MODELING ASSUMPTIONS & INPUTS

I. ENCOMPASS INPUTS AND ASSUMPTIONS

As discussed in Section 4, the Company has made a limited set of updates to our modeling assumptions for the purposes of this Reply. We provide a summary of major changes and new modeling inputs and assumptions, relative to the modeling in our June 2020 Supplement below, followed by further details regarding assumptions used in this round of modeling.

Topic	Assumption	Change from Supplement Filing	Rationale for Change
Generic wind and solar cost assumptions	▪ Extended federal Production Tax Credits (PTC) and Investment Tax Credits (ITC) to their current dates	▪ Previous Production Tax Credit and Investment Tax Credit schedule	▪ The federal Consolidated Appropriations Act of 2021 extended the qualification period for tax credits
Generic wind, solar and battery size	▪ 50 MW generic sizes for all wind, solar and battery resources	▪ Wind: 750MW ▪ Solar: 500MW ▪ Battery: 321 MW	▪ Better accounts for the modularity of these resources
Wind and solar resource production	▪ Include costs for curtailed generation of renewable resources	▪ Did not assign costs to curtailed generation of renewable resources	▪ Better reflects the costs of curtailment
Black Start Resources	▪ Add specific resources to represent near term black start resource needs in Alternate Plan	▪ Included placeholder capacity and associated life extension costs for black start resources	▪ Replace the placeholders with specific black start unit assumptions in Alternate Plan

Topic	Assumption	Change from Supplement Filing	Rationale for Change
Sherco and King gen-ties	▪ In Alternate Plan, include revenue requirements of 345 kV transmission lines to reutilize generation interconnection opening at Sherco and King when they retire	▪ None	▪ To incorporate costs for gen-ties that enable primarily renewables to reutilize interconnection rights at Sherco and King
Approved new and repowered resources	▪ Mower, Deuel Harvest, Elk Creek, St Cloud Hydro, Heartland Divide, Border, Nobles, GrandMeadow, Pleasant Valley, Ewington.	▪ Resources were not included in June 2020 Supplement because they were not yet approved as of our assumptions lock-in date	▪ Reflects expected lives and costs of recently approved resources
Resource adequacy sensitivity	▪ Increased effective reserve margin to 7.21 percent, based on a 9.4 percent planning reserve margin and 98 percent coincidence factor in one sensitivity	▪ No sensitivity conducted	▪ Reflects increasing reserve margin needs per recent MISO guidance

A. Discount Rate and Capital Structure

The discount rate used for levelized cost calculations and the present value of modeled costs is 6.47 percent. The rates shown below were calculated by taking a weighted average of each NSP jurisdiction's last allowed/settled electric retail rate case.

Table 1: Discount Rate and Capital Structure

Discount Rate and Capital Structure				
	Capital Structure	Allowed Return	Before Tax Electric WACC	After Tax Electric WACC
Long-Term Debt	45.72%	4.79%	2.19%	1.58%
Common Equity	52.39%	9.25%	4.85%	4.85%
Short-Term Debt	1.89%	3.55%	0.07%	0.05%
Total			**7.10%**	**6.47%**

B. Inflation Rates

The inflation rates are used for existing resources, generic resources, and other costs related to general inflationary trends in the modeling and are developed using long-term forecasts from Global Insight. The general inflation rate of 2% is from their long-term forecast for "Chained Price Index for Total Personal Consumption Expenditures" published in the second quarter of 2018.

C. Reserve Margin

The reserve margin at the time of MISO's peak is 8.9 percent from the 2020-2021 Loss Of Load Expectation Study Report, published November 2019. The coincidence factor between the NSP System and MISO system peak is 95 percent. Therefore, the effective reserve margin is:

$$(95\, percent\ coincidence\ factor) x\ (1 + 8.9\, percent) - 1$$
$$= \mathbf{3.46}\, percent\ effective\ reserve\ margin\ for\ NSP$$

We also examined a sensitivity scenario using increased effective reserve margin to reflect recent MISO guidance:

$$(98\, percent\ coincidence\ factor) x\ (1 + 9.4\, percent) - 1$$
$$= \mathbf{7.21}\, percent\ effective\ reserve\ margin\ for\ NSP$$

D. CO_2 Costs

The PVSC Base Case CO2 values are based on the high environmental cost values for CO2 through 2024 (page 31 of the Minnesota Public Utilities Commission's Order Updating Environmental Cost Values in Docket No. E999/CI-14-643 issued January 3, 2018.). All prices are converted to 2018 real dollars using the 2017 Gross Domestic Product Implicit Price Deflator (GDPIPD) of 113.416 and then escalate at general inflation thereafter.

The PVSC Base Case values starting in 2025 are based on the "high" end of the range of regulated costs (see page 12 of MPUC Order Establishing 2018 and 2019 Estimate of Future Carbon Dioxide Regulation Costs in Dockets No.E999/CI-07-1199 and E-999/DI-17-53 issued June 11, 2018). All prices escalate at general inflation.

The Order Establishing 2018 and 2019 Estimate of Future Carbon Dioxide Regulation Costs requires four alternative scenarios to be run in addition to the PVSC Base Case. The Order Extending Deadline for Filing Next Resource Plan issued January 30, 2019 also requires a scenario using the midpoint of the Commission's most recently approved externalities and regulatory costs of carbon. The values in the PVSC Base Case and alternative scenarios are set out below.

Table 2: CO2 Costs

CO2 Costs ($ per short ton)						
Year	Low Environmental Cost	High Environmental Cost	Low Environmental/ Regulatory Costs	Mid Environmental/ Regulatory Costs	PVSC - High Environmental/ Regulatory Costs	PVRR - Omitting CO2 Cost Considerations
2018	$9.09	$42.76	$9.09	$25.92	$42.76	$0.00
2019	$9.49	$44.58	$9.49	$27.04	$44.58	$0.00
2020	$9.90	$46.45	$9.90	$28.18	$46.45	$0.00
2021	$10.32	$48.39	$10.32	$29.35	$48.39	$0.00
2022	$10.77	$50.38	$10.77	$30.57	$50.38	$0.00
2023	$11.22	$52.43	$11.22	$31.82	$52.43	$0.00
2024	$11.69	$54.55	$11.69	$33.12	$54.55	$0.00
2025	$12.16	$56.72	$5.00	$15.00	$25.00	$0.00
2026	$12.67	$58.97	$5.10	$15.30	$25.50	$0.00
2027	$13.17	$61.29	$5.20	$15.61	$26.01	$0.00
2028	$13.70	$63.67	$5.31	$15.92	$26.53	$0.00
2029	$14.24	$66.12	$5.41	$16.24	$27.06	$0.00
2030	$14.80	$68.64	$5.52	$16.56	$27.60	$0.00
2031	$15.37	$71.24	$5.63	$16.89	$28.15	$0.00
2032	$15.97	$73.91	$5.74	$17.23	$28.72	$0.00
2033	$16.57	$76.67	$5.86	$17.57	$29.29	$0.00
2034	$17.21	$79.50	$5.98	$17.93	$29.88	$0.00
2035	$17.85	$82.41	$6.09	$18.28	$30.47	$0.00
2036	$18.52	$85.41	$6.22	$18.65	$31.08	$0.00
2037	$19.20	$88.50	$6.34	$19.02	$31.71	$0.00
2038	$19.91	$91.68	$6.47	$19.40	$32.34	$0.00
2039	$20.62	$94.96	$6.60	$19.79	$32.99	$0.00
2040	$21.38	$98.32	$6.73	$20.19	$33.65	$0.00
2041	$22.14	$101.78	$6.86	$20.59	$34.32	$0.00
2042	$22.94	$105.34	$7.00	$21.00	$35.01	$0.00
2043	$23.74	$109.00	$7.14	$21.42	$35.71	$0.00
2044	$24.58	$112.76	$7.28	$21.85	$36.42	$0.00
2045	$25.43	$116.63	$7.43	$22.29	$37.15	$0.00
2046	$26.33	$120.61	$7.58	$22.73	$37.89	$0.00
2047	$27.23	$124.71	$7.73	$23.19	$38.65	$0.00
2048	$28.17	$128.92	$7.88	$23.65	$39.42	$0.00
2049	$29.12	$133.24	$8.04	$24.13	$40.21	$0.00
2050	$30.12	$137.69	$8.20	$24.61	$41.02	$0.00
2051	$31.14	$142.26	$8.37	$25.10	$41.84	$0.00
2052	$32.18	$146.97	$8.53	$25.60	$42.67	$0.00
2053	$33.26	$151.80	$8.71	$26.12	$43.53	$0.00
2054	$34.36	$156.76	$8.88	$26.64	$44.40	$0.00
2055	$35.50	$161.87	$9.06	$27.17	$45.28	$0.00
2056	$36.66	$167.11	$9.24	$27.71	$46.19	$0.00
2057	$37.86	$172.51	$9.42	$28.27	$47.11	$0.00

E. All Other Externality Costs

The values of the criteria pollutants are derived from the high and low values for each of the 3 locations, as determined in the Minnesota Commission Order Updating Environmental Cost Values in Docket No. E999/CI-14-643 issued January 3, 2018. The midpoint externality costs are the average of the low and high values. All prices are escalated to 2018 real dollars using the 2017 (GDPIPD) of 113.416. The high, low and midpoint externality costs will be used in the CO2 sensitivities as described above.

