



DMSP Nighttime Lights

The California Grid

Goal: Anywhere, Anytime, No One Left Behind

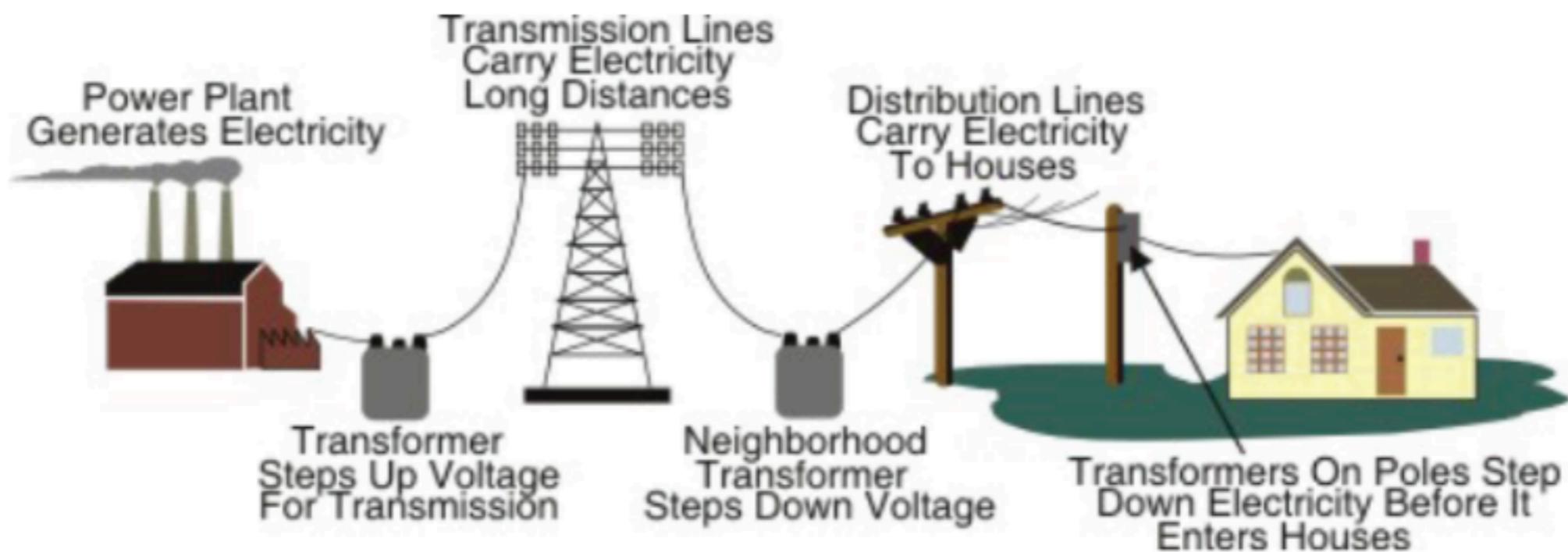
Grace Peng, PhD

LWV Water & Infrastructure Group

14 December 2023

General Idea

Electricity Supply and Delivery



Source: The NEED Project²³

Social Network

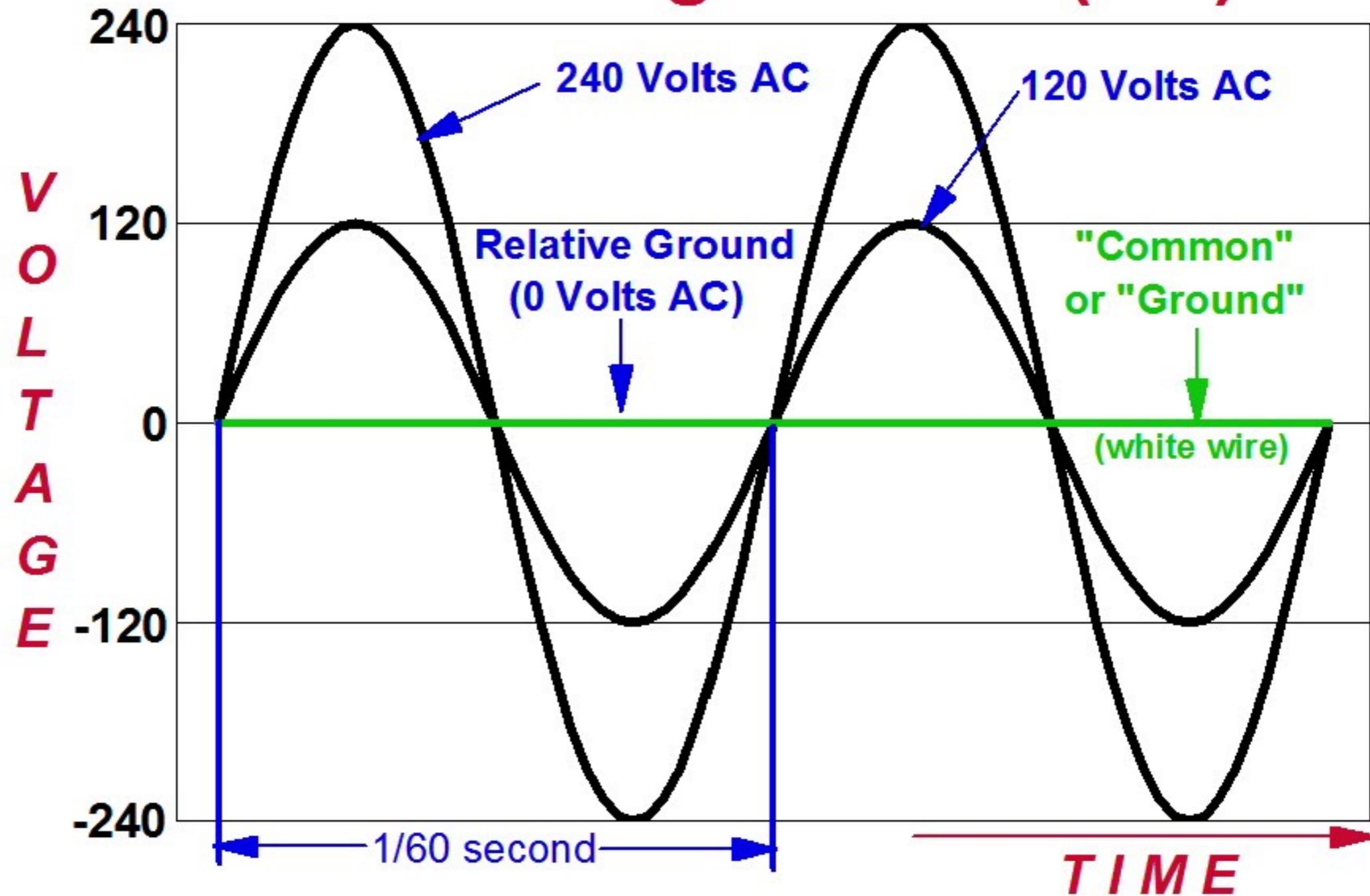
- ❖ Infrastructure:
 - ❖ physical systems
- ❖ Ultrastructure:
 - ❖ social & legal framework
- ❖ Early grids were private
 - ❖ then centralized / shared
 - ❖ privatized again (rooftop)

How
Infrastructure
Works

Inside the
Systems
That Shape
Our World

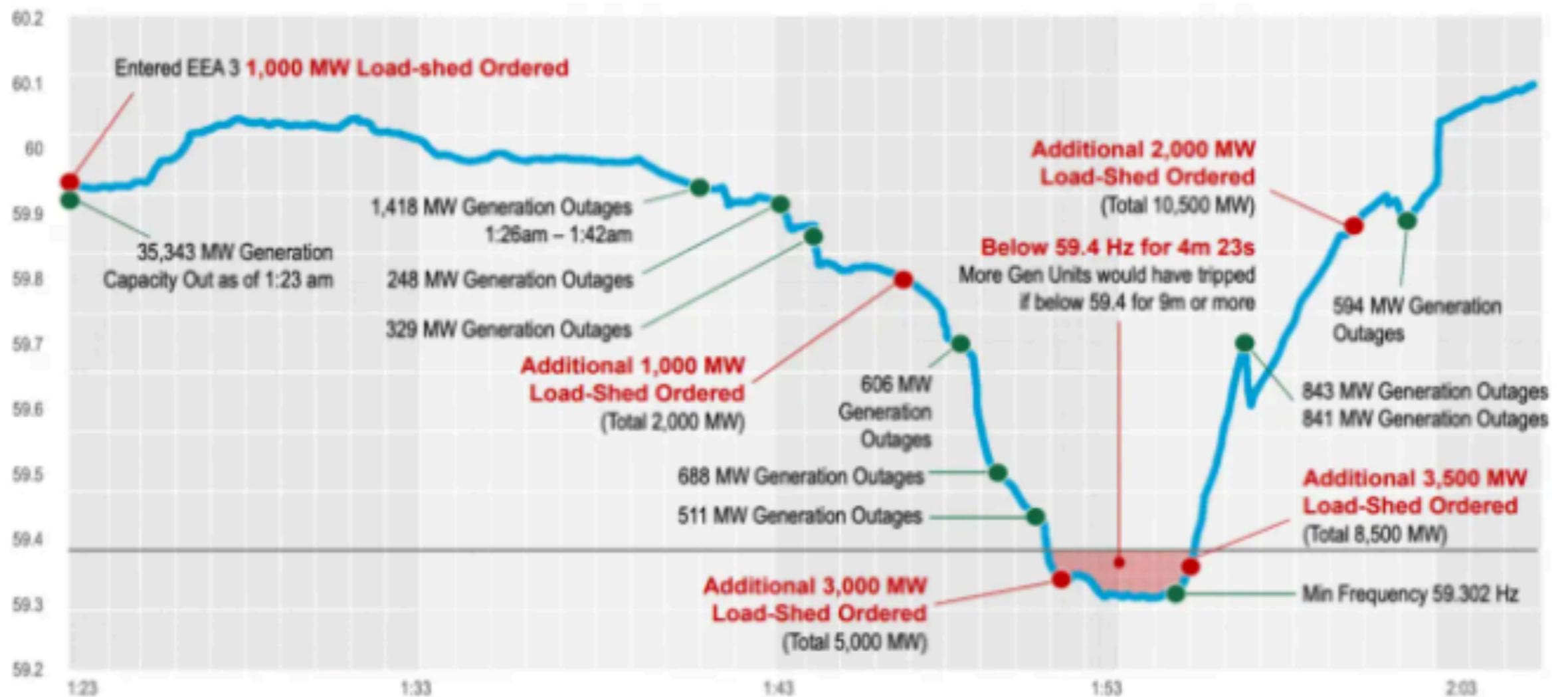
Deb Chachra

Alternating Current (AC)



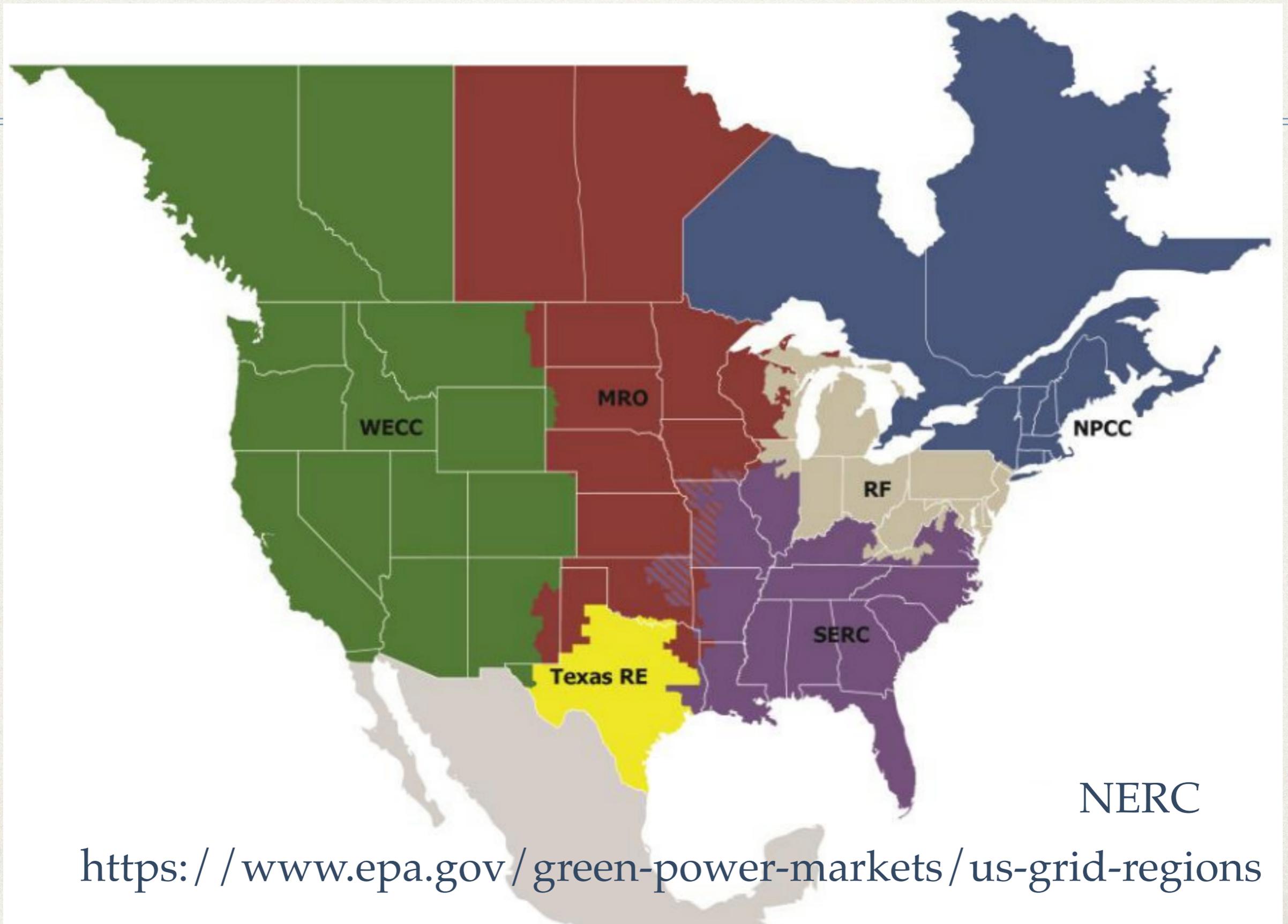
When Demand Doesn't Match Supply

Rapid Decrease in Generation Causes Frequency Drop



<https://www.houstonpublicmedia.org/articles/news/energy-environment/2021/02/24/392290/texas-power-grid-was-4-minutes-and-37-seconds-away-from-collapsing-heres-how-it-happened/>

