

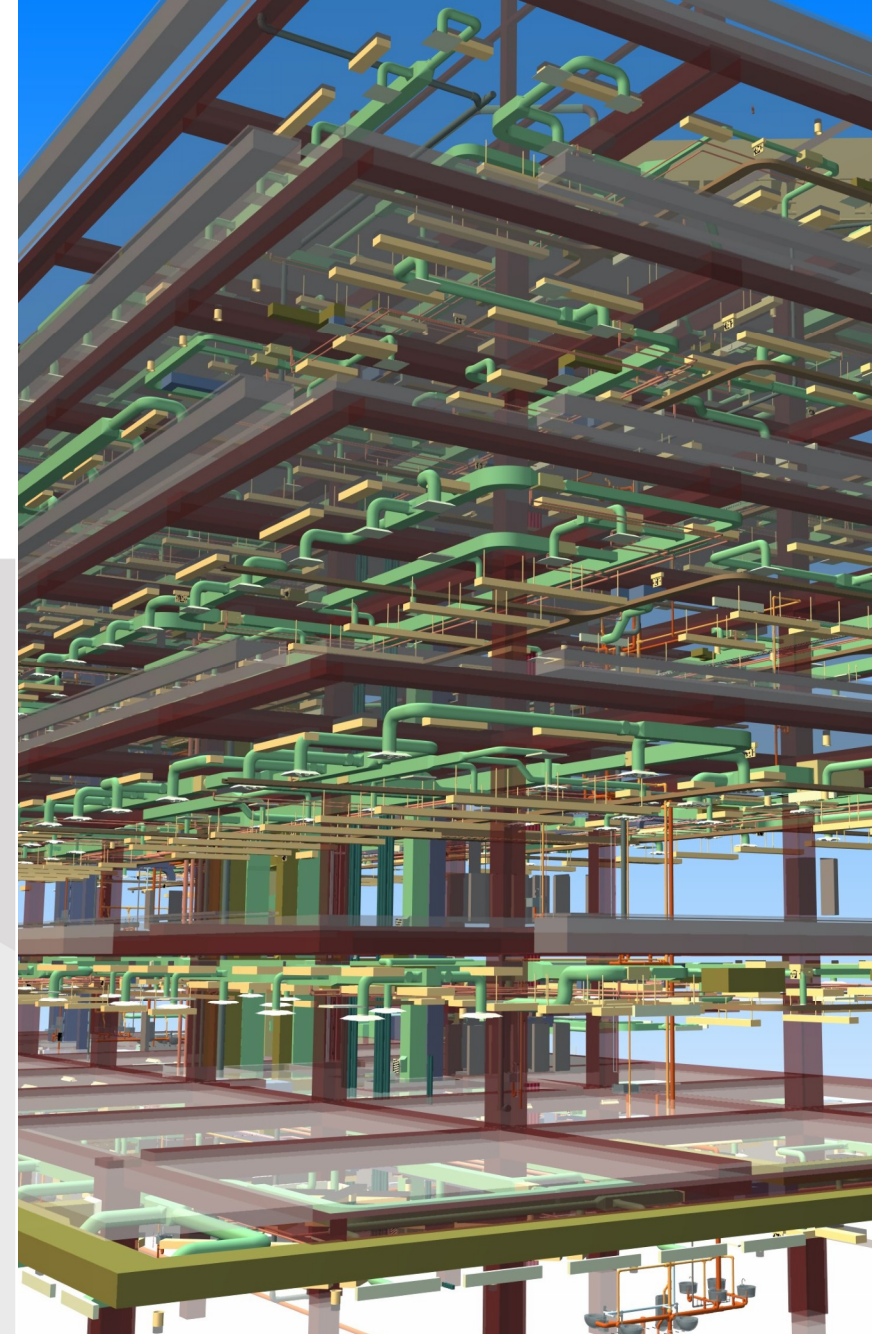


Mason & Hanger

A Day & Zimmermann Company

High Performance Building Technologies that (Still) Make Sense

SAME Annual Program Review, Savannah, GA



Agenda

- » Housekeeping
- » Introduction
- » Current state of high-performance building requirements and acknowledgement of uncertainty ahead
- » Building technologies and practices that have matured in the past 20 years
- » Reasons for optimism



Introduction

Your Speakers

» **Evan Riley, PE, BEMP, LEED AP BD+C**

Senior Energy and Sustainability Engineer

Mason & Hanger (A Day & Zimmermann Company)



» **Rob McAtee, PE, CEM, LEED AP BD+C**

Director of Energy and Sustainability Services

Mason & Hanger (A Day & Zimmermann Company)

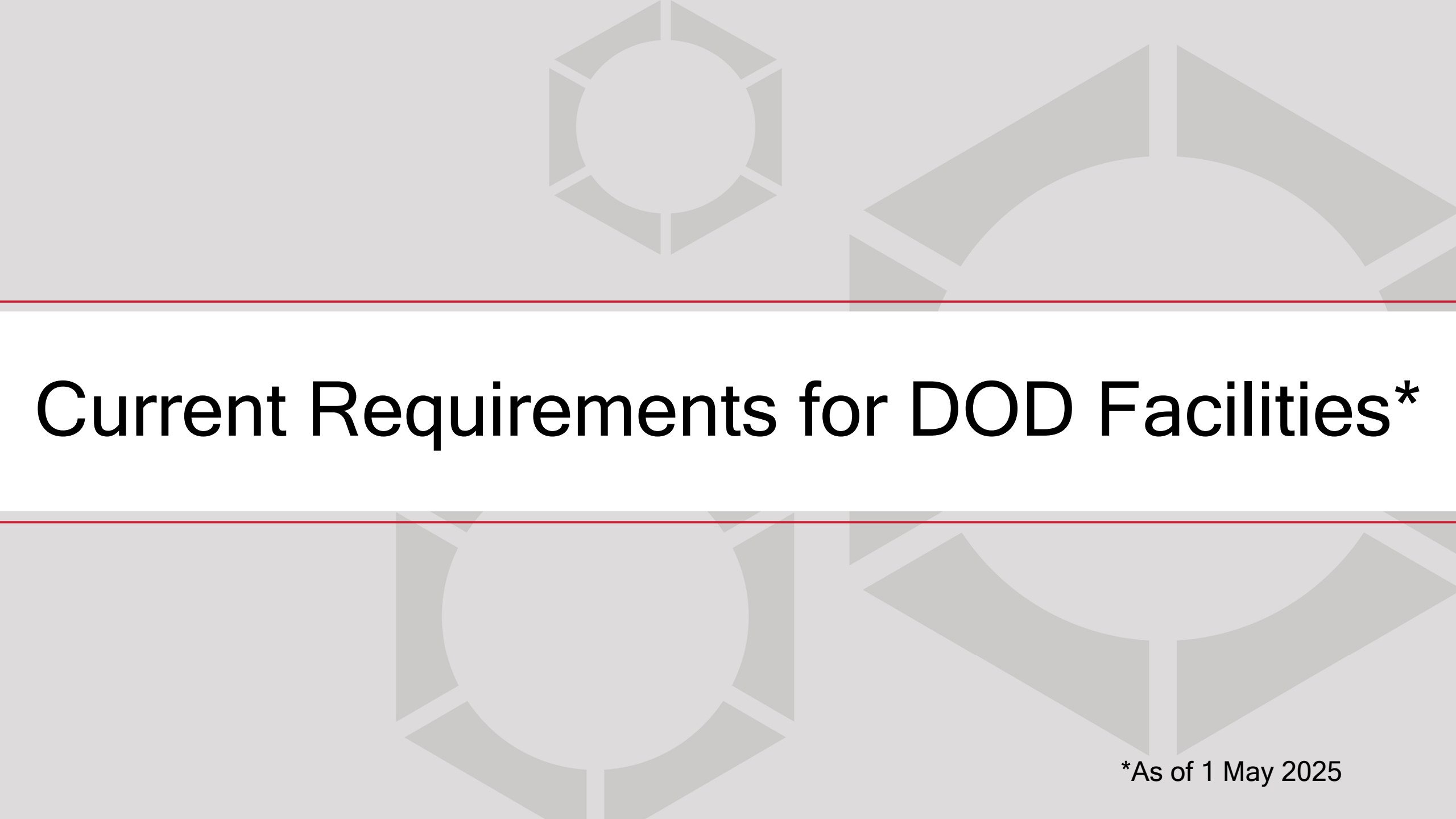


Introduction

- » Acknowledging the push and pull of ideas
 - » “Wood stove and a window” vs. State of the art facilities
 - » “Leave innovation to the private sector” vs. “Lead by example”
- » Aggressive targets
- » Rescinding of mandates
- » Good design still works. LCCA is still important
- » Examples of how buildings have gotten better

What do we want to say? (won't show this slide)

- » Federal building energy requirements have gotten increasingly more stringent. (examples 90.1-2019, electrification)
- » With the new administration, it is likely that these requirements will be significantly relaxed or even removed.
- » Before we abandon everything, it's worth reviewing technologies and practices that have proven to be life-cycle cost effective and have become part of best practices for building design and performance.
- » These have been gathered from the past 20 years, which coincides with the adoption of the Energy Policy Act of 2025.
- » Rob McAtee has been part of the entire journey and is a bitter, jaded, old man because of it.
- » Evan Riley has also lasted these 20 years but somehow remains cheerful and optimistic.



