

Promise Delivered

Examining Trends in the United States Natural Gas Underground Storage Utilization

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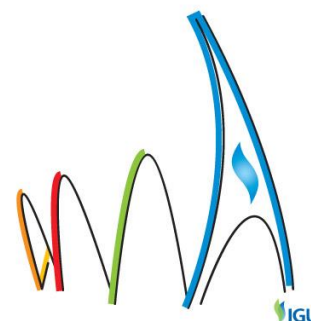
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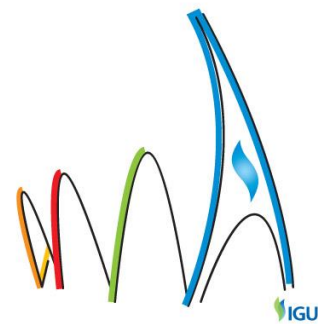
"GROWING TOGETHER TOWARDS A FRIENDLY PLANET"



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Background

By early April 2003, working gas inventories in U.S. underground storage facilities had fallen to below 650 billion cubic feet (Bcf) after beginning the winter heating season at 3,172 Bcf in late October 2002. At the end of that winter heating season, analysts and others were asking the obvious question of whether storage inventories could be sufficiently refilled in time to meet the requirements of the next winter—seven months away. History has taught us that the answer was yes; and, as history repeats itself, the familiar question was asked again following the 2013-14 winter heating season.

With record withdrawals from underground storage of three trillion cubic feet (Tcf) in the United States during the period November 1, 2013 through March 31, 2014, lessons were learned from the performance of this critical supply asset. This paper explores the storage-related metrics associated with the 2013-14 winter heating season in the US and examines the management of this supply tool, which is essential to meeting customer needs in winter. The choices made by storage providers and operators during critical winter days underlie the reliability and resiliency of the US natural gas system.

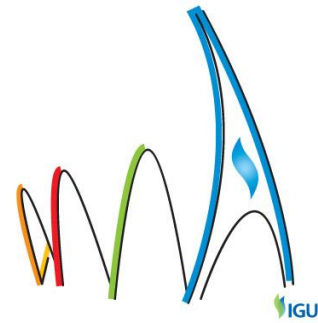
One of the most critical factors that makes natural gas reliable, efficient, affordable and available for customers in North America, even during periods of peak demand, is that it can be stored. Every year natural gas is injected into storage during the refill season (April - October), then transported for peak period consumption, primarily during the winter. In fact the U.S. has the largest natural gas storage system in the world along with the largest and most fully integrated pipeline system. Within this context, storage represents a physical hedge against weather-induced market uncertainty and can also serve as a price hedging tool. However, much has changed regarding the overall natural gas market during the decade following 2003, including domestic production and resource expectations, shifts in sector demand, pricing, and other measures along the natural gas value chain.

United States Underground Storage: Lessons Learned

Lesson # 1

The storage pie is larger today than it was ten years ago.

- By the end of the 2003-04 winter heating season, U.S. working gas inventories in underground storage had not surpassed the 3,300 Bcf historic mark, according to the Energy Information Administration (EIA).
- At the start of 2004-05 winter heating season (November 2004), there were more than 420 natural gas storage sites across the country, holding 3,327 Bcf of working gas (record volumes at the time). This launched a period of expansion and upgrades to underground storage facilities.



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- Today storage sites number close to 400; however, “operationally full” working gas routinely measures at 3,800 to 3,925 Bcf. The *Demonstrated Maximum Working Gas Volume* for U.S facilities is now more than 4.3 Tcf, according to the Energy Information Administration.
- Local gas utilities own about one-third of the existing U.S. storage capacity and contract for approximately another third from interstate and intrastate pipelines. The balance is owned by marketers and independent operators. Pipelines also own and operate some storage capacity, mainly for system integrity management.
- Local distribution companies (LDC) primarily use underground storage as a supply asset designed to meet peak demand loads and sustained demand pulls, principally during the winter heating season. As such, LDCs generally complete storage refills by mid-November, leaving more discretionary storage decisions to other players.

