Central-East Voltage Limit Study (CEVC-23)

A Report by Operations Engineering Staff
New York Independent System Operator

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Executive Summary

In light of the network upgrades and on-going work related to the Segment A and Segment B transmission projects, the NYISO deemed it appropriate to conduct a study of area voltage performance, including the investigation of voltage collapse transfer limits, for the Central-East operating interface. This report presents the methodology, analysis and results of this study.

The voltage collapse limits currently in use for the Central-East interface were developed in 2021, and reviewed in 2022, as part of on-going studies related to transmission network upgrades. This study re-evaluates these limits to maintain reliable operation of the bulk power system. New derates were developed to account for new transmission, such as the Princetown-New Scotland 345 kV 361 and 362 lines, and the new Knickerbocker 345 kV station and related transmission changes.

This study shows overall increases in voltage collapse limits as a result of new transmission strengthening the existing network. Analysis also shows that no adjustments to pre-contingency low voltage limits are necessary.

These limits will remain in effect until the Segment A and B projects are completed sometime at the end of 2023. An additional study will be conducted to account for the system configuration expected to be in-service in Winter 2023-24.

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Introduction

The purpose of this study is to evaluate the Central-East Voltage Collapse Transfer Limits for all-lines-in-service and significant equipment outage conditions expected for the system configuration for the Sumer 2023 season. This analysis was conducted on the NYISO Summer 2022 Operating Study base case. Details of base case development are included in this report.

This report documents the results of the analysis and provides recommendations based on the simulation results for operating criteria contingencies. Tables of the recommended derates, the contingencies evaluated, examples of power-voltage (PV) plots and summaries of the transfer base case conditions are included.

The New York State Reliability Council (NYSRC) Reliability Rules for Planning and Operating the New York State Power System provide the documented methodology employed to develop System Operating Limits (SOLs) within the NYISO Reliability Coordinator Area. NYSRC Reliability Rules require compliance with all North American Electric Reliability Corporation (NERC) Standards and Northeast Power Coordinating Council (NPCC) Standards and Criteria. NYSRC Rule C.1, Establishing Operating Transfer Capabilities, addresses the contingencies to be evaluated and the performance requirements to be applied. Rule C.1 also references NYISO Bus Voltage Limits as found in Tables A.2 and A3 of the "NYISO Emergency Operations Manual". The applicable process for establishing voltage collapse limits is established by the "Guideline for Voltage Analysis and Determination of Voltage-Based Transfer Limits" found in the NYISO "Transmission Expansion and Interconnection Manual" Attachment G.

Recommendations

It is recommended that the limits presented in this report be employed to secure the bulk power system for the applicable system conditions identified in this study. Figures 1 through 7 show the breakdown of the Central-East Voltage Collapse Transfer Limit components. Tables showing the changes in limits can be found in the Discussion section. In Figure 4, the additional penalty for not maintaining pre-contingency voltage at the Edic 345kV station above 351kV when the MSU1 is out-of-service is removed.

The results of the study also showed that no changes are needed for pre-contingency low voltage limits, given the recommended establishment of the Central-East interface voltage collapse limits.

Figure 1 – Oswego Generating Complex Limits

Oswego Generating Complex Limits						
	0 Oswego Cmplx I/S	1 Oswego Cmplx I/S	2 Oswego Cmplx I/S	3 Oswego Cmplx I/S	4 Oswego Cmplx I/S	5 Oswego Cmplx I/S
Base Limit	2390	2480	2595	2720	2800	2885

Figure 2 - Limit Derates for Independence Generating Station

Limit Derates for Independence Generating Station						
Independence Units I/S	0 Oswego Cmplx I/S	1 Oswego Cmplx I/S	2 Oswego Cmplx I/S	3 Oswego Cmplx I/S	4 Oswego Cmplx I/S	5 Oswego Cmplx I/S
0	460	405	290	280	260	220
1	375	330	245	235	210	180
2	285	255	195	190	160	140
3	195	175	145	145	105	95
4	130	120	100	100	70	65
5	65	60	50	50	35	35
6	0	0	0	0	0	0

Figure 3 - Limit Derates for Athens Generating Station

Limit Derates for Athens Generating Station						
Athens Units I/S	0 Oswego Cmplx I/S	1 Oswego Cmplx I/S	2 Oswego Cmplx I/S	3 Oswego Cmplx I/S	4 Oswego Cmplx I/S	5 Oswego Cmplx I/S
0	10	20	30	80	75	130
1	0	0	20	55	40	90
2	0	0	10	20	25	75

