2021 Economic Study: Future Grid Reliability Study Phase 1

Production Cost Results – Part 1

Patrick Boughan & Richard Kornitsky

SPECIAL STUDIES AND INTERREGIONAL PLANNING

Introduction

- On March 12, 2021, NEPOOL submitted the Future Grid Reliability Study (FGRS) Phase 1 as a 2021 Economic Study Request
- On April 1, 2021, ISO New England accepted the request and will perform the FGRS as the 2021 Economic Study
- Part one of study assumptions were presented by the ISO at the April 2021 PAC meeting; part two at the May 2021 PAC meeting
- Today's presentation will cover initial production cost simulation results

2021 Economic Study Past Presentations & Materials

Presentation & Materials	Date (Link)
High-level draft scope of work and assumptions (Part 2)	May 14, 2021
High-level draft scope of work and assumptions (Part 1)	April 14, 2021
FGRS Assumptions Table Submitted to ISO-NE	March 31, 2021
FGRS Framework Document Submitted to ISO-NE	March 31, 2021
ISO-NE Feedback on FGRS	March 31, 2021
Modeling of Electric Vehicles	February 22, 2021
ISO-NE Revised Schedule and Feedback on FGRS	February 22, 2021

GridView Matrix

Describes 34 Scenarios Reading "Down and Across"

	(Resource 1) OSW 8,000 MW DER 18,000 MW	(Resource 2) OSW 8,000 MW DER 25,000 MW	(Resource 3) OSW 17,000 MW DER 31,000 MW
(Load 1) Buildings 9,600 GWh Transport 7,300 GWh	**(5 Scenarios)** **Matrix Scenario 1 plus** **Alternatives A, C, D and E**	(3 Sensitivity Scenarios) Scenario 1 (Resource 2 and Load 1) Scenario 2 (Resource 2 and Load 1) Scenario 3 (Resource 2 and Load 1)	(3 Sensitivity Scenarios) Scenario 1 (Resource 3 and Load 1) Scenario 2 (Resource 3 and Load 1) Scenario 3 (Resource 3 and Load 1)
(Load 2) Buildings 6,600 GWh Transport 18,500 GWh	(3 Sensitivity Scenarios) Scenario 1 (Resource 1 and Load 2) Scenario 2 (Resource 1 and Load 2) Scenario 3 (Resource 1 and Load 2)	**(5 Scenarios)** **Matrix Scenario 2 plus** **Alternatives A, C, D and E**	(3 Sensitivity Scenarios) Scenario 1 (Resource 3 and Load 2) Scenario 2 (Resource 3 and Load 2) Scenario 3 (Resource 3 and Load 2)
(Load 3) Buildings 38,900 GWh Transport 37,500 GWh	(3 Sensitivity Scenarios) Scenario 1 (Resource 1 and Load 3) Scenario 2 (Resource 1 and Load 3) Scenario 3 (Resource 1 and Load 3)	(3 Sensitivity Scenarios) Scenario 1 (Resource 2 and Load 3) Scenario 2 (Resource 2 and Load 3) Scenario 3 (Resource 2 and Load 3)	**(6 Scenarios)** **Scenario 3 plus** **Alternatives A, B, C, D and E**

Naming Convention for Cases

	R1 OSW 8,000 MW DER 18,000 MW	R2 OSW 8,000 MW DER 25,000 MW	R3 OSW 17,000 MW DER 31,000 MW
L1 Buildings 9,600 GWh Transport 7,300 GWh	S1_L1R1 S1_L1R1_A S1_L1R1_C S1_L1R1_D S1_L1R1_E	S1_L1R2 S2_L1R2 S3_L1R2	S1_L1R3 S2_L1R3 S3_L1R3
L2 Buildings 6,600 GWh Transport 18,500 GWh	S1_L2R1 S2_L2R1 S3_L2R1	S2_L2R2 S2_L2R2_A S2_L2R2_C S2_L2R2_D S2_L2R2_E	S1_L2R3 S2_L2R3 S3_L2R3
L3 Buildings 38,900 GWh Transport 37,500 GWh	S1_L3R1 S2_L3R1 S3_L3R1	S1_L3R2 S2_L3R2 S3_L3R2	S3_L3R3 S3_L3R3_A S3_L3R3_B S3_L3R3_C S3_L3R3_D S3_L3R3_E

Overview of Scenario 1

- Has the least aggressive electrification and distributed energy resource build out
- Uses “import-priority” threshold prices
- Builds on the 2020 Economic Study
- Alternative C modifies the scenario by retiring all nuclear units

Import Priority Threshold Prices

Threshold Prices Prioritizing Imports:

- Triggers exports, curtail renewables when export capability is exhausted
- Imports are must run
- Referred to as “Import Priority”
- Used previously in the 2020 Economic Study Sensitives
- Note: only alternative scenario A will have an additional tie-line to facilitate energy banking

