2016 Economic Study Results: Peak-Gas-Day Capacity & Energy Analysis

Planning Advisory Committee

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SYSTEM PLANNING - RESOURCE ADEQUACY

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STUDY GOALS AND HIGHLIGHTS

Study Goals

- After meeting all firm natural gas customers' needs, determine whether New England's natural gas system capacity, under six resource expansion scenarios and six gas system topology cases, can satisfy:
  - The fuel requirements of gas-fired **installed capacity** assumed to have capacity supply obligations**.**
  - The fuel requirements of gas-fired **dispatched capacity** on the **winter** peak-gas-day.
  - The maximum hourly **energy requirements** of all gas-fired generation that were economically dispatched to produce electric energy over the summer and winter peaks.

Study Matrix

- Six Resource Expansion Scenarios
  1. RPS + Gas
  2. ISO Queue
  3. Renewables Plus
  4. No Retirements
  5. ACPs + Gas
  6. RPS + Geodiverse Renewables

- Six Natural Gas System Topologies
  1. Minimum Amount of Gas System Capacity
  2. Case 1 + LDC peak shaving growth
  3. Case 2 + pipeline growth
  4. Case 3 + Distragas
  5. Case 4 + offshore LNG
  6. Maximum Amount of Gas System Capacity

Differences Between Two ISO Studies

The primary differences between this 2016 NEPOOL Scenario Analysis: Peak-Gas-Day Natural Gas Capacity and Energy Analysis and the ISO-NE's upcoming Fuel Security Analysis (fall 2017) are:

- The objective of this ***Peak-Gas-Day Natural Gas Capacity and Energy Analysis*** is to identify surpluses/deficiencies in serving the installed capacity, dispatched capacity, and energy requirements of gas-fired and dual-fuel generators in the ***2016 NEPOOL Scenario Analysis*** for just the peak days of the study year.
- The objective of ISO-NE's upcoming ***Fuel Security Analysis*** is to quantify the operational risks associated with insufficient fuel(s) during the entire winter period and identify if there are energy shortfalls under various power system scenarios.

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Differences Between Two ISO Studies – cont'd

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- The ***NEPOOL Scenario Analysis*** focuses on the winter and summer peak-gas-day for 2025 and 203, while the ***Fuel Security Analysis*** will study the entire 90-day winter period.
- Both studies are intended to analyze different issues.
  - The ***NEPOOL Scenario Analysis*** looks at the system's maximum, short-term capability
  - The ***Fuel Security Analysis*** will look at how often during the course of the winter is the power system likely to be stressed under different scenarios.
- The ***NEPOOL Scenario Analysis*** assumes the natural gas and LNG supply chain is always fully available to satisfy the seasonal needs of shippers and customers.
- The two studies also differ in terms of specific modeling methodologies, metrics and scenarios.

Peak-Gas-Day Capacity and Energy Analysis

Study Highlights

- Under the maximum gas infrastructure case:
  - There is enough spare natural gas system capacity to serve electric sector capacity and energy requirements for all six resource expansion scenarios in the **summers** of 2025 and 2030.
  - There is not enough spare natural gas system capacity to satisfy electric sector installed capacity requirements for all six resource expansion scenarios in the **winters** of 2025 and 2030.
  - Only Scenario 3 (Renewables Plus) can satisfy the dispatched capacity and energy generation requirements in the **winters** of 2025 and 2030.

SIX SCENARIOS AND SIX GAS CASES

Peak-Gas-Day Capacity and Energy Analysis

NEPOOL's Six Resource Expansion Scenarios

S1 = RPS + Gas: Physically meet Renewable Portfolio Standards (RPS) and replace generator retirements with natural gas combined-cycle units.

S2 = ISO Queue: Physically meet RPS and replace generator retirements with new renewables/clean energy.

S3 = Renewables Plus: Physically meet RPS, add renewables/clean energy, EE, PV, PEV, storage, and retire older generating units.

S4 = No Retirements (beyond FCA #10): Meet RPS with new resources under development and use RPS' Alternative Compliance Payments (ACPs) for shortfalls. Add natural gas units.

S5 = ACPs + Gas: Meet RPS with new resources under development and use ACPs. Replace all retirements with natural gas units.

S6 = RPS + Geodiverse Renewables: Scenario 2 with a more geographically balanced mix of on/offshore wind and solar PV.

Six Natural Gas System Topology Cases

- Six natural gas system cases encompass the various combinations of gas system capacity and supply options regarding pipelines, LDC peak-shaving, expansion projects, LNG supplies, and future growth:
  - **Gas Case 1** = **Minimum amount of gas system capacity** available for gas LDC and power generation. Reflects existing gas pipelines, existing LDC peak-shaving & near-term pipeline expansion projects.
  - **Gas Case 2** = Includes Gas Case 1 plus LDC peak shaving growth.
  - **Gas Case 3** = Includes Gas Case 2 plus pipeline growth.
  - **Gas Case 4** = Includes Gas Case 3 plus Distrigas LNG.
  - **Gas Case 5** = Includes Gas Case 4 plus offshore LNG.
  - **Gas Case 6** = **Maximum amount of gas system capacity** available for both gas LDC and power generation. Includes Gas Case 5 plus Distrigas LNG and offshore LNG.

Peak-Gas-Day Capacity and Energy Analysis

Six Natural Gas System Topology Cases – cont'd

ADDITIONAL GAS

Natural Gas Infrastructure	Gas Case 1 Minimum Gas Capacity(*)	Gas Case 2 Case 1 + LDC Peak Shaving	Gas Case 3 Case 2 + Pipeline Growth	Gas Case 4 Case 3 + Distrigas LNG	Gas Case 5 Case 4 + Offshore LNG	Gas Case 6 Maximum Gas Capacity
Existing Pipelines	√	√	√	√	√	√
Existing LDC Peak Shaving	√	√	√	√	√	√
Pipeline Projects	√	√	√	√	√	√
LDC Peak Shaving Growth		√	√	√	√	√
Pipeline Growth			√	√	√	√
Distrigas				√		√
Offshore LNG (FSRU)					√	√

ADDITIONAL GAS

(*) This is the first case in which the gas-system assumptions provide adequate winter capacity to serve all regional LDC core-gas demands.

Peak-Gas-Day Capacity and Energy Analysis

Six Scenarios and Six Gas Cases

	Gas Case 1 Minimum Gas Capacity	Gas Case 2 Case 1 + LDC Peak Shaving	Gas Case 3 Case 2 + Pipeline Growth	Gas Case 4 Case 3 + Distrigas LNG	Gas Case 5 Case 4 + Offshore LNG	Gas Case 6 Maximum Gas Capacity
Scenario 1 RPS + Gas						
Scenario 2 ISO Queue						
Scenario 3 Renewables Plus						
Scenario 4 No Retirements						
Scenario 5 ACPs + Gas						
Scenario 6 RPS + Geodiverse Renewables						

Analysis of Six Scenarios and Six Gas Cases
(with 36 outcomes)
Completed For 2025 and 2030:

Installed Capacity
Dispatched Capacity
Energy Generation

ANALYSIS AND METHODOLOGY

INSTALLED CAPACITY ANALYSIS AND METHODOLOGY

Installed Capacity Analysis

Installed Capacity Analysis (MW)

- After meeting all firm natural gas customers' needs, determine whether New England's natural gas system capacity, under six gas system topology cases, can satisfy the gas-fired installed capacity requirements within the six NEPOOL resource expansion scenarios
  - Focus is on **summer** requirements
  - Represents a situation where all gas-fired capacity is assumed to operate at seasonal claimed capability (SCC)
  - Represents the upper band of gas consumption by the electric sector

Installed Capacity Analysis Methodology

Installed Capacity Analysis Methodology

- On the seasonal peak-gas-day, this methodology determines whether the gas-fired installed capacity requirements can be satisfied within each scenario:
  - Identify natural gas system installed capacity within all six gas cases
  - Identify firm natural gas customer demands
  - Determine if there is surplus* natural gas system capacity available to the electric sector
  - If so, compare surplus natural gas system capacity to the electric sector's installed capacity requirements
  - Results show a surplus or deficiency for installed capacity

** Note: Peak-gas-day surplus represent spare natural gas system capacity that may be utilized ratably by the electric sector over 24 hours.*

Peak-Gas-Day Capacity and Energy Analysis

Gas-Fired Installed Capacity in NEPOOL's Six Scenarios

2025 SCENARIO		GAS-FIRED INSTALLED CAPACITY (MW) (Note 1&2)
S1	RPS + Gas	16,847
S2	ISO Queue	16,190
S3	Renewables Plus	16,190
S4	No Retirements	16,297
S5	ACPs + Gas	17,335
S6	RPS + Geodiverse Renewables	16,190

2030 SCENARIO		GAS-FIRED INSTALLED CAPACITY (MW) (Note 1 & 2)
S1	RPS + Gas	19,770
S2	ISO Queue	15,625
S3	Renewables Plus	15,625
S4	No Retirements	16,297
S5	ACPs + Gas	20,458
S6	RPS + Geodiverse Renewables	15,625

Note 1: Total gas-fired installed capacity includes both gas-only and dual fuel capacity burning natural gas.
Note 2: Gas-fired installed capacity totals do not include 1,500 MW of Mystic 8 & 9 burning LNG and 16 MW of gas-fired generation located behind LDC city-gates.

