2019 CARIS 70x30 Scenario: Constraint Modeling, Energy Storage Sensitivity and Additional Case Results

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Agenda

- Scenario Background, Approach, and Assumptions
- Generation Pocket Analysis and Congestion Summary
- Preliminary Export Sensitivity Case Results
- Preliminary Energy Storage Resource Sensitivity
- Next Steps

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 Scenario Load Constraint Modeling, Nuclear Sensitivity and Additional Results

April 6, 2020

- Preliminary Base Load Constraint Modeling, Nuclear Sensitivity and Additional Results

Posted to ESPWG

March 16, 2020

- Monthly Case Energy Output MWh – Updated
- 70x30 Build Out Scenario Load

April 6, 2020

- Case Output By Type and By Zone
- Monthly Case Type Energy MWh
- 70x30 RE Buildout Base Load
- Preliminary 70x30 Scenario Pocket Map

April 23, 2020

- Case Output By Type and By Zone
- Case Output By Type and By Pocket
- Monthly Case Type Energy MWh
- Monthly Average Zonal LBMP
- Hourly Information By Pocket

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“70 by 30” Scenario

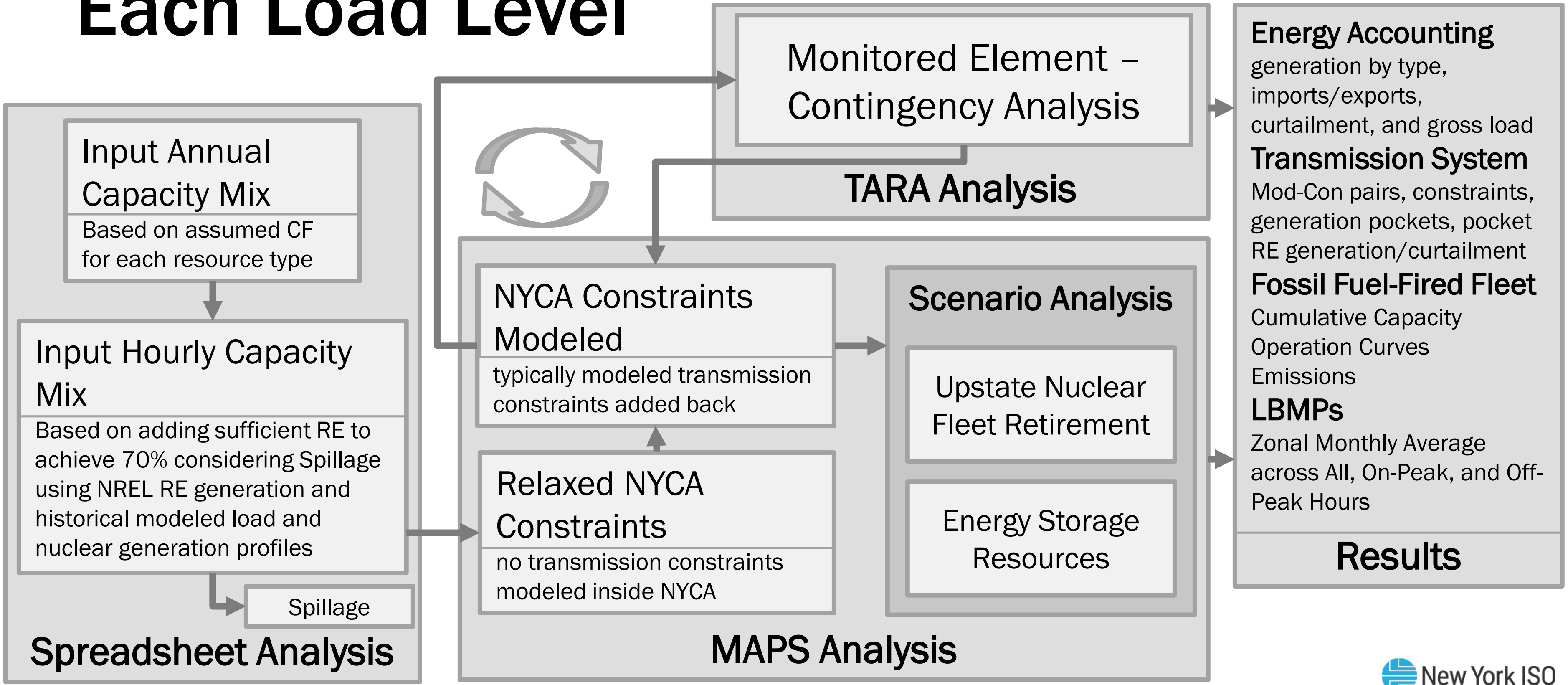
- The study will identify opportunities for transmission investment to un-bottle renewable energy to enable the state’s renewable energy production goals.
- The Climate Leadership and Community Protection Act (CLCPA) requires that a minimum of 70% of New York end-use electrical energy requirements shall be generated by renewable energy systems in 2030.
- The scenario examines two potential renewable build-out levels for one assumed distribution pattern across the state, but does not attempt to specifically compute the percentage of renewable energy relative to end-use energy.

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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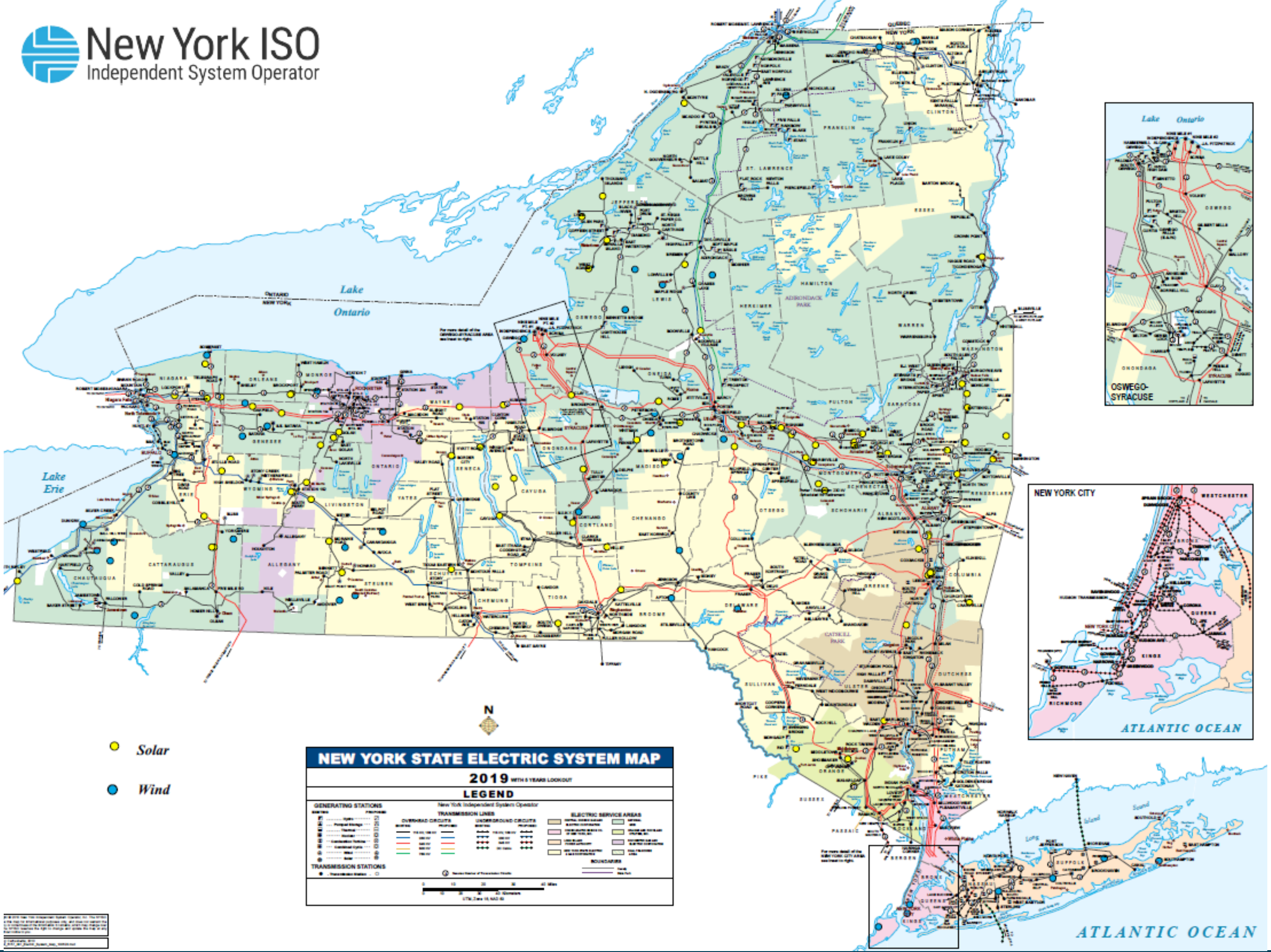
Renewable Addition Locations

- 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 4/6/2020 meeting materials


NEW YORK STATE ELECTRIC SYSTEM MAP
2019
LEGEND
Solar
Wind
Lake Ontario
Lake Erie
NEW YORK CITY
OSWEGO-SYRACUSE
ATLANTIC OCEAN

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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Considerations Outside the Scope of Assessment

- Injections for LBW and UPV are all assumed to be injected at 115kV or higher, the impact of injections at even lower voltage level such as 69kV is out of this study scope
- Identifying the impact of given constraints to the curtailment MW level is outside of this study scope

Considerations Outside the Scope of Assessment

- The study is intended to show transmission bottlenecks based on the assumed RE capacity and locations rather than providing idea locations for renewables
- The generation pocket is for illustration purposes only and NYISO does not intend to provide solutions to the findings of this study

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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

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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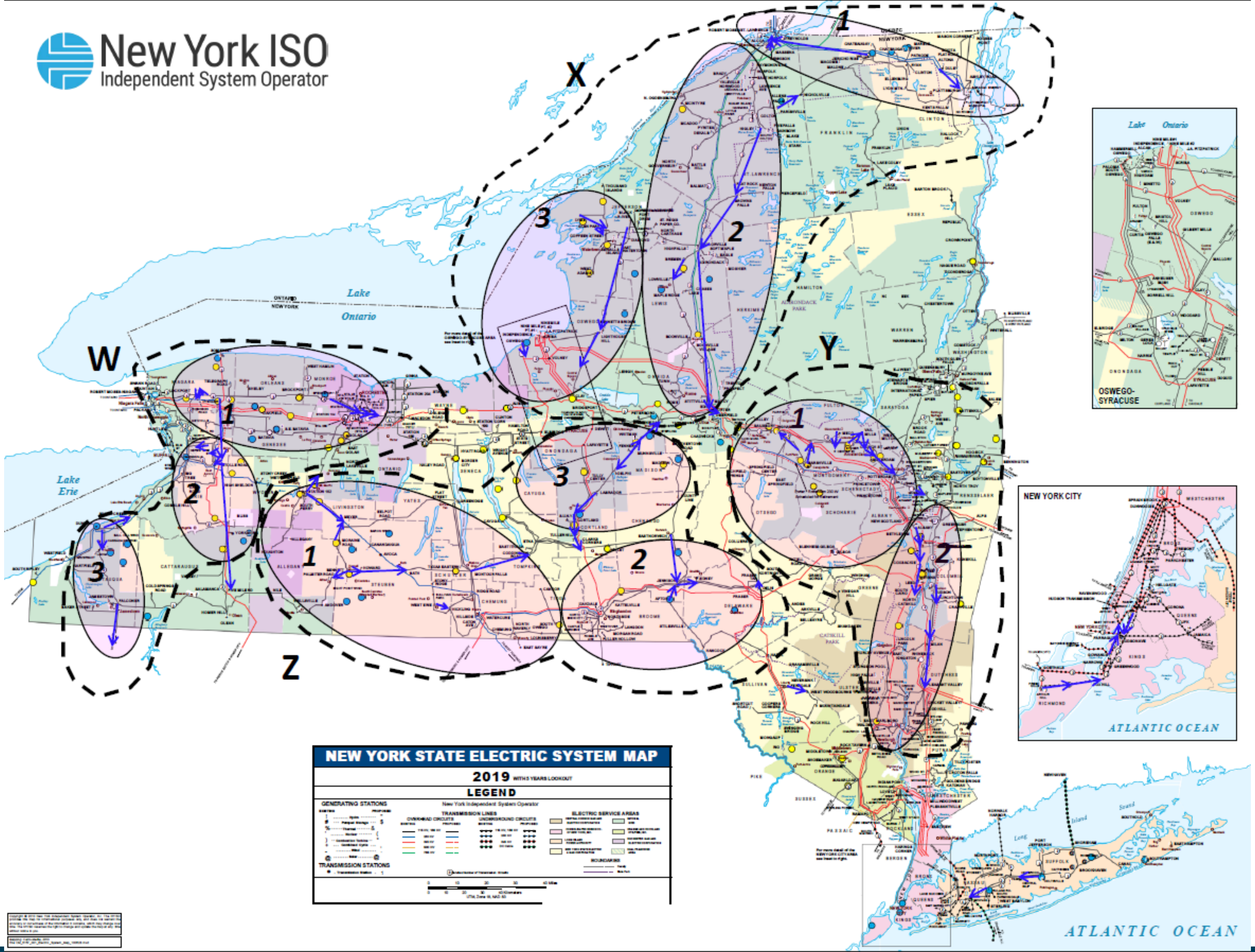
Additional Constrained Case Results: Congestion Summary

