Impacts of Possible Future CO_2 Restrictions
Nebraska Public Power District
March Board Retreat
March 10, 2021

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About Power Technologies International ("PTI Consulting")

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- ✓ **Economic** and **technical consulting** arm of Siemens Industry, Inc.
- ✓ Focused on **generation, transmission, distribution and consumption** of electric power in all U.S. markets
- ✓ About 60 U.S. employees in offices Nation-wide

Energy Market Analysis
> 30 years

- Long-term Planning
- Market Price Forecasting
- Market Assessments
- Transactions Evaluation
- Portfolio Optimization

Power System Analysis
> 50 years

- Trusted advisor for network planning and masterplans
- End-to-end network design including economics
- Solutions for reliable operations and maintenance

Software
> 45 years

- Powerful power system simulation and network model management
- Integration of IT/OT with unique grid data management
- Dynamic security assessments in operation
- Protection

Analysis Approach
Modeling Tool Used - AURORAxmp

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AURORAxmp (Aurora) is an accepted, industry standard model for electricity production costing and market simulations.

The model provides four key functions:

- Optimized capacity expansion
- Portfolio analysis
- Power market price forecasting
- Power market risk analysis

AURORA
BY ENERGY EXEMPLAR

Siemens utilizes Aurora for:

- Capacity expansion plans in each scenario, including decisions to build or retire plants
- Unit commitment and economic dispatch simulation to produce generation and pricing forecast
- Tracking other key outputs such as emissions, across scenarios

Analysis Approach
Process Flow - Power

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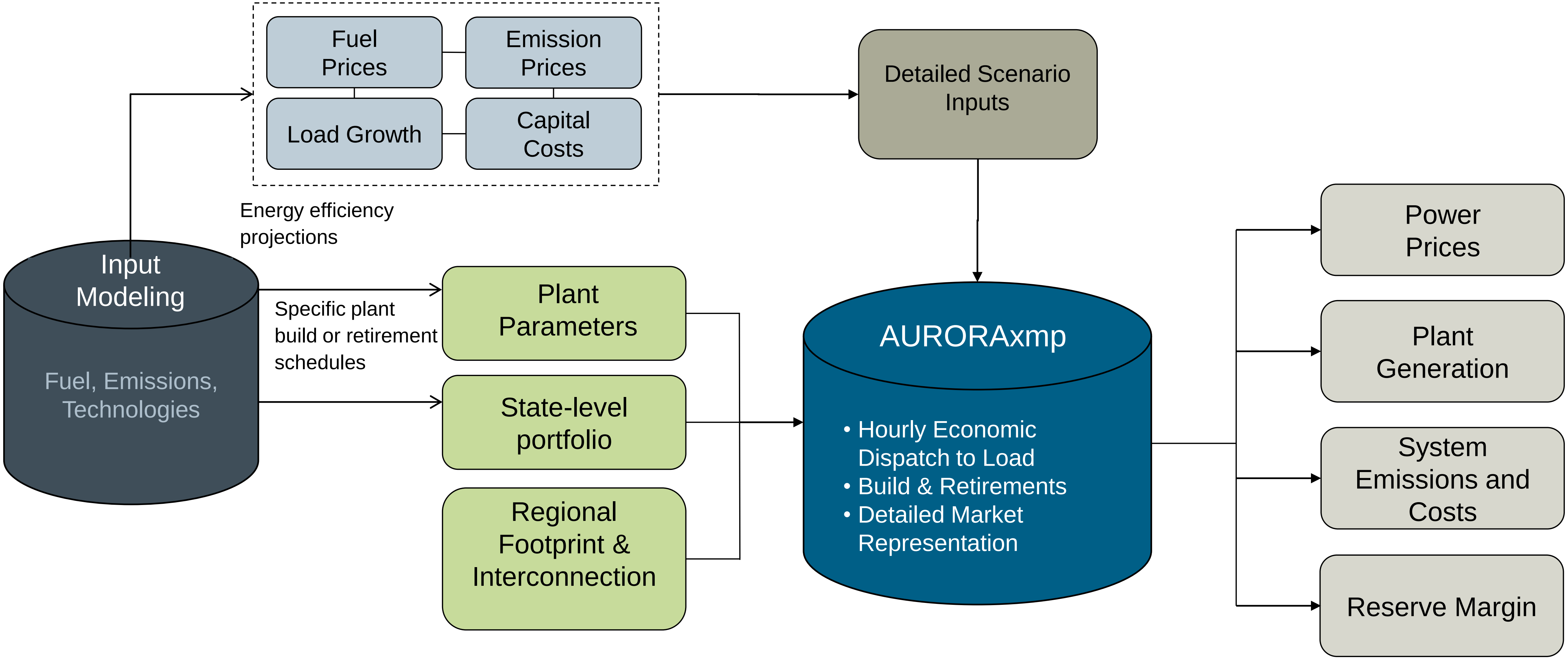

