The Effect of Electric Re-energization on Gas System Pressures

Chris Howard
Manager – Gas System Planning
Eversource Energy

Gas & Electric Interdependency Risk Identification

EVERSOURCE ENERGY

- Following the large-scale electric outage in Texas in 2021, Eversource increased its emergency program review to identify, understand, and address cross sector interdependency reliability risks between Gas and Electric distribution systems.
- Due to the high reliance on Natural Gas for New England’s power generation, Natural Gas shortages could be compounded by electricity shortages for capacity reliant on Natural Gas generation.
- In reviewing these risks, the impact to the Gas Distribution system during power restoration scenarios emerged as something critical to understand and plan for.

Gas & Electric Interdependency Risk Identification

- Concerns arose over the Gas Distribution system's ability to withstand the sudden influx of demand from gas customers who overlapped with electric circuit outages and had power restored simultaneously.
- In areas experiencing loss of power during even moderately cold weather, effectively all homes would demand gas for heat, hot water, etc. upon electric restoration.
- This level of coincident demand has the potential to create greater draw on the Gas Distribution system than normally present during standard operation.
- To better analyze this risk, discussions with subject matter experts and gas modeling specialists established a risk threshold of systems with 500+ customers (greater demand) and operating at lower pressures (limited ability to "pack" system)

Understanding the Risk

- Analysis
  - Align Gas service points on all 20psi and lower systems to the closest transformer (500' radius) to develop a list of Electric circuits that provide power to 500 or more Gas customers (individual or cumulative circuits in the same feeder rotation step)
  - Upon identification of potential "high-risk" circuits, additional analysis performed to determine Gas distribution system ability to drop to no less than 2.8" w.c.* based upon the Gas customer count and system design
- Mitigation
  - When feasible, mitigate "high-risk" circuits by reenergizing in smaller segments via SCADA recloser at the Electric Control Room

