2024 Economic Study

System Efficiency Needs Scenario – Sensitivity Results

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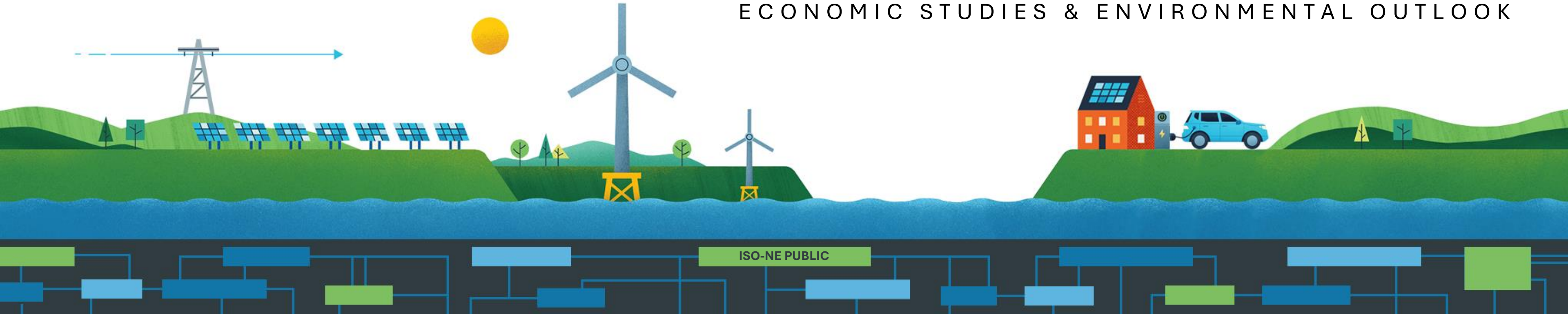
ECONOMIC STUDIES & ENVIRONMENTAL OUTLOOK



Overview of Presentation

- Economic Study Overview
- Sensitivity Overview
- HQ Resource Addition
- Diurnal Imports
- Gas Price Differential

OVERVIEW OF THE ECONOMIC STUDY

Objective of the Economic Study Process

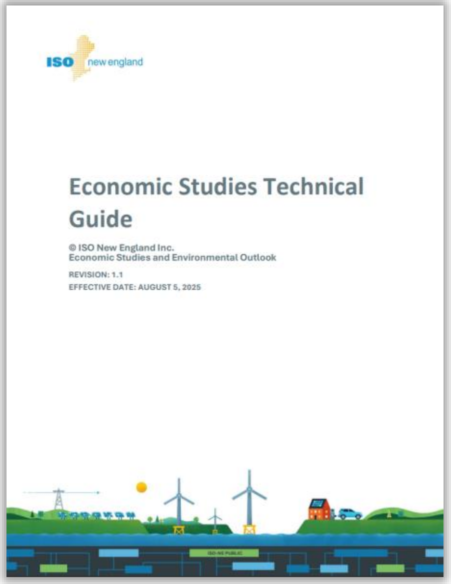
- Provide information to stakeholders to facilitate the evaluation of economic and environmental impacts of New England (NE) regional policies, federal policies, and various resource technologies on satisfying future resource needs in the region
  - Identify system efficiency issues on the pool transmission facility (PTF) portion of the New England Transmission System and, as applicable, evaluate competitive solutions to alleviate identified system efficiency needs
- The 2024 Economic Study will conclude in December 2025

Economic Study Reference Scenarios

- ✓ **Benchmark Scenario** – Model previous calendar year and compare it to historical system performance. This scenario's purpose is to test the fidelity of models against historical performance and improve the models for future scenarios
- ✓ **Policy Scenario** – Model future years (>10-year planning horizon) based on satisfying New England region and other energy policies and goals
- ✓ **System Efficiency Needs Scenario (SENS)** – Model future year (10-year planning horizon) based on the ISO's existing planning criteria to identify system efficiency issues that could meet the threshold for a system efficiency Needs Assessment which could result in a competitive solution process for System Efficiency Transmission Upgrades
- ✓ **Stakeholder-Requested Scenario** – Scenario with a region-wide scope that is requested by stakeholders and not covered by the other three scenarios or potential sensitivities on those other three scenarios

