
Overview of Report: Capacity Market Impacts and Implications of Alternative Resource Expansion Scenarios

An Element of the ISO New England 2016 Economic Analysis

Presentation to the ISO-NE Planning Advisory Committee

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May 17, 2017

Presentation to Planning Advisory Committee (“PAC”)

- Analysis Group was asked to assess outcomes in the ISO New England (“ISO-NE”) Forward Capacity Market (“FCM”) under alternative “Scenarios” evaluated as a part of the 2016 Economic Analysis.
- Analysis Group has developed a draft report, “Capacity Market Impacts and Implications of Alternative Resource Expansion Scenarios”, dated May 17, 2017. This document has been posted.
- At the PAC on May 24, 2017, Analysis Group will discuss the report, using this presentation. Questions about the report will be answered, although we do not plan to go through the report slide by slide.
- Process
 - May 25 : Discuss draft results with PAC
 - June 5, 2017: Stakeholder comments to be provided to PACMatters@iso-ne.com
 - June 15, 2017: PAC website postings of comments received, responses to comments, the final results
 - June 21, 2017: Discuss comments received, relatively minor comments, and points of clarification

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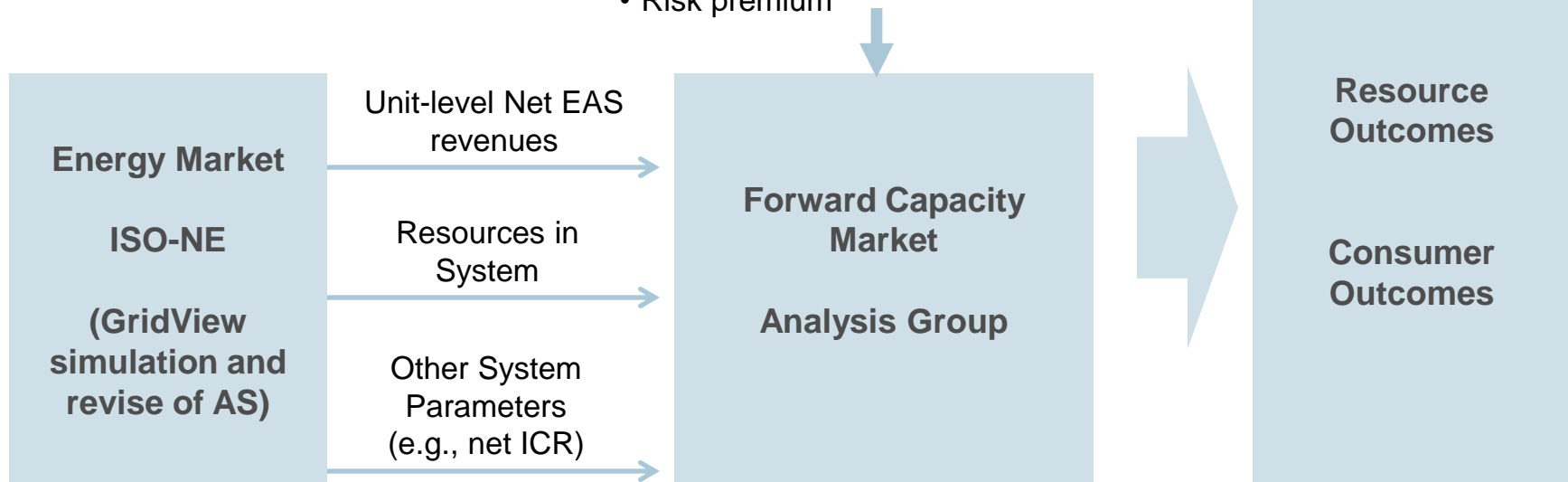
Results

Sensitivity Analysis

Assignment, Study Purpose and Policy Background

- Analysis Group was asked to assess outcomes in the ISO New England (“ISO-NE”) Forward Capacity Market (“FCM”) under alternative “Scenarios” evaluated as a part of the 2016 Economic Analysis.
- Our study is designed to complement and be consistent with ISO-NE’s analysis of outcomes in the ISO-NE energy markets under each of these Scenarios.
- The study assumes current FCM rules, and does not contemplate outcomes under alternative rules, including modifications that might emerge from the Integrating Markets and Public Policy (“IMAPP”) process.

- Ancillary Service (“AS”) revenues
- Fixed Costs (annual, investment, taxes)
- Pay-for-Performance
- Risk premium



NEPOOL's Six Base Scenarios

Our analysis considers the six scenarios identified by stakeholders for analysis in the 2016 Economic Analysis, summarized below. Scenarios differ largely in terms of (1) fossil resource retirements; (2) new resources used to fill a gap in resource adequacy; and (3) “clean” resources added to the system, defined to include wind, solar, battery storage, imports (hydro) and energy efficiency.

- 1. RPS + Gas:** Meet Renewable Portfolio Standards (“RPS”) with new renewable resources (wind) and additional natural gas (combined cycle) units for resource adequacy.
- 2. ISO Queue:** Meet RPS and resource adequacy with new renewable resources (wind).
- 3. Renewables Plus:** Meet RPS with new renewable resources (wind), with additional renewable resources (on- and off-shore wind), energy efficiency, photovoltaics (“PV”) (behind-the-meter), battery storage, and imports (hydropower).
- 4. No Retirements (beyond FCA #10):** Meet RPS with resources under development and Alternative Compliance Payments (“ACP”) for shortfalls; add natural gas units for resource adequacy.
- 5. Gas + ACPs:** Meet RPS with resources under development and ACP; add natural gas units for resource adequacy.
- 6. RPS + Geodiverse Renewables:** Scenario 2 with a more geographically balanced mix of on- and off-shore wind and solar PV.

All Scenarios – except Scenario 4 – assume the retirement of fossil-fired resources.

Scenarios Under Analysis

Scenario	Retire Oldest Oil/Coal	Gross Load	PV	EE	Wind	New NG Units	HQ and NB External Ties
1	½ in 2025 ½ in 2030	Based on 2016 Forecast	Based on 2016 Forecast	Based on 2016 Forecast	As needed to meet RPS and counted towards NICR	NGCC to meet NICR	Based on Historical Profiles
2	½ in 2025 ½ in 2030	Based on 2016 Forecast	Queue additions scaled up by same factor as wind	Based on 2016 Forecast	Queue additions scaled up to satisfy NICR	None	Based on Historical Profiles
3	½ in 2025 ½ in 2030	Based on 2016 Forecast	Provided by Stakeholders	Provided by Stakeholders	Provided by Stakeholders	None	Based on Historical Profiles plus additional Imports
4	None	Based on 2016 Forecast	Based on 2016 Forecast	Based on 2016 Forecast	Existing plus I.3.9	None	Based on Historical Profiles
5	½ in 2025 ½ in 2030	Based on 2016 Forecast	Based on 2016 Forecast	Based on 2016 Forecast	Existing plus I.3.9	NGCC to replace retirements and meet NICR	Based on Historical Profiles
6	½ in 2025 ½ in 2030	Based on 2016 Forecast	Provided by Stakeholders	Based on 2016 Forecast	Provided by Stakeholders	None	Based on Historical Profiles

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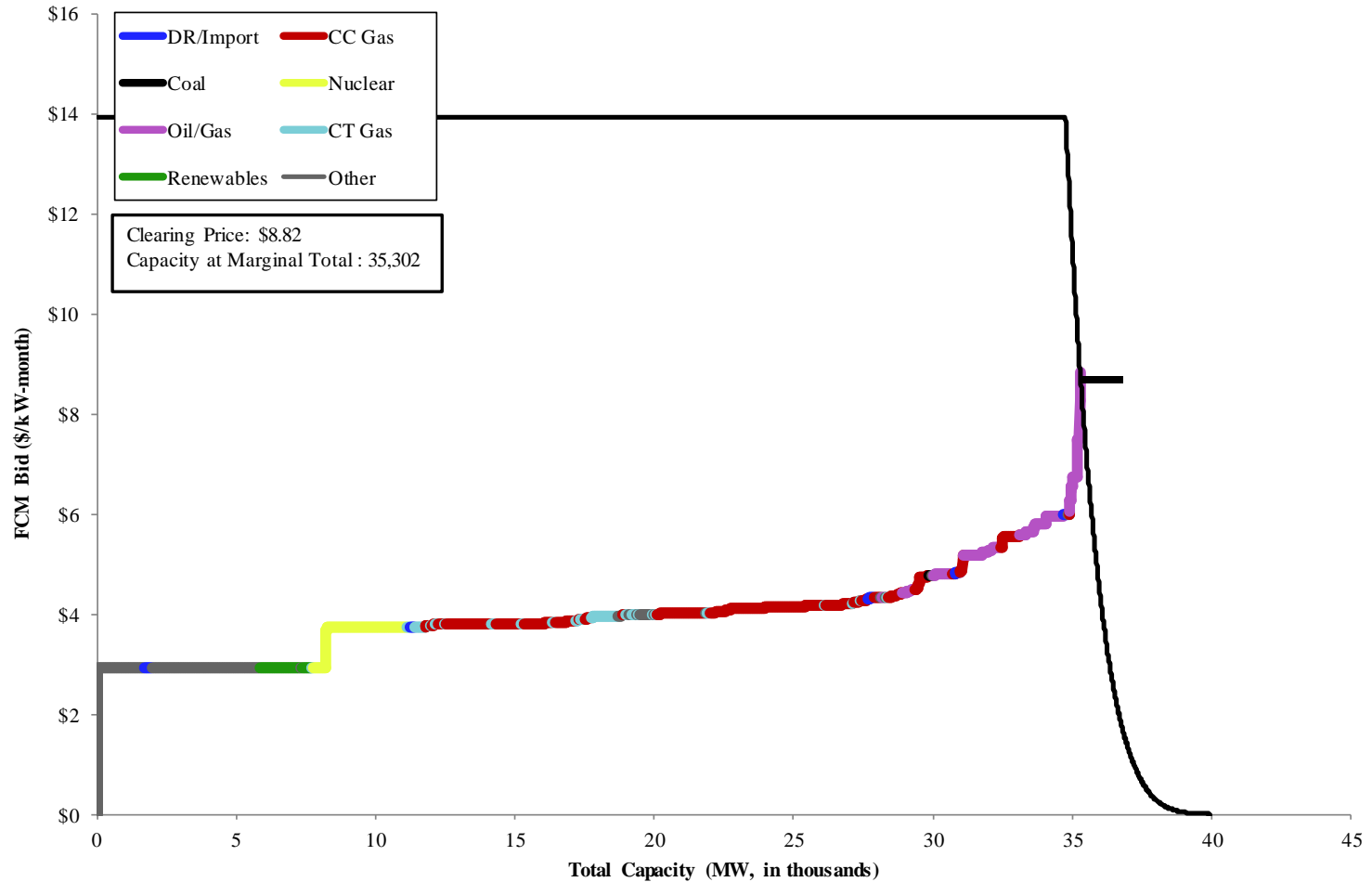
Sensitivity Analysis

Model Overview

FCM Model – Model Structure

- The FCM Model simulates FCM market outcomes. Market outcomes reflect the market-clearing price and quantity given a supply curve comprising offers from existing and new resources at their net Going Forward Costs (“GFC”) and the administratively-determined FCM Demand Curve.
- The supply curve comprises offers from individual resources.
- The FCM Demand Curve is based on the current demand curve construct, adjusted to anticipated future market conditions:
 - The demand curve has a non-linear slope, consistent with recent market modifications, and the curve is fit to the forecast net ICR in 2025 and 2030 used in ISO-NE’s analysis to identify capacity additions needed to maintain resource adequacy.
 - The analysis is performed for two years: compliance year 2025/2026 (FCA 16) to correspond to ISO-NE’s analysis of energy market outcomes in 2025; and compliance year 2030/2031 (FCA 21) to correspond to energy market outcomes in 2030.
- Market-clearing in the FCM Model follows the same rules as the descending clock auction
- The model incorporates the option to mitigate offers based on the Minimum Offer Price Rule (“MOPR”).
 - The current renewable exemption (200 derated MW per auction) is assumed to remain in effect.
 - The base case assumes no offer mitigation. Instead, offer mitigation is evaluated through sensitivity analysis.