Lesson # 2

Storage is a dynamic supply asset capable of meeting seasonal load variability.

Traditional perceptions and realities of storage facility dynamics often focus on the flexibility of salt caverns (in terms of deliverability and cycling capability) relative to depleted reservoirs or aquifers. This view of underground storage infrastructure is fundamental to understanding asset utilization and function in today’s natural gas market. That said, facilities operate not only on an individual basis but also on a regional and national scale, collectively providing a vital and diverse supply source during critical demand periods.

- During the five winters immediately prior to the 2013-14 winter heating season, natural gas customers (all sectors) required as little as 1,483 Bcf of natural gas from underground storage (November 2011 - March 2012) to as much as 2,261 Bcf (November 2010 - March 2011) during peak winter demand periods.
- For the aforementioned five-year period, storage accounted for about 17 percent of winter heating season consumption on average in the United States. In Figure 1 below, net storage volumes are shown as a positive supply asset and net storage injections as a negative.

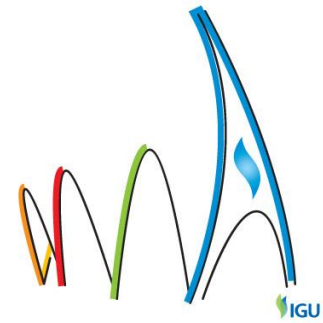
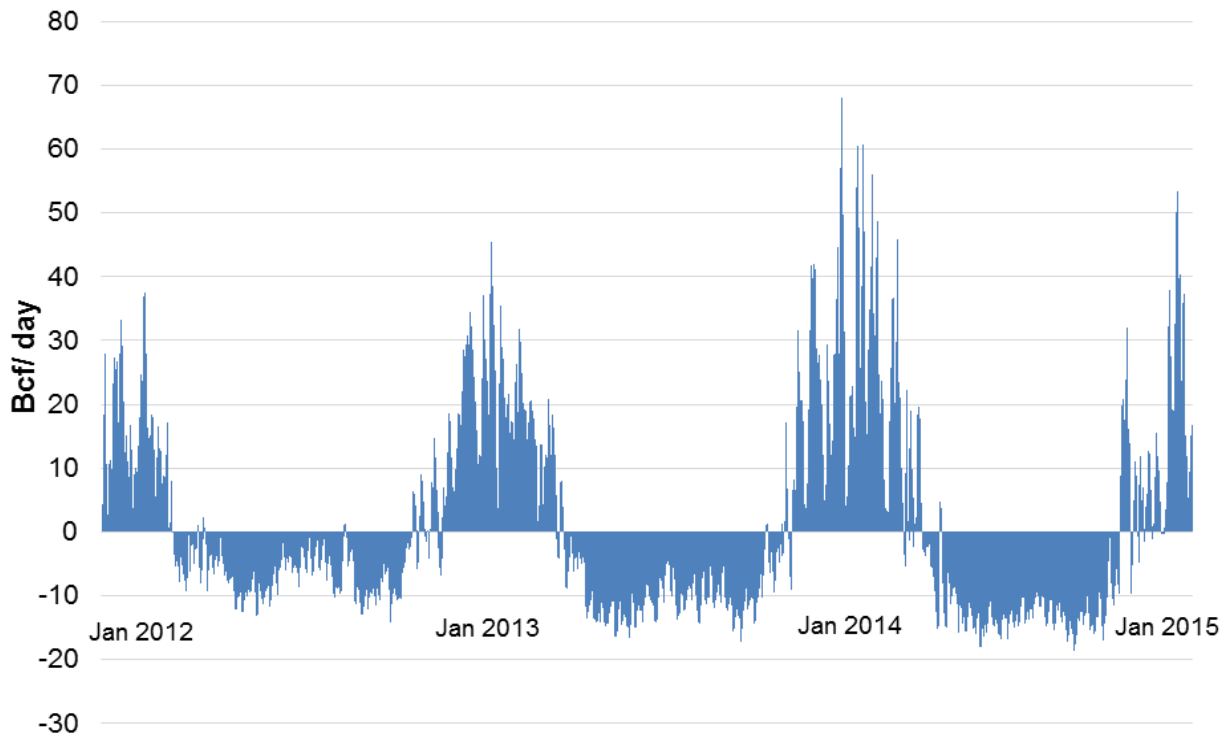


