NEW REPORT DEVELOPED FOR NDIC / NDTA / LEC: Forecasting Resource Adequacy in MISO Through 2035

LONG FORMAT PRESENTATION

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Objectives: Model Resource Adequacy and Cost Under Three Scenarios

Step 1: Develop Reasonable Accreditation Values for Wind and Solar

a. 2018-2022 hourly dataset
   i. Peak load availability
   ii. Net peak load availability

Step 2: Reference Scenario

a. MISO/EIA planned additions (7.5 GW Gas, 1 GW Wind, 4.2 GW Solar) and retirements (17.6 GW Coal, 4.8 GW Gas, 600 MW Other). Replace rest with modeled wind (64.4 GW), solar (98.7 GW), and four-hour storage (11 GW)
b. Peak load
c. Net Peak load

Step 3: Ozone Transport FIP Scenario

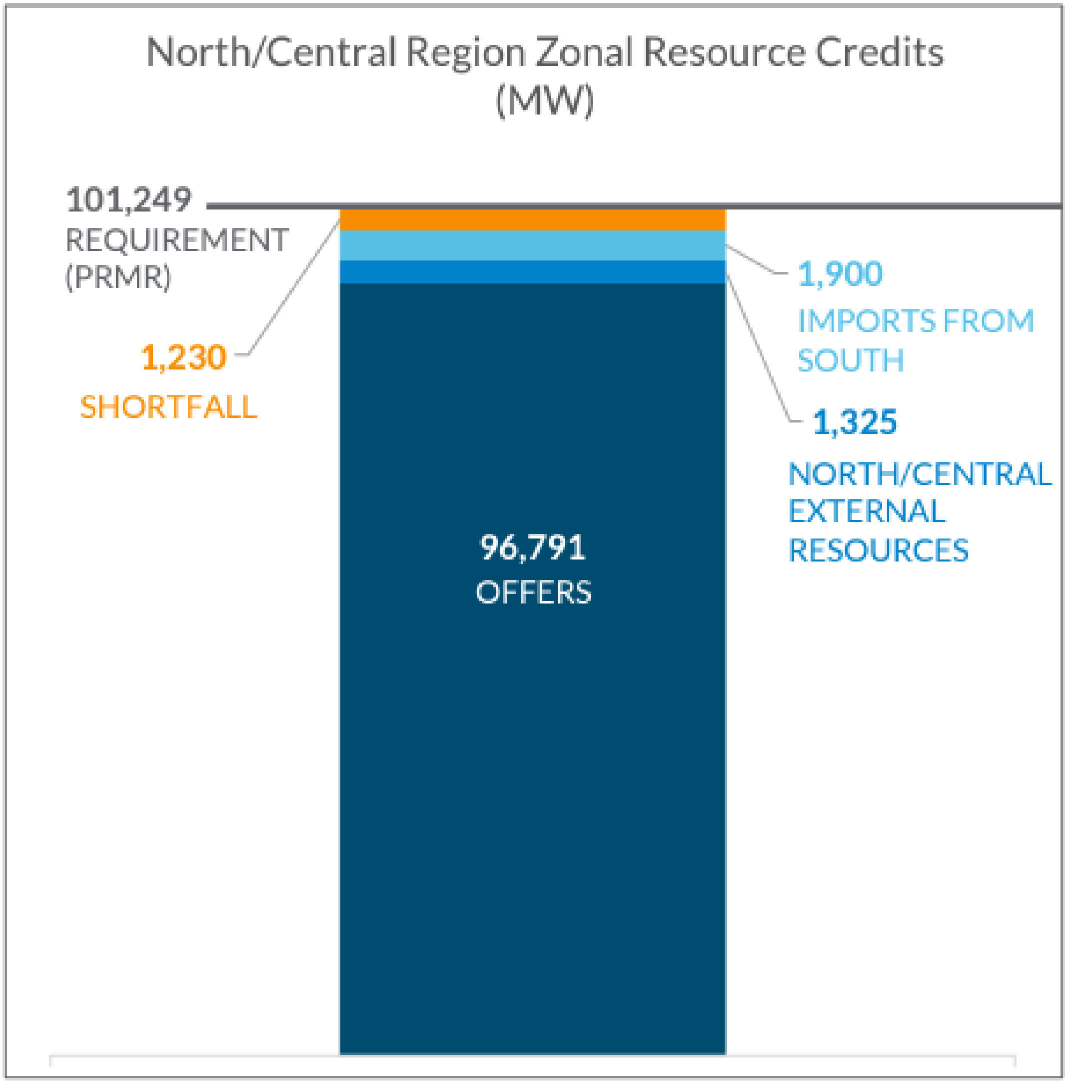
a. Loss of 30.3 GW of coal and 9.6 GW of gas by 2035. Replace with natural gas (7.5 GW), wind (130.7 GW), solar (202.8 GW), and four-hour storage (16.2 GW).
b. Peak load
c. Net Peak load

Step 4: Ozone + CCR Scenario

a. Loss of 33 GW of Coal and 9.6 GW of gas by 2035. Replace with natural gas (7.5 GW), wind (140.8 GW), solar (218.3 GW), and four-hour storage (17.5 GW).
b. Peak load
c. Net Peak load

Why Do We Care About MISO Resource Adequacy?

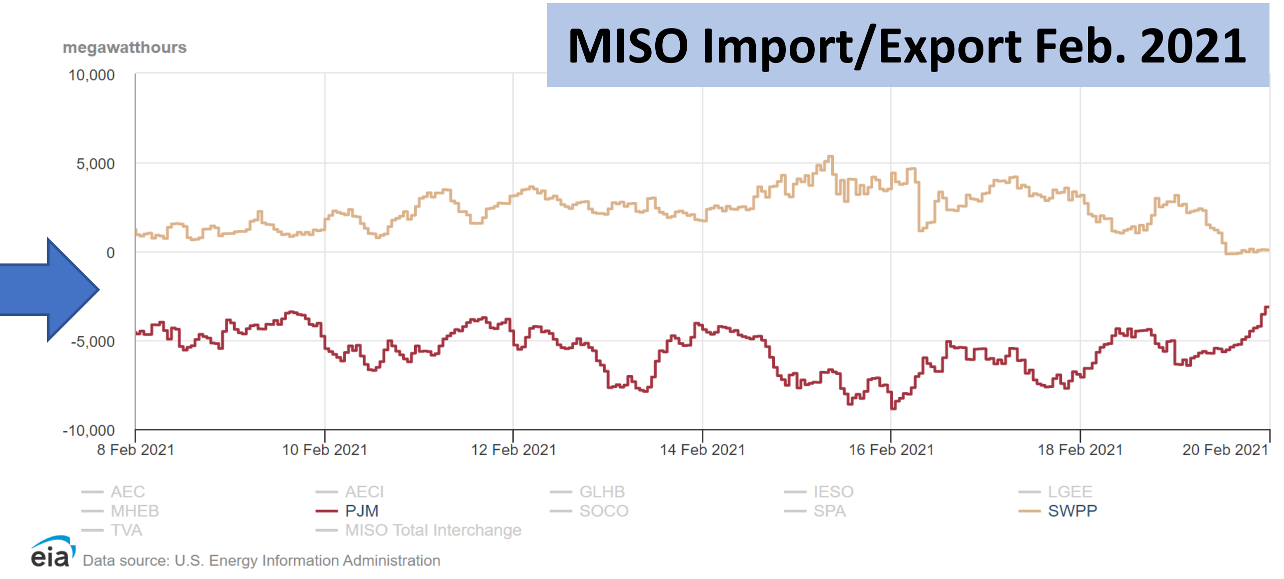
- MISO resource adequacy is challenged by a changing energy mix.
  - MISO had a 1,200 MW capacity shortfall from the Planning Reserve Margin (PRM) in the summer of 2022.
  - Max Gen Declarations have become more common over the last six years.
- Planned retirements and additions show a continued decline 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.

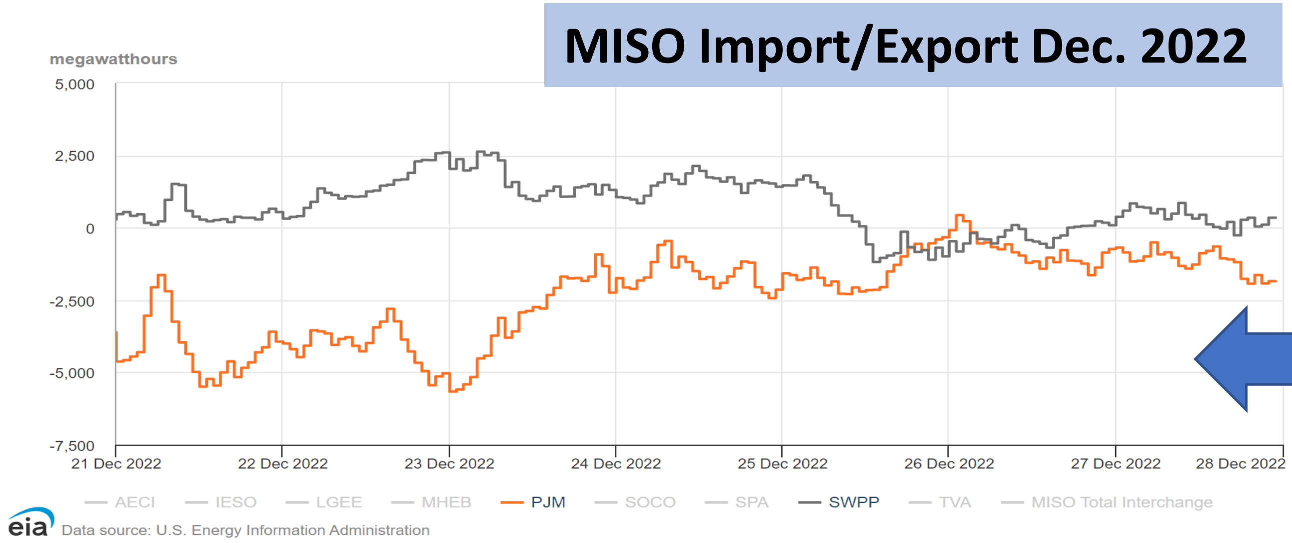


THE MISO GAMBLE: Betting on Imports & Weather

Feb. 2021:

MISO is saved from outages during Winter Storm Uri by more than 5000 MW of imports from PJM, peaking at nearly 9000 MW during the height of the storm.





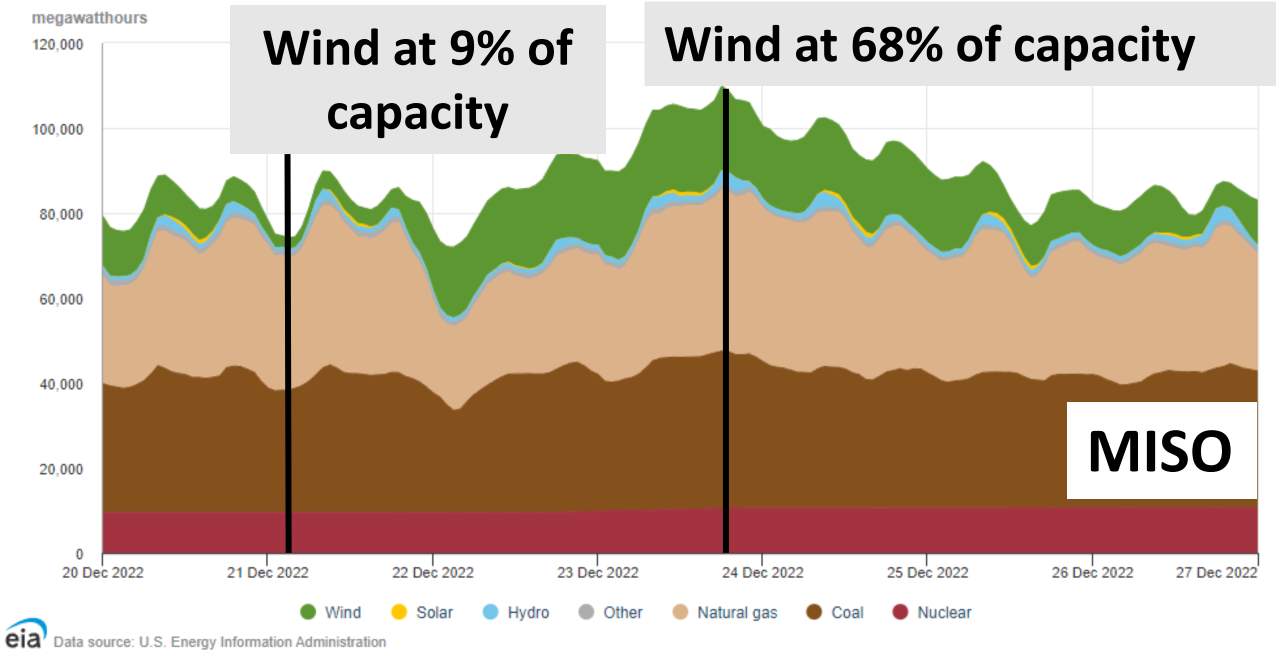
Dec. 2022:

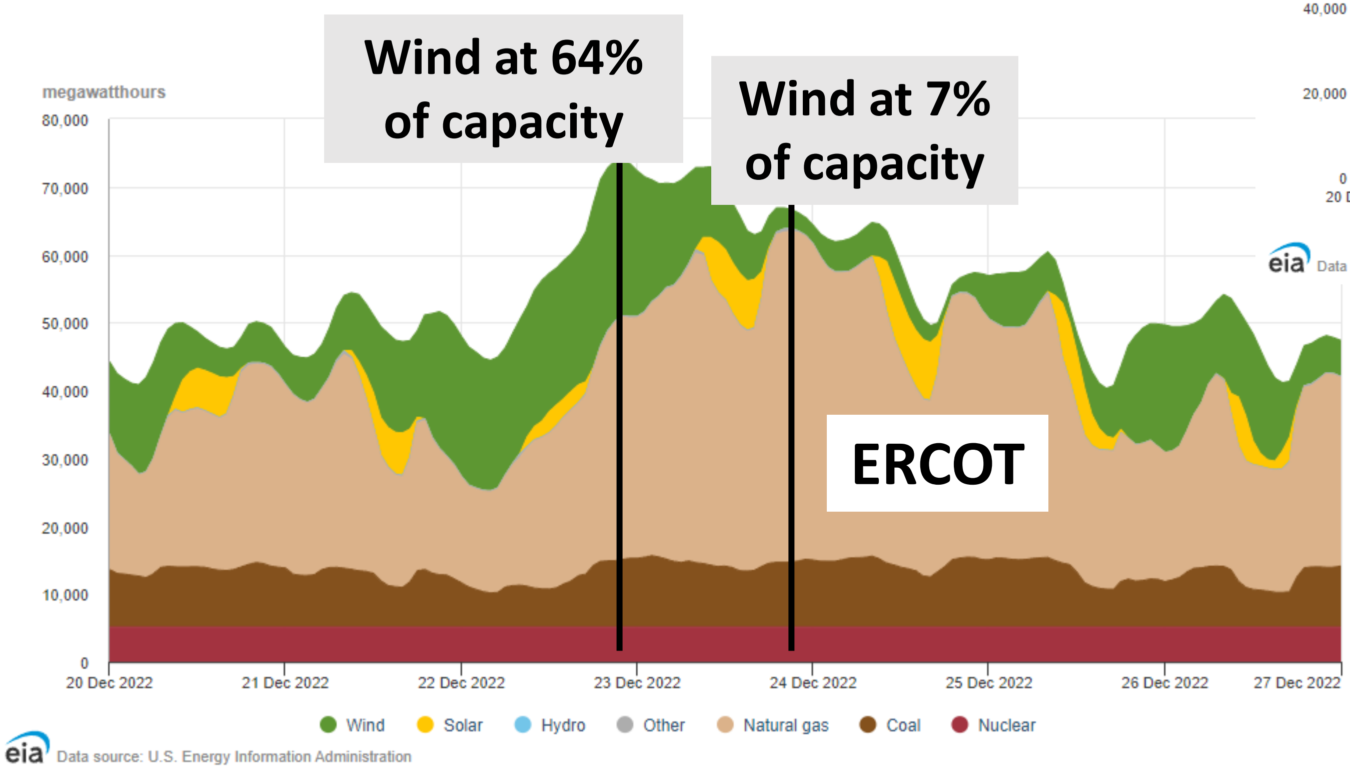
PJM imports drop below 2500 MW during the height of the storm and then go to zero on Christmas as PJM narrowly avoids outages.

CHRISTMAS GIFT: MISO and ERCOT Saved by Lucky Timing

Wind capacity factors in MISO were above 50% during the Dec. 2022 storm, despite being just 9% two days before the storm.

Outages would have occurred had the wind dropped off, as it did in ERCOT.





Wind capacity factors in ERCOT were above 60% during the height of the storm but fell to 7% the next day, at which point the region narrowly averted outages due mainly to less demand entering a holiday weekend.

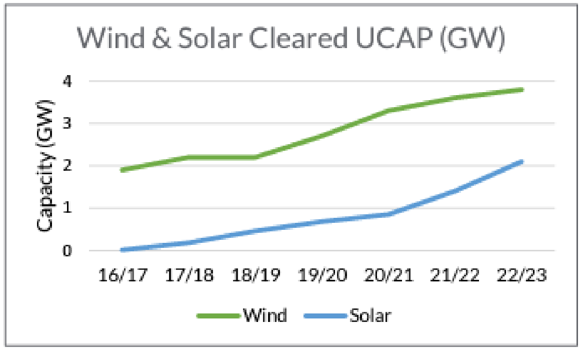
MISO’s Current Capacity Before Accreditation

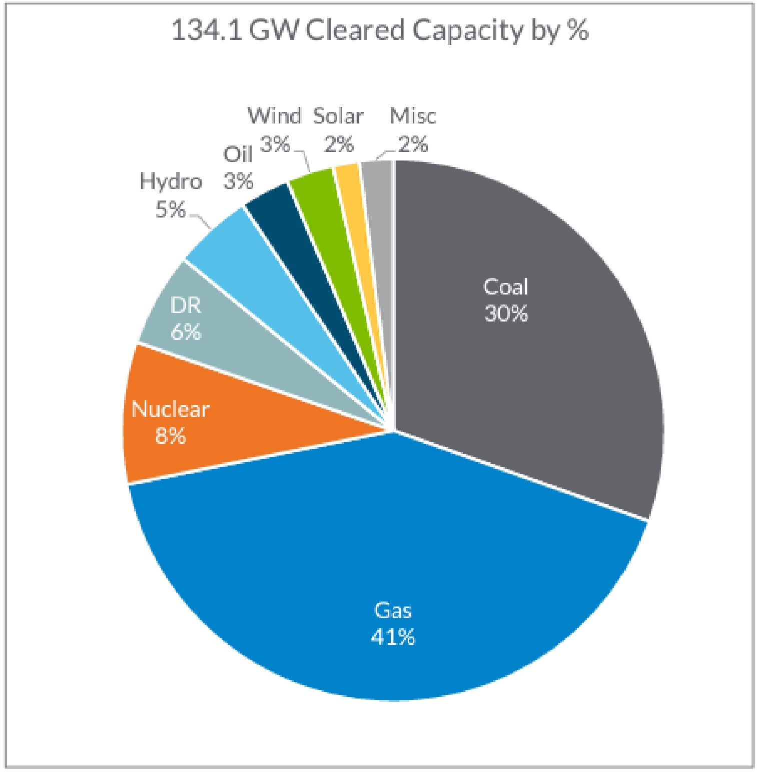
- MISO’s current UCAP mix is:
  - 41 percent natural gas
  - 30 percent coal
  - 8 percent nuclear
  - 5 percent hydro
  - 3 percent oil
  - 3 percent wind
  - 2 percent solar
  - 2 percent misc.

- 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.

