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Independent System Operator

2019 CARIS 70x30 Scenario: Preliminary Base Load Constraint Modeling, Nuclear Sensitivity and Additional Results

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Agenda

- Scenario Background, Approach, and Assumptions
- Preliminary Relaxed and Constrained Case Results
- Preliminary Nuclear Sensitivity Results
- Generation Pocket Analysis and Congestion Summary
- Fossil Fleet Operations
- Next Steps

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Scenario Background, Approach, and Assumptions

Background

- **Previously presented at ESPWG**
  - September 11, 2019
    - CARIS Preliminary 70 x 30 Scenario Development
  - October 4, 2019
    - CARIS Scenario Load Forecast Development
    - CARIS 1 70x30 Scenario ESR Modeling
  - October 23, 2019
    - CARIS 70x30 Scenario Assumptions and Calculation
  - November 18, 2019
    - Preliminary Scenario Results (High/Low Gas Prices and Loads)
  - February 27, 2020
    - Review of Assumptions and Resource Mix
  - March 16, 2020
    - Preliminary Constraint Modeling, Nuclear Sensitivity and Additional Results

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“70 by 30” Scenario

- The study will identify opportunities for transmission investment to un-bottle renewable energy to enable the state’s renewable energy production goals.
- The Climate Leadership and Community Protection Act (CLCPA) requires that a minimum of 70% of New York end-use electrical energy requirements shall be generated by renewable energy systems in 2030.

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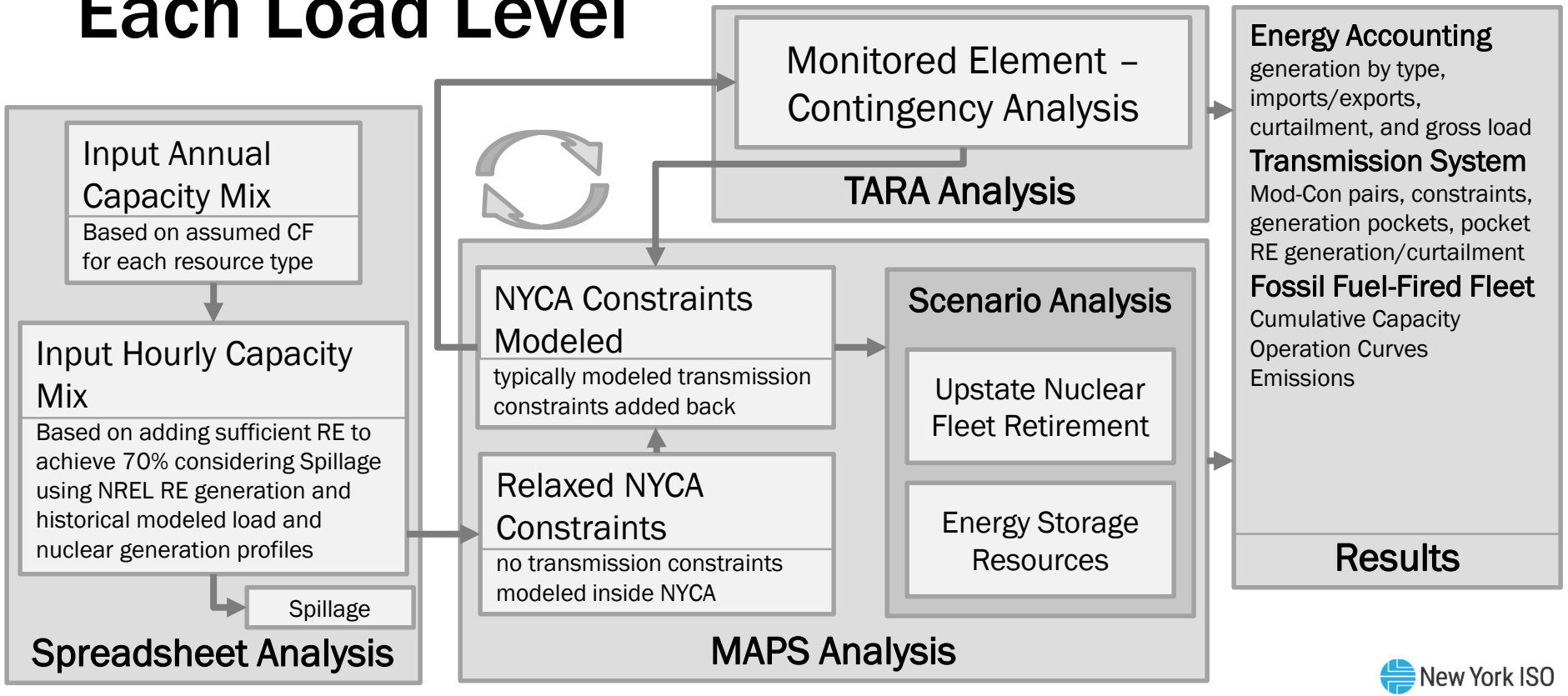
Scenario Study Approach

- **Develop assumptions for the major drivers that could impact transmission congestion patterns**
  - Develop 70x30 Scenario Load Forecast for comparison with the Base Case Forecast
  - Add renewable generation to approximate achievement of 70% renewable energy target for each load forecast, considering renewable energy "spillage" (*i.e.*, generation exceeds load)
- **Evaluate system production under "relaxed" conditions**
  - Model the resulting resource mix in GE-MAPS without internal NYCA transmission system constraints to establish a baseline of what the system "wants to do" when there are no transmission constraints
- **Evaluate the impact of transmission constraints on renewable energy production for the assumed renewable resource mix**
  - Identify transmission constraints that cause renewable curtailments (*i.e.*, renewable generation pockets)
  - Quantify the magnitude and frequency of the curtailments for each assumed resource mix
- **Sensitivity analysis to understand impact to system production and transmission constraints**
  - Sensitivity analysis of retirement of the entire nuclear fleet
  - Sensitivity analysis of 3,000 MW of Energy Storage Resources (ESR)

Annual Load (GWh)	A	B	C	D	E	F	G	H	I	J	K	NYCA
Base Case Load	14,590	9,695	15,394	5,337	7,095	11,312	9,544	2,807	5,881	51,749	19,608	153,012
70x30 Scenario Load	13,034	7,757	12,626	5,101	5,694	9,654	7,911	2,848	5,952	46,354	19,026	135,958

Scenario Study Approach Diagram For Each Load Level



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Renewable Addition Locations

- **Injection points are assumed to be the closest existing substations based on interconnection points from the NYISO Interconnection Queue**
- **Study Assumptions:**
  - UPV: 73 sites, injecting at various voltage levels from 345 kV – 115 kV
  - LBW: 30 sites, injecting at various voltage levels from 345 kV – 115 kV
  - OSW: 7 sites, injecting at 345 kV in Zone J and 138 kV – 69 kV in Zone K
  - Hydro imports: 1 site, injecting at 345 kV in Zone J (generic 1,310 MW HVDC)
- **Excel file containing modeled project details included with today's meeting materials**

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Considerations Outside the Scope of Assessment

- **This is NOT an interconnection study. System and substation specific upgrades will be identified based on project proposals in the interconnection process.**
- **The assessment did not review:**
  i. N-1-1 contingencies
  ii. Voltage or stability impacts
  iii. Year-round deliverability of energy or capacity to loads
  iv. Impact to the New York system reserve margin

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Modeling of Fossil Generation

- **Reasons why fossil generation runs in the model:**
  - Serve load in the absence of sufficient renewable resources
  - Meet locational reserve requirements
  - Meet Local Reliability Rules
  - Serve steam contracts
  - Operational limitations such as min. gen levels and min. runtime
- **Operational considerations not modeled in MAPS:**
  - Ramp rates and real-time sub-hourly variations
  - Energy and Ancillary Service co-optimization
  - Fuel availability or gas system constraints

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Zonal Wind and Solar Total 2030 Capacity (MW)

70x30 Scenario Load

2030 MW	OSW	LBW	UPV	BTM-PV
A		1,640	3,162	995
B		207	361	298
C		1,765	1,972	836
D		1,383		76
E		1,482	1,247	901
F			2,563	1,131
G			1,450	961
H				89
I				130
J	4,320			950
K	1,778		77	1,176
NYCA	6,098	6,476	10,831	7,542

Base Load

2030 MW	OSW	LBW	UPV	BTM-PV
A		2,286	4,432	995
B		314	505	298
C		2,411	2,765	836
D		1,762		76
E		2,000	1,747	901
F			3,592	1,131
G			2,032	961
H				89
I				130
J	4,320			950
K	1,778		77	1,176
NYCA	6,098	8,772	15,150	7,542

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Preliminary Case Results: Annual Energy

- Sample Weeks in Appendix

Annual Case Overview MAPS Output for 70x30 Scenario Cases

- Monthly values posted with today's meeting materials as excel file

Energy (GWh)	Base Case	ScenarioLoad Relaxed	ScenarioLoad Constrained	ScenarioLoad Constrained NuclearRetired	BaseLoad Relaxed	BaseLoad Constrained	BaseLoad Constrained NuclearRetired
Nuclear	27,091	27,435	27,433	-	27,436	27,433	-
Other	2,368	2,164	2,110	2,270	2,158	2,102	2,263
Fossil	69,028	26,390	28,185	42,924	31,268	35,181	49,448
Hydro	28,832	28,082	28,050	28,448	27,974	28,020	28,413
Hydro Imports	11,564	19,803	19,775	19,897	19,780	19,769	19,910
LBW	5,038	13,960	13,290	14,879	19,243	17,117	18,751
OSW	-	22,775	21,625	21,714	22,656	21,592	21,750
UPV	115	14,764	12,666	14,527	21,782	17,982	19,342
BTM-PV	4,988	9,269	9,266	9,356	9,302	9,327	9,359
Pumped Storage	(447)	(878)	(822)	(988)	(930)	(868)	(959)
Storage	-	-	-	-	-	-	-
IESO Net Imports	(2,862)	(5,550)	(5,817)	(4,090)	(6,030)	(6,250)	(4,264)
ISONE Net Imports	(535)	(7,791)	(6,418)	(4,385)	(6,710)	(5,073)	(2,867)
PJM Net Imports	12,239	(5,479)	(4,446)	287	(5,996)	(4,528)	591
Renewable Generation	50,537	108,653	104,672	108,821	120,736	113,808	117,525
Curtailment	0	6,239	10,151	6,069	7,124	14,020	10,338
Non-Renewable Generation	98,488	55,990	57,728	45,194	60,861	64,717	51,712
GrossLoad	157,418	144,948	144,897	144,838	161,934	161,807	161,733

Transmission System Modeling of Generation Pockets

RE Pocket Study Methodology

- The generation pockets with constrained transmission lines resulting from renewable generation injections were identified, as well as the MW levels of curtailments of the renewable generation.
- The binding constraints were grouped into “pockets” to identify the transmission constrained renewable generation.
- Two projected load conditions for year 2030 were simulated and analyzed to provide a probable outcome.
- The resulting renewable pockets serve as indicative potential transmission bottlenecks.

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Preliminary Constrained Case Results: Congestion Summary

- Nuclear Retired Cases in Appendix

Preliminary Constrained Case Bulk Level Congestion Summary

Congested Hours	Base Case	Scenario Load	Base Load
CENTRAL EAST	878	1,947	1,972
TIE-LINES: NORTH -VT	5,756	8,113	8,014
NorthTie: OH-NY	3,563	8,751	8,755
NEW SCOTLAND KNCKRBOC	28	611	687
DUNWOODIE TO LONG ISLAND	6,953	5,998	5,803
ISONE-NYISO	1,102	2,519	2,035
PRNCTWN NEW SCOTLAND	-	342	482
SUGARLOAF 138 RAMAPO 138	-	906	1,365
GREENWOOD	4,471	5,122	5,955
PJM-NYISO	2,045	4,417	4,295
EGRDNCTY 138 VALLYSTR 138 1	5,074	5,300	5,668
RAINEY VERNON	421	2,382	2,775
MOTTHAVEN RAINEY	275	116	144
FARRAGUT GOWANUS	-	2,273	2,250
DUNWOODIE MOTTHAVEN	2,349	154	669
E179THST HELLGT ASTORIAE	1,285	1,031	1,402
CRICKET VALLEY PLSNTVLY	1,056	38	91
N.WAVERLY LOUNS	2,049	805	1,457
LOUNS STAGECOA	45	54	34

Constraint Pockets

- **Pocket X: Northern NY Constraints**
  - X1: North Area Wind (mainly 230 kV in Clinton County)
  - X2: Mohawk Area Wind & Solar(mainly 115 kV in Lewis County)
  - X3: Mohawk Area Wind & Solar (115 kV in Jefferson & Oswego Counties)
- **Pocket Y: Eastern NY Constraints**
  - Y1: Capital Region Solar Generation(115 kV in Montgomery County)
  - Y2: Hudson Valley Corridor (115 kV)
- **Pocket Z: Southern Tier Constraints**
  - Z1: Finger Lakes Region Wind & Solar (115 kV)
  - Z2: Southern Tier Transmission Corridor(115kV)
  - Z3: Central and Mohawk Area Wind and Solar(115kV)
- **Pocket W: Western NY Constraints**
  - W1: Niagara-Orleans-Rochester Wind (115 kV)
  - W2: Buffalo Erie region Wind & Solar(115 kV)
  - W3: Chautauqua Wind & Solar(115kV)
- **NYC Constraints**
  - Offshore Wind Generation in Staten Island Load Pockets
- **LI Constraints**
  - Offshore Wind Generation in Holbrook Area

