

**Appendix F: Strategist Modeling Assumptions  
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HAS BEEN EXCISED**

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# 1 Sensitivities Evaluated

Figure 1 shows a grid of sensitivities evaluated in this resource plan. Otter Tail evaluated 58 sensitivities. Thirty-one sensitivities have externality values applied over the study period. Twenty-seven sensitivities do not have the externality values applied.

**Figure 1: Sensitivities Evaluated**

0 Base	Externality values applied	Zero Externalities
1 OTP Preferred Plan		
2 Wind -\$5/MWh		
3 Wind +\$5/MWh		
4 (CEO) Solar Declining price		
5 Solar -\$10/MWh		
6 Solar +\$10/MWh		
7 -50% NaturalGas price		
8 -25% NaturalGas price		
9 +25% NaturalGas price		
10 +50% NaturalGas price		
11 +100% NaturalGas price		
12 Low Coal price		
13 High Coal price		
14 Low LoadGrowth		
15 High LoadGrowth		
16 Low Energy Market Price		
17 High Energy Market Price		
18 Limit Market Energy Purchases		
19 Low Externality		
20 High Externality		
21 (CEO) \$59/ton CO2		
22 MN CO2 reduction Goal		
23 BAU MN Energy Efficiency		
24 1.6% MN Energy Efficiency		
25 1.7% MN Energy Efficiency		
26 1.8% MN Energy Efficiency		
27 1.9% MN Energy Efficiency		
28 2.0% MN Energy Efficiency		
29 (CEO) 1.0% ND Energy Efficiency		
30 Retire Peakers		

# 2 Wind Energy Assumptions

Figure 2 shows the wind energy assumptions used in the 2016 resource plan. Otter Tail evaluated wind energy resource alternatives as purchased power agreements (PPA) with a 20 year term and fixed pricing over that term. Wind integration costs are included in the fixed price assumptions.

In December 2015 legislation was enacted that extended the availability of production tax credits (PTC) associated with wind energy through 2019. The legislation also included a phase-out of the tax incentive.

The wind energy price assumptions incorporate the phasing out of the PTCs from 100 percent for projects that have started construction in 2016, to 40 percent for projects that have started construction in 2019. For projects that start construction after 2019, there are no PTCs assumed.

Wind project sizes are assumed to be 100 MW in size with a 40 percent net capacity factor and an accredited capacity of 15.6 percent (15.6 MW). Wind projects are made available for selection in the years 2018, 2020, 2022, 2023, 2025 and 2027. The low and high wind price sensitivities are #2 and #3 respectively.

**Figure 2: Wind Energy Assumptions**

Strategist Name	Construction Start	COD by end of	First Full Year of Operations	PTC	Fixed Price	Fixed Price	Fixed Price	NCF	Nameplate Capacity (MW)	Accredited Capacity	Year that one Superfluous unit available
					(\$/MWh) Low	(\$/MWh) Base	(\$/MWh) High			(15.6% of Nameplate) (MW)	
W16	2016	2020	2021	100%	\$25.00	\$30.00	\$35.00	40%	100	15.60	2018, 2020
W17	2017	2021	2022	80%	\$29.00	\$34.00	\$39.00	40%	100	15.60	2022
W18	2018	2022	2023	60%	\$34.00	\$39.00	\$44.00	40%	100	15.60	2023
W19	2019	2023	2024	40%	\$39.00	\$44.00	\$49.00	40%	100	15.60	
W20	2020	2024	2025	0%	\$48.00	\$53.00	\$58.00	40%	100	15.60	2025
W23	2023	2027	2028	0%	\$51.24	\$56.24	\$61.24	40%	100	15.60	2027
W26	2026	2030	2031	0%	\$54.69	\$59.69	\$64.69	40%	100	15.60	

### 3 Solar Energy Assumptions

Figure 3 shows the solar energy assumptions used in the 2016 resource plan. Otter Tail evaluated solar energy resource alternatives as purchased power agreements (PPA) with a 20 year term and fixed pricing over that term. Solar integration costs are included in the fixed price assumptions.

Similar to wind, the December 2015 legislation that was enacted extended the availability of investment tax credits (ITC). Solar projects that start construction by 2019 are eligible for the 30 percent ITC. The legislation includes a step-down provision of the ITC to the 10 percent level for projects that start construction after 2021.

Solar project sizes are assumed to be 30 MW in size with 15 percent net capacity factor and an accredited capacity of 50 percent (15 MW). Solar projects are made available for selection in the years 2020, 2022-2025, and 2028. Sensitivity #4 contains a declining price until the year 2020. The low and high solar price sensitivities are #5 and #6 respectively.

