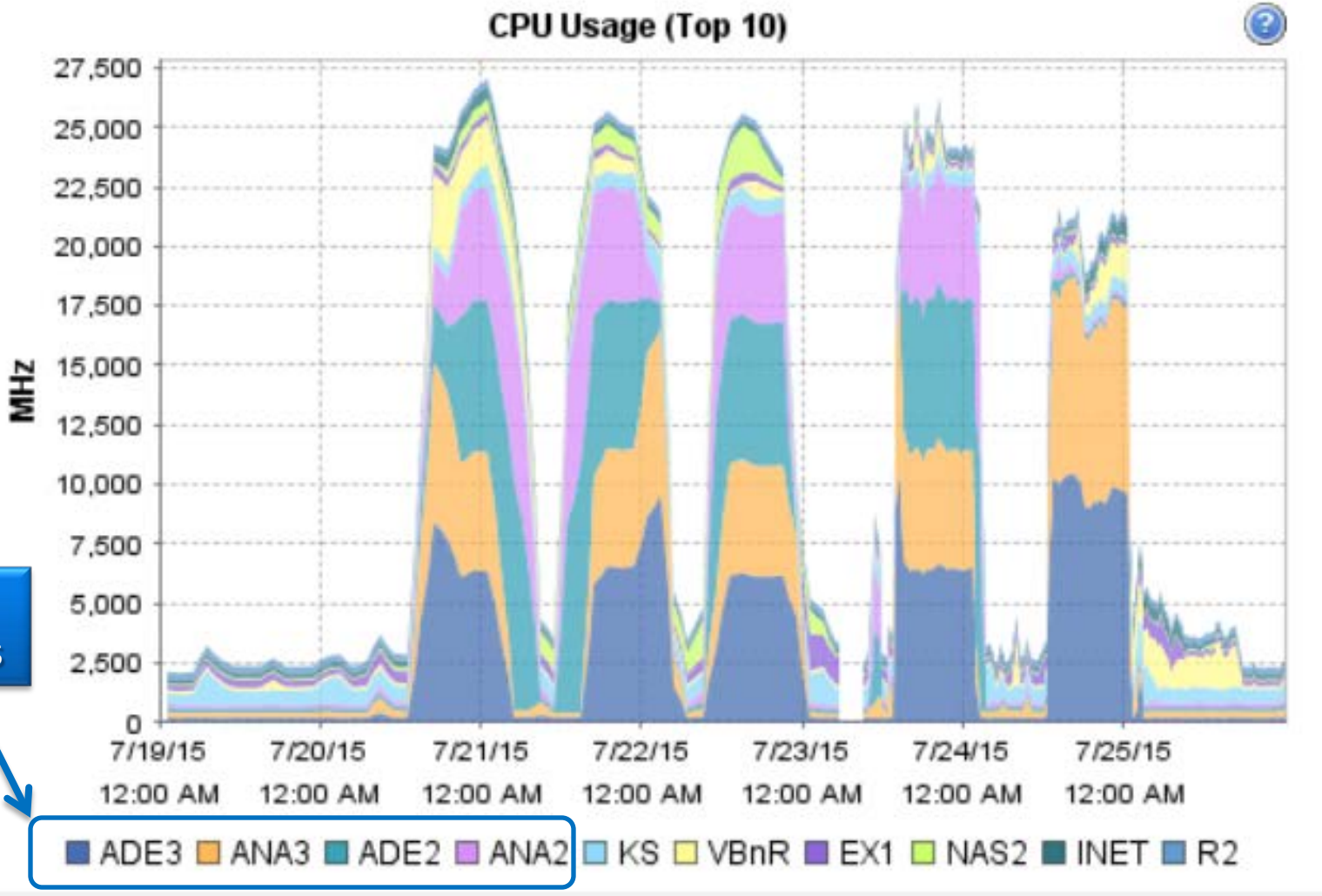
Selected Findings from Scenario and Sensitivity Analysis Conducted To Date

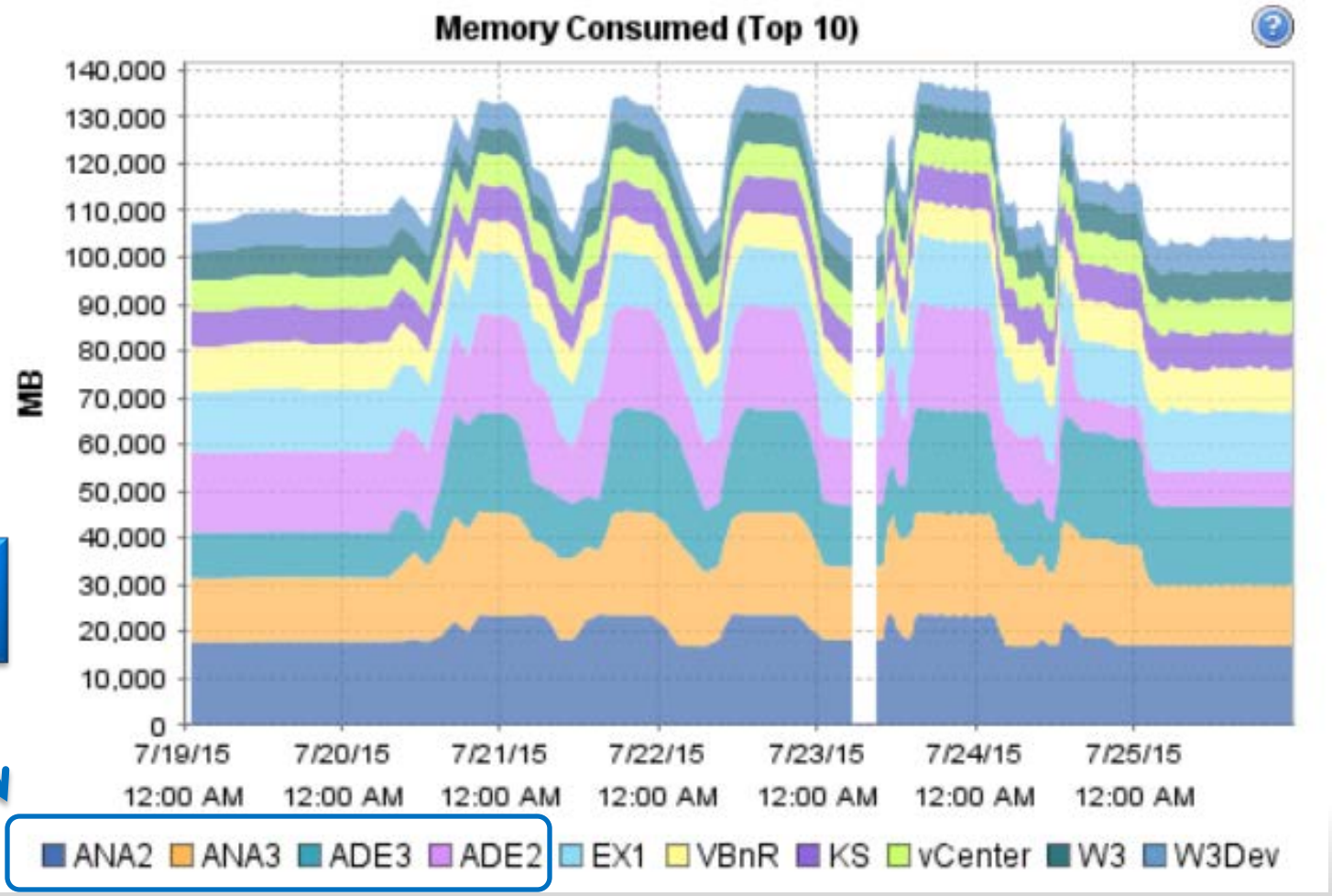
August 6, 2015

Progress Since The July Council Meeting: All Planned Scenario Analysis Completed!



RPM Systems

Progress Since The July Council Meeting: All Planned Scenario Analysis Completed!



RPM Systems

Scope of Today's Presentation
Scenario and Sensitivity Study Results

- Scenario Analysis Results
  - Scenario 4A – Unplanned Loss of Major Non-GHG Emitting Resource
  - Scenario 4B – Planned Loss of Major Non-GHG Emitting Resource
  - Scenario 5B – Increased Reliance on External Regional Market

- Sensitivity Study Results
  - Sensitivity S2.1 – Scenario 2C w/Lower Natural Gas Prices
  - Sensitivity S3.1 – Scenario 2C w/o Demand Response (DR)
  - Sensitivity S5 – Scenario 1B - 35% RPS
  - Sensitivity S9 – Scenario 1B – No "T&D" Deferral Credit

Summary of Findings: Remaining Scenarios

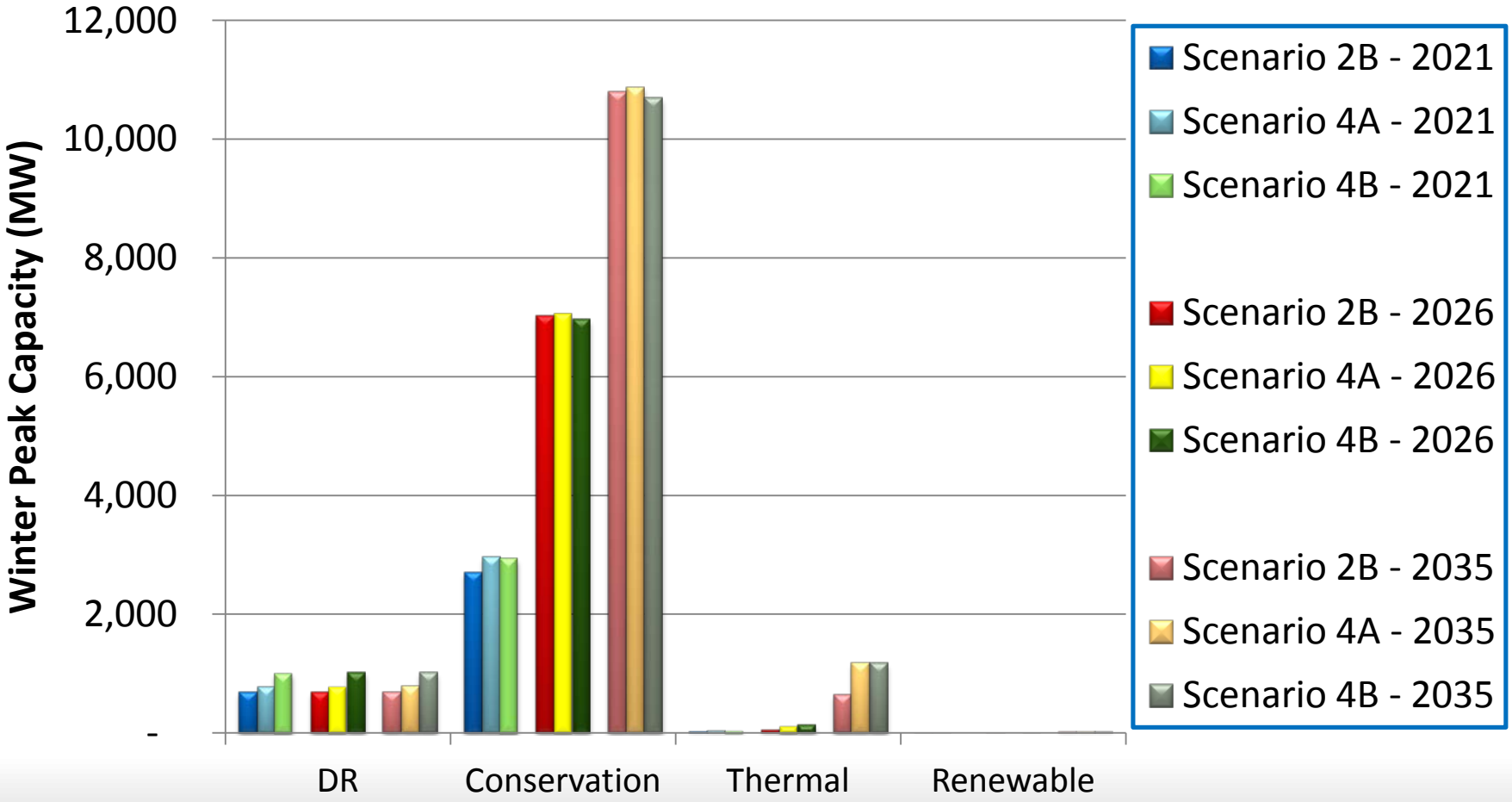
Scenario 4A – Unplanned Loss of Major Non-GHG Emitting Resources

- Assumptions
  - ~1200 NW Nameplate Resource
    - ~1000 aMW average annual generation
  - Probability of Loss Increases Through Time
  - 75% Probability Resource Lost by 2030, 100% by 2035
    - Assumes 111(d) compliance date remains unchanged from draft rule)
  - Scenario 2B – Social Cost of Carbon @ 3% Level Assumed as Baseline

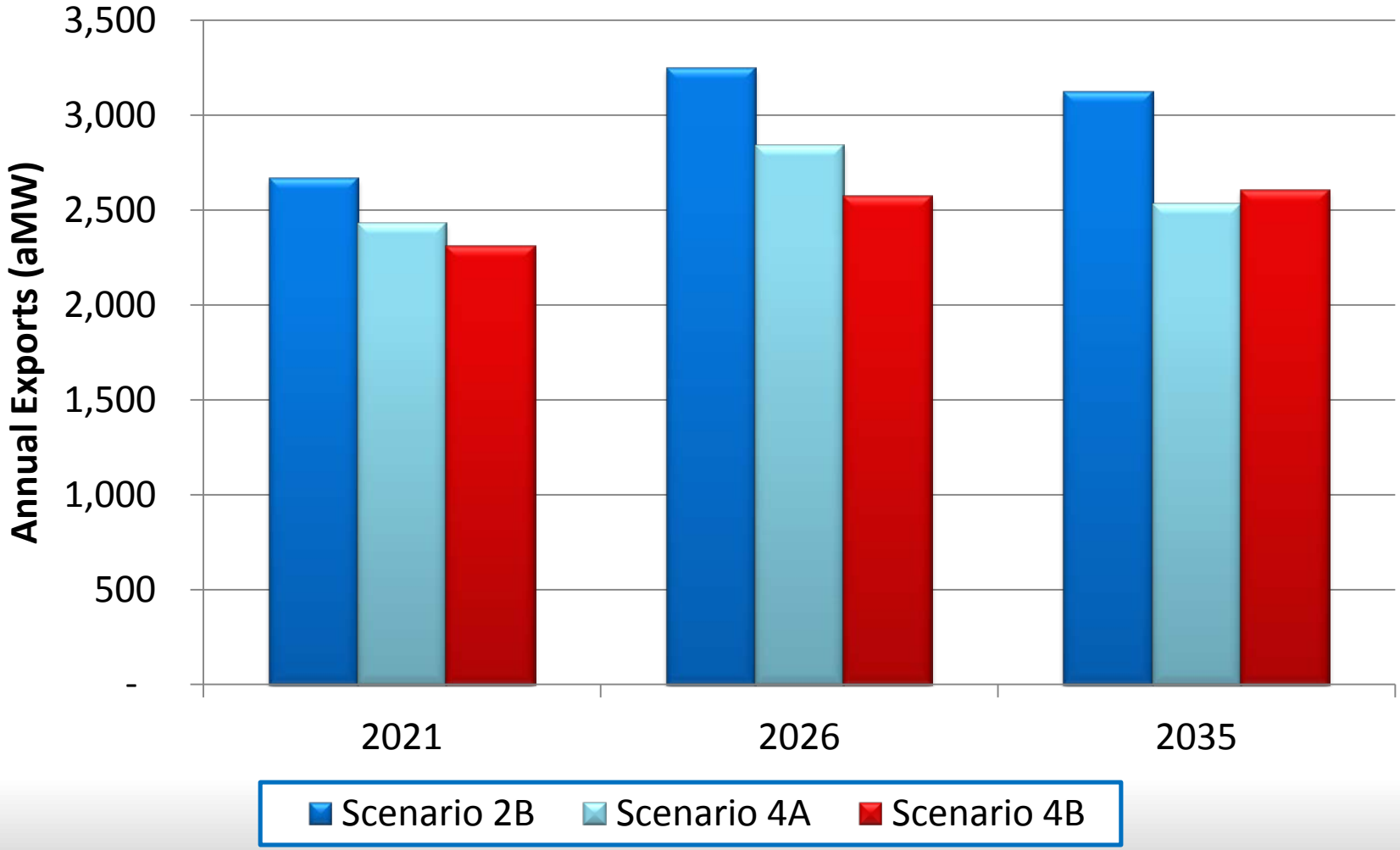
Scenario 4B – Planned Loss of Major Non-GHG Emitting Resources

- Assumptions
  - ~1000 MW Nameplate Resource
    - 855 aMW annual energy generation
  - Retired in ~855 aMW in roughly equal increments every 3-years
  - All retirements occur by 2030
    - Assumes 111(d) compliance date remains unchanged from draft rule
  - Scenario 2B – Social Cost of Carbon @ 3% Level Assumed as Baseline

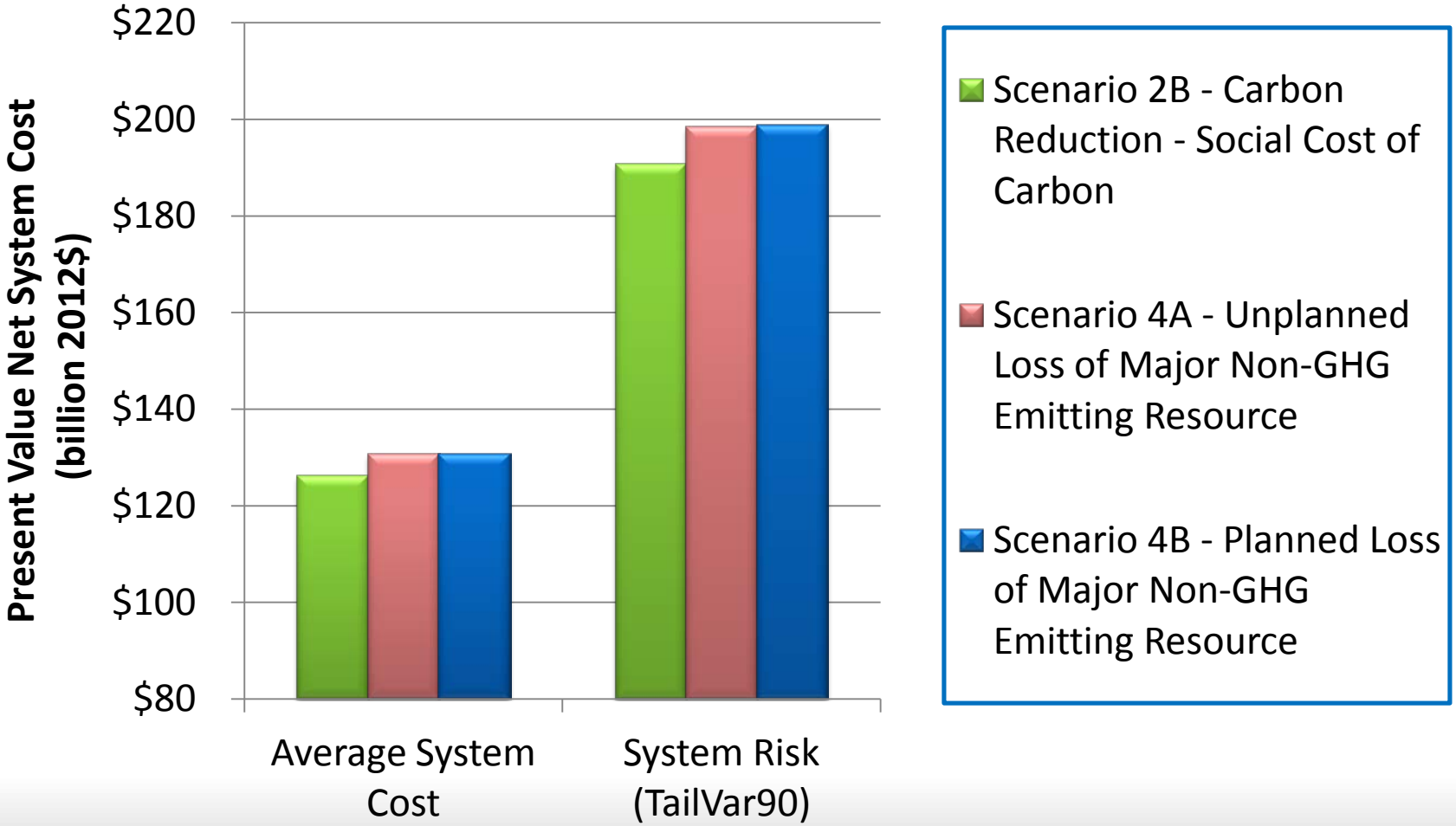
The Least Cost Resource Strategies in Scenarios 4A and 4B Compared to Scenario 2B Rely More on Demand Response and Gas Generation to Meet Winter Capacity Demands



The Least Cost Resource Strategies in Scenarios 4A and 4B Compared to Scenario 2B Rely on Reduced Regional Exports to Meet Energy Requirements



The Least Cost Resource Strategies in Scenarios 4A and 4B Compared to Scenario 2B Have Higher Net Present Value System Costs and Risks



Scenarios 4A and 4B Comparison to Scenario 2B – Social Cost of Carbon

Resource/Metric	4A – Unplanned Resource Loss	4B – Planned Resource Loss
Energy Efficiency – All Years	No Change	No Change
Demand Response – All Years	+ 90-95 MW	+ 320 MW
Renewable Resources - 2035	- 15 aMW	- 15 aMW
Coal Gen	Small (<5%) Increase	Small (<5%) Increase
Existing Gas Generation	Small (<5%) Increase	Small (<5%) Increase
New Gas Generation - 2035	+ 255 aMW	+ 245 aMW
Exports - 2021	- 240 aMW	- 360 aMW
Exports - 2026	- 410 aMW	- 675 aMW
Exports - 2035	- 590 aMW	- 520 aMW
PNW System CO2 Emissions - 2030	Same	Same
NPV	+$4 billion	+$4 billion
NPV System Risk	+$8 billion	+$8 billion

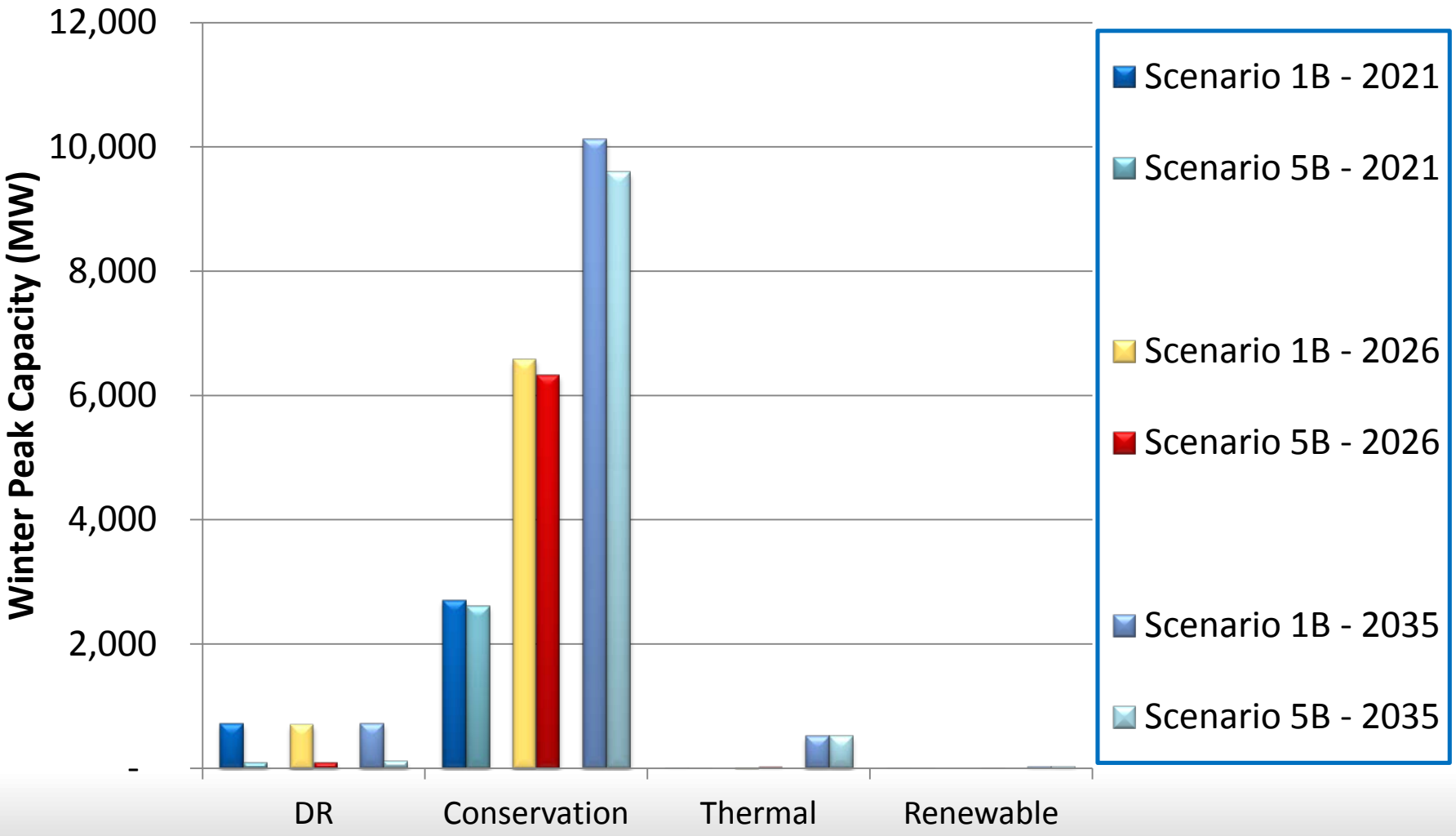
Observation from 4A and 4B Scenario Analysis Results