Preliminary Constrained Case Bulk Level Congestion Summary

Demand Congestion($M)	Base Case	Scenario Load	Base Load
CENTRAL EAST	167	464	577
NEW SCOTLAND KNCKRBOC	5	113	161
PRNCTWN NEW SCOTLAND	-	57	112
DUNWOODIE TO LONG ISLAND	28	66	56
ISONE-NYISO	4	47	36
SUGARLOAF 138 RAMAPO 138	-	26	59
GREENWOOD	10	18	26
PJM-NYISO	2	19	18
N.WAVERLY LOUNS	11	7	20
DUNWOODIE MOTTHAVEN	15	1	13
EGRDNCTY 138 VALLYSTR 138 1	4	6	7
RAINEY VERNON	0	2	5
CRICKET VALLEY PLSNTVLY	3	0	0
E179THST HELLGT ASTORIAE	1	0	1
FARRAGUT GOWANUS	-	0	2
LOUNS STAGECOA	0	1	0
MOTTHAVEN RAINEY	0	0	0



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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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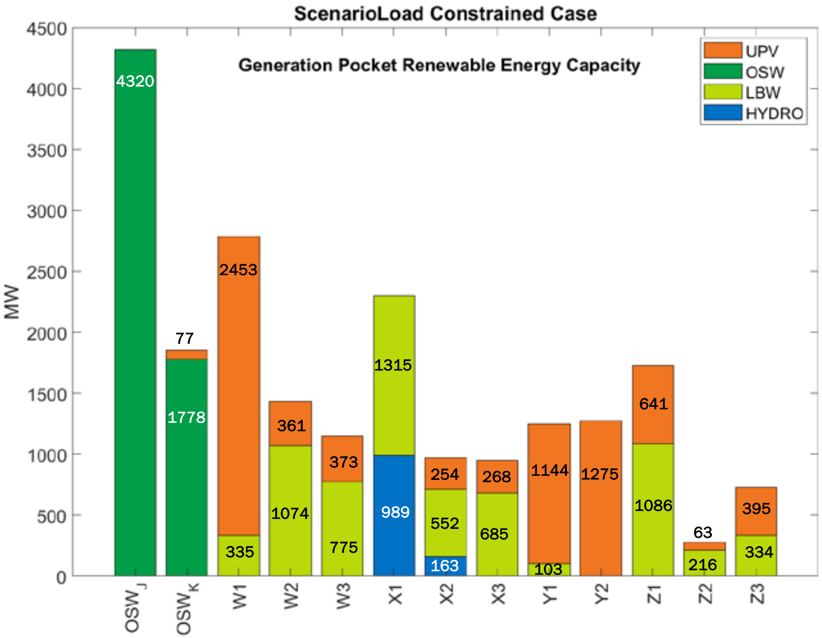
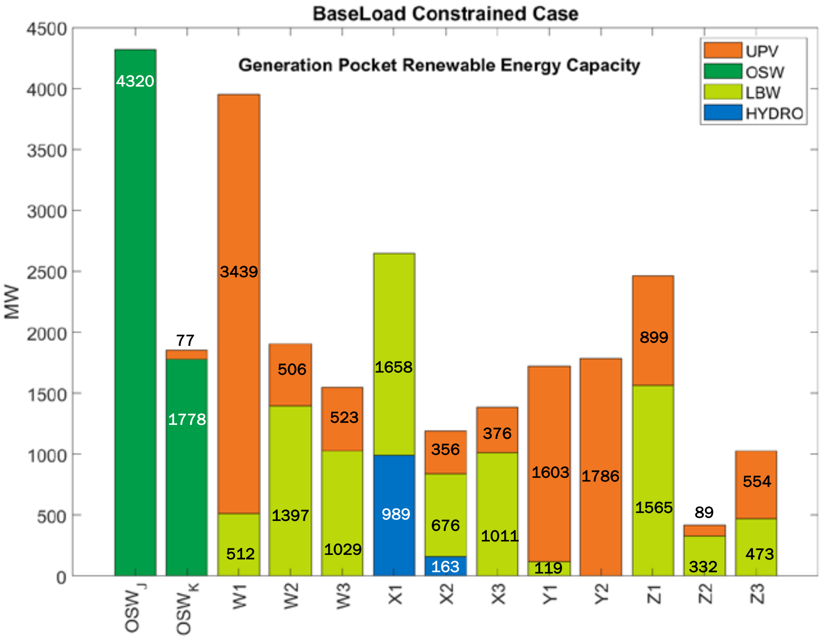
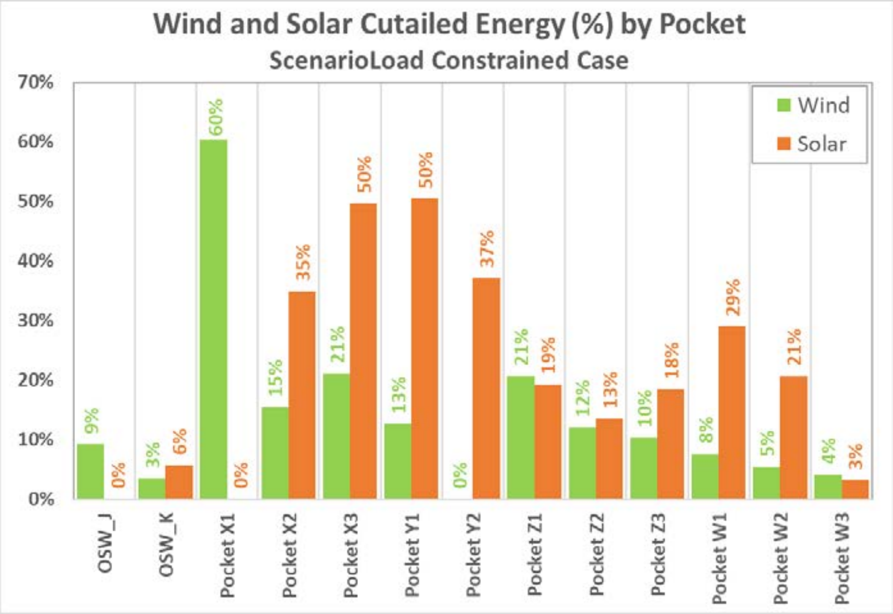
Scenario and Base Load Pocket Renewable Generation Capacity

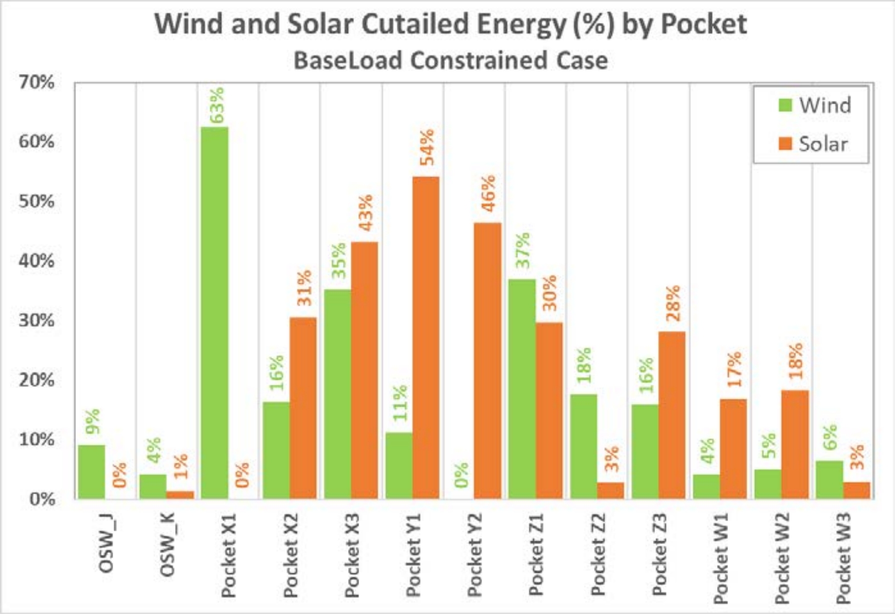




- Annual pocket metrics posted with today's meeting materials as excel file

Pocket Curtailment Overview





- Hourly pocket RE generation, curtailment, and congestion posted with today’s meeting materials as excel file

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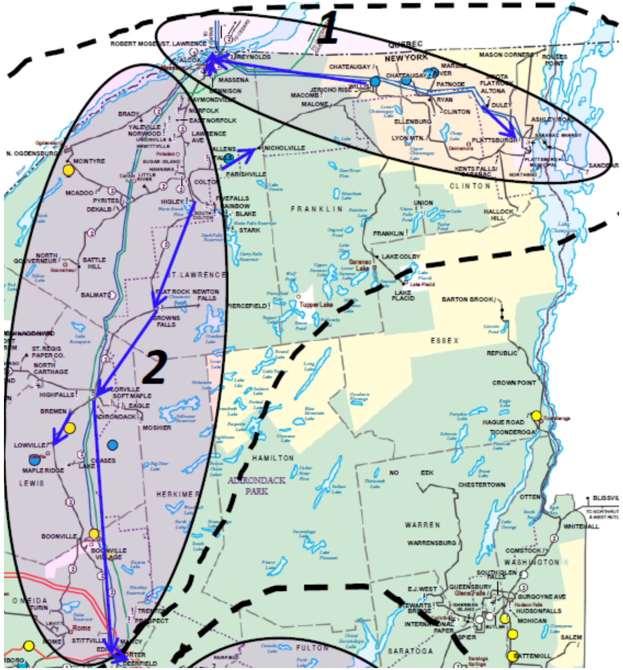
Pocket X1 Congestion Summary



Pocket X1

Congested Hours	Scenario Load	Base Load
TIE-LINES: NORTH -VT	8,113	8,014
NorthTie: OH-NY	8,751	8,755
ALCOA-NM 115.00-ALCOA N 115.00	839	766
DULEY 230.00-PLAT T#1 230.00	217	490
ALCOA-NM 115.00-DENNISON 115.00	387	355
MOSES W 230.00-WILLIS E 230.00	19	90

Type	Input RE (GWh)		Curtailed Energy (%)	
	Scenario Load	Base Load	Scenario Load	Base Load
Hydro	7,638	7,638	3%	3%
LBW	3,104	3,966	60%	63%

Curtailed Energy (%) = Curtailment/Input RE

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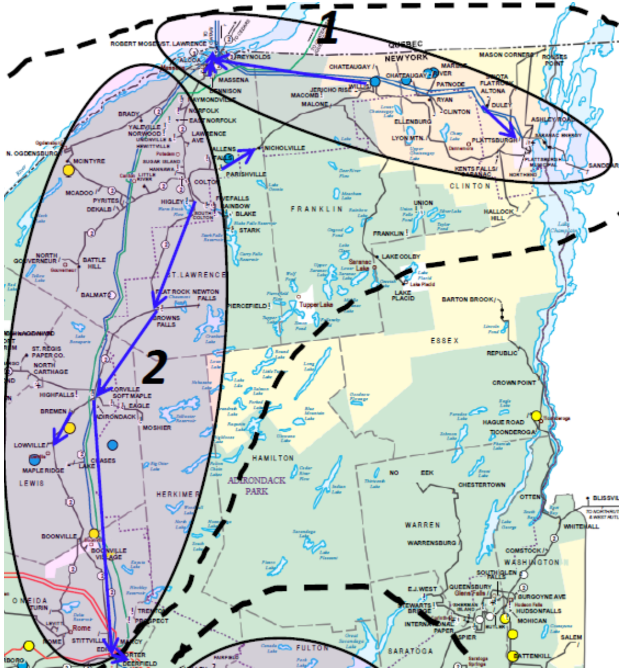
Pocket X2 Congestion Summary



Pocket X2

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

Type	Input RE (GWh)		Curtailed Energy (%)	
	Scenario Load	Base Load	Scenario Load	Base Load
Hydro	960	960	18%	16%
LBW	1,354	1,661	15%	16%
UPV	336	471	35%	31%

Curtailed Energy (%) = Curtailment/Input RE

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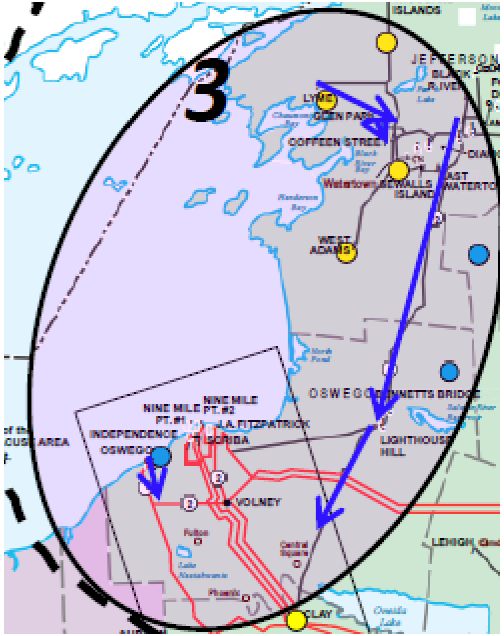
Pocket X3 Congestion Summary



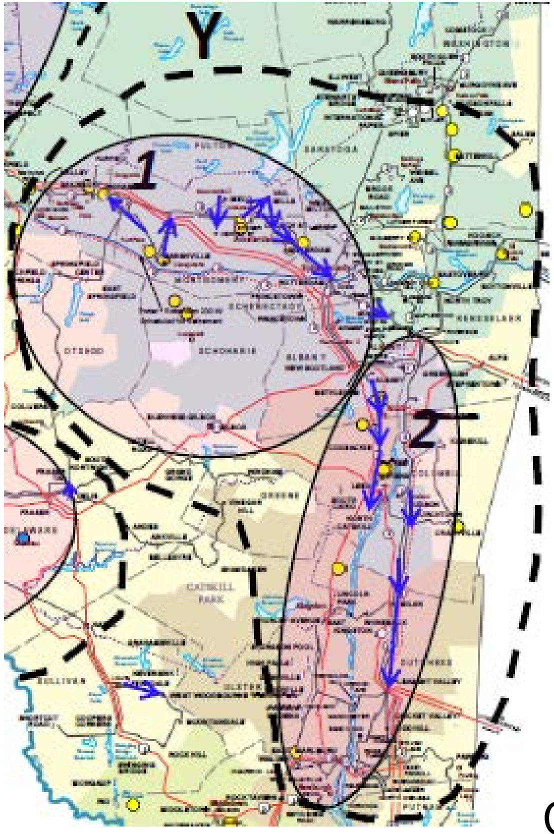
Pocket X3

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

Type	Input RE (GWh)		Curtailed Energy (%)	
	Scenario Load	Base Load	Scenario Load	Base Load
LBW	1,735	2,567	21%	35%
UPV	356	498	50%	43%