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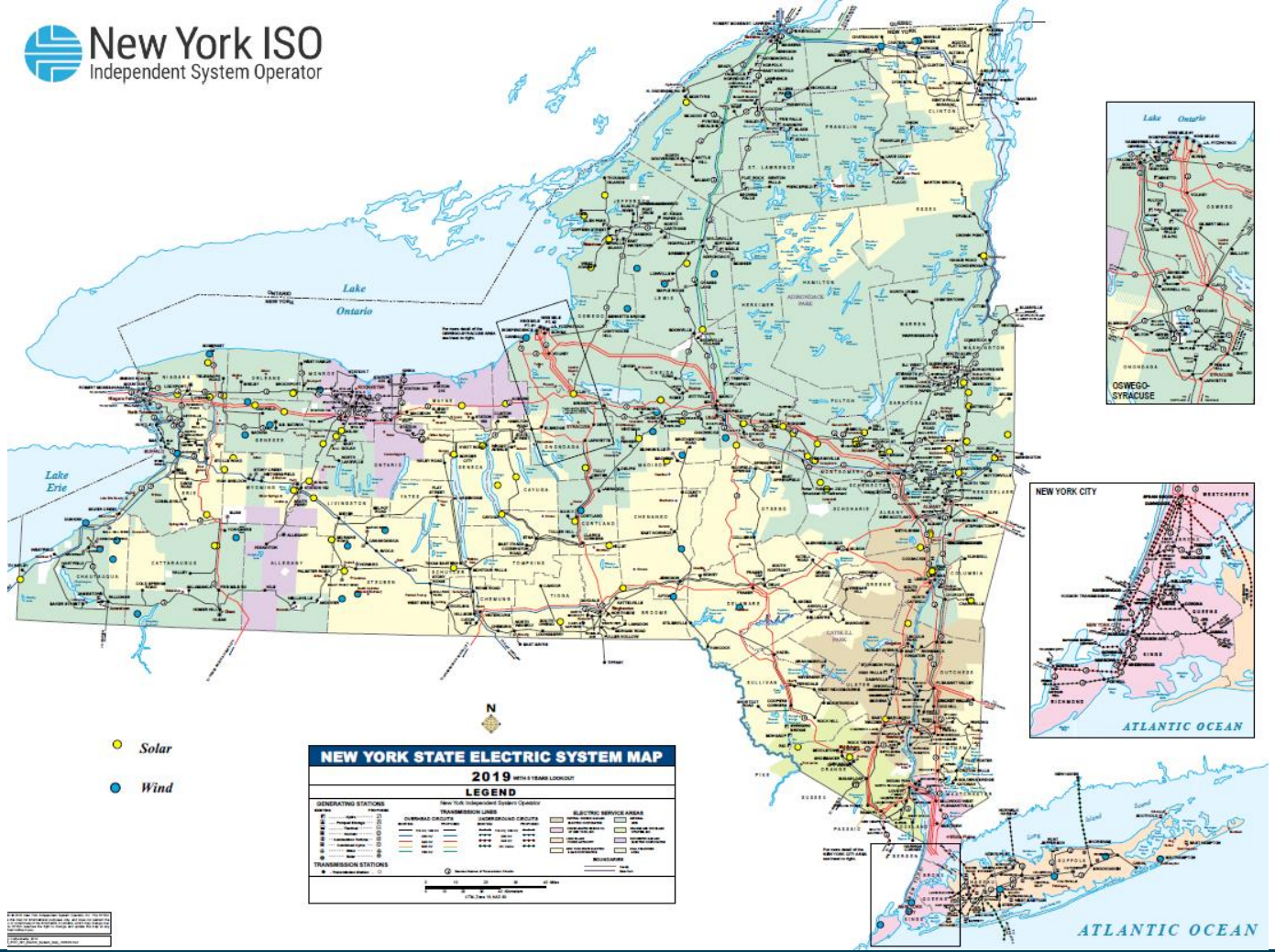
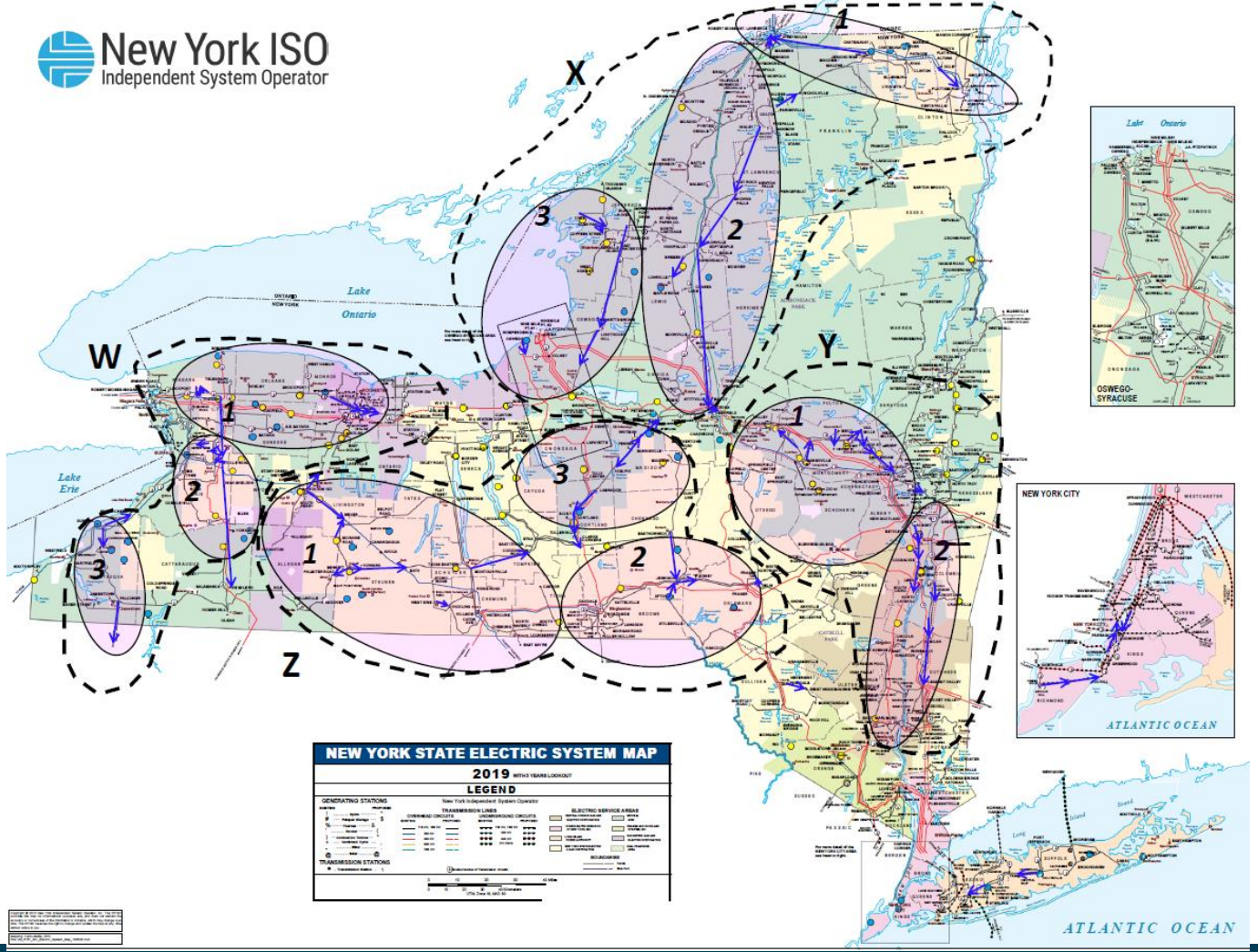
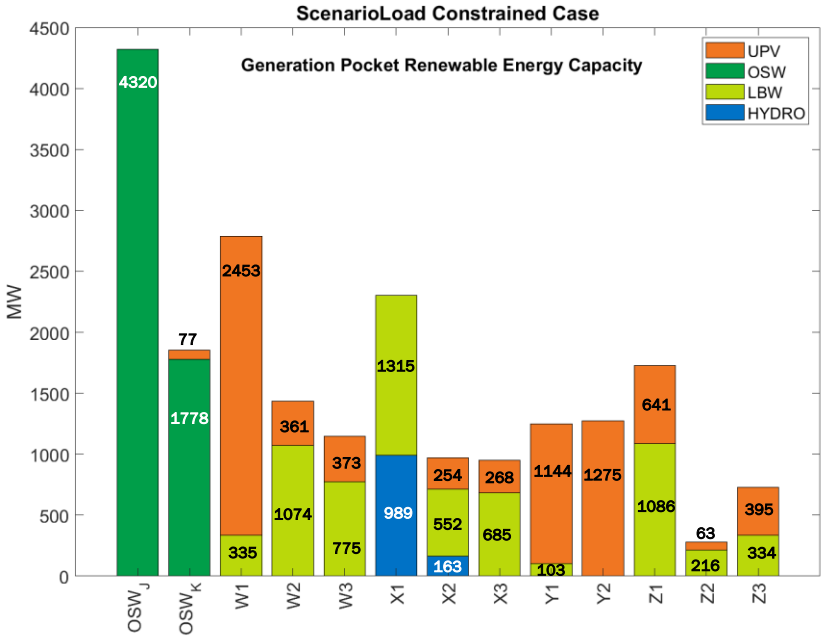
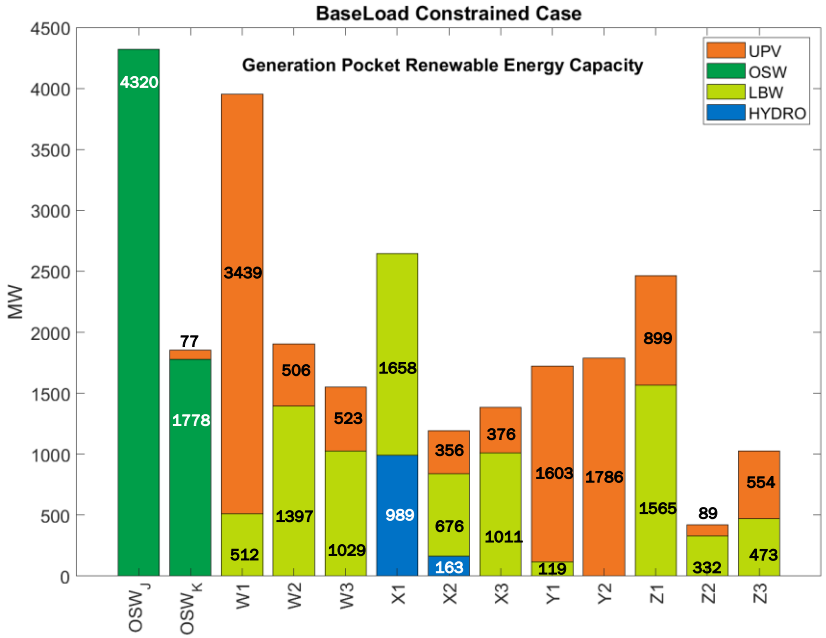


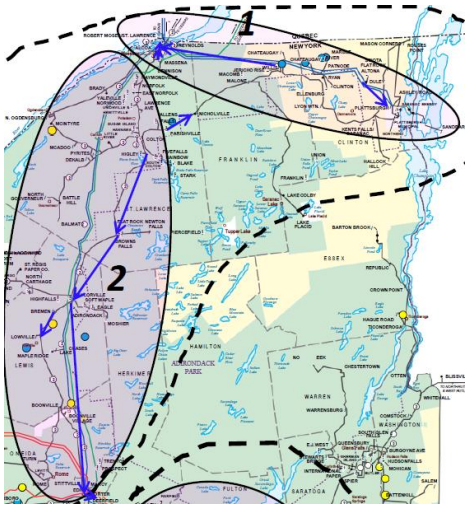


Scenario and Base Load Pocket Renewable Generation Capacity





Pocket X1 Congestion Summary



Congested_Hours	Pocket	Scenario Load	Base Load
ALCOA-NM 115.00-ALCOA N 115.00	Pocket X1	839	766
DULEY 230.00-PLAT T#1 230.00	Pocket X1	217	490
ALCOA-NM 115.00-DENNISON 115.00	Pocket X1	387	355
MOSES W 230.00-WILLIS E 230.00	Pocket X1	19	90

Curtailed Energy (%)	Pocket	Scenario Load	Base Load
Hydro	Pocket X1	3%	3%
LBW	Pocket X1	60%	63%

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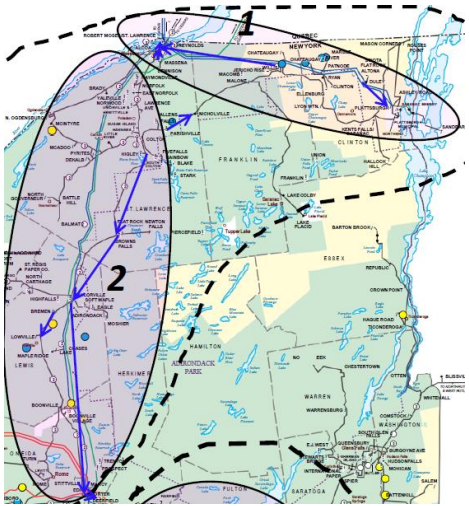
Pocket X2 Congestion Summary



Congested_Hours			Pocket	Scenario Load	Base Load
BREMEN	115.00-BU+LY+MO	115.00	Pocket X2	1,025	2,233
LOWVILLE	115.00-BOONVL	115.00	Pocket X2	633	1,712
BRNS FLS	115.00-TAYLORVL	115.00	Pocket X2	170	238
BRNS FLS	115.00-HIGLEY	115.00	Pocket X2	63	107
EDIC	345.00-PORTER 2	230.00	Pocket X2	11	17
PORTER 2	230.00-ADRON B2	230.00	Pocket X2	5	9
NICHOLVL	115.00-PARISHVL	115.00	Pocket X2	33	7

