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Independent Review of Hydraulic Modeling for Aliso Canyon Risk Assessment

Walker & Associates, Los Alamos National Laboratory

Joint Agency Workshop on Aliso Canyon Action Plan for Local Energy Reliability for Winter of 2016 to 2017

August 26, 2016

LA-UR-16-26378

UNCLASSIFIED

Outline

- **Project overview**
- Hydraulic modeling and risk analysis
- Summer assessment
- Winter assessment
- Findings and Recommendations

Project overview

Purpose

- Aliso Canyon leak requires significant change to SoCalGas system operations
- Action Plan Team (CEC, CPUC, CalSO, LADWP) needs to evaluate impact
- Transient pipeline modeling & hydraulic analysis expertise needed
- Review of SoCalGas analysis sought by independent experts

Goal: examine Action Plan Team & SoCalGas approach, make functional recommendations

Independent Review Team formed

- CEC contacted DOE for support
- DOE recommended LANL technical experts
- Walker contacted for industry operational and planning experience
- Coordinated with Action Plan Team

Review Team process

- Reviewed hydraulic modeling by SoCalGas engineers on site in LA
- Reviewed risk analysis
- Participated in follow-up discussions and winter analysis
- Required non-disclosure agreement (did not limit/impede review)

Team qualifications

Rod Walker, Principal – Walker & Associates Consultancy

- VP, Engineering, Construction, HSE & Strategic Planning at Westway Terminals
- Director, due diligence advisory and utility risk assessments at Black & Veatch
- Board of Directors, American Public Gas Association (APGA)
- Operations, Engineering, & Management, Atlanta Gas Light ‘85-’99 (B.S.E. ‘85 Clemson)

Scott Backhaus, Program Manager – Los Alamos National Laboratory

- Manager, DOE Office of Electricity & DHS Critical Infrastructure programs
- Team Leader, DHS National Infrastructure Simulation and Analysis Center (LANL-NISAC)
- Ph.D. in Physics (‘97) from the University of California at Berkeley

Anatoly Zlotnik, Theoretical Division – Los Alamos National Laboratory

- DOE/OE Advanced Grid Modeling Research (Optimal Control of Gas Pipeline Dynamics)
- LANL Principal Investigator – ARPA-e Project GECO on Gas-Electric system optimization
- Ph.D. in Electrical & Systems Engineering (‘14) from Washington University in St. Louis

Key observations

Risk comes from low likelihood but high impact events

- An entire year with no incidents does not mean there is zero risk of an incident
- Absence of incidents is not evidence of meeting criteria for a well-designed system

SoCalGas system is operating with a major infrastructure component offline

- No longer able to provide service under design conditions
- Unprecedented situation without a standard solution

Southern CA gas and electric systems have less safety margin than intended design

- Higher than normal risk of significant service interruptions
- Measures to mitigate potential issues are needed to provide standard safety factors

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Hydraulic modeling - Technology

Purpose – Natural Gas System modeling:

- Evaluate pipeline capacity for **planning**
- Given a set of conditions, quantify system pressures and flows in transient conditions

Key considerations:

- Complex physics of compressible gas flow
- Complex engineering of compressor stations
- Constraints (max & min line pressures, compressor horsepower)
- Pipeline vs. storage utilization
- Varying demand vs. steady supply (tariff rules)
- Human factors – actions of gas controllers – highly trained & experienced operators

Pipeline system controls:

- Valves (open/closed)
- Regulators (decrease pressure)
- Compressors (boost pressure)
- Storage fields (inject/withdraw)

Without Aliso Canyon facility:

- Large supply capacity to LA Basin is unavailable (max withdrawal depends on facility pressure)
- SoCalGas controllers must rely on other storage, flowing supplies, and **careful operation**

Hydraulic modeling - Technology

Transient analysis software:

- SoCalGas uses Synergi USM from DNV-GL
- A state-of-the-art pipeline simulation tool
- Given a set of conditions
    - Initial flows and pressures
    - Offtake profiles throughout the system
    - Compressor & regulator setpoints
- Predict pressures & flows throughout system

Requirements for planning engineer:

- Understand components and constraints of the specific system in detail
- Understand human factors of gas system operations and control

Human factors:

- Decisions of gas control department
- How to set compressor & regulator setpoints?
- When and where to order curtailment or OFOs?
- System is operated in **real time**
- **Simulation vs. reality**

Hydraulic modeling - Methodology

Design day:

- A low likelihood "worst-case" scenario (e.g. 1 day in 10 years – 1-in-10 – or 0.03%)
- Systems are **designed** for reliable operations in design day conditions (99.97% reliability)

Iterative analysis:

1. Initial steady flow (e.g. at night-time levels)
2. Transition system to linepack configuration at start of gas day & apply 24-hour load profiles
3. Engineers model gas control actions
    - Compressor & regulator control
    - Curtailments & operational flow orders
4. Return system line pack to initial conditions

Goals:

- Emulate what gas controllers would do with information and tools available to them
- Adjust offtake profiles (emulate curtailment) until acceptable simulation is achieved

Outcome:

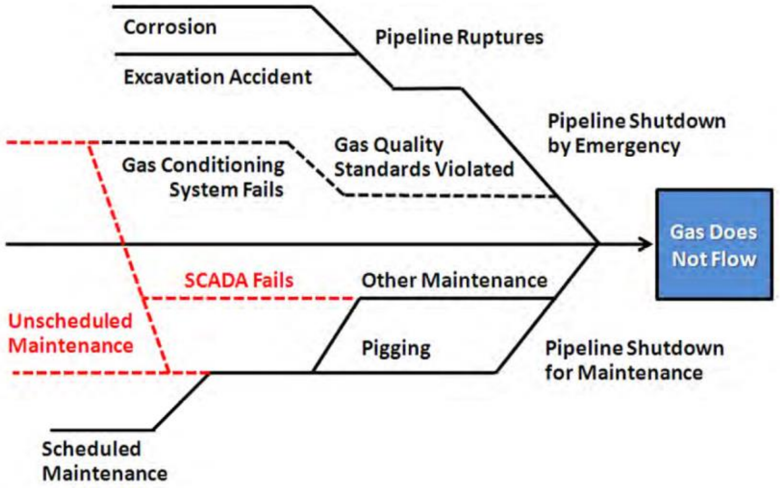
- Estimate of maximum ability of system to deliver to consumers **for a given load scenario**

- **This is industry best practice**

Hydraulic modeling - Methodology

Limitations:

- Iteration yields likely outcome for a scenario
- Labor-intensive – cannot perform hydraulic analysis on a large number of scenarios



- Justification for "worst case" design day

Many possible scenarios:

- Supply uncertainty – where supplies enter the system depends on market
- Demand uncertainty - when and where EG activity occurs depends on ISO
- Planned outages – system capacity changes with planned maintenance outages
- Unplanned outages – inspections may require action; equipment may fail
- Weather

