Energy Trust of Oregon

Pathways to Grid-Interactive Efficient Buildings

PRESENTED BY: CLARK BROCKMAN AIA, LEED Fellow
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OCTOBER 25, 2023

PAE

pae-engineers.com

SERA

seradesign.com

Objectives

1. Explain why green buildings need to move beyond "Net Zero"
2. Explain why building decarbonization needs to align to grid decarbonization
3. Walk through practical ways to make buildings good grid citizens

Agenda

PATHWAYS TO GRID-INTERACTIVE EFFICIENT BUILDINGS

WHAT IS A NET ZERO ENERGY BUILDING?
NREL DEFINITION:

Zero energy buildings produce at least as much energy as they consume on an annual basis.

It's so easy to say and understand…

…who wouldn't want one?

Net Zero Energy: A Brief History

1998

The USGBC releases the first version of LEED, introducing the concept of "green building" to the world

2006

ILFI releases the first version of the Living Building Challenge, boldly requiring "Net Zero" everything for buildings

2007

Ferreira Construction builds the first net zero electric building in the US (42,000 sf)

2013

The Bullitt Center, the first commercial scale Living Building opens in Seattle

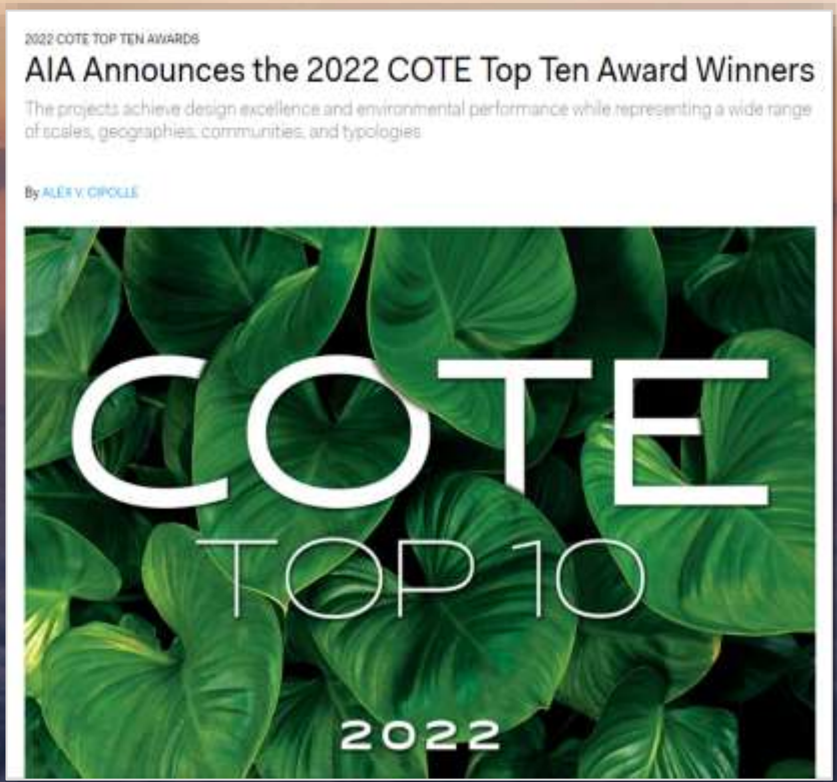
2019

United Therapeutics opens the "Unisphere" and at 135,000sf, it's one of the world's largest net zero buildings

2022

PAE opens their new Living Building in Portland, and at 58,000 s.f., it's the world's largest Living Building

Net Zero Energy: What has it gotten us?


2022 COTE TOP TEN AWARDS

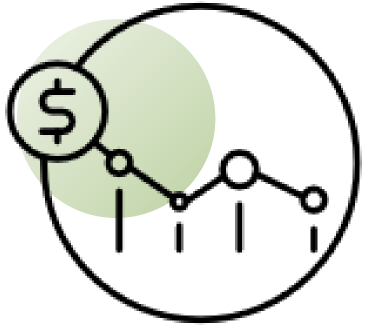
AIA Announces the 2022 COTE Top Ten Award Winners

The projects achieve design excellence and environmental performance while representing a wide range of scales, geographies, communities, and typologies

By ALEX V. CIPOLLE

Net Zero Energy: What has it gotten us?

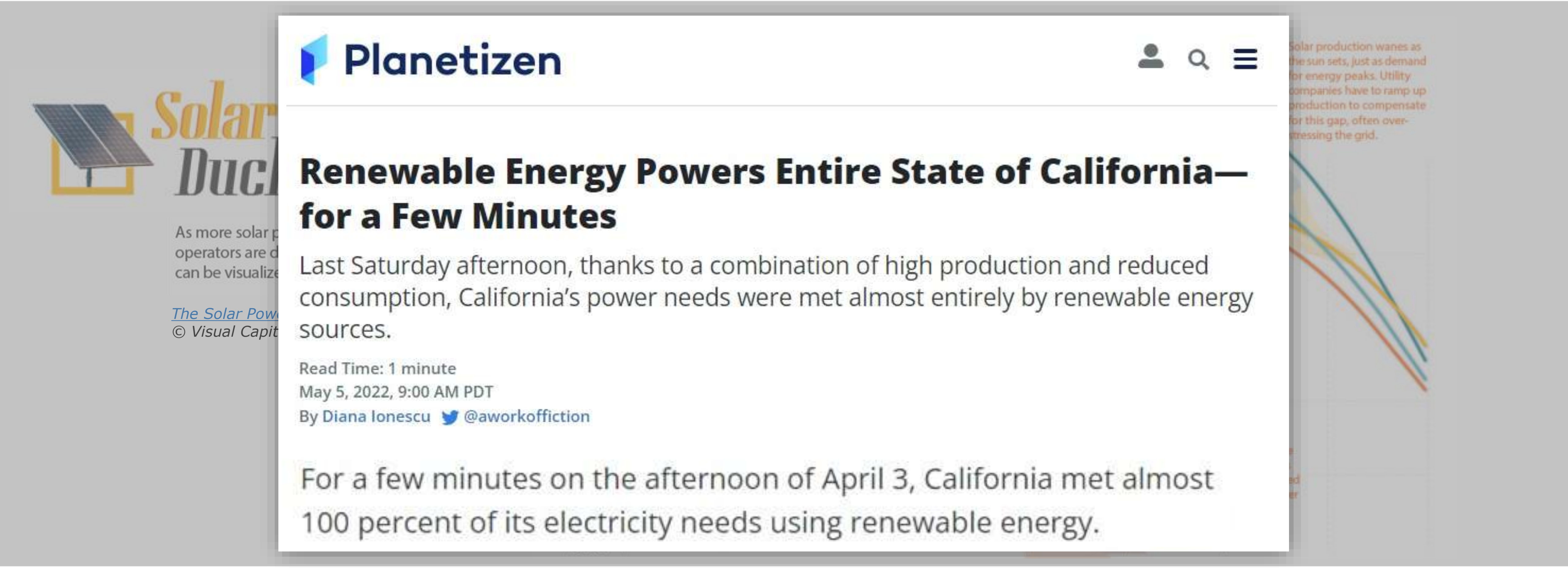
Green building bragging rights, smaller energy bills, and…



…architects (and everyone else) learning what EUI means!

THE KENDEDA BUILDING FOR INNOVATIVE SUSTAINABLE DESIGN | ATLANTA, GA
Credit: Lord Aeck Sargent and The Miller Hull Partnership

Net Zero Energy:
What’s actually happening?



Planetizen

Renewable Energy Powers Entire State of California—for a Few Minutes

Last Saturday afternoon, thanks to a combination of high production and reduced consumption, California’s power needs were met almost entirely by renewable energy sources.

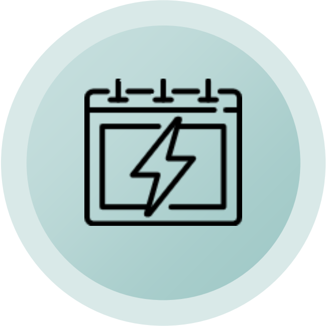
Read Time: 1 minute

May 5, 2022, 9:00 AM PDT

By Diana Ionescu @aworkoffiction

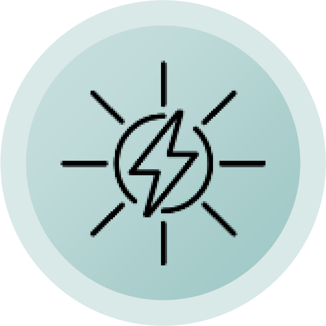
For a few minutes on the afternoon of April 3, California met almost 100 percent of its electricity needs using renewable energy.

“Net Zero Energy” means…



Annualized

(i.e. compounded across the year)

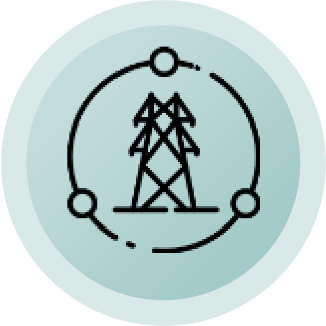


Energy is made when the sun is shining

(for solar)

“Hey Utility! Take all the clean energy I make and find a good use for it.”

(if you can)



When my building is not producing surplus renewable energy, it’s buying energy from the grid…

whatever energy is flowing on the grid at that time.

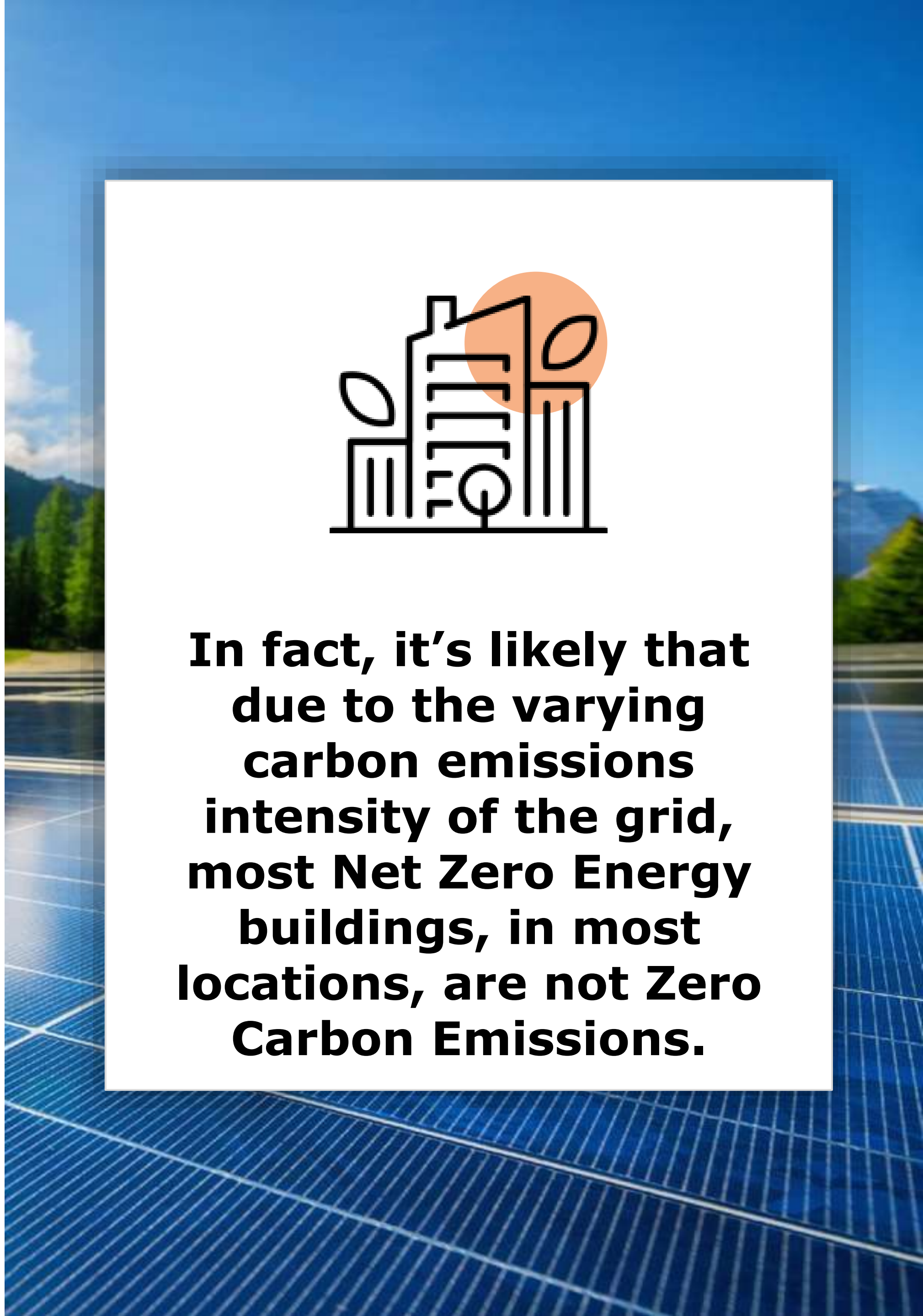
“Net Zero Energy” <u>is not…</u>

Addressing operational carbon emissions

“Zero Carbon”

The end game in Green Building…

But it is an important step along the way.



In fact, it’s likely that due to the varying carbon emissions intensity of the grid, most Net Zero Energy buildings, in most locations, are not Zero Carbon Emissions.

Unpacking Grid-Interactive Efficient Buildings

Why Do We Need Grid-Interactive Buildings?

Decarbonization

Resiliency

Cost Savings

Regulations

How to Talk Grid-Interactivity

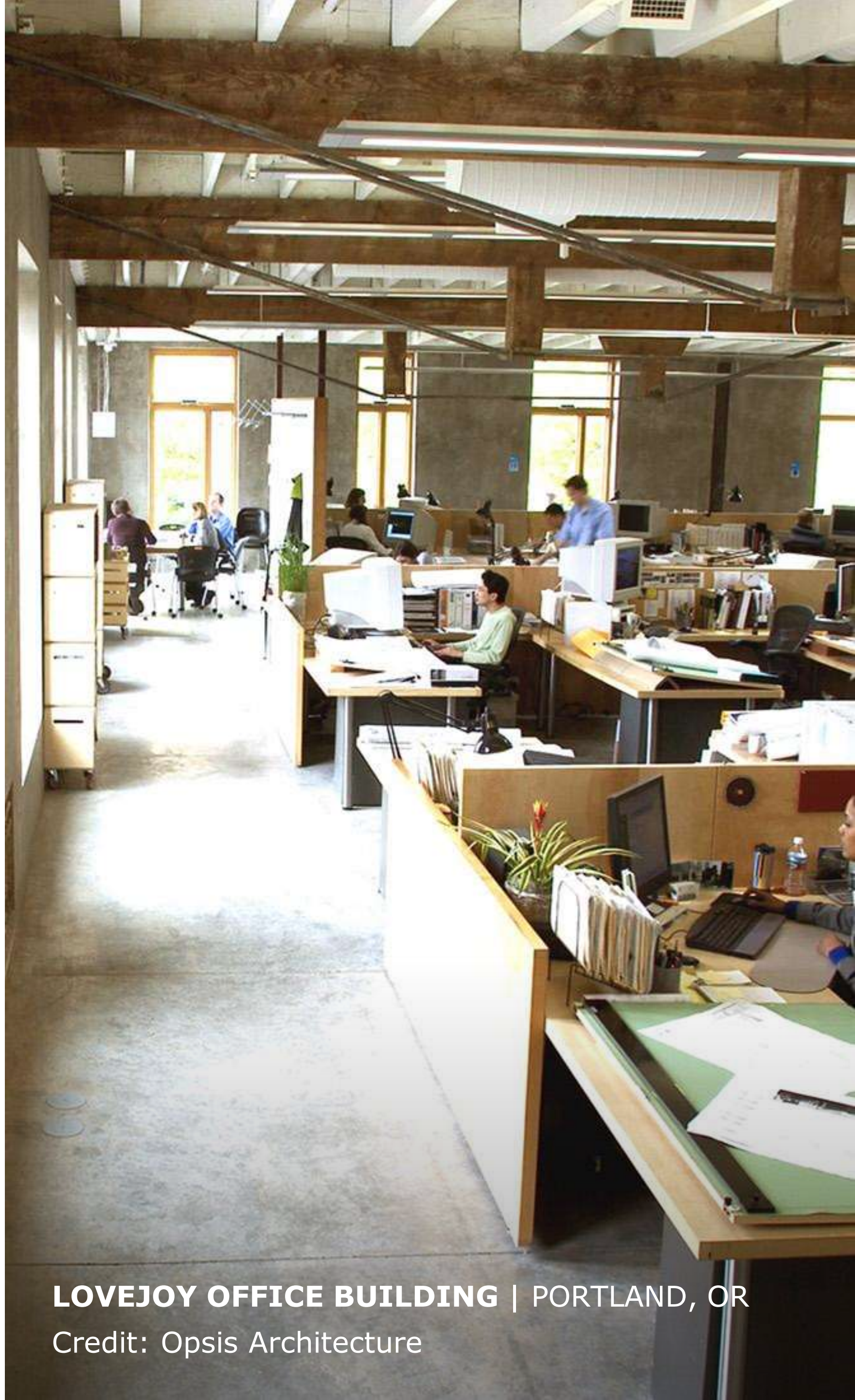
GRID-INTERACTIVE EFFICIENT BUILDING (GEB) A GEB is efficient, able to shape it's load, and is highly interconnected

GRID PEAK CONTRIBUTION (GPC)
How much does your building contribute to rush hour on the grid?

DEMAND FLEXIBILITY (DF)
What can your building do about it?

