

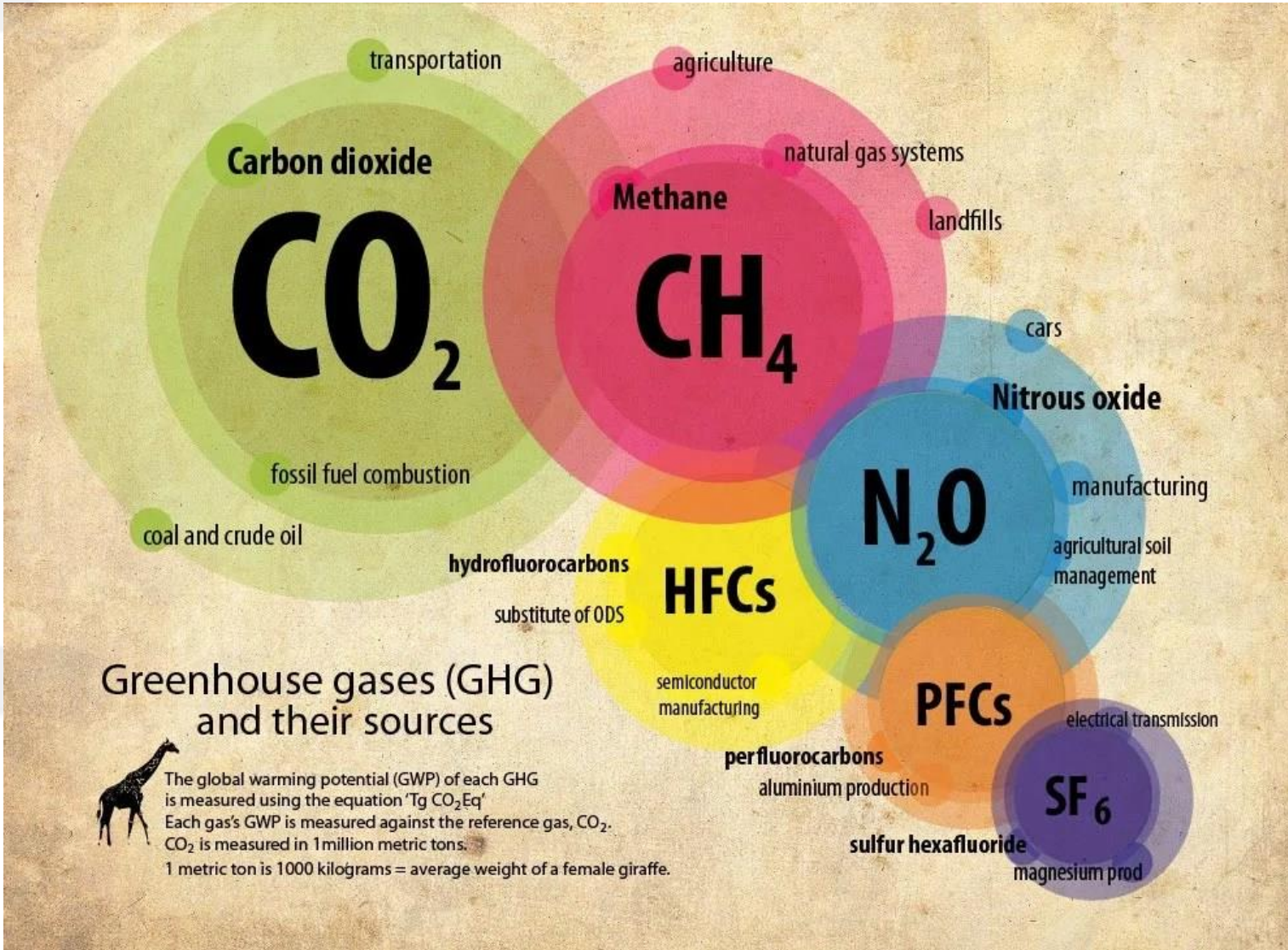
Leveraging **Cloud-Based Technologies** to Understand, Report, & **Reduce Emissions**

Ariana Axelrod, PE, CEM, VP Preconstruction
ariana.axelrod@controltechinc.com

**BUILDINGENERGY BOSTON
PRE-CONFERENCE WEBINAR**



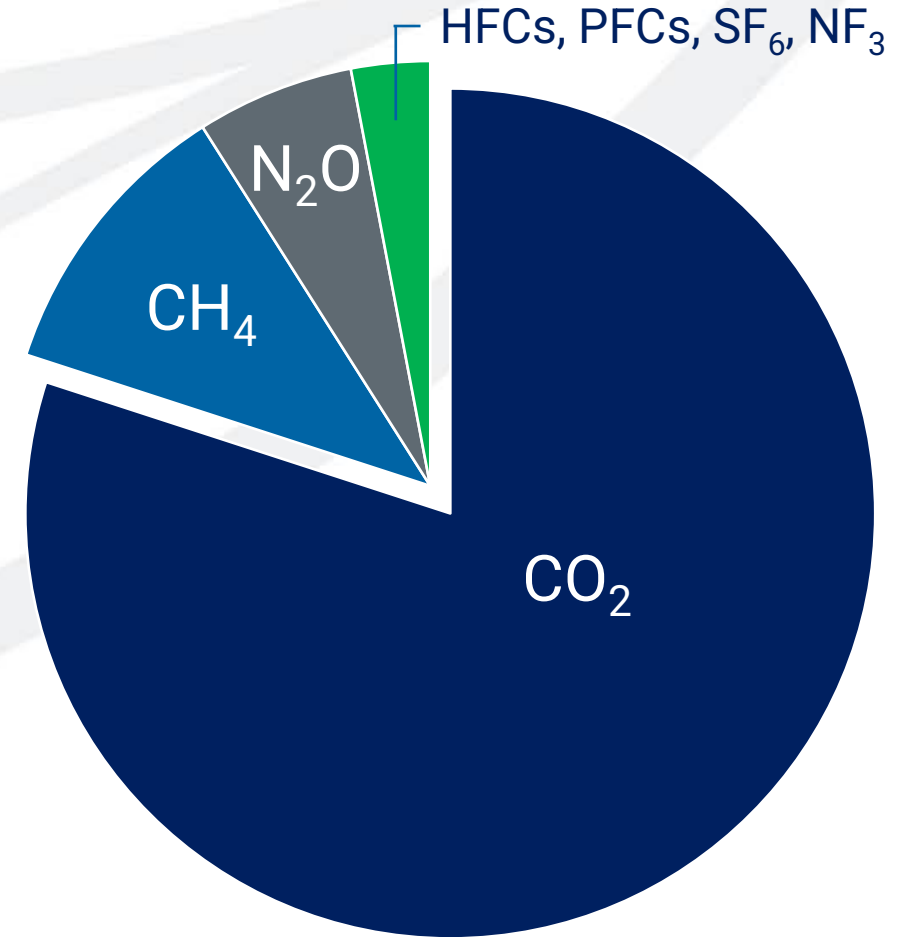
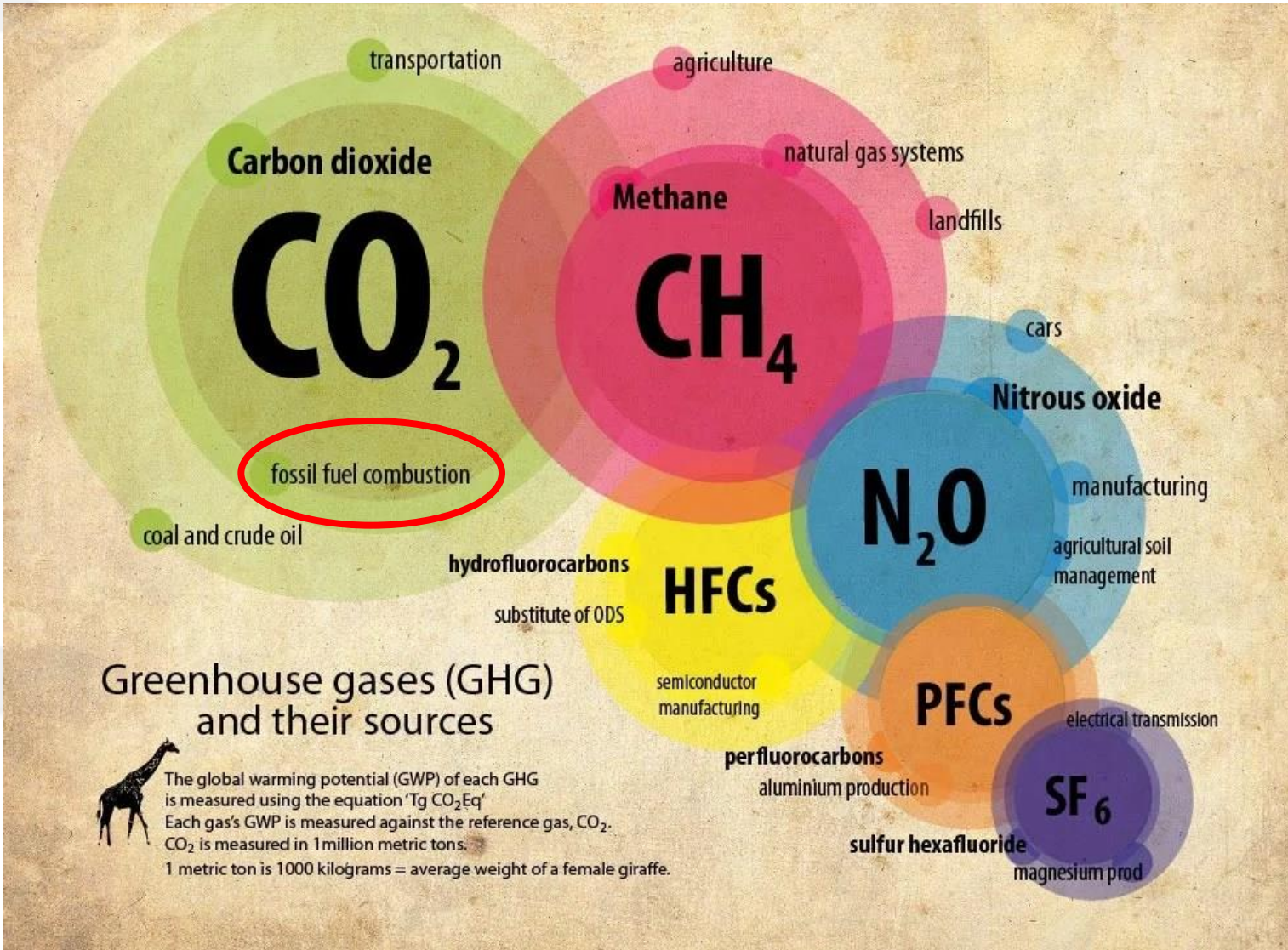
Greenhouse Gases (GHGs)



Gases within the atmosphere that trap heat



Greenhouse Gases (GHGs)



Energy from the sun reaches Earth



Some energy is reflected back into space

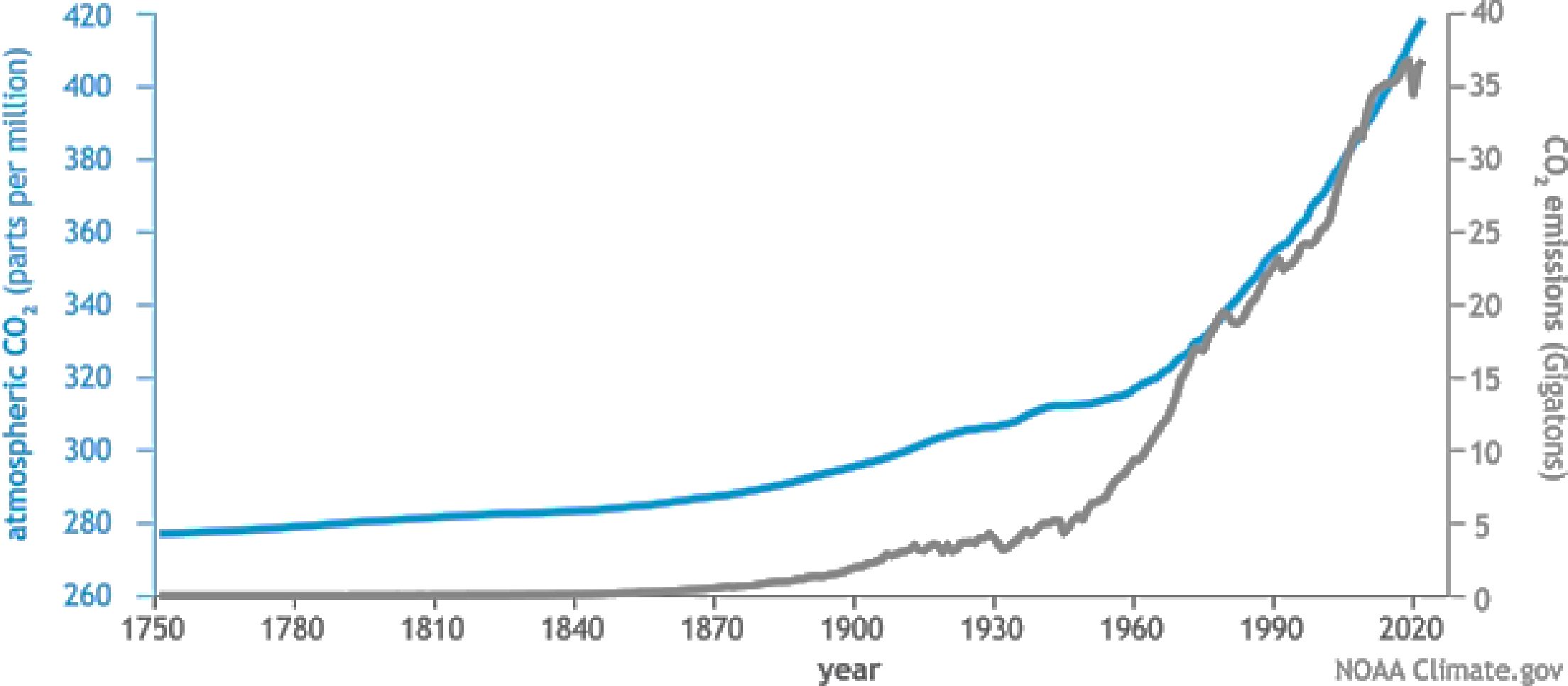
Some is absorbed by GHGs and re-radiated in all directions



As GHGs increase, less heat escapes

GHGs currently keep earth at about 59°F

Global atmospheric carbon dioxide compared to annual emissions (1751-2022)



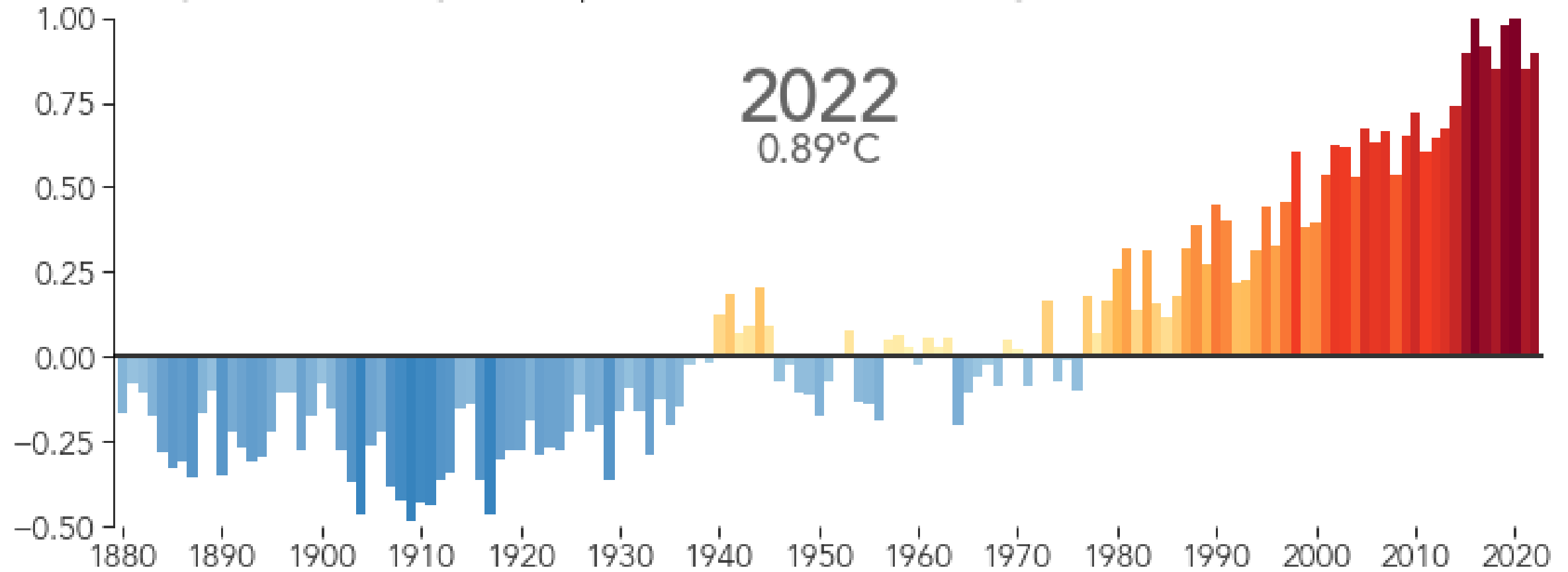
NOAA Climate.gov
Data: NOAA, ETHZ, Our World in Data