DISPATCHED CAPACITY ANALYSIS AND METHODOLOGY

Dispatched Capacity Analysis

Dispatched Capacity Analysis (MW)

- After meeting all firm natural gas customers' needs, determine whether New England's natural gas system capacity, under six gas system topology cases, can satisfy the gas-fired dispatched capacity requirements on the **winter** peak-gas-day for the six NEPOOL resource expansion scenarios:
  - Performed only for **winter** because summer capacity and energy margins are surplus
  - A sub-set of the installed capacity
  - Represents a situation where only a portion of the installed capacity is required to operate to serve electric demand
  - Represents the lower band of gas consumption by the electric sector

Dispatched Capacity Analysis Methodology

Dispatched Capacity Analysis Methodology

- On the **winter** peak-gas-day, this methodology determines whether the gas-fired dispatched capacity requirements can be satisfied within each scenario:
  - Identify natural gas system dispatched capacity within all six gas cases
  - Identify firm natural gas customer demands
  - Determine if there is surplus natural gas system capacity available to the electric sector
  - If so, compare surplus natural gas system capacity to the electric sector's maximum hourly, dispatched capacity requirements
  - Results show a surplus or deficiency for dispatched capacity

Peak-Gas-Day Capacity and Energy Analysis

Maximum Hourly, Gas-Fired Winter Dispatched Capacity in NEPOOL's Six Scenarios

2025 SCENARIO		MAX HOURLY GAS-FIRED WINTER DISPATCHED CAPACITY (MW)
S1	RPS + Gas	9,610
S2	ISO Queue	9,542
S3	Renewables Plus	6,779
S4	No Retirements	8,863
S5	ACPs + Gas	9,480
S6	RPS + Geodiverse Renewables	9,464

2030 SCENARIO		MAX HOURLY GAS-FIRED WINTER DISPATCHED CAPACITY (MW)
S1	RPS + Gas	9,929
S2	ISO Queue	9,149
S3	Renewables Plus	5,256
S4	No Retirements	9,207
S5	ACPs + Gas	10,098
S6	RPS + Geodiverse Renewables	9,131

ENERGY GENERATION ANALYSIS AND METHODOLOGY

Energy Generation Analysis

Energy Generation Analysis (MWh)

- After meeting all firm natural gas customers' needs, determine whether New England's natural gas system energy, under six gas system topology cases, can satisfy the maximum hourly electric energy production by gas-fired generation:
  - Represents the electric energy production from dispatched gas-fired resources within each scenario

Energy Generation Analysis Methodology

Energy Generation Analysis (MWh)

- On the seasonal peak-gas-day, this methodology determines whether the maximum hourly, gas-fired energy generation requirements can be satisfied within each scenario:
  - Identify natural gas system capacity within all six gas cases
  - Identify firm natural gas customer demands
  - Determine if there is surplus natural gas system capacity available to the electric sector
  - If so, convert surplus natural gas system capacity into a 24-hour energy equivalent
  - Compare the natural gas system's 24-hour energy equivalent to the electric sector's maximum hourly energy generation
  - Results show a surplus or deficiency for energy generation

2025 Peak-Gas-Day, Maximum Hourly Gas-Fired Energy Production in Six NEPOOL Scenarios

	RPS + Gas	ISO Queue	Renewables +	No Retirements	ACPs + Gas	RPS + Renewables
	2025_S1	2025_S2	2025_S3	2025_S4	2025_S5	2025_S6
Winter Maximum Hourly Energy (MWh)	9,610	9,542	6,779	8,863	9,480	9,464
Summer Maximum Hourly Energy (MWh)	15,409	14,477	9,930	14,935	15,744	14,605

2030 Peak-Gas-Day, Maximum Hourly Gas-Fired Energy Production in Six NEPOOL Scenarios

	RPS + Gas	ISO Queue	Renewables +	No Retirements	ACPs + Gas	RPS + Renewables
	2030_S1	**2030_S2**	**2030_S3**	**2030_S4**	**2030_S5**	**2030_S6**
Winter Maximum Hourly Energy (MWh)	9,929	9,149	5,256	9,207	10,098	9,131
Summer Maximum Hourly Energy (MWh)	16,087	13,875	6,779	15,008	16,493	10,218

RESULTS AND FINDINGS

Results and Findings – Installed Capacity

- Under the minimum gas infrastructure case (Gas Case 1), there is enough spare natural gas system capacity to serve electric sector capacity and energy requirements for all six resource expansion scenarios in the **summers** of 2025 and 2030.

- Under the maximum gas infrastructure case (Gas Case 6), there is not enough spare natural gas system capacity to serve all of the six resource expansion scenario's gas-fired installed capacity requirements in the **winters** of 2025 or 2030; these deficiencies equate to about half the amount of the gas-fired installed capacity for all scenarios.

Results and Findings – Dispatched Capacity and Energy Generation

- In **winter** of 2025 and 2030, the amount of gas-fired dispatched capacity ranges from about **one-third to one-half** of the total amount of gas-fired installed capacity across all six scenarios.
- In **summer** of 2025 and 2030, the amount of gas-fired dispatched capacity ranges from about **one-third to three-quarters** of the total amount of gas-fired installed capacity across all six scenarios.
- Under the maximum gas infrastructure case, only Scenario S3 (Renewables Plus) satisfies the dispatched capacity and energy generation requirements in the **winters** of 2025 and 2030.
- In winter of 2030, Scenario S3's dispatched capacity and energy generation requirements can also be satisfied without the need for offshore LNG.

Results and Findings – Renewables, Retirements and Gas

- Under the maximum gas infrastructure case, the following Scenarios still contain enough gas-fired generation to reflect capacity and energy deficiencies in the **winters** of 2025 and 2030:
  - Scenario S1 (RPS + Gas)
  - Scenario S2 (ISO Queue)
  - Scenario S4 (No Retirements)
  - Scenario S5 (ACPs + Gas)
  - Scenario S6 (RPS + Geodiverse Renewables)

Results and Findings - LNG

- LNG from Canaport, Distrigas and offshore FSRU's are critical for meeting the peak-gas-day requirements of the electric sector. Without these gas supply sources, approximately ~1.5 Bcf/day (~214,300 MWh/d) would be taken out the market.

  Should this occur during the **summer** peak-gas-day, this would reduce the surplus gas system capacity available to the electric sector to ~3.2 Bcf/d to ~4.4 Bcf/d (~457,100 to ~628,600 MWh/d).

  However, there would still be enough surplus gas system capacity to satisfy all the capacity and energy requirements of all six resource expansion scenarios, under all gas cases, in the **summers** of 2025 and 2030.

Results and Findings - Other

- Gas Case 1 (minimum gas infrastructure) has only enough natural gas system capacity to serve firm gas customer demands in **winter** of 2030. There is no spare gas system capacity available for electric sector use, thus deficiencies exist within all six scenarios in **winter** of 2030 under Gas Case 1.

SUMMARY OF THE RESULTS OF THE CAPACITY AND ENERGY ANALYSES

Summary of 2025 Winter Installed Capacity Analysis: Deficiencies (Ratable-Take MW)

Scenario		Gas Case 1 Minimum Gas Capacity	Gas Case 2 Case 1 + LDC Peak Shaving	Gas Case 3 Case 2 + Pipeline Growth	Gas Case 4 Case 3 + Distrigas LNG	Gas Case 5 Case 4 + Offshore LNG	Gas Case 6 Maximum Gas Capacity
S1	RPS + Gas	-15,823	-15,383	-13,127	-11,341	-10,746	-8,960
S2	ISO Queue	-15,166	-14,726	-12,470	-10,684	-10,089	-8,303
S3	Renewables Plus	-15,166	-14,726	-12,470	-10,684	-10,089	-8,303
S4	No Retirements	-15,273	-14,833	-12,577	-10,791	-10,196	-8,410
S5	ACPs + Gas	-16,311	-15,871	-13,615	-11,826	-11,234	-9,448
S6	RPS + Geodiverse Renewables	-15,166	-14,726	-12,470	-10,684	-10,089	-8,303

Surplus = + MW
Deficiency = - MW

Summary of 2030 Winter Installed Capacity Analysis: Deficiencies (Ratable-Take MW)

Scenario		Gas Case 1 Minimum Gas Capacity	Gas Case 2 Case 1 + LDC Peak Shaving	Gas Case 3 Case 2 + Pipeline Growth	Gas Case 4 Case 3 + Distrigas LNG	Gas Case 5 Case 4 + Offshore LNG	Gas Case 6 Maximum Gas Capacity
S1	RPS + Gas	-19,734	-19,181	-16,091	-14,306	-13,710	-11,925
S2	ISO Queue	-15,625	-15,036	-11,946	-10,161	-9,565	-7,780
S3	Renewables Plus	-15,625	-15,036	-11,946	-10,161	-9,565	-7,780
S4	No Retirements	-16,297	-15,708	-12,618	-10,833	-10,237	-8,452
S5	ACPs + Gas	-20,458	-19,869	-16,779	-14,994	-14,398	-12,613
S6	RPS + Geodiverse Renewables	-15,625	-15,036	-11,946	-10,161	-9,565	-7,780

