2021 PSE Integrated Resource Plan

I

Natural Gas Analysis Results

This appendix presents details of the methods and model employed in PSE's natural gas resource analysis and the data produced by that analysis.

Contents

1. NATURAL GAS PORTFOLIO MODEL

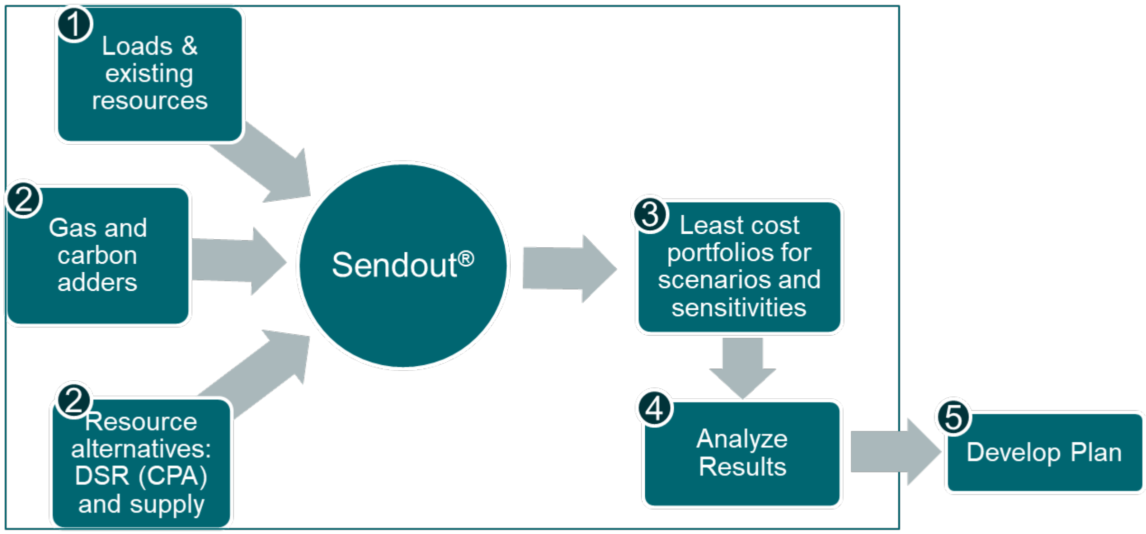
To model gas resources and alternatives for both long-term planning and natural gas resource acquisition activities, PSE uses a gas portfolio model (GPM). The GPM used in this IRP is SENDOUT® from ABB, a widely used software tool that helps identify the long-term least-cost combination of resources to meet stated loads. Other regional utilities that provide natural gas services, such as Avista, Cascade Natural Gas and FortisBC use the SENDOUT model. SENDOUT Version 14.3.0 was used for this analysis.

SENDOUT

SENDOUT is an integrated tool set for natural gas resource analysis that models the natural gas supply network and the portfolio of supply, storage, transportation and demand-side resources (DSR) needed to meet demand requirements. Figure I-1 shows how SENDOUT is used for natural gas resource analysis. Loads, existing resources, emission adders and resource alternatives are included as inputs into the SENDOUT model, which produces a least-cost portfolio based on those inputs.

SENDOUT can operate in two modes: For a defined planning period, it can determine the optimal set of resources to minimize costs; or, for a defined portfolio, it can determine the least-cost dispatch to meet demand requirements for that portfolio. SENDOUT solves both problems using a linear program (LP) to determine how a portfolio of resources (energy efficiency, supply, storage and transport), including associated costs and contractual or physical constraints, should be added and dispatched to meet demand in a least-cost fashion. The linear program considers thousands of variables and evaluates tens of thousands of possible solutions in order to generate a solution. A standard planning-period dispatch considers the capacity level of all resources as given, and therefore performs a variable-cost dispatch. A resource-mix dispatch can look at a range of potential capacity and size resources, including their fixed and variable costs.

