Charting Pathways to Deep Decarbonization: Challenges for Analysts, Policymakers, Advocates and the Public

Presentation to the UCSD Deep Decarbonization Initiative

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Clean Air Task Force

31 January 2018

Clean Air Task Force

- Established in 1997 to work on conventional air pollution issues
- Began to focus on climate change in 2000
- Current focus on innovation needed to bring forward scalable, cost-competitive low-carbon technologies for electricity, industry and transport
  - Advanced nuclear
  - Fossil CCS for utilities and industry
  - Ammonia and hydrogen as potential zero carbon liquid fuel substitutes
- Working assumption: deep decarbonization only happens if low-carbon substitutes are at cost parity with current options

A few words on modeling and models

- What is modeling for?
  - Defining the terrain in which possible solutions might lie
  - Framing important questions
- Hard data—soft data—analysis—interpretation
  - Where does one end and another begin?
- Which tools?
  - Fedex and Delta Airlines
  - Pathways to 2050

Deep decarbonization

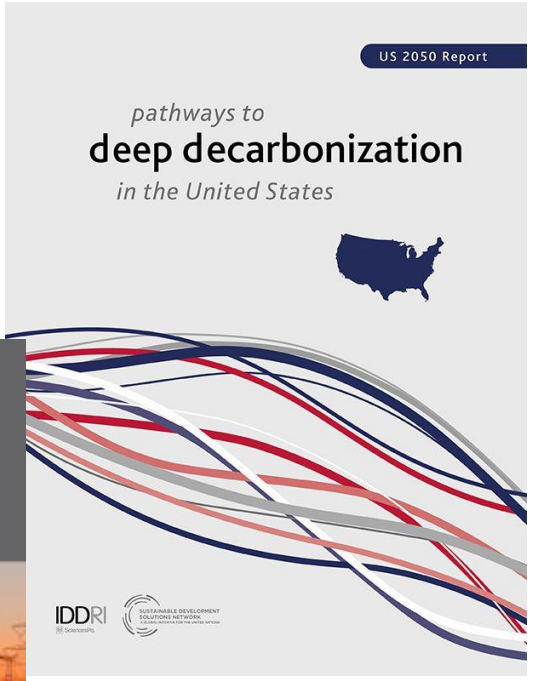
- How can we eliminate carbon from global electricity systems by 2050-2070 in light of the following constraints?
  - We will drive new end uses to electricity
  - We will provide electricity to 1.8 billion global citizens who have none
  - We will increase electricity supply to 2-3 billion global citizens who have *inadequate* access to electricity
  - We will minimize costs
  - We will maintain or improve current levels of system reliability
  - We will protect other environmental values

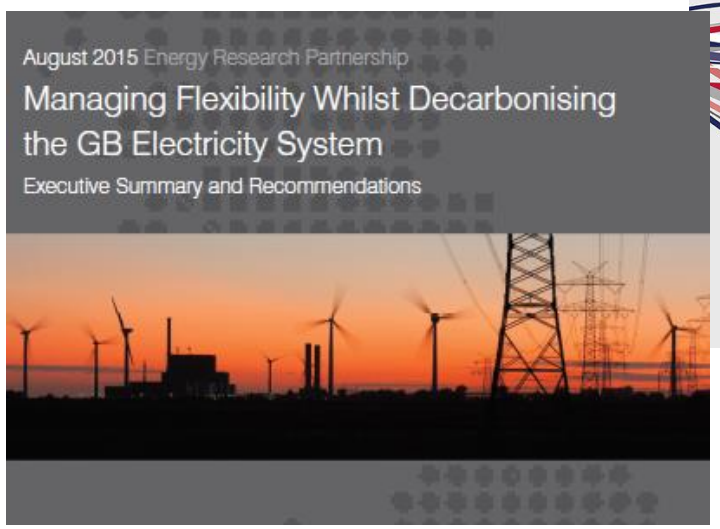
Top level conclusions

- If you aim to develop a 70 percent decarbonized grid, a combination of variable renewables and natural gas will do the job
- If you aim to develop a 90-100 percent decarbonized grid, a diverse portfolio (including zero carbon baseload of some sort) is needed
  - We don’t need (nor can we) select a final 2050 portfolio today (although this is what most of the fuss has been about….)
  - We do need to create as diverse an arsenal as possible for reducing emissions

Recent studies find …

- Systems with high proportions of wind and solar are
  - Larger
  - Costlier
  - Less effective at reducing carbon than diversified approaches
- Diversified portfolios that include zero carbon baseload yields systems that are
  - Smaller
  - Cheaper
  - Lower carbon





The Electricity Journal 29 (2016) 6–12
Contents lists available at ScienceDirect
The Electricity Journal
journal homepage: www.elsevier.com/locate/electr

Renewables and decarbonization: Studies of California, Wisconsin and Germany

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Two new meta-analyses find the same

EIRP
ENERGY INNOVATION REFORM PROJECT

DEEP DECARBONIZATION OF THE ELECTRIC POWER SECTOR
INSIGHTS FROM RECENT LITERATURE

JESSE D. JENKINS AND SAMUEL THERNSTROM

MARCH 2017

Renewable and Sustainable Energy Reviews 76 (2017) 1122–1133

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Burden of proof: A comprehensive review of the feasibility of 100% renewable-electricity systems

