2020 Integrated Resource Plan

Scenarios & Modeling Plan

March 11, 2020

IRP MODELING PROCESS

The 2020 IRP analysis will follow the modeling plan shown in Figure 1 below. This process is robust and flexible enough to examine the wide range of inputs and outcomes that will be considered in this IRP.

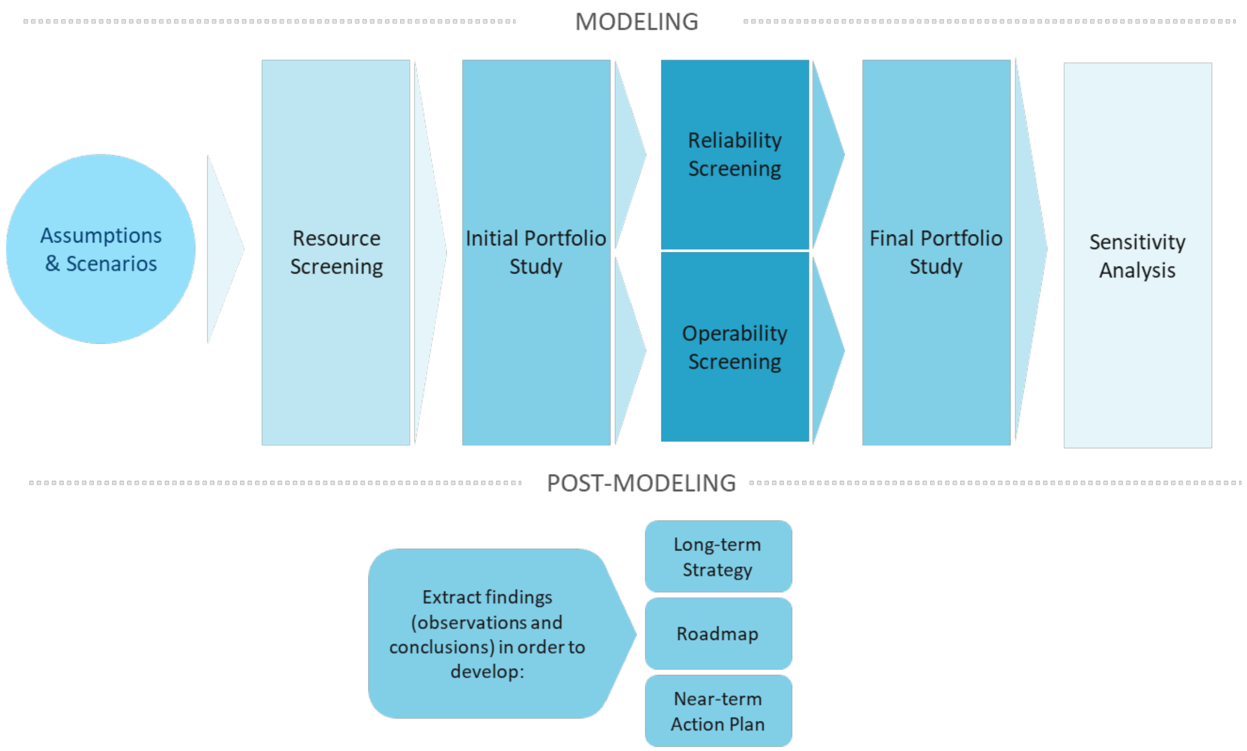

Figure 1 - IRP Modeling Plan Overview

Table 1 provides a description of each phase of the modeling plan.

Phase	Description
Resource Screening	Refine candidate resources to be available to model in each scenario (this may differ by scenario). Combination of qualitative evaluation and/or quantitative modeling using E3's RESOLVE model.
Initial Portfolio Study	Conduct capacity expansion optimization modeling with Plexos LT (supplemented with E3's RESOLVE model where required), which will result in an economically optimized resource portfolio for each scenario (e.g. the resource plan with the lowest 25 year NPV revenue requirement for that scenario's set of assumptions).
Reliability Screening	For select scenarios, evaluate the impacts on reliability parameters, including the ELCC of renewables (and diversity benefits) and the required Planning Reserve Margin for particular resource portfolios using E3's RECAP model. Identify changes to these assumptions for iteration.