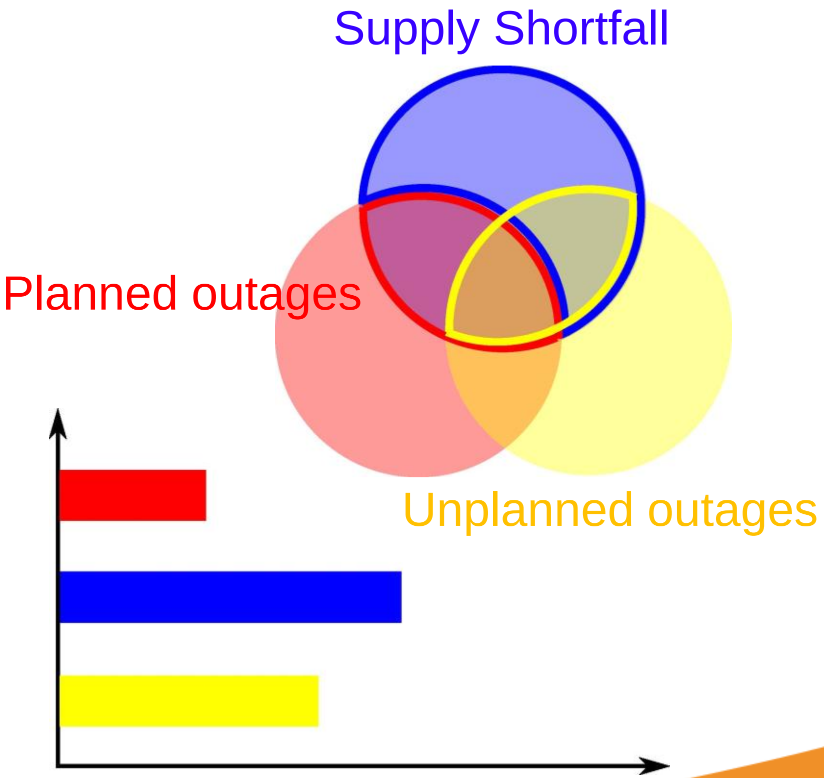
Risk analysis - Methodology

Usual risk analysis process:

- For design/planning of pipeline construction

Risk analysis process in this case:

1. Designate criteria for system risk with likely curtailment (e.g., load level & supply shortfall)
2. Classify conditions that could lead to lower gas availability (e.g., pipeline or storage outages) by level of impact
3. Assign scenarios to each set of conditions
4. Compute probability of each scenario by classifying historical data by scenario



- **Similar to industry studies on curtailment**

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Summer assessment – hydraulic analysis

Choosing a design day:

- Design and planning for SoCalGas system previously assumed availability of Aliso Canyon
- Action Plan Team needed a scenario to represent high system load
- Sept. 9 2015 had highest EG demand

Choosing risk criteria:

- Design day load was 3.2 BCF
- Iteration shows **curtailment likely** if 250 mmcfd supply shortfall
- 150 mmcfd supply shortfall chosen as threshold (human factors)

Figure 6: September 9, 2015 – Demand & Supply

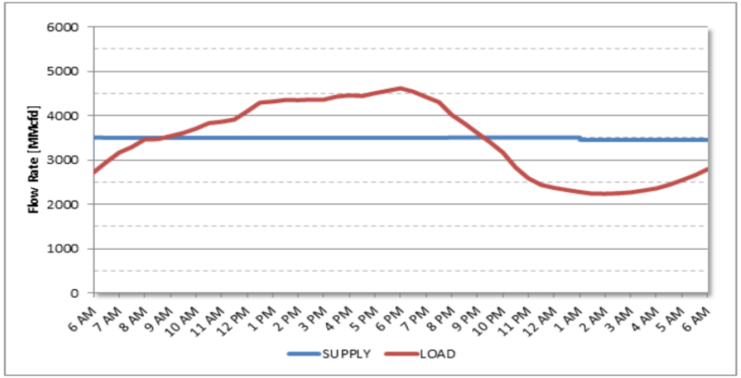
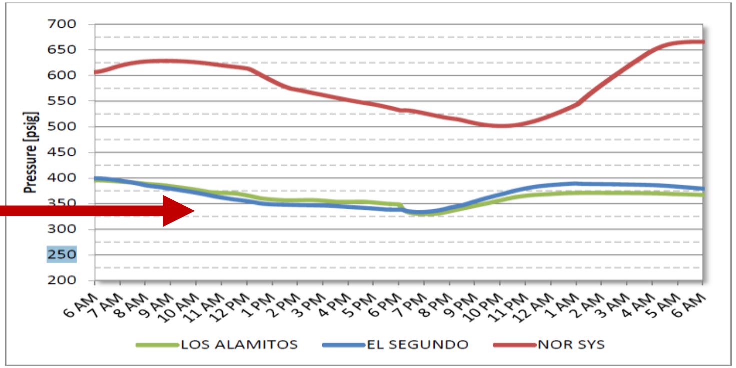