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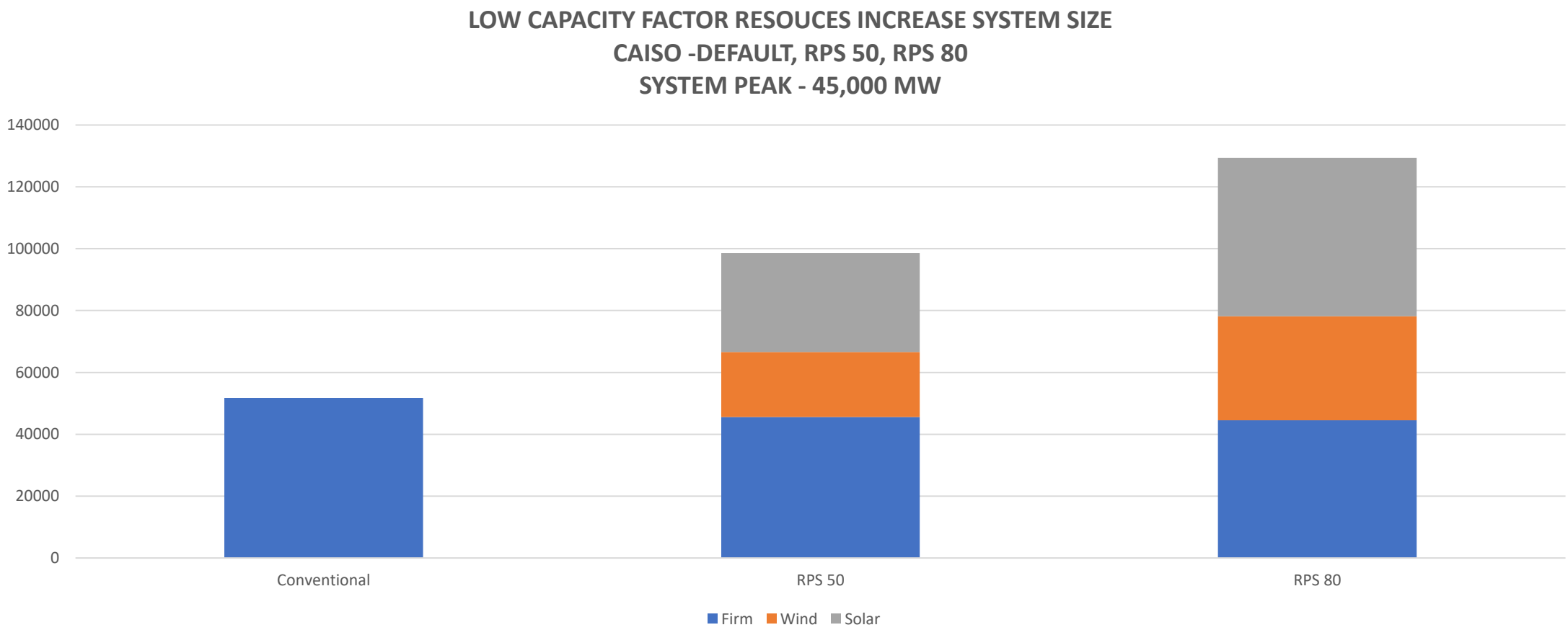
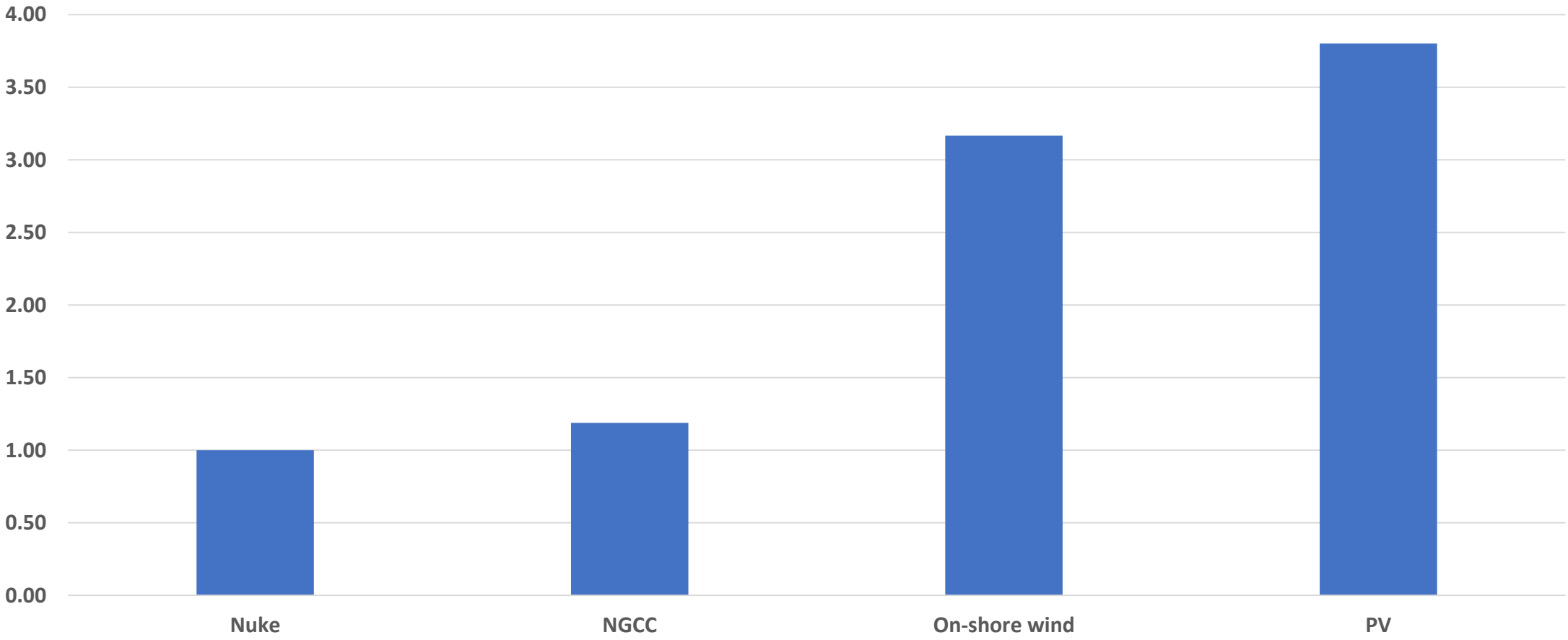
ARTICLE INFO

