System Resiliency:

A Critical Requirement of Natural Gas Systems

Prepared for

FORTIS BC

March 11, 2021

AGENDA

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- Scope of Engagement
- Summary of Opinion

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- Summary of Major Findings

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Qualifications and Duty of Independence

Guidehouse confirms awareness of its duty of independence

- Our findings in this report are provided on an objective basis and are based on our experience, which is comprised of direct experience in the natural gas industry and providing strategic advisory services to clients in the utility sector. Our analysis includes review of documents provided by FEI.

- Paul Moran is Associate Director in the Energy, Sustainability and Infrastructure practice at Guidehouse, and is responsible for leading engagements for clients in the energy sector including electric and gas utilities, power generators, pipeline and midstream companies, gas storage operators, and LNG export project developers in addition to private equity and infrastructure funds.
- Paul is an accomplished electric and gas utility professional with extensive background in the power and gas sectors including electric transmission and distribution, natural gas pipelines and distribution in addition to emerging energy technology, including Smart Grid technology assessments and evaluations.
- His 17 years of energy industry experience include providing subject matter expertise related to corporate strategic planning, power and natural gas market analysis and forecasting, business process improvement, organizational design and change management.
- Paul is a key author of a 2021 report commissioned by the American Gas Foundation entitled: ***Building a Resilient Energy Future: How the Gas System Contributes to US Energy System Resilience***

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Scope of Engagement

Guidehouse was retained to construct a framework to inform FEI's resiliency decision-making, not recommend the project

Guidehouse asked four questions

1. What does resiliency mean in the context of the natural gas market, supply and delivery system, and why is it important?
2. How is the resiliency of FEI's distribution system affected by the characteristics of the natural gas value chain, including midstream pipeline capacity and availability of storage (both off-system and on-system) and the composition of the load/customer base?
3. In the case of FEI, to what extent is on-system storage either an alternative to, or complementary to, other resiliency measures such as midstream pipeline infrastructure, off-system storage, or interruptible service and or other demand control measures?
4. What considerations should go into determining the optimal amount of on-system storage for FEI?

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Summary of Opinion

Key Findings: The Tilbury Tank Expansion project provides an effective means to strengthen resiliency on the FEI System.

Key Finding
Resiliency is mission-critical
Resiliency is not reliability and reliability does not always provide resiliency
The North American natural gas system features high inherent resiliency
B.C. does not have high inherent resiliency
Resiliency solutions need to be customized to the specific resiliency need
On-system storage offers a wide range and unique set of resiliency benefits to FEI that other alternatives do not provide

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Key Questions

Resilience and reliability are often referenced together, but they reflect critical differences in system design and operation

1	**What does resiliency mean in the context of the natural gas market, supply and delivery system, and why is it important?**
2	How is the resiliency of FEI’s distribution system affected by the characteristics of the natural gas value chain, including midstream pipeline capacity and availability of storage (both off-system and on-system) and the composition of the load/customer base?
3	In the case of FEI, to what extent is on-system storage either an alternative to, or complementary to, other resiliency measures such as midstream pipeline infrastructure, off-system storage, or interruptible service and or other demand control measures?
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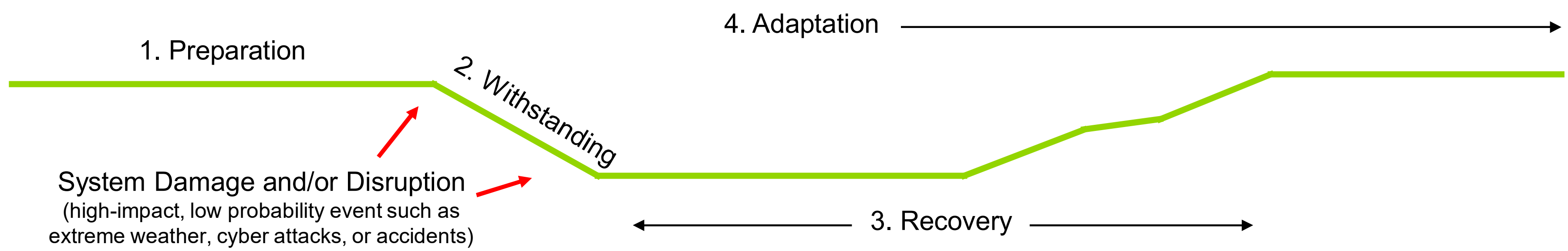
Energy System Resilience