Surplus = + MW
Deficiency = - MW

Summary of 2025 Summer Installed Capacity Analysis: Surpluses (Ratable-Take MW)

Scenario		Gas Case 1 Minimum Gas Capacity	Gas Case 2 Case 1 + LDC Peak Shaving	Gas Case 3 Case 2 + Pipeline Growth	Gas Case 4 Case 3 + Distrigas LNG	Gas Case 5 Case 4 + Offshore LNG	Gas Case 6 Maximum Gas Capacity
S1	RPS + Gas	+5,986	+5,986	+8,242	+10,028	+10,623	+12,409
S2	ISO Queue	+6,643	+6,643	+8,899	+10,685	+11,280	+13,066
S3	Renewables Plus	+6,643	+6,643	+8,899	+10,685	+11,280	+13,066
S4	No Retirements	+6,536	+6,536	+8,792	+10,578	+11,173	+12,959
S5	ACPs + Gas	+5,498	+5,498	+7,754	+9,540	+10,135	+11,921
S6	RPS + Geodiverse Renewables	+6,643	+6,643	+8,899	+10,685	+11,280	+13,066

Surplus = + MW
Deficiency = - MW

Peak-Gas-Day Capacity and Energy Analysis

Summary of 2030 Summer Installed Capacity Analysis: Surpluses (Ratable-Take MW)

Scenario		Gas Case 1 Minimum Gas Capacity	Gas Case 2 Case 1 + LDC Peak Shaving	Gas Case 3 Case 2 + Pipeline Growth	Gas Case 4 Case 3 + Distrigas LNG	Gas Case 5 Case 4 + Offshore LNG	Gas Case 6 Maximum Gas Capacity
S1	**RPS + Gas**	+2,748	+2,748	+5,837	+7,623	+8,218	+10,004
S2	**ISO Queue**	+6,893	+6,893	+9,982	+11,768	+12,363	+14,149
S3	**Renewables Plus**	+6,893	+6,893	+9,982	+11,768	+12,363	+14,149
S4	**No Retirements**	+6,221	+6,221	+9,310	+11,096	+11,691	+13,477
S5	**ACPs + Gas**	+2,060	+2,060	+5,149	+6,935	+7,530	+9,316
S6	**RPS + Geodiverse Renewables**	+6,893	+6,893	+9,982	+11,768	+12,363	+14,149

Surplus = + MW
Deficiency = - MW

Peak-Gas-Day Capacity and Energy Analysis

Summary of 2025 Winter Dispatched Capacity Analysis Results: Surplus / Deficiency (Ratable-Take MW)

Scenario		Gas Case 1 Minimum Gas Capacity	Gas Case 2 Case 1 + LDC Peak Shaving	Gas Case 3 Case 2 + Pipeline Growth	Gas Case 4 Case 3 + Distrigas LNG	Gas Case 5 Case 4 + Offshore LNG	Gas Case 6 Maximum Gas Capacity
S1	**RPS + Gas**	-8,586	-8,146	-5,890	-4,104	-3,509	-1,723
S2	**ISO Queue**	-8,518	-8,078	-5,822	-4,036	-3,441	-1,655
S3	**Renewables Plus**	-5,755	-5,315	-3,059	-1,273	-678	+1,108
S4	**No Retirements**	-7,839	-7,399	-5,143	-3,357	-2,762	-976
S5	**ACPs + Gas**	-8,456	-8,016	-5,760	-3,974	-3,379	-1,593
S6	**RPS + Geodiverse Renewables**	-8,440	-8,000	-5,744	-3,958	-3,363	-1,577

Surplus = + MW
Deficiency = - MW

Peak-Gas-Day Capacity and Energy Analysis

Summary of 2030 Winter Dispatched Capacity Analysis Results: Surplus / Deficiency (Ratable-Take MW)

Scenario		Gas Case 1 Minimum Gas Capacity	Gas Case 2 Case 1 + LDC Peak Shaving	Gas Case 3 Case 2 + Pipeline Growth	Gas Case 4 Case 3 + Distrigas LNG	Gas Case 5 Case 4 + Offshore LNG	Gas Case 6 Maximum Gas Capacity
S1	**RPS + Gas**	-9,929	-9,340	-6,250	-4,465	-3,869	-2,084
S2	**ISO Queue**	-9,149	-8,560	-5,470	-3,685	-3,089	-1,304
S3	**Renewables Plus**	-5,256	-4,667	-1,577	+208	+804	+2,589
S4	**No Retirements**	-9,207	-8,618	-5,528	-3,743	-3,147	-1,362
S5	**ACPs + Gas**	-10,098	-9,509	-6,419	-4,634	-4,038	-2,253
S6	**RPS + Geodiverse Renewables**	-9,131	-8,542	-5,452	-3,667	-3,071	-1,286

Surplus = + MW
Deficiency = - MW

Summary of 2025 Winter Energy Generation Analysis: Surplus / Deficiency (Ratable-Take MWh)

Scenario		Gas Case 1 Minimum Gas Capacity	Gas Case 2 Case 1 + LDC Peak Shaving	Gas Case 3 Case 2 + Pipeline Growth	Gas Case 4 Case 3 + Distrigas LNG	Gas Case 5 Case 4 + Offshore LNG	Gas Case 6 Maximum Gas Capacity
S1	**RPS + Gas**	-8,586	-8,146	-5,890	-4,104	-3,509	-1,723
S2	**ISO Queue**	-8,518	-8,078	-5,822	-4,036	-3,441	-1,655
S3	**Renewables Plus**	-5,755	-5,315	-3,059	-1,273	-678	+1,108
S4	**No Retirements**	-7,839	-7,399	-5,143	-3,357	-2,762	-976
S5	**ACPs + Gas**	-8,456	-8,016	-5,760	-3,974	-3,379	-1,593
S6	**RPS + Geodiverse Renewables**	-8,440	-8,000	-5,744	-3,958	-3,363	-1,577

Surplus = + MWh
Deficiency = - MWh

Summary of 2030 Winter Energy Generation Analysis: Surplus / Deficiency (Ratable-Take MWh)

Scenario		Gas Case 1 Minimum Gas Capacity	Gas Case 2 Case 1 + LDC Peak Shaving	Gas Case 3 Case 2 + Pipeline Growth	Gas Case 4 Case 3 + Distrigas LNG	Gas Case 5 Case 4 + Offshore LNG	Gas Case 6 Maximum Gas Capacity
S1	RPS + Gas	-9,929	-9,340	-6,250	-4,465	-3,869	-2,084
S2	ISO Queue	-9,149	-8,560	-5,470	-3,685	-3,089	-1,304
S3	Renewables Plus	-5,256	-4,667	-1,577	+208	+804	+2,589
S4	No Retirements	-9,207	-8,618	-5,528	-3,743	-3,147	-1,362
S5	ACPs + Gas	-10,098	-9,509	-6,419	-4,634	-4,038	-2,253
S6	RPS + Geodiverse Renewables	-9,131	-8,542	-5,452	-3,667	-3,071	-1,286

Surplus = + MWh
Deficiency = - MWh

Peak-Gas-Day Capacity and Energy Analysis

Summary of 2025 Summer Energy Generation Analysis: Surpluses (Ratable-Take MWh)

Scenario		Gas Case 1	Gas Case 2	Gas Case 3	Gas Case 4	Gas Case 5	Gas Case 6
S1	**RPS + Gas**	+7,424	+7,424	+9,680	+11,466	+12,061	+13,847
S2	**ISO Queue**	+8,356	+8,356	+10,612	+12,398	+12,993	+14,779
S3	**Renewables Plus**	+12,903	+12,903	+15,159	+16,945	+17,540	+19,326
S4	**No Retirements**	+7,898	+7,898	+10,154	+11,940	+12,535	+14,321
S5	**ACPs + Gas**	+7,089	+7,089	+9,345	+11,131	+11,726	+13,512
S6	**RPS + Geodiverse Renewables**	+8,228	+8,228	+10,484	+12,270	+12,865	+14,651

Surplus = + MWh
Deficiency = - MWh

Peak-Gas-Day Capacity and Energy Analysis

Summary of 2030 Summer Energy Generation Analysis: Surpluses (Ratable-Take MWh)

Scenario		Gas Case 1	Gas Case 2	Gas Case 3	Gas Case 4	Gas Case 5	Gas Case 6
S1	**RPS + Gas**	+6,431	+6,431	+9,520	+11,306	+11,901	+13,687
S2	**ISO Queue**	+8,643	+8,643	+11,732	+13,518	+14,113	+15,899
S3	**Renewables Plus**	+15,739	+15,739	+18,828	+20,614	+21,209	+22,995
S4	**No Retirements**	+7,510	+7,510	+10,599	+12,385	+12,980	+14,766
S5	**ACPs + Gas**	+6,025	+6,025	+9,114	+10,900	+11,495	+13,281
S6	**RPS + Geodiverse Renewables**	+12,300	+12,300	+15,389	+17,175	+17,770	+19,556