ABSTRACT

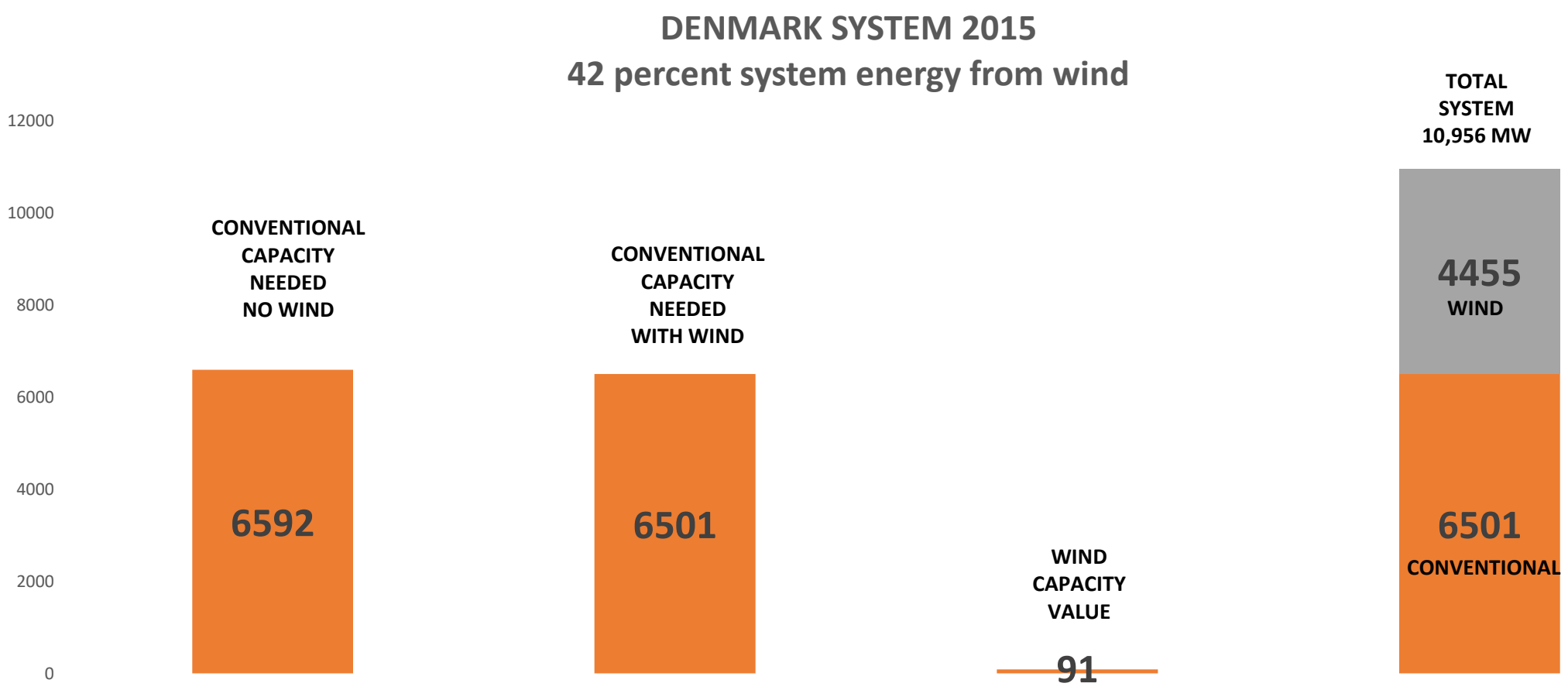
How much larger?



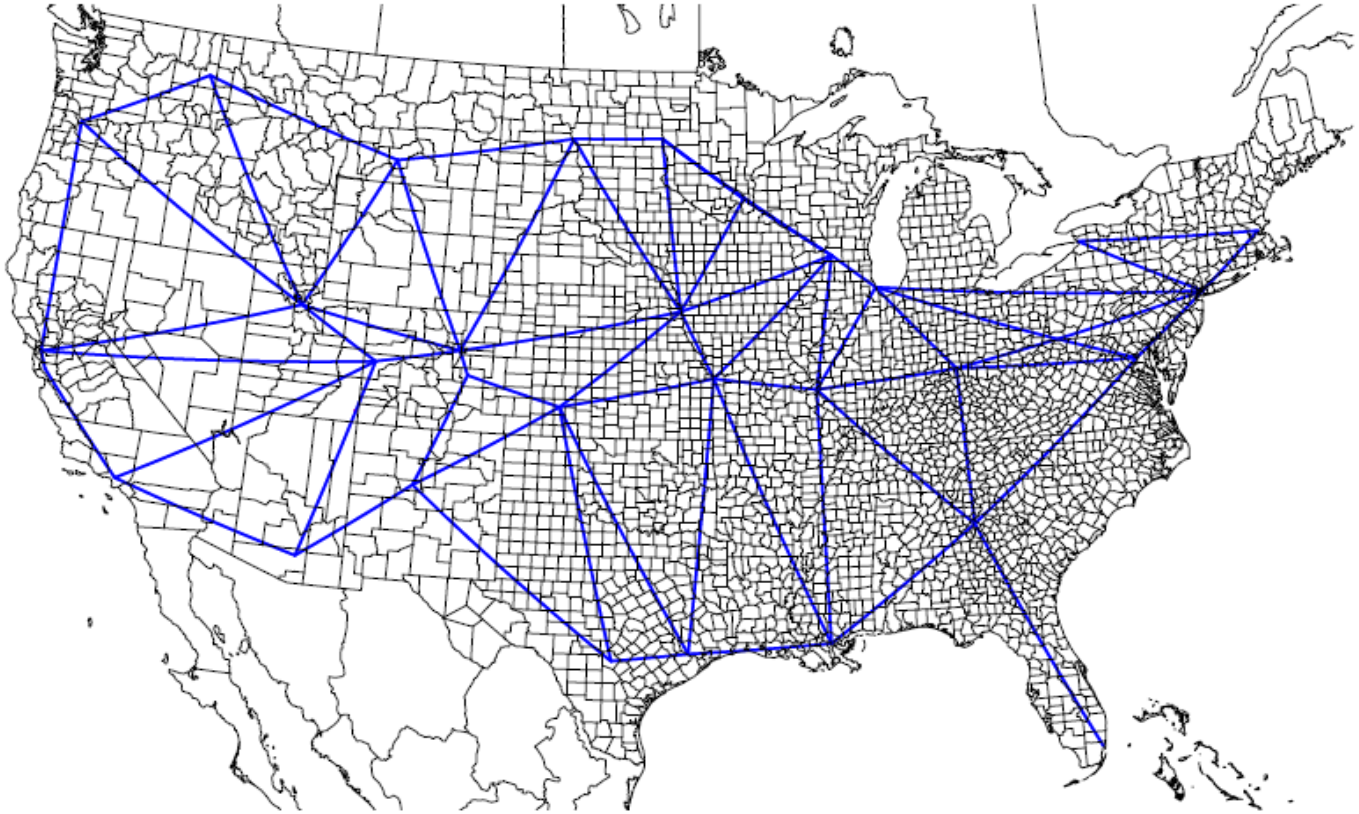
Larger, because more variable capacity is required to produce the same output …



