JANUARY 22, 2019

Achieving a near-zero carbon power grid

Presentation to the New Mexico Legislature, Senate Conservation Committee

CLEAN AIR TASK FORCE

Armond Cohen, Executive Director, Clean Air Task Force

Background on Clean Air Task Force

- National environmental organization dedicated to protecting climate and air quality through public policy and private sector action.
- Promotes direct regulation of greenhouse gasses and other air pollutants, and policies to commercialize low-carbon technology.
- More information at www. catf.us

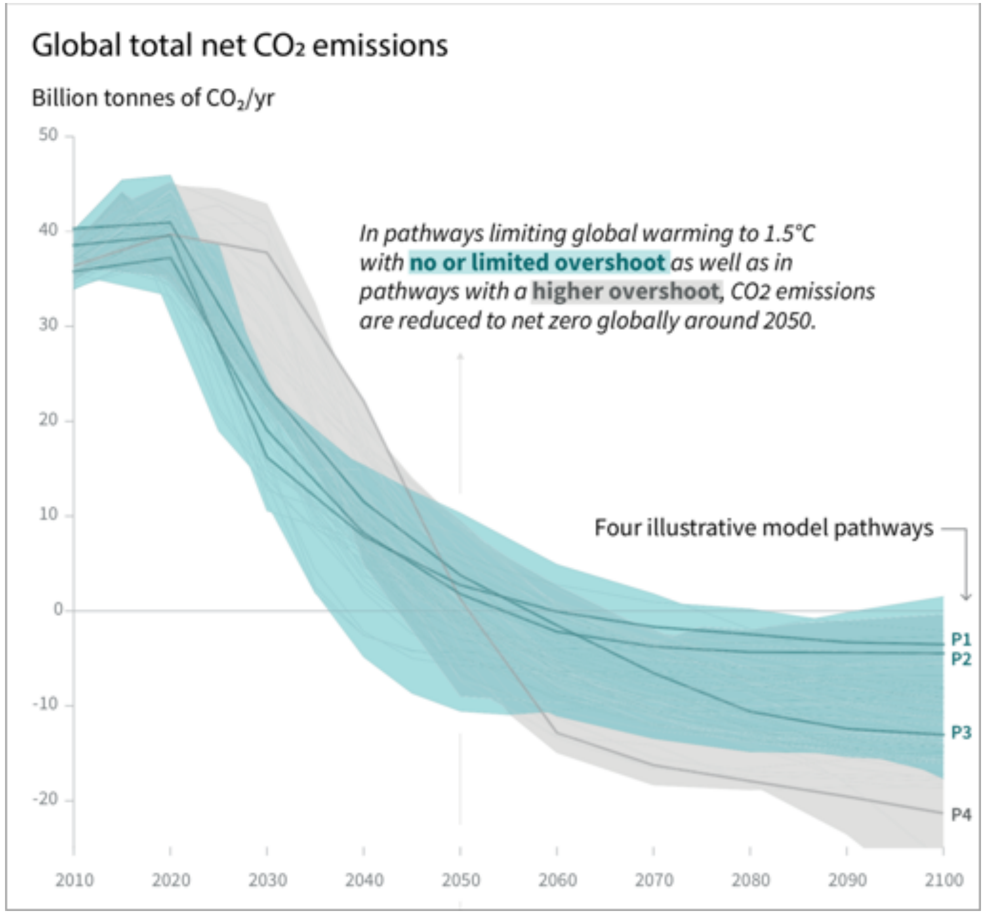
Key points

To address climate change, we need a near-zero carbon power system by mid-century

Our chances of reaching this goal are much better if, in addition to using renewables, we have the option to use a diversity of low carbon power sources, including firm sources

Public policies today should not foreclose diversity but should encourage it

To stabilize climate, we need to reduce carbon emissions to zero around mid-century



Intergovernmental Panel on Climate Change (2018)

Power must decarbonize sooner to help displace dirty fuels in transport, heat and industry – and expand 50+%

Key issues

Getting there in a few short decades – there is no “do over”!

Affordability – we won’t get there if the price tag is too high

We have a variety of low carbon electricity options

Variable/weather-dependent

Firm

Review of 40 studies: having firm zero carbon power available reduces costs and risks in achieving a zero carbon grid especially as reductions move > 50%

Please cite this article in press as: Jenkins et al., Getting to Zero Carbon Emissions in the Electric Power Sector, Joule (2018), https://doi.org/10.1016/j.joule.2018.11.013

Joule

CellPress

COMMENTARY

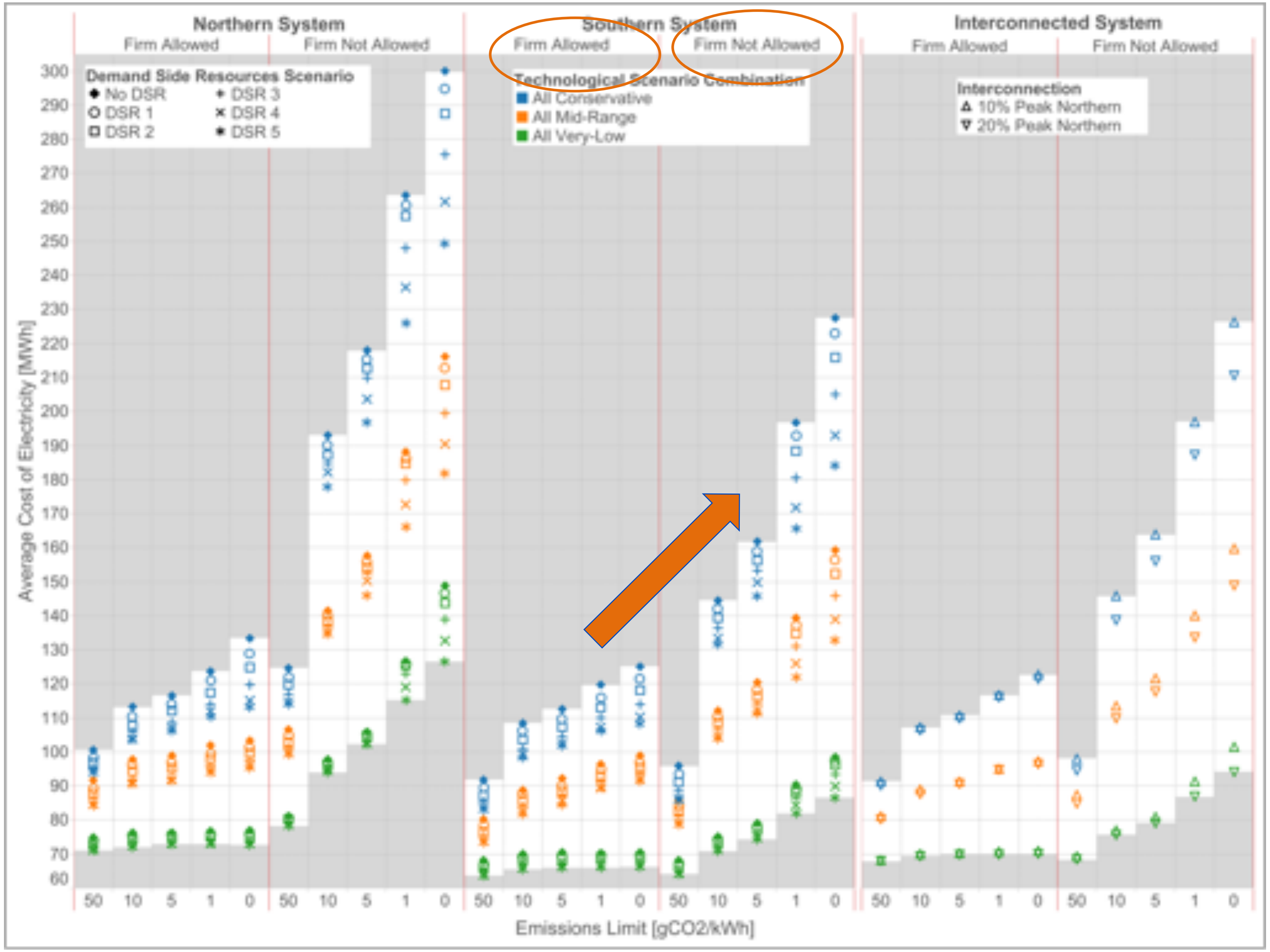
Getting to Zero Carbon Emissions in the Electric Power Sector

Jesse D. Jenkins,[1,*] Max Luke,[2] and Samuel Thernstrom[3]

energy economy. He is also a senior fellow at the Center for the National Interest.

