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Fuel and Energy Security Study Assumptions and Data

NYISO ICAPWG/MIWG/PRLWG

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Analysis Group

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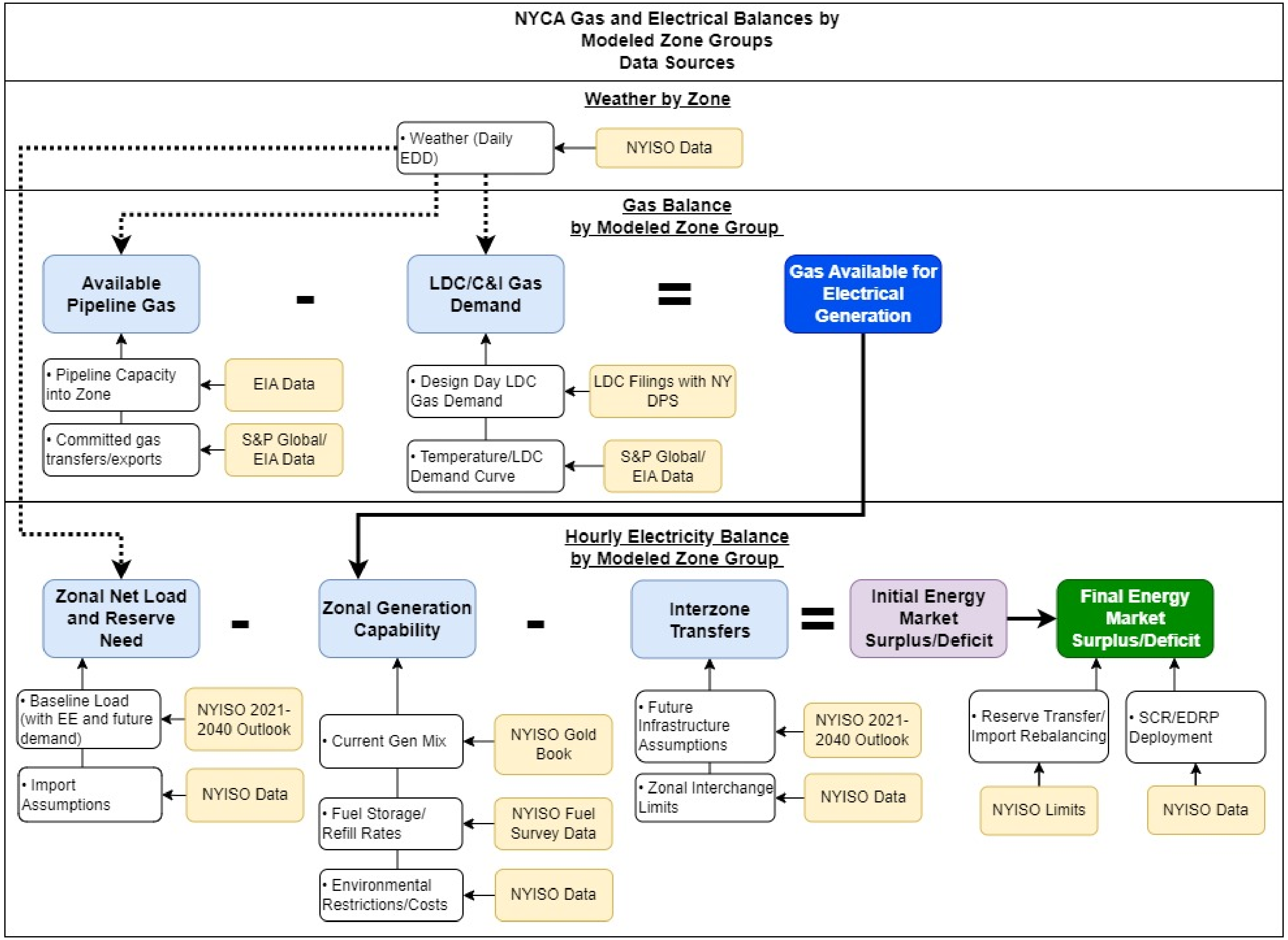
Table of Contents