Table 3: Externality Costs

MPUC Low Externality Costs 2018 $ per short ton				
	Urban	Metro Fringe	Rural	<200mi
SO2	$6,116	$4,829	$3,643	$0
NOx	$2,934	$2,622	$2,110	$28
PM2.5	$10,697	$6,856	$3,654	$872
CO	$1.65	$1.17	$0.31	$0.31
Pb	$4,857	$2,562	$624	$624

MPUC High Externality Costs 2018 $ per short ton				
	Urban	Metro Fringe	Rural	<200mi
SO2	$15,288	$12,030	$8,878	$0
NOx	$8,390	$7,798	$6,771	$158
PM2.5	$26,721	$17,091	$8,973	$1,327
CO	$3.51	$2.08	$0.63	$0.63
Pb	$6,011	$3,094	$695	$695

MPUC Midpoint Externality Costs 2018 $ per short ton				
	Urban	Metro Fringe	Rural	<200mi
SO2	$10,702	$8,430	$6,261	$0
NOx	$5,662	$5,210	$4,441	$93
PM2.5	$18,709	$11,974	$6,313	$1,099
CO	$2.58	$1.63	$0.47	$0.47
Pb	$5,434	$2,828	$659	$659

F. Demand and Energy Forecast

The Company's fall 2019 load forecast is used as the base assumption and assumes that EV impacts growth continues throughout the forecast period. The energy efficiency (EE) forecast included in the base forecast developed by the Company's Load Forecasting Department assumes somewhat less energy efficiency (EE) savings levels than those included in our initial Resource Plan's Preferred Plan.

The "Load Forecast with EE" shown in Table 4 below is the starting point for the load inputs. In all modeling scenarios, the "EE" is removed - the removal of these EE program effects, which have a 14-year life, impacts the load forecast through 2048. In the initial filing, the three EE Bundles (discussed below) were optimized as Proview Alternatives. For this supplemental filing, the first two EE Bundles are locked in all scenarios. The resulting forecast, before the optimized EE bundles are added, is shown below in Table 4 as

"Forecast Without EE." The forecasts shown do not include the impact of DG solar, as DG solar is modeled as a resource, not a load modifier.

Table 4: Demand and Energy Forecast

Demand and Energy Forecast				
	Demand (MW)		Energy (GWh)	
Year	Forecast with EE	Forecast without EE	Forecast with EE	Forecast without EE
2018	9,152	9,152	43,914	43,914
2019	9,084	9,084	43,558	43,558
2020	9,099	9,230	43,170	43,806
2021	9,079	9,312	42,741	44,018
2022	9,126	9,462	42,628	44,549
2023	9,165	9,604	42,440	45,004
2024	9,184	9,728	42,339	45,555
2025	9,238	9,849	42,324	45,976
2026	9,311	9,992	42,470	46,565
2027	9,414	10,164	42,757	47,296
2028	9,504	10,327	43,221	48,216
2029	9,525	10,416	43,006	48,432
2030	9,605	10,566	43,224	49,093
2031	9,679	10,710	43,420	49,734
2032	9,775	10,880	43,903	50,678
2033	9,979	11,058	44,532	51,299
2034	10,190	11,246	45,426	52,203
2035	10,343	11,269	46,158	52,299
2036	10,502	11,325	47,028	52,527
2037	10,673	11,393	47,647	52,503
2038	10,803	11,420	48,209	52,422
2039	10,936	11,449	48,833	52,394
2040	11,073	11,518	49,603	52,729
2041	11,209	11,585	50,055	52,737
2042	11,338	11,645	50,635	52,873
2043	11,467	11,701	51,267	53,048
2044	11,614	11,780	52,023	53,374
2045	11,722	11,818	52,468	53,375
2046	11,839	11,865	53,010	53,473
2047	11,951	11,903	53,545	53,547
2048	12,021	11,998	54,150	54,160
2049	12,045	12,045	54,202	54,202
2050	12,097	12,097	54,407	54,407
2051	12,149	12,149	54,611	54,611
2052	12,199	12,199	54,947	54,947
2053	12,252	12,252	55,022	55,022
2054	12,305	12,305	55,226	55,226
2055	12,357	12,357	55,431	55,431
2056	12,409	12,409	55,765	55,765
2057	12,461	12,461	55,840	55,840

The low load sensitivity includes high customer-adoption-based DG/DER growth and higher EE savings, which reduces load. The high load sensitivity includes high electrification load. These assumptions are shown in Table 5 and Table 6 and are incremental/decremental to the forecast shown in Table 4.

Table 5: High Load Sensitivity

High Electrification		
Year	Energy (GWh)	Demand (MW)
2018	35	8
2019	46	6
2020	59	7
2021	166	20
2022	276	33
2023	390	47
2024	507	62
2025	592	65
2026	692	77
2027	812	85
2028	939	98
2029	1,202	118
2030	1,578	162
2031	2,028	205
2032	2,538	251
2033	3,137	305
2034	3,857	367
2035	4,716	438
2036	5,657	515
2037	6,672	596
2038	7,741	679
2039	8,851	766
2040	9,996	854
2041	11,114	940
2042	12,199	1,025
2043	13,241	1,118
2044	14,229	1,796
2045	15,159	2,520
2046	16,037	3,173
2047	16,877	3,796
2048	17,696	4,647
2049	18,660	4,908
2050	19,530	5,407
2051	20,634	5,947
2052	21,645	6,418
2053	22,656	6,896
2054	23,666	7,384
2055	24,677	7,877
2056	25,688	8,352
2057	26,699	8,840

**Demand values are coincident to system peak*

Table 6: Low Load Sensitivity

	High DER Growth	
Year	Energy (GWh)	Demand (Nameplate MW)
2018	0	0
2019	0	0
2020	0	0
2021	207	122
2022	180	106
2023	159	94
2024	270	159
2025	258	152
2026	423	250
2027	423	250
2028	635	374
2029	641	379
2030	740	437
2031	826	487
2032	913	538
2033	996	588
2034	1,082	639
2035	1,167	689
2036	1,256	739
2037	1,338	790
2038	1,423	840
2039	1,509	891
2040	1,598	941
2041	1,631	963
2042	1,580	933
2043	1,529	903
2044	1,482	872
2045	1,425	842
2046	1,350	797
2047	1,296	765
2048	1,245	733
2049	1,187	701
2050	1,131	668
2051	1,063	628
2052	1,009	594
2053	932	550
2054	872	515
2055	807	476
2056	742	437
2057	671	396

G. Energy Efficiency Bundles

The EE "Program" and "Maximum" Bundles are based on the Minnesota Department of Commerce's Minnesota Energy Efficiency Potential Study: 2020-2029 published December 4, 2018. The "Optimal" Bundle was developed by the Company. The bundles are decremental (reducing energy and demand) to the "Forecast without EE" shown in Table 4.

Table 7: Energy Efficiency Bundles

	Energy(MWh)			Demand (MW)			Costs ($000)		
Year	Bundle 1: Program	Bundle 2: Optimal	Bundle 3: Max	Bundle 1: Program	Bundle 2: Optimal	Bundle 3: Max	Bundle 1: Program	Bundle 2: Optimal	Bundle 3: Max
2018	0	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0
2020	621	43	231	97	18	36	100,989	12,598	148,331
2021	1,326	91	493	207	38	77	113,525	13,905	167,221
2022	1,913	148	702	301	60	113	121,239	21,425	177,197
2023	2,555	211	928	407	86	154	133,614	23,931	196,474
2024	3,094	279	1,110	520	116	197	148,406	26,120	217,388
2025	3,629	346	1,289	635	146	241	152,433	26,077	223,293
2026	4,330	414	1,533	759	176	289	160,445	26,236	233,779
2027	5,054	482	1,785	886	206	338	167,718	26,637	242,963
2028	5,785	551	2,040	1,012	235	387	174,161	27,018	249,373
2029	6,454	606	2,280	1,127	259	432	162,170	23,442	233,114
2030	7,110	659	2,516	1,241	283	477	162,170	23,442	233,114
2031	7,753	710	2,748	1,354	307	522	162,170	23,442	233,114
2032	8,339	760	2,960	1,460	329	564	162,170	23,442	233,114
2033	8,909	808	3,168	1,564	352	605	162,170	23,442	233,114
2034	9,464	857	3,370	1,667	374	646	162,170	23,442	233,114
2035	9,250	846	3,294	1,648	370	638	0	0	0
2036	8,739	835	3,073	1,579	366	600	0	0	0
2037	8,088	789	2,829	1,470	347	557	0	0	0
2038	7,450	741	2,590	1,369	327	517	0	0	0
2039	6,841	685	2,372	1,267	304	475	0	0	0
2040	6,197	626	2,144	1,154	278	430	0	0	0
2041	5,543	562	1,919	1,036	250	384	0	0	0
2042	4,871	499	1,685	916	221	337	0	0	0
2043	4,220	434	1,457	796	191	291	0	0	0
2044	3,561	377	1,218	678	165	245	0	0	0
2045	2,912	318	990	562	139	201	0	0	0
2046	2,276	265	761	451	116	156	0	0	0
2047	1,746	212	573	349	93	117	0	0	0
2048	1,216	159	384	248	70	79	0	0	0
2049	686	106	195	146	46	40	0	0	0
2050	156	53	7	45	23	1	0	0	0
2051	0	0	0	0	0	0	0	0	0
2052	0	0	0	0	0	0	0	0	0
2053	0	0	0	0	0	0	0	0	0
2054	0	0	0	0	0	0	0	0	0
2055	0	0	0	0	0	0	0	0	0
2056	0	0	0	0	0	0	0	0	0
2057	0	0	0	0	0	0	0	0	0

***Demand values are coincident to system peak*

H. Demand Response Forecast

The base demand response forecast was developed by the Company and is included in all scenarios and sensitivities. The three demand response "Bundles" are from the Brattle Potential Study provided as Appendix G2 of the initial filing to this docket. The Bundles are incremental to the base demand response forecast. In the initial filing, the three DR Bundles were optimized as Proview Alternatives. Similar to this supplemental filing, the first DR Bundle is locked in all scenarios.

