Fuel and Energy Security Study Assumptions and Data

NYISO ICAPWG/MIWG

March 28, 2019

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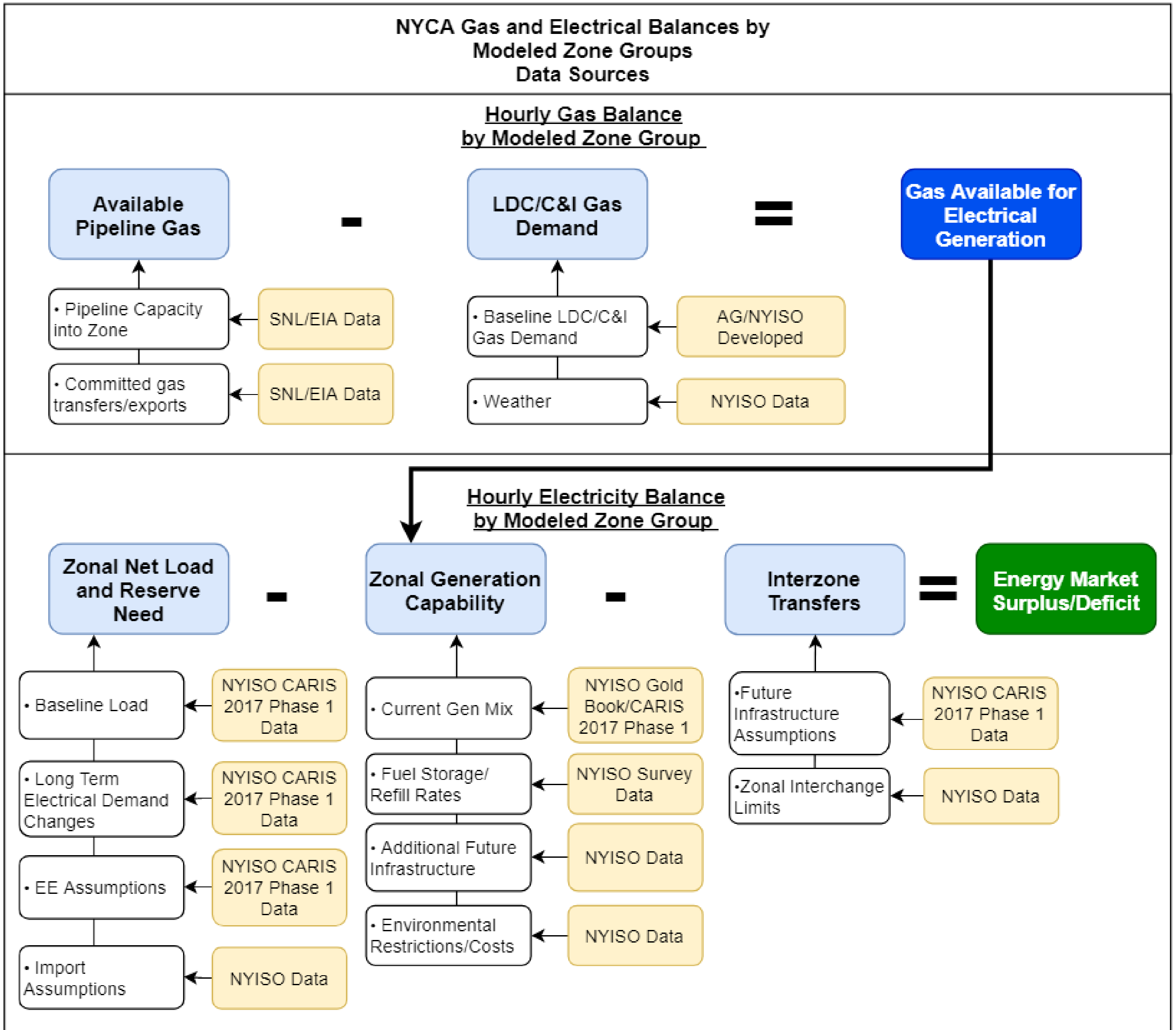
Context and Assignment

- Reminder: NYISO fuel security study will assess winter fuel/energy security for the New York Control Area (NYCA) under various assumptions (and variations to assumptions) and scenarios, and provide a report documenting the approach and findings
  - The analysis is not trying to predict the future; instead, conducting a scenario analysis
    - Creating future year baseline assuming an extended period of adverse cold weather conditions
    - Testing the resilience of the electric system to gas and electric system contingencies
    - Analysis conducted using a combined gas & power balance model
  - Scenarios/contingencies are not predictive – their development is an analytic tool intended to asses various adverse conditions for winter power system operations
- This presentation will review the proposed input assumptions and sources of data that feed into the fuel security model, along with alternative assumptions and system stress scenarios
  - Assumptions/scenarios will be merged to create a manageable number of cases representing a range of conditions
- Data used are a mix of publicly-available data and NYISO internal data, with preference to assumptions previously vetted with stakeholders (where possible)