Economic Studies Technical Guide

- The ISO published the first version of the Economic Studies Technical Guide (ESTG) on March 25, 2024
  - Revision 1.1 of the ESTG was released on August 5, 2025
  - Appendix C: System Efficiency Needs Scenario provides additional detail on the SENS
- The ESTG seeks to provide stakeholders, policy makers, and the public with a comprehensive document that describes the Economic Study process
  - The goal is to provide increased accessibility and understanding of the Economic Studies
- More resources including past presentations are available on the ISO's Economic Studies website



SENSITIVITY OVERVIEW

Sensitivity Overview

- As a reminder, potential system efficiency needs identified from a sensitivity analysis cannot be used to trigger a competitive solicitation process
- The ISO received four sensitivity requests for the SENS
  - Three from RENEW Northeast
  - One from the Hydro Quebec Interconnection Rights Holders Management (IRH) Committee
  - One from Steve Ingalls
- The ISO has performed three of the four requested sensitivities

Accepted Sensitivity Details

Sensitivity Name	Description
HQ Resource Addition*	Model incremental 3.9 GW of new hydro generation in HQ to reflect the MOU as if it had been implemented so that the resources reach Tier 1 status
Diurnal Imports	Model the 2035 system with historical diurnal imports (plus 1,090 MW/hour on NECEC)
Gas Price Differential	Remove the $3/MWh wheeling charge between regions and model gas price differentials between different areas

*The sensitivity request from the IRH Committee and Steve Ingalls have been combined into a single sensitivity

SENS SENSITIVITY - HQ RESOURCE ADDITION

Sensitivity Overview

- For the reference SENS model, a supply/demand mix for NPCC was sourced from the 2024 NERC Long Term Reliability Assessment (LTRA)
  - The supply mix only included existing resources and Tier 1 additions, which have inclusion criteria that must be met
  - Because demand grew significantly faster than supply, HQ became a net importer in the 2035 system
- In this sensitivity, consistent with the HQ Churchill River Study and Hydroelectric Developments, the HQ system was modeled with an additional 3.9 GW of hydro capability
  - The new hydro was assumed to operate at the same capacity factor as the existing Quebec hydro fleet for the 2019 weather year (56%)
  - This translates to an additional 19 TWh of available hydro generation
  - These resources were not HQ Tier 1 additions in the 2024 NERC LTRA, therefore they were not included as part of the reference SENS model

First Pass Comparison – Interregional Flows (MWh)

Case Name	HQ - NE	NB - NE	NY Upstate - NE	NY Downstate - NE	NE Net Import
Reference	3,165,499	-3,656,647	8,734,364	1,941,931	10,185,147
HQ Upgrade	8,759,636	-2,833,980	8,653,642	1,806,911	16,386,209
Change	+5,594,137	+822,667	-80,722	-135,020	+6,201,062

- Relative to the reference model, net imports into New England increase by 6.2 TWh
- The most significant increase in flows is between HQ and NE, which increases by 5.6 TWh. New England is still a net exporter to New Brunswick

Second Pass Comparison

Case Name	Production Cost (Million $)	CO2 Emissions (tons)	LMP ($/MWh)	LSEEE (Million $)
Reference	4,062	35,377,340	54.59	7,915
HQ Upgrade	3,614	31,189,562	51.97	7,542
Change	-448	-4,187,778	-3	-373

- With higher net imports into New England, all of the reported production cost metrics drop

Second Pass Most Congested Areas

Element Name	Hours Binding	Shadow Price ($/MWh)	Magnitude
Keene Road Export	1,663	25.0	41,560.5
Q195-1_101	201	36.9	7,409.0
Maine - New Hampshire	246	11.1	2,739.9
347-NGRID_101	1,007	2.4	2,400.7
New England West-East	578	1.3	747.4
Northwest Vermont Import	34	20.1	684.3
Connecticut Export	260	1.4	351.7
K149-VELCO_101	613	0.5	312.2
Sheffield-Highgate Export	23	8.2	189.4
New England North-South	93	1.4	126.3

- Just as with the reference SENS model, Keene Road is the most binding constraint
- ME-NH binds slightly more than in the reference model, but most of the top congestion points are the same

Second Pass Congestion Relief – Keene Road

Case Name	Production Cost (Million $)	CO_2 Emissions (tons)	LMP ($/MWh)	LSEEE (Million $)
HQ Upgrade	3,613.9	31,189,562	51.97	7,542
HQ Upgrade KR_255	3,613.2	31,186,974	52.07	7,547
Difference	-0.7	-2,587	+0.10	+5

