

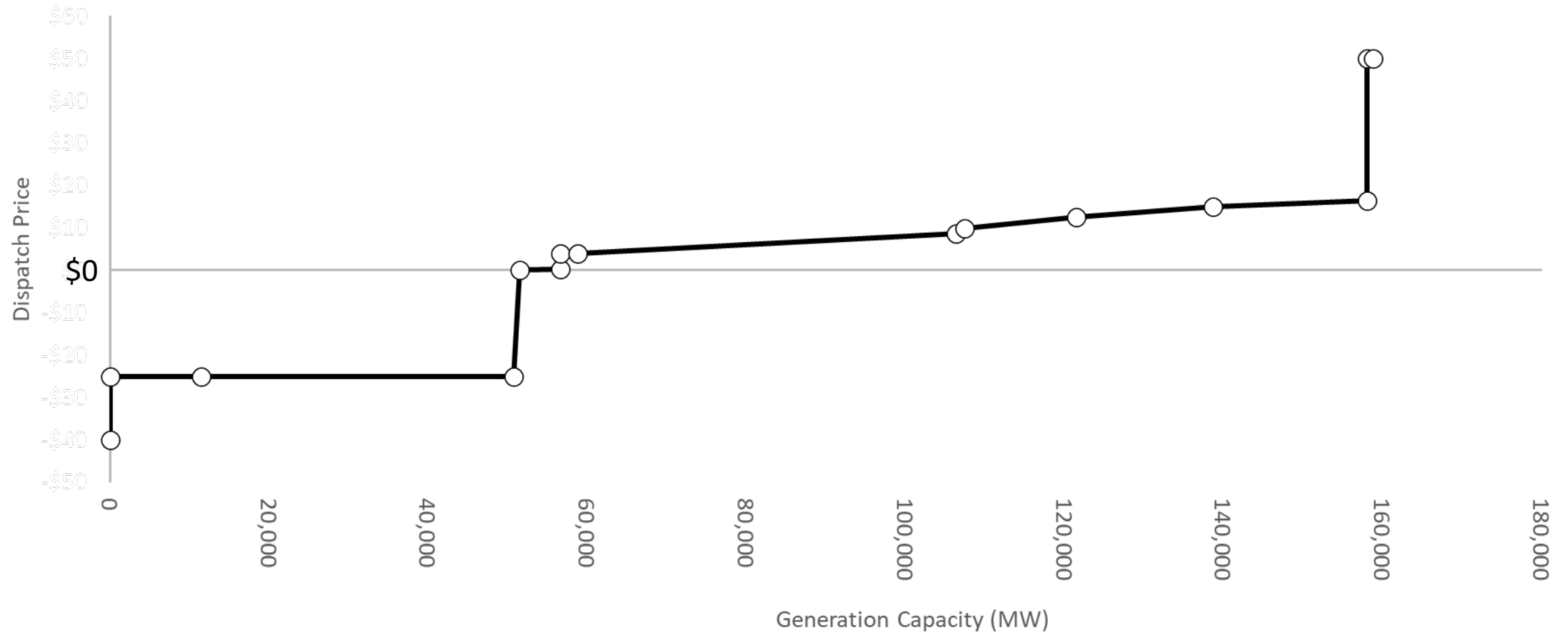


WHAT'S SHAPING THE FUTURE OF NATURAL GAS PRICING?

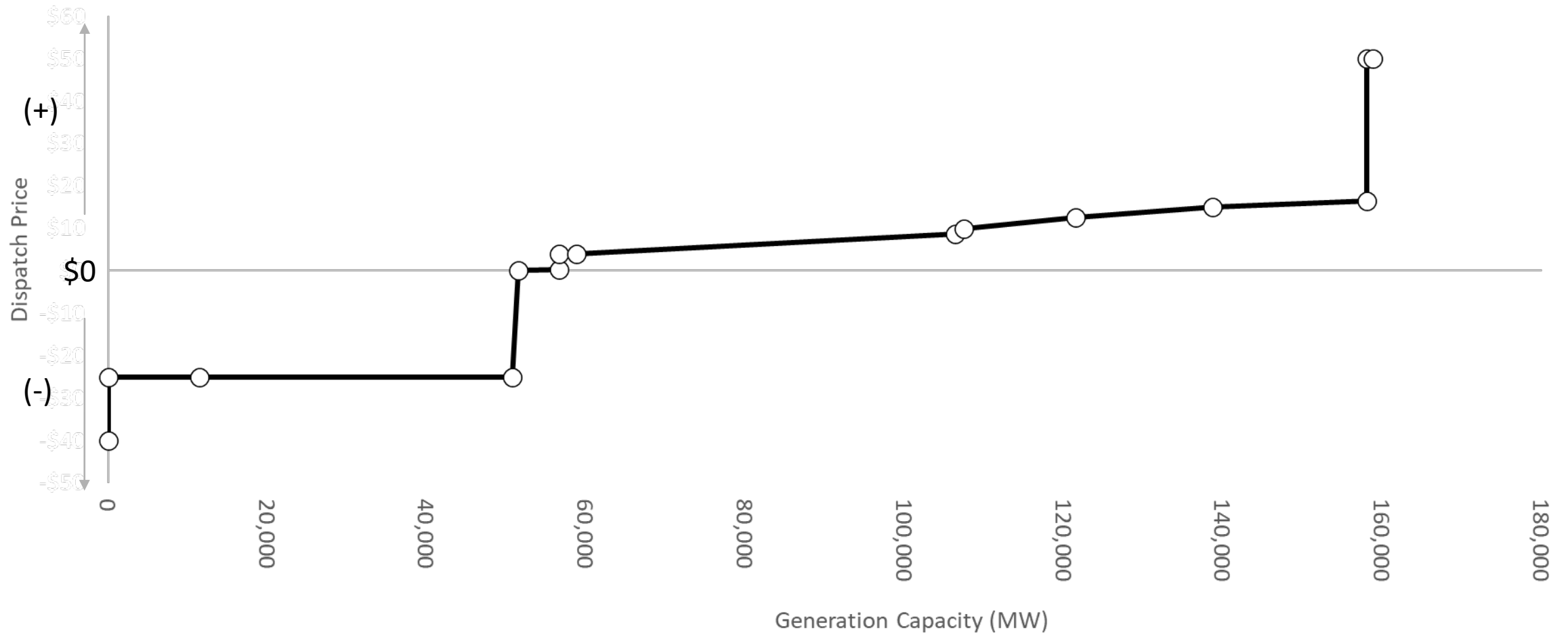
WITH A BRIEF FORAY INTO RENEWABLES

WHY IS NATURAL GAS IMPORTANT?

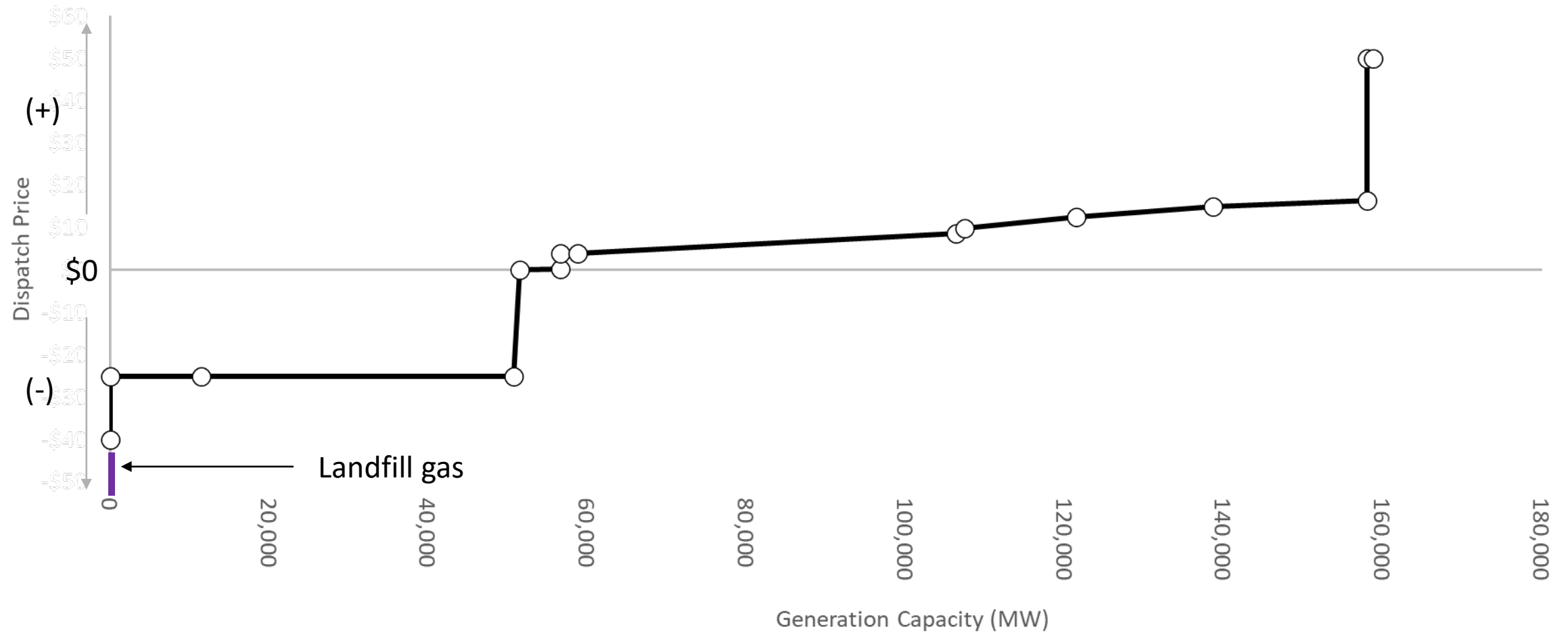
The merit order



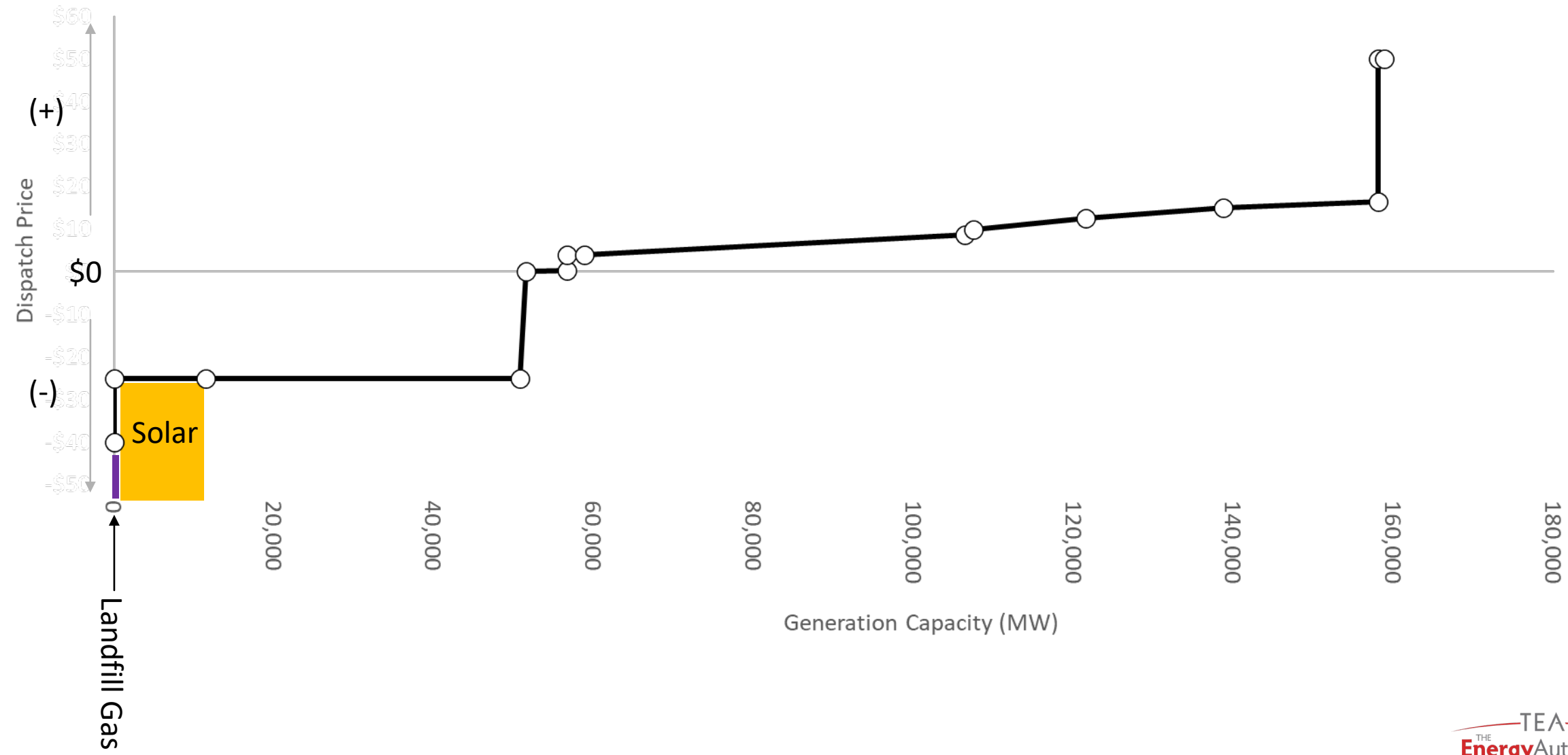
The merit order



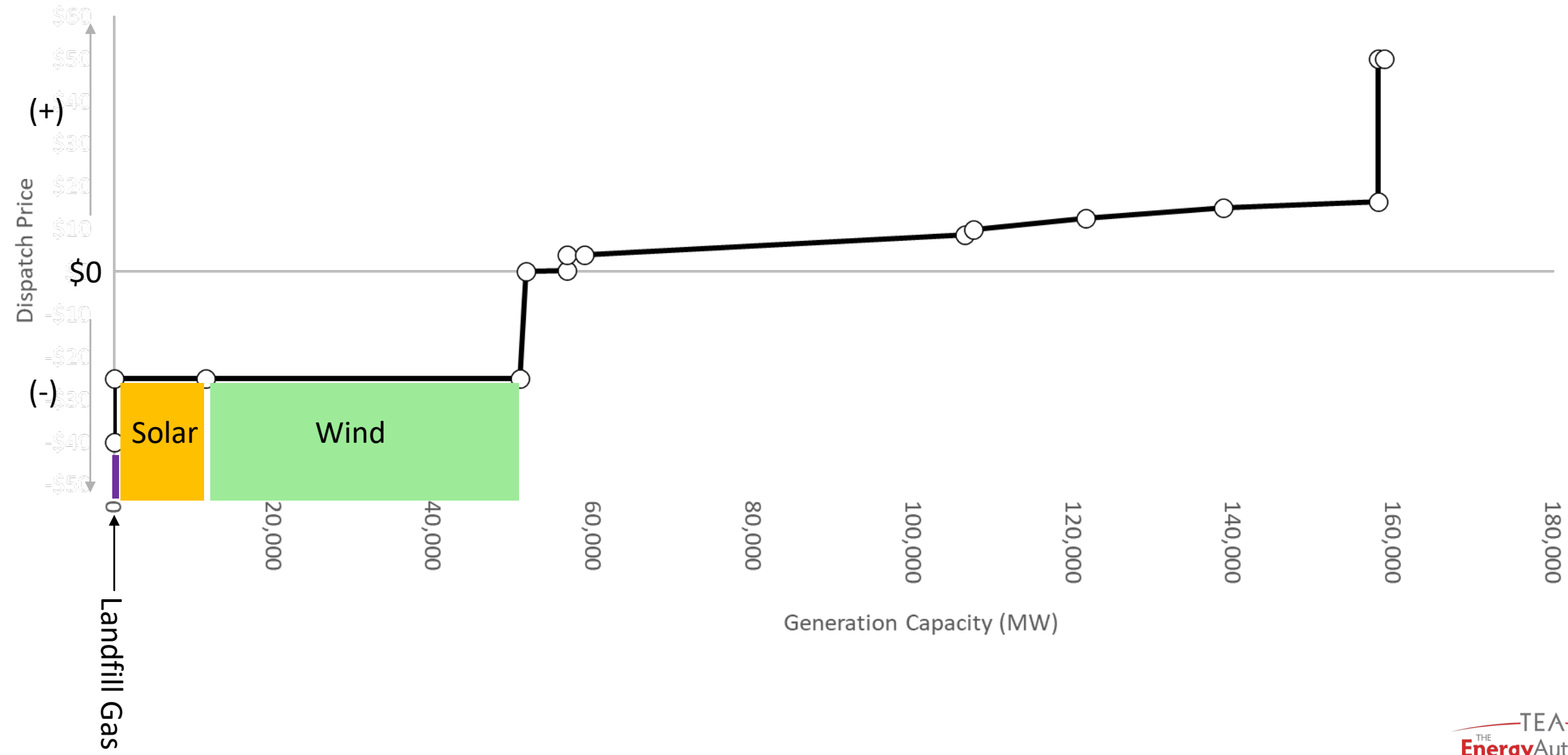
The merit order



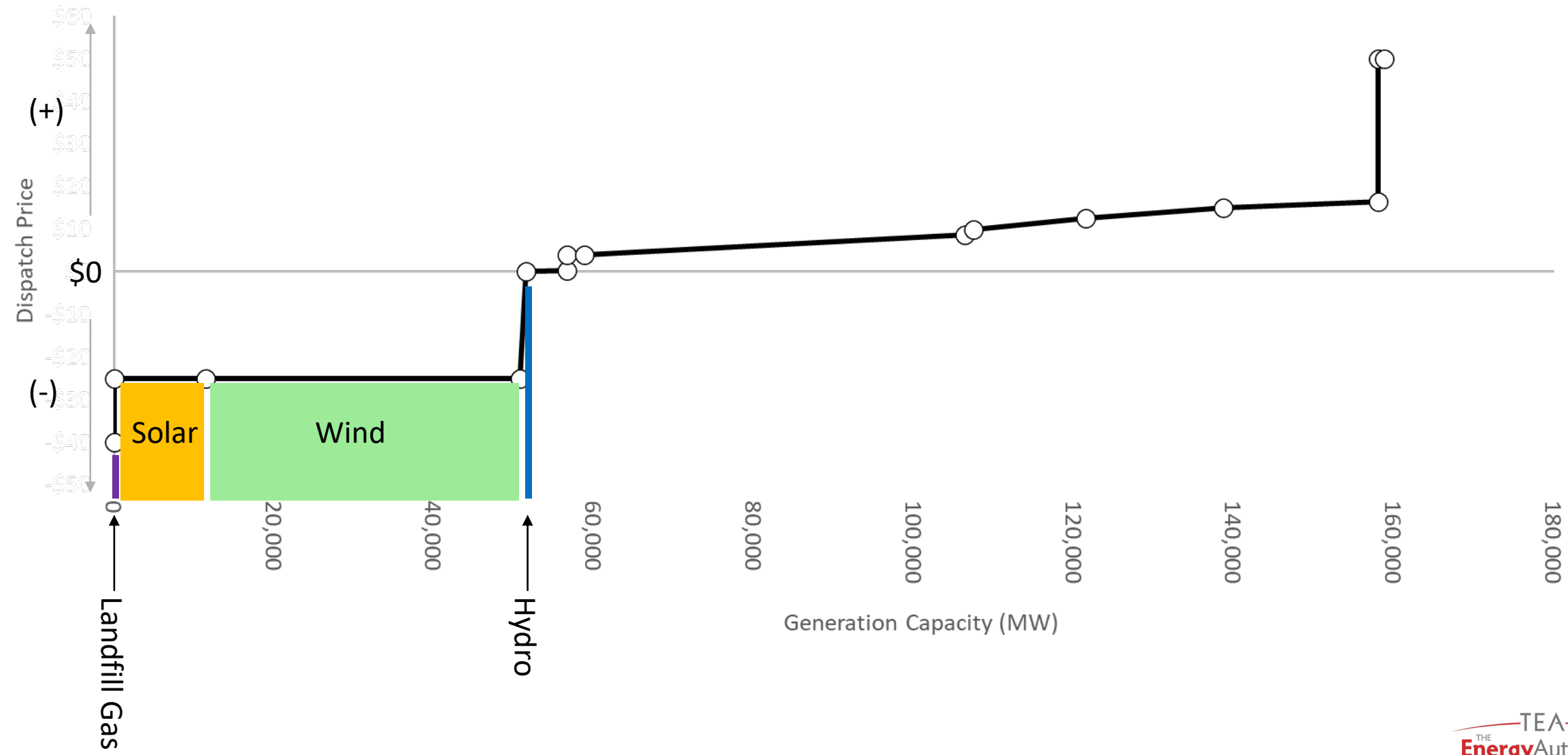
The merit order



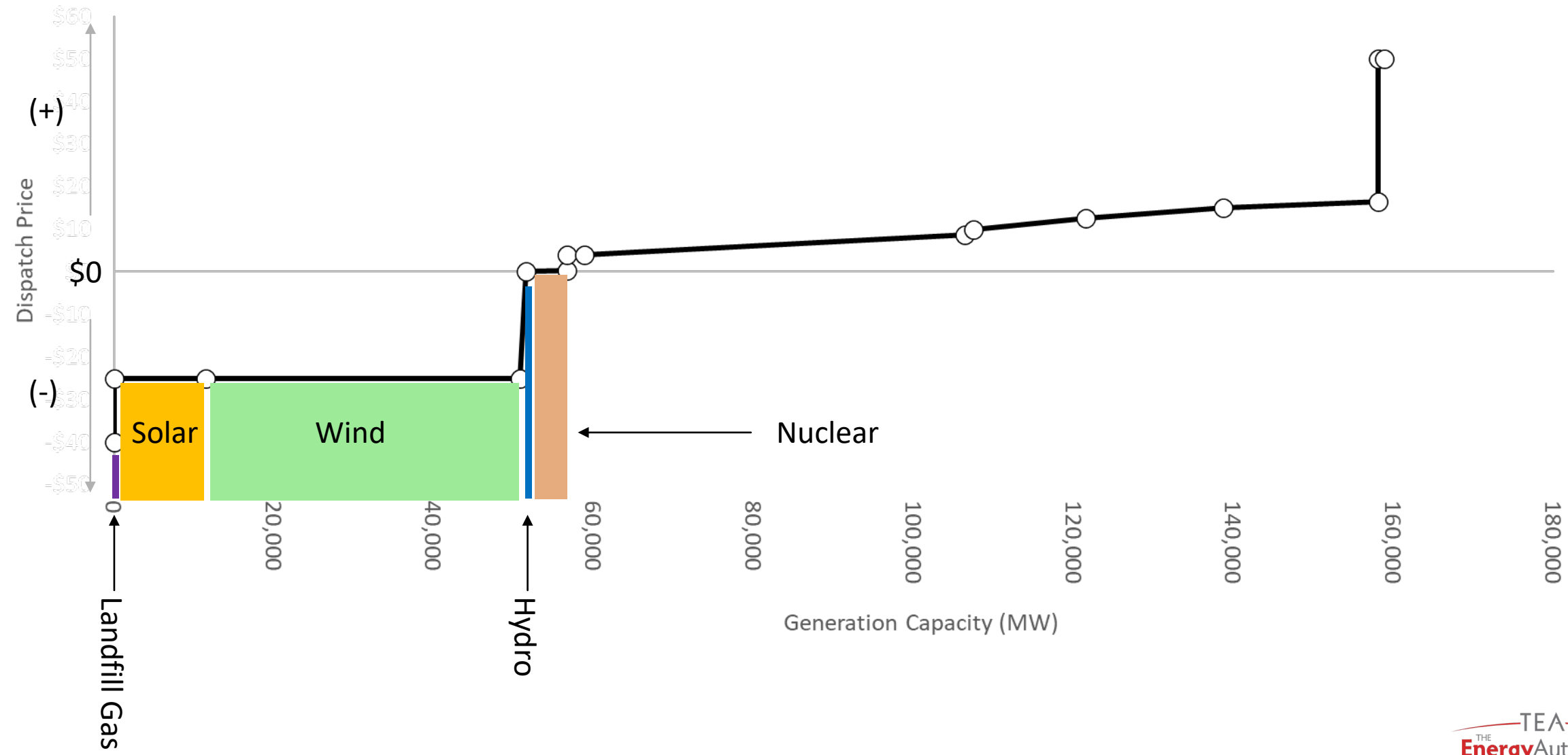
The merit order



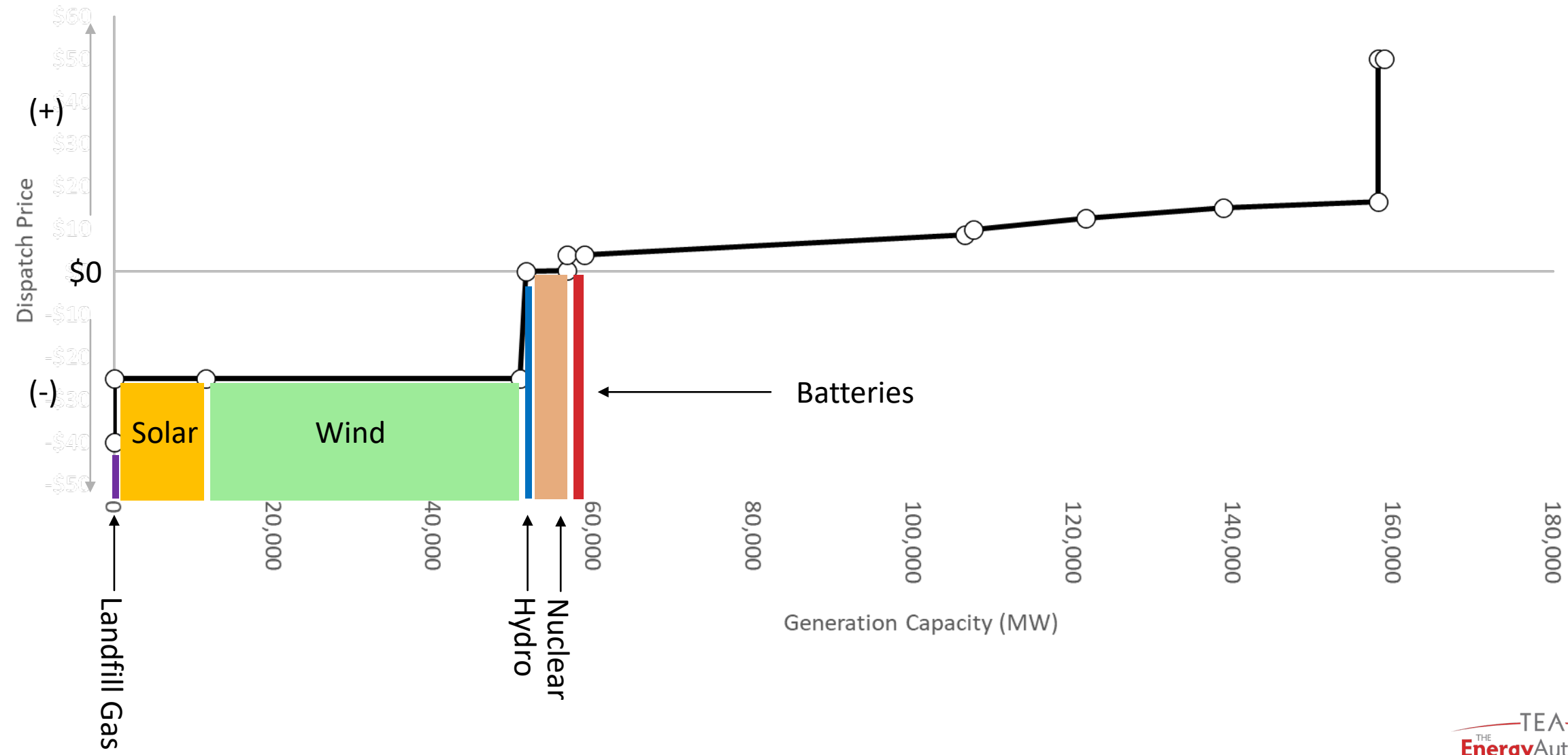
The merit order



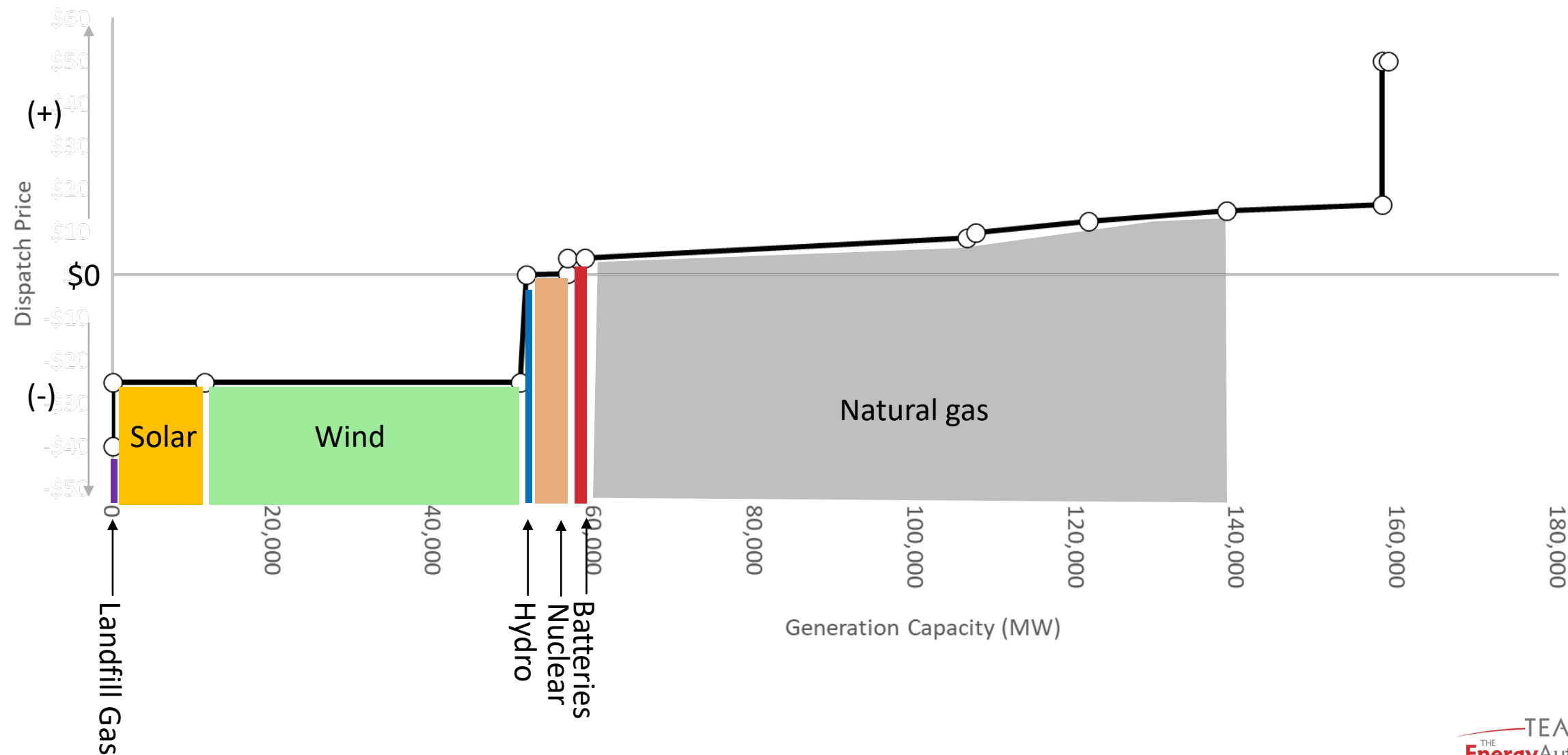
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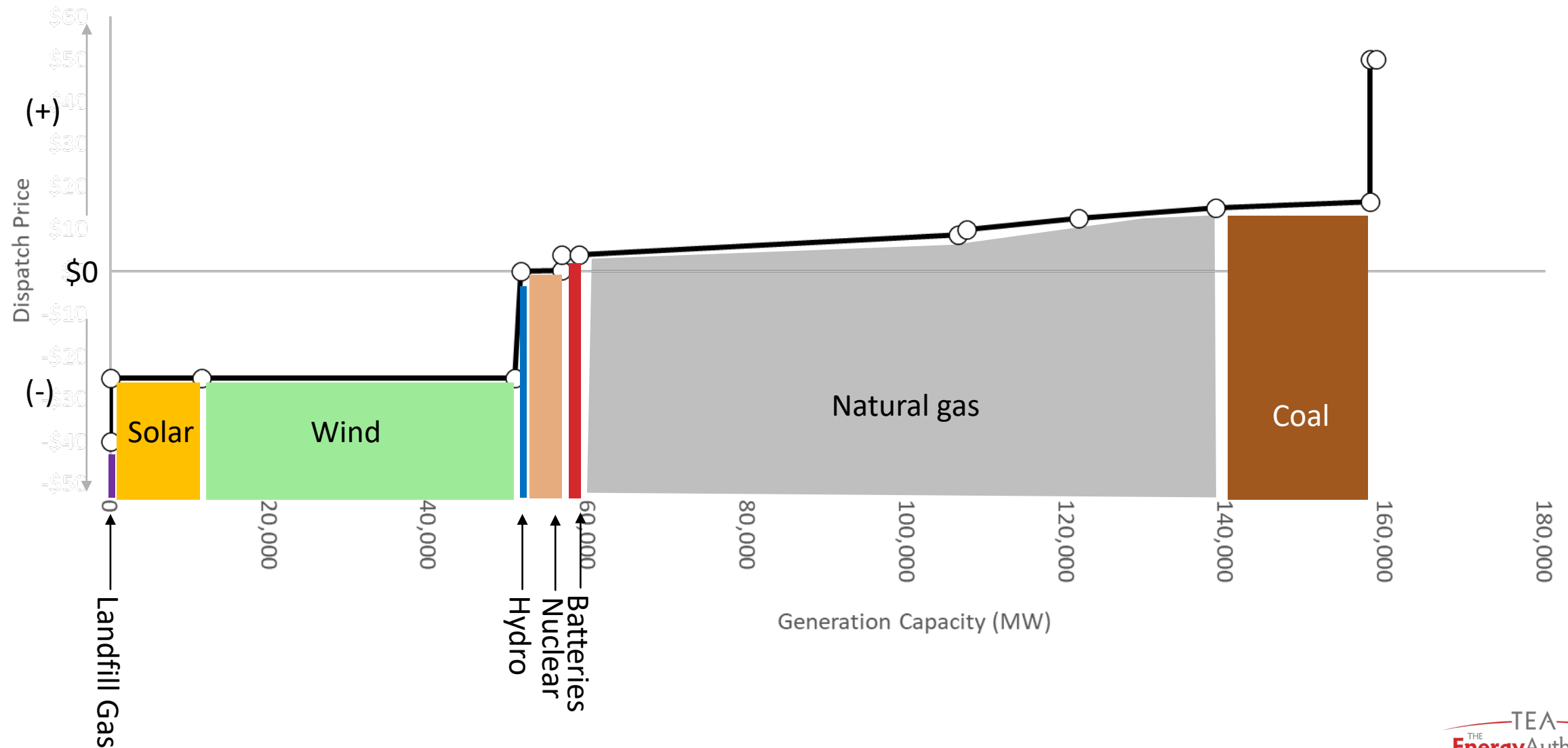
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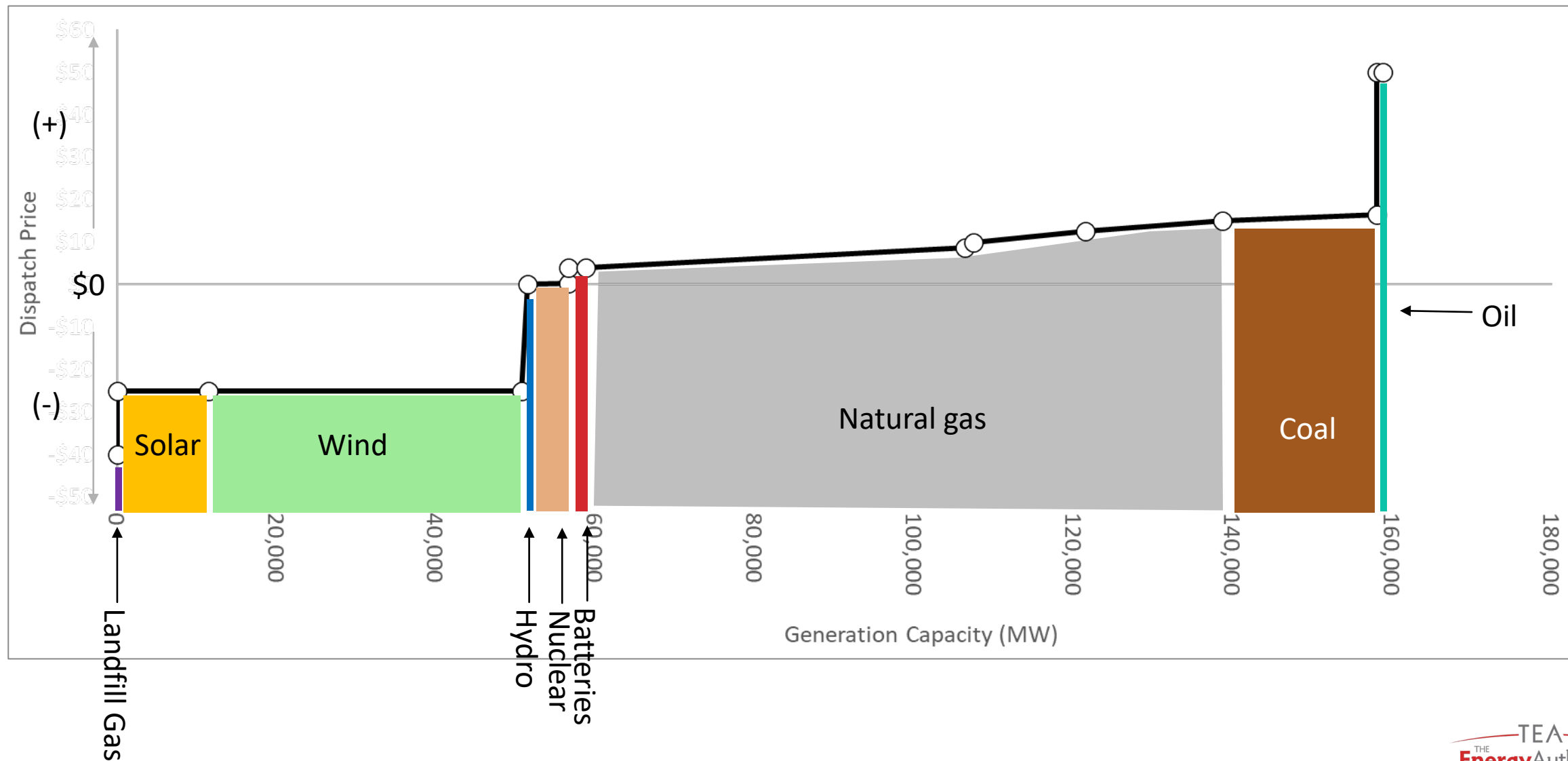
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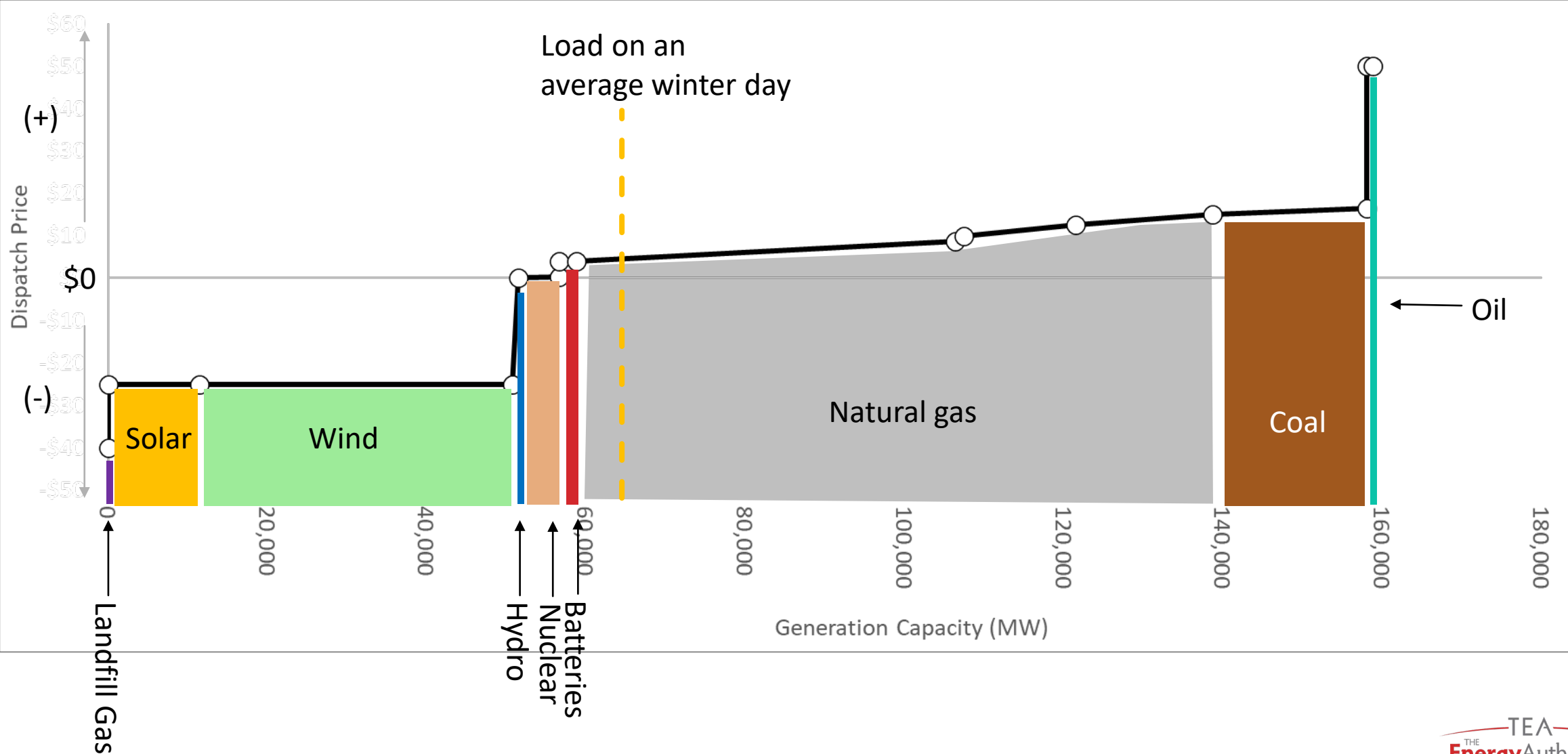
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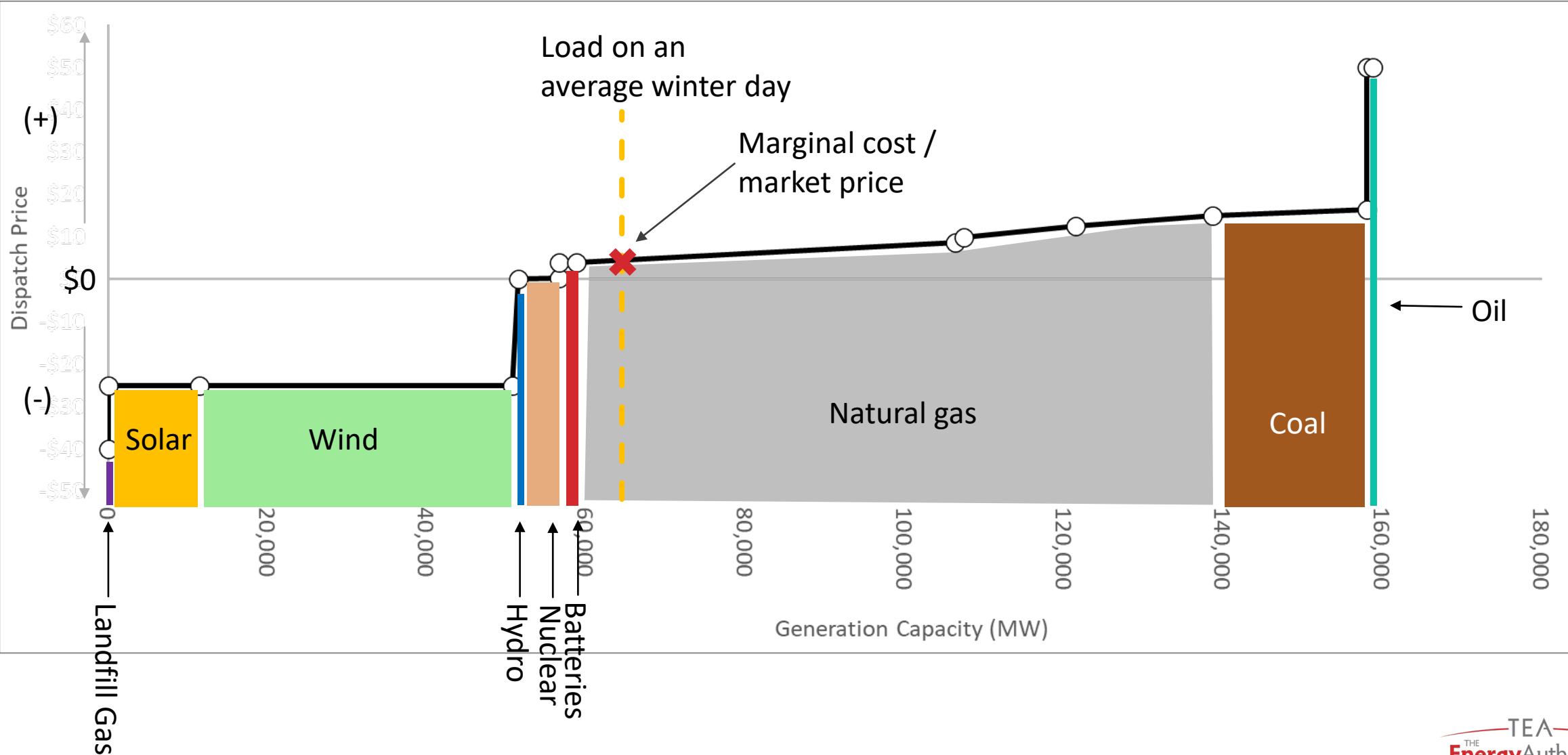
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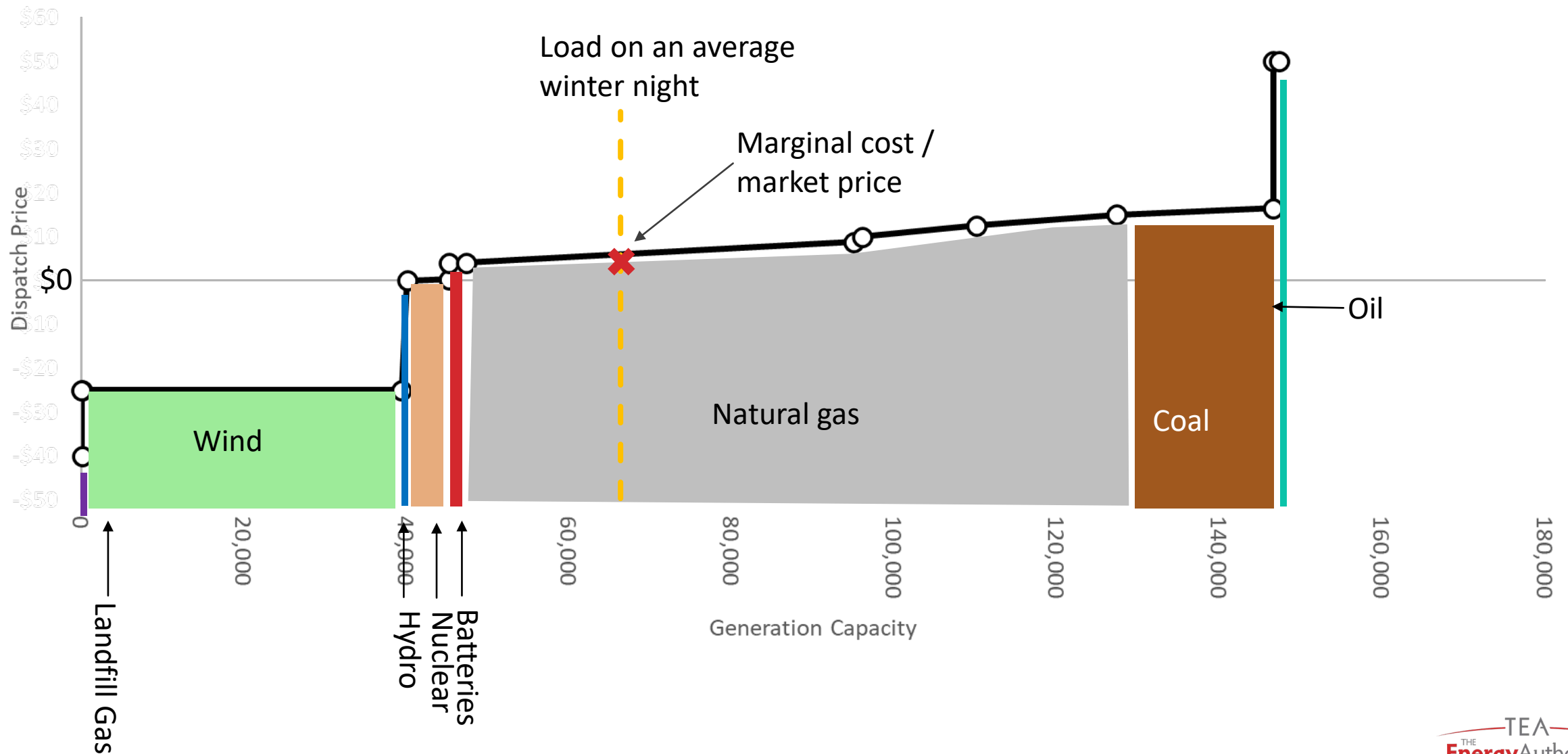
The merit order