Price-Taking Resource	Threshold Price ($/MWh)	Priority
Imports on New Tie Line	-5	First Curtailed
Trigger for Exports on New Line	-25	
Onshore Wind	-35	
Offshore Wind	-40	
FCM and Energy-only PV	-45	
Imports from Canada over Existing Lines	-50	
NECEC	-99	
Behind-the-Meter PV	-100	Last Curtailed

Threshold prices are used to facilitate the analysis of load levels where the amount of $0/MWh resources exceeds the system load
- They are not indicative of “true” cost, expected bidding behavior or the preference for one type of resource over another
- Use of a different order for threshold prices than indicated will produce different outcomes, particularly curtailment by resource

HISTORICAL CONTEXT

Long-range studies provide directional results

"It's tough to make predictions, especially about the future."

Yogi Berra

Keeping FGRS Results in Perspective

- “All forecasts are wrong, but some are useful”
- In 1978 the NEPOOL Long-Range Extra High Voltage Transmission Study evaluated the New England system with up to 80 GW of load and power plant parks with up to 10-12 GW of output to determine directionally whether to build out the backbone transmission system at 345 kV, 765 kV, or HVDC
- While many of the study assumptions and scenarios never came to fruition, the study helped system planners identify 345 kV infrastructure common to all scenarios and load levels, many lines of which were built and key to reliability today
- Results from FGRS should be viewed in the same light, don’t necessarily focus on the exact dollar amounts or percentages, but review the trends and look for commonality among scenarios to help guide discussions on how to prepare for the future grid

RESULTS

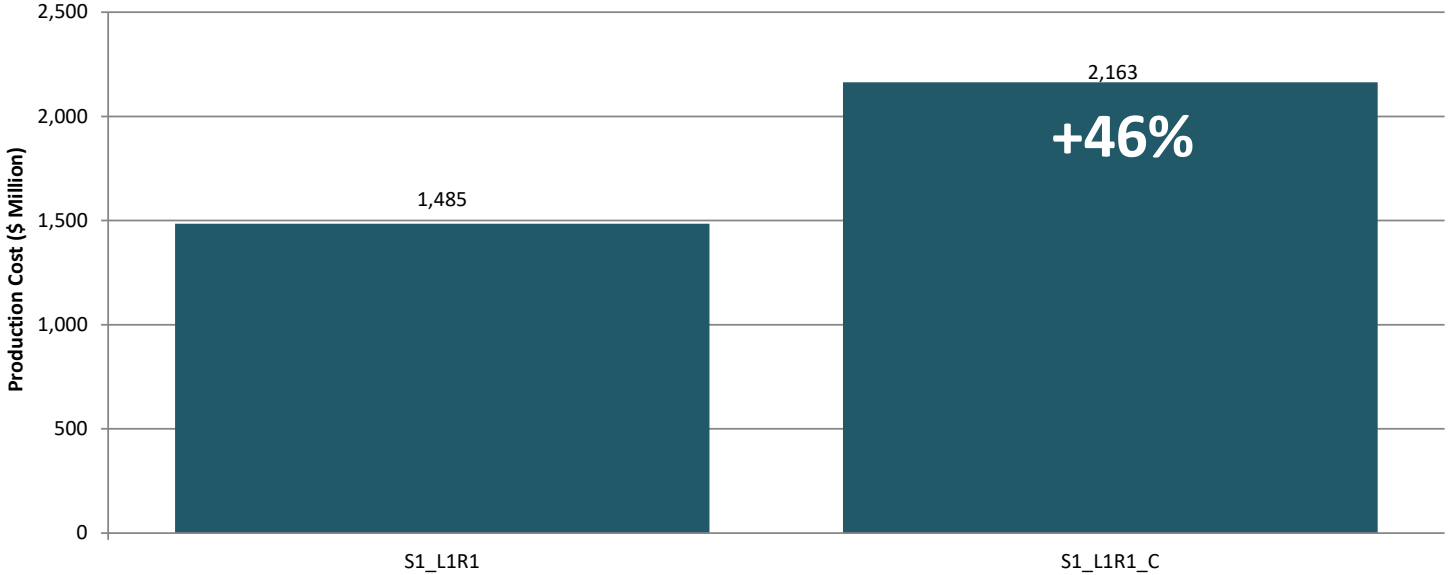
Production Cost Simulations - Scenario 1 & 1C

Summary of Results

- In Scenario 1 (S1_L1R1), load and resources are fairly balanced which resulted in minimal curtailment
- In Scenario 1C (S1_L1R1_C), the retirement of nuclear units results in increased natural-gas resource dispatch, increased production costs, and increased emissions
- Transmission interface limits for Surowiec-South and Maine-New Hampshire are exceeded for large portions of the year in the unconstrained simulation and will require additional review for high-level transmission analysis