Illustrative ISO-NE FCM Supply and Demand Curve



Supply or Offer Curve

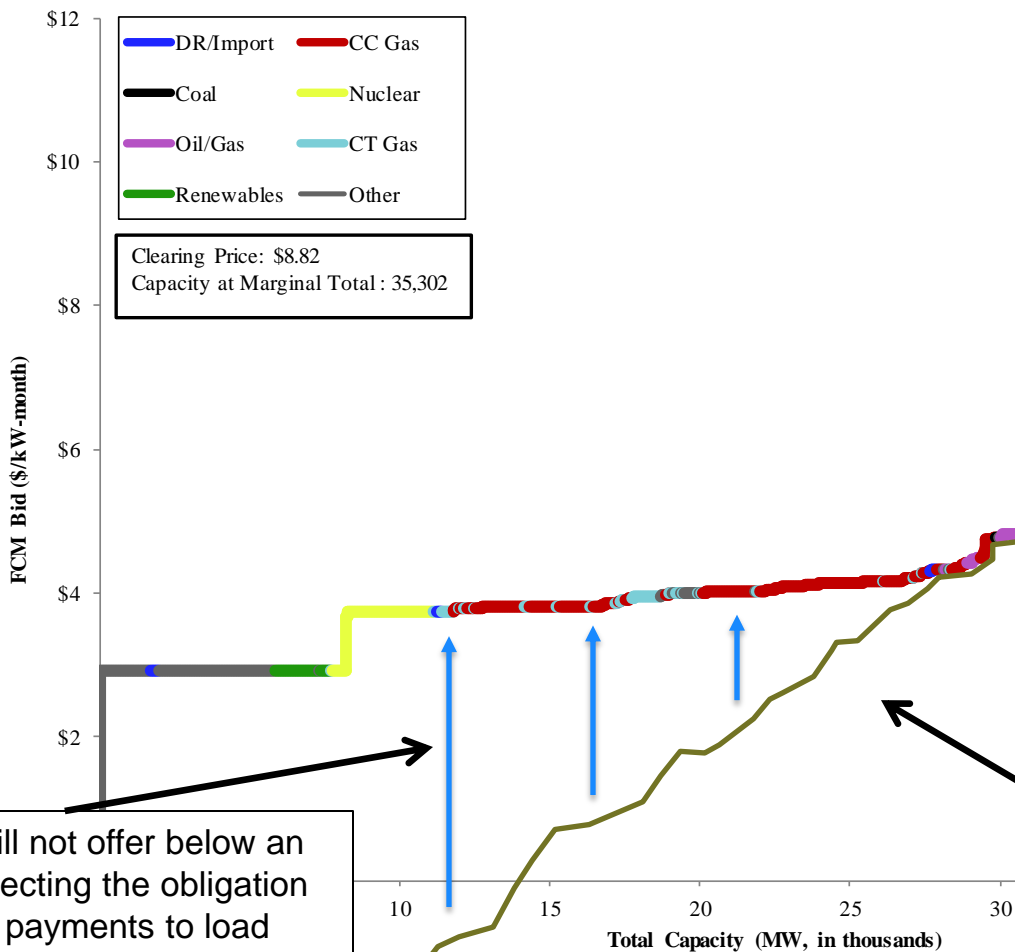
- The supply curve comprises offers from individual resources. Each resource's offer reflects several components. First we estimate the net GFC, reflecting net EAS market revenues, net PFP revenues operational fixed costs, incremental capital costs, and taxes – that is:

$$\text{Net GFC} = \text{Fixed Costs} + \text{Annualized Capital Costs} + \text{Taxes}$$

$$- \text{Net EAS Revenues} - \text{Expected Net PFP Revenues}$$

- The “avoidable” costs of plant operation generally include the **fixed costs** of plant operation, **on-going capital investment** to maintain plant operation, and **taxes**.
- **Net EAS revenues** reflect **net energy market revenues** from the ISO-NE analysis and estimates of ancillary service revenues.
 - **Ancillary service revenues** reflect resource-specific operating reserves revenues, based on an analysis of actual revenues earned by resources over the period 2012 to 2016. Resource-specific revenue estimates reflect Forward Reserve Market (“FRM”) outcomes (including resource assignment to meet FRM obligations), real-time reserve market outcomes, and appropriate adjustments for FCM revenues.
- **Expected Net PFP Revenues** are based on an estimate of the difference between expected PFP revenues and expected PFP payments (to load), which depends on the unit's output (performance) during reserve shortages. This adjustment can be positive or negative.
- Resource offers are allowed to include a **Risk Premium**, reflecting, for example, the risk of a catastrophic event or the risk greater than expected reserve deficiency hours.

Illustrative ISO-NE FCM Supply Curve With Adjustment for PFP Rules



Clearing Price: \$8.82
Capacity at Marginal Total: 35,302

New Gas-Fired Supply (Combustion Turbine) (at Net CONE = \$8.70)

Analysis does not consider additional new entry unless there are insufficient resources to clear demand

FCA offers reflect unit-specific "Going Forward Costs" based on fixed costs less net energy market revenues, ancillary service revenues and expected Pay-for-Performance revenues

Resources will not offer below an offer floor reflecting the obligation to make PFP payments to load that can otherwise be avoided by foregoing the Capacity Supply Obligation

Supply Curve Components

Component	Data Source(s)	Brief Detail
Net Energy Revenues	ISO-NE GridView Output	Modeled by ISO-NE, reflecting energy revenues net of variable and fuel costs
Ancillary Revenues	ISO-NE Historical Data	Analysis of unit-specific forward and real-time operating reserve prices and supply from 2012 to 2016 Does not consider any changes in ancillary service requirements
Fixed Costs	SNL Financial; ABB Ventyx	Detailed review of annual fixed costs modeled by SNL and Ventyx for individual units and by technology type
Investment Costs	SNL Financial	Analysis of annual investment costs for plants by technology type (2010 to 2015), excl. major investment
Taxes	Public Tax Rates and Property Assessments	Based on review of financial materials for 76 units of various capacity sizes and technology types
PFP Adjustment	ISO-NE Historical Data	Analysis of unit historical performance during reserve shortages
Risk Premium	ISO-NE Pre-Determined Formulas	Based on ISO-NE projected scarcity hours and other parameters

Additional details are available in the technical appendix

Resources Offering Into the FCM

Summary of Resources in the ISO-NE System in 2025 and 2030 (FCM Eligible Capacity)

Category	2025 S1	2025 S2	2025 S3	2025 S4	2025 S5	2025 S6	2030 S1	2030 S2	2030 S3	2030 S4	2030 S5	2030 S6
FCA 10 Cleared Renewables (non solar)	487	487	487	487	487	487	487	487	487	487	487	487
FCA 10 Cleared Solar & Solar added in S6	62	62	62	62	62	443	62	62	62	62	62	1,673
Forecasted EE & ADR w/o RTEG	4,163	4,163	5,663	4,163	4,163	4,163	5,058	5,058	8,328	5,058	5,058	5,058
FCA 10 Cleared Nuclear	3,347	3,347	3,347	3,347	3,347	3,347	3,347	3,347	3,347	3,347	3,347	3,347
FCA 10 Cleared Hydro	3,116	3,116	3,116	3,116	3,116	3,116	3,116	3,116	3,116	3,116	3,116	3,116
Citizen Block Load	30	30	30	30	30	30	30	30	30	30	30	30
Imports	1,006	1,006	2,506	1,006	1,006	1,006	1,006	1,006	3,006	1,006	1,006	1,006
Existing Wind (FCM+ L3.9) & Wind Added in S2 & S6	366	1,511	1,457	366	366	1,129	366	5,199	1,900	366	366	3,588
Gas after Retirement	16,582	16,582	16,582	16,676	16,582	16,582	16,011	16,011	16,011	16,676	16,011	16,011
Oil after Retirement	4,509	4,509	4,509	6,109	4,509	4,509	2,114	2,114	2,114	6,109	2,114	2,114
Coal after Retirement	0	0	0	917	0	0	0	0	0	917	0	0
Total Existing Resource after Retirement	33,668	34,813	37,759	36,279	33,668	34,812	31,597	36,430	38,401	37,174	31,597	36,430
Utility Scale Battery Storage	0	0	1,200	0	0	0	0	0	2,500	0	0	0
Capacity Added to Meet RPS	488	0	0	0	0	0	687	0	0	0	0	0
Total Existing Resource plus Storage and RPS Renewables	34,156	34,813	38,959	36,279	33,668	34,812	32,284	36,430	40,901	37,174	31,597	36,430
Net NICR	35,302	35,302	34,804	35,302	35,302	35,302	36,919	36,919	36,273	36,919	36,919	36,919
NGCC Capacity Added to Replace Retirement and to Meet NICRc	656	0	0	0	1,144	0	4,146	0	0	0	4,833	0
Wood	489	489	489	489	489	489	489	489	489	489	489	489
Total Capacity Modeled	35,302	35,302	39,448	36,768	35,302	35,301	36,919	36,919	41,390	37,663	36,919	36,919

Summary of Resource Retirements in 2025 and 2030

Plant Type	2025 Retired Summer Capacity (MW)						2030 Retired Summer Capacity (MW)					
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Coal	856	856	856	0	856	856	856	856	856	0	856	856
Oil/Gas Steam	1,600	1,600	1,600	0	1,600	1,600	3,805	3,805	3,805	0	3,805	3,805
Combustion Turbine	0	0	0	0	0	0	7	7	7	0	7	7
Total	2,457	2,457	2,457	0	2,457	2,457	4,668	4,668	4,668	0	4,668	4,668

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Key Drivers of Market Outcomes

FCM outcomes depend on several key drivers:

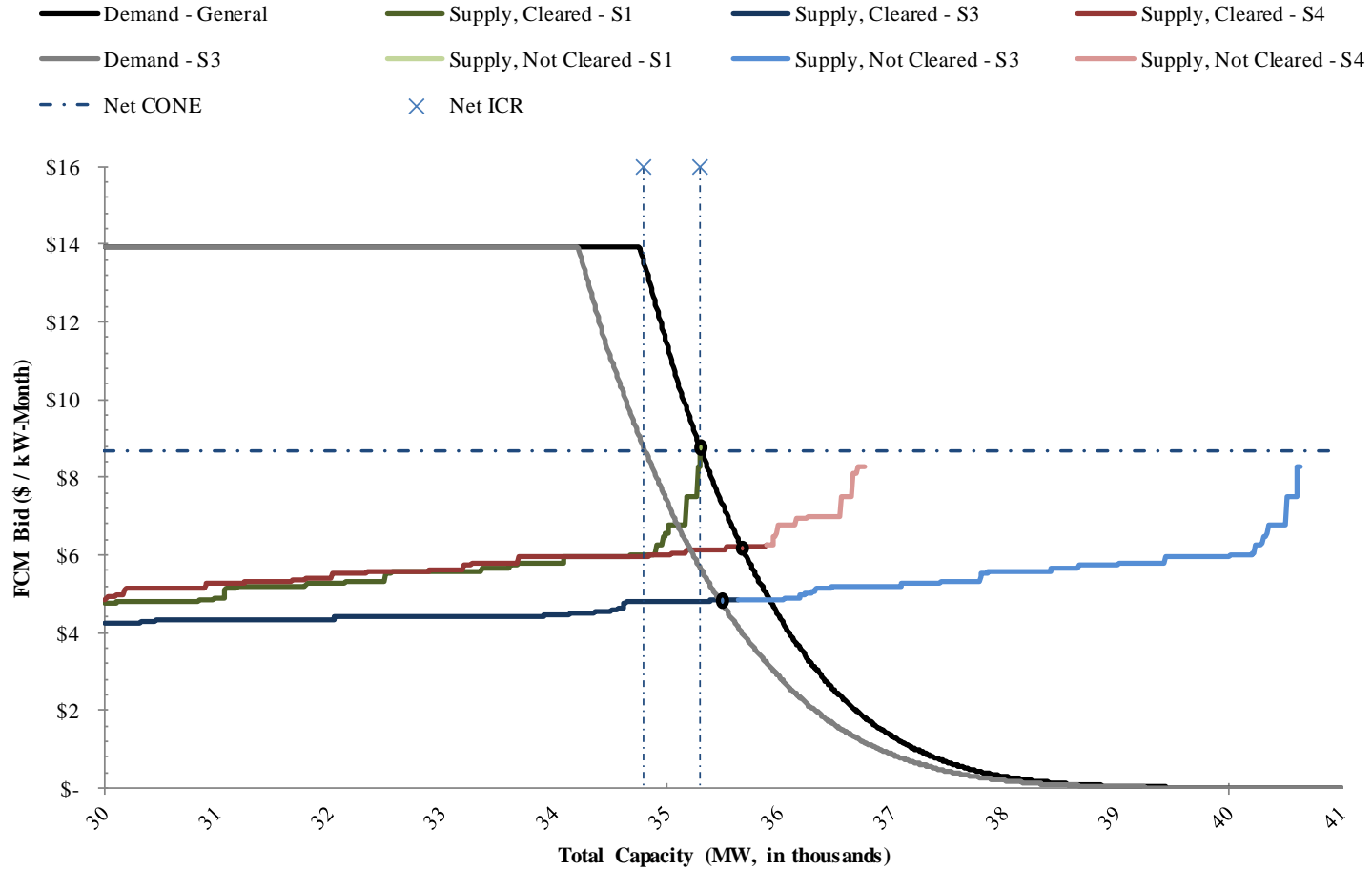
- Increased resource supply
 - Entry of new “clean” policy-supported renewable resources, which generally offer only a fraction of nameplate capacity into the Forward Capacity Auction (“FCA”)
 - Entry of other policy-supported resources, such as hydro imports and battery storage, which are assumed to offer capacity into the FCA at full nameplate value
- Decreased resource supply
 - Assumed retirements, which may occur due to low market prices, particularly in the FCM, or other (exogenous) factors, such as the need for one-time capital investment
- Changes in resource “going forward” costs, particularly net energy market revenues
 - Assumptions regarding relatively low Going Forward Costs (“GFC”) for existing fleet is confirmed by recent auction outcomes
- Reduced demand, i.e., net Installed Capacity Requirement (“ICR”)
 - Diminished peak load growth, due to, among other things, energy efficiency, behind-the-meter-PV, and demand-response programs.
- Minimum Offer Price Rule (“MOPR”) offer mitigation, including the scope of resources subject to mitigation and the renewable technology exemption

ISO-NE FCM 2016 Economic Analysis Scenario Outcomes

	2025 (Unconstrained)					
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Net CONE	\$8.70	\$8.70	\$8.70	\$8.70	\$8.70	\$8.70
Clearing Price (\$/kW-Month)	\$8.82	\$8.99	\$4.82	\$6.20	\$8.74	\$9.04
Cleared Capacity @ Marginal Total (MW, thousands)	35,302	35,299	35,627	35,665	35,302	35,302
Total FCM Payments (\$, millions)	\$3,736	\$3,808	\$2,061	\$2,653	\$3,702	\$3,830
Average FCM Payments (\$ per MWh)	\$24.57	\$25.06	\$12.77	\$17.53	\$24.35	\$25.20
Capacity Above ICR	0	-3	823	363	0	0
Not Cleared Capacity (MW, thousands)	0	0	5,010	891	0	0
Total Energy Revenue (\$, millions)	\$8,659	\$8,325	\$7,688	\$8,737	\$8,819	\$8,382
	2030 (Unconstrained)					
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Net CONE	\$9.61	\$9.61	\$9.61	\$9.61	\$9.61	\$9.61
Clearing Price (\$/kW-Month)	\$9.61	\$9.75	\$4.68	\$7.04	\$9.61	\$9.84
Cleared Capacity @ Marginal Total (MW, thousands)	36,919	36,916	37,439	37,332	36,920	36,920
Total FCM Payments (\$, millions)	\$4,257	\$4,319	\$2,103	\$3,154	\$4,257	\$4,360
Average FCM Payments (\$ per MWh)	\$26.67	\$27.18	\$11.98	\$19.75	\$26.68	\$27.43
Capacity Above ICR	0	-3	1,166	413	1	1
Not Cleared Capacity (MW, thousands)	0	0	5,989	331	0	0
Total Energy Revenue (\$, millions)	\$11,262	\$7,444	\$8,051	\$11,453	\$11,362	\$6,992

Note: Results are reported in nominal dollars (e.g., 2025 results are in \$2025).

ISO-NE FCM Auction Demand-Supply Curve Multiple Scenario Results



Overview of Results

Across the scenarios, market equilibrium outcomes can be grouped into three general categories:

- ***Retirements with Entry to Meet Net ICR*** (Scenarios 1, 2, 5, and 6)
 - Highest FCA prices, slightly above net CONE (clears at existing resource offer)
 - Capacity Supply Obligation (“CSO”) quantities roughly equal to net ICR, with all resources clearing
- ***No Retirements and No Major New Resources beyond FCA 10*** (Scenario 4)
 - Lower FCA prices
 - CSO quantities slightly in excess of net ICR (~ 300 to 400 MW)
 - ~ 400 to 1,000 MW does not clear the FCA
- ***Retirements with Substantial New Clean and Distributed Resources*** (Scenario 3)
 - Lowest FCA prices
 - Largest quantity of CSO’s in excess of net ICR (~ 600 to 800 MW)
 - Largest quantity of resources that do not clear the FCA (~4,900 to 5,700 MW)

- Market equilibrium for each of these cases is illustrated in the figure on the following slide.

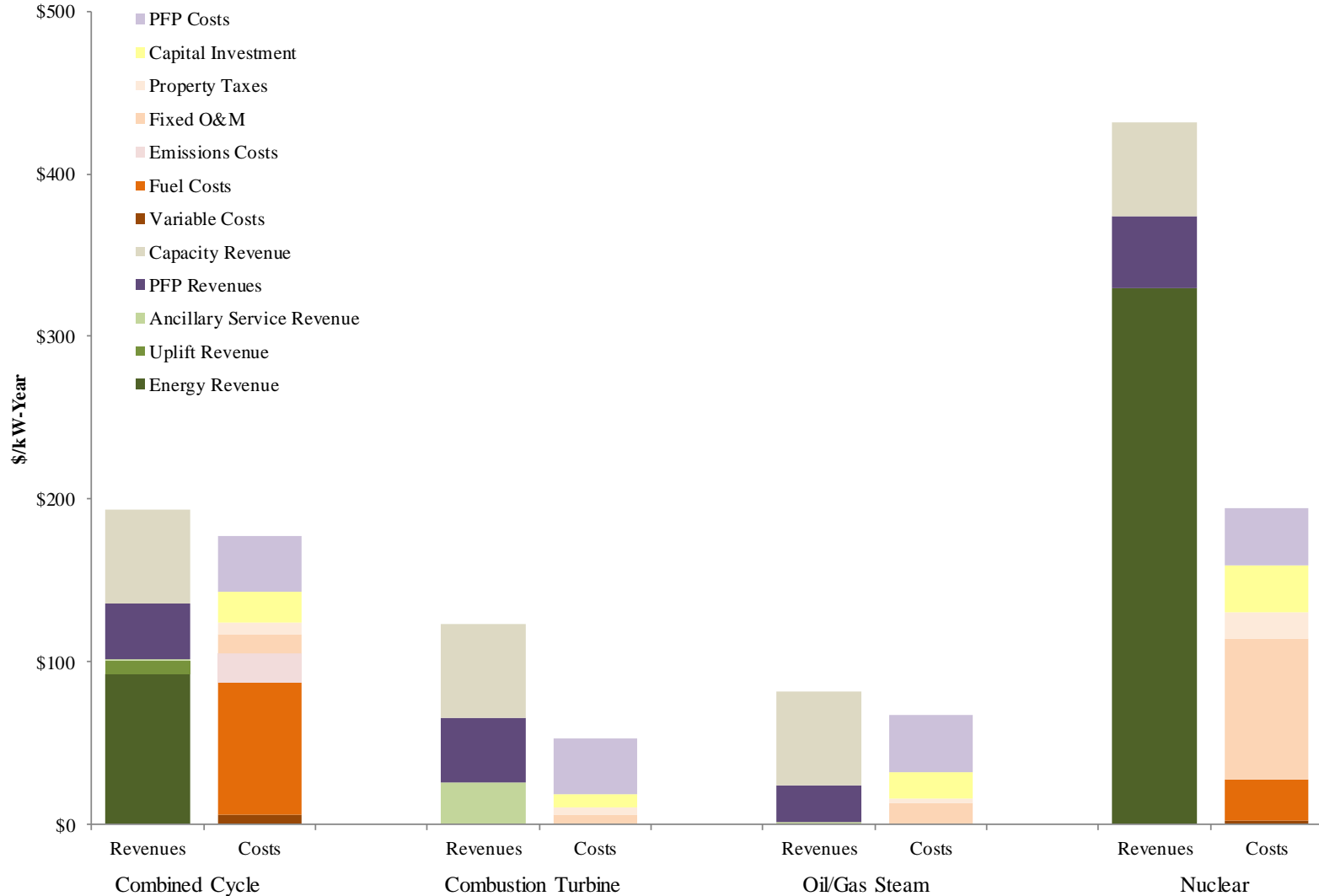
Implications of Resource Assumptions for FCA Outcomes

- Absent retirements, there is limited need for new resources (Scenario 4).
 - With low-load growth, growth in behind-the-meter resources and limited growth in new capacity, growth in demand is insufficient to drive the need for new resources.
- Retirements, such as assumed retirements of 2,457 MW by 2025 and 4,668 MW by 2030, can drive the need for new capacity to maintain resource adequacy.
 - While the type of capacity added – renewables only, gas-only or a mix of the two – does affect energy market outcomes (see ISO-NE results), there is relatively little impact on FCA outcomes (in Scenarios 1, 2, 5, and 6).
- Scenarios with renewable additions would require additional revenue streams outside the ISO-NE markets given the higher cost of new entry for these resources. Total ISO payments (FCM and energy market) included in the table on page 7 do not include these payments.
- Substantial expansion of clean resources (i.e., Scenario 3) would lower FCA prices, crowding out existing resources.
 - These impacts would depend on what portion of new renewables actually participate in the FCM and the extent of MOPR offer mitigation, which is tested in sensitivity analysis.
- As the quantity of new clean resources added to the system increases, the cost (per MWh or MW) of supporting clean resources increases. The gap in revenue requirement (for new entry) needs to be filled by other sources because of decreases in revenues from both the FCM and energy markets.