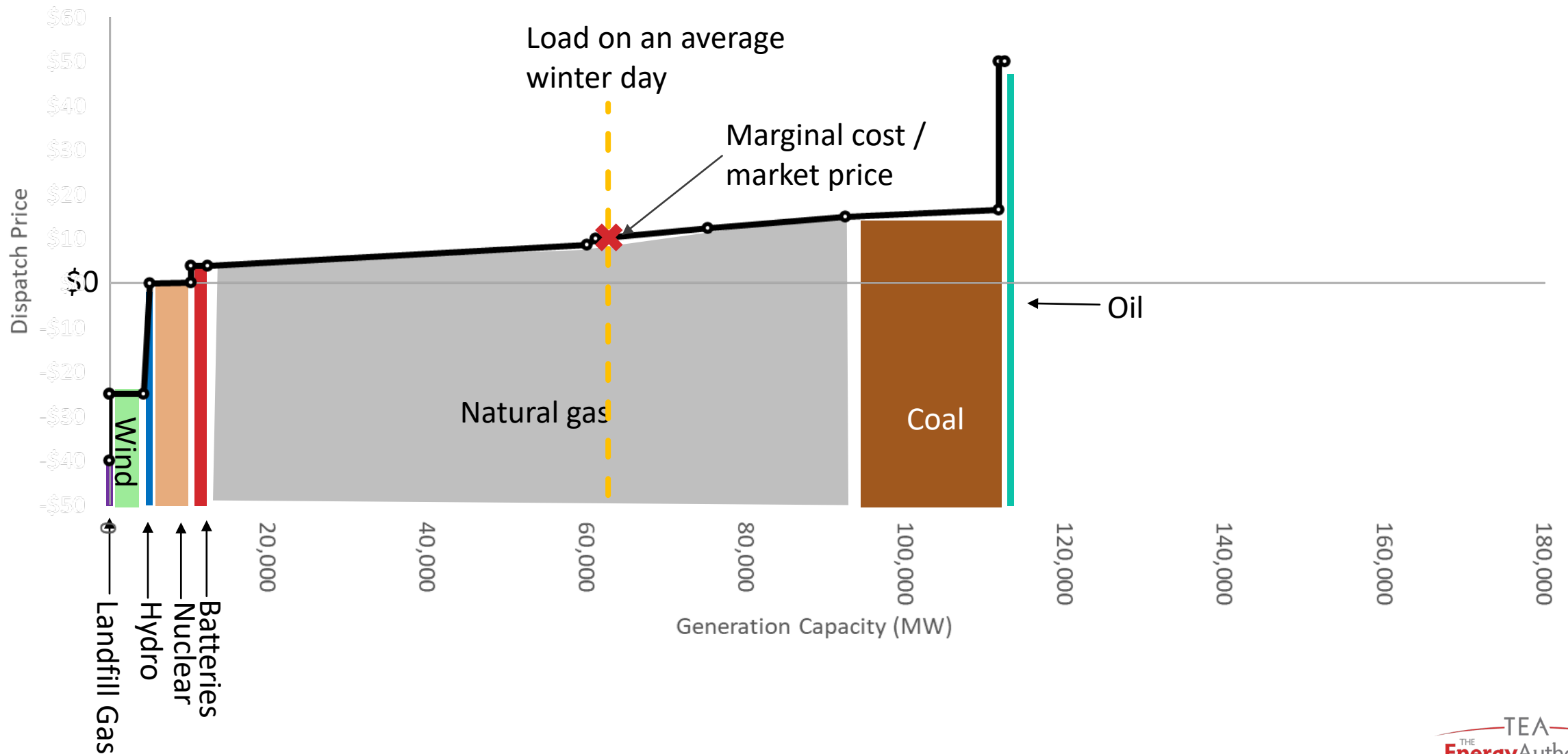
The merit order



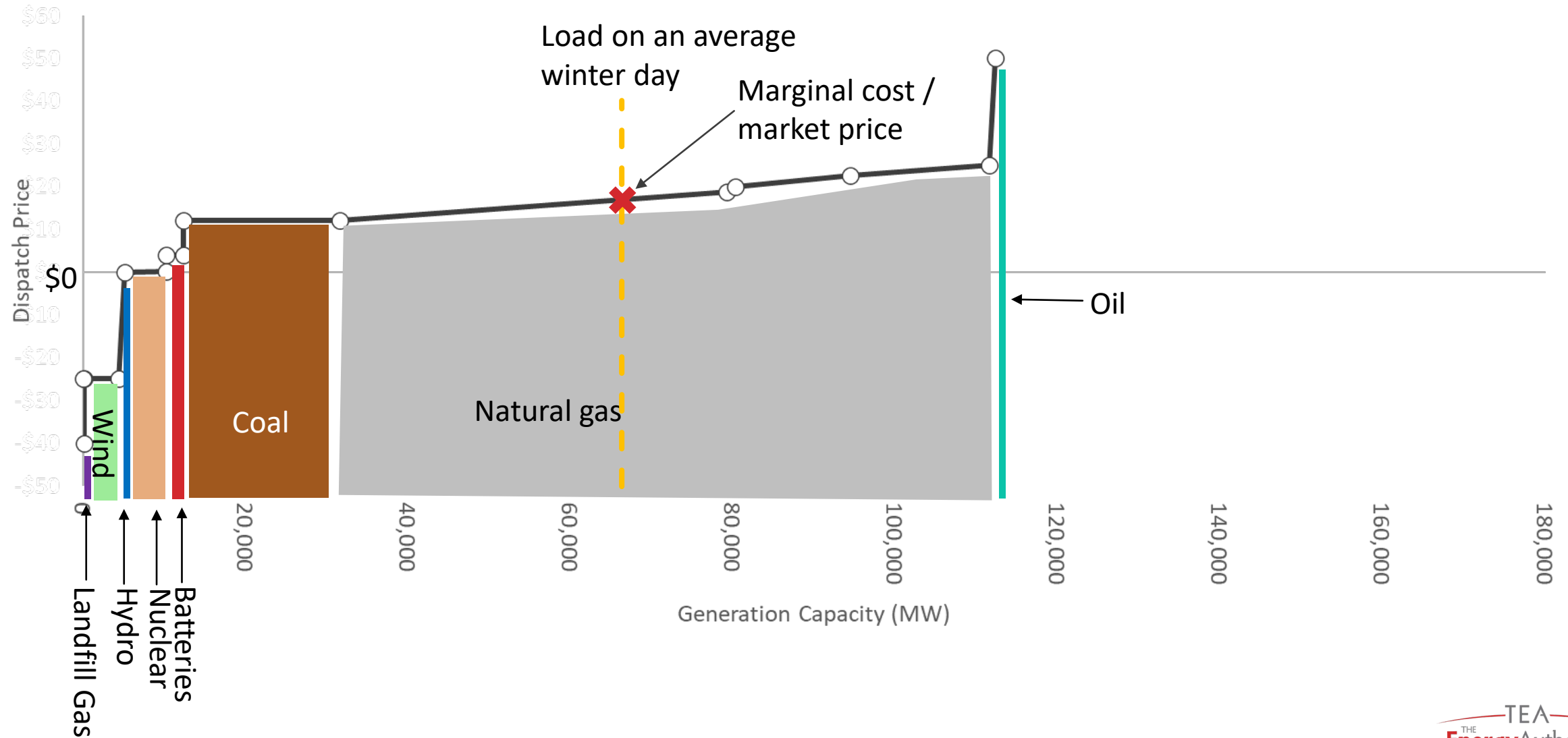
But what if it's nighttime?



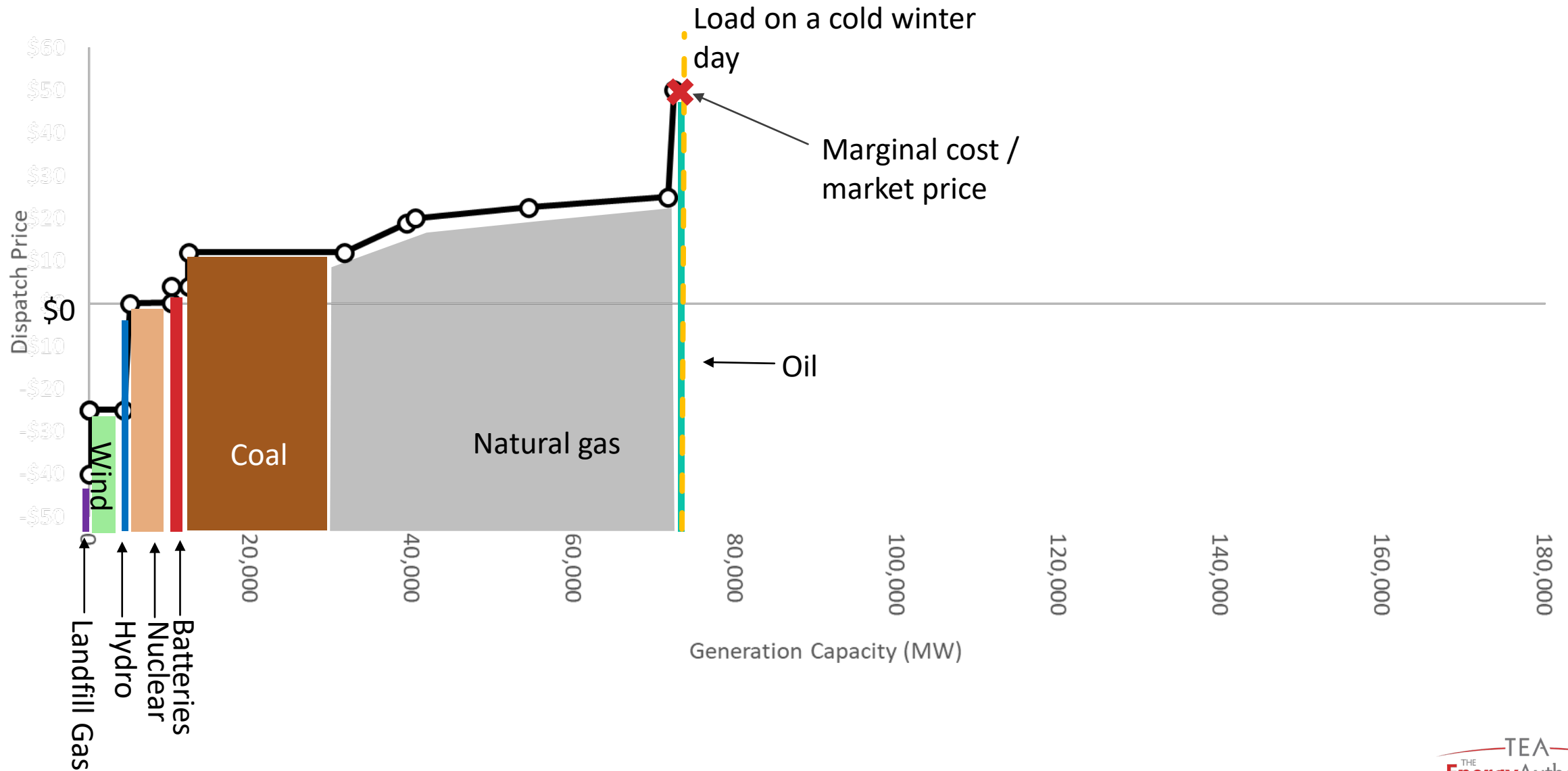
Or the wind stops blowing?



Or natural gas prices go higher?



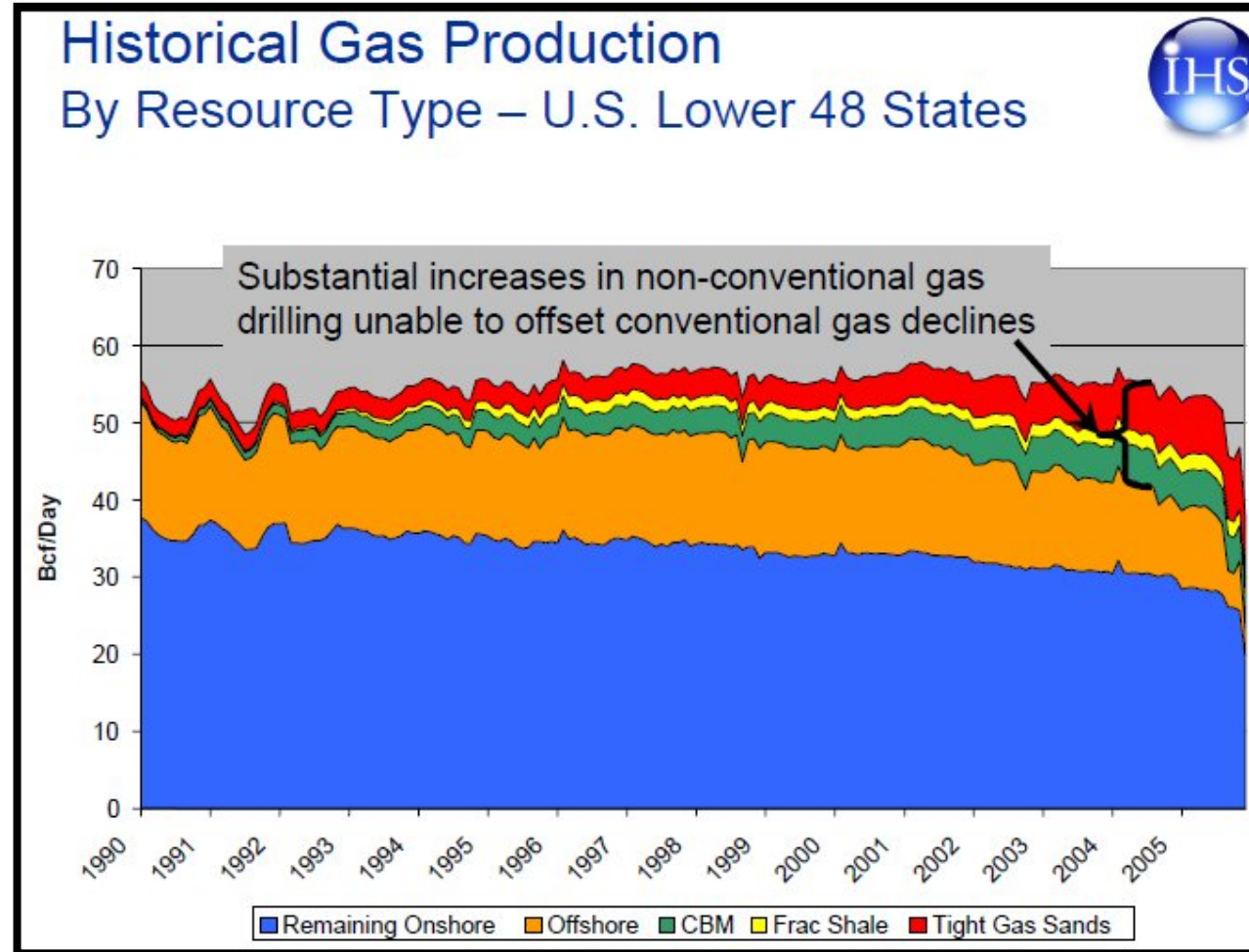
Expensive resources can set the marginal costs in extreme weather



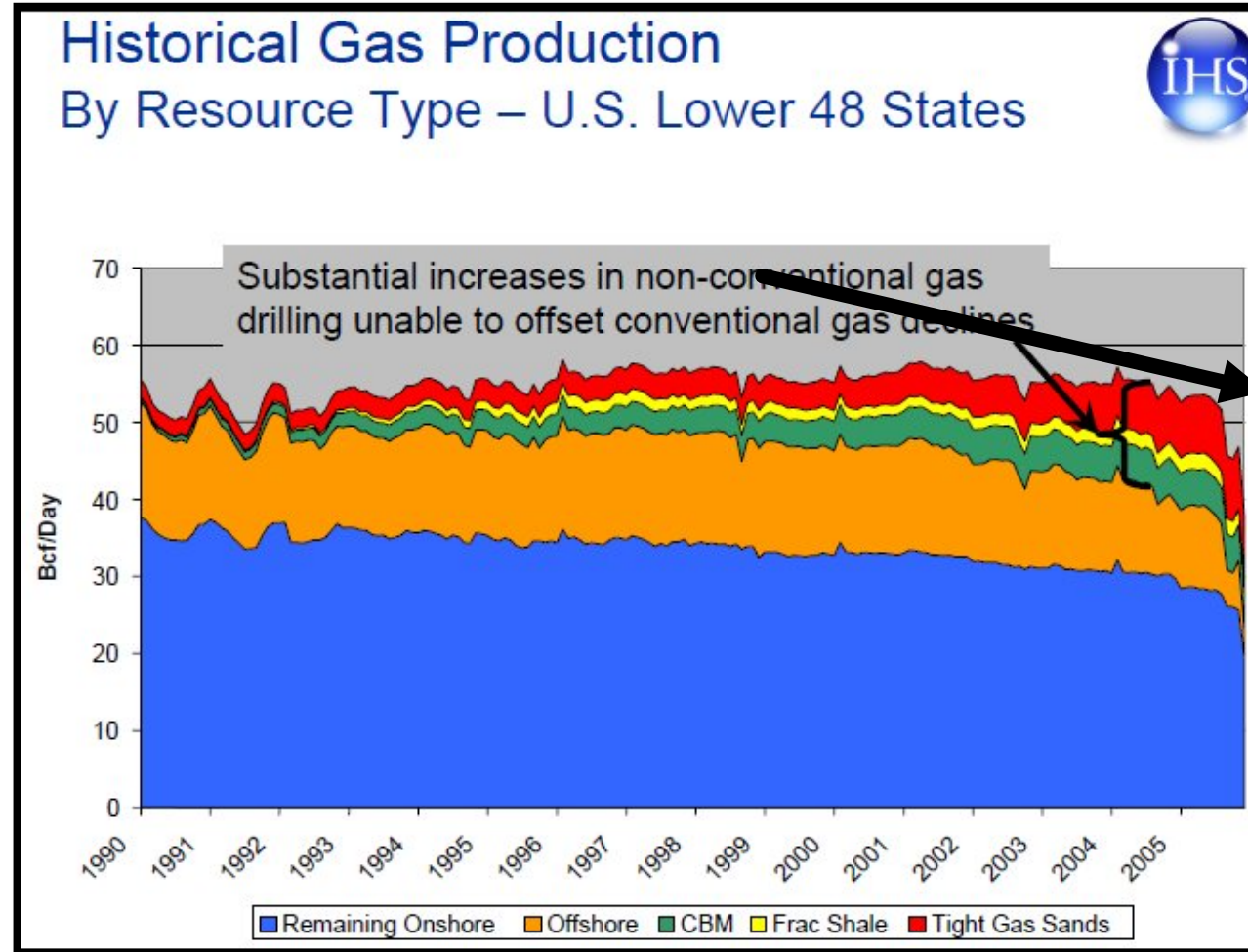
NATURAL GAS FUNDAMENTALS

A TRIP DOWN MEMORY LANE

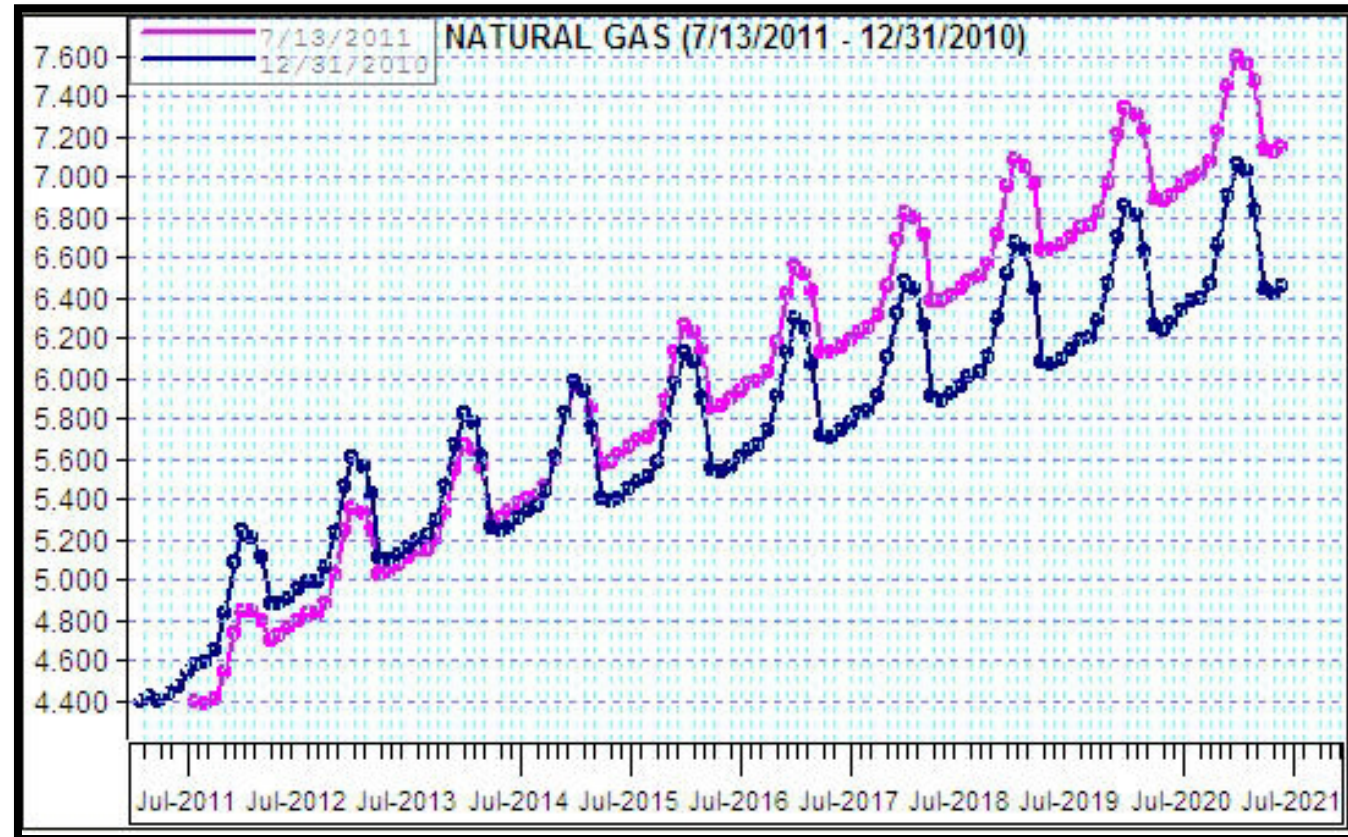
20 years ago...we were quickly running out of gas



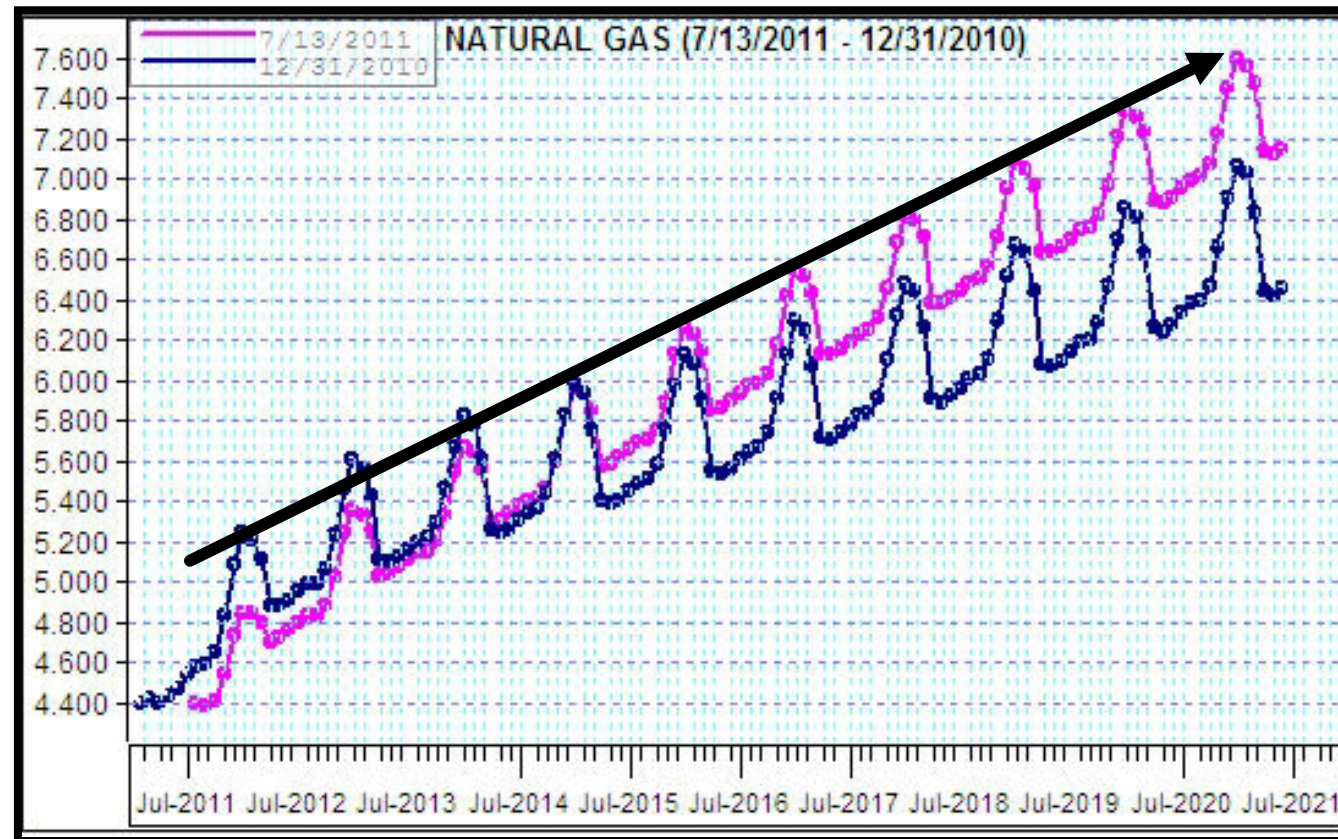
20 years ago...we were quickly running out of gas



Which led to this

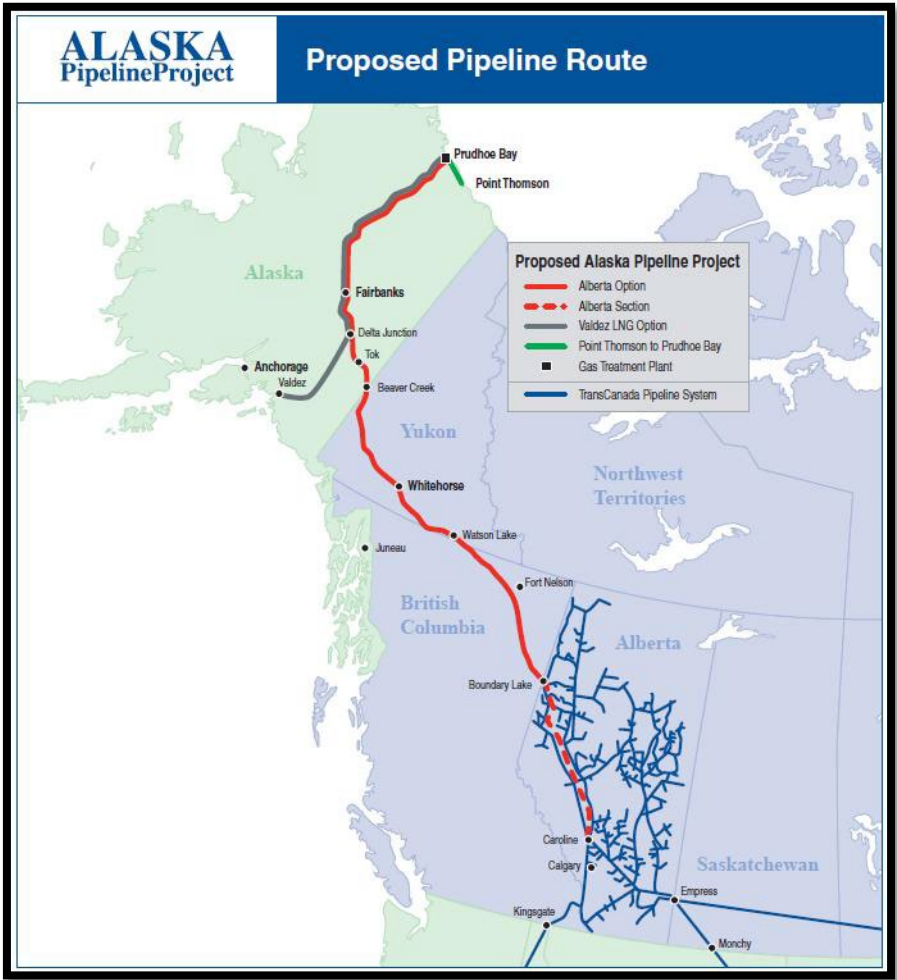


Which led to this

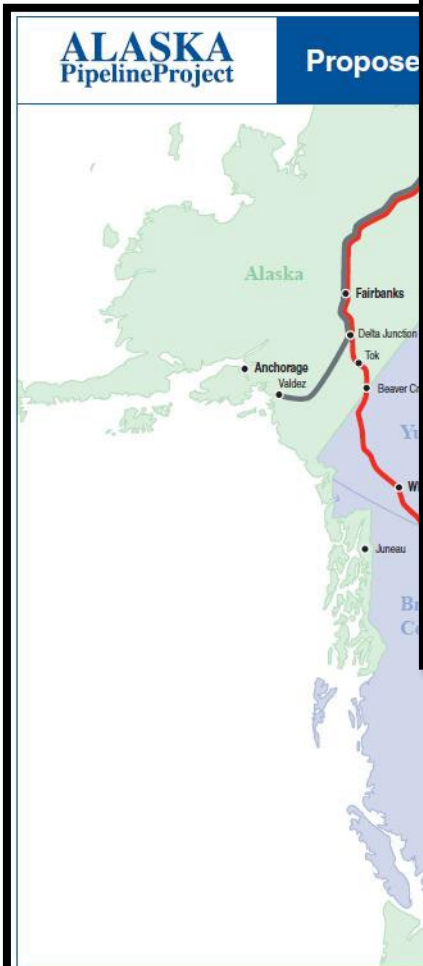


Forwards have gas increasing from \$4 to \$8 in a decade

And thus these



And thus these



ALASKA Pipeline Project

Proposed route from Fairbanks, Alaska, through Delta Junction, Tok, Anchorage, Valdez, and then south through the Yukon and Bristol Bay regions, ending near Juneau.

December 11, 2007

ExxonMobil

ExxonMobil Announces BlueOcean Energy, a Project to Bring Needed Natural Gas Supplies to New Jersey and New York via a Floating Offshore LNG Terminal

IRVING, Texas--(BUSINESS WIRE)--

Exxon Mobil Corporation (NYSE:XOM) today announced plans to seek regulatory approval for BlueOcean Energy, a floating liquefied natural gas (LNG) receiving terminal that will create a gateway to global supplies of clean-burning natural gas to help meet the growing energy needs of New Jersey and New York.

And thus these

ALASKA
PipelineProject

Propose

December 11, 2007

ExxonMobil

ExxonMobil Announces BlueOcean Project to Bring Needed Natural Gas Supplies to New Jersey and New York by Building Offshore LNG Terminal


(BUSINESS WIRE)--

ExxonMobil Corporation (NYSE:XOM) today announced plans to seek regulatory approval to build, own and operate a floating liquefied natural gas (LNG) receiving terminal that will receive global supplies of clean-burning natural gas to help meet the growing demand for natural gas in New Jersey and New York.


CHENIERE

WHO WE ARE ▾ OUR RESPONSIBILITY ▾ INVESTORS ▾

2008



Cheniere's Sabine Pass LNG facility, located in southwest Louisiana, was placed into service as a regasification facility. The original design and construction of this facility was intended to import LNG, store it and warm it into a gaseous state, and send the natural gas out via pipelines to be used in the United States.



And thus these

ALASKA Pipeline Project Propose


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CHENIERE WHO WE ARE ▾ OUR RESPONSIBILITY ▾ INVESTORS ▾

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2005

Construction begins on the LNG import project.
Freeport LNG applies with FERC for an expansion of the regas terminal.
A third TUA is executed with Mitsubishi for expansion volumes.

2006

FERC approves the regasification terminal expansion.
Freeport LNG begins construction of an underground natural gas storage cavern.

2008

Testing and commissioning cargoes for the regasification facility are delivered in April and May.
Regasification facilities enters commercial operations in June.

2009

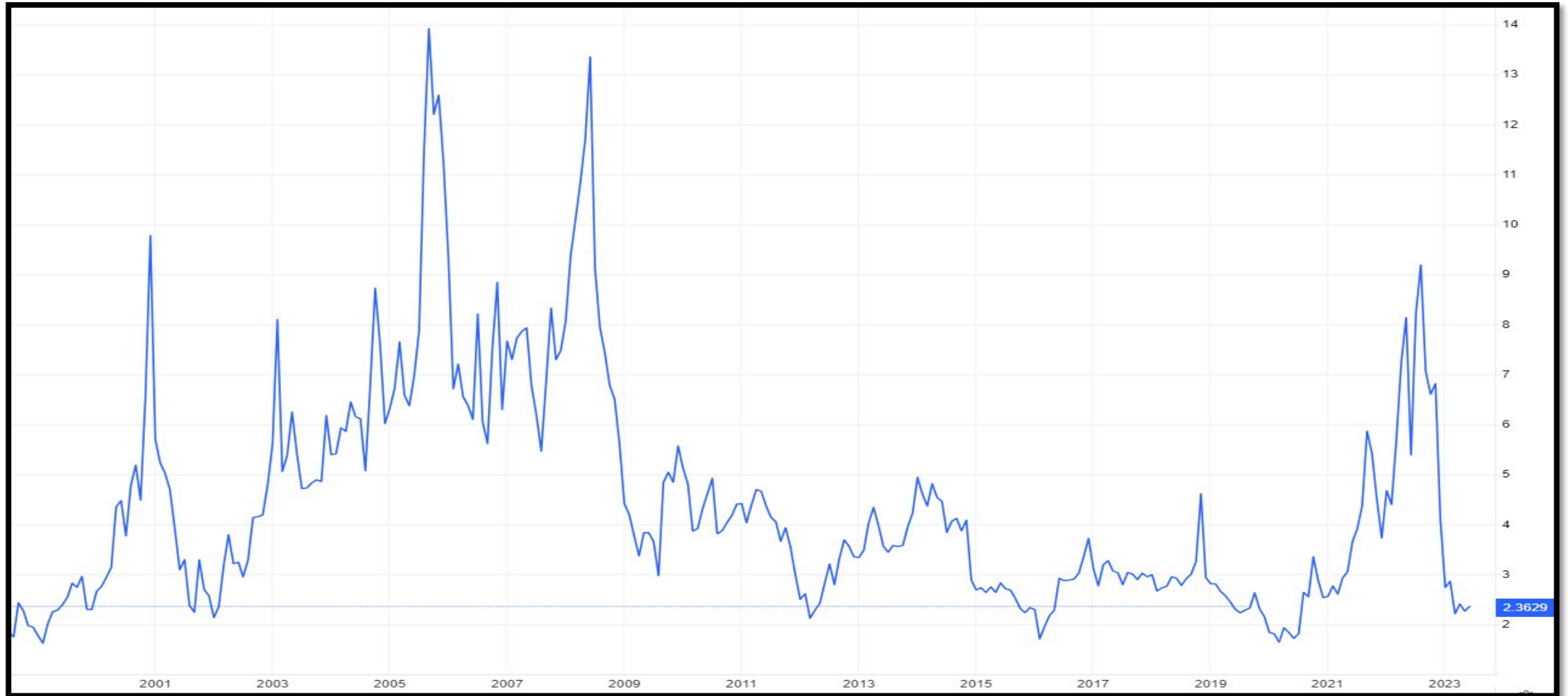
Freeport LNG is the first company to file with DOE to allow LNG to be imported, stored and then reexported.

And then this happened



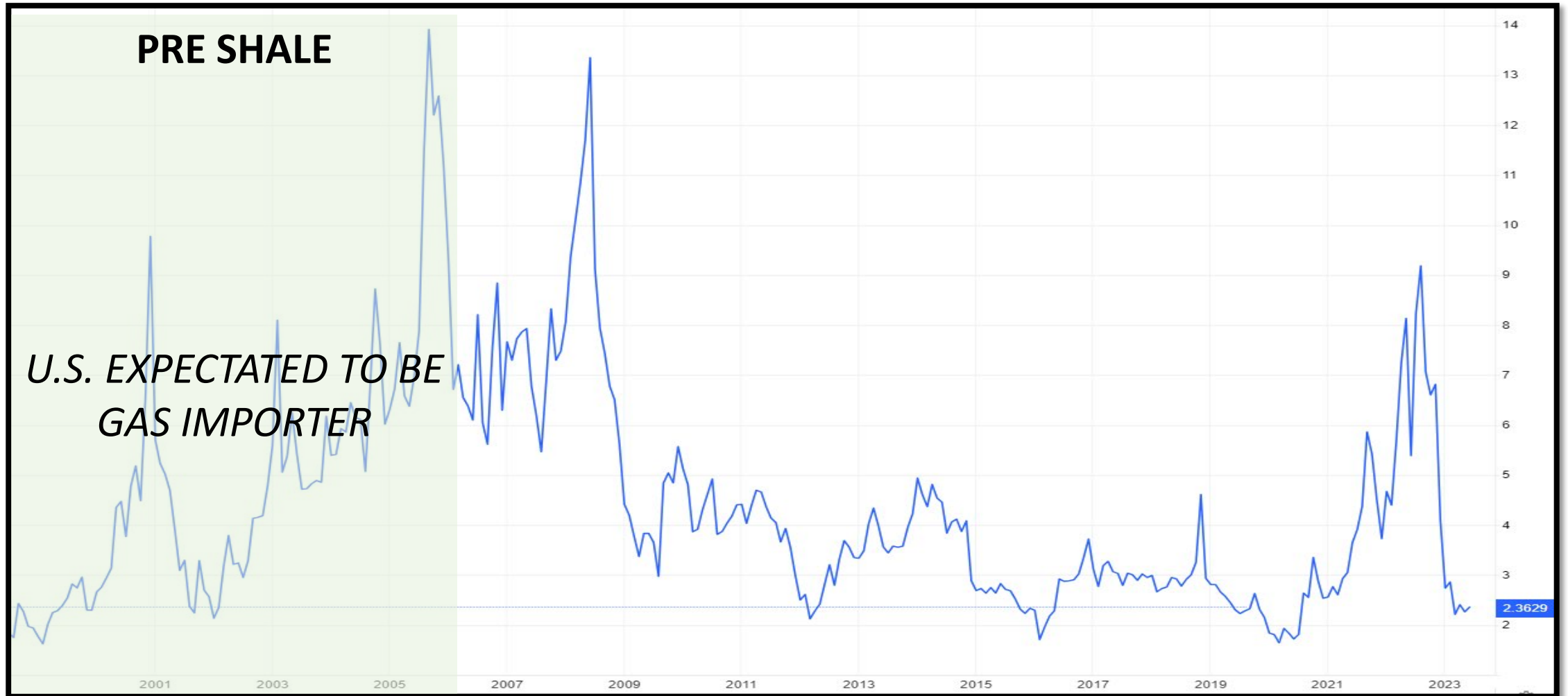
Commodity prices are path dependent

Henry Hub prompt month continuation (\$/mmbtu)



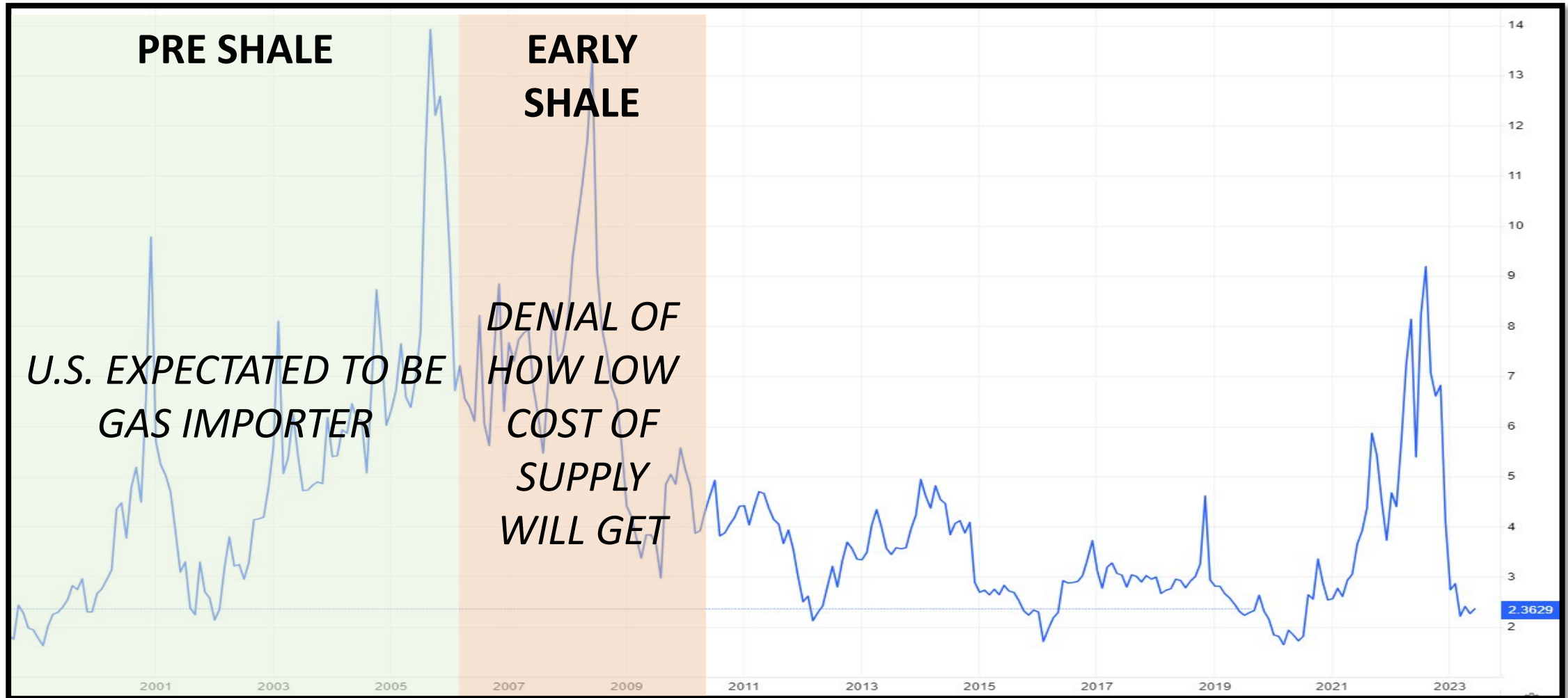
Commodity prices are path dependent

Henry Hub prompt month continuation (\$/mmbtu)