Production Costs ($ Million)

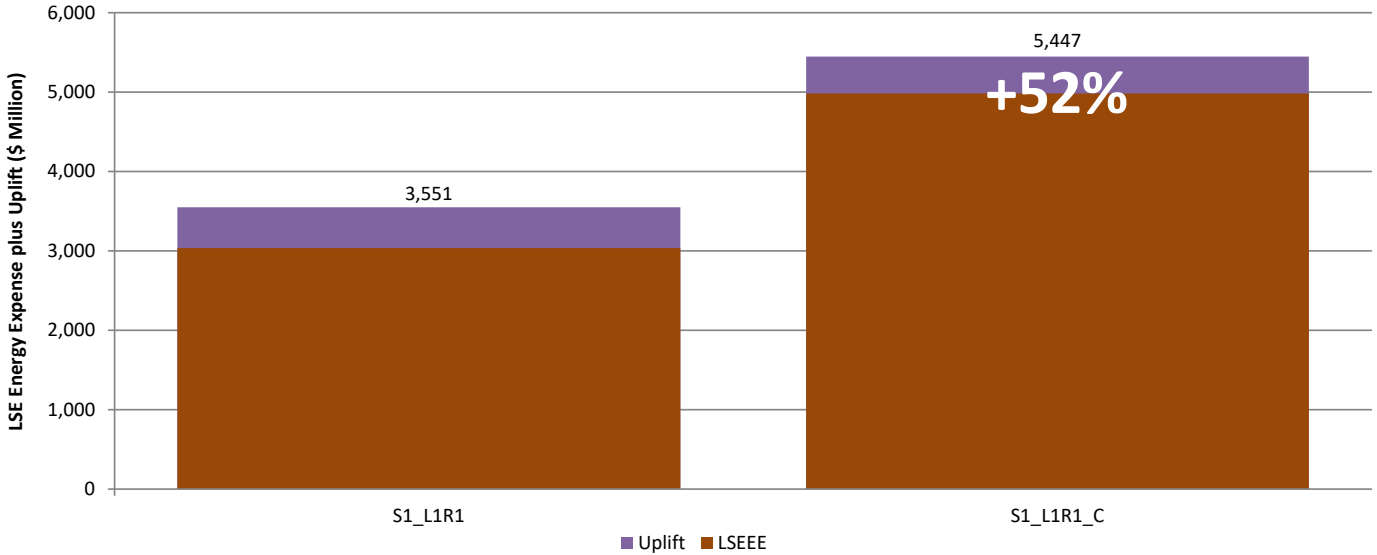
Comparison of Scenario 1 and Scenario 1C



- Retirement of nuclear units leads to a 46% increase in production costs from S1_L1R1 to S1_L1R1_C

Load Serving Entity Energy Expenses (LSEEE) and Uplift

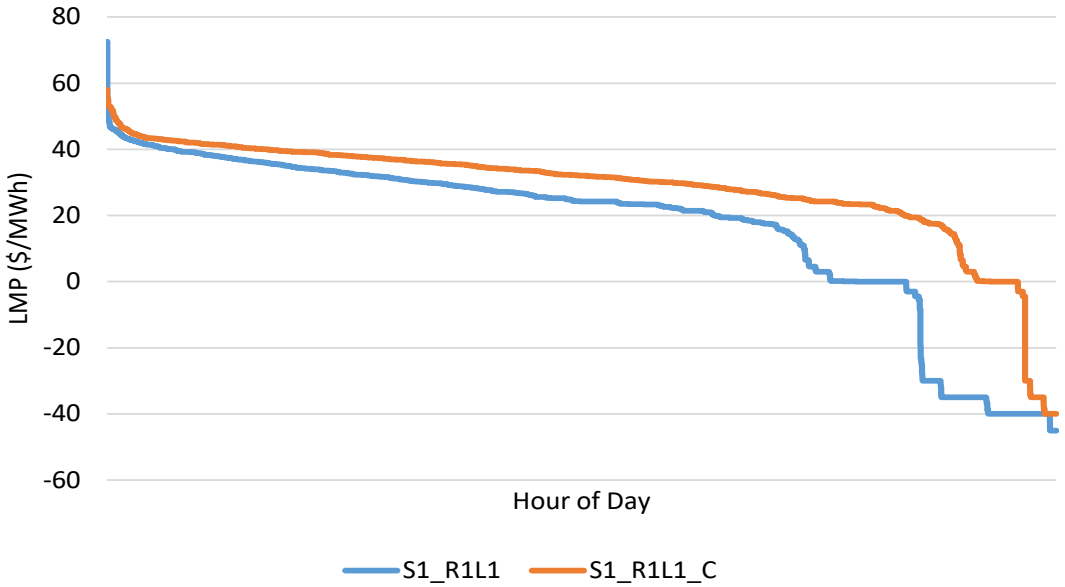
Comparison of Scenario 1 and Scenario 1C