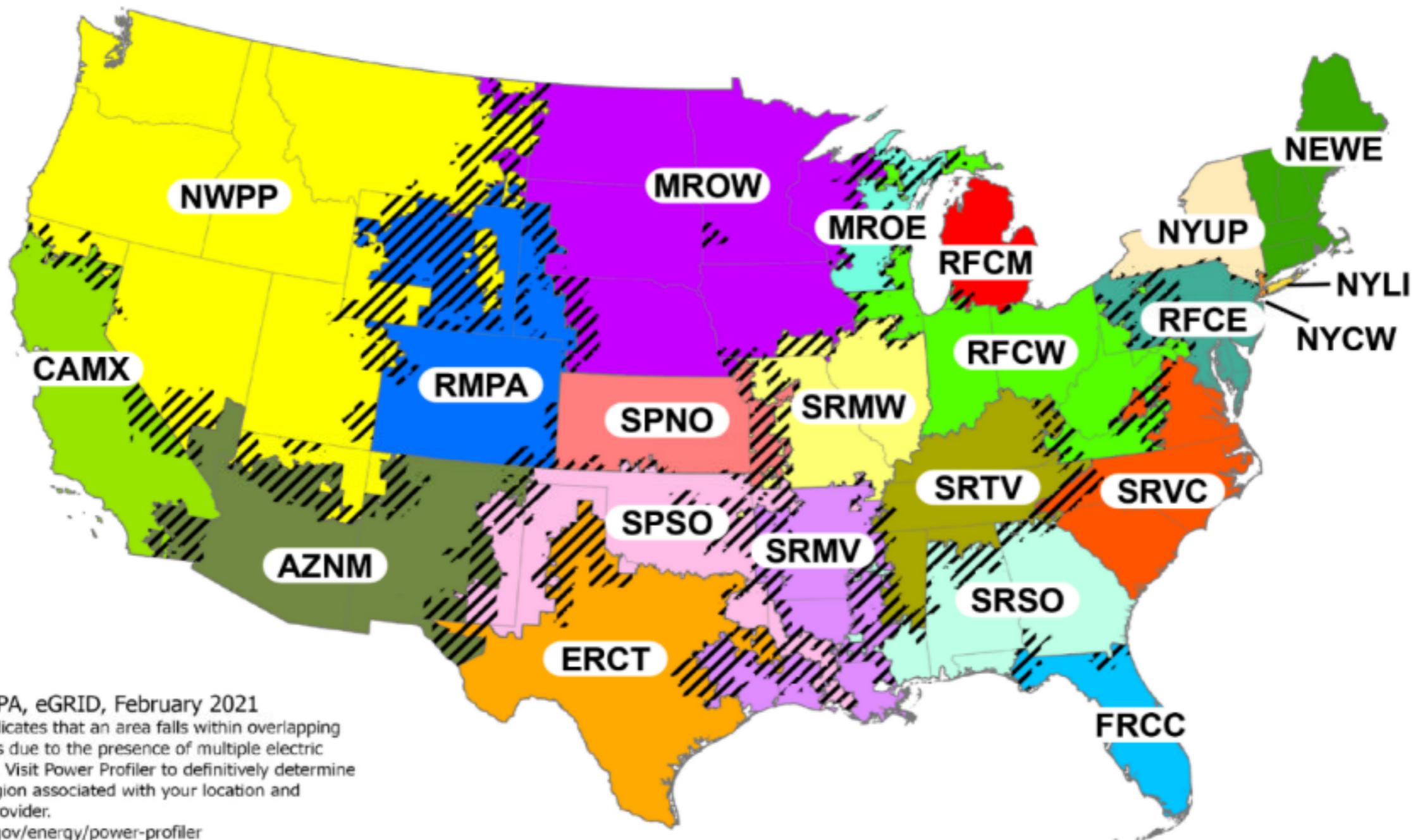
US Grid Regions



<https://www.epa.gov/green-power-markets/us-grid-regions>

Grid Subregions

Map of eGRID Subregions



USEPA, eGRID, February 2021

Crosshatching indicates that an area falls within overlapping eGRID subregions due to the presence of multiple electric service providers. Visit Power Profiler to definitively determine the eGRID subregion associated with your location and electric service provider.

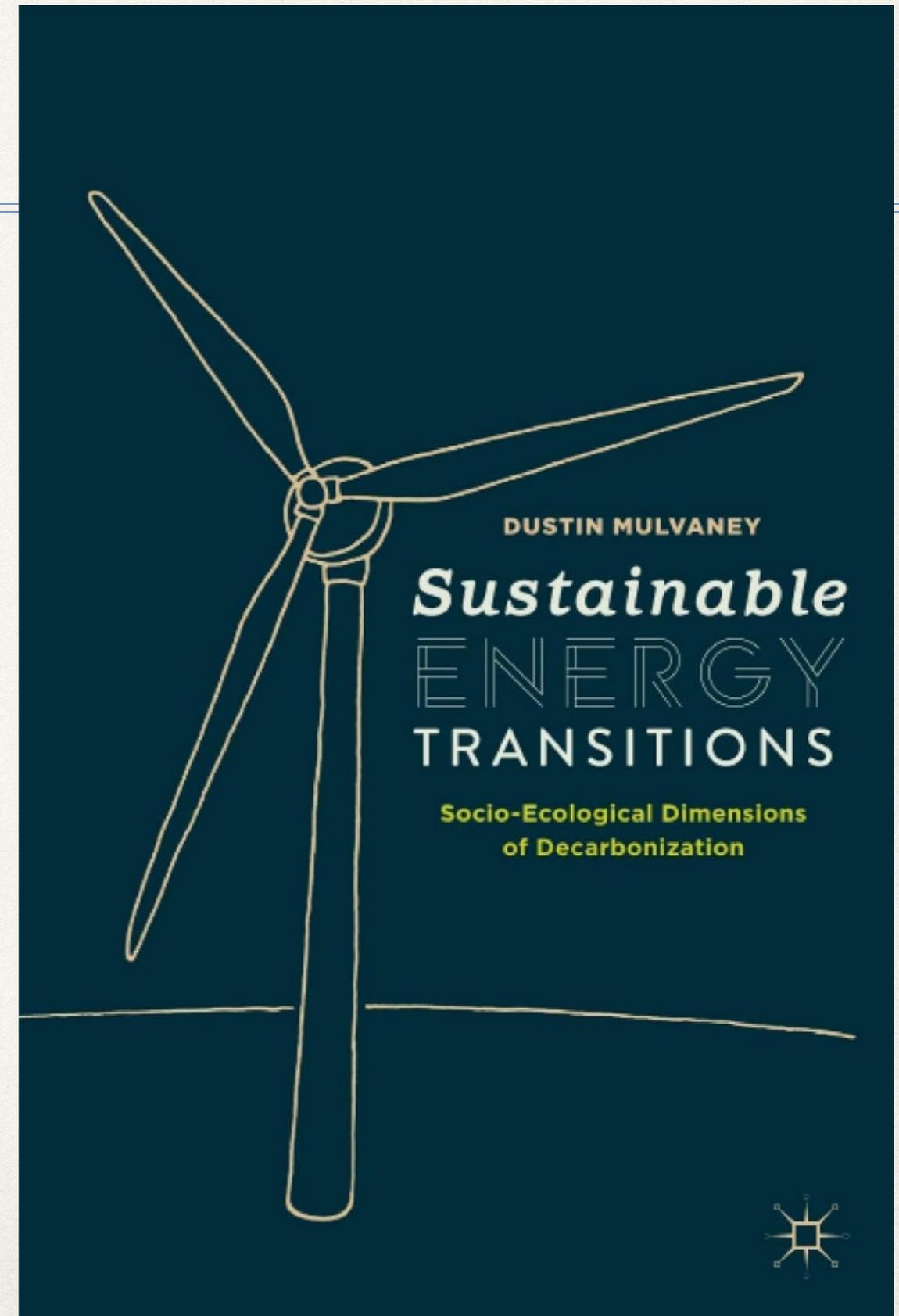
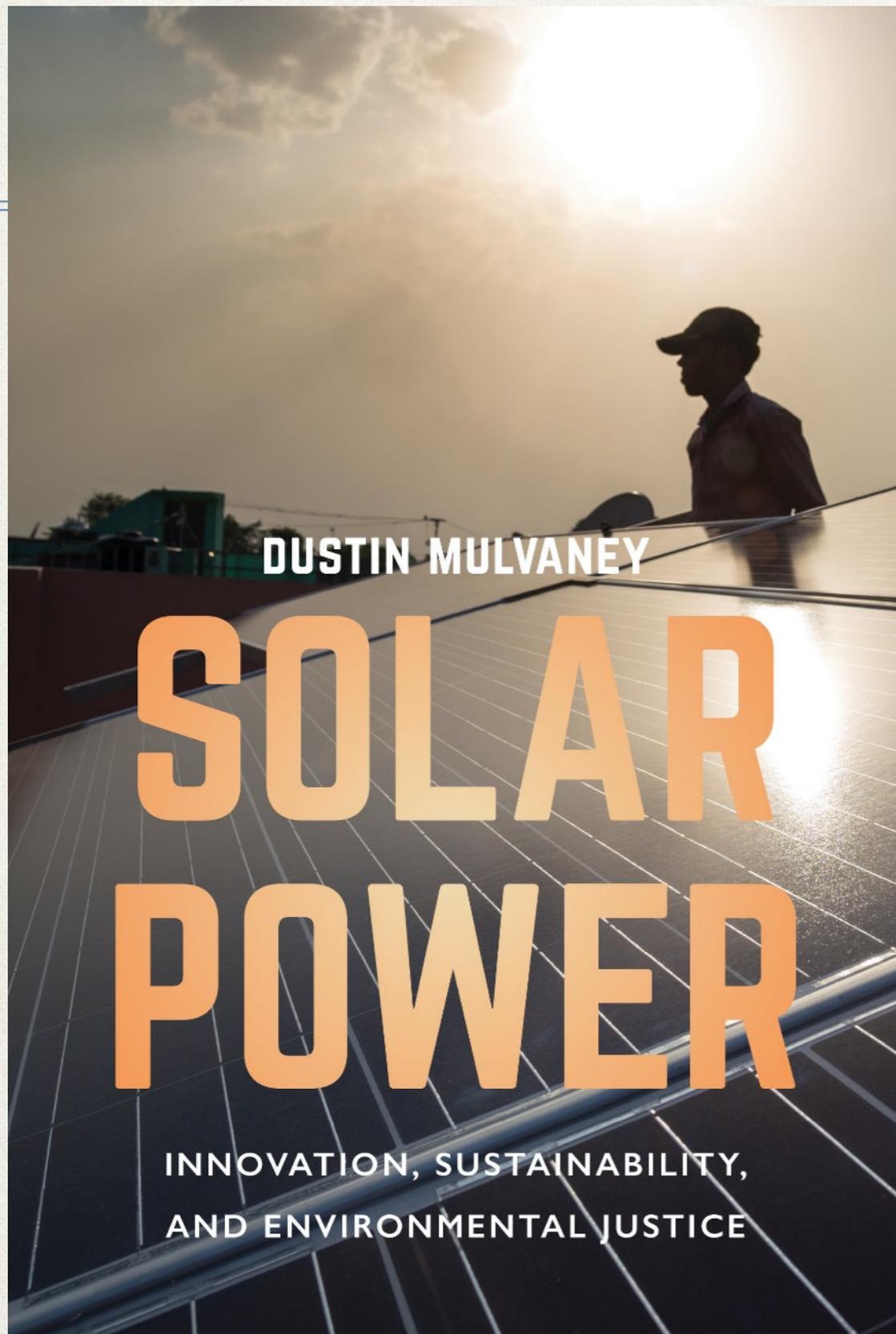
<http://www.epa.gov/energy/power-profiler>

<https://www.epa.gov/green-power-markets/us-grid-regions>

Further Reading

Book Title	Author	Subject Area	Emphasis
The Grid	Gretchen Bakke	Anthropology	History of creation of US Grid, people who run it today
California Burning	Katherine Blunt	History, Finance	History of PG&E, culture, governance, liability
Short Circuiting Power	Leah Stokes	Political Science	Regulatory capture, RPS best accountability measure
Shorting the Grid	Margaret Angwin	Governance	Why RTOs are expensive for consumers, fragility/resilience, the case for nuclear
Solar Power	Dustin Mulvaney	Industrial Science, History	Solar power industry, political power
Sustainable Energy Transition	Dustin Mulvaney	Environmental Science	Textbook for calculations and tradeoffs
Energy in World History	Vaclav Smil	Engineering, History	World history of energy production and use
Natural Gas	Vaclav Smil	Engineering, History	How natural gas was developed, different technology over time
How Infrastructure Works	Deb Chanchra	History, Engineering, Ethics	Physical and Social history and design of resilient and ethical infrastructure.

Old Transmission Laws-Bad Outcomes



Jurisdictions

FERC, RTO, ISO, PUC

Transource Pa. LLC v. Defrank

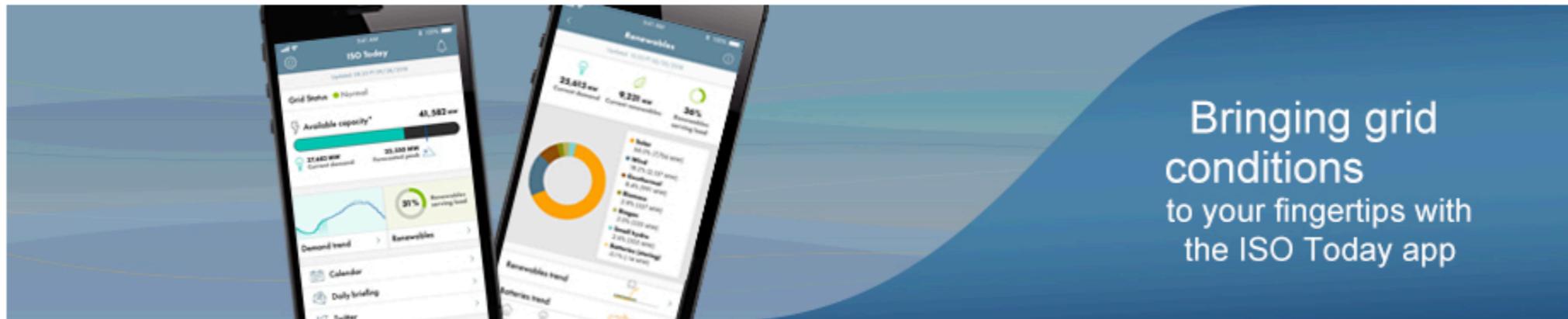
This case concerns federalism and the allocation of powers between federal and state entities. The federal government has reserved for itself the power to regulate the transmission of electric energy in interstate commerce, including in wholesale ratemaking and interstate and regional planning. The federal government exercises these powers through the Federal Energy Regulatory Commission (“FERC”). FERC has, in turn, delegated some of these powers to Regional Transmission Organizations (“RTOs”). The RTOs assess regional needs by methods approved by FERC, which include economic analyses. By contrast, the states retain the powers of siting, construction, and permitting for regional energy infrastructure.

RTO/ISO/CAISO



Search...