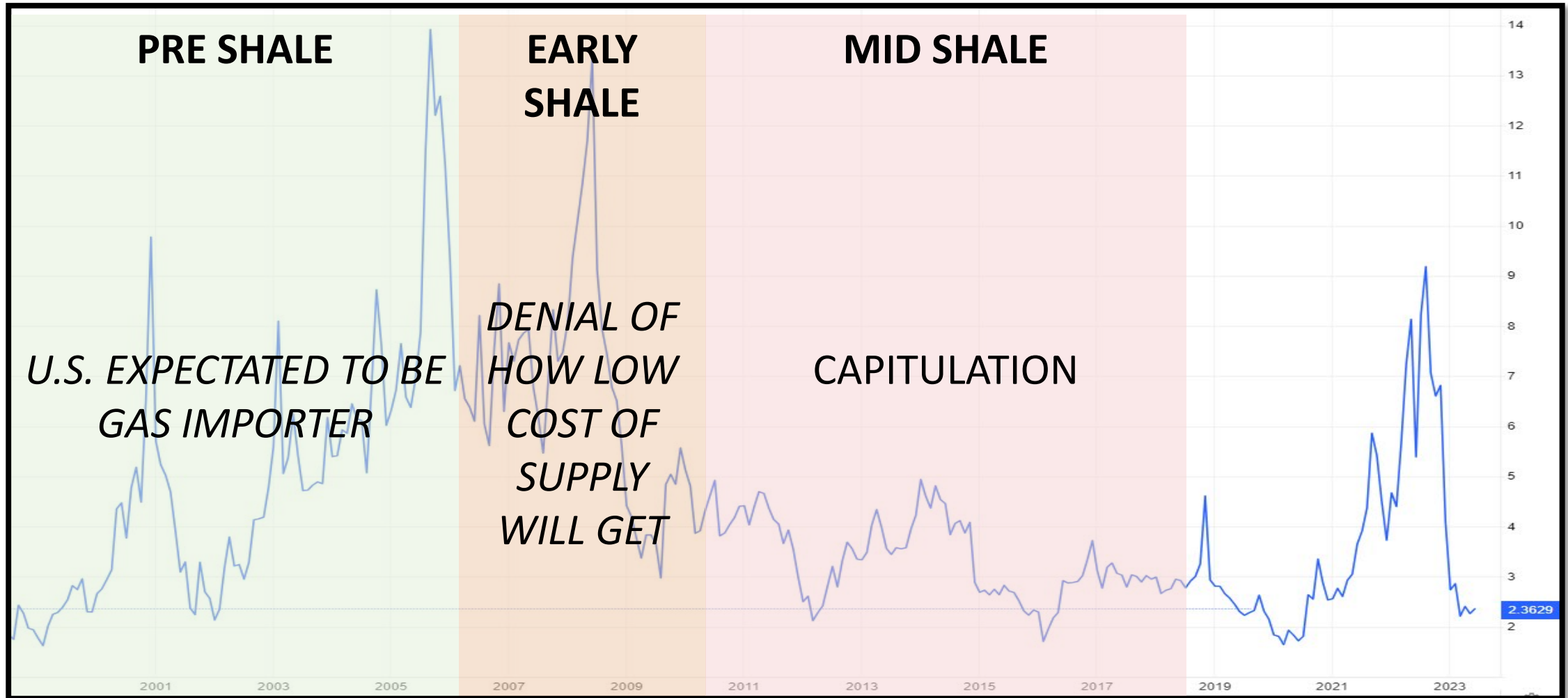
Commodity prices are path dependent

Henry Hub prompt month continuation (\$/mmbtu)



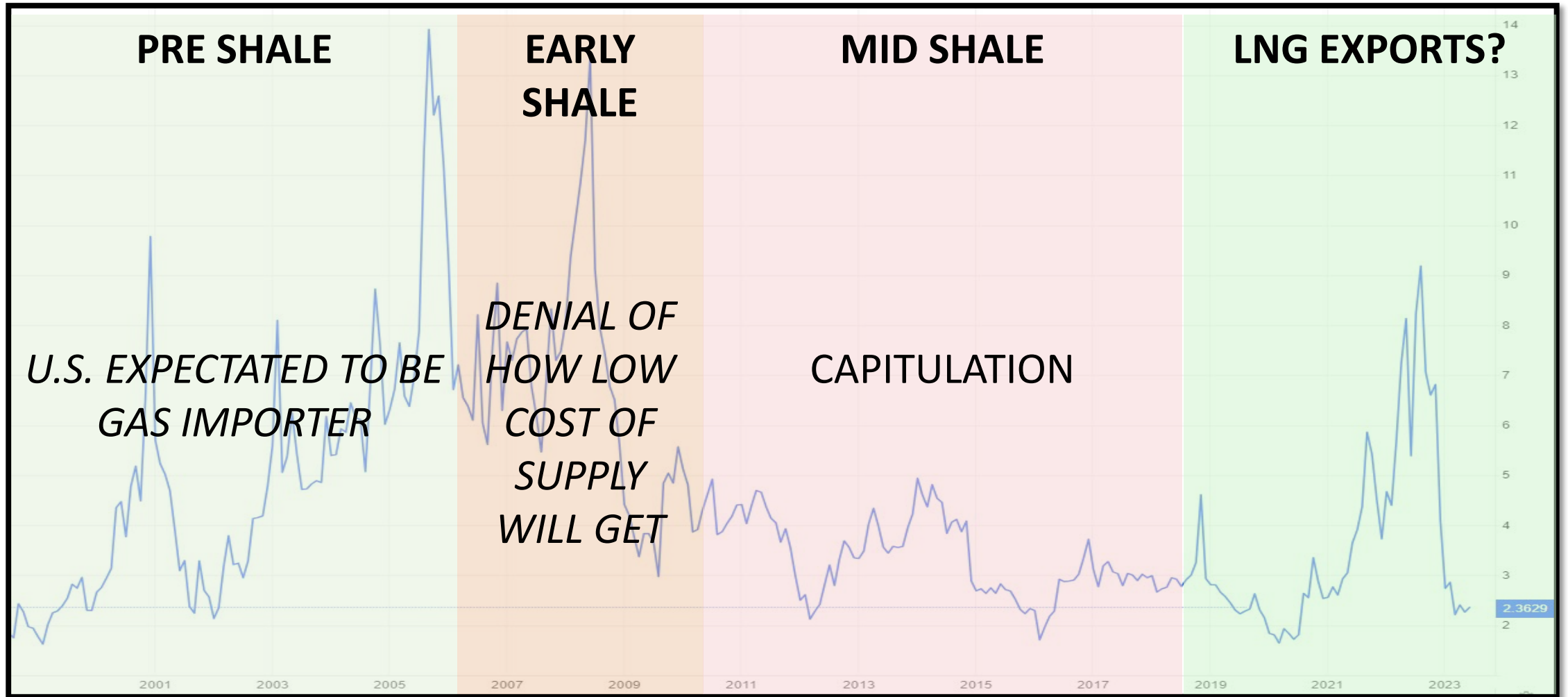
Commodity prices are path dependent

Henry Hub prompt month continuation (\$/mmbtu)



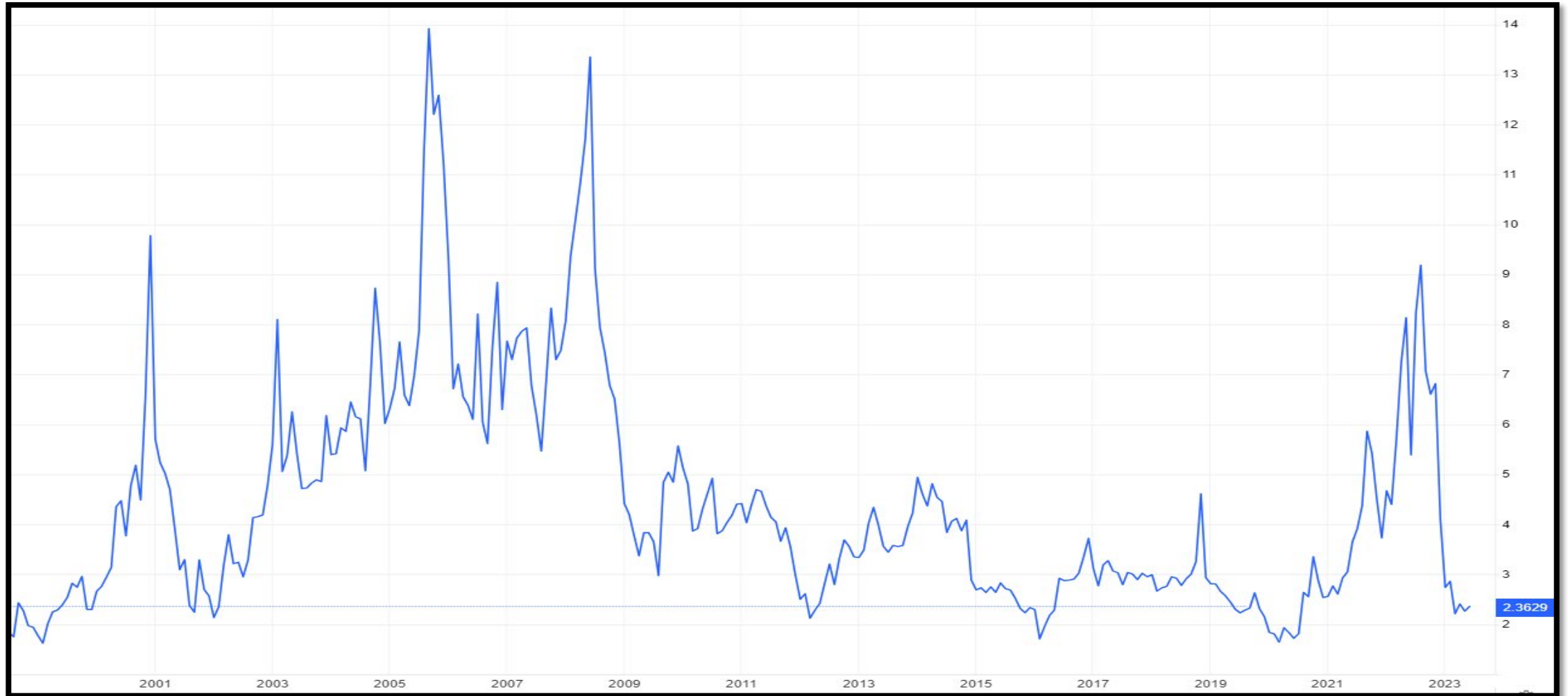
Commodity prices are path dependent

Henry Hub prompt month continuation (\$/mmbtu)



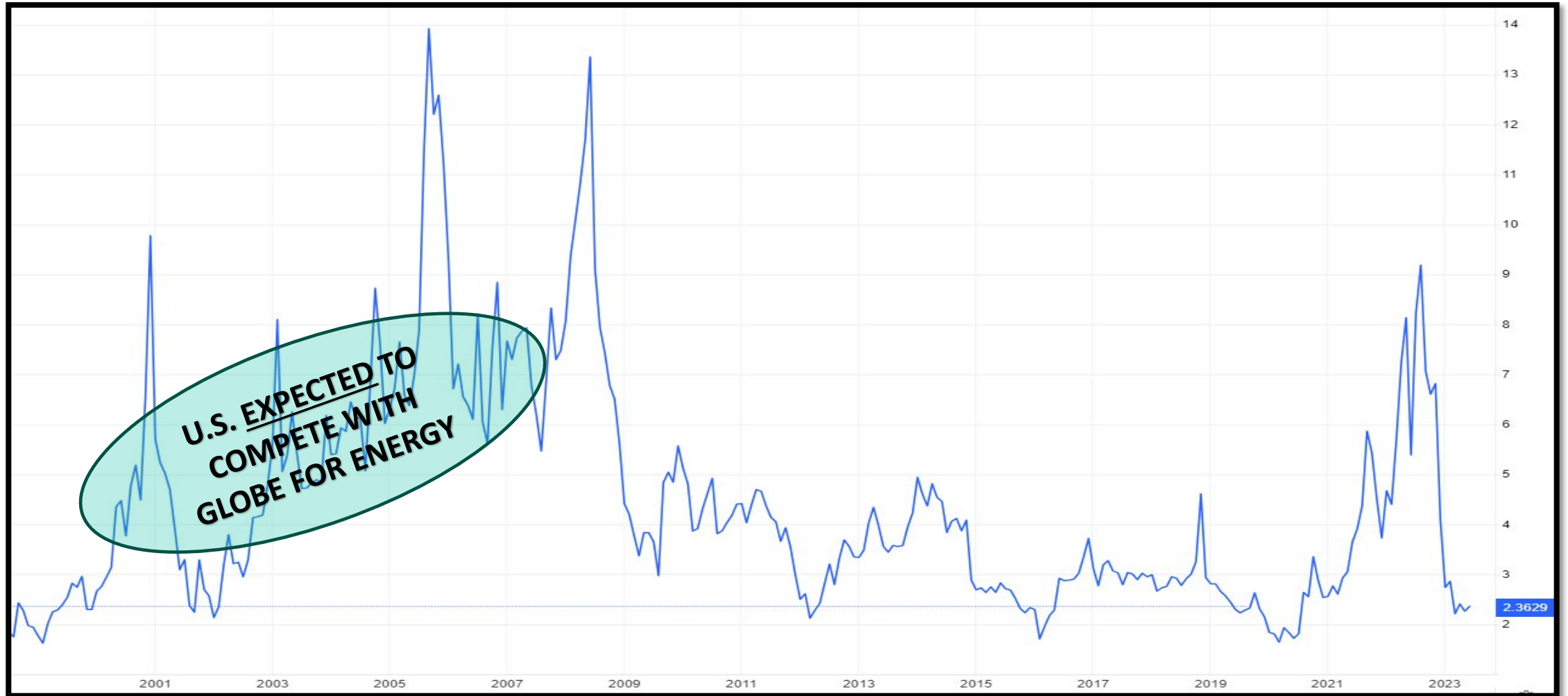
It simplifies down to this

Henry Hub prompt month continuation (\$/mmbtu)



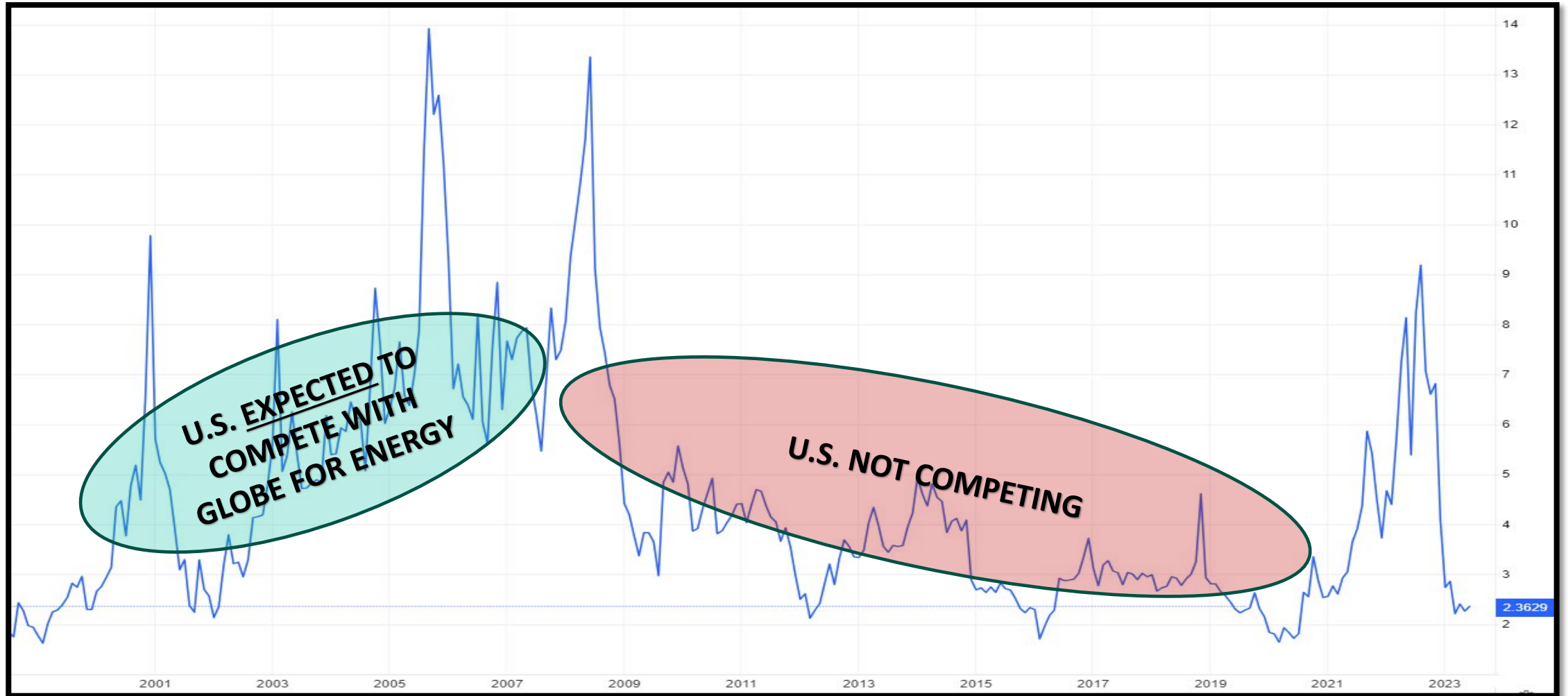
It simplifies down to this

Henry Hub prompt month continuation (\$/mmbtu)



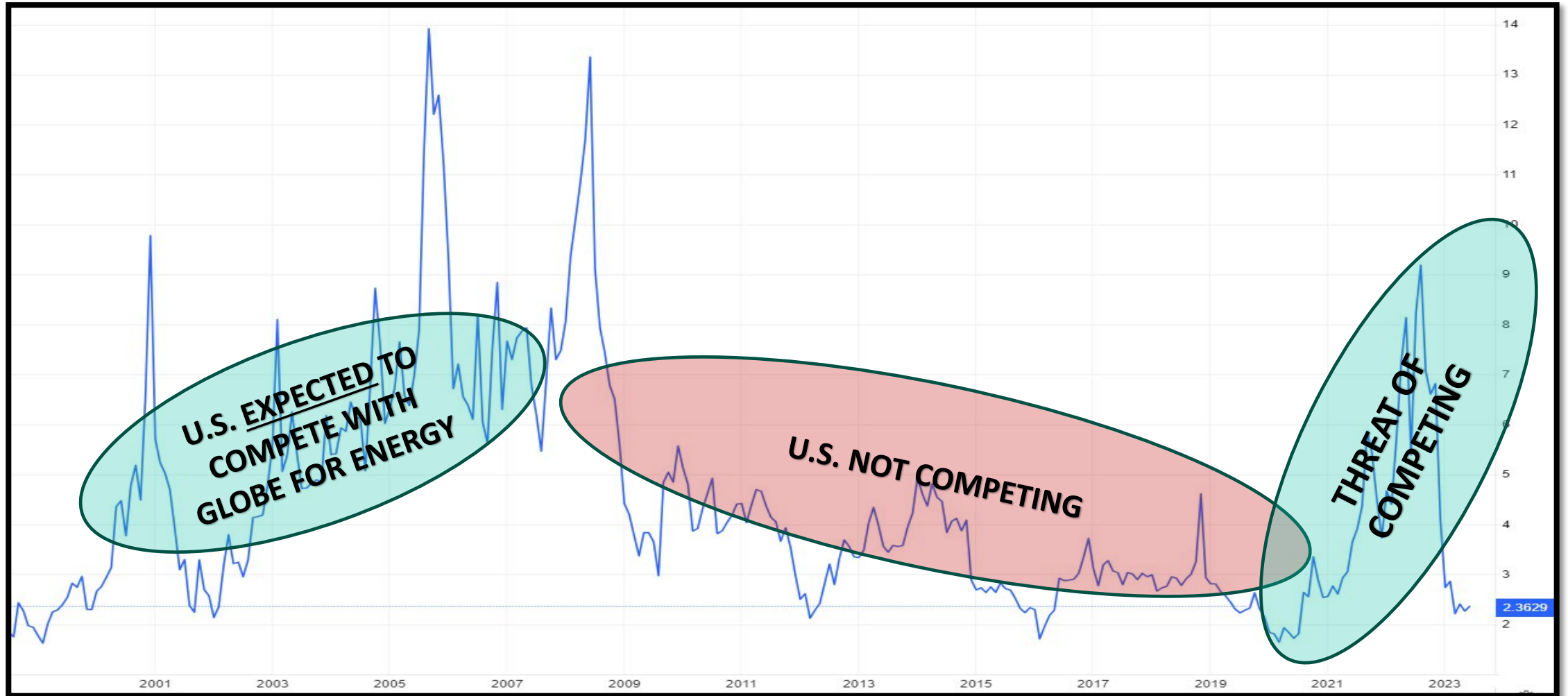
It simplifies down to this

Henry Hub prompt month continuation (\$/mmbtu)

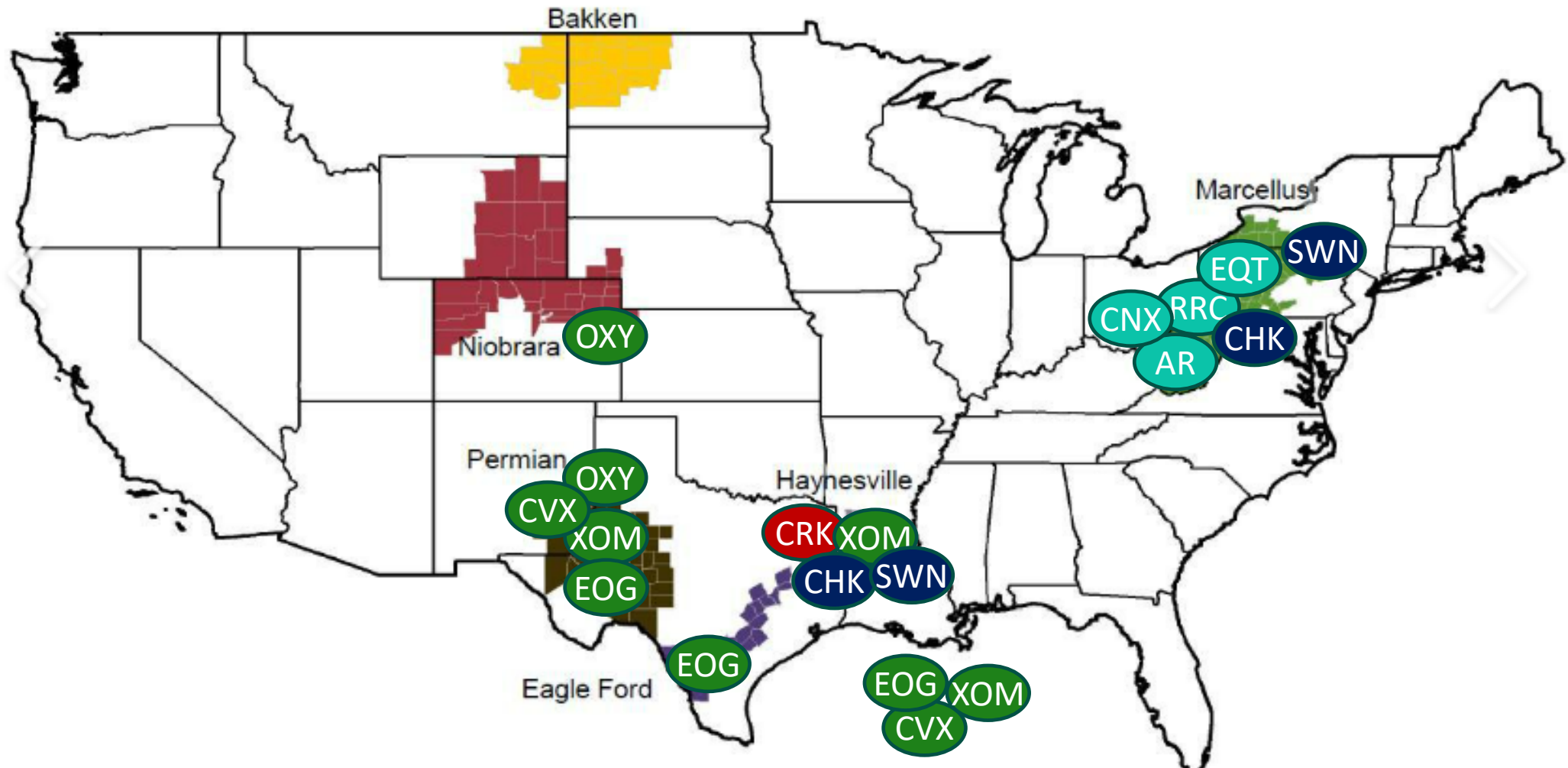


It simplifies down to this

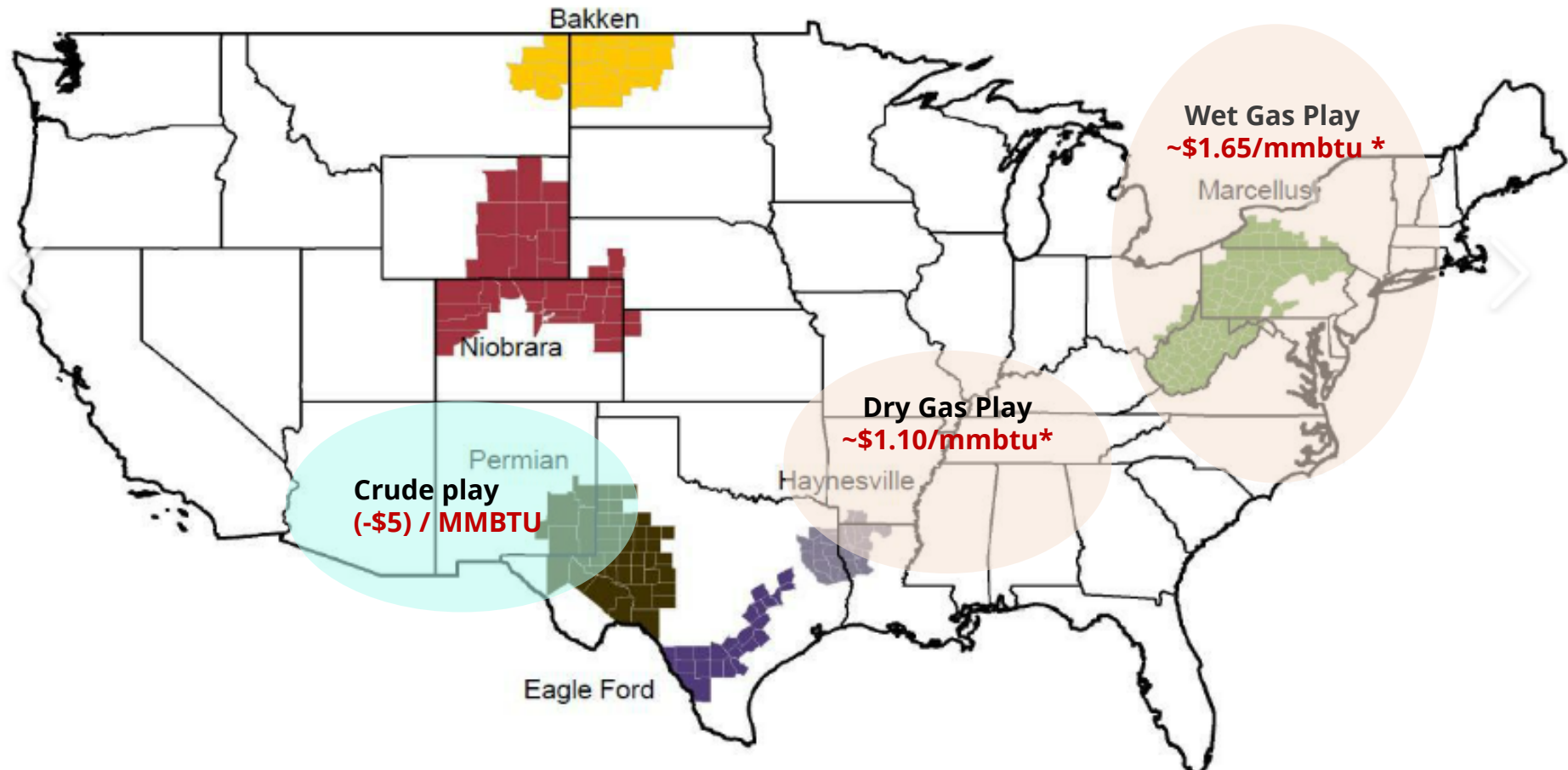
Henry Hub prompt month continuation (\$/mmbtu)



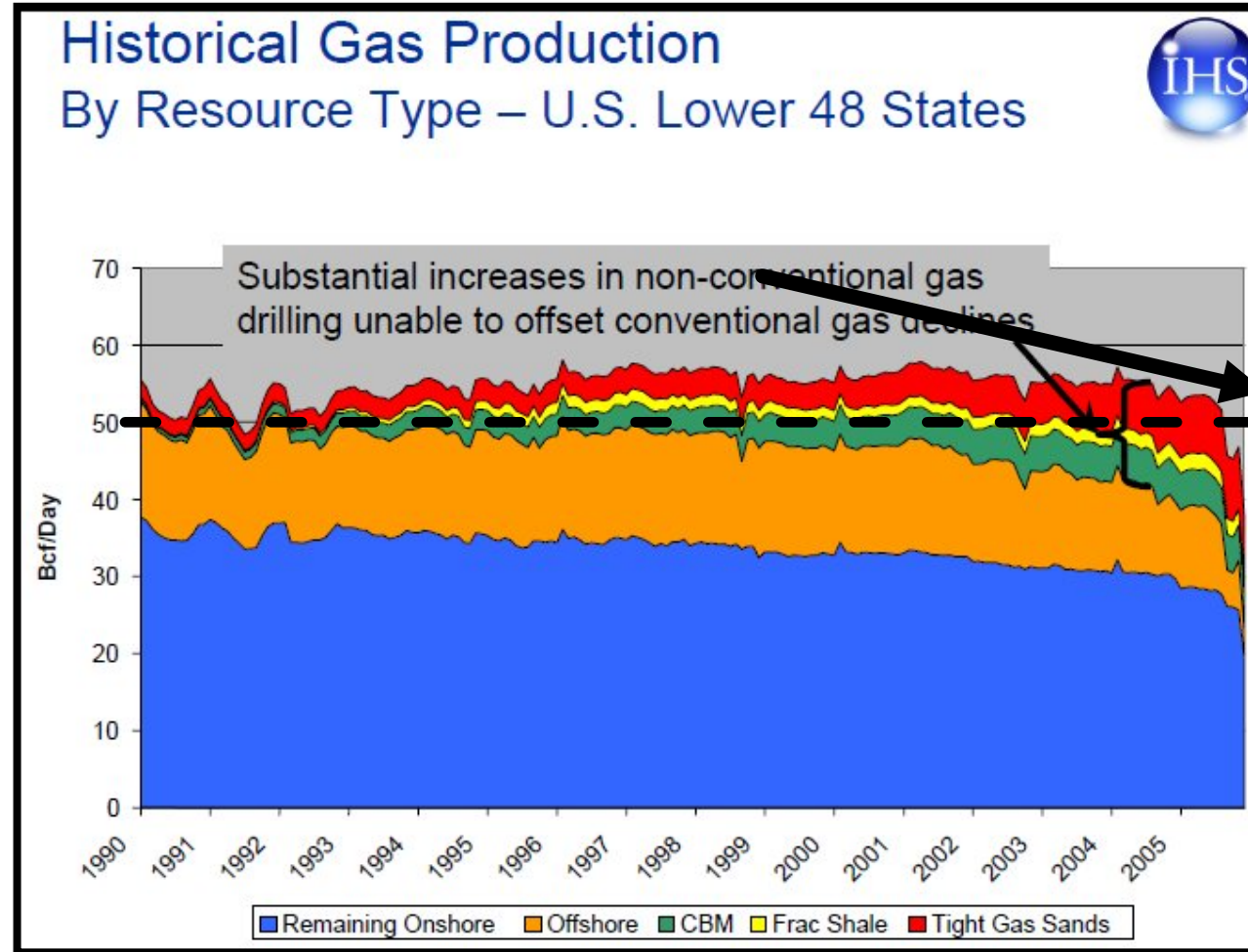
Gas is really cheap to produce



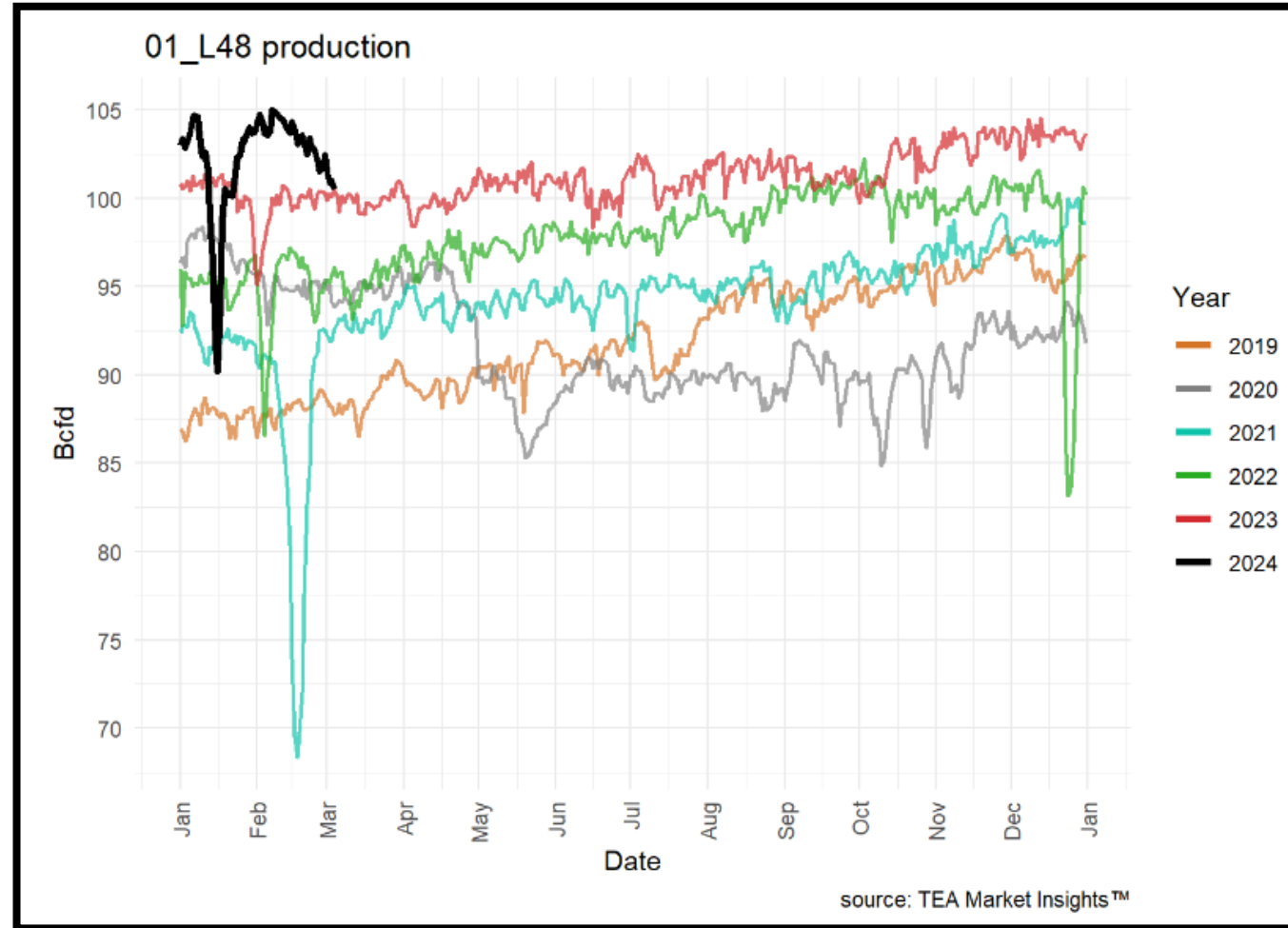
Natural gas is cheap to produce



And we produce a lot of it



And we produce a lot of it



NATURAL GAS DEMAND (AND PRICE) DRIVERS

How the US uses natural gas

Natural gas use by U.S. consuming sectors by amount and percentage share of total U.S. natural gas consumption in 2022 was:¹

38%

12.12 Tcf
electric power

32%

10.44 Tcf
industrial

15%

4.99 Tcf
residential

11%

3.52 Tcf
commercial

4%

1.24 Tcf
transportation

Source: <https://www.eia.gov/energyexplained/natural-gas/use-of-natural-gas.php>

1. Heating

Natural gas use by U.S. consuming sectors by amount and percentage share of total U.S. natural gas consumption in 2022 was:¹

38%
12.12 Tcf
electric power

32%
10.44 Tcf
industrial

15%
4.99 Tcf
residential

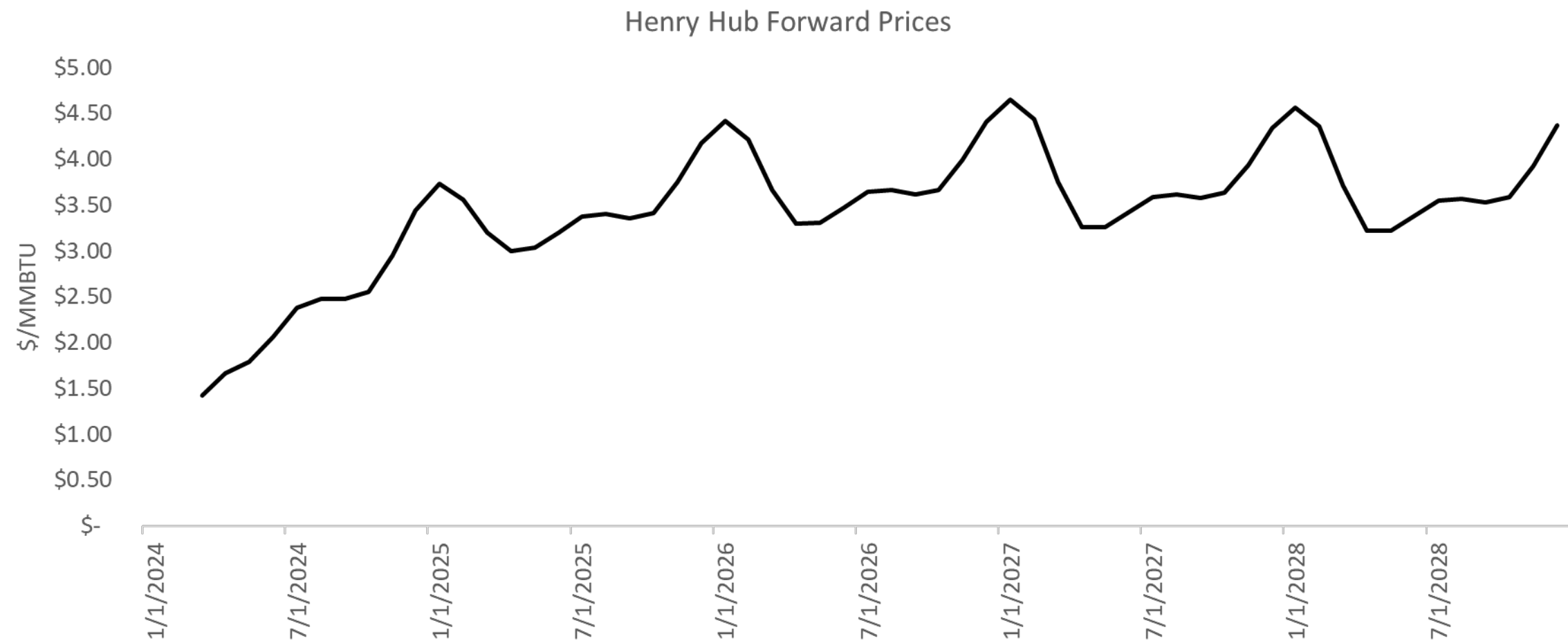
11%
3.52 Tcf
commercial

4%
1.24 Tcf
transportation

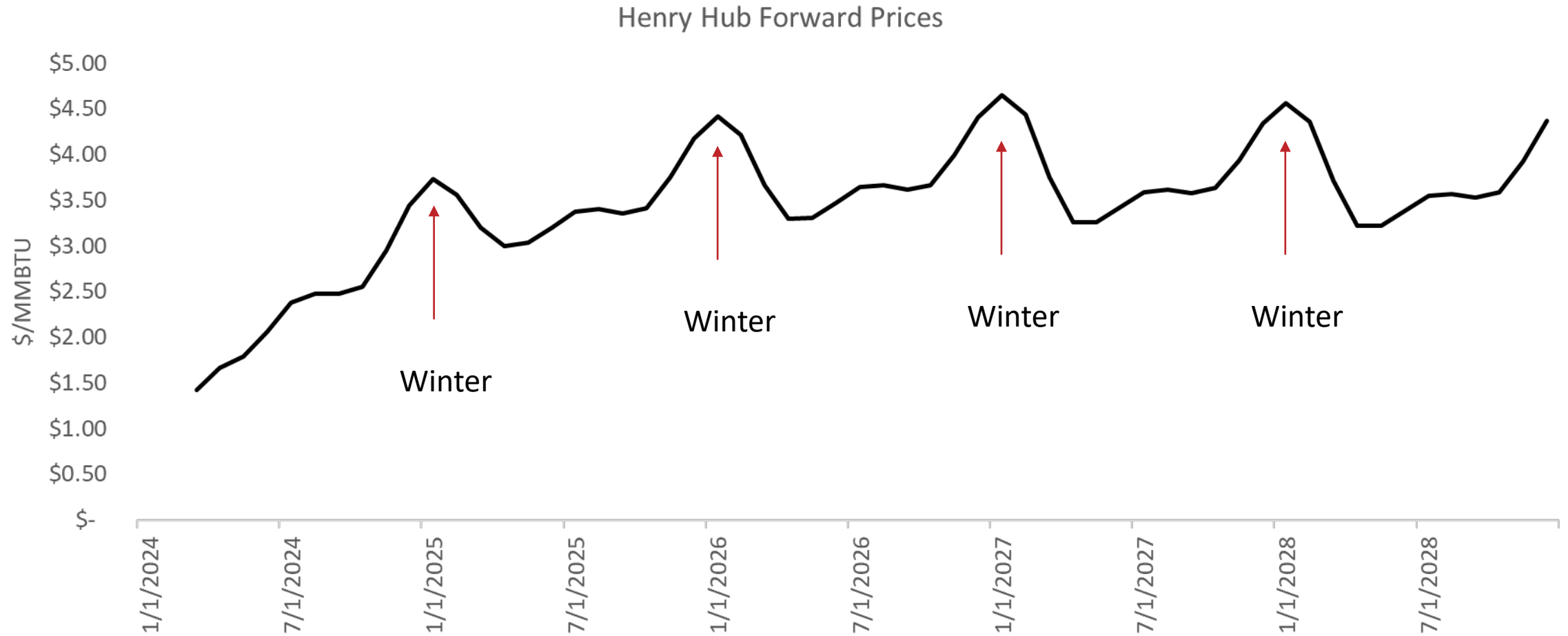
25% is used for
heating and cooking

Source: <https://www.eia.gov/energyexplained/natural-gas/use-of-natural-gas.php>

Expected heating demand impacts forward prices

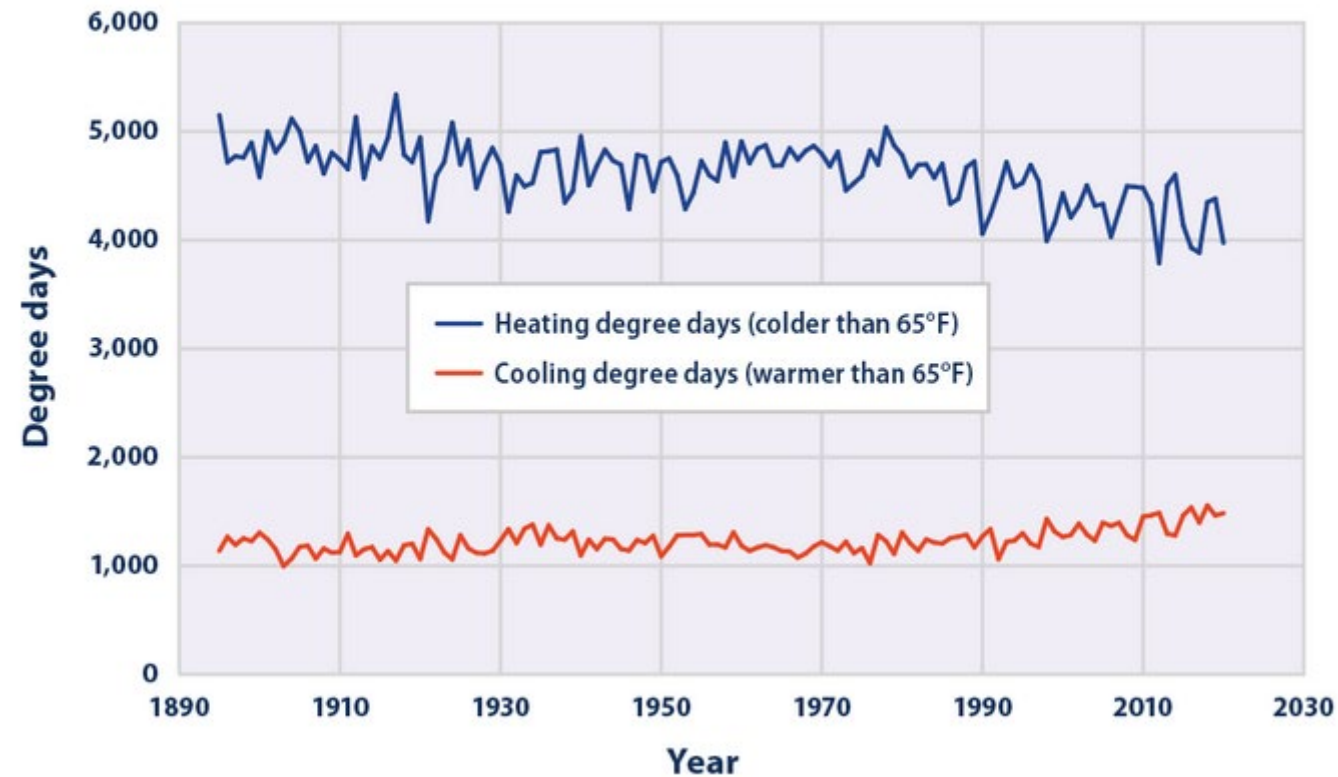


Expected heating demand impacts forward prices



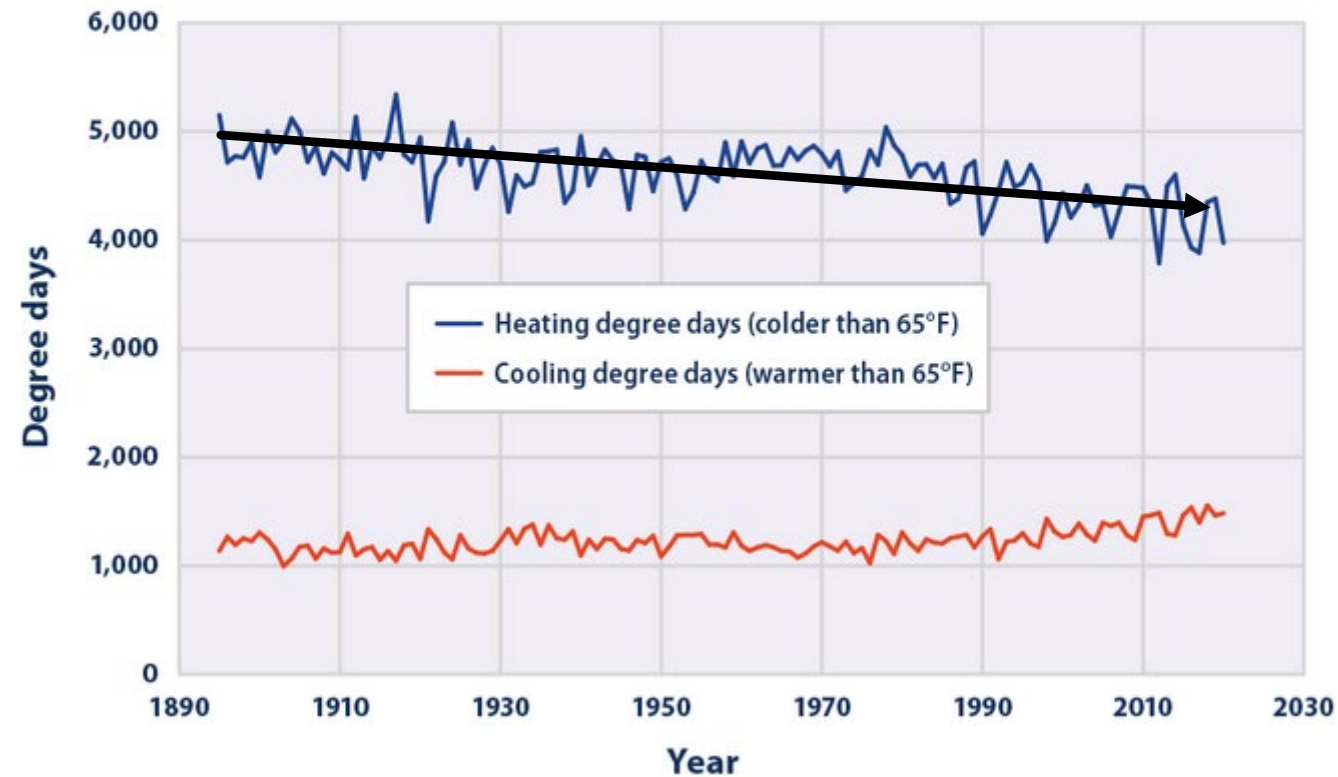
Both winter and summers are getting warmer

