FEBRUARY 20, 2020 | WESTBOROUGH, MA

NESCOE 2019 Economic Study - 8,000 MW Offshore Wind Results

Planning Advisory Committee Meeting

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Highlights

- Today's presentation discusses the NESCOE 2019 Economic Study for scenarios with 8,000 MW of offshore wind (OSW) additions connected in varying amounts to five different interconnection points.
- The 2015 weather year (scaled to 2030) is used in these results to inform the shape of load, wind, and solar profiles.
- Noteworthy Observations:
  - There is no significant transmission interface congestion caused by OSW.* As a result, differences among the 8,000 MW OSW scenarios are driven by different wind resource energy.
  - With Surowiec-South interface limit increased to 2,500 MW (from 1,500 MW), the Maine-New Hampshire interface binds occasionally.
  - Trends observed in the 0-6,000 MW scenarios continue in these results.
  - There is 15 TWh of spillage (imports, hydro, wind, and solar) annually in 8,000 MW OSW scenarios and is primarily the result of oversupply. However, spillage varies significantly by month from 0.15 to 2.69 TWh.

* While overall interfaces are not congested, the transmission analysis that will be presented by the April PAC meeting may reveal specific transmission interface line overloads that require upgrades.

BACKGROUND & ASSUMPTIONS

Three 2019 Economic Study Requests

- Requests were submitted by the New England States Committee on Electricity (NESCOE), Anbaric Development Partners (Anbaric) and RENEW Northeast (Renew).
  - Presented to the PAC on April 25, 2019.

Requester	Purpose of request
NESCOE	Impacts on transmission system and wholesale market of increasing penetration of offshore wind resources https://www.iso-ne.com/static-assets/documents/2019/04/a2_nescoe_2019_economic_study_request_presentation.pptx
Anbaric	Impacts on energy market prices air emissions of large penetration of offshore wind resources https://www.iso-ne.com/static-assets/documents/2019/04/anbaric_2019_economic_study_request.pdf
Renew	Economic impact of conceptual increases in hourly operating limits on the Orrington-South interface from conceptual transmission upgrades https://www.iso-ne.com/static-assets/documents/2019/04/a2_renew_2019_economic_study_request_presentation.pdf

- Draft scope of work and high-level assumptions for each of these requests were discussed with the PAC on May 21, 2019. More detailed assumptions were discussed on August 8, 2019, and a status update was given on November 20, 2019. Preliminary NESCOE results for cases up to 6,000 MW were presented on December 19, 2019, with a Q&A on January 23, 2020.
  - Reference these presentations for more details about the study.
  - Some assumption reference material and all 0 – 8,000 MW OSW scenario results can be found in the appendix of this presentation.

Summary: NESCOE 2030 Scenarios Model Varying Degrees of Resource Expansions

NESCOE Year 2030	Gross Demand	Energy Efficiency	Behind-the-Meter PV (Nameplate)	Utility Scale PV (Nameplate)	Supply (incl. Demand Resources)	Retirements	RFP Committed Generation	Off-Shore Wind Additions (Nameplate)	Demand from Heat Pumps	Demand from Electric Vehicles	Battery Storage Additions
8000_1	Based on 2019 CELT Forecast				2019 CELT generators and cleared FCA 13 resources	FCA 13 and Mystic 8&9	NECEC (1,090 MW of firm import) 1,000 MW of off-shore wind (nameplate)	7,000 MW	2,050 MW	550,000 vehicles	2,000 MW
8000_2											
8000_3											
8000_4											

Scenario	Interconnection Points (MW)						
	Block Island (RI)	Montville (CT)	Kent County (RI)	Brayton Point (SEMA)	Barnstable (SEMA)	Mystic (Boston)	Total
8000_1	29	800	1,000	1,600	2,400	2,200	8,029
8000_2	29	800	1,000	1,600	3,400	1,200	8,029
8000_3	29	800	1,000	2,600	2,400	1,200	8,029
8000_4	29	1,300	1,500	1,600	2,400	1,200	8,029

Threshold Prices Are Used to Decrease Production of $0/MWh Resources During Oversupply

*Use of different threshold prices than indicated will produce different outcomes, **particularly spillage by resource***

Price-Taking Resource	Threshold Price ($/MWh)
Behind-the-Meter PV	1
NECEC (1,090 MW)	2
Utility Scale PV	3
Onshore/Offshore Wind	4
New England Hydro	4.5
Imports from QC (Highgate & Ph. II)	5
Imports from NB	10

METRICS AND RESULTS

Summary of Results

- Total systemwide energy production by fuel type
- Systemwide production costs
- Annual average locational marginal prices (LMPs)
- Load-serving entity energy expense and uplift
- Congestion by interface
- Native New England Resource CO_2 emissions
- Spillage
- Sample daily production and spillage

Disclaimer: All results use the 2015 weather year to create the shape of load, solar, and wind profiles (scaled to 2030 forecasted values). The results are specific to this weather year. If a different weather year is used for profile shapes the results will differ – the trends would be similar but specific numeric results will change.

Key Observations

- OSW does not cause significant transmission interface congestion.*
- With no OSW-driven congestion, there is no significant result differences among the four interconnection point configurations.
- Observed trends from lower MW OSW cases continue:
  - Increased OSW production primarily depresses use of natural gas production and imports.
  - Significant decreases in production costs, LMPs, Load Serving Entity (LSE) energy expenses, and carbon emissions.
- Annually heat pumps and plug in electric vehicles (PHEVs) are only 4% of net load. However, during winter evening peaks they are ~10% of net load. This load addition is often served by storage or energy that would otherwise be spilled.

* While overall interfaces are not congested, the transmission analysis that will be presented by the April PAC meeting may reveal specific transmission interface line overloads that require upgrades.

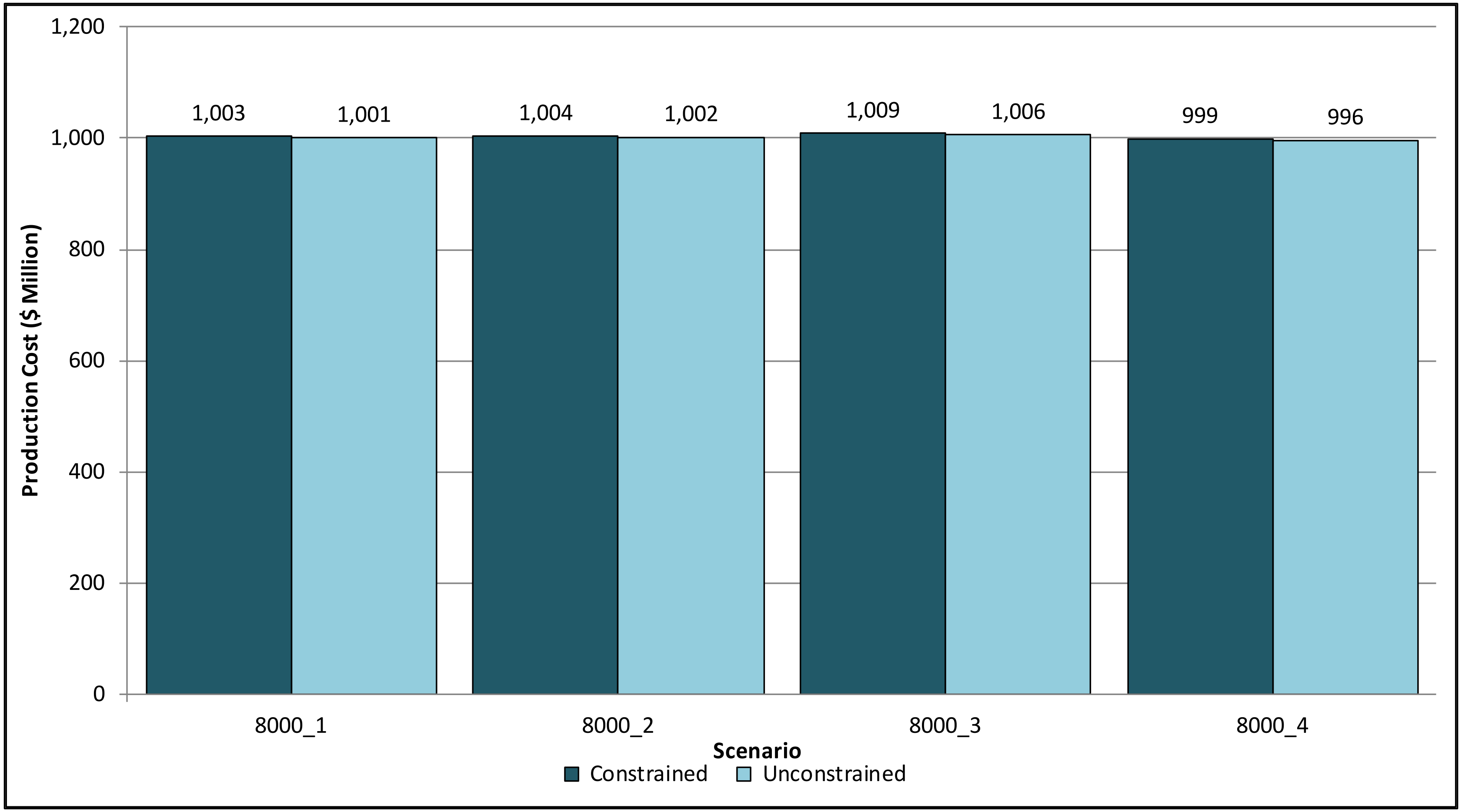
Total Systemwide Energy Production by Fuel Type (TWh)

For Constrained (Cstr.) and Unconstrained (Uncstr.) Transmission

Scenario	8000_1		8000_2		8000_3		8000_4	
Fuel Type	**Cstr.**	**Uncstr.**	**Cstr.**	**Uncstr.**	**Cstr.**	**Uncstr.**	**Cstr.**	**Uncstr.**
Offshore Wind	27.60	27.61	27.55	27.56	27.26	27.27	27.61	27.62
Onshore Wind	3.79	3.79	3.77	3.77	3.78	3.77	3.78	3.78
NG	16.63	16.64	16.67	16.67	16.77	16.77	16.55	16.54
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Imports	19.39	19.40	19.41	19.41	19.54	19.55	19.43	19.45
Coal	0.07	0.03	0.05	0.04	0.05	0.03	0.06	0.04
LFG/MSW	2.69	2.69	2.69	2.69	2.70	2.70	2.69	2.69
PV	9.47	9.47	9.47	9.47	9.47	9.47	9.47	9.47
Wood	4.70	4.70	4.70	4.70	4.70	4.70	4.70	4.69
Nuc	29.85	29.85	29.85	29.85	29.85	29.85	29.85	29.85
EE/DR	36.09	36.09	36.09	36.09	36.09	36.09	36.09	36.09
Hydro	6.26	6.27	6.27	6.28	6.33	6.33	6.29	6.30

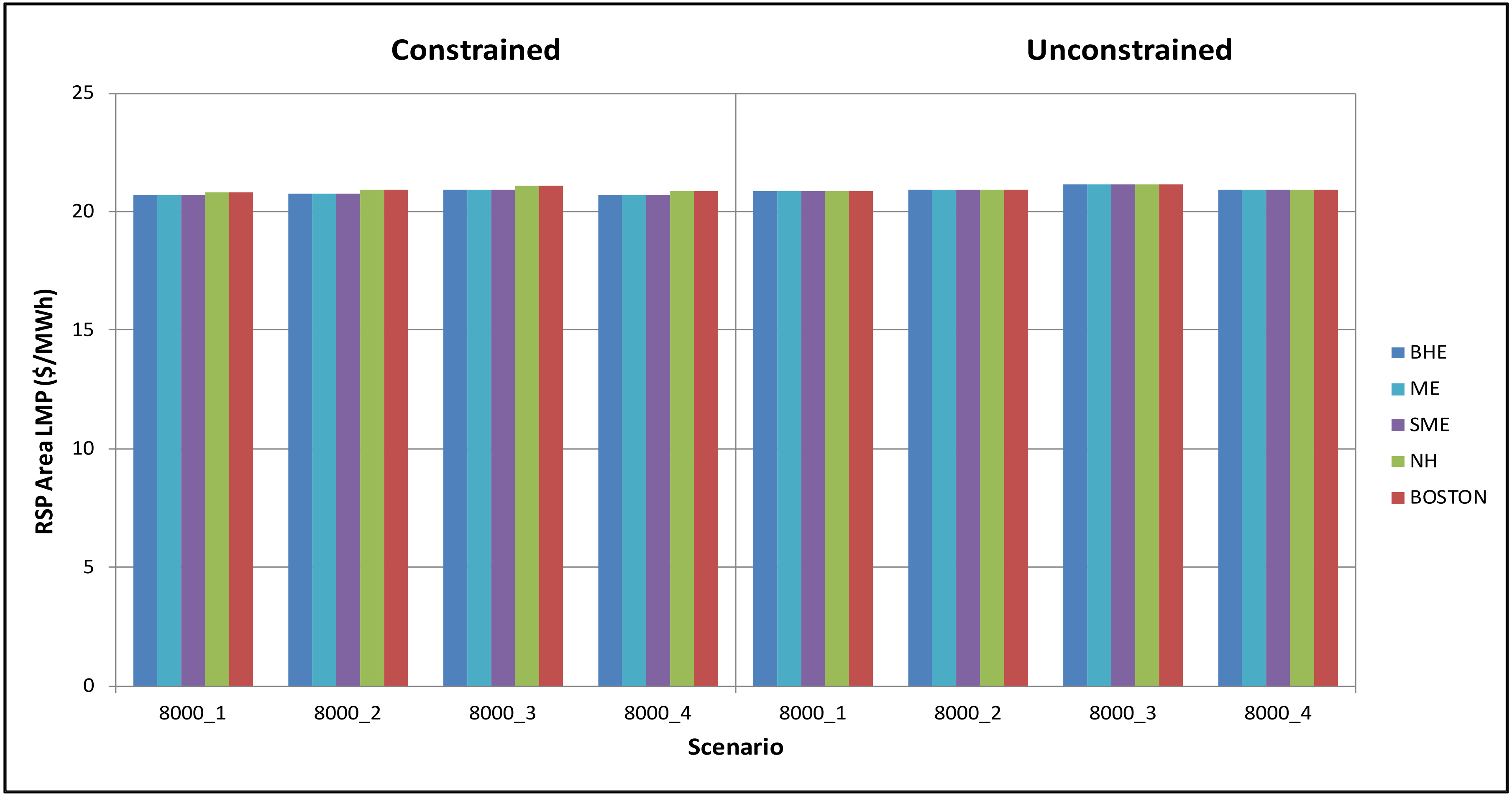
Note: See slides 45-46 or previous presentations for fuel price assumptions.

