Central East Voltage Collapse and Stability Limits for Marcy South Series Capacitors ALL EQUIPMENT I/S

Report #: CE-16

A report from the New York Independent System Operator

March 17th, 2016

Executive Summary

This study was conducted to establish the voltage collapse and stability limits for the Central East with the Marcy-South series compensation in-service.

The study recommends that the Central East Voltage Collapse Limits be modified to:

a) introduce an new equipment derate of 235 MW to be employed when any series capacitor is in-service,

b) increase the existing equipment derates associated with Massena-Marcy 765 kV,

c) increase the existing equipment derates associated with Edic-New Scotland 345 kV and Marcy-New Scotland 345 kV line outages and

d) increase the existing derates associated with Independence unit outages

The new proposed Central East Voltage Collapse limits can be found on pages 5 through 7. The adjustments to the existing limits are found on page 18.

The study recommends that the Central East Stability Limits be modified to:

a) introduce a new equipment derate of 250 MW to be employed when any series capacitor is in-service,

b) update the existing stability limits, and

c) remove the stability limit associated with the outage of the Moses Generation Rejection RAS. All transfers limits were stable without the need for generation rejection

The new proposed Central East Stability Limits can be found on page 8. The adjustments to the existing limits are found on page 27.

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Central-East Voltage Collapse Transfer Limits
Component Values

Oswego Generating Complex[1] 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	2630	2755	2870	2975	3035	3085

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	470	390	305	205	140	100
1	380	315	250	170	115	80
2	285	240	190	130	85	55
3	190	160	130	90	55	30
4	130	110	90	60	40	20
5	65	55	45	30	20	10
6	0	0	0	0	0	0

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	25	50	45	70	75	80
1	15	20	35	45	40	35
2	10	15	10	25	10	15
3	0	0	0	0	0	0

[1] Commitment and I/S AVR status of Fitzpatrick, Nine Mile 1, Nine Mile 2, Oswego 5, Oswego 6

Central-East Voltage Collapse Transfer Limits
Component Values

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	225	185	165	150	125	120
EDIC____-N.SCTLND_345_14	25170	615	650	695	735	745	750
PORTER__-ROTTRDAM_230_30	25173	115	140	140	170	155	150
PORTER__-ROTTRDAM_230_31	25194	115	140	140	170	155	150
MASSENA_-MARCY____765_MSU1	25224	825	795	765	710	655	595
MARCY___-N.SCTLND_345_18	25276	725	780	835	885	885	910
VOLNEY__-MARCY____345_19	25345	140	140	140	150	135	145
INGHAM_C_115_115_PAR_2	25242	75	75	75	75	75	75
S HERO__-PLATSBRG_115_PV20	25027	75	75	75	75	75	75

Central-East Voltage Collapse Transfer Limits
Component Values

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

Reactive Device Name	PTID	Derate MWs
EDIC_PTR_345KV_CAP_CAP _1	31400	60
FRASER___345KV_CAP_CAP _1	31336	20
FRASER ___345KV_CAP_CAP _2	31345	20
GILBOA____345KV_CAP_CAP _1	31337	25
LEEDS ____345KV_CAP_CAP _1	31338	20
LEEDS____345KV_CAP_CAP _2	31346	20
MARCY____345KV_CAP_CAP _1	31339	60
MARCY____345KV_CAP_CAP _2	31353	60
N.SCTLND_345KV_CAP_CAP _1	31349	30
N.SCTLND_345KV_CAP_CAP _2	31342	30
N.SCTLND_345KV_CAP_CAP _3	31350	30
OAKDALE__ 345KV_CAP_CAP _1	31394	30
ROTTRDAM_230KV_CAP_CAP _3	31365	30
ROTTRDAM_230KV_CAP_CAP _4	31366	30
MARCY___345_STATCOM SVC	31395	50
FRASER__345_FRASER SVC	31328	40
LEEDS___345_LEEDS SVC	31327	25

Limit Derates for Capacitors (in-service)

Reactive Device Name	PTID	Derate MWs
MARCY_SOUTH_SERIES_CAPACITORS	323205	235

Table 1 Recommended Stability Limits

Recommended Central East Stability Limits*									
			StatCom O/S				StatCom I/S		
			Leeds/Fraser SVC Status				Leeds/Fraser SVC Status		
Oswego Units	Sithe Units		Both I/S	One I/S	Both O/S		Both I/S	One I/S	Both O/S
5	5		3100	3000	2950		3100	3100	3100
	3		3050	2950	2850		3050	3050	3050
	0		2900	2850	2850		2900	2900	2900
4	5		3050	2950	2950		3100	3100	3100
	3		3050	2950	2900		3050	3050	3050
	0		2850	2800	2700		2850	2850	2850
3	5		3050	2950	2950		3050	3050	3050
	3		3000	2950	2900		3050	3050	3050
	0		2800	2700	2700		2900	2900	2900
2	5		3000	2900	2850		3050	3050	3050
	3		2900	2850	2800		2950	2950	2950
	0		2750	2700	2650		2800	2800	2800
1	5		2650	2650	2650		2900	2900	2900
	3		2450	2450	2450		2750	2750	2750
	0		2400	2400	2400		2550	2550	2550
0	5		2200	2200	2200		2400	2400	2400
	3		2000	2000	2000		2200	2200	2200
	0		1750	1750	1750		1900	1950	1950

* The limits on the table are to be employed when the series compensation on the Marcy South circuit are out-of-service *(i.e.* bypassed). When any of the series compensation on the Marcy South is in-service 250 MW reduction is applied to all the limits.

