O

2017 PSE Integrated Resource Plan

Gas Analysis

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

Contents

1. ANALYTICAL MODEL

To model gas resources and alternatives for both long-term planning and 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 gas resource analysis that models the gas supply network and the portfolio of supply, storage, transportation and demand-side resources (DSR) to meet demand requirements.

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.

Demand-side Resources (Energy Efficiency)

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 efficiency programs on load can be modeled at the same detail level as demand. SENDOUT has the ability to determine the most cost-effective size of energy efficiency programs on an integrated basis with supply-side alternatives in a long-run resource mix analysis.

Gas Supply

SENDOUT allows a system to be supplied by either long-term 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. Cost values 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.

As discussed, the gas system load is dependent on the weather pattern. The 2017 IRP used the most recent 30 years of data ending in 2016 to estimate the historical normal HDDs for each month. This monthly average HDD was then used to find an actual month that most closely matches this average. (Using an actual month produces a better distribution of daily temperatures for the representative month than simply using daily average temperatures.) In this way, months were selected to match the monthly average HDDs and a 12-month weather year was constructed for use in the IRP study. Finally, 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 2017 IRP.

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

Resource Alternatives Assumptions

Figure O-1 summarizes resource costs and modeling assumptions for the pipeline alternatives considered in the IRP, and Figure O-2 summarizes resource costs and modeling assumptions for storage alternatives.

Figure O-1: Prospective Pipeline Alternatives Available

Alternative	From/To	Capacity Demand ($/Dth/Day)	Variable Commodity ($/Dth)	Fuel Use (%)	Earliest Available	Comments
Short Term NWP TF-1	Sumas to PSE	0.38	0.08	1.9	Nov. 2018	Potential available in marketplace from third parties from Nov. 2018-Nov. 2020.
Incremental NWP - Backhaul	I-5 to PSE	0.28	0.08	1.9	Nov. 2021	Requires NWP Sumas South Expansion; Demand Charge Winter Only Rate
Westcoast + NWP Expansions	Station 2 to PSE	0.52 + 0.56	0.05 + 0.08	1.6 + 1.9	Nov. 2021	Westcoast expansion coupled with NWP expansion
Fortis BC / Westcoast (KORP) + NWP Expansions	Kingsgate to PSE via Sumas	0.42 + 0.56	0.05 + 0.08	1.6 + 1.9	Nov. 2021	Prospective projects & estimated project cost - Requires NGTL and Foothills
NGTL (Nova) Pipeline	AECO to Alberta / BC border	0.16	0	0	Nov. 2021	Prospective projects & estimated project cost.
Foothills Pipeline	Alberta / BC Border	0.097	0	1	Nov. 2021	Uncontracted capacity is available - Requires NGTL
GTN Pipeline	Kingsgate to Stanfield	0.177	0.044	1.4	Nov. 2021	Uncontracted capacity is available - Requires NGTL and Foothills.
Cross Cascades	Stanfield to PSE	0.8	0.005	2	Nov. 2022	Prospective project & estimated project cost - Requires GTN Backhaul or NGTL/Foothills/GTN.
GTN "Backhaul"	Malin to Stanfield	0.21	0.005	0	Nov. 2022	Uncontracted capacity is available
Tacoma LNG Distribution Upgrade	Tacoma LNG to PSE	0.23	0	0	Nov. 2021	Upgrade of the distribution system to connect the LNG plant to the PSE system

Figure O-2: 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. 2022	Prospective project, estimated size and costs, confidential
Swarr	90	30	3	-	Nov. 2018	Existing plant requiring Upgrades

Scenarios and Sensitivities Analyzed

Eleven scenarios were analyzed for the gas sales portfolio using the SENDOUT model. The assumptions used to create those scenarios are described in detail in Chapter 4, Key Analytical Assumptions, and summarized briefly below in Figure O-3.

Figure O-3: 2017 IRP Scenarios

	Scenario Name	Gas Price	CO$_2$ Price	Demand
1	**Low Scenario**	Low	Low	Low
2	**Base Scenario**	Mid	Mid	Mid
3	**High Scenario**	High	High	High
4	**High + Low Demand**	High	High	Low
5	**Base + Low Gas Price**	Low	Mid	Mid
6	**Base + High Gas Price**	High	Mid	Mid
7	**Base + Low Demand**	Mid	Mid	Low
8	**Base + High Demand**	Mid	Mid	High
9	**Base + Low Demand**	Mid	None	Mid
10	**Base + Low CAR CO$_2$ price**	Mid	Low	Mid
11	**Base + High CAR CO$_2$ price**	Mid	High	Mid

Four sensitivity analyses were also run through the SENDOUT model to isolate the effect a single resource has on the portfolio:

1. DEMAND SIDE RESOURCES

BASELINE: All cost-effective DSR per RCW 19.285.

SENSITIVITY > No DSR, all future resource needs met with supply-side resources.

2. ALTERNATE RESIDENTIAL CONSERVATION DISCOUNT RATE

BASELINE: All demand-side resources evaluated using the weighted average cost of capital (WACC) assigned to PSE.

SENSITIVITY > Evaluate residential DSR using an alternate discount rate. The WACC is still applied to the commercial and industrial energy efficiency measures.

3. RESOURCE ADDITION TIMING OPTIMIZATION

BASELINE: Swarr and LNG distribution expansions are built starting in 2019 and 2021 respectively, and offered every two years in the model.

SENSITIVITY > Swarr and LNG distribution expansions are allowed every year starting in 2019 and 2021 respectively.

4. ADDITIONAL GAS CONSERVATION

BASELINE: All cost-effective DSR per RCW 19.285.

SENSITIVITY > Add two more demand-side bundles above the cost-effective demand-side bundles chosen as cost-effective.

2. ANALYSIS RESULTS

The optimal portfolios of supply- and demand-side resources for each of the scenarios and sensitivities were identified using SENDOUT. The cumulative resources added in each of the gas sales scenarios for the winter periods 2018-19, 2022-23, 2026-27, 2030-31 and 2032-33 are shown in Figures O-4 through O-8. Graphs of the resource additions for each of the scenarios are shown in Figures O-9 thru O-18. Resource additions for the each of the two sensitivities are shown in Figures O-19 and O-20.

Figure O-4: Gas Sales Scenario Cumulative Resource Additions for 2021-22 (MDth/day)

Peak Day Capacity MDth/day (2021-22)	Base	Low	High	High + Low Demand	Base + Low Gas	Base + High Gas	Base + Low Demand	Base + High Demand	Base + No CO2	Base + Low CAR CO2	Base + High CAR CO2
NWP Additions + Westcoast	-	-	88	-	-	-	-	75	-	-	-
Short Term NWP	-	-	-	-	-	-	-	-	-	-	-
Cross Cascades - AECO	-	-	-	-	-	-	-	-	-	-	-
Cross Cascades - Malin	-	-	-	-	-	-	-	-	-	-	-
Swarr	-	-	30	-	-	-	-	30	-	-	-
LNG Distribution Upgrade	-	-	16	-	-	-	-	16	-	-	-
Mist	-	-	-	-	-	-	-	-	-	-	-
DSR (Incl Standard Bundle)	14	8	19	15	14	15	8	17	8	8	15
Total	14	8	153	15	14	15	8	138	8	8	15

Figure O-5: Gas Sales Scenario Cumulative Resource Additions for 2025-26 (MDth/day)

Peak Day Capacity MDth/day (2025-26)	Base	Low	High	High + Low Demand	Base + Low Gas	Base + High Gas	Base + Low Demand	Base + High Demand	Base + No CO2	Base + Low CAR CO2	Base + High CAR CO2
NWP Additions + Westcoast	-	-	116	-	-	-	-	100	16	16	-
Short Term NWP	-	-	-	-	-	-	-	-	-	-	-
Cross Cascades - AECO	-	-	-	-	-	-	-	42	-	-	-
Cross Cascades - Malin	-	-	66	-	-	-	-	34	-	-	-
Swarr	30	-	30	-	30	30	-	30	30	30	30
LNG Distribution Upgrade	-	-	16	-	-	-	-	16	-	-	-
Mist	-	-	-	-	-	-	-	-	-	-	-
DSR (Incl Standard Bundle)	31	16	43	32	31	32	17	38	16	17	32
Total	61	16	271	32	61	62	17	260	62	63	62