Figure 4 - Limit Derates for Transmission Facility Outages

Limit Derates for Transmission Facility Outages							
Transmission Facility Name	PTID	0 Oswego Cmplx I/S	1 Oswego Cmplx I/S	2 Oswego Cmplx I/S	3 Oswego Cmplx I/S	4 Oswego Cmplx I/S	5 Oswego Cmplx I/S
FITZPTRK-EDIC_____345_FE-1	25077	145	145	145	145	145	145
EDIC____-GORDONRD_345_14	327482	860	885	920	990	1020	1050
GORDONRD-ROTTRDAM_230_30	327485	25	25	25	25	25	25
GORDONRD-ROTTRDAM_230_31	327486	25	25	25	25	25	25
MASSENA_-MARCY____765_MSU1	25224	650	660	575	660	560	570
MARCY___-N.SCTLND_345_18	25276	880	910	970	1035	1075	1160
VOLNEY__-MARCY____345_19	25345	145	145	145	145	145	145
INGHAM_C_115_115_PAR_2	25242	120	120	120	120	120	120
S HERO__-PLATSBRG_115_PV20	25027	100	100	100	100	100	100
PRINCTWN-N.SCTLND_345_55	327492	25	25	25	25	25	25
PRINCTWN-N.SCTLND_345_361	625031	30	30	30	30	30	30
PRINCTWN-N.SCTLND_345_362	625032	30	30	30	30	30	30
GORDONRD-PRINCTWN_345_371	625030	285	310	310	425	485	565

Figure 5 - Limit Derates for Capacitors, SVCs, STATCOM (out-of-service)

Limit Derates for Capacitors, SVCs, STATCOM (out-of-service)		
Reactive Device Name	PTID	Derate MWs
EDIC_PTR_345KV_CAP_CAP _1	31400	85
FRASER___345KV_CAP_CAP _1	31336	20
FRASER ___345KV_CAP_CAP _2	31345	20
GILBOA____345KV_CAP_CAP _1	31337	5
LEEDS ____345KV_CAP_CAP _1	31338	15
LEEDS____345KV_CAP_CAP _2	31346	15
MARCY____345KV_CAP_CAP _1	31339	70
MARCY____345KV_CAP_CAP _2	31353	70
N.SCTLND_345KV_CAP_CAP _1	31349	40
N.SCTLND_345KV_CAP_CAP _2	31342	40
N.SCTLND_345KV_CAP_CAP _3	31350	40
OAKDALE__ 345KV_CAP_CAP_1	31394	35
ROTTRDAM_230KV_CAP_CAP_3	31365	55
ROTTRDAM_230KV_CAP_CAP_4	31366	55
VNWAGNER_345KV_CAP_CAP_1	319382	10
VNWAGNER_345KV_CAP_CAP_1	319384	10
MARCY___345_STATCOM SVC	31395	70
FRASER__345_FRASER SVC	31328	30
LEEDS___345_LEEDS SVC	31327	20

Figure 6 - Limit Derates for Marcy-South Series Capacitors

Limit Derates for Marcy-South Series Capacitors (bypass breaker open)		
Bypass Breaker Name	PTID	Derate MWs
FRASER___345KV_3322_____________CB	315800	45
FRASER___345KV_3722_____________CB	315804	135
FRASER___345KV_3822_____________CB	315808	90

Figure 7 - Limit Derates for Knickerbocker Series Capacitors

Limit Derates for Knickerbocker Series Capacitors (bypass breaker closed)		
Bypass Breaker Name	PTID	Derate MWs
KNICRBKR___345KV_RY5714_________CB	319359	50
KNICRBKR___345KV_RY5715_________CB	319360	45

Discussion

System Representation and Base Study Assumptions

The study was conducted on the 2022 NYISO Summer Peak Operating Study Base Case with a NYISO forecasted summer coincident peak load of 31,765 MW. This base case was selected as the most recently reviewed case available.

The initial base case is modeled as an all-lines-in-service representation with all generation in-service. A key level of conservatism in the development of voltage transfer limits developed for Operations is all analysis is conducted under peak load conditions. This is conservative for two reasons. First, it is the highest end user reactive load condition, and thereby consumes the greatest amount of inherent and controllable reactive resources at the point of delivery to the end user. Second, the delivery of power to the end user under peak load results in the highest level of reactive transmission losses across the system. Under anything less than peak load conditions, additional reactive resources are available to the system.

