A Bridge to the Future

The increasing role of natural gas storage in energy reliability.

A Black & Veatch Report

Prepared for Midstream Energy Holdings, LLC
September 2016
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Introduction

Black & Veatch Management Consulting, LLC (Black & Veatch) prepared this whitepaper on behalf of Midstream Energy Holdings, LLC (MEH). MEH retained Black & Veatch to examine the traditional and emerging new role of gas storage across the natural gas and electric industries. This white paper is a culmination of Black & Veatch’s expertise in gas-electric market reliability assessments and long-term market fundamental projections for the Rocky Mountain region and our experience in gas storage valuation methodologies.

About Black & Veatch

Black & Veatch Management Consulting, LLC is a wholly owned subsidiary of Black & Veatch Holding Company created to provide clients with comprehensive financial, technology and strategic consulting services within the electric, oil and gas and water markets.

Through our proprietary Energy Market Perspective, we have analyzed on numerous occasions and under various scenarios the current and future adequacy of natural gas infrastructure across North America and within specific regions. In addition to our fundamental market supply and demand forecast, we have created our Storage Valuation Advisor™ software to determine the intrinsic and extrinsic value of specific storage services. For additional information, please visit www.bv.com/consult.

About Midstream Energy Holdings, LLC

Midstream Energy Holdings, LLC owns and operates the East Cheyenne Gas Storage facility and is focused on developing, operating and acquiring midstream assets in the United States with an emphasis on high-deliverability, multi-cycle natural gas storage. The company was formed following the combination of Quantum NGS Holdings’ (a portfolio company of Quantum Energy Partners) two midstream asset development entities - Icon NGS, LLC and Merchant Energy Partners, LLC.

For storage facilities, Midstream Energy Holdings, LLC is active from the concept stage through commercial operations as well as evaluates the acquisition of in-process greenfield storage development projects and operating storage facilities that have significant expansion potential or can be operationally improved.
Executive Summary

NATURAL GAS FACTS

1. Natural gas storage is an integral infrastructure component in managing the growing variability in supply and demand.

2. Natural gas storage is key to future natural gas-fueled electric generation, including power generation facilities that provide quick response backup to intermittent renewable resources.

3. Natural gas storage offers increased liquidity, improved performance and maximization of profit to market participants.

Pipelines alone cannot deliver sufficient gas to meet all daily changes in demand — fast-response help from gas storage has proven to be essential. During cold winter episodes in the Rockies, such as in February 2014, day-to-day gas demand spikes of 25 percent or more require quick supply additions that only storage facilities are designed to provide.

Harnessing the abundant natural gas resources in the United States, and specifically within the Rocky Mountain region, cannot be achieved without the use of natural gas storage in locations where it is needed to support reliable delivery of gas to market participants. While pipelines can marginally alter gas capacities through temporary pressure changes, connection to natural gas storage facilities offers a far better solution by enabling pipelines to deliver significant volumes of gas on short notice.

The United States natural gas network is comprised of 305,000 total miles of pipeline and more than 400 underground gas storage facilities, including 30 underground gas storage facilities in the Rockies region. The region consumes about 2,200 billion cubic feet (Bcf) of gas per year and depends on storage facilities to assure on-demand gas services through an aggregated deliverable gas capacity of approximately 460 Bcf.

Underground natural gas storage facilities in the Rockies region serves an integral role in “banking” natural gas and assuring that the gas network can meet rapid changes in demand. For example, storage enables continual availability of natural gas to accommodate gas volumes produced or received by the Rockies region from pipelines connected to other producing regions, and assure flexible, on-demand swing supplies to consumers in the case of unforeseen events, such as extremely cold winter weather or other interruptions to natural gas production or supply.

Stored gas provides fuel reliability for gas-fired power generation — including the contingent supplies needed to provide gas-fired back-up for intermittent solar and wind power. At the growth rate expected for renewables in the Rockies, by 2020 a 20 percent increment for fast-response gas supplies might be needed to fuel quick response back-up generation for renewables, in addition to baseload power.
Emergence of solar, wind and other renewable power sources will modify the role of natural gas but is not expected to replace either gas or its storage assets for many decades to come. In fact, in states with the fastest rates of renewable energy deployment, natural gas networks have proven to be crucial to providing timely access to backup generation when conditions are unfavorable for renewable energy generation. The need for gas-fired generation to backfill for renewable power creates sudden demand for gas and requires rapid responsiveness available only from gas storage facilities.

The Rockies region is part of the territory where the Western Electricity Coordinating Council (WECC) promotes regional reliability. The overall renewable power portfolio in the area is expected to total 160,000 gigawatt-hours (GWh) by 2025, including 30 percent of power generated in Colorado by 2020 and 20 percent of power generated in Utah by 2025. The “flexible capacity” needed in the Rockies to back-up the expanded reliance on renewable power is estimated to be approximately 0.1 Bcf per day (Bcf/d) in addition to the requirement for about 0.5 Bcf/d to serve the baseload gas-fired portion of the portfolio. In effect, a 20 percent increment for fast-response gas supplies would be needed to provide renewable back-up.

Additionally, as state and federal regulatory targets for carbon reduction force utilities to decommission coal-fired electric generation plants in coming years, natural gas storage provides baseload and swing supplies to meet growing demand for clean, lower-emissions natural gas-fired electric generation.

**Gas storage supports market participants in making flexible choices, managing price risks and controlling overall portfolio fuel costs — which is especially crucial for utilities. Using an effective storage-based hedging program, a Rockies utility can expect to save 50 percent or more on prices paid for its stored gas compared with cash markets.**
Gas shippers often require flexibility not available from pipelines alone to reliably deliver gas to customers. Natural gas delivery requires reconciling — on monthly, daily and hourly timescales — imbalances between actual and nominated (planned) gas flows and the transfer of gas from one pipeline to another. To provide the otherwise missing flexibility, various gas storage facilities offer services such as balancing, no-notice service, park-and-loan and wheeling to make such adjustments possible.

Gas storage allows for cost-savings strategies, such as injections during the less expensive, lower demand summer season (typically referred to as the storage “injection” season) for use during peak pricing periods. The gas is held in storage and delivery is taken without paying the higher prices that would apply during the higher demand winter (or “withdrawal” season). For utilities, a hedge program leverages such price differences to provide the desired certainties for the cost of services, as the risks in the future purchasing prices in the winter months will be covered by the weighted average cost of gas (WACOG) in the summer plus associated storage and transportation costs. A physical storage asset is the only real asset that can provide hedges against daily gas price spikes. According to the National Association of Regulatory Utility Commissioners (NARUC), gas utilities use storage as a core hedging tool to manage price risk.

Market-based rates for storage-related services can be authorized to individual storage facilities by regulatory authorities and allow utilities and other market participants to negotiate for storage services under market conditions, thereby providing additional opportunities for cost-effective gas-supply portfolio management.

