# Update on Model Results

August 4, 2015

# Scenarios

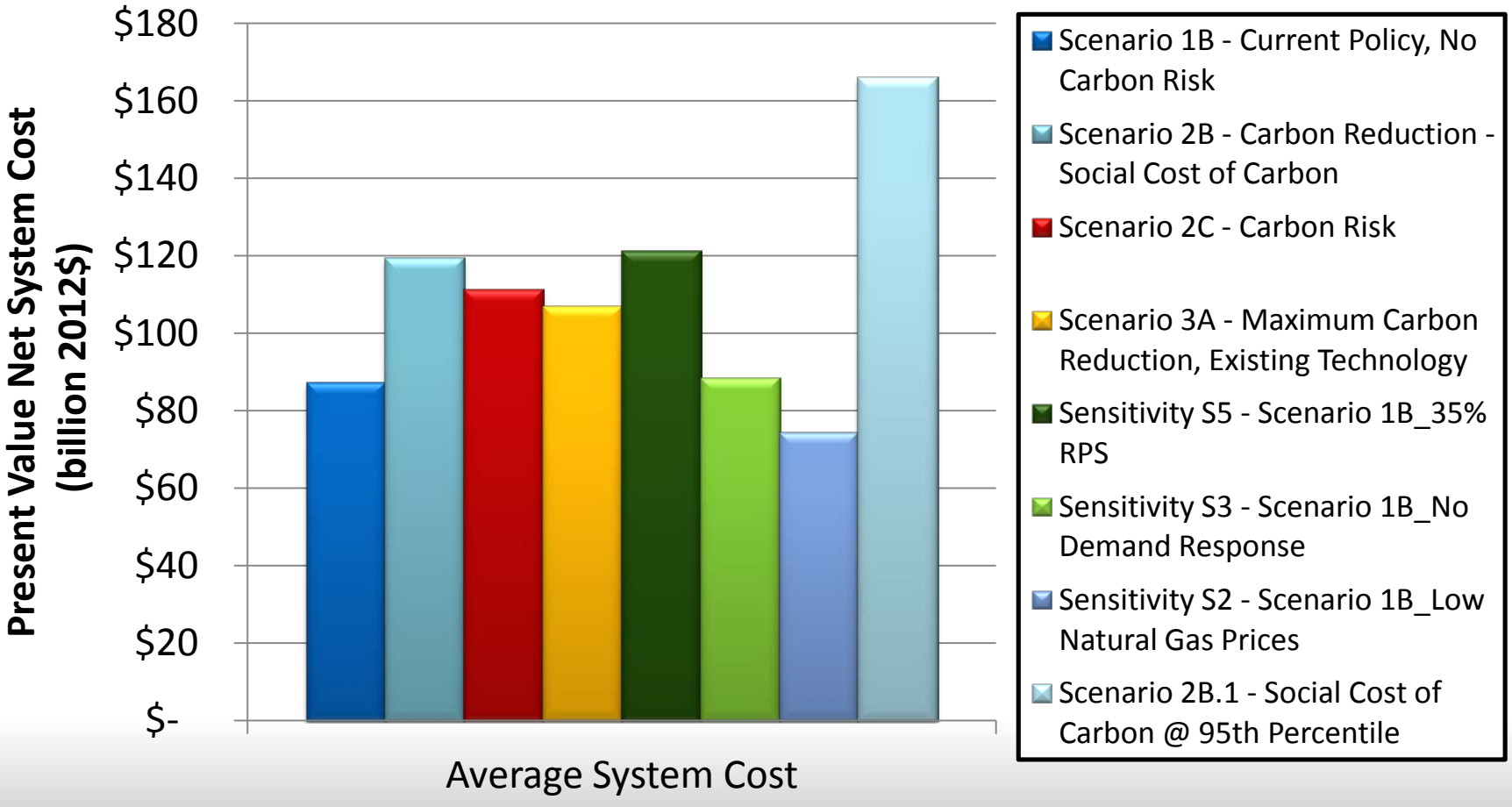
- Scenario 1B – Existing Policies, No Carbon Risk
- Scenario 2B – Social Cost of Carbon
- Scenario 2C – Carbon Risk
- Scenario 3A – Maximum Carbon Reduction with Current Technology
- Scenario 4A – Unplanned Loss of Major Non-GHG Emitting Resource
- Scenario 4B – Planned Loss of Major Non-GHG Emitting Resource
- Scenarios 4C and 4D – Alternative Conservation Near Term Maximum Acquisition Rates
- Scenario 5B – Increased Reliance on External Regional Market

# Sensitivity Studies

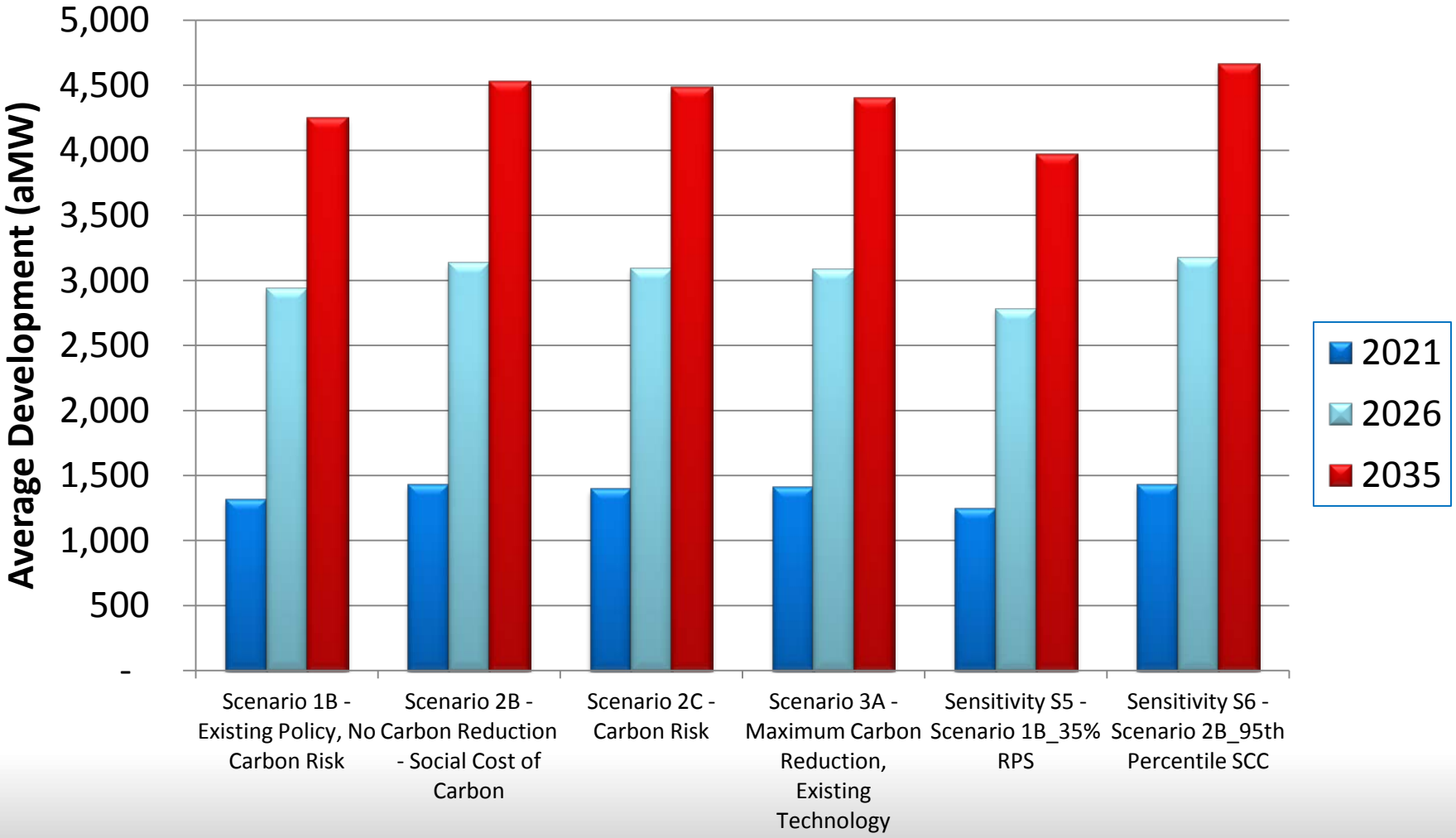
- Sensitivity S1 – No Coal Plant Retirements
- Sensitivity S2 – Scenario 1B w/Lower Natural Gas Prices
- Sensitivity S2.1 – Scenario 2C w/Lower Natural Gas Prices
- Sensitivity S3 – Scenario 1B w/o Demand Response (DR)
- Sensitivity S3.1 – Scenario 2C w/o Demand Response (DR)
- Sensitivity S5 – Scenario 1B - 35% RPS
- Sensitivity S9 – Scenario 1B – No "T&D" Deferral Credit
- Scenario 2B.1 – Social Cost of Carbon @ 95$^{th}$ Percentile estimate of damage cost (Added to the list of sensitivity studies after seeing 3A results)

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

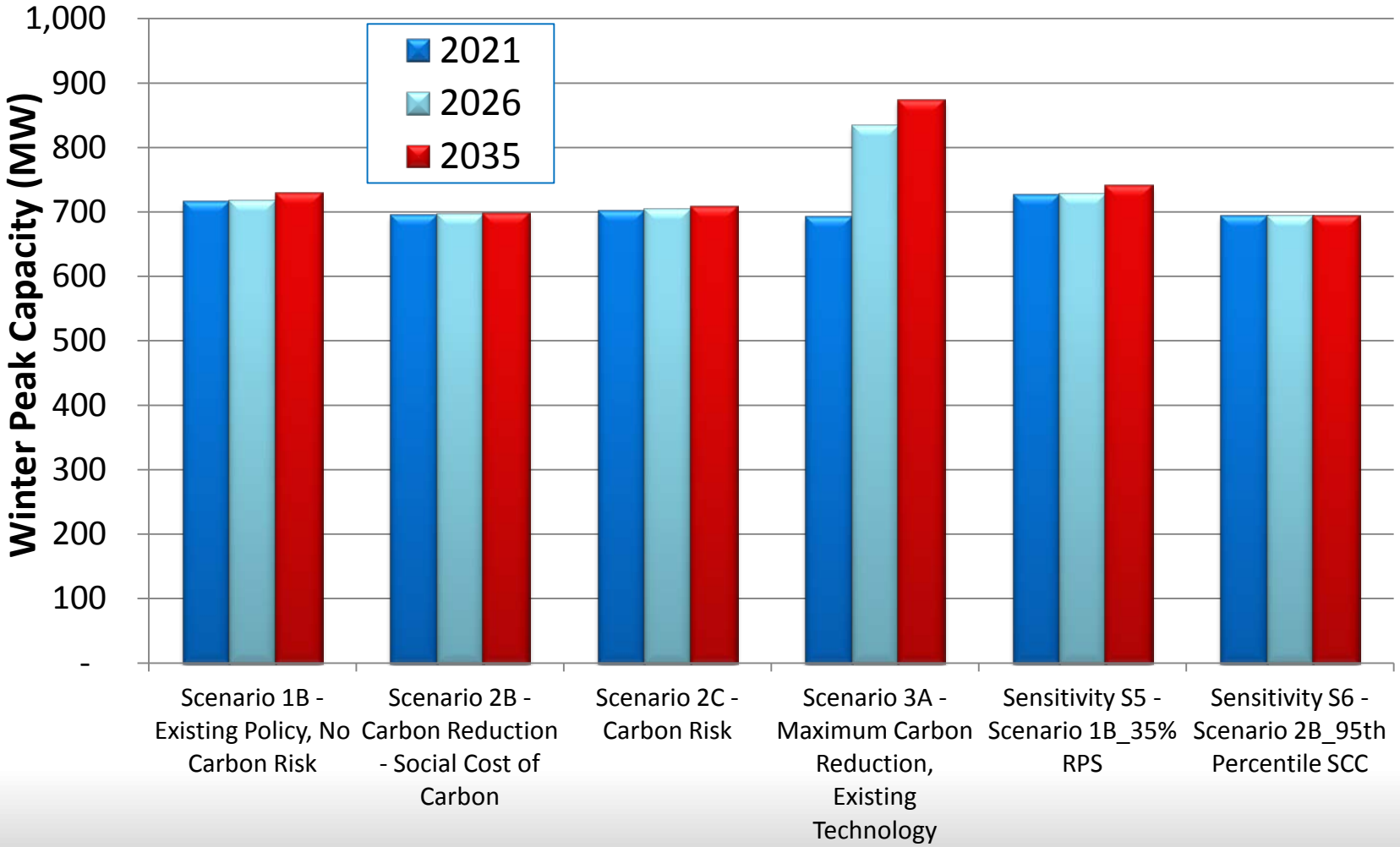
## NPV System Cost for Scenarios Vary Over a Wide Range – Primarily Due to the Cost of Carbon Emissions Reductions



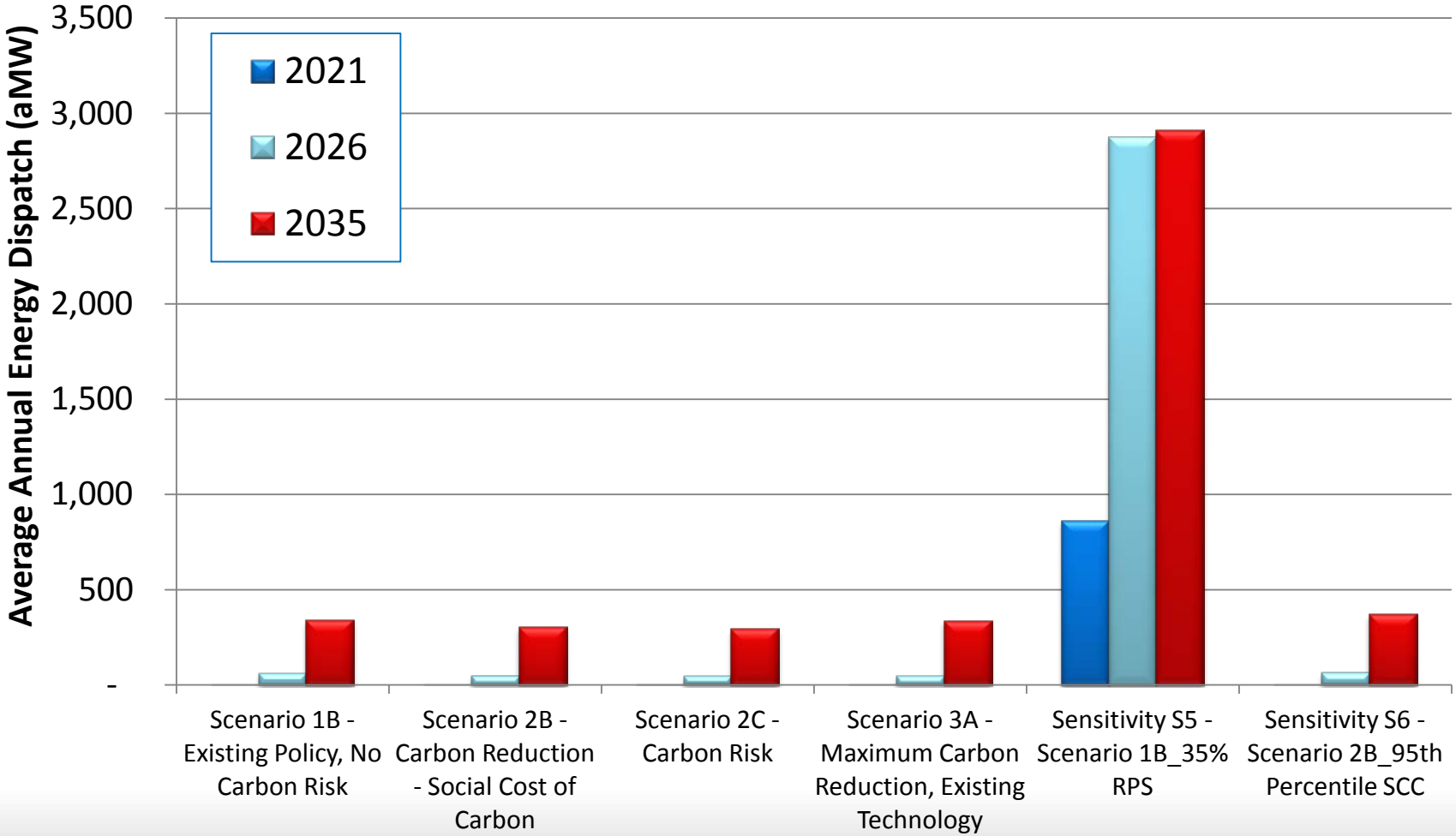
# Average Conservation Development Under Alternative Carbon Emissions Reduction Policies Is Very Similar, Except for RPS @ 35% Policy Which Develops Less Energy Efficiency Than Base Scenario