Surplus = + MWh
Deficiency = - MWh

Questions

APPENDICES

REVISIONS TO PRIOR ASSUMPTIONS & METHODOLOGY

Revisions to Prior Assumptions and Methodology

- The following changes were made within the revised *"2016 Economic Study - Natural Gas Analysis - Assumptions and Methodology"* presentation which was recently posted on the PAC web site at the following location: *https://www.iso-ne.com/static-assets/documents/2017/05/a3_2016_economic_study_natural_gas_system_capacity_and_energy_analysis_methodology_and_assumptions.pdf*
  - A sixth Scenario was added (S6 or RSP + Geodiverse Renewables)
  - Monthly peak-day LDC gas demand forecasts were used for each monthly profile versus the peak-load-exposure methodology
  - The maximum vaporization rate of Canaport LNG was increased, which resulted in elimination of the seasonal derations to the M&N pipeline
  - ICF Consulting revised (upward) the July peak-gas-day LDC demands

Revisions to Prior Assumptions and Methodology – cont'd

- Winter is the 4 months of December – March (121 days)
- Summer is the 4 months of June – September (122 days)
- Off-Peak is the 4 months of October, November, April and May (122 days)
- Miscellaneous editorials, acronyms and clarifications were made
- Link to original *"2016 Economic Study - Natural Gas Analysis - Assumptions and Methodology,"* PAC presentation dated December 14, 2016 is located at: *https://www.iso-ne.com/static-assets/documents/2016/12/a6_2016_economic_study_natural_gas_system_capacity_and_energy_analysis_methodology_and_assumptions.pdf*

INSTALLED CAPACITY ANALYSIS RESULTS AND SAMPLE CALCULATION

Installed Capacity Analysis Results

- Maximum **winter** peak-gas-day installed capacity deficiency:
  - -20,458 MW in Scenario 2030_S5 (ACPs + Gas) in Gas Case 1.
  - This value is equal to the installed capacity value in Scenario 5, because Gas Case 1 in 2030 has no spare winter capacity for electric sector use.
- Minimum **winter** peak-gas-day installed capacity deficiency:
  - -7,780 MW in Scenarios 2030_S2 (ISO Queue), 2030_S3 (Renewables Plus) and 2030_S6 (RPS + Geodiverse Renewables) in Gas Case 6.
- Maximum **summer** peak-gas-day installed capacity surplus:
  - +14,149 MW in Scenarios 2030_S2 (ISO Queue), 2030_S3 (Renewables Plus) and 2030_S6 (RSP + Geodiverse Renewables) in Gas Case 6.
- Minimum **summer** peak-gas-day installed capacity surplus:
  - +2,060 MW in Scenario 2030_S5 (ACPs + Gas) in Gas Cases 1 & 2.

Peak-Gas-Day Capacity and Energy Analysis

Example: 2030 Winter Installed Capacity Analysis for Scenario 3

Capacity Analysis Metric	Gas Case 1 Minimum Gas Capacity	Gas Case 2 Case 1 + LDC Peak Shaving	Gas Case 3 Case 2 + Pipeline Growth	Gas Case 4 Case 3 + Distrigas LNG	Gas Case 5 Case 4 + Offshore LNG	Gas Case 6 Maximum Gas Capacity
Winter Pipeline Surplus (Bcf/d)	0.000	0.099	0.618	0.918	1.018	1.318
Electrical Capacity Equivalent (MW)	0	589	3,679	5,464	6,060	7,845
Gas-Fired Installed Capacity (MW)	15,625	15,625	15,625	15,625	15,625	15,625
Gas-Fired Installed Capacity Deficiency (MW)	-15,625	-15,036	-11,946	-10,161	-9,565	-7,780

WINTER DISPATCHED CAPACITY ANALYSIS RESULTS AND SAMPLE CALCULATION

Winter Dispatched Capacity Analysis Results

- Maximum gas-fired dispatched capacity is +10,098 MW or 49.3% in 2030_S5 (ACPs + Gas) out of 20,458 MW installed capacity:
  - Due to no spare gas system capacity in Gas Case 1 in 2030, the maximum dispatched capacity deficiency is (the same) -10,098 MW.
- Minimum gas-fired dispatched capacity is +5,256 MW or 33.6% in 2030_S3 (Renewable Plus) out of 15,625 MW installed capacity.
  - Due to large amounts of spare gas system capacity in Gas Case 6 in 2030, the maximum dispatched capacity surpluses is +2,589 MW.
- In most Scenarios, **winter** dispatched capacity is the same within the constrained and unconstrained transmission cases.

Peak-Gas-Day Capacity and Energy Analysis

Example: 2030 Winter Dispatched Capacity Analysis- Scenario 3

Capacity Analysis Metric	Gas Case 1 Minimum Gas Capacity	Gas Case 2 Case 1 + LDC Peak Shaving	Gas Case 3 Case 2 + Pipeline Growth	Gas Case 4 Case 3 + Distrigas LNG	Gas Case 5 Case 4 + Offshore LNG	Gas Case 6 Maximum Gas Capacity
Winter Gas-System Surplus (Bcf/d)	0.000	0.099	0.618	0.918	1.018	1.318
Electrical Capacity Equivalent (MW)	0	589	3,679	5,464	6,060	7,845
Gas-Fired Dispatched Capacity (MW)	5,256	5,256	5,256	5,256	5,256	5,256
Gas-fired Dispatched Capacity Deficiency/Surplus (-/+ MW)	-5,256	-4,667	-1,577	+208	+804	+2,589

ENERGY GENERATION ANALYSIS RESULTS AND SAMPLE CALCULATION

Peak-Gas-Day Capacity and Energy Analysis

Energy Generation Analysis Results

- Maximum **winter** peak-gas-hour energy deficiency:
  - -10,098 MWh in Scenario 2030_S5 (ACPs + Gas) in Gas Case 1.
- Maximum **winter** peak-gas-hour energy surplus:
  - +2,589 MWh in Scenarios 2030_S3 (Renewables Plus) in Gas Case 6.
- Maximum **summer** peak-gas-hour energy surplus:
  - +22,995 MWh in Scenarios 2030_S3 (Renewables Plus) in Gas Case 6.
- Minimum **summer** peak-gas-hour energy surplus:
  - +6,025 MWh in Scenario 2030_S5 (ACPs + Gas) in Gas Cases 1.

2025 Maximum Hourly Gas-Fired Energy Production in Six NEPOOL Scenarios

	RPS + Gas	ISO Queue	Renewables +	No Retirements	ACPs + Gas	RPS + Renewables
	2025_S1	2025_S2	2025_S3	2025_S4	2025_S5	2025_S6
Winter Maximum Hourly Energy (MWh)	9,610	9,542	6,779	8,863	9,480	9,464
Summer Maximum Hourly Energy (MWh)	15,409	14,477	9,930	14,935	15,744	14,605