GRIDOPTIMAL
A robust program by our own local resource NBI (New Buildings Institute)

**Note: This program is the framework for the relatively new LEED pilot credit*



LOVEJOY OFFICE BUILDING | PORTLAND, OR
Credit: Opsis Architecture

GRIDOPTIMAL™
BUILDINGS INITIATIVE

https://newbuildings.org/gridoptimal/

GRIDOPTIMAL™
BUILDINGS INITIATIVE

Launched mid-2018 and ongoing today

- *New building-grid interaction metrics*
- Metrics published (blog, white paper)
- Design and Operations Guidance Materials
- LEED Credit: GridOptimal Buildings Alternative Compliance Path (pilot credit)
- Utility Program guidance (memo, web dashboard)
- Code, standards, and policy development
- Pilot projects leading the market

A JOINT INITIATIVE OF:

nbi new buildings institute

USGBC

SUPPORTING MEMBERS:

Southern California Edison

PG&E Pacific Gas and Electric Company

SMUD

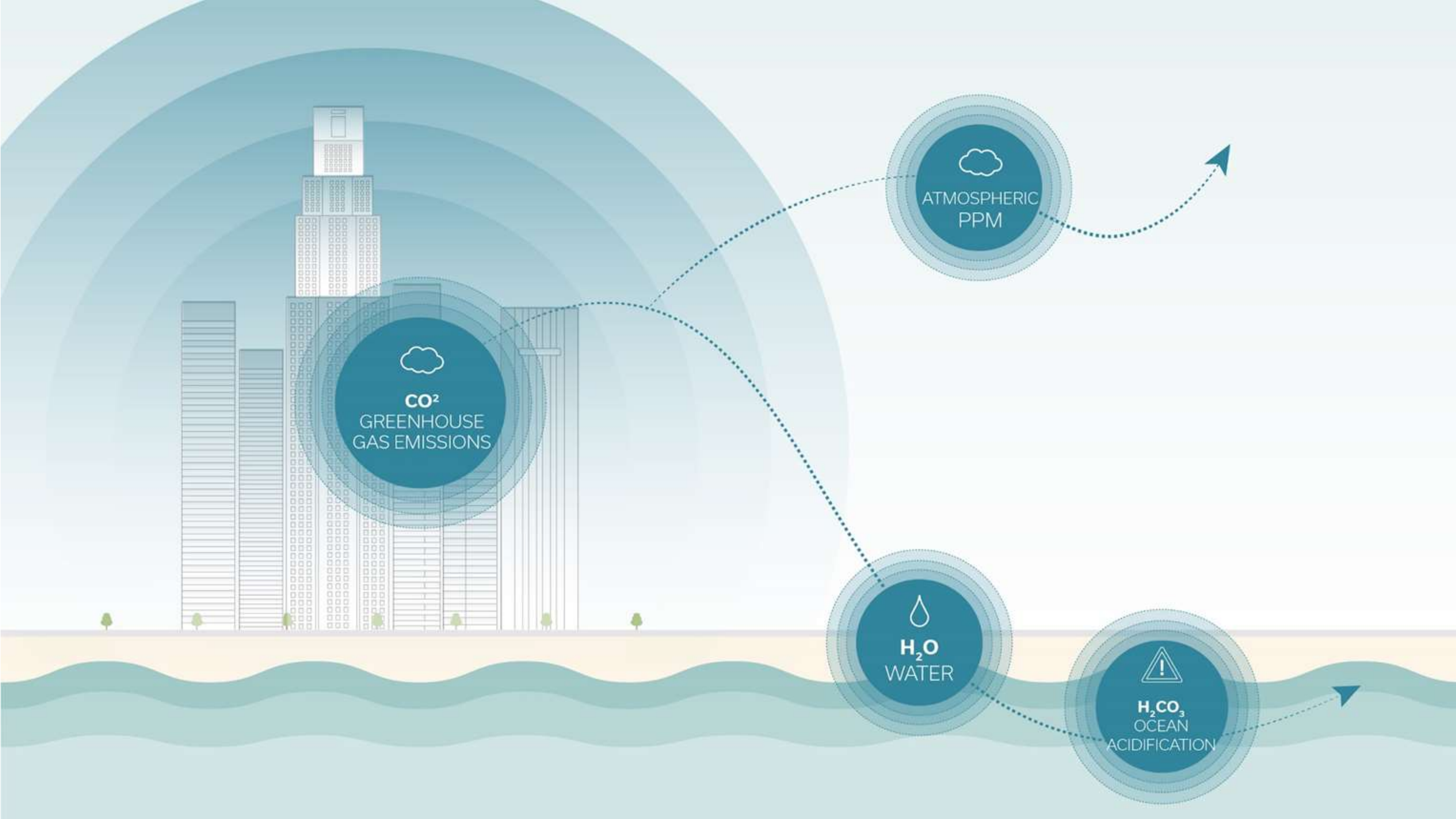
Austin Energy

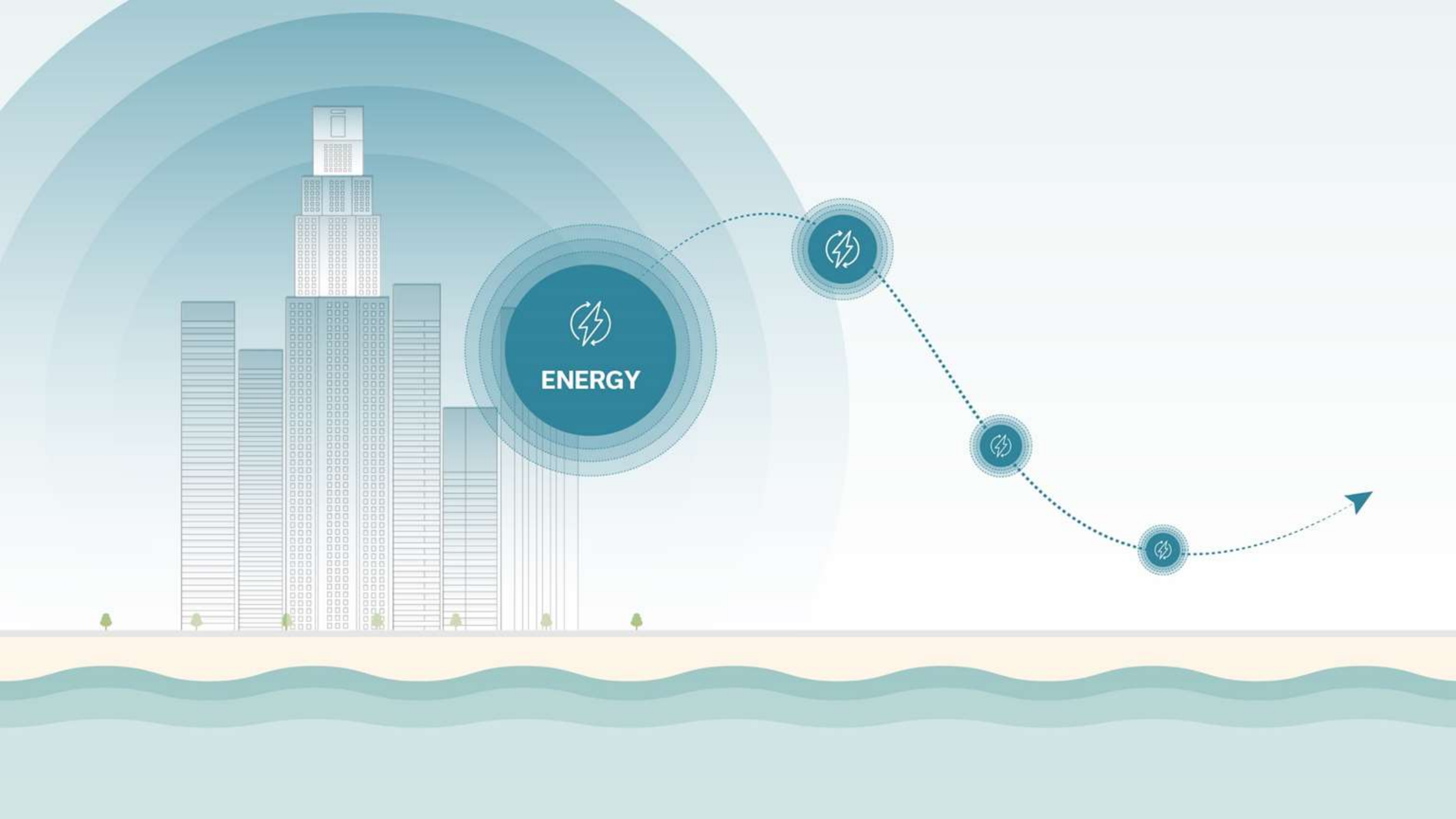
Efficiency Vermont

Energy Trust of Oregon

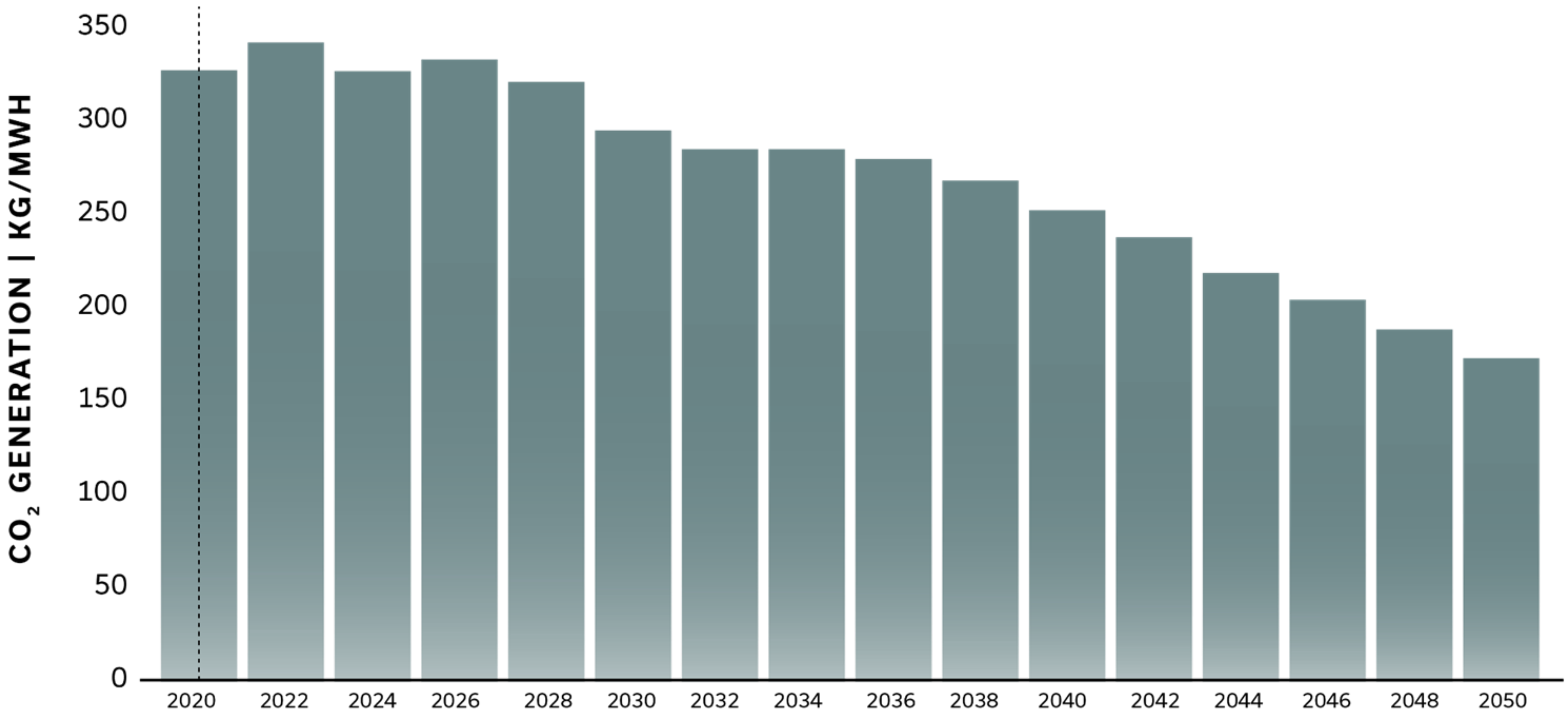
newbuildings.org/gridoptimal

Big Picture Context

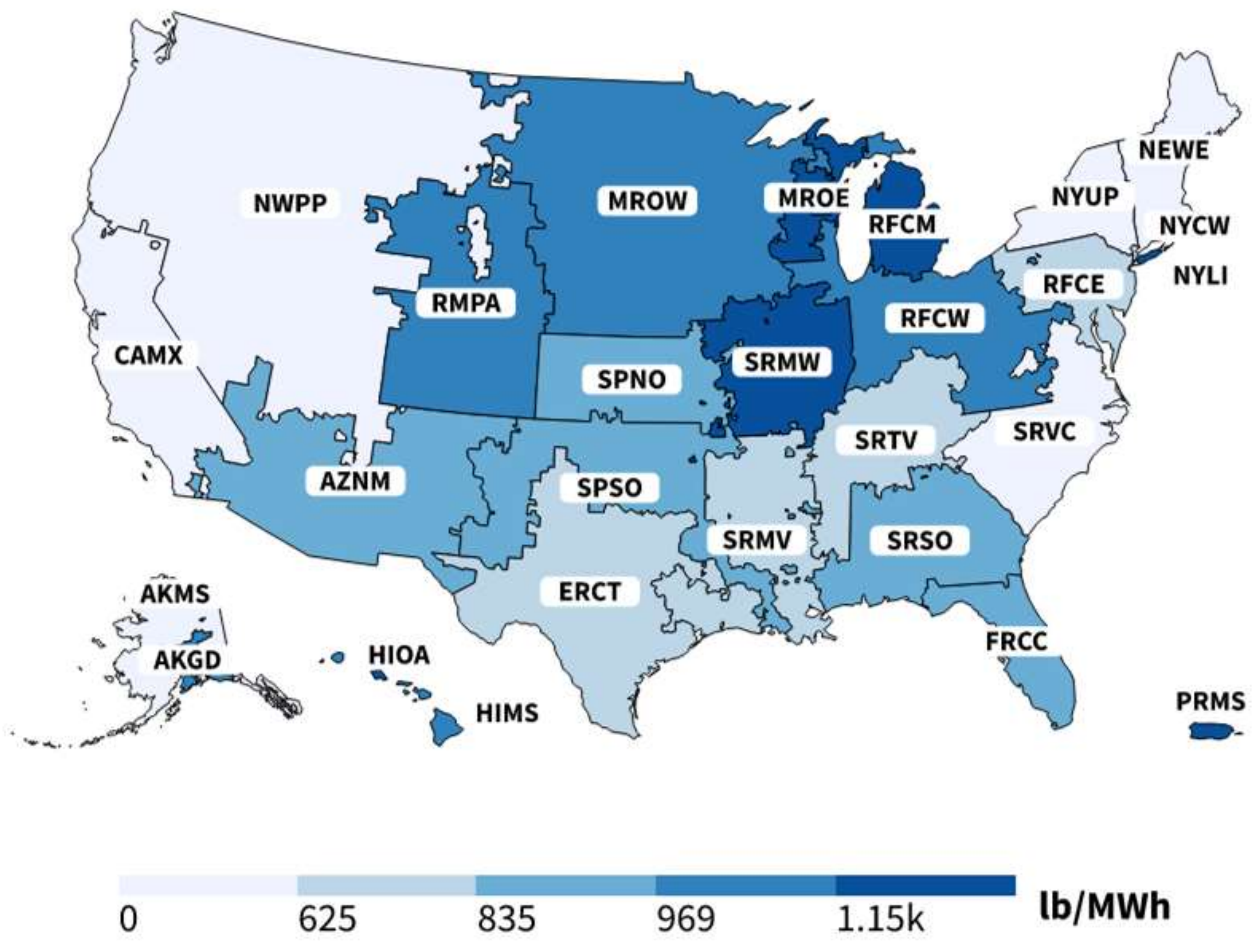

CO²
GREENHOUSE
GAS EMISSIONS
ATMOSPHERIC
PPM
H_2O
WATER
H_2CO_3
OCEAN
ACIDIFICATION

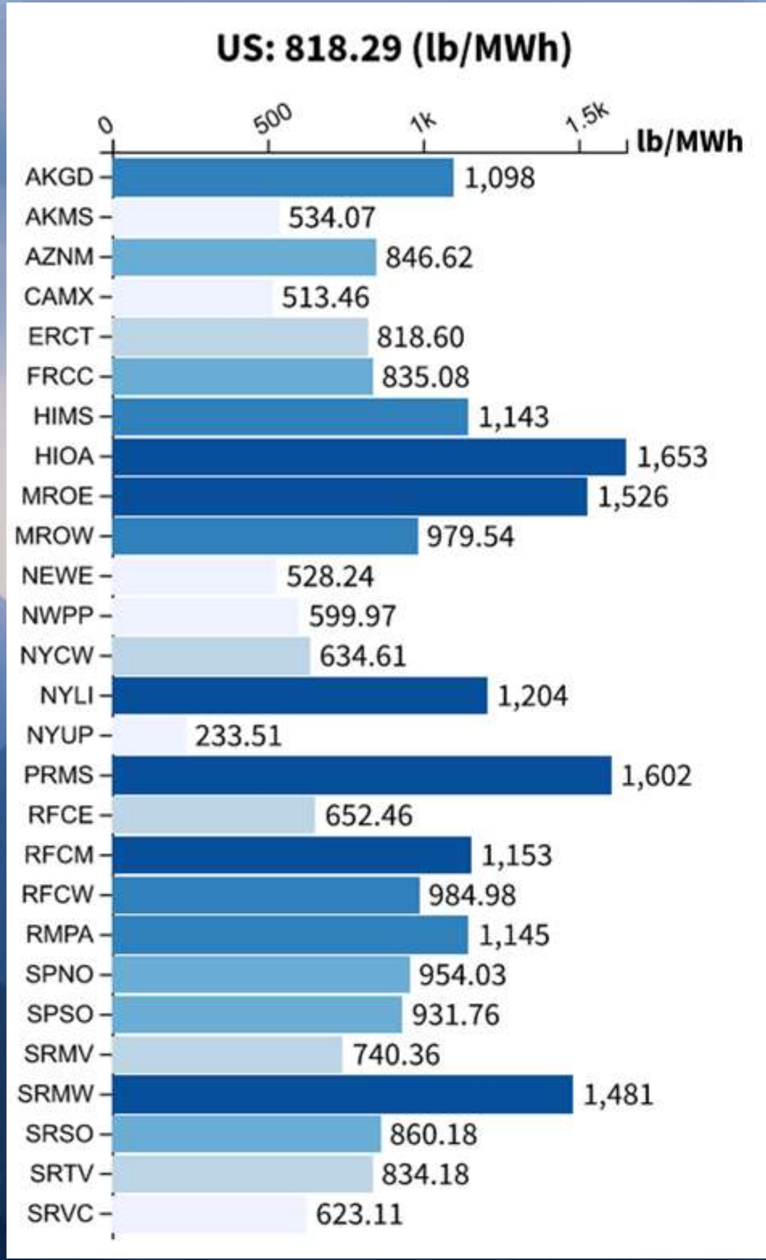

ENERGY

US Average Annual Electric Grid Emissions



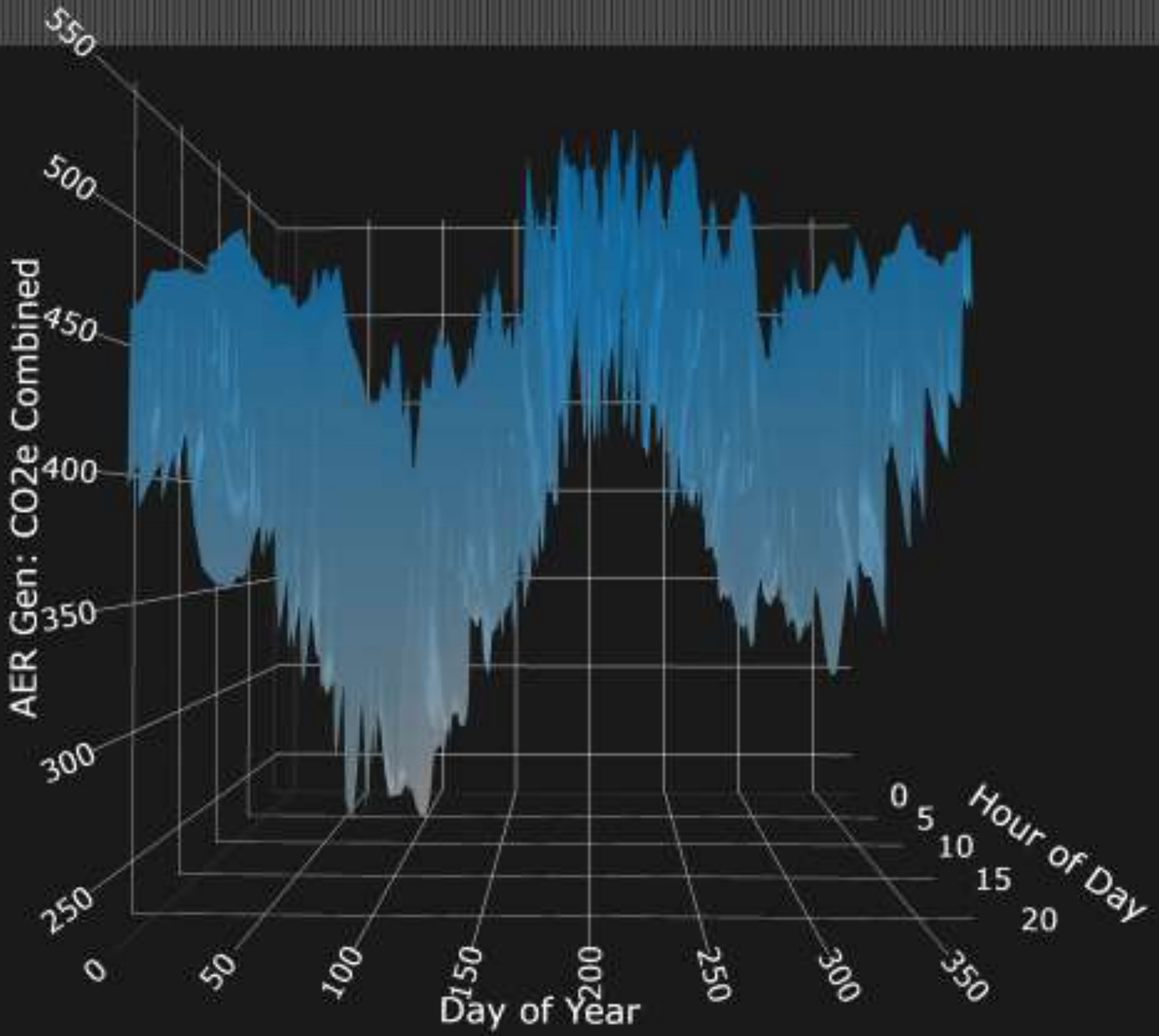
CO_2 Total Output Emission Rate (lb/MWh) by eGRID Subregion | 2020