Curtailed Energy (%) = Curtailment/Input RE

Pocket Y1 Congestion Summary



Pocket Y1

Congested Hours	Scenario Load	Base Load
RTRDM1 115.00-AMST 115 115.00	2,392	2,814
STONER 115.00-VAIL TAP 115.00	2,037	2,259
INGHAM-E 115.00-ST JOHNS 115.00	508	1,454
CHURCH-W 115.00-VAIL TAP 115.00	1,034	1,509
CLINTON 115.00-TAP T79 115.00	293	725
CHURCH-E 115.00-MAPLEAV1 115.00	293	543
AMST 115 115.00-CHURCH-E 115.00	149	302
CENTER-N 115.00-MECO 115 115.00	20	170
EVERETT 115.00-WOLF RD 115.00	149	7

Type	Input RE (GWh)		Curtailed Energy (%)	
	Scenario Load	Base Load	Scenario Load	Base Load
LBW	247	286	13%	11%
UPV	1,826	2,557	50%	54%

Curtailed Energy (%) = Curtailment/Input RE

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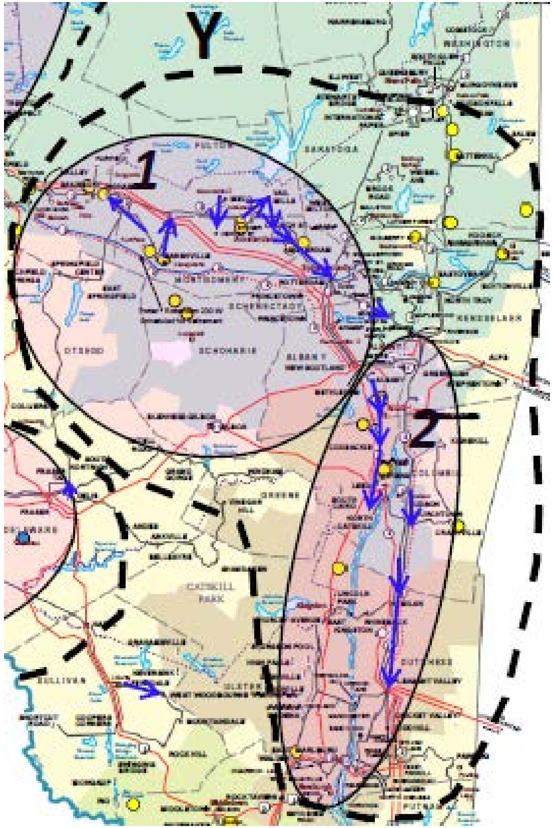
Pocket Y2 Congestion Summary



Pocket Y2

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

Type	Input RE (GWh)		Curtailed Energy (%)	
	Scenario Load	Base Load	Scenario Load	Base Load
UPV	2,142	2,993	37%	46%

Curtailed Energy (%) = Curtailment/Input RE

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Pocket Z1 Congestion Summary

Pocket Z1

Congested Hours	Scenario Load	Base Load
HICK 115 115.00-WERIE115 115.00	1,966	3,115
BATH 115 115.00-HOWARD11 115.00	1,438	2,694
BENET115 115.00-PALMT115 115.00	1,456	1,738
MEYER115 115.00-S.PER115 115.00	1,371	2,307
S.PER115 115.00-S PERRY 230.00	-	20
S.PER115 115.00-STA 162 115.00	-	1
STA 162 115.00-STA 158S 115.00	304	466
MEYER115 115.00-MORAI115 115.00	611	847
BENET115 115.00-HOWARD11 115.00	346	893
CODNT115 115.00-MONTR115 115.00	2	12

Type	Input RE (GWh)		Curtailed Energy (%)	
	Scenario Load	Base Load	Scenario Load	Base Load
LBW	3,064	4,479	21%	37%
UPV	1,073	1,503	19%	30%

Curtailed Energy (%) = Curtailment/Input RE

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Pocket Z2 Congestion Summary

Pocket Z2

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

Type	Input RE (GWh)		Curtailed Energy (%)	
	Scenario Load	Base Load	Scenario Load	Base Load
LBW	531	817	12%	18%
UPV	107	149	13%	3%

Curtailed Energy (%) = Curtailment/Input RE

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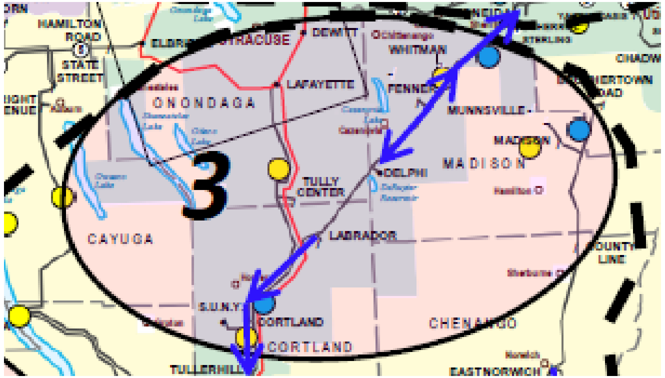
Pocket Z3 Congestion Summary



Pocket Z3

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

Type	Input RE (GWh)		Curtailed Energy (%)	
	Scenario Load	Base Load	Scenario Load	Base Load
LBW	883	1,276	10%	16%
UPV	653	913	18%	28%

Curtailed Energy (%) = Curtailment/Input RE

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Pocket W1 Congestion Summary

Pocket W1

Congested Hours	Scenario Load	Base Load
Q545A_DY 345.00-Q545A_DY 345.00	4,525	3,191
Q545A_ES 345.00-5MILE345 345.00	541	776
HINMN115 115.00-LOCKPORT 115.00	199	1
HINMN115 115.00-HARIS115 115.00	86	1
MORTIMER 115.00-SWDN-113 115.00	19	512
S135 115.00-S230 115 115.00	3,222	2,575
STA 89 115.00-PTSFD-25 115.00	301	431
PANNELLI 115.00-PTSFD-24 115.00	184	344
ROBIN115 115.00-A.LUD TP 115.00	-	1,065
ARS TAP 115.00-S82-1115 115.00	250	344
NIAGAR2W 230.00-NIAG115E 115.00	71	57

Type	Input RE (GWh)		Curtailed Energy (%)	
	Scenario Load	Base Load	Scenario Load	Base Load
LBW	975	1,497	8%	4%
UPV	3,452	4,838	29%	17%

Curtailed Energy (%) = Curtailment/Input RE

Pocket W2 Congestion Summary

Pocket W2

Congested Hours	Scenario Load	Base Load
STOLE115 115.00-GIRD115 115.00	594	495
DEPEW115 115.00-ERIE 115 115.00	227	519
STOLE115 115.00-STOLE345 345.00	124	218
CLSP-181 115.00-YNG-181 115.00	50	25
SPVL-151 115.00-ARCADE 115.00	-	54
ERIE 115 115.00-PAVMT115 115.00	15	50

Type	Input RE (GWh)		Curtailed Energy (%)	
	Scenario Load	Base Load	Scenario Load	Base Load
LBW	2,882	3,837	5%	5%
UPV	583	817	21%	18%

Curtailed Energy (%) = Curtailment/Input RE

Pocket W3 Congestion Summary

Pocket W3

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

Type	Input RE (GWh)		Curtailed Energy (%)	
	Scenario Load	Base Load	Scenario Load	Base Load
LBW	2,099	2,847	4%	6%
UPV	525	737	3%	3%

Curtailed Energy (%) = Curtailment/Input RE

Pocket NYC / LI OSW Congestion Summary

OSW_J

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

Type	Input RE (GWh)		Curtailed Energy (%)	
	Scenario Load	Base Load	Scenario Load	Base Load
OSW	16,100	16,100	9%	9%

OSW_K

Congested Hours	Scenario Load	Base Load
HOLBROOK 138.00-RONKONK 138.00	2,032	2,102
NEWBRGE 138.00-RULND RD 138.00	236	314

Type	Input RE (GWh)		Curtailed Energy (%)	
	Scenario Load	Base Load	Scenario Load	Base Load
OSW	7,259	7,259	3%	4%
UPV	115	115	6%	1%

Curtailed Energy (%) = Curtailment/Input RE

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Preliminary Export Sensitivity Case Results

Annual Case Overview MAPS Output for 70x30 Scenario Additional Export Sensitivity Cases

Energy (GWh)	Base Case	ScenarioLoad Constrained	ScenarioLoad Constrained 100xHurdleRate
Nuclear	27,091	27,433	27,419
Other	2,368	2,110	1,621
Fossil	69,028	28,185	21,434
Hydro	28,832	28,050	25,117
Hydro Imports	11,564	19,775	19,830
LBW	5,038	13,290	10,453
OSW	-	21,625	19,125
UPV	115	12,666	9,074
BTM-PV	4,988	9,266	9,072
Pumped Storage	(447)	(822)	(885)
Storage	-	-	-
IESO Net Imports	(2,862)	(5,817)	71
ISONE Net Imports	(535)	(6,418)	972
PJM Net Imports	12,239	(4,446)	1,616
Renewable Generation	50,537	104,672	92,671
Curtailment	0	10,151	18,985
Non-Renewable Generation	98,488	57,728	50,474
GrossLoad	157,418	144,897	144,921

- Additional sensitivities examined to assess impact of exports to neighboring regions
- Export Hurdle Rates were increased to 100x Base Case values, thus limiting exports based on economics
- Sensitivity results show:
  - Decreased exports
  - Decreased fossil and renewable generation
  - Increased curtailments

Energy Storage Resource Modeling Study Approach

Energy Storage Resource Modeling

- Capacity additions driven by state mandate of 3,000 MW
- Compare two system level modeling methods used to calculate ESR dispatches
  - MAPS's internal ESR model (weekly cycle/NYCA system)
  - external ESR dispatch optimization (daily/zonal) treated as hourly resource modifier (HRM) in MAPS
- Zonal capacity distribution roughly based on the NYSERDA Energy Storage Roadmap, ESR treated as distributed resource in MAPS
- Additional information in Oct. 4, 2019 ESR Modeling presentation - CARIS 1 70x30 Scenario ESR Modeling
- In addition, explore an example targeted ESR application within a generation pocket as part of this sensitivity

Zone	MW
A	150
B	90
C	120
D	180
E	120
F	240
G	100
H	100
I	100
J	1,320
K	480
NYCA	3,000

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ESR Sensitivity Methodology Overview

- **Study the impact of the placement of ESR (in load pockets) and resulting (optimization of) utilization in (economic) planning studies with 3 methods:**
  1. GE MAPS internal pumped storage model (1 MAPS run with ESR PSH model)
  2. Matlab external ESR dispatch optimization (1 MAPS run with Matlab ESR profile)
  3. Post-processing of MAPS output (based on NoESR case, 1 additional run in MAPS)
- **Methods 1 and 2: ESR modeled in MAPS using internal / external dispatch is assumed to be distributed to load bus on a load ratio share**
  - Same as how BTM-PV is modeled as a distributed resource
- **Method 3: Including additional test development of targeted ESR approach**
  - Load/generation pocket (sub-zonal) optimization to reduce local curtailments of individual collocated RE generators

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ESR Modeling Methodology Comparison

Parameter	MAPS ESR	HRM	RE Pocket
ESR Specifications	• 3,000 MW, 4-hour duration, 85% efficient storage modeled as distributed resource in MAPS	• 3,000 MW, 4-hour duration, 85% efficient storage modeled as Hourly Resource Modifier (HRM) distributed resource	• capacity and duration dependent upon curtailment event statistics, 85% efficient • each ESR modeled as HRM collocated with RE resource
ESR Dispatch Objective / Input Data	• internally optimized against NYCA load and supply / cost curve over a week • internal optimization does not need additional input data • ESR dispatch/charging profile conform to the ESR and transmission constraints	• external optimization to minimize daily net-load deviations on zonal basis • input zonal load and RE hourly profiles used to ESR create dispatch • other objectives possible	• minimize generator curtailment, absorbing curtailments and discharging when no curtailment • curtailment data from initial simulation without ESR
Additional Notes	• placing ESR in a load pocket will not target curtailment or congestion	• notional external optimization to generically study ESR in (economic) planning studies	• adding ESR at RE location may lead to curtailment of ESR discharge in hours without curtailment before ESR was added

ESR Sensitivity Modeling Considerations

- ESR models based on arbitrage of energy or costs are significant simplifications of complex, co-optimization bidding strategies and market opportunities which may be available to ESRs (*e.g.*, provision for regulation, reserves, dual-market participation, etc.) and are a function of the assumed zonal capacity distribution
- Results of distributed methods ignore potential locational benefits provided or anticipated for particular siting locations (*e.g.*, ESR awarded RFP may be utilized for local not bulk needs)
- ESR dispatch must be integrated into MAPS optimization to expose impact of operations on surrounding system
- Targeted application of ESR is labor intensive, iterative process which will require further understanding and methodological development to reliably include in modeling studies going forward

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Preliminary ESR Sensitivity Case Results