The electric power sector is widely expected to be the linchpin of efforts to reduce greenhouse gas (GHG) emissions. Virtually all credible pathways to

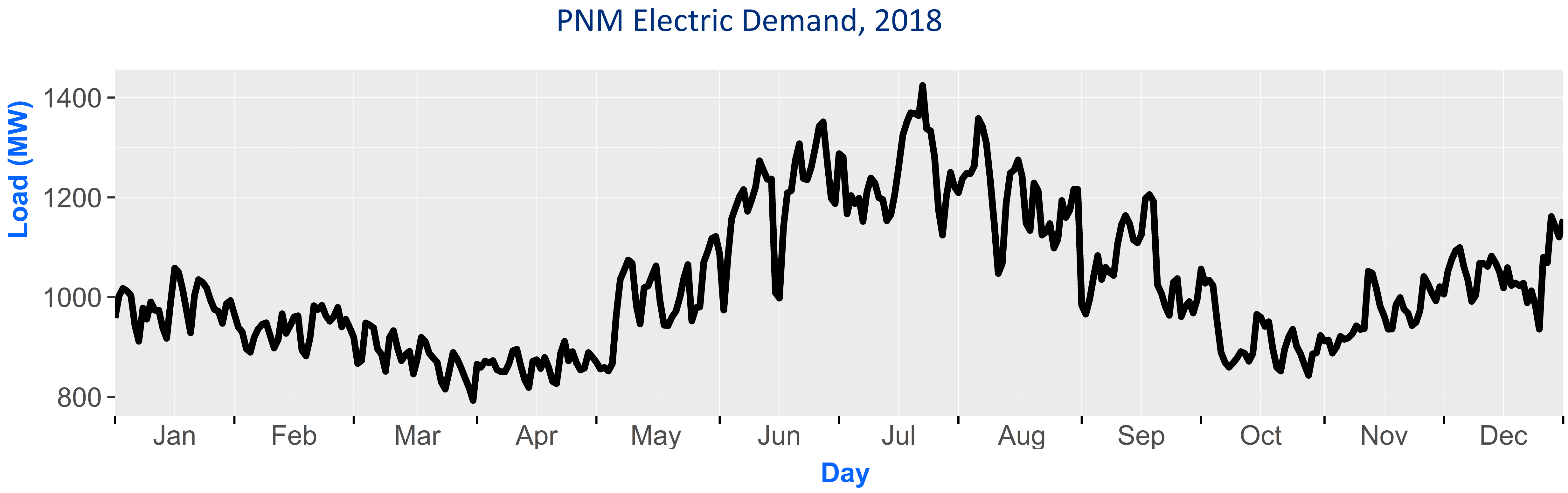
challenging—and requires a different set of low-carbon resources—than comparatively modest emissions reductions (e.g., CO_2 reductions of 50%–70%). This is chiefly because more modest goals can readily employ natural gas-fired power plants as firm resources. Pushing to near-zero emissions requires replacing the vast major-



Sepulveda, Nestor A., et al. "The role of firm low-carbon electricity resources in deep decarbonization of power generation." *Joule* 2.11 (2018): 2403-2420.

Why is this so?

Electricity must match load every second, minute, hour, day, week and month



Can we do this?

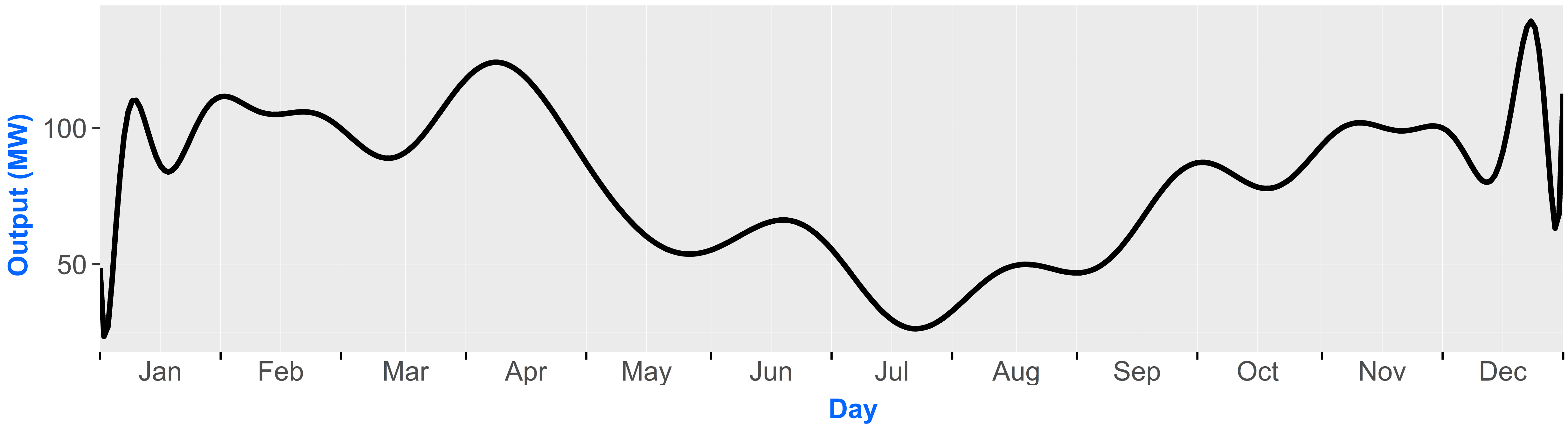
GO 100%

RENEWABLE ENERGY

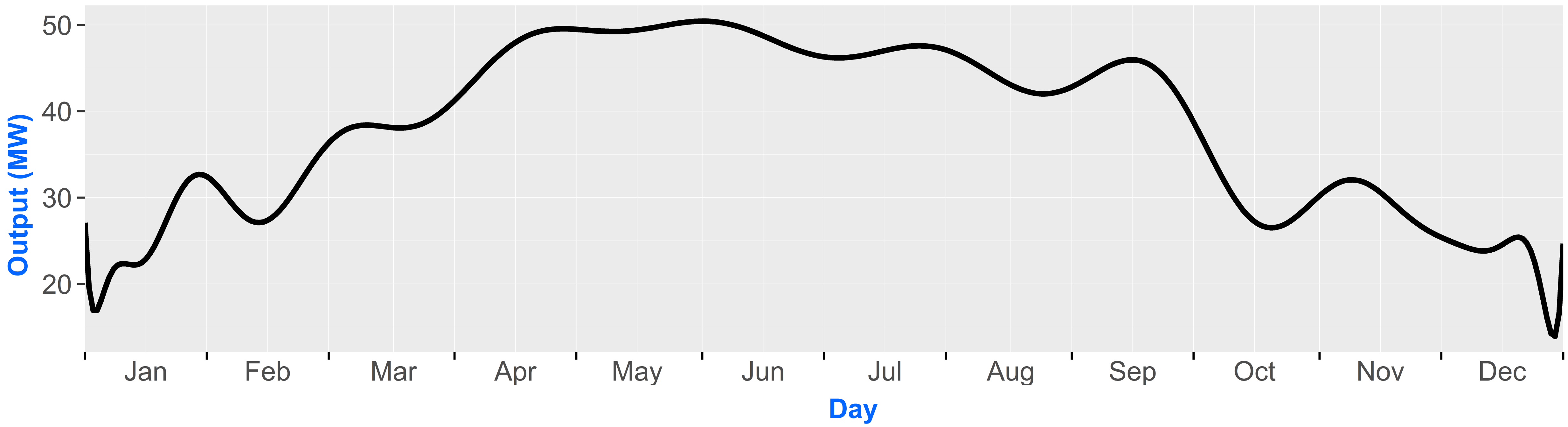
Wind and solar varies substantially not just daily but weekly-monthly, in a way that does not always match load

