CMWL 100% RENEWABLE STUDY

PROJECT PURPOSE AND SCOPE

Project Purpose: 20-year study (2024-2043) to determine impact of achieving 100% renewable energy and capacity by 2030.

Project Scope:

- Base Case
- Scenarios
  - Alternate case 1 – 100% renewable energy to serve CMWL load by 2030. Renewable energy credits (RECs) cannot be used to meet this requirement.
  - Alternate case 2 – Same as alternate case 1, but RECs are used to meet the requirement.
  - Alternate case 3 – Same as alternate case 1, but all coal resources are divested as soon as possible.
  - Alternate case 4 – Same as alternate case 1, but all thermal resources are divested/retired as soon as possible.
  - Alternate case 5 – Same as alternate case 1, with Sikeston retires early.

SCENARIO OVERVIEW

Scenarios	100% Renewable Requirement by 2030	Use of RECs?	Divest Coal Resources	Retire Natural Gas Resources	Retire Sikeston
Base Case	No	No	No	No	No
Alt Case 1	Yes	No	No	No	No
Alt Case 2	Yes	Yes	No	No	No
Alt Case 3	Yes	No	Yes	No	Yes
Alt Case 4	Yes	No	Yes	Yes	Yes
Alt Case 5	Yes	No	No	No	Yes

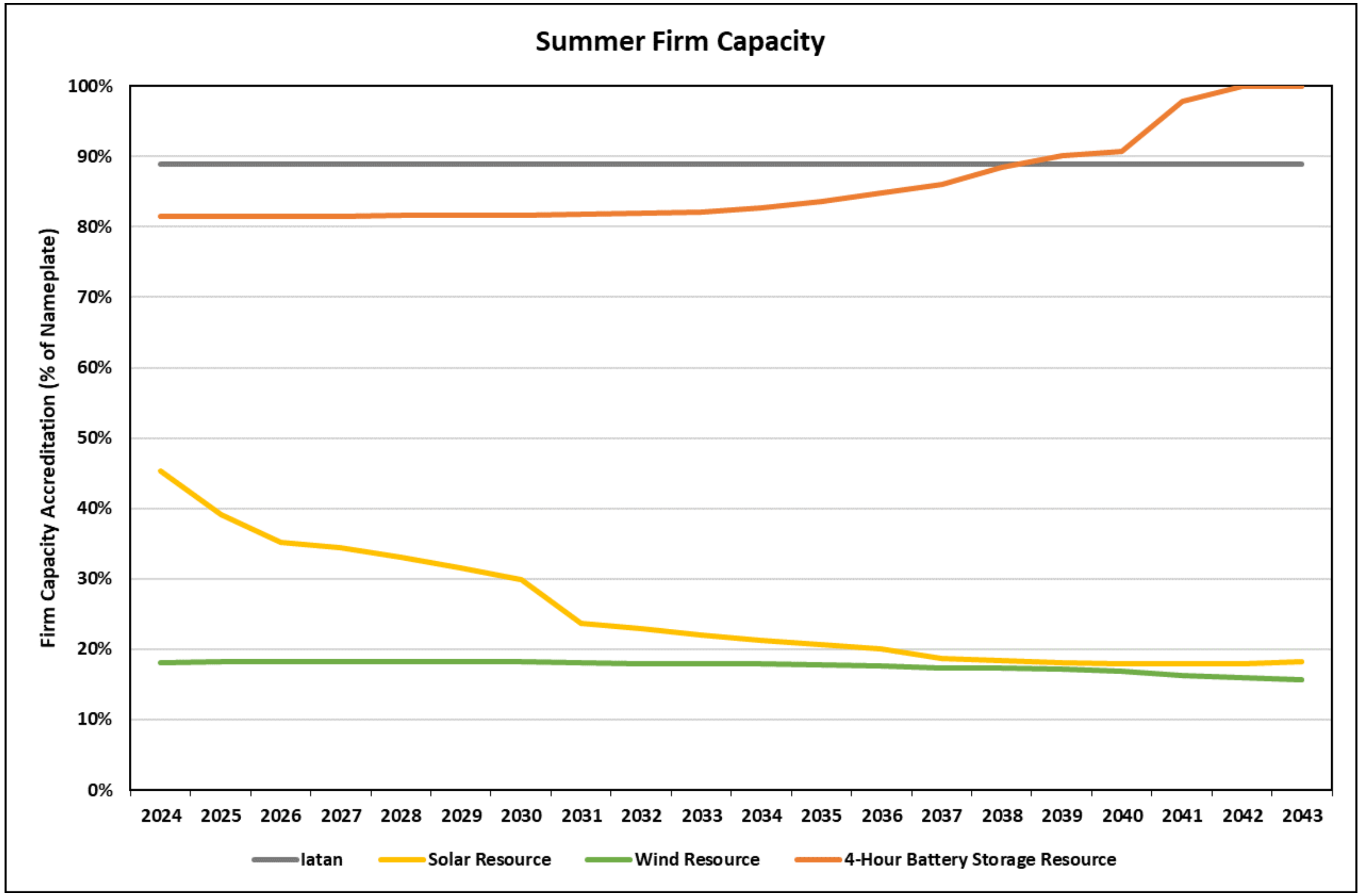
- Renewable energy credit (REC) – A tradable commodity representing 1 MWh of electricity generated from renewable sources.

MODEL ASSUMPTIONS

CAPACITY DEFINITIONS REVIEW

- Nameplate capacity – The maximum rated output of a generator.
  - Units are MW.
- Firm capacity – A measure of a generators ability to provide power to the grid when needed.
  - Calculated by MISO for planning requirements.
    - Columbia's total firm capacity must be at or above forecasted peak load plus a reserve margin (7.4% during the summer season).
  - Units are MW.
- Bilateral capacity – Firm capacity that is purchased directly from another utility/resource owner.
  - Purchased when additional firm capacity is needed to meet planning requirements.
  - This purchase can be long-term (10+ years) or short-term (one year/one season).
  - Units are MW.

FIRM CAPACITY FOR RENEWABLES



- Renewable resources are assumed to receive firm capacity based on performance during high-risk periods.
  - Known as Effective Load Carrying Capacity.
  - Based on MISO's 2022 Regional Resource Assessment.
  - Change over time is due to changes in generation mix on MISO's system.
- Thermal resource firm capacity is assumed to remain flat throughout the study.