- Savings from increasing the Keene Road interface are slightly lower than in the reference SENS model – with more available inexpensive energy to import, the impact of relieving internal constraints to access native generation is smaller
- LMPs (locational marginal prices) and LSEEE (load serving entity energy expense) rise as the frequency of negative pricing decreases
- Increasing the Keene Road interface limit slightly increased the frequency of congestion on MENH from 246 hours to 254 hours

Second Pass Congestion Relief – MENH

Case Name	Production Cost (Million $)	CO2 Emissions (tons)	LMP ($/MWh)	LSEEE (Million $)
HQ Upgrade	3,613.9	31,189,562	51.97	7,542
HQ Upgrade MENH_2800	3,613.7	31,184,185	52.06	7,547
Difference	-0.2	-5,377	+0.09	+5

- Production cost savings from increasing the ME-NH limit were small
- Hours of congestion on North-South increased from 93 hours to 145 hours, but the overall congestion magnitude was still very small

Sensitivity Takeaways

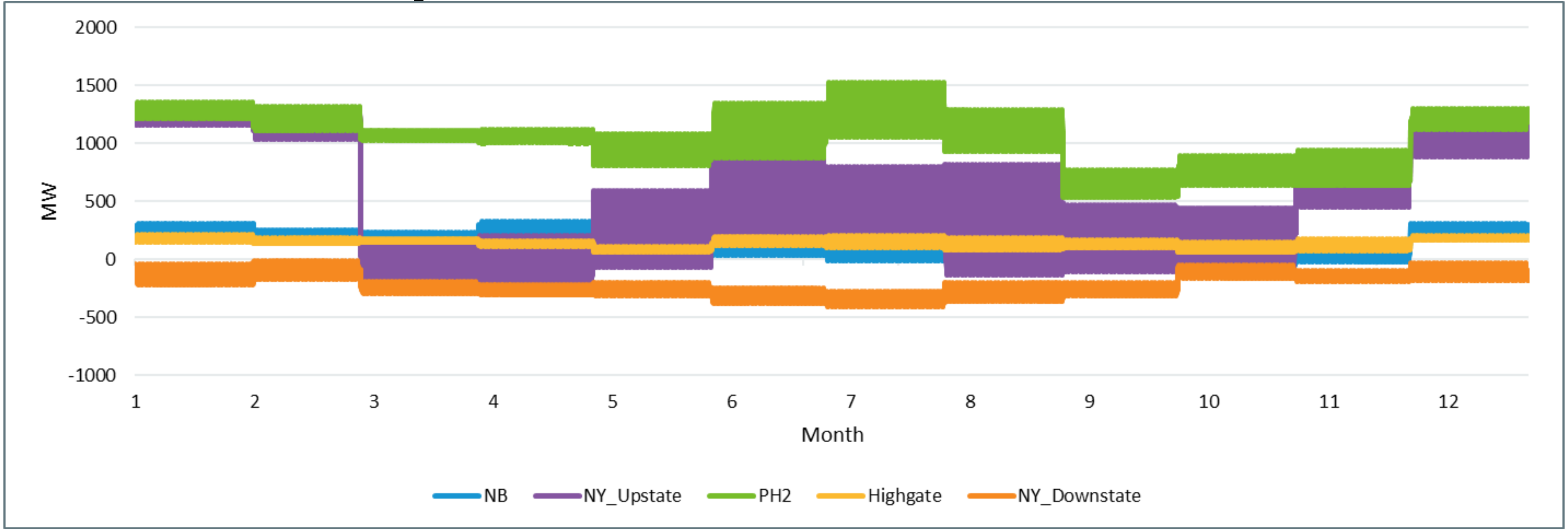
- Future resource development in HQ is likely, but resources will not be explicitly modeled in the SENS reference case until they are listed by HQ as Tier 1 or existing resources in future NERC LTRAs
- Interchange with Quebec is much more bidirectional than in recent years, which have seen mostly unidirectional interchanges
- Higher import levels from HQ reduce overall NE production costs and therefore reduce production cost savings from congestion relief
  - The relieved constraints are displacing cheaper units than in the reference case, as additional imports lead to lower cost units being on the margin within New England