The Rockies region has experienced limited success in developing new natural gas storage projects. Since 2009, only three storage fields have successfully entered into sustained commercial operations, while other projects fell victim to bankruptcy or cancellation. Among the independent, full-capability storage facilities operating near key market hubs, East Cheyenne Gas Storage (ECGS) is the only successfully developed facility with jurisdictional market-based rates. For that and other reasons, ECGS is a good candidate to deliver the next, independently available incremental capacity to address future storage needs.

Principal stakeholders in the beneficial use of Rockies gas resources include gas producers, pipeline operators, storage operators, power generators, electric-grid operators, utilities and end-use consumers — plus the regulatory agencies which must find prudent balances among the needs for reasonable commercial profitability and the costs passed through to ratepayers. As demonstrated by NARUC’s attention to issues of gas-power coordination and integration, the most sustainable market and regulatory solutions for natural gas should be sought through collaborations involving all key stakeholders, including operators of gas storage, which remains a proven cornerstone of reliability and price risk management.
Workings and Advantages of Gas Storage

All consumers of natural gas — including industrial, commercial, electric power generation and residential customers — favor natural gas as an abundant, clean-burning and affordable fuel. A major part of overall reliability is the infrastructure and operational capability to safely store large volumes of natural gas until it is needed and then deliver the gas promptly and in the amounts required through the extensive national network of gas pipelines.

Natural gas is readily stored underground in suitable geologic formations including sandstones and limestones\(^1\). Geology provides the gas container - tank farms are not needed. Suitability and reliability for gas containment has been ordained and time-tested by nature — geologic reservoirs that held natural oil, gas or water for millions of years (now depleted) can be counted on to hold stored gas over any conceivable commercial period. Using mature petroleum engineering technology, gas can be repeatedly injected and withdrawn from underground storage through controlled and predictable methods that maximize safety and economic value to commerce and consumers.

As of 2014, more than 400 underground natural gas storage facilities were in operation in the United States (FiGURE 1), involving an aggregated complement of working gas capacity equal to approximately 4,800 billion cubic feet (Bcf)\(^3\). Within the Rockies region, there are about 30 storage facilities with a combined working gas capacity of approximately 460 Bcf (FiGURE 2).

FiGURE 1. NATURAL GAS STORAGE FACILITIES IN U.S. (Lower 48 States, Featuring the Rockies Region)

Source: Map prepared by Black & Veatch using location data from EIA

\(^1\)See Section 9: Glossary
\(^2\)https://www.aga.org/gas-storage
\(^3\)EIA U.S. Energy Information Administration natural gas statistics (including prices, production, consumption and others) are available online at: http://www.eia.gov/naturalgas/data.cfm
How Gas Storage Creates Value

Natural gas storage facilities are used to manage the time-dependent differences between the production of natural gas and the market’s demand for natural gas. The supply side, which flows from oil and gas wells, is relatively stable except for occasional interruptions by extreme weather or upsets in pipeline takeaway capacity. However, the ability to instantaneously ramp up or shut in upstream production to match downstream demand is very limited or prohibitively expensive. Downstream demand side is difficult to predict with daily granularity, being highly sensitive to changeable weather conditions. With both upstream and downstream being inflexible, storage facilities are crucial midstream assets for managing the gas supply and demand imbalances.
By design, gas storage facilities are made to rapidly accept excess supply into storage or just as quickly serve excess demand from previously stored volumes. Pipelines without storage support are significantly limited in their abilities to change internal gas volumes — their only tool is variation of pressure but differences between maximum and minimum safe operating pressures are rather narrow and inflexible. Connection to storage is essential to maximize pipeline potential.

Traditionally, storage facilities are used in seasonal terms, injecting gas in summer and withdrawing gas in winter, reflecting market views of supply, demand and price in a given month. Increasingly, pipelines, utilities and gas generators are using gas storage assets to manage peak daily and hourly operations, manage price volatilities and provide balancing and flexibility services to facilitate gas flows.

**Role of Gas Storage in the Rockies**

In the Rockies region, a depleted reservoir (a subsurface geologic unit which previously contained natural oil or gas) is the most common type of storage field. Depleted reservoir facilities for commercial gas storage have been established in Colorado, Montana, Nebraska, New Mexico, Utah and Wyoming. These facilities have reliably served the balancing of seasonal injection/withdrawal cycles as needed to sustain the Rockies gas needs, including accommodation of the gas produced from the numerous fields within the region.

Large swings in volumes of working gas in storage reflect the seasonal pattern of summer gas injections and winter gas withdrawals, including pronounced demands for withdrawals during unusually cold winters such as the Polar Vortex of 2013-2014 (FIGURE 3).

**FIGURE 3. HISTORICAL GAS STORAGE INVENTORY IN THE ROCKIES REGION**

![Graph showing historical gas storage inventory in the Rockies region.](image)

*Source: Weekly Working Gas in Underground Storage, EIA*

4Pipeline operators sometimes increase pressure to create “line pack” (more gas) or decrease pressure to create “line draft” (less gas) for short time intervals to help manage gas flow imbalances. However, the range of pressure available for such adjustments is constrained by safety rules and limits imposed by regulatory authorities.

5See Appendix: Glossary
Historically, pipeline takeaway capacity out of the Rockies enjoyed most of the development attention until Rockies gas production reached its peak in 2009. Thereafter, the dominant region of national gas production shifted to the northeastern United States — specifically, the Marcellus Shale underlying Pennsylvania, Ohio and West Virginia — thereby affecting flow directions and volumes in many pipelines. Indeed, since the emergence of Marcellus Shale production, some pipelines have reversed their flow directions to bring Marcellus Shale gas westward into the Midwest to compete with eastward-flowing Rockies gas. During the expansion of Marcellus Shale production, gas storage capacity in the Rockies region remained essentially unchanged.

Regardless of whether the gas is produced in the Rockies or received from other production regions, the need for responsive storage capabilities will remain essential for Rockies gas system reliability.

Compared to the Lower 48 United States in aggregate, the Rockies gas storage is less certain to be filled by summer injections but is equally sensitive to the peak winter demand, with a 95 percent correlation for the inventory level at the end of winter, if only a 64 percent correlation at the beginning of the winter. The approximate 64 Bcf swing in demand for stored gas, as measured between the largest withdrawal of 135 Bcf in 2013 and 2014 and the smallest withdrawal of 71 Bcf in 2011 and 2012 (FIGURE 3), demonstrates the essential ongoing role that storage plays in assuring flexible and reliable gas supplies.

In the broad view, the production source of the gas is less important than the capacity to store and deliver gas to all sectors of Rockies consumers when they need it. Regardless of whether the gas is produced in the Rockies or received from other production regions, the need for responsive storage capabilities will remain essential for gas system reliability.

