Analysis of EPA's Proposed Carbon Rules One-Pager

Isaac Orr and Mitch Rolling, Center of the American Experiment

American Experiment modeled the resource adequacy, reliability, and cost of EPA's proposed Section 111 rules. We determined EPA's modeled MISO grid under the rules would not meet resource adequacy or reliability, and reliably meeting EPA's emissions targets would cost MISO ratepayers an additional $246 billion compared to EPA's assumed grid.

Resource (In)Adequacy

- EPA assumes massive changes to the MISO grid stemming from the Inflation Reduction Act (IRA). However, EPA did not conduct a resource adequacy or reliability analysis on this base case, it simply assumed the Post-IRA base case was adequate and reliable.
- **EPA's decision to narrowly tailor the resource adequacy analysis to only study the difference between the proposed rule and the Post-IRA base case is like studying the structural integrity of the top floor of a 100-story building without doing so for the preceding 99 floors.**
- EPA uses unrealistically high capacity values for wind (19% for existing 9-25% for new), solar (55% existing 55-32% for new), and 100% for battery and thermal resources.
- EPA's modeled MISO grid relies on wind, solar, and battery storage to meet projected peak demand and the target reserve margin, which is why EPA's modeled grid results in massive rolling blackouts.

Reliability: EPA's Modeled Grid Results in Massive Rolling Blackouts

- EPA did not evaluate the reliability of its modeled MISO grid.
- American Experiment compared EPA's modeled power plant capacity portfolio to historical hourly electricity demand and hourly wind and solar capacity factors in 2019, 2020, 2021, and 2022 and determined EPA's modeled MISO grid would result in rolling blackouts in each of these Historical Comparison Years (HCY).
- One blackout event would be a 26 GW capacity shortfall in January 2040 using the 2021 HCY, representing 19.5 percent of the demand at the time of the capacity shortfall. This means one in every five homes would experience a rolling power outage in the region.
- **EPA's modeled generation mix cannot prevent blackouts while hindcasting observed historical conditions. Therefore, we should have no confidence in its assurances that it will have no impact on electric reliability in the future.**

Cost: $246 billion in additional costs for ratepayers compared to EPA's assumptions

- EPA's rules will result in $246 billion in additional compliance costs in MISO, which is $7.7 billion in annual compliance costs for the MISO region alone.
- This figure exceeds EPA's totaled modeled benefits of $5.9 billion annually for the entire nation.

EPA is attempting to transform the entire U.S. electric grid using a process that is less rigorous and less transparent than a state integrated resource plan. More time and transparency is needed to thoroughly evaluate the impact of the proposed Section 111 rules in the entire country.

REPORT DEVELOPED FOR NDIC / NDTA :

Forecasting the Resource Adequacy, Reliability and Cost Impacts of EPA's 111 Rules Through 2055

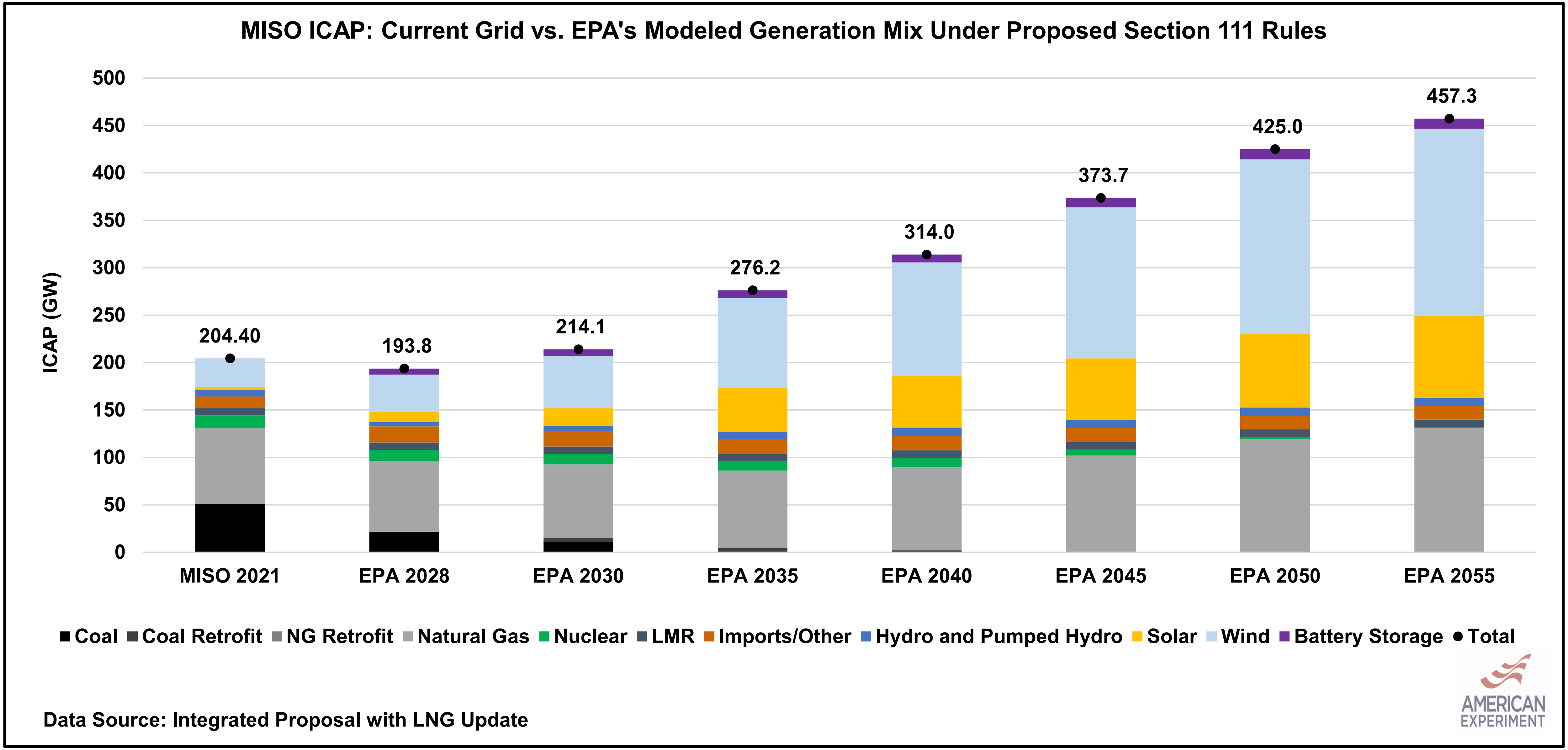
LONG FORMAT PRESENTATION

August 7, 2023

Isaac Orr and Mitch Rolling

AMERICAN EXPERIMENT

Executive Summary: EPA is Assuming Massive Changes to the MISO Grid Due to the IRA and Proposed Section 111 Rules



AMERICAN EXPERIMENT

Executive Summary: EPA's Modeled Grid Would Preserve Resource Adequacy Relative to the Base Case, But…

- EPA has narrowly defined the scope of the Regulatory Impact Analysis (RIA) of the regulations to maintain resource adequacy ***compared to its Post-IRA base case.***
- EPA did not evaluate the resource adequacy or reliability of its Post-IRA base case, it simply assumed they are sufficient.

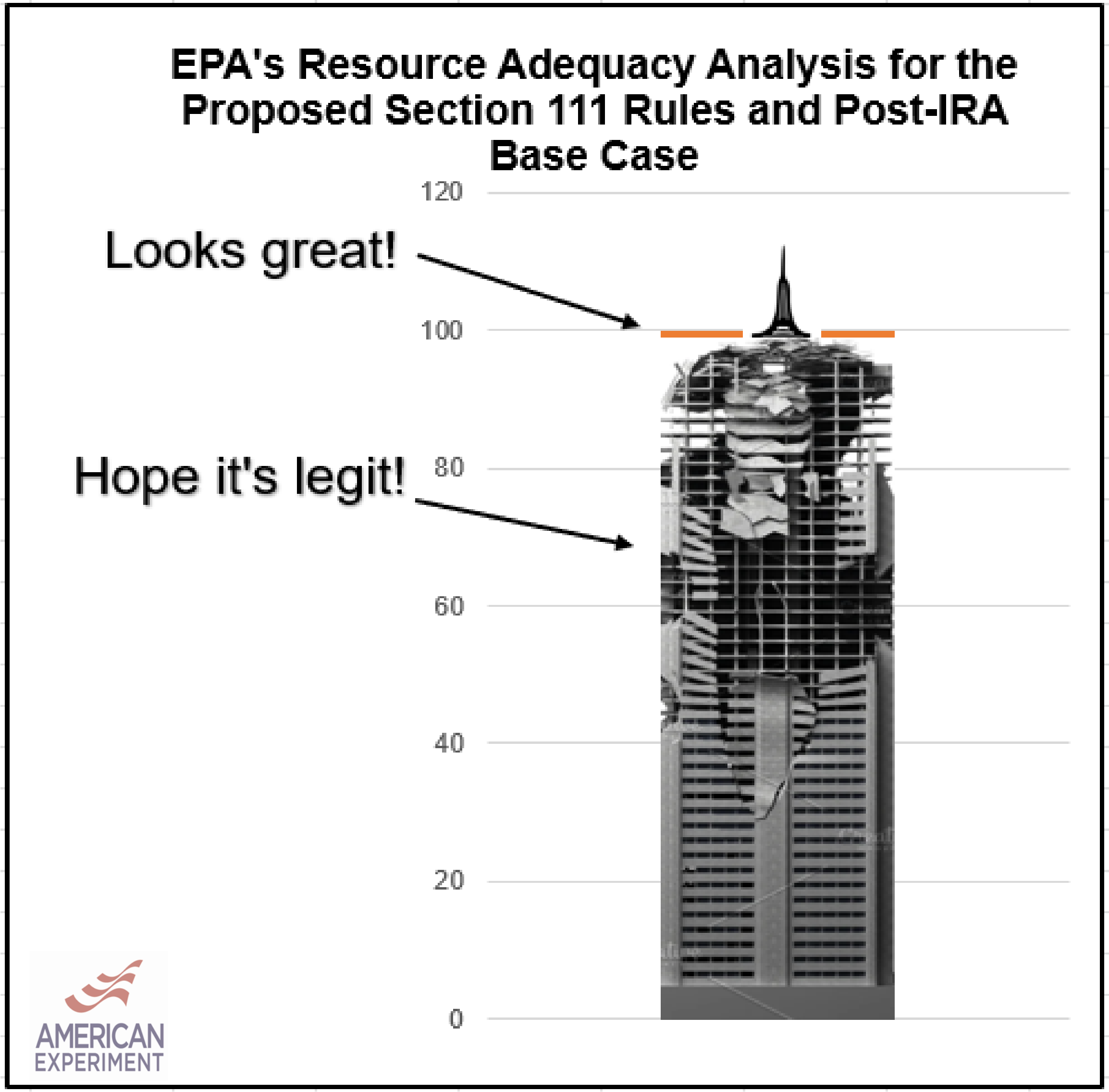
"The results presented in this document further demonstrate, for the specific cases illustrated in the Regulatory Impact Analysis (RIA), that the implementation of these rules can be achieved without undermining resource adequacy."

"The focus of the analysis is on ***comparing the illustrative proposed rules scenario from the RIA to a base case (absent the proposed requirements) that is assumed to be adequate and reliable." [emphasis added]***

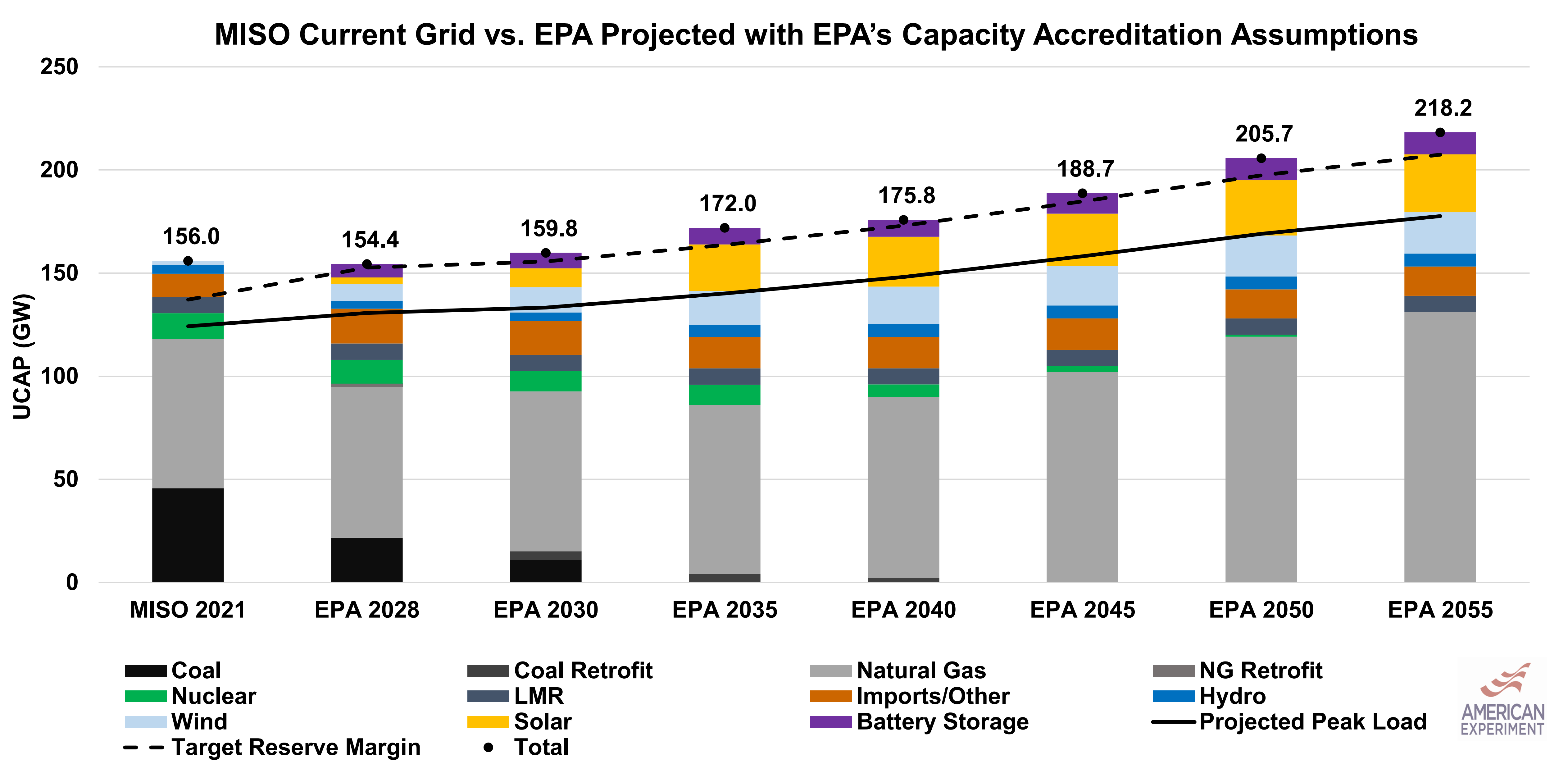
"In this framework, we emphasize the incremental changes in the power system that are projected to occur under the presence of the rules in the 2030, 2035 and 2040 model run years."

EPA Narrowly Tailors its Resource Adequacy Assessment

- EPA's decision to narrowly tailor the resource adequacy analysis to only study the difference between the proposed rule and the Post-IRA base case is like studying the structural integrity of the top floor of a 100-story building without doing so for the preceding 99 floors.

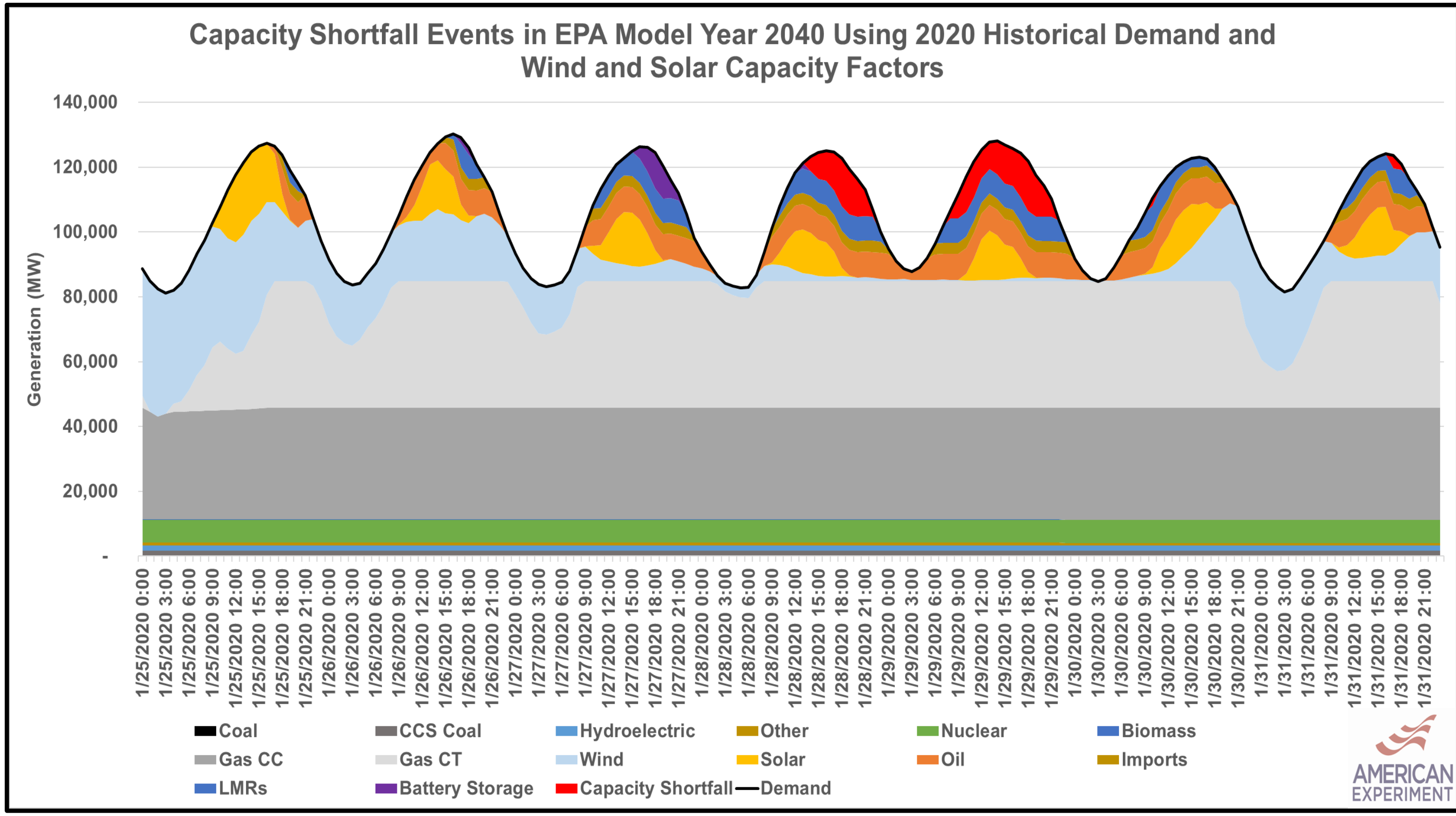


Executive Summary: EPA's Modeled Grid Only Meets EPA's Reserve Margin With Generous Wind and Solar Capacity Accreditation and LMR/Import Assumptions

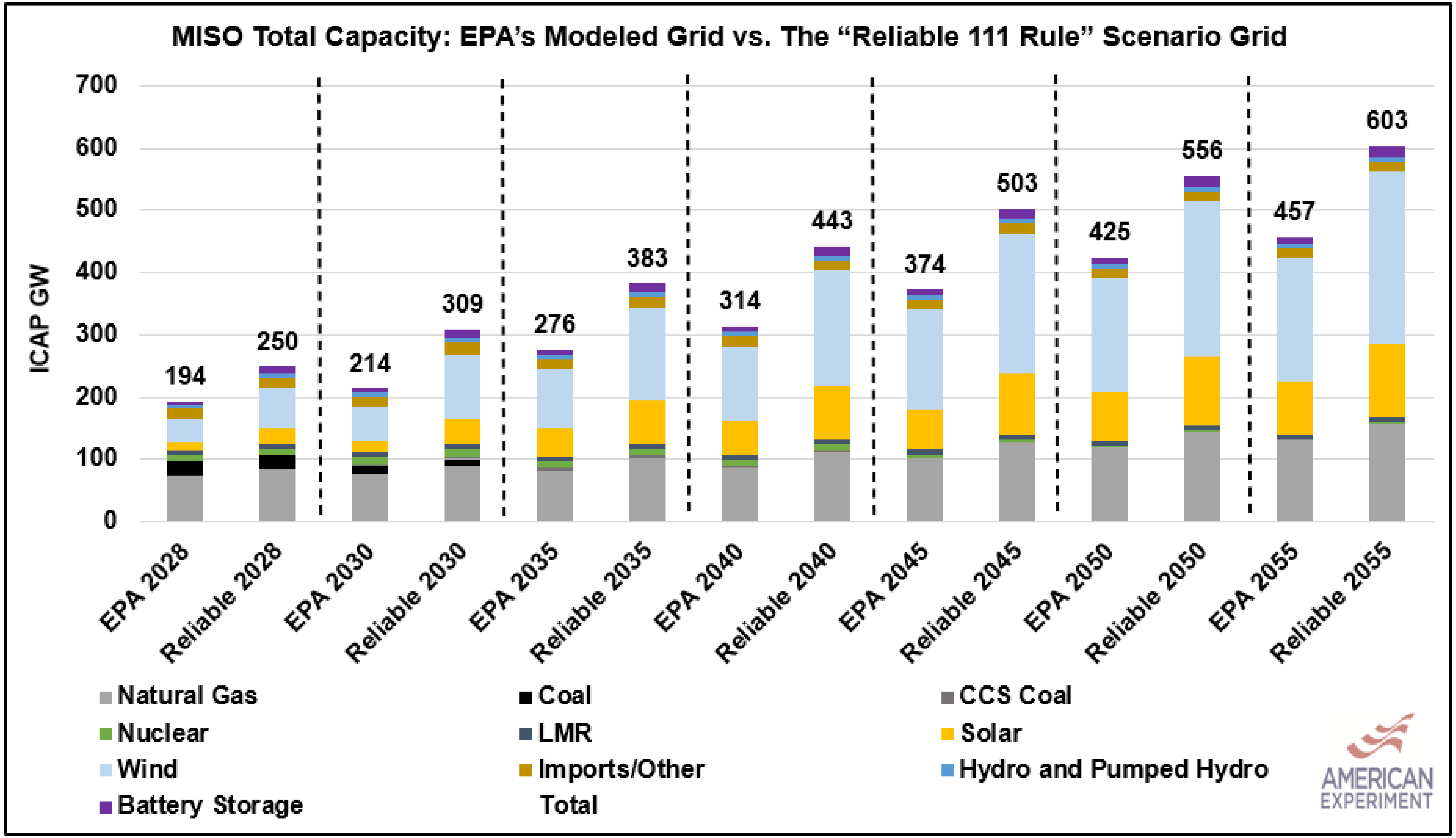


Executive Summary: EPA's Modeled Grid Would Result in Blackouts

- EPA's modeled resource portfolio cannot keep the lights on.
- Our modeling found severe capacity shortfalls (rolling blackouts) in MISO when conducting hourly reliability assessments based on historic hourly electricity demand and hourly wind and solar capacity factors.