Model Setup Diagram: Gas and Electric Balance



- *Assumptions* – vary "base case" load, resource, and LDC demand assumptions
- *Scenarios* – postulate natural gas and electric system failures to stress test the results

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Weather

- In the fuel security model, decreasing temperature has two effects:
  - Increase in LDC gas demand
  - Increase in electrical demand
- NYISO weather data analyzed from winters 1993-2018
- To set the modeling period, we identified 7 periods where temperatures hit 90^{th} percentile lows for wind-adjusted temperature for 14 or more consecutive days across NYISO system
  - Winter 2017-2018 was the coldest of these periods, with average temperature across all zones of 11.4 F for 14 days
- Model also includes a "cold snap" of 3 days, to represent hours of extreme system stress
  - In Winter 2017-2018, the coldest three days of the 14-day cold period had a 5.3 F average system temperature
  - In Winter 1993-1994, the coldest three days had a 2.9 F average system temperature
- **Proposed baseline assumptions**: 17 day period (including 3 day "cold snap") based on Winter 2017-18 average temperature profile with Winter 1993-94 cold snap profile

Historic Consecutive Multi-day Cold Periods

Extreme Weather Events Lasting Over 14 days
(Consecutive 90th Percentile Wind-Adjusted Coldest Days)

Cold Snap Period	Number of Days	Average Wind-Adjusted Temp (F)	Average Unadjusted Temp (F)	% Increase of Avg. Daily Energy Above Winter Baseline
12/19/2000 - 01/05/2001	17	10.6	20.7	3.1%
01/10/2003 - 01/28/2003	18	3.8	15.2	6.0%
01/18/2004 - 02/01/2004	14	2.1	14.6	8.2%
01/14/2005 - 01/29/2005	15	1.2	12.4	10.1%
02/02/2007 - 02/19/2007	17	4.6	17.4	9.0%
02/07/2015 - 02/21/2015	14	3.1	14.0	10.1%
12/25/2017 - 01/08/2018	14	-0.8	11.4	13.3%

Notes:

[1] Wind-Adjusted Temperature is calculated using the Wind-chill formula from Weather.gov, valid for temperatures (T) at or below 50 degrees F and wind speeds (W) above 3 mph: WindChill = 35.74 + (0.6215 × T) - (35.75 × W^0.16) + (0.4275 × T × W^0.16).

[2] Percentage Increase of Avg. Daily Energy Above Winter Baseline is calculated using: ((Average daily system load during cold snap - 50th percentile daily system load for that winter)/50th percentile daily system winter load for that winter).

[3] Daily load calculated by first summing hourly load and then averaging over the period of the cold snap.

Sources:

NYISO Weather Data 1993-2018; NYISO Hourly Load Data 1993-2018.