[ABOUT US](#) [PARTICIPATE](#) [STAY INFORMED](#) [PLANNING](#) [MARKET & OPERATIONS](#) [RULES](#) [ISO EN ESPAÑOL](#)



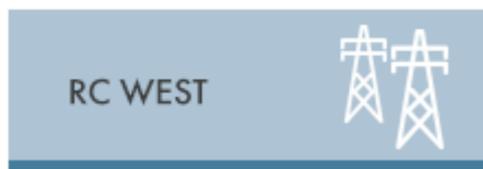
Today's Outlook AS OF 10:50 12/14/2023


26,091 MW
Current demand


28,645 MW
Forecasted peak


14,493 MW
Current renewables


56%
Renewables serving demand



CALENDAR

THURSDAY, 12/14/2023

- iCal** 08:00 AM - 09:15 AM  **Audit Committee Executive Session**
- iCal** 09:30 AM - 11:00 AM  **ISO Board of Governors General Session**
- iCal** 11:00 AM - 04:00 PM  **Market Performance and Planning Forum**
- iCal** 11:00 AM - 02:00 PM  **ISO Board of Governors Executive Session**

FRIDAY, 12/15/2023

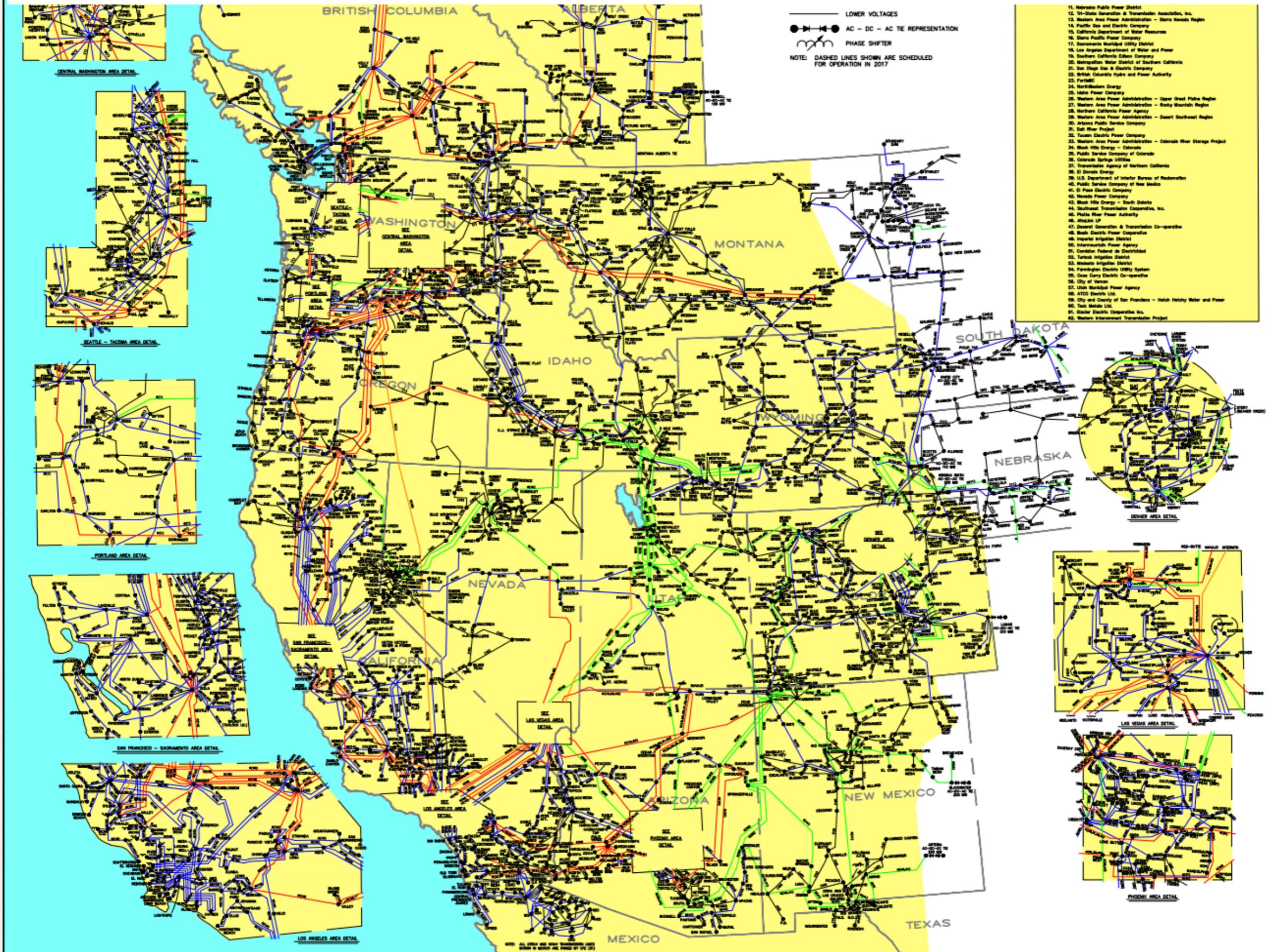
- iCal** 12:00 AM - 11:59 PM  **Comments due - Price Formation Enhancements Nov 16 Working Group**
- iCal** 12:00 AM - 11:59 PM  **Comments due - Gas Resource Management Working Group**

MONDAY, 12/18/2023

- iCal** 12:00 AM - 11:59 PM  **Comments due - Reliability Demand Response Resource Minimum Run Time**
- iCal** 12:00 AM - 11:59 PM  **Comments due - BPM Proposed Revision Requests 1538-1542**

[View all events](#)

<http://www.oatioasis.com/PPW/PPWdocs/2017-WECC-Map-of-Principal-Transmission-Lines.pdf>

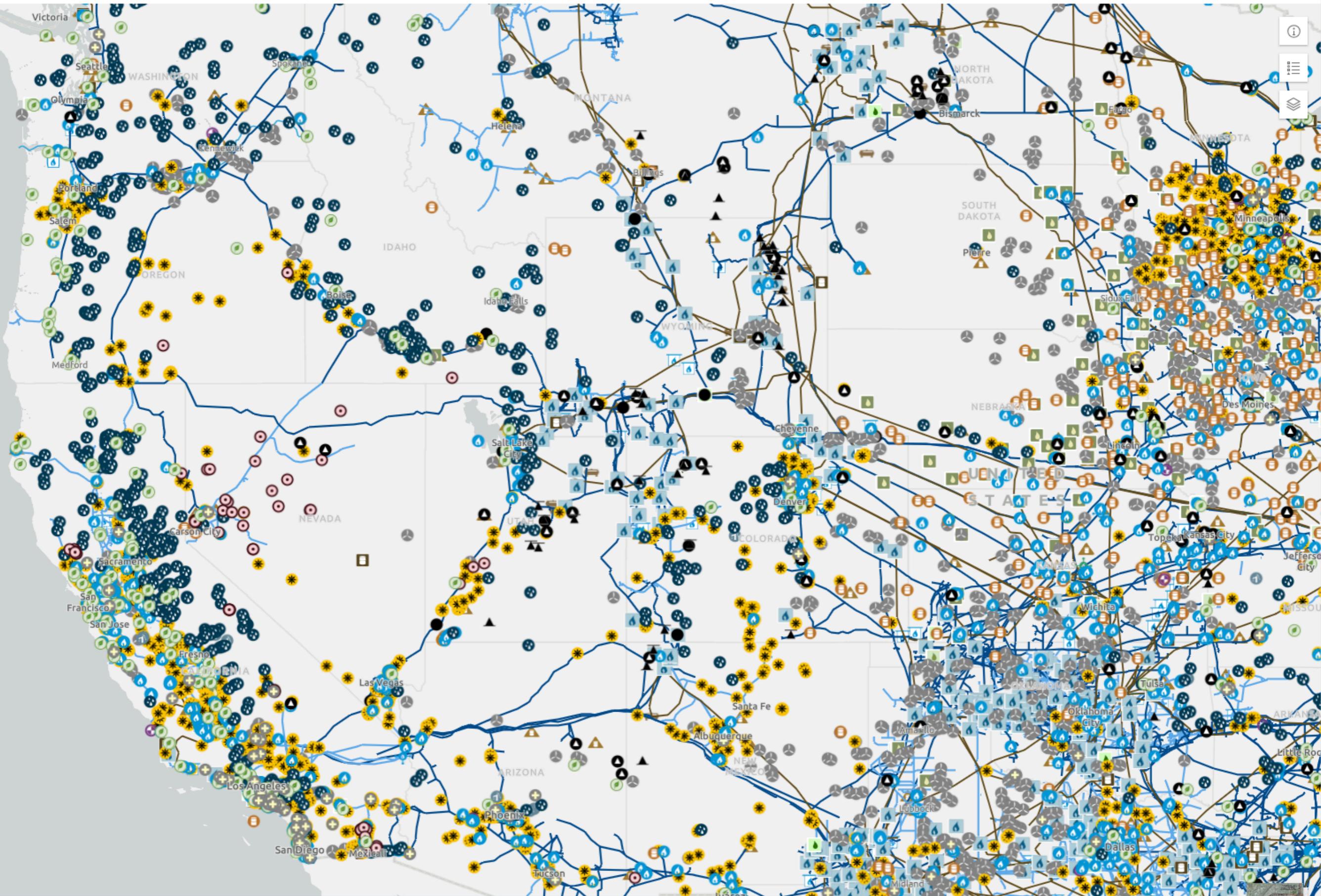


Pacific Intertie

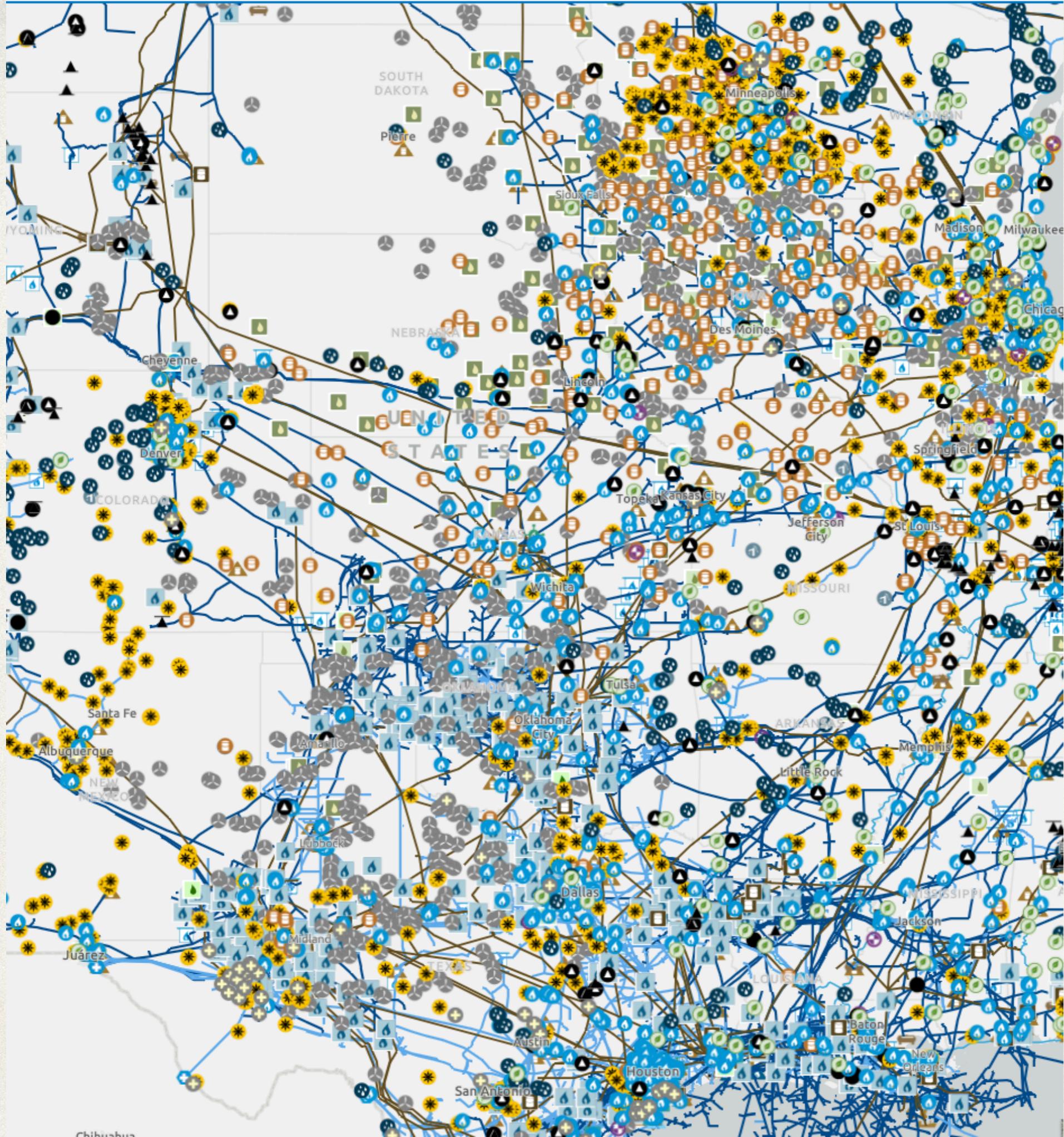
- ❖ AC current stays within Western Grid
- ❖ DC current can be moved between Grids
- ❖ Moves PNW Hydropower to SoCal
- ❖ PNW has the water, we have the customers (load)