Resilience is defined as a system's **ability to prevent, withstand, adapt to, and quickly recover** from system damage or operational disruption**.** These abilities can be conceptualized into distinct phases along a resilience curve:



Phase	Energy System Abilities	Timeframe
1. Preparation	The ability to prepare for and prevent initial system disruption	Leading up to disruption
2. Withstanding	The ability to withstand, mitigate, and manage system disruption	During the disruption
3. Recovery	The ability to quickly recover normal operations and repair system damage	Following the disruption
4. Adaptation	The ability to adapt and take action to improve resilience to future disruption events	Throughout, but especially during and following recovery

RESILIENCE

Characterized by the energy system's performance in response to high-impact, low-likelihood disruption events; such as extreme weather, cyber-attacks, and accidents.

RELIABILITY

Characterized by the energy system's performance in response to low-impact, high-likelihood fluctuation events; such as power surges and routine changes to supply or demand.

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How can a gas distribution company achieve resiliency?

An understanding of the source of resiliency and its benefit is critical to developing a resilient system

- A natural gas utility can achieve resiliency by creating a supply, transportation and distribution portfolio of assets (both contracted and owned/operated) that features diversity and redundancy with reduced reliance on a single point of failure
- On-system resources such as on-system storage provide a wide range of resiliency benefits and offer direct, operational control to natural gas utilities

Benefits of Resiliency Across the Four Phases

Characteristic	Preparation	Withstanding	Recovery	Adaptation
Underground Infrastructure	Reduces exposure to threat	Minimizes impact of potential disruptions	n/a	n/a
Looped and Parallel T&D Network	Improves deliverability in the event of regionally isolated gas network disruptionn			
Highly networked pipeline transmission system	Reduces risk of supply disruption		Provides alternative to access upstream supply	
Off-System Storage	Augments production volumes to serve demand during periods of high usage		Provides alternative access to upstream supply	
On-System Storage Capacity	Provides on-site reserve and injection	Balances supply and demand fluctuations	Provides operational control to manage an upstream disruption	Facilitates supply-side diversity

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Delivering Resiliency to an "End of Pipe" LDC

Geographic Adjacency & Market Availability of Infrastructure Informs Decision-making

- Across the value chain, from production to distribution, resiliency is enabled by the physical characteristics of natural gas system
- In general, the North American natural gas system is highly resilient due to:
  - Mostly underground system that is shielded from major disruptions
  - Highly networked system fosters overall system self-reliance
- Access to System Reliance is dependent on two factors:
  - The availability of uncontracted capacity on upstream pipelines and storage
  - The physical location of the LDC service territory in relation to the pipelines and storage facilities

Ability to contract for access to physical infrastructure is subject to both geographic availability (i.e., is infrastructure adjacent?) and market availability (i.e., is the physical infrastructure fully subscribed/contracted or is there capacity that is available?)

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Utilities across North America have sought and gained regulatory approval for investments related to improving system resiliency.

