

## **Appendix F: EnCompass Modeling Assumptions**

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# 1 Sensitivities Evaluated

Figure 1 shows a grid of sensitivities evaluated in this resource plan. As further described in the petition, for each sensitivity, this filing includes EnCompass modeling runs to provide insight into the impacts of Otter Tail continuing with its interest in Coyote Station through 2040 and 2028. Otter Tail includes all modeling runs with and without externalities in Appendix I.

**Figure 1: Sensitivities Evaluated**

Sensitivity	Description		
A	2023 Base Case	<b>Zero Externalities</b>	<b>Externality Values Applied</b>
A.1	Preferred Plan		
B	NG & Energy Markets +50%		
C	NG & Energy Markets +100%		
D	NG & Energy Markets -50%		
E	Regional Haze Mid Cost		
F	Regional Haze Mid Cost NGEM +100%		
G	Regional Haze High Cost		
H	Regional Haze High Cost NGEM +100%		
I	10% Increased Load		
J	10% Increased Load NGEM +100%		
K	25% Increased Load		
L	25% Increased Load NGEM +100%		
M	High Renewable Accreditation		
N	Low Renewable Accreditation		
O	Carbon Tax		
P	Renewables High Cost		
Q	Renewables High Cost NGEM +100%		
R	Solar and Battery Low Cost (40% ITC)		
S	Low Accreditation Regional Haze High		
T	25% Increased Load Regional Haze High		
U	Renewables High Cost Regional Haze High		

# 2 Wind Energy Assumptions

Figure 2 shows the wind energy assumptions used in the resource plan. Otter Tail evaluated wind energy resource alternatives as purchased power agreements (PPA) with a 35-year term and fixed pricing over that term. Wind integration costs are included in the fixed price assumptions.

The wind energy price assumptions through 2032 include the impacts of the August 2022 Inflation Reduction Act which provides for 100 percent production tax credit

(PTC) for projects that meet certain criteria. The wind energy price assumptions after 2032 do not include PTCs.

Wind project sizes are assumed to be 50 MW in size with a 50 percent net capacity factor. Accredited capacity varies by season. Otter Tail models wind projects as purchased power agreements with a fixed leveled cost of energy.

Otter Tail includes three categories for these wind projects: (1) Generic wind resources require a new generation site, (2) Surplus interconnection wind may be added alongside an existing generating facility where the generation of both resources does not exceed the existing interconnection amount of the original facility, and (3) Replacement interconnection wind resources reuse the existing interconnection rights of an existing resource that is retiring. Otter Tail includes Figure 2 below with the wind project alternatives included in the base model.

**Figure 2: Base Wind Energy Assumptions**

		Base Case \$/MWh						
Year available	Wind Project Alternatives	Size (MW)	Accredited capacity (% of Nameplate)	LCOE modeled as a fixed price PPA	PTC adjustment	Inconnection adder assuming \$500/kW	Congestion adder	Base Case (\$/MWh)
2025-2032	Generic - 100% PTC	50	Varies	\$36.00	(\$15.00)	\$10.00	\$3.50	\$34.50
After 2032	Generic	50	Varies	\$35.00	\$0.00	\$10.00	\$3.50	\$48.50
After 2032	Surplus Interconnection	50	0%	\$35.00	\$0.00	\$0.00	\$0.00	\$35.00
After 2032	Replacement Interconnection	50	Varies	\$35.00	\$0.00	\$0.00	\$0.00	\$35.00

Otter Tail does not forecast a low cost sensitivity for wind generation. The Inflation Reduction act provides for additional PTCs for domestic content and energy communities but these are considered on a project by project basis.

### 3 Solar Energy Assumptions

Otter Tail evaluated solar energy resource alternatives as purchased power agreements (PPA) with a 35-year term and fixed pricing over that term. Solar integration costs are included in the fixed price assumptions.

Similar to wind, the solar energy price assumptions for 2025 through 2032 include the impacts of the Inflation Reduction Act which provides for a 30 percent investment tax credit (ITC) for projects that meet certain criteria. The solar energy price assumptions after 2032 do not include ITCs.