All Energy Infrastructure and Resources

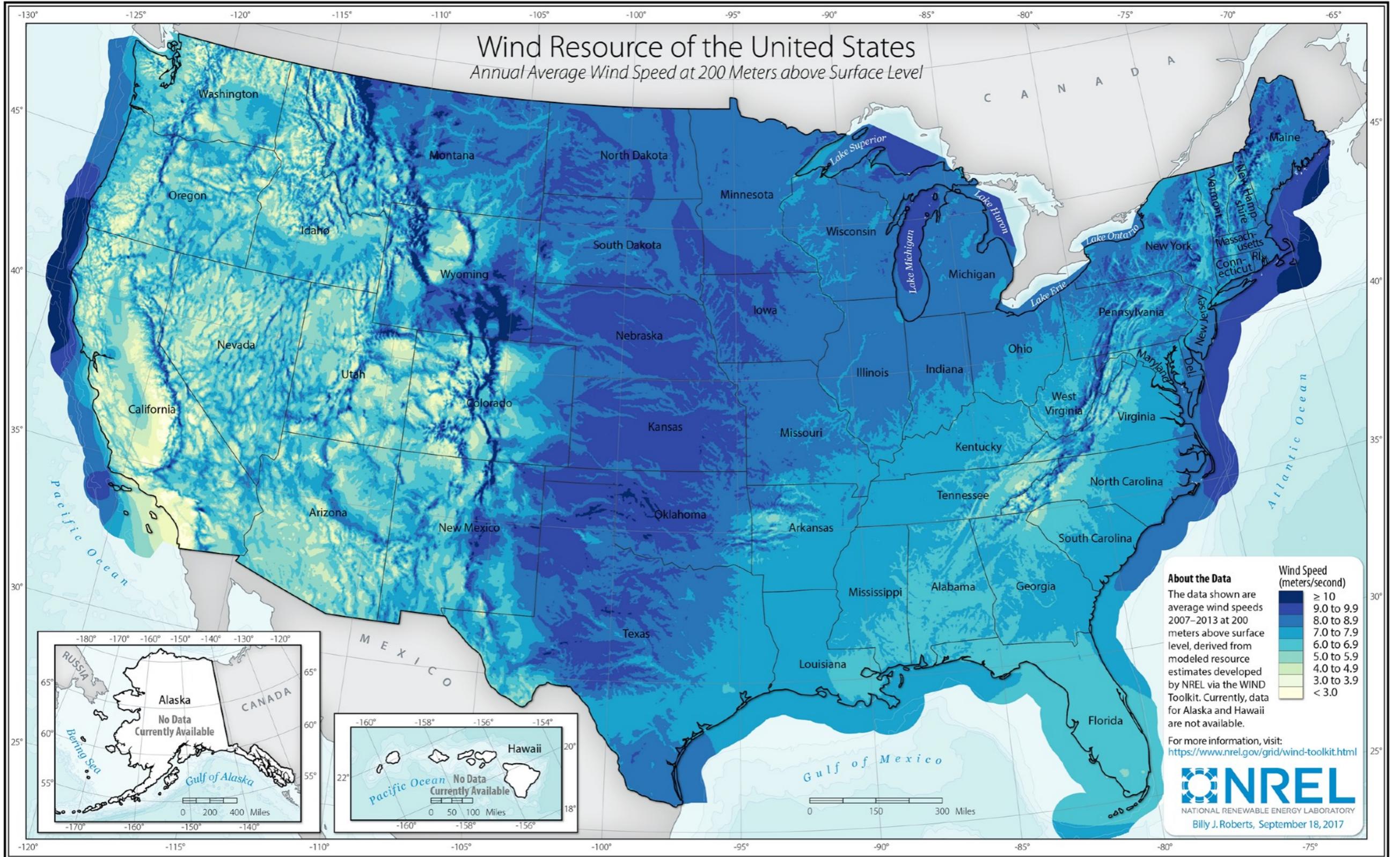


<https://atlas.eia.gov/apps/all-energy-infrastructure-and-resources/explore>



Wind Resource of the United States

Annual Average Wind Speed at 200 Meters above Surface Level



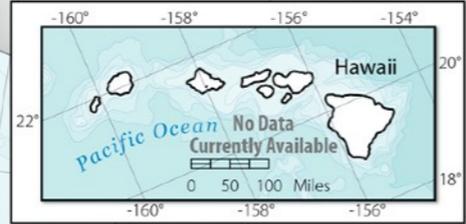
About the Data

The data shown are average wind speeds 2007–2013 at 200 meters above surface level, derived from modeled resource estimates developed by NREL via the WIND Toolkit. Currently, data for Alaska and Hawaii are not available.

For more information, visit: <https://www.nrel.gov/grid/wind-toolkit.html>

NREL
 NATIONAL RENEWABLE ENERGY LABORATORY
 Billy J. Roberts, September 18, 2017

Wind Speed (meters/second)
≥ 10
9.0 to 9.9
8.0 to 8.9
7.0 to 7.9
6.0 to 6.9
5.0 to 5.9
4.0 to 4.9
3.0 to 3.9
< 3.0