Curtailed Energy (%)	Pocket	Scenario Load	Base Load
Hydro	Pocket X2	18%	16%
LBW	Pocket X2	15%	16%
UPV	Pocket X2	35%	31%

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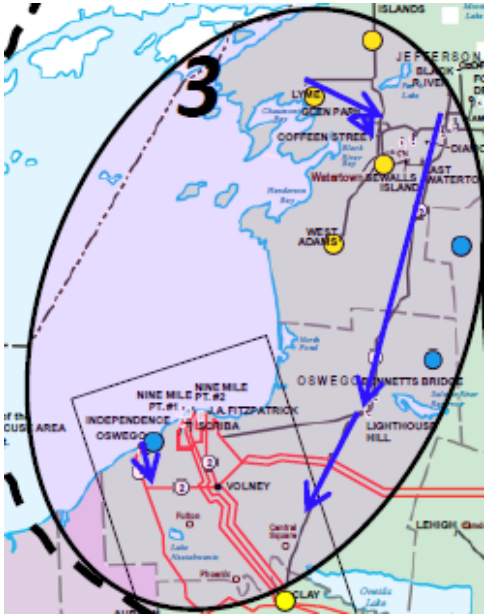
Pocket X3 Congestion Summary



Congested_Hours			Pocket	Scenario Load	Base Load
HTHSE HL	115.00-MALLORY	115.00	Pocket X3	2,530	3,718
HMMRMILL	115.00-WINE CRK	115.00	Pocket X3	457	1,448
COFFEEN	115.00-E WTRTWN	115.00	Pocket X3	535	883
COFFEEN	115.00-LYMETP	115.00	Pocket X3	3	87
HTHSE HL	115.00-COPEN_PO	115.00	Pocket X3	18	4
COFFEEN	115.00-GLEN PRK	115.00	Pocket X3	706	1,156

Curtailed Energy (%)	Pocket	Scenario Load	Base Load
LBW	Pocket X3	21%	35%
UPV	Pocket X3	50%	43%

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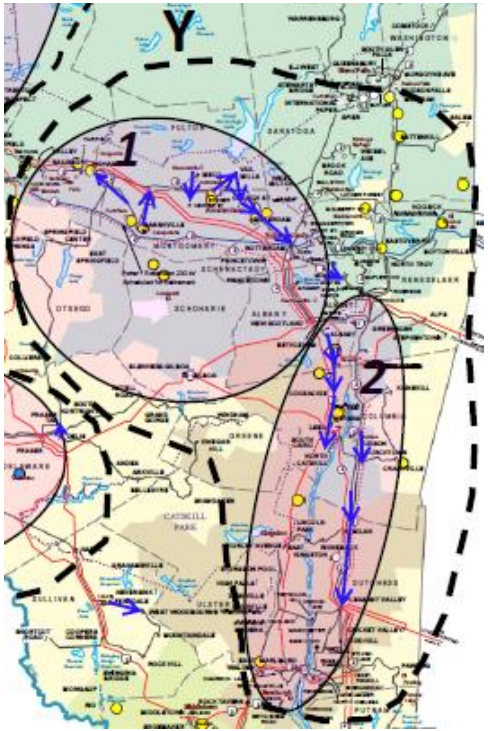
Pocket Y1 Congestion Summary



Congested_Hours			Pocket	Scenario Load	Base Load
RTRDM1	115.00-AMST 115	115.00	Pocket Y1	2,392	2,814
STONER	115.00-VAIL TAP	115.00	Pocket Y1	2,036	2,259
INGHAM-E	115.00-ST JOHNS	115.00	Pocket Y1	508	1,454
CHURCH-W	115.00-VAIL TAP	115.00	Pocket Y1	1,034	1,509
CLINTON	115.00-TAP T79	115.00	Pocket Y1	293	725
CHURCH-E	115.00-MAPLEAV1	115.00	Pocket Y1	293	543
AMST 115	115.00-CHURCH-E	115.00	Pocket Y1	149	302
CENTER-N	115.00-MECO 115	115.00	Pocket Y1	20	170
EVERETT	115.00-WOLF RD	115.00	Pocket Y1	149	7

Curtailed Energy (%)	Pocket	Scenario Load	Base Load
LBW	Pocket Y1	13%	11%
UPV	Pocket Y1	50%	54%

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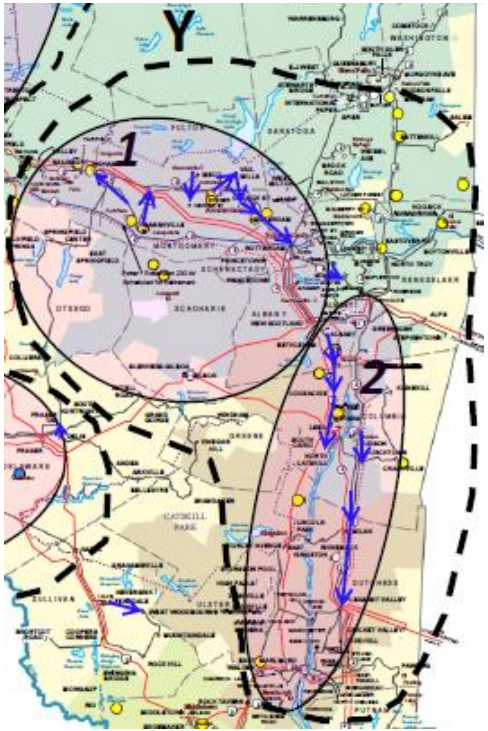
Pocket Y2 Congestion Summary



Congested_Hours	Pocket	Scenario Load	Base Load
N.CAT. 1 115.00-CHURCHTO 115.00	Pocket Y2	2,079	2,371
MILAN 115.00-PL.VAL 1 115.00	Pocket Y2	1,913	2,256
OW CRN E 115.00-BOC 7T 115.00	Pocket Y2	151	93
MILAN 115.00-BL STR E 115.00	Pocket Y2	145	282
JMC1+7TP 115.00-BLUECIRC 115.00	Pocket Y2	-	213
JMC2+9TP 115.00-OC W +MG 115.00	Pocket Y2	17	54
ADM 115.00-HUDSON 115.00	Pocket Y2	12	74
N.CAT. 1 115.00-BOC 2T 115.00	Pocket Y2	-	22

Curtailed Energy (%)	Pocket	Scenario Load	Base Load
UPV	Pocket Y2	37%	46%

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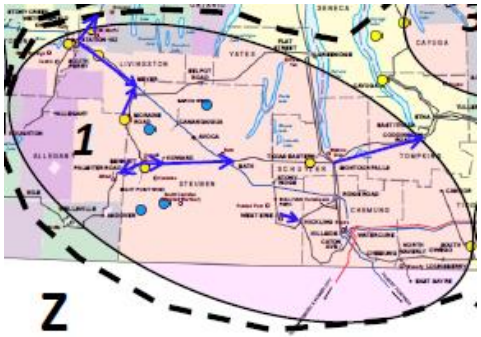
Pocket Z1 Congestion Summary



Congested_Hours	Pocket	Scenario Load	Base Load
HICK 115 115.00-WERIE115 115.00	Pocket Z1	1,966	3,115
BATH 115 115.00-HOWARD11 115.00	Pocket Z1	1,438	2,693
BENET 115 115.00-PALMT 115 115.00	Pocket Z1	1,456	1,738
MEYER115 115.00-S.PER115 115.00	Pocket Z1	1,371	2,307
S.PER115 115.00-S PERRY 230.00	Pocket Z1	-	20
S.PER115 115.00-STA 162 115.00	Pocket Z1	-	1
STA 162 115.00-STA 158S 115.00	Pocket Z1	304	466
MEYER115 115.00-MORAI115 115.00	Pocket Z1	611	847
BENET 115 115.00-HOWARD11 115.00	Pocket Z1	346	893
CODNT 115 115.00-MONTR115 115.00	Pocket Z1	2	12

Curtailed Energy (%)	Pocket	Scenario Load	Base Load
LBW	Pocket Z1	21%	37%
UPV	Pocket Z1	19%	30%

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Pocket Z2 Congestion Summary

Congested_Hours			Pocket	Scenario Load	Base Load
DELHI115	115.00-DEL T115	115.00	Pocket Z2	994	301
JENN 115	115.00-SIDNT115	115.00	Pocket Z2	575	2,018
JENN 115	115.00-AFTON115	115.00	Pocket Z2	-	48
E.NOR115	115.00-JENN 115	115.00	Pocket Z2	6	190
STILV115	115.00-AFTON115	115.00	Pocket Z2	-	40
W.WDB115	115.00-FERND115	115.00	Pocket Z2	17	60

Curtailed Energy (%)	Pocket	Scenario Load	Base Load
LBW	Pocket Z2	12%	18%
UPV	Pocket Z2	13%	3%

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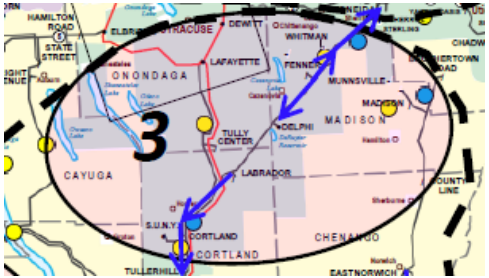
Pocket Z3 Congestion Summary



Congested_Hours	Pocket	Scenario Load	Base Load
CORTLAND 115.00-TULLER H 115.00	Pocket Z3	14	476
CLARKCRN 115.00-TULLER H 115.00	Pocket Z3	-	895
DELPHI 115.00-OM-FENNR 115.00	Pocket Z3	-	123
CORTLAND 115.00-LABRADOR 115.00	Pocket Z3	75	431
WHITMAN 115.00-ONEIDA 115.00	Pocket Z3	1,816	2,905
WHITMAN 115.00-FEN-WIND 115.00	Pocket Z3	290	506

Curtailed Energy (%)	Pocket	Scenario Load	Base Load
LBW	Pocket Z3	10%	16%
UPV	Pocket Z3	18%	28%

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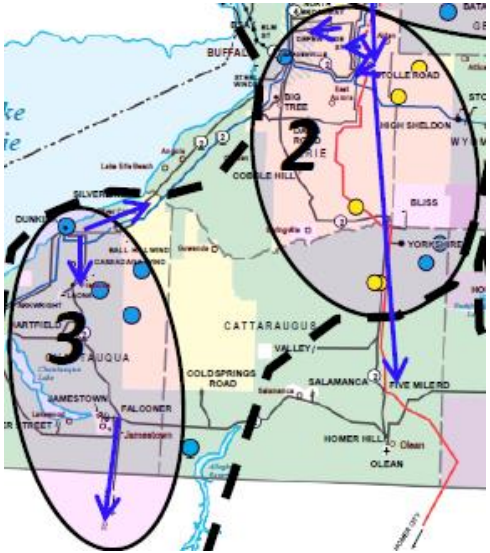
Pocket W1 Congestion Summary

Congested_Hours	Pocket	Scenario Load	Base Load
Q545A_DY 345.00-Q545A_DY 345.00	Pocket W1	4,525	3,190
Q545A_ES 345.00-5MILE345 345.00	Pocket W1	541	776
HINMN115 115.00-LOCKPORT 115.00	Pocket W1	199	1
HINMN115 115.00-HARIS115 115.00	Pocket W1	86	1
MORTIMER 115.00-SWDN-113 115.00	Pocket W1	19	512
S135 115.00-S230 115 115.00	Pocket W1	3,222	2,575
STA89 115.00-PTSFD-25 115.00	Pocket W1	301	431
PANNELLI 115.00-PTSFD-24 115.00	Pocket W1	184	344
ROBIN115 115.00-ALUD TP 115.00	Pocket W1	-	1,065
ARS TAP 115.00-S82-1115 115.00	Pocket W1	250	344
NIAGAR2W 230.00-NIAG115E 115.00	Pocket W1	71	57

Curtailed Energy (%)	Pocket	Scenario Load	Base Load
LBW	Pocket W1	8%	4%
UPV	Pocket W1	29%	17%

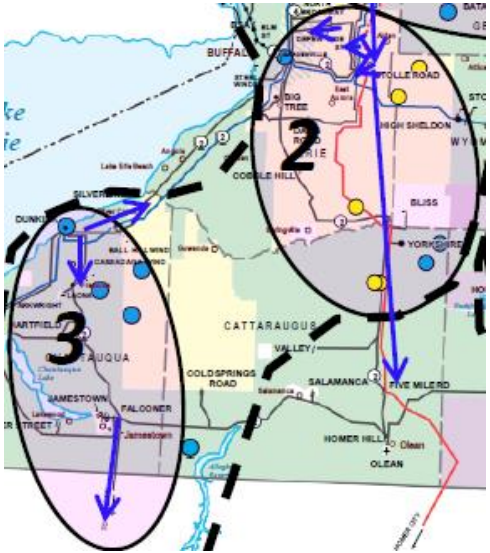
Pocket W2 Congestion Summary



Congested_Hours			Pocket	Scenario Load	Base Load
STOLE115	115.00-GIRD115	115.00	Pocket W2	594	495
DEPEW115	115.00-ERIE 115	115.00	Pocket W2	227	519
STOLE115	115.00-STOLE345	345.00	Pocket W2	124	217
CLSP-181	115.00-YNG-181	115.00	Pocket W2	50	25
SPVL-151	115.00-ARCADE	115.00	Pocket W2	-	54
ERIE 115	115.00-PAVMT115	115.00	Pocket W2	15	50