Atmospheric CO₂e is **50% higher** than pre-Industrial Revolution levels

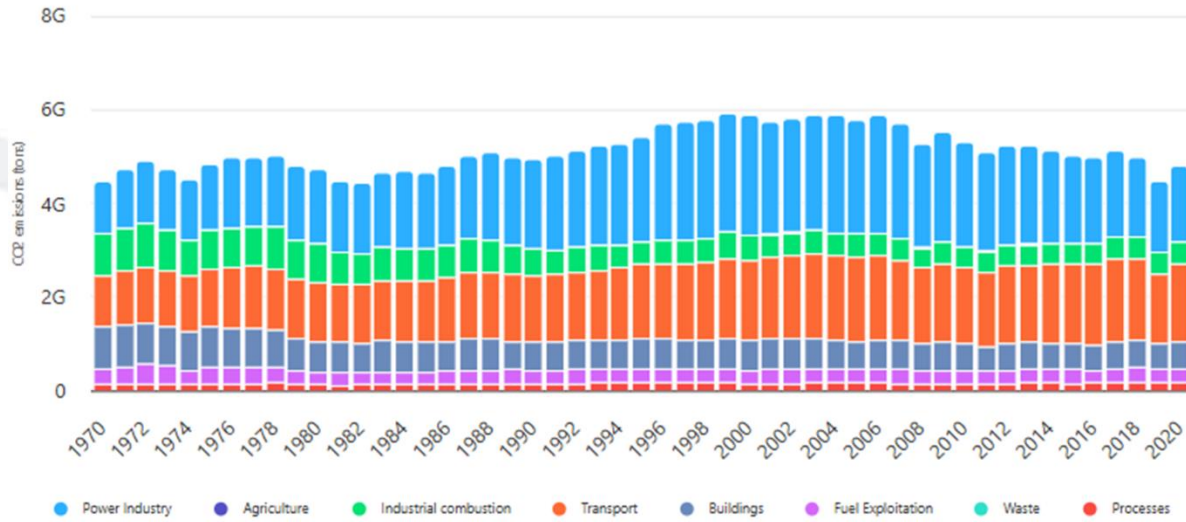


Last 9 Years Warmest on Record

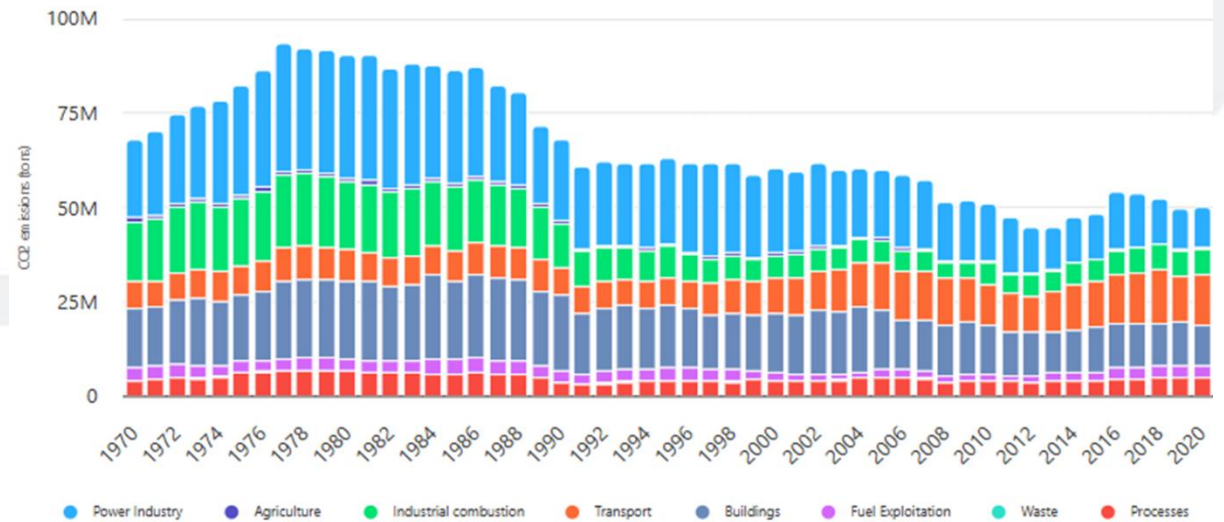
Global Temperature Anomaly (°C compared to the 1951-1980 average)



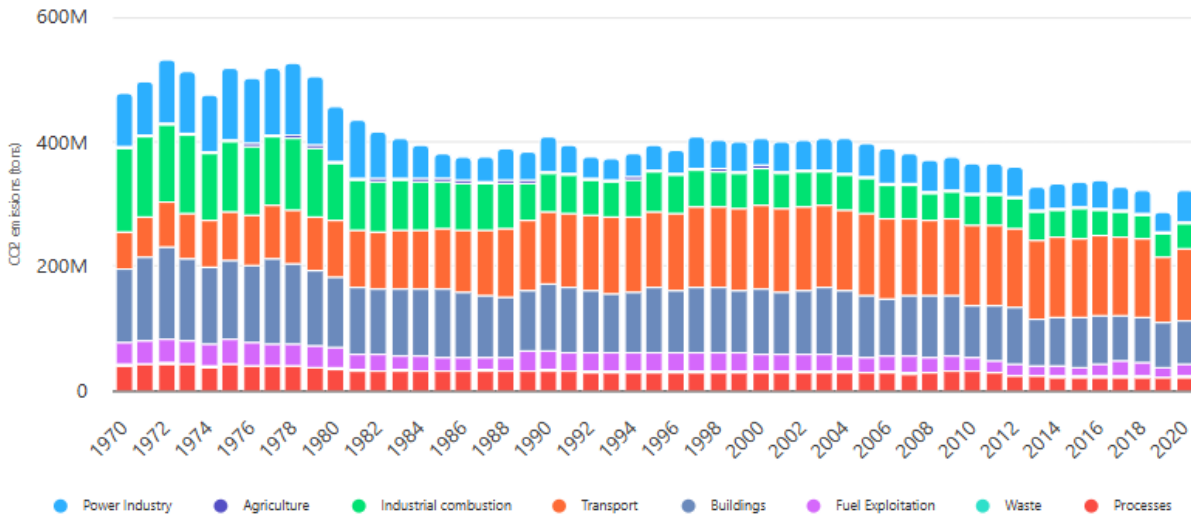
United States CO2 emissions by Year (tons)



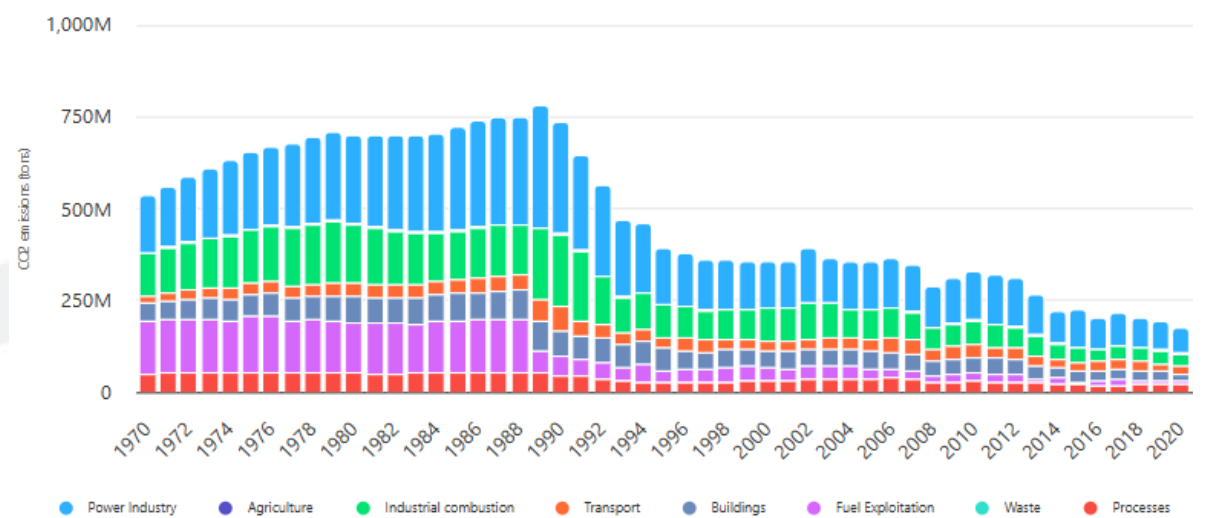
Hungary CO2 emissions by Year (tons)



France CO2 emissions by Year (tons)



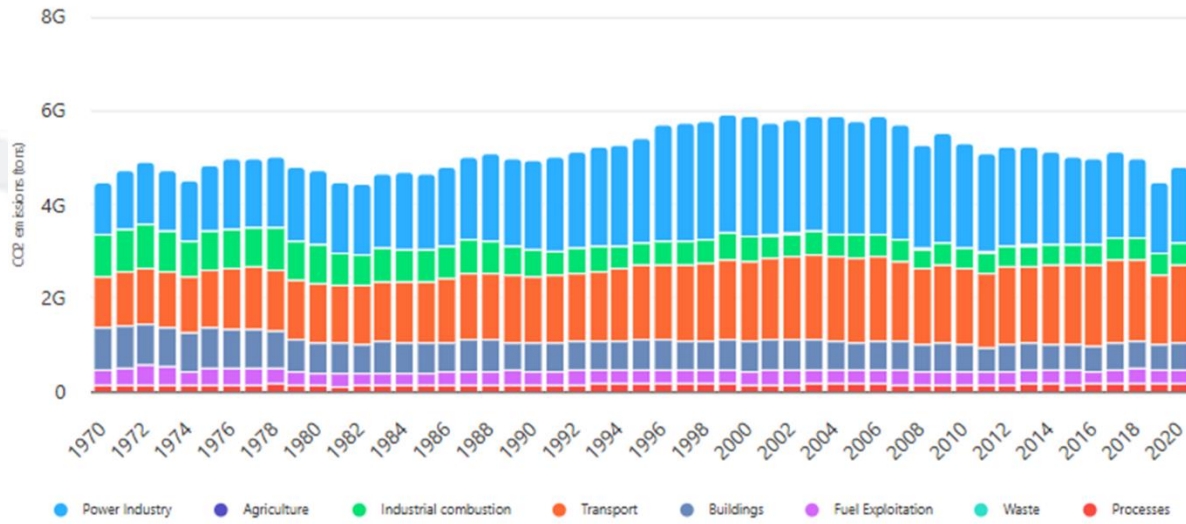
Ukraine CO2 emissions by Year (tons)



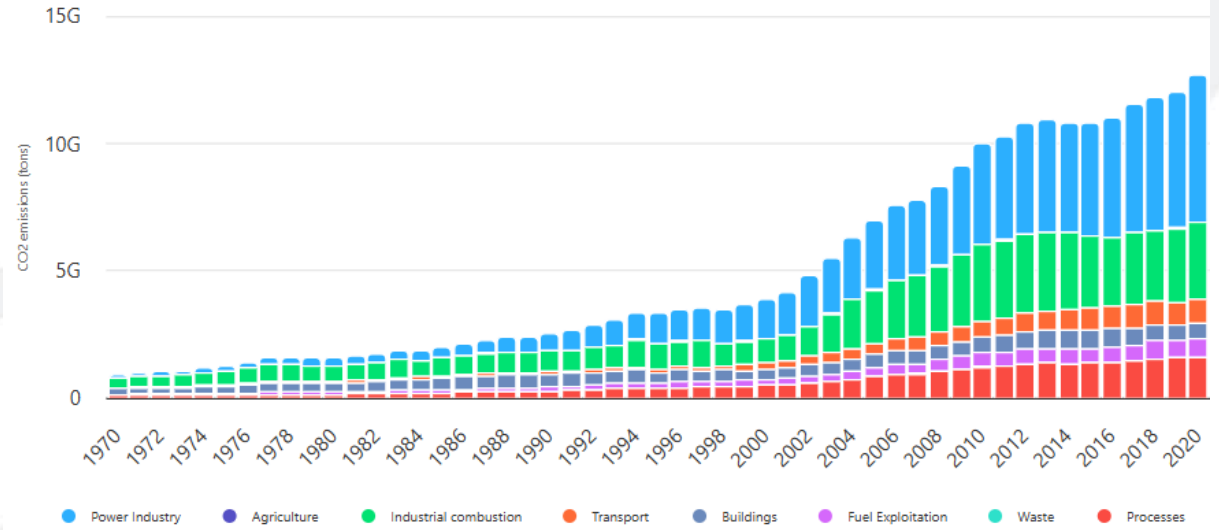
<https://www.worldometers.info/>



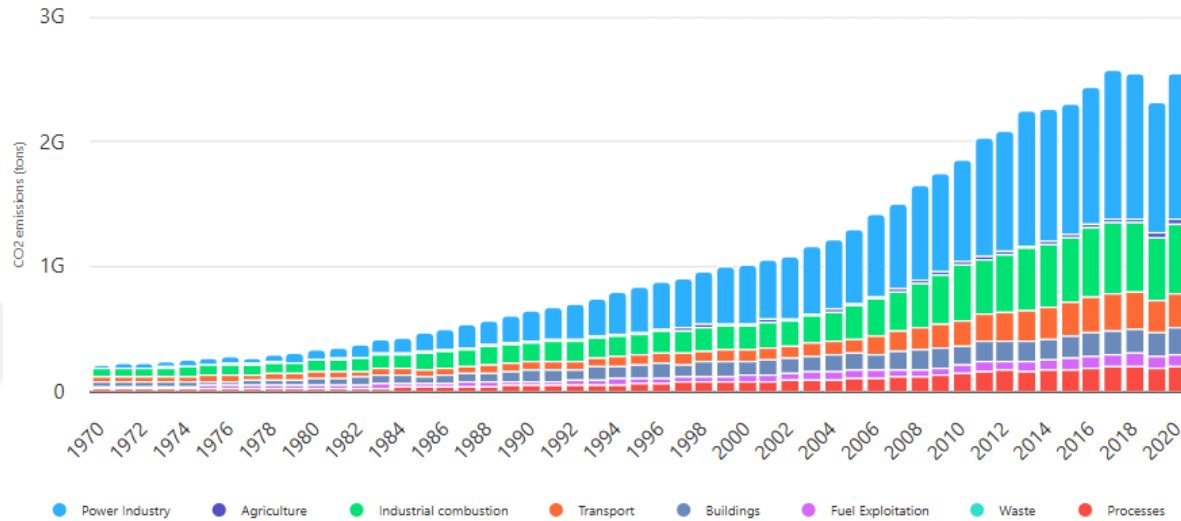
United States CO2 emissions by Year (tons)



China CO2 emissions by Year (tons)



India CO2 emissions by Year (tons)



52.5% of the World's Emissions



PARIS CLIMATE AGREEMENT

1.



Limit the avg. global temperature increase to $< 2^{\circ}$ centigrade + achieve net zero emissions by mid-century

2.



Enhance resilience and adaptation to climate impacts certain to occur

3.



Align financial flows in the world with these objectives

Emissions Goals

The image shows the cover of an IPCC special report titled 'Global Warming of 1.5°C'. The cover features the IPCC logo at the top, followed by the title in large blue letters. Below the title is a subtitle: 'An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.' The central graphic is a colorful, abstract representation of a globe with a wavy line across it, set against a dark blue background. At the bottom of the cover, there is a social media-style text block from UN Climate Change (@UNFCCC) dated Oct 8, which includes a quote: 'Limiting global warming to 1.5°C would require rapid, far-reaching and unprecedented changes in all aspects of society' and a link to a press release.

ipcc
INTERGOVERNMENTAL PANEL ON climate change

Global Warming of 1.5°C

An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.

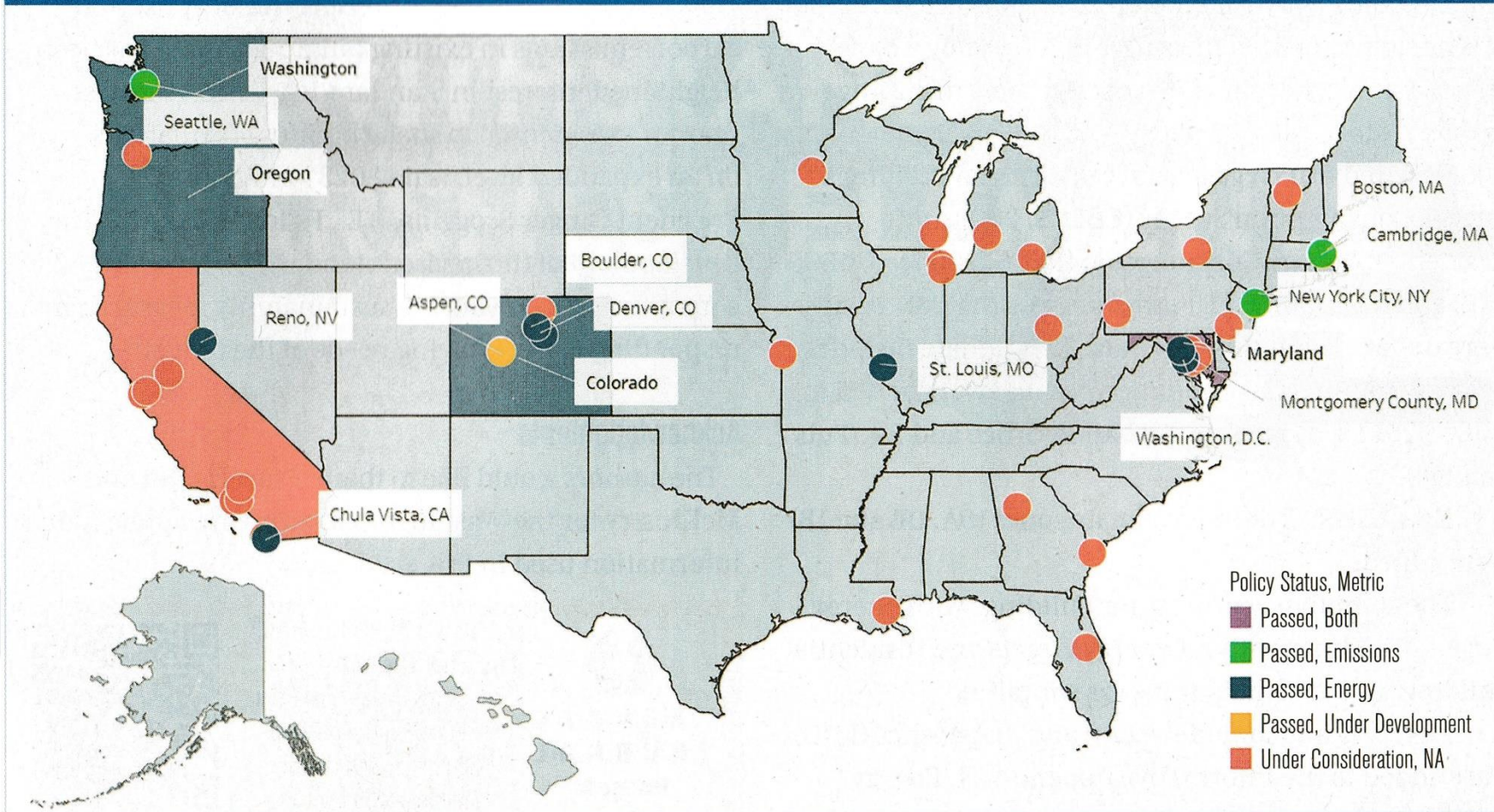
UN Climate Change @UNFCCC · Oct 8
"Limiting global warming to 1.5°C would require rapid, far-reaching and unprecedented changes in all aspects of society" bit.ly/2y6mirS Read @IPCC_CH press release on special report by the @UN Intergovernmental Panel on #ClimateChange #SR15 #COP24 #ParisAgreement

**70% of Boston's
emissions come from
buildings**



Government Ordinances

FIGURE 2 State and local building performance standards. Source U.S. Department of Energy, Updated 12/29/2023.