Operability Screening	For select scenarios, evaluate the production costs (e.g. fuel and purchased power) and dispatch constraints using the more granular Plexos MT/ST module. Identify changes required for the portfolio for iteration.
Final Portfolio Study	Using the output of the Reliability and Operability Screening phases, if required, conduct revised capacity expansion optimization modeling with Plexos (supplemented with E3's RESOLVE model where required).
Sensitivity Analysis	Using bookend values, as identified for each scenario, test the impact of future changes to key assumptions on the cost and performance of the portfolios. In some cases, sensitivities may also require the capacity expansion optimization to be re-run within a particular scenario.

Table 1 - IRP Modeling Plan Phase Descriptions

SCENARIO DEVELOPMENT APPROACH

NS Power has used a Portfolio Development approach to create the 2020 IRP Scenarios. This approach will allow the IRP to evaluate the broad range of potential futures and then develop a Roadmap and Action Plan based on the least regrets options that are common to the largest number of scenarios.

Figure 2 outlines the process to develop candidate scenarios by considering a range of potential drivers.

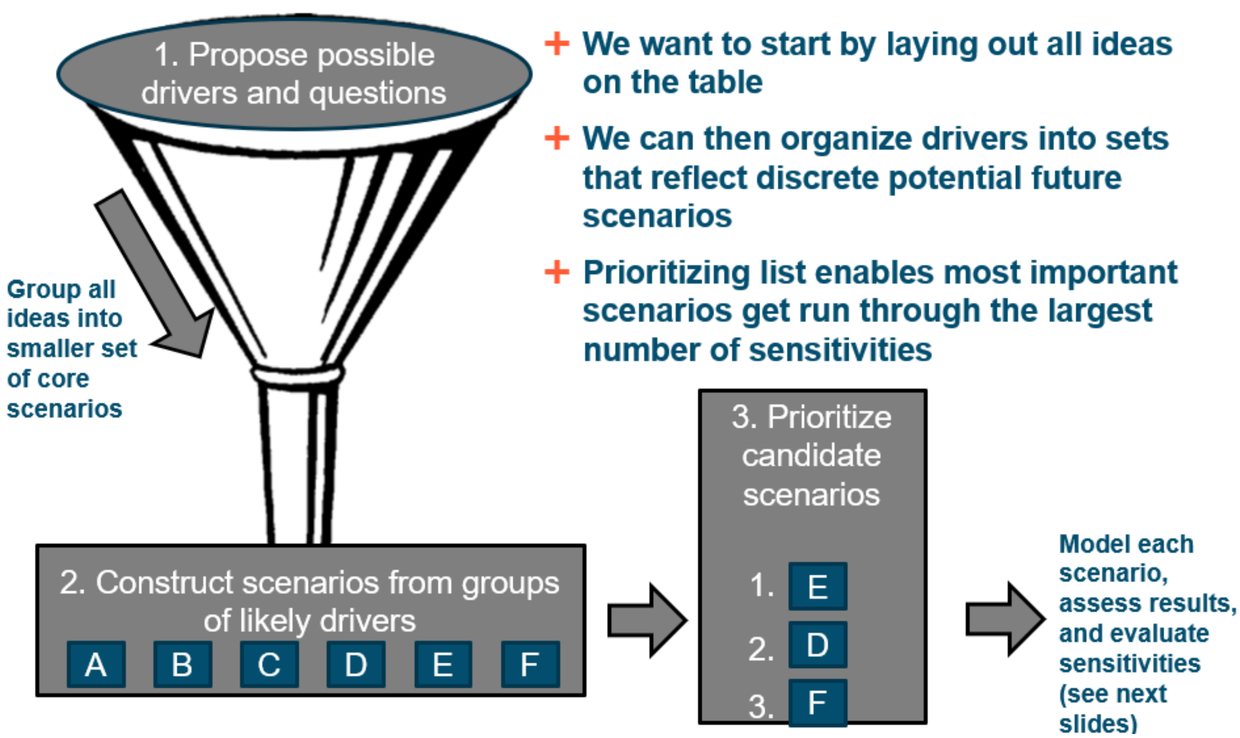

Figure 2 - Scenario Development Overview

In addition to the combinations of drivers into scenarios as illustrated above, NS Power has also proposed "Resource Strategies" to be paired with scenarios based on the feedback received from the IRP stakeholders to date, to ensure the appropriate breadth of potential future resources is captured. The modeling process for the Portfolio Study phase is illustrated in Figure 3.