Solar project sizes are assumed to be 25 MW in size with 24 percent net capacity factor and an accredited capacity of 25 percent. Otter Tail includes Figure 3 below with the solar project alternatives included in the base model.

**Figure 3: Base Case Solar Energy Assumptions**

			Base Case \$/MWh						
Year available	ITC	Solar Project Alternatives	Size (MW)	Accredited capacity (% of Nameplate)	LCOE modeled as a fixed price PPA	ITC adjustment	Inconnection adder assuming \$200/kW	Congestion adder	Base Case (\$/MWh)
2025-2032	30%	Generic	25	Varies	\$40.00	(\$8.00)	\$7.00	\$0.00	\$39.00
2025-2032	30%	Surplus Interconnection	25	0%	\$40.00	(\$8.00)	\$0.00	\$0.00	\$32.00
2025-2032	30%	Surplus Interconnection w/ Capacity	25	Varies	\$40.00	(\$8.00)	\$0.00	\$0.00	\$32.00
After 2032	0%	Generic	25	Varies	\$40.00	\$0.00	\$7.00	\$0.00	\$47.00
After 2032	0%	Surplus Interconnection	25	0%	\$40.00	\$0.00	\$0.00	\$0.00	\$40.00
After 2032	0%	Replacement Interconnection	25	Varies	\$40.00	\$0.00	\$0.00	\$0.00	\$40.00

Similar to wind, Otter Tail includes three categories for solar projects: (1) Generic solar resources require a new generation site, (2) Surplus interconnection solar may be added alongside an existing generating facility where the generation of both resources does not exceed the existing interconnection amount of the original facility, and (3) Replacement interconnection solar resources reuse the existing interconnection rights of an existing resource that is retiring. Figure 4 provides the assumptions included in the Low Sensitivity solar energy assumptions.

Otter Tail’s low solar price is included in the *Solar and Battery Low Cost (40% ITC)* sensitivity in Appendix I.

**Figure 4: Low Sensitivity Solar Energy Assumptions**

			40% ITC Low Cost Case \$/MWh						
Year available	ITC	Solar Project Alternatives	Size (MW)	Accredited capacity (% of Nameplate)	LCOE modeled as a fixed price PPA	ITC adjustment	Inconnection adder assuming \$200/kW	Congestion adder	Base Case (\$/MWh)
2025-2032	40%	Generic	25	Varies	\$40.00	(\$11.00)	\$7.00	\$0.00	\$36.00
2025-2032	40%	Surplus Interconnection	25	0%	\$40.00	(\$11.00)	\$0.00	\$0.00	\$29.00
2025-2032	40%	Surplus Interconnection w/ Capacity	25	Varies	\$40.00	(\$11.00)	\$0.00	\$0.00	\$29.00
After 2032	0%	Generic	25	Varies	\$40.00	\$0.00	\$7.00	\$0.00	\$47.00
After 2032	0%	Surplus Interconnection	25	0%	\$40.00	\$0.00	\$0.00	\$0.00	\$40.00
After 2032	0%	Replacement Interconnection	25	Varies	\$40.00	\$0.00	\$0.00	\$0.00	\$40.00

## 4 Battery Storage Assumptions

Otter Tail evaluated battery storage resource alternatives as purchased power agreements (PPA) with a 30-year term and fixed pricing over that term. Battery storage costs are included in the fixed price assumptions.

The battery storage price assumptions included below are based on Otter Tail’s industry knowledge and estimates specific to Otter Tail and include impacts of the Inflation Reduction Act which includes a 30 percent ITC for projects that meet certain criteria. The low price storage costs include a 25 percent reduction from the base assumptions which is the equivalent of an increase in the ITC from 30 percent to 40 percent. The results of this low cost battery sensitivity are included in the *Solar and Battery Low Cost (40% ITC)* sensitivity in Appendix I.

