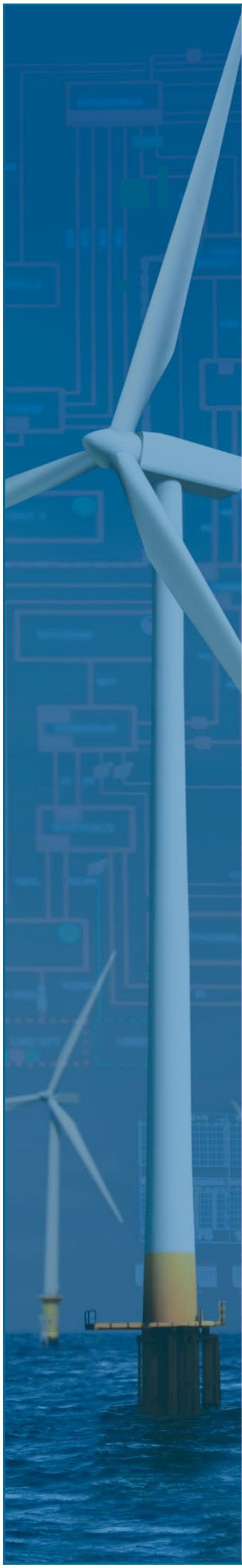


New York ISO
Independent System Operator

Draft Appendix []: Production Cost Model Benchmark

2023-2042 System & Resource Outlook

A Report from the New York Independent System Operator

DRAFT – For Discussion Purposes Only

Appendix []: Production Cost Model Benchmark

Overview

The System & Resource Outlook process starts with a benchmarking exercise ("benchmarking") of the production cost database to recent system and market operations. Benchmarking is a process by which historical actual system data is utilized as inputs to the production cost model (PCM) to validate key metrics by adjusting model parameters. This process allows the NYISO to examine and adjust the model according to the benchmark year's system conditions and to ensure model behavior aligns with actual system performance.

Production Cost Model (PCM)

The production cost model simulates the Security Constrained Unit Commitment (SCUC) and Security Constrained Economic Dispatch (SCED) market software to dispatch generators in the most economically efficient way possible to meet load on an hourly basis. The NYISO uses GE MAPS[1] production cost software to perform this optimization for each hour in the study period. For the benchmarking analysis, 2021 was chosen as the reference year to compare results from the PCM, as this was the most recent year with a complete set of system and market data available when the benchmarking process was initiated. The scope of the production cost model consists of modeling the generators, hourly loads, and transmission network for the New York Control Area (NYCA), PJM, ISO-NE, IESO, and scheduled imports from HQ.

Model Benchmark Process

The benchmarking process includes gathering actual historical system data as inputs to the PCM. Multiple iterations of the PCM simulations are performed to converge selected metrics to fall within acceptable tolerances compared to historical actual values. These iterative runs include incremental updates to the PCM wherein the inputs are layered into the model to examine the effect of each step change. The runs also include tuning model parameters to improve model output accuracy.

Inputs

The PCM utilizes input data from the historical benchmark year, which includes hourly actual net load, fuel prices, emission prices, actual renewable energy output, scheduled tie line flows, and facility outages. A mix of public and proprietary sources were used to update historical loads for the

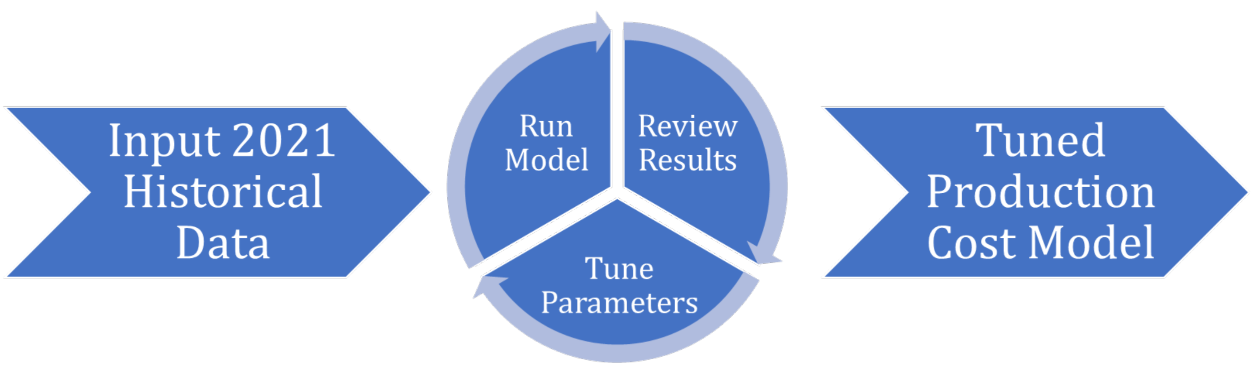
[1] General Electric Multi-Area Production Simulation (GE MAPS)

4-pool system (NYISO, PJM, ISO-NE and IESO). The table below summarizes the high-level model inputs and data sources:

Data	Source
Fuel Prices	S&P Global, EIA
Emissions Prices	RGGI, CSAPR Websites
Network	FERC 715 2021 Model
Facility Outages	NYISO Website
Generator Outage/Derate	NYISO Internal