Although conventional generation still provides the majority of capacity, wind and solar continue to grow

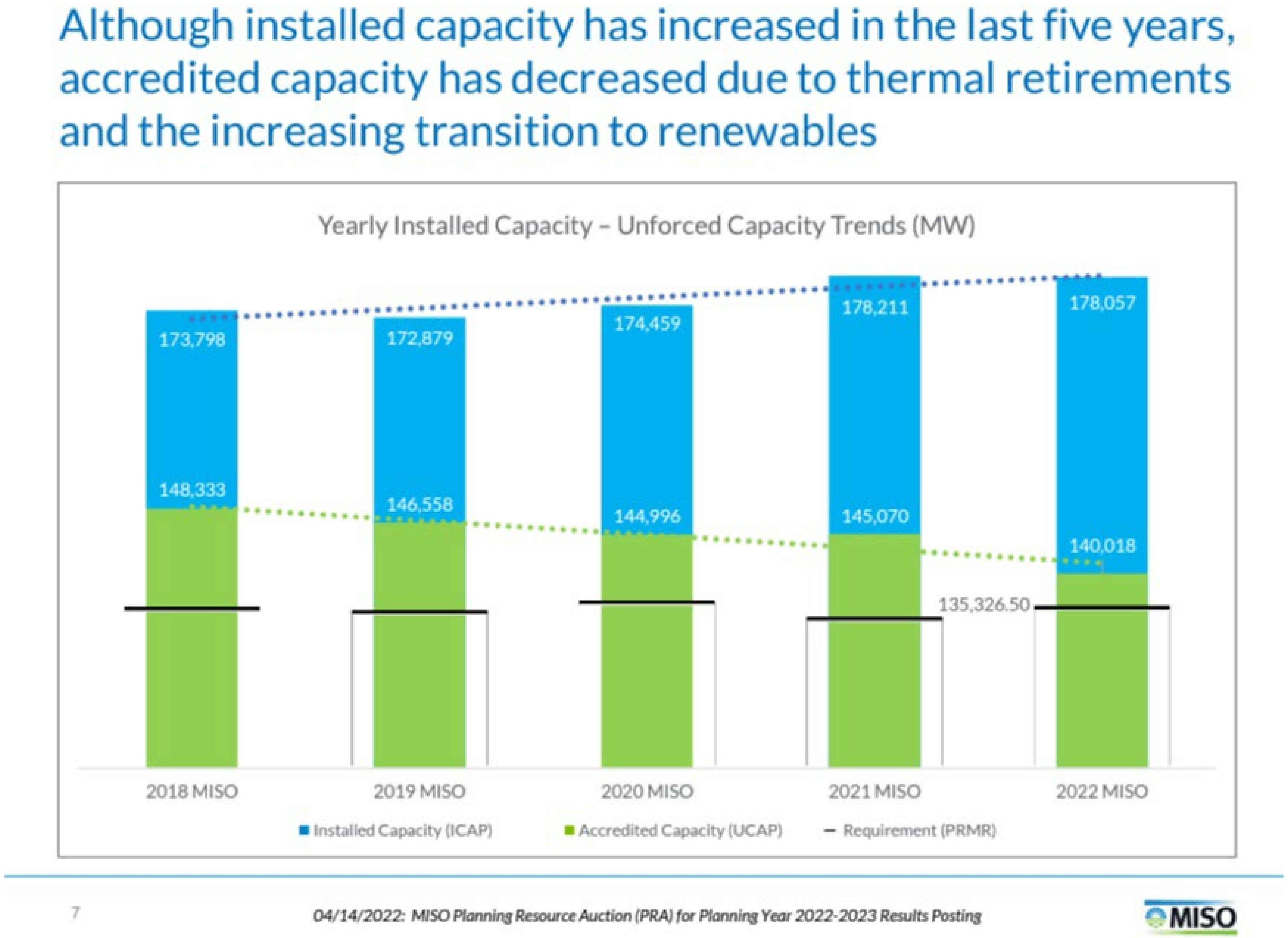
- 2.1 GW of solar cleared this year’s auction—an increase of 48% from Planning Year 2021-22 (1.4 GW)
- Similarly, 3.8 GW of wind cleared this year, an increase of 5% compared to last year. (3.6 GW)





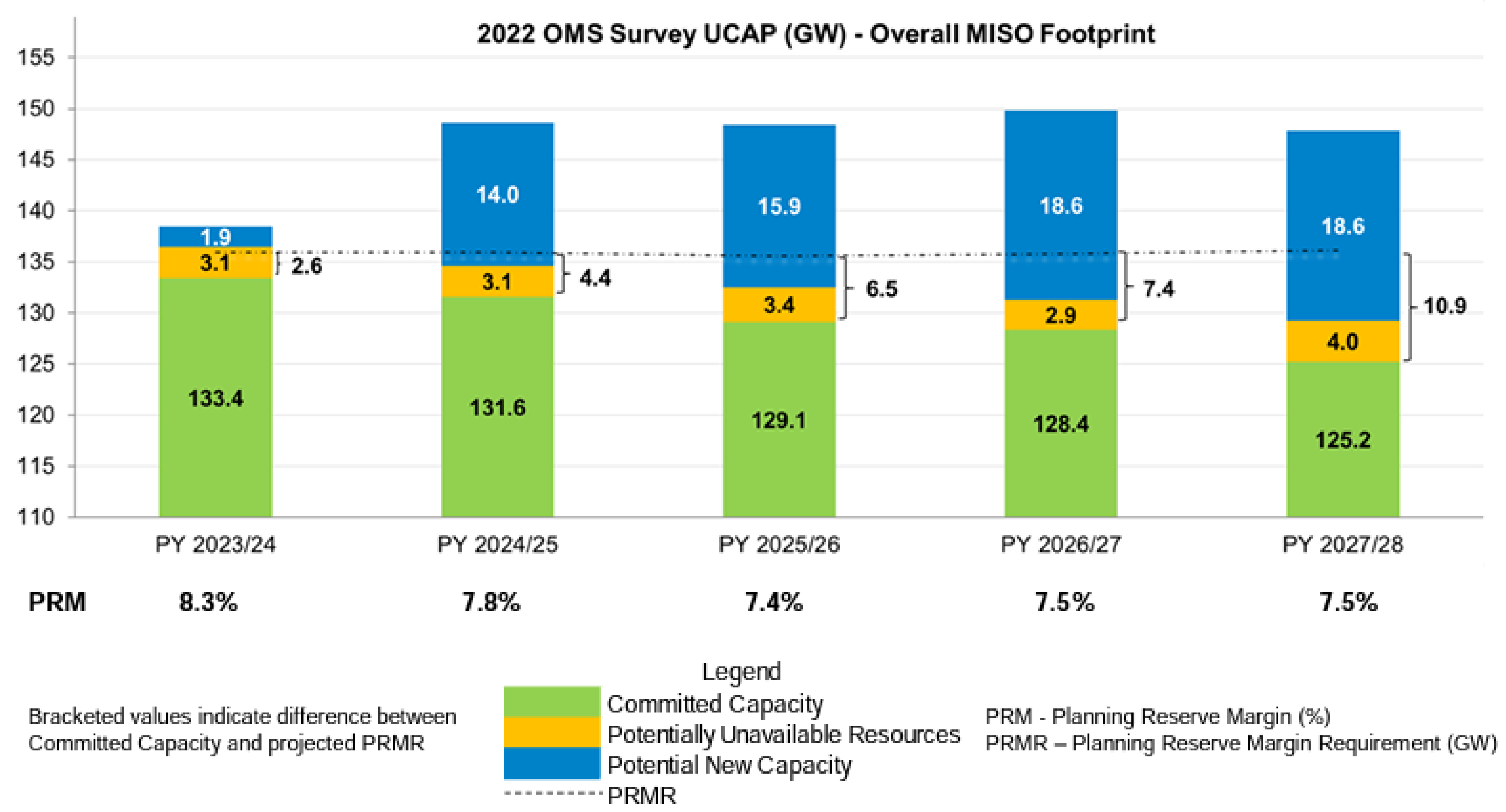
More Total Capacity, Less Accredited Capacity

- 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



Capacity Shortfalls Could Grow Over Time

- The 1,200 MW capacity shortfall in 2022 could grow to 2,600 MW in 2023, increasing the risk of power outages.
- By 2027/2028, the shortfall could reach 10,900 MW if new capacity does not come online.



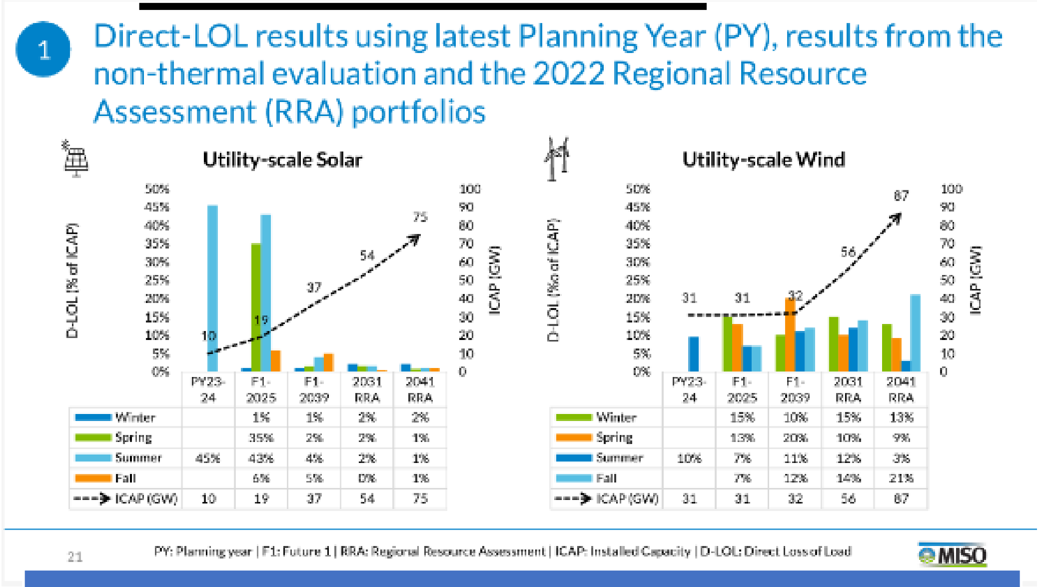
MISO Recently (since study completion) Updated Accreditation Values for Wind and Solar

- The previous slides may ***overstate*** the amount of UCAP on the system due to MISOs prior capacity accreditation method for wind and solar.
- Wind was assumed to produce 15.5% of potential output during 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.
- MISO is moving toward seasonal accreditation to more accurately accredit wind and solar, but this may or may not solve the problem as rising penetrations of intermittent resources make ***net*** peak loads a larger concern.
- Net peak is 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.

Comparing Highest Certainty Deliverability (HCD) Approach to the New Seasonal Approach MISO is Considering

- MISO is making well-intended (but potentially insufficient) changes to the accreditation process as they try to account for weather-dependent renewable penetration and shift from away from an Effective Load Carrying Capacity (ELCC) approach to a Direct-Loss of Load (LOL) accreditation approach.
- They are also switching to a seasonal accreditation model, which will require seasonal capacity auctions & significant differences between seasonal reserve margins (which probably won't address over-penetration of weather-dependent resources).
- HCD examines wind & solar accreditation values for peak & net-peak hours to provide consistent, year-round metrics for availability & reserve margins & provides a basis for a realistic (apples-to-apples) comparison of renewable & thermal performance.

MISO APPROACH



MISO's Proposed Seasonal Reserve Margins				
	Summer	Fall	Winter	Spring
Reserve Margin	7.40%	14.90%	25.50%	24.50%

HCD ALTERNATIVE APPROACH

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

How does the ND Study's HCD Approach Differ from MISO's New Seasonal Accreditation Approach?

- HCD accreditation values for wind are consistent with MISO's F1-25 values.
- HCD accreditation values for solar are lower than MISO's F1-25 values but higher than their F1-2039 values.

HCD approach is valuable for a few reasons:

- HCD provides consistent metrics for evaluating wind & solar that are independent of future modeling & not linked to significant adjustment of seasonal reserve margins.
- As more wind & solar are added to the grid, net peak will become more challenging than peak load demand.
- HCD manages the downside of wind & solar at net peak compared to ELCC and is more empirical than the options MISO is considering as they move away from ELCC to a Direct-LOL accreditation approach.

MISO APPROACH

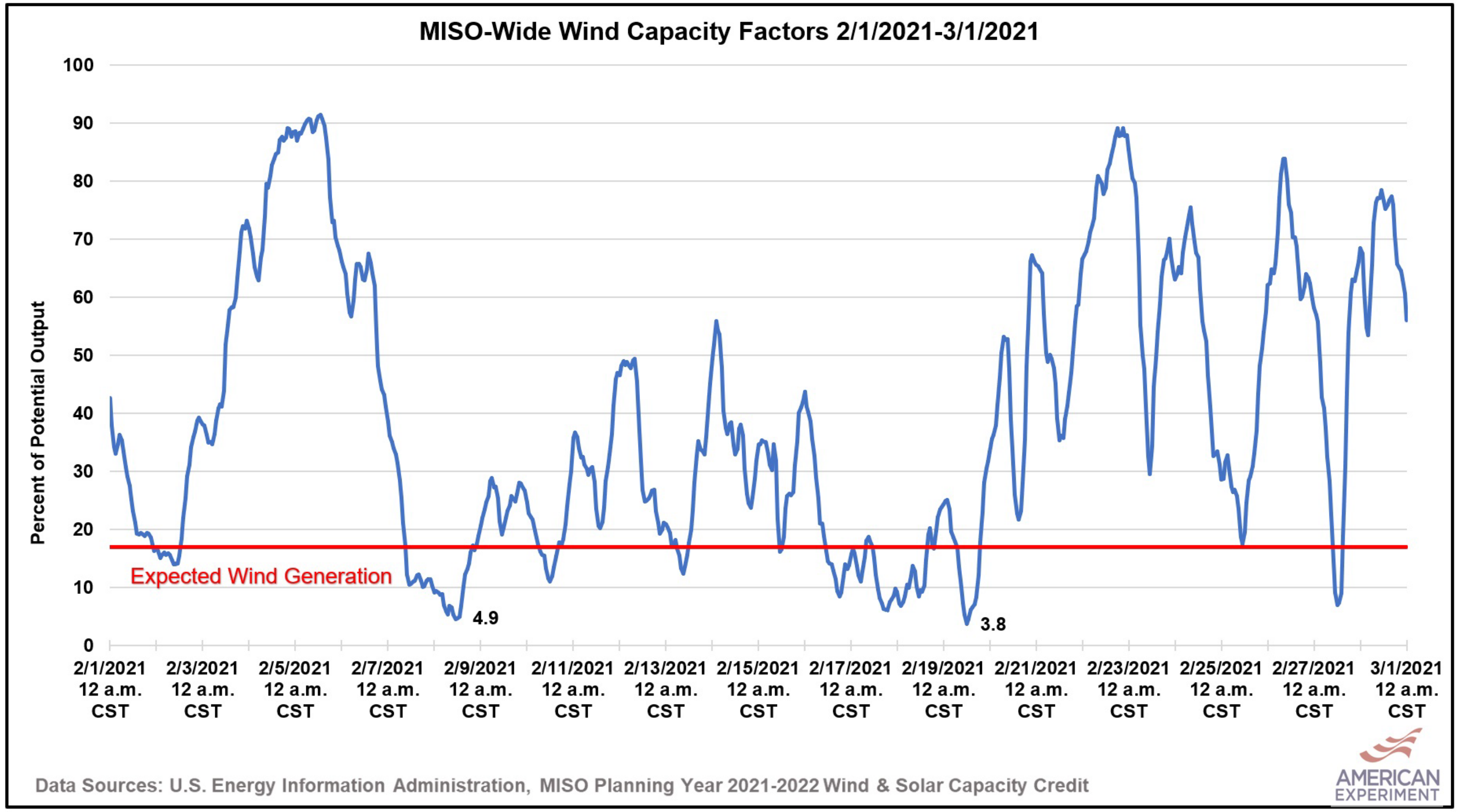
Seasonal Solar Accreditation				
	PY23-24	F1-25	F1-39	Reserve Margin
Winter		1%	1%	25.50%
Spring		35%	2%	24.50%
Summer	45%	43%	3%	7.40%
Fall		6%	5%	14.90%

Seasonal Wind Accreditation				
	PY23-24	F1-25	F1-39	Reserve Margin
Winter		15%	10%	25.50%
Spring		13%	20%	24.50%
Summer	10%	7%	11%	7.40%
Fall		7%	12%	14.90%

HCD ALTERNATIVE APPROACH

Mean of Lowest Quartile	Peak Accreditation	Net Peak Accreditation
Wind	7.10%	5.80%
Solar	12.40%	12.00%
Reserve Margin	15.50%	15.50%

MISO Wind Capacity Factors During Winter Storm Uri



- On several occasions during Storm Uri, MISO wind capacity factors fell below expected values based on MISO’s then-17.7 percent capacity accreditation. MISO’s high value for wind capacity accreditation has the potential of masking capacity shortfalls on the system.

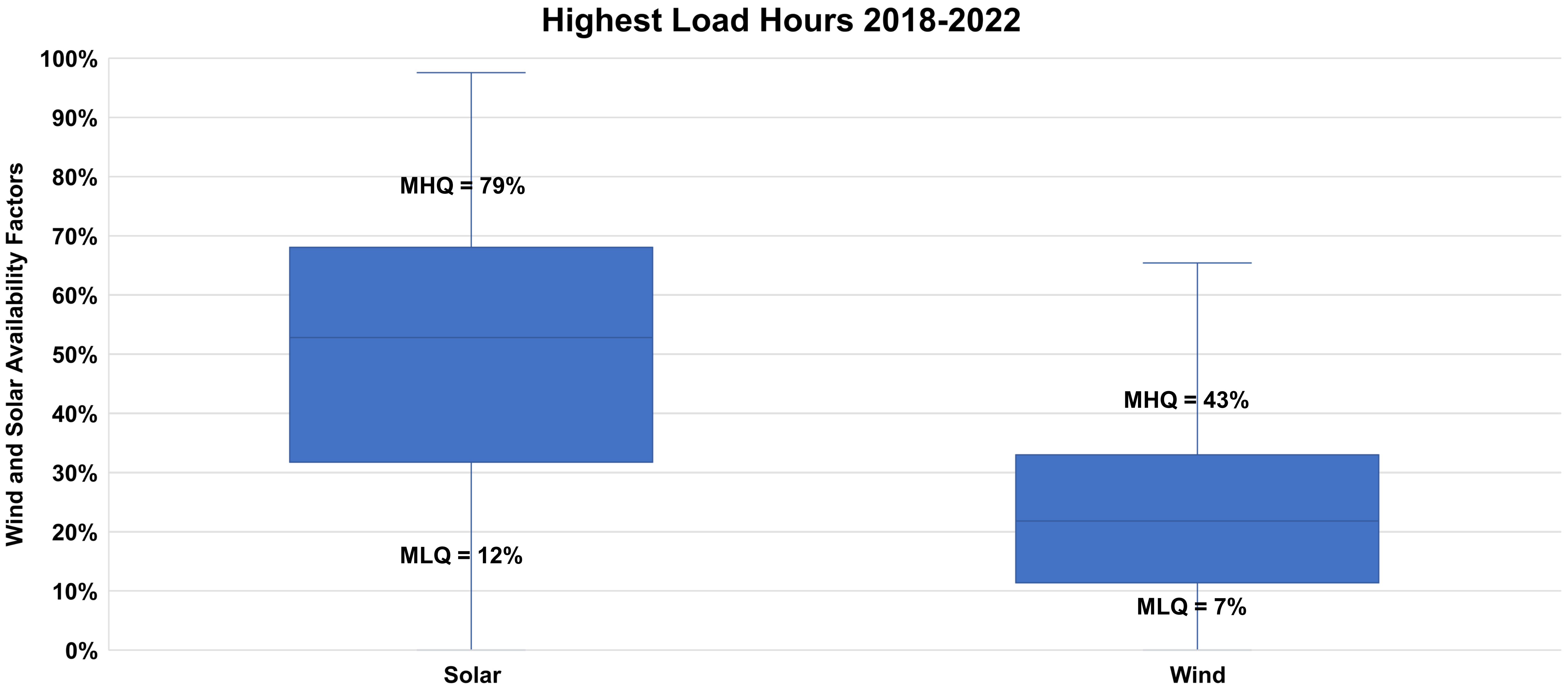
Methodology- Developing a Standardized Capacity Accreditation for Renewable Resources

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

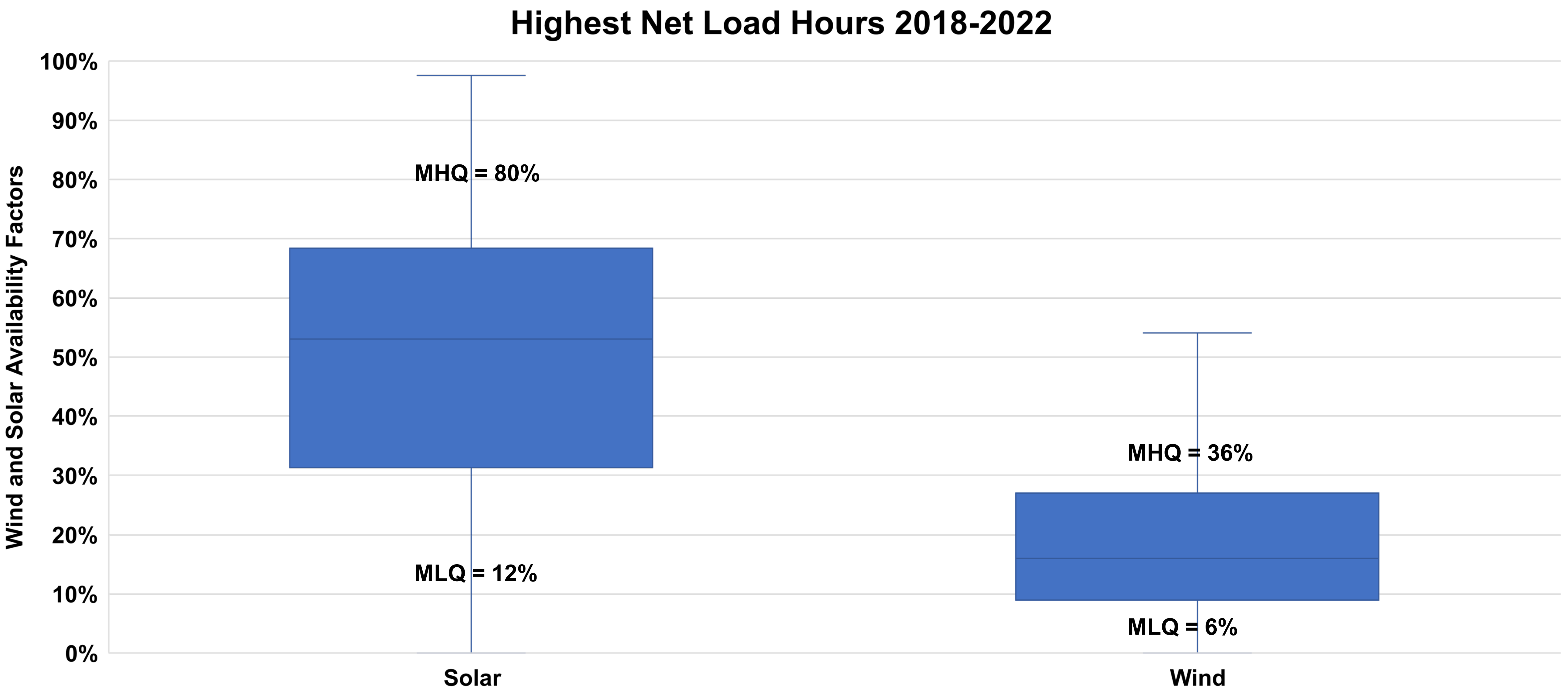
- Used the last 4 years of data from EIA Hourly Grid Monitor and Form 923. Peak and net peak occurred on July 19, 2019, and August 25, 2021, respectively.
- Mean of Lowest Quartile (HCD) to assess wind and solar accreditation.
  - Sample size of 2000 hours for wind & solar of the highest peak & net peak hours across 4 years.
  - Took the mean of the lowest 25 percent of wind and solar output during those hours to come up with 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%

Peak Load Availability Hours Wind and Solar



Net Peak Load Availability Hours Wind and Solar



Methodology- Capacity Additions and Retirements

Assessment of resource adequacy to 2035.

- Assumed both planned retirements per EIA data and hypothetical retirements under proposed EPA rules. Did not assume additional premature retirements or CCUS additions under the new regime of expanded and extended federal subsidies.
- Capacity additions of wind and solar would come online in proportion to coal and gas retirements to maintain MISO's reserve margin. (Ex: if 15 percent of retirements occur in 2025, 15 percent of new additions come online in that year).
    - Wind, solar, and battery storage additions are fewer than what would be expected given the net loss of firm capacity in each scenario. This is because our model accounts for all dispatchable capacity available to MISO and not only the plants that bid into its cleared capacity auction. This resulted in more dispatchable capacity being available to meet peak demand and reduced the need for more wind, solar, and storage additions.