Systemwide Production Costs ($ Million)



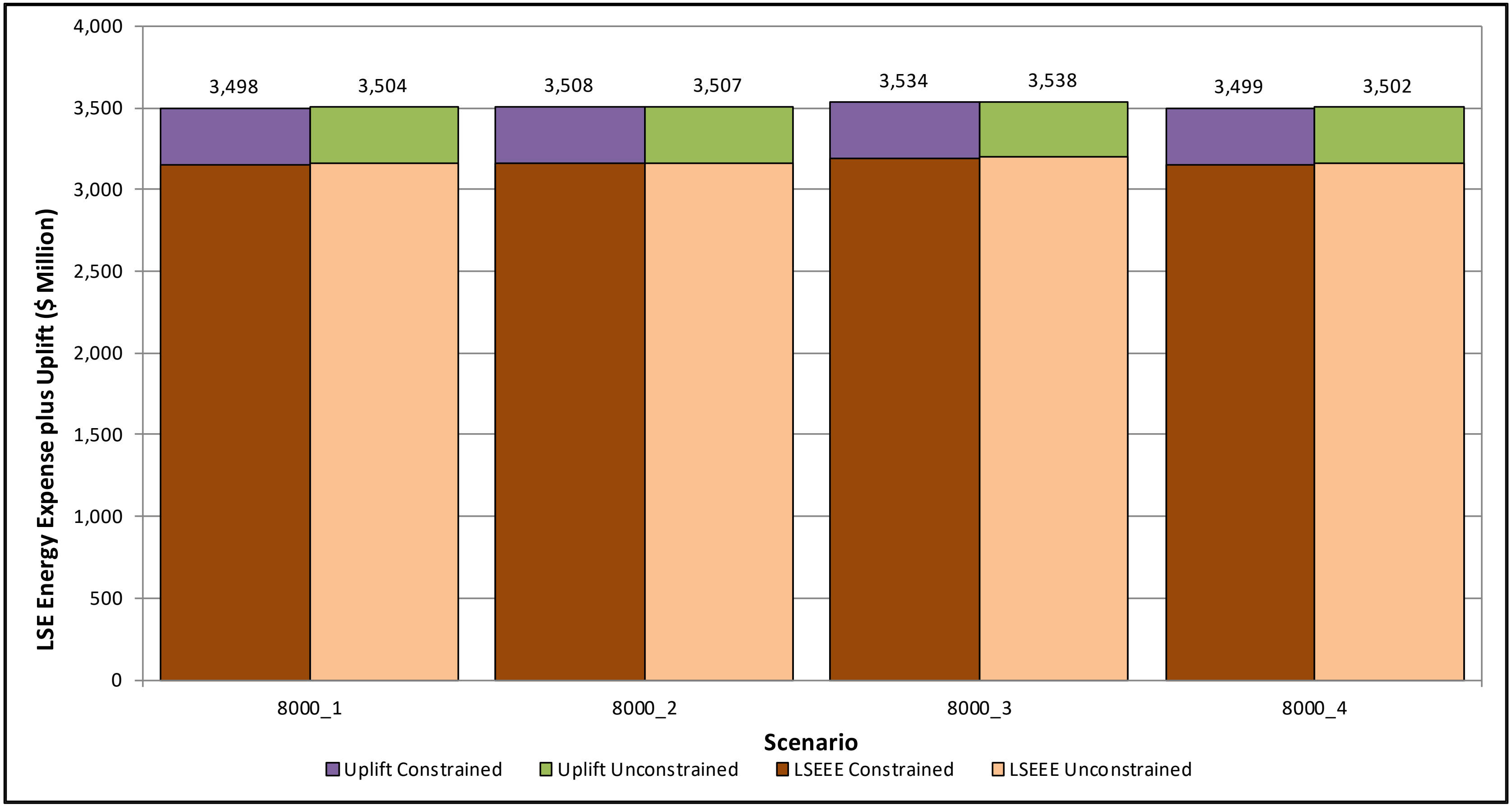
There is miniscule production cost differences among the scenarios depending on wind capacity factors of various portions of the BOEM lease area.

Annual Average LMPs by RSP Subarea ($/MWh)



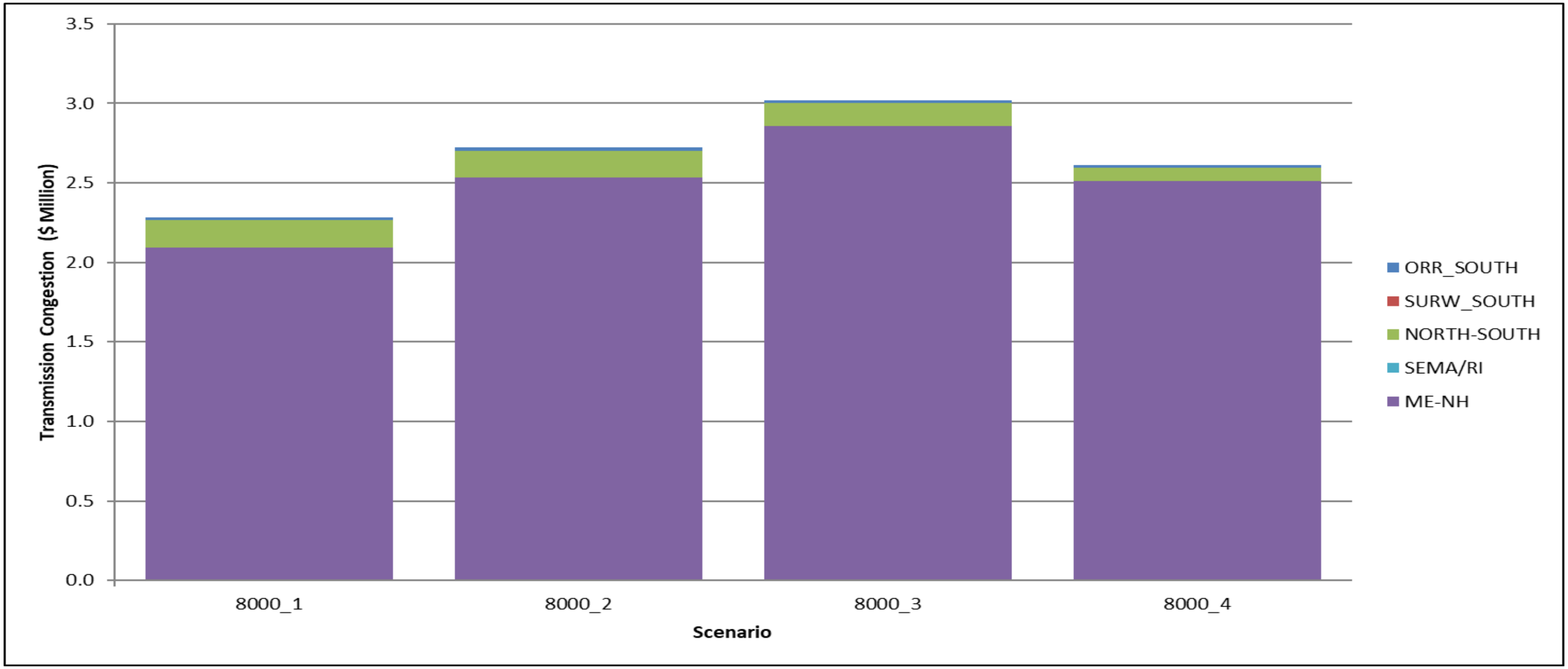
LMPs reflect minimal price separation at the ME-NH interface.

Load-Serving Entity Energy Expense (LSEEE) and Uplift ($ Million)



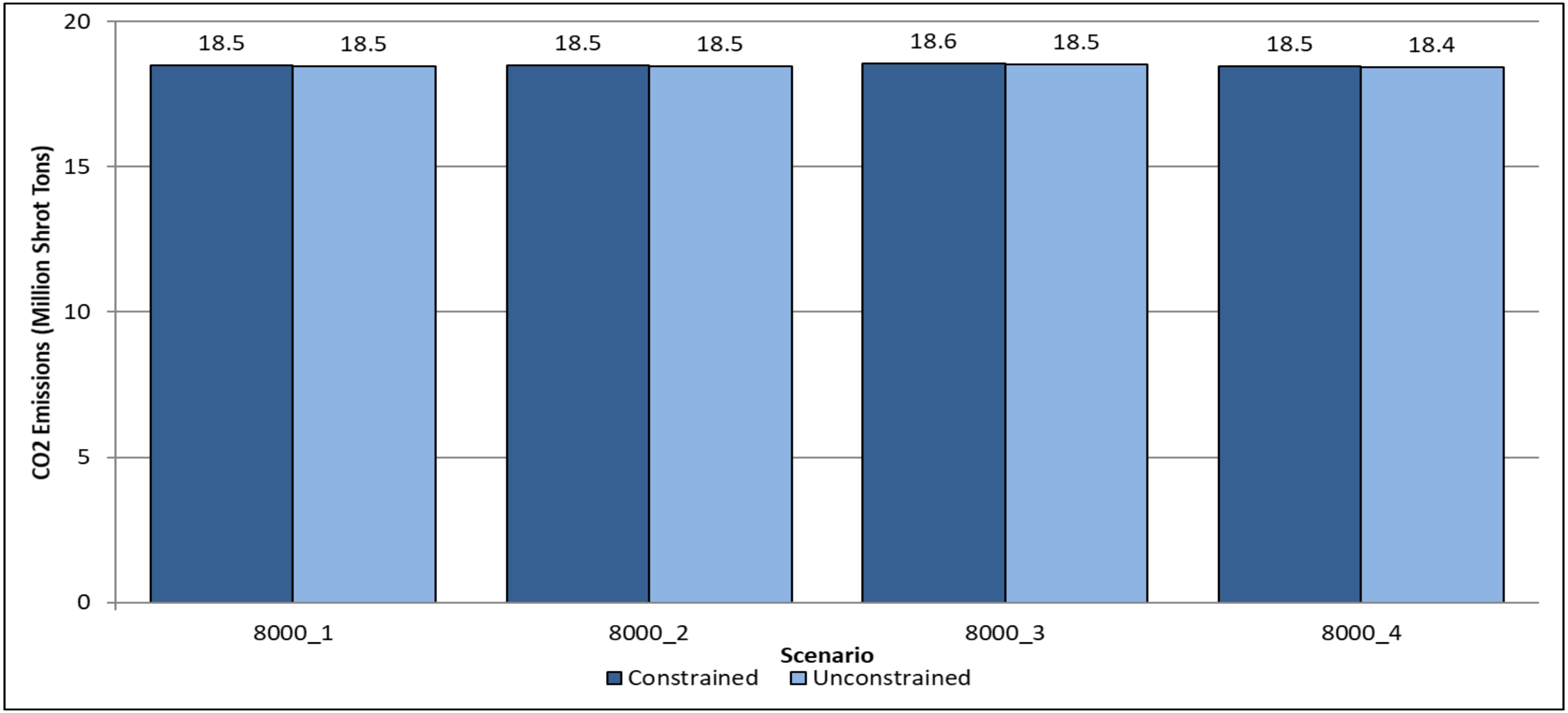
While there is some increase in uplift across the scenarios, the net of LSEEE and Uplift decreases by more than 50% between the 0 MW and 8000 MW OSW scenarios. (see slide 31).