Figure 1: Net Daily Change in Natural Gas in Underground Storage
(Jan 1, 2012 – Jan 22, 2015)¹

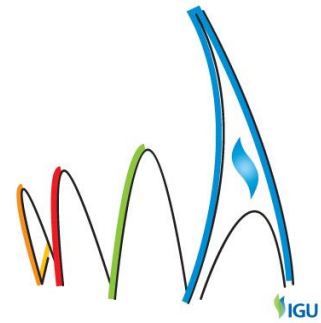


- During the 2013-14 winter heating season, natural gas demand was higher as was utilization of underground storage assets. For the first time in history, more than 3 Tcf of gas was required from working gas inventories (net withdrawals being 3,012 Bcf to be precise), and storage accounted for 22 percent of the natural gas consumed. Figure 1 illustrates this recent growth in seasonal utilization of this supply asset.

Lesson # 3

Domestic natural gas production has grown, and this influences expectations regarding summer underground storage injections.

- This growth in domestic natural gas production serves not only as a flowing supply resource for growing end-user demand but also as additional supply for an increasing summer cooling power generation load and for storage injections during the summer refill months.
- Dry natural gas production in the lower-48 states averaged 52 Bcf per day in 2003.



- Domestic gas production will average over 67 Bcf per day in 2014—a 29 percent increase from 2003.

Lesson # 4

Natural gas-fired power generation surges during the same periods in which natural gas heating loads peak, so on a cold winter day underground storage in effect serves both natural gas and electric power loads.

- During January 2014 natural gas to power generation ranged from about 14 Bcf on a relatively warm winter day to 31 Bcf on January 7 (the coldest day of the past winter in many regions), according to Bentek Energy.
- Natural gas-fueled power production surges in concert with natural gas peak heating demand. While seasonal variability in natural gas demand continues to be dominated by residential and small commercial customer heating loads, winter demand for power generation is gaining prominence and is expected to continue to grow.
- Natural gas also serves power generation loads in the United States during the cooling season (summer months) primarily for air conditioning. In the case of 2014, cooling requirements were modest (summer peaks Hardly more than winter peaks for natural gas delivered to power generators shown in Figure 2) and production continued to increase. Therefore, strong sustained injections into underground storage were possible.