Study Objectives

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- **Perform a third-party independent study regarding the impacts of possible future CO_2 restrictions as they relate to NPPD's future operations;**

- **Develop low cost, resilient, and reliable resource plans across four cases:**

  - Base Case – Assume no CO2 reduction;

  - Case A – Shall maintain the DISTRICT'S relative carbon position by reducing the carbon intensity for its share of owned and purchased resources relative to the industry, as projected by the Energy Information Agency (EIA) Balancing Authorities carbon intensity.

  - Case B – Shall assume a 50% reduction in carbon intensity from 2005 in the DISTRICT'S share of owned and purchased resources by 2030 and an 80% reduction by 2050.

  - Case C – Shall assume the DISTRICT'S share of owned and purchased resources becoming net neutral (based on generation) by 2050. Carbon intensity in 2030 will be based on a linear reduction between the actual 2005 carbon intensity value and the carbon intensity value (0) in 2050.

Case Results
Carbon emissions

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Historical carbon intensity

- NPPD carbon intensity in 2005 was approximately 1,650 lbs/MWh
- 2017/18 average carbon intensity was 1,100 lbs/MWh

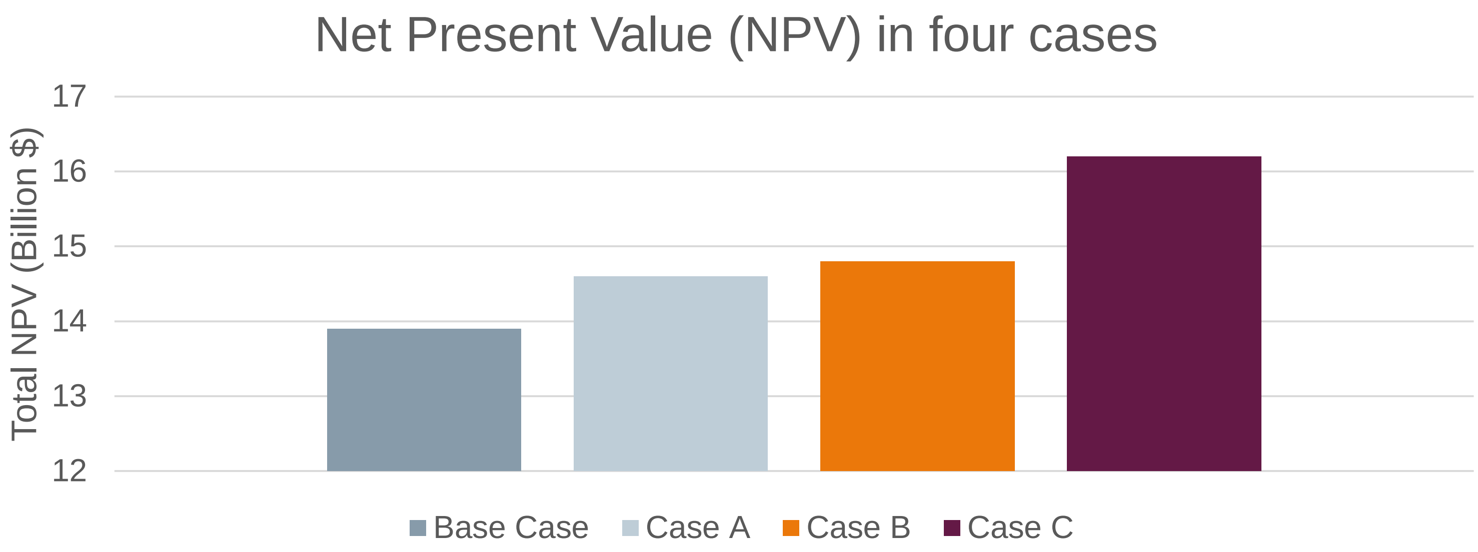
Model results

- Base case results are highest, but eventually drop below 1,000 lbs/MWh by the mid-2040s
- Cases A, B, & C all meet their carbon intensity reduction goals
- Cases A & B have similar emission rates over the last 10 years of the study

Description of case targets

- Scenario A: carbon intensity reductions relative to the industry, as projected by the Energy Information Agency (EIA) Balancing Authorities carbon intensity.
- Scenario B: 50% reduction in carbon intensity from 2005 by 2030 and an 80% reduction by 2050.
- Scenario C: 100% reduction in carbon intensity by 2050.

Case Results
Portfolio Costs - Total Costs



Observations

- NPPD total costs increase with the stringency of CO2 restrictions
- GGS operates to the end of the wholesale contract for all cases. In the Base Case the facility operates through the end of the study period.
- CNS retires before the end of the wholesale contract for all cases except for Case C. In Case C the model selects a second license extension.
- Sheldon converts to natural gas or retires before the end of the wholesale contract.

*Note: Chart depicts net present value of nominal costs at 4.25% discount rate

Case Results
New Resource Additions in NPPD through 2035 (Megawatts)

	Base	Case A	Case B	Case C
Cumulative NGCC additions	880	880	0	0
Cumulative NGCT additions	840	500	680	290
Cumulative Wind additions	0	40	150	20
Cumulative Solar PV additions	130	380	290	560
Cumulative Storage Additions	100	100	200	200