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; This effort is an update and refresh of the 2019 fuel security study
  - The analysis is not trying to predict the future; instead, conducting a scenario analysis
    - Creating three future year (limited to winter study periods) assessments assuming an extended period of adverse cold weather conditions
    - Testing the resilience of the electric system to gas/fuel and electric system contingencies
    - Analysis conducted using a combined gas/fuel & power balance model
  - Scenarios/contingencies are not predictive – their development is an analytic tool intended to assess 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 initial considerations for alternative assumptions and system stress scenarios
  - Assumptions/scenarios will be merged to create a manageable number of cases representing a range of conditions
  - Case construction will be informed by stakeholder feedback, a literature review of relevant and recent cold weather studies from NERC, FERC and other regions, as well as recently approved extreme cold weather reliability standards
  - Data used are a mix of publicly-available data and NYISO internal data, with a preference to use assumptions previously vetted with stakeholders (where possible)

Model Reminder: Gas and Electric Balance



- *Assumptions* – load, resource, and retail gas demand assumptions
- *Scenarios* – postulate natural gas and electric system failures to stress test the results

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Winter Periods Modeled

- AG will model three winter periods

1. 2023/24 Winter
   - The same winter period modeled in the 2019 study
   - Refresh reflects updated input data, discussed further below
   - Input data assumptions based on the 2023 Gold Book
2. 2026/27 Winter
   - Input data starting point assumptions based on the 2023 Gold Book and/or 2021-2040 Outlook
3. 2030/31 Winter
   - Input data starting point assumptions based on the 2023 Gold Book and/or 2021-2040 Outlook

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Literature Review

- AG is conducting a literature review of cold weather studies and rules from NERC, FERC, and other regions
- This review will inform the analytical modeling work, construction of scenarios, and interpretation of results
- Reviewing and considering responses to winter storms Uri and Elliott, and how those circumstances compare and differ to circumstances in New York State
- Documents being reviewed include:
  - NYISO Fuel and Security Updates and Winter Operations Reports
  - FERC and NERC Staff, Cold Weather Bulk Electric System Event of January 17, 2018
  - February 2021 Cold Weather Outages (Winter Storm Uri)
  - December 2022 Cold Weather Outages (Winter Storm Elliott)
  - NERC Project 2019-06 Cold Weather
  - NERC Project 2021-07 Extreme Cold Weather Grid Operations, Preparedness, and Coordination
  - NERC Project 2022-03 Energy Assurance with Energy-Constrained Resources
  - NERC Reliability Guideline: Fuel Assurance and Fuel-Related Reliability Risk Analysis
  - NERC Reliability Guideline: Generating Unit Winter Weather Readiness
  - NERC Reliability Guideline: Gas and Electrical Operational Coordination Considerations
  - Relevant reports from ISO-NE and PJM

Table of Contents

Weather Data and Assumptions

- 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 1993-2023
- Adding weather data from 2019 to March 2023 did not change the assumed modeling period of extended cold weather conditions
  - To set the modeling period, we identified the same 7 periods as the 2019 study where temperatures hit 90th percentile lows for wind-adjusted temperature for 14 or more consecutive days across New York
  - Winter 2017-2018 was the coldest of these periods, with average temperature across all zones of 11.4 F for 14 days
- Adding additional weather data also did not change the 2019 study assumption of a 3 day "cold snap" included in the modeling period, 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
- **Propose maintaining the 2019 study extended cold weather period assumptions**: 17-day period (including 3 day "cold snap") based on Winter 2017-18 average temperature profile with Winter 1993-94 cold snap profile

Historical 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 1993-2023; NYISO Hourly Load Data 1993-2023.