Figure O-6: Gas Sales Scenario Cumulative Resource Additions for 2029-30 (MDth/day)

Peak Day Capacity MDth/day (2029-30)	Base	Low	High	High + Low Demand	Base + Low Gas	Base + High Gas	Base + Low Demand	Base + High Demand	Base + No CO2	Base + Low CAR CO2	Base + High CAR CO2
NWP Additions + Westcoast	53	-	197	-	53	51	-	192	81	80	51
Short Term NWP	-	-	-	-	-	-	-	-	-	-	-
Cross Cascades - AECO	-	-	-	-	-	-	-	42	-	-	-
Cross Cascades - Malin	-		75	-	-	-	-	34	-	-	-
Swarr	30	-	30	-	30	30	-	30	30	30	30
LNG Distribution Upgrade	16	-	16	-	16	16	-	16	16	16	16
Mist	-	-	-	-	-	-	-	-	-	-	-
DSR (Incl Standard Bundle)	48	25	65	49	48	49	27	58	25	26	49
Total	**147**	**25**	**383**	**49**	**147**	**146**	**27**	**372**	**152**	**152**	**146**

Figure O-7: Gas Sales Scenario Cumulative Resource Additions for 2033-34 (MDth/day)

Peak Day Capacity MDth/day (2033-34)	Base	Low	High	High + Low Demand	Base + Low Gas	Base + High Gas	Base + Low Demand	Base + High Demand	Base + No CO2	Base + Low CAR CO2	Base + High CAR CO2
NWP Additions + Westcoast	133	-	310	-	133	51	-	305	170	170	130
Short Term NWP	-	-	-	-	-	-	-	-	-	-	-
Cross Cascades - AECO	-	-	-	-	-	83	-	42	-	-	-
Cross Cascades - Malin	-	-	75	-	-	-	-	34	-	-	-
Swarr	30	-	30	-	30	30	-	30	30	30	30
LNG Distribution Upgrade	16	-	16	-	16	16	-	16	16	16	16
Mist	-	-	-	-	-	-	-	-	-	-	-
DSR (Incl Standard Bundle)	65	35	85	67	66	67	37	77	35	36	67
Total	**244**	**35**	**516**	**67**	**245**	**247**	**37**	**504**	**251**	**252**	**243**

Figure O-8: Gas Sales Scenario Cumulative Resource Additions for 2037-38 (MDth/day)

Peak Day Capacity MDth/day (2033-34)	Base	Low	High	High + Low Demand	Base + Low Gas	Base + High Gas	Base + Low Demand	Base + High Demand	Base + No CO2	Base + Low CAR CO2	Base + High CAR CO2
NWP Additions + Westcoast	133	-	310	-	133	51	-	305	170	170	130
Short Term NWP	-	-	-	-	-	-	-	-	-	-	-
Cross Cascades - AECO	-	-	-	-	-	83	-	42	-	-	-
Cross Cascades - Malin	-	-	75	-	-	-	-	34	-	-	-
Swarr	30	-	30	-	30	30	-	30	30	30	30
LNG Distribution Upgrade	16	16	16	-	16	16	16	16	16	16	16
Mist	-	-	-	-	-	-	-	-	-	-	-
DSR (Incl Standard Bundle)	82	44	103	84	82	84	46	95	44	46	84
Total	261	60	534	84	261	264	62	522	260	262	260