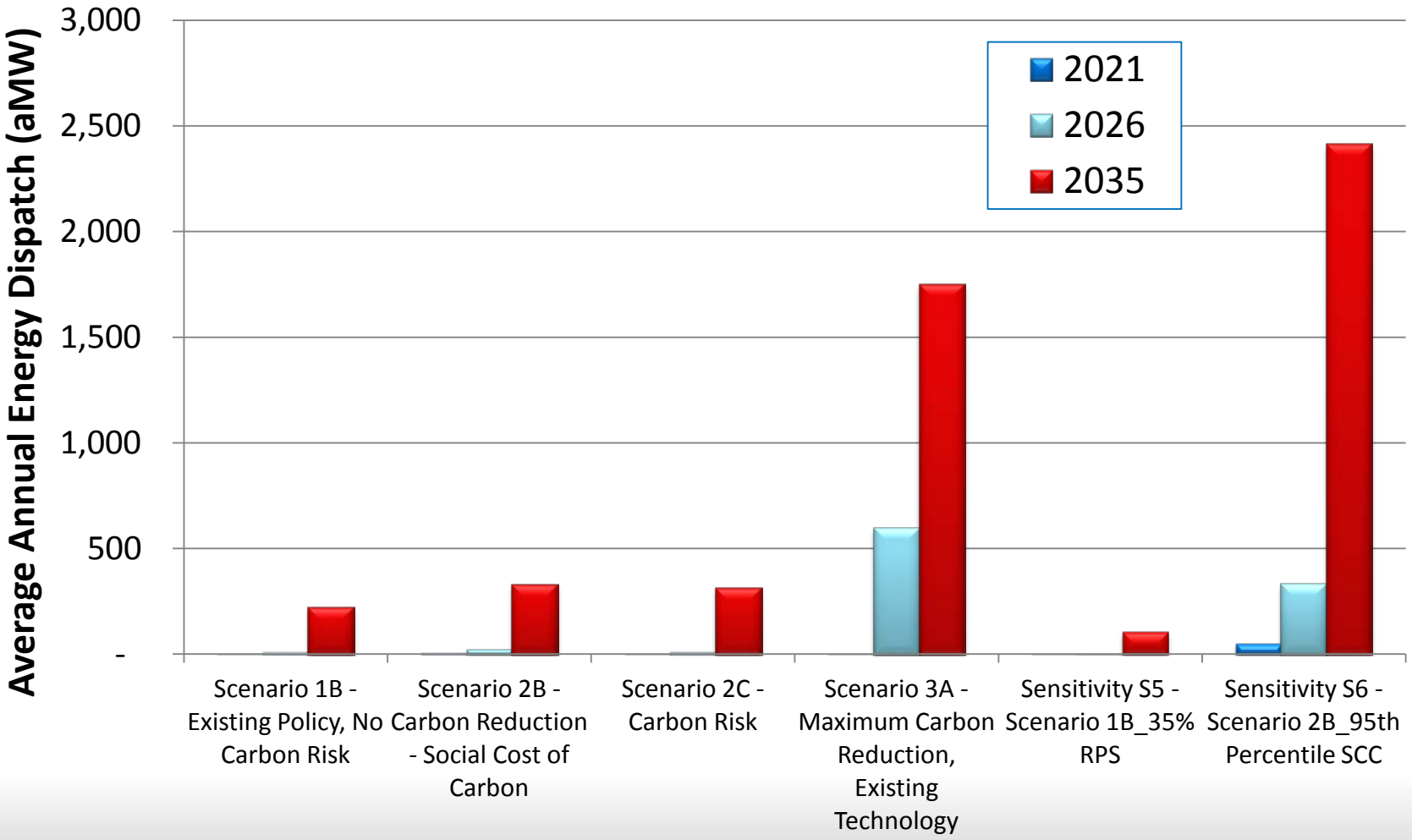
# Average Demand Response Development Under Alternative Carbon Emissions Reduction Policies is Similar To Base Scenario, Except for Post-2026 in the Maximum Carbon Reduction Scenario Policy (3A)



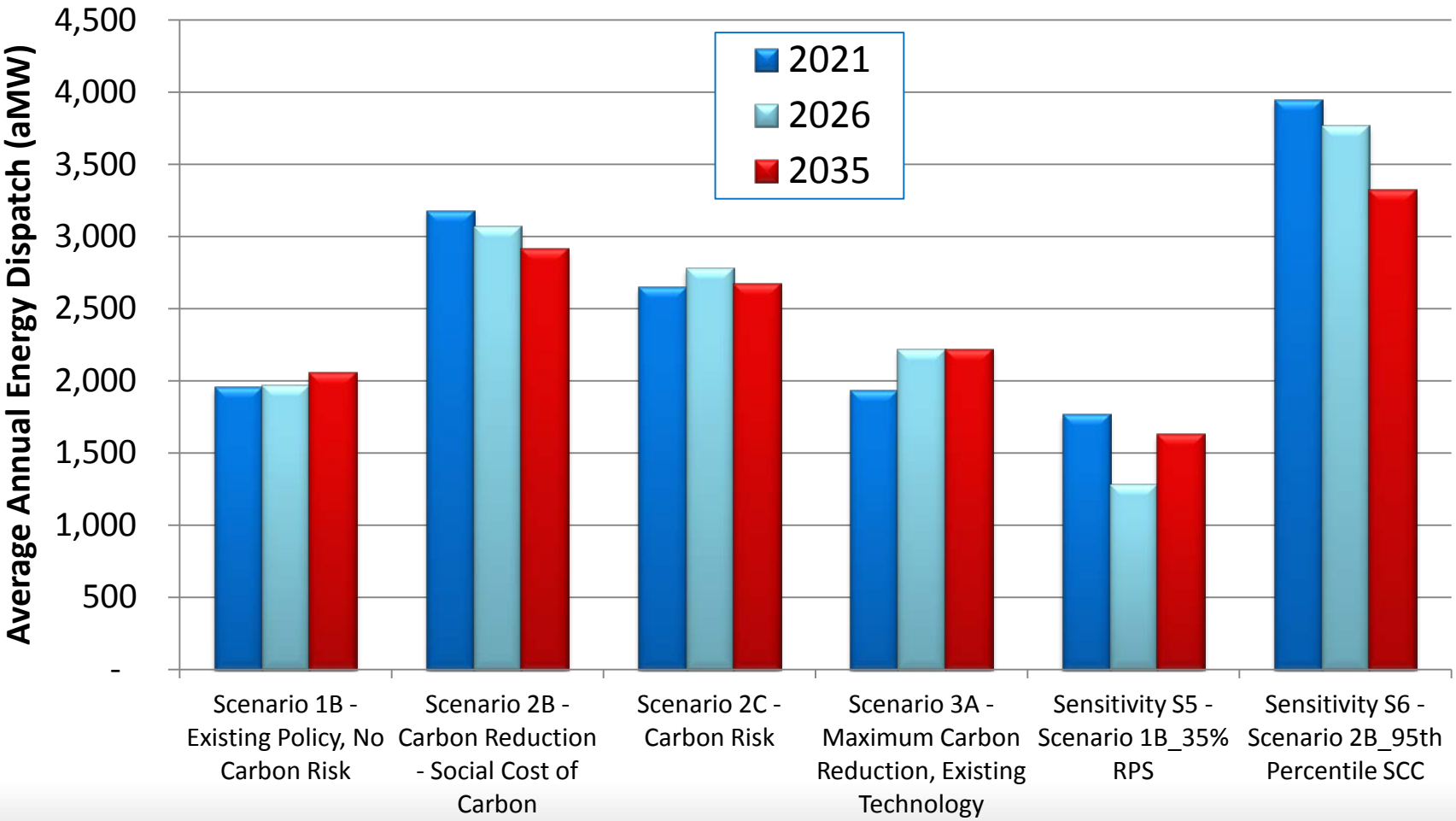
# Average Renewable Resource Development Under Alternative Carbon Emissions Reduction Policies Is Very Similar to the Base Scenario, Except for the RPS @ 35% Policy



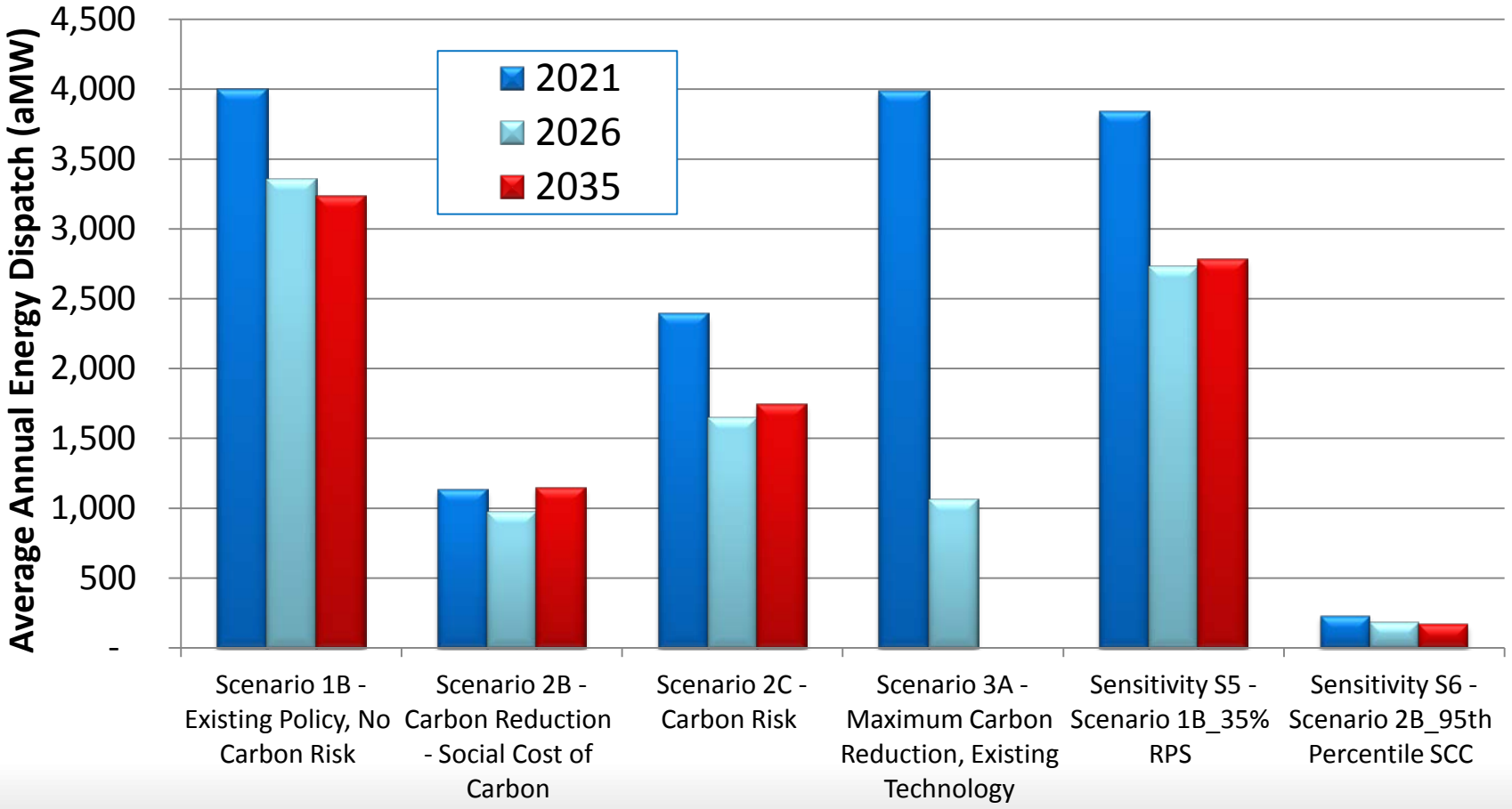
# Average New Gas Generation Development Under Alternative Carbon Emissions Reduction Policies Is Very Similar To the Base Scenario, Except for the Maximum Emissions Reduction Scenario (3A) and Social Cost of Carbon at the 95th Percentile Policies



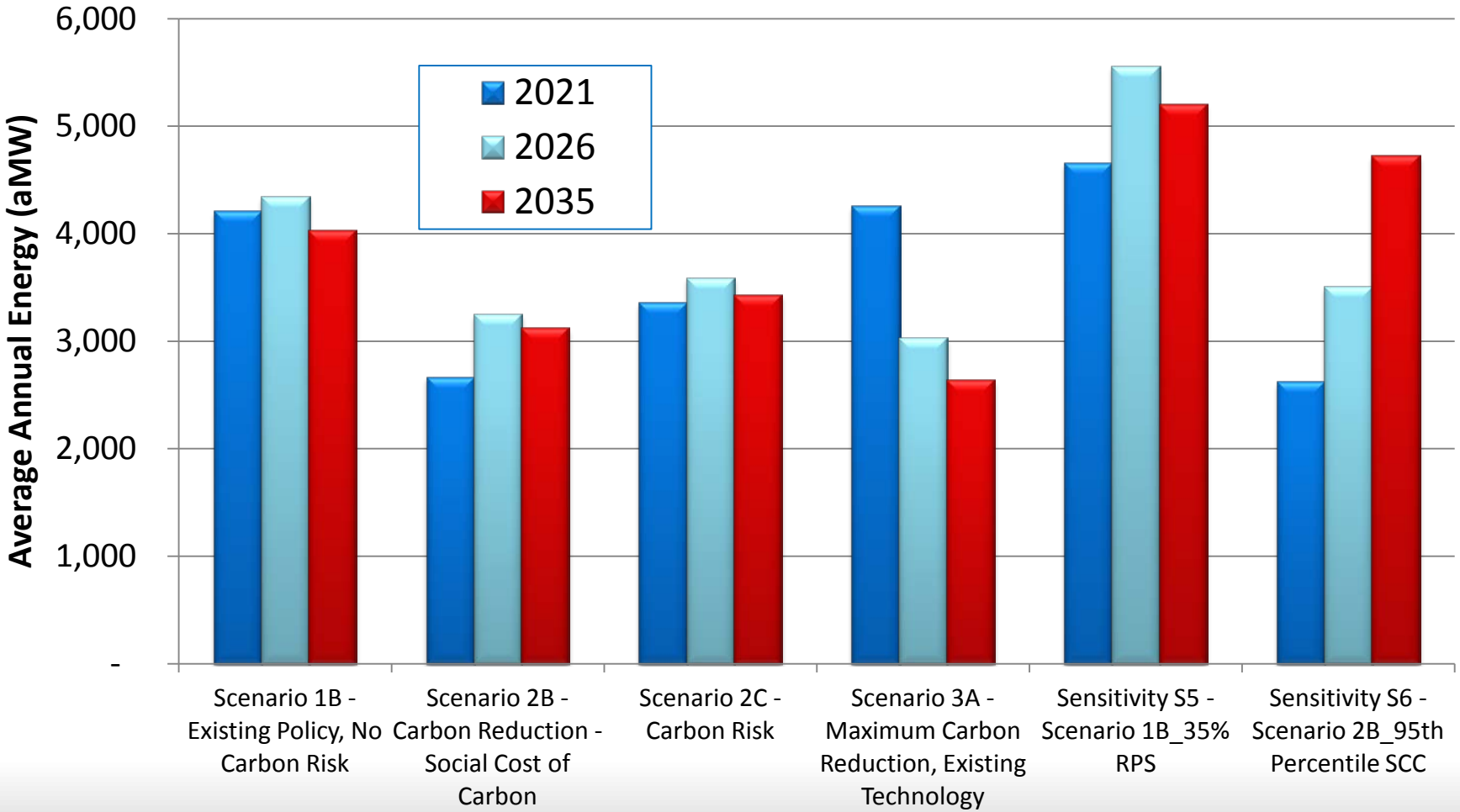
# Average Existing Gas Generation Dispatch Under Alternative Carbon Emissions Reduction Policies Is Generally Higher Than the Base Scenario, Except for the RPS @ 35% Policy



