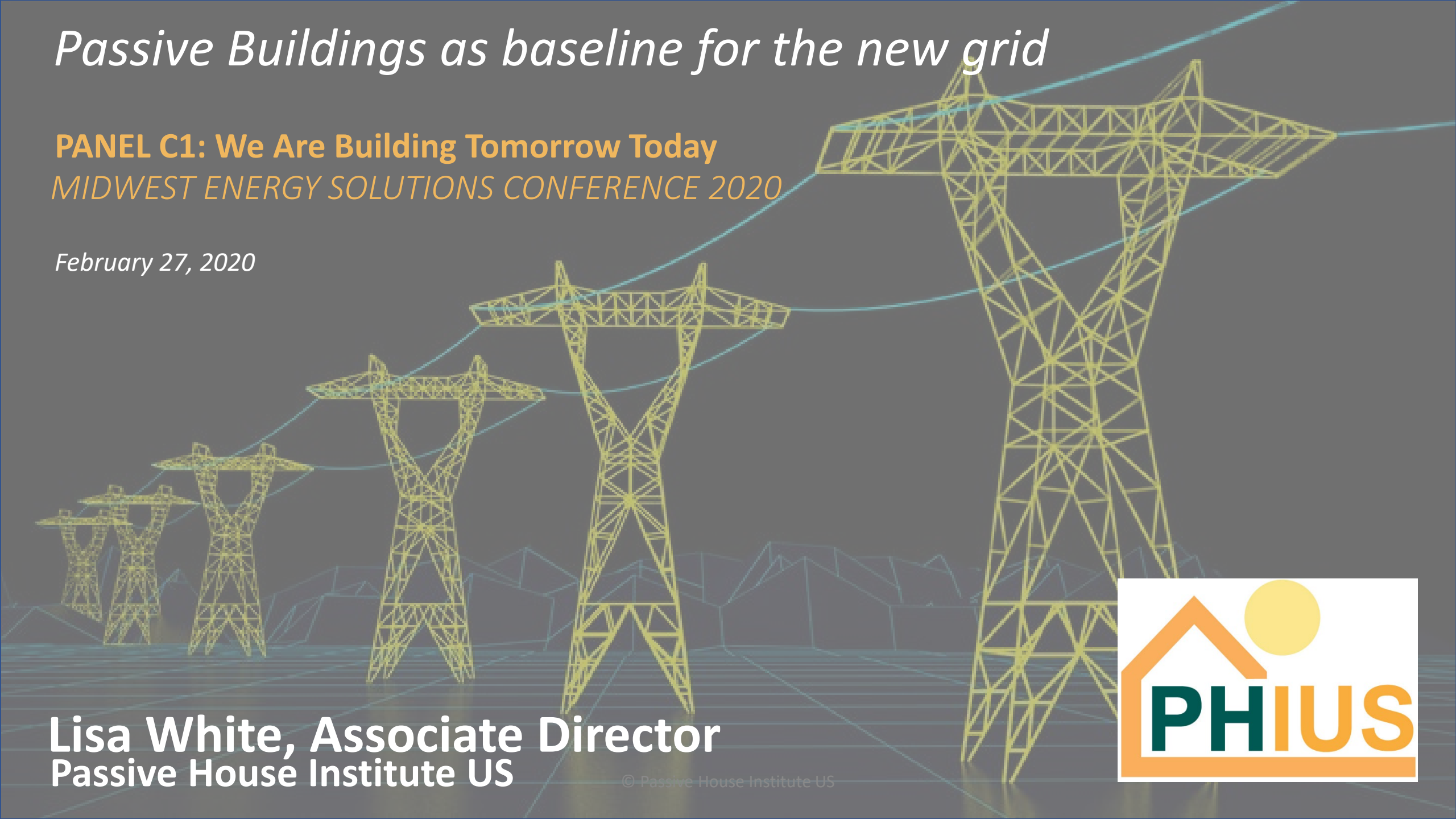
Passive Buildings as baseline for the new grid

PANEL C1: We Are Building Tomorrow Today

MIDWEST ENERGY SOLUTIONS CONFERENCE 2020

February 27, 2020



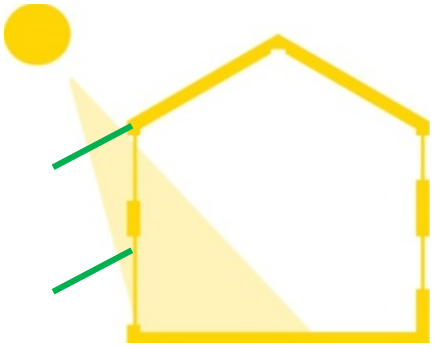
Lisa White, Associate Director
Passive House Institute US

PASSIVE BUILDING PRINCIPLES

Thermal Control

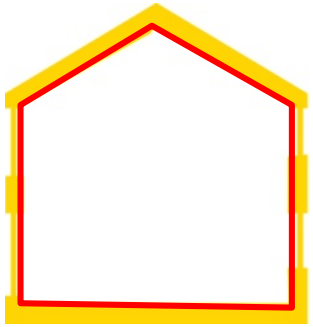
CONTINUOUS INSULATION

Radiation Control



OPTIMIZED WINDOWS & SOLAR GAINS

Air Control



AIR-TIGHT CONSTRUCTION

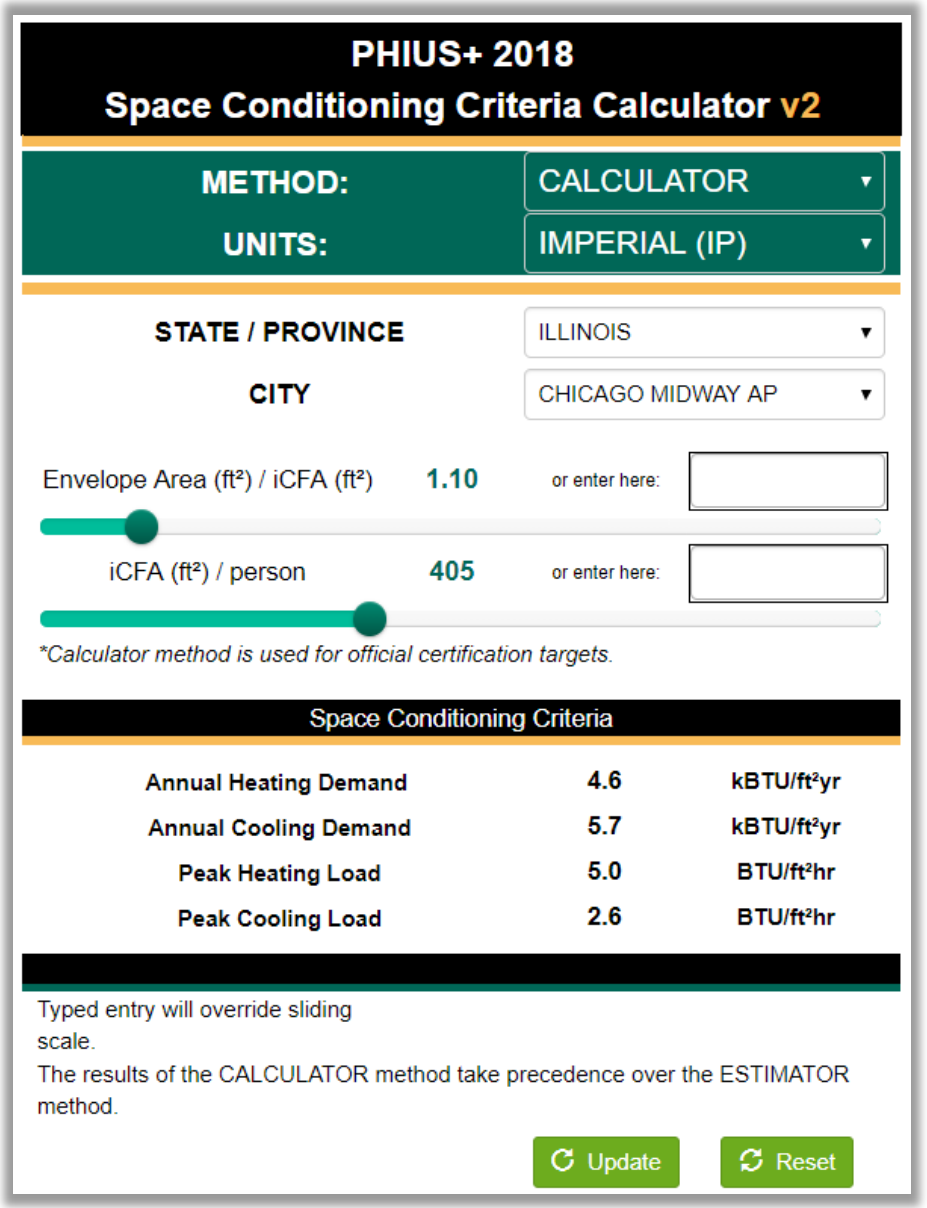
BALANCED VENTILATION WITH HEAT RECOVERY

MINIMIZED MECHANICAL SYSTEMS

PHIUS+2018

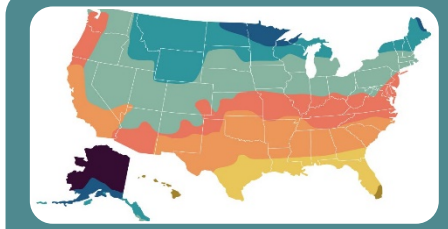
A *performance* based ***passive building standard*** with *prescriptive* requirements.

https://www.phius.org/phius-certification-for-buildings-products/project-certification/phius-2018-getting-to-zero



MAIN CERTIFICATION REQUIREMENTS

REQUREIEMTNS FOR ALL PHIUS+ CERTIFICATIONS



SPACE CONDITIONING TARGETS

- Based on cost optimization analysis
- Vary based on climate, occupant density, and envelope/floor area ratio

AIR-TIGHTNESS

- 0.060 CFM50/ft^2 envelope area
- Required limit set based on building durability. Pass/Fail.

PHIUS+ RATER

PHIUS+ VERIFIER

ON-SITE QUALITY ASSURANCE TESTING/INSPECTION

- Ensure quality for elements not reflected in energy modeling
- Required for all projects

VARIES

NET SOURCE ENERGY TARGET

- Used instead of site energy as a better proxy for carbon emissions
- Target and renewable energy offsets vary based on program version

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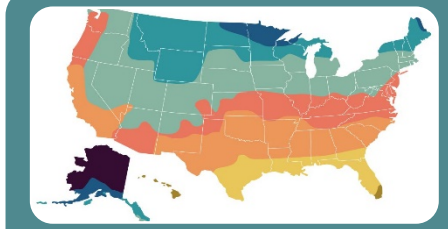

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VARIES

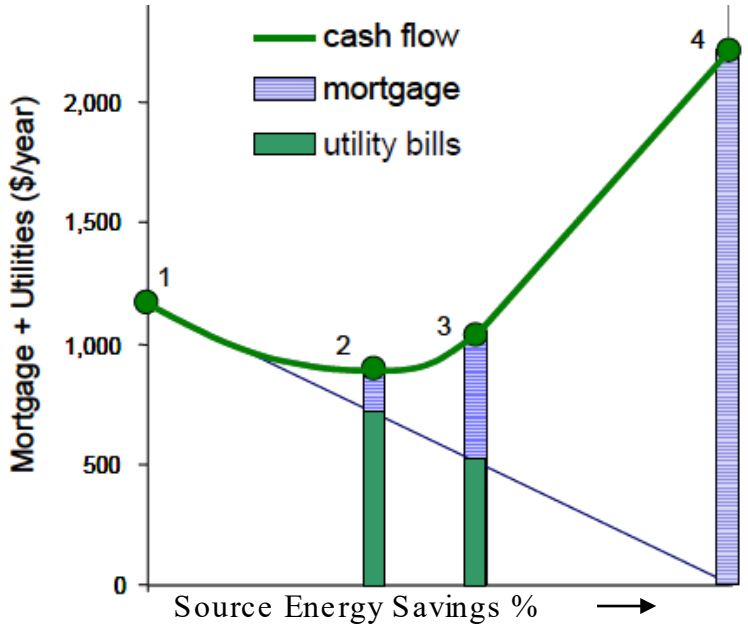
NET SOURCE ENERGY TARGET

- Used instead of site energy as a better proxy for carbon emissions
- Target and renewable energy offsets vary based on program version

How low can (and *should*) you go with passive measures, i.e. ***when to stop***?

TARGET SETTING METHODOLOGY

Setting Cost Competitive Space Conditioning Criteria

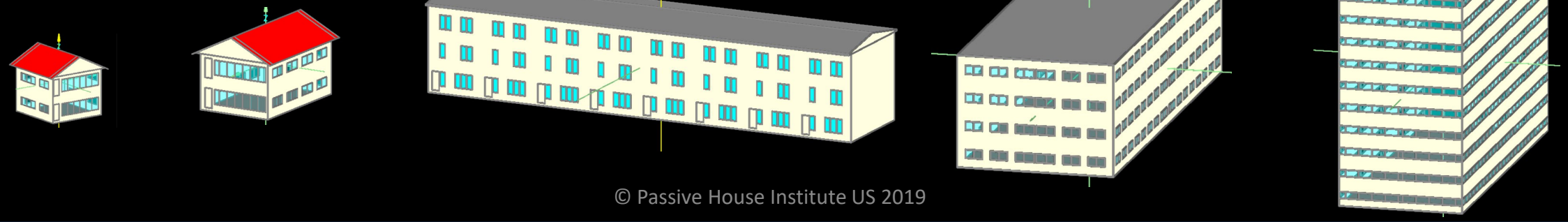


NREL BEopt optimizes upgrade package, set target at optimum point

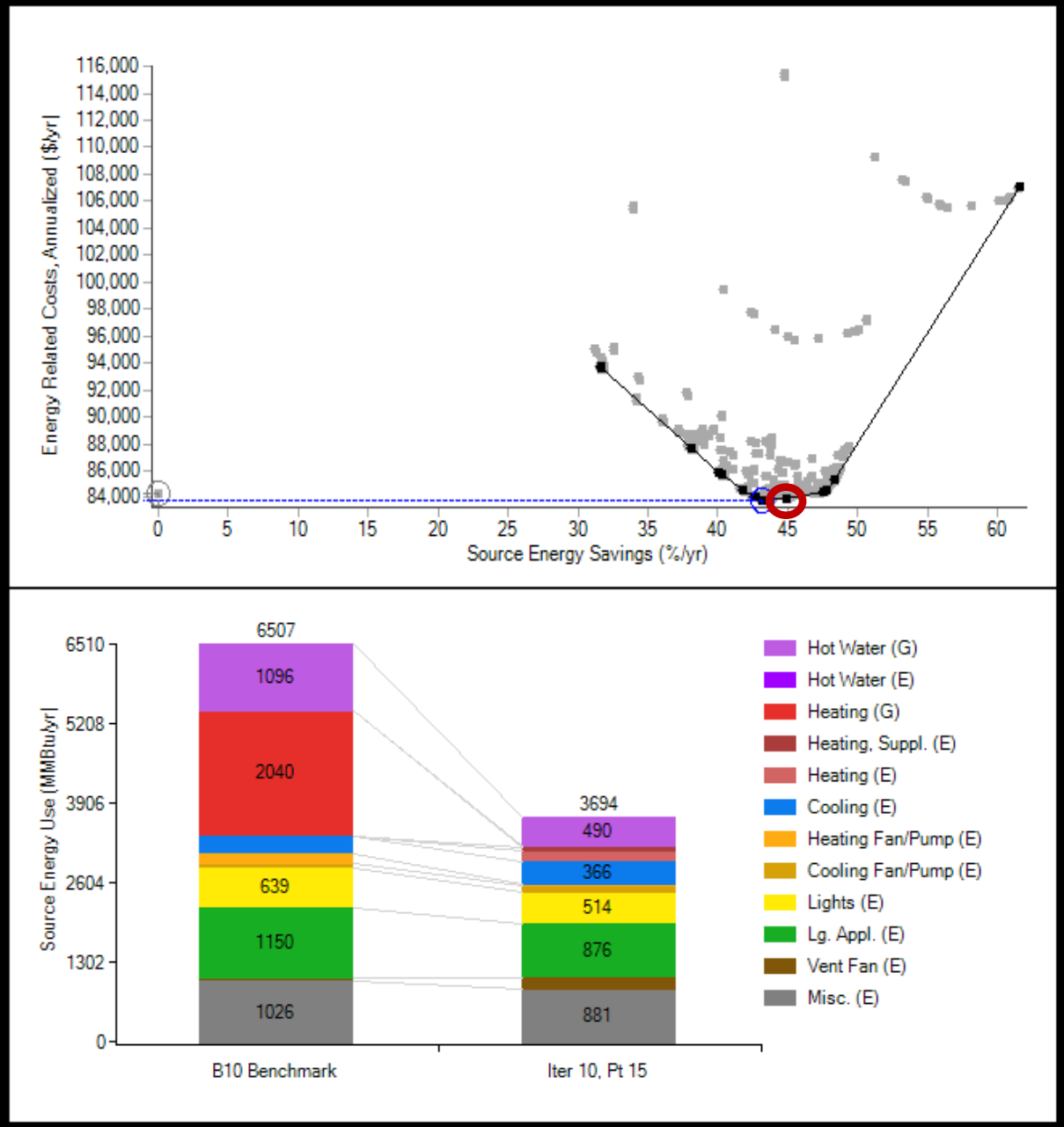
Factors:
Climate
Building Size
Occupant Density

Ignore PV for space conditioning targets!!

Forced Constraints:
Air-sealing (meet PHIUS+ target)
Window performance (comfort & low loads)



Cost optimal sweet-spot for investment in conservation



First Passive, then Zero

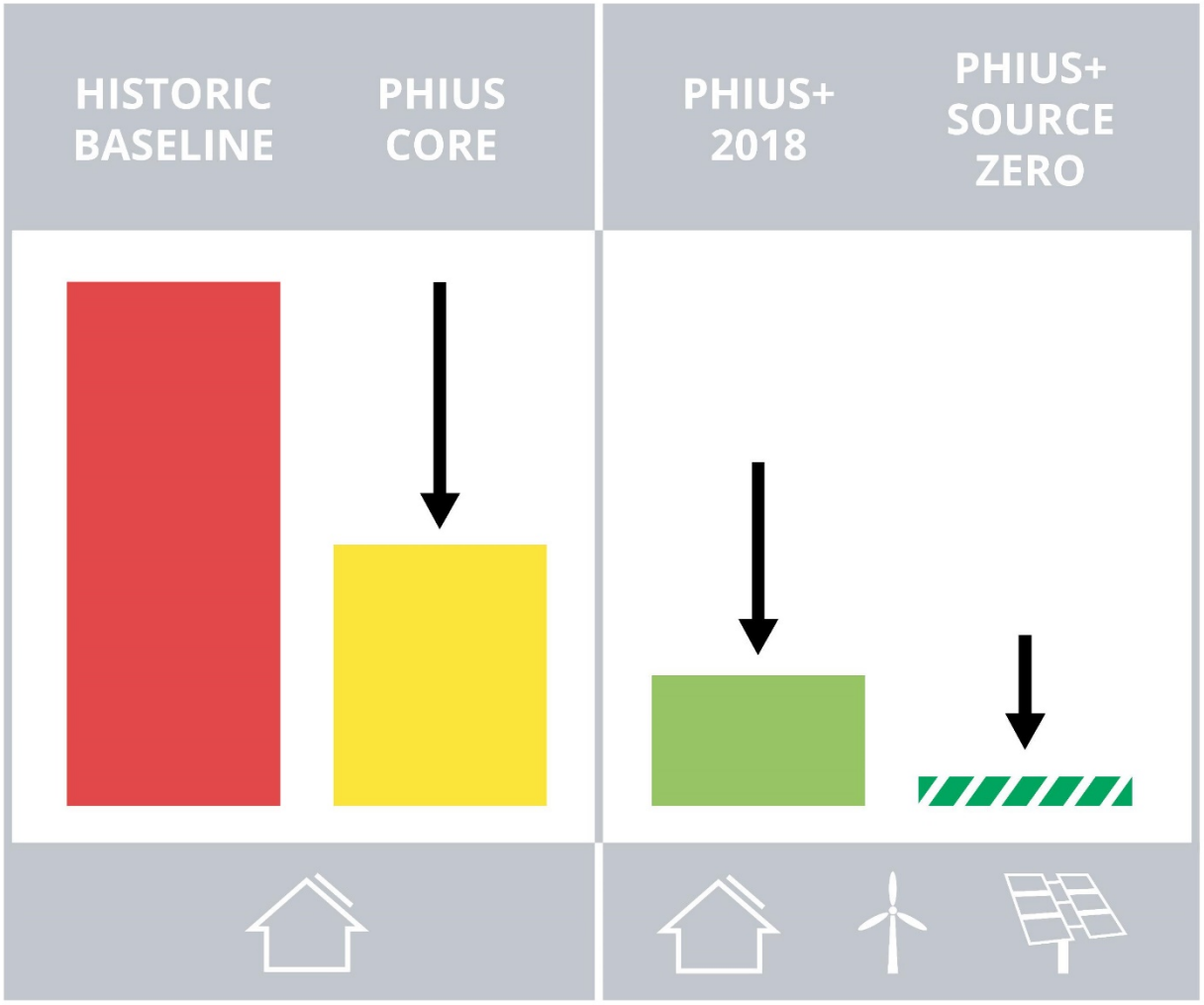
Passive building provides a proven methodology for designing a Net Zero energy building.

Step 1 - Conservation - first through passive measures, then through active measures.

