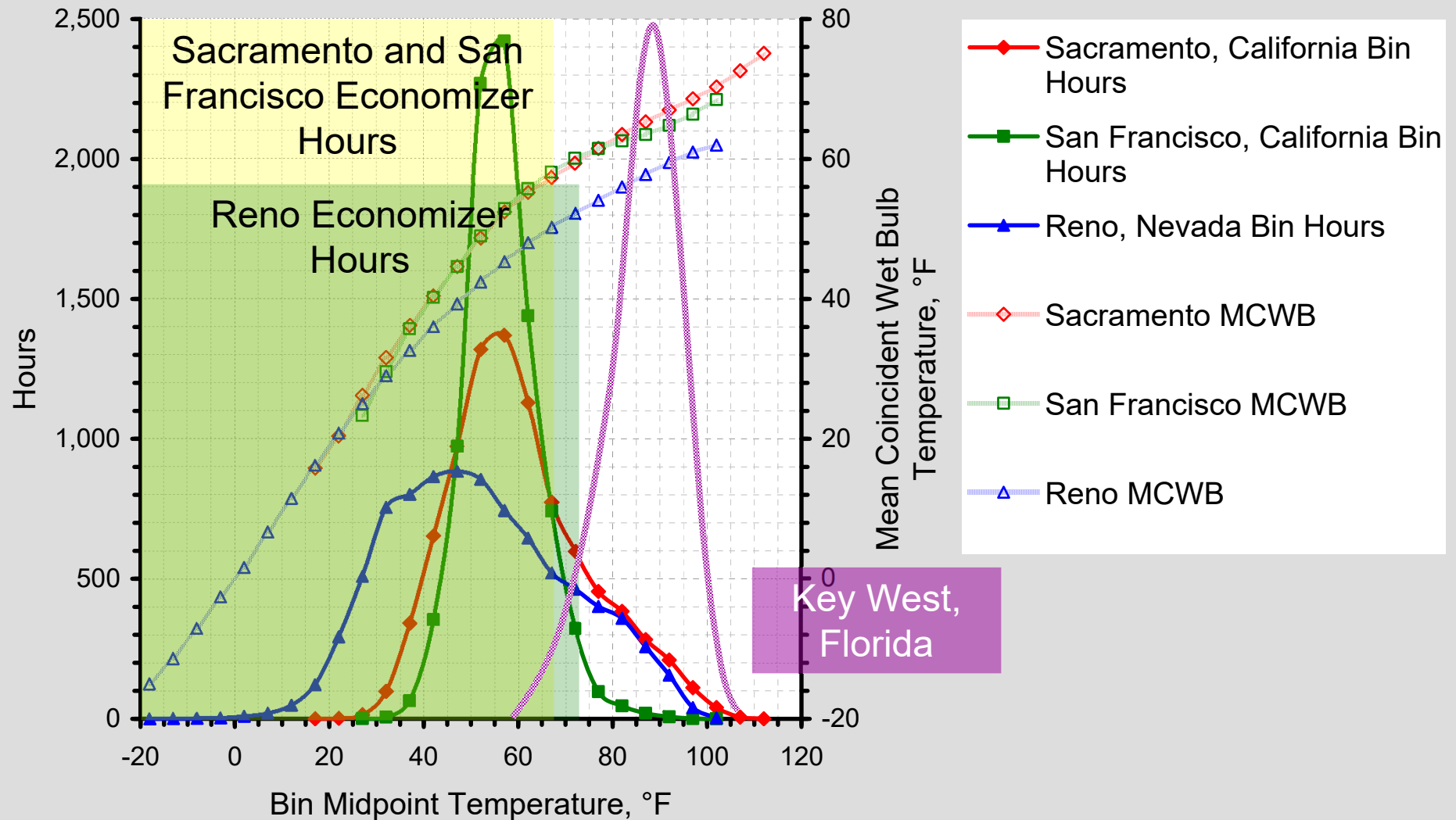
- 30 Simply not working
- + 36 No response to temperature change stimulus
- + 13 Demonstrate very poor performance

79 Failed Economizers

$$\frac{79 \text{ Failed Economizers}}{123 \text{ Tested Economizers}} = 64\% \text{ Failure Rate}$$

Why Go To All of That Trouble?