Congestion by Interface ($ Million)



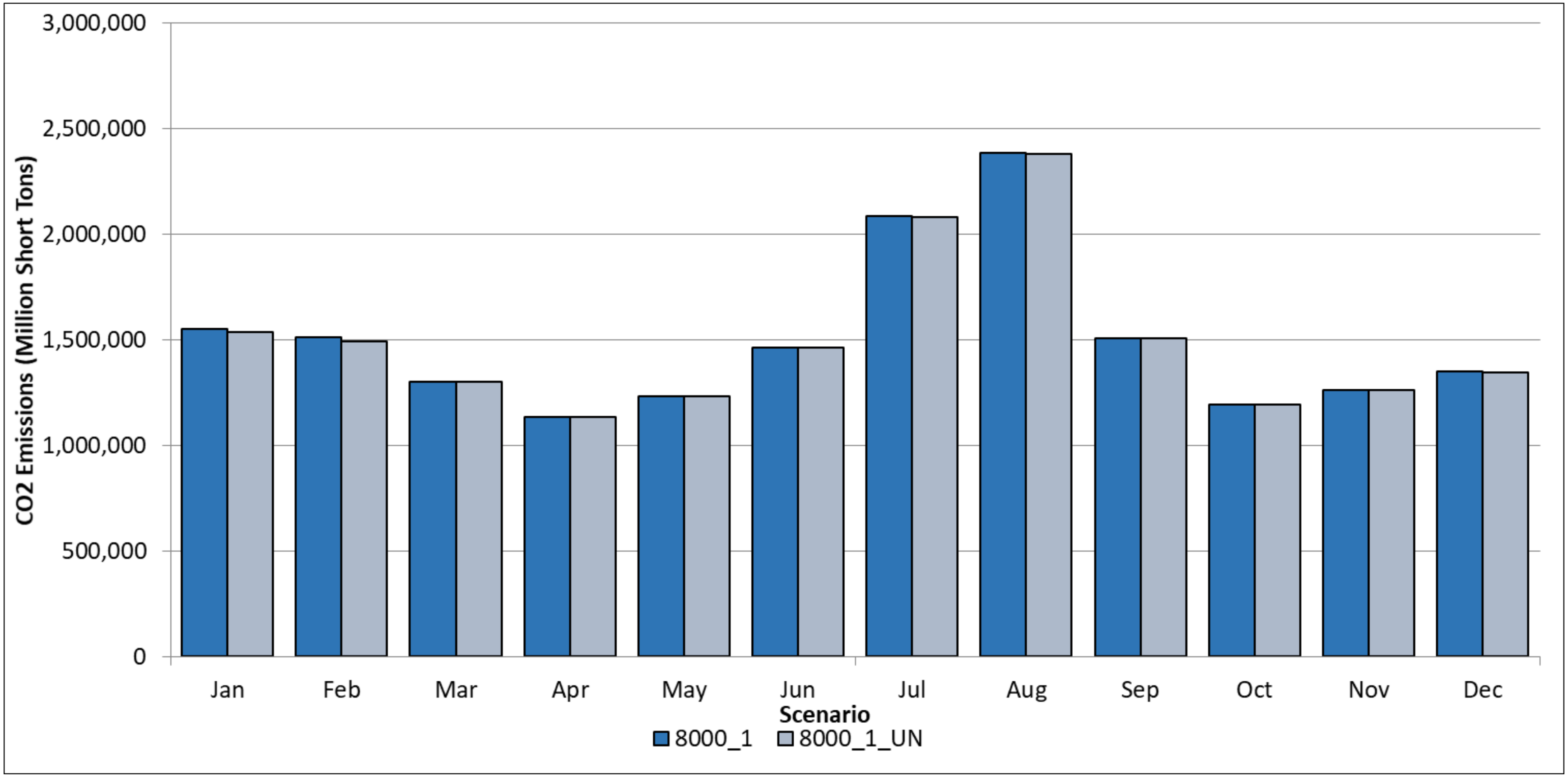
Congestion in the 8,000 MW scenarios is vastly less than in the 0 MW OSW scenario (see slide 32). When more OSW production is available, demand for constrained resources north of the constrained interface(s) decrease. Variations in congestion in the 8,000 MW scenarios are due to differing amounts of OSW energy production.

Native New England Resource CO_2 Emissions (millions of short tons)



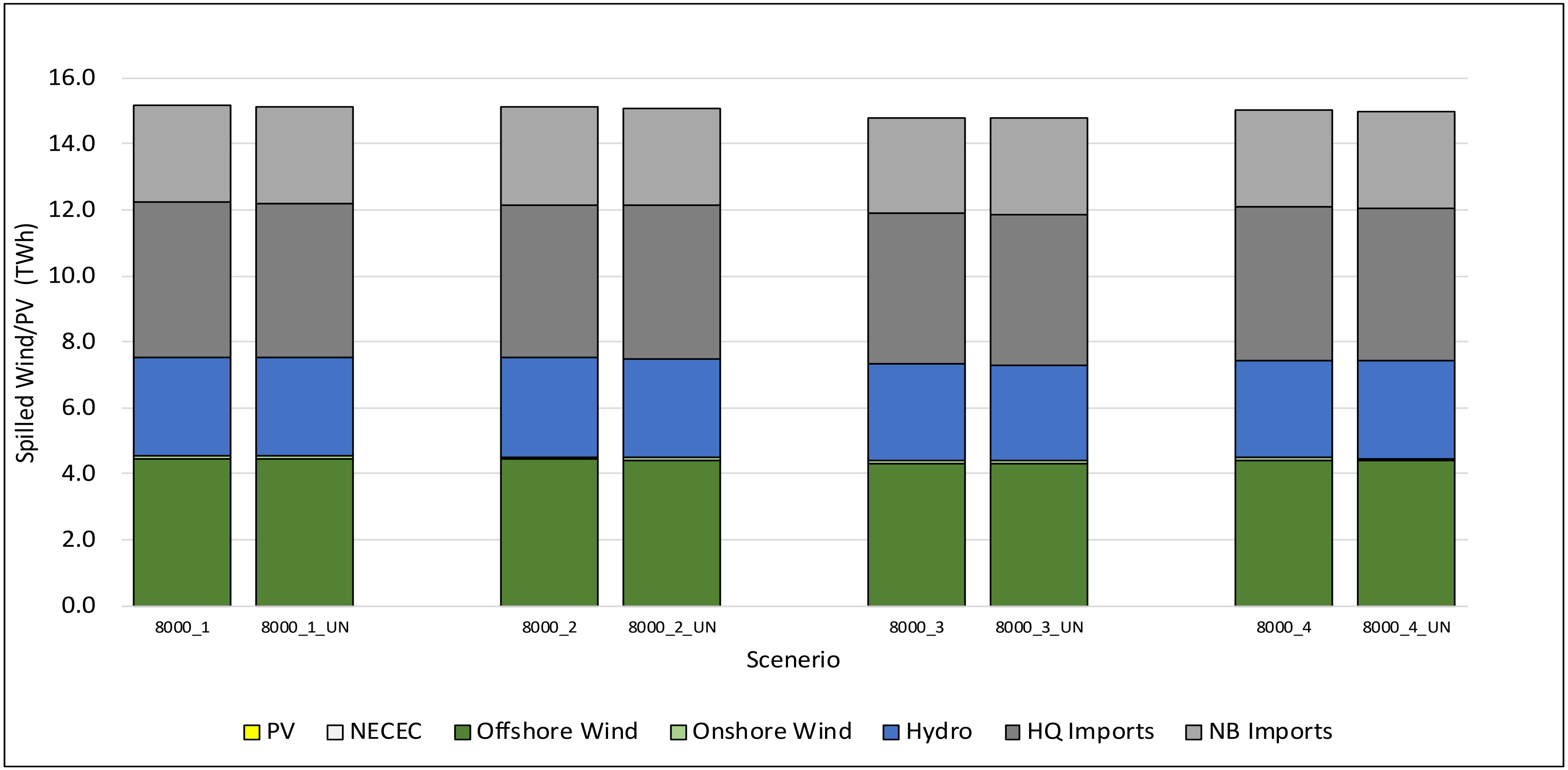
Carbon emissions are similar across the 8,000 MW OSW scenarios but are reduced by 1/3 from the 0 MW OSW scenario (see slide 34). ISO New England will explore providing marginal unit data in future results.

Native New England Resource CO_2 Emissions (millions of short tons) by Month



Wind and solar production are low in July and August of this weather year, combined with higher summer loads, this results in the highest emitting months. Similar results for the other 8,000 OSW MW scenarios.

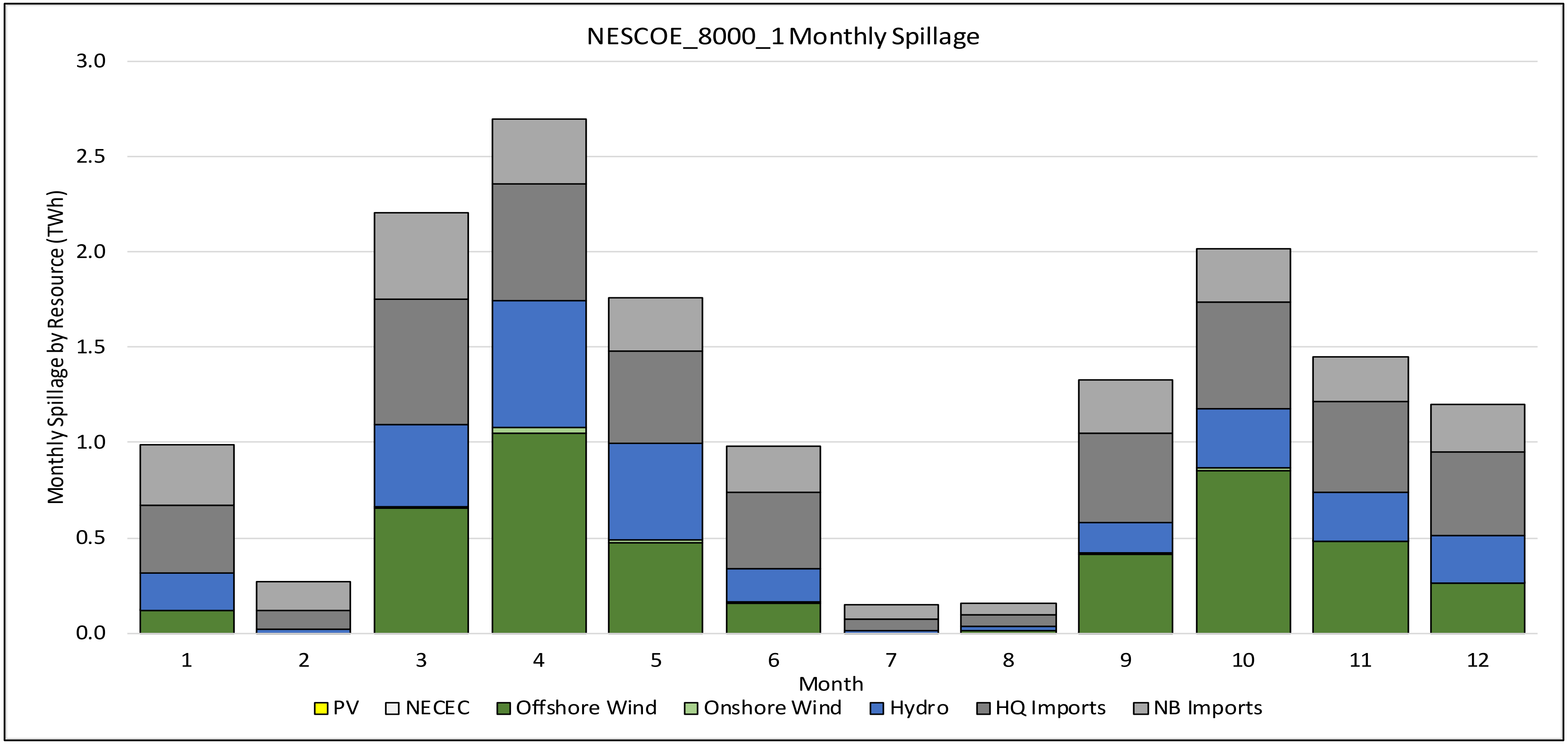
Total Amount of Spilled Resource Energy (TWh)



Spillage is very similar regardless of interconnection points due to the lack of congestion caused by OSW.

Curtailment of specific resources is driven by the threshold prices and order. This model uses the 2015 weather year to shape the 2030 wind, solar, and load profiles. If a different weather year is used, the results would differ.

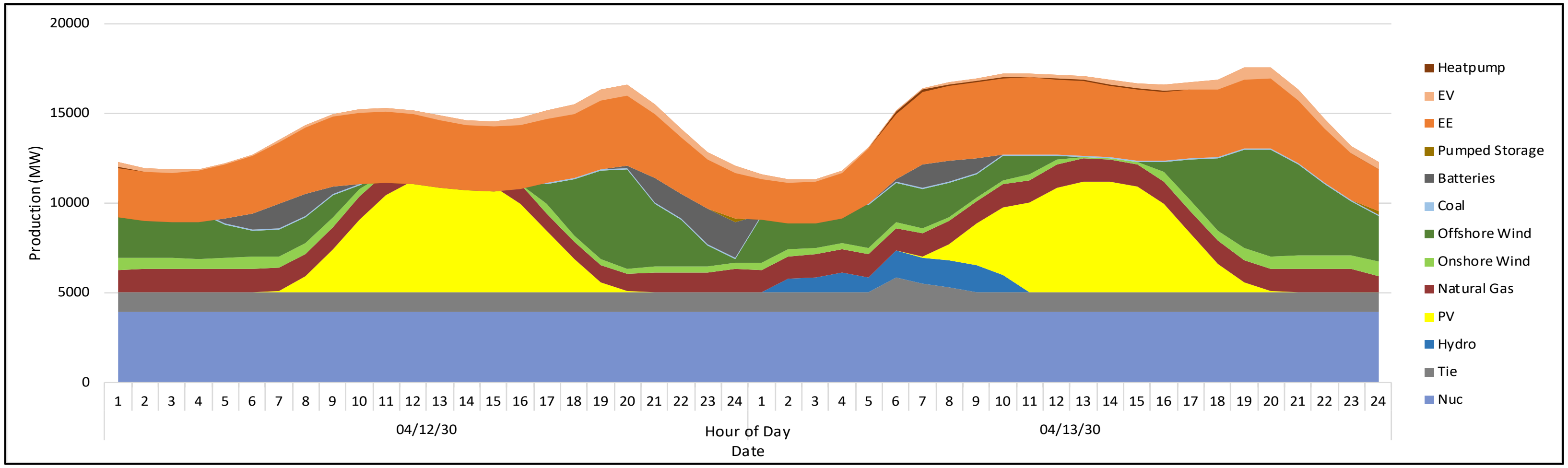
Resource Energy Spilled Each Month in 8000_1