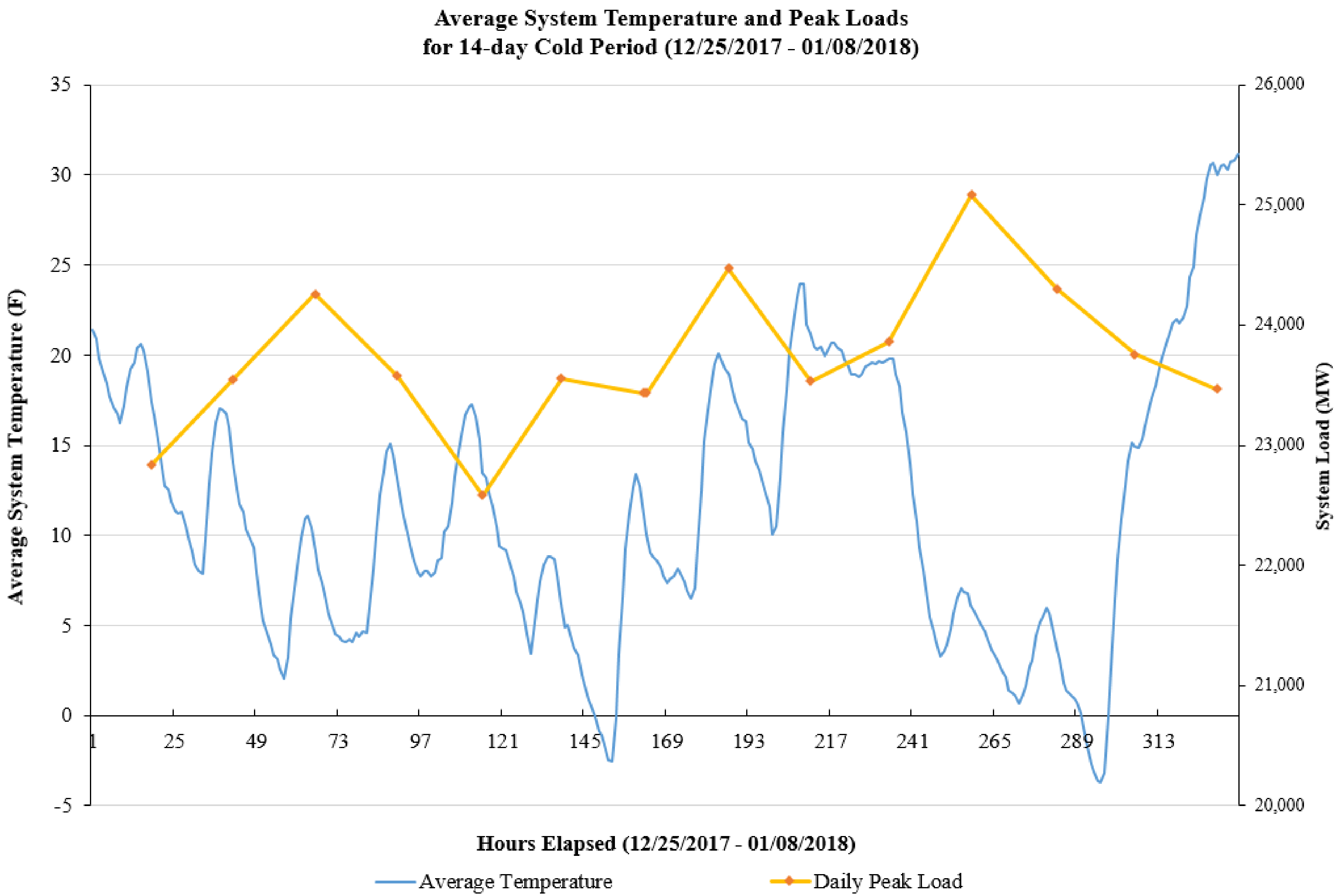
Historic Consecutive 3-day Cold Snaps

Coldest 3-day Minimum Winter Temperature Periods by Winter

Winter	3-day period w/min temperature	Average Temp during 3-day min temp period
1993 - 1994	01/18/1994 - 01/21/1994	2.9
2003 - 2004	01/13/2004 - 01/16/2004	3.4
2004 - 2005	01/20/2005 - 01/23/2005	5.2
2017 - 2018	01/04/2018 - 01/07/2018	5.3
1995 - 1996	01/04/1996 - 01/07/1996	5.8

Source:
NYISO Weather Data 1993-2018; NYISO Hourly Load Data 1993-2018.

Load and Temperature during 2017/18 Cold Period



Sources:
NYISO Weather Data 1993-2018; NYISO Hourly Load Data 1993-2018.

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Gas Demand

- Model of daily LDC gas demand by heating degree day (HDD)
  - NYISO weather data
  - Historical winter gas flow data from SNL
  - Estimated separately for upstate and downstate.
- Residual gas (available for electric generation) assumed ratable during study period – i.e., available hourly quantity for electric generation is 1/24th of daily residual quantity
- Winter Peak Day Demand by LDC based on NY DPS Winter Natural Gas Supply Readiness report 2018-2019
- We will scale gas demand model so that predicted system demand for ~65-75 HDD matches documented totals for peak design day demand
  - LDCs peg design-day demand to 65-75 HDD
  - Only net gas available through pipeline (not from storage or LNG) is considered as available for electric generation

LDC Design Day Capability from NYDPS/NYPSC filings for 2018/19

Winter Peak Day Capability Summary Table
New York State DPS Case 18-M-0272 2018-2019 Winter Supply Review Data Request Table 1

	NYISO Zone Group Capability		
	Upstate (MMcf)[1]	Downstate (MMcf)[2]	Total Design Day Capability (MMcf)
Zones Covered	A-F	G-K	
Pipeline[3]	1,964	3,306	5,270
Storage[4]	1,120	838	1,959
LNG	0	395	395
Other[5]	60	67	126
Total Design Day Capability (MMcf)	**3,143**	**4,605**	**7,749**

Notes:

[1] Upstate includes Corning Natural Gas Corporation, National Fuel Gas Distribution Corporation, National Grid: Niagara Mohawk, NYSEG, and Rochester Gas & Electric LDCs.

[2] Downstate includes Central Hudson, Consolidated Edison and National Grid: Brooklyn Union and KeySpan LDCs.

[3] Pipeline includes flowing supplies, less NFGSC fuel = National Fuel Gas Supply Co. natural gas pipeline, winter peaking service = "City Gate Delivered by Others and In-Territory Supplies (not LNG or CNG)", total marketer provided supplies, and recallable capacity (AMAs). Assumes all ConEd gas comes from pipeline.

[4] Storage includes storage withdrawals and CNG.

[5] Other includes cogen supplies, local production = "Local Production, landfill gas, renewables, etc. delivered directly into the LDC distribution system", and renewable gas = "Local Production, landfill gas, renewables, etc. delivered directly into the LDC distribution system".

Sources:

[A] Central Hudson Gas & Electric Corporation, Case 18-M-0272 - Winter Supply 2018-19 Forms, October 8, 2018, Table 1.

[B] Corning Natural Gas Corporation, Case 18-M-0272 - Winter Supply Review Data Request, July 5, 2018, Table 1.