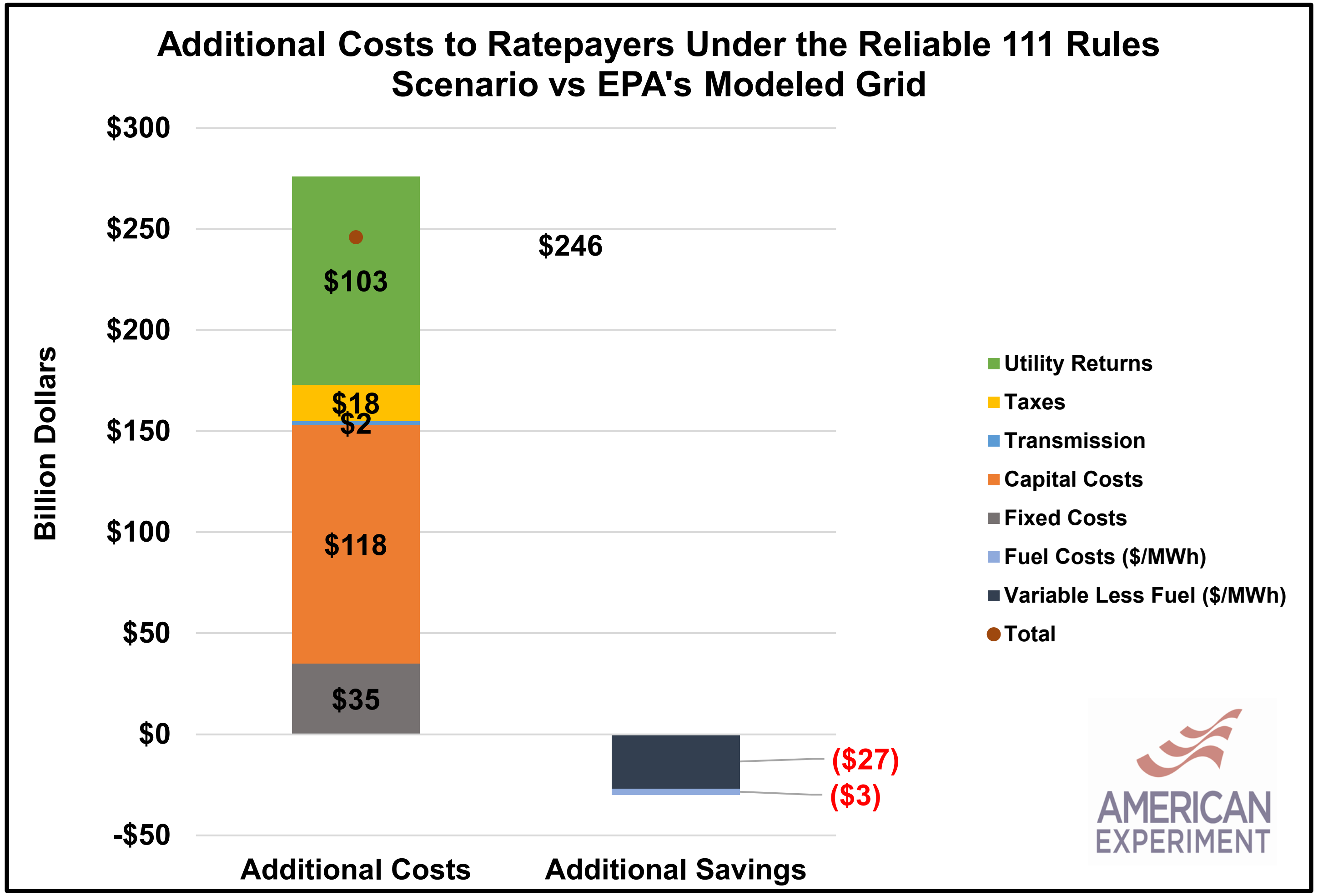


Executive Summary: Meeting EPA's Modeled Emissions Targets While Maintaining Reliability Will Require A Significant Increase in Capacity Relative to EPA's Modeled Grid



Executive Summary: Shoring Up EPA's Modeled Grid Would Cost $246 Billion

- Preventing capacity shortfalls while still meeting EPAs emission targets would require large capacity additions.
- These additions would increase the cost of compliance by $246 billion through 2055, or $7.7 billion annually, compared to the cost of EPA's modeled MISO grid in the Integrated Proposal with LNG Update.
- **This figure exceeds EPA's annual net benefit estimate of $5.9 billion for the entire country.**



Objectives: Model Resource Adequacy, Reliability, and Cost Under EPA's Proposed Section 111 Rules

Step 1: Evaluate the Resource Adequacy (RA) of EPA's modeled generation fleet under its proposed 111 rules

a. Determine if EPA's modeled grid meets its own RA/Reserve Margin requirements using EPA assumptions.

b. Analyze EPA's accreditation methods used to predict RA metrics for all generating resources in the proposed Section 111 rules.

Step 2: Evaluate the reliability of EPA's modeled generation portfolio under the new 111 rules

a. Evaluate whether EPA's modeled portfolio can keep the lights on based on historical hourly electricity demand and wind and solar capacity factors.

b. Historical MISO data for years 2019, 2020, 2021, and 2022 are used to "stress test' EPA's modeled grid.

Step 3: Develop reasonable accreditation values for wind and solar

a. 2019-2022 hourly dataset
    i. Peak load availability
    ii. Net peak load availability

Step 4: Calculate the cost of meeting load every hour of the year while meeting EPA's emission targets in the "Reliable 111 Rules Scenario."

a. Identify how much new capacity would be needed to maintain reliability and meet EPA emission targets.

b. Use a Cost-of-Service retail electricity price model to calculate the cost of the regulations.

Resource Adequacy

EPA Narrowly Tailors its Resource Adequacy Assessment

"The results presented in this document further demonstrate, for the specific cases illustrated in the Regulatory Impact Analysis (RIA), that the implementation of these rules can be achieved without undermining resource adequacy."

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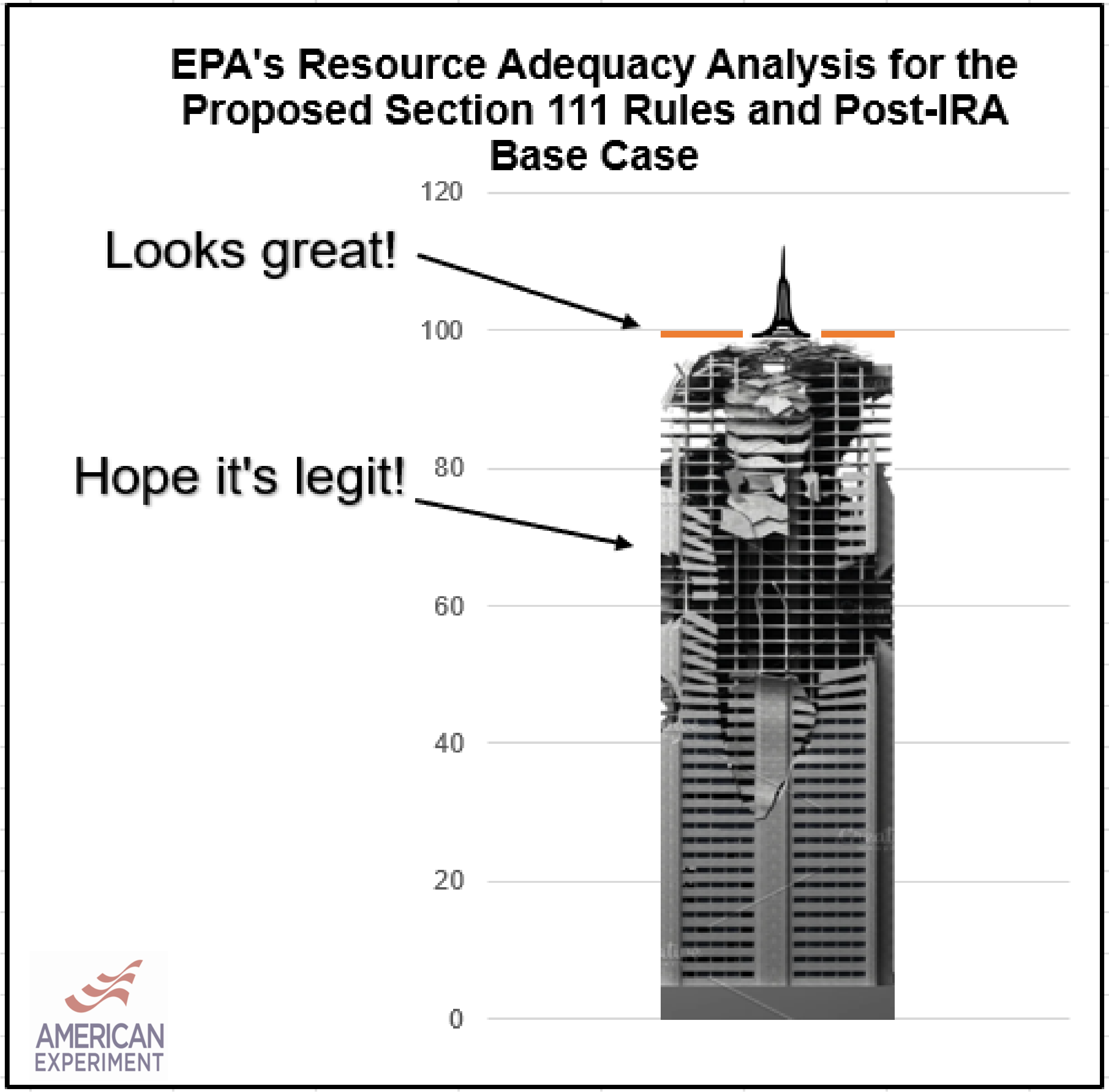
"In this framework, we emphasize the incremental changes in the power system that are projected to occur under the presence of the rules in the 2030, 2035 and 2040 model run years."

Table 1. Operational Capacity Summary (2030, 2035, 2040)[a]

Capacity (GW)	2030	2035	2040
Base Case Operational Capacity	1,338	1,632	1,908
Minus Retirements			
Coal	0.4	-22.2	-17.0
Oil/Gas	-0.5	-0.3	-0.3
NGCC	-0.1	0.0	0.0
NGCT	-0.3	-0.2	-0.2
Nuclear	0.0	0.0	0.0
Plus Additions			
NGCC	3.5	1.0	1.1
NGCT	0.3	23.1	18.2
Wind	0.4	2.0	-0.2
Solar	0.7	0.4	-1.0
Storage	-0.1	-2.2	-2.1
Other	0.0	0.0	0.0
Policy Case Operational Capacity	1,342	1,633	1,906

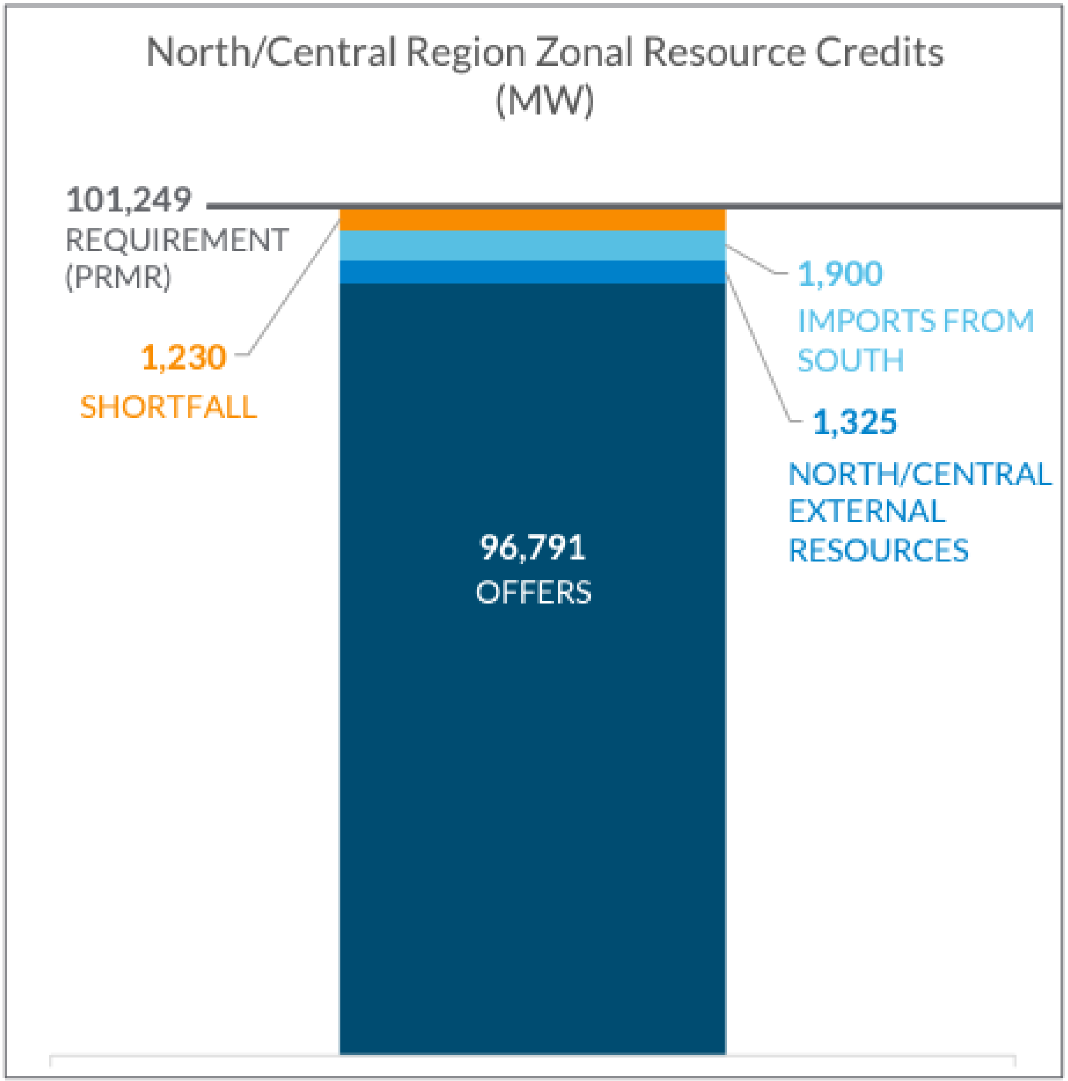
EPA Narrowly Tailors its Resource Adequacy Assessment

- EPA's decision to narrowly tailor the resource adequacy analysis to only study the difference between the proposed rule and the Post-IRA base case is like studying the structural integrity of the top floor of a 100-story building without doing so for the preceding 99 floors.



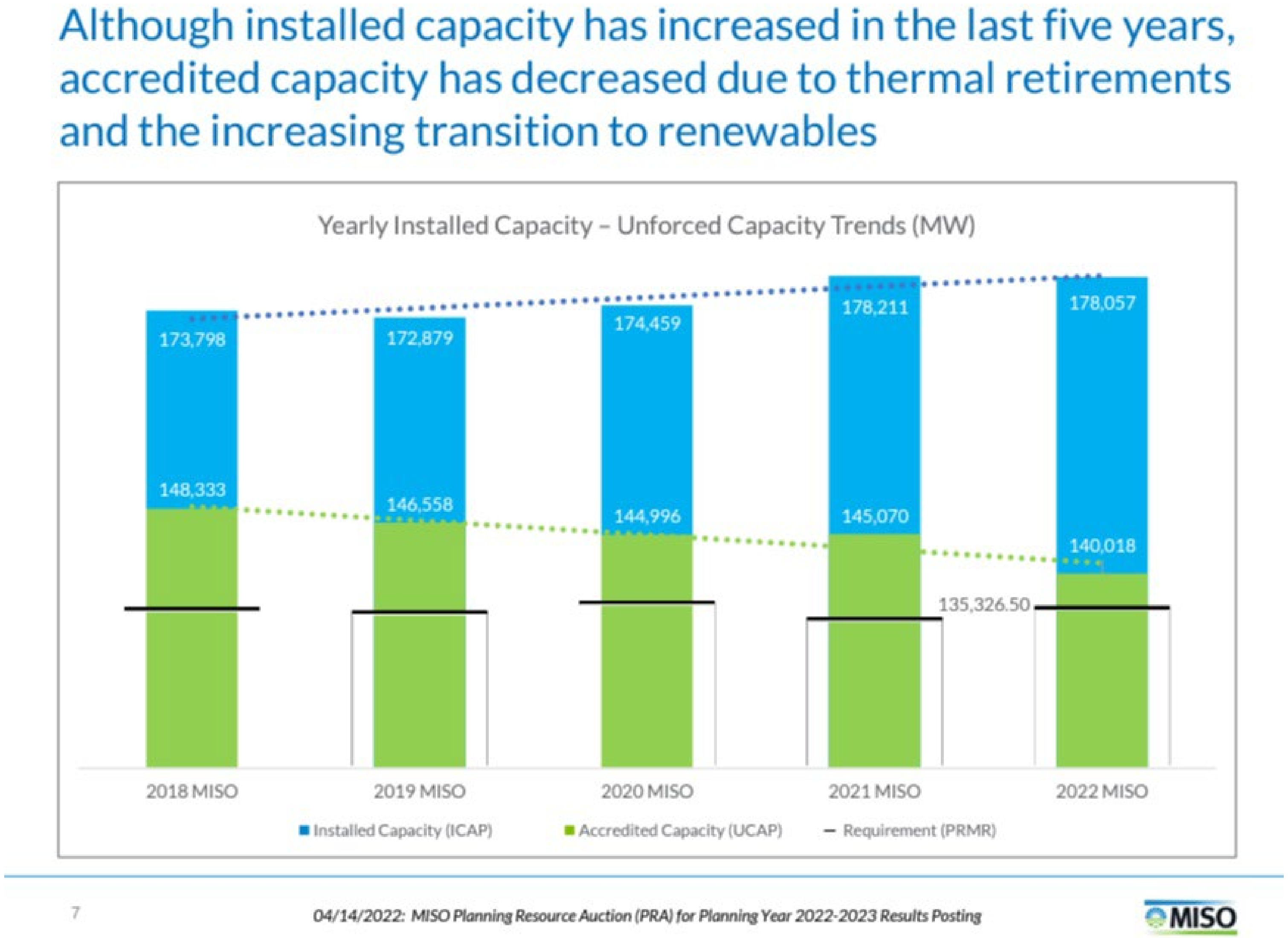
Why Do We Care About MISO Resource Adequacy?

- MISO resource adequacy is challenged by a changing energy mix.
  - MISO had a 1,200 MW capacity shortfall from the Planning Reserve Margin (PRM) in the summer of 2022.
- Planned retirements and additions show a continued decline in thermal generation and an increase in weather-dependent renewables.
- Given these trends, there is critical need to assess short term reliability risks to the MISO region.



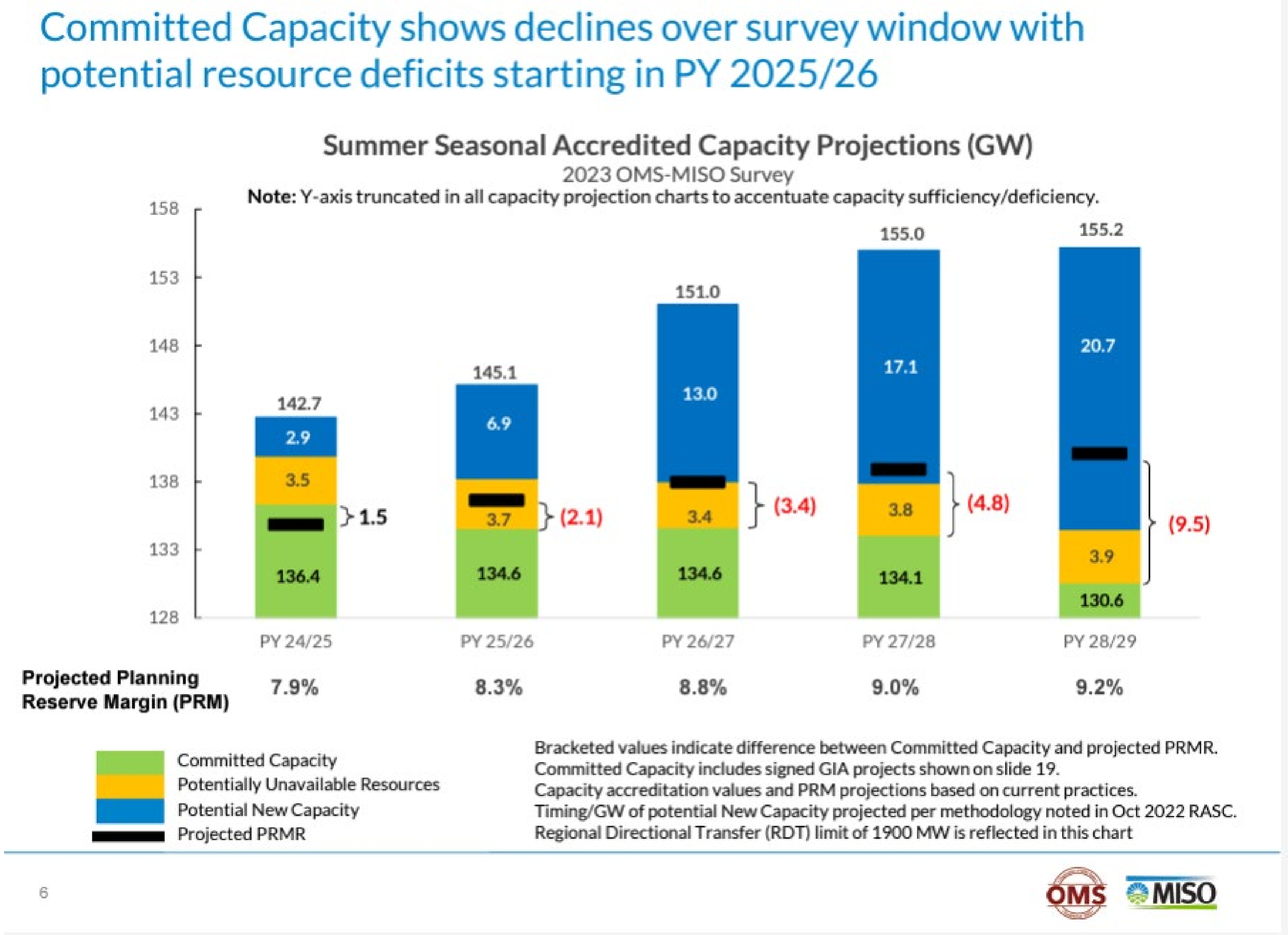
More Total Capacity, Less Accredited Capacity

- The total amount of installed nameplate capacity (ICAP) on the MISO system continues to grow, but the accredited capacity (UCAP) has fallen as a result of coal and some nuclear retirements.
- Source: [MISO 2022/2023 Planning Resource Auction (PRA) Results]



MISO Projects Future Capacity Shortages

- MISO/OMS survey projects a 1,500 MW surplus for Planning Year 2024-2025 because coal retirements have been delayed.
- Without continuation of such actions, a capacity deficit of 2,100 MW is projected for the summer of 2025/26 which grows in subsequent years.
- By PY28/29, MISO could have a 9.5 GW capacity shortfall.
- Source: [2023 OMS/MISO Survey Results](#).