Curtailed Energy (%)	Pocket	Scenario Load	Base Load
LBW	Pocket W2	5%	5%
UPV	Pocket W2	21%	18%

Pocket W3 Congestion Summary



Congested_Hours			Pocket	Scenario Load	Base Load
FALCONER	115.00-MOON-161	115.00	Pocket W3	718	1,272
EDNK-161	115.00-ARKWRIGH	115.00	Pocket W3	270	645
EDNK-162	115.00-ARKWRIGH	115.00	Pocket W3	15	71
SLVRC141	115.00-DUNKIRK1	115.00	Pocket W3	29	226

Curtailed Energy (%)	Pocket	Scenario Load	Base Load
LBW	Pocket W3	4%	6%
UPV	Pocket W3	3%	3%

Pocket NYC / LI OSW Congestion Summary

Congested_Hours			Pocket	Scenario Load	Base Load
WILOWBK2	138.00-FRESH KI	138.00	NYC_OSW	3,774	4,662
FARRAGUT	345.00-GOWANUS	345.00	NYC_OSW	2,273	2,250
E13ST 45	345.00-FARRAGUT	345.00	NYC_OSW	211	198
WILOWBK1	138.00-FRESH KI	138.00	NYC_OSW	116	97
RAINEY W	345.00-FARRAGUT	345.00	NYC_OSW	23	54

Curtailed Energy (%)	Pocket	Scenario Load	Base Load
OSW	NYC_OSW	9%	9%

Congested_Hours			Pocket	Scenario Load	Base Load
HOLBROOK	138.00-RONKONK	138.00	LI_OSW	2,032	2,102
NEWBRGE	138.00-RULND RD	138.00	LI_OSW	236	314

Curtailed Energy (%)	Pocket	Scenario Load	Base Load
OSW	LI_OSW	3%	4%
UPV	LI_OSW	6%	1%

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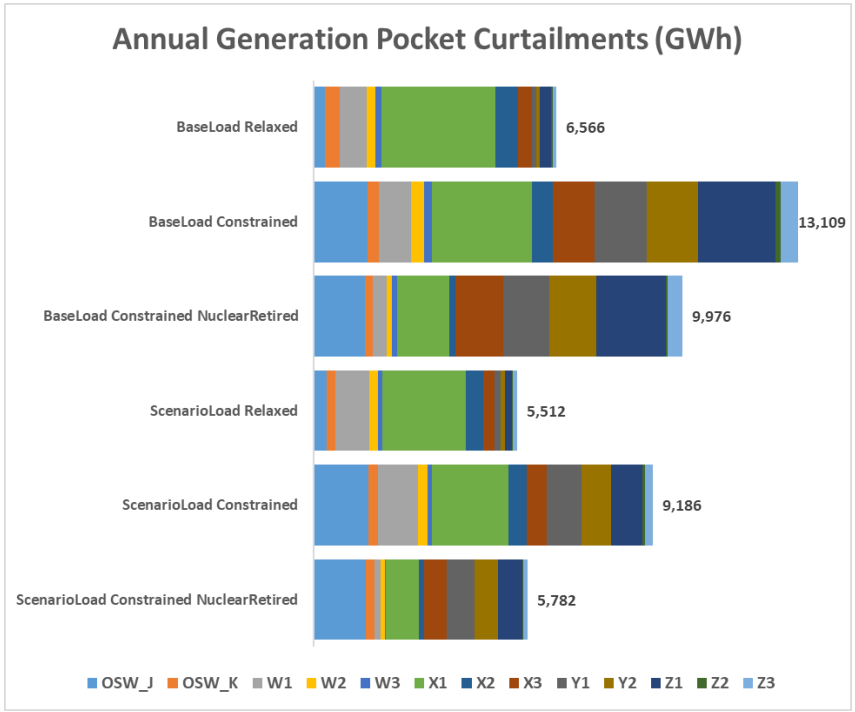
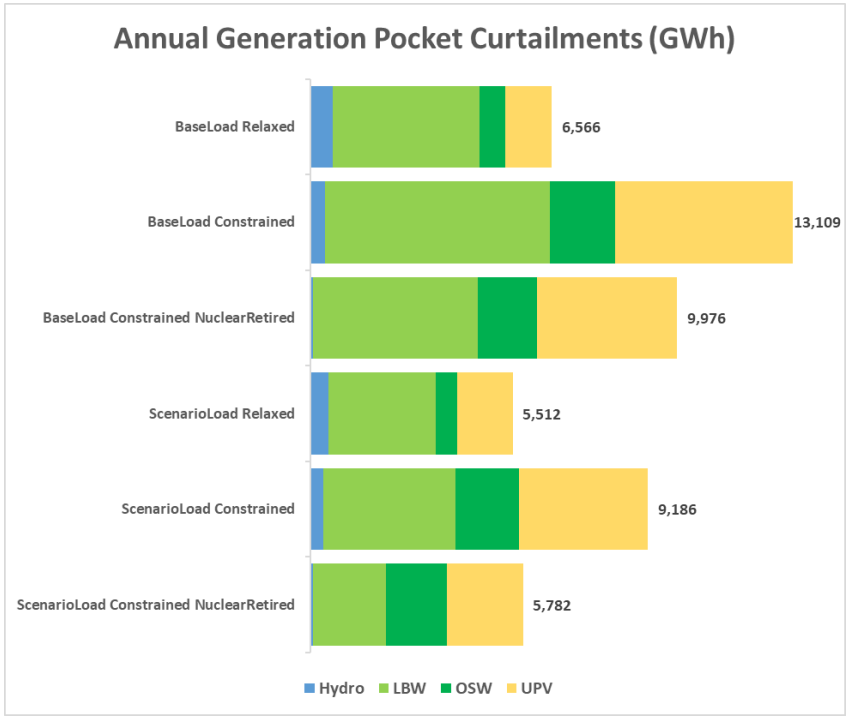
Pocket Curtailment Summary





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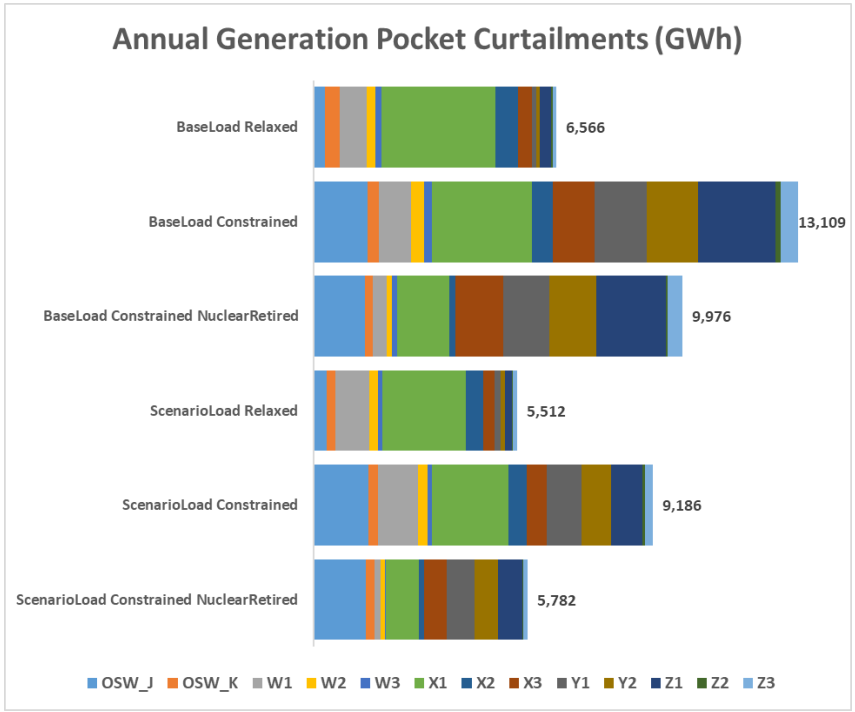
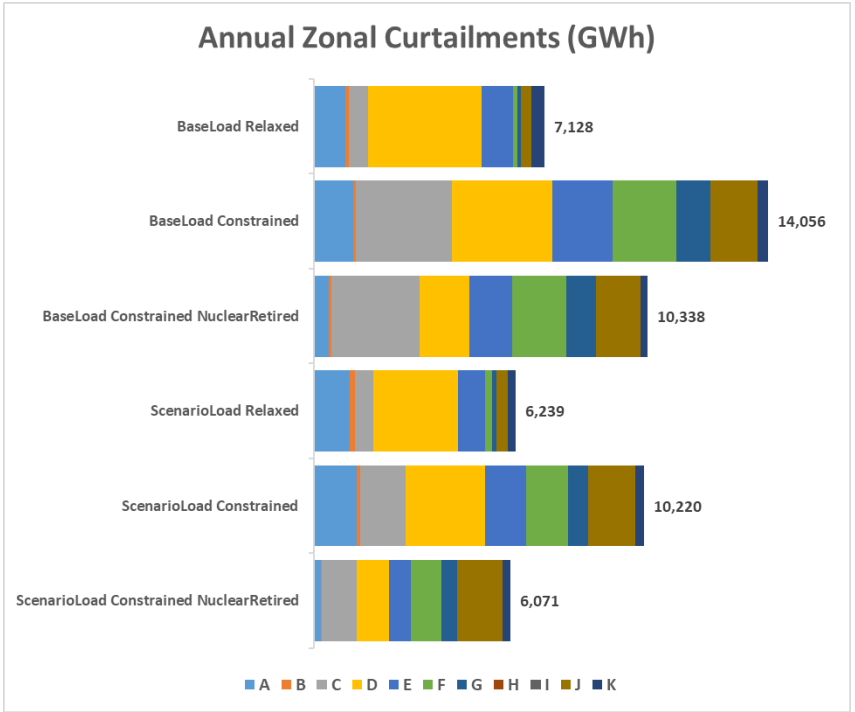
Pocket vs Zonal Curtailment Summary





Zonal Annual Aggregate results posted with today's meeting materials as excel file

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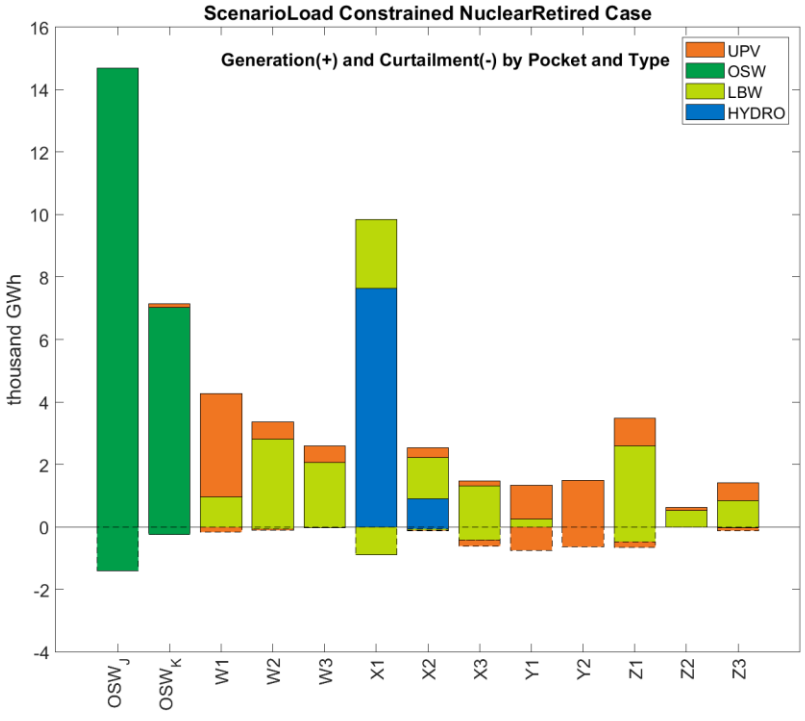
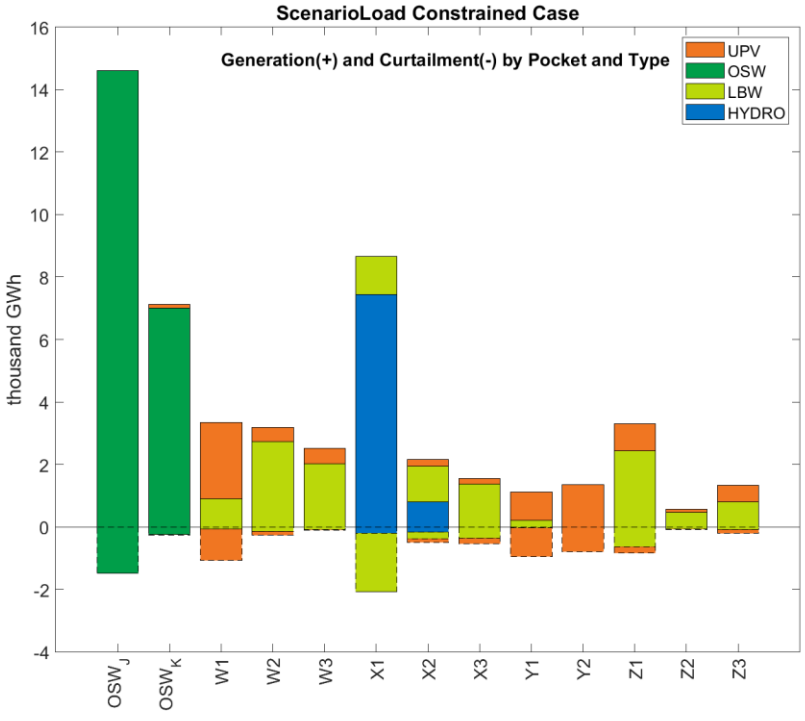
Scenario Load Generation/Curtailments Nuclear Retired Sensitivity

