SWEEP Southwest Gas Study

June 2022

Rod Walker & Associates Consultancy

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1 Introduction

1.1 Scope

The purpose of this study is to conduct a technically rigorous and independent analysis of the Southwest Gas distribution systems, with a focus on the utilities' service territories in Arizona and Nevada. The analysis will be conducted by an independent, technical expert and focus on key system components. Study partners seek an in-depth understanding of the Southwest Gas system as it relates to the safety, reliability, emissions profile, and the public health impacts of the utilities' operations.

The study will focus on seven major topics:

- SWG's Natural Gas Infrastructure
- Franchise Agreements
- Safety and Equity
- Fuel Usage/Delivery
- Alternative Fuels
- Fuel Switching/Electrification
- System Resiliency

This study was prepared by Rod Walker & Associates Consultancy (RWA). RWA is a unique team of former utility executives with broad industry and technical experience. The team includes members that have worked in various roles with large gas pipeline and distribution companies – serving in leadership roles in multiple acquisition due diligence and asset integrations and management.

This team is led by Rod Walker - an industry executive who brings thirty-seven years of technical engineering expertise and business acumen combined with deep organizational optimization, M&A, and Due Diligence experience to lead organizations and serve as a trusted advisor to clients in the energy industry domestically and worldwide.

This study is sponsored by the Southwest Energy Efficiency Project (SWEEP), in partnership with GridLab and in close collaboration with the groups that comprise the Energy Foundation coalitions in Arizona and Nevada.

1.2 Approach to Analysis

1.2.1 General

To accomplish the scope of this project as described above, RWA began its analysis using publicly available data. Public data sources include:

- Infrastructure data sourced from the Pipeline and Hazardous Materials Safety Administration (PHMSA);
- Benchmarking data available through the American Gas Association (AGA);
- SWG testimony and other filed documents in various dockets in Nevada and Arizona;
- Testimony and other filed documents in various dockets in other states;
- Emissions-related benchmarking data collected and summarized by the Environmental Protection Agency (EPA);
- Energy data from the US Energy Information Administration (EIA);
- Publicly available studies, research papers and academic articles from various experts in relevant fields;
- The most recent IPCC climate report drafts and workpapers; and
- Publicly available forms filed with the SEC such as 10Ks
- Other generally available public information found on the internet such as news articles, city, and county websites, the SWG website, internet archives, etc.

1.2.2 Peer Group Benchmarking

For the purposes of performing a benchmarking analysis regarding certain infrastructure metrics, the annual gas distribution summary reports provided by PHMSA were used for a Peer Group comparative analysis. These reports are publicly available directly from PHMSA and contain a summary of all the information provided in all United States natural gas operators' submissions of form PHMSA F 7100.1-1[1].

1.2.3 Peer Group Selection Methodology:

In order to provide a benchmarking analysis regarding certain metrics, a Peer Group was developed using a methodology that is independent of leak data and provides the most comparable group of utilities. To reduce the approximately 1,470 United Sates operators into a meaningful Peer Group for comparison with Southwest Gas Company, all operators in the PHMSA Annual Gas Distribution Summary were filtered three times:

The first filter was by system size *– all operators with approximately more than double or less than half the total miles of main were excluded. This removes disparately sized utilities.*

The second filter was by customer count *– all operators with approximately more than double or less than half the total number of services were excluded. This further removes disparately sized utilities with an alternate system layout.*

[1] https://www.phmsa.dot.gov/data-and-statistics/pipeline/gas-distribution-gas-gathering-gastransmission-hazardous-liquids.

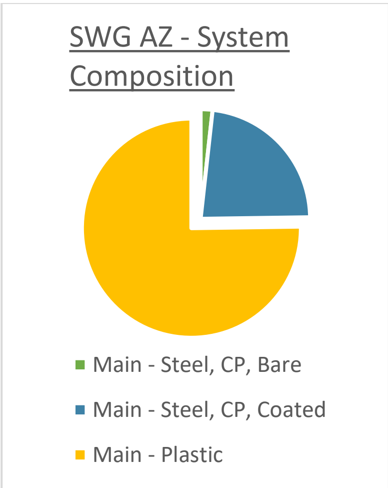
__The third filter was by system composition__ – a list of the most similar utilities, sorted by miles of leak-prone pipe such as cast iron main, and miles of uncoated steel main were selected. This removes utilities with less modern systems that have large amounts of cast iron or bare steel.

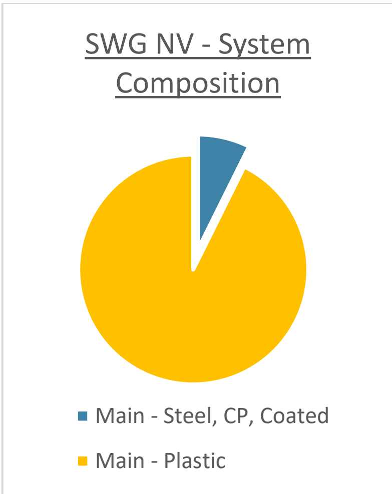
The total number of peers in the Peer Group is a function of the availability of similarly-sized systems with comparable material composition, balanced with the need for a meaningful sample size. Data used for the purposes of this testimony came from the reporting year 2021, which is the most recent report available at the time of this writing.

2 Executive Summary

2.1 SWG's Natural Gas Infrastructure

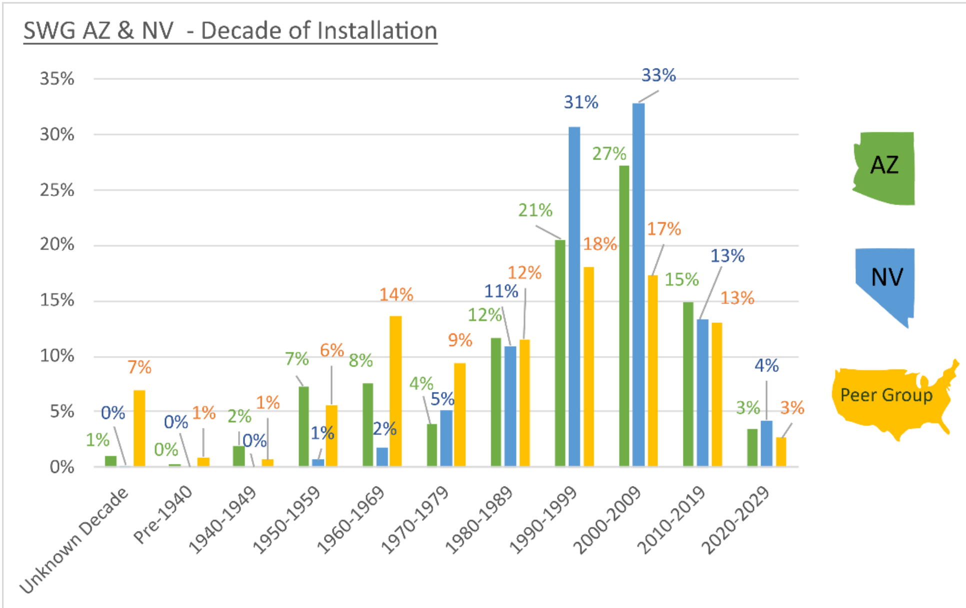
Southwest Gas's Arizona and Nevada distribution systems are comprised primarily of modern piping materials. There are minimal piping materials typically considered to be leak-prone in the Arizona and Nevada systems.





By age, the distribution pipe in both the AZ and NV systems is newer than the industry averages and a selected peer group. To generalize, an estimated life expectancy for steel pipes is 70-80 years old and for PE plastic pipes 80+. This generalization is not absolute and there are exceptions to the rule, but it makes for a general baseline from which to compare the age of a utility's system.

Generally, there is very little main installed in either of the NV & AZ SWG systems that is approaching a typical end of useful life (pre-1950's).



The summary table below compares the SWG AZ and SWG NV leak metrics to those of the industry at large. Peer Group averages are simple mean averages.

Leak Summary Table

Metric	AZ	NV	Peer Group
Total Leaks	5,818	1,570	3,379
Leaks per Mile of Main	.283	0.176	0.334
Total Haz Leaks	1,427	745	1,384
Haz Leaks per Mile of Main	0.163	0.037	0.131
End of Year Leak Inventory	29	14	1,195

While total leaks and total hazardous leaks are higher than Peer Group averages, the leaks per mile and hazardous leaks per mile metrics are lower. This is typical of a large utility with a relatively modern and very large, but well maintained, system.

KEY TAKEAWAYS

By all metrics reviewed, the SWG systems outperform those of their peers (similarly sized and similar system composition). Leaks per mile, hazardous leaks, and unrepaired year-end leaks all have been in decline over the past 5 years.

The SWG Arizona system has some uncoated steel main to replace, but this represents only 2% of the system total main.

The SWG transmission system is also in relatively good condition with minimal leaks, and a small percentage of pipe made of leak-prone materials in the system.

2.2 Franchise Agreements

SWG holds franchise agreements (FAs) with dozens of municipalities throughout Arizona and Nevada. These agreements allow the utility to install natural gas pipelines in public rights-of-way in exchange for a fee and agreement to certain terms.

In Arizona and Nevada, the laws surrounding FAs differ. In Arizona, the laws are stricter and SWG is not allowed to pass through the costs of these FAs directly to the ratepayers in base. In Nevada, SWG is allowed to do so.

After a review of a representative sample of SWG franchise agreements, RWA concludes that the agreements mostly share typical terms such as:

- 25-year term
- 2-5% franchise fees
- Common clauses for liability, severability, insurance, non-exclusivity, construction standards, etc.

RWA also found that the Arizona municipalities generally collect a 2% franchise fee while Nevada municipalities collect a 5% franchise fee and sometimes an additional business license fee. This may be due to the ability of SWG to pass the higher franchise fees through to the ratepayers.

A distinct difference in most of the FAs is the way that the franchise fees are calculated. In all the FAs RWA reviewed, the fee is calculated as a percent of the gross revenues collected by SWG in the municipality. The differences are in how "Gross revenues" are defined. In some cases this definition excludes revenues collected from sales to electric generation customers, in others it excludes miscellaneous revenues like late fees, street lighting revenue, etc. Generally, the more comprehensive the definition is, the higher the franchise fee income will be for the municipality.

Regarding renewal and negotiation of franchise agreements; these agreements are usually uncontested at renewal. Given the long, 25-year term of most agreements, the opportunities to renegotiate are few. However, RWA performed an analysis of other franchise agreements with other utilities and other states and found that there is more variety nationally that within AZ/NV. This variety of approaches and terms may offer some inspiration for the pursuit of policy options in AZ and NV and are discussed in more detail in the body of this report.

KEY TAKEAWAYS

Existing SWG Franchise Agreements are similar in scope and contain largely similar terms and are generally renewed uncontested.

Other states and other utilities generally utilize similar terms and FA structure to SWG's agreements in AZ & NV. Exceptions to this rule may provide inspiration for negotiation topics and terms to pursue in future SWG FA renewals.

2.3 Safety and Equity

Regarding Safety and Equity, RWA looked at four major subtopics: 1) Natural gas incidents, 2) Demographics of the SWG service area, 3) Replacement programs, and 4) Stranded assets.

Natural Gas Incidents:

Incidents on the SWG systems are less frequent and less severe by all metrics than the industry averages. The table below summarizes the results of RWA's analysis of all natural gas incidents in the country since 2010:

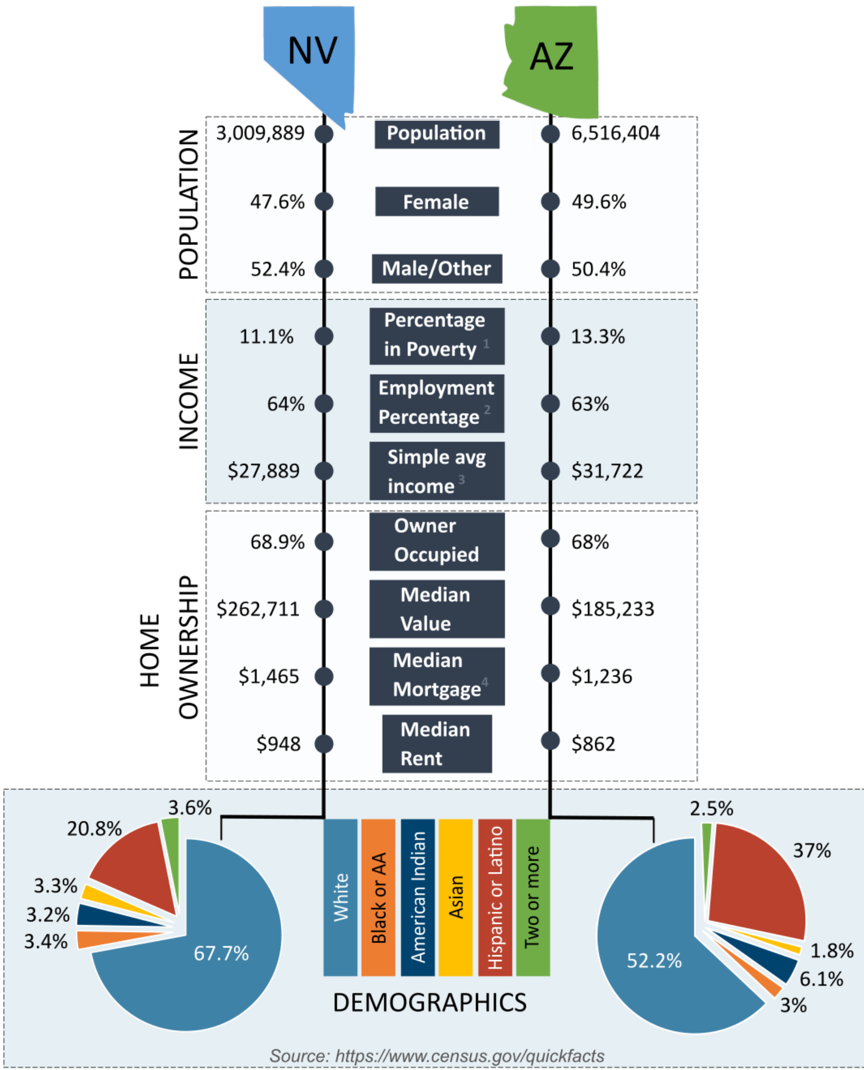
Severity of Incidents					
Location	Lost Gas Per Incident (Mcf)	Injuries Per Incident	Fatalities Per Incident	Customers Affected per Incident	Approx. Cost Per Incident
Industry	1474.7	0.44	0.09	141	$1,973,490
AZ/NV	330	0.13	0.00	675	$595,314
SWG AZ/NV	456	0.11	0.00	848	$798,044

As the data shows, SWG compares favorably with the industry averages in terms of severity of the average incident. It appears that, on average, SWG incidents are relatively minor and are resolved quickly.

RWA further performed a root cause analysis which identified Excavation damage and Vehicle impacts as the two primary causes of incidents. Compared to other potential causes such as corrosion or material, these root causes also indicate a healthy system.

Demographics

RWA performed a high-level demographics analysis of the counties that make up the SWG service area. The results of this analysis are presented in the figure below:



1 - Median value, ranges from 8%-13.2%
2 - Employment in 18-64 year olds
3 - Total payroll / employable population
4 - Monthly costs with mortgage

Replacement Programs

SWG has been replacing leak-prone pipe in its distribution and transmission systems for many years. RWA performed a 30-year analysis of both the AZ and NV distribution systems to get a historical perspective on the materials SWG has had in their systems. The findings of this analysis were atypical for Nevada, and somewhat atypical for Arizona when compared to the industry as a whole and to the Peer Group. Whereas most utilities had large quantities of cast iron, bare steel, and unprotected steel pipe in their systems over this time period, and have been slowly phasing them out, SWG hasn't had large percentages of these materials in their AZ/NV systems for at least 30 years.

This appears to be due in part to replacements and in part to the relatively newness of the states' natural gas systems in general as compared to other parts of the country, especially the New England states.

Given the relatively good condition of the pipe in both systems, the SWG replacement efforts have focused primarily on the remaining bare steel in Arizona[2], aging pipe in both states, and sub-par vintage plastic pipes in both states such as PVC, Aldyl-A, Driscopipe 7000, and older plastics in general. These vintage plastic pipes have been the subject of several recent accelerated replacement attempts with little success given the relatively low leak rates of such pipe.