[C] National Fuel Gas Distribution Corporation, Case 18-M-0272 - Winter Supply Review Data Request, July 16, 2018, Table 1.

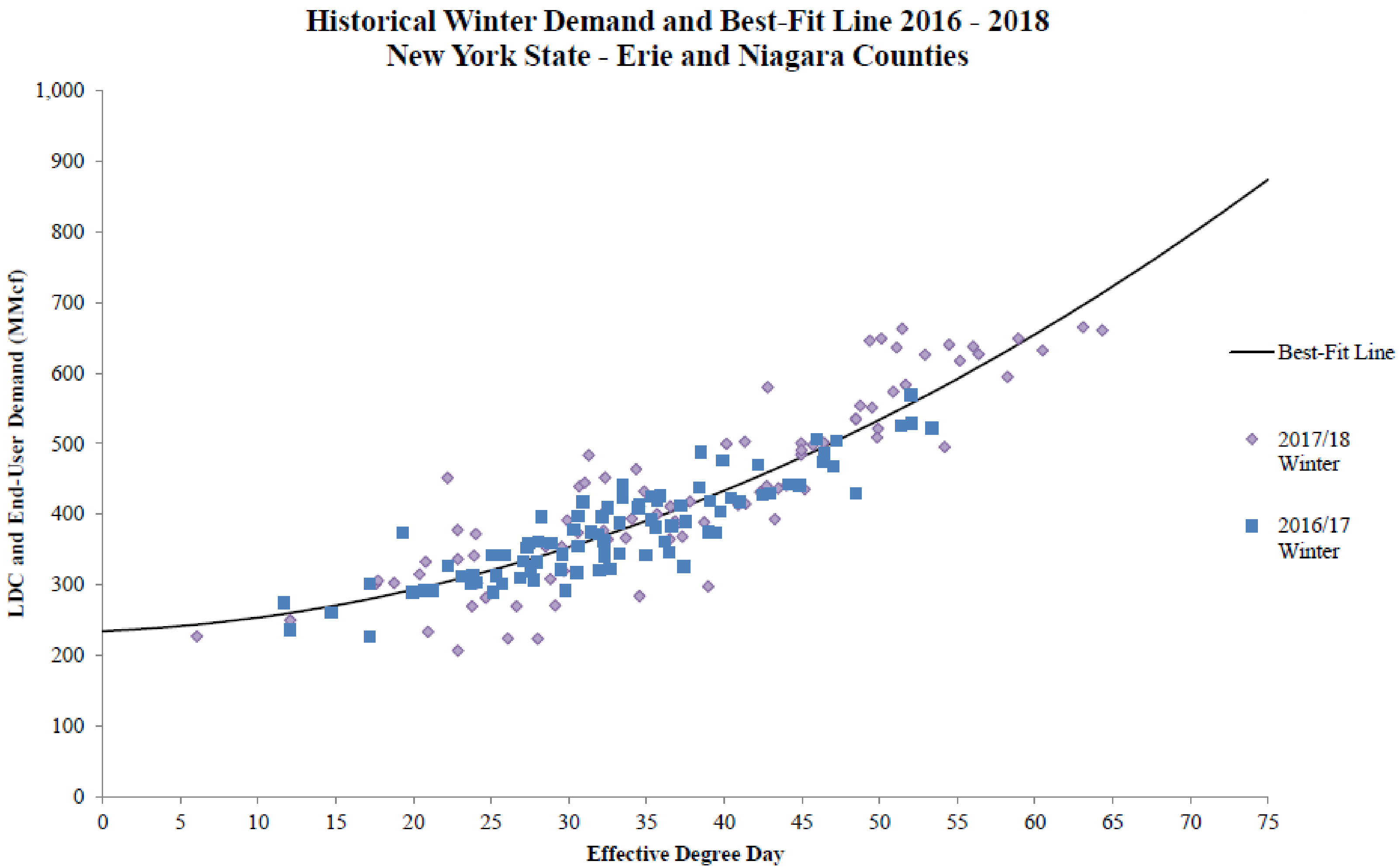
[D] Brooklyn Union and KeySpan: National Grid, Case 18-M-0272 - Winter Supply 2018-19 Forms, November 9, 2018, Table 1.

[E] Niagara Mohawk: National Grid, Case 18-M-0272 - Winter Supply 2018-19 Forms, September 10, 2018, Table 1.

[F] New York State Electric & Gas and Rochester Gas and Electric, Case 18-M-0272 - 2018-2019 Winter Supply Plans September 2018 Update, Table 1.