Case Results
NPPD Capacity Mix in 2050 in Four Scenarios

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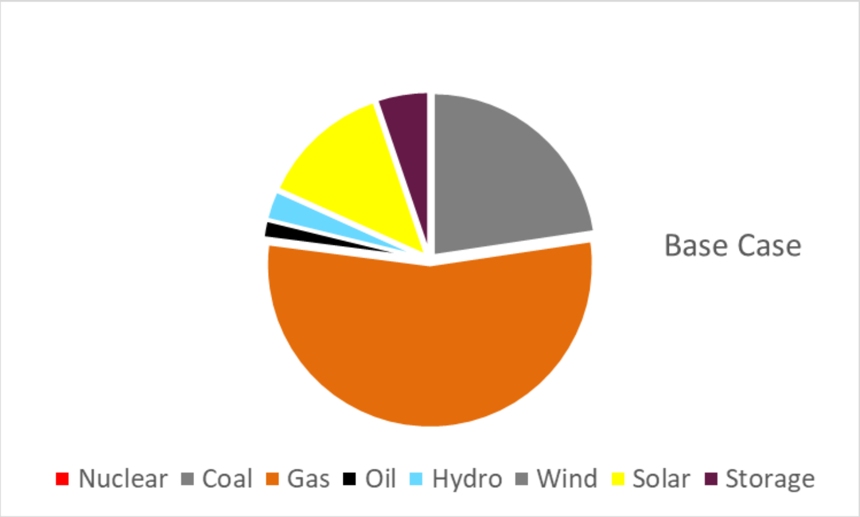
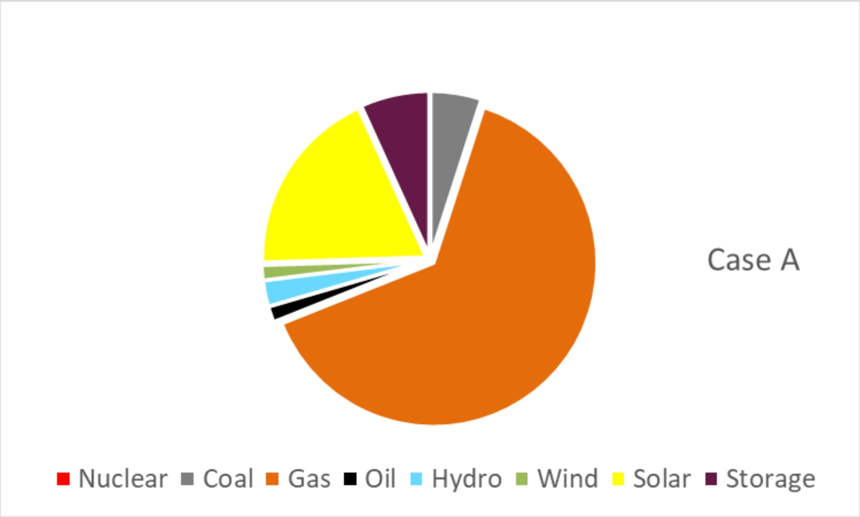
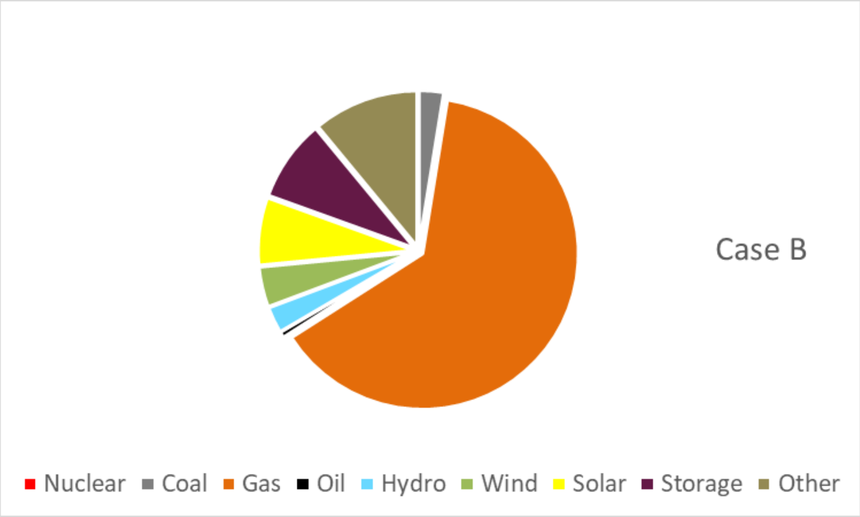
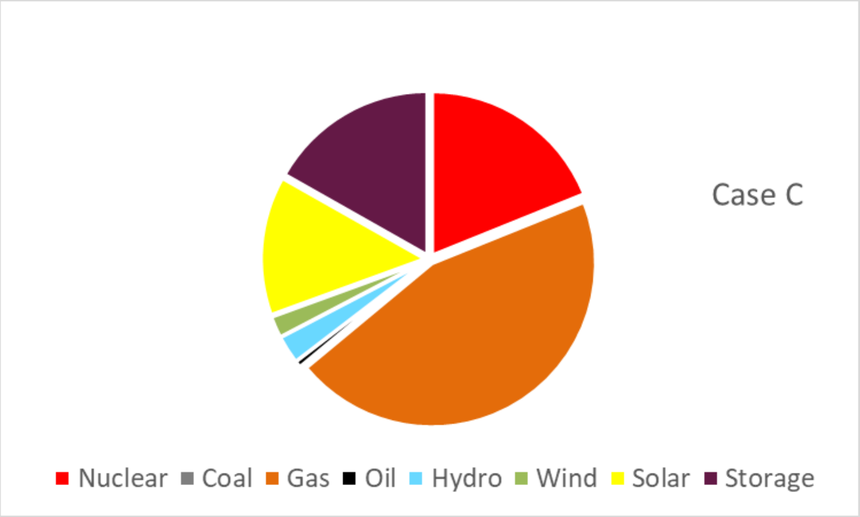
More stringent CO2 restrictions drive a shift towards solar, wind capacity in NPPD









Case Results
Net Energy Position

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- The model allows purchasing up to 30% of the annual native load energy.

- NPPD becomes a net purchaser or slight net seller when CNS retires.

