Contingency Modeling Enhancements

Prototype Analysis with Production Cases

August 17, 2017

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Revision History

Date	Revision
08/17/2017	Initial release

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1. Executive summary

The ISO performed various types of analyses to evaluate CME's impact to the market from different angles. It analyzed twelve stressed system cases covering multiple system topologies and seasons. It conducted parallel operations of the CME constraints over a two week period. It analyzed CME commitment on a stressed non-binding day compared to MOC commitment on the same day. It analyzed the cost efficiency of the CME constraint compared to the MOC constraint. Finally, it analyzed the price impact of the constraint under a binding condition.

These analyses lead the team to the following conclusions:

- The CME constraint ensures that effective unloaded capacity is available to meet the reliability standard via unit commitments and positioning units, and CME may also leverage bid-in demand
- Under realistic system conditions, even when the system is stressed, CME is unlikely to bind, and CME produces a more efficient solution than to enforce the MOC constraint in the market
- When the CME constraint is binding, it sends correct market price signals to the system
- When meeting the same load target and resolving the same reliability need, the CME constraint commits less units and costs less to the market

All of the CME test scenarios and cases meet the expectation that the CME constraints are more precise and efficient than the MOC constraints to manage the reliability criteria, and CME can increase market efficiency.

2. Purpose

In 2013, the ISO built a CME prototype to test the preventive-corrective constraint functionality on an actual production market case and prove that the technology will work in practice. In the end, the team built and iterated many enhancements to the prototype, tested the prototype on twelve stressed system production cases, performed varying analyses on these cases, and completed a stint of running CME in parallel to the production market for a continuous two week period.

We broke from the one simple objective of the analysis for three specific purposes. First, we wanted to see if corrective capacity is sufficient in the system, and in the case that it is not, observe how CME resolves the reliability concern. Second, we wanted to observe how CME may impact the market in terms of commitment and cost, particularly compared with the minimum online commitment (MOC) approach used today. Third, we wanted to get a sense of how frequently CME constraints may bind in the market on a day-to-day basis.

We developed the following analyses to address these purposes:

1. Analysis of stressed system scenarios
2. Analysis of MOC commitment and CME commitment
3. Analysis of reliability constraint efficiency
4. Parallel operations

Due to limited time and resources, all analyses were performed on day-ahead production cases.

3. Analysis of stressed system scenarios

In this analysis, we observe if corrective capacity is sufficient in the system, and in the case that it is not, we observe how CME resolves the reliability concern.

3.1. Methodology

We designed twelve test scenarios for to cover the various likely system conditions. Each scenario represents a combination of a particular network topology and season. Operations engineers targeted six network topologies at conditions in which they may choose to enforce a minimum online commitment constraint in the day-ahead market (due to load profile or daily outages). They then chose a representative stressed day in two seasons to match that network topology. For each of the test scenarios, the analysis used one day-ahead production case in 2014, 2015 or 2016. First, operations engineers looked for production cases that matched their criteria, and then introduced specific ways to stress the system for the purpose of the analysis. To build the test cases, the team started with the selected day-ahead case as a base case, then made a few modifications:

- Defined the preventive-corrective constraints (five constraints simultaneously enforced: Path 26, Path 15, PACI, SCIT and SDGE)
- Removed the related and enforced MOCs
- Set the preventive-corrective constraint parameters such as the 20 minute correction time and the binary variable for potential release of operating reserves
- In some cases, created outages to stress the condition further (for example, create a Path 26 outage in N1S2 if the base case had Path 26 all lines in service)

Table 1 describes the identifier for the network condition and season selected.

Network condition	Season 1	Season 2
N0. All lines in service	N0S1	N0S2
N1. Path 26 outage	N1S1	N1S2
N2. Path 15 outage	N2S1	N2S2
N3. COI (PACI) outage	N3S1	N3S2
N4. SCIT outage	N4S1	N4S2
N5. SDGE IMP BG outage	N5S1	N5S2

Table 1: CME analysis scenarios

We provide detailed information about each of the scenarios in ***Appendix A***.

3.2. Non-binding scenarios

CME constraints were non-binding in eleven of twelve stressed system scenarios.