**Figure 6: Battery Storage Assumptions**

Year available	Battery Storage Alternative	Size (MW)	Accredited	Base Cost	Low Cost
			capacity (% of Nameplate)	Fixed Cost (\$/Year)	Fixed Costs (\$/Year)
2025-2032	25 MW Surplus Battery	25	Varies	\$3,000,000	\$2,250,000
2025-2032	25 MW Battery	25	Varies	\$3,300,000	\$2,500,000
After 2032	25 MW Replacement Battery	25	Varies	\$3,300,000	\$2,500,000
After 2032	25 MW Battery	25	Varies	\$4,300,000	\$3,200,000

## 5 Natural Gas Fuel Price Assumptions

Figure 7 shows the forecasted monthly natural gas fuel prices used in the 2021 resource plan. Otter Tail used the Wood Mackenzie July 2022 North American Power Service for determining the natural gas fuel prices used in the resource plan. Otter Tail evaluated natural gas prices at +/- 50 percent of the base case and at +100 percent of the base case. The natural gas price sensitivities are included in Appendix I.

**Figure 7: Natural Gas Fuel Price Assumptions**

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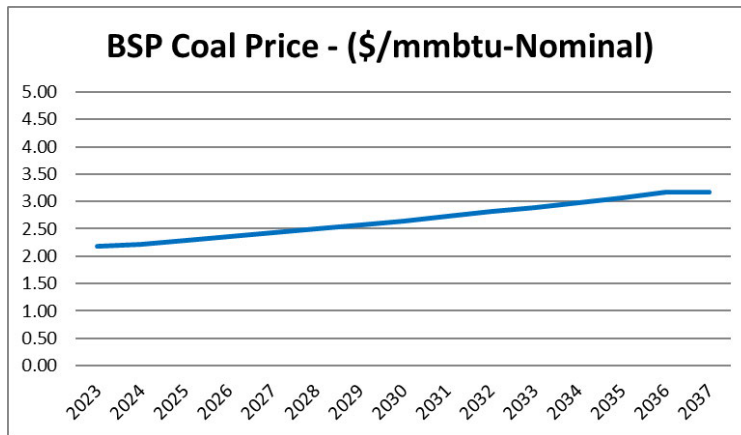
## 6 Coal Price Assumptions

Otter Tail’s coal price forecasts for its two coal-fired thermal units are developed using existing coal and freight contracts. For modeling purposes in this resource plan coal fuel prices are broken into two portions: fixed fuel costs and variable fuel costs. The 2022 fixed fuel costs modeled for Big Stone reflect the rail car lease costs of

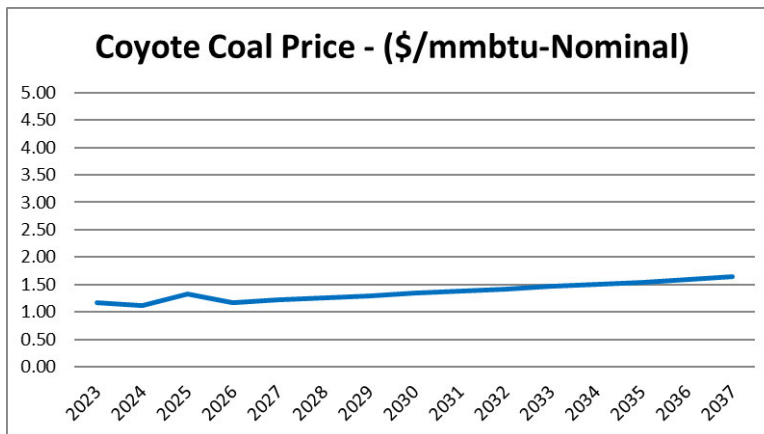
**[PROTECTED DATA BEGINS... ..PROTECTED DATA ENDS]** (OTP portion) annually. The 2022 fixed fuel costs modeled for Coyote station are modeled at **[PROTECTED DATA BEGINS... ..PROTECTED DATA ENDS]** (OTP portion) annually and represent the non-variable portion of the fuel supply agreement.

The variable cost portion of fuel costs are shown in Figure 8 (Big Stone Plant) and Figure 9 (Coyote Station.)