- Resource strategies to address both planned and unplanned resource loss rely on
  - Increased DR (especially in planned case)
  - Increased new gas-generation
  - Reduced regional exports
- Still achieve final 111(b) + 111(d) carbon emissions reductions by 2030
- Increase net system cost and risk

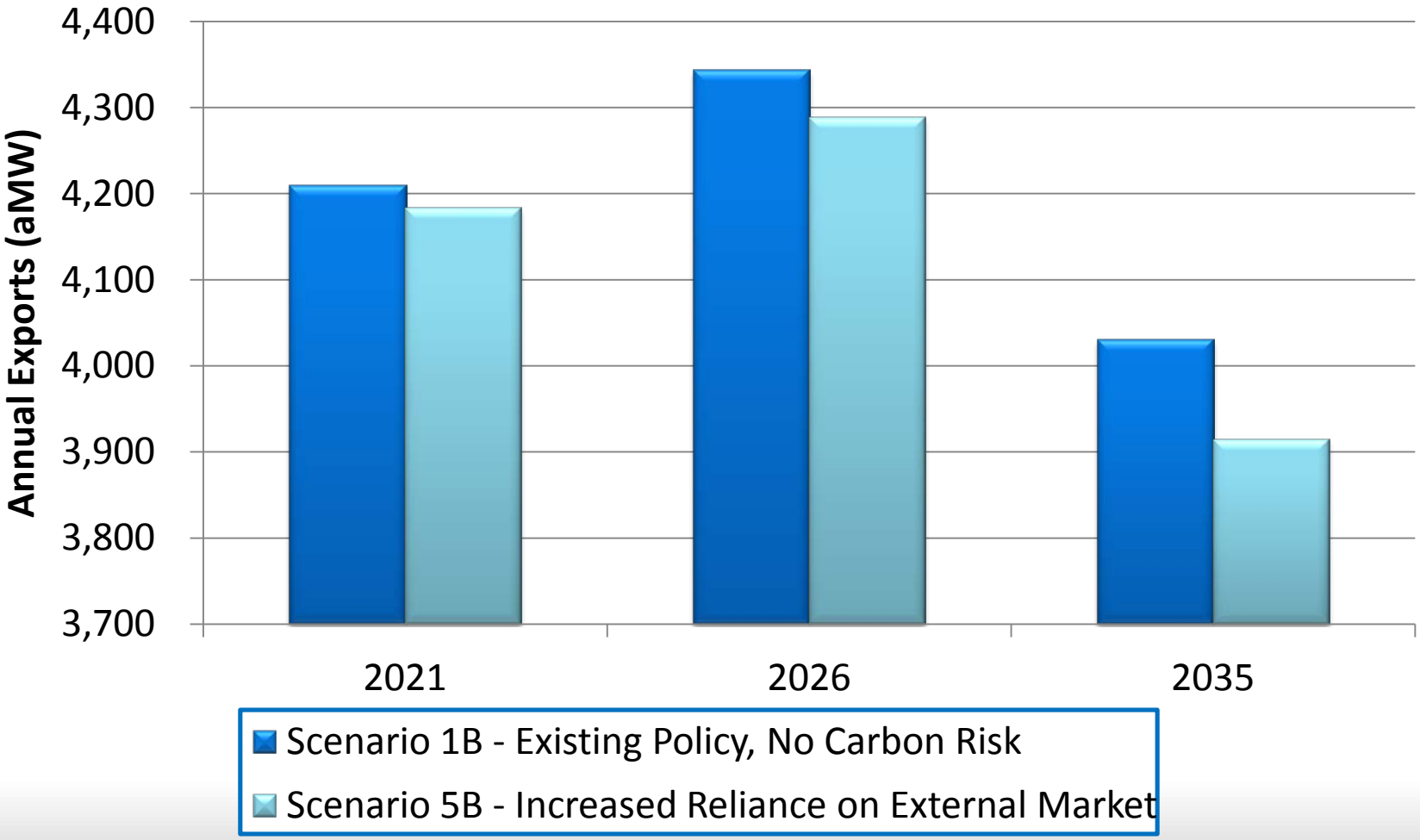
Scenario 5B – Increased Reliance on Extra-Regional Market

- Assumptions
  - Resource Adequacy Standard constraint changed from 2500 aMW to 3400 aMW for high load hours in winter quarter
  - GENESYS used to estimate revised Adequacy Reserve Margins (ARMs) for capacity and energy
  - Scenario 1B – Existing Policies, No Carbon Risk Assumed as Baseline

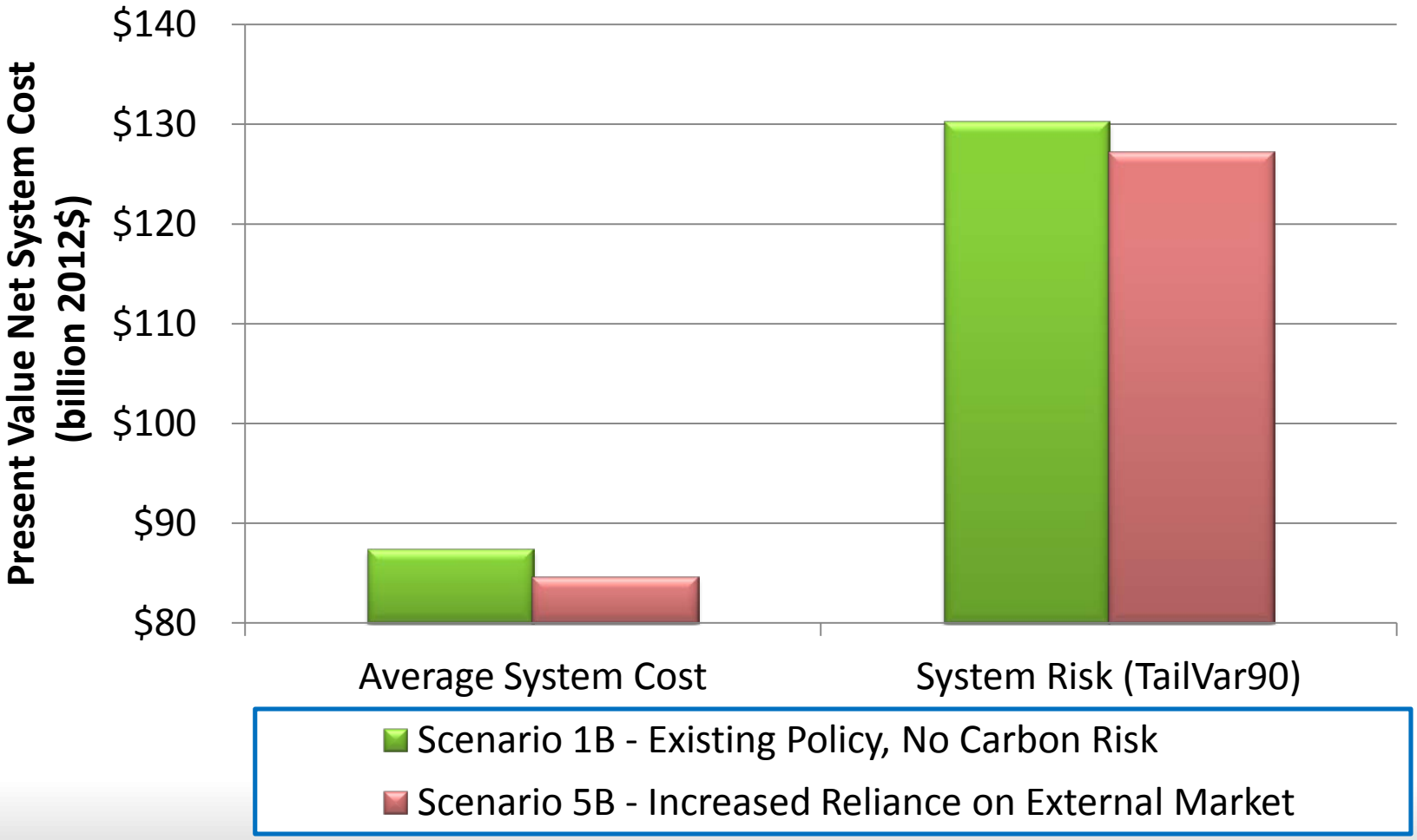
The Least Cost Resource Strategy in Scenario 5B Compared to Scenario 1B Relies Less on Demand Response and Conservation to Meet Winter Peaks



The Least Cost Resource Strategy in Scenario 5B Compared to Scenario 1B Slightly Reduces Regional Exports to Meet Annual Energy Requirements



The Least Cost Resource Strategy in Scenario 5B Compared to Scenario 1B Has a Lower Net Present Value System Costs and Risks



Scenario 5B Comparison to Scenario1B – Existing Policies, No Carbon Risk

Resource/Metric	5B - Increased External Market Reliance
Energy Efficiency - 2021	- 45 aMW
Energy Efficiency - 2026	- 110 aMW
Energy Efficiency - 2035	- 215 aMW
Demand Response – All years	- 620 MW
Renewable Resource - 2035	- 110 aMW
Coal Generation - All years	No Change
Existing Gas Generation - All years	No Change
New Gas Generation – All years	No Change
Exports - All years	Small Reduction
PNW System CO2 Emissions - 2030	No Change
NPV System Cost	$-2.7 billion
NPV System Risk	$-3.0 billion

Observations from 5B Scenario Analysis Results

- Resource strategies that place greater reliance on external markets rely on:
  - Slightly less Energy Efficiency for capacity and energy
  - Significantly less Demand Response for capacity
  - Slightly decreased regional exports for energy
- Decrease Net System Cost and Risk
- Still achieve final 111(b) + 111(d) carbon emissions reductions
- Potential for large reduction in NPV system cost suggests Council should recommend review of current Resource Adequacy Assessment limits on external market reliance for winter capacity

Summary of Findings: New Sensitivity Studies

- Sensitivity S2.1 – Scenario 2C w/Lower Natural Gas Prices
- Sensitivity S3.1 – Scenario 2C w/o Demand Response (DR)
- Sensitivity S5 – Scenario 1B - 35% RPS
- Sensitivity S9 – Scenario 1B – No "T&D" Deferral Credit

Staff generated after review of results from Scenario 2B_Social Cost of Carbon using 95% percentile estimate of SCC

Requested by SAAC

Sensitivity Studies S2.1 and S3.1 Comparison to Scenario 2C – Carbon Risk

Resource/Metric	S2.1 – Low Natural Gas Prices	S3.1 – No Demand Response
Energy Efficiency – 2021	- 100 aMW	No Change
Energy Efficiency – 2026	- 180 aMW	- 15 aMW
Energy Efficiency – 2035	- 335 aMW	- 70 aMW
Demand Response – All Years	No Change	- 700 MW
Renewable Resources - 2035	+ 55 aMW	+15 aMW
Coal Generation - 2021	- 555 aMW	No Change
Coal Generation - 2026	- 665 aMW	No Change
Coal Generation - 2035	-1,170 aMW	No Change
Existing Gas Generation	+ 335 – 540 aMW	Small (<1%) Decrease
New Gas Generation - 2035	+ 180 aMW	+ 100 aMW
Exports	+ 300 - 800 aMW	Small (<1%) Decrease
PNW System CO2 Emissions - 2030	Increase by 15%-35%	Same
NPV	- $17 billion	(Not equivalent reliability)
NPV System Risk	- $32 billion	(Not equivalent reliability)

Observation from Sensitivity Studies 2.1 and 3.1

- Resource strategies in scenarios with *systematically lower natural gas and electricity prices* in futures where the Social Cost of Carbon is considered increase regional reliance on existing natural gas generation and reduce conservation development and coal generation
  - Least cost strategies with lower gas and electricity prices have a lower cost and risk
- Resource strategies that *exclude demand response* in futures where the Social Cost of Carbon is considered rely on increased use of natural gas
  - Least cost strategies without DR have a higher net system cost and risk
- Under both sensitivity studies the final 111(b) + 111(d) carbon emissions targets are achieved by 2030

Sensitivity S9 – No T&D Credit Comparison to Scenario1B – Existing Policies, No Carbon Risk

Resource/Metric	S9- No T & D Deferral Credit
Energy Efficiency - 2021	- 60 aMW
Energy Efficiency - 2026	- 140 aMW
Energy Efficiency - 2035	- 175 aMW
Demand Response – All years	+85 to 95 MW
Renewable Resource - 2035	+ 35 aMW
Coal Generation - All years	No Change
Existing Gas Generation - All years	No Change
New Gas Generation – 2035	+50 aMW
Exports - All years	Small (<1%) Reduction
PNW System CO2 Emissions - 2030	No Change
NPV System Cost	$+7.7 billion
NPV System Risk	$+9.5 billion

Observation from Sensitivity Study S9 – Scenario 1B without Transmission and Distribution Deferral Credit

- Removal of "T&D Credit" increases cost of energy efficiency, demand response and "west side" natural gas-fire generation
- Since this effects both demand side and supply side resources it slightly reduces conservation and demand response development and modestly increases new gas-fired generation post-2026

Sensitivity S6 - 35% RPS Comparison to Scenario1B – Existing Policies, No Carbon Risk

Resource/Metric	S6 – 35% RPS
Energy Efficiency - 2021	- 70 aMW
Energy Efficiency - 2026	- 160 aMW
Energy Efficiency - 2035	- 275 aMW
Demand Response – All years	Small (<1%) Increase
Renewable Resource - 2021	+860 aMW
Renewable Resource - 2026	+2800 aMW
Renewable Resource - 2035	+2560 aMW
Coal Generation - All years	Gradually decreases by 160 – 620 aMW
Existing Gas Generation - All years	Gradually decreases by 185 – 685 aMW
New Gas Generation – 2035	-120 aMW
Exports - All years	Gradually Increases from 450 aMW to 1200 aMW
PNW System CO2 Emissions - 2030	- 7 MMTE
NPV System Cost	$+34 billion
NPV System Risk	$+20 billion

Observations from Sensitivity Study S5 – 35% RPS

- Compared to No Carbon Risk scenario, a policy requiring the increased use of renewable resources
  - Slightly reduces conservation development
  - Modestly reduces coal and gas-fired generation
  - Increases regional exports
  - Produces 20% lower carbon emissions
  - Increases NPV system cost and system risk

Sensitivity S6 - 35% RPS Comparison to Scenario 2C – Carbon Risk

Resource/Metric	S6 – 35% RPS
Energy Efficiency - 2021	- 150 aMW
Energy Efficiency - 2026	- 310 aMW
Energy Efficiency - 2035	- 515 aMW
Demand Response – All years	Small (25 MW) Increase
Renewable Resource - 2021	+860 aMW
Renewable Resource - 2026	+2825 aMW
Renewable Resource - 2035	+2615 aMW
Coal Generation - All years	Decreases by 1,035 – 1,450 aMW
Existing Gas Generation - All years	Decreases by 880 – 1,500 aMW
New Gas Generation – 2035	-200 aMW
Exports - All years	Increase by 480 aMW to 200 aMW
PNW System CO2 Emissions - 2030	+ 4 MMTE
NPV System Cost	$+10 billion
NPV System Risk	$-30 billion

Observations from Sensitivity Study S5 – 35% RPS

- Compared to Carbon Risk (adding carbon cost) a policy requiring the increased use of renewable resources
  - Modestly reduces conservation development
  - Modestly reduces coal and gas-fired generation
  - Increases regional exports
  - Produces higher carbon emissions
  - Increases NPV system cost, but reduces NPV system risk, by reducing exposure to futures with high gas prices

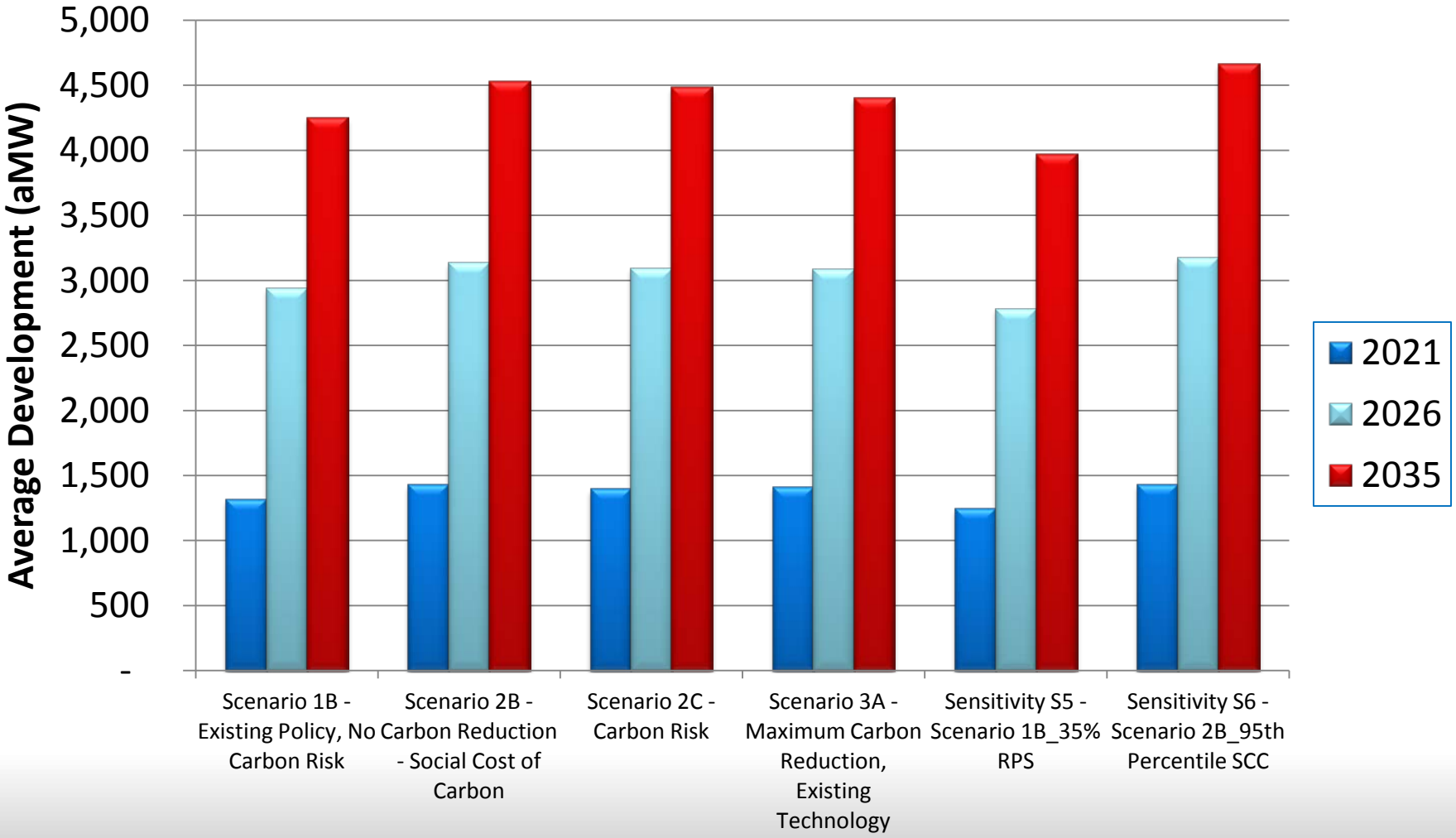
Carbon Reduction Policy Comparisons

August 6, 2015

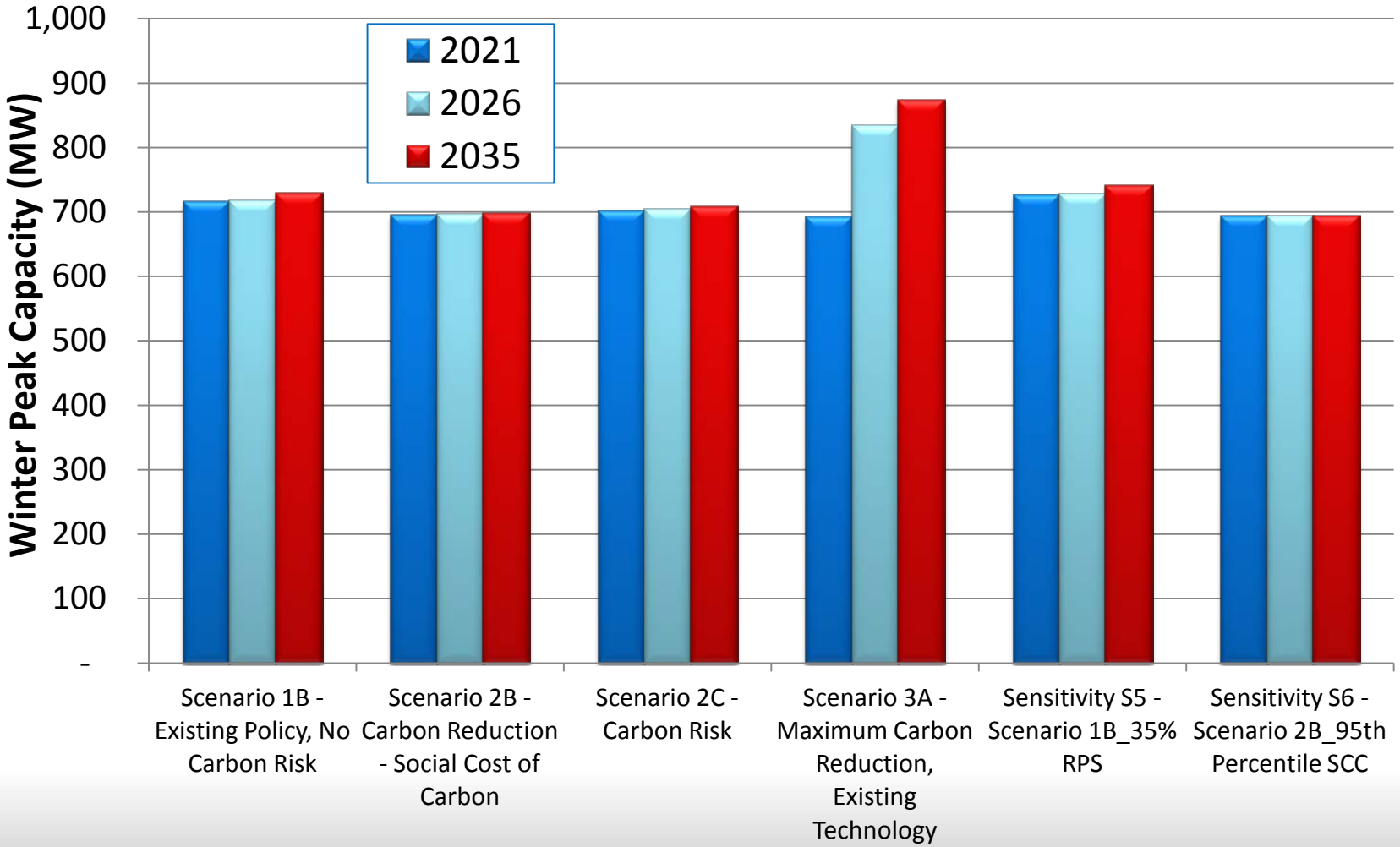
Carbon Reduction Policy Comparisons

- Review of Five Scenarios/Sensitivity Studies
  - Scenario 2B – Social Cost of Carbon (@ 3% Estimate of SCC)
  - Scenario 2C – Carbon Risk
  - Scenario 3A – Maximum Carbon Reduction with Existing Technology
  - Sensitivity S5 – Social Cost of Carbon @ 95% Percentile Estimate of SCC
  - Sensitivity S6 – Renewable Portfolio Standard @ 35%
- Basis of Comparison: Scenario 1B – Existing Policies, No Carbon Risk