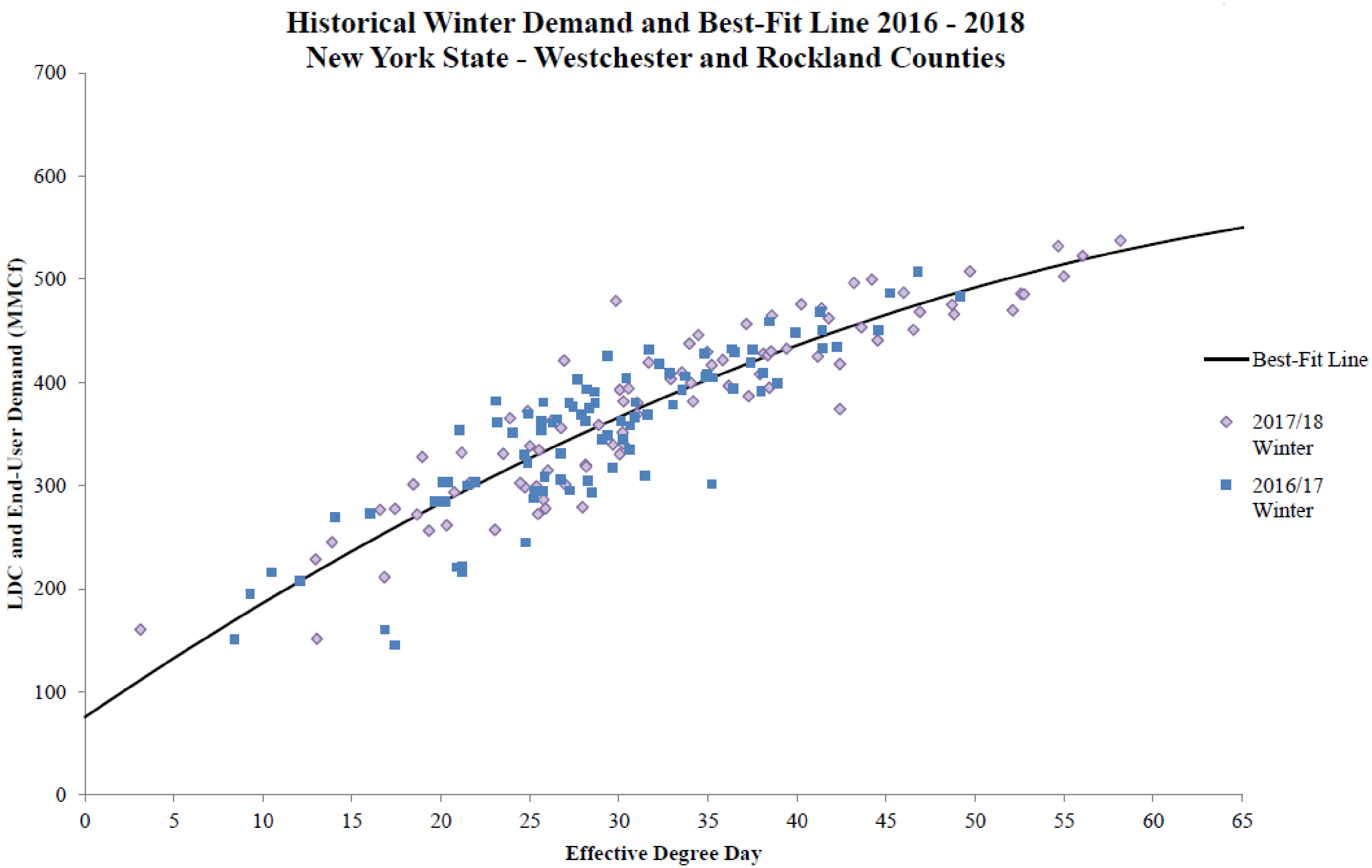
[G] Consolidated Edison, Inc. and Consolidated Edison Company of New York, Inc., Form 10-K, for the fiscal year ended December 31, 2017, p. 24.

LDC Demand vs Degree Day - Upstate



Notes:
[1] Total deliveries are the sum of scheduled capacity during the intraday 3 nomination cycle to LDCs and End Users. Chart includes all Erie and Niagara county gas points in the National Fuel Gas LDC territory not located right next to a gas power plant.
[2] Winter is defined as December, January, and February.
[3] Effective degree day is defined as 65 degrees - Temperature, and is taken from Zone A temperature data.
Sources:
[A] LDC and End-User Demand: S&P Global Market Intelligence.
[B] Temperature: NYISO.

LDC Demand vs Degree Day - Downstate



Notes:
[1] Total deliveries are the sum of scheduled capacity during the intraday 3 nomination cycle to LDCs and End Users. Chart includes all Westchester and Rockland county gas points not located right next to a gas power plant.
[2] Winter is defined as December, January, and February.
[3] Effective degree day is defined as 65 degrees - Temperature, and is taken as the simple average of Zone H and Zone I temperature data.
Sources:
[A] LDC and End-User Demand: S&P Global Market Intelligence.
[B] Temperature: NYISO.