Figure I-1: SENDOUT Inputs and Outputs in the 2021 PSE IRP



PSE's gas portfolio model analysis follows a six-step process.

1. Set up database with existing resources and demand forecast.
2. Update inputs for natural gas prices, carbon adders and new resource alternatives.
3. Perform long-run capacity expansion analysis to get least cost portfolio for each scenario and sensitivity.
4. Analyze results.
5. Develop resource plan.

SENDOUT Model Inputs

NATURAL GAS PRICES. For natural gas prices, PSE uses a combination of forward market prices and fundamental forecasts acquired in Spring 2020 from Wood Mackenzie. The natural gas price forecast is an input into the SENDOUT; the natural gas price inputs as described in Chapter 5.

CO_2 PRICE INPUTS. RCW 80.28.380 requires that the natural gas analysis include the cost of greenhouse gases when evaluating the cost-effectiveness of natural gas conservation targets. To implement this requirement, the SCGHG is added to the natural gas commodity price. Detailed inputs are provided in Chapter 5.

DEMAND-SIDE RESOURCES. SENDOUT provides a comprehensive set of inputs to model a variety of energy efficiency programs. Costs can be modeled at an overall program level or broken down into a variety of detailed accounts. The impact of demand-side resources on load can be modeled at the same level of detail as demand. SENDOUT has the ability to integrate demand- and supply-side resources in the long-run resource mix analysis to determine the most cost-effective size of demand-side resources.

NATURAL GAS SUPPLY. SENDOUT allows a system to be supplied by either long-term natural gas contracts or short-term spot market purchases. Specific physical and contractual constraints can be modeled on a daily, monthly, seasonal or annual basis, such as maximum flow levels and minimum flow percentages. SENDOUT uses standard gas contract costs; the rates may be changed on a monthly or daily basis.

STORAGE. SENDOUT allows storage sources (either leased or company-owned) to serve the system. Storage input data include the minimum or maximum inventory levels, minimum or maximum injection and withdrawal rates, injection and withdrawal fuel loss to and from interconnects, and the period of activity (i.e., when the gas is available for injection or withdrawal). There is also the option to define and name volume-dependent injection and withdrawal percentage tables (ratchets), which can be applied to one or more storage sources.

TRANSPORTATION. SENDOUT provides the means to model transportation segments to define flows, costs and fuel loss. Flow values include minimum and maximum daily quantities available for sale to gas markets or for release. Costs include standard fixed and variable transportation rates, as well as a per-unit cost generated for released capacity. Seasonal transportation contracts can also be modeled.

DEMAND. SENDOUT allows the user to define multiple demand areas, and it can compute a demand forecast by class based on weather. The demand input is segregated into two components: 1) base load, which is not weather dependent, and 2) heat load, which is weather dependent. Both factors are further computed as a function of customer counts. The heat load factor is estimated by dividing the remaining non-base portion of the load by historical monthly average heating degree days (HDD) and monthly forecasted customer counts to derive energy per HDD per customer. The demand is input into SENDOUT on a monthly basis and includes the customer forecast, the baseload factors and the heat load factors computed over the entire 20-year demand forecast period. More information on the natural gas demand forecast can be found in Chapter 6.

The gas analysis uses a design day peak standard of 52 HDD.[1] This design peak day demand value is manually inserted into the historical peak month, which is December for this 2021 IRP. More information on the design peak day can be found in Chapter 9, Natural Gas Analysis.

Resource Alternatives Assumptions

Figure I-2 summarizes resource costs and modeling assumptions for the pipeline alternatives considered in the 2021 IRP, and Figure I-3 summarizes resource costs and modeling assumptions for storage alternatives.

1 / The design day peak standard of 52 Heating Degree Days was established in PSE's 2005 IRP, Appendix I, Gas Planning Standard.