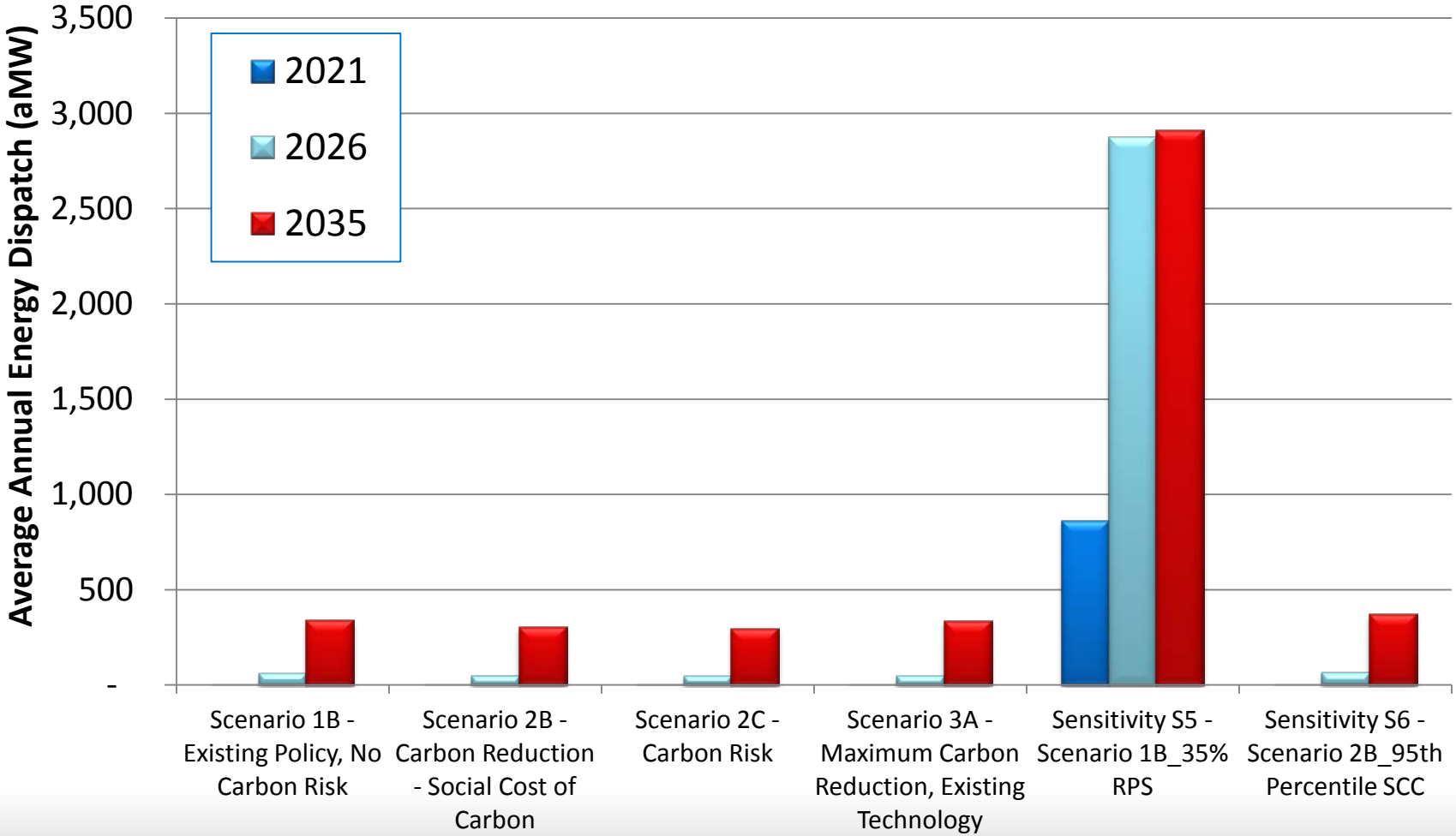
Average Conservation Development Under Alternative Carbon Emissions Reduction Policies Is Very Similar, Except for RPS @ 35% Policy Which Develops Less Energy Efficiency Than Base Scenario



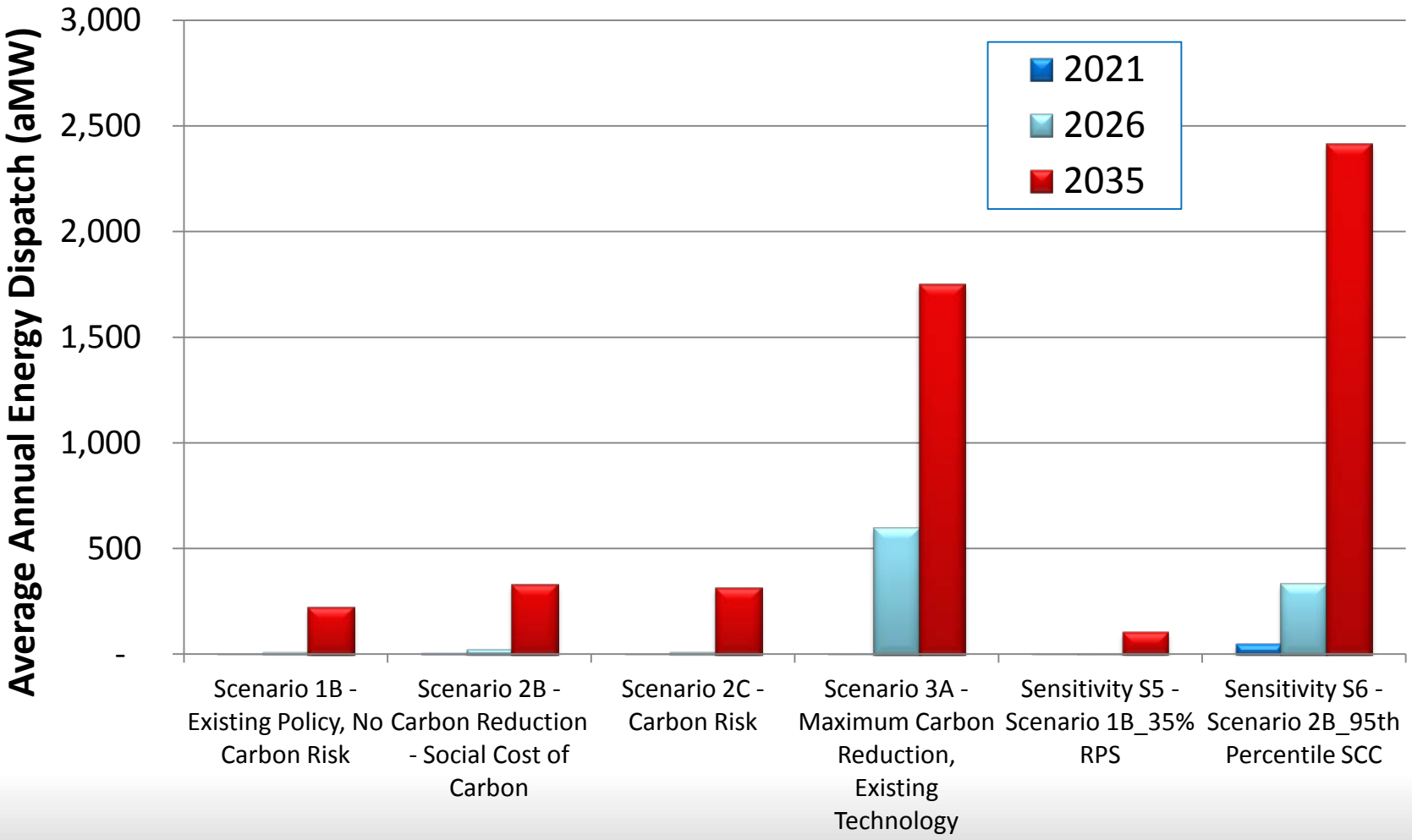
Average Demand Response Development Under Alternative Carbon Emissions Reduction Policies is Similar To Base Scenario, Except for Post-2026 in the Maximum Carbon Reduction Scenario Policy (3A)



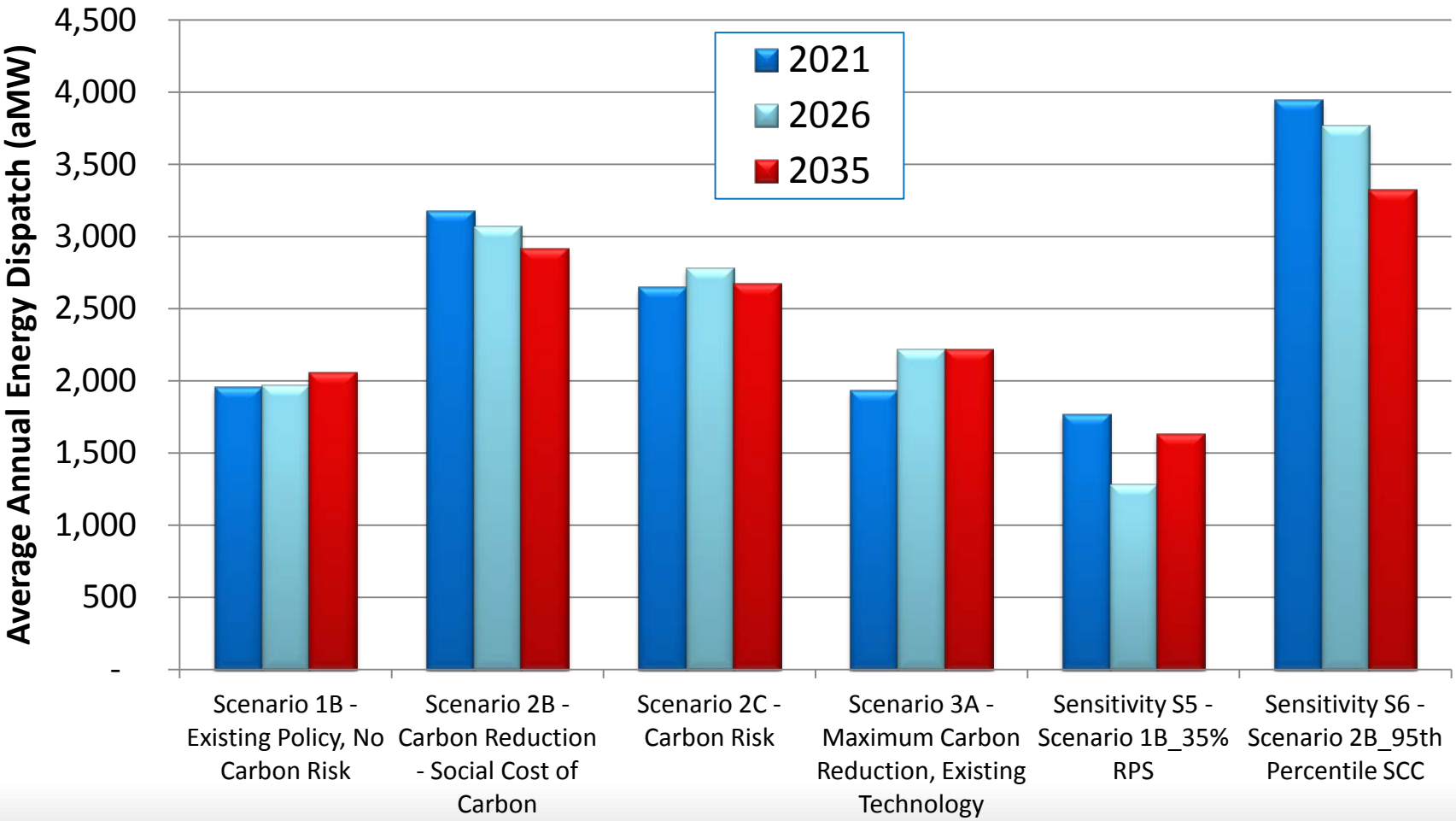
Average Renewable Resource Development Under Alternative Carbon Emissions Reduction Policies Is Very Similar to the Base Scenario, Except for the RPS @ 35% Policy



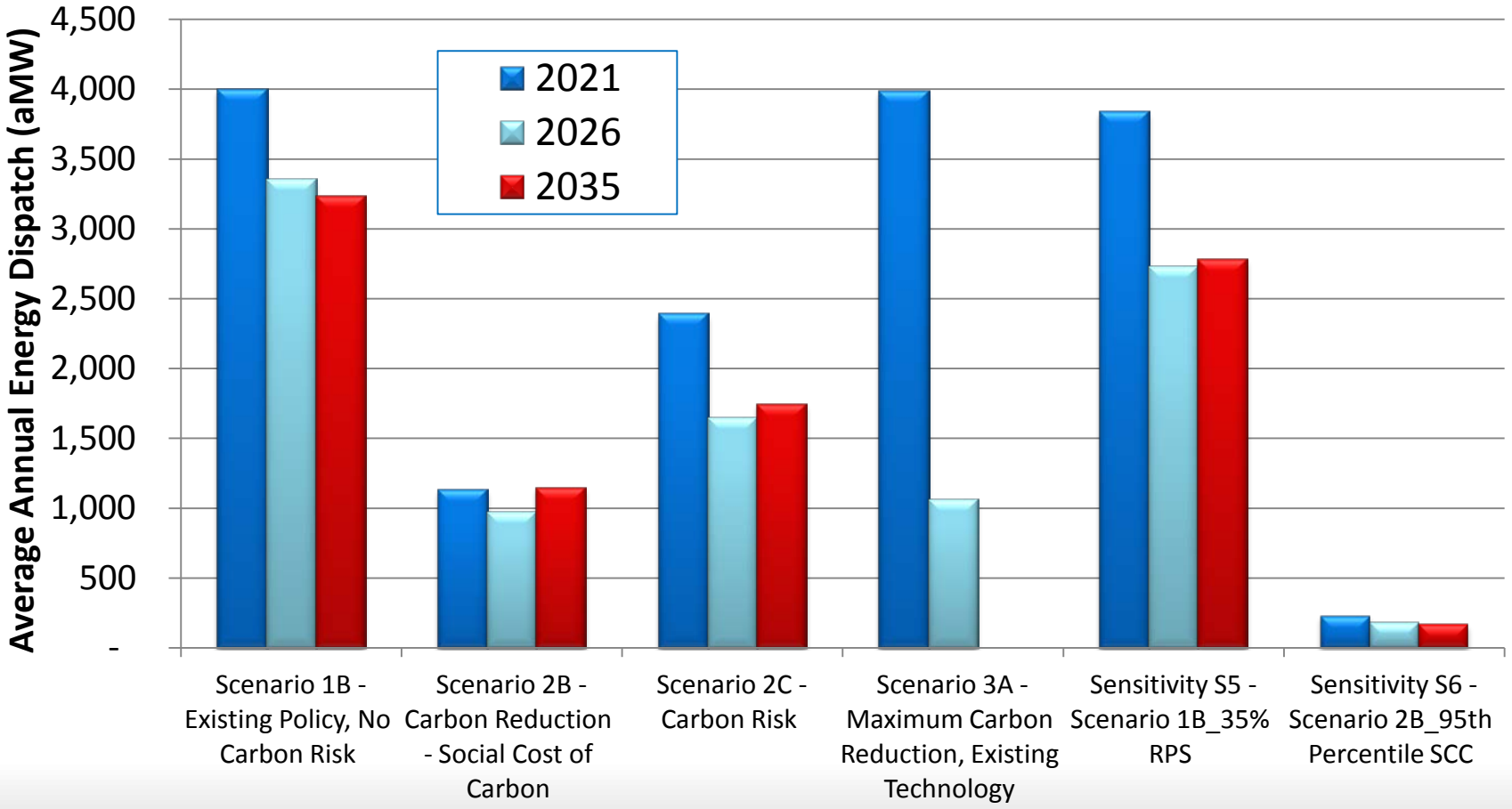
Average New Gas Generation Development Under Alternative Carbon Emissions Reduction Policies Is Very Similar To the Base Scenario, Except for the Maximum Emissions Reduction Scenario (3A) and Social Cost of Carbon at the 95th Percentile Policies



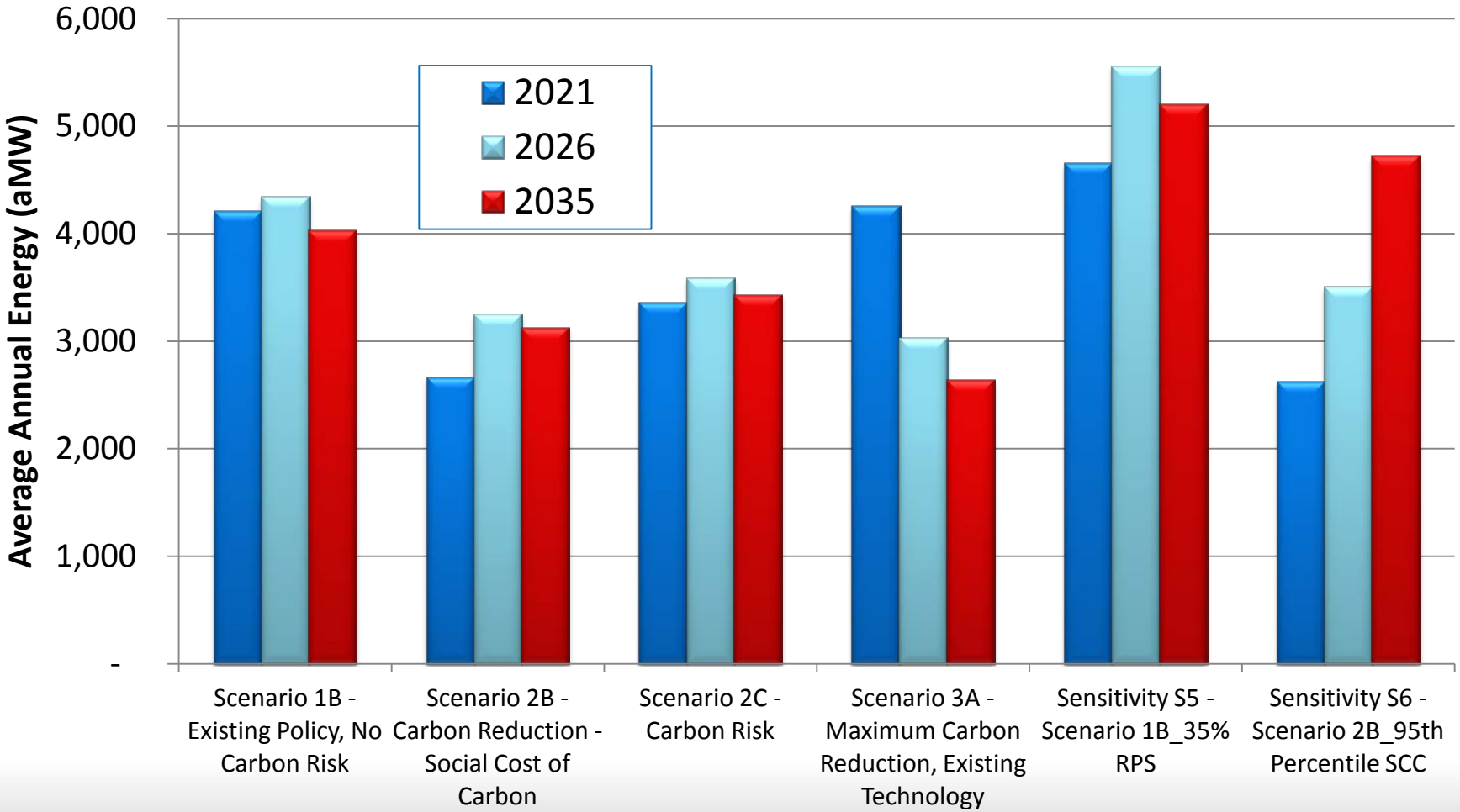
Average Existing Gas Generation Dispatch Under Alternative Carbon Emissions Reduction Policies Is Generally Higher Than the Base Scenario, Except for the RPS @ 35% Policy



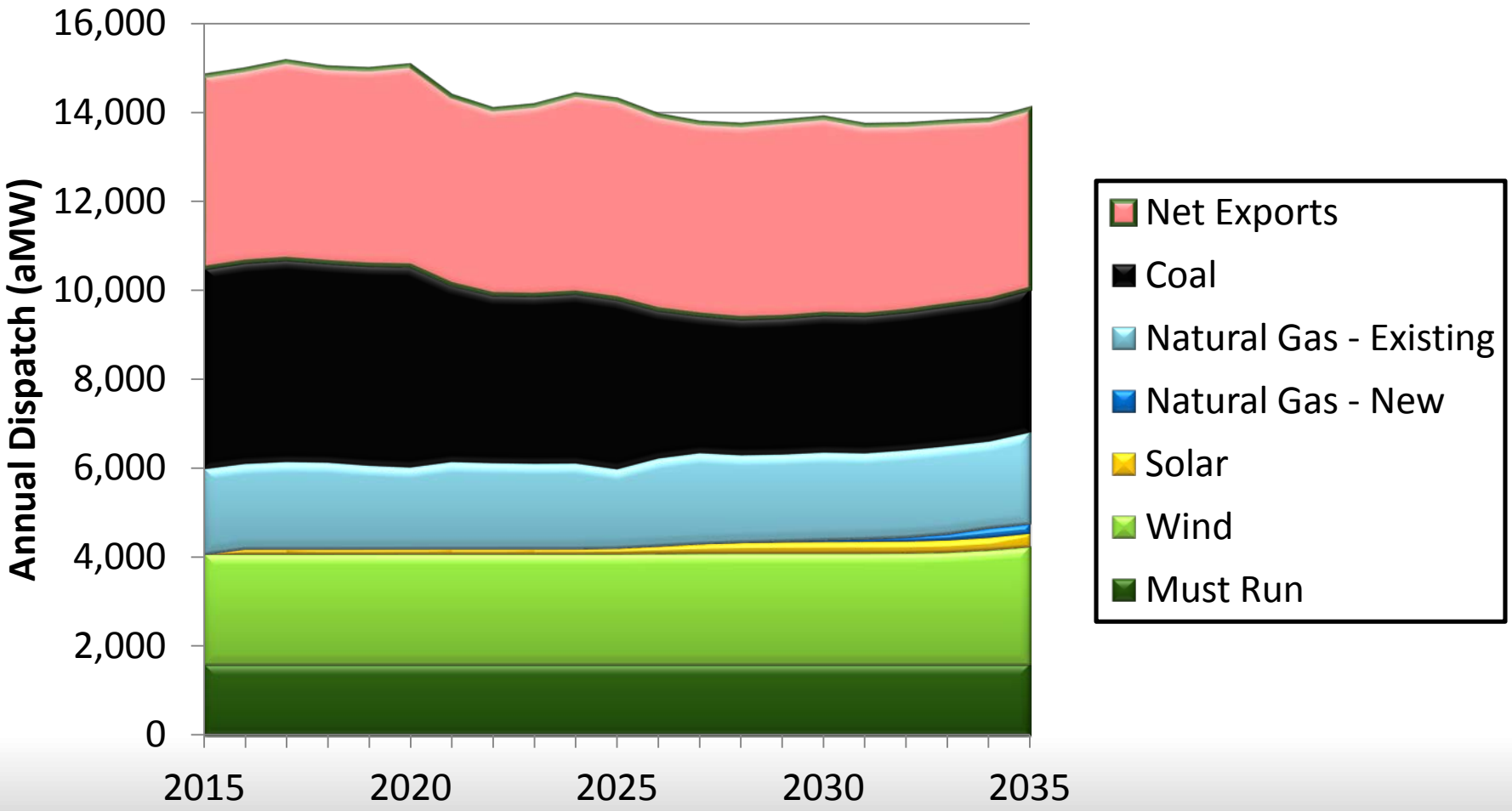
Average Existing Coal Generation Dispatch Under Alternative Carbon Emissions Reduction Policies Is Significantly Reduced or Eliminated Under Most Strategies, With The Least Long Term Reduction Occurring Under the RPS @ 35% Policy



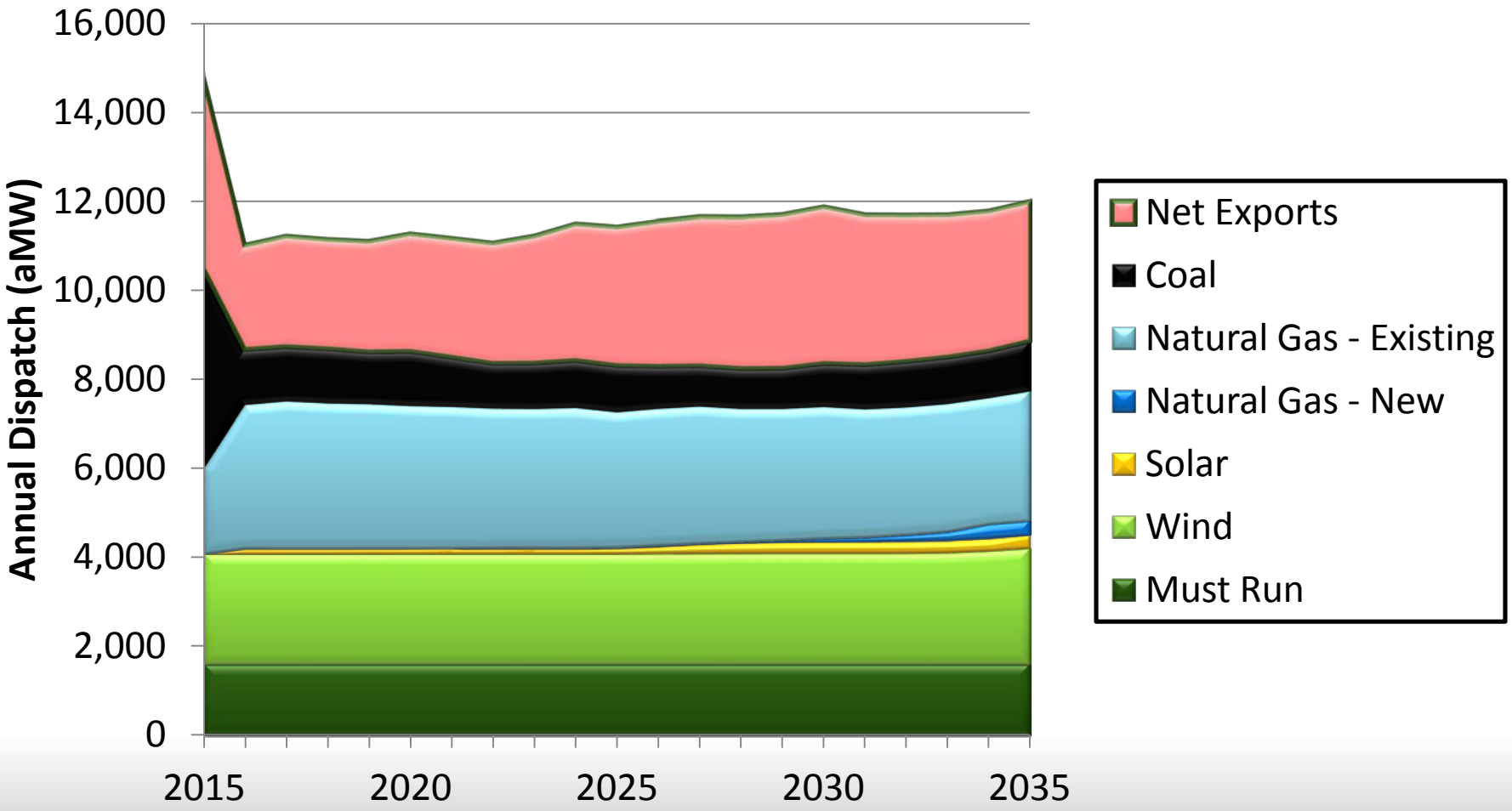
Average Net Regional Exports Under Alternative Carbon Emissions Reduction Policies Are Generally Lower than the Base Scenario, Except for the RPS @ 35% Policy



