Considerations for a Clean and Renewable Energy Standard

Presentation to the Maryland Commission on Climate Change

Mitigation Working Group

September 2017

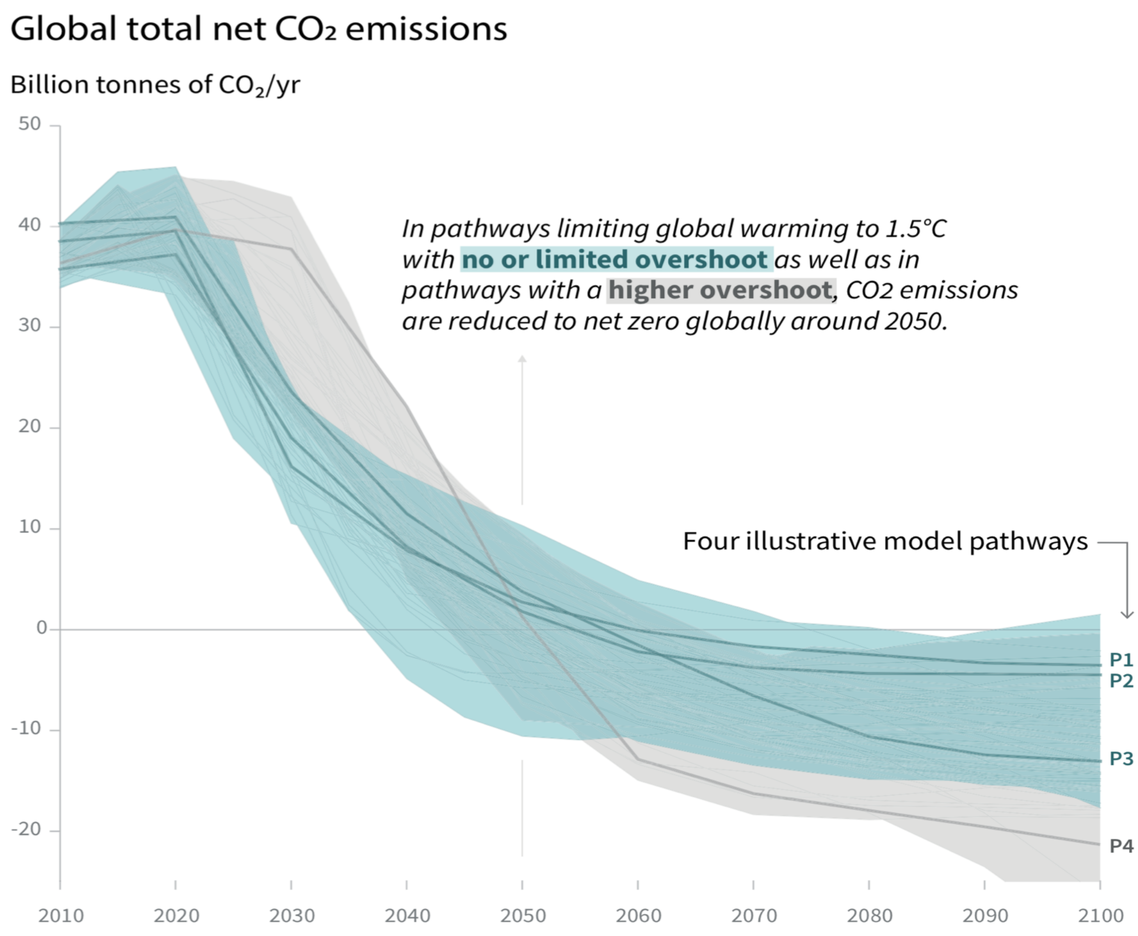
CLEAN AIR TASK FORCE

CENTER FOR CLIMATE AND ENERGY SOLUTIONS

Key points

- **To stabilize climate, electric power sector emissions need to fall to near-zero around mid-century**
- **Numerous analyses, and Maryland data, suggest that the chances of achieving this transition affordably will be greater if policy allows for a diversity of technologies, including firm/dispatchable power generation such as nuclear and fossil with carbon capture.**
- **Six states have adopted this technology-inclusive approach, and Maryland should follow suit.**

The challenge: a rapid drop in carbon emissions to zero by midcentury



Source: Intergovernmental Panel on Climate Change (2018)

Power must decarbonize sooner to help displace dirty fuels in transport, heat and industry – and grow 50+% at the same time