2. Introduction

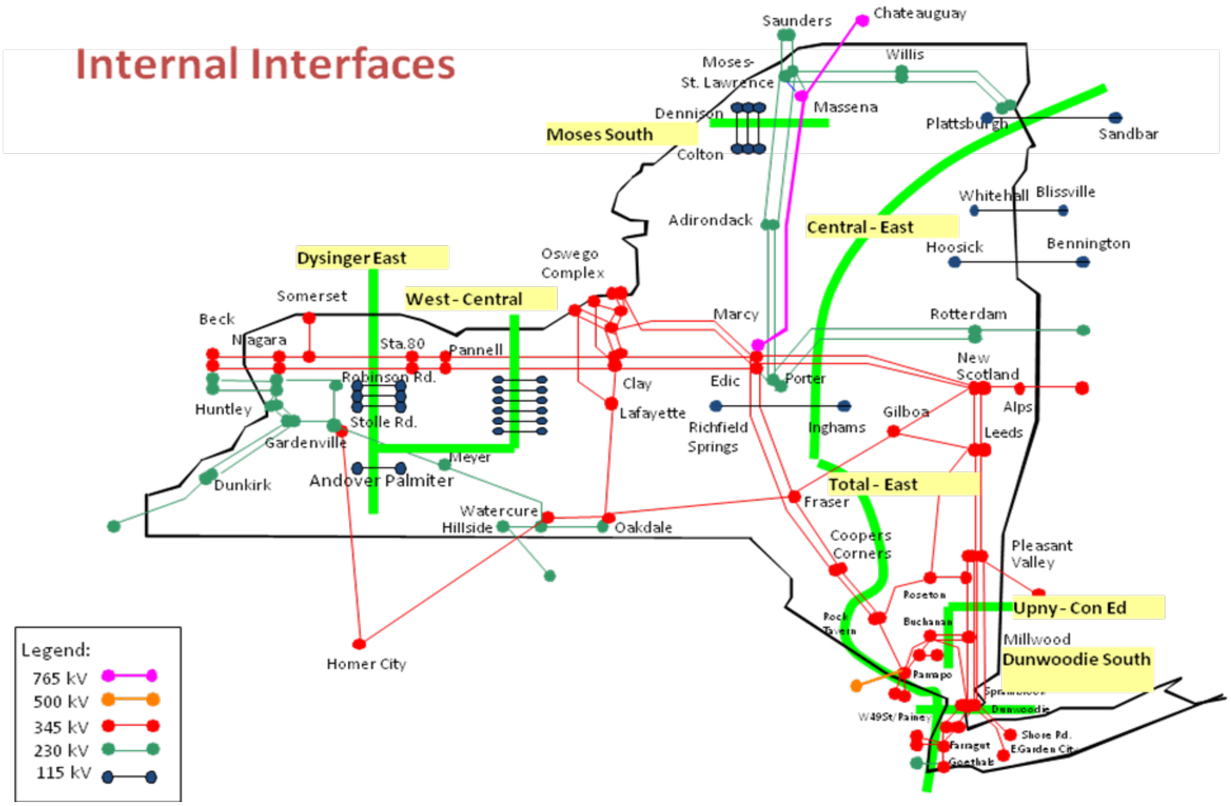
This report addresses a revaluation of the Central East interface transient stability limits for all-lines-in-service for the system with the series compensation on the Marcy South circuits both in and out of service. The geographic location of these interfaces is shown on the “Internal Interfaces” diagram below.

Table 2 Central East Interface definition

CENTRAL EAST		
Mohawk Valley (Zone E) – Capital (Zone F)		
Name	**Line ID**	**Voltage (kV)**
Edic-New Scotland*	14	345
Marcy-New Scotland*	18	345
Porter-Rotterdam*	30	230
Porter-Rotterdam*	31	230
East Springfield - Inghams*	942	115
Inghams PAR	PAR	115
Inghams Bus Tie	R81	115
North (Zone D) – ISONE (Zone N)		
*Plattsburgh - Grand Isle	PV-20	115