New demand for gas-fired electric-power generation is expected to develop in response to both state and federal laws which aim to reduce air emissions, including sulfur and nitrogen gases and heavy metals. Colorado’s Clean Air Clean Jobs Act (CACJA) was enacted in 2010 with multiple provisions, including the conversion of 443 megawatts (MW) of power generation capacity from coal to gas. All states, including those in the Rockies region, will be affected by the Clean Power Plan (CPP) of 2015 as administered by the United States Environmental Protection Agency (EPA) to reduce greenhouse gas (GHG) emissions measured as equivalent carbon dioxide (CO₂e).

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6In meteorology, a polar vortex is a normal, high-latitude circular wind pattern above one of Earth’s polar regions. The Polar Vortex, as popularly named for the Winter 2013-2014 event affecting North America, occurred when a northern polar vortex moved frigid polar air unusually far southward into the conterminous U.S.


9CPP was officially published in the Federal Register on October 23, 2015 (Pages 64,661–65,120) as “40 CFR Part 60. Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units; Final Rule.” https://www.epa.gov/cleanpowerplan/clean-power-plan-existing-power-plants#CPP-final

A Bridge to the Future
Although renewable resources are expected to contribute to CPP-driven CO₂e reductions, intermittency of solar and wind power will require a prudent amount of gas-fired generation capacity in reserve to maintain power system reliability. Additional CO₂e reductions will be accomplished through CPP-driven replacement of coal-fired assets with gas-fired power generation in the base portfolios. Details of these anticipated new sources of gas demand are explained in a later section of this paper.

Although assuring reliability of the physical gas system is a paramount contribution made by gas storage, it also supports regional price discovery and liquidity. At locations where multiple gas pipelines interconnect with each other, or with major locales for gas production and consumption, market hubs emerge as price points for the full spectrum of gas transactions. Gas storage facilities located in close proximity to market hubs, such as the Cheyenne Hub near the Colorado-Wyoming border, play an enhanced role in supporting reliability of commerce as well as reliability of the physical system.

Gas storage facilities located in close proximity to market hubs, such as the Cheyenne Hub near the Colorado-Wyoming border, play an enhanced role in supporting reliability of commerce as well as reliability of the physical system.

Looking ahead, Rockies gas storage will play the following key roles:

- Accommodate gas volumes produced in the Rockies region or received from pipelines connected to other producing regions, including support for pipelines that do not own or operate storage assets.

- Assure flexible and on-demand swing supplies to consumers in response to changeable demand, including extreme cold weather events.

- Provide swing supplies and supply balancing to support growing demand for new gas-fired electric-power generation.

- Provide swing supplies and supply balancing to support gas-fired generation capacity which may be required to back up intermittent, renewable power sources.

- Support commercial gas price discovery and transaction liquidity at Rockies’ market hubs.
Traditionally, gas storage services have been used to manage imbalances in gas supply and demand. Storage has a key role within utility portfolios, mitigating daily gas price volatilities and peak demand risks. In addition to balancing seasonal demand and supply variations, storage provides essential, year-round risk management and reliability services across the value chain.

**Balancing Seasonal Demand and Supply**

The United States aggregated supply of natural gas is a combination of the gas produced domestically, the volumes held in storage and the dwindling amounts which are imported to meet unique needs of a few specific locales. In fact, the United States is well on its way to becoming a sustainable net-exporter of gas as a result of surging domestic production.

Total production of natural gas in the Lower-48 United States reached over 70 Bcf per day (Bcf/d) in 2016 (FIGURE 4); additional supplies of 2-3 Bcf/d arrive mostly through pipelines from Canada and a few, highly situational imports of liquefied natural gas (LNG) at locations inadequately served by pipelines.

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Both producers and consumers of gas — nationally and in the Rockies region — need storage to facilitate differences in timing between production and consumption.

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The annual peak of national gas demand — driven largely by winter heating needs — has been about 80-100 Bcf/d, with the excess demand relative to production being met using gas in storage. Baseline demand in all seasons includes industry, general commerce and gas-fired electric-power generation along with emerging categories of pipeline exports to Mexico and global LNG exports.

Thanks to year-on-year growth of domestic gas production, storage volumes withdrawn in winter have been readily replaced by injections during summer. Although peak winter demand varies by year, strong advances in production have enabled net growth of gas supplies since 2010 (FIGURE 4).
Going forward, as strong domestic production facilitates increasing exports, it is anticipated that the supply-demand picture will become more balanced with total market growth to exceed 100 Bcf/d over the next 20 years. Nonetheless, both producers and consumers of gas will continue to need storage services to facilitate differences in timing between production and consumption. Those storage needs will apply both nationally and regionally, including in the Rockies region.

Cost Savings for Seasonal Gas Supply

In transactional terms, a producer or seller of gas will continue to require storage for a certain volume of gas before it is taken for delivery by a gas buyer. Likewise, a buyer or consumer of gas will continue to require storage for a certain volume of gas where the exact timing of its consumption is difficult to forecast. Therefore, gas storage acquires a time-dependent financial value which is defined by the scope and circumstances of the transaction.

Storage may be a financially and operationally superior tool to hedge gas price risks for utilities, providing benefits that cannot be achieved through financial hedges.

For a gas market participant, the cost-saving strategy is to buy less expensive gas during the injection season, hold it in storage and then take delivery without paying the higher prices which would apply in cash markets during the high-demand withdrawal season. The general application of this strategy is the same in the Rockies region as elsewhere although details will vary with the needs of each market participant.

The cost-saving strategy is to buy less expensive gas during the injection season, hold it in storage and then take delivery without paying the higher prices which would apply in cash markets during the high-demand withdrawal season.
FIGURE 5. EXAMPLE OF STORAGE CUSTOMER USING FORWARD MARKET TO LOCK IN SEASONAL SPREAD

Intrinsic Value of Storage: Example from 2016-17 Gas Year

Injection/Withdrawal Amount - CIG Forward Curve, March 27, 2016

TABLE 1. EXAMPLE COST SAVINGS FOR A CONSUMER SEASONAL GAS STORAGE TRANSACTION

<table>
<thead>
<tr>
<th>ACTION BY CONSUMER (CAPACITY HOLDER) WITH COST-SAVING BENEFIT</th>
<th>SUMMER</th>
<th>WINTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Injection (Withdrawal), Dth</td>
<td>APR 50</td>
<td>JAN (50)</td>
</tr>
<tr>
<td>Forward Gas Price, $/Dth</td>
<td>MAY 1.550</td>
<td>JAN 2.907</td>
</tr>
<tr>
<td>Gas Sale (Purchase) Price, $</td>
<td>($77.50)</td>
<td>($83.65)</td>
</tr>
<tr>
<td>Gross Cost Savings to Capacity Holder, $/Dth</td>
<td>($1.296)</td>
<td>($145.35 - $77.50 - $83.65)/100</td>
</tr>
</tbody>
</table>

Source: ME NYMEX & ClearPort
An illustrative example of applying the storage-based cost-saving strategy can be shown for Colorado Interstate Gas (CIG) as the indicative storage provider (FIGURE 5; TABLE 1). In this example, a storage capacity holder of 100 dekatherms (Dth)\(^{10}\) can plan to inject gas in April/May 2016 and withdraw gas in January/February 2017, using a financial hedge built upon the then-current CIG forward prices and lock in a gross cost savings of $1.30/Dth\(^{11}\). Compared with buying gas in the cash markets during winter, the value of the storage-based, cost-saving transaction is equivalent to 55 percent of the higher cash price which otherwise would have prevailed during the winter gas-withdrawal season. Although results will vary with the exact terms of the transaction, the use of such seasonal spreads should benefit storage-based market participants with cost savings of 50 percent or more over alternative cash prices during the high-demand winter seasons.