Table 8: Demand Response Forecast

Demand (MW) Adjusted For Reserve Margin					Costs ($000)		
Year	Base Demand Response Forecast	Bundle 1	Bundle 2	Bundle 3	Bundle 1	Bundle 2	Bundle 3
2018	852	0	0	0	0	0	0
2019	928	0	0	0	0	0	0
2020	1012	33	107	90	1,752	7,659	11,311
2021	1027	165	112	98	8,917	8,150	12,587
2022	1041	232	117	107	12,748	8,676	14,016
2023	1055	294	121	110	16,489	9,137	14,758
2024	1066	341	133	101	19,512	10,277	13,829
2025	1072	382	145	92	22,305	11,459	12,858
2026	1077	394	152	93	23,475	12,207	13,326
2027	1078	407	159	95	24,786	13,080	13,845
2028	1077	423	168	97	26,245	14,086	14,418
2029	1071	440	178	99	27,859	15,231	15,047
2030	1059	458	190	102	29,637	16,522	15,734
2031	1048	478	202	104	31,551	17,926	16,467
2032	1037	499	215	107	33,612	19,451	17,251
2033	1026	521	228	110	35,832	21,109	18,088
2034	1016	545	243	113	38,224	22,911	18,984
2035	1005	570	259	116	40,802	24,870	19,943
2036	995	596	275	120	43,582	26,999	20,971
2037	985	624	293	123	46,580	29,313	22,072
2038	976	654	312	127	49,814	31,829	23,253
2039	966	686	332	132	53,305	34,564	24,522
2040	957	720	353	136	57,073	37,537	25,884
2041	948	720	353	136	58,215	38,288	26,402
2042	939	720	353	136	59,379	39,054	26,930
2043	930	720	353	136	60,566	39,835	27,468
2044	922	720	353	136	61,778	40,632	28,018
2045	914	720	353	136	63,013	41,444	28,578
2046	906	720	353	136	64,274	42,273	29,150
2047	898	720	353	136	65,559	43,118	29,733
2048	890	720	353	136	66,870	43,981	30,327
2049	882	720	353	136	68,208	44,860	30,934
2050	875	720	353	136	69,572	45,758	31,552
2051	868	720	353	136	70,963	46,673	32,183
2052	860	720	353	136	72,382	47,606	32,827
2053	853	720	353	136	73,830	48,558	33,484
2054	847	720	353	136	75,307	49,530	34,153
2055	840	720	353	136	76,813	50,520	34,836
2056	833	720	353	136	78,349	51,531	35,533
2057	827	720	353	136	79,916	52,561	36,244

**Demand values are coincident to system peak.*

I. Fuel Price Forecasts

The natural gas prices are developed using a blend of market information (New York Mercantile Exchange futures prices) and long-term fundamentally-based forecasts from Wood Mackenzie, Cambridge Energy Research Associates (CERA) and Petroleum Industry Research Associates (PIRA).

Coal price forecasts are developed using two major inputs: the current contract volumes and prices combined with current estimates of required spot volumes and prices to cover non-contracted coal needs. Typically coal volumes and prices are under contract on a plant by plant basis for a one to five-year term with annual spot volumes filling the estimated fuel requirements of the coal plant based on recent unit dispatch. The spot coal price forecasts are developed from price forecasts provided by Wood Mackenzie, JD Energy, and John T Boyd Company, as well as price points from recent Request for Proposal (RFP) responses for coal supply. Added to the spot coal forecast, which is just for the coal commodity, are: transportation charges, SO_2 costs, freeze control and dust suppressant, as required.

In addition to resources that exist within the NSP System, the Company is a participant in the MISO Market. Electric power market prices are developed from fundamentally-based forecasts from Wood Mackenzie, CERA and PIRA using a similar methodology as is used for the gas price forecast. Table 9 below shows the market prices under zero CO_2 cost assumptions. The market purchases and sales limit for transaction volume between the Company and MISO is 1,350 MWh/h in 2018, 1,800 MWh/h from 2019-2022, and 2,300 MWh/h for 2023 and beyond.

High and low price sensitivities were performed by adjusting the growth rate up and down by 50 percent from the base forecast starting when the long-term fundamentally-based forecasts are blended with the market information (New York Mercantile Exchange futures prices).

Table 9: Fuel and Market Price Forecasts

	Base Price Forecast				Low Price Forecast				High Price Forecast			
	Fuel Price ($/mmBTu)		Market Price ($/MWh)		Fuel Price ($/mmBTu)		Market Price ($/MWh)		Fuel Price ($/mmBTu)		Market Price ($/MWh)	
Year	Generic Coal	Ventura Hub	Minn Hub On-Peak	Minn Hub Off-Peak	Generic Coal	Ventura Hub	Minn Hub On-Peak	Minn Hub Off-Peak	Generic Coal	Ventura Hub	Minn Hub On-Peak	Minn Hub Off-Peak
2018	$2.19	$2.74	$28.60	$21.61	$2.19	$2.74	$28.60	$21.61	$2.19	$2.74	$28.60	$21.61
2019	$2.08	$2.60	$26.93	$20.98	$2.08	$2.60	$26.93	$20.98	$2.08	$2.60	$26.93	$20.98
2020	$2.11	$2.26	$25.78	$20.13	$2.11	$2.26	$25.78	$20.13	$2.11	$2.26	$25.78	$20.13
2021	$2.14	$2.23	$25.32	$19.06	$2.14	$2.23	$25.32	$19.06	$2.14	$2.23	$25.32	$19.06
2022	$2.19	$2.33	$26.92	$20.45	$2.17	$2.28	$26.33	$20.00	$2.24	$2.38	$27.52	$20.90
2023	$2.25	$2.45	$29.31	$22.19	$2.19	$2.34	$27.96	$21.17	$2.36	$2.57	$30.68	$23.23
2024	$2.30	$2.58	$30.00	$23.20	$2.22	$2.40	$27.94	$21.60	$2.46	$2.76	$32.16	$24.87
2025	$2.35	$2.79	$31.47	$24.36	$2.24	$2.50	$28.17	$21.80	$2.57	$3.11	$35.04	$27.12
2026	$2.40	$2.98	$32.30	$24.99	$2.27	$2.58	$28.01	$21.67	$2.69	$3.42	$37.09	$28.70
2027	$2.45	$3.12	$33.35	$26.71	$2.29	$2.64	$28.28	$22.64	$2.81	$3.66	$39.16	$31.36
2028	$2.51	$3.26	$34.09	$26.97	$2.32	$2.71	$28.25	$22.35	$2.93	$3.92	$40.92	$32.38
2029	$2.57	$3.44	$35.21	$28.25	$2.34	$2.78	$28.42	$22.79	$3.07	$4.24	$43.38	$34.80
2030	$2.62	$3.70	$38.27	$30.69	$2.37	$2.88	$29.83	$23.92	$3.20	$4.71	$48.76	$39.09
2031	$2.68	$3.87	$39.33	$32.07	$2.40	$2.95	$29.97	$24.44	$3.35	$5.04	$51.22	$41.77
2032	$2.75	$4.02	$39.75	$33.14	$2.43	$3.01	$29.71	$24.77	$3.51	$5.34	$52.76	$43.99
2033	$2.81	$4.10	$39.93	$33.46	$2.45	$3.03	$29.58	$24.79	$3.67	$5.48	$53.47	$44.80
2034	$2.87	$4.20	$41.13	$34.56	$2.48	$3.07	$30.08	$25.28	$3.83	$5.70	$55.76	$46.86
2035	$2.94	$4.35	$42.15	$35.66	$2.51	$3.13	$30.32	$25.65	$4.00	$6.00	$58.12	$49.17
2036	$2.99	$4.47	$42.79	$36.60	$2.53	$3.17	$30.37	$25.97	$4.14	$6.24	$59.80	$51.13
2037	$3.07	$4.65	$44.00	$38.21	$2.56	$3.24	$30.61	$26.58	$4.36	$6.63	$62.69	$54.44
2038	$3.14	$4.86	$44.95	$39.45	$2.60	$3.31	$30.60	$26.85	$4.58	$7.08	$65.43	$57.42
2039	$3.23	$5.04	$45.82	$40.48	$2.63	$3.37	$30.63	$27.06	$4.83	$7.47	$67.88	$59.98
2040	$3.31	$5.22	$46.61	$41.48	$2.66	$3.43	$30.61	$27.25	$5.06	$7.87	$70.25	$62.53
2041	$3.37	$5.32	$46.52	$41.48	$2.69	$3.46	$30.27	$26.99	$5.26	$8.10	$70.79	$63.12
2042	$3.45	$5.47	$47.61	$42.64	$2.72	$3.51	$30.57	$27.38	$5.51	$8.43	$73.40	$65.74
2043	$3.53	$5.62	$48.37	$43.71	$2.75	$3.56	$30.64	$27.69	$5.77	$8.78	$75.56	$68.28
2044	$3.62	$5.78	$49.72	$44.99	$2.79	$3.61	$31.04	$28.09	$6.05	$9.17	$78.79	$71.29
2045	$3.70	$5.99	$51.23	$46.37	$2.82	$3.68	$31.45	$28.46	$6.31	$9.65	$82.57	$74.73
2046	$3.78	$6.17	$52.49	$47.53	$2.85	$3.73	$31.74	$28.74	$6.59	$10.09	$85.85	$77.73
2047	$3.86	$6.29	$53.27	$48.57	$2.88	$3.77	$31.89	$29.08	$6.88	$10.40	$87.98	$80.22
2048	$3.95	$6.46	$54.39	$49.88	$2.91	$3.82	$32.15	$29.49	$7.20	$10.80	$90.96	$83.42
2049	$4.04	$6.66	$55.69	$50.92	$2.95	$3.88	$32.43	$29.65	$7.53	$11.30	$94.52	$86.43
2050	$4.13	$6.77	$56.64	$51.71	$2.98	$3.91	$32.70	$29.85	$7.87	$11.60	$96.97	$88.53
2051	$4.22	$6.96	$58.23	$53.16	$3.01	$3.96	$33.16	$30.27	$8.21	$12.08	$101.05	$92.24
2052	$4.31	$7.13	$59.62	$54.42	$3.04	$4.01	$33.56	$30.63	$8.57	$12.51	$104.64	$95.53
2053	$4.41	$7.29	$61.00	$55.68	$3.08	$4.06	$33.94	$30.99	$8.94	$12.95	$108.29	$98.85
2054	$4.50	$7.46	$62.38	$56.95	$3.11	$4.10	$34.33	$31.34	$9.33	$13.39	$111.97	$102.21
2055	$4.60	$7.62	$63.76	$58.21	$3.14	$4.15	$34.71	$31.69	$9.73	$13.83	$115.69	$105.61
2056	$4.69	$7.79	$65.15	$59.47	$3.17	$4.19	$35.09	$32.03	$10.12	$14.28	$119.45	$109.05
2057	$4.79	$7.95	$66.53	$60.73	$3.21	$4.24	$35.46	$32.37	$10.52	$14.74	$123.26	$112.52