- BERDO 2.0 (Boston)
- BEUDO (Cambridge)
- NYC Local Law 97

**NET ZERO BY
2050**

Building Emissions Reduction Disclosure Ordinance

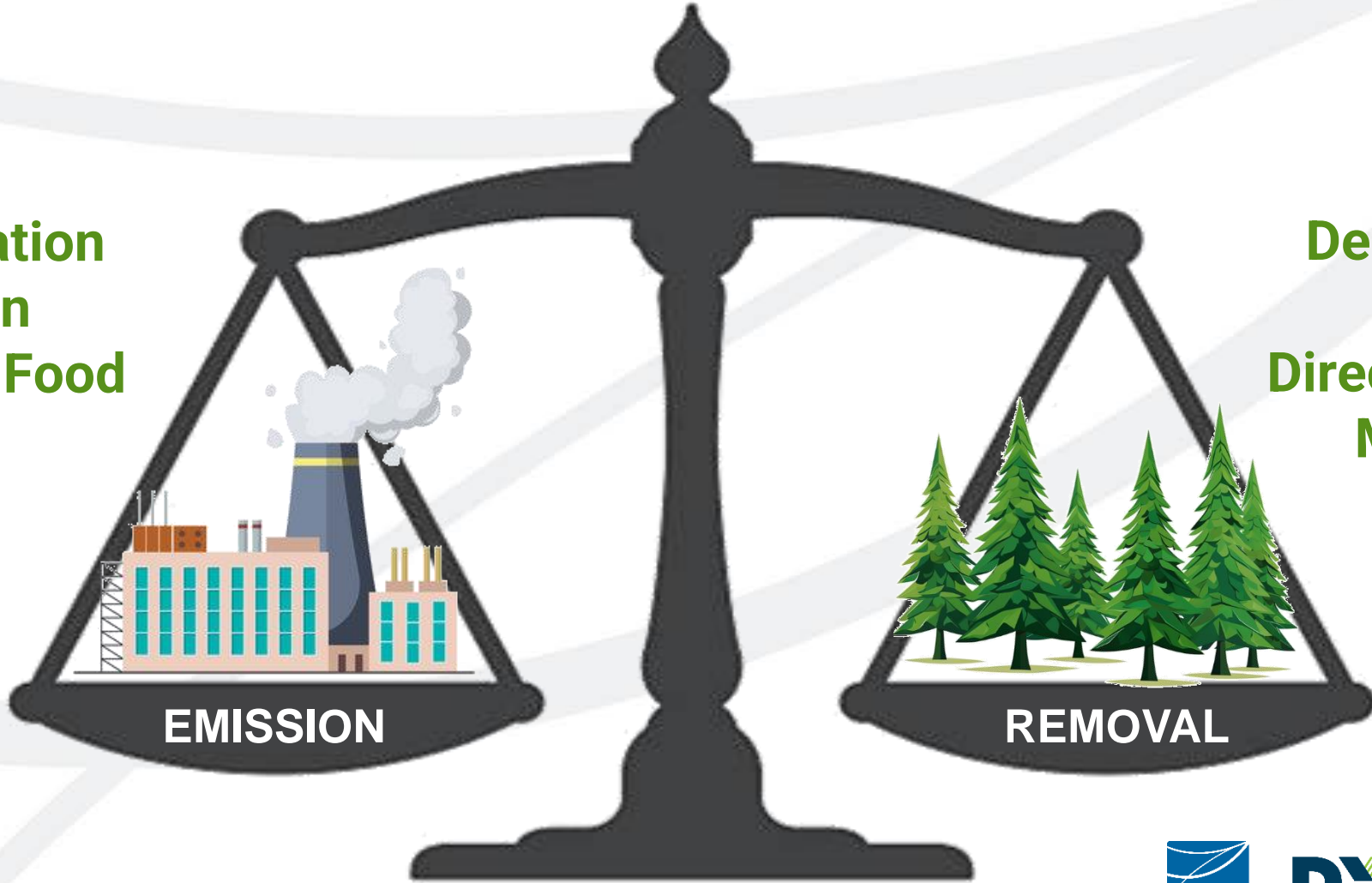


Building **Emissions** Reduction Disclosure Ordinance



What is Net Zero?

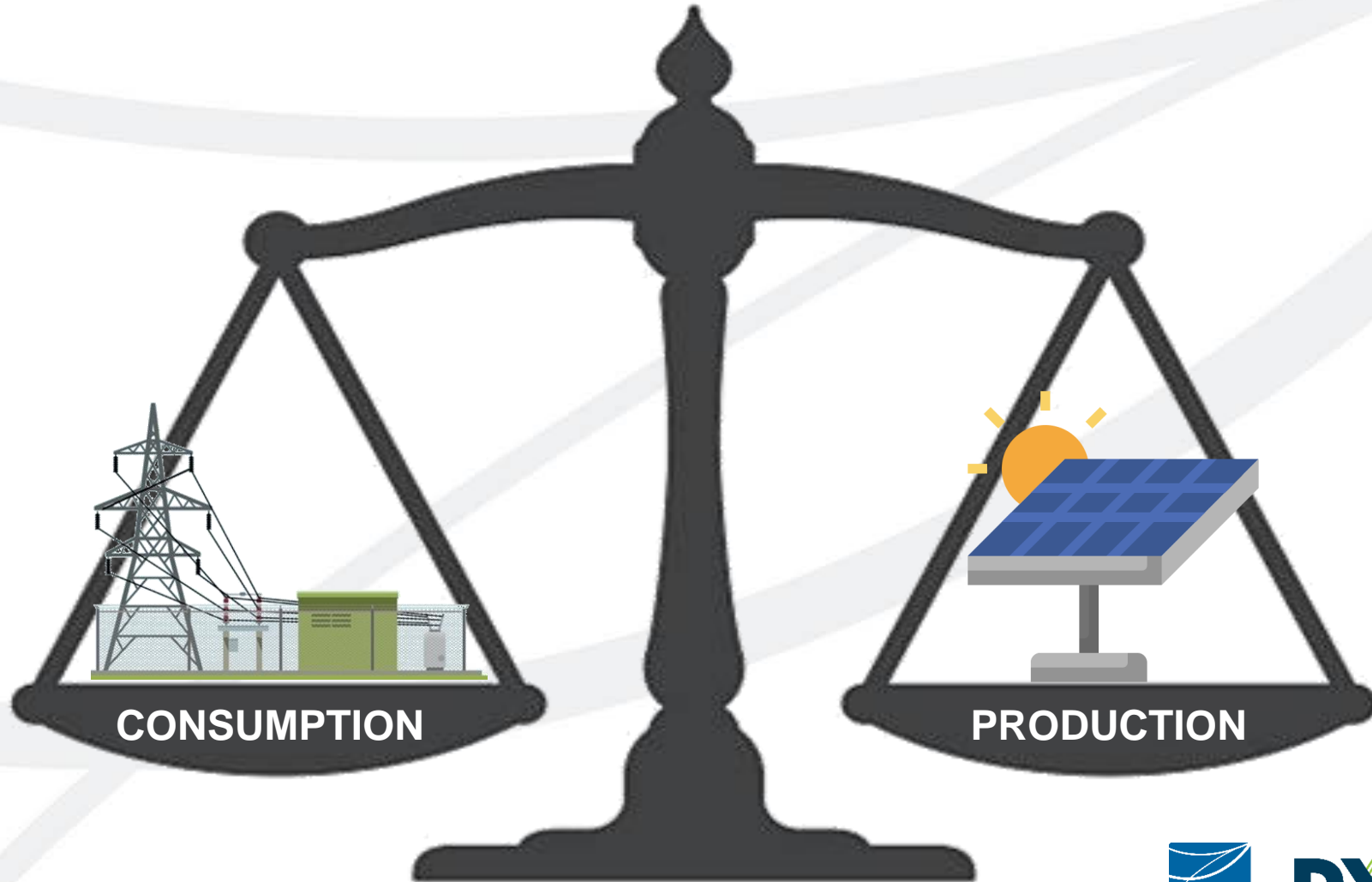
Power Generation
Transportation
Agriculture & Food
Deforestation



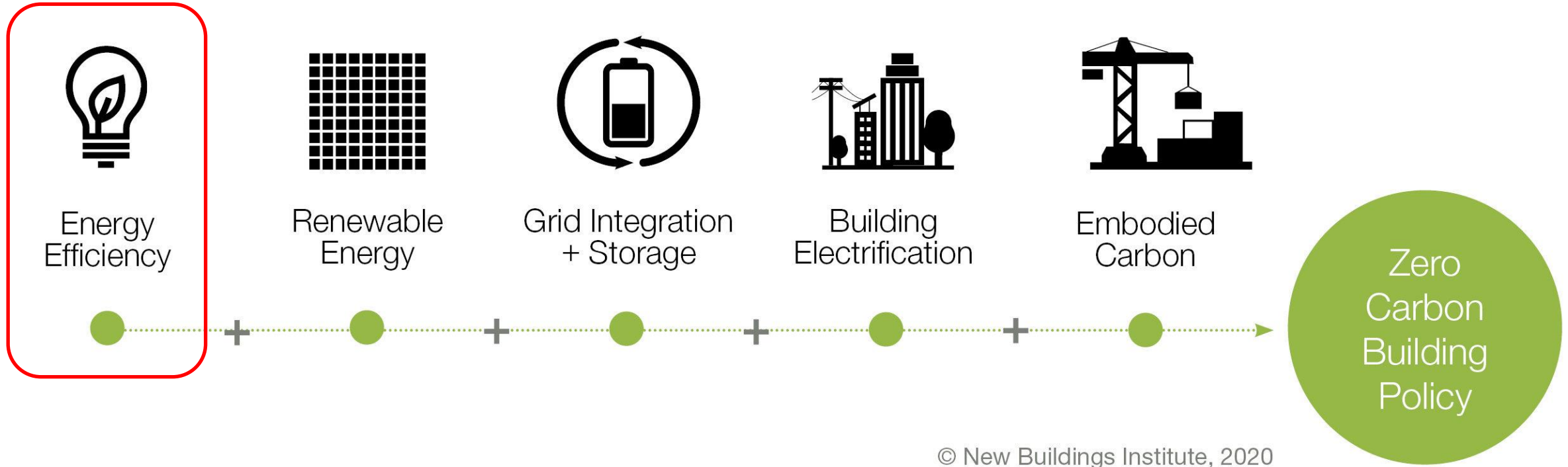
Decarbonization
Reforestation
Direct Air Capture
Mineralization



What is Net Zero?



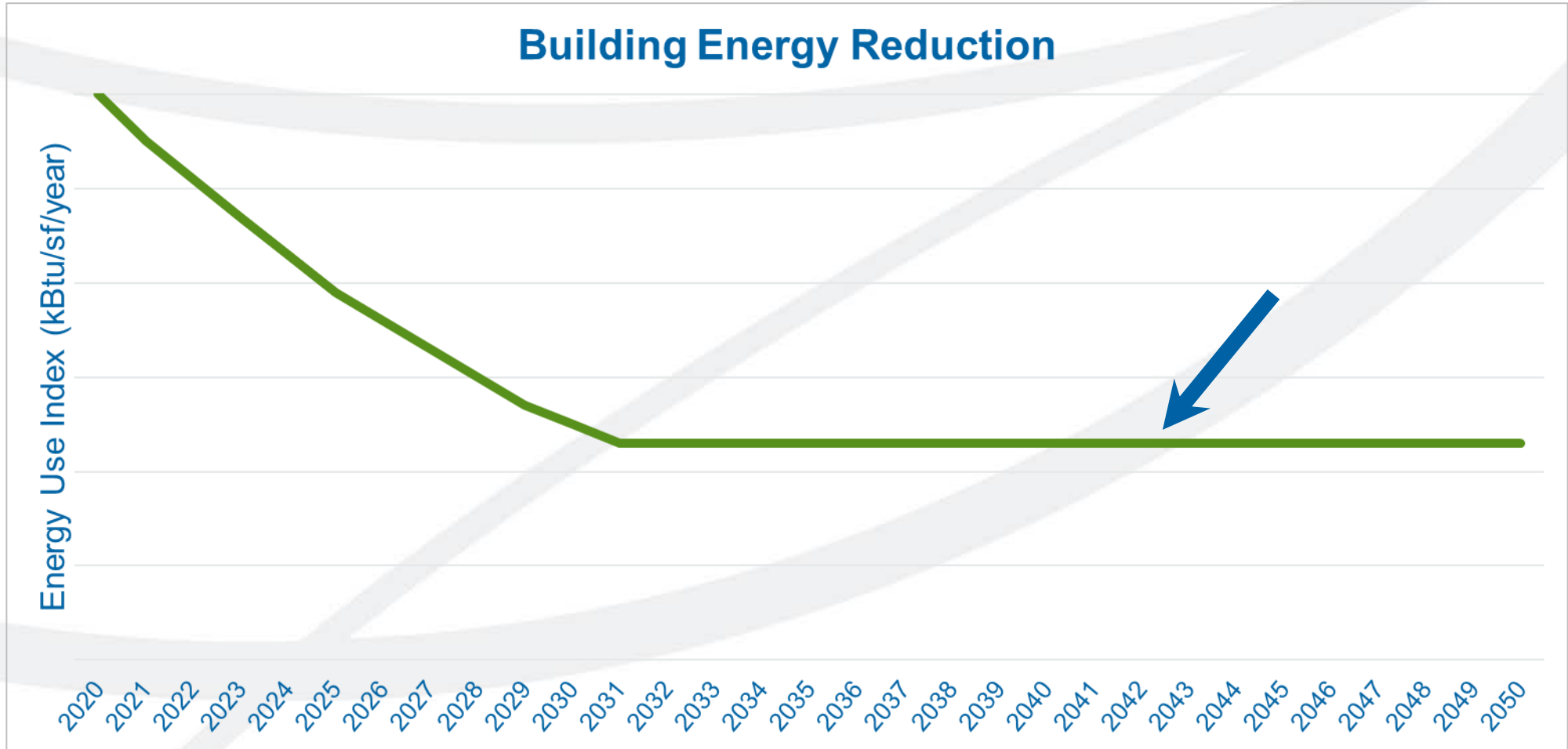
The Five Foundations of Zero Carbon Building Policies



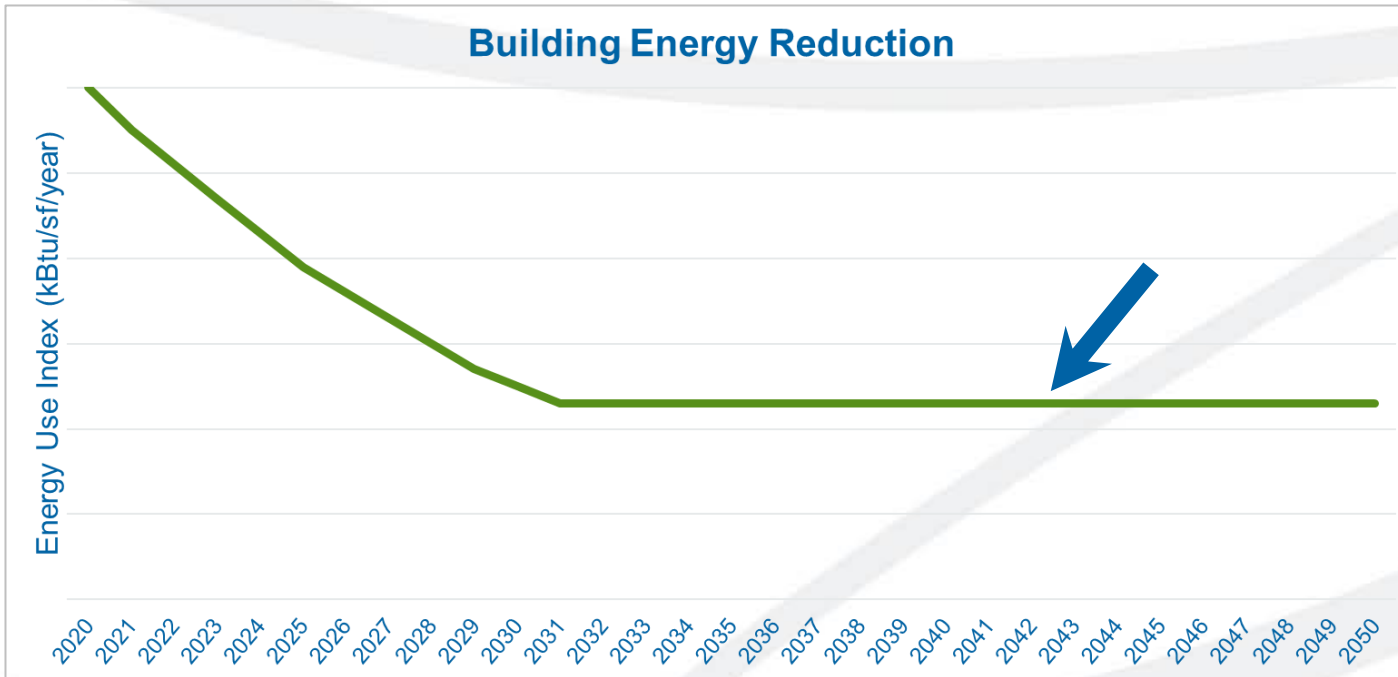
© New Buildings Institute, 2020



Energy Efficiency: Measure & Maintain



Energy Efficiency: Measure & Maintain



**61% Average Persistence
in Energy Savings**

Factors Affecting Persistence

Total Project Cost Savings

Major Retrofit

Training

BAS Management

Size of Building

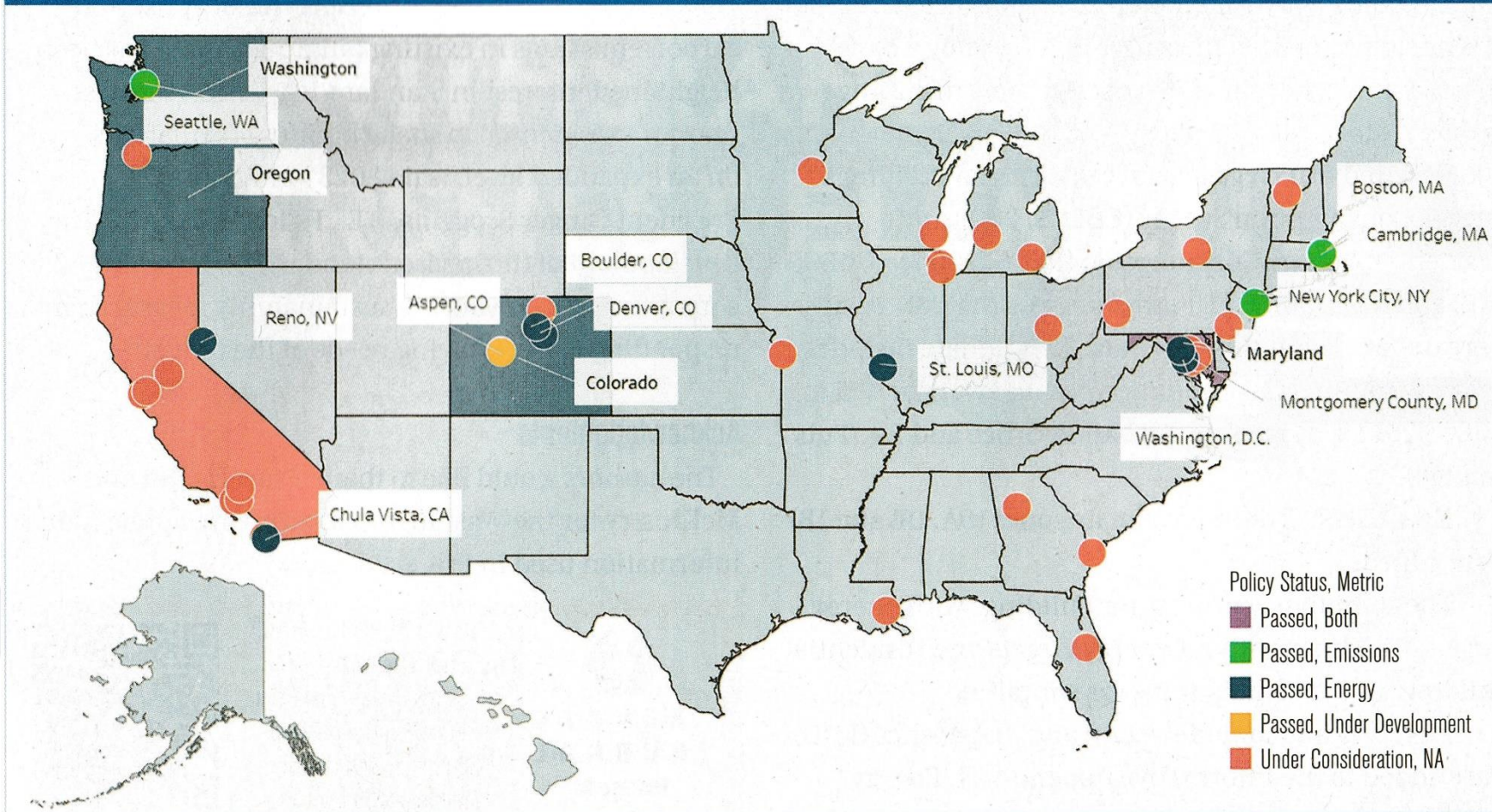
Staff Turnover

Building Type



Government Ordinances

FIGURE 2 State and local building performance standards. Source U.S. Department of Energy, Updated 12/29/2023.