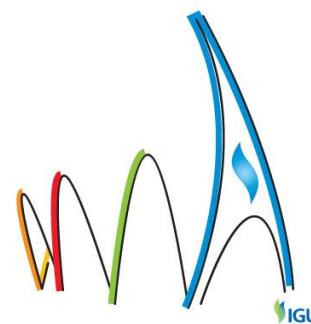
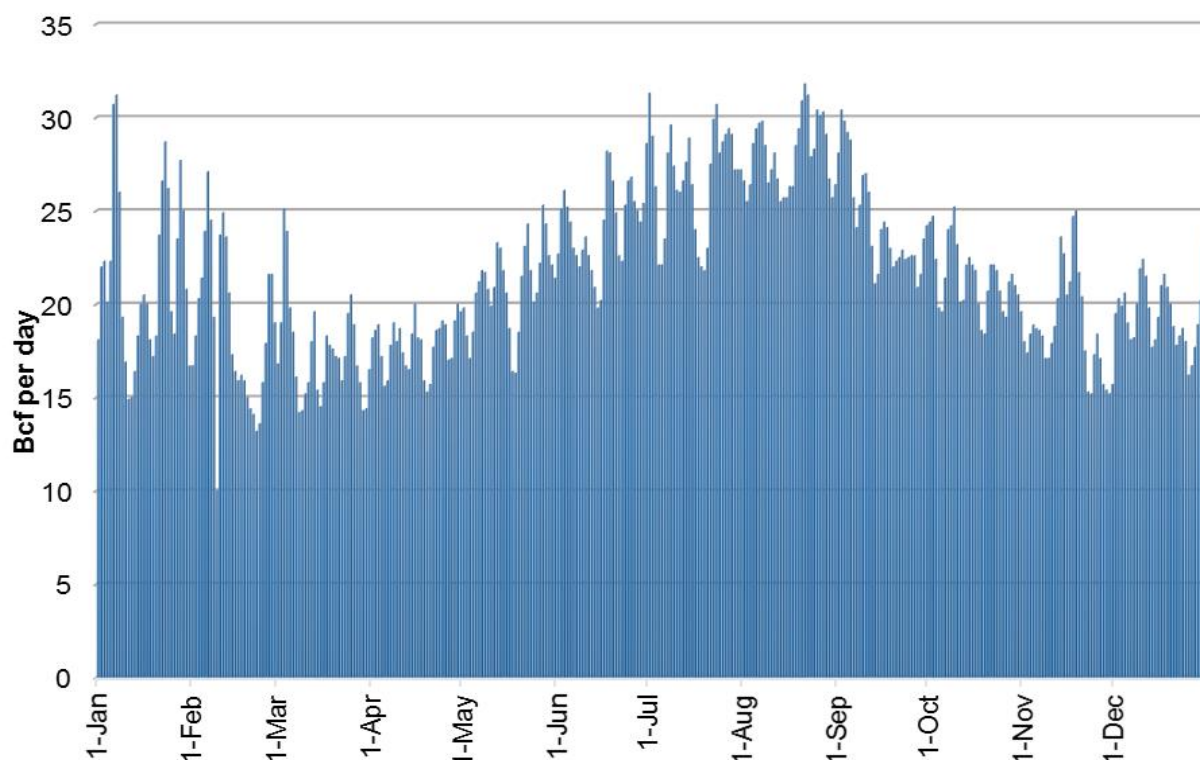


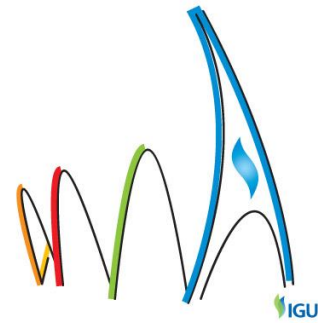
Figure 2: Natural Gas into Power Generation 2014²



Lesson # 5

The traditional view of underground storage injection patterns may not tell the whole story.

- Following the 2002-03 winter heating season, when domestic underground storage inventories dipped below 650 Bcf, many US storage operators invested in facility improvements to enhance daily deliverability. For example, new wells were drilled in existing fields and compression and other upgrades were completed.
- With the upgrades came capacity additions—via new facilities and expansions to existing ones—as well as reclassifications of base gas to working gas and vice versa, depending on the field. The impact of these improvements was a net increase in the design capacity of more than 400 Bcf over the ensuing 10 years.
- The domestic underground storage system is now larger and more adaptable than a decade ago, recognizing that certain facility types, such as shallow aquifer facilities,