Figure I-2: Prospective Pipeline Alternatives Available

Alternative	From/To	Capacity Demand ($/Dth/Day)	Variable Commodity ($/Dth)	Fuel Use (%)	Earliest Available	Comments
Westcoast + NWP Expansions	Station 2 to PSE	0.52 + 0.56	0.05 + 0.09	1.6 + 1.5	Nov. 2025	Westcoast expansion coupled with NWP expansion
Short Term NWP TF-1	Sumas to PSE	0.38	0.09	1.5	Nov. 2021	Potentially available from PSE Power Book, possibly from 3rd parties
Fortis BC / Westcoast (KORP) + NWP Expansions	Kingsgate to PSE via Sumas	0.42 + 0.56	0.05 + 0.09	1.6 + 1.5	Nov. 2025	Prospective projects & estimated project cost - requires NGTL and Foothills
NGTL (Nova) Pipeline	AECO to Alberta / BC border	0.16	0	0	Nov. 2025	Prospective projects & estimated project cost - requires Foothills and GTN
Foothills Pipeline	Alberta / BC Border	0.12	0	1	Nov. 2025	Prospective projects & estimated project cost - requires NGTL and GTN
GTN Pipeline	Kingsgate to Stanfield	0.2	0.044	1.4	Nov. 2025	Prospective projects & estimated project cost - requires NGTL and Foothills.
NWP Columbia Gorge	Stanfield to PSE	0.8	0.005	2	Nov. 2025	Prospective project & estimated project cost - requires NGTL/Foothills/GTN.
Incremental NWP - Backhaul	I-5 to PSE	0.28	0.09	1.5	Nov. 2025	capacity resulting from NWP Sumas South Expansion; Demand Charge Winter Only rate requires Mist Storage
Long Term NWP TF-1	Plymouth to PSE	0.38	0.09	1.5	Apr. 2023	Maximum 15 MDth/d, available from 3rd parties effective Apr. 2023
Tacoma LNG Distribution Upgrade	Tacoma LNG to PSE	0.23	0	0	Nov. 2025	Upgrade of the distribution system to connect the LNG plant to additional area of the PSE system

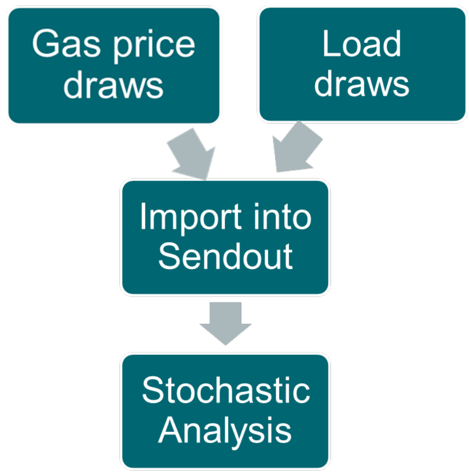
Figure I-3: Prospective Storage Alternatives Available

Alternative	Storage Capacity (MDth)	Maximum Withdrawal Capacity (MDth/day)	Days of Full Withdrawal (days)	Max. Injection Capacity (MDth/day)	Earliest Available	Comments
Mist Expansion	1,000	50	20	20	Nov. 2025	Prospective project, estimated size and costs, confidential - requires NWP backhaul capacity
Plymouth LNG	241.7	15	16	-	Apr. 2023	Existing plant - requires LT firm NWP capacity
Swarr	90	30	3	-	Nov. 2024	Existing plant requiring upgrades; on-system, no pipeline required

2. STOCHASTIC MODEL

For the stochastic analyses, the natural gas prices and load draws are varied in order to provide varied inputs for the SENDOUT model. Figure I-4 shows how SENDOUT is used for stochastic gas resource analysis.