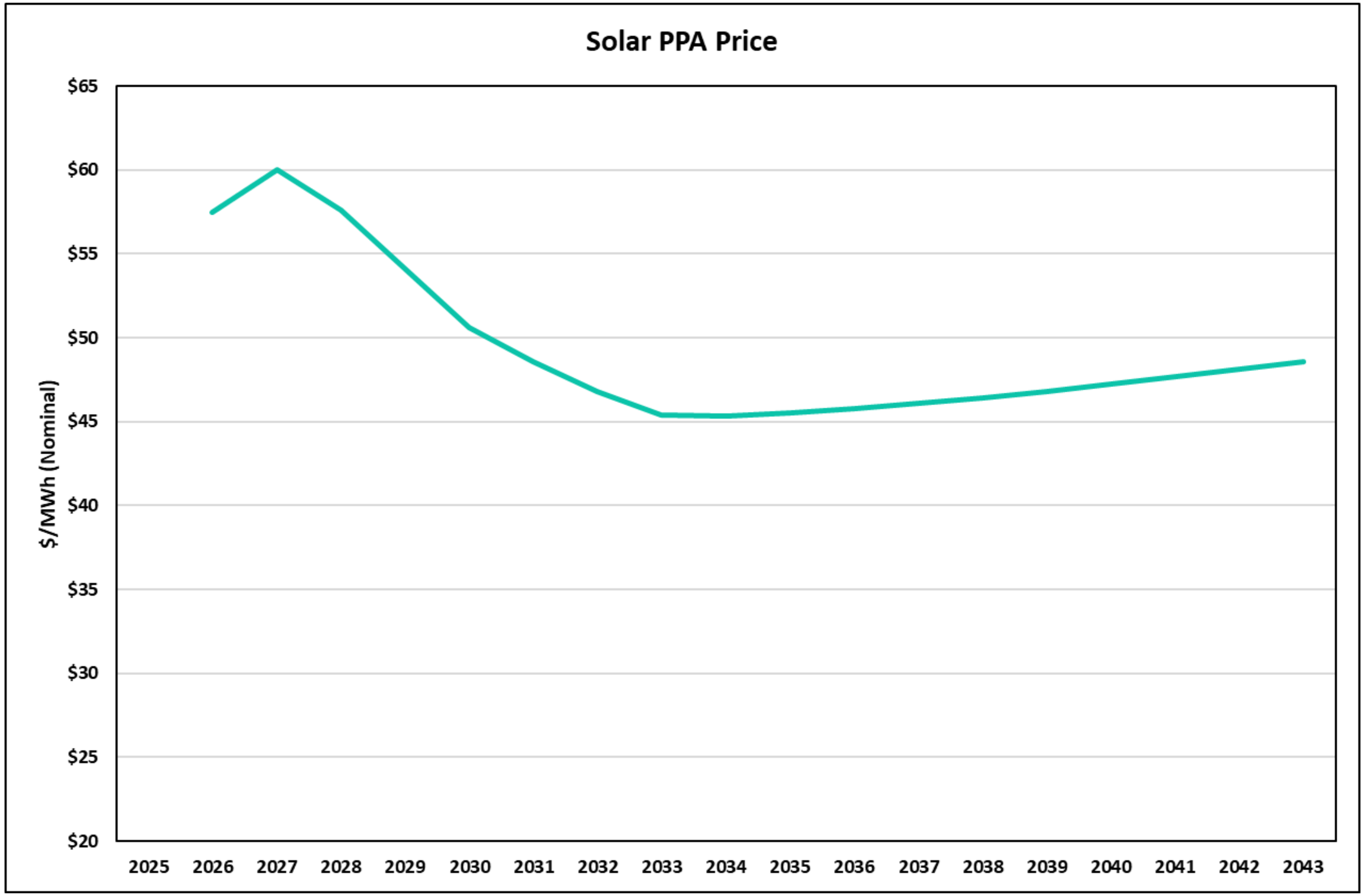
RESOURCE OPTIONS

Resource Option	Fuel Type	Variable O&M ($/MWh)	Fixed O&M ($/kW-yr)	Nameplate Capacity (MW)	Contract Length (years)	Lead Time (years)
Solar PPA	Solar	57.50	0	50	15	3
Wind PPA	Wind	45.00	0	50	15	3
Battery Storage PPA (4-Hour)	Lithium-Ion	0	138	25	15	3
Bilateral Capacity PPA	N/A	0	90	5	1	0
Renewable Energy Credit	N/A	3.50	0	N/A	1	0

Figures are initial 2023 values; PPA rate and capacity prices change through the duration of the study

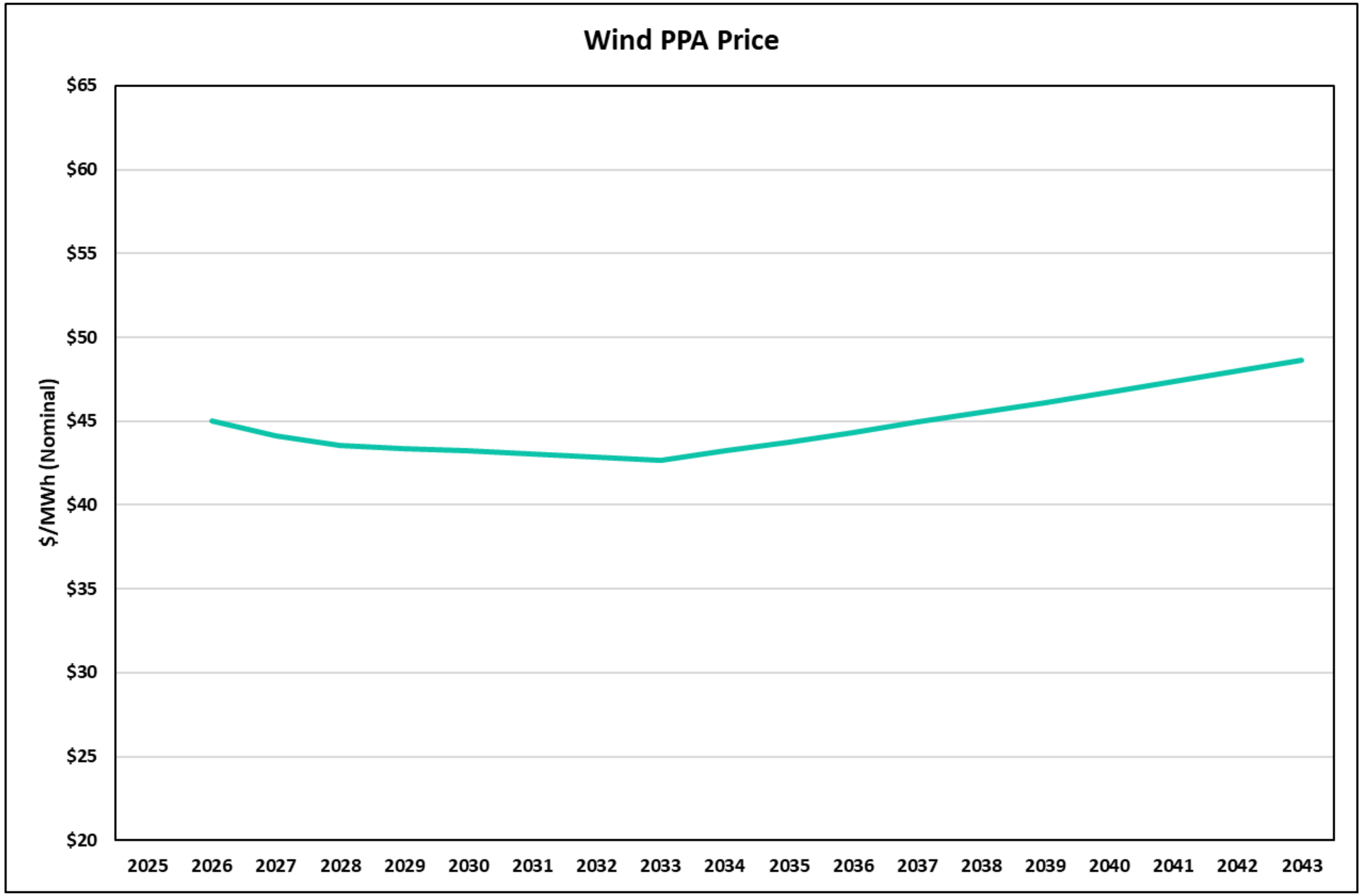
- Purchase power agreement (PPA) – An agreement to purchase power from a generation owner.