- BERDO 2.0 (Boston)
- BEUDO (Cambridge)
- NYC Local Law 97

NET ZERO BY 2050

Definitions

Benchmarking

Comparison of energy use to similar facilities

EUI

Energy Use Intensity (energy/ft²/year)

EnergyStar Score

EPA EnergyStar's benchmark score



Government Ordinance Requirements

Welcome Account | Notifications | ENERGY STAR Notifications | Contacts | Help | Sign Out
arianaaxelrod: Settings

MyPortfolio | Sharing | Reporting | Recognition

EPA Sample University
314 Einstein Place, Springfield, VT 05156 | Map It
Portfolio Manager Property ID: 33105685
Year Built: 1901
Edit

Not currently eligible for ENERGY STAR Certification

Weather Normalized Source EUI (kBtu/ft²)
Current: 155.9 (13.66% lower than median.)
Baseline: 165.7 (8.25% lower than median.)

Summary | Details | Energy | Water | Waste & Materials | Goals | Design

Source EUI Trend (kBtu/ft²)
Change Metric

Metrics Summary

Metric	Dec 2014 (Energy Baseline)	Mar 2017 (Energy Current)	Change
ENERGY STAR Score (1-100)	Not Available	Not Available	N/A
Source EUI (kBtu/ft ²)	167.5	154.9	-12.60 (-7.50%)
Site EUI (kBtu/ft ²)	81.1	70.5	-10.60 (-13.10%)
Energy Cost (\$)	3,040,941.24	2,807,209.75	-233,731.49 (-7.70%)
Total (Location-Based) GHG Emissions Intensity (kgCO ₂ e/ft ²)	5.4	4.8	-0.60 (-11.10%)
Water Use (All Water Sources) (kgal)	87,634.4	90,491.1	2,856.70 (3.30%)
Total Waste (Disposed and Diverted) (Tons)	3,823.93	3,141.05	-682.88 (-17.90%)

(Chart current as of 03/07/2024 07:26 PM EST) Refresh Chart

- Reporting
- Compliance
- Improvement



BERDO Emissions Standard (kgCO₂e/ft²/yr)

Building Use	2025-2029	2030-2034	2035-2039	2040-2044	2045-2049	2050-
Assembly	7.8	4.6	3.3	2.1	1.1	0
College/University	10.2	5.3	3.8	2.5	1.2	0
Education	3.9	2.4	1.8	1.2	0.6	0
Food Sales & Service	17.4	10.9	8.0	5.4	2.7	0
Healthcare	15.4	10.0	7.4	4.9	2.4	0
Lodging	5.8	3.7	2.7	1.8	0.9	0
Manufacturing/Industrial	23.9	15.3	10.9	6.7	3.2	0
Multifamily Housing	4.1	2.4	1.8	1.1	0.6	0
Office	5.3	3.2	2.4	1.6	0.8	0
Retail	7.1	3.4	2.4	1.5	0.7	0
Services	7.5	4.5	3.3	2.2	1.1	0
Storage	5.4	2.8	1.8	1.0	0.4	0
Technology/Science	19.2	11.1	7.8	5.1	2.5	0



BEUDO Benchmarking

Baseline: 2018 & 2019

>100,000 sqft

Year	May Not Exceed
2026-2029	80% of baseline
2030-2034	40% of baseline
2035-	GHG emissions shall not exceed 0

25,000-99,999 sqft

Year	May Not Exceed
2026-2029	100% of baseline
2030-2034	60% of baseline
2035-2039	40% of baseline
2040-2044	20% of baseline
2045-2049	10% of baseline
2050-	GHG emissions shall not exceed 0



Manage Bills (Meter Entries) for [EPA Sample University \(including one child building\)](#)

Meter Selection: Electric Grid Meter - 182113433

Basic Meter

Energy Meters

Electric Grid Meter - 182113433

Natural Gas - 182113436

Water Meters

Potable Indoor Meter - 182113434

Potable Outdoor Meter - 182113435

Waste Meters

Composted- Compostable - Mixed/Other - 182113438

to the left to expand this section)

Display Year(s):

2017

	Start Date		Thousand Watt-	Total Cost (\$)	Estimation	Green Power	Demand (kW)	Demand Cost (\$)	Last Updated
<input type="checkbox"/>	12/12/2016		79	173,841.96	<input type="checkbox"/>	<input type="checkbox"/>			3/7/2024 arianaaxelrod
<input type="checkbox"/>	1/11/2017	2/15/2017	3,200,000	250,000	<input type="checkbox"/>	<input type="checkbox"/>			3/7/2024 arianaaxelrod
<input type="checkbox"/>	2/15/2017	3/16/2017	2,300,000	175,000	<input type="checkbox"/>	<input type="checkbox"/>			3/7/2024 arianaaxelrod
<input type="checkbox"/>	3/16/2017	4/16/2017	2,280,000	174,000	<input type="checkbox"/>	<input type="checkbox"/>			3/7/2024

Can we automate this?

Automate Your Reporting

- **High Speed Infrastructure**
- **Metering**
- **Data Storage**



Automate Your Reporting

- **High Speed Infrastructure**
- Metering
- Data Storage



BAS Architecture

Enterprise



Server

Building (Global Control)



Building A



Building B

Equipment (AHU/Plant Control)



AHU-1



AHU-2



AHU-1



Central
Plant

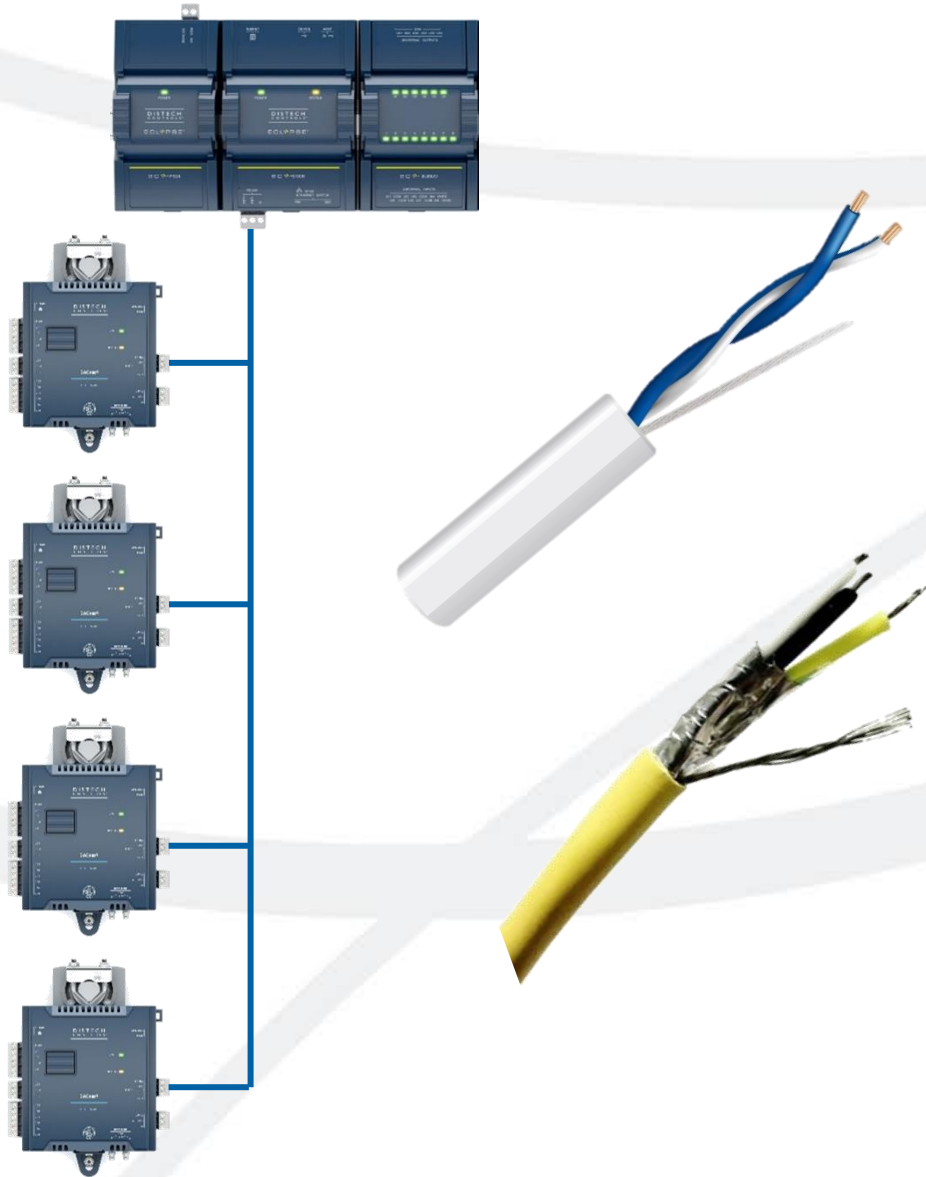
Sensors and Actuators (Device Control)



Field Devices



Serial Communication Networks



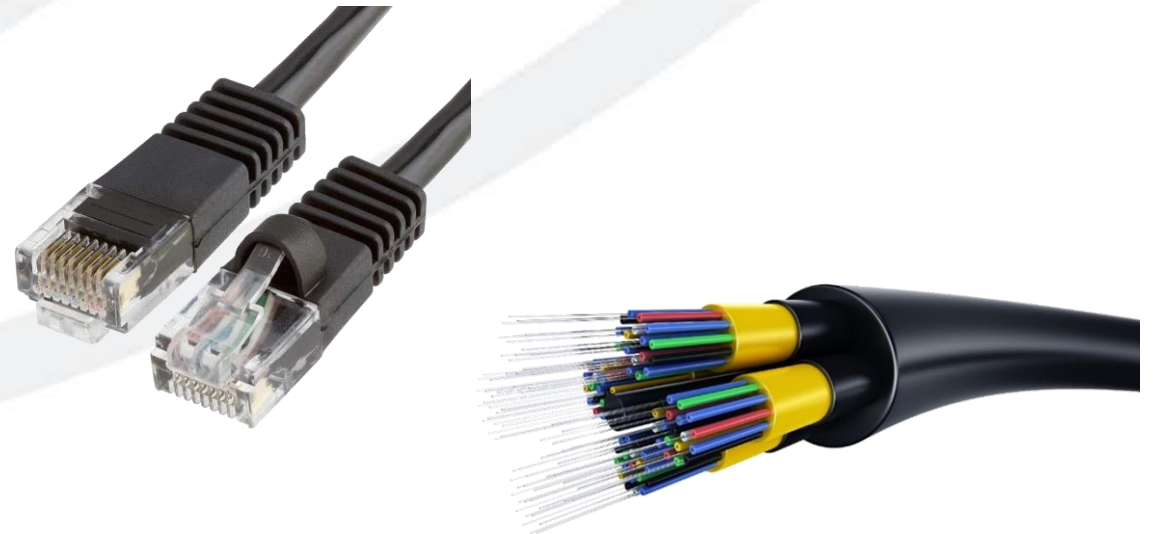
Protocol	Max Data Rate
LONTalk	12.5 kbps
BACnet MS/TP	78.4 kbps



BACnet IP



Protocol	Max Data Rate
LONTalk	12.5 kbps
BACnet MS/TP	78.4 kbps
BACnet IP	100 <u>M</u> bps



BACnet IP



Protocol	Max Data Rate
LONTalk	12.5 kbps
BACnet MS/TP	78.4 kbps
BACnet IP	100 <u>M</u> bps

**100x
FASTER**

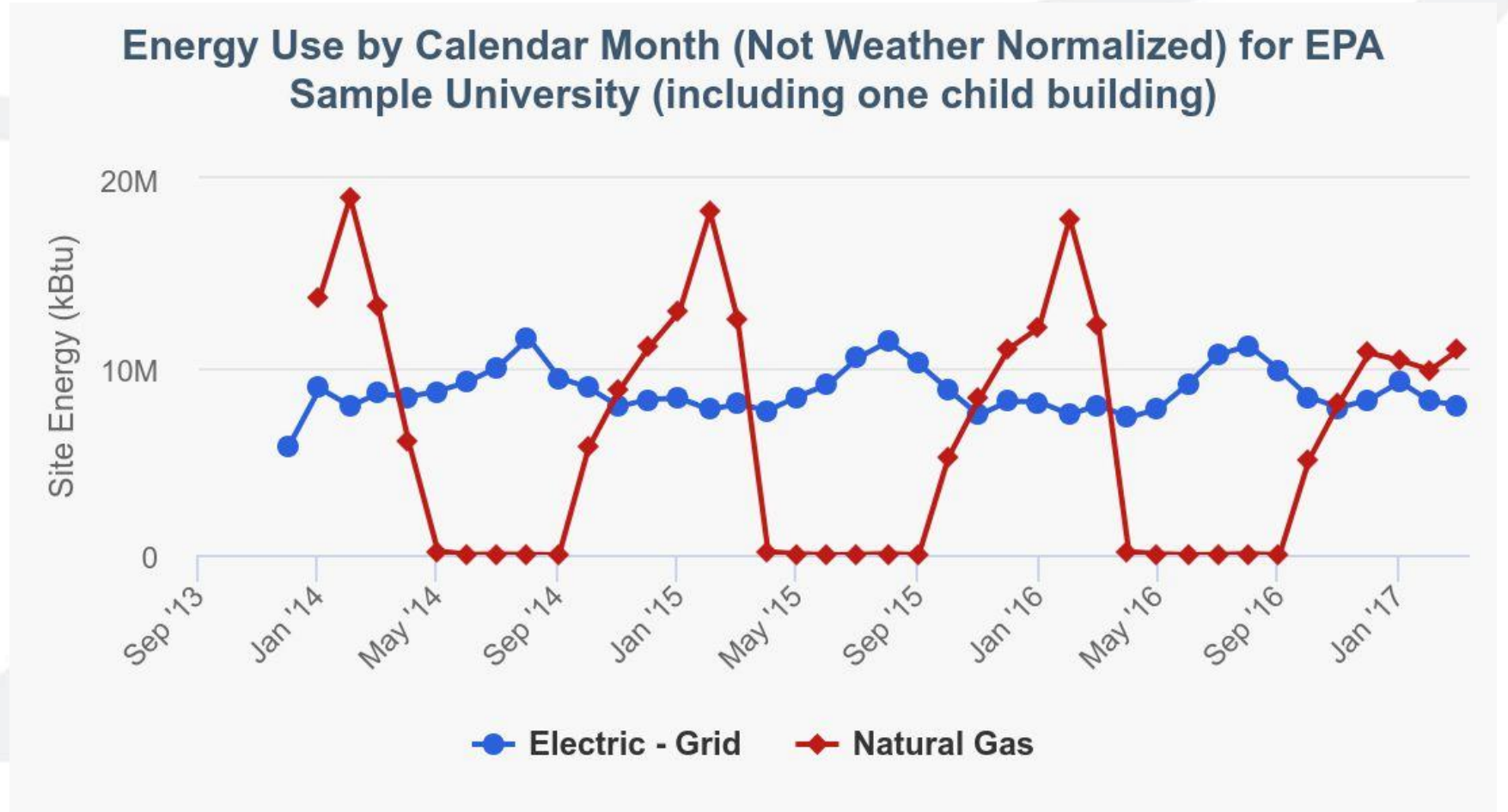


Automate Your Reporting

- High Speed Infrastructure
- **Metering**
- Data Storage



Energy Disaggregation



Energy Audits

Collect Energy Data

Collect 2-3 years of utility data

Site Survey

Collect nameplate from building systems

Analysis

Calculate system specific energy usage

Identify ECMs

Identify areas of potential energy savings

Economic Evaluation

Complete cost analysis and calculate payback



Energy Audits

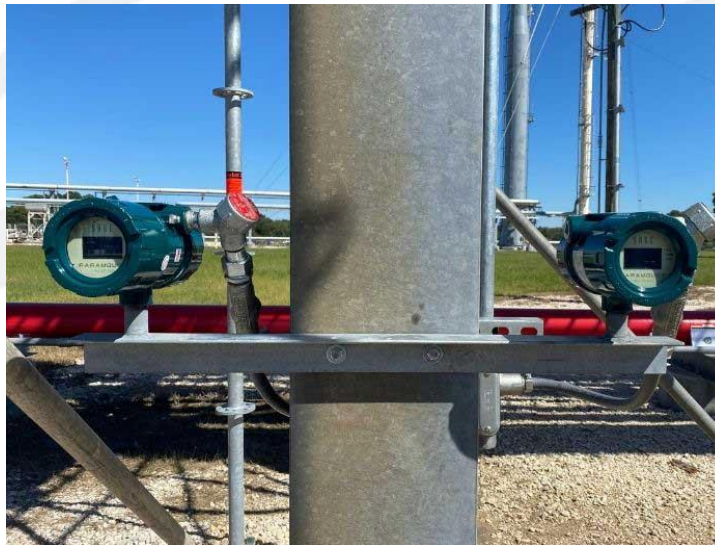
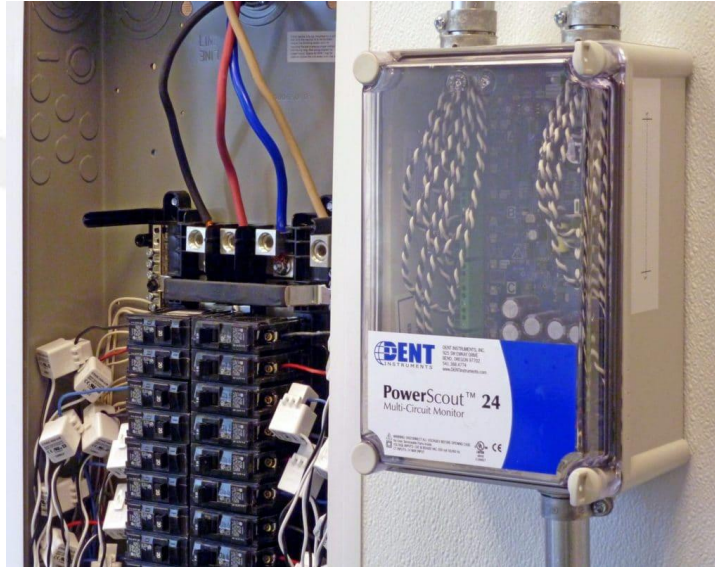
Analysis