Figure I-4: The Stochastic Natural Gas Analysis Process



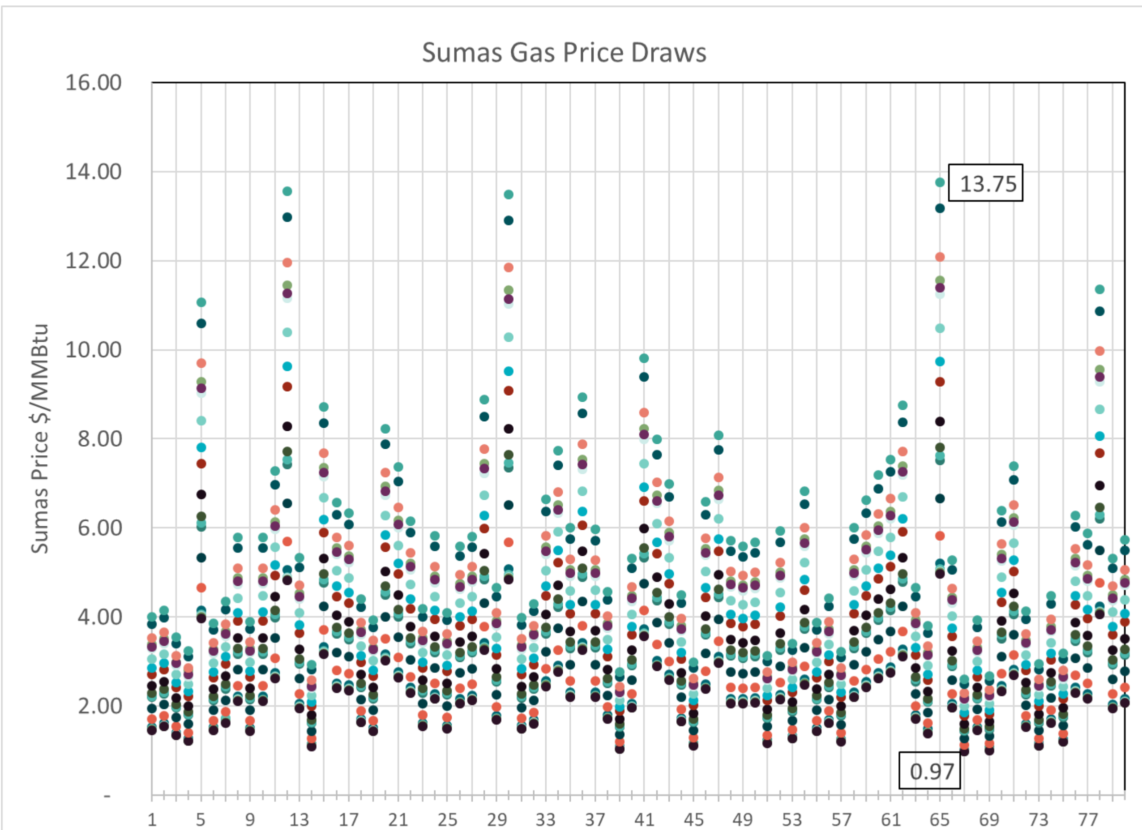
Stochastic Model Inputs

The development of natural gas price draws and demand draws is the starting point for the stochastic analysis. Eighty natural gas price draws were developed using the risk functionality tool in the electric AURORA model, mirroring the natural gas price and demand draws used in the electric analysis. For the demand draws, the 250 draws that the load forecasting group used to develop the Low and High Scenarios were used.

NATURAL GAS PRICE DRAWS. For the Sumas, AECO, Rockies and Stanfield natural gas hubs, the natural gas stochastic analysis used the same 80 natural gas price draws developed for the electric stochastic analysis.[2] Natural gas prices for Station 2 and Malin were generated in SENDOUT using the basis differential pricing off one of the four hubs. The 80 draws were also repeated to create 250 draws. For each hub, a total of 19,200 prices (80 draws x 12 months/year x 20 years), were repeated to obtain 60,000 natural gas prices for each hub.

Each natural gas price draw was then adjusted to include the SCGHG and upstream emission adders in SENDOUT. With the addition of SCGHG and upstream emissions, the expected natural gas price shifted from $2.25/MMBtu to $7.57/MMBtu in 2022.