SOLAR PPA PRICE



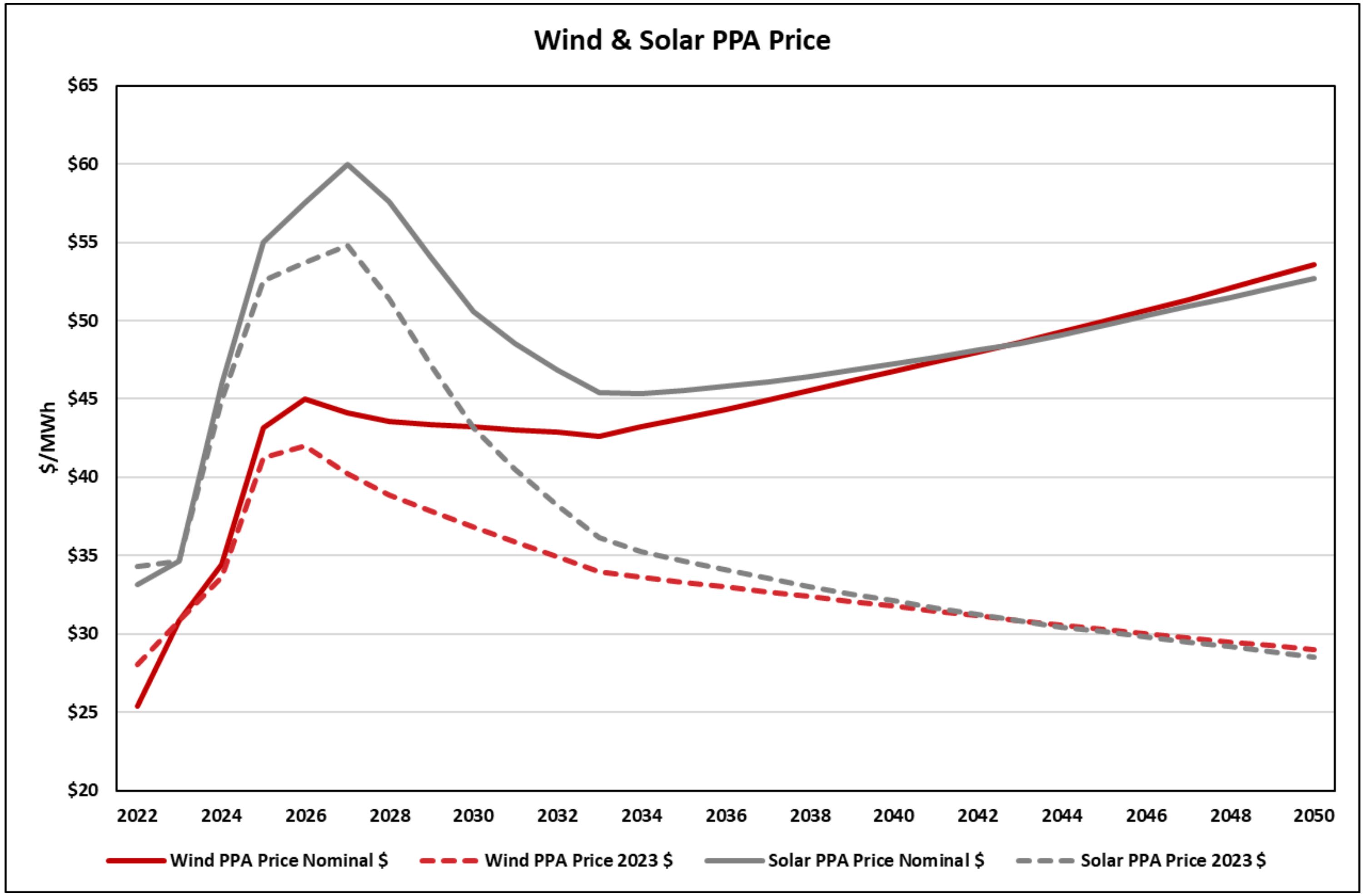
- Prices reflect year project begins operation (3-year lag from when PPA is signed)
- Price forecasts derived using:
  - LevelTen Energy data
  - Capital cost projections from NREL and S&P Commodity Insights
- Substantial drop in prices from 2027-2033 as technological improvements and easing of supply-chain constraints outpace inflationary impacts.

WIND PPA PRICE



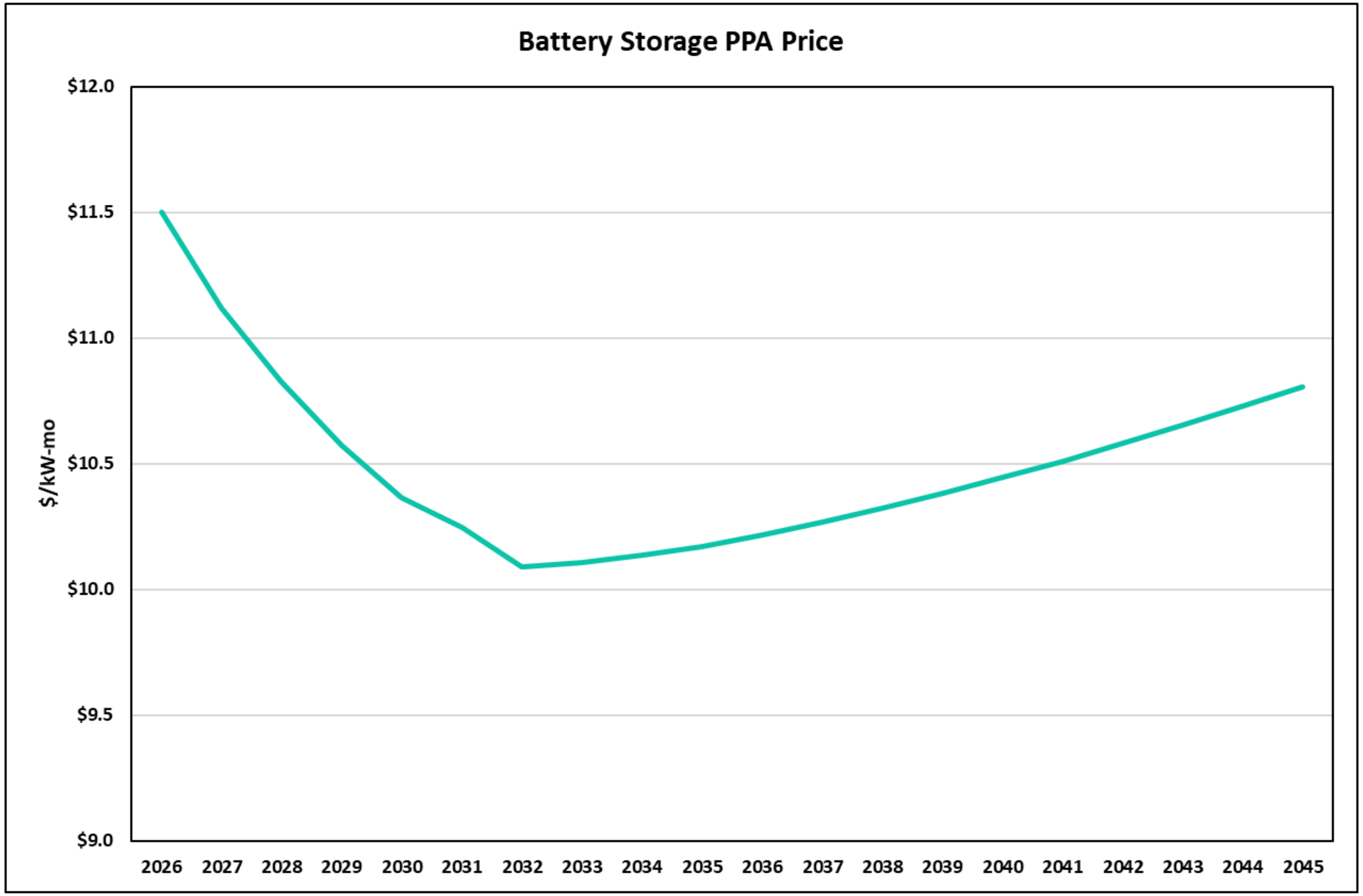
- Prices reflect year project begins operation (3-year lag from when PPA is signed)
- Price forecasts derived using:
  - LevelTen Energy data
  - Capital cost projections from NREL and S&P Commodity Insights
- Shallow drop in prices from 2025-2033 reflect easing of supply-chain constraints outpacing inflationary impacts.

