



DMSP Nighttime Lights

# The California Grid

Goal: Anywhere, Anytime, No One Left Behind

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Grace Peng, PhD

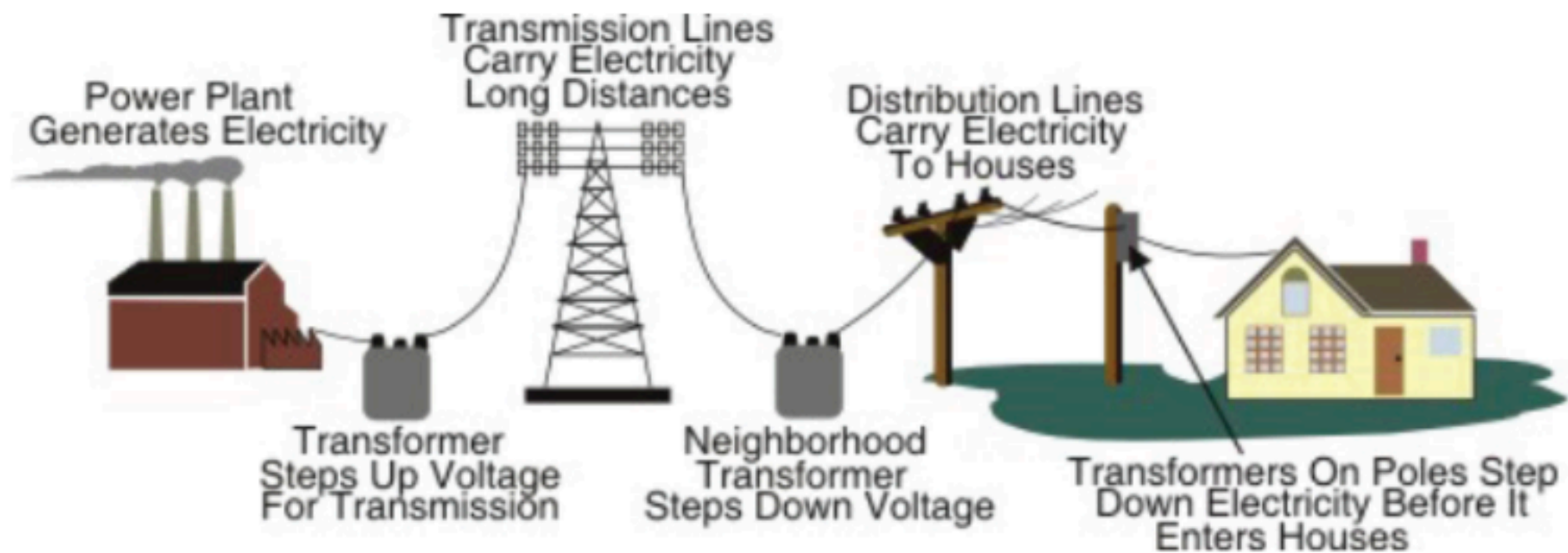
LWV Water & Infrastructure Group

14 December 2023



# General Idea

## Electricity Supply and Delivery



Source: The NEED Project<sup>13</sup>



# Social Network

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

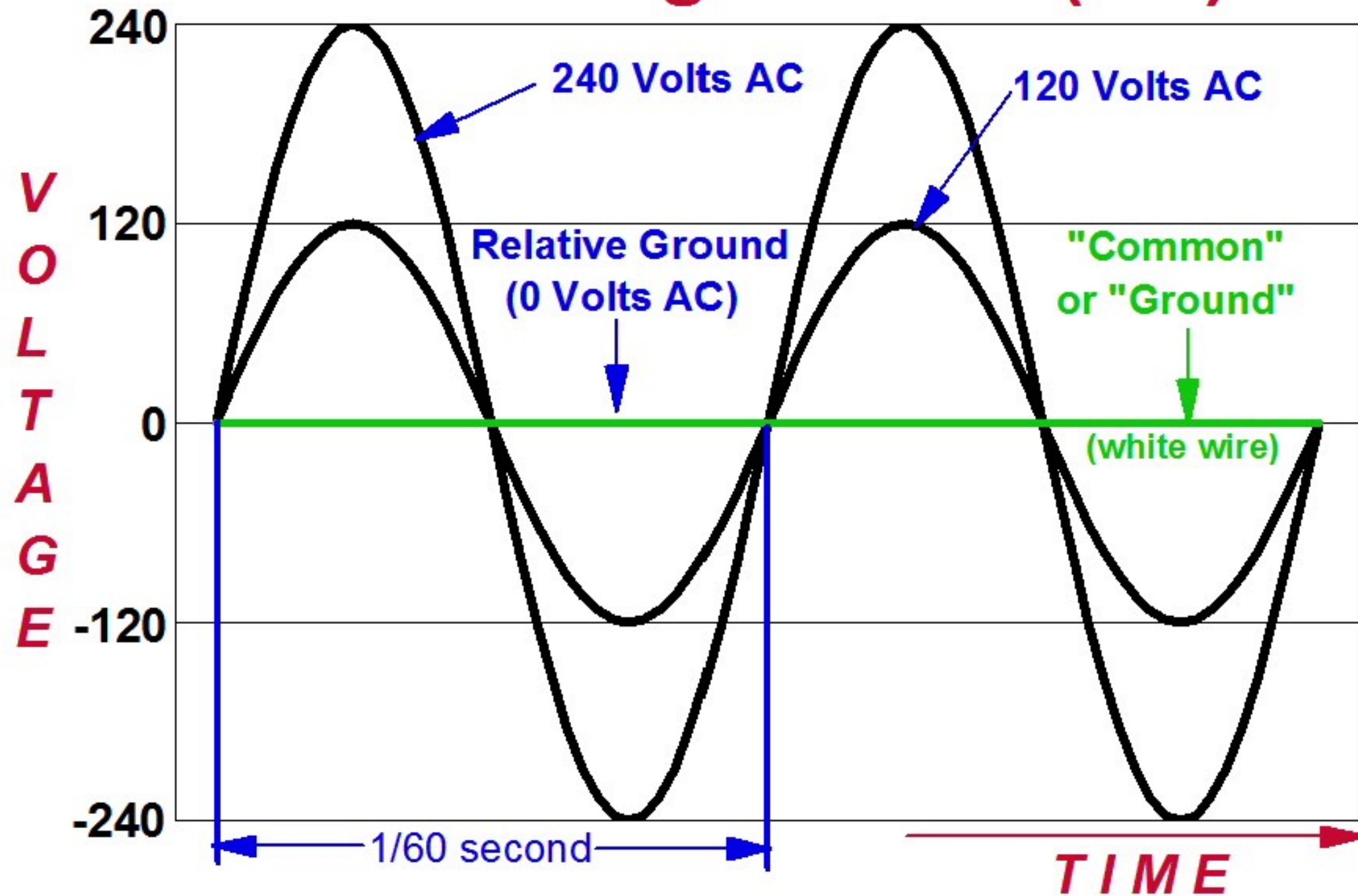
How  
Infrastructure  
Works

Inside the  
Systems  
That Shape  
Our World

Deb Chachra



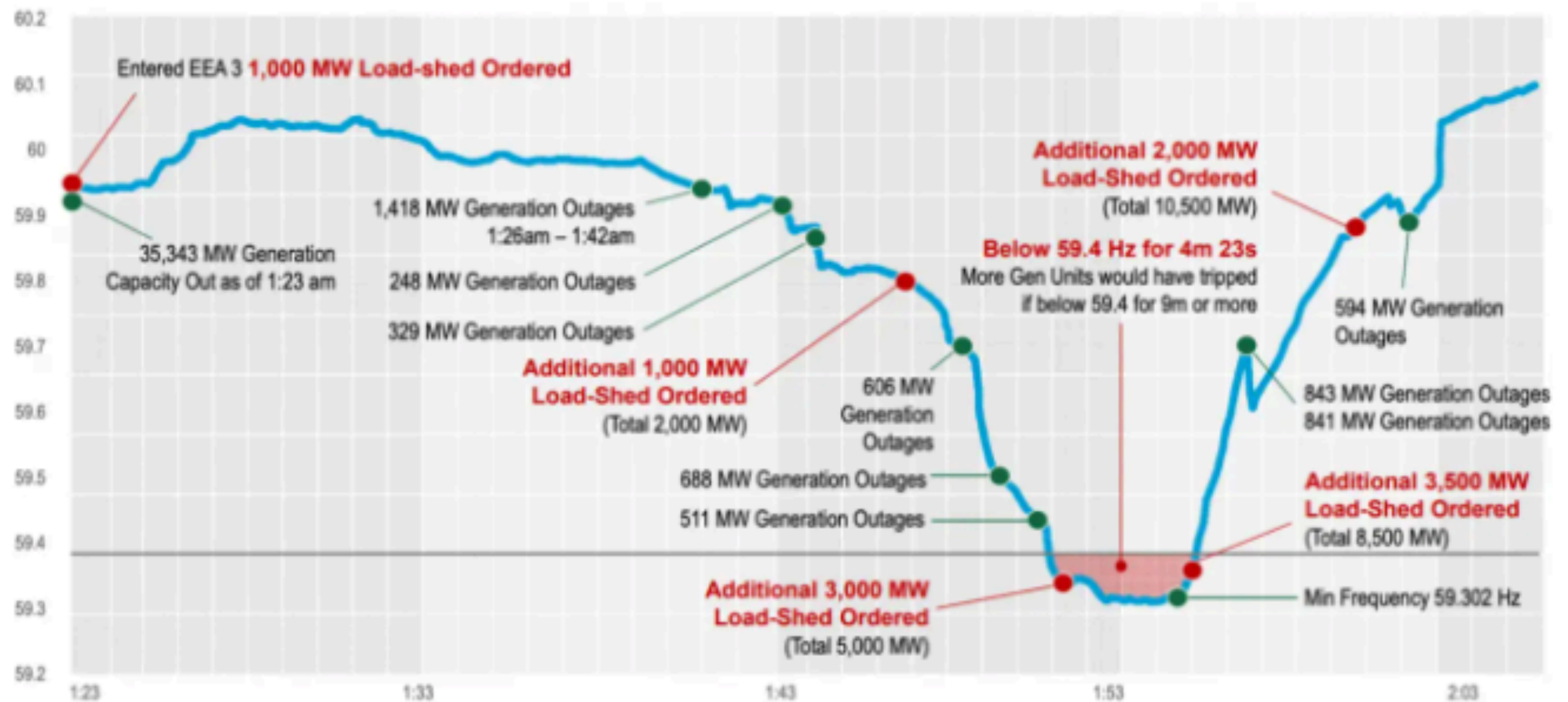
# Alternating Current (AC)





# When Demand Doesn't Match Supply

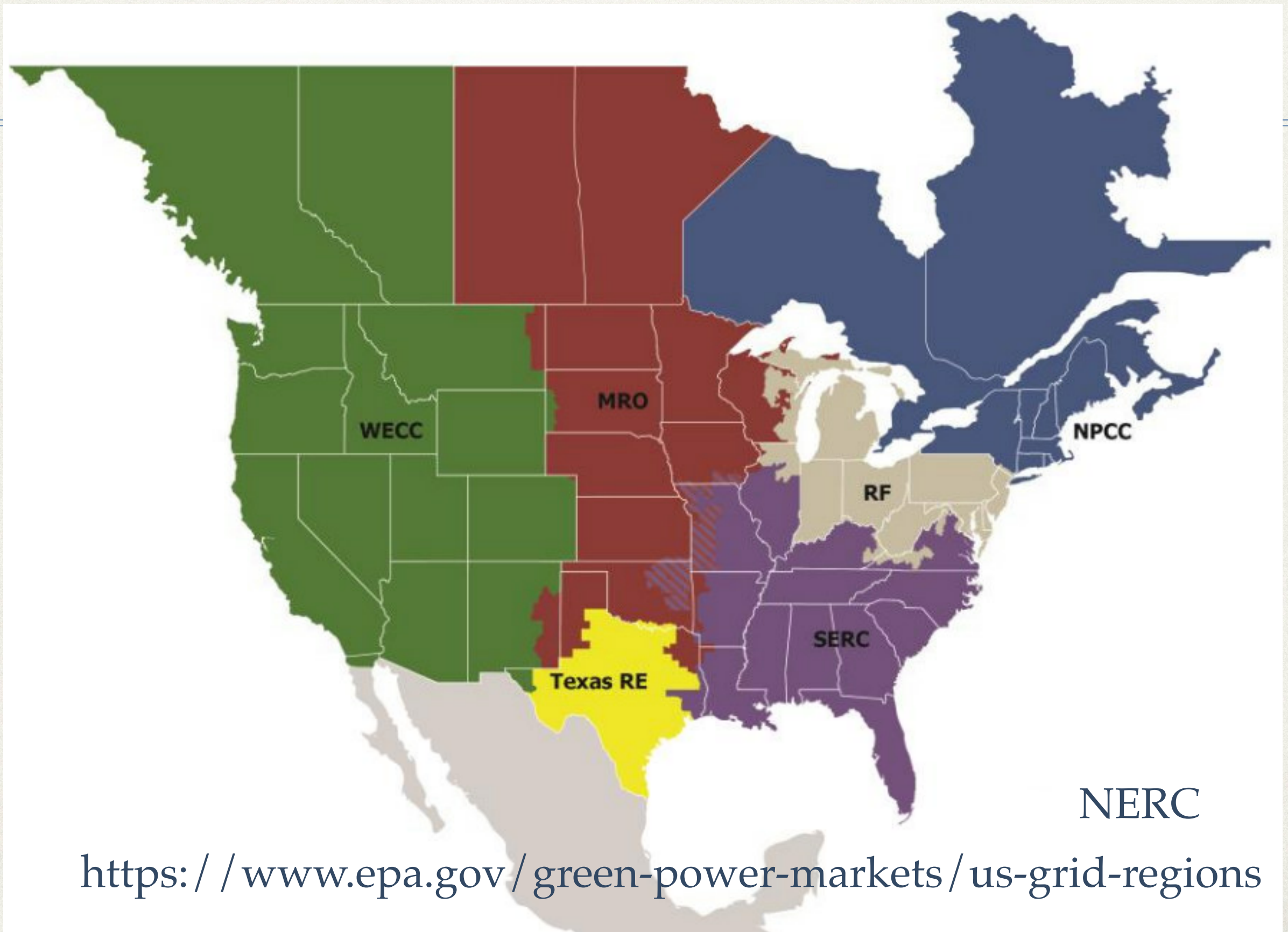
## Rapid Decrease in Generation Causes Frequency Drop