SWG also has a history of replacing customer-owned yard lines (COYL). COYLs are services where the meter is generally located at the property line or public right-of-way, some distance from the customer premises, and the customer currently owns and is responsible for replacing/repairing the service line if there are any problems with it. In 2012, the Commission gave permission to establish a COYL program[3] that would survey existing COYLs and replace COYLs that were found to have leaks. Since then, SWG has identified tens of thousands of COYLs to replace and has begun replacing them.

Both the COYL and Vintage Steel programs have allowed SWG to replace this infrastructure and recovery the costs of doing so at an accelerated rate. Accelerated replacement of infrastructure is generally allowed in cases where the risk of the target infrastructure is so great that replacing it under the normal course of business would be imprudent.

In Arizona, SWG has an ongoing rate case that includes the accelerated replacement of mains and services in its system. This rate case includes $140 million of investment in pipe replacements and an additional $7.1 million in COYL replacements.[4] The targets of the pipe replacements are primarily the oldest steel mains and services remaining in the system.

Stranded assets

Stranded assets are generally defined as those assets that, at some time prior to the end of their economic life, are no longer able to earn an economic return (i.e. meet the company's internal rate of return), because of changes associated with the lack of continuing need for the asset for various reasons, which recently has become noteworthy for the potential transition to a low-carbon economy.

While it is the duty of natural gas system operators to safely maintain their systems and provide reliable service – often through capital spending and upgrades, the potential for stranded assets must also be considered.

Southwest Gas does not appear to have taken the risk of stranded assets or stranded capital costs into account in any of their recent capital programs, investor relations publications, or regulatory filings.

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[2] The "Vintage Steel Replacement Program" authorized in Decision No. 76069

[3] Decision No. 72723

[4] http://docket.images.azcc.gov/E000016855.pdf?i=1651080545154

KEY TAKEAWAYS

SWG compares favorably with the industry incident averages in terms of severity of the average incident. It appears that, on average, SWG incidents are relatively minor in cost, scale, and frequency; and are resolved quickly.

SWG has replaced the majority of its leak-prone pipe through past replacement programs, and further replacements are ongoing to improve pipeline safety by removing remnant leak-prone pipe and the small amount of aging infrastructure. SWG in Arizona is attempting further accelerated replacement of pipe in 2022.

The economic risk of stranded assets does not appear to have been considered by SWG in the development of its capital programs. As efforts are advanced to reduce natural gas usage in SWG's service territory the impact of stranded costs or infrastructure assets will only increase.

2.4 Fuel Usage/Delivery

To assess fuel usage and delivery rates for SWG, we looked at annual sales volumes provided by SWG.

Annual peak gas sales forecasting by SWG were only available for Arizona and only for the last 10 years. This data shows that annual gas sales have increased year over year in total. However, the blend of peak sales by customer type has changed over the past decade. Over the last 10 years, projected peak gas sales to retail customers (which include residential, commercial, and industrial customers) have increased in volume by 13% while forecasted peak gas sales to transport customers have increased by 34%.[5] This is typical of many gas systems, and often indicates that residential and commercial loads are remaining relatively static while loads for power generation and large industrial customers are rising.

Meanwhile, actual gas sales over the last 10 years have increased at a more moderate pace of approximately 4.8%.[6] Further data from SWG indicates that this growth in demand is heavily weighted by several operating districts. For example, over the last 10 years, gas sales to 70% of SWG Arizona's districts have declined. This is inclusive of all customer classes and includes both retail and transport customers. As the table below shows, there is one primary district that accounts for the most growth – the Phoenix Operating District. This district alone represents approximately 91% of all growth that SWG Arizona has seen.[7]

Ten Year Change in Gas Sales		
Operating District	**Change in Volume (Dth)**	**Change in Volume (%)**
Valley (D32)	-12,633,398	-34.5%
Eastern (D33)	+40,487	+3.7%
Bullhead (D34)	-412183	-7.0%

[5] Docket No. G-01551A-21-0368, SWEEP-01-003_Attachment

[6] Docket No. G-01551A-21-0368, SWEEP-01-006_Attachment

[7] *id*

Tucson (D36)	-4,179,988	-2.5%
Phoenix (D42)	+57,301,152	+14.0%
Ajo/Gila Bend (D44)	+5,573,339	+149.0%
Mountain (D46)	-729,844	-12.2%
Southeast (D47)	-8,594,156	-22.1%
Yuma (D48)	-2,654,334	-11.8%
Parker/Wickenburg (D49)	-153,032	-5.6%
Total *(net)*	+33,558,043	+4.8%

Table 1: 10-Year Change in Gas Sales

Looking at this same data from a year over year change perspective rather than a total change yields similar results and more clearly highlights the share of new gas load that the Phoenix division is responsible for. The figure below illustrates annual change in total gas sales over the 2011 to 2021 period, using 2011 as the baseline.

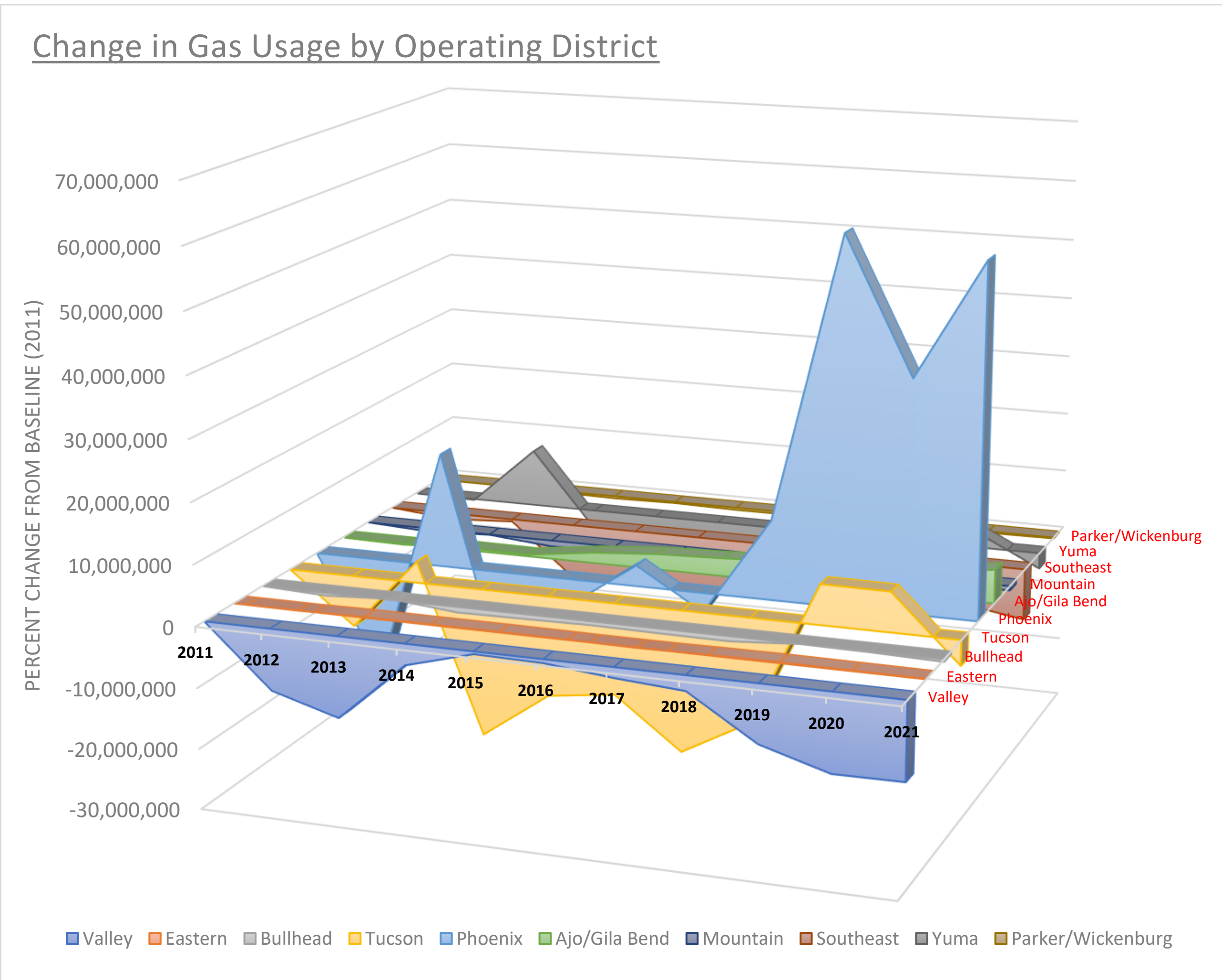

Figure 1: Change in Gas Usage by Operating District

KEY TAKEAWAYS

Gas sales have increased steadily over the past decade with sales to commercial and industrial customers growing quicker than sales to residential customers.

The Phoenix operating district has represented over 90% of the above-referenced growth in gas sales, while making up about 64% of the total SWG-AZ system by sales volume.

There has been a notable decline in gas sales in other operating districts – particularly the Tucson operating district which declined 2.5% while making up 23% of the system total.

SWG has been escalating the peak load conditions for which is prepares its system capacity to handle at a faster rate than system sales have been growing.

2.5 Alternative Fuels

RWA reviewed two primary alternative fuels in this report: Renewable Natural Gas (RNG) and Hydrogen.

RNG

RNG is produced from feedstocks such as landfill waste, animal manure, and other organic waste. Generally the gas produced is captured, cleaned/filtered/dehydrated then compressed and delivered to natural gas utilities for distribution or for further compression for use in CNG vehicles.

RNG availability in AZ/NV at the time of this reporting appears to be very minimal with only a handful of facilities in operation. Nationally, the story isn't much different. In the future, availability will likely increase, but large scale RNG production at volumes to meet a meaningful percentage of a gas system.

SWG's current plans for RNG appear to be focused on an RNG-fed CNG supply chain for busses in Nevada and two small-scale dairy farm RNG projects.

RWA compiled our research into the pros and cons of RNG into several pages in the body of this report. These pros and cons are summarized in the list below:

Potential benefits of RNG:

- **Diverted Methane Emissions**: an RNG supply chain for gas has the potential to divert methane that would have otherwise been release int the atmosphere.
- **Extend useful life**: Many natural gas assets will face increasing risk of early retirement and thus become stranded assets as natural gas usage decreases naturally or artificially. RNG may provide a less climate-intensive use for such assets during a transition period.

Potential Issues with RNG

- **Costs**: broadly speaking, RNG will most likely cost more than traditionally-sourced natural gas. Current estimates are roughly 3-10x the cost of traditional natural gas.

- **Emissions:** While RNG diverted from the atmosphere has a net negative effect on emissions, RNG created for the sole purpose of use as RNG is likely not emissions-negative or not economically so.
- **New Infrastructure:** at scale, RNG will require capital investment into new interconnects, pipelines, and other infrastructure solely for the purpose of utilizing RNG. This **is** likely to perpetuate reliance on methane for energy rather than lessen it.
- **Efficiency of Combustion vs. Flaring:** Waste methane that can be captured can be flared or burned on site for various applications. Flaring has efficiencies of 99%+, so any use for that methane has to be at least as efficient. When accounting for transportation and compression energy costs, distribution leaks and inefficiencies, and emissions from less efficient end use, RNG is likely to be more emissions intensive in most cases than a simple flare or use onsite of production.
- **Perpetuate Reliance on Methane:** RNG can function as a stop gap or used during a natural gas decommissioning process in small percentages to prevent the release of methane in industrial applications, but at scale does not have the effect of reducing methane reliance.
- **RNG Availability**: At volumes projected by some of the more extreme gas utility plans, RNG would need to be intentionally manufactured from various feedstocks en masse. There does not appear to be sufficient supply available now, nor does it appear likely that such a supporting industry will arise without significant subsidies and pressure. Some utilities are even contemplating starting subsidiary RNG facilities to sell RNG to themselves.
- **Potential for "Double-dipping":** When a utility distributes RNG, it can claim to have offset some of the impact of natural gas use. However, in regions where transferable carbon credits are made available, it is critical to ensure that companies are not acquiring such credits and using or selling them, while making claims regarding emissions reductions.
- **"Green Attribute" Transfer**: In order to operate a profitable business, RNG suppliers are incentivized to acquire carbon credits, grants, or other government economic incentives. These are often used to offset the costs of the RNG business. As such, they may not be willing to transfer these benefits to the buyers of RNG.

<u>Hydrogen</u>

Hydrogen is generally utilized in one of two ways in the natural gas industry: Blended Fuel combustion and "Power to Gas" (P2G),

Blended fuel combustion refers to the combustion of hydrogen and methane together. In this use case, hydrogen from various sources is injected into the system by a distribution company (like SWG) and is carefully blended at controlled percentages and then sent to end use customers to use like regular natural gas. The blending threshold at which the increased risk transitions from minor to moderate is at approximately 20% hydrogen. Higher concentrations of Hydrogen would require further technical studies before implementation.

Hydrogen for distribution can come from various sources. There are three typical pathways that result in hydrogen:

1. **“Brown Hydrogen”** is the result of using coal or similar feedstock in a high heat steam environment with the addition of oxygen to gasify the volatiles in the feedstock which are then filtered and cleaned to produce hydrogen.
2. **“Grey” Hydrogen**, or as the gas industry prefers “Blue” hydrogen, is produced with the reaction of methane with steam and other catalysts in a process known as steam reformation to produce hydrogen.
3. **“Green Hydrogen”** is produced by a process called electrolysis in which water is split into oxygen and hydrogen – typically using renewable electricity or low-carbon electricity such as hydroelectric or nuclear.

Hydrogen available for use in blended fuel situations is difficult to assess. It appears that much of the currently-available hydrogen is being used for other industrial processes. There are also many pilot programs headed by natural gas utilities involving the production of green hydrogen from renewables like solar. These are all small scale proof-of-concept pilot projects and not at-scale yet.

Distributing Hydrogen in a blended fuel poses challenges to the distributor utility. There are concerns surround the nature of the gas itself and its flammability and explosiveness – some of which are similar to natural gas, and some which differ.

There are also concerns regarding the impact of hydrogen on distribution infrastructure such as embrittlement of steel or hydrogen permeation through plastic piping. These concerns extend to end-use equipment ranging from cooking stoves to specialized industrial equipment. Many if not all of these concerns appear to be able to be mitigated by reducing the hydrogen blended into the natural gas mixture down to 20% hydrogen. This is supported by most technical analyses and pilot programs available at the time of this writing.

SWG’s current plans for hydrogen appear to be confined to two small pilot projects with Arizona State University (ASU) and the University of Nevada, Las Vegas (UNLV). SWG is also likely to continue to pursue transportation-sector customers broadly, some of which may end up being interested in hydrogen cell vehicles.

KEY TAKEAWAYS

From our analysis, RNG appears to have some usefulness in situations where captured waste methane can be repurposed with minimal infrastructure upgrades required. At scale, and in many other cases, the use of RNG does not appear viable. Among other things, availability, emissions, and cost issues with RNG make this “alternate” fuel unattractive at scale.

Blending hydrogen into natural gas pipeline networks at low concentrations (20% or less) has the potential to increase utilization of renewable energy in the near term. Using green hydrogen to do so will likely be a climate-friendly move as well, depending on the energy source. Any implementation of hydrogen blending must be done carefully and with full awareness of the impacts to infrastructure, system integrity management, and end use equipment.

2.6 Fuel Switching/Electrification

In Arizona, the Arizona Corporation Commission ordered the state's Public Service Corporations to develop a strategic, long-term Transportation Electrification (TE) plan for Arizona. There may be some portions of this plan that relate to natural gas and SWG in the areas of CNG vehicles replacing gasoline or diesel vehicles. Phase II of this plan was published in 2021 and primarily focuses on two parallel efforts: 1) rigorous analysis of the costs and benefits of several near-term electrification opportunities, specifically assessing five promising vehicle segments, and 2) stakeholder engagement, to both provide a forum for knowledge sharing and the discussion of critical issues for different groups, and to leverage the expertise of a diverse set of Arizonans interested in TE.[8]

In Nevada, the PUCN opened an investigation for the long-term planning of fossil gas utility services in the state in May 2021. This investigation is groundbreaking and asks many questions that get at the heart of the electrification issue such as "If natural gas sales decline, at what point does the gas system become operationally and financially unviable?" The results of this investigation will likely drive the state's gas-related climate goals and inform SWG's decisions.

RWA reviewed the high-level costs and impacts of electrification. This review generally covered two areas: operational considerations and economic considerations.