Larger, because variable resources have limited capacity value …

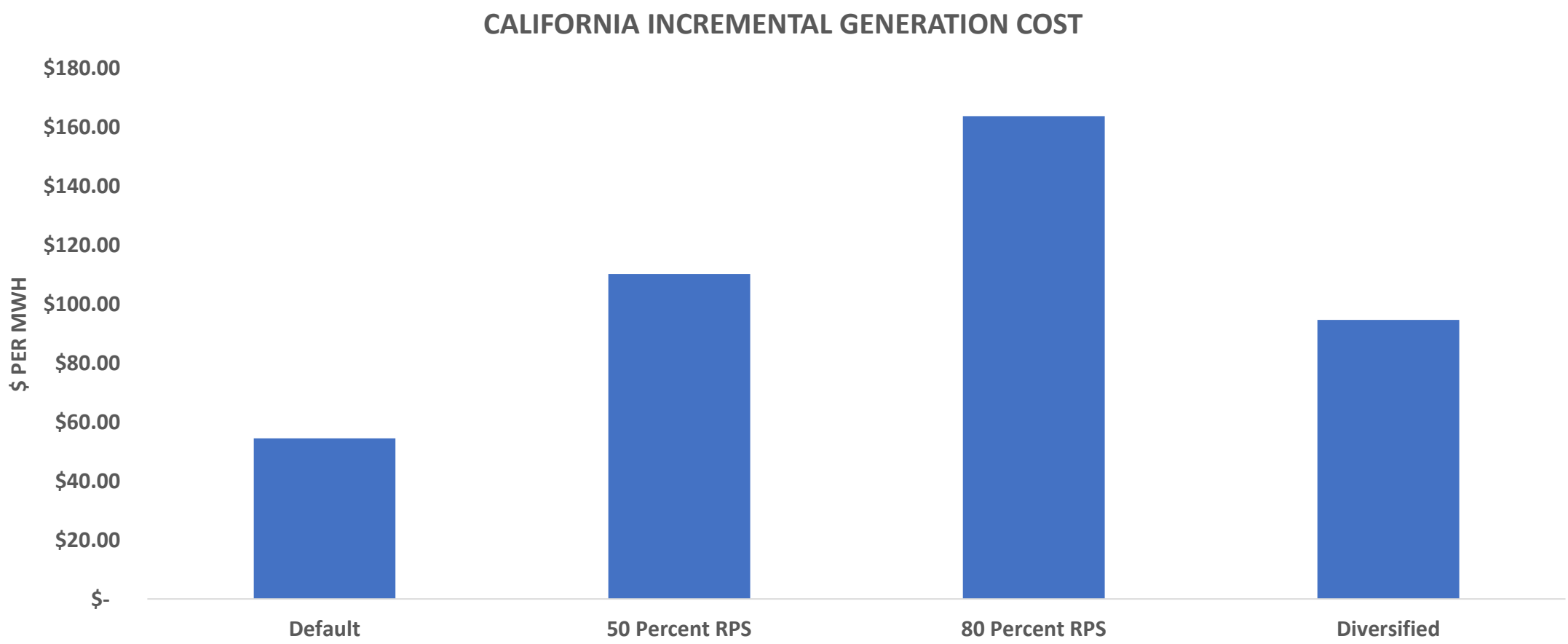


Larger, because systems with high penetrations of variable resources require more transmission …