For utilities, a simple hedge program as shown above will provide the desired certainties for the cost of services, as the risks in the future purchasing prices in the winter months will be replaced by the weighted average cost of gas (WACOG) in the summer plus associated storage and transportation costs.

**In the CIG example for the Rockies region, the value of the storage-based cost savings is equivalent to 55 percent of the higher cash price.**

Furthermore, as the forward price curve fluctuates throughout the respective monthly contract lifetimes, the storage capacity holder can revise the injection/withdrawal and related hedging positions to the extent such revisions will increase the cost savings to be realized from the storage operation. In that regard, storage is a highly desirable asset with real options for which higher price volatility actually increases the value of storage. It is a hedge not only to the price level, but also to the uncertainties (i.e., volatilities) in the prices\(^{12}\).

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\(^{10}\)Rather than simple volume (for example, Bcf), dekatherm (Dth) is the energy-content volume prescribed in most transactions. 1 Dth = 1 million British thermal units (MMBtu).

\(^{11}\)The gross cost savings is before payment of service fees charged by the gas storage operator. Such fees vary by storage facility and type of service but in the Rockies firm-storage fees are typically about $0.30/Dth to $0.30/Dth per month, including injection/withdrawal.

\(^{12}\)The simple example presented here represents a rolling-intrinsic approach to seasonal hedging. If different timelines or storage facilities are used together in a portfolio, a basket-of-spreads approach is another common strategy for capturing the extrinsic financial value associated with storage assets.
Hedging Daily Gas Supply Costs

A physical storage asset is the only real asset that can provide bona fide hedges against daily gas price spikes. Indeed, the National Association of Regulatory Utility Commissioners (NARUC) continues to find that gas utilities use storage as the core hedging tool to manage price risk.

Most of the benchmark gas-supply contracts have monthly granularity, uniform rates for gas flows inside the contract month and are premised on first-of-the-month (FOM) gas prices at their respective pricing points. To the extent there is unexpected demand (or supply interruptions) in the daily market, the purchase price of additional or replacement supplies — beyond the terms of the monthly contract — will be subject to the daily spot-price (cash market) volatilities.

As illustrated below for the Cheyenne Hub, differences between daily spot prices and FOM prices can be financially impactful when unplanned gas demand suddenly appears. In the example shown (FIGURE 6), extreme cold from the Polar Vortex of 2013-2014 created abrupt and intermittently large demands for gas, resulting in immediate and extended spikes in daily spot prices. Holding title to gas in storage would be the best way to limit effects of price spikes on a supply portfolio.

FIGURE 6. DAILY SPOT PRICE VS. FIRST-OF-THE-MONTH PRICE FOR GAS AT CHEYENNE HUB IN WINTER 2013-2014

Source: ME NYMEX & ClearPort

13Financial hedges, including use of futures contracts, options, collars, and swaps, can potentially benefit a balance sheet but they do not directly reduce the cost of buying the physical gas needed to serve customers.

14See, for example, presentations on risk and reliability made to NARUC at their committee meetings of July 24-27, 2016. https://www.naruc.org/summermeetings/agenda/
A gas consumer holding contracted capacity in a storage asset will be free to withdraw gas when new demand appears — contingent upon the capacity held and the physical deliverability which the storage facility can provide. By design, storage facilities can be responsive to the intra-month, intra-day and even hourly volatilities in demand, increasing withdrawals on high-demand days and returning to injections on low-demand days, thereby providing options for constraining negative impacts of price volatility.

Some storage operators offer additional daily flexibility by participating in services involving daily call options or swing-gas products — as contract instruments offered in the marketplace — but in the role of physical delivery of the gas as may be specified in the third-party contracts. Although the actual option or swing-gas contracts may be offered by gas marketers, the availability of such contracts is only possible when physical storage assets exist.

**Cost Reductions for Utilities**

To minimize overall cost, such as WACOG, for its gas-supply portfolio, an LDC must compare options for pipeline transportation services and storage services in light of customer load profiles and the expectations for sizes and durations of peak loads. In doing such comparisons, the large majority of LDCs finds that contracted storage capacity is essential for minimizing WACOG.

FIGURE 7 provides an example of such a comparative cost calculation for the Rockies based on the Questar rates for gas firm-storage service (FSS) and pipeline transportation service (T-1).

**FIGURE 7. COMPARISON OF QUESTAR STORAGE COST VS. TRANSPORTATION COST FOR GAS**

![Chart showing comparison of Questar storage cost vs. transportation cost for gas.](chart)

Source: Pipeline and storage costs calculated based on the Questar tariff; realized injection and peak day prices calculated based on Cheyenne historical daily prices between 2010-2016 (Platts).
The cost of pipeline transportation is calculated as the total annual demand charges divided by the number of days the transportation services are utilized, expressed in units of $/Dth. As shown in FIGURE 7, the normalized cost of transportation services (dark blue columns) and the normalized cost of storage services (solid blue line) both can be very expensive if used only for a small number of peak-demand days in winter. That is, unit costs are higher the less the services are utilized.

In this example, if only fixed costs are considered, the storage costs can be higher than the pipeline transportation costs. However, if seasonal hedges are used for storage by the utility as described in the preceding sections (FIGURE 5, TABLE 1), the actual cost to the utility is the net cost after the savings realized from the storage hedge. Namely, the net unit cost (dotted blue line) is the average realized prices during the corresponding days of services minus the average prices realized over the summer injection season.

Gas Supply Flexibility for the Gas Networks — Including Emergencies

Although utilities must dutifully compare and contrast costs for pipeline transportation and storage services, the fact remains that gas storage and gas pipelines are mutually supportive parts comprising the greater national and regional gas networks. Whether they are owned and operated by separate businesses or are integral to pipeline businesses, gas storage assets always have been essential players in providing flexibility to gas shippers using transportation services on pipelines.

TABLE 2 describes some of the key services which gas storage facilities provide to enhance the effectiveness of natural gas networks. In each case, the named service typically spares the gas shipper significant opportunity costs for rapid changes in plans. Going forward, as gas demand increases these services will take on increasing importance.