SENS SENSITIVITY – DIURNAL IMPORTS

Sensitivity Overview

- The ISO received a sensitivity request to run a second pass model using historical import profiles
- Instead of running the interregional model, previously the ISO would run a model using diurnal profiles based on the past three years of flows; these profiles were priced at $0/MWh (zero-cost)
  - Note that part of the reason for the creation of the interregional model was to move away from valuing imports at $0/MWh by identifying what the marginal price was at the border node
  - Also note that, as described in previous presentations, assuming a marginal cost of $0/MWh may overstate the benefits of relieving congestion and past import patterns may not be indicative of imports ten years in the future

Diurnal Imports



- Diurnal imports are calculated as the daily "average" profile for each month and area. These have been calculated based on import and export profiles from 2022 – 2024
  - Note: NY upstate includes NY-AC and PV20, while NY_downstate includes CSC and Northport
- In recent years, net imports from New Brunswick have dropped somewhat compared to a longer running historical average

First Pass Comparison – Interregional Flows (MWh)

Case Name	HQ-NE	NB - NE	NY Upstate - NE	NY Downstate - NE	NE Net Import
Reference	3,165,499	-3,656,647	8,734,364	1,941,931	10,185,147
Diurnal Imports (+ NECEC)	19,670,554	1,308,748	4,609,856	-1,945,834	23,643,324
Change	+16,505,055	+4,965,395	-4,124,508	-3,887,765	+13,458,177

- A first pass interregional model was not run for the historical imports. However, the flows in the table above are being used to compare the reference against the historical import assumptions
- Total net imports in the reference model are significantly lower than historical levels
- Compared to historical flows, the model showing net imports from downstate NY may be symptomatic of modeling assumptions. The first pass only enforces interregional transmission constraints, and actual net flows may differ if upstate to downstate NY transmission constraints were enforced

Second Pass Comparison

Case Name	Production Cost (Million $)	CO2 Emissions (tons)	LMP ($/MWh)	LSEEE (Million $)
Reference	4,062	35,377,340	54.59	7,915
Diurnal Imports	2,607	25,997,044	50.21	7,277
Change	-1,455	-9,380,296	-4	-638

- Production costs, emissions, LMPs, and LSEEE are significantly lower with large amounts of zero-cost imports on the system

Second Pass Most Congested Areas

Element Name	Hours Binding	Shadow Price ($/MWh)	Magnitude
Keene Road Export	1,638	27.12	44,426.31
Q195-1_101	108	50.29	5,430.93
Northwest Vermont Import	70	10.32	722.38
Maine - New Hampshire	49	6.49	317.77
New England North-South	26	0.87	22.62
NNE - Scobie + 394	8	2.29	18.35
K149-VELCO_101	233	0.06	13.46
Sheffield-Highgate Export	15	0.85	12.81
Connecticut Export	6	1.19	7.15
347-NGRID_101	9	0.32	2.88

- The top congestion points are mostly the same as the reference SENS model, though NWVT import does bind slightly more (70 hours vs. 34 hours)
- Keene Road has a very similar number of hours binding and shadow price

Second Pass Congestion Relief

Case Name	Production Cost (Million $)	CO2 Emissions (tons)	LMP ($/MWh)	LSEEE (Million $)
Diurnal Imports	2,607.0	25,997,044	50.21	7,277
Diurnal Imports KR_255	2,606.3	25,989,643	50.23	7,273
Difference	-0.69	-7,401	+0.02	-4

- Production costs and emissions are significantly lower with large amounts of zero-cost imports on the system
- ME-NH binds slightly more (65 hours vs. 49 hours) with the Keene Road limit increased