The initial base case dispatch real power transfers were adjusted to stress conditions through:

- L34 PAR modeled out-of-service
- Ontario generation set to attain an import of ~1780 MW across Frontier and Adirondack interfaces
- 7040 flow set to 1,300 MW import from Hydro-Québec
- 200 MW import on Cedars-Dennison
- Sandbar PAR set to achieve 100 MW flow on PV20
- Ontario-Michigan PARS set to maintain Lake Erie circulation near zero
- Interfaces at Dysinger-East interface and Moses-South stressed to 1,700 and 2,270 MW respectively.

To ensure utilization of available reactive resources, the following actions were taken:

- All capacitors in-service were switched in.
- All generator terminal voltages were set to local control, between .95 and 1.05.
- Assorted Generator and LTC control parameters were adjusted to maintain all bulk power buses within historic operating voltage ranges.
- Oswego area 345 kV stations modeled to typical voltages which can exceed 1.06 p.u.
- Marcy-South Series Capacitors were modeled out-of-service

Updates to the base case included additional transmission as part of the Segment A and B projects. This included the addition of the following elements:

- Princetown-New Scotland 345kV 361 and 362 lines
- Knickerbocker 345 kV station, which divides the New Scotland-Alps 345 kV 2 line into the New Scotland-Knickerbocker 2 and Knickerbocker-Alps 6 lines
- Knickerbocker-Pleasant Valley 345 kV 57 line
- Series compensation at Knickerbocker station on the 57 line
- VanWagner 345 kV station which intersects the Athens-PV and Leeds-PV 345 kV 91 and 92 lines
- Two switched-shunt capacitors at VanWagner station totaling 270 MVAr

Study Criteria

This analysis was conducted in accordance with the "NYSRC Reliability Rules, Standards for Planning and Operation the New York ISO Bulk Power System" and "NPCC Regional Reliability Reference Directory # 1 Design and Operation of the Bulk Power System".

The NYISO Transmission Expansion and Interconnection Manual, Attachment G: NYISO Transmission Planning Guideline #2-1 "Guideline for Voltage Analysis and Determination of Voltage-Based Transfer Limits" describes the methodology employed to determine voltage transfer limits.

A pre-contingency kV limit is determined when the post-contingency voltages falls below the post-contingency low voltage limit. In this analysis the pre-contingency low voltages were recorded at the highest transfer at which the post-contingency low solved voltage reached the defined post-contingency low limit. The NYISO post-contingency low voltages employed in the analysis are found in the NYSO Emergency Operations Manual, Attachment A, Table A-2 "NYISO Voltage Limits".

Study Methodology

The Voltage Contingency Analysis Procedure (VCAP) is used to evaluate the steady state voltage performance of the power system for a series of power transfer conditions. A transmission interface in the vicinity of the area of the system to be studied is tested by preparing a series of power flow base cases with increasing MW transfer levels across that interface. The pre-contingency cases are then subjected to the most severe voltage contingencies for the area involved. The post-contingency cases are then reviewed for voltage performance at each of the monitored buses to best determine reactive conditions and develop guidelines for the operation of the system.

The basic principle employed is to develop a set of power transfer vs. voltage (PV) curves through the VCAP application. These PV curves are developed by progressively increasing transfers across Central-East interface and recording the post contingency voltage for severe contingencies. Two potential limits are obtained through examination of the PV curves. A post-contingency voltage transfer limit is defined when the post contingency voltage crosses the predefined post contingency low voltage limit. A voltage collapse transfer limit is defined by identifying the highest transfer where post contingency power flow stopped increasing, also called the “knee” of the post contingent flow curve, and then applying a 5% margin. The voltage collapse transfer limit is then compared to that transfer level obtained by applying the applicable post-contingency low voltage limit. To ensure that a voltage-based transfer limit is determined with a safe margin, the lower of the two power transfer levels from the foregoing comparison is to be selected as the interface transfer limit.