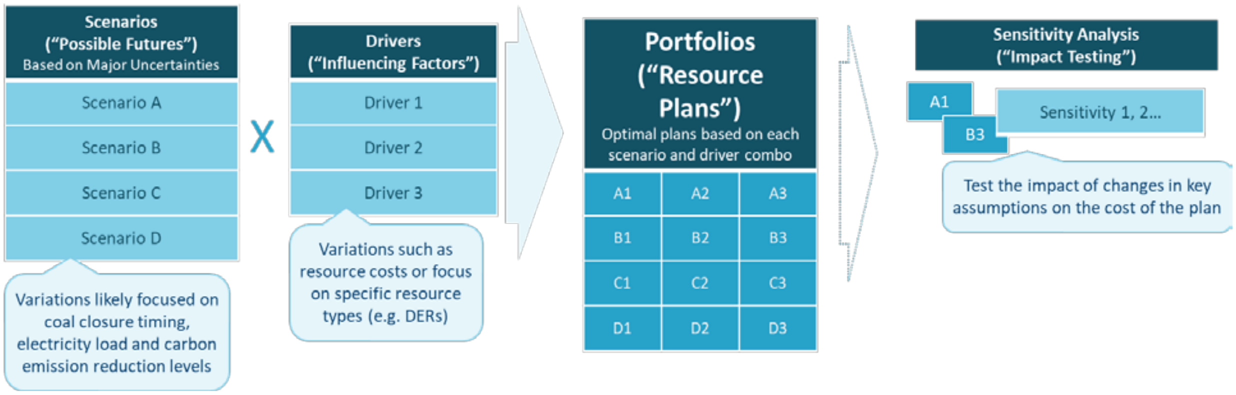

Figure 3 - IRP Portfolio Study Modeling Approach

KEY POLICY DRIVERS

NS Power is proposing three key policy drivers to form the basis of scenarios:

1. Provincial clean energy policy (e.g. Sustainable Development Goal Act)

    Policy Driver 1.1: Greenhouse gas emissions by electricity sector

    Policy Driver 1.2: Load changes driven by varying degrees of electrification

2. Federal clean energy policy:

    Policy Driver 2.1: Coal unit end dates

1. Provincial Clean Energy Policy Drivers

1.1 Greenhouse Gas Emissions by Electricity Sector

This driver represents the carbon dioxide emissions allowable by the electricity sector, which will be implemented as a constraint in the model. Based on stakeholder discussions, NS Power proposes three GHG scenarios for consideration to represent the range of the outcomes of provincial carbon policy, as shown in Figure 4 and Table 2 below.