In an electrification scenario in the SWG service territory must consider some practical operational constraints such as:

- The location and needs of large commercial and industrial customers
- The location and needs of electric generation facilities
- The location of interconnects with various gas supply sources
- The pressures that each section of the system can sustain
- The hydraulic design of each section of the system, and the changing hydraulic design of the system as a whole as each section is removed.
- The readiness of the electric grid to take on additional load
- The fuel costs passed on to remaining customers in late stages as the utility purchases less gas
- The percentage of customers who are willing to switch fuels in each area

Any attempt at widespread electrification will likely involve sectionalizing the system into many distinct sub-sections and then systematically transitioning each section off natural gas to electricity or an alternate fuel like blended hydrogen or RNG. This process is aided by the existing shutoff valves in each system that are required under federal code.

Economic considerations regarding electrification in the SWG service territory are two fold – those that pertain to natural gas customers and those that pertain to the gas utility itself.

Economic considerations for end use customers are the most-talked about topic in electrification. The goal is to create a means for customers to switch fuels in a cost-effective manner. While these challenges appear daunting, the solutions to solve them exist or are coming soon. As solutions are developed in various areas of the country, they are being ported to other applications. SWG in

[8] https://illumeadvising.com/files/AZ_Statewide_Transportation_Electrification_Plan_2021-03-30.pdf

particular serves an area with minimal winter space heating load – relative to much of the rest of the country, making the transition to electric heating much easier. Thus, as far as end users are concerned, the challenge is often not one of technological barriers but one of economics and pace. In other words, how quickly can end users be convinced that making the switch is an economically beneficial choice.

Regarding the economic concerns facing natural gas utilities, the most obvious economic concern that natural gas utilities will face is that of profitability. Most natural gas utilities are investor owned or privately owned companies. The profit-driven incentives in such a company are often in opposition to the entire concept of electrification. There is no easy way to align these incentives with a large-scale electrification effort but understanding the motives and drivers of these companies can be helpful when pursuing policy options or working in regulatory proceedings. In an environment in which electrification is not widely supported, understanding the nuances of gas system operation can help stakeholders come to agreements with all parties and maximize impact.

Policy options for stakeholders to pursue in the near-term include:

- Intervening in the current and future SWG rate cases in both Arizona and Nevada
- Monitoring for new regulation proposals made by SWG or other parties
- Develop and pursue cooperative agreements at the municipal level with SWG
- Nevada's Future of Gas Investigation
- Clark County, NV's "Sustainability & Climate Action Plan"

KEY TAKEAWAYS

There are electrification initiatives in both Arizona and Nevada at the state, county, and city levels. These initiatives will have varying impacts on the use of natural gas in SWG's territory, but all will involve the consideration of the future decline in the use of gas.
Generally, the high-level goal of fuel-switching is to reduce reliance on natural gas and do so in a relatively cost effect manner to the end use customers. To achieve this, there are operational and economic factors that must be considered.

Operational considerations include infrastructure condition, customer loads and location, replacement needs, hydraulic system design, and other similar factors. Cost considerations include both consumer costs to fuel switch, and utility cost motives.
A clear understanding of both consumer and utility cost and operational concerns will provide an ideal foundation for policy-making efforts.

2.7 System Resiliency

RWA performed a high-level threat analysis of the SWG systems in AZ and NV. SWG's systems appear to be relatively resilient to load spikes. The infrastructure is relatively modern, outages appear limited, and there is likely a large stable base load vs. severe seasonal swings.

Regarding resilience to extreme weather, the recent February 2021 winter weather event known as Winter Storm Uri which caused massive outages across much of the south-central US did affect SWG's gas supply and load conditions. It does not appear that SWG experienced widespread outages or even any loss of service to customers during a storm that, for all intents and purposes, can be used as a benchmark for system performance for all utilities affected by it.

Regarding resiliency to decay, the SWG distribution system is comprised entirely of plastic and cathodically protected and coated steel pipe. These materials, as a category, are among the most resilient to decay of all materials used in gas distribution for the reasons discussed above.

Regarding resiliency to fire, the SWG system does not appear to be at any more risk than any other system – proportional to its area that is wooded, and fire is possible. Actions that a utility could take to mitigate risk of fire damage to the system include burying any above ground pipe that exists (if any), contributing to preventative measures in their services areas, clearing land of combustibles around critical regulator stations and other facilities, and working to have a thorough, annually reviewed emergency response plan. Additionally, mock emergency activities benefit utility employees, local first responders, media, and the public and could include a fire-related incident if reasonable for the operating area.

KEY TAKEAWAYS

SWG’s infrastructure is relatively modern, outages appear limited, and there is likely a large stable base load vs. severe seasonal swings. Further, the lack of severe outages, low pressure incidents, or other major issues during the 2021 winter store Uri indicate that the system is likely resilient to weather-induced load spikes.

SWG’s system resilience to decay is excellent given the relatively modern system composition, age, and maintenance.

SWG’ system resilience to other off-system threats such as fire, vandalism, vehicle strikes, and so on is comparable to those of other utilities, and no evidence of abnormal susceptibility to those threats was found.

3 Overview of the Natural Gas Industry

This section seeks to provide readers with a general overview of the natural gas industry, types of gas utilities, the process by which natural gas is acquired, processed, and moved to end users' meters, an overview of pipeline safety, and an overview of the regulatory process.

This information is very high-level and not comprehensive but should provide context for readers with little to no technical experience with natural gas systems.

3.1 Types of Natural Gas Utilities

3.1.1 Municipal Utilities

These are usually government-owned utilities that are funded by utility natural gas sales and operate similar to a non-profit – with any excess revenue being reinvested into the gas system's infrastructure (pipes, upgraded equipment, etc.) or payment made to the municipal to support other parts of the government (police, fire, public works, etc.). These utilities have oversight from a council (i.e. city, county) or board that is created by the municipality or municipalities that it serves.

3.1.2 Investor-Owned or Privately-Owned Utilities

These utilities are owned by individuals or corporations who operate the utility as a for-profit company – therefore, the profits will be reinvested with an eye on the impact to shareholder value. These entities are regulated and have oversight by a state-run commission or board.

3.1.3 Cooperatives

These utilizes are the least common type and are owned by the customers of the utility. These utilities are typically nonprofits, therefore revenue can be reinvested into infrastructure or distributed to its members. Cooperatives have oversight through a board of trustees, elected by the members of the cooperative.

3.2 The Flow of Gas From the Ground to Your House

3.2.1 Overview

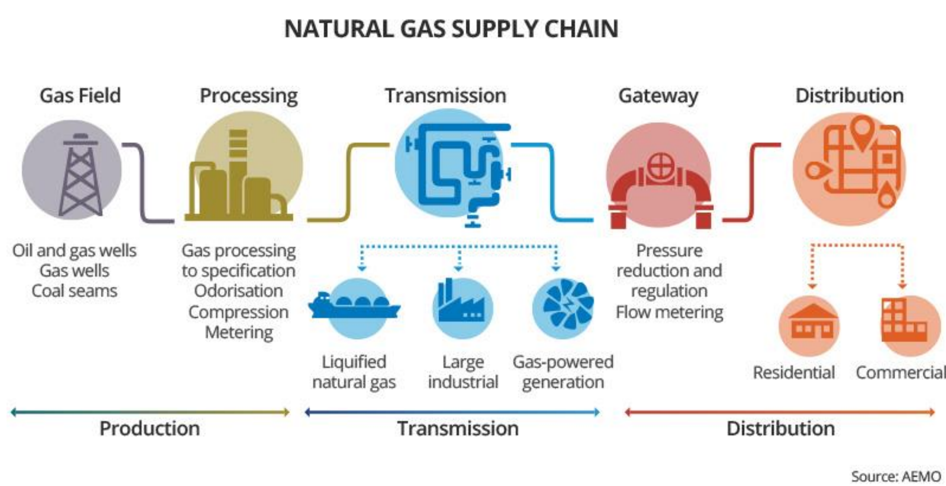

Figure 2: Natural Gas Supply Chain

There are many links in the chain of custody for gas as it moves from the earth through multiple companies and finally to the utility that sells it to customers like you. While there are many secondary services, companies, and industries around gas, there are four main types of companies that physically handle gas before it makes it to the customer:

3.2.2 Production

Most natural gas is produced in wells – sometimes as a byproduct of oil drilling, but there are also many natural gas wells. Natural gas can also be captured from various biological waste sources such as landfills, animal waste, and farm crop waste. These biological sources are usually called "renewable Natural Gas" or RNG. Natural gas production is not typically done by utilities, but by a separate company who then sells the gas to the next link in the chain – Transmission companies. The gas from production is gathered and processed for ultimately getting to the transmission system through gathering lines.

3.2.3 Transmission

Gas transmission (and sometimes "gathering") involves moving gas from one place to another. The companies that operate transmission systems typically receive gas from gas production sources such as wells, or storage facilities and move it to another location. Gas utilities sometimes operate transmission systems, but often these are separate companies. Transmission infrastructure is mostly a network of large diameter, high pressure pipes that can move large volumes of gas. The gas is typically moved to either storage, or the next link in the chain: Distribution:

3.2.4 Distribution

Gas distribution is the final step in delivering natural gas to customers and is the job of what we know as "the gas company" or gas distribution utilities. These are the companies that "tap" into a transmission line and receive gas that they then distribute to end-use customers. There are two main categories of pipe that distribution companies use the most to move gas to customers: Mains and Services. Mains are the medium-sized pipes that run along highways and streets and move gas through the company's services area. Service lines are the small, low-pressure pipes that connect a main to a customer – if you have gas at your house, then the service line is the pipe that ends at your gas meter. Distribution companies has different types of customers, most commonly broken down into:

- **Residential**: Single family or multi-family homes
- **Commercial**: small and large businesses
- **Industrial**: Large factories, plants, high-use industries
- **Transport**: Very high-volume customers like gas power plants use so much gas that they often bypass the distribution system and tap directly into a high-pressure gas line.

Large parts of the work that gas distribution companies do includes:

- Regulating the pressure of gas from the high-pressure transmission pipes to the lower pressure on mains and services;
- Maintaining the thousands of miles of main and services as they age, leak, or need improvement;

- Controlling the supply and flow of gas from the various sources (transmission, storage, production, etc.) to make sure that there is enough gas stored to meet peak demand periods.
- Providing customer service, leak detection, gas line locating, meter reading, new main and service installations, and similar services to their customers.

3.2.5 Storage

Storage fits in various parts of the gas system. It is used by production companies to store gas on-site until it can be moved to another location; storage is used by transmission companies to ensure sufficient pressure in all parts of its system; and storage is used by distribution companies in off-peak times to hold excess gas as a reserve for the peak demand times.

Storage facilities can be above or below ground storage tanks, or they can be natural caverns in the ground that have been emptied, cleaned, and sealed – often old mining caverns that are dry are used for gas storage, such as salt caverns.

3.3 Distribution and Safety

Local distribution companies maintain the highest safety standards to ensure that preventable accidents are avoided, and problems with the distribution network are remedied in a timely fashion. Safety measures at the local level include:

- **Leak Detection Equipment** – Utilities have in place sophisticated leak detection equipment, designed to locate leaks of natural gas from the distribution network. Utilities also add very strong odorants to the natural gas to make it easier to detect a leak.
- **Safety Education Programs** – Utilities typically run natural gas safety seminars to ensure customers are well versed in natural gas safety procedures and know what to do in the event of a leak or emergency.
- **Technicians on Call** – Utilities maintain fleets of technicians on call 24/7 to respond to customers' problems and concerns.
- **Emergency Preparedness** – Utilities participate in community and local emergency preparedness programs, educating and preparing for emergency events such as natural disasters.
- **One Call Systems** – Provides customers, contractors, and excavators with a single phone number to call before commencing excavation or construction, to ensure that the pipelines, and other buried facilities are not damaged. A national "call-before-you-dig" phone number of "811" was adopted in 2008 with the support of utilities, communities, emergency responders and government officials.

3.4 Regulation of Gas Companies

3.4.1 Overview of Regulation

Traditionally, local gas utilities have exclusive rights or assigned certificated areas to distribute natural gas in a specified geographic area, as well as perform services like billing, safety inspection, and providing natural gas hookups for new customers. Utilities have historically had certificated areas which allow them to be the sole provider of natural gas to that area.

Because of the high cost of constructing the distribution infrastructure, it is uneconomic nor a good idea from a safety perspective to lay multiple redundant distribution networks in any one area, resulting in only one utility offering distribution services. Because of their position as sole provider of natural gas in a given geographic area, distribution companies have historically been regulated to ensure that as the sole provider, natural gas consumers do not fall victim to overly high distribution costs or inefficient delivery systems.

3.4.2 Federal Regulation

At the federal level, gas distribution and transmission utilities are governed by the regulations found in 49 CFR 191 and 192[9]. These regulations are focused on pipeline safety and include detailed guidelines for the construction and operation of natural gas distribution and transmission systems. These regulations include annual reporting requirements to the Department of Transportation's Pipeline and Hazardous Materials Safety administration (PHMSA) branch. PHMSA then delegates the inspection and enforcement of these regulations to the state commissions for all gas distribution systems (IOUs and municipals).

3.4.3 State Regulation

State entities – usually called Public Utility Commissions (PUC) are charged with the oversight and regulation of investor owned local natural gas utilities. Those utilities owned by local governments are typically governed by local government boards or agencies to ensure that the needs and preferences of customers are met in a cost effective manner and are only regulated by state commissions for the pipeline safety aspects of their distribution systems.

State regulation of local distribution companies has a variety of objectives, including ensuring adequate supply, dependable service, and reasonable prices for consumers, while also allowing for a fair rate of return for Investor owned Utilities.

State regulators can also be responsible for overseeing the construction of new distribution networks, including approving installation sites and proposed additions to the network. Regulatory orders and methods of oversight vary from state to state.

Often this work is focused on ensuring that the costs of infrastructure that a utility wants to pass on to its customers (the ratepayers) are reasonable and provide the customers with a proportional benefit (safety, reliability, resiliency, etc.).

3.4.4 Other Entities

In each state, there are other parties that do participate in the regulatory process. These entities do not have authority to regulate the gas companies like the Commission does, but often work hand-in-hand with the state to provide review of utilities' activities from various perspectives i.e. technical, economic, supply, safety and reliability, etc.

This work is most often done by entities like the state's Attorney General, Rate Counsel but other entities dedicated to consumer advocacy, public legal defense, or gas ratepayer protection may exist in any given state.

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[9] https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-D/part-192?toc=1

4 Southwest Gas's Natural Gas Infrastructure

4.1 SWG Overview

Southwest Gas (SWG) is a natural gas local distribution company founded in 1931, providing service to over 2.1 million customers in Arizona, Nevada, and portions of California. SWG had 2,286 regular full-time equivalent employees as of the end of 2021 across all of its operations[10].

Southwest Gas also has a wholly owned subsidiary, Great Basin Gas Transmission Company (Great Basin), formerly known as Paiute Pipeline Company (Paiute), that operates as an intrastate pipeline and is regulated by the FERC.

Southwest Gas' operations are divided geographically into five operating divisions: Central Arizona, Southern Arizona, Southern California, Northern Nevada, and Southern Nevada. Each division operates independently of the others and may include portions of multiple ratemaking jurisdictions. All divisions are supported by staff located at the Company's corporate headquarter

SWG is regulated at the state level by the Public Service Commission of Nevada (PUCN), the Utilities Division of the Arizona Corporation Commission (ACC) and the California Public Utilities Commission (CPUC).

4.2 Distribution System

4.2.1 Pipe Quantities and Material Composition

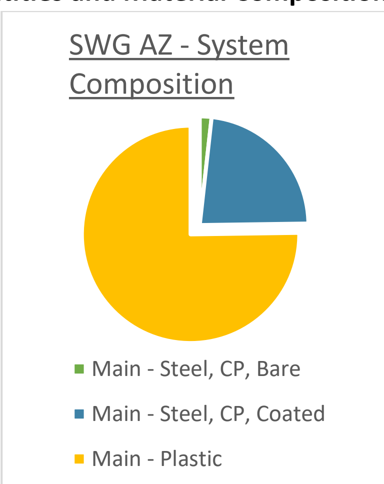

Figure 3: SWG AZ - System Composition

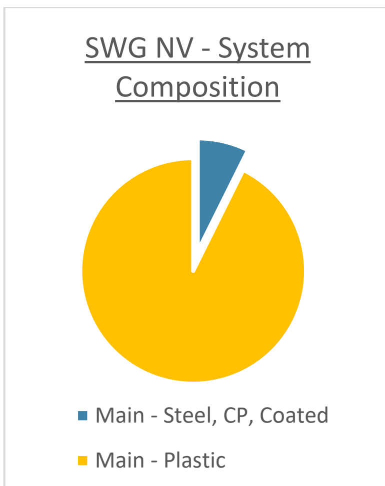

Figure 4: SWG NV - System Composition

The vast majority of main installed on the SWG NV and AZ systems is made of cathodically protected and coated steel or plastic with a minimal amount of uncoated steel in AZ. There is no "leak-prone pipe: (LPP) such as cast iron, ductile iron, copper, or unprotected steel main on either system. Leak prone materials such as these have a higher statistical chance of leaking due to their susceptibility to

[10] https://last10k.com/sec-filings/swx#i5fde4b39497345eaa5bf050f867a214e_986

corrosion[11] and breaking[12]. Additionally, there is no main in the system whose material composition is unknown to SWG. The services on the systems are similar in composition profile.