<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

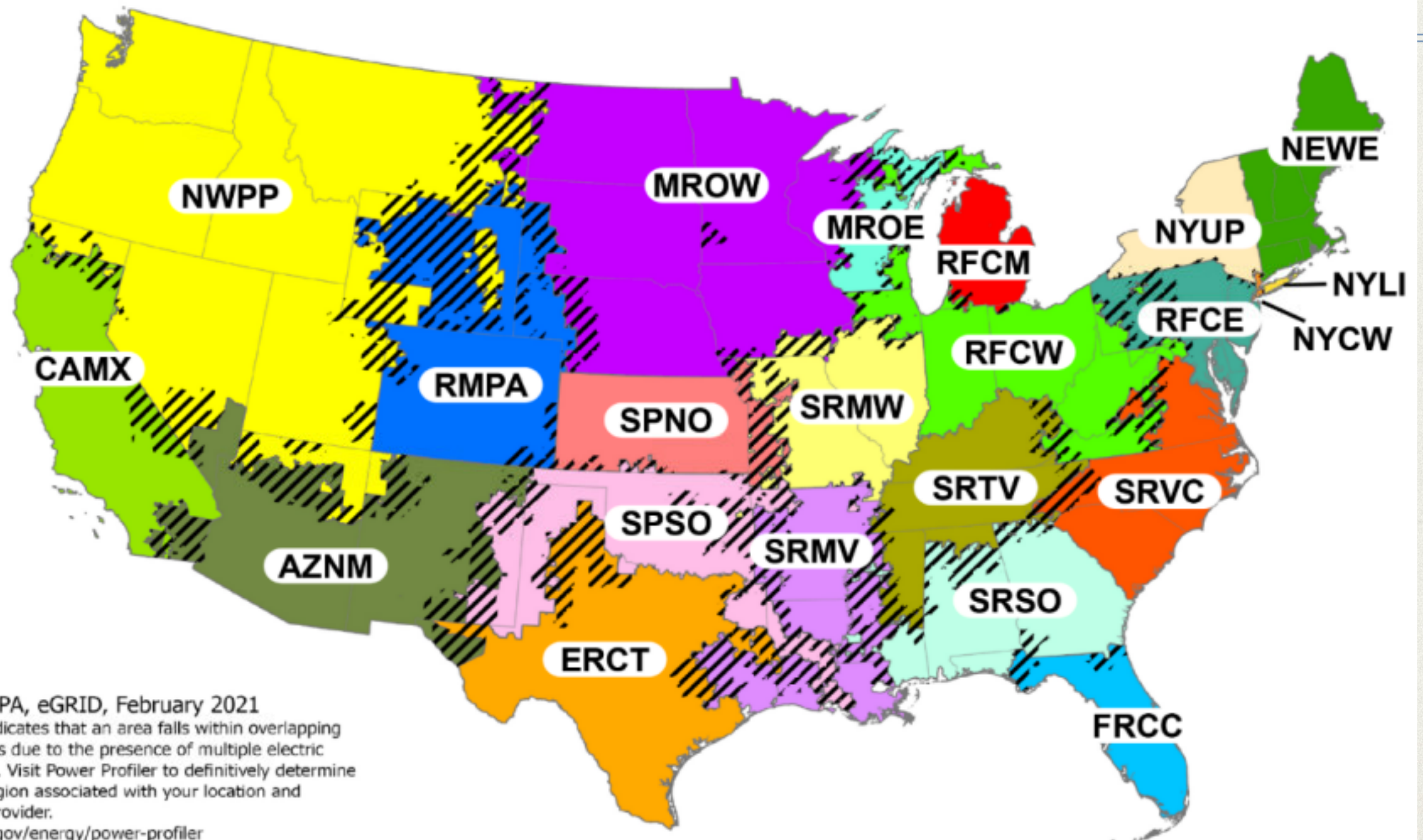


<https://www.epa.gov/green-power-markets/us-grid-regions>



# 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>



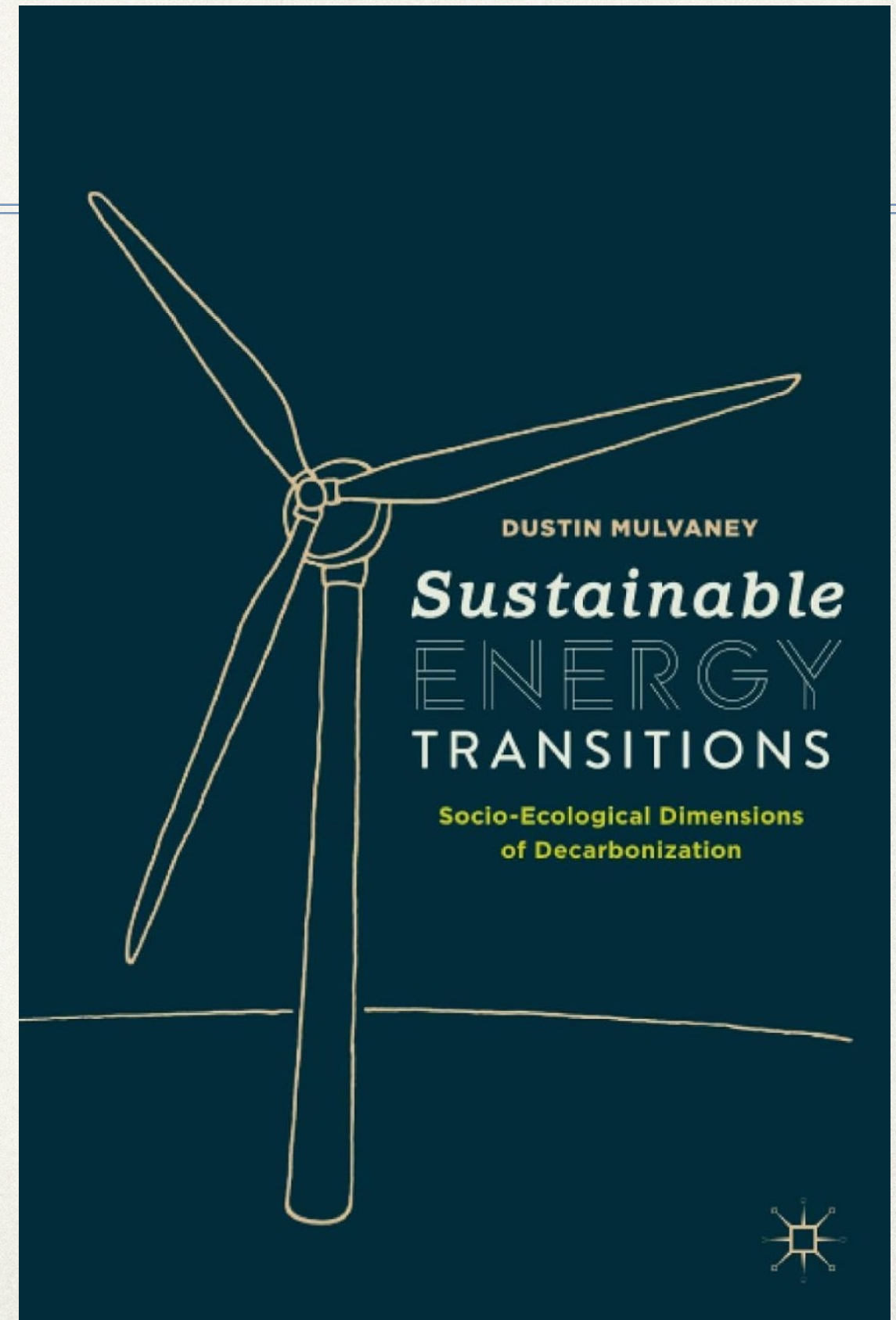
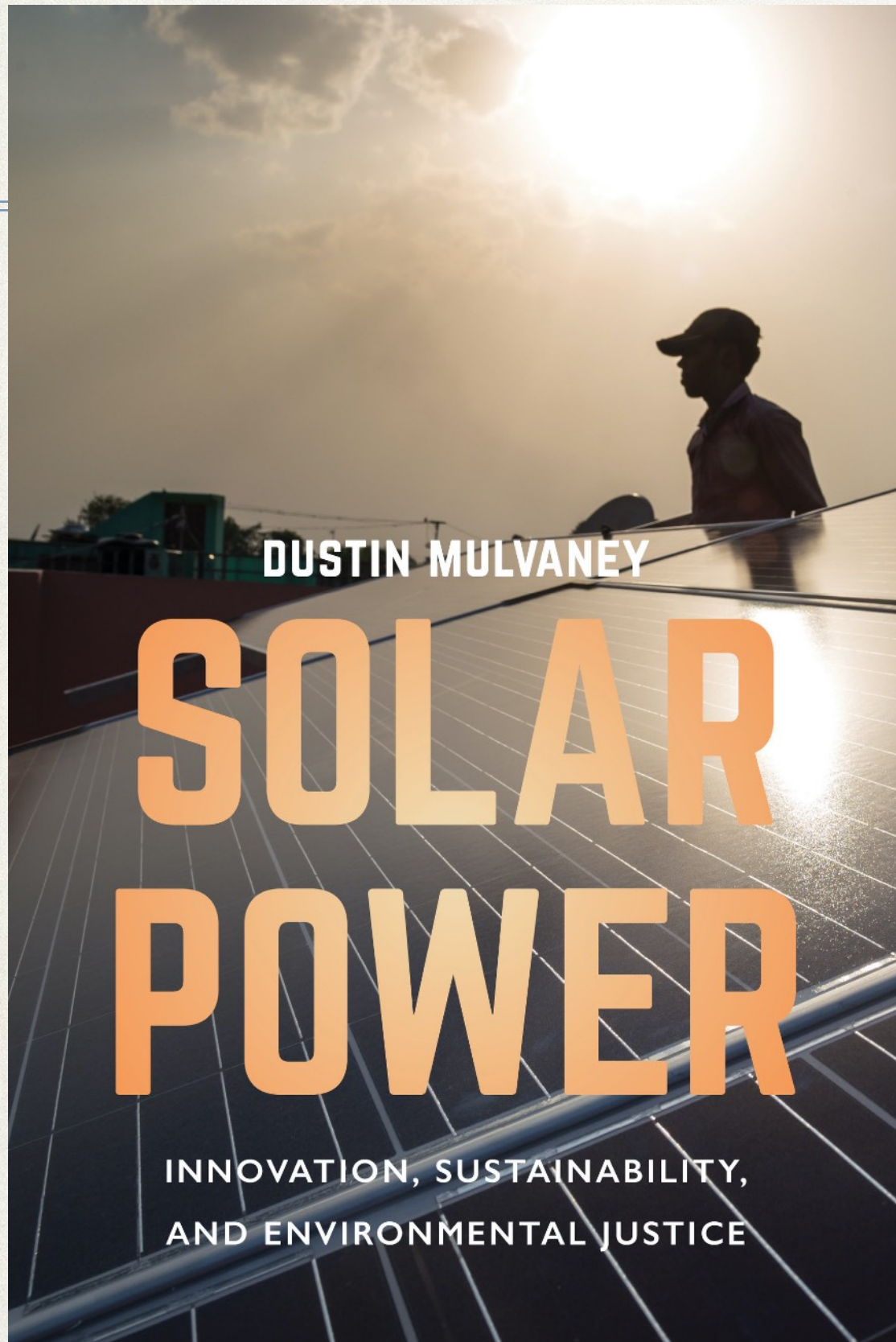
# Further Reading

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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
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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

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### 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.