Sensitivity Takeaways

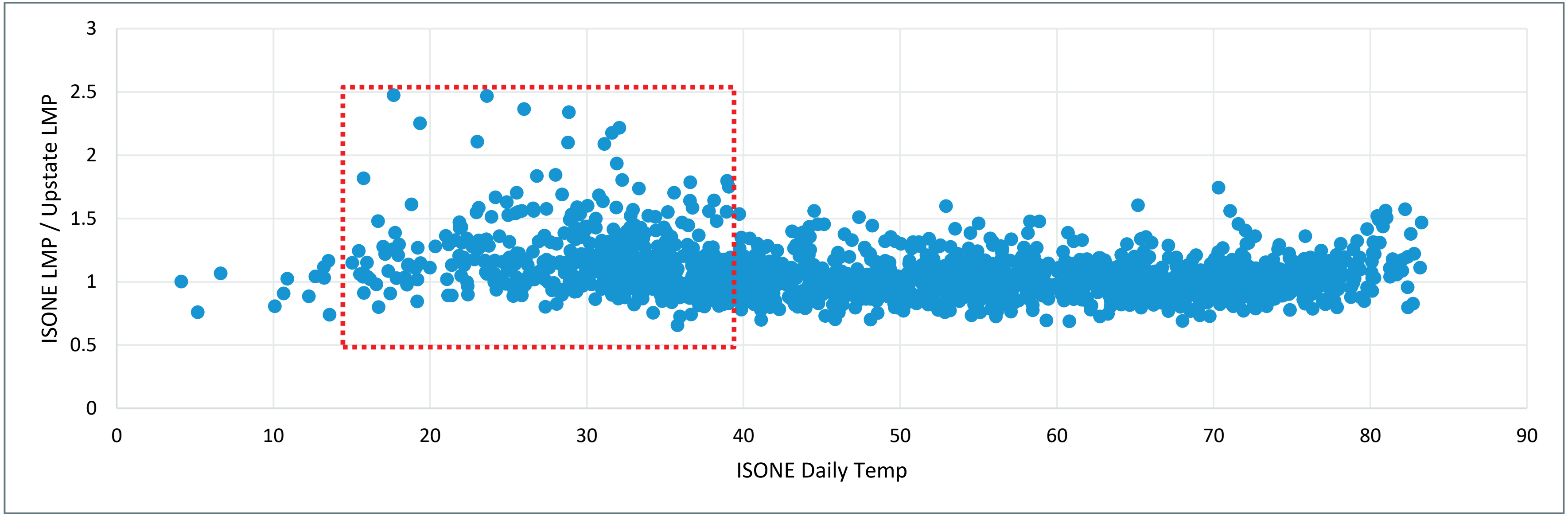
- Higher import levels from HQ reduce overall NE production costs and therefore reduce production cost savings from congestion relief
  - The relieved constraints displace cheaper units than in the reference case
- Historical import levels combined with future NECEC imports are significantly higher than modeled imports from the interregional model (even with additional HQ resource development)
  - Actual flows will depend on uncertain resource development and load growth, as well as year by year weather conditions
  - ISO-NE models show that New England's future may be defined by net import levels that are significantly lower than those observed in recent past

SENS SENSITIVITY – GAS PRICE DIFFERENTIAL

Sensitivity Overview

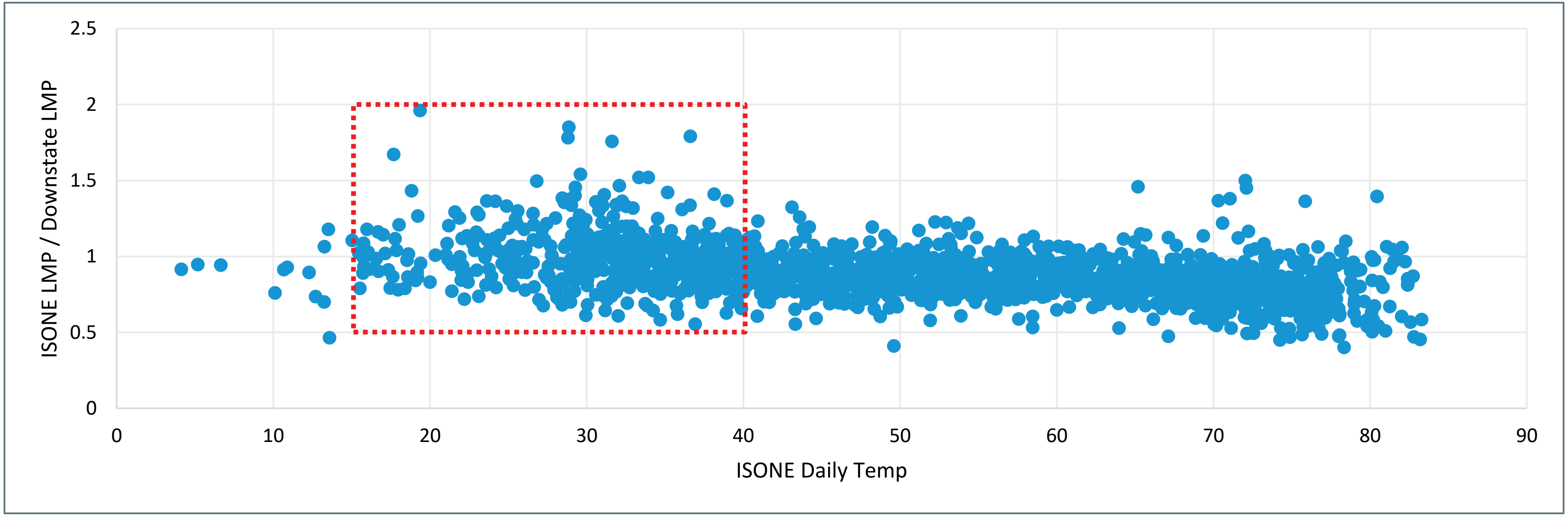
- For the reference SENS model, the ISO modeled a uniform gas and emissions price across all NPCC regions
  - The New York and New England areas were modeled with a joint gas constraint, based on analysis of historic temperatures, pipeline and LNG supply, and forecast gas utility (LDC) demands
- This is still an area of research at ISO-NE. However, New York has similar gas constraints during low temperatures and relies heavily upon residual oil/dual fuel units during cold weather operations
- ISO-NE performed an analysis of daily 2019-2023 temperature and LMP data to try to determine a trend that would show a natural gas price differential
  - The results are not conclusive and suggest the need for additional work to further quantify the relationship