Grid Emissions

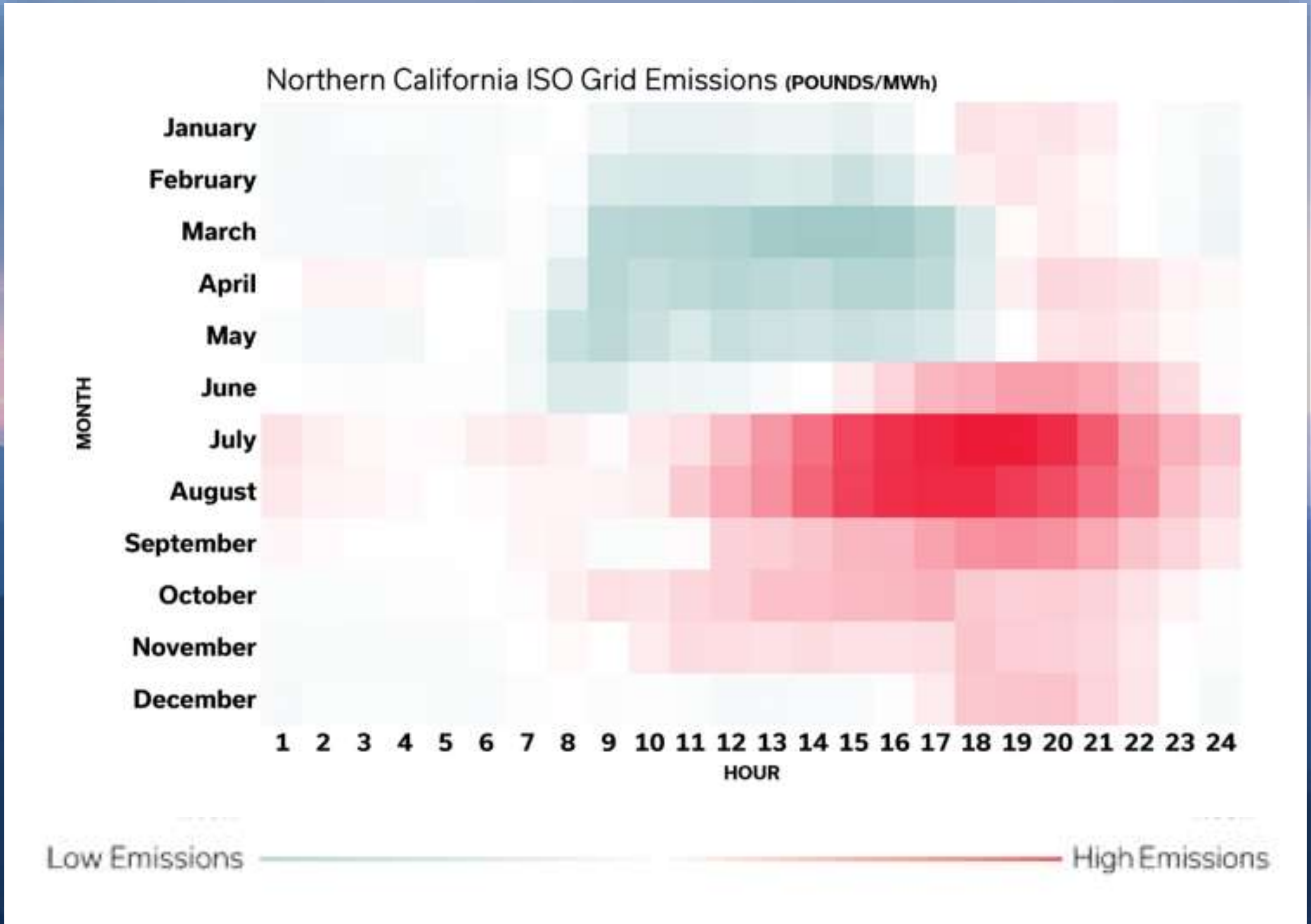
DYNAMIC + EVOLVING



Source: NREL Cambium Modeling

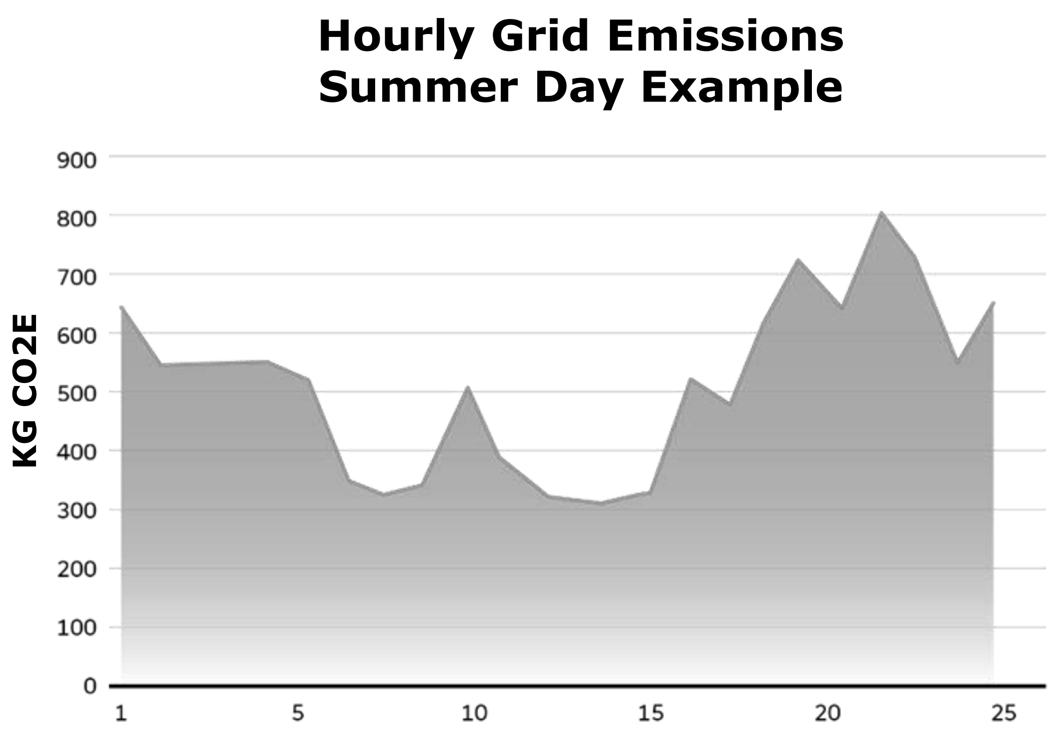
Time of Use Grid Emissions

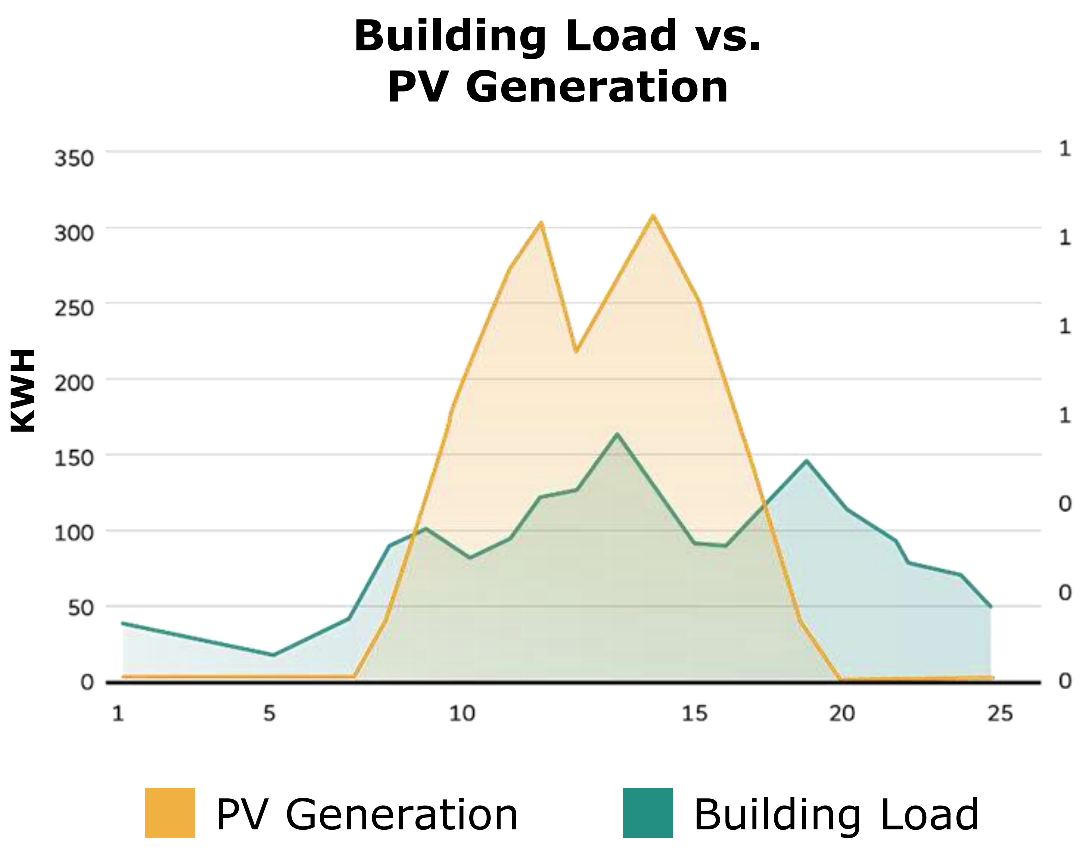
Annual utility emissions in time-of-use impacts



Source: WattTime Grid Emissions Intensity

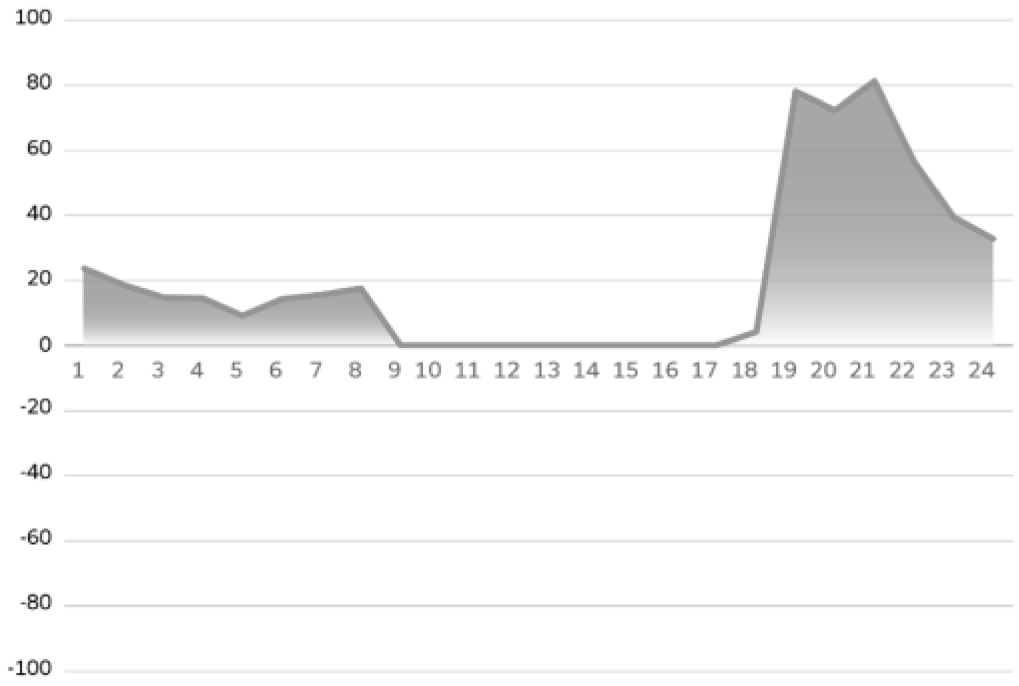
What about NZE?





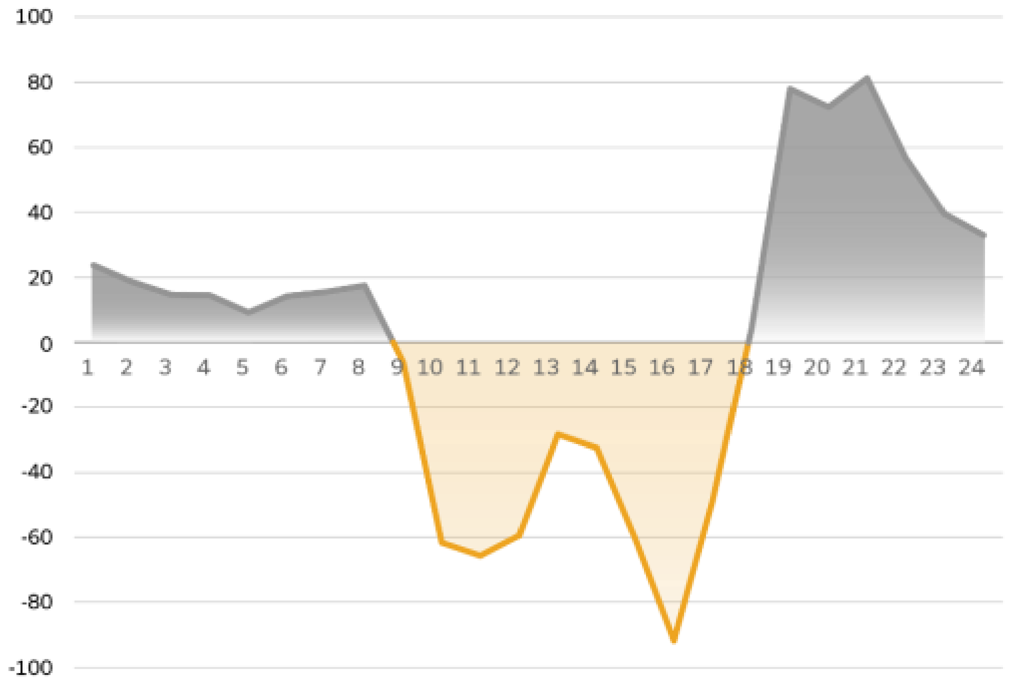
What about NZE?

Hourly Emissions (kg CO_2e)
TYPICAL SUMMER DAY



Without taking credit for the backfeed of the PV, the **daily emissions impact** of this net positive system is **490 kg CO_2e**.

Hourly Emissions (kg CO_2e)
TYPICAL SUMMER DAY



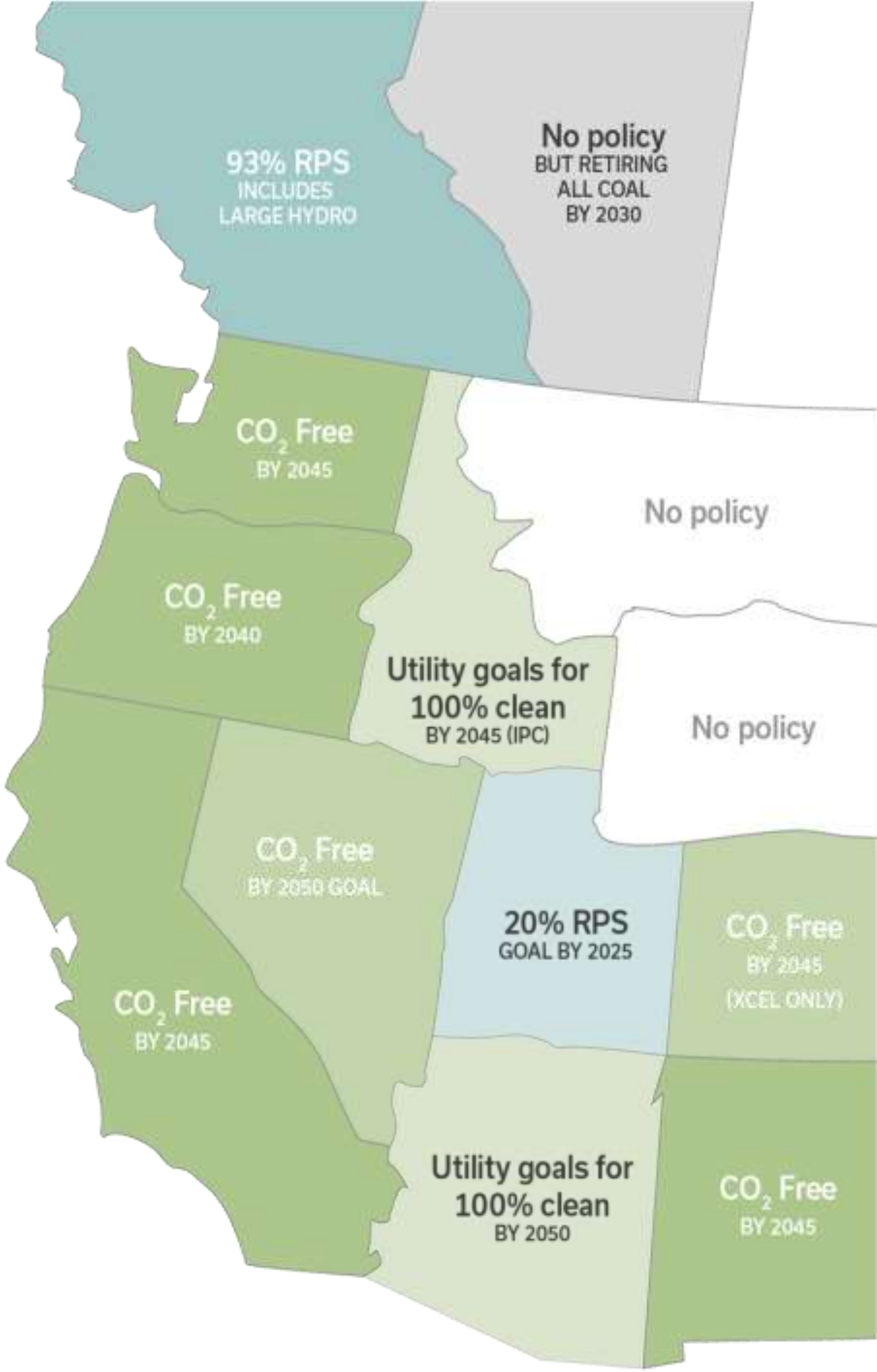
But even *with* taking credit for the backfeed of the PV, the daily emissions impact of this net positive system is **still 40 kg CO_2e**!