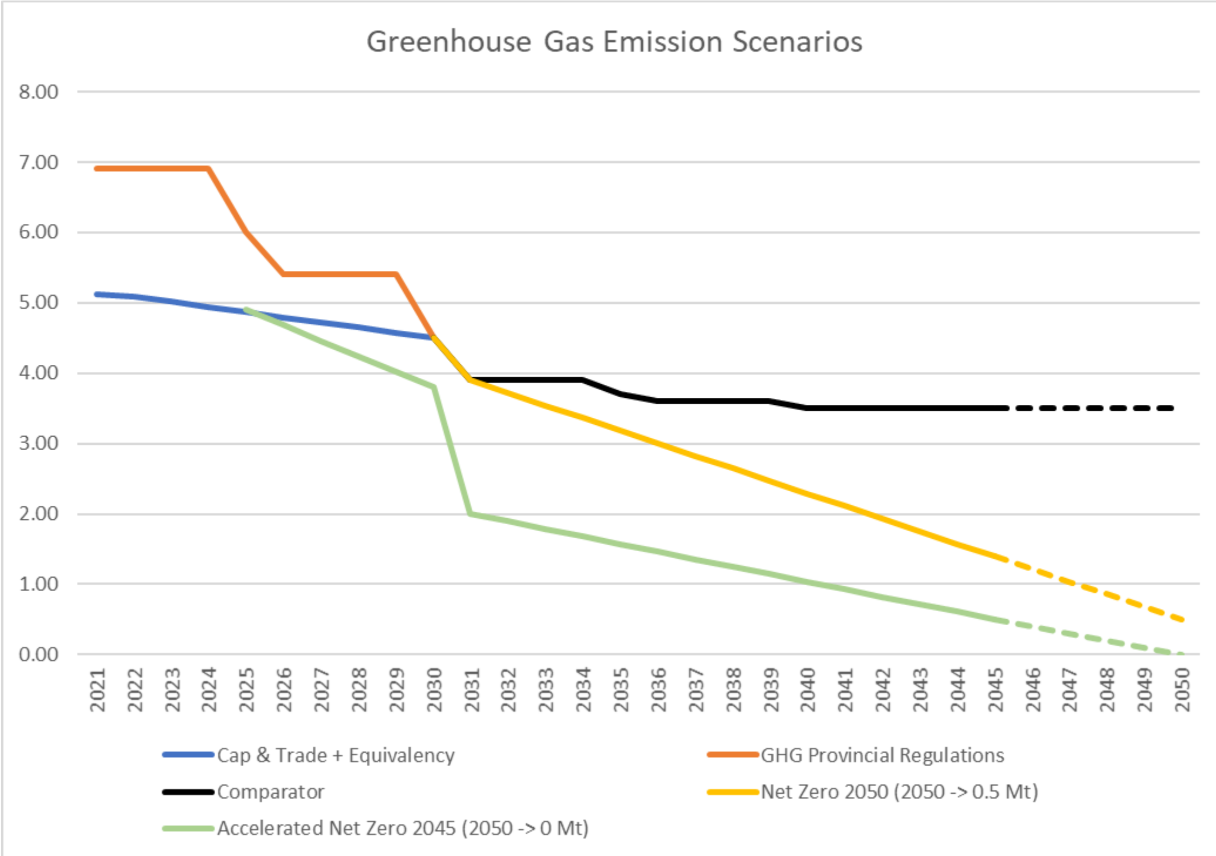

Figure 4 - Greenhouse Gas Emissions Scenarios Graph

	CO2 2030	CO2 2031	CO2 2040	CO2 2045	CO2 2050*
Comparator GHG Case	4.5	3.9	3.5	3.5	3.5
Reductions consistent with equivalency agreement and continued future decline	*(58% reduction from 2005)*	*(63% reduction from 2005)*	*(67% reduction from 2005)*	*(67% reduction from 2005)*	*(67% reduction from 2005)*
Net Zero 2050 (2050 -> 0.5 Mt)	4.5	3.9	2.3	1.4	0.5
Reduction to 0.5 Mt by 2050 (assumes achievement of "net zero" via mechanism)	*(58% reduction from 2005)*	*(63% reduction from 2005)*	*(78% reduction from 2005)*	*(87% reduction from 2005)*	*(95% reduction from 2005)*
Accelerated Net Zero 2045 (2050 -> 0 Mt)	3.8	2.0	1	0.5	0
Reduction to 0.5 Mt by 2045 with acceleration of pace beginning in 2025	*(64% reduction from 2005)*	*(81% reduction from 2005)*	*(91% reduction from 2005)*	*(95% reduction from 2005)*	*(100% reduction from 2005)*

Table 2 - Greenhouse Gas Emissions Scenarios

**Note: IRP modeling period ends in 2045; 2050 is shown here to demonstrate a potential end value of each curve (relative to SDGA 2050 target year).*

1.2 Load Changes

This driver represents the impact provincial greenhouse gas reduction and/or “net zero” policy (e.g. the Sustainable Development Goals Act or SDGA) has on the expected load for the electricity sector. The electrification cases will be based on E3’s Pathways assessment of the potential impact of economy-wide decarbonization on the electricity sector. The Pathways Study contains further information on the load impact of electrification scenarios.