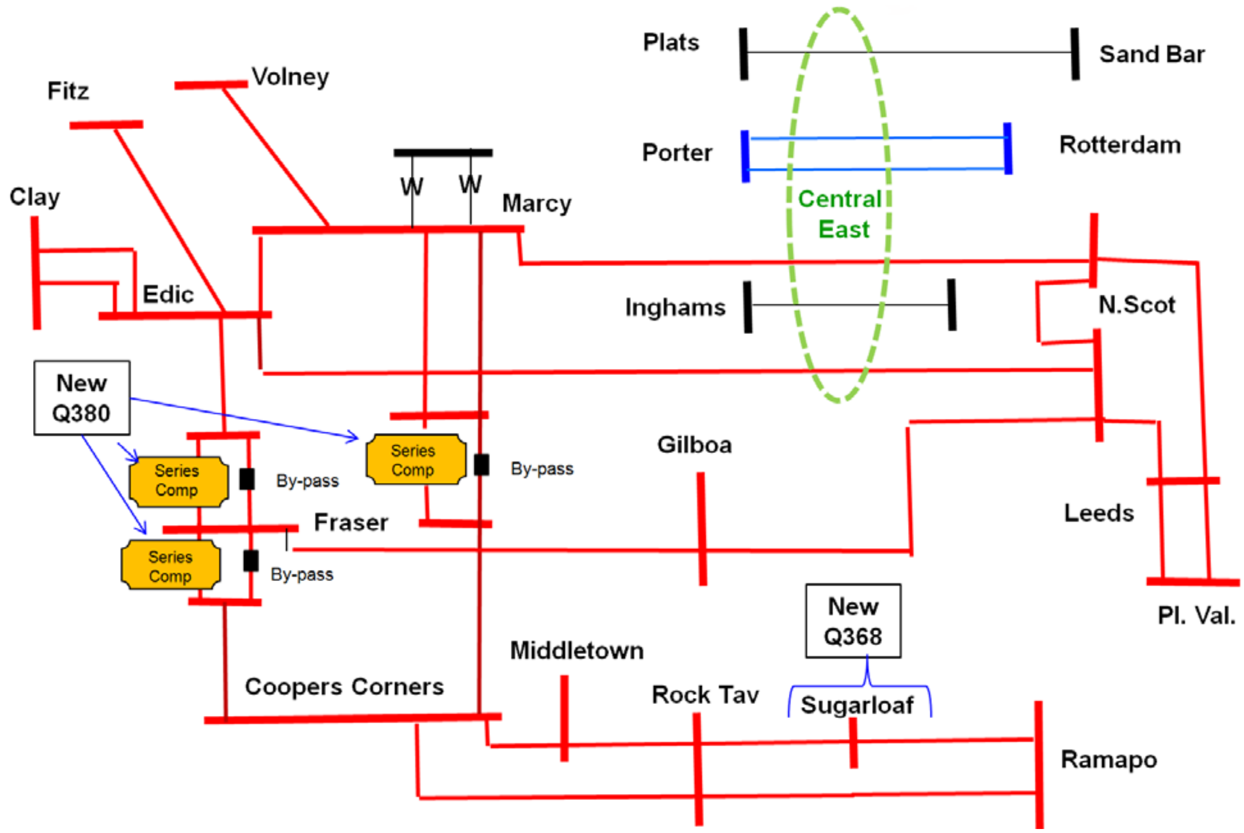
* indicates the metered end of the line.

Figure 1 NYISO Internal Interfaces



The Marcy South Series Capacitors are one of two upstate system enhancements associated with the Transmission Owner Transmission Solution (TOTS) project. The other system enhancement is the addition of a second Rock Tavern – Ramapo 345 kV circuit. The impacts of the series capacitors were evaluated in the System Impact Study for the Marcy South Series Compensation Project (NYISO – Queue #380). The impact of the second Rock Tavern Ramapo line was evaluated in the System Impact Study for Con Edison's Rock Tavern – Ramapo 345 kV Line 76 Project (NYISO – Queue #368). A high level system overview of the upstate elements of the TOTS project is shown in Figure 2.

Figure 2 Upstate TOTS Project Overview



3. System Representation

The stability analysis utilized the 2015 NYISO Operations Dynamics Base Case. The 2015 NYISO Operations Dynamics Base Case was developed from the NYISO Summer 2015 Operating Study base case for the New York representation and the 2014 series NERC/MMWG dynamic base case for the external network representation.

The NYISO load was modeled at **33,567 MW**.

The Summer Operating Study New York base case was modified with the following items;

- Model adjustments to add series compensation
- Addition of second RockTavern Ramapo 345 KV line and Sugarloaf 345 KV station
- Chateauguay HVDC taken out of service, Chateauguay transfers maintained with Beau units.
- SW 345 KV station (a.k.a. 5 Mile Station)
- Return of Dunkirk 3 & 4 units

The base case was established with a high transfer on Dysinger East (> 2900 MW) and Moses South (> 2700 MW) to provide a consistent frame of reference when adjusting Central East flow with Central generation. These base case flows both exceed the levels of flow observed over the past three years on Dysinger East and Moses South and constitute a stressed case for testing Central East.

The Voltage Collapse study was performed on a 2015 NYISO Summer Peak Operating Base Case with a NYISO load of 33,567 MW. The Summer 2015 NYISO Summer Operating Study was selected as the most recently reviewed case available.

Additions to the base case include:

- Transmission Owners Transmission Solutions (TOTS) projects
- New stations at Eastover Rd 230 kV, Mainesburg 345 kV, Farmer's Valley 345 kV and Five Mile Rd. 345 kV.

The initial base case was an all-lines-in-service representation with all Sithe Independence and Athens units in-service as well as Marcy South Series Compensation in-service (*i.e.,* bypass breakers open)

4. Interface Voltage Collapse Limits

4.1. 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 Central East Voltage Transfer Limits.

4.2. Transfer Case Development

To model the incremental increases in transfer, the following actions were taken:

- To minimize stress on the sub-345kV system, only generators closely connected to the 345kV system were utilized in power shifts.
- Two groups of generators were selected:
    - An area consisting of ISONE units in the Berkshires, plus Empire generating station in Capital, was created where generation would be decreased and become the power flow sink; and
    - An area consisting of Oswego units 5 & 6 (with AVRs out-of-service as appropriate) and Independence units 1-6.

4.3. Tested Contingencies

Table 3 Voltage Contingency Definitions lists the contingencies that were evaluated for each configuration studied.