Total Payments

- With the change in prices and quantities, total FCM payments vary across scenarios.
 - In Scenario 1, 2, 5 and 6, total FCM payments range from \$3.7 to \$3.8 billion in 2025 and \$4.3 to \$4.4 billion in 2030.
 - Scenario 4 total FCM payments are \$2.7 billion in 2025 and \$3.1 billion in 2030, a reduction of approximately 27 to 30 percent relative to Scenario 1, 2, 5 and 6.
 - Scenario 3 payments are lower still – \$2.1 billion in both 2025 and 2030, a reduction of approximately 43 to 52 percent relative to Scenario 1, 2, 5 and 6.
 - Estimates reflect one-year “snapshots”, although year-to-year outcomes may vary given the dynamics of long-run equilibrium and policies.
- Total payments in ISO-NE markets ranges from \$9.7 to \$15.6 billion (excluding ancillary service payments)
 - Costs are lowest in Scenario 3 and highest in the Scenarios requiring new entry to meet net ICR (Scenarios 1, 2, 5 and 6)
 - These total payments do not include the costs associated with state policies. These costs would be incremental to payments associated with the ISO-NE markets, with an incidence that reflects the particular states undertaking these policies.
- The estimated payments in Table 5 *do not* reflect social costs, but only the costs to consumers.
 - Estimates of social costs were developed by ISO-NE, based on the U.S. Energy Administration Agency’s cost of developing new resources. The difference in outcomes reflects transfers from producers to consumers.

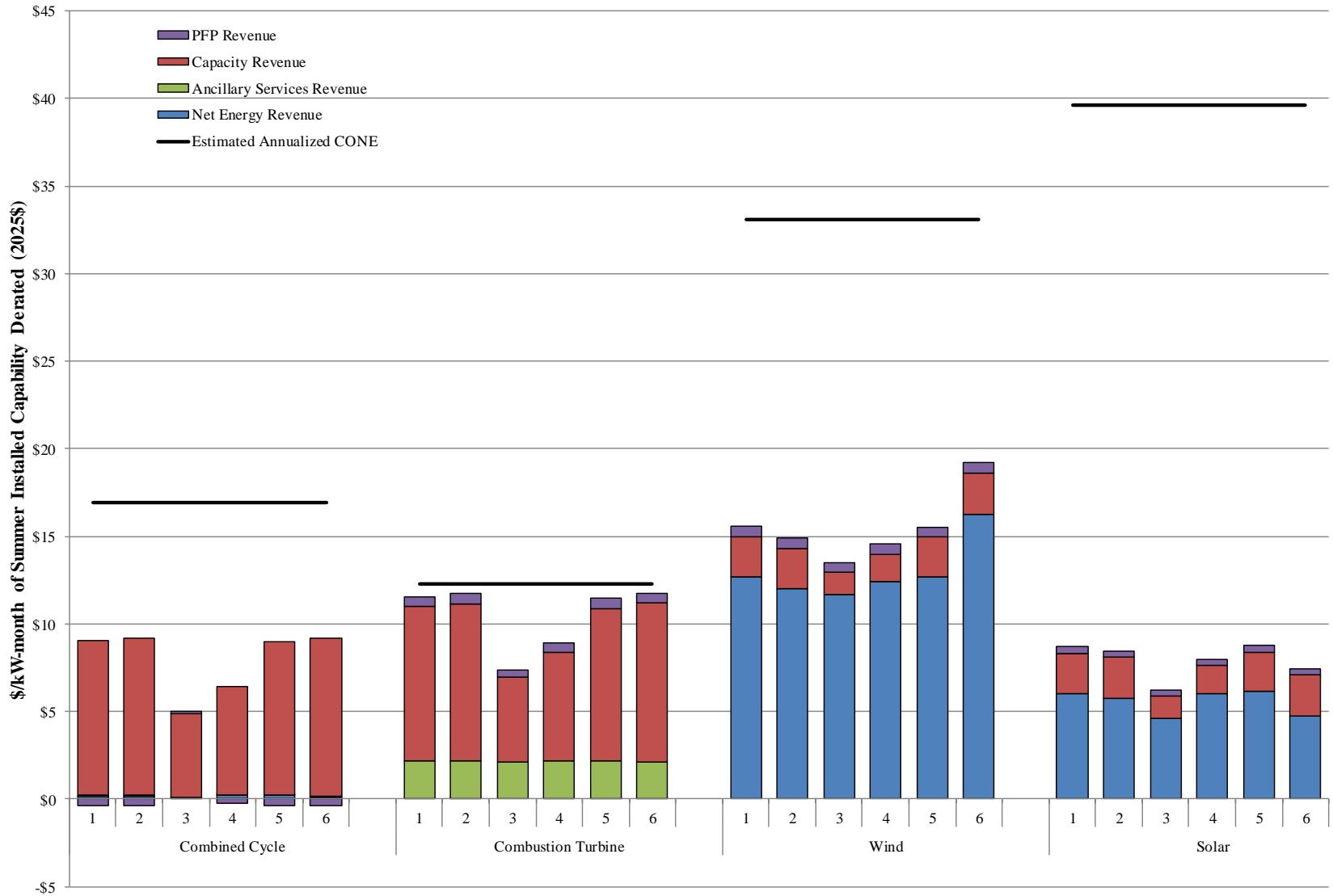
Average Revenue and Costs: Scenario 3, 2025 Unconstrained Select Unit Types



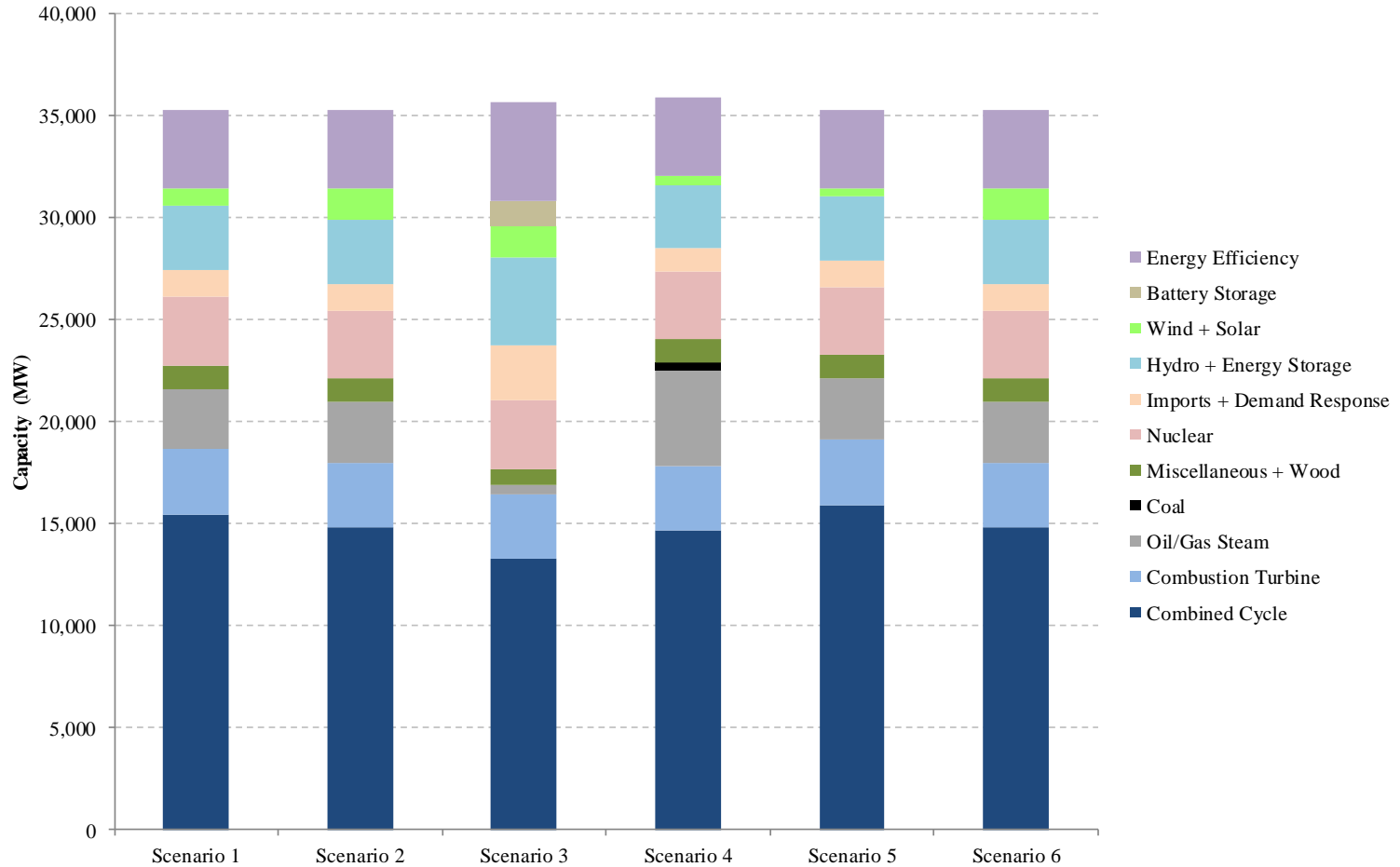
Generator Revenue Outcomes

- **The following slide** compares revenues from the ISO-NE markets against an estimate of the (gross) cost of new entry for various technologies. Values are derived from the most recent Net CONE/ ORTP Study.
- Under Scenarios 1, 2, 5 and 6, the ISO-NE EAS markets and the FCM provide sufficient revenues to support the entry of the new gas-fired combustion turbine resources that are assumed to enter in these Scenarios.
- Revenues from the ISO-NE markets are insufficient to financially support the development of all other new resources assumed to enter the market in each scenario.
 - In Scenarios 3 and 4, revenues are insufficient to support new gas-fired combustion turbines.
 - Revenues are not sufficient for new gas-fired combined-cycle resources in any Scenario.
 - “Clean” resources, including renewables, off-shore wind, imports, battery storage and behind-the-meter solar, would require financial support through state policies, including state RPS. Our analysis does not make assumptions about the policies that would be adopted to achieve the clean resources assumed to be developed in each scenario.
- Additional revenues needed to support the entry of clean resources varies across Scenarios.
 - Needed revenues increase with the expansion of clean resources, as these resources reduce prices in both the energy and capacity markets. Despite the de-rating of capacity, reductions in FCM revenues are greater than reductions in net EAS revenues (assuming that the resource receives these revenues streams at all, given the potential for offer mitigation under the MOPR).