- For Carbon Case C (net zero in 2050), NPPD becomes a significant seller at the end of the study period.
  - CNS – 2nd license extension
  - Solar – Significant additions for CO_2 intensity reduction and for capacity

To be updated

Case Results
Impacts on NPPD Wholesale Rates

- NPPD's rates remain below the CFC 45th percentile forecast from 2020-25 in every case
- From 2025-2035, wholesale rates remain relatively flat, on average. Base Case & Case A rates are lower than Case B & C.
- Wholesale rates are slightly higher for Cases B and C in the 2040s
- Wholesale rates increase in all cases, but generally at less than the rate of inflation
- An exception is Case C where wholesale rates more than double by 2050 (relative to 2035)

Case Results
NPPD Debt for New Resources and Retrofits as of 2035

Case	2035 Outstanding Principal for New Builds and Retrofits (2019 $ in billions)
Base	$1.4
A	$2.7
B	$2.5
C	$1.9

Analysis Assumes:

- Debt Life as Included Above in Technology Inputs
- Real Interest Rate of ~2.25%
- Includes the estimated outstanding principal on debt for new builds and retrofits selected by the model

Case Results Scorecard

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Criteria Measure	Base	Case A	Case B	Case C
Maintaining Cost Competitiveness Total cost (billion $ NPV)	$13.92	$14.59	$14.80	$16.00
Wholesale rates	Estimated wholesale rates below CFC metric in short term			Highest rates driven by extremely deep CO2 reduction requirements
Ensuring ongoing reliability LOLE evaluation	No loss of load due to inadequate generation in 2040 in any Cases			

Signposts
General Observations

- As expected, more stringent CO_2 restrictions drive a shift towards solar, wind capacity in NPPD.
- NPPD total costs increase with the stringency of CO_2 restrictions.
- In general, the average market power prices decrease with increasing CO_2 restrictions because more low- and zero-cost marginal resources are added to the system.
- While fuel and variable OM costs decline in a lower-CO_2 case, these costs reductions are offset by increased fixed cost and capital expenditures, and increased transmission costs.
- The base case shows NPPD's position changing from a net seller to a net purchaser when baseload units retire. The other cases show similar trends, although NPPD regains a relatively strong net seller position towards the very end of Case C.
- NPPD's wholesale rates remain below the CFC 45th percentile forecast from 2020-25 in every case.
- NPPD experiences the highest wholesale rates from 2040-50 in Case C.
- Gerald Gentleman retires around the end of the wholesale contract in most cases
- Cooper's retirement date becomes later as the stringency of CO_2 restrictions increases
- Sheldon using natural gas may provide more value to NPPD than coal operation, as well as helping NPPD achieve lower CO_2 intensity.
- Beatrice becomes uneconomic towards the end of the forecast.

Case Results
Resilience Analysis

- Siemens constructed a tool to test the resiliency of each case. This tool compared available NPPD generation to demand over a high demand winter and summer day. An hour where demand exceeded available NPPD generation indicated the necessity of *imported energy or demand curtailment*. Note that this does not necessarily imply loss of load because it includes the possibility of imported or purchased energy. The methodology measures load not served by native generation.
- Several market conditions were tested against the Case with varying degrees of load increases, solar generation decreases, and wind generation decreases. Total energy not served by native generation and highest hour of energy not served by native generation were the key metrics used to compare the Cases.

Case Name	Load Increase	Solar Derate	Wind Derate
Extreme	7.50%	60%	30%
Solar Extreme	7.50%	90%	0%
Wind Extreme	7.50%	0%	60%
Load Extreme	12.00%	0%	0%

Case Results
Resilience Analysis: Total Energy Comparison (Summer 2040)