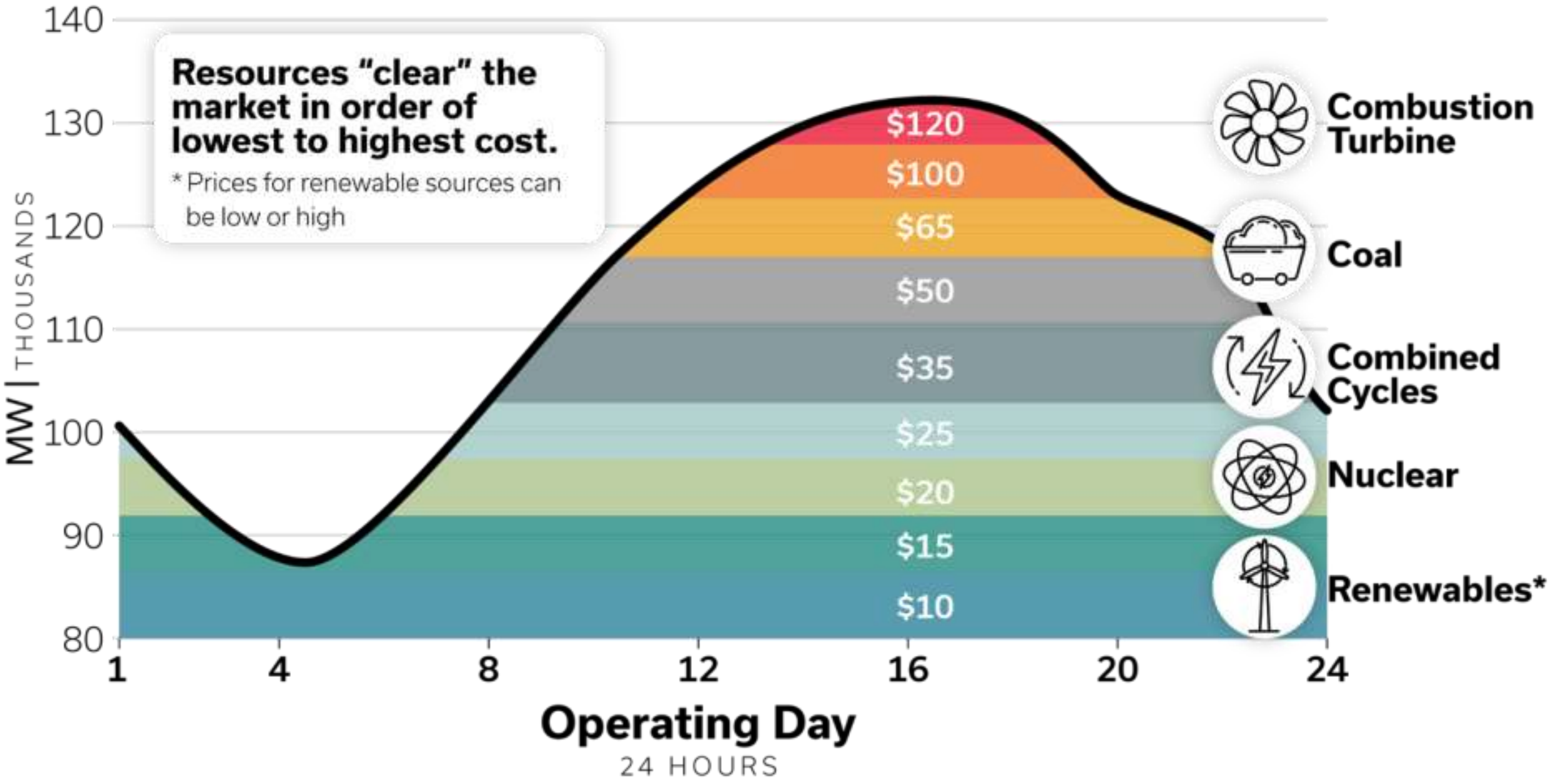
Decarbonization in the West

Decarbonization efforts throughout the west will lead to unprecedented generation and transmission development.

States across the West have a **commitment** to decarbonize electricity supply.

Some states with no policy are served by utilities that have publicly communicated their **intent** to decarbonize.

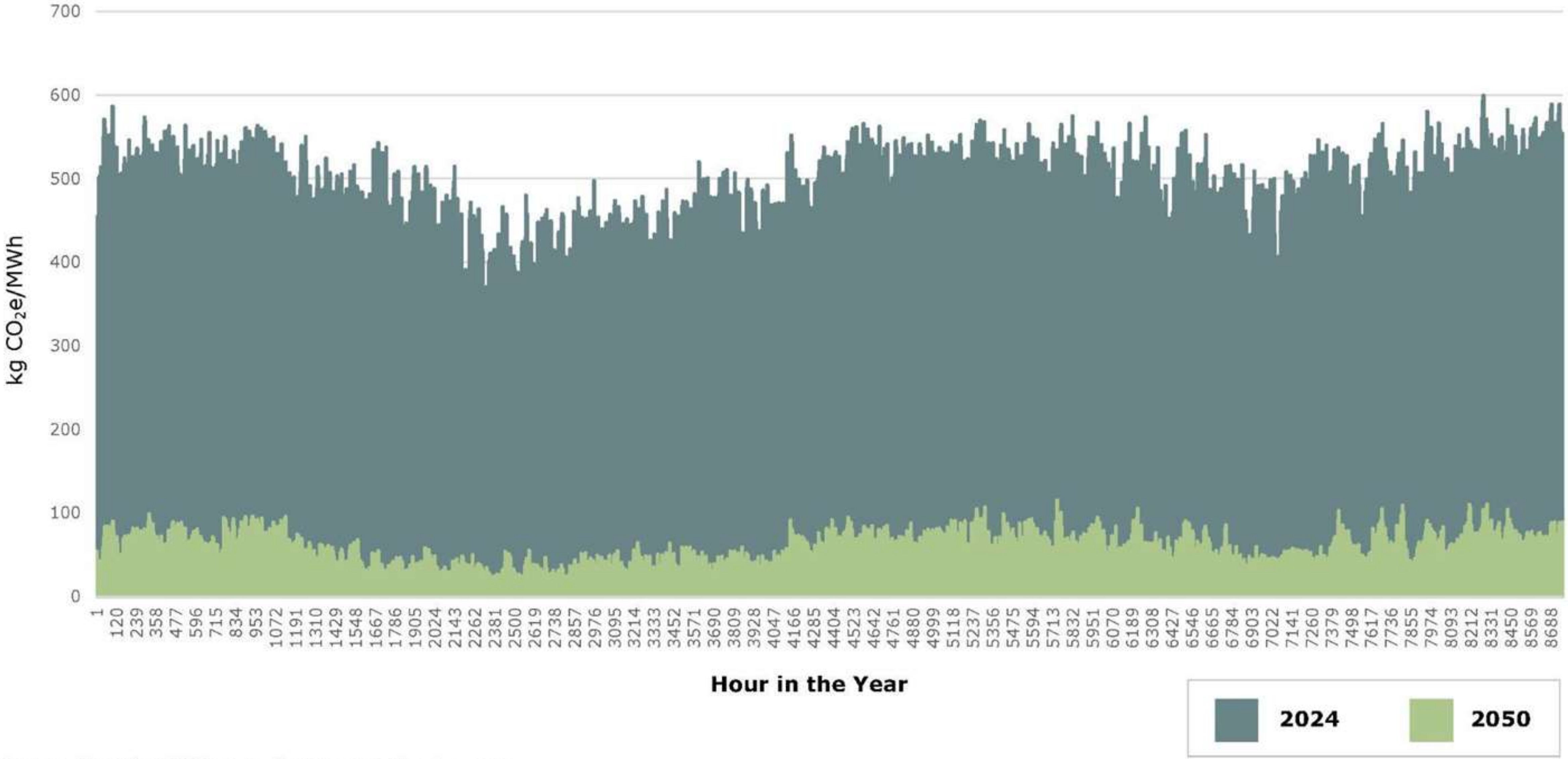



Resources "clear" the market in order of lowest to highest cost.
* Prices for renewable sources can be low or high
140
130
120
110
100
90
80
MW | THOUSANDS
$120
$100
$65
$50
$35
$25
$20
$15
$10
Combustion Turbine
Coal
Combined Cycles
Nuclear
Renewables*
1
4
8
12
16
20
24
Operating Day
24 HOURS
pjm Learning Center

Emissions Trends

Source: *CAISO Historical Emissions Trend*

The grids can't solve this alone



Source: Cambium 2022, Low-Cost Renewables Scenario

Buildings + Grid Collaboration

Grid Stands Alone

Rethink Loads

"…over **$10 billion worth of capital invested** [by BPA] in transmission and distribution **sits idle for over 8100 hours per year**"

- CRITFC ENERGY VISION

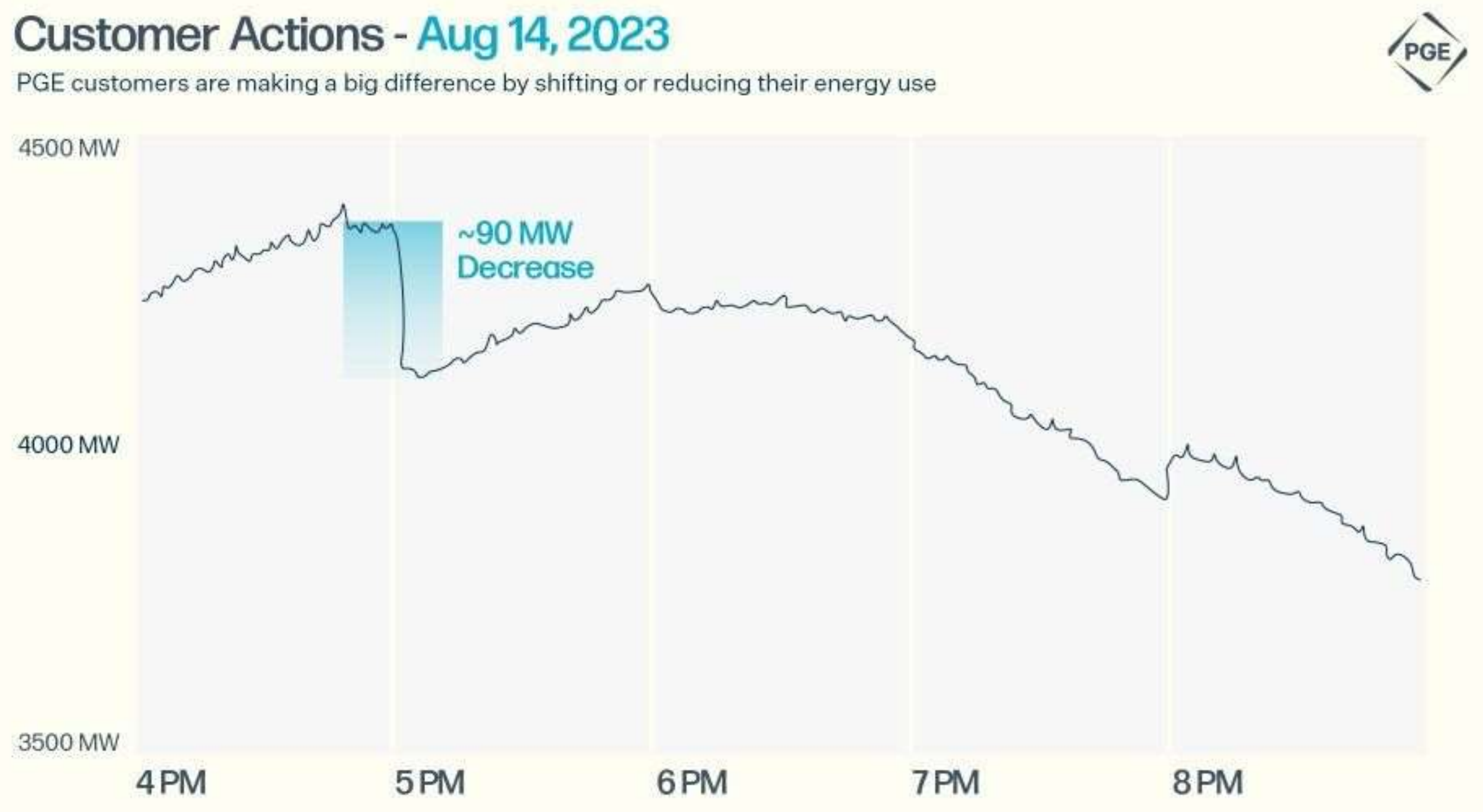
"…a massive investment in commercial and residential building investments could cut annual power system costs involved with achieving nationwide carbon-free electricity by 2050 by as much as **$107 billion per year**.

Those savings would require both significant investments in energy efficiency, as well as outfitting buildings with the technology required to shift electricity use based on the ups and downs of solar and wind power, a capability known as "demand flexibility."

- BUILDING SECTOR DECARBONIZATION SCENARIOS TO 2050, LBNL AND BRATTLE GROUP

PAE LIVING BUILDING | PORTLAND, OR
Credit: ZGF

Little Actions = Big Impact



What does this mean for building design?

In the past, grids shaped supply to match demand.

In the future, grids will shape demand to match supply.

What is a Virtual Power Plant?

Traditional Generation

Electricity Generation → Transmission Power → Power Distribution

Virtual Power Plant + Smart Grid

Forecast

PRICE | PRODUCTION | DEMAND

→

Smart Grid

FLEXIBLE DEMANDS

SOLAR PV

ENERGY STORAGE

WIND GENERATION

BUILDING-GRID INTEGRATION

Building-grid integration allows buildings and the electrical grid to coordinate energy supply and demand to

- optimize energy consumption
- reduce peak demand
- offer more clean energy
- provide a reliable electricity supply.

Source: NBI

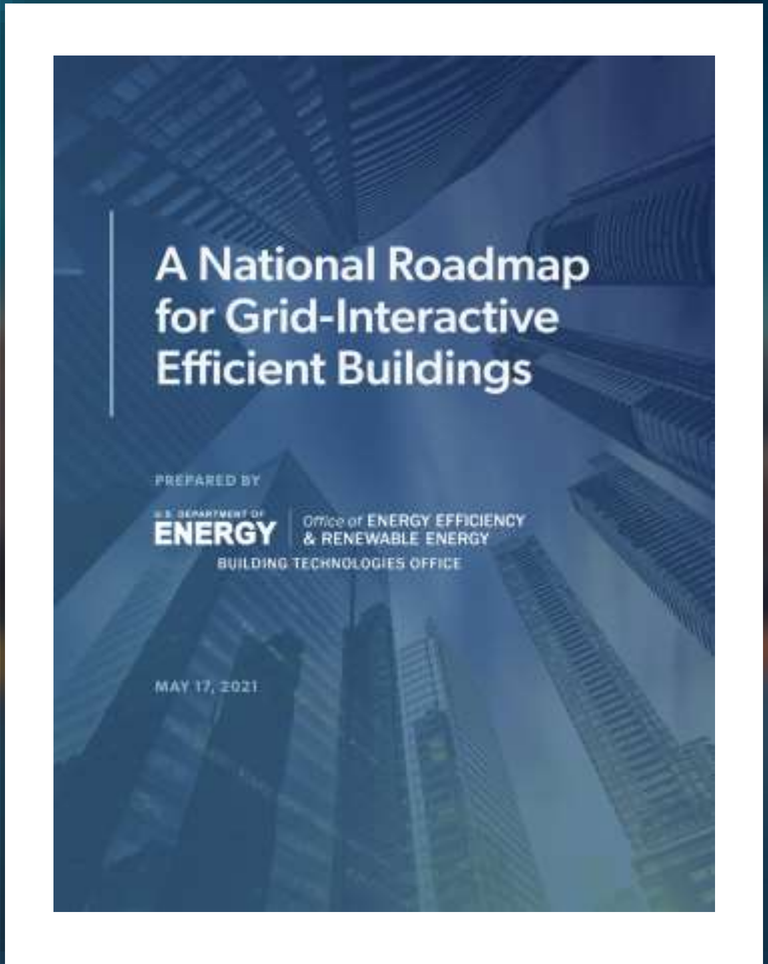
Grid-Interactive Buildings

What is a Grid-Interactive Building?

DEFINITION

Grid-interactive efficient buildings (GEBs) are **energy efficient** buildings with **smart technologies** characterized by the **active use of distributed energy resources** (DERs) to optimize energy use for grid services, occupant needs and preferences, and cost reductions in a continuous and integrated way.

A Grid-Interactive building is **efficient, able to shape its loads** and **highly interconnected**


A National Roadmap for Grid-Interactive Efficient Buildings

PREPARED BY

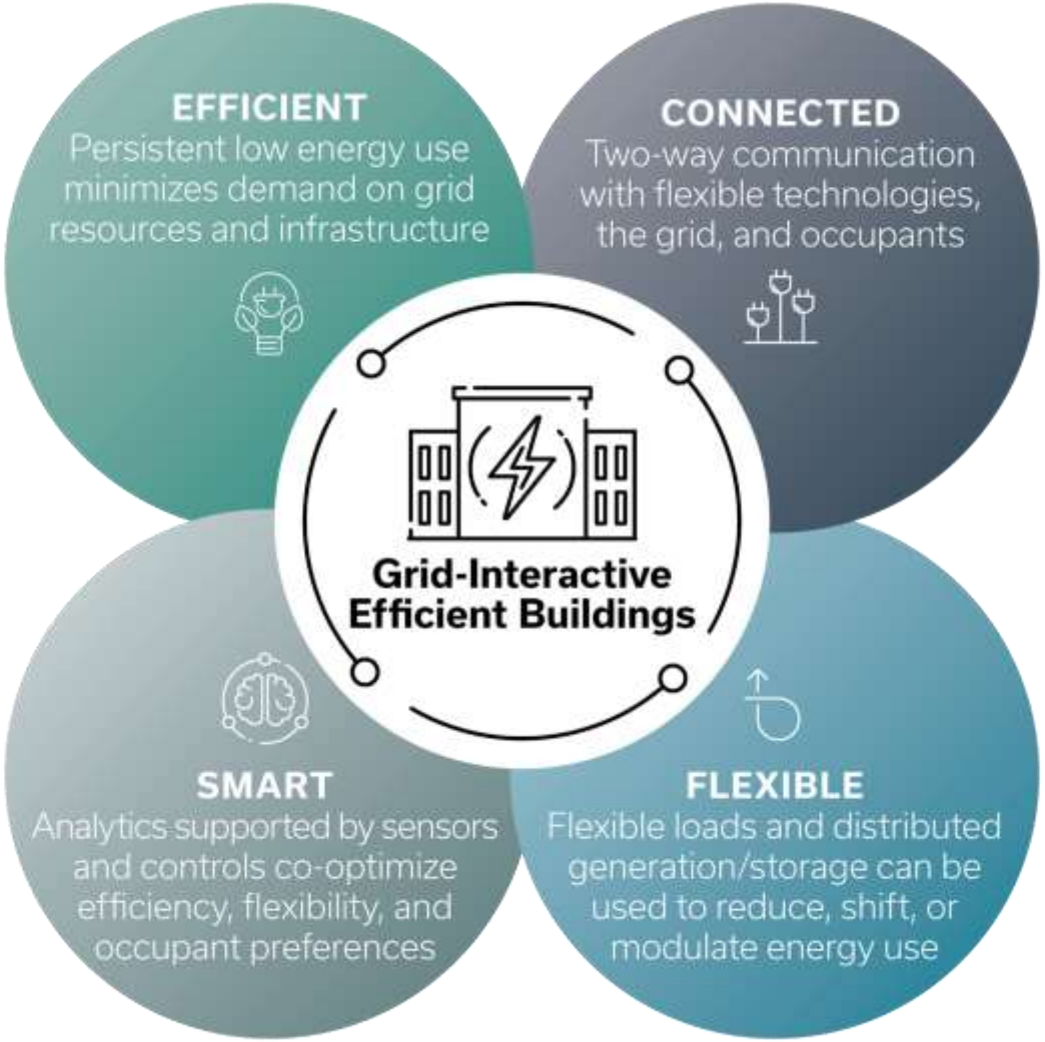
U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