In the eleven scenarios described below, the system already had sufficient corrective capacity without the help of CME. In the ***Table 2***, we show a representative hour from each non-binding scenario, which has relatively heavy flows in the pre-contingency case, to compare the corrective capacity demand and supply per constraint. For example, in scenario N1S1 on May 31 2015 hour 3 GMT, Path 26 flow is 1301 in the pre contingency case. The Path 26 post contingency rating is 1000 MW, which means, at least 301 MW of corrective capacity is needed to bring the flow down from 1301 MW to 1000 MW. The supply in the system from unloaded generation capacities, which are 20 minutes ramp feasible, is 714 MW, more than doubling the 301 MW need. The excess effective capacity explains why the preventive-corrective constraint is not binding in the case. The other scenarios in ***Table 2*** all look similar to N1S1 except that the constraints under consideration may be different.

We validated all non-binding scenarios against a base case in which no CME constraints or MOC constraints were enforced to verify that there was little to no impact on energy prices with the addition of the CME constraint.

Scen -ario	Date:hour (GMT)	CME case	Path	Path Flow	Post-Conti. Rating	Capacity Required	Unloaded Capacity
N0S1	02FEB2015:02	CME_PACI	PACI_MSL	2523	1834	689	1282
N0S2	30MAR2015:22	CME_PACI	PACI_MSL	3288	1834	1454	3846
N1S1	31MAY2015:03	CME_PATH26	PATH26_BG	1301	1000	301	714
N1S2	04OCT2015:01	CME_PATH26	PATH26_BG	3343	1000	2343	4481
N2S1	02JUN2015:14	CME_PATH15	PATH15_BG	2008	2650	0	1267
N2S2	30MAR2015:07	CME_PATH15	PATH15_BG	3079	2650	429	1404
N3S1	05DEC2014:04	CME_PACI	PACI_MSL	2175	1633	542	2435
N3S2	06OCT2015:16	CME_PACI	PACI_MSL	2382	1333	1049	1552
N4S1	04MAY2015:16	CME_SCIT	SCIT_BG	8722	13750	0	3870
N4S2	09OCT2015:23	CME_SCIT	SCIT_BG	13541	14920	0	392
N5S2	06OCT2015:19	CME_SDGE	CME_SDGE	1943	1400	543	910

Table 2: Selected non-binding CME hours

These results indicate that even on stressed days, there may be low likelihood of the preventive-corrective constraint binding. The actual reliability need that precipitated the enforcement of minimum online commitment constraints on these days is found to have been met by the market cleared capacity without mandating pre-selected resources to be online.

3.3. Binding scenario

Among all the scenarios that were selected, CME constraints were binding only in scenario N5S1, which is a SDGE outage case with summer load.

In scenario N5S1, constraint SDGEIMP_BG binds in four hours as shown in ***Table 3***. For example, in hour 23JUL2016:00 GMT, the pre-contingency flow on SDGEIMP_BG is 1919 MW. The post-contingency rating is 1400 MW. This means 1,919 - 1,400 = 519 MW of corrective capacity is needed in SDGE to reduce the flow from 1919 MW to the post-contingency rating 1400 MW. CME awards 531 MW of corrective capacity, which is just sufficient after accounting for loss difference between the pre contingency case and the post contingency case. The pre-contingency flow on SDGEIMP_BG would have been 2264 MW without CME constraints being enforced. The available corrective capacity in the no CME case is 275 MW, and it is not sufficient to bring the flow down to 1400 MW if the contingency occurs. CME does not only try to get more corrective capacity in SDGE, but also tries to economically bring down the pre-contingency flow, so that capacity inside SDGE can be sufficient. There are about 531-275 = 256 MW capacity being withheld from serving load in CME case to become corrective capacity. In doing so, CME has to dispatch resources out of economic merit order, and increase LMP inside SDGE.

Date:hour (GMT)	CME case	Path	Path flow	Post-Conti. Rating	Capacity Required	CC Award	Shadow price	No CME flow	Unloaded capacity
23JUL2016:00	SDGE	SDGEIMP_BG	1919	1400	519	531	18.87	2264	275
23JUL2016:01	SDGE	SDGEIMP_BG	1921	1400	521	521	11.64	2183	273
23JUL2016:02	SDGE	SDGEIMP_BG	1906	1400	506	517	7.06	2066	273
23JUL2016:03	SDGE	SDGEIMP_BG	2065	1400	665	674	6.16	2170	363