2030 Maximum Hourly Gas-Fired Energy Production in Six NEPOOL Scenarios

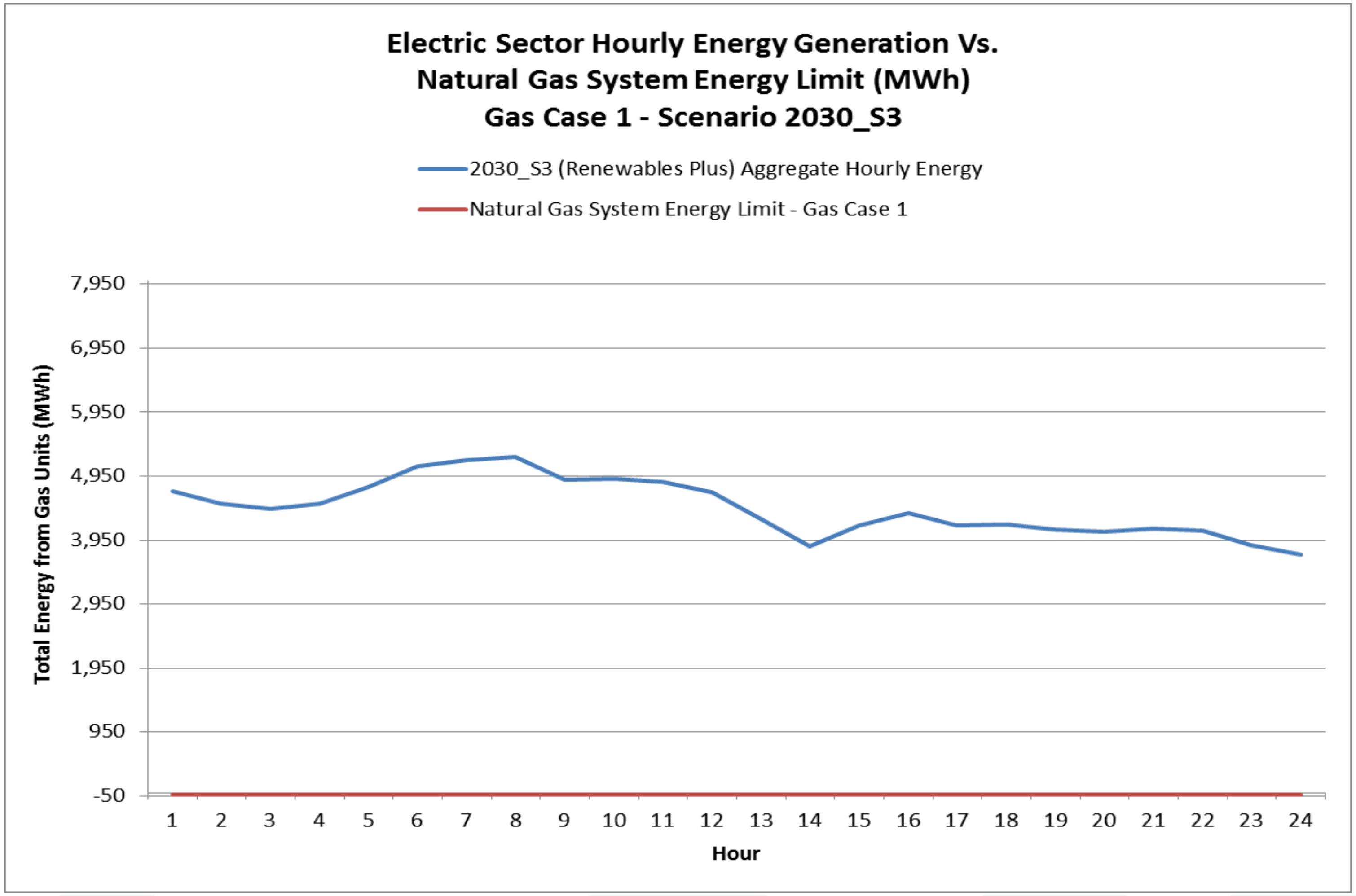
	RPS + Gas	ISO Queue	Renewables +	No Retirements	ACPs + Gas	RPS + Renewables
	2030_S1	2030_S2	2030_S3	2030_S4	2030_S5	2030_S6
Winter Maximum Hourly Energy (MWh)	9,929	9,149	5,256	9,207	10,098	9,131
Summer Maximum Hourly Energy (MWh)	16,087	13,875	6,779	15,008	16,493	10,218

Peak-Gas-Day Capacity and Energy Analysis

Example: 2030 Winter Energy Generation Analysis - Scenario 3 Surplus / Deficiencies (Ratable-Take MWh)

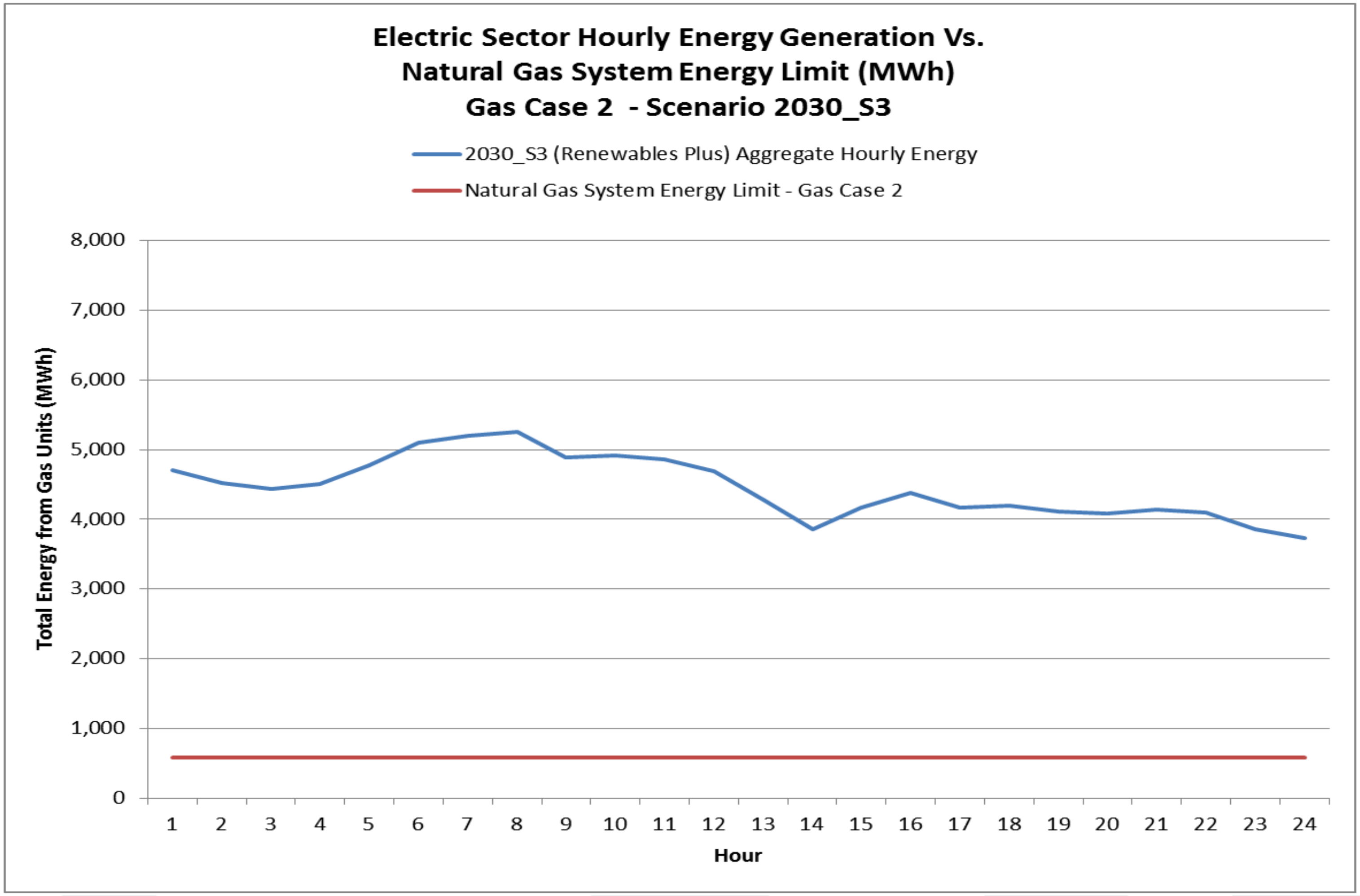
Energy Analysis Metric	Gas Case 1 Minimum Gas Capacity	Gas Case 2 Case 1 + LDC Peak Shaving	Gas Case 3 Case 2 + Pipeline Growth	Gas Case 4 Case 3 + Distrigas LNG	Gas Case 5 Case 4 + Offshore LNG	Gas Case 6 Maximum Gas Capacity
2030 Winter Gas-System Daily Capacity Surplus (Bcf/d)	0.000	0.099	0.618	0.918	1.018	1.318
2030 Winter Gas-System Daily Energy Equivalent (MWh/d)	0	14,136	88,296	131,136	145,429	188,280
2030 Winter Gas-System Hourly Energy Equivalent (MWh)	0	589	3,679	5,464	6,060	7,845
2030 Winter Peak-Gas-Hour Energy Requirement (MWh)	5,256	5,256	5,256	5,256	5,256	5,256
2030 Peak-Gas-Hour Energy Surplus/Deficiency (MWh)	-5,256	-4,667	-1,577	+208	+804	+2,589

Graphics of 2030 Winter Energy Generation Analysis: Scenario 3 - Gas Case 1 - (Ratable-Take MWh)