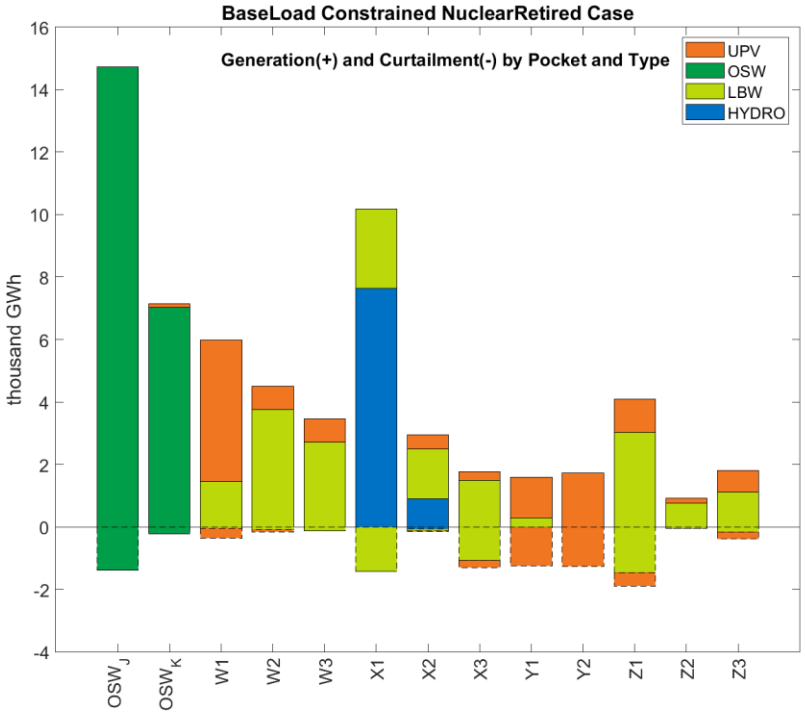


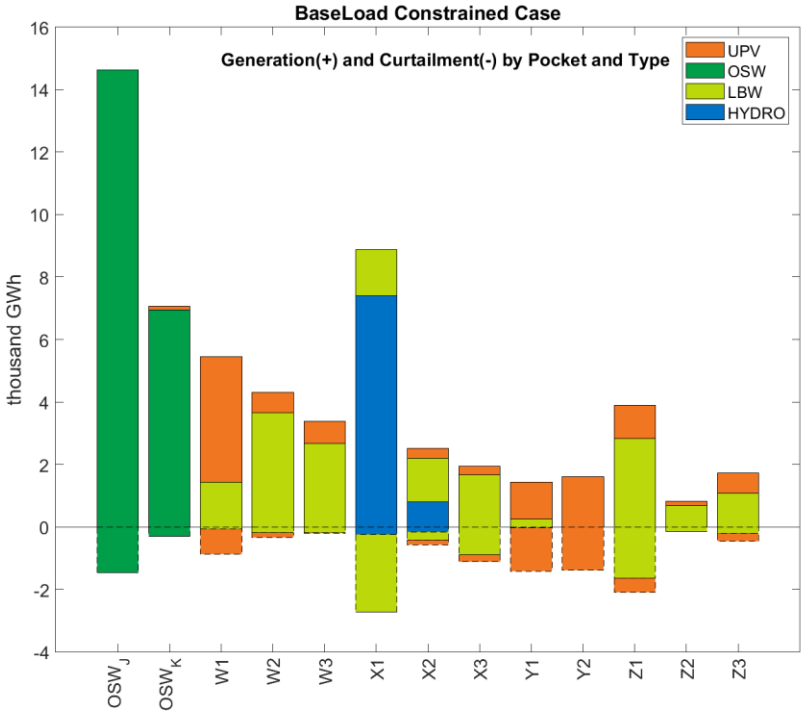
Generation

Curtailment



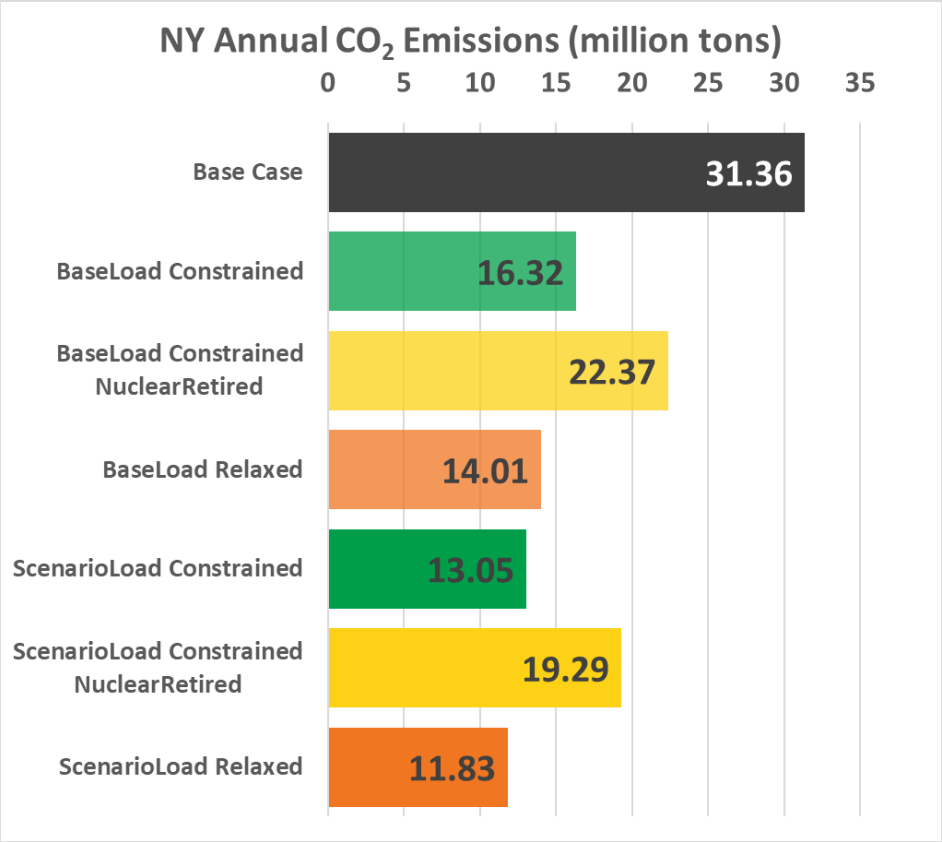
Base Load Generation/Curtailments Nuclear Retired Sensitivity





Fossil Fleet Operations

NY CO_2 Emissions Projection



- CO_2 emissions decrease in scenario cases due to lower loads, increased RE output, and corresponding decreased fossil fleet operations relative to the Base Case
- Higher loads in Base Load cases increase emissions relative to the Scenario Load cases
- Higher exports in Relaxed cases (served in part by fossil generation) partially explain modest emission reductions from the Constrained cases

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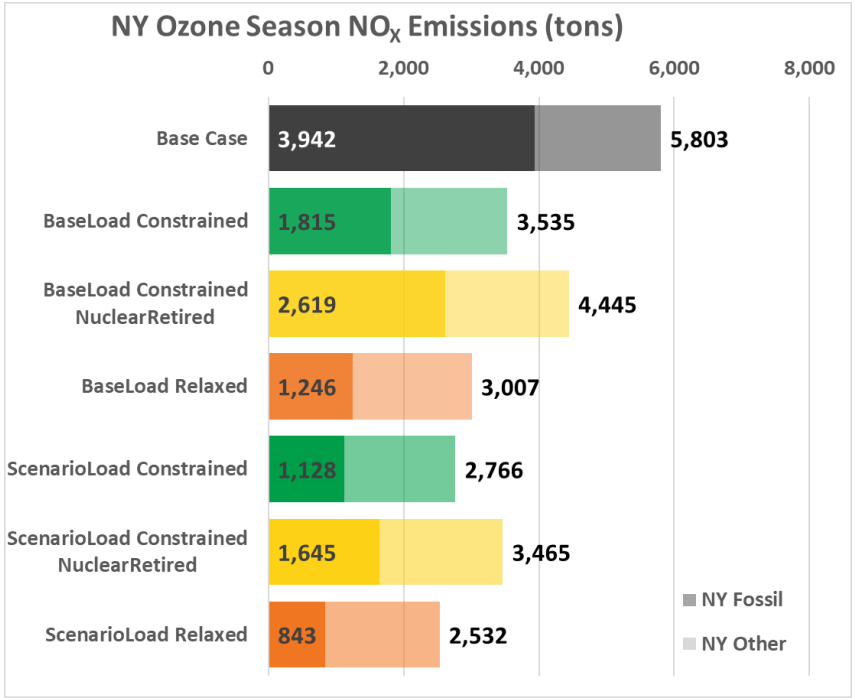
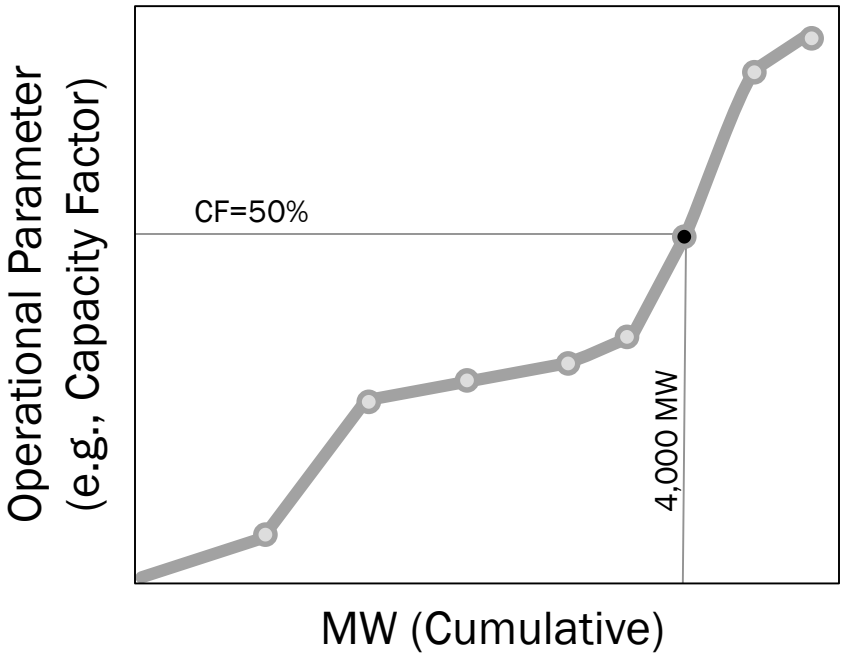
NY Ozone Season NO_X Emissions Projection



- **Emissions of Fossil (program) and Other generators reported separately**
  - NO_X emissions from the Other fleet become an increasing portion of NY ozone season NO_X emissions (no assumed modeling change for Other units in the 70x30 Scenario)
- **Current NY ozone season NO_X Budget ~5,135 tons**
  - Ozone season NO_X emissions of the fossil fleet is comparable to the Budget, generally Other units are not included under the cap and emissions are not costed
  - Ozone season defined as May – September each year

"Other" includes Methane (Biogas), Refuse (Solid Waste), and Wood fuel-fired generators

Cumulative Capacity Curve: Example



- Cumulative capacity curves show amount of capacity that operated at or below a given operational parameter
- Each point on the curve represents one unit's annual operation
- In this example 4,000 MW of capacity operated at or below an annual capacity factor of 50%

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Cumulative Capacity Curve: Parameters Examined

- Capacity Factor (CF) is a measure of a generator's energy output to potential maximum energy output over a given time period, *e.g.*, CF = MWh/(MW*8760) over a year
- Number of starts per year

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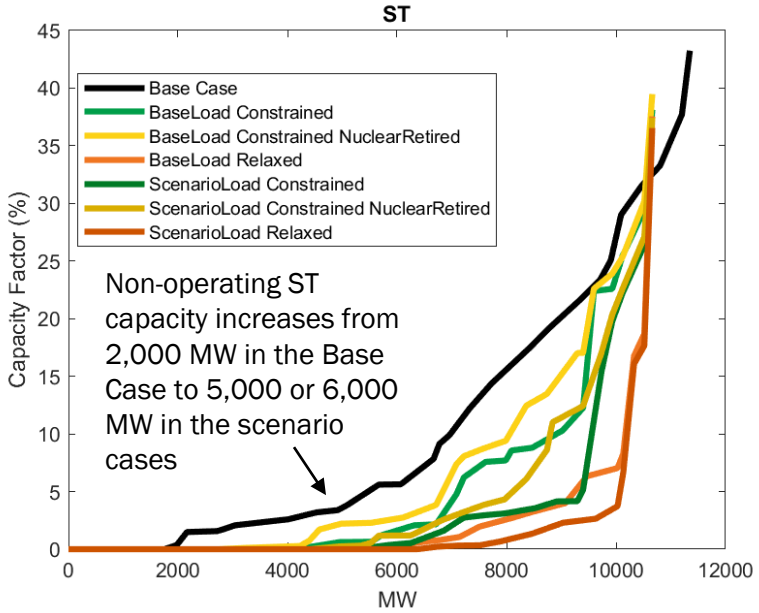
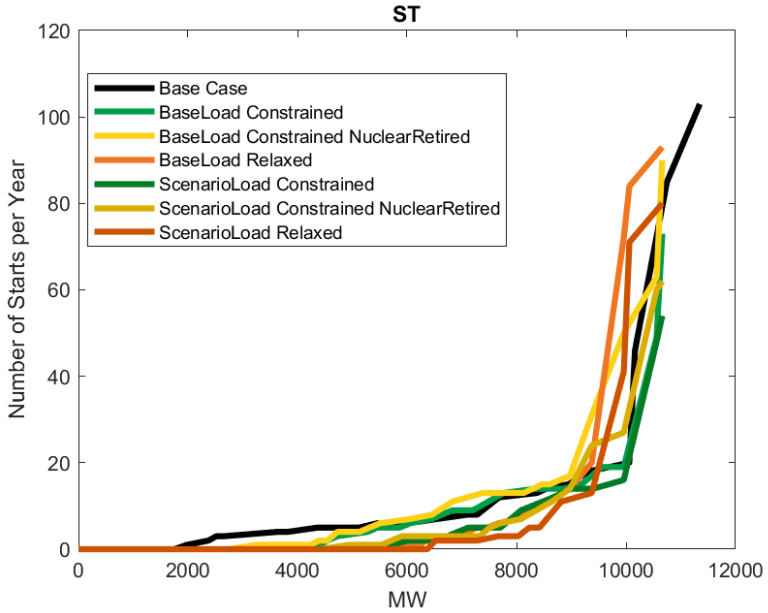
Cumulative Capacity Curve: NYCA Steam Turbine Fleet Operations