A key level of conservatism in the development of voltage transfer limits developed for operations is all analysis is conducted under peak load conditions. This is conservative for two reasons. First, it is the highest end user reactive load condition, and thereby consumes the greatest amount of innate and controllable reactive resources at the point of delivery to the end user. Secondly, the delivery of power to the end user under peak load results in the highest level reactive transmission losses across the system. Under anything less than peak load conditions, additional reactive resources are available to the system.

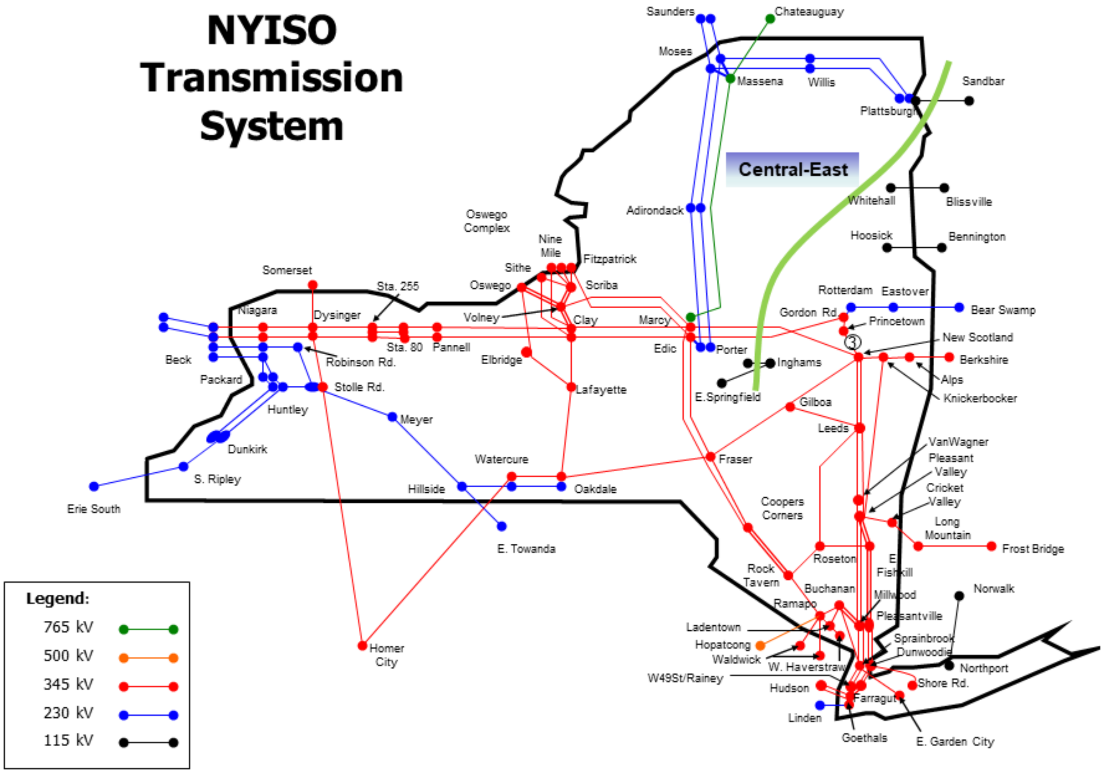
Central-East Interface Definition

The Central-East interface definition is given below in Figure 8 and illustrated in Figure 9.

Figure 8 – Central-East Interface Definition

CENTRAL EAST			
Mohawk Valley (Zone E) – Capital (Zone F)			
	Name	**Line ID**	**Voltage (kV)**
	Edic-Gordon Road*	14	345
	Marcy-New Scotland*	18	345
	East Springfield-Inghams*	7-942	115
	Inghams PAR	PAR	115
	Inghams Bus Tie	R81	115
North (Zone D) – ISONE (Zone N)			
	*Plattsburgh-Sand Bar	PV20	115

Figure 9 - NYISO Transmission System (Central-East inset)



Transfer Case Development

Transfer cases were developed by sourcing generation in the Oswego Complex. Power was sinked to major generation on the 345 kV network in western Massachusetts. For some configurations it was necessary to adjust imports from Ontario and Western New York. For base transfer conditions the bulk power system voltages were maintained in the .95-1.05 p.u. range.

To ensure full utilization of available reactive resources, the following actions were taken.

- All switched shunt capacitors were switched in so long as it did not cause excessively high voltage
- Generator and LTC voltage control parameters were adjusted to maintain adequate voltages. In some cases, where generator step up transformer ratios warranted, plant voltage settings were set higher than 1.05 p.u.