New Jersey Natural Gas

- New Jersey Natural Gas (NJNG) experienced five major storms in 2011 and 2012 including Superstorm Sandy in October 2012 that caused major energy supply disruptions across electricity and natural gas
- These events revealed the inherent lack of resilience across the NJNG system and its upstream points of connection
- NJNG sought and gained approval for a series of investments to:
  - increase its access to upstream physical infrastructure to strengthen supply diversity
  - Strengthen and reinforce distribution system redundancy
  - Increase and optimize on-system storage to improve ability to withstand a resiliency event

Dominion Energy

- Dominion Energy Utah sought to improve its ability to withstand supply disruptions that resulted when periods of extreme winter weather impacted upstream production
- It considered a range of options including upstream storage or 3rd party supply and transportation agreements as well as on-system storage
- The company received approval for the on-system storage solution

These two examples are applicable because they demonstrate the following:
- **Major system failures causing supply disruption have revealed the need for improved system resiliency**
- **Regulatory precedent exists to seek and gain approval for system investments in resiliency to improve the ability to respond to low probability/high impact events**
- **The approved resiliency options are very much dependent on the resiliency need: ability to withstand an upstream disruption as well as an on-system disruption**

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Key Questions

1	What does resiliency mean in the context of the natural gas market, supply and delivery system, and why is it important?
2	**How is the resiliency of FEI's distribution system affected by the characteristics of the natural gas value chain, including midstream pipeline capacity and availability of storage (both off-system and on-system) and the composition of the load/customer base?**
3	In the case of FEI, to what extent is on-system storage either an alternative to, or complementary to, other resiliency measures such as midstream pipeline infrastructure, off-system storage, or interruptible service and or other demand control measures?
4	What considerations should go into determining the optimal amount of on-system storage for FEI?

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2. How is the resiliency of FEI's distribution system affected by gas value chain?

Key considerations include midstream pipeline capacity and availability of storage (both off-system and on-system) and the composition of the load/customer base

- BC has significant natural gas resources, especially since the growth of shale gas.
- BC's pipeline infrastructure covers long distances and connects supply resources in the North, and in Alberta, to load centres throughout the province.
- FEI is critically dependent on the existing transportation and storage infrastructure in BC, especially the Enbridge BC pipeline, and the province of BC has a relatively low amount of interconnectedness compared to other regions of North America.
- Pipeline utilization in the Pacific Northwest has reached 100% in recent years, resulting in large gas price spikes. Demand growth is expected to increase, putting further pressure on regional infrastructure.
- There is limited on-system storage in the FEI service territory. The utility has contractual relationships with storage assets in the Pacific Northwest but has no operational control over these assets.

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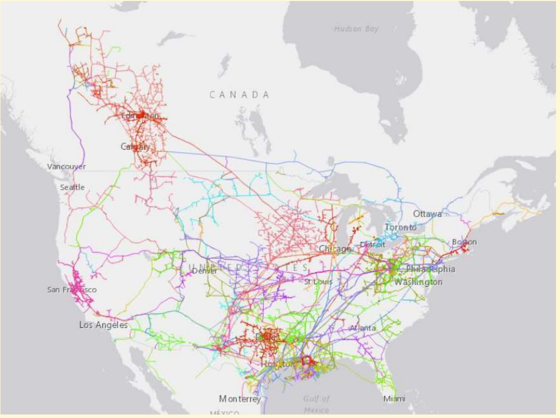
Introduction | **Discussion** | Conclusion | Questions

B.C. has access to multiple sources of natural gas, but limited access to natural gas pipeline and storage infrastructure

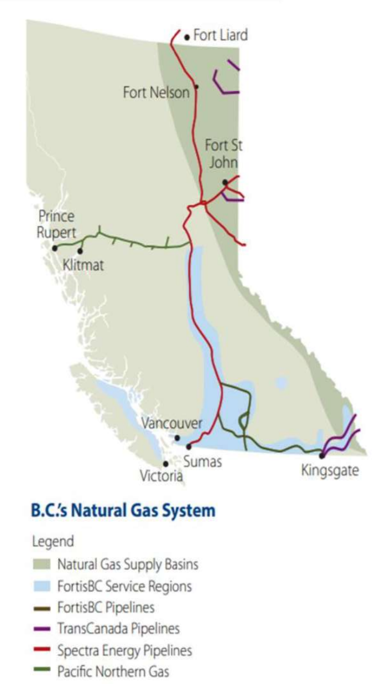
North American Natural Gas Pipeline System



- The highly networked North American natural gas pipeline system is a source of natural gas system resiliency
- The Western Canada does not feature the same level of interconnectivity as the central U.S.