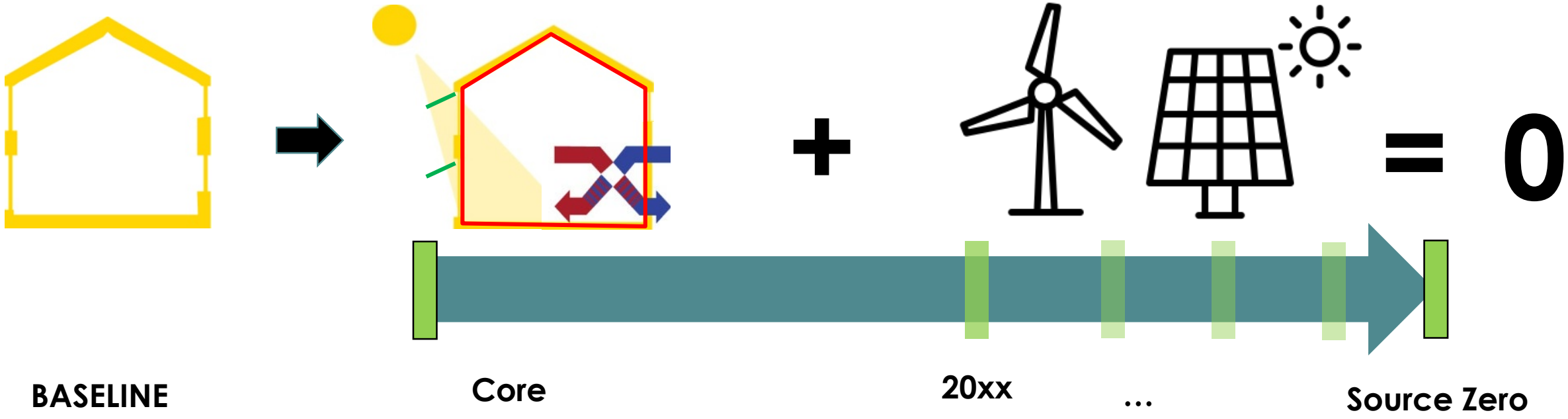
Step 2 – Renewable Energy - on-site or off-site renewable energy to offset remaining energy use.

With reduced loads, less renewable energy is needed, and less grid support is needed when the building isn't powered by renewable energy production. **Conservation efforts up-front will be critical for the wide-spread facilitation of Net Zero buildings into the existing electric grid.**

NET SOURCE ENERGY

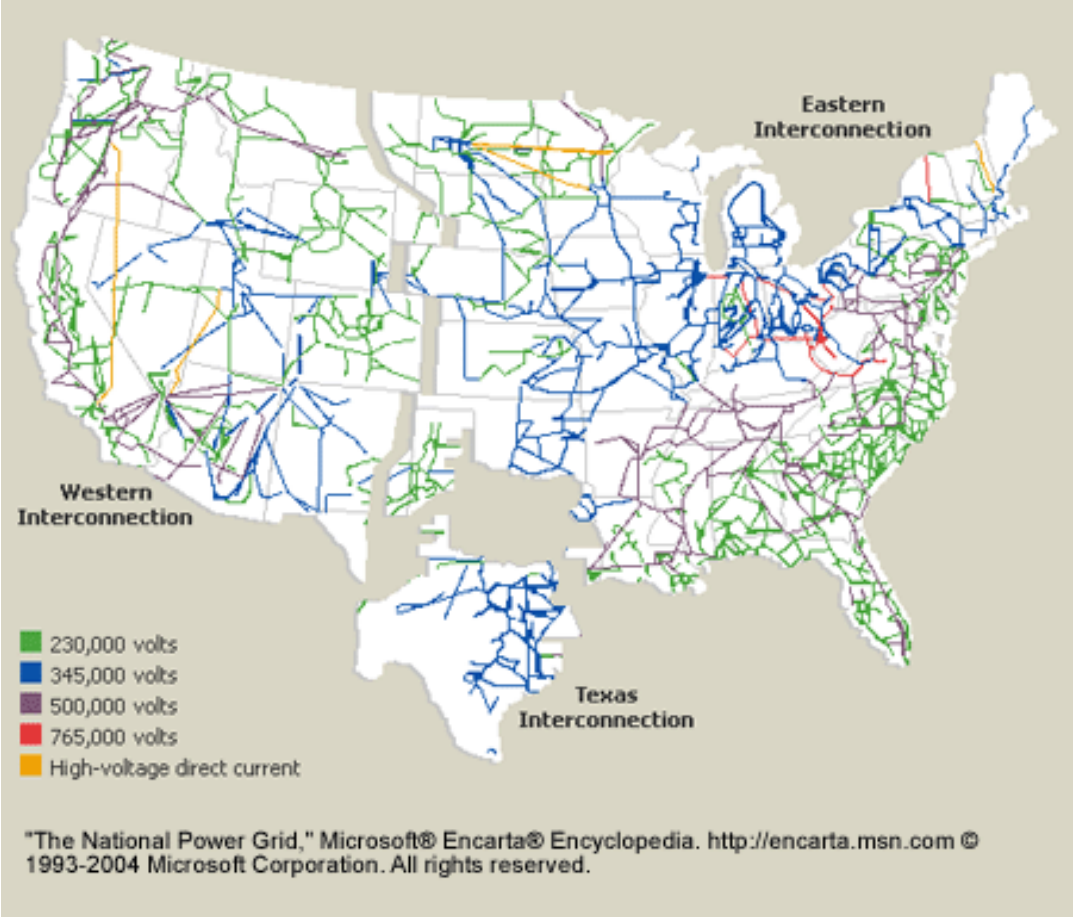


NET SOURCE ENERGY GOALS

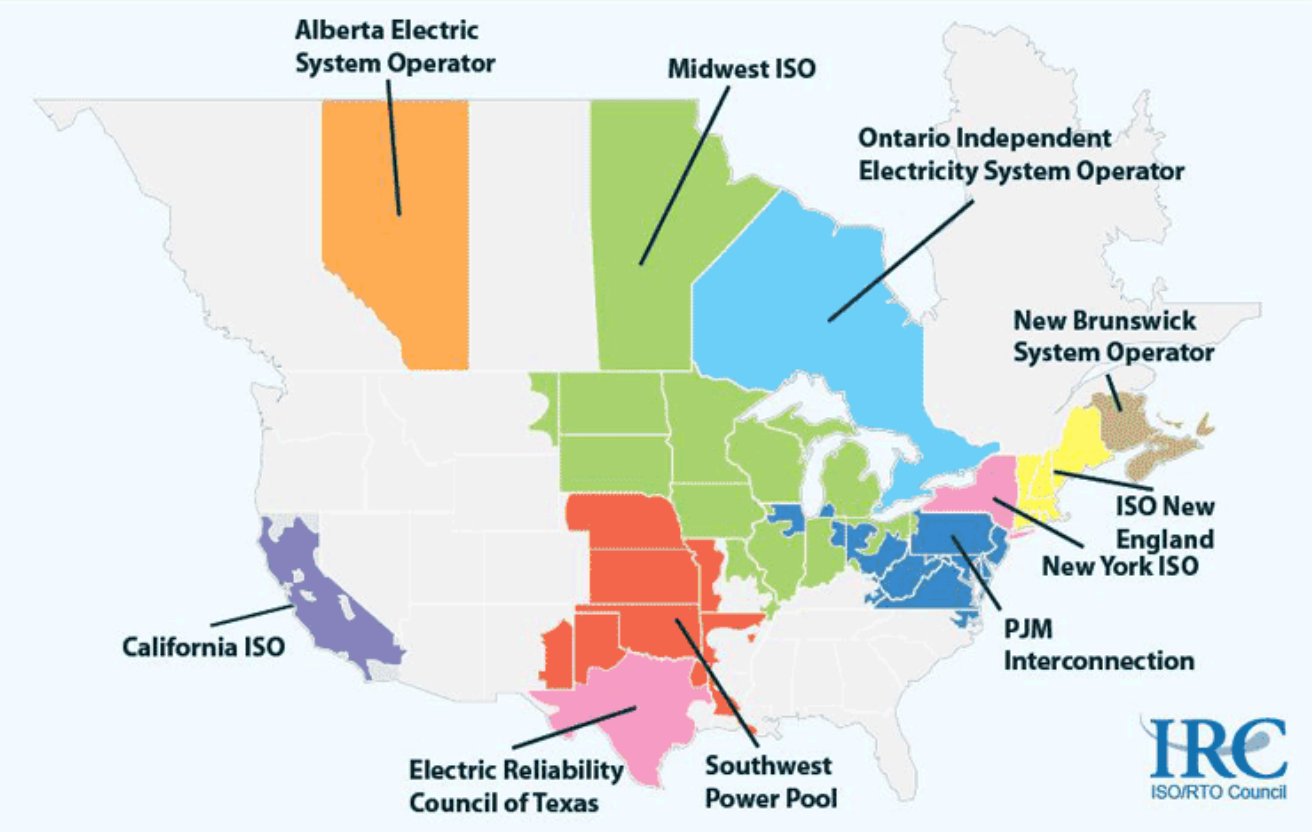


If PV was free (or very cheap), why would I invest in conservation at all?

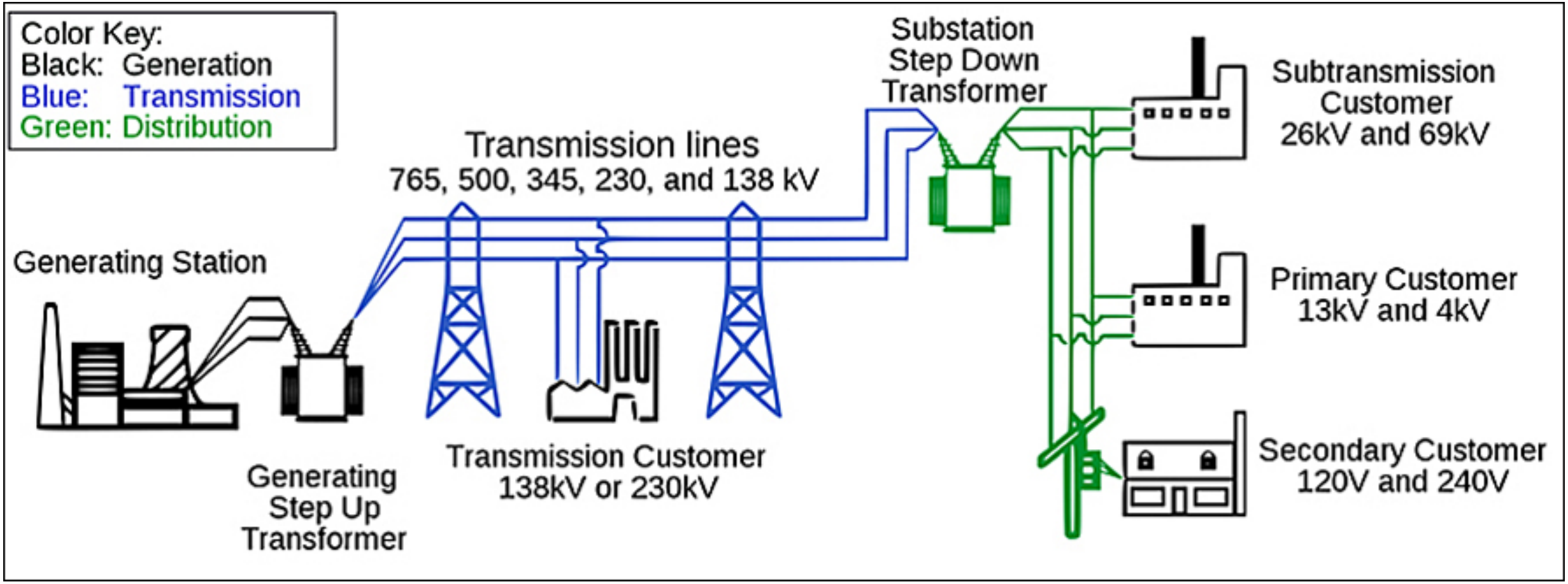
“The biggest machine on earth”



3 Interconnections



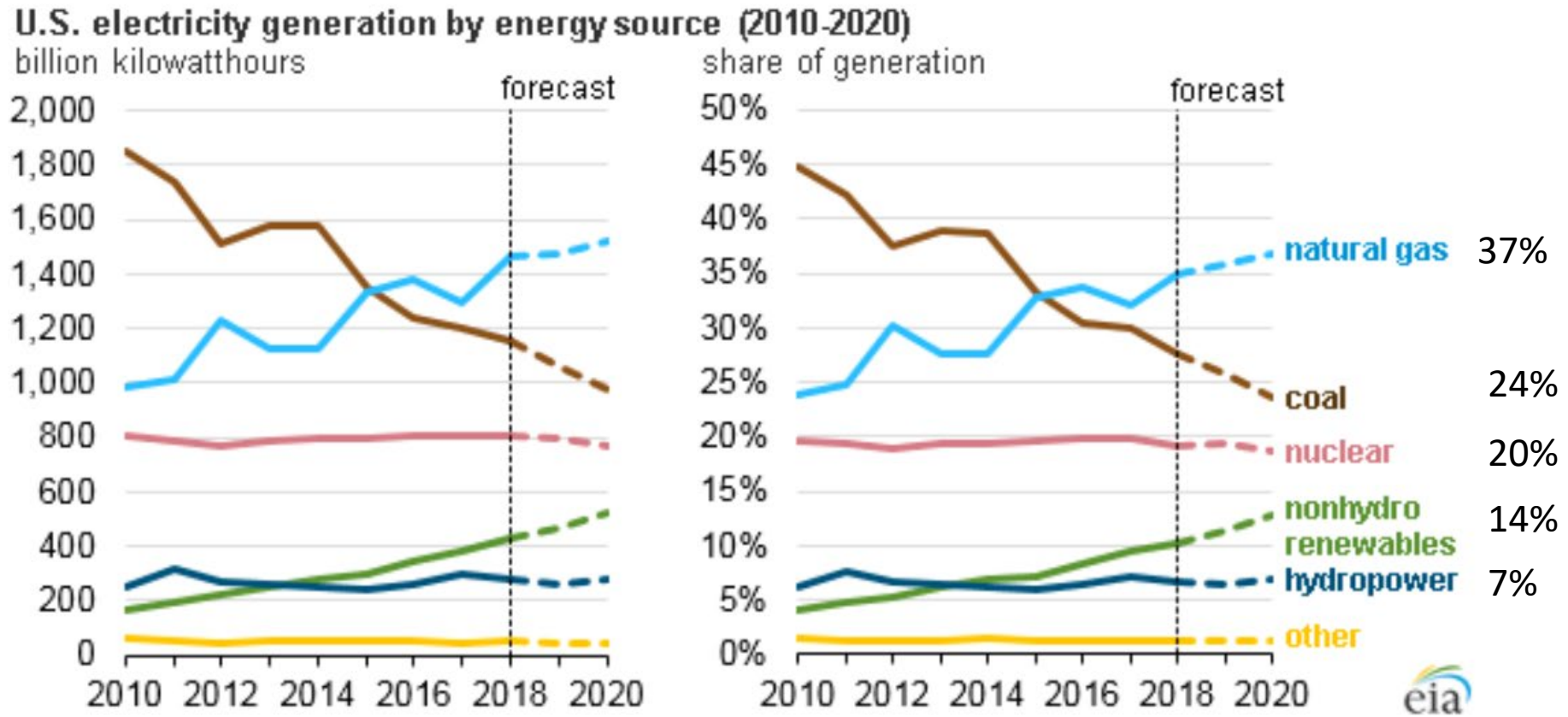
ISO‘s (Independent Service Operators)



CURRENT INFRASTRUCTURE

GENERATION RESOURCES

EIA forecasts renewables will be fastest growing source of electricity generation



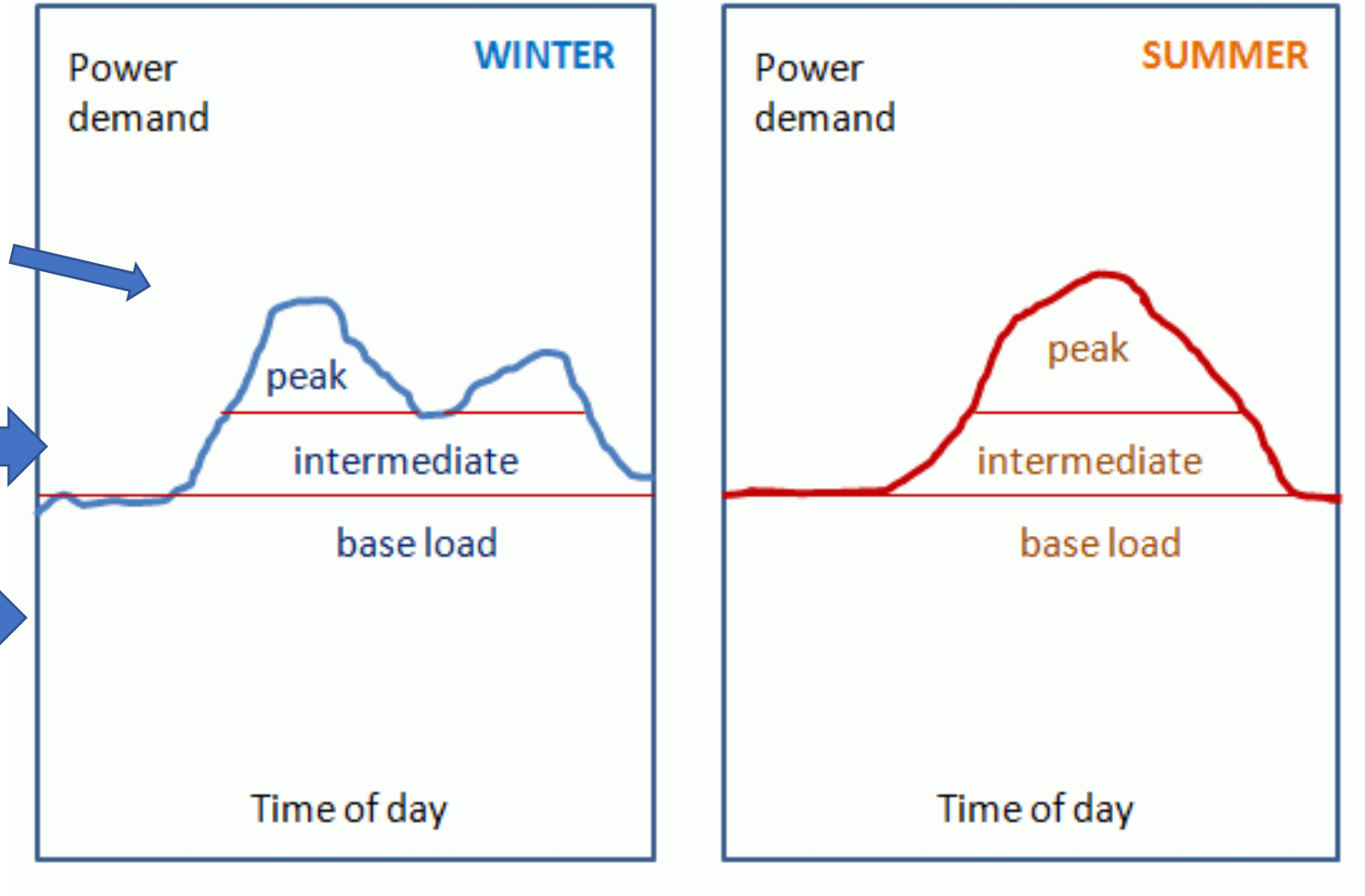
Source: U.S. Energy Information Administration, *Short-Term Energy Outlook*, January 2019
Note: Confidence interval derived from NYMEX options market information.