Revenue Breakdown by Resources Type, 2025 Unconstrained



2025 Unconstrained Scenarios 1-6 Cleared Capacity by Technology and Fuel Type



2025 Unconstrained Scenarios 1-6 Uncleared Capacity by Technology and Fuel Type

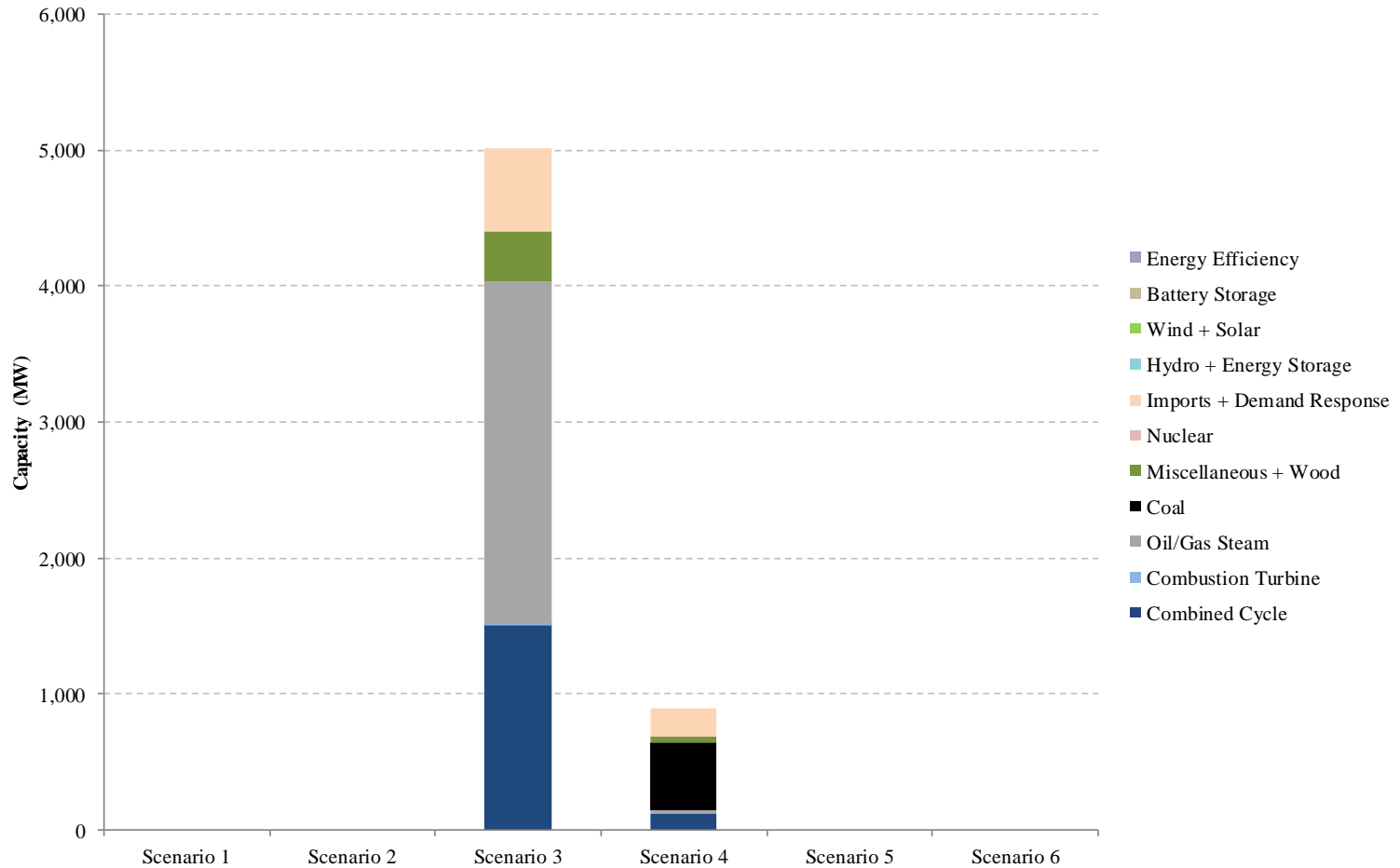


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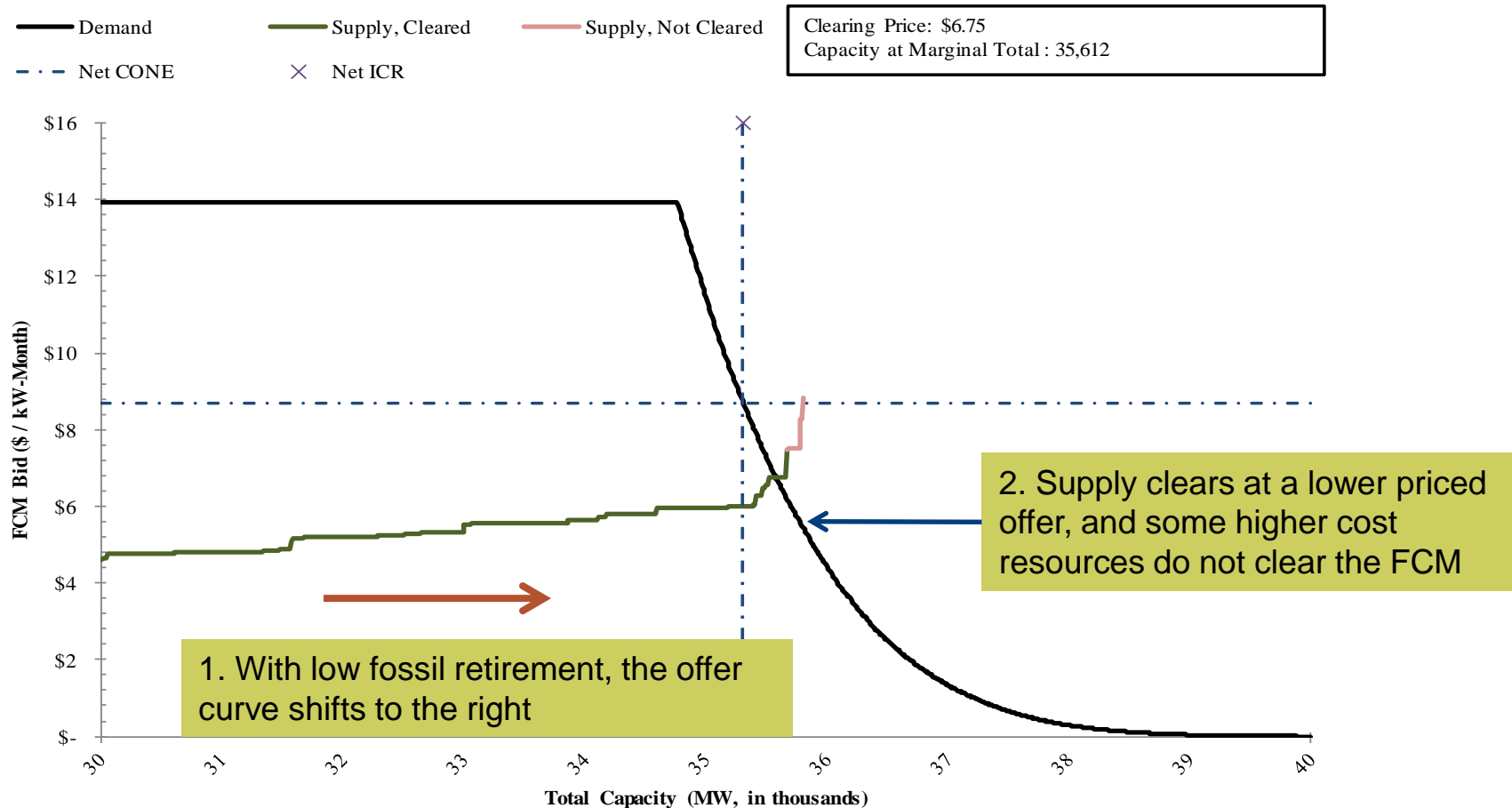
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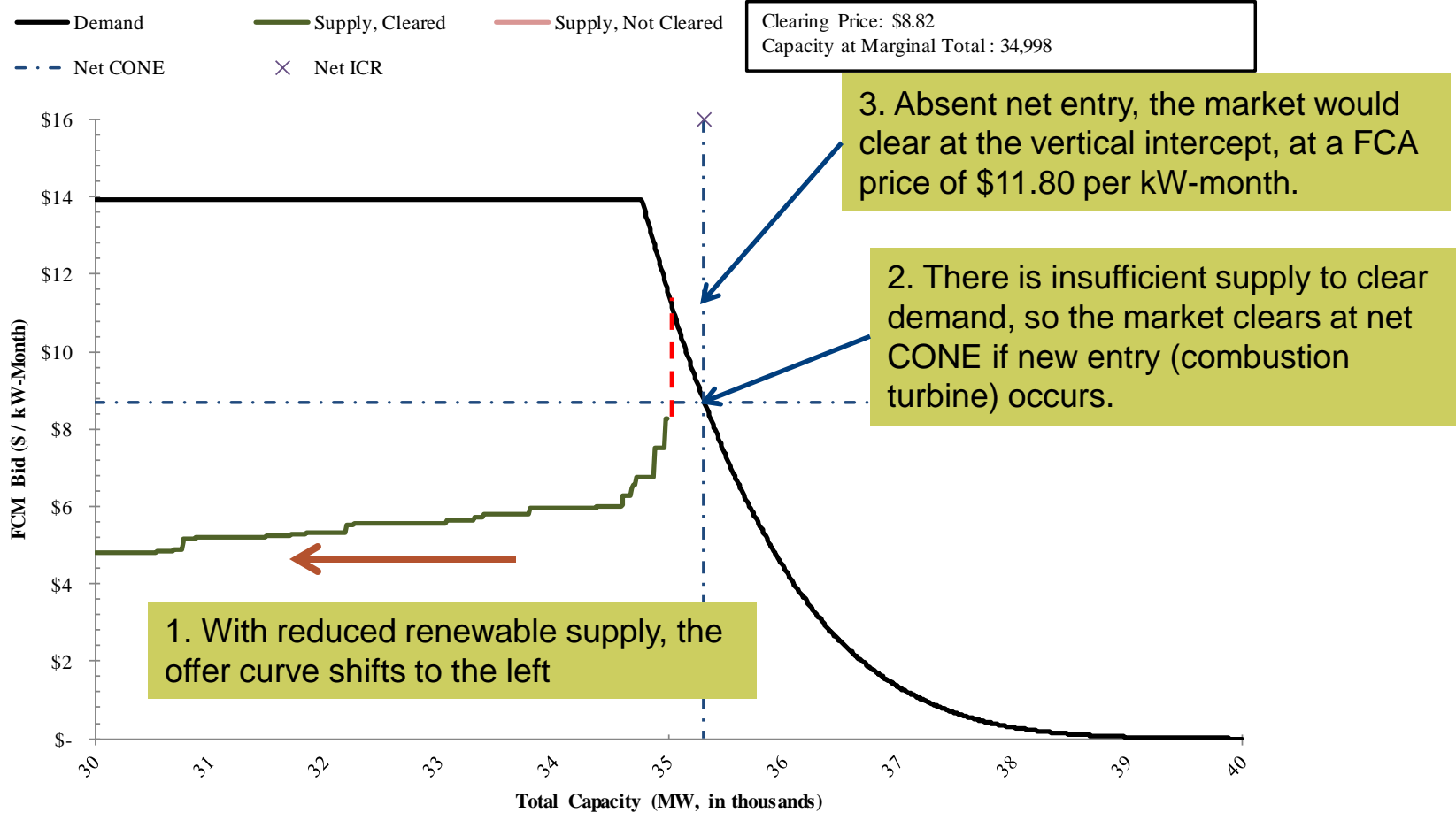
Overview of Sensitivity Analyses

- We analyze the sensitivity of the Scenario outcomes to several key drivers of market outcomes.
- In particular, we consider the following six Sensitivity analyses addressing both the *Market Participation* of assumed resources and the *Market Mitigation* of future resources.
 - Market Participation
 - **Sensitivity 1:** Higher than assumed additional resources (to meet resource adequacy)
 - **Sensitivity 2 and 3:** Lower than expected renewable participation rates
 - Market Mitigation
 - **Sensitivity 4 to 6:** Minimum Offer Price Rule (MOPR) review and mitigation of imports, renewables, and imports and renewables
- These sensitivities are considered for all Scenarios, when relevant.