**Figure 3: Solar Energy Assumptions**

Strategist Name	Construction Start	COD by end of	First Full Year of Operations	ITC	Fixed Price (\$/MWh)				NCF	Nameplate Capacity (MW)	Accredited Capacity (50% of Nameplate) (MW)	Year that one Superflous unit available
					Declining	Low	Base	High				
S19	2016	2018	2019	30%	\$80.00	\$70.00	\$80.00	\$90.00	15%	30	15.00	
S19	2017	2019	2020	30%	\$70.00	\$70.00	\$80.00	\$90.00	15%	30	15.00	2020
S19	2018	2020	2021	30%	\$62.00	\$70.00	\$80.00	\$90.00	15%	30	15.00	
S19	2019	2021	2022	30%	\$55.00	\$70.00	\$80.00	\$90.00	15%	30	15.00	2022
S20	2020	2022	2023	26%	\$48.00	\$75.00	\$85.00	\$95.00	15%	30	15.00	
S21	2021	2023	2024	22%	\$48.00	\$80.00	\$90.00	\$100.00	15%	30	15.00	2024
S22	2022	2024	2025	10%	\$48.00	\$94.00	\$104.00	\$114.00	15%	30	15.00	
S22	2025	2027	2028	10%	\$48.00	\$94.00	\$104.00	\$114.00	15%	30	15.00	2026, 2028

## 4 Natural Gas Fuel Price Assumptions

Figure 4 shows the forecasted monthly natural gas fuel prices used in the 2016 resource plan. Otter Tail used the Wood Mackenzie January 2016 North American Power Service for determining the natural gas fuel prices used in the resource plan. Otter Tail evaluated natural gas prices at +/- 25percent of the base case and +/- 50 percent of the base case and at +100 percent of the base case. The natural gas price sensitivities are #7-11.

**Figure 4: Natural Gas Fuel Price Assumptions**

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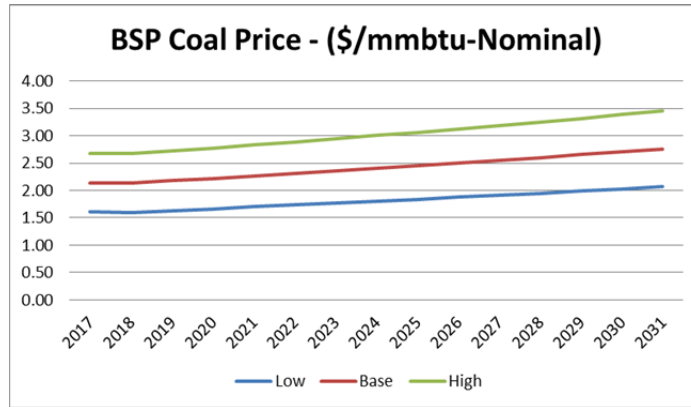
## 5 Coal Price Assumptions

Otter Tail’s coal price forecasts for its three 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 fixed fuel costs modeled for Hoot Lake and Big Stone reflect the rail car lease costs[PROTECTED DATA BEGINS...

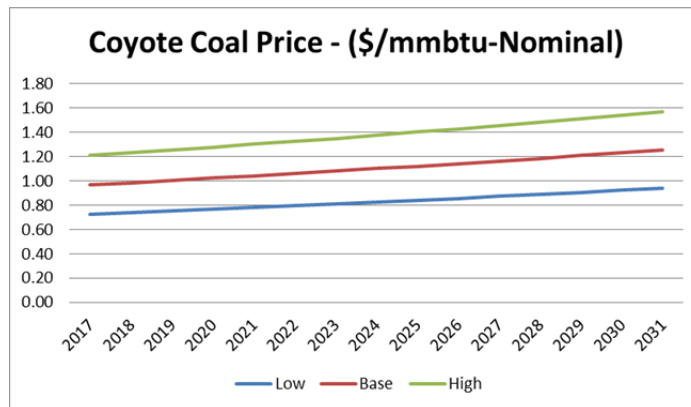
...PROTECTED DATA ENDS](OTP portion) annually. The fixed fuel costs modeled for Coyote station are modeled at [PROTECTED DATA BEGINS... ...PROTECTED DATA ENDS] (OTP portion) annually and represent the non-variable portion of the fuel supply agreement.

The variable cost portion of fuel costs are shown in Figure 5 (Big Stone plant), Figure 6 (Coyote station), and Figure 7 (Hoot Lake plant). Otter Tail evaluated coal price at +/- 25% of the base case. The coal price sensitivities are #12 and #13.