**Coal prices are delivered prices, while gas and market prices are hub prices.*

J. Baseload Retirement "Leave Behind" Costs

Based on the MISO Y2 retirement studies performed on existing coal and nuclear resources, the Company developed transmission reinforcement or "leave behind" estimates, which reflect costs required to mitigate localized grid impacts of the retirement of major baseload resources. The reinforcement costs are included as a one-time charge based on the timing of the resource retirement.

Specifically, we have included the following proxy leave behind costs related to our baseload resource retirements as estimated from the MISO studies. We applied these costs in the modeling as soon as the resource is retired, over a three-year period, to reflect the estimated local transmission reinforcement costs assumed to be required upon retirement. All numbers below are in real dollar terms ($2020).

- King: $48 million
- Sherco 3: $48 million
- Monticello: $96 million
- Prairie Island 1: $96 million
- Prairie Island 2: $96 million

K. Surplus Capacity Credit

The surplus capacity credit of up to 500 MW is applied for all twelve months of each year and is priced at the avoided capacity cost of a generic brownfield H-Class combustion turbine on an economic carrying charge basis.

Table 10: Surplus Capacity Credit

Surplus Capacity Credit																				
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
$/kw-mo	4.57	4.66	4.75	4.85	4.95	5.05	5.15	5.25	5.35	5.46	5.57	5.68	5.80	5.91	6.03	6.15	6.27	6.40	6.53	6.66
	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057
$/kw-mo	6.79	6.93	7.07	7.21	7.35	7.50	7.65	7.80	7.96	8.12	8.28	8.44	8.61	8.79	8.96	9.14	9.32	9.51	9.70	9.89

L. Effective Load Carrying Capability (ELCC) Capacity Credit for Wind, Solar, and Battery Resources

The ELCC for existing wind units is based on current MISO accreditation. The ELCC for generic wind is equal to 16.7 percent of their nameplate rating per MISO 2020/2021 Wind Capacity Report. The ELCC for generic solar is based on the values provided in MISO's

Transmission Energy Planning Report 2019, (MTEP) in Appendix E,[1] and is 50 percent of the AC nameplate capacity through 2023, declining 2 percent annually to 30 percent by 2033 where it remains for the remainder of the forecast period. The ELCC assigned for a generic 4-hour battery is equal to 100 percent of the alternating current (AC) equivalent capacity. The ELCC used for hybrid options are the same as the individual components.

M. Spinning Reserve Requirement

Spinning reserve is the online reserve capacity that is synchronized to the grid to maintain system frequency stability during contingency events and unforeseen load swings. The level of spinning reserve modeled is 137 MW and is based on a 12-month rolling average of spinning reserves carried by the NSP System within MISO.

N. Emergency Energy

Emergency energy is used to cover events where there are not enough native resources or market purchase energy.available to meet system energy requirements. In Encompass, we use the default value of $10,000/MWh. Emergency energy is a "soft constraint" in EnCompass modeling that allows emergency energy to "dispatch" as a last resort resource, in order for the model to find a feasible solution. The EnCompass price is set to a high level to ensure that all other available resources – including those that may have a very high effective $/MWh cost resulting from startup costs spread over a very small required run time – are utilized before emergency energy.

O. Transmission Delivery Costs and Interconnection Costs

Transmission delivery costs for generic resources were developed by the Company. They are based on evaluation of recent and historical MISO studies and queue results. These costs represent "grid upgrades" to ensure deliverability of energy from these facilities to the overall bulk electric system.

We note additionally that interconnection costs for generic resources are included in the costs provided in Part U of this Appendix and represent "behind the fence" costs associated with substation and representative gen-tie construction.

[1] Available at: https://cdn.misoenergy.org//MTEP19%20Appendix%20E-Futures%20Assumptions382958.pdf

Table 11: Transmission Delivery Costs

Transmission Delivery Costs				
	CC	CT	Wind	Solar
$/kw	500	200	500	200

In the Alternate Plan, we propose to build transmission tie-lines from Sherco and King sites that can interconnect incremental wind and resource resources. The total costs of the tie lines include capital costs plus VAR support such as installing synchronous condensers and series compensation of the lines; and while these are general cost estimates and subject to change as we would undertake detailed project design, they are in line with the Company's experience on other projects. The total capacities of generator reuse are based on the existing interconnection rights at Sherco and King.

Table 12: Sherco and King Gen-tie Assumptions

	Total Costs (in 2021 Dollars)	Interconnection Rights
Sherco gen-tie	$528 million	1996 MW
King gen-tie	$ 36 million	591 MW

Table 13: Retiring Coal Units and Selection Windows for Gen-tie Resources

Retiring Unit	Open Interconnection	Modeled Replacement Resource Window	Replacement Resources Allowed
Sherco 2	720 MW	2024-2026	Solar only
Sherco 1	710 MW	2027-2029	Solar, and Wind + ~400 MW of CTs (2028-2029)
Sherco 3	566 MW	2030-2032	Solar + Wind
AS King	591 MW	2028-2030	Solar only

P. Integration and Congestion Costs

Integration costs are taken from studies conducted by Enernex and apply to new wind and solar resources only. Congestion costs were not included in the model.

Table 14: Integration Costs

Integration Costs ($/MWh)		
Year	Wind	Solar
2018	0.00	0.00
2019	0.00	0.00
2020	0.41	0.41
2021	0.42	0.42
2022	0.43	0.43
2023	0.44	0.44
2024	0.45	0.45
2025	0.46	0.46
2026	0.47	0.47
2027	0.48	0.48
2028	0.49	0.49
2029	0.49	0.49
2030	0.50	0.50
2031	0.51	0.51
2032	0.53	0.53
2033	0.54	0.54
2034	0.55	0.55
2035	0.56	0.56
2036	0.57	0.57
2037	0.58	0.58
2038	0.59	0.59
2039	0.60	0.60
2040	0.62	0.62
2041	0.63	0.63
2042	0.64	0.64
2043	0.65	0.65
2044	0.67	0.67
2045	0.68	0.68
2046	0.69	0.69
2047	0.71	0.71
2048	0.72	0.72
2049	0.74	0.74
2050	0.75	0.75
2051	0.77	0.77
2052	0.78	0.78
2053	0.80	0.80
2054	0.81	0.81
2055	0.83	0.83
2056	0.84	0.84
2057	0.86	0.86

Q. Distributed Generation and Community Solar Gardens

The distributed solar and Community Solar Gardens inputs are based on the most recent Company forecasts. Distributed Solar is modeled assuming a degradation of half a percent annually in generation. Community Solar Gardens are modeled assuming a degradation of half a percent annually in generation, and a twenty-five-year service life. After a "vintage" of additions reach end of life, it is assumed 90% of the capacity is replaced at then-current costs.