This system composition is ideal and is at relatively low risk compared to systems that contain LPP. In contrast to SWG, there are systems in the US that still have thousands of miles of cast iron and bare steel mains in service today.

4.2.2 Age of the Distribution Systems

Age of a particular piece of pipe is typically a factor in determining its relative risk of leaking. Pipe manufacturing processes such as metallurgy and seam welding, pipeline construction practices such as pipe coating and hydrostatic pressure testing, and O&M practices such as in-line inspections and cathodic protection have all improved over time – giving longer life to newer pieces of pipe.

Identifying a concrete life expectancy for a piece of pipe is difficult given the vast number of variables that affect the expected life span of a given piece of pipe. Generally speaking, as pipe approaches roughly 50 years of age (pre-1970 pipe), there will typically be in increase in the number of internal corrosion, external corrosion, stress cracking and other material failure leaks[13]. This is due in part to the implementation of federal regulations on pipeline operators that were put in place in 1971, construction practices, metallurgical practices, and more. That said, there is pipe installed and in service today that is approaching 100 years old – particularly in the northeastern parts of the country. To generalize, an estimated life expectancy for steel pipes is 70-80 years old and for PE plastic pipes 80+. This generalization is not absolute and there are exceptions to the rule, but it makes for a general baseline from which to compare the age of a utility's system.

Generally, there is very little main installed in either of the NV & AZ SWG systems that is approaching a typical end of useful life (pre-1950's).

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[11] https://www.phmsa.dot.gov/data-and-statistics/pipeline-replacement/bare-steel-inventory
[12] https://www.phmsa.dot.gov/data-and-statistics/pipeline-replacement/cast-and-wrought-iron-inventory
[13] https://www.ingaa.org/file.aspx?id=19307

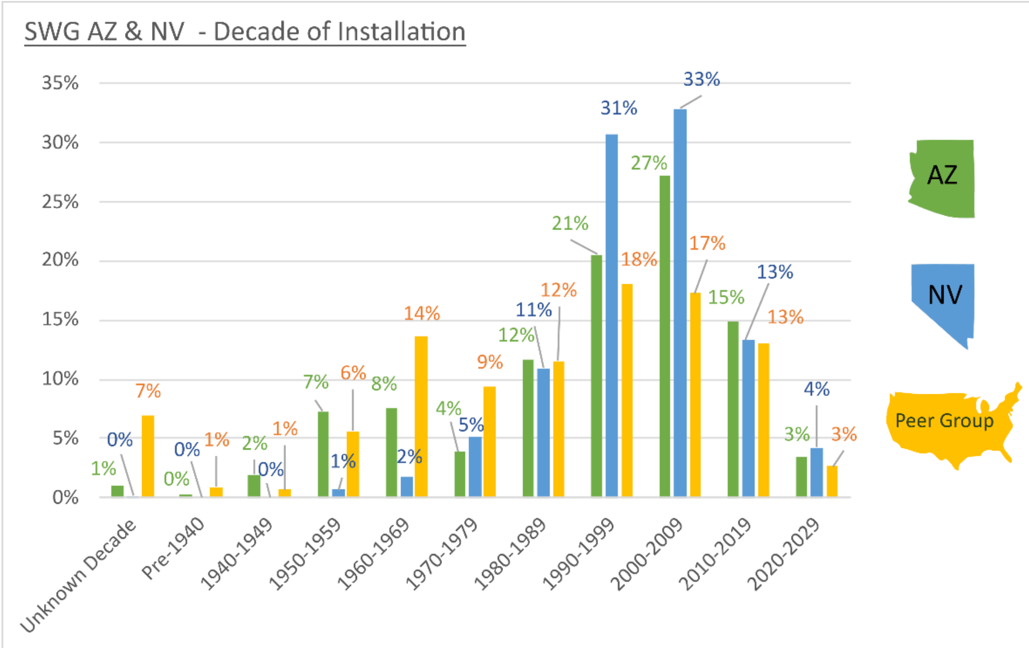

Figure 5: Distribution Main by Decade of Installation Comparison

As can be seen in the figure above, compared to the peer group age of main, both SWG systems compare favorably with significantly newer main. The services on the system are similar in age profile for both the SWG systems and the peer group average.

In contrast to SWG, there are systems in the US that have many miles of pipe that were installed in the early 1900's – or so long ago that no records exist.

4.2.3 Leak Analysis Methodology

Leaks occur on all natural gas systems regardless of age and material composition. Leaks can be caused by natural forces like earthquakes, excavation damage, corrosion, etc. Generally, systems can be evaluated for condition by analyzing the number of leaks, the cause of the leaks and the severity of the leaks.

In the natural gas industry, leaks are generally graded using an industry standard system which identifies the severity of the leak (1, 2, or 3) and the actions required to mitigate, make safe, and/or monitor. These leak grade definitions are sometimes modified at the state level to increase the requirements on gas utilities, but are generally defined as follows:

1. **Grade 1 leaks** – are leaks that represent an existing or probable hazard to persons or property and require immediate repair or continuous action until the conditions are no longer hazardous; i.e., a leak that can be seen, heard, or felt, and which is in a location that may endanger the general public or property.
2. **Grade 2 leaks** – are leaks that are recognized as being non-hazardous at the time of detection, but justify scheduled repair based on probable future hazard; i.e., a leak requiring action within six months and repair within fifteen months.
3. **Grade 3 leaks** – are leaks that are non-hazardous at the time of detection and can be reasonably expected to remain non-hazardous.

Both Grade 1 leaks (also termed hazardous leaks) and total leaks are separated from the total leak count during analysis and used as an additional indicator of a utility's management of its infrastructure and the condition of that infrastructure

Because systems vary wildly in size, the leaks on a system are analyzed in various ways, and sometimes adjusted for utility size by using a leak per mile metric. The leak metrics that RWA used in this analysis are as follows:

1. **Total Leaks**: This metric includes all leaks that the system experienced in the calendar year and that the utility repaired. Most often Total Leaks are used to derive the Leaks per Mile metric.
2. **Leaks per Mile**: This metric is equal to the Total Leaks metric divided by the miles of main in the system. Expressed as a ratio (i.e. 0.2 leaks per 1 mile.
3. **Hazardous Leaks**: This metric includes all grade 1 leaks that the system experienced in the calendar year and that the utility repaired.
4. **Known Leaks**: This metric includes all leaks that the system operator is aware of but has not repaired at the end of the calendar year. Typically, this is mostly small, grade 3 leaks or leaks that occurred on the last day or two of the year.

4.2.4 Distribution Leak Trends

4.2.4.1 Leaks per Mile

On a per-mile basis, both the NV and AZ SWG systems experienced a lower leaks per mile rate than the Peer Group average. This positive metric is further supported by a 5-year trend analysis in which it is clear that the SWG system leaks have been steadily declining to a rate lower than that of their peers, as can be seen in the figure below.

Leaks Per Mile - 5-Year Trend (AZ & NV)			
Year	Total Leaks	Leaks Per Mile	YoY # Change
2017	13764	0.493	-
2018	11011	0.391	-20.7%
2019	10219	0.360	-8.0%
2020	9387	0.328	-8.9%
2021	9112	0.316	-3.6%

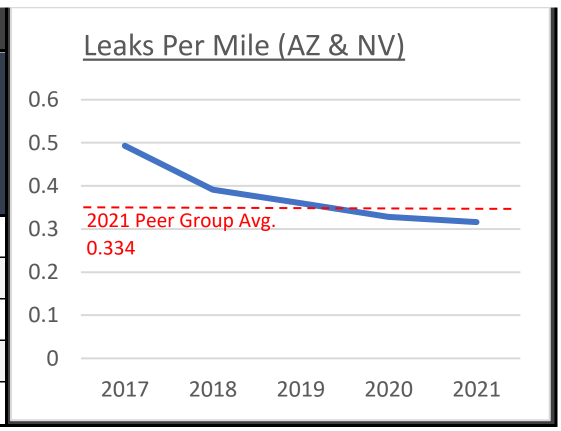

Table 2: Leaks Per Mile - 5-Year Trend

4.2.4.2 Hazardous Leak Trends

Similar to total leaks, hazardous leaks on the SWG systems have been trending downwards over the past 5 years.

Total Hazardous Leaks - 5-Year Trend (NV & AZ)					
Year	Total Haz Leaks - Main	Total Haz Leaks - Services	Total Haz Leaks - All Causes	YoY % Change	YoY # Change
2017	362	1341	1703	-	-
2018	369	1113	1482	-13%	-221
2019	374	950	1324	-11%	-158
2020	376	919	1295	-2%	-29
2021	364	909	1273	-2%	-22

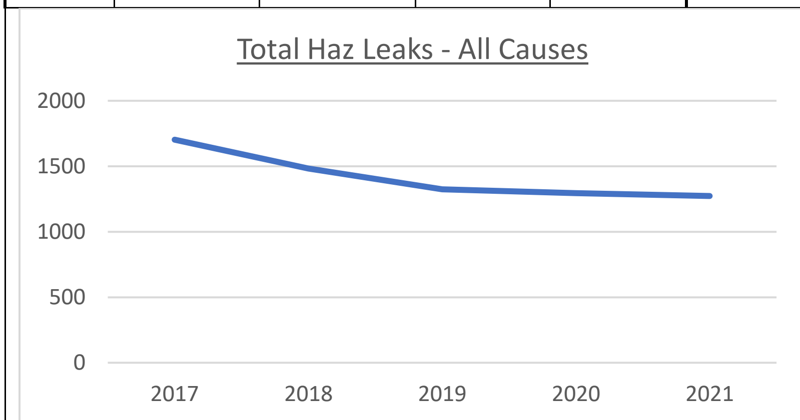

Figure 6: SWG AZ/NV Hazardous Leak Trend

The hazardous leak per mile of main metric for Nevada (.037) is much lower than that of its peers (.131), and Arizona's (.163) is somewhat higher than that of its peers.

Additionally, hazardous leaks as a percentage of total leaks and hazardous leaks per mile are trending downwards – both indicators that the system is being continually improved with no major maintenance/operation issues. Although the hazardous leak per mile ratio is trending downward, the total number of hazardous leaks is large. Given the absolute quantity of the hazardous leaks on the system, RWA performed a root cause analysis to determine the primary causes of these hazardous leaks to gain better insight into the condition of the system. The largest contributors to hazardous leaks on both systems combined were Outside Forces and Excavation. Corrosion only accounted for approximately 16% of all hazardous leaks between both systems, and a total of four leaks on all main in both systems from corrosion.

While, of course, there is room for improvement, particularly in the area of excavation damages, these primary root causes are typical of a system without severe infrastructure concerns which further supports our analysis that, aside for a somewhat higher rate of hazardous leaks in Arizona, the systems are in relatively good condition and exhibit minimal signs of distressed infrastructure.

4.2.4.3 End-of-year Leak Inventory

The year-end leak inventory, reported as "Known Leaks," is the total number of leaks that the Company has yet to repair on its system at year end. These leaks are almost always low-risk leaks classed as Grade 3 leaks which are not required to be immediately repaired or are leaks that were discovered immediately before the end of the year and have yet to be repaired.

Both the Nevada and Arizona SWG systems carry over low inventories of leaks from year to year, with the most recent year (2021) resulting in 14 in NV and 29 in AZ – far below the average of the Peer Group (1,195).

4.2.5 Leak Metrics Summary

The summary table below compares the SWG AZ and SWG NV leak metrics to those of the industry at large. Peer Group averages are simple mean averages.

2021 Leak Summary Metric:	AZ	NV	Peer Group
Total Leak Repairs	5818	1570	3379
Leak Repairs per Mile of Main	.283	0.176	0.334
Total Hazardous Leak Repairs	1427	745	1384
Hazardous Leak Repairs per Mile of Main	.163	0.037	0.131
End of Year Leak Inventory	29	14	1195

While total leaks and total hazardous leaks are higher than Peer Group averages, the leaks per mile and hazardous leaks per mile metrics are lower. This is typical of a large utility with a relatively modern and well maintained system.

4.2.6 Lost And Unaccounted For Gas (LAUF)

LAUF, put simply, is the difference between gas purchased or produced by the utility and gas delivered to customers after appropriate adjustments have been made. LAUF is expressed as a percentage of the total gas purchased in a calendar year that is unaccounted for.

LAUF is one of the metrics that can be used to evaluate the general thoroughness of a utility in managing leaks, recordkeeping, and general management of the system. In other words, the farther from zero (both positive and negative), the less gas the utility was able to account for and the greater the potential for issues such as missing/mismanaged data or leaks.

For SWG, both the NV and AZ systems have maintained a LAUF very close to zero for the past 5 years, straying no further than 0.6% from zero. Compared to the Peer Group average of 2.12%, this is another indicator of the efficacy of system management and leak management.

4.2.7 Excavation Damages

Excavation damages are also reported annually by all system operators. An analysis of the excavation damages of a system is a good indicator of the quality and efficacy of damage prevention, contractor communication, and public education programs – as well as locating practices.

Data is reported annually for the total number of excavation tickets, number of damages, and cause of those damages. In our analysis, we calculated the “hit rate” of each operator (damages per ticket), as well as performed an analysis of the root cause of each system’s excavation damages to gain an understanding of the primary causes of damages. Additionally, we reviewed the sub-cause of damage to gain a general understanding of where the primary responsibility for the damage lies (third party or SWG). A Peer Group analysis revealed that the average Peer had 23% of its damages being due to poor locating practices.

4.2.7.1 Arizona

For SWG's AZ system, there were very few excavation damages in 2021 – with only 460 damages occurring, despite the approximately 749,000 excavation tickets the Company received. That results in a an exceptionally low hit rate of 0.0006 damages per ticket, which is less than a quarter of the Peer Group average. This damage rate becomes harder and harder to maintain as a system grows and becomes larger so SWG's record is particularly good given the size of the systems. Regarding the sub-cause of excavation damages, 80% of the 460 excavation damages resulted from insufficient excavation practices or insufficient OneCall practices, 11.5% from poor locating practices, and the remaining 5% being "other".

4.2.7.2 Nevada

SWG's NV system performed well too in 2021 with only 308 damages occurring on approximately 172,000 tickets, or a hit rate of 0.0018 – an excellent metric when compared to the Peer Group average of 0.0025. 75% of the 308 damages resulted from insufficient excavation practices or insufficient OneCall practices, 10.7% from poor locating practices, and with the remaining 6% being "other" cause. In other words, the majority of the fault for the few excavation damages that did occur lies on third parties, rather than SWG directly.

4.3 Transmission System

4.3.1 Overview

SWG operates some transmission infrastructure via the primary Southwest Gas Company, as well as a secondary company – Southwest Gas Transmission Company (SWGTC).

There are two distinct portions of the SWG transmission infrastructure

1. An approximately 9.5-mile intrastate segment within Arizona operated by SWGTC; and
2. An approximately 504-mile interstate network that connects the SWG AZ system to the SWG NV system, as well as a connect to California and is operated by SWG. This network is mostly split between AZ and NV with a small amount in CA as shown in the figure below.

SWG Transmission Pipe Location (2020)		
State	**Miles**	**%**
Arizona	217.5	43%
California	0.1	0%
Nevada	286.5	57%
Total	504.1	-

4.3.2 Transmission Infrastructure Condition

The 9.5-mile SWGTC segment in Arizona is made entirely of cathodically protected and coated steel.

The 504-mile network is entirely steel, most of which is cathodically protected and coated, with the exception of approximately 15 miles which are not coated.

The 9.5-mile SWGTC segment was mostly installed in the 1970s, with a small portion replaced or added in the early 2000's.