Real-World Event: Winter Storm Elliott

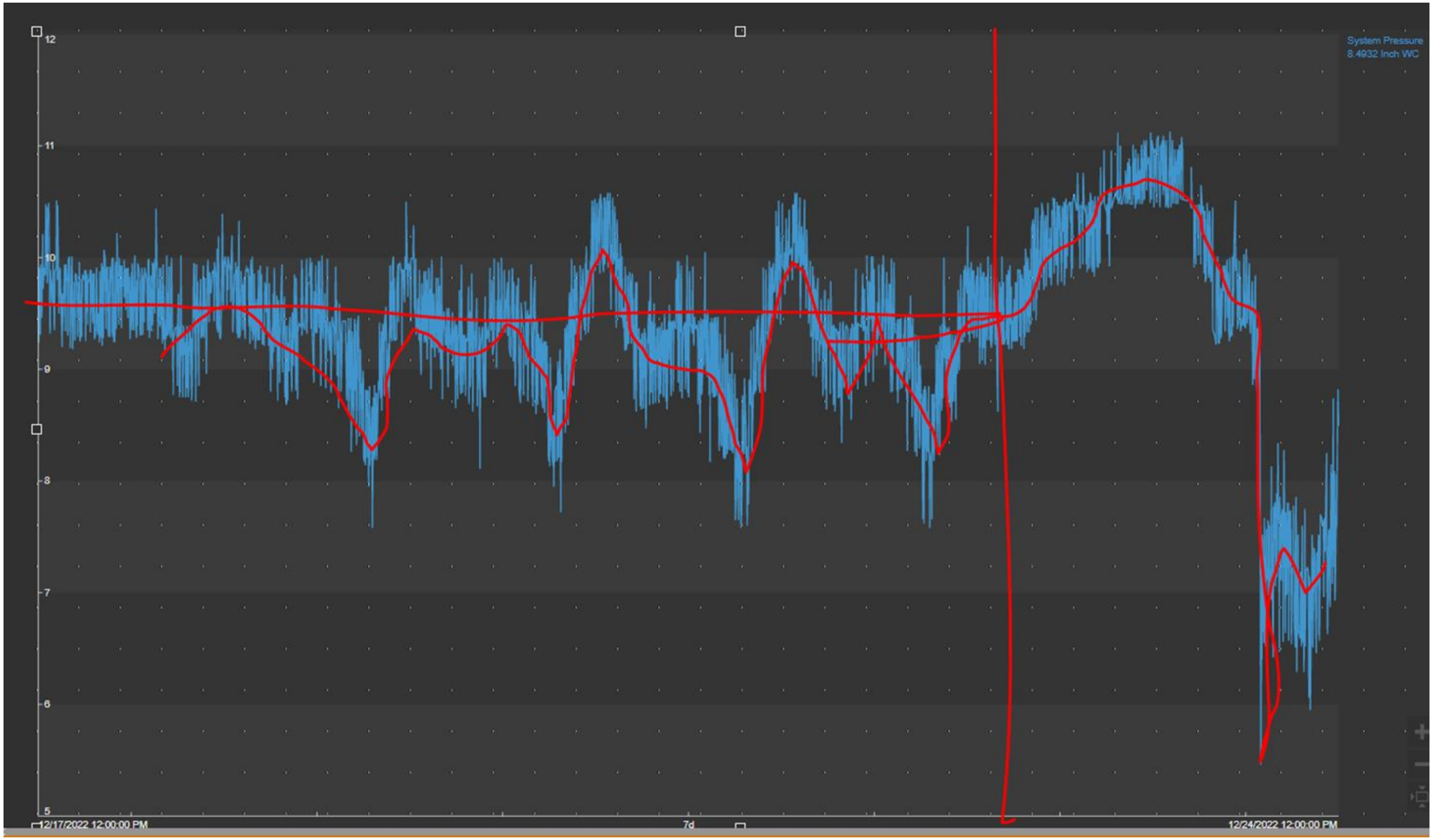
EVERSOURCE ENERGY

- In December of 2022, Winter Storm Elliot brought cold temps, strong winds and blizzard conditions to several New England states.
- This resulted in numerous electric customer outages, which in conjunction with cold temps, put gas systems potentially at risk when re-energizing due to the influx of demand.
- The ELP system in Wallingford CT and LP system in Methuen MA had electric outages that overlapped with a significant number of Eversource Gas customers.