RENEWABLE PPA PRICE



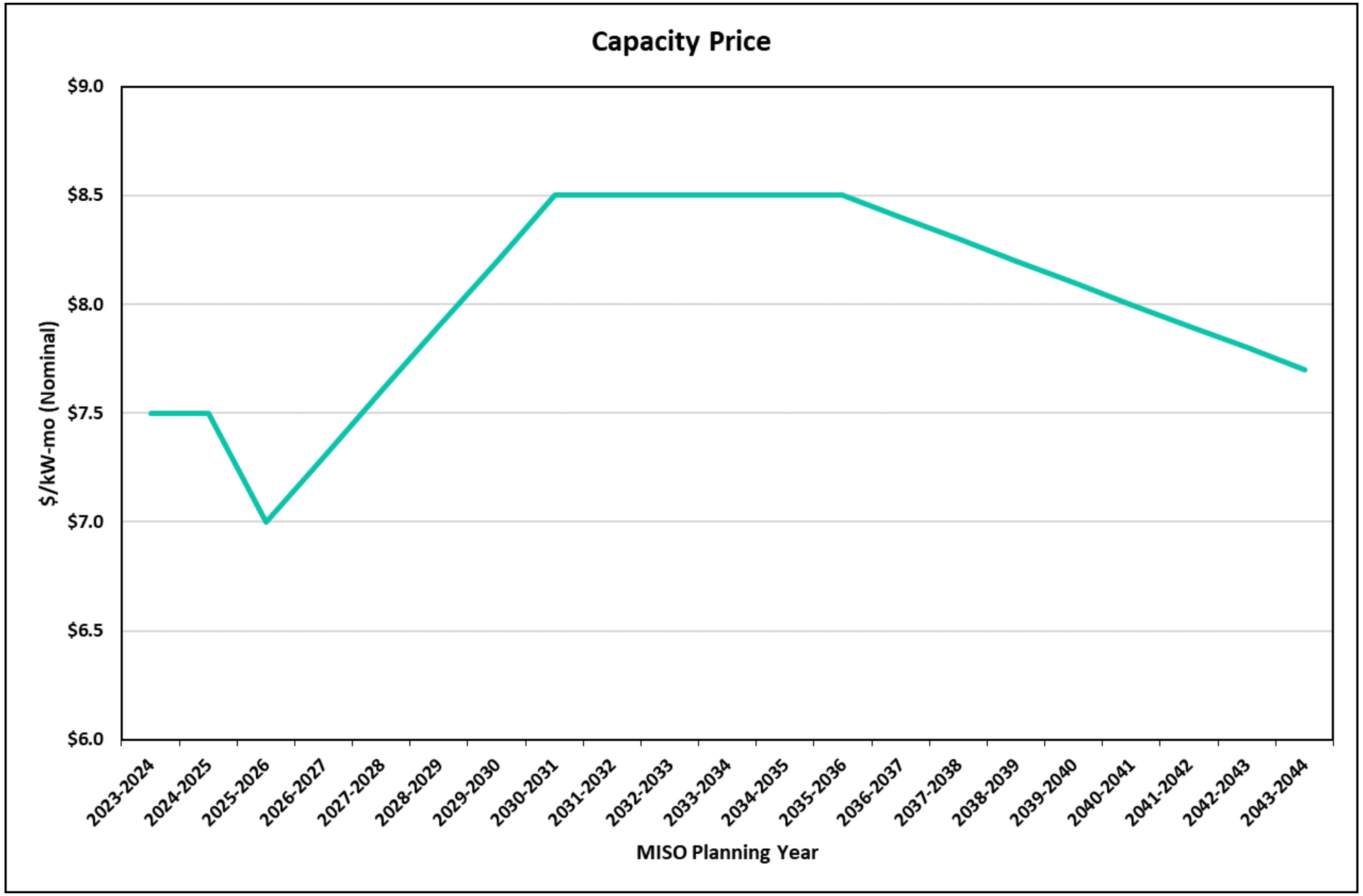
- Heavy premium in solar PPA prices relative to wind through the 2020s.
- Wind and solar PPA price forecast reaches minimums from 3023-3034 in nominal dollars.
  - In real dollars, PPA prices continue to decline through the remainder of the study.
- From the mid-2030s onward, projected wind and solar PPA prices are fairly comparable.

BATTERY STORAGE PPA PRICE



- Prices reflect year project begins operation (3-year lag from when PPA is signed)
- Price forecasts derived using:
  - PPA quotes
  - Capital cost projections from NREL and S&P Commodity Insights
- Substantial drop in prices from 2027-2033 as technological improvements and easing of supply-chain constraints outpace inflationary impacts.

BILATERAL CAPACITY PRICE



- Price shown for entire planning year.
  - Assuming bilateral capacity cannot be purchased for a specific season.
- Prices reflect cost of bilateral capacity from any available resource (not specific to renewable resources).

BASE CASE RESULTS

FINANCIAL METRIC DEFINITIONS

- Two financial metrics evaluated for this study:
  - Net Present Value ($M)
    - Cost positive
    - Includes fixed generation costs, variable generation costs, generation revenues, and load purchase costs.
    - Discount rate is applied to determine present-day value of future cash flows in 2023 dollars.
  - Levelized Cost of Energy ($/MWh)
    - Net Present Value divided by discounted total load volume.