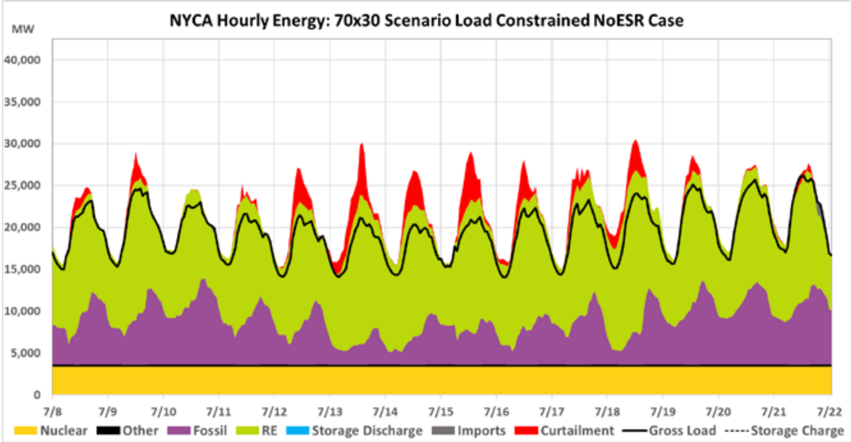
- Base Load Sample Weeks in Appendix

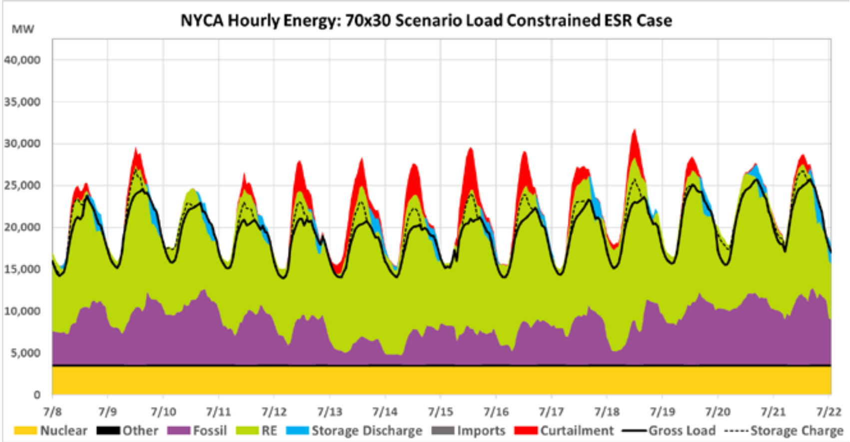
Annual Case Overview MAPS Output for 70x30 Scenario ESR Sensitivity Cases

Energy (GWh)	BaseLoad Constrained	BaseLoad Constrained ESR	BaseLoad Constrained HRM	ScenarioLoad Constrained	ScenarioLoad Constrained ESR	ScenarioLoad Constrained HRM
Nuclear	27,433	27,434	27,435	27,433	27,434	27,434
Other	2,102	2,115	2,117	2,110	2,130	2,126
Fossil	35,181	33,667	33,603	28,185	26,290	26,294
Hydro	28,020	28,084	28,091	28,050	28,123	28,114
Hydro Imports	19,769	19,802	19,808	19,775	19,820	19,808
LBW	17,117	17,322	17,376	13,290	13,515	13,532
OSW	21,592	21,656	21,821	21,625	21,682	21,743
UPV	17,982	18,256	18,350	12,666	13,234	13,124
BTM-PV	9,327	9,332	9,329	9,266	9,287	9,288
Pumped Storage	(868)	(562)	(671)	(822)	(514)	(630)
Storage	-	(604)	(756)	-	(613)	(693)
IESO Net Imports	(6,250)	(6,136)	(6,145)	(5,817)	(5,788)	(5,755)
ISONE Net Imports	(5,073)	(4,695)	(4,723)	(6,418)	(5,902)	(5,847)
PJM Net Imports	(4,528)	(3,859)	(3,838)	(4,446)	(3,798)	(3,648)
Renewable Generation	113,808	114,452	114,775	104,672	105,661	105,609
Curtailment	14,020	13,369	13,097	10,151	9,174	9,266
Non-Renewable Generation	64,717	63,215	63,155	57,728	55,853	55,853
GrossLoad	161,807	161,811	161,797	144,897	144,897	144,888

- Monthly values posted with today's meeting materials as excel file
- Introduction of a distributed ESR model increases RE and decreases fossil, exports, and curtailments
- Impact of HRM are slightly more pronounced than MAPS ESR, due to higher storage utilization

Constrained Output Profiles MAPS ESR: Peak Loads





Hours where generation is in excess of load result in exports of NY generation to neighboring areas
"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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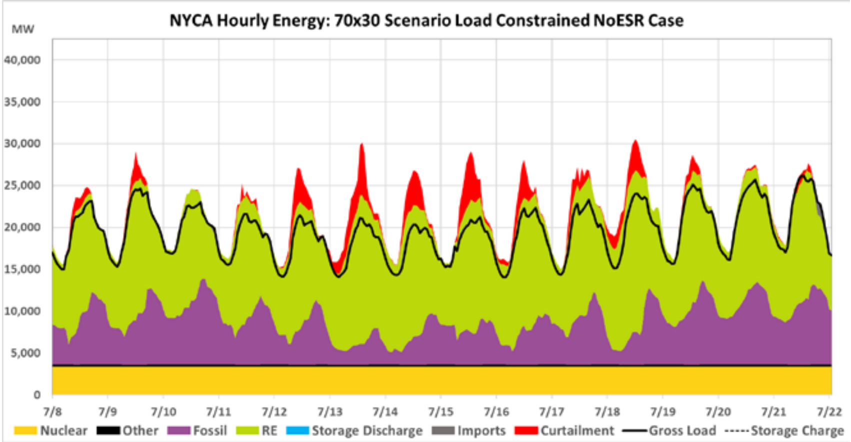
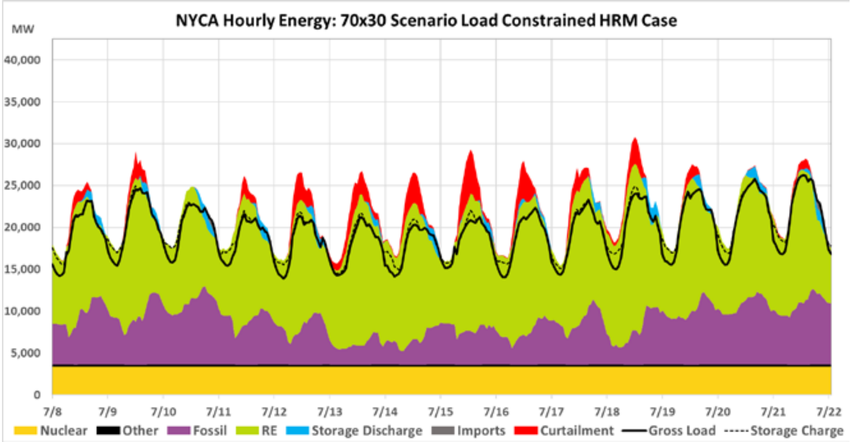
Constrained Output Profiles HRM ESR: Peak Loads





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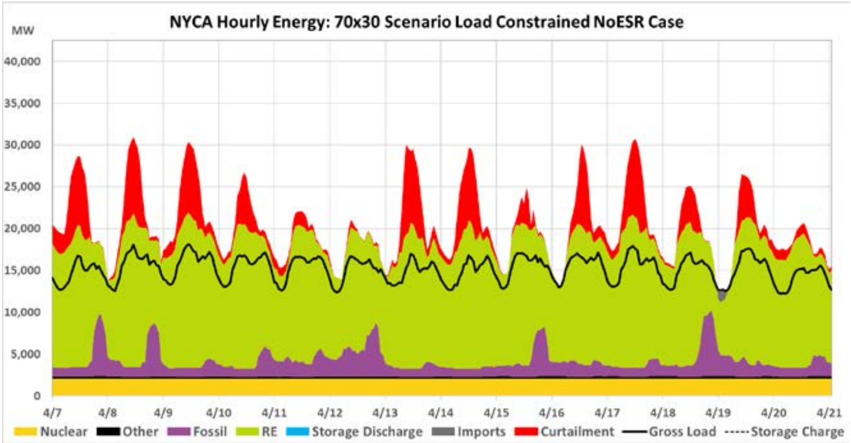
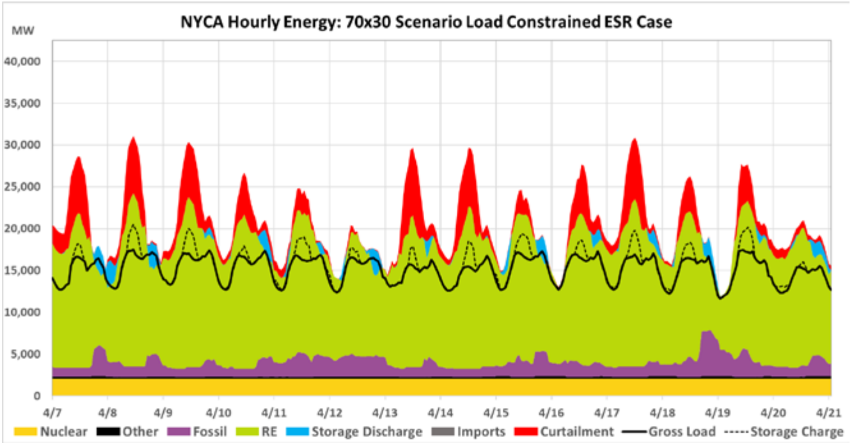
Constrained Output Profiles MAPS ESR : Low Net Loads





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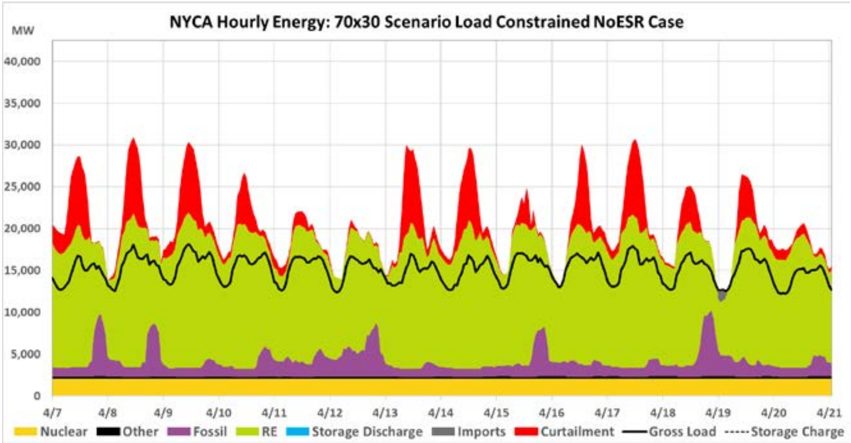

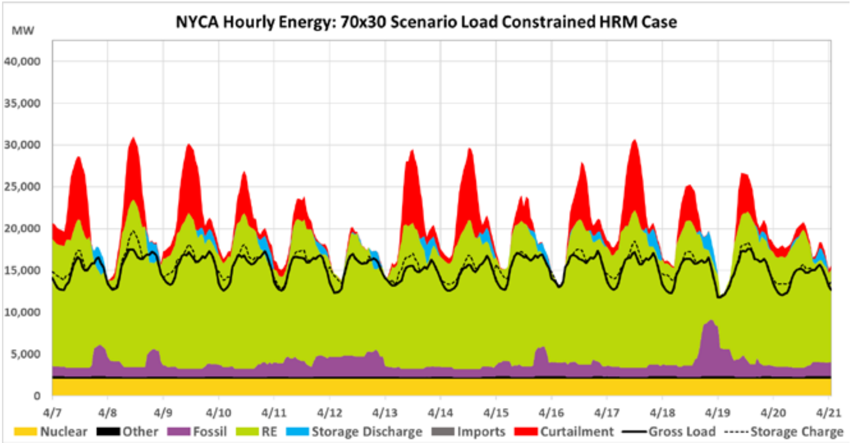

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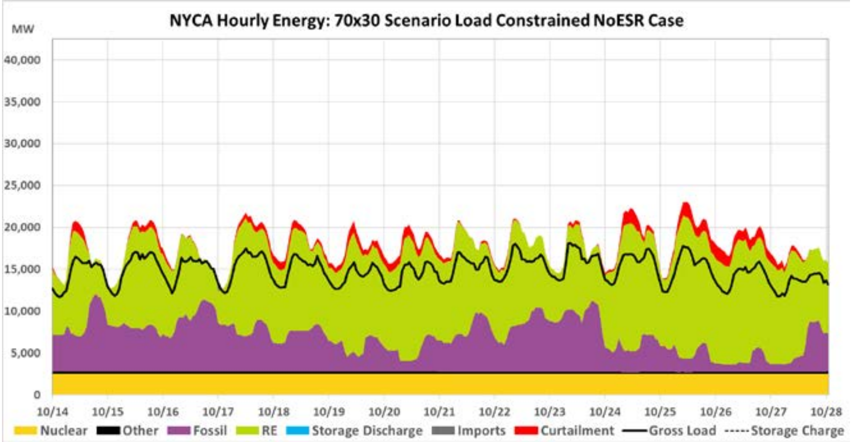
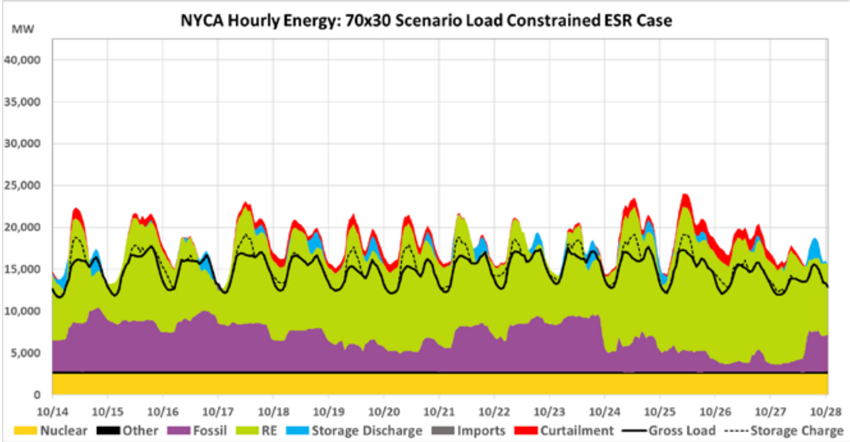
Constrained Output Profiles MAPS ESR : Low Renewable Generation