Figure O-9: Base Scenario Optimal Portfolio – Gas Sales
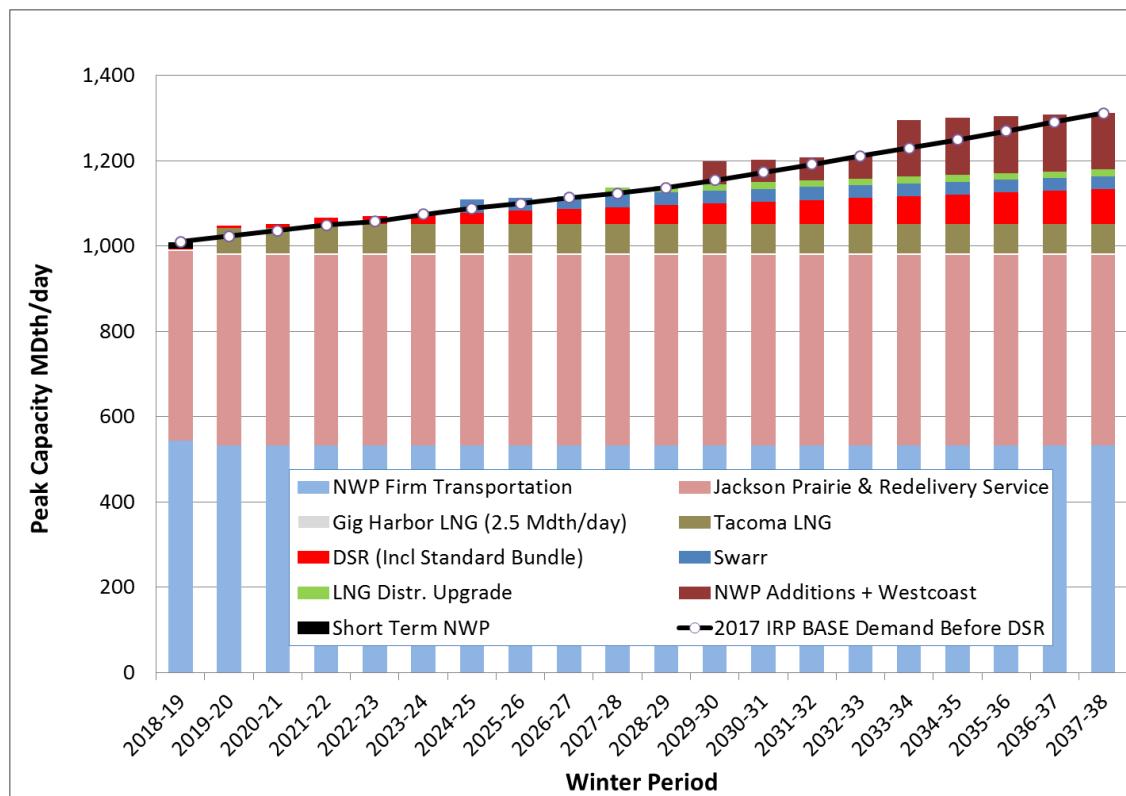
Figure O-10: Low Scenario Optimal Portfolio – Gas Sales
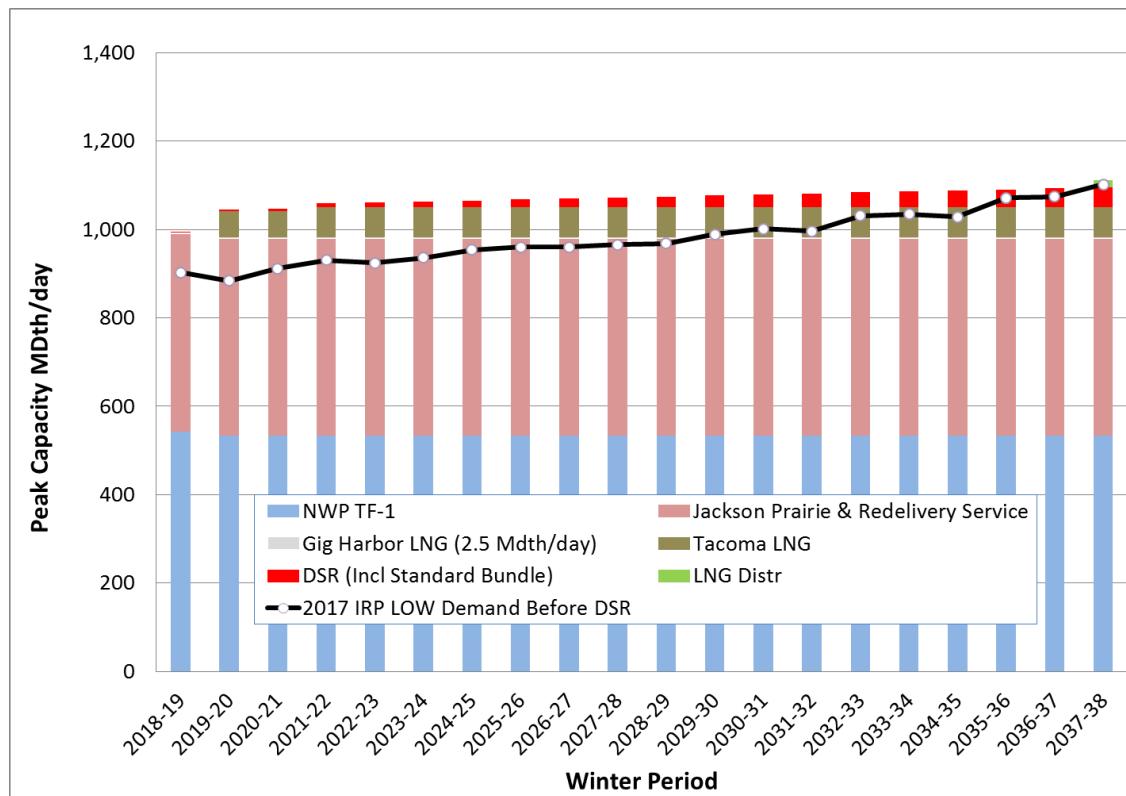
Figure O-11: High Scenario Optimal Portfolio – Gas Sales
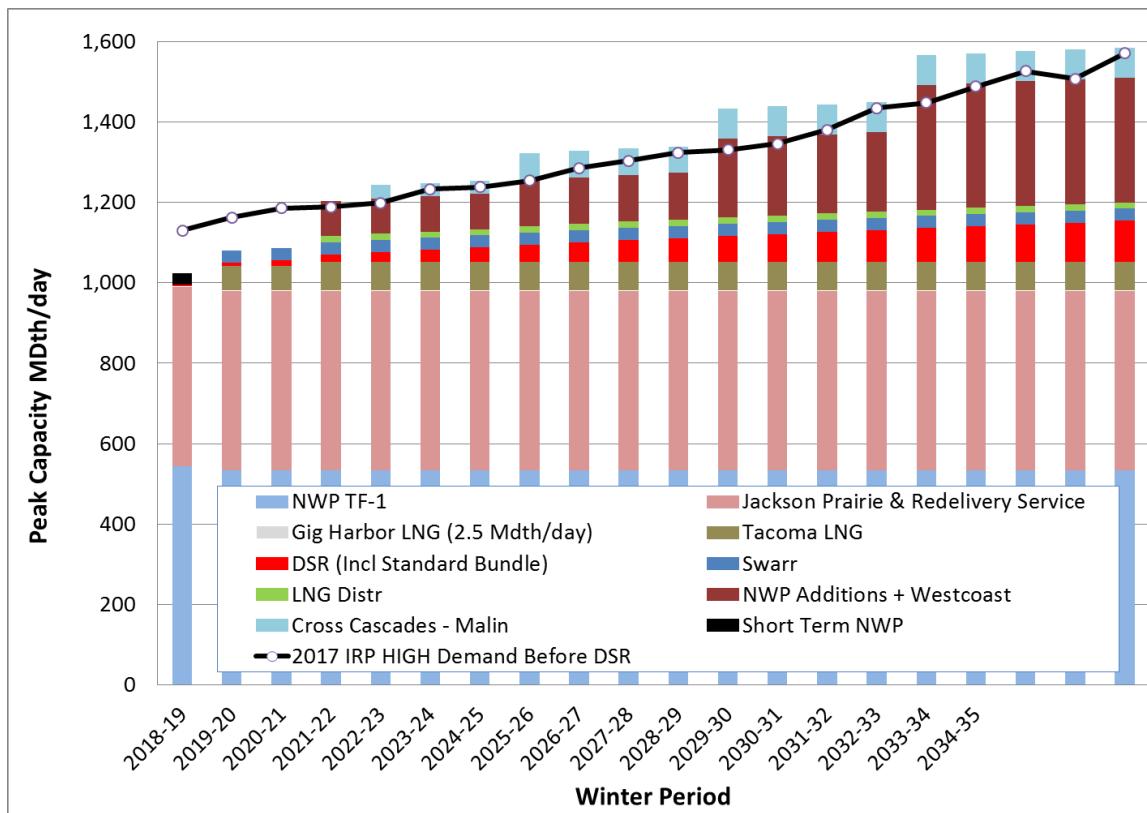
Figure O-12: High + Low Demand Optimal Portfolio – Gas Sales
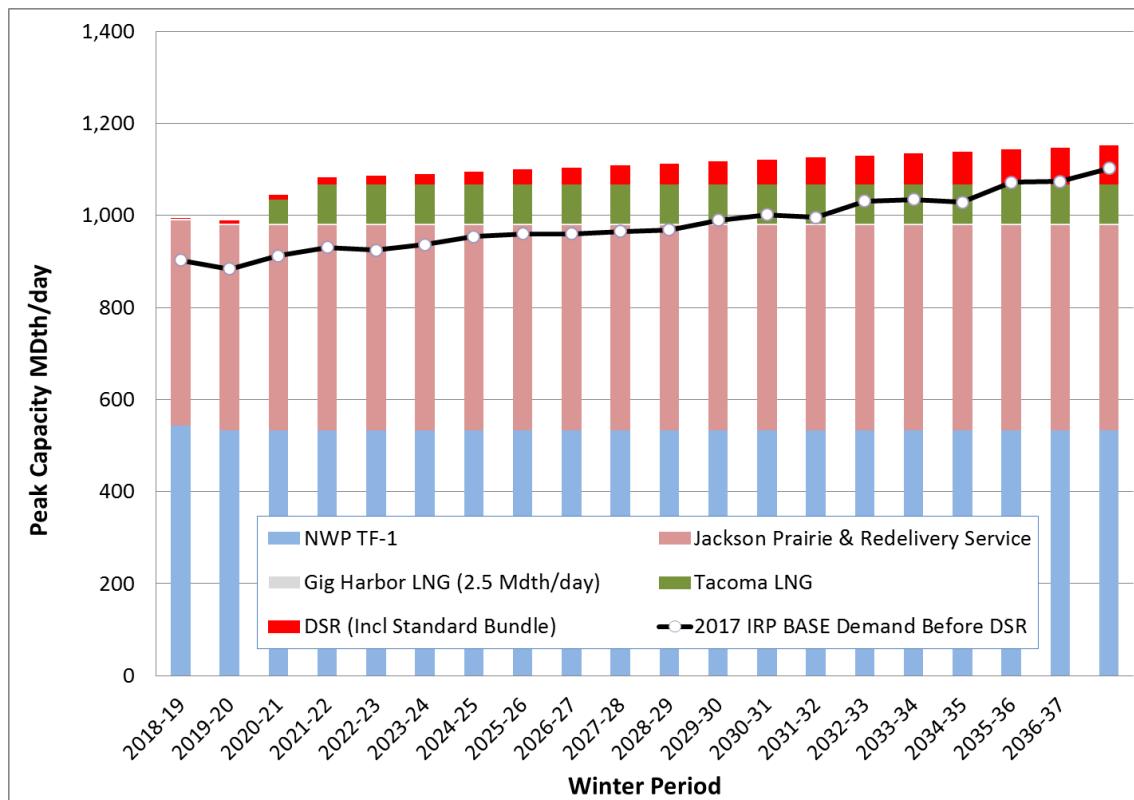
Figure O-13: Base + Low Gas Price Scenario Optimal Portfolio – Gas Sales
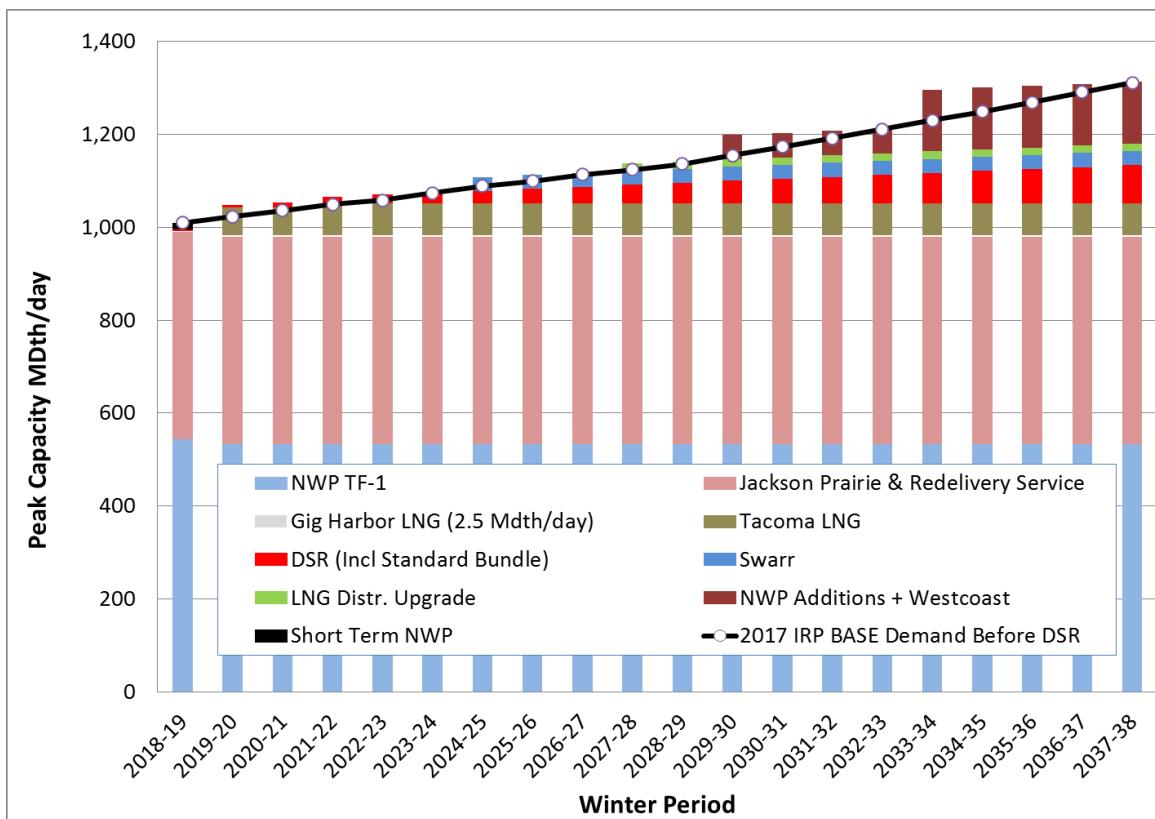