Calculate system specific energy usage

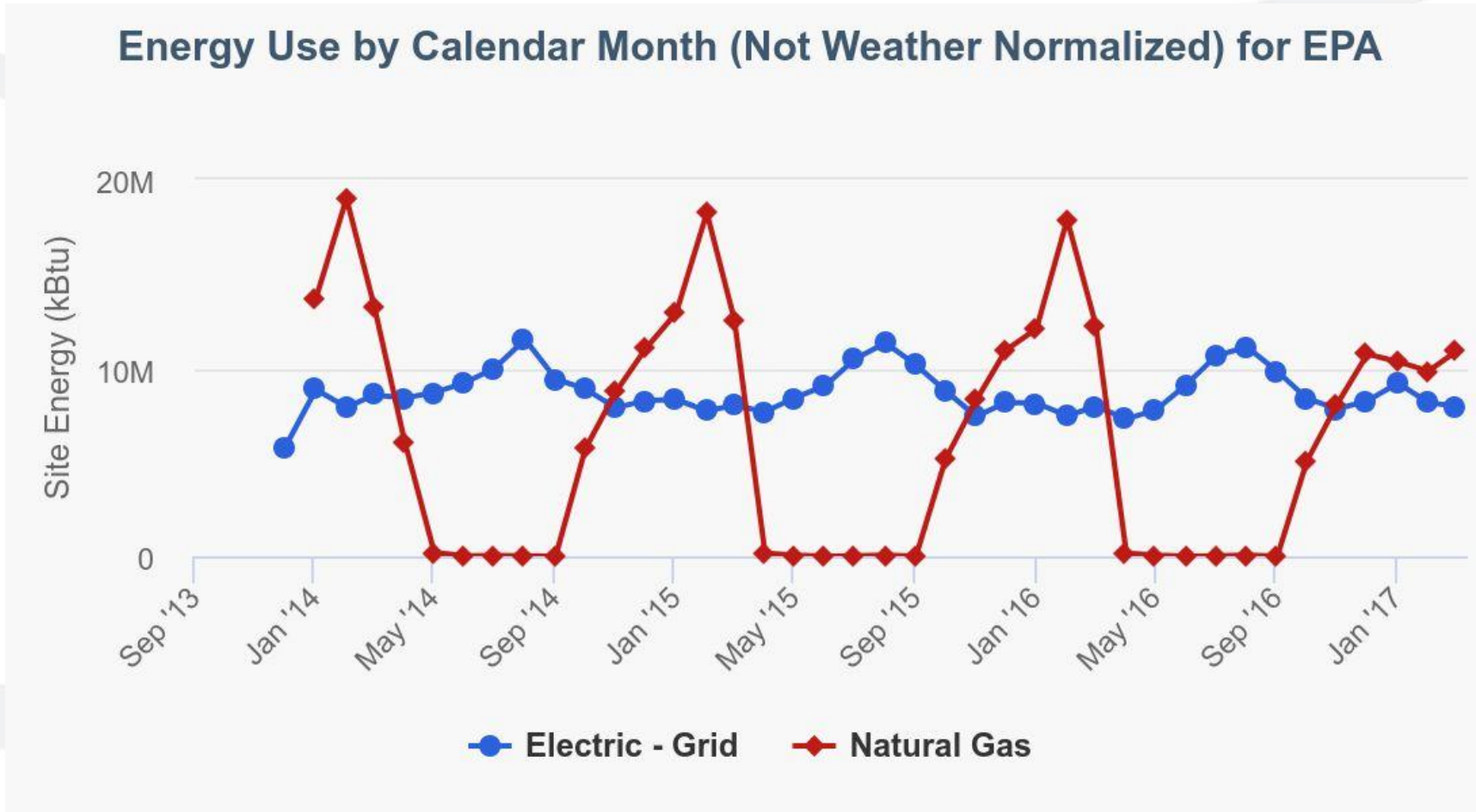
- Makes **assumptions** about general operating hours and building use
- Uses historical weather data to **estimate** system loads
- Uses nameplate data, which assumes **ideal conditions**
- Subject to **human error**



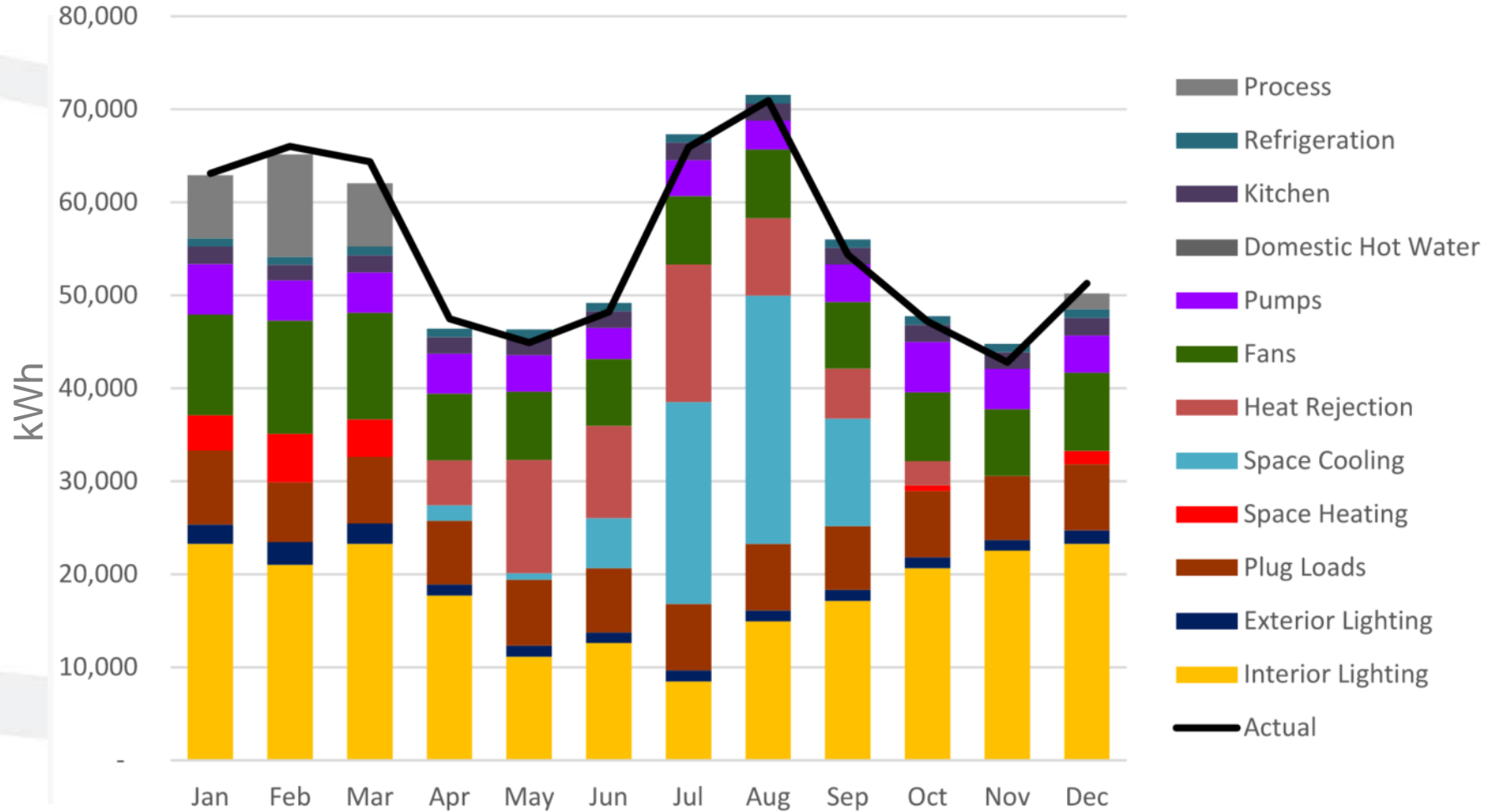
Energy Disaggregation



Energy Disaggregation



Energy Disaggregation



**Chiller
Plant**

**Hot Water
Plant**

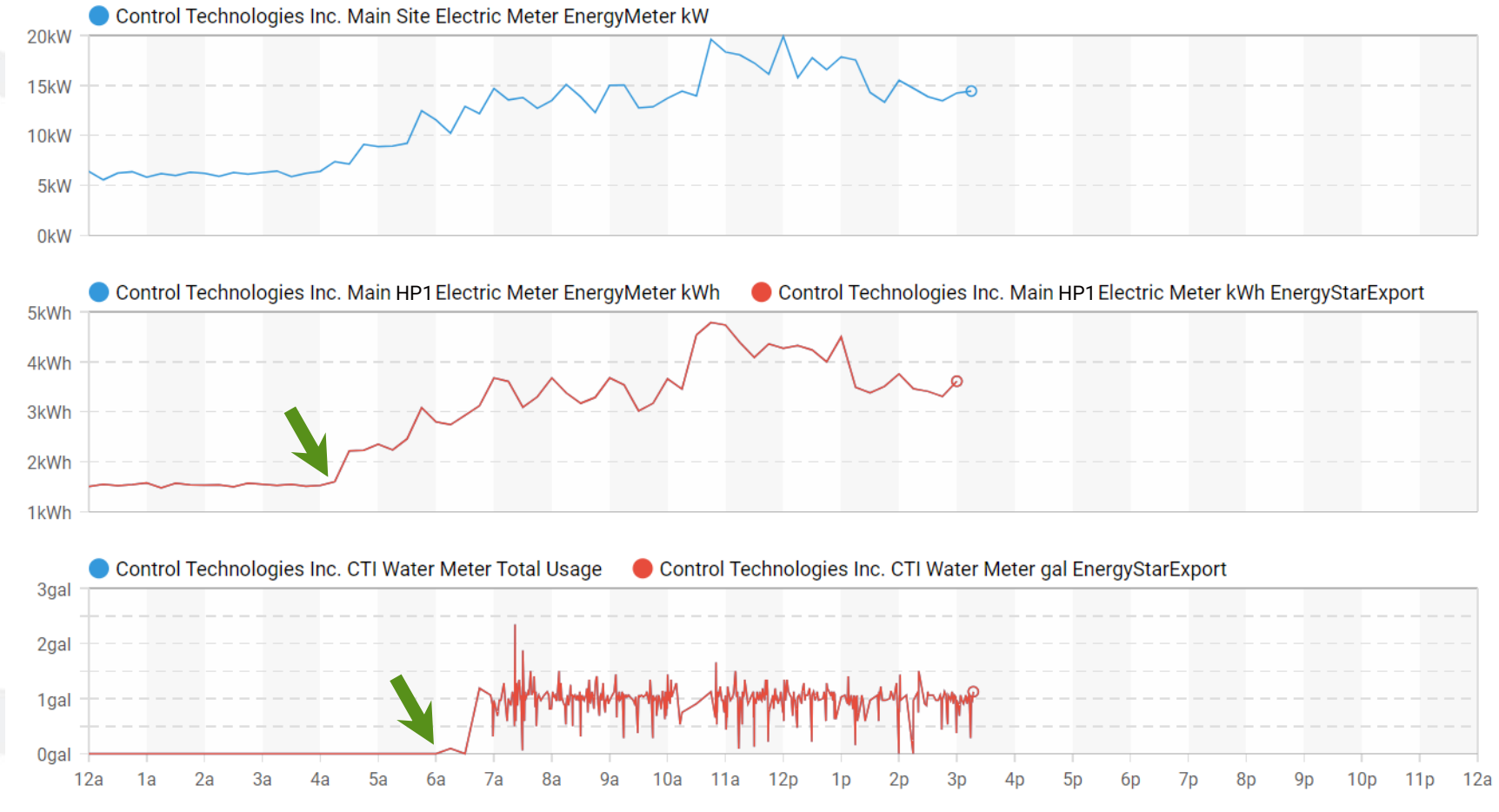
**Air Handling
Systems**

**Backbone
Infrastructure**

**Terminal
Units**



Energy Disaggregation



Automate Your Reporting

- High Speed Infrastructure
- Metering
- **Data Storage**



BAS Architecture

Enterprise

Building
(Global Control)



Server



Building A



Building B



What is the Cloud?



My boss told me to put my files in the cloud.



What is the Cloud?



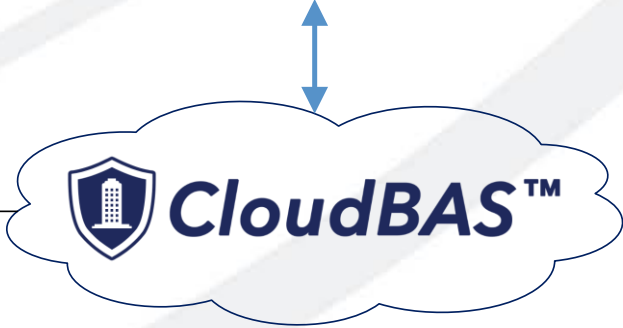
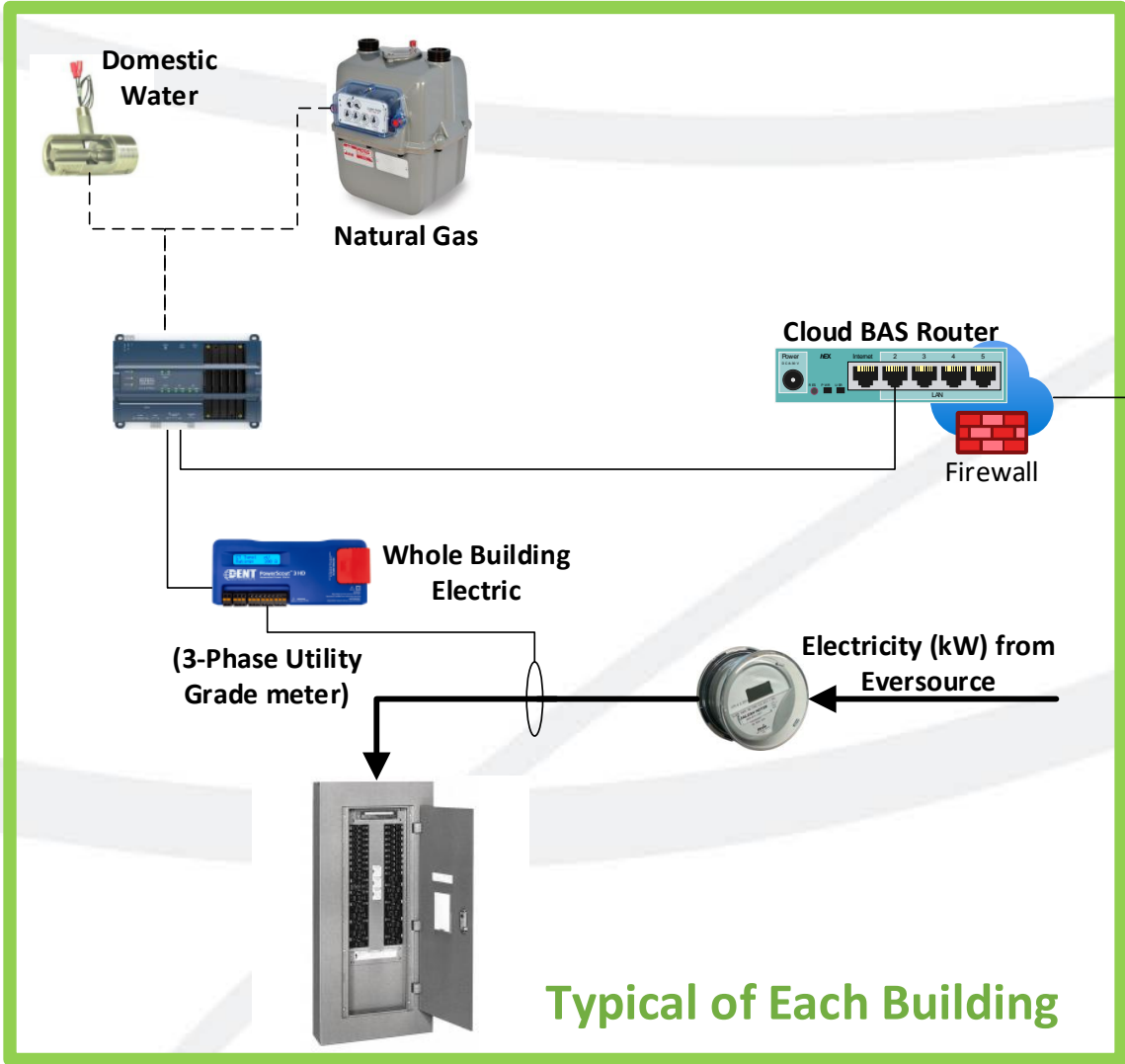
My boss told me to put my files in the cloud.



What is the Cloud?