# 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

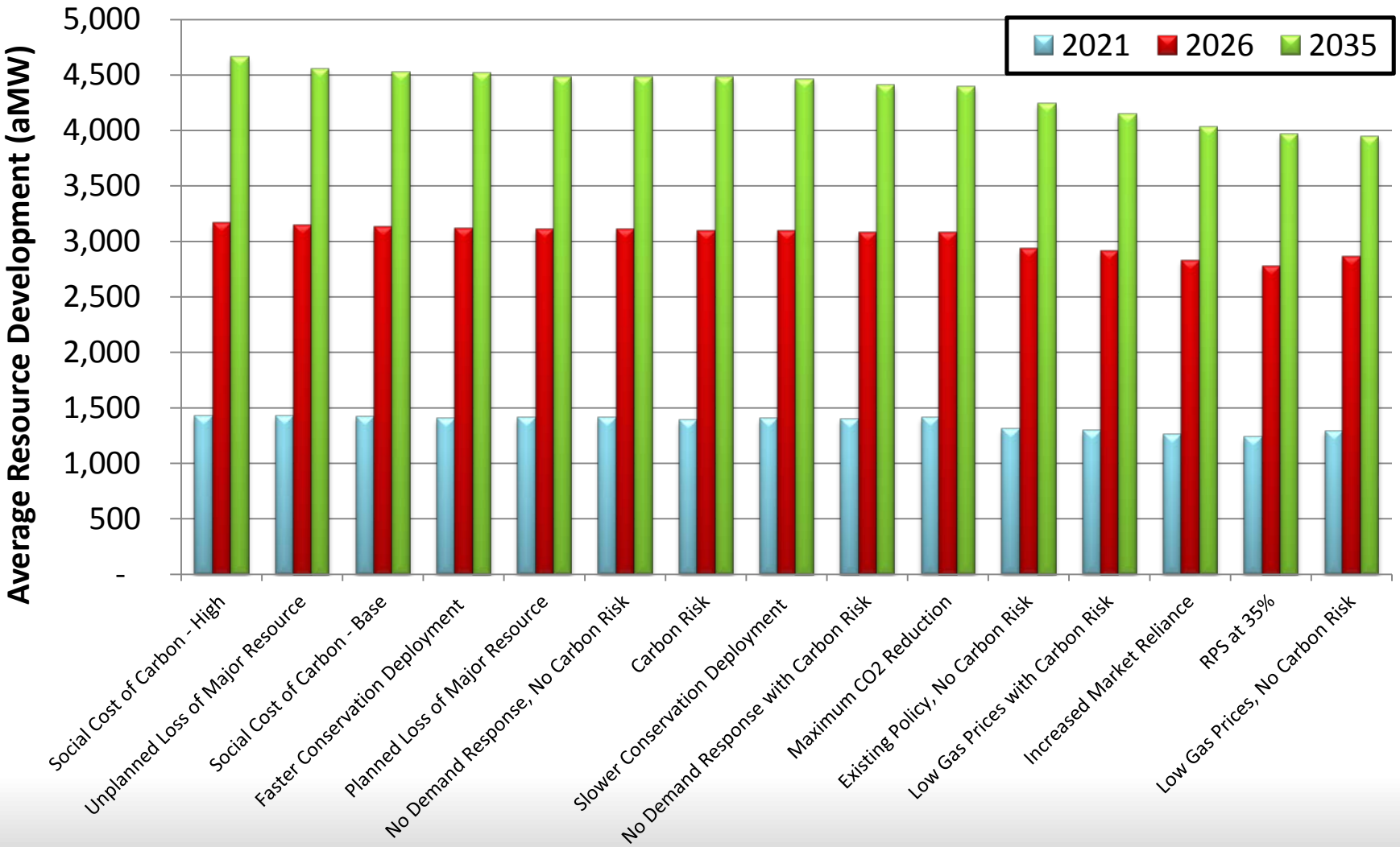


# Average Net Regional Exports Under Alternative Carbon Emissions Reduction Policies Are Generally Lower than the Base Scenario, Except for the RPS @ 35% Policy



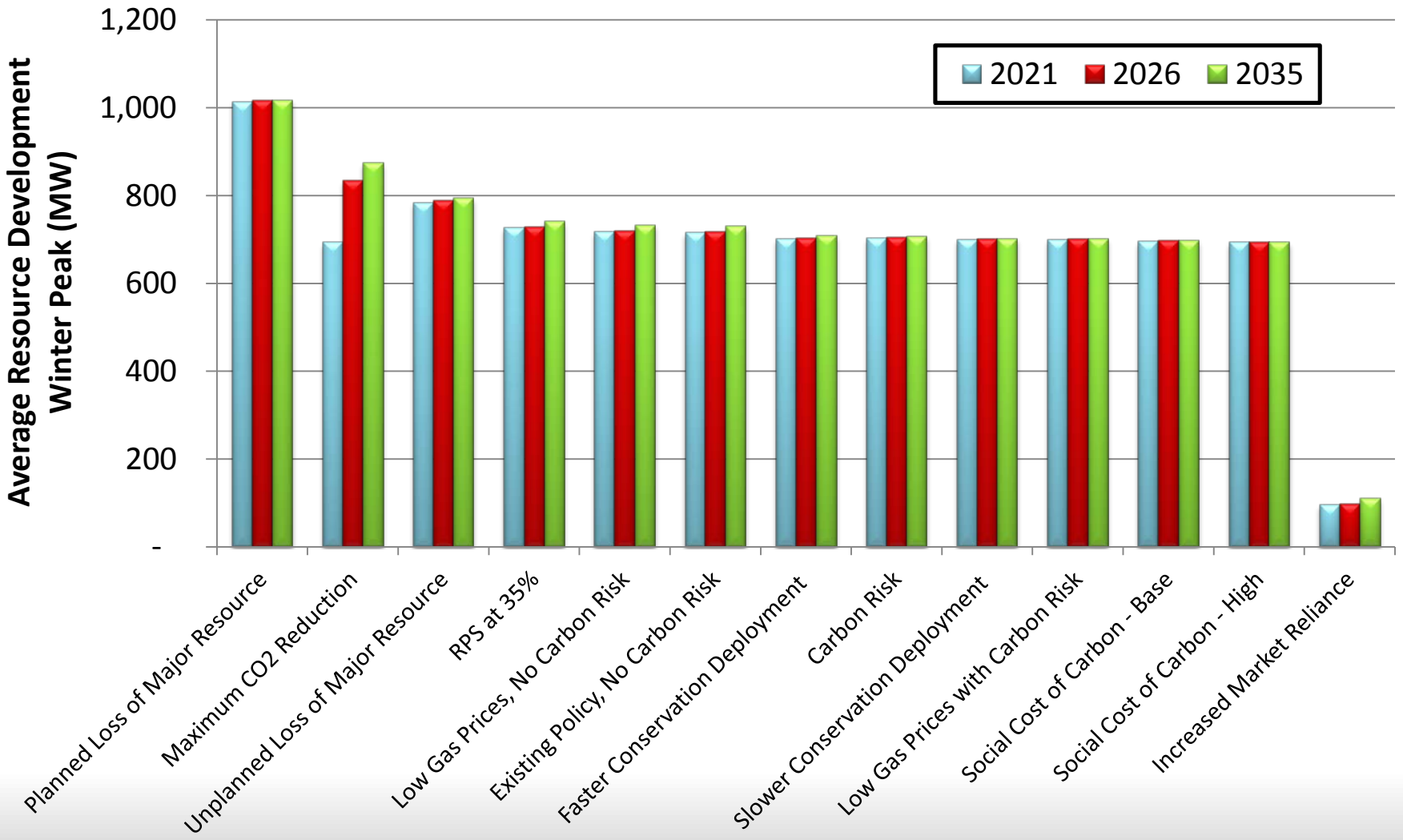
# Key Findings

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

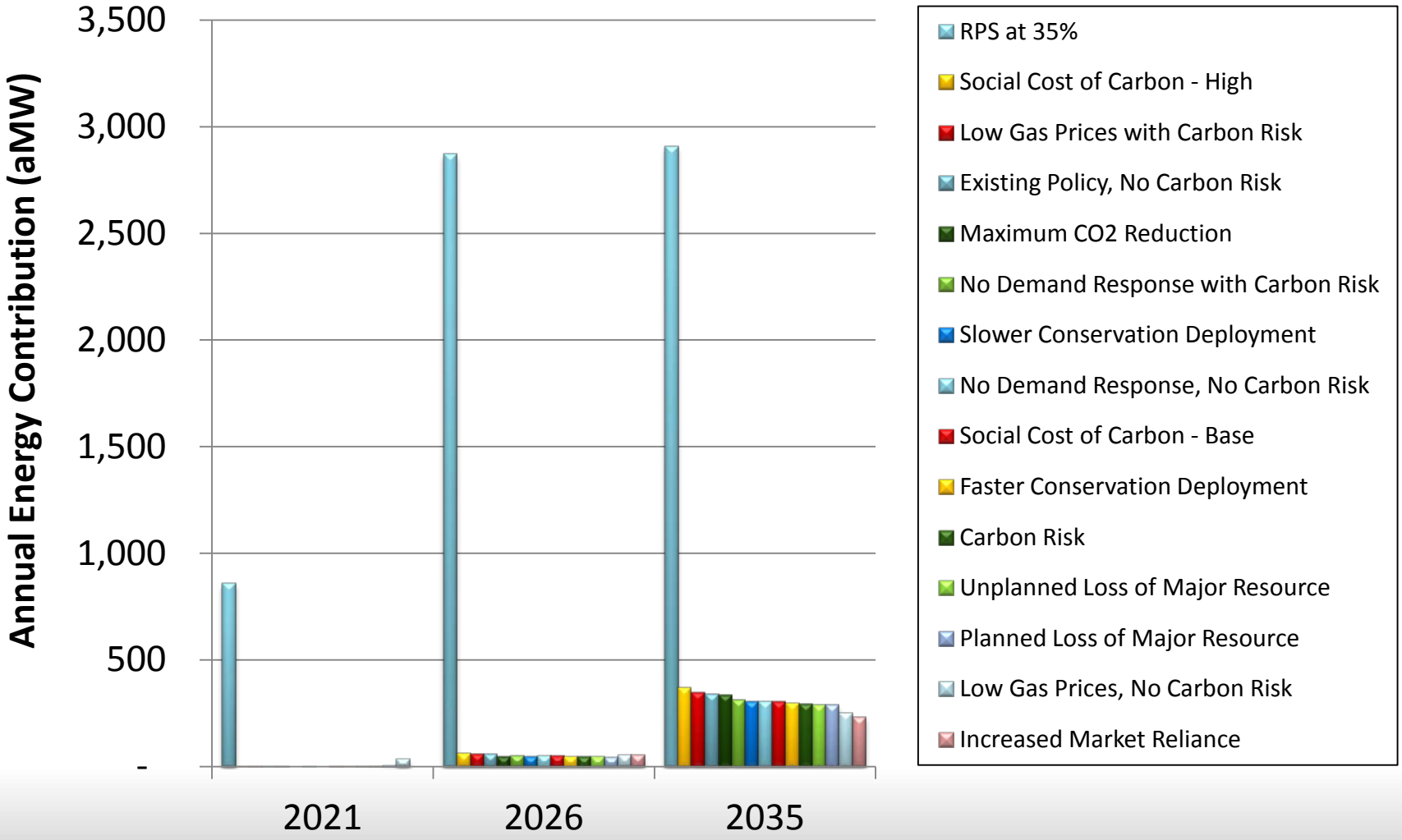


# Key Finding:

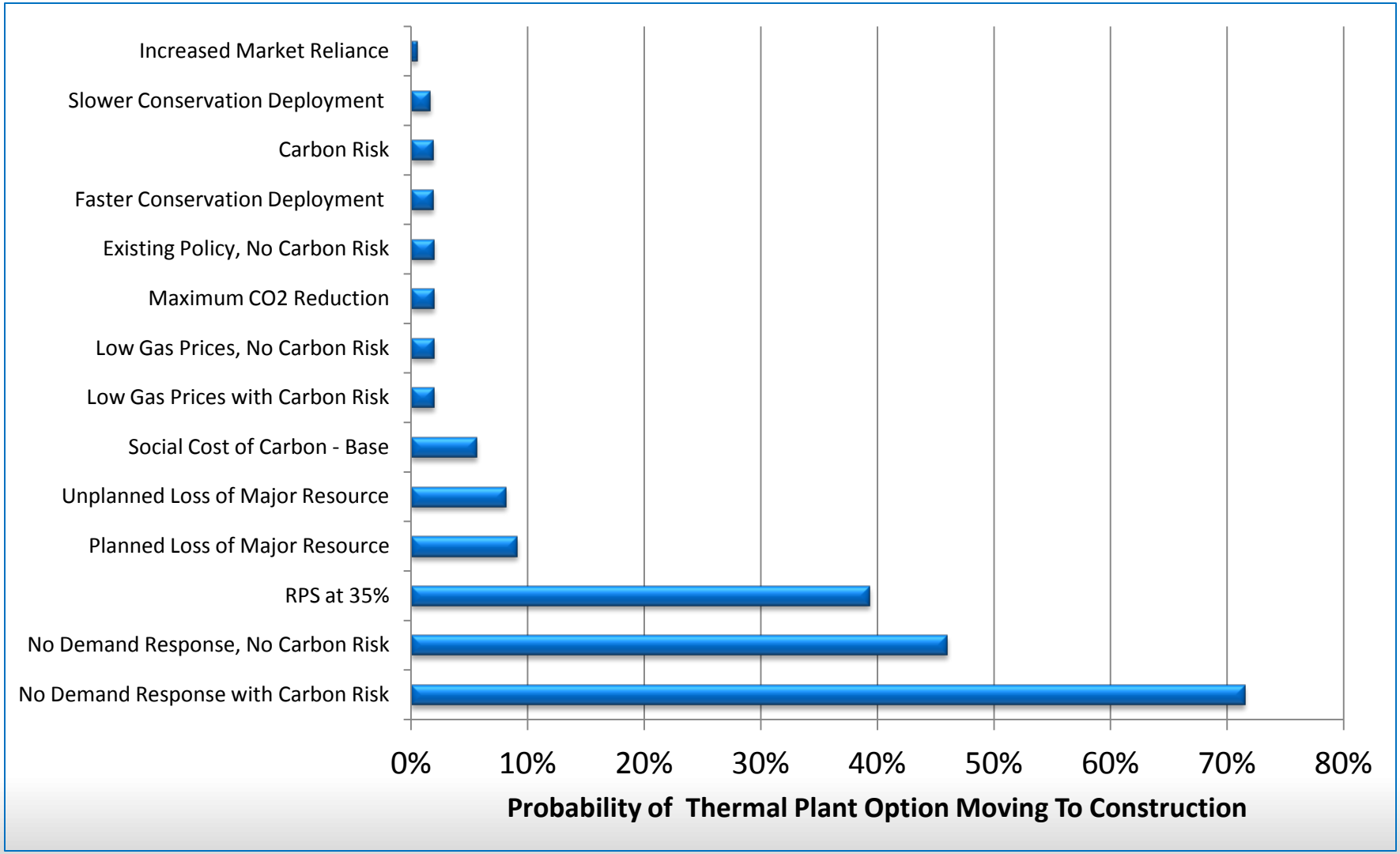
## Average Demand Response Development Across Scenarios Varies Little Across Scenarios Except in Scenarios with Major Resource Loss or Increased External Market Reliance



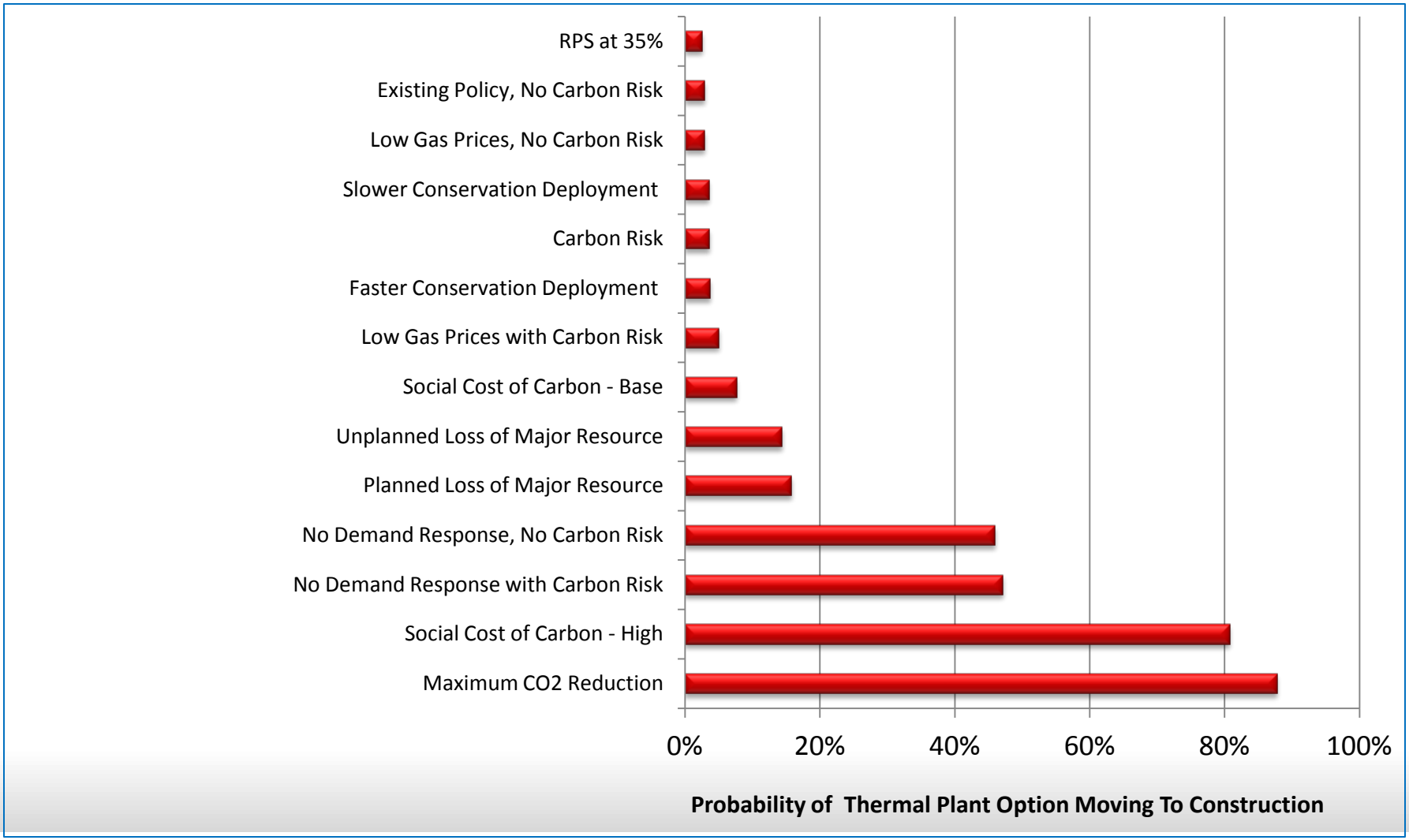
# Key Finding:
# Average New Renewable Resource Development Does Significantly Increase In Carbon Emissions Reduction Policy Scenarios Except For A Policy That Sets Renewable Portfolio Standard at 35%