- Output is reduced in scenario cases relative to the Base Case
- Decreased number of starts in scenario cases relative to the Base Case
- Reduced capacity result of Coal Rule assumption in scenario cases

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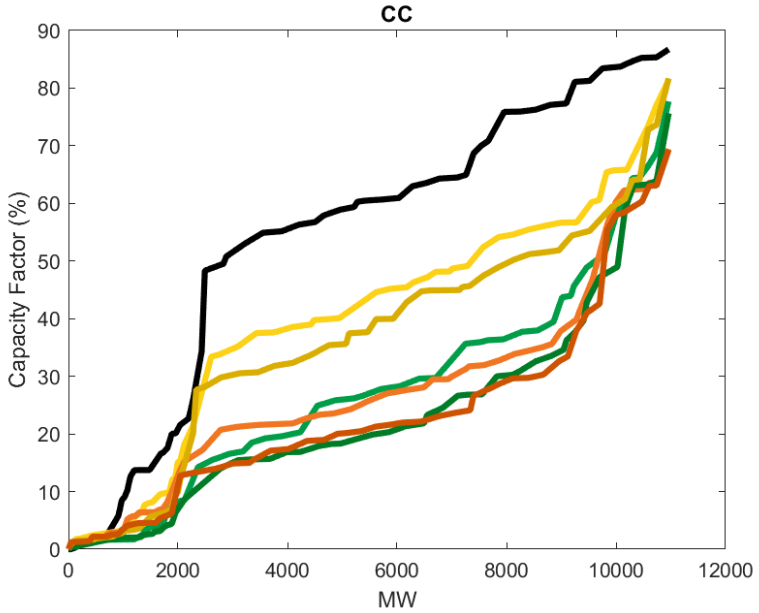
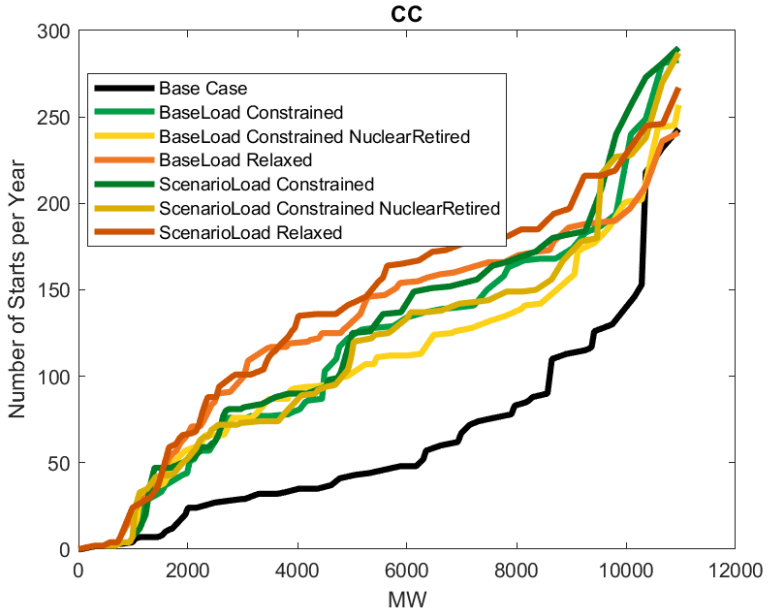
Cumulative Capacity Curve: NYCA Combined Cycle Fleet Operations





- Output is reduced in scenario cases relative to the Base Case
- Increase in number of starts in Scenario cases relative to the Base Case
- Combined Cycle fleets modeled consistent between Base and Scenario cases

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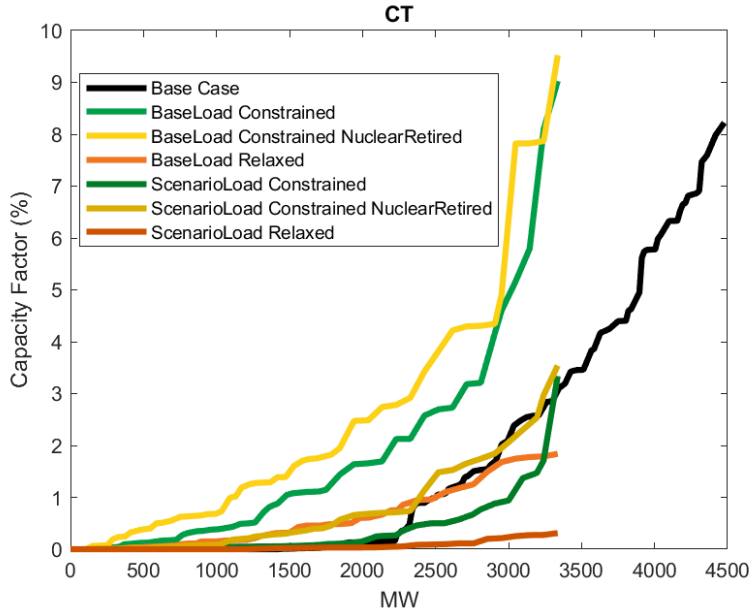
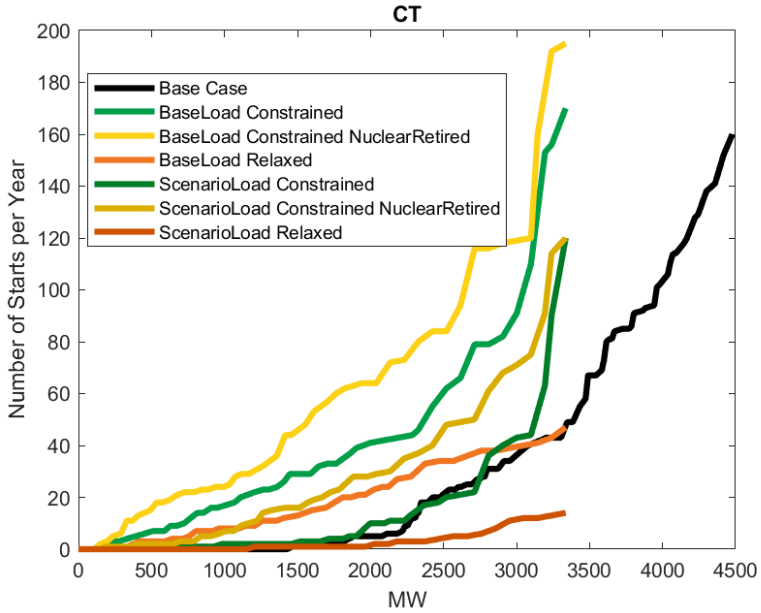
Cumulative Capacity Curve: NYCA Gas Turbine Fleet Operations





- Output increases in Base Load cases relative to the Base Case and Base Load cases
- Number of starts per year increase in Constrained cases and decrease in Relaxed case
- Reduced capacity result of Peaker Rule assumption in Scenario Load cases

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Cumulative Capacity Curve: Key Points

- Combined cycle resources operate as marginal units filling in between renewable energy resources and in the absence of nuclear generation and therefore has more starts at a lower capacity factor in the scenario cases
- Less steam turbine capacity operates in scenario cases, some operations set by contract
- Relaxed transmission cases have more impact on combustion turbine and steam turbine operations than on combined cycle units
- Fossil output higher for higher Base Load than Scenario Load cases

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Next Steps

- Review additional sensitivity analysis of nuclear retirements and energy storage
- Continue identification of transmission constraints that cause renewable curtailments (*i.e.*, renewable generation pockets)
- For each pocket, quantify the magnitude and frequency of the curtailments for each assumed resource mix

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Questions?

Our mission, in collaboration with our stakeholders, is to serve the public interest and provide benefit to consumers by:

- Maintaining and enhancing regional reliability
- Operating open, fair and competitive wholesale electricity markets
- Planning the power system for the future
- Providing factual information to policymakers, stakeholders and investors in the power system

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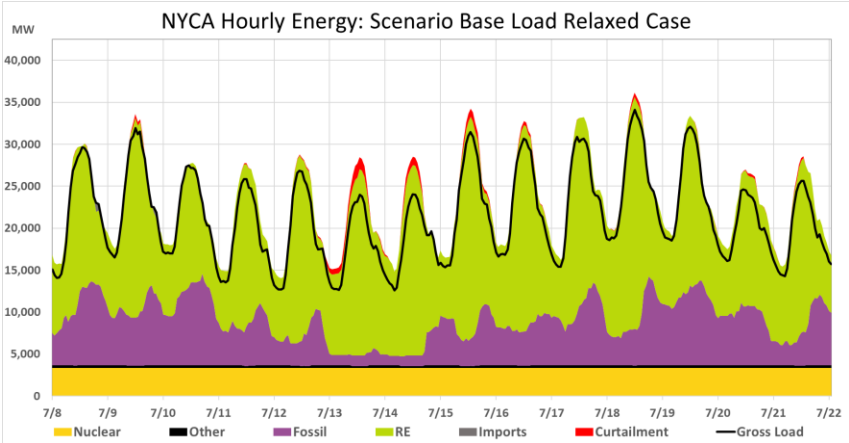
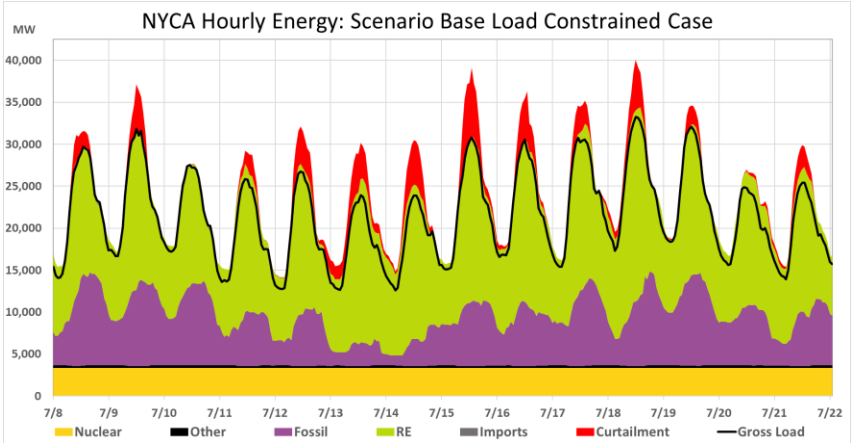
Preliminary Case Results: Base Load Relaxed and Constrained Sensitivity

Relaxed/Constrained Output Profiles: Peak Loads





"Other" includes Methane (Biogas), Refuse (Solid Waste), and Wood fuel-fired generators
"Imports" includes imports from IESO, ISO-NE, and PJM

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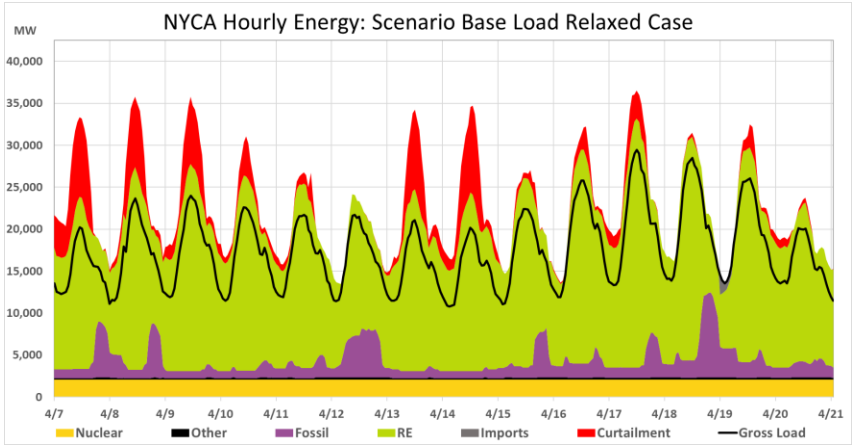
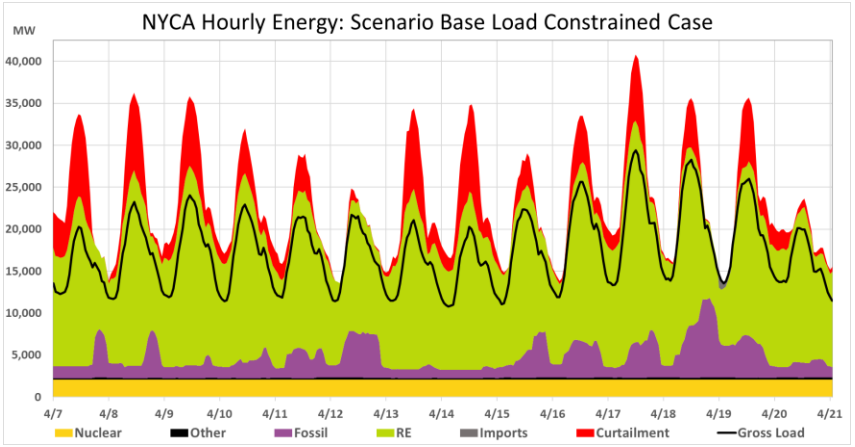
Relaxed/Constrained Output Profiles: Low Net Loads