Figure O-14: Base + High Gas Price Optimal Portfolio – Gas Sales
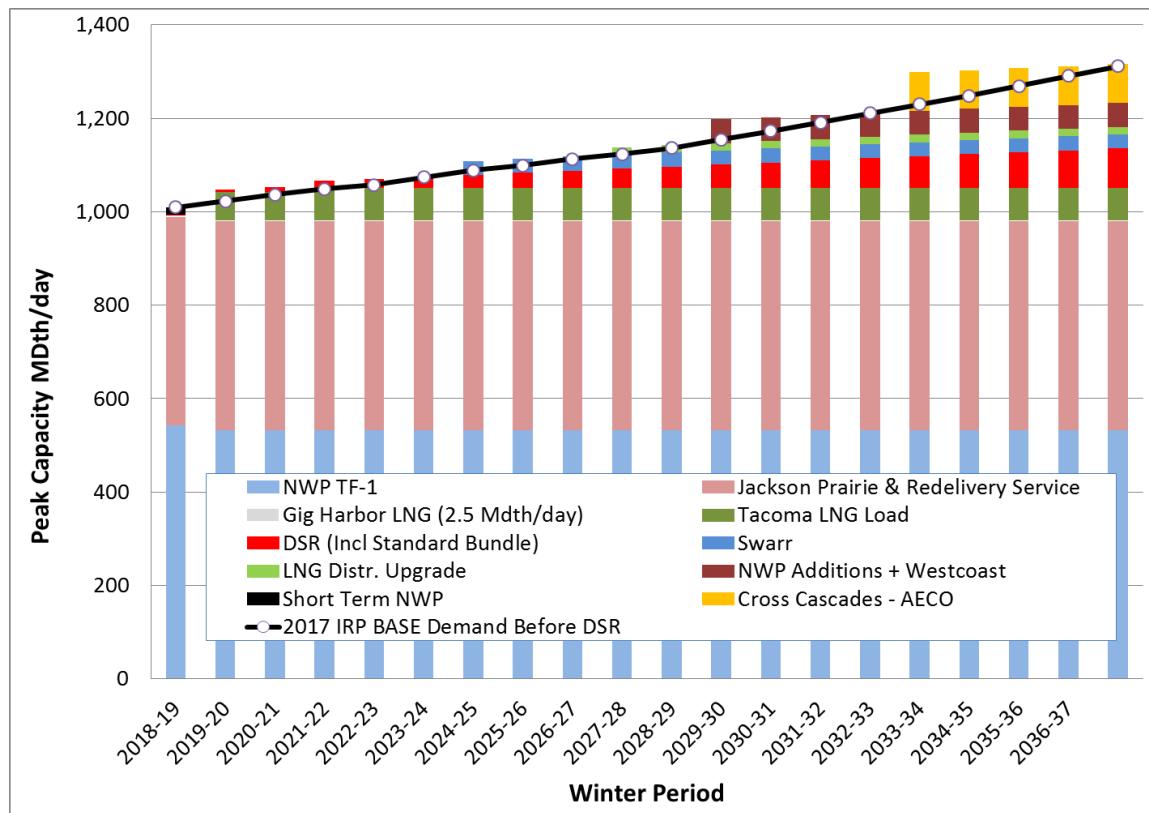
Figure O-15: Base + Low Demand Optimal Portfolio – Gas Sales
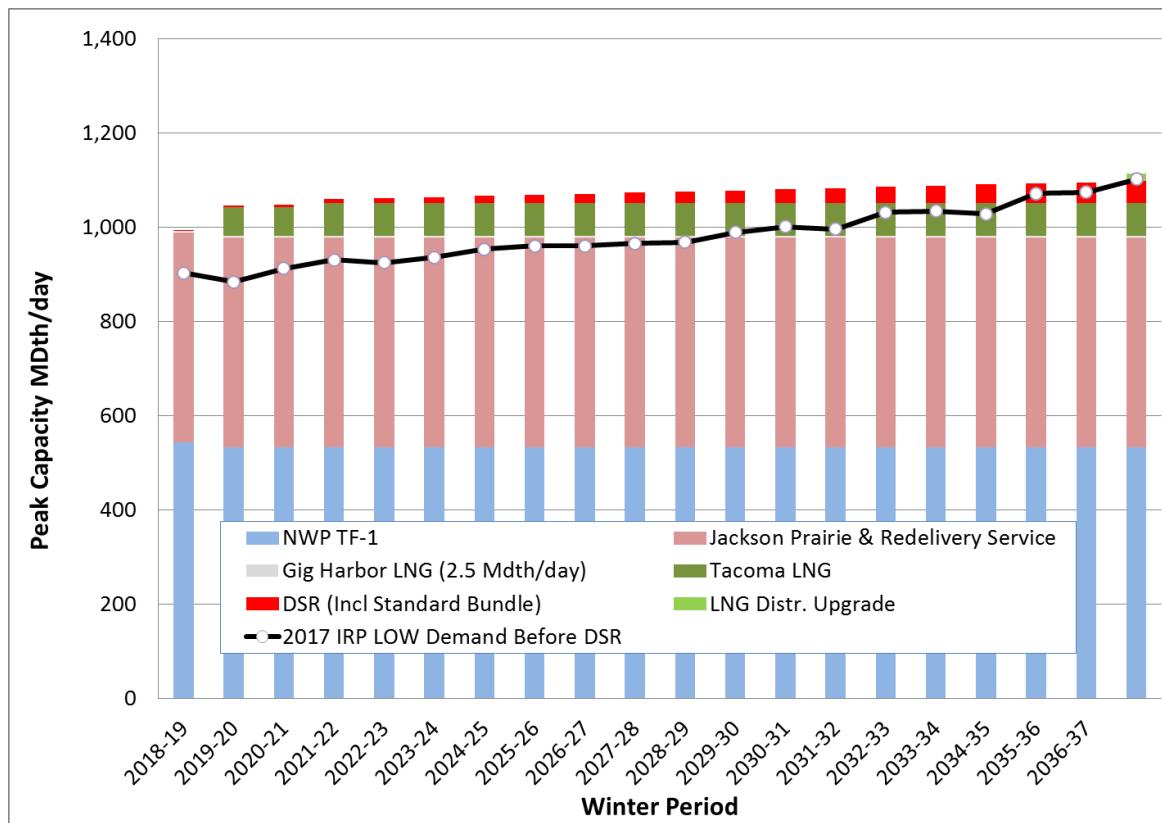
Figure O-16: Base + High Demand Optimal Portfolio – Gas Sales
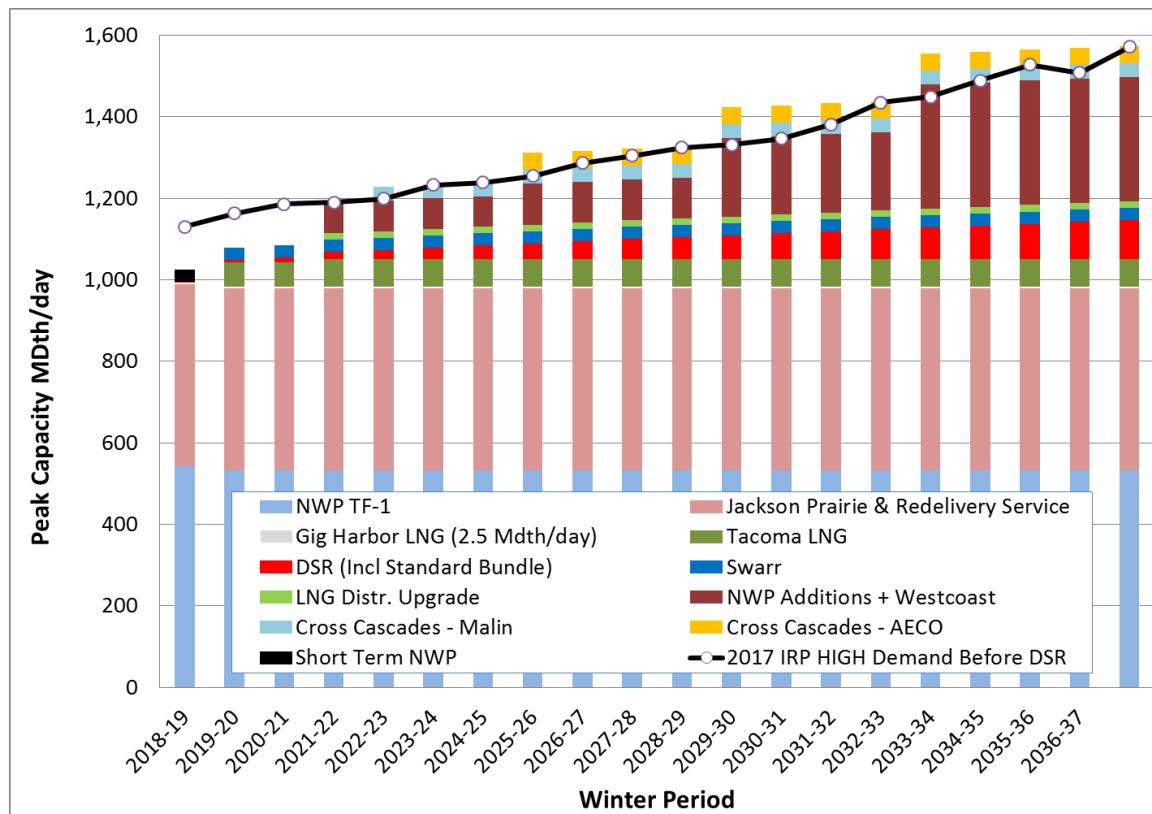
Figure O-17: Base + No CO$_2$ Optimal Portfolio – Gas Sales
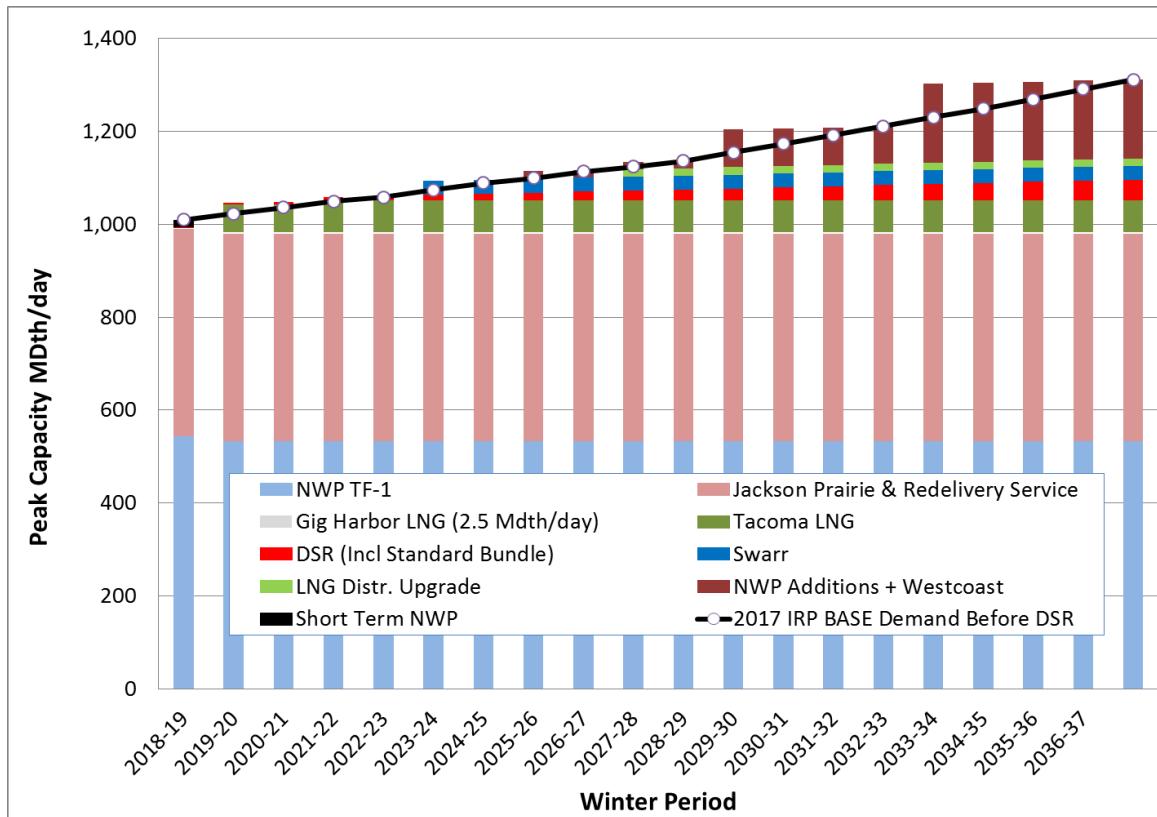
Figure O-18: Base + Low CAR CO$_2$ price Optimal Portfolio – Gas Sales