Current Requirements for DOD Facilities*

*As of 1 May 2025

Current State of Energy and Sustainability Requirements

ENERGY POLICY ACT OF 2005

» (EPACT)

- » Required all federal buildings to meet 30% energy reductions.
- » Basis of comparison was **ASHRAE Standard 90.1-2004**



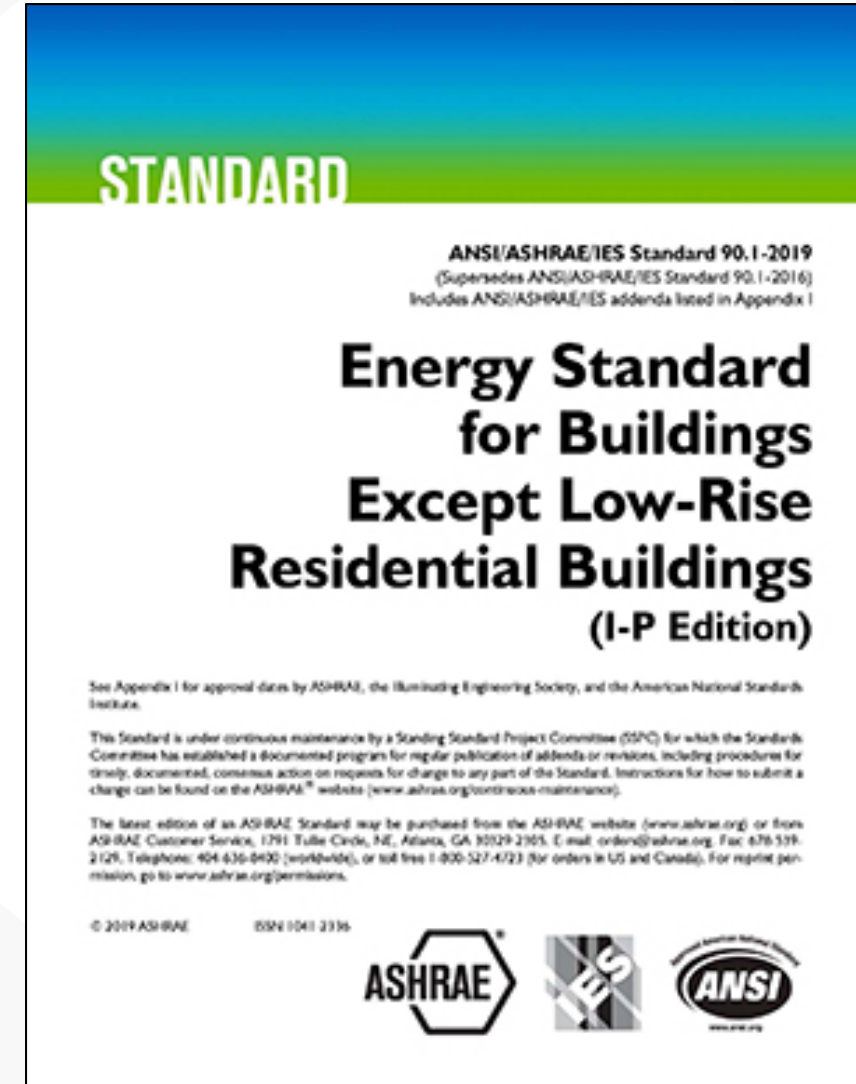
Current State of Energy and Sustainability Requirements

» Energy Independence and Security Act (EISA), 10 CFR 433

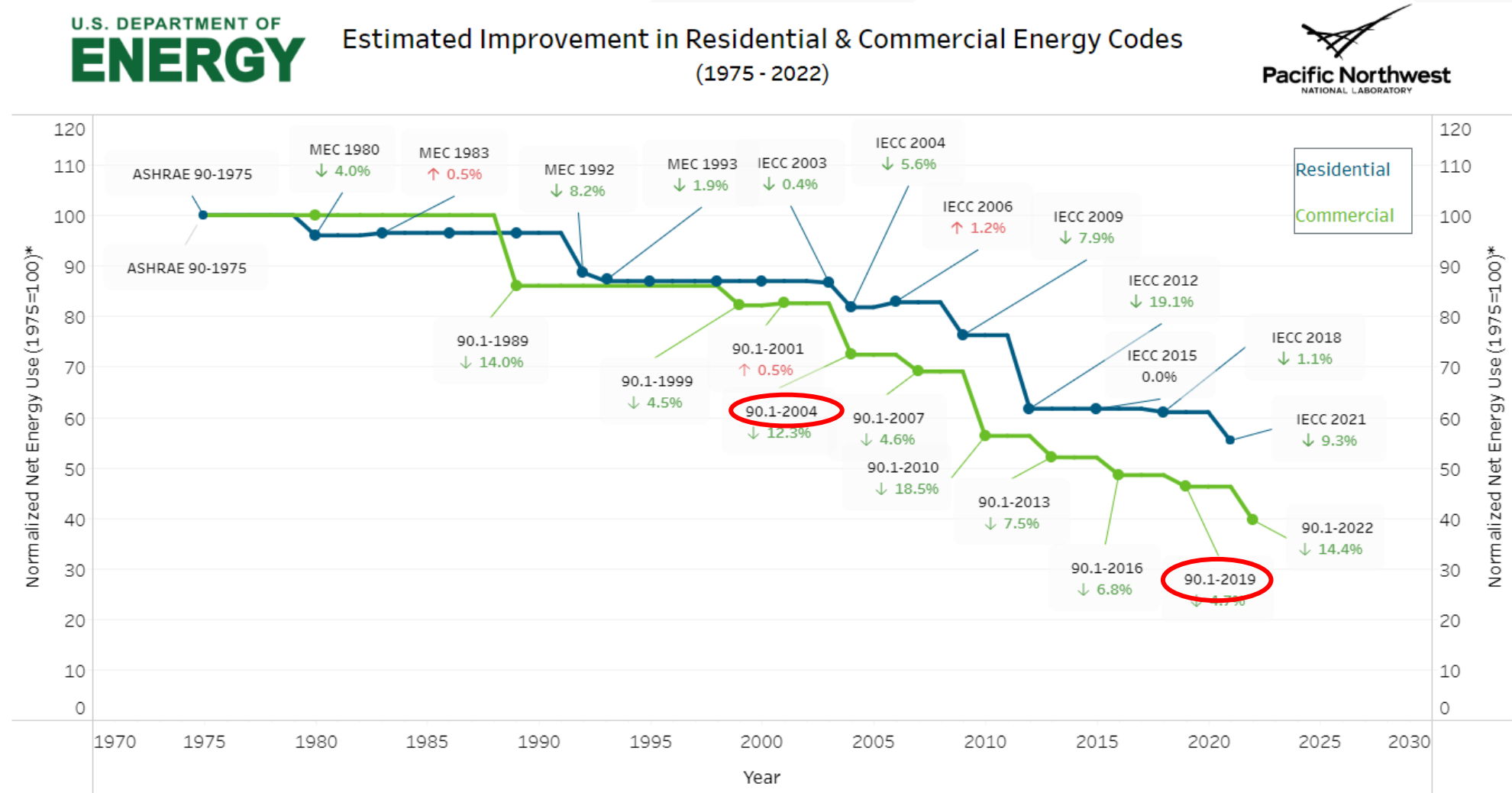
» Implements EPACK

» Updated to require comparison using the more-stringent

ASHRAE 90.1-2019



ASHRAE Standard Progressively Better



*Net energy use includes the contribution of renewable energy generation

» UFC 1-200-02

- » DOD document that implements EPACT
- » Previously, 30% savings calculated based on simple energy improvements predicted by models that met the then-current ASHRAE standard (2013).

UFC 1-200-02
01 DECEMBER 2020
Change 02, 01 JUNE 2022

UNIFIED FACILITIES CRITERIA (UFC)

HIGH PERFORMANCE AND SUSTAINABLE BUILDING REQUIREMENTS



Energy Performance Calculation

» Now, UFC 1-200-02 ...

- » Returns to 2004 basis, but....
- » Includes process loads
- » Stiff building performance improvement factor

$$PCI_{target} = \frac{[Baseline \text{ Unregulated Energy Cost} + (Building \text{ Performance Factor} \times Baseline \text{ Regulated Energy Cost})]}{Total \text{ Baseline Energy Cost}}$$

- The **Building Performance Factor** lowers the target energy use by dramatically reducing the regulated, i.e., non-process loads of the **2004**-equivalent baseline.