The 504-mile SWG network's pipe was installed between the 1940's and 2020's. The distribution of age of this network is shown in the figure below:

SWG Transmission Pipe by Decade of Installation									
State	1940-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2009	2010-2019	2020-2029
Arizona	3.9	57.6	51.1	31.4	12.7	0.9	25.7	31.1	3.0
California	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Nevada	0.0	80.1	72.5	19.1	1.3	78.7	32.6	2.2	0.0
Percent of Total	1%	27%	25%	10%	3%	16%	12%	7%	1%

Table 3: SWG Transmission pipe

The weighting of this age distribution towards the 1950's-1960's era (or 60-70 years old) indicates that there will likely be need for some replacements in the next decade or two if the pipe is to see continued use. These replaced segments will likely last another 70-80 years or more given the quality of modern materials, corrosion prevention techniques, the arid climate of SWG' service area, and probable future improvements to system integrity management.

4.3.3 Leaks

There were very few leaks on SWG's transmission pipe. The leaks that did occur (8) were primarily caused by construction and excavation damage. There were two leaks repaired that were caused by external corrosion – most likely on some of the older segments of pipe.

4.4 Other Infrastructure

4.4.1 Liquefied Natural Gas (LNG) Equipment

SWG operates the Tucson LNG facility, which is its only reported LNG asset (2020).

The Tucson LNG facility was installed in 2019 and is a storage facility that is used for peakshaving during high-demand periods. There is no liquefaction equipment at this facility, so the facility is supplied with LNG via trucks.

5 Franchise Agreements

5.1 What is a Franchise Agreement?

A utility franchise is a privilege conferred by a municipal corporation, such as a city or county, to a public utility company for the use of the municipality's public rights-of-way. Cities in 40 states across the country have the ability to pursue franchise agreements, and have been since at least the late 1800's – for example, at the link below is a franchise agreement signed in 1881 in Seattle, WA: http://clerk.seattle.gov/~archives/Ordinances/Ord_234.pdf.

Over time, Franchise Agreements have evolved slowly with typical terms changing generally to better protect the municipality and/or taxpayers. That said, there are relatively few requirements for

Franchise Agreements codified into state law. For Southwest Gas, there are several requirements in NV/AZ that are important to know:

Arizona state law and many cities' charters require that a public utility franchise be approved by a majority of the city's qualified voters and the franchise agreement's term cannot exceed 25 years.[14] Arizona also prohibits the "passing through" of this franchise fee in rates or as a rider. This "passing through" is s typical way for a utility to shed costs by simply incrementally increasing rates to recover money to cover these costs.

Nevada state law is more lenient and requires less public involvement[15] (a public notice for example). Nevada also implicitly allows utilities to pass through franchise fee-related costs to ratepayers.

5.2 Typical terms in a FA

Southwest Gas has Franchise Agreements with many AZ/NV municipalities and each jurisdiction's terms vary.

Most agreements have typical terms such as non-exclusivity, right to relocate SWG facilities, shared rights-of-way, insurance and liability clauses, construction guidance, right to audit, etc.

Of potential interest, some of the FAs that we reviewed included clauses that defined natural gas to include RNG – and some would arguably include blended hydrogen. This was almost surely unintentional, and the language was likely intended to be inclusive of natural gas produced by manufactured gas plants (MGPs) – an antiquated and environmentally hazardous method of manufacturing natural gas from coal and other feedstocks. Regardless, the language exists in generic terms such as in the City of Maricopa, AZ's agreement:

"[…] natural gas and/or artificial gas, including manufactured by any

method whatsoever, and or gas containing a mixture of natural

gas and such artificial gas."[16]

Regarding specific financial terms of the SWG FAs, a 2% franchise fee is common among most municipalities in AZ and 5% in NV, however the gross revenue on which the 2-5% is based is defined differently from place to place. As mentioned above, this fee **shall not** be passed on to ratepayers per Arizona law, however it appears that Nevada allows the passing through of such costs to ratepayers – which is likely a contributing factor to the higher franchise fees in NV.

Some agreements do include a Capital Expenditures Fund fee, and others do not. This fee ranges from an additional 0.5% to 2% and may or may not result in net income for the municipality. This fee may also be passed on to the SWG customers as a rider or in base rates.

Finally, most agreements allow for auditing of the fee payment process by city auditors and impose a 1.5-5% interest for underpaid fees.

[14] i.e. AZ Constitution, Article 13, Section 4
[15] Nevada Revised Statutes 709
[16] https://www.maricopa-az.gov/Home/ShowDocument?id=4606

Often these agreements are only made public for a limited time period prior to voting, and then are removed. There does not appear to be a central location for all SWG franchise agreements. As such the sample set of FAs that RWA reviewed was limited to approximately 15-20 agreements.

5.3 Analysis of Relative Value Given per Municipality

The agreements we found for review contained largely the same terms throughout with the exception of SWG's agreement with the City of Peoria, AZ which is the oldest agreement we reviewed and the most favorable to the city. There was little variation and certainly no terms requiring commitments from SWG to take any specific operational actions and nothing tying performance to the franchise fee.

There was some variation from state to state, with the NV municipalities generally having higher franchise fees, but fewer beneficial terms.

5.4 Franchise Agreements in Other States

Other states and other utilities generally utilize similar terms and FA structure to SWG's agreements in AZ & NV. While RWA has not performed an exhaustive analysis of all franchise agreements, all utilities, or all states; we have identified some exceptions of interest from around the country, with a focus on the western half of the country and on larger gas utilities:

1. **The City of Los Angeles, CA** utilities a 2% franchise fee and 25-year term, but also received a $6,000,000 onetime fee from SoCal Gas at the start of the FA[17].
2. **The City of San Francisco, CA** signed a franchise agreement with PG&E for 1% of gross sales with an "in perpetuity" term **in 1939**. They have tried to get out of the agreement at least once due to the disadvantageous terms but have failed.
3. **Portland, OR** collects its 5% franchise fee from Northwest Natural Gas on gross revenue that specifically includes transmission, not just distribution[18]. It also has a climate-related clause focused on end use efficiency:

> **Section 12. COOPERATION REGARDING LOCAL ACTION PLAN ON GLOBAL WARMING**
>
> NW Natural's services shall include assistance to its customers in increasing the efficiency of their energy consumption. The level of expenditure on efficiency programs is established by the OPUC. NW Natural shall support efficiency programs for its customers consistent with OPUC requirements. Within the regulatory framework established by state law and the OPUC, NW Natural agrees to work with the City to identify mutually acceptable ways for Grantee to support the City's efforts to meet the goals contained in the April 2001 Local Action Plan on Global Warming, or successor climate-protection action plans adopted by the Council during the Franchise term.

Figure 7: Portland, OR Franchise Agreement Climate Clause

4. **St. Louis, MO** attempted to implement an account-based franchise fee rather than a percentage of gross revenue.[19] From a high-level review, it is unclear if this was passed and is

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[17] https://lacontroller.org/wp-content/uploads/2019/05/R17_04_SoCalGasFranchise.pdf
[18] https://www.portlandoregon.gov/oct/article/400928
[19] https://www.stlouispark.org/home/showdocument?id=12852

active but nonetheless is an interesting deviation from the typical percentage-based approach.

5. **Minneapolis, MN** has a clause that grants severability of the franchise agreement if its gas provider Centerpoint Energy does not work in good faith to honor its obligations under the City's Clean Energy Partnership.[20]
6. **Washington State** does not allow cities to impose a franchise fee greater than any administrative costs. Instead they impose a special tax[21].
7. The Municipal Research and Services Center (MRSC) which is a nonprofit organization that helps local governments across Washington State prepared a "Model Franchise" for transmission companies to use as a template. The MRSC template includes a per-lineal foot based franchise fee which also appears unusual.[22]
8. The American Public Works Association also prepared a guide regarding franchise agreements for municipalities to use.[23] This approach to agreement structuring appears common in many of the franchise agreements RWA reviewed nation-wide.

5.5 Potential Negotiating Topics

Unfortunately, major negotiation of franchise agreements seems unlikely. There may be some merit in attempting to block a renewal unless terms are met but, given the general overwhelming support that the voters have historically shown for most of these FAs (65-80% is typical), that appears unlikely to succeed. Further, SWG's attitude towards franchise agreements is that:

"These franchises are renewed regularly as they

expire, and Southwest anticipates no serious

difficulties in obtaining future renewals"[24]

This seems to indicate that even for the franchise agreements that RWA was unable to find for review, there are likely few, if any, that are ever contested seriously.

Nonetheless, a few ideas that may be worthy of pursuit include:

- Negotiating a matching fee/benefit escalator into all renewals. This would be beneficial for each municipality in the state if it were possible to achieve.
- In major cities, developing a memorandum of understanding regarding climate goals that has measurable responsibilities – and then negotiating a severability cluse into the FA if those responsibilities are not pursued (as in the Minneapolis, MN example above).
- Negotiating a climate cooperation clause as in Portland, OR's agreement discussed above which is tied to the municipality's climate action plan or other similar plan.
- Negotiating a leak reduction performance metric that is tied to an additional 1-2% fee.
- Negotiating a commitment for X% RNG or hydrogen.

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[20] https://lims.minneapolismn.gov/Download/PriorMetaData/-41320/2014-083.pdf
[21] https://mrsc.org/getdoc/9f9dbc59-6560-42af-a199-9efe7e72c93a/
[22] https://mrsc.org/getmedia/D8B3BF57-7200-4332-B0EF-AC5341BD1EC1/modgas.aspx
[23] https://ilsr.org/energy/utility-franchise-fees/
[24] 2021 Southwest Gas Holdings, Inc. (SWX) SEC Filing 10-K, Item 2: Properties

According to NREL, using electric FAs as a tool to compel electric utilities to meet climate goals is an emerging trend.[25] [26] NREL has also compiled a voluminous list of electric franchise agreements and terms that could be reviewed for ideas to transfer to gas FA negotiations:
https://data.nrel.gov/system/files/124/Municipal%20Franchise%20Agreement%20Data.xlsx

6 Safety & Equity

6.1 Natural Gas Incidents

Every year, natural gas incidents (large leaks or ruptures) that meet one of several criteria are required to be reported to PHMSA. Incidents that must be reported include all natural gas ignitions, explosions, leaks, or ruptures that involve:

- A death or serious injury,
- Estimated property damage over $122,000,
- Gas loss of three million cubic feet or more,
- The emergency shutdown of an LNG or a UNGSF facility, or
- An event that is otherwise significant in the judgment of the operator.[27]

This aggregated data is made public in raw form, so RWA accessed this data and used it to perform an analysis of the SWG system's incident history. The analysis covers the relative quantity of incidents experienced in the country, Nevada/Arizona, and the SWG systems in Nevada/Arizona. Additionally, RWA analyzed gas released, injuries and fatalities, costs, and customers affected per event to measure the severity of the incidents. Finally, this analysis included a root cause analysis to look for trends in the types of causes that lead to these incidents.

At a high level, both the AZ/NV and the SWG systems in those states experienced comparable levels of incidents over the past decade.

[25] https://www.sciencedirect.com/science/article/abs/pii/S0038092X2031183X?via%3Dihub
[26] https://www.nrel.gov/solar/market-research-analysis/municipal-franchise-agreements.html
[27] CFR §191.3

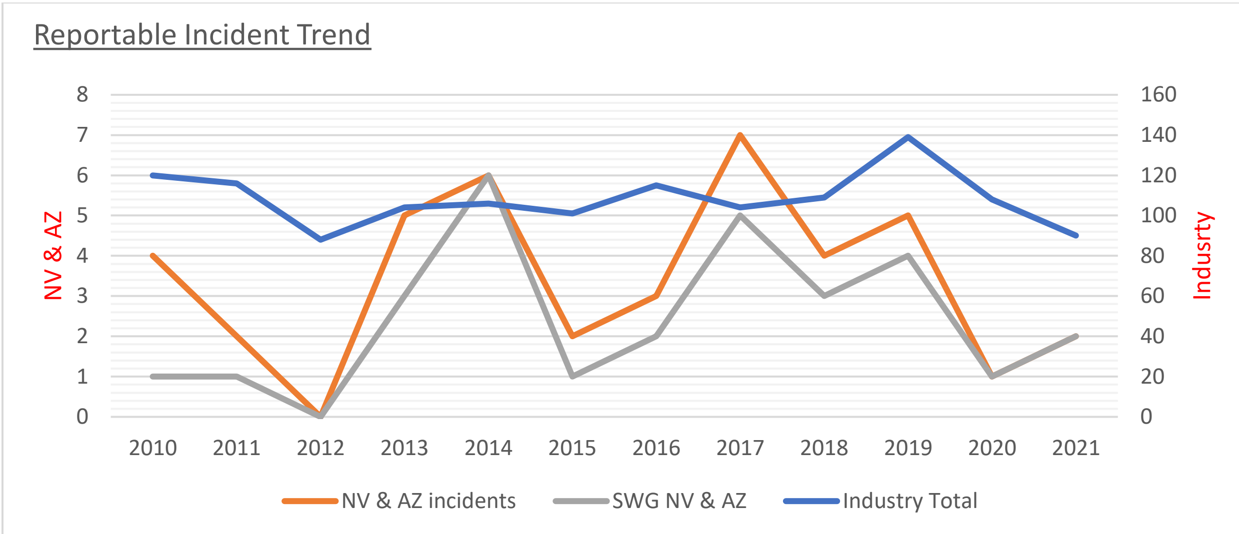


Figure 8: 10-Year Incident Trend

As can be seen in the figure above, with the exception of 2017, the NV and AZ incidents track with state and national incident levels. Please note that the blue line for total industry incidents utilizes a secondary vertical axis as shown on the right side of the figure, while the orange and grey NV & AZ lines utilize the left side vertical axis.

Further, the industry as a whole experienced 0.092 incidents per thousand 2020 miles of main per year on average over the past decade. Over the same time period, SWG experienced 0.096 incidents per thousand miles of main per year on average.

As the primary distributor of gas in Nevada and Arizona, SWG was responsible for the majority of the incidents as can be seen in the table below.

Incidents by State		
State	**SWG**	**Other**
Arizona	12 (63%)	7 (37%)
Nevada	17 (76%)	5 (24%)

Table 4: Incidents by State

After an exhaustive review of all incidents in the last decade nation-wide, RWA has prepared the following summary table that summarizes the relative severity of incidents in each area:

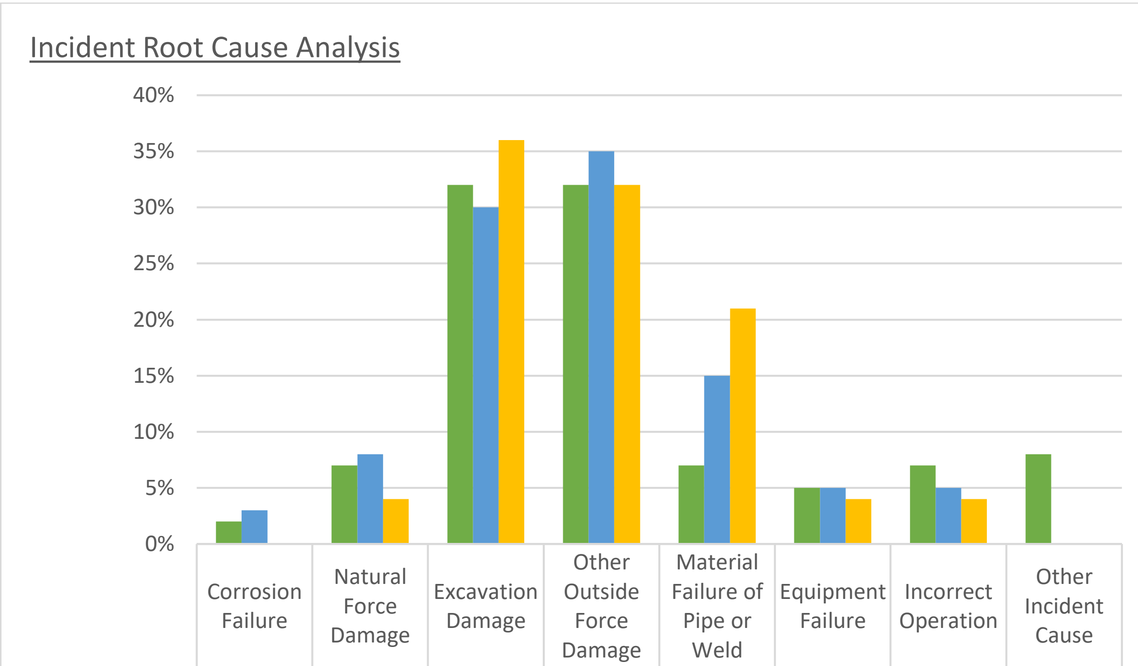
Severity of Incidents (2010-2021)					
Location	**Lost Gas Per Incident (Mcf)**	**Injuries Per Incident**	**Fatalities Per Incident**	**Customers Affected per Incident**	**Approx. Cost Per Incident**
Industry	1474.7	0.44	0.09	141	$1,973,490
AZ/NV	330	0.13	0.00	675	$595,314
SWG AZ/NV	456	0.11	0.00	848	$798,044

Table 5: Relative Severity of Incidents[28]

[28] Utilizes 2010-2020 data

As the data shows, SWG compares favorably with the industry averages in terms of severity of the average incident. It appears that, on average, SWG incidents are relatively minor and are resolved quickly. A few items of note from our review of the data:

- SWG has had zero fatalities at all in the 2010-2020 timeframe reviewed.
- The average cost per incident includes lost gas, property damage, emergency services, and cost of replacing equipment/infrastructure. SWG's average skewed drastically by to a 2021 incident involving the theft of equipment which led to total costs estimated to exceed $2,000,000. Without this number, the SWG average cost per incident is $85,856.
- Finally, RWA performed an analysis of the root causes of incidents on the SWG systems in AZ/NV, the state averages, and the national averages.
- The figure below illustrates the **percentages** that each root cause makes up of the total incidents reported:



	Corrosion Failure	Natural Force Damage	Excavation Damage	Other Outside Force Damage	Material Failure of Pipe or Weld	Equipment Failure	Incorrect Operation	Other Incident Cause
Industry	2%	7%	32%	32%	7%	5%	7%	8%
AZ/NV	3%	8%	30%	35%	15%	5%	5%	0%
SWG AZ/NV	0%	4%	36%	32%	21%	4%	4%	0%

Figure 9: Incident Root Cause Analysis

The SWG system tracks the industry average somewhat closely with excavation damage and "Other Outside Force" as the leading two causes of incidents and making up about two thirds of the total incidents.