SEASONAL LOAD PROFILES ON GRID

Natural gas “peaker plants”
Hydro

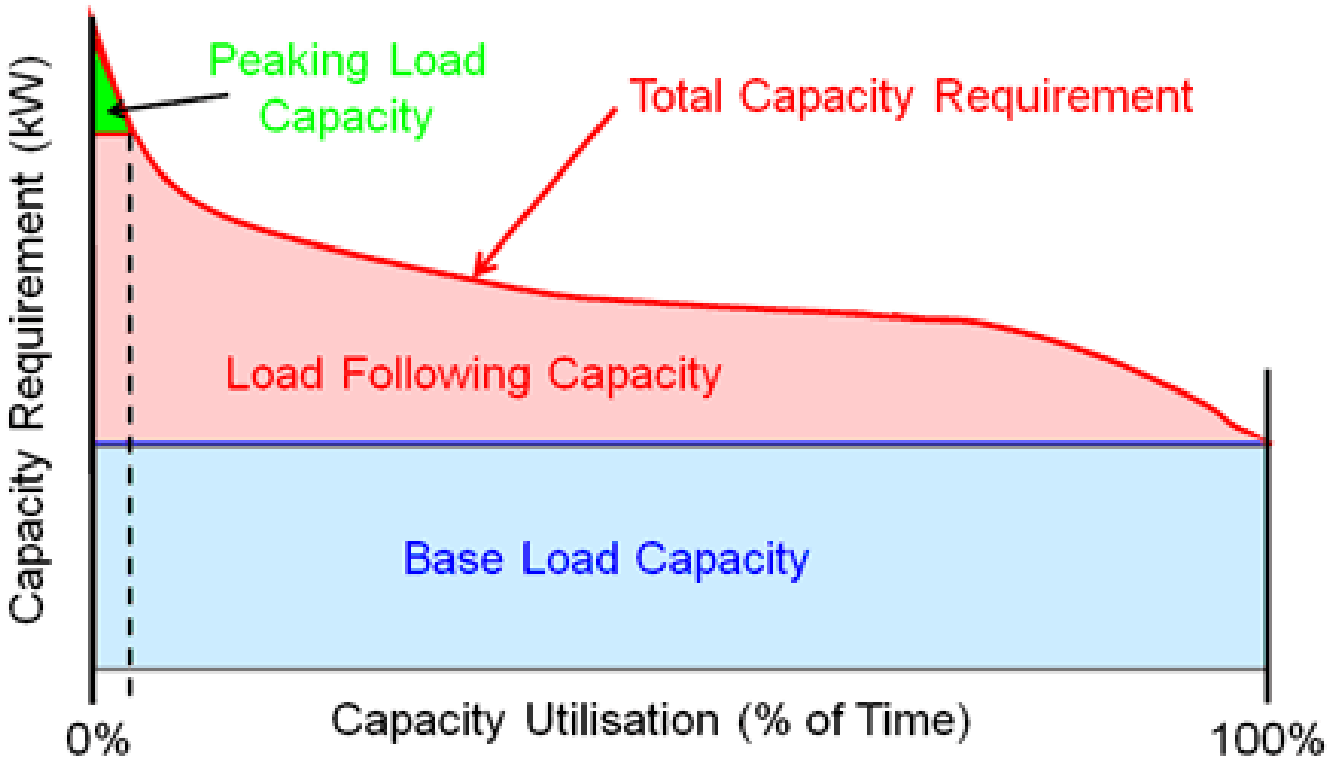
Natural gas CC
Some renewables

Coal
Nuclear
Some renewables



*Baseload power is constrained to a constant output

Electricity Generation Sector – **Load Duration Curve**

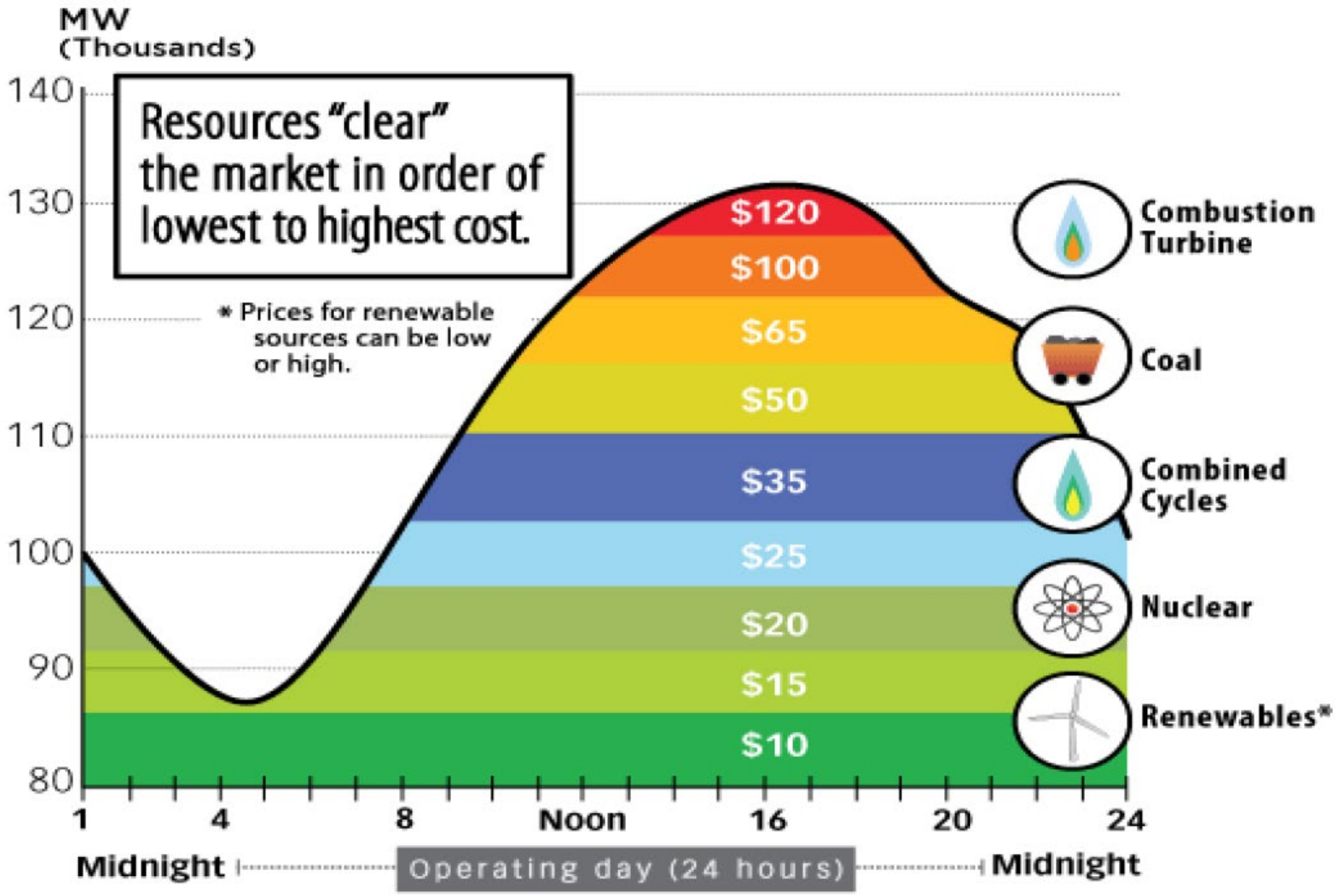


- US currently has about 1.2 TW of generating capacity - 2.5x higher than what's used annually.

- Vehicles + building heating conversion to electricity may <u>double</u> consumption

Image Source: Mark Pruitt

MEETING THE ELECTRIC LOAD



Electricity Generation Sector - Scheduling

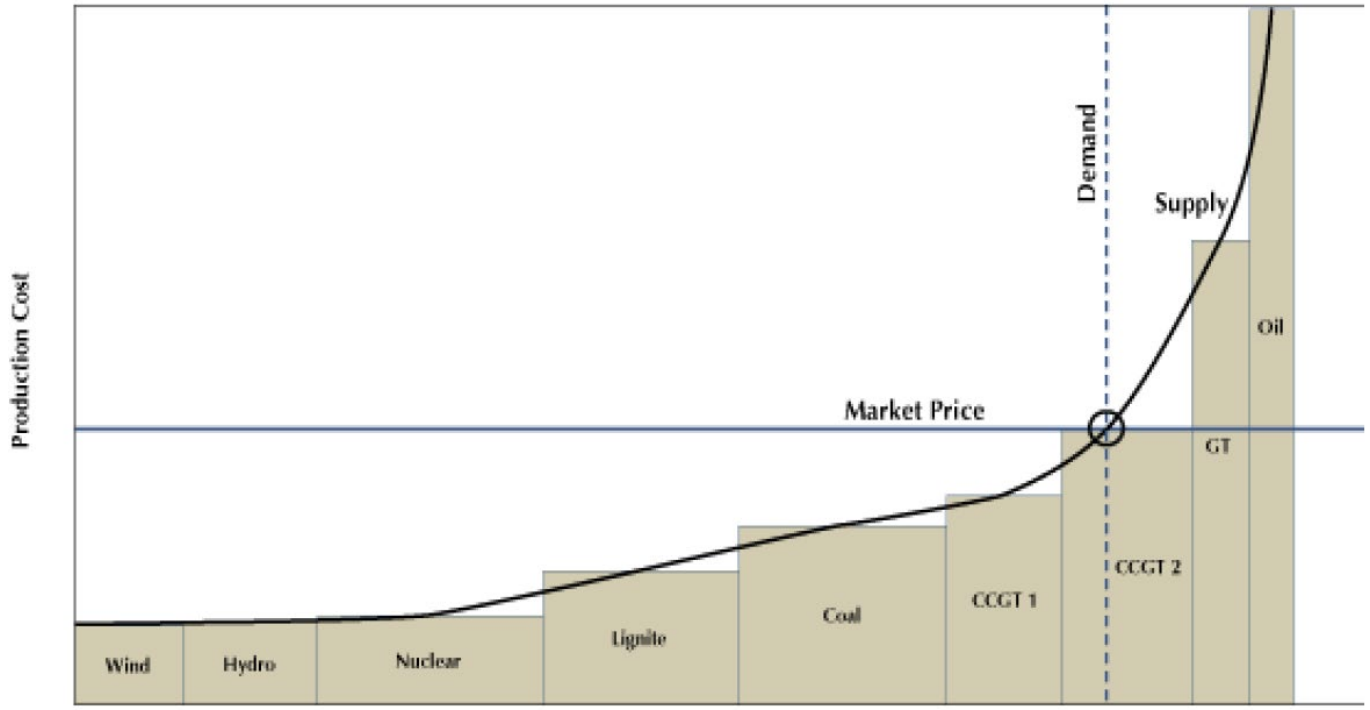
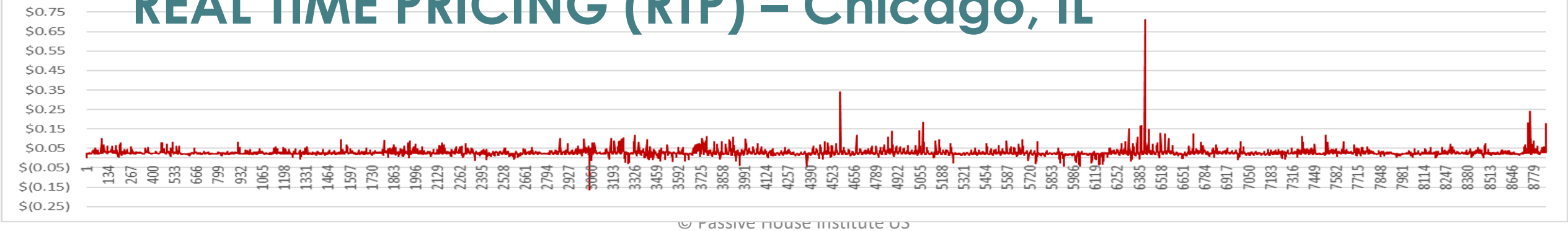


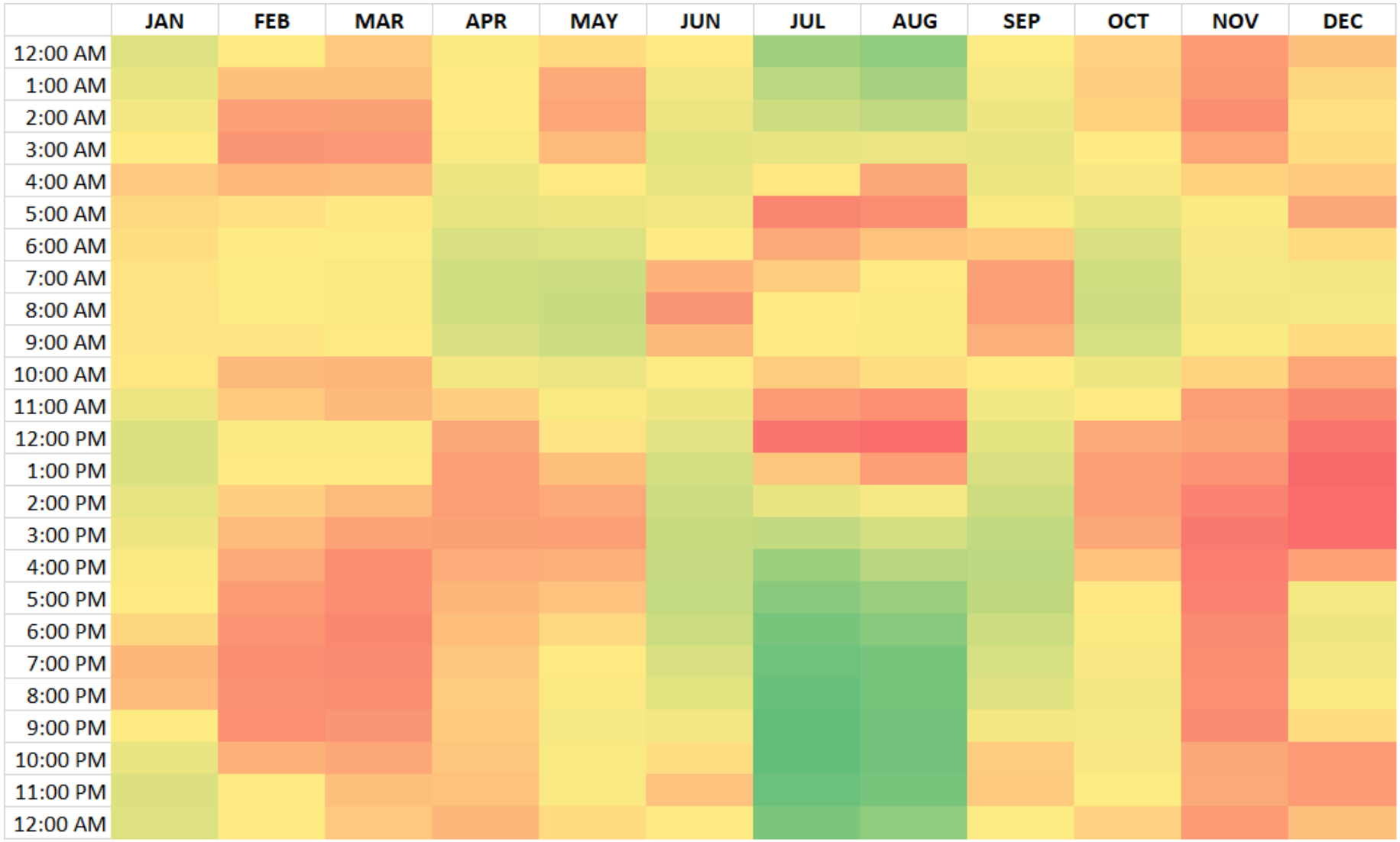
Image Source: Mark Pruitt

REAL TIME PRICING (RTP) – Chicago, IL



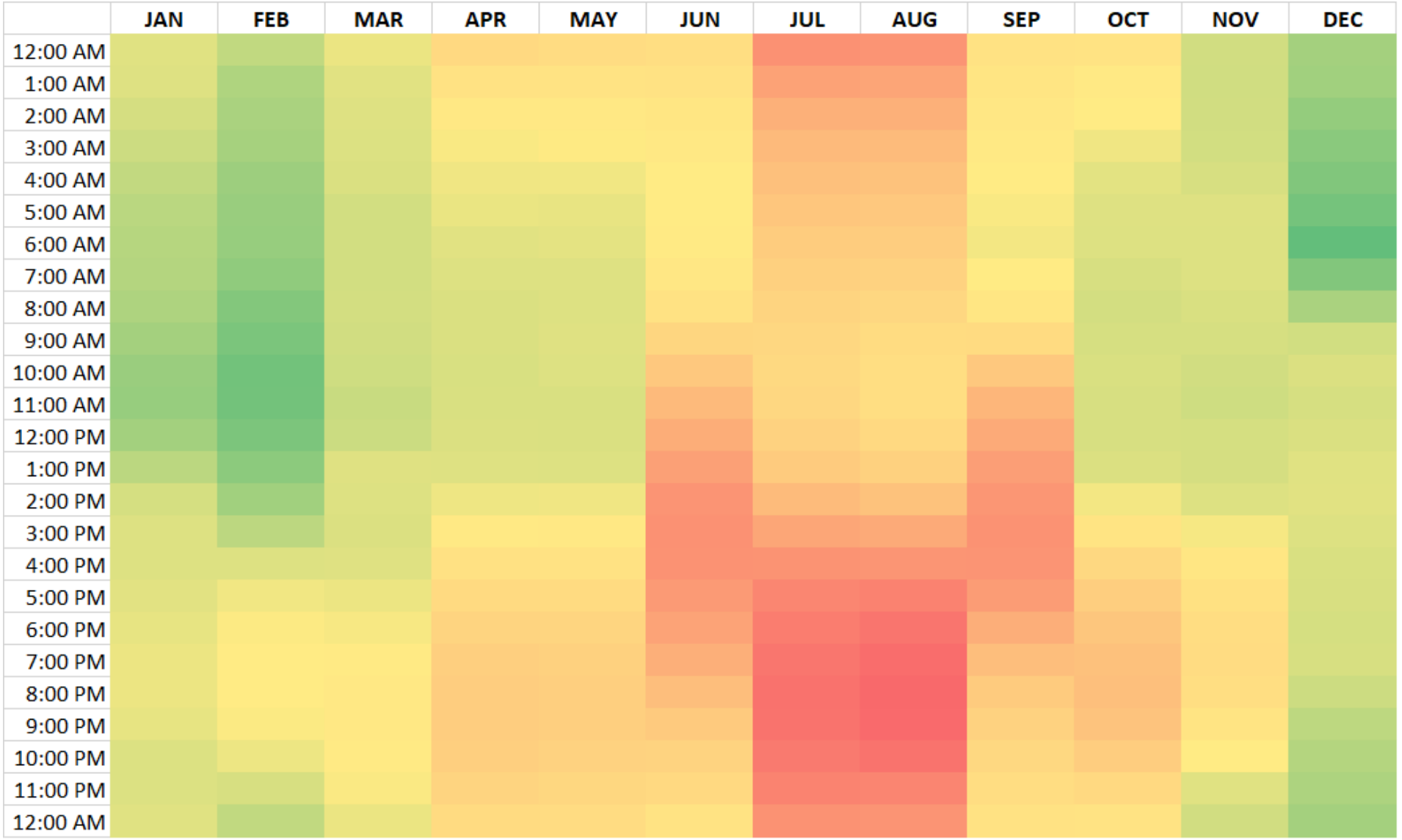
MARGINAL CARBON EMISSIONS

CHICAGO, IL - 2019



MARGINAL CARBON EMISSIONS

LOS ANGELES, CA - 2019



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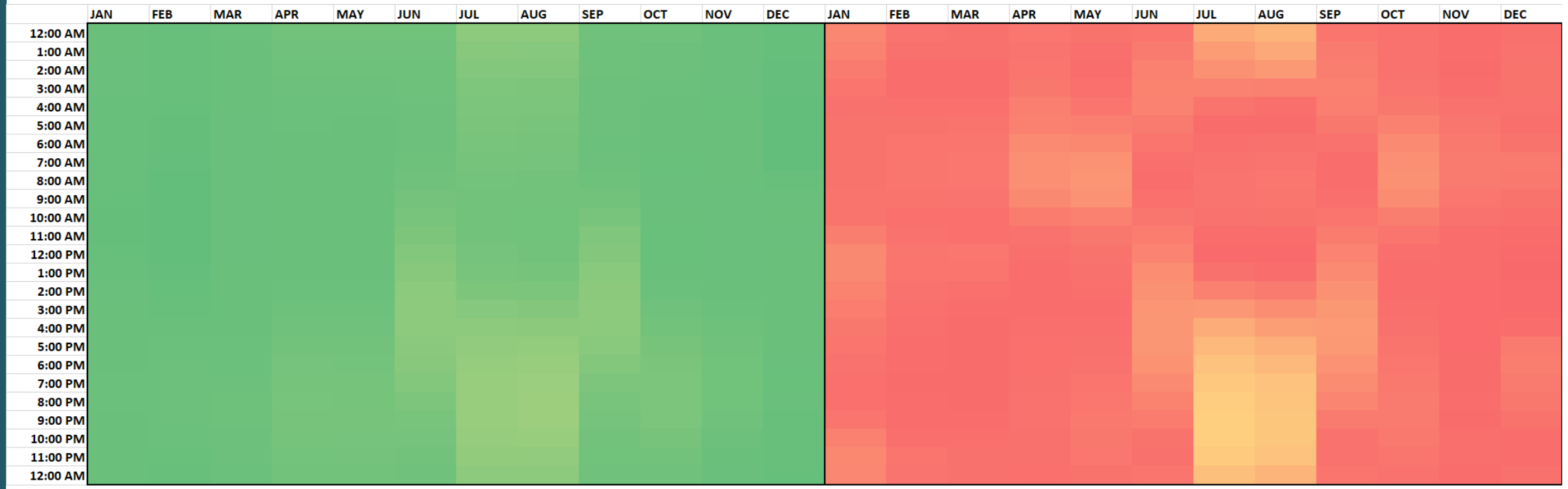
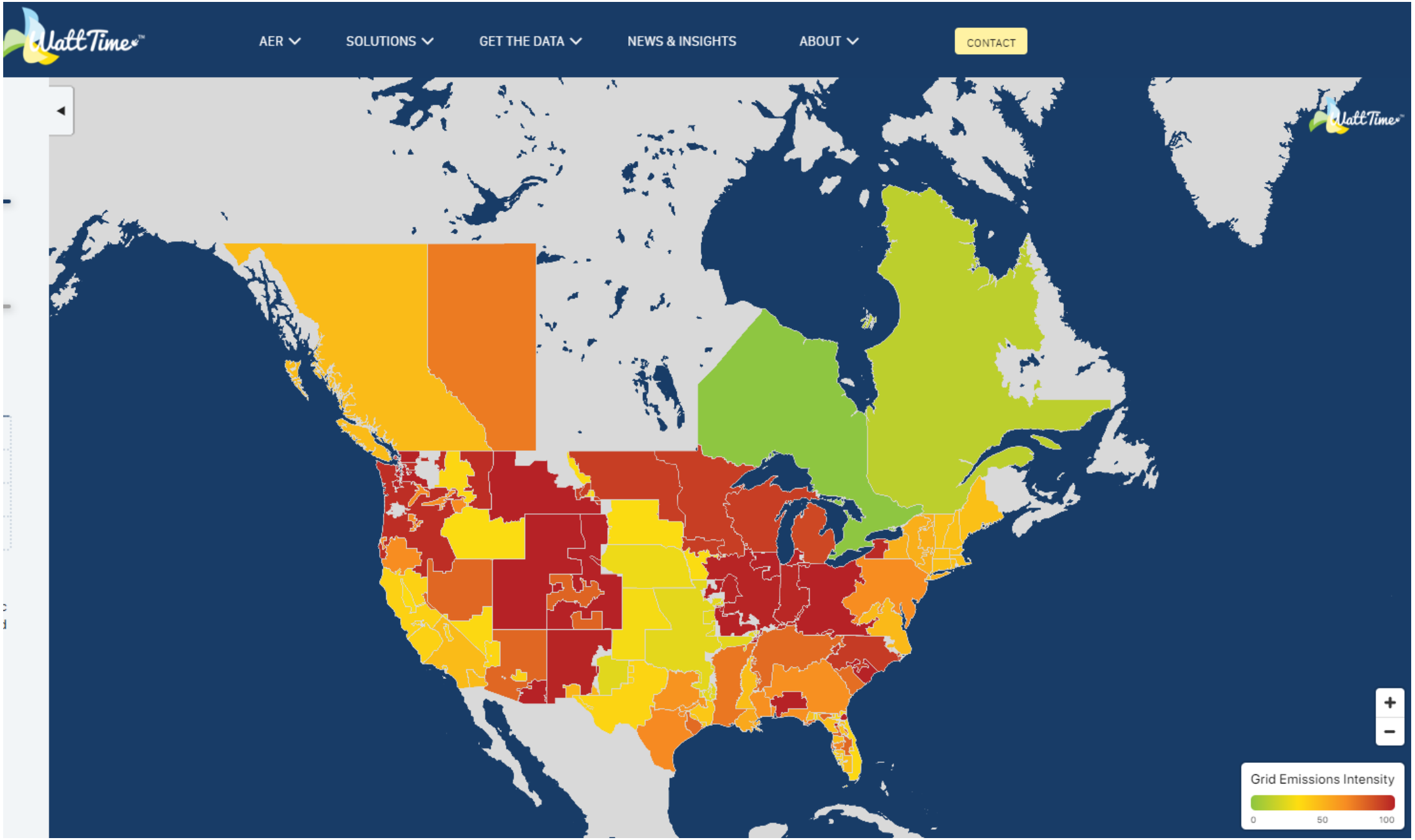
CHICAGO, IL - 2019