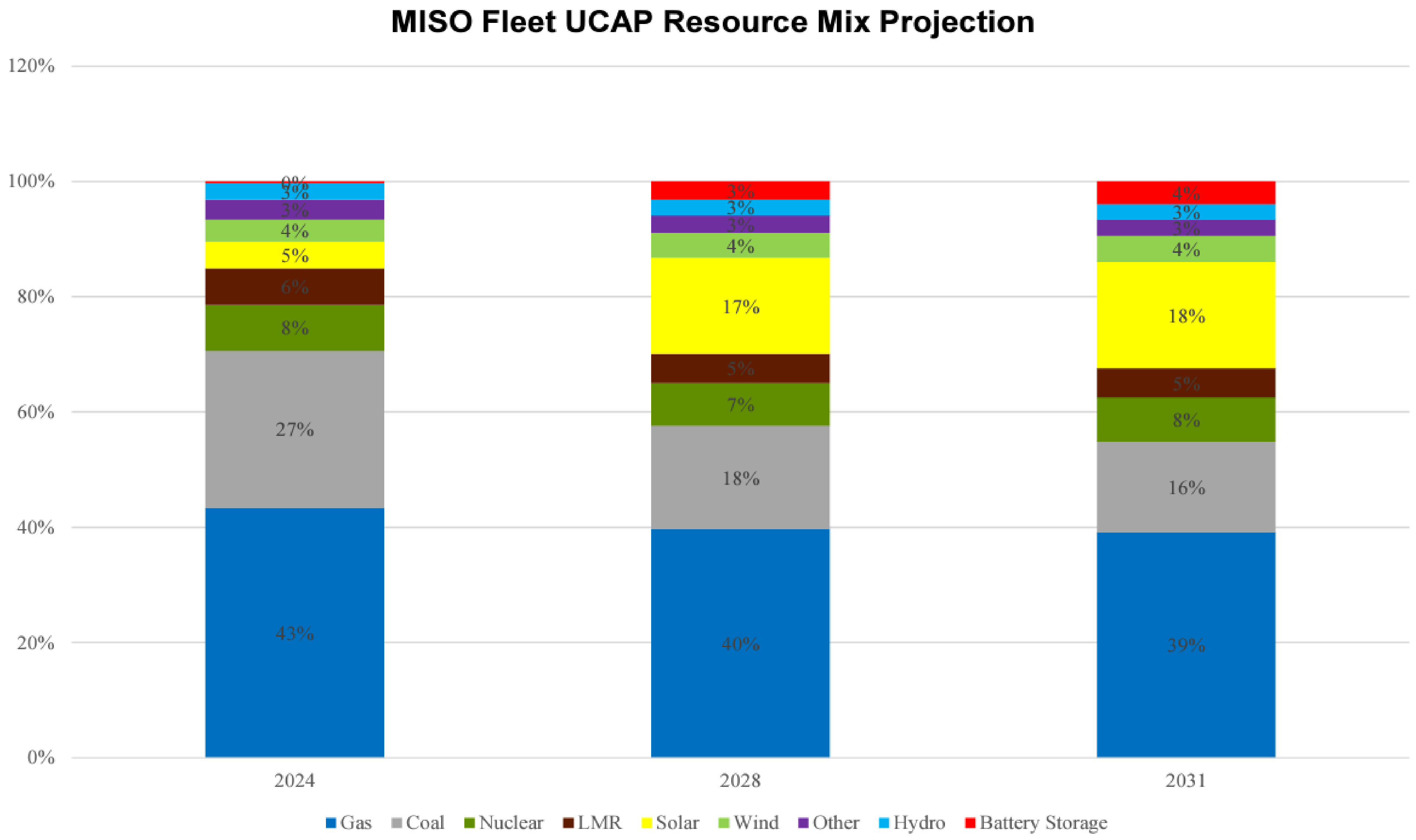


MISO's Current UCAP Capacity Mix

- MISO's current UCAP mix is largely natural gas, coal, nuclear, and demand response with wind and solar constituting 8 percent of the UCAP.
- UCAP is based on MISO's cleared capacity at auction, which is capacity that MISO can reliably call upon and is less than total installed capacity on MISO's grid.
- This mix will change rapidly moving forward due to state policies, utility decisions, IRA subsidies, and the proposed Section 111 rules.

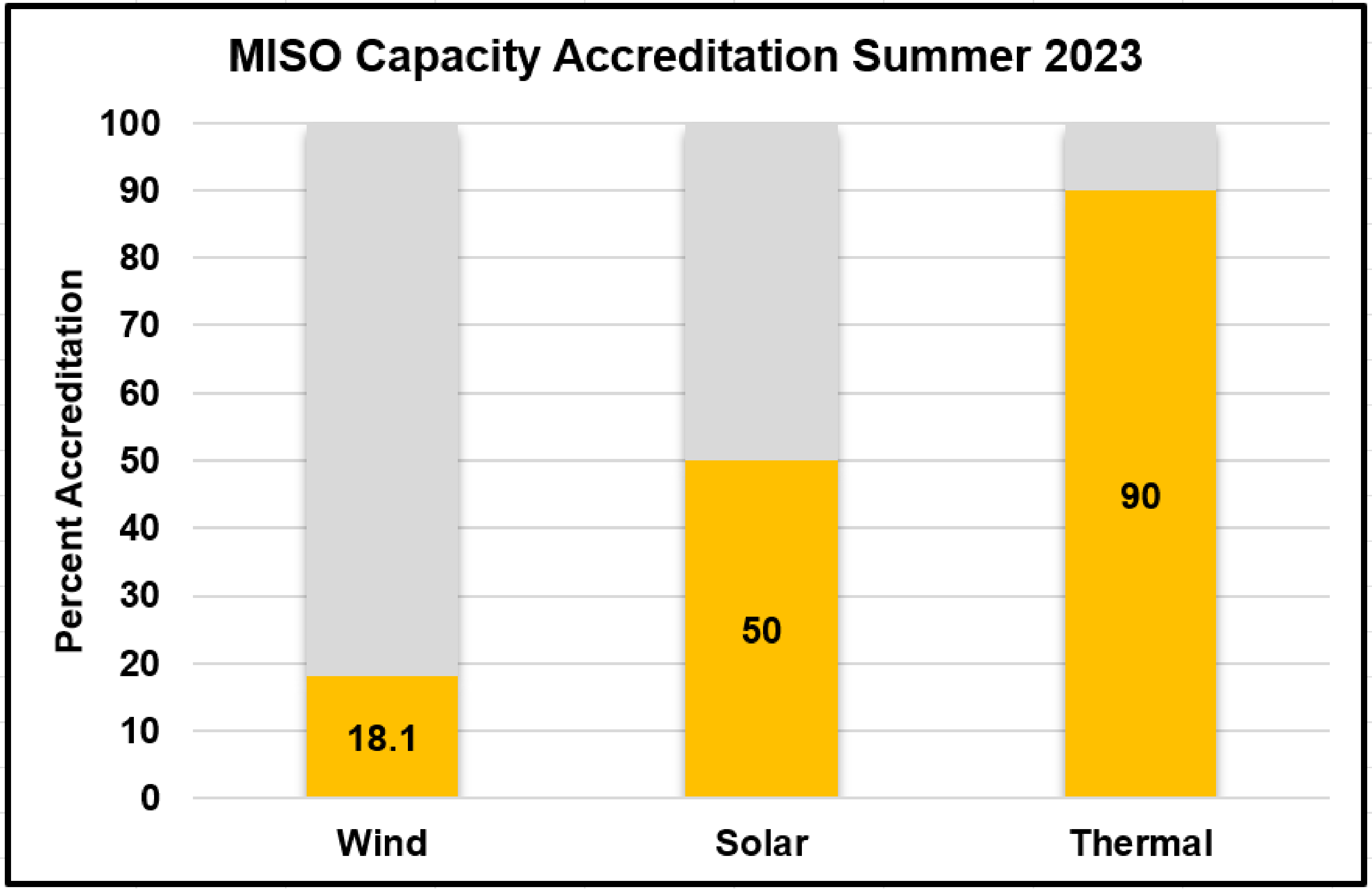
Resources	GW	Percent UCAP
Coal	37	28%
Gas	56	42%
Nuclear	11	9%
Demand Response	8	6%
Hydroelectric	7	5%
Oil	4	3%
Wind	5	4%
Solar	3	2%
Misc.	2	2%

MISO Sees Growing Solar and Wind in Capacity Stack, But It Is Still Counting on Significant MW of Coal Through 2031

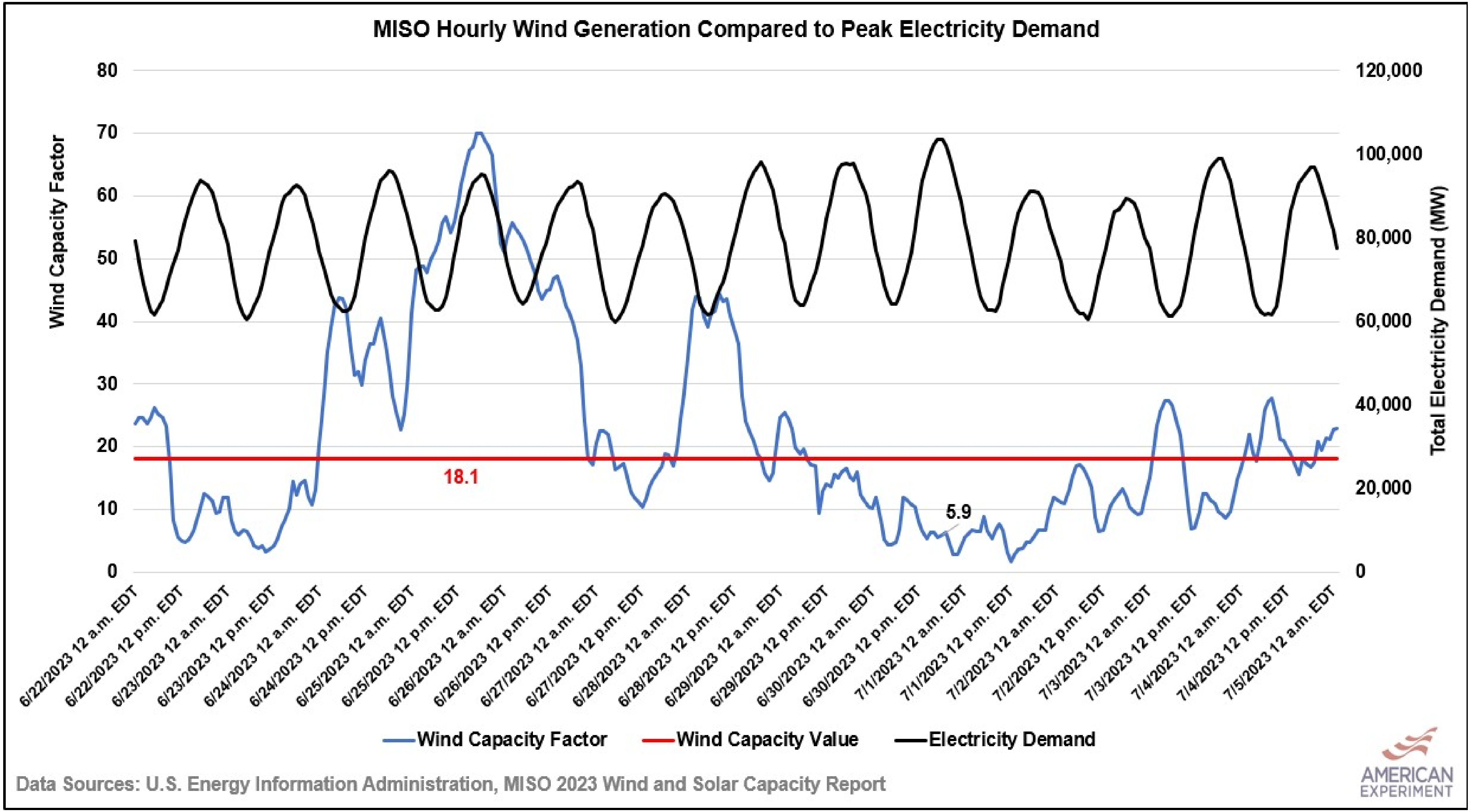


MISO’s Accreditation Methods and “Phantom Firm” Resources

- The previous slides may ***overstate*** the amount of UCAP that will be on the system due to MISO's capacity accreditation method for wind and solar.
- Wind is assumed to produce 18.1% of potential output during summer peak hours and new solar was expected to produce 50% for the first year in operation.
- However, wind and solar routinely underperform accreditation causing “Phantom Firm” resources to potentially enter into capacity auctions and the PRM capacity stack.
- This could give grid operators a false sense of security when it comes to reliability.



UCAP Underperformance is Not Uncommon



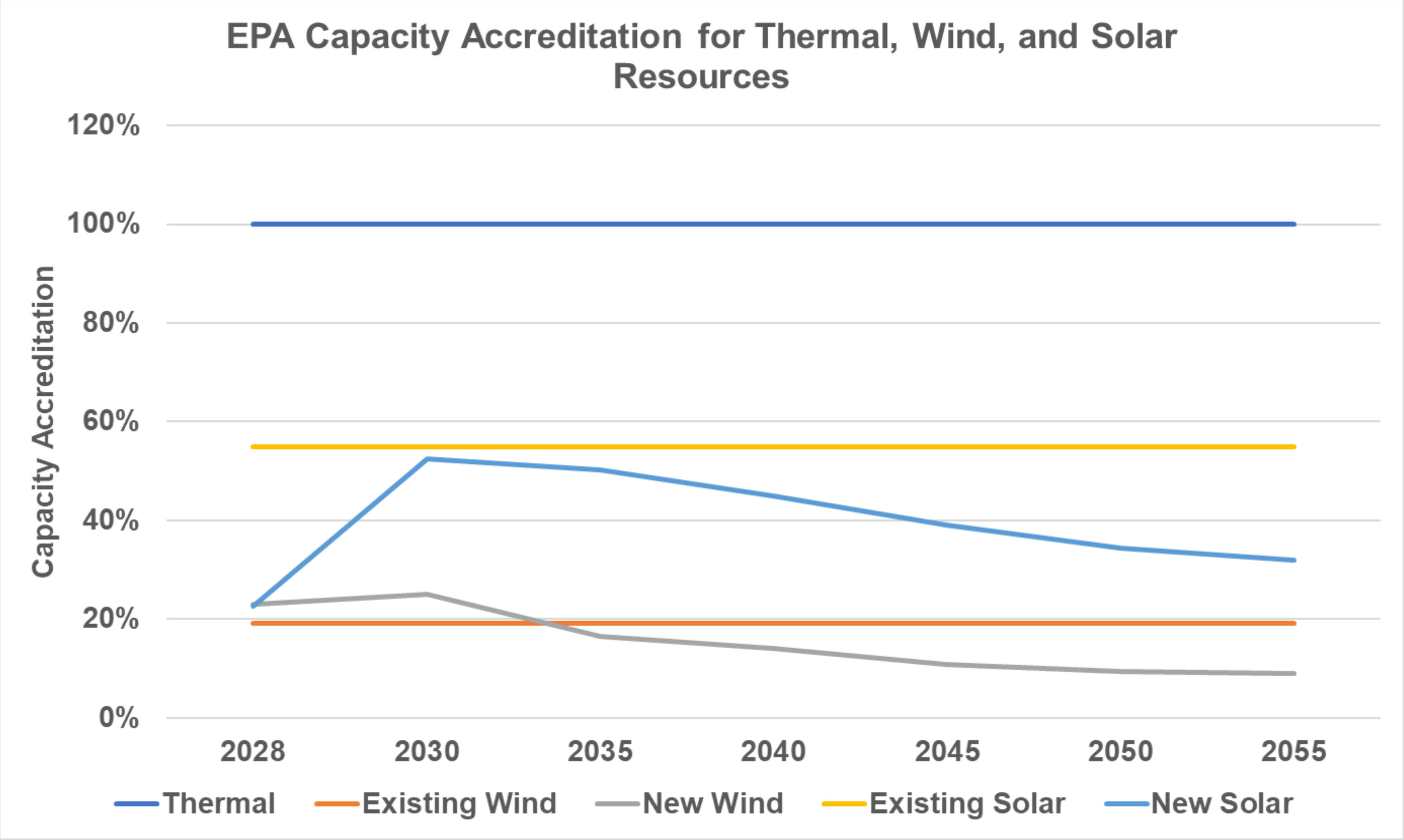
Resource Accreditation Under EPA's Proposal

- According to the Resource Adequacy Technical Support Document, EPAs Integrated Planning Model (IPM) selects resources using a target reserve margin in each region as the basis for determining how much accredited capacity (UCAP) to keep operational (or build) to preserve resource adequacy.
- Capacity accreditation is assumed to be 100 percent for thermal resources, and variable technologies (primarily wind and solar) receive region-specific capacity credits to help meet target reserve margin constraints. Due to their variability, resources such as wind and solar received a derate relative to the nameplate capacity when solving for reserve margin.
- EPA has **NOT** conducted a resource adequacy or reliability analysis on its Post-IRA base case, which is a large oversight.

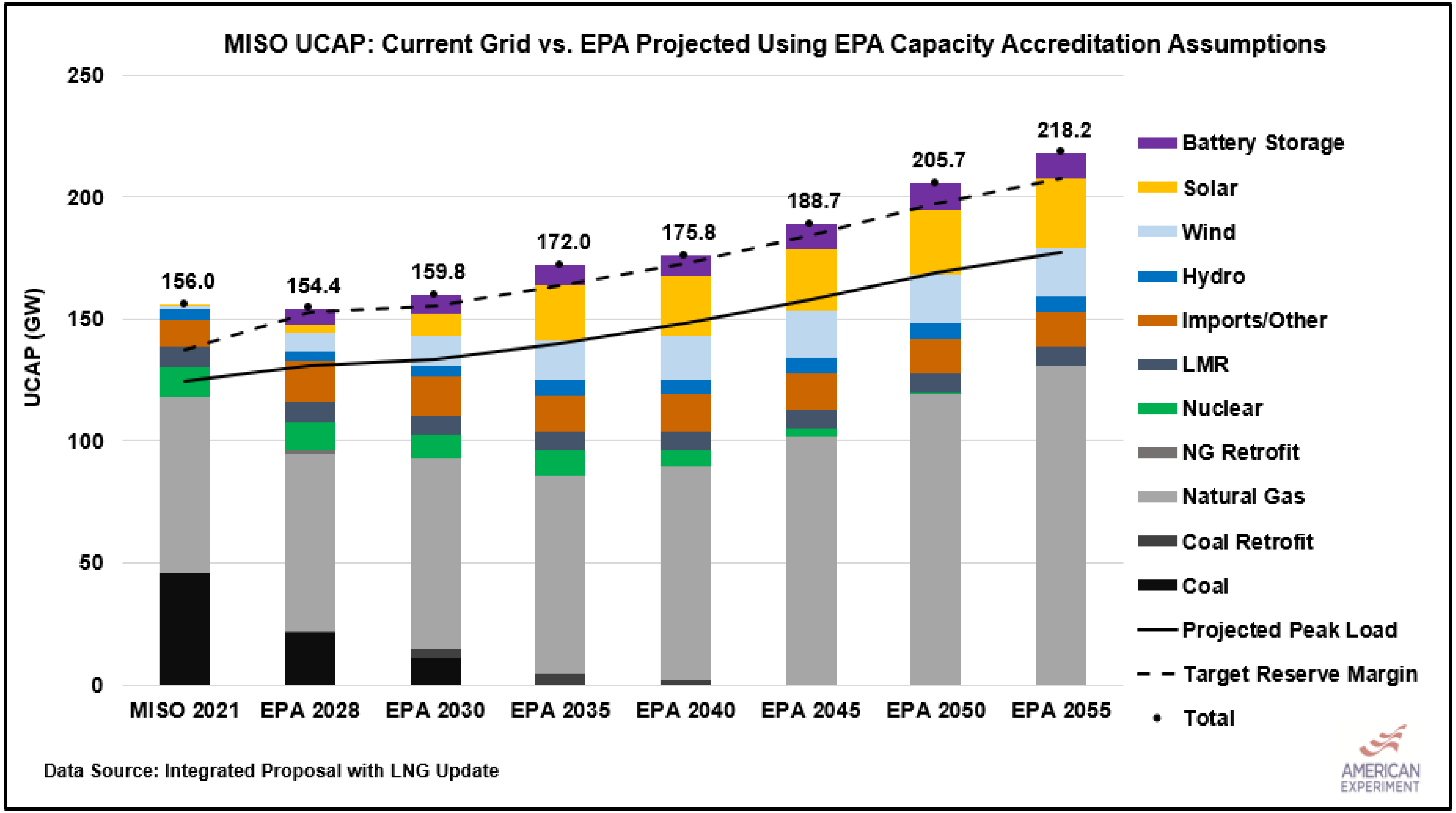
EPA's Proposed 111 Regulations	
Resource	EPA's Capacity Accreditation in MISO
Existing Onshore Wind	19%
Existing Solar	55%
New Onshore Wind	9%-25%
New Solar	32%-52%
Existing Thermal	100%
Existing Hydro	56%
New Hydro	65%
Existing Energy Storage	48%
Pumped Storage	95%
New Battery Storage	100%

EPA's Yearly Capacity Values

- EPA assumes thermal resources maintain a constant 100% accreditation throughout the model run.
- Existing wind and solar resources maintain a constant accreditation of 19% and 55%, respectively.
- New wind and solar resources experience declining capacity values as the penetration of intermittent resources increases over time.



EPA's Modeled Portfolio in MISO Under the Proposed 111 Rules Relies on Wind, Solar, and Storage to Peak Demand and Reserve Margins



Year	Reserve Margin
2022	25.6%
2028	**18.2%**
2030	**19.9%**
2035	**22.2%**
2040	**18.7%**
2045	**19.3%**
2050	**21.7%**
2055	**22.9%**

Estimated firm capacity using EPA's accreditation values for wind, solar, storage (100%), and thermal resources (100%). EPA assumes a 16.8 percent reserve margin. Different than MISO cleared UCAP (unforced [accredited] capacity). Red indicates intermittent generation is necessary to meet Target Reserve Margins.

Resource Adequacy Takeaways

- EPA relies on wind, solar, and battery storage to meet its peak demand and target reserve margin in 2028.
- From 2030 and beyond, EPA relies on wind, solar, and battery storage to meet peak electricity demand.
- This **<u>will result in rolling blackouts</u>** if wind and solar are not performing at their capacity accreditation metrics.

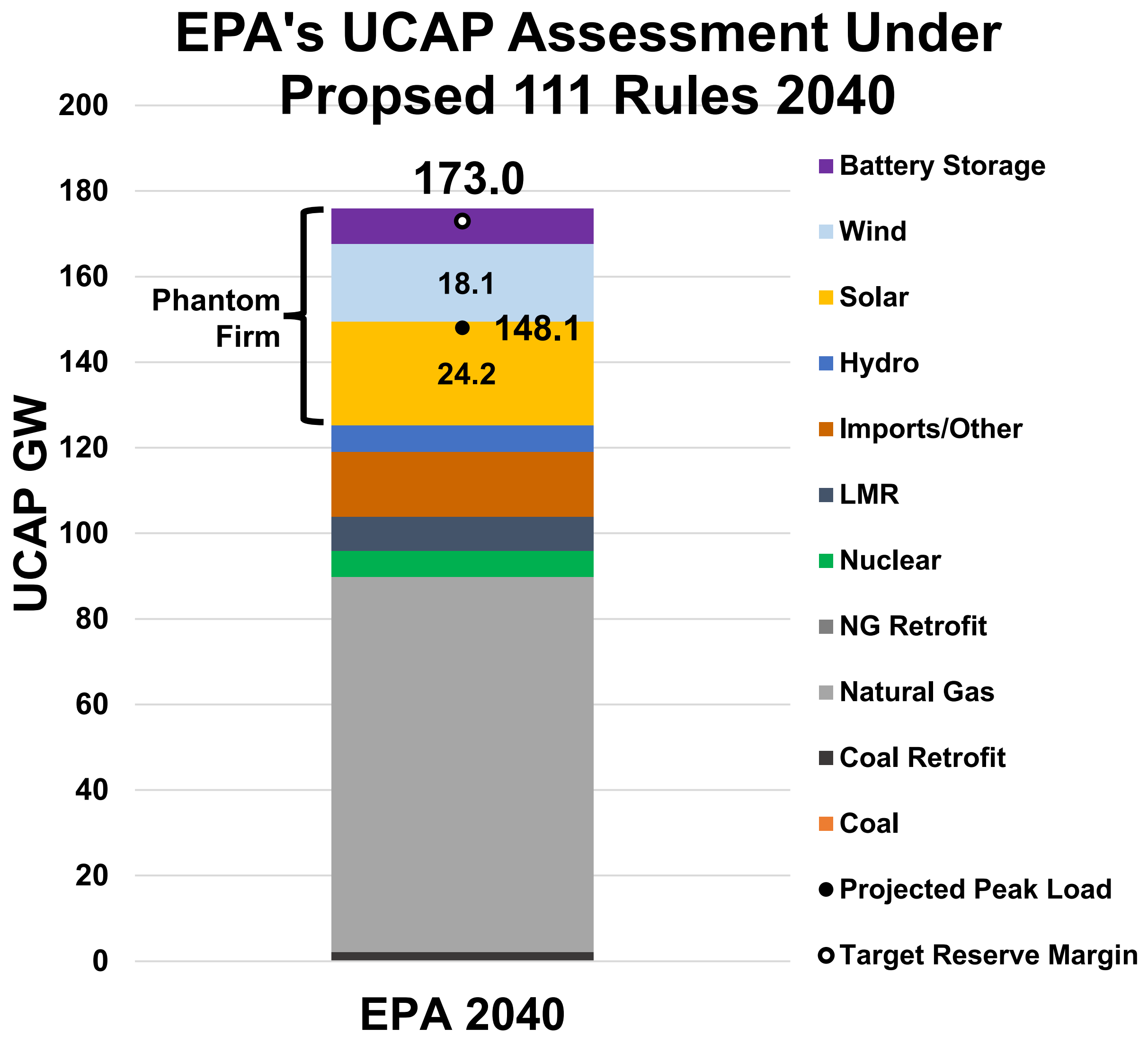
Reliability

EPA Distinguishes Between Resource Adequacy and Reliability

- EPA distinguishes between resource adequacy and reliability in its Resource Adequacy Technical Support Document:
  - "As used here, the term **resource adequacy** is defined as the provision of adequate generating resources to meet projected load and generating reserve requirements in each power region, while **reliability** includes the ability to deliver the resources to the loads, such that the overall power grid remains stable." **[emphasis added].**
  - "**This document is meant to serve as a resource adequacy assessment** of the impacts of the final rule and how projected outcomes under the final rule **compare with projected baseline outcomes in the presence of the IRA." [emphasis added].**
- EPA's definition of reliability is critically important because the deliverability of electricity was not analyzed by the agency in its modeling. EPA goes on to say that "resource adequacy … is necessary (but not sufficient) for grid reliability."