<https://casetext.com/case/transource-pa-llc-v-defrank>



# RTO/ISO/CAISO

[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

GOING GREEN



ENERGY MATTERS  
BLOG

RC WEST



## 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**

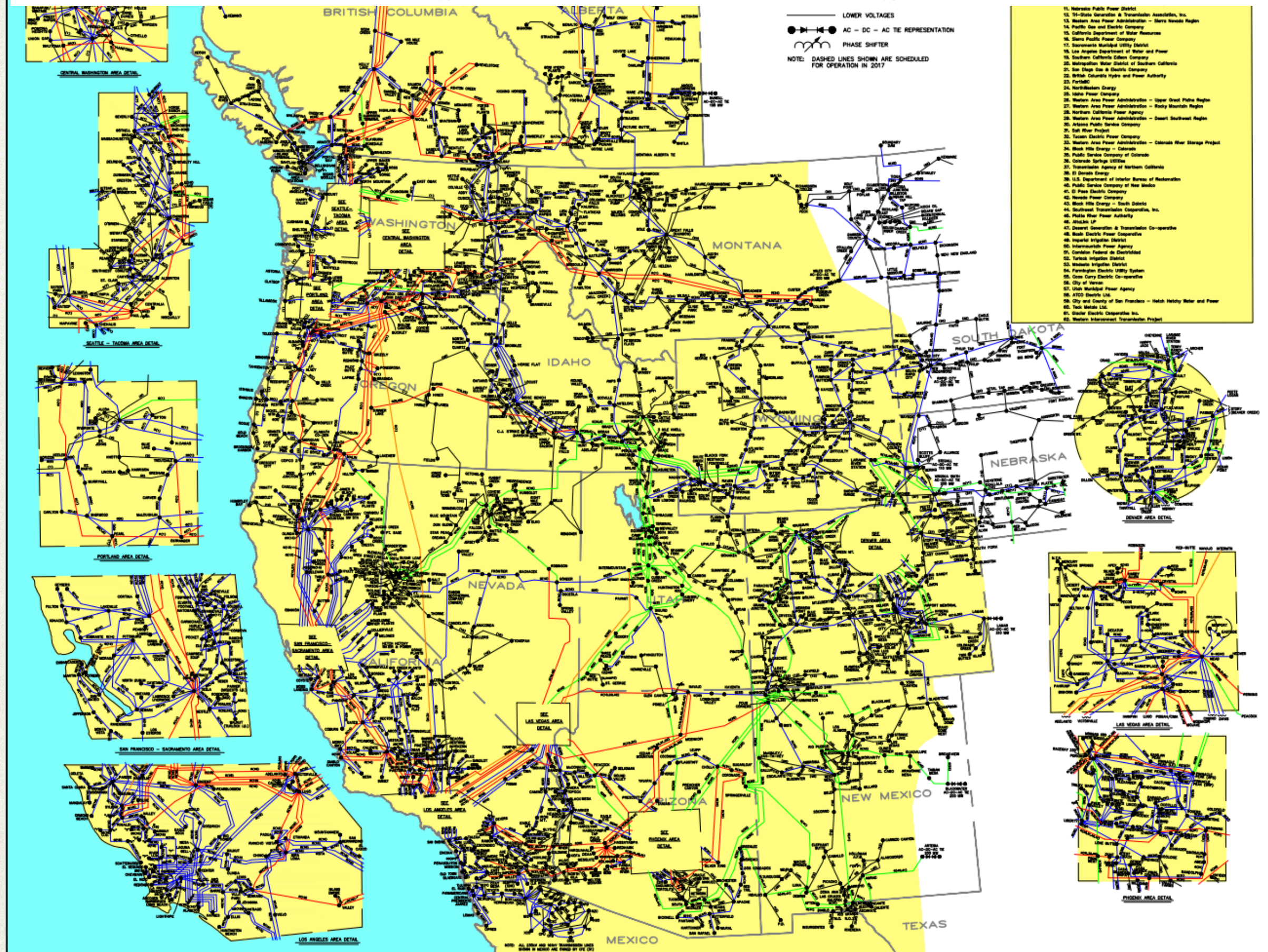
### MONDAY, 12/18/2023

- 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

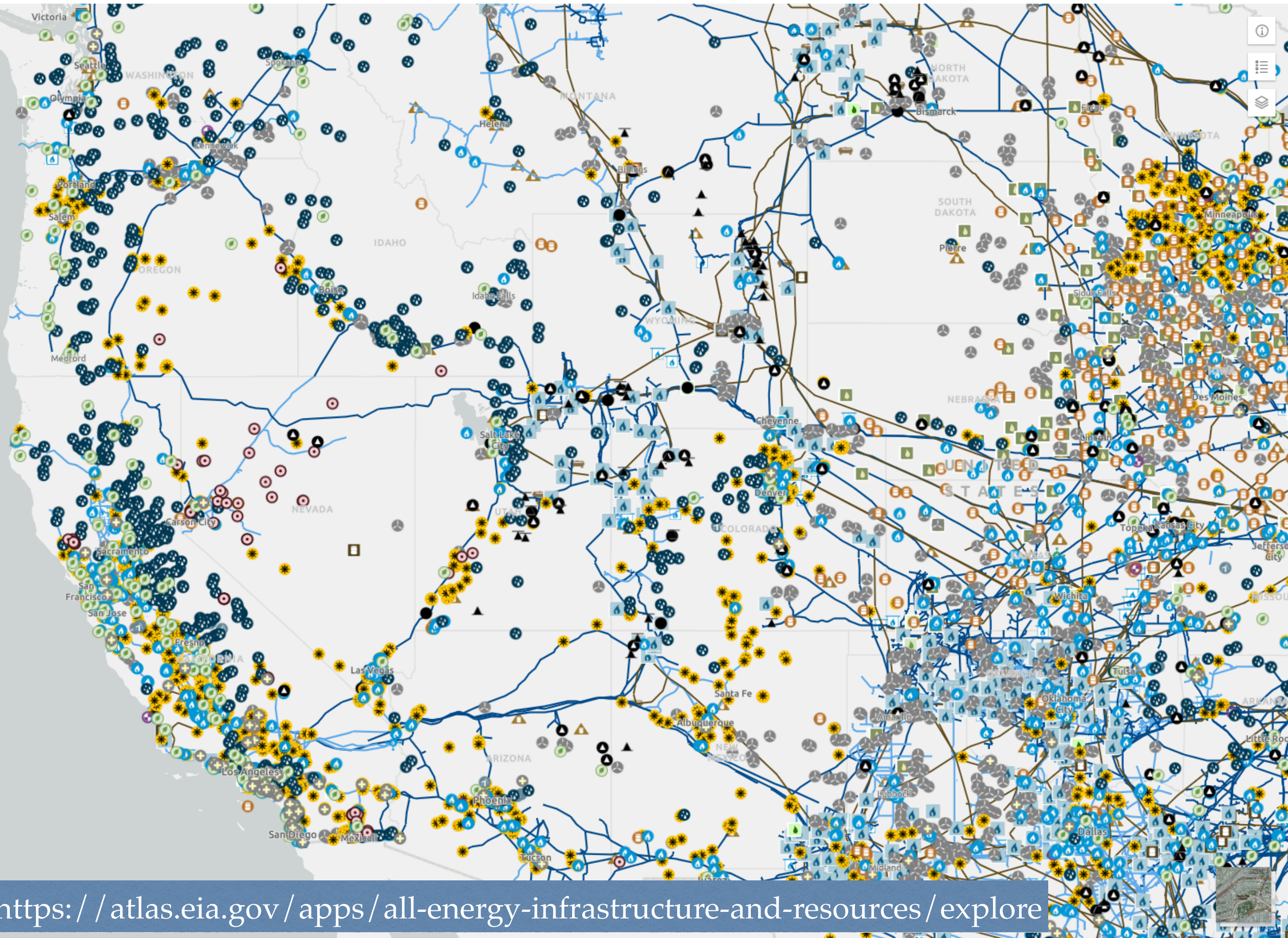
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- ❖ AC current stays within Western Grid
- ❖ DC current can be moved between Grids
- ❖ Moves PNW Hydropower to SoCal
- ❖ PNW has the water, we have the customers (load)