Gas Pipeline Supply

- Pipeline capacities for delivery to generation by zone based on SNL and EIA data, net of average outflows to neighboring regions (see Appendix A for details)
- No LNG or storage capacity is assumed to be available for delivery to generators
- Model will reflect limitations of supply to gas generators based on temperature, as provided by LDCs

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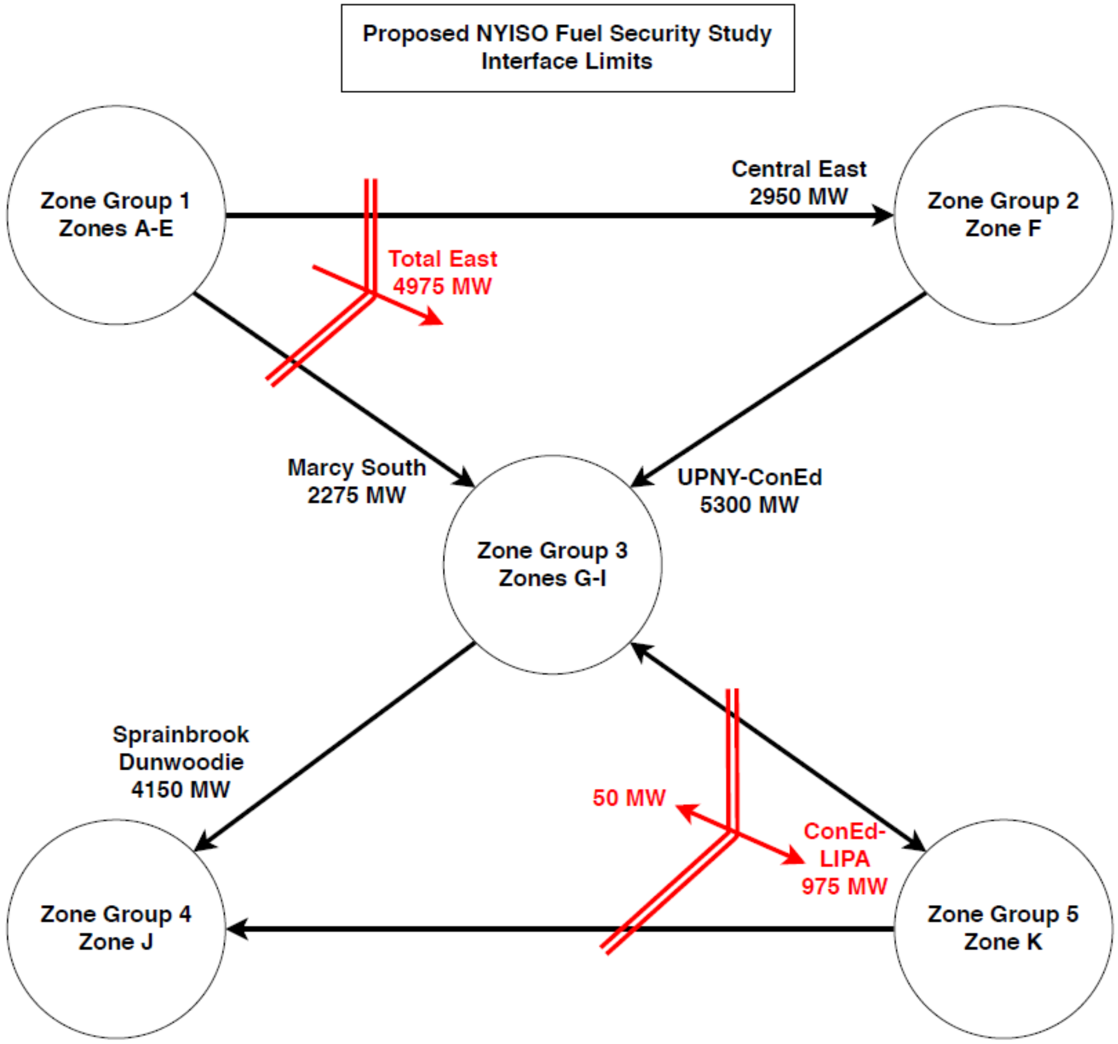
Electrical Demand, Supply, and Reserves

- NYISO zonal load and EE forecasts for 2023/2024 from 2017 CARIS Phase 1 Study used as starting point to derive estimated future load during modeled cold weather event
- Model of daily load increase by heating degree day (HDD) based on historical NYISO winter data, similar to LDC demand model
- Existing resources generally consistent with 2017 CARIS Phase 1 "System Resource Shift" case (see Appendix B for additional details)
  - All NY coal units retired
  - Indian Point retired
  - Assumptions regarding simple cycle gas turbine deactivations in response to the proposed NYSDEC "peaker rule"
  - Integration of new renewables and energy efficiency to meet 50 by 30 Clean Energy Standard
- No changes assumed to existing natural gas system infrastructure
- Imports/exports fixed with 0 MW net interchange between neighboring regions
- Emissions restrictions based on NYISO review of public sources
- Liquid fuel replenishment based on NYISO fuel survey data; baseline scenario assumes winter refuel available for all units consistent with historical averages
- Zonal required reserves based on NYISO data