- LSEEE and Uplift increase 52% from S1_L1R1 to S1_L1R1_C
- Uplift in S1_L1R1 is $517.6 million and in S1_L1R1_C is $462.3 million
- Note: LSEEE that it is not reflective of the true cost to customers for electricity, just the wholesale component

Locational Marginal Price Duration Curve ($/MWh)

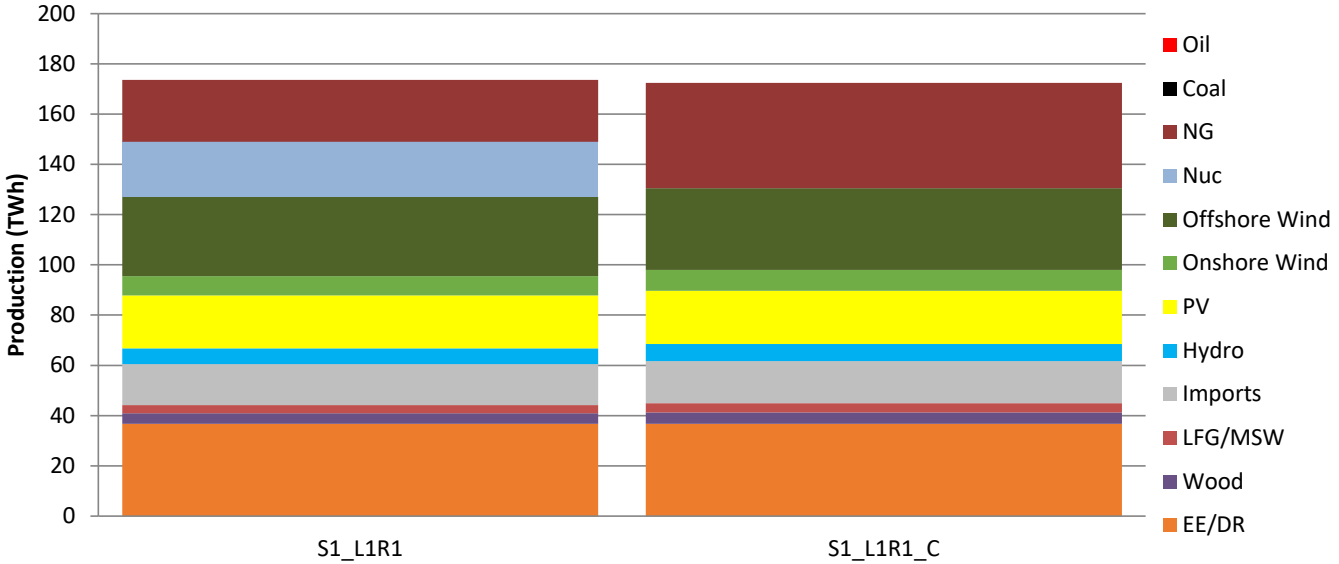
Comparison of Scenario 1 and Scenario 1C



- Retirement of nuclear units increased the average annual locational marginal prices (LMPs) by 63%
- The average LMP for S1_L1R1 was $17.86 and S1_L1R1_C was $29.21

Total System-Wide Energy Production by Fuel Type (TWh)

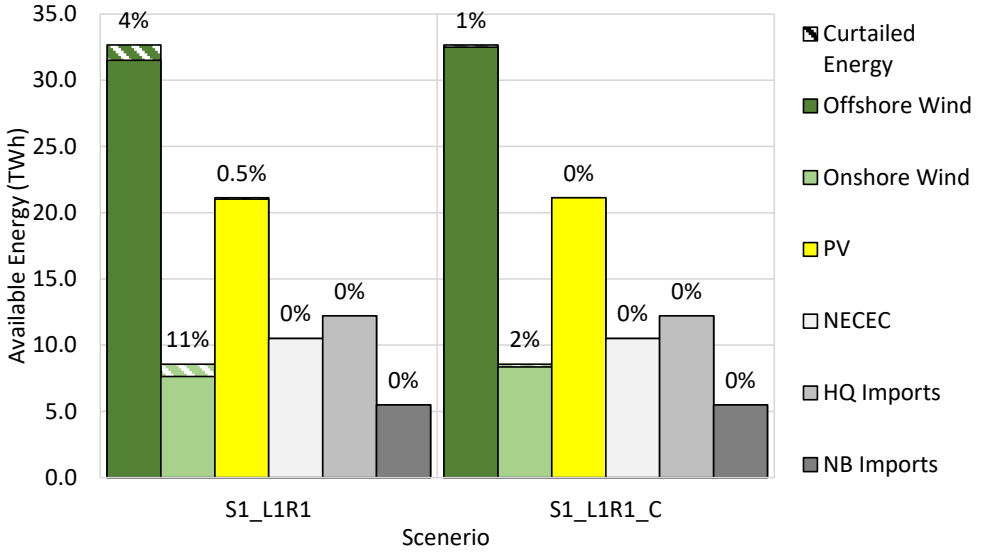
Comparison of Scenario 1 and Scenario 1C