Methodology- Capacity Additions and Retirements

Assessment of resource adequacy to 2035 (cont'd)

- The replacement resource mix (the mix of wind, solar, and battery storage added to replace retiring coal and natural gas power plants) is optimized for cost.
  - The model selected the amount of wind and solar additions based on the retirements of coal and natural gas and the need to build capacity to meet MISO's reserve margin.
  - The ratio of wind and solar (40/60) was determined by the least cost of serving load to consumers through 2035.
  - More solar was chosen due to its higher capacity accreditation.
  - This is in line with MISO's interconnection que, where the majority of requests are for solar facilities.

Methodology- Cost

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

- MISO Interconnect queue data were used to input ~7GW of new natural gas to replace retiring coal and gas facilities.
- Wind, solar, and 4-hour battery storage capacities were determined based on a cost-optimized model.

Assumptions include:

- Capital costs based on weighted average of MISO regions in EIA's Assumptions to the 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.
- Transmission costs in accordance with MISO TRANCHE 1 and average cost of active projects at the point of interconnect, which is about $48,000 per MW of wind and solar installed.
- New natural gas fuel cost of $5.46 per MMBtu.

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

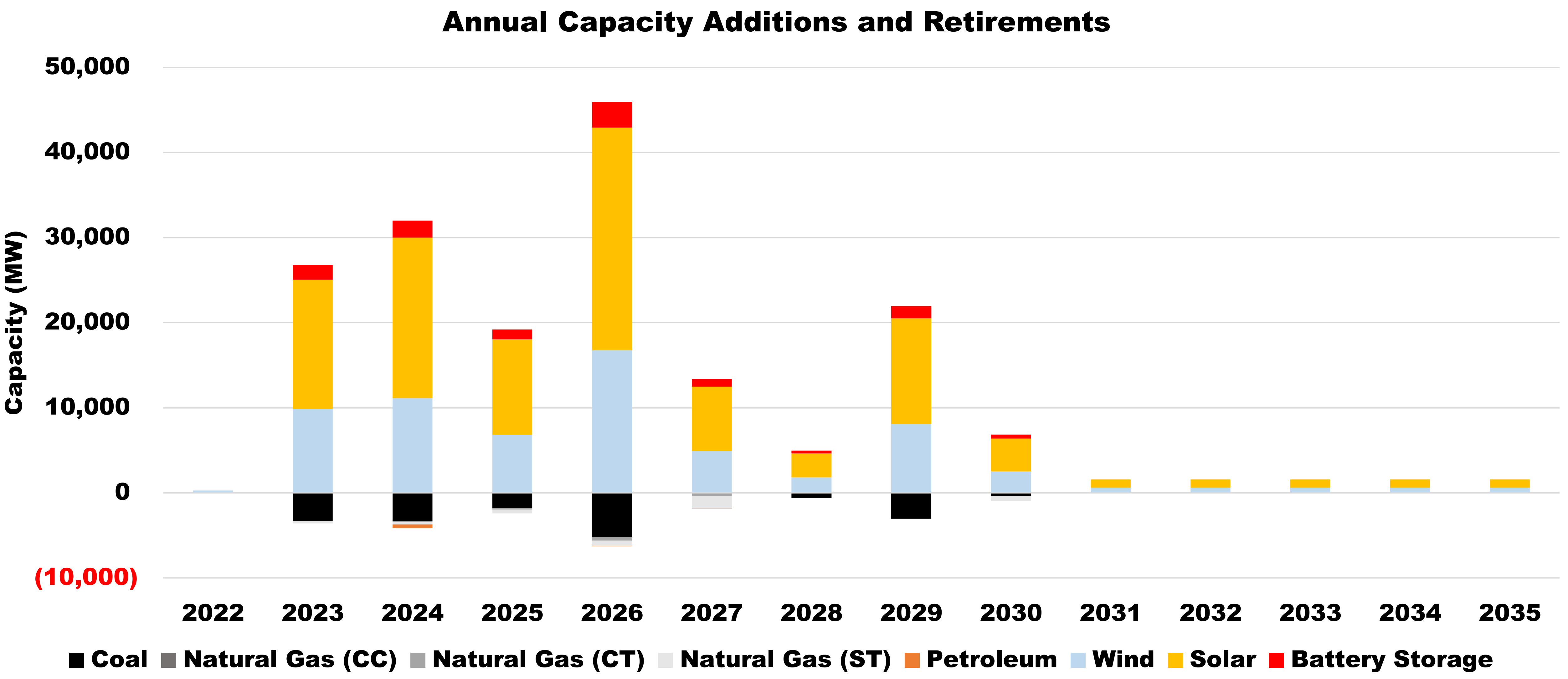
Reference Scenario: Retirements

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Total
Coal	0	(3,312)	(3,306)	(1,796)	(5,175)	0	(617)	(3,034)	(365)	0	0	0	0	0	(17,605)
Natural Gas (CC)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas (CT)	0	0	(76)	(168)	(433)	(360)	0	0	0	0	0	0	0	0	(1,037)
Natural Gas (ST)	0	(275)	(321)	(446)	(612)	(1,486)	0	0	(582)	0	0	0	0	0	(3,721)
Petroleum	0	0	(410)	0	(53)	(4)	0	0	0	0	0	0	0	0	(466)
Hydroelectric	0	0	(35)	(2)	(2)	0	(23)	0	0	0	0	0	0	0	(63)
Wind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass	0	(3)	(30)	0	0	0	(48)	0	0	0	0	0	0	0	(82)
Battery Storage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Reference Scenario: Additions

Additions	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Total
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
Natural Gas (CC)	0.0	2,290.0	75.0	767.8	100.0	0.0	0.0	682.0	0.0	0.0	0.0	0.0	0.0	0.0	3,914.8
Natural Gas (CT)	0.0	460.7	0.0	894.0	371.1	1,602.7	0.0	263.0	0.0	0.0	0.0	0.0	0.0	0.0	3,591.5
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
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
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
Wind	283.7	9,887.6	11,152.2	6,830.9	16,747.7	4,934.6	1,837.8	8,098.7	2,526.7	625.5	625.5	625.5	625.5	625.5	65,427.6
Solar	0.0	15,174.4	18,856.2	11,214.2	26,198.8	7,557.3	2,814.6	12,403.0	3,869.6	958.0	958.0	958.0	958.0	958.0	102,878.2
Biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Battery Storage	0.0	1,724.2	2,006.8	1,158.1	3,013.7	888.0	330.7	1,457.3	454.7	0.0	0.0	0.0	0.0	0.0	11,033.7

Reference Scenario: Retirements and Additions



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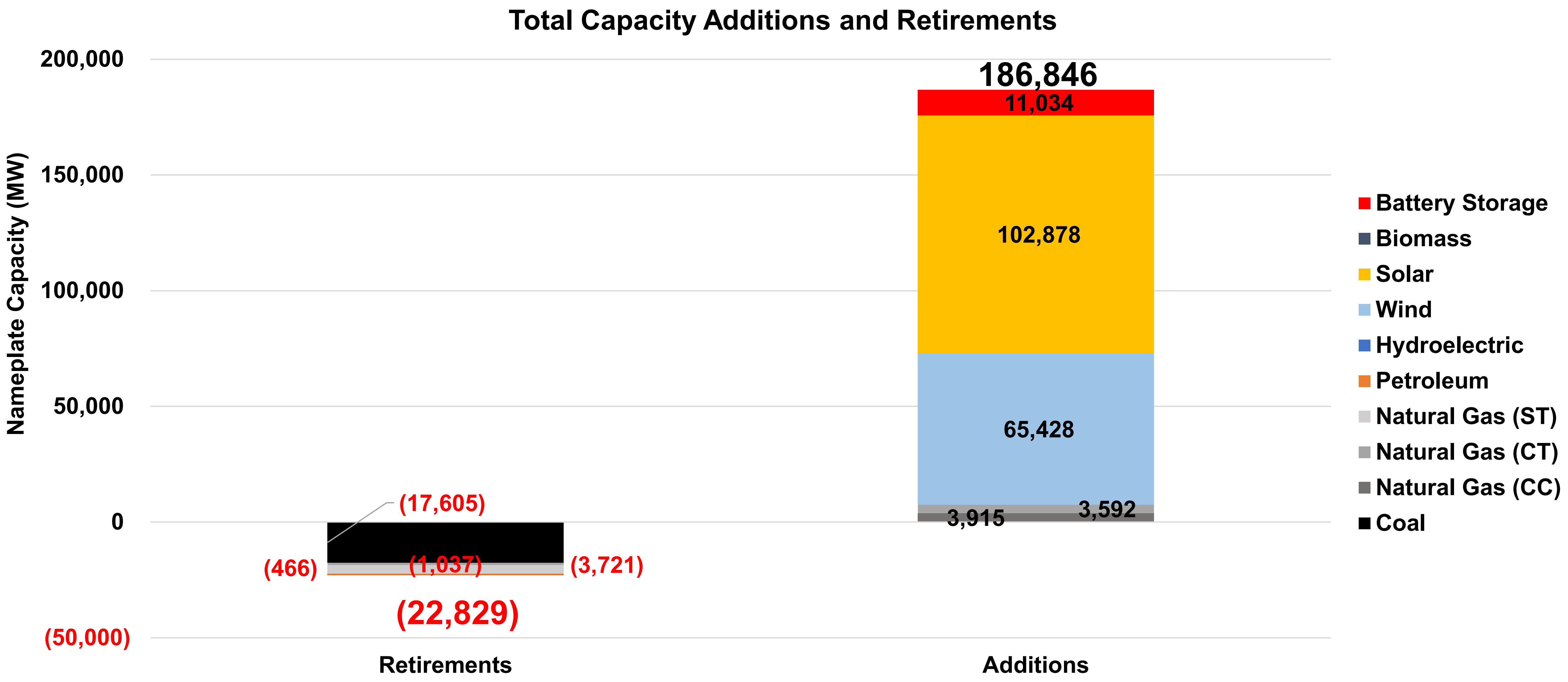


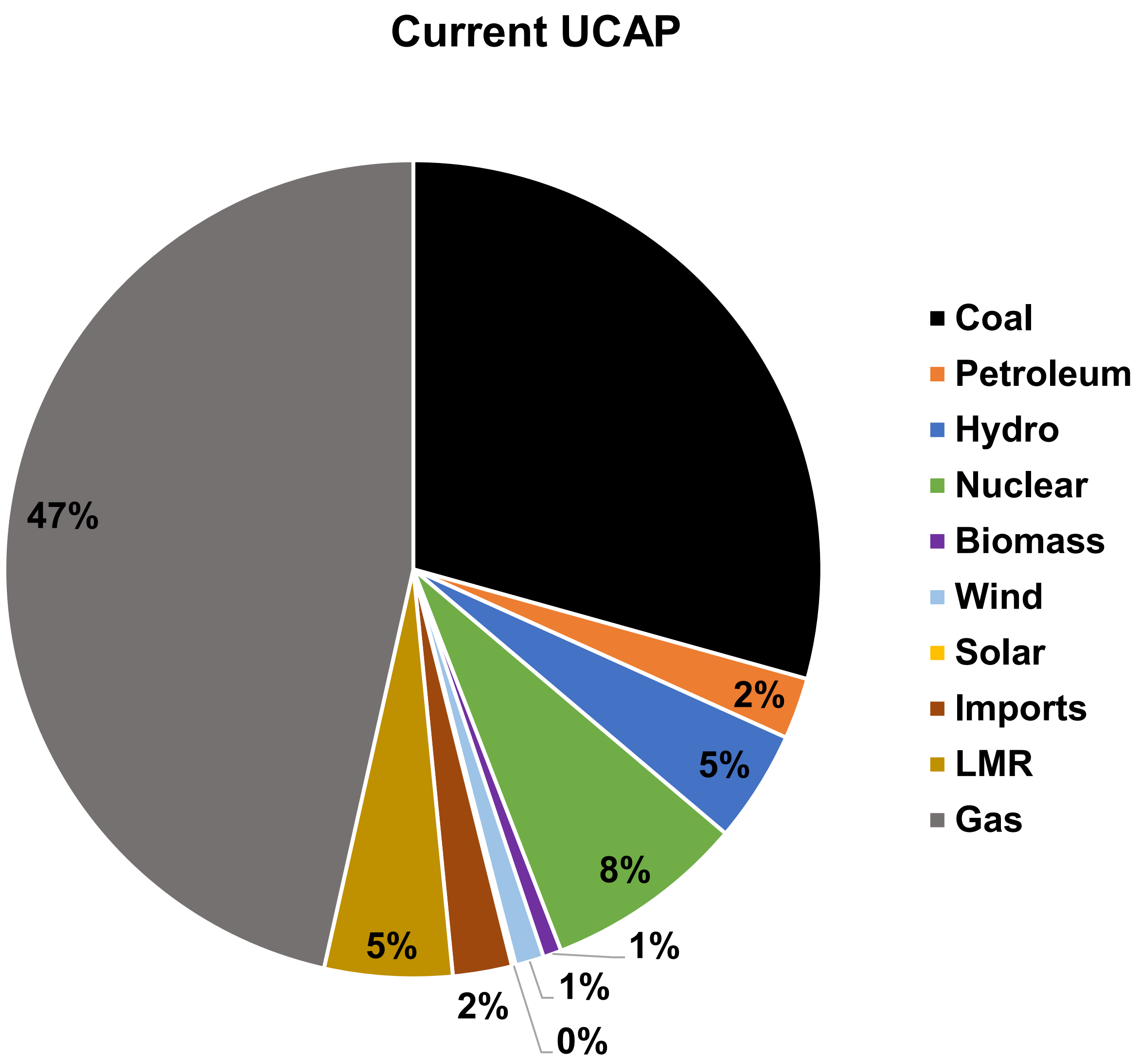
Reference Scenario: Annual ICAP Mix (MW)

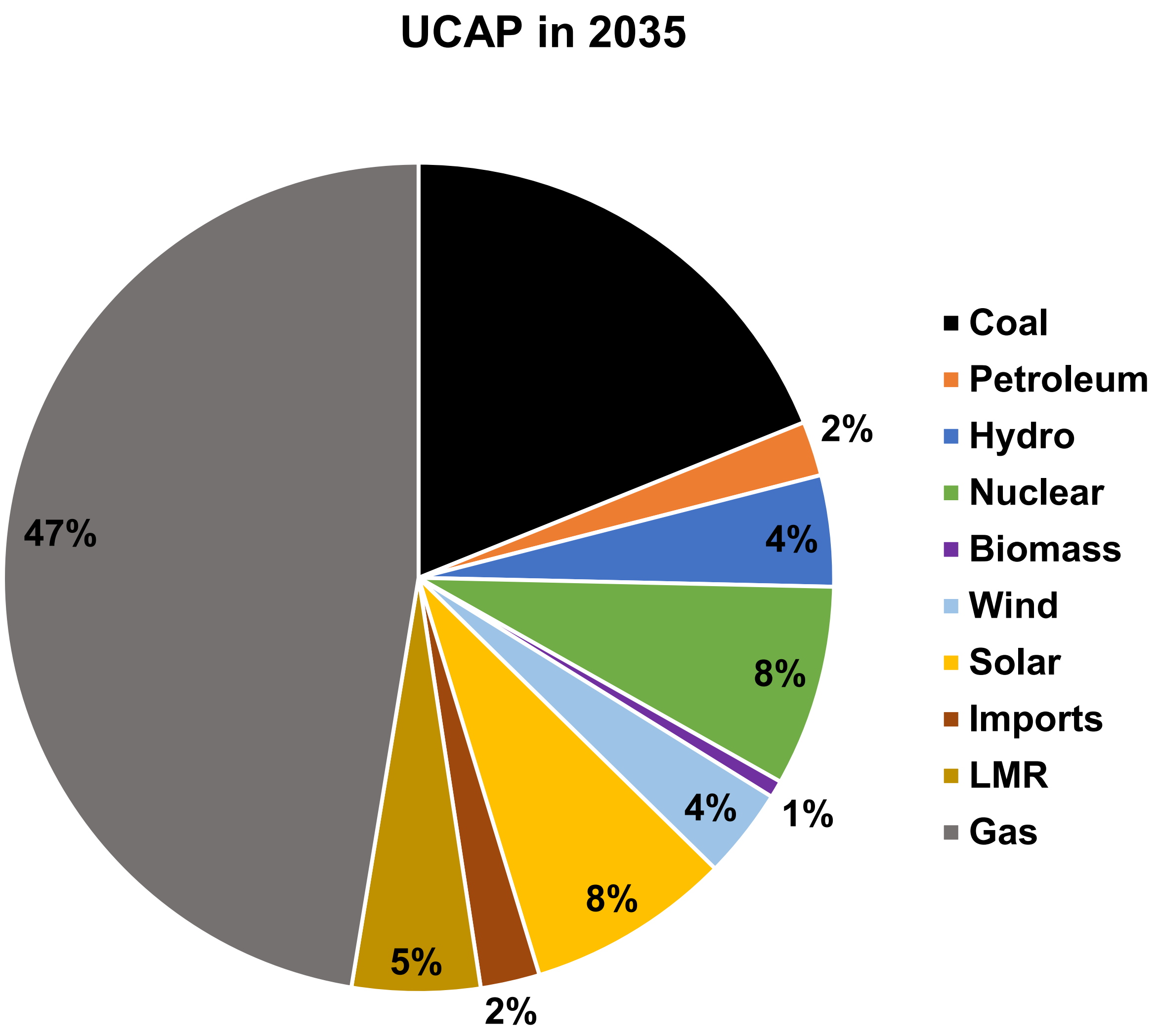
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	
Coal	50,772	47,460	44,154	42,358	37,183	37,183	36,566	33,532	33,167	33,167	33,167	33,167	33,167	33,167	10%
Natural Gas (CC)	32,981	35,271	35,346	36,114	36,214	36,214	36,214	36,896	36,896	36,896	36,896	36,896	36,896	36,896	11%
Natural Gas (CT)	29,570	30,030	29,954	30,680	30,618	31,861	31,861	32,124	32,124	32,124	32,124	32,124	32,124	32,124	9%
Natural Gas (ST)	17,946	17,671	17,350	16,905	16,293	14,808	14,808	14,808	14,225	14,225	14,225	14,225	14,225	14,225	4%
Petroleum	4,199	4,199	3,789	3,789	3,736	3,732	3,732	3,732	3,732	3,732	3,732	3,732	3,732	3,732	1%
Hydroelectric	6,962	6,962	6,927	6,925	6,923	6,923	6,899	6,899	6,899	6,899	6,899	6,899	6,899	6,899	2%
Existing Nuclear	13,026	13,026	13,026	13,026	13,026	13,026	13,026	13,026	13,026	13,026	13,026	13,026	13,026	13,026	4%
Onshore Wind	30,624	40,511	51,663	58,494	75,242	80,177	82,014	90,113	92,640	93,265	93,891	94,516	95,142	95,768	27%
Utility Solar	1,997	17,171	36,028	47,242	73,441	80,998	83,813	96,216	100,085	101,043	102,001	102,959	103,917	104,875	29%
Biomass	1,254	1,250	1,220	1,220	1,220	1,220	1,172	1,172	1,172	1,172	1,172	1,172	1,172	1,172	0%
Storage	0	1,724	3,731	4,889	7,903	8,791	9,122	10,579	11,034	11,034	11,034	11,034	11,034	11,034	3%
Total	189,330	215,276	243,188	261,642	301,798	314,932	319,226	339,096	345,000	346,584	348,167	349,751	351,334	352,918	

Reference Scenario: Annual UCAP Mix (MW)