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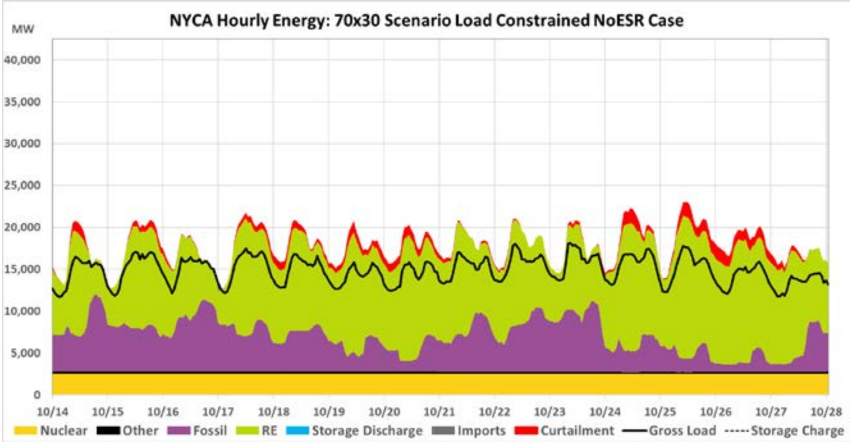
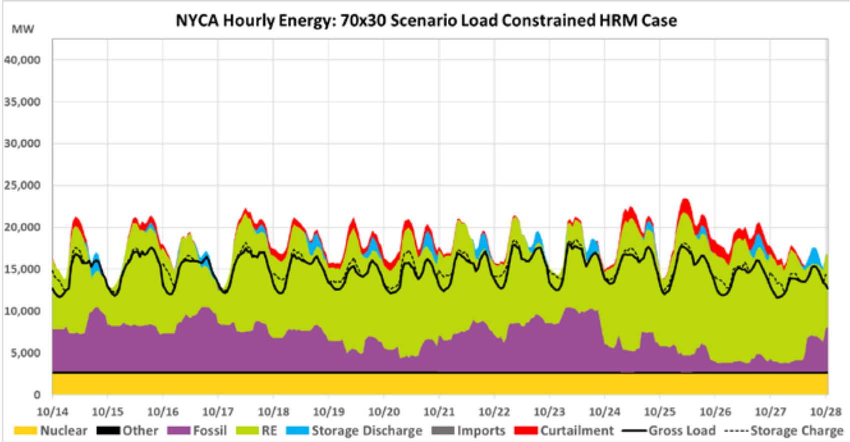
Constrained Output Profiles HRM ESR : Low Renewable Generation





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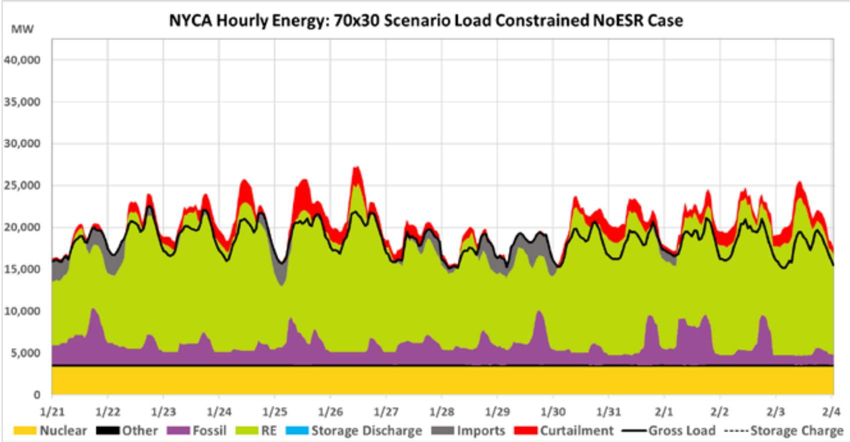
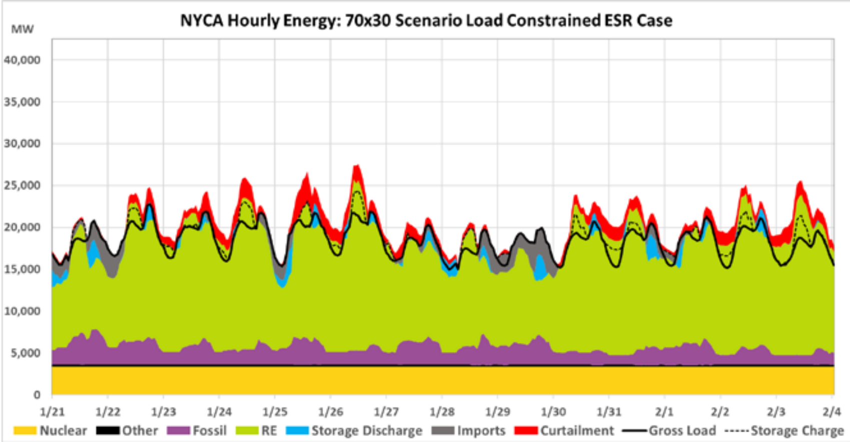
Constrained Output Profiles MAPS ESR : Winter





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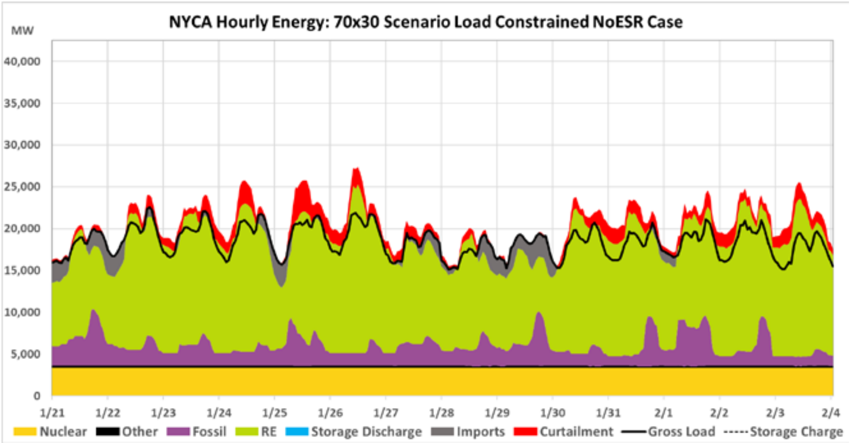
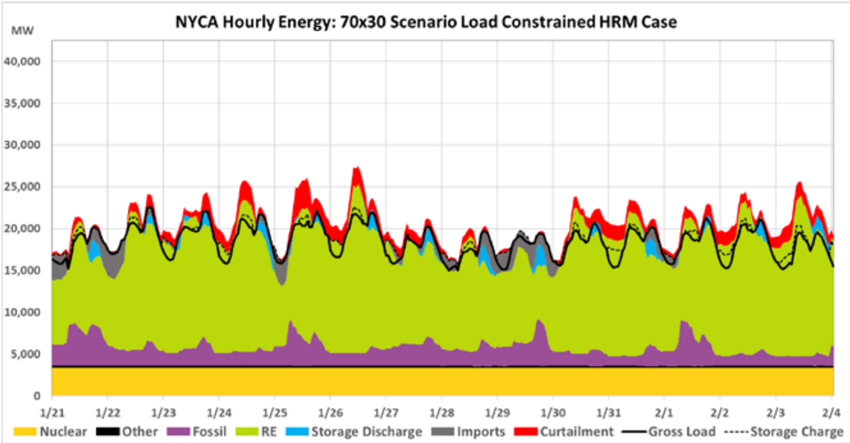
Constrained Output Profiles HRM ESR : Winter





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Additional ESR Modeling Approach

- Results for MAPS ESR and HRM methodologies were generally consistent, as both attempt to optimize thermal unit operations or minimize net load deviations
- Performed limited study of augmenting 5 UPV generators in Pocket Y1 with curtailment targeted ESR
  - ESR objective was to capture as much UPV curtailment as possible given ESR constraints
  - ESR sizing was based upon curtailment event durations, energy, and power parameters
    - MW rating based upon percentile of hourly curtailment values
    - Duration in hours set to reduce annual curtailments by specified amounts

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Scenario Load (NoESR) Case Results

- Selected 5 UPV units with higher curtailed energy in Pocket Y1 to augment with ESR
- Curtailment percentages range from 20% to 80% of total unit input energy
- Added ESR at same nodes as UPV to capture RE curtailments in Pocket Y1

RE unit	Area	Bus name	Capacity (MW)	Curtailed RE (GWh)	Curtailed %
UPV1	CAPITAL	MARSH115	213	172	50%
UPV2	CAPITAL	AMST 115	196	245	78%
UPV3	CAPITAL	MARSH115	109	37	21%
UPV4	CAPITAL	CHURCH-E	87	65	47%
UPV5	CAPITAL	CLINTON	174	177	63%

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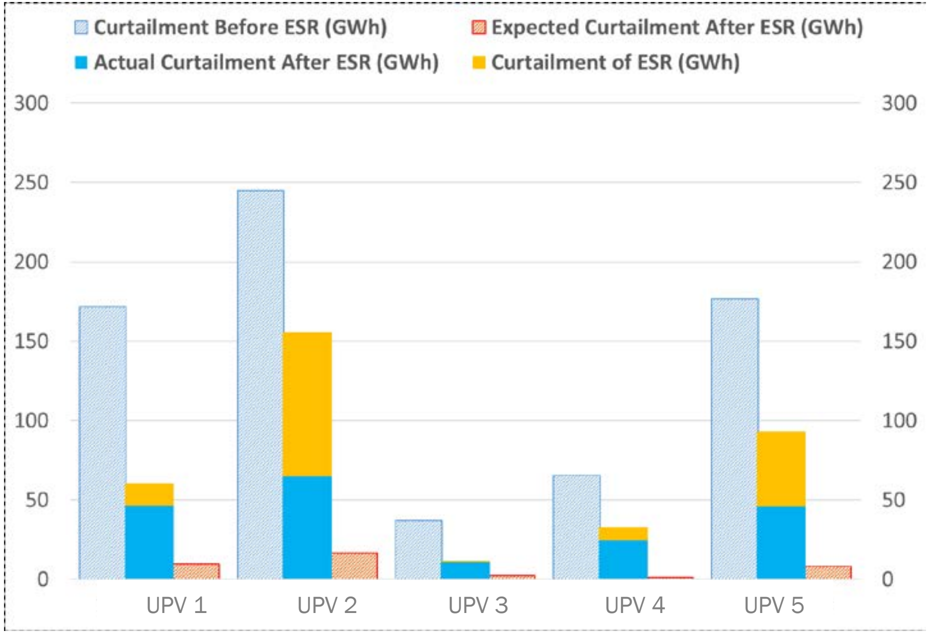
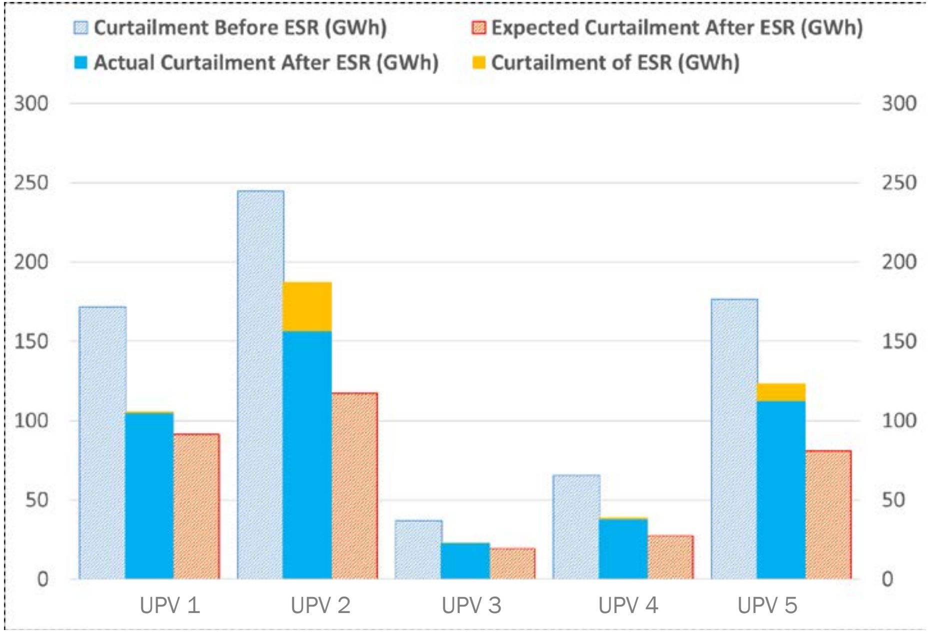
Preliminary MAPS Simulation Results: In-Pocket Collocated ESRs



- Higher Rating ESR: ~75th percentile of curtailment MW, 8-hour duration
- Of expected 69% reduction only 41% was observed



- Lower Rating ESR: ~50th percentile of curtailment MW, 4-hour duration
- Of expected 38% reduction only 25% was observed

If additional ESRs are placed in neighboring pockets, the total curtailment will be higher because of the combined effect of multiple ESR compared to curtailment for each individual pocket studied