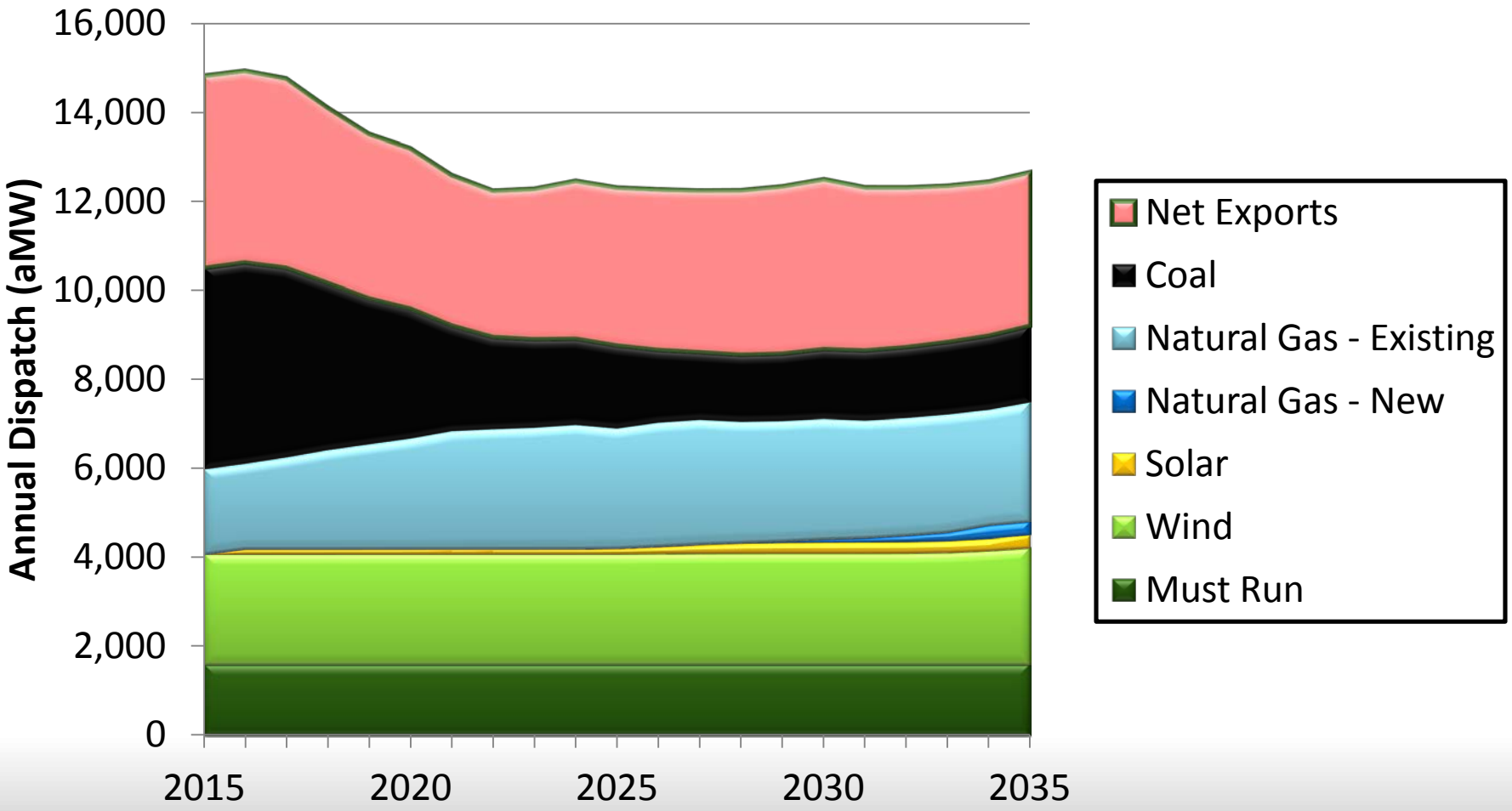
Changes in Average Thermal Resource Dispatch in the No Carbon Risk Scenario (1B) Are Driven by Announced Coal Plant Retirements



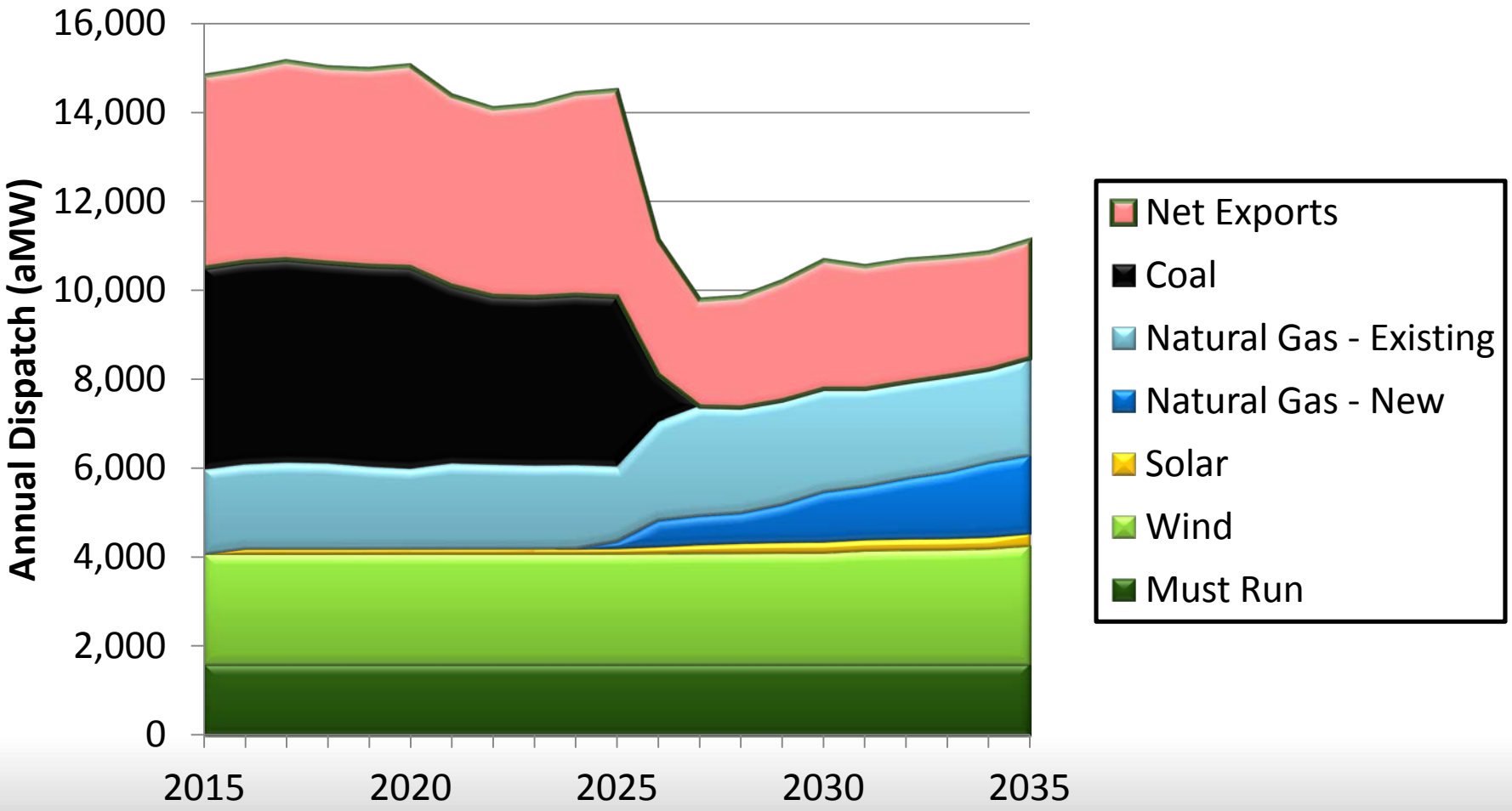
Changes in Average Thermal Resource Dispatch and Exports in the Social Cost of Carbon Scenario (2B) Are Driven by Increased Competiveness of *Existing* Gas-Fired Generation Compared to Coal-Fired Generation After Assumed Carbon Cost Are Imposed



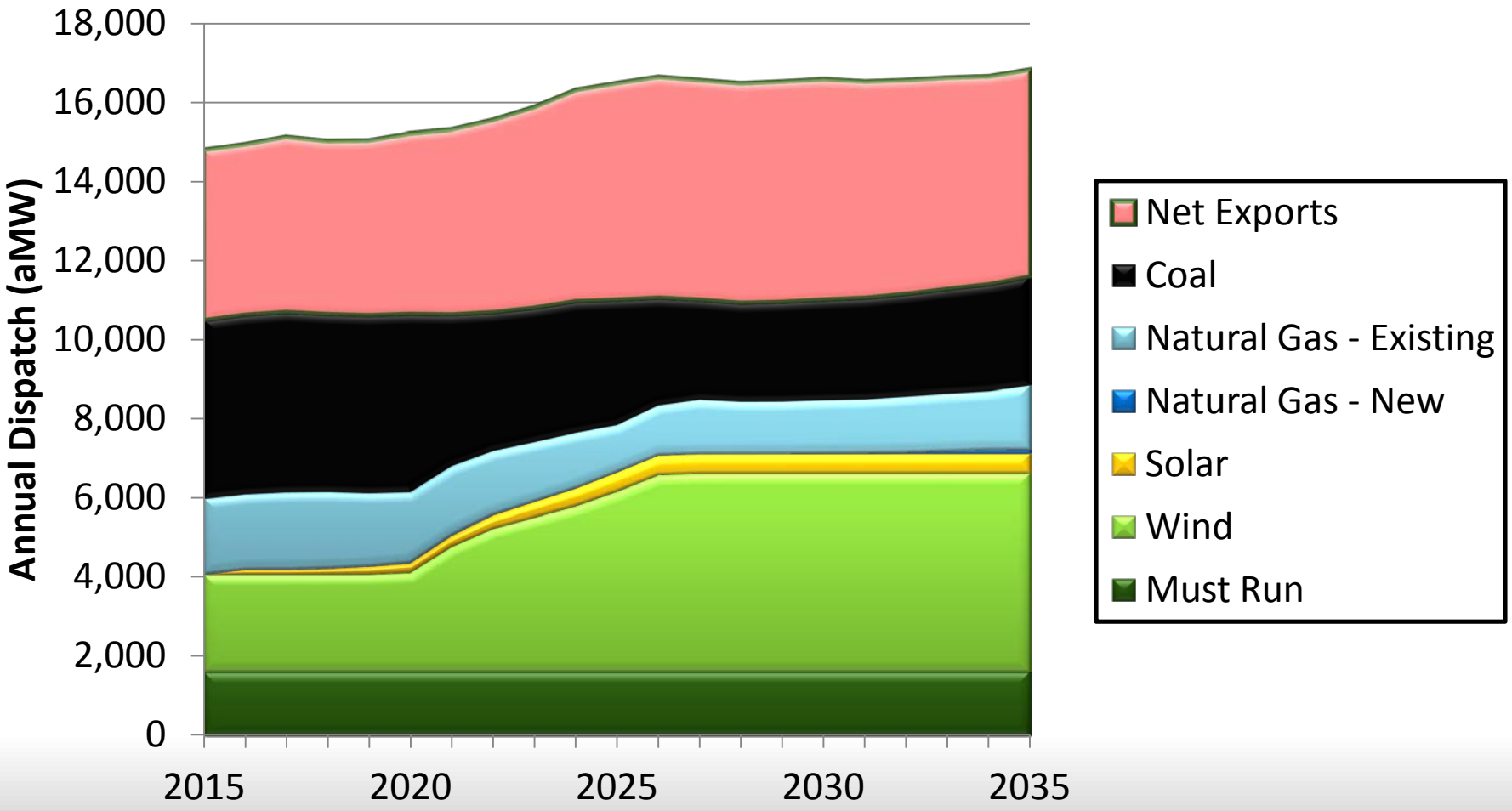
Changes in Average Thermal Resource Dispatch and Net Exports in the Carbon Risk Scenario(2C) Are Driven by The Increased Competiveness of Existing Gas-Fired Generation Compared to Existing Coal-Fired Generation When Assumed Carbon Cost Are Imposed



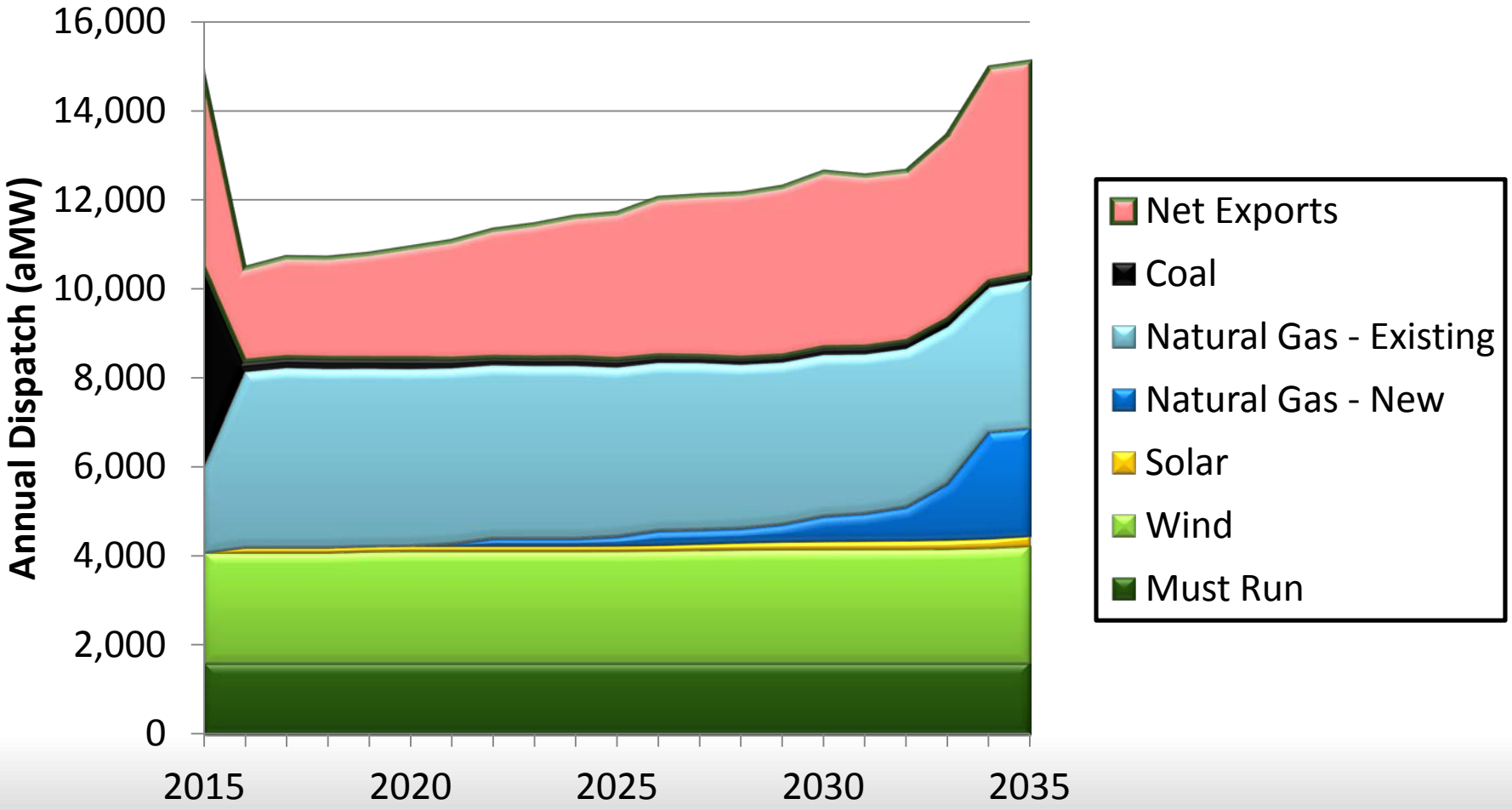
Changes in Average Thermal Resource Dispatch in the Maximum Carbon Reduction with Existing Technology Scenario (3A) Are Driven by Assumed Coal and Inefficient Gas Generation Retirements



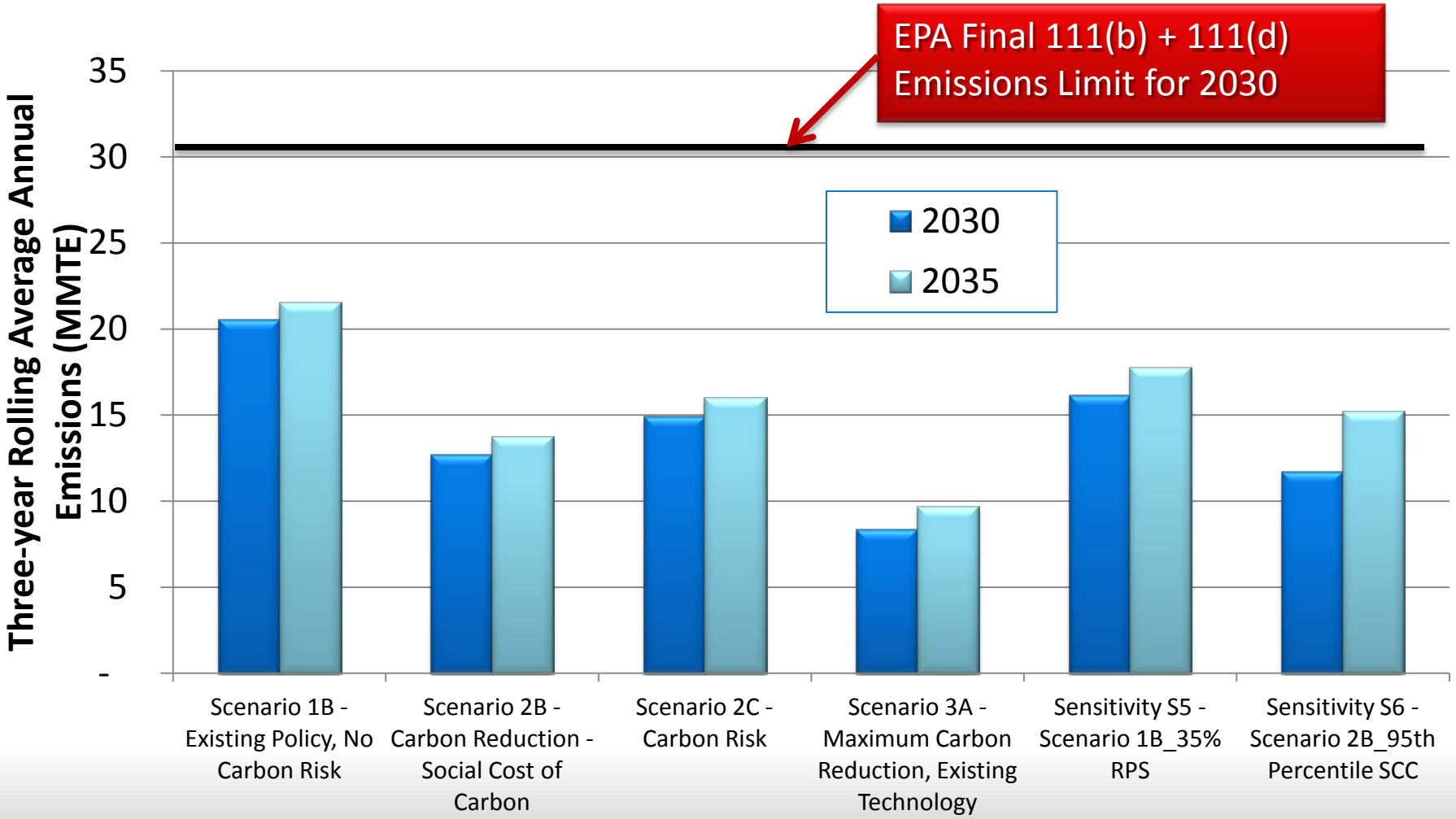
Changes in Average Thermal Resource Dispatch in the RPS @ 35% Sensitivity Study (S6) Are Driven by the Addition of Low Variable Cost Renewable Resource Generation, While Both Coal and Existing Natural Gas Resources Are Dispatched To Maintain Resource Adequacy



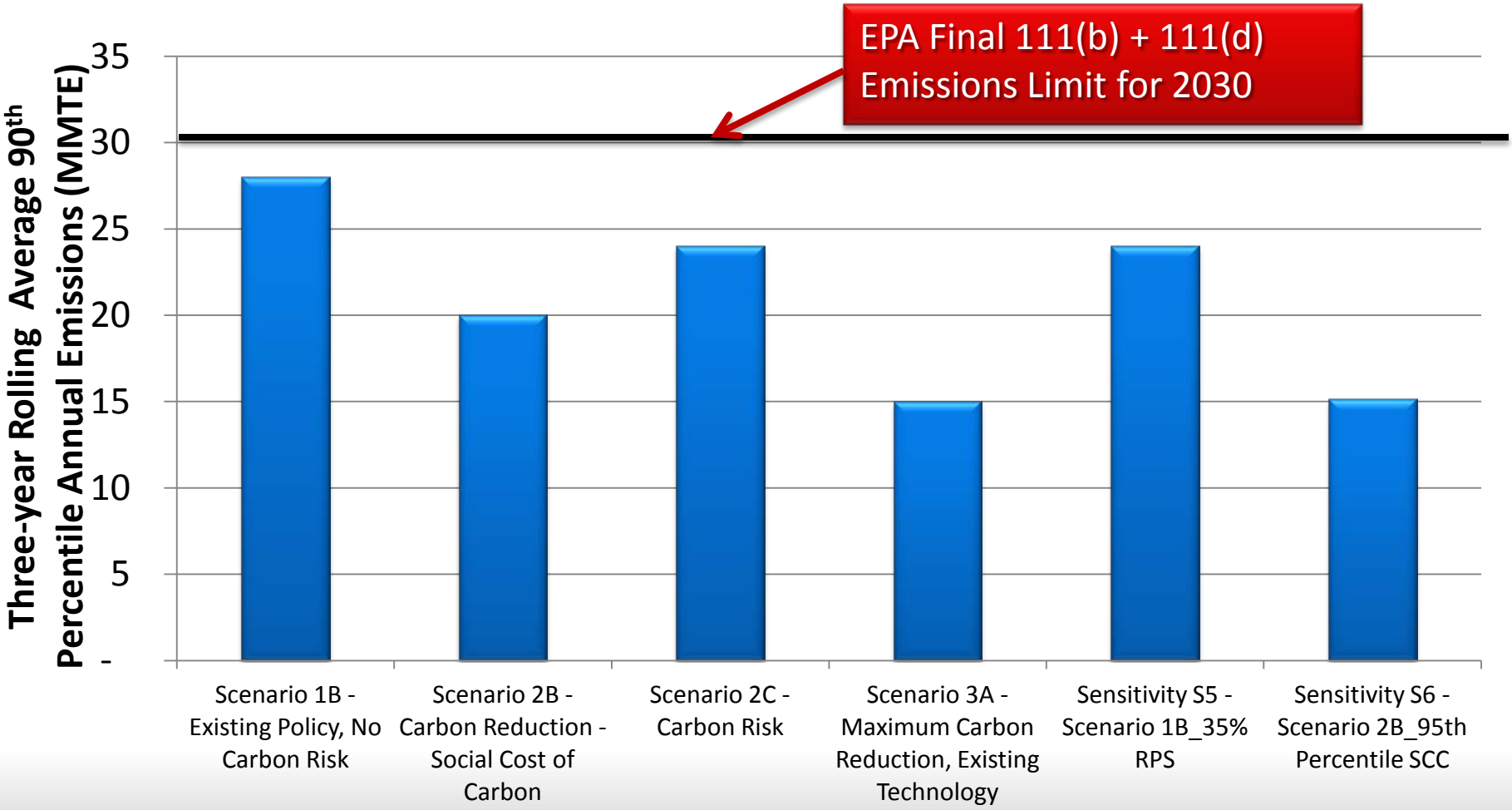
Changes in Average Thermal Resource Dispatch in the 95th Percentile Social Cost of Carbon Sensitivity Study (S5) Are Driven by Increased Competiveness of both *New and Existing* Gas-Fired Generation Compared to Coal-Fired Generation When Assumed Carbon Cost Are Imposed