Wind Development Speedbumps

Deep Water

Endangered Species

Dark Money Opposition

Jones Act

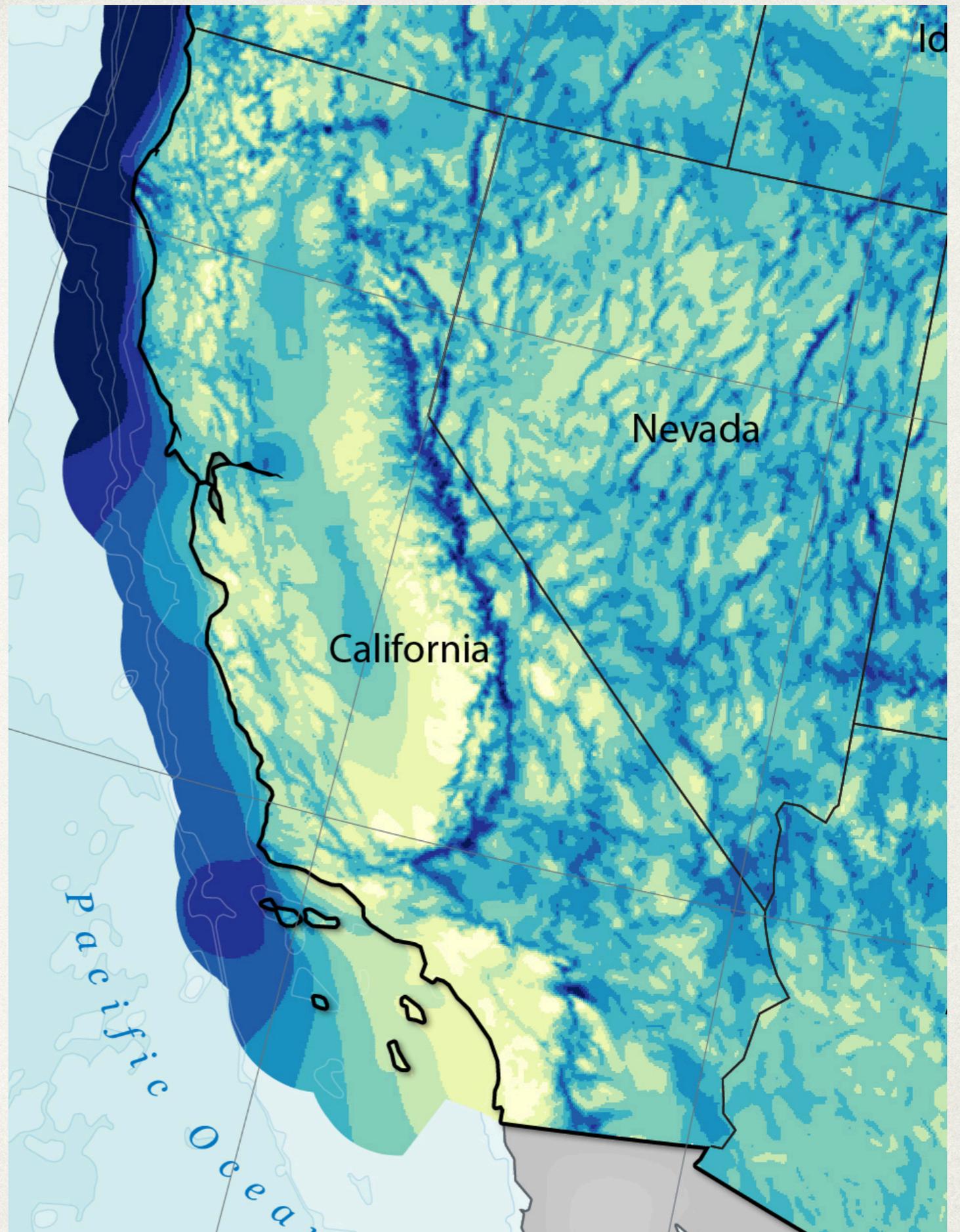
NIMBYs

Interest Rates

Supply Chain

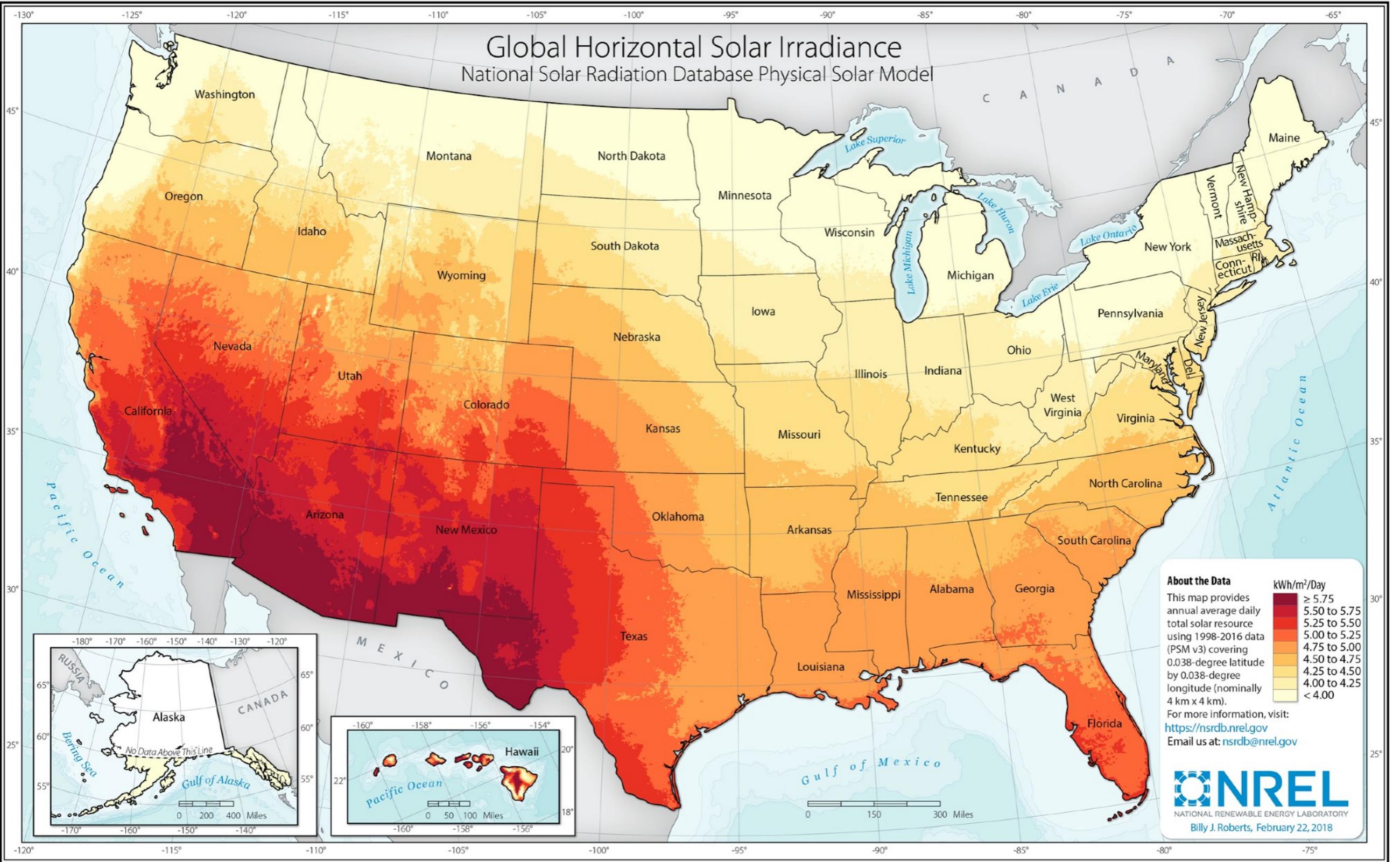
Buy American

IRA \$ helps,
but also need reform



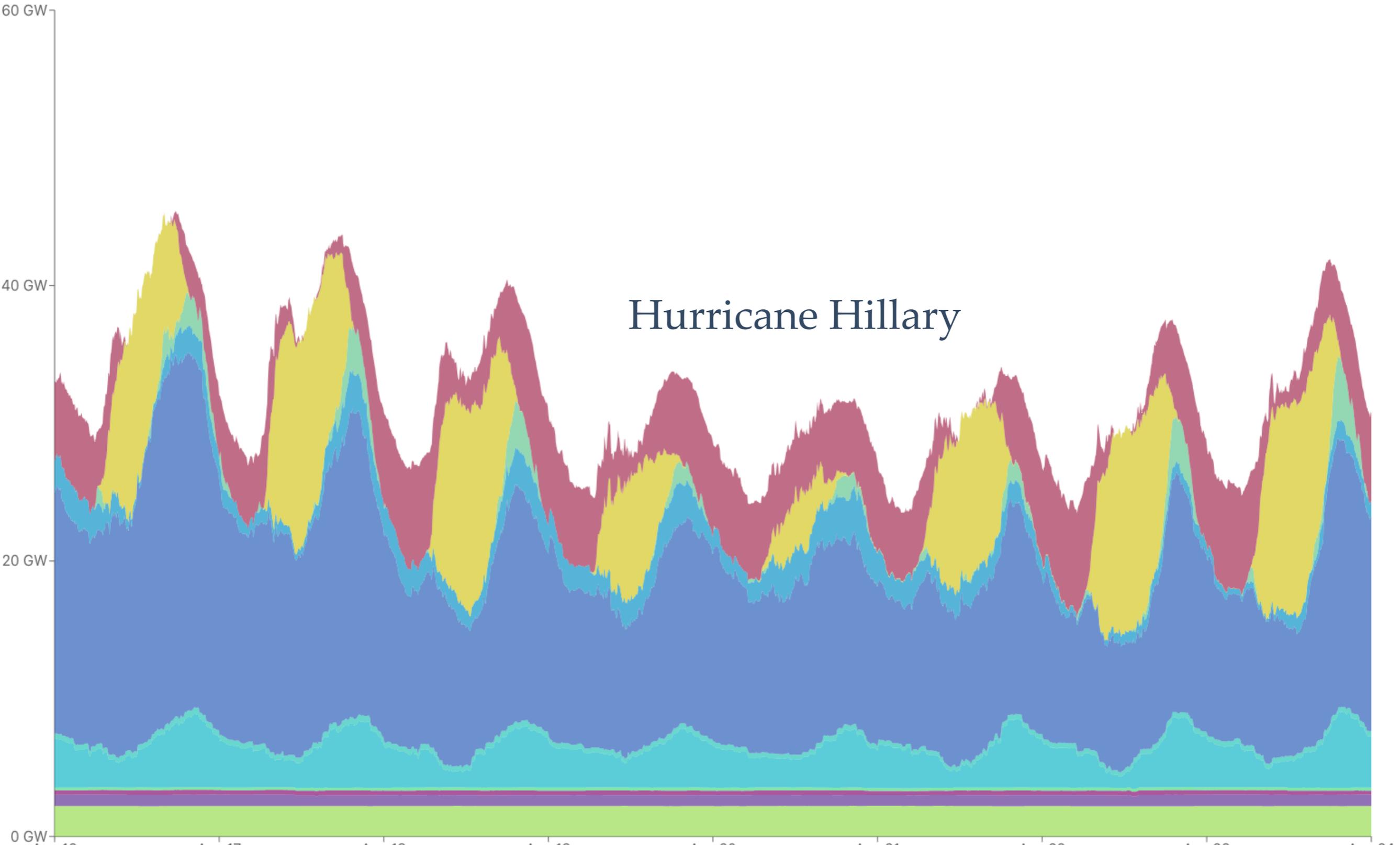
Global Horizontal Solar Irradiance

National Solar Radiation Database Physical Solar Model



Fuel Mix - CAISO

Aug 16 - Aug 23, 2023

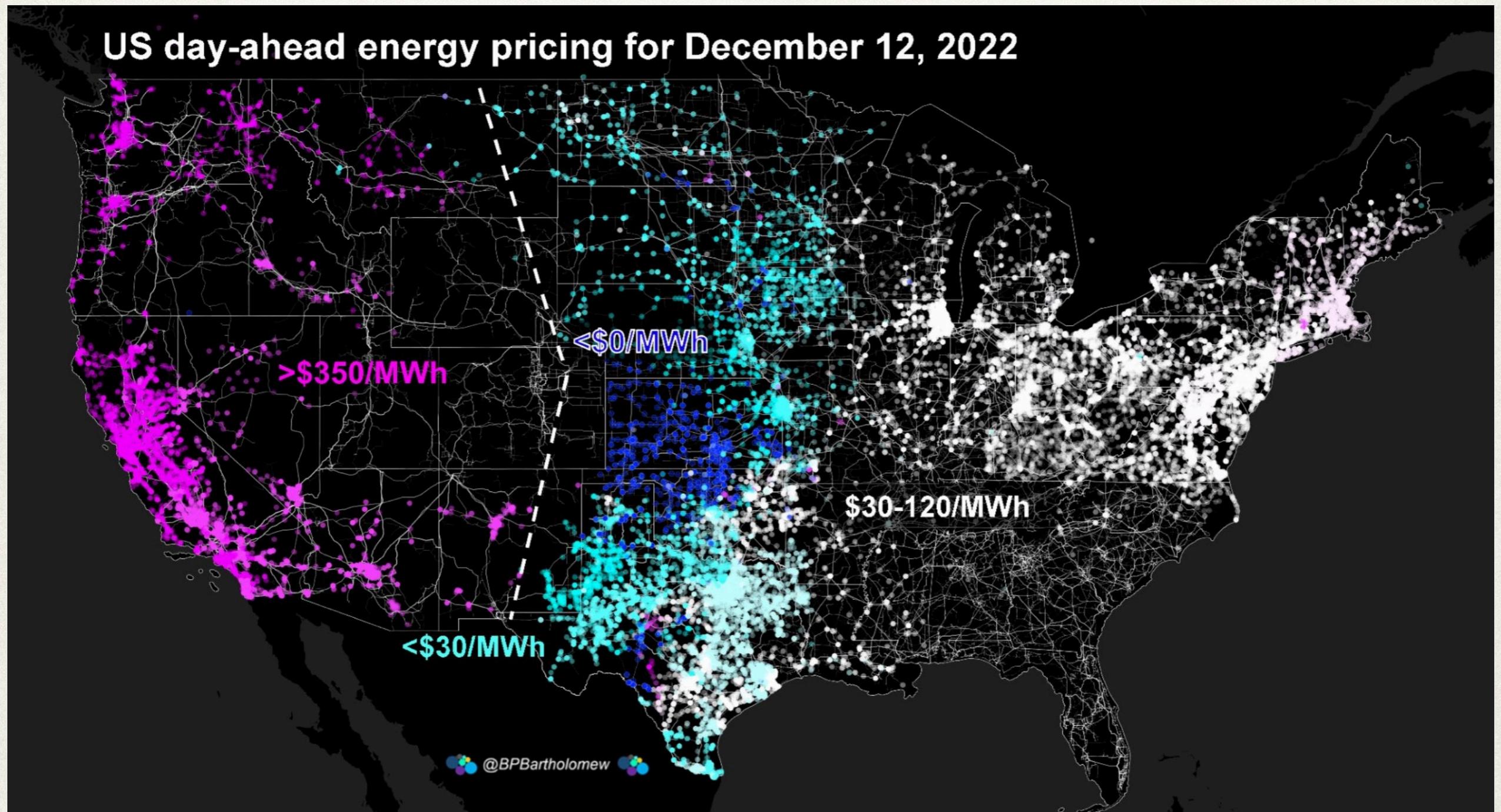


Hurricane Hillary

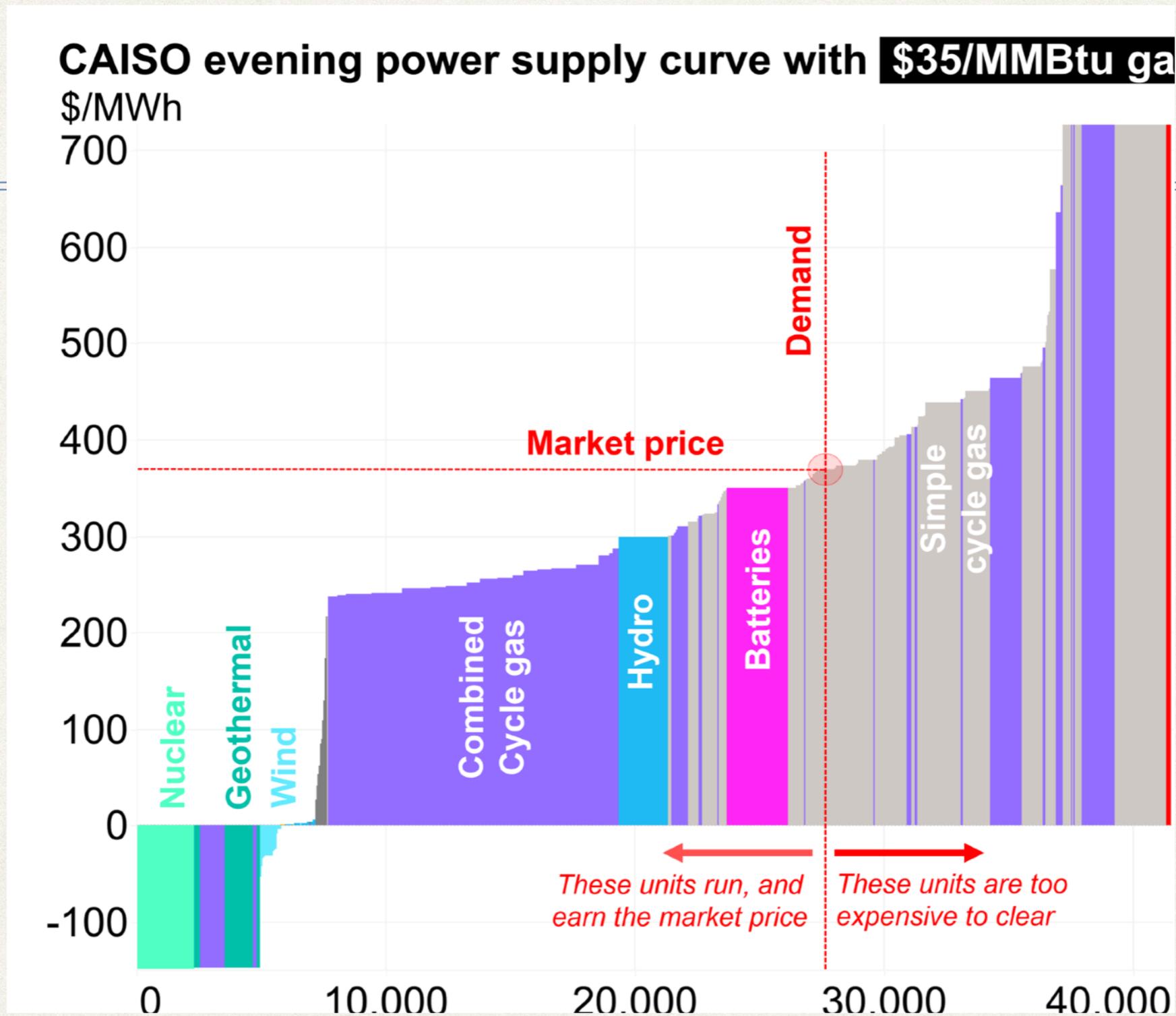
Nuclear Geothermal Biomass Biogas Large Hydro Small Hydro Natural Gas Coal Wind Batteries Solar Imports

Location, Location, Location

<https://themeritorder.substack.com/about>



The Merit Order

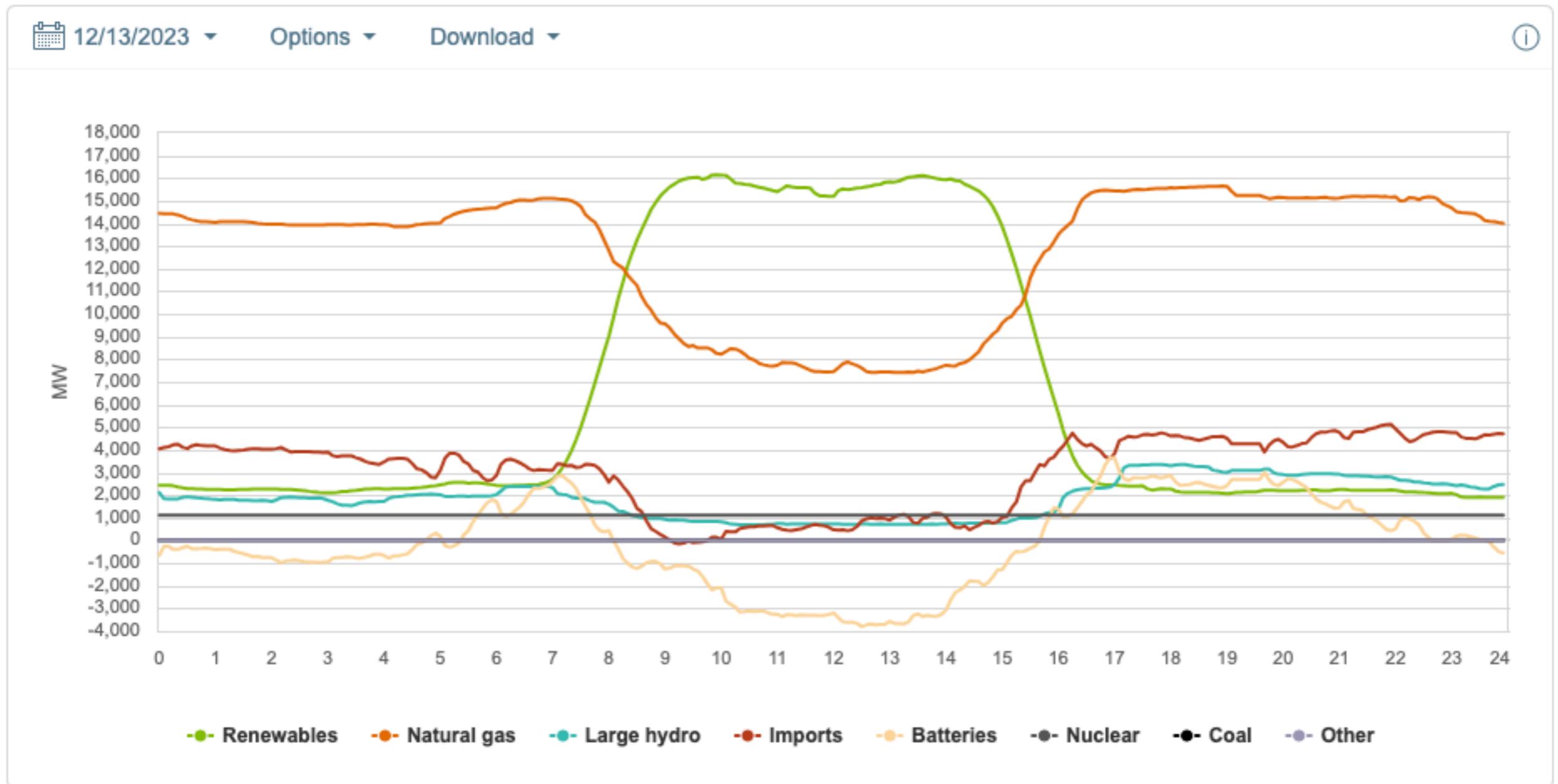


Brian Bartholomew <https://themeritorder.substack.com/about>
<https://www.nrel.gov/docs/fy23osti/85332.pdf>

CAISO Accountability

Supply trend

Energy in megawatts broken down by resource in 5-minute increments.



<https://www.caiso.com/TodaysOutlook/Pages/supply.html>

Demand Response Saved the Grid

Today's Outlook

Demand

Supply

Emissions

Prices

AS OF 15:45 09/08/2022

Current

Demand trend

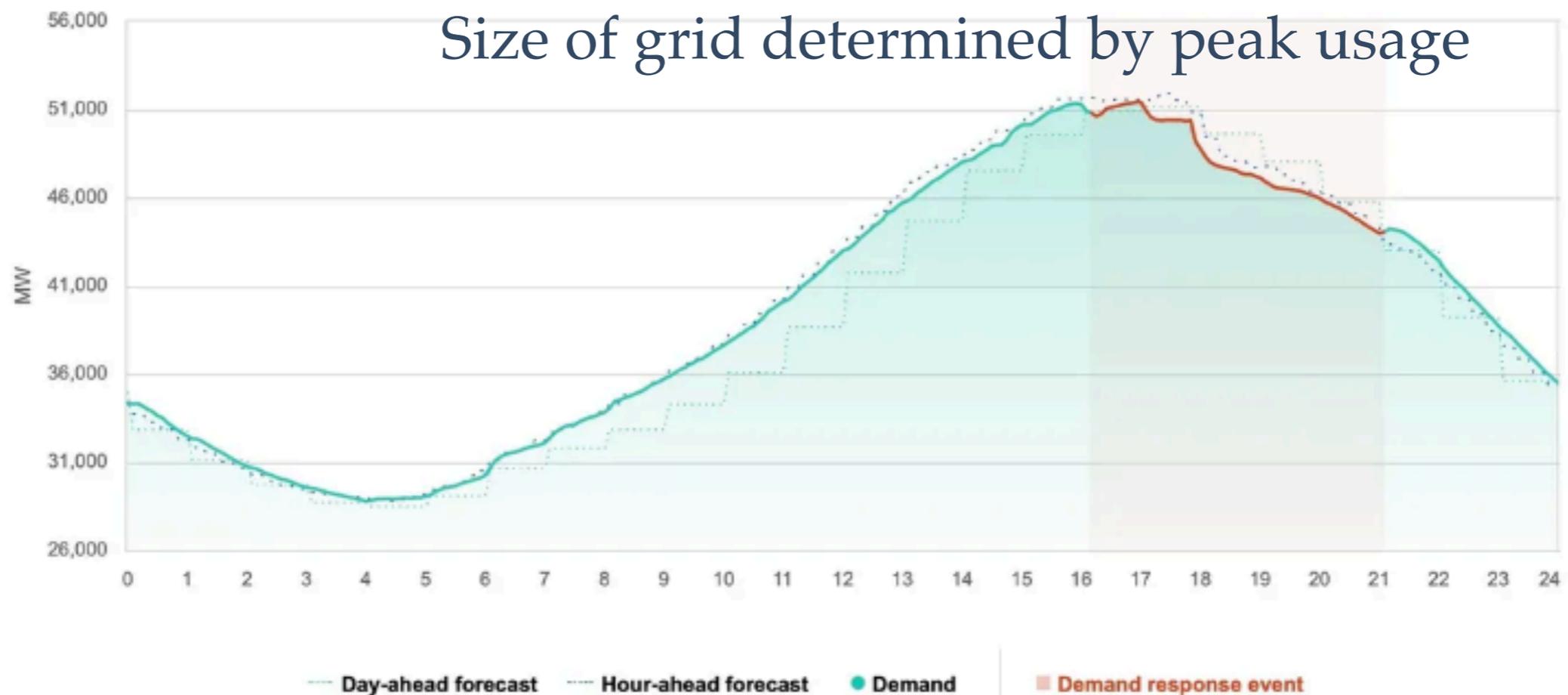
Net demand trend

Resource adequacy trend

7-day resource adequacy trend

System demand, in megawatts, compared to the forecasted demand in 5-minute increments.