At high levels of wind and solar energy (> 50-60% of system energy), “filling the gap” begins to pose cost challenges

Smoothed Actual Wind Production in PNM, 2018

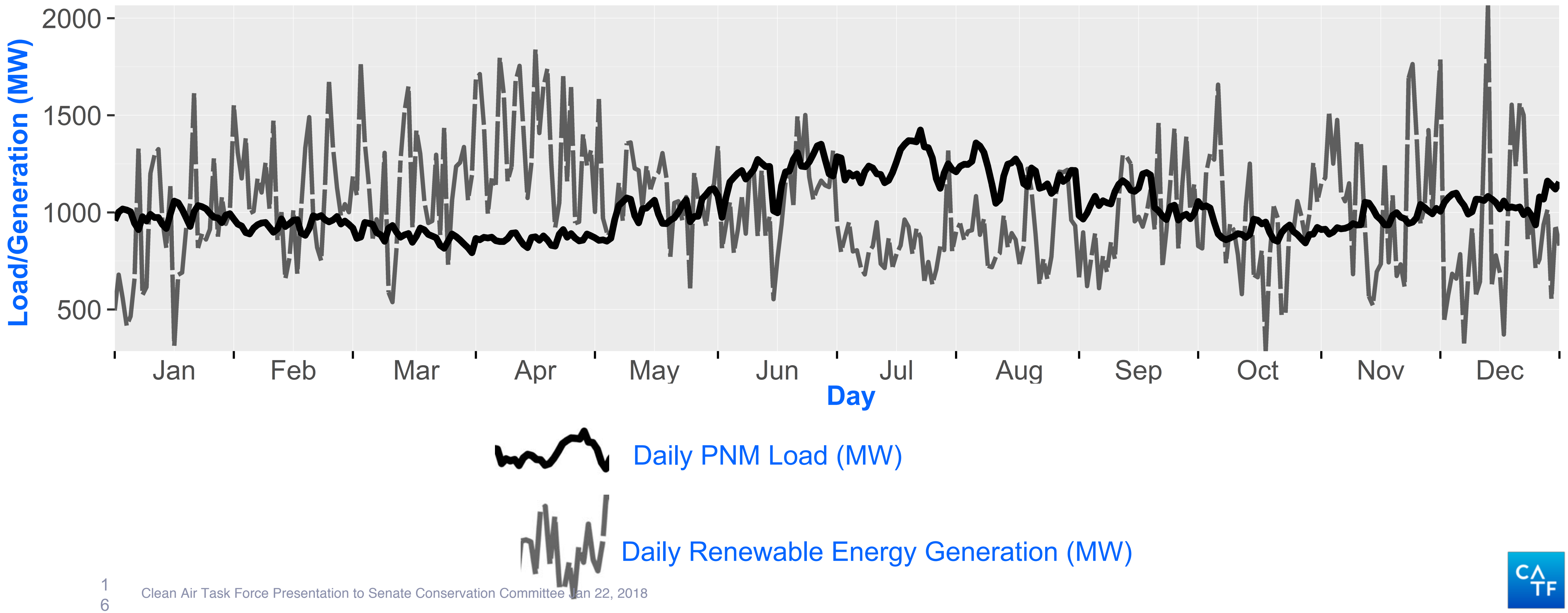


Smoothed Actual Solar Production in PNM, 2018



Daily Load & Renewable Energy Generation, Mixed Renewable Scenario

Scenario definition: 2018 wind and solar generation scale in equal proportion to meet total 2018 PNM load



Smoothed Daily Load & Renewable Energy Generation, Mixed 100% Renewable Scenario

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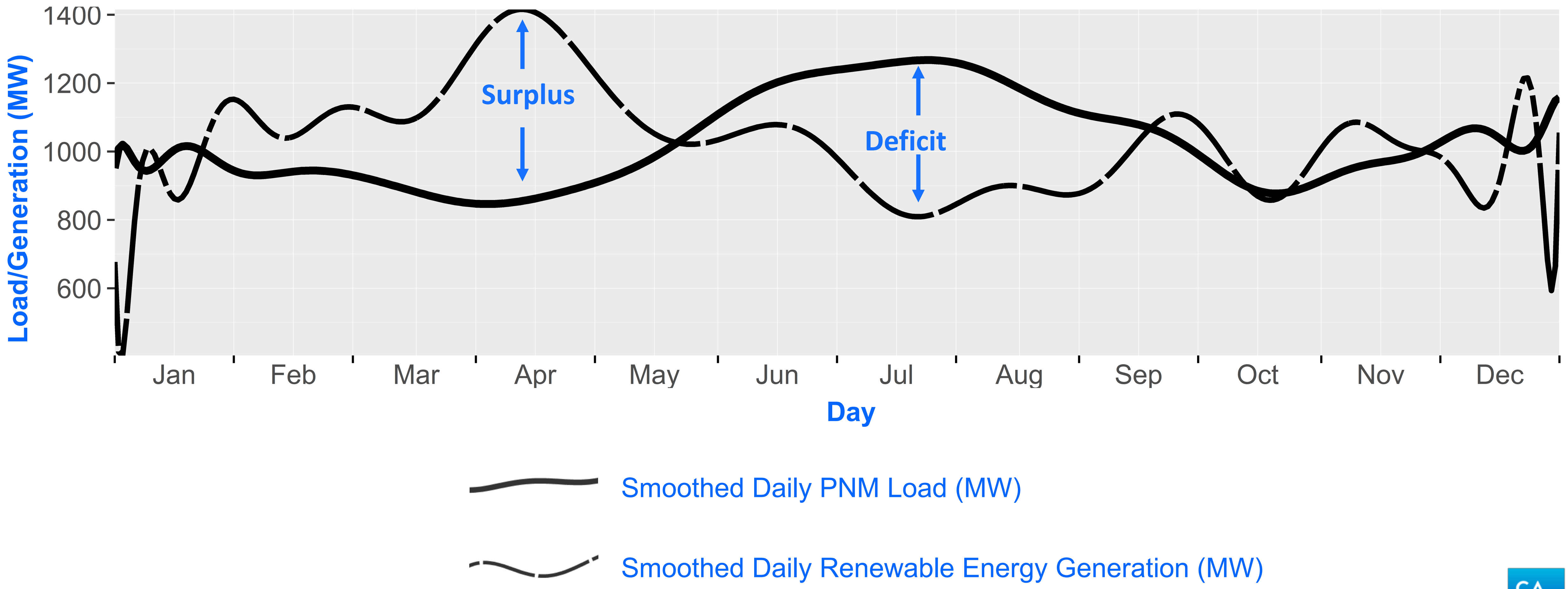