Interzonal Transmission Capability

- Transmission Limits between Zone Groups based on N-1-1 contingency analysis



Resource Dispatch

- Reminder: Fuel security study does not include an economic commitment/dispatch model
- Solar and Wind generation dispatched based on 2023/24 hourly profiles used in 2017 CARIS Phase 1 “System Resource Shift” case
- Hydroelectric and Nuclear assumed at fixed capacity factor based on historical winter averages; do not respond to load
- Fossil units run in the following order during modeling period, within type by heat rate:
  - Natural Gas Only (to extent pipeline gas available)
  - Dual Fuel using NG as fuel (to extent pipeline gas available)
  - Dual Fuel using Oil as fuel (if inventory available)
  - Oil Only (if inventory available)
  - No.6 oil-only units
- Hourly liquid inventory tracked at plant level
  - Each hour, ending inventory is starting inventory minus amount used
  - Assumed replenishments are based on historical data from NYISO fuel surveys

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Key Output Metrics

- Identified inabilities to meet reserve and/or load requirements
  - Hours with deficits that violate reserve requirements and necessitate emergency actions (e.g. required SCR/EDRP activations to maintain reserves)
  - Hours with deficits where load is not met with emergency actions
  - Magnitude of any identified reserve and/or supply deficits
  - Duration and frequency of any identified reserve and/or supply deficits
- Restrictions on gas and oil units' availability due to fuel shortage/restrictions (i.e., gas- and oil-fired capability not operating due to fuel unavailability)
- Indications of gas pipeline tightness or LDC system restrictions (available gas supply for electric generation, by zone)
- Restrictions on units' availability due to environmental limits (if any)
- Amount of gas and oil used during modeling period
- Category of scenario (e.g. baseline, more severe cold, baseline with contingencies, more severe cold with contingencies)

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Variations in Assumptions

- Baseline
  - Reference case for comparison with other alternatives
- Variations – four basic categories (at least one variation per category)
  1. Higher than expected load due to factors such as:
     - Greater economic growth
     - Electrification of heating
     - Electrification of transportation
  2. Lower than expected load due to factors such as:
     - Increased investment in energy efficiency
     - Increased distributed resource output
     - Lower economic growth
  3. Increased reliance on gas-fired capability due to factors such as:
     - Increased non-gas generation retirements due to market factors
  4. Increased transferability due to factors such as:
     - New transmission in response to the WNY and AC Transmission public policy needs

Scenarios

- Will apply to baseline/business as usual, as well as the four alternatives discussed previously
- Purpose: stress-test results against low probability/high impact events
- Four basic event types (at least one scenario per event type)

1. Extreme temperature – colder temperatures than historical-based profile (e.g., colder than design-day conditions)
2. Weather event-driven restrictions on fuel replenishment
3. Higher than anticipated generation outages – Loss of key non-gas generating capacity (e.g., nuclear) on top of typical seasonal average outage rates
4. Gas system event – loss of major interstate pipeline capability

Combination Cases

- Develop a manageable set of cases to run and evaluate
- Goal – capture a plausible range of futures, and a representative set of potentially extreme events
- This represents an initial set; as cases are run, others may need to be developed if gaps in the assessment are identified
- Current thinking
  - Run each scenario category on the baseline/BAU and each variation in assumptions
  - Minimum of 20 cases
  - Consider additional groupings based on initial results
- Possible cases
  - Baseline/BAU with no contingencies
  - High load + Extreme weather
  - Decreased non-gas generation + Large upstate generation outage
  - Total loss of gas supply to generators

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- Tentative Schedule
  - Early/Mid April 2019: Follow-up on assumptions/data and scenarios
  - Late April 2019: AG presentation of initial fuel security analysis findings
  - June 2019: AG presentation of final findings and initial recommendations
  - July 2019: AG presentation of final recommendations

Appendix A: New York State Pipeline Capacity

New York State Current Pipeline Capacity (MMcf/d)

Pipeline Groupings	From PA	From ON	From NJ	From CT	Import	To PA	To ON	To NJ	To CT	To MA	Export	Net
National Fuel Gas Supply Co												
National Fuel Gas Supply Co	757	0	0	0	**757**	(484)	0	0	0	0	**(484)**	*273*
Penn York Energy Corp	95	0	0	0	**95**	(60)	0	0	0	0	**(60)**	*35*
Norse Pipeline Co	10	0	0	0	**10**	(2)	0	0	0	0	**(2)**	*8*
Empire Pipeline Inc												
Empire Pipeline Inc	350	750	0	0	**1,100**	0	(350)	0	0	0	**(350)**	*750*
Transcontinental Gas P L Co												
Transcontinental Gas P L Co	0	0	1,696	0	**1,696**	0	0	0	0	0	**0**	*1,696*
Texas Eastern Trans Corp												
Texas Eastern Trans Corp	0	0	1,500	0	**1,500**	0	0	0	0	0	**0**	*1,500*
Tennessee Gas Pipeline Co												
Tennessee Gas Pipeline Co	1,230	1,297	377	0	**2,904**	0	(700)	0	(222)	(1,169)	**(2,091)**	*813*
Iroquois Pipeline Co												
Iroquois Pipeline Co	0	1,150	0	620	**1,770**	0	0	0	(866)	0	**(866)**	*904*
St Lawrence Gas	0	62	0	0	**62**	0	0	0	0	0	**0**	*62*
North Country P L Co	0	56	0	0	**56**	0	0	0	0	0	**0**	*56*
Columbia Gas Trans Corp												
Columbia Gas Trans Corp	281	0	0	0	**281**	0	0	0	0	0	**0**	*281*
Dominion Transmission Co												
Dominion Transmission Co	1,113	0	0	0	**1,113**	(150)	0	0	0	0	**(150)**	*963*
Central New York Oil and Gas Company												
Central New York Oil and Gas Company	812	0	0	0	**812**	(812)	0	0	0	0	**(812)**	*0*
Algonquin Gas Trans Co												
Algonquin Gas Trans Co	0	0	1,492	275	**1,767**	0	0	(275)	(1,697)	0	**(1,972)**	*(205)*
New York State Pipeline Total	**4,648**	**3,315**	**5,065**	**895**	**13,923**	**(1,508)**	**(1,050)**	**(275)**	**(2,785)**	**(1,169)**	**(6,787)**	*7,136*