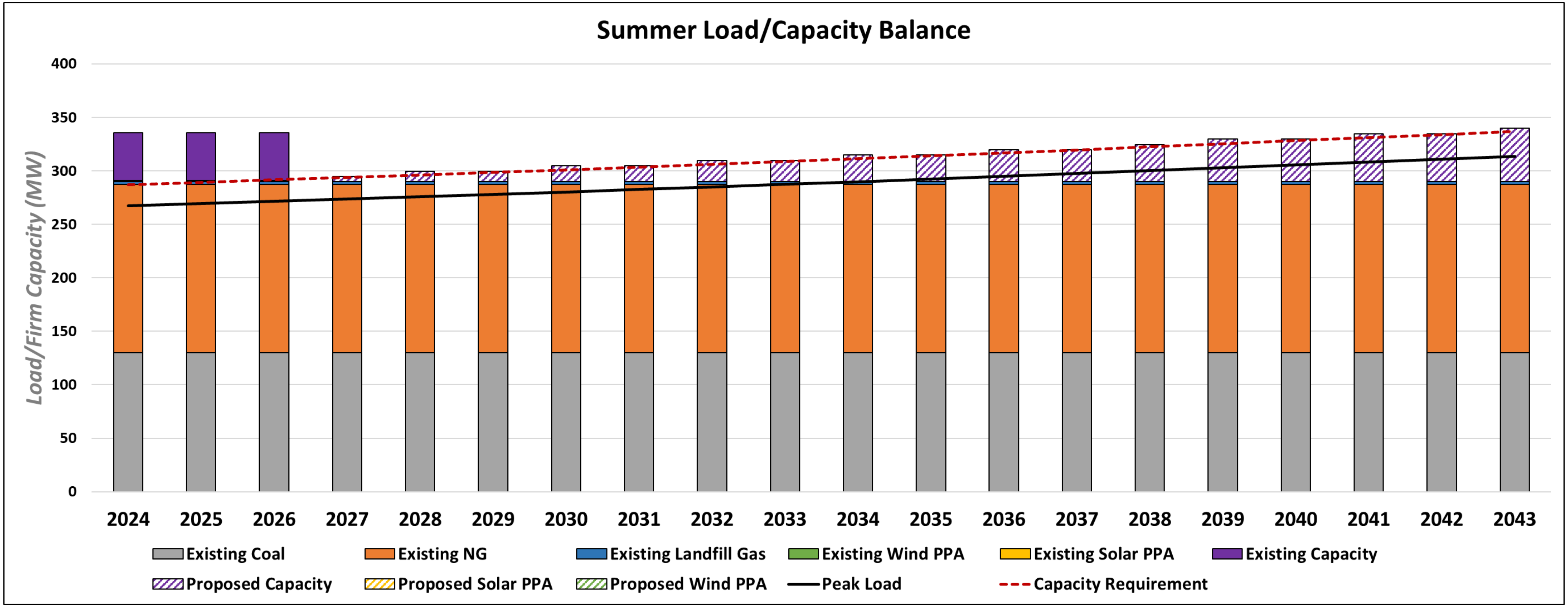
RESOURCE BUILDS/RETIREMENTS

Solution Comparison																							
Scenario	Nameplate Capacity (MW)	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	NPV ($M)	LCoE ($/MWh)
Base	Existing Thermal																					$1,024	$60.47
	Solar PPA																						
	Wind PPA				-6																		
	Battery Storage PPA																						
	Bilateral Capacity				-40	10	10	15	15	20	20	25	25	30	30	35	40	40	45	45	50		

*Bilateral capacity purchases are for one planning year.

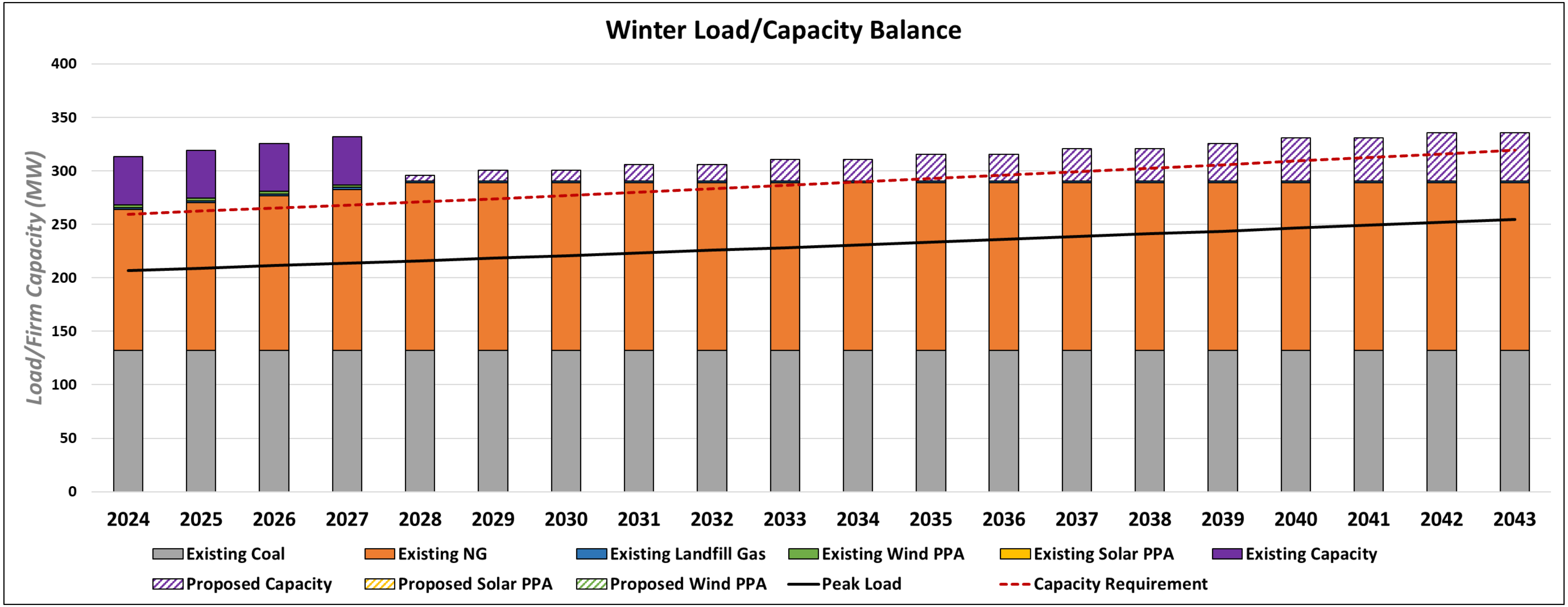
- Dynegy capacity contract and Bluegrass wind PPA expires at the end of May 2027.
- Increasing volumes of bilateral capacity are purchased during the late 2020s and from the mid-2030s onward to meet capacity requirements.
- No solar, wind, or battery storage PPAs were selected in the base case.
- 2024 budget assumptions for purchase power cost are $58.69/MWh of load ($74.4M total).
  - Purchase power cost includes energy charges, capacity charges, and market purchase costs.

LOAD/FIRM CAPACITY BALANCE - SUMMER



- Firm capacity requirements for summer met using bilateral capacity.

LOAD/FIRM CAPACITY BALANCE - WINTER



- Firm capacity requirements for winter met using bilateral capacity.
- Winter capacity not as much of a concern as summer until the mid-2030s.

ALTERNATE CASE RESULTS

ALTERNATE CASE 1 – 100% RENEWABLE NO RECS

Solution Comparison																							
Scenario	**Nameplate Capacity (MW)**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**NPV ($M)**	**LCoE ($/MWh)**
	Existing Thermal																						
	Solar PPA																						
Base	Wind PPA				-6																	**$1,024**	**$60.47**
	Battery Storage PPA																						
	Bilateral Capacity				-40	10	10	15	15	20	20	25	25	30	30	35	40	40	45	45	50		
	Existing Thermal																						
100% Renewable	Solar PPA						50	150	50							50				50	100		
	Wind PPA				-6	150	100														-100	**$1,193**	**$70.46**
	Battery Storage PPA																						
	Bilateral Capacity				-40																		

*Bilateral capacity purchases are for one planning year.