The *Average* Annual 111(b) + 111(d) System CO2 Emissions for the Least Cost Resource Strategies for All Scenarios Are Below The EPA's Proposed Limit for 2030, and Remain So Through 2035

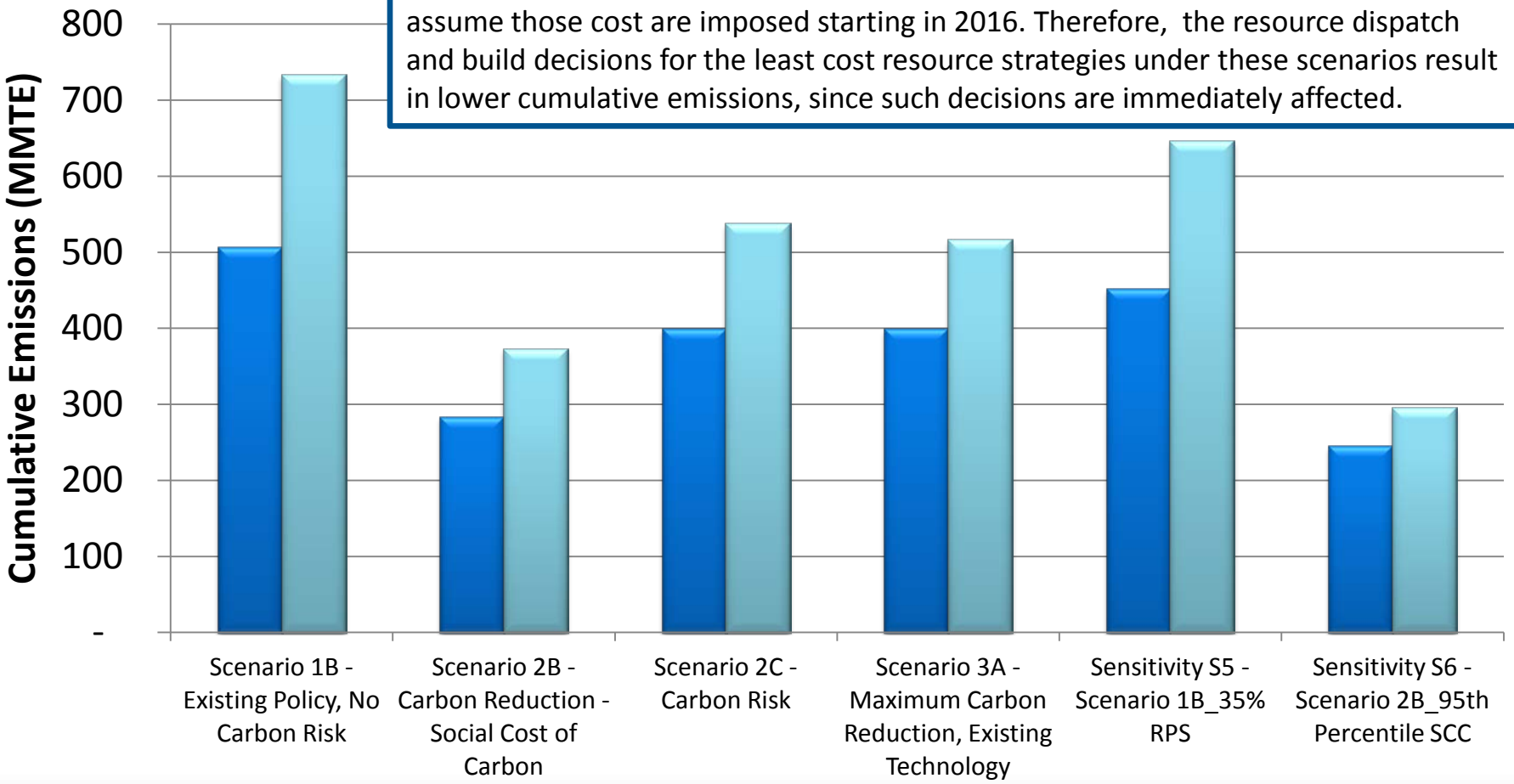


The *90th Percentile* Annual 111(d) System CO2 Emissions for the Least Cost Resource Strategies for All Scenarios Are Below The EPA's Proposed Limit for 2030

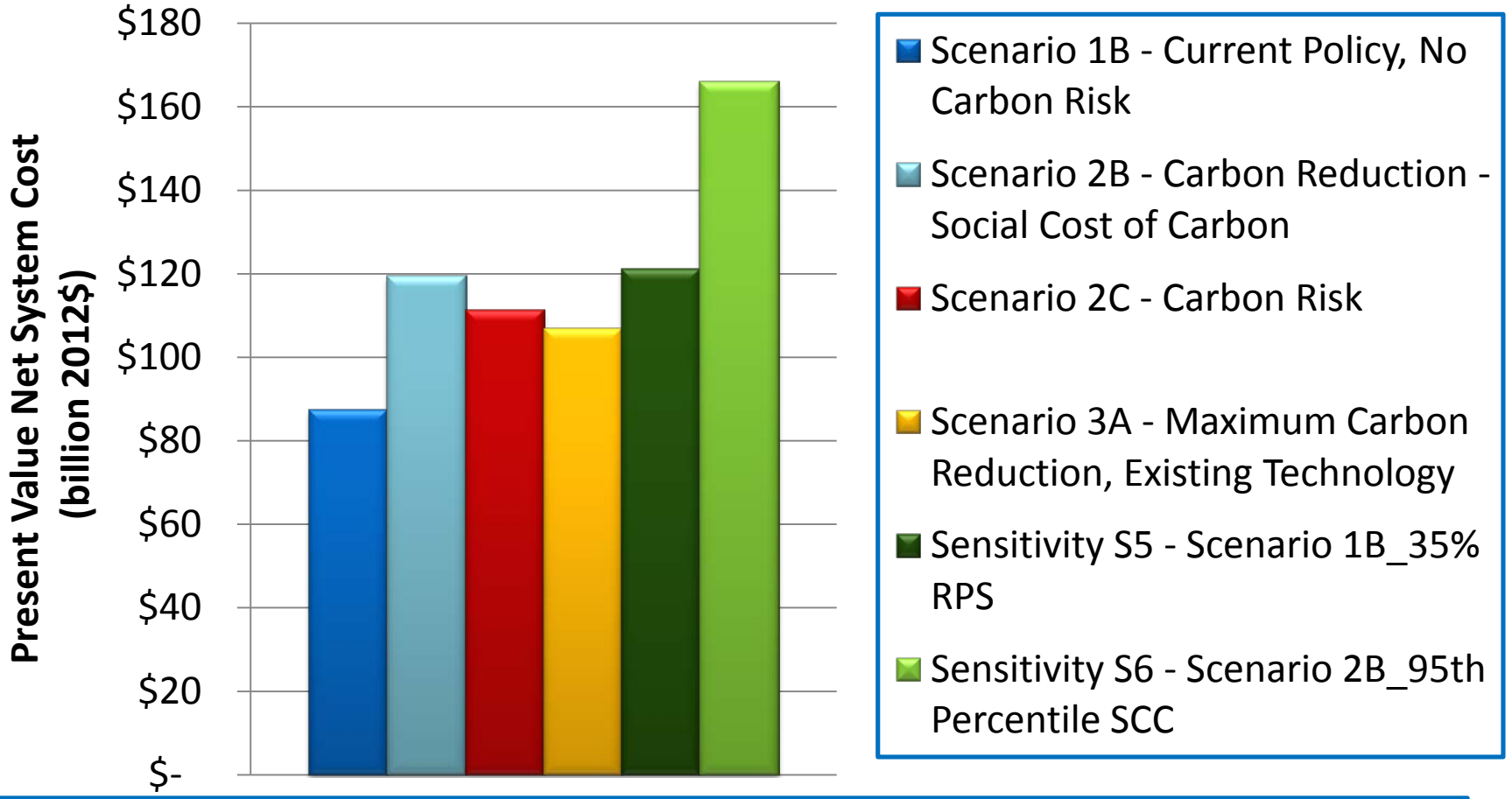


Cumulative PNW Power System CO2 Emission 2016-2035 Under Alternative Carbon Emissions Reduction Policies

CAUTION: The Social Cost of Carbon (2B, S5 & S6) and Carbon Risk (2C) Scenarios assume those cost are imposed starting in 2016. Therefore, the resource dispatch and build decisions for the least cost resource strategies under these scenarios result in lower cumulative emissions, since such decisions are immediately affected.

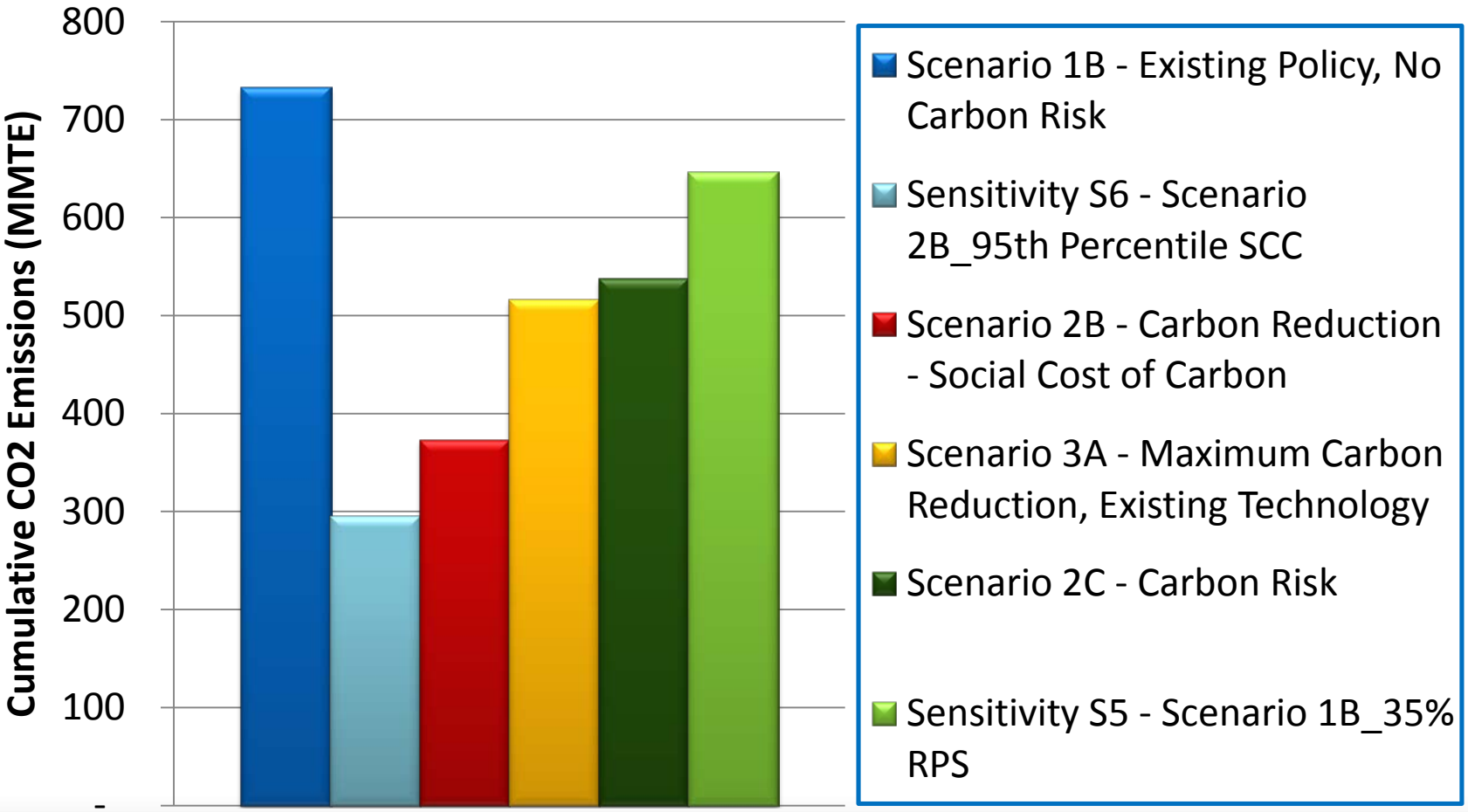


The Average Present Value Net System Cost for Least Cost Resource Strategies *Without* Carbon Cost*

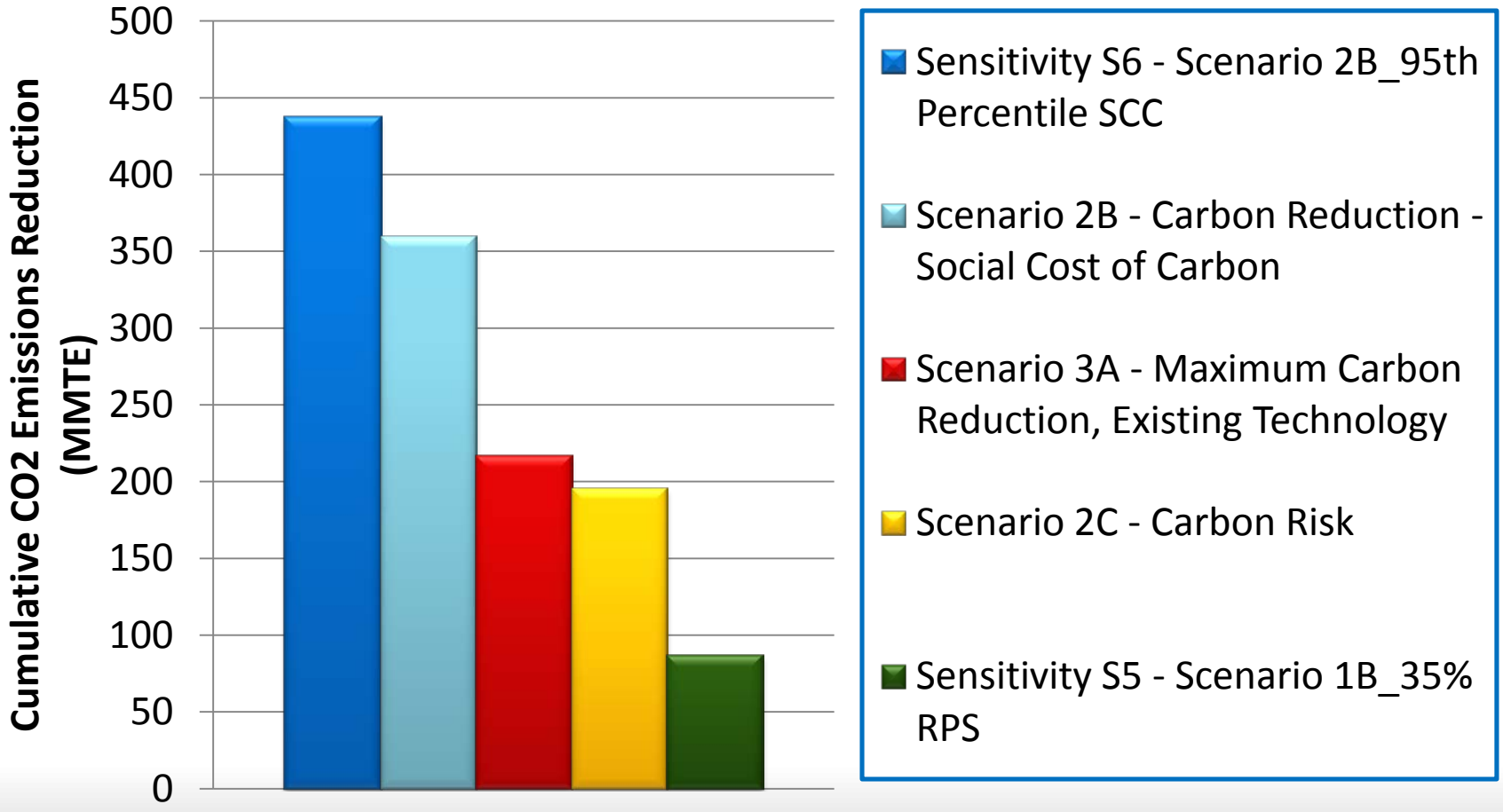


*Carbon "tax" revenues were subtracted from the NPV System Cost to assess the actual resource portfolio cost, including capital, fuel and other operating cost.

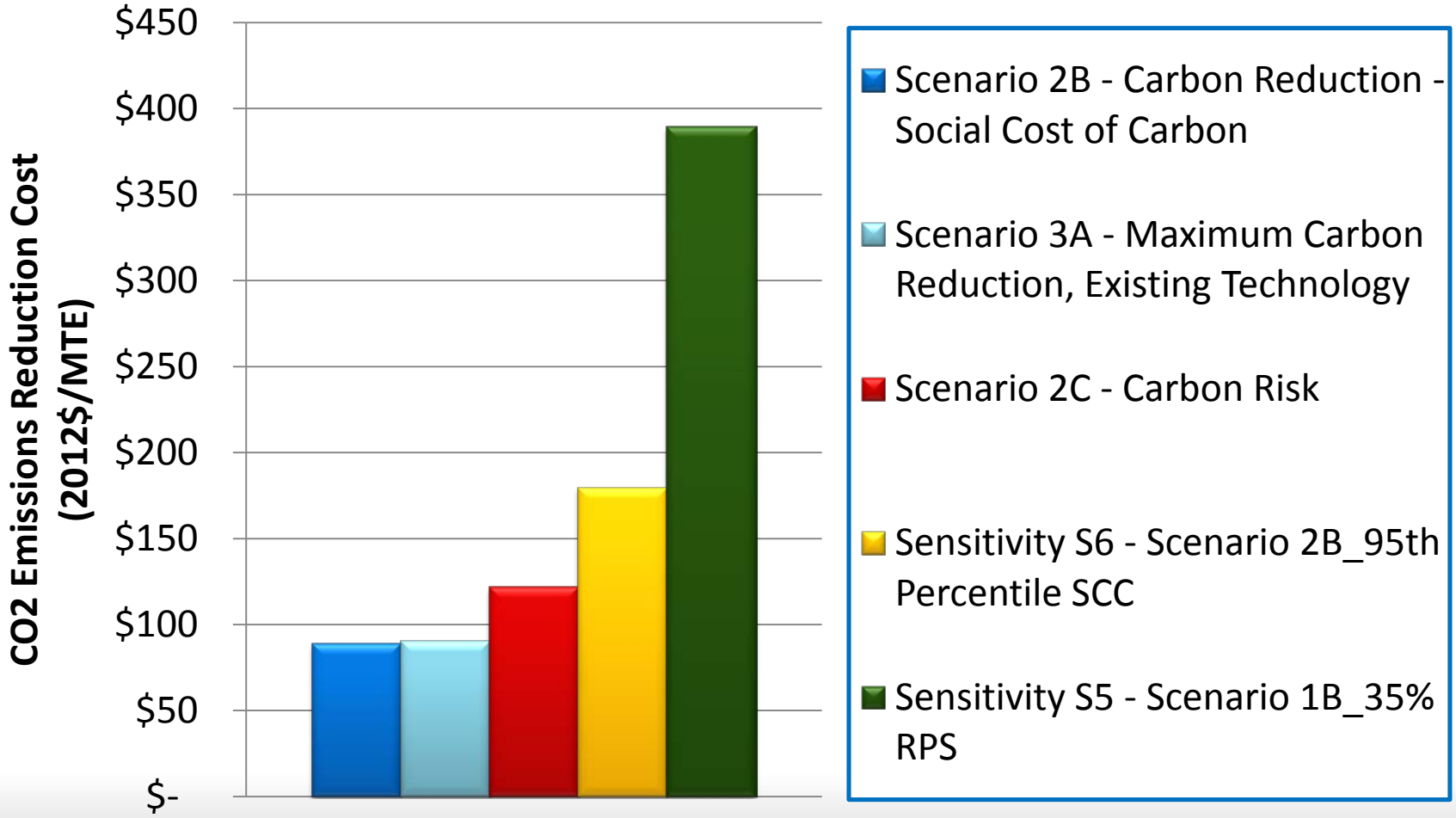
The Lowest PNW Power System Cumulative CO2 Emissions from 2016-2035 Occur Under Alternative Resource Strategies That Immediately Must Respond To Carbon Reduction Policies



The Largest PNW Power System Cumulative CO2 Emissions Reductions Also Occur Under Alternative Resource Strategies That Must Respond Immediately to Carbon Reduction Policies



The Lowest Cost PNW Power System CO2 Emission Reduction Resource Strategies Are Those That Result From Adaptation to Carbon Cost or Direct Retirement of Coal and Inefficient Gas Generation



Observations from Scenario Analysis: Carbon Emissions Reduction

- The *least cost* resource strategies that meet proposed CO2 Emissions Limits *at the regional level:*
  - Meet all (or nearly all) load growth with energy efficiency
  - Meet near and mid-term needs for capacity with demand response
  - Retire and/or reduce the dispatch of existing coal plans and replace them by first increasing existing gas-fired generation and later with new combined cycle combustion turbines
  - Do not significantly expand the use of renewable resources
- Why
  - Increasing the dispatch of the more efficient existing gas-fired generation to offset reductions in coal-fired generation produces lower cost carbon emissions reduction than the development of renewable resources
  - In addition, currently commercially available Renewable Resources (solar PV and wind) provide limited or no winter peaking capacity, hence are not good matches for system need, so increasing RPS is currently the most costly policy option for reducing CO2 emissions

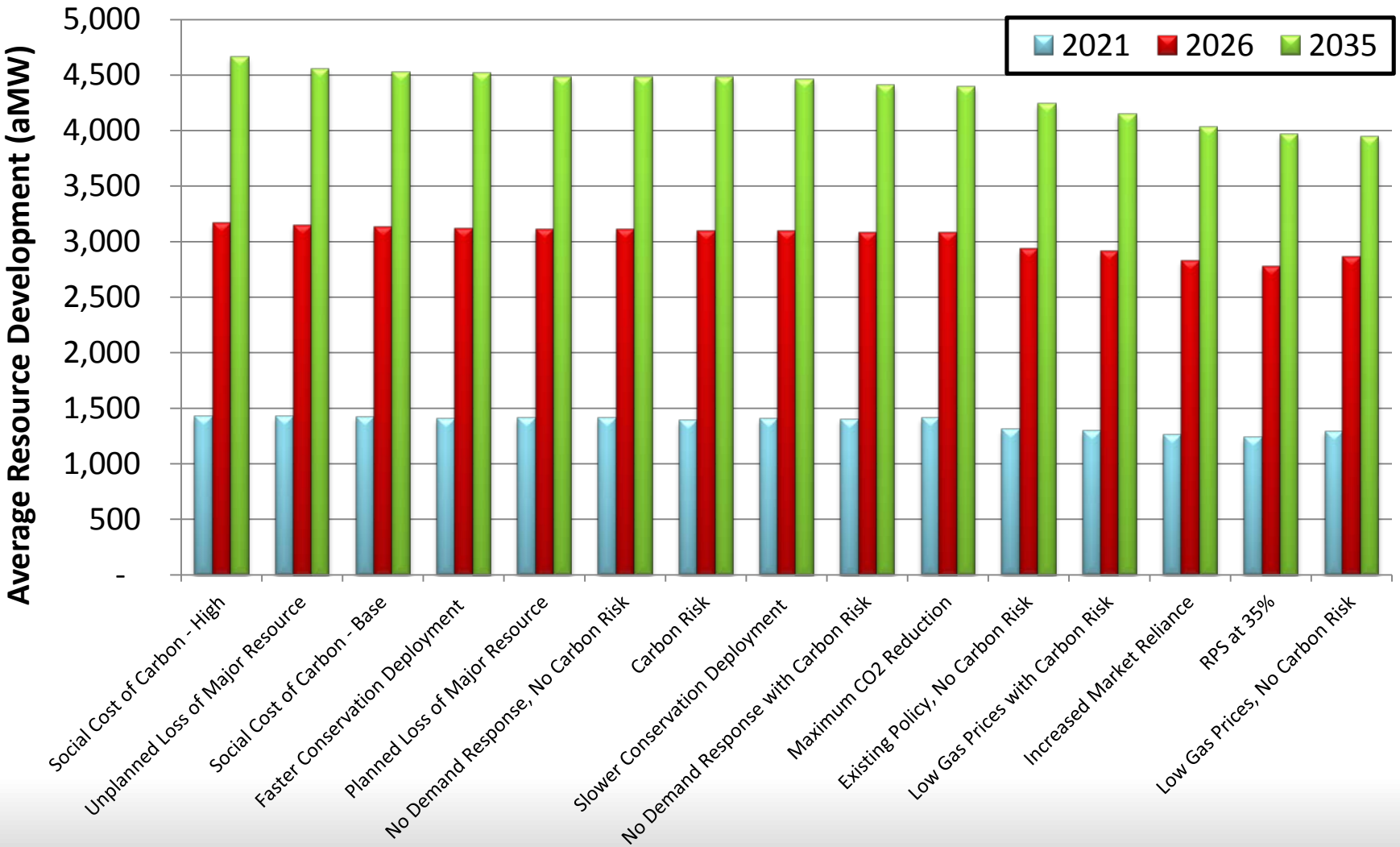
Proposed Major Elements of Draft Resource Strategy