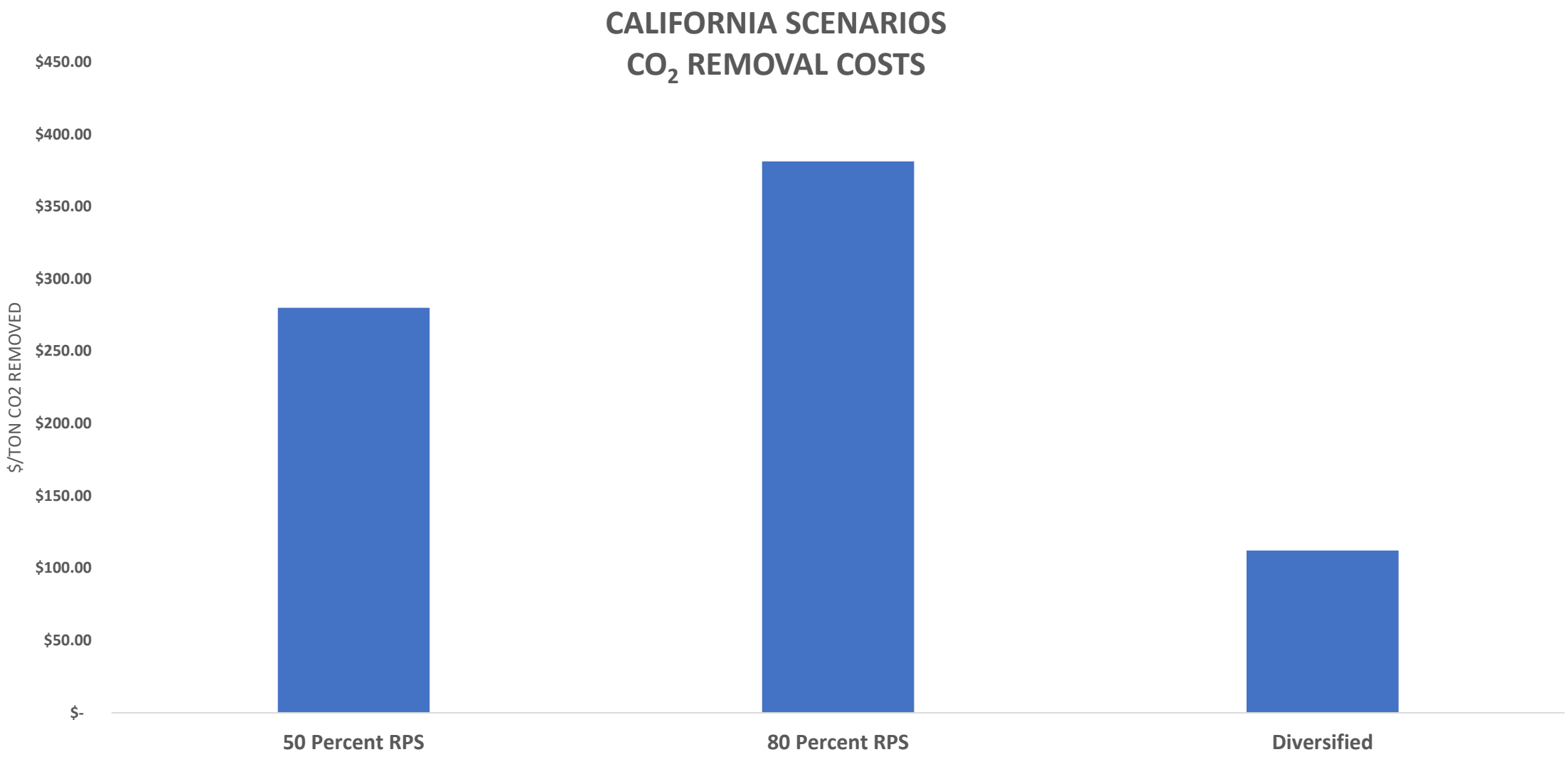


Source: MacDonald, et. al., Nature Climate Change, DOI:10.1038/NCLIMATE2921

Costlier, because they are larger …



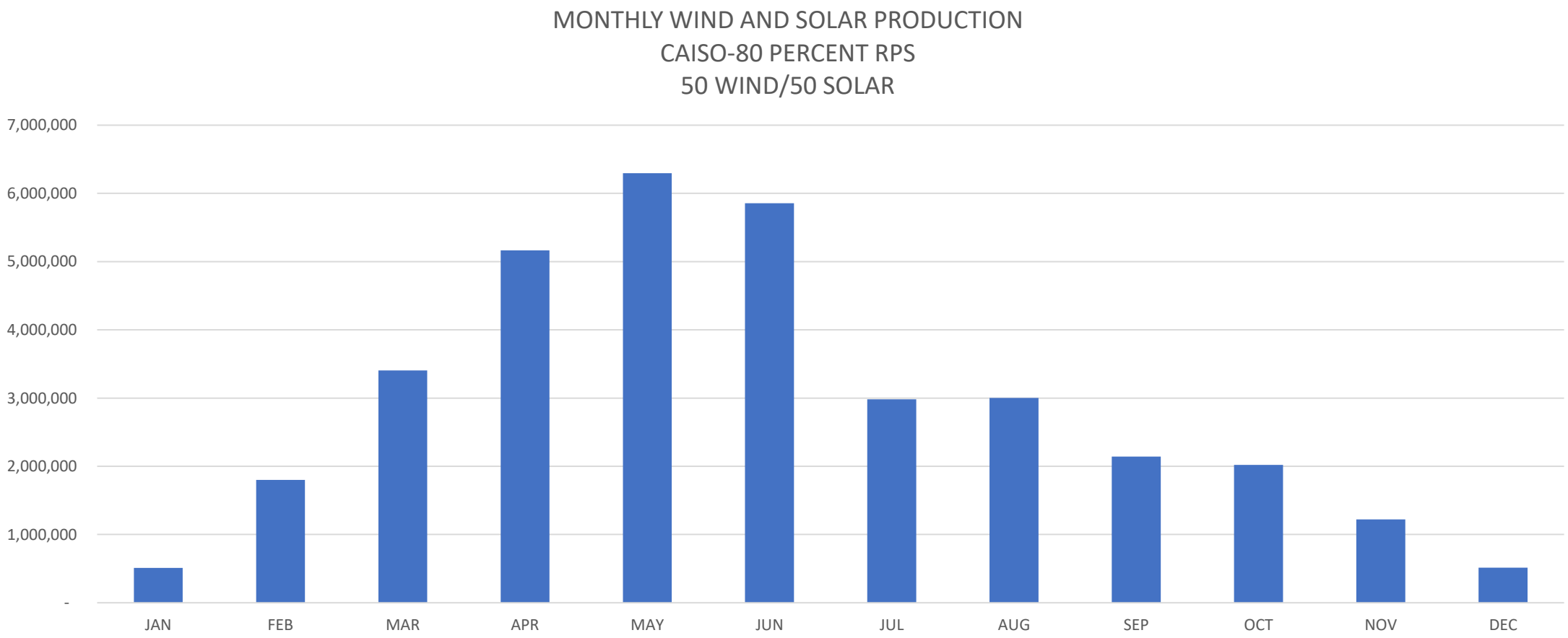
Less effective in terms of $/ton of CO_2 removed …



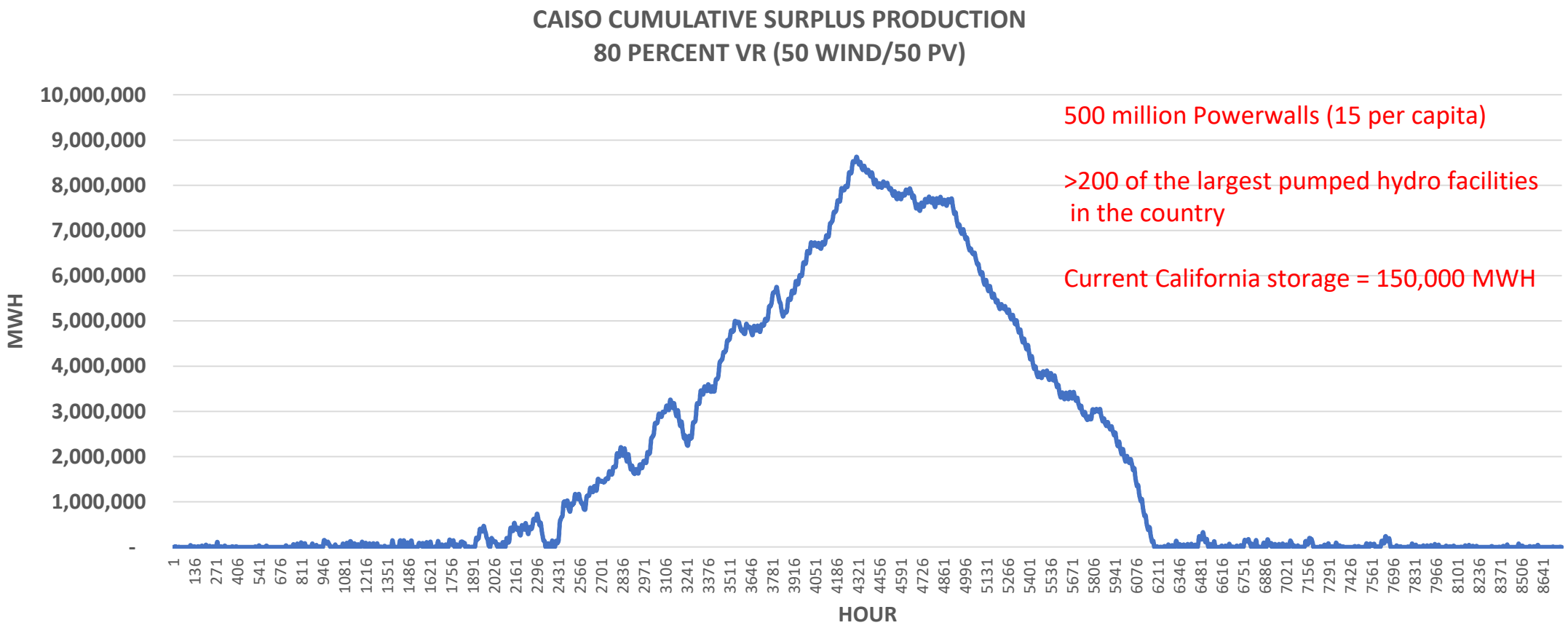
Finding Number 1: Storage doesn't materially change the conclusions