Our options


Variable/weather-dependent



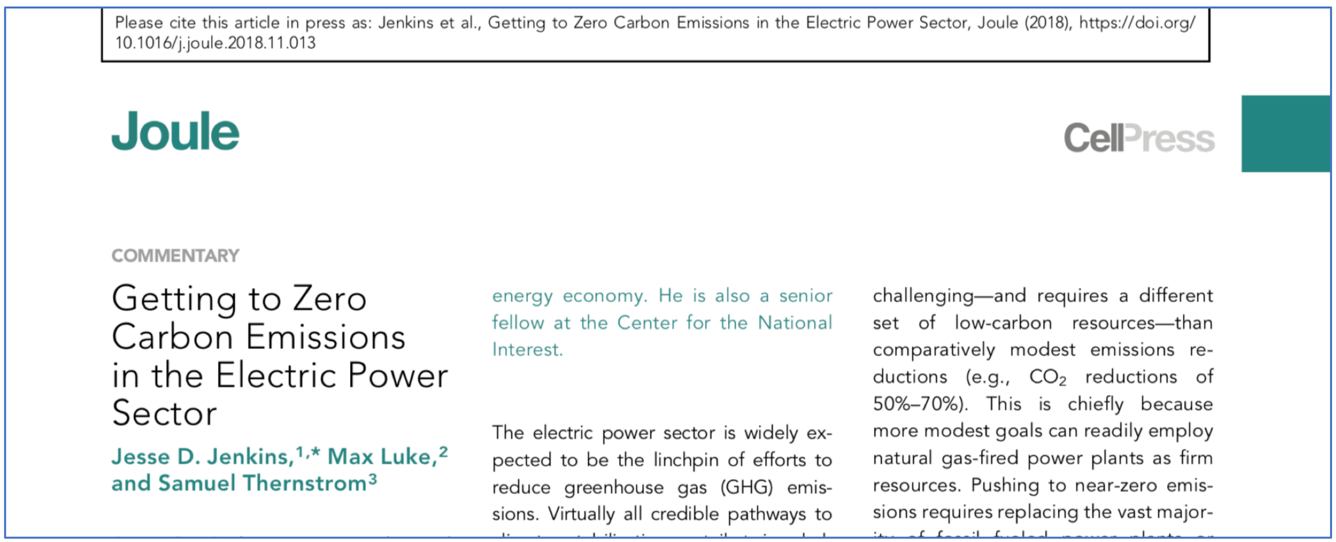


Dispatchable/firm

Why not just variable renewable energy like wind and solar?

Why include firm energy?

Review of 40 studies: having firm zero carbon power available reduces costs and risks in achieving a zero carbon grid especially as CO2 reductions move > 50%



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Joule

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COMMENTARY

Getting to Zero Carbon Emissions in the Electric Power Sector

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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-

Why is this so?

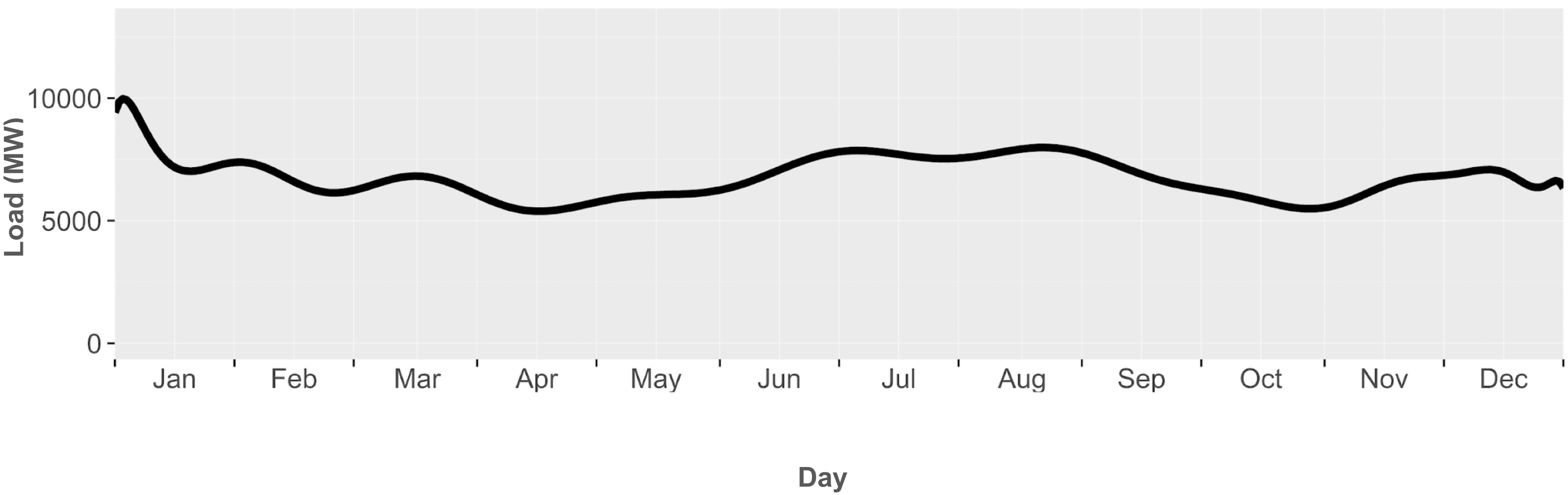
Let's look at the Maryland data.*

*Load data used in this presentation is from Baltimore Gas and Electric and PEPCO Maryland combined, and modeled generation inputs and outputs are scaled to those two service territories.

Electricity supply must meet hourly demand in every hour of the year

Smoothed Daily Load (2018)

BG & E plus PEPCO Maryland

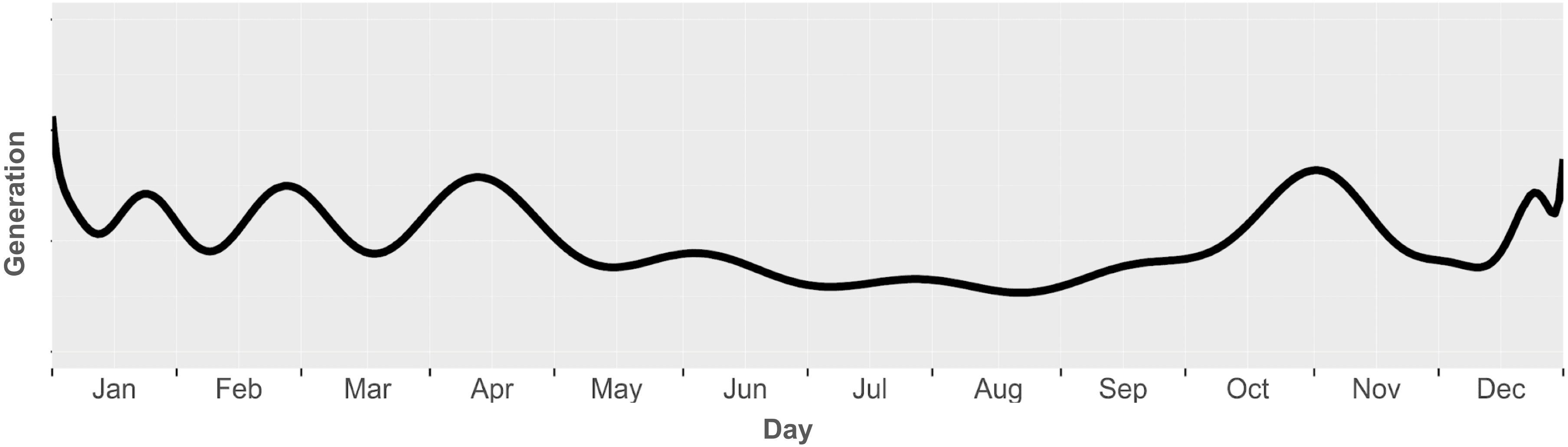


But in the Maryland region, as in most of the Northern Hemisphere, wind and solar varies substantially not just *daily* but *weekly-monthly*, in a way that does not always match load