Figure 1. Heating and Cooling Degree Days in the Contiguous 48 States, 1895–2020



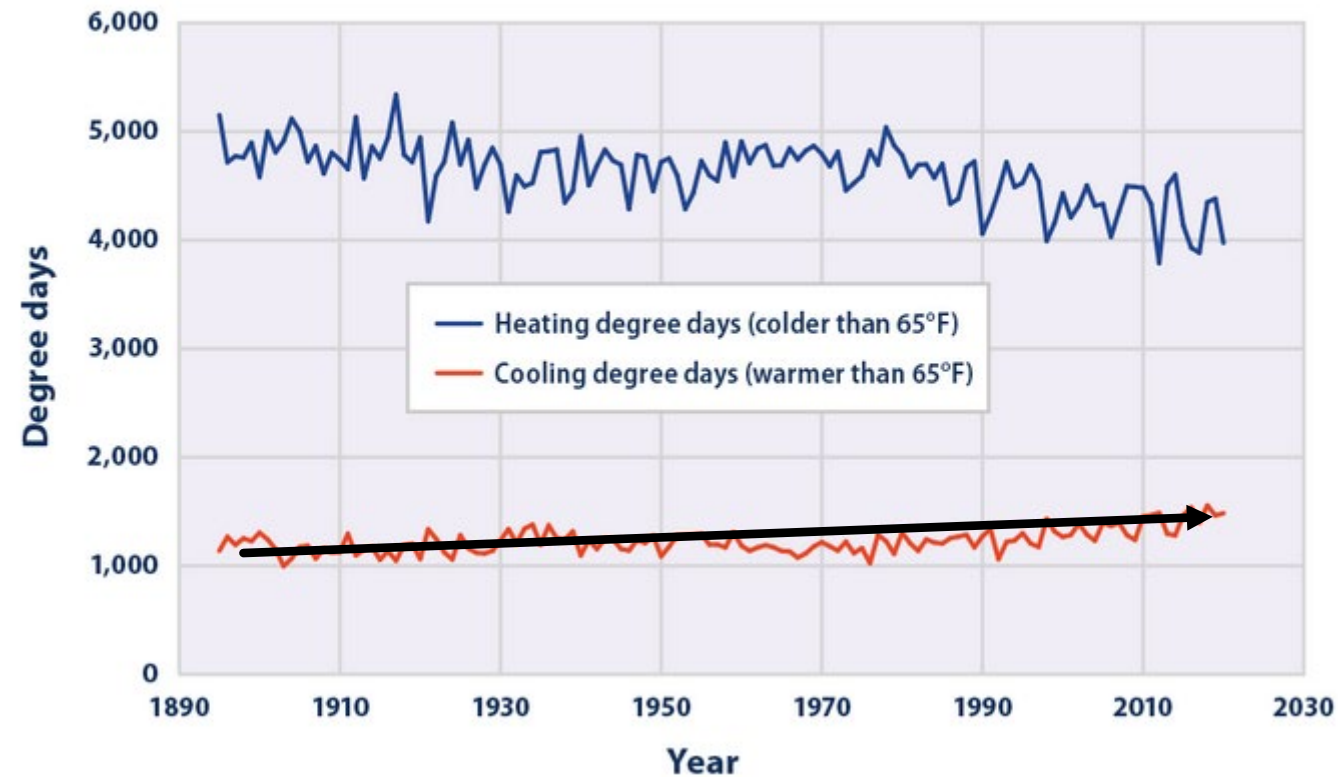
Both winter and summers are getting warmer

Figure 1. Heating and Cooling Degree Days in the Contiguous 48 States, 1895–2020



Both winter and summers are getting warmer

Figure 1. Heating and Cooling Degree Days in the Contiguous 48 States, 1895–2020



2. Industrial and LNG exports

Natural gas use by U.S. consuming sectors by amount and percentage share of total U.S. natural gas consumption in 2022 was:¹

38%

12.12 Tcf
electric power

32%

10.44 Tcf
industrial

15%

4.99 Tcf
residential

11%

3.52 Tcf
commercial

4%

1.24 Tcf
transportation

Includes 3.85 Tcf
exported

Source: <https://www.eia.gov/energyexplained/natural-gas/use-of-natural-gas.php>

2. Industrial and LNG exports

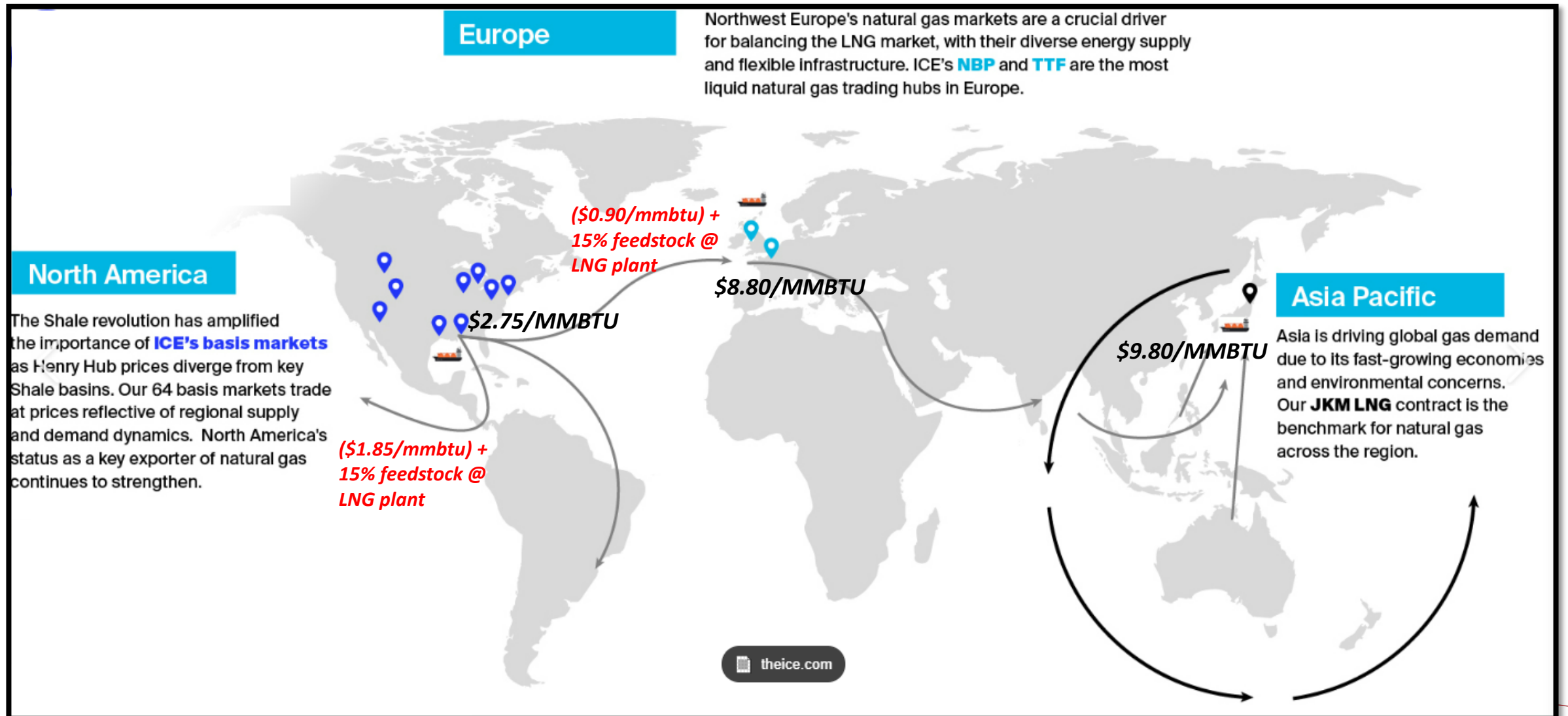
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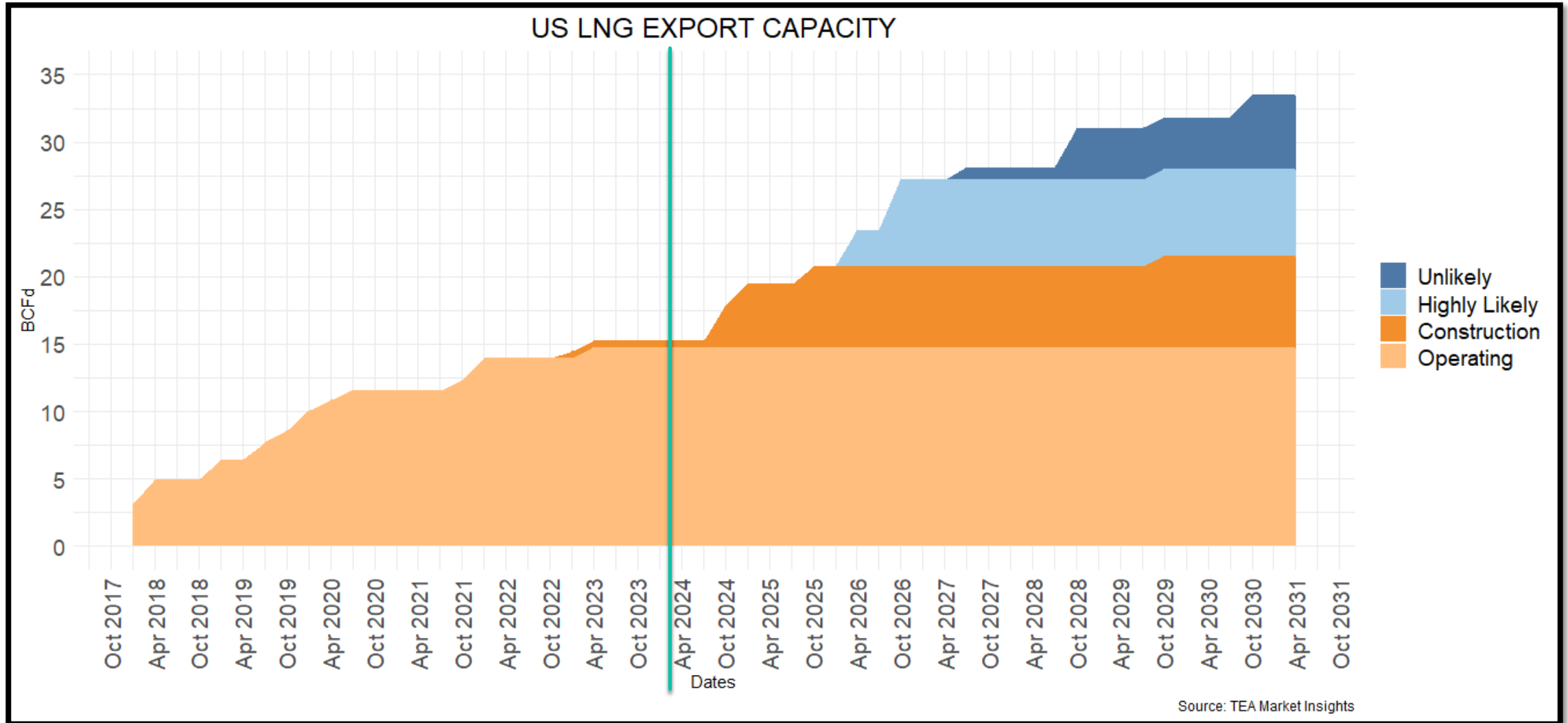
About 15% are LNG exports

Source: <https://www.eia.gov/energyexplained/natural-gas/use-of-natural-gas.php>

LNG exports are a function of price and capacity



LNG export capacity continues to grow



3. Electricity generation

Natural gas use by U.S. consuming sectors by amount and percentage share of total U.S. natural gas consumption in 2022 was:¹

38%

12.12 Tcf
electric power

32%

10.44 Tcf
industrial

15%

4.99 Tcf
residential

11%

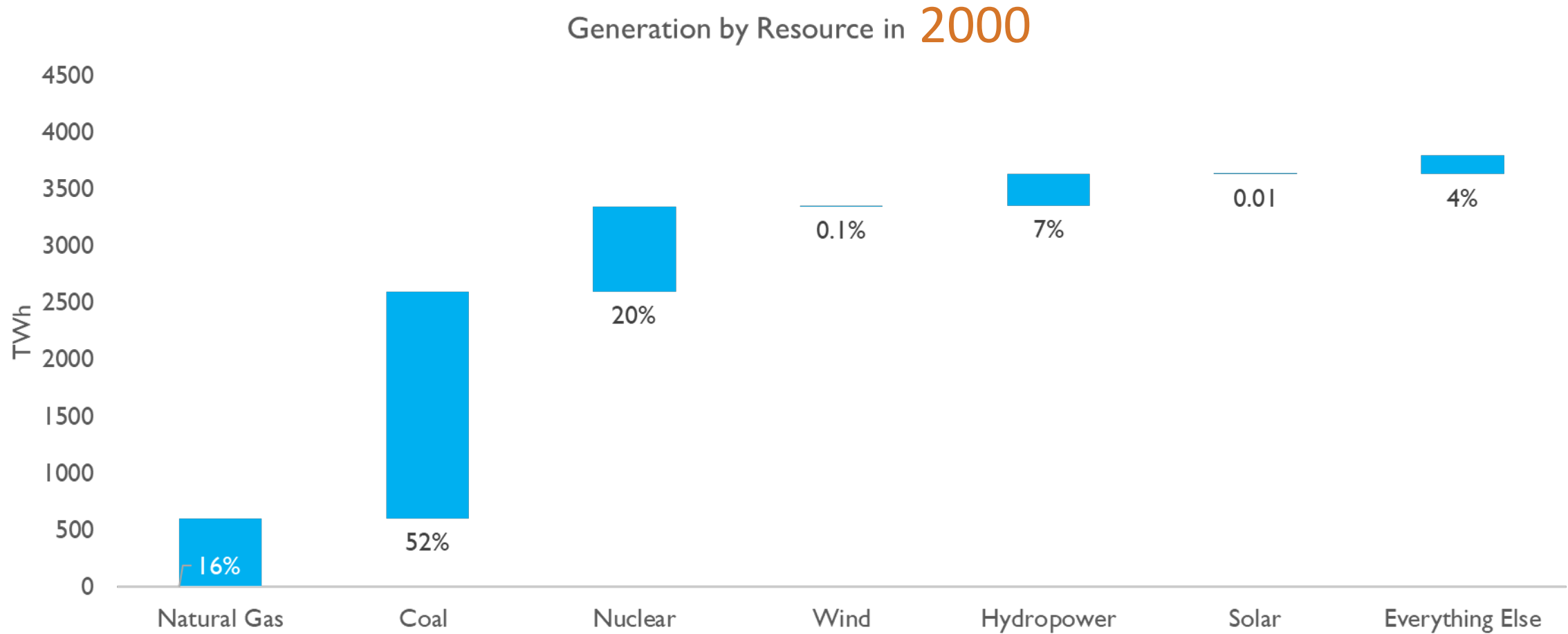
3.52 Tcf
commercial

4%

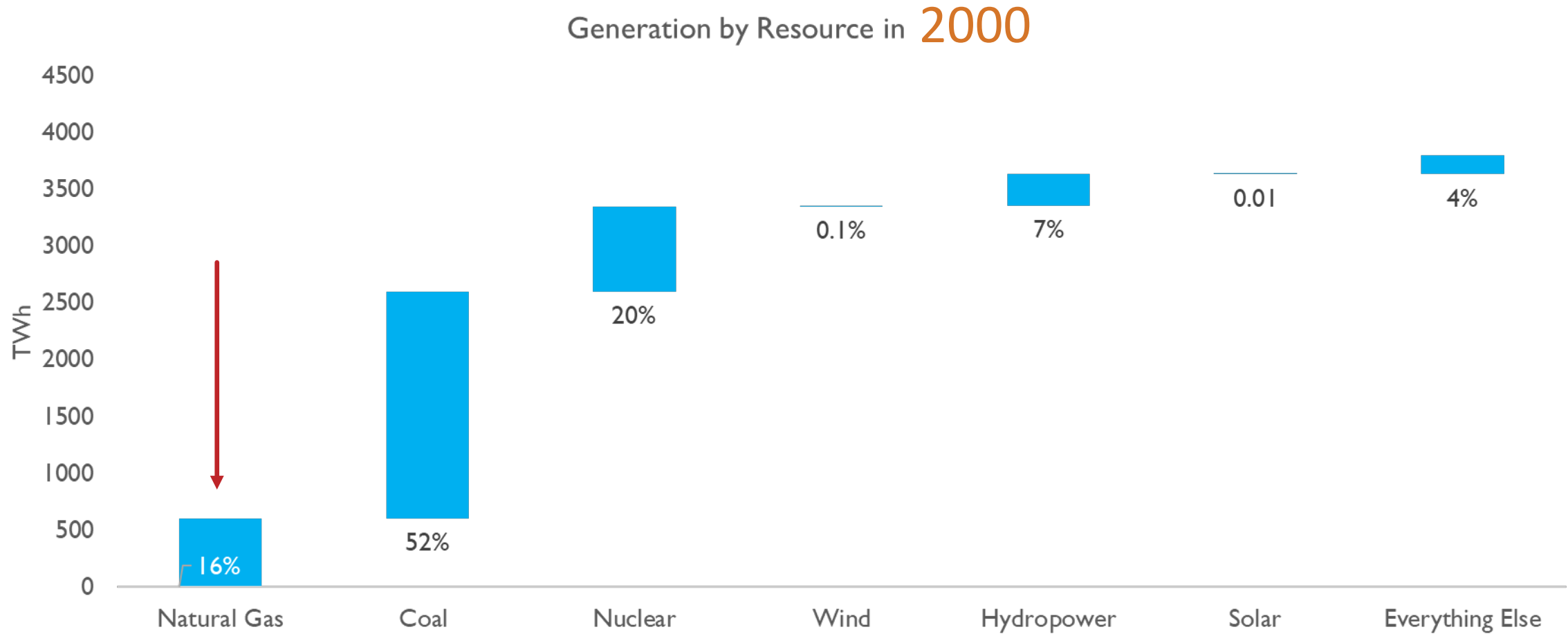
1.24 Tcf
transportation

Source: <https://www.eia.gov/energyexplained/natural-gas/use-of-natural-gas.php>

Our resource mix changed a lot in 20 years

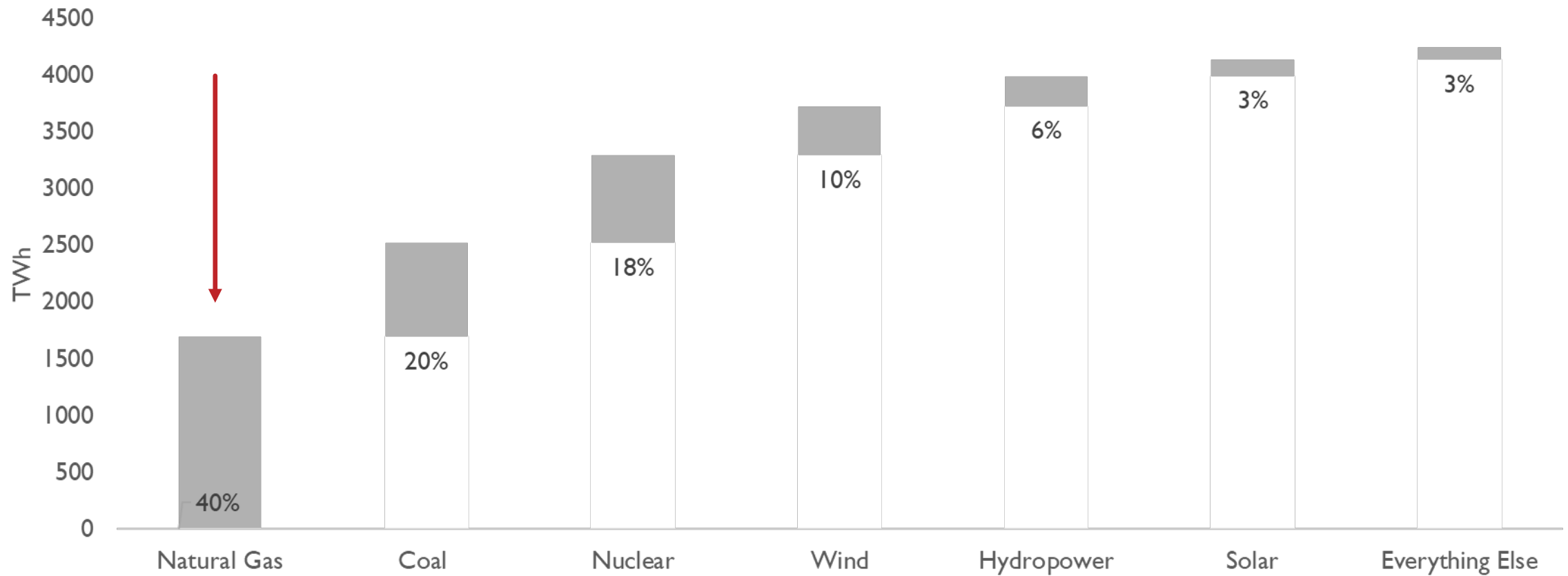


Our resource mix changed a lot in 20 years

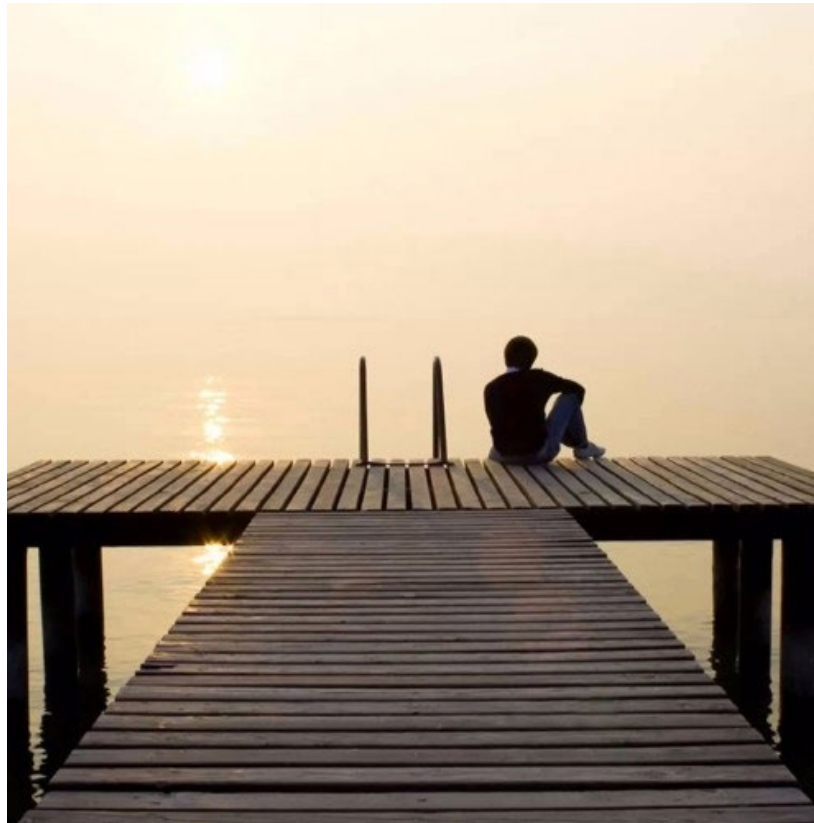


Gas jumped from 16% to 40%

Generation by Resource in 2022



There's no shortage of load growth

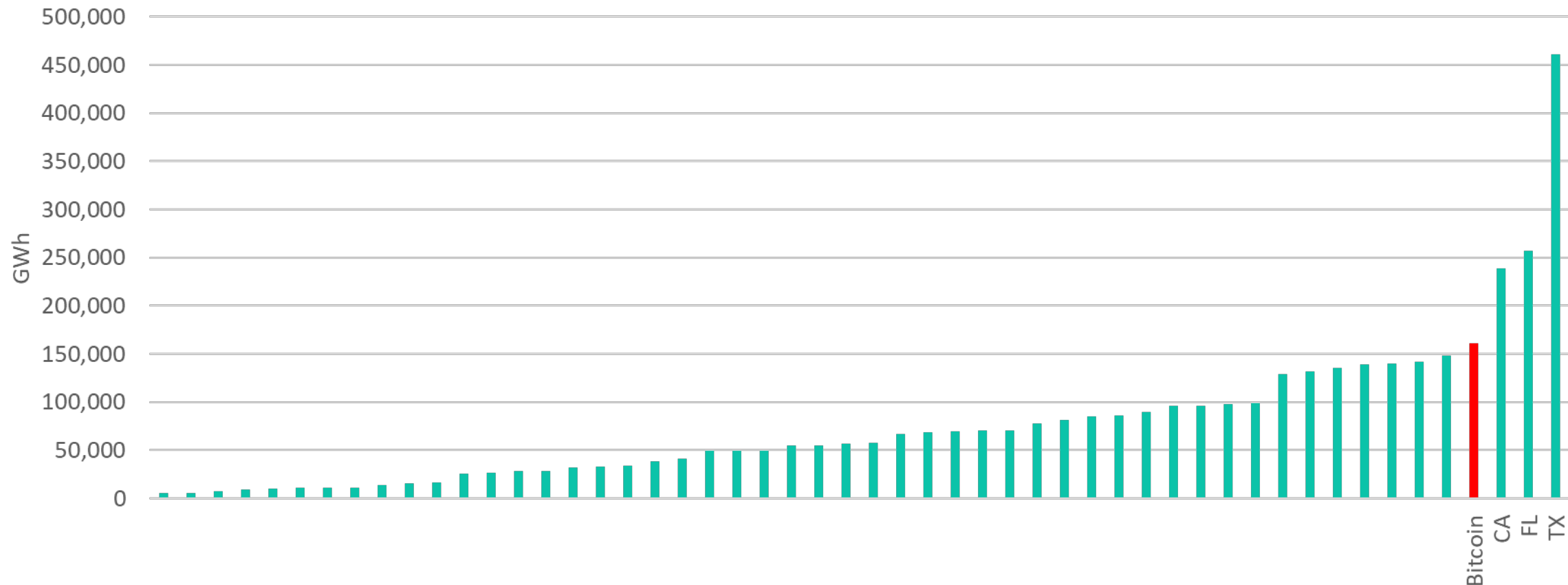


NETFLIX



Bitcoin uses *a lot* of energy

All 50 States Annual Energy Consumption + Bitcoin

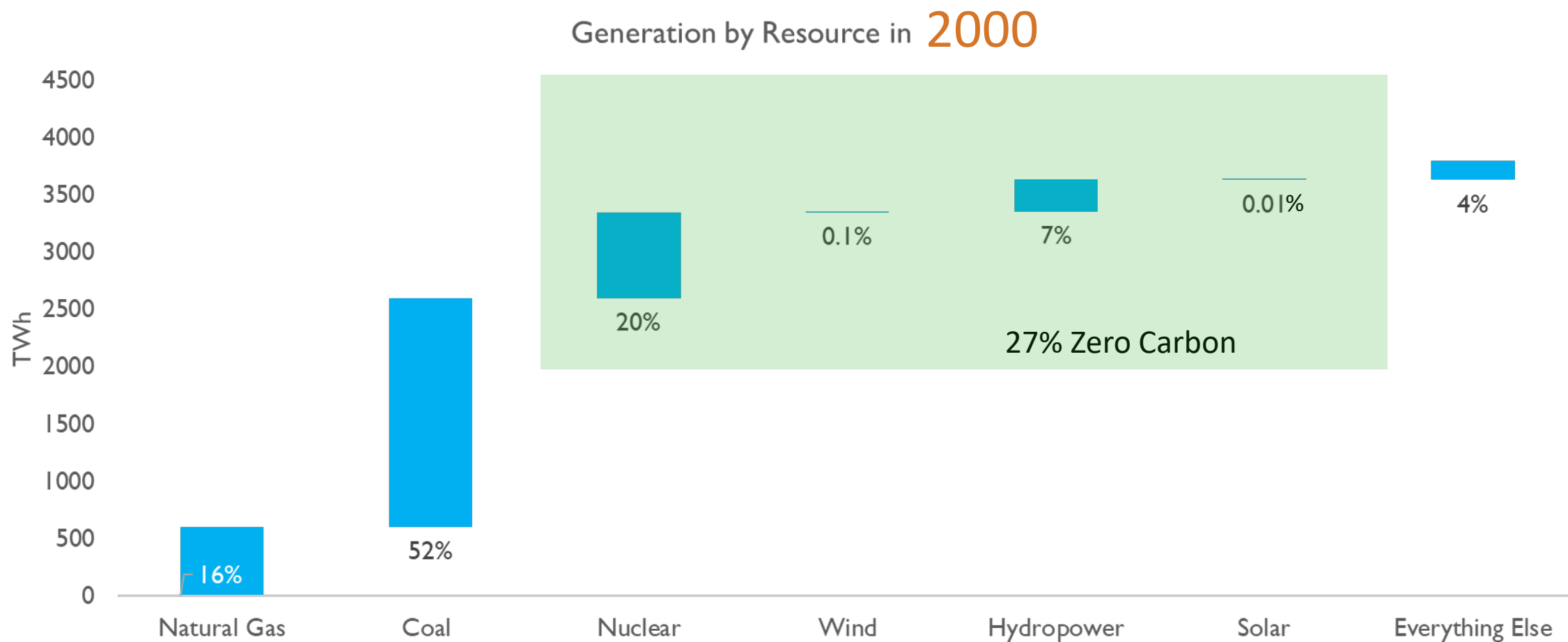


RENEWABLE FUNDAMENTALS

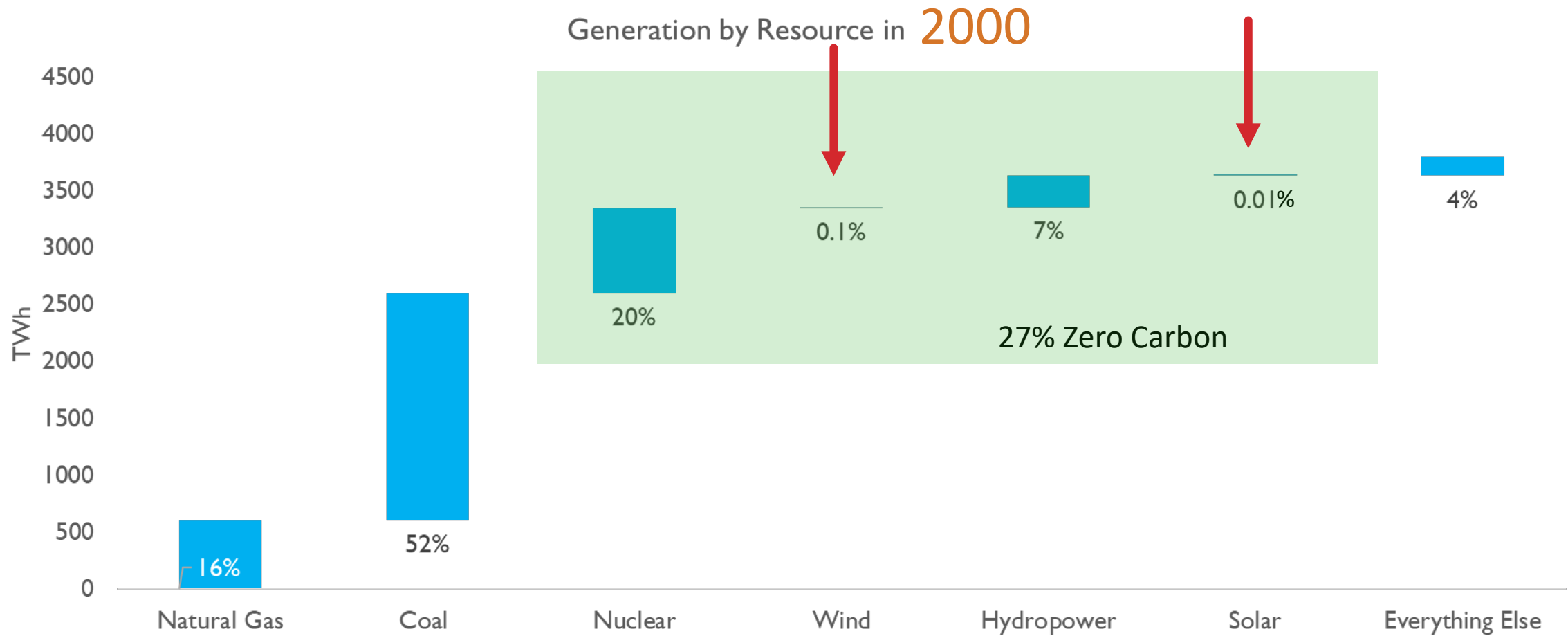
THE “OTHER” PRICE DRIVER



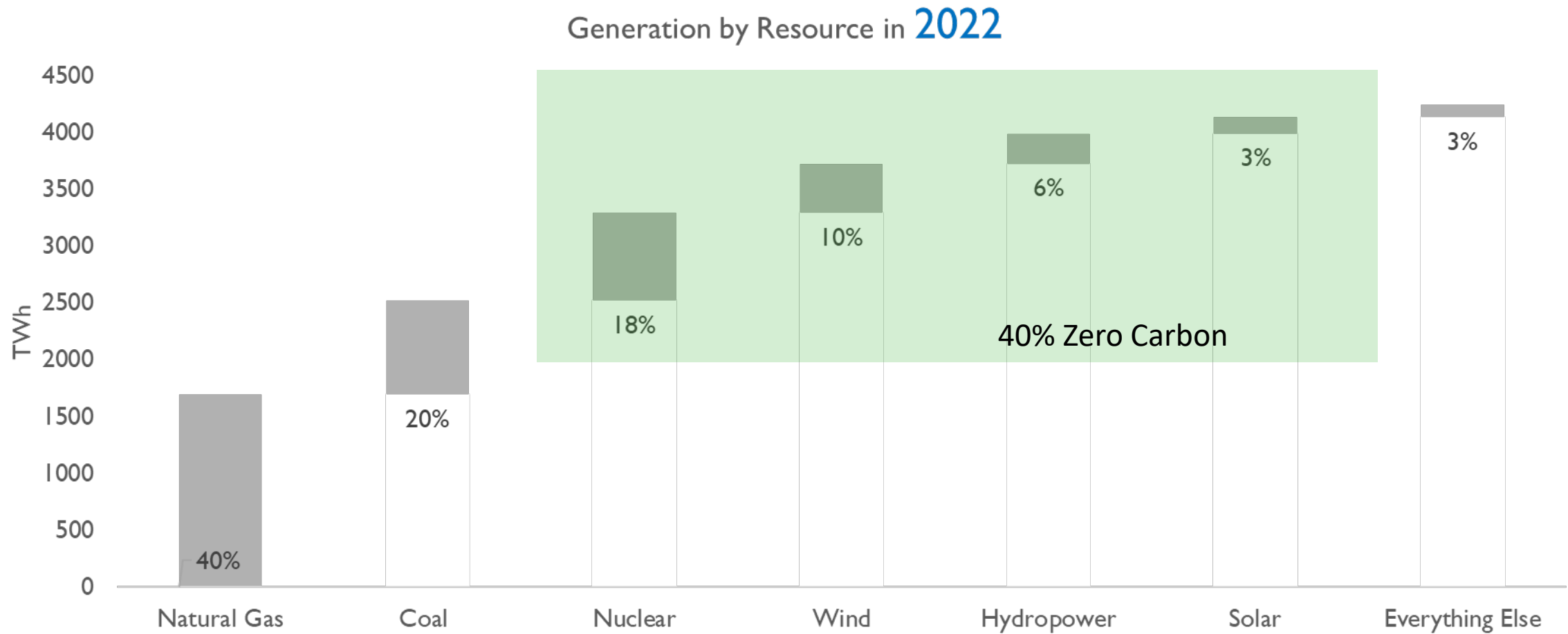
HOW MUCH DID RENEWABLES CONTRIBUTE YESTERDAY?



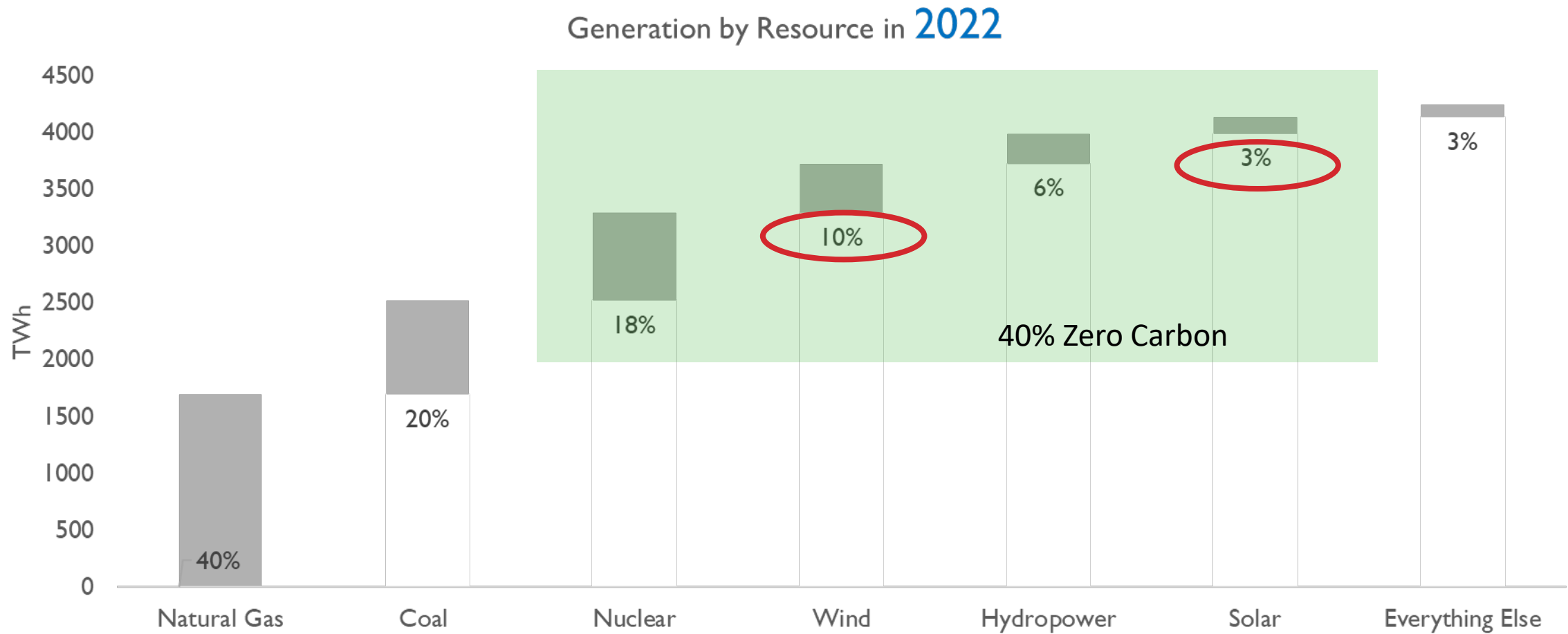
HOW MUCH DID RENEWABLES CONTRIBUTE YESTERDAY?



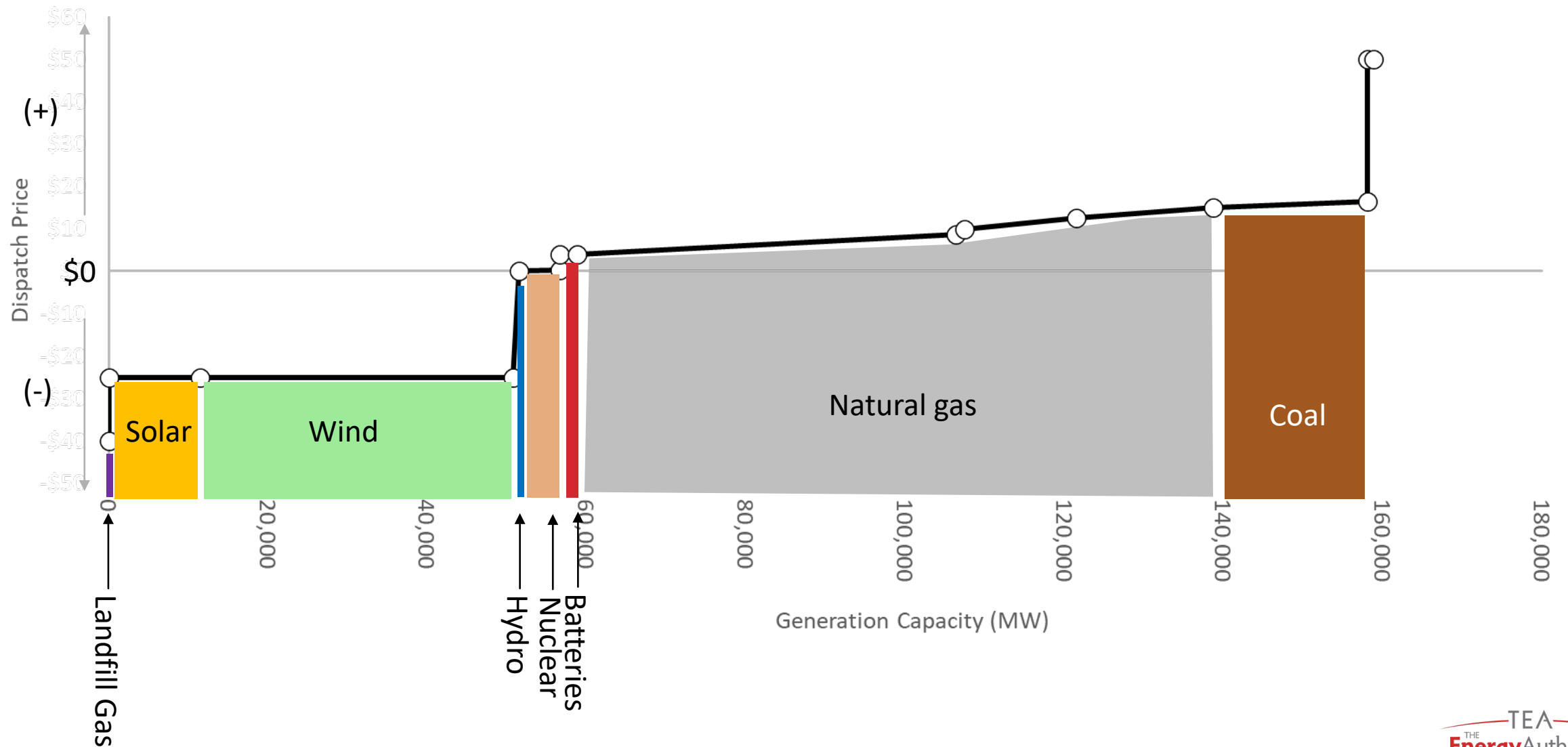
HOW MUCH DO RENEWABLES CONTRIBUTE TODAY?



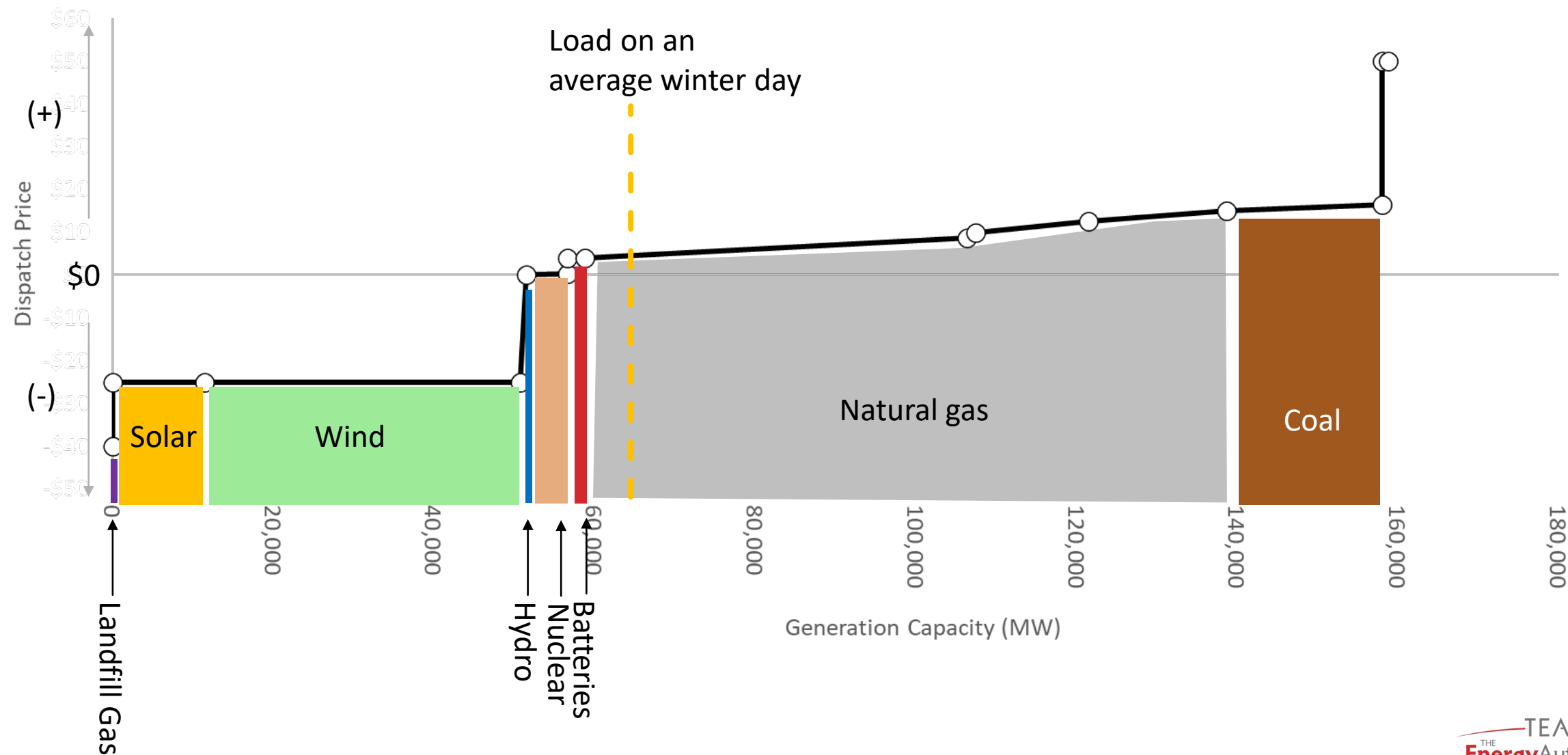
HOW MUCH DO RENEWABLES CONTRIBUTE TODAY?