ESR Modeling: Key Takeaways

- **Targeted pocket bound ESR may reduce RE curtailments, but**
  - transmission limitations in pockets cannot be directly solved with ESR so MAPS will either curtail the ESR injection or some other renewable unit
  - results in associated ESR curtailments, examined UPV only pocket where curtailments are most aligned with ESR parameters,
  - while curtailment will be reduced in hours that showed curtailed RE energy, some hours with no previous curtailment may end up showing curtailment
  - to model <u>each</u> ESR is highly labor intensive process to identify and set up problem then review results
- **Additional work to study potential of implementing targeted ESR applications in MAPS**
- **Results for MAPS ESR and HRM methodologies were generally consistent given overall similarity in these approaches and is not directly comparable to the targeted investigation in pockets**
- **External optimization HRM approach is a reasonable compromise between implementation complexity and granularity for system level planning studies and represents an improvement from internal MAPS model due to (potential) flexibility in modeling ESR**

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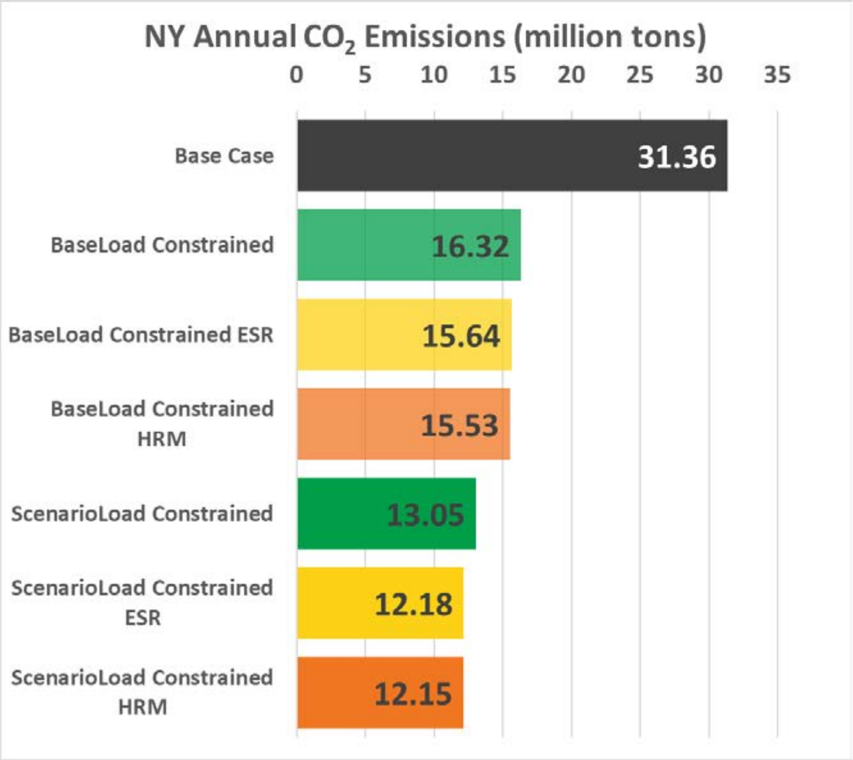
Fossil Fleet Operations

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
- Slightly larger reduction in emissions in HRM cases than ESR due to higher ESR utilization in the HRM cases

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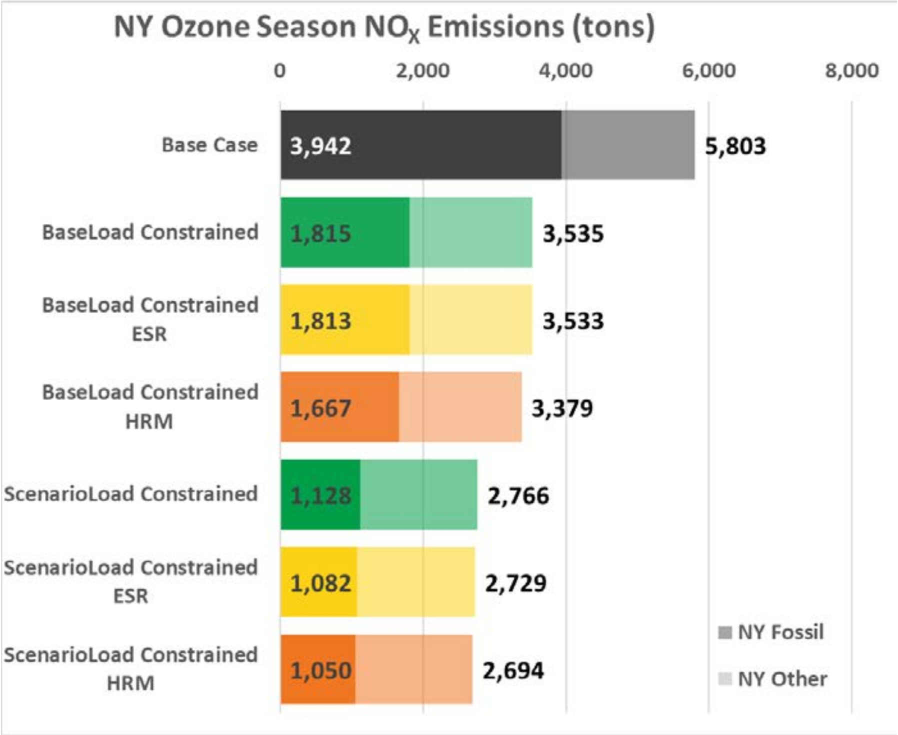
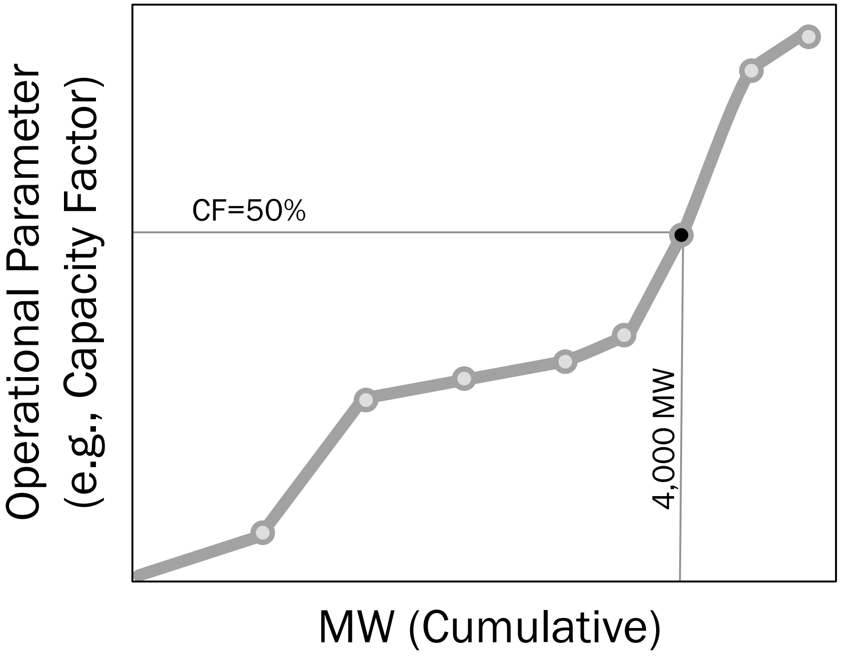
NY Ozone Season NO_X Emissions Projection



- **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%

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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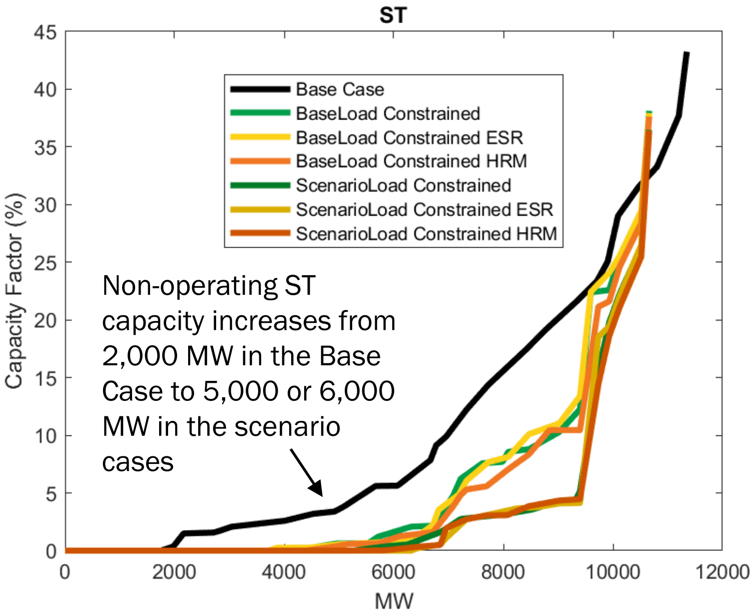
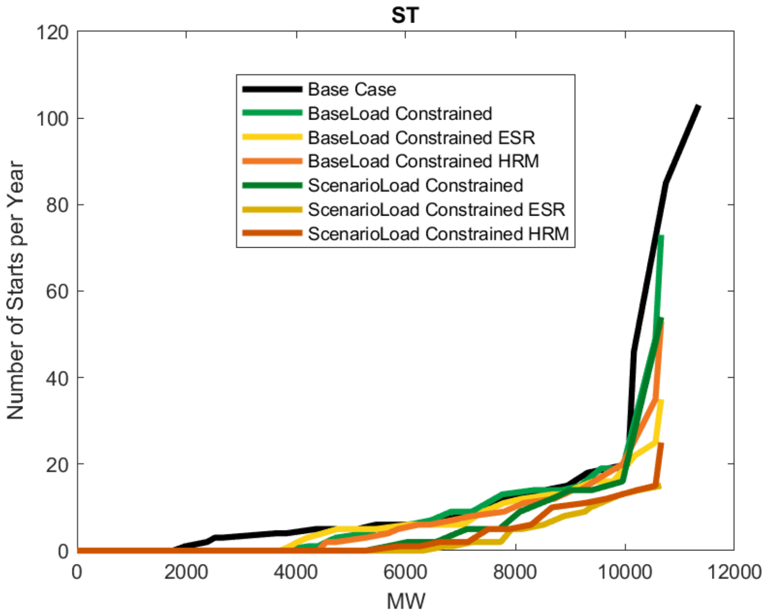
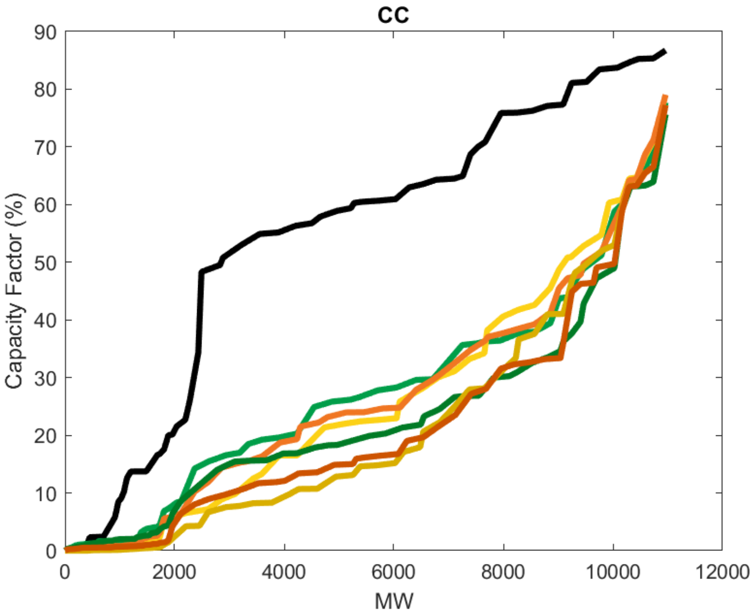
Cumulative Capacity Curve: NYCA Steam Turbine Fleet Operations

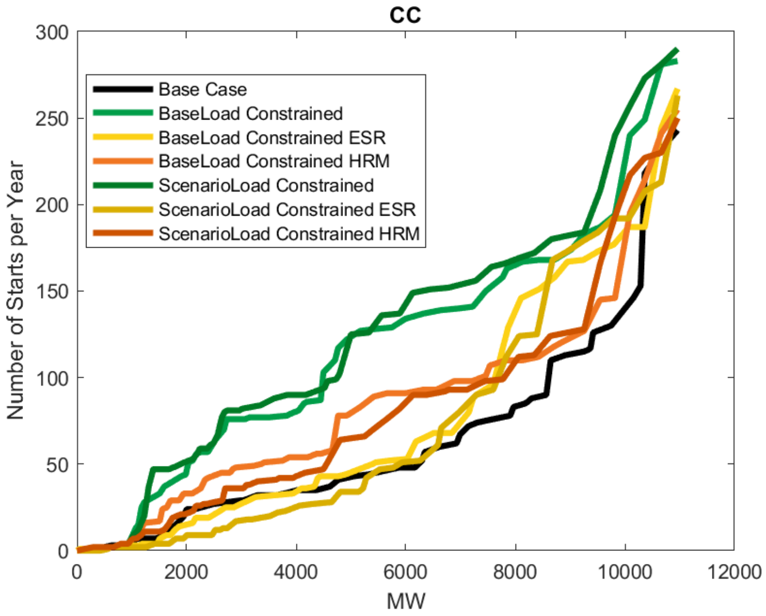




- Output is reduced in scenario cases relative to the Base Case
- Decreased number of starts in scenario cases relative to the Base Case
- Reduced capacity result of Coal Rule assumption in scenario cases