"Other" includes Methane (Biogas), Refuse (Solid Waste), and Wood fuel-fired generators
"Imports" includes imports from IESO, ISO-NE, and PJM

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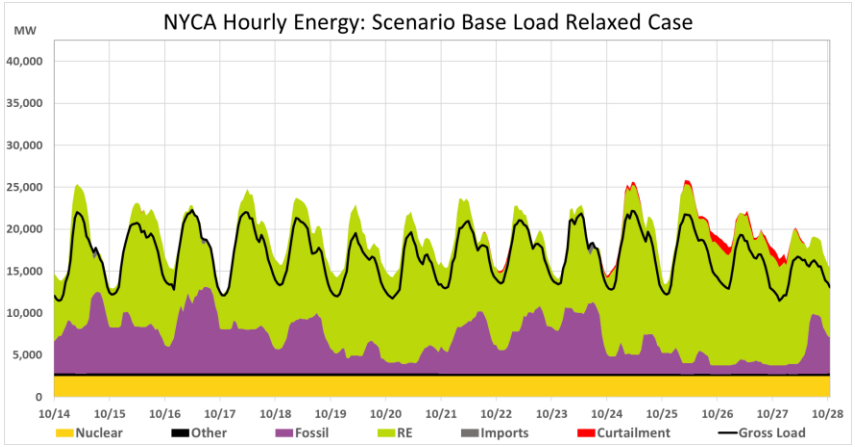
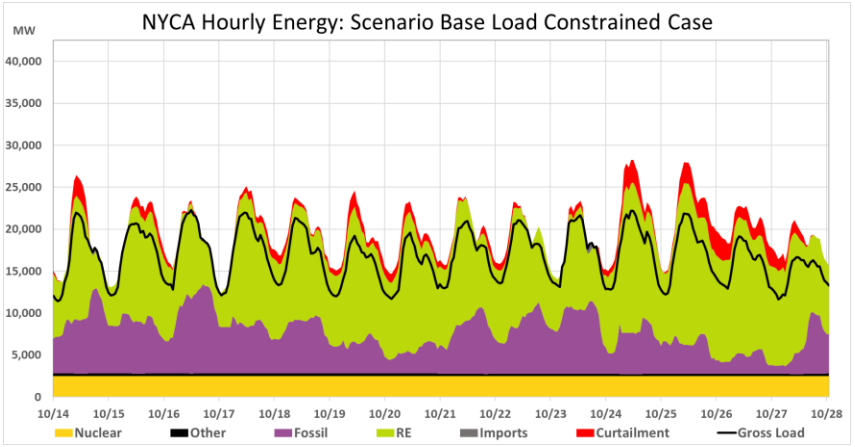
Relaxed/Constrained Output Profiles: Low Renewable Generation





"Other" includes Methane (Biogas), Refuse (Solid Waste), and Wood fuel-fired generators
"Imports" includes imports from IESO, ISO-NE, and PJM

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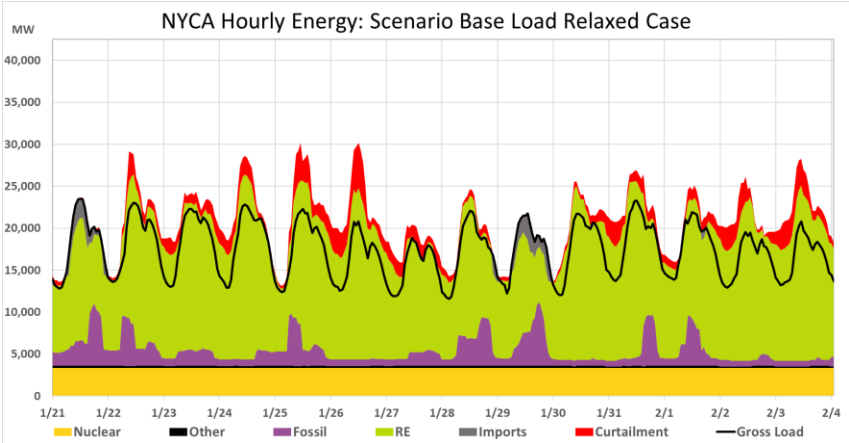
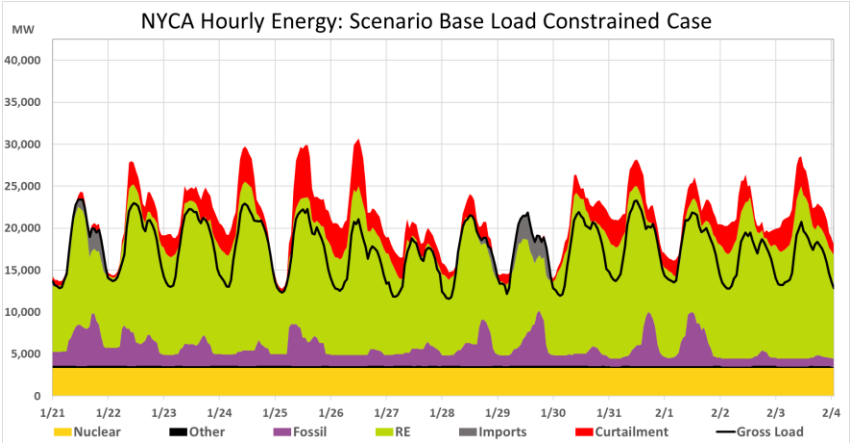
Relaxed/Constrained Output Profiles: Winter





"Other" includes Methane (Biogas), Refuse (Solid Waste), and Wood fuel-fired generators
"Imports" includes imports from IESO, ISO-NE, and PJM

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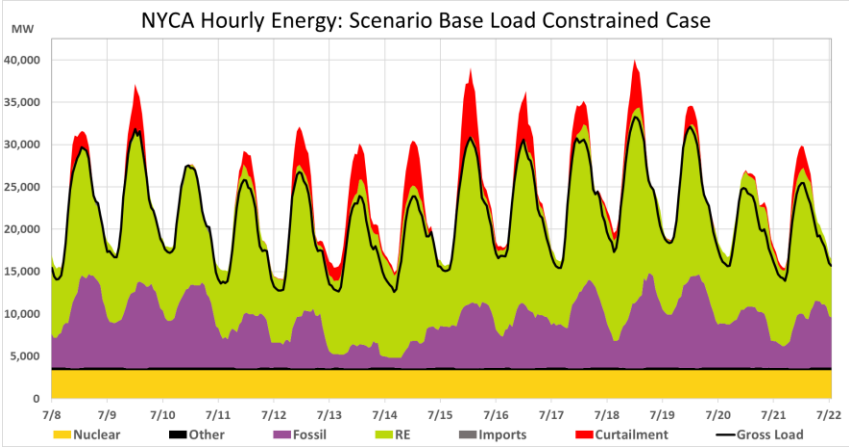
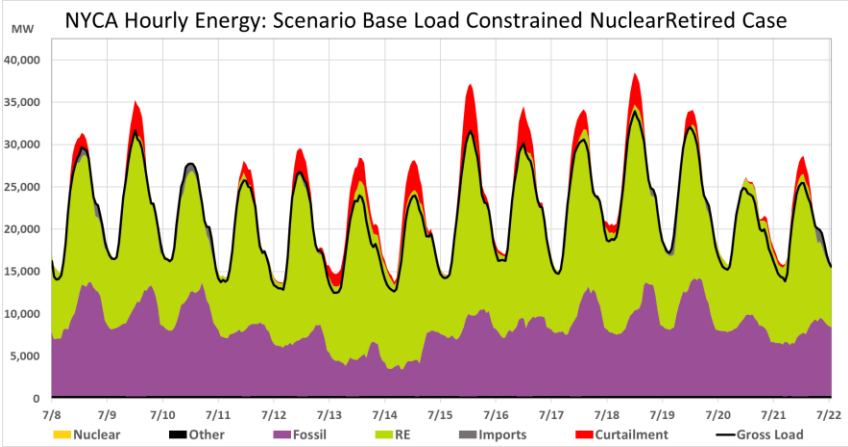
Preliminary Case Results: Base Load Constrained Nuclear Retirement Sensitivity

Constrained Nuclear Retirement Sensitivity Output Profiles: Peak Loads





"Other" includes Methane (Biogas), Refuse (Solid Waste), and Wood fuel-fired generators
"Imports" includes imports from IESO, ISO-NE, and PJM

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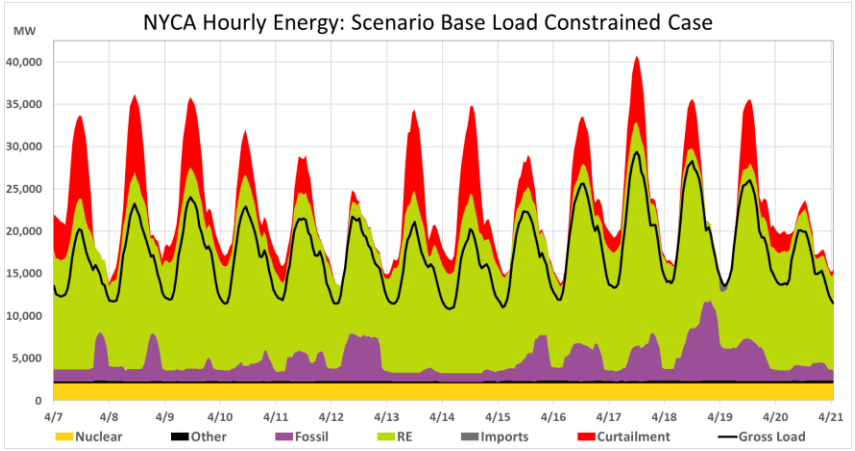
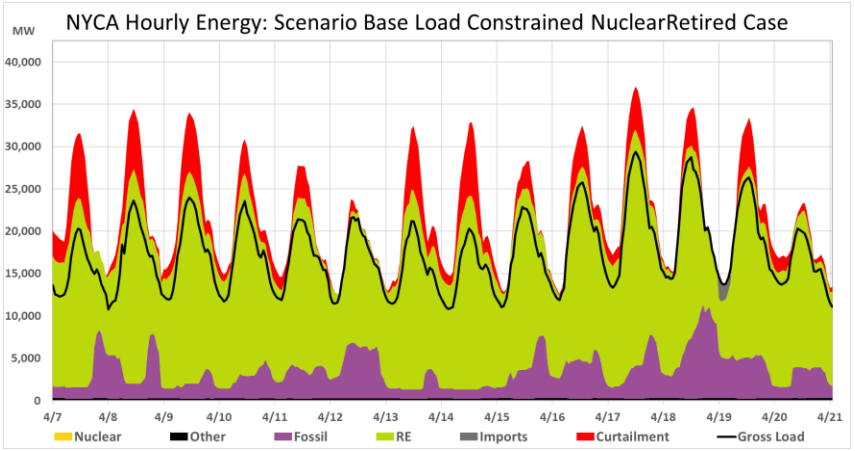
Constrained Nuclear Retirement Sensitivity Output Profiles: Low Net Loads





"Other" includes Methane (Biogas), Refuse (Solid Waste), and Wood fuel-fired generators
"Imports" includes imports from IESO, ISO-NE, and PJM

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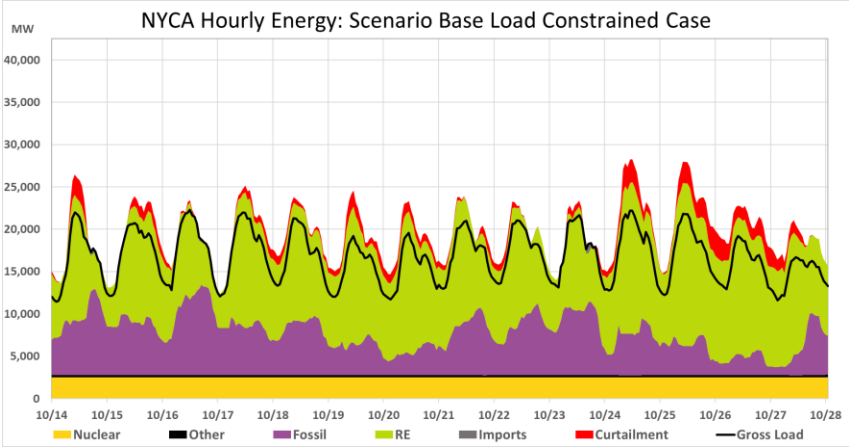
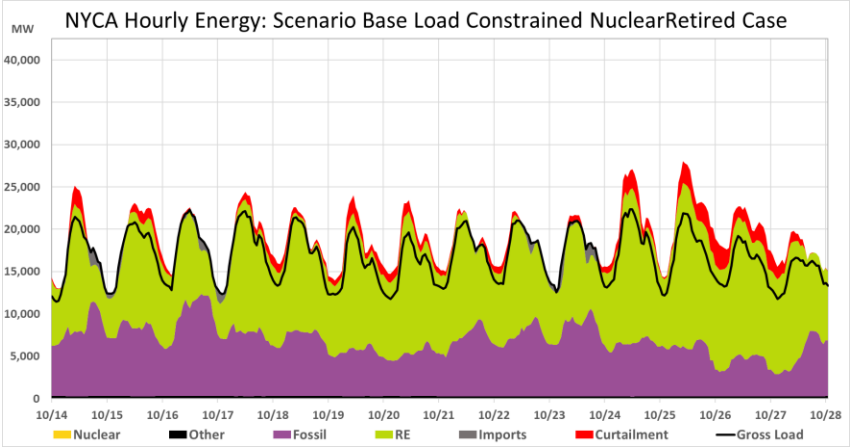
Constrained Nuclear Retirement Sensitivity Output Profiles: Low Renewable Generation





