State Policies for Local Energy Collaboration

LOCAL ENERGY COLLABORATION PROJECT PRELIMINARY REPORT – TOPICAL PERSPECTIVE

IRESN

Perspective – Resiliency of the U.S. Natural Gas System[1]

Ron Edelstein

January 2018

Thanks to the shale gas revolution, the United States has abundant supplies of natural gas, with up to 100 years of technically recoverable reserves.[2] Since 2010, gas production has grown by almost 30 percent, with production reaching a record of (average) delivery of nearly 75 Bcf (billion cubic feet) of natural gas per day, or over 27 Tcf (trillion cubic feet) per year.

Residential and commercial customer demand for natural gas has remained steady, with industrial demand growing from 6.6 quads (Quadrillion BTU's) in 2008 to 7.9 quads by 2017. Power generation demand has grown the most rapidly, increasing from 6.6 quads in 2008 to 9.2 quads in 2017. Total consumption has risen from 22.2 quads in 2008 to 27.1 quads by 2017, as note above.[3]

Given this rapid increase in demand, despite increased reserves being available, questions have arisen as to the reliability and resilience of the natural gas system. We distinguish between the two terms, reliability and resilience:

> Reliability - the quality of being trustworthy or of performing consistently well
>
> Resiliency – the capacity of a system to recover from perturbations

Thus, reliability can be measured in terms of equivalent availability or equivalent forced outage rate. Resiliency measures are more difficult, but might be: "The ability to withstand and reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to, and/or rapidly recover from such events."[4]

So, we will explore why the natural gas system is reliable as well as resilient, despite increases in demand. We will also look at contract arrangements, that is, "firm" vs. "interruptible" contracts, and what this means for reliability.

---

[1] Natural Gas Supply Association, "Natural Gas Systems, Reliable & Resilient" July 2017
[2] Potential Gas Committee, "Biennial Report of Potential Supply of Natural Gas in the United States", 12/31/2014
[3] https://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm
[4] FERC, "Grid Resilience in Regional Transmission Organizations and Independent System Operators", Issued January 8, 2018.

From an MIT study[5]:

"The [U.S.] natural gas network has few single points of failure that can lead to system-wide propagating failure. There are a large number of wells, storage is relatively widespread the transmission system can continue to operate at high pressure even with failure of half the compressors, and the distribution network can run unattended and without power. This is in contrast to the electricity grid, which has, by comparison, few generating points, requires oversight to balance load and demand on a tight timescale, and has a transmission and distribution network that is vulnerable to single point, cascading failures."

The intrinsic characteristics of the natural gas system are important factors in this set of conclusions. Unlike the electric grid, where electricity travels at the speed of light along the path of least electrical resistance, natural gas is pressurized by a series of compressors that moves it through the system. In contrast to the speed of electricity, natural gas moves through the gas system at about 15-20 mph on average. This allows *time* for pipeline operators to manage the flow of natural gas and to adjust their operations in the unlikely event of a disruption or disruptions in the system.

On the supply side, natural gas production comes from diverse geographic supply areas in the U.S. and Canada. There are over half a million producing gas wells spread across thirty states. There are hundreds of natural gas producers, with even the largest contributing less than five percent of supply. This diversified supply is connected to an extensive pipeline network, with over 300,000 miles of gathering lines and transmission pipe and over 1.3 million miles of gas mains, and over 65 million gas service lines (900,000 miles).

Another unique characteristic quality of natural gas is its ability to be stored, in contrast to electricity, where storage is limited to lifting of water in hydro systems and the emerging battery storage and other limited alternatives (e.g., compressed air storage or systems relying on inertia of a spinning body). Natural gas is most commonly stored in underground formations, mostly depleted gas or oil reservoirs (80%) or aquifers (10%) or salt caverns (10%). Other alternatives are available for gas storage, including LNG peaking and offshore facilities, CNG storage. There are about 400 underground storage facilities in 30 states. In fact, over 4 Tcf of working gas is stored in underground facilities in the U.S. About 20 percent of natural gas consumed during the heating season comes from underground storage.[6]

Gas storage provides operational flexibility in the event of constraints in the pipeline or distribution network, or wellhead interruptions.

The natural gas system is not particularly vulnerable to weather related events. Natural gas systems are primarily underground and protected from inclement weather. Natural gas systems are far more resilient than electric systems. In 2016, fewer than 100,000 natural gas customers (out of 65 million) experienced disruption, compared to 8.1 *million* (out of 110 million) electric customers.[7]

[5] MIT, "Interdependence of the Electricity Generation System and Implications for Energy Security", 5/15/2013
[6] www.energyinfrasturcture.org
[7] EIA, Electric Monthly Table B2, "Major Disturbances and Unusual Occurrences", 2016

According to an INGAA survey[8] of 51 interstate pipelines, over a ten-year period (2006-2016) gas pipelines delivered 99.79 percent of "firm" contractual commitments (more on firm vs. interruptible service later).