There are several items of note from our review:

- "Material Failure of Pipe or Weld" makes up a larger than typical percentage of incidents. RWA reviewed each narrative provided with each incident report. These narratives seem to generally indicate that this category of root cause is most often related to the decay or degradation of vintage plastics like PVC and Aldyl-A. To clarify, the "21%" in this category of cause includes a total of six incidents in the past decade, so while a large percentage, the absolute quantity is not egregious.

- "Other Outside Force" is a somewhat catch-all category that can include many other causes. In the case of SWG, RWA reviewed each narrative provided with each incident report. The result of this review leads us to conclude that the majority of the "other outside force" incidents were caused by vehicle impacts. There were also several incidents caused by one-off conditions such as water erosion under the pipe that led to bending.

6.1.1 Conclusions of incident review

In general, SWG has experienced a similar number of incidents per year as the industry average.

The incidents that do occur on the SWG system are relatively less severe than the industry average by most metrics. Customers affected are higher than average – due largely to several more widespread outages during incidents in the 2010-2017 timeframe.

Root causes of incidents are comparable to industry average distribution. Outlying data points include no corrosion-related incidents and 4-5 vintage plastic-related incidents.

6.2 Demographics in Service Area

6.2.1 What is the SWG Service Area?

RWA's understanding is that the SWG service territory in AZ and NV encompasses all or part of the following counties:

Arizona	Nevada
Yavapai	Washoe[29]
Maricopa	Pershing
Pima	Churchill
Gila	Storey
Pinal	Lyon
Graham	Carson City
Greenlee	Douglas
Cochise	Clark
Santa Cruz	Humboldt

Table 6: SWG Service Area by County

This service territory is illustrated visually in the figure below:

[29] While SWG does serve portions of Washoe County, much of Washoe is served by NV Energy.

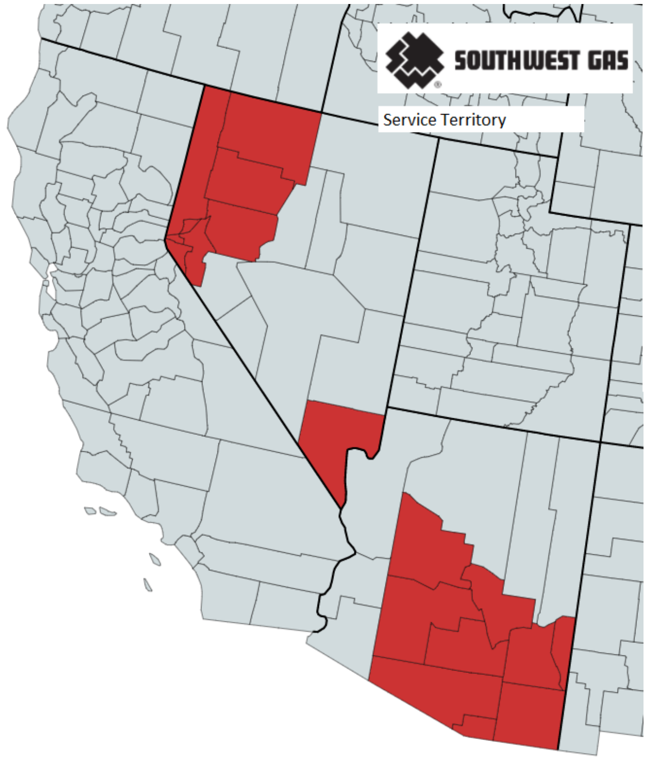
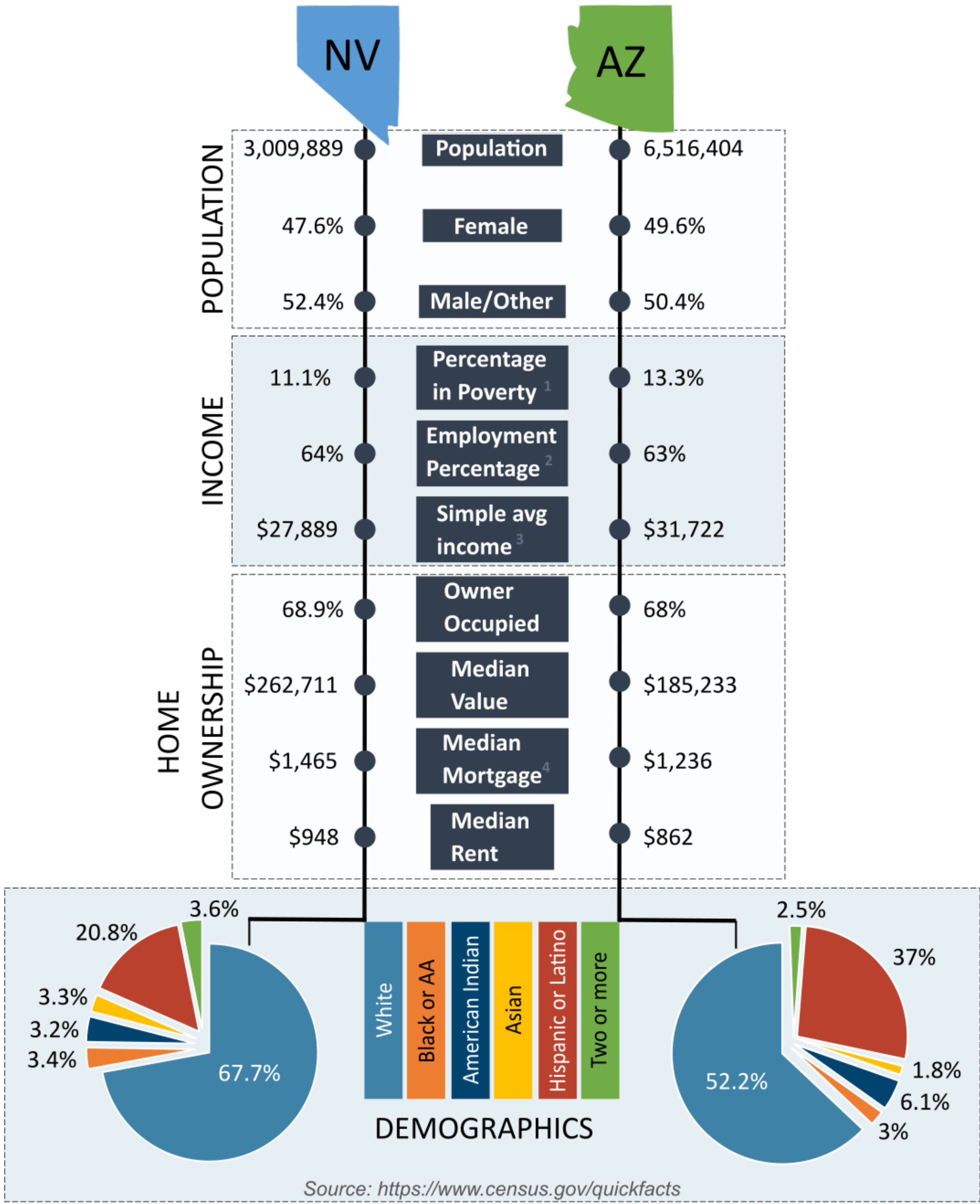


Figure 10: SWG Service Area Map

Average demographic data was collected from 2020 census reporting for the counties listed above and key metrics were picked out and generally summarized in the figure below:



1 - *Median value, ranges from 8%-13.2%*
2 - *Employment in 18-64 year olds*
3 - *Total payroll / employable population*
4 - *Monthly costs with mortgage*

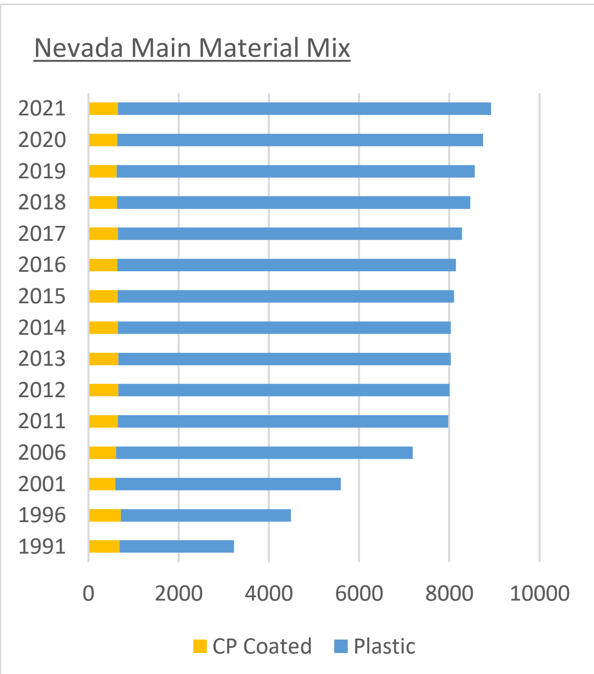
Figure 11: SWG Service Territory - Selected Demographics

SWG does not appear to have any programs targeted at particular demographic groups except one – the Low Income Ratepayer Assistance. This plan is for customers whose income does not exceed a certain percentage of the federal poverty level. In the past, this was at 150% of the federal poverty rate, but now is 200% and in Arizona, SWG is requesting that that expand to 250%. This program gives a 30% discount on the first 150 therms used each month from November through April (although SWG is looking to expand this to year-round in its Arizona rate case.

6.3 Replacement Programs

SWG has been replacing leak-prone pipe in its distribution and transmission systems for many years. RWA performed a 30-year analysis of both the AZ and NV distribution systems to get a historical perspective on the materials SWG has had in their systems. This analysis looked at the annual inventory of distribution main in SWG's NV and AZ systems for each of the last 10 years, and then every 5 years going back to 1991.

The findings of this analysis were atypical for Nevada, and somewhat atypical for Arizona. Whereas most utilities had large quantities of cast iron, bare steel, and unprotected steel pipe in their systems over this time period, and have been slowly phasing them out, SWG hasn't had large percentages of these materials in their AZ/NV systems for at least 30 years. As the pair of figures below illustrate, the SWG Arizona had eliminated most unprotected steel pipe by the mid to late 1990's and has been steadily reducing its inventory of uncoated pipe by an average of 25 miles, or 5% per year for the last 10 years.



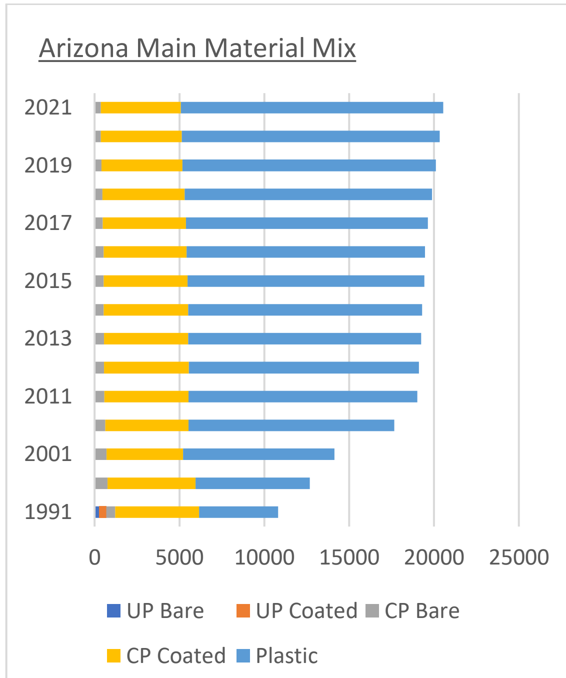


Figure 12: 30-Year Main Pipe Material History

SWG's Nevada system, on the other hand, has effectively had no cast iron, bare steel, unprotected steel in its system at all for the entire duration of the period that we reviewed.

Given the relatively good condition of the pipe in both systems, the SWG replacement efforts have focused primarily on the remaining bare steel in Arizona, aging pipe in both states, and sub-par plastic pipes in both states.

Plastic natural gas piping has a long history which involves the use of many materials, mixtures, and manufacturing processes.[30] There are several types of vintage plastic pipe that were used at one

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[30] https://www.aga.org/contentassets/c139635bd829446eb292e2801b321e88/plastic-pipe-timeline-11-2019.pdf

point for gas distribution but have since been deemed at risk of cracking or accelerated degradation. Common vintage plastic types that are often the target of replacements include:

- PVC – at risk of accelerated cracks and fractures.
- Aldyl-A – is the name of a Dupont plastic product produced from 1965 onwards. The concern with this pipe was largely confined to earlier variants of Aldyl-A pipe. Poor plastic blends, bad manufacturing processes, and poor resilience to construction hazards rendered much of this pipe at accelerated risk of failures.[31]
- Older plastics in general – in 1999,2002, and 2007, PHMSA and the NTSB issued advisory bulletins warning operators of gas systems against the potential for older plastics to leak.[32]
- Driscopipe 7000 – a specific pipe that may exhibit higher risk of cracking in high-heat environments. This issue is minor compared to the concerns above and miniscule compared to other leak-prone pipe such as cast iron or bare, unprotected steel.

In Arizona in recent years, SWG has been replacing older steel mains on an accelerated basis but was recently stopped from doing so on an accelerated basis by regulators.[33] This decision was based on the lack of evidence supporting SWG's claims regarding the threat of vintage steel pipe. To the extent that SWG discovers future leaks on its system, we expect the Company to make the necessary repairs and otherwise fulfill its obligation to provide safe and reliable service to customers without the VSP program

SWG also has a history of replacing customer-owned yard lines (COYL). COYLs are services where the meter is generally located at the property line or public right-of-way, some distance from the customer premises, and the customer currently owns and is responsible for replacing/repairing the service line if there are any problems with it. SWG no longer installed services in this manner, consistent with industry best practices, but has been assessing the risk of a large number of COYLs in its system for some time and replacing as needed.

The risk of a COYL stems from the inevitable need to replace the service in a safe manner – a responsibility which SWG's customers are intended to bear. Practically, however, the maintenance and repair of such lines are typically not done, so to replace the line with a new service and simultaneously move the meter to the customer premises, away from the property line is typically preferred.

In 2012, the Commission gave permission to establish a COYL program that would survey existing COYLs and replace COYLs that were found to have leaks.[34] Since then, SWG has identified tens of thousands of COYLs to replace and has begun replacing them.

Both the COYL and Vintage Steel programs have allowed SWG to replace this infrastructure and recovery the costs of doing so at an accelerated rate. Accelerated replacement of infrastructure is

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[31] https://www.cpuc.ca.gov/-/media/cpuc-website/files/legacyfiles/r/8947-ra-doc-10-aldyla.pdf
[32] https://www.federalregister.gov/documents/2007/09/06/07-4309/pipeline-safety-updated-notification-of-the-susceptibility-to-premature-brittle-like-cracking-of
[33] https://docket.images.azcc.gov/0000202746.pdf?i=1608248143528
[34] ACC Decision No. 72723 (January 6, 2012)

generally allowed in cases where the risk of the target infrastructure is so great that replacing it under the normal course of business would be imprudent.