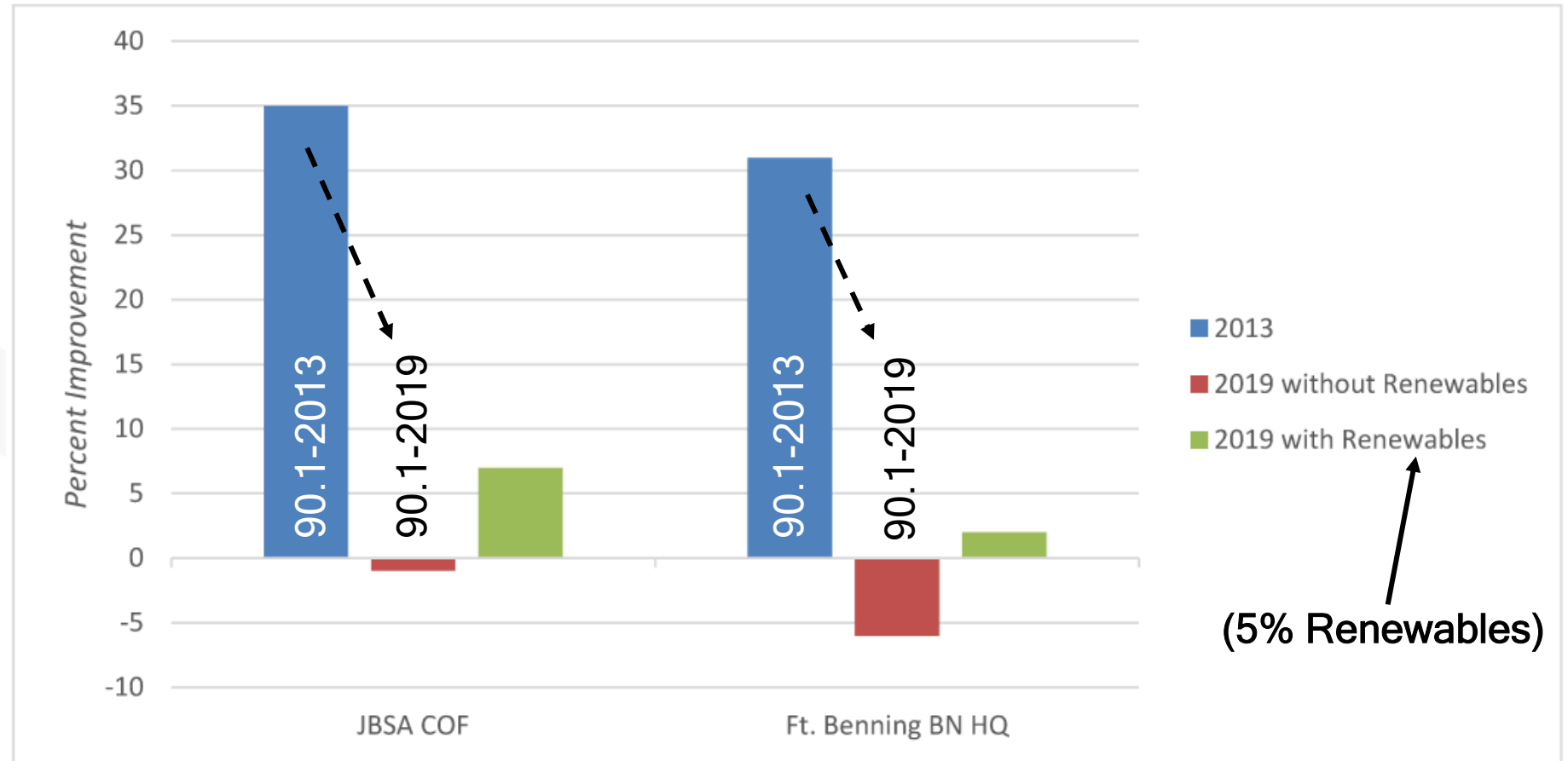
Table 4.2.1.1 Building Performance Factor (BPF)

Building Area Type	Climate Zone												
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A
Multifamily	0.69	0.68	0.71	0.70	0.72	0.72	0.71	0.76	0.63	0.69	0.76	0.71	0.6
Healthcare/hospital	0.69	0.69	0.70	0.68	0.67	0.65	0.65	0.66	0.64	0.64	0.66	0.63	0.6
Hotel/motel	0.66	0.66	0.69	0.65	0.65	0.64	0.64	0.65	0.65	0.63	0.65	0.63	0.6
Office	0.54	0.54	0.53	0.52	0.52	0.52	0.50	0.54	0.48	0.48	0.53	0.48	0.4
Restaurant	0.62	0.59	0.57	0.57	0.57	0.53	0.57	0.53	0.51	0.55	0.54	0.54	0.5
Retail	0.51	0.49	0.48	0.48	0.44	0.43	0.43	0.43	0.44	0.42	0.43	0.46	0.4
School	0.52	0.57	0.57	0.56	0.52	0.53	0.52	0.49	0.50	0.46	0.47	0.47	0.4
Warehouse	0.26	0.26	0.22	0.25	0.21	0.22	0.25	0.21	0.19	0.25	0.22	0.22	0.2
All others	0.62	0.60	0.62	0.59	0.55	0.51	0.53	0.52	0.55	0.53	0.52	0.55	0.5



Energy Performance Calculation

- » The difference looks like this from USACE studies of two military buildings (ECB 2023-1)
- » But can still get there with renewables.



Energy Performance Calculation

- » There may be relief on the horizon.
- » Addenda to ASHRAE 90.1-2019 allow other ways to calculate savings.
 - » Greenhouse gas emissions savings
 - » Site energy (as opposed to energy cost) savings
 - » Source energy savings
- » Though not currently allowed by UFCs, they are part of ASHRAE 90.1-2022, which may be invoked in future.

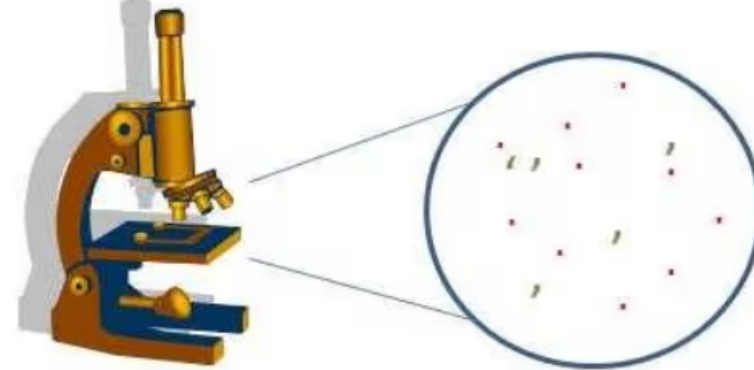


Still, The Industry is Doing Better

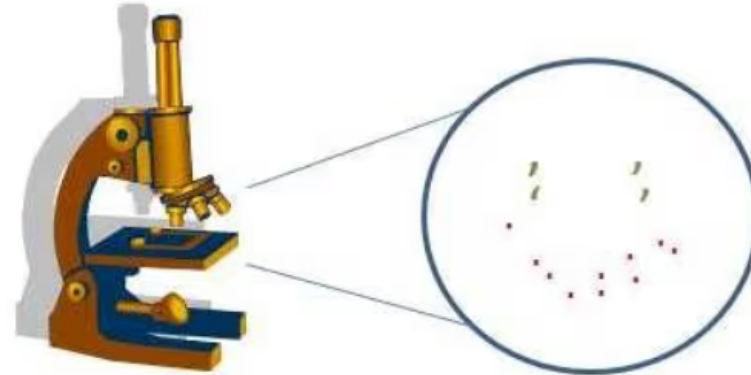
The Hawthorne effect and energy awareness

Daniel Schwartz^{a,1}, Baruch Fischhoff^{a,b}, Tamar Krishnamurti^{b,c}, and Fallaw Sowell^c

- » The feeling of being observed or merely participating in an experiment can affect individuals' behavior. In an experiment where homeowners were sent reminders that they were part of an experiment on energy use, even with no instruction, their energy use dropped.



When No One is Watching



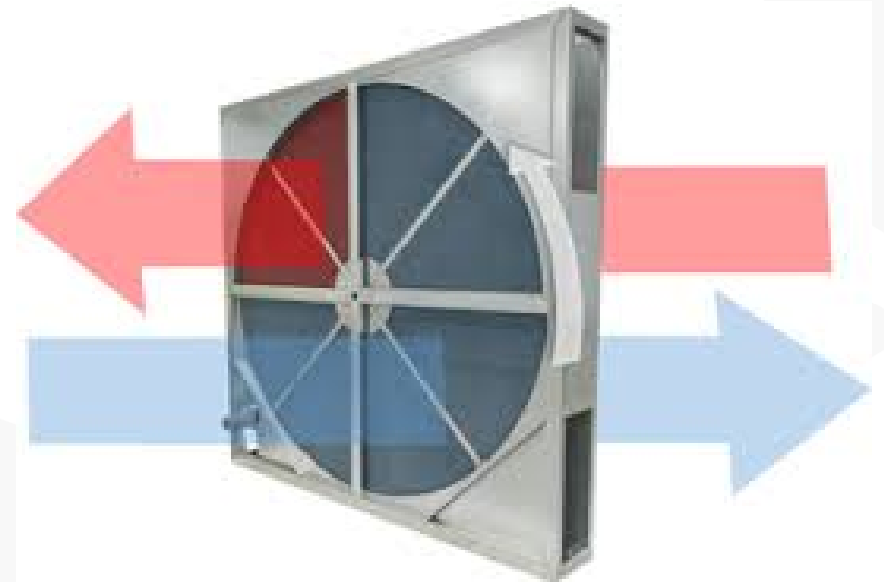
Add An Observer



Technologies and Practices

Technologies and Practices - General

- » Following are examples of technologies and practices that have become, or are becoming, commonplace in buildings in the past 20 years.
- » Some technologies still need to ride down the cost curve, but buildings today are generally much better built and more energy efficient that they were in 2005.



Equipment and Systems

ENVELOPE

Triple+ paned glass
Low-e coatings (not dark)
Foam insulation
Combined air/water barriers
Thermal breaks



Envelope items are arguably most impactful since they are passive and last the life of the facility.