Voltage Contingency Evaluation

Figure 10 below lists the contingencies that were evaluated for each configuration studied.

Figure 10 – Central-East Contingencies

ID	Name	Description
ce01	Edic-Gordon Rd. 345	CE01 L/O EDIC- GORDON RD. (14)
ce02	Marcy-N.Scot 345	CE02 L/O MARCY-NEW SCOTLAND (18)
ce03	N.Scot-Leeds 345	CE03 L/O NEW SCOTLAND-LEEDS (94)
ce07	Marcy South N.	CE07 TWR NORTHERN MARCY SOUTH DBL CKT
ce08	Marcy South S.	CE08 TWR SOUTHERN-MARCY SOUTH DBL CKT
ce11	SBK Edic R140	CE11 STK EDIC R140 BKR 14&Edic 3/2&Prtr 3/1
ce13	Volney-Marcy	CE13 L/O VOLNEY-MARCY (VU-19)
ce15	SBK Marcy R3108	CE15 STK MARCY R3108 BKR VU-19&UE1-7
ce20	SBK Edic R70	CE20 STK EDIC R70 BRKR
ce30	SBK Princetown 345	CE30 STK PRINCETOWN BRKR G220 (361&371)
ce31	Princetown-N.Scot 345	CE31 L/O PRINCETOWN-NEW SCOTLAND (55)
ce32	361-362 Dlb Ckt Twr 345	CE32 TWR PRNCETWN-N.SCTLAND 361/362 DBL CKT
ce33	351-352 Dlb Ckt Twr 345	CE33 TWR EDIC-PRINCETOWN 351/352 DBL CKT
log09	Ravenswood 3	LOG09 L/O RAVENSWOOD 3
log15	Ph2 DC 1500	LOG15 L/O SANDY POND HVDC @ 1500 MW

Configuration Modeling

Figure 11 below lists the equipment outages that were modeled and studied. Figure 12 below lists the reactive devices modeled and studied.

Figure 11 – Central-East Line Outages

Equipment Status	ID	Voltage (kV)
0-5 Oswego Units IS	-	-
Fitz-Edic 1 O/S	FE-1	345
Edic-Gordon Rd 14 O/S	14	345
Gordon Rd-Rotterdam 30 O/S	30	345/230
Gordon Rd-Rotterdam 31 O/S	31	345/230
Massena-Marcy 1 O/S	MSU1	765
Marcy-New Scotland 18 O/S	18	345
Volney-Marcy 19 O/S	19	345
Princetown-New Scotland 55 O/S	55	345
Gordon Rd-Princetown 371 O/S	371	345
Princetown-New Scotland 361 O/S	361	345
Princetown-New Scotland 362 O/S	362	345

Figure 12 - Central-East Reactive Devices Studied

Equipment Status	ID	Voltage (kV)
Marcy-Coopers Corners SR IS	3722	345
Edic-Fraser SR IS	3822	345
Fraser-Coopers Corners SR IS	3322	345
Knickerbocker SC 1 Bypassed	RY5714	345
Knickerbocker SC 2 Bypassed	RY5715	345
Edic Cap O/S		345
Fraser Caps O/S (2)		345
Gilboa Cap O/S		345
Leeds Caps O/S (2)		345
Marcy Caps O/S (2)		345
New Scotland Caps O/S (3)		345
Oakdale Cap O/S		345
Rotterdam Caps O/S (2)		230
VanWagner Caps O/S (2)		345
Fraser SVC O/S		345
Leeds SVC O/S		345
Marcy STATCOM O/S		345

Monitored Buses

All buses in the Emergency Operations Manual A2 Bus List were monitored for pre-contingency and post-contingency low voltage limits.

Results

The Appendices contain all the tabular results. Due to the volume of material, the Appendices are a separate document. As an example, the results of the 3 Oswego units in-service base case analysis are presented here.

Figure 13 below shows the post-contingency flows for the most limiting contingencies for the 3 Oswego units in-service base case. From this graph the knees of the curves are identified. In this case the most limiting contingency is the loss of the UCC2-41/EF24-40 double-circuit (Marcy-South north end double circuit contingency).