Three load cases are proposed for evaluation within the IRP scenarios:

- **Business as usual:** *represents the 2019 Load Forecast as filed with the UARB in April 2019 (adjusted where required to reflect E1’s 2019 DSM Potential Study profiles to reflect potential demand side resources).*
- **Moderate degree of electrification:** *represents the 2019 Load Forecast, adjusted to reflect the incremental load due to partial electrification of buildings and vehicles as indicated in E3’s “Moderate Electrification” Pathways scenario (adjusted where required to reflect E1’s 2019 DSM Potential Study profiles to reflect potential demand side resources).*
- **High degree of electrification:** *represents the 2019 Load Forecast, adjusted to reflect the incremental load due to broad electrification of buildings and transportation as indicated in E3’s “High Electrification” Pathways scenario (adjusted where required to reflect E1’s 2019 DSM Potential Study profiles to reflect potential demand side resources).*

2. Federal Clean Energy Policy Drivers

2.1 Coal Closure Policy

The two states of this driver are:

- All coal units retired by 2040 – assumes retention of the ongoing Equivalency Agreement
- All coal units retired by 2030 – assumes adherence to the applicable Federal regulations

Note: Coal units can be economically retired by the IRP model in any year earlier than the end dates described above.

SCENARIO SCREENING: IDENTIFYING KEY SCENARIOS OF INTEREST

Qualitative Screening

Combining all the variants of the major scenario drivers produces 18 potential candidate scenarios, shown below in Table 3.

GHG Scenario	Load Driver	Coal End Date
Comparator GHG Case	High Electrification	2030
Comparator GHG Case	Moderate Electrification	2030
Comparator GHG Case	Business as Usual	2030
Comparator GHG Case	High Electrification	2040
Comparator GHG Case	Moderate Electrification	2040
Comparator GHG Case	Business as Usual	2040
Net Zero 2050	High Electrification	2030
Net Zero 2050	Moderate Electrification	2030
Net Zero 2050	Business as Usual	2030
Net Zero 2050	High Electrification	2040
Net Zero 2050	Moderate Electrification	2040
Net Zero 2050	Business as Usual	2040
Accelerated Net Zero 2045	High Electrification	2030
Accelerated Net Zero 2045	Moderate Electrification	2030
Accelerated Net Zero 2045	Business as Usual	2030
Accelerated Net Zero 2045	High Electrification	2040
Accelerated Net Zero 2045	Moderate Electrification	2040
Accelerated Net Zero 2045	Business as Usual	2040

Table 3 - Potential Candidate Scenarios

Qualitative screening was used to identify six key scenarios of interest (highlighted in Table 4 in green) and to eliminate scenarios with unlikely combinations of drivers. Consistent with the scenarios in E3's Pathways Report, higher levels of load are generally paired with larger carbon budgets, which reflects overall economy decarbonization resulting from the removal of emissions from other sectors.

GHG Scenario	Load Driver	Coal End Date
Comparator GHG Case	High Electrification	2030
Comparator GHG Case	Moderate Electrification	2030
Comparator GHG Case	Business as Usual	2030
Comparator GHG Case	High Electrification	2040
Comparator GHG Case	Moderate Electrification	2040
Comparator GHG Case	Business as Usual	2040
Net Zero 2050	High Electrification	2030
Net Zero 2050	Moderate Electrification	2030
Net Zero 2050	Business as Usual	2030
Net Zero 2050	High Electrification	2040
Net Zero 2050	Moderate Electrification	2040
Net Zero 2050	Business as Usual	2040
Accelerated Net Zero 2045	High Electrification	2030
Accelerated Net Zero 2045	Moderate Electrification	2030
Accelerated Net Zero 2045	Business as Usual	2030
Accelerated Net Zero 2045	High Electrification	2040
Accelerated Net Zero 2045	Moderate Electrification	2040
Accelerated Net Zero 2045	Business as Usual	2040