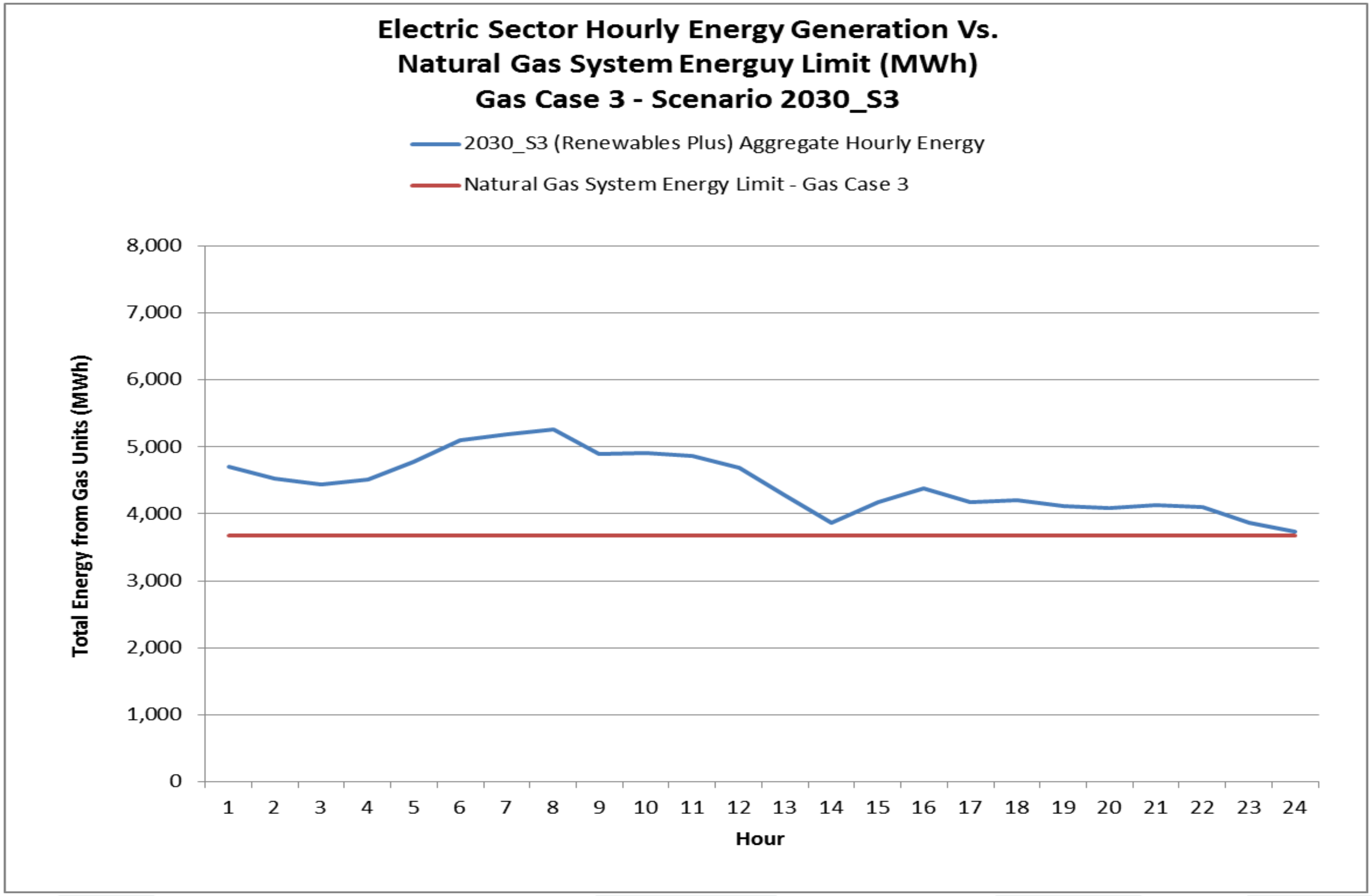
Peak-Gas-Day Capacity and Energy Analysis

Graphics of 2030 Winter Energy Generation Analysis: Scenario 3 - Gas Case 2 - (Ratable-Take MWh)



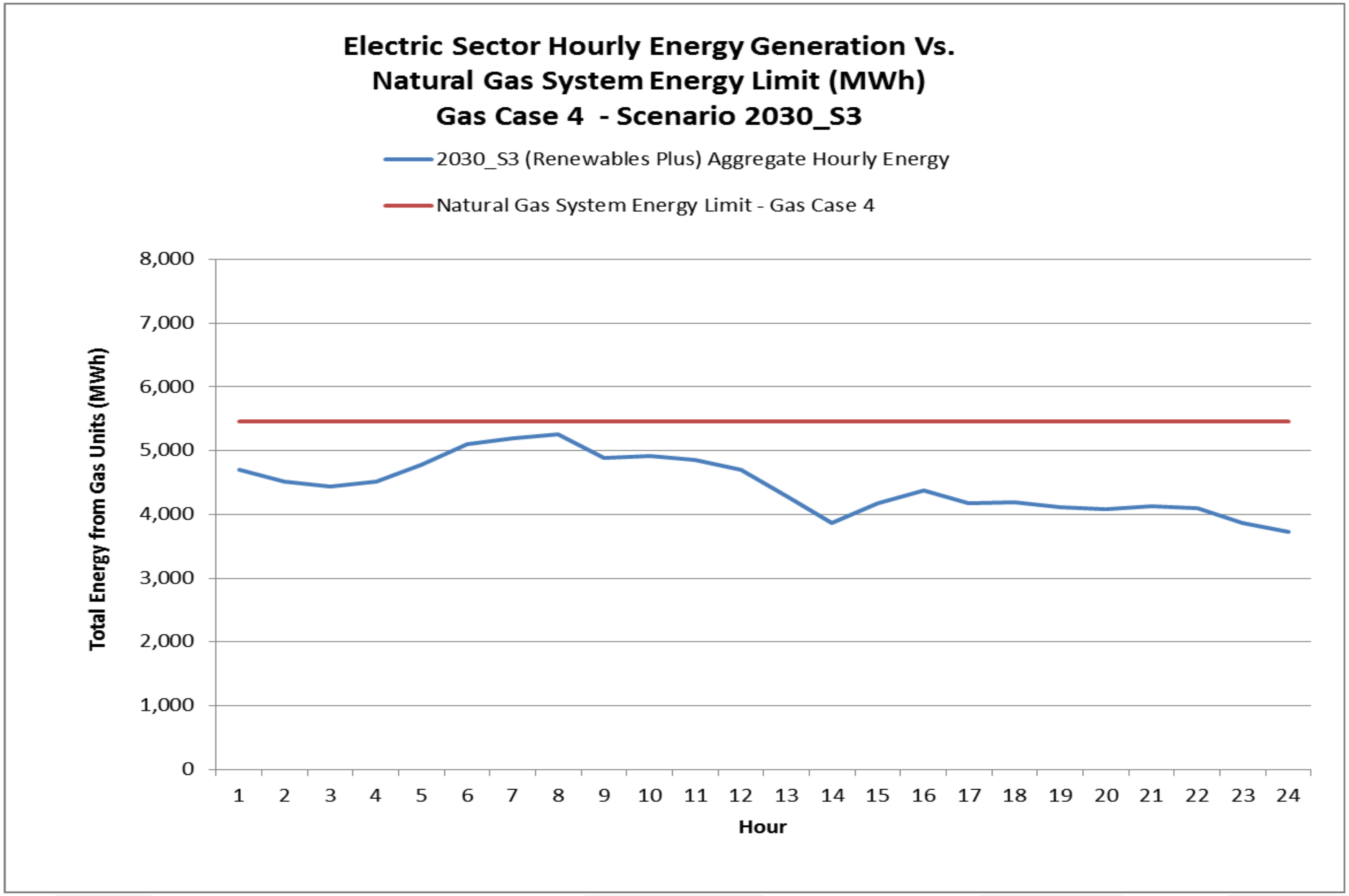
Peak-Gas-Day Capacity and Energy Analysis

Graphics of 2030 Winter Energy Generation Analysis: Scenario 3 - Gas Case 3 - (Ratable-Take MWh)



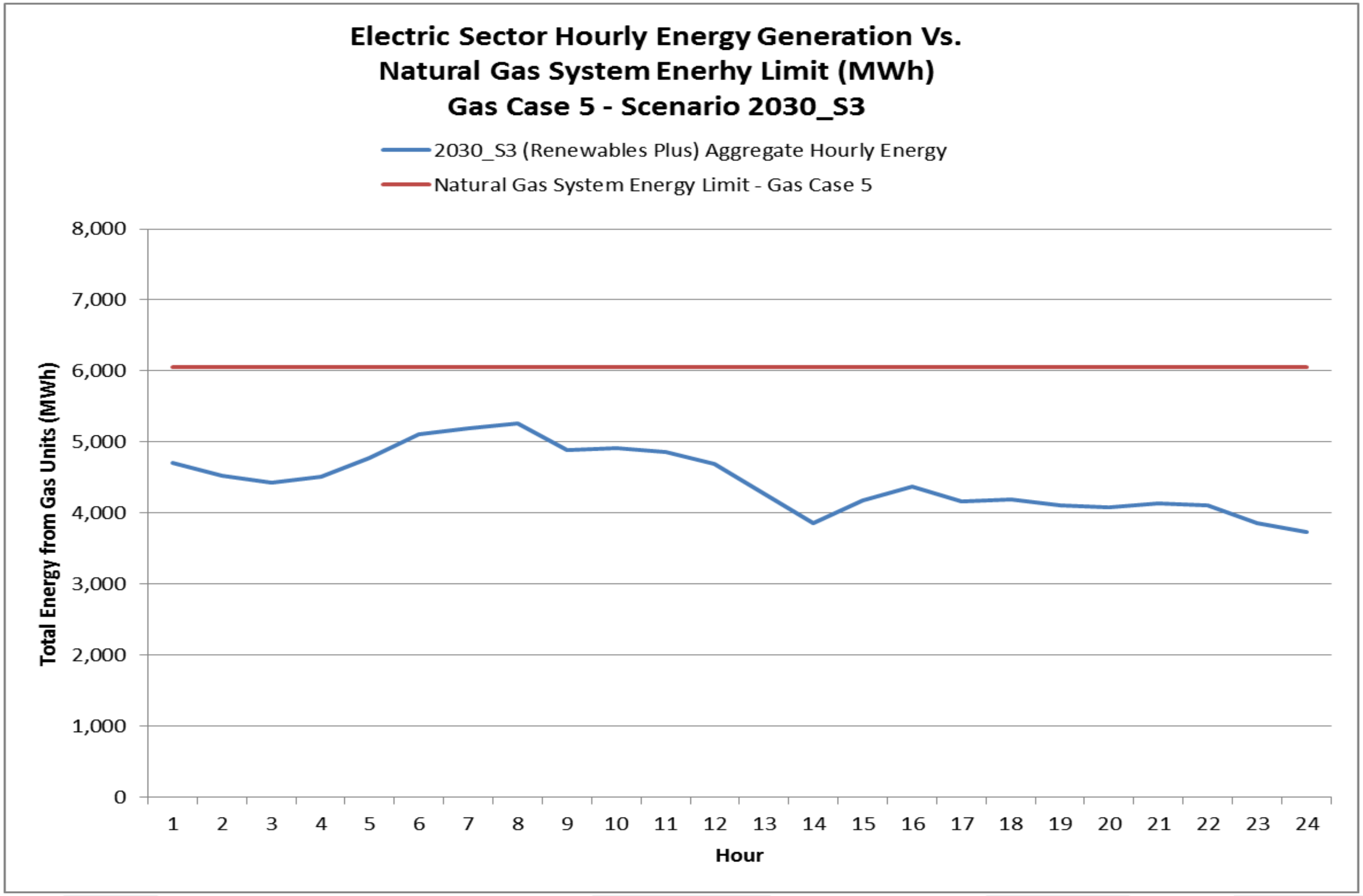
Peak-Gas-Day Capacity and Energy Analysis