Percent of Hourly Load Served, Mixed 100% Renewable Scenario

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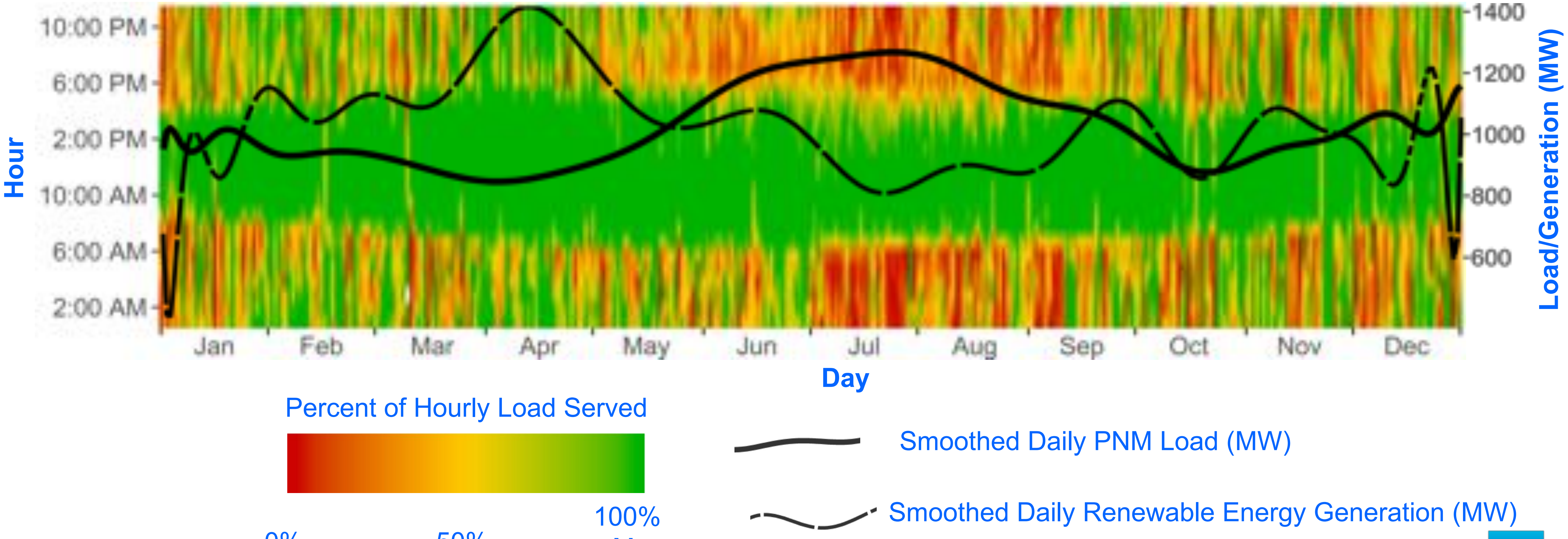
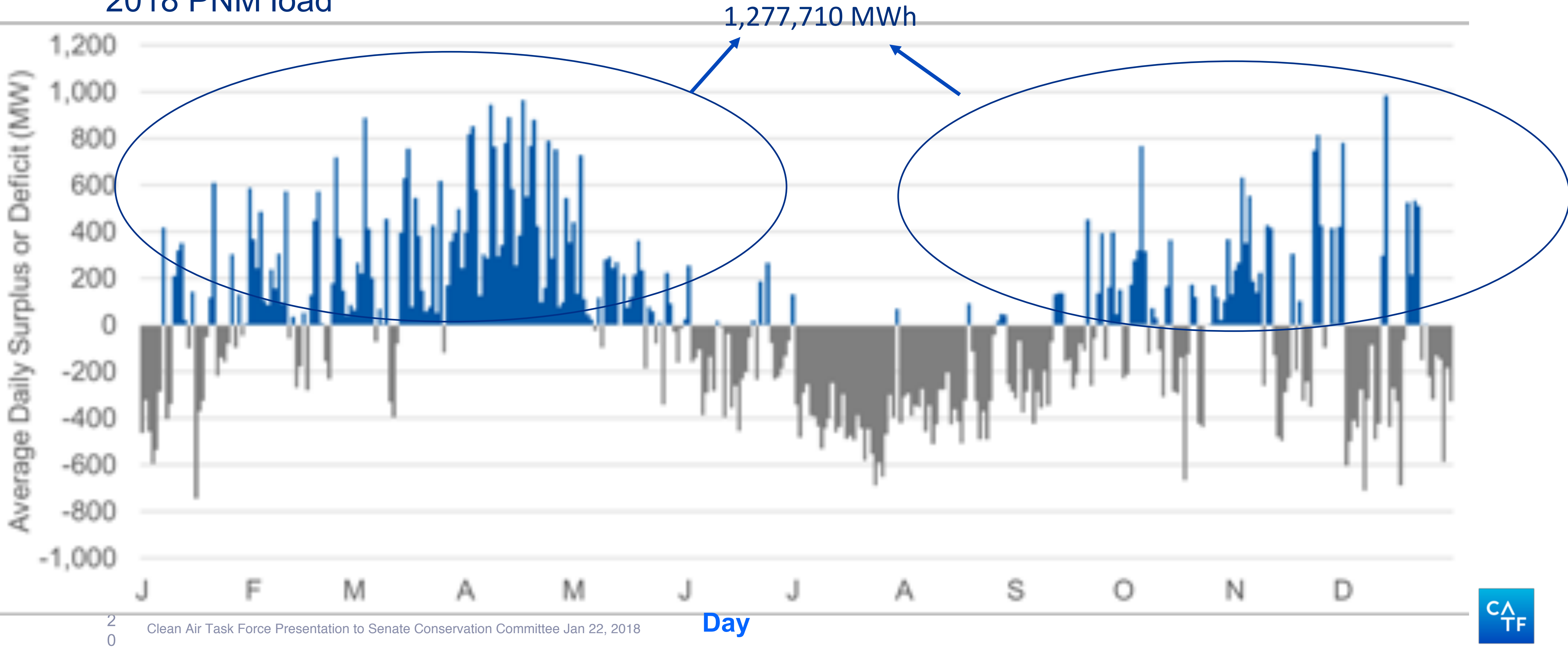


Can we solve this problem with batteries or other energy storage to capture the seasonal surplus and use it in deficit periods?

Daily Renewable Energy Generation Surpluses and Deficits, Mixed 100% Renewable Scenario

Scenario definition: 2018 wind and solar generation scale in equal proportion to meet total 2018 PNM load



The storage solution

Surplus to store = 1,277,710 MWh, 15% of annual PNM load

$100/kwh for storage capacity (a third of today's costs)

Capital cost = $12.7 Billion

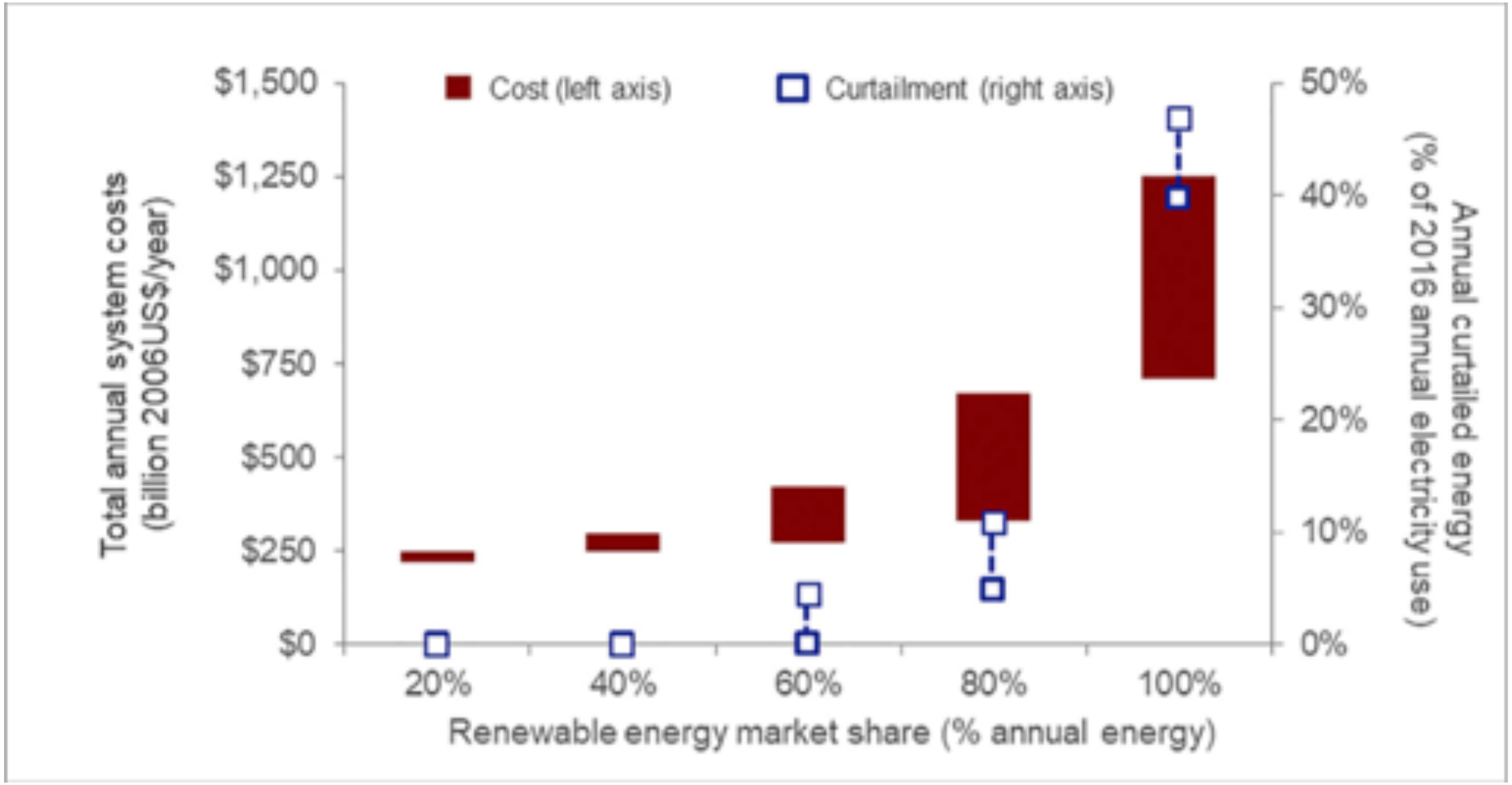
Utilization factor < 1%

Total cost of wind + solar+ storage = $10,800/MWH (vs current generation cost of $60/MWH)

Are there similar surplus/deficit management issues at less than 100% renewable?