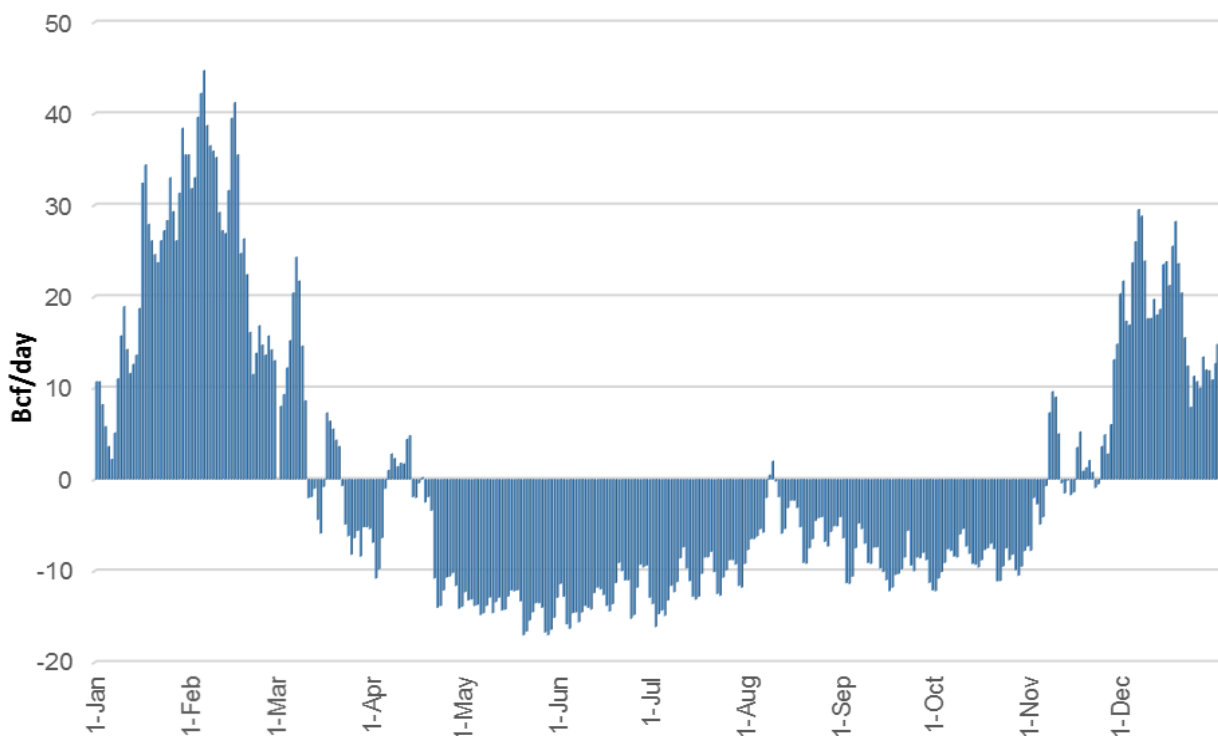


are not as flexible in terms of cycling (or inventory turnover) capability as salt caverns or high permeability depleted reservoirs, but all storage provides valuable flexibility for operators in balancing daily supplies with daily demand.

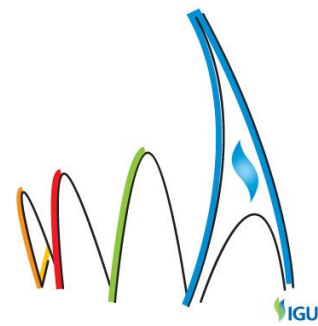
- Traditional patterns of storage management appear to be giving way to newer trends.

Figure 3 represents daily *net* injection patterns for U.S. underground storage during calendar year 2007—the traditional view. Positive values are net winter heating season withdrawals and thus represent a supply source, while spring and summer injections are depicted as negative supply volumes, captured as working gas inventories for those days. The traditional storage management pattern is evident in this chart, where stronger seasonal injections are made in the May-June period, followed by brief storage withdrawals in the middle of summer due to draws from power generation (a relatively recent development at the time), and wrapping up the refill season with a declining injection slope in the September-October period, as facilities fill up and reservoir pressure builds.