- Using the electric outage area and telemetry data from before, during and after the outage, the Eversource System Planning team analyzed gas system response throughout this event.

Methuen Event

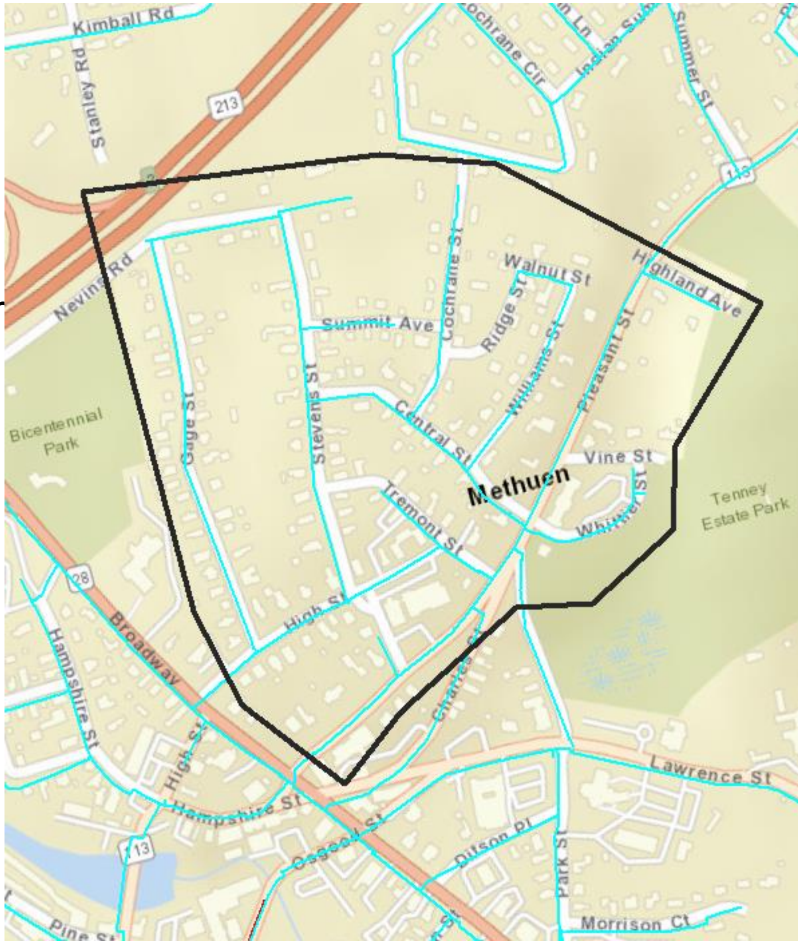
- National Grid experienced an outage of 369 electric customers in northern Methuen
- The outage duration was about 21 hours
- During the time electric power was out, appliances were not running and pressure in the 12" w.c. LP system packed.
- Once power was restored, all furnaces turned on and pulled gas system pressures down by +/- 5.5" w.c. (from 11" to 5.46") before recovering to 7.5" w.c.
- Ambient temperature was 14ºF, resulting in lower capacity in the low pressure system.