Figure 13 - Post-Contingency Flows for 3 Oswego Units IS Base Case

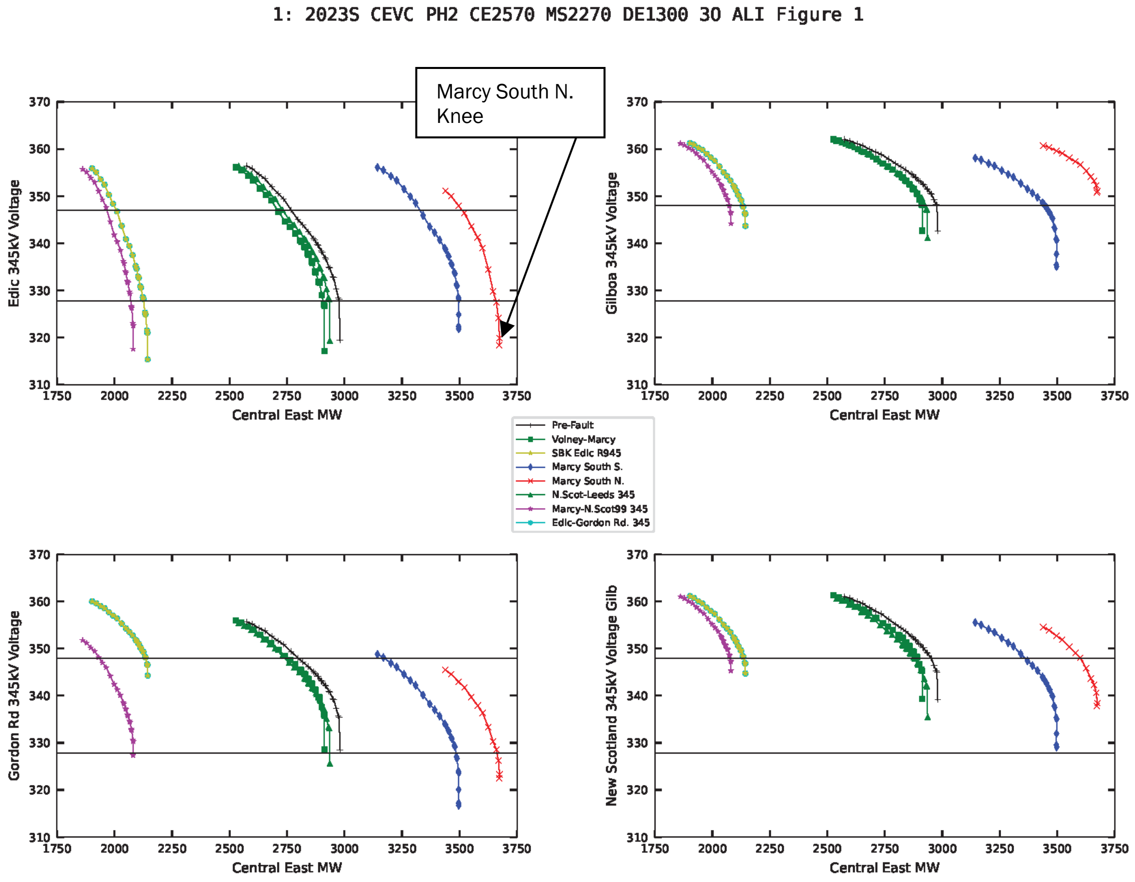


Figure 14 below shows the pre-contingency base flow with the respective post-contingency voltage for each of the most limiting contingencies. The graph is marked with at the MW level corresponding to the knee of the curve from the previous post-contingency plot. It is also marked at the MW level of the 5% margin of this knee. From this it can be seen that the 5% margin is more limiting than the post-contingency low voltage limit at Edic 345kV station.