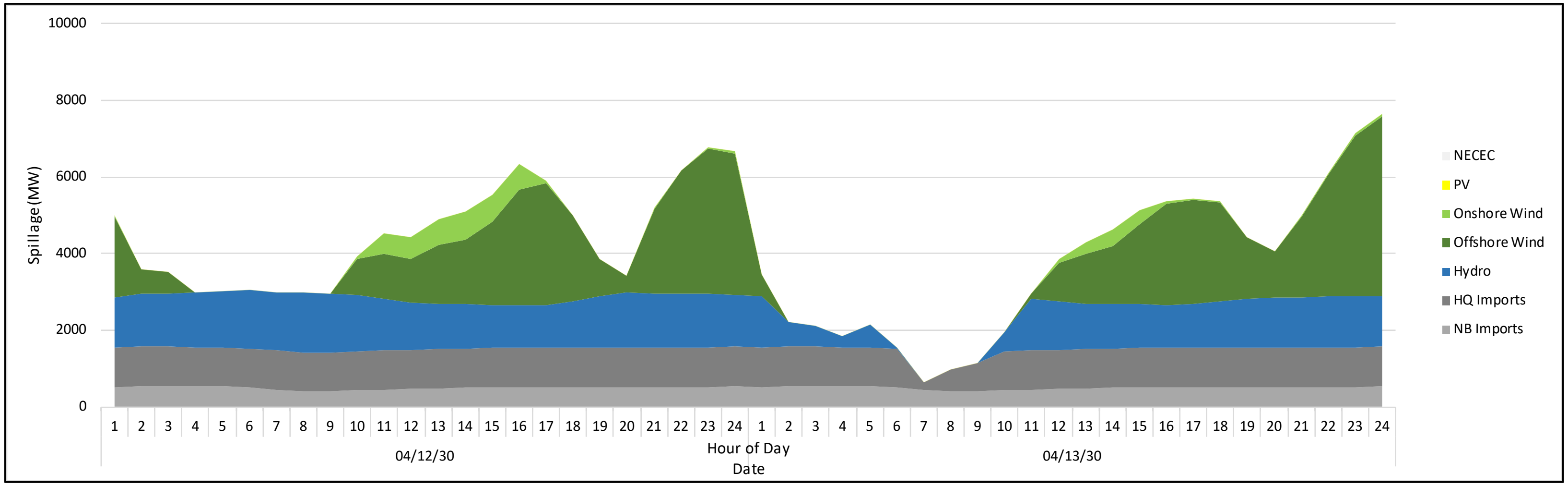


Spillage varies by month (July 0.15 TWh to April 2.69 TWh) depending on interaction of wind, solar, and load profiles and results in significantly different dispatch of non-profiled resources.

Curtailment of specific resources is driven by the threshold prices and order. This model uses the 2015 weather year to shape the 2030 wind, solar, and load profiles. If a different weather year is used, the results would differ.

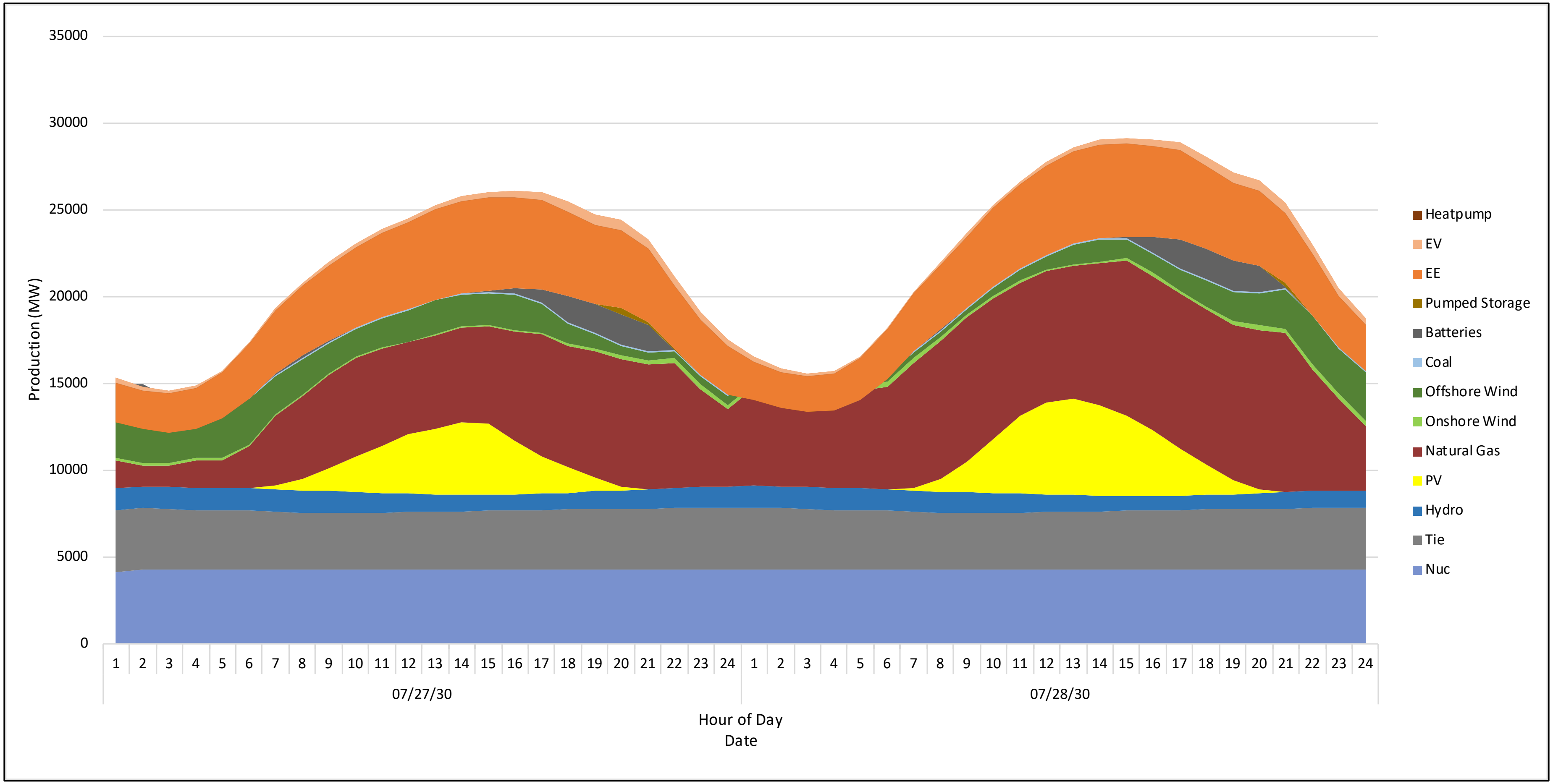
Production and Spillage: Two High-Spill Days





Curtailment of specific resources is driven by the threshold prices and order. This model uses the 2015 weather year to shape the 2030 wind, solar, and load profiles. If a different weather year is used, the results would differ.

Production and Spillage: Two Low-Spill Days



There is essentially no spill during these two days. (July and August are low-spill months in these results.)

Curtailment of specific resources is driven by the threshold prices and order. This model uses the 2015 weather year to shape the 2030 wind, solar, and load profiles. If a different weather year is used, the results would differ.

NEXT STEPS

Timeline to Complete Studies

- **NESCOE** – Complete ancillary service analysis by May. Publish final report by June 1.
- **Anbaric** – Present GridView results with 2015 load/PV/wind profiles in March. Publish final report in June/July.
- **Transmission** – Present NESCOE and Anbaric transmission cost estimates in March and April.
- **RENEW** – Present GridView results with 2015 load/PV/wind profiles in April. Publish final report in July.
- **Fuel Security** – ISO New England will not perform Anbaric's requested fuel security analysis.

Questions

APPENDIX: 0-8,000 MW OSW SCENARIOS RESULTS USING 2015 SOLAR/WIND/LOAD PROFILES

Summary: NESCOE 2030 Scenarios Model Varying Degrees of Resource Expansions

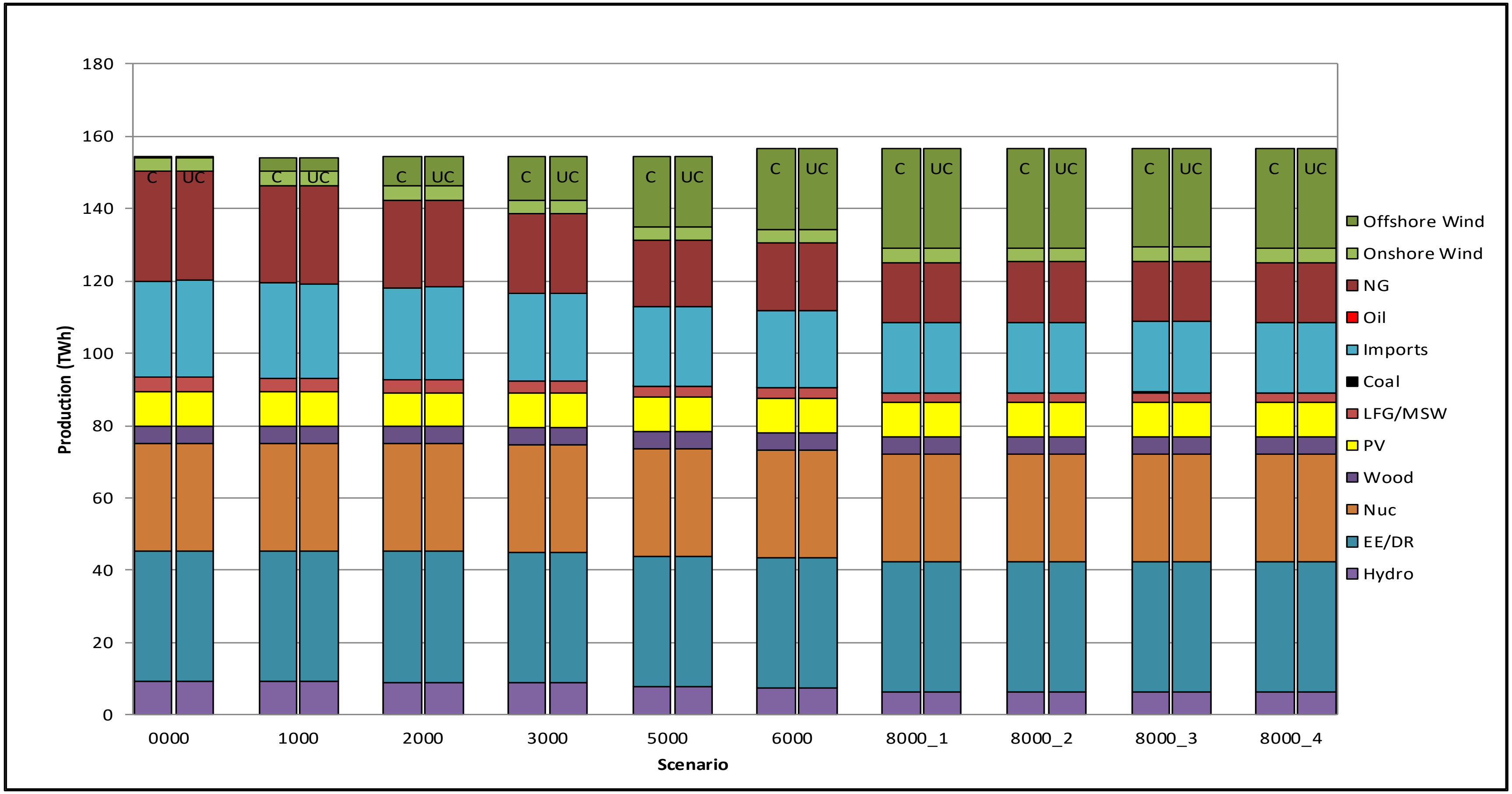
<table>
<tr><th>NESCOE Year 2030</th><th>Gross Demand</th><th>Energy Efficiency</th><th>Behind-the-Meter PV (Nameplate)</th><th>Utility Scale PV (Nameplate)</th><th>Supply (incl. Demand Resources)</th><th>Retirements</th><th>RFP Committed Generation</th><th>Off-Shore Wind Additions (Nameplate)</th><th>Demand from Heat Pumps</th><th>Demand from Electric Vehicles</th><th>Battery Storage Additions</th></tr>
<tr><td>NESCOE_2000</td><td colspan="4" rowspan="5">Based on 2019 CELT Forecast</td><td rowspan="5">2019 CELT generators and cleared FCA 13 resources</td><td rowspan="5">FCA 13 and Mystic 8&9</td><td rowspan="5">NECEC (1,090 MW of firm import) 1,000 MW of off-shore wind (nameplate)</td><td>1,000 MW</td><td rowspan="3">None</td><td rowspan="5">550,000 vehicles</td><td rowspan="5">2,000 MW</td></tr>
<tr><td>NESCOE_3000</td><td>2,000 MW</td></tr>
<tr><td>NESCOE_5000</td><td>4,000 MW</td></tr>
<tr><td>NESCOE_6000</td><td>5,000 MW</td><td rowspan="2">2,050 MW</td></tr>
<tr><td>NESCOE_8000</td><td>7,000 MW</td></tr>
</table>

Scenario	Interconnection Points (MW)						
	Block Island (RI)	Montville (CT)	Kent County (RI)	Brayton Point (SEMA)	Barnstable (SEMA)	Mystic (Boston)	Total
0 MW	29	0	0	0	0	0	29
1000 MW	29	0	0	500	500	0	1029
2000 MW	29	0	700	500	800	0	2029
3000 MW	29	0	700	800	1500	0	3029
5000 MW	29	800	1000	800	2400	0	5029
6000 MW	29	800	1000	1600	2400	200	6029

See slide 5 for interconnection point information for 8,000 MW scenarios

Total Systemwide Energy Production by Fuel Type (TWh)

For Constrained (C) and Unconstrained (UC) Transmission



Total energy is higher in the 6,000 and 8,000 MW OSW scenarios due to the inclusion of heat pump demand.