Many assumptions are involved and it depends on location

But national scale analysis suggests costs in a 50-60% variable energy scenario appear manageable – uncertainty increases at higher levels



Jenkins et al., Getting to Zero Carbon Emissions in the Electric Power Sector, Joule (2018), https://doi.org/ 10.1016/j.joule.2018.11.013, adpated from Frew, Bethany A., et al. "Flexibility mechanisms and pathways to a highly renewable US electricity future." *Energy* 101 (2016): 65-78.

But ***all*** low carbon resources (firm and non-firm) have significant challenges

Nuclear – current cost challenges, public concern above waste and safety

Gas with carbon capture – still in early commercial stage, need to site pipeline and storage infrastructure, need to abate upstream emissions

Hydro – habitat, siting

Biomass – impact on land use and related carbon emissions, competition for cropping space

Solar and wind – cost challenges at high penetration described previously, large capacity times peak demand required, transmission siting

But innovations could change the game

Ultra-low cost “firm seasonal” energy storage (would need to be 1-10% of most current optimistic price) could facilitate a much lower cost 100% renewable system

New ”Allam Cycle” gas/carbon capture reaches technical maturity, progress on upstream emissions reduces methane leaks to near-zero

Advanced nuclear using non-water coolants

Because of the uncertainties and risks, it makes sense to hedge our bets for now ... so we have the best chance of meeting our mid-century goal!

CATF

A possible approach

A zero carbon energy standard

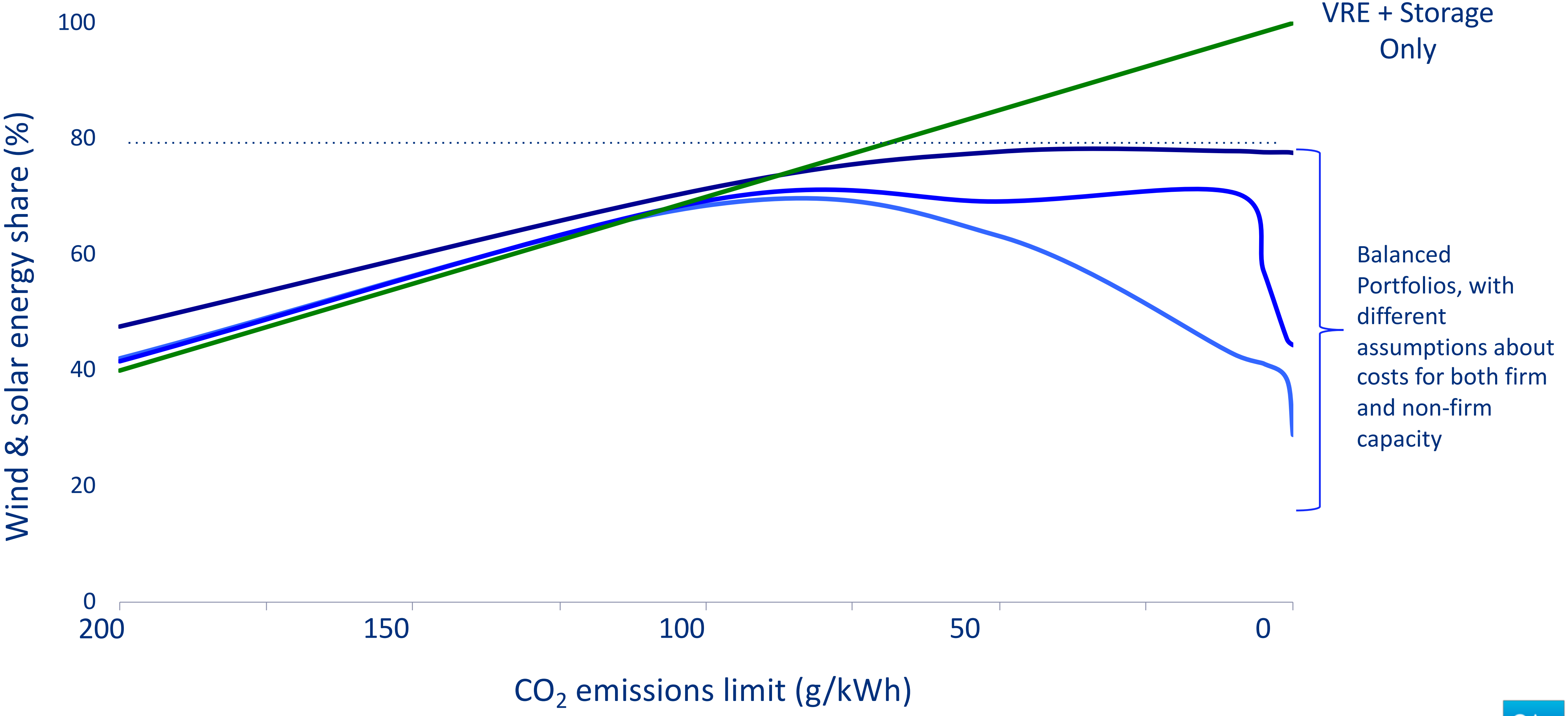
E.g. California SB 100 – 100% carbon-free by 2045, with renewable energy minimum of 60%

Similar policies being pursued in NY and in place in MA

This creates incentive for both firm and non-firm zero carbon technologies to innovate and compete, and avoids “lock in” of a single pathway that may prove later to be unsustainable.