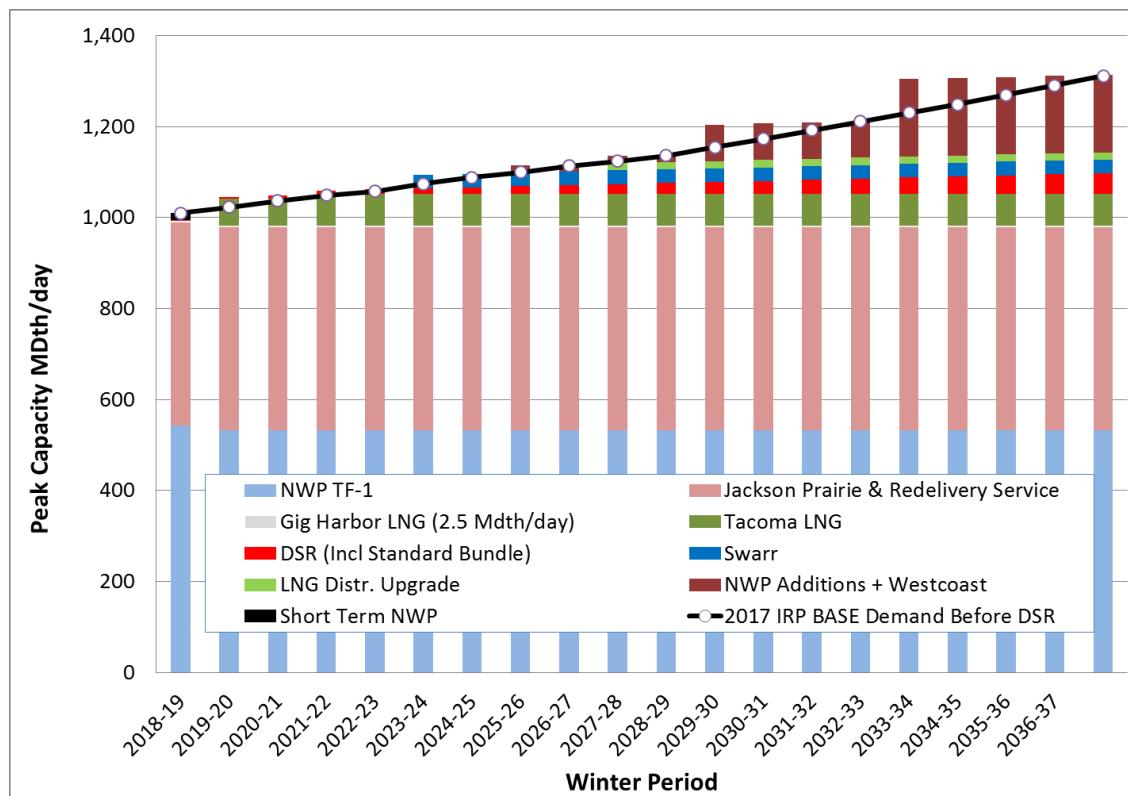
Figure O-19: Base + High CAR CO$_2$ price Optimal Portfolio – Gas Sales
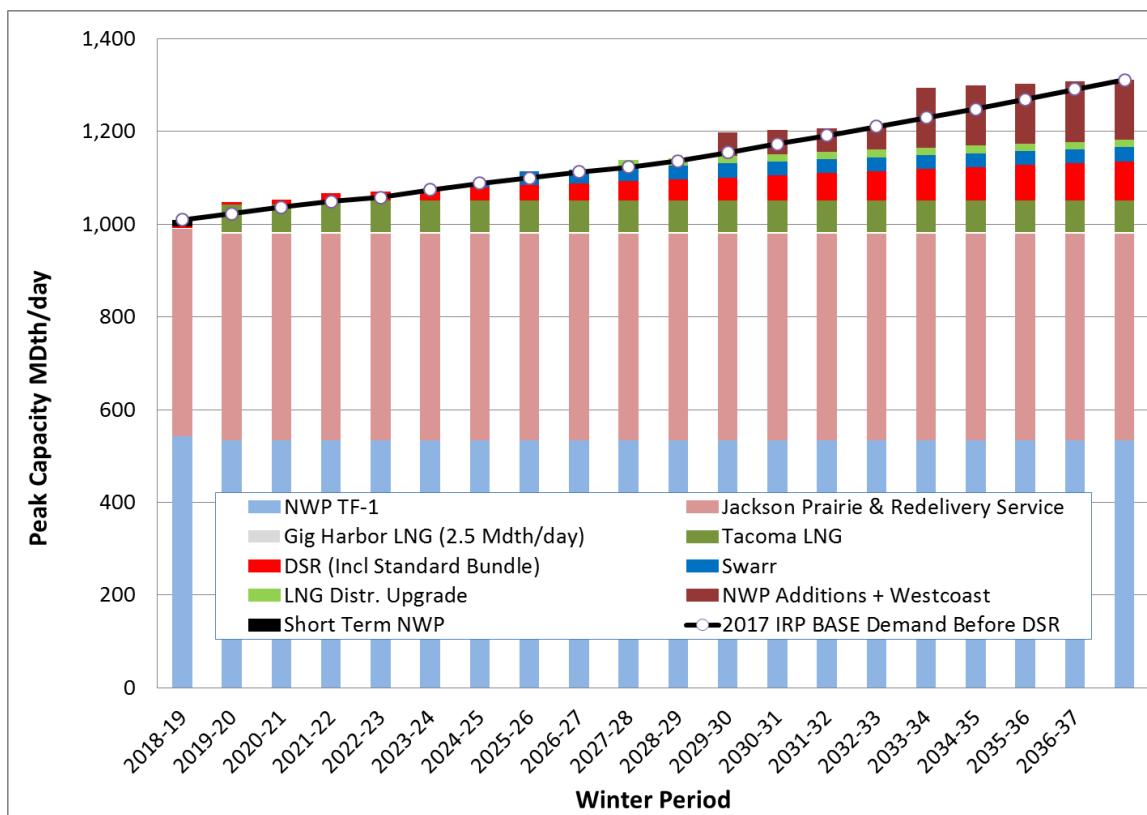
Figure O-20: Alternate Discount Rate Sensitivity
Gas Sales Cumulative Resource Additions (MDth/day)
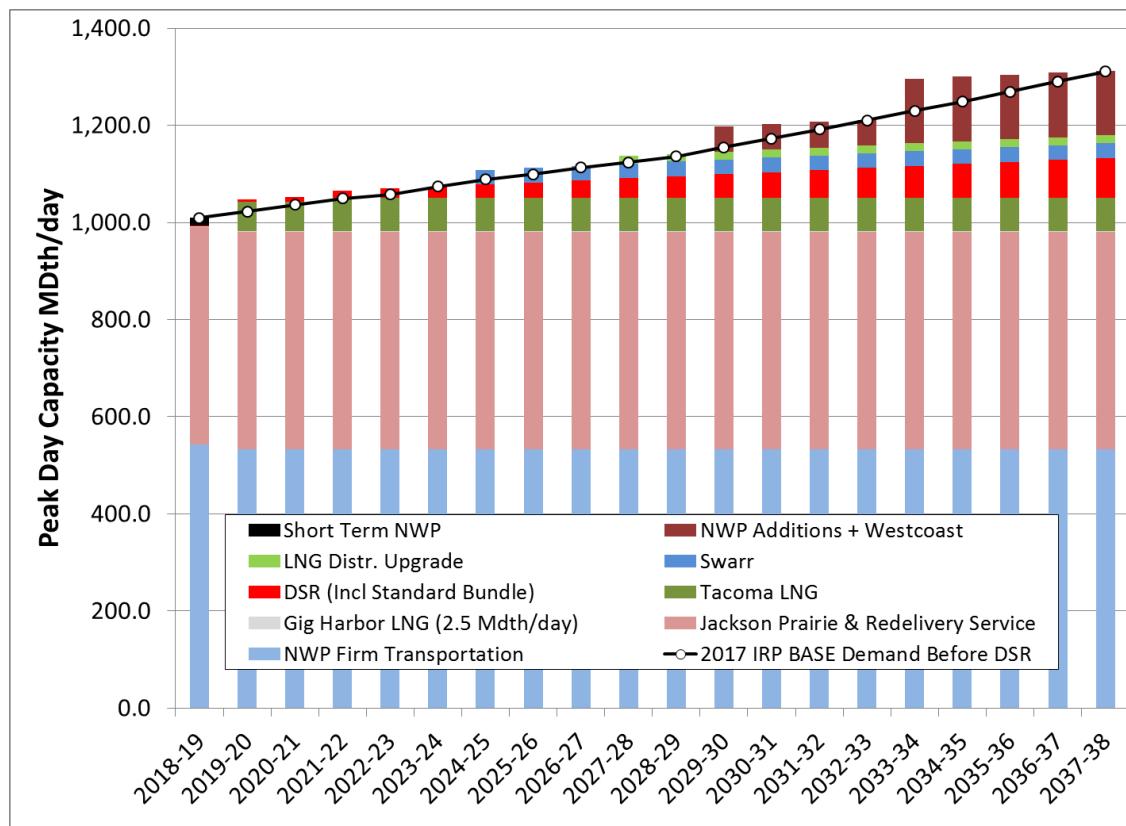
Figure O-21: PSE-controlled Resource Timing Sensitivity
Gas Sales Cumulative Resource Additions (MDth/day)
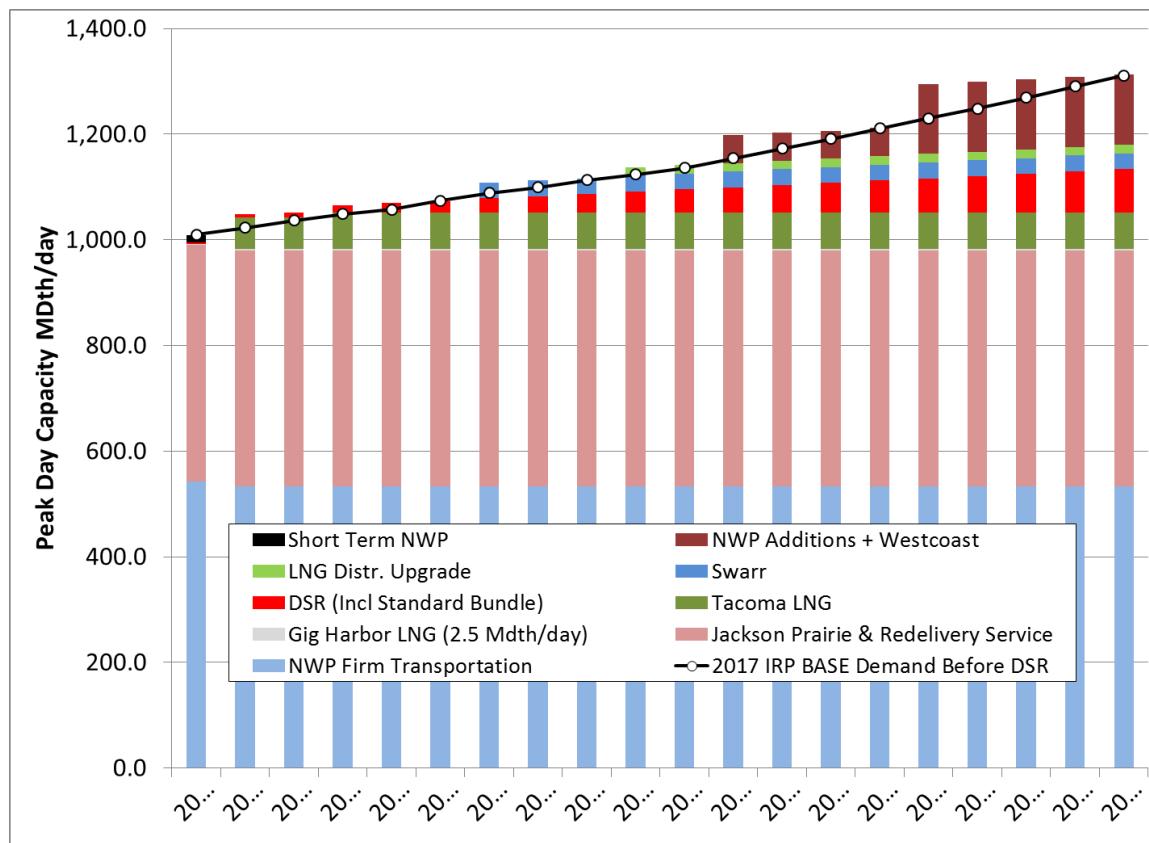
Figure O-22: Scenario Portfolio Capacity Expansion Results – Base (MDth)