Emissions prices, which include RGGI CO_2, CSAPR Group 3 NO_x and Group 1 SO_2, and Massachusetts CO_2, were updated to reflect historical 2021 prices. For fuel prices, daily natural gas prices were updated using S&P Global hub data. The annual uranium price and weekly oil and coal prices were updated using EIA data. Derates and outages for generators within the NYCA were included in the model. Hourly generation shapes were updated for renewable generators utilizing actual generation from 2021. Hourly shapes for scheduled imports from HQ and PJM through Neptune were updated based on publicly available data on the NYISO website. Outages for nuclear power plants external to the NYCA were included. The FERC 715 powerflow case for year 2021 was used to represent the NYISO system topology for the benchmark analysis. The Central East dynamic limit nomogram was updated by capturing derates and line outages for associated generators, lines, and capacitor banks.

Figure 1: Benchmark Process Diagram



Model Tuning

The PCM was updated with inputs mentioned above in successive runs to test the directional impact of each modeling input. After all inputs were included, a set of model output metrics were compared to historical actual data. Several input parameters were checked and adjusted to align the output model metrics with actual values. The hurdle rates were a key parameter utilized for model tuning. Hurdle rates are costs modeled in the PCM to simulate the carry-over charge of transmission across two control areas. These charges can represent real costs (e.g., toll charges) or market friction costs that represent differences in inter-regional market commitment and dispatch to serve external load. The hurdle rates utilized for the 2021 benchmark are shown below.

Figure 2: Commitment Hurdle Rates

Commitment Hurdle Rate	Export (from NYCA)		Import (into NYCA)	
	2021 System & Resource Outlook	2023 System & Resource Outlook	2021 System & Resource Outlook	2023 System & Resource Outlook
PJM	$4.00	$4.00	$2.00	$5.50
Linden VFT	$5.00	$5.00	$2.50	$2.50
Neptune	$8.00	$8.00	$1.80	$1.80
HTP	$8.00	$8.00	$3.00	$6.00
ISONE	$3.00	$3.20	$2.00	$2.00
Cross Sound Cable	$2.00	$2.00	$1.00	$1.00
Northport Norwalk Cable	$4.00	$4.00	$2.00	$2.00
IMO	$6.00	$7.50	$3.00	$3.00

Figure 3: Dispatch Hurdle Rates

Dispatch Hurdle Rate	Export (from NYCA)		Import (into NYCA)	
	2021 System & Resource Outlook	2023 System & Resource Outlook	2021 System & Resource Outlook	2023 System & Resource Outlook
PJM	$2.00	$2.00	$0.50	$4.50
Linden VFT	$3.00	$3.00	$0.50	$0.50
Neptune	$6.00	$6.00	$0.80	$0.80
HTP	$6.00	$6.00	$1.00	$4.00
ISONE	$1.00	$1.20	$ -	$ -
Cross Sound Cable	$ -	$ -	$ -	$ -
Northport Norwalk Cable	$2.00	$2.00	$1.00	$1.00
IMO	$4.00	$5.50	$1.00	$1.00

Benchmark Metrics

To benchmark the production cost model, several simulation output metrics are chosen to evaluate model performance. The primary metrics that are evaluated by the NYISO are as follows:

- Zonal Annual Generation (GWh)
- NYCA Import/Export Energy (GWh)
- Generation and Load Payments ($)
- Zonal Demand Congestion ($)
- Locational Based Marginal Price (LBMP) ($/MW)

Benchmark Results

The final benchmark results are listed in Figure 4 to Figure 13 below for the 2021 benchmark year. The results were presented to NYISO stakeholders for discussion at the ESPWG on July 17, 2023.

Figure 4: Zonal Generation Summary (Annual GWh)

2021 Zonal Generation	Actual	Benchmark
West	17,150	17,675
Genesee	4,848	4,880
Central	29,350	30,051
North	8,900	8,760
Mohawk Valley	2,906	2,864
Capital	12,679	12,288
Hudson Valley	10,781	10,182
Millwood	3,134	3,385
Dunwoodie	0	0
New York City	23,655	24,122
Long Island	11,524	9,850
NYCA	124,927	124,058

Figure 5: Zonal Load (Annual GWh)

2021 Zonal Load	Actual	Benchmark
West	14,731	14,698
Genesee	9,797	9,776
Central	15,560	15,521
North	5,415	5,408
Mohawk Valley	7,616	7,596
Capital	11,827	11,802
Hudson Valley	9,262	9,244
Millwood	2,884	2,877
Dunwoodie	5,781	5,772
New York City	48,832	48,785
Long Island	20,273	20,251
NYCA	151,979	151,731

Figure 6: NYCA Import Energy (Annual GWh)

2021 Import Energy	Actual	Benchmark
PJM-NYISO	5,611	6,283
LINDEN VFT	2,252	2,369
NEPTUNE	2,730	2,730
HTP	2,807	2,799
ISONE-NYISO	424	121
CROSS SOUND CABLE	1,937	2,114
NORTHPORT NORWALKCABLE	818	932
IMO-NYISO	5,711	5,776
HQ-NYISO CHAT	9,904	9,902
HQ-NYISO CEDARS	850	846
TOTAL IMPORT	33,045	33,871