Hour at Different Temperatures
San Francisco, CA; Sacramento, CA and Reno, NV



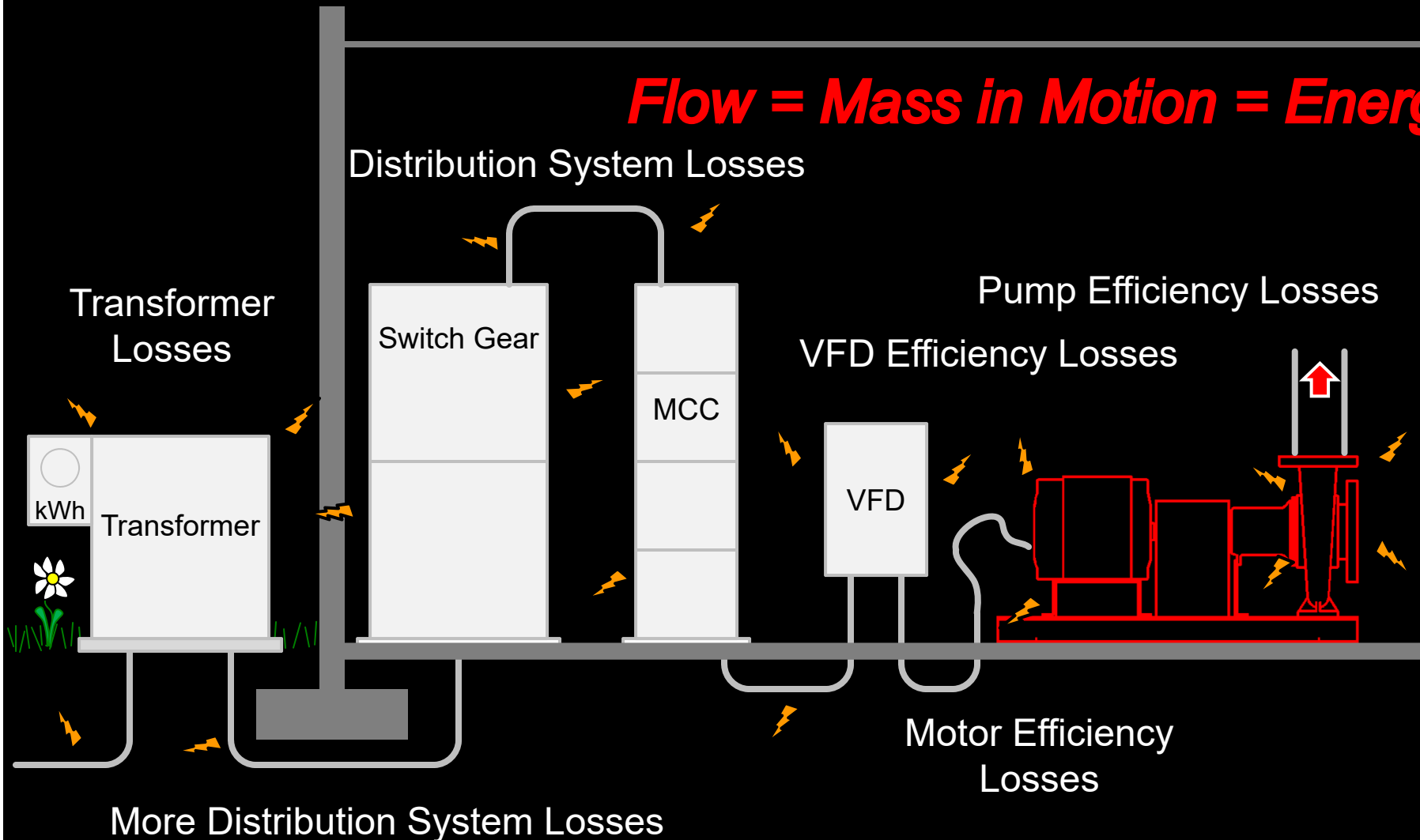
What's All This Trouble Worth?