August 6, 2015

Key Findings

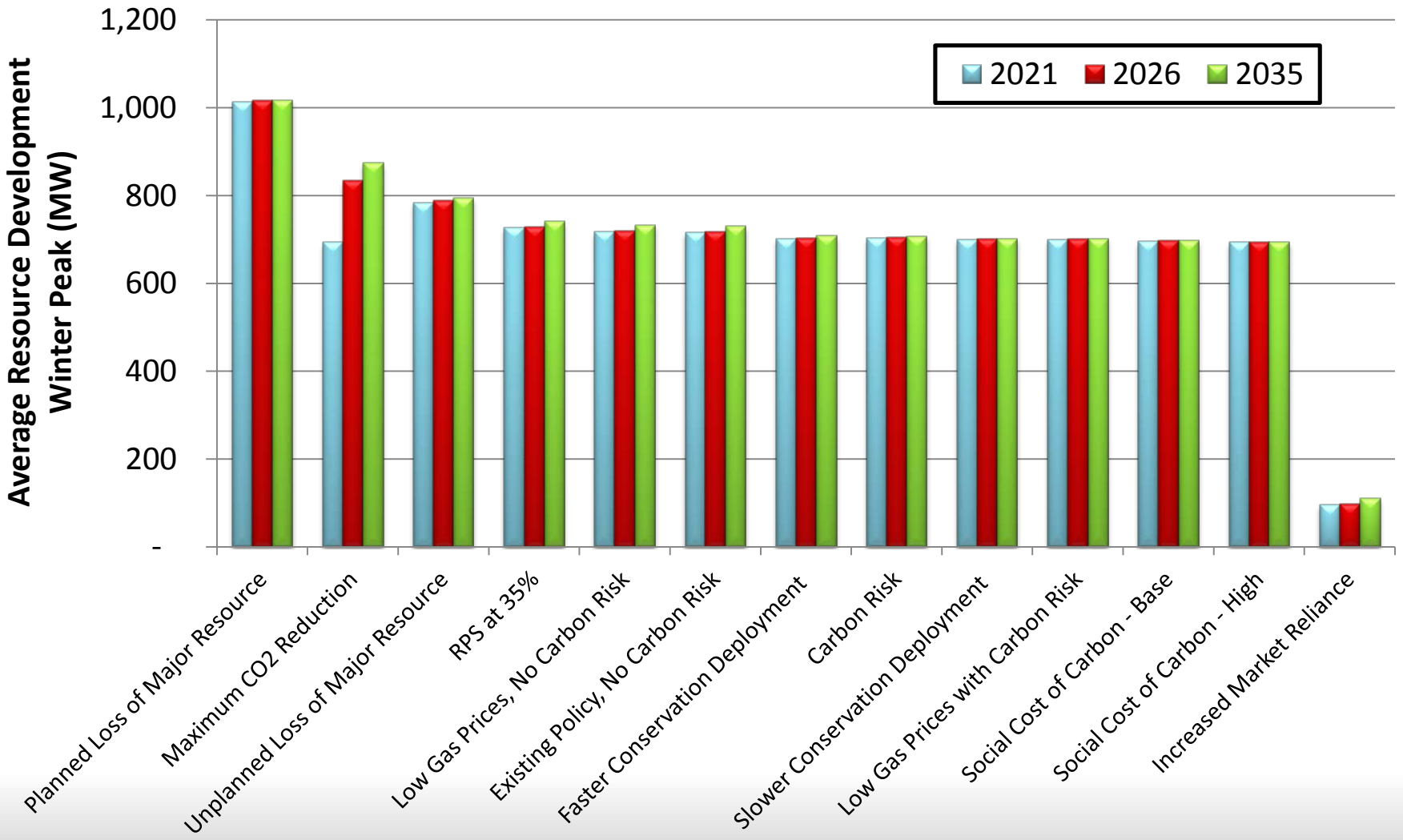
- Least Cost Resource Strategies Consistently Rely on Conservation and Demand Response to Meet Future Energy and Capacity Needs
- Demand Response or Increased Reliance on External Markets are Competitive Options for Providing Winter Capacity
- Replacement of announced coal plant retirements can generally be achieved with only modest new development of natural gas generation
- Compliance with EPA CO2 emissions limits *at the regional level*, is attainable through resource strategies that do not depart significantly from those that are not constrained by those regulations.

Key Finding:
Average Conservation Development Across Scenarios Varies Little Across Scenarios Except Under Sustained Low Gas Prices and Increased RPS

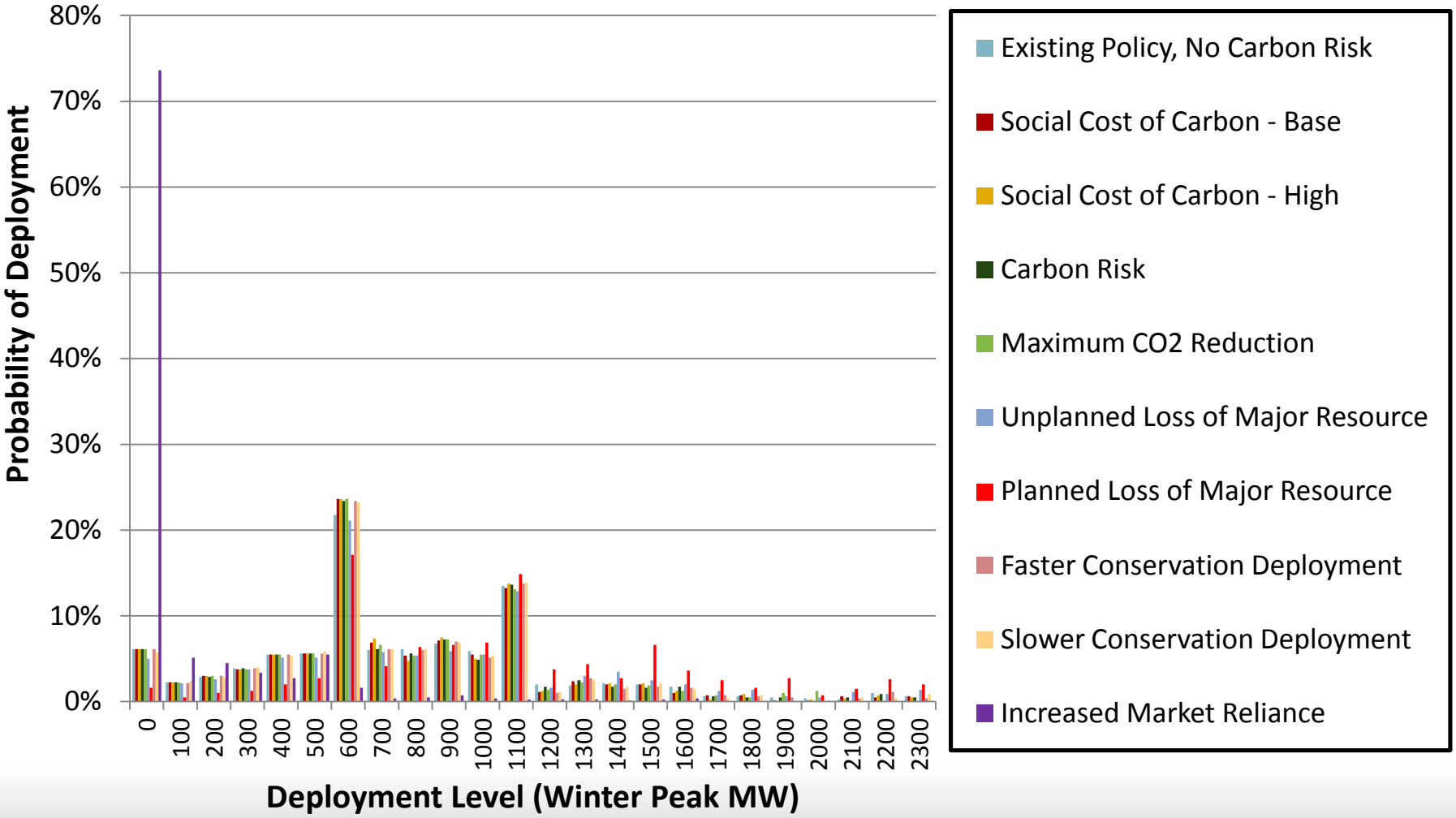


Key Finding:

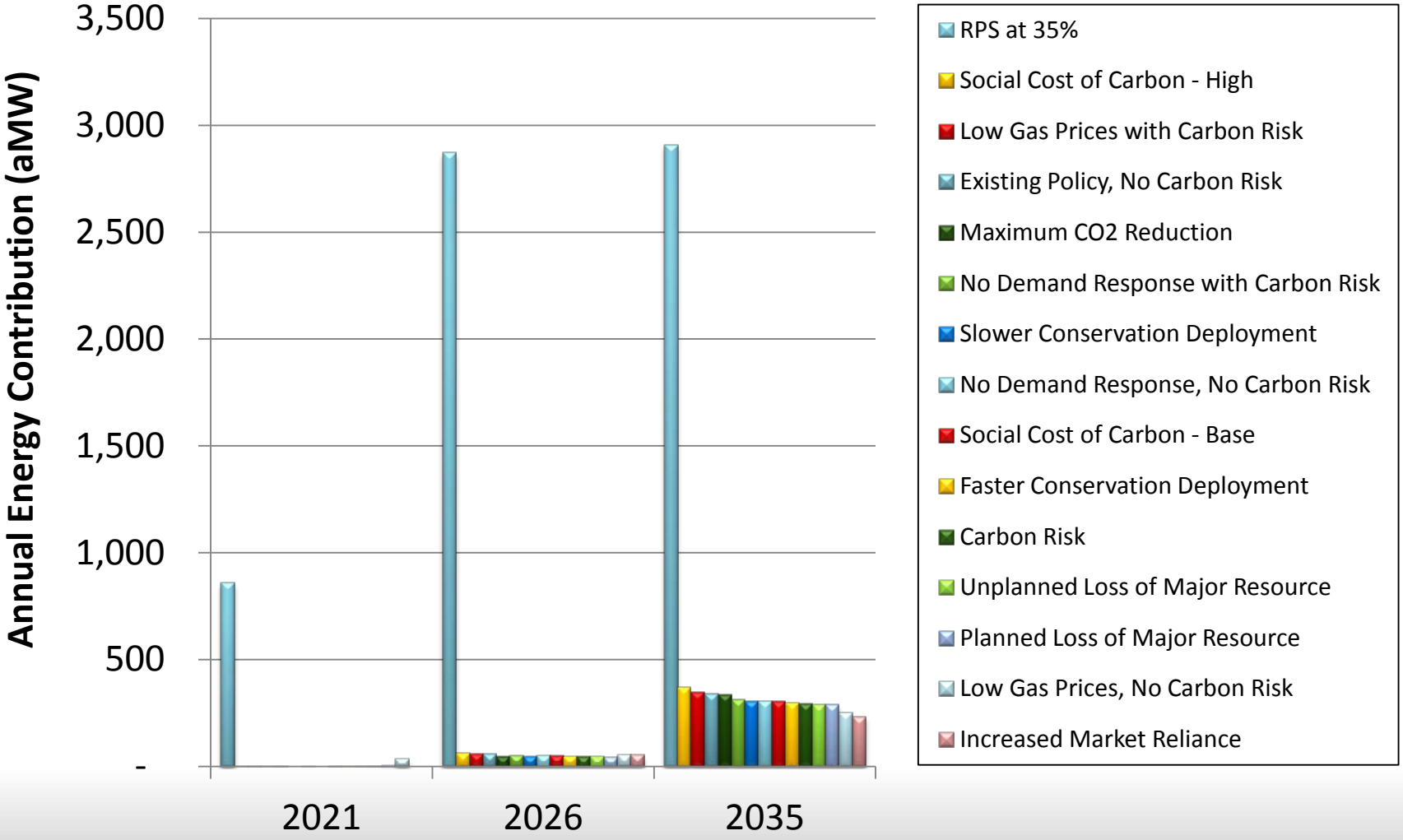
Average Demand Response Development Across Scenarios Varies Little Across Scenarios Except in Scenarios with Major Resource Loss or Increased External Market Reliance



Key Finding:
The *Probability and Amount* of Demand Response Varies Over a Wide Range, and is Particularly Sensitivity to Extra-Regional Market Reliance Assumptions

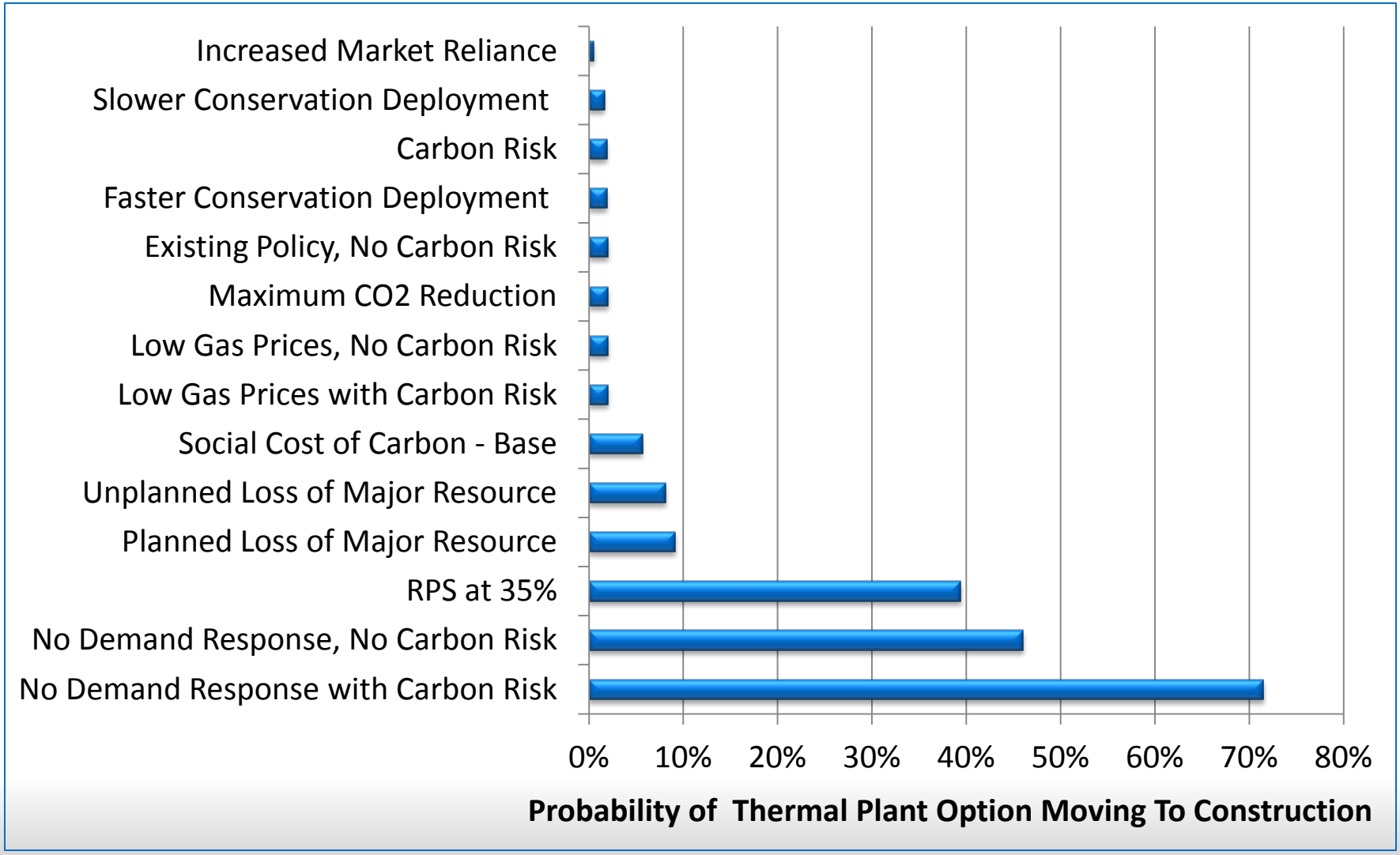


Key Finding:
Average New Renewable Resource Development *Does Not* Significantly Increase In Carbon Emissions Reduction Policy Scenarios Except For A Policy That Sets Renewable Portfolio Standard at 35%

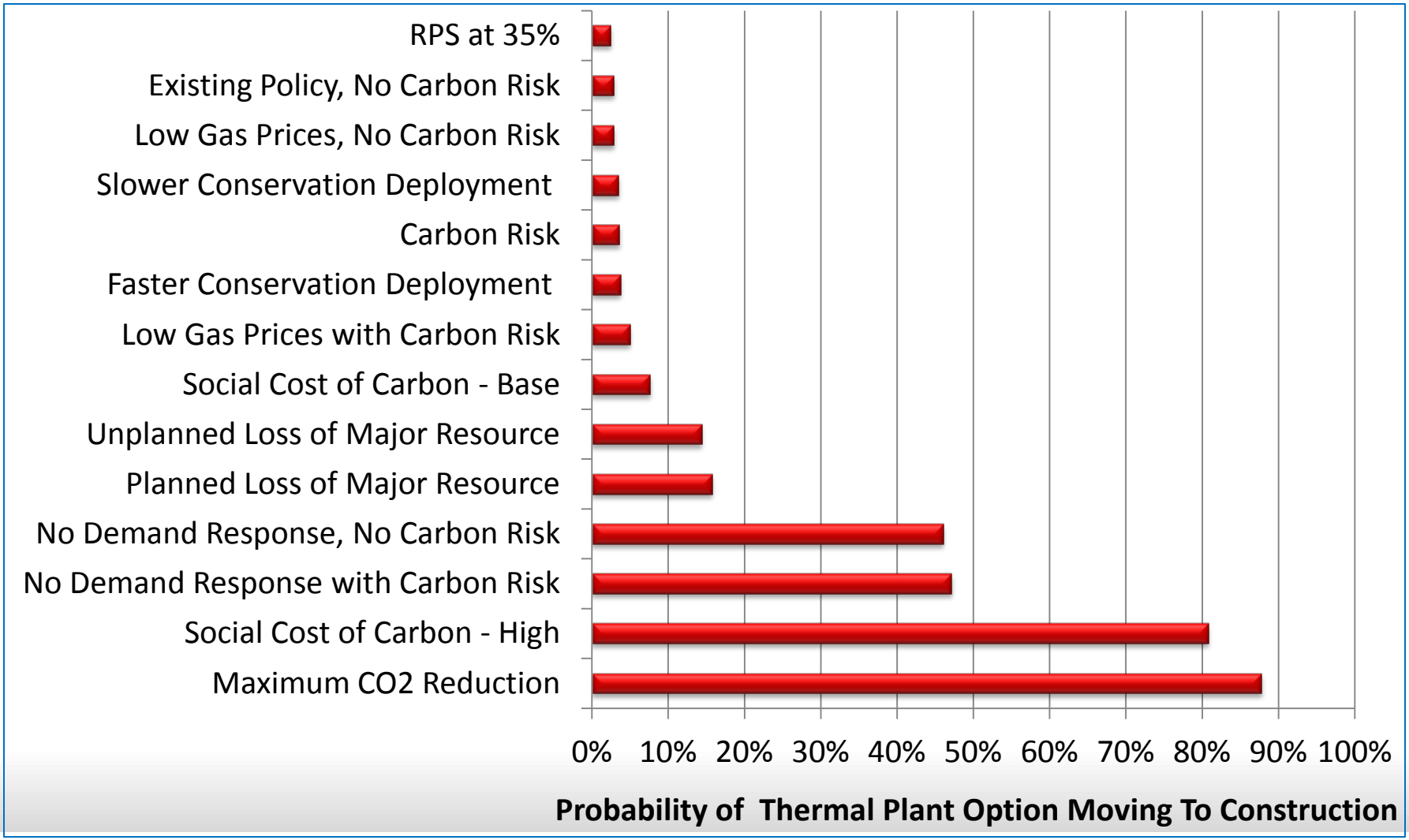


Key Finding:

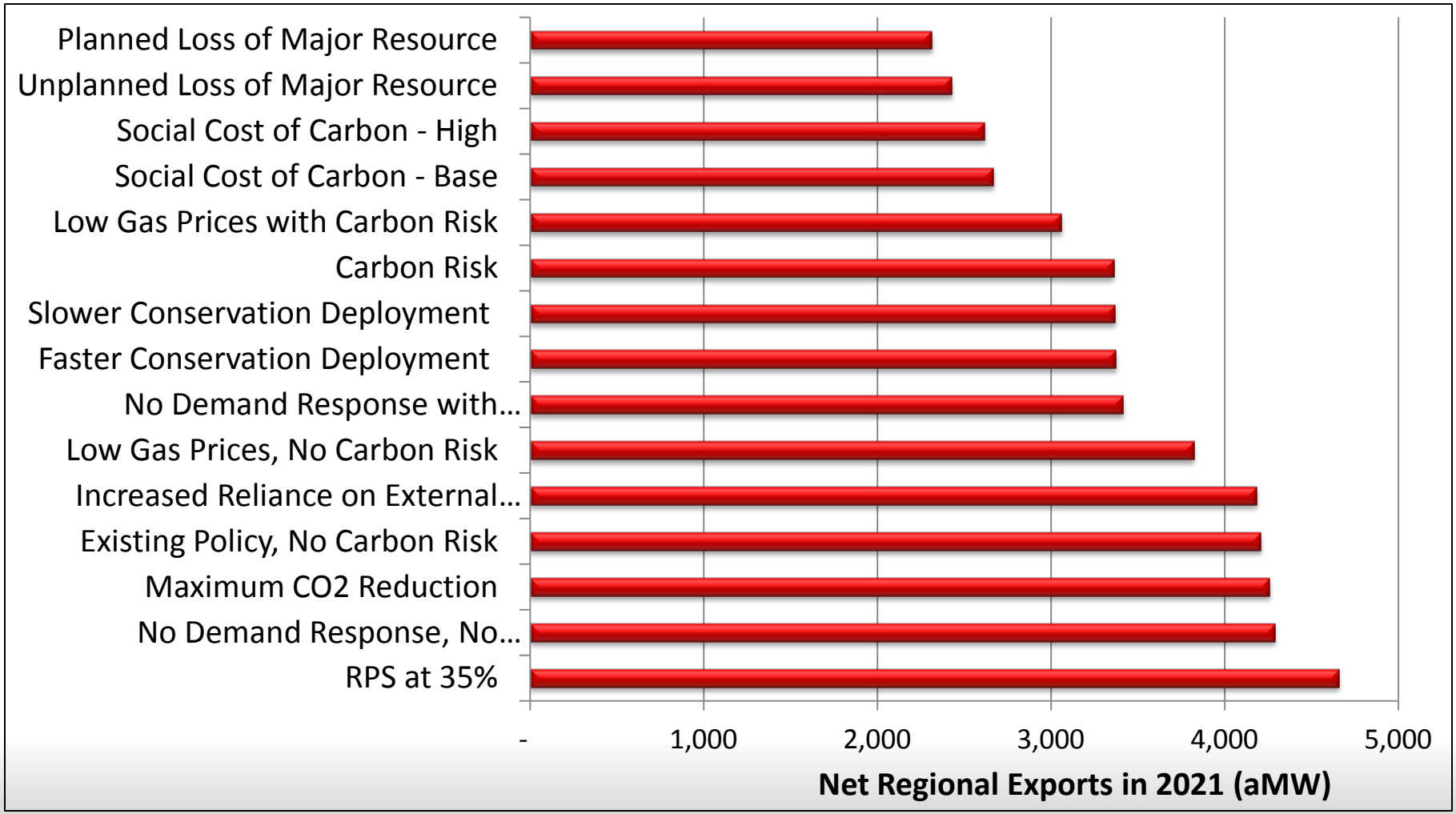
There is a Low Probability of Any Thermal Development by 2021 Except Under Scenarios That Increase RPS or Do Not Develop Demand Response