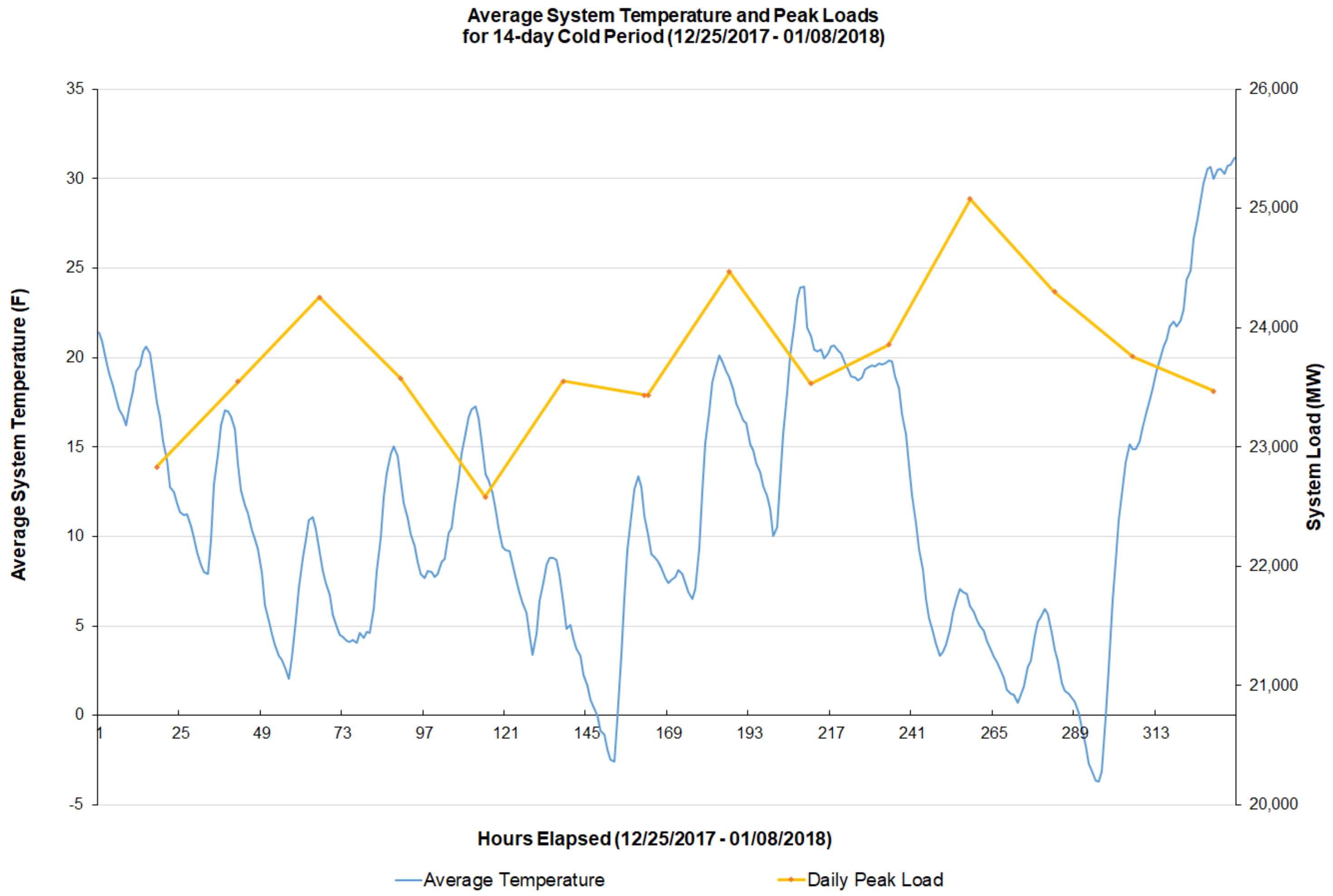
Historical Consecutive 3-day Cold Snaps

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 1993-2023; NYISO Hourly Load Data 1993-2023.

Load and Temperature during 2017/18 Cold Weather Period



Sources:
NYISO Weather Data 1993-2023; NYISO Hourly Load Data 1993-2023.

Table of Contents

Gas Demand

- Model of daily LDC gas demand by heating degree day (HDD)
  - Using NYISO weather data for the analysis
  - Using historical winter gas flow data from S&P Global
  - Estimating gas demand separately for upstate and downstate regions
- 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
- Determined winter peak day demand by LDC generally using LDC-specific 2022-2023 NY DPS Winter Natural Gas Supply Readiness reports
  - Central Hudson’s report is redacted and the previous year’s report used instead
- Using the same method as the 2019 study, AG will scale gas demand model so that predicted system demand for ~65-75 HDD matches documented totals for peak design day demand
  - LDCs set 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
- AG plans to review and compare results of its analyses to the Market Monitoring Unit’s October 2022 Eastern New York gas availability assessment
- Future winter period gas demand modeling will be informed by expected policy driven changes in gas usage

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LDC Design Day Capability from NYDPS/NYPSC filings for 2022/23