During the 2014 "polar vortex" event that stretched across the United States, natural gas was delivered nationwide at a rate of 137 BCF in a single day, almost double average daily deliveries (See above). Despite unprecedented levels of demand, the gas industry honored *all* firm fuel supply and delivery contracts.

In the Southwest U.S. 2014 electricity outages, with historically cold weather conditions, NERC[9] noted similar findings, with only 50,000 gas customers experiencing curtailments, compared to 4.4 million electricity customer outages. The gas outages were due to well freeze offs (some electricity driven) and, ironically, shutoffs of some electricity-powered gas compressors by the electricity system operator. Less than 10 percent of electric outages were due to fuel supply problems. (Other electric system issues included ice formation on wind turbine blades).

Other characteristics of the U.S. gas system contribute to its reliability and resilience. The gas transmission system is composed of interconnected pipelines that offer redundant, alternative flow pathways. Often, two or more pipelines are laid in the same right-of-way, making it possible to shut off one loop while keeping the other operating.

In the event of compressor failures (like in the SW outages due to electric compressors), natural gas pipelines can usually continue to operate at pressures necessary to maintain deliveries, at least outside the affected segment, allowing them to continue to deliver gas to downstream customers.

In the event of a well or wells failure (like the well freeze offs), with hundreds of thousands of gas wells available, plus gas storage, the upstream supply system offers multiple pathways to continue to supply gas when needed.

The natural gas system is also focused on cyber security, working with the Federal and state governments and within the industry, using ISAC (Information and Sharing Analysis Centers) as an adaptive tool to share information across the industry, and with other critical infrastructure sectors. For instance, the gas/water/electric nexus and increased interdependencies has long been a focus of NARUC (National Association of Regulatory Utility Commissioners) meetings.

So, we have discussed the high reliability of gas delivered to firm customers. What does it take to be a firm customer? First, a little background. Since the U.S. natural gas system has been restructured in the 1990's, natural gas pipelines no longer own the gas they ship through their systems. Thus, they have become for the most part, "common carriers." So, for a gas utility, large, industrial, or power generation customer to ensure firm contractual arrangements, they must arrange for two things: firm supply commitments *and* firm capacity arrangements (that is, reserving pipeline capacity). Interruptible service, on the other hand, is less expensive, but in the event of cold weather, or unforeseen events, the firm customers, like gas utilities, will receive the gas first. In the past, many

[8] INGAA,
[9] NERC, Southwest Cold Weather Report

large industrial customers and electric utilities got used to reliable service under interruptible contracts, but this is not assured. Bottom line: If one wants reliable service, one must be a firm customer.

In the event of extreme situations that require that action be taken to maintain the operational integrity of the system or maintain natural gas service to high-priority customers, state statutes allow a gas utility to curtail services to some customers. These state requirements give highest priority to "essential human need" customers, like residential customers or hospitals or schools without short-term alternatives. As a result, other natural gas customers, like power generators, need to be aware of these requirements. Alternatives can be maintained, including onsite LNG or CNG storage.

Underground gas storage is a critical and integral part of the nation's natural gas supply and delivery system. With over 4.7 Tcf, of working gas in storage, some located close to load centers, the gas storage system is a critical link in ensuring gas system reliability and resiliency.

In conjunction with a storage discussion, the Aliso Canyon incident should be mentioned. While regrettable, it involved one well, much gas (up to 5 Bcf) released to the atmosphere, and the temporary shut-down ordered by state regulators of 113 other wells in the gas storage field. Over 50 of these wells have been returned to operation.

So, how does the reliability and resiliency of the nation's natural gas system effect the use of natural gas for community-based clean energy systems? Given the reliability and resiliency of the natural gas system, firm delivery of natural gas for local power generation and direct gas use offer a partnership to renewable systems at the local and community level. Individual gas-fired home CHP or distributed generation systems offer many advantages to the homeowner and community. Direct use of natural gas is a "natural fit" with heat-actuated absorption cooling or hot water systems power by solar.

The ability of today's natural gas system to survive weather incidents is critical to ensuring micro-grids, municipal electricity grids, hospitals, universities, and homes can continue to have heat and hot water *and* local power generation.

Remaining issues? Resiliency of natural gas systems under fire conditions needs to be investigated. The underground facilities should be safe, but what about meter sets, in-home gas lines, above ground compressor stations and vaults? Contractual arrangement (firm vs. interruptible) need to be investigated as well as state requirements to serve essential human need customers first. It does little good to have local gas generators on interruptible service in extreme weather or other events.

In conclusion, the nation's natural gas system is not susceptible to widespread failure from a single point of disruption in the same manner as the nation's electricity system. The redundant nature and underground location of the nation's supply, transmission, and storage systems mean low vulnerability to weather events. The resilient nature of the system allows it to come back on line quickly in the rare event of a natural or manmade disruption. Natural gas should continue be part of the nation's future energy system, in partnership with renewable and other options, and can help to ensure continued energy system reliability *and* resiliency.