HVAC

Variable Frequency Drives
Condensing Boilers
EC Motors
Variable Speed Chillers
Cold climate heat pumps
Energy recovery units
Dedicated outside air systems



Cold climate heat pumps will be a game changer, but costs need to come down. (More to follow)

Electrical

LED Lighting

Plug load monitoring/switching
Daylighting controls
Improved lighting controls
Power monitoring

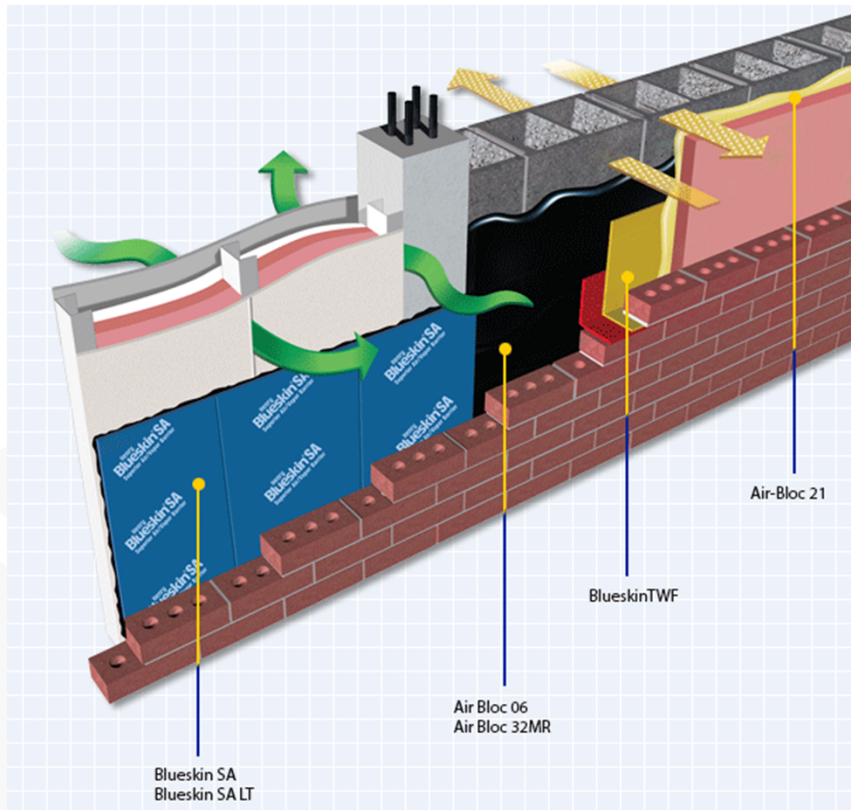


LED Lighting has been a huge contributor to energy and maintenance reductions.

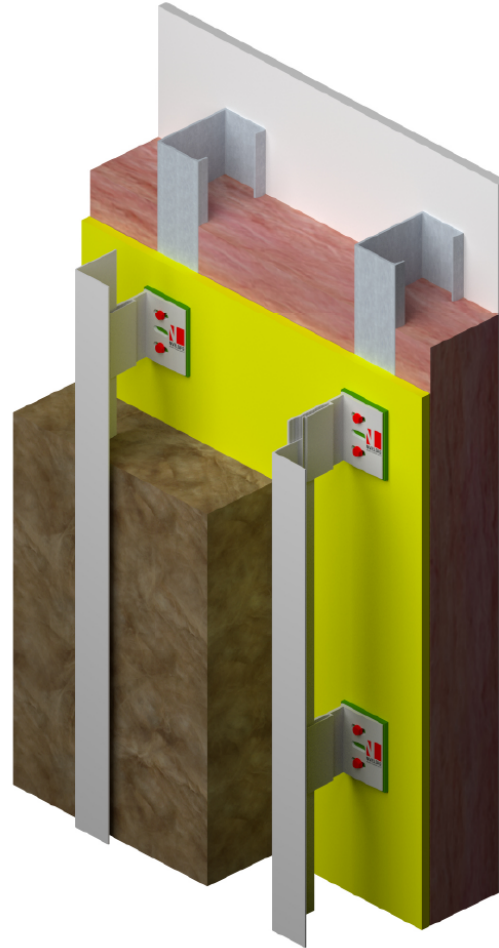
Water

Waterless urinals
Low-flow fixtures
Rainwater harvesting
Water metering

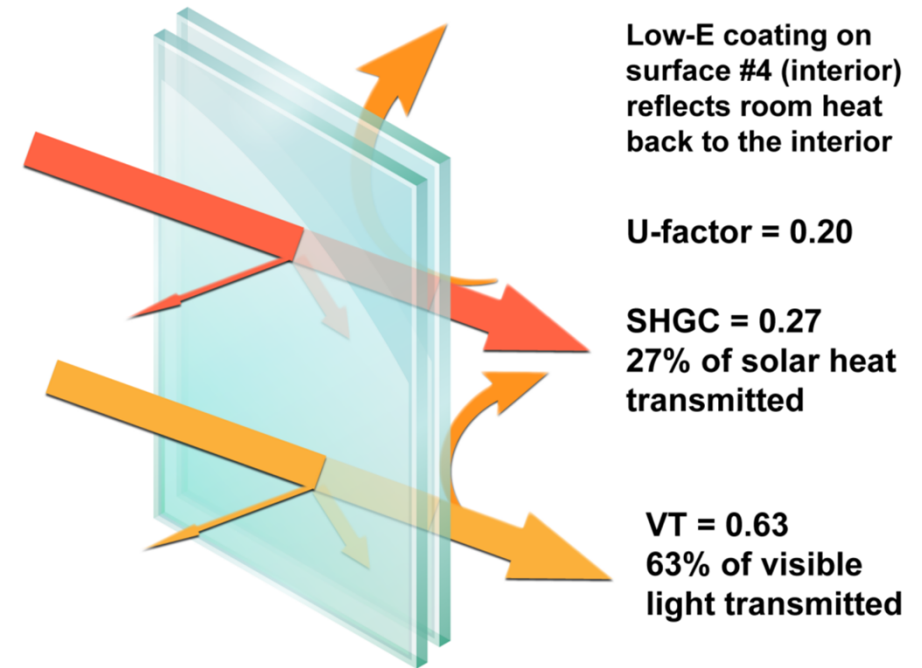
Equipment - Envelope



Anatomy of a wall. Lots of layers!



Portion of wall system showing thermal breaks



Double-glazed window with low-E coating and high VT

Envelope – Going Backward?

- Sadly, the glass boxes aren't going away
- They look cool, but are expensive, difficult to seal, and inefficient.
- On the plus side, today's glass boxes are better than 2005's.



Equipment - HVAC

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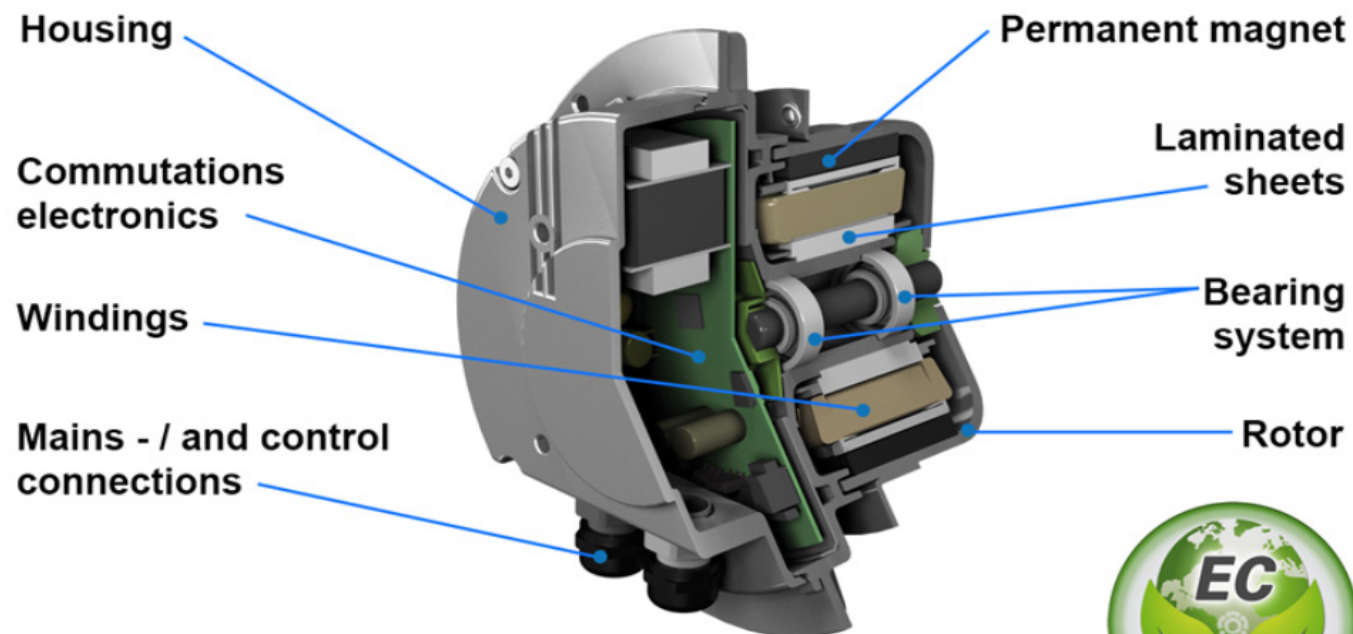


*Cold climate heat pumps
will be a game changer, but
costs need to come down.
(More to follow)*