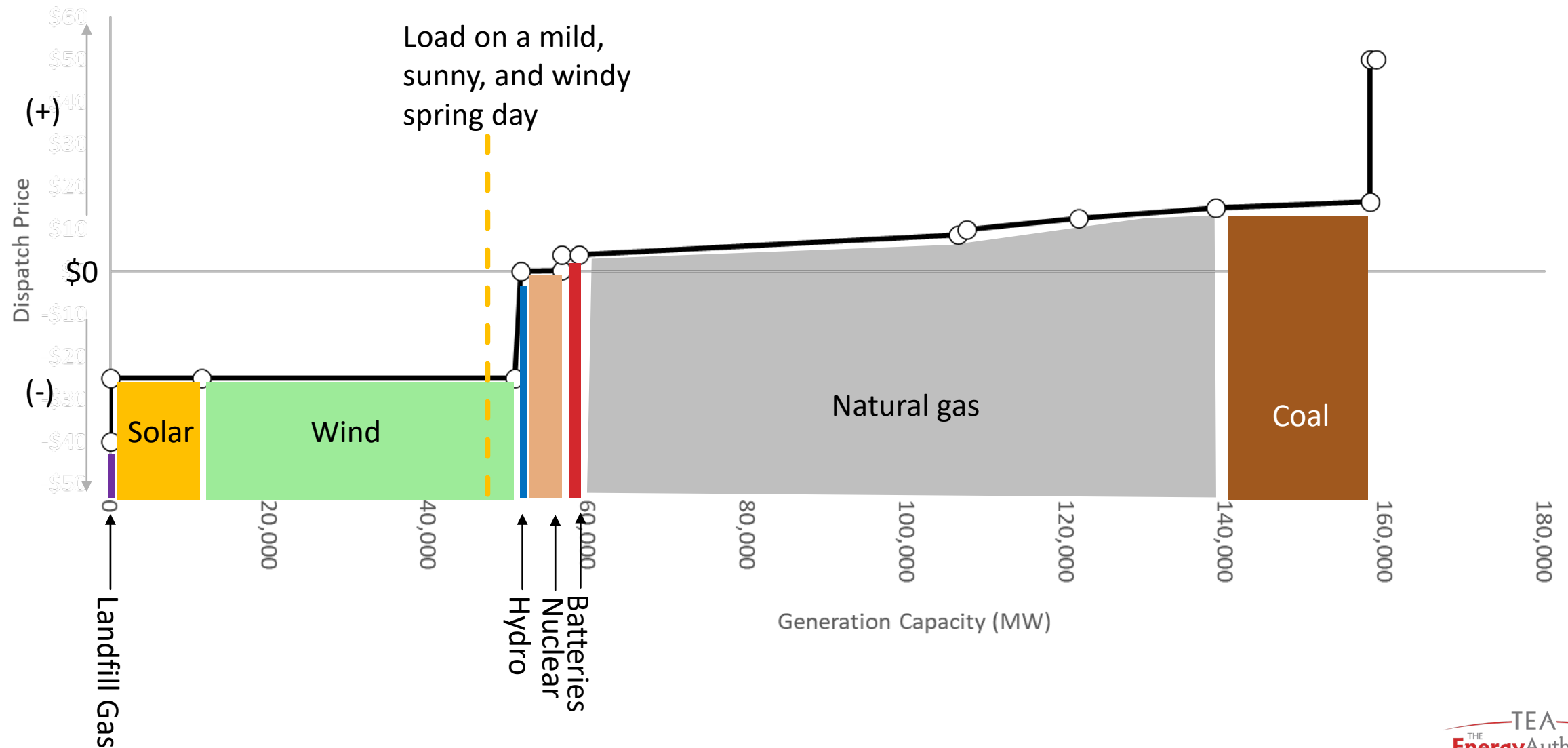
The merit order



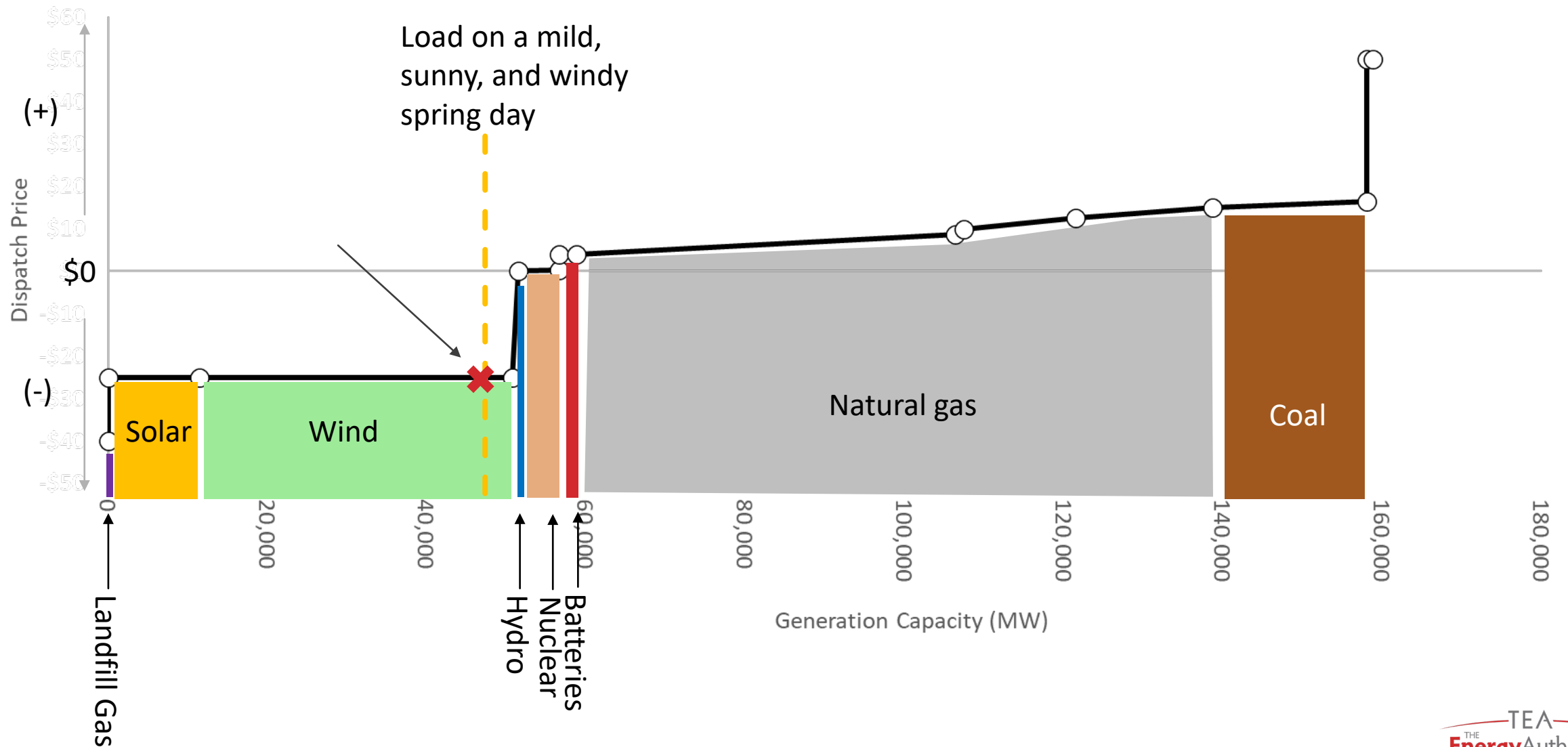
The merit order



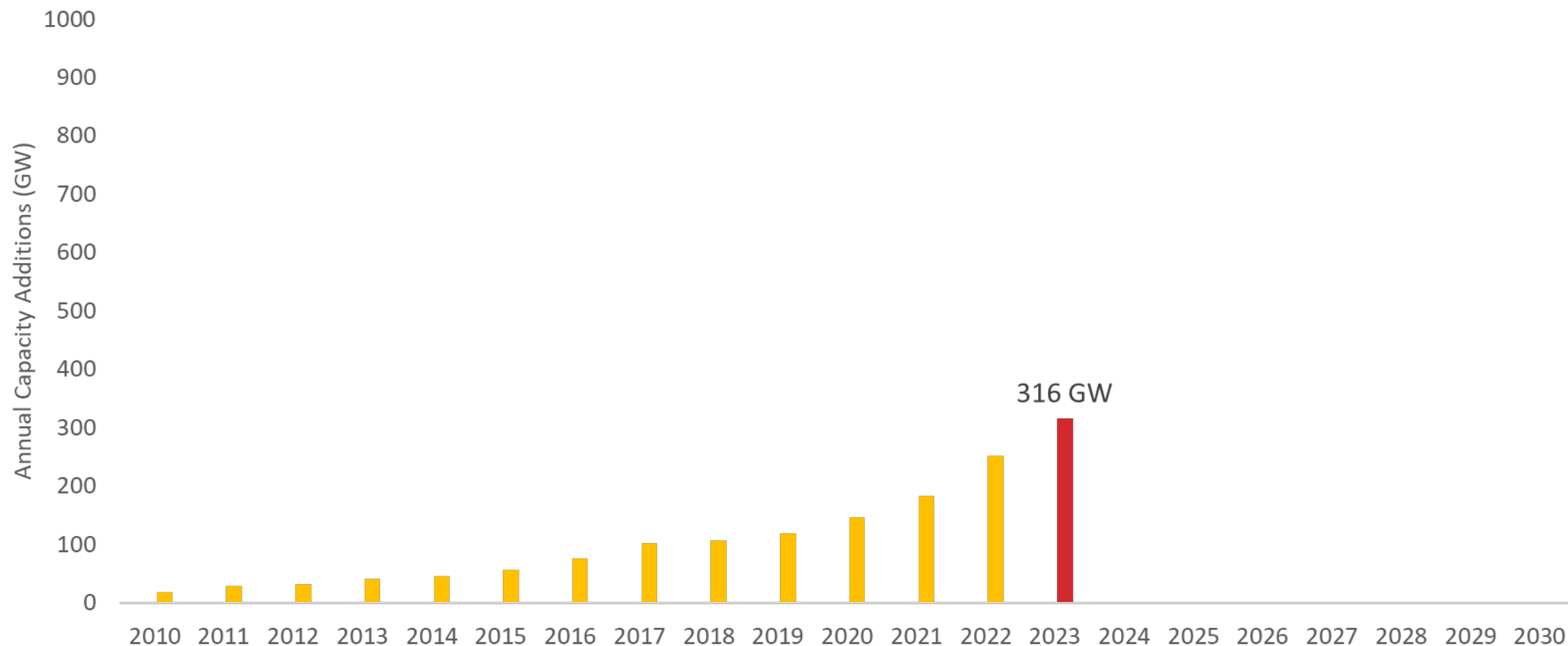
The merit order



The merit order

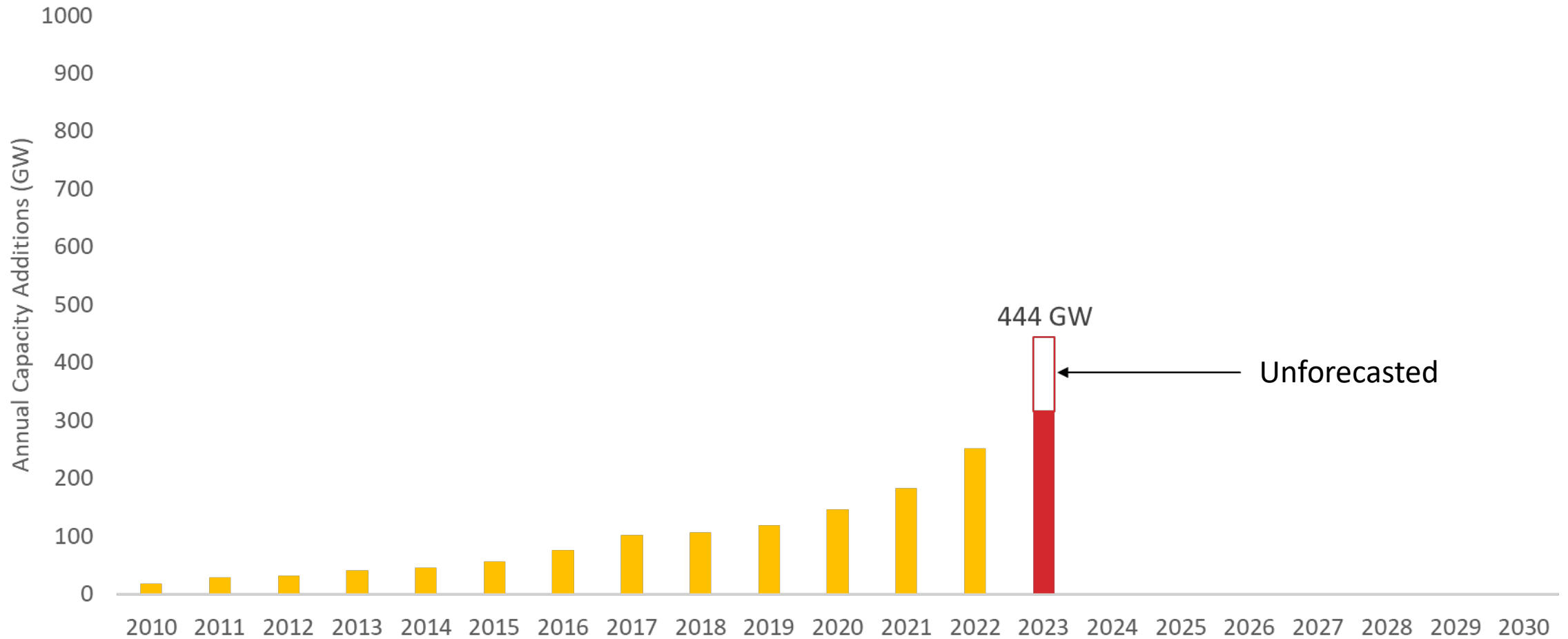


How did the solar forecast for 2023 compare to actuals (globally)?



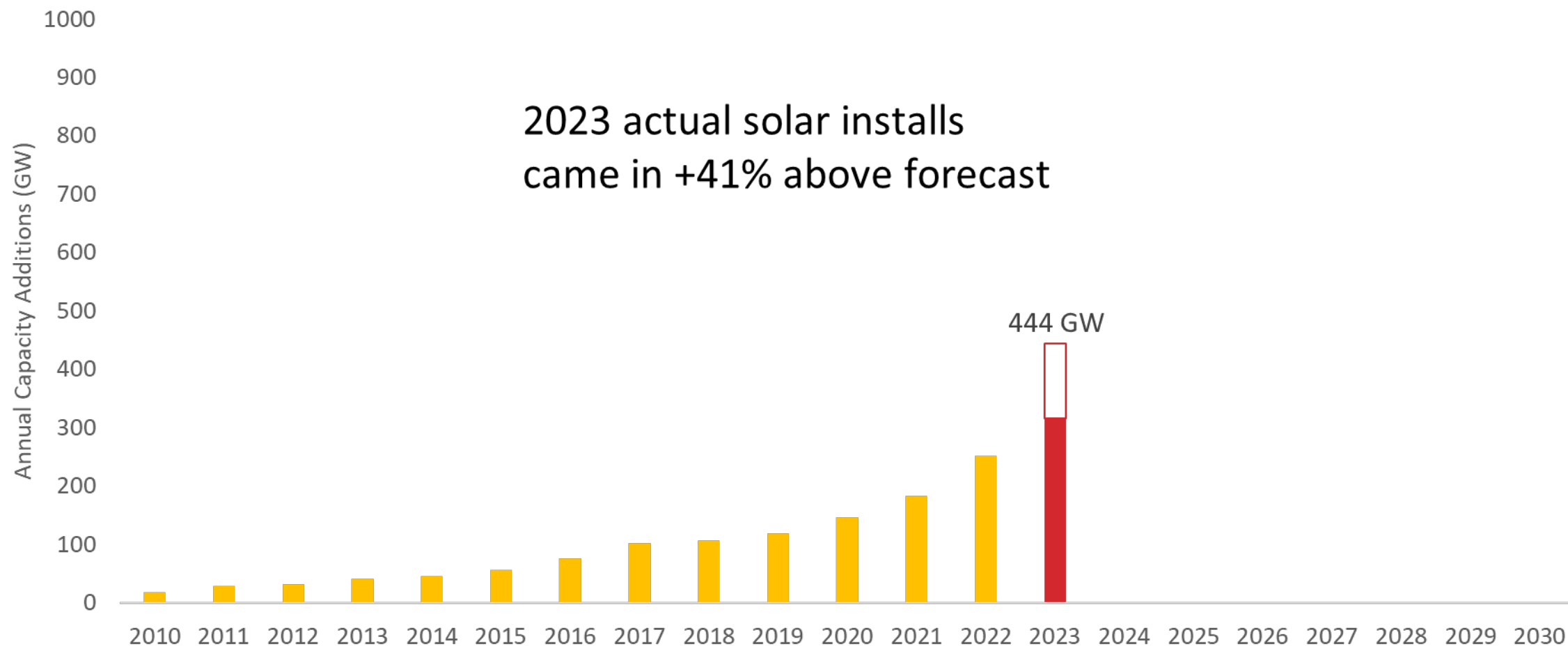
Source: 1Q 2023 Global PV Market Outlook

Actual installations were 130GW higher than forecasted



Source: BNEF 1Q 2023 Global PV Market Outlook; Jenny Chase (BNEF)

Actual installations were 130GW higher than forecasted

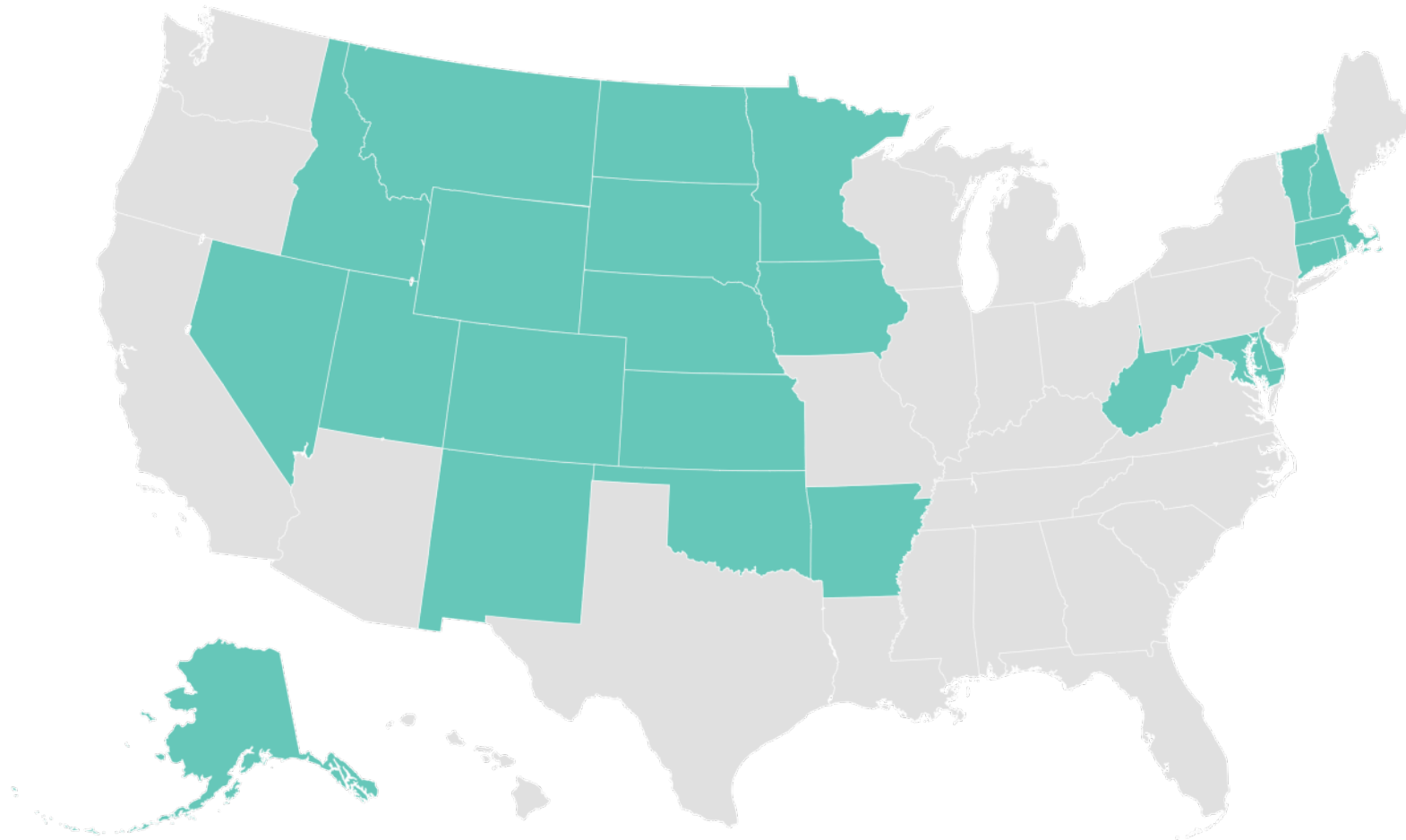


Source: BNEF 1Q 2023 Global PV Market Outlook; Jenny Chase (BNEF)

443 GW is a lot of capacity. And energy.

$$443\text{GW} \times 8760\text{ hrs} \times 23\% \text{ CF} = 892,556 \text{ GWh}$$

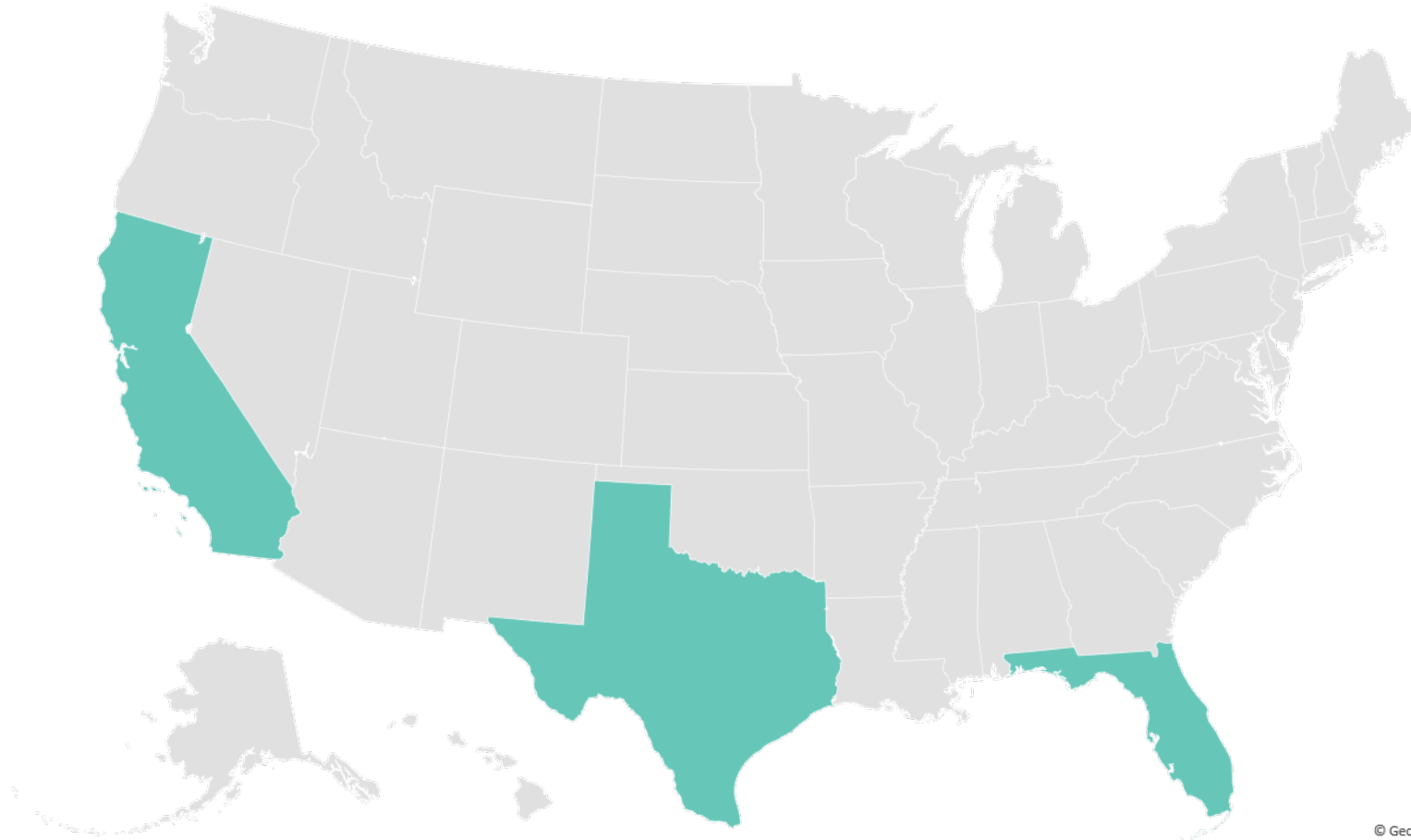
Enough solar was installed in 2023 to satisfy energy (not capacity!) needs of 29 states



443 GW is a lot of capacity. And energy.

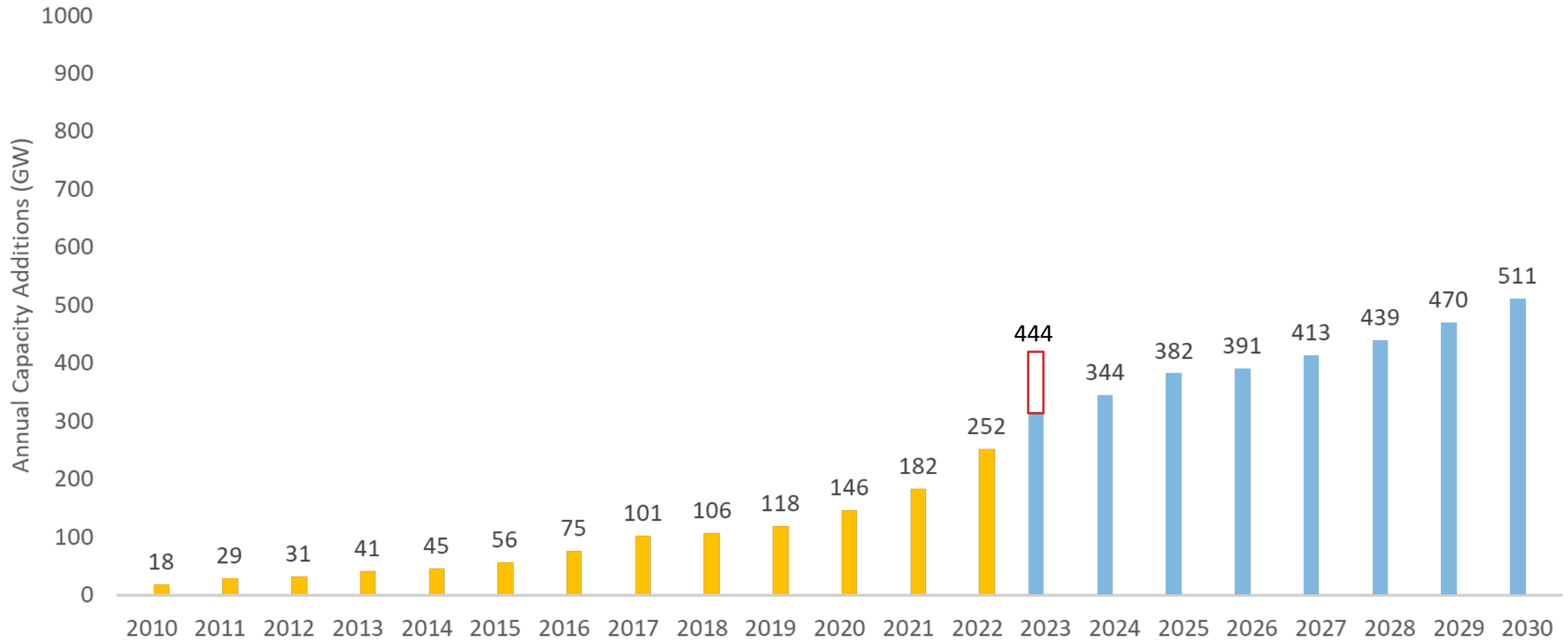
$$443\text{GW} \times 8760\text{ hrs} \times 23\% \text{ CF} = 892,556 \text{ GWh}$$

Enough solar was installed in 2023 to nearly power the 3 largest economies in the US



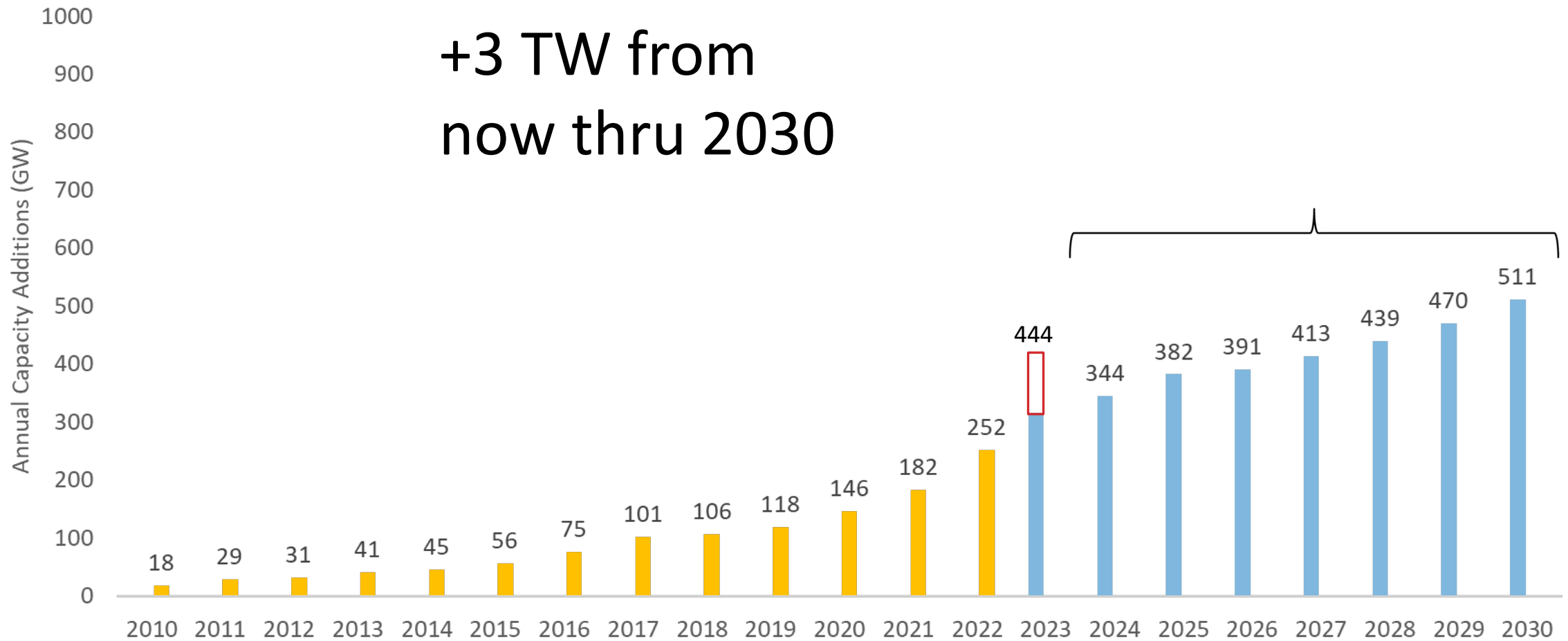
Powered by Bing
© GeoNames, Microsoft, TomTom

Here's the rest of the forecast (globally).



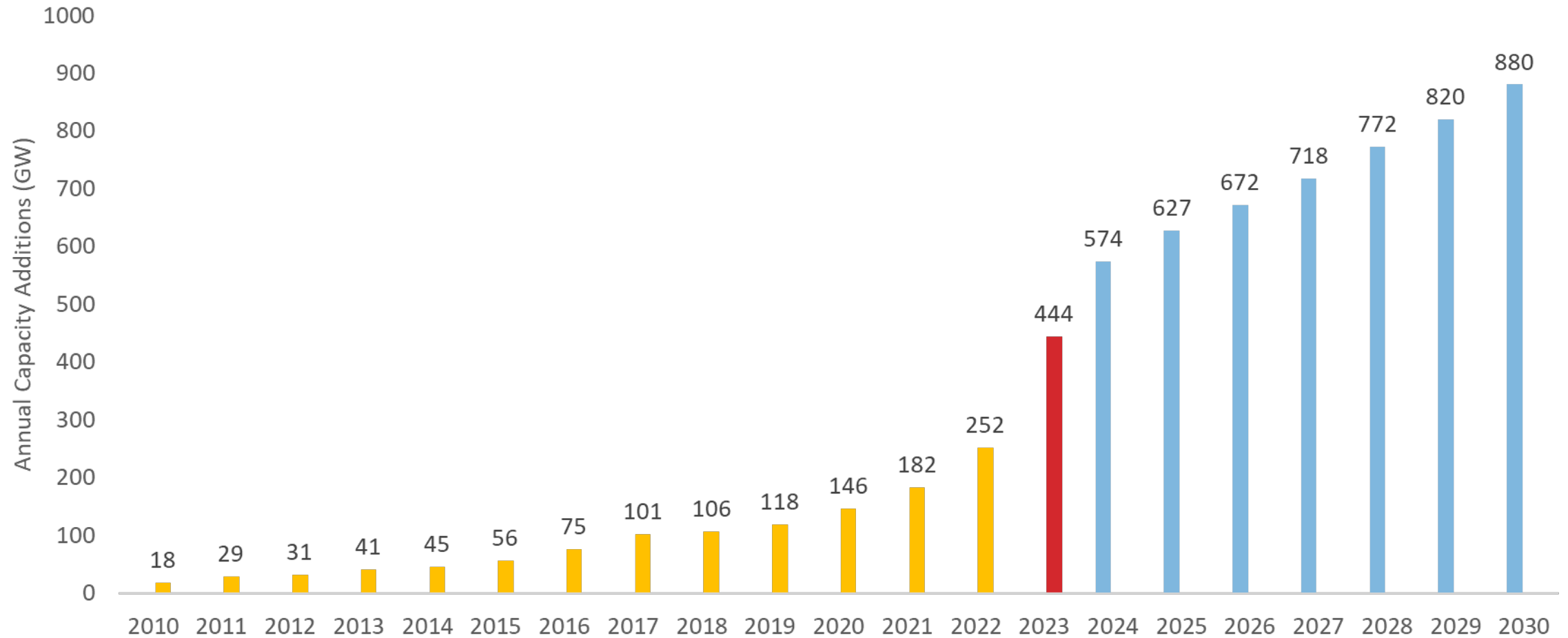
Source: BNEF 1Q 2023 Global PV Market Outlook; Jenny Chase (BNEF)

Here's the 2023 forecast (globally).



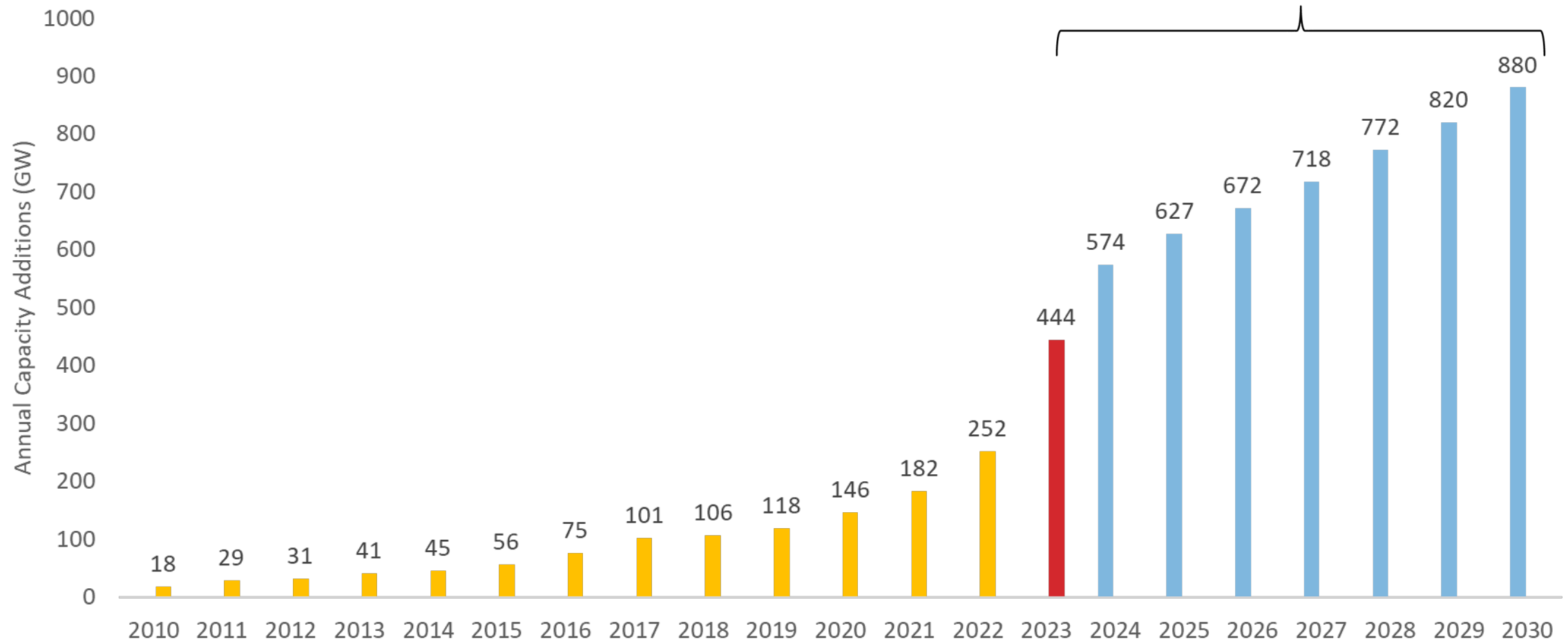
Source: BNEF 1Q 2023 Global PV Market Outlook; Jenny Chase (BNEF)

Now let's compare it to 2024 (globally).



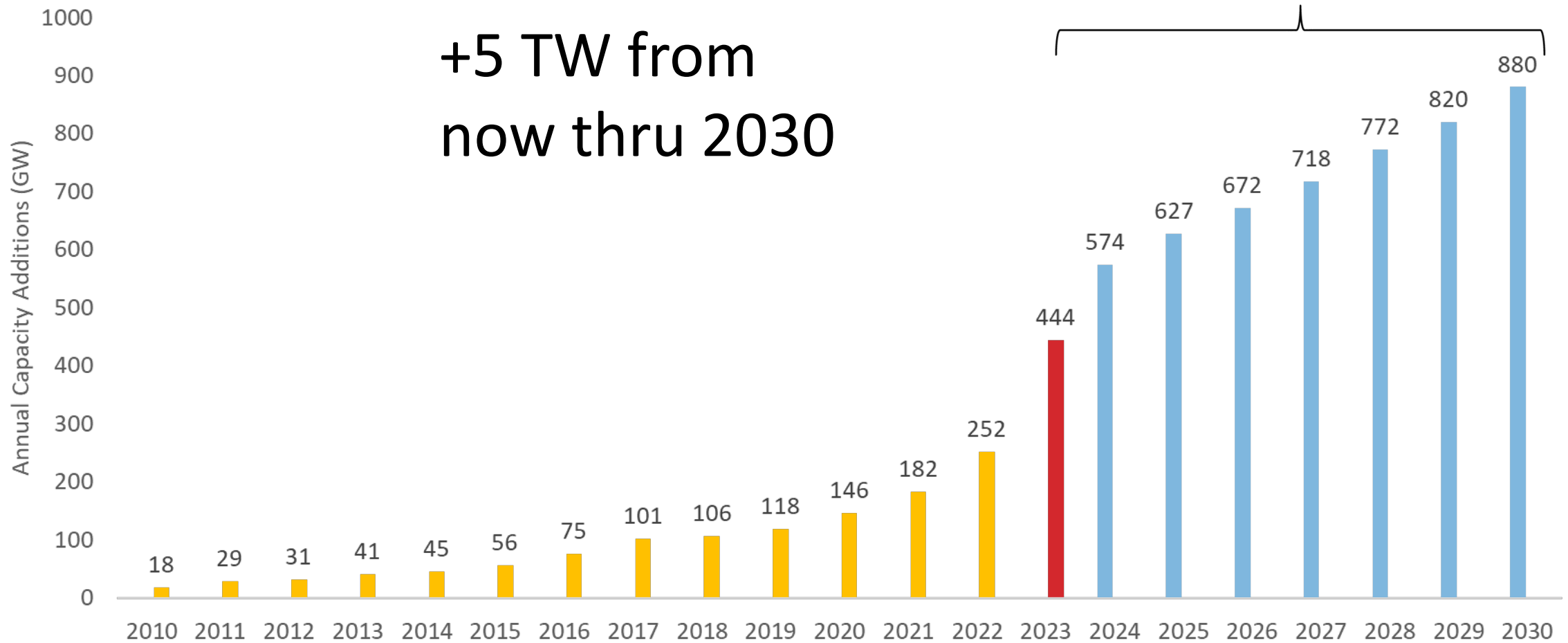
Source: BNEF 1Q 2024 Global PV Market Outlook

Mind boggling annual solar capacity additions (globally)



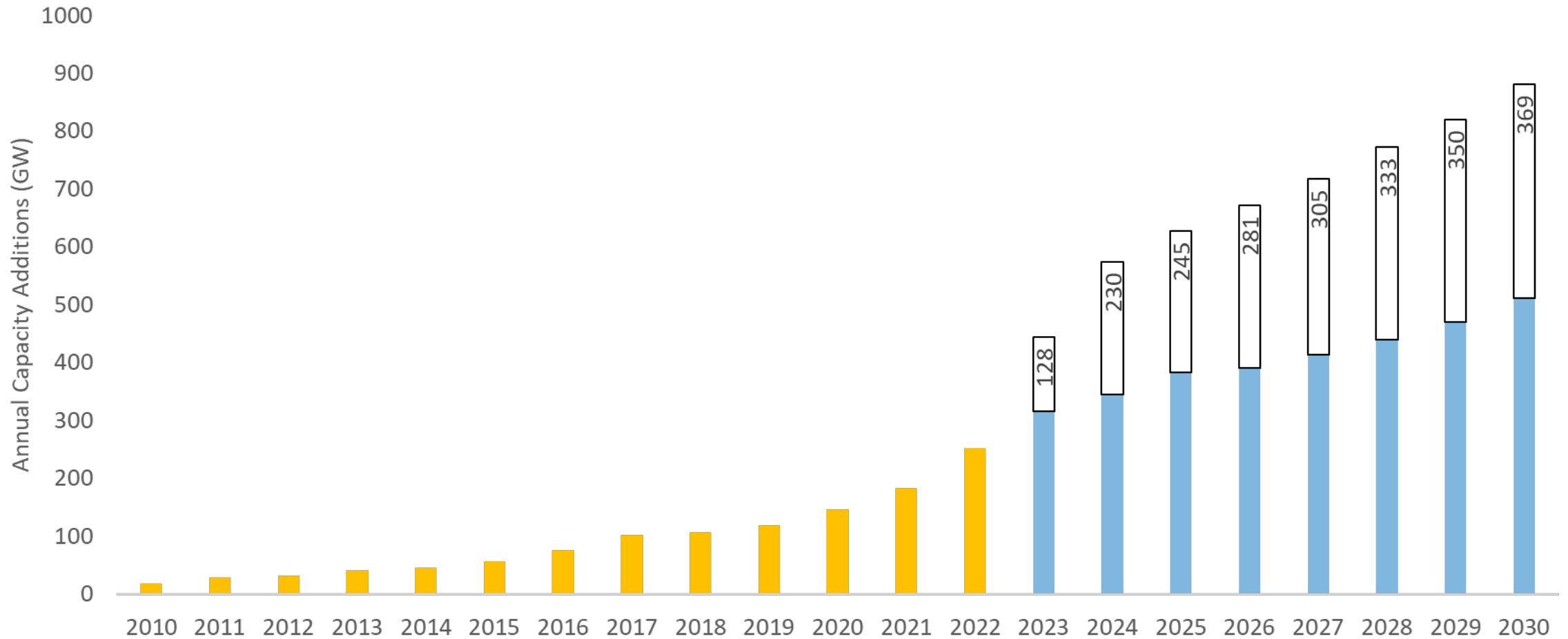
Source: BNEF 1Q 2024 Global PV Market Outlook

Mind boggling annual solar capacity additions (globally)



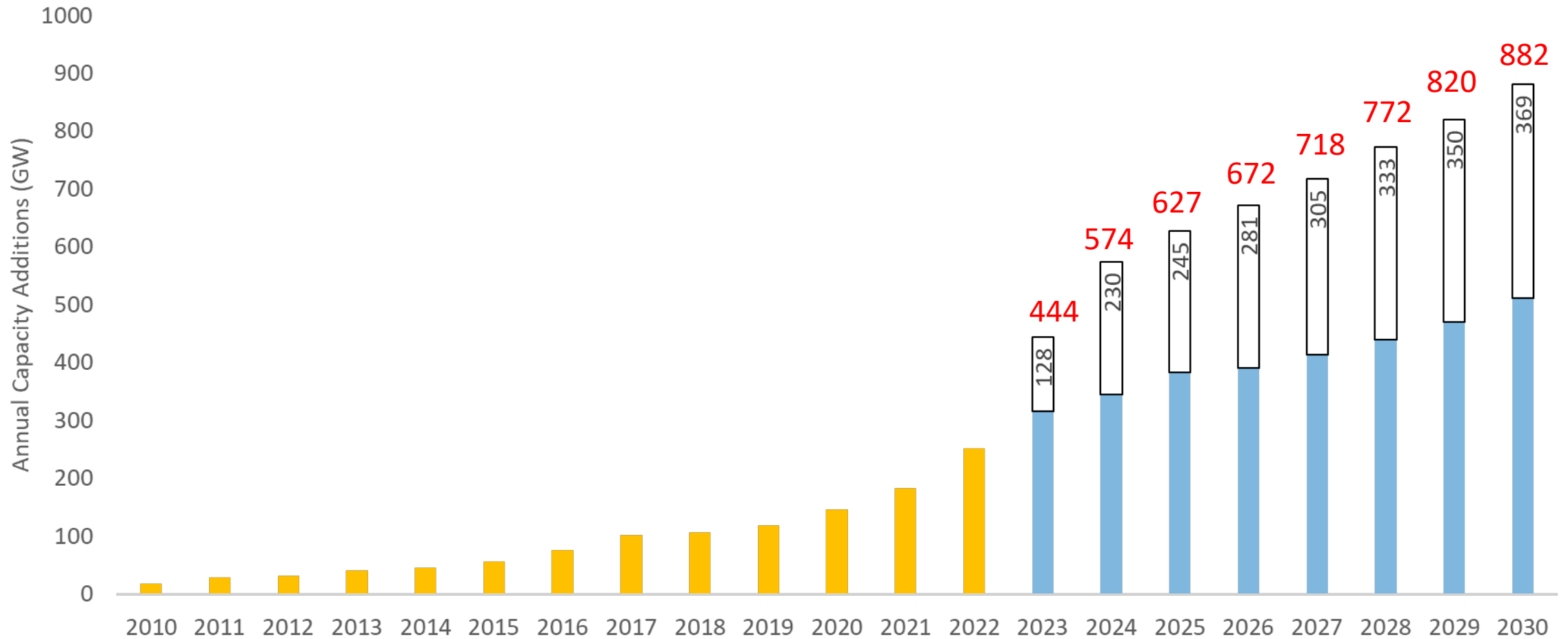
Source: BNEF 1Q 2024 Global PV Market Outlook

What changed in a year? A lot!