Winter Period	NWP Additions + Westcoast	Short Term NWP	Cross Cascades - AECO	Cross Cascades - Malin	Swarr	LNG Distr. Upgrade	Mist	DSR (Incl Standard Bundle)
2018-19		15						2
2019-20								6
2020-21								10
2021-22								14
2022-23								18
2023-24								22
2024-25					30			27
2025-26					30			31
2026-27					30			35
2027-28					30	16		40
2028-29					30	16		44
2029-30	53				30	16		48
2030-31	53				30	16		52
2031-32	53				30	16		56
2032-33	53				30	16		61
2033-34	133				30	16		65
2034-35	133				30	16		69
2035-36	133				30	16		73
2036-37	133				30	16		78
2037-38	133				30	16		82

Figure O-23: Scenario Portfolio Capacity Expansion Results – Low (MDth)

Winter Period	NWP Additions + Westcoast	Short Term NWP	Cross Cascades - AECO	Cross Cascades - Malin	Swarr	LNG Distr	Mist	DSR (Incl Standard Bundle)
2018-19								1
2019-20								3
2020-21								6
2021-22								8
2022-23								10
2023-24								12
2024-25								14
2025-26								16
2026-27								19
2027-28								21
2028-29								23
2029-30								25
2030-31								28
2031-32								30
2032-33								33
2033-34								35
2034-35								37
2035-36								39
2036-37								42
2037-38						16		44