Figure 7: NYCA Export Energy (Annual GWh)

2021 Export Energy	Actual	Benchmark
PJM-NYISO	121	105
LINDEN VFT	3	7
NEPTUNE	0	0
HTP	0	0
ISONE-NYISO	5,588	5,917
CROSS SOUND CABLE	0	0
NORTHPORT NORWALKCABLE	83	117
IMO-NYISO	27	67
HQ-NYISO CHAT	0	0
HQ-NYISO CEDARS	0	0
TOTAL EXPORT	5,823	6,213

Figure 8: NYCA Net Import Energy (Annual GWh)

2021 Net Import Energy	Actual	Benchmark
PJM-NYISO	5,490	6,178
LINDEN VFT	2,249	2,362
NEPTUNE	2,730	2,730
HTP	2,807	2,799
ISONE-NYISO	-5,164	-5,796
CROSS SOUND CABLE	1,937	2,114
NORTHPORT NORWALKCABLE	735	815
IMO-NYISO	5,685	5,709
HQ-NYISO CHAT	9,904	9,902
HQ-NYISO CEDARS	850	845
TOTAL NET IMPORT	27,222	27,658

Figure 9: Zonal Average LBMP ($/MWh)

2021 Zonal Average LBMP	Actual	Benchmark
West	30.09	28.95
Genesee	28.55	26.89
Central	29.57	27.67
North	23.52	22.67
Mohawk Valley	30.08	27.07
Capital	44.16	41.98
Hudson Valley	40.09	37.43
Millwood	41.75	37.91
Dunwoodie	41.44	37.77
New York City	42.46	37.98
Long Island	54.78	45.26

Figure 10: Zonal Load Payment (Nominal $M)

2021 Zonal Load Payment	Actual	Benchmark
West	480	426
Genesee	298	263
Central	483	420
North	130	120
Mohawk Valley	239	202
Capital	544	495
Hudson Valley	392	346
Millwood	129	108
Dunwoodie	253	221
New York City	2,184	1,894
Long Island	1,262	964
NYCA	6,393	5,458

Figure 11: Zonal Generation Payment (Nominal $M)

2021 Zonal Generation Payment	Actual	Benchmark
West	487	482
Genesee	128	123
Central	837	734
North	198	199
Mohawk Valley	73	66
Capital	567	496
Hudson Valley	442	357
Millwood	113	118
Dunwoodie	0	0
New York City	1,078	948
Long Island	733	469
NYCA	4,656	3,993

Figure 12: Demand Congestion by Constraint (Nominal $M)

2021 Top 10 Demand Congestion Constraints	Actual	Benchmark
CENTRAL EAST	1,155	1,211
DUNWOODIE TO LONG ISLAND	90	80
PORTER ROTTERDAM	36	0
EIWOOD 69 PULASKI 69	26	24
LEEDS PLEASANT VALLEY	22	0
RAINEY VERNON	17	1
NIAGARA PACKARD	15	1
PACKARD 115 NIAGBLVD 115	14	13
GREENWOOD	14	13
DUNWOODIE MOTTHAVEN	11	1

Figure 13: Demand Congestion by Zone (Nominal $M)

2021 Zonal Demand Congestion	Actual	Benchmark
West	63	62
Genesee	11	22
Central	175	45
North	18	5
Mohawk Valley	11	15
Capital	175	196
Hudson Valley	100	105
Millwood	33	34
Dunwoodie	60	67
New York City	566	575
Long Island	523	414
NYCA	1,733	1,541

The benchmark results show that the simulated zonal load and generation, imports, and exports are close to historical actuals. The modeled zonal LBMPs, load payments, and generator payments were slightly lower than historic values. There are several factors that contribute to this. Not all transmission outages, generator outages, and generator derates from 2021 can be included in the model due to modeling limitations. Major construction-related outages along the Central East corridor (Porter-Rotterdam 230kV) and outages on other major lines, such as Y49 and Y50, were not captured in the benchmark model. This leads to the commitment and dispatch decisions that differ from historic operations. Differences in system simulation and actual operations are the key factor driving the deviation in results in the benchmark simulation.

Summary

The benchmarking analysis shows that the PCM outputs are close to historical annual outputs for generation, load, LBMPs, generator payments, load payments, zonal demand congestion, and import/export flows. While there exists differences in the model outputs versus actual historic values, these can mostly be attributed to modeling limitations (e.g., transmission line outages) and nuances related to real-time operations of the actual markets. The PCM attempts to mimic day-ahead commitments and real-time dispatch of generators in the 4-pool system, but there are out-of-market commitments and operator actions in real-time that are not captured by the model. These differences are a result of utilizing a mathematical model to approximate real system conditions.

The PCM model resulting from the benchmarking analysis will be further updated to reflect future system conditions by incorporating, among other things, forecasts for load, fuel prices, emission prices, and future transmission and generation buildout. This updated model will be utilized in the 2023-2042 System & Resource Outlook study cases.