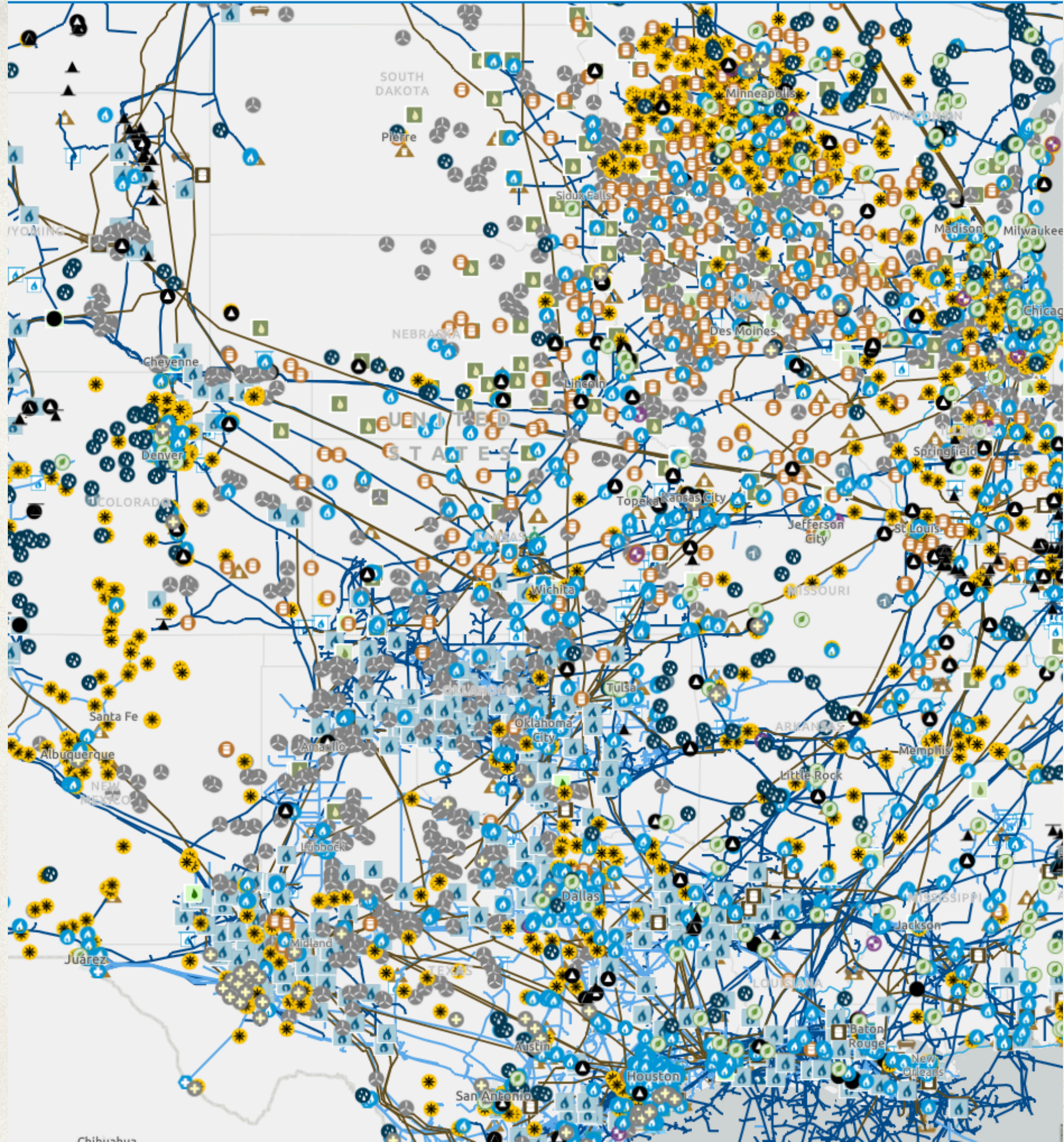




# All Energy Infrastructure and Resources



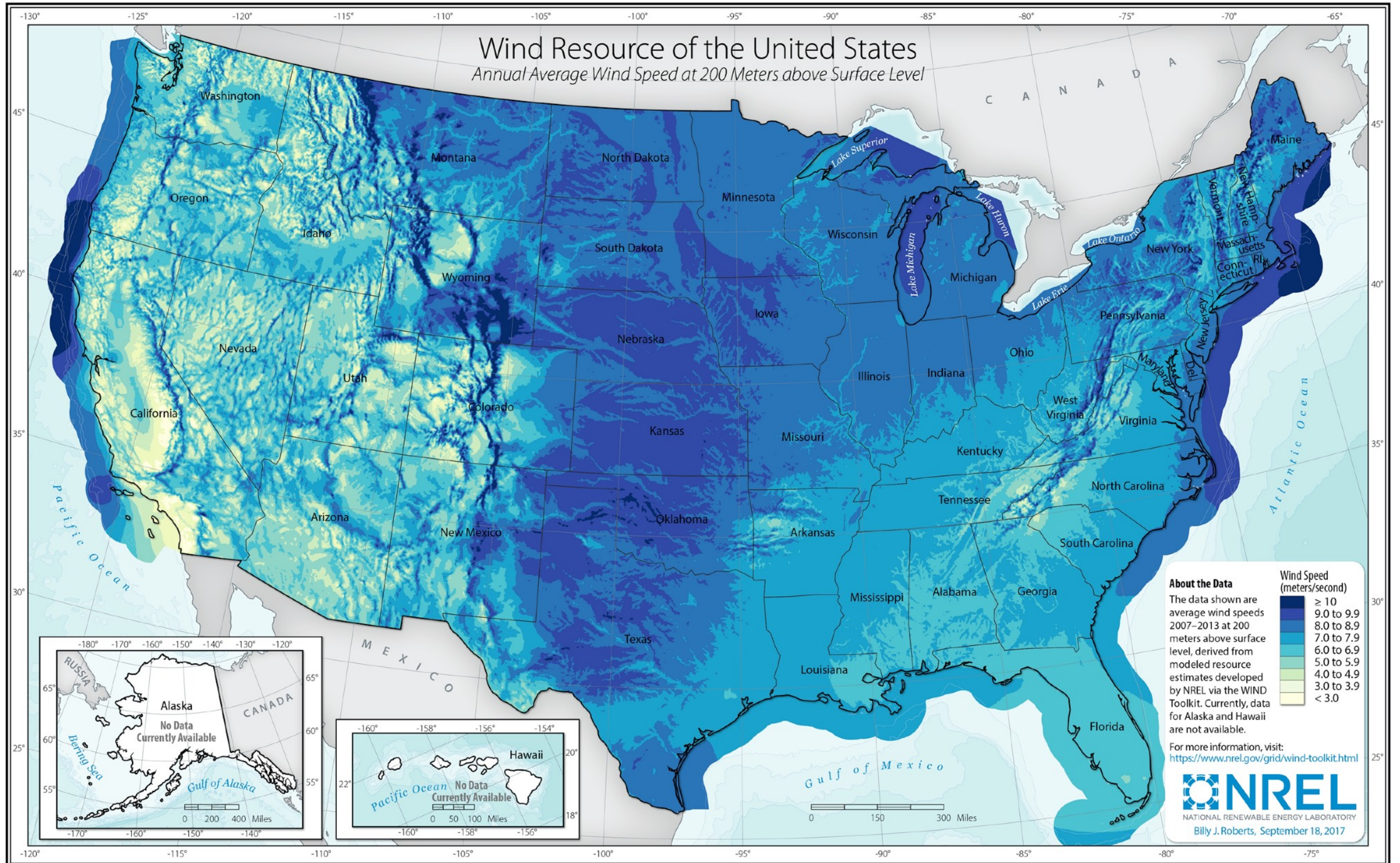






# Wind Resource of the United States

Annual Average Wind Speed at 200 Meters above Surface Level





# Wind Development Speedbumps

Deep Water

Endangered Species

Dark Money Opposition

Jones Act

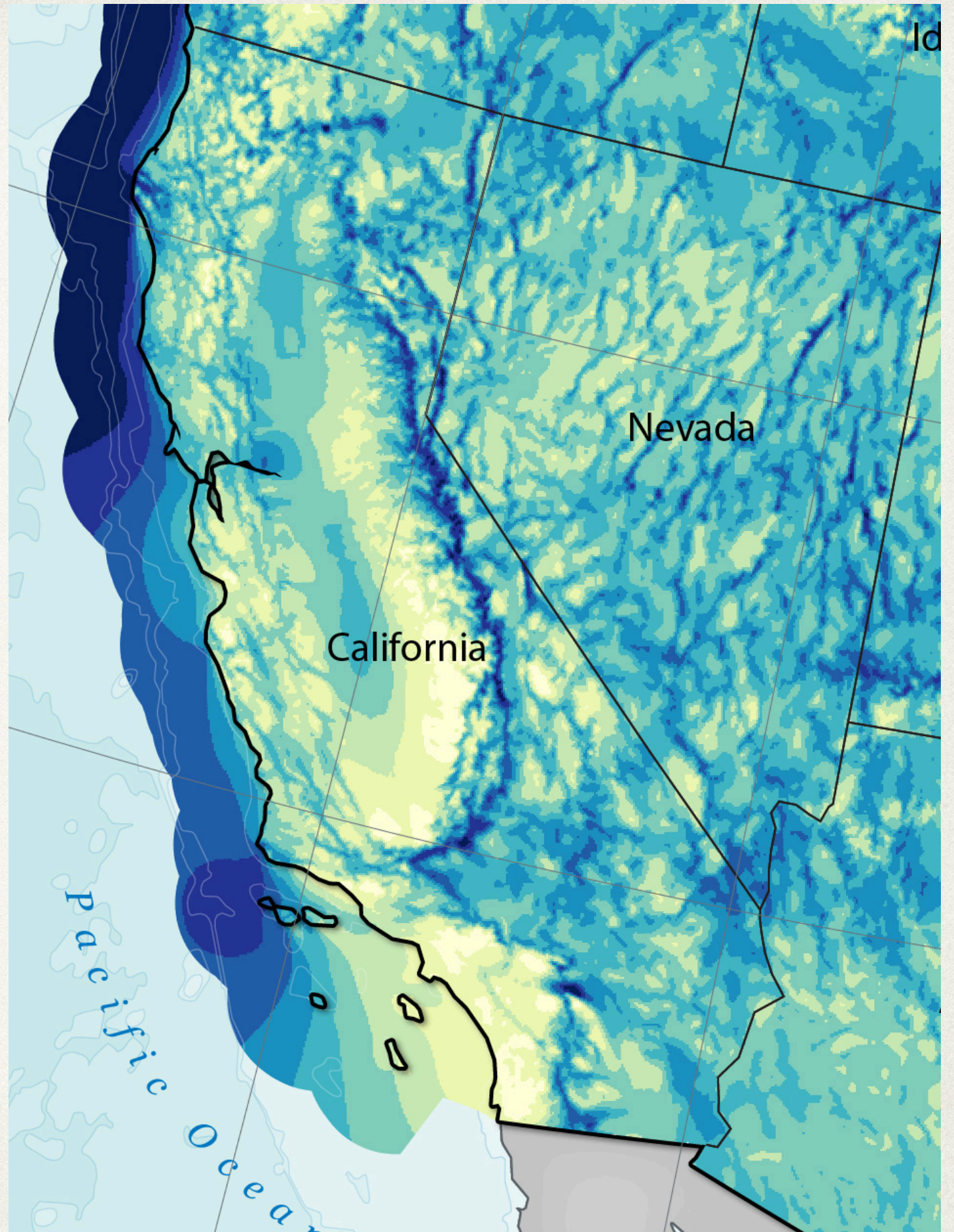
NIMBYs

Interest Rates

Supply Chain

Buy American

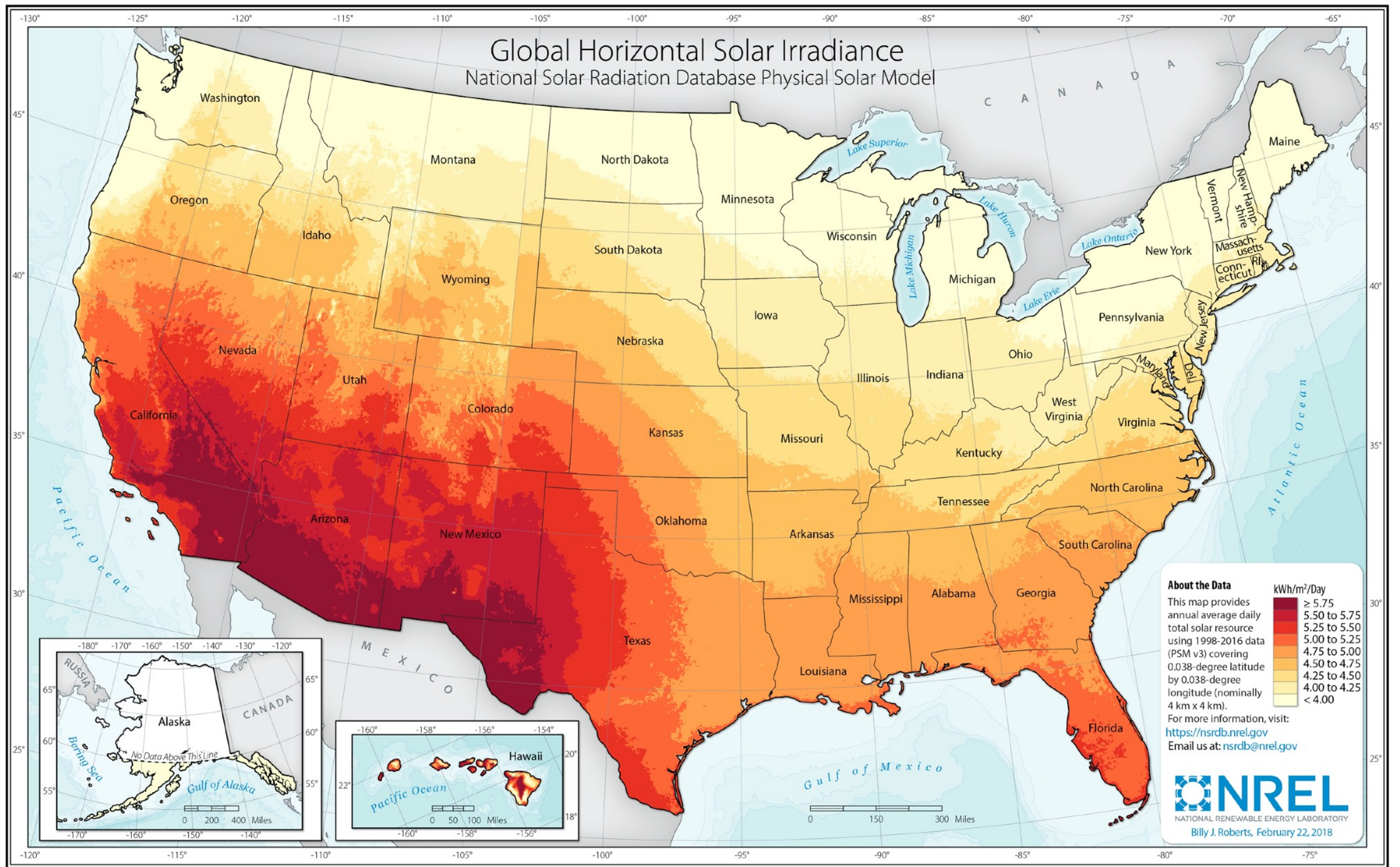
IRA \$ helps,  
but also need reform





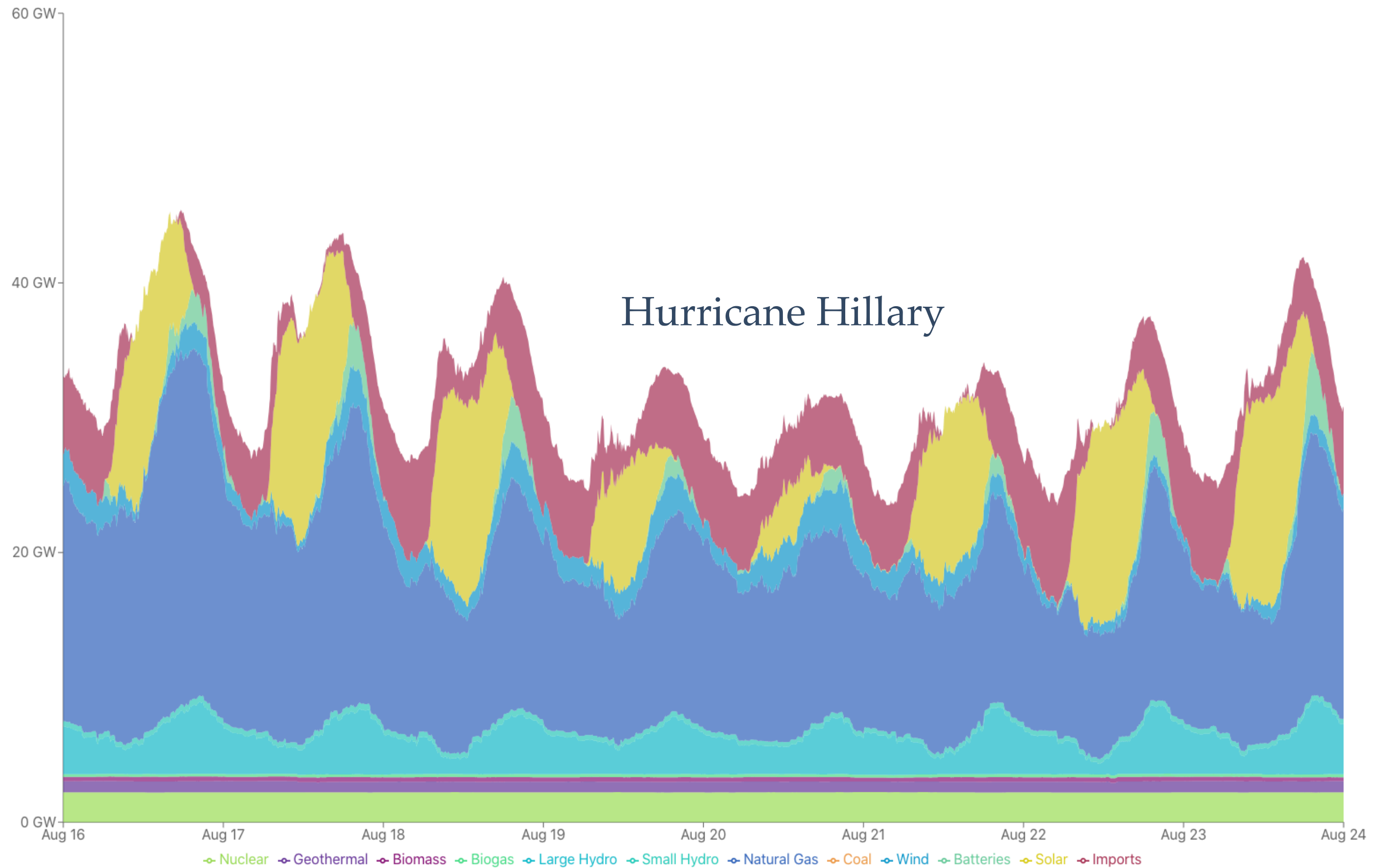
# Global Horizontal Solar Irradiance

## National Solar Radiation Database Physical Solar Model





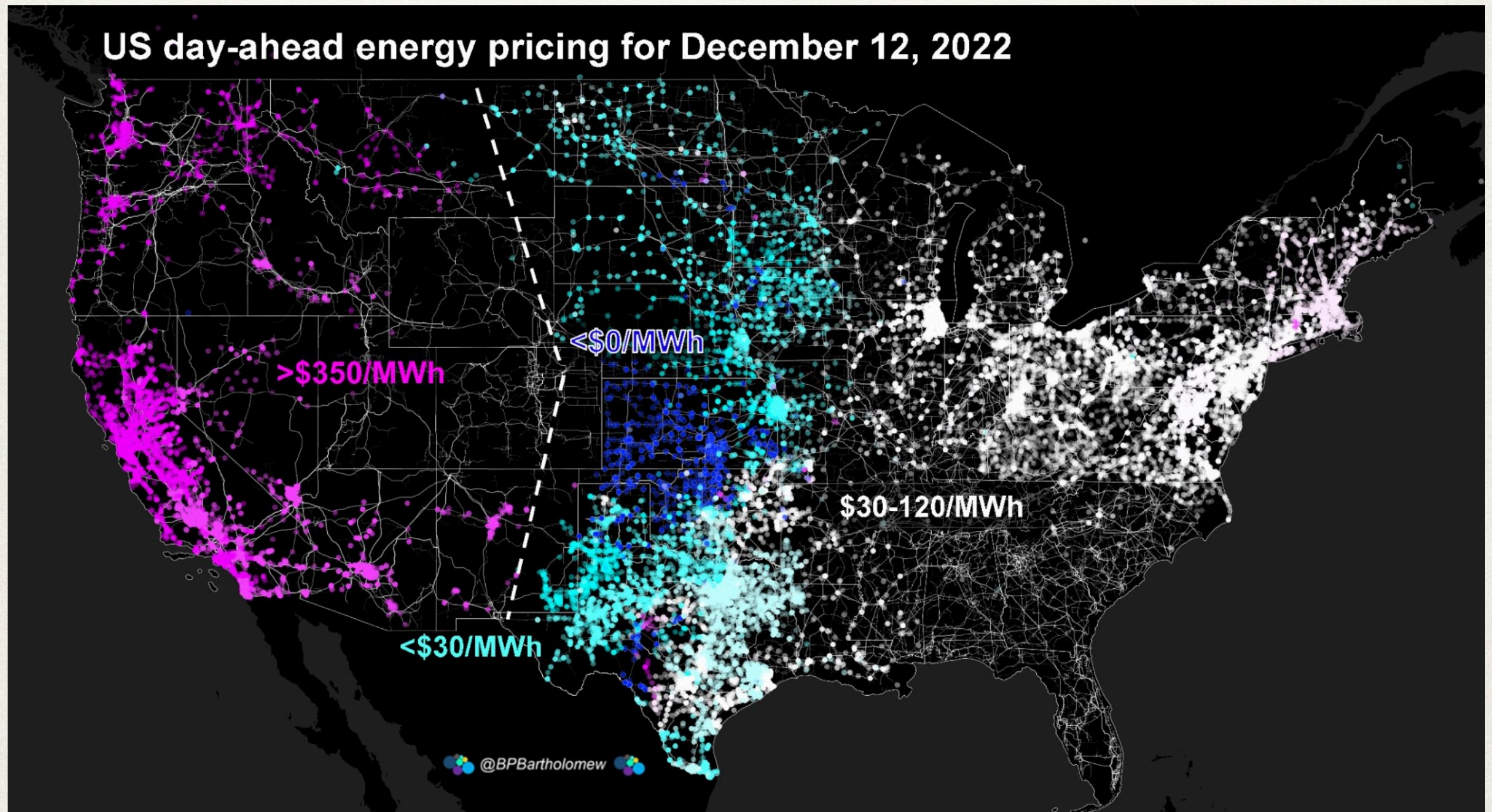
Aug 16 - Aug 23, 2023





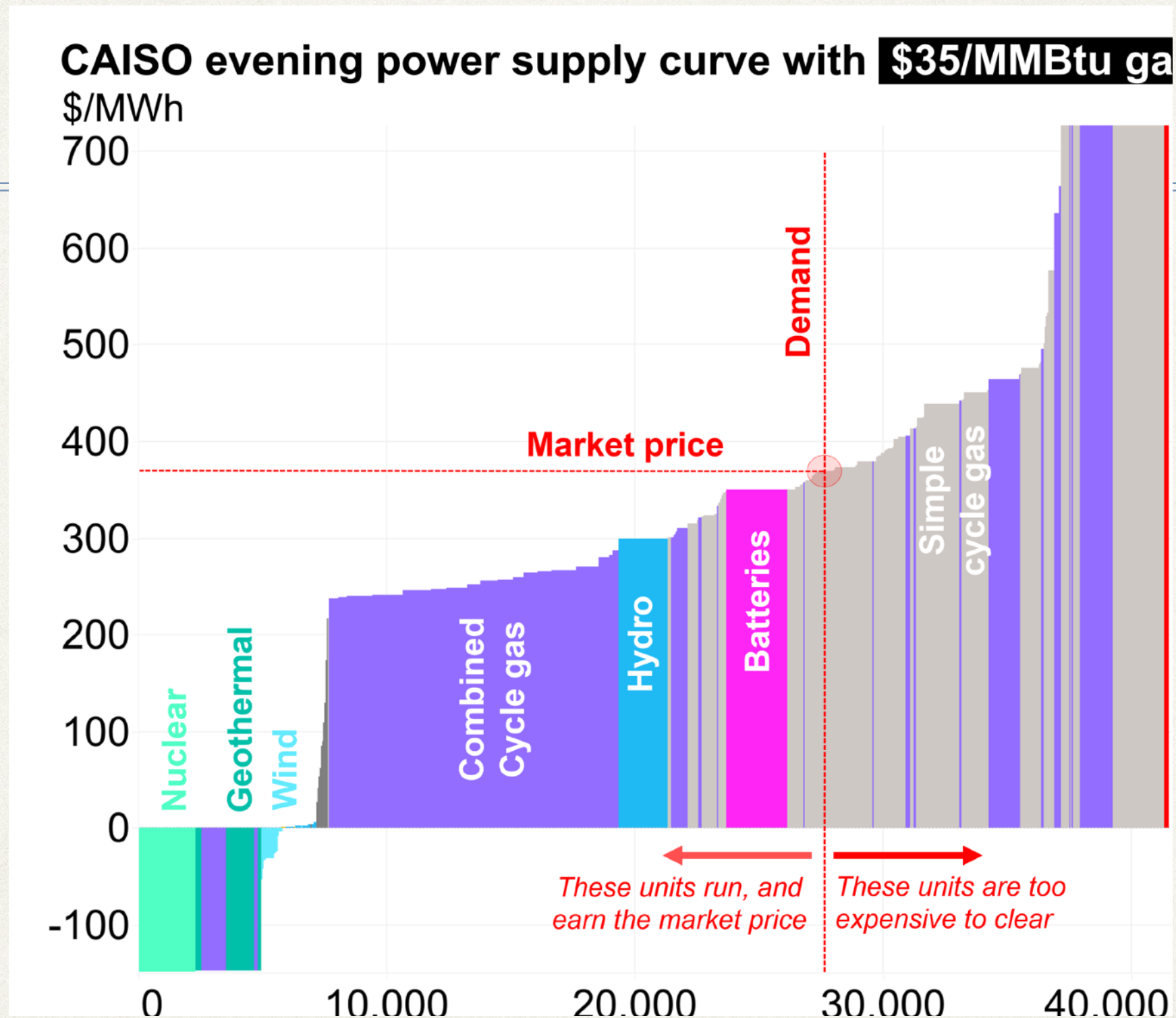