Graphics of 2030 Winter Energy Generation Analysis: Scenario 3 - Gas Case 4 - (Ratable-Take MWh)



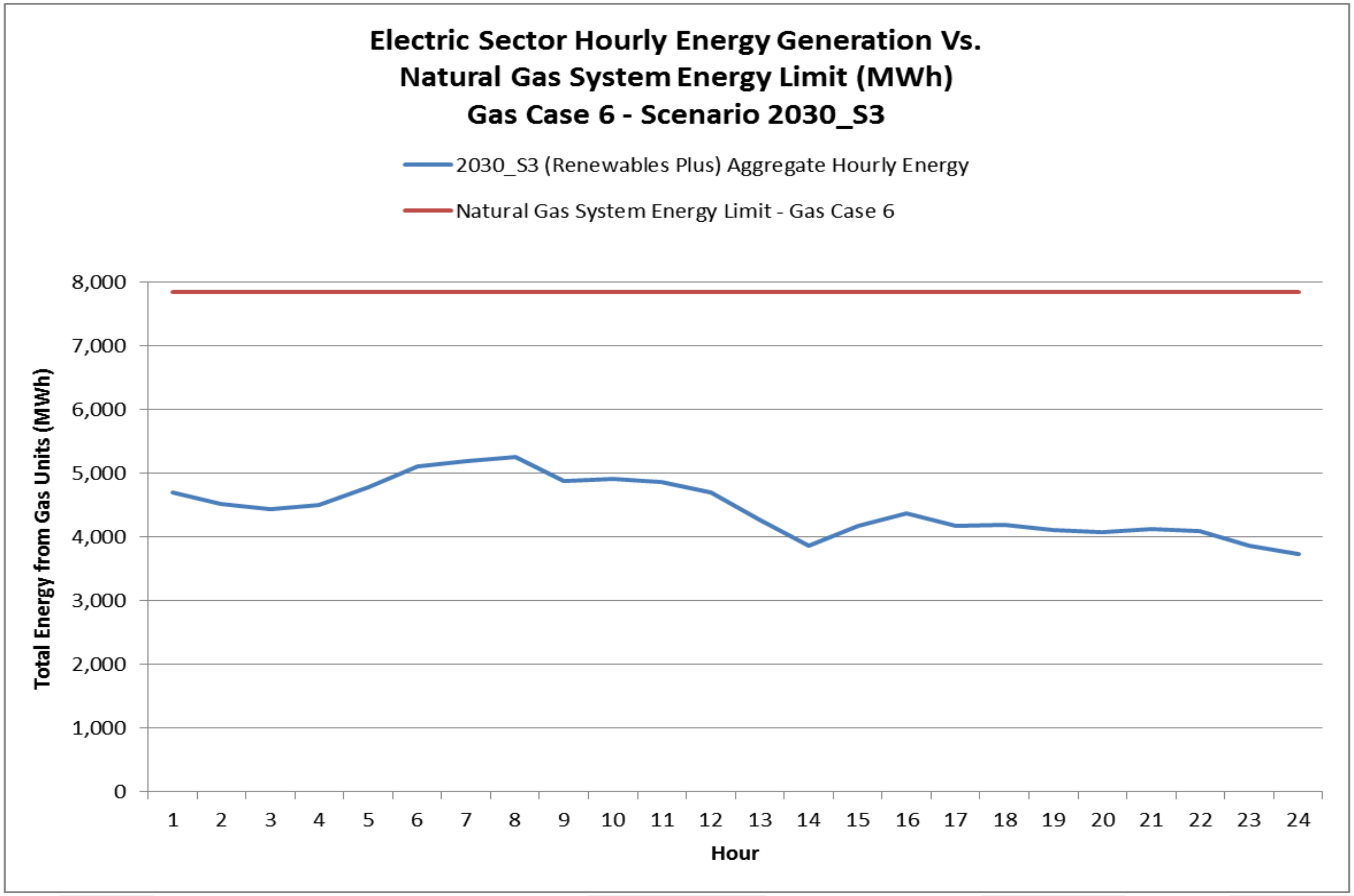
Peak-Gas-Day Capacity and Energy Analysis

Graphics of 2030 Winter Energy Generation Analysis: Scenario 3 - Gas Case 5 - (Ratable-Take MWh)



Peak-Gas-Day Capacity and Energy Analysis

Graphics of 2030 Winter Energy Generation Analysis: Scenario 3 - Gas Case 6 - (Ratable-Take MWh)



NATURAL GAS SYSTEM CASES

Peak-Gas-Day Capacity and Energy Analysis

Six Natural Gas System Topology Cases

ADDITIONAL GAS

Natural Gas Infrastructure	Gas Case 1 Minimum Gas Capacity(*)	Gas Case 2 Case 1 + LDC Peak Shaving	Gas Case 3 Case 2 + Pipeline Growth	Gas Case 4 Case 3 + Distrigas LNG	Gas Case 5 Case 4 + Offshore LNG	Gas Case 6 Maximum Gas Capacity
Existing Pipelines	√	√	√	√	√	√
Existing LDC Peak Shaving	√	√	√	√	√	√
Pipeline Projects	√	√	√	√	√	√
LDC Peak Shaving Growth		√	√	√	√	√
Pipeline Growth			√	√	√	√
Distrigas				√		√
Offshore LNG (FSRU)					√	√

ADDITIONAL GAS

(*) This is the first case in which the gas-system assumptions provide adequate winter capacity to serve all regional LDC core-gas demands.

Natural Gas System Capacity Assumptions (Bcf/d)

Natural Gas Infrastructure	2020 Winter Capacity (Bcf/d)	2025 Winter Capacity (Bcf/d)	2030 Winter Capacity (Bcf/d)
Existing Pipelines	4.043	4.043	4.043
LDC Peak Shaving	0.853	0.853	0.853
Pipeline Projects	0.654	0.654	0.654
Peak Shaving Growth	0.000	0.074	0.105
Pipeline Growth	0.000	0.379	0.519
Distrigas (AGT & TGP)	0.300	0.300	0.300
Offshore LNG (AGT)	0.400	0.400	0.400
Winter Total	**6.250**	**6.703**	**6.874**

Peak-Gas-Day Capacity and Energy Analysis

Natural Gas System Capacity Under Six Gas Cases (Bcf/d)

Total Gas System Capacity	Gas Case 1 Minimum Gas Capacity	Gas Case 2 Case 1 + LDC Peak Shaving	Gas Case 3 Case 2 + Pipeline Growth	Gas Case 4 Case 3 + Distrigas LNG	Gas Case 5 Case 4 + Offshore LNG	Gas Case 6 Maximum Gas Capacity
2025 Winter (January)	5.550	5.624	6.003	6.303	6.403	6.703
2025 Summer (July)	4.697	4.697	5.076	5.376	5.476	5.776
2030 Winter (January)	5.550	5.655	6.174	6.474	6.574	6.874
2030 Summer (July)	4.697	4.697	5.216	5.516	5.616	5.916

Peak-Gas-Day Capacity and Energy Analysis

Natural Gas System Equivalent Electrical Capacity Under Six Gas Cases (MW) – Assumes a 7,000 Btu/kWh Heat Rate