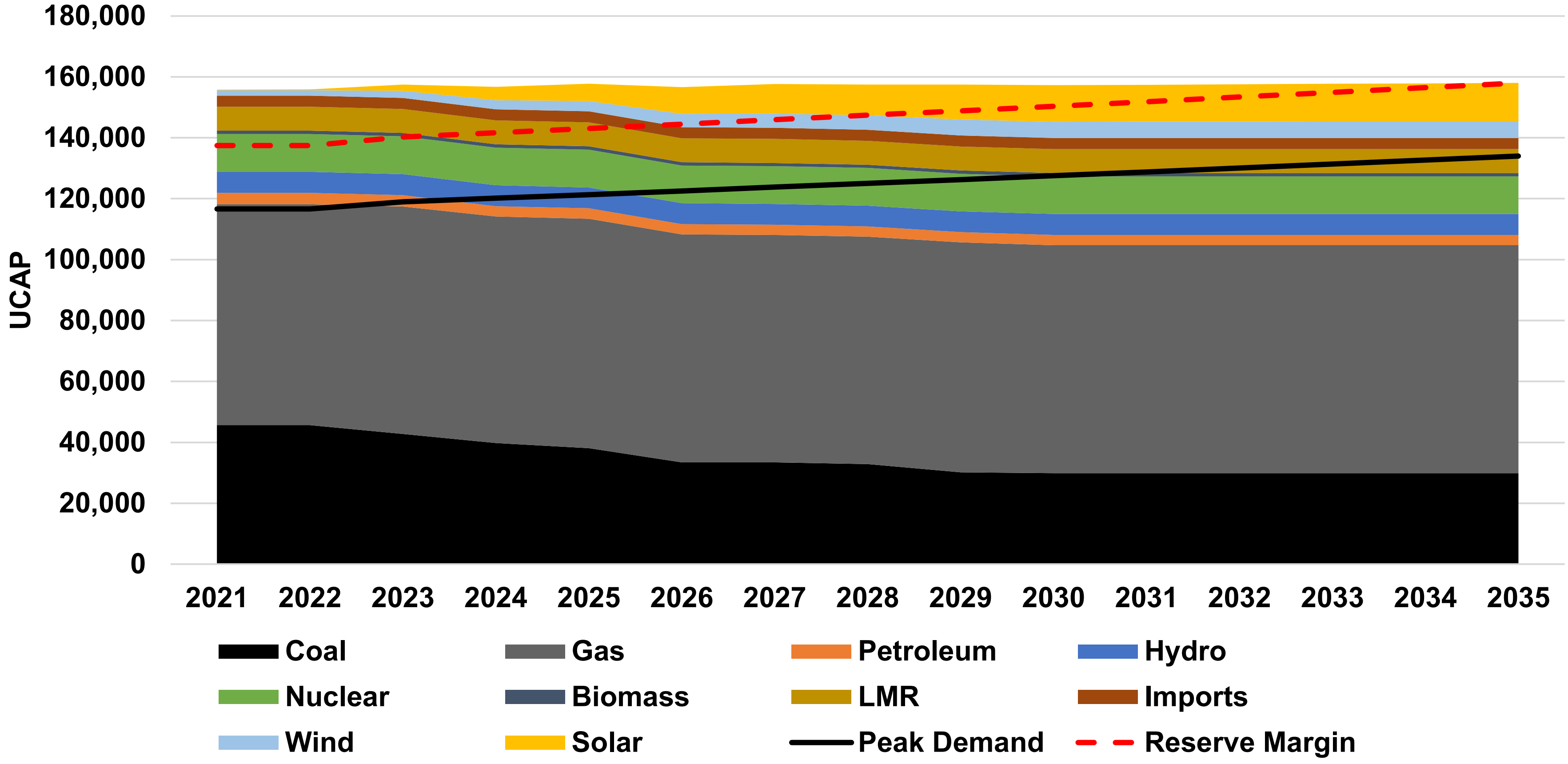
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	
Coal	45,695	45,695	42,714	39,739	38,122	33,465	33,465	32,909	30,178	29,850	29,850	29,850	29,850	29,850	29,850	19%
Natural Gas (CC)	29,683	29,683	31,744	31,811	32,503	32,593	32,593	32,593	33,206	33,206	33,206	33,206	33,206	33,206	33,206	21%
Natural Gas (CT)	26,613	26,613	27,027	26,959	27,612	27,556	28,675	28,675	28,912	28,912	28,912	28,912	28,912	28,912	28,912	18%
Natural Gas (ST)	16,152	16,152	15,904	15,615	15,214	14,664	13,327	13,327	13,327	12,803	12,803	12,803	12,803	12,803	12,803	8%
Petroleum	3,779	3,779	3,779	3,410	3,410	3,362	3,359	3,359	3,359	3,359	3,359	3,359	3,359	3,359	3,359	2%
Hydro	6,900	6,900	6,900	6,865	6,862	6,860	6,860	6,837	6,837	6,837	6,837	6,837	6,837	6,837	6,837	4%
Nuclear	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	8%
Biomass	1,128	1,128	1,125	1,098	1,098	1,098	1,098	1,055	1,055	1,055	1,055	1,055	1,055	1,055	1,055	1%
Wind	1,758	1,774	2,347	2,993	3,389	4,359	4,645	4,751	5,220	5,367	5,403	5,439	5,475	5,512	5,548	4%
Solar	239	239	2,057	4,316	5,659	8,797	9,702	10,039	11,525	11,989	12,103	12,218	12,333	12,448	12,562	8%
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	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	5%
Total UCAP	155,833	155,849	157,484	156,693	157,757	156,641	157,611	157,433	157,507	157,265	157,416	157,567	157,718	157,869	158,020	

Reference Scenario: Current UCAP vs. 2035





Even With No EPA impact
MISO Relying Upon Weather & Imports for Reserve

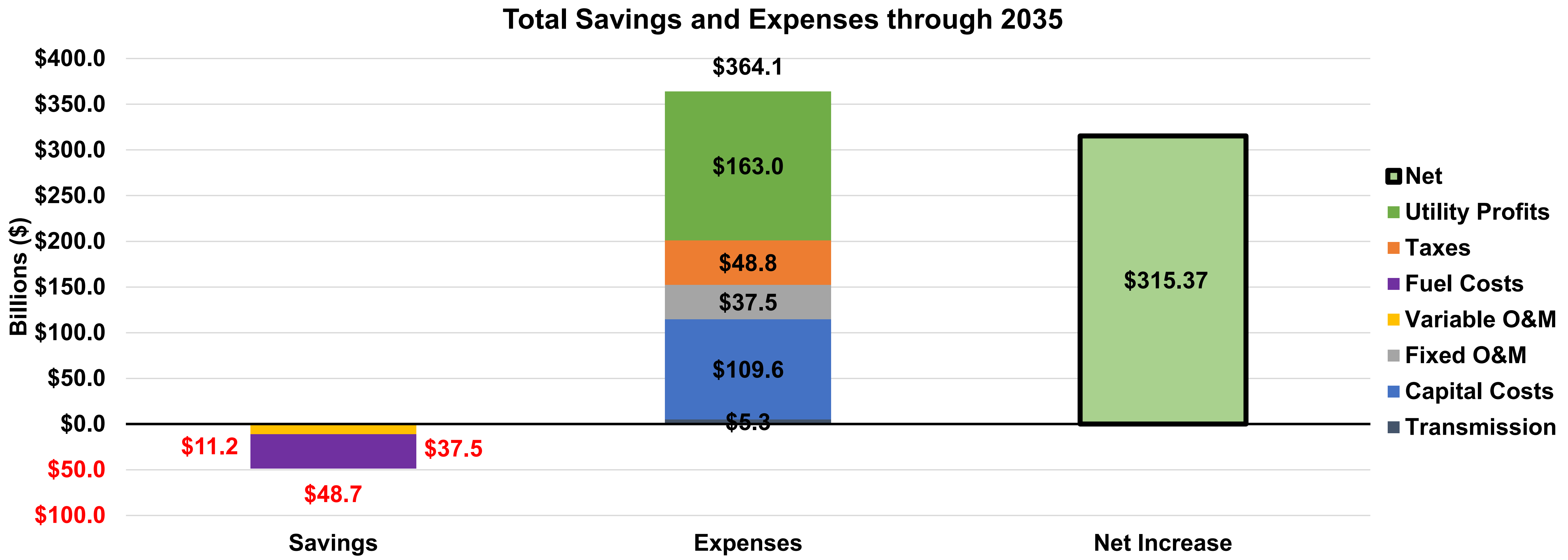


Estimated firm capacity using net peak load capacity accreditation values for wind (5.8%) and solar (12%), 95% for nuclear, and 90% for other thermal generators. Different than MISO cleared UCAP (unforced [accredited] capacity).

Year	Reserve Margin
2022	34%
2023	32%
2024	30%
2025	30%
2026	28%
2027	**27%**
2028	**26%**
2029	**25%**
2030	**23%**
2031	**22%**
2032	**21%**
2033	**20%**
2034	**19%**
2035	**18%**

Cost of Reference Scenario

The total additional cost to ratepayers in the Reference Scenario would be $315.4 billion through 2035 using net peak accreditation for wind and solar.



Ozone Transport FIP: Retirements (MW)

Retirements	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Total
Coal	0	(3,312)	(3,306)	(1,796)	(6,428)	(4,595)	(4,539)	(5,964)	(365)	0	0	0	0	0	(30,304)
Natural Gas (CC)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas (CT)	0	0	(76)	(168)	(433)	(360)	0	0	0	0	0	0	0	0	(1,037)
Natural Gas (ST)	0	(275)	(321)	(446)	(612)	(6,293)	0	0	(582)	0	0	0	0	0	(8,528)
Petroleum	0	0	(410)	0	(53)	(4)	0	0	0	0	0	0	0	0	(466)
Hydroelectric	0	0	(35)	(2)	(2)	0	(23)	0	0	0	0	0	0	0	(63)
Wind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass	0	(3)	(30)	0	0	0	(48)	0	0	0	0	0	0	0	(82)
Battery Storage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

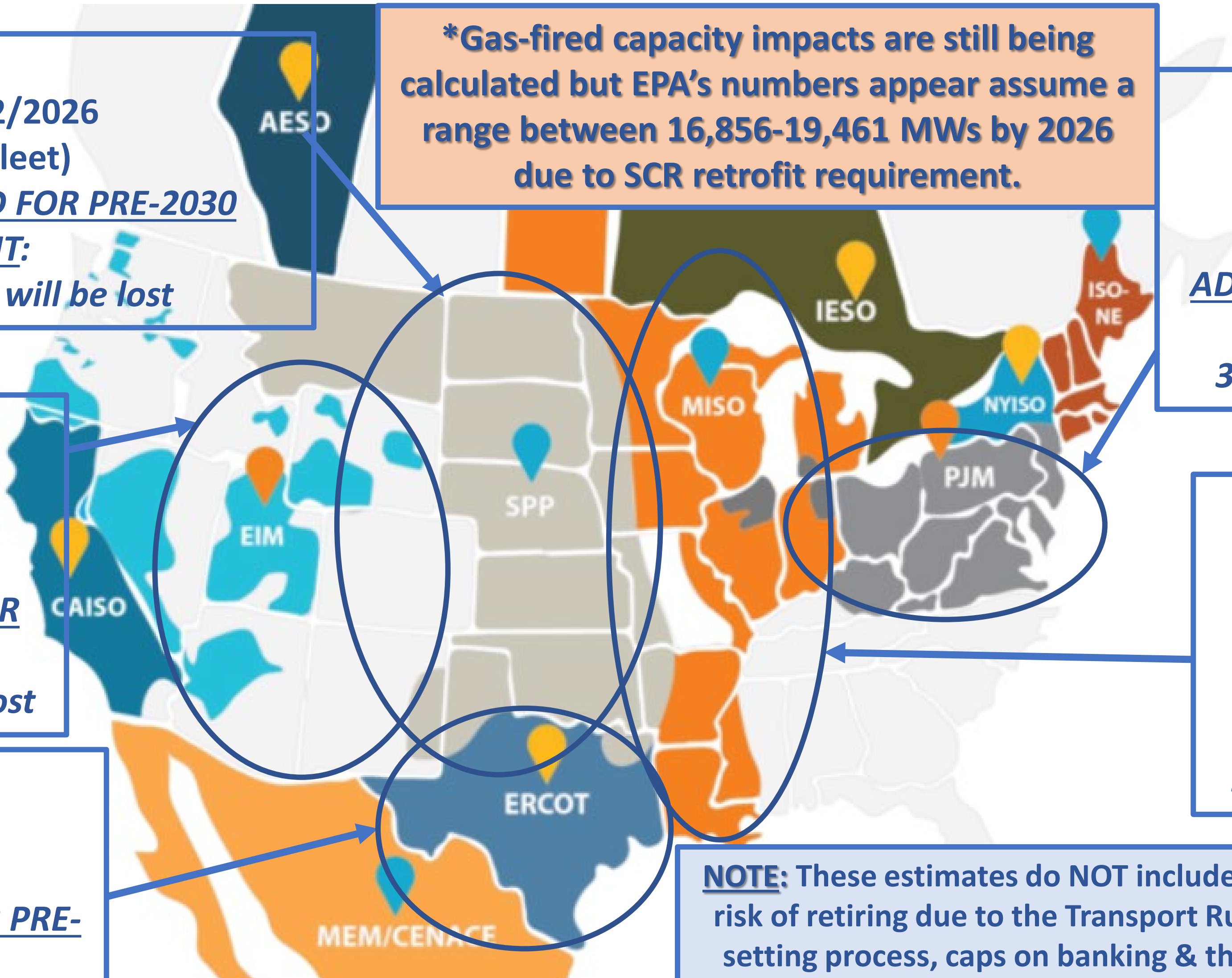
Methodology- Retirement Assumptions (OTR)

SPP:
8,184 MW by 12/2026
(37% of Coal Fleet)
ADDED TO UNITS SLATED FOR PRE-2030 RETIREMENT:
37% of coal capacity will be lost

***Gas-fired capacity impacts are still being calculated but EPA's numbers appear assume a range between 16,856-19,461 MWs by 2026 due to SCR retrofit requirement.**

PJM:
6,626 MW
by 12/2026
(15% of Coal Fleet)
ADDED TO UNITS SLATED FOR PRE-2030 RETIREMENT:
33% of coal capacity will be lost

MOUNTAIN WEST:
8,892 MW
by 12/2026
(38% of Coal Fleet)
ADDED TO UNITS SLATED FOR PRE-2030 RETIREMENT:
44% of coal capacity will be lost



MISO:
16,996 MW
by 12/2026
(34% of Coal Fleet)
ADDED TO UNITS SLATED FOR PRE-2030 RETIREMENT:
51% of coal capacity will be lost

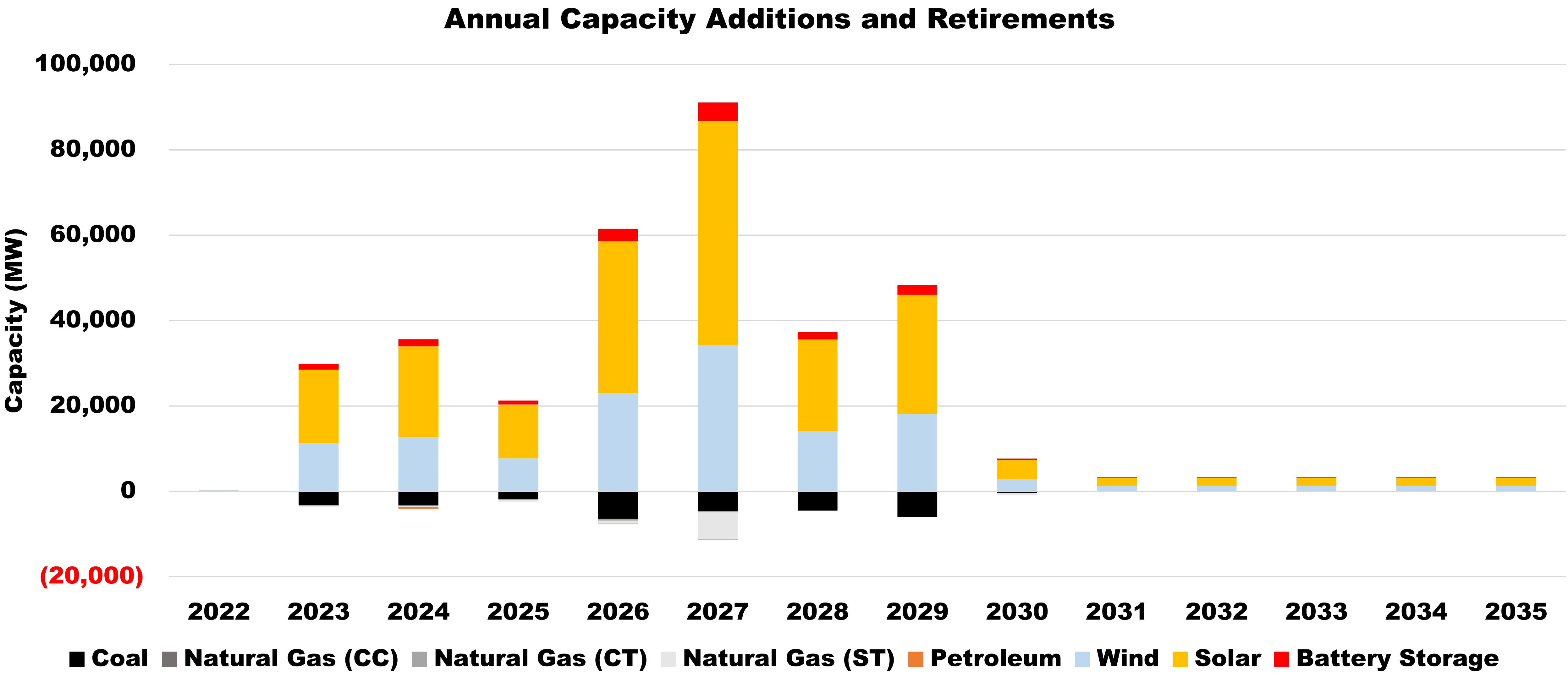
ERCOT:
7,867 MW by 12/2026
(55% of Coal Fleet)
ADDED TO UNITS SLATED FOR PRE-2030 RETIREMENT:
55% of coal capacity will be lost

NOTE: These estimates do NOT include SCR-controlled units that are also at risk of retiring due to the Transport Rule FIP's stringent & dynamic budget setting process, caps on banking & the daily max NOx emission rate. Nor does this capture retirements due to new interpretations of the CCR Rules EPA is attempting to impose on the states (i.e. this is the low end of impact).

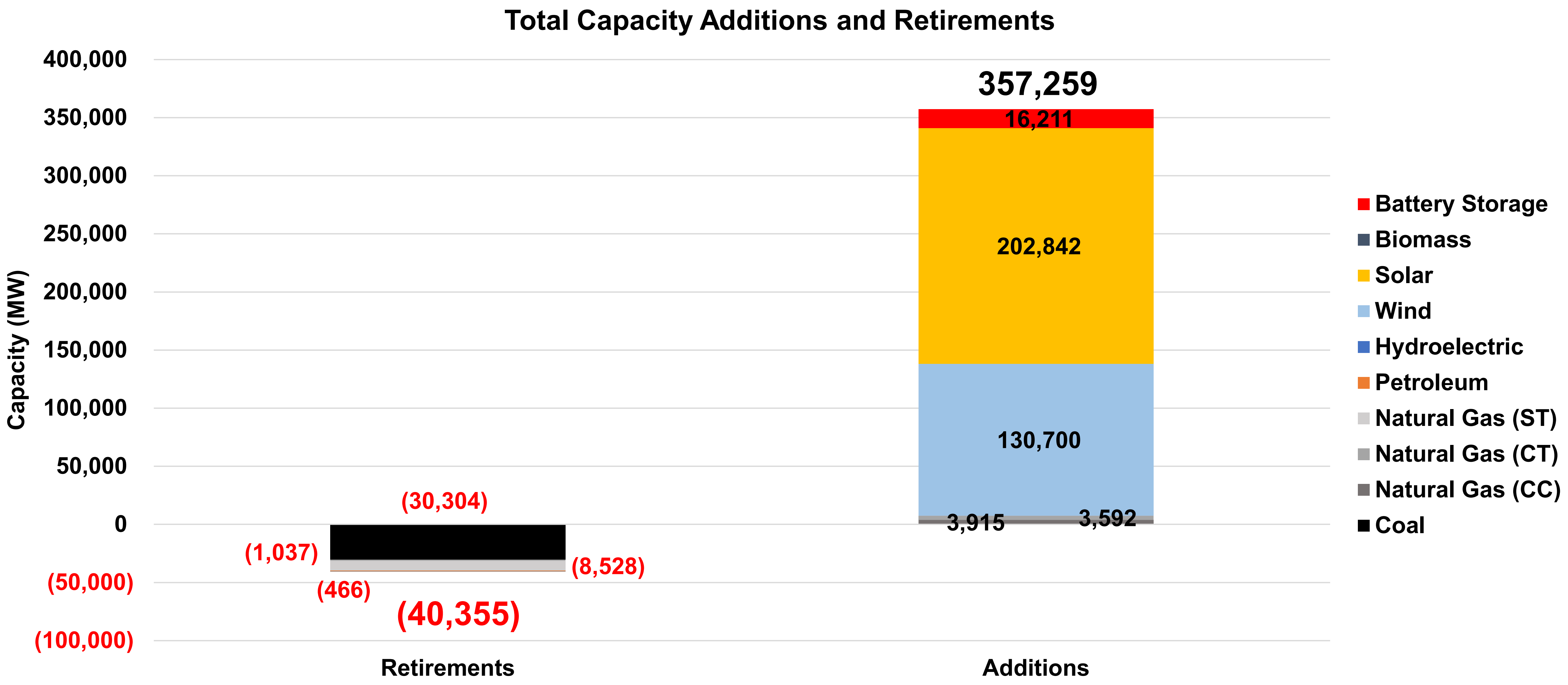
Ozone Transport FIP: Additions (MW)

Additions	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Total
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
Natural Gas (CC)	0.0	2,290.0	75.0	767.8	100.0	0.0	0.0	682.0	0.0	0.0	0.0	0.0	0.0	0.0	3,914.8
Natural Gas (CT)	0.0	460.7	0.0	894.0	371.1	1,602.7	0.0	263.0	0.0	0.0	0.0	0.0	0.0	0.0	3,591.5
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
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
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
Wind	283.7	11,251.8	12,740.0	7,747.2	22,952.2	34,303.7	14,056.3	18,182.7	2,886.4	1,259.1	1,259.1	1,259.1	1,259.1	1,259.1	130,699.7
Solar	0.0	17,263.7	21,287.9	12,617.5	35,701.0	52,535.7	21,527.0	27,846.6	4,420.5	1,928.3	1,928.3	1,928.3	1,928.3	1,928.3	202,841.6
Biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Battery Storage	0.0	1,368.0	1,592.2	918.8	2,868.4	4,287.1	1,756.7	2,272.4	360.7	157.4	157.4	157.4	157.4	157.4	16,211.1