NE Temp vs. DA LMP/LBMP Differential (NE/Upstate NY)



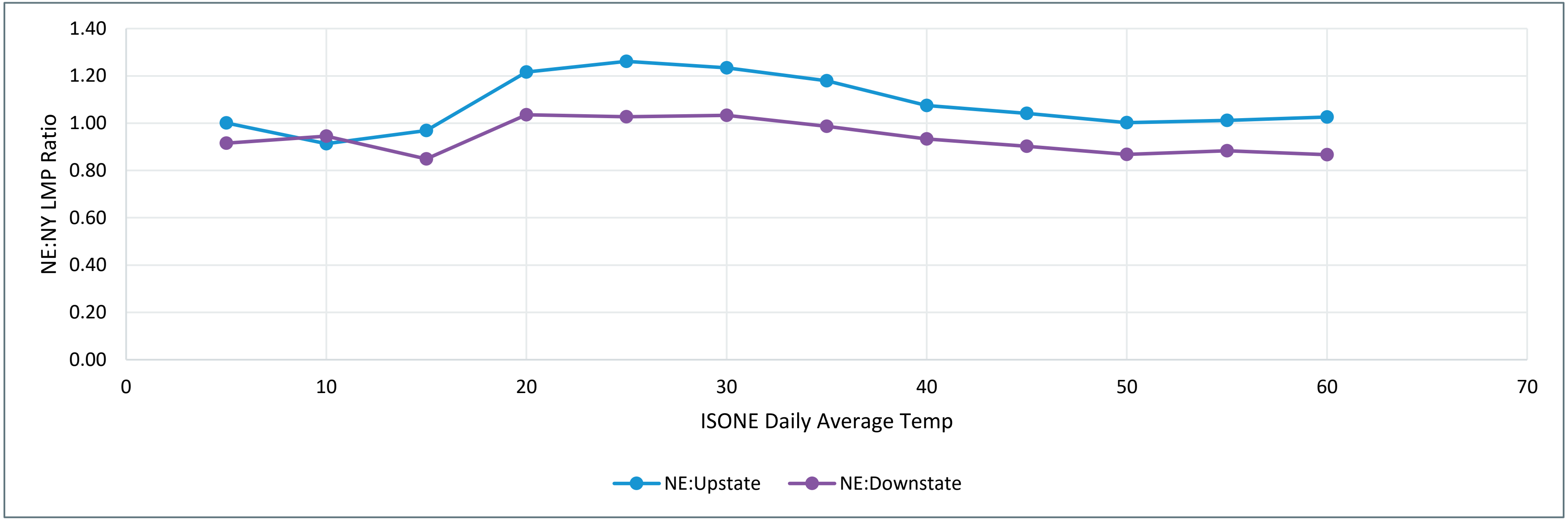
- Note: NE LMPs are being compared to the average LMBPs (locational marginal bus prices) of zone F (Capital) and zone G (Hudson Valley)
- Between upstate NY and NE, there is a weak trend of price differential rising in the 15 – 40 degree temperature range. However, this does not always occur. Though the sample size is small, this trend appears to recede below 15 degrees