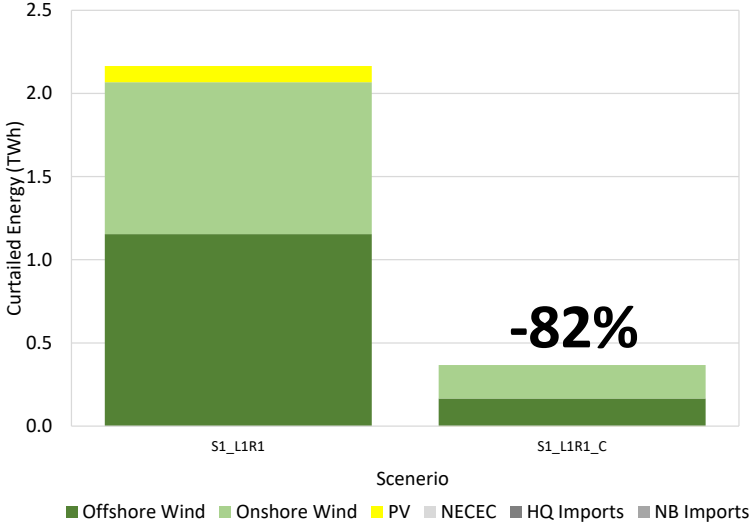


- Nuclear generation is primarily replaced by natural gas resources
- Some previously curtailed renewable resources replaced nuclear, but were already fully delivered for most hours when nuclear power needed to be replaced

Curtailment by Resource (TWh)

Comparison of Scenario 1 and Scenario 1C

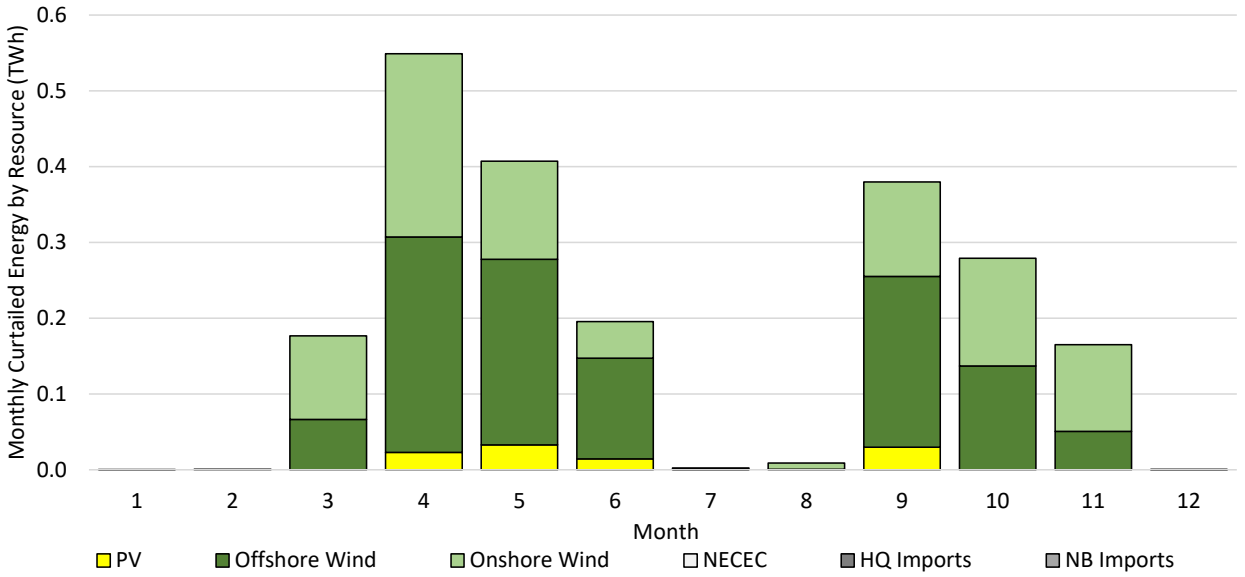




- There were 950 hours (~11%) of oversupply in S1_L1R1 vs. 217 hours (2.5%) of oversupply in S1_L1R1_C.
- Curtailed energy decreased by 82% without nuclear units

Monthly Systemwide Curtailment (TWh)