Total Gas System Capacity	Gas Case 1 Minimum Gas Capacity	Gas Case 2 Case 1 + LDC Peak Shaving	Gas Case 3 Case 2 + Pipeline Growth	Gas Case 4 Case 3 + Distrigas LNG	Gas Case 5 Case 4 + Offshore LNG	Gas Case 6 Maximum Gas Capacity
2025 Winter (January)	33,036	33,476	35,732	37,518	38,113	39,899
2025 Summer (July)	27,958	27,958	30,214	32,000	32,595	34,381
2030 Winter (January)	33,036	33,661	36,750	38,536	39,131	40,917
2030 Summer (July)	27,958	27,958	31,048	32,833	33,429	35,214

Peak-Gas-Day Capacity and Energy Analysis

Surplus Gas System Capacity for Electric Sector Use (Bcf/d)

Total Gas System Capacity	Gas Case 1 Minimum Gas Capacity	Gas Case 2 Case 1 + LDC Peak Shaving	Gas Case 3 Case 2 + Pipeline Growth	Gas Case 4 Case 3 + Distrigas LNG	Gas Case 5 Case 4 + Offshore LNG	Gas Case 6 Maximum Gas Capacity
2025 Winter (January)	0.172	0.246	0.625	0.925	1.025	1.325
2025 Summer (July)	3.836	3.836	4.215	4.515	4.615	4.915
2030 Winter (January)	0.000	0.099	0.618	0.918	1.018	1.318
2030 Summer (July)	3.783	3.783	4.302	4.602	4.702	5.002

Peak-Gas-Day Capacity and Energy Analysis

Surplus Natural Gas System Equivalent Electrical Capacity (MW) - Assumes a 7,000 Btu/kWh Heat Rate

Total Gas System Capacity	Gas Case 1 Minimum Gas Capacity	Gas Case 2 Case 1 + LDC Peak Shaving	Gas Case 3 Case 2 + Pipeline Growth	Gas Case 4 Case 3 + Distrigas LNG	Gas Case 5 Case 4 + Offshore LNG	Gas Case 6 Maximum Gas Capacity
2025 Winter (January)	1,024	1,464	3,720	5,506	6,101	7,887
2025 Summer (July)	22,833	22,833	25,089	26,875	27,470	29,256
2030 Winter (January)	0	589	3,679	5,464	6,059	7,845
2030 Summer (July)	22,518	22,518	25,607	27,393	27,988	29,774

Peak-Gas-Day Capacity and Energy Analysis

Surplus Natural Gas System Equivalent Electrical Energy (MWh) - Assumes a 7,000 Btu/kWh Heat Rate

Total Gas System Capacity	Gas Case 1 Minimum Gas Capacity	Gas Case 2 Case 1 + LDC Peak Shaving	Gas Case 3 Case 2 + Pipeline Growth	Gas Case 4 Case 3 + Distrigas LNG	Gas Case 5 Case 4 + Offshore LNG	Gas Case 6 Maximum Gas Capacity
2025 Winter (January)	24,576	35,136	89,280	132,144	146,424	189,288
2025 Summer (July)	547,992	547,992	602,136	645,000	659,280	702,144
2030 Winter (January)	0	14,136	88,296	131,136	145,416	188,280
2030 Summer (July)	540,432	540,432	614,568	657,432	671,712	714,576

DEFINITIONS, ASSUMPTIONS, AND DISCLAIMERS

Definitions

- **Peak-Gas-Day** – The winter and summer day in which the consumption of natural gas by both the gas and electric sectors is at maximum.

- **Peak-Gas-Hour** – The peak-gas-day in winter and summer, in which the hourly consumption of natural gas by both the gas and electric sectors is at maximum (a.k.a. maximum hourly).

- **Ratable-Take** – Consuming natural gas from a pipeline in equal amounts over a 24-hour (gas-day) period. Consuming 1/24th of the total volume of gas in each hour for 24 hours. This condition is usually mandated by Gas Control Operators to help balance customers' receipts and deliveries of natural gas. This mandate usually occurs on peak-gas-day conditions.

Definitions – cont'd

- **Natural Gas-Fired Installed Capacity (MW)** – The amount of gas-fired generating capacity that are installed in each of the six NEPOOL resource expansion scenarios. Includes gas-only and dual fuel units burning natural gas. See Slides 16-18.

- **Natural Gas-Fired Dispatched Capacity (MW)** – The amount of gas-fired generating capacity that are committed and economically dispatched within the GridView simulation model. A subset of the installed capacity. Includes gas-only and dual fuel units burning natural gas. See Slides 20-22.

- **Natural Gas-Fired Energy Generation (MWh)** – The amount of electric energy that was produced by all gas-fired resources within the GridView simulation model. A by-product of the dispatched capacity. Includes gas-only and dual fuel units burning natural gas. See Slides 24-27.

Definitions & Notes

- **Distrigas** – Distrigas is a LNG receiving, storage, and regasification terminal located in Everett, MA. The gas supply benefits of the LNG facility is modeled via gas injections into the Algonquin and Tennessee gas pipelines. Because Distrigas also directly fuels Exelon's Mystic 8 & 9 units from regasified LNG, those two gas-fired units are NOT included within this capacity and energy analyses.

- **Note on Canaport LNG** – Canaport is a receiving, storage, and regasification LNG terminal located in St. John, New Brunswick. The gas supply benefits of the LNG facility is modeled via gas injections into the Brunswick and Maritimes & Northeast (M&N) natural gas pipelines.

Definitions & Notes – cont'd

- **FSRU** – Floating Storage Regasification Unit. A FSRU is a special type of ship used for LNG transfer which is capable of storing, transporting, and regasifying LNG onboard the ship. Floating regasification also requires either an offshore terminal, which typically includes a buoy and connecting undersea pipeline to transport regasified LNG to shore, or an onshore dockside receiving terminal. The gas supply benefits of Northeast Gateway's FSRU is modeled via gas injections into the Algonquin's undersea HubLine pipeline. Noted as "Offshore LNG."

Peak-Gas-Day Capacity and Energy Analysis

Assumptions

- **Winter** peak-gas-day operations would dictate that Gas Control operators would most likely have issued Operational Flow Orders (OFOs) to balance customers' receipts and deliveries of natural gas. As such, gas-fired generators would prefer to minimize fluctuations in their output by ratably-taking their fuel. The results within this presentation reflect spare gas system capacity being used ratably by the electric sector to comply with such OFOs.
- **Summer** peak-gas-day operations would dictate that the regional pipelines should have enough operational flexibility to accommodate the non-ratable-taking of fuel by power plants. This would allow gas-fired units to vary their output in response to ISO dispatch instructions, which enhances unit flexibility.

Peak-Gas-Day Capacity and Energy Analysis

Assumption – cont'd

- The North American Energy Standards Board's (NAESB) 24-hour "Natural-Gas-Day" starts at 9:00 AM on Day X and ends at 8:59 AM on Day X+1 Central Clock Time (CCT). Because of the 1 hour advanced time zone difference, New England's natural-gas-day is from 10:00 AM on Day X and ends at 9:59 on Day X+1 Eastern Clock Time (ECT).
- In New England, the 24-Hour "Electric-Day" starts at 12:00 AM on Day X and ends at 11:59 PM on Day X Eastern Clock Time (ECT).
- These three analyzes did not take these differences in market timelines into account, because ISO-NE assumed that the seasonal peak-gas-day "occurs" on the seasonal peak-electric-day.

Disclaimer

- This analysis provides information about a range of hypothetical future scenarios that may or may not materialize within New England's natural gas and electric sectors. The electric sector input assumptions are the direct results from the 2016 Economic Study - Scenario Analysis Report and do not constitute a roadmap for the timing, location, or quantities of existing or future resource additions or attrition. ISO-NE welcomes comments, suggestions or clarification from the Planning Advisory Committee for any assumptions or data related to this analysis.

- For the **winter** peak-gas-day analyses, it is assumed that no natural gas infrastructure is forced out of service. Should this assumption be invalid, the electric sector's non-firm transportation entitlements would be the first to be reduced by the equivalent gas sector capacity reductions.

- For the **summer** peak-gas-day analyses, it is assumed that scheduled maintenance, construction activities or forced outages on natural gas infrastructure does not occur. Should this assumption be invalid, the electric sector's non-firm transportation entitlements would be the first to be reduced by the equivalent gas sector capacity reductions.

Presentation Notes

- The 2016 Scenario Analyses constrained and unconstrained electric transmission cases are very similar in terms of natural gas consumption. Therefore, the unconstrained electric transmission case results were omitted from this presentation to reduce the number of sensitivities and slides. The electric transmission constrained cases are slightly more stringent in terms of consumption of natural gas by gas-fired generation.
- All three sets of analyses are performed on the seasonal peak-gas-day or peak-gas-hour. These results reflect assumptions for that 24 hour peak-period only and are not indicative of conditions that may exist throughout the four-month winter or summer season. Therefore, the term “peak-gas-day or peak-gas-hour” has been eliminated from some slides for brevity purposes.