# Location, Location, Location

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





# The Merit Order



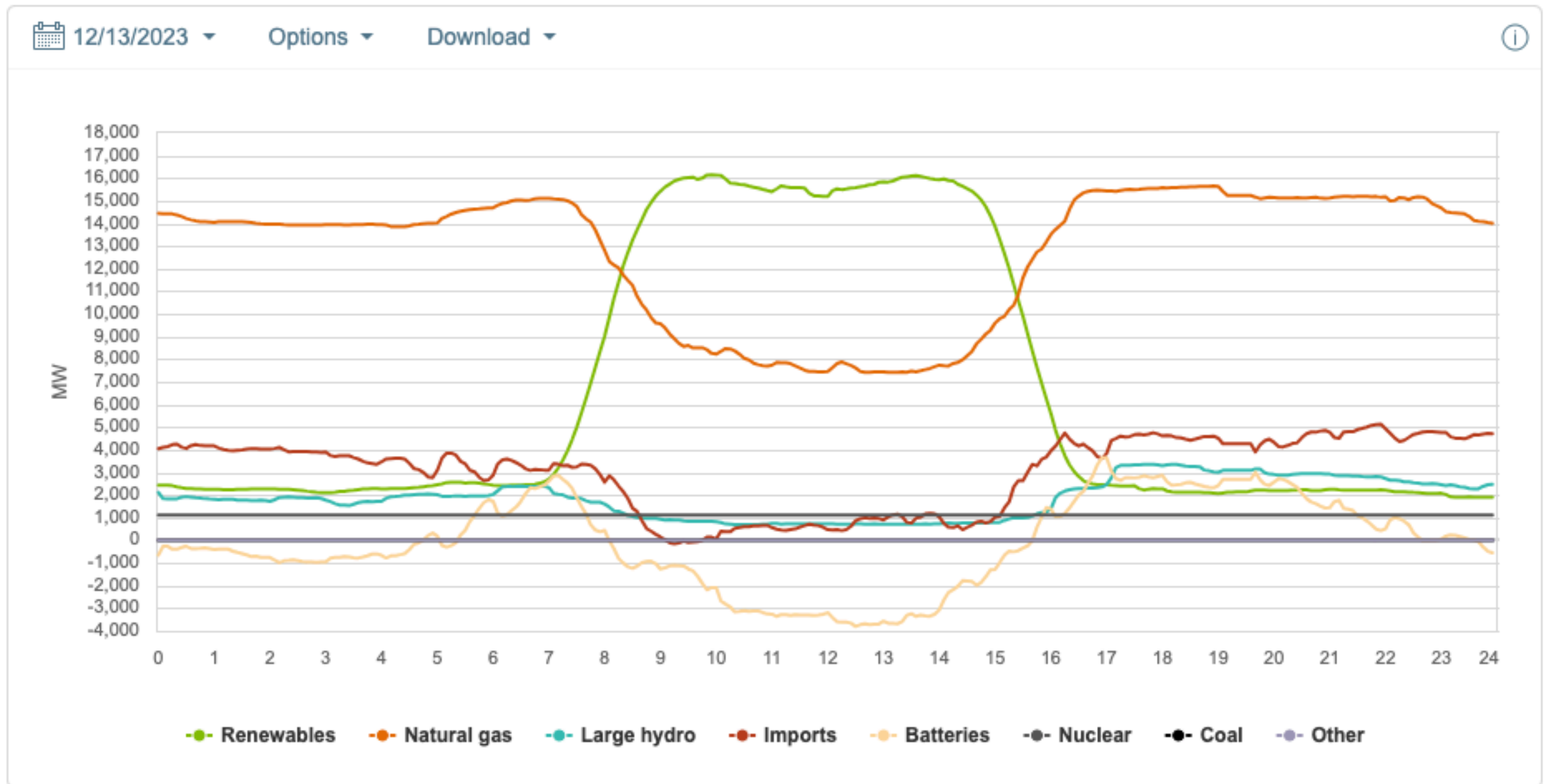
Brian Bartholomew <https://themeritorder.substack.com/about>  
<https://www.nrel.gov/docs/fy23osti/85332.pdf>



# 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

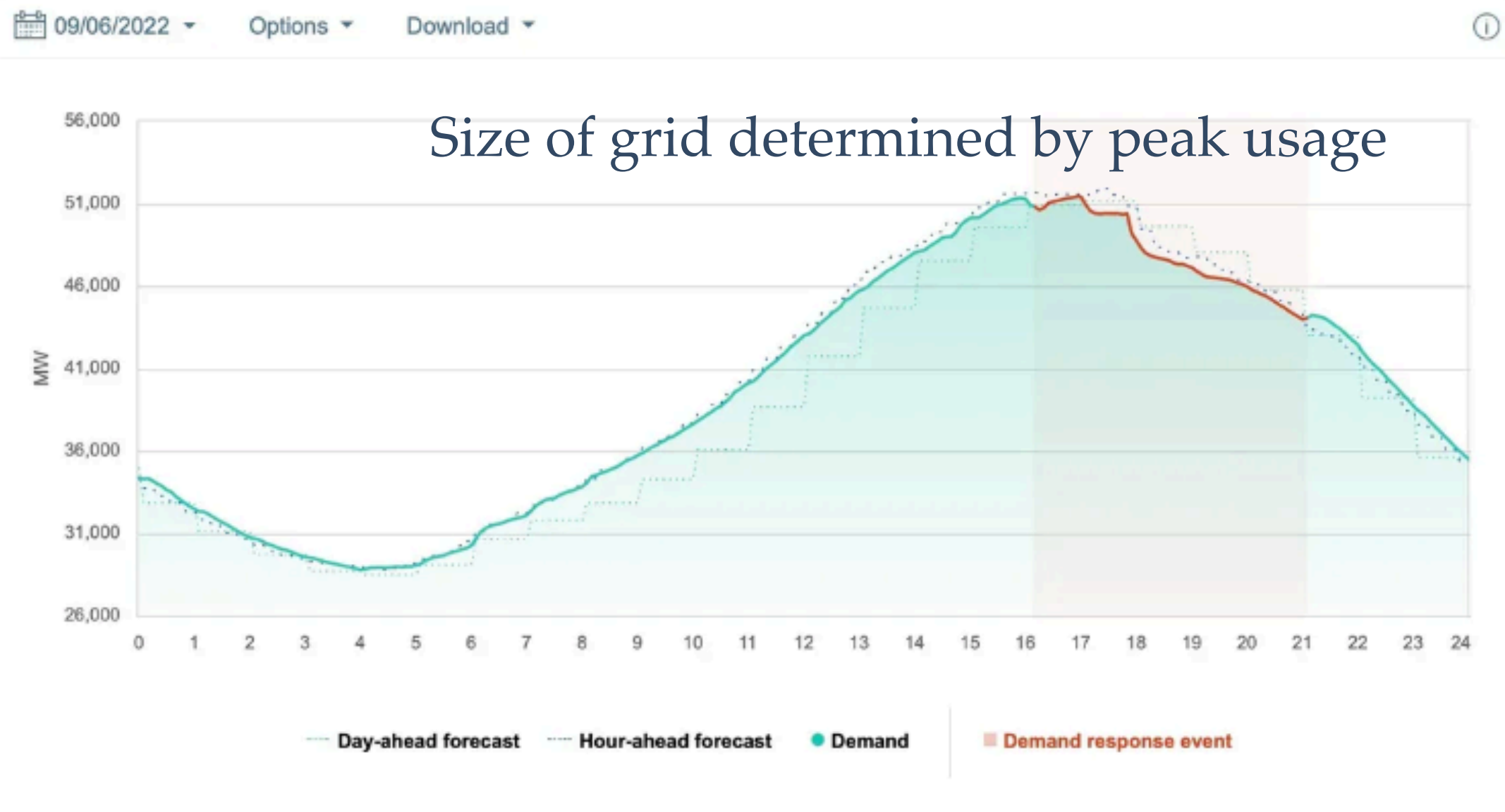
**Demand trend**

Net demand trend

Resource adequacy trend

7-day resource adequacy trend

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



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

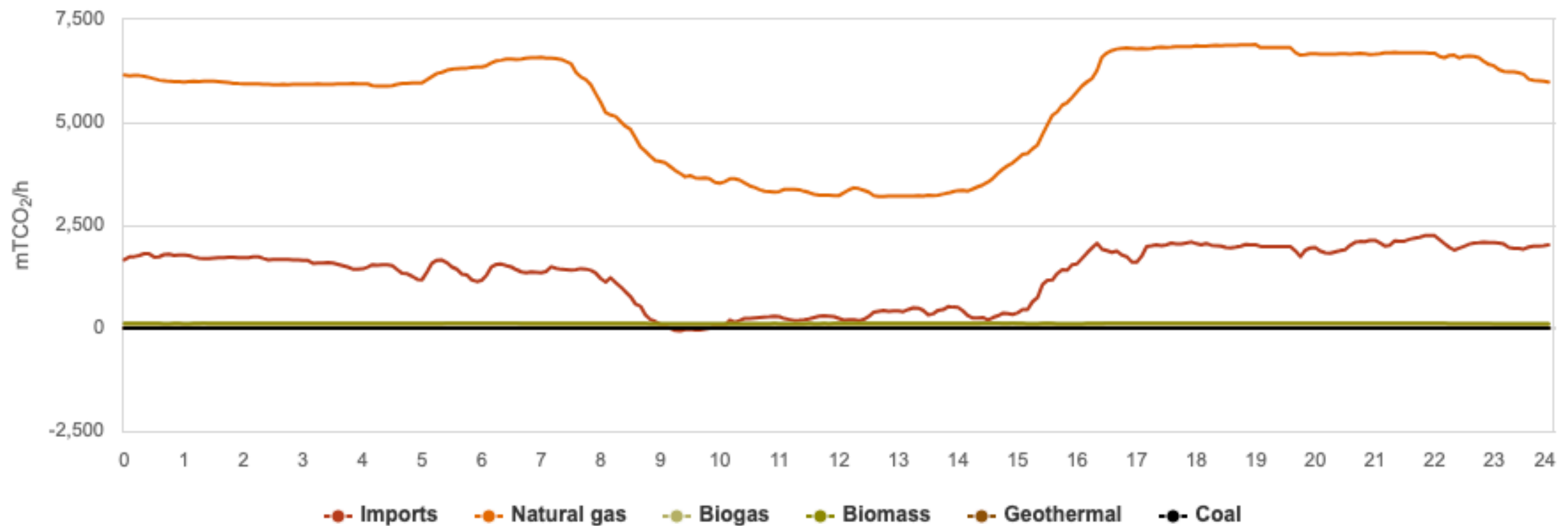


# CO<sub>2</sub> Reporting

## CO<sub>2</sub> per resource trend

CO<sub>2</sub> broken down by resource in five-minute increments.