At high levels of wind and solar energy (> 60% of system energy), "filling the gap" begins to pose serious cost challenges

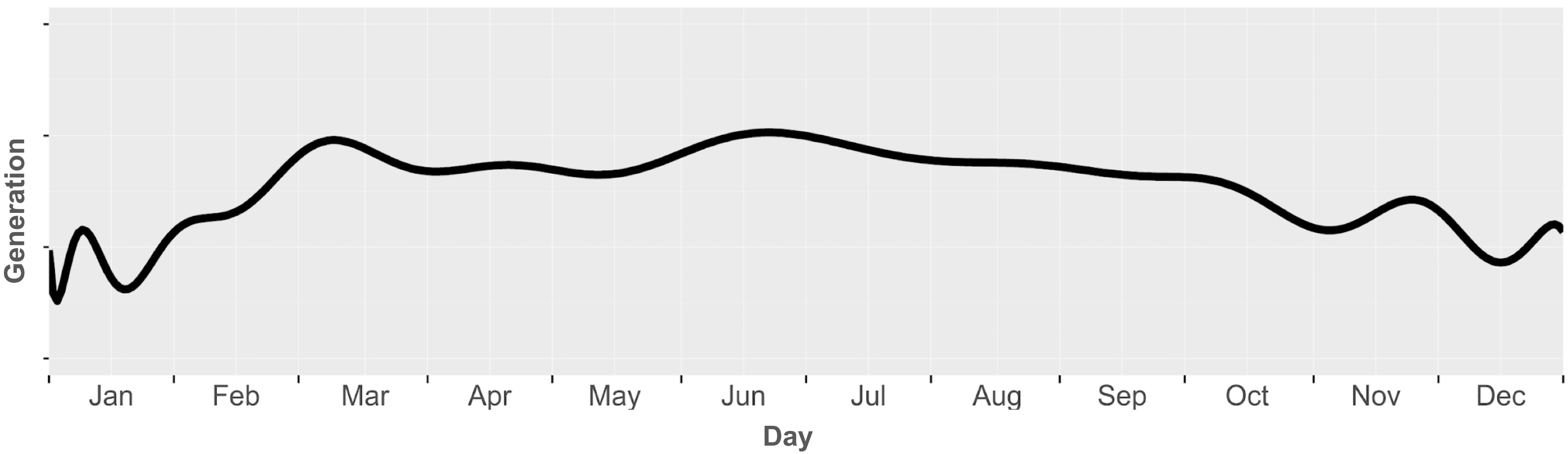
Smoothed Daily Wind Generation Profile (Simulated in NREL SAM)

In Maryland

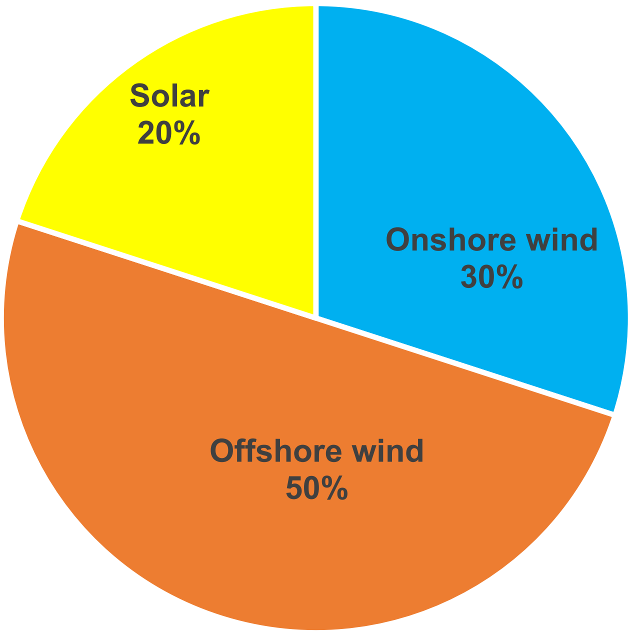


Smoothed Daily Solar Generation Profile (Simulated in NREL SAM)