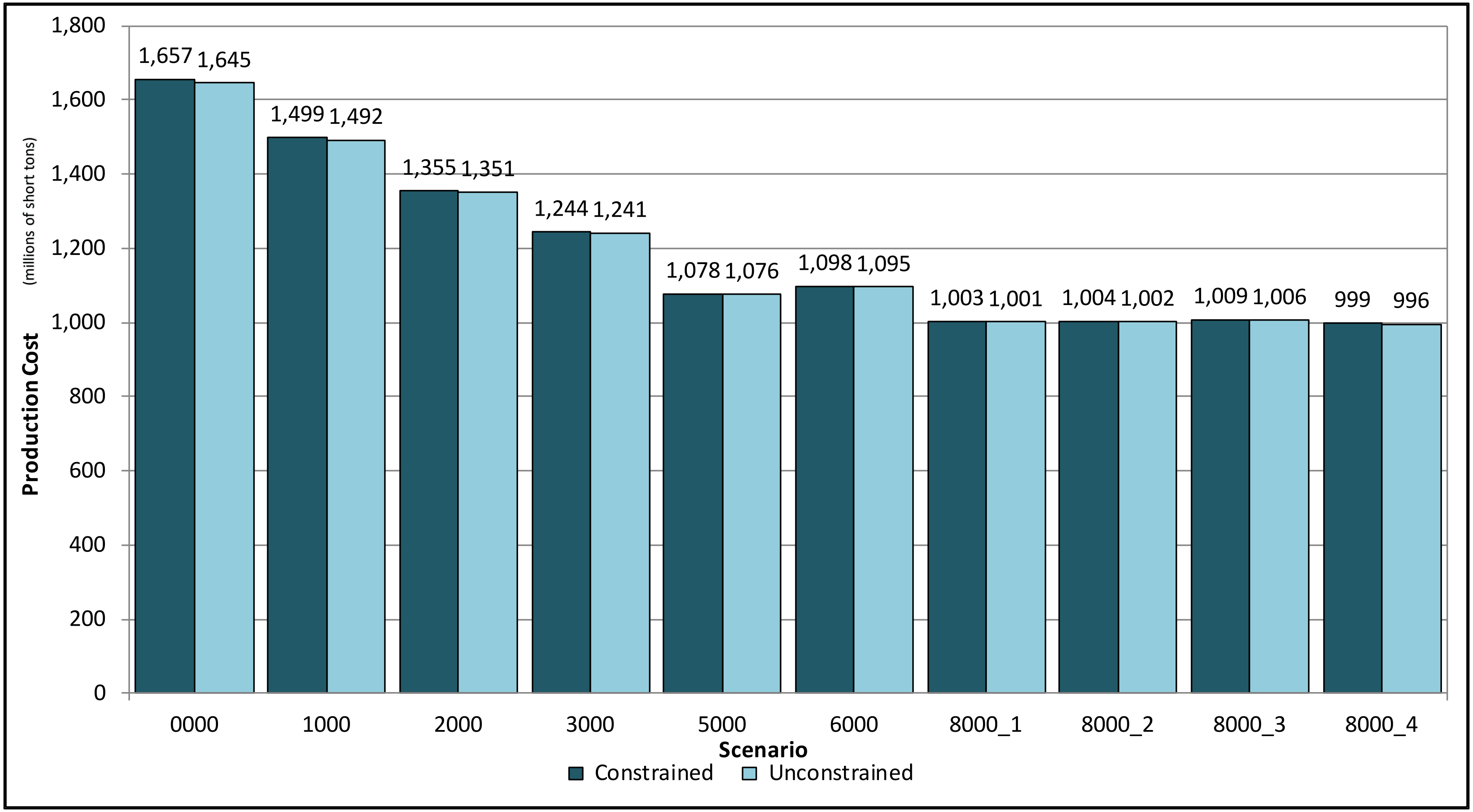
Total Systemwide Energy Production by Fuel Type (TWh), cont.

For Constrained (Cstr.) and Unconstrained (Uncstr.) Transmission

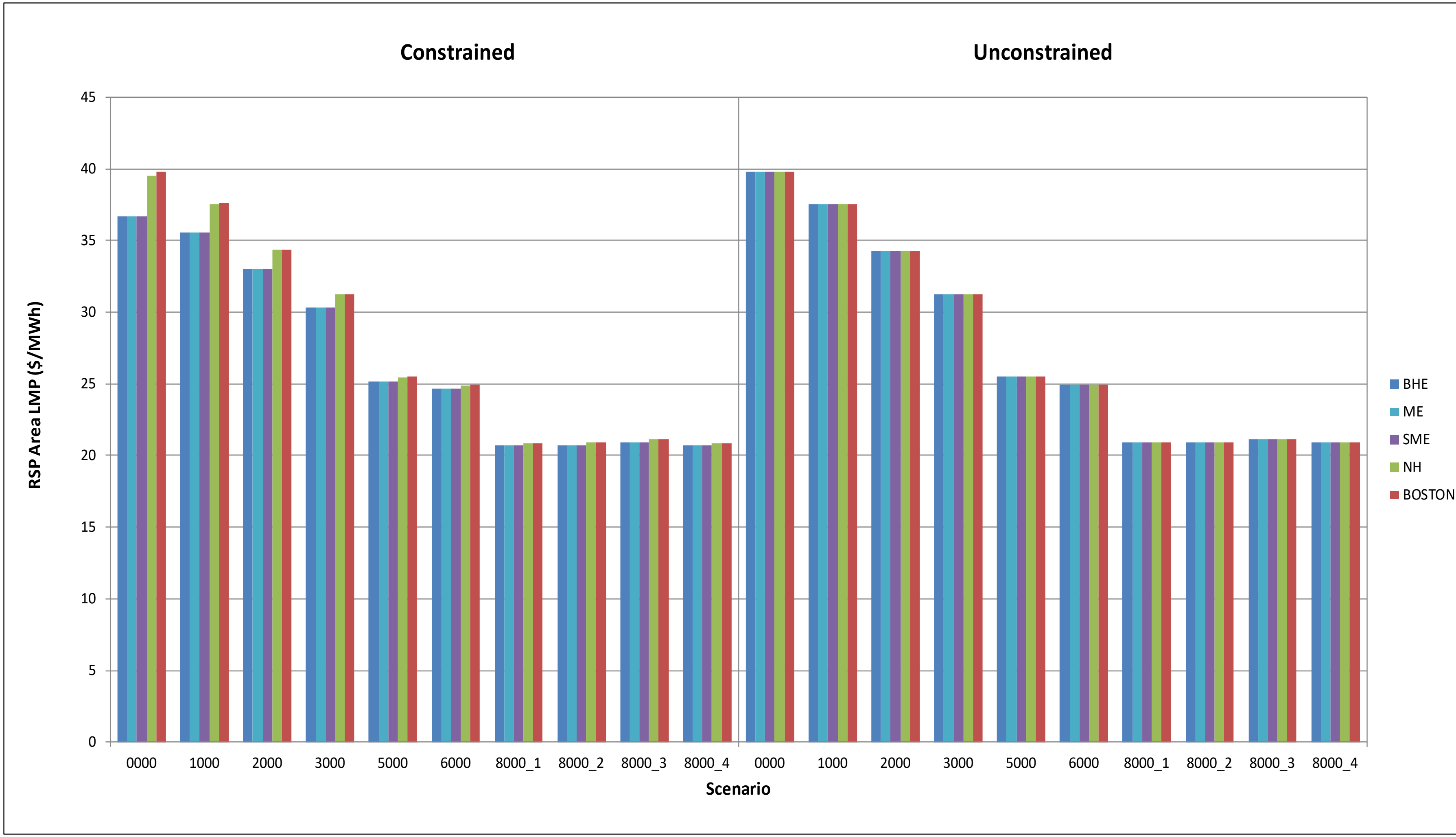
Scenario	0000		1000		2000		3000		5000		6000	
Fuel Type	Cstr.	Uncstr.	Cstr.	Uncstr.	Cstr.	Uncstr.	Cstr.	Uncstr.	Cstr.	Uncstr.	Cstr.	Uncstr.
Offshore Wind	0.12	0.12	3.94	3.94	7.99	7.99	11.83	11.83	19.28	19.28	22.28	22.28
Onshore Wind	3.86	3.86	3.86	3.86	3.85	3.85	3.84	3.84	3.81	3.81	3.80	3.80
NG	30.22	30.10	27.06	27.10	24.18	24.14	21.88	21.87	18.37	18.36	18.66	18.64
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Imports	26.43	26.52	26.09	26.14	25.38	25.41	24.36	24.38	21.92	21.92	21.34	21.36
Coal	0.26	0.30	0.16	0.06	0.06	0.08	0.04	0.03	0.02	0.02	0.06	0.06
LFG/MSW	3.91	3.92	3.77	3.78	3.57	3.57	3.37	3.37	2.99	2.99	2.94	2.94
PV	9.47	9.47	9.47	9.47	9.47	9.47	9.47	9.47	9.47	9.47	9.47	9.47
Wood	4.71	4.71	4.71	4.71	4.71	4.71	4.70	4.70	4.69	4.69	4.70	4.70
Nuc	29.85	29.85	29.85	29.85	29.85	29.85	29.85	29.85	29.85	29.85	29.85	29.85
EE/DR	36.09	36.09	36.09	36.09	36.09	36.09	36.09	36.09	36.09	36.09	36.09	36.09
Hydro	9.20	9.20	9.15	9.15	9.04	9.04	8.80	8.80	7.77	7.77	7.35	7.35

See slide 10 for 8,000 MW scenarios results. See slides 45-46 or previous presentations for fuel price assumptions.

Systemwide Energy Production Costs ($ Million)



Annual Average LMPs by RSP Subarea ($/MWh)



Price separation at the Maine-New Hampshire interface decreases as OSW production replaces demand for constrained zero-cost resources.

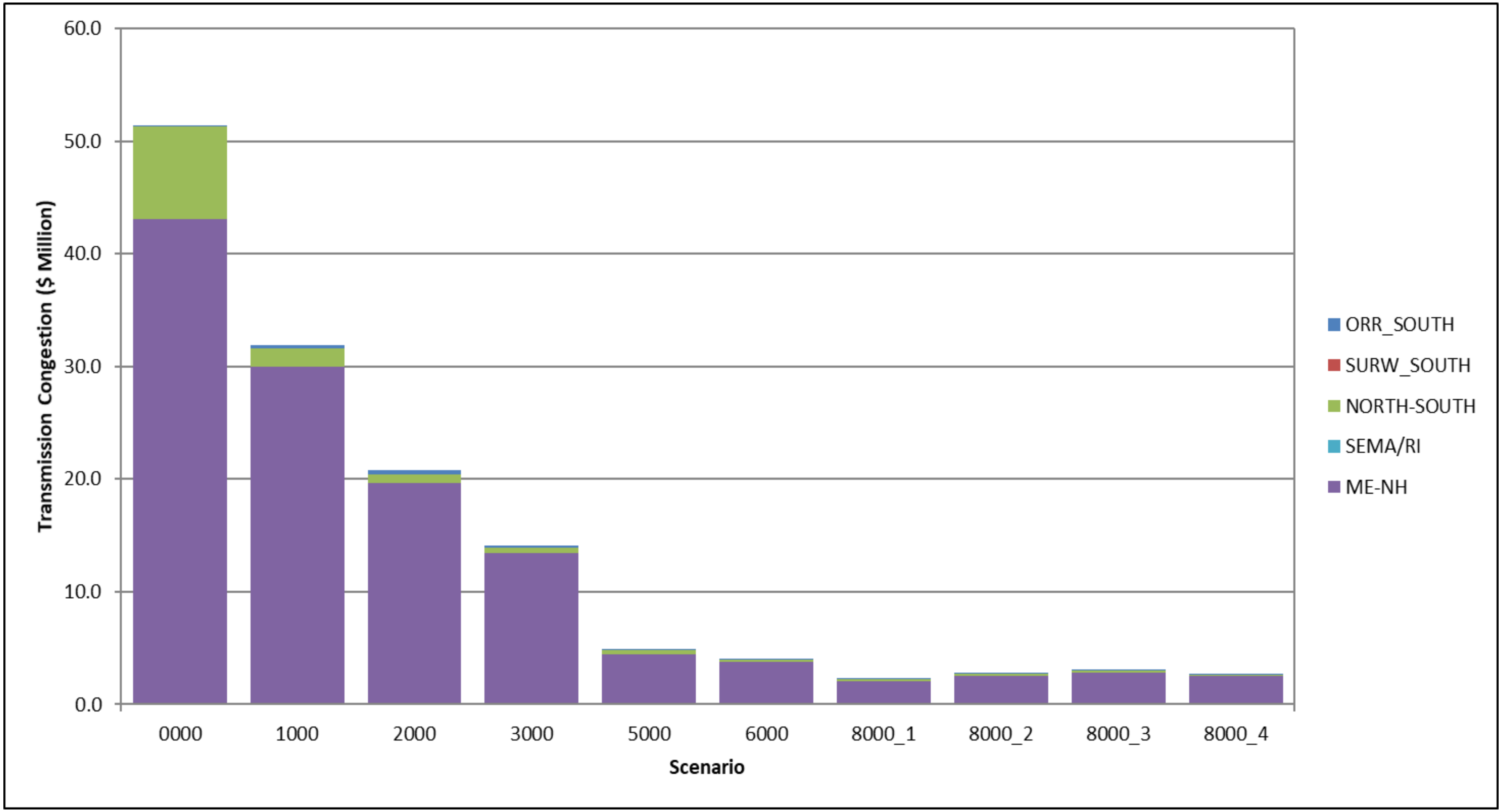
Annual Average LMPs by RSP Subarea ($/MWh), cont.