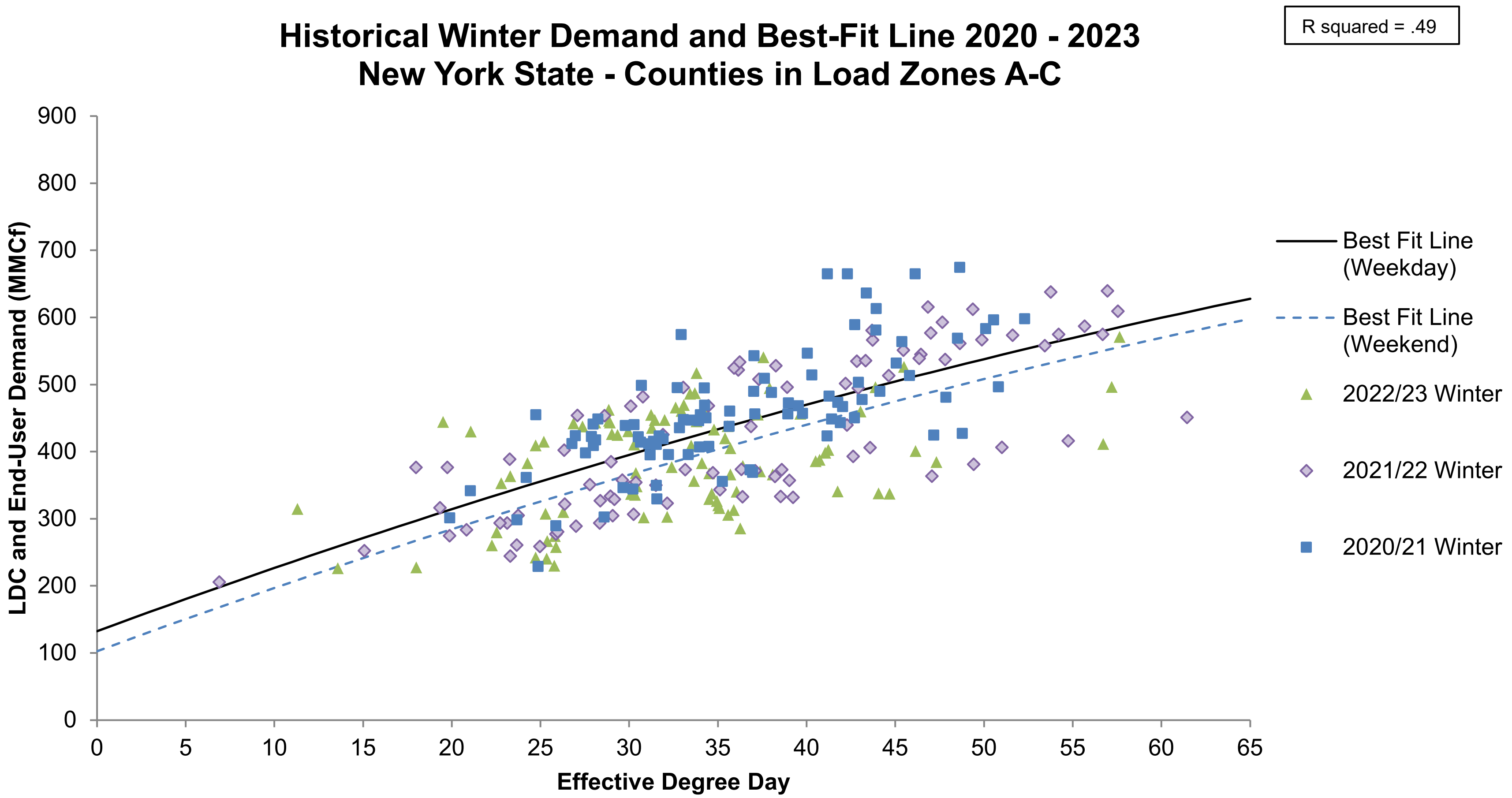
Winter Peak Day Capability Summary Table
New York State DPS Case 22-M-0247 Winter Supply Review Data Request Table 1

	NYISO Zone Group Capability		
	Upstate (MMcf)[1]	**Downstate (MMCf)[2]**	**Total Design Day Capability (MMcf)**
Zones Covered	A-F	G-K	
Pipeline[3]	1,895	2,910	4,805
Storage[4]	1,184	1,457	2,642
LNG	0	561	561
Other[5]	22	110	132
Total Design Day Capability (MMcf)	**3,101**	**5,038**	**8,140**