- BC's pipeline infrastructure covers long distances and connects supply resources in the North, and in Alberta, to load centres throughout the province.
- FEI is critically dependent on the existing transportation and storage infrastructure in BC, especially the Enbridge BC pipeline, and the province of BC has a relatively low amount of interconnectedness compared to other regions of North America.

British Columbia Natural Gas Infrastructure



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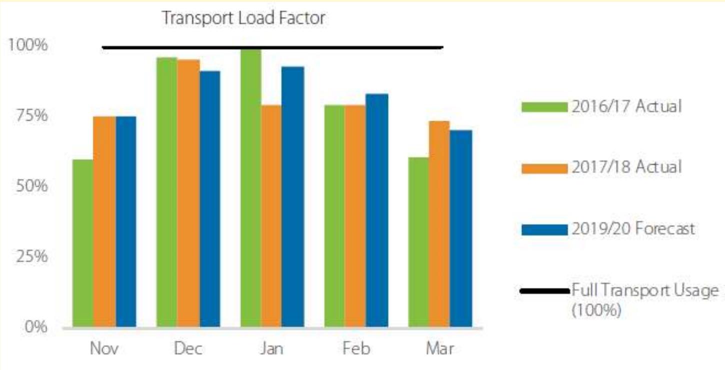
Regional Pipeline Utilization

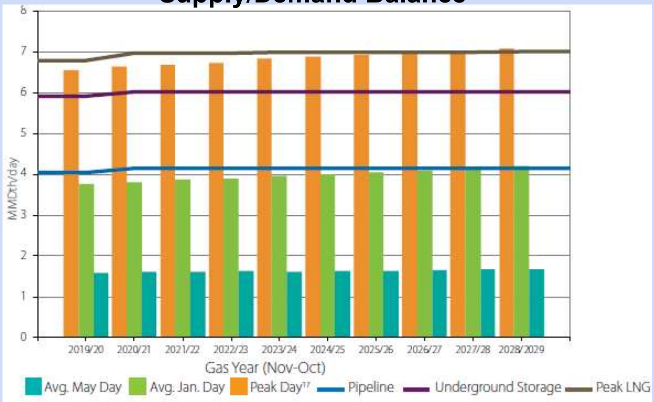
B.C. and the U.S. PNW feature high pipeline utilization and are highly dependent on storage and LNG sendout to meet peak day requirements

- High pipeline utilization in the region means the system is less able to respond to unplanned outages.
- Regional pipeline capacity utilization reached 100% in January 2017.

B.C. and U.S. Pacific Northwest Regional Pipeline Capacity Utilization



B.C. and U.S. Pacific Northwest Peak and Average Supply/Demand Balance



- Pipeline capacity is sufficient to meet demand for an average day in January, throughout most of the forecast.
- Both underground storage and peak LNG are required to meet peak day demand. In the later years of the forecast, the supply-side resources are insufficient to meet peak day demand for the region.