Methuen Telemetry Point Pressures



Modeling the Methuen Outage

- Using the lowest observed end point pressure of 5.46” w.c. the steady state Synergi model was used to estimate how much load per customer was needed to recreate the observed performance.
- A multiplication factor was applied iteratively to customer demand in the model until a modified load was reached at which the end of line pressure matched the lowest pressure seen in the telemetry data
- This resulted in a multiplication factor of 2.2x and corresponded to an average load per customer of 64 cfh during reenergization (as compared to 29 cfh on the base winter model)

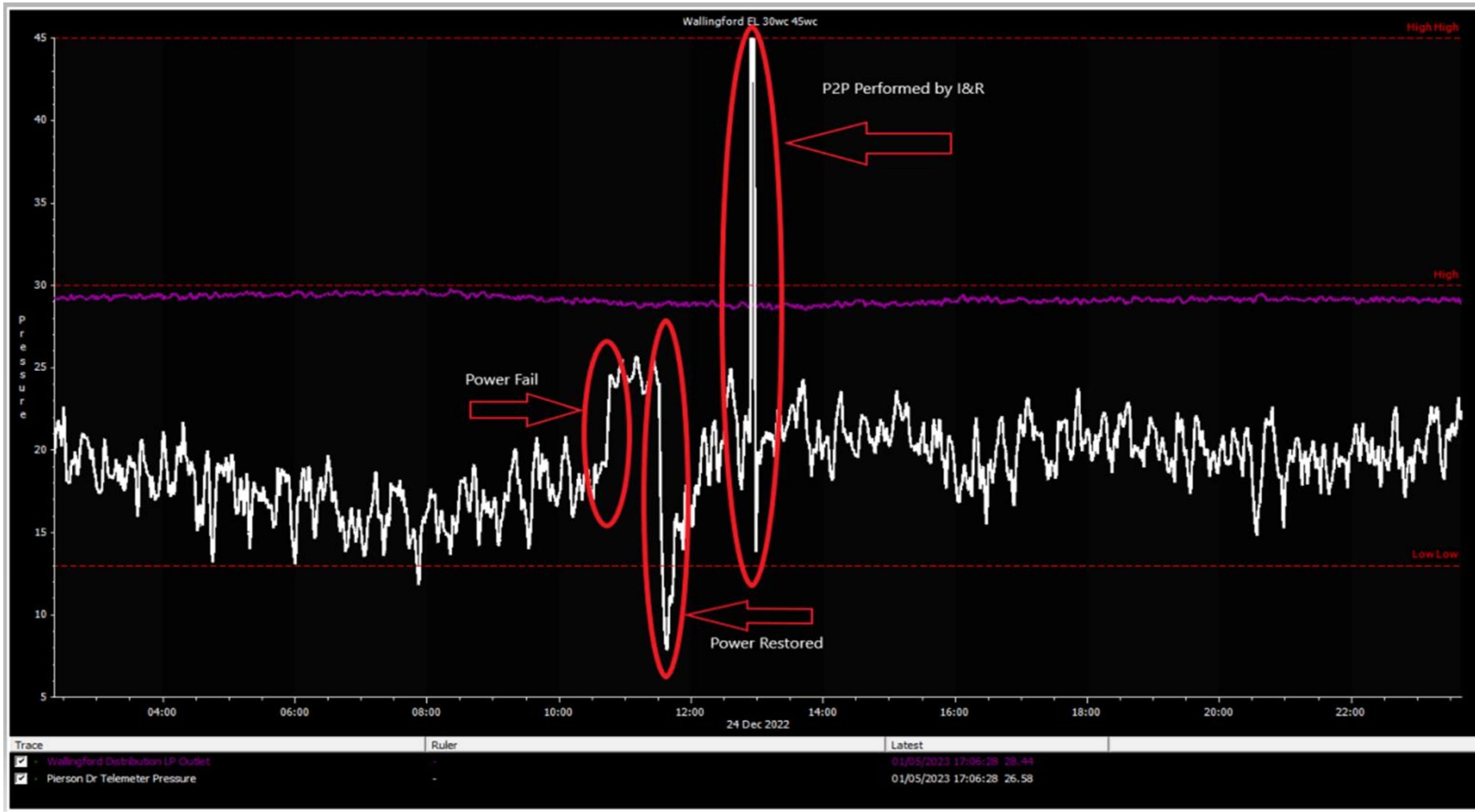