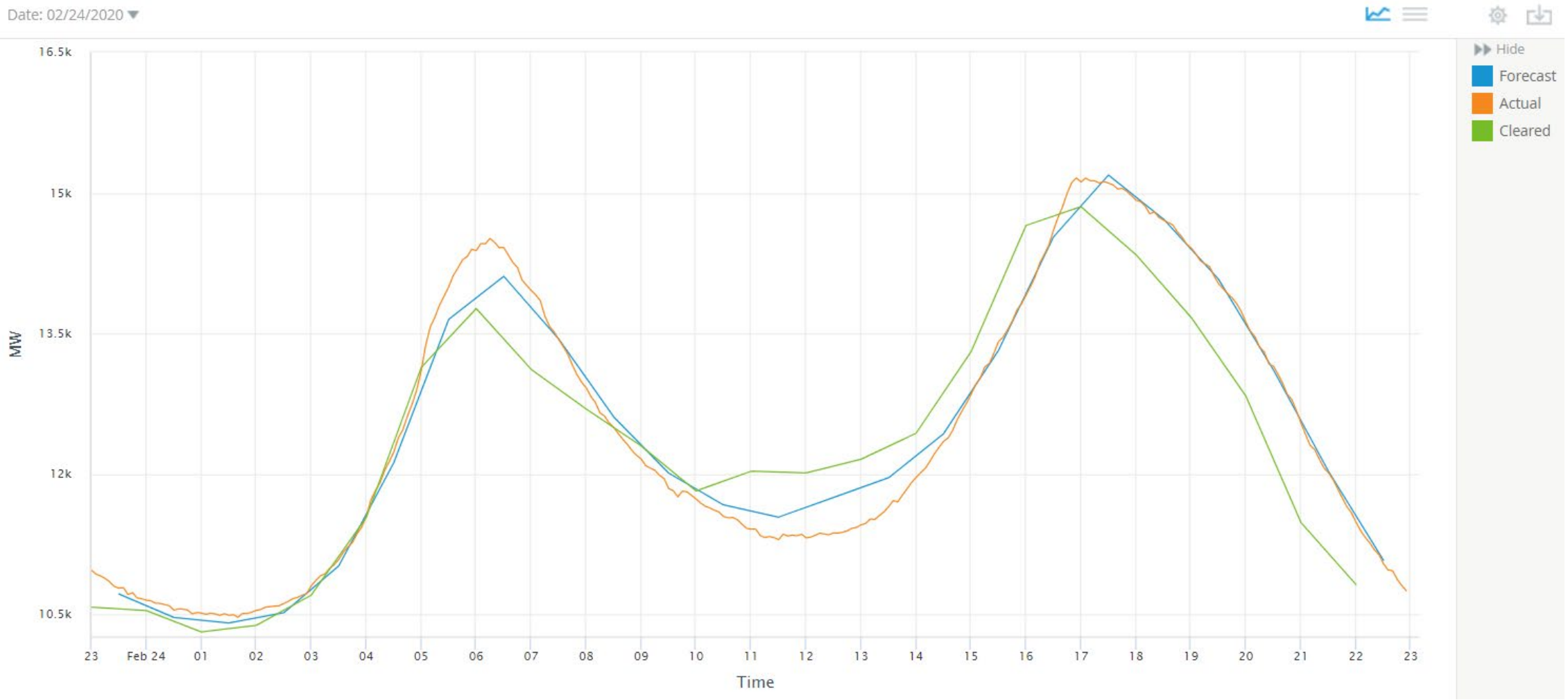
WattTime™

MARGINAL CARBON EMISSIONS



NEW ENGLAND ISO

New England ISO - February 24, 2020



Source: https://www.iso-ne.com/isoexpress/

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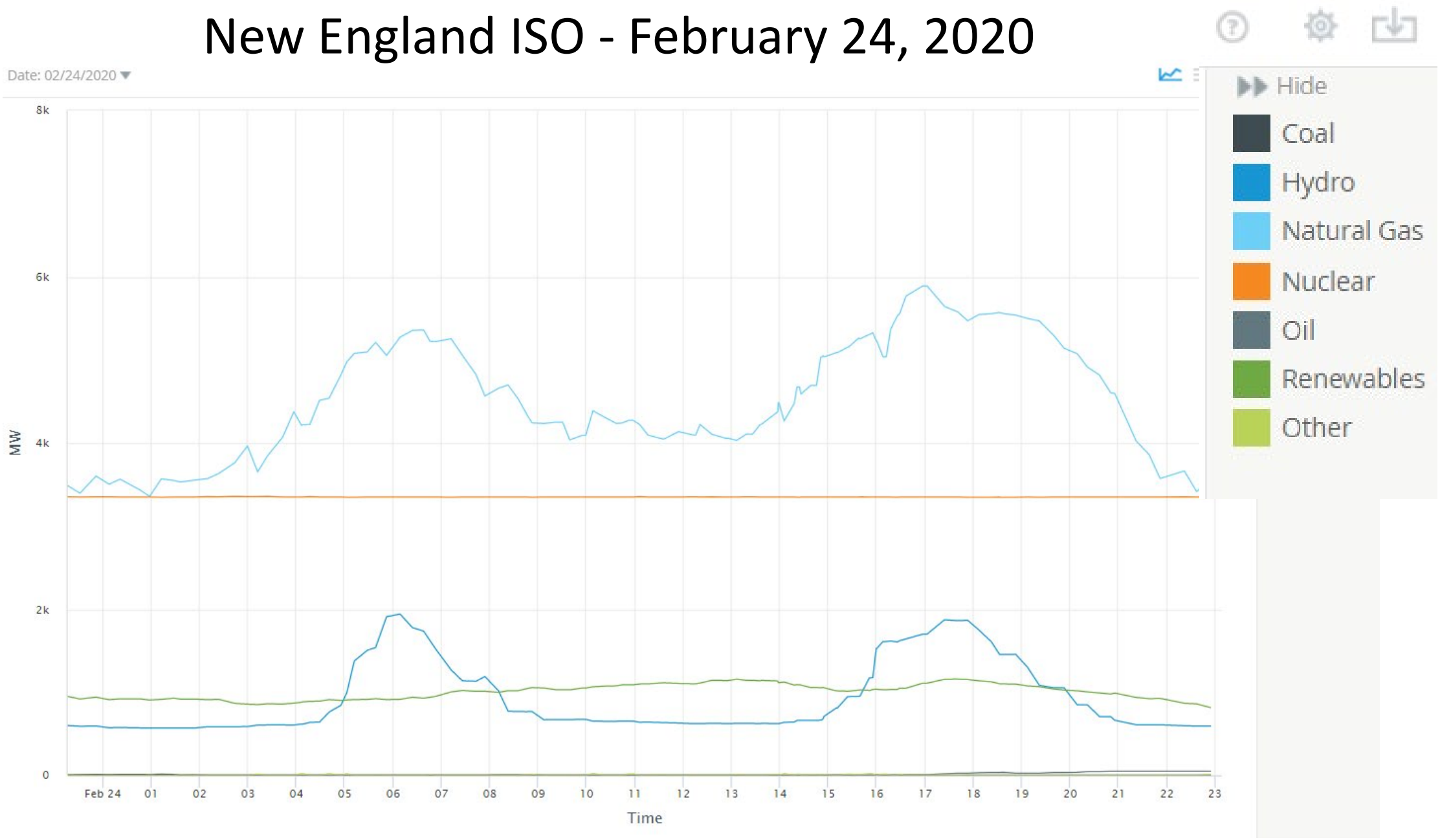


Source: https://www.iso-ne.com/isoexpress/

DECENTRALIZATION

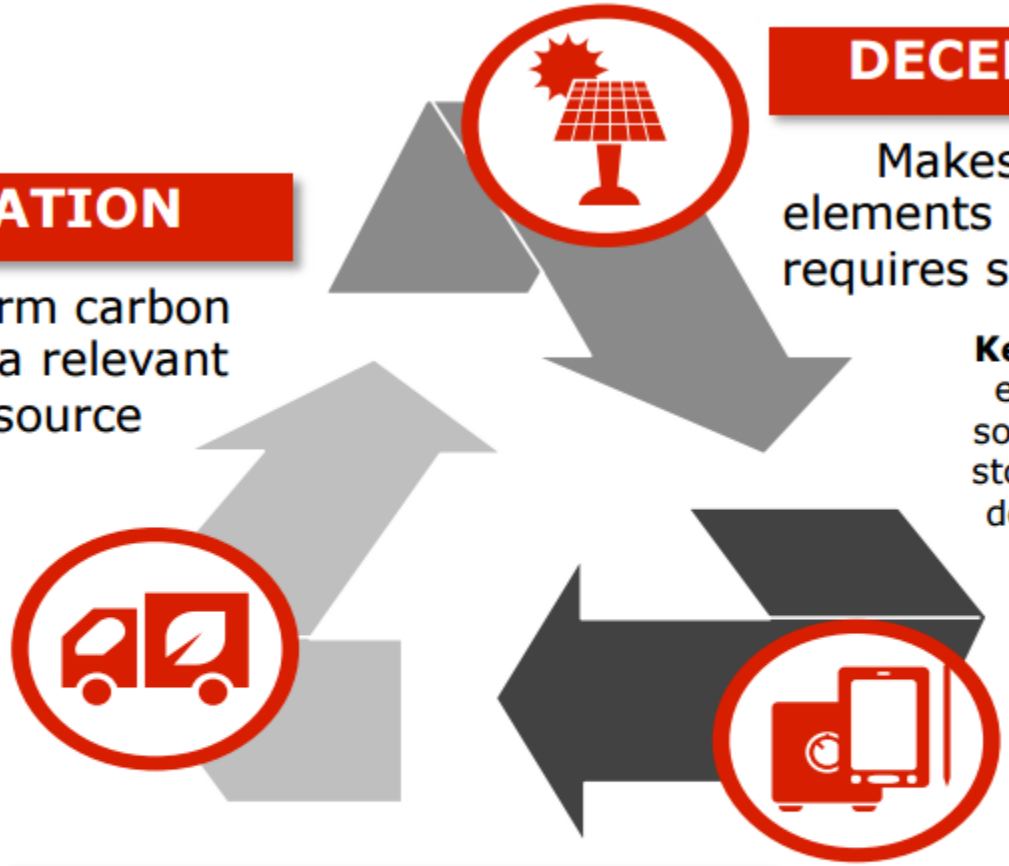
Makes customers active elements of the system, though requires significant coordination

Key technologies:
energy efficiency, solar PV, distributed storage, microgrids, demand response,

ELECTRIFICATION

Critical to long-term carbon goals and will be a relevant distributed resource

Key technologies:
Electric vehicles, vehicle to grid/home, smart charging, heat pumps



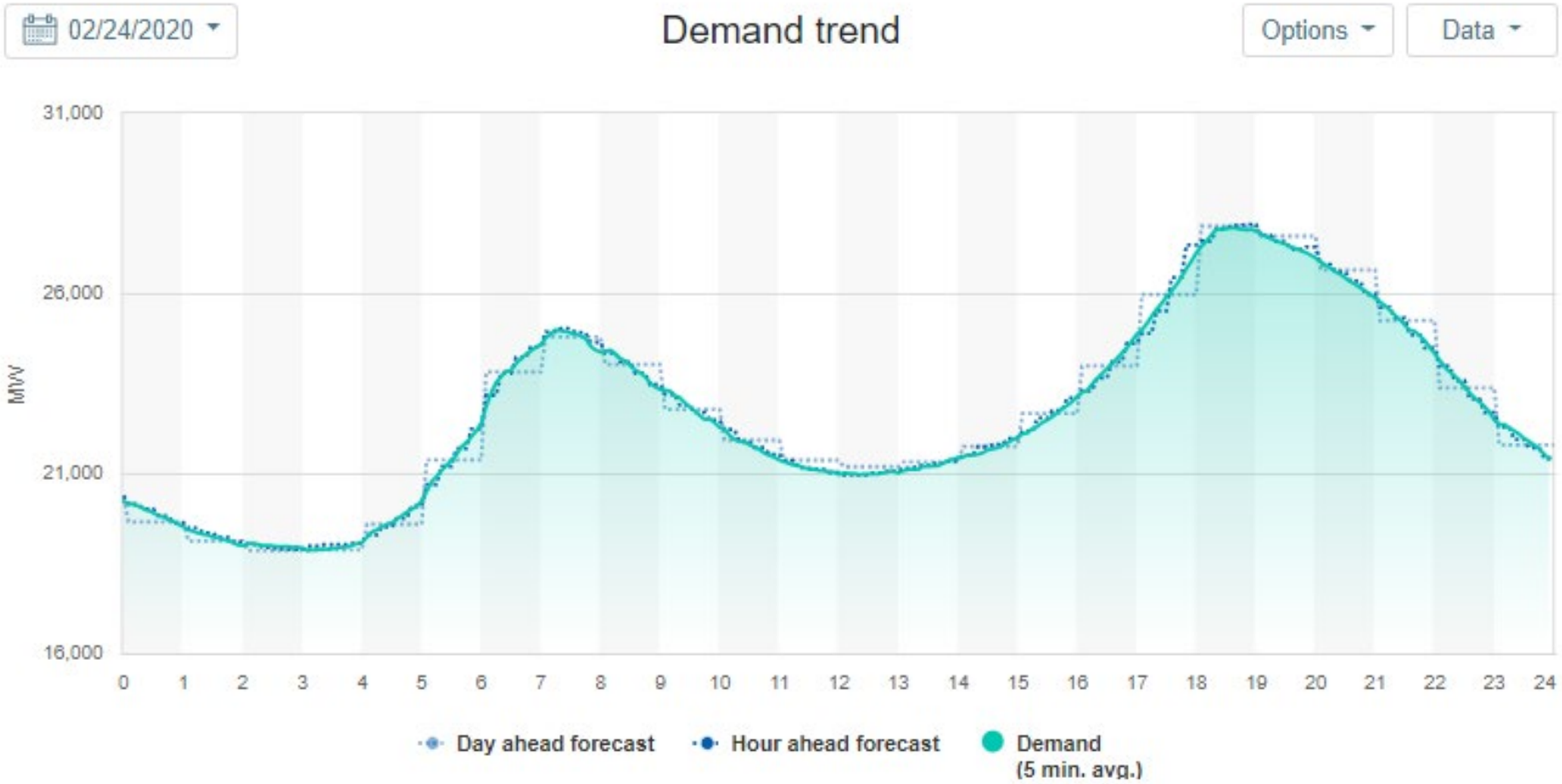
DIGITALIZATION

Allows for open, real-time, automated communication and operation of the system

Key technologies:
Network technologies *(smart metering, remote control and automation systems, smart sensrs)* and beyond the meter *(optimization and aggregation platforms, smart appliances and devices, IoT)*

CALIFORNIA ISO

California ISO (CAISO) – February 24, 2020



http://www.caiso.com

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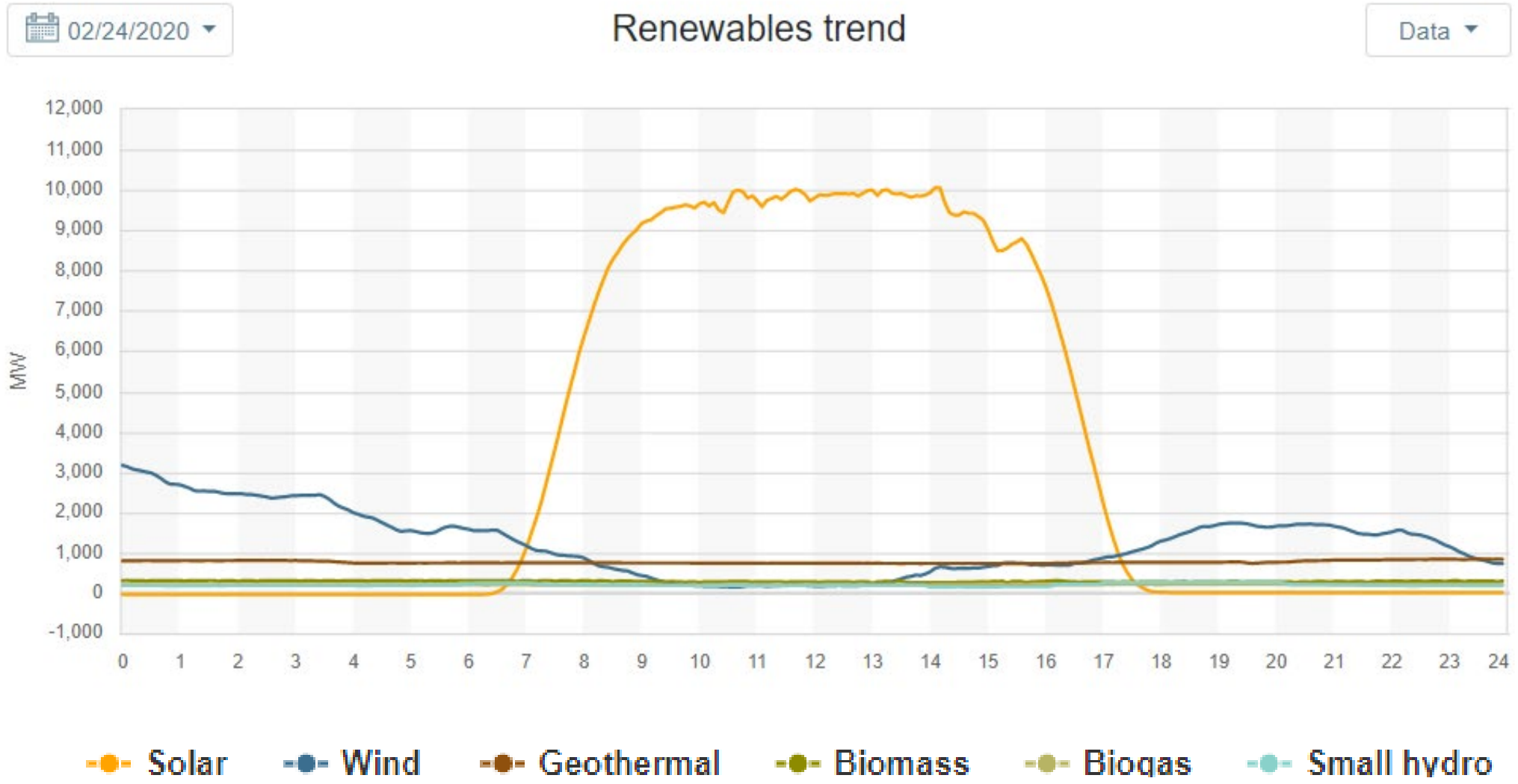