OTR Scenario: Retirements and Additions



OTR Scenario: Retirements and Additions



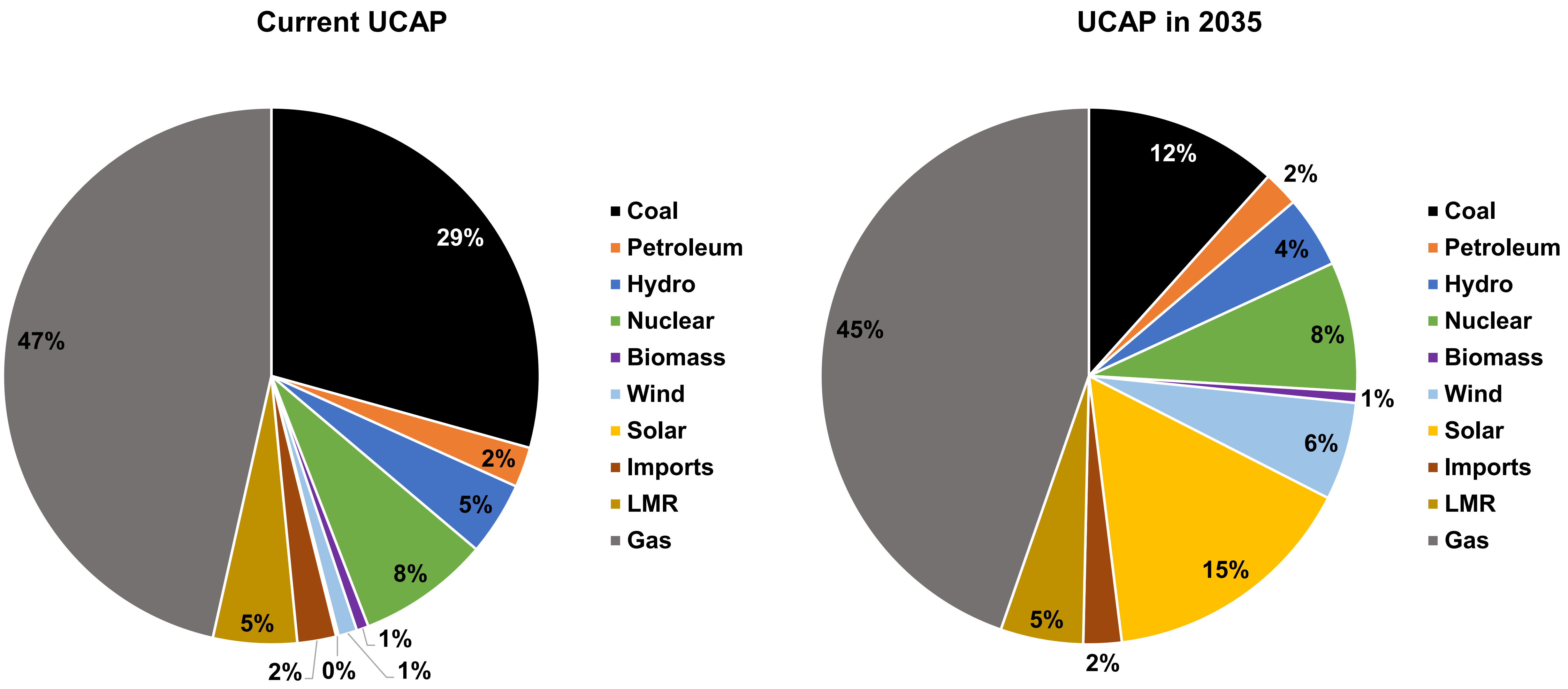
Ozone Transport FIP: Annual ICAP Mix

	2022	2023	2024	2025	2026	2027	2028	2029	2030	
Coal	50,772	47,460	44,154	39,080	33,226	21,373	21,373	20,833	20,468	5%
Natural Gas (CC)	32,981	35,271	35,346	36,114	36,214	36,214	36,214	36,896	36,896	9%
Natural Gas (CT)	29,570	30,030	29,954	30,680	30,618	31,861	31,861	32,124	32,124	8%
Natural Gas (ST)	17,946	17,671	17,350	16,905	16,293	10,001	10,001	10,001	9,418	2%
Petroleum	4,199	4,199	3,789	3,789	3,736	3,732	3,732	3,732	3,732	1%
Hydroelectric	6,962	6,962	6,927	6,925	6,923	6,923	6,899	6,899	6,899	2%
Existing Nuclear	13,026	13,026	13,026	13,026	13,026	13,026	13,026	13,026	13,026	3%
Onshore Wind	30,624	39,624	49,743	63,916	80,759	125,585	125,757	127,065	129,358	32%
Utility Solar	1,997	15,813	33,087	55,546	81,890	150,540	150,804	152,807	156,318	38%
Biomass	1,254	1,250	1,220	1,220	1,220	1,220	1,172	1,172	1,172	0%
Storage	0	110	238	412	624	1,191	1,193	1,209	1,238	0%
Total	189,330	211,416	234,834	267,612	304,528	401,664	402,032	405,764	410,650	

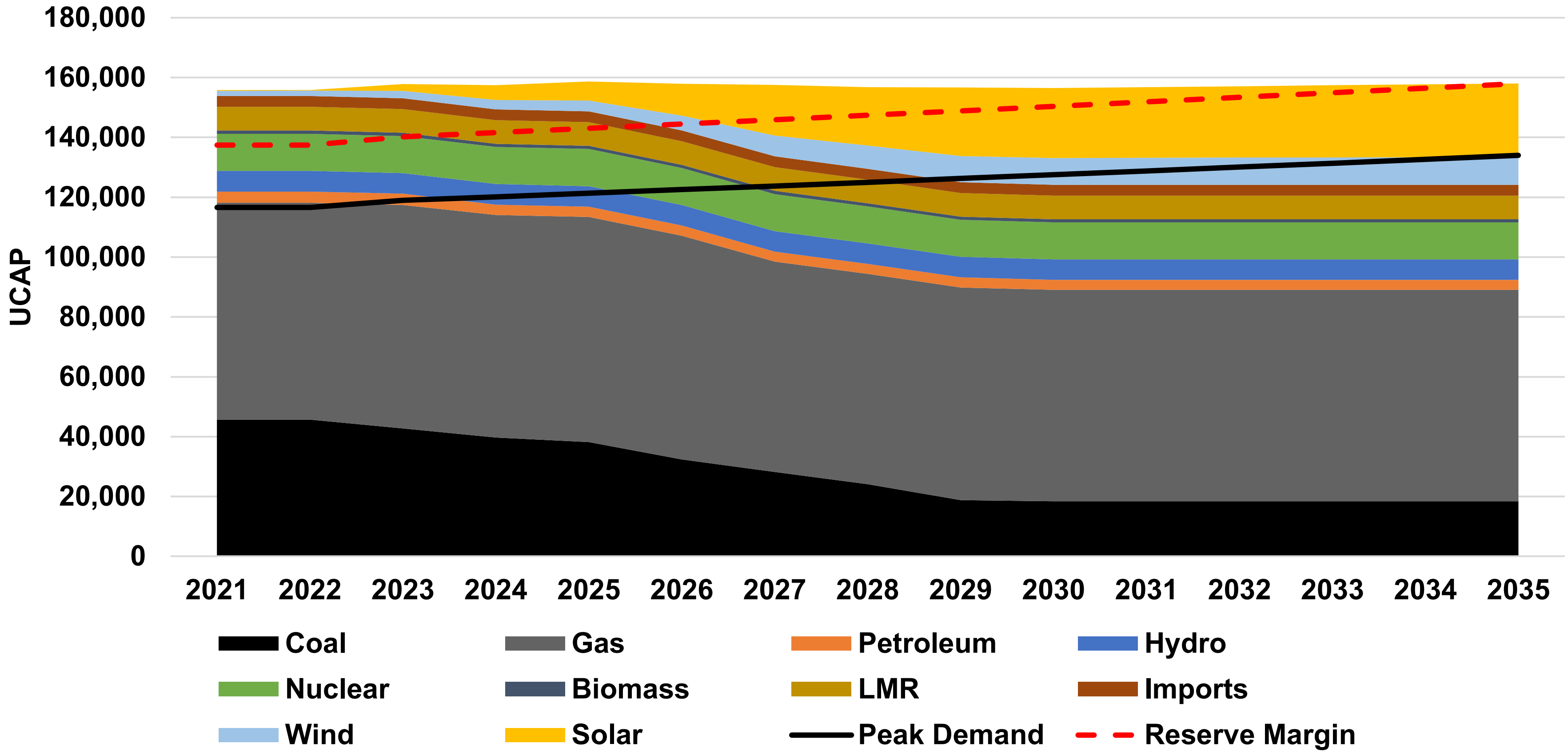
Ozone Transport FIP: Annual UCAP Mix

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	
Coal	45,695	45,695	42,714	39,739	38,122	32,337	28,202	24,117	18,749	18,421	18,421	18,421	18,421	18,421	18,421	12%
Natural Gas (CC)	29,683	29,683	31,744	31,811	32,503	32,593	32,593	32,593	33,206	33,206	33,206	33,206	33,206	33,206	33,206	21%
Natural Gas (CT)	26,613	26,613	27,027	26,959	27,612	27,556	28,675	28,675	28,912	28,912	28,912	28,912	28,912	28,912	28,912	18%
Natural Gas (ST)	16,152	16,152	15,904	15,615	15,214	14,664	9,000	9,000	9,000	8,476	8,476	8,476	8,476	8,476	8,476	5%
Petroleum	3,779	3,779	3,779	3,410	3,410	3,362	3,359	3,359	3,359	3,359	3,359	3,359	3,359	3,359	3,359	2%
Hydro	6,900	6,900	6,900	6,865	6,862	6,860	6,860	6,837	6,837	6,837	6,837	6,837	6,837	6,837	6,837	4%
Nuclear	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	8%
Biomass	1,128	1,128	1,125	1,098	1,098	1,098	1,098	1,055	1,055	1,055	1,055	1,055	1,055	1,055	1,055	1%
Wind	1,758	1,774	2,426	3,164	3,613	4,942	6,930	7,744	8,797	8,964	9,037	9,110	9,183	9,256	9,329	6%
Solar	239	239	2,307	4,857	6,368	10,645	16,938	19,516	22,852	23,381	23,612	23,843	24,074	24,305	24,536	16%
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	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	5%
Total UCAP	155,833	155,849	157,813	157,405	158,690	157,945	157,542	156,783	156,656	156,500	156,804	157,108	157,412	157,716	158,020	

Ozone Transport FIP: Current UCAP vs. 2035



OTR Scenario: Capacity Shortfall Risk

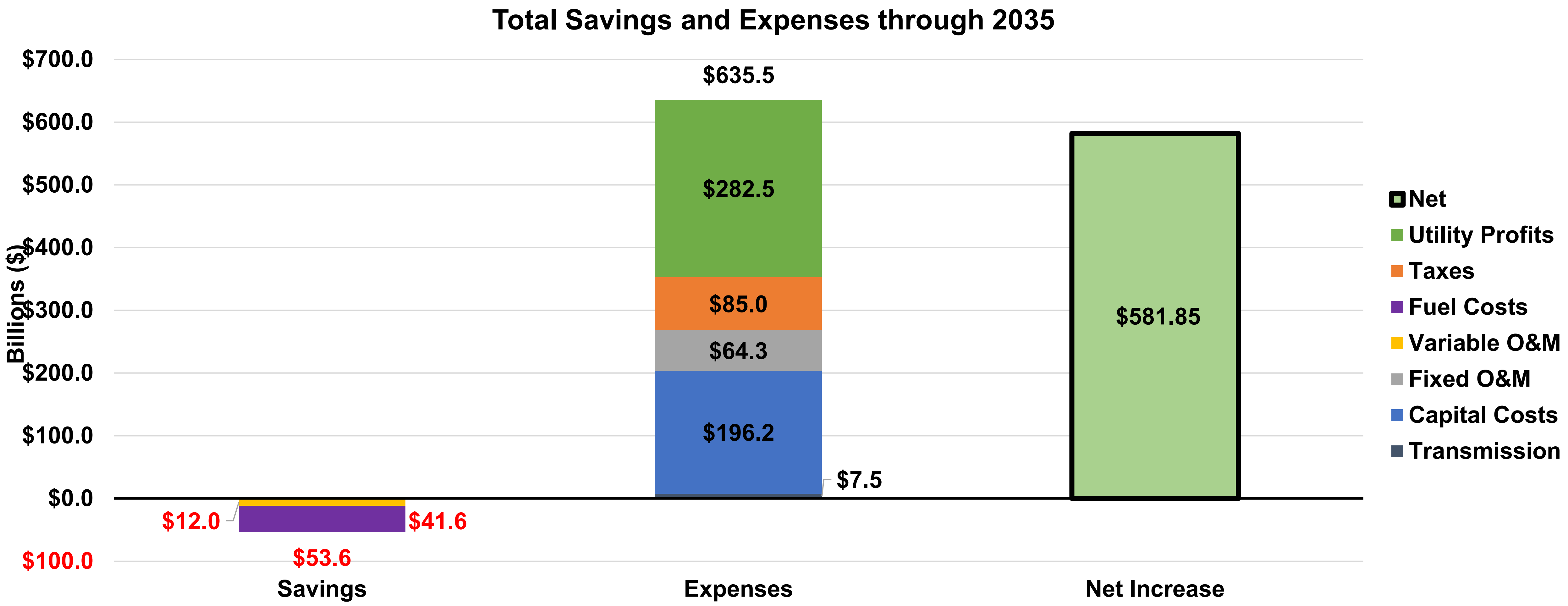


Estimated firm capacity using net peak load capacity accreditation values for wind (5.8%) and solar (12%), 95% for nuclear, and 90% for other thermal generators. Different than MISO cleared UCAP (unforced [accredited] capacity). Under this scenario, MISO dependent on intermittent resources to meet peak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

Year	Reserve Margin
2022	34%
2023	33%
2024	31%
2025	31%
2026	**29%**
2027	**27%**
2028	**25%**
2029	**24%**
2030	**23%**
2031	**22%**
2032	**21%**
2033	**20%**
2034	**19%**
2035	**18%**

OTR Scenario Costs

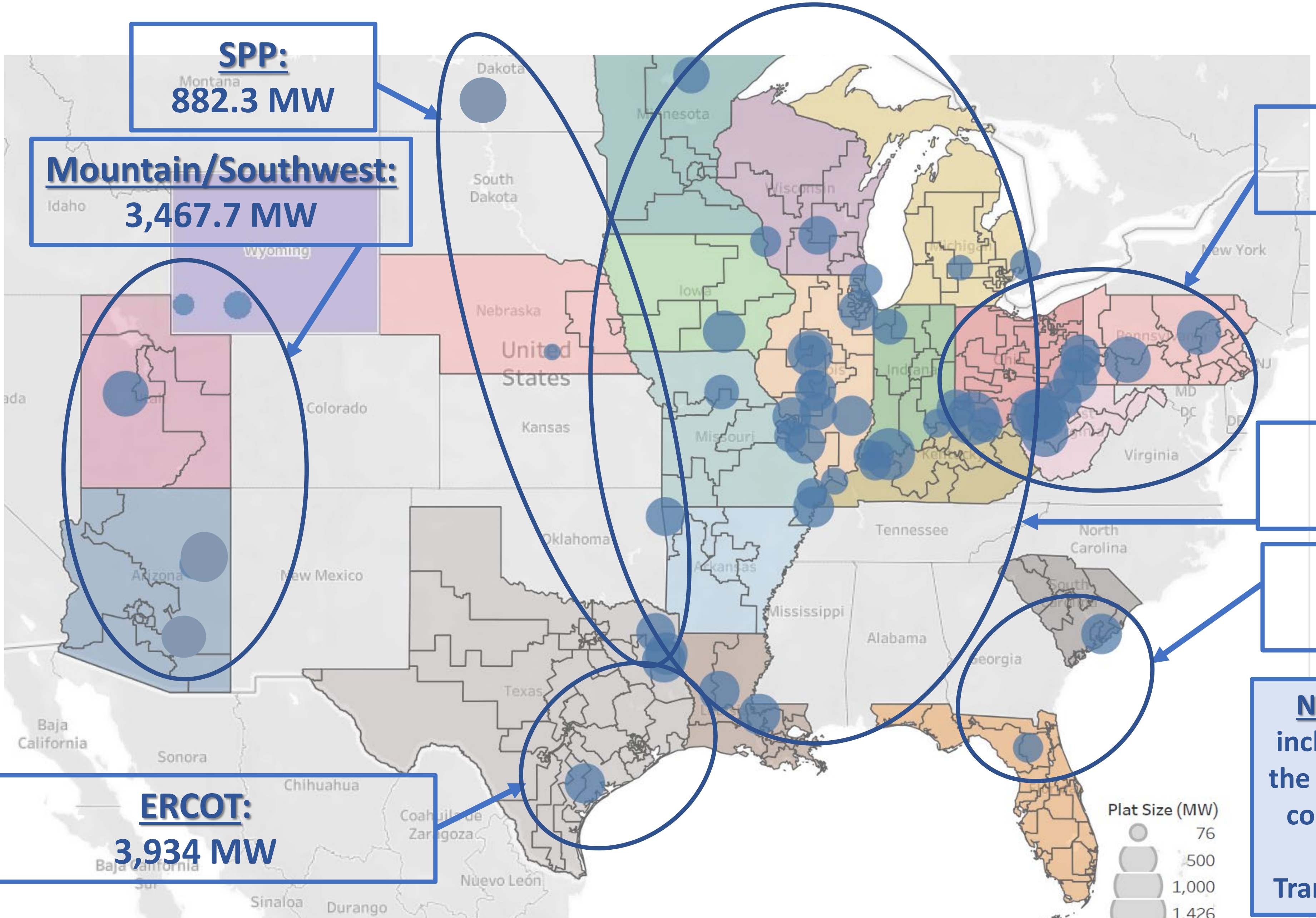
The total additional cost to ratepayers in the OTR Scenario would be $581.85 billion through 2035.



Ozone + CCR: Retirements (MW)

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Total
Coal	0	(3,312)	(3,923)	(10,578)	(3,118)	(3,978)	(2,765)	(5,345)	0	0	0	0	0	0	(33,019)
Natural Gas (CC)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas (CT)	0	0	(76)	(168)	(433)	(360)	0	0	0	0	0	0	0	0	(1,037)
Natural Gas (ST)	0	(275)	(321)	(446)	(612)	(6,293)	0	0	(582)	0	0	0	0	0	(8,528)
Petroleum	0	0	(410)	0	(53)	(4)	0	0	0	0	0	0	0	0	(466)
Hydroelectric	0	0	(35)	(2)	(2)	0	(23)	0	0	0	0	0	0	0	(63)
Wind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass	0	(3)	(30)	0	0	0	(48)	0	0	0	0	0	0	0	(82)
Battery Storage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Methodology- Retirement Assumptions (CCR)



SPP:
882.3 MW

Mountain/Southwest:
3,467.7 MW

PJM:
17,768.2 MW

MISO:
12,576.9 MW

SOUTHEAST:
894.7 MW

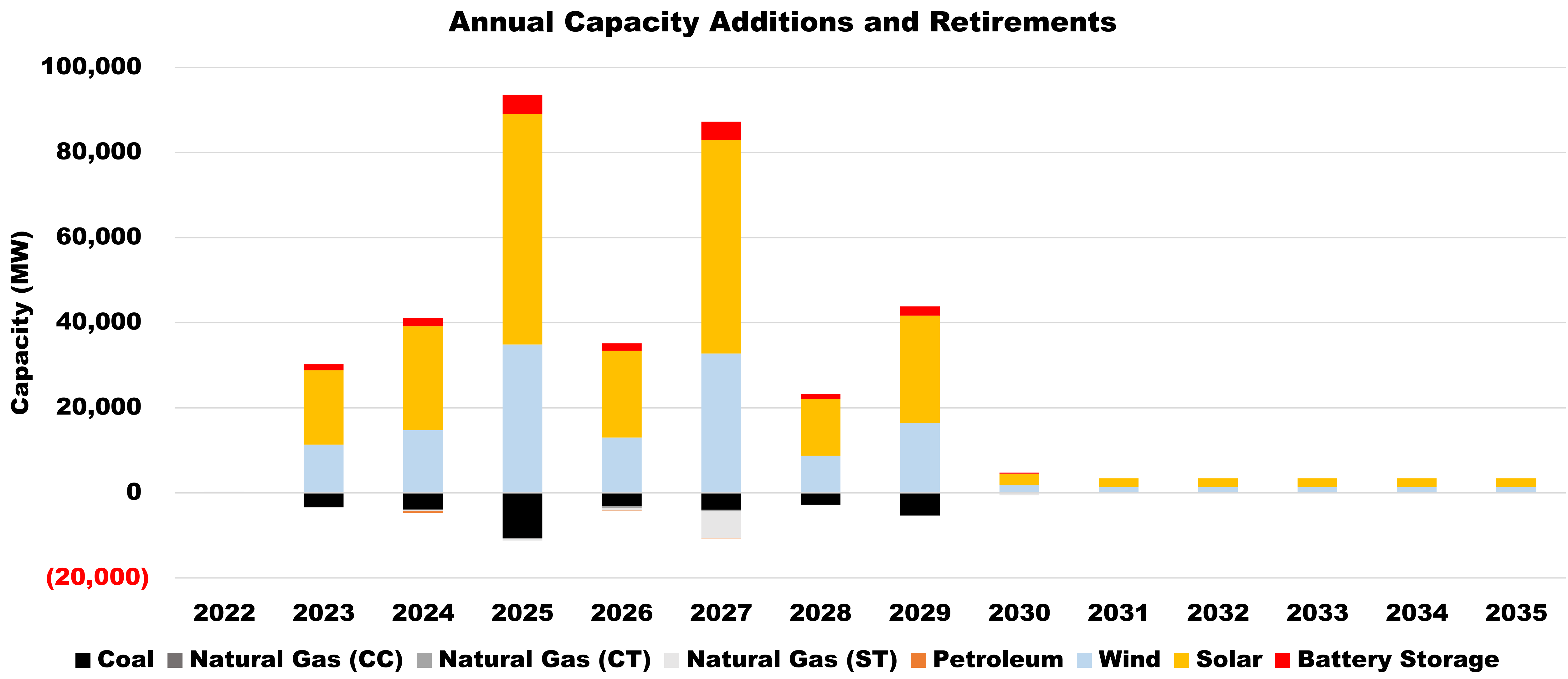
ERCOT:
3,934 MW

NOTE: These estimates do NOT include units already retired (or in the process) because of cost of CCR compliance or or the threatened imposition of EPA's Ozone Transport Rule FIP (> 50,000 MWs)