BUILDING TECHNOLOGIES OFFICE

MAY 17, 2021

Source: *US Department of Energy Office of Energy Efficiency & Renewable Energy*

The Future is Grid Interactive

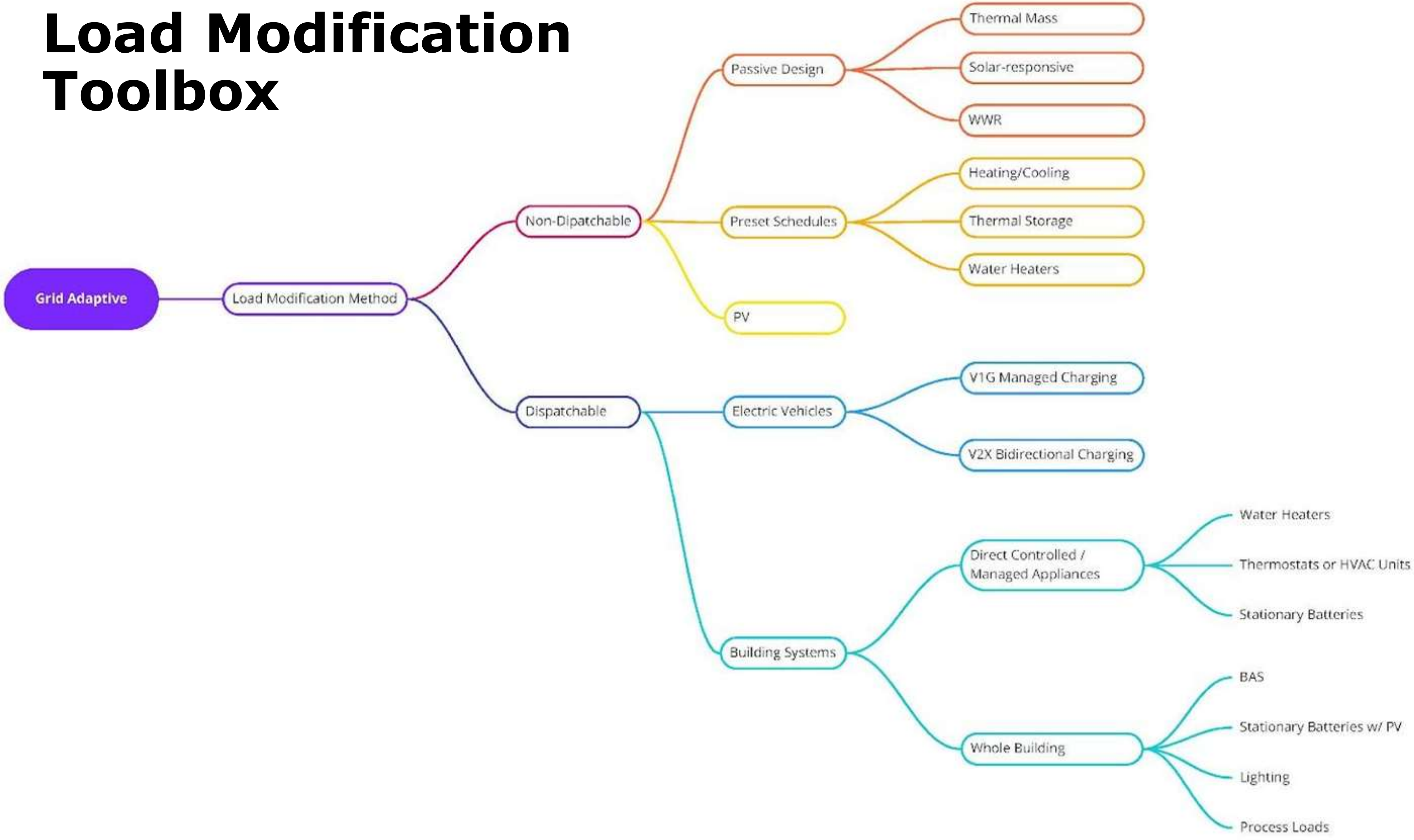


- DOE Definition, graphic originally by RMI

"…devices in GEB buildings – loads, storage, and generation – need to coordinate with each other both to manage flows of power, and to provide effective building and grid services"

- A National Roadmap for Grid-Interactive Efficient Buildings, 2021

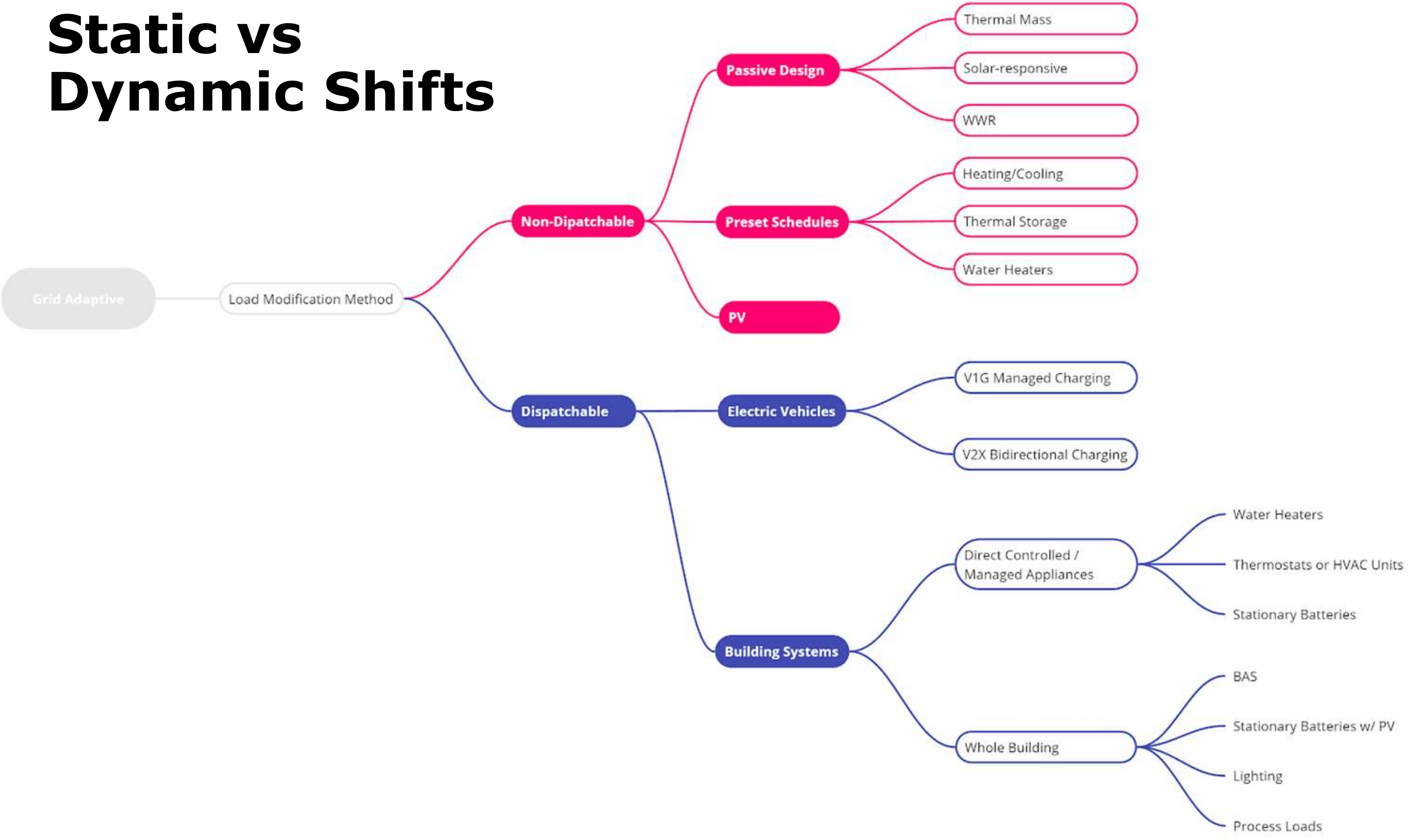
Load Modification Toolbox



Non-Dispatchable

Dispatchable

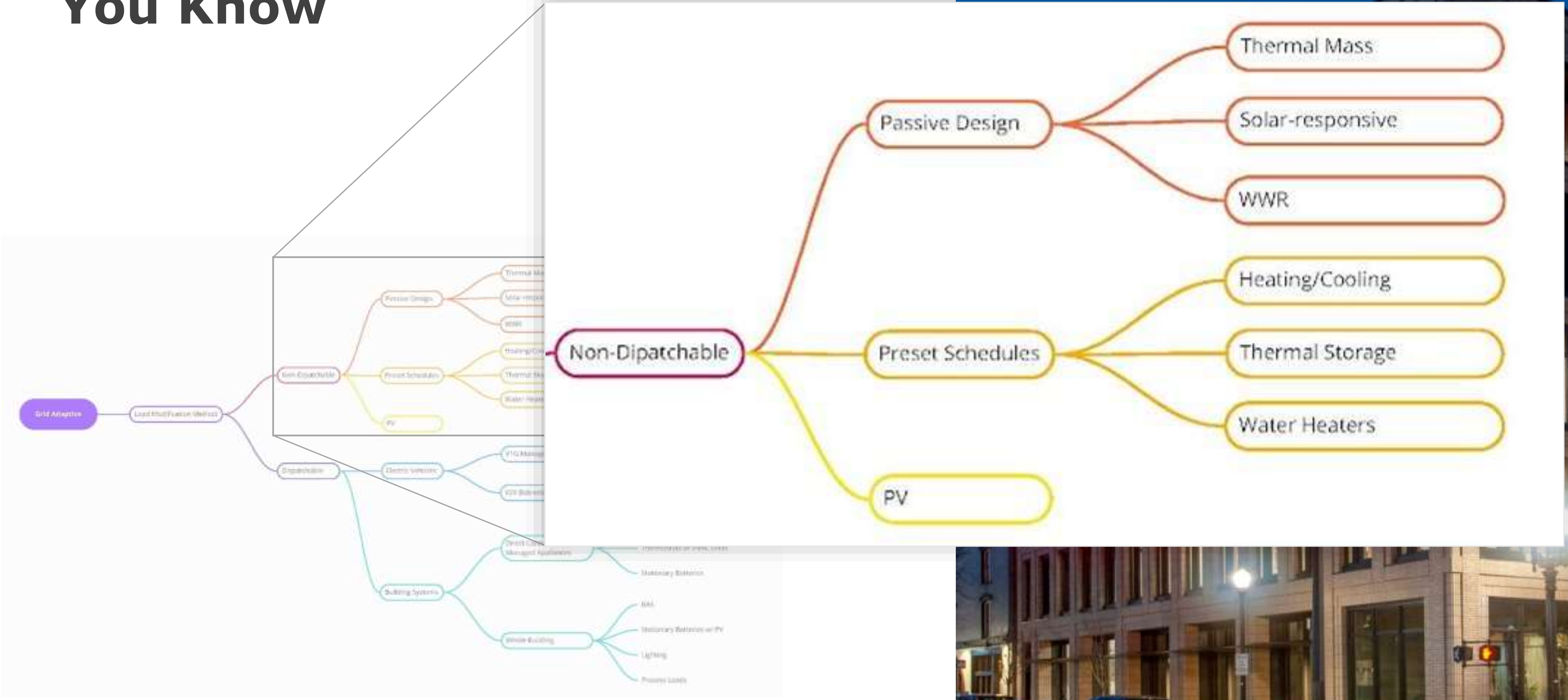
Static vs Dynamic Shifts



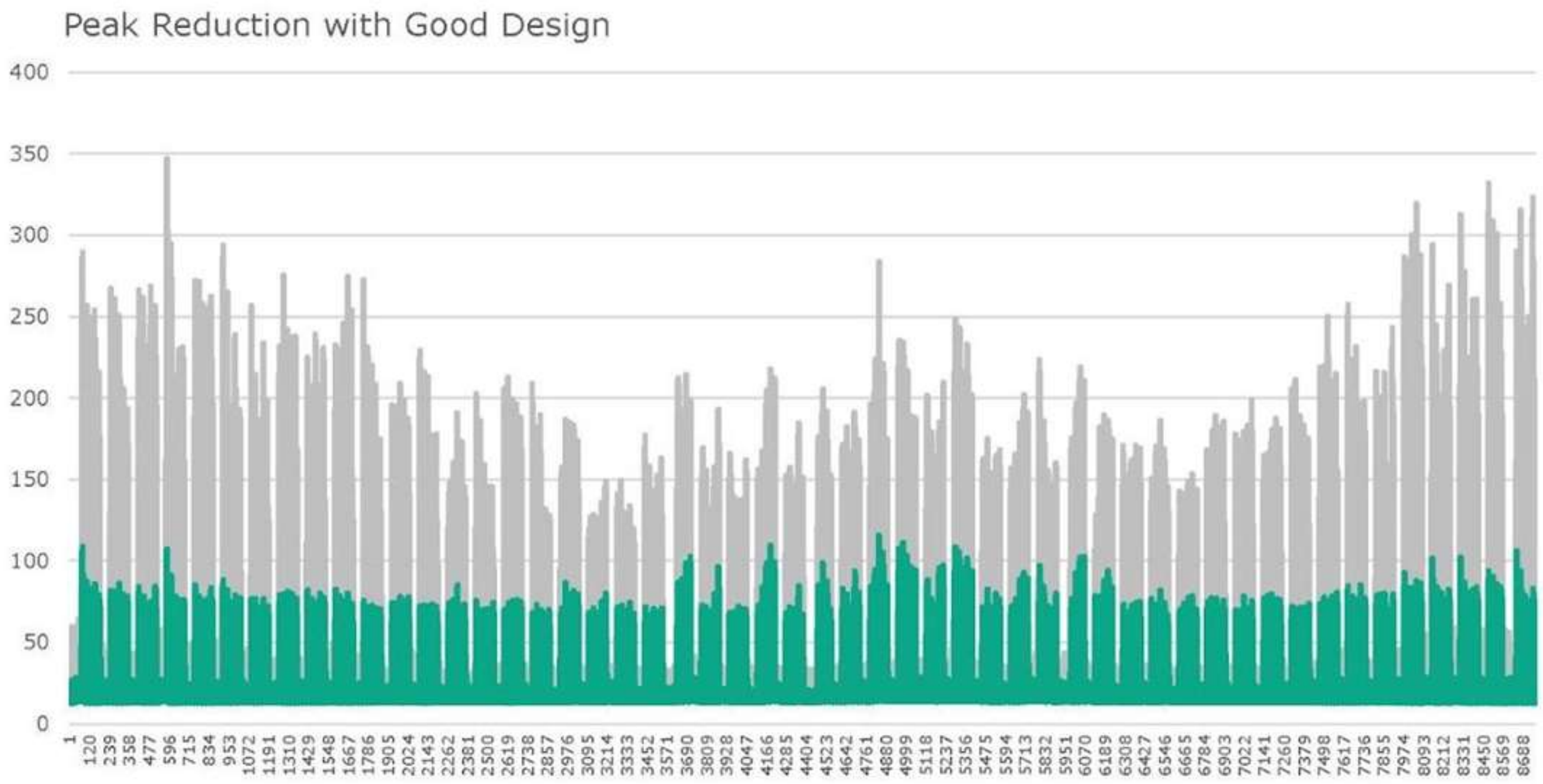
KEY

- Locked In or Prescheduled
- Real Time Dynamic

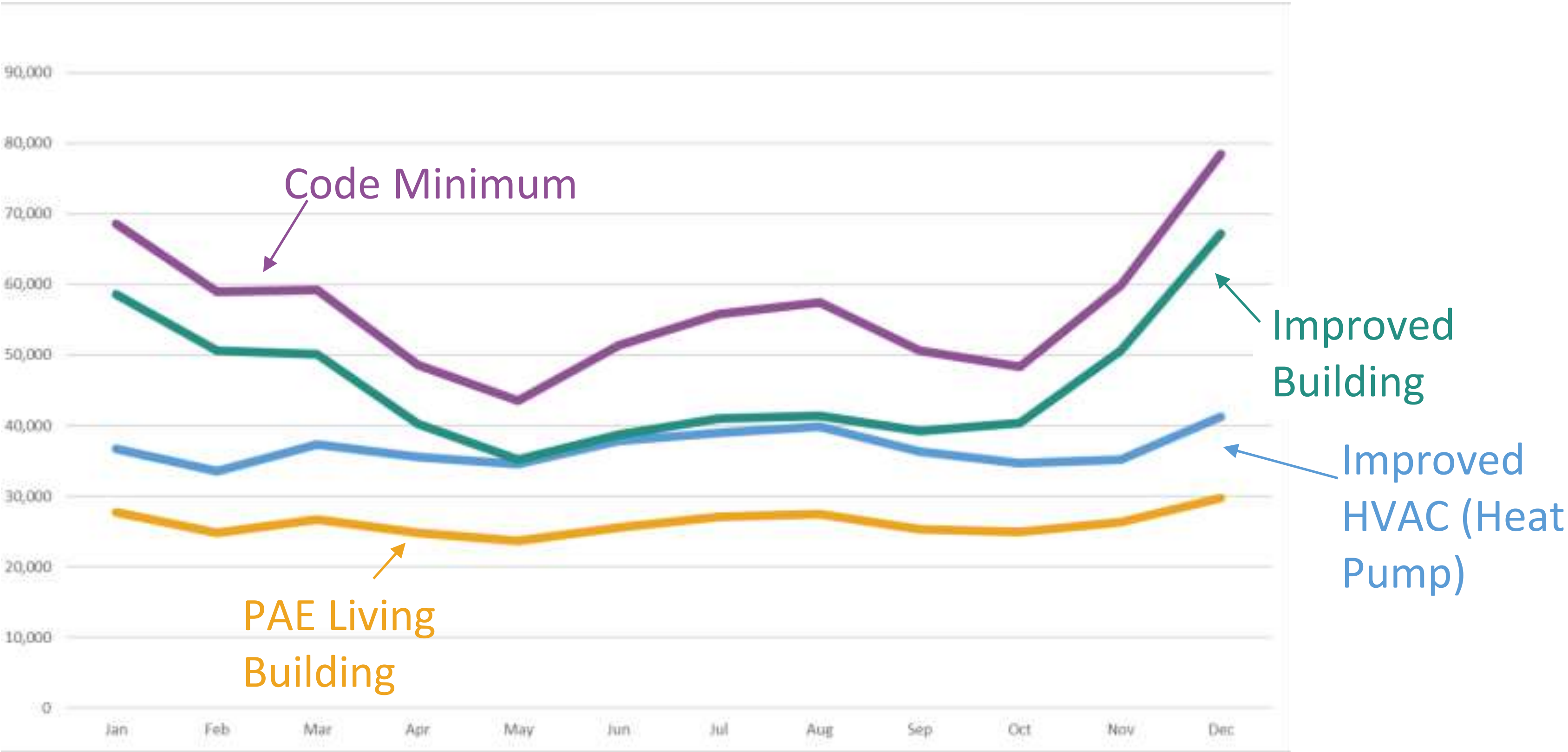
Begin with What You Know



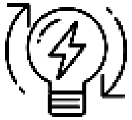
Stop Peaks Before They Start



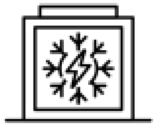
Reduce Peaks Through Design



PEAK REDUCTION THROUGH DESIGN:



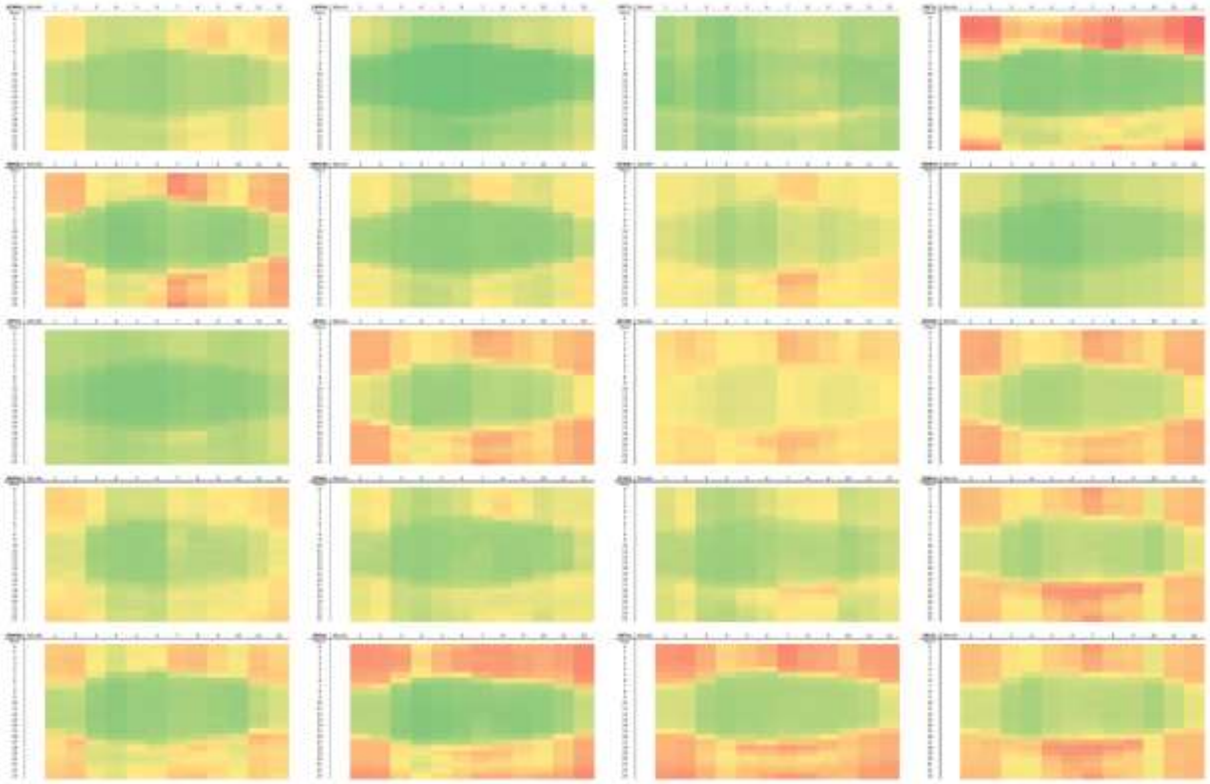
Improved Building = Summer Peak Reductions



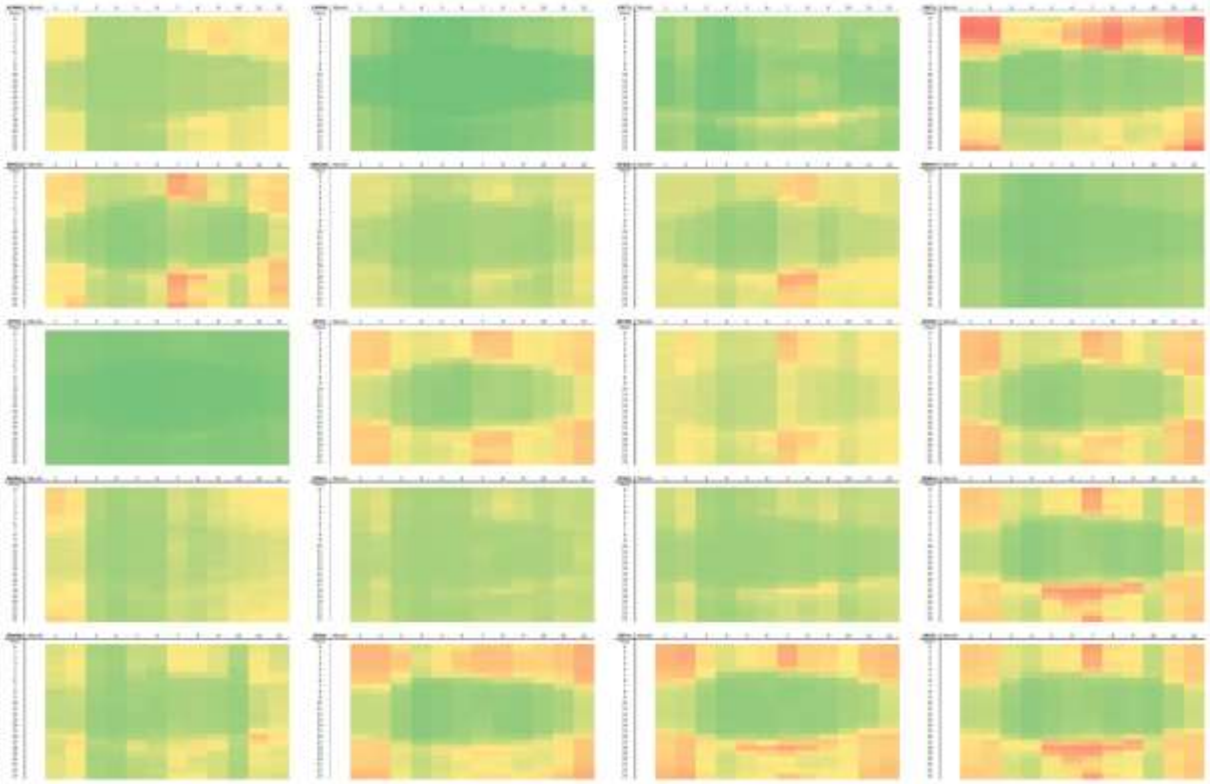
Heat Pump = Winter Peak Reduction

Future Outlook for Time Varying Emissions

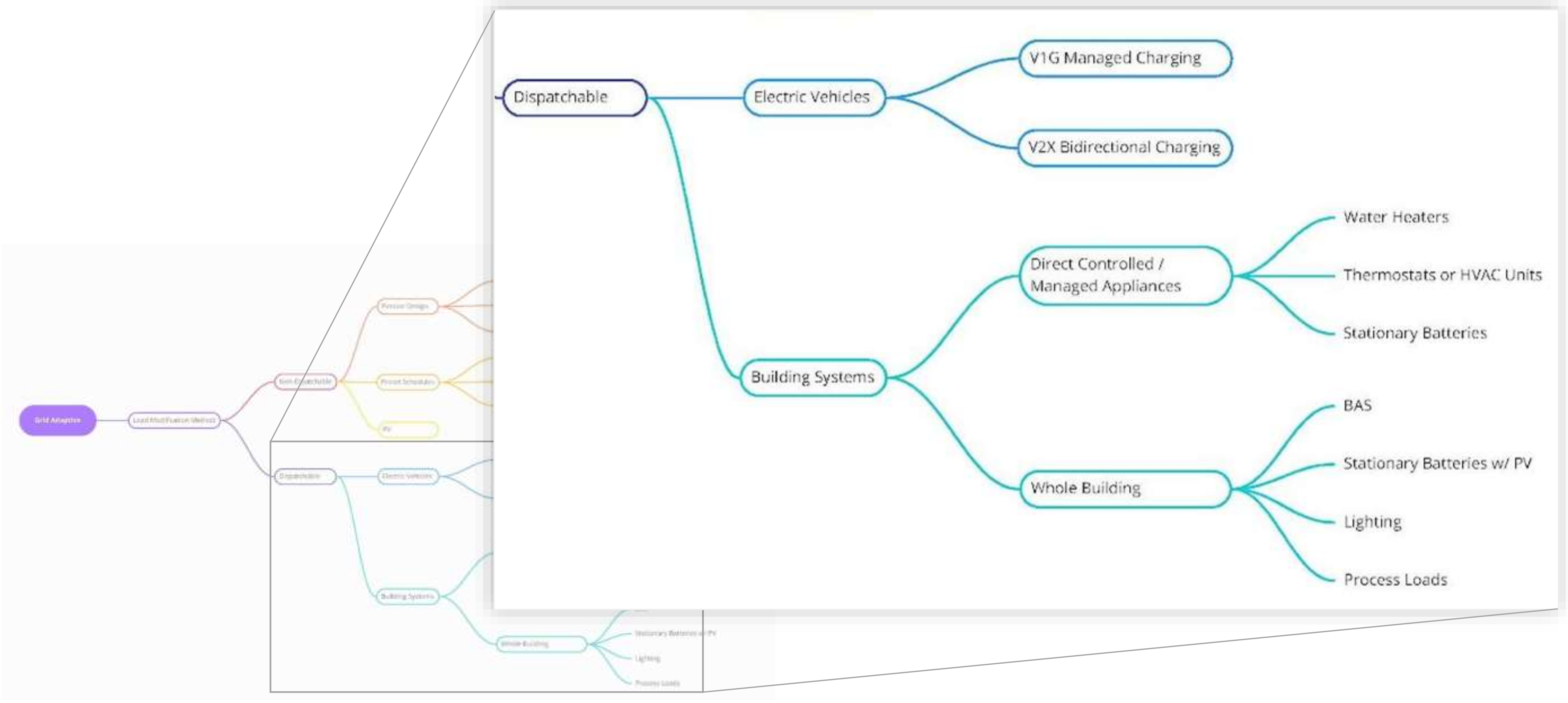
2023



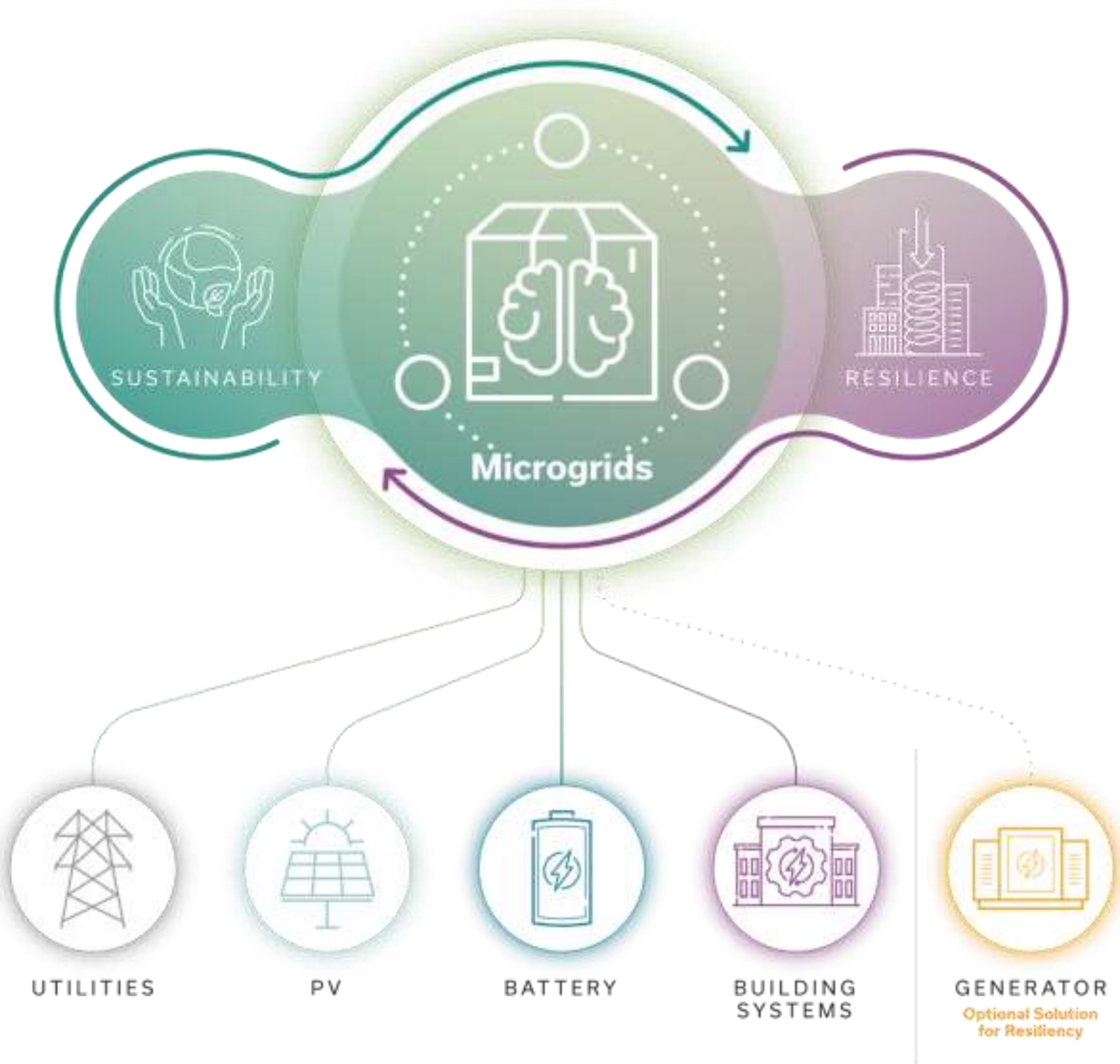
2030

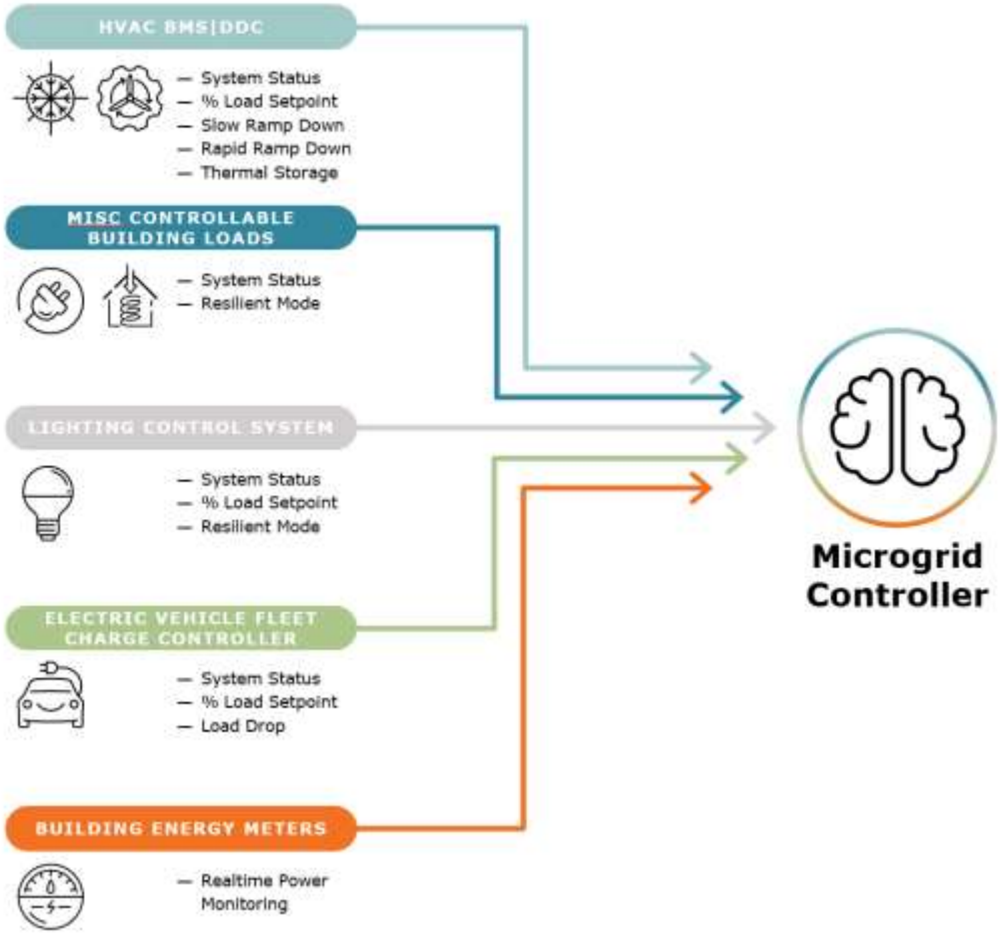


Activate What You Can



Microgrids and DERs

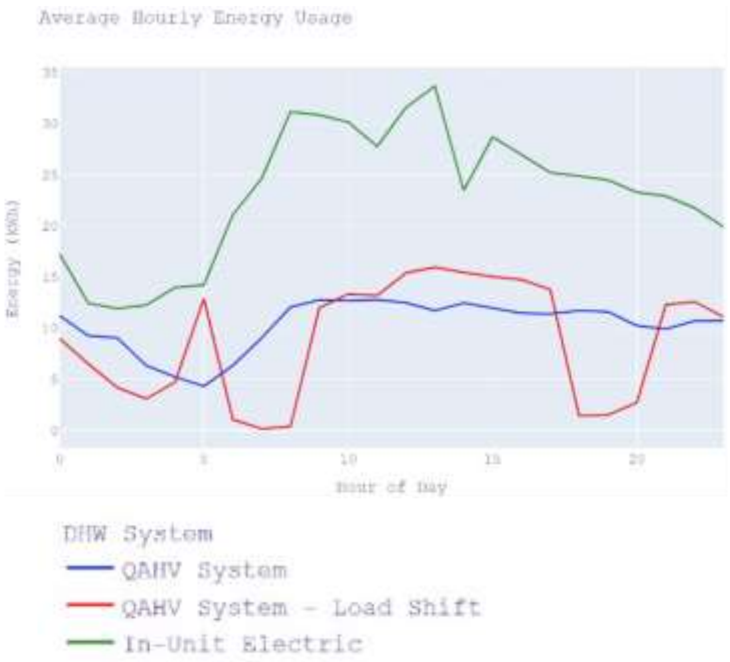




Water – The Other Storage

Photo credit: Ecotope

Bayview Towers demonstrates CHPWH technology, inclusion, environmental stewardship, and energy savings



Project Credit: Ecotope

How can I be flexible?