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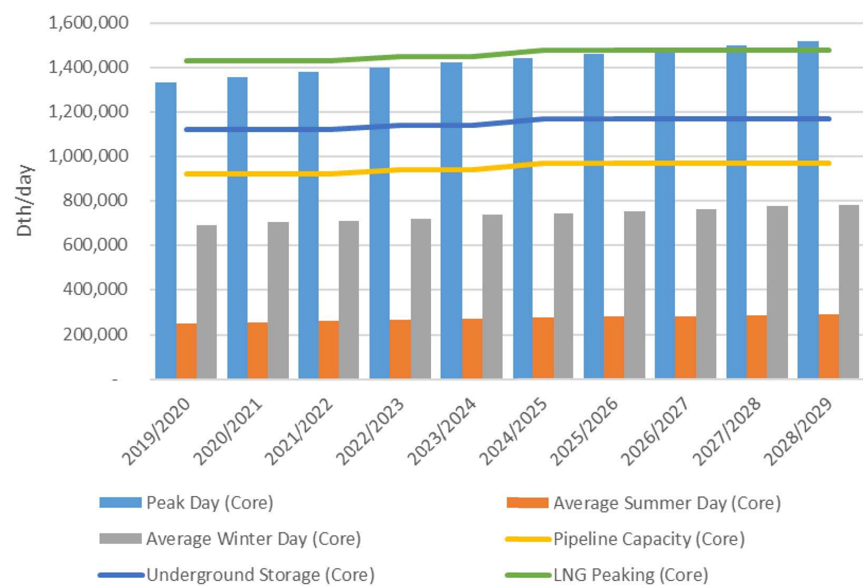
FEI Gas Supply/Demand Balance

Peak day demand exceeds pipeline capacity: storage is vital to meeting seasonal demand

- FEI features highly seasonal demand.
  - For the 2021/22-year, average winter day demand is approximately 2.7 times greater than the average summer day.
  - Existing pipeline capacity serves about 70% of the peak demand, while market area storage and on-system LNG serve about 30% of the peak.
  - This showcases the importance of underground market-based storage and LNG on-system storage to serve peak demand on the FEI system.

B.C. and U.S. Pacific Northwest Peak and Average Supply/Demand Balance[1]



1. Shows the supply/demand balance for the FEI Annual Contracting Plan that services Rate Schedules 1 to 7 (Core rates).

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Implications for FEI

Resiliency of the FEI distribution system is highly dependent upon five critical factors

	Factor	Key Characteristics	Implication to FEI
1	The sources of natural gas supply that serve the province and the FEI system	Highly dependent on B.C. production	FEI ability to secure geographic supply diversity is difficult to achieve
2	The natural gas pipeline and storage infrastructure serving the region	FEI is highly dependent on the Enbridge BC system	FEI ability to reduce reliance on a single pipeline is difficult to achieve due to lack of alternatives
3	The physical layout of the FEI distribution system	FEI system serves the major population centers in B.C. and is highly dependent on regional infrastructure for supply	FEI system is not as inherently resilient as other gas utilities with more interconnectivity options
4	The amount and location of FEI on-system storage	Limited amount of on-system storage	FEI system is dependent on off-system storage for reliability and resiliency
5	The profile of FEI's customers' demand, especially the seasonality of demand	High seasonal demand in the winter period	The risk of a supply disruption during a period of peak demand

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Key Questions

Long duration & seasonal storage are key to resiliency

1	What does resiliency mean in the context of the natural gas market, supply and delivery system, and why is it important?
2	How is the resiliency of FEI's distribution system affected by the characteristics of the natural gas value chain, including midstream pipeline capacity and availability of storage (both off-system and on-system) and the composition of the load/customer base?
3	**In the case of FEI, to what extent is on-system storage either an alternative to, or complementary to, other resiliency measures such as midstream pipeline infrastructure, off-system storage, or interruptible service and or other demand control measures?**
4	What considerations should go into determining the optimal amount of on-system storage for FEI?

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3. To what extent is on-system storage an alternative to other resiliency measures?

Alternatives include midstream pipeline infrastructure, off-system storage, or interruptible service and or other demand control measures

- On-system storage is a primary asset that can help FEI respond to short-term supply disruptions.
- Alternatives, including line pack, third party contractual arrangements and industrial curtailment have limitations in terms of responsiveness to short-term supply disruptions relative to on-system storage.
- Storage assets are efficient for short duration supply disruptions and peak shaving applications, while pipelines are more efficient for longer deliverability applications.
- On-system storage and pipelines are complimentary assets.
- Guidehouse observes that the FEI distribution system is comprised of multiple, formerly independent systems that were combined to form FortisBC Energy.
- Each of these systems have their own unique operating characteristics and gas supply receipt points.