**Figure 8: Big Stone Plant Variable Portion Coal Price Assumptions**



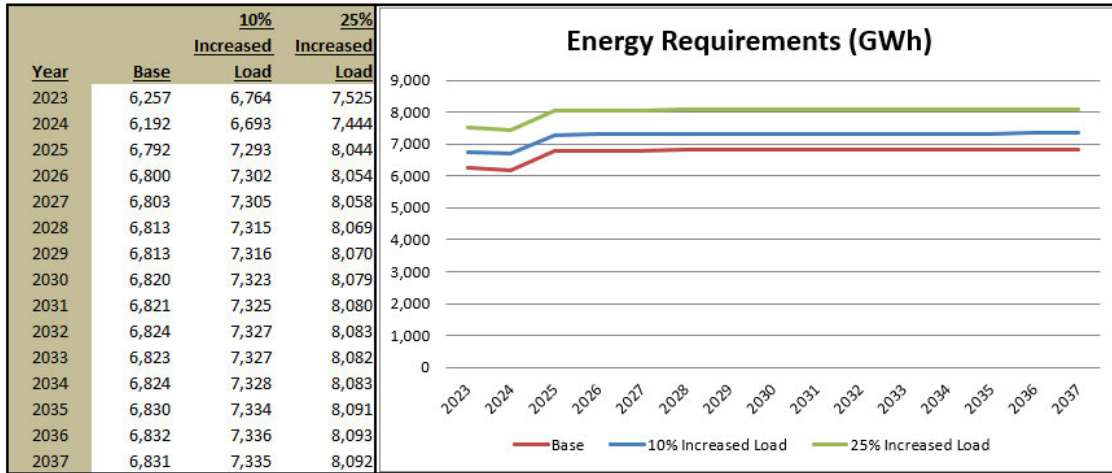
**Figure 9: Coyote Station Variable Portion Coal Price Assumptions**



## 7 Increased Load Assumptions

Figure 10 shows the energy requirement assumptions used in the resource plan. The increased load sensitivities are provided in Appendix I.

**Figure 10: Increased Load Assumptions**



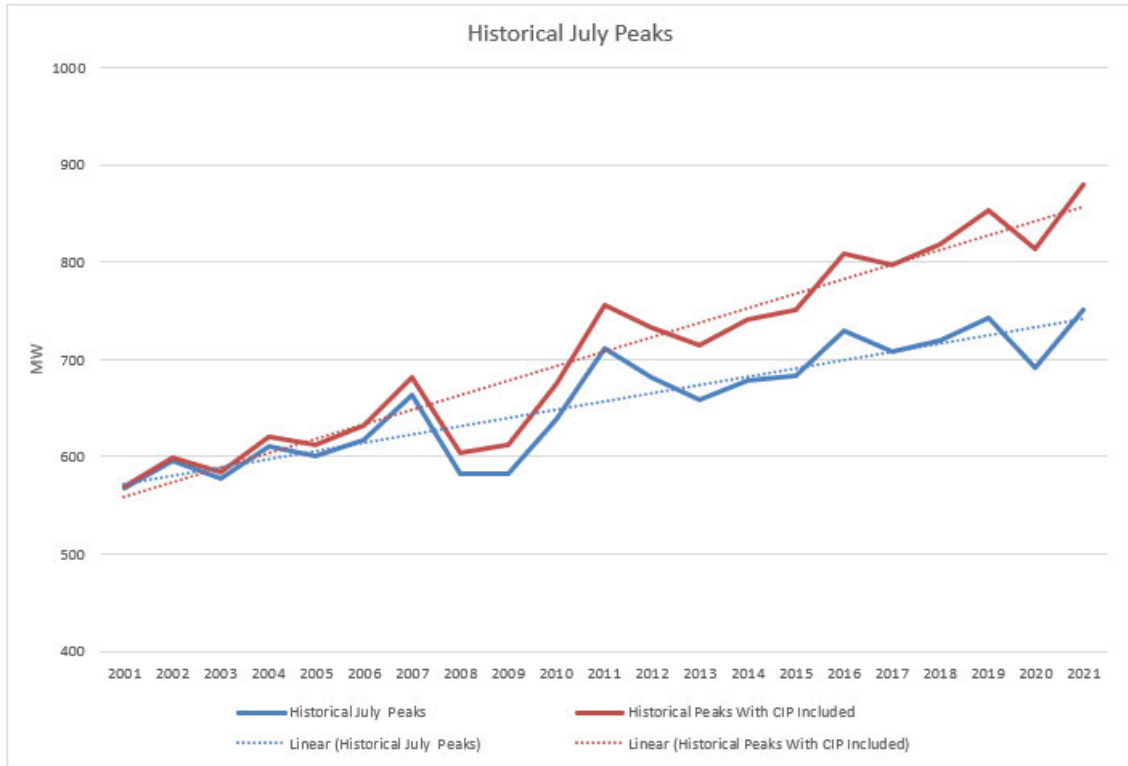
## 8 Energy Efficiency Assumed in Forecast