Table 3 Voltage Contingency Definitions

Contingency	ID	Elements lost	Line IDs	Voltage (kV)
Edic-N.Scot 345	CE01	Edic-New Scotland	14	345
Marcy-N.Scot 345	CE02	Marcy - New Scotland	18	345
Marcy South N	CE07	Marcy-Coopers Edic –Fraser	UCC2-41 EF24-40	345 345
Marcy South S	CE08	Marcy –Coopers Fraser – Coopers	UCC2-41 33	345 345
Fitz-Edic-N.Scot	CE09	Fitzpatrick – Edic Edic - New Scotland	FE1 14	345 345
Volney- Marcy	CE13	Volney-Marcy	19	345
SBK Marcy R3108	CE15	Volney – Marcy Edic – Marcy	19 UEI7	345 345
Tower 34/42	CE18	Coopers -Rock Tavern Coopers – Middletown	CRT-42 CMT-34	345 345
SBK Edic R70	CE20	Edic – Marcy Edic Porter Transformer Edic Porter Transformer	UEI7 T2 T4	345 345/230 345/115
Ravenswood 3	LOG09	Ravenswood 3		
Seabrook 1	LOG11	Seabrook 1		
Ph2 DC 1500	LOG15	Sandy Pond HVDC @1500		
NS Bus 77-Alps	TE32	Edic - New Scotland New Scotland - Alps New Scotland - Leeds New Scotland Transformer	14 2 93 T2	345 345 345 345/115
NS Bus 99-Gilboa	TE33	Marcy - New Scotland New Scotland - Gilboa New Scotland - Leeds New Scotland Transformer	18 GNS-1 94 T1	345 345 345 345/115

4.4. Monitored Parameters

The following buses were monitored for pre-contingency low voltage limits for all-lines-in-service for all Oswego Complex configurations.

Table 4 Monitored Buses

Station Name	Voltage (kV)
Clay	345
Coopers Corners	345
Edic	345
Fraser	345
Gilboa	345
Leeds	345
Marcy	345
New Scotland	345

4.5. Limit Development Process

The Voltage Contingency Analysis Procedure (VCAP) is used to evaluate the steady state voltage performance of the power system for a series of system 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 was 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 and recording the post contingency voltage for severe contingencies, to the point where post contingency power flow no longer solves. The inability to obtain a post contingency power flow is the indication of a voltage collapse.

A voltage collapse transfer limit is defined by applying a 5% margin to the highest transfer where a post contingency power flow was attainable for all Central East contingencies. 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 that all analyses are 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.

The challenge in stressing Central East under peak load conditions with a series of equipment outages is getting sufficient power to Central which can be transmitted to East. The initial base case dispatch real power transfers were adjusted to stress conditions through:

- L33/34 PARs set to 500 MW
- Ontario generation set to attain a western import of ~1270 MW.
- 7040 flow set to 1,375 MW
- 200 MW import on Cedars-Dennison
- Sandbar PAR set to achieve 150MW flow on PV20
- Ontario-Michigan PARS set to maintain Lake Erie circulation to zero
- Interfaces at Dysinger-East interface and Moses-South stressed to 2,560.

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 0.95 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 exceed 1.06.

For base transfer conditions the bulk power system voltages were maintained in the 0.95-1.05 p.u. range.

4.6. Transfer Limit Tests

In addition to the all-lines-in-service base case, the following conditions were also modeled and evaluated:

- Variants of the base case are created for each scenario of Oswego Complex AVRs units in-service
- For each Oswego complex scenario the limit is evaluated for 0, 3 and 6 Sithe Independence units and 0, 1, 2, and 3 Athens units in-service
- For each Oswego complex scenario the limit is evaluated for the transmission facility outages listed in Table 5 Transmission Equipment Outages Evaluated.
- For each Oswego complex scenario the limit is evaluated for the reactive element outages listed in Table 6 Reactive Equipment Outages Evaluated.
- The two Porter-Rotterdam lines, 30 and 31, are electrically identical and only one VCAP run is performed with the results being applied to both lines.

Table 5 Transmission Equipment Outages Evaluated

Transmission Facility Name	Line ID
Fitzpatrick-Edic	FE1
Edic/Porter-N. Scotland	14
Edic/Porter-Rotterdam	30
Massena-Marcy	MSU1
Marcy-N. Scotland	18
Volney-Marcy	19

Table 6 Reactive Equipment Outages Evaluated

Reactive Equipment Name	# of Devices
Edic/Porter Capacitor	1
Fraser Capacitors	2
Gilboa Capacitor	1
Leeds Capacitors	2
Marcy Capacitors	2
New Scotland Capacitors	3
Oakdale Capacitor	1
Rotterdam Capacitors	2
Marcy STATCOM SVC	1
Fraser SVC	1
Leeds SVC	1

4.7. Discussion

With Marcy South Series Compensation in-service (*i.e.,* not bypassed) the effects of contingencies CE07 and CE 15 become more pronounced for certain configurations. The effect of the series capacitors is to shift power flows from Central-East to Marcy-South and thus magnify the effect of these two contingencies that directly impact availability of Marcy-South circuitry. In particular, the greatest effect is seen for configurations where dynamic resources are limited to Edic, such as when Sithe Independence is out-of-service, or when power flow is limited from Moses-South, such as when MSU-1 is out-of-service.

4.8. Voltage Limit Recommendations

Based on the analysis conducted, it is proposed that a new 235 MW equipment outage penalty be defined, which will apply when any of the bypasses on the Central East series capacitors are open. It is also recommended that certain voltage collapse limit derates are increased as shown below:

Table 7 Change in Equipment Derates

Change in Equipment Derates for CEVC w/MSSC IS						
	Number of Oswego AVRs IS					
Equipment Outage	**0**	**1**	**2**	**3**	**4**	**5**
0/6 Sithe Independence AVR IS	65	60	65	25	10	25
3/6 Sithe Independence AVR IS	15	25	25	20	5	15
Edic-N.Scotland 14-EN O/S	40					
Massena-Marcy MSU1 O/S	155	55	75	50	40	20
Marcy-N.Scotland 18-MNS O/S	35					

5. Interface Stability Limits

The stability transfer limit study for the Central East interface was conducted in accordance with the stability criteria indicated in NPCC Regional Reliability Reference Directory # 1 Design and Operation of the Bulk Power System Section 5.4.1 and the NYSRC Reliability Rules for Planning and Operating the New York State Power System Section E-R3.