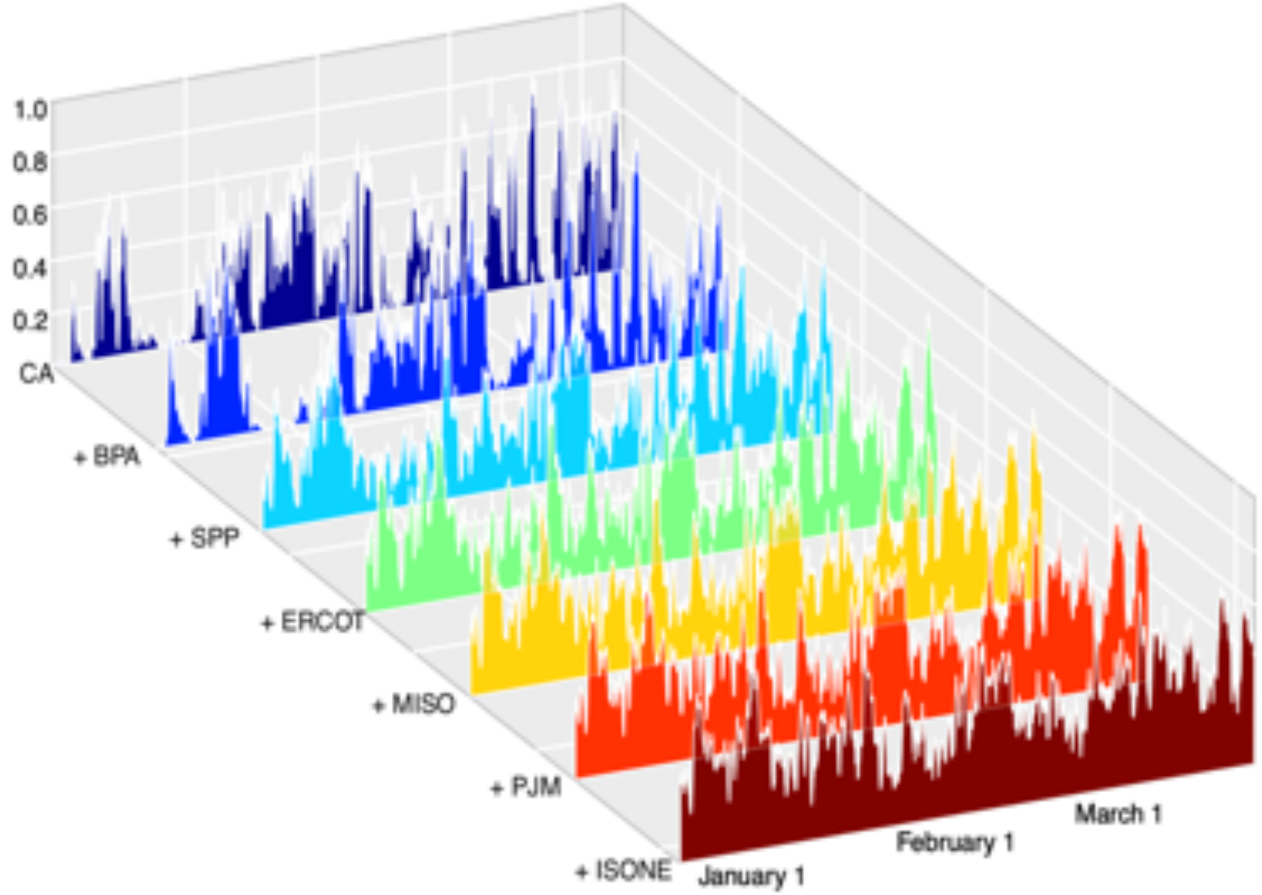
Back-up slides, will not be distributed

Uncertainty about least-cost variable energy shares at higher levels



Data source: Sepulveda, N., Jenkins, J.D., et al. (2018), “The role of firm low-carbon resources in deep decarbonization of electric power systems,” *Joule* (in press).

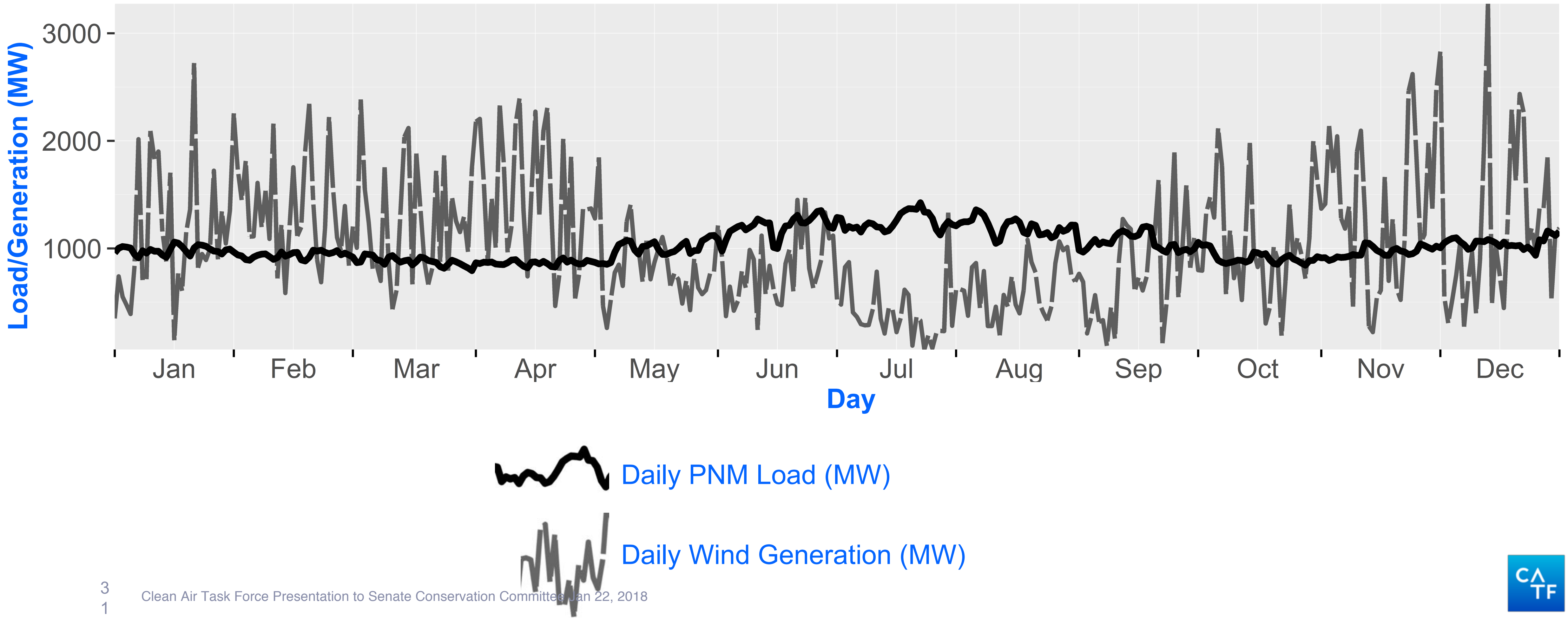
Wind output across regions (winter), progressively smoothed



CATF from NREL data

Daily Load & Wind Generation, 100% Wind Scenario

Scenario definition: 2018 wind generation scales to meet total 2018 PNM load



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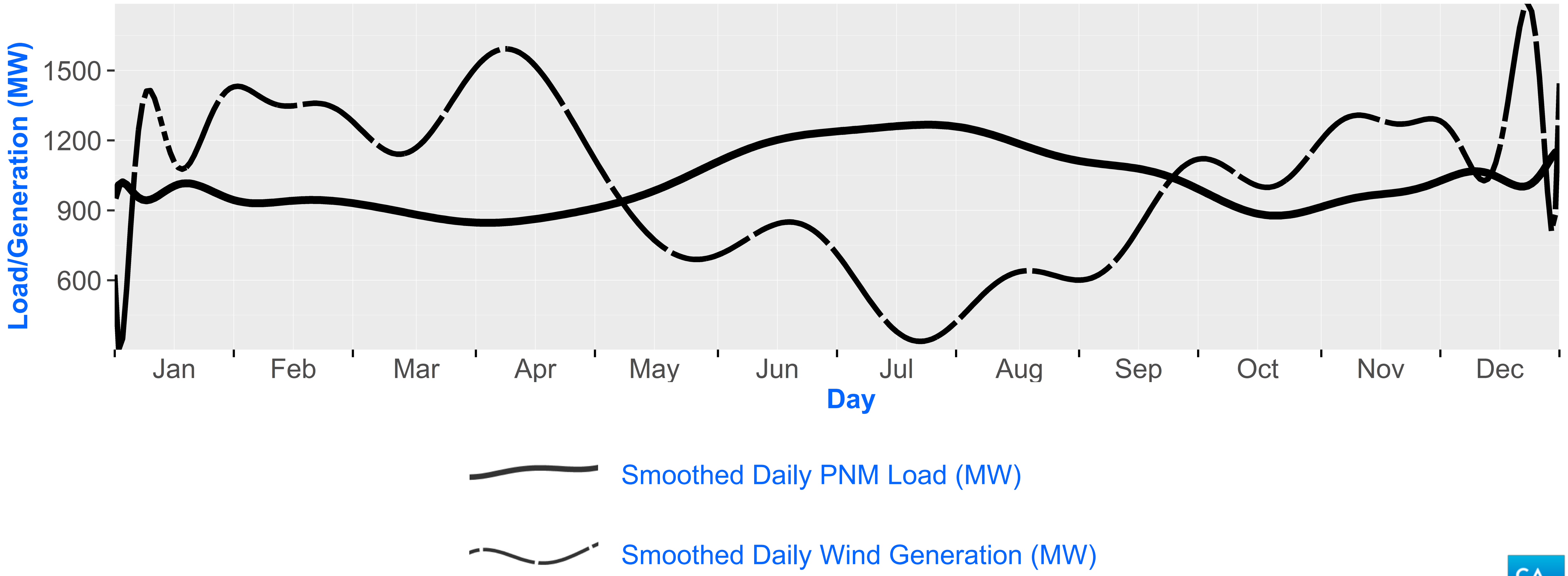