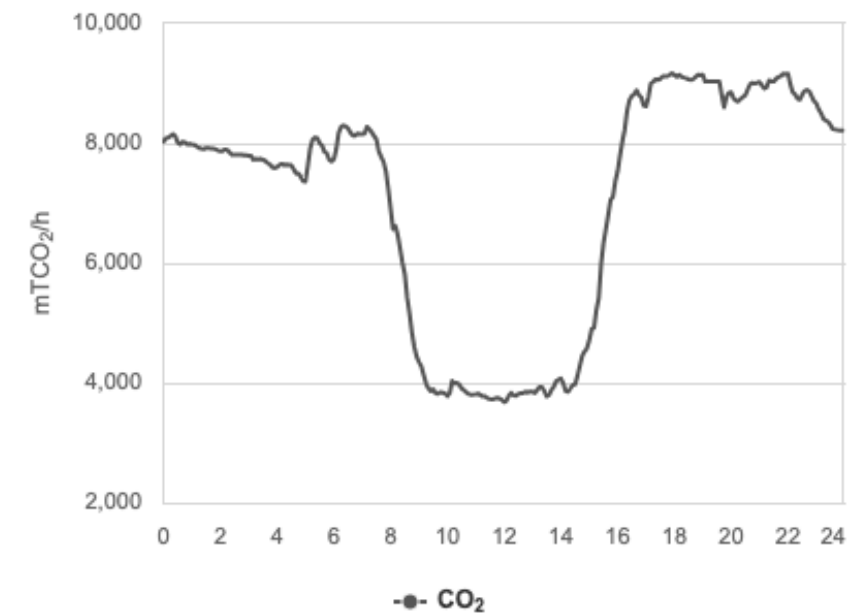
12/13/2023 Download



## Total CO<sub>2</sub> trend

Total CO<sub>2</sub> produced in five-minute increments.

12/13/2023 Options Download



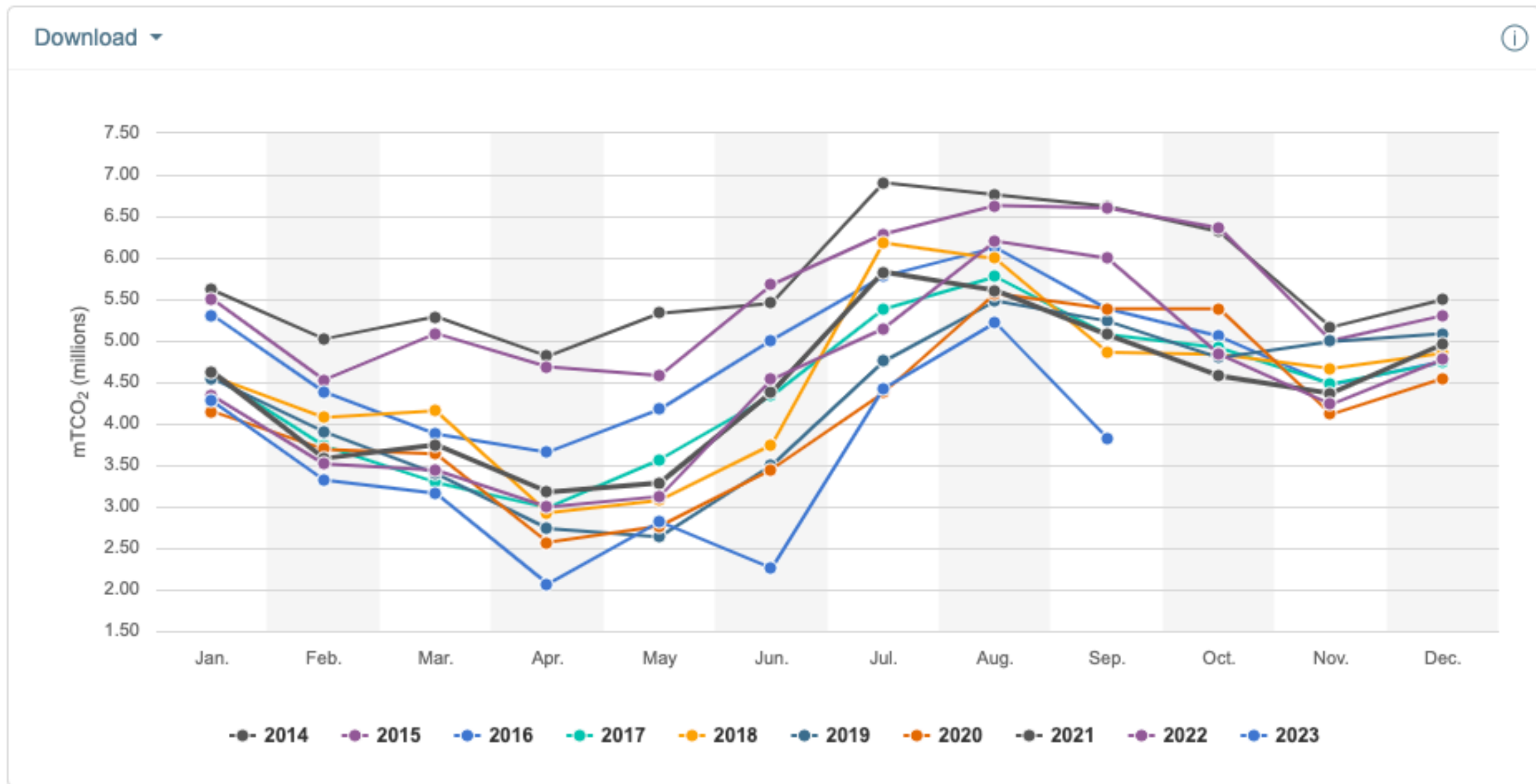


# Uneven Progress

## Historical CO<sub>2</sub> trend

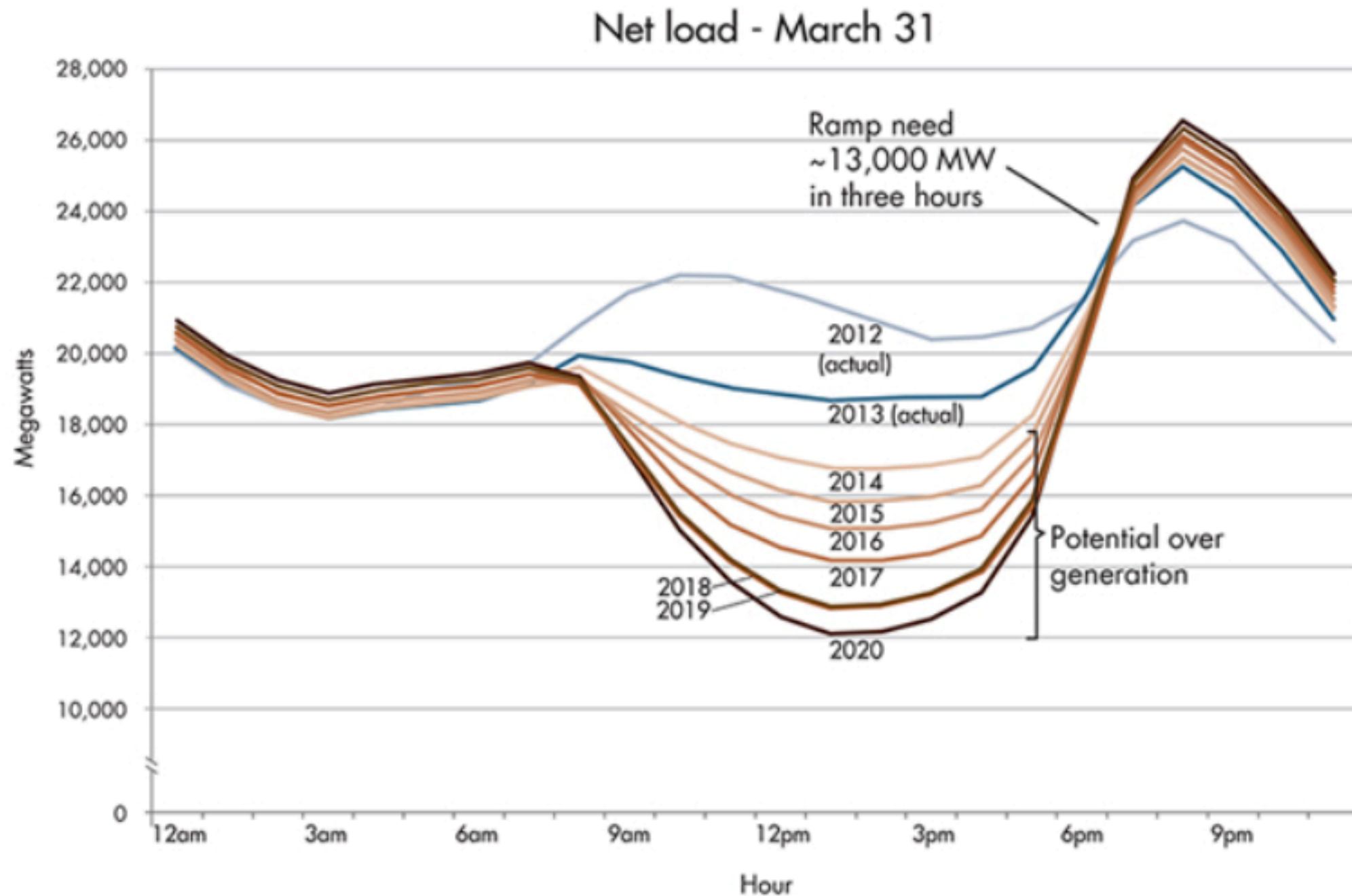
Yearly snapshot of CO<sub>2</sub> emissions by month.