Sources:
[1] EIA, State to State Pipeline Capacity, Jan. 2019

Appendix B: 2017 CARIS Phase 1 “System Resource Shift” Case Assumptions

ANALYSIS GROUP
ECONOMIC, FINANCIAL and STRATEGY CONSULTANTS

- Resource Additions
  - New capacity by year shown in graphic
- Energy Efficiency Impact
  - 17,816 GWh energy reduction in NYCA for 2024
  - 1,638 MW Winter coincident peak reduction in NYCA for 2024
- Distributed Generation Impact
  - 2,323 GWh energy reduction in NYCA for 2024
  - 332 MW Winter coincident peak reduction in NYCA for Winter 2023-2024

Zone	Capacity (MW)	2017	2018	2019	2020	2021	2022	2023	2024
Total	Land-Based Wind	-	89	541	463	498	360	345	854
	Utility-Scale Solar	-	-	-	605	746	1,082	1,088	1,804
	Offshore Wind	-	-	-	-	-	-	-	-
	Imports	-	-	-	-	-	229	229	-
Zone A	Land-Based Wind	-	89	445	364	66	278	95	-
	Utility-Scale Solar	-	-	-	-	-	-	894	-
	Offshore Wind	-	-	-	-	-	-	-	-
Zone B	Land-Based Wind	-	-	-	-	-	-	-	-
	Utility-Scale Solar	-	-	-	-	-	-	-	-
	Offshore Wind	-	-	-	-	-	-	-	-
Zone C	Land-Based Wind	-	-	-	-	-	-	-	-
	Utility-Scale Solar	-	-	-	-	-	1,082	-	-
	Offshore Wind	-	-	-	-	-	-	-	-
Zone D	Land-Based Wind	-	-	-	-	-	-	-	-
	Utility-Scale Solar	-	-	-	-	-	-	-	-
	Offshore Wind	-	-	-	-	-	-	-	-
Zone E	Land-Based Wind	-	-	-	-	175	-	137	537
	Utility-Scale Solar	-	-	-	-	-	-	-	-
	Offshore Wind	-	-	-	-	-	-	-	-
Zone F	Land-Based Wind	-	-	55	65	185	82	80	240
	Utility-Scale Solar	-	-	-	605	502	-	-	1,804
	Offshore Wind	-	-	-	-	-	-	-	-
Zone G	Land-Based Wind	-	-	41	34	72	-	32	-
	Utility-Scale Solar	-	-	-	-	127	-	195	-
	Offshore Wind	-	-	-	-	-	-	-	-
Zone H	Land-Based Wind	-	-	-	-	-	-	-	-
	Utility-Scale Solar	-	-	-	-	11	-	-	-
	Offshore Wind	-	-	-	-	-	-	-	-
Zone I	Land-Based Wind	-	-	-	-	-	-	-	-
	Utility-Scale Solar	-	-	-	-	-	-	-	-
	Offshore Wind	-	-	-	-	-	-	-	-
Zone J	Land-Based Wind	-	-	-	-	-	-	-	-
	Utility-Scale Solar	-	-	-	-	-	-	-	-
	Offshore Wind	-	-	-	-	-	-	-	-
Zone K	Land-Based Wind	-	-	-	-	-	-	-	77
	Utility-Scale Solar	-	-	-	-	106	-	-	-
	Offshore Wind	-	-	-	-	-	-	-	-
Imports	LBW Quebec	-	-	-	-	-	-	-	-
	Ontario Utility Scale	-	-	-	-	-	-	-	-
	LBW Ontario	-	-	-	-	-	229	229	-
	LBW PJM	-	-	-	-	-	-	-	-
	PJM Utility Scale Sol	-	-	-	-	-	-	-	-
Total		0	89	541	1,068	1,244	1,671	1,662	2,659

Contact

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