New York ISO
Independent System Operator

Appendix A: Production Cost Model Benchmark

2023-2042 System & Resource Outlook

A Report from the New York Independent System Operator

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Appendix A: Production Cost Model Benchmark

Overview

The System and Resource Outlook model development process starts with benchmarking the latest version of the production cost database. Benchmarking is a process by which historical actual system data is utilized as inputs to the production cost model to validate key metrics by adjusting model parameters. This process allows the NYISO to examine and adjust the model according to the benchmark year real-time operations and to ensure model behavior aligns with reality. For the 2023-2042 System & Resource Outlook process, the NYISO selected 2021 for the benchmarking year given data availability.

Production Cost Model

The production cost model simulates the unit commitment and economic dispatch market software used in actual operations to dispatch generators in the most economically efficient way possible to meet load on an hourly basis. The NYISO uses GE MAPS as the software to perform this optimization for each hour in 2021 for the benchmarking analysis. The scope of the production cost model consists of modeling the generators, hourly load, and the transmission network for the NYCA, PJM, ISO-NE, IESO, and scheduled imports from Hydro-Québec (HQ).

Model Benchmark Process

The benchmarking process includes gathering actual historical system data as inputs to the production cost model. Multiple iterations of the production cost model simulations were run to converge the metrics to be within acceptable tolerances compared to actual values. These iterative runs include incremental updates to the production cost model database where the inputs are layered into the model to examine the effect of each step change. The iterative runs also include tuning model parameters to improve model output accuracy.

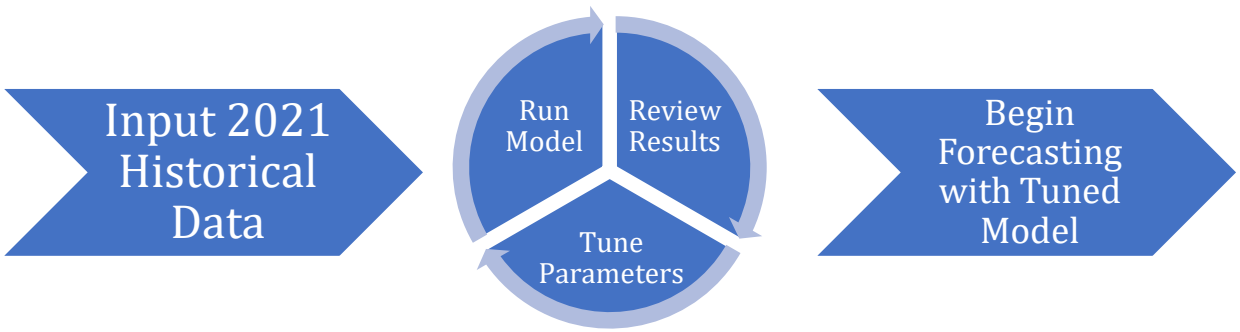
Inputs

The production cost model utilizes input data from the historical benchmark year (2021), which includes hourly actual net load, fuel prices, emission prices, actual renewable energy output, scheduled tie line flows, and generation facility outages. The NYISO used a mix of public and proprietary sources to update historical loads for the four-pool system (i.e., NYISO, PJM, ISO-NE, and IESO).

The NYISO updated the emissions prices, which include RGGI CO_2, CSAPR Group 3 NO_x and Group 1 SO_2, and Massachusetts CO_2, to reflect historical 2021 prices. For fuel prices, daily natural

gas prices were updated using S&P Global hub historic data. The annual uranium price and weekly oil and coal prices were updated using EIA historic 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 NYISO used year 2021 from the FERC 715 power flow case to represent the NYISO system topology for the benchmark analysis. Individual transmission outages were not included in the network topology due to modeling complexity. Lastly, the Central East interface dynamic limit nomogram[1] was updated by capturing derates and line outages for associated generators, lines, and capacitor banks.