Dry Years: 2012-2016, 2020-2022





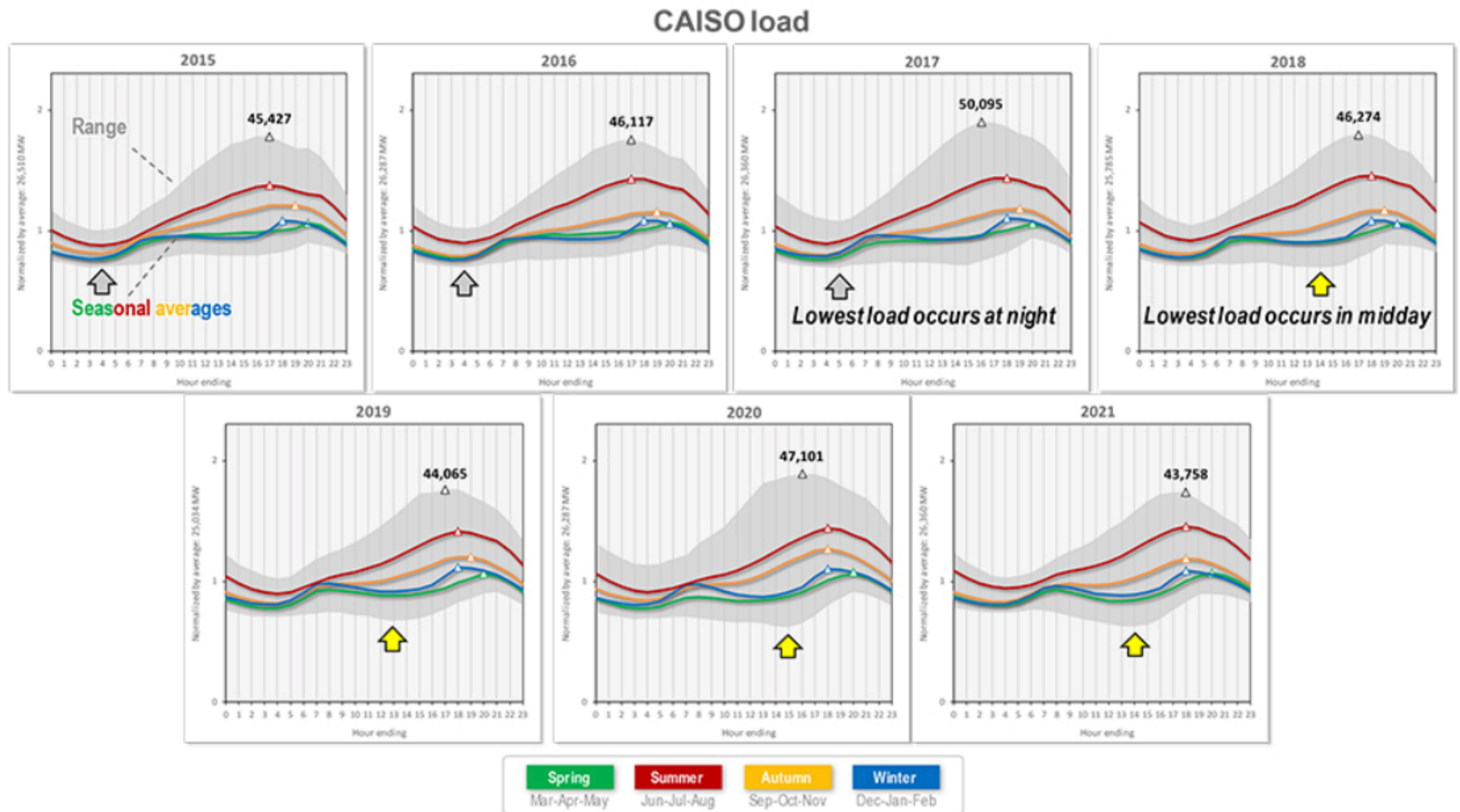
# Duck Curve



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



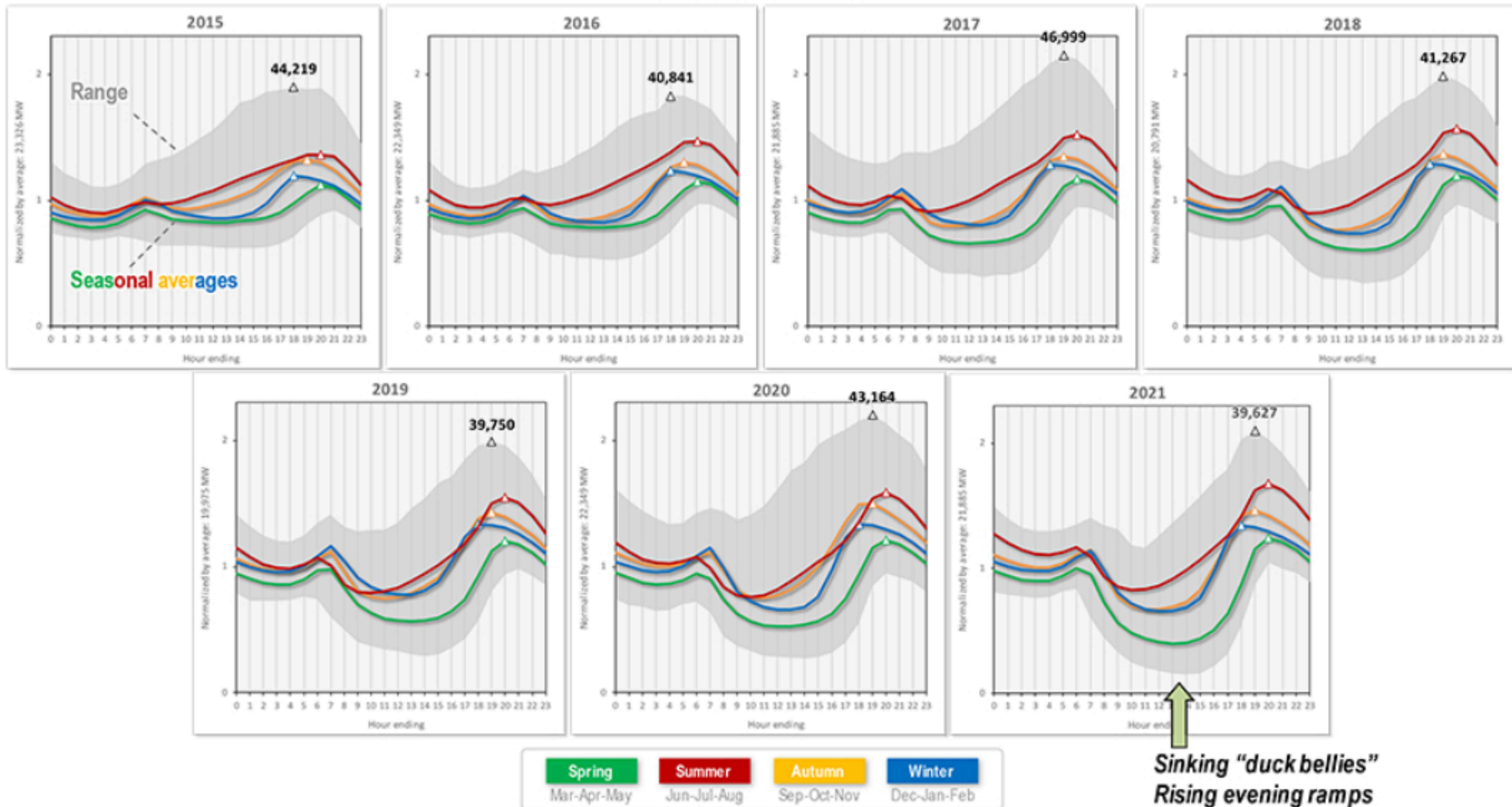
<https://www.caiso.com/about/Pages/Blog/Posts/Our-Evolving-Grid.aspx>





# Sinking Belly, Rising Morning/Evening Ramps

## CAISO net load



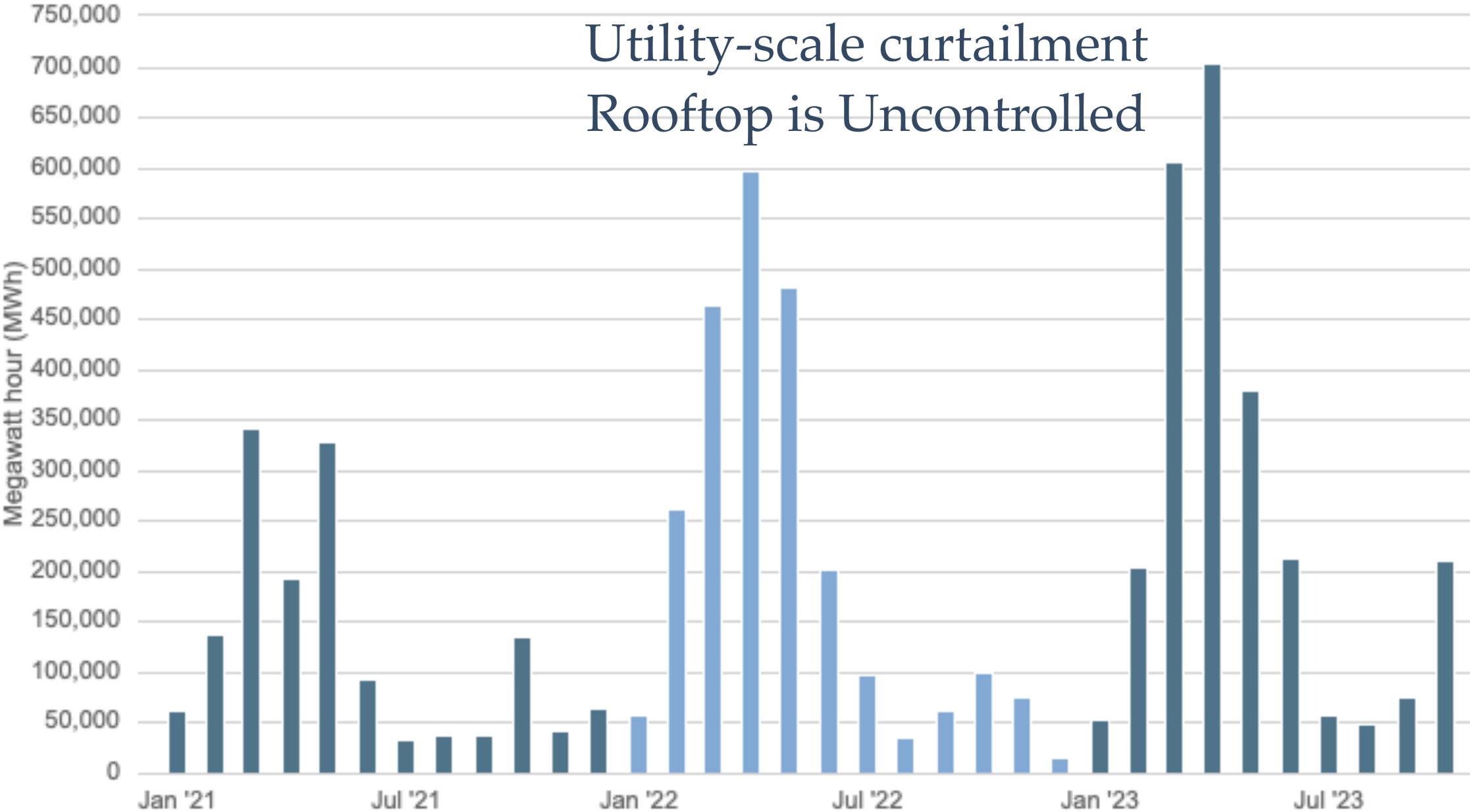


# CAISO Curtailment

Wind and solar curtailment totals by month

View ▾

Download ▾







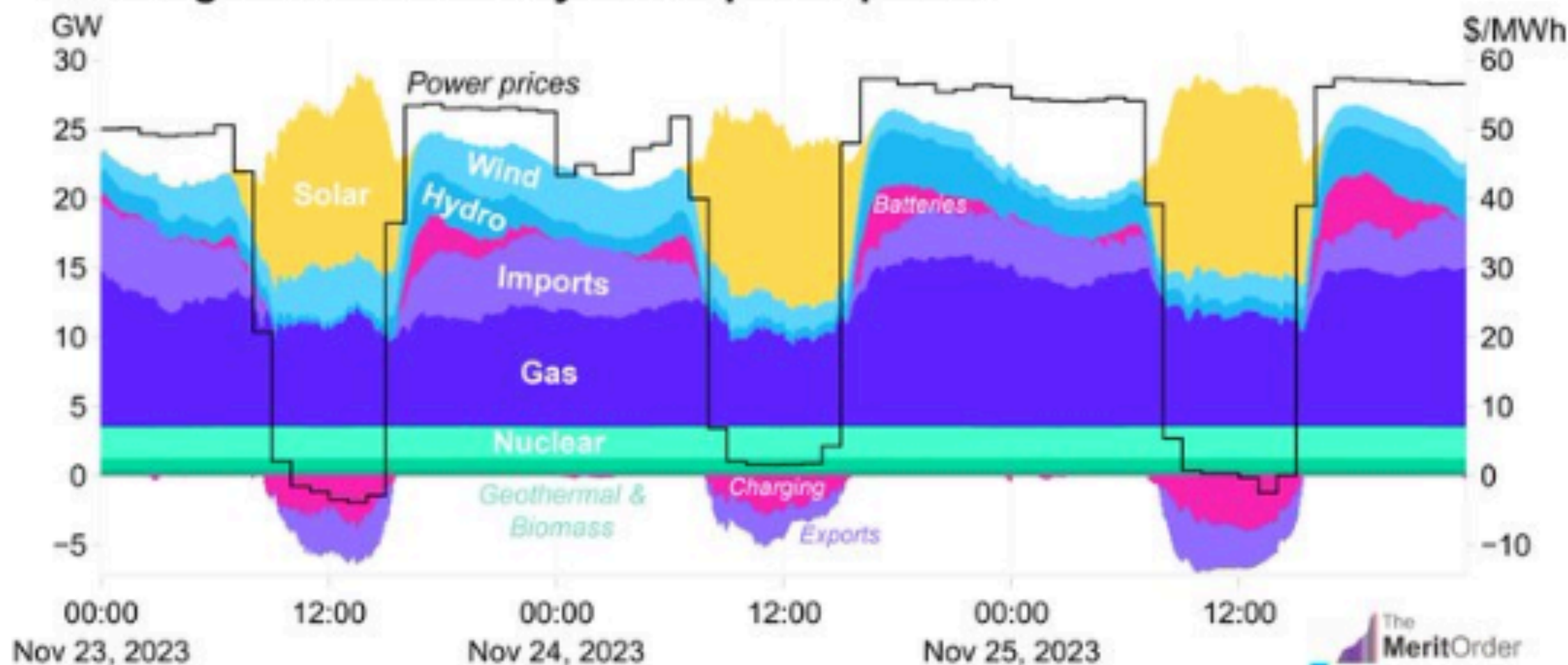
**Brian Bartholomew**

@BPBartholomew



Some great Black Friday deals on California midday power

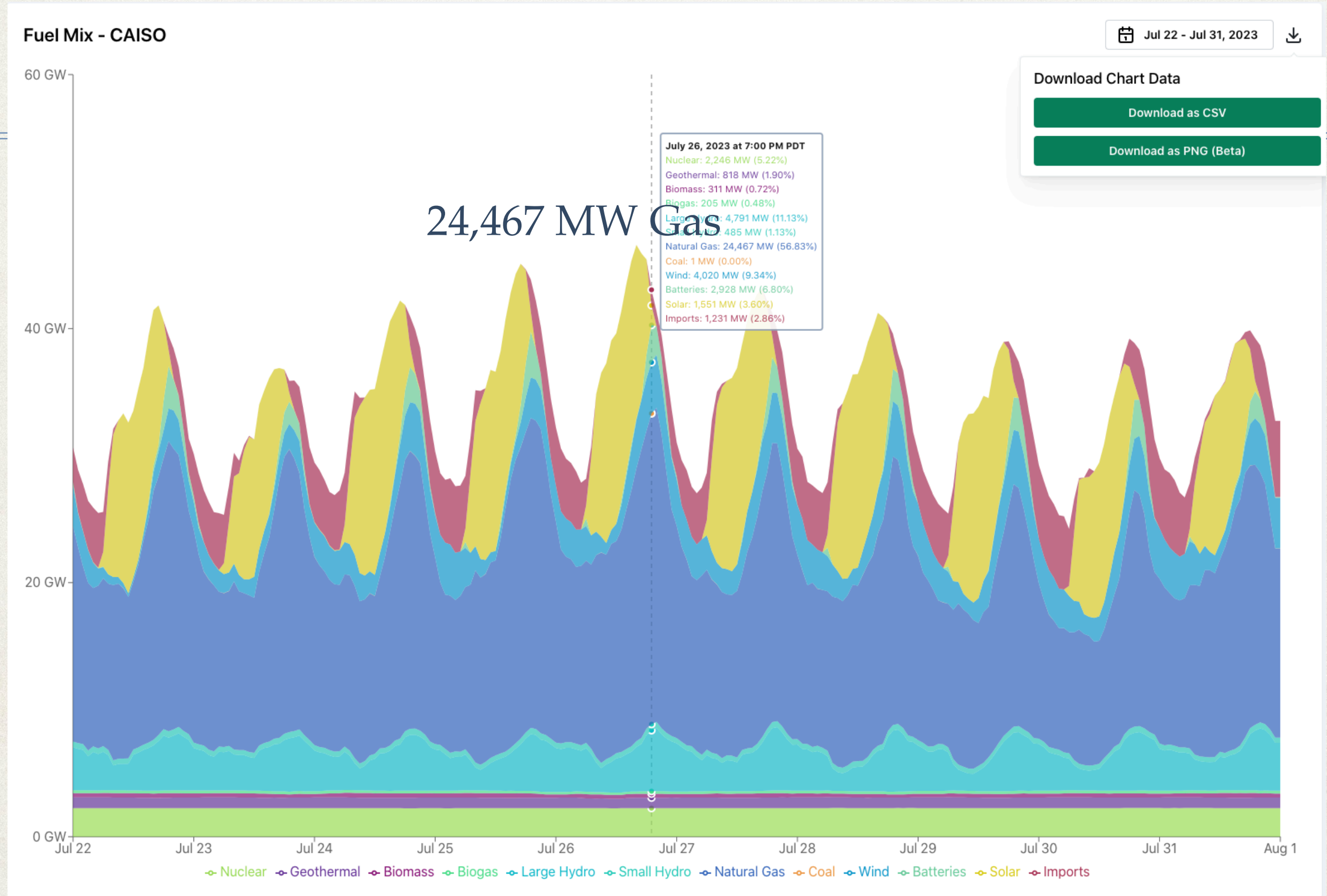
### CAISO generation and day-ahead power prices