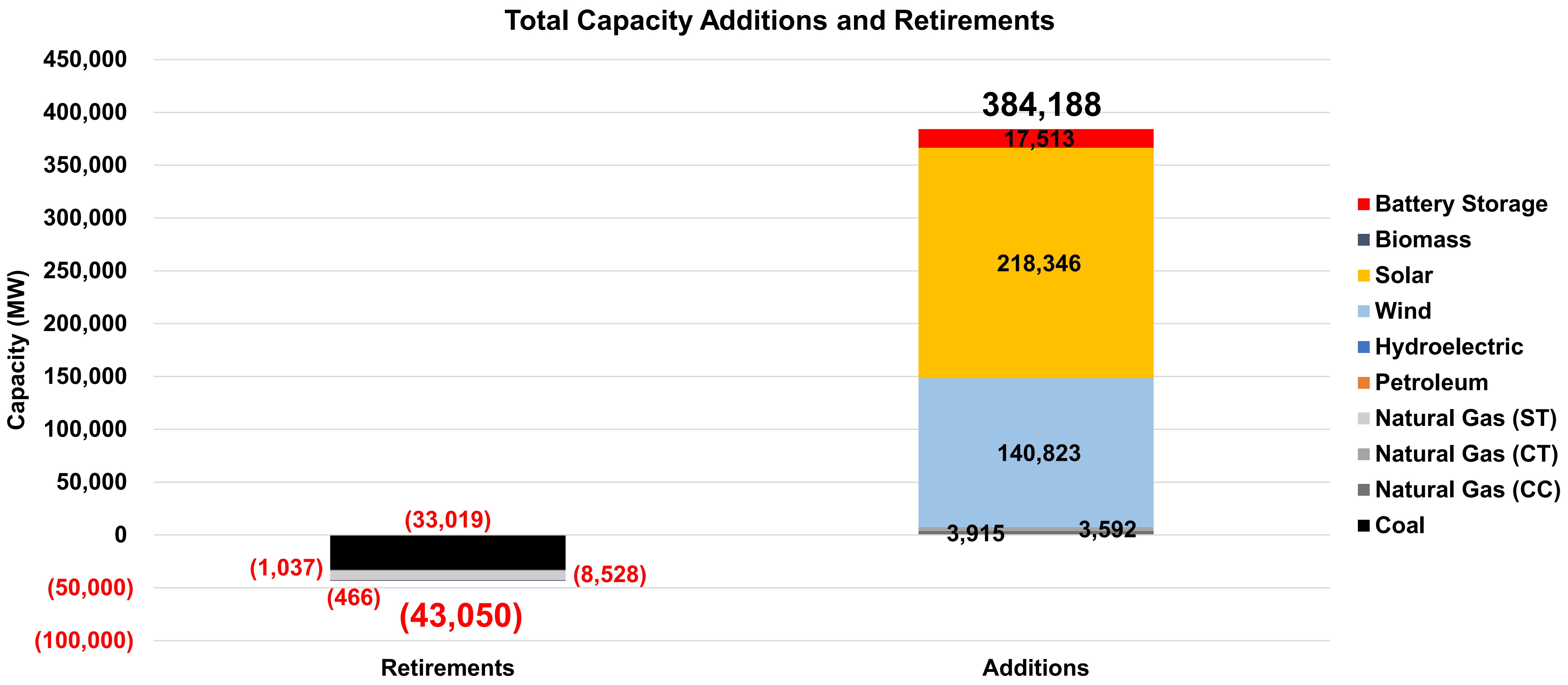
Ozone + CCR: Additions (MW)

Additions	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Total
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
Natural Gas (CC)	0.0	2,290.0	75.0	767.8	100.0	0.0	0.0	682.0	0.0	0.0	0.0	0.0	0.0	0.0	3,914.8
Natural Gas (CT)	0.0	460.7	0.0	894.0	371.1	1,602.7	0.0	263.0	0.0	0.0	0.0	0.0	0.0	0.0	3,591.5
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
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
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
Wind	283.7	11,364.4	14,772.8	34,874.6	12,993.3	32,754.6	8,736.6	16,462.9	1,793.3	1,357.4	1,357.4	1,357.4	1,357.4	1,357.4	140,823.2
Solar	0.0	17,436.0	24,401.0	54,162.7	20,449.1	50,163.3	13,380.0	25,212.8	2,746.5	2,078.8	2,078.8	2,078.8	2,078.8	2,078.8	218,345.6
Biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Battery Storage	0.0	1,455.6	1,944.5	4,538.5	1,710.3	4,311.4	1,150.0	2,167.0	236.1	0.0	0.0	0.0	0.0	0.0	17,513.3

CCR Scenario: Retirements and Additions



CCR Scenario: Retirements and Additions



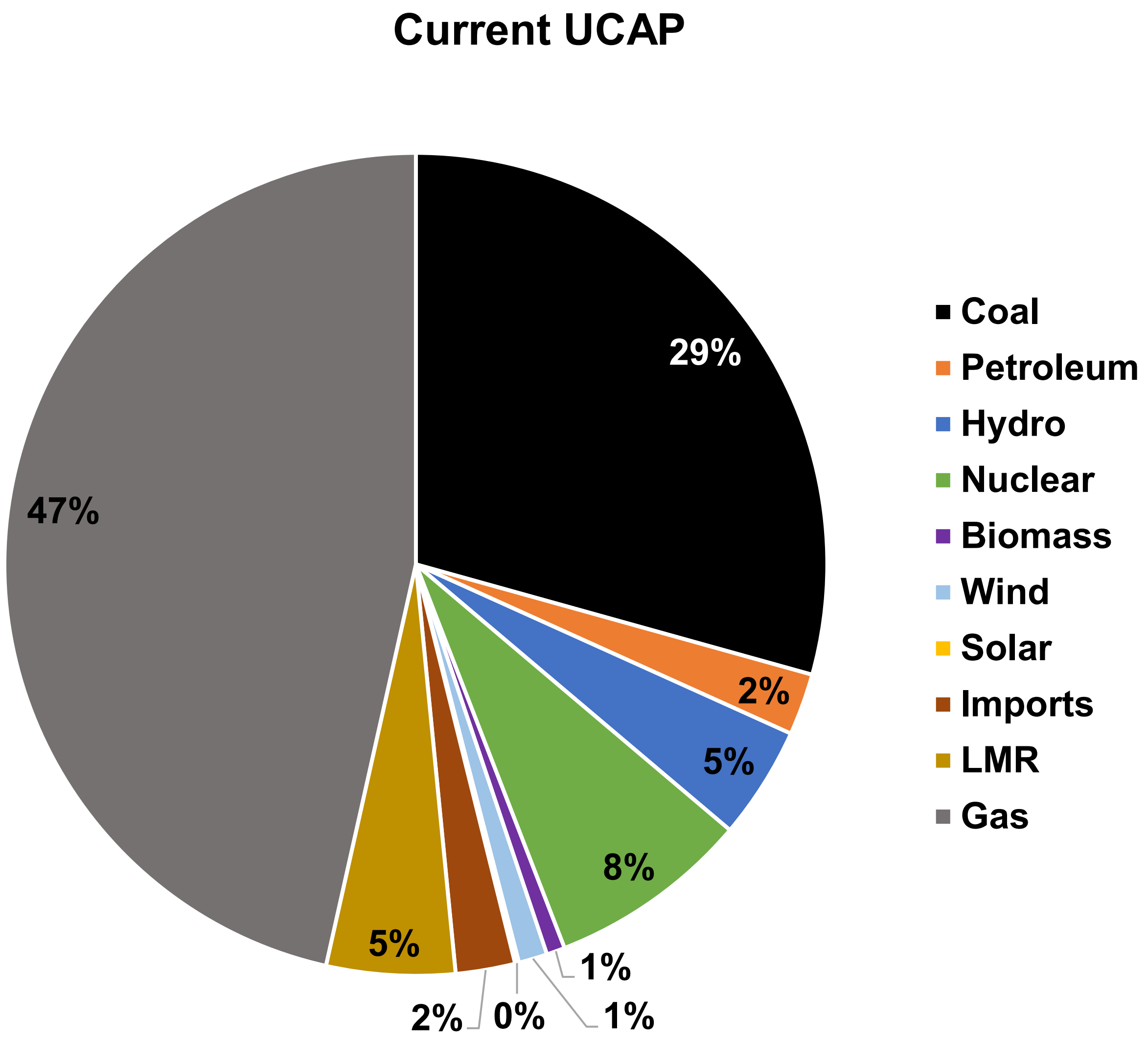
Ozone + CCR: Annual ICAP Mix (MW)

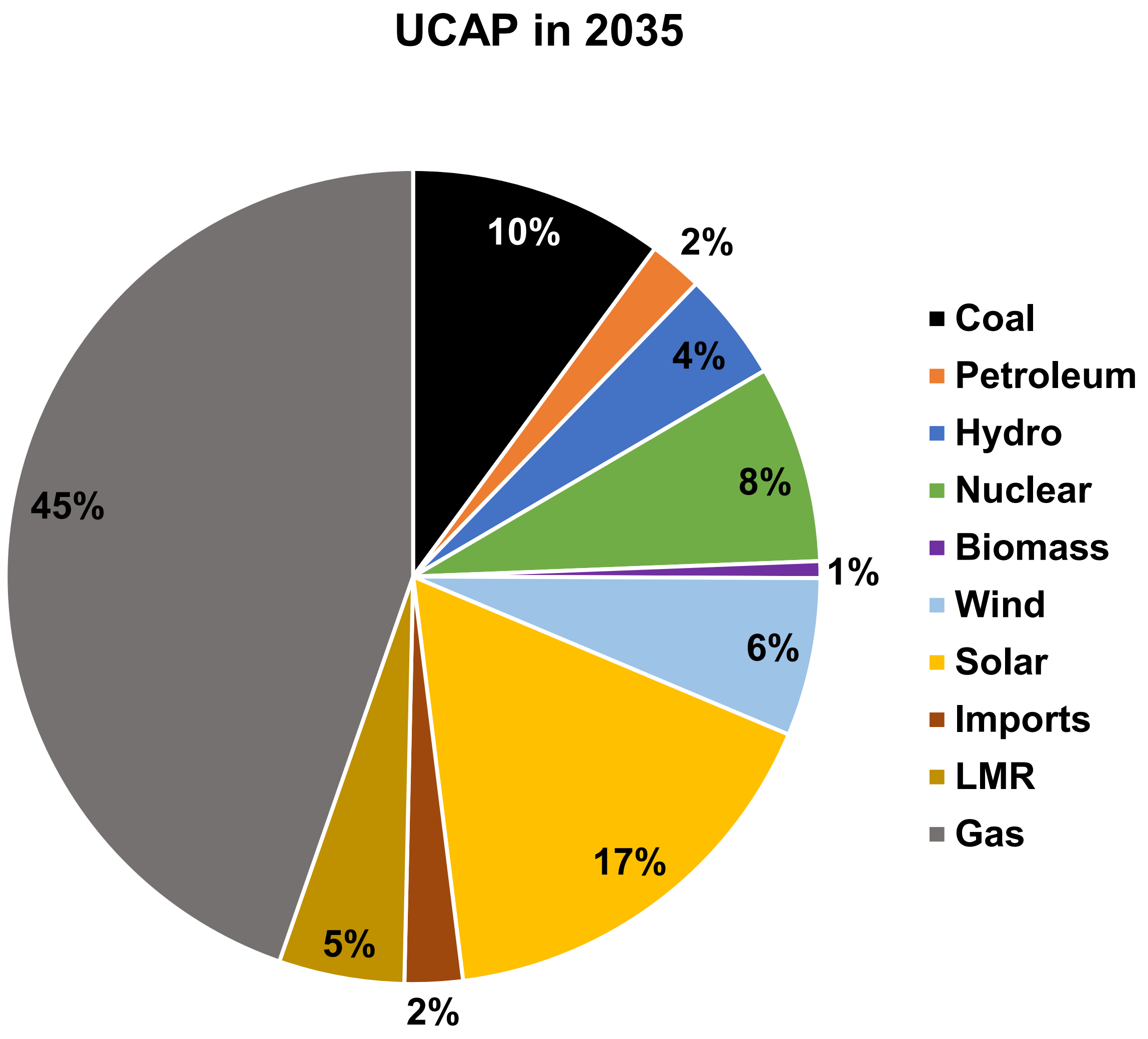
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	
Coal	50,772	47,460	43,537	32,959	29,841	25,863	23,098	17,753	17,753	17,753	17,753	17,753	17,753	17,753	3%
Natural Gas (CC)	32,981	35,271	35,346	36,114	36,214	36,214	36,214	36,896	36,896	36,896	36,896	36,896	36,896	36,896	7%
Natural Gas (CT)	29,570	30,030	29,954	30,680	30,618	31,861	31,861	32,124	32,124	32,124	32,124	32,124	32,124	32,124	6%
Natural Gas (ST)	17,946	17,671	17,350	16,905	16,293	10,001	10,001	10,001	9,418	9,418	9,418	9,418	9,418	9,418	2%
Petroleum	4,199	4,199	3,789	3,789	3,736	3,732	3,732	3,732	3,732	3,732	3,732	3,732	3,732	3,732	1%
Hydroelectric	6,962	6,962	6,927	6,925	6,923	6,923	6,899	6,899	6,899	6,899	6,899	6,899	6,899	6,899	1%
Existing Nuclear	13,026	13,026	13,026	13,026	13,026	13,026	13,026	13,026	13,026	13,026	13,026	13,026	13,026	13,026	3%
Onshore Wind	30,624	41,988	56,761	91,635	104,629	137,383	146,120	162,583	164,376	165,734	167,091	168,448	169,806	171,163	32%
Utility Solar	1,997	19,433	43,834	97,997	118,446	168,609	181,989	207,202	209,948	212,027	214,106	216,185	218,264	220,343	41%
Biomass	1,254	1,250	1,220	1,220	1,220	1,220	1,172	1,172	1,172	1,172	1,172	1,172	1,172	1,172	0%
Storage	0	1,456	3,400	7,939	9,649	13,960	15,110	17,277	17,513	17,513	17,513	17,513	17,513	17,513	3%
Total	189,330	218,746	255,144	339,188	370,593	448,792	469,222	508,665	512,859	516,295	519,731	523,167	526,604	530,040	

Ozone + CCR: Annual UCAP Mix (MW)

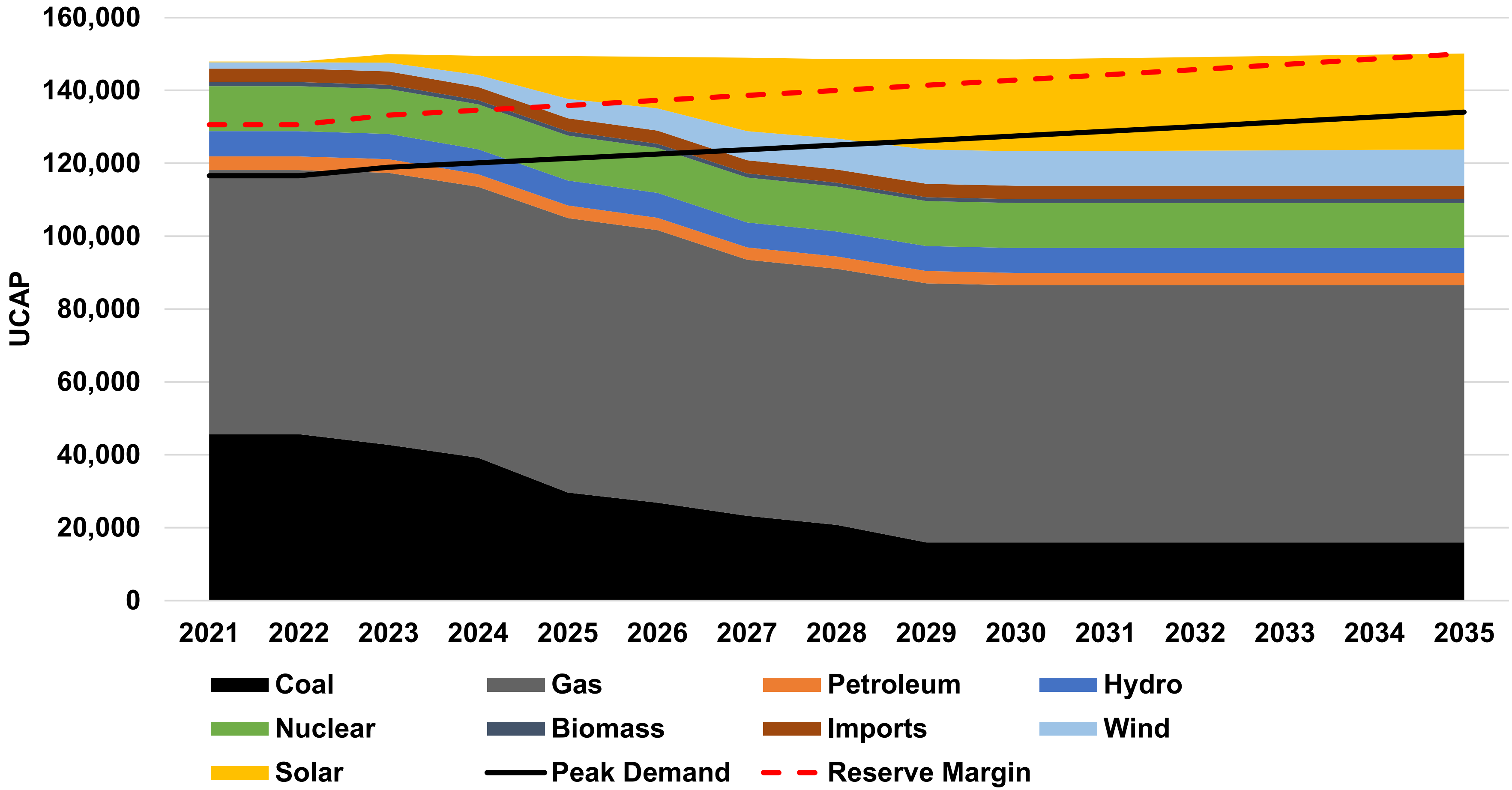
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	
Coal	45,695	45,695	42,714	39,183	29,663	26,856	23,277	20,788	15,978	15,978	15,978	15,978	15,978	15,978	15,978	10%
Natural Gas (CC)	29,683	29,683	31,744	31,811	32,503	32,593	32,593	32,593	33,206	33,206	33,206	33,206	33,206	33,206	33,206	21%
Natural Gas (CT)	26,613	26,613	27,027	26,959	27,612	27,556	28,675	28,675	28,912	28,912	28,912	28,912	28,912	28,912	28,912	18%
Natural Gas (ST)	16,152	16,152	15,904	15,615	15,214	14,664	9,000	9,000	9,000	8,476	8,476	8,476	8,476	8,476	8,476	5%
Petroleum	3,779	3,779	3,779	3,410	3,410	3,362	3,359	3,359	3,359	3,359	3,359	3,359	3,359	3,359	3,359	2%
Hydro	6,900	6,900	6,900	6,865	6,862	6,860	6,860	6,837	6,837	6,837	6,837	6,837	6,837	6,837	6,837	4%
Nuclear	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	12,374	8%
Biomass	1,128	1,128	1,125	1,098	1,098	1,098	1,098	1,055	1,055	1,055	1,055	1,055	1,055	1,055	1,055	1%
Wind	1,758	1,774	2,432	3,288	5,308	6,061	7,959	8,465	9,419	9,522	9,601	9,680	9,758	9,837	9,916	6%
Solar	239	239	2,328	5,251	11,738	14,188	20,197	21,799	24,819	25,148	25,397	25,646	25,895	26,144	26,393	17%
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	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	5%
Total UCAP	155,833	155,849	157,841	157,367	157,297	157,126	156,905	156,459	156,473	156,382	156,709	157,037	157,365	157,692	158,020	

Ozone + CCR: Current UCAP vs. 2035





OTR + CCR Scenario: Capacity Shortfall Risk

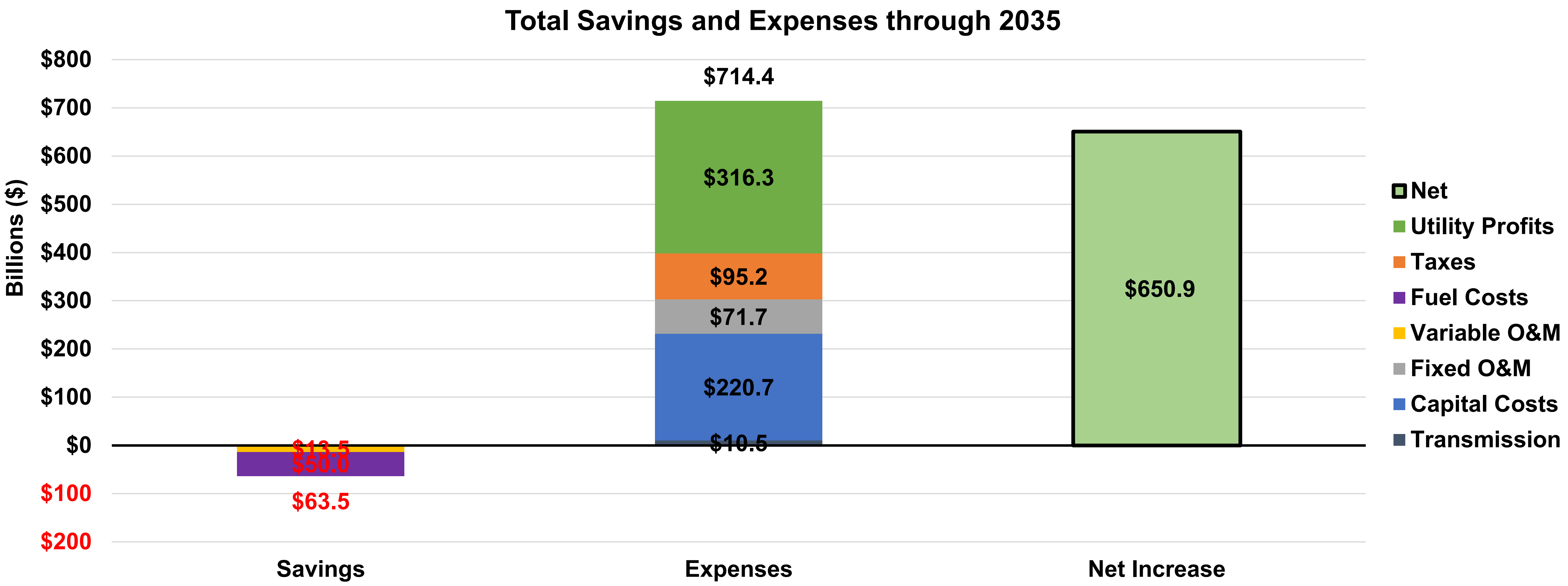


Estimated firm capacity using net peak load capacity accreditation values for wind (5.8%) and solar (12%), 95% for nuclear, and 90% for other thermal generators. Different than MISO cleared UCAP (unforced [accredited] capacity). Under this scenario, MISO would be dependent on intermittent resources to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

Year	Reserve Margin
2022	34%
2023	33%
2024	31%
2025	**30%**
2026	**28%**
2027	**27%**
2028	**25%**
2029	**24%**
2030	**23%**
2031	**22%**
2032	**21%**
2033	**20%**
2034	**19%**
2035	**18%**

OTR+CCR Scenario Cost

The total additional cost to ratepayers in the CCR Scenario would be $651 billion through 2035.



Conclusions

1. Our findings represent a best-case scenario for reliability due to our HCD accreditation standard, which is more stringent than MISO's prior accreditation process and could enhance their recently-adopted Seasonal Accreditation Construct (SAC).

2. Different standards, such as seasonal accreditation being explored by MISO, will produce varying levels of reliability that must be examined in light of these results.

3. Costs were relatively modest due to the large amount of thermal capacity remaining on the MISO system through 2035, but costs increase substantially as more thermal retirements occur and Load Serving Entities (LSEs) attempt to replace this lost generation with wind, solar, and battery storage.

4. Policymakers must understand the challenges regarding reliability, resiliency and affordability that are growing every year.