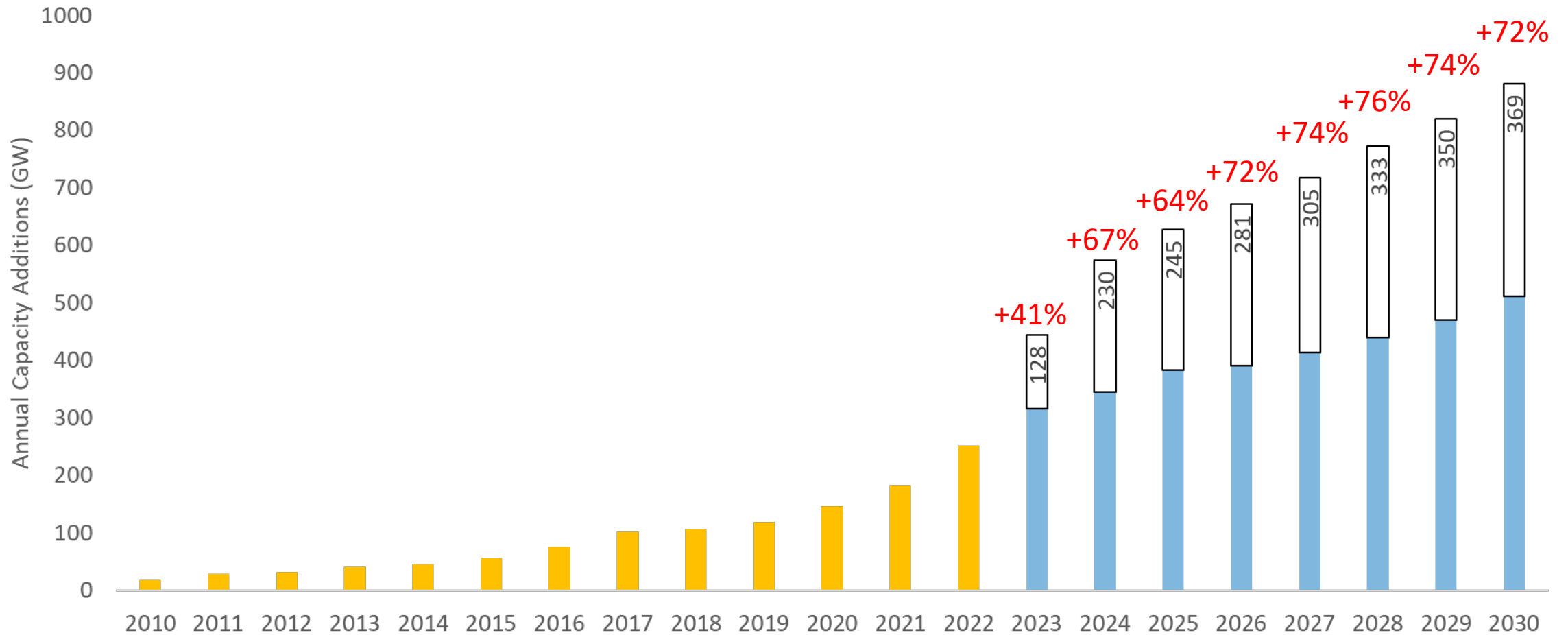


Source: BNEF 1Q 2024 Global PV Market Outlook

What changed in a year? A lot!



What changed in a year? A lot!

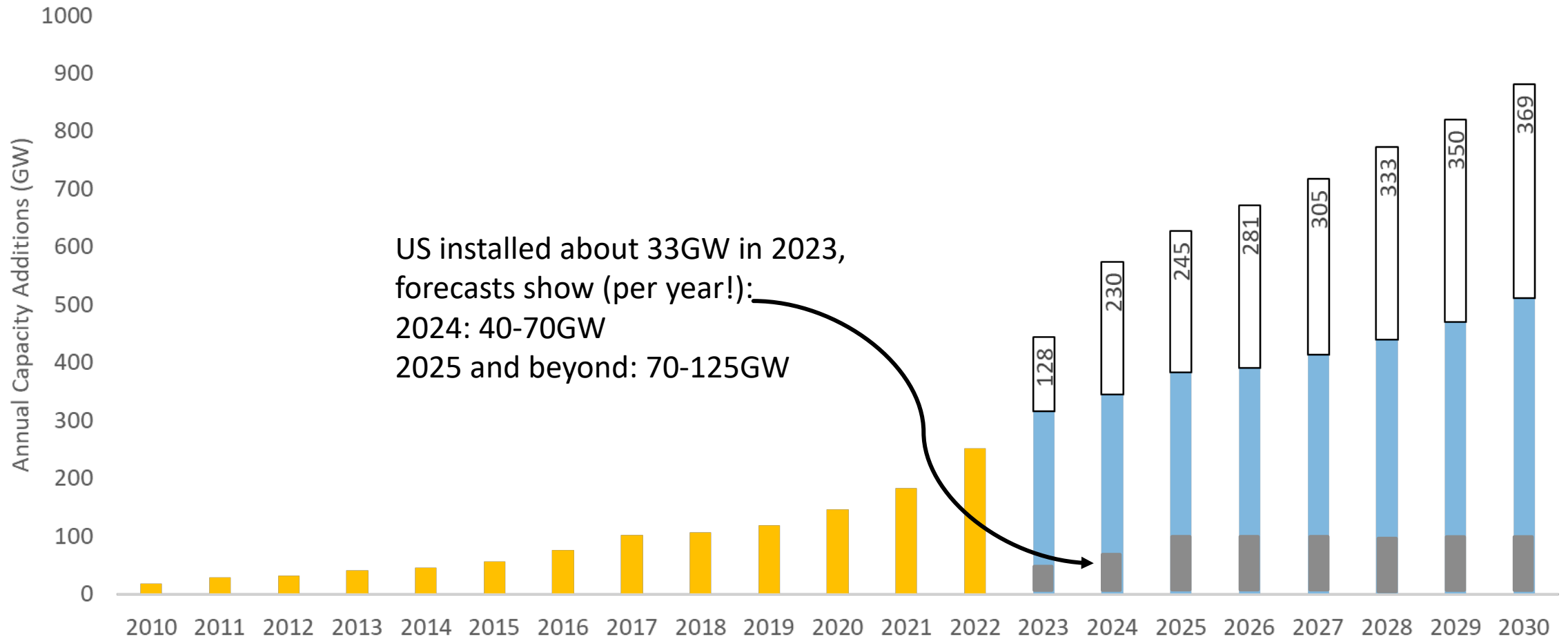


65% upward revision to the forecast!

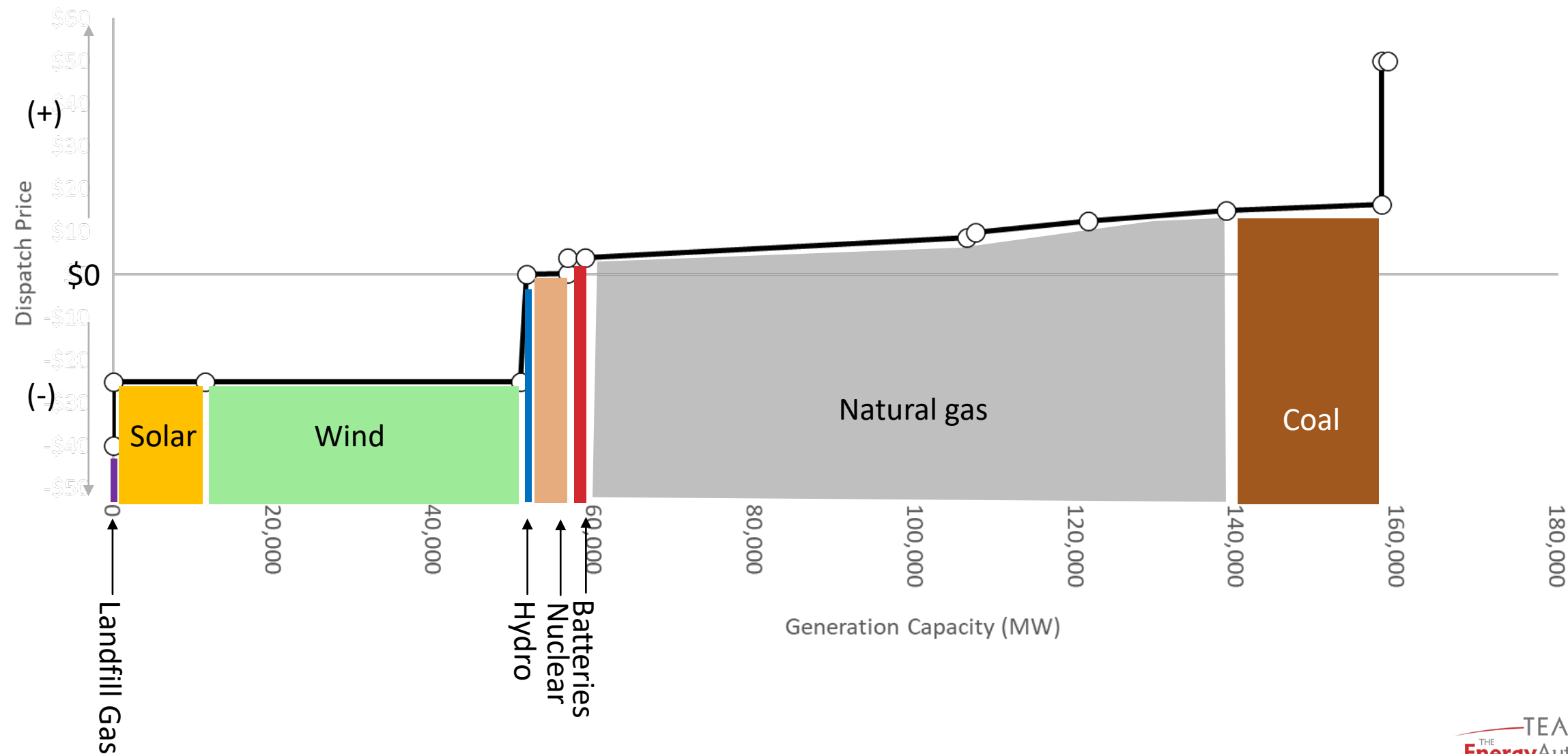
Overall +2 TW revision.
In 1 year!



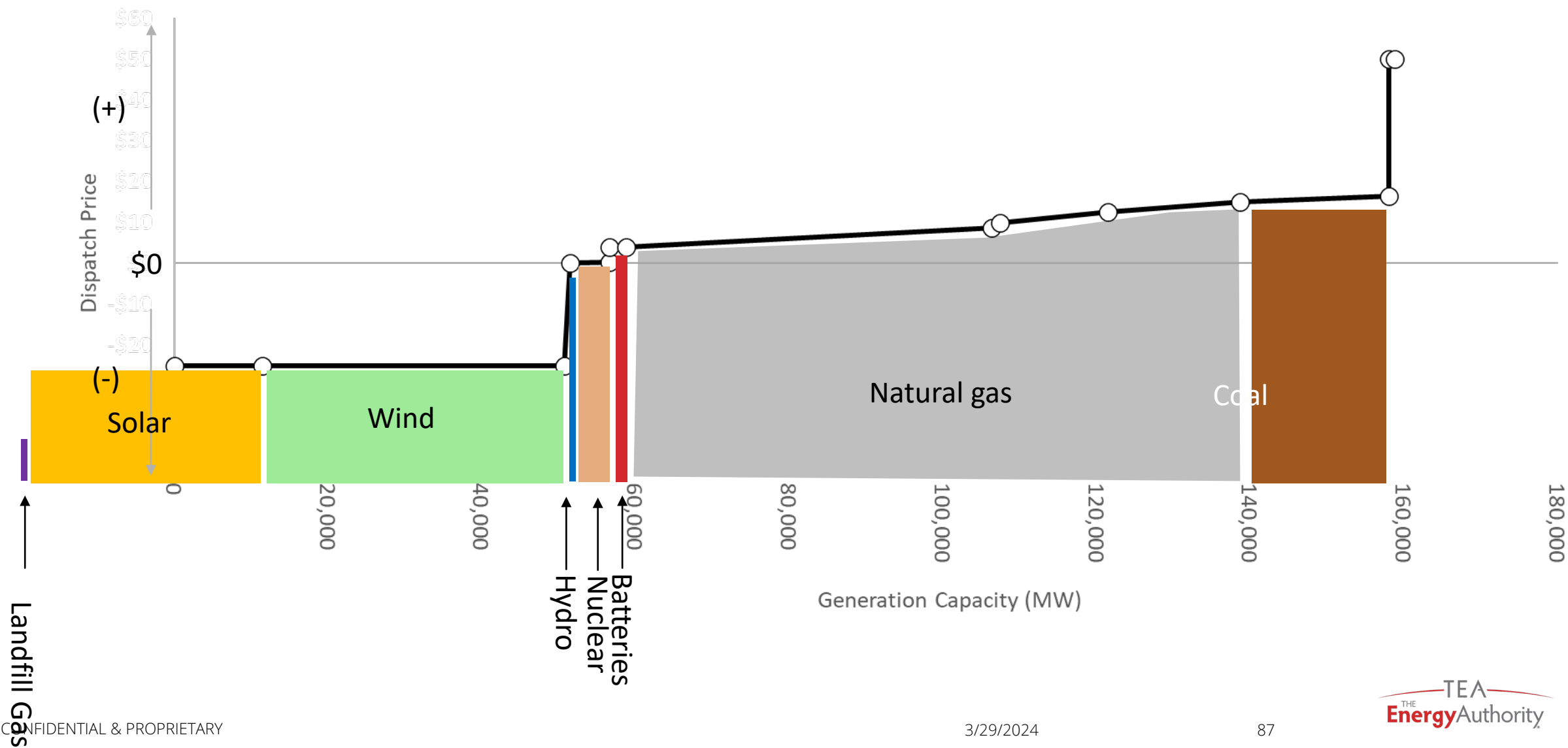
40% upward revision to the forecast!



The merit order

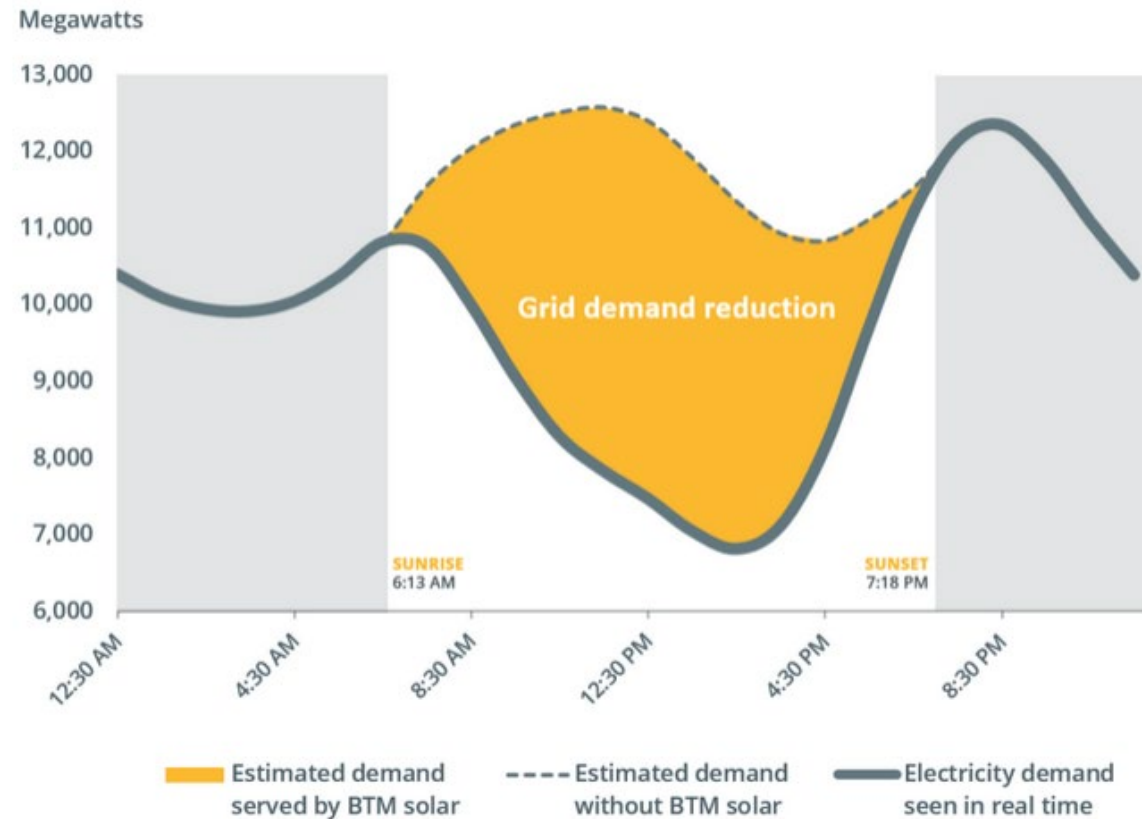


The merit order



Solar oversupply can cause problems

Estimated impact of behind-the-meter solar on April 9, 2023



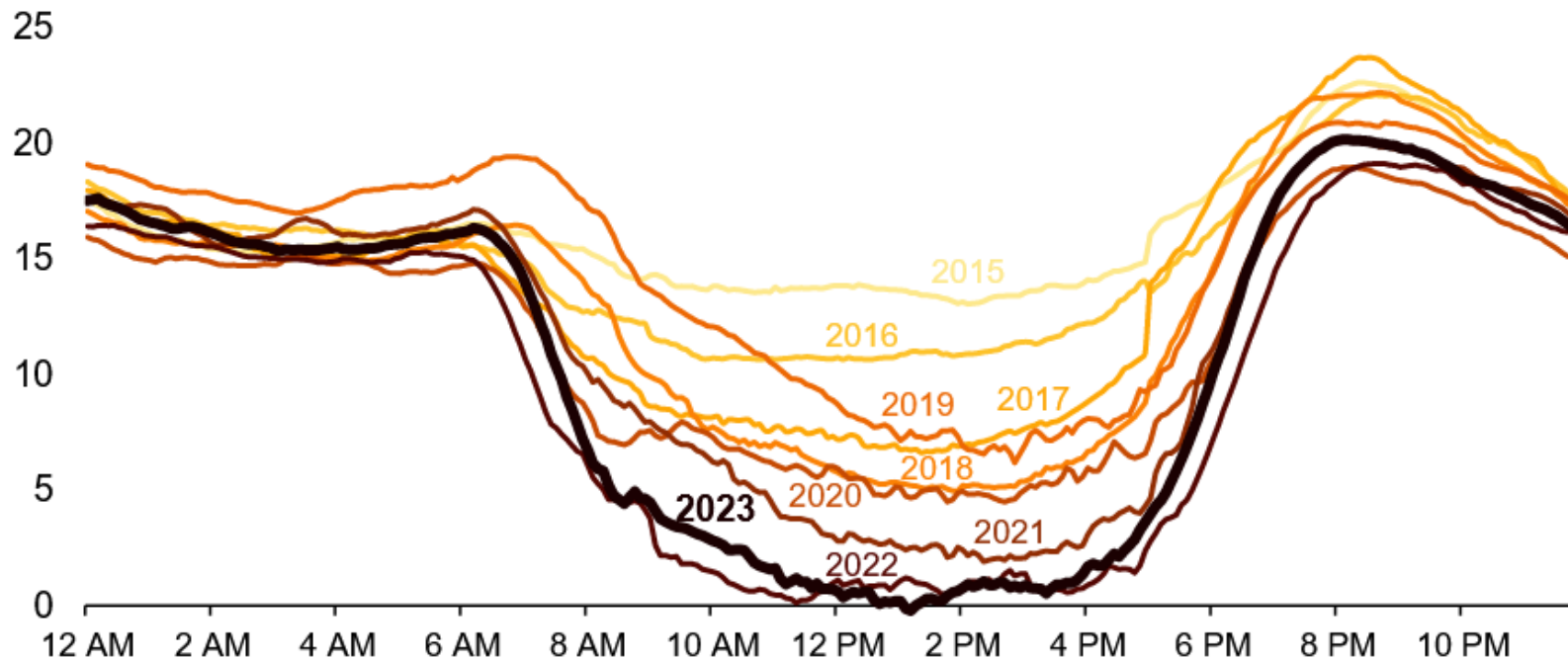
Source: <https://isonewswire.com/2024/02/28/duck-curve-days-becoming-more-frequent-as-solar-power-spreads/>

And it's worse in California

As solar capacity grows, duck curves are getting deeper in California

California's duck curve is getting deeper

CAISO lowest net load day each spring (March–May, 2015–2023), gigawatts



Data source: [California Independent System Operator \(CAISO\)](https://www.eia.gov/todayinenergy/detail.php?id=56880)

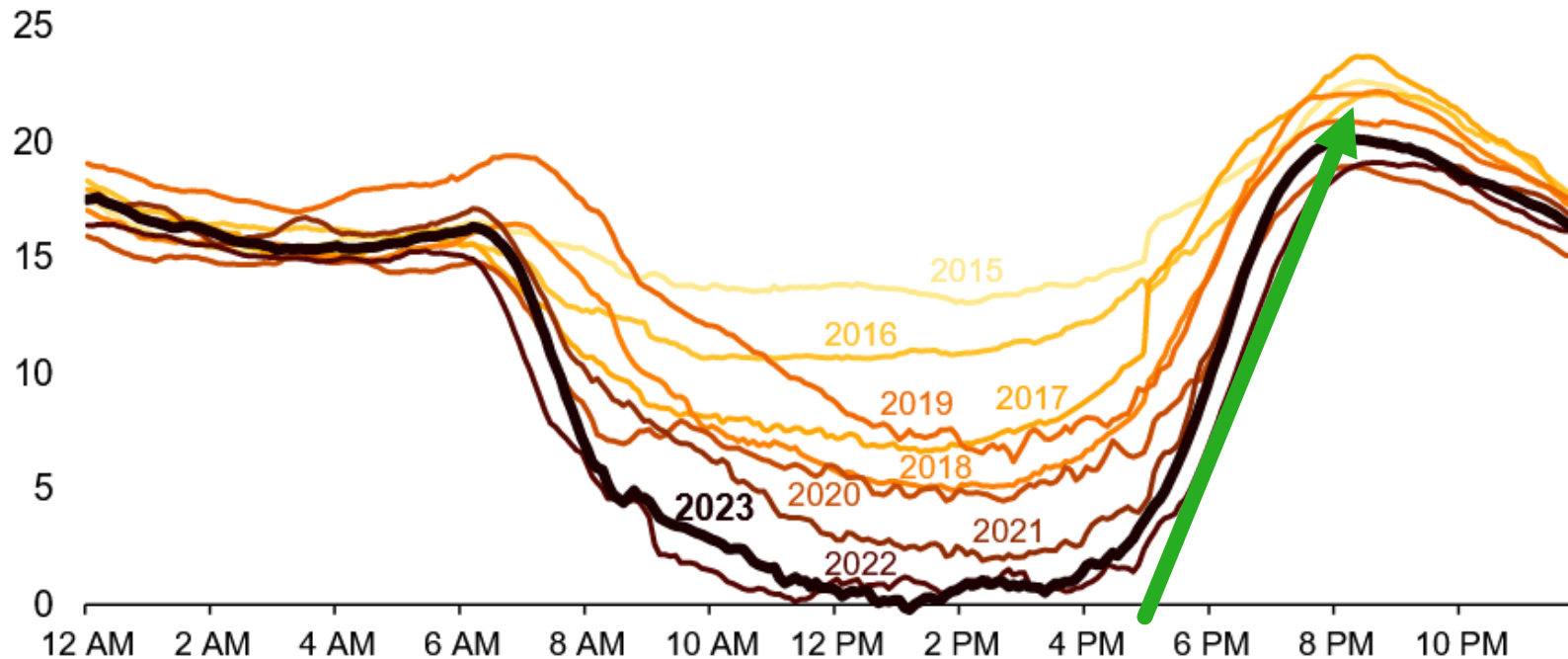
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Source: <https://www.eia.gov/todayinenergy/detail.php?id=56880>

Batteries to the rescue

370GW

Projected 2023-30 US solar build, nearly three times the total solar capacity installed as of 2022.

128GW

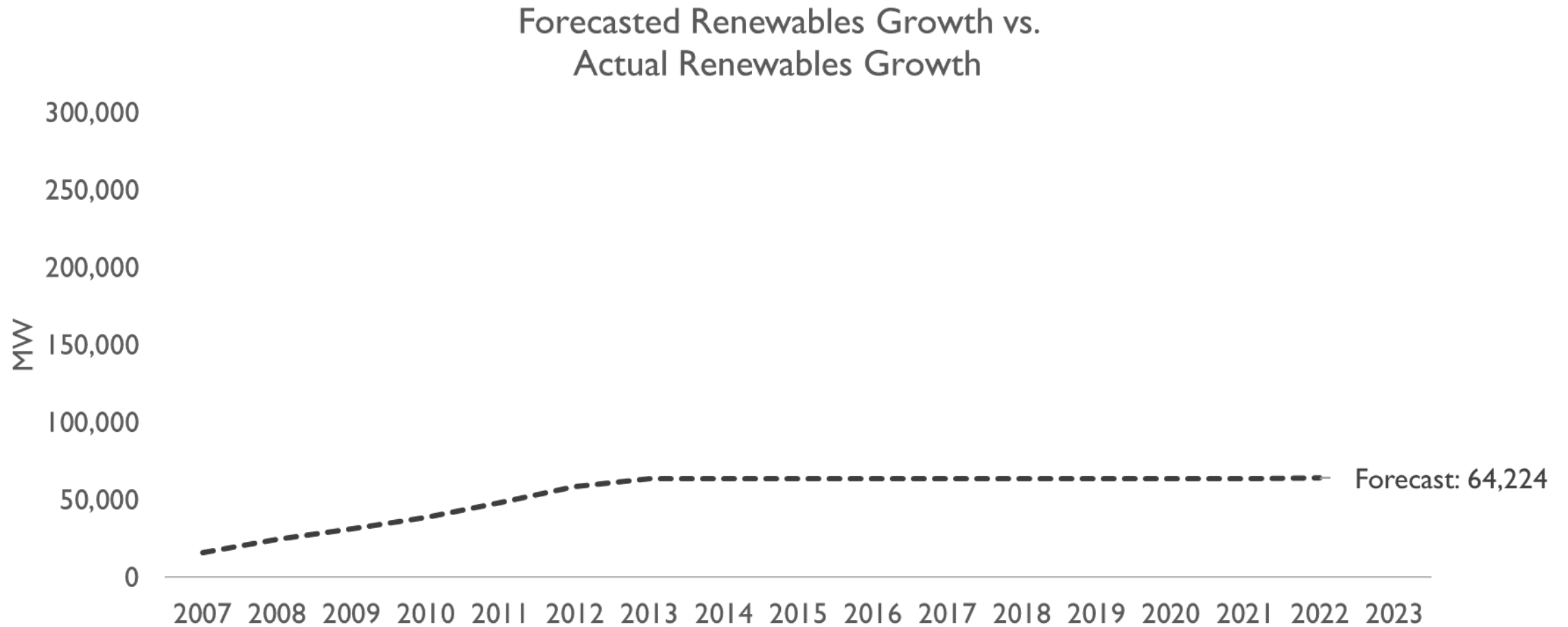
Projected 2023-2030 US wind build, nearly doubling total wind capacity installed as of 2022.

121GW

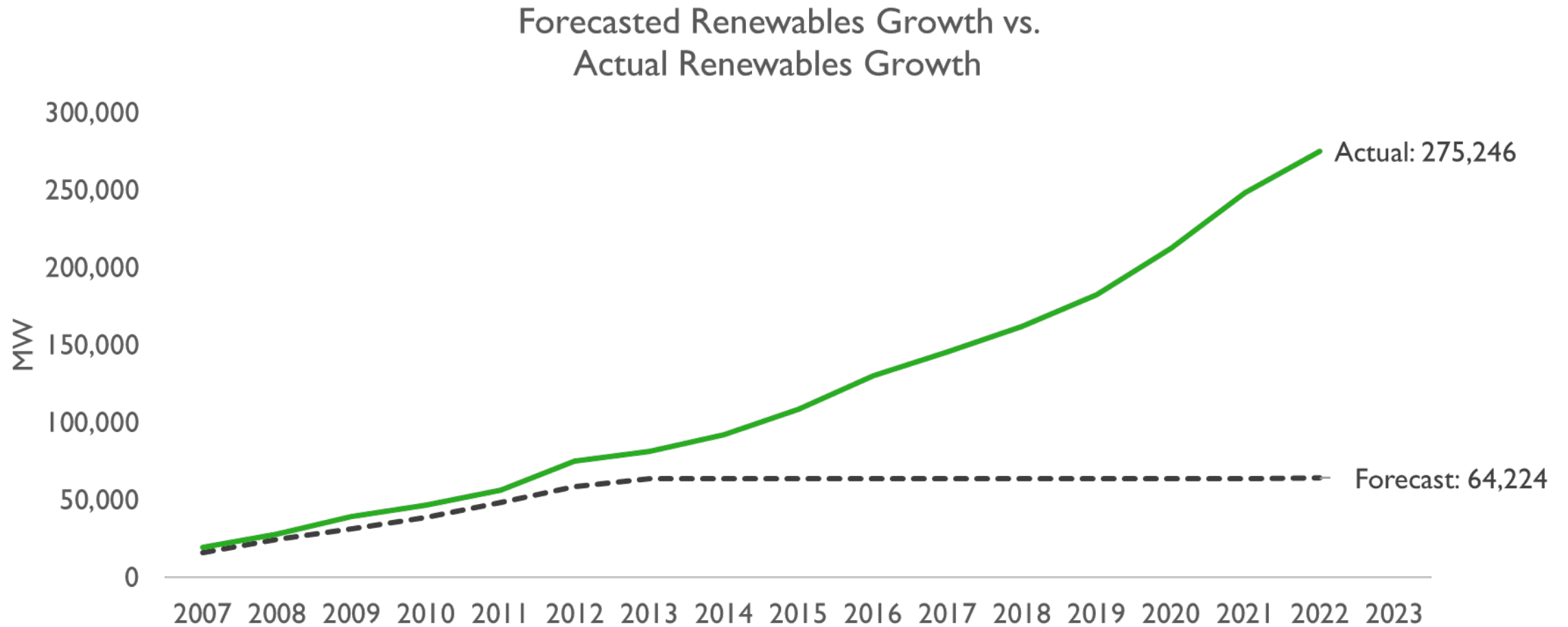
Projected 2023-30 US battery storage build, almost 10 times the total storage capacity installed as of 2022.

WHY ARE RENEWABLES DOMINATING NEW RESOURCE BUILDS?

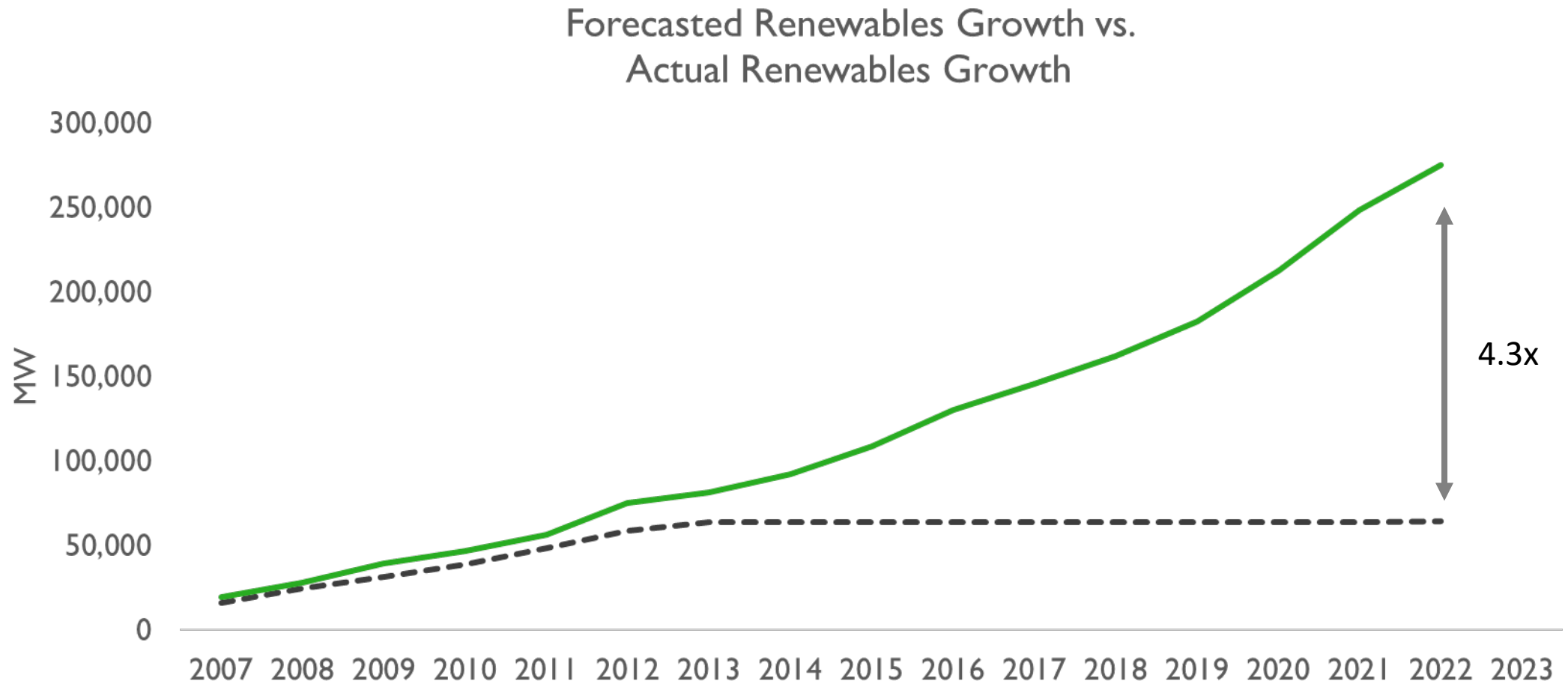
Nobody really saw this coming: 2010 forecast vs. reality



Nobody really saw this coming: 2010 forecast vs. reality



Nobody really saw this coming: 2010 forecast vs. reality








Why are most new resource builds renewables?

1. Politics
2. Economics

Renewable portfolio standards drive renewables procurement



Installed renewable resources *(as of 02/01/2024)*

		Megawatts
	Solar	18,517
	Wind	8,358
	Geothermal	1,610
	Small hydro	1,180
	Biofuels	778
TOTAL		30,443



Installed battery capacity⁴
7,261 MW
As of 02/07/24; subject to change.

But Texas, without renewable mandates is still crushing California



Fact Sheet

February 2024

37,725 MW

of installed wind capacity as of July 2023, the most of any state in the nation

18,364 MW

of utility-scale installed solar capacity as of September 2023






4,048 MW

of installed battery storage as of September 2023



California ISO

Installed renewable resources *(as of 02/01/2024)*

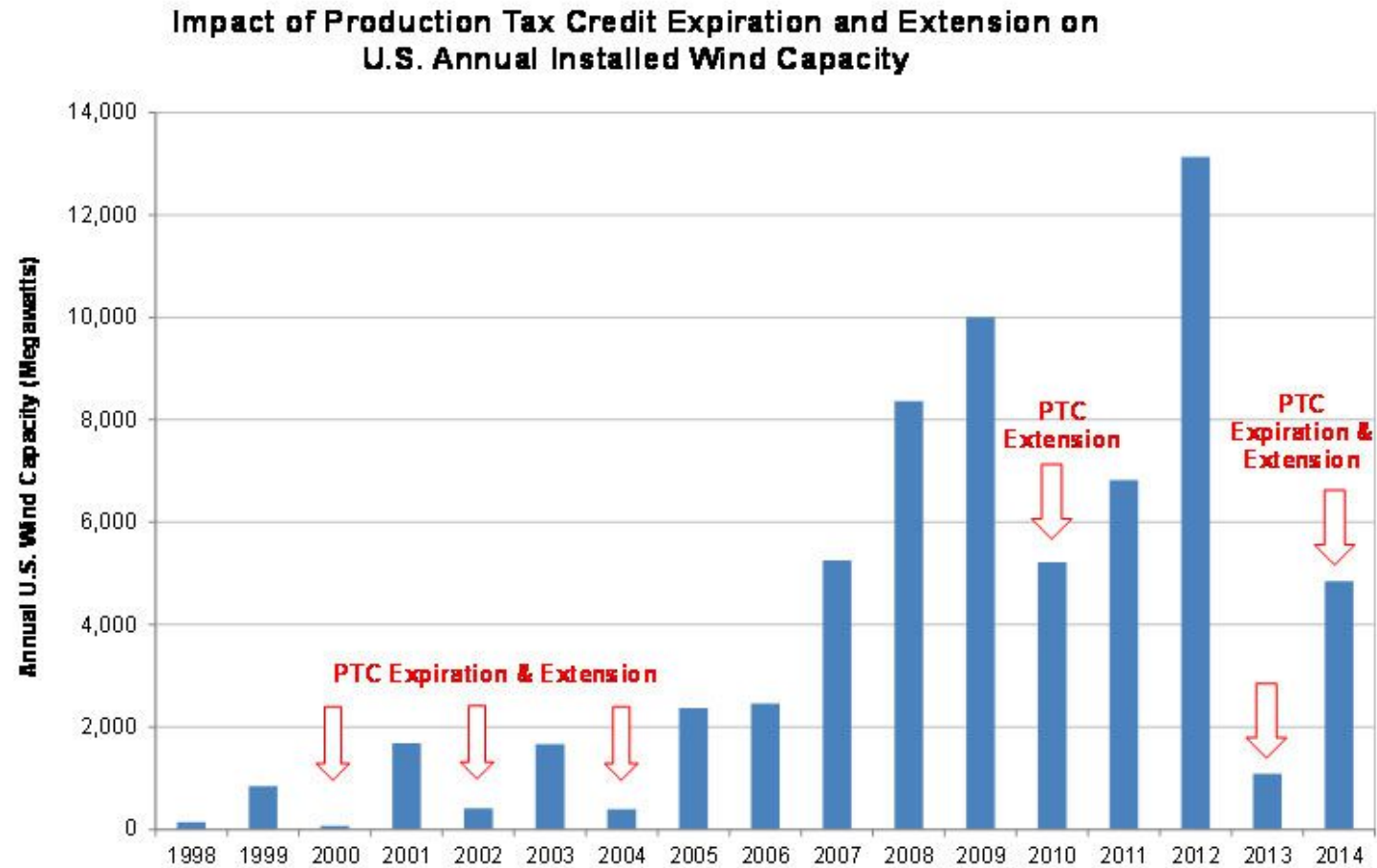
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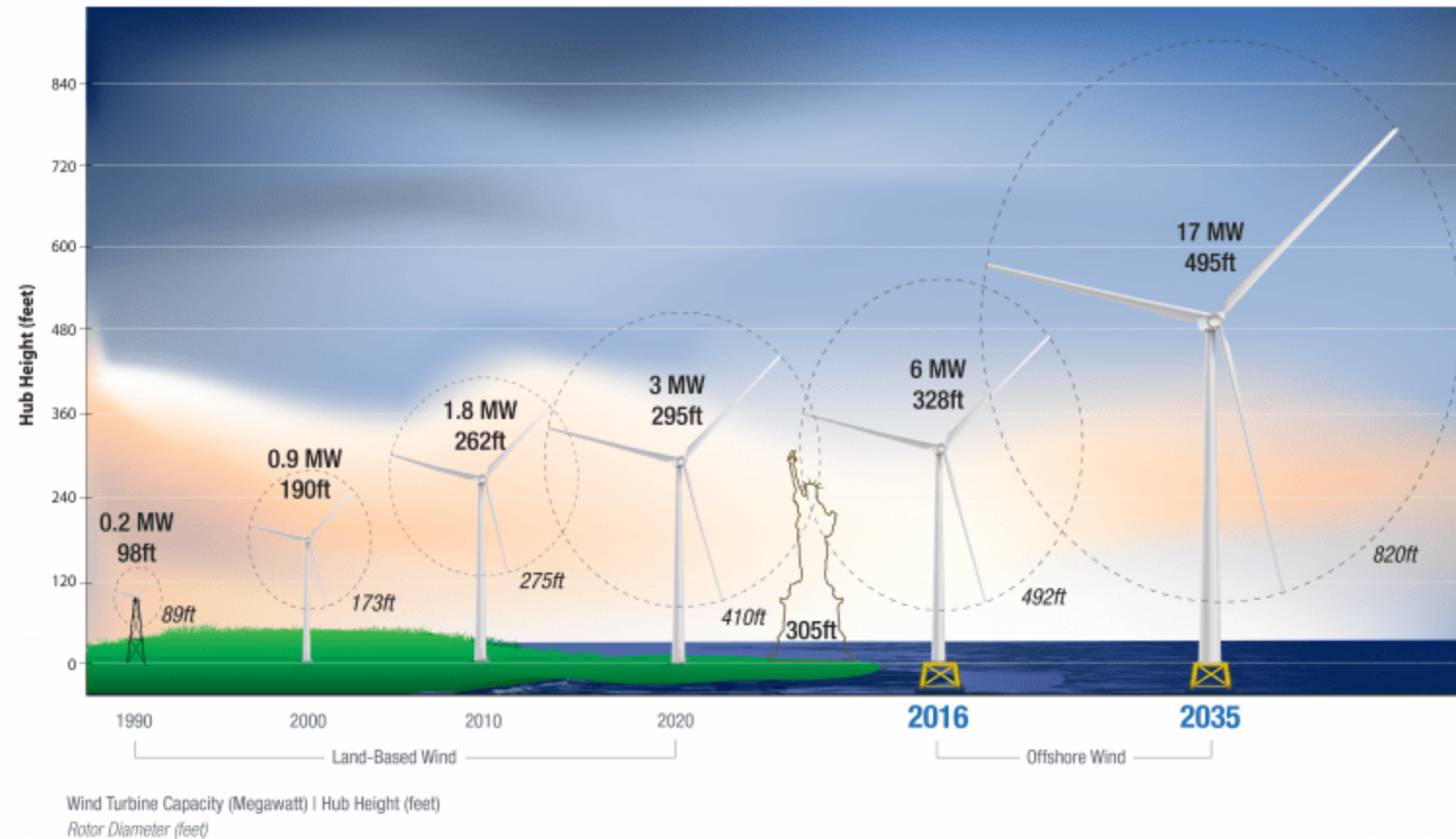
As of 02/07/24; subject to change.