4:42 PM · Nov 26, 2023 · **83.3K** Views

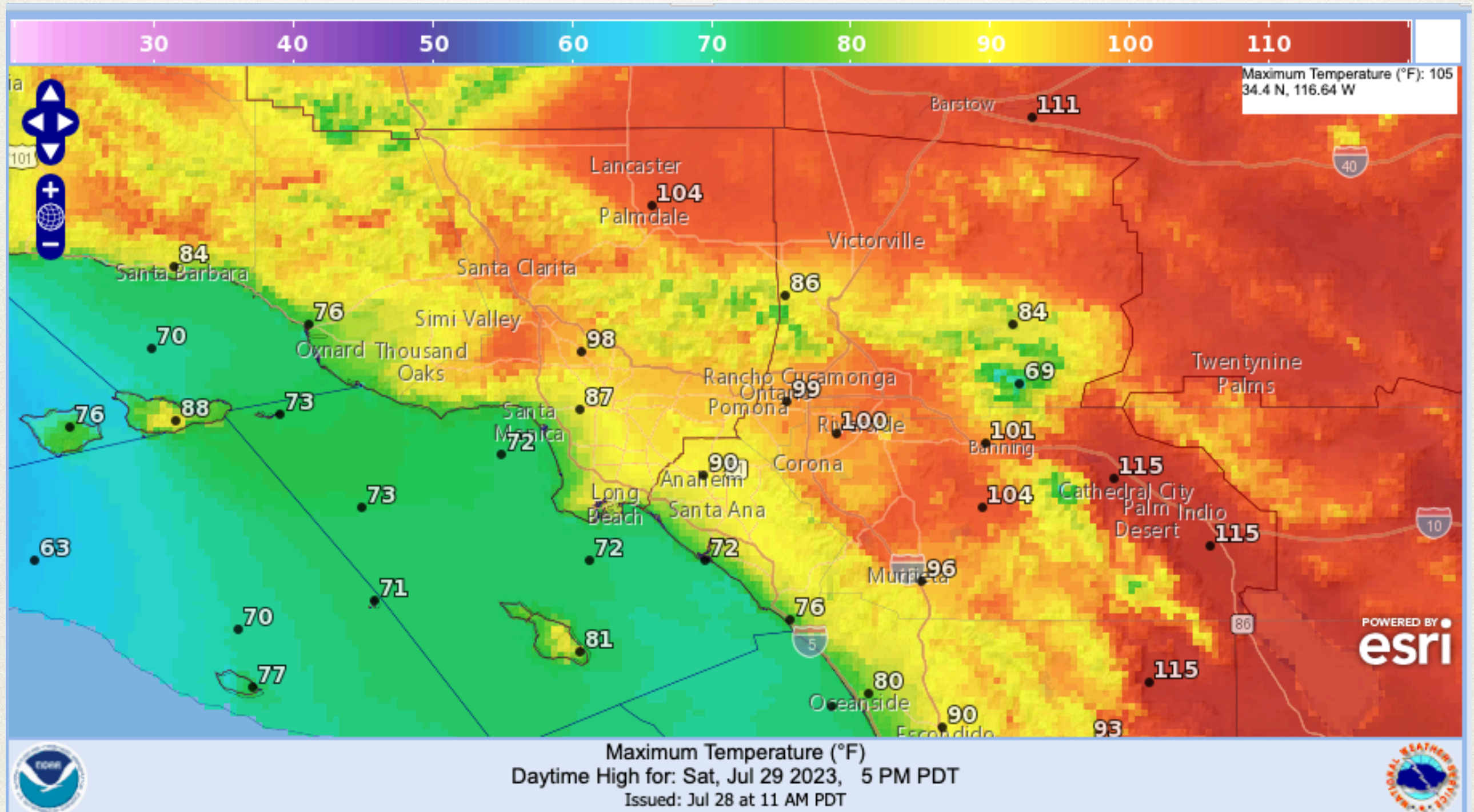


# Impact of Inland Housing Growth





# Cool Coast, Inland Inferno





# Electricity Demand w/ Cool Coast

Fuel Mix - CAISO

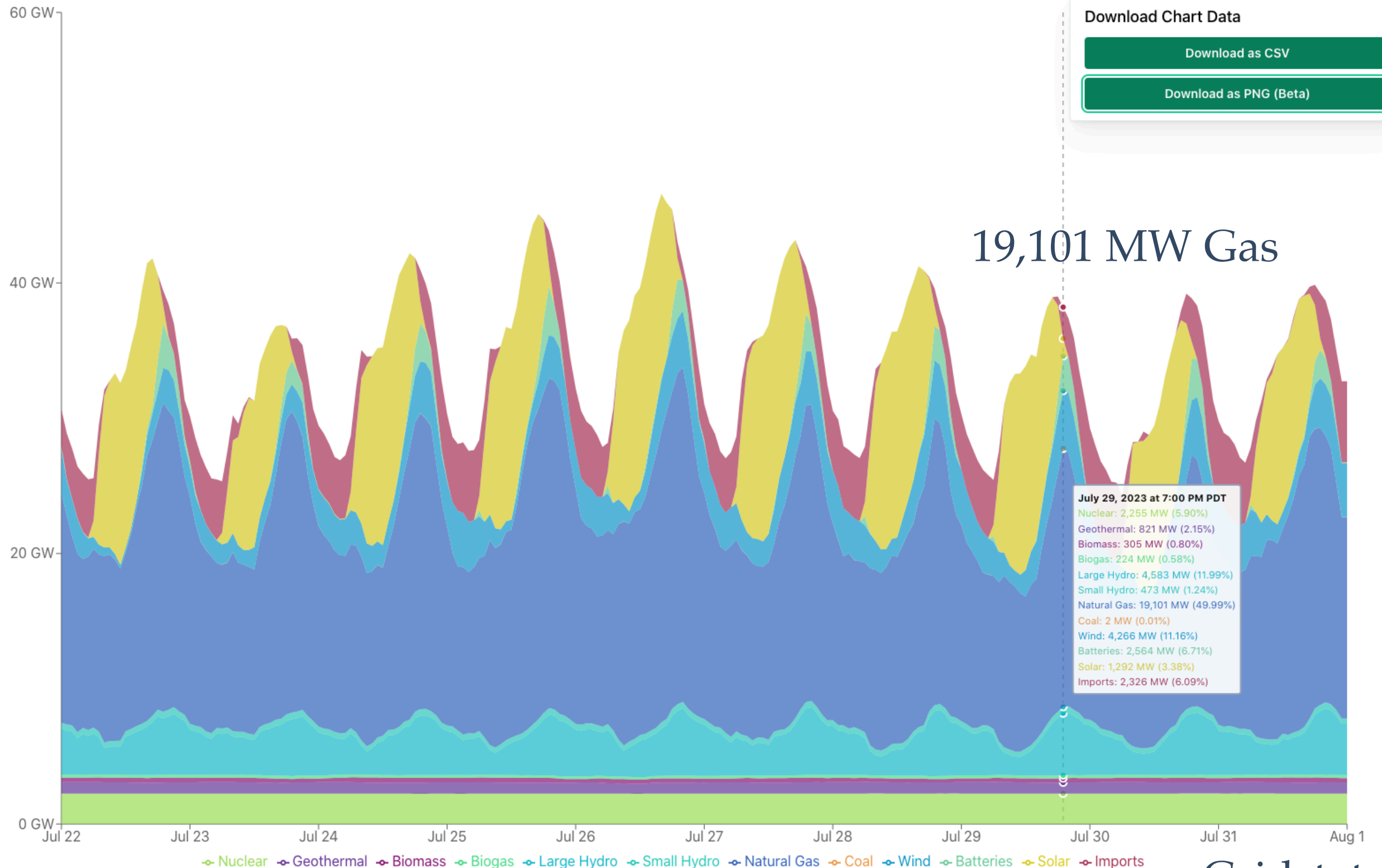
Jul 22 - Jul 31, 2023



Download Chart Data

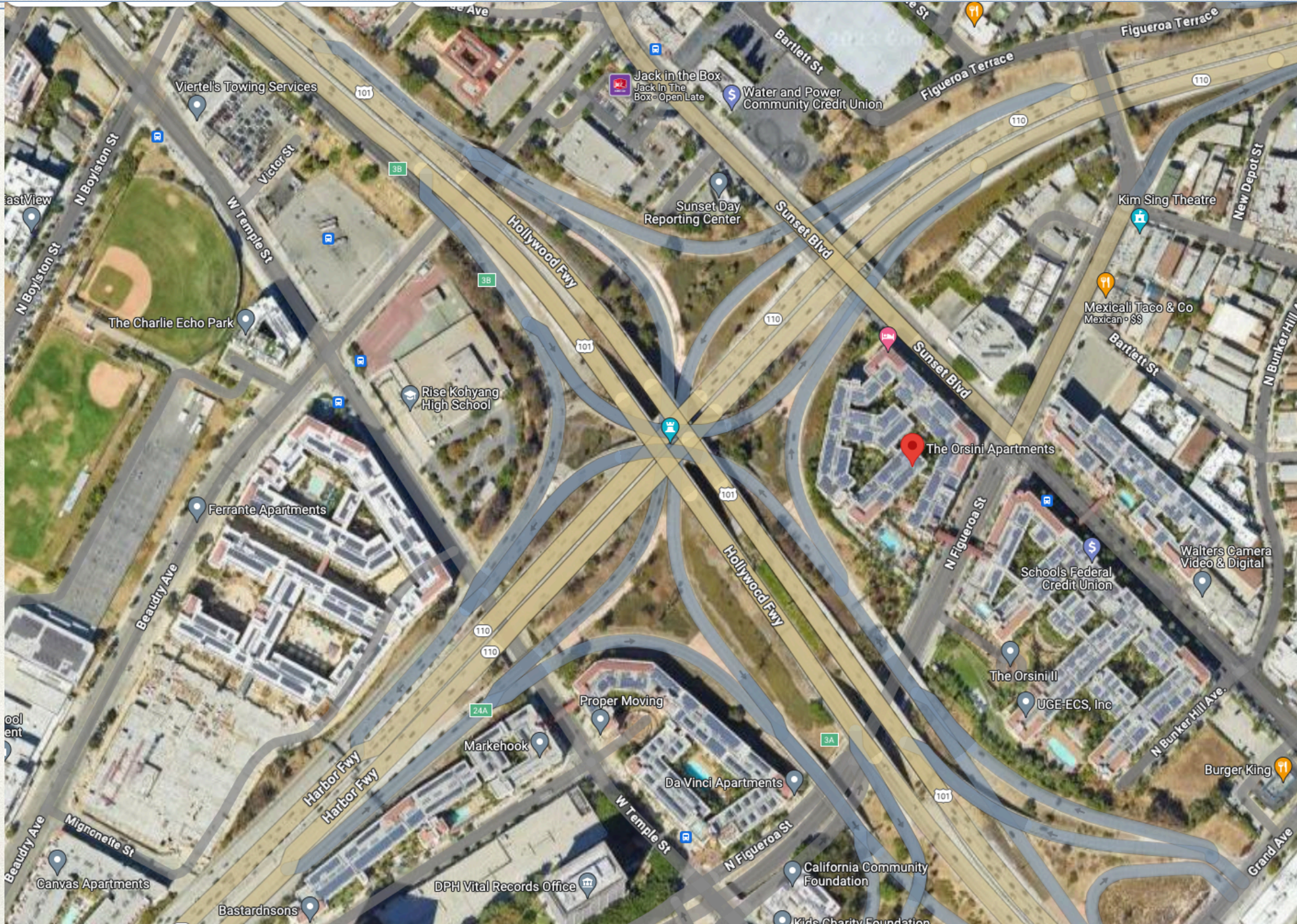
Download as CSV

Download as PNG (Beta)





# Freeway Homes: HVAC Required





# 1000+ Homes in one complex

## Hazardous to open windows

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# What can we do to hasten Decarbonization

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- ❖ 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

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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
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How Infrastructure Works	Deb Chanchra	History, Engineering, Ethics	Physical and Social history and design of resilient and ethical infrastructure.



# Useful Sites

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- ❖ 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/>