- *Seasonal imbalances* created by wind and solar cannot be managed by known or anticipated storage technologies
  - Batteries may be useful on a diurnal basis in behind-the-meter or distribution level applications, but not for long-term storage of seasonal surplus from variable renewables
  - Pumped hydro is costly, environmentally destructive and geographically limited

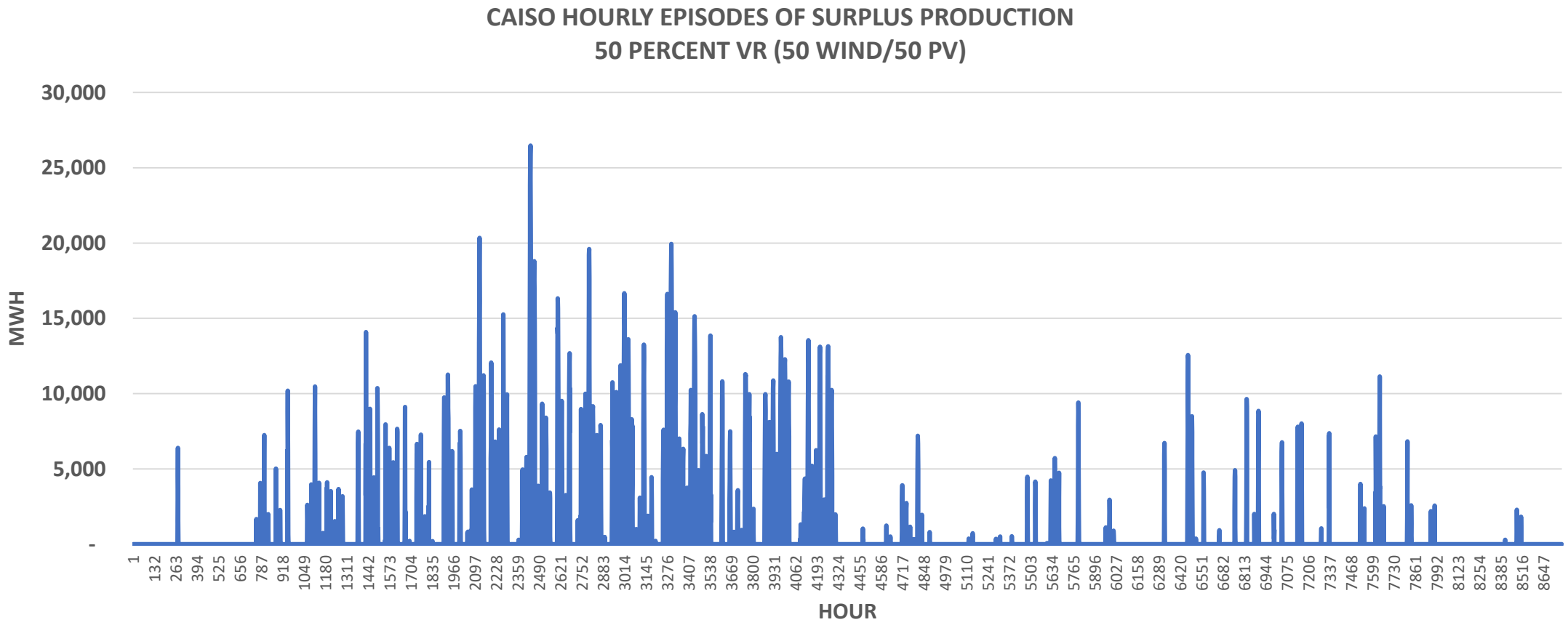
Seasonality of wind and solar is the major challenge



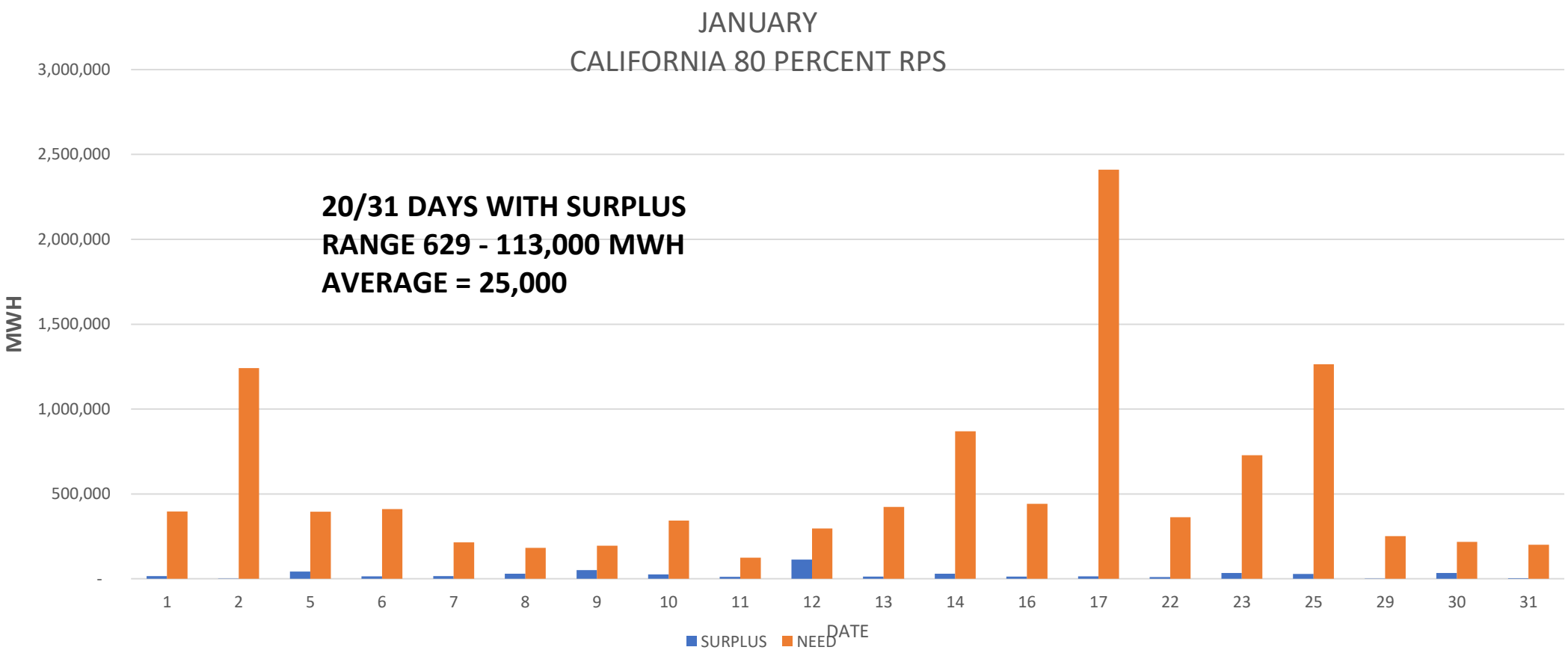
Cumulative surplus is very difficult to manage