Figure O-24: Scenario Portfolio Capacity Expansion Results – High (MDth)

Winter Period	NWP Additions + Westcoast	Short Term NWP	Cross Cascades - AECO	Cross Cascades - Malin	Swarr	LNG Distr	Mist	DSR (Incl Standard Bundle)
2018-19		30						3
2019-20					30			8
2020-21					30			14
2021-22	88				30	16		19
2022-23	88			33	30	16		25
2023-24	88			33	30	16		30
2024-25	88			33	30	16		37
2025-26	116			66	30	16		43
2026-27	116			66	30	16		49
2027-28	116			66	30	16		55
2028-29	116			66	30	16		60
2029-30	197			75	30	16		65
2030-31	197			75	30	16		70
2031-32	197			75	30	16		75
2032-33	197			75	30	16		80
2033-34	310			75	30	16		85
2034-35	310			75	30	16		90
2035-36	310			75	30	16		94
2036-37	310			75	30	16		99
2037-38	310			75	30	16		103

Figure O-25: Scenario Portfolio Capacity Expansion Results – High + Low Demand (MDth)

| Winter Period	NWP Additions + Westcoast	NWP + KORP	Cross Cascades - AECO	Cross Cascades - Malin	Swarr	PSE LNG Project	Mist	DSR (Incl Standard Bundle)
2018-19								2
2019-20								6
2020-21								11
2021-22								15
2022-23								19
2023-24								23
2024-25								27
2025-26								32
2026-27								37
2027-28								41
2028-29								45
2029-30								49
2030-31								54
2031-32								58
2032-33								63
2033-34								67
2034-35								72
2035-36								76
2036-37								80
2037-38								84

Figure O-26: Scenario Portfolio Capacity Expansion Results – Base + Low Gas (MDth)

Winter Period	NWP Additions + Westcoast	Short Term NWP	Cross Cascades - AECO	Cross Cascades - Malin	Swarr	LNG Distr. Upgrade	Mist	DSR (Incl Standard Bundle)
2018-19		15						2
2019-20								6
2020-21								10
2021-22								14
2022-23								19
2023-24								23
2024-25					30			27
2025-26					30			31
2026-27					30			36
2027-28					30	16		40
2028-29					30	16		44
2029-30	53				30	16		48
2030-31	53				30	16		53
2031-32	53				30	16		57
2032-33	53				30	16		61
2033-34	133				0	16		66
2034-35	133				0	16		70
2035-36	133				0	16		74
2036-37	133				0	16		78
2037-38	133				0	16		82

Figure O-27: Scenario Portfolio Capacity Expansion Results – Base + High Gas (MDth)

Winter Period	NWP Additions + Westcoast	Short Term NWP	Cross Cascades - AECO	Cross Cascades - Malin	Swarr	LNG Distr. Upgrade	Mist	DSR (Incl Standard Bundle)
2018-19		15						2
2019-20								6
2020-21								11
2021-22								15
2022-23								19
2023-24								23
2024-25					30			27
2025-26					30			32
2026-27					30			37
2027-28					30	16		41
2028-29					30	16		45
2029-30	51				30	16		49
2030-31	51				30	16		54
2031-32	51				30	16		58
2032-33	51				30	16		63
2033-34	51		83		30	16		67
2034-35	51		83		30	16		72
2035-36	51		83		30	16		76
2036-37	51		83		30	16		80
2037-38	51		83		30	16		84

Figure O-28: Scenario Portfolio Capacity Expansion Results – Base + Low Demand (MDth)

Winter Period	NWP Additions + Westcoast	Short Term NWP	Cross Cascades - AECO	Cross Cascades - Malin	Swarr	LNG Distr. Upgrade	Mist	DSR (Incl Standard Bundle)
2018-19								1
2019-20								4
2020-21								6
2021-22								8
2022-23								10
2023-24								12
2024-25								15
2025-26								17
2026-27								20
2027-28								22
2028-29								24
2029-30								27
2030-31								29
2031-32								32
2032-33								34
2033-34								37
2034-35								39
2035-36								41
2036-37								44
2037-38						16		46