Table 15: Distributed Solar Forecast

Distributed Solar (Nameplate MW)			
Year	Solar Rewards	Community Gardens	Total
2018	29	246	274
2019	61	504	565
2020	80	658	738
2021	95	714	809
2022	109	787	897
2023	123	841	964
2024	138	852	989
2025	152	853	1,005
2026	166	854	1,020
2027	180	855	1,035
2028	194	857	1,050
2029	208	858	1,066
2030	222	859	1,080
2031	236	860	1,095
2032	249	861	1,110
2033	263	862	1,125
2034	276	863	1,140
2035	290	864	1,154
2036	303	866	1,169
2037	317	867	1,184
2038	330	868	1,198
2039	343	869	1,212
2040	357	870	1,227
2041	370	871	1,241
2042	383	869	1,252
2043	396	852	1,247
2044	409	830	1,239
2045	421	818	1,239
2046	434	814	1,248
2047	447	808	1,255
2048	460	805	1,264
2049	472	805	1,277
2050	491	806	1,297
2051	504	807	1,311
2052	518	808	1,326
2053	531	809	1,340
2054	545	810	1,355
2055	559	811	1,369
2056	572	812	1,384
2057	586	812	1,398

R. Owned Unit Modeled Operating Characteristics and Costs

Company owned units are modeled based upon their tested operating characteristics and projected costs. Below is a list of typical operating and cost inputs for each company owned resource.

a. Retirement Date
b. Maximum Capacity
c. Current Unforced Capacity (UCAP) Ratings
d. Minimum Capacity Rating
e. Seasonal Deration
f. Heat Rate Profiles
g. Variable O&M
h. Fixed O&M
i. Maintenance Schedule
j. Forced Outage Rate
k. Emission rates for SO_2, NO_x, CO_2, Mercury and particulate matter (PM)
l. Contribution to spinning reserve
m. Fuel prices
n. Fuel delivery charges

S. Thermal Power Purchase Agreement (PPA) Operating Characteristics and Costs

PPAs are modeled based upon their tested operating characteristics and contracted costs. Below is a list of typical operating and cost inputs for each thermal PPA.

a. Contract term
b. Maximum Capacity
c. Minimum Capacity Rating
d. Seasonal Deration
e. Heat Rate Profiles
f. Energy Schedule
g. Capacity Payments
h. Energy Payments
i. Maintenance Schedule
j. Forced Outage Rate
k. Emission rates for SO_2, NO_x, CO_2, Mercury and Particulate Matter
l. Contribution to spinning reserve
m. Fuel prices
n. Fuel delivery charges

T. Renewable Energy (PPAs and Owned) Operating Characteristics and Costs

PPAs are modeled based upon their tested operating characteristics and contracted costs. Company owned units are modeled based upon their tested operating characteristics and projected costs. Below is a list of typical operating and cost inputs for each renewable energy unit.

a. Contract term
b. Name Plate Capacity
c. Accredited Capacity
d. Annual Energy
e. Hourly Patterns
f. Capacity and Energy Payments
g. Integration Costs

Wind and solar hourly patterns are developed through a "Typical Meteorological Year" process where individual months are selected from the years 2017-2019 to develop a representative typical year. Actual generation data from the selected months is used to develop the profile for each unit. For units where generation data is not complete or not available, data from a nearby similar unit is used.

U. Generic Assumptions

Generic resources are modeled based upon their expected operating characteristics and projected costs. Generic thermal costs are developed by the Company. For the modeling of our Alternate Plan, we also added cost and operational assumptions for smaller reciprocating engines and aeroderivative turbines that support black start. Generic renewable and battery costs are from National Renewable Energy Laboratory's 2019 *Annual Technology Baseline* data. Utility-scale wind and solar costs shown below include transmission costs from Table 11, while distributed solar costs do not.

In addition to base cost data for renewables, low and high costs are used for various sensitivities. Low and high wind, solar, and battery costs are based on the National Renewable Energy Laboratory's 2019 *Annual Technology Baseline* data.

The costs for wind and solar in base, low and high levels are now updated to incorporate recent federal extensions to the Production and Investment Tax Credit. The costs of wind and solar resources selected to replace the interconnection capacity of Sherco and King are calculated based on the Company's owned revenue requirements under current tax law[2] and remove incremental transmission costs (as the gen-tie costs are already accounted for elsewhere in the model). For the capacity above the interconnection threshold at Sherco and King, we consider them as PPA resources and apply the costs from the National Renewable Energy Laboratory's 2019 *Annual Technology Baseline* data without incremental transmission costs (shown in Table 24).

Below is a list of typical operating and cost inputs for each generic resource.

Thermal

a. Retirement Date
b. Maximum Capacity
c. UCAP Ratings
d. Minimum Capacity Rating
e. Seasonal Deration
f. Heat Rate Profiles
g. Variable O&M
h. Fixed O&M
i. Maintenance Schedule
j. Forced Outage Rate
k. Emission rates for SO_2, NO_x, CO_2, Mercury and PM
l. Contribution to spinning reserve
m. Fuel prices
n. Fuel delivery charges

Renewable

a. Contract term
b. Name Plate Capacity
c. Accredited Capacity
d. Annual Energy
e. Hourly Patterns
f. Capacity and Energy Payments
g. Integration Costs

[2] We already use the Company's general financing assumptions in our evaluation of generic resource costs. Differences between generic and owned revenue requirements primarily reflect differences in how the Company is able to utilize ITCs and PTCs, from solar and wind projects respectively. Firm dispatchable units included in these tranches of resource additions reflect generic pricing, as there is no inherent difference between our assumed revenue requirements for owned dispatchable units vs contracted units.

Table 12: Thermal Generic Information (Costs in 2018 Dollars)

Thermal Generic Information					
Resource	**Sherco CC**	**Generic CC**	**Generic CT**	**Generic CT**	**Generic CT**
Technology	7H	7H	7H	7F	7H
Location Type	Brownfield	Greenfield	Brownfield	Brownfield	Greenfield
Cooling Type	Wet	Dry	Dry	Dry	Dry
Book life	40	40	40	40	40
Nameplate Capacity (MW)	835	901	374	232	374
Summer Peak Capacity (MW)	750	856	331	206	331
Capital Cost ($000) 2018$	$837,068	$906,588	$174,700	$114,766	$193,500
Electric Transmission Delivery ($000) 2018$	NA	$410,505	NA	NA	$74,804
Ongoing Capital Expenditures ($000-yr) 2018$	$6,200	$6,200	$1,784	$892	$1,784
Gas Demand ($000-yr) 2018$	$31,725	$19,058	$2,165	$1,342	$2,165
Capital Cost ($/kW) 2018$	$1,002	$1,006	$467	$495	$517
Electric Transmission Delivery ($/kW) 2018$	NA	$455	NA	NA	$200
Ongoing Capital Expenditures ($/kW-yr) 2018$	$7.42	$6.88	$4.77	$3.85	$4.77
Gas Demand ($/kW-yr) 2018$	$37.98	$21.14	$5.79	$5.79	$5.79
Fixed O&M Cost ($000/yr) 2018$	$6,592	$6,592	$1,253	$1,203	$1,253
Variable O&M Cost ($/MWh) 2018$	$1.04	$1.04	$0.99	$1.03	$0.99
Levelized $/kw-mo (All Fixed Costs) $2018	$15.26	$16.06	$5.91	$6.22	$8.06
Summer Heat Rate 100% Loading (btu/kWh)	6,359	6,848	9,264	10,025	9,264
Summer Heat Rate 75% Loading (btu/kWh)	6,547	6,874	9,738	10,581	9,738
Summer Heat Rate 50% Loading (btu/kWh)	6,985	7,334	11,120	12,515	11,120
Summer Heat Rate 25% Loading (btu/kWh)	8,004	8,404	11,558	13,430	11,558
Forced Outage Rate	3%	3%	3%	3%	3%
Maintenance (weeks/yr)	5	5	2	2	2
CO2 Emissions (lbs/MMBtu)	118	118	118	118	118
SO2 Emissions (lbs/MWh)	0.00	0.00	0.00	0.00	0.00
NOx Emissions (lbs/MWh)	0.05	0.05	0.90	0.32	0.90
PM10 Emissions (lbs/MWh)	0.02	0.02	0.03	0.03	0.03
Mercury Emissions (lbs/MMWh)	0.00	0.00	0.00	0.00	0.00

Table 17. New Thermal Unit Information (Costs in 2018 Dollars)