09/06/2022 Options Download

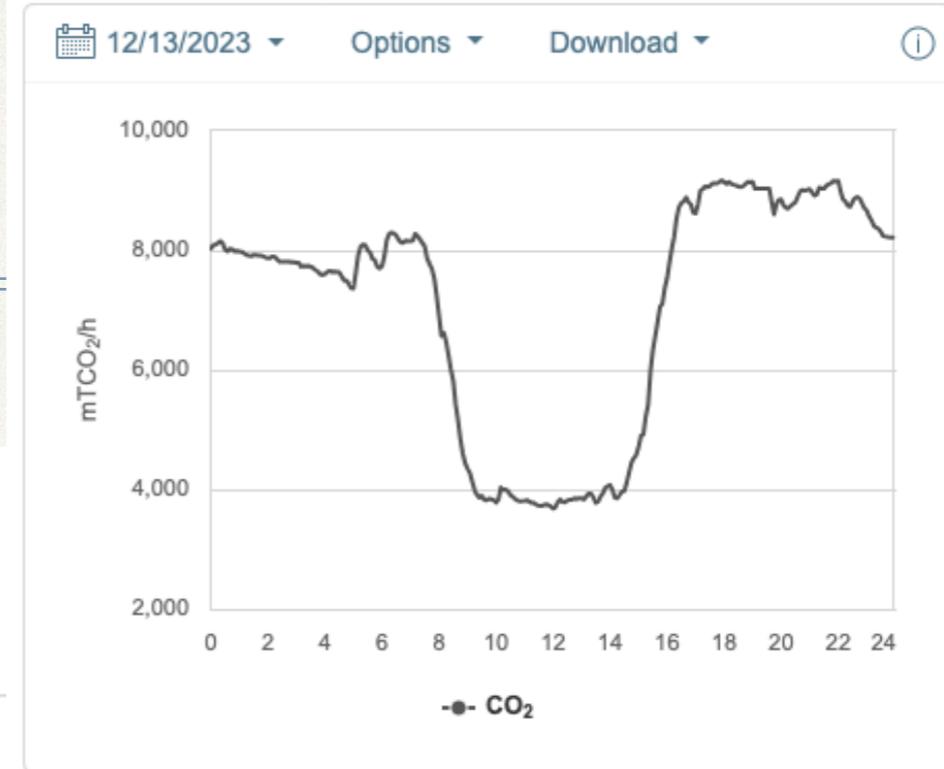


CAISO's actual and forecasted demand for Sept. 6, when emergency text alerts led to a 2,000-megawatt decrease in electricity use (CAISO)

CO2 Reporting

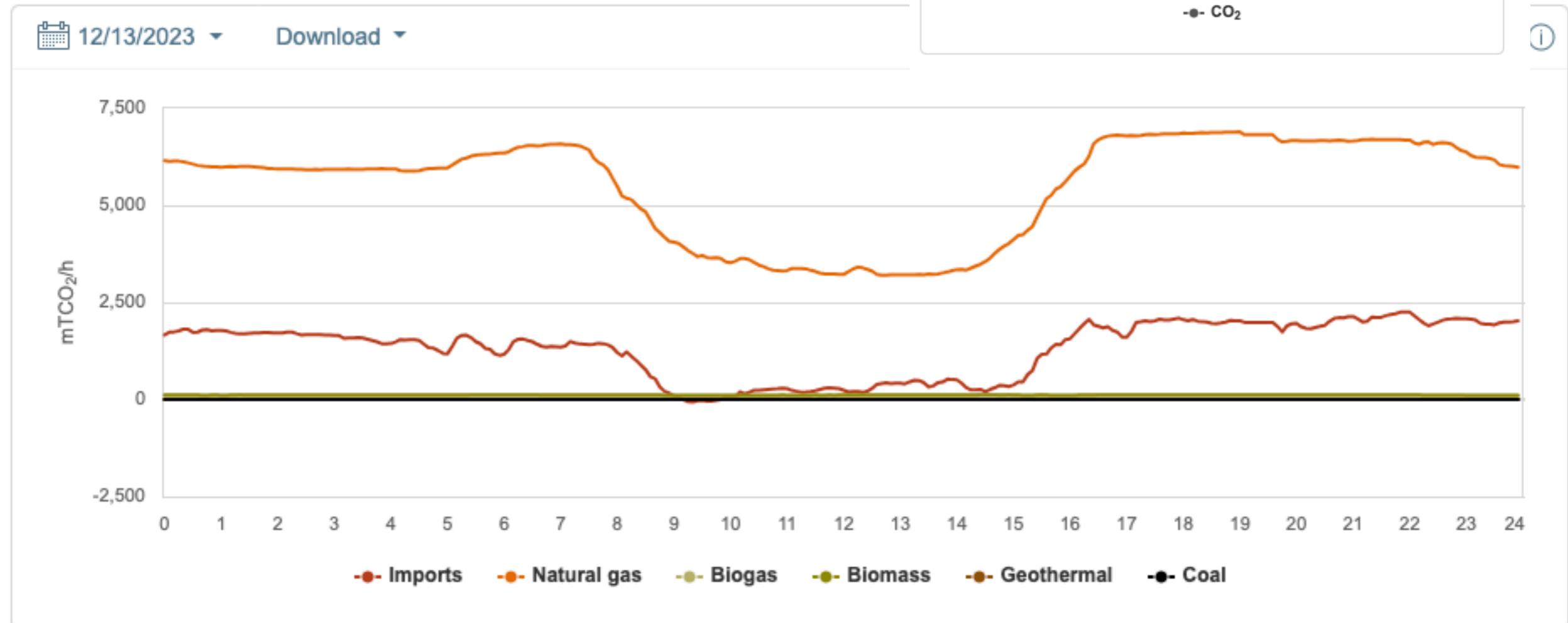
Total CO2 trend

Total CO2 produced in five-minute increments.



CO2 per resource trend

CO2 broken down by resource in five-minute increments.

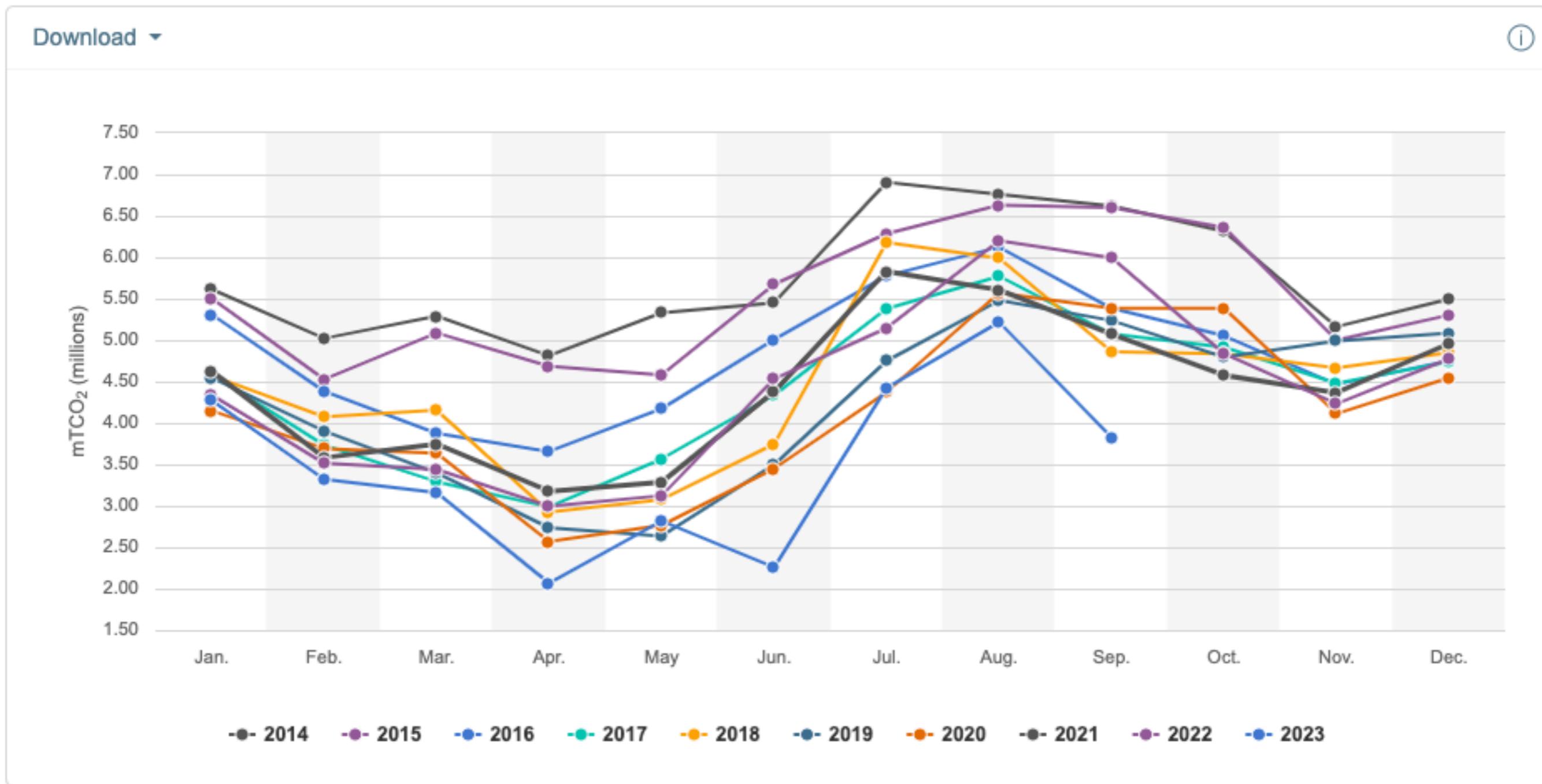


Uneven Progress

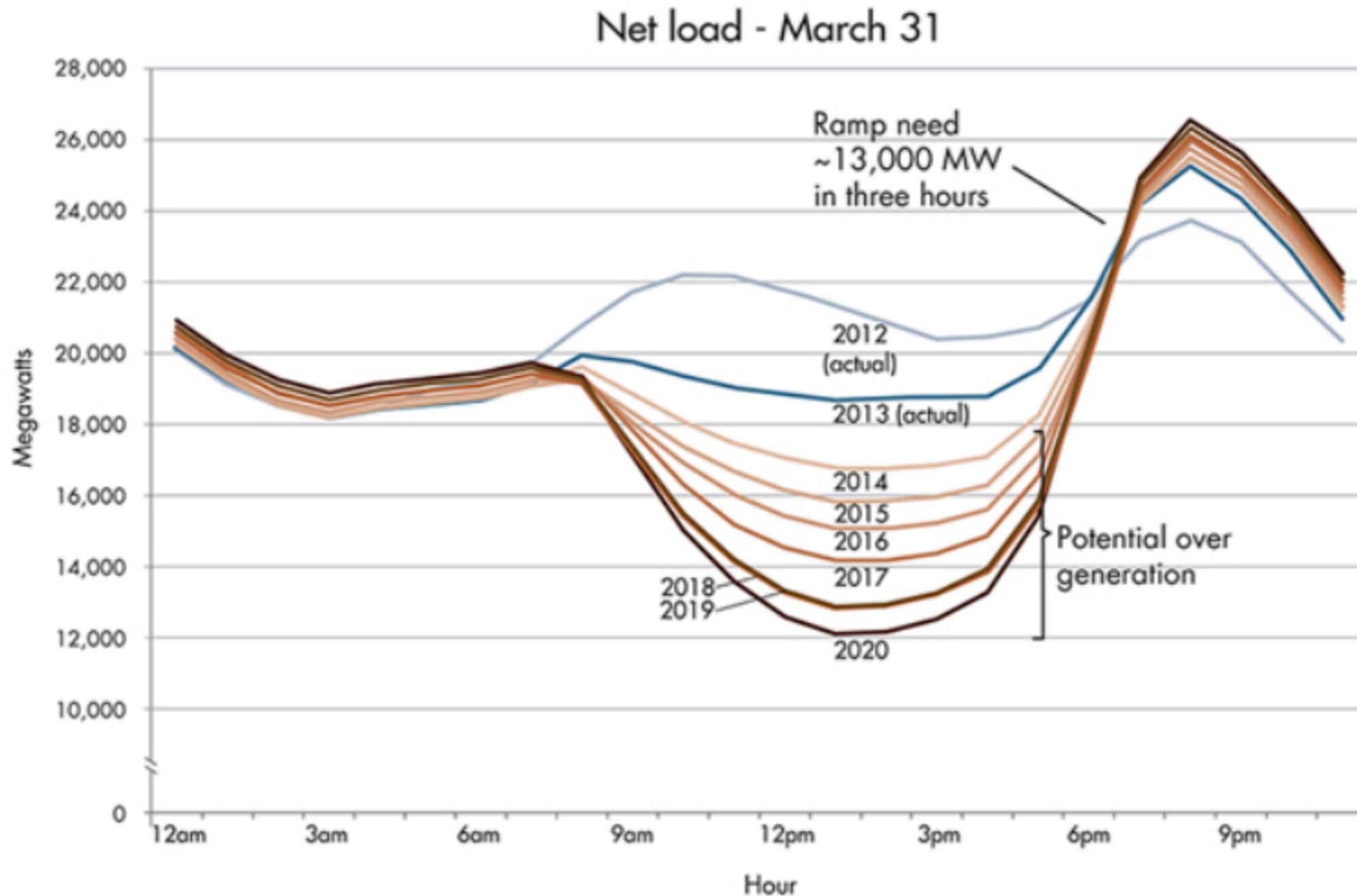
Historical CO₂ trend

Yearly snapshot of CO₂ emissions by month.