NE Temp vs. DA LMP/LMBP Differential (NE/Downstate NY)



- Note: NE LMPs are being compared to zone K (Long Island) LMBPs
- Between downstate NY and NE, a similar weak trend exists, though again not for all conditions. The trend tends to recede on days with average temperatures below 15 degrees

Average Price Differential by Temperature



- On average, New England LMPs tend to be higher than upstate NY LMPs in the 15 – 40 degree temperature range
- Outside of that range, prices in upstate NY tend to be approximately equal to prices in New England. Prices tend to be higher in downstate NY compared to New England
- For this sensitivity, the natural gas prices in downstate New York and New England were modified according to the identified trend. This analysis assumed that LMP differentials were only due to gas prices and not affected by oil prices in dual fuel resources. For example, during a day with an average temperature of 30 degrees in NE, the downstate gas price is equal to the New England gas price, which is equal to ~1.2x the upstate gas price

First Pass Comparison – Interregional Flows (MWh)

Case Name	HQ-NE	NB - NE	NY Upstate - NE	NY Downstate - NE	NE Net Import
Reference	3,165,499	-3,656,647	8,734,364	1,941,931	10,185,147
Gas Price Differential	3,243,796	-3,496,462	11,387,136	2,607,339	13,741,810
Change	+78,297	+160,185	+2,652,772	+665,408	+3,556,663

- Net imports into New England increase by 3.6 TWh while using a gas price differential, with most of the additional energy coming from NY
- Interchange with HQ and NB does not change significantly

Second Pass Comparison

Case Name	Production Cost (Million $)	CO2 Emissions (tons)	LMP ($/MWh)	LSEEE (Million $)
Reference	4,062	35,377,340	54.59	7,915
Gas Price Differential	4,176	34,170,378	55.96	8,095
Change	+114	-1,206,962	+1.37	+180

- NE production costs, LMPs, and LSEEE are higher than the reference model due to the increased gas prices in New England
- NE emissions are slightly lower due to higher net imports displacing native fossil-fueled generation

Second Pass Most Congested Areas

Element Name	Hours Binding	Shadow Price	Magnitude
Keene Road Export	1,656	26.27	43,507.67
Q195-1_101	236	34.09	8,045.37
347-NGRID_101	1,277	2.50	3,186.45
1771_101	28	89.85	2,515.78
Maine - New Hampshire	149	14.83	2,209.73
K27_101	325	6.36	2,067.88
New England West-East	897	1.50	1,347.92
A127W-4_ES_101	16	62.31	996.99
K54_101	863	1.03	888.94
Connecticut Export	391	1.71	670.34

- The top congestion points are mostly the same as the reference SENS model
- Congestion is slightly more frequent on interfaces & elements in the West to East direction, likely due to higher import levels from NY

Second Pass Congestion Relief

Case Name	Production Cost (Million $)	CO2 Emissions (tons)	LMP ($/MWh)	LSEEE (Million $)
Gas Price Differential	4,180.0	34,170,378	55.87	8,094
Gas Price Differential KR_255	4,178.9	34,165,457	55.96	8,102
Difference	-1.1	-4,920	+0.09	+7.8

- NE production cost savings are higher than the reference case ($876 thousand) due to relieved generation displacing higher cost resources
- NE LMPs and LSEEE slightly increase

Sensitivity Takeaways

- Gas price differentials and gas constraints exist in the NY and NE regions
  - Analysis indicates that low temperature partially contributes to a LMP differential, but behavior is different under very low temperature conditions
- This is an area of active interest to ISO-NE. ISO-NE will continue to investigate and evaluate this topic in future Economic Studies
  - However, ISO-NE does not have detailed insight into all the trends and dynamics affecting fuel prices. This is especially true for a system that is ten years in the future, where regional gas and electric system topologies could be completely different
  - For that reason, the reference SENS model will not include specific gas price differentials

Questions