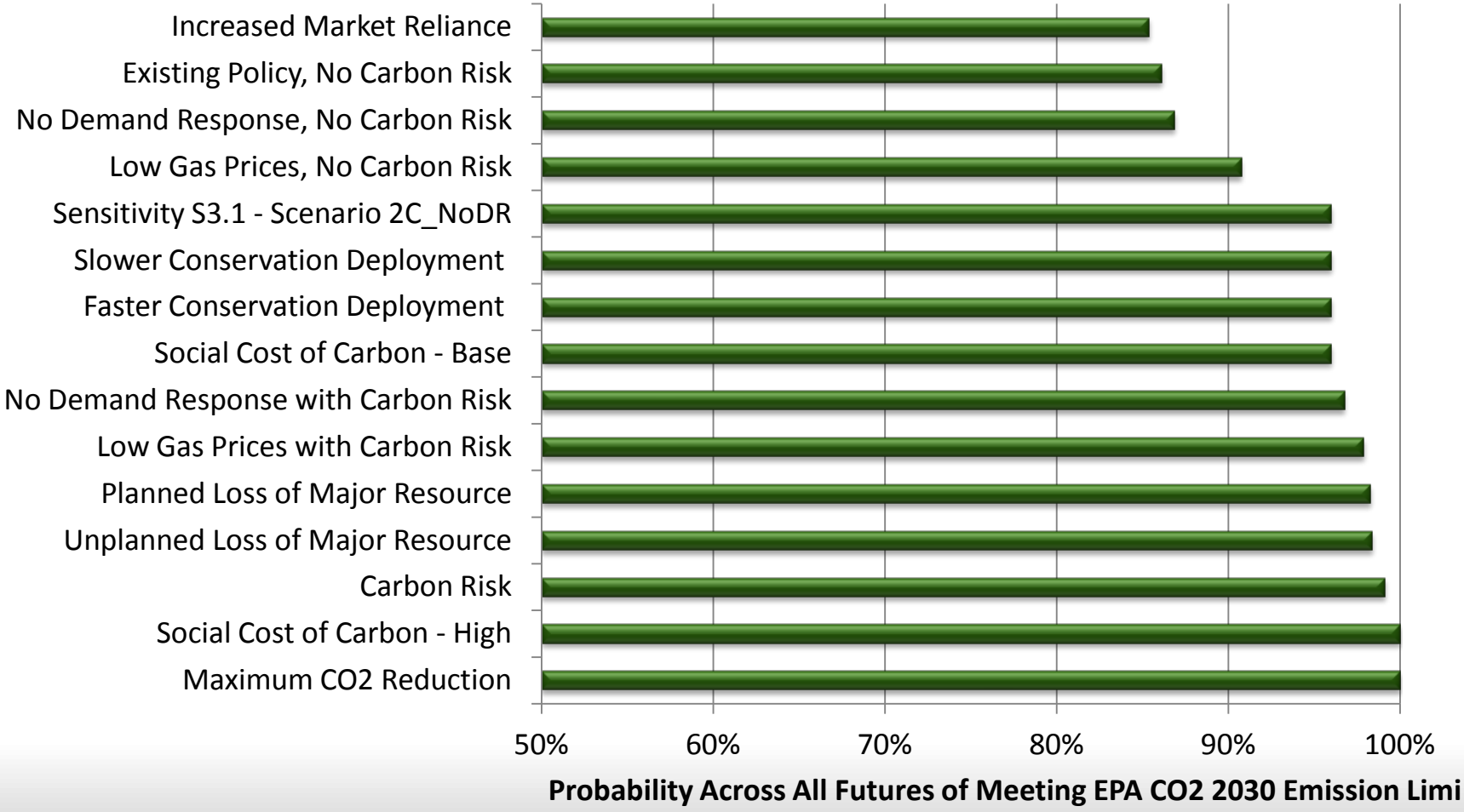
# Key Finding:
## There is a Low Probability of Any Thermal Development by 2021 Except Under Scenarios That Increase RPS or Do Not Develop Demand Response



# 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

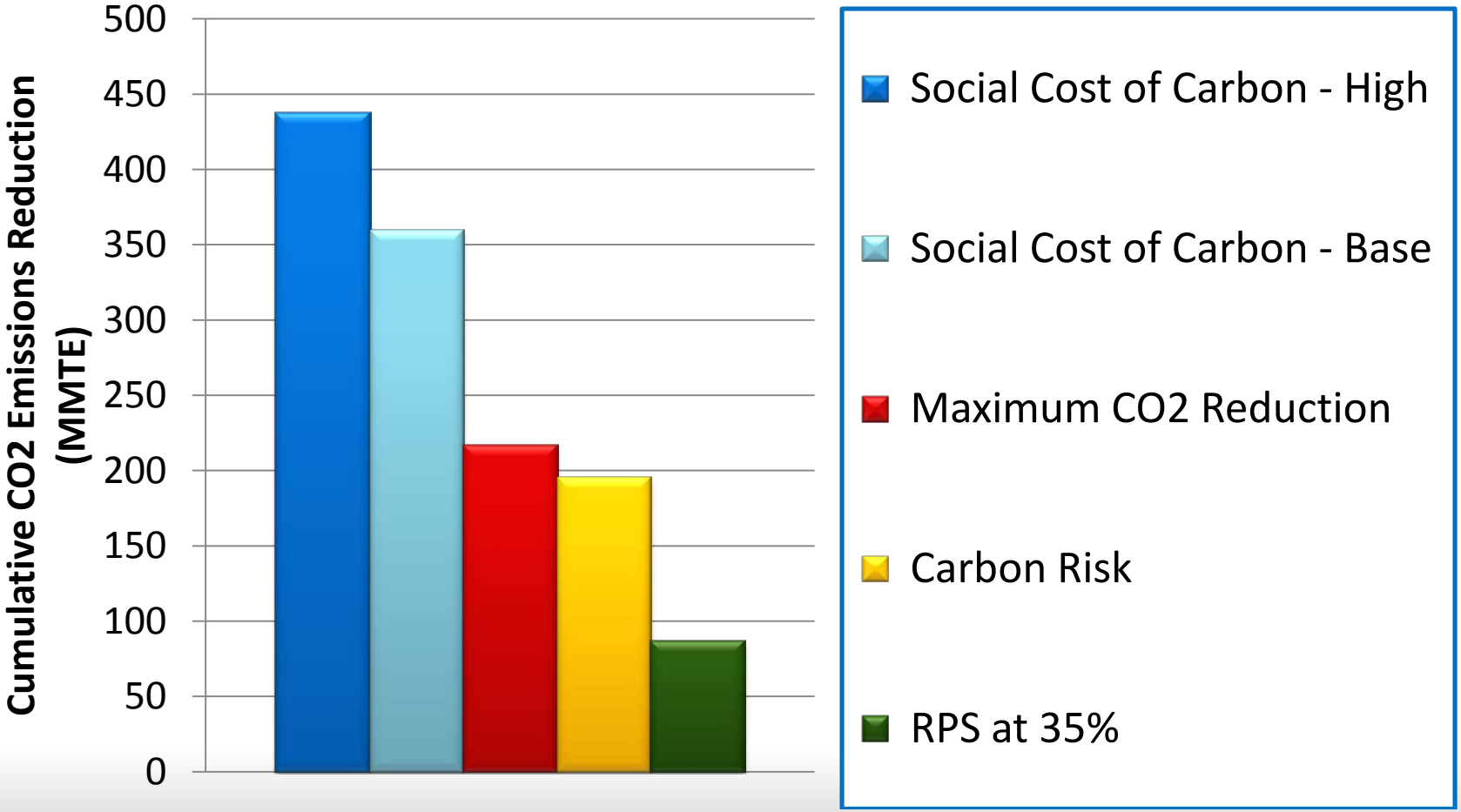


# Key Finding:
# There is A Very High Probability of Meeting EPA 111(d) Emissions Limits Across Nearly All Scenarios and Future Conditions Tested



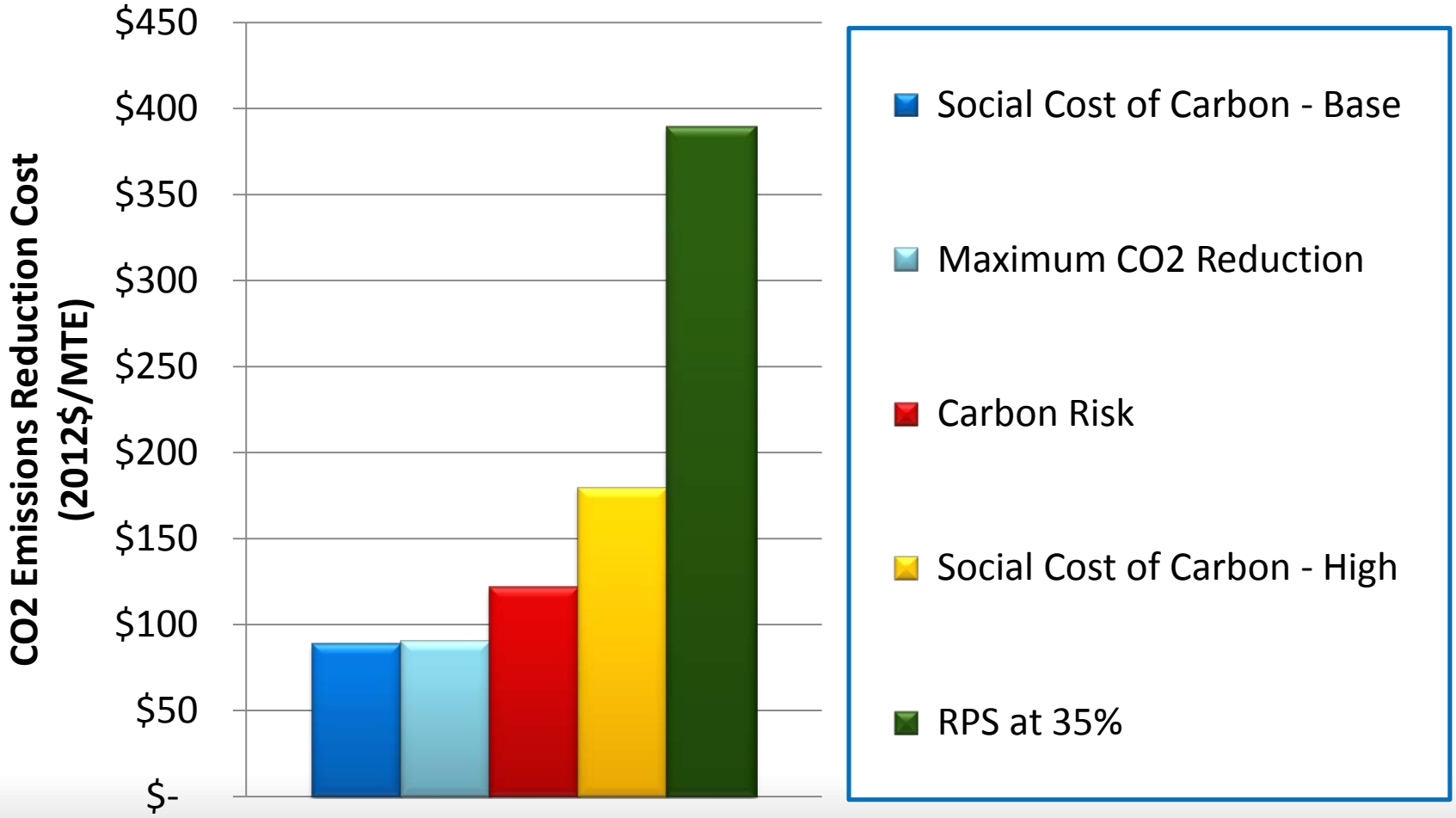
# Key Finding:

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

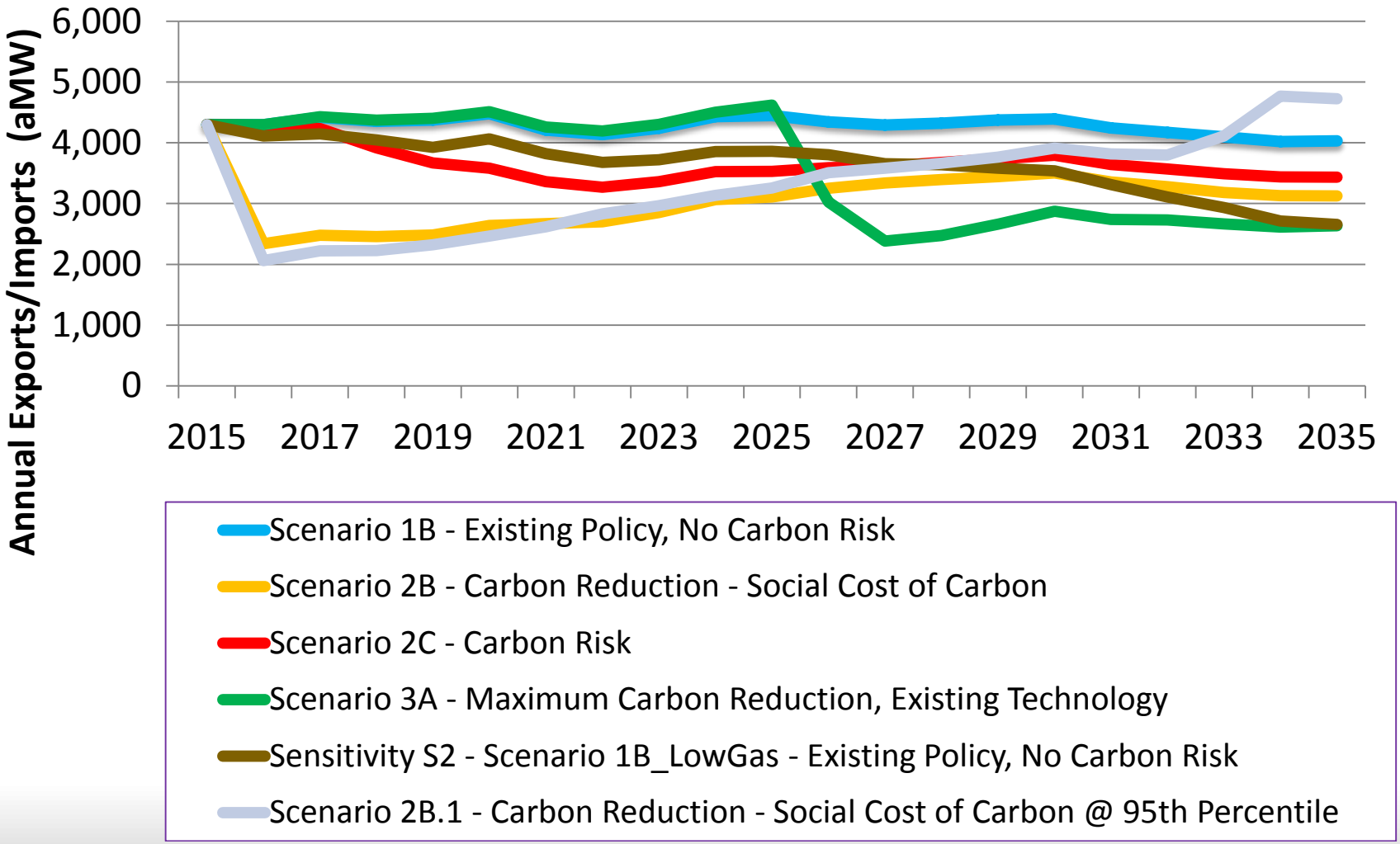


# Key Finding:

## 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

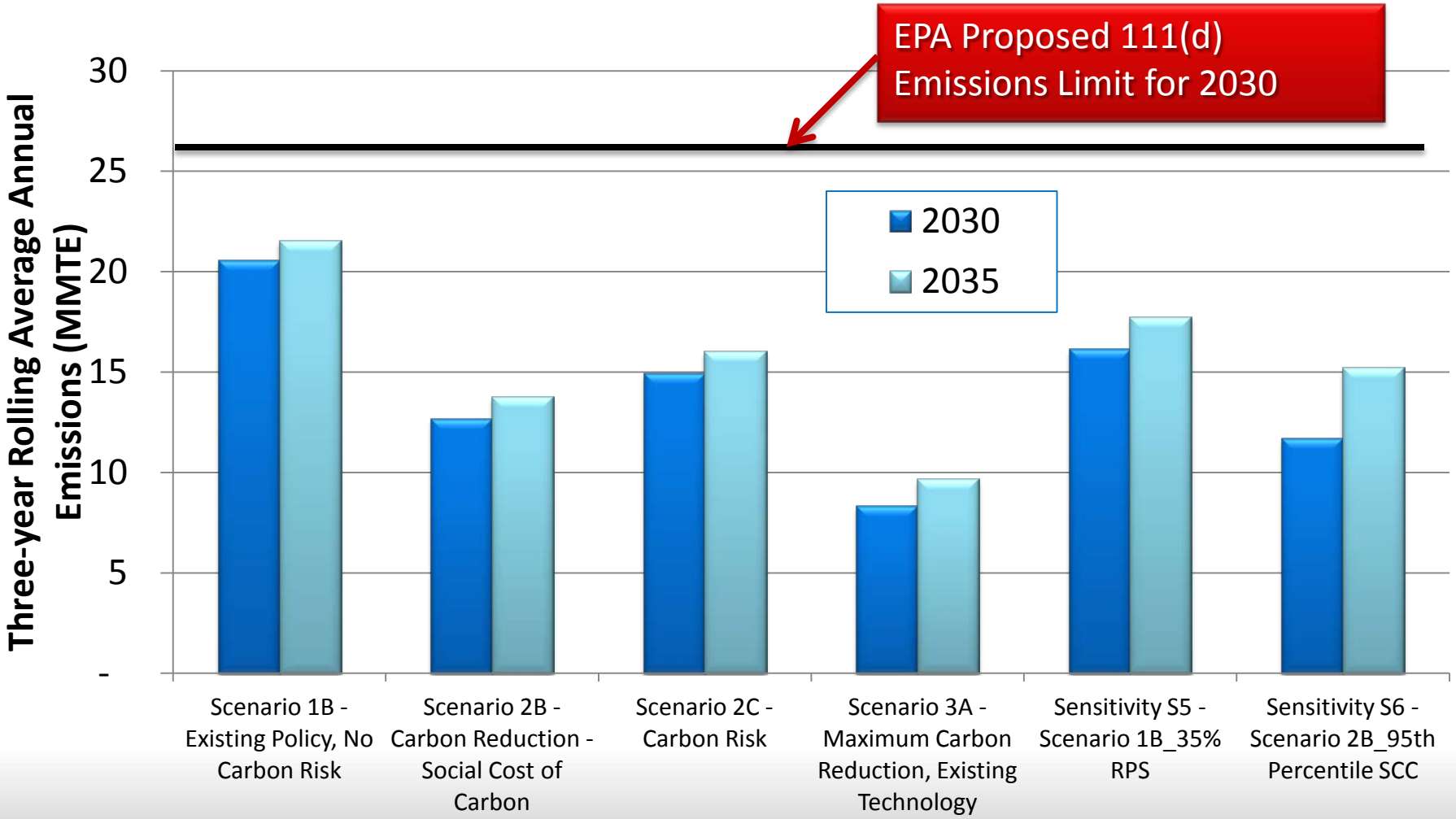


# Key Finding:
# Many scenarios rely on reducing regional exports as part of the least cost resource strategy

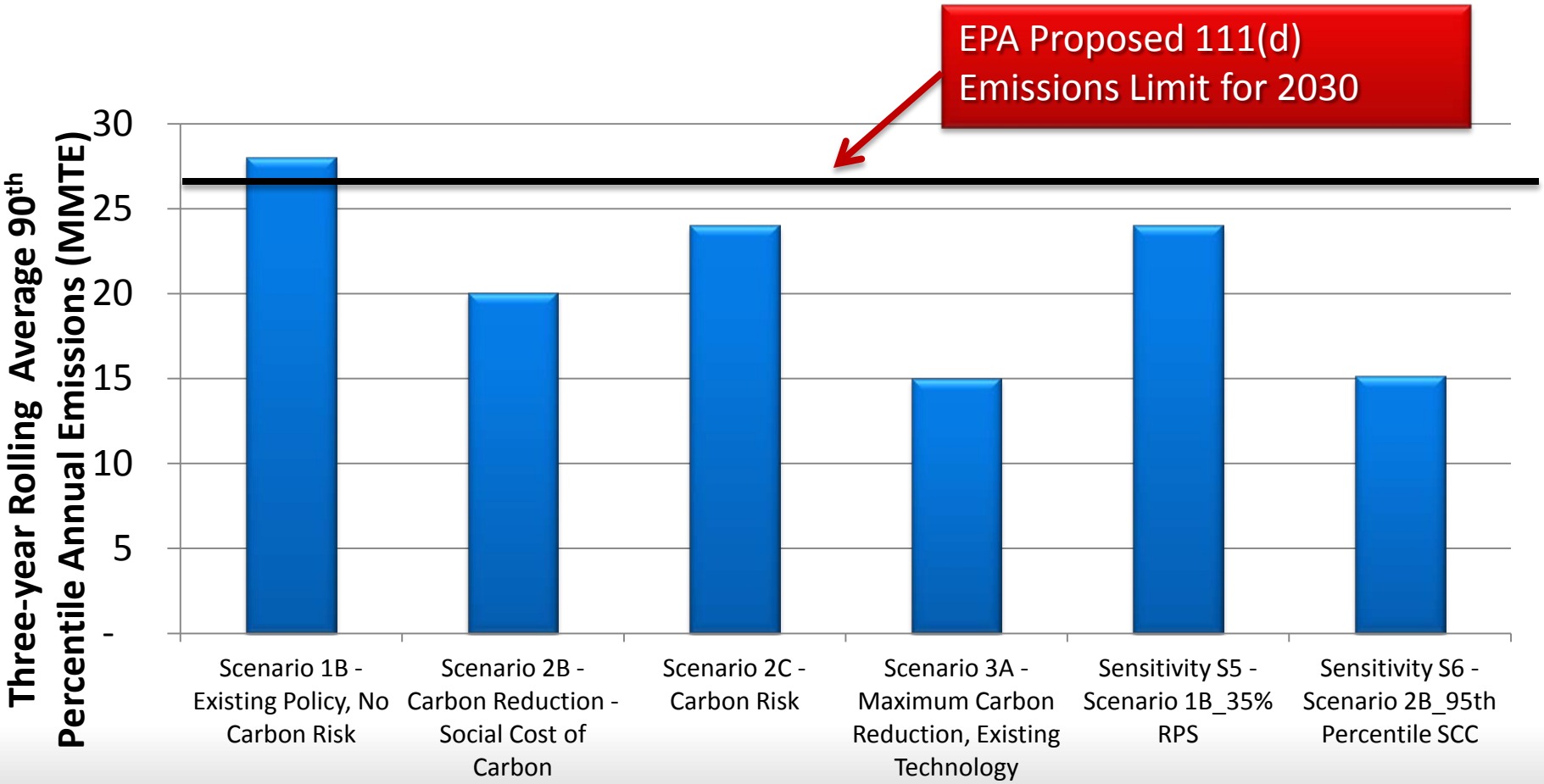


# CO2 Comparison

# The *Average* Annual 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

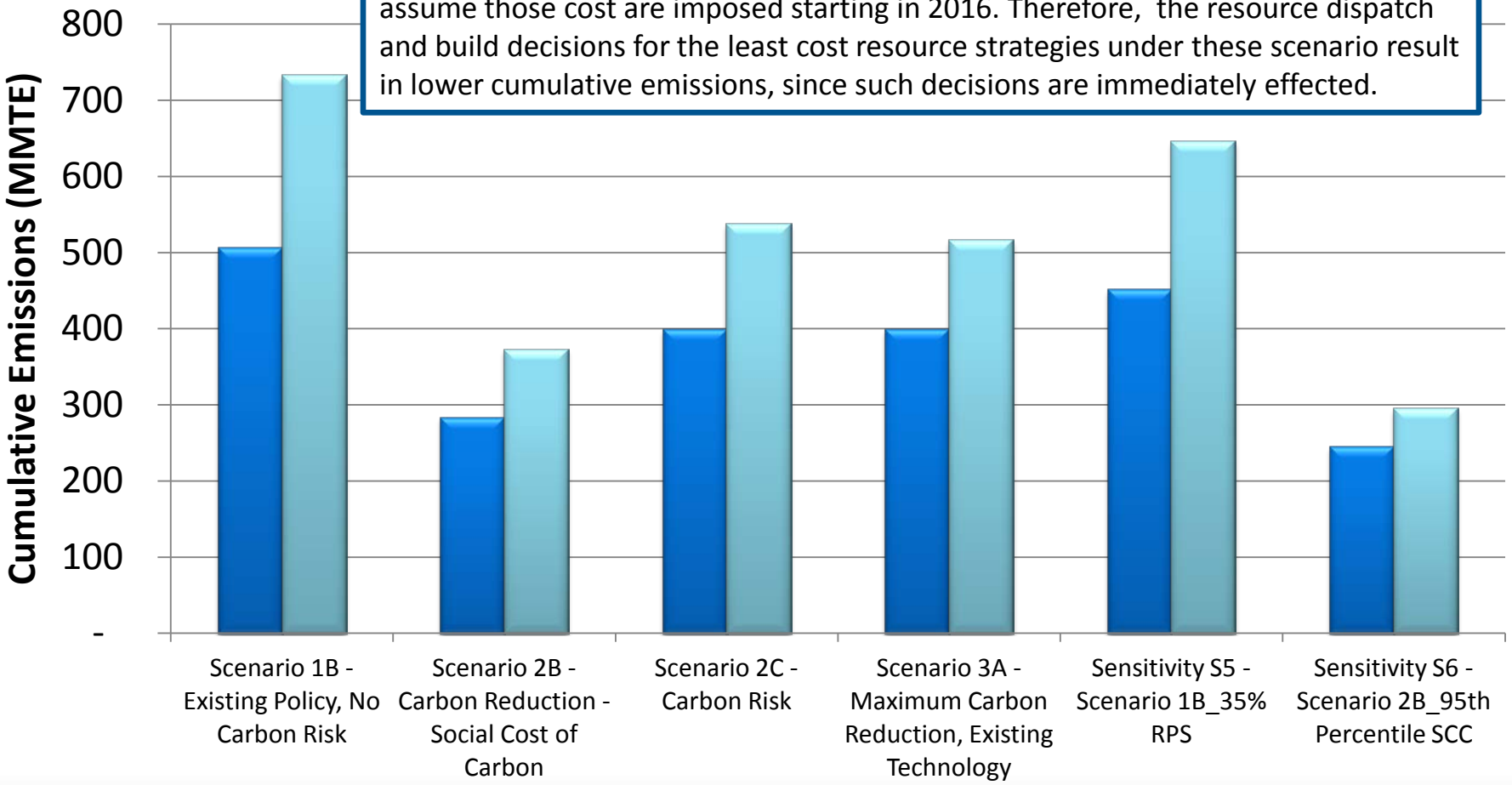


# The *90th Percentile* Annual 111(d) System CO2 Emissions The Least Cost Resource Strategies for All Carbon Reduction Scenarios Are Below The EPA's Proposed Limit for 2030, While the Base Scenario Barely Exceeds The Proposed Limit

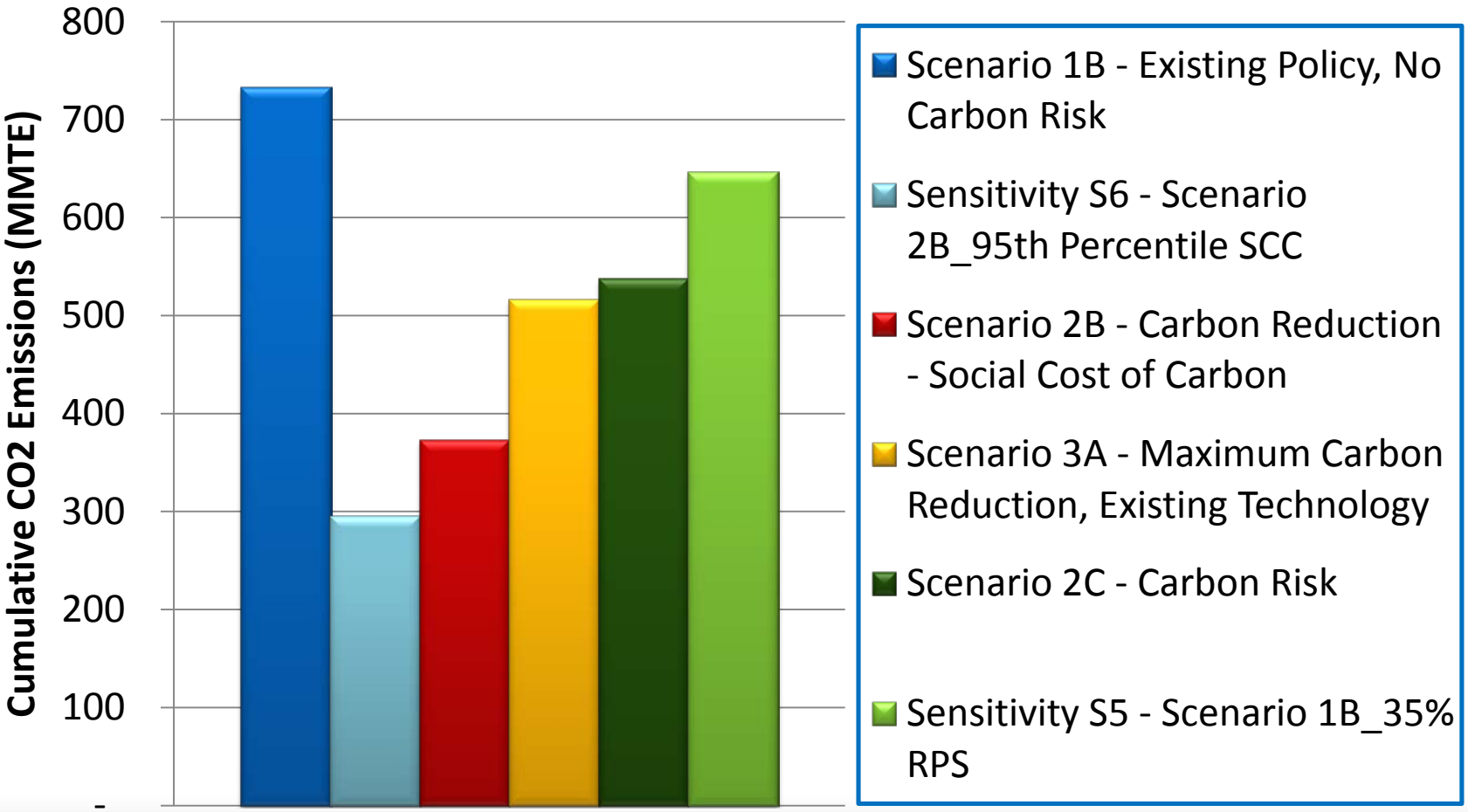


# Cumulative PNW Power System CO2 Emission 2016-2035 Under Alternative Carbon Emissions Reduction Policies

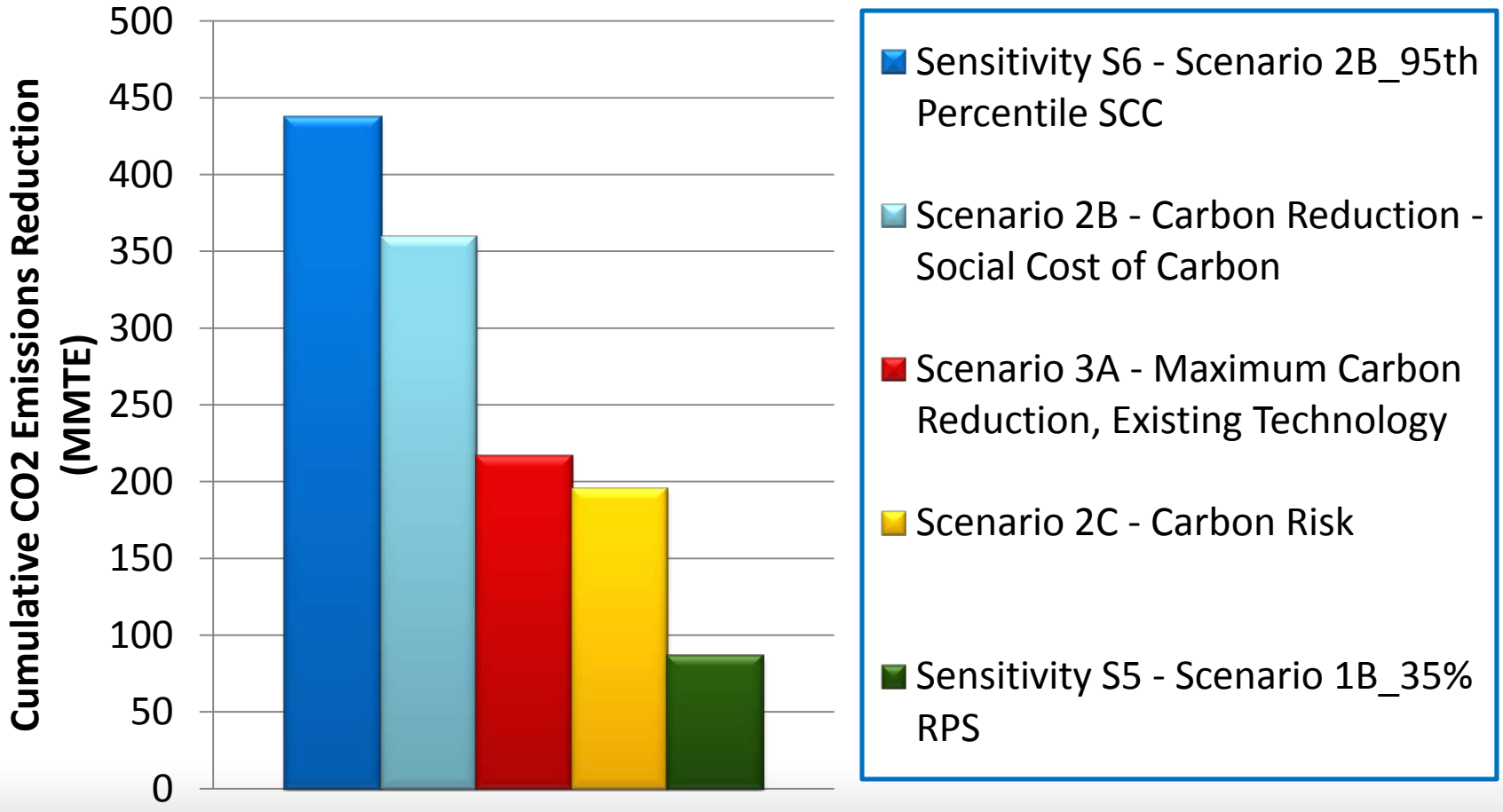
CAUTION: The Social Cost of Carbon (2B, S5 & S6) and Carbon Risk (2C) Scenarios assume those cost are imposed starting in 2016. Therefore, the resource dispatch and build decisions for the least cost resource strategies under these scenario result in lower cumulative emissions, since such decisions are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