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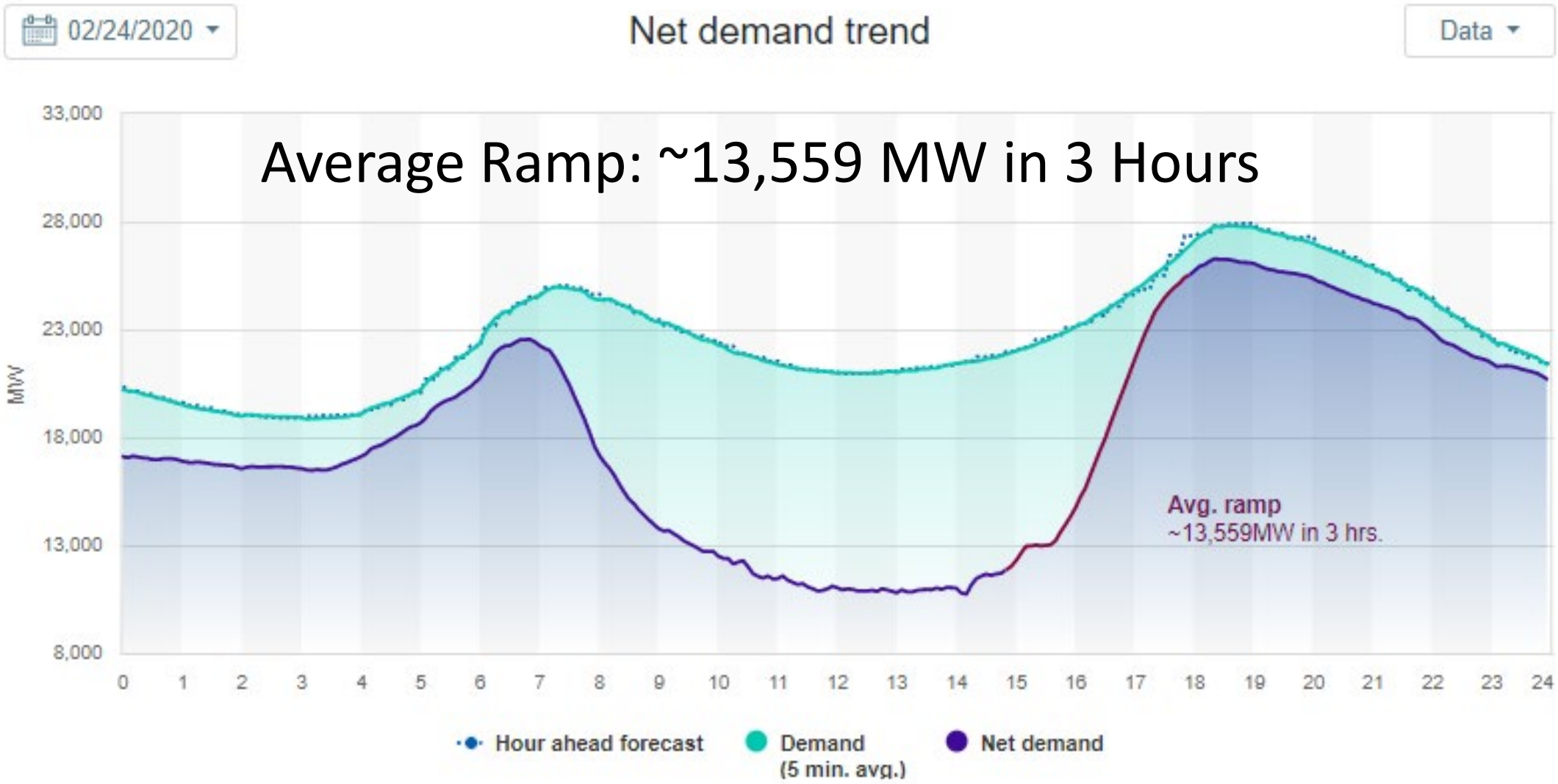
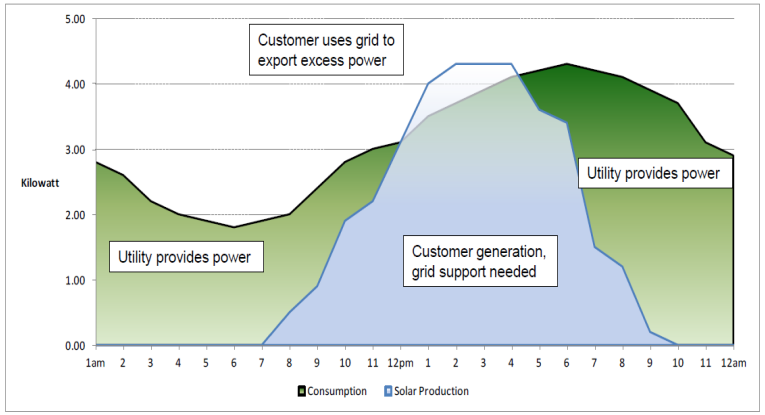
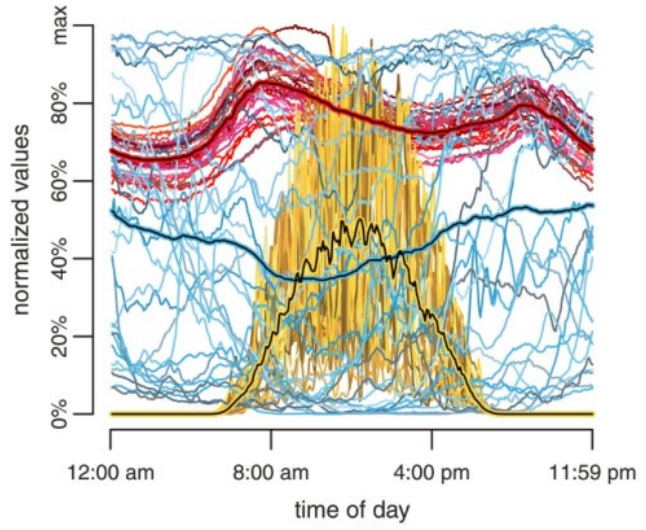


http://www.caiso.com

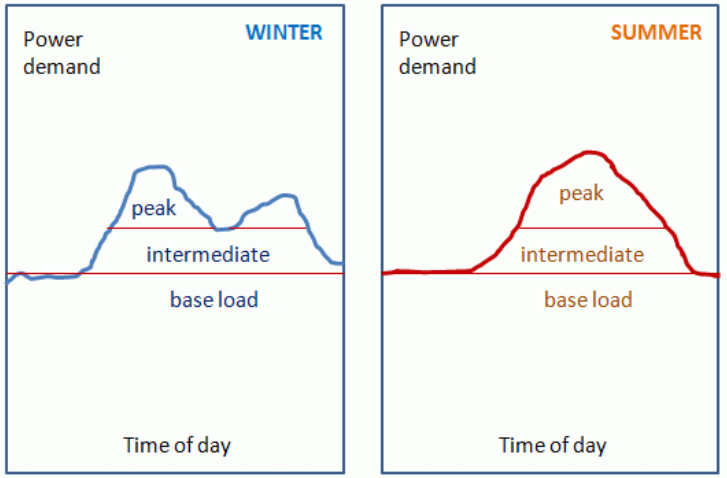
CHALLENGES OF RENEWABLE ENERGY INTEGRATION



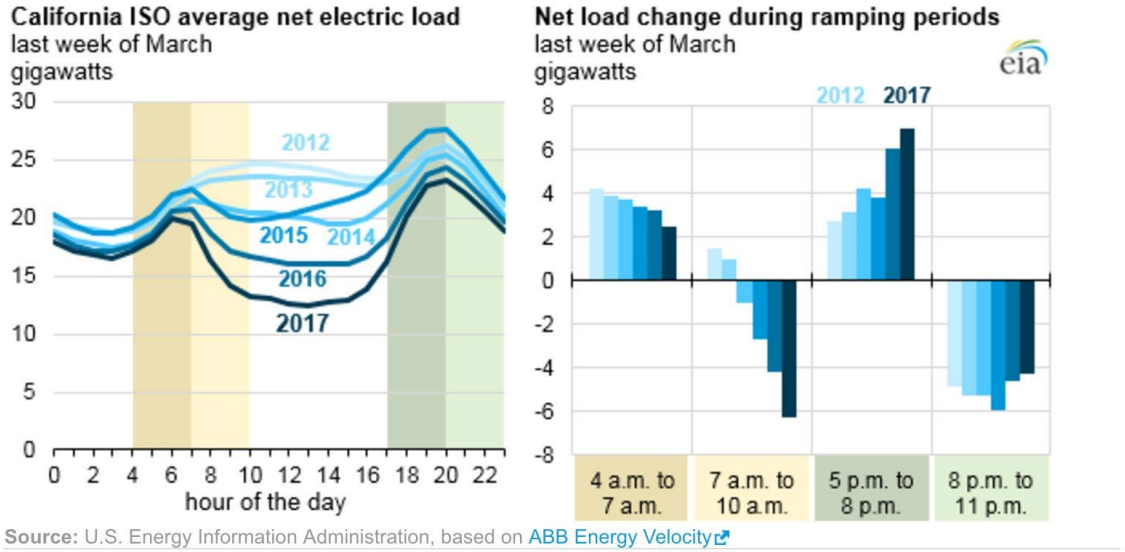
MISMATCH



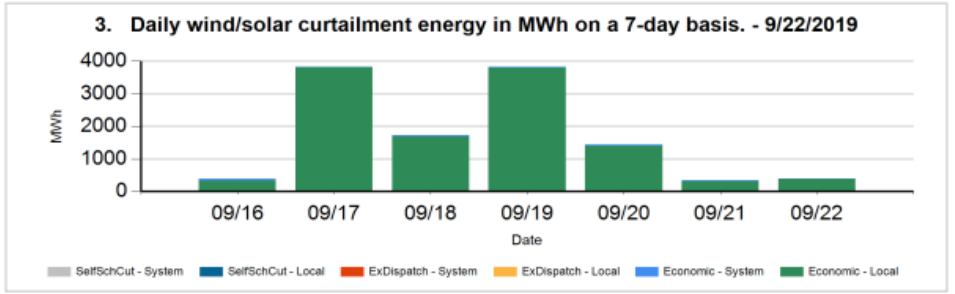
INTERMITTENCY

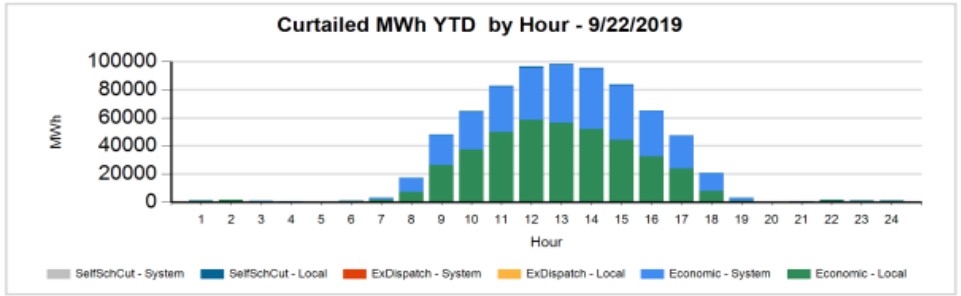


BASELOAD CHALLENGES



NET LOAD/RAMPING





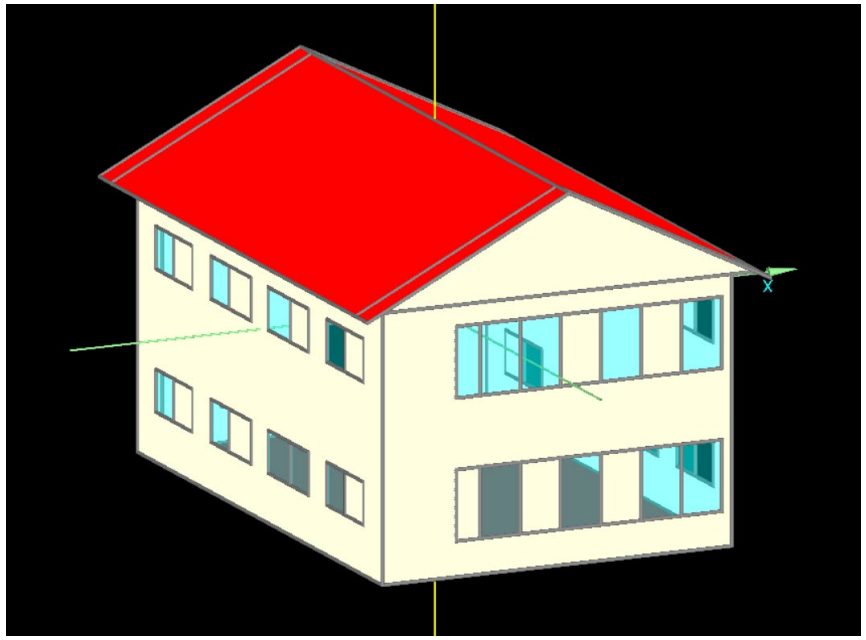
CURTAILMENT

"GRID-FRIENDLY" STRATEGIES

Passive at core

1. Reduce overall electrical load / peak
   Build passive
2. Flatten daily electrical load curve
   Build passive
3. Reduce mismatch between on-site PV generation and energy use
   Build passive
4. Deploy flexibility/demand response systems
   Better suited to passive buidlings than conventional
5. Control electric water heaters
   Electric water heaters common in passive buildings

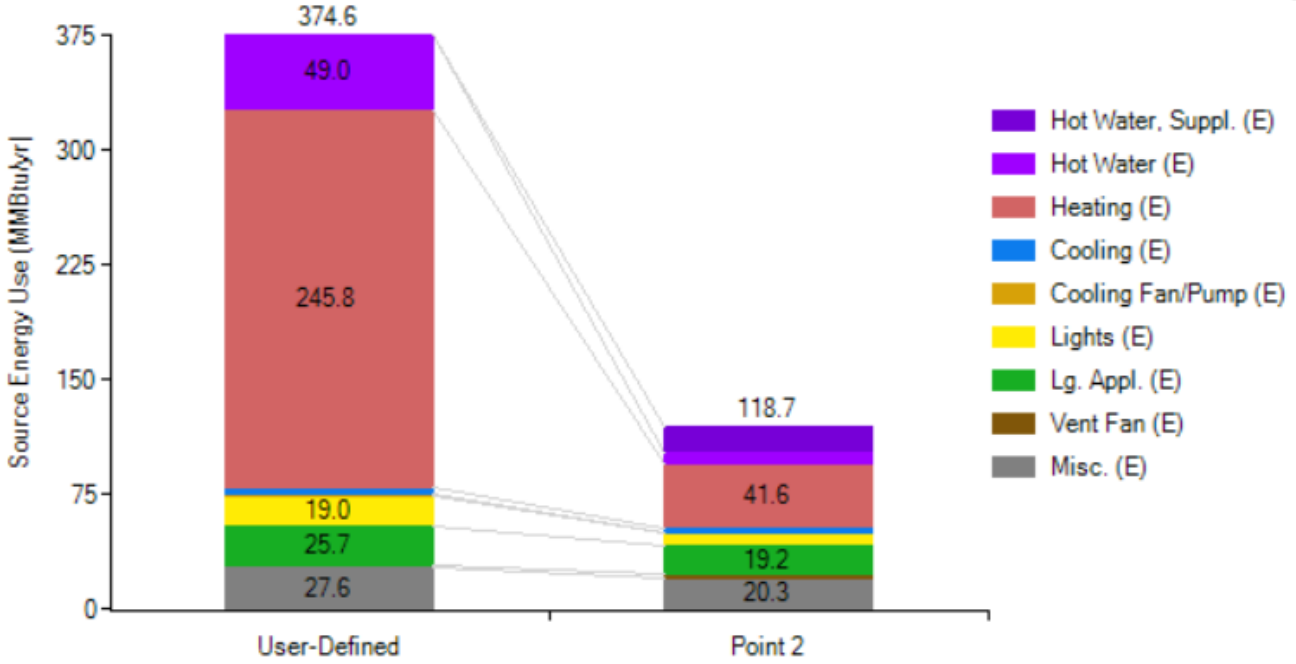
CASE STUDY PROTOTYPE – PEAK SHAVING



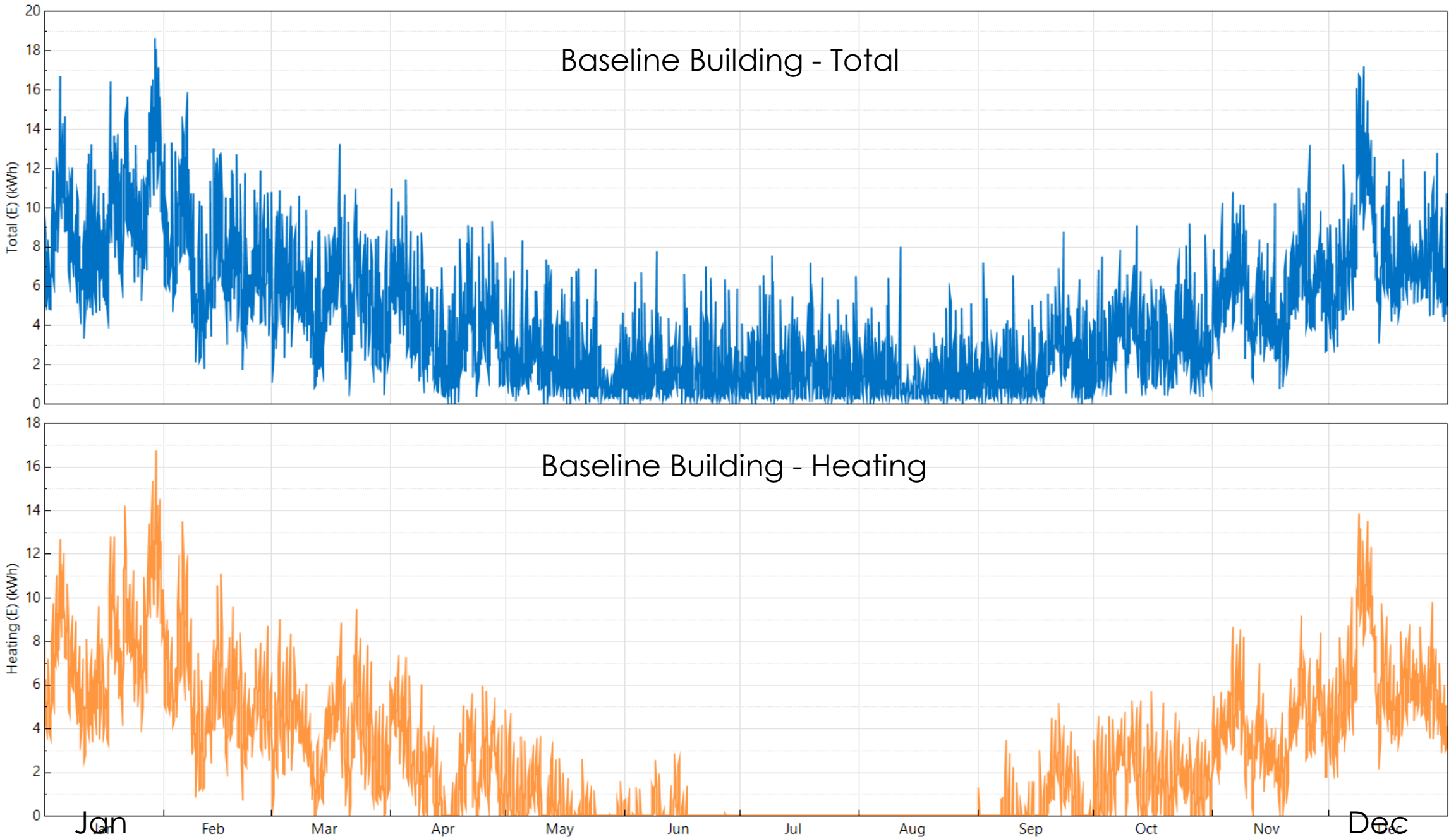
Single Family building
Location: Minneapolis, MN
5 occupants, ~1,800 sf
<u>All Electric – Elec resistance heating **only**</u>
Energy Model: BeOpt (Energy Plus engine)