"Other" includes Methane (Biogas), Refuse (Solid Waste), and Wood fuel-fired generators
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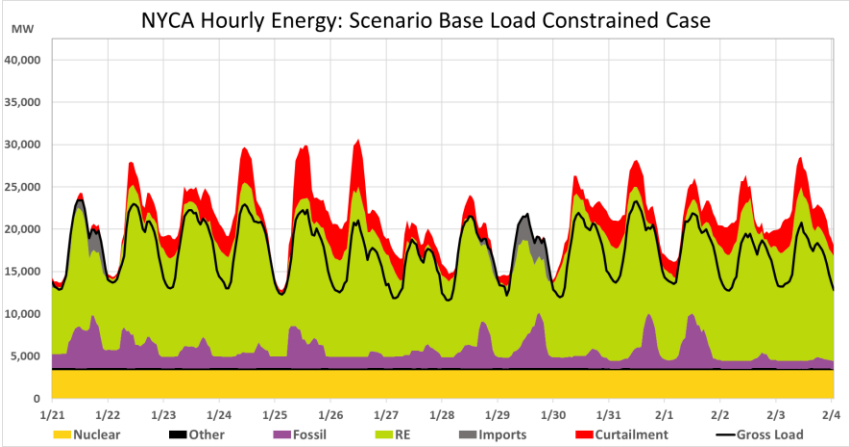
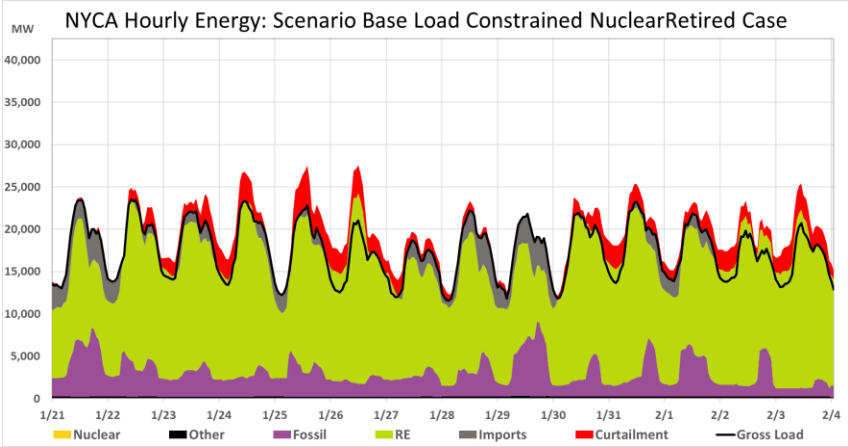
Constrained Nuclear Retirement Sensitivity Output Profiles: Winter





"Other" includes Methane (Biogas), Refuse (Solid Waste), and Wood fuel-fired generators
"Imports" includes imports from IESO, ISO-NE, and PJM

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Appendix: Nuclear Retirement Sensitivity Preliminary Congestion Results

Bulk Level Congestion Summary

Congested Hours	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
CENTRAL EAST	113	166
TIE-LINES: NORTH -VT	8,185	8,303
NorthTie: OH-NY	8,720	8,735
NEW SCOTLAND KNCKRBOC	17	37
DUNWOODIE TO LONG ISLAND	5,222	5,037
ISONE-NYISO	1,691	1,172
PRNCTWN NEW SCOTLAND	-	7
SUGARLOAF 138 RAMAPO 138	521	904
GREENWOOD	4,991	5,877
PJM-NYISO	2,557	1,982
EGRDNCTY 138 VALLYSTR 138 1	5,778	6,078
RAINEY VERNON	1,517	1,759
MOTTHAVEN RAINEY	284	303
FARRAGUT GOWANUS	2,682	2,669
DUNWOODIE MOTTHAVEN	74	396
E179THST HELLGT ASTORIAE	1,194	1,575
CRICKET VALLEY PLSNTVLY	163	406
N.WAVERLY LOUNS	656	858
LOUNS STAGECOA	183	225

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Pocket X1, X2 and X3 Congestion Summary

Congested_Hours	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
ALCOA-NM 115.00-ALCOA N 115.00	Pocket X1	1,336	1,376
DULEY 230.00-PLAT T#1 230.00	Pocket X1	1,009	1,600
ALCOA-NM 115.00-DENNISON 115.00	Pocket X1	361	215
MOSES W 230.00-WILLIS E 230.00	Pocket X1	119	363

Congested_Hours	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
BREMEN 115.00-BU+LY+MO 115.00	Pocket X2	638	1,632
LOWVILLE 115.00-BOONVL 115.00	Pocket X2	380	1,642
BRNS FLS 115.00-TAYLORVL 115.00	Pocket X2	523	661
BRNS FLS 115.00-HIGLEY 115.00	Pocket X2	285	328
EDIC 345.00-PORTER 2 230.00	Pocket X2	71	81
PORTER 2 230.00-ADRON B2 230.00	Pocket X2	10	37
NICHOLVL 115.00-PARISHVL 115.00	Pocket X2	20	-

Congested_Hours	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
HTHSE HL 115.00-MALLORY 115.00	Pocket X3	4,131	4,891
HMMRMILL 115.00-WINE CRK 115.00	Pocket X3	601	1,525
COFFEEN 115.00-E WTRTWN 115.00	Pocket X3	425	746
COFFEEN 115.00-LYMETP 115.00	Pocket X3	1	160
HTHSE HL 115.00-COPEN_PO 115.00	Pocket X3	304	113
COFFEEN 115.00-GLEN PRK 115.00	Pocket X3	1,261	2,134

Curtailed Energy (%)	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
Hydro	Pocket X1	0%	0%
LBW	Pocket X1	29%	36%

Curtailed Energy (%)	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
Hydro	Pocket X2	6%	7%
LBW	Pocket X2	3%	4%
UPV	Pocket X2	6%	7%

Curtailed Energy (%)	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
LBW	Pocket X3	25%	42%
UPV	Pocket X3	53%	44%

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Pocket Y1 and Y2 Congestion Summary

Congested_Hours	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
RTRDM1 115.00-AMST 115 115.00	Pocket Y1	2,512	2,840
STONER 115.00-VAIL TAP 115.00	Pocket Y1	1,144	1,213
INGHAM-E 115.00-ST JOHNS 115.00	Pocket Y1	1,531	2,123
CHURCH-W 115.00-VAIL TAP 115.00	Pocket Y1	844	1,107
CLINTON 115.00-TAP T79 115.00	Pocket Y1	868	1,401
CHURCH-E 115.00-MAPLEAV1 115.00	Pocket Y1	522	765
AMST 115 115.00-CHURCH-E 115.00	Pocket Y1	189	234
CENTER-N 115.00-MECO 115 115.00	Pocket Y1	267	825
EVERETT 115.00-WOLF RD 115.00	Pocket Y1	26	64

Curtailed Energy (%)	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
LBW	Pocket Y1	1%	1%
UPV	Pocket Y1	41%	49%

Congested_Hours	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
N.CAT. 1 115.00-CHURCHTO 115.00	Pocket Y2	2,232	2,418
MILAN 115.00-PL.VAL 1 115.00	Pocket Y2	1,340	1,668
OW CRN E 115.00-BOC 7T 115.00	Pocket Y2	459	248
MILAN 115.00-BL STR E 115.00	Pocket Y2	510	619
JMC1+7TP 115.00-BLUECIRC 115.00	Pocket Y2	-	561
JMC2+9TP 115.00-OC W +MG 115.00	Pocket Y2	128	258
ADM 115.00-HUDSON 115.00	Pocket Y2	33	176
N.CAT. 1 115.00-BOC 2T 115.00	Pocket Y2	-	108

Curtailed Energy (%)	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
UPV	Pocket Y2	30%	42%

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Pocket Z1 Congestion Summary

Congested_Hours	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
HICK 115 115.00-WERIE115 115.00	Pocket Z1	1,934	3,223
BATH 115 115.00-HOWARD11 115.00	Pocket Z1	1,592	3,037
BENET115 115.00-PALMT115 115.00	Pocket Z1	1,276	1,501
MEYER115 115.00-S.PER115 115.00	Pocket Z1	1,305	2,423
S.PER115 115.00-S PERRY 230.00	Pocket Z1	-	34
S.PER115 115.00-STA 162 115.00	Pocket Z1	18	128
STA 162 115.00-STA 158S 115.00	Pocket Z1	1,238	1,914
MEYER115 115.00-MORAI115 115.00	Pocket Z1	702	779
BENET115 115.00-HOWARD11 115.00	Pocket Z1	323	968
CODNT115 115.00-MONTR115 115.00	Pocket Z1	345	422

Curtailed Energy (%)	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
LBW	Pocket Z1	15%	33%
UPV	Pocket Z1	17%	29%

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Pocket Z2 and Z3 Congestion Summary

Congested_Hours	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
DELHI115 115.00-DEL T115 115.00	Pocket Z2	230	101
JENN 115 115.00-SIDNT115 115.00	Pocket Z2	189	888
JENN 115 115.00-AFTON115 115.00	Pocket Z2	-	219
E.NOR115 115.00-JENN 115 115.00	Pocket Z2	11	73
STILV115 115.00-AFTON115 115.00	Pocket Z2	-	218
W.WDB115 115.00-FERND115 115.00	Pocket Z2	1	3

Congested_Hours	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
CORTLAND 115.00-TULLER H 115.00	Pocket Z3	-	165
CLARKCRN 115.00-TULLER H 115.00	Pocket Z3	-	286
DELPHI 115.00-OM-FENNR 115.00	Pocket Z3	-	288
CORTLAND 115.00-LABRADOR 115.00	Pocket Z3	180	606
WHITMAN 115.00-ONEIDA 115.00	Pocket Z3	1,910	3,322
WHITMAN 115.00-FEN-WIND 115.00	Pocket Z3	299	370

Curtailed Energy (%)	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
LBW	Pocket Z2	3%	6%
UPV	Pocket Z2	2%	0%

Curtailed Energy (%)	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
LBW	Pocket Z3	4%	13%
UPV	Pocket Z3	12%	25%

New York ISO

Pocket W1 Congestion Summary

Congested_Hours	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
Q545A_DY 345.00-Q545A_DY 345.00	Pocket W1	2,103	1,046
Q545A_ES 345.00-5MILE345 345.00	Pocket W1	470	463
HINMN115 115.00-LOCKPORT 115.00	Pocket W1	342	6
HINMN115 115.00-HARIS115 115.00	Pocket W1	106	9
MORTIMER 115.00-SWDN-113 115.00	Pocket W1	159	1,181
S135 115.00-S230 115 115.00	Pocket W1	-	-
STA 89 115.00-PTSFD-25 115.00	Pocket W1	-	-
PANNELLI 115.00-PTSFD-24 115.00	Pocket W1	-	-
ROBIN115 115.00-A.LUD TP 115.00	Pocket W1	-	1,387
ARS TAP 115.00-S82-1115 115.00	Pocket W1	693	797
NIAGAR2W 230.00-NIAG115E 115.00	Pocket W1	10	4

Curtailed Energy (%)	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
LBW	Pocket W1	1%	3%
UPV	Pocket W1	5%	7%

New York ISO

Pocket W2 and W3 Congestion Summary

Congested_Hours	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
STOLE115 115.00-GIRD115 115.00	Pocket W2	578	404
DEPEW115 115.00-ERIE 115 115.00	Pocket W2	610	1,262
STOLE115 115.00-STOLE345 345.00	Pocket W2	23	106
CLSP-181 115.00-YNG-181 115.00	Pocket W2	51	30
SPVL-151 115.00-ARCADE 115.00	Pocket W2	-	83
ERIE 115 115.00-PAVMT115 115.00	Pocket W2	5	33

Congested_Hours	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
FALCONER 115.00-MOON-161 115.00	Pocket W3	907	1,594
EDNK-161 115.00-ARKWRIGH 115.00	Pocket W3	247	399
EDNK-162 115.00-ARKWRIGH 115.00	Pocket W3	28	44
SLVRC141 115.00-DUNKIRK1 115.00	Pocket W3	28	391

Curtailed Energy (%)	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
LBW	Pocket W2	2%	2%
UPV	Pocket W2	8%	9%

Curtailed Energy (%)	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
LBW	Pocket W3	2%	4%
UPV	Pocket W3	0%	0%

New York ISO

Pocket NYC and LI OSW Congestion Summary

Congested_Hours	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
WILOWBK2 138.00-FRESH KI 138.00	NYC_OSW	3,862	4,822
FARRAGUT 345.00-GOWANUS 345.00	NYC_OSW	2,682	2,669
E13ST 45 345.00-FARRAGUT 345.00	NYC_OSW	752	555
WILOWBK1 138.00-FRESH KI 138.00	NYC_OSW	212	151
RAINEY W 345.00-FARRAGUT 345.00	NYC_OSW	1	55

Congested_Hours	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
HOLBROOK 138.00-RONKONK 138.00	LI_OSW	2,508	2,616
NEWBRGE 138.00-RULND RD 138.00	LI_OSW	451	611

Curtailed Energy (%)	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
OSW	NYC_OSW	9%	9%

Curtailed Energy (%)	Pocket	ScenarioLoad NuclearRetired	BaseLoad NuclearRetired
OSW	LI_OSW	3%	3%
UPV	LI_OSW	3%	1%

New York ISO