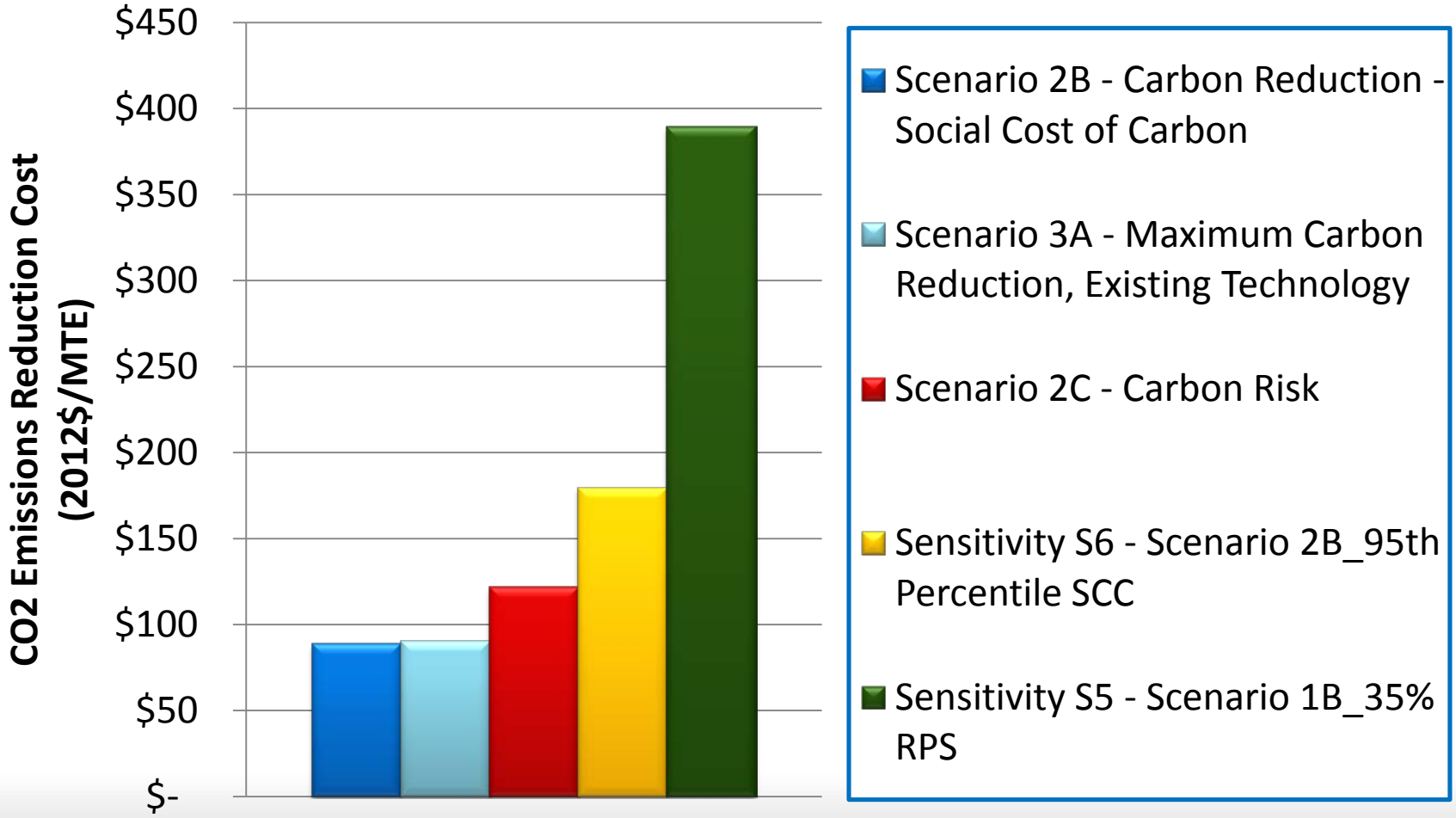
# The Lowest PNW Power System Cumulative CO2 Emissions from 2016-2035 Occur Under Alternative Resource Strategies That Immediately Must Respond To Carbon Reduction Policies



# 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



# Scenarios 4A and 4B

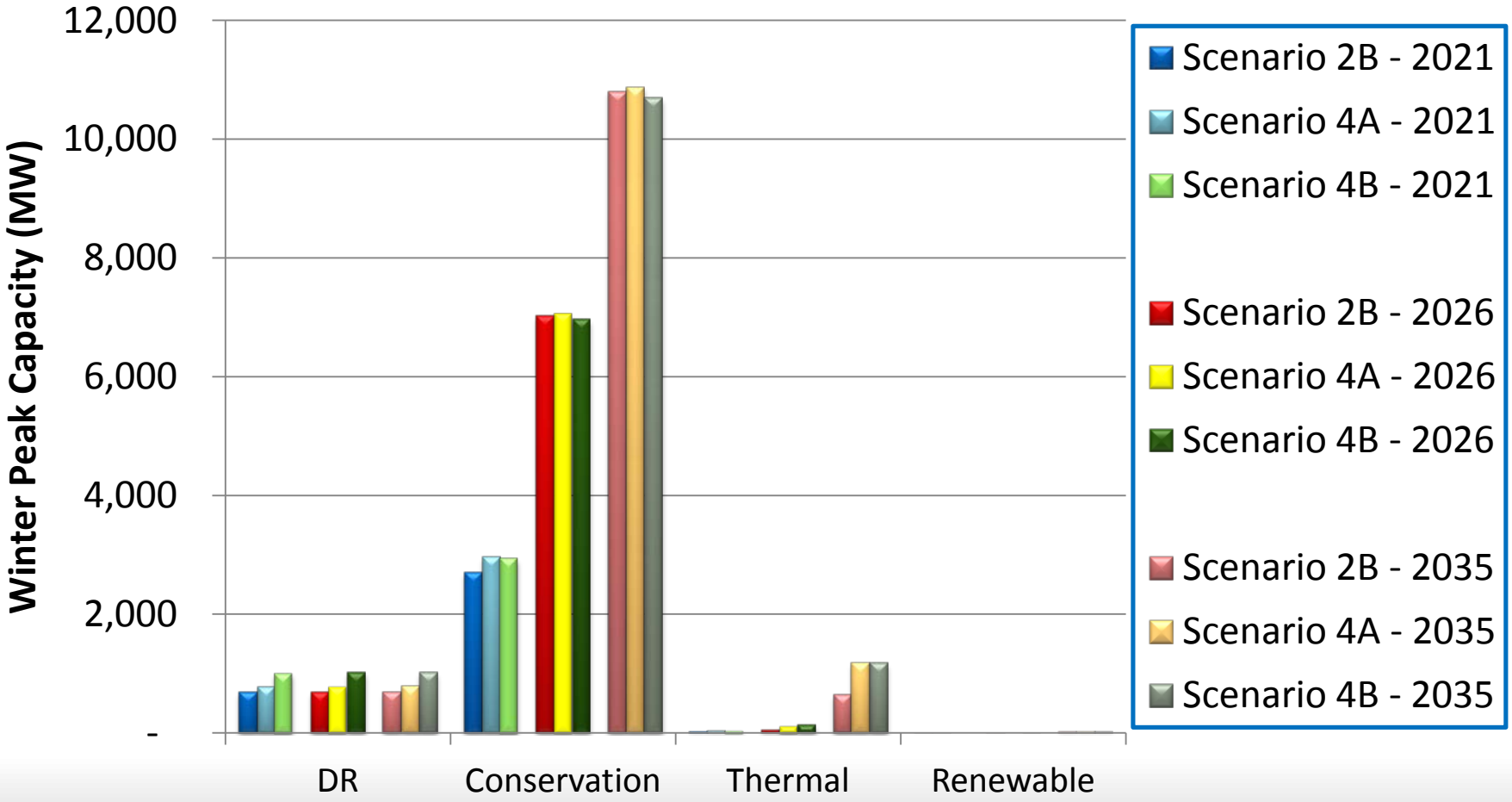
# Scenario 4A – Unplanned Loss of Major Non-GHG Emitting Resources

- 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

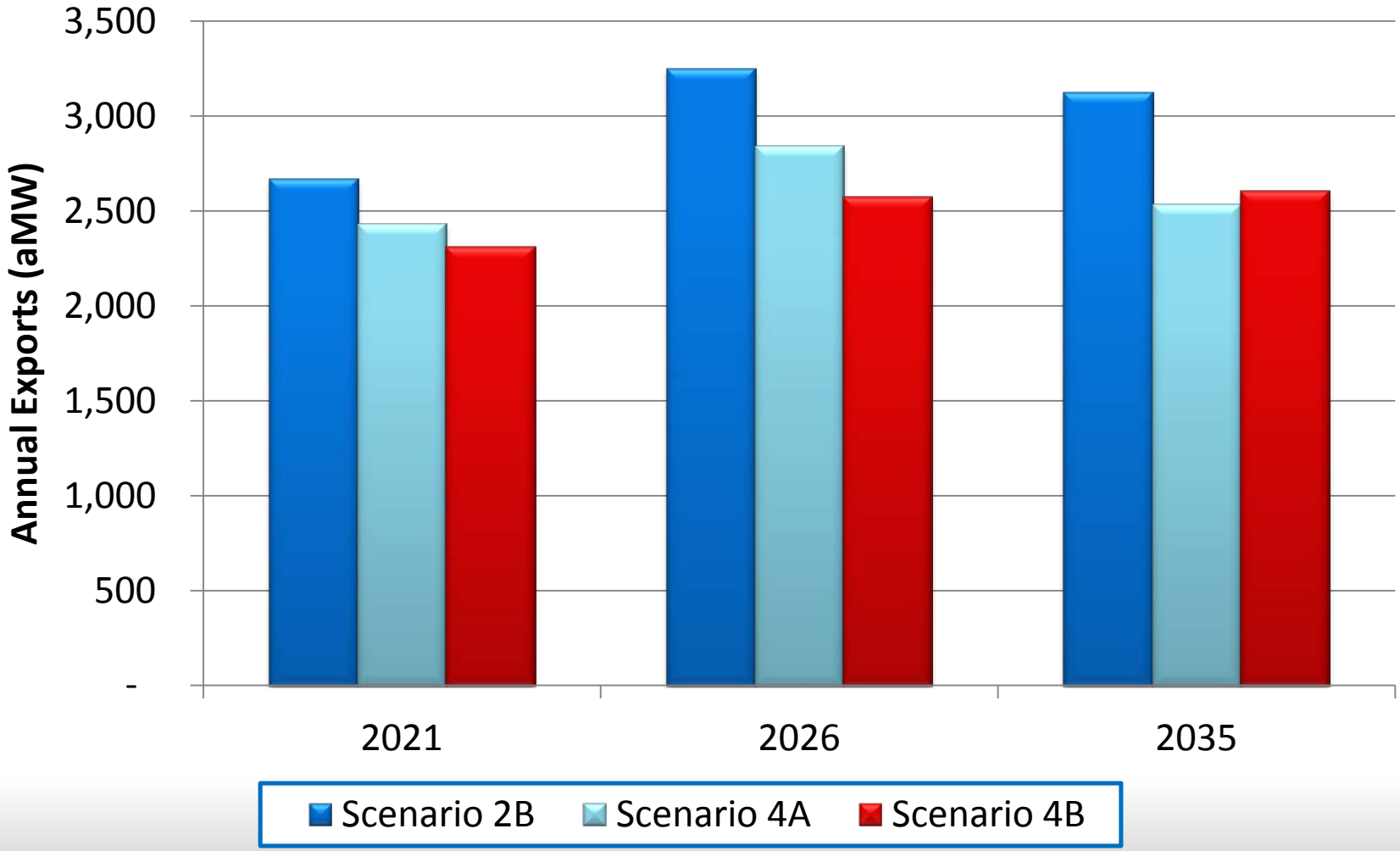
# Scenario 4B – Planned Loss of Major Non-GHG Emitting Resources

- 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

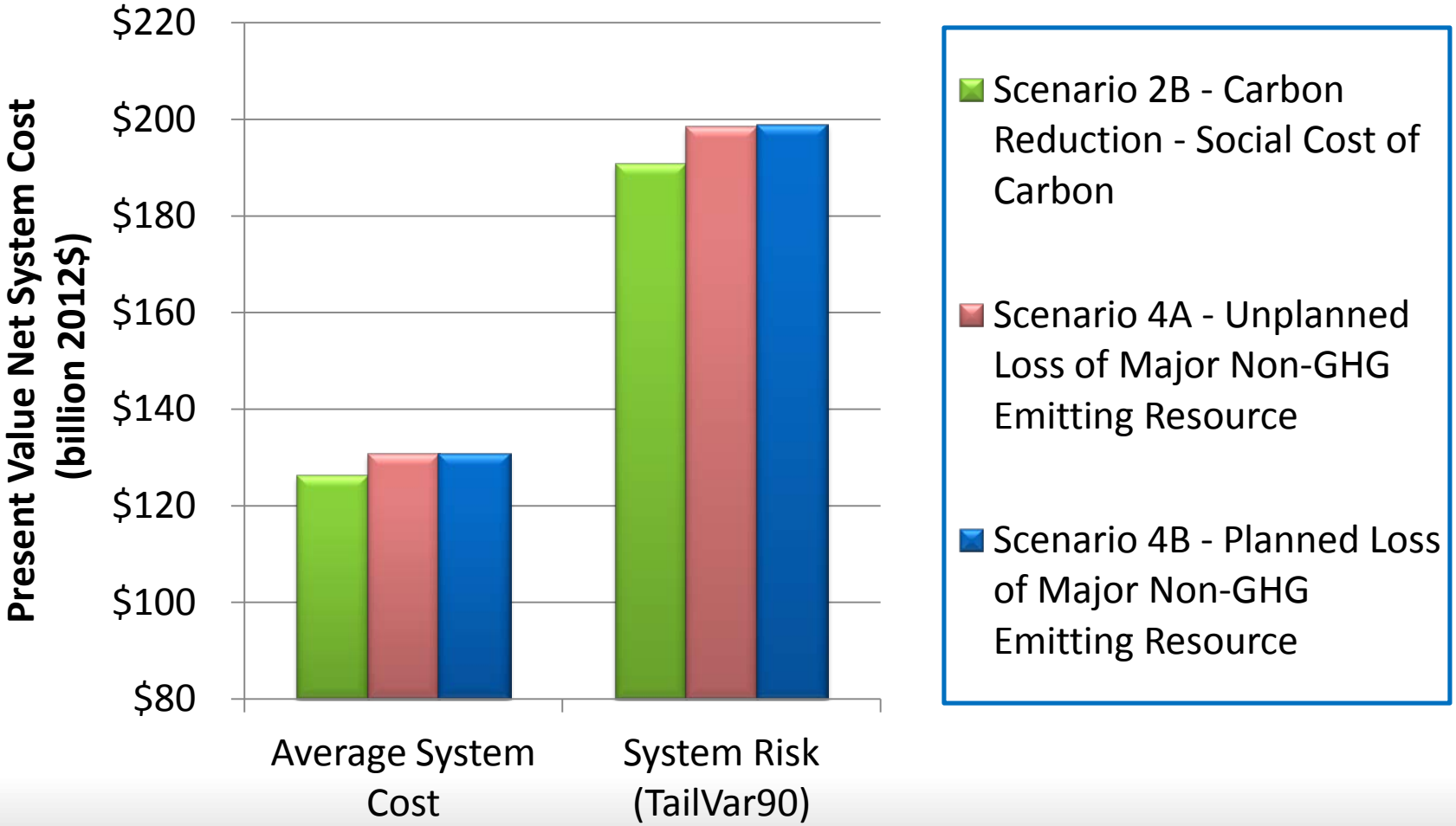
# The Least Cost Resource Strategies in Scenarios 4A and 4B Compared to Scenario 2B Rely More on Demand Response and Gas Generation to Meet Winter Capacity Demands