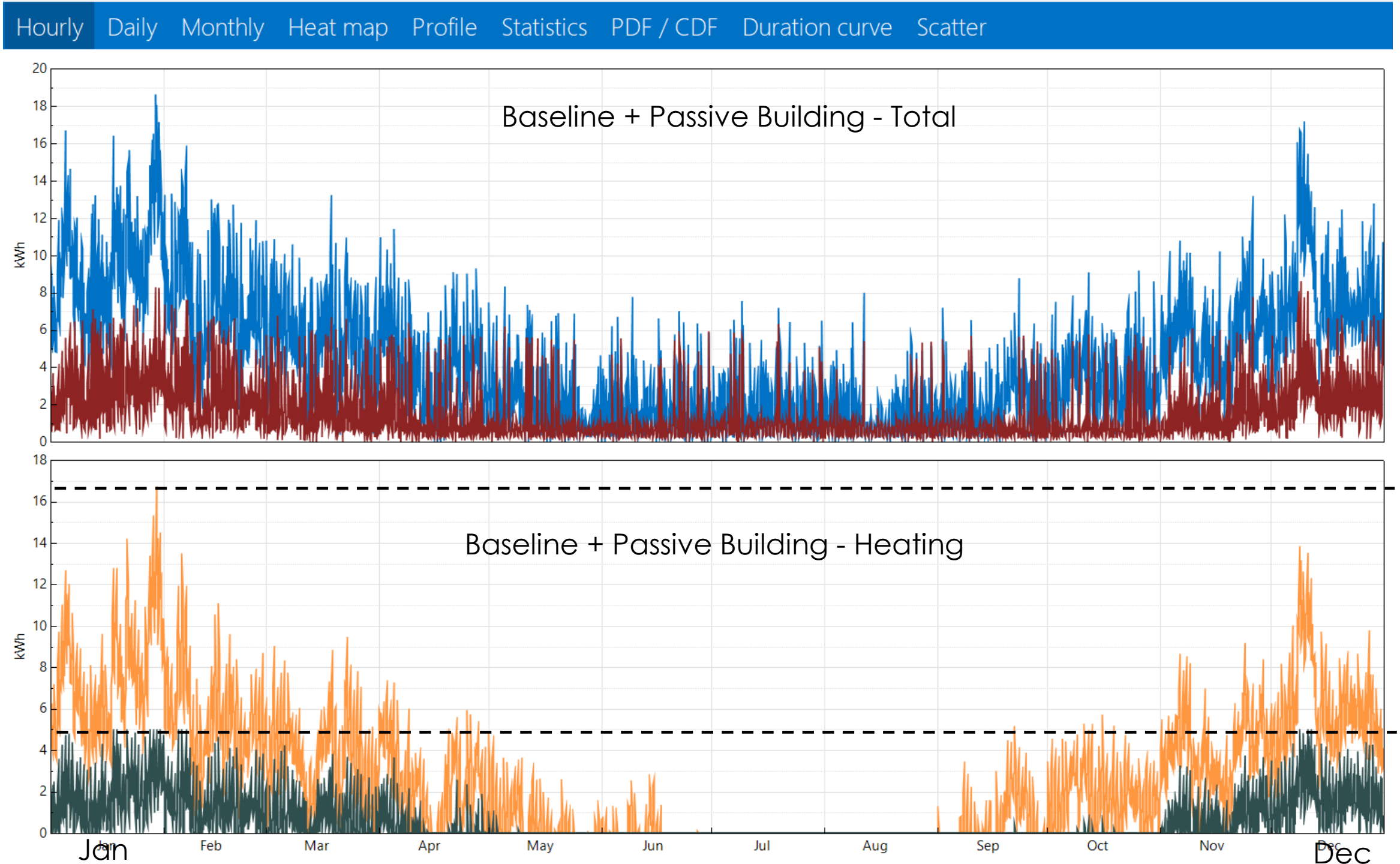
<u>Two buildings studied:</u>

1. Building America 2009 Benchmark
2. Passive building - (PHIUS+ Core)

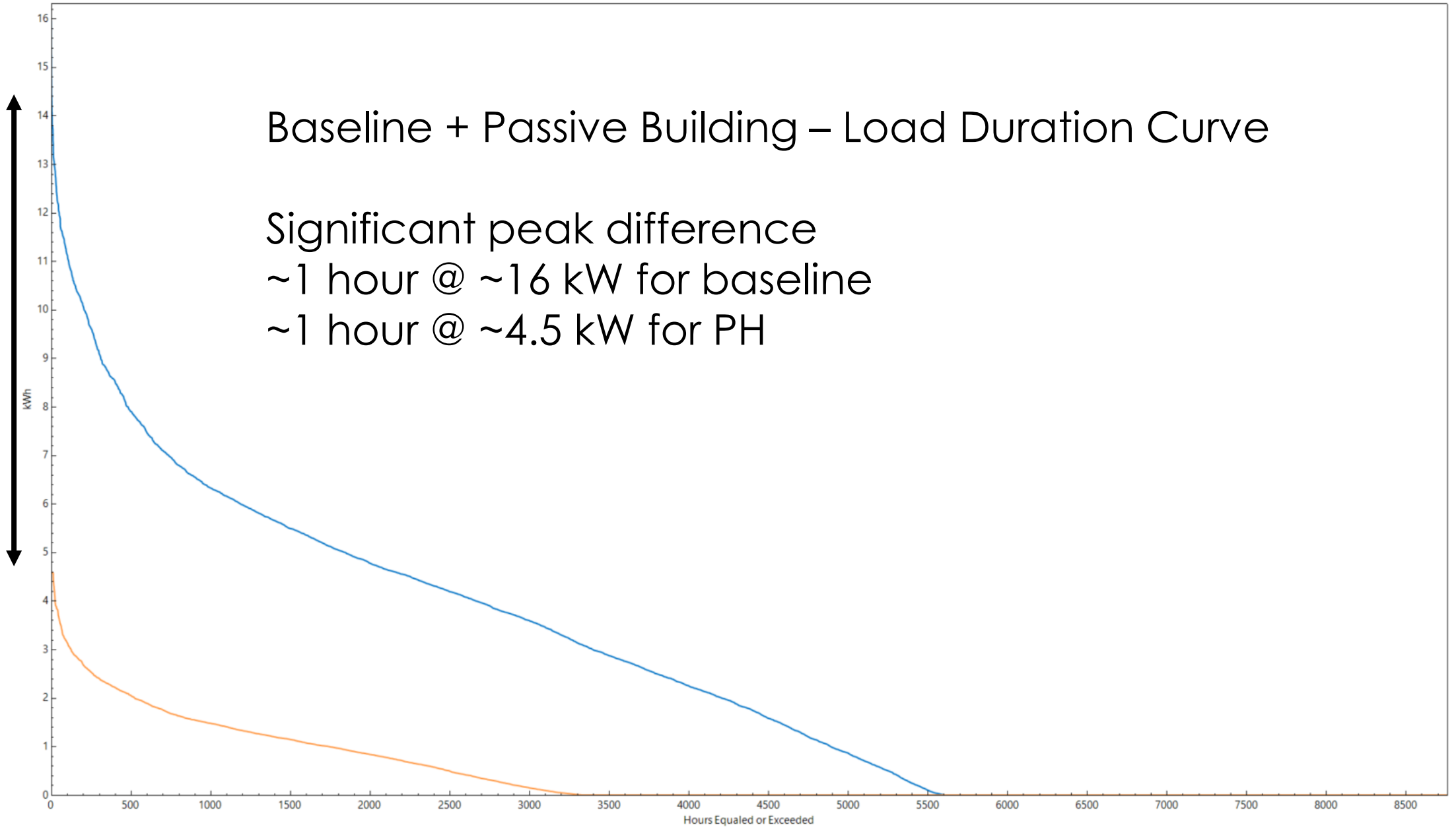


Hourly | Daily | Monthly | Heat map | Profile | Statistics | PDF / CDF | Duration curve | Scatter




Hourly
Daily
Monthly
Heat map
Profile
Statistics
PDF / CDF
Duration curve
Scatter
Baseline + Passive Building - Total
kWh
Baseline + Passive Building - Heating
kWh
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Hourly Daily Monthly Heat map Profile Statistics PDF / CDF Duration curve Scatter

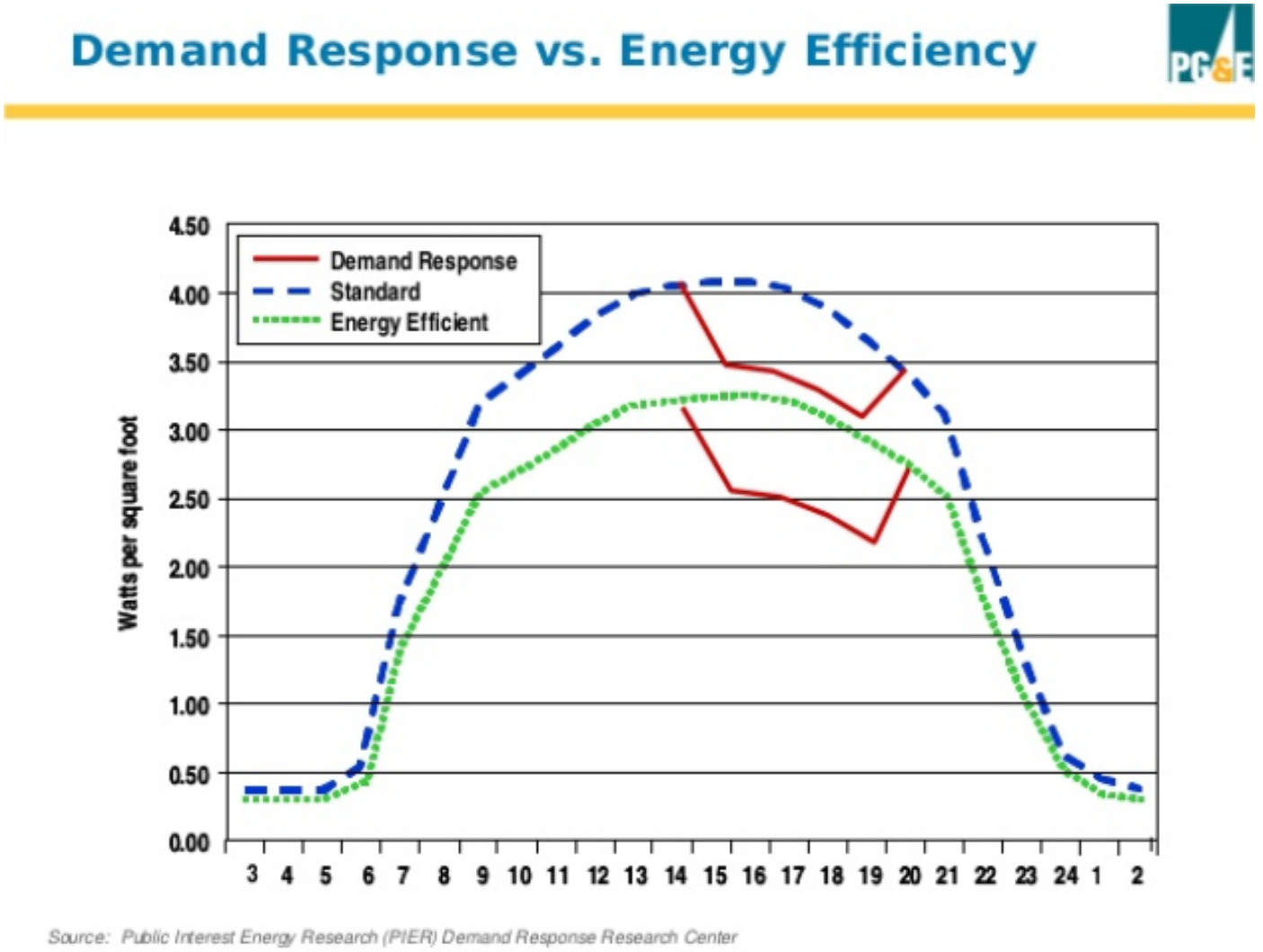


Baseline + Passive Building – Load Duration Curve

Significant peak difference
~1 hour @ ~16 kW for baseline
~1 hour @ ~4.5 kW for PH

DEMAND RESPONSE / LOAD FLEXIBILITY

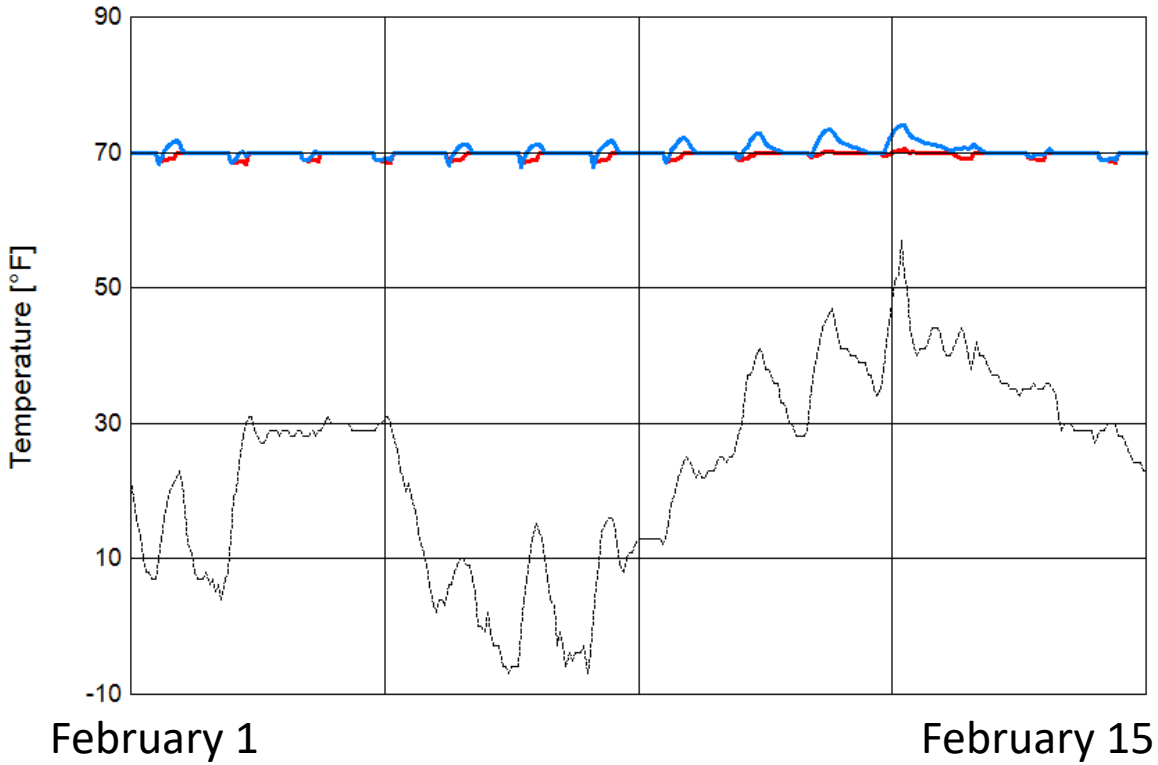
Passive buildings can shift and change the load shape!



DEMAND RESPONSE – NO HEATING FROM 8 AM - 2 PM FOR 2 WEEKS IN FEBRUARY

Starting set-point for Heating 70F

HIGH MASS

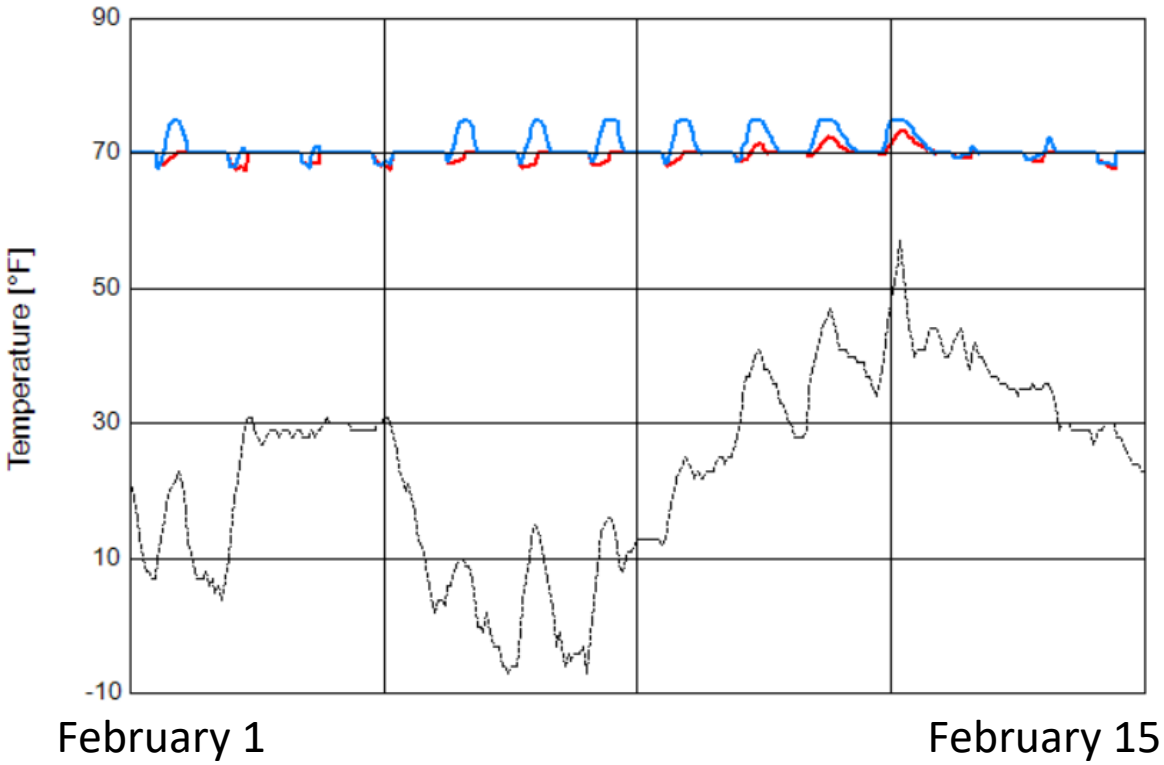


Temp of Interior Air (20% WWR)

Temp of Interior Air (60% WWR)

Temp of Exterior Air

LOW MASS

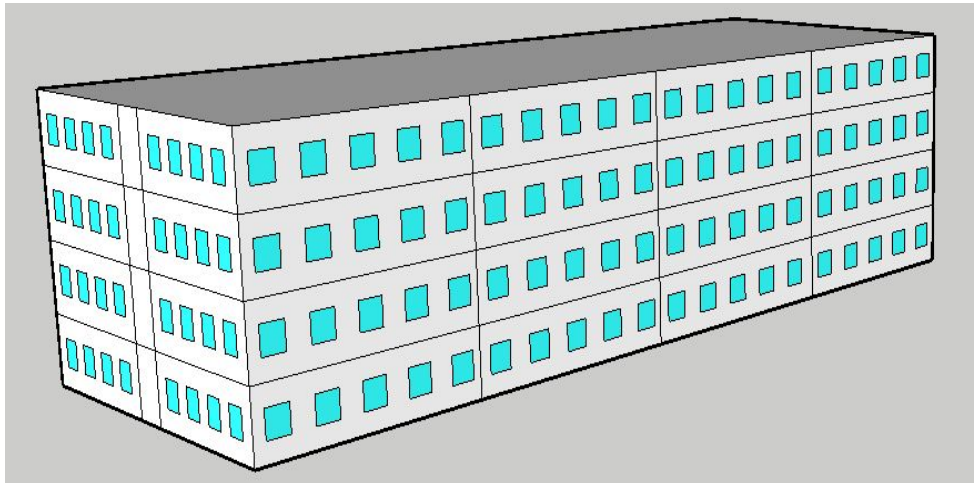


Temp of Interior Air (20% WWR)

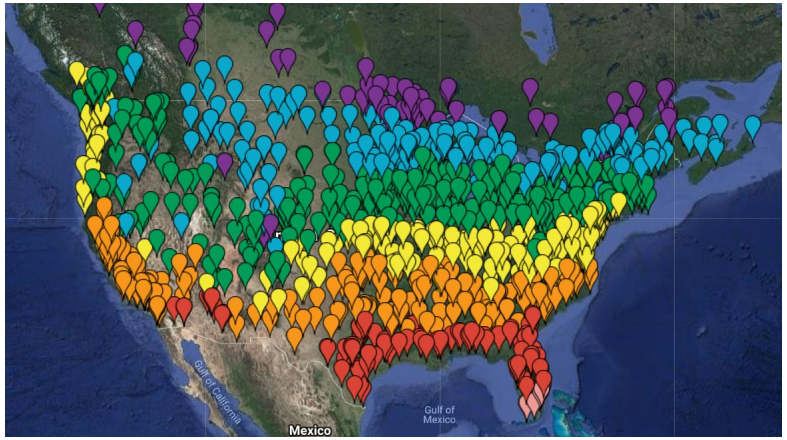
Temp of Interior Air (60% WWR)

Temp of Exterior Air

GRID IMPACT - '**NET ZERO**' CASE STUDY PROTOTYPE



Multifamily Building – DOE Prototype
Location: Chicago, IL
32 units, 96 occupants, ~35,000 sf iCFA
All Electric
Energy Model: BeOpt (Energy Plus engine)



Two 'Net Zero' buildings studied:

1. Baseline "Renewable Oriented" (code compliant):
290 kW PV Array
All south facing, 10 degree tilt

2. Passive building (PHIUS+ 2015 compliant):
159 kW PV Array
All south facing, 10 degree tilt

‘NET ZERO’ MULTIFAMILY

290 kW PV Array
All south facing, 10 degree tilt
Site EUI: **33.4** kBTU/ft^2.yr

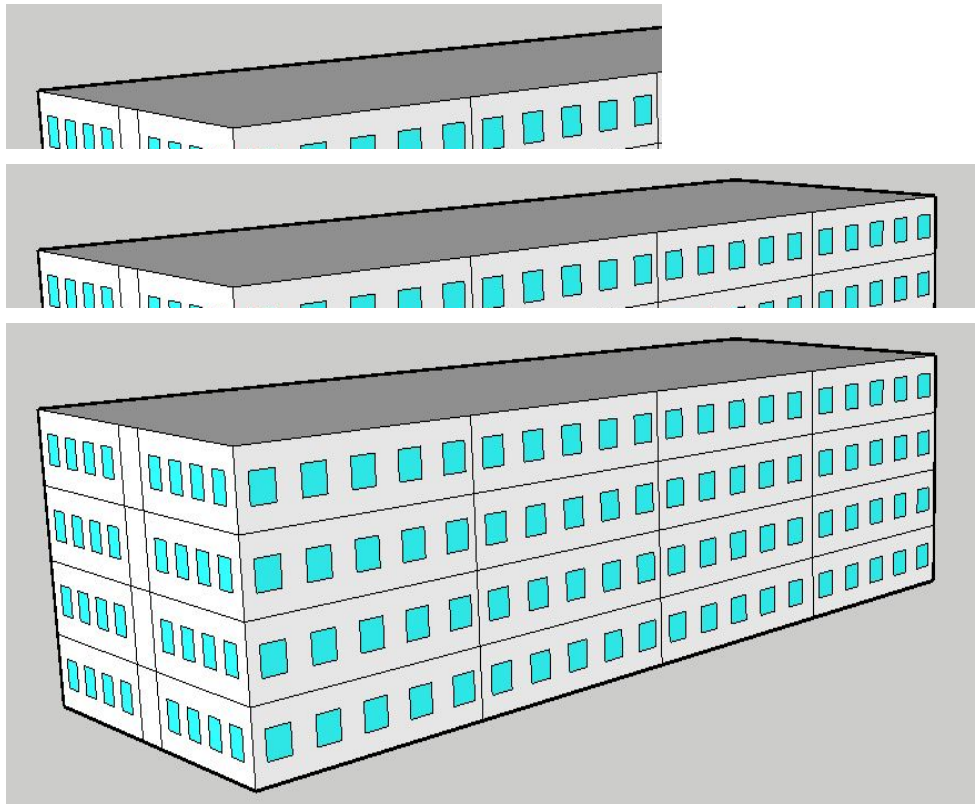
Baseline building

Roof Area = 9,000 ft^2
Estimate 80% usable = 7,200 ft^2
Estimate 1 ft^2 = ~15 W

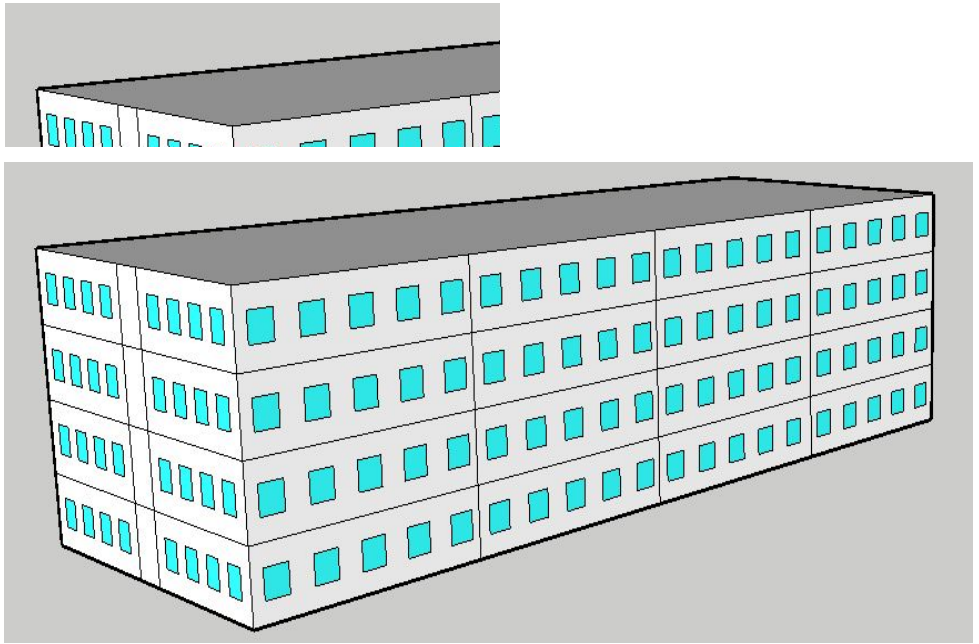
159 kW PV Array
All south facing, 10 degree tilt
Site EUI: **18.7** kBTU/ft^2.yr

Passive building

Need 19,333 ft2, or **2.7x** roof area!