Table 3: Binding CME hours in Scenario N5S1

The SDGE DLAP price goes up by nearly the same amount of the CME shadow price compared with other DLAPs. This is because the shadow price of the CME SDGE will be added to all the pricing nodes multiplied by corresponding shift factors. The shift factor difference between a node inside the SDGEIMP_BG constraint and a node outside the SDGEIMP_BG constraint is one. So the price difference between DLAP SDGE (inside the SDGEIMP_BG constraint) and DLAP SCE (outside the SDGEIMP_BG constraint) is about equal to the shadow price of the

SDGEIMP_BG constraint. For example, in hour 23JUL2016:00 GMT, the SDGEIMP_BG constraint is binding with $18.87 shadow price under SDGE CME contingency case. The DLAP SDGE LMP congestion component is $20.35, and the DLAP SCE LMP congestion component is $1.69. So the difference between them is $20.35-$1.69 = $18.66, which nearly equals the SDGEIMP_BG shadow price.

Because DLAP SDGE has bid-in demand in day-ahead market, the cleared demand drops by 4,364 - 4,195 = 169 MW with LMP being higher in the CME case. With less cleared demand inside SDGE, the flow on SDGEIMP_BG going into SDGE is reduced. Resource ELCAJN_6_LM6K is de-committed in the CME case to provide corrective capacity. There is no significant change in ancillary service procurement in hour 23JUL2016:00 GMT. In hour 23JUL2016:01 GMT, 23JUL2016:02 GMT, and 23JUL2016:03 GMT, CME procures 115 MW, 110 MW, and 77 MW of more upward ancillary service respectively in AS zone SP26.

Table 4 shows the price impact in different DLAPs. Energy prices are higher than the non-CME/non-MOC base case by the cost of the corrective capacity.

Date:hour (GMT)	DLAP	LMP with CME	Congestion with CME	LMP without CME	Congestion without CME
23JUL2016:00	PG&E	$51.32	$-7.28	$50.48	$-7.51
23JUL2016:00	SCE	$63.03	$1.69	$65.77	$4.85
23JUL2016:00	SDGE	$84.19	$20.35	$68.20	$4.56
23JUL2016:00	VEA	$60.57	$1.06	$62.88	$3.98
23JUL2016:01	PG&E	$60.18	$-2.38	$60.25	$-1.65
23JUL2016:01	SCE	$65.11	$-0.26	$65.92	$1.11
23JUL2016:01	SDGE	$79.57	$11.33	$68.77	$1.05
23JUL2016:01	VEA	$63.62	$-0.41	$64.21	$0.92
23JUL2016:02	PG&E	$59.98	$-2.09	$60.00	$-1.26
23JUL2016:02	SCE	$65.28	$0.32	$65.00	$0.81
23JUL2016:02	SDGE	$75.16	$7.31	$67.95	$1.03
23JUL2016:02	VEA	$63.76	$0.15	$61.78	$-0.94
23JUL2016:03	PG&E	$49.98	$-0.60	$50.00	$-1.76
23JUL2016:03	SCE	$52.27	$-0.60	$55.00	$1.09
23JUL2016:03	SDGE	$60.79	$5.56	$57.98	$1.60
23JUL2016:03	VEA	$50.93	$-0.60	$50.09	$-2.40

Table 4: Impact of binding CME constraints on DLAP prices

Table 5 shows a small impact on ancillary services procurement between the CME case and the non-CME/non-MOC base case.

Date:hour (GMT)	Comm odity	Region	MW with CME	MW without CME	Price with CME	Price without CME
23JUL2016:00	En	SDGE	4195	4364	84.19	68.20
23JUL2016:01	En	SDGE	4107	4276	79.57	68.77
23JUL2016:02	En	SDGE	4061	4145	75.16	67.95
23JUL2016:03	En	SDGE	4056	4090	60.79	57.98
23JUL2016:01	Up AS	SP26	982	963	0	0
23JUL2016:02	Up AS	SP26	1076	961	0	0
23JUL2016:03	Up AS	SP26	928	818	0	0
23JUL2016:04	Up As	SP26	655	578	0	0

Table 5: Impact of binding CME constraints on cleared demand and AS procurement

3.4. Other observations

After observing in the binding case scenario that CME chose to economically clear less load in the day-ahead market, the question arose as to how the constraint would behave if it could not economically clear less load. Would CME commit more units to meet the reliability concern as expected?