Figure O-29: Scenario Portfolio Capacity Expansion Results – Base + High Demand (MDth)

Winter Period	NWP Additions + Westcoast	Short Term NWP	Cross Cascades - AECO	Cross Cascades - Malin	Swarr	LNG Distr. Upgrade	Mist	DSR (Incl Standard Bundle)
2018-19		30						2
2019-20					30			7
2020-21					30			12
2021-22	75				30	16		17
2022-23	75			34	30	16		22
2023-24	75			34	30	16		27
2024-25	75			34	30	16		32
2025-26	100		42	34	30	16		38
2026-27	100		42	34	30	16		43
2027-28	100		42	34	30	16		48
2028-29	100		42	34	30	16		53
2029-30	192		42	34	30	16		58
2030-31	192		42	34	30	16		63
2031-32	192		42	34	30	16		67
2032-33	192		42	34	30	16		72
2033-34	305		42	34	30	16		77
2034-35	305		42	34	30	16		81
2035-36	305		42	34	30	16		86
2036-37	305		42	34	30	16		90
2037-38	305		42	34	30	16		95

Figure O-30: Scenario Portfolio Capacity Expansion Results – Base + No CO$_2$ (MDth)

Winter Period	NWP Additions + Westcoast	Short Term NWP	Cross Cascades - AECO	Cross Cascades - Malin	Swarr	LNG Distr. Upgrade	Mist	DSR (Incl Standard Bundle)
2018-19		16						1
2019-20								3
2020-21								6
2021-22								8
2022-23								10
2023-24					30			12
2024-25					30			14
2025-26	16				30			16
2026-27	16				30			19
2027-28	16				30	16		21
2028-29	16				30	16		23
2029-30	81				30	16		25
2030-31	81				30	16		28
2031-32	81				30	16		30
2032-33	81				30	16		33
2033-34	170				30	16		35
2034-35	170				30	16		37
2035-36	170				30	16		39
2036-37	170				30	16		42
2037-38	170				30	16		44

Figure O-31: Scenario Portfolio Capacity Expansion Results – Base + Low CAR CO$_2$ (MDth)

Winter Period	NWP Additions + Westcoast	Short Term NWP	Cross Cascades - AECO	Cross Cascades - Malin	Swarr	LNG Distr. Upgrade	Mist	DSR (Incl Standard Bundle)
2018-19		16						1
2019-20								3
2020-21								6
2021-22								8
2022-23								10
2023-24					30			12
2024-25					30			15
2025-26	16				30			17
2026-27	16				30			20
2027-28	16				30	16		22
2028-29	16				30	16		24
2029-30	80				30	16		26
2030-31	80				30	16		29
2031-32	80				30	16		31
2032-33	80				30	16		34
2033-34	170				30	16		36
2034-35	170				30	16		39
2035-36	170				30	16		41
2036-37	170				30	16		44
2037-38	170				30	16		46

Figure O-32: Scenario Portfolio Capacity Expansion Results – Base + High CAR CO$_2$ (MDth)

Winter Period	NWP Additions + Westcoast	Short Term NWP	Cross Cascades - AECO	Cross Cascades - Malin	Swarr	LNG Distr. Upgrade	Mist	DSR (Incl Standard Bundle)
2018-19		15						2
2019-20								6
2020-21								11
2021-22								15
2022-23								19
2023-24								23
2024-25					30			27
2025-26					30			32
2026-27					30			37
2027-28					30	16		41
2028-29					30	16		45
2029-30	51				30	16		49
2030-31	51				30	16		54
2031-32	51				30	16		58
2032-33	51				30	16		63
2033-34	130				30	16		67
2034-35	130				30	16		72
2035-36	130				30	16		76
2036-37	130				30	16		80
2037-38	130				30	16		84

Figure O-33: Scenario Portfolio Capacity Expansion Results –
Alternate Discount RateSensitivity (MDth)

Winter Period	NWP Additions + Westcoast	Short Term NWP	Cross Cascades - AECO	Cross Cascades - Malin	Swarr	LNG Distr. Upgrade	Mist	DSR (Incl Standard Bundle)
2018-19		15						2
2019-20								6
2020-21								10
2021-22								14
2022-23								18
2023-24								22
2024-25					30			27
2025-26					30			31
2026-27					30			35
2027-28					30	16		40
2028-29					30	16		44
2029-30	53				30	16		48
2030-31	53				30	16		52
2031-32	53				30	16		56
2032-33	53				30	16		61
2033-34	133				30	16		65
2034-35	133				30	16		69
2035-36	133				30	16		73
2036-37	133				30	16		78
2037-38	133				30	16		82

Figure O-34: Scenario Portfolio Capacity Expansion Results –
Timing Sensitivity for LNG Distribution (MDth)

Winter Period	NWP Additions + Westcoast	Short Term NWP	Cross Cascades - AECO	Cross Cascades - Malin	Swarr	LNG Distr. Upgrade	Mist	DSR (Incl Standard Bundle)
2018-19		15						2
2019-20								6
2020-21								10
2021-22								14
2022-23								18
2023-24								22
2024-25					30			27
2025-26					30			31
2026-27					30			35
2027-28					30	16		40
2028-29					30	16		44
2029-30	53				30	16		48
2030-31	53				30	16		52
2031-32	53				30	16		56
2032-33	53				30	16		61
2033-34	133				30	16		65
2034-35	133				30	16		69
2035-36	133				30	16		73
2036-37	133				30	16		78
2037-38	133				30	16		82

3. PORTFOLIO DELIVERED GAS COSTS

The average delivered portfolio cost for the gas sales scenarios are shown graphically in Chapter 7. They are presented below in tabular form in Figure O-22. Note however, these costs represent the cost of gas delivered to PSE's system; they do not include distribution system costs.

Figure O-35: Portfolio Delivered Gas Costs ($/Dth)

Year	Base	Low	High	High + Low Demand	Base + Low Gas	Base + High Gas	Base + Low Demand	Base + High Demand	Base + No CO2	Base + Low CAR CO2	Base + High CAR CO2
2018	6.2	5.7	13.2	13.8	6.5	8.5	6.3	6.0	4.2	5.2	10.9
2019	6.0	5.5	12.9	13.2	6.5	8.8	6.2	5.8	4.0	4.8	10.4
2020	6.1	5.3	13.6	13.8	6.2	9.3	6.3	5.9	3.9	4.9	10.4
2021	6.3	5.6	13.5	13.7	6.7	9.5	6.5	6.2	4.1	5.2	10.5
2022	6.7	5.9	13.6	13.7	7.1	9.4	6.9	6.7	4.2	5.3	10.6
2023	6.9	6.2	13.8	13.8	7.3	9.9	7.5	7.2	4.5	5.7	11.0
2024	7.7	6.7	14.4	14.6	8.0	10.4	8.1	7.9	4.8	6.2	11.2
2025	8.1	6.9	14.3	14.2	8.1	11.1	8.4	8.3	5.1	6.5	11.6
2026	8.6	7.4	15.8	15.7	8.9	12.2	8.9	8.9	5.5	7.0	11.9
2027	9.2	7.8	16.0	15.8	9.5	12.4	9.6	9.5	5.9	7.3	12.2
2028	9.7	8.4	16.1	15.9	10.0	13.1	10.1	10.0	6.1	7.9	12.5
2029	10.3	8.4	16.3	16.1	10.3	13.3	10.7	10.5	6.5	8.2	12.8
2030	10.9	8.8	16.7	16.4	11.0	14.1	10.9	11.1	6.7	8.6	13.2
2031	11.4	9.1	16.9	16.8	11.2	14.7	11.7	11.7	7.0	9.1	13.4
2032	12.0	9.2	16.9	16.7	11.7	14.9	12.3	12.3	7.3	9.5	13.7
2033	12.3	9.3	17.3	17.0	11.9	15.5	12.9	12.8	7.5	9.8	13.9
2034	13.2	10.0	17.9	17.5	13.0	16.5	13.4	13.3	7.7	10.2	14.1
2035	13.6	10.2	18.3	17.7	13.6	17.3	14.1	14.1	8.1	10.8	14.5
2036	14.4	10.7	18.7	18.2	14.1	18.1	14.7	14.7	8.2	11.1	14.6
2037	14.9	11.1	18.9	18.2	14.4	18.4	15.1	15.2	8.4	11.5	14.8