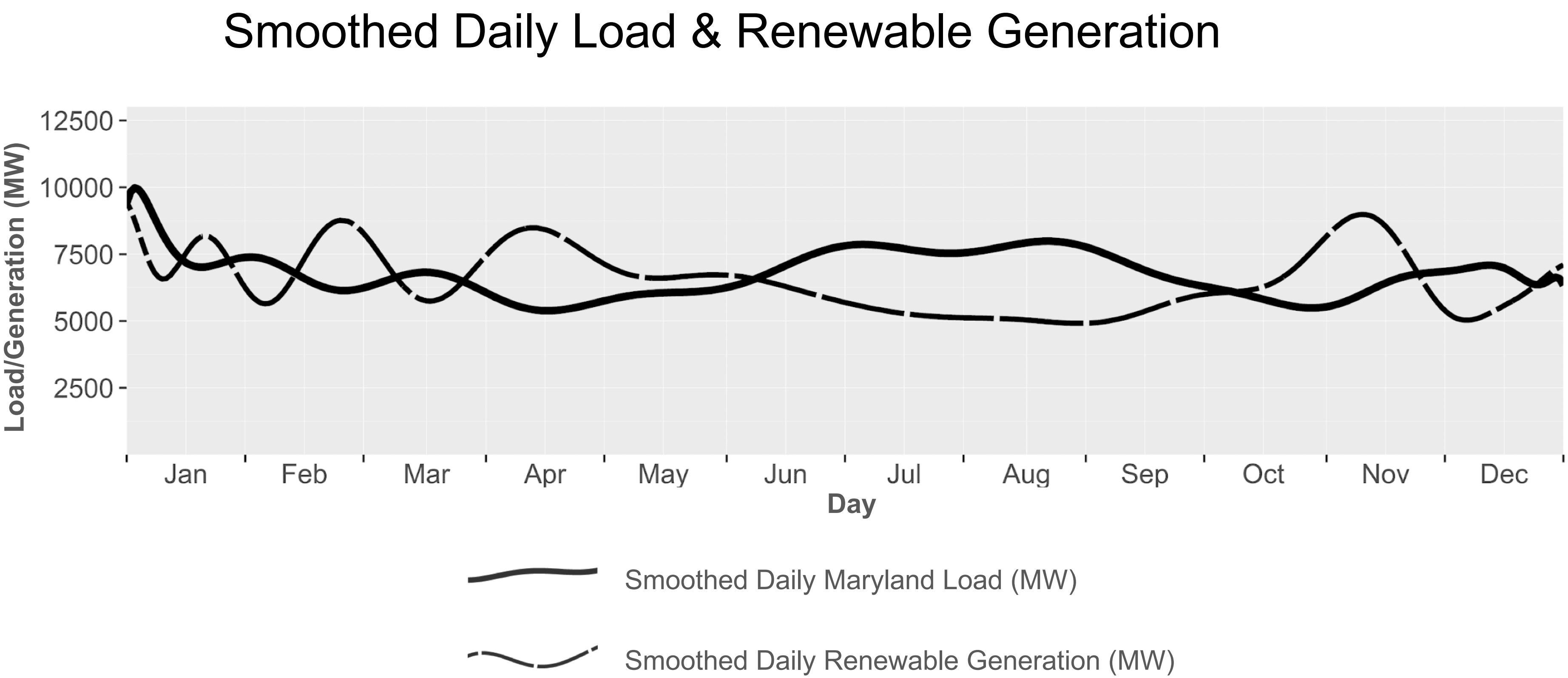
In Maryland



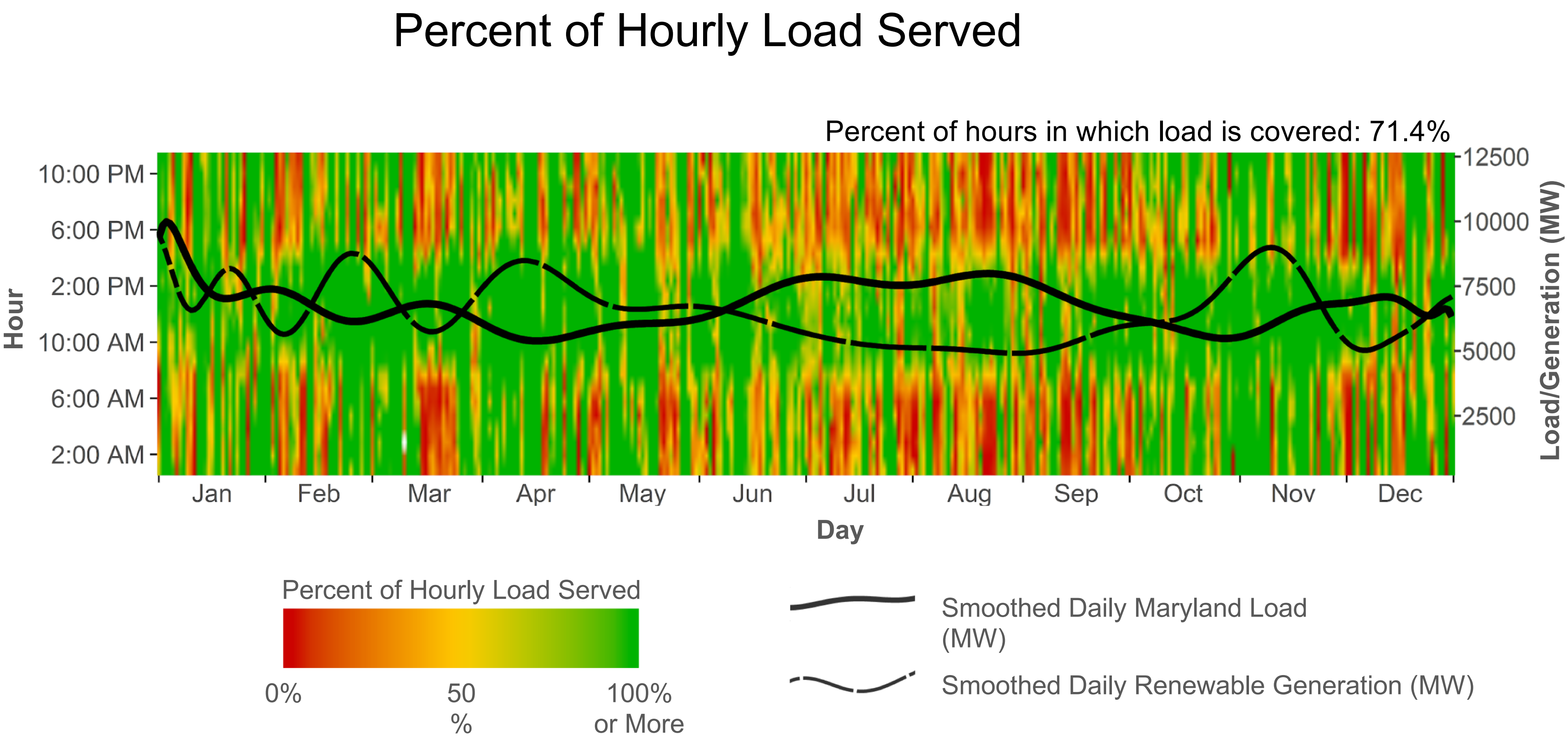
100% Renewable Scenario Definition: Offshore wind*, solar PV, and onshore wind scale to meet 50%, 30%, and 20% of the 2018 Maryland load, respectively.