Figure 8: September 9, 2015 – Northern System & Los Angeles Basin Pressures



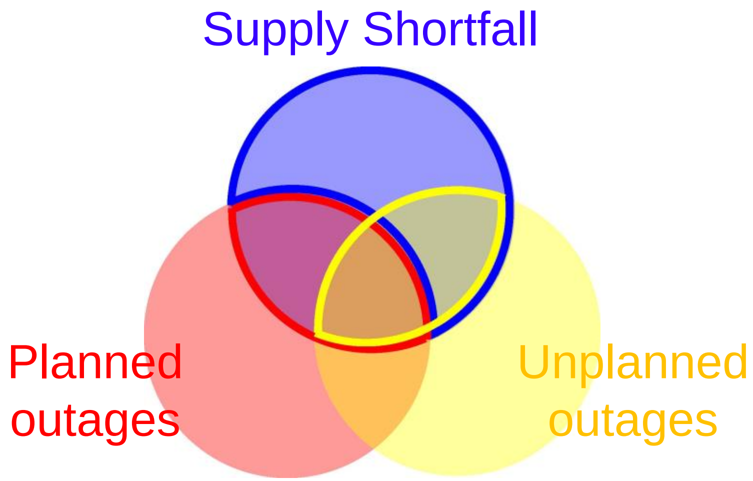
Summer assessment – risk analysis

Outage factors:

- Pipeline and storage outages
- Planned and unplanned

Scenarios:

1. System at risk of curtailment (3.2 BCF, >150 mmcfd shortfall)
2. Storage outages, non-Aliso (>400 mmcfd delivery impacts)
3. Pipeline outages (>500 mmcfd delivery impacts)
4. Both storage and pipeline outages (>1.1 BCF impacts)



SoCalGas curtailment risk view:

- 11 days per year of >150 mmcfd curtailments (2 days in summer)
- 12-21 days per year of >400 mmcfd curtailments (>5 days in summer)

Summer assessment – observations

Methodology and practice:

- Risk is complicated to quantify - system complexity, many possible scenarios, long time required for hydraulic analysis
- LA Basin situation is unique, unprecedented
- Historical data gives limited insight
- Action Plan Team needed to modify standard curtailment analysis to assess risk in this unprecedented situation

Hydraulic analysis view:

- Load level and imbalance are main predictors of system stress
- Outages have high impact on ability to deliver gas

Review Team view on risk analysis:

- Appears to **overestimate the likelihood of low impact events** (e.g. days with 150mmcfd curtailment)
- Appears to **underestimate impact of low likelihood events** (i.e. planned & unplanned outage on high load day)

Review Team conclusion:

- **Mitigation measures key to avoiding expected curtailments**
- **Mitigation was not accounted for in the initial risk assessment**

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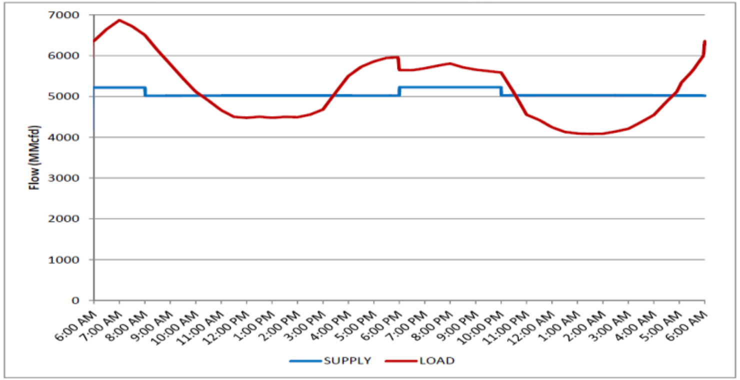
Winter assessment – hydraulic analysis

Choosing a design day:

- Design and planning for SoCalGas system previously assumed availability of Aliso Canyon facility
- Use design day conditions for hydraulic analysis in absence of Aliso Canyon

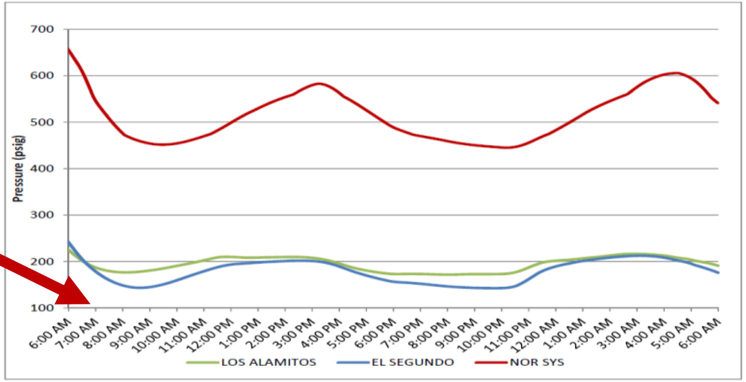
Figure 5: 5.2 Bcfd, No Additional Outages – Supply and Demand