Wallingford Event

EVERSOURCE ENERGY

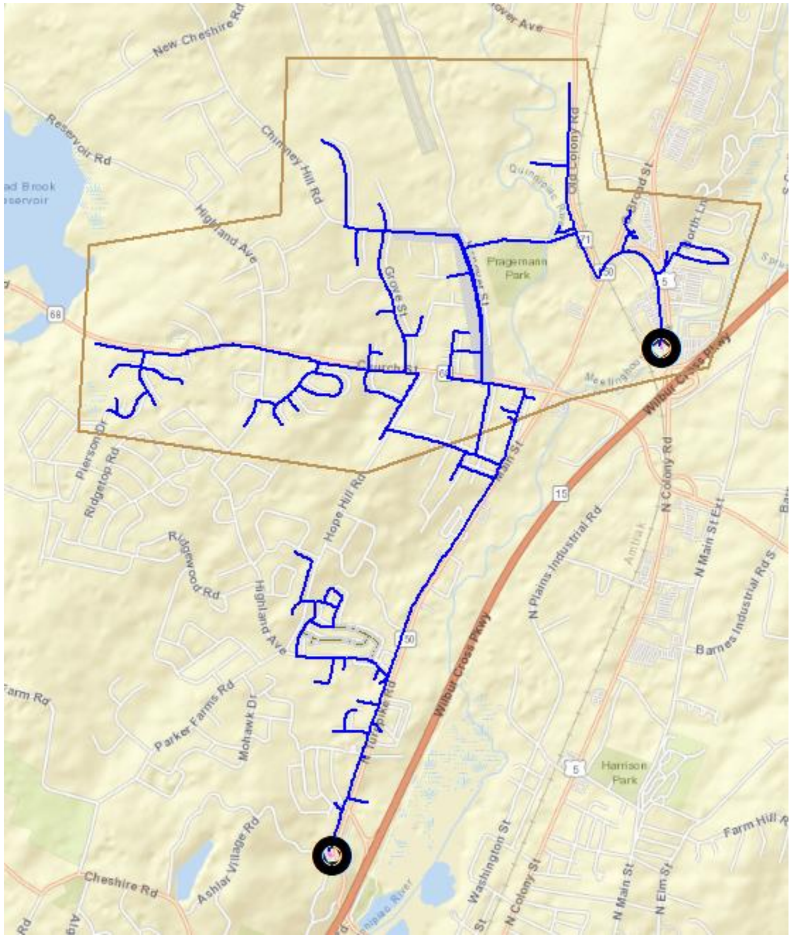
- Wallingford Electric experienced an outage of 278 electric customers in the northwest end of Wallingford
- The outage duration was about 45 min
- During the time electric power was out, appliances were not running and pressure in the 30” w.c. ELP system packed.
- Once power was restored, all furnaces turned on and pulled gas system pressures down by +/-18” w.c. (from 25” to 7.6”) before recovering to 20” w.c.
- Ambient temperature was 15ºF, resulting in lower capacity in the elevated low pressure system - especially in a single fed 4” main with 1” service lines.