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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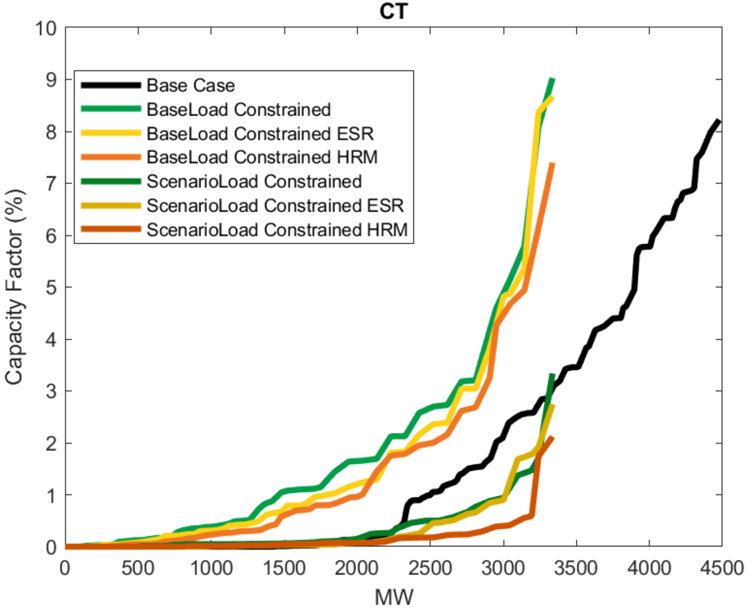
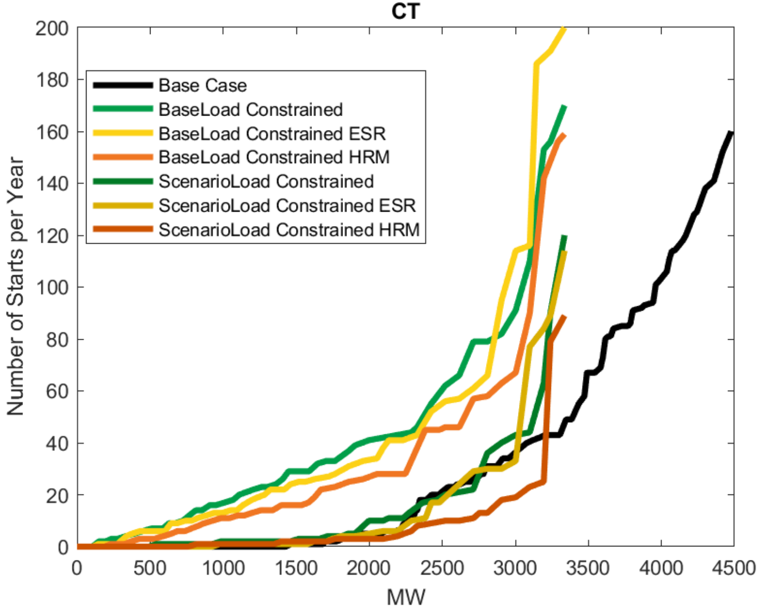
Cumulative Capacity Curve: NYCA Gas Turbine Fleet Operations





- Output and starats per year increases in Base Load cases relative to the Base Case and Scenario Load cases
- Reduced capacity result of Peaker Rule assumption in Scenario Load cases

Cumulative Capacity Curve: Key Points

- Fossil output higher for higher Base Load than Scenario Load cases, particularly for combustion turbine fleet
- ESR has smallest impact on steam turbine fleet operations
- Inclusion of ESR in the case leads to more efficient utilization of the fossil fleet, particularly the combined cycle fleet
- MAPS ESR and HRM methodology impact fossil fleet operations in different ways because of the difference in model approach and storage dispatch

Next Steps

- Review stakeholder feedback and provide remaining responses
- Continue review of CARIS Draft Report in May
- Seek approval from BIC and MC in June
- Seek approval from Board of Directors in July

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: All cases

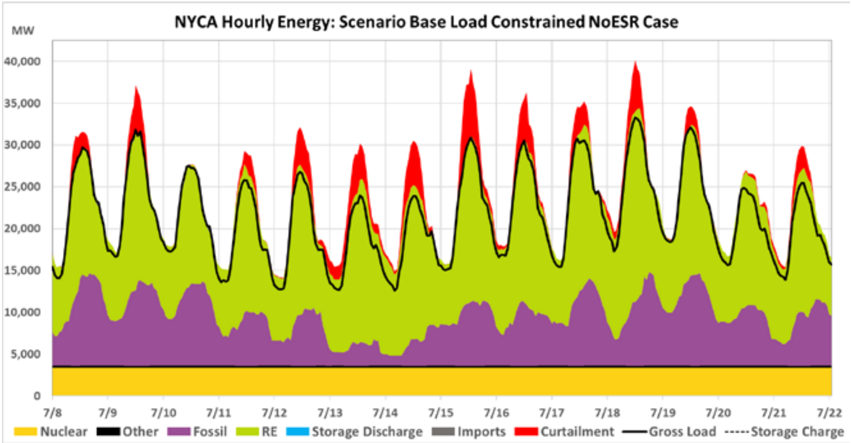
Annual Case Overview MAPS Output for 70x30 Scenario Cases

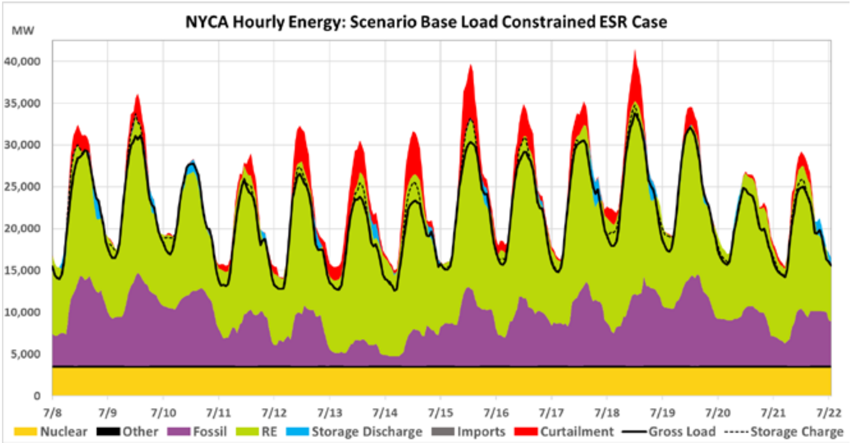
- Monthly values posted with today's meeting materials as excel file

Energy (GWh)	Base Case	BaseLoad Constrained	BaseLoad Constrained ESR	BaseLoad Constrained HRM	BaseLoad Constrained NuclearRetired	BaseLoad Relaxed	ScenarioLoad Constrained	ScenarioLoad Constrained ESR	ScenarioLoad Constrained HRM	ScenarioLoad Constrained NuclearRetired	ScenarioLoad Relaxed	ScenarioLoad Constrained 100xHurdleRate
Nuclear	27,091	27,433	27,434	27,435	-	27,436	27,433	27,434	27,434	-	27,435	27,419
Other	2,368	2,102	2,115	2,117	2,263	2,158	2,110	2,130	2,126	2,270	2,164	1,621
Fossil	69,028	35,181	33,667	33,603	49,448	31,268	28,185	26,290	26,294	42,924	26,390	21,434
Hydro	28,832	28,020	28,084	28,091	28,413	27,974	28,050	28,123	28,114	28,448	28,082	25,117
Hydro Imports	11,564	19,769	19,802	19,808	19,910	19,780	19,775	19,820	19,808	19,897	19,803	19,830
LBW	5,038	17,117	17,322	17,376	18,751	19,243	13,290	13,515	13,532	14,879	13,960	10,453
OSW	-	21,592	21,656	21,821	21,750	22,656	21,625	21,682	21,743	21,714	22,775	19,125
UPV	115	17,982	18,256	18,350	19,342	21,782	12,666	13,234	13,124	14,527	14,764	9,074
BTM-PV	4,988	9,327	9,332	9,329	9,359	9,302	9,266	9,287	9,288	9,356	9,269	9,072
Pumped Storage	(447)	(868)	(562)	(671)	(959)	(930)	(822)	(514)	(630)	(988)	(878)	(885)
Storage	-	-	(604)	(756)	-	-	-	(613)	(693)	-	-	-
IESO Net Imports	(2,862)	(6,250)	(6,136)	(6,145)	(4,264)	(6,030)	(5,817)	(5,788)	(5,755)	(4,090)	(5,550)	71
ISONE Net Imports	(535)	(5,073)	(4,695)	(4,723)	(2,867)	(6,710)	(6,418)	(5,902)	(5,847)	(4,385)	(7,791)	972
PJM Net Imports	12,239	(4,528)	(3,859)	(3,838)	591	(5,996)	(4,446)	(3,798)	(3,648)	287	(5,479)	1,616
Renewable Generation	50,537	113,808	114,452	114,775	117,525	120,736	104,672	105,661	105,609	108,821	108,653	92,671
Curtailment	0	14,020	13,369	13,097	10,338	7,124	10,151	9,174	9,266	6,069	6,218	18,985
Non-Renewable Generation	98,488	64,717	63,215	63,155	51,712	60,861	57,728	55,853	55,853	45,194	55,990	50,474
GrossLoad	157,418	161,807	161,811	161,797	161,733	161,934	144,897	144,897	144,888	144,838	144,948	144,921

Preliminary Case Results: Base Load Storage Sensitivity

Constrained Output Profiles MAPS ESR: Peak Loads





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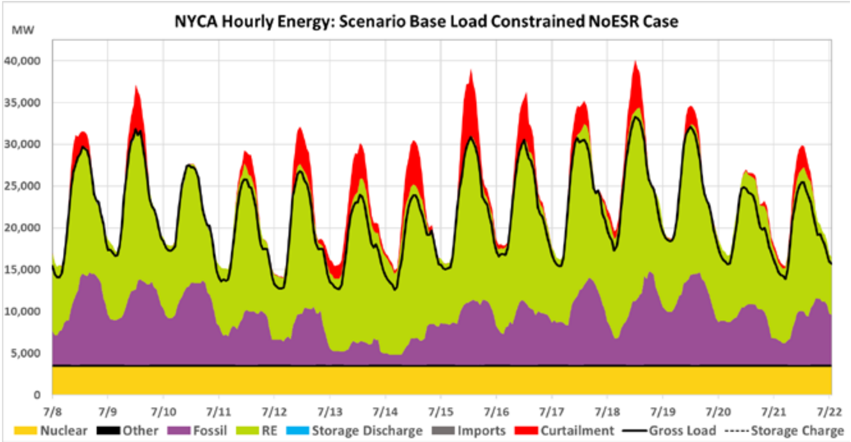
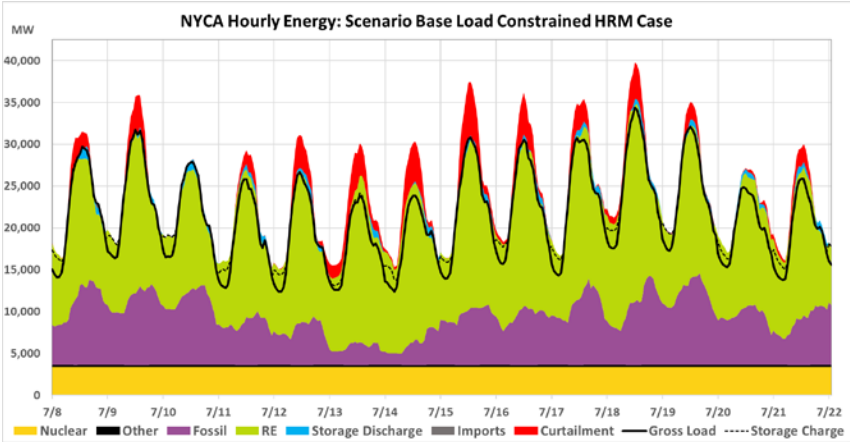
Constrained Output Profiles HRM ESR: Peak Loads





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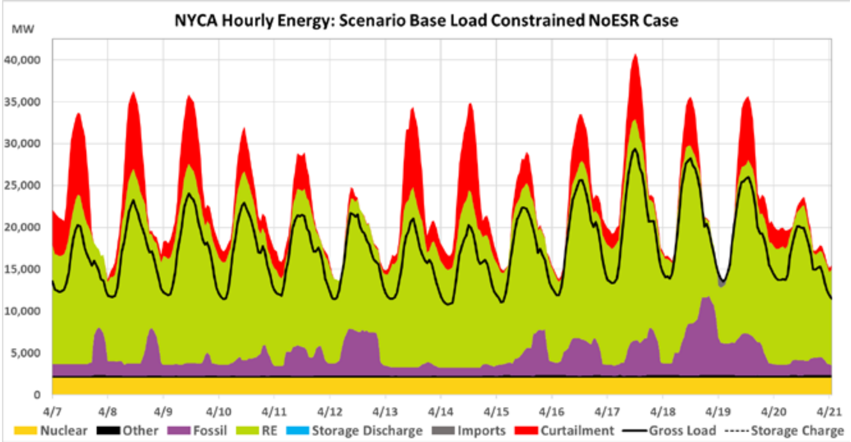
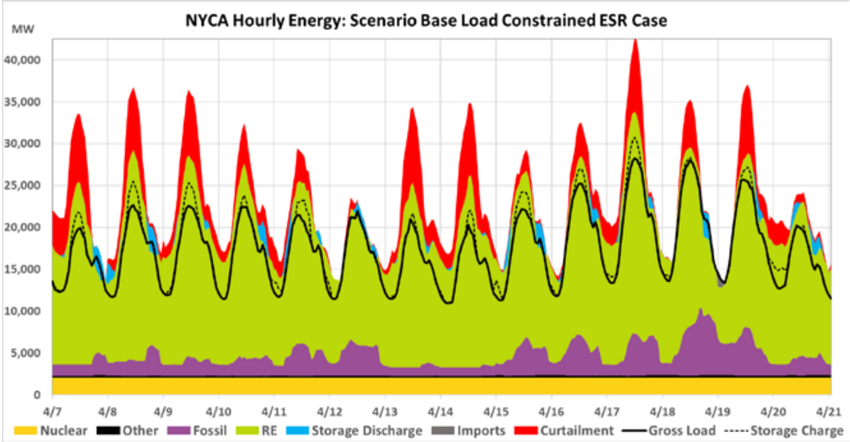
Constrained Output Profiles MAPS ESR : Low Net Loads