Figure 3: Daily Net Underground Injections and Withdrawals – 2007³

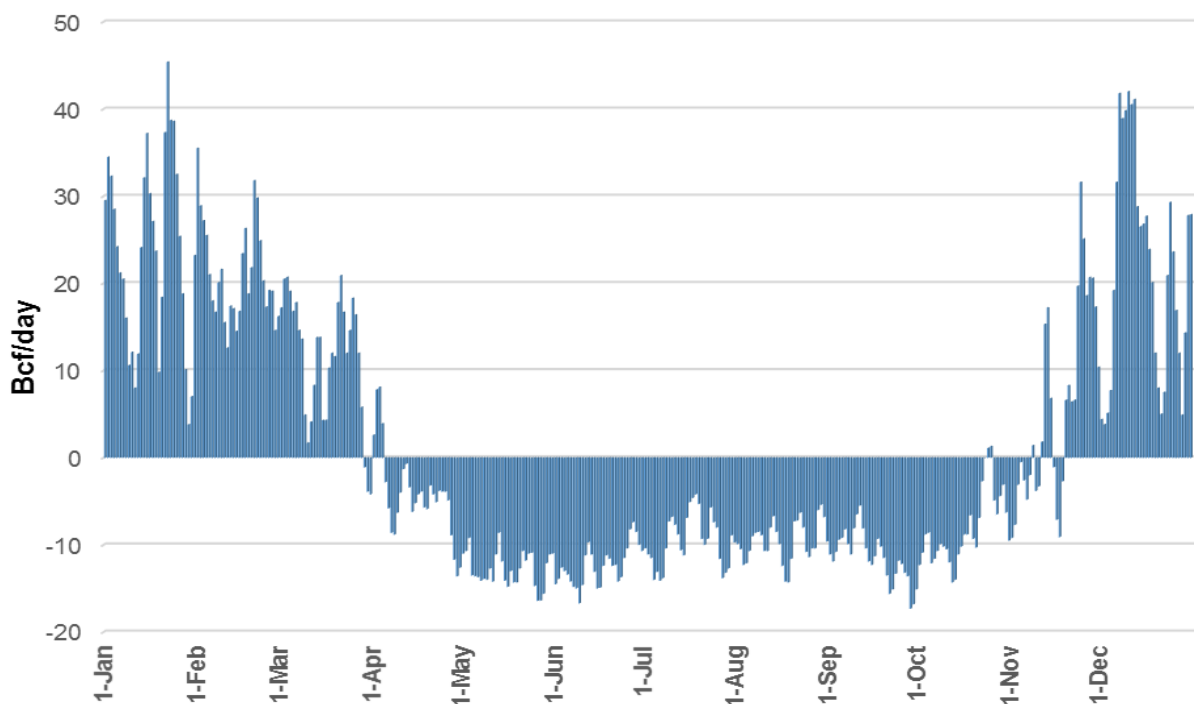


A look at calendar year 2013 (Figure 4) and calendar year 2014 (included in Figure 1) show at a minimum subtle changes to the traditional pattern of storage management, and at best, a shift to a new norm in injection practices. During 2013, the early to mid-injection season (May-August) was as expected—strong in May and June, followed by declining injections as natural gas to power generation competed with natural gas injection volumes.



However, the later injection season pattern was decidedly different than in 2007. In fact, daily storage injections in September and October 2013 were as strong as those made during the early spring and summer an observation repeated in 2014. While many reasons drive injection decisions—particularly concerning discretionary volumes outside utility winter heating season planning—it is likely that cumulative improvements to underground storage facilities as well as capacity additions and expansions (mainly salt caverns and depleted reservoirs) have ultimately changed the industry mindset regarding underground storage utilization and management practices.

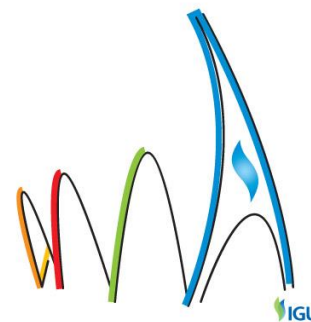
Figure 4: Daily Net Withdrawals and Injections into Underground Storage 2013⁴



Lesson # 6

The 2013-14 winter heating season was the first real winter test of this *new* underground storage system and of the entire natural gas value chain.