Otter Tail has been actively incorporating energy efficiency and Demand Side Management (DSM) programs since 1992. As time goes on and energy efficiency programs grow, a portion of future energy efficiency is included in the energy and demand forecasts. This conclusion was reached based on the fact that our historical load growth has been incrementally lowered by the existing energy efficiency programs which will translate to a lower future load growth through the forecasting process. In other words, the forecast assumes additional new energy efficiency to maintain the reduced load growth rates caused by the historical energy efficiency programs.

Figure 11 shows the historical DSM for 2001 through 2021 where the solid blue line provides the actual historical July peaks, and the solid orange line provides the historical July peak had Otter Tail not had any demand reductions. The dotted blue line provides the actual historical slope of 8.51 compared to the orange dotted line slope of 14.94 if Otter Tail had not had any demand reductions.



**Figure 11: DSM Assumptions**



The values for each year are listed in Figure 12, along with the three other seasons' data that were analyzed for the resource plan.

**Figure 12: Built-In DSM/EE**

12-Year Cumulative Total				Summer		Fall		Winter		Spring	
Summer	Fall	Winter	Spring	Historical July Peaks	Historical Peaks With CIP Included	Historical November Peaks	Historical Peaks With CIP Included	Historical January Peaks	Historical Peaks With CIP Included	Historical March Peaks	Historical Peaks With CIP Included
2.0	2.0	1.9	2.0	567	569.0	594	596.0	618	619.9	569	571.0
3.7	7.4	11.0	14.7	596	599.7	594	601.4	635	646.0	621	635.7
6.5	12.9	19.1	25.6	578	584.5	610	622.9	668	687.1	666	691.6
9.8	19.7	29.1	39.0	610	619.8	610	629.7	686	715.1	616	655.0
12.4	24.7	36.5	48.9	600	612.4	644	668.7	656	692.5	606	654.9
15.3	30.6	45.2	60.6	617	632.3	669	699.6	652	697.2	617	677.6
18.2	36.5	53.9	72.2	663	681.2	676	712.5	697	750.9	647	719.2
22.2	44.4	65.6	87.9	582	604.2	692	736.4	688	753.6	677	764.9
30.2	60.5	89.4	119.8	582	612.2	640	700.5	800	889.4	752	871.8
36.5	73.0	108.0	144.6	638	674.5	729	802.0	817	925.0	698	842.6
43.2	86.4	127.7	171.0	712	755.2	668	754.4	811	938.7	768	939.0
50.5	101.0	149.3	199.9	682	732.5	708	809.0	824	973.3	665	864.9
56.1	56.1	53.7	56.3	659	715.1	752	808.1	797	850.7	739	795.3
62.1	62.2	59.5	62.3	679	741.1	783	845.2	874	933.5	834	896.3
68.4	68.5	65.5	68.7	683	751.4	733	801.5	897	962.5	805	873.7
79.0	79.1	75.6	79.3	730	809.0	723	802.1	876	951.6	765	844.3
88.7	88.8	84.9	89.0	708	796.7	800	888.8	894	978.9	832	921.0
99.5	99.6	95.2	99.8	719	818.5	834	933.6	912	1007.2	763	862.8
111.7	111.8	106.9	112.1	742	853.7	795	906.8	924	1030.9	819	931.1
121.9	122.0	116.6	122.3	691	812.9	714	836.0	845	961.6	759	881.3
128.6	128.7	123.1	129.1	751	879.6	767	895.7	830	953.1	780	909.1
SLOPE				8.51	14.95	10.09	15.90	15.00	19.89	11.36	15.94