The stability transfer limits were determined using the methodology cited in the NYISO Transmission Expansion and Interconnection Manual Attachment H NYISO Transmission Planning Guideline #3-1 Section 2.

Plots of the system response at the transfer test levels were reviewed by the NYISO Operating Studies Task Force.

The existing NYISO all-lines-in Central East Stability Limits prior to the enhancements evaluated in this study are provided on Table 8 Current all-lines-in Central East Stability Limits. Since the 1980s, Central East Stability Limits have been identified in terms of Oswego Complex units. The units included in the Oswego Complex are Nine Mile 1, Nine Mile 2, Fitzpatrick, Oswego 5 and Oswego 6. When this report refers to Oswego units it is referring to these units. The large combined cycle plant in the Oswego area is referred to as Sithe, and accounted for separately.

Table 8 Current all-lines-in Central East Stability Limits

		Central East Stability Analysis							
		Recommended Central East Stability Limit (Includes NYISO 10% Safety Margin)							
		STATCOM Out of Service				STATCOM In Service			
		Leeds/Fraser SVC Status				*Leeds/Fraser SVC Status*			
Oswego Units	*Sithe Units*	*Both I/S*	*One I/S*	*Both O/S*	*St.L G/R O/S*	*Both I/S*	*One I/S*	*Both O/S*	*St.L G/R O/S*
5	**5**	**3100**	**3000**	**2950**	**2700**	**3100**	**3050**	**3050**	**3050**
5	**3**	**3050**	**2950**	**2850**	**2700**	**3050**	**3050**	**3050**	**3050**
5	**0**	**2850**	**2800**	**2750**	**2700**	**2900**	**2850**	**2850**	**2850**
4	**5**	**3100**	**3000**	**2950**	**2700**	**3100**	**3100**	**3050**	**3050**
4	**3**	**3050**	**2950**	**2900**	**2700**	**3100**	**3050**	**3050**	**3050**
4	**0**	**2850**	**2800**	**2700**	**2700**	**2850**	**2850**	**2850**	**2850**
3	**5**	**3050**	**2950**	**2900**	**2700**	**3050**	**3050**	**3000**	**3000**
3	**3**	**3000**	**2950**	**2900**	**2700**	**3050**	**3050**	**3000**	**3000**
3	**0**	**2800**	**2800**	**2700**	**2700**	**2900**	**2900**	**2850**	**2850**
2	**5**	**3050**	**2900**	**2850**	**2800**	**3100**	**3050**	**3050**	**3000**
2	**3**	**2950**	**2850**	**2800**	**2800**	**3000**	**3000**	**3000**	**2850**
2	**0**	**2800**	**2700**	**2650**	**2650**	**2850**	**2850**	**2850**	**2850**
1	**5**	**2800**	**2800**	**2800**	**2800**	**2900**	**2900**	**2900**	**2900**
1	**3**	**2750**	**2700**	**2650**	**2650**	**2750**	**2750**	**2750**	**2750**
1	**0**	**2500**	**2500**	**2500**	**2500**	**2550**	**2550**	**2550**	**2550**
0	**5**	**2400**	**2400**	**2400**	**2400**	**2400**	**2400**	**2400**	**2400**
0	**3**	**2200**	**2200**	**2200**	**2200**	**2200**	**2200**	**2200**	**2200**
0	**0**	**1950**	**1950**	**1950**	**1950**	**1950**	**1950**	**1950**	**1950**

Source: Central East Voltage and Stability Analysis for Marcy FACTS Project – Phase I 4/11/01

5.1. Criteria Statement

This study is conducted in accordance with NYSRC Reliability Rules for Planning and Operating the New York State Power System, Section E-R3.

The following excerpt from attachment H “Guideline for Stability Analysis and Determination of Stability-Based Transfer Limits” of the NYISO Interconnection Manual addresses the potential for interaction between voltage based transfer limits and stability based transfer limits.

To confirm that power transfer levels will not be restricted by a stability constraint, the stability simulation shall be initially conducted at a value of at least ten percent above the controlling thermal or voltage-based transfer limit. The voltage-based transfer limit (“voltage transfer limit”) shall be determined in accordance with NYISO Transmission Planning Guideline #2, "Guideline for Voltage Analysis and Determination of Voltage-Based Transfer Limits." If a converged powerflow cannot be achieved at this higher transfer level, then the stability simulation shall be conducted at the highest achievable transfer level above the voltage transfer limit. If the stability simulation at that level is deemed to be stable, then voltage control facilities in the form of capacitive compensation shall be artificially added to the powerflow case to achieve a convergence at a transfer level equal to the voltage transfer limit divided by 0.90. This procedure ensures that the application of the margin does not result in the determination of a “stability limit” that is lower than the voltage transfer limit when the restriction is actually due to voltage. The amount and location of any such artificially added capacitive compensation shall be reported in the study results.

Stability limits shall be determined for interfaces on an independent basis. In doing so, it is recognized that interfaces for which the stability limit is not being determined may exceed their thermal, voltage or stability transfer capabilities.

5.2. Transfer Case Development

Central East transfers were developed from generation shifts between IESO and NYISO West (Zone A) through Central (Zone C) to Capital (Zone F), and ISO New England.