<table>
<thead>
<tr>
<th>FLEXIBILITY SERVICE</th>
<th>CAUSE OR CONDITION REQUIRING SERVICE</th>
<th>FLEXIBILITY PROVIDED BY GAS STORAGE*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly / Daily Balancing Service</td>
<td>• The actual metered receipts/deliveries for any individual shipper (or shippers in aggregate) differ from the nominated receipts/deliveries. • Pipelines allow specific tolerances for imbalances (usually % of nomination) beyond which financial penalties are applied.</td>
<td>• Storage allows surplus/deficit gas to be stored/withdrawn to reconcile imbalances. • Use of storage can reduce pipeline imbalance penalties otherwise charged to the shipper</td>
</tr>
<tr>
<td>Hourly Balancing/No-Notice Service (NNS)</td>
<td>• No-Notice Service (NNS) allows shippers to receive gas without nomination or significantly deviate from the nominated quantities, without incurring the imbalance charges. • It is useful for utilities to serve peak loads that are difficult to forecast or measure accurately. • Provided as rate schedules in some pipeline tariffs.</td>
<td>• Storage allows rapid withdrawal of gas to fill needs not previously contracted with a pipeline. • Especially valuable to utilities and power generators experiencing extreme peak loads</td>
</tr>
<tr>
<td>Park &amp; Loan Service (PAL)</td>
<td>• A shipper is faced with an unexpected excess or deficit of gas which cannot be handled through regular imbalance procedures – requiring the need to “park” or take out on “loan” (i.e., borrow) a certain amount of gas. • Provided as rate schedules in some pipeline tariffs.</td>
<td>• Storage allows shippers to “park” (temporarily inject) or take out on “loan” (temporarily withdraw) gas for a contracted period of time. • Shippers use storage PAL to mitigate unexpected demand or supply interruptions. • Works best when the storage facility has multiple pipeline connections.</td>
</tr>
<tr>
<td>Wheeling</td>
<td>• Gas supply as managed by shipper requires gas transfer from one pipeline to another</td>
<td>• Storage connected to multiple pipelines allows shippers to inject receipts from one pipeline then withdraw to deliver into a second pipeline.</td>
</tr>
</tbody>
</table>

*Contingent upon suitable storage contracts and appropriate deliverability by the subject storage facilities. A storage facility may be a stand-alone business with pipeline connectivity or part of a pipeline company.
Gas storage is expected to play an increasingly important role over the next 20 years and longer — both to continue existing, crucial services and to help sustain reliability in a rapidly changing framework of energy supply and demand.

The key areas where gas storage will be essential include:

- Facilitating changing directions and volumes of gas pipeline flows — ongoing changes in production sources and demand centers require the capability to make rapid adjustments to the gas networks.
- Assuring reliable and responsive fuel support to new, baseload gas-fired electric-power generation — retirement of coal-fired and nuclear power plants in favor of gas-fired plants requires rapid response to changing fuel demand.
- Providing flexible back-up support to renewable power generation — power grid stability requires quick-start, gas-fired power generation to smooth out the intermittency of wind and solar power sources.

**Facilitate Changing Directions and Volumes of Gas Pipeline Flows**

Since 2009-2010, gas production from shales and other unconventional plays has significantly redefined supply sources relative to demand centers (FIGURE 8).

**FIGURE 8. EMERGING CHANGES TO U.S. NATURAL GAS NETWORK**
Traditional production sources along the Gulf Coast fed pipeline flows headed north and east, surging production from the Marcellus Shale has begun to reverse some pipeline flows. In light of those changes, including declining pipeline imports from Canada, traditional eastward gas flows from the Rockies are likely to refocus on westward flow toward Pacific Coast demand centers.

As pipeline flows change, storage assets will be required along each revised flow pathway. Regardless of the source or ultimate destination of the gas, the flexible services provided by storage will be needed for gas network reliability.

**Fuel Reliability for Gas-Fired Power Generation**

The share of gas-fired electric power generation in power supply portfolios is steadily increasing both regionally and nationally — driven by favorable economics of abundant and affordable gas and by emissions-reduction imperatives such as the Clean Air-Clean Job Act and CPP. Gas storage is essential to making this fuel-based transition successful.

The Black & Veatch Energy Market Perspective (EMP)™, projects that a total of 49 gigawatts (GW) of coal-fired electric-power generation capacity will be retired across the United States by 2020, and that it will be replaced by a combination of natural gas-fired combined-cycle and combustion turbines as well as renewables (FIGURE 9). For the Rocky Mountain region, approximately 35 percent (6 GW of total 17 GW) of coal-fired capacity is estimated to be retired by 2020 as a consequence of facility age, regulations or economics (TABLE 3).

Combined-cycle gas units replace retired coal units as baseload resources while combustion turbine units satisfy regional reserve margin requirements. United States natural gas demand for power generation is expected to grow by 5 Bcf/d by 2020 and by nearly 15 Bcf/d by 2040 under the CPP. New gas-fired plants will require must-run fuel reliability as provided by gas storage.

New baseload, gas-fired power generation means that there will develop a new, elevated baseline for the required delivery of fuel gas for must-run generation facilities. New gas-fired reserve generation can be expected to intermittently demand fuel on short notice. Ongoing and upgraded gas storage will be necessary to assure reliability of the natural gas fuel supply for all gas-fired power generation — both baseload and reserve.

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“Risks to natural gas generation during summer season — not just a winter problem.”

- John Moura (July 2016), presentation to the National Association of Regulatory Utility Commissioners (NARUC)

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15The Black & Veatch Energy Market Perspective (EMP)™ is a proprietary market analysis which is updated twice per year for subscribers. The EMP is designed to capture both the broad policy assumptions and detailed structural market representations to arrive at a consistent, integrated view for gas and power markets.

16Renewable power generation is understood to include wind, biomass, geothermal, small hydroelectric, solar photovoltaic (PV) and solar thermal infrastructure.

Flexible Fuel Supply for Power Generation

As driven by the CPP and state laws such as the Clean Air-Clean Job Act, and in accordance with the renewable portfolio standard (RPS) adopted individually by each United State, renewable power generation will continue to develop in parallel with gas-fired power generation to achieve necessary reductions in air emissions while also meeting electric load growth. Some renewable resources enjoy development subsidies such as the federal government’s solar Investment Tax Credit (ITC)\(^8\). Growth of distributed solar generation also is being financially incented by some utilities such as the Public Service Company of Colorado\(^9\).

In addition to any other state programs, the implementation of the CPP will include an individual rate-based (pounds of CO\(_2\)e per megawatt-hour [lb CO\(_2\)e/MWh]) average for each state\(^{10}\). Based on the
current expectations of generation capacity changes and regional plans to reduce emissions, states along the Pacific Coast are likely to meet the CPP targets under existing plans. However, states like Montana, North Dakota and Wyoming will need to retire the coal plants and add natural gas, renewables, and demand-side resources in order to comply with the CPP.

The Rockies region is part of the territory where the Western Electricity Coordinating Council (WECC) promotes regional reliability. Overall, annual RPS requirements for western states will total 160,000 gigawatt-hours (GWh) by 2025, including 30 percent RPS for Colorado by 2020, and 20 percent of portfolio goal for Utah by 2025. Idaho, Wyoming, and Nebraska currently do not have any mandated RPS goals. Other states such as Oregon have legislation in place that will establish a 50 percent RPS by 2040 that will limit electricity imports from coal plants in the Rockies.