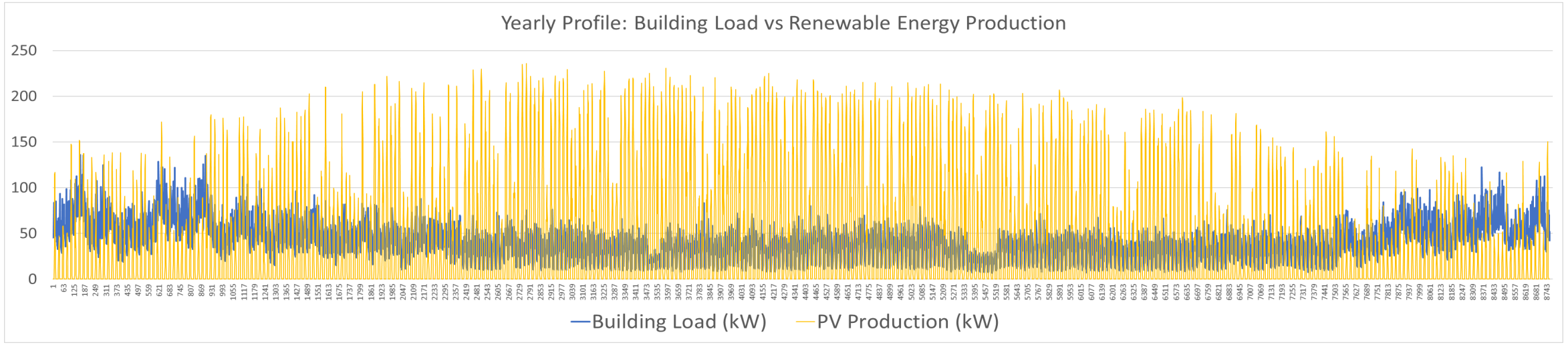


Need 10,600 ft2, or **1.5x** roof area!

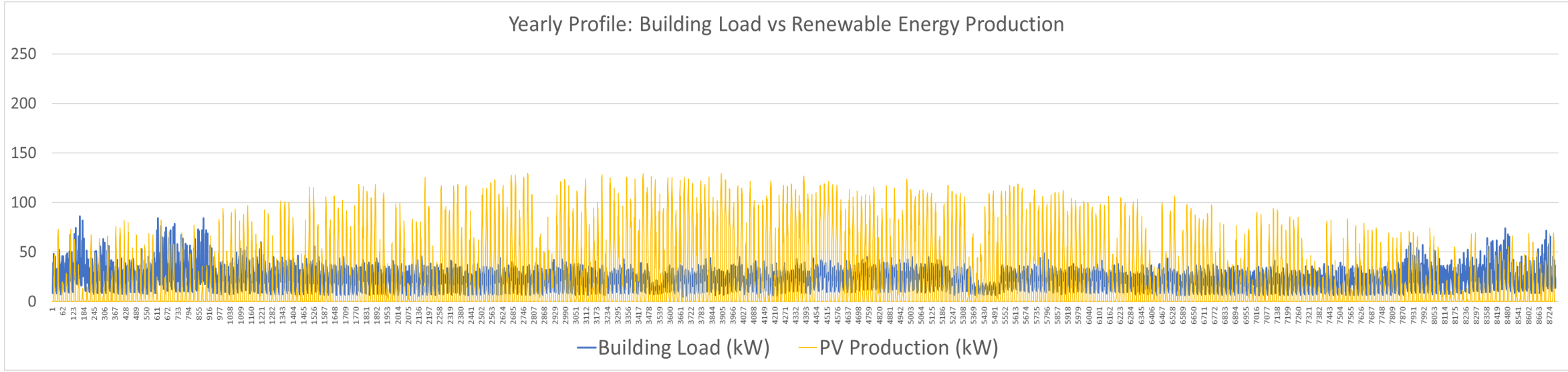


CASE STUDY

Baseline building



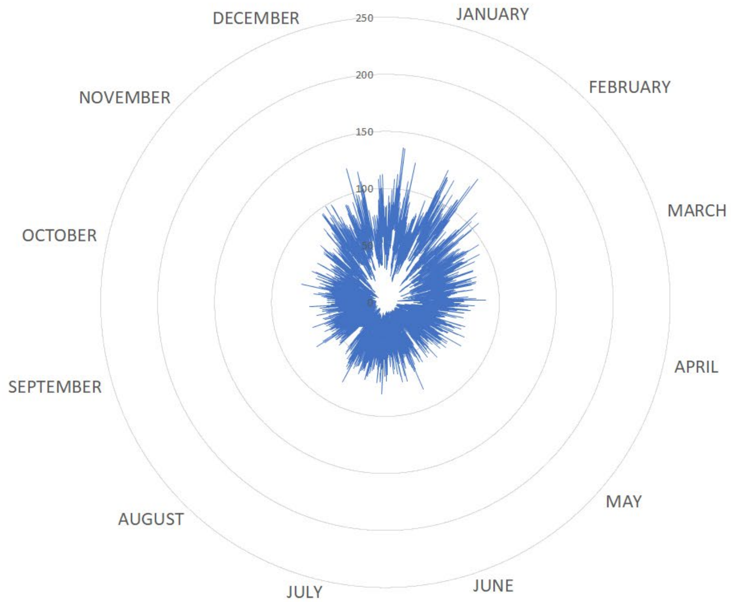
Passive (PHIUS+) building

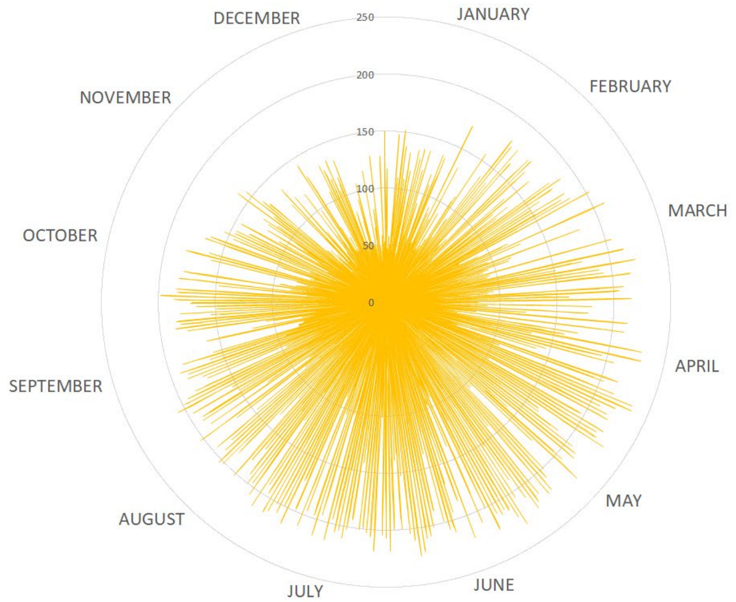


CASE STUDY

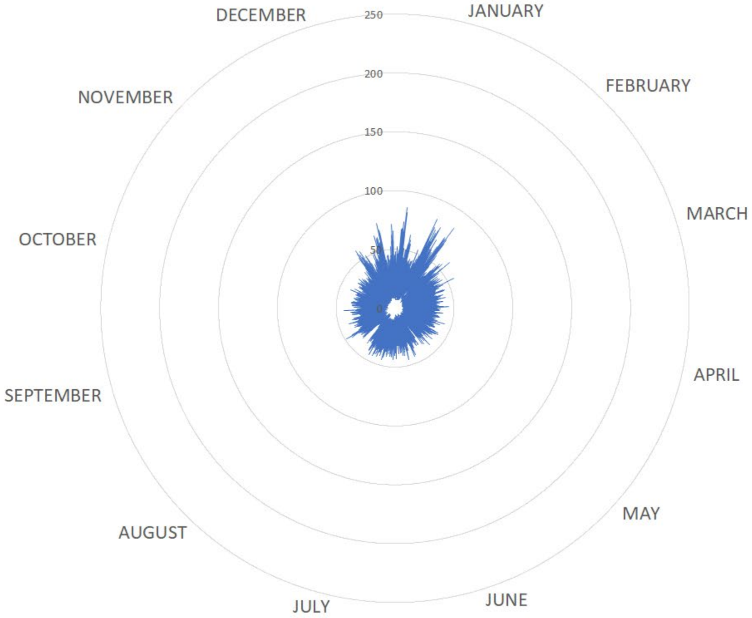
	Hourly Building Load (kW)	Hourly PV Production (kW)