# 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

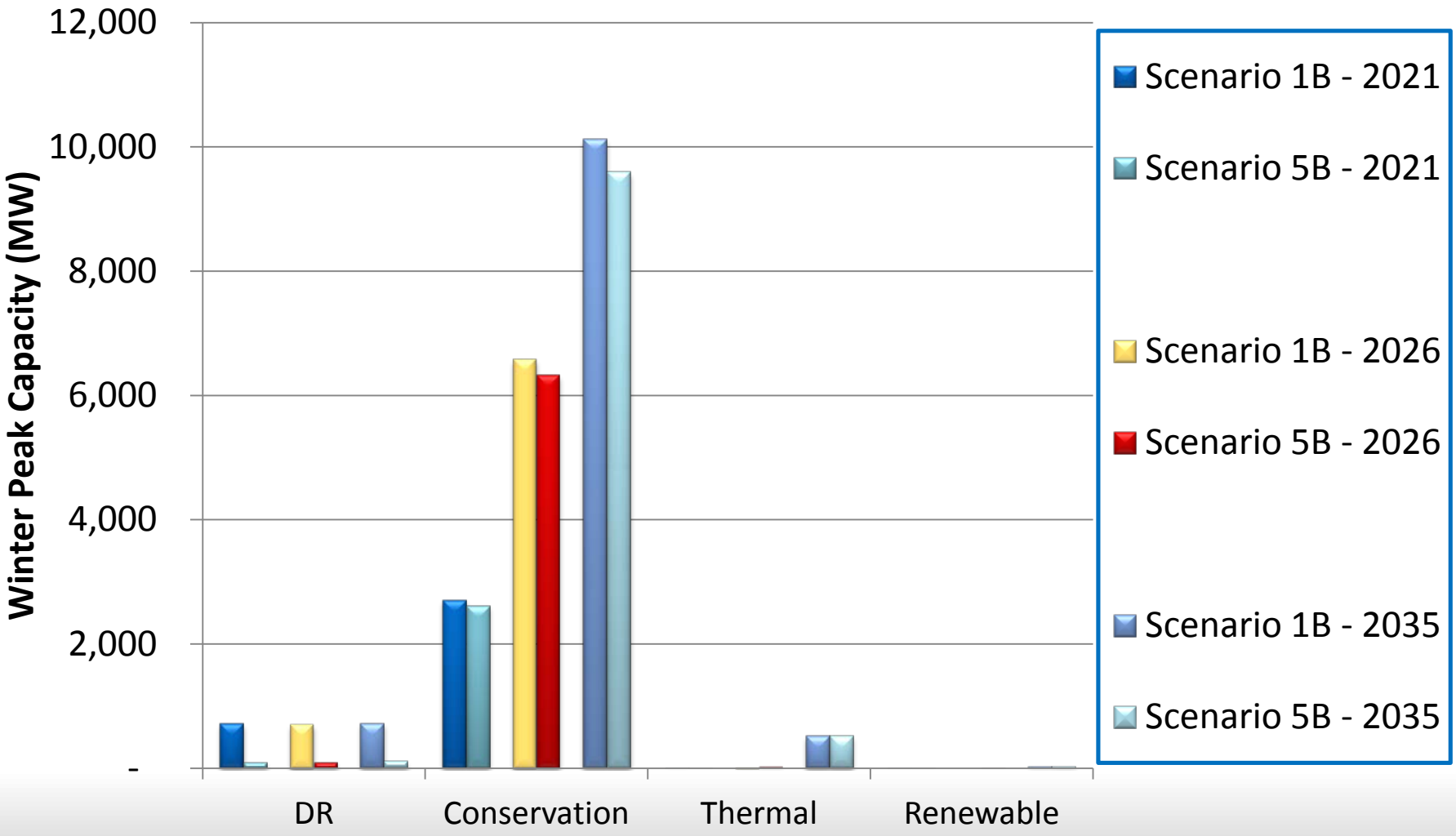
| Resource/Metric | 4A – Unplanned Resource Loss | 4B – Planned Resource Loss |
|---|---|---|
| Energy Efficiency – All Years | No Change | No Change |
| Demand Response – All Years | + 90-95 MW | + 320 MW |
| Renewable Resources - 2035 | - 15 aMW | - 15 aMW |
| Coal Gen | Small (<5%) Increase | Small (<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 |

# Scenario 5B

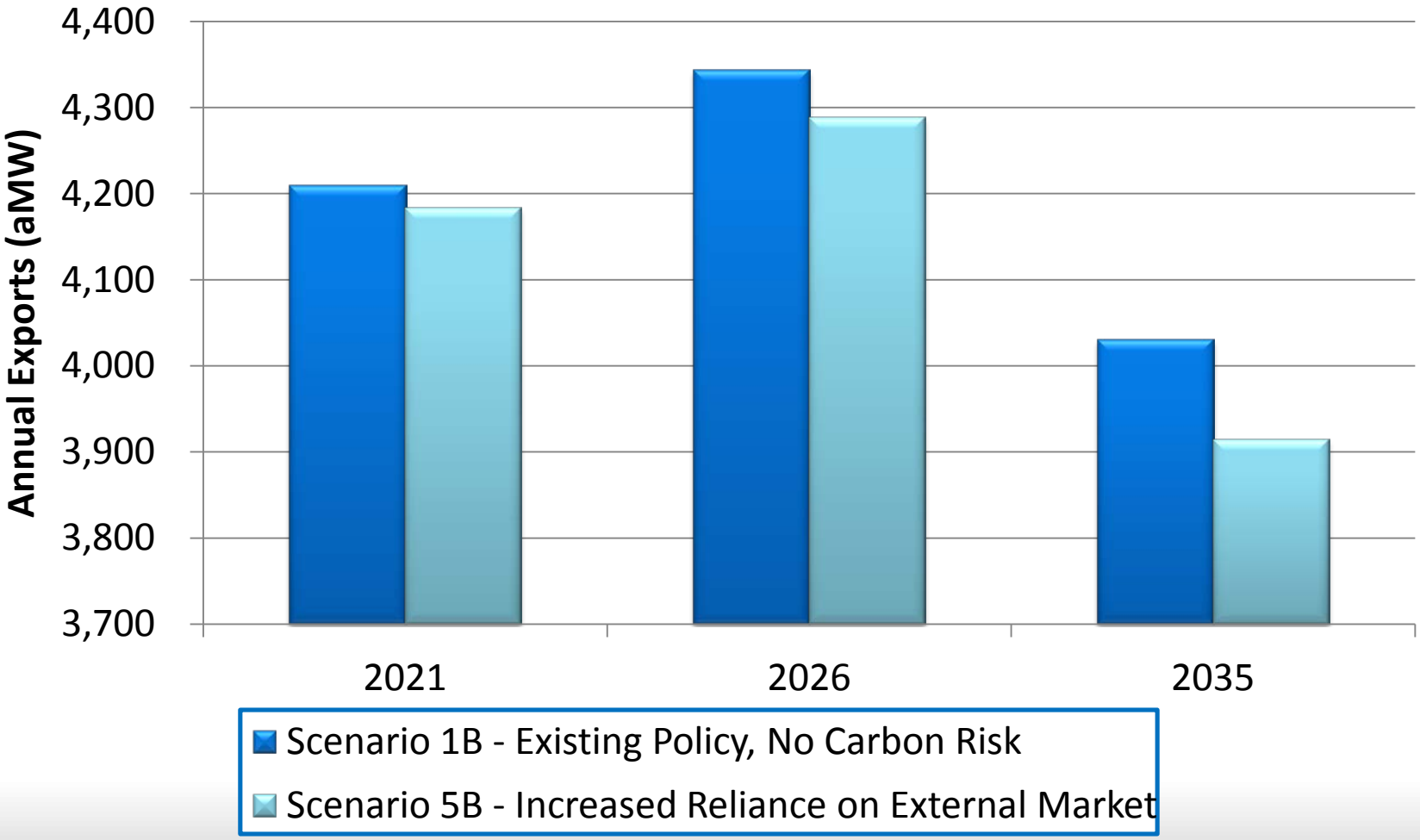
# Scenario 5B – Increased Reliance on Extra-Regional Market

- 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

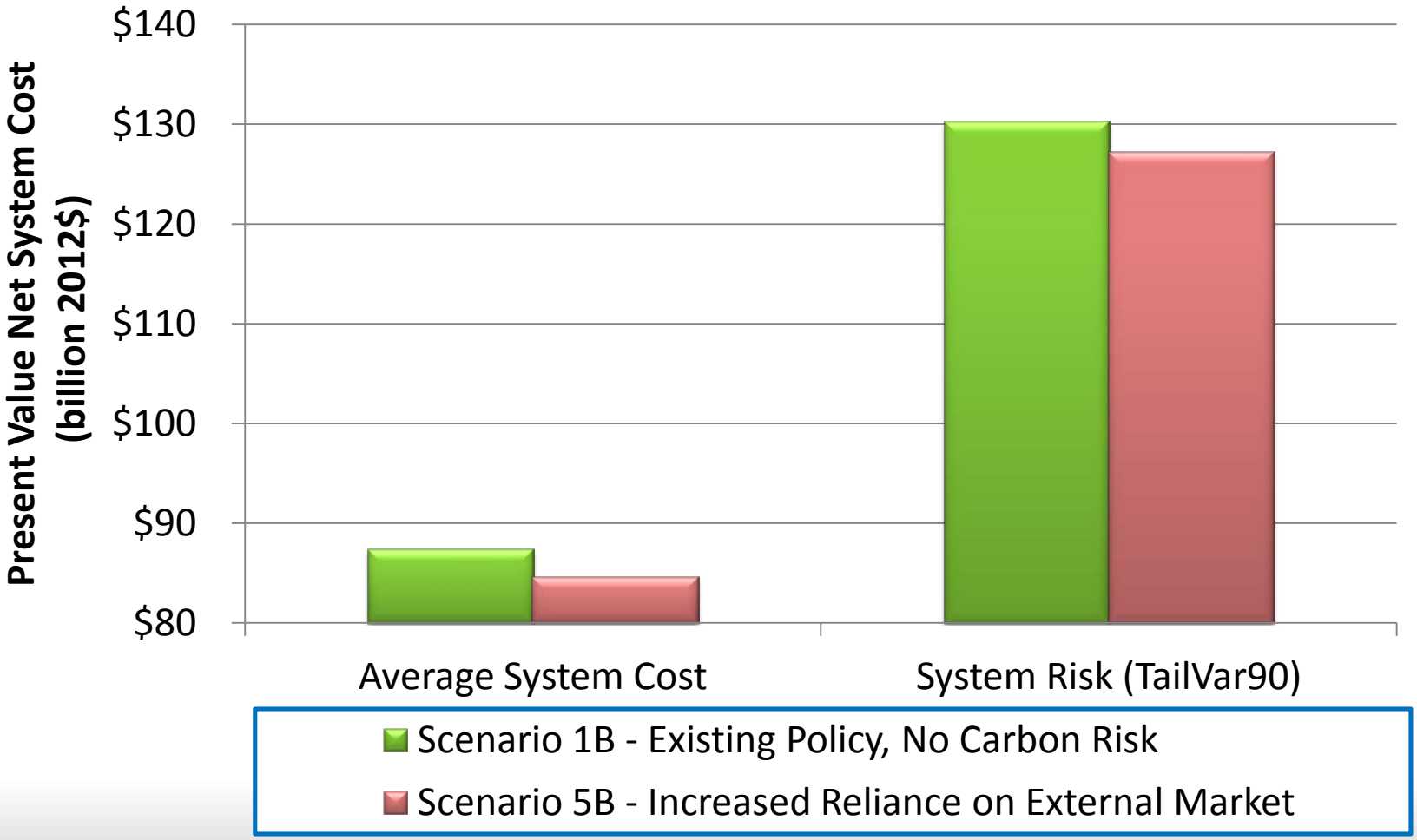
# The Least Cost Resource Strategy in Scenario 5B Compared to Scenario 1B Relies Less on Demand Response and Conservation to Meet Winter Peaks



# 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

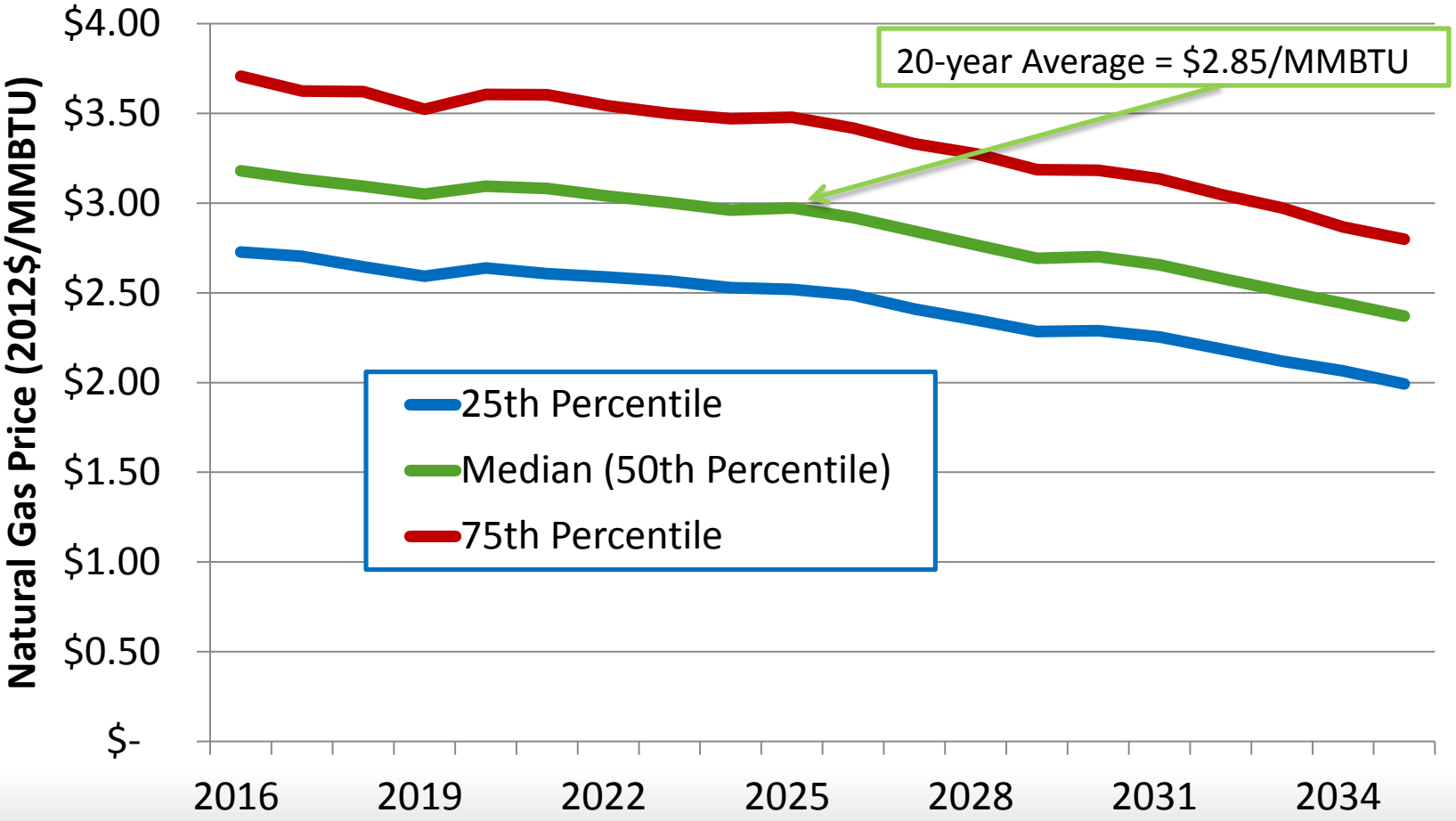
| Resource/Metric | 5B - Increased External Market Reliance |
|---|---|
| Energy Efficiency - 2021 | - 45 aMW |
| Energy Efficiency - 2026 | - 110 aMW |
| Energy Efficiency - 2035 | - 215 aMW |
| Demand Response – All years | - 620 MW |
| Renewable Resource - 2035 | - 110 aMW |
| Coal Generation - All 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 |