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Consideration of Alternatives to On-System Storage

Alternatives are considered in terms of efficacy and ability to execute

Alternative	Guidehouse Assessment
Contracting for additional pipeline and underground storage capacity	Given lack of alternatives, FEI could only contract for additional capacity on the Enbridge BC System that will contribute to exacerbating FEI's dependence on the Enbridge BC system and increase, rather than decrease, the single point of failure risk presented by the Enbridge BC system.
Third-party commercial agreements for transportation and/or storage services	Limited opportunities exist to execute. Does not remedy FEI exposure to Enbridge BC dependency Does not provide operational control to choose how to utilize upstream transport and storage during an emergency
Utilizing line-pack	Limited duration and volumes means that line pack is not a dependable resiliency option
Industrial curtailment and demand response measures	Curtailment can aid emergency response by lowering demand and required pressure support. However, it is not supply and is not a remedy for a disruption of supply.
On-system above ground storage	On-system location enables FEI control and enhanced responsiveness. Strengthens resiliency by improving ability to prepare, withstand and recover from a supply disruption.

Only on-system storage, from the perspective of efficacy and availability, offers a remedy to the susceptibility of the FEI system to a single point of failure

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Key Questions

Operational flexibility is critical to recovery from high impact events

1	What does resiliency mean in the context of the natural gas market, supply and delivery system, and why is it important?
2	How is the resiliency of FEI's distribution system affected by the characteristics of the natural gas value chain, including midstream pipeline capacity and availability of storage (both off-system and on-system) and the composition of the load/customer base?
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Framework for Determining Necessary Storage and Vaporization

The Guidehouse framework enables evaluating options in terms of contributions to enhancing resiliency

Risk Mitigation and Resiliency

- On-system storage provides insurance by mitigating the risk of a supply disruption to the FEI system
- The insurance benefit is provided by the duration of the asset
  - how much time is required to respond to a system disruption?
  - how much volume is required?

Key Considerations

- A supply disruption can have a significant impact on the daily lives of FEI's customers
- It can also have significant repercussions on system integrity
  - A loss of supply can lead to pressure failure that can contribute to the collapse of the gas distribution system
- Avoiding and mitigating these consequences requires FEI to be able to respond with the appropriate level of resiliency

Guidehouse developed a framework that defines the critical capabilities needed for resiliency and establishes the criteria by which to consider the reasonableness of FEI's approach to determining recommendations on duration

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Considerations for Optimal Amount of On-System Storage

Framework for Determining Necessary Storage and Vaporization

Capability	Attributes	Critical Defining Factors
Preparation	The ability to prepare for and prevent initial system disruption	• The anticipated time required to conduct a planned shutdown, i.e., an orderly curtailment of customers to reduce the amount of work and time required to restore service.
Withstanding	The ability to withstand, mitigate, and manage system disruption	• The amount of load on the system at the time of disruption • The amount of load needed to be retained in the event of a supply disruption in order to prevent a collapse of the system, i.e., hydraulic failure.
Recovery	The ability to quickly recover normal operations and repair system damage	• The time of year, i.e., a disruption in the beginning of winter may exhaust the stored gas, requiring time to refill and limits the ability to respond to subsequent disruptions. A disruption in the summer will have a different impact • The anticipated time, level of effort and expense required to restore a supply disruption.