Economics of renewables part 1: subsidies



Source: Union of Concerned Scientists, Vox "How big a deal was Congress extending the renewable energy tax credits? A very, very big deal." 3/29/2024

Economics of renewables part 2: technology

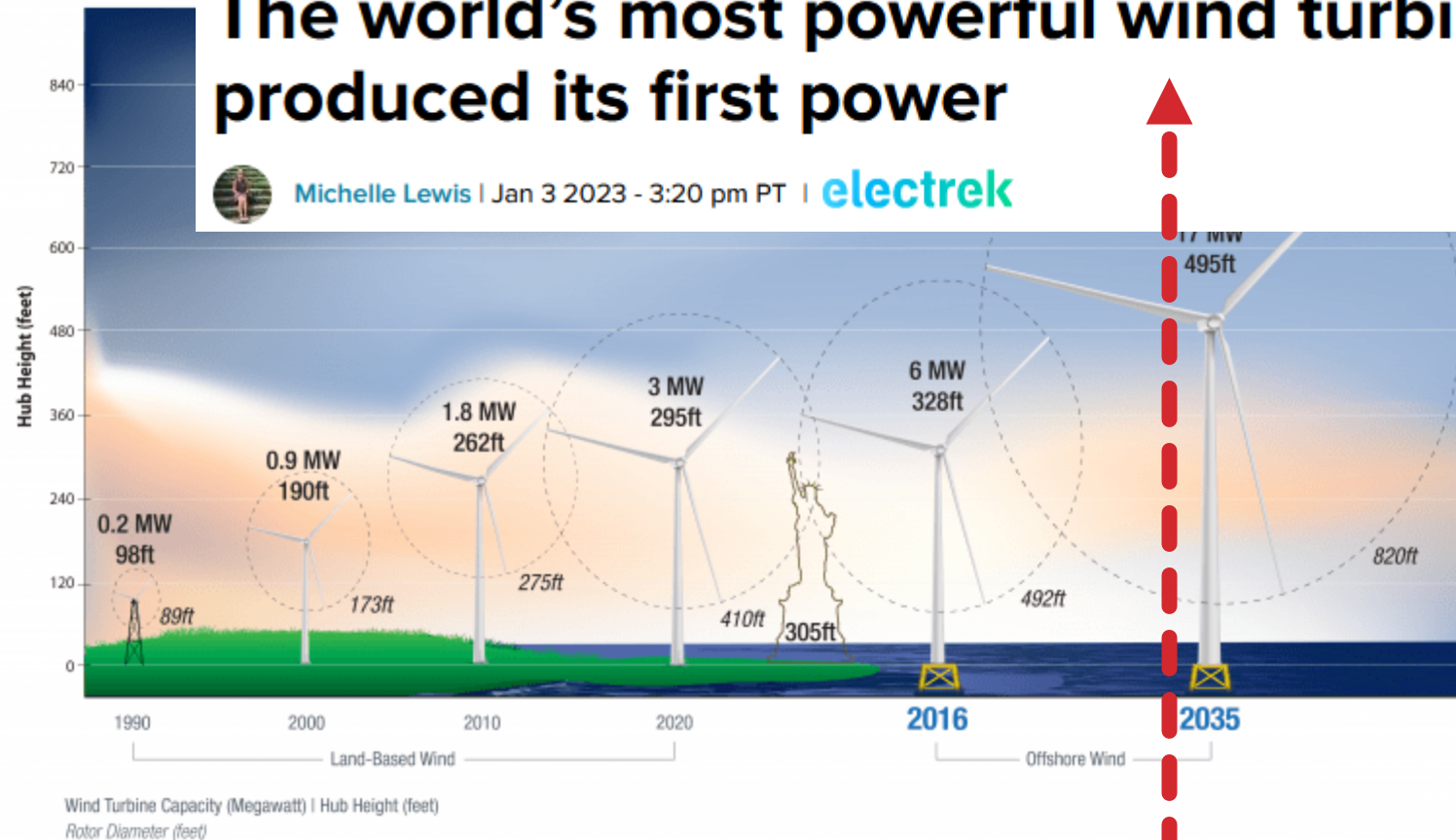


Bigger is better

The world's most powerful wind turbine has produced its first power

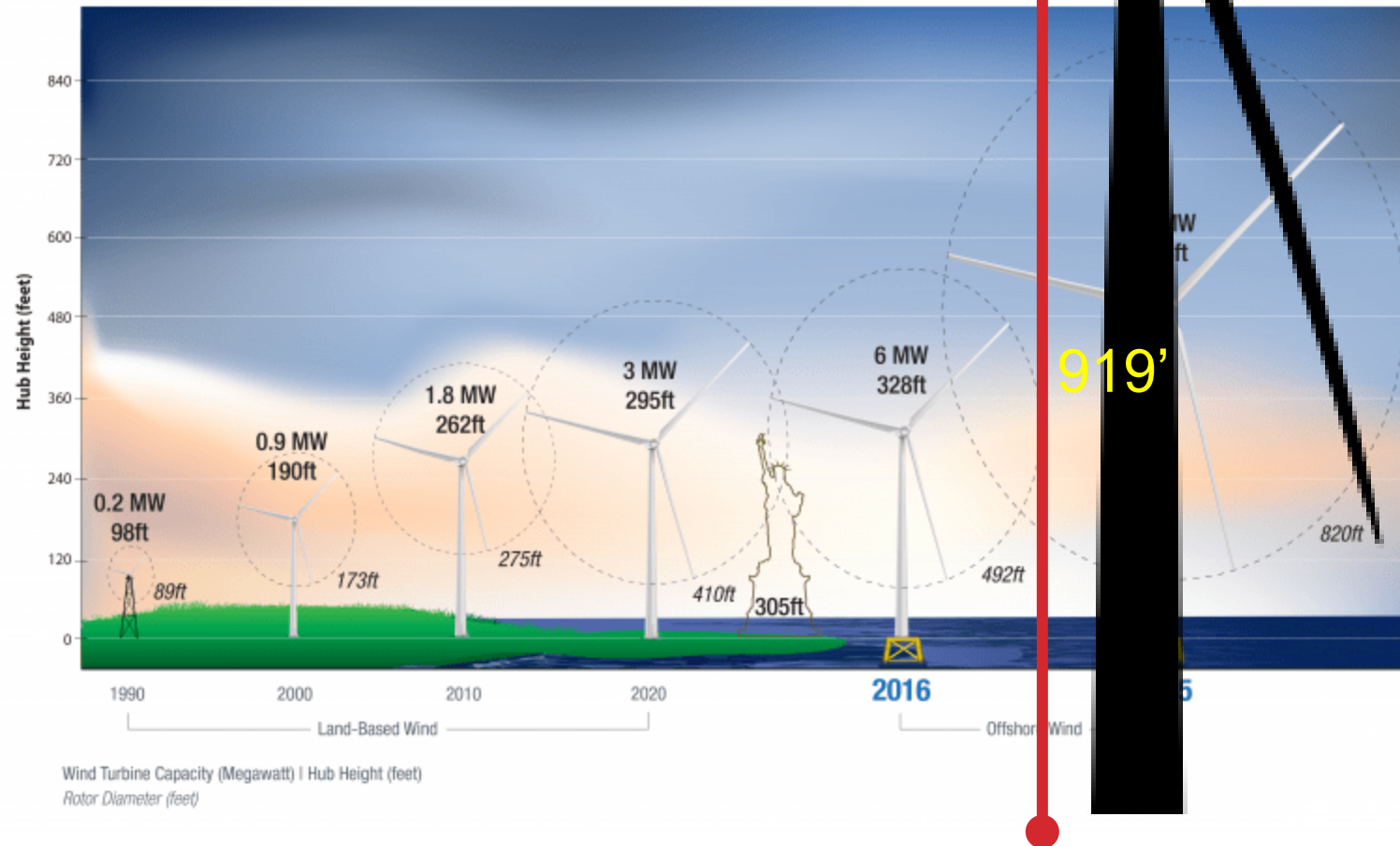


Michelle Lewis | Jan 3 2023 - 3:20 pm PT | **electrek**

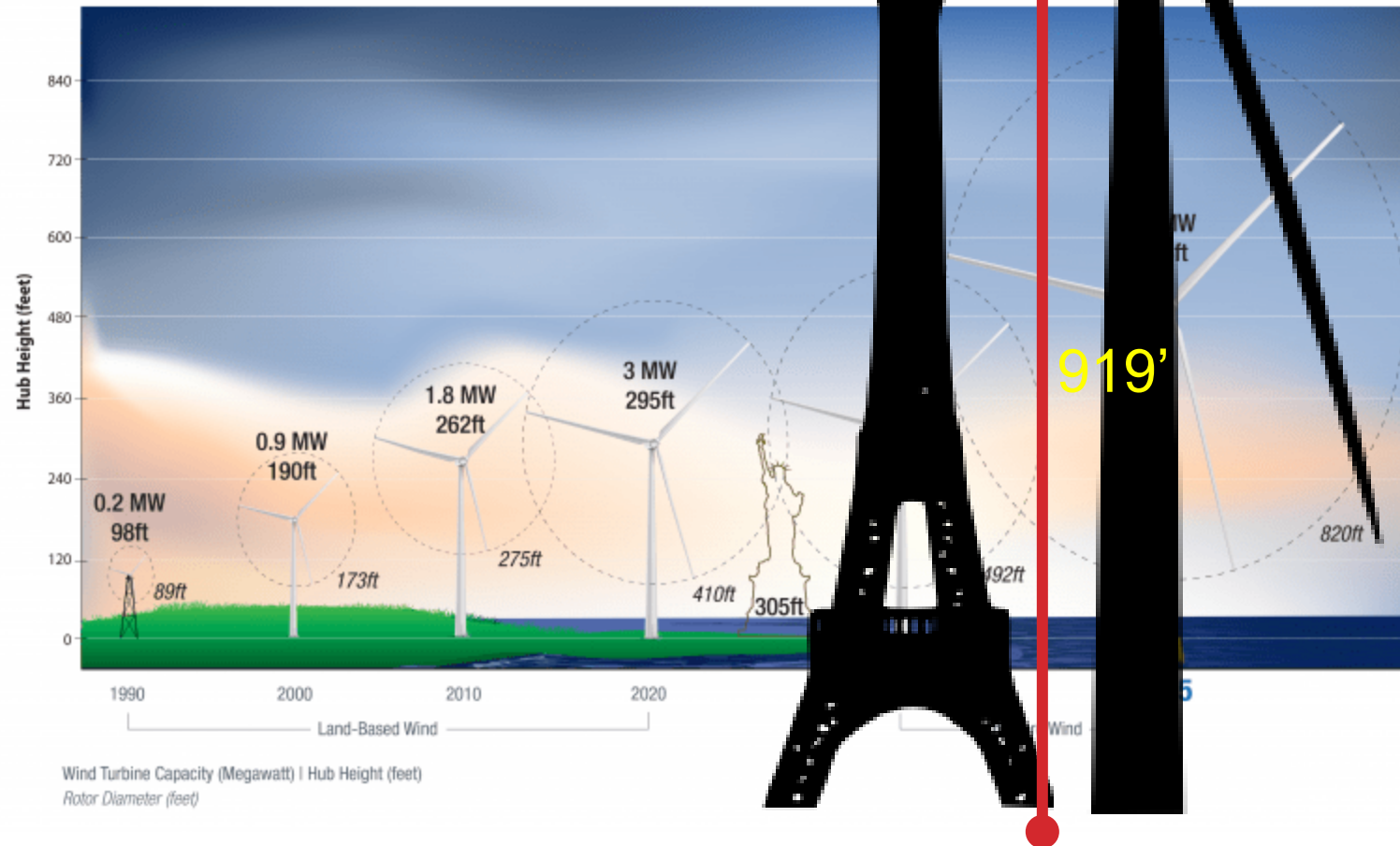


2023

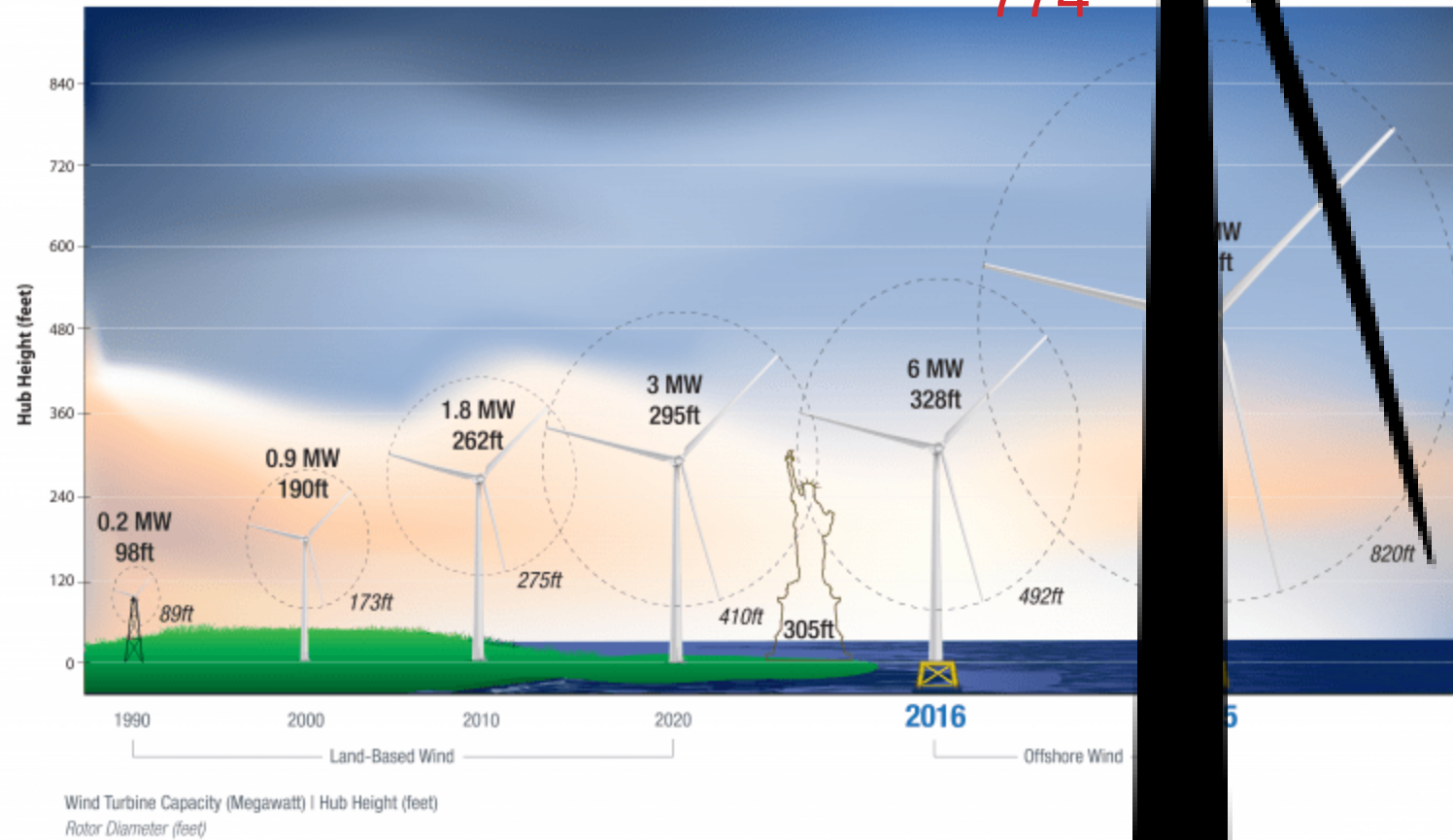
Bigger is better



Bigger is better

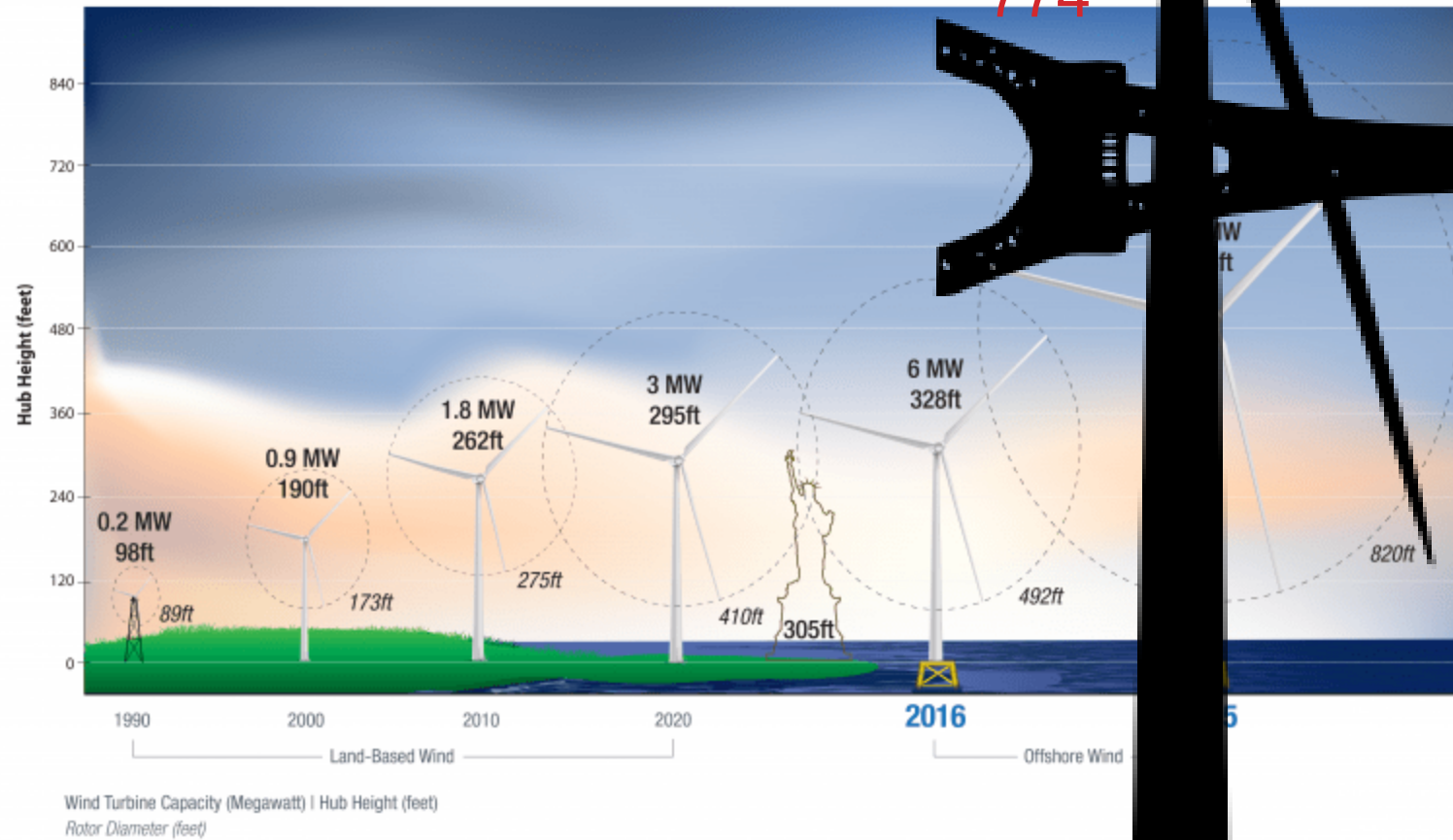


Bigger is better



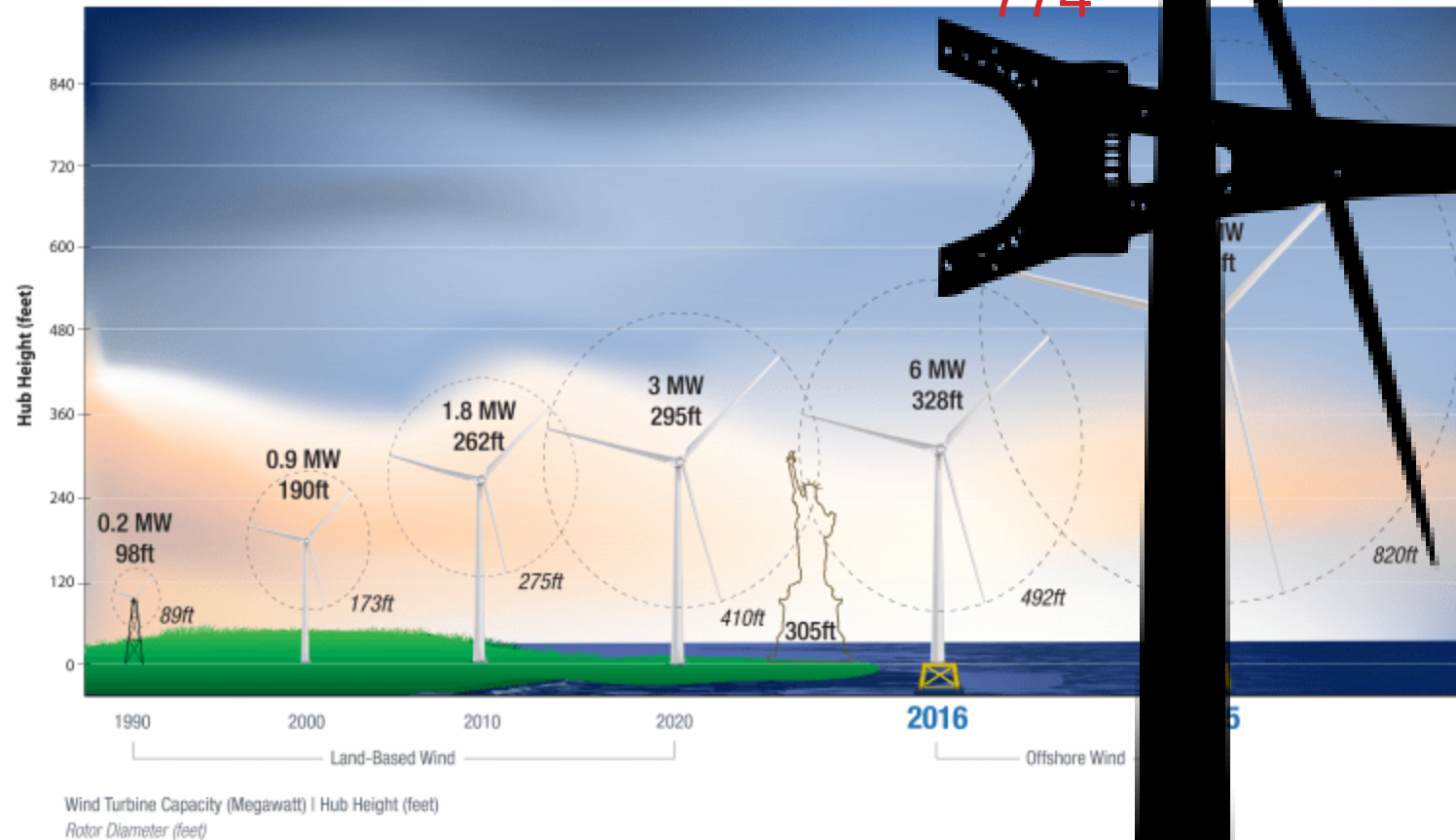
2023

Bigger is better



2023

Bigger is better



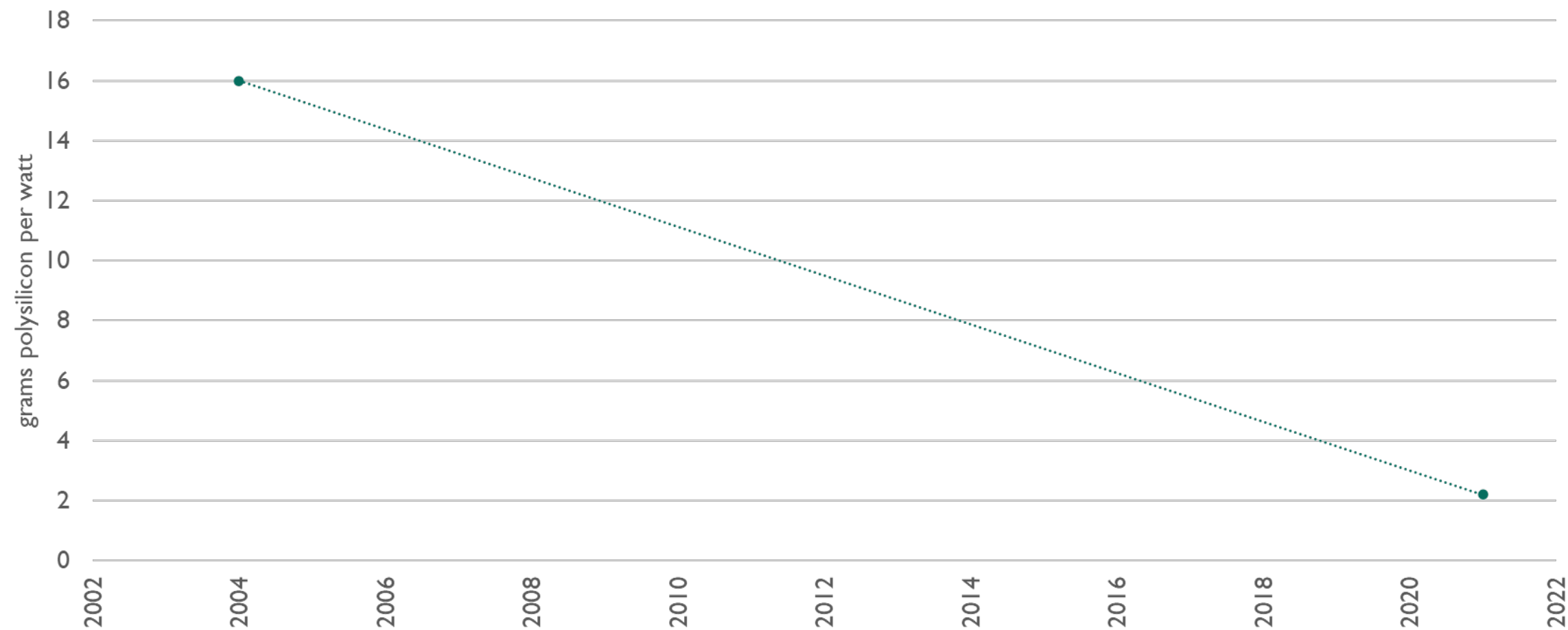
Bigger is better



But not too big



Solar panels use 85% less silicon today than 20 years ago

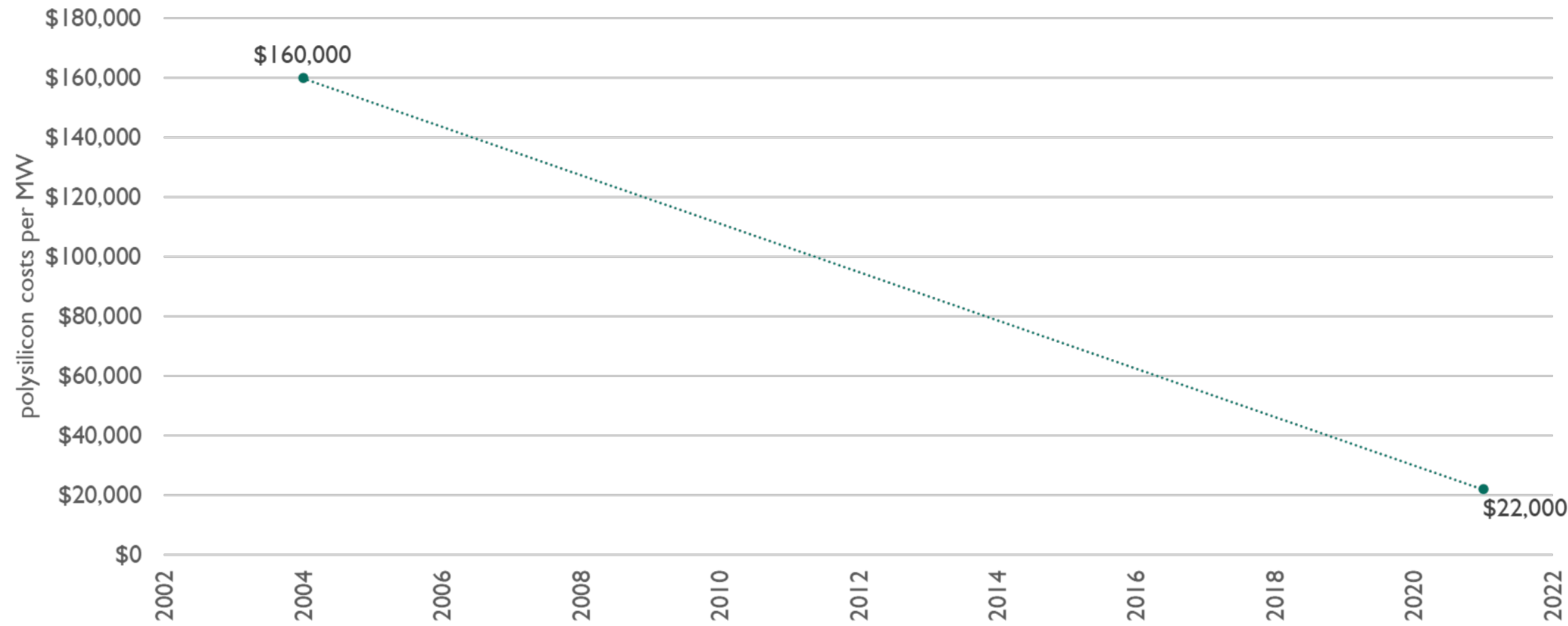


Source: Weaver, Fitzgerald John, "Polysilicon costs have slid by 96% per watt over past two decades." January 11, 2023. Accessed: June 10, 2023.
3/29/2024

New silicon demand = new silicon supply = lower silicon prices!

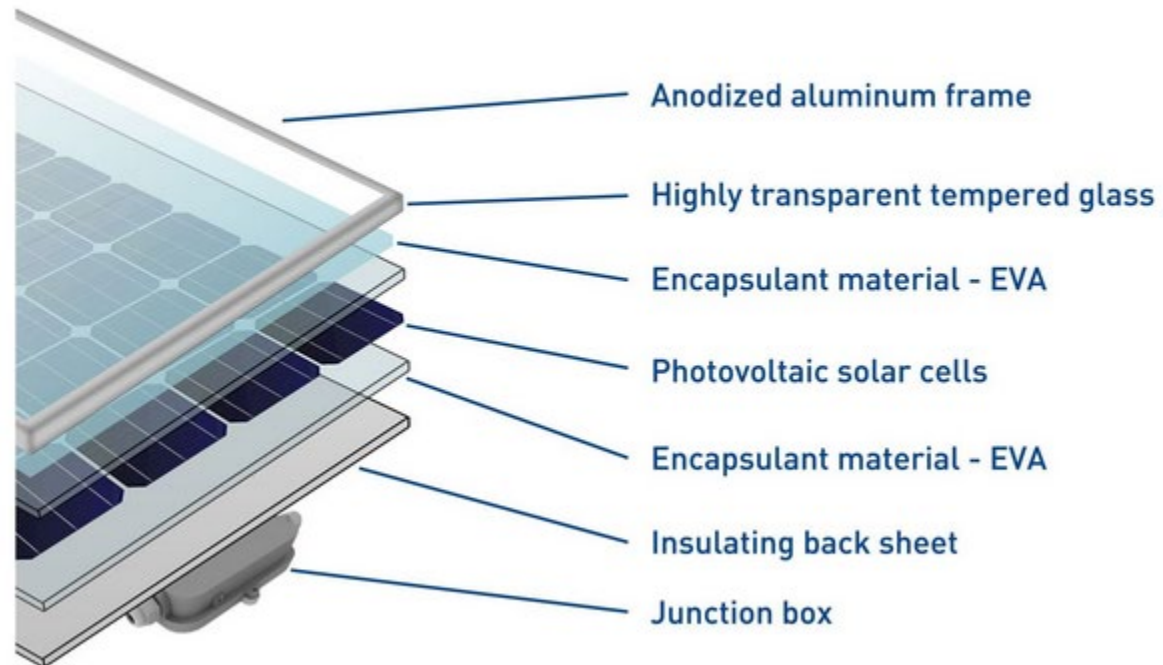


Silicon inputs drop by 85% too



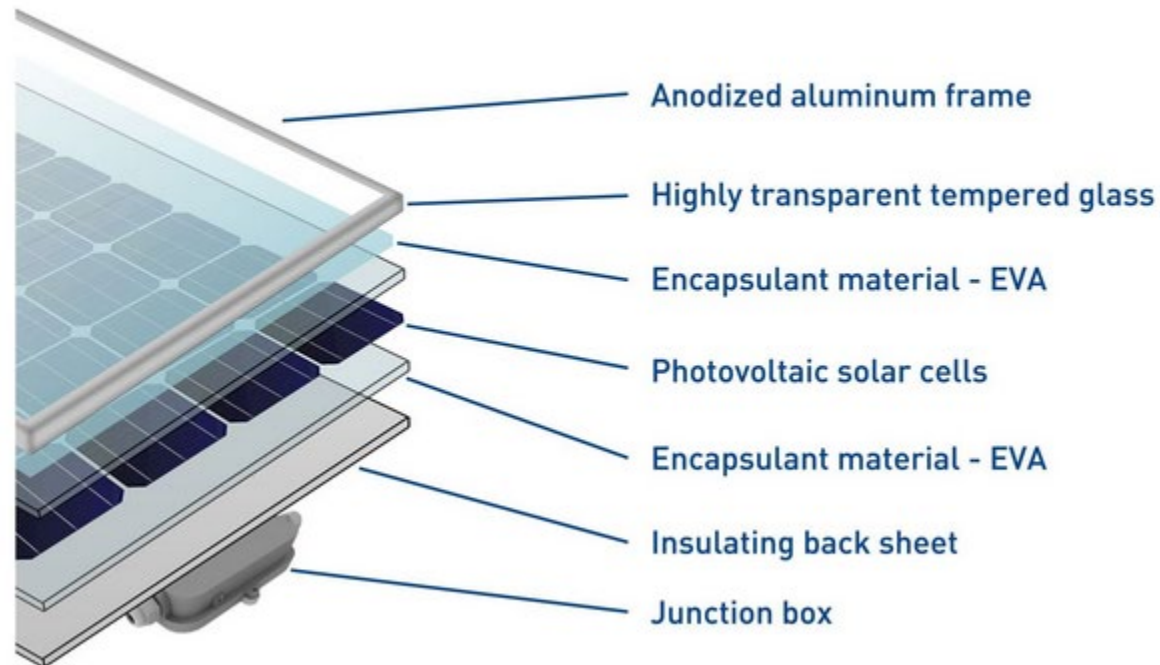
Source: Weaver, Fitzgerald John, "Polysilicon costs have slid by 96% per watt over past two decades." January 11, 2023. Accessed: June 10, 2023.
3/29/2024

Everything gets better



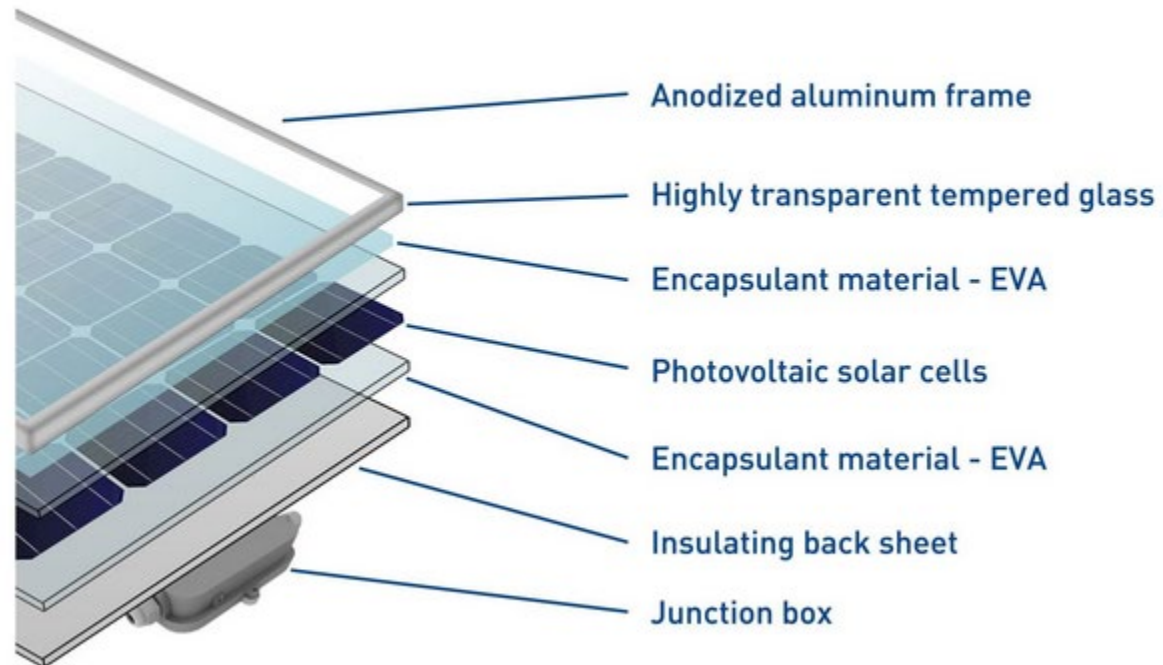
Panels are becoming more efficient at converting sunlight