Reliability Under EPA's Proposal

- Resource Adequacy and reserve margin analyses can be useful tools for determining resource adequacy and reliability, but **the shift away from dispatchable thermal resources toward intermittent wind and solar generators increases the complexity and uncertainty in these analyses** and makes them increasingly dependent on the quality of the assumptions used to construct capacity accreditations.
- As the grid becomes more reliant upon variable generators, it is crucial to "stress test" the assumptions used to create capacity accreditations by performing an hourly reliability analysis that accounts for fluctuations in electricity demand, and hourly variation in wind and solar capacity factors.
- EPA has **NOT** conducted a reliability analysis on its modeled grid to stress test their post IRA-Base Case assumptions.

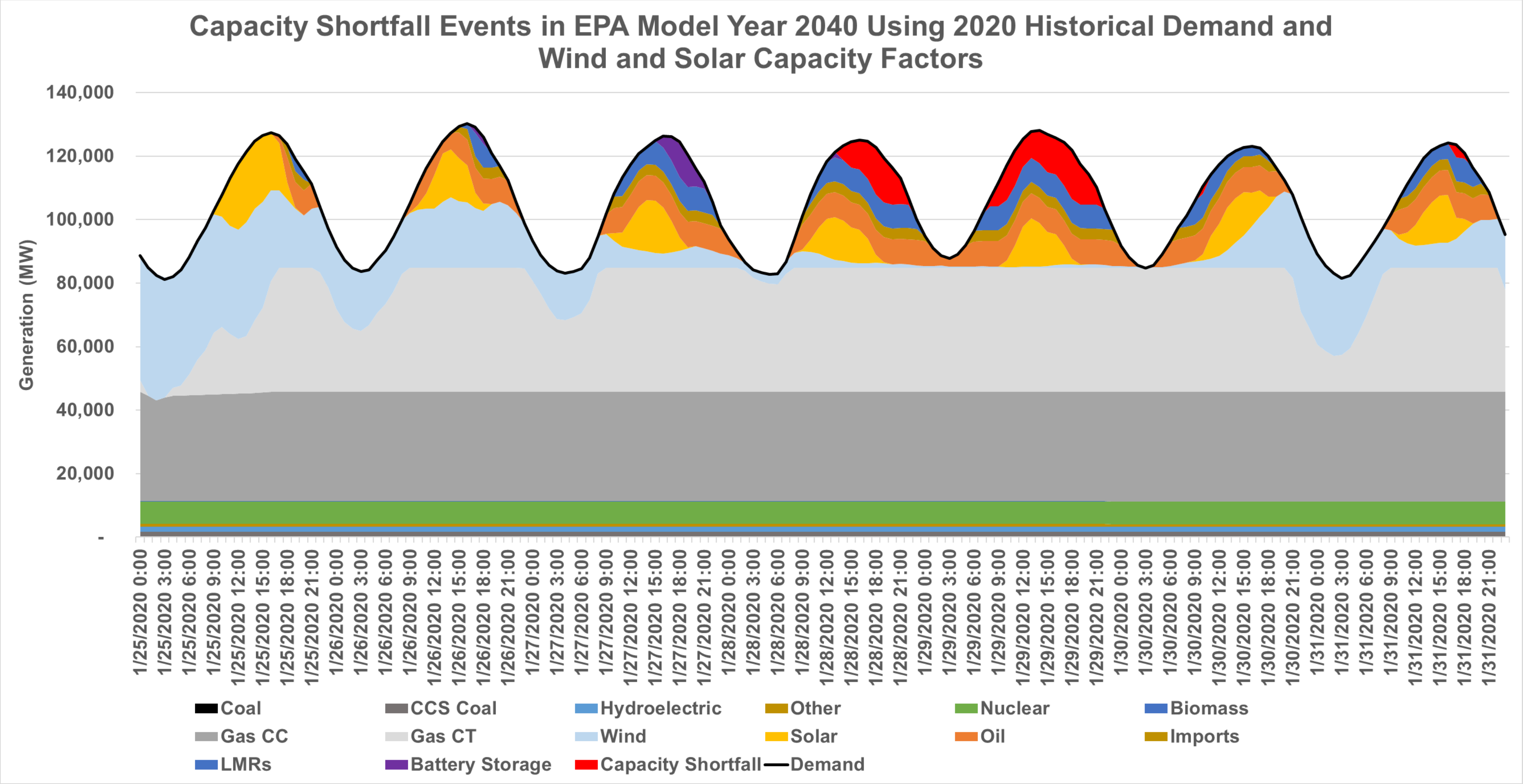


Assessing Reliability Under EPA's Proposal

- American Experiment conducted a reliability analysis on EPA's modeled generation portfolio in the MISO region under the proposed Section 111 rules by using EPA's installed capacity assumptions from the Integrated Proposal with LNG Update.
- The analysis was conducted by comparing EPA's modeled generation portfolio to the historical hourly electricity demand and hourly capacity factors for wind and solar in 2019, 2020, 2021, and 2022 to assess whether the installed resources would be able to serve load for all hours in each Historic Comparison Year (HCY).
- Hourly demand and wind and solar capacity factors were adjusted upward to meet EPA's peak load, annual generation, and capacity factor assumptions.
  - This assumption is generous to EPA because it increases the annual output of wind and solar generators to levels that are not generally observed in MISO.
  - Additionally, other policies pursued by the EPA may increase peak load even further, but this additional load was not studied in this analysis.
- Will EPA's modeled grid be able to meet demand based on these observed, real-life model inputs?

EPA's Modeled Generation Portfolio Cannot Reliably Meet Electricity Demand

- EPA's modeled generation mix cannot prevent blackouts while hindcasting observed historical conditions. Therefore, we should have no confidence in its assurances that it will have no impact on future electric reliability.



Assessing Reliability Under EPA's Proposal

- EPA's modeled MISO grid cannot keep the lights on.
- Our model observed a total of 607 hours of capacity shortfalls in the modeled years.
- In no year that EPA modeled was the modeled grid able to maintain reliability for the entirety of the four years of historical data used.

Historical Comparison Year	Number of Hours of Capacity Shortfalls (Total Hours of Blackouts)						
	2028	2030	2035	2040	2045	2050	2055
2019	12	43	70	79	40	22	8
2020	0	0	20	29	21	15	7
2021	14	24	37	40	30	22	16
2022	9	18	15	16	0	0	0

Assessing Total Blackout Hours in EPA's Modeled Proposal

- EPA's modeled grids experienced over 7 million megawatt hours (MWh) of shortfalls in the EPA modeled years.
- For example, our analysis found EPA's modeled grid would result in over 1.4 million MWhs of shortfalls using 2019 historical data and EPA modeled capacity in 2040.

Historical Comparison Year	Megawatt Hours of Unserved Load						
	2028	2030	2035	2040	2045	2050	2055
2019	56,235	201,102	507,873	1,488,223	890,790	519,640	314,825
2020	0	0	131,763	234,407	167,052	89,840	37,191
2021	92,736	205,888	450,108	526,546	394,755	283,706	210,027
2022	20,216	73,362	65,507	74,128	0	0	0

Assessing the Social Cost of Blackouts

- Using the modeled hours of capacity shortfalls, American Experiment calculated the “Social Cost of Blackouts,” based on the theory of Value of Lost Load (VoLL). We estimated capacity shortfalls cost $14,250 per MWh.
- For example, our analysis found EPA’s modeled grid would result in $57 billion in blackout costs in the seven model years examined using 2019 hourly electricity demand, and hourly wind and solar capacity factors.

Historical Comparison Year	Value of Lost Load							
	2028	2030	2035	2040	2045	2050	2055	Total
2019	$801,348,750	$2,865,703,500	$7,237,190,250	$21,207,177,750	$12,693,757,500	$7,404,870,000	$4,486,256,250	$56,696,304,000
2020	$0	$0	$1,877,622,750	$3,340,299,750	$2,380,491,000	$1,280,220,000	$529,971,750	$9,408,605,250
2021	$1,321,488,000	$2,933,904,000	$6,414,039,000	$7,503,280,500	$5,625,258,750	$4,042,810,500	$2,992,884,750	$30,833,665,500
2022	$288,078,000	$1,045,408,500	$933,474,750	$1,056,324,000	$0	$0	$0	$3,323,285,250

Assessing the Duration of Blackouts Under EPA's Proposal

- EPA modeled capacity would result in a 9 to 15 hour blackout event in each of the modeled years, depending on the historical year studied.
- For example, our analysis found EPA's modeled grid would result in a multiple 15-hour shortfall events in 2040 and multiple 14- hour shortfall events in 2035, 2040, 2045, and 2050.

Historical Comparison Year	Longest Duration Blackout (Hours)						
	2028	2030	2035	2040	2045	2050	2055
2019	9	11	14	15	14	14	13
2020	0	0	13	14	14	13	7
2021	9	11	14	15	14	14	13
2022	7	8	4	4	0	0	0

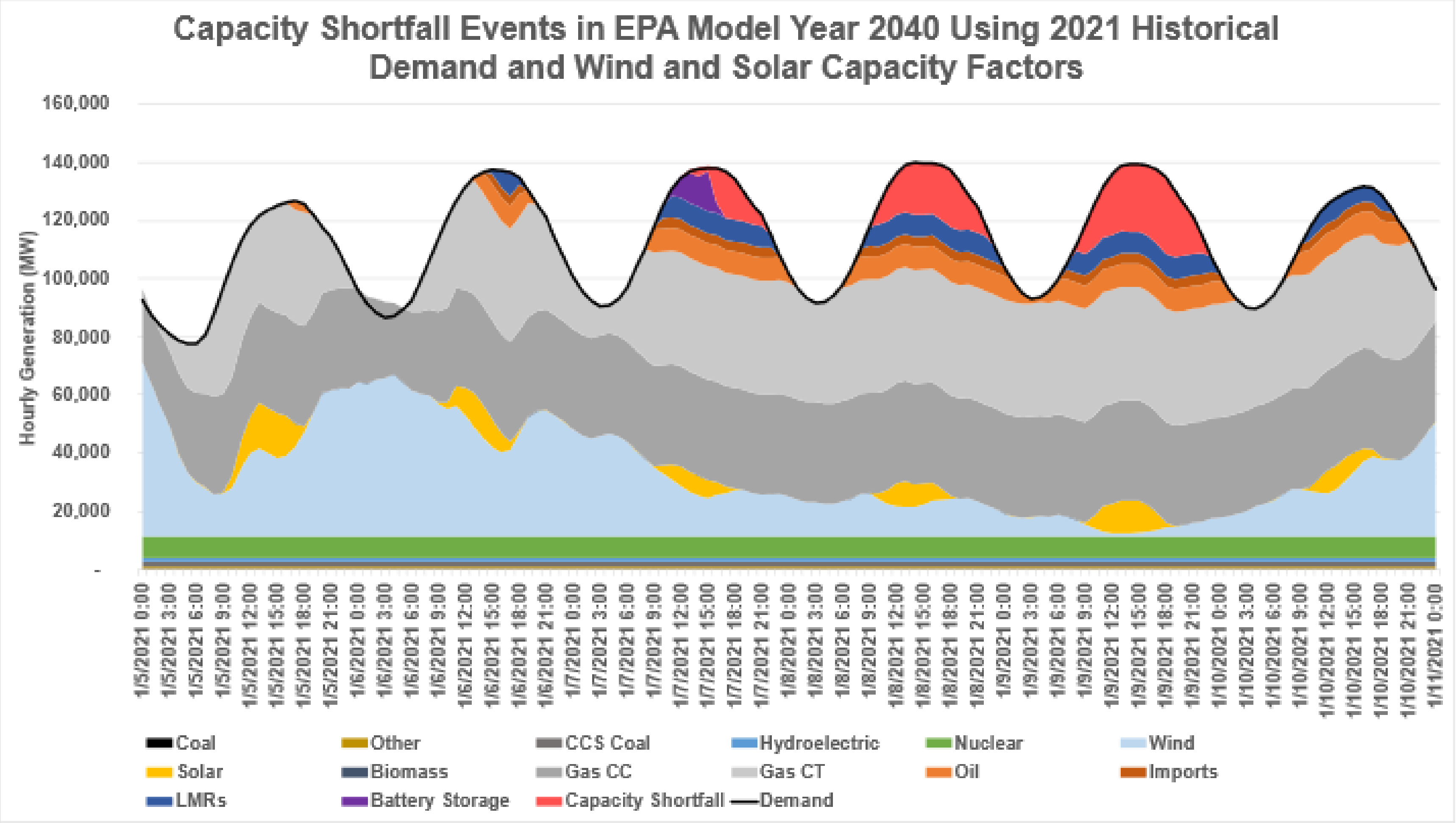
Assessing Severity of the Blackouts

- Our model observed a maximum shortfall event of anywhere from 9,200 to 26,350 MW in each of the modeled years using EPA modeled capacity.
- For example, our analysis found EPA's modeled grid would result in a shortfall of over 26 GW in 2040 and 2045 using 2021 historical data, which is 17.5% of EPA's projected peak load in 2040.

Historical Comparison Year	**Severity of Worst Blackout (MW)**						
	2028	2030	2035	2040	2045	2050	2055
2019	7,966	12,330	20,253	24,273	23,730	22,382	20,956
2020	0	0	11,261	15,279	14,959	13,130	11,185
2021	9,204	13,444	21,976	26,351	26,147	24,917	23,563
2022	4,169	8,392	11,348	12,843	0	0	0

Assessing Severity of the Blackouts

- The worst capacity shortfall is a 26 GW capacity shortfall that would occur in January 2040 using the 2021 HCY, accounting for 19.5 percent of the electricity demand at the time of the shortfall.
- This is the equivalent of needing to implement a blackout 12 minutes out of every hour.



Why do the Blackouts Occur?

- **Blackouts occur for several reasons**:

1. EPA assumes the base case scenario is adequate and reliable and adjusts the proposal scenario accordingly. This assumption could not be more wrong.
2. EPA is relying on variable wind and solar resources to meet its resource adequacy needs, but these generators frequently underperform their capacity accreditations, leaving the system short of energy.
3. EPA resource adequacy capacity accreditation values are hardly seen in the real-world by Regional Transmission Organizations (RTOs). For example, EPA uses 100 percent accreditation for thermal resources, compared to historical values of 80-90 percent by RTOs. Additionally, EPA uses different accreditation values for existing renewables and new renewables, whereas regional grids generally accredit these resources together.
4. EPA assumptions resulted in overestimating reliable capacity on the grid.
5. Shoring up EPA's grid requires building more capacity using reasonable capacity accreditations for all resources, especially wind and solar.

Reliability Takeaways

- According to the preamble to the proposed rule, “EPA has carefully considered the importance of resource adequacy and grid reliability in developing these proposals and is confident that these proposed rules and emission guidelines … can be successfully implemented in a manner that preserves the ability of power companies and grid operators to maintain the reliability of the nation’s electric power system.”
- EPA claims that its modeled resource portfolio will maintain resource adequacy and reliability out to 2055, but it cannot even reliably meet electricity demand while hindcasting the resource portfolio in MISO for any of the four previous years (2019, 2020, 2021, 2022).
- In order to claim the proposal can reliably serve load, EPA should have actually tested the reliability of the modeled grid.

Creating Reasonable Capacity Accreditation Metrics

Using More Realistic Capacity Accreditation Methods to Improve Resource Adequacy, Reliability, and Cost Measures

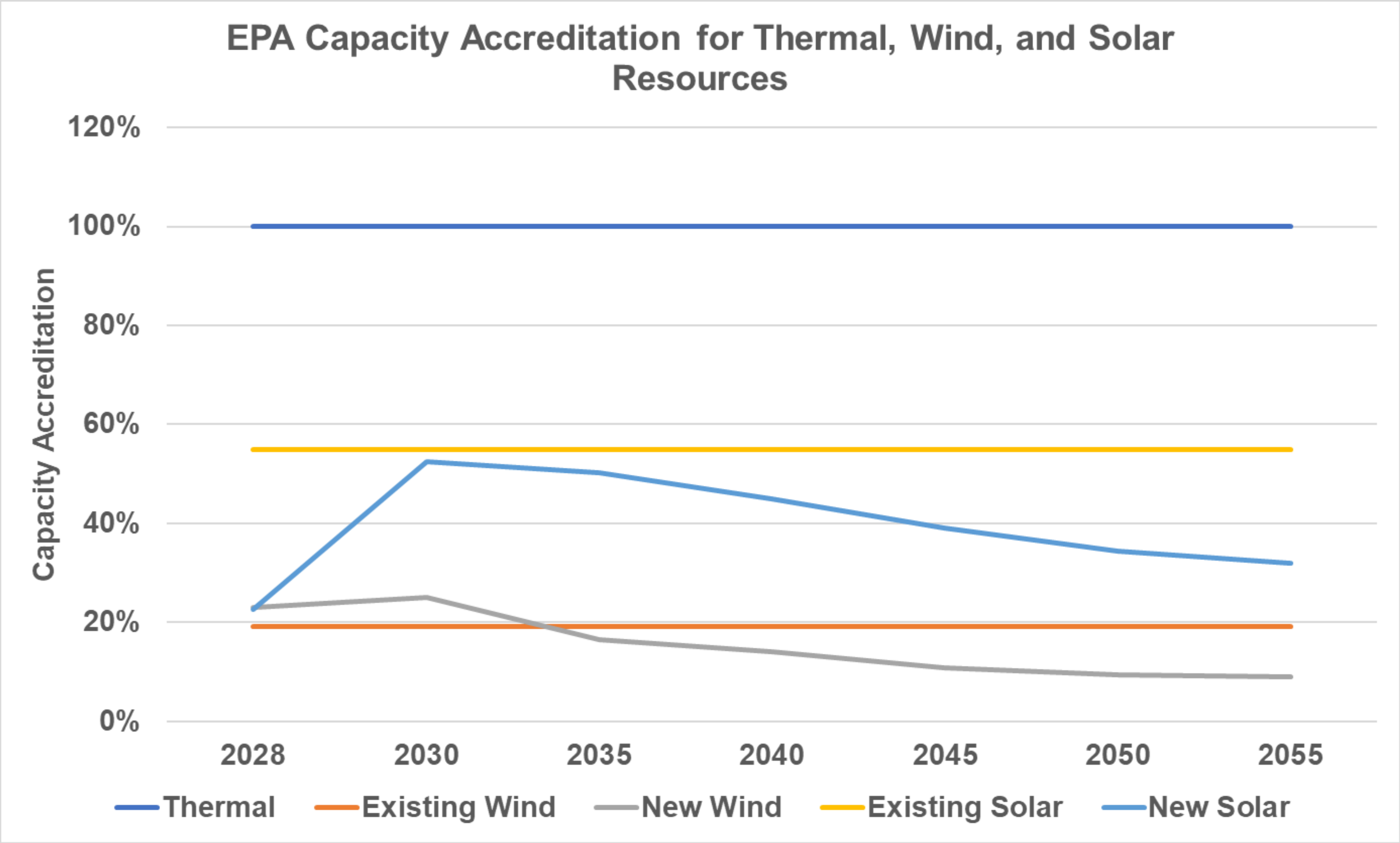
- EPA's accreditation for onshore wind and solar (both new and existing) are too high, which results in "Phantom Firm" resources in the capacity stack.
- This allows EPA's projected MISO grid to meet its reserve margin and resource adequacy criteria on paper, but not reality.
- More realistic capacity accreditation will increase the quality of resource adequacy calculations, the reliability of the system, and allow for a calculation of the true cost of EPA's proposed rules.

EPA's Accreditation Values for Wind and Solar Are Too High

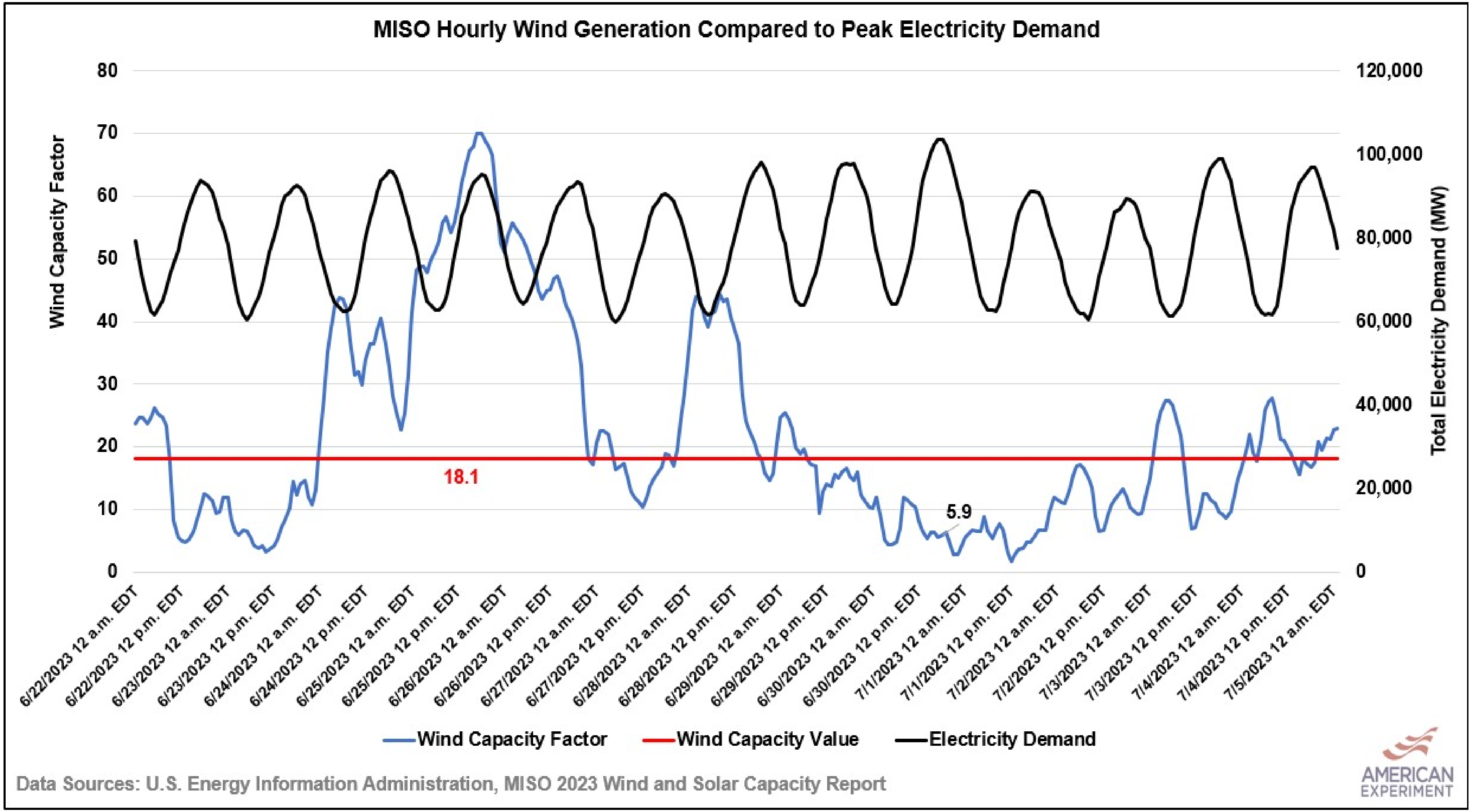
- EPA's accreditation for onshore wind and solar (both new and existing) are too high.
- For example, MISO gives existing wind and solar a
- EPA's decision to give different values to new and existing wind and solar doesn't make sense.