Resource	Reciprocating Engine	Aeroderivative Turbine
Book life	30	30
Nameplate Capacity (MW)	9	30
Summer Peak Capacity (MW)	9	27
Capital Cost ($000) 2018$	$21,898	$47,818
Electric Transmission Delivery ($000) 2018$	N/A	N/A
Ongoing Capital Expenditures ($000-yr) 2018$	$16	$457
Gas Demand ($000-yr) 2018$	N/A	N/A
Capital Cost ($/kW) 2018$	$2,433	$1,594
Electric Transmission Delivery ($/kW) 2018$	NA	NA
Ongoing Capital Expenditures ($/kW-yr) 2018$	$1.74	$15.23
Gas Demand ($/kW-yr) 2018$	$0.00	$0.00
Fixed O&M Cost ($000/yr) 2018$	$208	$47
Variable O&M Cost ($/MWh) 2018$	$6.16	$0.63
Levelized $/kw-mo (All Fixed Costs) $2018	$26.33	$18.52
Summer Heat Rate 100% Loading (btu/kWh)	8,438	10,087
Summer Heat Rate 75% Loading (btu/kWh)	8,802	10,937
Summer Heat Rate 50% Loading (btu/kWh)	9,663	13,122
Summer Heat Rate 25% Loading (btu/kWh)	10,190	15,338
Forced Outage Rate	3%	2%
Maintenance (weeks/yr)	Varies based on fired hours	Varies based on fired hours
CO2 Emissions (lbs/MMBtu)	118	118
CO Emissions (lbs/MWh)	0.27	0.56
SO2 Emissions (lbs/MWh)	0.00	0.00
NOx Emissions (lbs/MWh)	0.18	0.92
PM10 Emissions (lbs/MWh)	0.00	0.00
Mercury Emissions (lbs/MMWh)	0.00	0.00

Table 18: Renewable Generic Information (Costs in 2018 Dollars)

Renewable Generic Information				
Resource	Wind	Utility Scale Solar	Distributed Solar Commercial	Distributed Solar Residential
ELCC Capacity Credit (%)	16.7%	50% declines to 30%		
Capacity Factor	50.0%	22.0%	18.0%	18.0%
Book life	25	25	25	25
Electric Transmission Delivery ($/kW)	500	200	0	0

Table 139: Storage Generic Information (Costs in 2018 Dollars)

Storage Generic Information	
Resource	Battery
Technology	Li Ion
Location Type	NA
Book life	40
Nameplate Capacity (MW)	50
Summer Peak Capacity (MW)	50
Storage Volume (hrs)	4
Cycle Efficiency (%)	1
Equivalent Full Cycles per Year	250
Electric Transmission Delivery ($000) 2018$	0
Levelized $/kw-mo (All Fixed Costs) $2023	$18.18

Table 20: Levelized Capacity Costs by Year

Levelized Capacity Costs by In-Service Year ($/kw-mo)								
COD	CT - 7H Greenfield	CT - 7F Brownfield	CT - 7H Brownfield	CC	Sherco CC	Base Battery	Low Battery	High Battery
2018	$8.06	$6.22	$5.91	$16.06	$15.26			
2019	$8.22	$6.34	$6.02	$16.38	$15.56			
2020	$8.38	$6.47	$6.15	$16.71	$15.87	$20.04	$17.86	$22.94
2021	$8.55	$6.60	$6.27	$17.05	$16.19	$19.44	$16.81	$23.19
2022	$8.72	$6.73	$6.39	$17.39	$16.51	$18.82	$15.73	$23.45
2023	$8.89	$6.86	$6.52	$17.73	$16.85	$18.18	$14.62	$23.71
2024	$9.07	$7.00	$6.65	$18.09	$17.18	$17.52	$13.47	$23.97
2025	$9.25	$7.14	$6.78	$18.45	$17.53	$16.84	$12.30	$24.24
2026	$9.44	$7.28	$6.92	$18.82	$17.88	$16.63	$11.75	$24.51
2027	$9.63	$7.43	$7.06	$19.20	$18.23	$16.41	$11.18	$24.78
2028	$9.82	$7.58	$7.20	$19.58	$18.60	$16.19	$10.60	$25.06
2029	$10.02	$7.73	$7.34	$19.97	$18.97	$15.95	$10.00	$25.34
2030	$10.22	$7.88	$7.49	$20.37	$19.35	$15.71	$9.38	$25.62
2031	$10.42	$8.04	$7.64	$20.78	$19.74	$15.83	$9.38	$26.06
2032	$10.63	$8.20	$7.79	$21.19	$20.13	$15.94	$9.37	$26.50
2033	$10.84	$8.36	$7.95	$21.62	$20.53	$16.04	$9.36	$26.94
2034	$11.06	$8.53	$8.11	$22.05	$20.94	$16.15	$9.35	$27.40
2035	$11.28	$8.70	$8.27	$22.49	$21.36	$16.26	$9.33	$27.86
2036	$11.50	$8.88	$8.44	$22.94	$21.79	$16.36	$9.31	$28.32
2037	$11.73	$9.05	$8.60	$23.40	$22.23	$16.46	$9.28	$28.80
2038	$11.97	$9.24	$8.78	$23.87	$22.67	$16.56	$9.25	$29.28
2039	$12.21	$9.42	$8.95	$24.34	$23.12	$16.65	$9.21	$29.78
2040	$12.45	$9.61	$9.13	$24.83	$23.59	$16.74	$9.17	$30.27
2041	$12.70	$9.80	$9.31	$25.33	$24.06	$16.83	$9.13	$30.78
2042	$12.96	$10.00	$9.50	$25.83	$24.54	$16.76	$9.00	$30.97
2043	$13.22	$10.20	$9.69	$26.35	$25.03	$16.66	$8.85	$31.12
2044	$13.48	$10.40	$9.88	$26.88	$25.53	$16.55	$8.70	$31.25
2045	$13.75	$10.61	$10.08	$27.42	$26.04	$16.42	$8.53	$31.35
2046	$14.02	$10.82	$10.28	$27.96	$26.56	$16.26	$8.35	$31.41
2047	$14.30	$11.04	$10.49	$28.52	$27.09	$16.08	$8.16	$31.44
2048	$14.59	$11.26	$10.70	$29.09	$27.64	$15.88	$7.95	$31.42
2049	$14.88	$11.48	$10.91	$29.68	$28.19	$15.65	$7.73	$31.35
2050	$15.18	$11.71	$11.13	$30.27	$28.75	$15.39	$7.49	$31.23
2051	$15.48	$11.95	$11.35	$30.88	$29.33	$15.70	$7.64	$31.85
2052	$15.79	$12.19	$11.58	$31.49	$29.91	$16.01	$7.79	$32.49
2053	$16.11	$12.43	$11.81	$32.12	$30.51	$16.33	$7.95	$33.14
2054	$16.43	$12.68	$12.05	$32.76	$31.12	$16.66	$8.10	$33.80
2055	$16.76	$12.93	$12.29	$33.42	$31.75	$16.99	$8.27	$34.48
2056	$17.10	$13.19	$12.54	$34.09	$32.38	$17.33	$8.43	$35.17
2057	$17.44	$13.45	$12.79	$34.77	$33.03	$17.68	$8.60	$35.87

Table 21: Base Renewable Levelized Costs by Year

Levelized Costs by In-Service Year $/MWh (LCOE)				
COD	Wind	Utility Scale Solar	Distributed Solar Commercial*	Distributed Solar Residential*
2023	$40.91	$46.52	$60.46	$84.12
2024	$36.03	$46.62	$59.99	$81.21
2025	$35.78	$48.51	$62.70	$82.40
2026	$50.28	$53.97	$71.70	$91.23
2027	$50.32	$53.99	$71.00	$87.23
2028	$50.36	$54.01	$70.26	$83.07
2029	$50.41	$54.00	$69.47	$78.75
2030	$50.46	$53.98	$68.64	$74.26
2031	$51.13	$54.60	$69.31	$74.25
2032	$51.81	$55.21	$69.97	$74.23
2033	$52.50	$55.83	$70.64	$74.17
2034	$53.19	$56.45	$71.31	$74.08
2035	$53.89	$57.07	$71.98	$73.96
2036	$54.60	$57.70	$72.65	$73.81
2037	$55.31	$58.32	$73.32	$73.62
2038	$56.03	$58.96	$73.98	$73.40
2039	$56.76	$59.59	$74.65	$73.15
2040	$57.49	$60.23	$75.31	$72.86
2041	$58.23	$60.94	$75.87	$73.52
2042	$58.98	$61.66	$76.42	$74.18
2043	$59.73	$62.38	$76.97	$74.84
2044	$60.49	$63.10	$77.51	$75.49
2045	$61.26	$63.83	$78.04	$76.15
2046	$62.03	$64.57	$78.56	$77.43
2047	$62.81	$65.31	$79.08	$78.73
2048	$63.60	$66.05	$79.58	$80.05
2049	$64.39	$66.80	$80.08	$81.40
2050	$65.19	$67.55	$80.56	$82.76