Figure I-5: Natural Gas Price Draws for Sumas Hub

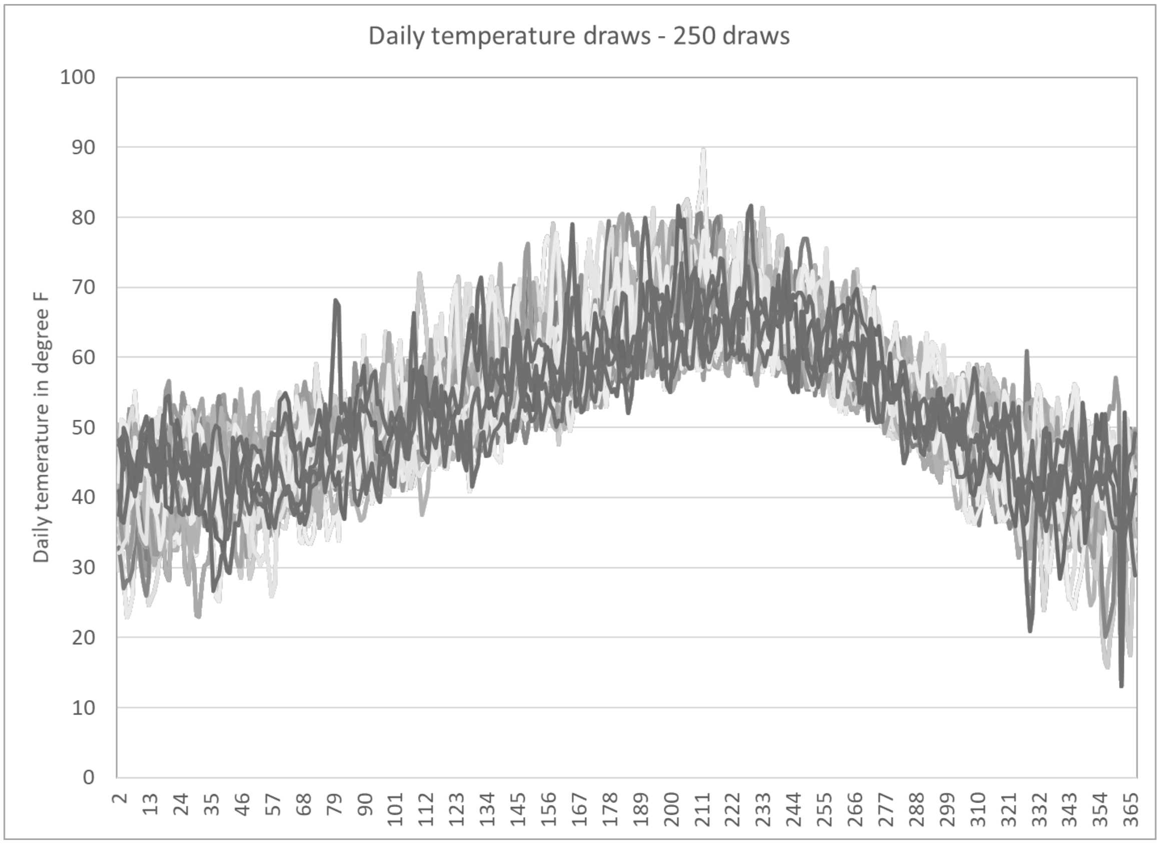


SCGHG AND UPSTREAM EMISSIONS. The deterministic SCGHG and upstream emissions costs were added to each natural gas price draw.

2 / *The natural gas price draws were developed from the monthly forecasts that were used in the deterministic models, taking hub and lag correlations into account. See Appendix G, Electric Analysis Models, for a more detailed description of the methodology.*

LOAD DRAWS. SENDOUT uses temperature draws to calculate demand. The 250 demand draws were developed from the “normal” weather data used in the Base Demand Forecast, defined as the average monthly weather recorded at NOAA’s Sea-Tac Airport station over the past 30 years ending in 2019. Before the draws were imported into SENDOUT, they were adjusted to include the natural gas planning peak day temperature. Figure I-6 below shows the temperature draws.