- Model invests heavily in wind (250 MW) and solar (250MW) PPAs during the late 2020s – early 2030s to ensure 100% renewable requirements are met.
- Bilateral capacity is not needed in this scenario since capacity requirements are being met with existing resources and the renewable PPAs.
- $169M increase in net present value when compared to the base case.

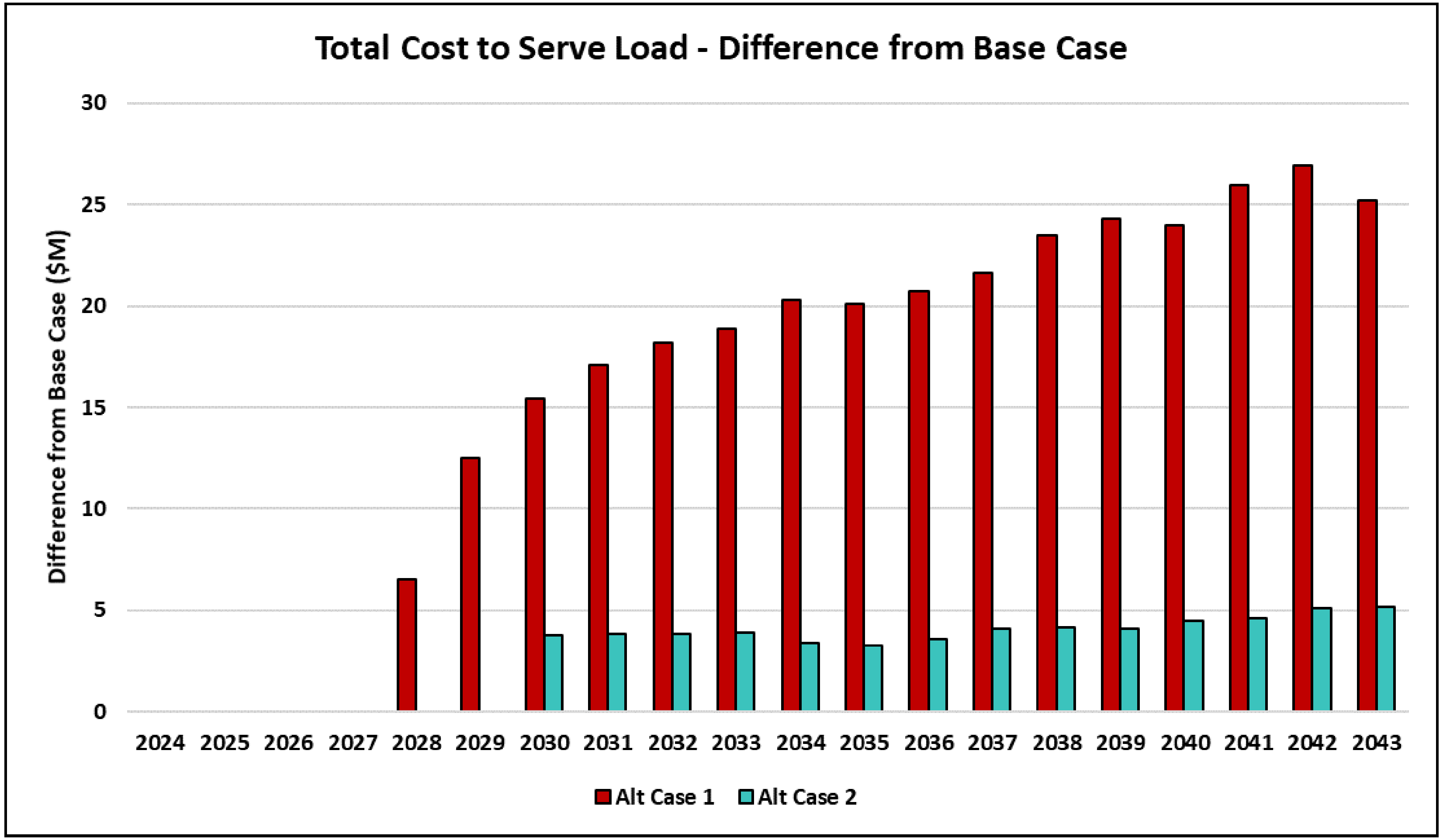
ALTERNATE CASE 2 – 100% RENEWABLE WITH RECS

Solution Comparison																							
Scenario	Nameplate Capacity (MW)	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	NPV ($M)	LCoE ($/MWh)
Base	Existing Thermal																					$1,024	$60.47
	Solar PPA																						
	Wind PPA				-6																		
	Battery Storage PPA																						
	Bilateral Capacity				-40	10	10	15	15	20	20	25	25	30	30	35	40	40	45	45	50		
100% Renewable - With RECs	Existing Thermal																					$1,054	$62.22
	Solar PPA										100												
	Wind PPA				-6																		
	Battery Storage PPA																						
	Bilateral Capacity				-40	10	10	15	15	20		5	5	10	15	15	20	25	25	30	30		

*Bilateral capacity purchases are for one planning year.

- Model invests in solar PPAs during early 2033 to help meet the 100% renewable requirement along with summer capacity needs.
- Bilateral capacity is added intermittently.
- $30M increase in net present value when compared to the base case.

COST DIFFERENCE – ALT CASES 1-2



- Substantial cost increases in alternate case 1 due to lower revenues from solar PPAs.
  - Power price congestion assumed to increase over time as more solar/wind is added onto MISO's system.
- REC price is constant through forecast duration, making alt case 2 cost increase relatively flat over time.

ALTERNATE CASE 3 – 100% RENEWABLE DIVEST COAL

Solution Comparison																							
Scenario	**Nameplate Capacity (MW)**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**NPV ($M)**	**LCoE ($/MWh)**
	Existing Thermal																						
	Solar PPA																						
Base	Wind PPA				-6																	**$1,024**	**$60.47**
	Battery Storage PPA																						
	Bilateral Capacity				-40	10	10	15	15	20	20	25	25	30	30	35	40	40	45	45	50		
	Existing Thermal							-137															
	Solar PPA						50	150	50		50									100	150		
100% Renewable - Divest Coal	Wind PPA				-6	150	100														-150	**$1,637**	**$96.69**
	Battery Storage PPA																						
	Bilateral Capacity				-40	10	25	50	45	50	45	45	50	60	65	70	70	75	80	70	65		

*Bilateral capacity purchases are for one planning year.

- Model invests heavily in wind (250 MW) and solar (250MW) PPAs during the late 2020s – early 2030s to ensure 100% renewable requirements are met.
  - Additional bilateral capacity needed to ensure CMWL is meeting capacity requirements.
- $613M increase in net present value when compared to the base case.
  - Heavily impacted by $726M assumed cost of divestiture for Iatan and Prairie State contracts in 2030.