Distributed Energy Resources:

- Solar photovoltaics
- Thermal Storage
- Energy storage
- Electric Vehicles
- Combined heat and power plants

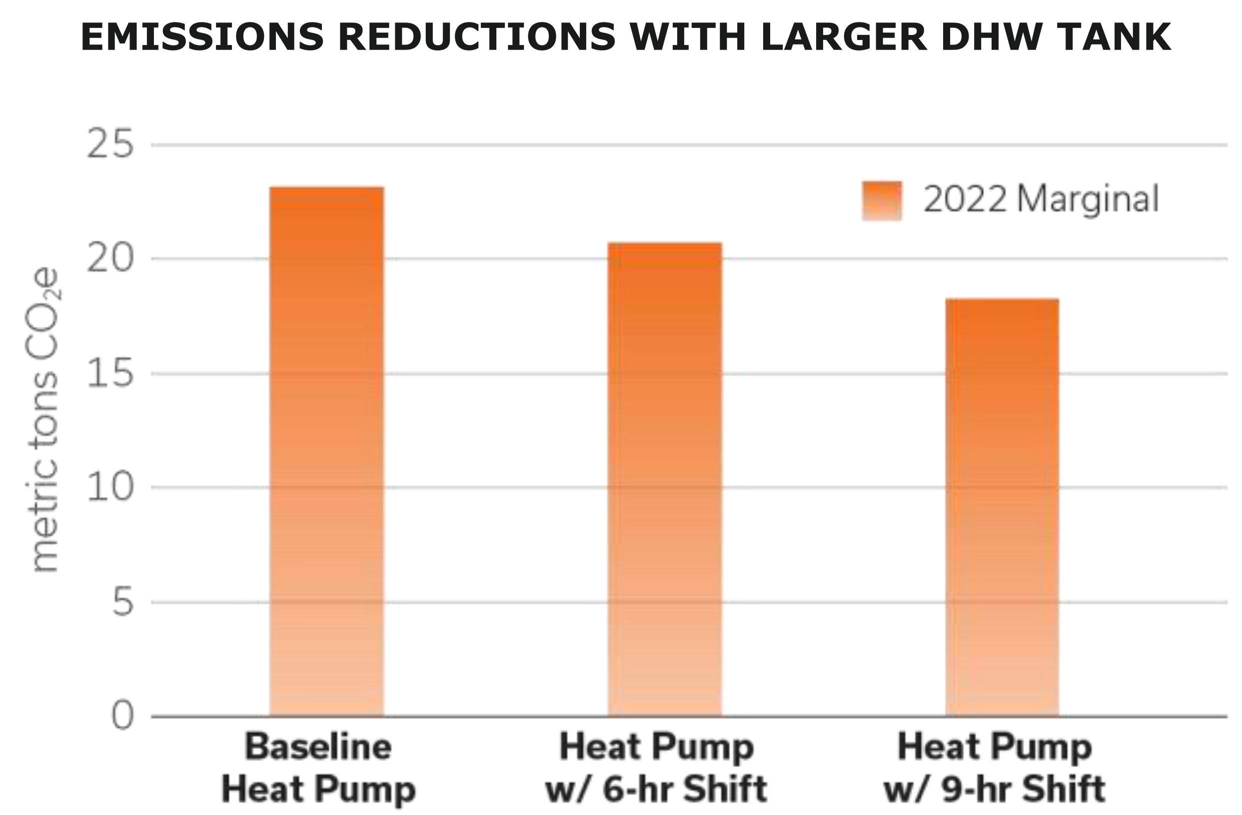
Grid-friendly Building Strategies:

Permanent Efficiency
- Efficient systems

Peak Shifting and Flexible Loads
- Smart controls
- Thermal mass
- Energy storage / batteries

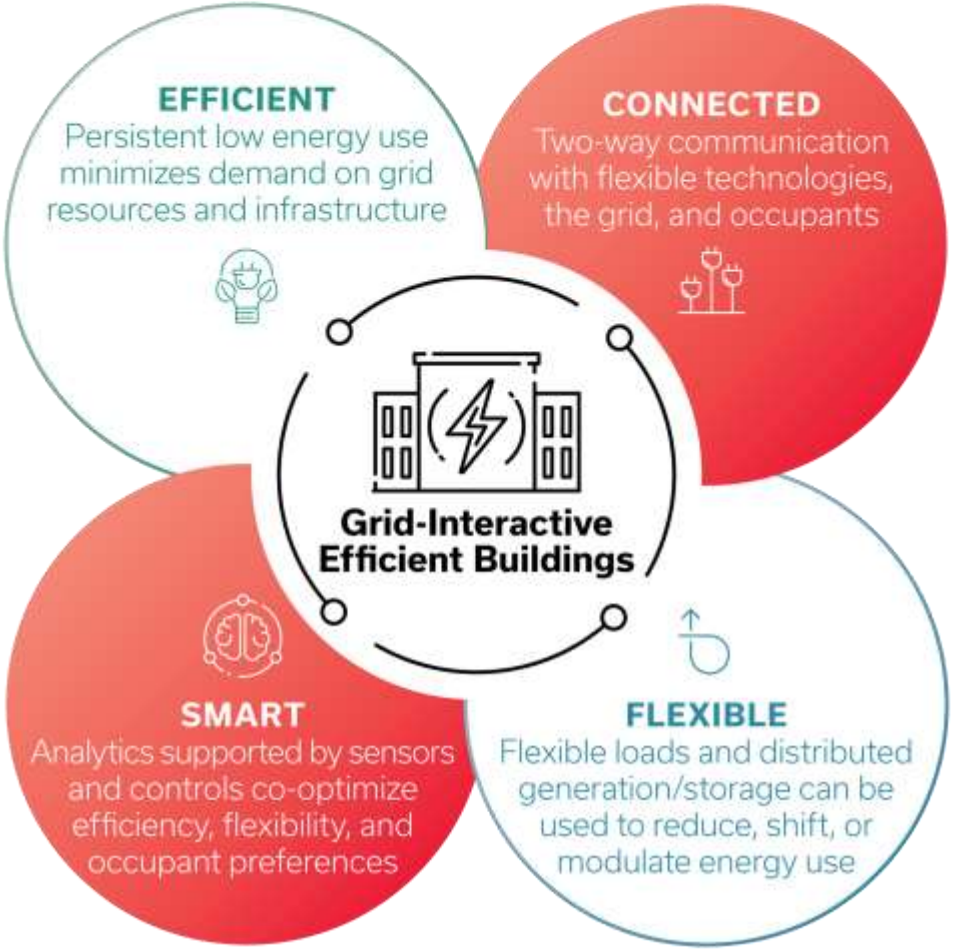
Dispatchable Energy Storage
- Intelligent, grid-integrated communication
- Smart systems and devices for HVAC, water heating, lighting, and electric vehicles, can align building energy

Source: NBI



Source: PAE, PGE

The Long Arc to GEBs



- DOE Definition, graphic by RMI

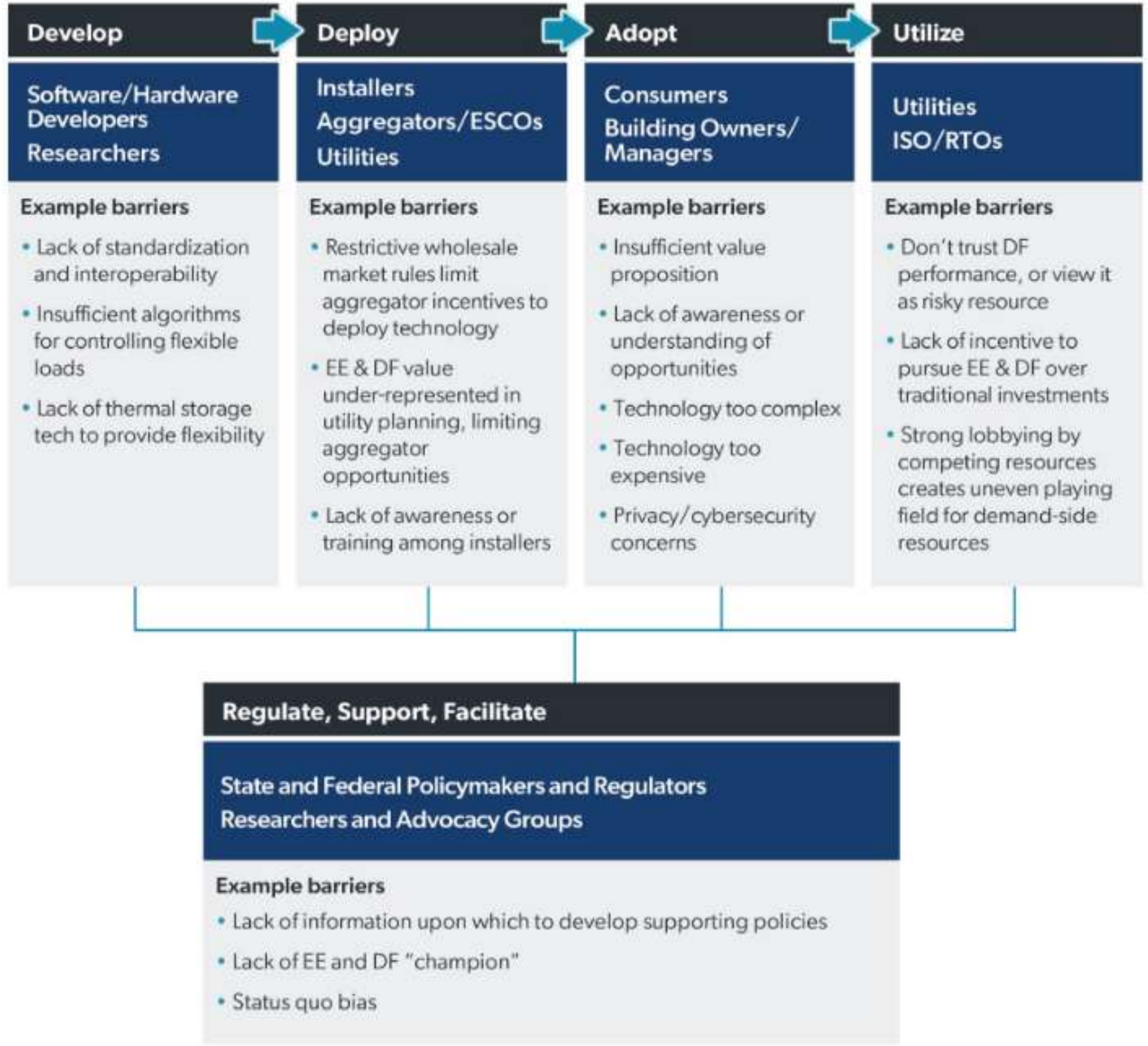


FIGURE 10: GEB VALUE CHAIN AND KEY BARRIERS

- A National Roadmap for Grid-Interactive Efficient Buildings, 2021

Designing the Future

Case Studies

COMMERCIAL

PAE Living Building

PORTLAND, OR

QUICK STATS

OWNER Multiple Owners

ARCHITECT ZGF Architects

PROGRAM Commercial + Corp. Office

PAE SCOPE Mechanical, Electrical, Plumbing, Technology Design, Building Performance Analysis, Renewable Energy Systems, Greenhouse Gas Consulting, Commissioning, Architectural Lighting Design (via LUMA)

DELIVERY CMGC

SIZE 58,000 sf

Pursuing Living Building

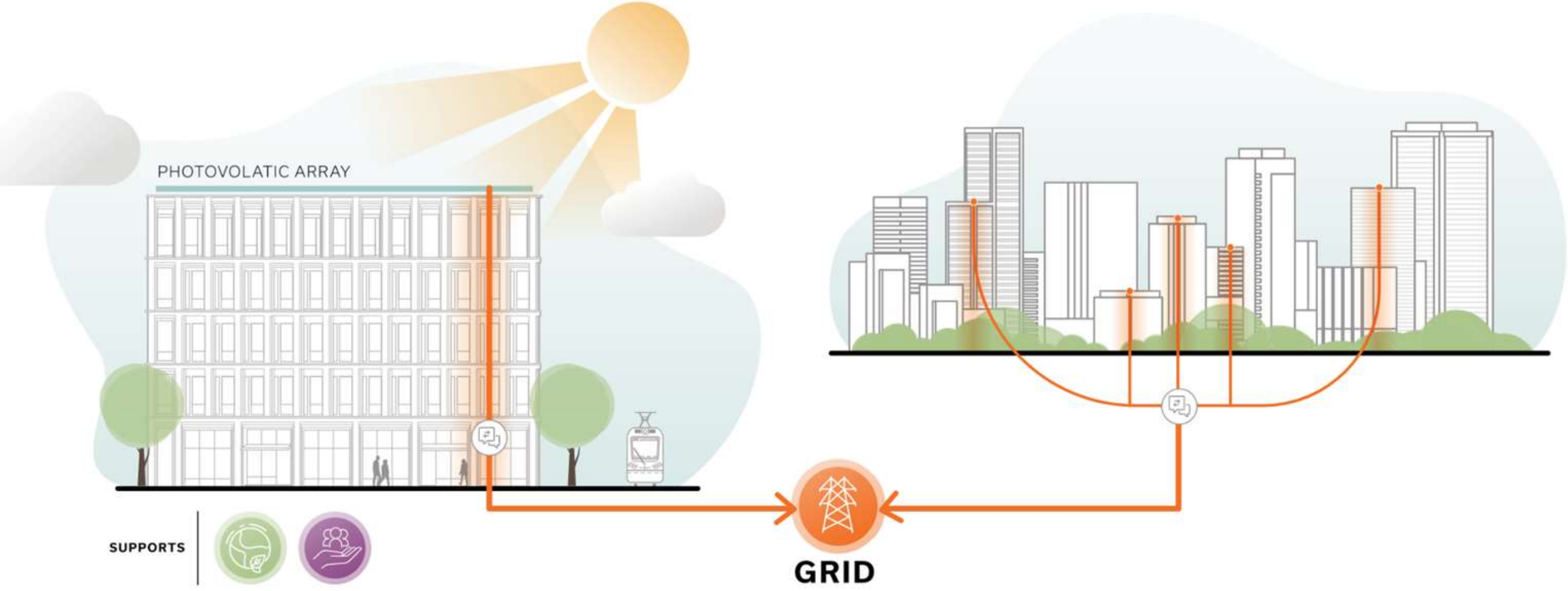
19
Energy Usage Intensity

Pursuing Net Zero Energy

99/100
Walk Score

Pursuing Net Zero Water

PAE Living Building



SBP St. Peter Multifamily

NEW ORLEANS, LA

QUICK STATS

OWNER	SBP AmeriCorps Disaster Corps
ARCHITECT	Eskew+Dumez+Ripple
PROGRAM	Affordable Housing
SIZE	45,000 sf, 50 apartments

Targeting Net Zero Energy

18
pEUI

$164
Per Square Foot

Battery Storage

Enterprise Green Communities


FAST COMPANY

LOGIN

09-02-21

In New Orleans, a solar microgrid is keeping lights on in this affordable apartment building

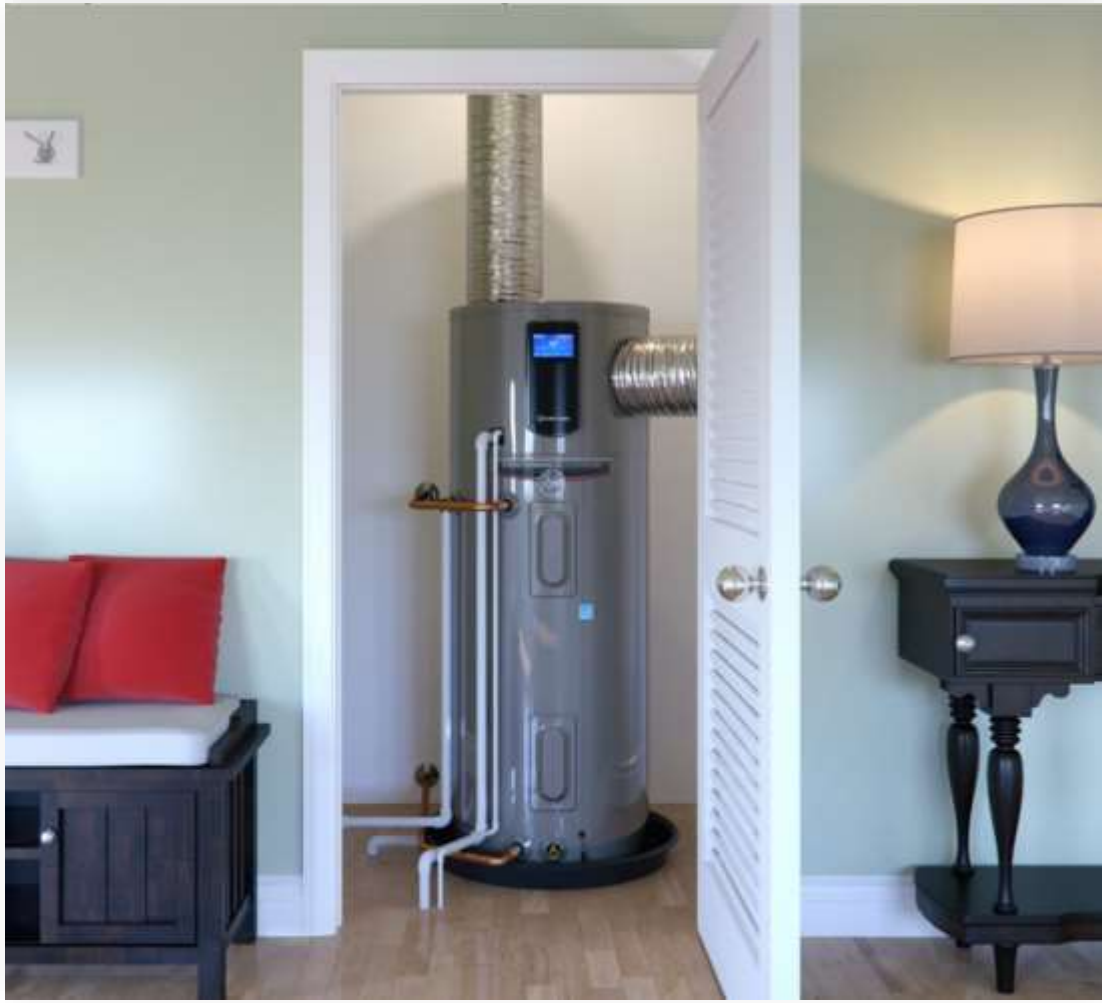
While the rest of the neighborhood is dark, the residents at the St. Peter Apartments still have power. Can it be a model for more resilient architecture?

[Photo: courtesy Eskew Dumez + Ripple]

178 kW PV array

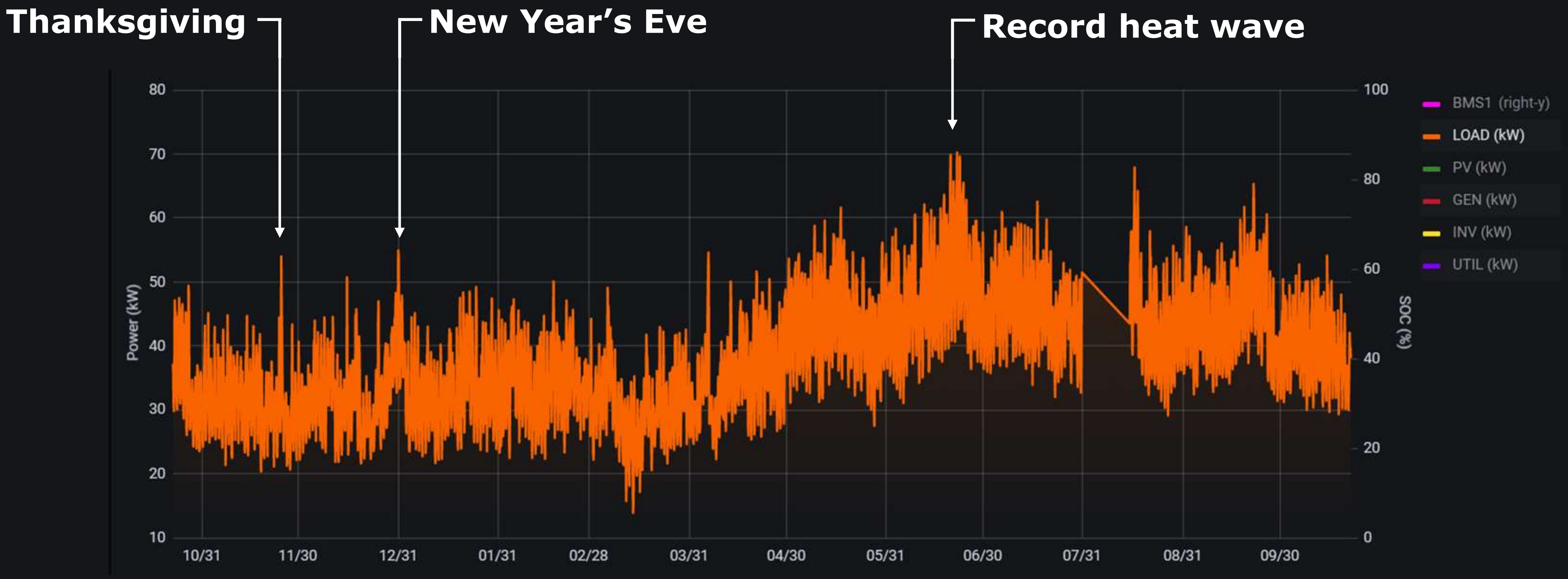
125kW / 371 kWh battery

😊 **HAPPY RESIDENTS:**
Energy bills < $35/month



Heat pump water heaters help cool and dehumidify apartments

Building Energy Consumption



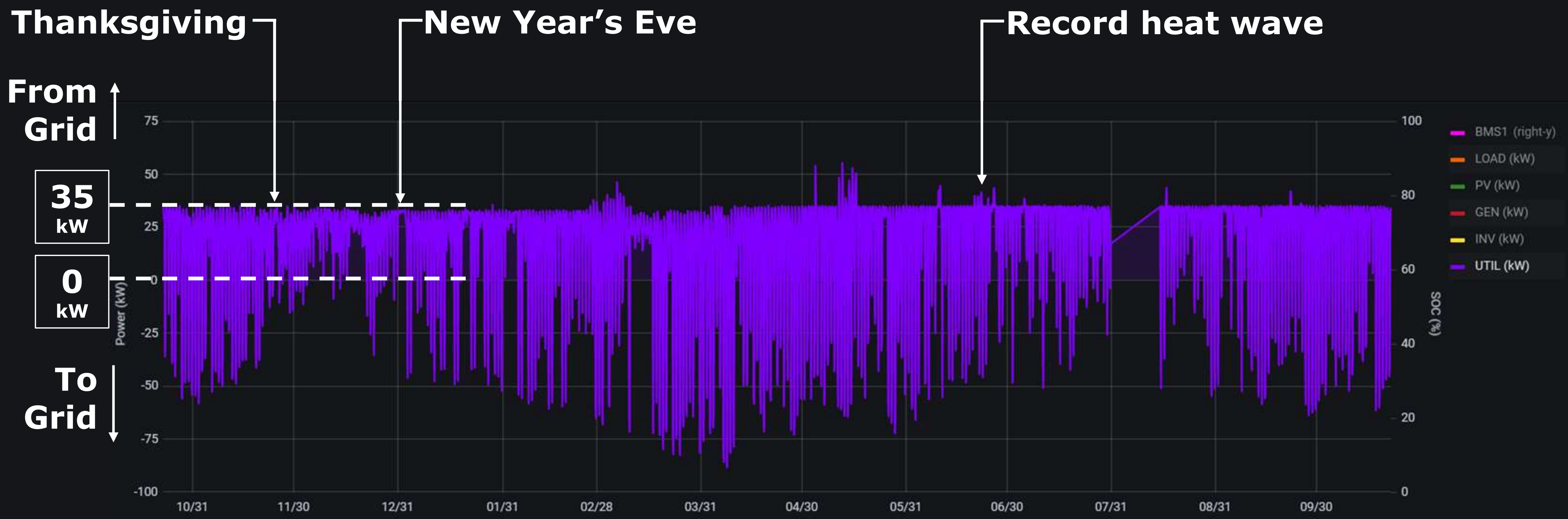
Solar Production

Thanksgiving

New Year's Eve

Record heat wave

How this building looks to the utility



Best Practices Principles + Latest Technologies (To De-Peak the Building)

- Cellulose cavity insulation + continuous insulation sheathing
- Field-verified airtight construction
- Moderate glazing (WWR 10%)
- Exposed thermal mass

- High-SEER/HSPF heat pumps
- Heat pump water heaters
- Solar PV – cover the available flat roof
- Battery capacity = 15 h average consumption
- Islanded off-grid after Hurricane Ida

- AFFORDABLE housing: $164/sf

Simple metrics for grid adaptive buildings?