**Distributed Solar costs represent at the meter values before grossing up for losses.*

Table 22: Low Renewable Levelized Costs by Year

Low Levelized Costs by In-Service Year $/MWh (LCOE)				
COD	Wind	Utility Scale Solar	Distributed Solar Commercial*	Distributed Solar Residential*
2023	$36.12	$38.99	$49.46	$82.47
2024	$30.57	$38.49	$48.30	$76.99
2025	$29.69	$39.29	$47.11	$71.34
2026	$43.59	$42.57	$45.87	$65.52
2027	$43.05	$41.82	$44.59	$59.54
2028	$42.55	$41.04	$43.26	$53.38
2029	$42.07	$40.23	$41.89	$47.05
2030	$41.62	$39.40	$40.48	$40.54
2031	$42.10	$39.43	$40.22	$40.29
2032	$42.57	$39.45	$39.94	$40.02
2033	$43.05	$39.46	$39.63	$39.73
2034	$43.53	$39.45	$39.30	$39.41
2035	$44.01	$39.43	$38.95	$39.06
2036	$44.50	$39.59	$38.57	$38.69
2037	$44.98	$39.74	$38.16	$38.29
2038	$45.47	$39.88	$37.72	$37.86
2039	$45.96	$40.01	$37.25	$37.41
2040	$46.45	$40.14	$36.75	$36.92
2041	$46.94	$40.51	$37.10	$37.03
2042	$47.43	$40.89	$37.46	$37.13
2043	$47.92	$41.26	$37.81	$37.22
2044	$48.41	$41.63	$38.17	$37.31
2045	$48.90	$42.01	$37.15	$37.38
2046	$49.40	$42.47	$37.76	$37.91
2047	$49.89	$42.93	$38.38	$38.45
2048	$50.38	$43.40	$39.01	$39.00
2049	$50.88	$43.87	$39.65	$39.55
2050	$51.37	$44.34	$40.30	$40.11

**Distributed Solar costs represent at the meter values before grossing up for losses.*

Table 23: High Renewable Levelized Costs by Year

High Levelized Costs by In-Service Year $/MWh (LCOE)				
COD	Wind	Utility Scale Solar	Distributed Solar Commercial*	Distributed Solar Residential*
2023	$47.16	$50.92	$88.34	$126.50
2024	$43.38	$51.94	$90.11	$129.03
2025	$44.24	$55.12	$91.91	$131.61
2026	$59.88	$62.79	$93.75	$134.24
2027	$61.08	$64.04	$95.63	$136.93
2028	$62.30	$65.32	$97.54	$139.67
2029	$63.55	$66.63	$99.49	$142.46
2030	$64.82	$67.96	$101.48	$145.31
2031	$66.11	$69.32	$103.51	$148.22
2032	$67.43	$70.71	$105.58	$151.18
2033	$68.78	$72.12	$107.69	$154.20
2034	$70.16	$73.56	$109.85	$157.29
2035	$71.56	$75.03	$112.04	$160.43
2036	$72.99	$76.53	$114.28	$163.64
2037	$74.45	$78.07	$116.57	$166.91
2038	$75.94	$79.63	$118.90	$170.25
2039	$77.46	$81.22	$121.28	$173.66
2040	$79.01	$82.84	$123.70	$177.13
2041	$80.59	$84.50	$126.18	$180.67
2042	$82.20	$86.19	$128.70	$184.29
2043	$83.85	$87.91	$131.28	$187.97
2044	$85.52	$89.67	$133.90	$191.73
2045	$87.23	$91.47	$136.58	$195.57
2046	$88.98	$93.30	$139.31	$199.48
2047	$90.76	$95.16	$142.10	$203.47
2048	$92.57	$97.06	$144.94	$207.54
2049	$94.43	$99.01	$147.84	$211.69
2050	$96.31	$100.99	$150.79	$215.92

**Distributed Solar costs represent at the meter values before grossing up for losses.*

Table 24: Sherco and King Gen-tie Renewable Levelized Costs by Year[3]

Levelized Costs by In-Service Year $/MWh (LCOE)						
COD	Wind	Utility Scale Solar	Low Wind	Low Utility Scale Solar	High Wind	High Utility Scale Solar
2023	$25.27	$33.71	$20.47	$26.19	$31.51	$38.12
2024	$20.07	$33.56	$14.61	$25.43	$27.41	$38.88
2025	$19.50	$35.19	$13.41	$25.97	$27.96	$41.80
2026	$33.67	$40.38	$26.98	$28.98	$43.27	$49.20
2027	$33.38	$40.14	$26.12	$27.96	$44.14	$50.18
2028	$33.09	$39.87	$25.27	$26.90	$45.02	$51.19
2029	$32.79	$39.58	$24.45	$25.81	$45.92	$52.21
2030	$32.49	$39.28	$23.65	$24.69	$46.84	$53.25
2031	$32.80	$39.59	$23.76	$24.43	$47.78	$54.32
2032	$33.11	$39.91	$23.87	$24.15	$48.73	$55.40
2033	$33.43	$40.22	$23.98	$23.85	$49.71	$56.51
2034	$33.74	$40.53	$24.07	$23.53	$50.70	$57.64
2035	$34.05	$40.83	$24.17	$23.20	$51.72	$58.80
2036	$34.36	$41.13	$24.25	$23.03	$52.75	$59.97
2037	$34.67	$41.43	$24.33	$22.85	$53.81	$61.17
2038	$34.97	$41.73	$24.41	$22.65	$54.88	$62.40
2039	$35.28	$42.01	$24.47	$22.44	$55.98	$63.64
2040	$35.58	$42.30	$24.53	$22.21	$57.10	$64.92
2041	$35.88	$42.65	$24.59	$22.23	$58.24	$66.21
2042	$36.18	$43.00	$24.63	$22.23	$59.41	$67.54
2043	$36.48	$43.35	$24.67	$22.23	$60.59	$68.89
2044	$36.78	$43.70	$24.69	$22.23	$61.81	$70.27
2045	$37.07	$44.04	$24.71	$22.21	$63.04	$71.67
2046	$37.36	$44.38	$24.72	$22.28	$64.30	$73.11
2047	$37.64	$44.71	$24.72	$22.34	$65.59	$74.57
2048	$37.92	$45.05	$24.71	$22.39	$66.90	$76.06
2049	$38.20	$45.37	$24.69	$22.44	$68.24	$77.58
2050	$38.47	$45.70	$24.66	$22.49	$69.60	$79.13

V. Market Purchases and Sales Carbon Rate

In order to estimate emissions rates associated with market purchases, the Company assumes an annual average carbon emissions pounds/MWh rate, as shown in the table below. These estimates were developed using MISO's MTEP Futures modeling results.

[3] The costs provided in this table are based on the National Renewable Energy Laboratory's 2019 Annual Technology Baseline data without incremental transmission costs. For the first 2000 MW of renewable additions at Sherco site and the first 600 MW of renewable additions at King site, we further adjust costs based on an estimate of the Company's owned revenue requirements.

Market sales emissions rates reflect an average emissions rate for our system resources, and vary according to each individual scenario and sensitivity capacity expansion portfolio.

Table 25: Market Purchase Carbon Rate

Market Purchase CO2 Rate																				
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
lbs/MWh	1372	1307	1241	1176	1110	1045	1042	1039	1036	1034	1031	1018	1006	993	980	968	955	943	930	917
	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057
lbs/MWh	905	892	880	867	854	842	829	817	804	792	779	766	754	741	729	716	703	691	678	666

II. RELIABILITY ANALYSIS – STAKEHOLDER INPUT, ASSUMPTIONS AND MODELING SCENARIOS

The Initial Comments submitted by several parties indicated concerns with the Company's approach to analyzing the relative reliability of various potential generation portfolios modeled in the June 2020 Supplement. In general, concerns were focused in two areas: 1) that such an analysis inappropriately ignored the presence and availability of the MISO market; and 2) detailed methodological concerns, i.e. around the generic wind shapes chosen for the analysis.

As we outline in Section 2 – Reliability of this Reply there are times when MISO's import capability may not be available, and the number of MISO-declared emergencies has risen in the past few years. As such, studying whether the Company has enough available capacity to serve its own load for all hours of a year in an hourly chronological dispatch model is valuable for our customers. It shows us whether we have the technical capability to cover the equivalent of our load with our own resources in the case of severe underavaialbility of other resources, and as such is an indication of potential reliability and/or risk concerns[4]. Additionally, while many of the metrics evaluate the ability of the Company's system generation to cover its own load under different constraints, EnCompass production cost modeling underlying this analysis does incorporate purchases and sales. Furthermore, three of the metrics evaluated directlyconsider the ability to access resources in the broader MISO market, given the relevant transmission constraints.

[4] Some of the feedback in the Initial Comments from external parties focused on which generation was economic to dispatch during different time intervals, instead of the level of available capacity. This focus misses the point of these reliability analyses, which is to evaluate, in an hourly chronological model, whether the company has enough online capacity that it can technically serve all of its load with its own resources, should it need to do so for emergency purposes.We believe this provides helpful data points for considering comparative reliability between plans.

The table below outlines the reliability tests conducted in this Reply. We then further discuss how we addressed feedback from parties' Initial Comments and include a definition of terms in subsequent sections.