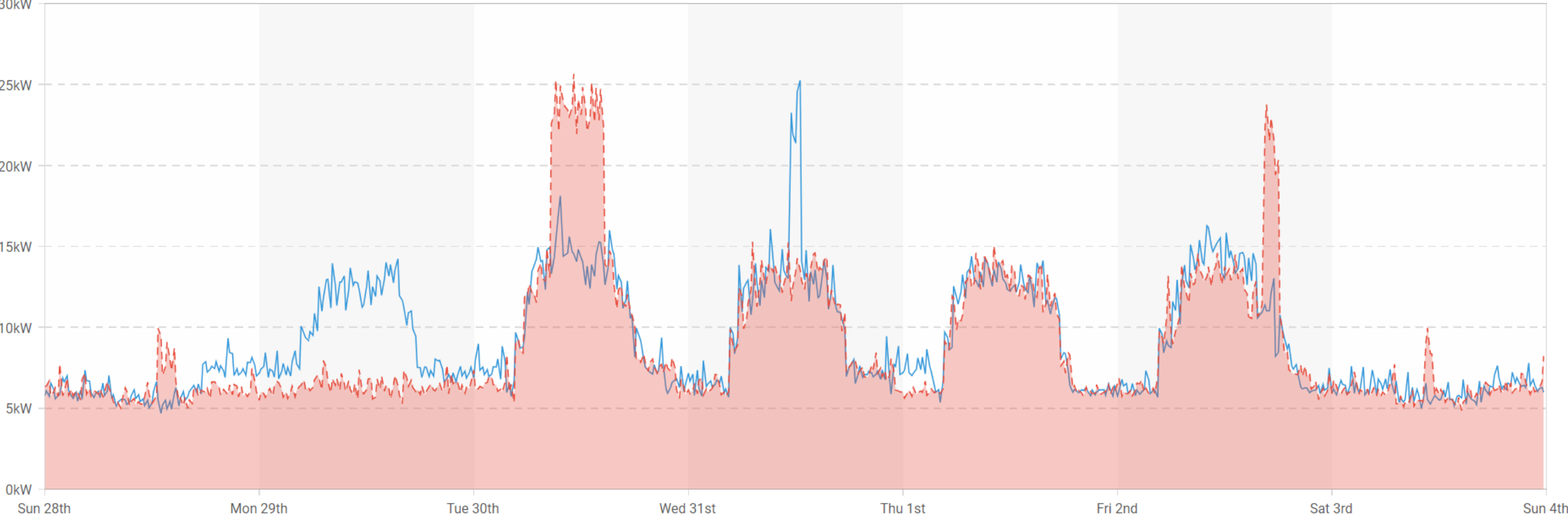
CloudZERO^eTM



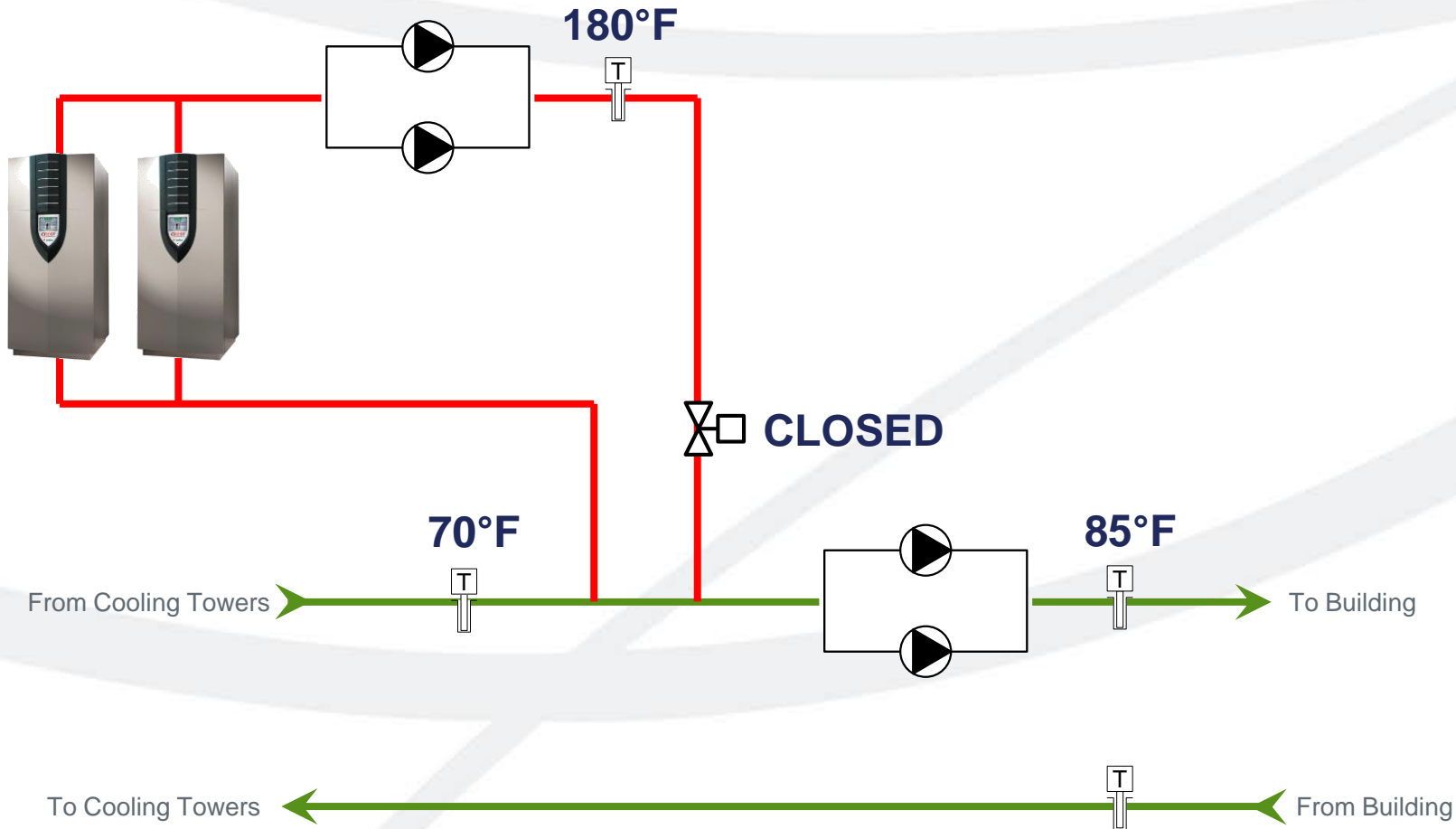
Elec Power • Week of 28-Jan-2024

Peak over 10min • Baseline Prev Month

● Control Technologies Inc. ● Baseline Energy Previous Week



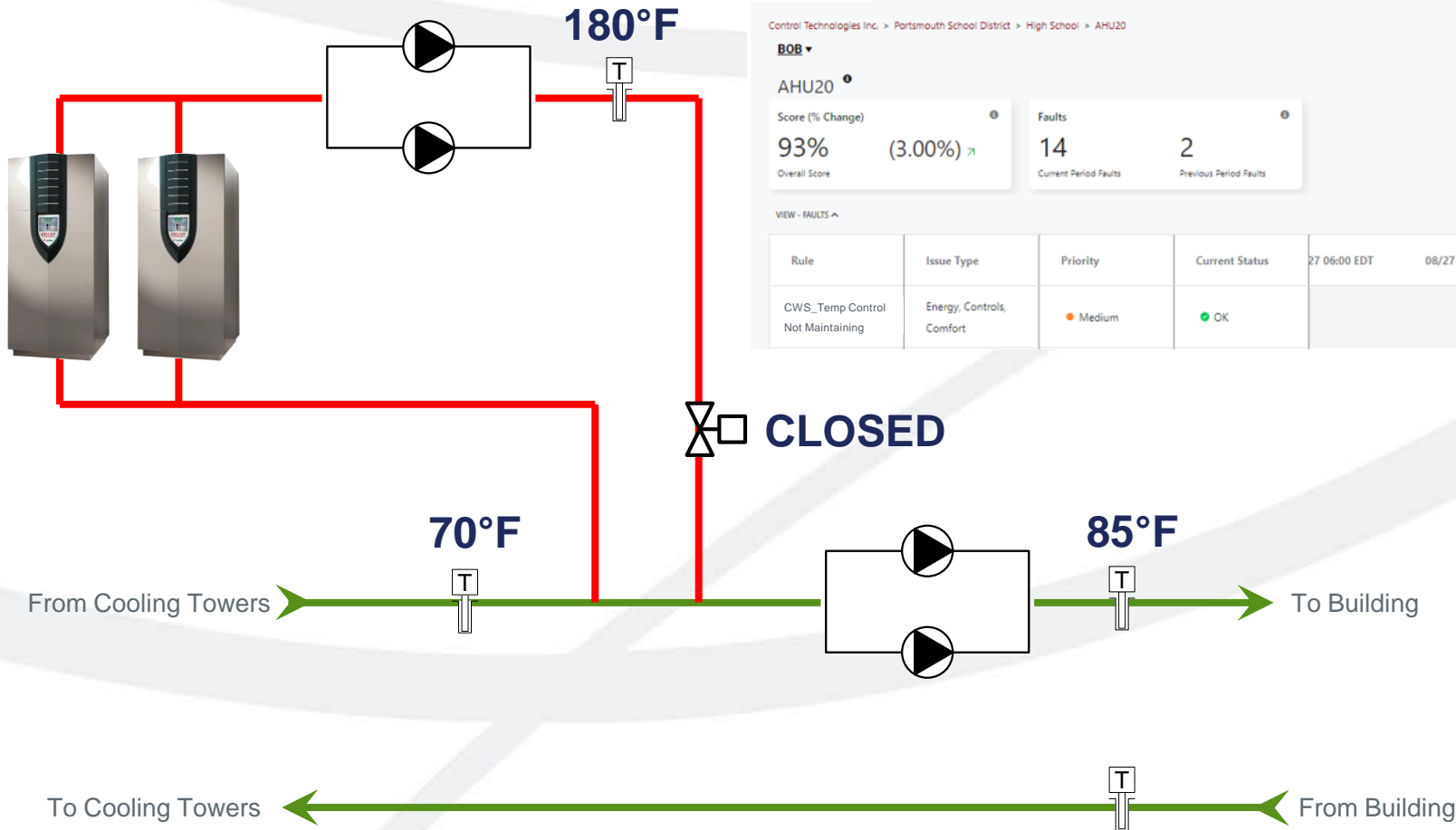
Fault Detections & Diagnostics (FDD)



CWS Set Point: 80°F
Alarm Limits: Below 60°F
Above 95°F



CloudFDD™



Company: Control Tec... Client: Portsmouth... Site: High School Equipment: AHU20

Control Technologies Inc. > Portsmouth School District > High School > AHU20

BOB

AHU20

Score (% Change): 93% (3.00%)

Faults: 14 (Current Period Faults), 2 (Previous Period Faults)

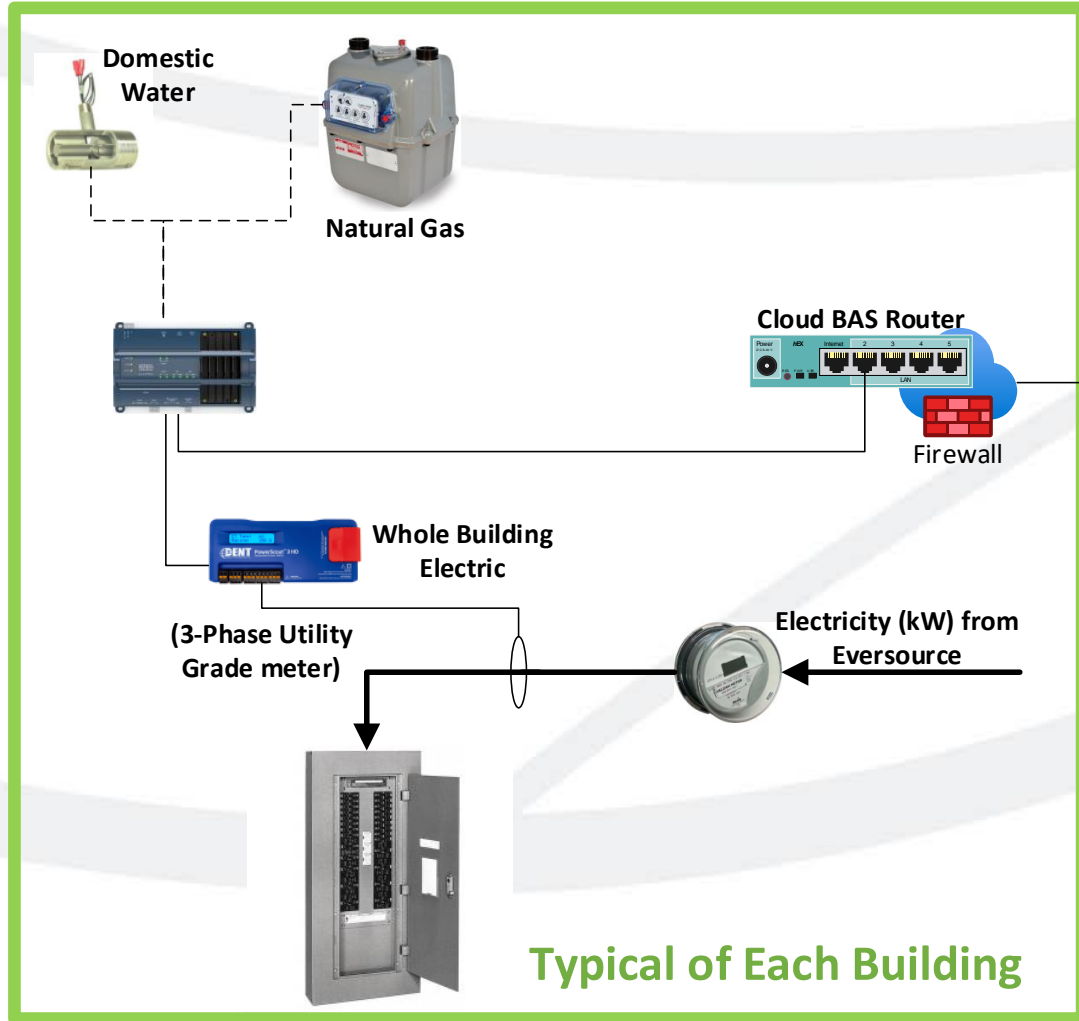
VIEW - FAULTS

Rule	Issue Type	Priority	Current Status	27 06:00 EDT	08/27 10:00 EDT	08/27 13:00 EDT	08/27 15:00 EDT	08/27 18:00 EDT	08/27 20:00 EDT	08/30 06:00 EDT
CWS_Temp Control Not Maintaining	Energy, Controls, Comfort	Medium	OK							

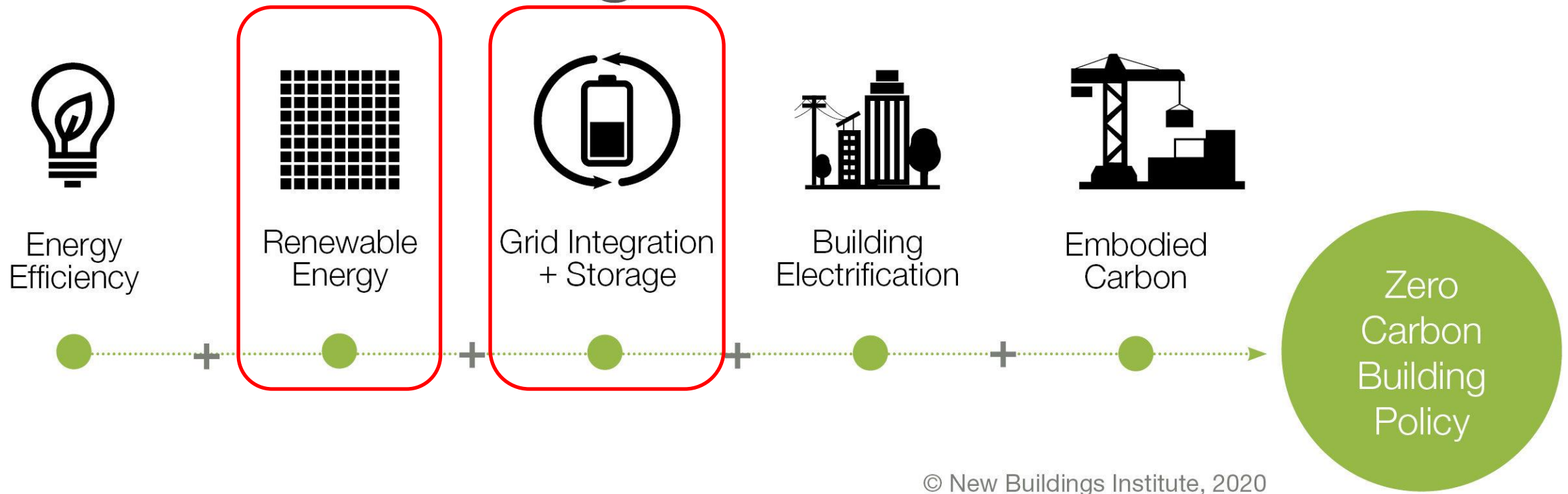
CWS Set Point: 80°F
Alarm Limits: Below 60°F
Above 95°F