Sustained periods of frigid temperatures across a wide swath of the lower-48 states, framed by successive winter events, particularly in January and February 2014, challenged the durability and reliability of the natural gas delivery infrastructure. The degree to which natural gas system performance was tested is unprecedented.



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However, the natural gas system had evolved during the preceding decade, enabling it to withstand this test. Domestic production (bolstered by "shale gale") increased significantly, storage infrastructure grew in capacity and flexibility, pipelines expanded in build-outs and capacity (although not equally in all regions), and regulatory structures evolved.

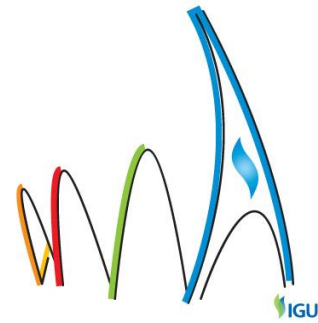
The following observations from AGA members regarding their individual underground storage utilization during the first quarter of 2014 reflect this winter's experiences and the new realities of the underground storage system.

- *Highest seasonal volume withdrawal in fifteen years.*
- *The extended extreme cold winter of 2013-14 resulted in a heavy demand for stored natural gas. A record single-day withdrawal was set on January 7, 2014, and the withdrawal season ended with a record low working gas inventory of 3 percent. This was a good test of our storage system, which performed as expected despite heavy demand.*
- *Here is a short summary of some of the winter conditions. January 4th - 6th produced 17 inches of snow with drifts pushing 4 feet. The wind chill ranged from -20 to -40 degrees. During that time, Gas Control needed a maximum rate, resulting in three of us (field men) getting our trucks stuck within sight of each other. Some wells within range, we walked to, and then we shoveled our trucks out and were able to plow our way in. This scenario played out much of the harsh winter. The horizontal wells really made it possible to deliver gas in a short time.*
- *Because of supply demands and shortages, storage supply was more critical for a longer time than in the recent past. Our operators worked almost double the normal overtime in order to address and prevent any developing issues in a timely manner and to ensure that storage field volumes were available.*

Lesson # 7

The influence of storage assets on natural gas markets and physical system reliability does not end with the completion of a winter heating season.