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, Conslidated Edision 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 21-M-0243 - Winter Supply 2021-22 Forms, July 16, 2021, Table 1.
[B] Consolidated Edison Company, Inc., Case 22-M-0247 - Winter Supply Review Data Request, August 3, 2022, Table 1.
[C] Corning Natural Gas Corporation, Case 22-M-0247 - Winter Supply Review Data Request, July 18, 2022, Table 1.
[D] National Fuel Gas Distribution Corporation, Case 22-M-0247 - Winter Supply Review Data Request, July 15, 2022, Table 1.
[E] Brooklyn Union and KeySpan: National Grid, Case 22-M-0247 - Winter Supply 2022-23 Forms, November 9, 2022, Table 1a.
[F] Niagara Mohawk: National Grid, Case 22-M-0247 - Winter Supply 2022-23 Forms, July 15, 2022, Table 1b.
[G] New York State Electric & Gas and Rochester Gas and Electric, Case 22-M-0247 - 2022-23 Winter Supply Plan September 2022 Update, Table 1.

LDC Demand vs Degree Day - Upstate



Notes:
[1] Total deliveries are the sum of scheduled capacity during the intraday 3 nomination cycle to LDCs, End Users, and select Pool points. Chart includes all Load Zone A, B, and C 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 - Dry Bulb Temperature, and is taken as the simple average of Load Zones A, B, and C temperature data.
Sources:
[A] LDC and End-User Demand: S&P Global Market Intelligence.
[B] Temperature: NYISO.

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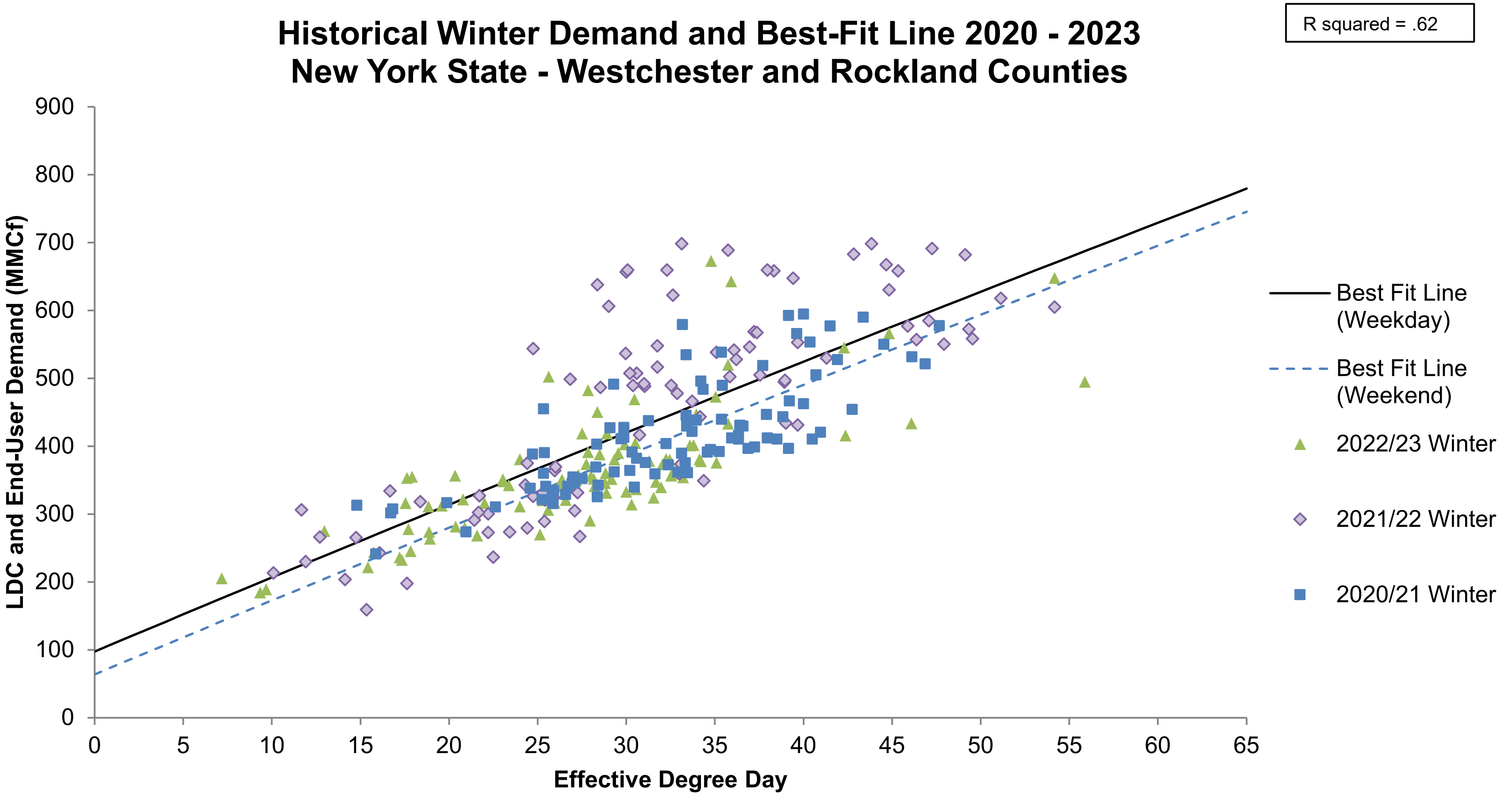
LDC Demand vs Degree Day – Lower Hudson Valley