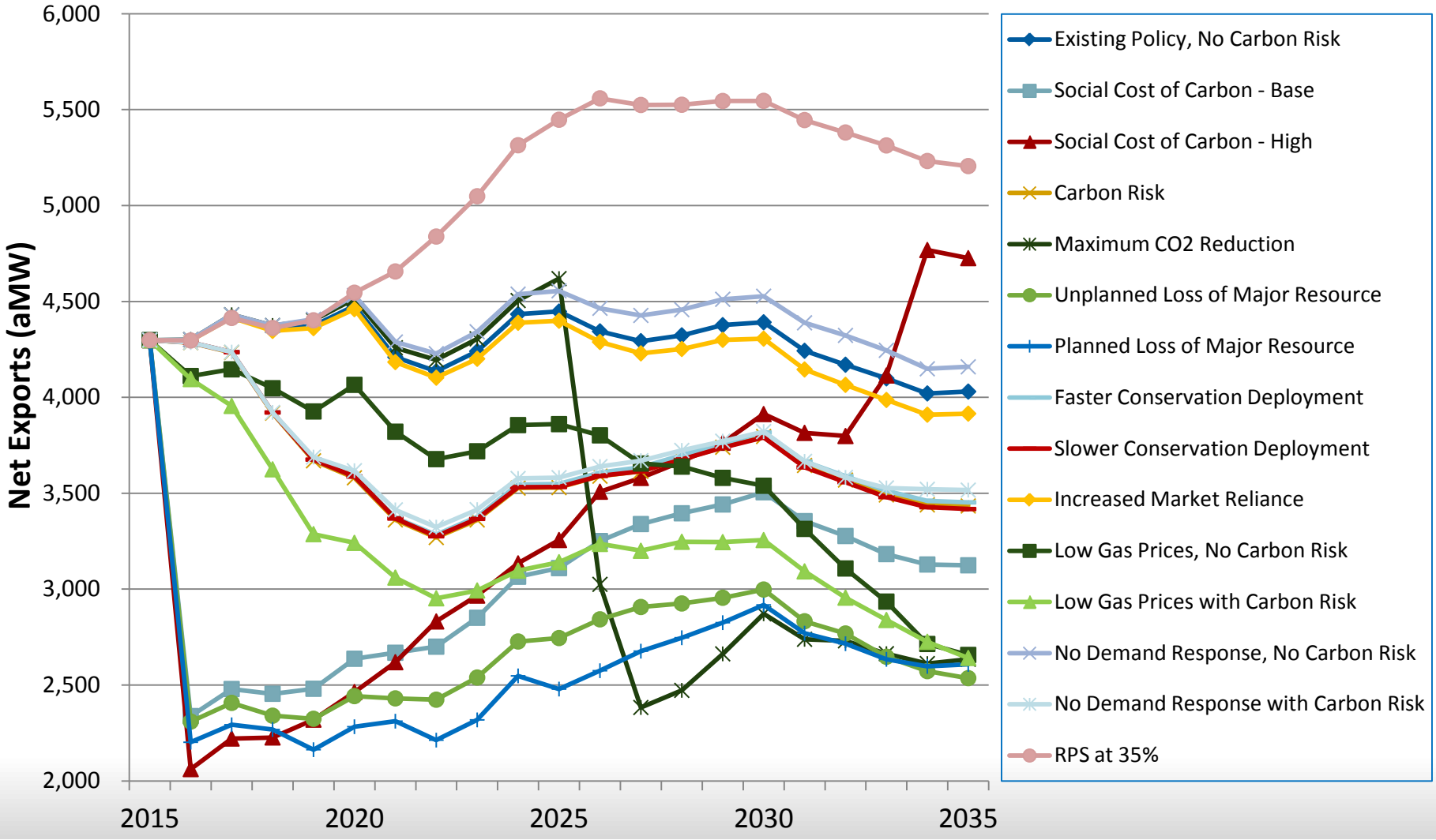
Key Finding:
The Probability of Thermal Development by 2026 Is Modest
Except In Scenarios That Assume All Coal Plant Retirements or Do Not Develop Demand Response



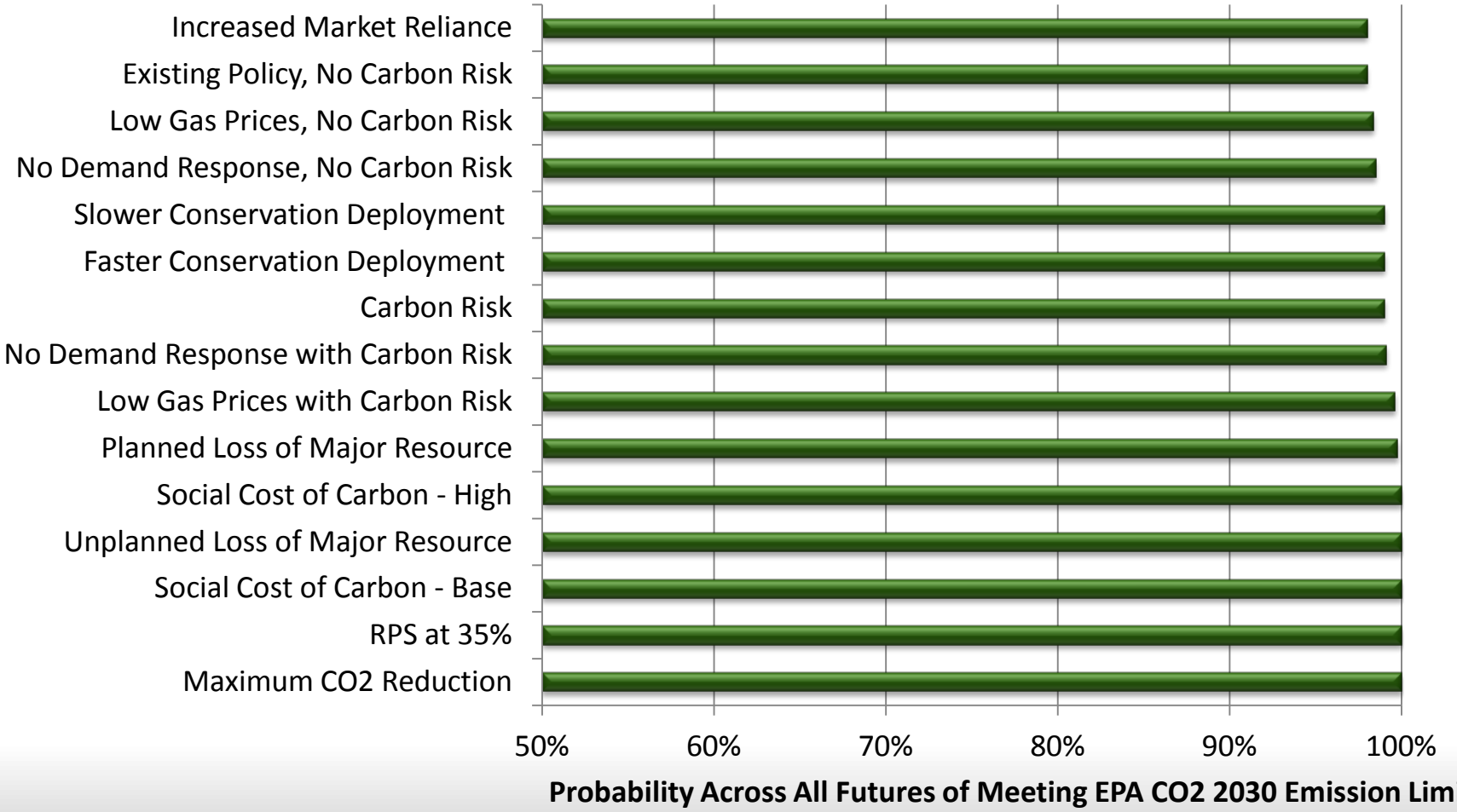
Key Finding:
Reduction of Regional Exports Generally Reduces Need for In Region Resource Development, Except with Increased RPS or When No Carbon Cost Risks Are Considered



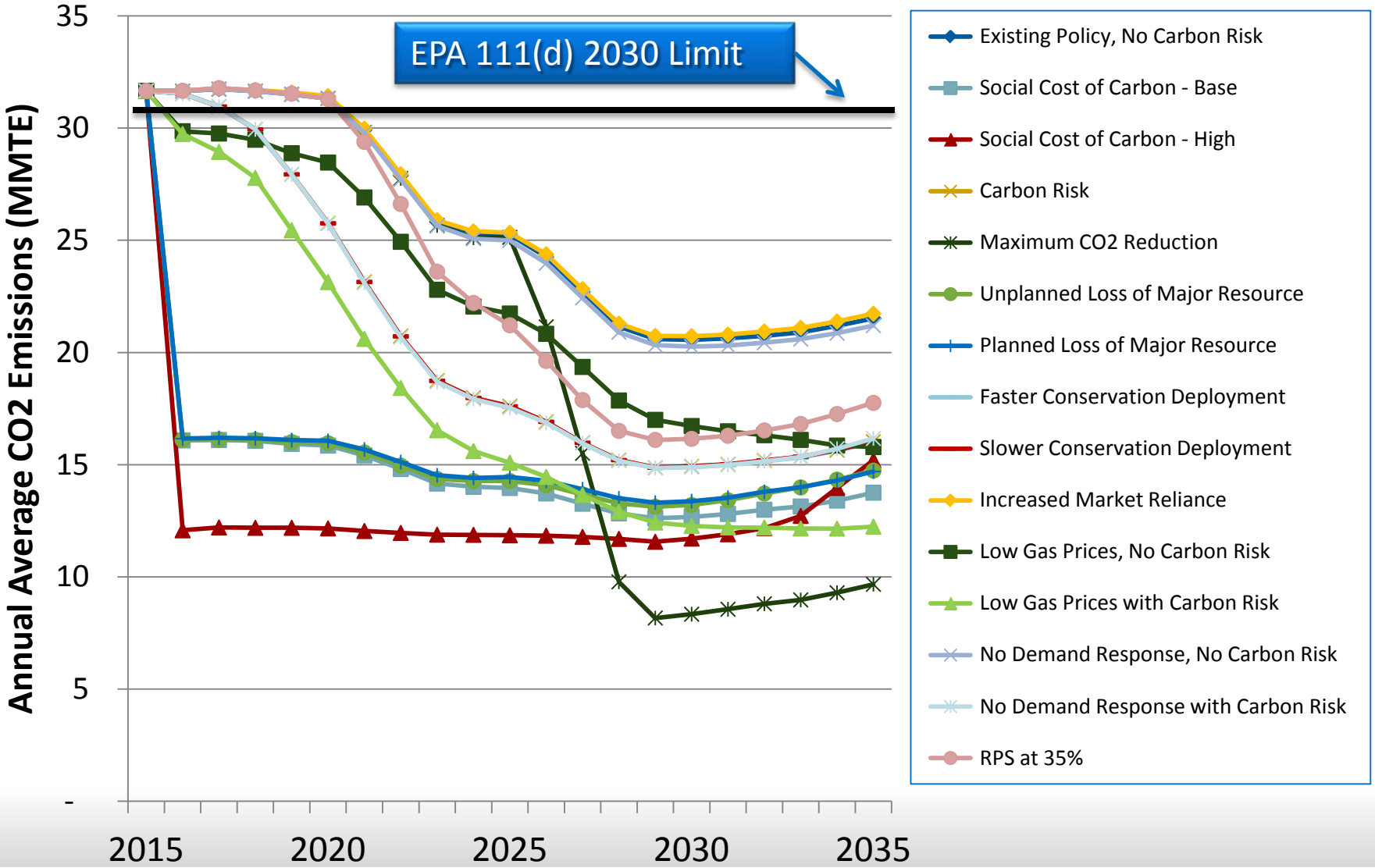
Key Finding: Exports Have A Major Influence on Regional Resource Development



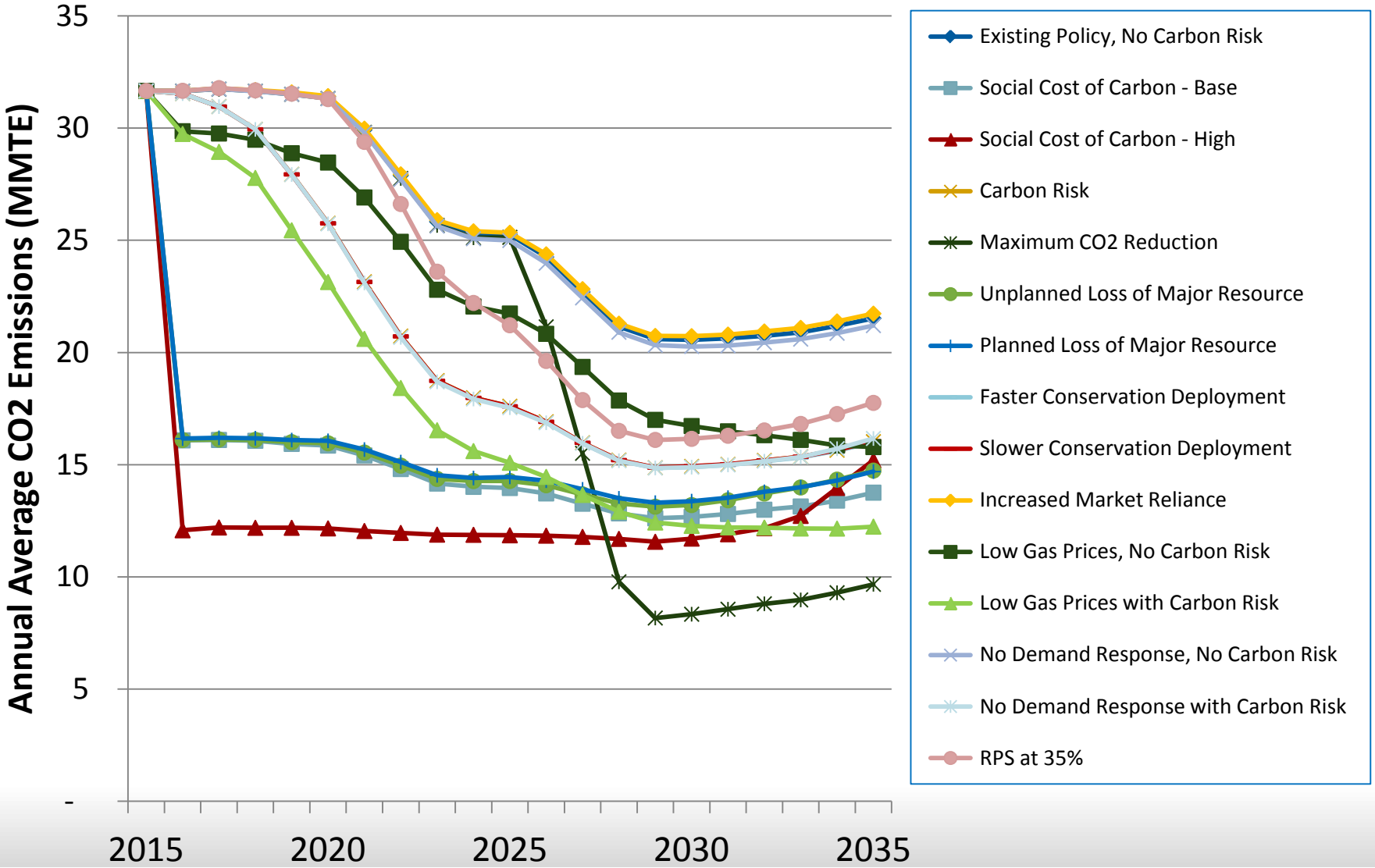
Key Finding:
There is A Very High Probability of Meeting EPA 111(d) Emissions Limits Across All Scenarios and Future Conditions Tested



Annual Average CO2 Emissions by Scenario for 111(d) System

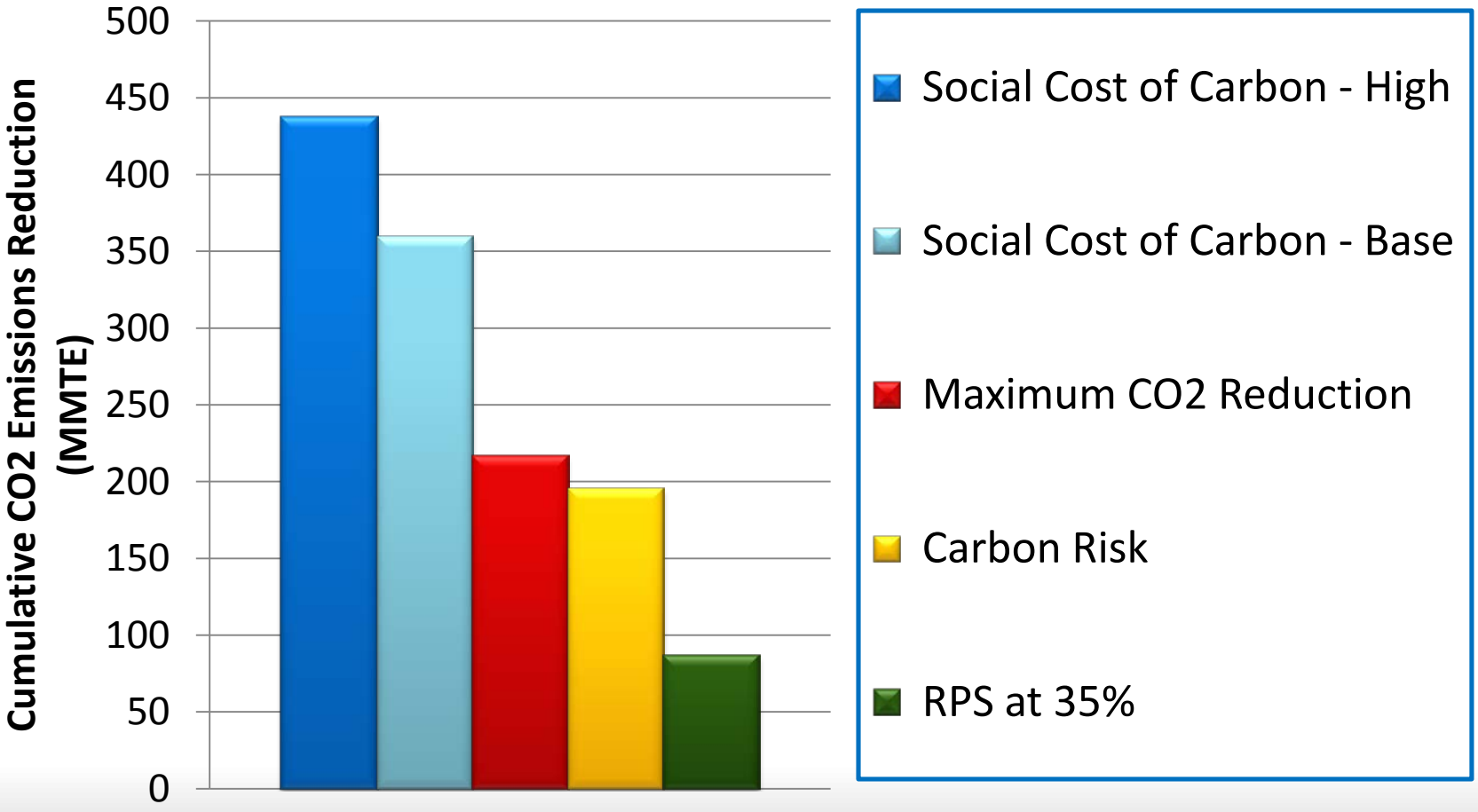


Annual Average CO2 Emissions by Scenario PNW Power System



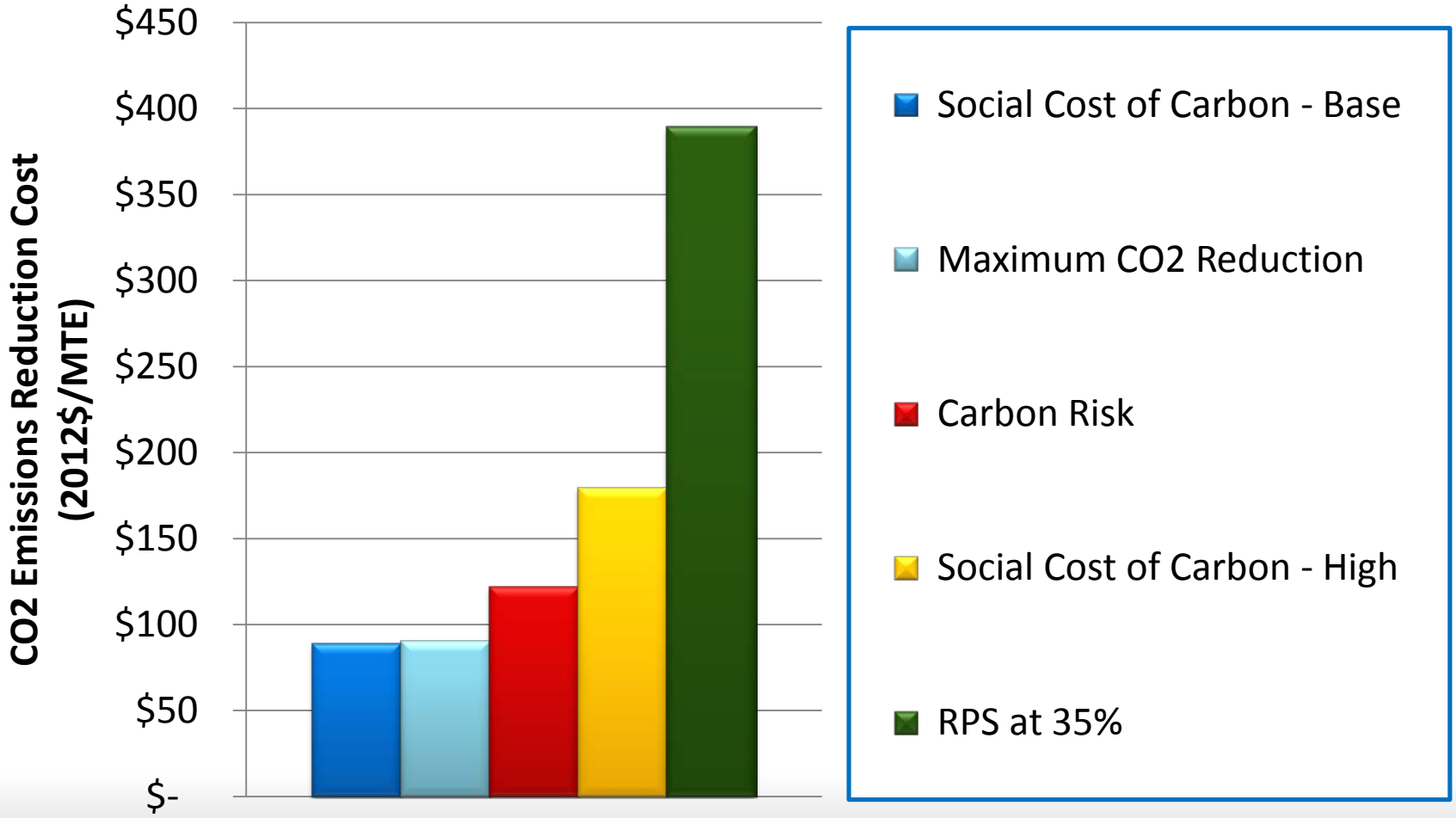
Key Finding:

The Largest PNW Power System Cumulative CO2 Emissions Reductions Occur Under Resource Strategies That Must Respond Immediately to Carbon Reduction Policies



Key Finding:

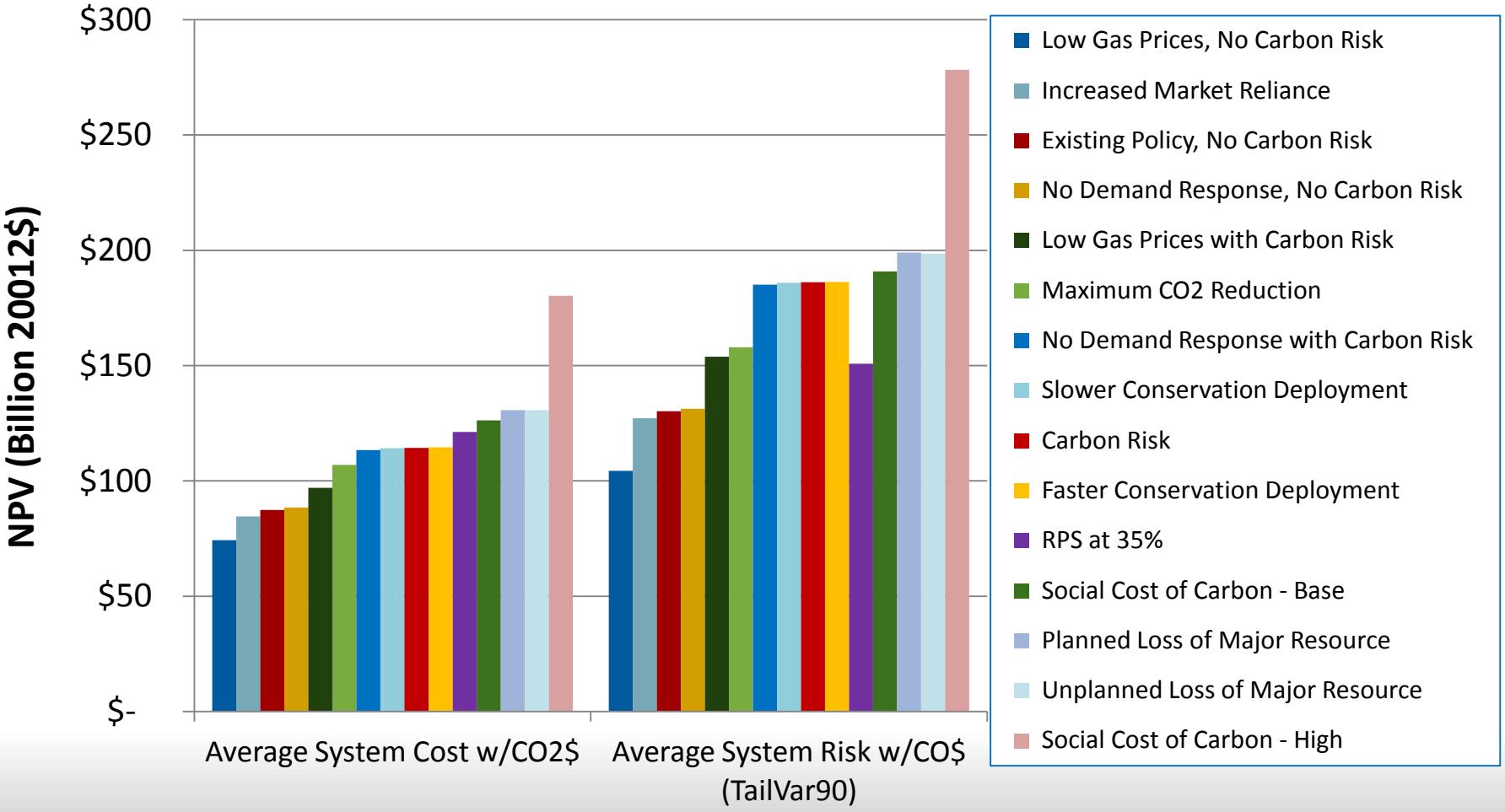
The Lowest Cost PNW Power System CO2 Emission Reduction Resource Strategies Are Those That Result From Adaptation to Carbon Cost or Direct Retirement of Coal and Inefficient Gas Generation