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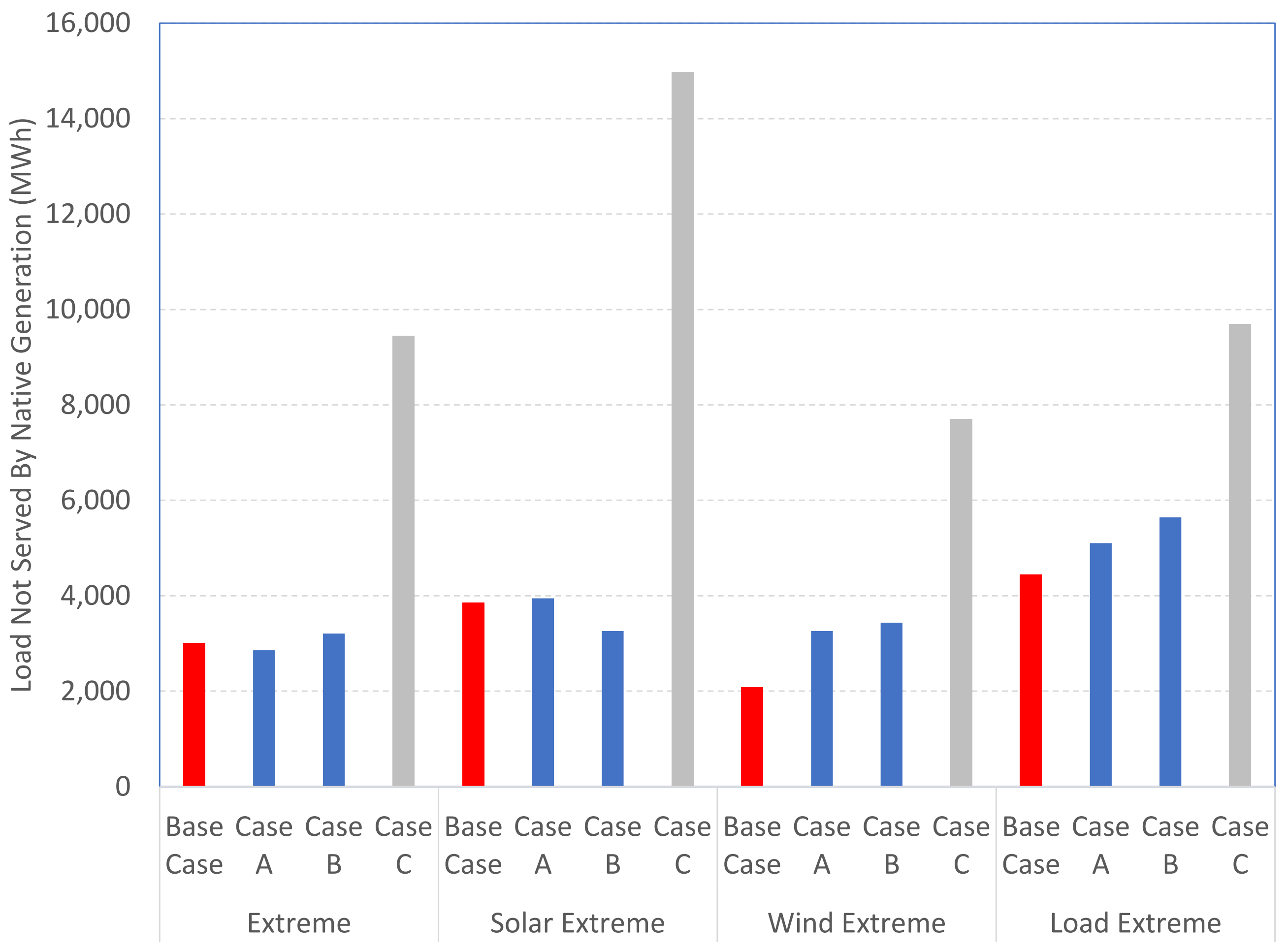
- Displayed is an example of how the resiliency tool represents total load not served by native generation experienced in each case under various market conditions for the specified seasonal day.
- Case C, for instance, is the least resilient under all conditions using this metric.
- Case B, which is out performed by Case A and the Base case in the Extreme and Wind Extreme cases, shows exposure to wind volatility risk.



Case Results
Resilience Analysis: Total Energy Comparison (Winter 2040)

- The high demand Winter day has a lower load than the Summer day. As such, under the same renewable and load change conditions the amount of energy not served by native generation is much lower.
- In Winter the only case that showed a shortage of native generation was Case C, and that was only for the Wind and Load Extreme cases.
- Even in these cases the amount of energy shortfall was much lower than the Summer day.