Wallingford Telemetry Point Pressures



Modeling the Wallingford Outage

- Using the lowest observed end point pressure of 7.6" w.c. the steady state Synergi model was used to estimate how much load per customer was needed to recreate the observed performance.
- A multiplication factor was applied iteratively to customer demand in the model until a modified load was reached at which the end of line pressure matched the lowest pressure seen in the telemetry data
- This resulted in a multiplication factor of 1.46x and corresponded to an average load per customer of 57 cfh during reenergization (as compared to 39 cfh on the base winter model)



Extrapolation to Other Temperatures

- The pressure drop before and after an outage does not have a linear relationship with temperature and is impacted by other factors such as the length of the electric outage.
- Based on the trend seen in colder conditions, the end of line pressure before and after the outage drops lower as temperature is reduced, but the differential between the pre- and post-outage pressures gets smaller. This indicates that a pressure drop seen in warmer weather is not necessarily indicative of the pressure drop that will occur in colder weather.
- Ex: If, at 14ºF a pressure drop is seen from 9" w.c. to 6" w.c. (a change of 3" w.c.) and there is a pre outage pressure of 7" w.c. at –10ºF, a pressure drop of LESS than 3" can be expected.

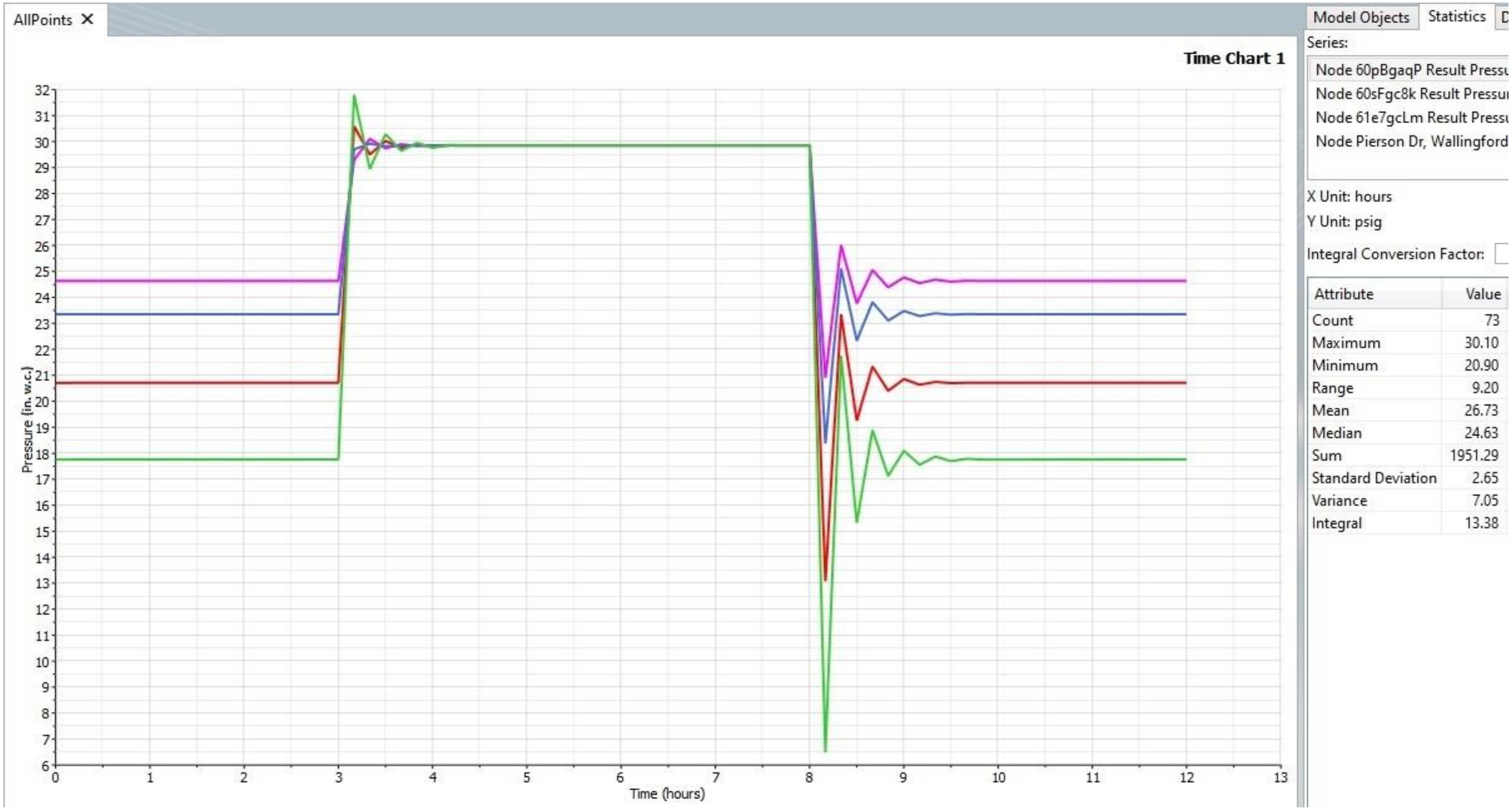
Area	Temp	Base Pressure	Re-energizaton Pressure	Drop
Methuen	-18ºF	5.35"	2.67"	2.68"
Methuen	14ºF	9.18"	5.96"	3.22"
Methuen	30ºF	10.51"	6.83"	3.68"
Wallingford	-2ºF	12.11"	5.08"	7.03"
Wallingford	14ºF	17.5"	7.89"	9.16"
Wallingford	30ºF	23.0"	12.46"	10.54"

Unsteady State Analysis

- Based on observed system performance and discussions with subject matter experts, backing into lowest pressures in steady state actually overloads the system in an effort to model instantaneous drop during power restoration
- Contracted DNV to perform "unsteady state" modeling to better analyze system impact and performance
- Part of discussion to establish guidelines for the study was whether to model an increased "turn-on load" to simulate greater demand with all customers coming back online at the same instant
  - Determined that an arbitrary increase to the turn-on load was unnecessary, as the 'peak hourly demand' for each customer in Synergi captures the max usage for each customer independently, with no diversity or coincidence factors applied
- Ran unsteady state analysis on 4 of Eversource's identified "at-risk" systems
  - 3 LP and 1 LIP (4 psi)
  - Done at design day temps and demand profiles
  - 600-1,300 affected customers
  - Loss of power for 5 hours, then entirely restored at same instant