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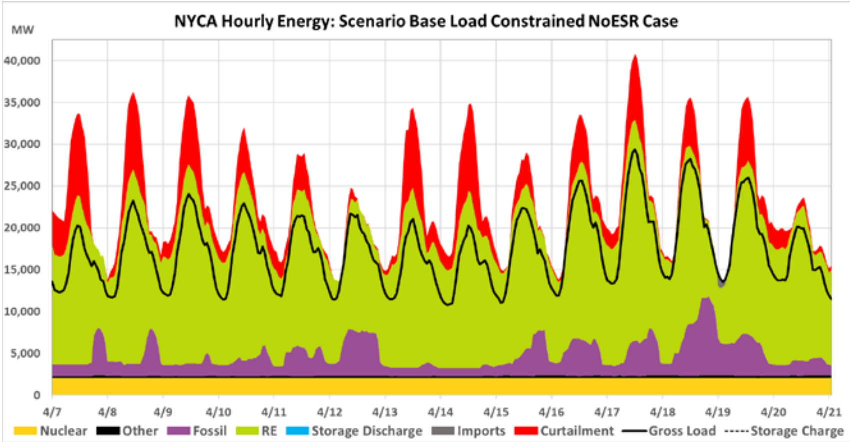
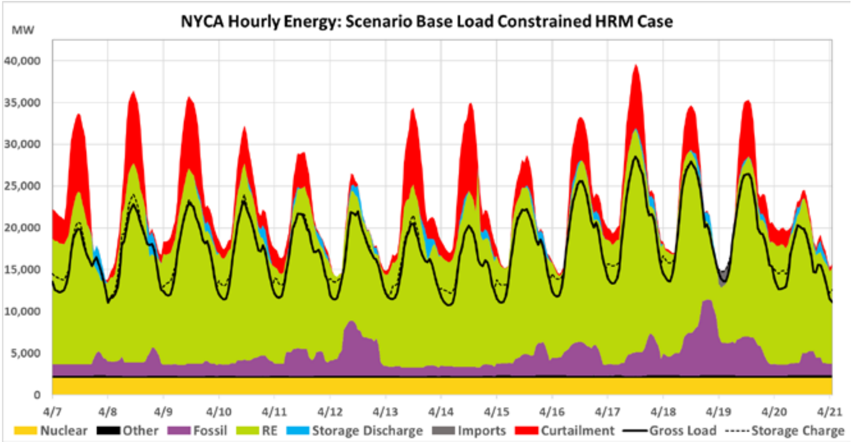
New York ISO

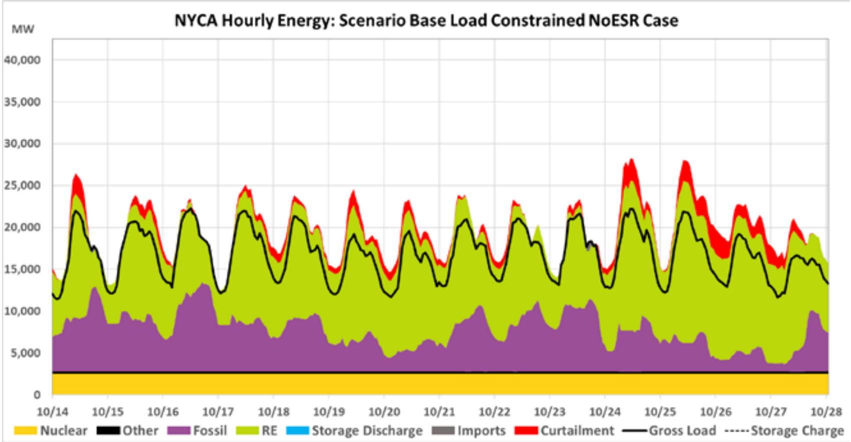
Constrained Output Profiles HRM ESR : Low Net Loads

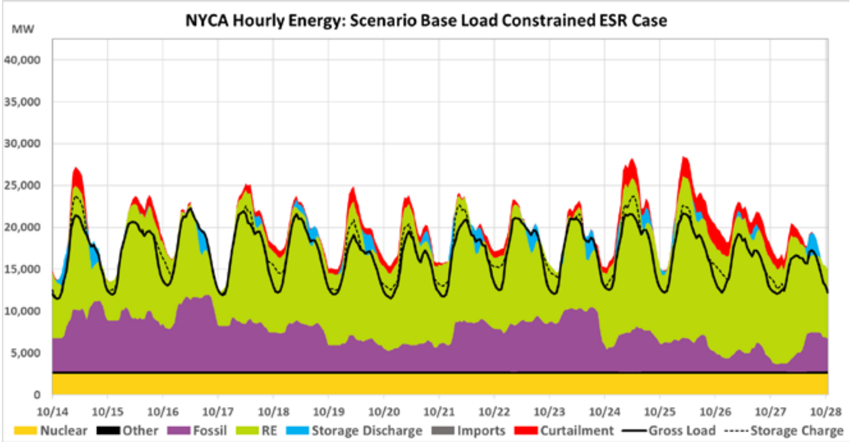




Hours where generation is in excess of load result in exports of NY generation to neighboring areas
"Other" includes Methane (Biogas), Refuse (Solid Waste), and Wood fuel-fired generators
"Imports" includes imports from IESO, ISO-NE, and PJM

Constrained Output Profiles MAPS ESR : Low Renewable Generation





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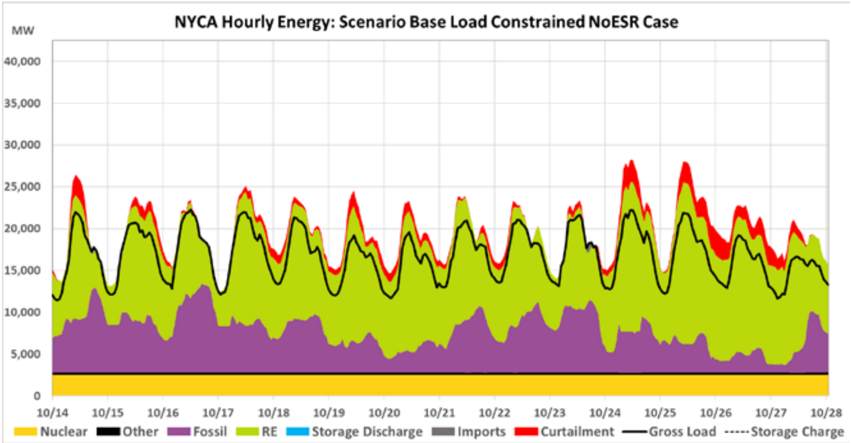
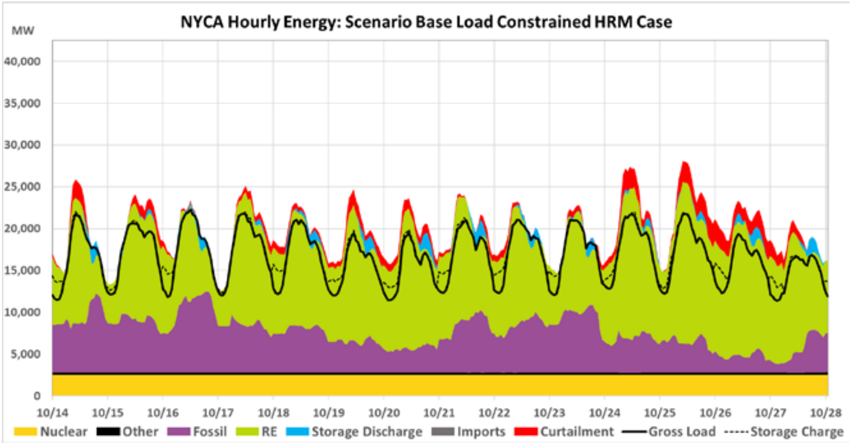
Constrained Output Profiles HRM ESR : Low Renewable Generation





Hours where generation is in excess of load result in exports of NY generation to neighboring areas
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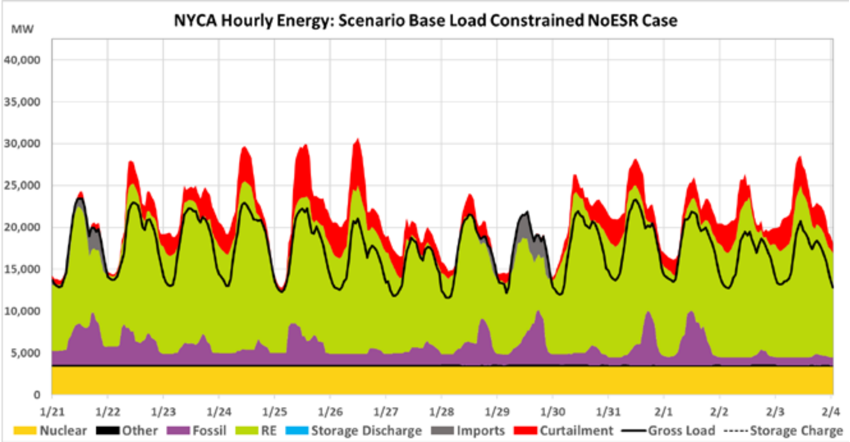
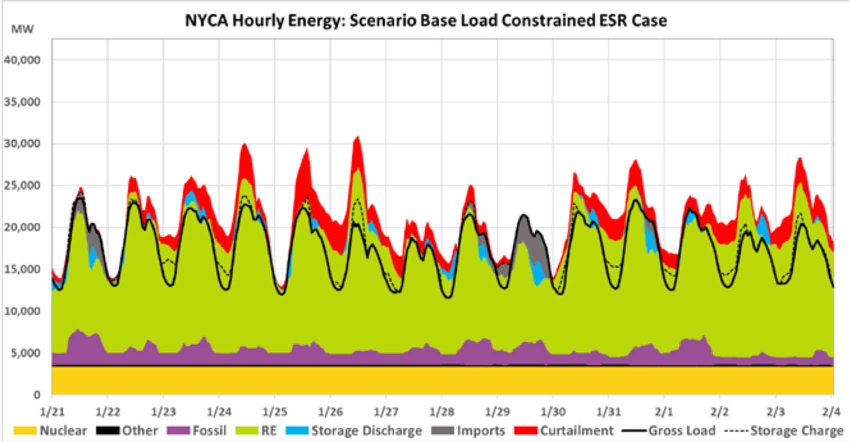
Constrained Output Profiles MAPS ESR : Winter

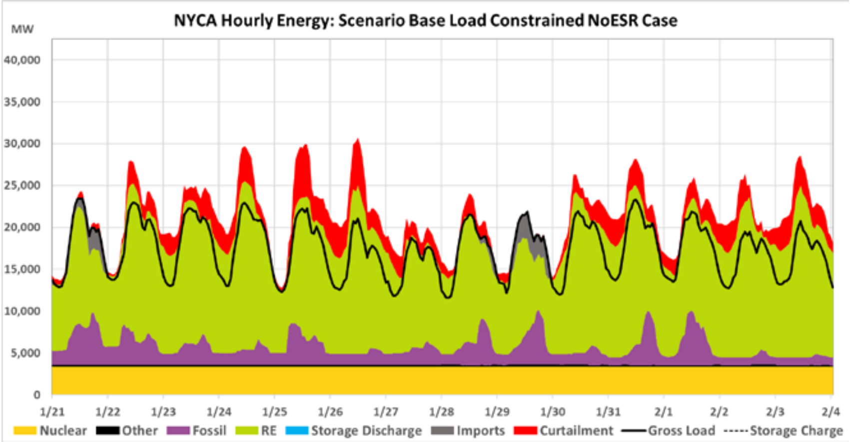


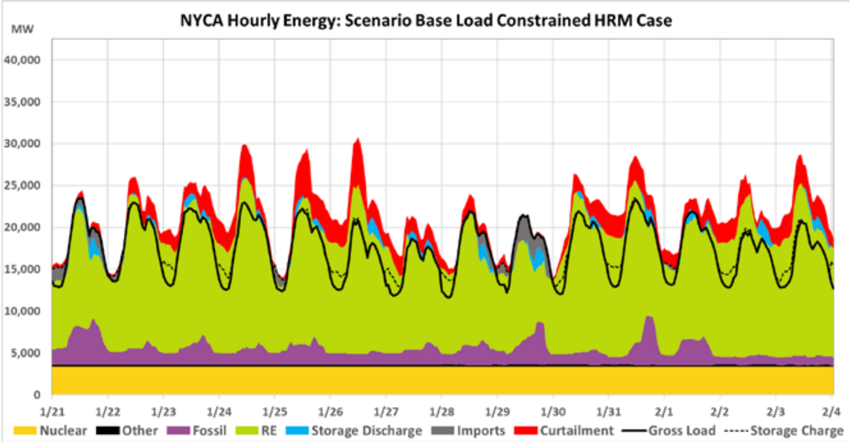


Hours where generation is in excess of load result in exports of NY generation to neighboring areas
“Other” includes Methane (Biogas), Refuse (Solid Waste), and Wood fuel-fired generators
“Imports” includes imports from IESO, ISO-NE, and PJM

New York ISO

Constrained Output Profiles HRM ESR : Winter





Hours where generation is in excess of load result in exports of NY generation to neighboring areas
“Other” includes Methane (Biogas), Refuse (Solid Waste), and Wood fuel-fired generators
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