Figure 14 - Pre-Contingency Flows for 3 Oswego Units IS Base Case

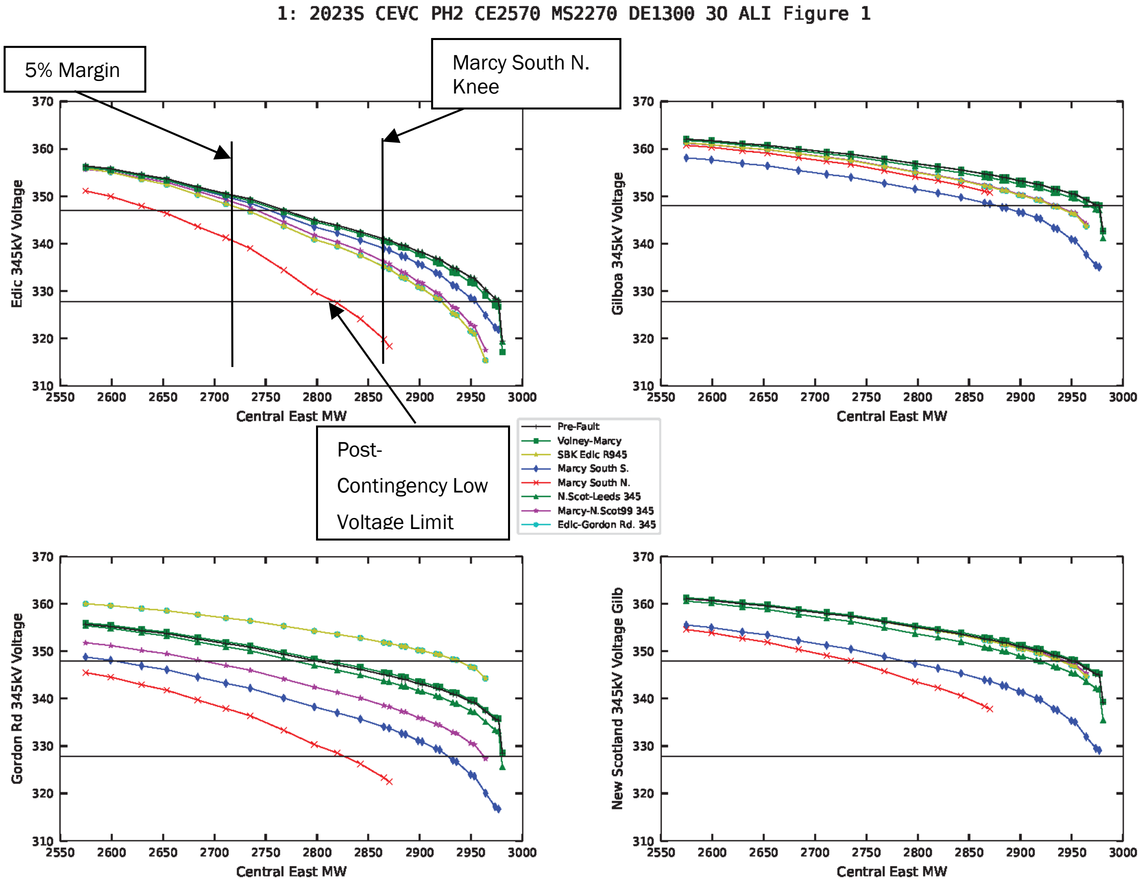


Figure 15 below shows the limits in tabular form listing the limiting elements in increasing value. The results of nearly every scenario suggest that flows may be limited in real-time operations by pre-contingency low voltage limits.

Figure 15 - Tabular Limit Results for 3 Oswego Units IS Base Case

Limit	<------------FACILITY------------>	<---CONTINGENCY--->
2721	limit with 5% margin	Marcy South N.
2755	Marcy 345kV Voltage	Pre-Fault
2768	Edic 345kV Voltage	Pre-Fault
2776	Gordon Rd 345kV Voltage	SBK Princetown 345
2789	limit with 5% margin	Ph2 DC 1500
2797	Gordon Rd 345kV Voltage	Pre-Fault
2805	limit with 5% margin	Marcy-N.Scot99 345
2805	limit with 5% margin	Marcy South S.
2815	limit with 5% margin	Edic-Gordon Rd. 345
2815	limit with 5% margin	SBK Edic R945
2816	Edic 345kV Voltage	Marcy South N.
2819	Marcy 345kV Voltage	Marcy South N.

All-Lines-In-Service Base Limits

Figure 16 below shows a comparison of the existing and new limits for the All-Lines-In-Service cases.

Figure 16 - Base Limits for Oswego AVR Status with All-Lines-In-Service

	Number of Oswego AVRs In-Service					
	0	1	2	3	4	5
New ALI Limit	2390	2480	2595	2720	2800	2885
Existing Limit	2365	2440	2530	2585	2640	2645
Change	25	40	65	135	160	240

Derates for Sithe Independence

Figure 17 below shows a comparison of the existing and new derates for Sithe Independence.