Unsteady State Results

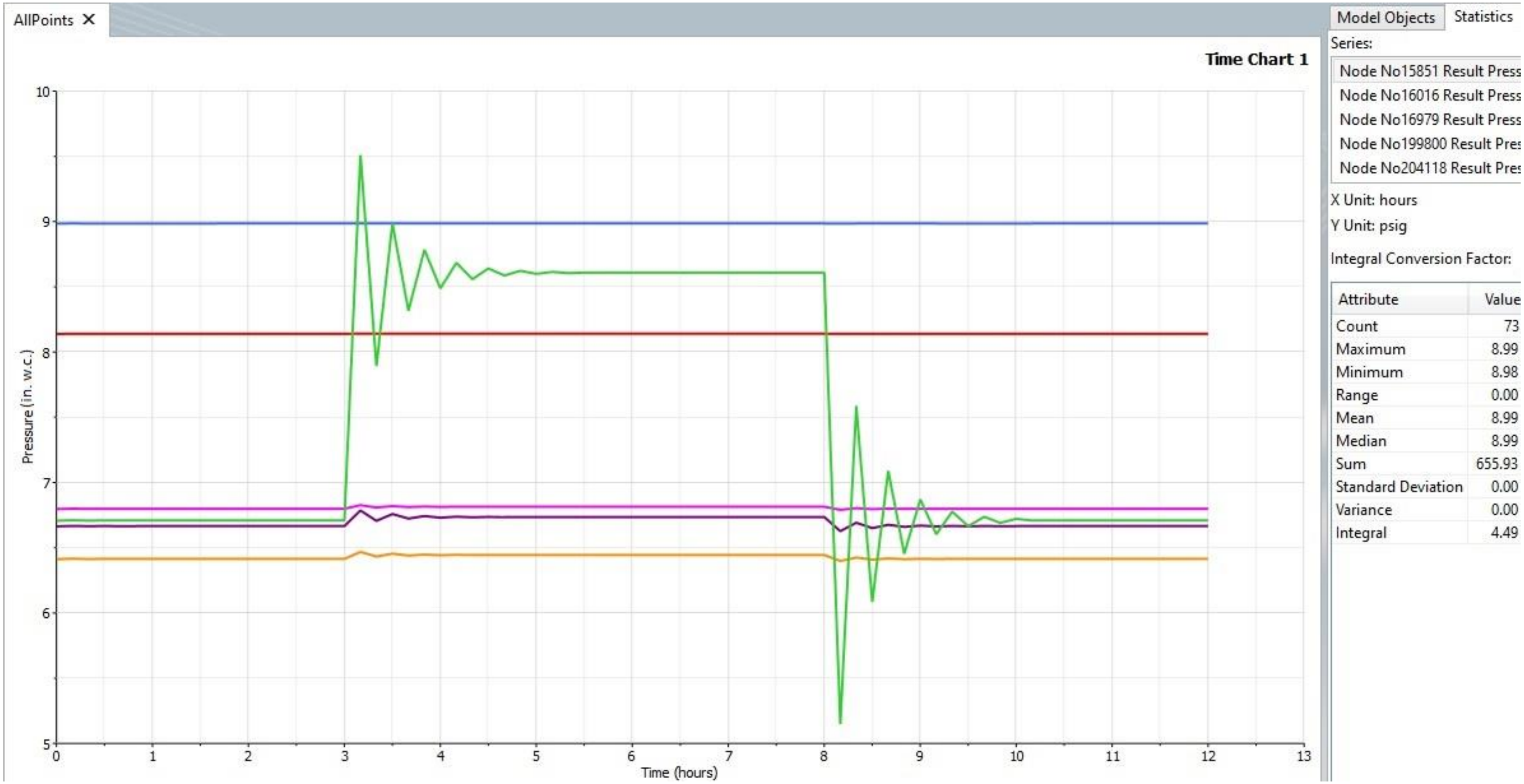
Wallingford 30" ELP system



steady state → loss of power → system packs → restoration of power → steady state

Unsteady State Results

Cambridge 14” LP system



steady state → loss of power → system packs → restoration of power → steady state

Takeaways

- Both observed and theoretical results support the established "at-risk" criteria of systems/circuits with 500+ gas customers and operating at low pressure

- Gas system risk can be effectively mitigated by identifying these "at-risk" areas, segmenting associated electric circuits into <500 customer groupings, and staggering re-energization during electric outage scenarios

Continuing Actions / Next Steps

1. Improve communications between Gas and Electric companies to focus on cross-utility analysis and communications
2. Continuing to engage DEMHS/MEMA and FEMA, through ESF-12, to develop a coordinated Regional Response Plan to identify all available Federal and State resources
3. Synchronized messaging through DEMHS/MEMA to incorporate all utilities into a single message that incorporates State and Local plans along with the utilities
4. Assess potential long-term infrastructure improvements to minimize the number of low-pressure Gas customers impacted per circuit
5. Annual analysis of interdependencies