Using the binding N5S1 scenario, the team built two cases. First it built a base case that did not enforce the MOC and did not enforce the CME constraint. It used this case to find the load level that would economically clear absent this reliability concern. The team then built a case with the CME constraint enforced and fixed the load at the cleared level in the base case. After fixing the load and enforcing the preventive-corrective constraint, CME did commit more units. For example, in GMT hour 23JUL2016:03, the optimization committed three more units. The optimization also decommitted one unit, but it did so to have it provide corrective capacity of 43 MW. The CME decommitted unit is a fast start resource with 8 minutes startup time, so it can provide corrective capacity.

4. Analysis of MOC commitment and CME commitment

In this analysis, we observe how CME would impact the market in terms of unit commitment.

The team compared the MOC commitment on a day in which the CME constraint was non-binding to the CME commitment on the same resources within the MOC definition to find whether CME would save some commitments.

One concern related to the preventive-corrective constraints not binding most of the time was whether CME committed more resources than the associated minimum online commitment constraint, which could have then made the CME constraints non-binding.

The team took the N3S1 case to compare the minimum online commitment constraint requirement with the committed capacity to meet it in the CME case. This analysis compared the commitment of the resources within the MOC definition between a case with the MOC enforced and a case with the associated CME constraints enforced.

Table 6 shows the hours that CME committed less resources than the MOC requirement from the same pool of resources in the MOC definition. For these hours and MOC constraints, we can see that CME committed less than MOC. This confirms that

- Some of the MOC requirements are conservatively defined to meet the reliability criteria
- CME resolves the reliability criteria with less commitments
- The CME constraints are not over-committing units to result in the non-binding outcome

Date	Hour	MOC	MOC Requirement	CME MOC Supply
4-Dec-14	10	MOC NP15	3,350	3,211
4-Dec-14	11	MOC NP15	3,315	3,211
4-Dec-14	14	MOC NP15	3,297	3,213
4-Dec-14	8	SCIT MOC	4,600	4,205
4-Dec-14	9	SCIT MOC	4,600	4,205
4-Dec-14	10	SCIT MOC	4,600	4,205
4-Dec-14	11	SCIT MOC	4,600	4,249
4-Dec-14	12	SCIT MOC	4,600	4,249
4-Dec-14	13	SCIT MOC	4,600	4,249
4-Dec-14	14	SCIT MOC	4,600	4,249
4-Dec-14	15	SCIT MOC	4,600	4,249
4-Dec-14	16	SCIT MOC	4,600	4,249
4-Dec-14	17	SCIT MOC	4,600	4,249
4-Dec-14	18	SCIT MOC	4,600	4,358
4-Dec-14	19	SCIT MOC	4,600	4,358
4-Dec-14	20	SCIT MOC	4,600	4,358
4-Dec-14	21	SCIT MOC	4,600	4,249

Table 6: MOC supplied by CME

5. Analysis of reliability constraint efficiency

In this analysis, we observe how CME would impact the market in terms of objective cost.

The team directly compared total cost of CME constraints versus their equivalent MOC constraints to estimate the market efficiency improvements that the CME may provide. We created a test case similar to N3S2 with modifications to isolate the impact of CME. We did not directly compare cost of two IFM cases, because the IFM has bid-in demand, and the IFM optimizes the total social welfare. We want to compare the costs for meeting the same load target and same reliability need. The team fixed the bid-in load so that it could not be changed in the optimization; this allowed both the CME constraint and the MOC constraint to compete on the same target. In order to find the appropriate fixed load level, the team first solved the N3S2 scenario case without the MOC constraints and without the CME constraints.

The team then created a CME case and an MOC case, each with the same fixed bid-in demand target that cannot be changed in the optimization. The team enforced two CME constraints in the CME case: NP15 and SCIT. The team enforced the equivalent two MOC constraints in the MOC case.

With these modifications to the cases, we can isolate the impact of CME, so the cost difference can be attributable to CME, not difference in load or other complicating factors. The objective function value when the optimization finishes is the minimum total cost solution. The optimal objective function value of the CME case was $7,168,661, and the optimal objective function value of the MOC case was $7,179,846, so the cost savings of CME constraint compared to the MOC constraint is $11,185.

Model	Minimum cost to meet load
CME	$7,168,661
MOC	$7,179,846
CME cost saving	$11,185

Table 7: MOC cost vs CME cost to meet the same load

The results from this analysis combined with the results from the analysis of MOC commitment and CME commitment on the non-binding case day in ***Section 5*** allow us to conclude that CME is committing less resources and saving cost compared with MOC.