5.3. Tested Contingencies

Table 9 Tested Stability Contingencies

Contingencies – Single fault events	
CE01	3PH-NC@EDIC345 – L/O EDIC-NEW SCOTLAND #14 W/RCL
CE02	3PH-NC@MARCY345 – L/O MARCY-N.SCOTLAND (UNS-18) W/RCL
CE03	SLG-STK@EDIC345 (BKR R935) – L/O EDIC-N.SCOT #14 / BKUP CLR FE1
CE05	3PH-NC@EDIC345 – L/O EDIC-MARCY UE1-7
CE06	3PH-NC@MARCY345 – L/O EDIC-MARCY (UE1-7)
CE07Q380	LLG@MARCY/EDIC - L/O MARCY-COOPERS (UCC2-41) & EDIC-FRASER (EF24-40) DCT
CE08Q380	LLG@COOPERS - L/O MARCY-COOPERS (UCC2-41)/FRASER-COOPERS (FCC33) DCT
CE09	SLG-STK@EDIC345KV – L/O FITZ-EDIC #FE-1/BKUP CLR#14
CE10	SLG-STK@MARCY345 (BKR3308) – L/O MARCY-N.SCOT (UNS-18)
CE11	SLG-STK@FRASER345 (BKR B1/3562) – L/O FRASER-GILBOA (GF-5)
CE12	3PH-NC@NSCOT345 – L/O EDIC-N.SCOT #14 W/H.S RCL
CE13	3PH-NC@VOLNEY345 – L/O VOLNEY-MARCY (VU-19)
CE14	3PH-NC@MARCY345 – L/O VOLNEY-MARCY (VU-19)
CE15	SLG-STK@MARCY345(BKR 3108) – L/O VOLNEY-MARCY (VU-19) / BKUP CLR#UE1-7
CE16Q380*	SLG-STK@EDIC345 (BKR R915) – L/O EDIC-FRASER (EF24-40) / BKUP CLR#2-15
CE17Q380	SLG-STK@MARCY(BKR 3208)- L/O MARCY-COOPERS(UCC2-41)
CE18Q368**	LLG@ROCK – L/O COOPERS CORNERS-ROCK TAVERN DCT
CE19Q368	LLG@COOPERS – L/O COOPERS CORNERS-ROCK TAVERN DCT
CE20	SLG-STK@EDIC345 (BKR R70) – L/O EDIC-MARCY UE1-7/ BKUP CLR EDIC T2 & T4
CE21Q380	SLG-STK@FRASER – L/O FRASER-COOPERS 33 / BKUP CLR#32@OAKDALE
CE22Q380	3PH-NC@EDIC345 – L/O EDIC-FRASER EF-24/40
CE23Q380	LLG@FRASER – L/O MARCY-COOPERS(UCC2-41)/EDIC-FRASER(EF24-40) DCT
CE24Q380	3PH-NC@FRASER – L/O FRASER-COOPERS CORNERS FCC-33
CE25Q380	3PH-NC@COOPERS – L/O FRASER-COOPERS CORNERS FCC-33
CE26Q380	3PH-NC@COOPERS – L/O MARCY-COOPERS CORNERS UCC-2/41
CE27	3PH-NC@COOPERS – L/O COOPERS CORNERS-ROCK TAVERN CCRT-34
CE27AR	3PH-NC@COOPERS – L/O COOPERS CORNERS-ROCK TAVERN CCRT-34 W/RCL
CE28	3PH-NC@COOPERS – L/O COOPERS CORNERS-ROCK TAVERN CCRT-42
CE28AR	3PH-NC@COOPERS – L/O COOPERS CORNERS-ROCK TAVERN CCRT-42 W/RCL
CE32Q380	3PH-NC@FRASER – L/O EDIC - FRASER EF-24/40
CE33	3PH-NC@FITZ – L/O EDIC - FITZPATRICK FE-1
CE99	SLG-STK@SCRIBA345 (BKR R935) – L/O SCRIBA-VOLNEY 21 / BKUP CLR FITZ-SCRIBA #10
MS02	3PH-NC@MOSES230 – L/O MOSES-ADIR W/NO REJ.
MS150	LLG@MOSES230 – L/O MOSES-ST.LAWRENCE L33/34P DCT W/NO REJ
NE01	3PH-NC@SEABROOK345 – L/O SEABROOK G1
NE03	L/O PHASE II INTERCONNECTION W/O FAULT (N-1)

	Contingencies – Multi Reclose Events
CE01AR	3PH-NC@EDIC345 – L/O EDIC-NEW SCOTLAND #14 W/HS&AUTO RCL
CE07ARQ380	LLG@MARCY/EDIC - L/O MAR-COOPERS (UCC2-41) & EDIC-FR (EF24-40) DCT W/RCL
CE08ARQ380	LLG@COOPERS – L/O MARCY-COOPERS (UCC2-41)/FRASER-COOPERS (FCC33) DCT
CE18ARQ368	LLG@ROCK – L/O COOPERS CORNERS-ROCK TAVERN DCT W/ RCL
CE19ARQ368	LLG@COOPERS – L/O COOPERS CORNERS-ROCK TAVERN DCT W/ RCL
CE22ARQ380	3PH-NC@EDIC345 – L/O EDIC-FRASER EF-24/40 W/RCL@FRASER
CE23ARQ380	LLG@FRASER – L/O MARCY-COOPERS(UCC2-41)/EDIC-FRASER(EF24-40) DCT W/RCL
CE24ARQ380	3PH-NC@FRASER – L/O FRASER-COOPERS CORNERS FCC-33 W/RCL
CE27AR	3PH-NC@COOPERS – L/O COOPERS CORNERS-ROCK TAVERN CCRT-34 W/RCL
CE28	3PH-NC@COOPERS – L/O COOPERS CORNERS-ROCK TAVERN CCRT-42
CE28AR	3PH-NC@COOPERS – L/O COOPERS CORNERS-ROCK TAVERN CCRT-42 W/RCL
CE32Q380	3PH-NC@FRASER – L/O EDIC - FRASER EF-24/40
CE33	3PH-NC@FITZ – L/O EDIC - FITZPATRICK FE-1
CE99	SLG-STK@SCRIBA345 (BKR R935) – L/O SCRIBA-VOLNEY 21 / BKUP CLR FITZ-SCRIBA #10
MS02	3PH-NC@MOSES230 – L/O MOSES-ADIR W/NO REJ.
MS150	LLG@MOSES230 – L/O MOSES-ST.LAWRENCE L33/34P DCT W/NO REJ
NE01	3PH-NC@SEABROOK345 – L/O SEABROOK G1
NE03	L/O PHASE II INTERCONNECTION W/O FAULT (N-1)