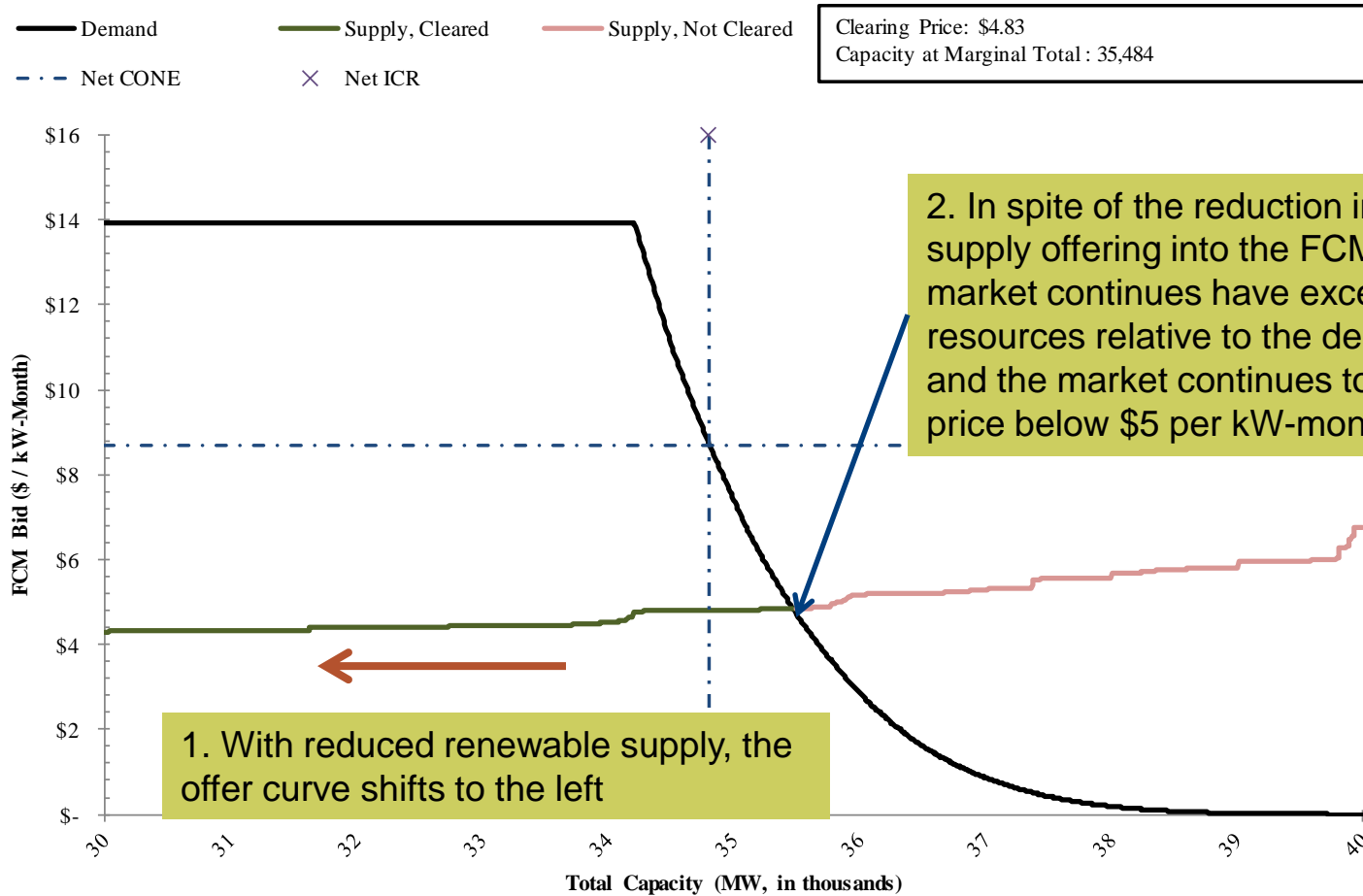
Illustrative Case for High Resource Additions ISO-NE FCM Auction Demand-Supply Curve Scenario 1 Unconstrained 2025 - Higher Additions



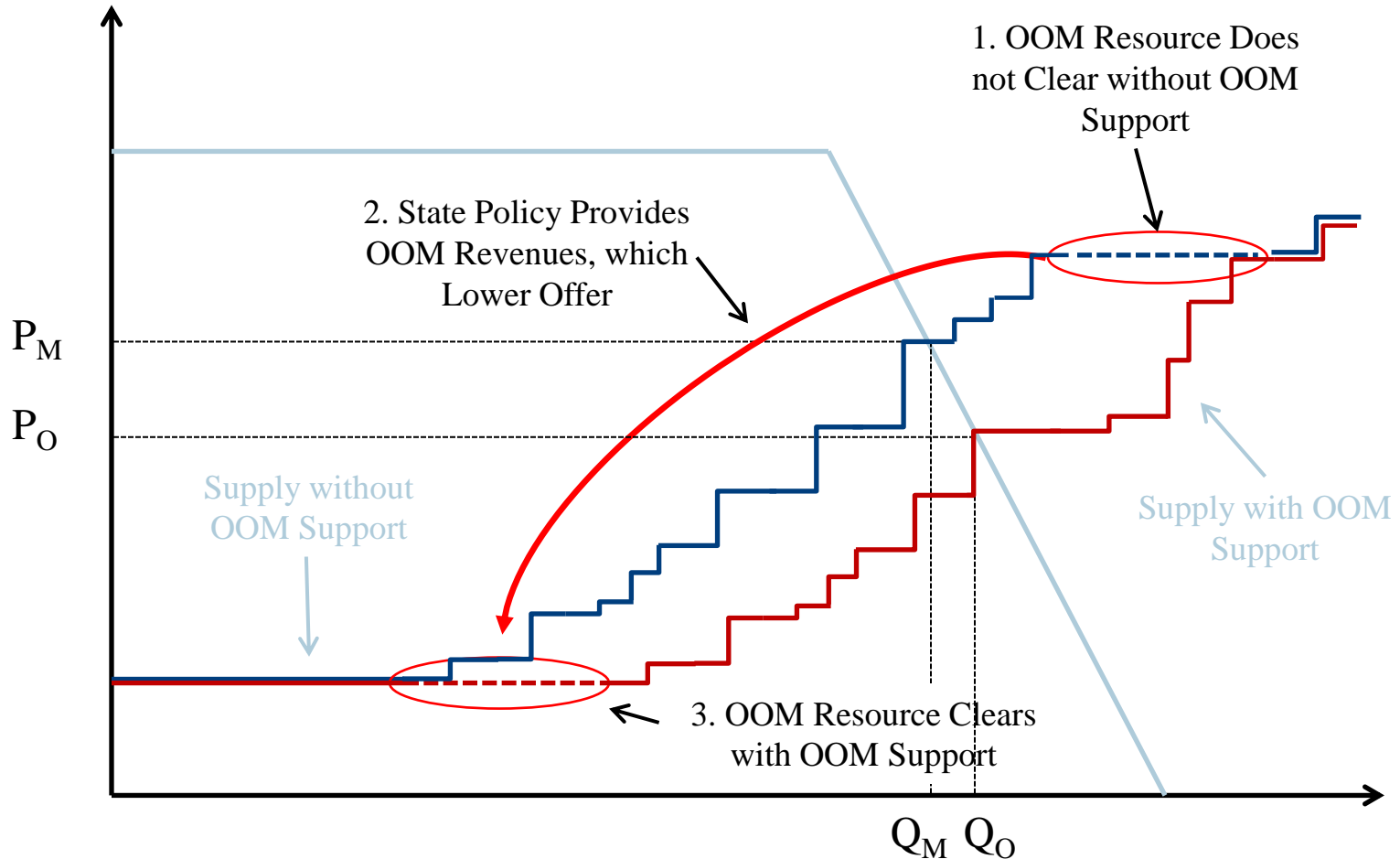
Illustrative Case for Low Renewable Participation ISO-NE FCM Auction Demand-Supply Curve Scenario 1 Unconstrained 2025 - Low Renewable Participation



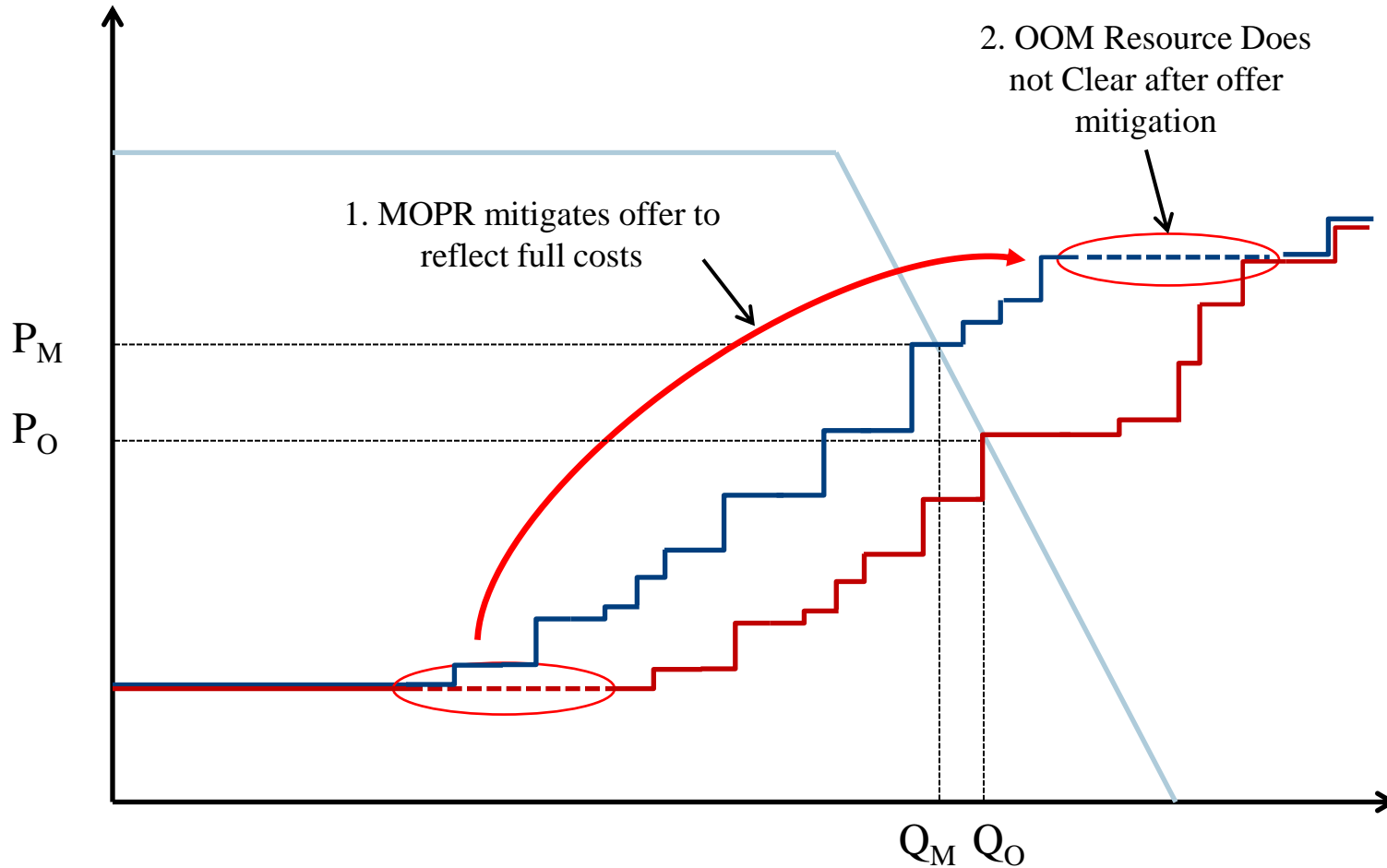
Illustrative Case for Low Renewable Participation ISO-NE FCM Auction Demand-Supply Curve Scenario 3 Unconstrained 2025 - Low Renewable Participation