Table 4 – Scenarios of Interest

RESOURCE STRATEGIES

Three resource strategies are proposed to ensure the IRP analysis covers key areas of importance and interest:

A. Current Landscape
New in-province supply and demand resources available, with no new interconnections to other regions.
B. Distributed Resources
Distributed supply and demand resources are preferred where possible (e.g. distributed solar and battery storage) and high uptake of DERs is assumed.
C. Regional Integration
New interconnections to other regions and corresponding access to out-of-province resources for energy and capacity are available, in addition to in-province supply and demand resources.

SCREENING POLICY DRIVER & STRATEGY PAIRS

Building on to the screening exercise above, NS Power has qualitatively identified the key combinations of policy drivers and resources strategies to initially examine as Key Scenarios, which are shown in Table 5 below. NS Power has also paired a DSM level to each scenario to produce an associated load forecast; alternate DSM levels will be examined as sensitivities for candidate resource plans of interest.

Scenario	Features	Load Drivers	Coal Retires	Resource Strategies Tested	Key Sensitivities
1.0 **Comparator**	Equivalency GHG	Low Elec. Base DSM	2040	A - Current Landscape	
2.0 **Net Zero 2050** **Low Electrification**	GHG targets decline linearly from 2030 to 0.5Mt in 2050	Low Elec. Base DSM	2040	A - Current Landscape C - Regional Integration	• DSM Levels
2.1 **Net Zero 2050** **Mid Electrification**	GHG targets decline linearly from 2030 to 0.5Mt in 2050	Mid Elec. Base DSM	2040	A - Current Landscape B - Distributed Resources C - Regional Integration	• DSM Levels • No New Emitting • Target Case for Sensitivity Evaluation
2.2 **Net Zero 2050** **High Electrification**	GHG targets decline linearly from 2030 to 0.5Mt in 2050	High Elec. Max DSM	2040	A - Current Landscape C - Regional Integration	• DSM Levels • No New Emitting
3.1 **Accelerated Net Zero 2045** **Mid Electrification**	GHG targets decline from 2025 to 0.5Mt in 2045; path to Absolute Zero 2050	Mid Elec. Base DSM	2030	B - Distributed Resources C - Regional Integration	• DSM Levels • No New Emitting • Target Case for Sensitivity Evaluation
3.2 **Accelerated Net Zero 2045** **High Electrification**	GHG targets decline from 2025 to 0.5Mt in 2045; path to Absolute Zero 2050	High Elec. Max DSM	2030	B - Distributed Resources C - Regional Integration	• DSM Levels

Table 5 – Key Scenarios

These Key Scenarios represent the twelve initial modeling runs to be conducted in Plexos LT in the Initial Portfolio Study Phase. Consistent with the scenario screening discussed above, additional scenarios may be tested using E3's RESOLVE model to assess if they should be included as a key modeling run.

SENSITIVITY ANALYSES

Following completion of the portfolio studies and operability and reliability screening phases, NS Power will work with stakeholders to prioritize the sensitivities and identify applicable portfolios and/or scenarios for them to be paired with, based on emerging insights from the ongoing analysis throughout the IRP modeling phase.

Potential sensitivities to be evaluated include:

- Increase in Renewable Energy Standard policy
- Low capital cost of wind
- Low capital cost of storage
- Low/High pricing of import energy
- Low/High pricing of natural gas
- High Pricing of Biomass
- High Sustaining Capital Costs
- Loss of Large Industrial Load
- Mersey Hydro System retired
- No New Emitting Resources
- Fuel security sensitivities
- Resiliency testing

It should be noted that some of these sensitivities will require the capacity expansion optimization to be rerun (e.g. DSM, Sustaining Capital), while others are run on the resource plan without reoptimizing (e.g. Fuel Prices).