Smart Grid

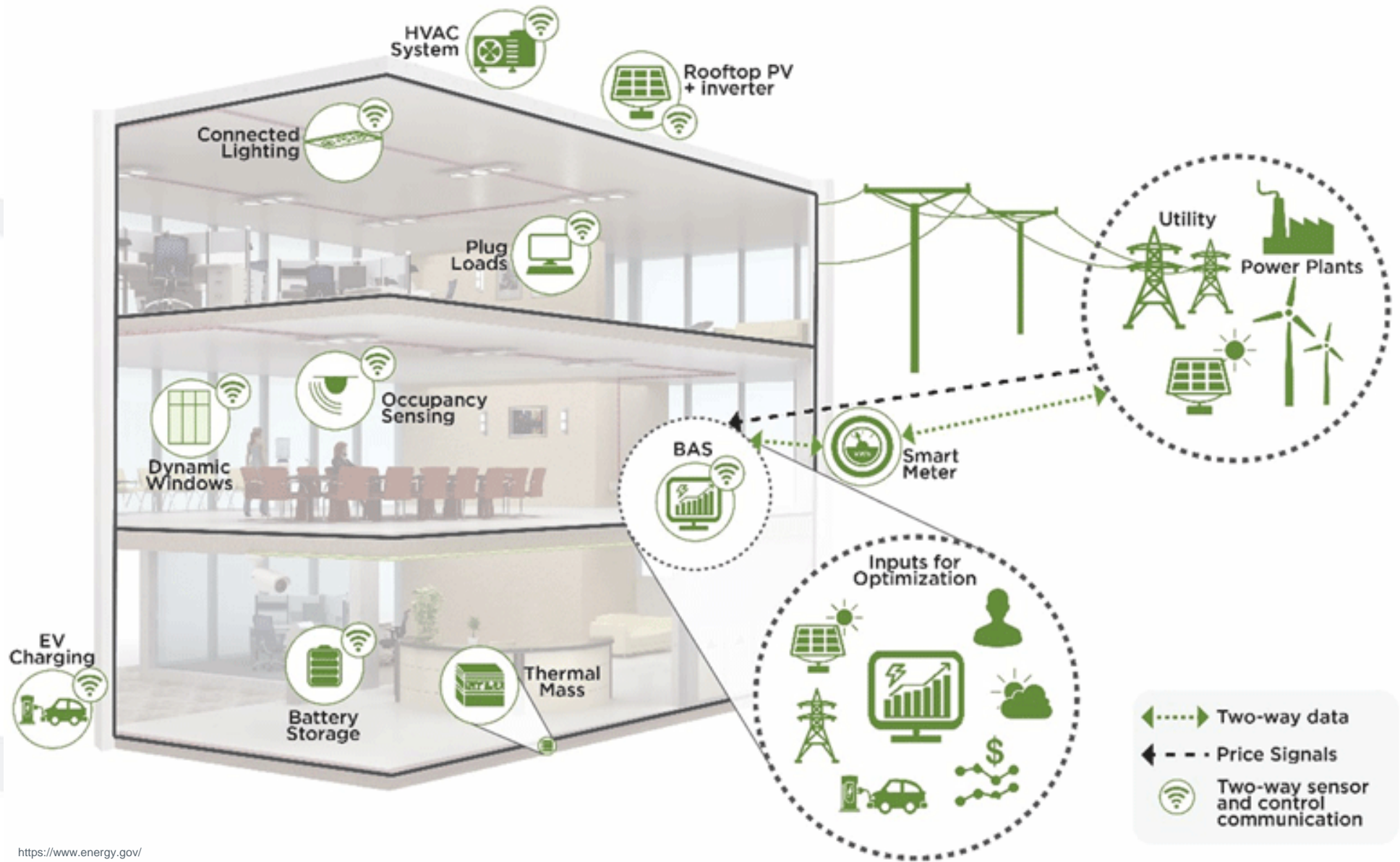


The Five Foundations of Zero Carbon Building Policies



© New Buildings Institute, 2020

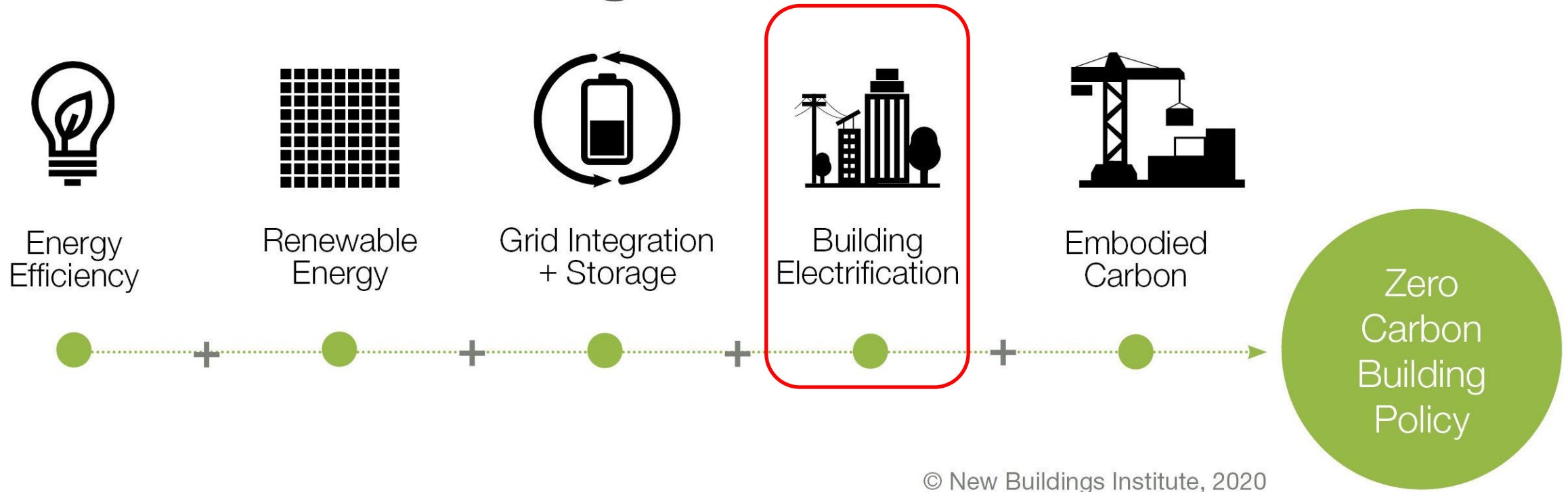




<https://www.energy.gov/>



The Five Foundations of Zero Carbon Building Policies



Carbon Dioxide Emissions Coefficients

Carbon Dioxide (CO₂) Factors: **Pounds CO₂**
Per Unit of Volume or Mass

For homes and businesses

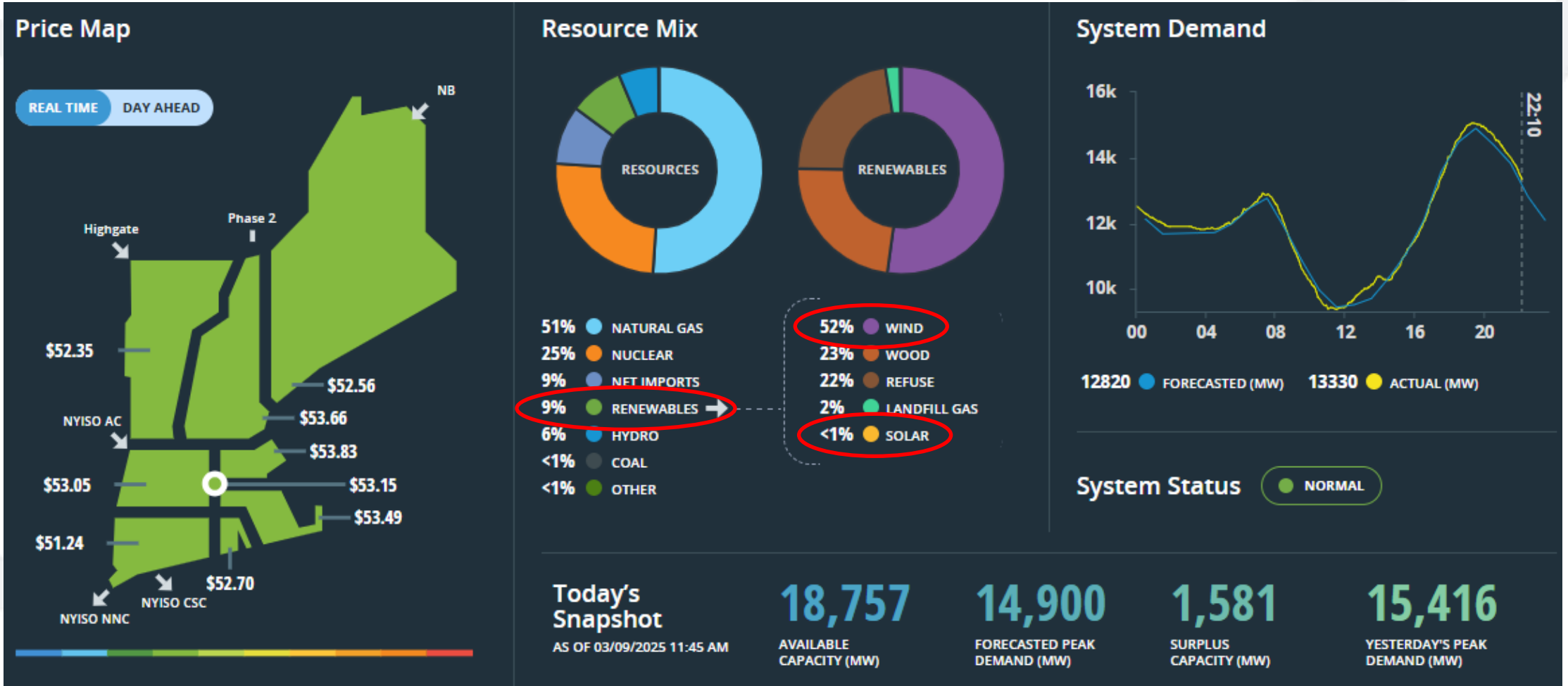
Propane	12.68 gallon
Diesel and Home Heating Fuel (Distillate Fuel Oil)	22.45 gallon
Kerosene	21.78 gallon
Coal (All types)	3,890.78 short ton
Natural Gas	120.96 thousand cubic feet
Finished Motor Gasoline ^a	17.86 gallon
Motor Gasoline	19.37 gallon
Residual Heating Fuel (Businesses only)	24.78 gallon

<https://www.eia.gov/>

What about
electricity?



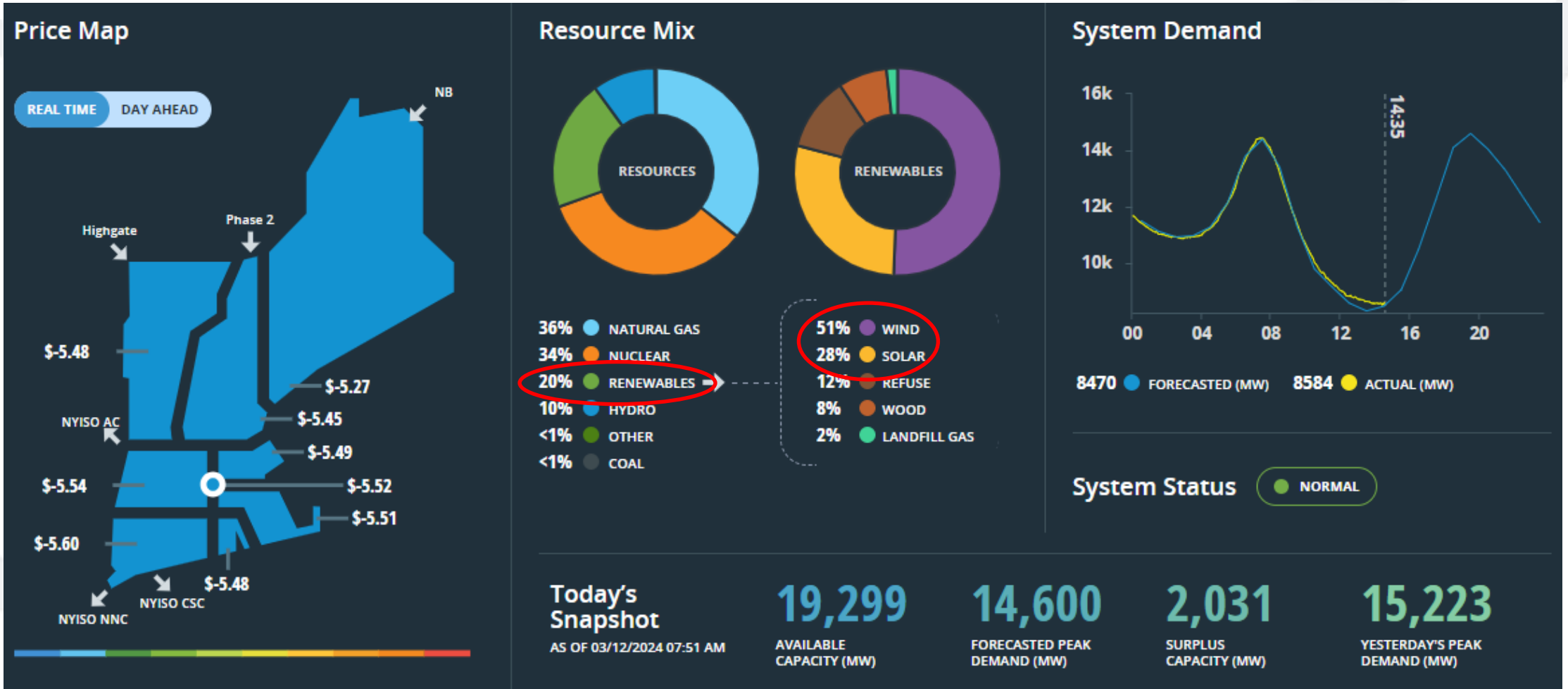
New England Resource Mix – 3/9/2025



<https://www.iso-ne.com/>



New England Resource Mix – 3/12/2024



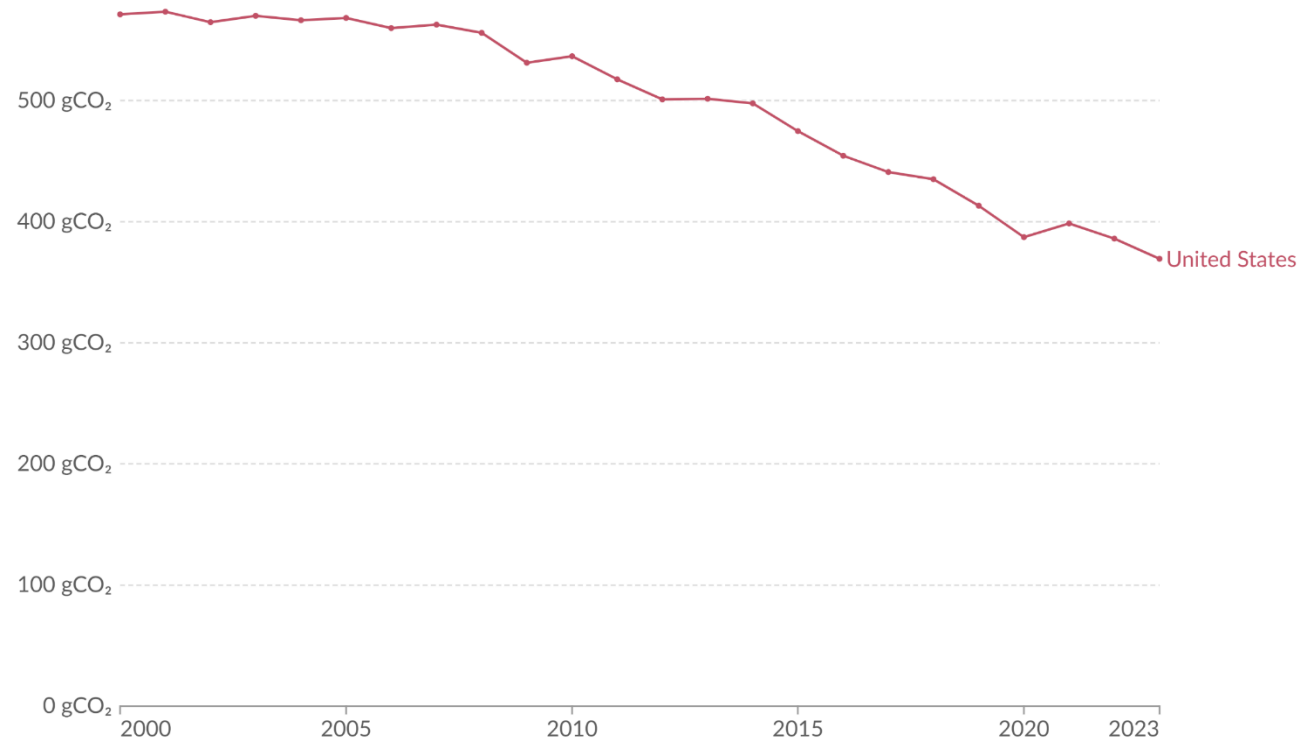
<https://www.iso-ne.com/>



Electrification

Carbon intensity of electricity generation, 2000 to 2023

Carbon intensity is measured in grams of carbon dioxide-equivalents¹ emitted per kilowatt-hour² of electricity generated.



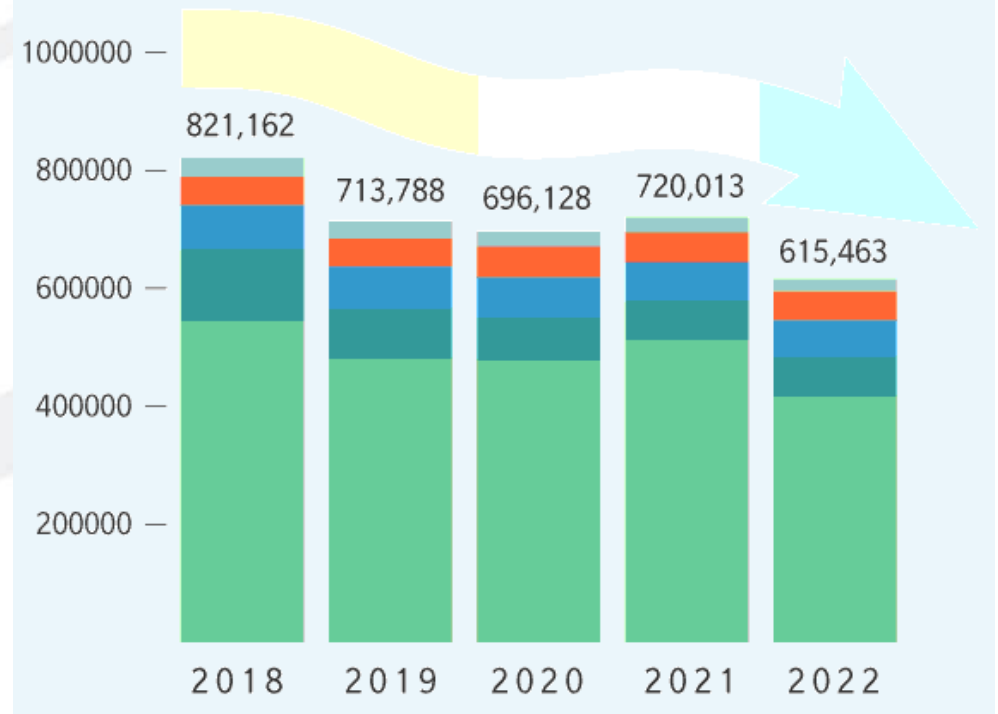
Data source: Ember (2024); Energy Institute - Statistical Review of World Energy (2023)