Recommendations

Policy Recommendations in Light of Findings of the Study:

1. **PAUSE RETIREMENTS:** The timeline of coal and natural gas retirements in MISO, even in the reference case, is too short for replacement capacity to come online.

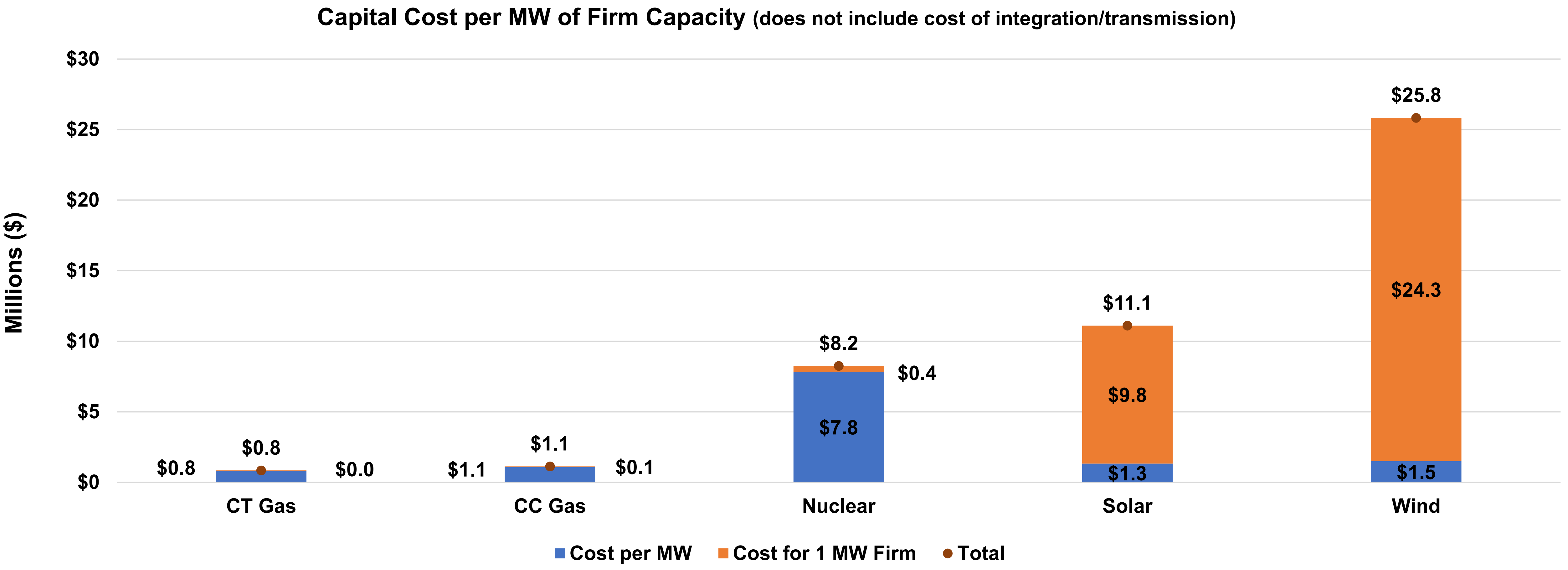
2. **ANCHOR ACCREDITATION TO FORESEEABLE WEATHER RISKS:** Even if wind and solar resources are built in time, there is still a chance that they may be performing under MISO's and our updated accredited values, meaning capacity shortfalls may still present challenges to grid operators. This is because at any given time, wind and solar may be producing no electricity at all.

    - MISO should have the same reliability standards for wind and solar as it does dispatchable energy sources like coal, natural gas, and nuclear, meaning it would require wind and solar to meet capacity obligations 7/8ths of all peak hours of the year, which is a standard dispatchable units meet or exceed. Our method of accreditation – the Mean of Lowest Quartile – can better assess wind and solar reliability based on this standard.

    - Ultimately, the goal is to appropriately measure and price the variability of wind and solar, instead of foisting the costs of that variability on the entire system.

Recommendations (*continued*)

3. LOOK BEYOND LCOE: Make clear that capital cost per MW installed of wind and solar is vastly different than capital cost per FIRM MW installed of wind and solar. Example below:



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.

Future Research

Our findings represent a best-case scenario for reliability due to our HCD accreditation standard to MISO's new Seasonal Accreditation Construct (SAC) for wind and solar.

- Set standards not just based on reserve margin but also based on probability of loss of load.
- Explore appropriate sample size hours for peak and net peak load for HCD accreditation for wind and solar.

Make clear that capital cost per MW installed of wind and solar is vastly different than capital cost per FIRM MW installed of wind and solar.

Consider additional state and federal policy drivers.

- Additional FERC and EPA regulations, expanded subsidies from the Inflation Reduction Act.

Consider the effects of different policy solutions.

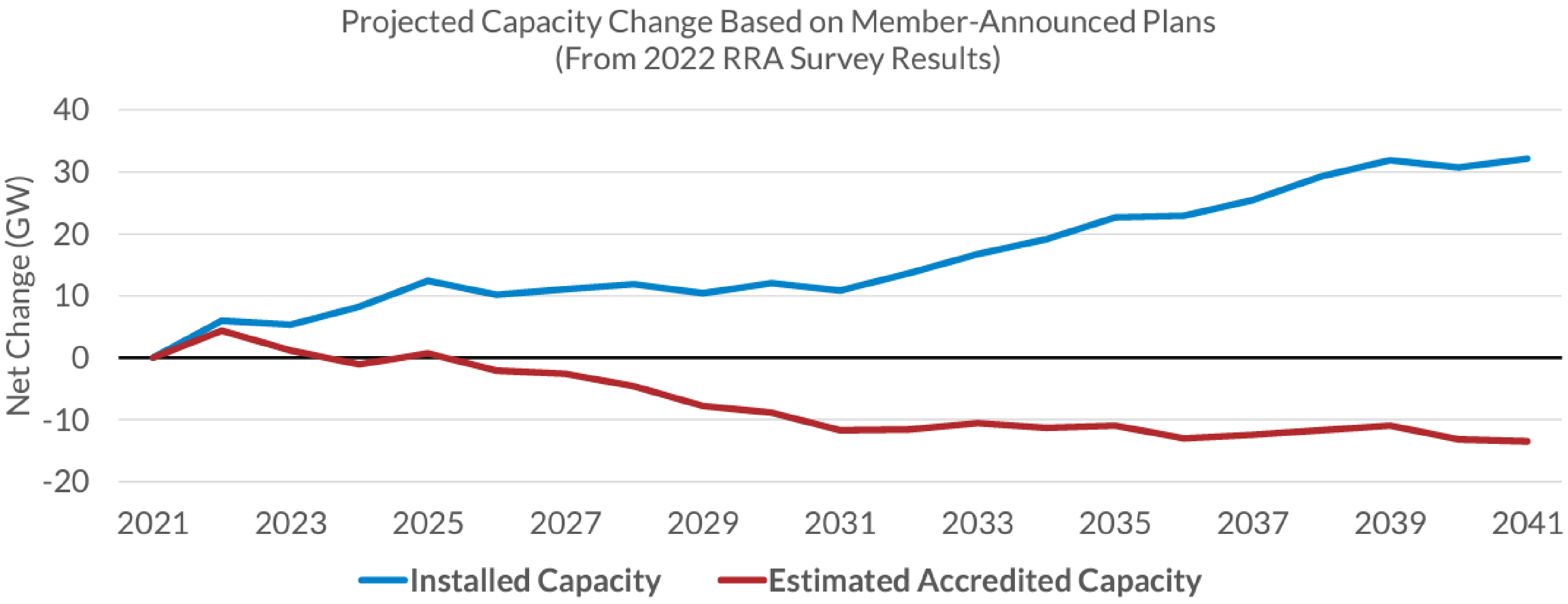
- For example, what would be the cost and reliability effects of increasing the planning reserve margin under varying penetration levels of wind and solar?
- What would be the effect of applying some level of cost allocation, either transmission or reliability, to wind and solar projects?

Future Research

Examine resource adequacy beyond 2035:

MISO’s ICAP vs UCAP trends are projected to deteriorate further beyond 2035 as the reliance on weather-dependent resources is projected to grow.

INSIGHT 1: The 2022 snapshot of MISO member plans indicates an increase in the overall amount of installed capacity, but a decline in accredited capacity compared to current levels



Note: Over the study period, RRA assumes wind accreditation stays at ~16.7%, solar declines from 50% to 20%, hybrid declines from 60% to 30%, and battery declines from 100% to 75%. Thermal units are accredited between 90% and 100%. The assumptions in RRA should not be taken as indicative of the outcomes of the non-thermal accreditation reform effort underway

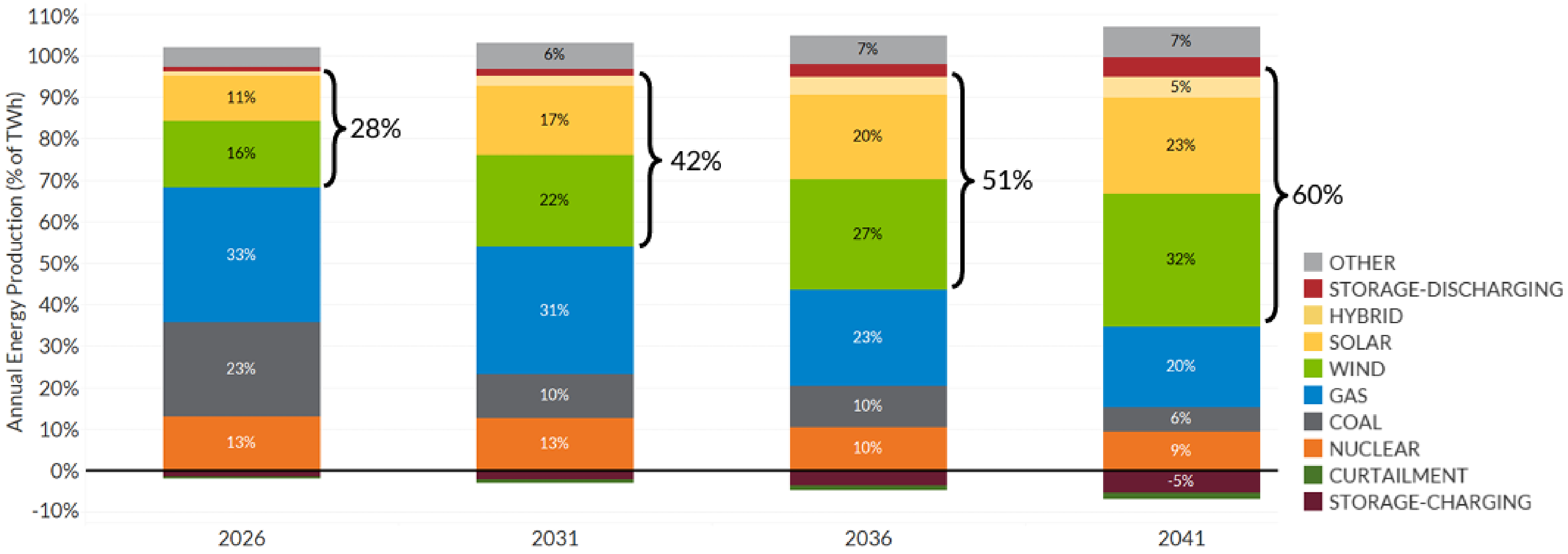
MISO

Future Research

MISO expects wind and solar to account for 60 percent of load by 2041.

- This will require conducting additional net load accreditation calculations for wind and solar as their share of energy provided increases.

INSIGHT 3: Wind and solar generation are projected to serve 60% of MISO's annual load by 2041, which would reduce emissions by nearly 80% relative to 2005 levels but also sharply increase the complexity of reliably operating and planning the system.

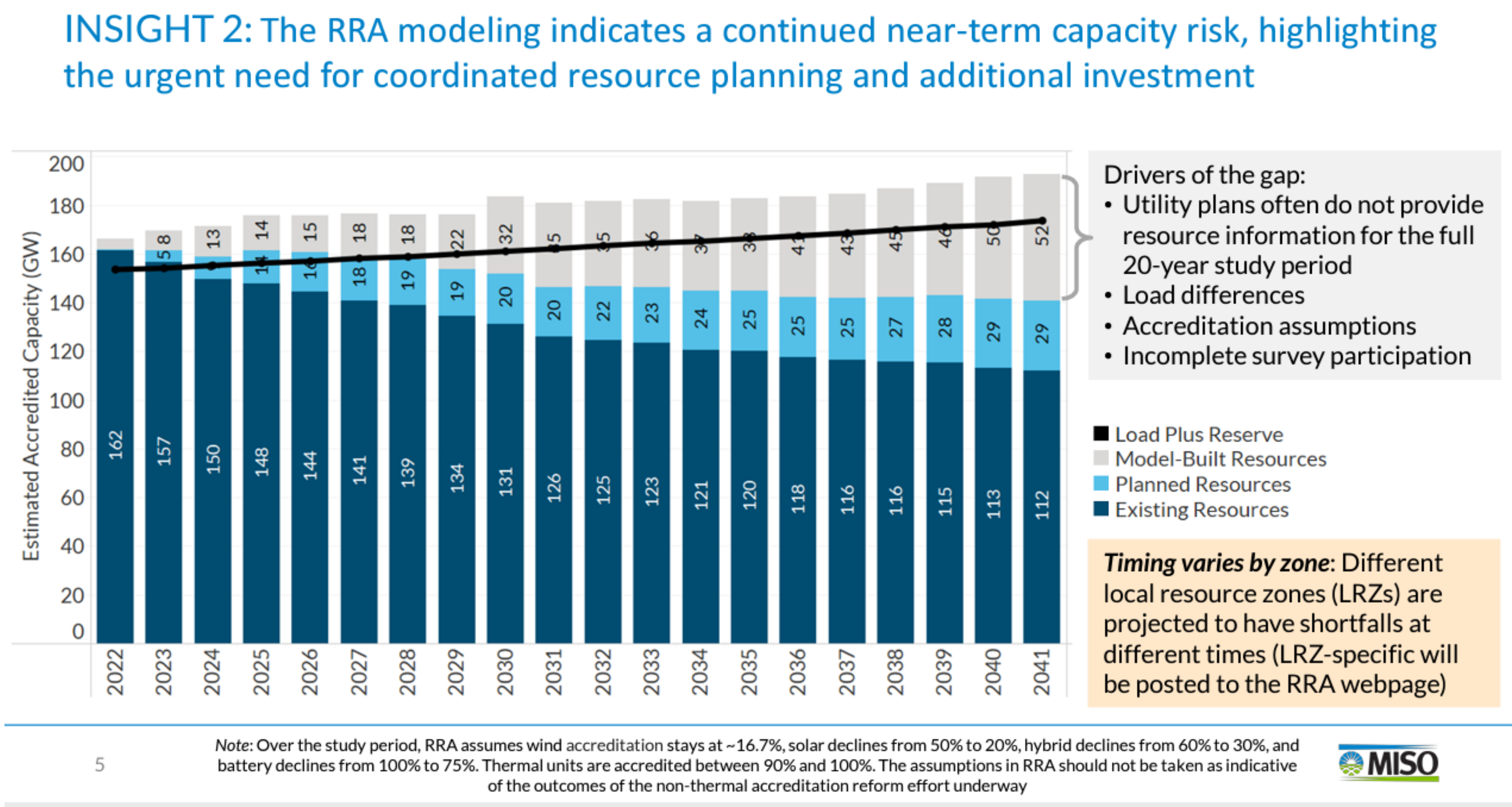


*Solar includes DGPV, while "Other" includes demand response and energy efficiency
Note: expansion was performed for each LRZ using a model that does not include the transmission system

MISO

Future Research

Reliability will suffer in the future if current trends continue.



Other Scenarios to Explore

- What if the gas plants in the interconnect queue can't come online due to environmental pushback or EPA regulations?
- Scenarios demanding 100 percent carbon free electricity by 2035, 2040, or 2050.
- Negative capacity value for wind in winter due to wind turbines shutting down at -22° F?
- Study the cost implications of transmission system built to be "bigger than the weather."
- Will MISO's seasonal accreditation produce good enough results?
- Use a 1-in-10 LOLE to determine system resiliency/reliability.
- Refine Load Modifying Resources assumptions to better reflect real-world response to calls for load management, which have yet to be fully tested.

Demand Response

Load Modifying Resources (LMR) constitutes 7,875 MW of capacity in the model, based on the amount of LMRs bidding into MISO's capacity auctions, constituting 7 percent of MISO's peak demand.

Planning Year	2021-22 Cleared UCAP	
GADS Fuel Type	System (MW)	% Fuel
Coal	45,110	33.69%
Nuclear	12,232	9.13%
Water	5,332	3.98%
Oil	3,523	2.63%
Gas	51,894	38.75%
Load Modifier (DR/EE)	7,875	5.88%
Wind	3,614	2.70%
Solar	1203	0.90%
Miscellaneous	3,119	2.33%
SYSTEM	**133,902**	**100%**

Demand Response and Load Modifying Resources

- Refine Load Modifying Resources assumptions to better reflect real-world response to calls for load management and to account for limitations on the duration and frequency of interruptions.

Cleared Load Modifying Resources (LMR) notification times and maximum interruptions for 2022-23

- Over 60% of LMRs have a notification time of less than or equal to 2 hours
- Over 70% of LMRs can be interrupted at least 6 times

				Notification Times			Maximum Interruptions		
	LBAs	FRAP + Cleared MWs		Less than or equal to 2 hours	Greater than 2hr and less than 6 hr	Greater than or equal to 6hr	0 to 5	6 to 10	Greater than 10
Zn 1	DPC, GRE, MDU, MP, NSP, OTP, SM	3040.1	26.0%	2,645.6	394.5	0.0	1,307.0	1,577.0	156.1
Zn 2	ALTE, MGE, UPPC, WEC, WPS, MIUP	1160.5	9.9%	562.1	598.4	0.0	117.2	902.9	140.4
Zn 3	ALTW, MEC, MPW	1073	9.2%	369.5	687.3	16.2	283.1	681.0	108.9
Zn 4	AMIL, CWLP, SIPC, GLH	594.1	5.1%	297.0	291.8	5.3	245.0	349.1	0.0
Zn 5	AMMO, CWLD	193.8	1.7%	173.4	20.4	0.0	30.9	96.5	66.4
Zn 6	BREC, CIN, HE, IPL, NIPS, SIGE	1799.1	15.4%	843.5	955.0	0.6	73.3	1,289.2	436.6
Zn 7	CONS, DECO	2494.7	21.3%	2,021.9	472.8	0.0	1,009.2	1,485.5	0.0
Zn 8	EAI	801.3	6.8%	15.2	786.1	0.0	319.4	481.9	0.0
Zn 9	CLEC, EES, LAFA, LAGN, LEPA	432.8	3.7%	116.8	316.0	0.0	0.0	432.8	0.0
Zn 10	EMBA, SME	122.7	1.0%	41.5	81.2	0.0	0.0	88.4	34.3
		11,712.10	100.0%	7,086.5	4,603.5	22.1	3,385.1	7,384.3	942.7

Imports

MISO Imports were assumed to be 3,638 MW based on the capacity bid into MISO's planning capacity auction.

	Offered (ZRC)			Cleared (ZRC)		
Planning Resource	2020-21	2021-22	2022-23	2020-21	2021-22	2022-23
Generation	125,341	125,225	121,506.5	120,143	118,884	118,745.0
External Resources	3,832	3,914	3,638.9	3,736	3,798	3,638.9
Behind the Meter Generation	3,997	4,131	4,169.3	3,892	4,068	4,169.3
Demand Resources	7,754	7,294	7,591.4	7,557	7,152	7,541.5
Energy Efficiency	650	0	0	650	0	0
Total	**141,574**	**140,564**	**136,906.1**	**135,979**	**133,903**	**134,094.7**

Summary Slides

The following slides provide “the short version” of the findings of each scenario in terms of capacity additions and retirements, costs, and impact on reliability. Many of these slides are repeated from earlier components of this study deck but included here for referenced to align with separately-produced condensed versions of the study.

<u>OBJECTIVE</u>: Model Resource Adequacy & Cost For Three Scenarios

1. **Reference Scenario**
   - MISO/EIA planned additions (7.5 GW Gas, 1 GW Wind, 4.2 GW Solar) and retirements (17.6 GW Coal, 4.8 GW Gas, 600 MW Other). Replace rest with modeled wind (64.4 GW), solar (98.7 GW), and four-hour storage (11 GW).
2. **Ozone Transport Federal Implementation Plan (FIP) Rule (hereinafter "OTR") Scenario**
   - Loss of 30.3 GW of coal and 9.6 GW of gas by 2035. Replace with natural gas (7.5 GW), wind (130.7 GW), solar (202.8 GW), and four-hour storage (16.2 GW).
3. **Ozone + Coal Combustion Rule ("CCR") Scenario**
   - Replace with natural gas (7.5 GW), wind (140.8 GW), solar (218.3 GW), and four-hour storage (17.5 GW).

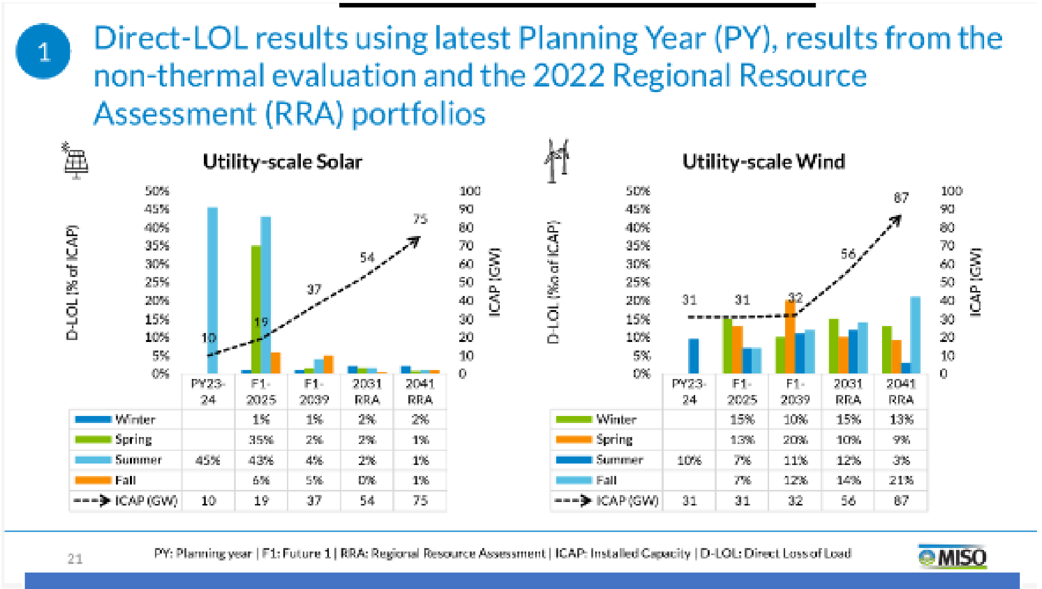
<u>ADDITIONAL BENEFIT OF STUDY</u>: Derive more relevant accreditation values for wind and solar given that peak net load has become the time of greatest system stress - Selected the mean of the lowest quartile (HCD) of wind and solar generation during peak & net peak hours to develop peak & net peak capacity accreditation values.