Dry Years: 2012-2016, 2020-2022

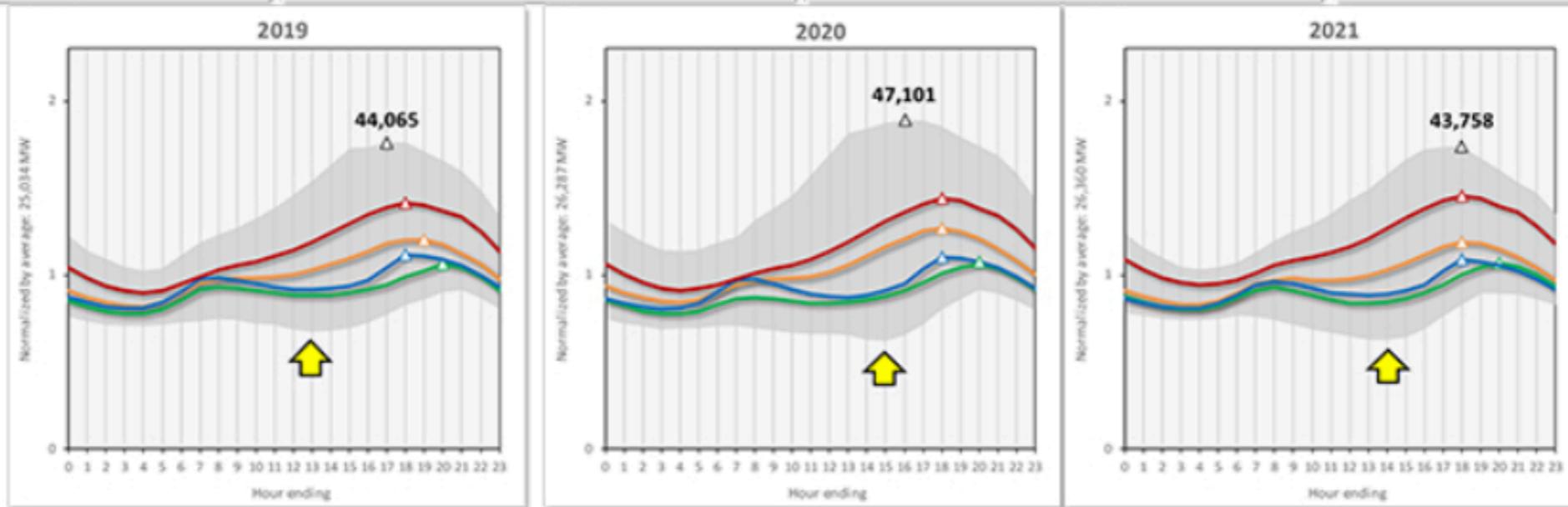
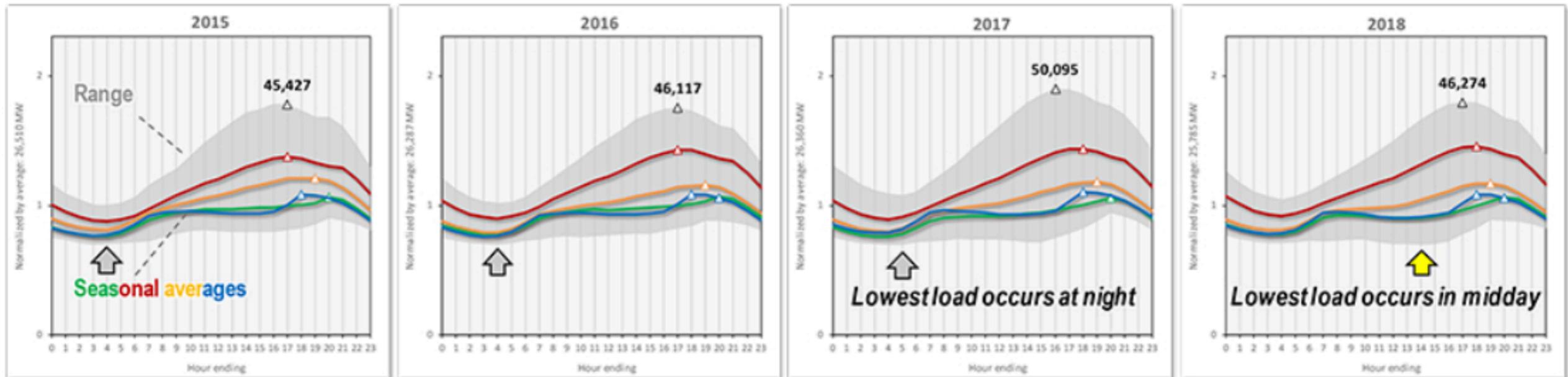


Duck Curve



<https://www.caiso.com/about/Pages/Blog/Posts/Storage-surpasses-5000-MW-on-the-CAISO-grid.aspx>

CAISO load

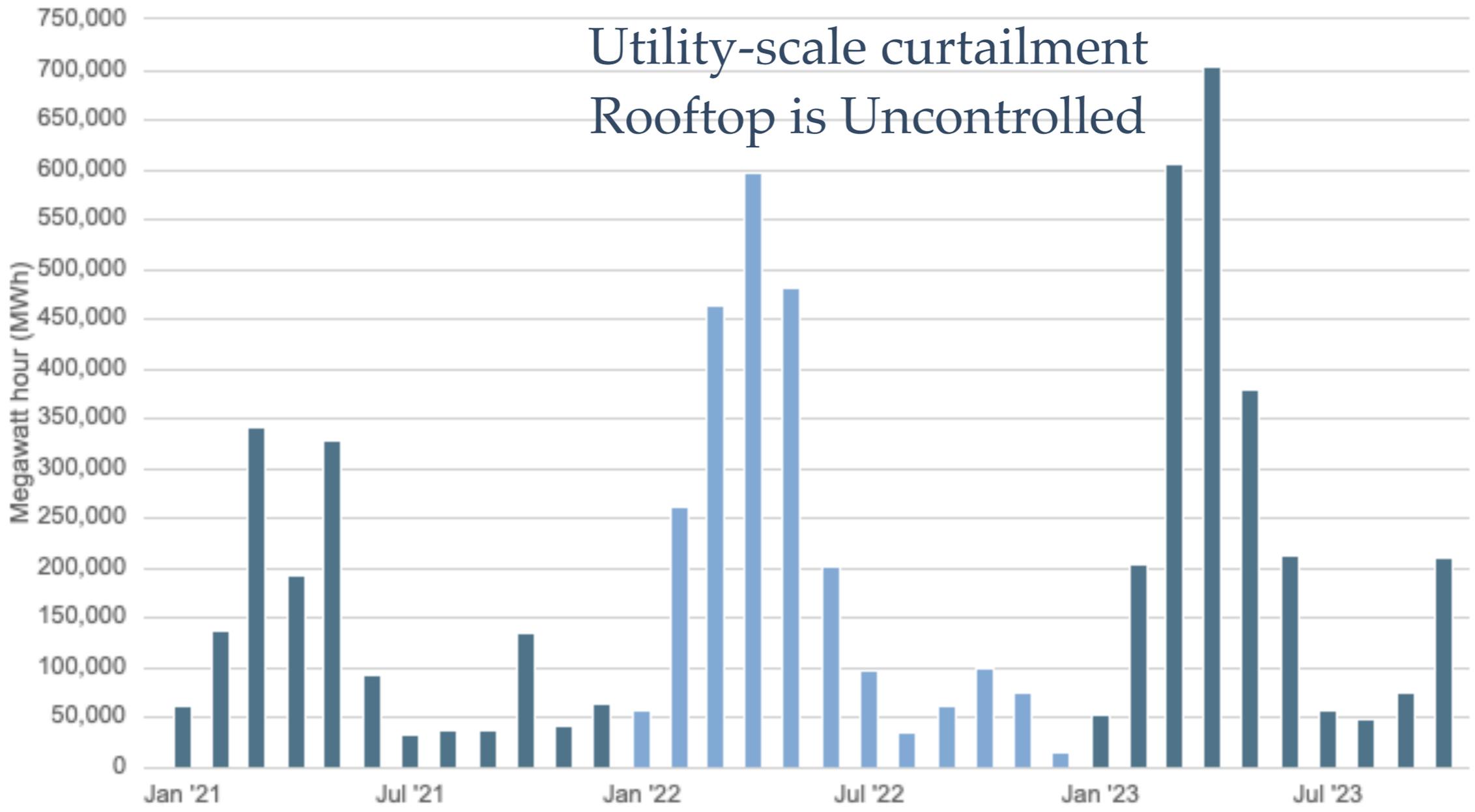


CAISO Curtailment

Wind and solar curtailment totals by month

View ▾

Download ▾





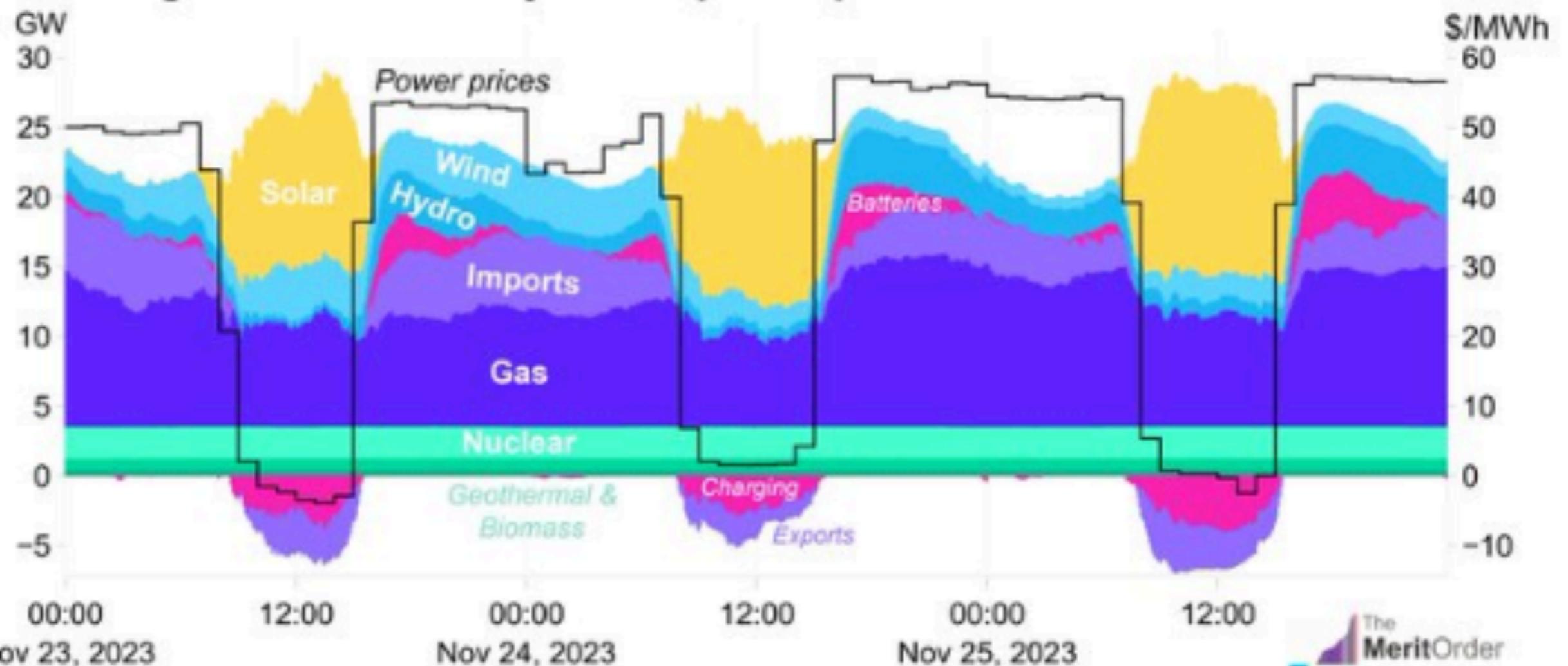
Brian Bartholomew

@BPBartholomew



Some great Black Friday deals on California midday power

CAISO generation and day-ahead power prices

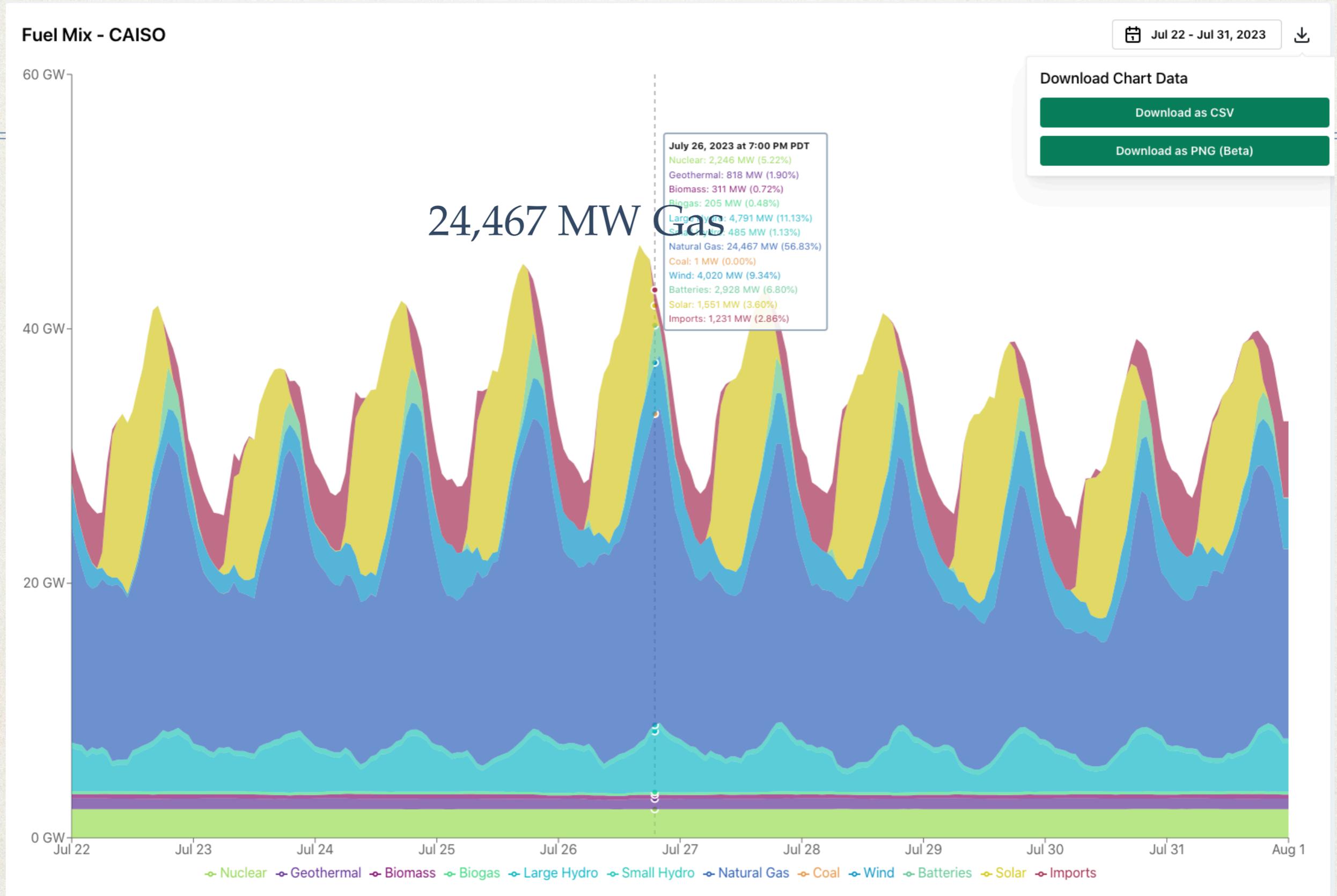


Data: CAISO, GridStatus | Chart: @BPBartholomew | Note: Utility-scale only, SP15 hub prices