6. Parallel operations

To support its decision on potential changes to the congestion revenue rights market, the ISO sought to discover the potential impact that the preventive-corrective constraint would have on the day-ahead market over a period of time. For two weeks at the end of March 2017 through the beginning of April 2017 the ISO ran its CME prototype in parallel to its day-ahead market. During this two week period, operations engineers studied outages on those days, determined applicable CME constraints, and enforced those constraints in the parallel market consistent with the system conditions. Over the course of the parallel operations period, the contingency modeling enhancements constraints did not bind, further indicating that there may be a low likelihood of the constraint binding in practice.

7. Summary and conclusion

The ISO performed various types of analyses to evaluate CME's impact to the market from different angles. With twelve stress test scenarios analyzed, the team observed that CME does not bind for 11 scenarios without enforcing the corresponding MOC constraints. In addition, over the course of two weeks of CME parallel operation, the CME constraints did not bind for any hour with real market inputs. This means that under realistic conditions, even when the system is stressed, CME is unlikely to bind.

The team further examined whether CME over committed resources to cause the constraints not bind. It looked at two cases one with bid-in load and one with fixed load. With bid-in load, we observe that the capacity committed by CME toward meeting the MOC is less than the MOC requirement. With fixed load, we observe that the total cost to meet the same amount of load is less with CME than with MOC. Therefore, we conclude that generally CME would commit less capacity than MOC, and can replace the MOC with higher market efficiency.

The team also observed one scenario where CME binds in SDGE. This is a stressed scenario with high load in SDGE. Without CME and without MOC, if the contingency happens, we may fail to bring the flow to the post contingency rating within 30 minutes. Seeing this, CME strategically positioned units to resolve the constraint, and it also leveraged bid-in load to do so. CME manages to get sufficient corrective capacity to bring pre-contingency flow post contingency rating. In doing so, CME increases the DLAP price of SDGE compared with out DLAPs. The team also explored whether CME could commit more units if it could not economically clear less load. As expected, CME did bring on more units to meet the CME constraints.

All the CME test scenarios and cases meet the ISO’s expectation that the CME constraints are more precise and efficient than the MOC constraints to manage the reliability criteria, and CME can increase market efficiency.

Appendix: Stressed system analysis scenarios

Case-Season	CME Path	P-C from rating	P-C to rating	CME Contingency
N0S1 ALIS Spring	PACI	2450	1834	Table Mtn - Vaca 500kV line
N0S1 ALIS Spring	Path 15	9999	3400	Diablo - Gates 500kV line
N0S1 ALIS Spring	Path 26	2000	1450	Midway-Whirlwind 500kV line
N0S1 ALIS Spring	SCIT	16450	9999	North Gila - Imperial Valley 500kv line
N0S1 ALIS Spring	SDGE_CFEIMP	2660	9999	Ecounty - Miguel 500kV line
N0S2 ALIS Summer	PACI	2450	1834	Table Mtn - Vaca 500kV line
N0S2 ALIS Summer	Path 15	9999	3400	Diablo - Gates 500kV line
N0S2 ALIS Summer	Path 26	2000	1450	Midway-Whirlwind 500kV line
N0S2 ALIS Summer	SCIT	16750	9999	North Gila - Imperial Valley 500kv line
N0S2 ALIS Summer	SDGE_IMP	2660	9999	Ecounty - Miguel 500kV line
N1S1 Path 26 outage Spring	PACI	2450	1834	Table Mtn - Vaca 500kV line
N1S1 Path 26 outage Spring	Path 15	9999	3400	Diablo - Gates 500kV line
N1S1 Path 26 outage Spring	Path 26	1000	1000	Midway-Vincent #2 500kV line
N1S1 Path 26 outage Spring	SCIT	16450	9999	North Gila - Imperial Valley 500kv line
N1S1 Path 26 outage Spring	SDGE_CFEIMP	2660	9999	Ecounty - Miguel 500kV line
N1S2 Path 26 Outage Summer	PACI	2450	1834	Table Mtn - Vaca 500kV line
N1S2 Path 26 Outage Summer	Path 15	9999	3400	Diablo - Gates 500kV line
N1S2 Path 26 Outage Summer	Path 26	1000	1000	Midway-Vincent #2 500kV line
N1S2 Path 26 Outage Summer	SCIT	16750	9999	North Gila - Imperial Valley 500kv line
N1S2 Path 26 Outage Summer	SDGE_IMP	2660	9999	Ecounty - Miguel 500kV line
N2S1 Path 15 outage Spring	PACI	2450	1834	Table Mtn - Vaca 500kV line