Notes:
[1] Total deliveries are the sum of scheduled capacity during the intraday 3 nomination cycle to LDCs, End Users, and select Pool points. 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 - Dry Bulb Temperature, and is taken as the simple average of Load Zone H and Load 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 S&P Global 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

Table of Contents

Electrical Demand, Supply, and Reserves

- NYISO zonal load and EE forecasts for 2023/2024 from 2023 Gold Book. Future modeling periods use 2023 Gold Book and/or 2021-2040 Outlook as starting point to estimate future loads.
- 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 2023 Gold Book. Future modeling periods use 2023 Gold Book and/or 2021-2040 Outlook as starting point to define resource additions.
  - Integration of new renewables and energy efficiency to meet the Clean Energy Standard (CES) and Climate Leadership and Community Protection Act (CLCPA) using 2021-2040 Outlook for future periods
  - Transmission system upgrades anticipated to be placed in-service during forecast period
- No changes assumed to existing natural gas system infrastructure
- Imports/exports fixed with 900 MW import to NYC/LI from PJM and 1,600 MW export to New England for starting point assumptions
- Emissions restrictions based on NYISO data
- 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

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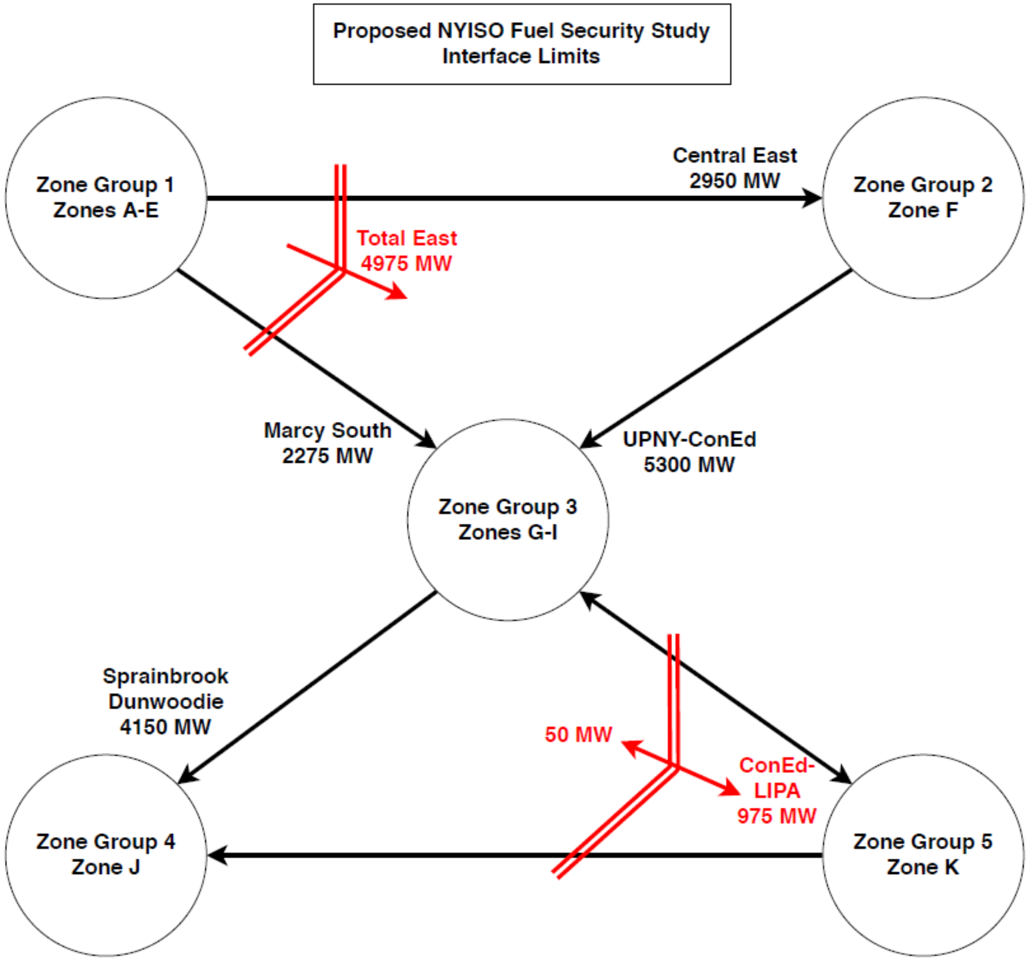
Interzonal Transmission Capability