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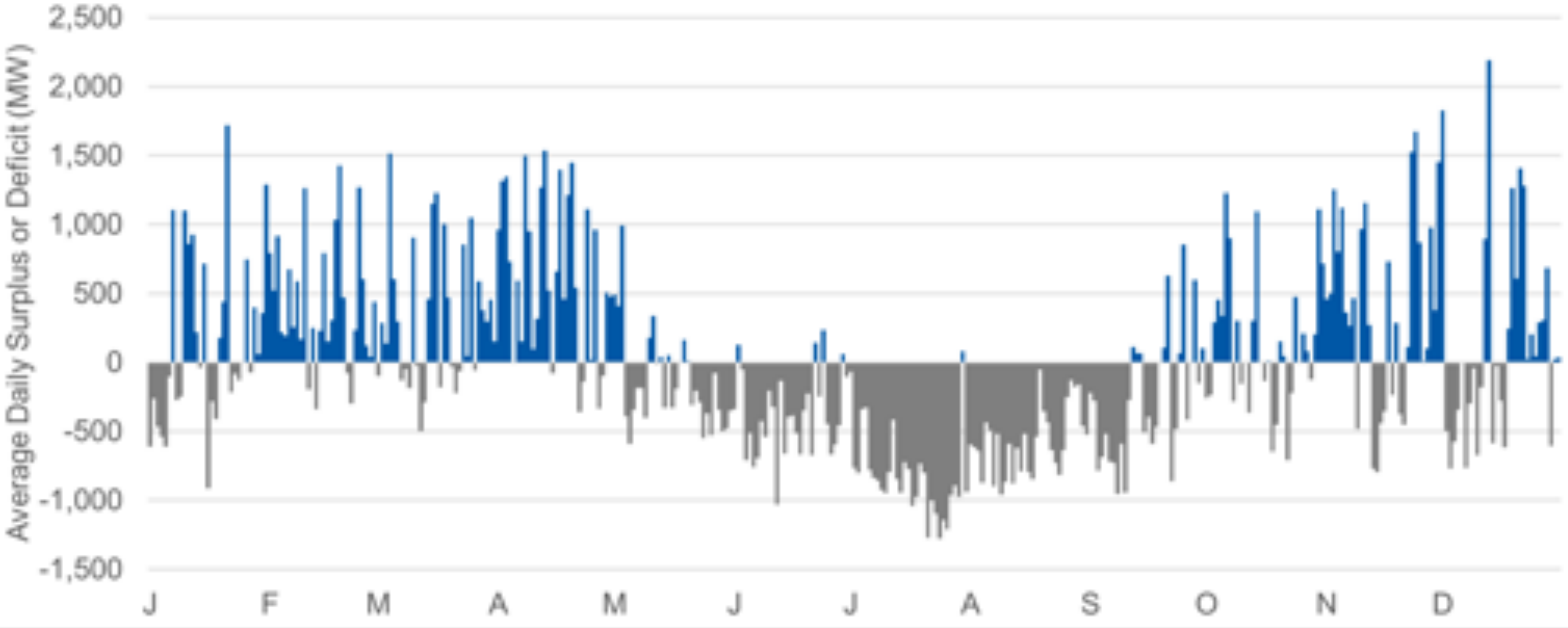

Day

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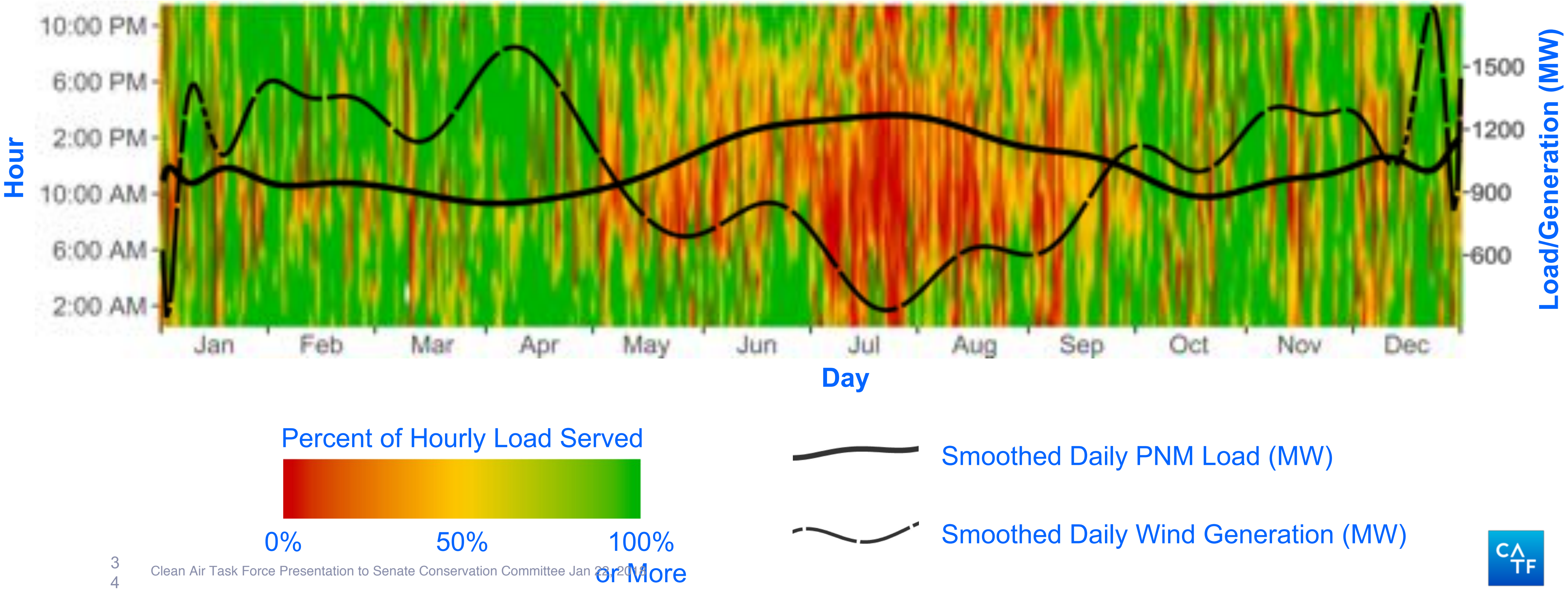