Figure A-1: Benchmark Process Diagram



Model Tuning

The NYISO updated the production cost model with the inputs described above in successive runs to test the directional impact of each modeling input. After all inputs were included, the NYISO compared the model metrics to the historical actuals for validation. Several parameters were adjusted to align the model metrics with actual historic values. One of the key parameters utilized for model tuning is hurdle rates. Hurdle rates are costs modeled in the production cost model to simulate the carry over charge of transmission across two control areas. The hurdle rates utilized for the 2021 benchmark, as well as the 2021-2040 System & Resource Outlook, are as shown in the figure below.

[1] Central East Voltage Collapse Limit Nomogram: https://www.nyiso.com/documents/20142/2268509/CE-VC-Static-limit-posting-FINAL-20231222.pdf/

Figure A-2: Commitment Hurdle Rates

Commitment Hurdle Rate	Export (from NYCA)			Import (into NYCA)		
	Transaction Cost	2021-2040 Outlook	2023-2042 Outlook	Transaction Cost	2021-2040 Outlook	2023-2042 Outlook
PJM	$ 8.00	$ 4.00	$ 4.00	$ 5.00	$ 2.00	$ 5.50
Linden VFT	$ 8.00	$ 5.00	$ 5.00	$ 5.00	$ 2.50	$ 2.50
Neptune	$ 8.00	$ 8.00	$ 8.00	$ 5.00	$ 1.80	$ 1.80
HTP	$ 8.00	$ 8.00	$ 8.00	$ 5.00	$ 3.00	$ 6.00
ISONE	$ 2.00	$ 3.00	$ 3.20	$ 2.00	$ 2.00	$ 2.00
Cross Sound Cable	$ 2.00	$ 2.00	$ 2.00	$ 2.00	$ 1.00	$ 1.00
Northport Norwalk Cable	$ 2.00	$ 4.00	$ 4.00	$ 2.00	$ 2.00	$ 2.00
IMO	$ 6.00	$ 6.00	$ 7.50	$ 4.00	$ 3.00	$ 3.00

Figure A-3: Dispatch Hurdle Rates

Dispatch Hurdle Rate	Export (from NYCA)			Import (into NYCA)		
	Transaction Cost	2021-2040 Outlook	2023-2042 Outlook	Transaction Cost	2021-2040 Outlook	2023-2042 Outlook
PJM	$ 6.00	$ 2.00	$ 2.00	$ 3.00	$ 0.50	$ 4.50
Linden VFT	$ 6.00	$ 3.00	$ 3.00	$ 3.00	$ 0.50	$ 0.50
Neptune	$ 6.00	$ 6.00	$ 6.00	$ 3.00	$ 0.80	$ 0.80
HTP	$ 6.00	$ 6.00	$ 6.00	$ 3.00	$ 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	$ 4.00	$ 5.50	$ 2.00	$ 1.00	$ 1.00

Benchmark Metrics

To benchmark the production cost model, the NYISO chose several metrics to evaluate model performance. The NYISO focuses its benchmarking on the following metrics:

- Generator Annual Generation (GWh)
- Transmission Constraint Congestion (Hours)
- Import/Export Energy (GWh)
- LBMPs ($/MW)

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 A-4: Zonal Load Payment Summary (nominal $M)

2021 Zonal Load Payment	Actual	Benchmark
West	480	416
Genesee	298	257
Central	483	443
North	130	121
Mohawk Valley	239	206
Capital	544	494
Hudson Valley	392	347
Millwood	129	108
Dunwoodie	253	221
New York City	2,184	1,897
Long Island	1,262	964
NYCA	6,393	5,473

Figure A-5: Zonal Generator Payment Summary (nominal $M)

2021 Zonal Generation Payment	Actual	Benchmark
West	564	462
Genesee	134	121
Central	904	752
North	204	201
Mohawk Valley	84	67
Capital	594	493
Hudson Valley	464	364
Millwood	114	118
Dunwoodie	-	-
New York City	1,090	959
Long Island	777	470
NYCA	4,929	4,007

Figure A-6: Zonal Demand Congestion Summary (nominal $M)