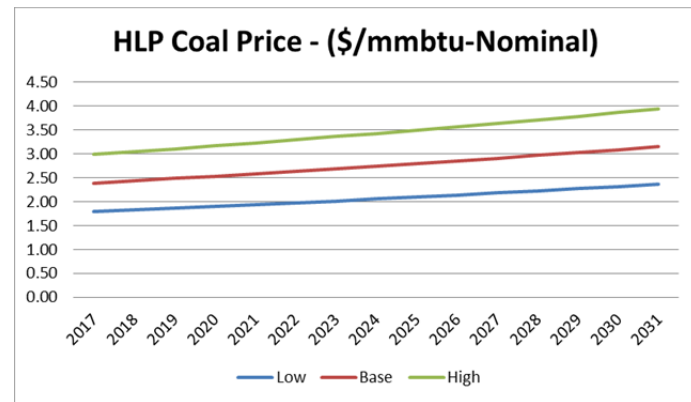
**Figure 5: Big Stone Plant Coal Price Assumptions**



**Figure 6: Coyote Station Coal Price Assumptions**



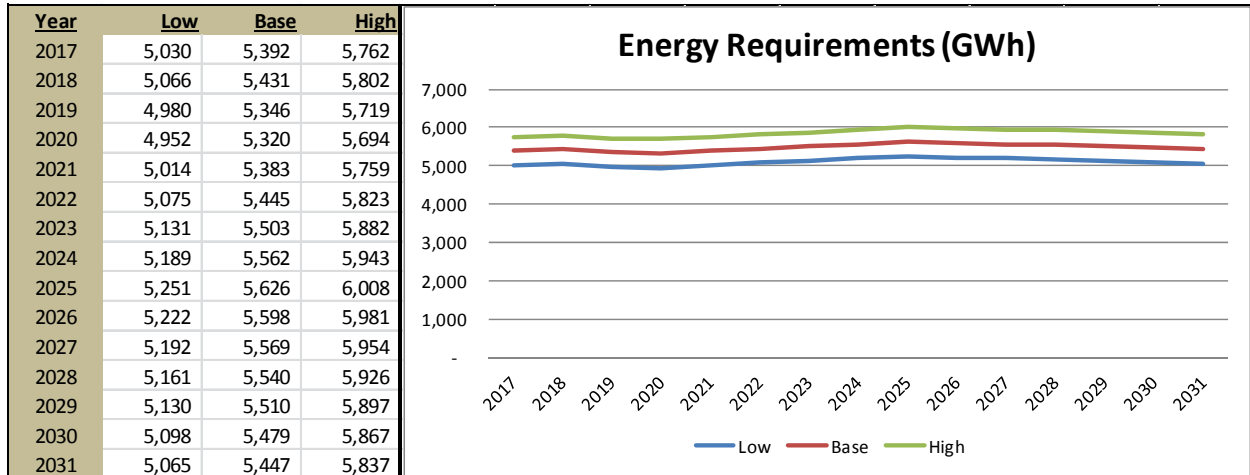
**Figure 7: Hoot Lake Plant Coal Price Assumptions**



## 6 Load Growth Assumptions

Figure 8 shows the energy requirement assumptions used in the 2016 resource plan. The load growth sensitivities are #14 and #15.