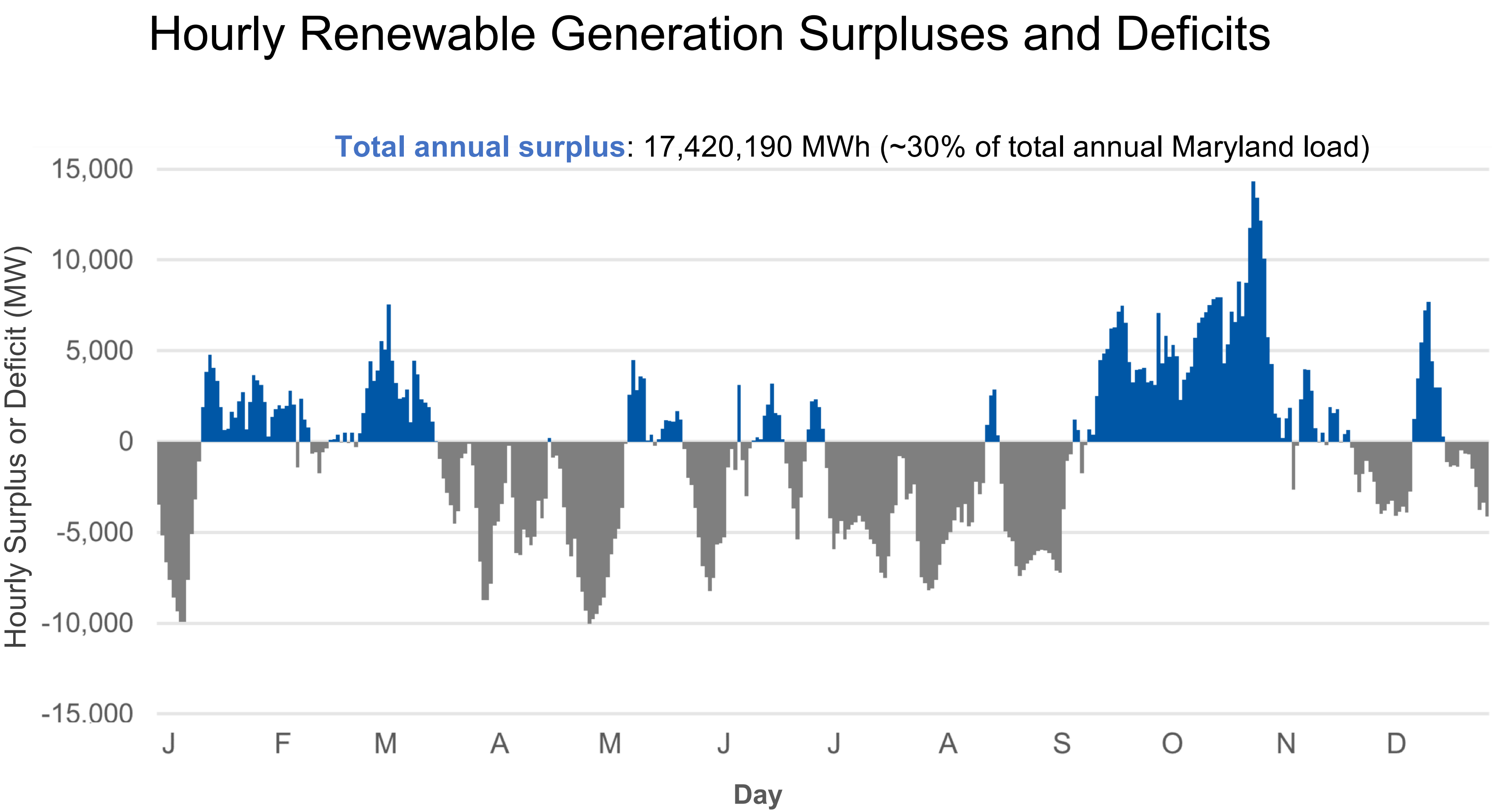
This scenario generates ***seasonal*** surpluses and deficits in the range of 2500-3500 MW…



.. Leaving about 30% of annual hours uncovered by renewable generation.