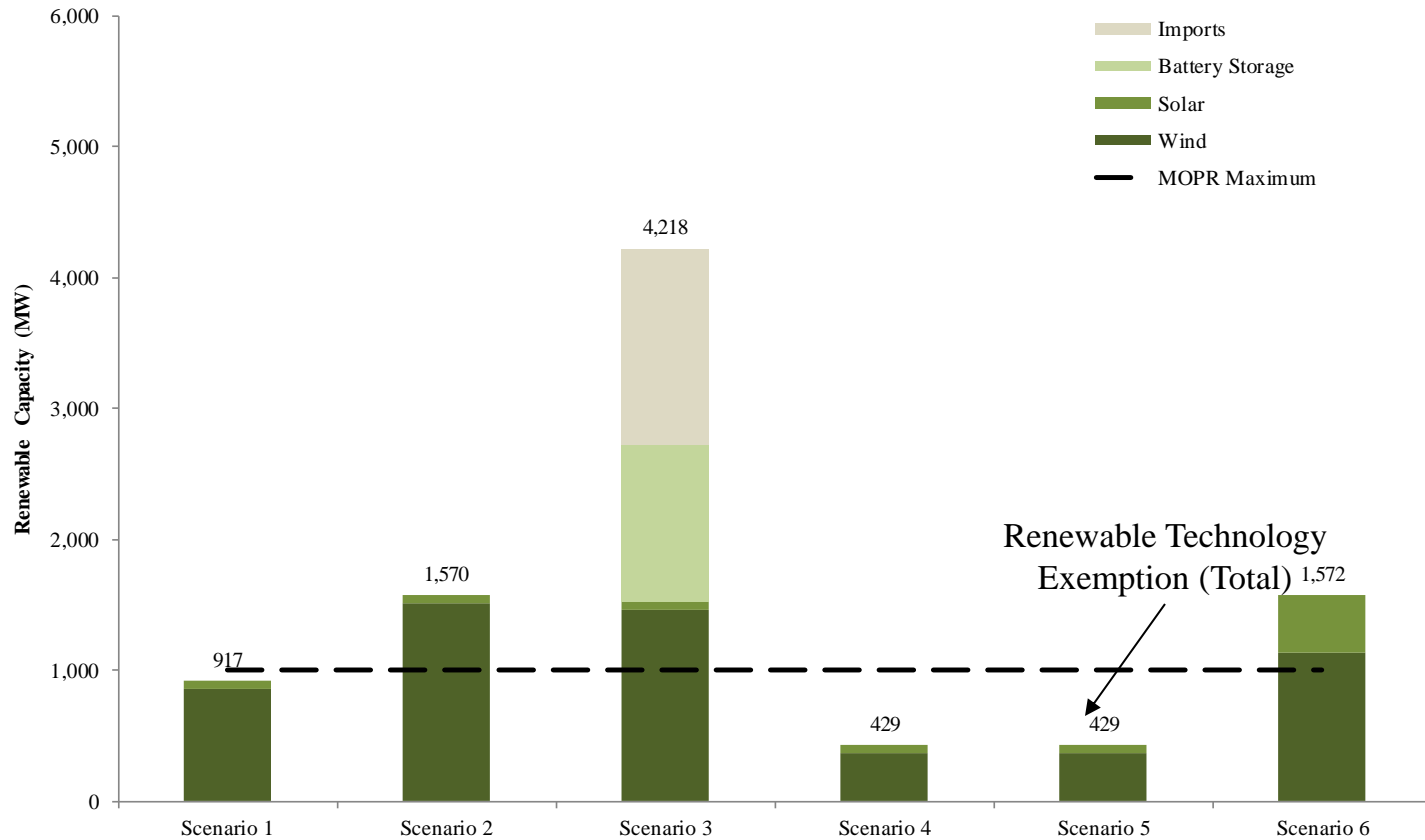
Impact of Out-of-Market Resource Offer on FCM Market Outcomes



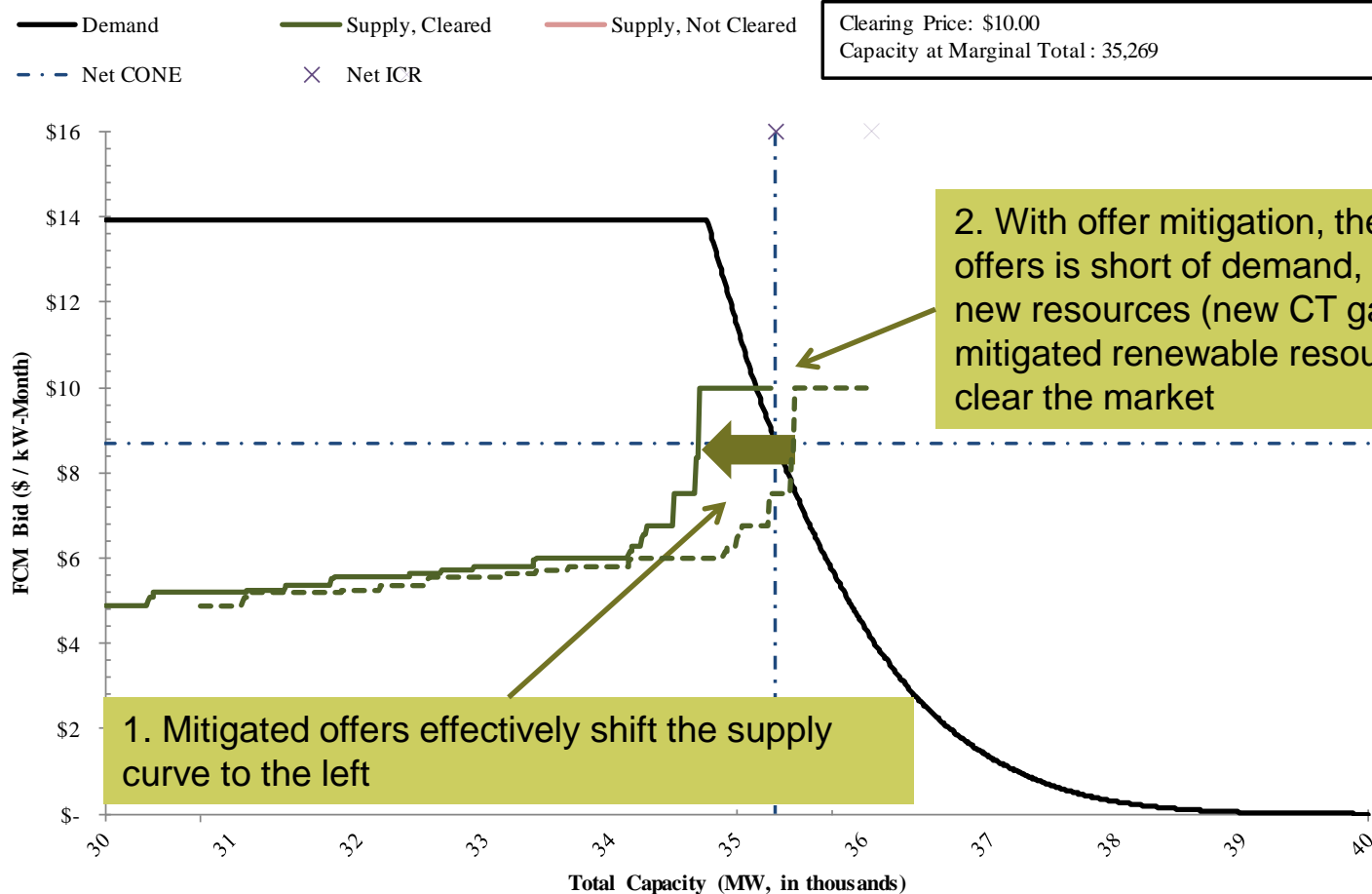
Implementation of MOPR on Out-of-Market Resource Offer



Renewable Capacity Potentially Subject to MOPR 2025 Scenarios 1-6



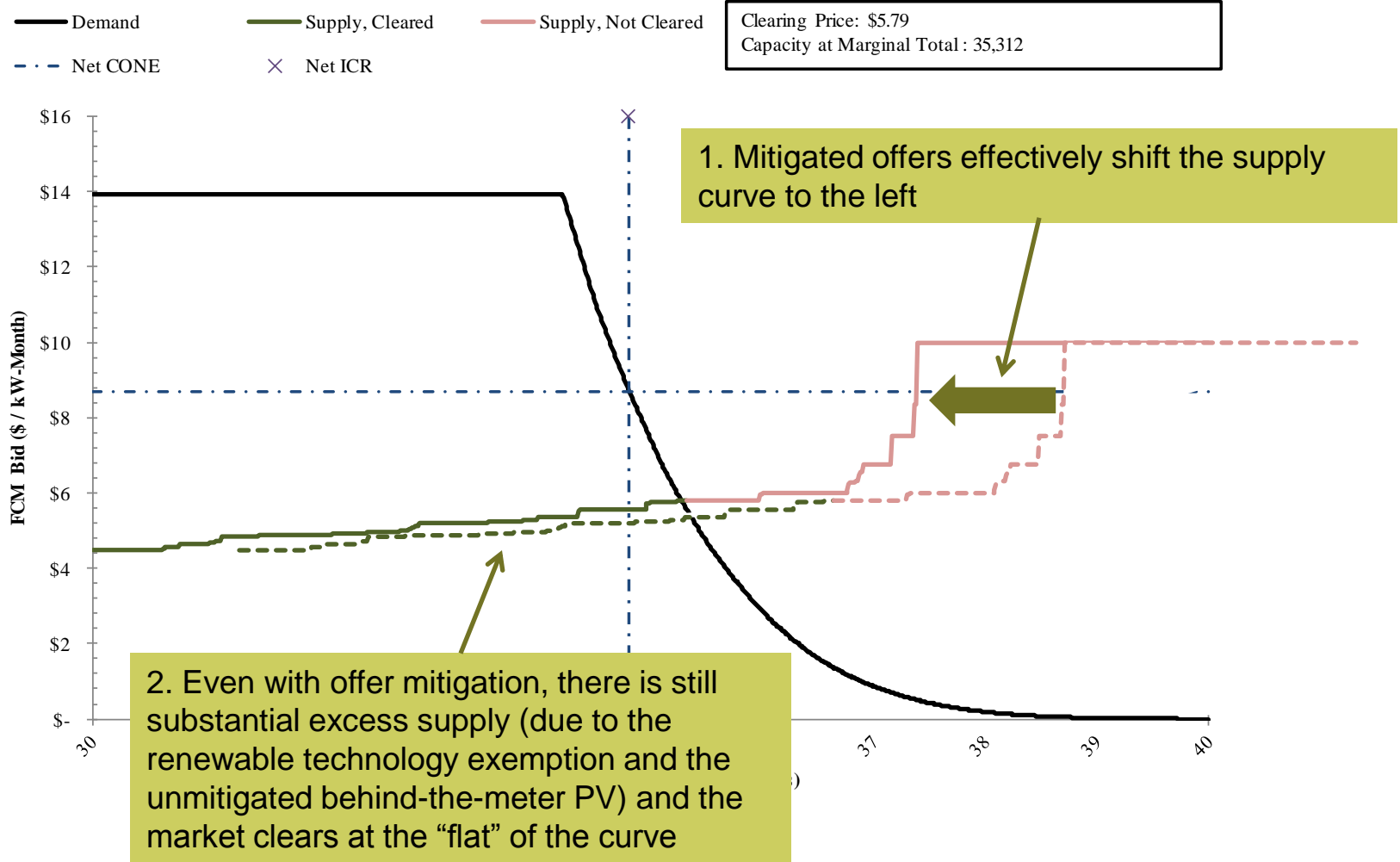
Illustrative Case for MOPR ISO-NE FCM Auction Demand-Supply Curve Scenario 2 Unconstrained 2025 - MOPR Renewables