Equipment - HVAC

EC Motors and VFDs

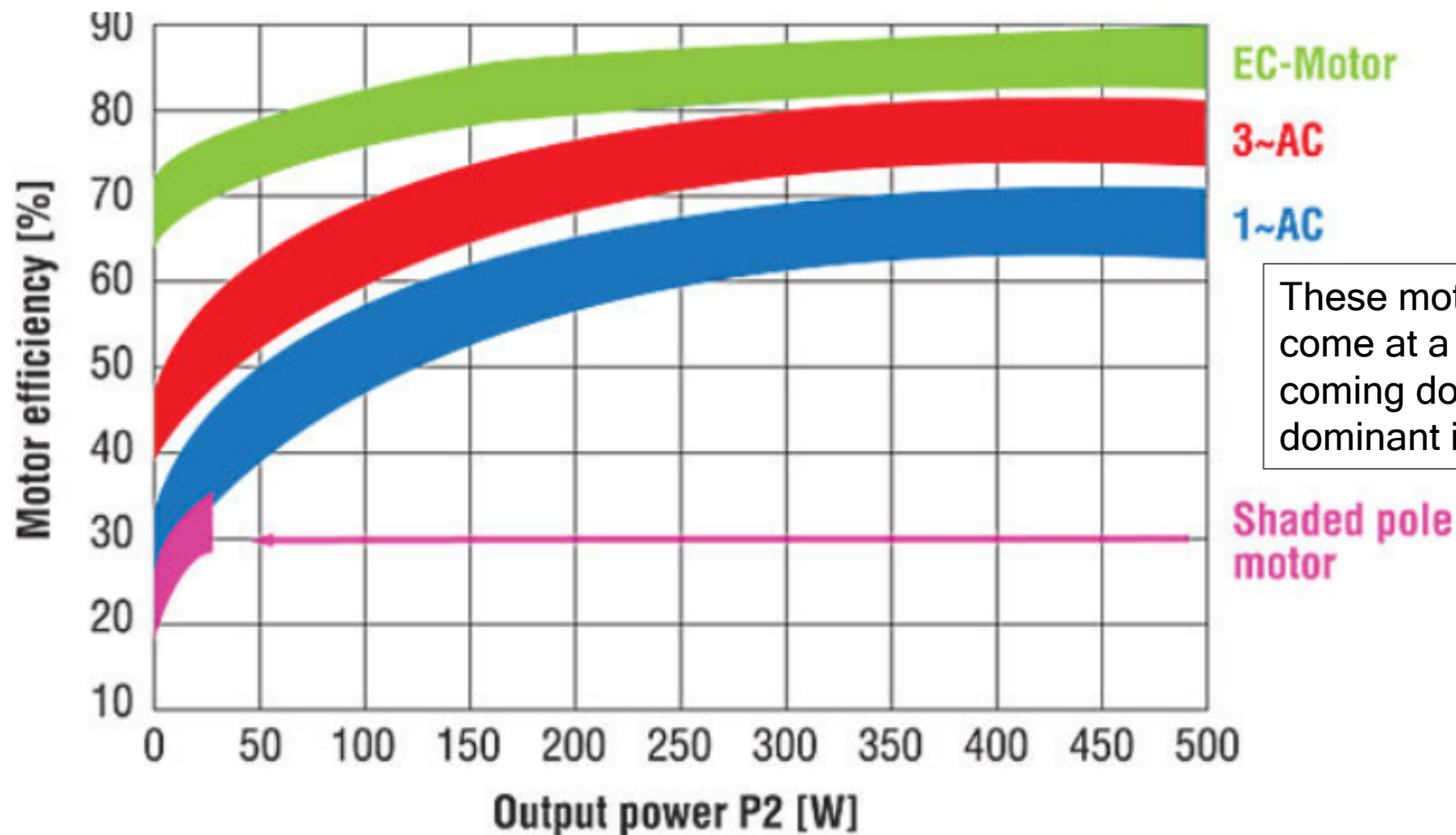
- » Brushless direct current
- » Higher efficiency than AC motors, especially at low load
- » Integrated speed control, so no VFD needed
- » More common in smaller applications, upper limit 25-30 hp



<https://www.airtechnics.com/>



Equipment - HVAC



EC Motors (Continued)

These motors are great, but they come at a premium. Costs are finally coming down as they are becoming dominant in the industry

Equipment - HVAC

Some manufacturers have replaced permanent split-capacitor motors with EC motors across the board for certain products, like terminal HVAC units and split systems.

Very commonly included by default in selections for these and other smaller HVAC systems.



EC Motors (Continued)

Computer Room Unit Application

Speed	Model FH 600C, 72F°/50% RH, 45E WT, 10° Water TD 0.3” External Static Pressure	Net Sensible Cooling Capacity (kBTUH)	Motor kW	EER (kBTUH/kW)	CFM	Savings from Base
100%	Centrifugal blowers w/VSD --- EC motorized impeller under floor	284.0	11.0	25.8	17,000	—
		296.0	7.6	38.9	17,000	-30.9%
260.0		8.0	32.4	15,300	-27.1%	
268.0		5.5	48.4	15,300	-49.6%	
233.0		5.6	41.4	13,600	-48.8%	
239.0		3.9	61.4	13,600	-64.6%	
192.0		3.8	50.5	10,710	-65.5%	
194.0		2.6	74.6	10,710	-76.4%	

Emersonnetworkpower.com



Equipment – HVAC

What is a Heat Pump

- » Heat pumps are just air conditioning systems in reverse. They extract heat from the air (or other source) and deliver it to the building.
- » For every unit of electrical energy used, heat pumps can deliver 2-4 units of heat. (200%-400% efficient!)
- » Cold climate heat pumps are finally available in the U.S. Costs need to decline.



Air to water heat pump

Cold Climate Heat Pumps – A Long Evolution



Circa 3200 BCE
Robust but non-functional



Circa 100 CE
Stylish but heavy and expensive.
Also, non-functional



Circa 1890 CE
Steam powered.
Low COP. Not even a heat pump



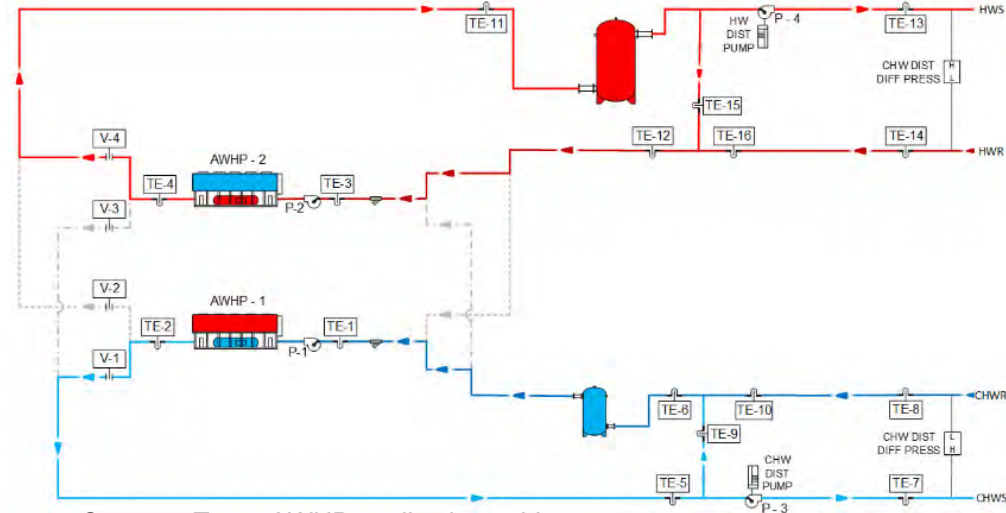
Circa 1990 CE
Pretty good, but poor heat output below 40°F



Circa 2025 CE
Finally! Acceptable heat output in ambient temperatures well below freezing

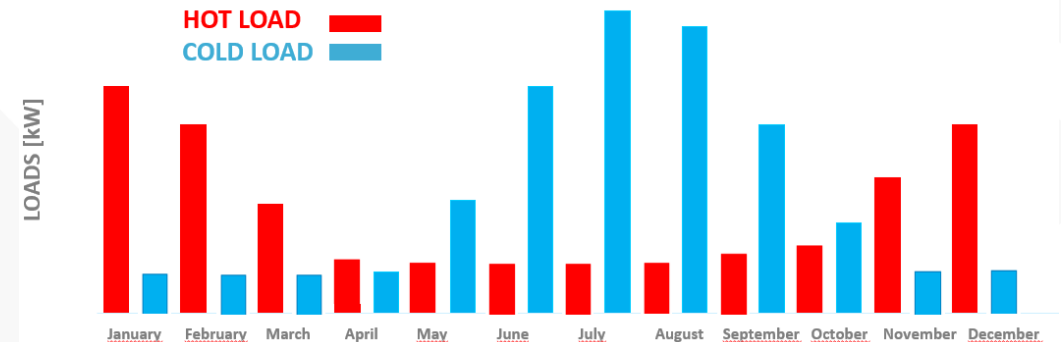
Air to Water Heat Pumps for Bigger Buildings

- » We already have air-cooled chillers
- » Air to water heat pumps are chillers that can produce hot water, too.
- » Some can produce both simultaneously
- » Terms and conditions apply...