Notes:

* The Q380 denotes that this fault deck has been modified to accommodate the series capacitors

** The Q368 denotes that this fault deck has been modified to accommodate the second Rock Tavern Ramapo line.

5.4. Monitored Parameters

Reporting for this report focuses on the post contingency voltage response at Edic 345 kV and the reactive responses of the dynamic voltage response resources in central New York.

5.5. Limit Development Process

The stability transfer limits indicated in this study were developed in accordance with the NYISO Transmission Expansion and Interconnection Manual Attachment H, NYISO Transmission Planning Guideline #3-1, Section 2 excerpted below:

> ***2 TRANSFER LEVEL***
>
> *The determination of interface transfer limits requires the consideration of thermal, voltage and stability limitations. When determining a stability limit, a margin also shall be applied to the power transfer level to allow for uncertainties associated with system modeling. This margin shall be the largest of ten percent of the highest stable transfer level simulated or 200 MW. The margin also shall be applied in establishing a stability limit for faults remote from the interface for which the power transfer limit is being determined.*
>
> *To confirm that power transfer levels will not be restricted by a stability constraint, the stability simulation shall be initially conducted at a value of at least ten percent above the controlling thermal or voltage-based transfer limit. The voltage-based transfer limit ("voltage transfer limit") shall be determined in accordance with NYISO Transmission Planning Guideline #2, "Guideline for Voltage Analysis and Determination of Voltage-Based Transfer Limits." If a converged powerflow cannot be achieved at this higher transfer level, then the stability simulation shall be conducted at the highest achievable transfer level above the voltage transfer limit. If the stability simulation at that level is deemed to be stable, then voltage control facilities in the form of capacitive compensation shall be artificially added to the powerflow case to achieve a convergence at a transfer level equal to the voltage transfer limit divided by 0.90. This procedure ensures that the application of the margin does not result in the determination of a "stability limit" that is lower than the voltage transfer limit when the restriction is actually due to voltage. The amount and location of any such artificially added capacitive compensation shall be reported in the study results.*
>
> *Stability limits shall be determined for interfaces on an independent basis. In doing so, it is recognized that interfaces for which the stability limit is not being determined may exceed their thermal, voltage or stability transfer capabilities.*

To assess the stability performance of the bulk power system, system stability and generator unit stability shall be considered.

2.1 System Stability

Overall power system stability is that property of a power system which ensures that it will remain in operating equilibrium through normal and abnormal conditions. The bulk power system shall be deemed unstable if, following a disturbance, the stability analysis indicates increasing angular displacement between various groups of machines characterizing system separation. Further, a power system exhibits "oscillatory instability" (sustained or cumulative oscillations) for a particular steady-state operating condition if, following a disturbance, its instability is caused by insufficient damping torque.

For a stability simulation to be deemed stable, oscillations in angle and voltage must exhibit positive damping within ten seconds after initiation of the disturbance. If a secondary mode of oscillation exists within the initial ten seconds, then the simulation time shall be increased sufficiently to demonstrate that successive modes of oscillation exhibit positive damping before the simulation may be deemed stable.

2.2 Generator Unit Stability

A generator is in synchronous operation with the network to which it is connected if its average electrical speed (the product of its rotor angular velocity and the number of pole pairs) is equal to the angular frequency of the alternating current network voltage.

For those cases where the stability simulation indicates generator unit instability, the NYISO shall determine whether a power transfer limit shall be invoked or whether the unit instability shall be considered to be acceptable. To determine whether the generator unit instability may be deemed acceptable, the stability simulation shall be re-run with either the generator unit in question tripped due to relay action or modeled unstable to assess such impact on overall bulk power system performance. The result of this latter simulation shall determine whether a stability-based transfer limit shall be applied at the simulated power transfer level.

5.6. Transfer Limit Testing

The Central East stability limits are tested within each individual section:

- both Leeds and Fraser SVCs in-service,
- one of either Leeds or Fraser SVC in-service, and
- both Leeds and Fraser SVCs out–of-service.

Transfer test level power flow *cases* developed using the 2015 NYISO Dynamics Base Case power flow case and fifty-four (54) contingencies were applied to the boundary power flow case to evaluate system stability. The most responsive contingencies were then evaluated over the remainder of the transfer cases.

All Central East contingencies listed on Table 9 Tested Stability Contingencies were tested for the following high and low available dynamic voltage response scenarios:

- Three Oswego, five Sithe and the Marcy StatCom in-service; Leeds SVC, Fraser SVC out-of-service
- Two Oswego, zero Sithe, and the Marcy StatCom in-service; Leeds SVC, Fraser SVC out-of-service

The contingencies that resulted in the largest continuing oscillation of Edic voltage after 15 seconds were employed to determine all the proposed limits presented on Table 1 Recommended Stability Limits.