EPA's Proposed 111 Regulations	
Resource	EPA's Capacity Accreditation in MISO
Existing Onshore Wind	19%
Existing Solar	55%
New Onshore Wind	9%-25%
New Solar	32%-52%
Existing Thermal	100%
Existing Hydro	56%
New Hydro	65%
Existing Energy Storage	48%
Pumped Storage	95%
New Battery Storage	100%

EPA's Yearly Capacity Values



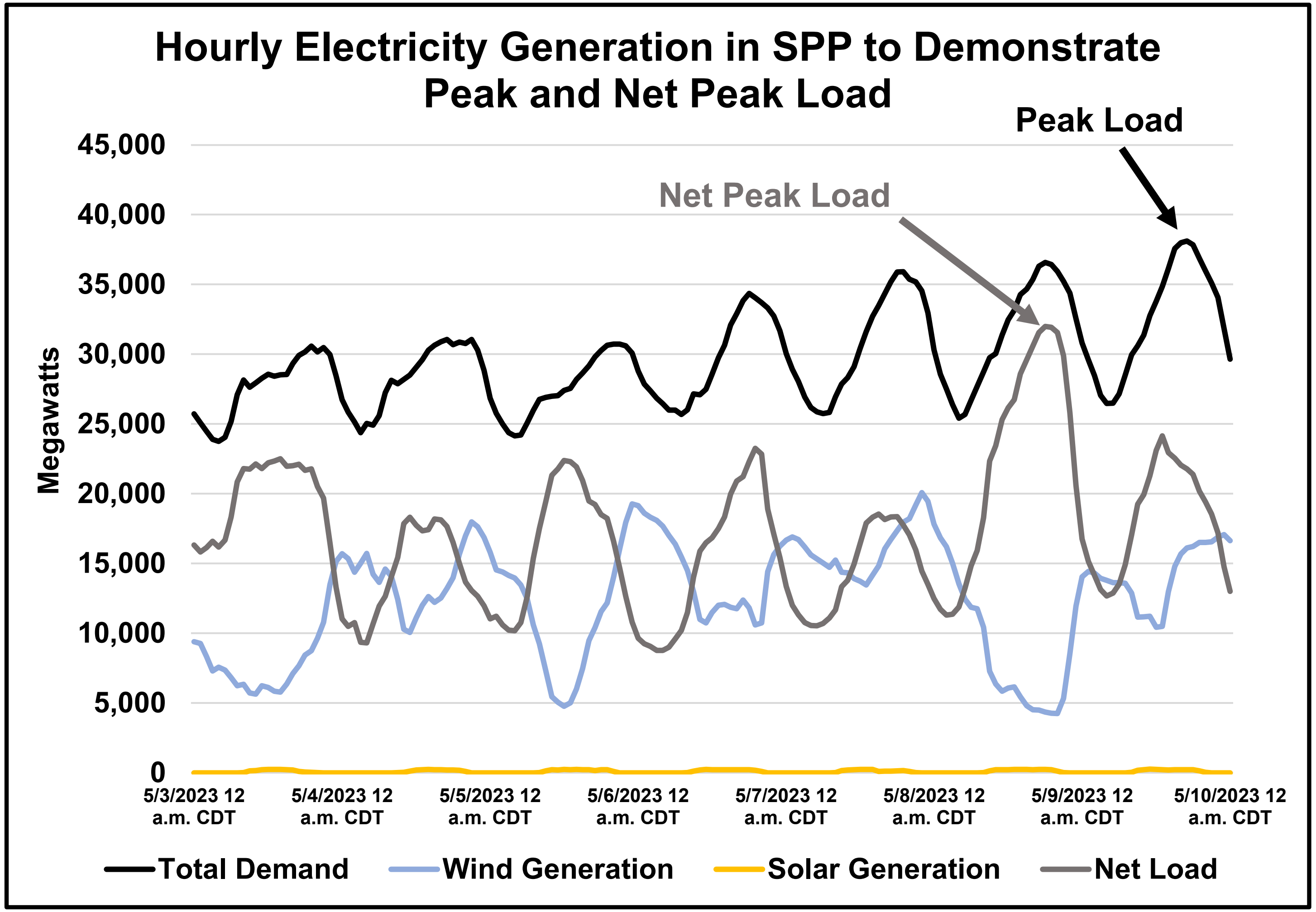
Unreasonably High Capacity Values Can Result in Energy Shortfalls



Creating Reasonable Accreditation Values for Wind and Solar

Assess wind and solar variability during peak load and net peak load hours

- As electric grids experience rising penetrations of intermittent resources, meeting ***net*** peak load will become increasingly challenging.
- **Peak Load:** The hours with the highest electricity demand.
- **Net peak load:** Gross demand minus wind and solar generation, which allows us to assess the highest demand hours where wind and solar output is the lowest.
- This is the standard new wind and solar resources should be judged by going forward.



Methodology- Developing a Standardized Capacity Accreditation for Renewable Resources

Assess wind and solar variability during peak load and net peak load hours.

- Used the last 4 years of data from EIA Hourly Grid Monitor and Form 923. Peak and net peak occurred on July 19, 2019, and August 25, 2021, respectively.
- Highest Certainty Deliverability (HCD) to assess wind and solar accreditation.
  - Sample size of 2,000 hours for wind & solar of the highest peak & net peak hours across 4 years.
  - Took the mean of the lowest 25 percent of wind and solar output during those hours to determine our accredited capacity values for peak and net peak.
- Using this methodology, we developed peak capacity and net peak capacity values for wind and solar.

	Peak Accreditation	Net Peak Accreditation
Wind	7.1%	5.8%
Solar	12.4%	12.0%

Comparing Highest Certainty Deliverability (HCD) Accreditation to the EPA's Capacity Accreditation

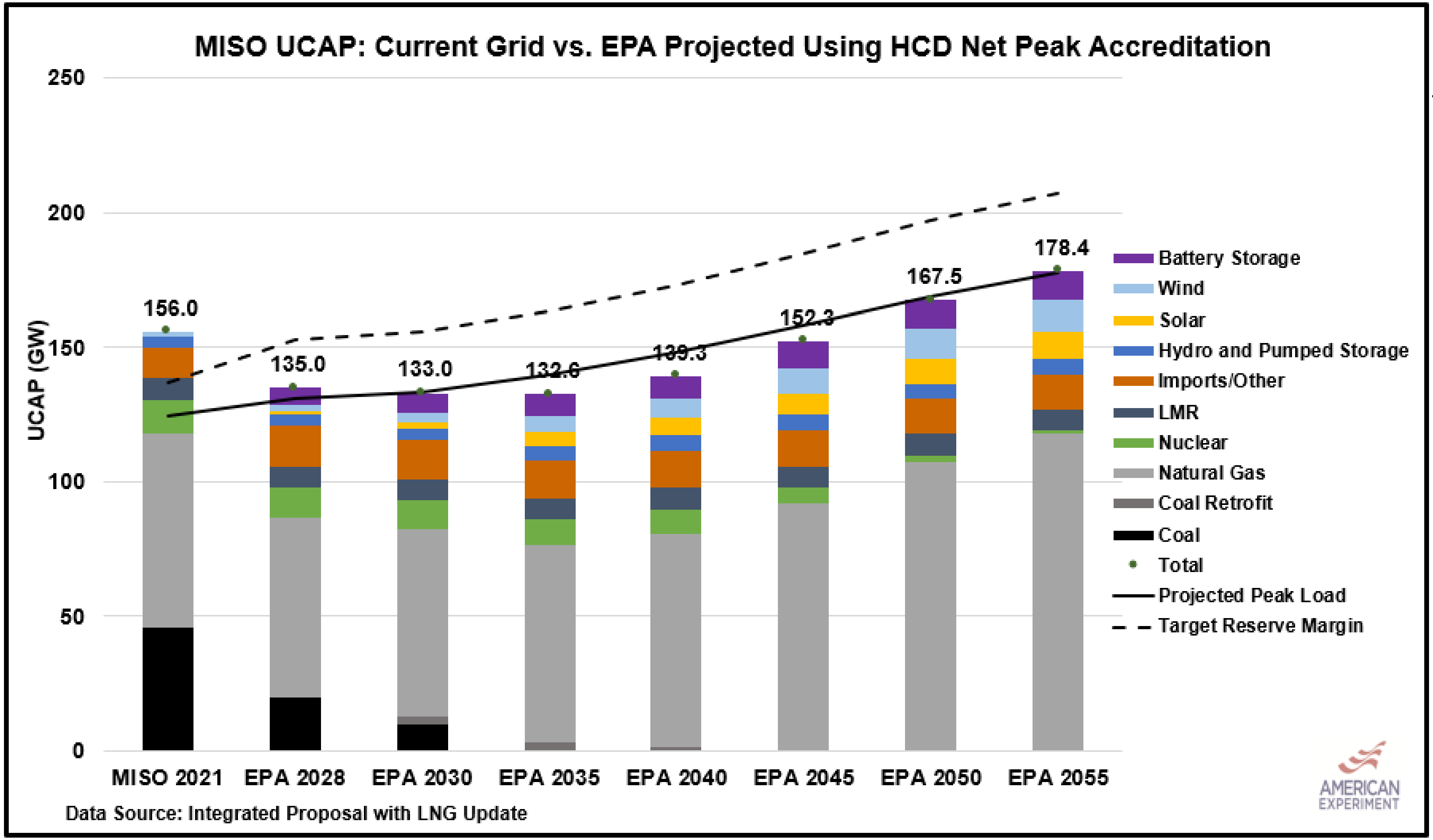
HCD APPROACH

Highest Certainty Deliverability		
Resouce	**Peak Accreditation**	**Net Peak Accreditation**
Wind	7.1%	5.8%
Solar	12.4%	12.0%
Battery Storage	100.0%	100.0%
Thermal	90.0%	90.0%
Reserve Margin	16.8%	16.8%

EPA APPROACH

EPA's Proposed 111 Regulations	
Resource	EPA's Capacity Accreditation in MISO
Existing Onshore Wind	19%
Existing Solar	55%
New Onshore Wind	9%-25%
New Solar	32%-52%
Existing Thermal	100%
Existing Hydro	56%
New Hydro	65%
Existing Energy Storage	48%
Pumped Storage	95%
New Battery Storage	100%

EPA's Modeled MISO Grid Does Not Meet Resource Adequacy Targets Using Real-World Accreditation Metrics



Year	Reserve Margin
2022	25.6%
2028	3.3%
2030	-.2%
2035	-5.4%
2040	-5.9%
2045	-3.7%
2050	.9%
2055	.5%

Estimated firm capacity using HCD accreditation values for wind, solar, storage, and thermal resources. EPA assumes a 16.8 percent reserve margin. Different than MISO cleared UCAP (unforced [accredited] capacity). Red indicates intermittent generation is necessary to meet Target Reserve Margins.

Takeaways on Creating a Realistic Accreditation for Intermittent Renewable Resources

- Unrealistically optimistic resource accreditation for wind and solar leaves EPA with too many phantom firm resources and too few dispatchable power plants in its projected MISO grid under the proposed Section 111 rules.
- More realistic capacity accreditation indicates EPA needs significantly more capacity on the system to reliably meet electricity demand while meeting its proposed emissions targets.
- This additional capacity will be costly but necessary to meet electricity demand amidst modeled coal and natural gas retirements.

Calculating the True Cost of EPA's Proposed 111 Regulations

Calculating the Cost of Meeting EPA's Emissions Targets in the "Reliable 111 Rules" Scenario

EPA's modeled grid is so unreliable that it is not a realistic basis for understanding the financial impact of the proposed Section 111 rules.

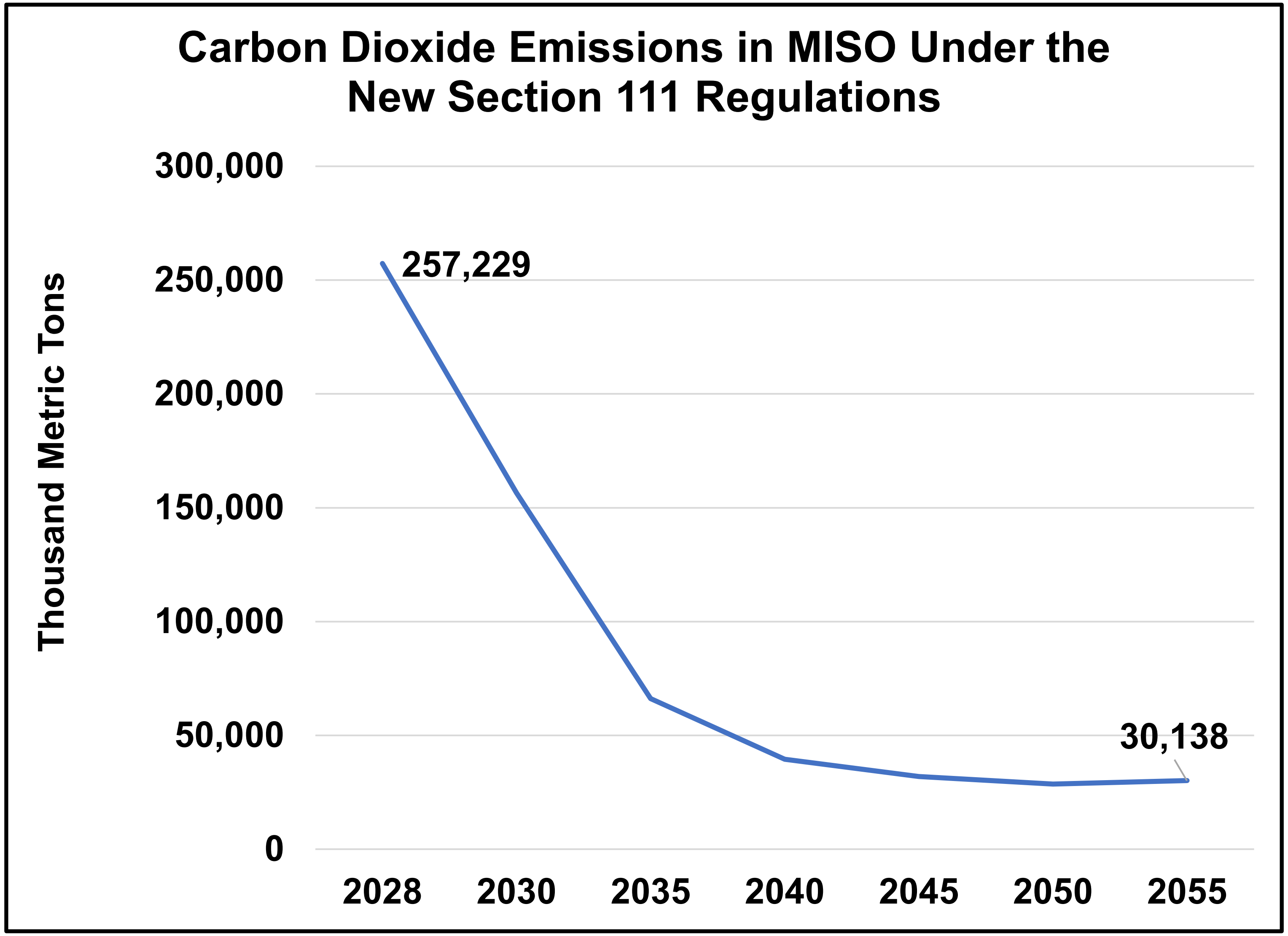
- EPA assumes its Post-IRA base case maintains resource adequacy and reliability, but EPA's modeled resource portfolio is not reliable, and does not meet resource adequacy targets when realistic capacity accreditation values for wind, solar, and thermal resources are used.
- Meeting EPA's modeled emissions reductions in MISO while maintaining reliability will require an extensive capacity buildout of additional wind, solar, battery storage, and CT gas plants to provide sufficient electricity during periods of low wind and solar generation.
- This capacity buildout in this "Reliable 111 Rules" Scenario will be expensive, drastically changing the cost estimate of complying with the rules.
- These costs must be fully understood to make a reasoned cost/benefit analysis of the proposed rules.

Reliability Criteria in the “Reliable 111 Rules” Scenario

- Evaluating the true cost of the EPA’s proposed Section 111 rules requires that its proposed grid meet electricity demand without rolling blackouts in the MISO region.
  - Solving for resource adequacy only, and not analyzing reliability, may be acceptable on a grid with sufficient dispatchable power plants. However, on grids that are heavily reliant on non-dispatchable, intermittent resources like wind and solar, traditional resource adequacy methods are not sufficient to maintain reliability because wind and solar may at times be performing below their accreditation values.
- American Experiment used the real-time hourly electricity demand and wind and solar capacity factors beginning January 1, 2019, and ran the model through December 31, 2022, requiring EPA’s modeled grid to meet electricity demand for every hour during this four-year period.
- Wind, solar, battery storage, and combustion turbine (CT) natural gas plants are added as needed to maintain reliability on the power grid during the model run.
- **NOTE:** These incremental capacity additions are on top of the capacity additions baked into the Updated Baseline with LNG Update base case and the Integrated Proposal with LNG Update and therefore constitute an additional cost relative to these modeled scenarios by EPA.

EPA's Emissions Estimates for MISO

- EPA assumes dramatic reductions in carbon dioxide emission in MISO during the modeled timeframe.
- Emissions fall from 257.2 million metric tons in 2028 to 30.1 million metric tons in 2055.
- Achieving these emissions reductions while maintaining reliability will require increasing the installed capacity of wind, solar, battery storage, and CT natural gas plants on the MISO system.



Methodology- Capacity Additions and Retirements in the Reliable 111 Rules Scenario

Assessment of the cost of meeting reliability and resource adequacy need through 2055.

- Used EPA's projected retirements and retrofits for coal, natural gas, and nuclear power plants in the Integrated Proposal with LNG Update in each model year.
- Assumed new capacity additions for wind, solar, battery storage, and CT natural gas plants are made as needed to ensure reliability in each of the target years.
- Additions occur in proportion to the UCAP capacity additions in EPA's Integrated Proposal with LNG Update. Net Peak HCD UCAP values are used for wind and solar resources.

Methodology- Capacity Additions and Retirements

Assessment of the cost of meeting reliability and resource adequacy needs through 2055 (cont'd)

- The replacement resource mix (the mix of wind, solar, battery storage, and CT natural gas added to replace retiring coal and natural gas power plants) is optimized for reliability, emissions targets, and cost.
  - The model also assumes all natural gas power plants will run below the thresholds requiring the use of CCS or co-firing green hydrogen.

Methodology- Cost

Assessment of the <u>retail</u> cost of replacing existing coal and natural gas resources with planned natural gas, wind, solar, and battery storage capacity.

Assumptions include:

- Capital costs based on weighted average of MISO regions in EIA's Assumptions to the Annual Energy Outlook Electricity Market Module.
- Rate of return assumption of 9.9 percent with debt/equity split of 48.92/51.08 based on the rate of return and debt/equity split of the ten-largest investor-owned utilities in MISO.
- Property tax costs of 1.3 percent of the rate base.
- Discount rate of 3.76.
- Transmission costs in accordance with the Electricity Futures Study published by the National Renewable Energy Laboratory and MISO's Transmission Cost Estimation Guide for MTEP22.
- Interconnection costs were determined by using the average cost of active projects at the point of interconnect, which is about $48,000 per MW of wind and solar installed.
- EPA's assumed natural gas fuel costs are used throughout the model run.

Capital Costs:
https://www.eia.gov/outlooks/aeo/assumptions/pdf/electricity.pdf

Reliable Section 111 Rules Scenario: Retirements (ICAP)

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Coal	0	0	(5,811)	(5,811)	(5,811)	(5,811)	(5,811)	(5,397)	(5,397)	(2,174)	(2,174)	(2,174)	(2,174)	(2,174)	0	0	0
Natural Gas (CC)	0	0	(247)	(247)	(247)	(247)	(247)	0	0	(200)	(200)	(200)	(200)	(200)	0	0	0
Natural Gas (CT)	0	0	(748)	(748)	(748)	(748)	(748)	(157)	(157)	0	0	0	0	0	(13)	(13)	(13)
Natural Gas (IC)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas (ST)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum	0	0	(2,414)	(2,414)	(2,414)	(2,414)	(2,414)	0	0	(101)	(101)	(101)	(101)	(101)	(3)	(3)	(3)
Nuclear	0	0	(285)	(285)	(285)	(285)	(285)	(296)	(296)	(244)	(244)	(244)	(244)	(244)	0	0	0
Wind	0	0	(1,215)	(1,215)	(1,215)	(1,215)	(1,215)	0	0	0	0	0	0	0	0	0	0
Solar	0	0	(40)	(40)	(40)	(40)	(40)	0	0	0	0	0	0	0	0	0	0
Biomass	0	0	(245)	(245)	(245)	(245)	(245)	(5)	(5)	0	0	0	0	0	0	0	0
Storage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	(283)	(283)	(119)	(119)	(119)	(119)	(119)	0	0	0

	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	Total
Coal	0	0	0	0	0	0	0	(8)	(8)	(8)	(8)	(8)	0	0	0	0	0	(50,757)
Natural Gas (CC)	0	0	(227)	(227)	(227)	(227)	(227)	0	0	0	0	0	0	0	0	0	0	(3,369)
Natural Gas (CT)	(13)	(13)	(612)	(612)	(612)	(612)	(612)	0	0	0	0	0	0	0	0	0	0	(7,180)
Natural Gas (IC)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas (ST)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum	(3)	(3)	0	0	0	0	0	(217)	(217)	(217)	(217)	(217)	0	0	0	0	0	(13,674)
Nuclear	0	0	(751)	(751)	(751)	(751)	(751)	(635)	(635)	(635)	(635)	(635)	(375)	(375)	(375)	(375)	(375)	(12,041)
Wind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(6,076)
Solar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(199)
Biomass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(1,233)
Storage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(1,160)

Reliable Section 111 Rules Scenario: Additions (ICAP)

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas (CC)	0.0	0.0	998.5	998.5	998.5	998.5	998.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas (CT)	0.0	0.0	4,305.2	4,305.2	4,305.2	4,305.2	4,305.2	2,550.0	2,550.0	2,523.7	2,523.7	2,523.7	2,523.7	2,523.7	1,596.5	1,596.5	1,596.5
Natural Gas (IC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas (ST)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Petroleum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hydroelectric	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nuclear SMR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Distributed Solar	0.0	0.0	563.0	563.0	563.0	563.0	563.0	179.4	179.4	173.8	173.8	173.8	173.8	173.8	221.2	221.2	221.2
Wind	0.0	0.0	8,363.2	8,363.2	8,363.2	8,363.2	8,363.2	18,430.5	18,430.5	9,137.0	9,137.0	9,137.0	9,137.0	9,137.0	7,451.1	7,451.1	7,451.1
Solar	0.0	0.0	3,722.8	3,722.8	3,722.8	3,722.8	3,722.8	9,092.4	9,092.4	5,814.3	5,814.3	5,814.3	5,814.3	5,711.7	2,734.5	2,734.5	2,734.5
Biomass	0.0	0.0	7.6	7.6	7.6	7.6	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Battery Storage	0.0	0.0	2,299.1	2,299.1	2,299.1	2,299.1	2,299.1	982.2	982.2	328.0	328.0	328.0	328.0	328.0	124.0	124.0	124.0