Courtesy Trane AWHP application guide

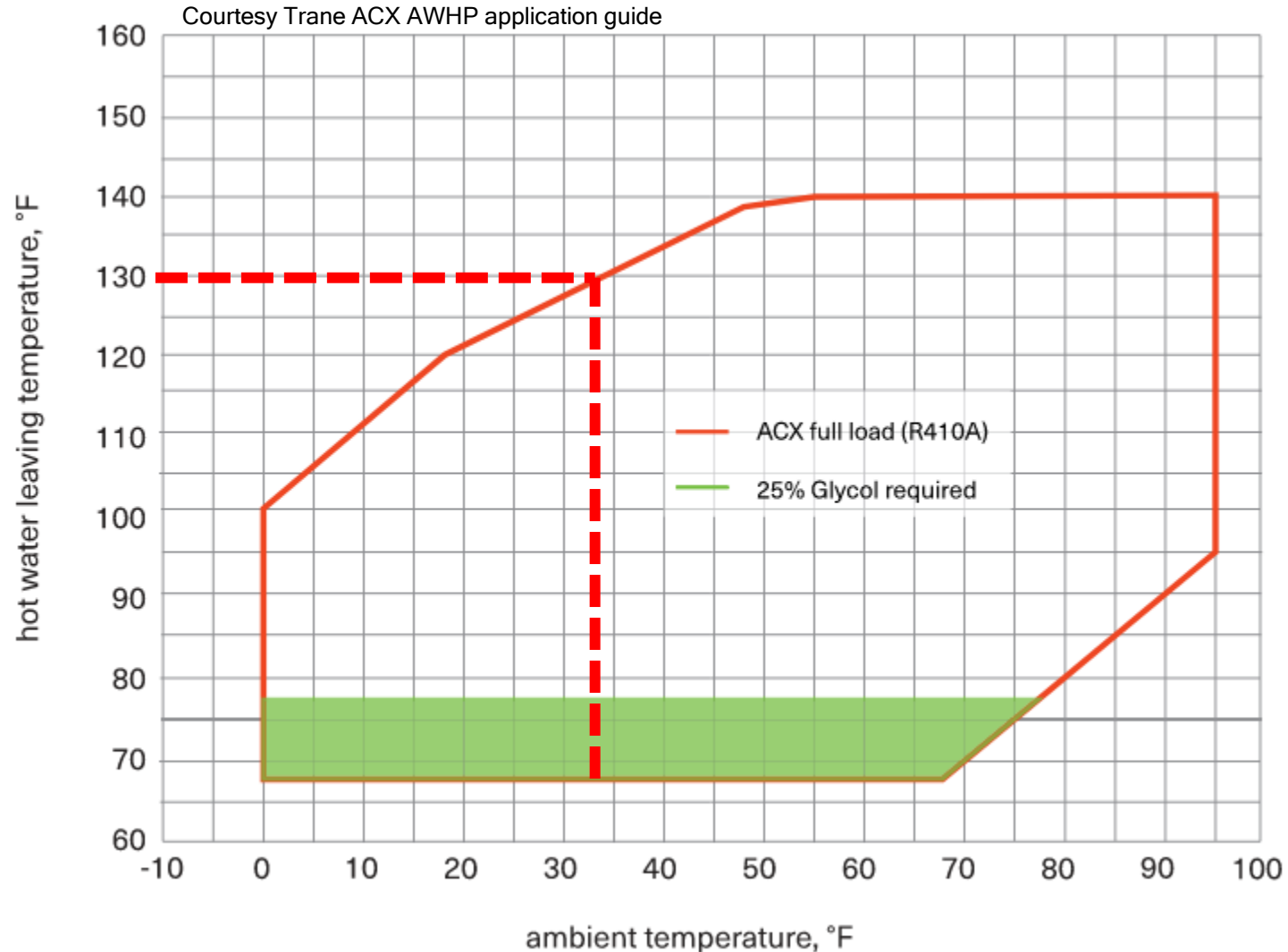
A single system provides cooling and heating all round year



Courtesy Daikin 4Z

Air to Water Heat Pumps

- » Be aware that manufacturers claim operation down to 0 °F or lower, but capacity and heating water temperature may not meet requirements at that temperature.
- » Supplemental heat (boiler) may be required in very cold climates.



Make Buildings “Heat Pump Ready”

- » Since electrification may take a while:
 - » Design hydronic heating systems for not more than 130°F supply temperature. This is a high-efficiency practice even without gas boilers.
 - » Use condensing NG boilers if necessary for a hybrid system
 - » Install future electrical infrastructure for future heat pumps

A note about electrical demand:

In most of the country, peak electrical demand is set in summer months by air conditioning.

In some states, like Virginia, peak demand is in winter mornings. This is because conventional heat pumps rely on lots of electric resistance heating.

Equipment - Electrical

ENVELOPE

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Foam insulation

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Renewable Energy



LED Lighting has been a huge contributor to energy and maintenance reductions.

Water

Waterless urinals

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Equipment – Electrical

LED Lighting

Cheaper, and now better in every category of lighting

By far the most life-cycle cost effective lighting technology

Double-win since it reduces cooling load..



Equipment – Electrical

On-site Renewable Energy (PV)

Fixed-tilt PV systems are continuing to fall in cost and require very little maintenance.

Their life-cycle cost is less than many other energy saving measures.

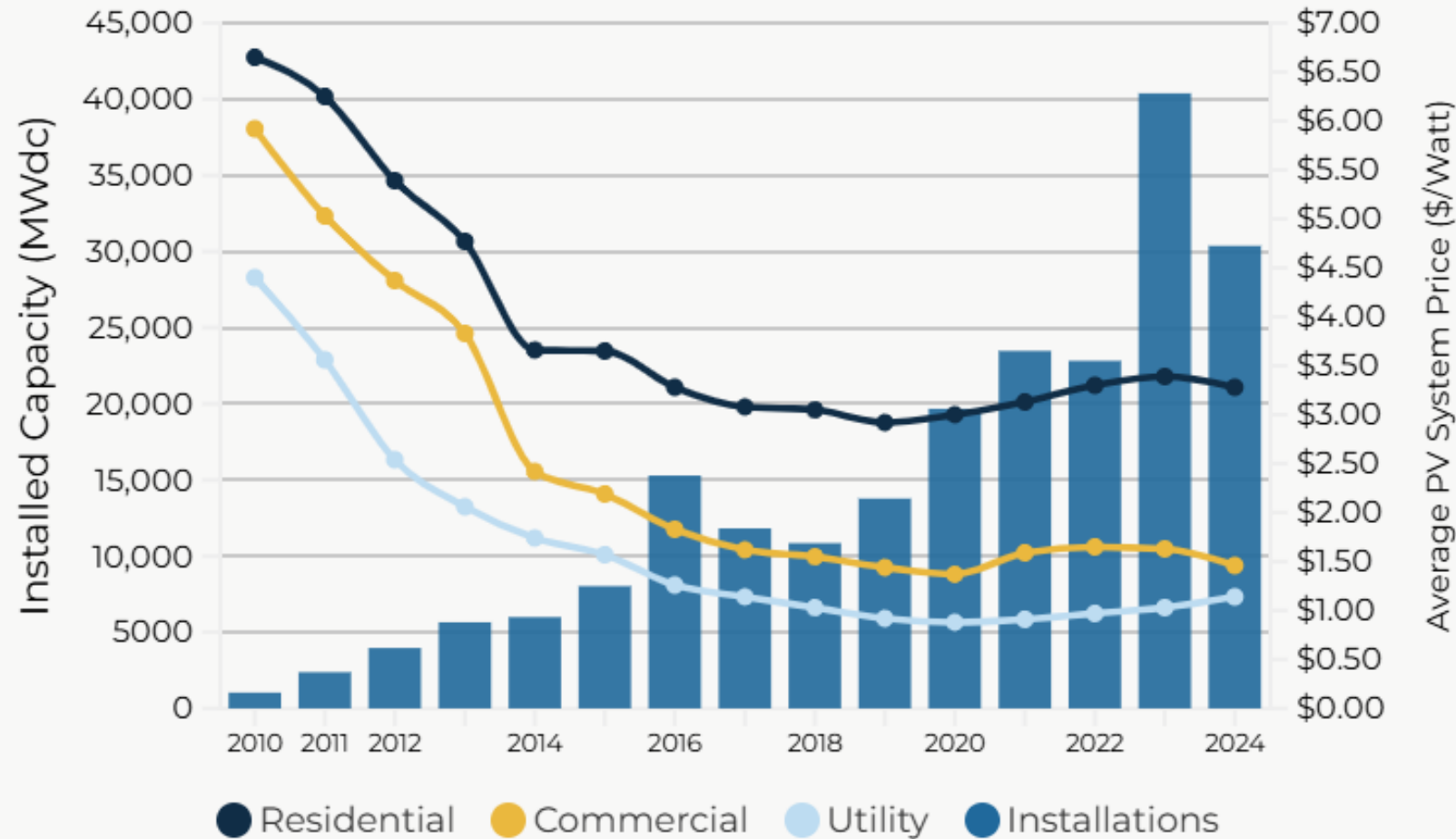


Example: PV less expensive than some aggressive envelope improvements



Equipment - Electrical

U.S. Solar PV Pricing Trends & Deployment Growth



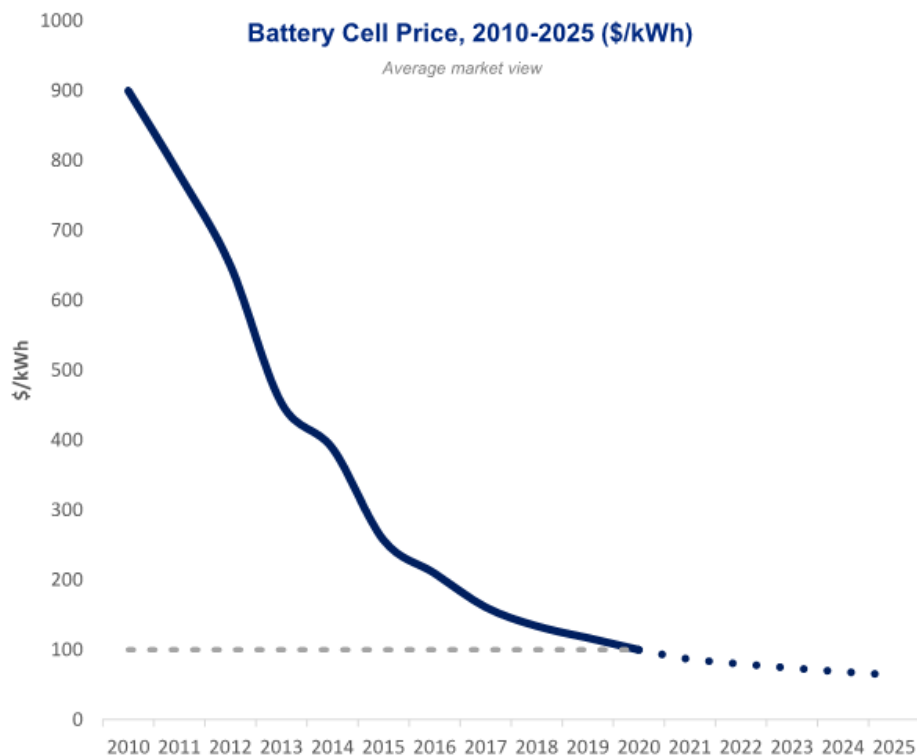
Source: [SEIA/Wood Mackenzie Power & Renewables U.S. Solar Market Insight Q4 2024](#)