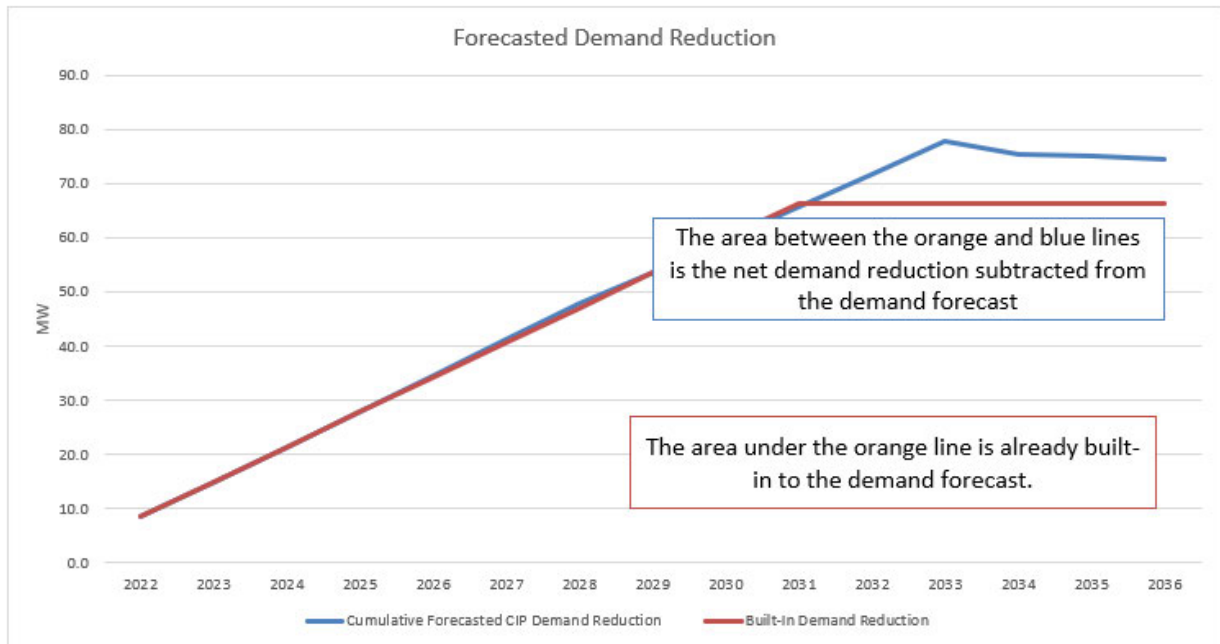
Otter Tail forecasts expected demand reductions for the resource planning period. Figure 13 below provides those forecasted demand reductions and utilizes the historical data provided above to determine the amount of those forecasted demand reductions already built-in to the forecast. This amount assumed to already be part of the forecast is removed from the annual forecasted demand reduction to arrive at the Net Demand Reduction that Otter Tail includes in the forecast for CIP demand reduction. This was completed on a seasonal basis

**Figure 13: Net CIP Demand Reduction to Forecast**

Cumulative Forecasted CIP Demand Reduction				Built-In Demand Reduction				Net CIP Demand Reduction			
Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring
8.3	8.2	8.3	8.3	8.3	8.2	8.3	8.3	0.0	0.0	0.0	0.0
14.7	14.6	14.7	14.6	14.8	14.1	13.2	12.8	-0.1	0.5	1.5	1.7
21.1	20.9	21.0	20.9	21.2	19.9	18.1	17.4	-0.1	1.0	2.9	3.5
27.8	27.5	27.7	27.6	27.7	25.7	23.0	22.0	0.1	1.8	4.7	5.6
34.5	34.1	34.4	34.2	34.1	31.5	27.9	26.6	0.4	2.7	6.5	7.6
41.3	40.8	41.1	40.9	40.6	37.3	32.8	31.2	0.7	3.5	8.3	9.7
47.7	47.2	47.5	47.3	47.0	43.1	37.7	35.8	0.7	4.0	9.8	11.5
53.7	53.1	53.5	53.2	53.5	48.9	42.6	40.3	0.3	4.2	10.9	12.9
59.7	59.0	59.5	59.2	59.9	54.7	47.5	44.9	-0.2	4.3	12.0	14.3
65.7	65.0	65.4	65.1	66.3	60.6	52.4	49.5	-0.6	4.4	13.1	15.6
71.7	70.9	71.4	71.1	66.3	60.6	52.4	49.5	5.4	10.3	19.0	21.6
77.7	76.8	77.4	77.0	66.3	60.6	52.4	49.5	11.4	16.3	25.0	27.5
75.4	74.5	75.0	74.7	66.3	60.6	52.4	49.5	9.0	14.0	22.7	25.2
75.0	74.1	74.6	74.3	66.3	60.6	52.4	49.5	8.6	13.6	22.3	24.8
74.6	73.7	74.2	73.9	66.3	60.6	52.4	49.5	8.2	13.2	21.9	24.4