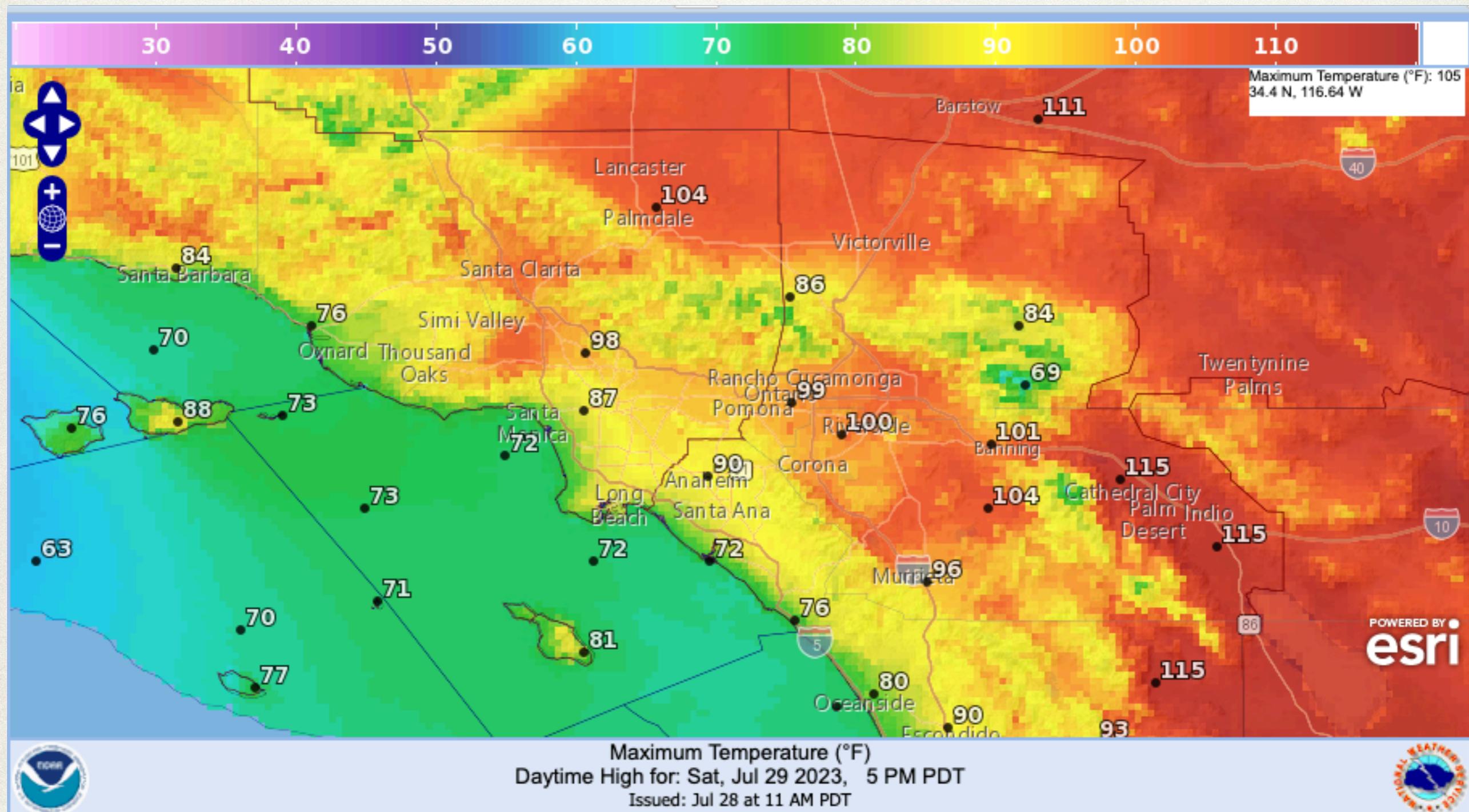


4:42 PM · Nov 26, 2023 · 83.3K Views

Impact of Inland Housing Growth



Cool Coast, Inland Inferno



Electricity Demand w/ Cool Coast

Fuel Mix - CAISO

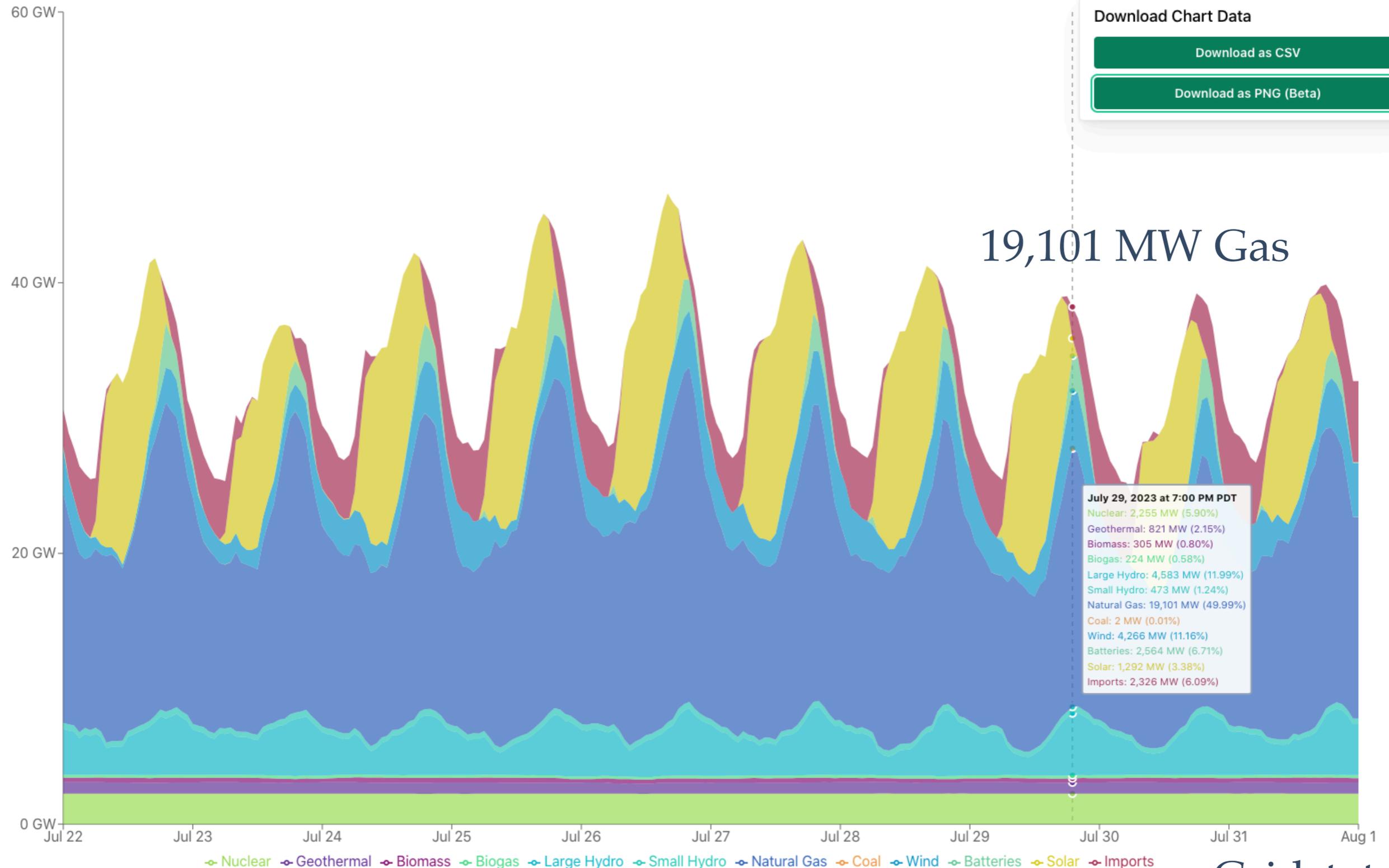
Jul 22 - Jul 31, 2023



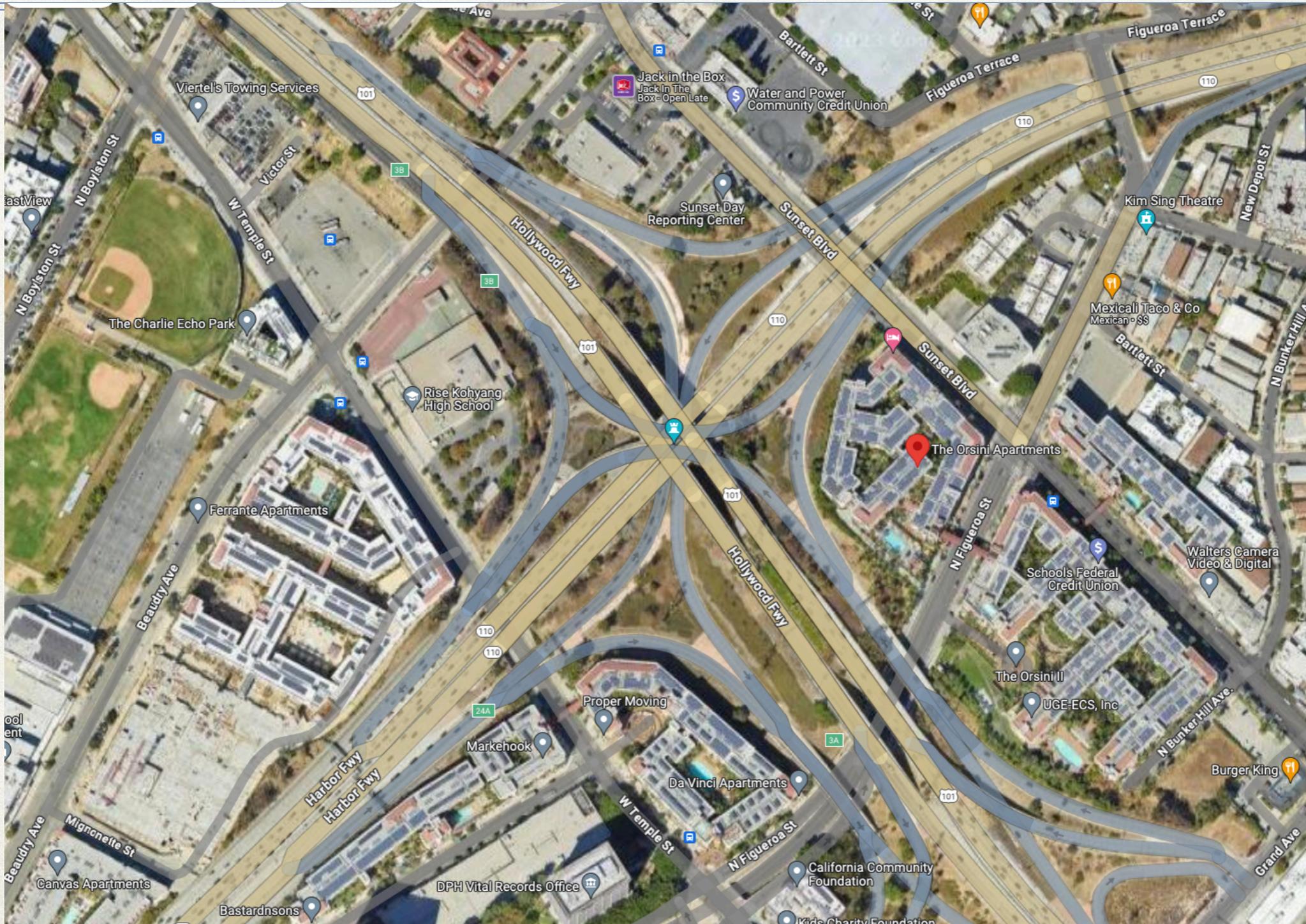
Download Chart Data

Download as CSV

Download as PNG (Beta)



Freeway Homes: HVAC Required



1000+ Homes in one complex

Hazardous to open windows



What can we do to hasten Decarbonization

- ❖ Combat NIMBYism & Dark Money
- ❖ Center vulnerable, Repeal 218, UBI (rent, utilities, food, mobility)
- ❖ Infill housing near jobs, in milder climates
- ❖ Regional Transmission to Wind
- ❖ Demand Response
- ❖ Stop driving cars, use right-sized vehicles (eBikes), use transit
 - ❖ EVs (eCars) are a last resort, not first resort

The EVs we need: eBikes/eTrikes

Cargo-Ready

The GSD is made to fit your life, including all your stuff. Our ecosystem of accessories includes a wide range of cargo-carrying gear designed to keep your loads secure and stable for wobble-free hauling. You may not have thought of using a bike to pick up groceries, home improvement supplies, or plants for your garden –but now you will.



Tern GSD ad

- 2 eBikes = cargo capacity of Tesla Y
- 160 Cargo Bikes for same battery materials
- Park 10 eBikes in car stall
- Move 10x more in 10' lane

The EVs we need: Electric Trains



The EVs we need: Trolley Buses



<https://www.sfmta.com/getting-around/muni/munis-electric-trolley-buses>



More EVs



Attachable eHand-bike for Wheelchairs



Further Reading

Book Title	Author	Subject Area	Emphasis
The Grid	Gretchen Bakke	Anthropology	History of creation of US Grid, people who run it today
California Burning	Katherine Blunt	History, Finance	History of PG&E, culture, governance, liability
Short Circuiting Power	Leah Stokes	Political Science	Regulatory capture, RPS best accountability measure
Shorting the Grid	Margaret Angwin	Governance	Why RTOs are expensive for consumers, fragility/resilience, the case for nuclear
Solar Power	Dustin Mulvaney	Industrial Science, History	Solar power industry, political power
Sustainable Energy Transition	Dustin Mulvaney	Environmental Science	Textbook for calculations and tradeoffs
Energy in World History	Vaclav Smil	Engineering, History	World history of energy production and use
Natural Gas	Vaclav Smil	Engineering, History	How natural gas was developed, different technology over time
How Infrastructure Works	Deb Chanchra	History, Engineering, Ethics	Physical and Social history and design of resilient and ethical infrastructure.

Useful Sites

- ❖ eia.gov
- ❖ CAISO.com
- ❖ gridinfo.io
- ❖ nrel.gov
- ❖ lbl.gov
- ❖ <https://www.energy.ca.gov/programs-and-topics/programs/power-source-disclosure/power-content-label>
- ❖ <https://energyathaas.wordpress.com/>
- ❖ <https://themeritorder.substack.com/>