2004: 150 W



And more energy dense in general

2023: 550 W

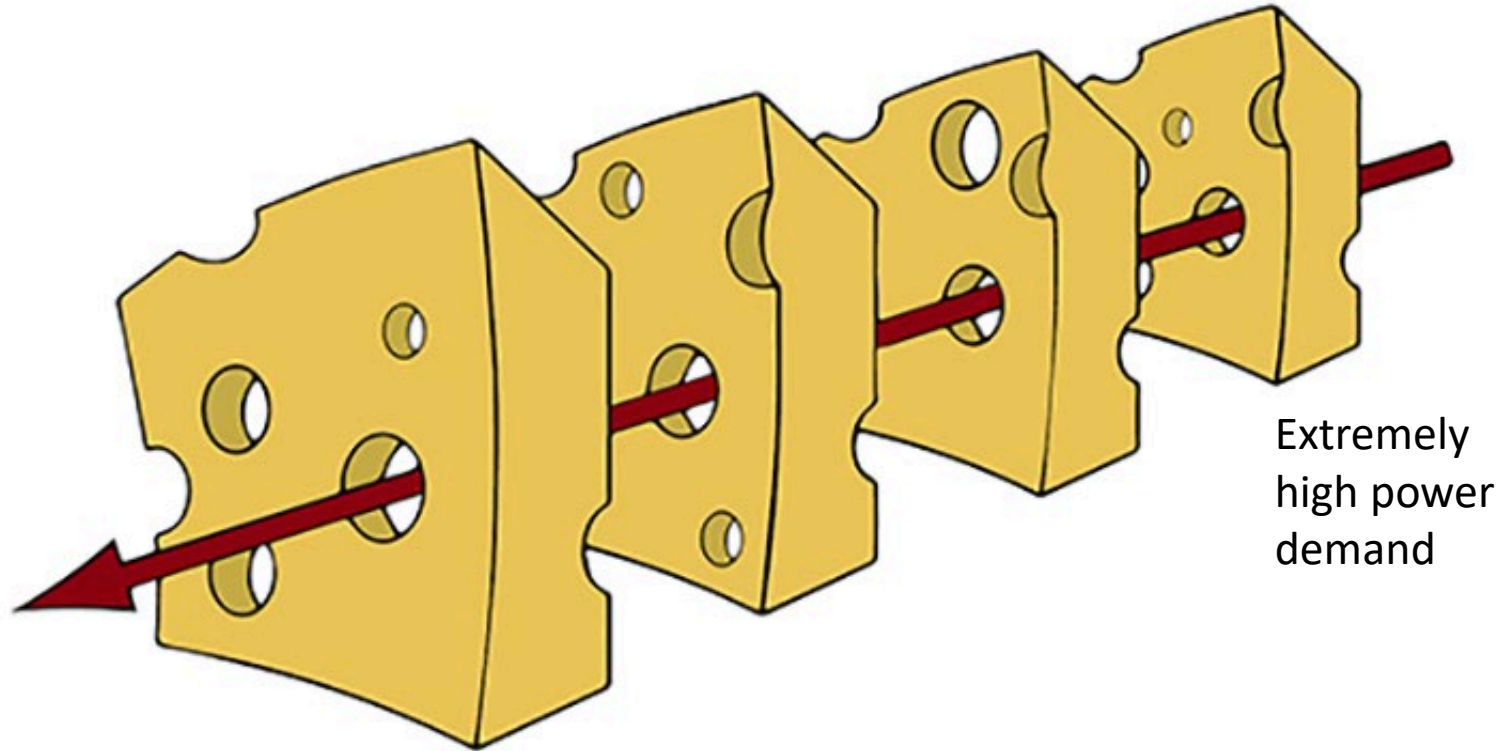


Step 3: Lather, rinse, repeat

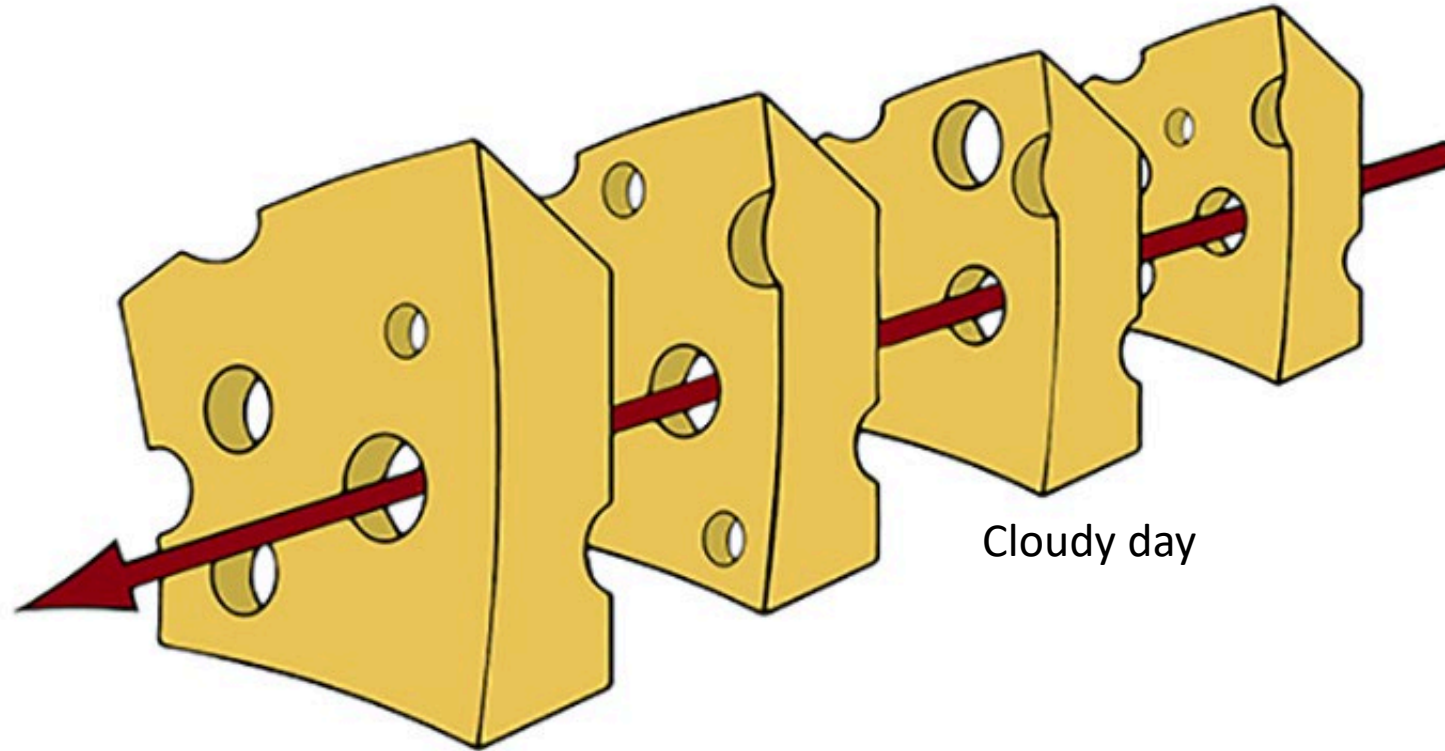


CURRENT GRID CHALLENGES

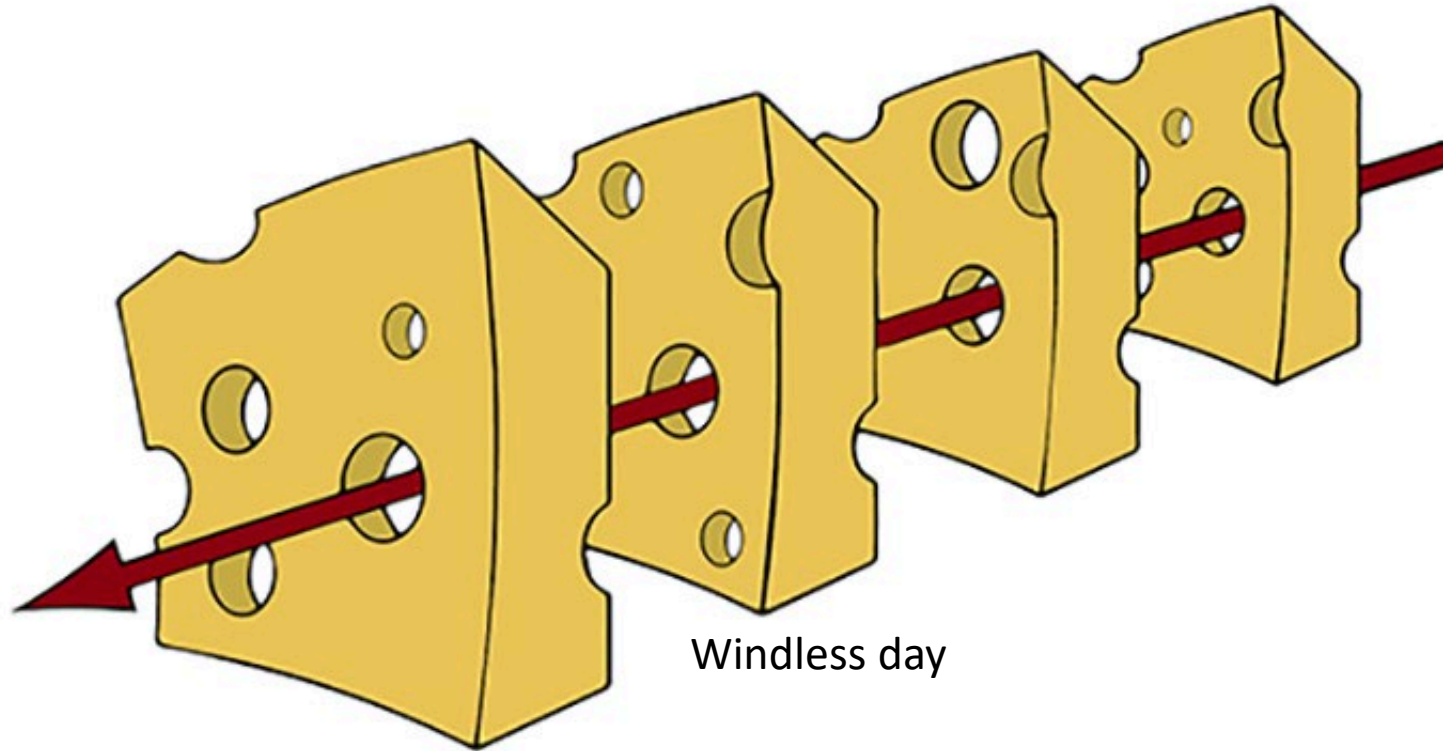
How extreme weather stresses our grid



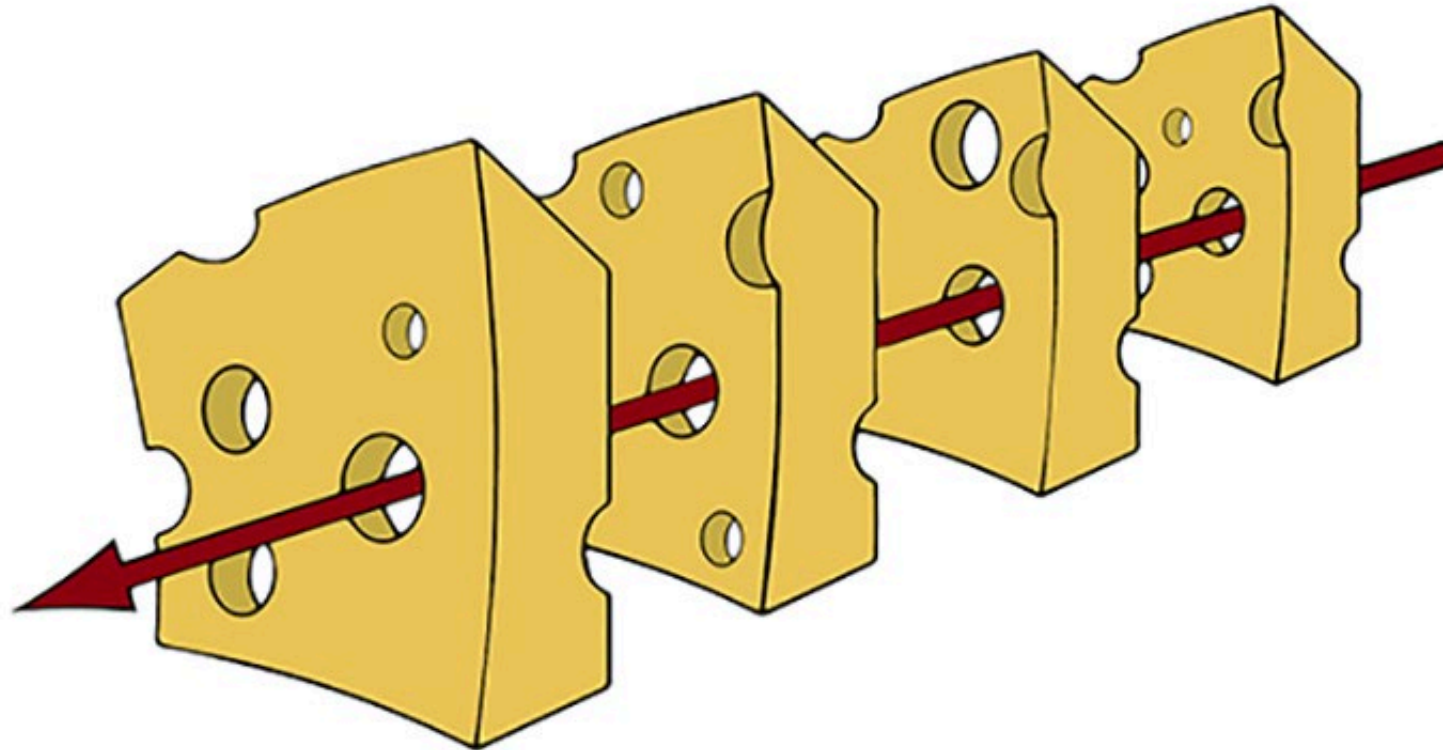
How extreme weather stresses our grid



How extreme weather stresses our grid

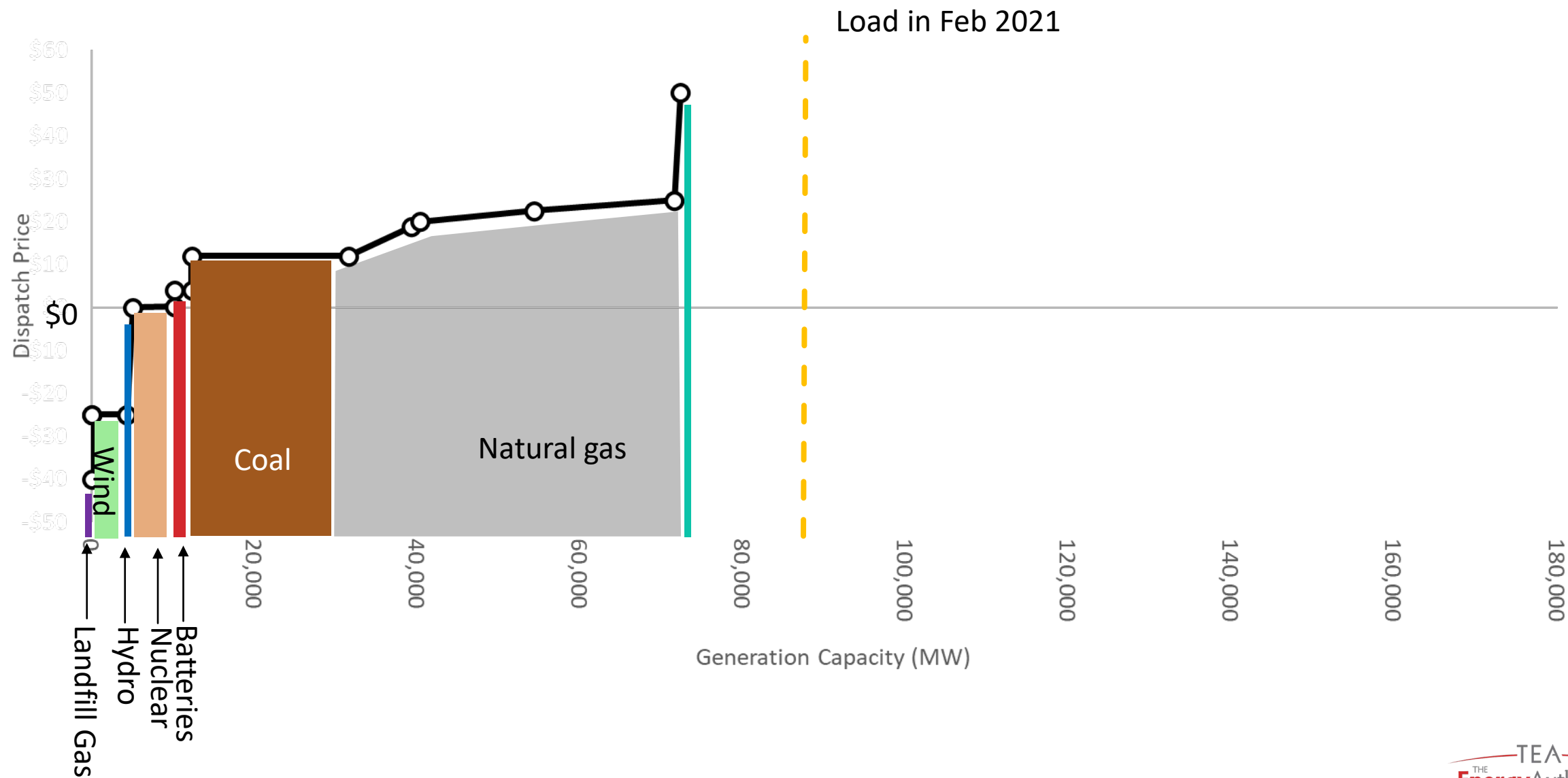


How extreme weather stresses our grid

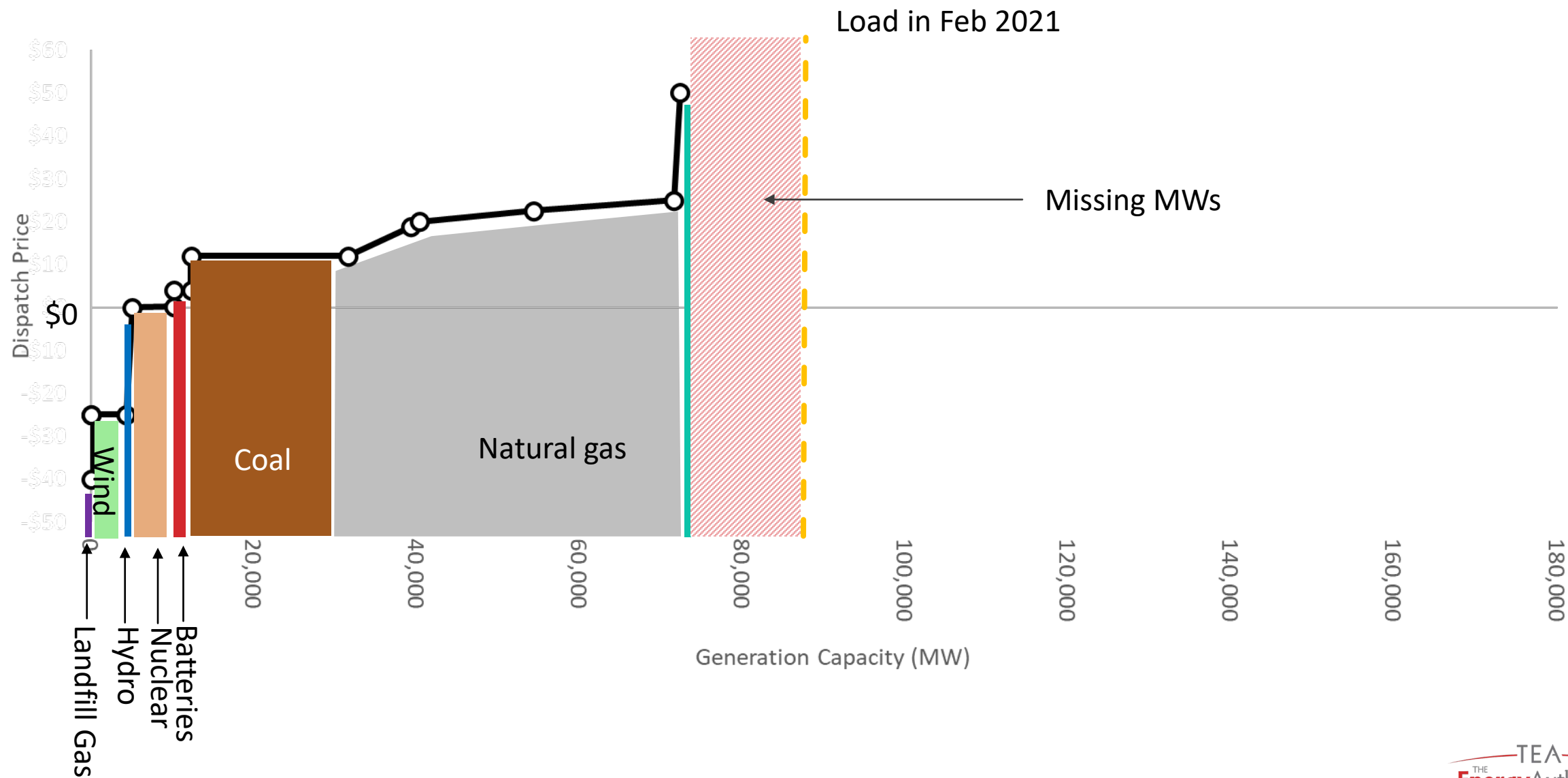


Fuel availability
issues

Here's what happened in Texas in February 2021



Here's what happened in Texas in February 2021



Our ability meet load is getting tested more often

Similarities to Past Extreme Cold Weather Events

	2011 Event	2014 Event	2018 Event	2021 Event	2022 Event
Significant levels of incremental unplanned electric generating unit losses with top causes found to be mechanical/electrical, freezing, and fuel issues.	✓	✓	✓	✓	✓
Significant natural gas production decreases occurred, with some areas of the country more severely affected.	✓			✓	✓
Short-range forecasts of peak electricity demands were less than actual demands for some BAs in event area.	✓		✓	✓	✓



This report was prepared by the staff of the Federal Energy Regulatory Commission in consultation with staff from the North American Electric Reliability Corporation and its Regional Entities. This report does not necessarily reflect the views of the Commission.

8

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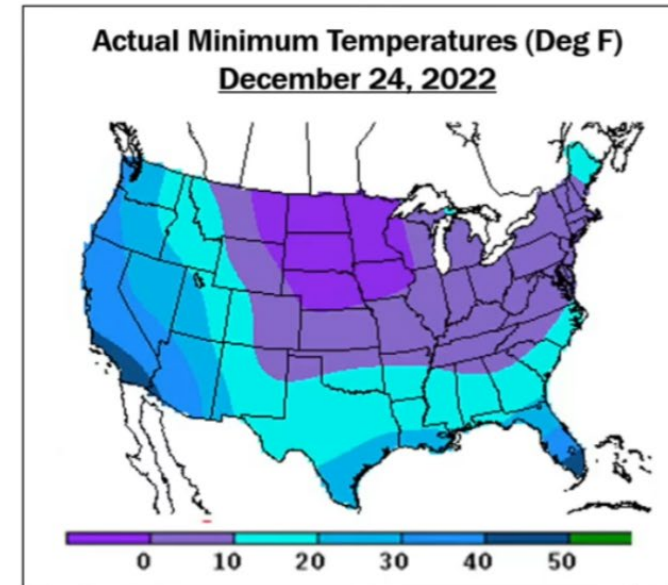
8

Dispatchable resources are also contributing to the problem

Winter Storm Elliott's Effects on the Bulk-Power System*

- **December 21-26, 2022:** Frigid arctic air with strong winds arrived over the eastern half of the country.
- Peak winter electricity demands, coupled with significant unplanned electric generation supply losses exceeding **70,000 MW**, occurred during the coldest weather across the Southeastern, Mid-Atlantic, Midwest, and Northeastern U.S..
- Several southeastern U.S. Balancing Authorities (BAs) ordered firm load shed on December 24, 2022, in total exceeding **5,000 MW**.

* Inquiry team is still gathering and analyzing data on all of these subjects.



FERC Commission Meeting | June 2023 Open Meeting



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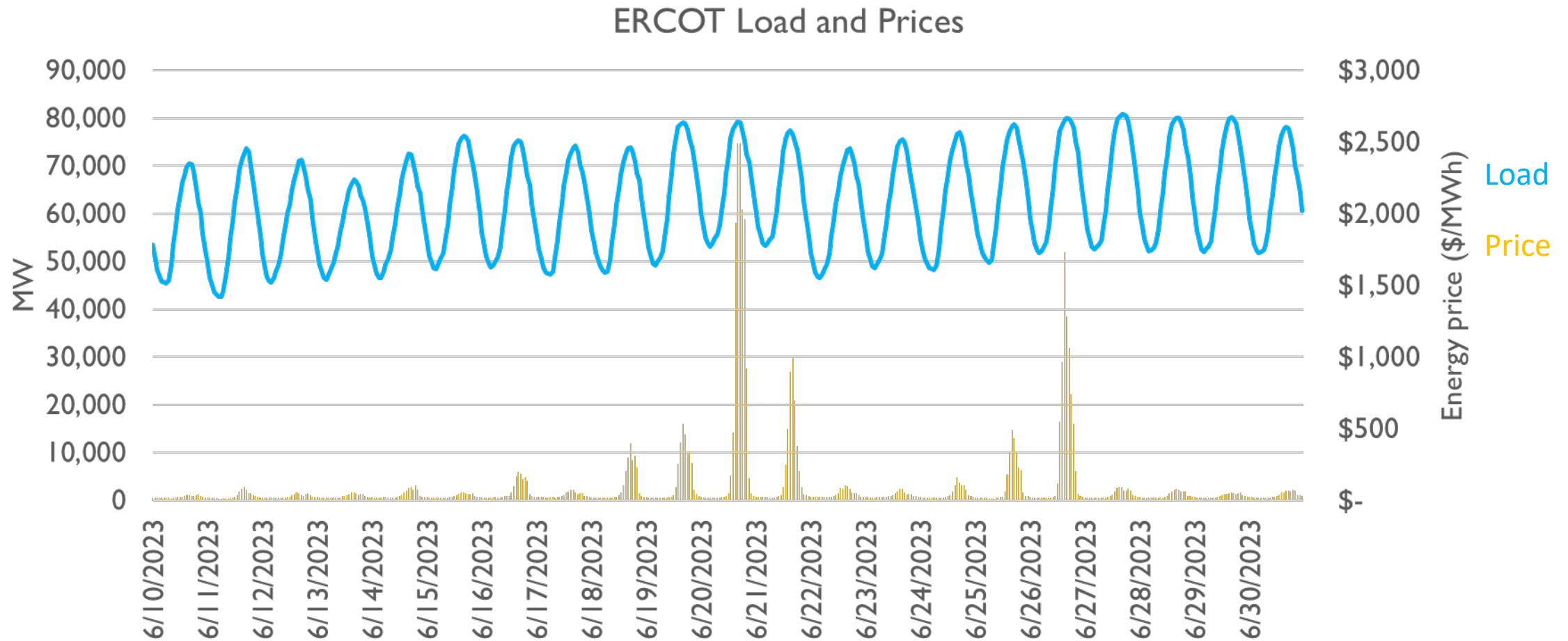
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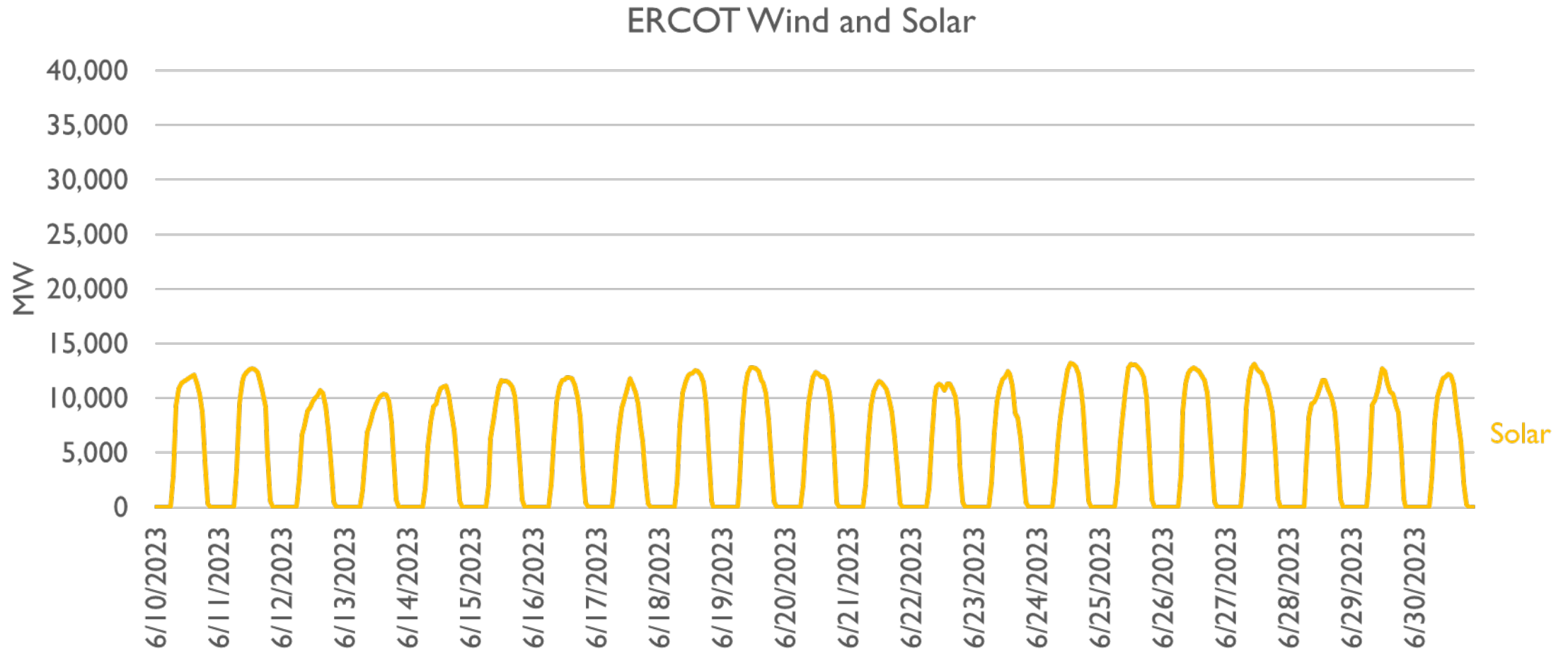


Source: June 2023 FERC Commission Meeting

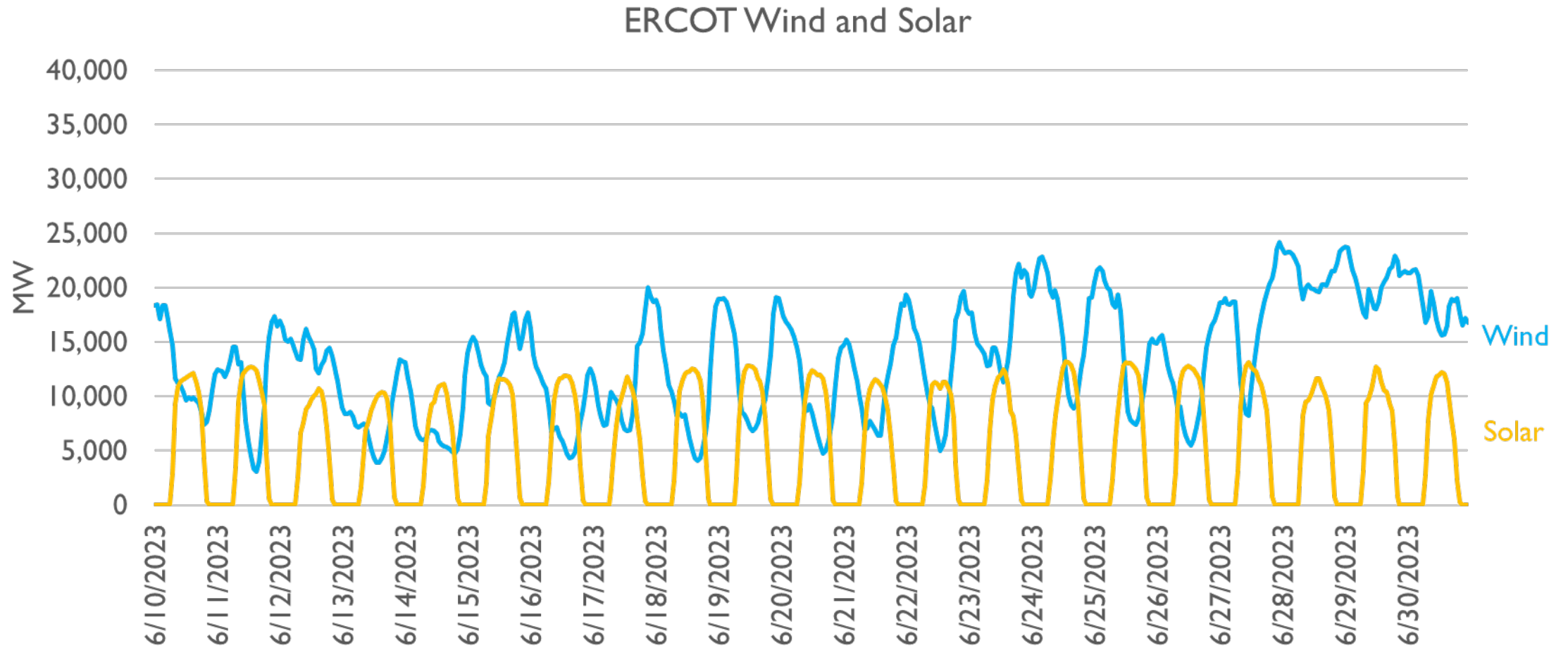
ERCOT prices during the June 2023 heat wave



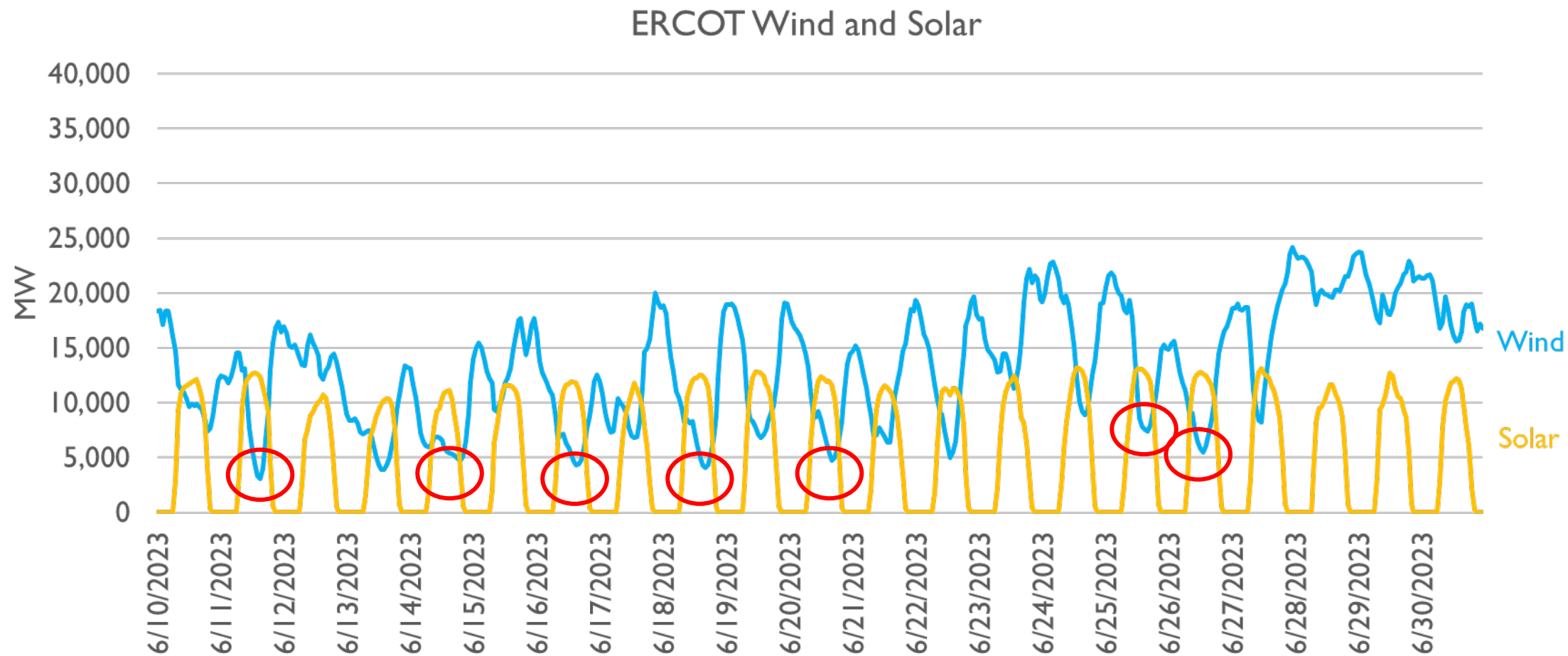
Reconstructing the event



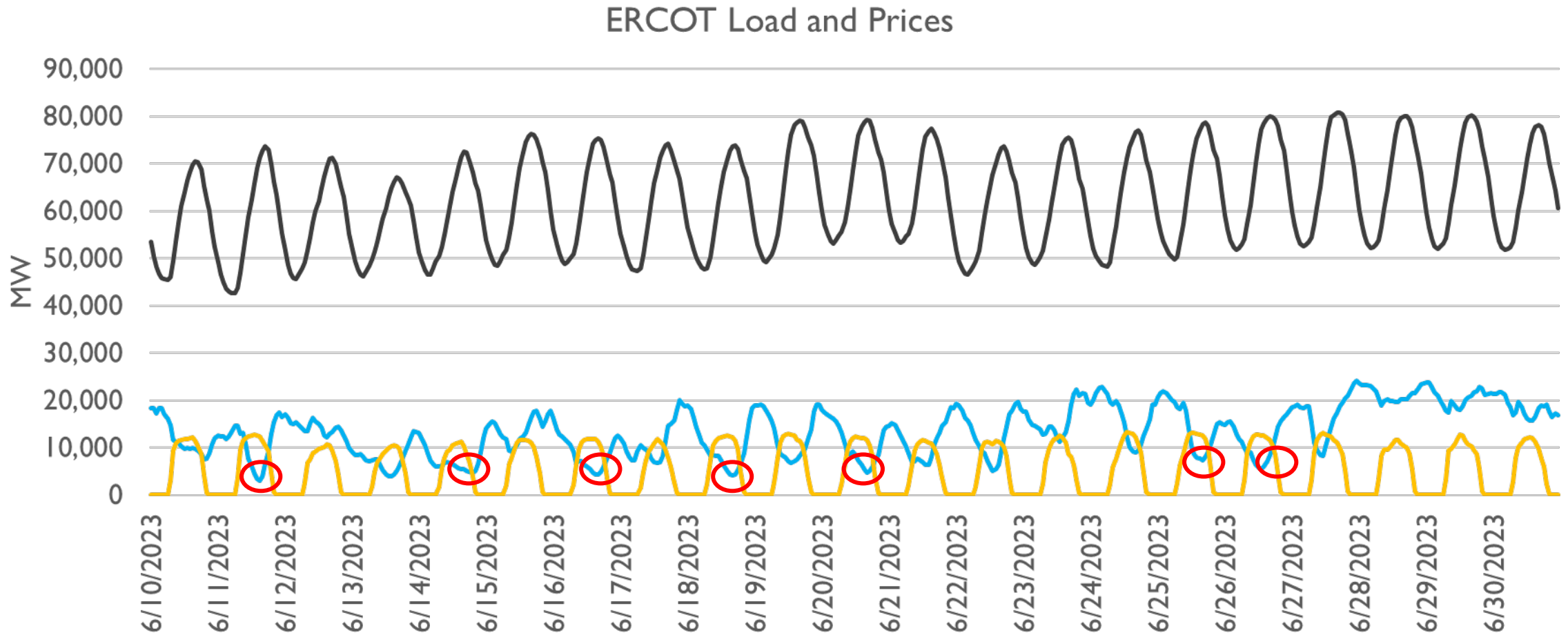
Reconstructing the event



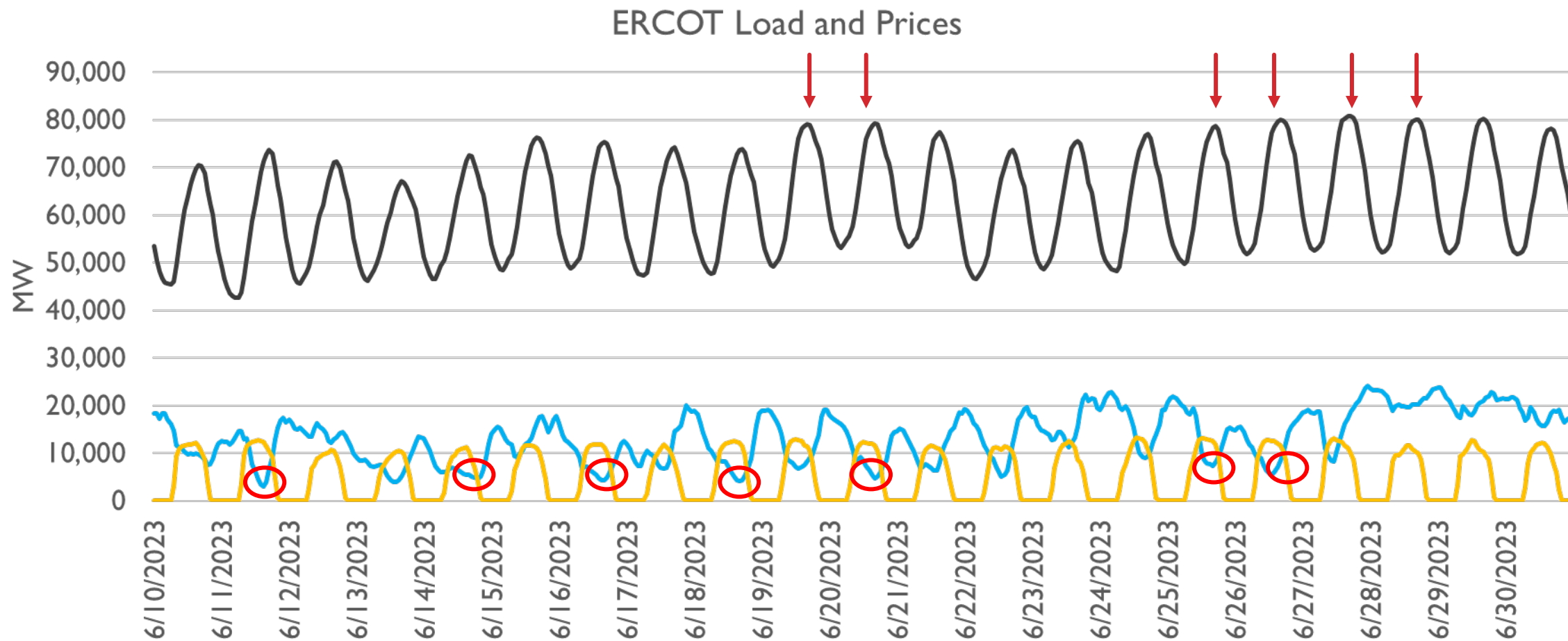
Reconstructing the event



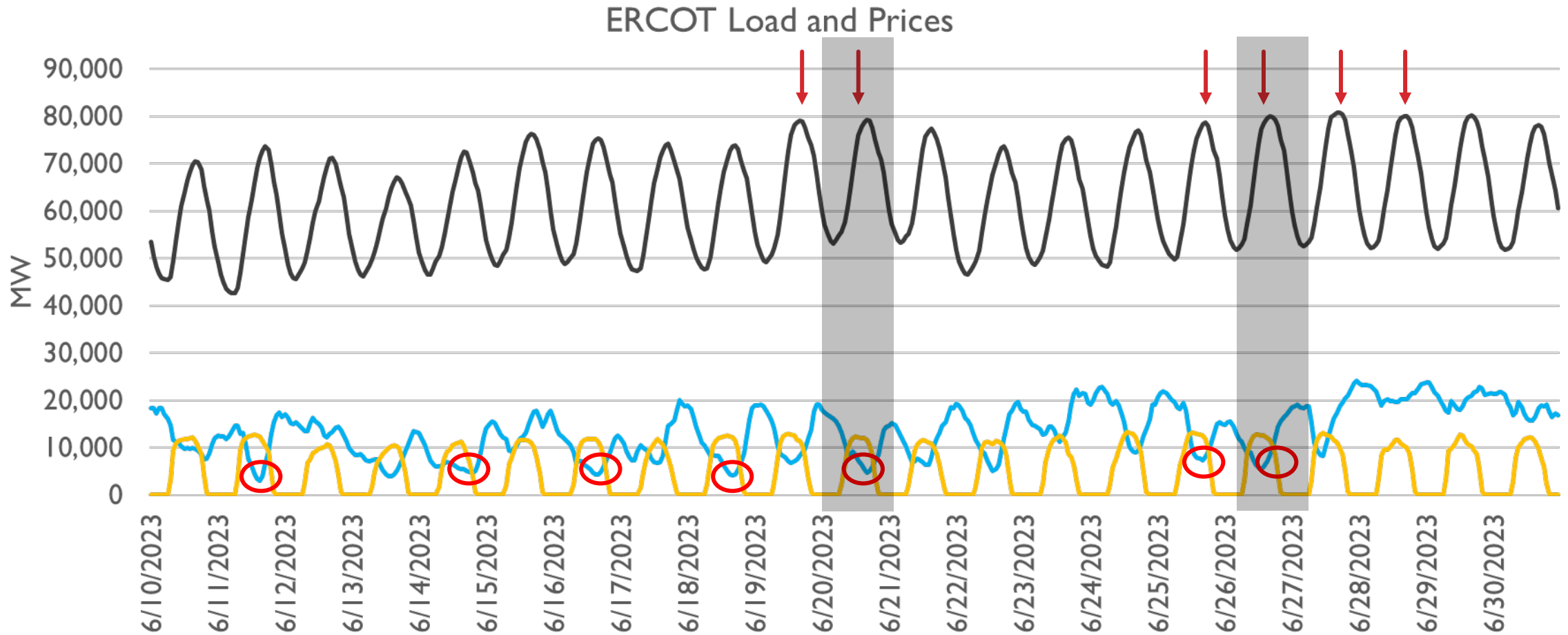
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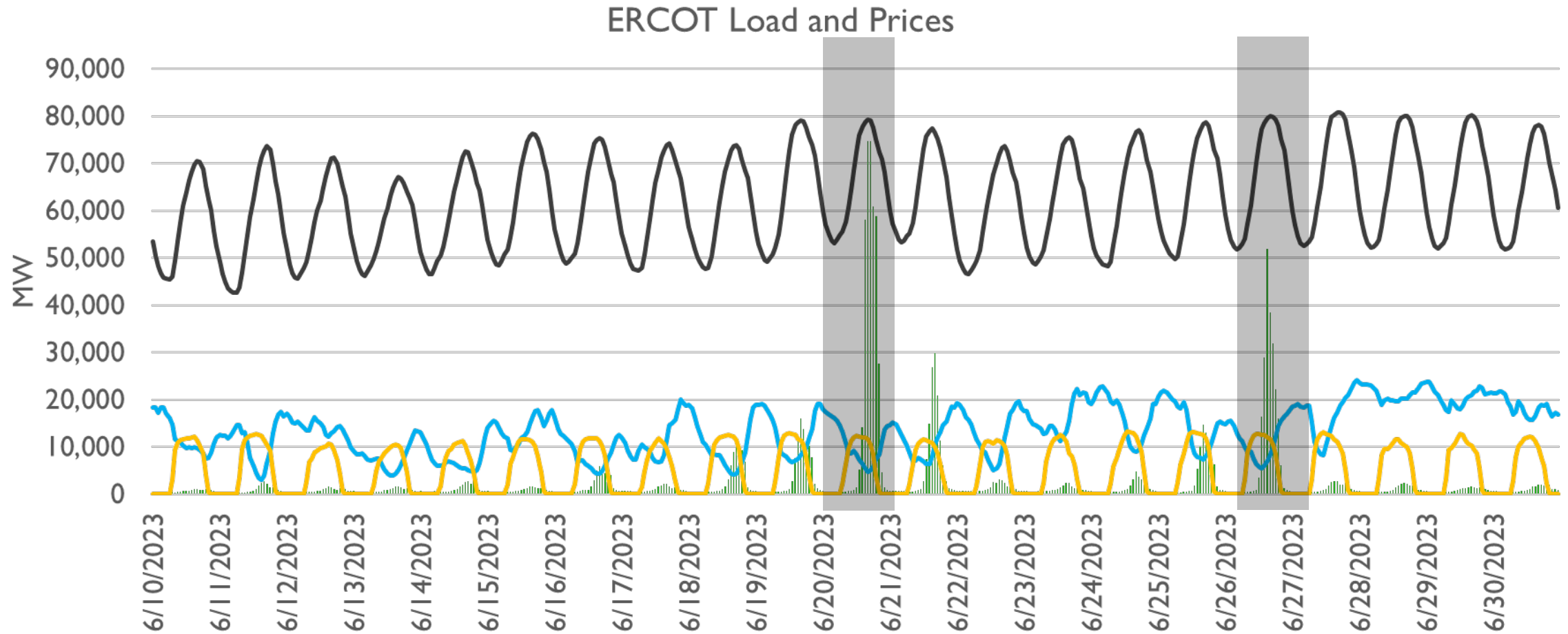
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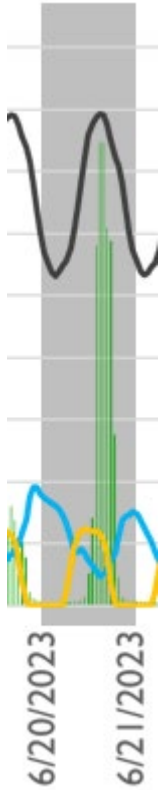
Reconstructing the event



Reconstructing the event

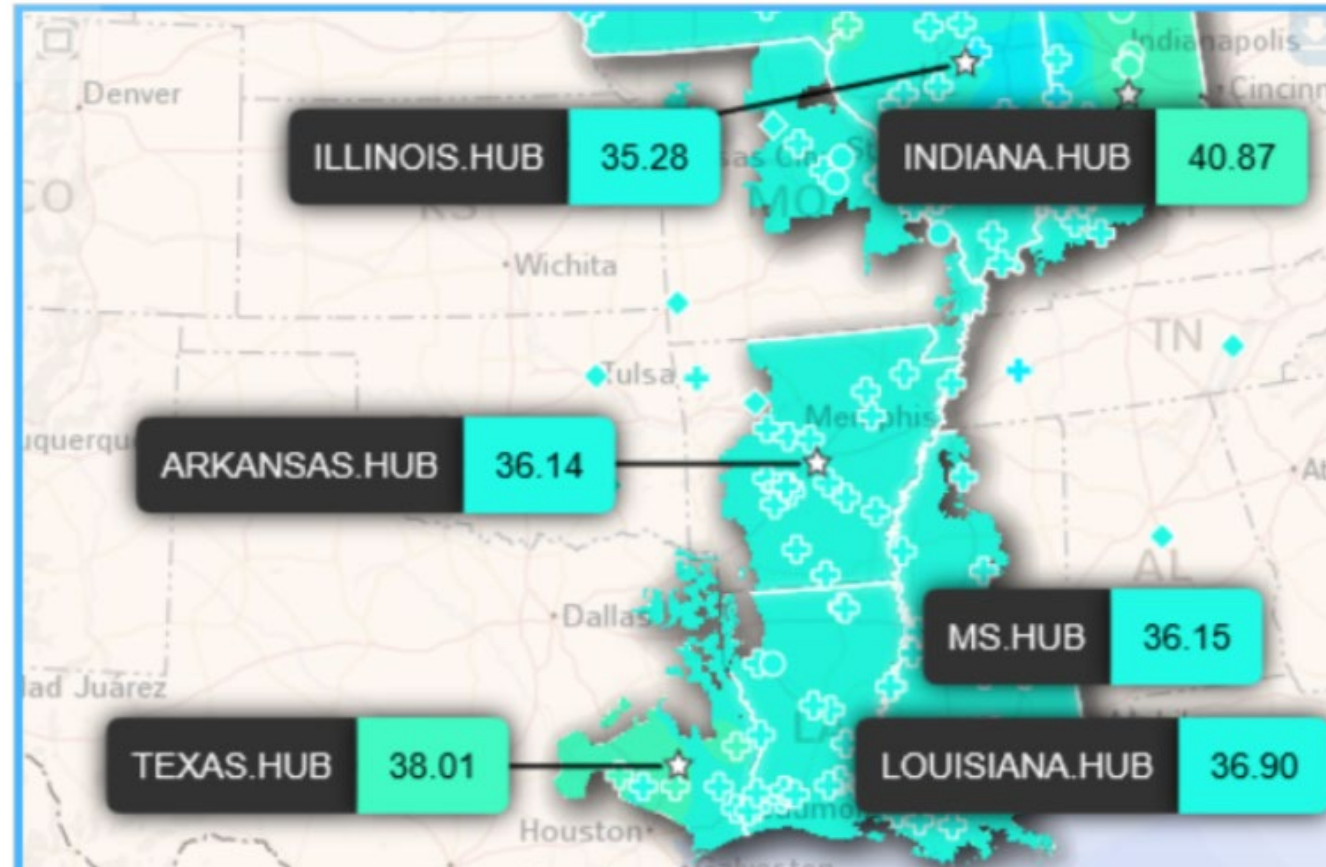
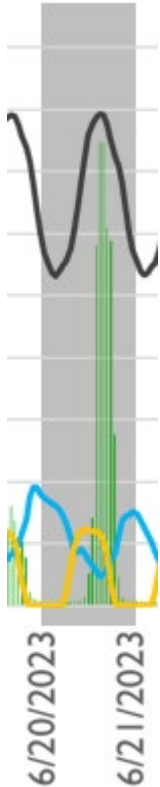


Reconstructing the event

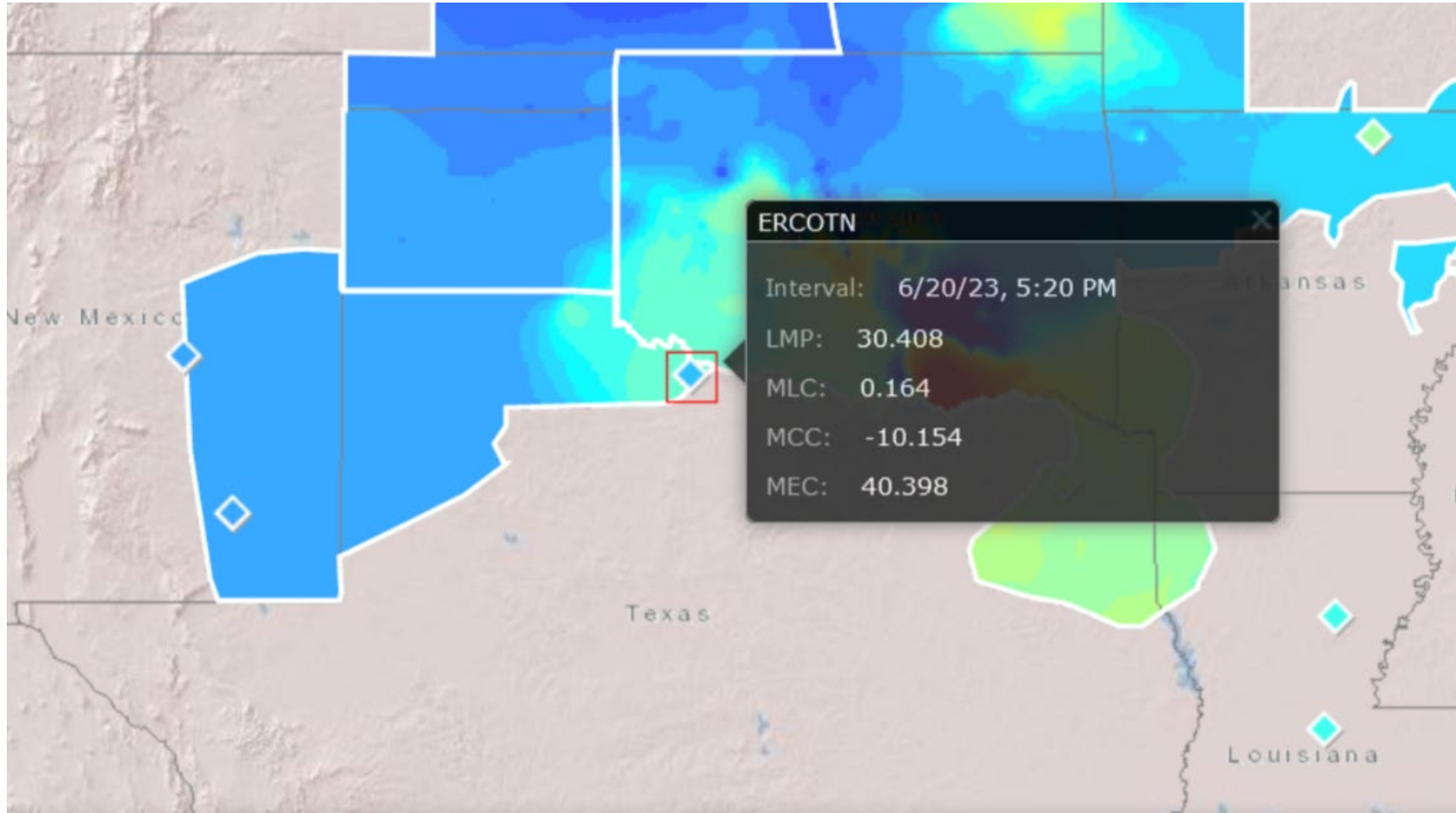
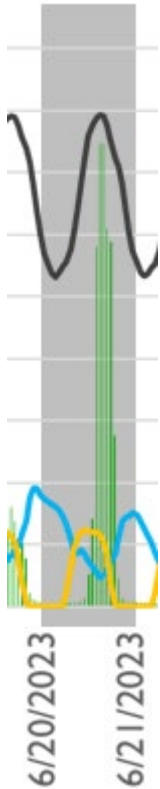


Reconstructing the event

20-Jun-2023 - 19:15 EST



Reconstructing the event



Cost for 5 hours of energy on June 20, 2023

Estimated cost:

$$78,000 \text{ MW} * 5 \text{ hours} * \frac{\$2,180}{\text{MWh}} = \$850,000,000$$

Cost for 5 hours of energy on June 20, 2023

What if there was more transmission capacity between ERCOT and MISO/SPP?

$$78,000 \text{ MW} * 5 \text{ hours} * \frac{\$40}{\text{MWh}} = \$15,600,000$$

Could've built a lot of transmission for that cost!

BLM clears way for \$3B TransWest Express transmission project to start construction this year

The 732-mile project is designed to deliver 3,000 MW of wind generation from Wyoming to California and the Southwest.

Ethan Howland

Published April 12, 2023



Takeaways

1. Even though they don't have an on/off switch, renewables enhance grid reliability
2. #1 is kind of scary
3. Renewables will continue to grow both due to politics and economics, but mostly economics
4. Load growth is real and will continue
5. #1 and #4 highlight the need for an all-of-the-above approach! We need energy! And we haven't even talked about EVs!



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