Transmission Case	Scenario	BHE	ME	SME	NH	BOSTON
Constrained	0000	36.66	36.68	36.68	39.49	39.83
	1000	35.55	35.58	35.58	37.52	37.60
	2000	33.00	33.04	33.04	34.35	34.38
	3000	30.34	30.35	30.35	31.25	31.28
	5000	25.16	25.17	25.17	25.48	25.49
	6000	24.64	24.65	24.65	24.91	24.92
	8000_1	20.68	20.68	20.68	20.83	20.84
	8000_2	20.74	20.74	20.74	20.91	20.92
	8000_3	20.91	20.91	20.91	21.11	21.12
	8000_4	20.69	20.70	20.70	20.87	20.87
Unconstrained	0000	39.81	39.81	39.81	39.81	39.81
	1000	37.52	37.54	37.54	37.54	37.53
	2000	34.31	34.31	34.31	34.31	34.31
	3000	31.28	31.28	31.28	31.28	31.28
	5000	25.53	25.53	25.53	25.53	25.53
	6000	24.92	24.92	24.92	24.92	24.92
	8000_1	20.88	20.88	20.88	20.88	20.88
	8000_2	20.92	20.92	20.92	20.92	20.92
	8000_3	21.15	21.15	21.15	21.15	21.15
	8000_4	20.90	20.90	20.90	20.90	20.90

Load-Serving Entity Energy Expense and Uplift ($ Million)

Transmission Case	Type	Scenario									
		0000	1000	2000	3000	5000	6000	8000_1	8000_2	8000_3	8000_4
Constrained	LSEEE	5,972	5,654	5,178	4,715	3,848	3,762	3,147	3,160	3,188	3,152
	Uplift	189	201	225	252	302	311	351	348	346	347
	Total	6,161	5,855	5,403	4,967	4,150	4,073	3,498	3,508	3,534	3,499
Unconstrained	LSEEE	6,016	5,672	5,185	4,727	3,858	3,766	3,156	3,162	3,197	3,159
	Uplift	173	193	220	248	298	307	347	346	342	343
	Total	6,189	5,865	5,405	4,975	4,157	4,073	3,504	3,507	3,538	3,502

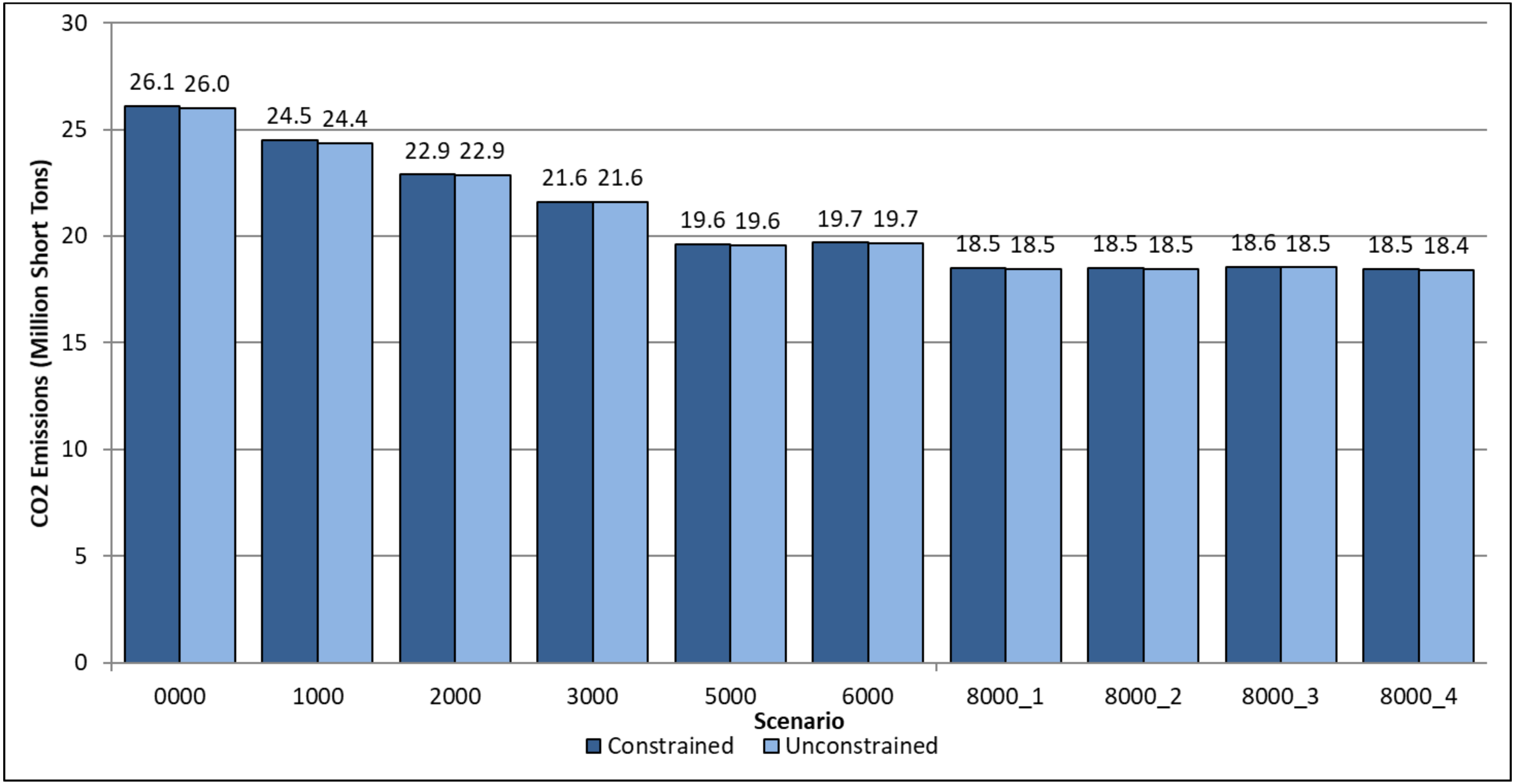
Congestion by Interface ($ Million)



Congestion by Interface ($ Million), cont.

Interface	Scenario									
	0000	1000	2000	3000	5000	6000	8000_1	8000_2	8000_3	8000_4
Orrington South	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Surowiec South	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
North-South	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SEMA/RI	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
ME-NH	43.1	30.0	19.7	13.4	4.4	3.7	2.1	2.5	2.9	2.5
Total	**43.3**	**30.0**	**19.7**	**13.4**	**4.5**	**3.8**	**2.2**	**2.6**	**2.9**	**2.6**

Native New England Resource CO_2 Emissions (millions of short tons)

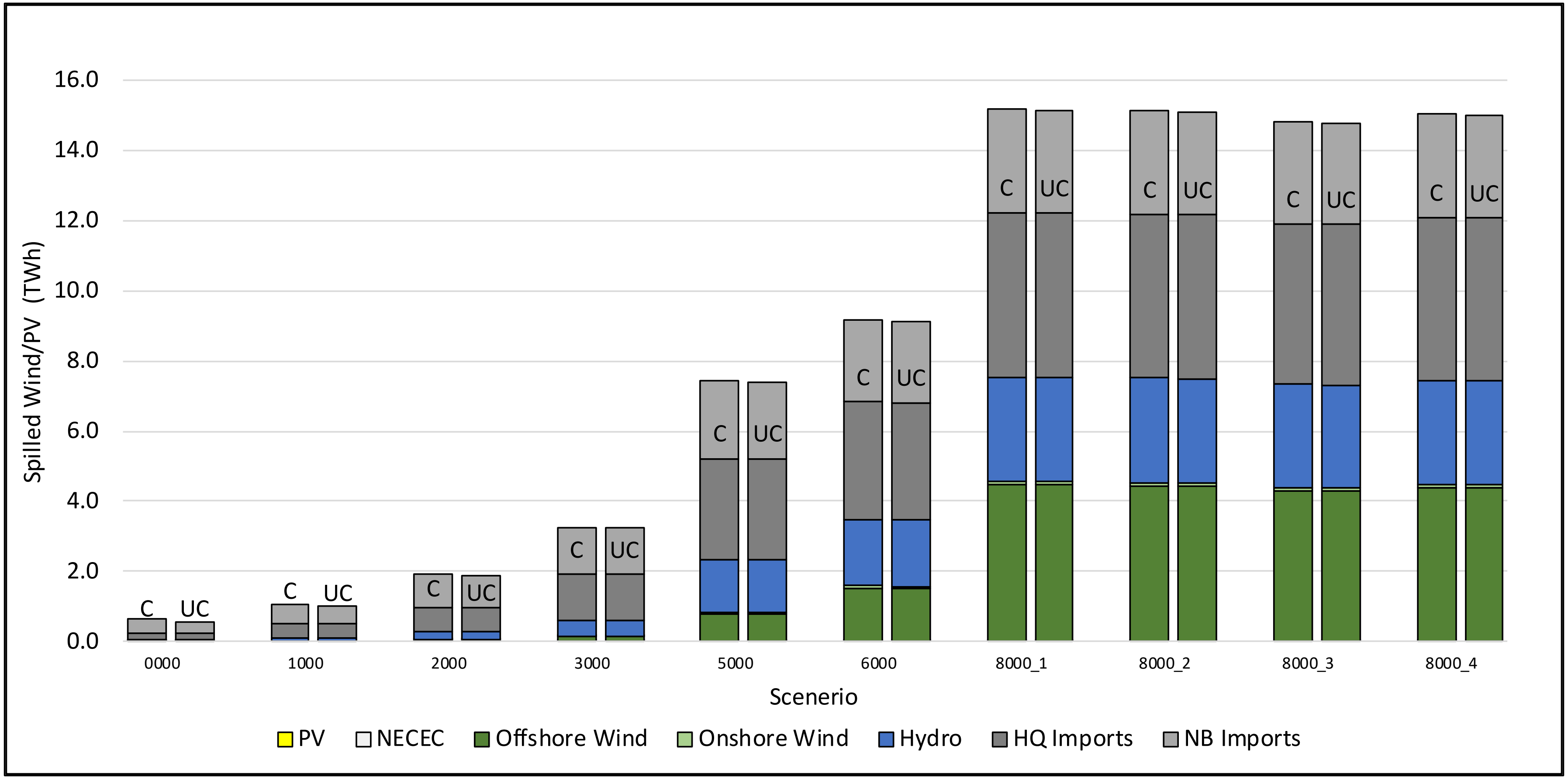


Native New England Resource CO_2 Emissions, cont. (millions of short tons)

Scenario	Transmission Case	
	Constrained	Unconstrained
0000	26.09	26.02
1000	24.49	24.37
2000	22.88	22.86
3000	21.62	21.58
5000	19.60	19.59
6000	19.69	19.66
8000 _1	18.50	18.46
8000 _2	18.50	18.48
8000 _3	18.56	18.53
8000 _4	18.46	18.43

Total Amount of Spilled Resource Energy (TWh)

For Constrained (Cstr.) and Unconstrained (Uncstr.) Transmission



Curtailment of specific resources is driven by the threshold prices and order. This model uses the 2015 weather year to shape the 2030 wind, solar, and load profiles. If a different weather year is used, the results would differ.

Total Amount of Spilled Resource Energy (TWh), cont.

Scenario	Offshore Wind		On-Shore Wind		PV		NECEC		Hydro		HQ Imports		NB Imports	
	C	UC	C	UC	C	UC	C	UC	C	UC	C	UC	C	UC
0000	0.000	0.000	0.005	0.005	0.000	0.000	0.000	0.000	0.056	0.056	0.178	0.177	0.400	0.314
1000	0.014	0.014	0.009	0.009	0.000	0.000	0.000	0.000	0.105	0.104	0.372	0.371	0.547	0.501
2000	0.048	0.048	0.012	0.012	0.000	0.000	0.000	0.000	0.218	0.218	0.716	0.714	0.914	0.892
3000	0.134	0.133	0.021	0.022	0.000	0.000	0.000	0.000	0.458	0.457	1.300	1.296	1.349	1.335
5000	0.788	0.788	0.050	0.051	0.000	0.000	0.000	0.000	1.481	1.481	2.906	2.904	2.188	2.186
6000	1.523	1.519	0.063	0.064	0.000	0.000	0.000	0.000	1.909	1.905	3.329	3.326	2.340	2.328
8000_1	4.474	4.465	0.079	0.080	0.000	0.000	0.000	0.000	2.993	2.986	4.679	4.677	2.946	2.936
8000_2	4.433	4.423	0.094	0.098	0.000	0.000	0.000	0.000	2.983	2.978	4.656	4.655	2.947	2.945
8000_3	4.306	4.295	0.090	0.092	0.000	0.000	0.000	0.000	2.929	2.927	4.572	4.567	2.900	2.896
8000_4	4.400	4.393	0.083	0.084	0.000	0.000	0.000	0.000	2.964	2.958	4.633	4.626	2.945	2.938

Curtailment of specific resources is driven by the threshold prices and order. This model uses the 2015 weather year to shape the 2030 wind, solar, and load profiles. If a different weather year is used, the results would differ.