Figure 14 below shows the growth of these demand reductions included in Otter Tail’s forecast for the summer season using the data above.

**Figure 14: Forecast Demand Reduction**



## 9 Market Energy Price Assumptions

Otter Tail used the Wood Mackenzie July 2022 North American Power Service as the basis for the market energy prices used in this resource plan. Otter Tail applied the Wood Mackenzie forecasted monthly on-peak and off-peak energy prices to an hourly profile to reflect the hourly variability/volatility of the energy market. Otter Tail

evaluated market energy at +/- 50 percent and +100 percent of the base case. Figure 15 shows the market energy price basis for the assumptions used in the resource plan. The market energy price sensitivities are provided in Appendix I.

**Figure 15: Market Energy Price Assumptions**

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## 10 Externality Price Assumptions

Otter Tail includes all modeling runs with and without externalities in Appendix I. For the modeling runs with externalities Figure 16 provides the application of the externalities for Otter Tail Generating Resources.

**Figure 16: Application of Externalities for Otter Tail Generating Resources**

	Regulatory Cost of Carbon	CO2 Externality Values	Criteria Values
Big Stone	X		X
Coyote	X		
Astoria	X		X
Solway	X	X	X

As identified in Appendix A, in compliance with Minnesota Docket Nos. CI-07-1199, CI-14-643, and DI-19-406, Otter Tail includes externality sensitivities. For these sensitivities, Otter Tail includes the criteria values for PM2.5, NOX, and SO2 defined in Minnesota Docket No. CI-14-643 and the CO2, for 2020-2024, and Regulatory Cost of Carbon values determined in Minnesota Docket Nos CI-07-1199 and DI-19-406. These values are provided in Figure 17 below.

**Figure 17: Externality Values**

**CO2 Externality Values (2020-2024)**

	Low	Median	High
2020	\$9.05	\$25.76	\$42.46
2021	\$9.25	\$26.31	\$43.36
2022	\$9.46	\$26.86	\$44.26
2023	\$9.66	\$27.41	\$45.16
2024	\$9.87	\$27.97	\$46.06

**Regulatory Cost of Carbon (2025-2050)**

	Low	Median	High
2025+	\$5.00	\$15.00	\$25.00

**Criteria Values (2020-2050)**

	Low	Median	High
PM2.5	\$3,437	\$6,220	\$8,441
NOX	\$1,985	\$4,762	\$6,370
SO2	\$3,427	\$6,159	\$8,352

## 11 New Firm Dispatchable Alternative Assumptions

Figure 18 shows key assumptions used for new dispatchable alternatives in the resource plan. For the purposes of this resources plan Otter Tail utilized thermal resource alternatives as guidelines for project costs and expects that developing technologies may provide different firm dispatchable options in the future.

**Figure 18: New Firm Dispatchable Alternatives**

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## 12 Existing Unit Input Assumptions

Figure 19 shows key input assumptions used for existing baseload units.

**Figure 19: Existing Baseload Unit Assumptions**

Existing Baseload Units		
Name	Big Stone Plant	Coyote Station
Coal Type	sub-bituminous	lignite
Retirement Date	2046	2041
Nameplate Capacity (MW)	255.8	149.8
Firm Capacity (MW) Summer	253.242	142.31
Firm Capacity (MW) Fall	243.01	142.31
Firm Capacity (MW) Winter	253.242	142.31
Firm Capacity (MW) Spring	253.242	134.82
Heat Rate at Minimum (Btu/kwh)	12,669	12,786
Heat Rate at Maximum (Btu/kwh)	10,032	11,011
O&M Escalation	2%	2%
Fixed O&M (2022\$/kw-yr)	\$44.50	\$99.50
Variable O&M (2022\$/MWh)	\$3.42	\$3.15

Figure 20 shows key input assumptions used for existing peaking units.