In Arizona, SWG has an ongoing rate case that includes the accelerated replacement of mains and services in its system. This rate case includes $140 million of investment in pipe replacements and an additional $7.1 million in COYL replacements.[35] The targets of the pipe replacements are primarily the oldest steel mains and services remaining in the system.

6.4 Stranded Assets

Stranded assets are generally defined as those assets that, at some time prior to the end of their economic life, are no longer able to earn an economic return (i.e. meet the company's internal rate of return), because of changes associated with the lack of continuing need for the asset for various reasons, which recently has become noteworthy for the potential transition to a low-carbon economy. These changes can result in lower than anticipated demand / higher prices for customers. The difference in value is relative to that which is assumed at the initial investment decision point, so with the potential transition because of policy changes requiring low-carbon energy, it is becoming more important that at that initial point that contemplation of the potential for stranded assets must be considered. There are already examples of coal mines, coal and gas power plants, gas wells, and other hydrocarbon reserves which have become stranded by economic or regulatory changes.

This issue has seen increasing awareness in the risk-averse financial space[36], particularly in the US, Europe, China, and Australia; however, it is uncommon for this consideration to be made by utilities in regulatory proceedings or other public-facing discussions of the necessity of infrastructure.

While it is the duty of natural gas system operators to safely maintain their systems and provide reliable service – often through capital spending and upgrades, the potential for stranded assets must also be considered. This is not to say that no further capital expenditures will be necessary to address on-going safety and reliability concerns and this discussion is heavily location dependent as regulatory policies are very different between, for example, Alaska and California.

When attempting to determine the risk of an asset becoming stranded, a utility must consider many variables, potential economic and regulatory changes. Environment-related risks that can cause asset stranding include:

- Environmental challenges (e.g., climate change, natural capital degradation)
- Changing resource landscapes (e.g., shale gas abundance, phosphate scarcity)
- New government regulations (e.g., carbon pricing, air pollution regulation)
- Falling clean technology costs (e.g., solar, onshore wind, electric vehicles, or additional nuclear development)
- Evolving social norms (e.g., fossil fuel divestment campaigns) and consumer behavior (e.g., certification programs)

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[35] http://docket.images.azcc.gov/E000016855.pdf?i=1651080545154
[36] https://publications.iadb.org/publications/english/document/Stranded-Assets-A-Climate-Risk-Challenge-(Summary).pdf

- Litigation (e.g., carbon liability) and changing statutory interpretations or changing requirements on disclosures.

Southwest Gas does not appear to have taken the risk of stranded assets or stranded capital costs into account in any of their recent capital programs, investor relations publications, or regulatory filings.

7 Fuel Usage/Delivery

7.1 Volumes

7.1.1 How much total peak capacity does SWG have access to?

To assess fuel usage and delivery rates for SWG, we looked at annual sales volumes provided by SWG.

Annual peak gas sales forecasting by SWG were only available for Arizona and only for the last 10 years. This data shows that annual gas sales have increased year over year in total. However, the blend of peak sales by customer type has changed over the past decade. Over the last 10 years, projected peak gas sales to retail customers (which include residential, commercial, and industrial customers) have increased in volume by 13% while forecasted peak gas sales to transport customers have increased by 34%.[37] This is typical of many gas systems, and often indicates that residential and commercial loads are remaining relatively static while loads for power generation and large industrial customers are rising.

As of 2021, SWG has planned for a peak load of 775,809 Dth/day.[38]

7.1.2 How much gas does SWG deliver?

Utilizing public data, we can see that Arizona and Nevada have both seen historical growth in natural gas usage over the past few decades consistent with the rest of the country. However, Arizona's increases have been somewhat sharper in the past 5 years, driven mostly by increased demand for gas for power generation. The figure below shows Arizona and Nevada's combined natural gas consumption for the period of time for which data is available (1998-2020) broken down by customer class, with gas consumption for power generation overlaid in the background and utilizing a secondary vertical axis.

[37] Docket No. G-01551A-21-0368, SWEEP-01-003_Attachment
[38] *id*

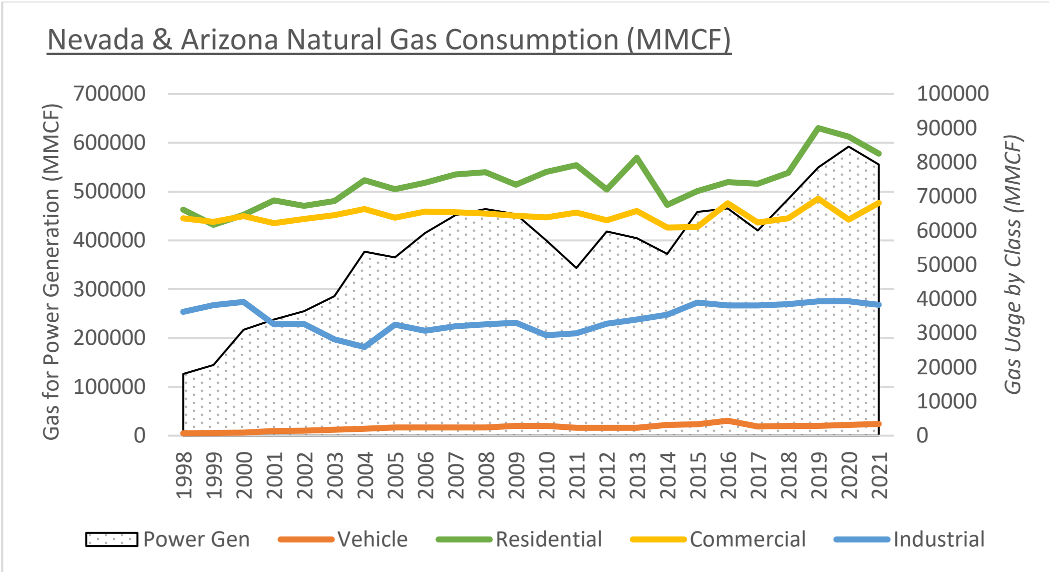

Figure 13: AZ & NV Gas Consumption by Customer Class

As mentioned above, SWG plans for an increasingly large peak demand day. Actual gas sales over the last 10 years have increased at a more moderate pace of approximately 4.8%.[39] Further data from SWG indicates that this growth in demand is heavily weighted by several operating districts. For example, over the last 10 years, gas sales to 70% of SWG Arizona's districts have declined. This is inclusive of all customer classes and includes both retail and transport customers. As the table below shows, there is one primary district that accounts for the most growth – the Phoenix Operating District. This district alone represents approximately 91% of all growth that SWG Arizona has seen.[40]

Ten Year Change in Gas Sales		
Operating District	**Change in Volume (Dth)**	**Change in Volume (%)**
Valley (D32)	-12,633,398	-34.5%
Eastern (D33)	+40,487	+3.7%
Bullhead (D34)	-412183	-7.0%
Tucson (D36)	-4,179,988	-2.5%
Phoenix (D42)	+57,301,152	+14.0%
Ajo/Gila Bend (D44)	+5,573,339	+149.0%
Mountain (D46)	-729,844	-12.2%
Southeast (D47)	-8,594,156	-22.1%
Yuma (D48)	-2,654,334	-11.8%
Parker/Wickenburg (D49)	-153,032	-5.6%
Total *(net)*	+33,558,043	+4.8%

[39] Docket No. G-01551A-21-0368, SWEEP-01-006_Attachment
[40] *id*

Table 7: 10-Year Change in Gas Sales

Looking at this same data from a year over year change perspective rather than a total change yields similar results and more clearly highlights the share of new gas load that the Phoenix division is responsible for. The figure below illustrates annual change in total gas sales over the 2011 to 2021 period, using 2011 as the baseline.

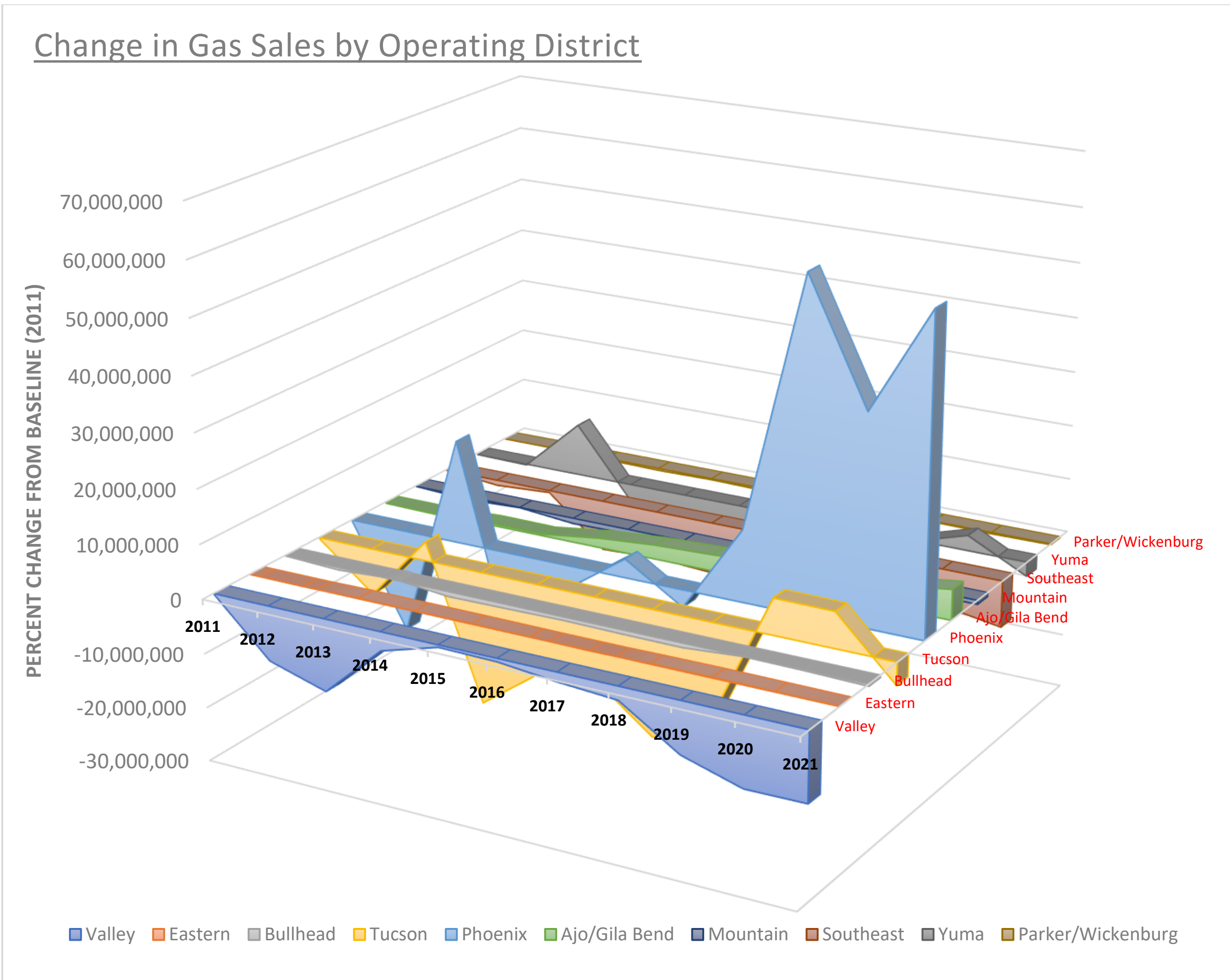

Table 8: Change in Gas Sales by Operating District

A final gas usage metric was provided by SWG in the form of low monthly volumes, high monthly volumes and the average monthly volumes of gas delivered from 2011 to 2021. Looking at the average monthly gas delivered,[41]there was an approximately 2.2% **decrease** in the average monthly gas delivered. This value went from 5,874,768 in 2021.

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[41] "Gas Delivered" includes quantities delivered to the Company's distribution systems on behalf of transportation customers served pursuant to Arizona Schedule No. T-1.

7.2 Supply sources

7.2.1 Where does SWG get its gas from and how much from each source?

Two interstate pipelines deliver gas supplies to the Company's Arizona distribution systems. Those interstate pipelines are El Paso Natural Gas Company, LLC (EPNG) and Transwestern Pipeline Company, LLC (TWPL). Those pipelines interconnect with the Company's Arizona distribution systems at hundreds of locations and individual upstream purchases are not individually tracked to each of those hundreds of interconnection points.[42]

In addition to gas purchased and secured by Southwest Gas for resale to its sales customers and pursuant to Schedule No. T-1, Southwest Gas also receives gas supplies into its Arizona distribution systems from customers that secure their own gas supplies upstream of the Company's Arizona distribution systems.[43] This is a relatively small volume of gas compared to the pipeline supplies.

In its current rate case in Arizona, SWG briefly outlines some recent changes it has made to its gas purchasing procedures and processes in response to the Feb 2021 winter storm. Southwest Gas believes that these procedure and process changes are reasonable and prudent and may help to 1) identify market anomalies and critical weather events, 2) prepare for those conditions, and 3) reduce the potential for supply disruptions.

8 Alternative Fuels

8.1 Renewable Natural Gas (RNG)

8.1.1 What is RNG?

At its simplest definition, RNG is a gas which has been sourced from a non-fossil source (such as landfill gas capture) and has been upgraded to a quality similar to fossil natural gas by filtering out contaminants and other gasses which results in the gas having a methane concentration comparable to that of traditional natural gas.

Typical RNG Feedstocks	
Anaerobic Digestion Feedstocks	Landfill Gas
	Animal Manure
	Water Resource Recovery Facility
	Food Waste
Thermal Gassification Feedstocks	Agricultural Residue
	Forestry & Forestry Residue
	Energy Crops
	Municipal Solid Waste

Figure 14: Typical RNG Feedstocks

[42] Docket No. G-01551A-21-0368, SWEEP-01-005.
[43] *Id.*

RNG is often hailed as a solve-all for climate worries: a climate-friendly fuel that can be used with the same piped distribution network, same meters, same furnaces, same boilers, with no sacrifices.

8.1.2 How is RNG made?

RNG is typically produced by one of two methods using one of two techniques:

- **Method 1 – Anaerobic Digestion (AD):** Using AD to produce RNG involves adding microorganisms to an organic feedstock. The microorganisms then convert organic matter into a mixed biogas. The mixed biogas contains primarily methane (CH4), carbon dioxide (CO), water (H2O), and hydrogen sulfide (H2S). Creating pipeline quality renewable gas involves drying the gas to drive off water, filtering out contaminants like the H2S and driving off CO2 down to levels of approximately two percent or less. This method is typically used on high-water content feedstocks like food waste, wastewater, and some animal manures.

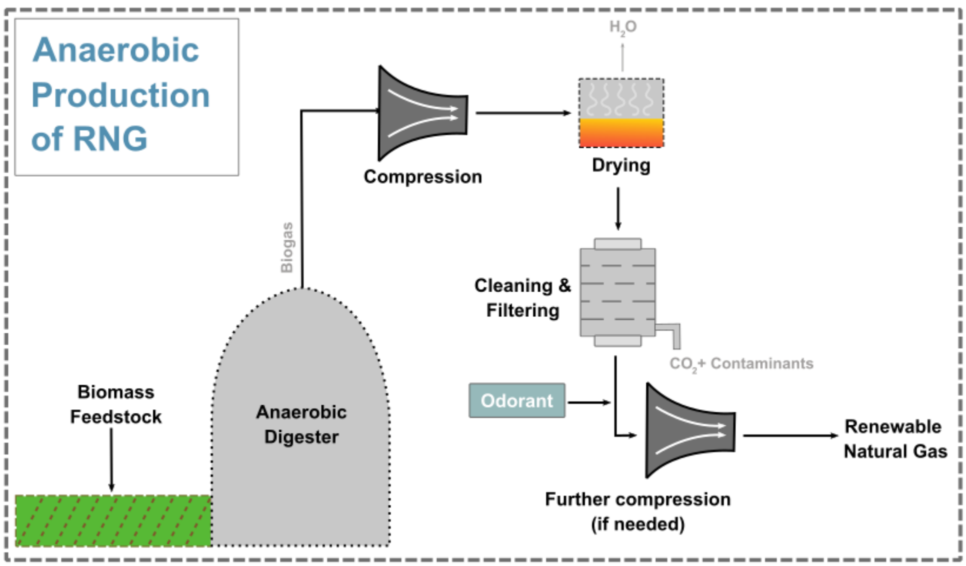

Figure 15: Anaerobic Production of RNG

- **Method 2 – Thermal Gasification (TD):** Production of RNG via TD involves the production of a synthesis gas ("syngas") in a gasifier through the thermal breakdown of solid biomass into non-condensable gases. There are numerous chemical reactions that occur throughout the TG process and steam and oxygen are often added to promote the necessary reactions. The resulting syngas is comprised mostly of hydrogen (H2), carbon monoxide (CO), carbon dioxide (CO2), water vapor (H2O), and methane (CH4), as well as smaller amounts of hydrogen sulfide (H2S). Syngas cleaning involves removing any tars, particulate, H2S and any other contaminants. To produce RNG, H2 and CO are converted to methane via a process known as "methanation." The resulting CO2 from that reaction is then removed. Unlike AD, TG works best with low-moisture feedstocks, such as wood chips and woody biomass residues, crop residues (e.g., corn stover) and energy crops such as perennial grasses. Since some of these feedstocks have high moisture content when harvested, they may require drying before gasification.