Choosing risk criteria:

- Design day load is 5.2 BCF
- Iteration shows **curtailment very likely** in the LA basin in the morning even if supply is shipped in through the day

Figure 6: 5.2 Bcfd, No Additional Outages – Northern System and Los Angeles Basin Pressures



Winter assessment – hydraulic analysis

Location and time considerations:

- System conditions depend on timing, location, & volume of offtakes & supplies
- SoCalGas may need to choose whether to supply LA Basin or San Diego

Examine linepack in subsystems:

- Line pack does not recover in LA Basin
- Successive days of high load would create additive stress on system if curtailments are not used to limit offtakes
- Shipping of additional gas for the next day under these conditions is problematic

Figure 7: 5.2 Bcfd, No Additional Outages – Northern System and Moreno Pressures

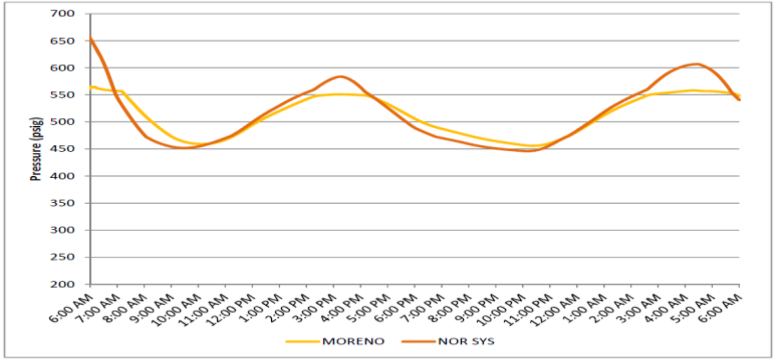
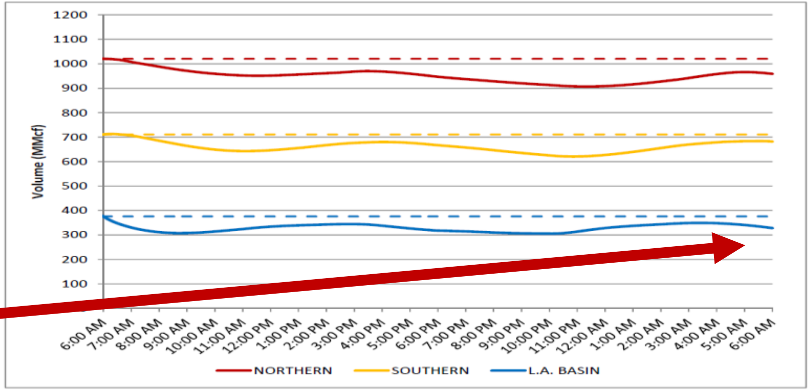


Figure 8: 5.2 Bcfd, No Additional Outages – Subsystem Linepacks
(Initial levels Indicated as Dotted Line)



Winter assessment – hydraulic analysis

Maximum capacity estimate:

- Maximum delivery with usual distribution of consumptions, everything in service
- 4.7 BCF found to be the **estimate of maximum system utilization, given all operational factors, and capabilities of commercially available software**
- Pipeline vs. storage tradeoff (Honor Rancho)

Justification:

- System pressures are maintained
- Subsystem linepacks are recovered
- **Based on operating protocols of SoCalGas gas control department**

Figure 10: 4.7 Bcfd, No Additional Outages – Northern System and Los Angeles Basin Pressures