2021 Zonal Demand Congestion	Actual	Benchmark
West	63	47
Genesee	11	13
Central	175	62
North	18	5
Mohawk Valley	11	16
Capital	175	191
Hudson Valley	100	103
Millwood	33	33
Dunwoodie	60	65
New York City	566	558
Long Island	523	405
NYCA	1,733	1,499

Figure A-7: Top Transmission Constraint Congestion Summary (nominal $M)

2021 Top 10 Demand Congestion Constraints	Actual	Benchmark
CENTRAL EAST	1,155	1,183
DUNWOODIE TO LONG ISLAND	90	80
PORTER ROTTRDAM	36	0
ELWOOD 69 PULASKI 69	26	23
LEEDS PLEASANT VALLEY	22	0
RAINEY VERNON	17	1
NIAGARA PACKARD	15	1
PACKARD 115 NIAGBLVD 115	14	0
GREENWOOD	14	12
DUNWOODIE MOTTHAVEN	11	1

Figure A-8: Zonal LBMP Summary ($/MWh)

2021 Zonal Average LBMP	Actual	Benchmark
West	30.09	28.29
Genesee	28.55	26.33
Central	29.57	28.97
North	23.52	22.85
Mohawk Valley	30.08	27.49
Capital	44.16	41.92
Hudson Valley	40.09	37.49
Millwood	41.75	37.96
Dunwoodie	41.44	37.81
New York City	42.46	38.00
Long Island	54.78	45.26

Figure A-9: Zonal Generation Summary (GWh)

2021 Zonal Generation	Actual	Benchmark
West	17,150	17,645
Genesee	4,848	4,889
Central	29,350	30,556
North	8,900	8,771
Mohawk Valley	2,906	2,869
Capital	12,679	12,180
Hudson Valley	10,781	10,281
Millwood	3,134	3,385
Dunwoodie	-	-
New York City	23,655	24,450
Long Island	11,524	9,863
NYCA	124,927	124,890

Figure A-10: Zonal Load Summary (GWh)

2021 Zonal Load	Actual	Benchmark
West	14,731	14,697
Genesee	9,797	9,776
Central	15,560	15,520
North	5,415	5,407
Mohawk Valley	7,616	7,595
Capital	11,827	11,801
Hudson Valley	9,262	9,243
Millwood	2,884	2,876
Dunwoodie	5,781	5,772
New York City	48,832	48,784
Long Island	20,273	20,250
NYCA	151,979	151,722

Figure A-11: Import Summary (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 NET IMPORT	33,045	33,871

Figure A-12: Export Summary (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 NET IMPORT	5,823	6,213

Figure A-13: Net Import Summary (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

The benchmark results highlight accurate zonal load and generation, imports, and exports. The modeled zonal LBMPs, load payments, and generator payments were slightly lower than historical values. There are several factors that contribute to the lower than historical values. For instance, not all transmission outages, generator outages, and generator derates from 2021 can be included in the model due to modeling complexity and software limitations. This leads to the optimization committing and dispatching the cheapest generators; however, in real-time operations, those generators and/or transmission lines may not have been available. For the 2023-2042 simulations performed in this study, EFORd values are used to simulate generator outages and derates. The NYISO anticipates that the use of EFORd values will result in higher LBMPs, load payments, and generator payments and, therefore, will improve the model's accuracy.

Additionally, the production cost model attempts to mimic day-ahead commitments and real-

time dispatch in the four-pool system, but out-of-market commitments and operator actions in real time are not captured by the model. These differences are a result of utilizing a mathematical model to approximate real system conditions.

Summary

The benchmarking analysis found that the production cost model outputs are close to historical annual outputs for generation, load, LBMPs, generator payments, load payments, zonal demand congestion, and import/export flows. While differences remain in the model outputs compared to actual historical values, the differences can mostly be attributed to modeling limitations and real-time operations of the actual markets.

The NYISO further updated the production cost model from the benchmarking analysis to reflect future system conditions. Such updates incorporate forecasts for, among other things, load, fuel prices, emission prices, future transmission, and generation buildout to be utilized in the 2023-2042 System and Resource Outlook reference cases.