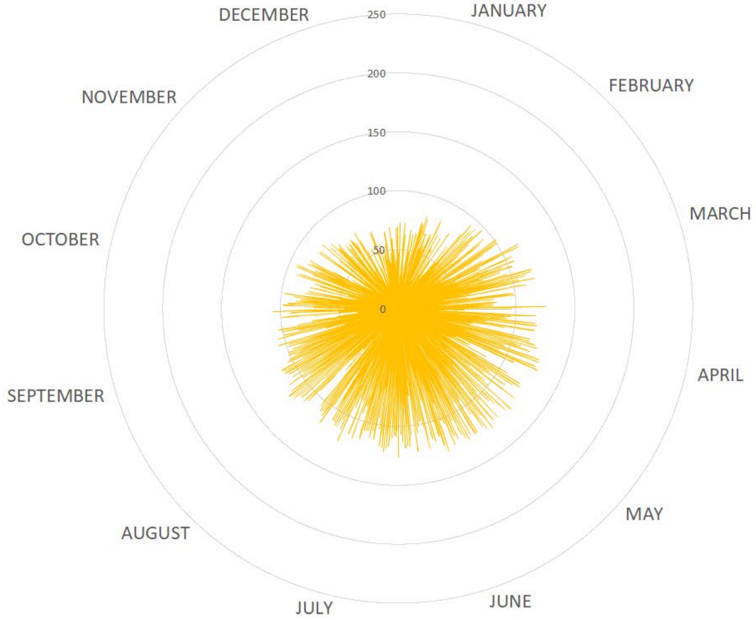
Baseline building





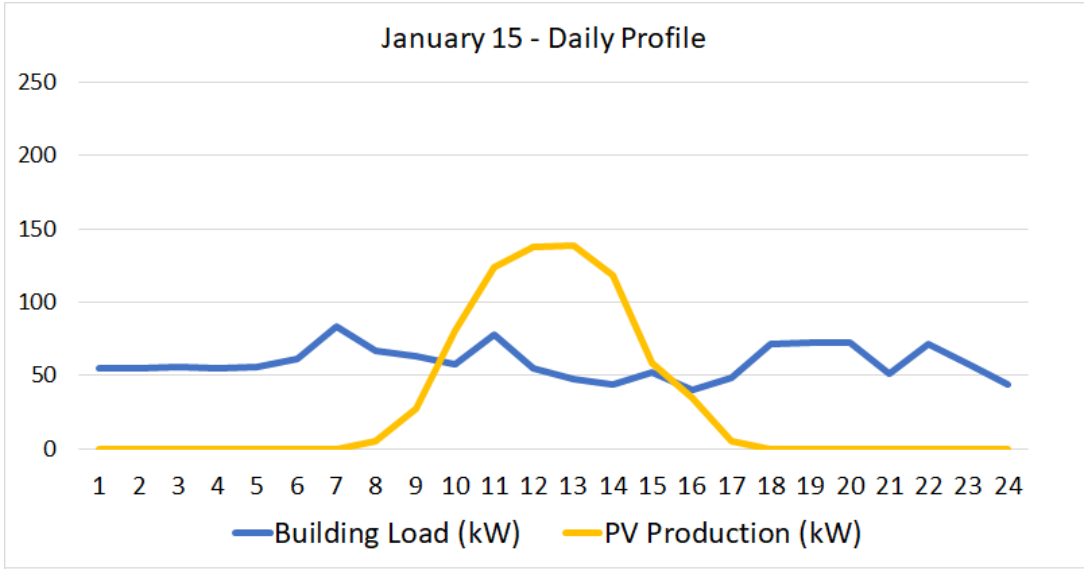
Passive building

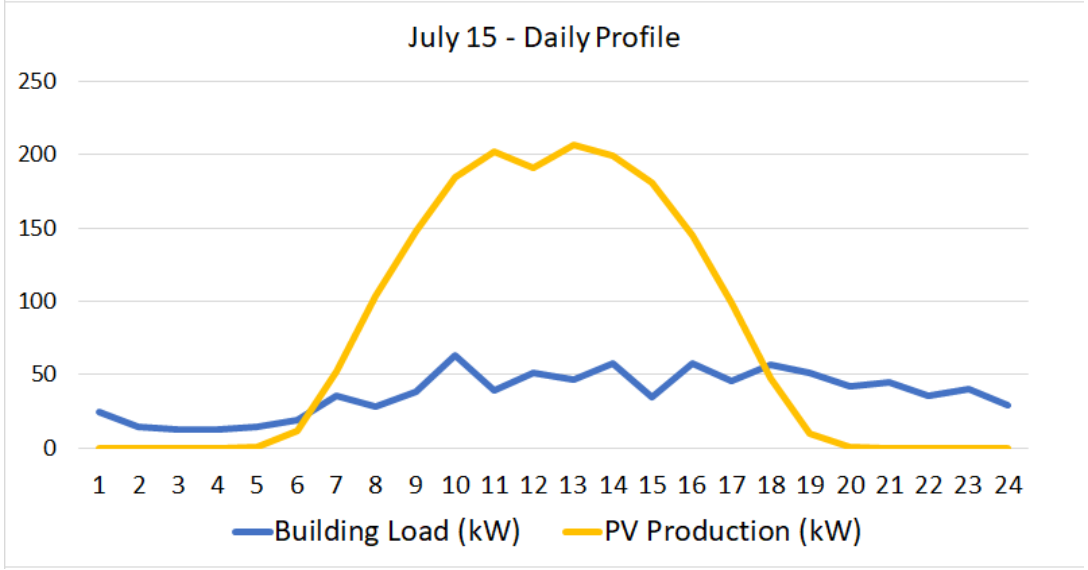




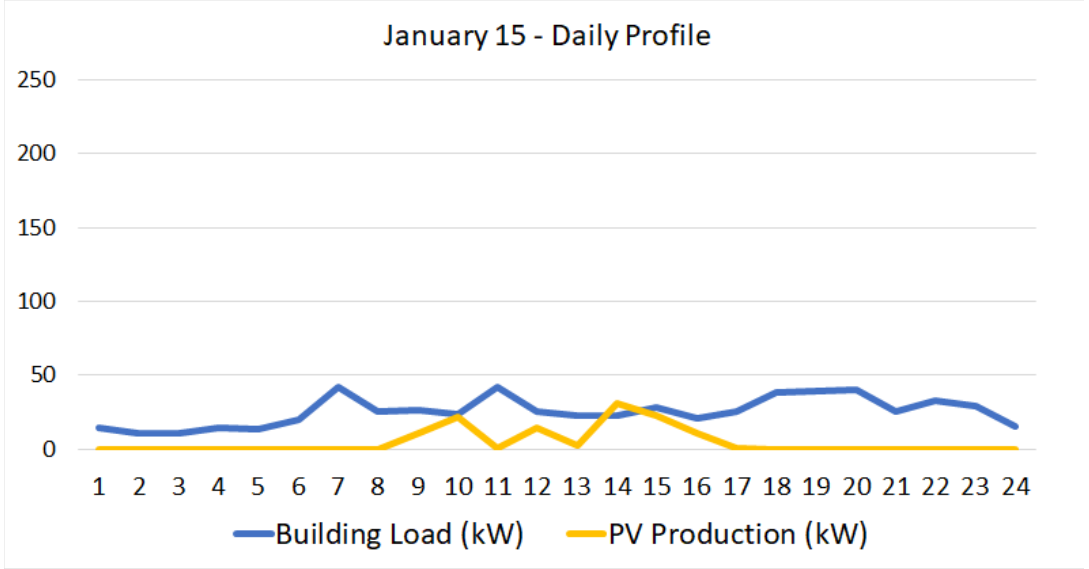
CASE STUDY

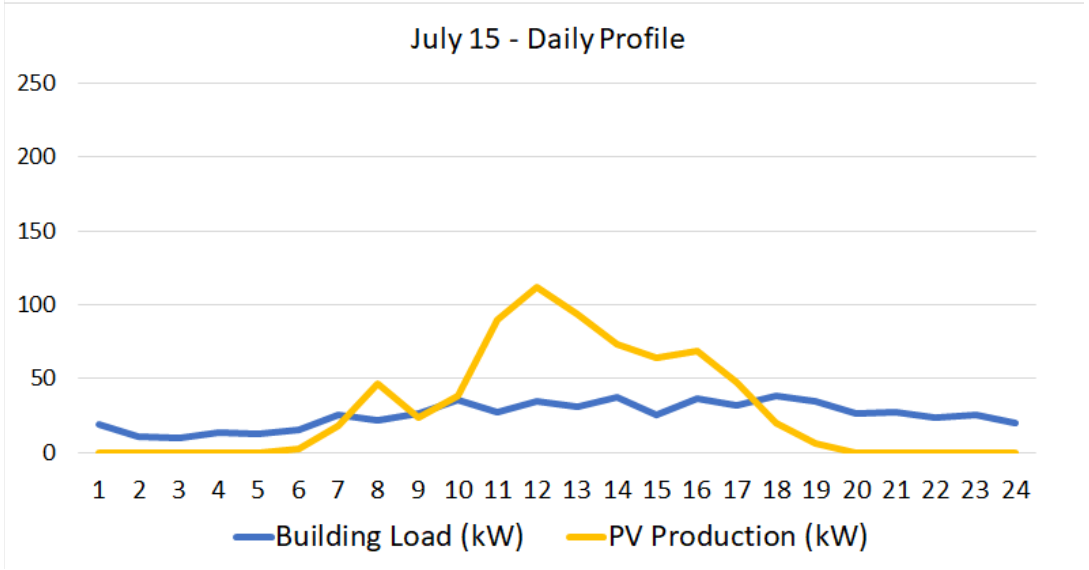
Daily Analysis – January & July





Baseline building

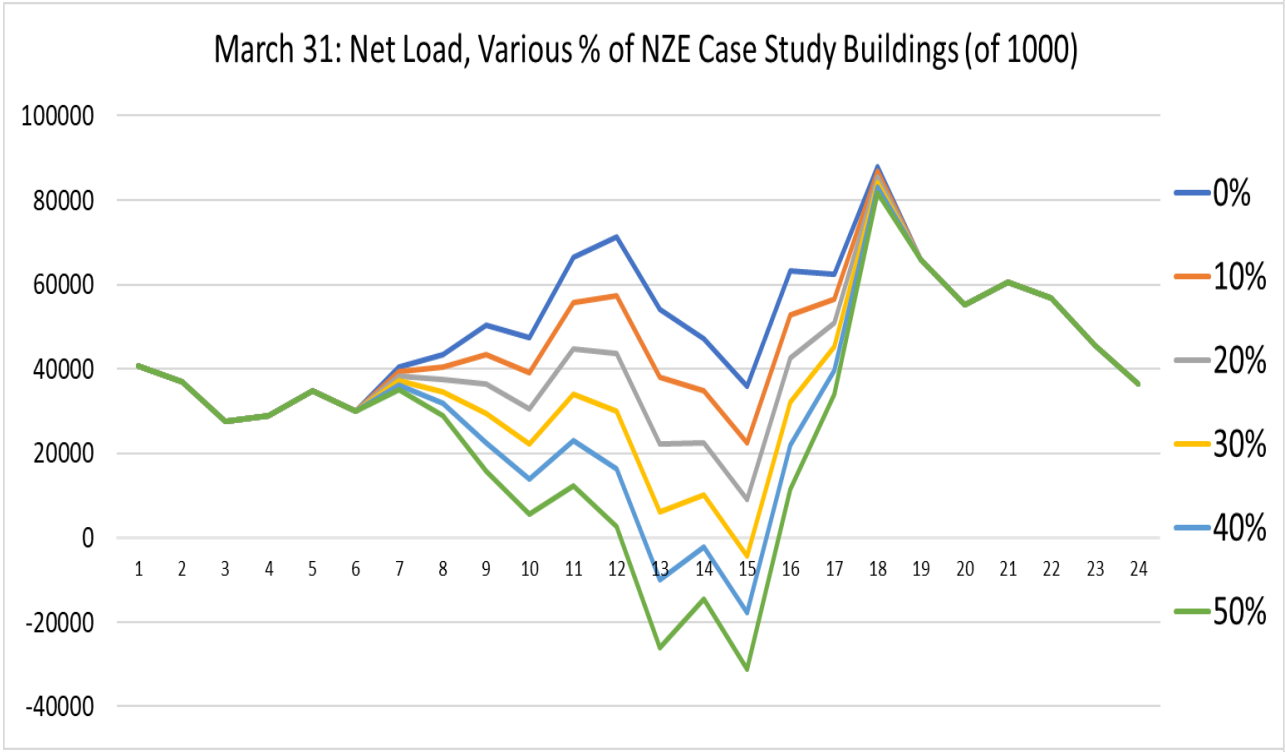




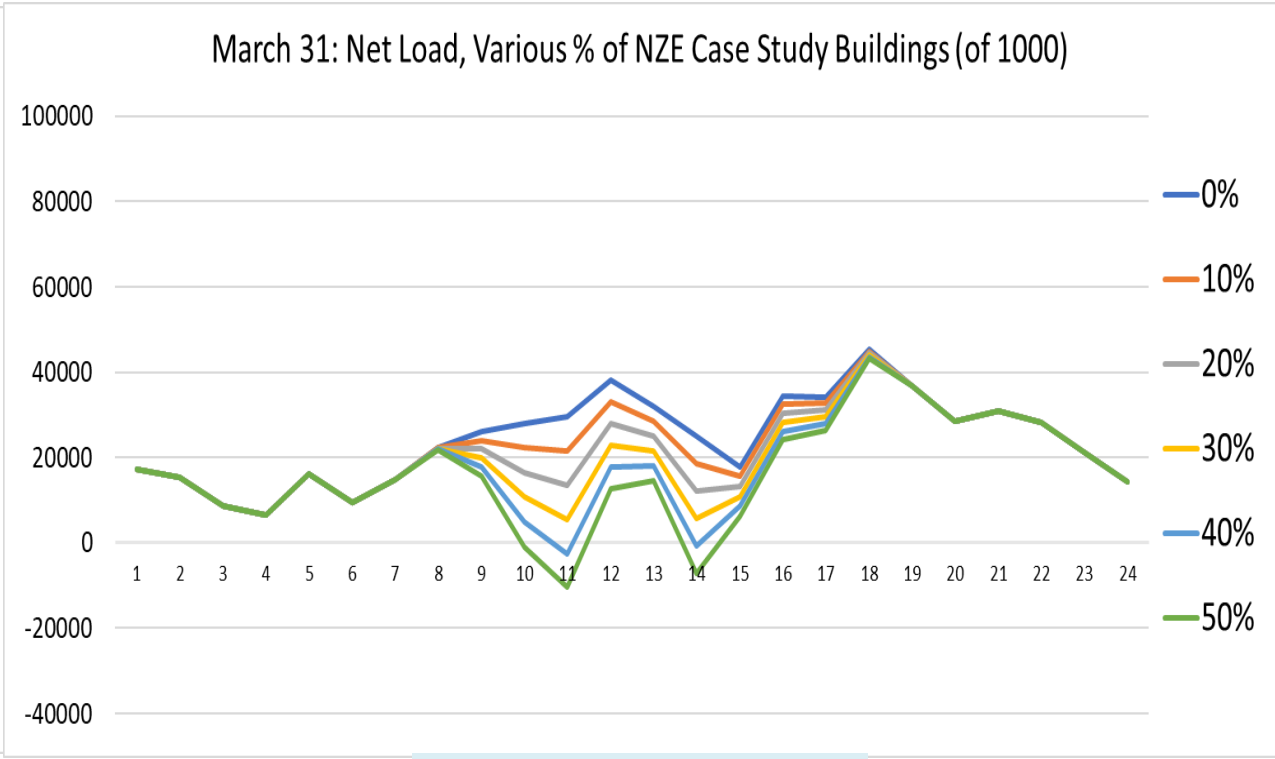
Passive building

Net Load on Grid/Ramping Analysis

Community Scale -- Of 1000 Multifamily Buildings - % OF NZE Integrated



Baseline building



Passive building

Greatest 3-hr ramp ~3x higher than passive building

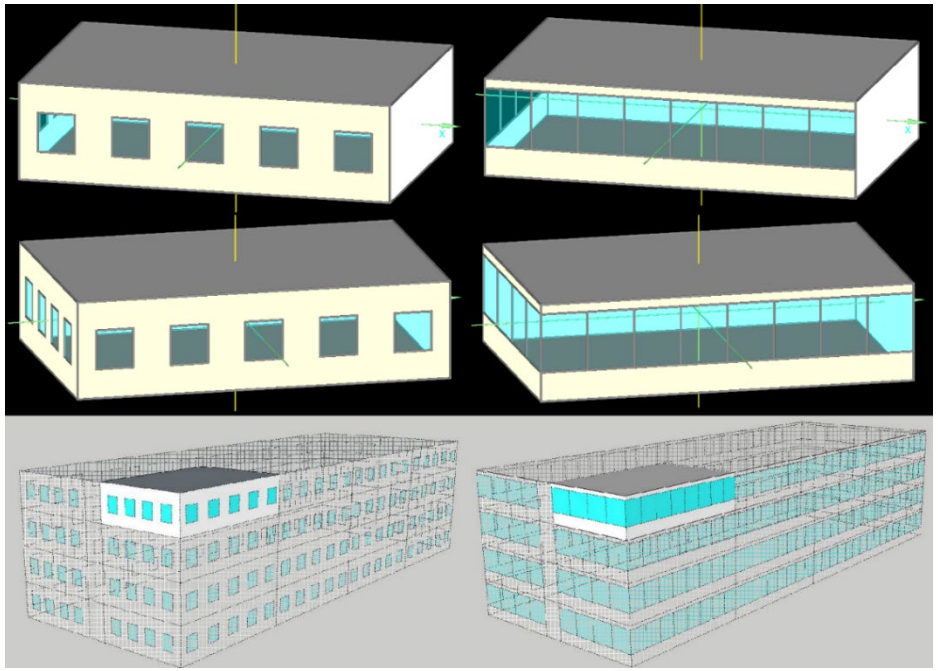
CASE STUDY

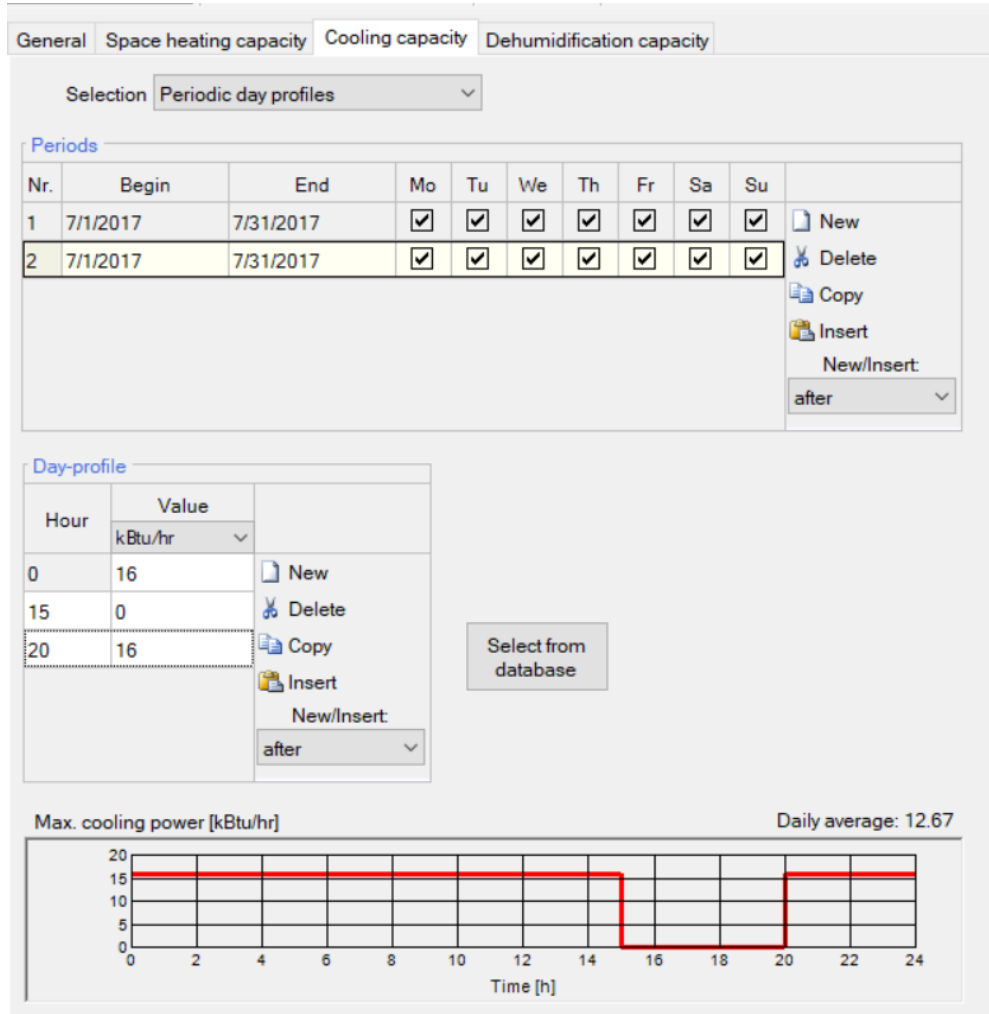
DEMAND RESPONSE SIMULATION

Remove space cooling/dehumidification capacity from 3pm-8pm

July 14-July 21– Chicago O'Hare

Single SW corner unit of study building
20% & 60% WWR, Low Mass & High Mass

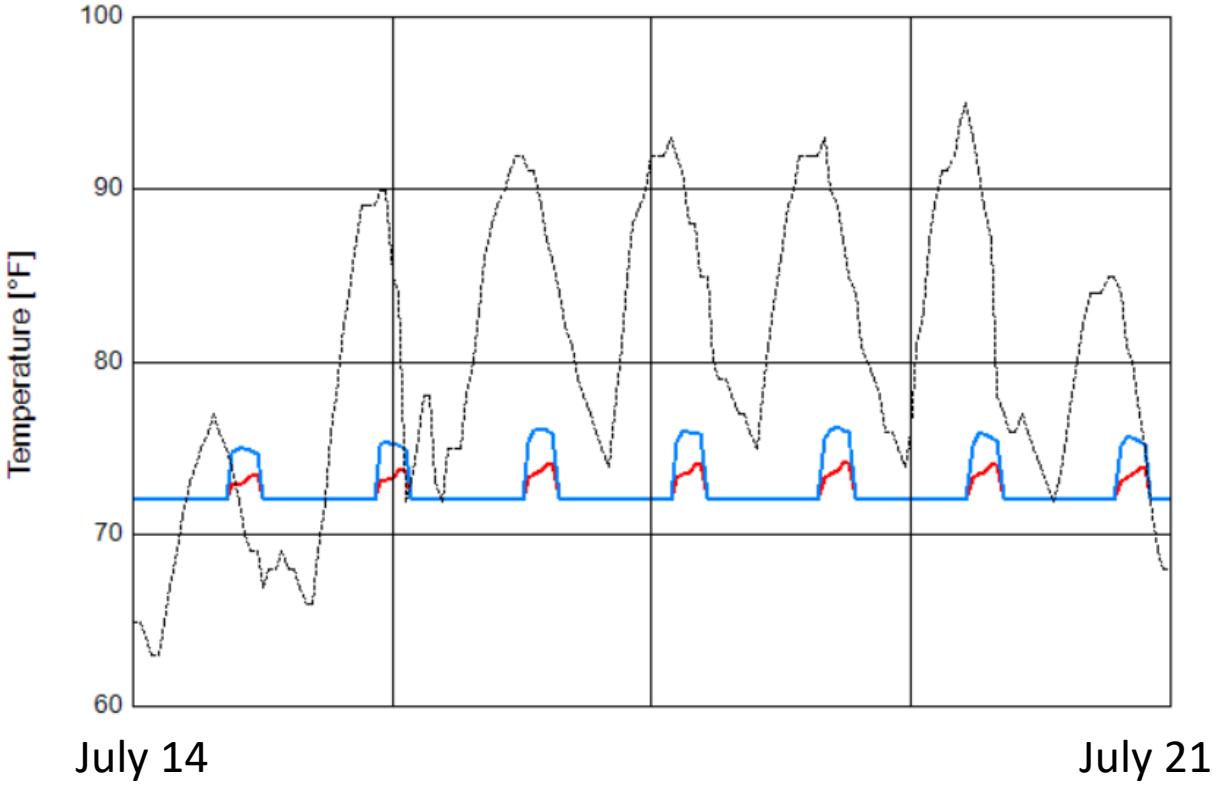




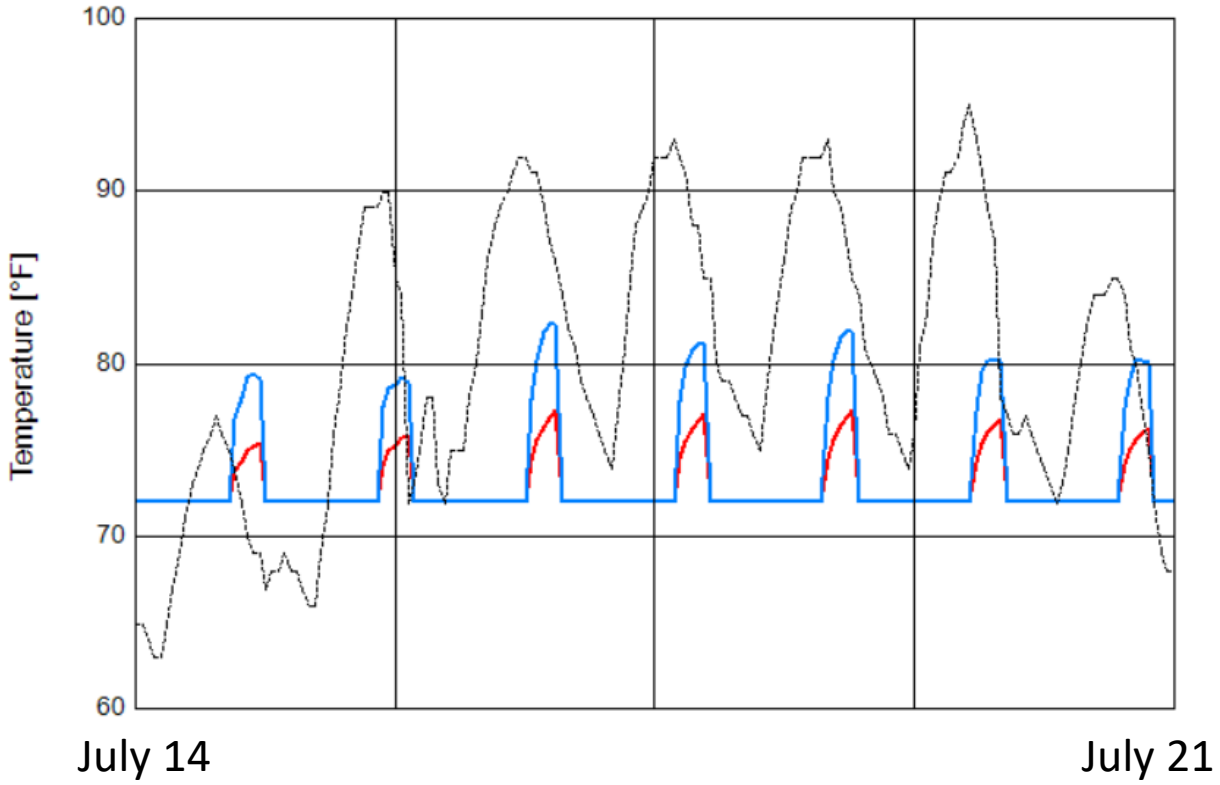
DEMAND RESPONSE – NO COOLING/DEHUM FROM 3-8 PM FOR A WEEK IN JULY

Starting set-point for cooling 72F

HIGH MASS

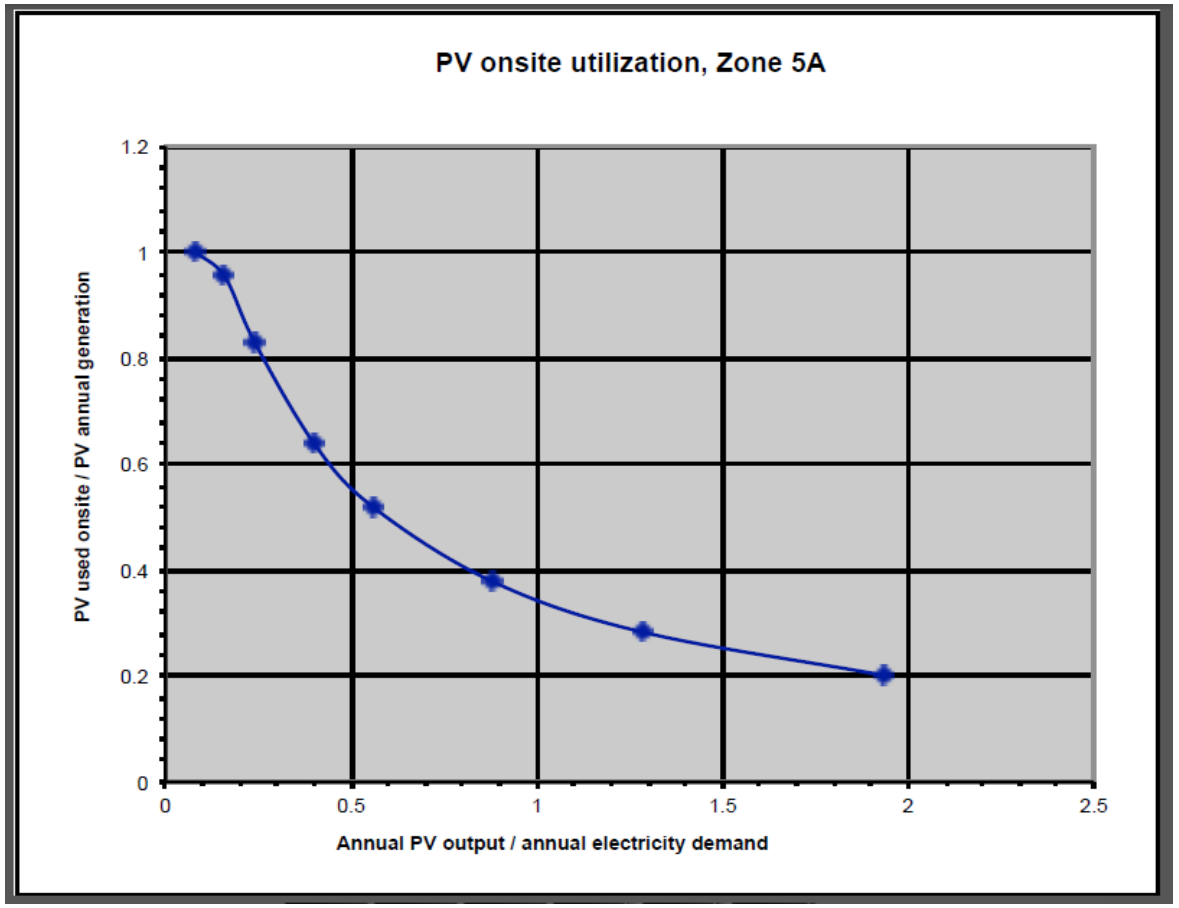


LOW MASS



PHIUS PV UTILIZATION CALC

	Site Energy Use (kWh/yr)	PV Production (kWh/yr)	Utilization Factor (%)	On-site Coverage (kWh/yr)	Covered by Grid (kWh/yr)
CODE/BASELINE	**352,162**	352,187	**36%**	126,788	**225,374**
PHIUS+	**197,636**	198,234	**36%**	71,364	**126,272**



Two 'NZE' buildings:

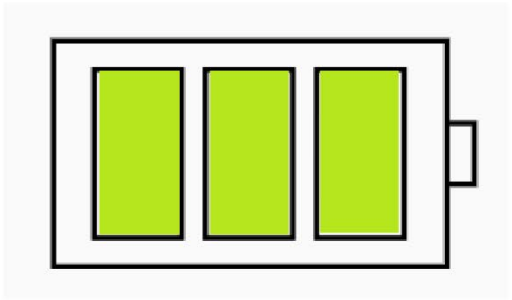
BUT, the difference in electricity covered by grid = **99,102 kWh/yr!**

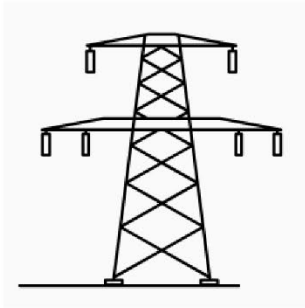
That's half the annual energy use of the PHIUS+ building.

The Ripple Effect of Conservation

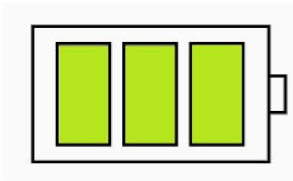
Conservation means less generation, less storage, and less transmission capacity needed

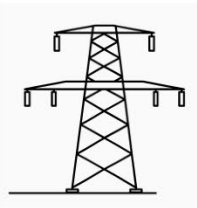
60,000
kWh/yr





36,000
kWh/yr





Questions?

Lwhite@PHIUS.org