The eastern part of the Rockies and the Plains states, including North Dakota, South Dakota, Iowa, Kansas and Oklahoma, have rich wind-power resources that have reached grid parity with other generation sources. Additional economic wind power built in these states might exceed their respective RPS goals and targets.

The top-level WECC view for the Rockies region is that wind-power generation distributed across diverse locations will help reduce the amount of flexible (back-up) capacity required as long as substantial coal-fired generation remains part of the state portfolios. However, emissions-driven coal retirements, as discussed above, will require gas-fired generation to become the principal back-up for wind power in the Rockies. In the high-renewables power curtailment scenario analyzed by WECC, as much as 10 percent of the renewable-generation capacity could require gas-fired back-up. Accordingly, the gas-fired back-up for Rockies renewable power in 2020 would be approximately 0.1 Bcf/d of gas in addition to the requirement for about 0.5 Bcf/d to serve the baseload gas-fired portion of the portfolio. In effect, a 20 percent increment for fast-response gas supplies would be needed to provide the back-up for renewables.

Gas-fired back-up for Rockies renewable power in 2020, in effect, would require a 20 percent increment for fast-response gas supplies in addition to that needed for baseload gas-fired generation.

Using Gas Storage to Load-Balance Solar Power

In successfully preparing the Rockies region for the changing power-generation framework, it is beneficial to review how the State of California is recognizing the underappreciated role of natural gas in making renewable power usable.

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18As created by the Energy Policy Act of 2005 (P.L. 109-58), the Investment Tax Credit (ITC) is a 30 percent federal tax credit claimed against the tax liability of residential (Section 25D) and commercial and utility (Section 48) investors in solar energy property.
20Basic formula for the state is pounds of CO₂e from affected sources, divided by state electricity generation (MWh) from affected sources.
22These estimates use data in Table 3 and assume the following: Combined-cycle gas turbine heat rate of 7,000 Btu/kWh; fuel energy content of 1,030 Btu/scf; generation capacity factor of 25 percent; flexible capacity average requirement of 10 percent. The actual range calculated for required back-up gas was 0.06 Bcf/d to 0.17 Bcf/d.
In California, solar is the lower cost renewable technology. To comply with the state RPS, 33 percent by 2020 and 50 percent by 2030, California load-serving entities will procure about 15,000 MW in utility-scale solar power by 2020 and just over 25,000 MW by 2030. The addition of this much solar to the system will impact natural gas demand on a daily and seasonal basis. Solar power will displace daytime natural gas-fired generation and push natural gas demand towards the daily super-peak period of Hour Ending (“HE”) 17-20 (5-8 PM) (FIGURE 10) when natural gas-fired turbines are needed to meet power demand—unless (or until) a breakthrough in battery technology and proliferation of battery-storage infrastructure can provide additional solar-generated power.

FIGURE 10. AVERAGE ELECTRICITY PRICES PROJECTED FOR SOUTHERN CALIFORNIA IN 2030

Although the simple plan would be to use solar power in daytime and gas-fired power at night (FIGURE 10), the practical realization has been that daytime solar can be adversely affected by cloudy weather with only marginally effective predictability. In the opposite scenario, when renewable generation exceeds forecasts, natural gas-fired generation will need to be curtailed. In this scenario, natural gas storage is needed to house nominated but unused gas.

California has recognized that gas-fired generation must be able to start multiple times a day, ramp down when the sun is shining, and restart quickly to meet evening peaks. Indeed, the California Independent System Operator (CAISO), which manages California’s electric grid, requires a specific amount of flexible capacity to counteract day-to-day effects of intermittent renewable power (FIGURE 11). With fast ramping capabilities, natural gas-fired combined cycle units or combustion turbine units provide the majority of 8,000-10,000 MW of the flexible capacity that is required by the electric grid. Natural gas storage is needed to follow the hourly load curve because such large load variation will likely exceed line packing capabilities of natural gas pipelines.

As gas-fired power generation is the primary source of Flexible Capacity required by CAISO, gas storage is increasingly important for load-balancing fuel demand for gas-fired power units. In that regard, the loss of functionality of the Aliso Canyon gas storage facility — California’s largest — in late 2015 led CAISO to predict as many as 14 days of power interruptions during summer 2016.

Using Gas Storage to Load-Balance Wind Power

Wind-generated electric power is subject to intermittent availability based on variable wind strength and duration that cannot be perfectly forecasted. Therefore, loads otherwise served by de-rated wind power must be backed by other resources, such as gas-fired generation facilities.

One example of how natural gas storage has been used to balance wind generation uncertainties came during a day in December 2014, when the actual gas burn on the Public Service Company of Colorado (PSCO) system exceeded the nomination by approximately 200,000 Dth/day due to the combination of coal unit outage and low wind output. Withdrawals from storage were used to support increased gas-fired power generation to meet demand. Conversely, when wind generation exceeds the forecast, gas-fired generation can be ramped down, resulting in gas injection into storage.

Cost Savings From Hedging Against Spikes in Winter Prices

For all of the reasons discussed above, natural gas storage will be called upon to provide baseload and emergency-response services to maintain reliability of both the gas network and electric-power generation networks of different sizes. In all cases, baseload and intermittent demand for gas will remain subject to spikes driven by extreme cold weather events. The Polar Vortex of Winter 2013-2014 illustrates demand spikes of the type that can be mitigated by storage-supported gas flexibility.
On February 5, 2014, the temperature in Denver dropped to -19 degrees Fahrenheit (F) - a near record low. From February 4 to February 5, heating degree days (HDDs) in Denver increased 27 percent. Nationally, gas demand jumped more than 15 percent in one week. Large withdrawals of gas from storage reduced overall stored inventory nearly 33 percent below the five-year average.

The extreme conditions caused regional pipelines to issue multiple critical notices and operational flow orders (OFO) limiting gas supplies due to lack of production and/or transportation constraints. Demand spikes from disrupted gas flows created spot-market price spikes. Among the several pricing points in the Rockies and adjacent markets, Cheyenne Hub registered the highest prices with a $15/Dth premium in excess of the SoCal gas prices.

Based on the cost-savings example presented previously (Balancing Seasonal Demand and Supply), gas consumers without storage capacity suffered the full impact of the weather-driven price spikes. But consumers holding storage capacity were able to mitigate their costs significantly.

The future occurrence of another Polar Vortex event remains unknown. However, the value of gas storage to protect against supply disruptions and price spikes will remain strong as long as the necessary facility and commercial infrastructure stays healthy.

**FIGURE 12. SPOT MARKET GAS PRICES DURING THE POLAR VORTEX OF WINTER 2013-2014**

HDDs are a first-order variable used by load forecasters to predict heating demand. Weather data from U.S. National Weather Service, Denver-Boulder CO Office, Form CF-6 for February 2014.