# Sensitivity Studies Comparison

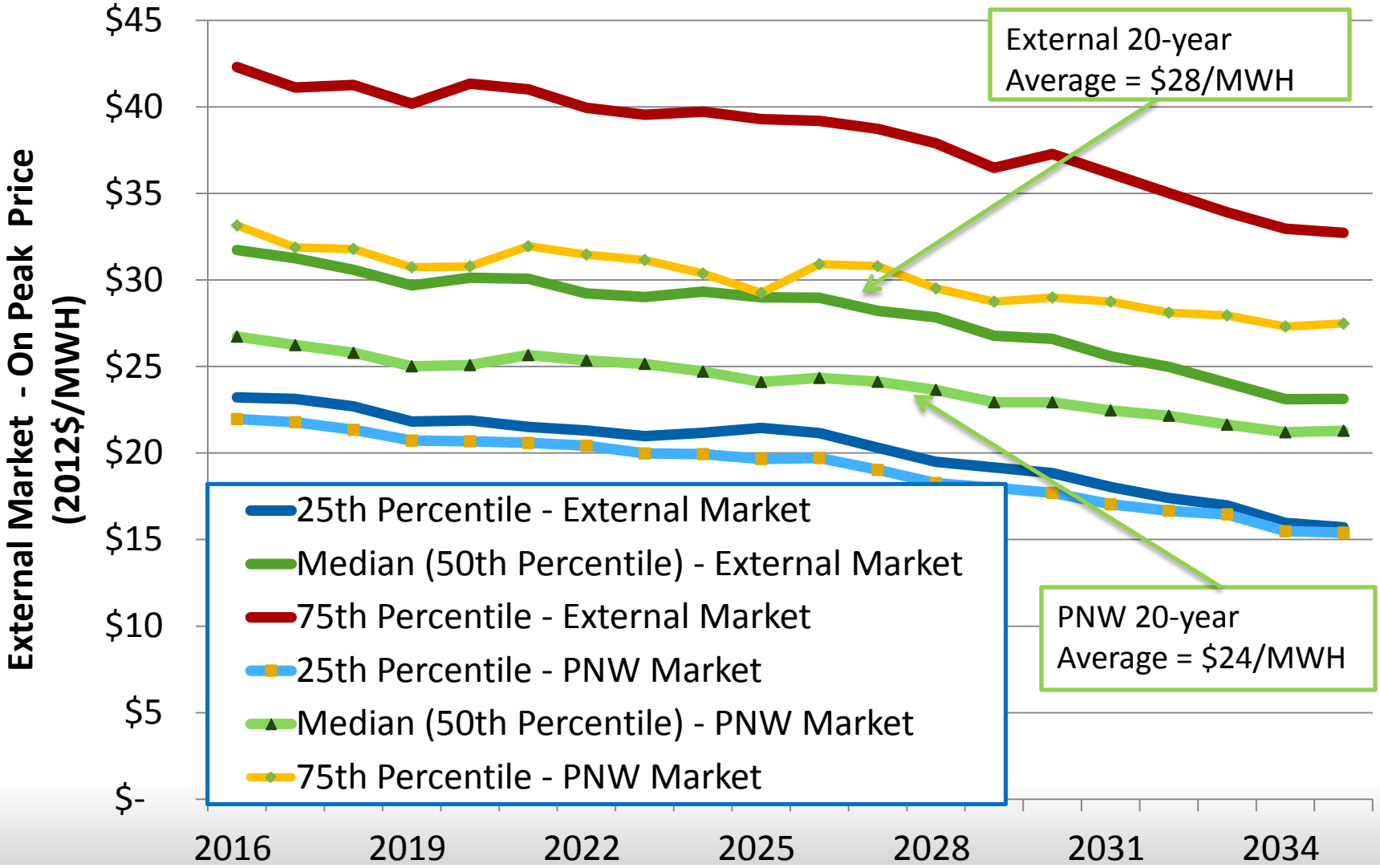
# Sensitivity S1 – No Coal Plant Retirements Comparison to Scenario 1B – Existing Policies, No Carbon Risk

| 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 |

# Sensitivity Study S2 –
## Scenario 1B with Low Gas Price Assumptions

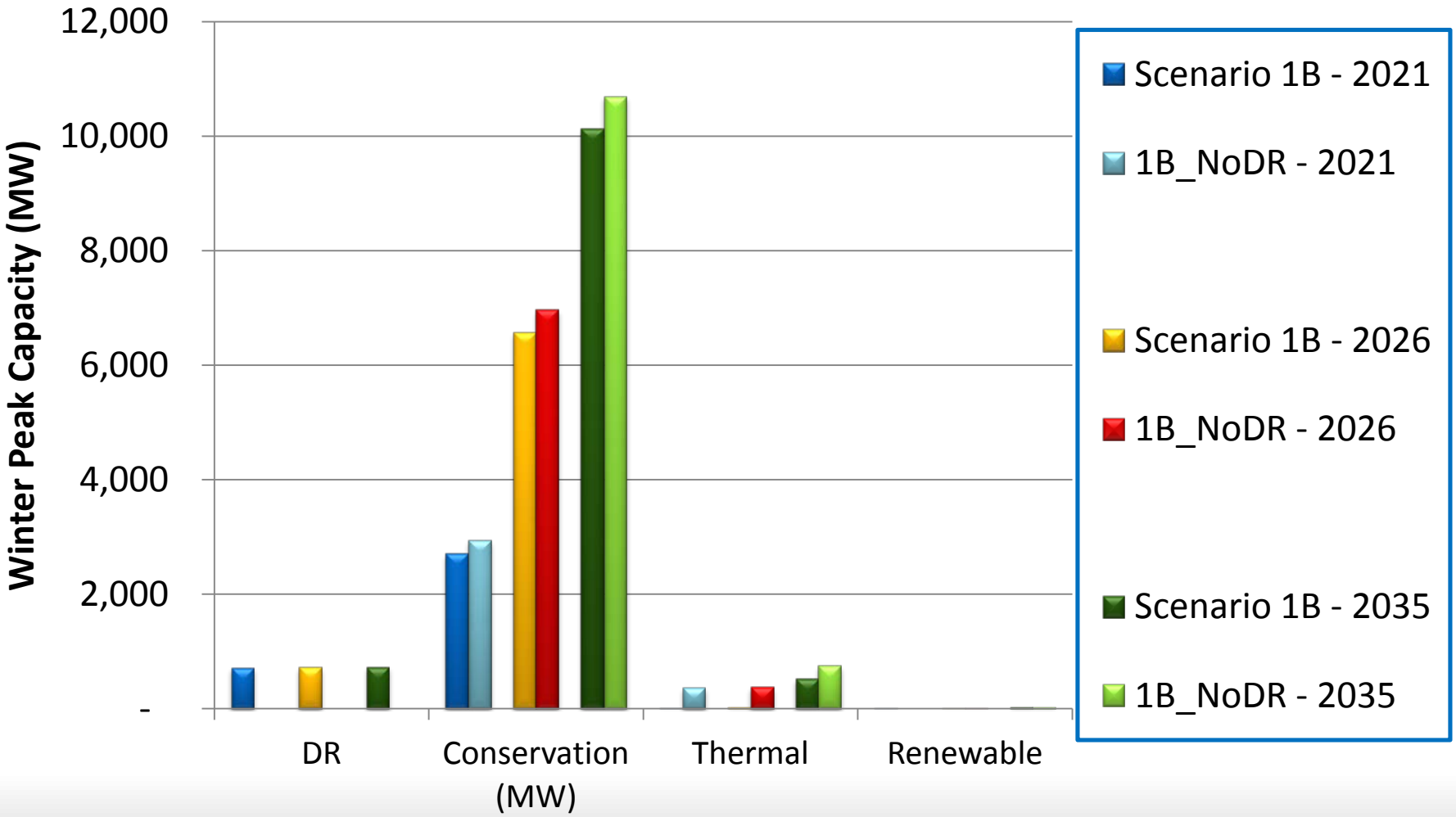


# Sensitivity Study S2 – Scenario 1B Electricity Market Price Assumptions

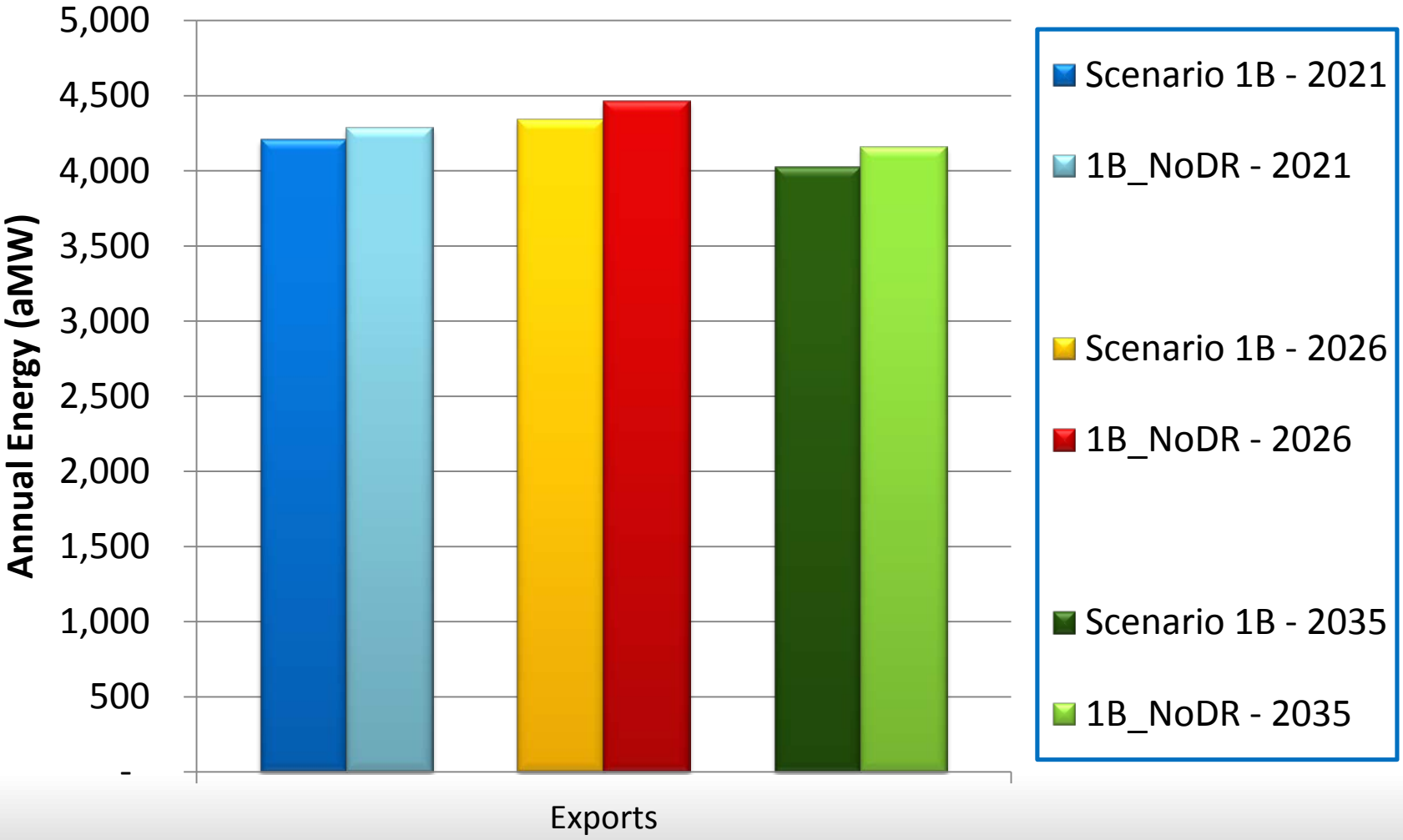


# Sensitivity S3 – Scenario 1B with No Demand Response

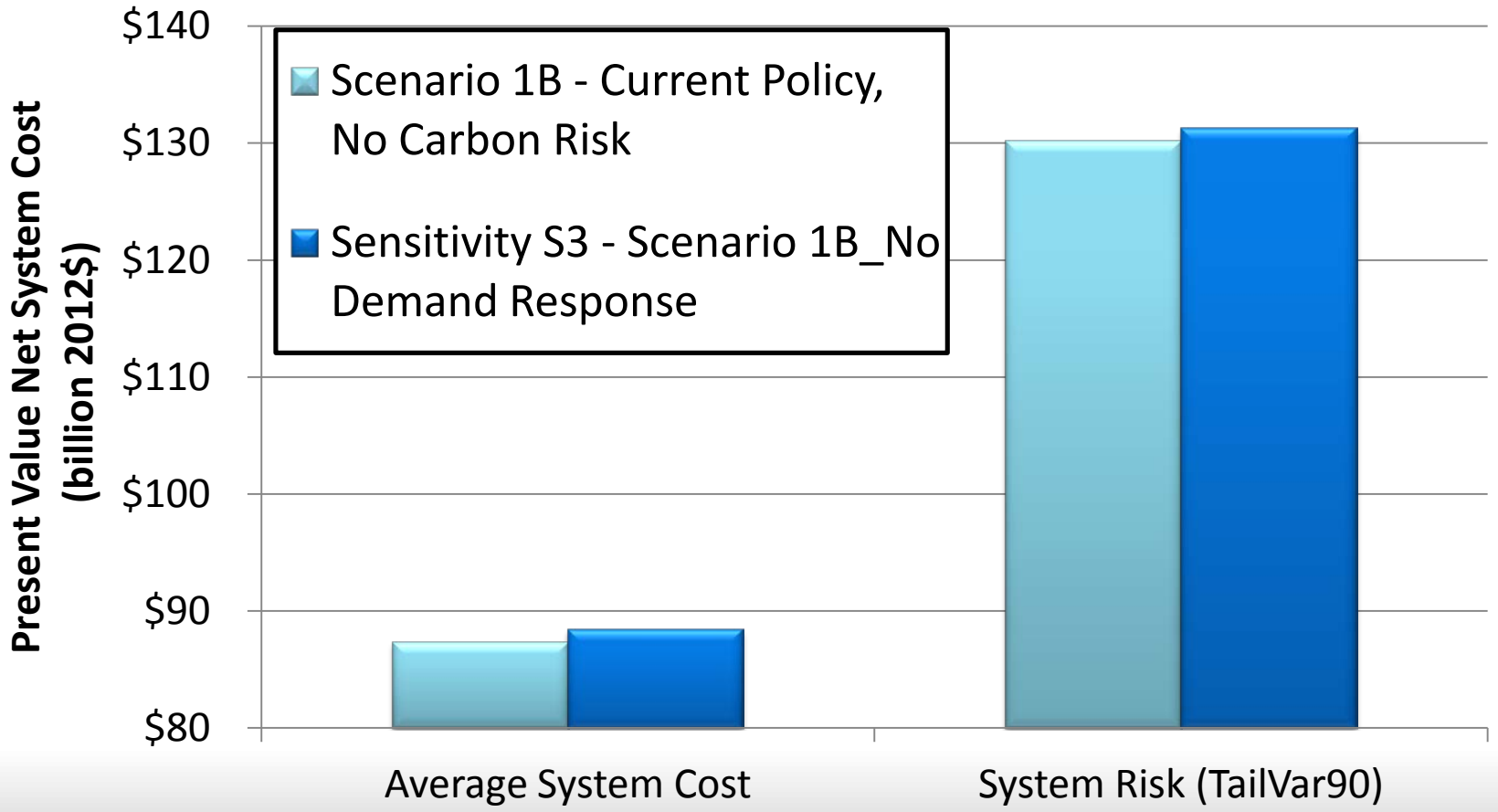
## ~700 MW of DR is Replaced by EE and Thermal Resources



# Sensitivity S3 – Scenario 1B with No Demand Response The Additional EE Resources Result in Slightly Larger Regional Energy Exports



# Sensitivity S3 – No Demand Response Without DR Both Net Present Value System Cost and System Risk Increase by ~$1 billion



# 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) |

# 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 |

# 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 |

# 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 |

# Sensitivity Study 2B.1 – Scenario 2B with Social Cost of Carbon @ 95th Percentile

- Compared to 1B – Existing Policy, No Carbon Risk
  - Slightly increased conservation development
    - 2021 = +75 aMW
    - 2026 = +130 aMW
    - 2035 = +170 aMW
  - DR development similar until 2026, then increases by ~150 – 200 MW
  - Slightly increased (30 aMW) renewable resource development
  - Effectively eliminated coal generation
    - - 3,200 aMW
  - Significantly increased new natural gas generation capacity
    - 225 MW vs. 2,400 MW in 2035
  - Slightly increased regional exports (+700 aMW)