N2S1 Path 15 outage Spring	Path 15	9999	2650	Gates 500/230kV Bank 11
N2S1 Path 15 outage Spring	Path 26	2000	1450	Midway-Whirlwind 500kV line
N2S1 Path 15 outage Spring	SCIT	16450	9999	North Gila - Imperial Valley 500kv line
N2S1 Path 15 outage Spring	SDGE_CFEIMP	2660	9999	Ecounty - Miguel 500kV line
N2S2 Path 15 outage Summer	PACI	2450	1834	Table Mtn - Vaca 500kV line
N2S2 Path 15 outage Summer	Path 15	9999	2650	Gates 500/230kV Bank 11
N2S2 Path 15 outage Summer	Path 26	2000	1450	Midway-Whirlwind 500kV line
N2S2 Path 15 outage Summer	SCIT	16750	9999	North Gila - Imperial Valley 500kv line
N2S2 Path 15 outage Summer	SDGE_IMP	2660	9999	Ecounty - Miguel 500kV line
N3S1 COI outage Spring	PACI	833	1133	Malin- Round Mountain #1 500kV line
N3S1 COI outage Spring	Path 15	9999	3400	Diablo - Gates 500kV line
N3S1 COI outage Spring	Path 26	2000	1450	Midway-Whirlwind 500kV line
N3S1 COI outage Spring	SCIT	16450	9999	North Gila - Imperial Valley 500kv line
N3S1 COI outage Spring	SDGE_CFEIMP	2660	9999	Ecounty - Miguel 500kV line
N3S2 COI outage Summer	PACI	833	1133	Captain Jack - Olinda 500 kV line
N3S2 COI outage Summer	Path 15	9999	3400	Diablo - Gates 500kV line
N3S2 COI outage Summer	Path 26	2000	1450	Midway-Whirlwind 500kV line
N3S2 COI outage Summer	SCIT	16750	9999	North Gila - Imperial Valley 500kv line
N3S2 COI outage Summer	SDGE_IMP	2660	9999	Ecounty - Miguel 500kV line
N4S1 SCIT outage Spring	PACI	2450	1834	Table Mtn - Vaca 500kV line
N4S1 SCIT outage Spring	Path 15	9999	3400	Diablo - Gates 500kV line
N4S1 SCIT outage Spring	Path 26	2000	1450	Midway-Whirlwind 500kV line
N4S1 SCIT outage Spring	SCIT	13750	9999	North Gila - Imperial Valley 500kv line
N4S1 SCIT outage Spring	SDGE_CFEIMP	2660	9999	Ecounty - Miguel 500kV line

N4S2 SCIT outage Summer	PACI	2450	1834	Table Mtn - Vaca 500kV line
N4S2 SCIT outage Summer	Path 15	9999	3400	Diablo - Gates 500kV line
N4S2 SCIT outage Summer	Path 26	2000	1450	Midway-Whirlwind 500kV line
N4S2 SCIT outage Summer	SCIT	14920	9999	North Gila - Imperial Valley 500kv line
N4S2 SCIT outage Summer	SDGE_IMP	2660	9999	Ecounty - Miguel 500kV line

N5S1 SDGE outage Spring	PACI	2450	1834	Table Mtn - Vaca 500kV line
N5S1 SDGE outage Spring	Path 15	9999	3400	Diablo - Gates 500kV line
N5S1 SDGE outage Spring	Path 26	2000	1450	Midway-Whirlwind 500kV line
N5S1 SDGE outage Spring	SCIT	16450	9999	North Gila - Imperial Valley 500kv line
N5S1 SDGE outage Spring	SDGE_CFEIMP	1400	9999	Ecounty - Miguel 500kV line

N5S2 SDGE outage Summer	PACI	2450	1834	Table Mtn - Vaca 500kV line
N5S2 SDGE outage Summer	Path 15	9999	3400	Diablo - Gates 500kV line
N5S2 SDGE outage Summer	Path 26	2000	1450	Midway-Whirlwind 500kV line
N5S2 SDGE outage Summer	SCIT	16750	9999	North Gila - Imperial Valley 500kv line
N5S2 SDGE outage Summer	SDGE_IMP	1400	9999	Ecounty - Miguel 500kV line