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Key Conclusions

Key Conclusions

Summary of Key Findings

Key Finding	Description and Implications
Resiliency is mission-critical	Fundamentally, it is necessary for the natural gas system to be resilient to unexpected, low probability and high-risk impact events. The system must have characteristics that enable operators to manage threats and recover from disruptions quickly so that continuity of service can be maintained for customers when other physical and commercial resources that enable service are challenged.
Resiliency is not reliability and reliability does not always provide resiliency	System resiliency is as important to natural gas delivery as is reliability. Given an LDC's obligation to serve, a gas utility must seek to strengthen its resiliency while balancing the need for operational control, redundancy and emergency response capabilities, at a reasonable cost to ratepayers.
The North American natural gas system features high inherent resiliency	There are key features throughout the integrated natural gas value chain that allow for system resiliency, including a networked long-haul transportation system that connects natural gas production and underground storage, with distribution systems that deliver to end-users.
B.C. does not have high inherent resiliency	The province of BC is highly dependent on a single midstream pipeline for natural gas supply and has minimal on- and off-system storage, resulting in a system that does not have an abundance of inherent resiliency.
Resiliency solutions need to be customized to the specific resiliency need	A balanced portfolio of capabilities, i.e., the ability to maintain system pressure and provide customers with supply, that factor into resiliency is required to optimize for any given natural gas LDC.
On-system storage offers a wide range and unique set of resiliency benefits to FEI that other alternatives do not provide	There are certain aspects of system resiliency to the natural gas utility, its customers and to the communities it serves, that only on-system storage can provide. These include, emergency responsiveness, i.e., the ability to continue to provide reliable service in the event of a significant upstream pipeline disruption, the ability to prevent collapse of the system due to a drop in hydraulic pressure, and rapid response capability after a failure to avoid system collapse.

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Questions and Discussion

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Qualifications

Craig Sabine

- Craig Sabine is a Director in the Global Energy Practice at Guidehouse, leads the firm's Utilities and Energy Companies segment in Canada and is past Chair of Guidehouse's regulatory transformation initiative. Craig is a strategic partner and trusted advisor to Canadian utilities, energy sector organizations, the financial services sector and large energy consumers on strategic planning, investment decision making, risk management and other organizational challenges.
- Working with executive management teams, Craig focuses on the strategic market opportunities and regulatory challenges within and across the energy value chain and has supported regulatory filings related to system planning, cost allocation, affiliates, working capital and rate design.
- Craig is a recognized leader in the analysis of energy markets in Canada, including expertise in provincial regulatory and policy development. Notable impactful assignments have afforded Craig the opportunity to assess the gas supply risk management program of SaskPower, review the full cost risk in the Bruce Power refurbishment agreement, provide expert testimony regarding Manitoba Hydro's $25 billion capital investment plan and build an internal compliance program (ICP) for TransAlta related to NERC compliance.
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Paul Moran

- Paul Moran is Associate Director in the Energy, Sustainability and Infrastructure practice at Guidehouse, and is responsible for leading engagements for clients in the energy sector including electric and gas utilities, power generators, pipeline and midstream companies, gas storage operators, and LNG export project developers in addition to private equity and infrastructure funds.
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Energy and utilities

Our 750-strong practice - the largest energy and sustainability consulting team in the industry - combined with…

Public sector

…our deep experience with government and public sector clients on infrastructure, economic and workforce development initiatives

OUR EXPERIENCE

50 of the world's largest electric, water and gas utilities

20 of the world's largest independent power generators

20 of the world's largest gas distribution and pipeline companies

30 government clients on topics of infrastructure, growth and economic impact

OUR PEOPLE

39% racially diverse

8,000 employees

5 generations of professionals

5 employee affinity groups

50% **50%**

5% Veteran & Active Duty

OUR AWARDS

4 consecutive years

Forbes | 2019 AMERICA'S BEST MID-SIZE EMPLOYERS POWERED BY STATISTA

Great Place To Work. Certified APR 2019–APR 2020 USA

BEST PLACES TO WORK 2020 for LGBTQ Equality 100% CORPORATE EQUALITY INDEX

Malcolm Baldrige National Quality Award

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