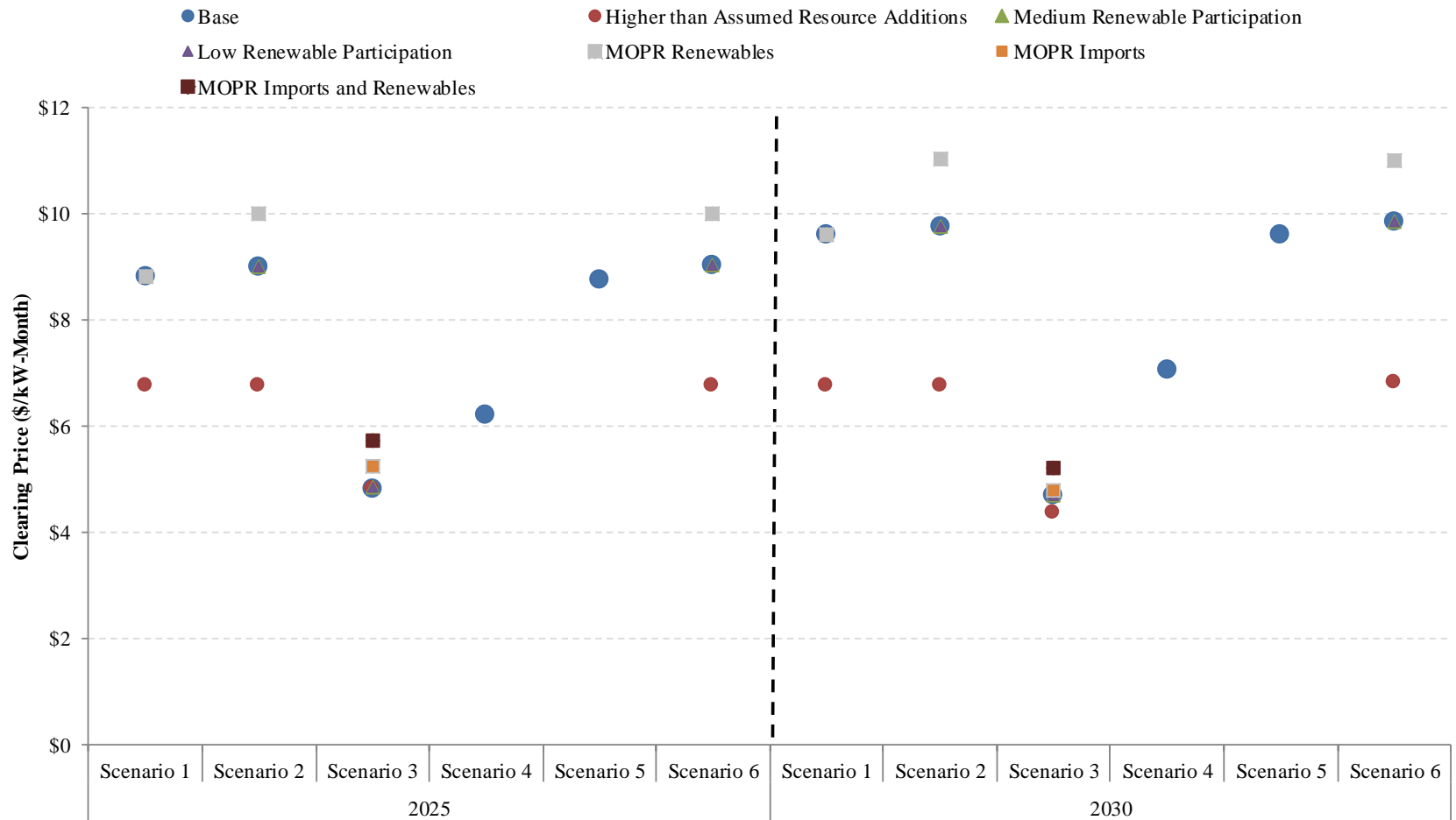
Illustrative Case for MOPR

ISO-NE FCM Auction Demand-Supply Curve

Scenario 3 Unconstrained 2025 - MOPR Imports and Renewables

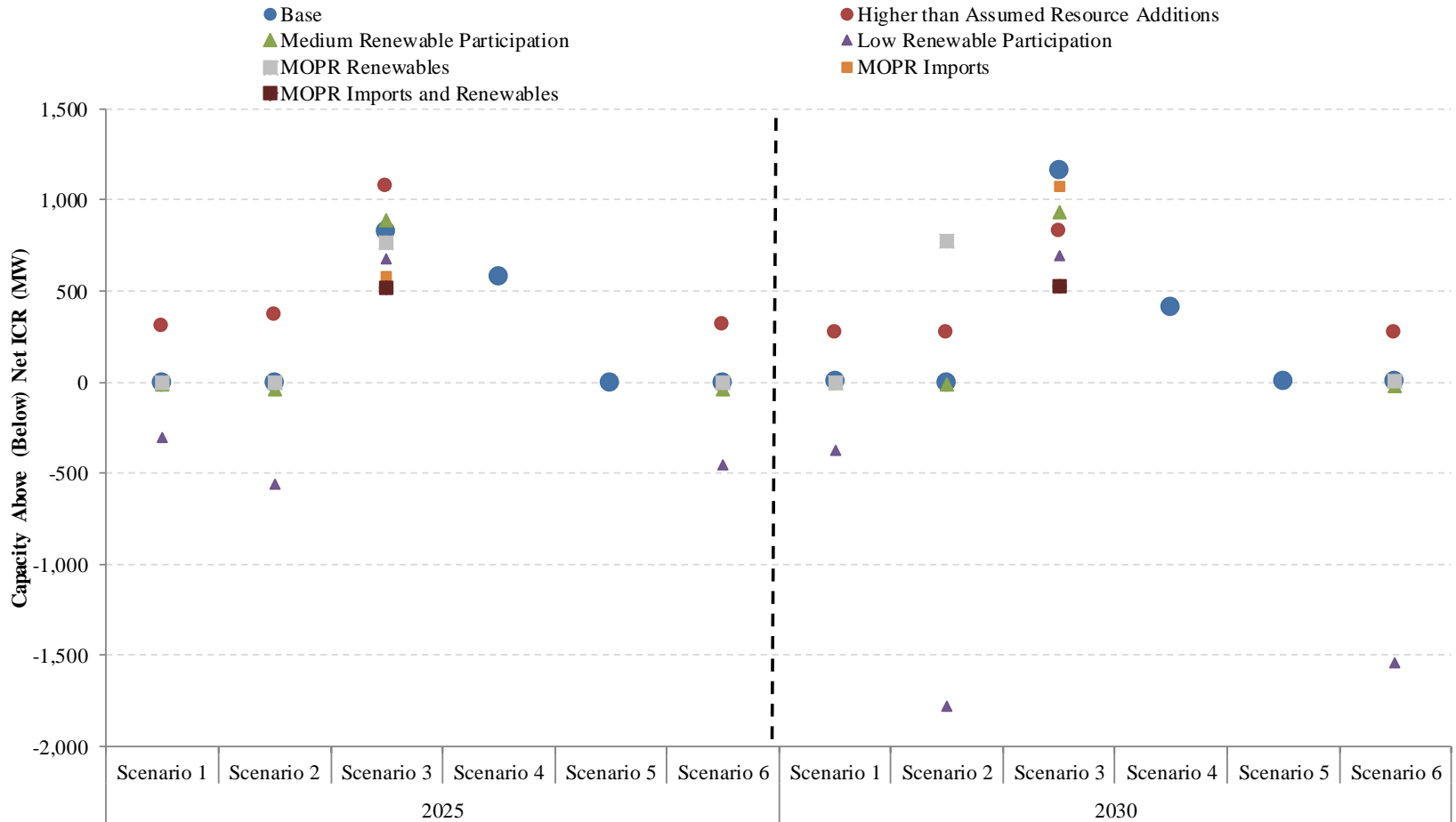


FCA Clearing Prices (\$/kW-month) Scenarios 1-6 with Sensitivities

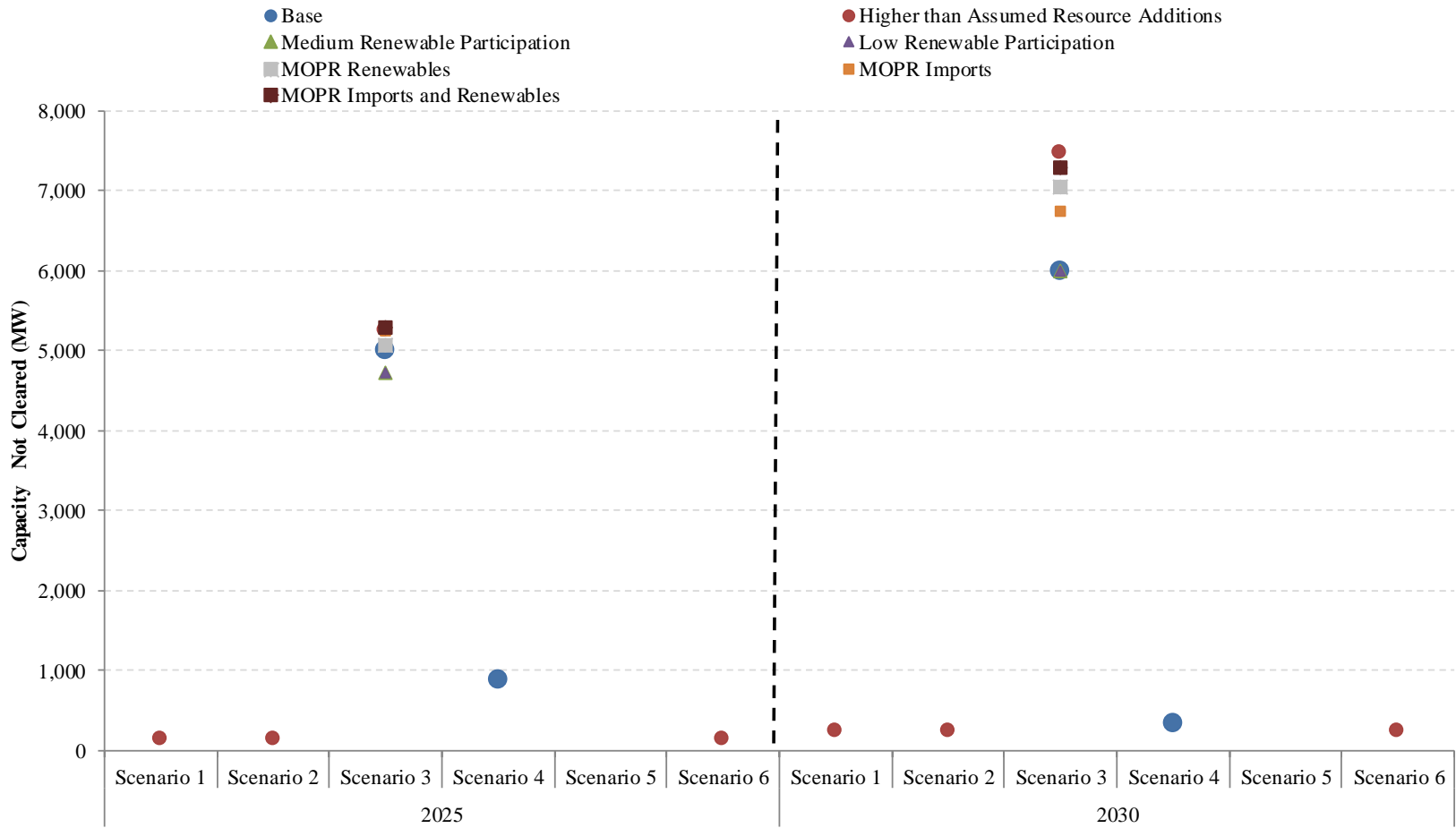


Note: Results are reported in nominal dollars (e.g., 2025 results are in \$2025).

Capacity Above (Below) Net ICR (MW) Scenarios 1-6 with Sensitivities



Capacity Not Cleared (MW) Scenarios 1-6 with Sensitivities



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