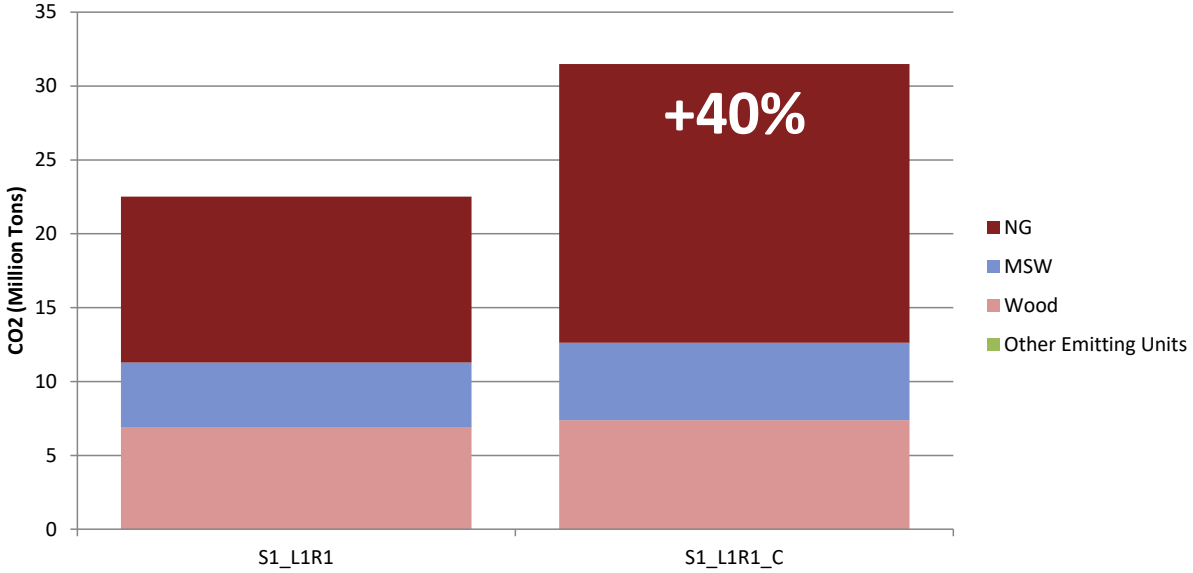
Scenario S1_L1R1



- There were minimal resource curtailments in the winter and summer months

CO_2 Emissions (Millions Tons)

Comparison of Scenario 1 and Scenario 1C

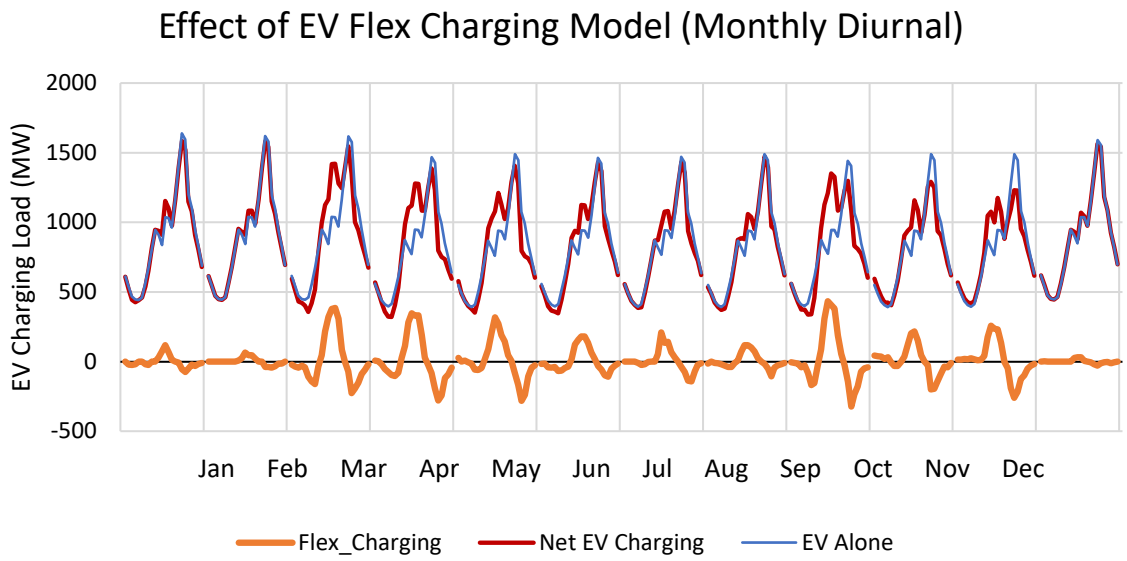


- Natural-gas production increased without nuclear units
- Total emissions increased by 40% in S1_L1R1_C