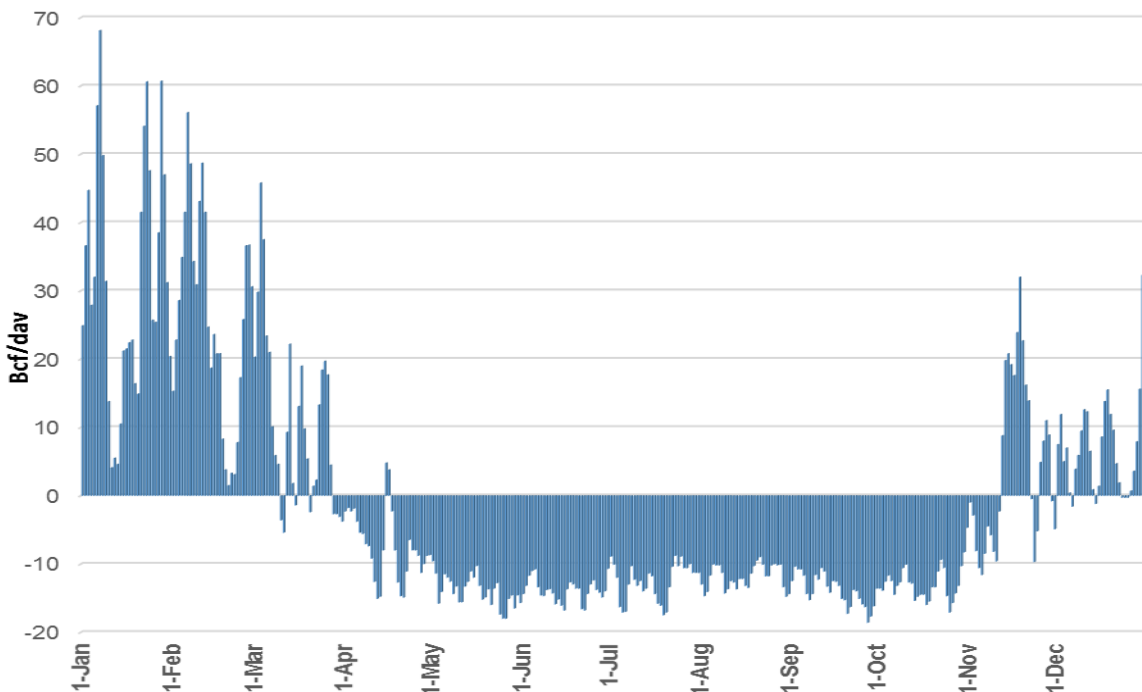
- As noted in Lesson 3 above, natural gas production in the United States has grown significantly during the past decade. Coupled with growth in underground storage capacity these domestic assets form the backbone for meeting increased natural gas consumption during critical high demand periods of the five month US winter heating season. Imports from Canada and even liquefied natural gas imports play a role, also.
- However, the relationship between domestic production and underground storage does not stop there. US dry gas production now averages over 70 Bcf per day. That is 70 Bcf per day or more in the winter, the spring, the summer and fall. Total gas



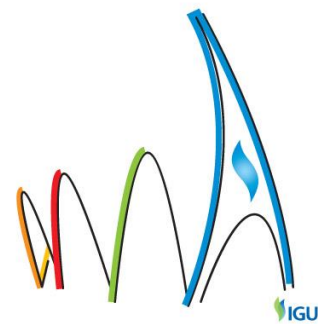
consumption in the United States from April 1 to November 1 averages less than 70 Bcf per day, in fact, less than 60 Bcf per day for much of that period. Flowing supplies beyond daily consumption must be directed somewhere and essentially go to underground storage.

- This, of course, not only permits underground storage capacity to be filled for the coming winter but offers opportunities for location and price arbitrage of gas resources during what amounts to a more than 200 day net storage injection season. Today, gas directed to storage injections competes with natural gas directed to power generation for summer cooling loads in the US.
- Figure 5 shows the strong and consistent pattern of storage injections from April 2014 to November 1. In fact, the summer injection season for 2014 resulted in record net increases in working gas for the period – nearly 2.8 Tcf injected before net withdrawals first appeared in November. A more normal “strong” net injection season during the past decade would have resulted in 2.2-2.3 Tcf of working gas increases.

Figure 5: Daily Net Withdrawals and Injections into Underground Storage 2014⁵



During the 2014 summer, demands on natural gas for power generation were modest and domestic production was flowing at record volumes. This combination provided the



opportunity for storage inventories to recover from the record volume of gas utilized from underground storage from November 2013 through March 2014.

This observation serves another conclusion that has evolved for the past decade and more. The US natural gas industry is no longer a seasonal business driven only by the need to perform reliably during a five month winter heating season. The five month core of the summer injection season (May through September) can just as easily influence the price and availability of natural gas for a coming winter, as power generation loads and net injection requirements compete for natural gas supply during the now critical summer months.

Conclusion

Each of "lessons learned" identified in this narrative point to an understanding of the underground storage of natural gas and its impact on current markets, as well as service reliability to customers. As a natural gas supply asset within a portfolio of assets available to local gas utility planners, underground storage has evolved, has grown and has increased its value in sustaining system integrity, service to customers and even arbitrage opportunities in support of price discovery. It is a physical hedge for supply planning and, importantly, is a critical part of what makes the domestic natural gas system the most flexible and enduring in the world.

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