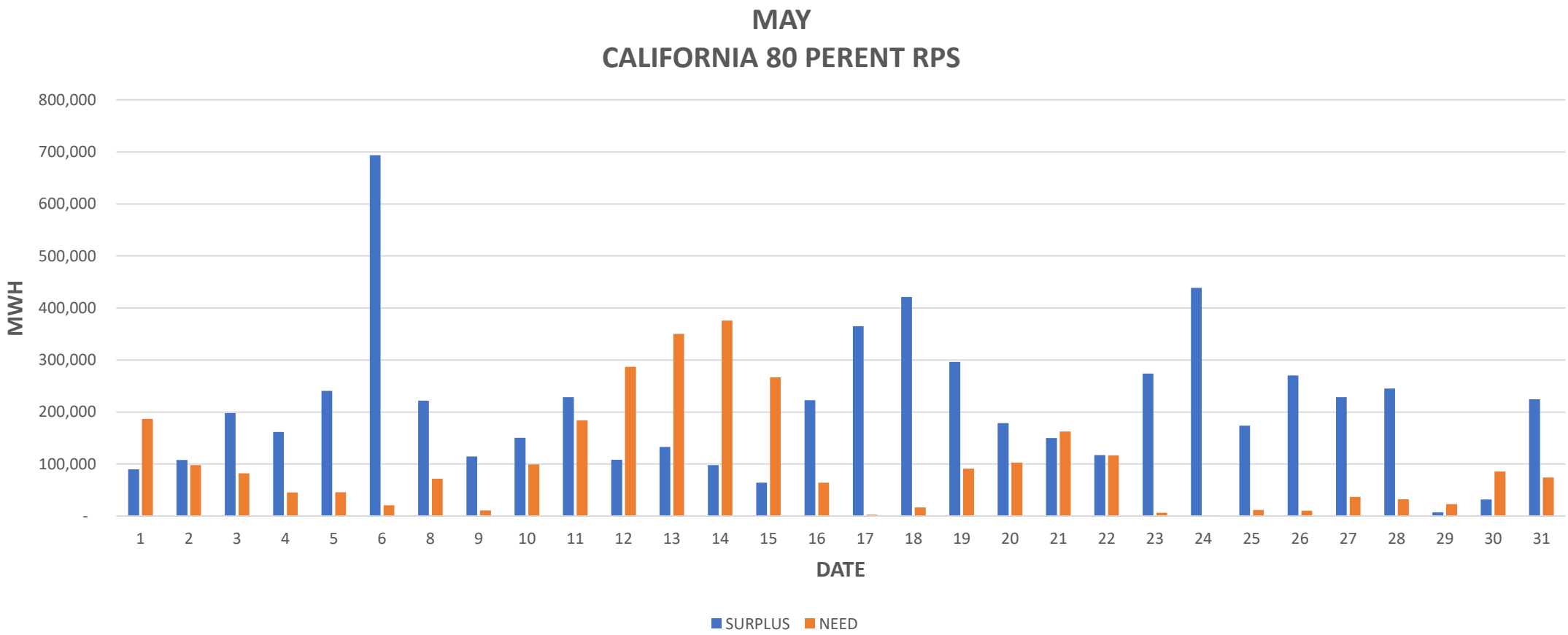
Commercial challenge—
how do you size a storage system to use this product?