Equipment - Electrical

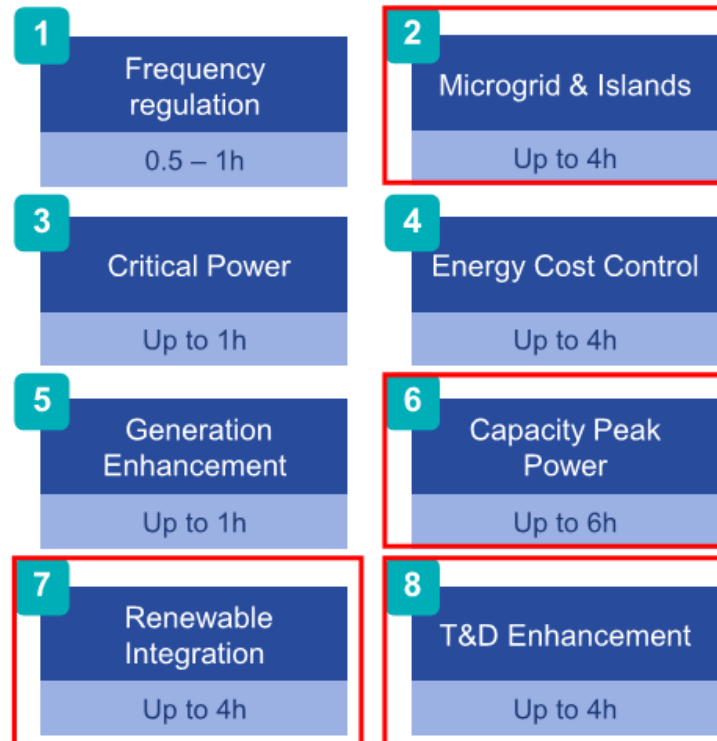
Cost Curve for Batteries

Steep battery price decline enables more applications in more markets to be deployed economically

Cost development: Energy Storage

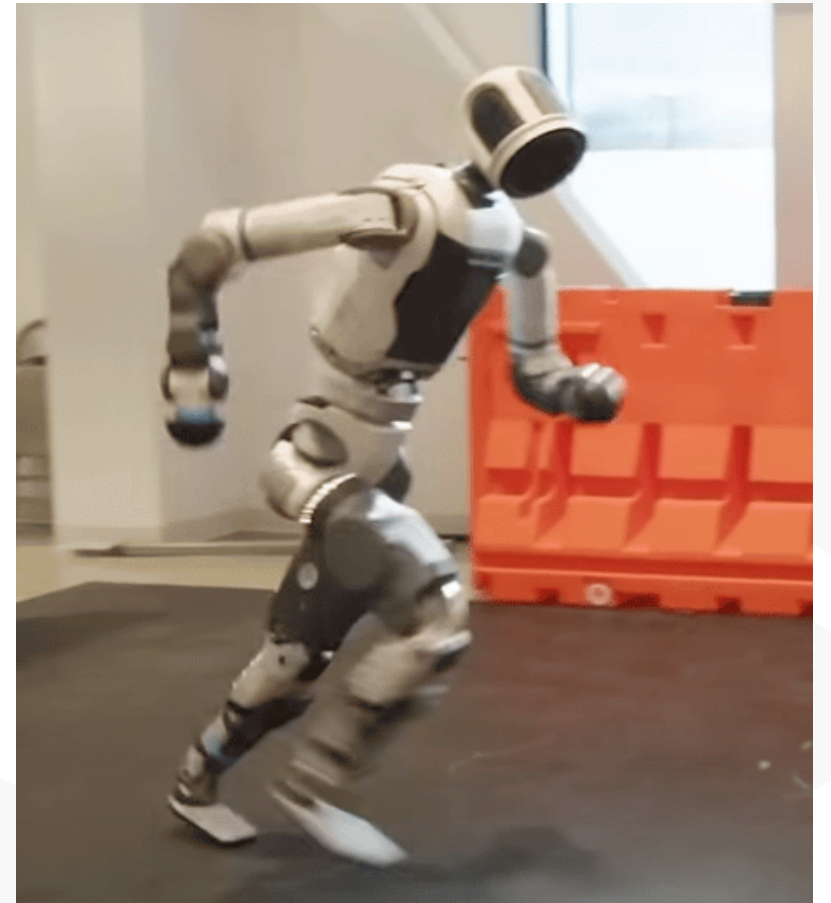


Energy storage market applications



Equipment - Electrical

Why Batteries will Keep Getting Better and Cheaper





Controls

Controls

ENVELOPE

Window shade controls
Self-tinting Glass

HVAC

Common BAS protocols
Chiller plant optimization

*Still waiting for
better interfaces
and self diagnostics*

ELECTRICAL

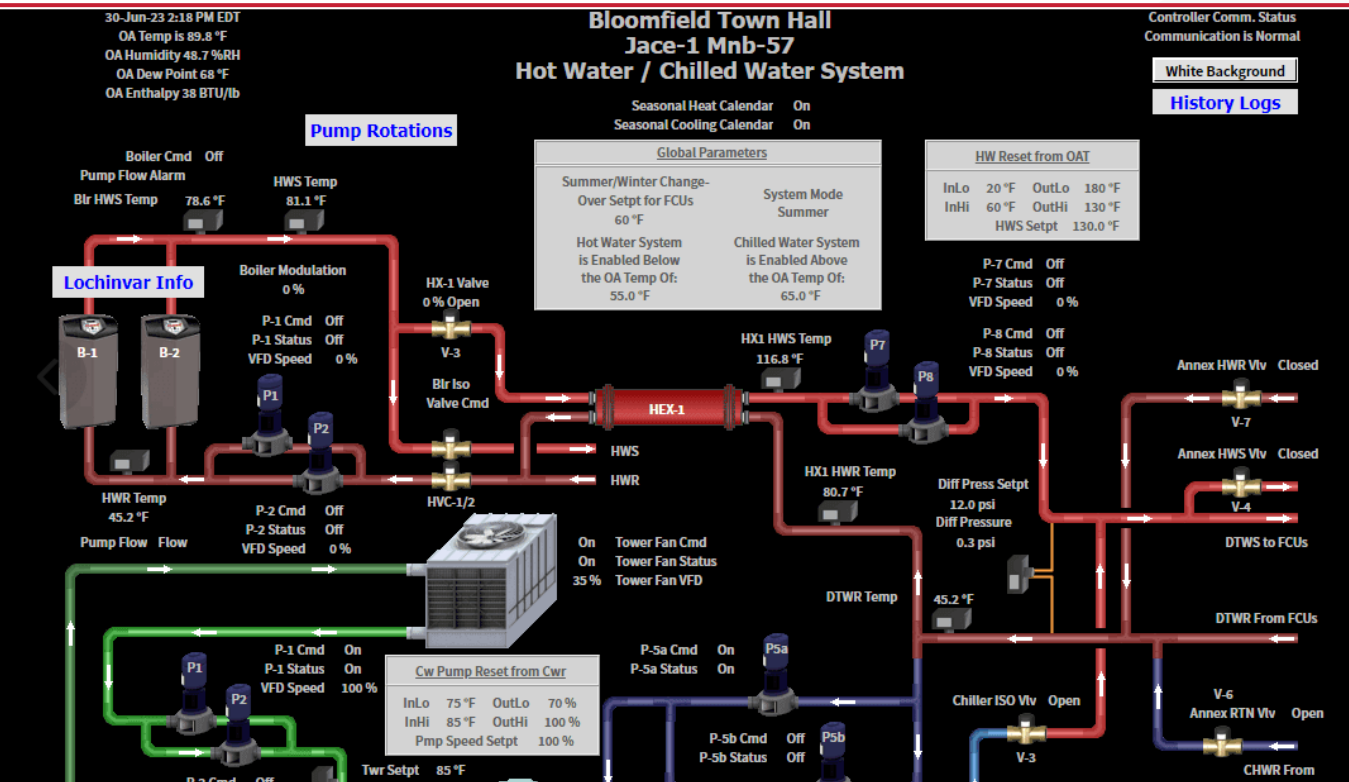
Lighting Controls
Power monitoring
Power control systems