ALTERNATE CASE 4 – 100% RENEWABLE DIVEST COAL AND NATURAL GAS

Solution Comparison																							
Scenario	Nameplate Capacity (MW)	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	NPV ($M)	LCoE ($/MWh)
Base	Existing Thermal																					$1,024	$60.47
	Solar PPA																						
	Wind PPA				-6																		
	Battery Storage PPA																						
	Bilateral Capacity				-40	10	10	15	15	20	20	25	25	30	30	35	40	40	45	45	50		
100% Renewable - Divest Coal & Natural Gas	Existing Thermal							-137					-191									$1,747	$103.15
	Solar PPA						50	150	50				50							100	150		
	Wind PPA				-6	150	100														-150		
	Battery Storage PPA																						
	Bilateral Capacity				-40	10	25	50	45	50	55	195	210	220	220	225	230	235	235	225	220		

*Bilateral capacity purchases are for one planning year.

- Model invests heavily in wind (250 MW) and solar (250MW) PPAs during the late 2020s – early 2030s to ensure 100% renewable requirements are met.
  - Additional bilateral capacity needed to ensure CMWL is meeting capacity requirements.
- $723M increase in net present value when compared to the base case.
  - Heavily impacted by $726M assumed cost of divestiture for Iatan and Prairie State contracts in 2030 and $90M transmission upgrade cost needed to retire local gas units.

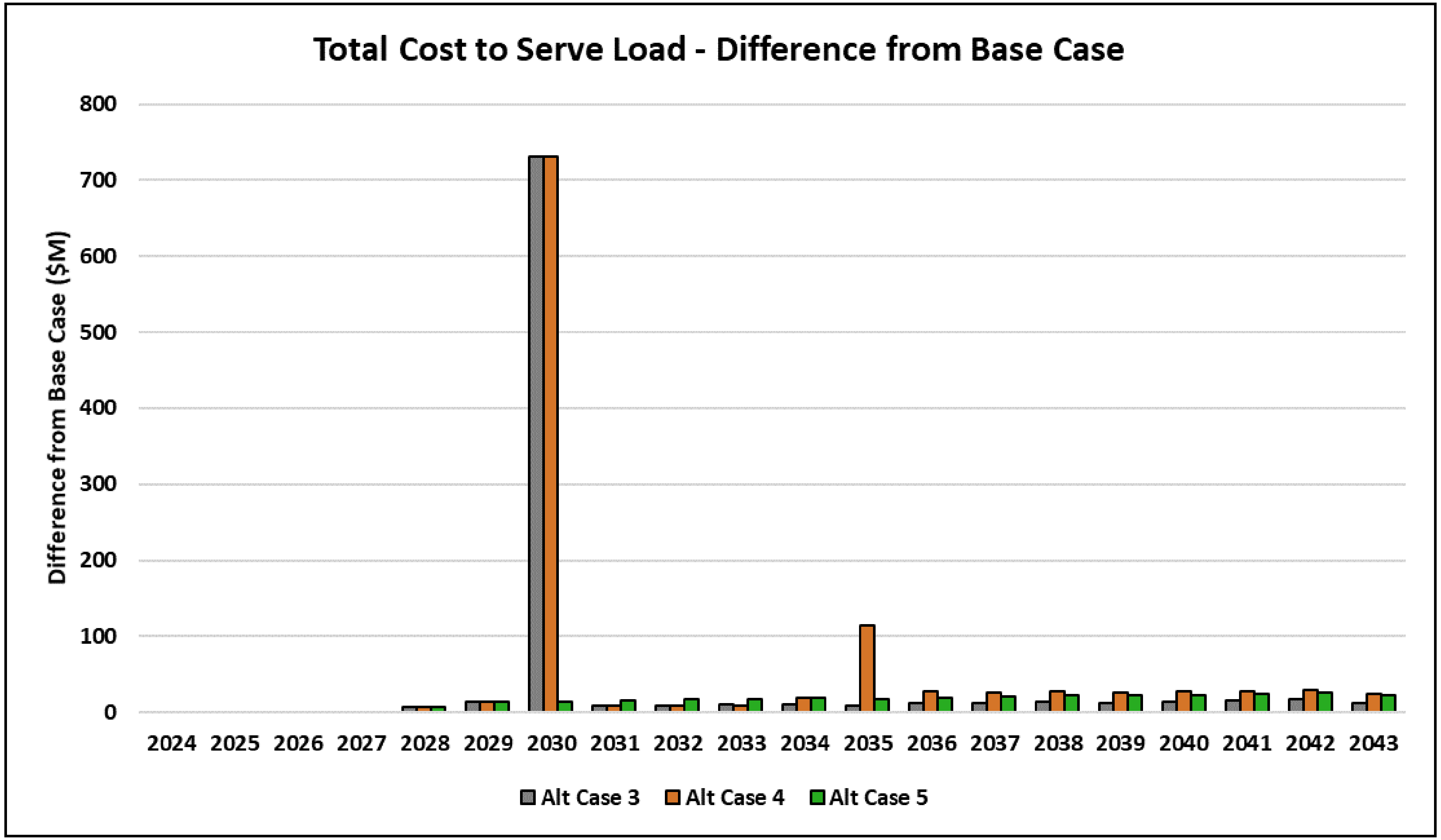
ALTERNATE CASE 5 – 100% RENEWABLE RETIRE SIKESTON EARLY

Solution Comparison																							
Scenario	Nameplate Capacity (MW)	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	NPV ($M)	LCoE ($/MWh)
Base	Existing Thermal																					$1,024	$60.47
	Solar PPA																						
	Wind PPA				-6																		
	Battery Storage PPA																						
	Bilateral Capacity				-40	10	10	15	15	20	20	25	25	30	30	35	40	40	45	45	50		
100% Renewable - Retire Sikeston in 2028	Existing Thermal					-66																$1,181	$69.81
	Solar PPA						50	150	50							50				50	50		
	Wind PPA				-6	150	100														-100		
	Battery Storage PPA																						
	Bilateral Capacity				-40	45	15							5	5	5	5	10	15	15	5		

*Bilateral capacity purchases are for one planning year.