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

Comparing Mean of Lowest Quartile (HCD) Approach to the New Approach MISO is Considering With the HCD Approach (ND Study)

- MISO is making well-intended (but potentially insufficient) changes to the accreditation process as they try to account for weather-dependent renewable penetration and shift from away from an Effective Load Carrying Capacity (ELCC) approach to a Direct-Loss of Load (LOL) accreditation approach.
- They are also switching to a seasonal accreditation model, which will require seasonal capacity auctions & significant differences between seasonal reserve margins (which probably won't address over-penetration of weather-dependent resources).
- HCD examines wind & solar accreditation values for peak & net-peak hours to provide consistent, year-round metrics for availability & reserve margins & provides a basis for a realistic (apples-to-apples) comparison of renewable & thermal performance.

MISO APPROACH



MISO's Proposed Seasonal Reserve Margins				
	Summer	Fall	Winter	Spring
Reserve Margin	7.40%	14.90%	25.50%	24.50%

HCD ALTERNATIVE APPROACH

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

How does the ND Study's HCD Approach Differ from MISO's New Seasonal Accreditation Approach?

- HCD accreditation values for wind are consistent with MISO's F1-25 values.
- HCD accreditation values for solar are lower than MISO's F1-25 values but higher than their F1-2039 values.

<u>HCD approach is valuable for a few reasons</u>:

- HCD provides consistent metrics for evaluating wind & solar that independent on future modeling & not linked to significant adjustment of seasonal reserve margins.
- As more wind & solar are added to the grid, net peak will become more challenging than peak load demand.
- HCD manages the downside of wind & solar at net peak compared to ELCC and is more empirical than the options MISO is considering as they move away from ELCC to a Direct-LOL accreditation approach.

MISO APPROACH

Seasonal Solar Accreditation				
	PY23-24	F1-25	F1-39	Reserve Margin
Winter		1%	1%	25.50%
Spring		35%	2%	24.50%
Summer	45%	43%	3%	7.40%
Fall		6%	5%	14.90%

Seasonal Wind Accreditation				
	PY23-24	F1-25	F1-39	Reserve Margin
Winter		15%	10%	25.50%
Spring		13%	20%	24.50%
Summer	10%	7%	11%	7.40%
Fall		7%	12%	14.90%

HCD ALTERNATIVE APPROACH

Mean of Lowest Quartile	Peak Accreditation	Net Peak Accreditation
Wind	7.10%	5.80%
Solar	12.40%	12.00%
Reserve Margin	15.50%	15.50%

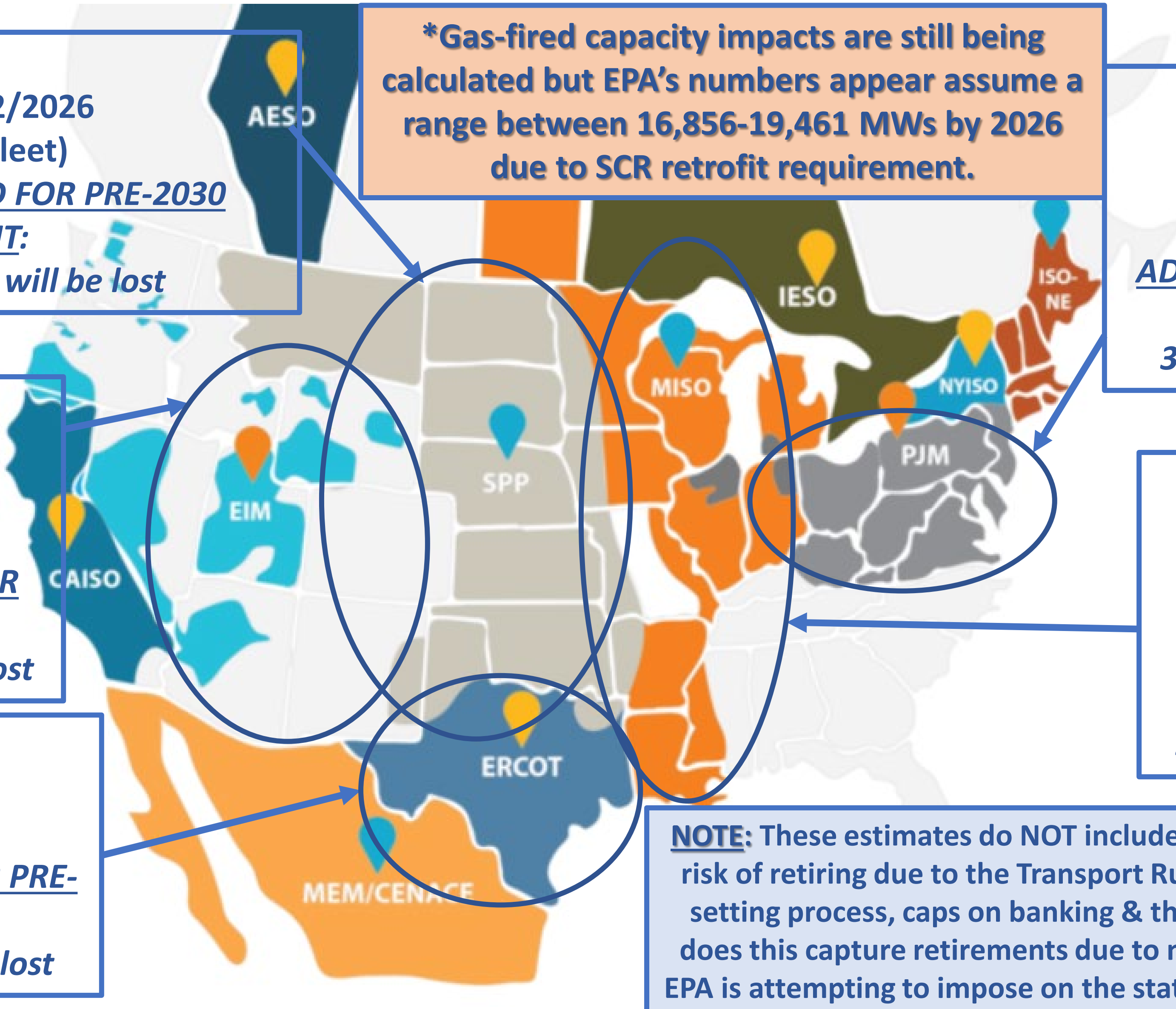
Methodology- Retirement Assumptions (OTR)

SPP:
8,184 MW by 12/2026
(37% of Coal Fleet)
ADDED TO UNITS SLATED FOR PRE-2030 RETIREMENT:
37% of coal capacity will be lost

MOUNTAIN WEST:
8,892 MW
by 12/2026
(38% of Coal Fleet)
ADDED TO UNITS SLATED FOR PRE-2030 RETIREMENT:
44% of coal capacity will be lost

ERCOT:
7,867 MW by 12/2026
(55% of Coal Fleet)
ADDED TO UNITS SLATED FOR PRE-2030 RETIREMENT:
55% of coal capacity will be lost

***Gas-fired capacity impacts are still being calculated but EPA's numbers appear assume a range between 16,856-19,461 MWs by 2026 due to SCR retrofit requirement.**

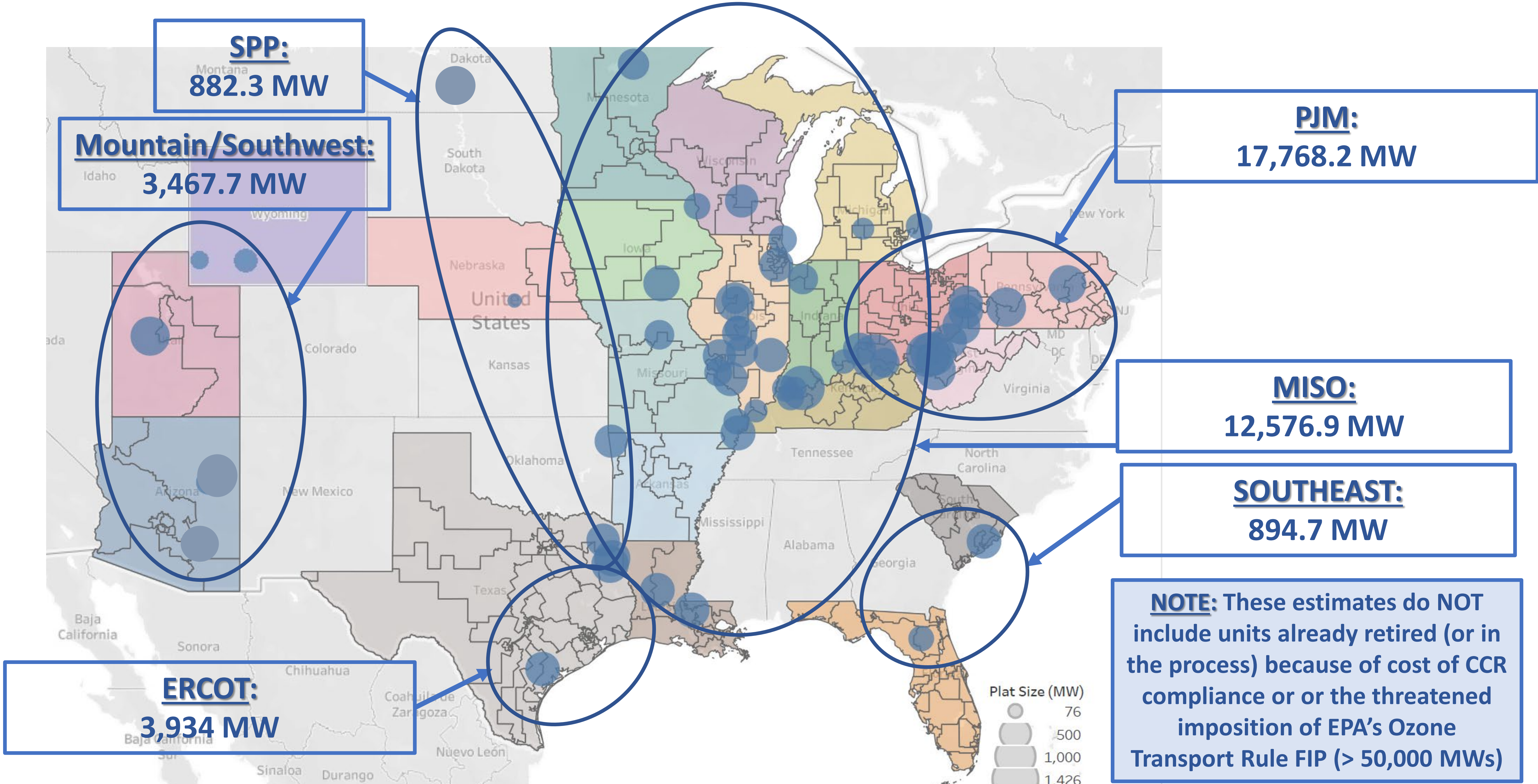


PJM:
6,626 MW
by 12/2026
(15% of Coal Fleet)
ADDED TO UNITS SLATED FOR PRE-2030 RETIREMENT:
33% of coal capacity will be lost

MISO:
16,996 MW
by 12/2026
(34% of Coal Fleet)
ADDED TO UNITS SLATED FOR PRE-2030 RETIREMENT:
51% of coal capacity will be lost

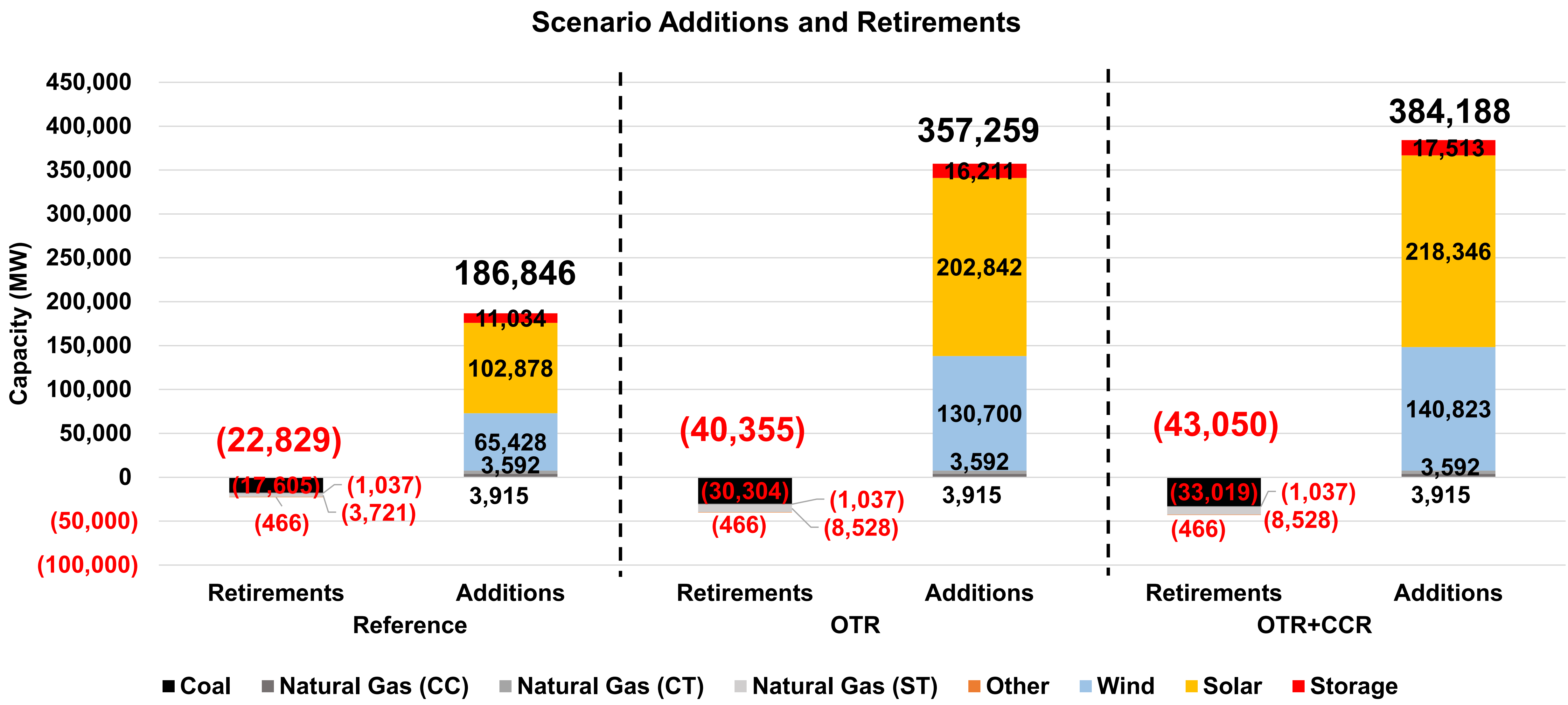
NOTE: These estimates do NOT include SCR-controlled units that are also at risk of retiring due to the Transport Rule FIP's stringent & dynamic budget setting process, caps on banking & the daily max NOx emission rate. Nor does this capture retirements due to new interpretations of the CCR Rules EPA is attempting to impose on the states (i.e. this is the low end of impact).

Methodology- Retirement Assumptions (CCR)

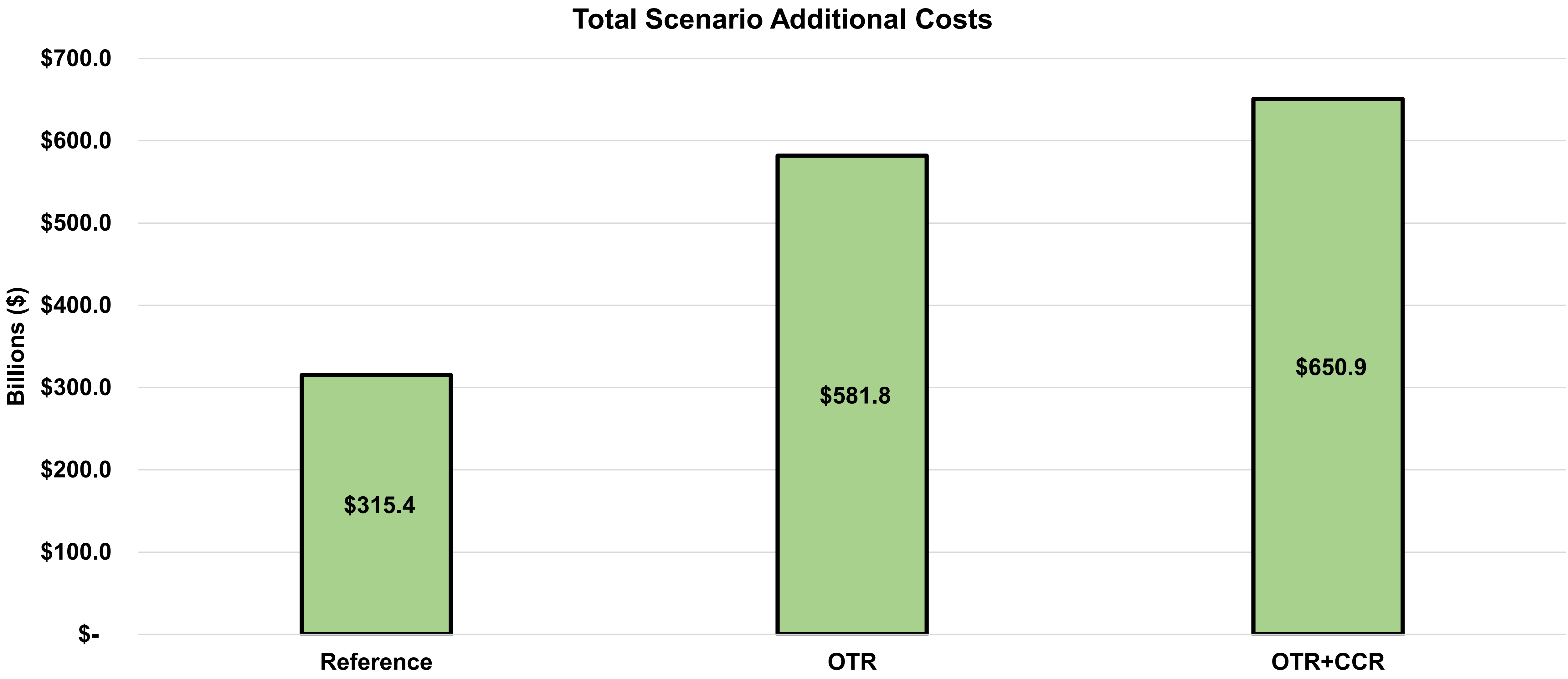


NOTE: These estimates do NOT include units already retired (or in the process) because of cost of CCR compliance or or the threatened imposition of EPA's Ozone Transport Rule FIP (> 50,000 MWs)

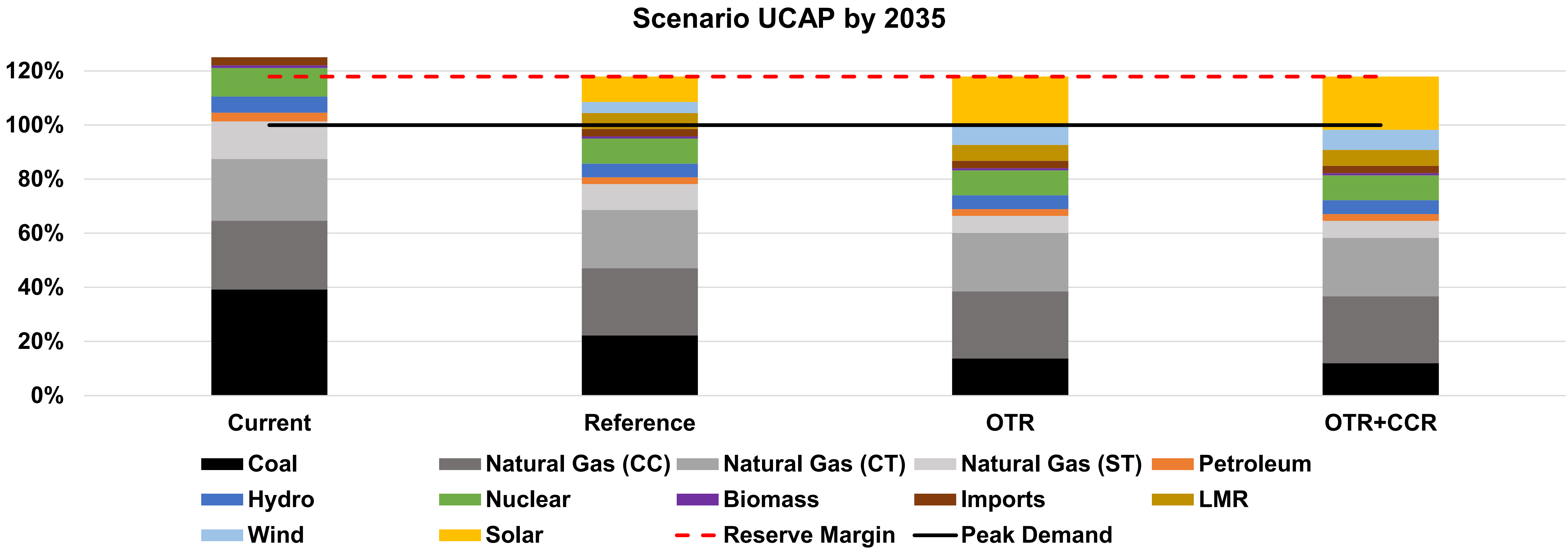
If EPA Rules Force Early Retirements by 2035



Costs for Each Scenario Through 2035



Recap of Increasing Risk of Capacity Shortfall



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