Effect of EV Flex Charging Model

NEW SLIDE

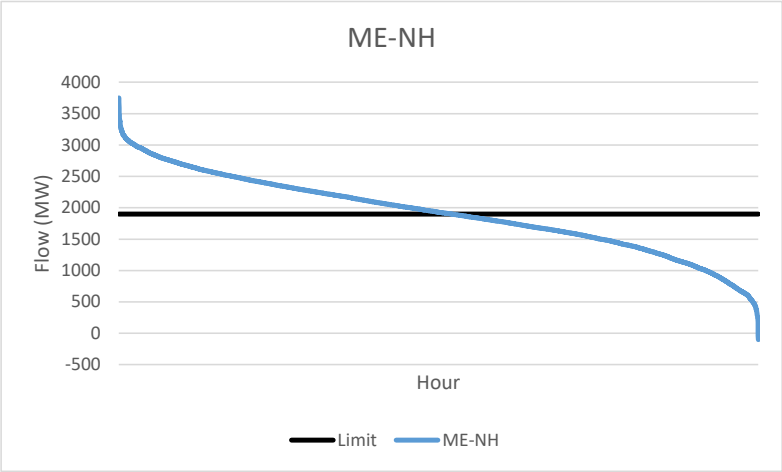
Scenario S1_L1R1

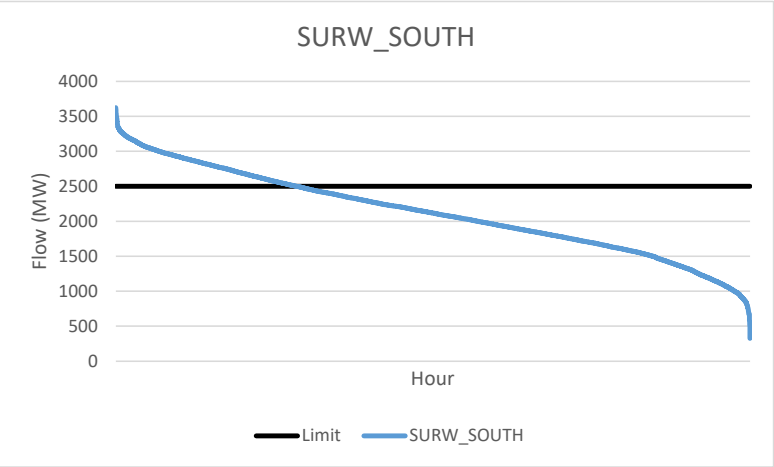


- LMPs vary more during the shoulder months
- EV flex charging has more impact during the shoulder months when LMPs are lowest

Unconstrained Transmission Duration Flows

Scenario 1





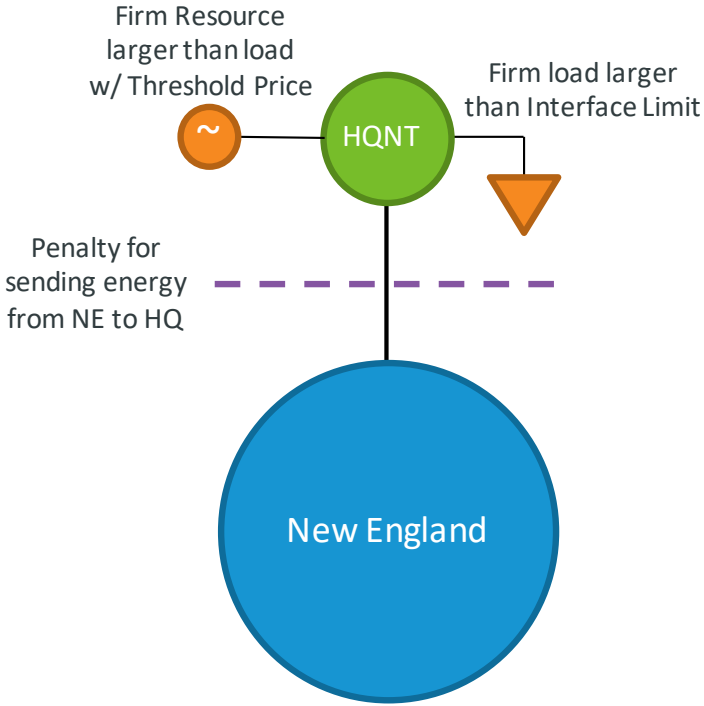
- ME-NH: Over limit 52% of the year, 2,202 GWh over limit
- Surowiec-South: Over limit 28% of the year, 845 GWh over limit
- Will evaluate benefits of increased limits in future presentation

MODELING CHALLENGES

Alternative A

Energy Banking Model

- A large resource is put in the HQNT (Hydro Québec New Tie) area (outside NE) with a threshold price equal to the import cost
  - When NE LMP falls below threshold, the resource won't supply energy to NE
- Penalty price ($20) put on interface that is gap between export threshold price ($-25) and import threshold price ($-5) into NE
  - When LMP is NE = firm resource threshold price – penalty price, energy from NE will serve load in HQNT
- If energy is exported to HQ and not returned to New England, it will be tracked and reported as part of curtailment metrics