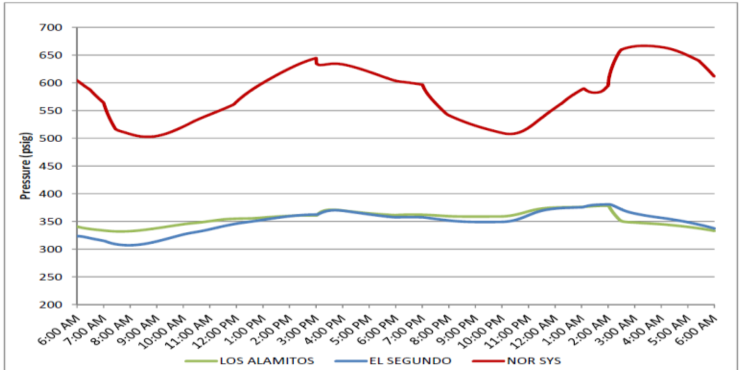
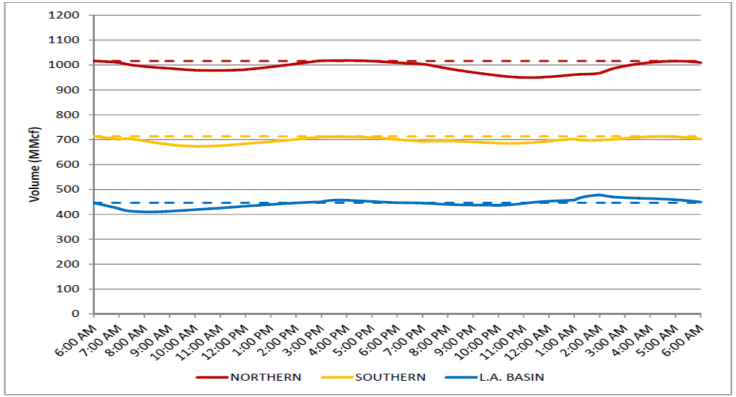


Figure 12: 4.7 Bcfd, No Additional Outages – Subsystem Linepacks (Initial Levels Indicated as Dotted Line)



Winter assessment – observations

Interpreting modeling outcomes:

- Many factors affect transport capacity of gas systems with pipelines & storage facilities
- One number cannot reflect all complexities
- Geographic distribution of customers determines ability to service them under high load circumstances
- SoCalGas examined conditions specific to LA Basin and San Diego

Hydraulic analysis outcome:

- Maximum load level estimate obtained by SoCalGas is intended to be a **reasonable, conservative** estimate of system utilization under expected high load conditions
- Because analysis is conservative, number of curtailments may be lower than predicted by risk analysis

Review Team views:

- **Conservative operations prevent high impact events** (safety factor for max capacity)
- **Mitigation measures are key to reliability** (balancing, coordination, conservation)

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- Project overview
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- **Findings and recommendations**

Findings and recommendations – hydraulic modeling

Key findings:

- Methods used by SoCalGas appear to be adequate for estimating availability of gas and assessing potential for curtailment
- Aliso Canyon facility is an integral part of the SoCalGas system, without which the system cannot function at maximal designed utilization or handle potential shortages of gas (beyond SoCalGas control)
- The method used by SoCalGas to assess its system capacity under transient conditions reflects full utilization of available software and appropriately accounts for operational factors

Key recommendations:

- Examine aggregate offtakes in and deliveries to LA Basin to determine whether flows through city gates can be controlled to more closely balance load in the LA Basin
- Use multiple design days for hydraulic analysis to determine multiple sets of system stress criteria to refine fidelity of the risk analysis to assess intermediate levels of risk

Findings and recommendations – risk analysis

Key findings:

- Method used for statistical risk analysis should be evaluated for potential changes because of new operating conditions
- Statistical framework used for the summer assessment can be improved with respect to categorizing combinatorial factors related to impacts of unplanned outages that affect risk of curtailment

Key recommendations:

- For clarity, a table of all examined scenarios and corresponding probabilities should be provided to ensure consistency of statistical analysis and categorize risk of curtailments by frequency and impact
- Given the unique situation in the LA Basin, it may be prudent to go beyond industry practice of using a single design day to assess risk
- Effect of mitigation measures could be evaluated by comparing risk analysis for historical data with and without supply balance

Findings and recommendations – Action Plan

Key findings:

- The number of days with gas curtailments to EG customers has been lower than predicted, to date
- Action Plan mitigation measures (balancing, coordination, conservation, prudent storage use, prudent operations) have prevented risk to gas and electric systems and promoted reliability

Key recommendations:

- Tightening balancing rules to more closely align with standards for interstate pipelines that do not rely on storage facilities
- Deferral of maintenance (when possible) so that planned pipeline and storage outages do not occur simultaneously, especially during expected times of peak winter demand
- Continuation of mitigation measures