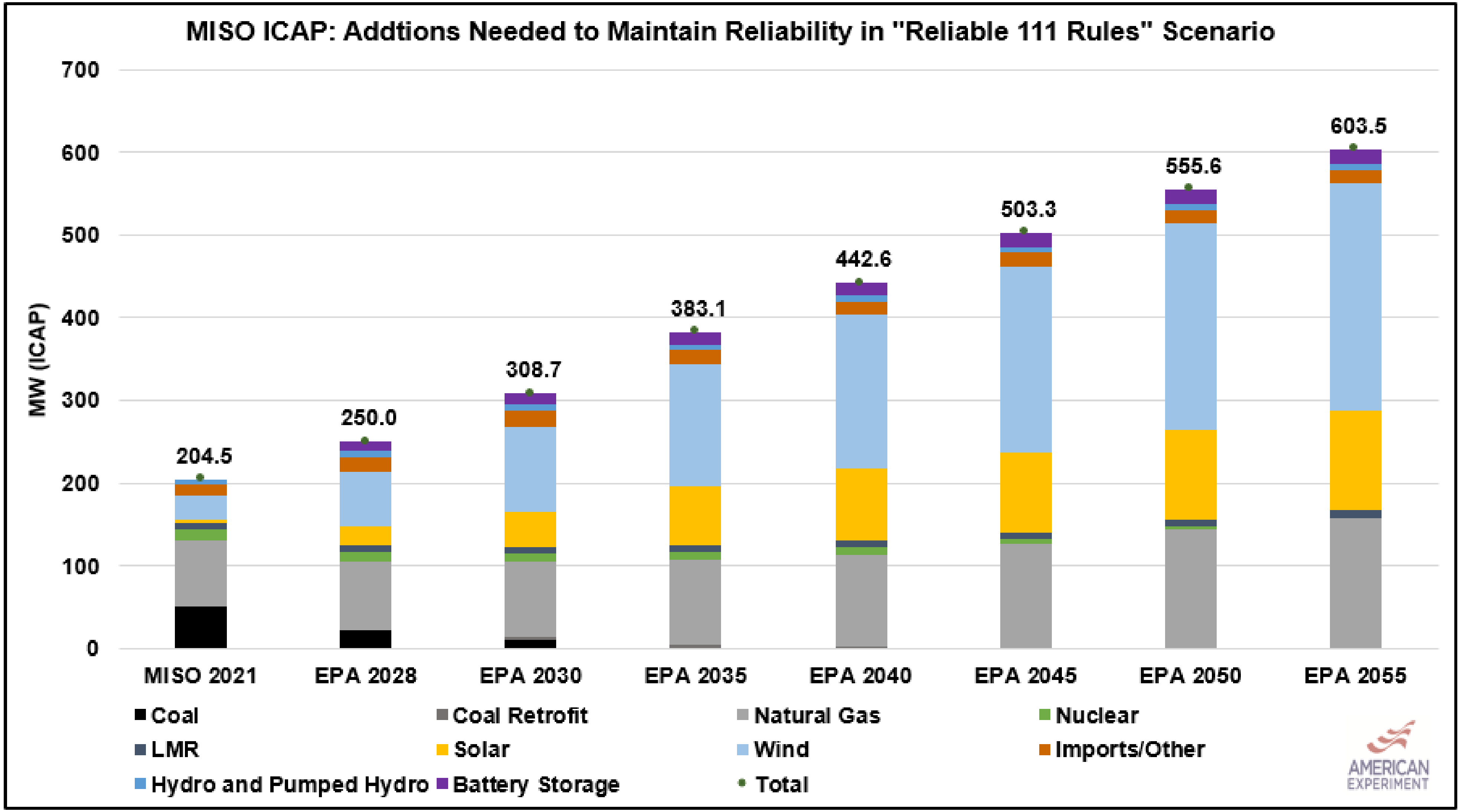
2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	Total
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,992.6
1,596.5	1,596.5	3,692.6	3,692.6	3,692.6	3,692.6	3,692.6	3,420.7	3,420.7	3,420.7	3,420.7	3,420.7	2,397.2	2,397.2	2,397.2	2,397.2	2,397.2	94,779.6
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
221.2	221.2	223.1	223.1	223.1	223.1	223.1	264.7	264.7	264.7	264.7	264.7	336.1	336.1	336.1	336.1	336.1	9,268.4
7,451.1	7,451.1	7,893.9	7,893.9	7,893.9	7,893.9	7,893.9	5,019.7	5,019.7	5,019.7	5,019.7	5,019.7	4,137.3	4,137.3	4,137.3	4,137.3	9,137.3	251,872.4
2,734.5	2,734.5	1,820.7	1,820.7	1,820.7	1,820.7	1,820.7	2,253.3	2,253.3	2,253.3	2,253.3	2,253.3	1,872.5	1,872.5	1,872.5	1,872.5	1,872.5	109,173.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.0

Reliable Section 111 Rules Scenario: Annual ICAP Mix (MW)

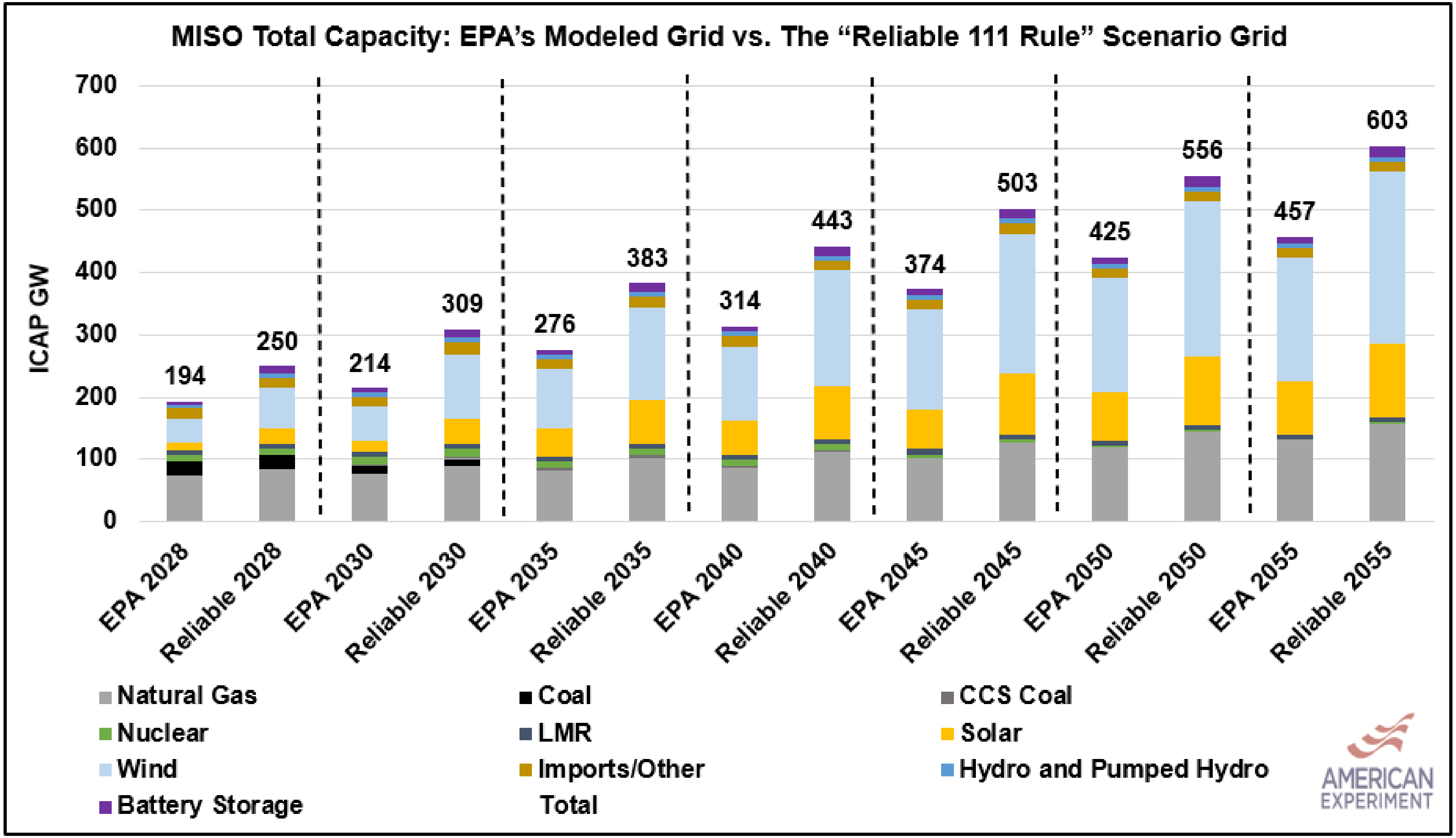
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Coal	50,772	50,772	44,961	39,151	33,340	27,529	21,719	16,322	10,925	8,751	6,576	4,402	2,228	54	54	54	54
Natural Gas (CC)	32,981	32,981	33,733	34,485	35,236	35,988	36,740	36,740	36,740	36,540	36,340	36,140	35,940	35,740	35,740	35,740	35,740
Natural Gas (CT)	29,570	29,570	33,126	36,683	40,240	43,797	47,353	49,747	52,140	54,664	57,188	59,712	62,235	64,759	66,342	67,926	69,509
Oil/Gas	22,145	22,145	19,731	17,316	14,902	12,488	10,073	10,073	10,073	9,972	9,871	9,770	9,669	9,568	9,566	9,563	9,561
Hydro & Pumped Storage	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962
Nuclear	13,026	13,026	12,741	12,456	12,171	11,886	11,601	11,304	11,008	10,764	10,520	10,276	10,032	9,788	9,788	9,788	9,788
Other	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120
Wind	30,340	30,340	37,488	44,636	51,784	58,932	66,080	84,510	102,941	112,078	121,215	130,352	139,489	148,626	156,077	163,528	170,979
Solar	1,997	1,997	6,243	10,489	14,735	18,981	23,227	32,498	41,770	47,758	53,746	59,735	65,723	71,608	74,564	77,520	80,475
Biomass	1,254	1,254	1,016	779	542	305	68	63	58	58	58	58	58	58	58	58	58
Storage	0	0	2,299	4,598	6,897	9,197	11,496	12,478	13,460	13,788	14,116	14,444	14,772	15,100	15,224	15,348	15,472
Total	192,166	192,166	201,421	210,675	219,929	229,184	238,438	263,818	289,198	304,456	319,713	334,971	350,229	365,384	377,495	389,607	401,719

	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	
Coal	54	54	54	54	54	54	54	46	38	31	23	15	15	15	15	15	15	0%
Natural Gas (CC)	35,740	35,740	35,513	35,286	35,059	34,832	34,605	34,605	34,605	34,605	34,605	34,605	34,605	34,605	34,605	34,605	34,605	6%
Natural Gas (CT)	71,093	72,676	75,757	78,838	81,918	84,999	88,080	91,501	94,921	98,342	101,763	105,183	107,581	109,978	112,375	114,772	117,170	20%
Oil/Gas	9,558	9,555	9,555	9,555	9,555	9,555	9,555	9,338	9,121	8,904	8,687	8,470	8,470	8,470	8,470	8,470	8,470	1%
Hydro & Pumped Storage	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962	6,962	1%
Nuclear	9,788	9,788	9,036	8,285	7,534	6,783	6,031	5,397	4,762	4,127	3,493	2,858	2,483	2,108	1,734	1,359	984	0%
Other	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	1%
Wind	178,430	185,881	193,775	201,669	209,563	217,457	225,351	230,370	235,390	240,410	245,430	250,449	254,587	258,724	262,861	266,999	276,136	47%
Solar	83,431	86,387	88,431	90,474	92,518	94,562	96,606	99,124	101,642	104,160	106,678	109,196	111,405	113,613	115,822	118,031	120,239	21%
Biomass	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	0%
Storage	15,596	15,720	16,050	16,380	16,709	17,039	17,369	17,533	17,696	17,860	18,024	18,188	18,188	18,188	18,188	18,188	18,188	3%
Total	413,830	425,942	438,312	450,682	463,052	475,422	487,792	498,054	508,317	518,580	528,843	539,106	547,474	555,843	564,211	572,580	585,948	

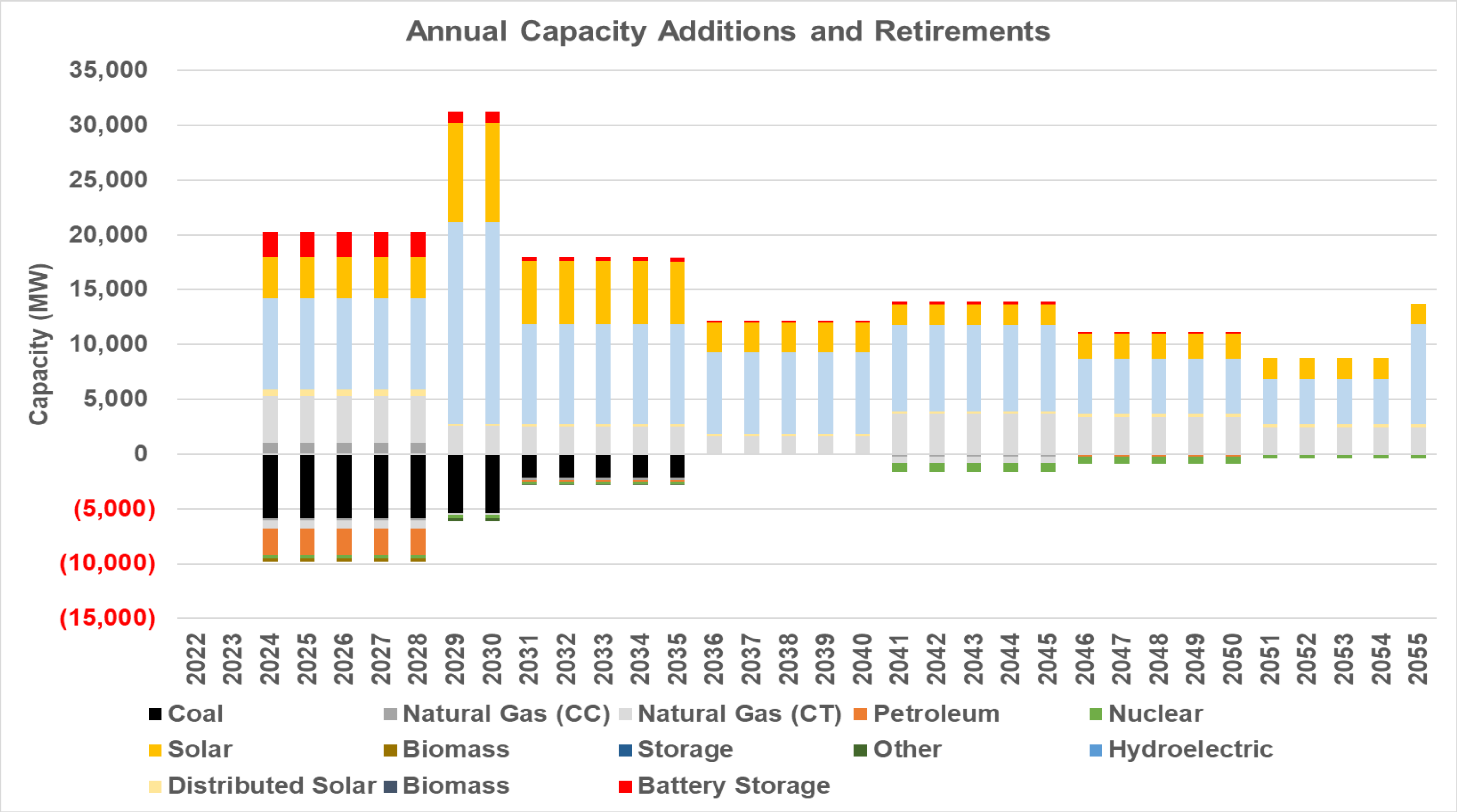
Results- Total Installed Capacity in Reliable 111 Rules Scenario (ICAP)



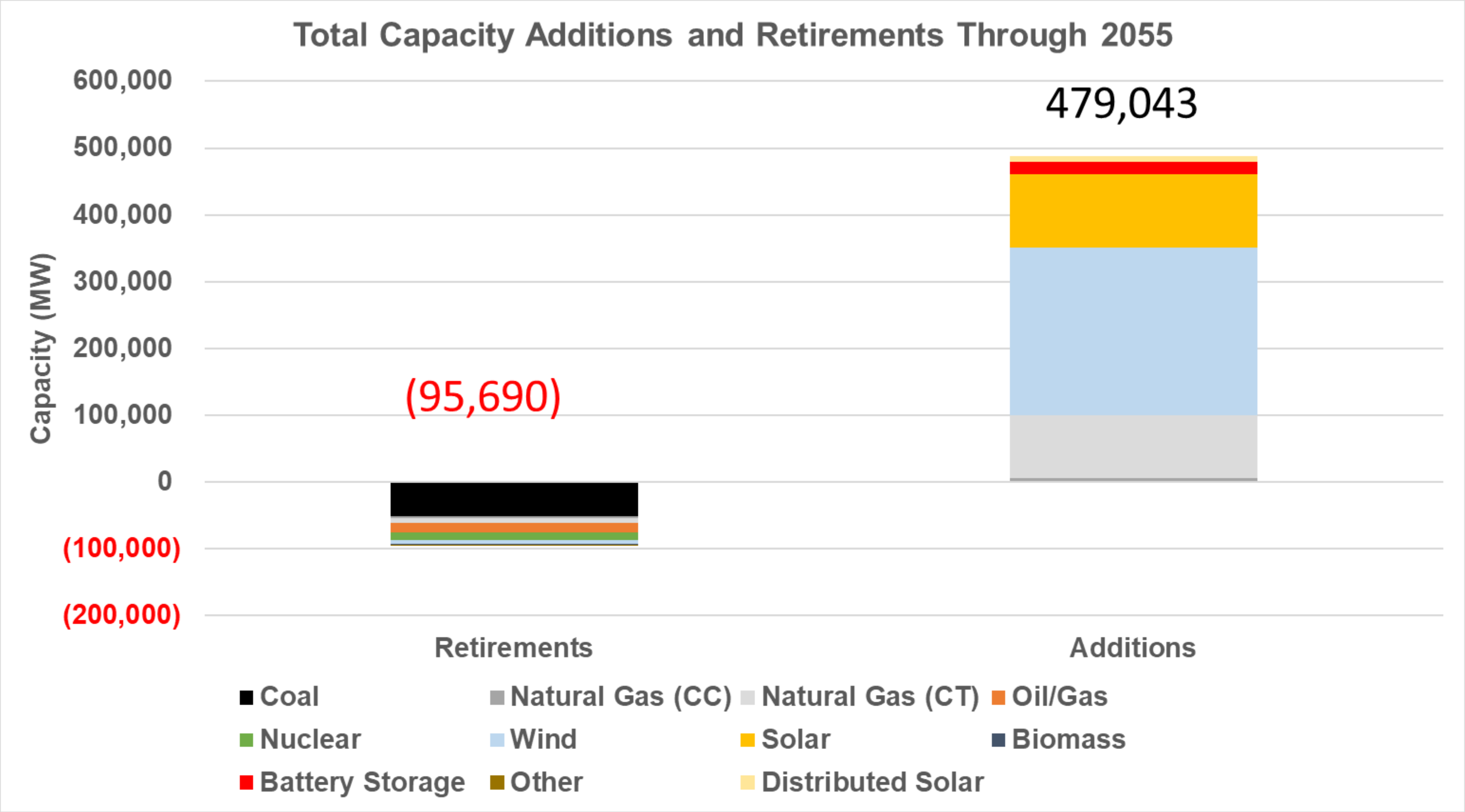
Results- Difference in Installed Capacity: EPA's Modeled Grid vs. Reliable 111 Rules Scenario (ICAP)



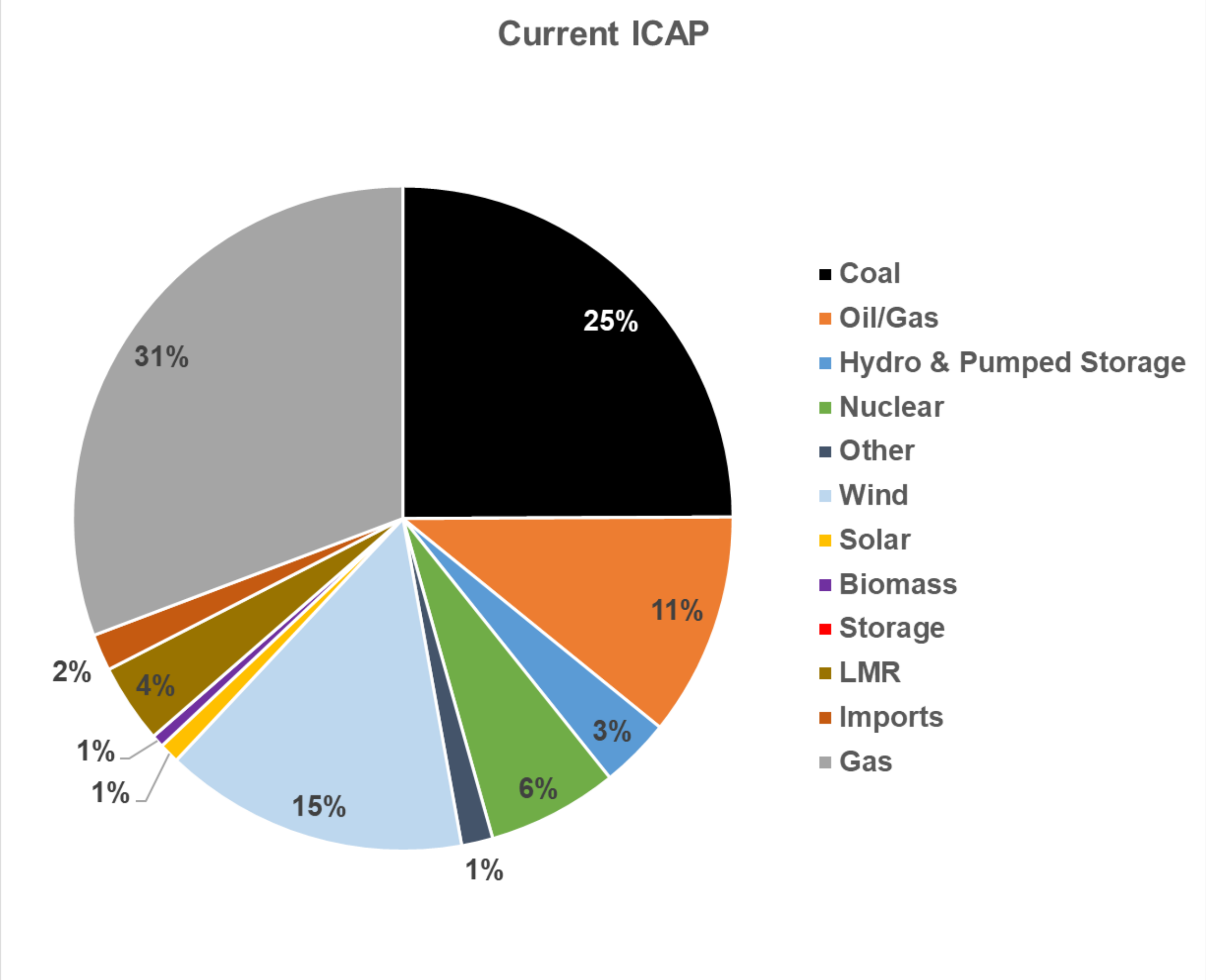
and Additions (ICAP)