Further Work Needed on Alternative A

- First iteration is run to see how much energy is exported into HQNT from NE without allowing imports from HQNT to NE
- Algorithm for the reimport of energy during times of high LMP is dependent on having an import interface limit
  - Energy banking tool does not track the energy stored in real-time during simulation
- If there is no import limit on the tie-line (current assumption), then the entire system load would be served by the new tie
  - The most optimistic times to return banked energy must be determined and manually set as the interface import limit
  - Algorithms to achieve this outcome are currently being tested and will be presented at a future meeting

NEXT STEPS

Next Steps

- Preliminary production cost results for other scenarios will be presented in July and August 2021 beginning with Scenario 3, followed by Scenario 2
- Preliminary ancillary services analysis results for Scenario 1 are expected in September 2021
- Results for probabilistic analyses and final round of production cost and ancillary services are expected in Q3/Q4 2021

Questions

APPENDIX I

Results in Table Form

Total System-Wide Energy Production by Fuel Type (TWh)

Resource	S1_L1R1	S1_L1R1_C
Existing Imports + NECEC	16.3	16.3
Offshore Wind	31.5	32.5
Onshore Wind	7.7	8.4
NG	24.7	41.9
Oil	0.0	0.0
LFG/MSW	3.2	3.7
PV	21.0	21.1
Wood	4.2	4.6
Nuc	21.9	0.0
EE/DR	36.7	36.7
Hydro	6.3	6.9
Total	**173.6**	**170.9**

Annual Curtailed Energy (TWh)

Scenario	Offshore Wind	Onshore Wind	PV	NECEC	HQ Imports	NB Imports
S1_L1R1	1.1	0.9	0.1	0.0	0.0	0.0
S1_L1R1_C	0.2	0.2	0.0	0.0	0.0	0.0

Monthly Curtailment S1_L1R1 (TWh)

Month	PV	NECEC	Offshore Wind	Onshore Wind	HQ Imports	NB Imports	Total
1	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**
2	0.000	0.000	0.000	0.001	0.000	0.000	**0.001**
3	0.000	0.000	0.067	0.110	0.000	0.000	**0.177**
4	0.023	0.000	0.284	0.242	0.000	0.000	**0.549**
5	0.033	0.000	0.245	0.129	0.000	0.000	**0.407**
6	0.014	0.000	0.133	0.048	0.000	0.000	**0.196**
7	0.000	0.000	0.001	0.002	0.000	0.000	**0.003**
8	0.000	0.000	0.001	0.008	0.000	0.000	**0.009**
9	0.030	0.000	0.225	0.125	0.000	0.000	**0.380**
10	0.000	0.000	0.137	0.142	0.000	0.000	**0.279**
11	0.000	0.000	0.051	0.114	0.000	0.000	**0.165**
12	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**

Native New England Resource CO_2 Emissions by Fuel Type (Millions of Short Tons)

Scenario	NG	MSW/LFG	Wood	Other Emitting Resources
S1_L1R1	11.2	4.4	6.9	0.000
S1_L1R1_C	18.8	5.2	7.4	0.000

APPENDIX II

Acronyms

Acronyms

ACDR	Active Demand Capacity Resource	EE	Energy Efficiency
ACP	Alternative Compliance Payments	EFORd	Equivalent Forced Outage Rate demand
AGC	Automatic Generator Control	EIA	U.S. Energy Information Administration
BESS	Battery Energy Storage Systems	EPECS	Electric Power Enterprise Control System
BTM PV	Behind the Meter Photovoltaic	EV	Electric Vehicle
BOEM	Bureau of Ocean Energy Management	FCA	Forward Capacity Auction
CCP	Capacity Commitment Period	FCM	Forward Capacity Market
CELT	Capacity, Energy, Load, and Transmission Report	FGRS	Future Grid Reliability Study
CSO	Capacity Supply Obligation	FOM	Fixed Operation and Maintenance Costs
Cstr.	Constrained	HDR	Hydro Daily, Run of River
DER	Distributed Energy Resource	HDP	Hydro Daily, Pondage
DR	Demand-Response	HQ	Hydro-Québec

Acronyms, cont.

HY	Hydro Weekly Cycle	OSW	Offshore Wind
LBW	Land Based Wind	O&M	Operation and Maintenance
LFG	Landfill Gas	PHII	Phase II line between Radisson and Sandy Pond
LFR	Load Following Reserve	PV	Photovoltaic
LMP	Locational Marginal Price	RECs	Renewable Energy Credits
LSE	Load-Serving Entity	RFP	Request for Proposals
MSW	Municipal Solid Waste	RGGI	Regional Greenhouse Gas Initiative
NECEC	New England Clean Energy Connect	RPS	Renewables Portfolio Standards
NESCOE	New England States Committee on Electricity	SCC	Seasonal Claimed Capability
NG	Natural Gas	Uncstr.	Unconstrained
NICR	Net Installed Capacity Requirement	VER	Variable Energy Resource
NREL	National Renewable Energy Laboratory		