**Figure 8: Load Growth Assumptions**

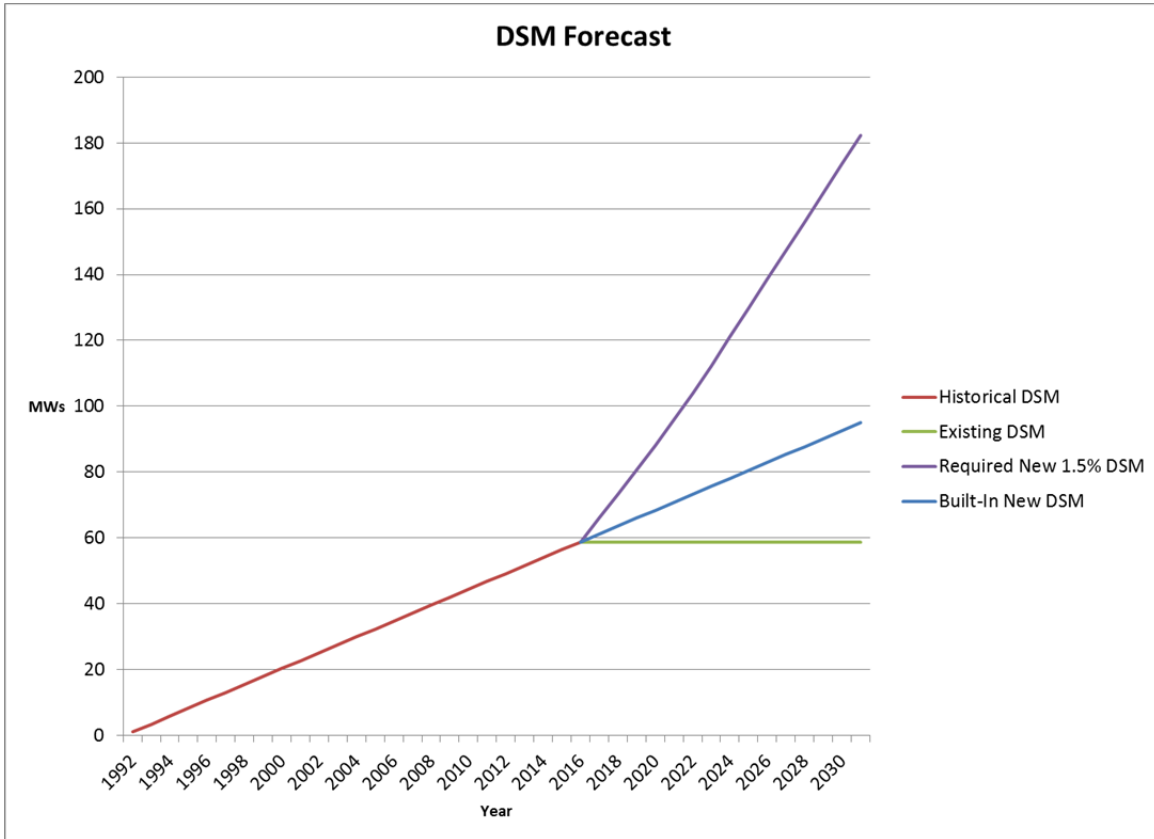


## 7 Energy Efficiency Assumed in Forecast

Otter Tail has been actively incorporating energy efficiency and Demand Side Management (DSM) programs in Minnesota since 1992. It can be assumed that as time goes on and energy efficiency programs grow, a portion of future energy efficiency will be 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 9 shows the amount of existing DSM for each historical year, and the assumed amount of included DSM in the future years required to maintain a similar load reduction.

**Figure 9: DSM Assumptions**



The gap between the green and blue lines is the assumed new DSM that is “built-in” to the forecast. The values for each year are listed in Figure 10.

**Figure 10: Built-In DSM/EE**

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Built-in DSM (MWs)	3.5	5.9	8.3	10.7	13.1	15.5	17.9	20.3	22.7	25.1	27.5	29.9	32.3	34.8	37.2
Built-in EE (GWHs)	11.9	23.5	35.2	46.8	58.4	70.1	81.7	93.4	105.0	116.6	128.3	139.9	151.6	163.2	174.9

## 8 Market Energy Price Assumptions

Otter Tail used the Wood Mackenzie January 2016 North American Power Service as the basis for the market energy prices used in the 2016 resource plan. Otter Tail applied the Wood Mackenzie forecasted monthly average energy price to an hourly day-ahead (DA) load zone price profile to reflect the hourly variability/volatility of the energy market. Otter Tail evaluated market energy at +/- 25% of the base case. Figure 11 shows the market energy price basis for the assumptions used in the 2016 resource plan. Figure 11 shows the market capacity price basis for the assumptions used in the 2013 resource plan. The market price sensitivities are #16 and #17.

**Figure 11: Market Energy Price Assumptions**  
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## 9 Externality Price Assumptions

Figure 12 shows the externality price assumptions used in the 2016 resource plan. The values are from the *Notice of Revised Updated Environmental Externality Values* as issued by the Minnesota Public Utilities Commission on May 27, 2015 and escalated at 2 percent. Hoot Lake, Solway, and market purchases use the “Rural” values. Big Stone plant and the proposed combustion turbine use the “within 200 miles of Minnesota” values. Coyote Station does not have the externality values applied to it since it is over 200 miles from Minnesota, except for CO<sub>2</sub> starting in 2022. The base case with externalities uses the mid-point values. The low and high externality price sensitivities are #19 and #20 respectively. Sensitivity #21 used CO<sub>2</sub> values that started at \$59/ton starting in 2017 and increased by \$1/ton until 2022 where the mid-point range on CO<sub>2</sub> resumed for the rest of the study period. Otter Tail did not apply any externality/allowance price to SO<sub>2</sub> emissions.