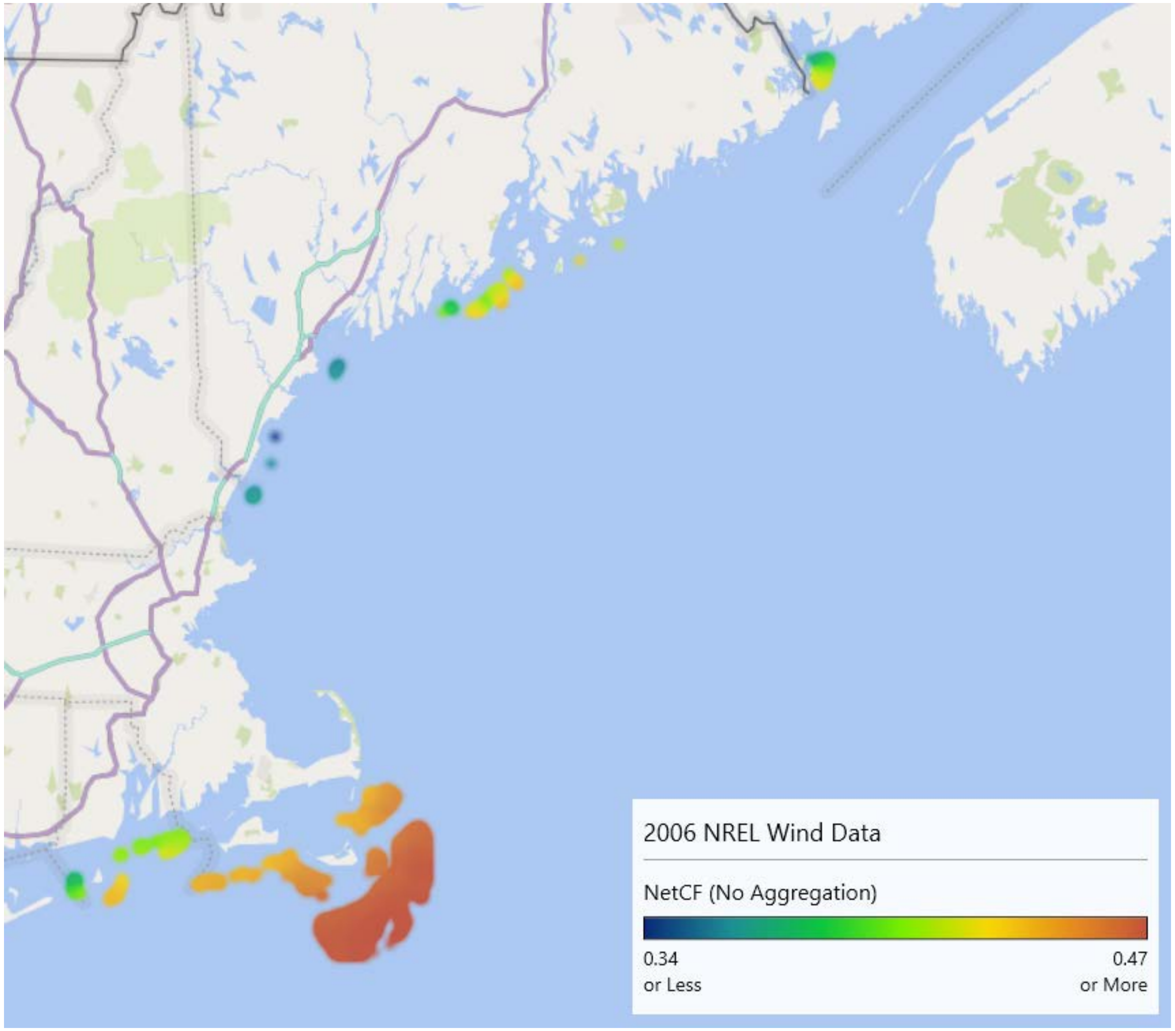
Total Amount of Resource Energy Spilled Each Month in 8000_1 (TWh)

Month	PV	NECEC	Offshore Wind	Onshore Wind	Hydro	HQ Imports	NB Imports	Total
1	0.000	0.000	0.116	0.001	0.196	0.360	0.318	0.990
2	0.000	0.000	0.001	0.000	0.024	0.096	0.152	0.273
3	0.000	0.000	0.653	0.011	0.431	0.653	0.457	2.207
4	0.000	0.000	1.052	0.026	0.668	0.611	0.337	2.694
5	0.000	0.000	0.475	0.014	0.507	0.488	0.274	1.757
6	0.000	0.000	0.160	0.001	0.175	0.401	0.240	0.978
7	0.000	0.000	0.001	0.000	0.013	0.058	0.076	0.149
8	0.000	0.000	0.010	0.000	0.022	0.067	0.055	0.154
9	0.000	0.000	0.411	0.008	0.159	0.475	0.274	1.326
10	0.000	0.000	0.853	0.011	0.316	0.559	0.278	2.017
11	0.000	0.000	0.479	0.005	0.254	0.477	0.232	1.448
12	0.000	0.000	0.263	0.002	0.249	0.434	0.253	1.201

Curtailment of specific resources is driven by the threshold prices and order. This model uses the 2015 weather year to shape the 2030 wind, solar, and load profiles. If a different weather year is used, the results would differ.

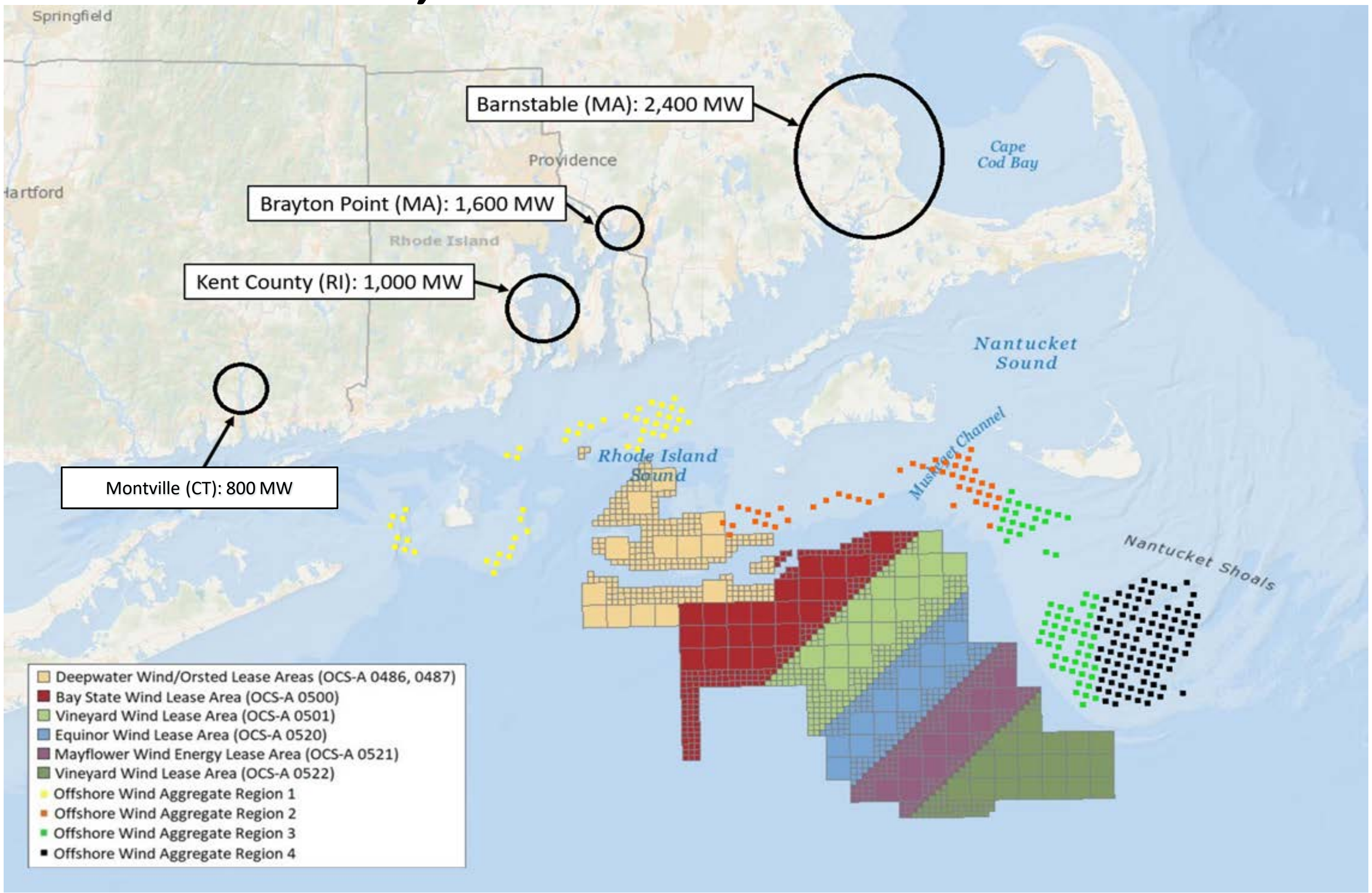
National Renewable Energy Laboratory (NREL) Data

Capacity Factor for Offshore Wind in New England



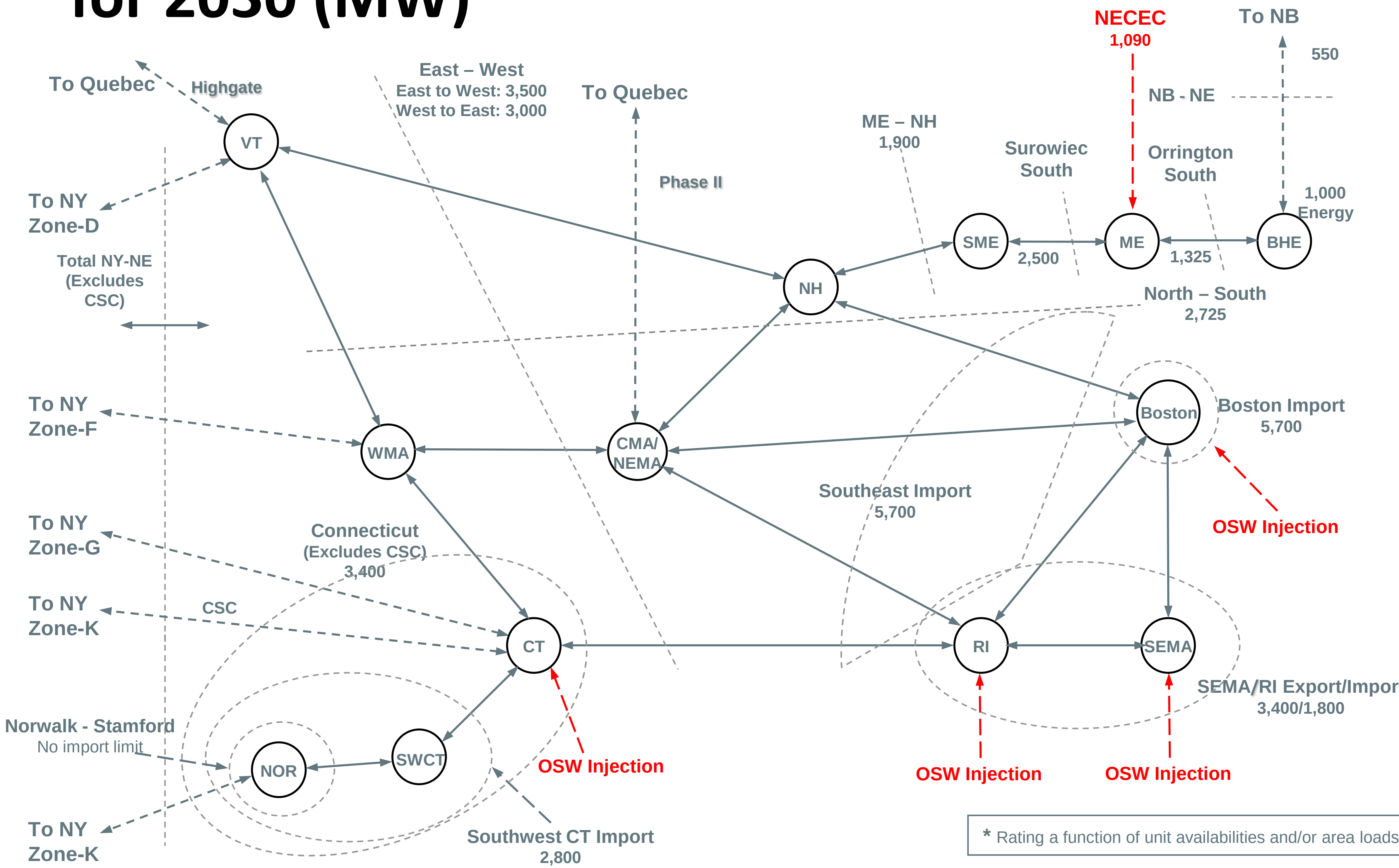
This map shown for reference, while the results in this presentation use 2015 wind data from a different source than NREL the trends are similar.

Locations of NREL OSW Sites and Interconnection Points Used for 6,000 MW OSW Scenario



Approximate locations shown with 6,000 MW OSW injection values, an additional 200 MW injected into Boston is not shown.

Assumed New England System Representation for 2030 (MW)



* Rating a function of unit availabilities and/or area loads.