Some examples included: (1) Colorado Interstate Gas Company, L.L.C (CIG) warned about underperformance at receipt points and place performance caps on the receipts; (2) Kern River warned about supply shortfall in the Opal gathering area and low line pack status, and limited shippers’ ability to undersupply the physical receipt points or overdraft the physical deliveries; (3) Southern Star Central curtailed interruptible services to its customers; (4) Tallgrass curtailed interruptible storage withdrawals; (5) The downstream LDCs, including PG&E, Southwest, and SoCal Gas declared OFO and restricted services to their customers.
There is approximately 160 Bcf of working gas storage capacity in the Rockies production area that includes Colorado, Wyoming and Utah. This storage capacity includes facilities located close to the market center or interconnected through regional pipelines.

The Rockies can be further divided into the western and the eastern markets. The western market is primarily served through the Opal Hub with inter-regional exports through Kern River, Ruby and Northwest Pipeline. In the eastern market, Cheyenne Hub provides gas supplies to the Rockies Express pipeline, accesses the Oklahoma and Kansas markets through Trailblazer, CIG, Cheyenne Plains and KM Interstate, and serves the growing Denver and Front Range markets (FIGURE 13). The Cheyenne Hub is served by approximately 60 Bcf of nearby natural gas storage, including facilities associated with CIG, Trailblazer, TIGT and Public Service Company of Colorado (PSCO). The subject pipelines have tariffs that incorporate peak-shaped storage services to address the hourly balancing and other flexibilities needed by power-generation customers.

Among the storage facilities in the key Rockies market areas (TABLE 4), East Cheyenne Gas Storage (ECGS) and Ryckman Creek Resources LLC (Ryckman Creek) are the independent storage facilities with market-based rates approved by the Federal Energy Regulatory Commission (FERC). In addition to the traditional firm and interruptible storage services, ECGS provides hourly balancing for power generation, renewables build-out and mitigating risks from gas price volatility.

FIGURE 13. LOCATIONS OF ROCKIES REGIONAL GAS STORAGE FACILITIES

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28East Cheyenne and Ryckman Creek are independent in that neither is owned or operated by an interstate pipeline company.
FIGURE 14. CHEYENNE HUB INTERCONNECTIONS AND ECGS

Source: Velocity Suite, ABB Enterprise Software
<table>
<thead>
<tr>
<th>FACILITY</th>
<th>STATE</th>
<th>PIPELINE INTERCONNECTIONS</th>
<th>FLEXIBILITY SERVICES OFFEREDA,B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>BALANCING</td>
</tr>
<tr>
<td>EAST CHEYENNE GAS STORAGE LLC (Peetz West)</td>
<td>CO</td>
<td>Trailblazer</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Potential: Rockies Express Pipeline, Tallgrass Interstate Gas Transmission, CIG, Xcel, Southern Star and Cheyenne Plains</td>
<td></td>
</tr>
<tr>
<td>WILLISTON BASIN INTERSTATE PIPELINE (Baker)</td>
<td>MT</td>
<td>WBI</td>
<td>(*)</td>
</tr>
<tr>
<td>KINDER MORGAN INTERSTATE GAS TRANSMISSION (Huntsman)</td>
<td>NE</td>
<td>Tallgrass</td>
<td>(*)</td>
</tr>
<tr>
<td>EL PASO NATURAL GAS COMPANY (Washington Ranch)</td>
<td>NM</td>
<td>El Paso</td>
<td>(*)</td>
</tr>
<tr>
<td>QUESTAR PIPELINE COMPANY (Clay Basin)</td>
<td>UT</td>
<td>Questar, Northwest</td>
<td>+</td>
</tr>
<tr>
<td>RYCKMAN CREEK RESOURCES LLC (Ryckman Creek)</td>
<td>WY</td>
<td>Kern River, Questar, Northwest, Overthrust, Ruby</td>
<td>+</td>
</tr>
</tbody>
</table>

Notes:

*Services offered in addition to basic storage (injection/withdrawal) of gas. See Table 2 for description of service details.

*Capabilities based on active use. + = Service available and scheduled per approved tariff for this facility. (*) = Service identified as part of an approved tariff for a larger pipeline system which includes this facility.
Need for More Gas Storage

Rockies gas production is not going away and neither is the need for gas storage. In fact, as argued above, the need for additional gas storage will become more important as gas and electric markets adjust to multiple economic and regulatory forces.

Despite growth in northeastern gas production, principally from the Marcellus Shale and Utica Shale, Rockies gas production (Power River Basin, Green River Basin, Piceance, Uinta, Wind River, Big Horn, and Raton Basin) has been holding steady, only down slightly from its peak of approximately 12 Bcf/d reached in 2009.

Going forward, Black & Veatch projects stable to growing gas production in the Rockies to support the western market, including the role of Rockies gas in displacing declining pipeline imports from Canada. In addition, there is a large amount of potential and probable gas in the Mancos Shale (Piceance Basin)\(^29\). Those yet-to-be-developed Rockies gas resources will be important as gas production peaks and declines in other regions beyond 2020 and greater attention returns to other prospects, including Rockies gas plays.

Yet, the Rockies region has experienced limited success in developing new natural gas storage projects. Since 2009, only the CIG storage fields Totem and Latigo (both in Colorado) and ECGS have successfully entered into sustained commercial operations\(^30\). Several other projects, such as Windy Hill, Blue Sky, and Leader One, either have withdrawn or canceled their projects completely. In December 2015, the Magnum storage project filed for relocation of the facility and extension of the FERC approval that was received in March 2011\(^31\).

ECGS is a good candidate to deliver the next, independently available incremental capacity to address future storage needs\(^32\).

Benefits for Open Commerce: Market Access

The Cheyenne Hub has been in operation since 2000 and it provides important trading liquidity and flexibility for regional gas flows. It is the site of interconnections to eight interstate and regional pipelines with considerable support from the associated gas storage.

Using ECGS to provide balancing and wheeling services can improve the operations of Cheyenne Hub. ECGS has received FERC waiver of the “Shipper Must Have Title Rule” that allows it to obtain off-system capacity to provide injection and delivery services at the Cheyenne Hub\(^33\). Therefore, ECGS can be considered as virtual storage directly at the Cheyenne Hub.

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\(^{30}\) Totem, Latigo and East Cheyenne were independently certificated by FERC in 2010 and Ryckman Creek in 2011. As of 2016, Ryckman Creek was operating under protection of the U.S. Chapter 11 bankruptcy code.


\(^{32}\) ECGS developed plans (currently on hold) for a phase II expansion.

\(^{33}\) FERC Docket CP10-34-000
Natural gas underground storage has a long, proven track record in keeping national and regional gas pipeline networks flowing reliably and helping gas utilities effectively manage their supply portfolios at the lowest possible costs. As environmental and regulatory policies drive the retirement of baseload coal-fired electric-power generation, gas-fired generation will become increasingly important as will the role of gas storage in assuring reliable fuel supplies.