**Figure 12: Externality Price (\$/ton)**

	Rural Externality values (used for HLP, Solway, Market Purchases)			Within 200 milies of MN (used for BSP, new CT)			Beyond 200 milies of MN (used for Coyote)		
	Low	Mid	High	Low	Mid	High	Low	Mid	High
	SO <sub>2</sub>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PM <sub>10</sub>	820.39	1034.25	1248.10	820.39	1034.25	1248.10	0.00	0.00	0.00
CO	0.30	0.45	0.60	0.30	0.45	0.60	0.00	0.00	0.00
NO <sub>X</sub>	26.28	87.59	148.90	26.28	87.59	148.90	0.00	0.00	0.00
Pb	586.83	620.40	653.97	586.83	620.40	653.97	0.00	0.00	0.00
CO <sub>2</sub> (before 2022)	0.44	2.49	4.53	0.00	0.00	0.00	0.00	0.00	0.00
CO <sub>2</sub> (starting 2022)	9.00	21.50	34.00	9.00	21.50	34.00	9.00	21.50	34.00



## 10 New Thermal Alternative Assumptions

Figure 13 shows key assumptions used for new thermal alternatives in the 2016 resource plan.

**Figure 13: New Thermal Alternatives**

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## 11 Existing Unit Input Assumptions

Figure 14 shows key input assumptions used for existing baseload units. Figure 15 shows key input assumptions used for existing peaking units. Figure 15 shows key input assumptions used for existing wind purchased power agreements. Figure 17 shows key assumptions used for Otter Tail-owned wind generation that is modeled as transactions in Strategist.

**Figure 14: Existing Baseload Unit Assumptions**

Existing Baseload Units				
Name	Big Stone	Coyote	Hoot Lake #2	Hoot Lake #3
<b>Fuel</b>	sub-bituminous coal	lignite coal	sub-bituminous coal	sub-bituminous coal
<b>Retirement Date</b>	Jun-2046	Jun-2041	Jun-2021	Jun-2021
<b>Nameplate Capacity(MW)</b>	255.8	149.8	58.7	81.4
<b>Accredited Capacity(MW)</b>	238.8	131	56.6	79.8
<b>Heat Rate at Minimum (Btu/kwh)</b>	11,650	12,310	11,620	11,345
<b>Heat Rate at Maximum (Btu/kwh)</b>	10,450	10,900	11,482	11,755
<b>O&amp;M Escalation</b>	2%	2%	2%	2%
<b>Fixed O&amp;M (2017\$/kw-yr)</b>	\$ 10.61	\$ 11.44	\$ 31.06	\$ 30.89
<b>Variable O&amp;M (2017\$/MWh)</b>	\$ 1.44	\$ 1.73	\$ 0.44	\$ 0.86

**Figure 15: Existing Peaking Unit Assumptions**

Existing Peaking Units				
Name	Solway	Lake Preston	Jamestown 1	Jamestown 2
Fuel	natural gas	fuel oil	fuel oil	fuel oil
Retirement Date	Jun-2038	Jun-2033	Jun-2033	Jun-2033
Nameplate Capacity(MW)	42.5	20.4	20.7	21.1
Accredited Capacity(MW)	41.2	17	19.3	16.2
Heat Rate at Minimum (Btu/kwh)	11,450	16,320	18,480	18,480
Heat Rate at Maximum (Btu/kwh)	9,600	13,000	13,000	13,000
O&M Escalation	2%	2%	2%	2%
Fixed O&M (2017\$/kw-yr)	\$ 17.76	\$ 6.86	\$ 6.28	\$ 6.16
Variable O&M (2017\$/MWh)	\$ 4.09	\$ 5.79	\$ 5.79	\$ 5.79

**Figure 16: Existing Wind Energy Transaction Assumptions**

Existing Wind Purchased Power Transactions				
Name	(Edgeley)	Langdon PPA	Ashtabula III	Small DG
Transaction End Date	11/31/2028	Nov-2032	Sep-2038	Dec-2033
Nameplate Capacity(MW)	21	19.5	62.4	NA
Accredited Capacity(MW)	3.6	4.7	15.4	NA
Net Capacity Factor	30%	43%	42%	NA

**Figure 17: Existing Otter Tail-Owned Wind Assumptions**

Existing Otter Tail-Owned Wind (Modeled as Transactions in Strategist)			
Name	Langdon	Ashtabula	Luverne
Transaction End Date	Dec-2032	Dec-2033	Dec-2034
Nameplate Capacity(MW)	40.5	48	49.5
Accredited Capacity(MW)	9.5	11.5	13.5
Net Capacity Factor	41%	37%	40%

## 12 Other Assumptions

- General Inflation Rate – 2%
- Capital Cost Escalation Rate – 3%
- Long Term Debt Rate – 5.51%
- Discount Rate – 8.61%
- Composite Tax Rate – 39.1%