5.7. Discussion

Comparison of system responses with the series compensation bypassed

With the series compensation bypassed, the limits are defined by highest attainable transfer and identifiable damping. The updates to the base Central East stability limits, prior to implementation of the series compensation are shown below on Table 10 Updates to the Existing Stability Limits with the Series Caps Bypassed

Table 10 Updates to the Existing Stability Limits with the Series Caps Bypassed

# of Oswego	# of Sithe	StatCom O/S									StatCom I/S								
		Both SVCs I/S			One SVC O/S			Both SVCs O/S			Both SVCs I/S			One SVCO/S			Both SVCs O/S		
		Current	Tested	Diff	Current	Tested	Diff	Current	Tested	Diff	Current	Tested	Diff	Current	Tested	Diff	Current	Tested	Diff
5	5	3100	3100	0	3000	3000	0	2950	2950	0	3100	3100	0	3050	3100	50	3050	3100	50
	3	3050	3050	0	2950	2950	0	2850	2850	0	3050	3050	0	3050	3050	0	3050	3050	0
	0	2850	2900	50	2800	2850	50	2750	2850	100	2900	2900	0	2850	2900	50	2850	2900	50
4	5	3100	3050	-50	3000	2950	-50	2950	2950	0	3100	3100	0	3100	3100	0	3050	3100	50
	3	3050	3050	0	2950	2950	0	2900	2900	0	3100	3050	-50	3050	3050	0	3050	3050	0
	0	2850	2850	0	2800	2800	0	2700	2700	0	2850	2850	0	2850	2850	0	2850	2850	0
3	5	3050	3050	0	2950	2950	0	2900	2950	50	3050	3050	0	3050	3050	0	3000	3050	50
	3	3000	3000	0	2950	2950	0	2900	2900	0	3050	3050	0	3050	3050	0	3050	3050	0
	0	2800	2800	0	2800	2700	-100	2700	2700	0	2900	2900	0	2900	2900	0	2850	2900	50
2	5	3050	3000	-50	2900	2900	0	2850	2850	0	3100	3050	-50	3050	3050	0	3050	3050	0
	3	2950	2900	-50	2850	2850	0	2800	2800	0	3000	2950	-50	3000	2950	-50	3000	2950	-50
	0	2800	2750	-50	2700	2700	0	2650	2650	0	2850	2800	-50	2850	2800	-50	2850	2800	-50
1	5	2850	2750	-100	2800	2750	-50	2800	2750	-50	2900	2900	0	2900	2900	0	2900	2900	0
	3	2750	2550	-200	2700	2550	-150	2650	2550	-100	2750	2750	0	2750	2750	0	2750	2750	0
	0	2500	2500	0	2500	2500	0	2500	2500	0	2550	2550	0	2550	2550	0	2550	2550	0
0	5	2400	2300	-100	2400	2300	-100	2400	2300	-100	2400	2400	0	2350	2400	50	2400	2400	0
	3	2200	2100	-100	2200	2100	-100	2200	2100	-100	2200	2200	0	2200	2200	0	2200	2200	0
	0	1950	1850	-100	1950	1850	-100	1950	1850	-100	1900	1900	0	1950	1950	0	1950	1950	0

Limiting Contingencies

The most severe contingency related to Central East stability continues to be CE-15, a fault on the Marcy-Volney line which results in the back-up clearing of the Edic-Marcy 345 kV line. This is the same contingency that defines the Central East voltage collapse limit.

Other contingencies that merit monitoring on Central East are CE-05, CE-07, and MS-150. Contingencies CE-05 with a fault on Edic-Marcy 345 kV line, CE-07 with faults on Marcy-Coopers and Edic-Fraser 345 kV lines, and MS-150 with fault on Moses – St. Lawrence 230 kV interconnection between St. Lawrence/FDR (NY) and St. Lawrence/Saunders (Ontario).

The previous analysis indicated that when both the Leeds and Fraser SVCs are *not* available, there were configurations where the most severe contingency for Central East transfers is a phase-phase-ground fault (MS150) on the New York-Ontario 230kV interconnections between St. Lawrence/FDR (NY) and St. Lawrence/Saunders (Ontario), circuits L33P and L34P and generation rejection was required. All configurations tested stable for MS-150 contingency without the series compensation in-service. This is consistent with the findings of the recently completed Moses South stability limits

<u>Comparison of system responses with the series compensation in-service</u>

The most severe contingency is relating to Central East stability with the series compensation in-service is continues to be CE-15.

Other contingencies that merit monitoring on Central East are CE-05, CE-07, and MS-150. Contingencies CE-05 with a fault on Edic-Marcy 345 kV line, CE-07 with faults on Marcy-Coopers and Edic-Fraser 345 kV lines, and MS-150 with fault on Moses – St. Lawrence 230 kV interconnection between St. Lawrence/FDR (NY) and St. Lawrence/Saunders (Ontario).

All configurations tested stable for MS-150 with the series compensation in-service.

5.8. Stability Limit Recommendations

The Central East Stability Transfer Limit analysis was conducted for the system configuration with all the upstate TOTS system enhancements in-service. Base limits for the new configuration were calculated. The base limits were observed to decline over the range of 50 - 350 MW over all the combinations of available reactive resources.

For the limited instances where a 350 MW derate was required, a 100 MW derate was applied to the base limit (0 and 1 Oswego, with StatCom O/S)

A 250 MW reduction will be applied to all base stability limits when any of the series compensation is in-service.

The stability limits associated with the outage of the Moses Generation Rejection RAS will be removed.

The updated Central East stability limits will be revised as noted in Table 1 Recommended Stability Limits, on page 8.