Table 26: Three Scenarios Investigated For Each Capacity Expansion Plan in the Reliability Analysis

Scenario	Battery Forced Outage Rate (Percent)	Shapes for Generic Wind Units	All Other Assumptions
TMY Hourly Load & Generation	0	TMY	No change from those used in the June 2020 Supplement
2019 Actual Hourly Load & Generation (Low End of Range)	0	Same as the Reliability Analysis in the IRP Supplement	No change from those used in the June 2020 Supplement
2019 Actual Hourly Load & Generation (High End of Range)	5	"Highest" Observed NCF	No change from those used in the June 2020 Supplement

A. Response to methodological feedback

Regarding methodological concerns about the reliability analysis, we examined the feedback provided in the Initial Comments and discuss our findings below. Additionally, the Company adds a few concerns and updates as well.

Table 27: Reliability Analysis Initial Comments Topics

Concern raised	**How the Company addresses this concern in this Reply**
Intervenor plans had not been evaluated using actual 2019 hourly load data	The CEO's and Sierra Club's Preferred Plans were tested with the 2019 actual hourly load and renewable shapes in addition to TMY shapes. Results appear in Section 4 of this Reply, in Table 4-14.
Capacity factors for wind and solar generic units were too low	CEO Initial Comments indicated a concern with the net capacity factor (NCF) assumption for generic wind units in some of reliability scenarios in the IRP Supplement. In particular, the concern was that for the 2019 actual year conditions, the generic unit wind NCF was significantly lower than what the Company used in its standard PVSC and PVRR production cost modeling. Since a main objective of the reliability analysis was to test each plan with different, "non-TMY" hourly data, the NCFs will differ by default. However, to address this concern, as a "bookend" reflecting the <u>best</u> possible outcome, we used the highest observed wind NCF for the year 2019 for the shape of all generic wind resources in a set of reliability runs. These runs complemented another set of runs with the original wind NCF chosen. Where results between the two sets of runs differ in Table 4-14 in Section 4, a range is now presented. No changes are made to the choice of solar shape used in "2019 Actual Hourly Load and Generation" scenarios. This is because the reliability analysis provided in the IRP Supplement was already using the solar unit with the highest observed solar NCF for the year 2019.
The Demand Response resource contains an extra cost adder	The Company's response to CEO IR-130 describes why this approach was taken in our modeling. This adder is discussed further below; we do not remove it from the EnCompass models we used to conduct the main reliability analysis.[5]

[5] While removing this adder certainly increases DR dispatch throughout the modeled year, it does not largely impact the reliability results because most of the reliability analysis deals with the level of available capacity relative to our demand, not the level or type of generation actually dispatched. Since EnCompass considers DR to be available capacity in scenarios both with and without the DR cost adder, changing this setting does not alter the number or characteristics of capacity shortfalls. Some of the feedback in the Initial Comments from external parties focused on which generation was economic to dispatch during different time intervals, instead of the level of available capacity. This focus misses the point of these reliability analyses, which is to evaluate, in a hourly chronological model, whether the company has enough online/available capacity that it can technically serve all of its load with its own resources.

<u>Concern raised</u>	<u>How the Company addresses this concern in this Reply</u>
All generic wind and solar units use the same shape	The concern expressed in the Initial Comments was that using the same NCF shape for all generic units may impact the reliability analysis by underrepresenting the benefits of geographic diversity. Using the Sierra Club's Preferred Plan we randomly simulated generic unit wind shapes for the entire year of 2034 and conducted 50 separate production cost runs for the month of December. We evaluate the reliability results for each run in the footnote below.[6] The results of the simulation do not differ greatly from our "high" and "low" interval estimates we show for the Sierra Club Preferred Plan in Table 4-14 of Section 4. In some cases the simulated shapes perform better on average, in other cases worse or in between our "high" and "low" interval estimates. Simulating wind shapes for only 8 generic wind units for only a single year produced a large volume of data; based on the results of this exercise its not yet clear that simulated data in and of itself produces different or better outcomes for this analysis.
Hours with high amounts of MISO imports may not signify a reliability issue, but rather an economic issue	We appreciate this feedback and modified our metric in response. The metric now studies the amount of MISO market purchases only during hours in which a capacity shortfall is occurring. In this way, it more appropriately represents periods in which Company would not have access to sufficient capacity regardless of dispatch economics. We examine the number of hours in which MISO imports are within 5 percentof the 2,300 MW import limit to indicate reliability risk.

[6] The table below includes sample reliability results for the 50 production cost runs with simulated wind shapes for generic wind units, compared to the reliability results from using observed 2019 wind shapes for generic wind units. The least reliable plan in each category is underlined and in bold. We note that that there is not a systematic trend or change in overall outcome associated with varying the wind shapes.

	Number of Native Capacity Shortfalls	Average Shortfall Intensity (MW)	Peak Capacity Shortfall (MW)	Longest Shortfall (Hrs)
Sierra Club Preferred Plan - *Using Different Observed 2019 Wind Shapes*	**<u>7-9</u>**	407-448	1,281 – **<u>1,683</u>**	3-4
Sierra Club Preferred Plan - *Average of Results from 50 Runs with Simulated Wind Shapes*	4	**<u>664</u>**	1,534	**<u>6</u>**

Concern raised	How the Company addresses this concern in this Reply
High net load ramps may not signify a reliability issue, but rather a economic issue	Feedback from intervenors indicated a focus on which resources were actually dispatched during net load ramps, whereas our intention with this metric is to study whether the Company has enough available capacity that it could theoretically meet the entire ramp with its own resources. This is discussed further in the footnote below[7]. No change was made this metric for the reliabilyt analysis included in Section 4 of this Reply.
LOLH and EUE were not examined using stochastic analysis	In Initial Comments, parties claimed that that these metrics were less meaningful because these events are most typically recorded at the ISO/RTO level and because they "are based on deterministic and not stochastic simulations with enough iterations to demonstrate convergence."[8] The Company disagrees with this interpretation. These metrics can be also be used to provide important information about future plans, including moments when it might be most at risk even with the availability of RTO/ISO resources. Additionally LOLH and EUE calculations do not necessarily need to be stochastic simulations to provide meaningful insights and context. As one example, the ELCC update made by the Company for the most recent Public Service Company of Colorado Energy Resource Plan uses historical observed data, which fully preserves the hourly relationship between load and resource variability that has occurred in recent years. While simulations of hourly load can also provide helpful information, the ability of each plan to meet all hourly electrical needs during conditions the Company faced recently is an appropriate basis for measuring reliability.
Lack of forced outage rate (FOR) assumption for batteries	While not raised by intervenors, we determined that it would be appropriate to examine a 5 percent FOR to batteries in "Battery FOR" scenarios in Table 4-14 in Section 4. We note that batteries were the only resource assigned a UCAP of 100 percent, or in other words, a 0 percent FOR. Given the amount of standalone storage and hybrid solar and storage units selected in several plans, we examine a FOR similar to that of other dispatchable generation.

[7] Net load ramps help us evaluate potential hourly chronological reliability risks, rather than just examining a total number of hours a native capacity shortfall could be expected to occur. Whether EnCompass dispatches available capacity or imports it from MISO during the actual reliability test is irrelevant to the test; we are simply examining the relative ability of given plans to meet the steepest net load ramp with native resources, if this became necessary. Given recent net load ramp events observed in MISO – like the April 2021 event discussed in the Reliability section – and CAISO's inclusion of Flexible Ramp requirements – we believe it is appropriate to examine this metric. This is especially true because it is possible that – as more variable generation is adopted across MISO – other load-serving entities in the MISO region may be relying on the market at the same time.
[8] EFG Attachment to CEO Initial Comments 15-21, submitted February 11, 2021. Page 31.

B. Characteristics studied in the reliability analyses

Native Capacity Shortfall: A count of the hours when Company does not have enough available/online generation capacity to cover its full need. As outlined in Section 4, we believe it is important to examine the ability of different plans to cover our full load under a variety of assumptions. This metric looks at the amount of available capacity that that Company has each hour, versus the demand for that hour. Regardless of whether available capacity is dispatched for that hour, this metric reveals whether the Company has enough available capacity to even be capable of covering its full load if needed.

Average Intensity of Shortfall Events: On average, the amount of native capacity – in MW – by which the plan was short during native capacity shortfalls.

Peak Capacity Shortfall: The maximum amount of native capacity – in MW – by which the plan was short during an hour of the modeled year.

Longest Shortfall: This is longest period of time – in hours – in each plan where there is insufficient native capacity available to serve the Company's load.

Max 3 Hour Upward Ramp: Maximum three-hour net load ramp observed by each scenario, where net load equals load minus renewable generation. This ramp is compared against the amount of other available/online generation the Company has at each given hour. The objective of this metric is to see whether the Company simply has enough generation capacity available to serve a rapid increase in net load with its own resources, regardless of whether those resources are ultimately dispatched by the model. See footnote 7 for a further discussion.

LOLH and EUE: Standard industry metrics - Loss-of-Load Hours and Expected Unserved Energy – that quantify the number of hours with loss of load and the amount of energy "unmet." These occur when there is not enough energy – etiher generated or imported by the Company – to provide power to all customers we serve.