*Power control systems
can increase resilience
and save money*

WATER

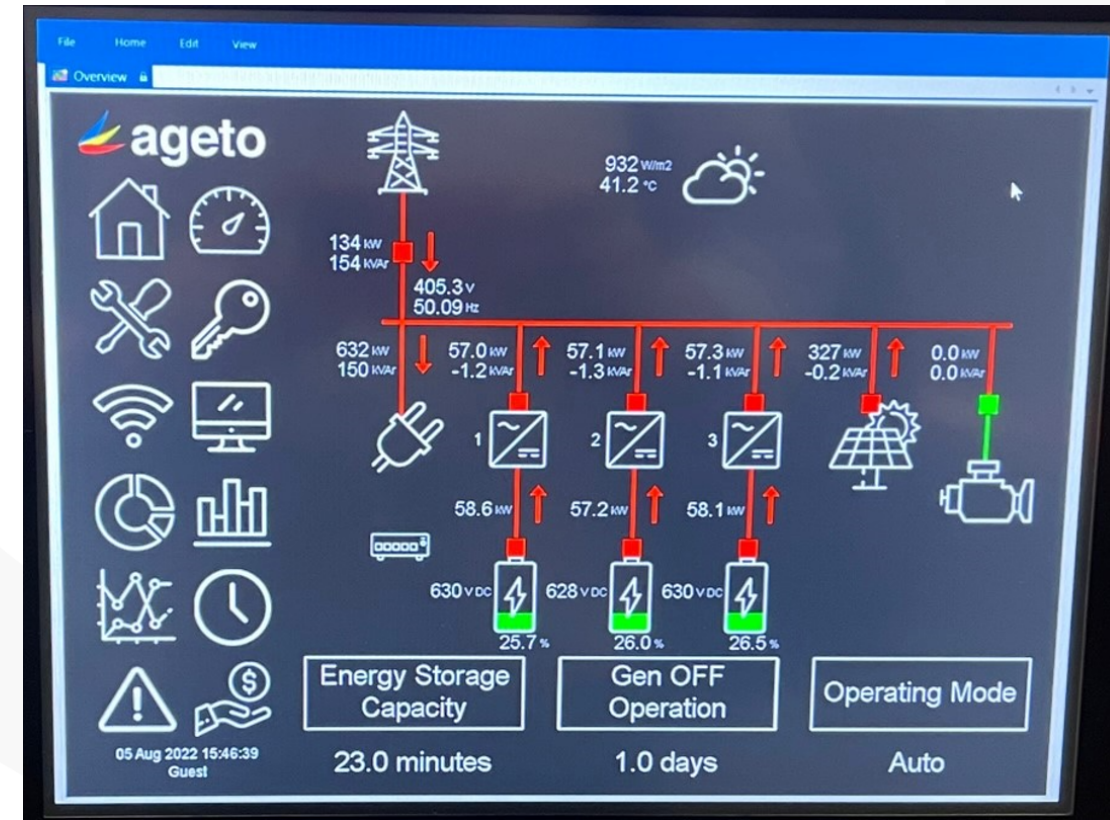
Water metering
Irrigation controls

Controls - Examples



↑ Building Automation System (BAS)
Provides a wealth of information including status and trends. Typically, able to integrate multiple protocols.

Power control system
(in this case, a microgrid controller)
Building level controls can provide multiple benefits



Controls – Case Study

GSA Green Proving Ground

135,000 ft² building, circa-2000 cooling plant

In 2016, upgraded controls. Nothing very fancy by today's controls standards.

- Application of VFDs (though not on chillers)
- Monitoring: sensors sensors sensors!

35% energy performance improvement

All of this is the norm in today's energy standards.



General Services Administration
Public Buildings Service



GPG-028 | SEPTEMBER 2016

CHILLER PLANT CONTROL OPTIMIZATION SYSTEM



Simplified Chilled Water System Optimization Increases Plant Efficiency

Chiller plants, the dominant source of space conditioning for commercial buildings with more than 200,000 ft² of floor space, are arguably the unsung heroes of occupant comfort. Still, conventional chillers are typically designed to run most efficiently at peak loads, when, in reality, peak load conditions are rare. For this reason, and because over 80% of GSA floor space is in large buildings, GSA has a keen interest in optimizing its chiller operations. A new technology, a control optimization system for chiller plants, aims to improve chiller plant efficiency at part load and to minimize total power consumption in two ways: by aligning pressure and temperature setpoints with real-time system dynamics and by controlling pump and fan speeds. In 2013, GSA's GPG program commissioned the Department of Energy's Pacific Northwest National Laboratory (PNNL) to assess the control optimization system under real-world conditions at the Frank M. Johnson Jr. Federal Building and U.S. Courthouse in Montgomery, Alabama. Comparing the technology's performance with an estimated baseline, researchers found a 35% energy savings and payback of five years, assuming a national average energy rate of \$0.11/kWh.



Testing

Testing

Commissioning, MEP

Required. Saves time and money

Commissioning, Envelope

Not required but a good idea

Building Pressurization Testing

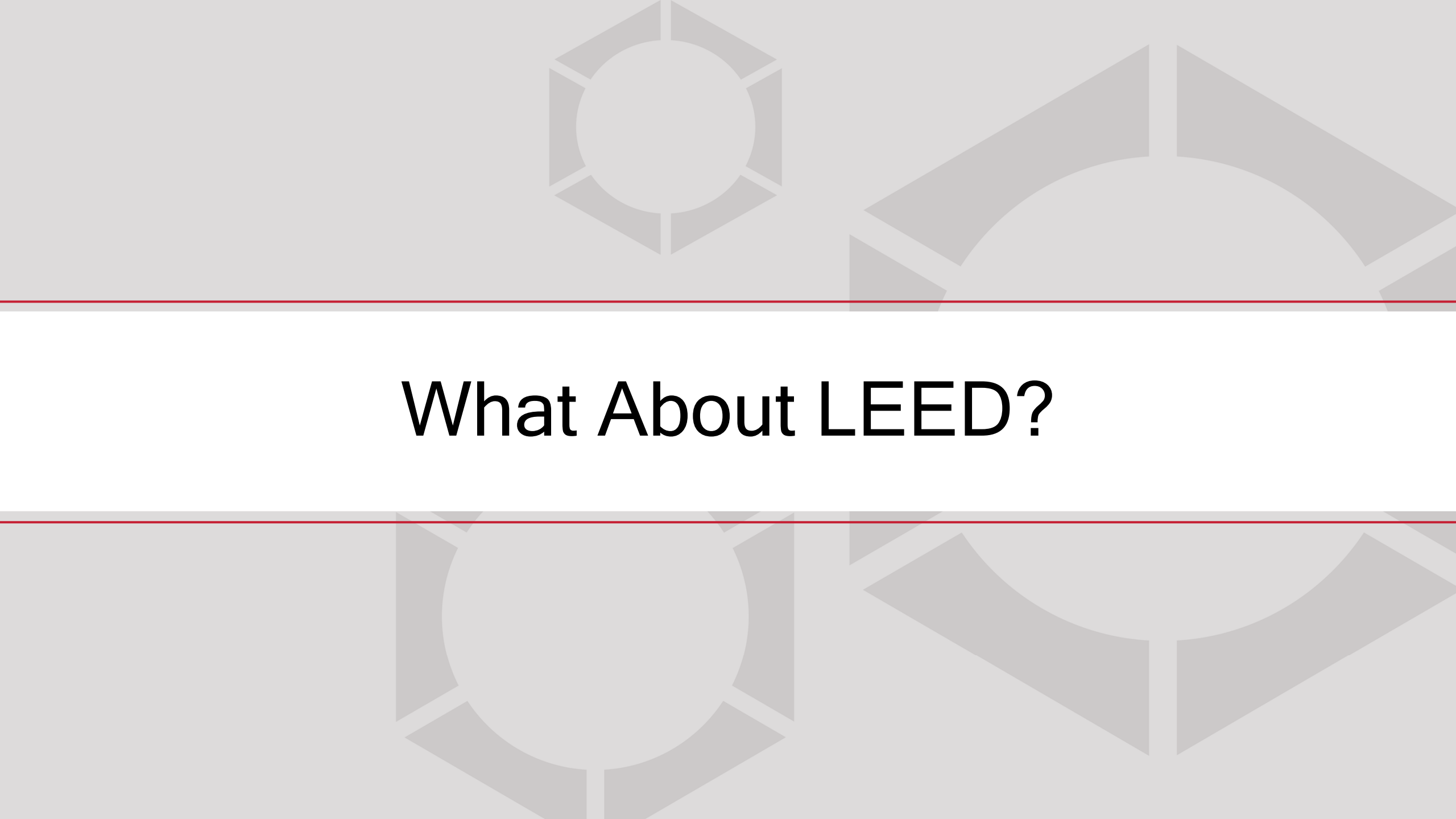
Required by Architecture UFC 3-101-01

Honorable Mention:
Black Start Testing
Identifies issues and
improves resilience



*Arguably, the most important step
in improving building performance*





What About LEED?

Green Building Rating Systems

- » LEED, Green Globes, and other green-building rating systems were established to ensure that claims related to building efficiency, occupant comfort, and responsible sourcing of materials could be verified.
- » These standards have changed the way buildings are designed and constructed.
- » They are intended to get more stringent and are broadening in scope.

LEED Credit Categories



Avoiding Greenwashing

- » What's wrong with this picture?
- » Buildings are complex and expensive, involving hundreds of people to design and build.
- » How do we keep everyone focused (and honest)?





Questions / Discussion