A Lot in Many California Environments

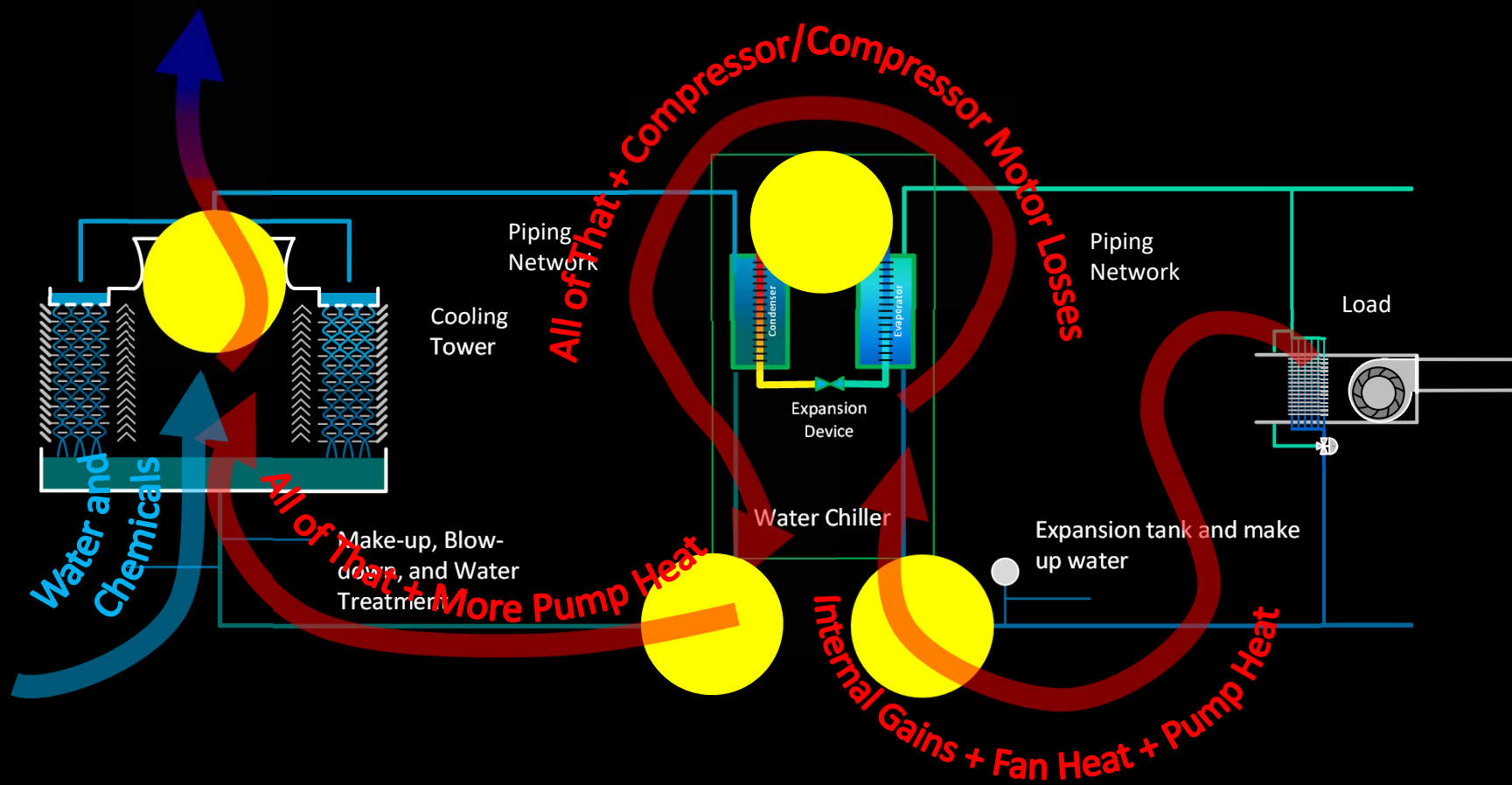
Economizer Savings for Different Size Office Buildings in Different Climates								
Location	30,000 square feet				250,000 square feet			
	Central Plant Cooling		Air Cooled DX Cooling		Central Plant Cooling		Air Cooled DX Cooling	
	kWh	\$	kWh	\$	kWh	\$	kWh	\$
San Francisco, California	22,100	\$3,300	34,400	\$5,200	184,100	\$27,600	286,300	\$42,900
Sacramento, California	17,300	\$2,600	26,900	\$4,000	144,300	\$21,600	224,400	\$33,700
Reno, Nevada	22,000	\$3,300	34,200	\$5,100	183,100	\$27,500	284,800	\$42,700