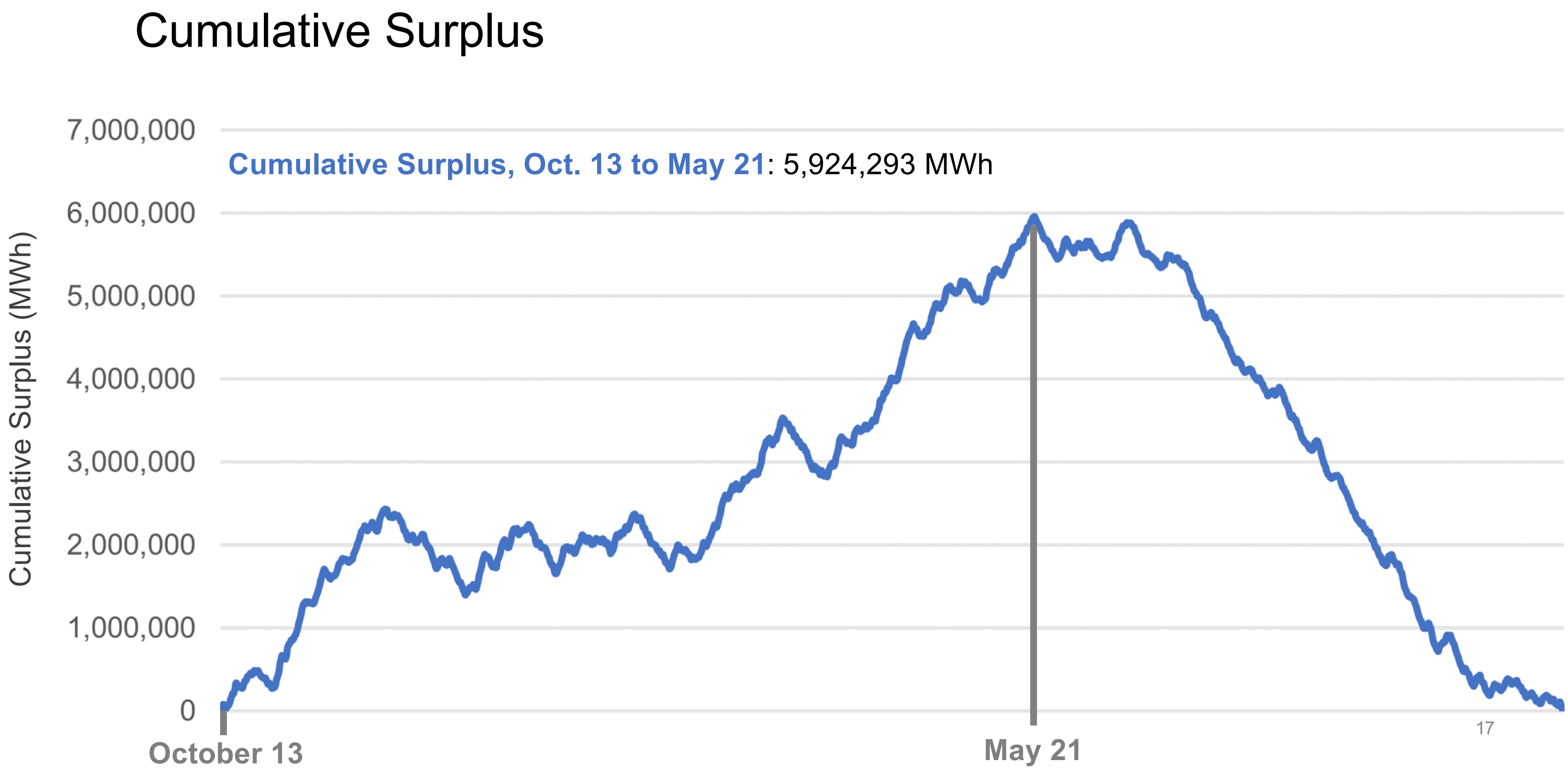
And deficits are weekly-monthly in duration



Q. Can’t storage solve this problem?

A. In theory, but managing multi-week and monthly surpluses and deficits will be very expensive.

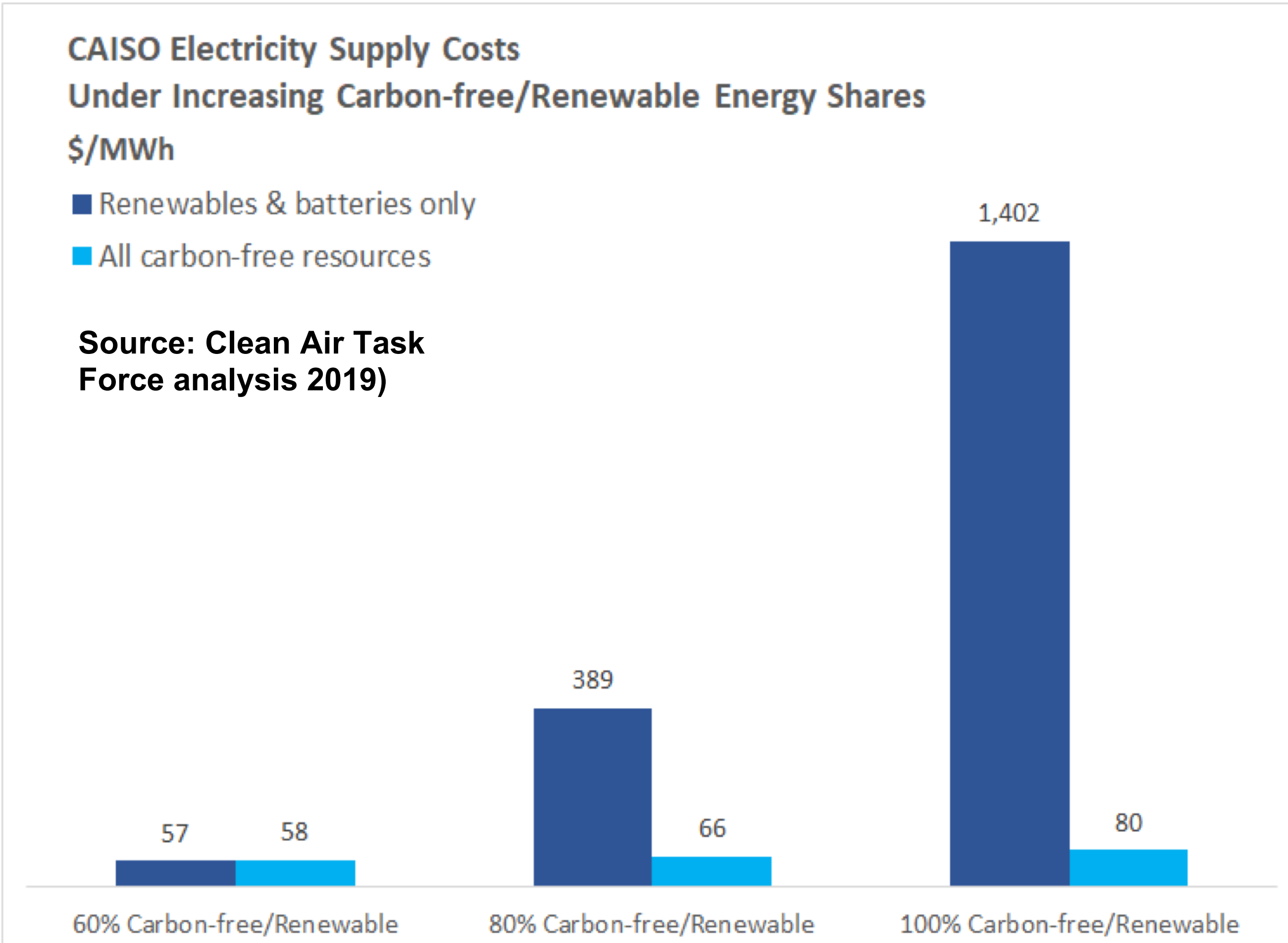
For example, utilizing all renewable generation surplus would require about 6 TWh of battery capacity