- 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 hourly profiles used in 2021-2040 Outlook aligned to the cold weather period.
- Nuclear, Hydro run-of-river, Biomass, Refuse, and Flywheel assumed at fixed capacity factor based on historical winter averages; do not respond to load
- Pumped storage and large pondage hydro assumed at fixed hourly profile for one day, repeated on each day in the modeled period; do not respond to load
- Evaluate Battery Energy Storage System (BESS) operational assumptions
  - Currently considering assumption of 4-hour on-peak discharge with off-peak charging
- 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)
  - No.6 oil-only units
  - Dual Fuel using Oil as fuel (if inventory available)
  - Oil Only (if inventory available)
- 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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Table of Contents

Key Output Metrics

- Identified deficiencies in meeting 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)
- Energy storage data
- Amount of gas and oil used during modeling period
- Scenario/condition type/category (e.g., starting point conditions, more severe cold, starting point conditions with contingencies, more severe cold with contingencies)

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Table of Contents

Variations in Assumptions

- Starting point case assumptions for each winter period analyzed
- Variations in assumptions base on the future winter period analyzed
  - Load forecast and resource mixture assumptions modified based on 2021-2040 Outlook contract and policy cases
  - Review and incorporate expected policy impacts on natural gas demand
  - Future reserve requirements and possible market design changes to be reviewed

Scenarios

- Will apply to each starting point case
- Purpose: stress-test results against various events ranging in probability and expected impact; will include assessment of "low probability/high impact" events
- Examples of event types (at least one scenario or disruption 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 or large quantities renewable generation) on top of typical seasonal average outage rates
  4. Gas system event – loss of all or part of major interstate pipeline capability
  5. Changes in interchange levels (imports/exports)
  6. Limited offshore wind resource production
  7. Any additional events to consider based on consideration of stakeholder feedback and literature review

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Combination Cases

- Develop a manageable set of cases to run and evaluate; each case will be run for each of the three winter periods modeled
- Goal – capture a plausible range of futures, and a representative set of potentially impactful events
- As cases are run, others may need to be developed if gaps in the assessment are identified
- Possible cases, reflective of refreshed input assumptions
  - Starting point conditions with no contingencies
  - High load + extreme weather (i.e., more severe conditions than the modeled extended cold weather event)
  - Higher than anticipated generation outages and limited offshore wind production
  - Decreased non-gas generation + large upstate generation outage
  - Total loss of gas supply to generators

Table of Contents

Next Steps

- Tentative Schedule
  - Today: AG presentation of study assumptions, data and scenarios
  - May/June 2023: further discussion of study assumptions/data and development of scenarios
  - June/July 2023: AG presentation of fuel security analysis results/findings and initial recommendations
  - August/September 2023: AG presentation of final report

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	787	0	0	0	**787**	-484	0	0	0	0	**-484**	***303***
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	650	750	0	0	**1,400**	0	-650	0	0	0	**-650**	***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	1,123	0	0	0	**1,123**	-150	0	0	0	0	**-150**	***973***
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	1,625	275	**1,900**	0	0	-275	-1,830	0	**-2,105**	***-205***
New York State Pipeline Total	**4,988**	**3,315**	**5,198**	**895**	**14,396**	**-1,508**	**-1,350**	**-275**	**-2,918**	**-1,169**	**-7,220**	***7,176***

Sources:
[1] EIA, 2022 State to State Pipeline Capacity, January 2023, available at: https://www.eia.gov/naturalgas/data.cfm#pipelines.

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