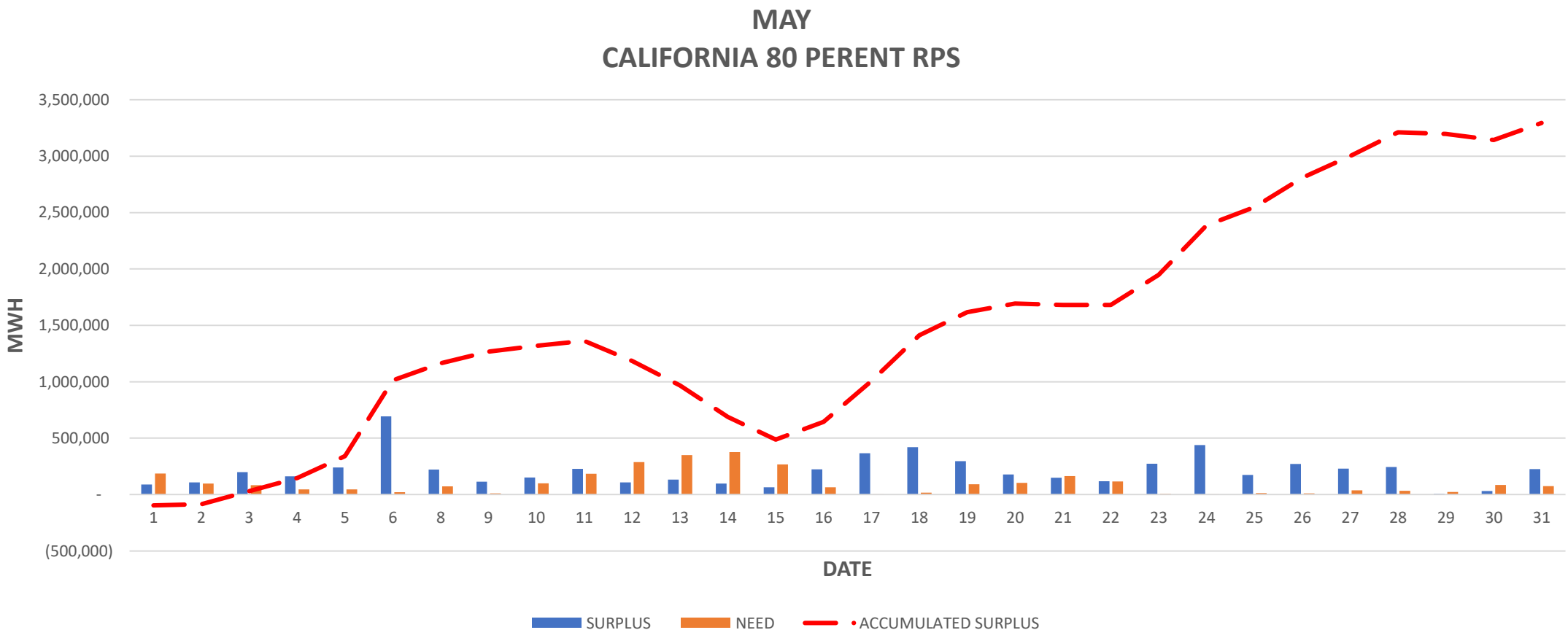
A truly wicked problem



Wicked, continued

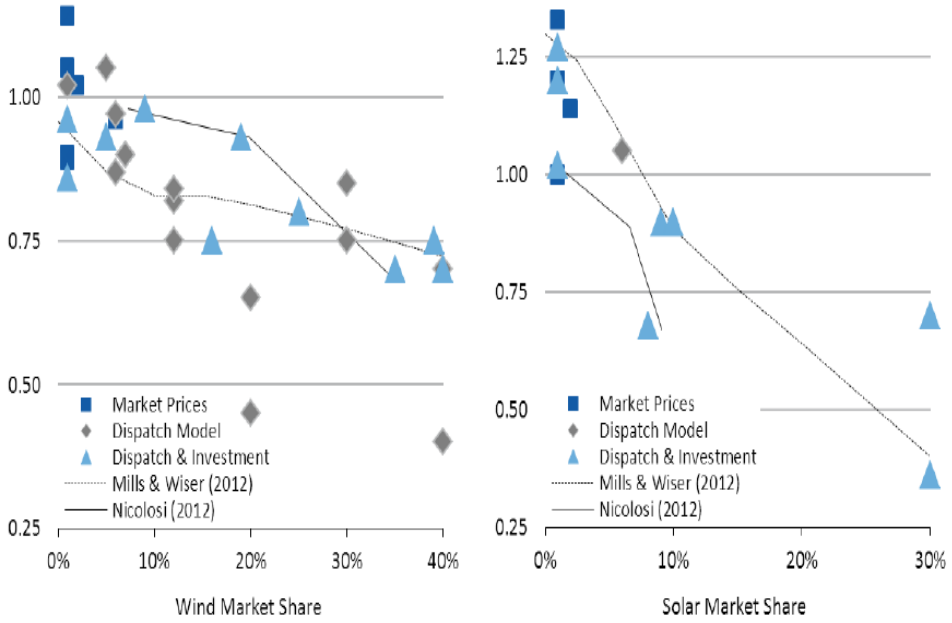


Wicked, continued

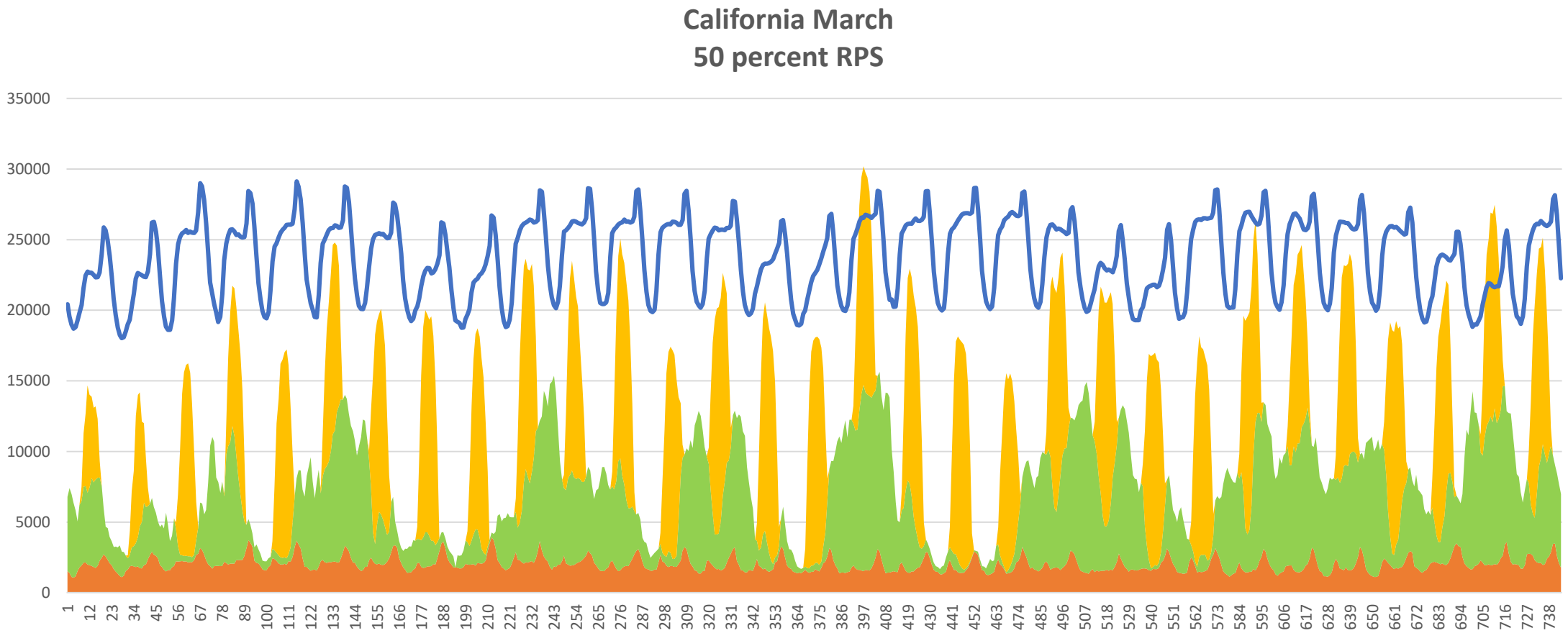


Finding Number 2: At penetrations above 30-40 percent, wind and solar eat their own lunch …

- Surplus electricity production drives costs to zero
  - Surplus in inherent in penetrations above 40-50 percent
- This HURTS developers of wind and solar, as the addition of incremental capacity leads to diminishing returns for all



Finding Number 3: Even modest penetrations of wind and solar could preclude zero carbon baseload from competing



Finding Number 4: Systems with high penetrations of wind and solar top out at 70-80 percent CO_2 reduction ….

- If 70-80 percent reduction is all that is wanted, this may be okay
- Costs and system size remain genuine concerns
- **This path may be a dead-end with respect to deep-decarbonization**

Troubling confusion of ends and means

- Much of the green community and its political allies have conflated renewable/efficiency with climate mitigation
  - Given the size of the lift, limiting the options seems unwise
- Evident in Paris and in the shape of the CPP
  - Why did they not choose to spell out 2° or 1.5° C?
- Why was there not more outcry from the green community over the toothless nature of the Paris agreements?

Balanced portfolios

- Have room for all types of resources
  - Variable renewables: 30-40 percent
  - Zero carbon base resources: 30-40 percent
  - As much efficiency as possible
- Achieve deeper carbon reductions at lower cost than constrained portfolios