Battery storage as a solution?

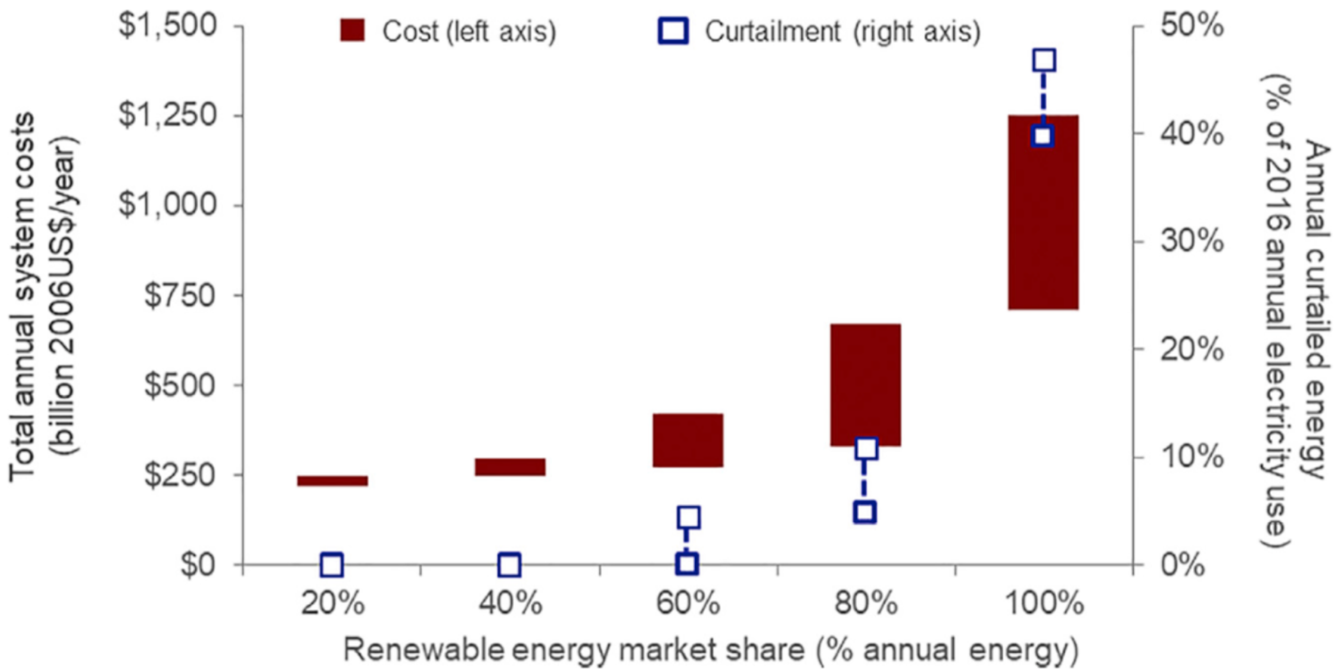
- 5,924 GWH required
- Assuming 8 hour storage, this is the equivalent of 740 GW of generation, or roughly fifty times Maryland peak demand
- Drop storage capacity costs to $80/kwh (from $300-400 today)
- Total capital cost = $473 Billion
- But this understates cost as batteries cannot hold seasonal charge; additional capacity would be required to account for leakage

Analysis in other jurisdictions shows rapidly escalating costs from very high penetration of wind and solar + batteries*



*** In this analysis, generation and storage were optimized i.e. storage was only utilized where it was cheaper than over-building with wind and solar and curtailing when supply exceeds demand.**

The same conclusions hold at national scale with full transcontinental transmission interconnection, demand response and storage