**Figure 20: Existing Peaking Unit Assumptions**

Existing Peaking Units					
Name	Astoria Station	Solway	Lake Preston	Jamestown 1	Jamestown 2
Fuel	natural gas	natural gas	fuel oil	fuel oil	fuel oil
Retirement Date	2056	2038	2033	2033	2033
Nameplate Capacity(MW)	242 to 288	42.5	20.4	20.7	21.1
Firm Capacity (MW) Summer	235.9	41.4	18.7	19.7	19.3
Firm Capacity (MW) Fall	244.5	41.4	18.7	19.7	19.3
Firm Capacity (MW) Winter	280.6	41.4	18.7	19.7	19.3
Firm Capacity (MW) Spring	256.6	41.4	18.7	19.7	19.3
Heat Rate at Minimum (Btu/kwh)	13,509	13,853	26,961	25,082	25,338
Heat Rate at Maximum (Btu/kwh)	10,022	9,637	16,567	15,300	15,519
O&M Escalation	2%	2%	2%	2%	2%
Fixed O&M (2022\$/kw-yr)	\$2.54	\$4.49	\$4.50	\$2.74	\$2.74
Variable O&M (2022\$/MWh)	\$0.47	\$3.61	\$8.73	\$4.91	\$5.31

Figure 21 shows key input assumptions used for existing wind purchased power agreements.

**Figure 21: Existing Wind Energy Purchases**

Existing Wind Purchased Power Transactions		
Name	ND Wind II (Edgeley)	Langdon PPA
<b>Transaction End Date</b>	Nov-2028	Nov-2032
<b>Nameplate Capacity(MW)</b>	21	19.5
<b>Firm Capacity (MW) Summer</b>	3.8	3.5
<b>Firm Capacity (MW) Fall</b>	4.9	4.5
<b>Firm Capacity (MW) Winter</b>	8.5	7.9
<b>Firm Capacity (MW) Spring</b>	4.8	4.5
<b>Net Capacity Factor</b>	26%	41%

Figure 22 shows key input assumptions used for Otter Tail owned wind facilities.

**Figure 22: Existing Otter Tail-Owned Wind Facilities**

Existing Otter Tail-Owned Wind					
Name	Langdon	Ashtabula	Luverne	Merricourt	Ashtabula III
<b>End of Life Date</b>	Dec-2042	Dec-2043	Dec-2044	Dec-2055	Sep-2038
<b>Nameplate Capacity(MW)</b>	40.5	48	49.5	150	62.4
<b>Firm Capacity (MW) Summer</b>	7.3	8.7	9.0	27.2	11.3
<b>Firm Capacity (MW) Fall</b>	9.4	11.1	11.4	34.7	14.4
<b>Firm Capacity (MW) Winter</b>	16.3	19.3	19.9	60.5	25.1
<b>Firm Capacity (MW) Spring</b>	9.3	11.0	11.4	34.5	14.4
<b>Net Capacity Factor</b>	40%	36%	41%	50%	39%

Figure 23 shows key input assumptions used for Otter Tail’s owned Hoot Lake Solar facility which is expected to be in commercial operation in 2023.

**Figure 23: Existing Otter Tail-Owned Solar Facility**

Existing Otter Tail Owned Solar	
Name	Hoot Lake Solar
<b>Expected Commission Date</b>	Jan-2023
<b>Nameplate Capacity(MW)</b>	49
<b>Firm Capacity (MW) Summer</b>	22.2
<b>Firm Capacity (MW) Fall</b>	12.4
<b>Firm Capacity (MW) Winter</b>	3.1
<b>Firm Capacity (MW) Spring</b>	7.4
<b>Net Capacity Factor</b>	24%

## 13 Other Assumptions

General Inflation Rate – 2%

Capital Cost Escalation Rate – 1%

Debt Rate – 4.77%

Discount Rate – 7.34%

Composite Tax Rate – 26.26%

Debt Ratio – 47.50%