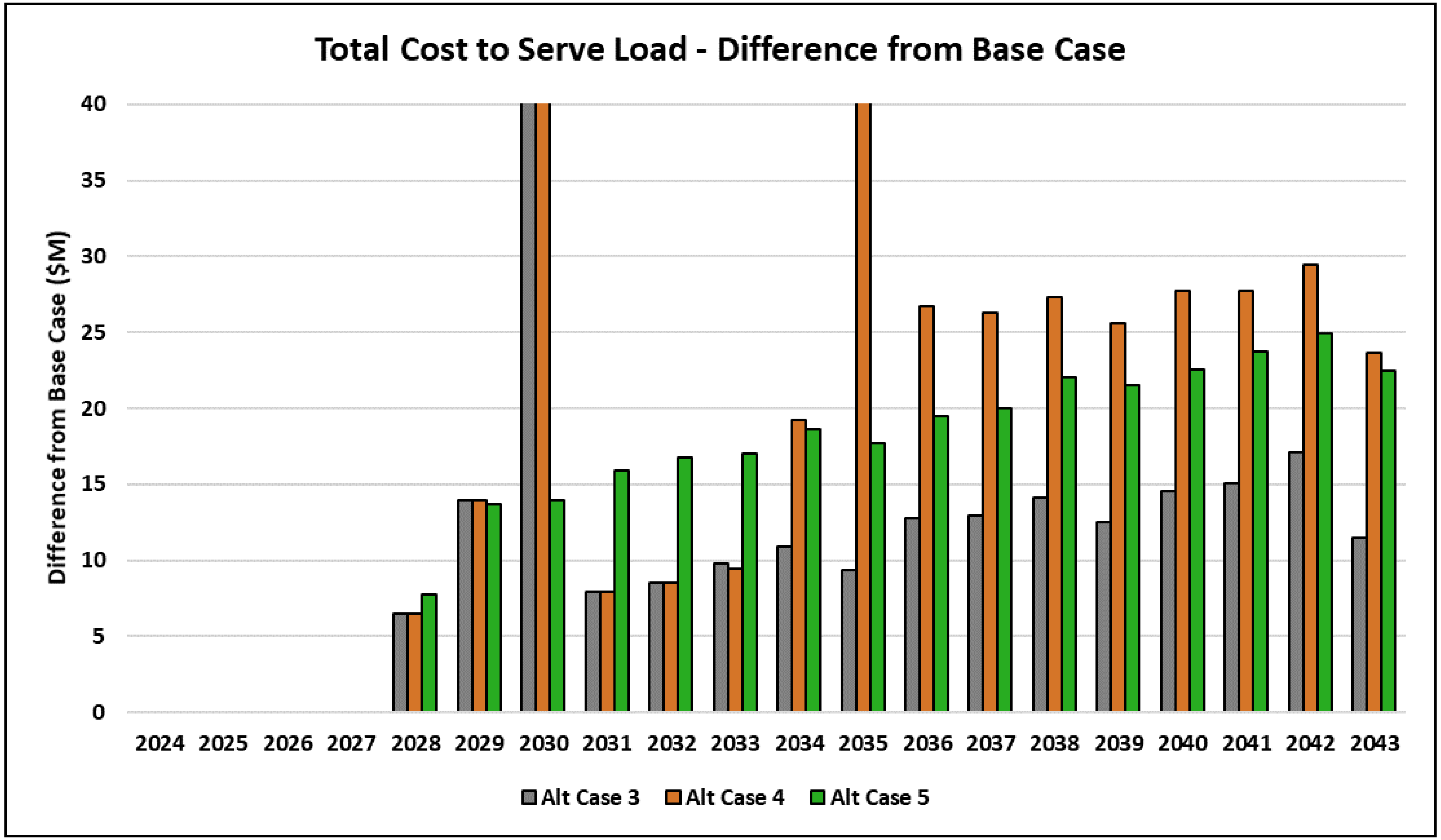
- Model invests heavily in wind (250 MW) and solar (250MW) PPAs during the late 2020s – early 2030s to ensure 100% renewable requirements are met.
  - Additional bilateral capacity needed to ensure CMWL is meeting capacity requirements.
- $157M increase in net present value when compared to the base case.

COST DIFFERENCE – ALT CASES 3-5



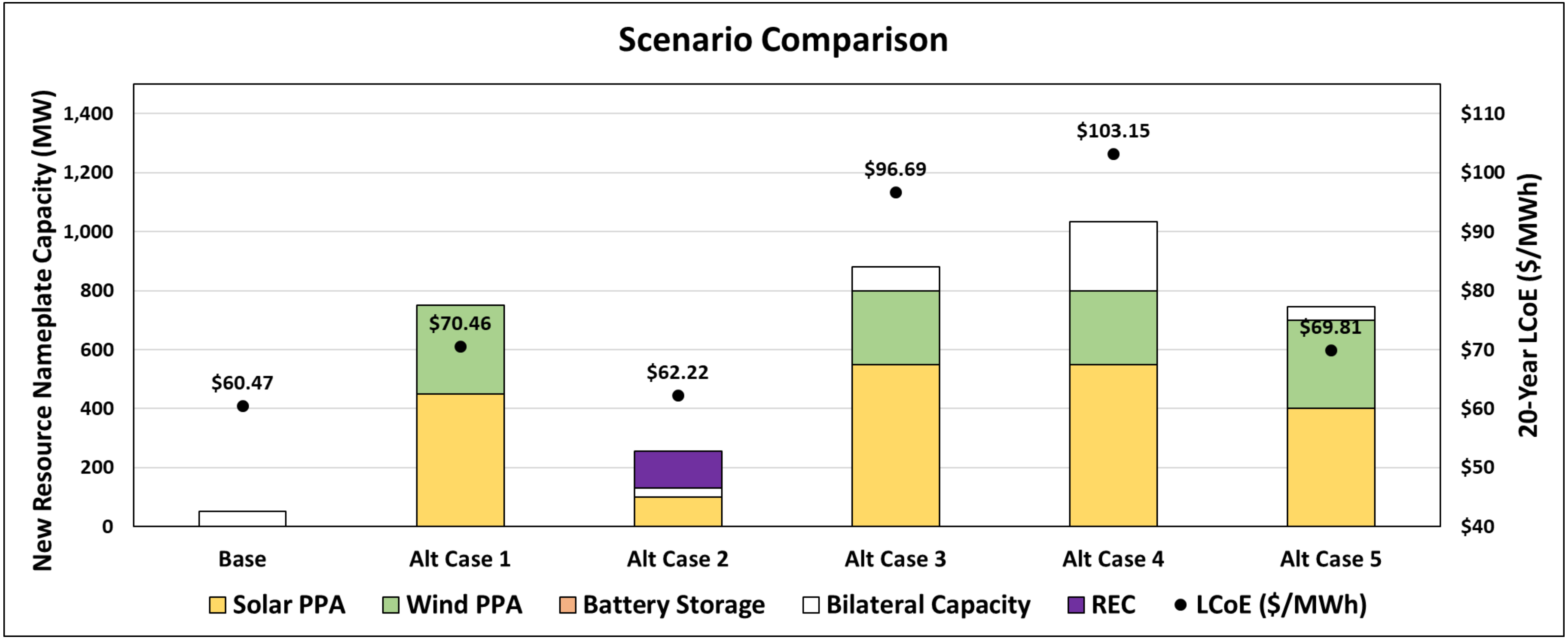
- High cost increases during 2030 and 2035 in scenarios involving coal contract divestiture and natural gas unit retirements.

COST DIFFERENCE – ALT CASES 3-5



- High cost increases during 2030 and 2035 in scenarios involving coal contract divestiture and natural gas unit retirements.
- Outside of 2030, alt case 5 has higher annual costs than alt case 3.
  - Coal resources have higher costs than revenues, particularly in the later years.
  - CMWL has a substantial amount of excess firm capacity in alt case 5.

SCENARIO COMPARISON



- Bilateral capacity represents the largest annual bilateral capacity purchase volume during the 20-year study period.
- REC volume shown represents the maximum annual purchase volume divided by the number of hours in a year.

MAIN TAKEAWAYS

- Largest financial impact to Columbia in achieving 100% renewable is if existing thermal resources are retired early.
  - Additional risks present if thermal resource retirements are not approved by MISO.
- Retirement of existing thermal resources results in substantial bilateral capacity purchases.
  - Bilateral capacity assumed to be purchased from any available resource, purchasing strictly from renewable resources would likely result in increased costs.
- There is value in setting incremental renewable goals rather than a single goal at a specified year.
  - Renewable PPA prices are changing over time, this presents a risk when investing in a large volume of PPAs in just one year.
- Additional risks associated with loss of local generation in extreme weather events were not evaluated in this study.
  - Congestion rights costs and ancillary services not considered in this study.
- Assumed transmission upgrades in alternate case 4 to be complete by 2035 is improbable.
  - Transmission upgrade cost is an estimate, further evaluation required for reliability impacts and definite costs.