Figure 17 - Derates for Sithe Independence

	New Derates							Existing Derates							Change					
# Sithe Units IS	**# Oswego AVRs IS**																			
	0	1	2	3	4	5		0	1	2	3	4	5		0	1	2	3	4	5
0	460	405	290	280	260	220		345	325	300	190	165	60		115	80	-10	90	95	160
1	375	330	245	235	210	180		280	270	245	155	140	45		95	60	0	80	70	135
2	285	255	195	190	160	140		215	215	190	120	115	30		70	40	5	70	45	110
3	195	175	145	145	105	95		150	155	130	80	85	15		45	20	15	65	20	80
4	130	120	100	100	70	65		100	105	90	55	60	10		30	15	10	45	10	55
5	65	60	50	50	35	35		50	55	45	30	30	5		15	5	5	20	5	30
6	0	0	0	0	0	0		0	0	0	0	0	0		0	0	0	0	0	0

Derates for Athens

Figure 18 below shows a comparison of the existing and new derates for Athens.

Figure 18 - Derates for Athens

	New Derates							Existing Derates							Change					
# Athens Units IS	# Oswego AVRs IS																			
	0	1	2	3	4	5		0	1	2	3	4	5		0	1	2	3	4	5
0	10	20	30	80	75	130		40	55	60	35	90	100		-30	-35	-30	45	-15	30
1	0	0	20	55	40	90		35	45	35	25	55	60		-35	-45	-15	30	-15	30
2	0	0	10	20	25	75		5	15	15	0	25	25		-5	-15	-5	20	0	50
3	0	0	0	0	0	0		0	0	0	0	0	0		0	0	0	0	0	0

Derates for Reactive Devices

Figure 19 below shows a comparison of the existing and new derates for reactive devices on the system.

Figure 19 - Derates for Reactive Devices

Devices	New Derates	Existing Derates	Change
Edic Cap O/S	85	60	25
2 Fraser Caps O/S	40	60	-20
Gilboa Cap O/S	5	15	-10
2 Leeds Caps O/S	30	40	-10
2 Marcy Caps O/S	140	120	20
3 New Scotland Caps O/S	120	120	0
Oakdale Cap O/S	35	25	10
2 Rotterdam Caps O/S	110	130	-20
Marcy Statcom OON	70	50	20
Fraser SVC OON	30	35	-5
Leeds SVC OON	20	15	5
UCC2-41 SC Byp Open	135	130	5
EF24-40 SC Byp Open	90	70	20
FCC33 SC Byp Open	45	25	20

Derates for Existing Line Outages

Figure 20 below shows a comparison of the existing and new derates for existing line outages.

Figure 20 - Derates for Existing Line Outages

	New Derates						Existing Derates						Change					
Line O/S	# Oswego AVRs IS																	
	0	1	2	3	4	5	0	1	2	3	4	5	0	1	2	3	4	5
FE-1	145	145	145	145	145	145	105	105	105	105	105	105	40	40	40	40	40	40
14	860	885	920	990	1020	1050	800	825	860	890	890	880	60	60	60	100	130	170
MSU1	650	660	575	660	560	570	995	1005	850	865	830	790	-345	-345	-275	-205	-270	-220
18	880	910	970	1035	1075	1160	1030	1075	1140	1185	1220	1220	-150	-165	-170	-150	-145	-60
19	145	145	145	145	145	145	110	110	110	110	110	110	35	35	35	35	35	35
30 or 31	25	25	25	25	25	25	50	50	50	50	50	50	-25	-25	-25	-25	-25	-25
55	25	25	25	25	25	25	395	430	485	540	575	570	-375	-425	-470	-515	-560	-505
PV20	100	100	100	100	100	100	75	75	75	75	75	75	25	25	25	25	25	25
ING_PAR	120	120	120	120	120	120	75	75	75	75	75	75	45	45	45	45	45	45

New Derates

Figure 21 below shows new derates that were developed as a result of system configuration changes.

Figure 21 - New Derates

	Number of Oswego AVRs In-Service					
	0	1	2	3	4	5
Gordon Rd.-Princetown 371 O/S	285	310	310	425	485	565
Princetown-N.Scotland 361 or 362 O/S	30	30	30	30	30	30
VanWagner Caps O/S (2)	20	20	20	20	20	20
Knickerbocker RY5714 BYP (SC O/S)	50	50	50	50	50	50
Knickerbocker RY5715 BYP (SC O/S)	45	45	45	45	45	45