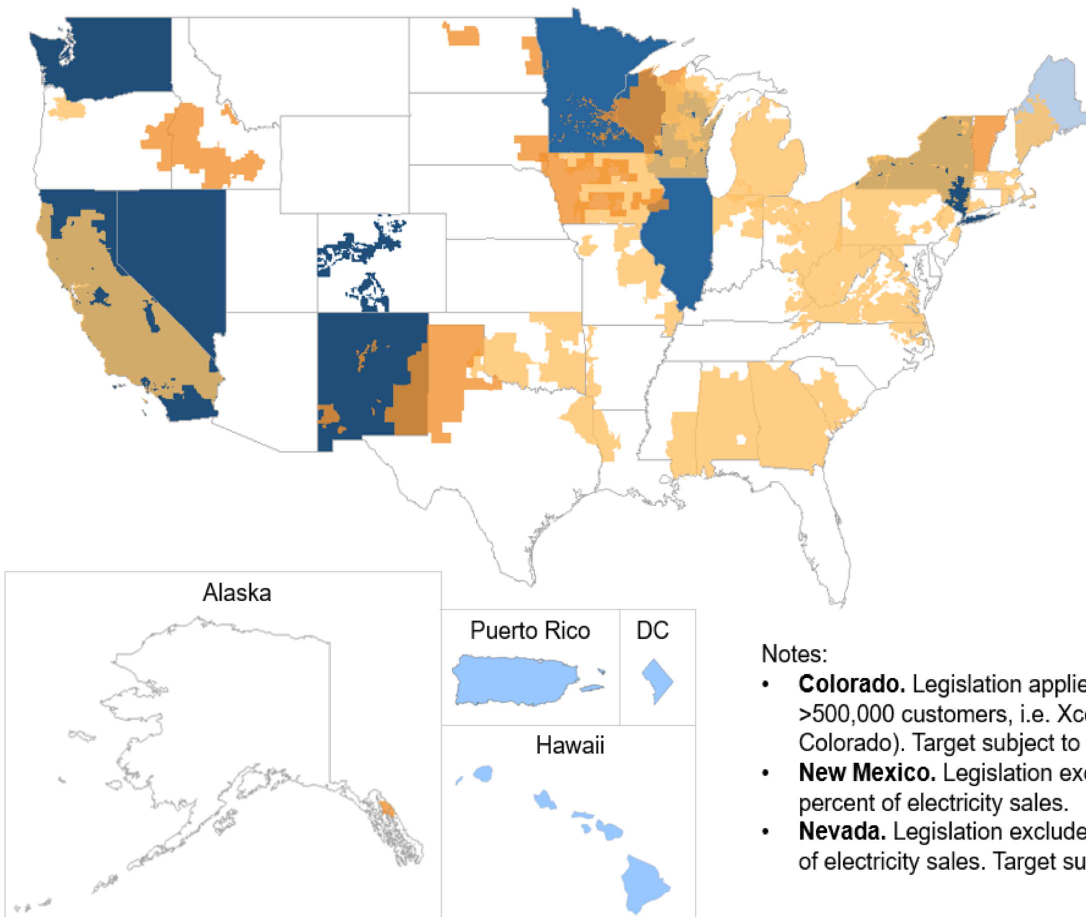


Jenkins et al., Getting to Zero Carbon Emissions in the Electric Power Sector, Joule (2018), https://doi.org/ 10.1016/j.joule.2018.11.013, adapted from Frew, Bethany A., Jacobson, M. et al. "Flexibility mechanisms and pathways to a highly renewable US electricity future." *Energy* 101 (2016): 65-78.

A cost effective, option-based approach: Renewables, Storage and Zero Emission Firm

- Push non-hydro renewables beyond 50% (10x from today)
- Appropriate storage for near-term management of renewables (daily to a few days)
- Keep open option for mix of zero emitting firm sources for the remainder

Six states have adopted technology-inclusive 100% clean energy standards, representing 15% of US electric sales; technology-inclusive utility 100% carbon free pledges bring the total covered US sales to 25%



Notes:

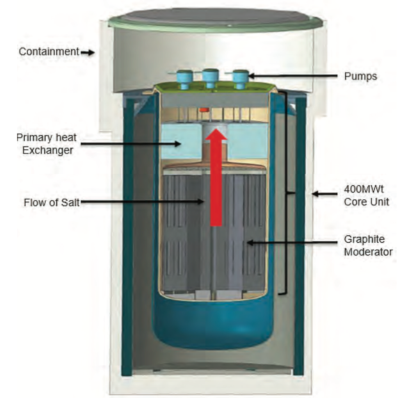
- **Colorado.** Legislation applies only to non-municipal utilities that serve >500,000 customers, i.e. Xcel Energy (Public Service Company of Colorado). Target subject to later study or action.
- **New Mexico.** Legislation excludes co-ops, which account for about 20 percent of electricity sales.
- **Nevada.** Legislation excludes co-ops, which account for about 6 percent of electricity sales. Target subject to later study or action.

Source: Clean Air Task Force, https://www.catf.us/resource/state-utility-climate-change-targets/

There are other obstacles to very high renewable penetration

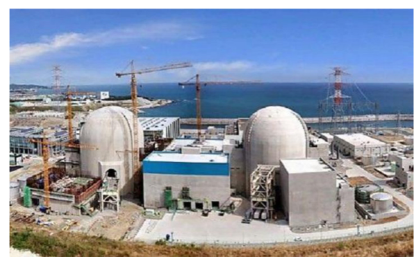
What are our real firm options apart from existing nuclear and hydro?

NetPower Zero Carbon Nat Gas
Allam Cycle

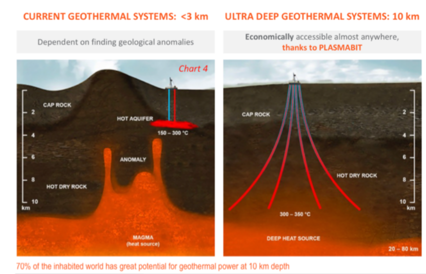


Advanced non-light water nuclear

Ammonia or hydrogen as a generation fuel produced from natural gas reforming plus CCS, or from surplus renewables electrolysis



Gen III nuclear built with best project management practices (UAE-KEPCO reactors delivered at $3,000/kw)



Engineered supercritical deep geothermal

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**
- **Solar and wind – cost challenges at high penetration described previously, large capacity times peak demand required, transmission siting**
- **Biomass – impact on land use and related carbon emissions, competition for cropping space**

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!

Conclusions

- **Firm electricity will likely be necessary for affordable deep decarbonization of the power sector and therefore the energy system as a whole**
- **It is therefore wise to keep all plausible *zero/low carbon* options on the table, while ramping up renewables significantly in the next decade**
- **The Maryland Clean and Renewable Energy Standard, like the standards recently set in other states such as CA, NM, WA, NV, NY, and CO, should establish a 100% carbon-free goal and keep technology pathways open to allow for evolving innovation and costs**