EVALUATION CRITERIA

NS Power has developed the following evaluation criteria against which potential plans and resource portfolios will evaluated under each scenario, as shown in Table 6 below:

Metric	Description
Minimization of the cumulative present value of the annual revenue requirements over the planning horizon (adjusted for end-effects)	25 year NPV Revenue Requirement
Magnitude and timing of electricity rate effects	10 year NPV Revenue Requirement
Reliability requirements for supply adequacy	Evaluation of PRM, resource capacity adequacy, operating reserve requirements, etc.
Provision of essential grid services for system stability and reliability	Quantitative and qualitative assessment of the status of essential grid services provision for each portfolio.
Plan robustness (the ability of a plan to withstand plausible potential changes to key assumptions)	Magnitude of the plan's exposure to changes in key assumptions (via sensitivity analysis) as well as resiliency to risks.
Reduction of greenhouse gas and/or other emissions	Quantitative reductions as output by Plexos, e.g. Mt of CO_2 reduced relative to 2005 actuals
Flexibility (limitation of constraints on future decisions arising from the selection of a particular path)	Qualitative assessment of timing of investments

Table 6 - Resource Plan Evaluation Criteria

While the primary metric of plan value will continue to be minimization of net present value of revenue requirement, by adding these additional metrics to the 2020 IRP, additional insight will be gained into the value of flexibility, reliability, and robustness which will inform the IRP Roadmap and Action Plan.

SUMMARY

The major policy drivers which emerged from scenario discussions are:

- 1. Provincial clean energy policy (e.g. Sustainable Development Goal Act)
    - Policy Driver 1.1: Greenhouse gas emissions by electricity sector
    - Policy Driver 1.2: Load changes driven by varying degrees of electrification
- 2. Federal clean energy policy:
    - Policy Driver 2.1: Coal unit end dates

Variants of these drivers have been combined to form the following "scenarios":

- Comparator Case / Low Electrification / 2040 Coal Closure
- Net Zero 2050 / Low Electrification / 2040 Coal Closure
- Net Zero 2050 / Mid Electrification / 2040 Coal Closure

- Net Zero 2050 / High Electrification / 2040 Coal Closure
- Accelerated Net Zero 2045 / Mid Electrification / 2030 Coal Closure
- Accelerated Net Zero 2045 / High Electrification / 2030 Coal Closure

The potential resource strategies, to be paired with scenarios to influence the constraints around portfolios, also emerged from scenario discussions:

A - Current Landscape

B - Distributed Resources Promoted

C - Regional Integration

Modeling scenarios with various resource strategies will result in economically optimal portfolios for each scenario/strategy combination. In Table 7 NS Power proposes ten preliminary scenario and strategy combinations for the initial portfolio modeling.

Scenario	GHG Curve	Load Driver	Resource Strategy
1.0A	Comparator	Low Electrification / Base DSM	Current Landscape
2.0A	Net Zero 2050	Low Electrification / Base DSM	Current Landscape
2.0C	Net Zero 2050	Low Electrification / Base DSM	Regional Integration
2.1A	Net Zero 2050	Mid Electrification / Base DSM	Current Landscape
2.1B	Net Zero 2050	Mid Electrification / Base DSM	Distributed Resources
2.1C	Net Zero 2050	Mid Electrification / Base DSM	Regional Integration
2.2A	Net Zero 2050	High Electrification / Max DSM	Current Landscape
2.2C	Net Zero 2050	High Electrification / Max DSM	Regional Integration
3.1B	Accelerated Net Zero 2045	Mid Electrification / Base DSM	Distributed Resources
3.1C	Accelerated Net Zero 2045	Mid Electrification / Base DSM	Regional Integration
3.2B	Accelerated Net Zero 2045	High Electrification / Max DSM	Distributed Resources
3.2C	Accelerated Net Zero 2045	High Electrification / Max DSM	Regional Integration

Table 7 – Preliminary Scenario and Resource Strategy Combinations

Additionally, several potential sensitivities to be tested on key portfolios of interest have been identified. The specific sensitivity analysis plan will be refined once the insights from the preliminary modeling have emerged.