A Bigger Perspective on Unloading the Cooling Coil

Flow = Mass in Motion = Energy



A Bigger Perspective on Delivering Mass in Motion



Fossil Fuel Base Generation Has Ripple Effects

Conservation of mass and energy says that the most of the mass of all of this coal will eventually show up as gasses going up the stack

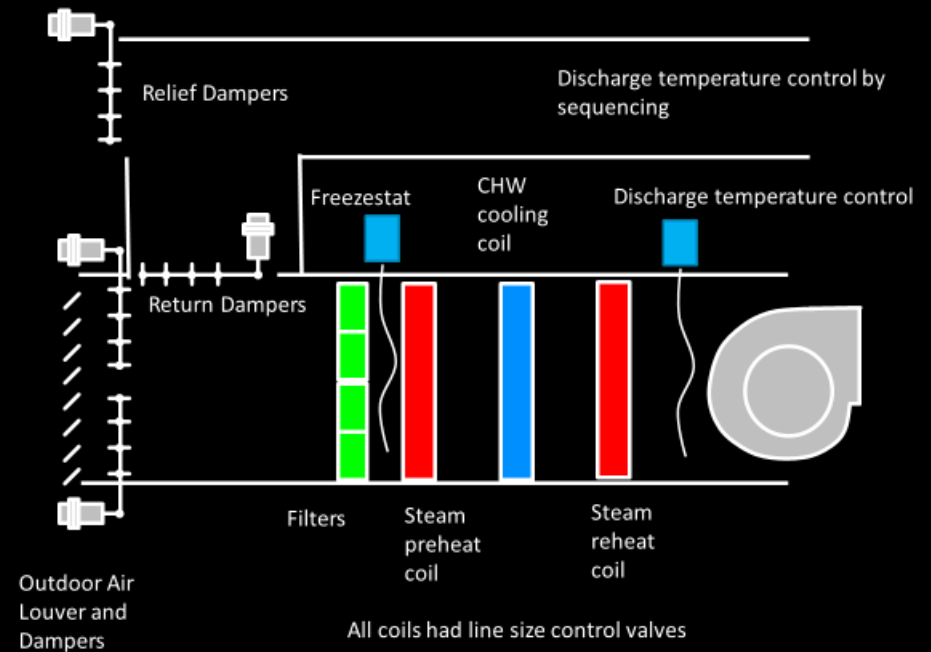
- Most plants run on electricity
- A lot of electricity comes from fossil fuel
 - The current heat rate for fossil fuel plants is about 10,000 Btu/kWh
 - A kWh is 3,413 Btu

Bottom Lines

- Modern buildings often require year round cooling and economizer cycles endeavor to meet that need by using cold outdoor air one way or another
- Building dynamics are complex
- While simple on concept, economizers are complex to implement successfully
- Delivering a successful economizer process
 - Deliver savings to the system it serves
 - Deliver savings in the utility systems serving the economizer equipped system
 - Generate positive ripple effects all the way back to the energy source

Lets Review

What Are the Parts of an Economizer?



ECONOMIZERS; WHAT THEY ARE AND WHY WE USE THEM

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