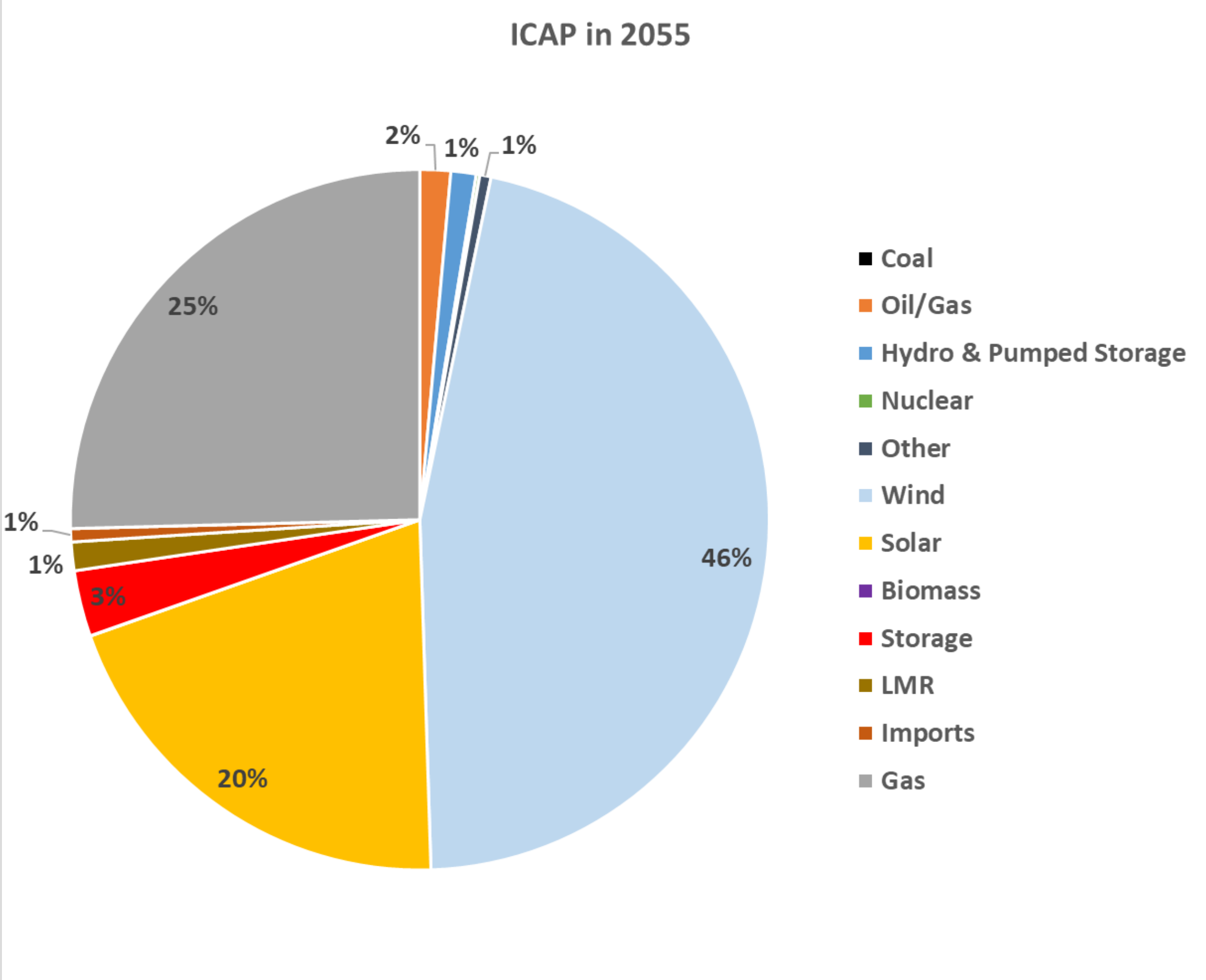


Reliable Section 111 Rules Scenario: Retirements and Additions Through 2055 (ICAP)



Reliable Section 111 Rules Scenario: Current ICAP vs. 2055



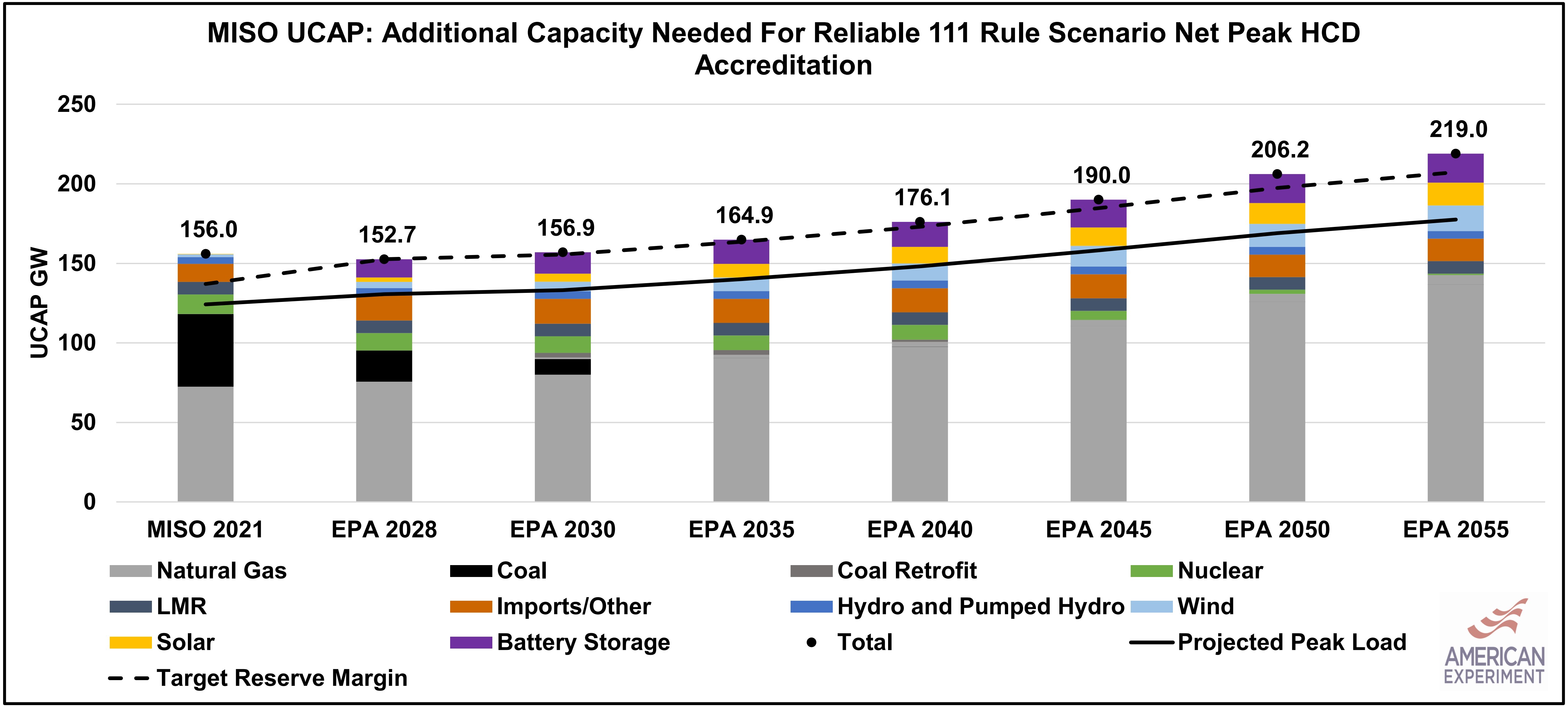


Reliable Section 111 Rules Scenario: Annual UCAP Mix (MW)

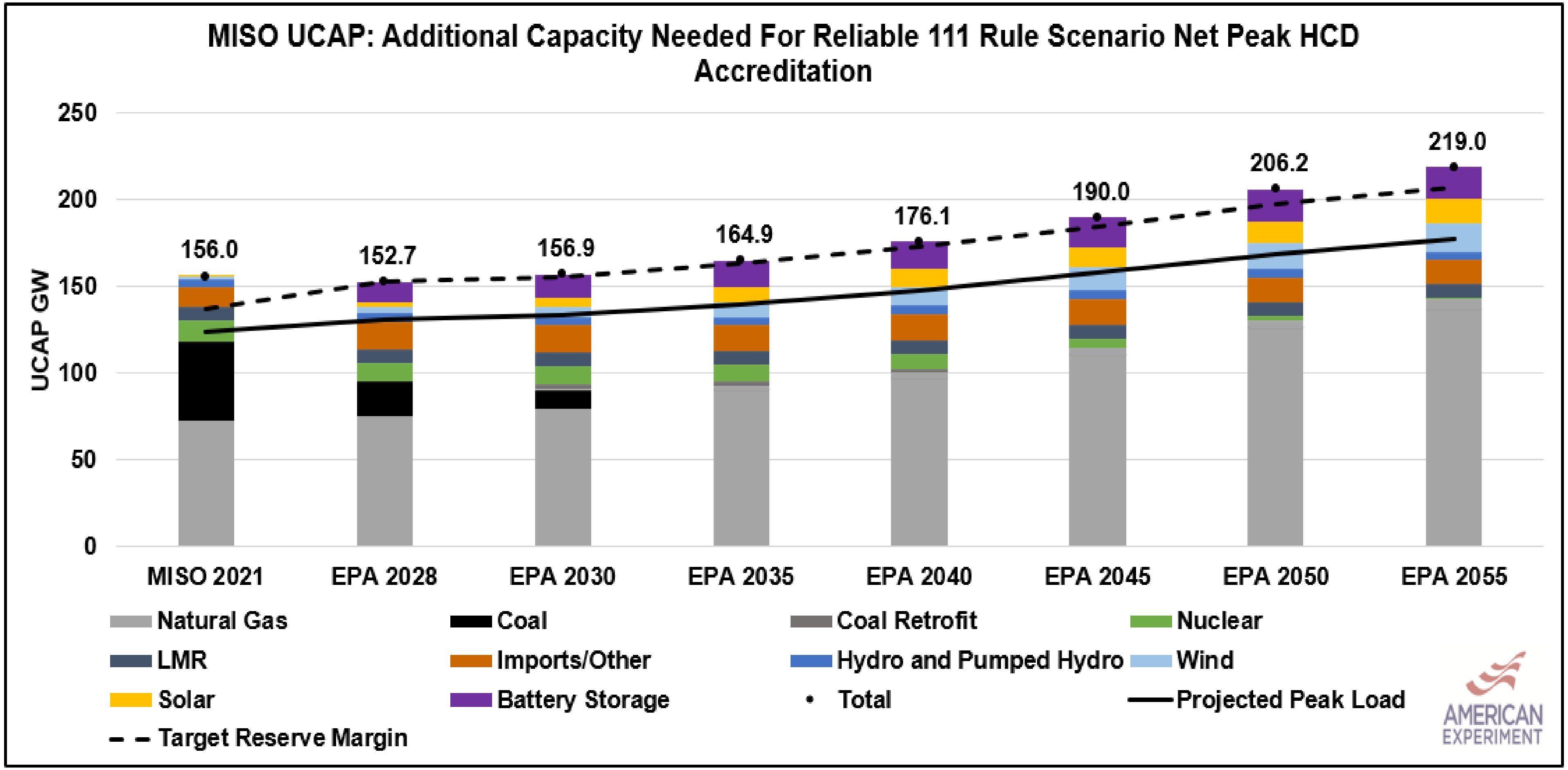
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Coal	45,695	45,695	45,695	40,465	35,235	30,006	24,776	19,547	14,689	9,832	7,875	5,919	3,962	2,005	48	48	48	48
Natural Gas (CC)	29,683	29,683	29,683	30,360	31,036	31,713	32,389	33,066	33,066	33,066	32,886	32,706	32,526	32,346	32,166	32,166	32,166	32,166
Natural Gas (CT)	26,613	26,613	26,613	29,814	33,015	36,216	39,417	42,618	44,772	46,926	49,198	51,469	53,740	56,012	58,283	59,708	61,133	62,558
Other	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808
Natural Gas (ST)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Petroleum	19,930	19,930	19,930	17,758	15,585	13,412	11,239	9,066	9,066	9,066	8,975	8,884	8,793	8,702	8,611	8,609	8,607	8,605
Hydro	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845
Nuclear	12,374	12,374	12,374	12,104	11,833	11,562	11,291	11,020	10,739	10,457	10,225	9,994	9,762	9,530	9,298	9,298	9,298	9,298
Biomass	1,128	1,128	1,128	915	701	488	274	61	57	52	52	52	52	52	52	52	52	52
Wind	1,758	1,758	1,758	2,172	2,586	3,000	3,414	3,828	4,896	5,963	6,493	7,022	7,551	8,081	8,610	9,042	9,473	9,905
Solar	239	239	239	748	1,256	1,765	2,274	2,782	3,893	5,003	5,721	6,438	7,155	7,873	8,577	8,932	9,286	9,640
Imports	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638
LMR	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875
Storage	-	-	-	2,299	4,598	6,897	9,197	11,496	12,478	13,460	13,788	14,116	14,444	14,772	15,100	15,224	15,348	15,472
Total UCAP	156,586	156,586	156,586	155,799	155,012	154,225	153,438	152,650	152,822	152,994	154,380	155,766	157,153	158,539	159,913	162,246	164,578	166,911

	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	
Coal	48	48	48	48	48	48	48	41	34	28	21	14	14	14	14	14	14	0%
Natural Gas (CC)	32,166	32,166	31,962	31,757	31,553	31,349	31,144	31,144	31,144	31,144	31,144	31,144	31,144	31,144	31,144	31,144	31,144	15%
Natural Gas (CT)	63,983	65,408	68,181	70,954	73,726	76,499	79,272	82,351	85,429	88,508	91,586	94,665	96,823	98,980	101,138	103,295	105,453	50%
Other	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	2,808	1%
Natural Gas (ST)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0%
Petroleum	8,602	8,600	8,600	8,600	8,600	8,600	8,600	8,405	8,209	8,014	7,819	7,623	7,623	7,623	7,623	7,623	7,623	4%
Hydro	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	4,845	2%
Nuclear	9,298	9,298	8,585	7,871	7,157	6,443	5,730	5,127	4,524	3,921	3,318	2,715	2,359	2,003	1,647	1,291	935	0%
Biomass	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	0%
Wind	10,337	10,768	11,226	11,683	12,140	12,597	13,055	13,345	13,636	13,927	14,218	14,509	14,748	14,988	15,228	15,467	15,997	8%
Solar	9,994	10,348	10,593	10,837	11,082	11,327	11,572	11,873	12,175	12,477	12,778	13,080	13,344	13,609	13,874	14,138	14,403	7%
Imports	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	3,638	2%
LMR	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	4%
Storage	15,596	15,720	16,050	16,380	16,709	17,039	17,369	17,533	17,696	17,860	18,024	18,188	18,188	18,188	18,188	18,188	18,188	9%
Total UCAP	169,243	171,576	174,462	177,349	180,235	183,122	186,009	189,038	192,068	195,097	198,127	201,156	203,462	205,768	208,074	210,380	212,975	

Reliable Section 111 Rules Scenario UCAP



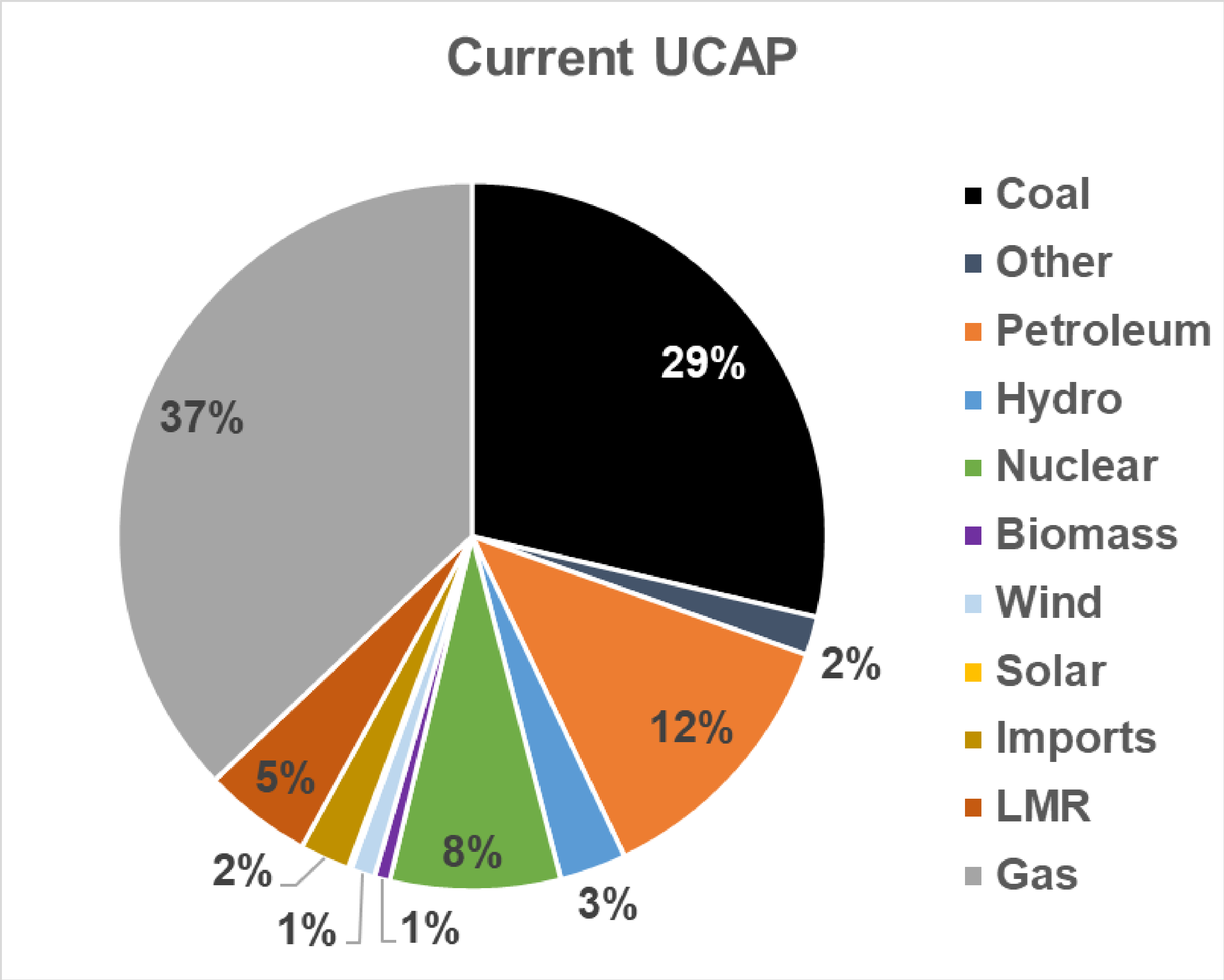
Reliable Section 111 Rules Scenario: Capacity Shortfall Risk

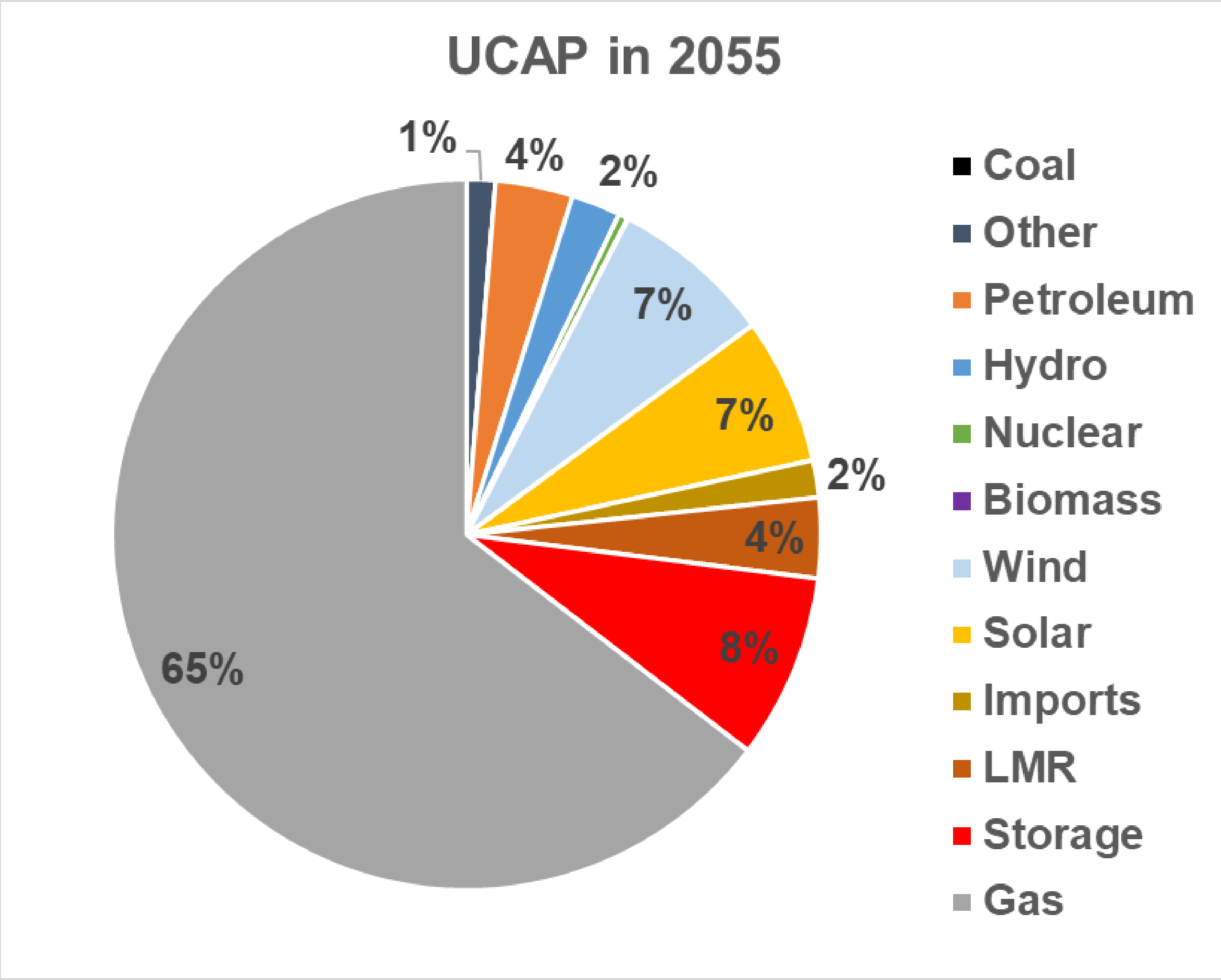


Year	Reserve Margin
2022	25.6%
2028	16.8%
2030	17.8%
2035	17.7%
2040	18.9%
2045	20.1%
2050	22%
2055	23.3%

Estimated firm capacity using net peak load capacity accreditation values for wind (5.8%) and solar (12%), 95% for nuclear, and 90% for other thermal generators. Different than MISO cleared UCAP (unforced [accredited] capacity). Under this scenario, MISO would be dependent on intermittent resources to meet peak load.