Make your building efficient, electric, and able to shape its load

	GOOD	BETTER	BEST
Efficient	75^{th} percentile EUI	90^{th} percentile EUI	95^{th} percentile EUI
Peak demand on utility	<3x annual average building consumption	<2x annual average building consumption	<1.5x annual average
Demand reduction on request	Able to shed 25% of load for 4h	Able to shed 50% of load for 4h	Go off-grid for 24h
Provide power to the grid		Able to push annual average demand for 1h	Able to push annual average demand onto grid for 4h
Carbon balance		Able to reduce demand in response to a marginal carbon intensity signal	'Net Zero Carbon': carbon emissions associated with power pushed onto the grid >= carbon emissions associated with power drawn from the grid

GridOptimal

Design guidance available for 6 building types and for 7 regions of the US

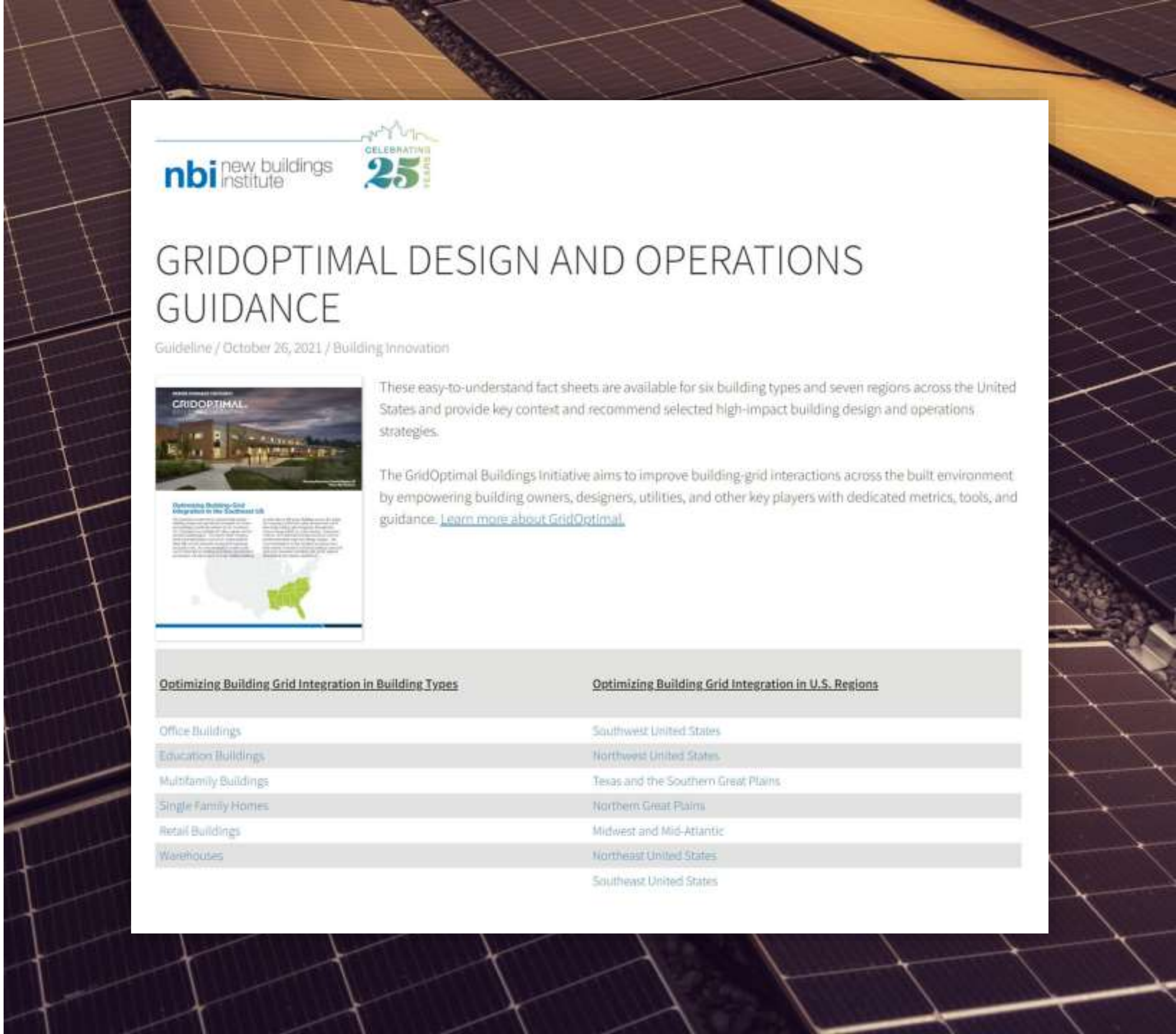
BUILDING TYPES:

- Office
- Education
- Multifamily Housing
- Single Family Homes
- Retail
- Warehouses

USA GRID REGIONS:

- Southwest
- Northwest
- Texas + Southern Great Plains
- Northern Great Plains
- Midwest & Mid-Atlantic
- Northeast
- Southeast

https://newbuildings.org/resource/gridoptimal-design-guidance/



nbi new buildings institute — CELEBRATING 25 YEARS

GRIDOPTIMAL DESIGN AND OPERATIONS GUIDANCE

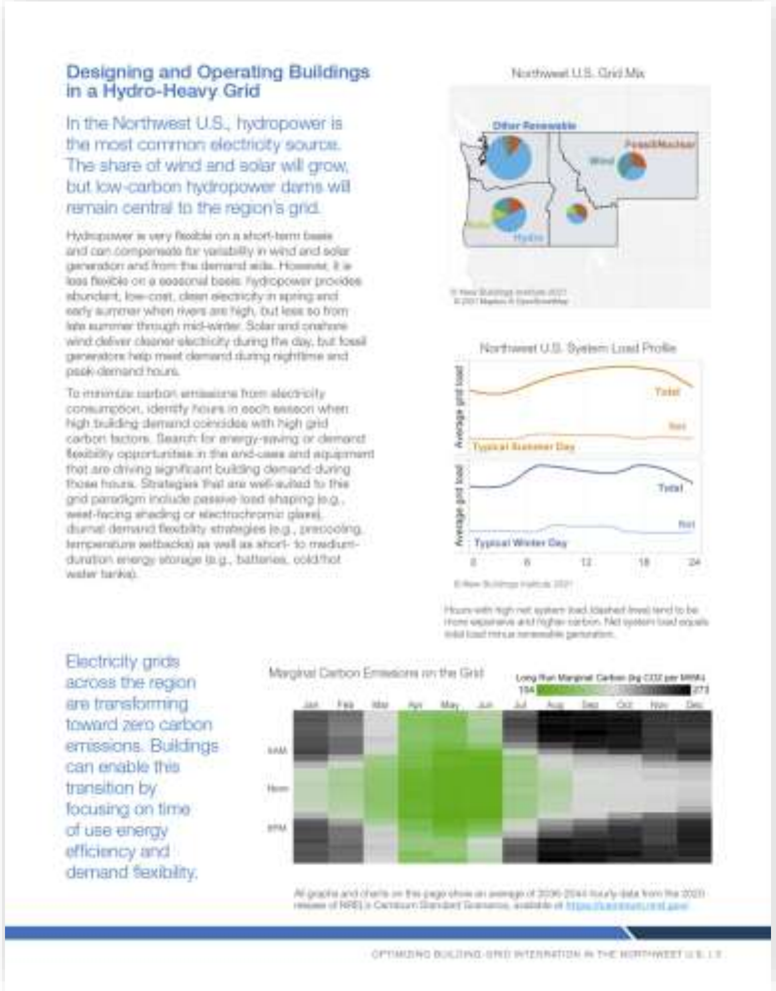
Guideline / October 26, 2021 / Building Innovation

These easy-to-understand fact sheets are available for six building types and seven regions across the United States and provide key context and recommend selected high-impact building design and operations strategies.

The GridOptimal Buildings Initiative aims to improve building-grid interactions across the built environment by empowering building owners, designers, utilities, and other key players with dedicated metrics, tools, and guidance. Learn more about GridOptimal.

Optimizing Building Grid Integration in Building Types	Optimizing Building Grid Integration in U.S. Regions
Office Buildings	Southwest United States
Education Buildings	Northwest United States
Multifamily Buildings	Texas and the Southern Great Plains
Single Family Homes	Northern Great Plains
Retail Buildings	Midwest and Mid-Atlantic
Warehouses	Northeast United States
	Southeast United States

GridOptimal Guidance Example: Northwest



Designing and Operating Buildings in a Hydro-Heavy Grid

In the Northwest U.S., hydropower is the most common electricity source. The share of wind and solar will grow, but low-carbon hydropower dams will remain central to the region's grid.

Electricity grids across the region are transforming toward zero carbon emissions. Buildings can enable this transition by focusing on time of use energy efficiency and demand flexibility.

Top 5 GridOptimal Building Design and Operation Strategies:

Northwest U.S.

Smart HVAC controls.

Managed EV charging.

Building envelope.

Energy storage.

Efficient systems.

Key Enablers: Energy Efficiency and Distributed Energy Resources

Energy efficiency

Passive strategies

Active strategies

Distributed Energy Resources

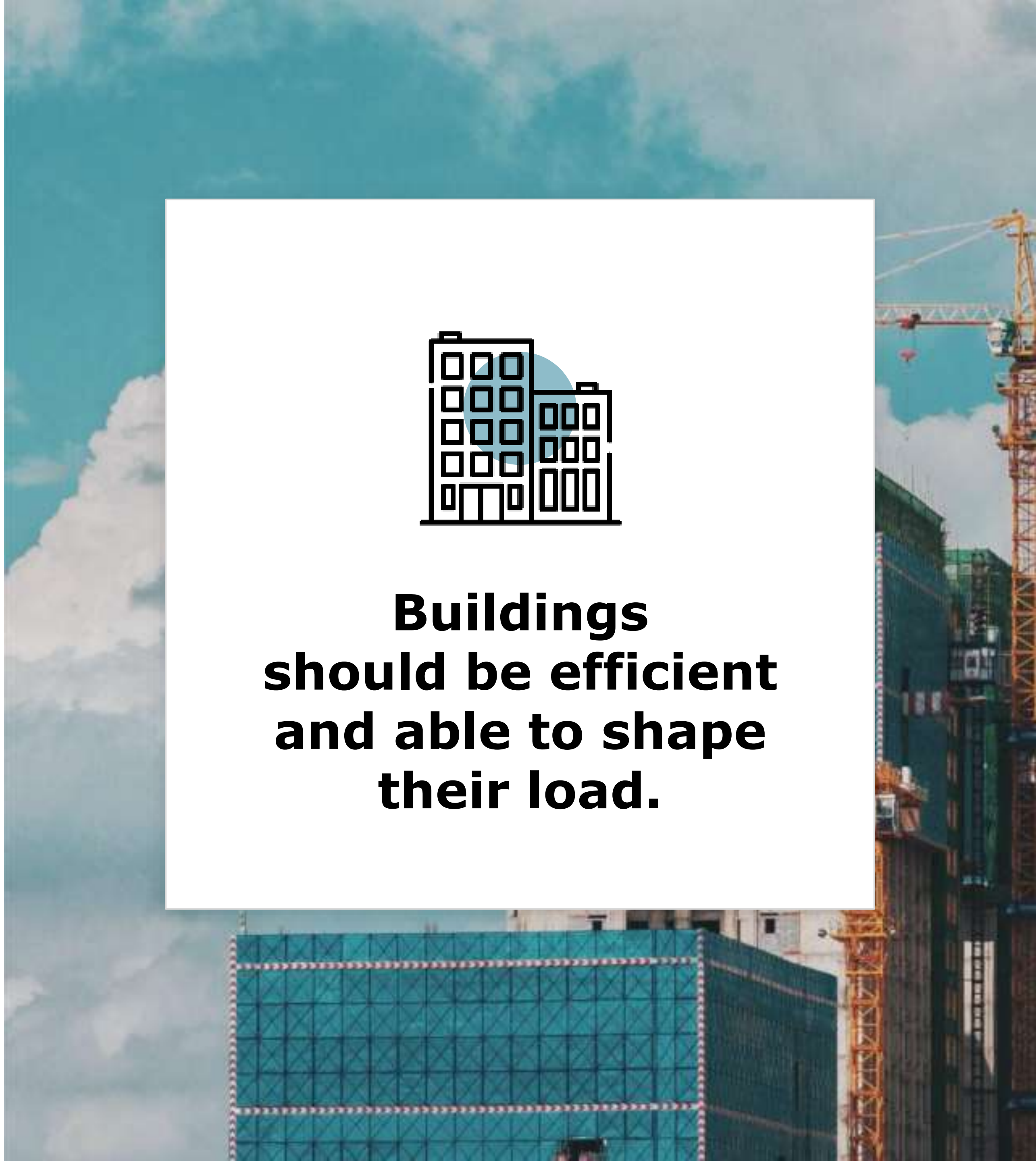
Efficient systems. Efficient mechanical systems (HVAC and water heating) meet occupant thermal comfort needs with decreased energy use. Consider variable-capacity heat pump HVAC systems and grid-connected heat pump water heaters to maximize energy savings and carbon emissions reductions. Paired with an efficient building envelope, efficient systems improve resiliency by prolonging the building's ability to remain comfortable and habitable through a partial or complete power outage. Efficient systems are an enabler and often an impact multiplier for demand flexibility.

What should building designers do?

— Start with NBI GridOptimal guides–then match to your project

— Apply old-school passive design principles first, then new tech to make your project less “peaky”, efficient, and able to shape its load

— Taking responsibility for your project’s consumption with onsite & offsite renewable power is the *starting* point. NZE is good, but grid-adaptive is better



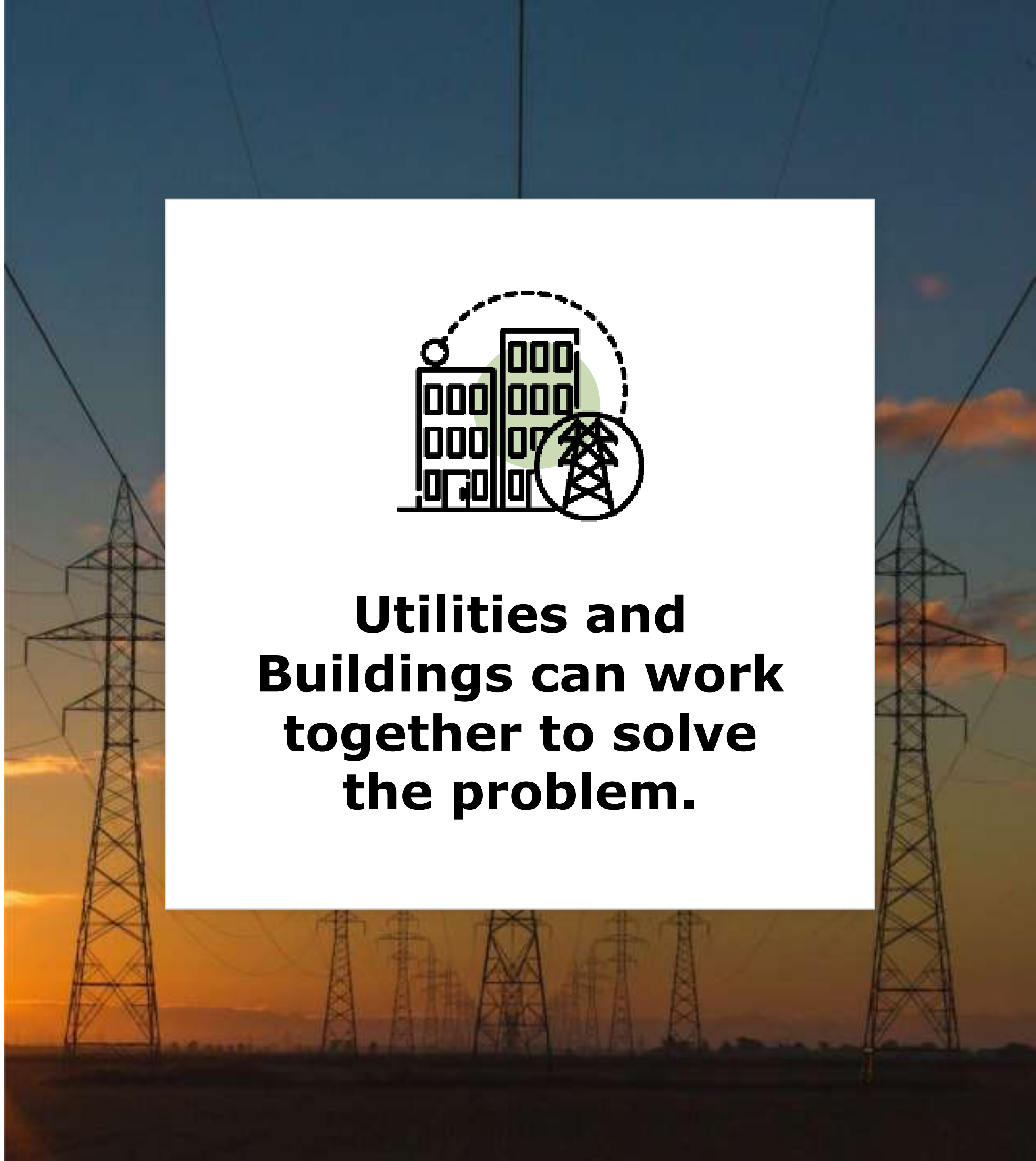
Buildings should be efficient and able to shape their load.

What do we need from utilities?

Partnership and Transparency

- —Better real-time data
- —Normalized two-way communications
- —Clear direction on what utilities need from buildings

More and better examples of Time-Of-Use (TOU) pricing to incentivize decarbonizing behavior



Calls to Action

The **potential** is huge.
The **barriers** are real

Share knowledge between all stakeholders:

- Designers
- Owners/Operators
- Utilities
- Manufacturers
- Research institutions and labs
- Venture capitalists
- Policy and program developers

Every project can **implement a solution today.**

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