OurWorldInData.org/energy | CC BY

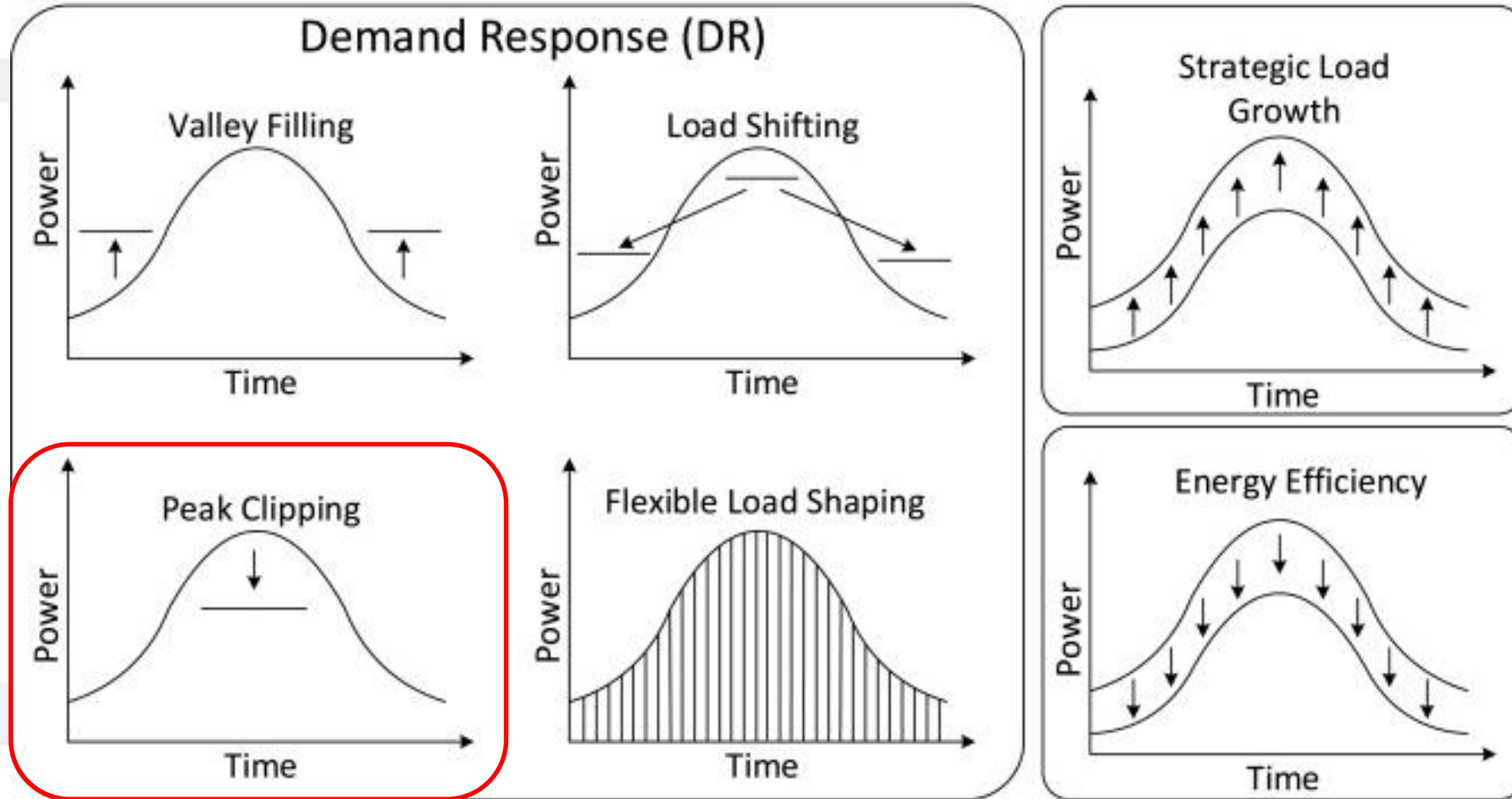
Our World in Data

Eversource Emissions Progress

Operational Emissions (Scopes 1 and 2) in MT CO_{2e}

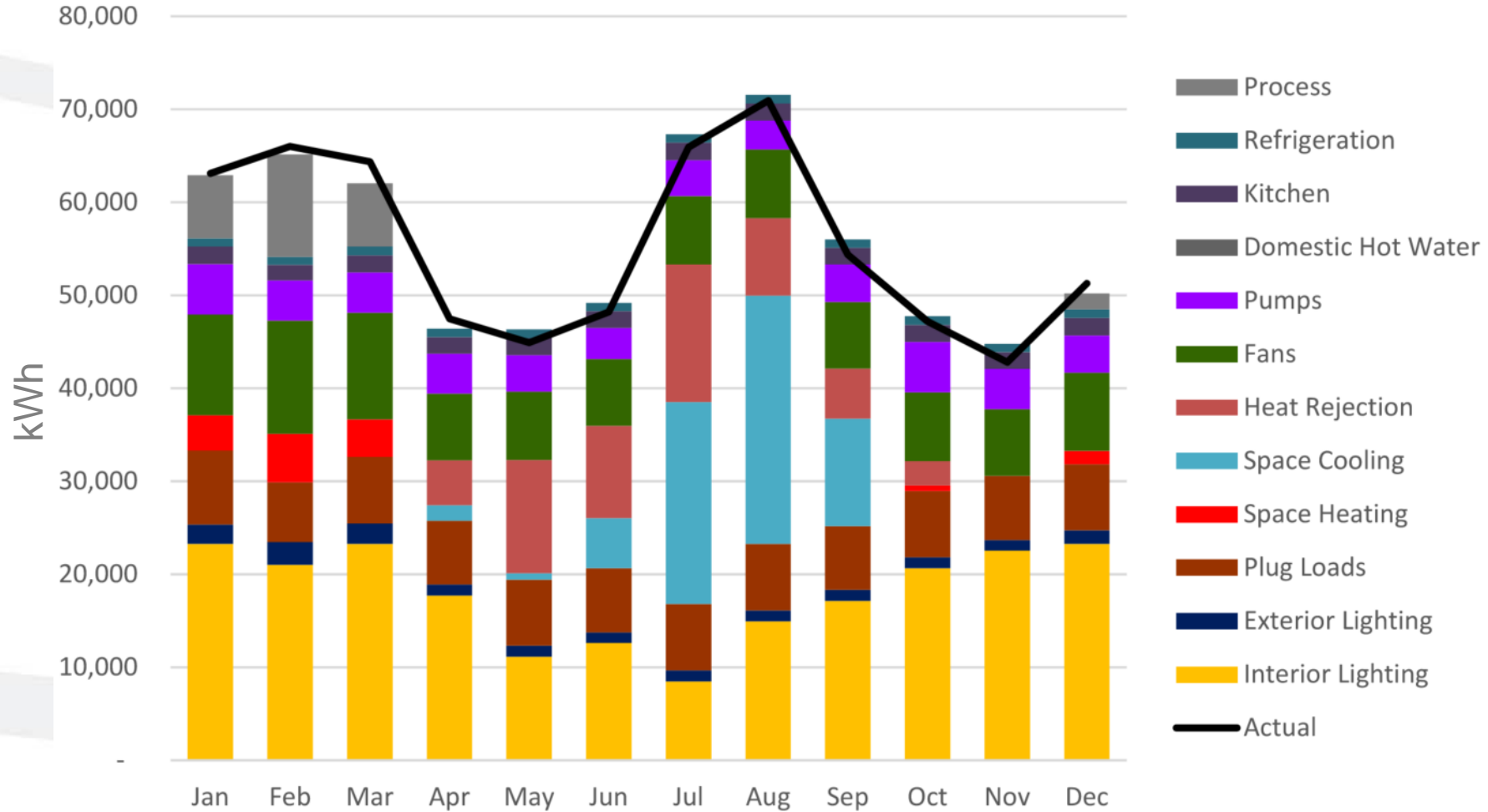


Demand Side Management



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

Energy Disaggregation



BEUDO Benchmarking

Baseline: 2018 & 2019

>100,000 sqft

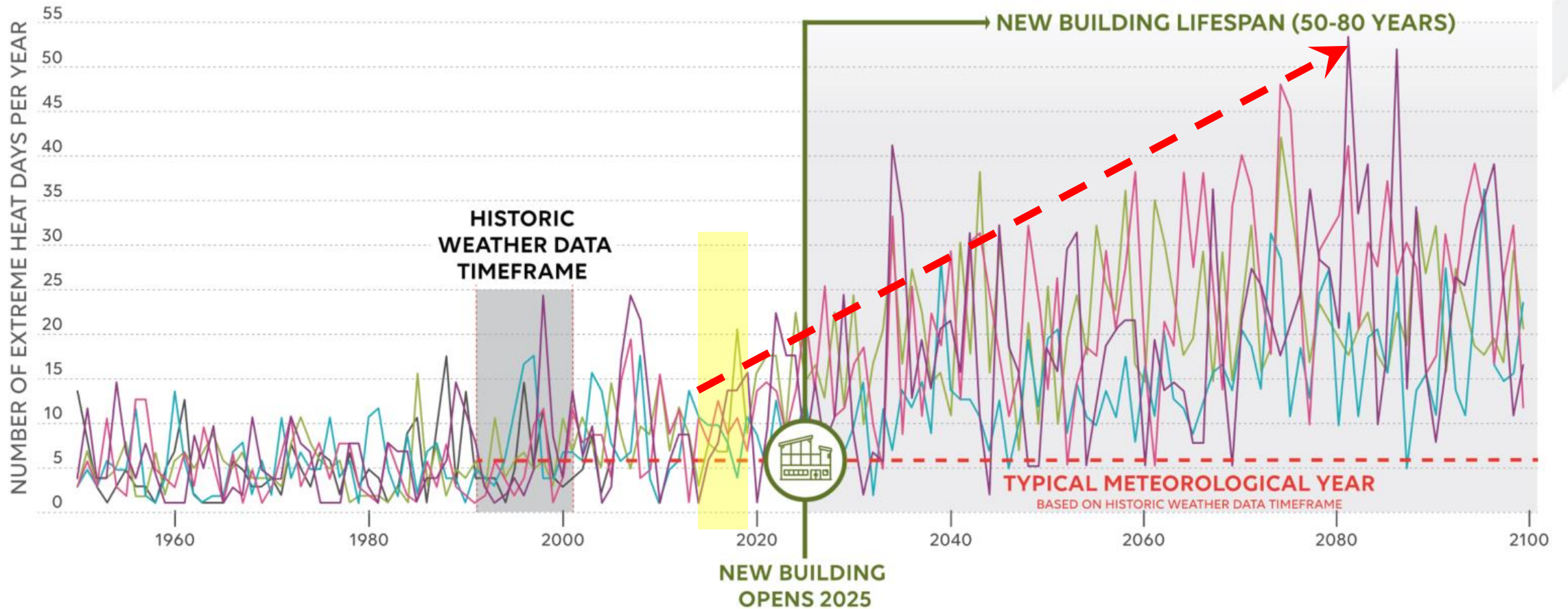
Year	May Not Exceed
2026-2029	80% of baseline
2030-2034	40% of baseline
2035-	GHG emissions shall not exceed 0

25,000-99,999 sqft

Year	May Not Exceed
2026-2029	100% of baseline
2030-2034	60% of baseline
2035-2039	40% of baseline
2040-2044	20% of baseline
2045-2049	10% of baseline
2050-	GHG emissions shall not exceed 0



RISKS OF USING HISTORIC WEATHER DATA FOR BUILDING DESIGN

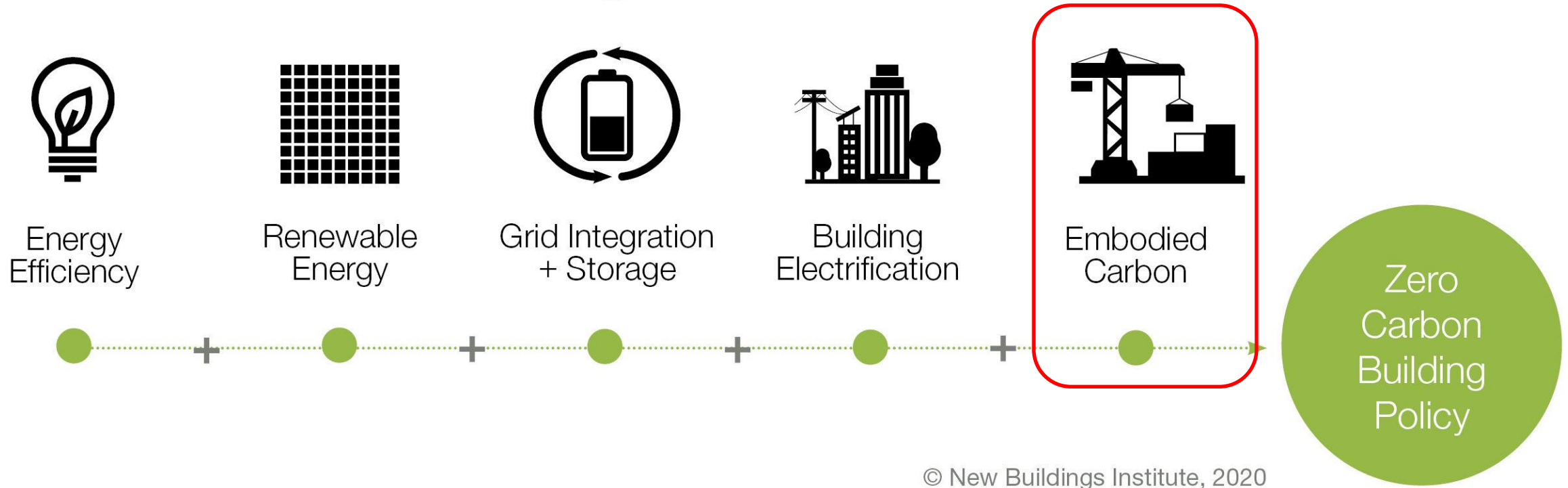


MODELS: ■ Observed ■ Warm/Dry ■ Cool/Wet ■ Average ■ Complement
 - - - Typical meteorological year (TMY) based on historic weather data

Model location: Sacramento, CA with a daily maximum temperature above 103.9 °F and a medium emissions (RCP 4.5) scenario.
 Source: Cal-Adapt. Data: LOCA Downscaled CMIP5 Climate Projections (Scripps Institution of Oceanography), Gridded Observed Meteorological Data (University of Colorado Boulder), LOCA Derived Products (Geospatial Innovation Facility).
 Climate Forward? How Architects and Engineers Are(n't) Using Climate Projections to Inform Design, March 2023



The Five Foundations of Zero Carbon Building Policies



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ASHRAE Standard 100-2024

STANDARD

ANSI/ASHRAE/IES Standard 100-2024

(Supersedes ANSI/ASHRAE/IES Standard 100-2018)

Includes ANSI/ASHRAE/IES addenda listed in Appendix N

Energy and Emissions Building Performance Standard for Existing Buildings

See Informative Appendix N for approval dates by ASHRAE, the Illuminating Engineering Society, and American National Standards Institute.

American National Standards Institute This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. Instructions for how to submit a change can be found on the ASHRAE® website (www.ashrae.org/continuous-maintenance).

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2018:

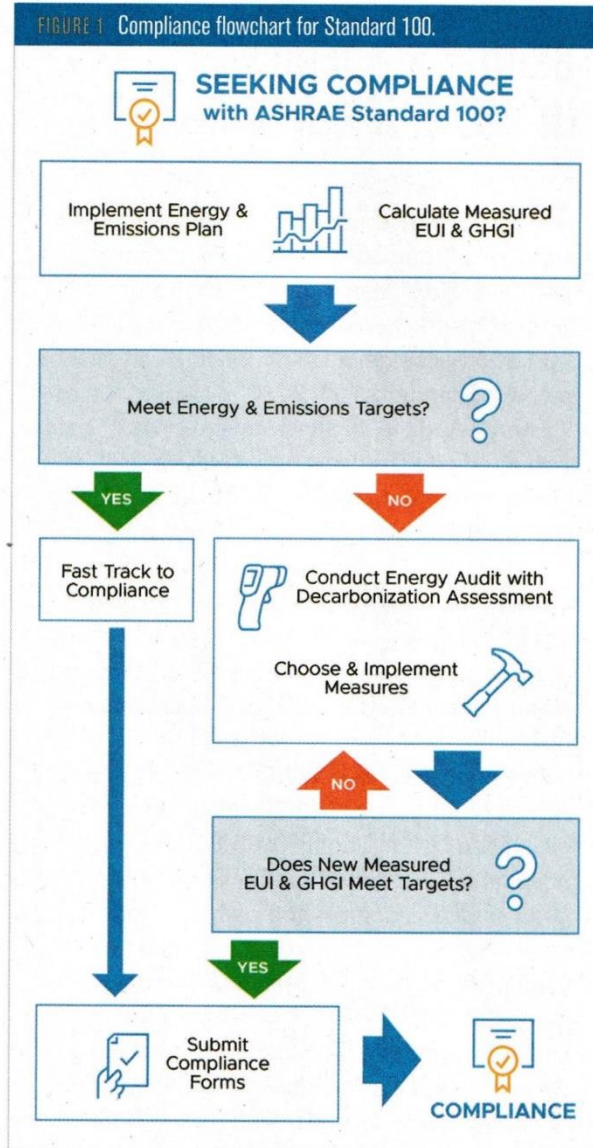
Energy Efficiency in Existing Buildings

2024:

“Model for building performance standard adoption across the U.S. and internationally”



ASHRAE Standard 100-2024



2018:

Energy Efficiency in Existing Buildings

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ASHRAE Standard 100-2024

IM NOT LAZY.
IM JUST ON MY
ENERGY
SAVING
MODE



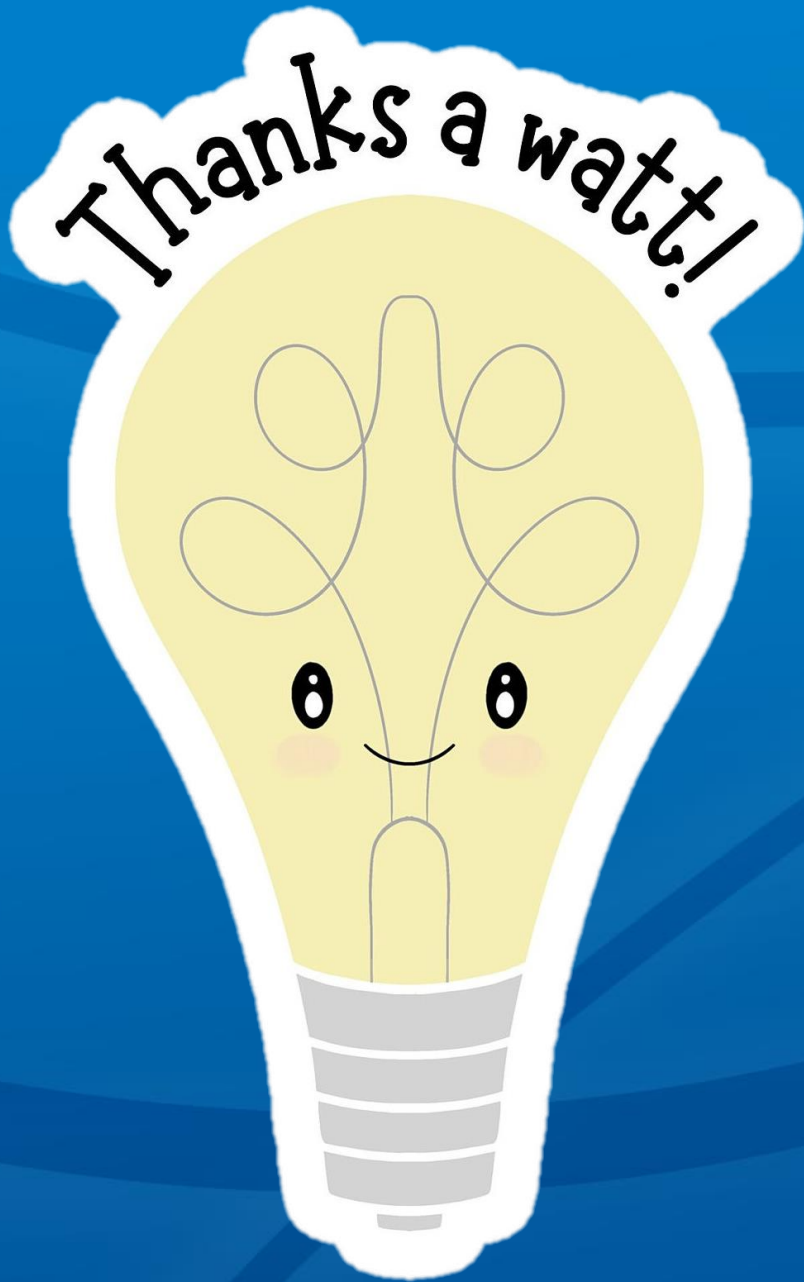
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