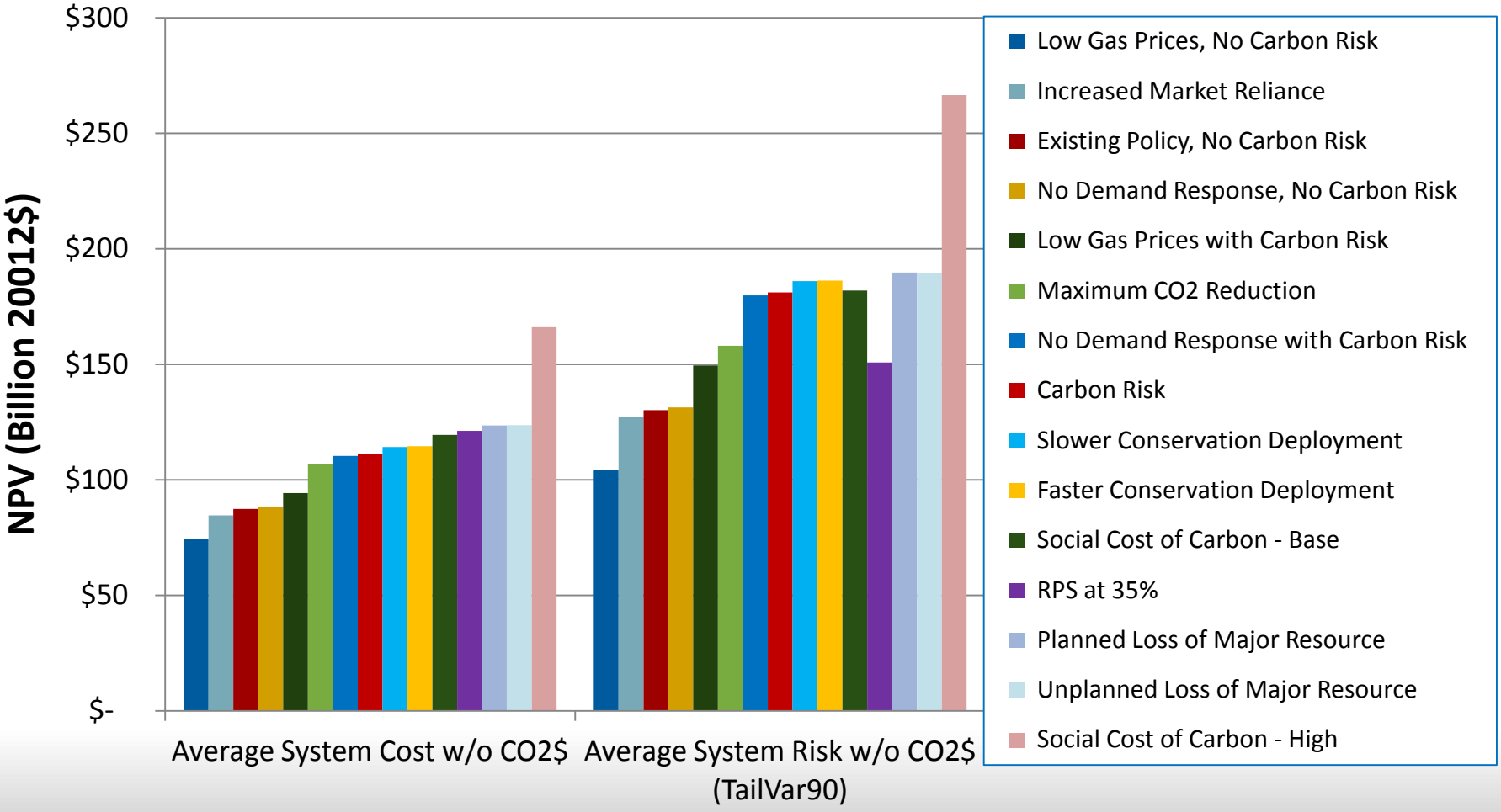
Seven Principle Elements

- Develop Conservation
  - 1400 aMW by 2021
  - 3100 aMW by 2026
  - 4500 aMW by 2035
- Expand Use of Demand Response
  - Prepare to develop 700 MW by 2021
- Satisfy Existing Renewable Portfolio Standards
- Option gas-fired generation for capacity and other ancillary services as dictated by local utility circumstances
- Reducing regional exports in order to serve in-region energy and capacity demand can result in lower total NPV System Cost and less need for new resource development
- Expand Resource Alternatives (EE & Non-GHG emitting)
- Monitor and Be Prepared to Adapt to Changing Conditions

Net Present Value System Cost and Risk <u>with</u> Carbon Cost Included



Net Present Value System Cost and Risk <u>without</u> Carbon Cost Included

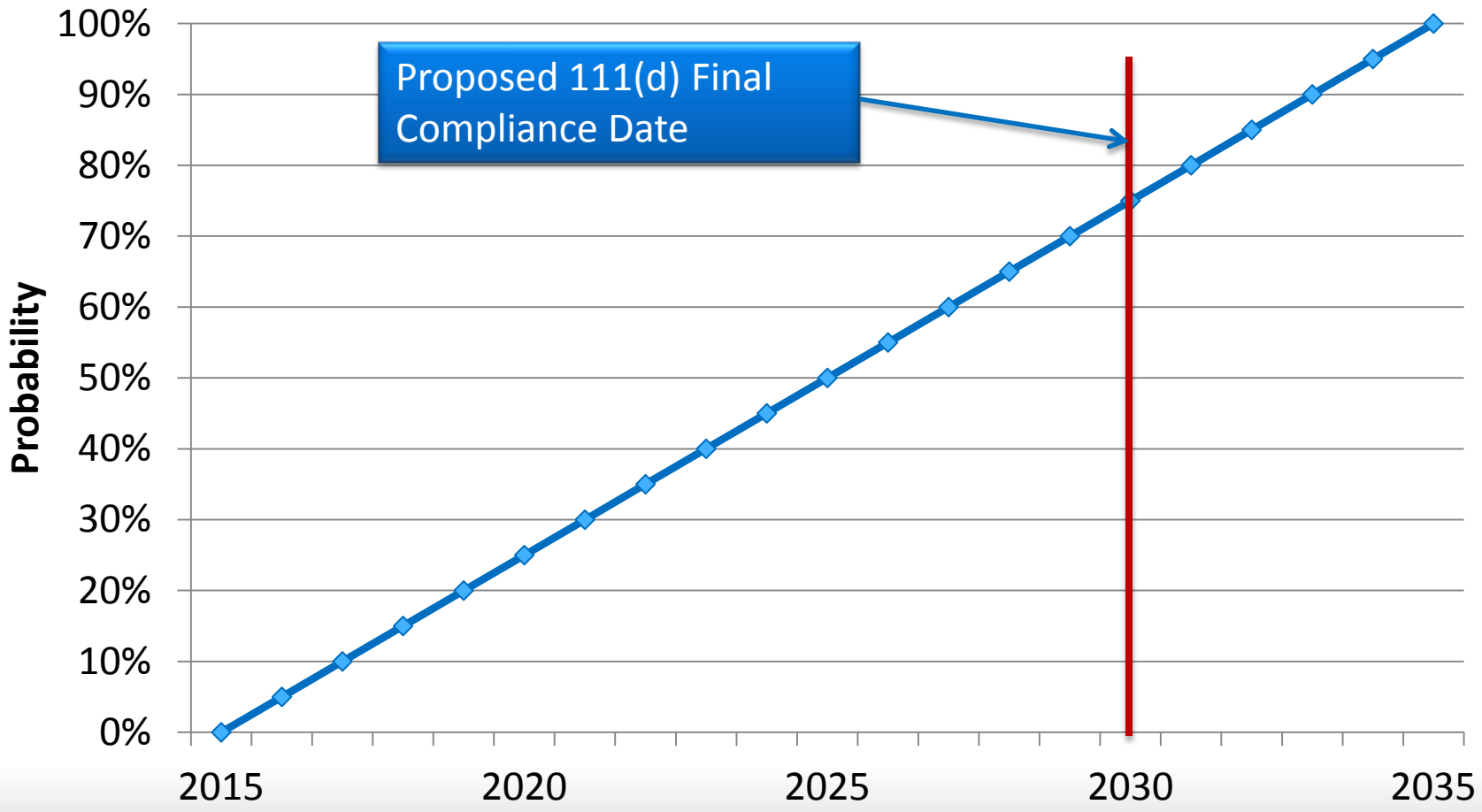


Next Steps

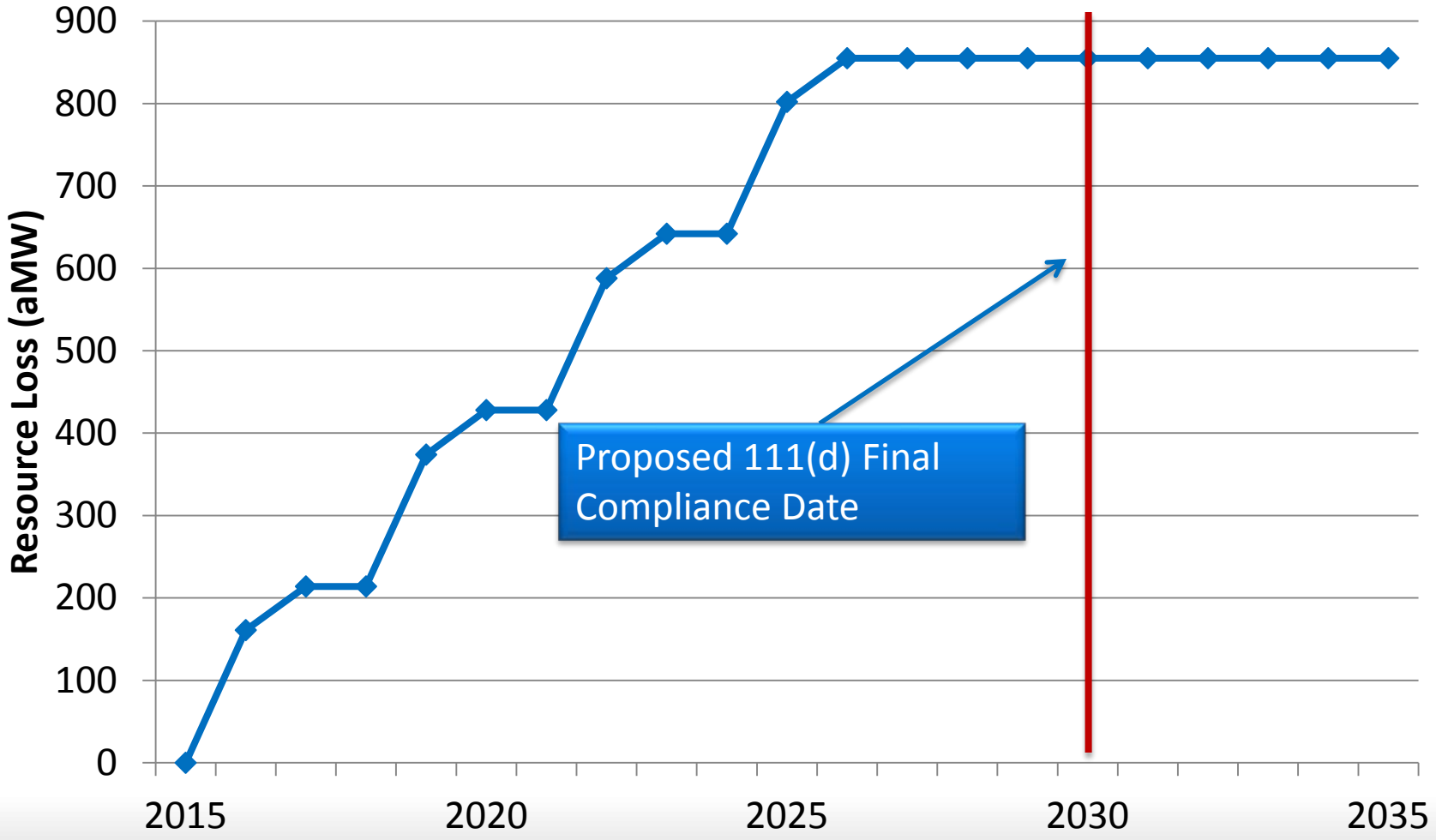
- Power Committee Meeting August 11th
  - Review Draft Plan Chapters
  - Review Proposed Major Elements of Draft Resource Strategy
- August 21st and/or 28th Webinars
  - Review Scenario 3B "Narrative"
    - Emerging technology options for further reducing PNW Power System CO2 Emissions
  - Review Proposed Draft Resource Strategy

Backup Slides

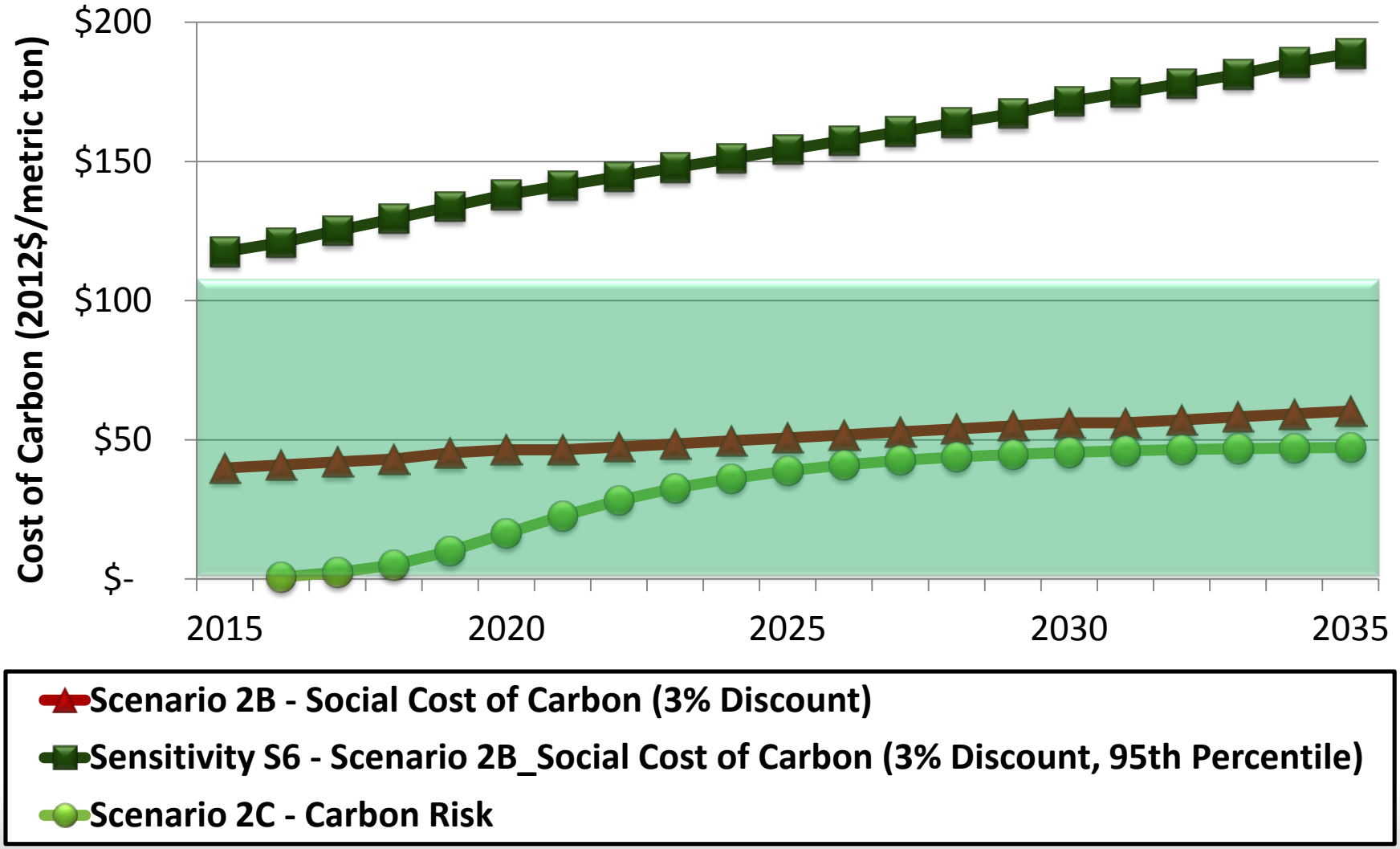
Scenario 4A –
Assumed Probability of Resource Loss By Year



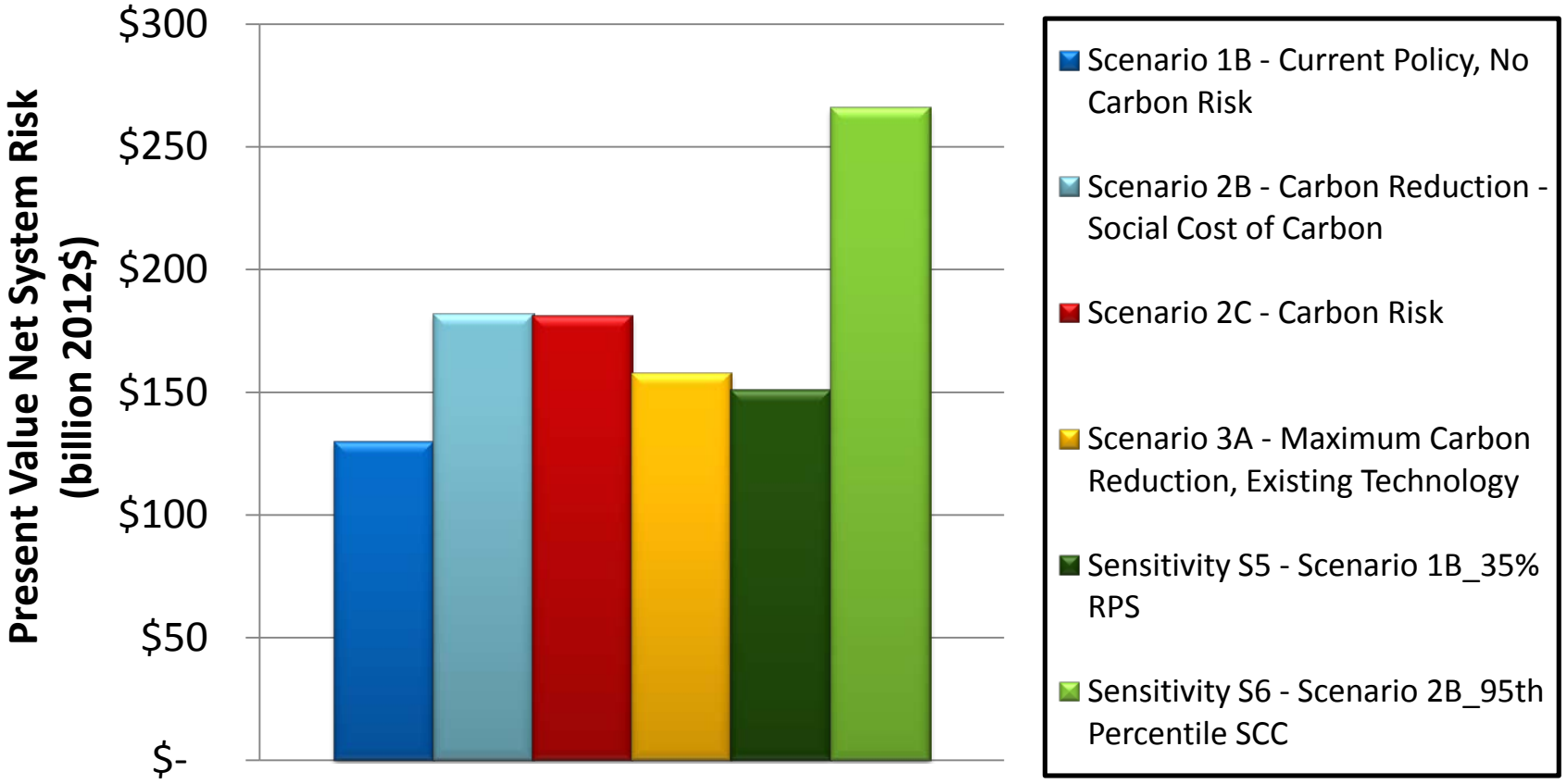
Scenario 4B – Assumed Resource Loss by Year



Carbon Cost Assumptions Used in Scenario Analysis



The Average Present Value Net System Risk for Least Cost Strategies *Without* Carbon Cost*

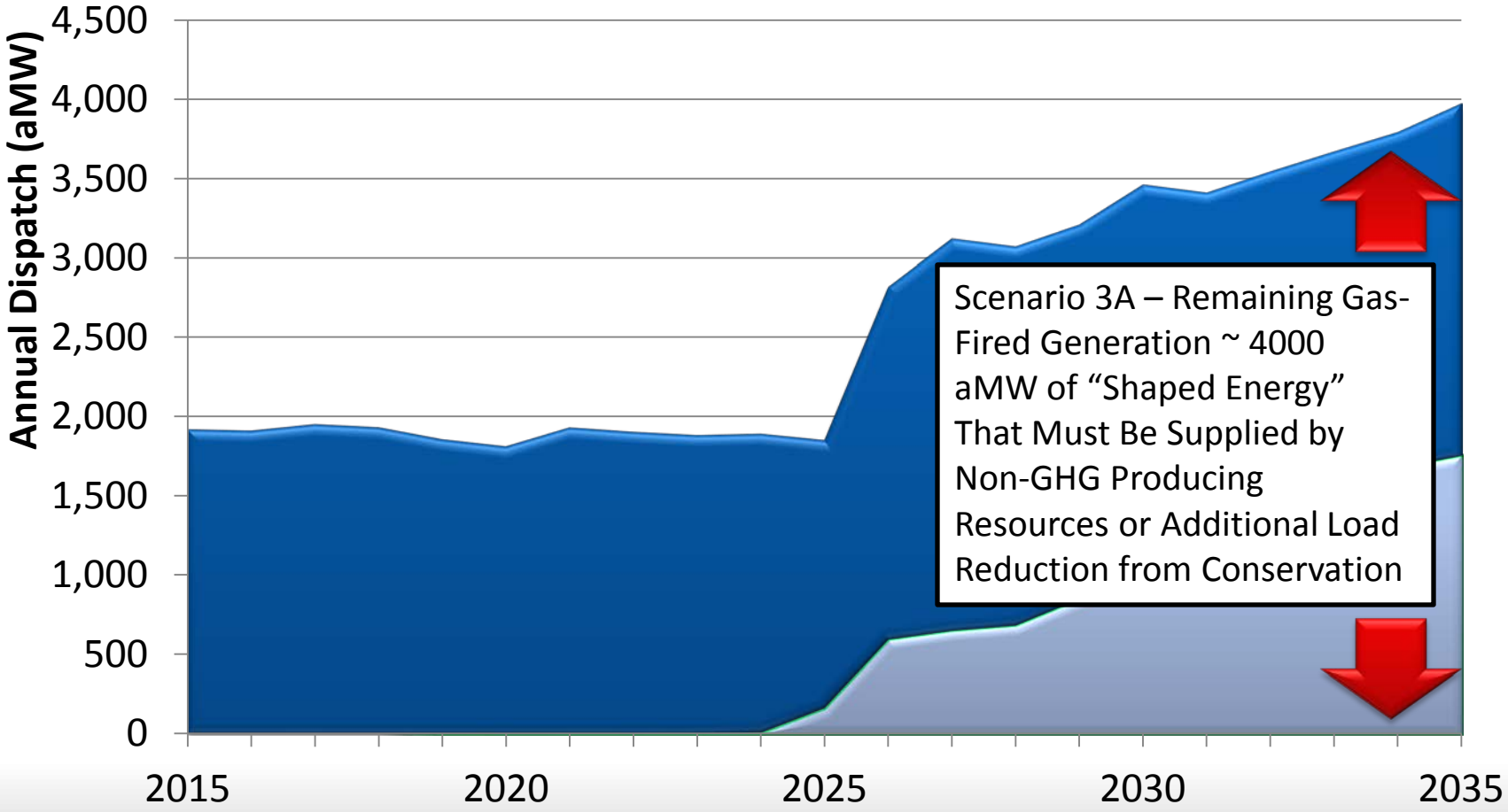


*Carbon "tax" revenues were subtracted from the NPV System Cost to assess the actual resource portfolio cost, including capital, fuel and other operating cost.

Sensitivity S1 – No Coal Plant Retirements Comparison to Scenario 1B – Existing Policies, No Carbon Risk

Resource/Metric	S1 – No Coal Plant Retirements
Energy Efficiency - 2021	- 5 aMW
Energy Efficiency - 2026	- 40 aMW
Energy Efficiency - 2035	- 140 aMW
Demand Response – All years	Small (15 - 25 MW) Decrease
Renewable Resource – All years	No Change
Coal Generation - 2026	+ 1,245 aMW
Coal Generation - 2035	+1,590 aMW
Existing Gas Generation - All years	Decreases by 140 – 440 aMW
New Gas Generation – 2035	-160 aMW
Exports - All years	Gradually Increases by 340 aMW to 930 aMW
PNW System CO2 Emissions - 2030	+ 10 MMTE
NPV System Cost	$-2 billion
NPV System Risk	$-7 billion

Scenario 3B – Carbon Reduction with Emerging Technology "The Energy Problem Statement"



Scenario 3B – Carbon Reduction with Emerging Technology "The Capacity Problem Statement"