Emergence of solar, wind and other renewable power sources will modify the role of natural gas but is not expected to replace either gas or its storage assets for many decades to come. Experience within states that have aggressive rates of renewable energy deployment, such as California, demonstrates the crucial role of the natural gas network and natural gas storage. The need for gas-fired generation to backup for renewable power creates sudden demand for gas that only gas storage facilities can fulfill.

The role of gas storage in the Rockies region is of equal or greater significance relative to national needs for integrated gas-power reliability. A combination of regulatory policy and economics is driving growth of new gas-fired power generation in the Rockies that will require fuel supply flexibility that is available only through gas storage.

Despite clear needs for natural gas storage in the Rockies region, few storage projects have been developed since 2009. The East Cheyenne Gas Storage facility is a notable example of the type of capability required to serve the Rockies region as well as the commercial connections between the Rockies and neighboring regions.

Principal stakeholders in the beneficial use of Rockies gas resources include gas producers, pipeline operators, storage operators, power generators, electric-grid operators, utilities and end-use consumers — plus the regulatory agencies which must find prudent balances among the needs for reasonable commercial profitability and the costs passed through to ratepayers. As demonstrated by NARUC attention to issues of gas-power coordination and integration, the most sustainable market and regulatory solutions for natural gas should be sought through collaborations involving all key stakeholders, including operators of gas storage, which remains a proven cornerstone of reliability and price risk management.
Expanding Importance of Natural Gas Storage Services in the Rocky Mountain Region

Natural gas storage is an integral infrastructure component in managing the growing variability in supply and demand.

- Accommodate Rockies gas supplies when there is insufficient demand or during periods of pipeline interruptions,
- Assure flexible, on-demand swing supplies to consumers in the case of unforeseen events, such as extremely cold winter weather or other interruptions to natural gas production or supply.

Natural gas storage is key to supporting the expansion of lower-emission electric generation, including a growing share of natural gas-fueled baseload generation facilities and facilities that back up intermittent renewable resources.

- Supports fast ramping needs for gas–fired generations resulted from the “duck curve”.
- Provides a home to nominated but unused gas if renewable generations exceed forecasted levels (avoids curtailing renewable power).
- A 20 percent increment for fast-response gas supplies would be needed to provide the renewables back-up in the Rockies by 2025.

Natural gas storage offers increased liquidity, improved performance and maximizes profits to market participants.

- Gas storage supports market participants in making flexible choices, managing price risks and controlling overall portfolio fuel costs.
- A physical storage asset is the only real asset that can provide hedges against daily gas price spikes.
- According to the National Association of Regulatory Utility Commissioners (NARUC), gas utilities use storage as the core hedging tool to manage price risk.

ECGS is a good candidate to deliver the next, independently available incremental capacity to address future storage needs.

- The East Cheyenne Gas Storage facility is a notable example of the type of capability required to serve the Rockies region as well as the commercial connections between the Rockies and neighboring regions.
- ECGS is considered a virtual storage hub at Cheyenne Hub and can provide the needed balancing and wheeling services to improve operational capabilities.
Natural Gas Industry & Storage Background Terms

Underground storage of natural gas developed along with the United States national gas pipeline network and remains integral to the success of pipeline systems. The first-ever such storage facility in the United States was the Zoar Field near Buffalo, New York, which opened for business in 191634.

The many strong advantages of underground natural gas storage include the following:

- Geology provides the gas container — tank farms are not needed — and cumulative geologic knowledge identifies the best prospects for each storage location

- Suitability and reliability for gas containment was largely ordained and time-tested by nature — reservoirs that held natural oil, gas or water for millions of years can be counted on to hold stored gas over any conceivable commercial lifetime

- Development and operation of underground gas storage fields can be effectively and reliably accomplished using oilfield technologies matured over more than 100 years

- Gas can be repeatedly injected and withdrawn from underground storage in controlled and predictable ways that maximize safety as well as economic value to commerce and consumers

Capabilities of underground gas storage facilities are compared using three main performance characteristics:

- **Working Gas** capacity is the volume of stored gas deliverable to consumers

- **Total Gas** capacity includes working gas plus an additional volume of Cushion (Pad) Gas which is used to pressurize the working gas to keep it deliverable. Working gas and cushion gas exist together in the same reservoir and define the total field gas.

- **Deliverability** denotes how fast stored working gas can be withdrawn (Bcf per day) to serve demand.

As of 2014, the Rockies region was host to 30 different underground gas storage facilities comprising, in aggregate, 464 Bcf of working gas capacity, 913 Bcf of total gas capacity and deliverability of 3.9 Bcf/d.

The Rockies region hosts the single largest underground storage field in the United States at the Baker Field in Fallon County, Montana, with a working gas capacity of 164 Bcf and a total gas capacity of 287 Bcf.

Sandstones, limestones and salt beds (or domes) are the gas storage reservoirs of choice.

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**Depleted reservoirs** (sandstones or limestones originally filled with oil or gas before resource extraction) constitute the majority of underground gas storage reservoirs in the United States and host about 81 percent of United States gas in underground storage.

**Aquifers** (similar to depleted reservoirs but filled with brine or other non-potable water) are useful storage formations in some regions, especially the United States Midwest, but altogether they hold only about 9 percent of United States gas stored underground.

**Salt caverns** are highly effective storage reservoirs where geology is supportive, including numerous Gulf Coast locations, and represent about 10 percent of United States gas in underground storage.

Rockies storage reservoirs are almost exclusively of the depleted reservoir type although three Rockies facilities are built in aquifers: Questar storage fields in Utah (Coalville and Chalk Creek) and in Wyoming (Leroy).

Gas storage facilities are regulated by federal and state government agencies.

- As of 2014, 74 percent by number of all United States gas storage facilities were regulated principally by state agencies with the remaining 26 percent regulated by the Federal Energy Regulatory commission (FERC).
- FERC typically has purview over facilities which are connected to interstate gas pipelines and therefore are engaged in interstate commerce. FERC has authority to approve market-based rates for such facilities.
- State agencies regulate storage businesses which are not under FERC purview and typically will monitor technical operations and maintenance for all facilities within their respective borders.
- The **Pipes Act of 2016**[^35] authorized and required the Pipeline and Hazardous Materials Safety Administration (PHMSA) to establish operational safety requirements by June 2018 for all United States gas storage facilities.
- Gas storage facilities might also become regulated in the context of greenhouse gas (GHG) emissions if the United States Environmental Protection Agency (EPA) establishes such inclusive rules. As of 2016, no EPA GHG rules exist for gas storage facilities although EPA announced a formal Information Collection Request (ICR) which may affect later rules for all oil and gas facilities[^36].


[^36]: “EPA’s Actions to Reduce Methane Emissions from the Oil and Natural Gas Industry: Draft Information Collection Request for Existing Sources,” U.S. Environmental Protection Agency, May 16, 2016, 4 p.
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