Profiles Used in the 2019 Study

- Net load profiles (load shape and daily peak) reflect price-taking resources, including EE, PV, wind, hydro and imports.
- Profiles for charging plug-in hybrid electric vehicles (PHEVs) model charging based on recent EnviroPro data showing peak charging in the evening.
- New England Clean Energy Connect (NECEC) modeled as importing 1,090 MW at all times (excluding threshold price curtailment).
- The storage and discharge of energy by pumped-storage generation and battery systems are dispatched by GridView to further smooth out the net load profile after PHEV, PV, wind, local hydro, interchange and new imports.

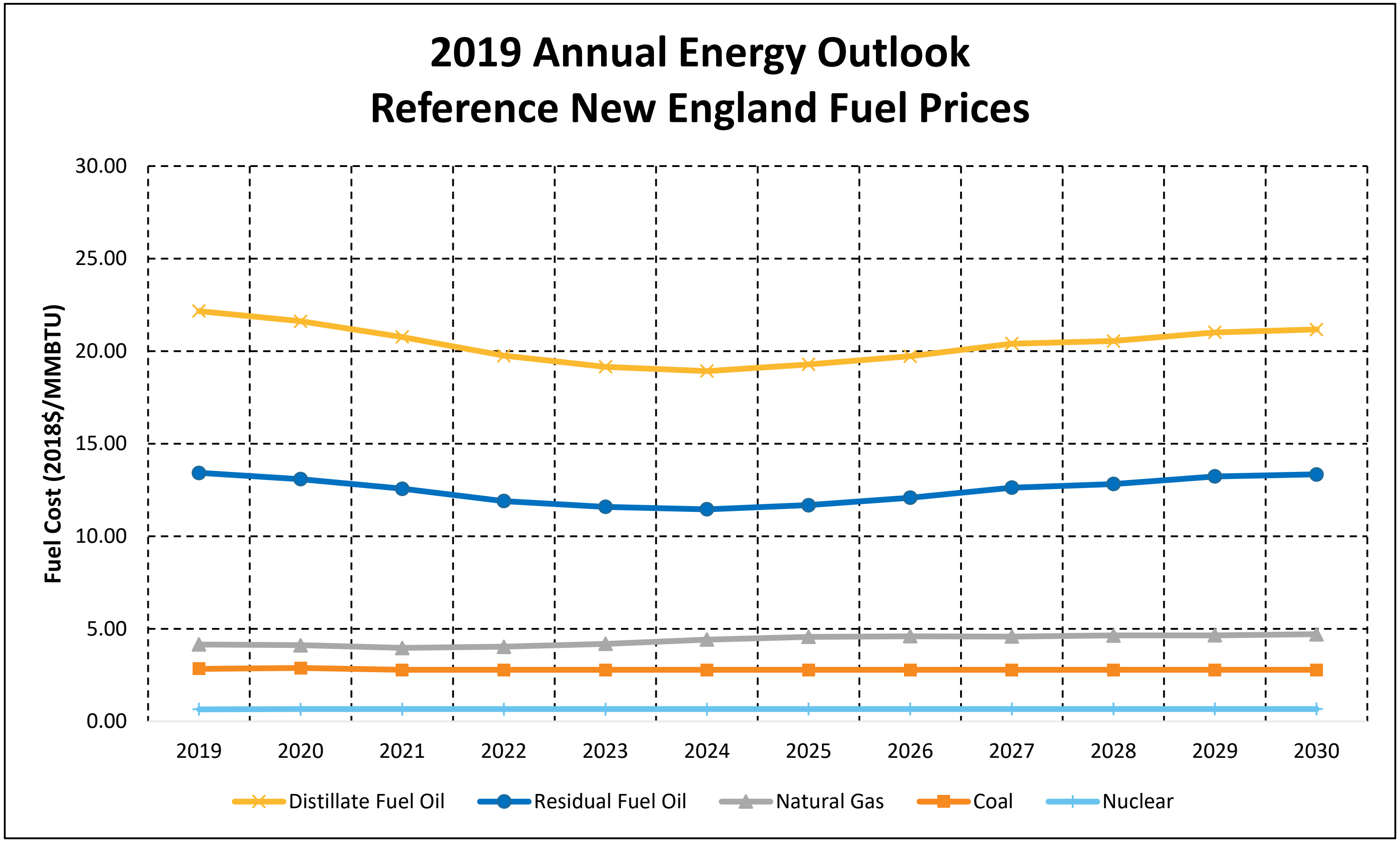
The 2019 Study Uses the Same Basic Assumptions That Were Used in Recent Economic Studies

- Gross demand, solar photovoltaic (PV), and energy-efficiency (EE) forecasts summarized in the ISO's *2019 Capacity, Energy, Load, and Transmission (CELT) Report* are used to establish net load for 2025. The quantities for 2030 assume growth continuing at the same rate for 2028 compared with 2027.
- A representative installed reserve margin of 13.7% above the net 50/50 peak load and rounding to the nearest 100 MW is assumed to meet the net Installed Capacity Requirement.
- The fleet of supply and demand resources expected as of 2019/2020 using the results of the thirteenth Forward Capacity Auction (FCA 13) are reflected in the simulations. These cleared resources include renewables (i.e., biofuel, landfill gas, and other fuels); utility scale PV (FCM and energy-only); coal-, oil-, and gas-fired generators; nuclear; hydroelectric and pumped-storage resources; and external capacity contracts, which will have Capacity Supply Obligations from June 1, 2022 to May 31, 2023. Retired resources known as of FCA 13 are also removed from the simulation databases.

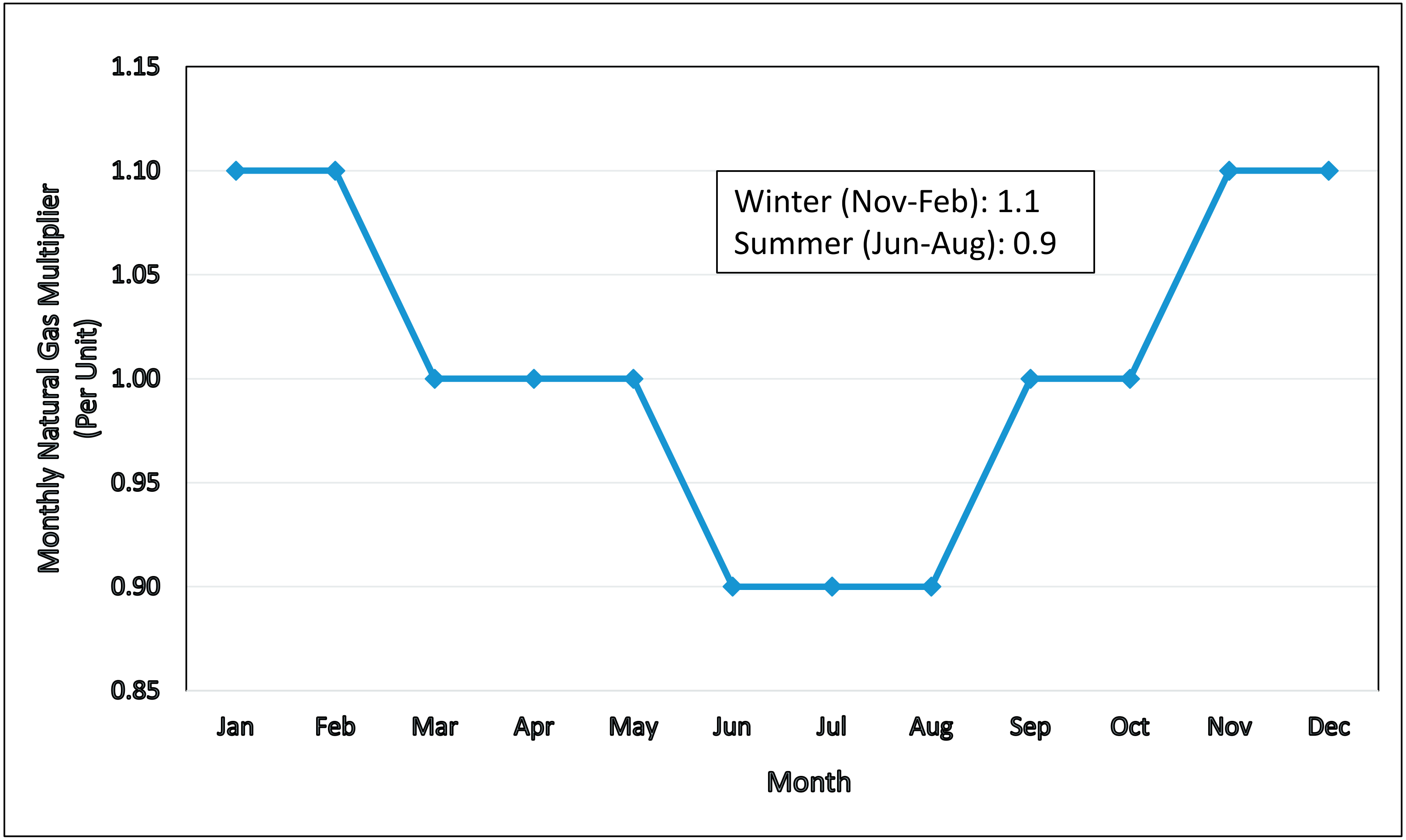
The 2019 Study Uses the Same Basic Assumptions That Were Used in Recent Economic Studies, cont.

- FCM and energy-only generators are simulated at their summer seasonal claimed capabilities (SCC) and then reduced to reflect forced outages and average daily unavailabilities of generators.
- The as-planned transmission system is used for estimating the system's transfer limits for internal and external interfaces under constrained conditions. The 2030 internal and external transmission-interface transfer capabilities are based on the values established for 2025 for regional planning studies. However, Surowiec South uses a projected limit of 2,500 MW based on the project's filing with the Maine PUC and per request from NESCOE for this study.
- U.S. Energy Information Administration (EIA) fuel-price forecasts, with reference projections to 2030, are used for estimating costs to produce electric energy. Monthly multipliers have been applied to the EIA forecasted natural gas price to reflect seasonal adjustment.
- Prices for the Regional Greenhouse Gas Initiative (RGGI) carbon (CO_2) emission allowances and allowances for other environmental emissions are specified at $24/ton for 2030 and used for estimating the costs to produce electric energy.

Fuel Price Forecast: EIA's 2019 AEO Base Forecast

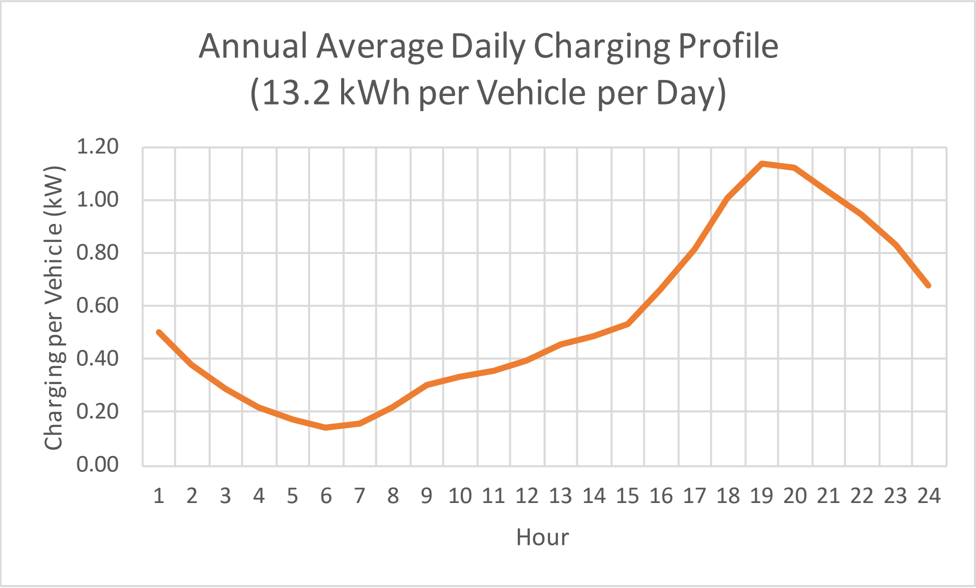


Fuel Price Forecast: Per Unit Multiplier for Monthly Natural Gas Price Assumptions



PHEVs Characteristics

- Historical data from NREL suggests that PHEV charging tends to start in the later part of the day and continue into the night
  - The ISO modified the daily PHEV charging profile it used in the 2016 Economic Study to reflect this shift in the charging period
  - Charging ramps-up between 4 pm and midnight



Penetration (Thousand PHEVs)	550
Max charging (MW) (7PM)	627
Annual Charging Energy (GWh)	2,650

Acronyms

- BOEM – Bureau of Ocean Energy Management
- CELT – Capacity, Energy, Load, and Transmission Report
- CSO – Capacity Supply Obligation
- Cstr. – Constrained
- DR – Demand-Response
- EE – Energy Efficiency
- EIA – U.S. Energy Information Administration
- FCA – Forward Capacity Auction
- FCM – Forward Capacity Market
- LMP – Locational Marginal Price
- LSE – Load-Serving Entity
- MSW – Municipal Solid Waste

Acronyms, cont.

- NECEC – New England Clean Energy Connect
- NESCOE – New England States Committee on Electricity
- NG – Natural Gas
- NICR – Net Installed Capacity Requirement
- NREL – National Renewable Energy Laboratory
- OSW – Offshore Wind
- PHEV – Plug-in Hybrid Electric Vehicle
- PV – Photovoltaic
- RFP – Request for Proposals
- RGGI – Regional Greenhouse Gas Initiative
- SCC – Seasonal Claimed Capability
- Uncstr. – Unconstrained