Daily Load & Wind Generation, 100% Solar Scenario

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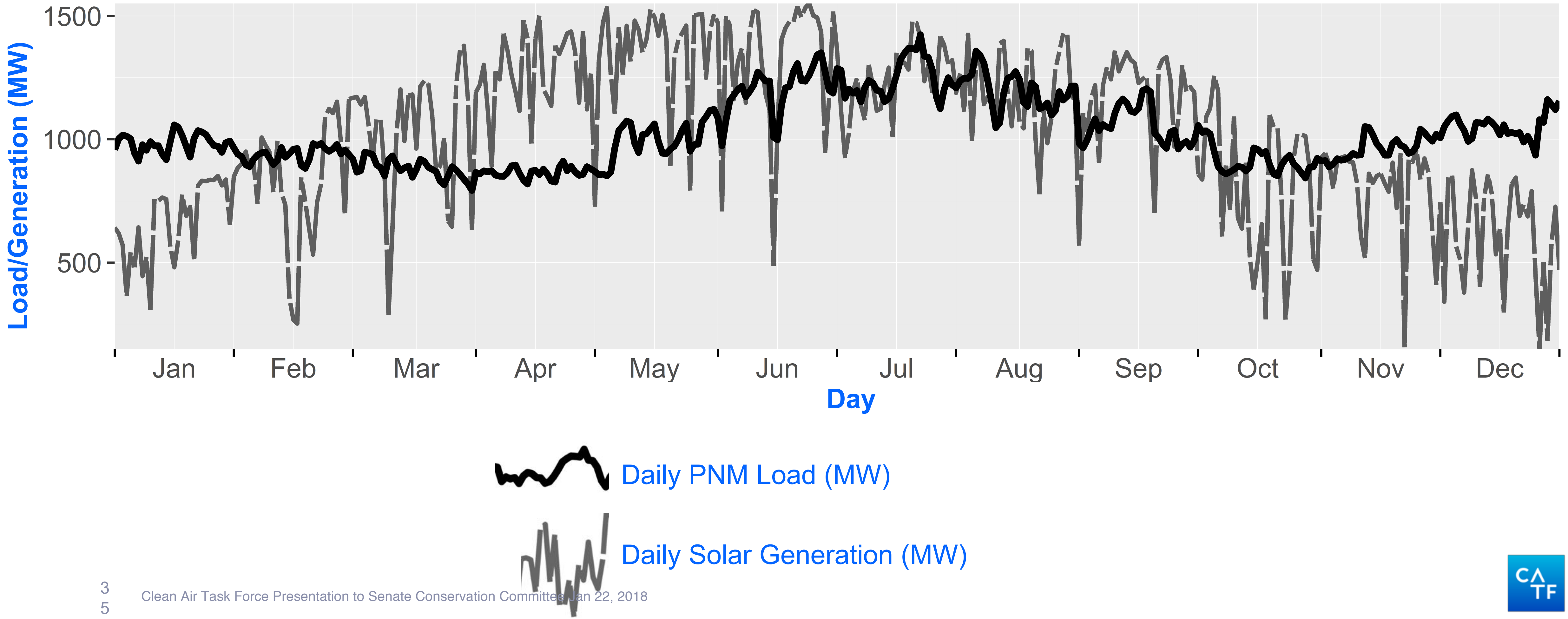

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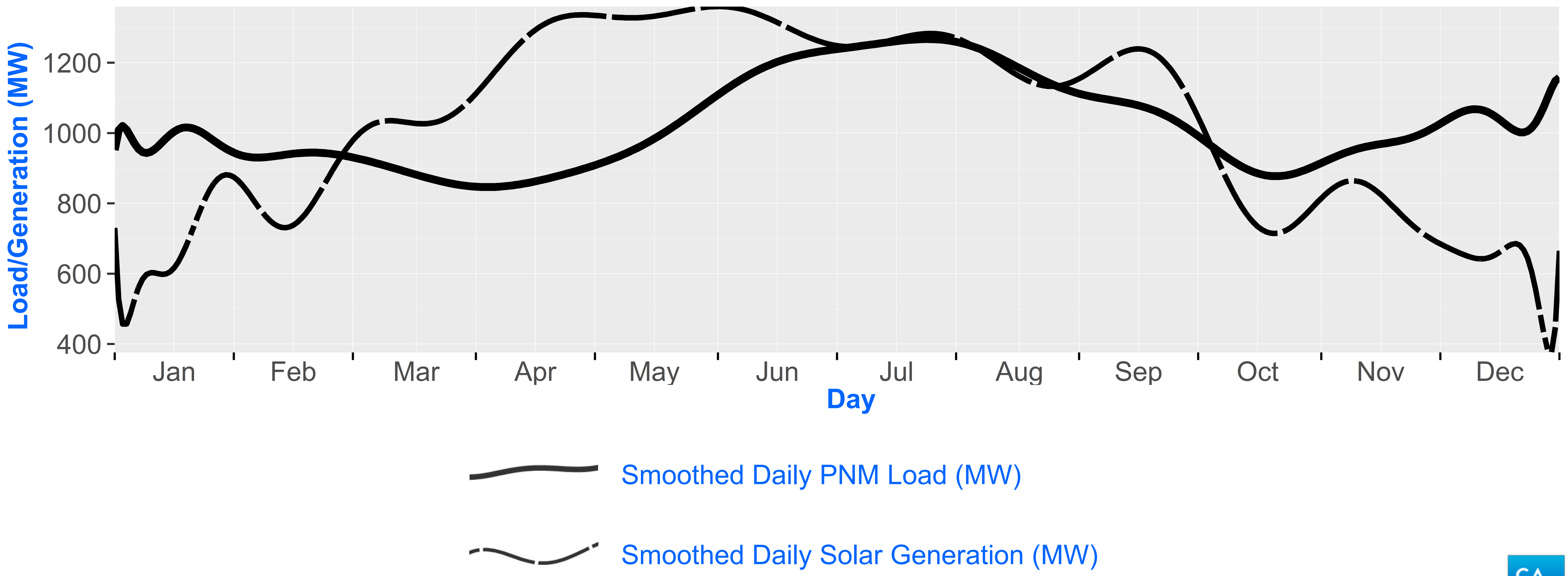

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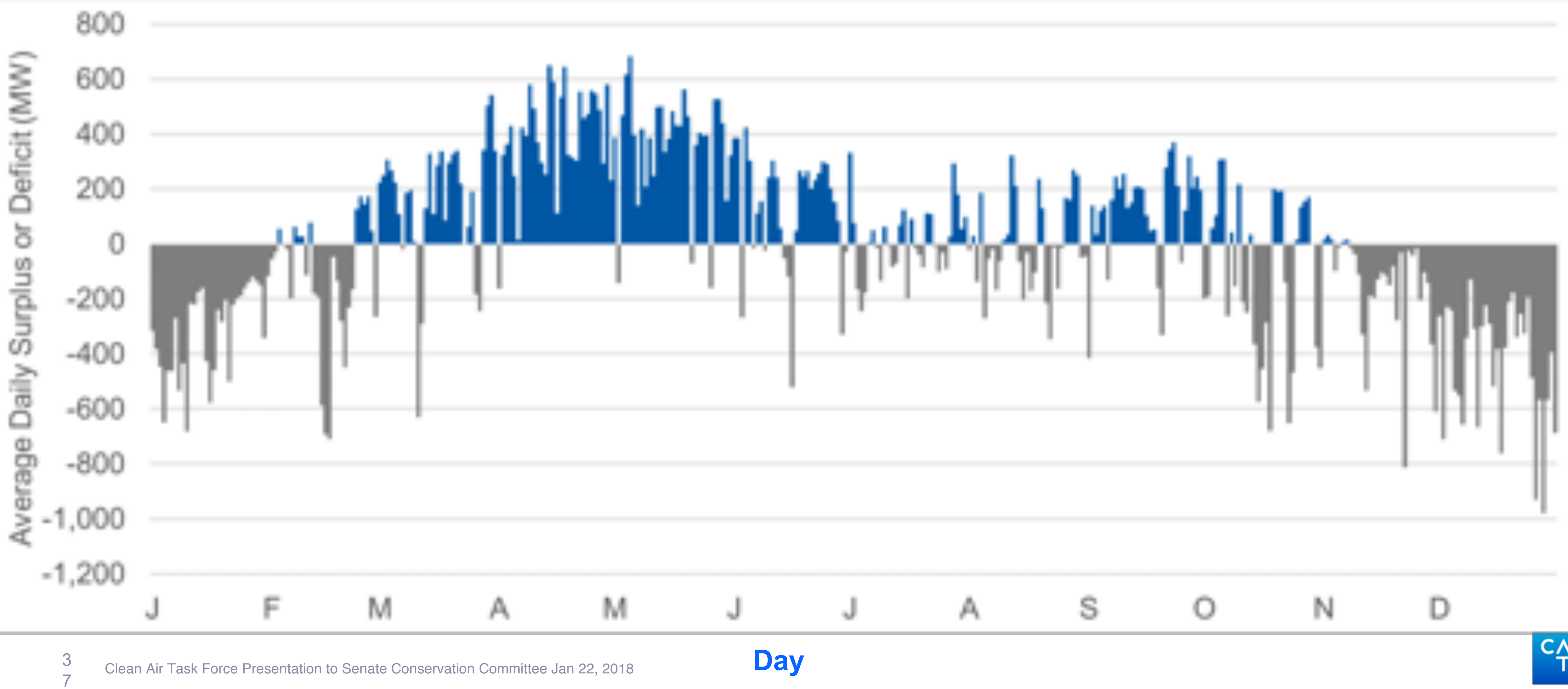

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