Reliable Section 111 Rules Scenario: Current UCAP vs. 2035

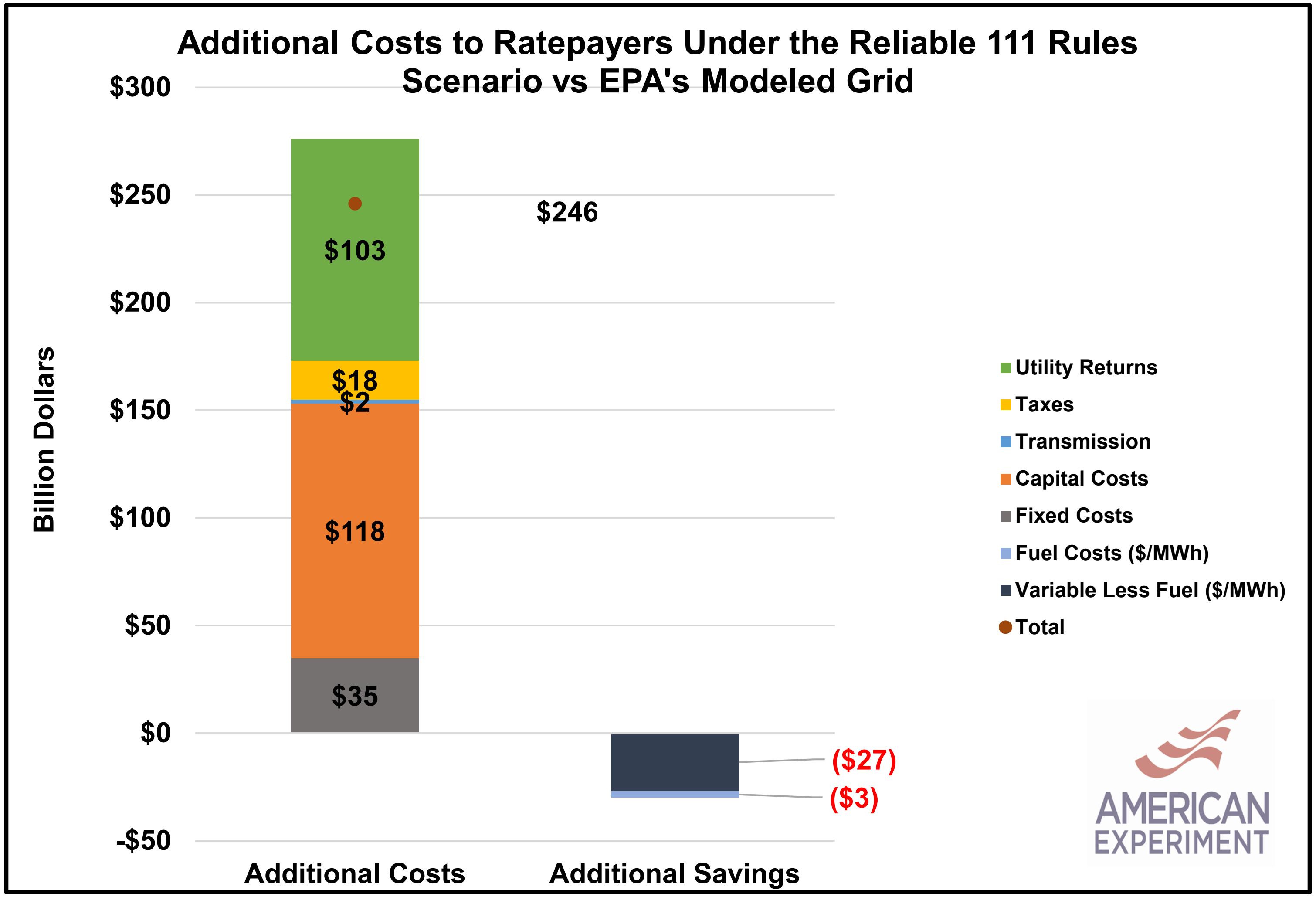




Cost of Reliable Section 111 Rules Scenario

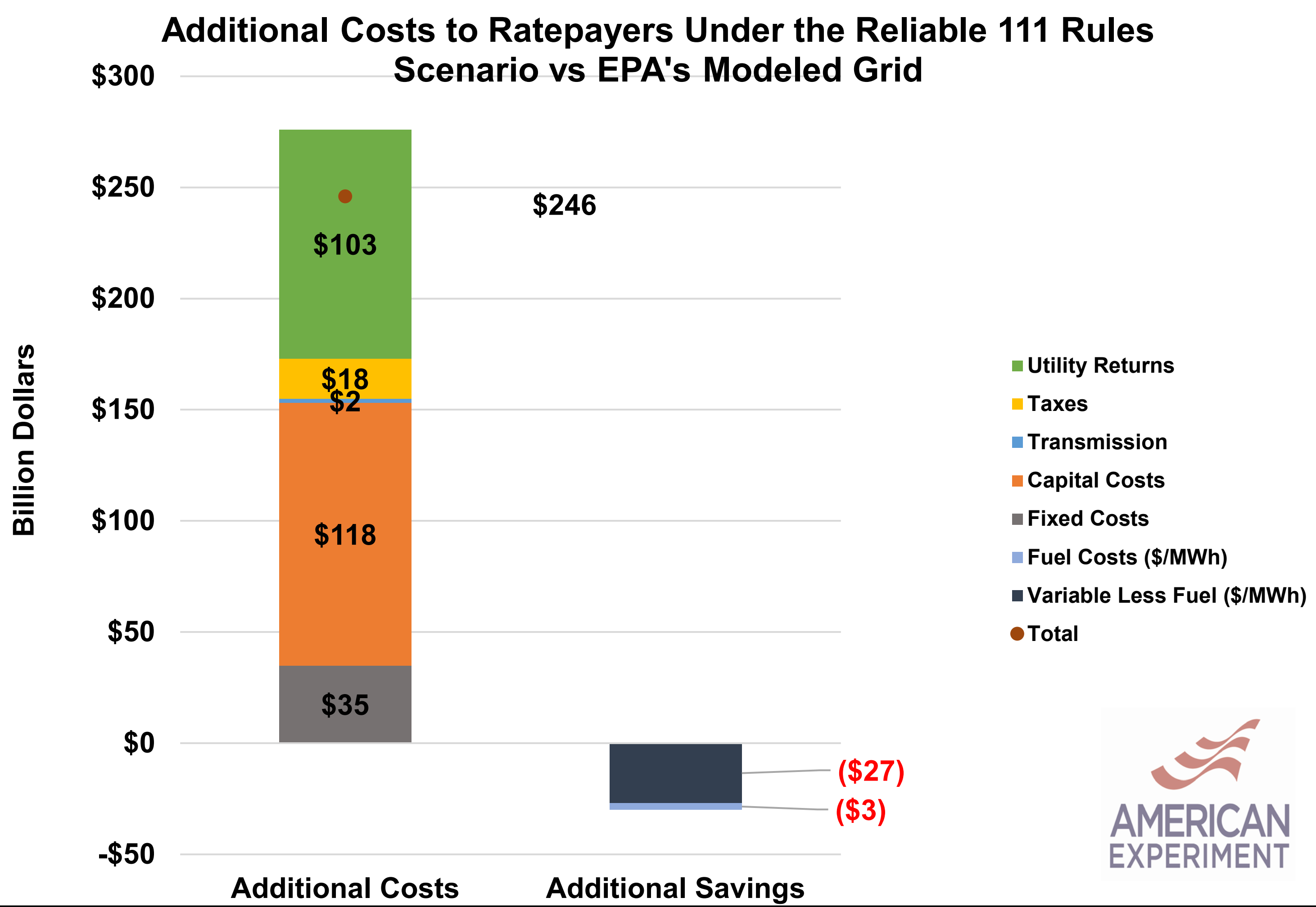
The total additional cost to ratepayers in the Reliable Section 111 Rule Scenario would be $246 billion more than the modeled EPA grid.

- These cost estimates exclude the massive subsidies for wind, solar, and carbon capture in the IRA.
- Values are discounted at 3.7%, the same metric used by EPA.
- EPA values are originally in $2019 and were adjusted for inflation.



Additional Costs of the Reliable 111 Rules Scenario

- The true cost of the proposed rules to ratepayers is $246 billion in additional costs compared to the cost of EPA's modeled grid.
- This figure excludes IRA subsidies.
- This amounts to $7.7 billion per year in additional compliance costs for ratepayers.
- This value exceeds EPA's estimated net benefits for the rules of $5.9 billion per year ***for the entire country in just one RTO.***



AMERICAN EXPERIMENT

Reliable 111 Rules Scenario Impact on Retail Electricity Prices

- EPA's RIA suggests the Proposed 111 Rules will have minimal impact on retail electricity rates.
- However, electricity rates in the Reliable 111 Rules Scenario increase substantially as a result of building enough capacity to prevent rolling blackouts.
- By 2040, electricity price increases will be 27.8 percent higher in the Reliable 111 Rules Scenario than in EPA's RIA.
- EPA values are originally in $2019 and were adjusted for inflation.

Average MISO Retail Electricity Prices ($2022 Cents Per kWh)

Year	Reliable 111 Rules Scenario	EPA's RIA	Difference
2030	11.27	10.45	.82
2035	11.66	9.59	2.07
2040	12.00	9.39	2.61

Conclusions

1. EPA's projected capacity mix for the MISO region under the proposed Section 111 rules is unreliable, resulting in 607 of hours of capacity shortfalls in the EPA modeled years (2028, 2030, 2035, 2040, 2045, 2050, 2055) using historical data from 2019 to 2022.
2. Blackouts occur because EPA is using unrealistically high capacity values for intermittent wind and solar resources with insufficient dispatchable backup resources.
3. EPA's methodology downwardly biases the agency's cost estimates for the Proposed Section 111 rules.
4. Achieving EPA's stated emissions goals while maintaining reliability will cost ratepayers an additional $246 billion through 2055. Taxpayers will pay billions more, as well.
5. Policymakers must understand the challenges regarding reliability, resiliency and affordability that are growing every year.

Recommendations

Policy Recommendations in Light of the Findings of the Study:

1. **EPA MUST ASSESS RELIABILITY:** EPA is proposing massive changes to the U.S. electrical grid without performing the most basic reliability stress testing if its assumptions.
2. **STUDY REMAINING U.S. REGIONS:** MISO constitutes approximately 14 percent of the U.S. population. Similar analyses should be conducted for the rest of the country to determine if EPA's modeled grid can reliably meet electricity demand based on hourly load conditions and wind and solar performance.
3. **EXTEND THE PUBLIC COMMENT PERIOD:** In light of the massive shortcomings with EPA's analysis, the agency should extend the public comment period for at least 90 days so further reliability analysis can be conducted.

Future Research

EPA is proposing massive changes to the electric generating fleet for the entire U.S.

- Our findings represent the results in the MISO market, which serves 45 million Americans constituting only 13.6 percent of the U.S. population.
- More study is needed to evaluate the impact on reliability and affordability that the proposed Section 111 rules will have on the rest of the U.S. electric grid and to model the exchange of electricity between regions.
- More time is needed to evaluate these regions before the final rulemaking is issued. EPA should extend the comment period for the proposed rules by at least 60 days.

APPENDIX

- What follows are slides documenting additional context / assumptions / background, ideas for potential future work, and other resources (including a “short version” of the slides) not included in the primary study slide deck.

Electricity Demand, Consumption, and Reserve Margin Assumptions

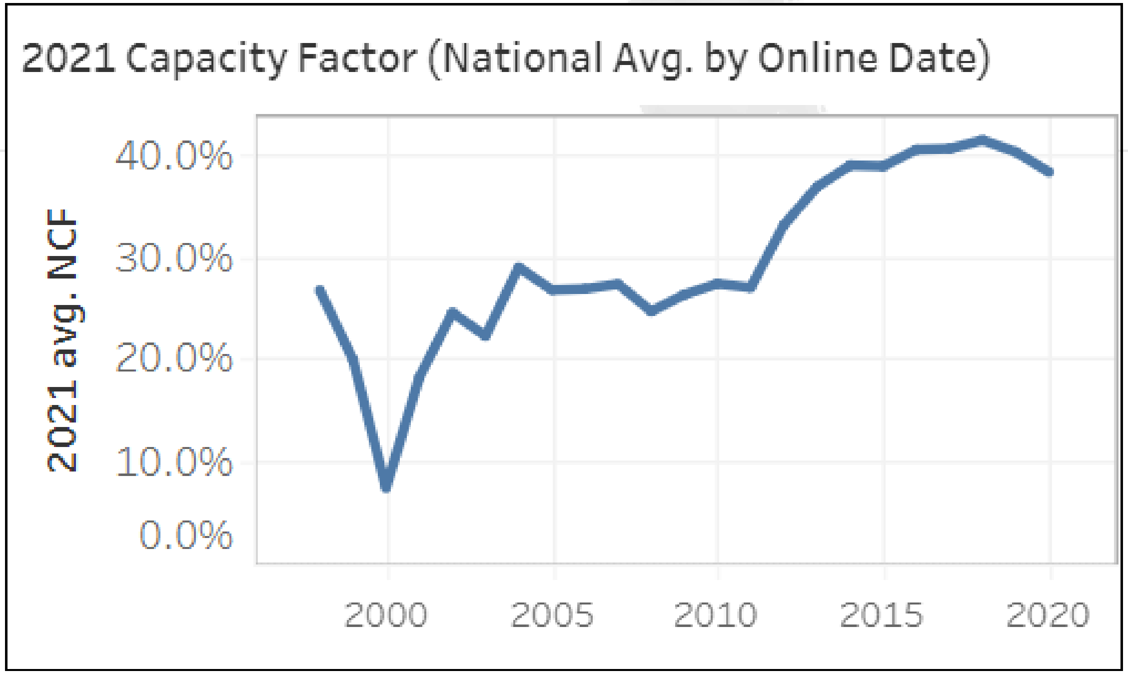
- Annual electricity consumption is increased in accordance with EPA's assumptions in the IPM in each of the MISO subregions.
- The modeled peak demand and reserve margin in each of the model years is increased in accordance with the IPM in each of the MISO subregions in the Integrated Proposal with LNG Update.

Time Horizon Studied

- This analysis studies the impact of the proposed Section 111 rules from 2024 through 2055 to capture the long-term cost of the regulations and to compare these costs to those generated by EPA.
- This timeline downwardly biases the cost of compliance with the regulations because power plants are long term investments, often paid off over a 30-year time period. This means the changes to the resource portfolio in MISO resulting from these rules will affect electricity rates for decades beyond 2055.

Hourly Load, Capacity Factors, and Peak Demand Assumptions

- Hourly load shapes and wind and solar generation were determined using data for the entire MISO region obtained from EIA's Hourly Grid Monitor. Load shapes were obtained for 2019, 2020, 2021, and 2022.
- These inputs were entered into the model to assess hourly load shapes, capacity shortfalls, and calculate storage capacity needs.
- Capacity factors used for wind and solar facilities were adjusted upward to match EPA assumptions that new wind and solar facilities will have capacity factors as high as of 43.7 and 25.5 percent, respectively.
- This is a generous assumption because the current MISO-wide capacity factor of existing wind turbines is only 36 percent, and solar is 20 percent.
- Our analysis upwardly adjusted observed capacity factors to EPA's estimates despite the fact that EPA's assumptions for onshore wind are significantly higher than observed capacity factors reported from Lawrence Berkeley National Labs.



Line Losses

- Line losses are assumed to be 5 percent of the electricity transmitted and distributed in the United States based on U.S. on EIA data from 2017 through 2021.
- Energy Information Administration, “How Much Electricity is Lost in Electricity Transmission and Distribution in the United States,” Frequently Asked Questions, https://www.eia.gov/tools/faqs/faq.php?id=105&t=3

Battery Storage

- Battery storage facilities were assumed to be 4-hour storage, while pumped storage facilities were assumed to be 8-hour storage.
- Battery storage efficiency losses were 5 percent on both ends (charging and discharging).
- Maximum battery discharge was held to the maximum capacity rating less battery storage efficiency losses.
  - This is a generous assumption because it allows the entire battery to discharge and not be constrained by any other limits. Most battery storage units recommend a depth of discharge (DoD) of 80—95 percent.

Value of Lost Load (VoLL)

- The value of lost load (VoLL) is a monetary indicator expressing the costs associated with an interruption of electricity supply, expressed in dollars per megawatt hour (MWh) of unserved electricity.
- Our analysis uses a conservative midpoint estimate of $14,250 per MWh for VoLL. This value is higher than MISO's previous VoLL estimate of $3,500 per MWh, but significantly lower than the Independent Market Monitor's suggested estimate of $25,000 per MWh.
- Potomac Economics, "2022 State of the Market Report for the MISO Electricity Markets," Independent Market Monitor for the Midcontinent ISO, June 15, 2023, https://www.potomaceconomics.com/wp-content/uploads/2023/06/2022-MISO-SOM_Report_Body-Final.pdf.

Plant Retirement Schedules

- Our modeling does not make decisions about which individual plants will retire due to the proposed Section 111 rules. Rather, coal and natural gas plant capacity is retired to match the changes modeled by EPA in the Integrated Proposal with LNG Update.

Load Modifying Resource, Demand Response, and Import Assumptions

- Our model allows for the use of 7,875 MW of Load Modifying Resources (LMRs) and 3,638 MW external resources (imports) in determining how much reliable capacity will be needed within MISO to meet peak electricity demand under the new Section 111 rules. These capacity assumptions represent an XAMOUNT increase relative to the MISO 2023-2024 Planning Reserve Margin Auction Results (See Table XMISOPRM).

2023-2024 Seasonal Supply Offered and Cleared

	Offered (ZRC)				Cleared (ZRC)			
Planning Resource	Summer 2023	Fall 2023	Winter 2023-2024	Spring 2024	Summer 2023	Fall 2023	Winter 2023-2024	Spring 2024
Generation	122,375.6	121,403.5	122,375.6	121,403.5	116,989.7	111,713.8	116,989.7	110,195.8
External Resources	4,514.6	4,095.4	4,514.6	4,095.4	4,072.5	3,979.6	4,072.5	3,409.1
Behind the Meter Generation	4,175.2	3,874.2	4,175.2	3,874.2	4,129.4	3,842.8	4,129.4	4,058.9
Demand Resources	8,303.5	7,004.2	8,303.5	7,004.2	7,694.6	6,254.4	7,694.6	6,720.0
Energy Efficiency	5.0	4.9	5.0	4.9	5.0	4.8	5.0	5.3
Total	139,373.9	136,382.2	139,373.9	136,382.2	132,891.2	125,795.4	132,891.2	124,389.1

Utility Returns

- Most of the load serving entities in MISO are vertically integrated utilities operating under the Cost-of-Service model. The amount of profit a utility makes on capital assets is called the Rate of Return (RoR) on the Rate Base.
- For the purposes of our study, the assumed rate of return is 9.9 percent with debt/equity split of 48.92/51.08 based on the rate of return and debt/equity split of the ten-largest investor-owned utilities in MISO.

Transmission

- This analysis assumes the transmission capacity on the MISO system will need to increase by 27,354 miles, constituting a 40 percent increase in the amount of transmission installed in MISO's U.S. footprint.
- According to MISO's Renewable Integration Impact Analysis (RIIA) study, most of the required increases in transmission capacity would occur in high voltage transmission lines, meaning those over 230 kilovolts (kV), with the largest increases needed for lines over 345 kV.
- MISO has approximately 68,000 circuit-miles of transferred functional control transmission lines serving as the backbone of the footprint in the United States, with approximately 10,409-line miles of 230 kV transmission lines, 12,435-line miles of 345 kV, 2,250-line miles of 500 kV, and 148-line miles of 765 kV.
- Line miles are estimated based on the author's best interpretation of Figure 1.1-4 in the Midcontinent Independent Systems Operator, "MISO Transmission Expansion Plan 2022," Accessed July 27, 2023, https://cdn.misoenergy.org/MTEP22%20Chapter%201%20-%20MTEP%20Overview627346.pdf.

Transmission Continued

- In its Electricity Futures Study, the National Renewable Energy Laboratory suggests grids powered by 85 percent wind, solar, and battery storage resources will require additional transmission buildouts of 85.6 percent. This study increases the number of line miles for transmission lines of 230 kV and higher by 85.6 percent.
- This buildout of transmission lines is estimated to cost $102.9 billion. Costs were calculated using the distance per mile costs from the 2021 Midcontinent Independent Systems Operator Transmission Cost Estimation Guide. We assume all transmission expenses are paid by MISO ratepayers.
- These transmission buildouts are consistent with, and more conservative than, the estimated transmission needs in the Net-Zero America study Reference Case, which suggests the nation will need to expand transmission capacity by 47 percent at a cost of $954 billion.
- Interconnection costs were estimated to be approximately $48,000 per MW of wind or solar installed, the average cost of active projects at the point of interconnect.

- National Renewable Energy Laboratory, “Renewable Electricity Futures Study: Executive Summary,” U.S Department of Energy, 2012, https://www.nrel.gov/docs/ fy13osti/52409-ES.pdf.
- Midcontinent Independent Systems Operator, “Transmission Cost Estimation Guide for MTEP21,” April 27, 2021, https://bit. ly/3AZu59l.
- Andrew Pascale et al., “Princeton’s Net-Zero America study Annex F: Integrated Transmission Line Mapping and Costing,” Princeton University, August 1, 2021, https://netzeroamerica.princeton.edu/img/NZA%20Annex%20F%20-%20HV%20Transmission.pdf.
- Lawrence Berkeley Labs, “Data from MISO Show Rapidly Growing Interconnection Costs,” Electricity Markets and Policy, October 7, 2022, https://emp.lbl.gov/news/data-miso-show-rapidly-growing.

Taxes and Subsidies

- Additional tax payments for utilities were calculated to be of 1.3 percent of the rate base.
- State income tax rate of 7.3 percent was estimated by averaging the states within the MISO region.
- Federal income tax rate is 21 percent.
- Production Tax Credit of $27.50.
- Investment Tax Credit of 30 percent through 2032, 26 percent in 2033, and 22 percent in 2034.
- Coal 45-Q Subsidy of $85 per ton CO_2 sequestered.

Capital costs and Fixed and Variable Operations and Maintenance Costs

- Capital costs, for all new generating units are sourced from the EIA 2023 Assumptions to the Annual Energy Outlook (AOE) Electricity Market Module (EMM). These costs are held constant throughout the model run. Expenses for fixed and variable O&M for new resources were also obtained from the EMM. Capital costs were an average of the MISO regions, and national fixed and variable O&M costs were obtained from Table 3 in the EMM report.
- U.S. Energy Information Administration, "Electricity Market Module," Assumptions to the Annual Energy Outlook 2023, March 2023, Assumptions to the Annual Energy Outlook 2023: Electricity Market Module (eia.gov)

Unit Lifespans and Repowering

- Different power plant types have different useful lifespans. Our analysis takes these lifespans into account. Wind turbines are assumed to last for 20 years, solar panels are assumed to last 25 years, battery storage for 15 years.
- New natural gas plants are assumed to last for 30 years.
- Existing natural gas plants are presumed to be capable of continued operation throughout the model run.
- Our model assumes wind turbines, solar panels, and battery storage facilities are repowered after they reach the end of their useful lives. Our model also excludes economic repowering, a growing trend whereby wind turbines are repowered after just 10 to 12 years to recapture the wind Production Tax Credit (PTC). This trend will almost certainly grow in response to IRA subsidies.
- EPA does not appear to take repowering into consideration because the amount of existing wind on its systems never changes, and the capacity accreditations for existing wind remain constant. If our understanding of EPA's methodology is accurate, this a large oversight that must be corrected.

Fuel Cost Assumptions

- Fuel costs for existing power facilities were estimated using FERC Form 1 filings and adjusted for current fuel prices. Fuel prices for new power plants were estimated using the most recent nuclear fuel cost data provided by EIA.
- **Natural gas fuel costs**
- Existing natural gas prices were assumed to be $23.00 per MWh and $35.76 per MWh for CC and CT plants, respectively, based on data obtained from 2020 FERC Form 1 filings and adjusted for fuel prices used by EPA throughout the model.
- **Coal fuel costs**
- Existing coal fuel cost assumptions of $17.82 per MWh were based on 2020 FERC Form 1 filings for MISO coal plants.
- **Hydrogen fuel costs**
- Fuel prices for green hydrogen are assumed to be $5 per kilogram (kg) based on recent estimates from the U.S. Department of Energy. A $3 per kg subsidy from the IRA is retroactively accounted applied to this these fuel expenditures.
- An assumed cost of $5 per kg is much higher than EPAs assumed cost of $1 and $0.50 per kg assumptions at various points throughout its model run. The agency does not offer a satisfactory explanation of why prices drop so dramatically.
- One reason cited by EPA for falling prices are subsidies paid out as a result of the Inflation Reduction Act, but subsidies don't change how much a good or service costs; it simply shifts who pays for it.
- The agency also fails to account for the cost of the massive hydrogen infrastructure that would be needed to use green hydrogen at scale, an enormous shortcoming in its analysis.

- https://tradingeconomics.com/commodity/natural-gas
- https://data.nasdaq.com/data/EIA/COAL-us-coal-prices-by-region
- https://www.eia.gov/opendata/v1/qb.php?category=40694&sdid=SEDS.NUEGD.WI.A