Figure I-6: Daily Temperature Draws



Stochastic Analysis

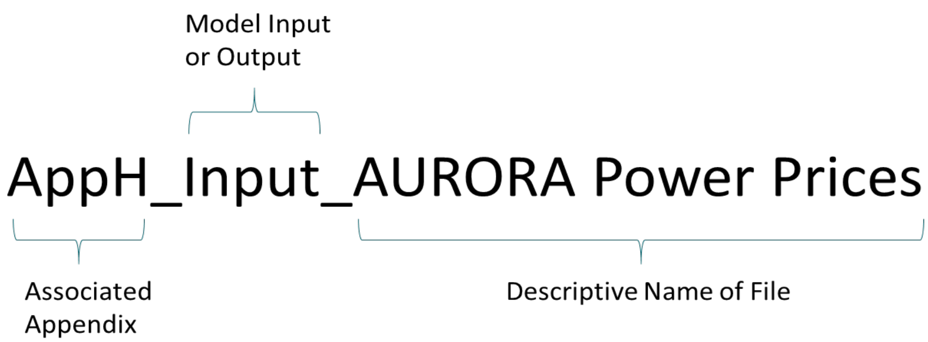
In order to test the portfolios developed in the deterministic scenario analysis under a wider range of demand and natural gas prices, PSE ran the portfolio two different ways

1. **Resource/Cost Optimization**: This analysis tests the portfolio against 250 variations (draws) of different demand and natural gas price combinations. The model was allowed to change the resource additions to optimize portfolio cost for the different demand and price conditions. This results in a different portfolio for each draw.
2. **Mid Fixed Portfolio:** This analysis tests the robustness of a deterministic portfolio. The resource portfolio is fixed and then run through the 250 demand and natural gas price combinations to evaluate the portfolio's cost and reliability risks. This analysis tests the robustness and risks around a single portfolio.

3. APPENDIX I DATA FILES

For the 2021 IRP, PSE is providing Microsoft Excel files containing input and output data in separate files instead of presenting static data tables. The direct access to the data provides usable files for stakeholders as opposed to static tables in a PDF format. Technical limitations on how PSE is able to submit files to the WUTC and host files online for stakeholder access has prevented PSE from keeping the files organized in a series of folders. To overcome this, a descriptive naming system has been developed in order to identify different files. Figure I-7 provides an example of how the files will be named in Appendix H, Electric Analysis Inputs and Results. The same format is used for files from Appendix I. Each Excel file also contains a "Read Me" sheet with specific details related to the data contained in that file.

Figure I-7: Naming Conventions for Appendix H and Appendix I Data Files



The Appendix I files contain the energy savings, costs and peak contributions of the DSR data in the Mid Scenario and the natural gas DSR sensitivities. The values include DSR values for both firm and interruptible programs. Values that are broken down by sector (Industrial, Commercial, and Residential) are recombined before being used in any model. The addition of these breakdowns were provided by Cadmus and are included in the files, but were not used separately in the 2021 IRP. Figure I-8 provides the file names of these datasets, and more information about DSR data can be found in Appendix E, Conservation Potential Assessment and Demand Response Assessment.

Figure I-8: Appendix I File Names

File Names	Description
Appl_Input_Gas DSR Base	Contains the normal bundles, as well as codes and standards (C&S), combined heat and power (CHP), and Solar DSR outputs.
Appl_Input_Gas DSR 6Yr	Applies a 6-year ramp rate to conservation measures implemented in the DSR dataset instead of 10 years.
Appl_Input_Gas DSR NEI	Includes additional non-energy impacts in the energy savings of the bundles.
Appl_Input_Gas DSR SDR	Applies a 2.5% discount rate to the conservation measures.
Appl_Output_SENDOUT	This file contains a high-level overview of SENDOUT results. The Mid, Low, and High Scenarios, as well as the 6-Year Ramp, Social Discount Rate, and Non-energy Impact sensitivities on conservation values.