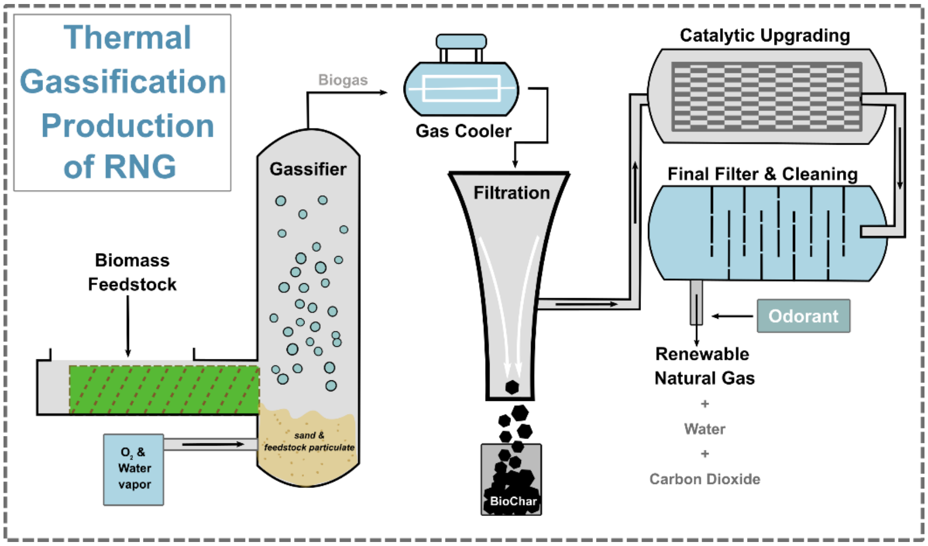

Figure 16: Thermal Gasification

- Both of these processes are complex chemical reactions and with many feedstocks and multiple processing methods it can be a complex topic to fully grasp. To facilitate a high-level understanding of the RNG process, we have provided a summary table below outlining each method, typical feedstocks, typical additives required for the process, and secondary byproducts.

RNG Production Overview by Process	Anaerobic Digestion	Thermal Gasification
Typical Feedstocks	- Animal Manure - Municipal Solid Waste - Food Waste - Silage - Other High-Organics Mass	- Roundwood - Forestry Waste - Lumber Industry Residues
Additives Required	- Electricity - Heat - Bacteria - Odorant	- Electricity - Oxygen - Water vapor - Catalyst material - Heat - Odorant
Secondary Byproducts of Process	- Carbon Dioxide - Hydrogen Sulfide - Water - Various contaminants such as Siloxane and Sulfur compounds depending on feedstock - Solids/Sludge	- Water - Carbon Dioxide - Carbon "Biochar" Solids

Table 9:RNG Production Overview

8.1.3 How much Biogas is technically available?

There are two approaches to gas availability that are often used, and each has its own, very distinct implications.

Actual availability – Actual availability, as the name implies, refers to resources that can immediately be acquired/utilized. This metric generally refers to the present availability for utilization. Future projections for expected actual availability most often use an exponent or percentage of this total (i.e. 1.05x growth year over year, or 5% growth year over year.)

Technical availability – technical availability refers to the quantities of gas that may be available given no financial, technical, policy, legal, or other constraints. Technical availability assumes the best case scenario and aims to identify the upper limit of availability. Future projections relying on technical availability most often use a fraction of this total (i.e. 20% of technically available supply). Importantly, as the percentage of technically available biogas acquired goes up, the cost of acquiring more will generally rise. For example, acquiring the first 40% of all technically available biogas may cost the same amount as acquiring the next 15%[44].

8.1.4 How much of such biogas is methane or "RNG"?

The conversion efficiency of raw biogas to "pipeline quality"[45] methane depends on the feedstock used. In general this appears to range from 20-80%.

To provide some analytical support for this generalization, RWA performed an analysis of the 235 RNG projects on the above-mentioned Argonne list of RNG sites. The average conversion efficiency of raw biogas to project and upgraded gas for each active RNG project was 57%. Average efficiencies by feedstock in the report are as shown in the table below:

RNG Conversion Efficiency by Feedstock (SCFD)			
Feedstock	**Raw Biogas to Project**	**Upgraded Gas**	**Percentage Efficiency**
Food Waste	27,244,704	15,406,823	57%
Landfills	417,460,034	224,260,974	54%
Ag Waste	95,477,405	61,921,898	65%
WWRF	25,133,488	13,387,805	53%
Averages	**141,328,908**	**78,744,375**	**57%**

Table 10: RNG Conversion Efficiency by Feedstock

Our conclusion is that using 60% as a baseline assumption of efficiency of conversion is reasonable. That said, some producers make claims of 90%+ conversion efficiency[46], and further post processing of waste gasses can result in more methane produced, although at greater energy expense.

[44] Percentages are illustrative, not actual

[45] Pipeline quality is a term that is often used to describe RNG that has been filtered/clean to the point that it is functionally indistinguishable and interchangeable with geologic natural gas.

[46] https://www.brightbiomethane.com/upgrading-biogas-to-biomethane-how-does-it-work

A further, less critical, observation is that as solids in the feedstock increase, efficiency appears to go down moderately.

8.1.5 How much RNG is available in AZ/NV?

8.1.5.1 Actual Availability

The Argonne National Laboratory maintains a list of active and imminent RNG projects in the US and Canada.[47] This list contains data on potential and actual production volumes of biogas.

There are four active projects on the list in Arizona and none in Nevada. The four active AZ RNG projects are summarized in the table below.

Arizona RNG Facilities List						
Project Name	**Feedstock**	**Raw Biogas (SCFD)**	**Upgraded gas production (SCFD)**	**MMBtu/yr**	**End Use**	**Receiving entity**
Sunoma Renewable Biofuel Project	Animal Manure	910,758	546455	179,510	Pipeline	SWG
Green Gas Partners Stanfield Project	Animal Manure	6,000,000	3600000	1,182,600	Pipeline	unknown
91st Avenue, Phoenix WWRF	WRRF	4680000	2350300	600000	Pipeline	unknown
Tres Rios Wastewater Reclamation Facility	WRRF	696000	417600	152424	Pipeline	SWG - CA
Totals	-	**12,286,758**	**6,914,355**	**2,114,534**	-	-

Table 11: Arizona RNG Facilities Detail

8.1.5.2 Technical Availability

An industry-led group funded a study in 2019 to look at the technical availability of RNG[48]. This study estimates that there will be a potential 91.7 to 222.5 trillion Btu of RNG available in the mountain west US[49] alone by 2040. This estimate is incredibly optimistic and relies on logarithmic growth in availability. Estimates of current availability by region was not part of the report's scope.

A 2017 study by ICF summarizes the results of several other RNG availability studies in the US, including the US Department of Energy (DOE) study on biomass availability performed by the Oak Ridge National Laboratory called the Billion Ton Report[50], the American Gas Foundation (AGF)-sponsored study performed by ICF[51], and a National Petroleum Council (NPC)-sponsored report[52]. Most of these reports are sponsored and/or performed by industry-led organizations with the exception of the DOE report.

The results of this comparison are that the reports are not in alignment. As can be seen in the table below, there is a wide range of potentially available RNG.

[47] https://www.anl.gov/sites/www/files/2020-07/RNG_database_2019_update_0720.xlsx
[48] Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment, ICF, (2019)
[49] Referring to Census Region 4, District 8 – "Mountain" which includes Arizona and Nevada
[50] https://www.energy.gov/sites/default/files/2016/12/f34/2016_billion_ton_report_12.2.16_0.pdf
[51] https://gasfoundation.org/2019/12/18/renewable-sources-of-natural-gas/
[52] https://npchardtruthsreport.org/Hard_Truths-Topic_Papers/8-STG-Biomass.pdf

RNG Potential (Bcf/y)	NPC	AGF	DOE
High Potential	Not provided	932	1,212
Low Potential	Not provided	2,397	9,230
Average Potential	5,667	1,665	5,221

Table 12:RNG Potential Availability Estimates

8.1.6 What are SWG's plans for RNG?

In 2021, SWG released its 2021 Sustainability Report[53], focused on the governance, environmental, and social efforts the company is undertaking. This report includes an entire section on RNG.

The very first sentence of this section says: "Like power obtained from wind and solar, RNG is an energy source harvested from landfills, dairy farms and wastewater treatment facilities" From there, the report outlines SWG's plans to use RNG. Highlights of this plan include:

- NV – SWG won a contract to supply RNG-sourced compressed natural gas (CNG) to a fleet of busses in southern Nevada operated by the Regional Transportation Commission. The RTC's website indicates that *"Since 2007, the RTC has been transitioning its fleet to a more environmentally friendly fuel called Compressed Natural Gas (CNG)* […] *with a goal of a near 100% CNG fleet by 2023."*[54] The RTC also has pilot programs with electric busses and fuel cell busses.
- AZ - SWG has four new interconnect projects with RNG facilities in 2021. One is a wastewater facility, and the other three are dairy farms.

While SWG lauds the potential for RNG to help the Company meet climate goals it is mandated to meet, it does not appear that the Company plans to implement RNG on a material scale. In its 2021 SEC 10K filing, when listing risks to the Company and in reference to its RNG and biogas initiatives, SWG says:

"while certain forms of renewable energy initiatives compete with natural gas, the abundance and low cost of natural gas, as well as the convenience and comfort it provides to our customers, result in competitive advantages across our portfolio of customers."

This statement accepts the implicit fact that RNG will likely be more expensive than traditional natural gas. SWG goes on to say that:

"Overall, management does not anticipate any material adverse impact on operating margin from fuel switching or alternative energy initiatives over the near term."[55]

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[53] https://www.swgasholdings.com/wp-content/uploads/2021/12/SWGH-Sustainability-Rep-2021.pdf
[54] https://www.rtcsnv.com/news/rtc-awarded-3-8-million-federal-grant-to-continue-to-invest-in-clean-energy-vehicles/
[55] 2021 Southwest Gas Holdings, Inc. (SWX) SEC Filing 10-K

A gas supply portfolio that contains a large percentage of RNG would likely see material impacts to its margins or would see material increases in its rates assuming regulatory approval.

Also of note, SWG submitted an application to the Arizona Corporation Commission (ACC) to establish an RNG Program to incorporate RNG into its gas supply portfolio at 1 percent by 2025, 2 percent by 2030, and 3 percent by 2035 and which was denied by the ACC on 12/17/20.[56]

In Nevada, SWG drafted proposed regulation regarding RNG activities.[57] A version of these regulations were adopted by the NUC in 2020 and require utilities wishing to pursue RNG options to meet certain criteria. A utility seeking approval for RNG activity must describe the activity proposed, estimate costs and revenue requirements, an explanation of the environmental benefits of the activity, the mechanism the utility proposes to recover costs associated with the activity, and an estimate of the activity's impact on the utility's rate base.[58]

8.1.7 Benefits of RNG

- **Diverted Methane Emissions:** RNG can potentially be a way to divert waste methane from select existing industrial and agricultural processes that would have otherwise been vented into the atmosphere. In some cases, this can extract useful energy from what would otherwise be a destructive waste product while simultaneously preventing its release.
  This does not necessarily apply to all RNG installations, as there are other factors to consider such as emissions that would otherwise not have been generated such as those from the transportation, distribution, storage, and end use of RNG.
- **Extended Useful Life:** The life of a typical piece of modern steel or plastic natural gas pipe can exceed 75 years – particularly in dry areas like the SWG service territory. The hundreds of millions of dollars spend on these capital projects become at risk of being a stranded cost in total electrification scenarios unless the useful life of such infrastructure is extended. This, of course, has other implications; but as a standalone fact, RNG could extend the useful life of existing infrastructure, thus mitigating some potentially stranded assets.

8.1.8 Issues with RNG

- **Costs**: Broadly speaking, the costs of RNG appear to make it difficult to justify beyond select applications. A report by the industry-led American Gas Foundation found that RNG is likely to be available at costs of $7/MMBtu to $45/MMBtu.[59] An earlier report done for the California Air Resources Board found that costs for RNG ranged from $30 to over $100 per MMBtu for dairies, $15 to $22 for municipal solid waste, $7 and over $50 for landfills, and between $9

[56] https://docket.images.azcc.gov/0000202746.pdf?i=1617116898784
[57] https://pucweb1.state.nv.us/PDF/AxImages/DOCKETS_2015_THRU_PRESENT/2019-6/40633.pdf
[58] https://pucweb1.state.nv.us/PDF/AxImages/DOCKETS_2015_THRU_PRESENT/2019-6/45251.pdf
[59] https://www.gasfoundation.org/wp-content/uploads/2019/12/AGF-2019-RNG-Study-Full-Report-FINAL-12-18-19.pdf

and $50 for wastewater treatment plants.[60] A PGW-funded study found that RNG is cost-prohibitive at scale with costs ranging from $9 to $80/MMBtu.[61]

According to the EIA, the city gate price of fossil gas has averaged about $4.50/MMBtu over the last 10 years – including recent spikes to the $6/MMBtu range.[62] While cost should not be the only factor in considering alternate-fuel solutions, the combination of higher costs with the other issues discussed in this report, make RNG unattractive at scale.

Examples of actual RNG pricing, proposed or agreed upon are hard to come by. In Massachusetts, Liberty Utilities is attempting to secure a contract for RNG at $9.25/MMBtu[63] with an inflation escalator as of the time of this writing. In other areas RWA has also seen RNG contracts that price the gas at the current index price plus a set of fees/upcharges.

Regardless, under even the most optimistic circumstances at very low production volumes, these data imply that RNG is over twice as expensive as fossil gas. As more RNG is produced, less optimal sources must be used, driving up the price and exacerbating the differential with fossil gas. Given the probable economic impracticality of RNG, it would need to have significant environmental benefits.

- **Emissions**: RNG is often touted as being "carbon neutral" or even carbon negative. The idea behind this is that the organic matter used as feedstock would have eventually decayed, thus releasing methane into the atmosphere. What is ignored is that this is neither the only, nor the primary source for biogas for use as RNG.

  A recent research project[64] by a professor at the Georgia Institute of Technology summarized the relative emissions of these sources for RNG well by categorizing the sources as follows:

  (1) RNG produced from waste methane that would have otherwise been emitted to the atmosphere (Path 1);
  (2) RNG produced from waste methane that would have otherwise been flared with 99% destructive efficiency (Path 2); and
  (3) RNG produced from intentionally created methane (Path 3).

  This study analyzed the relative emissions of RNG from each path in the negative, or counterfactual sense. In other words, what would have happened to the methane were it not converted into RNG.
  In the majority of the cases, RNG that is sourced from Path 1 above, is likely carbon neutral, and commonly carbon negative (depending on system leakage rates). But RNG from options 2 and 3 above are definitely more carbon intensive than traditional natural gas, leading to net increases in emissions, even at very low system leakage rates. These results are

[60] https://ww2.arb.ca.gov/sites/default/files/classic/research/apr/past/13-307.pdf
[61] https://www.phila.gov/media/20210430132543/April-2021-E3-PGW-Diversification-Study-Draft-Materials-FINAL.pdf
[62] https://www.eia.gov/dnav/ng/hist/n3050us3a.html
[63] https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/14748151
[64] https://iopscience.iop.org/article/10.1088/1748-9326/ab9335/pdf

summarized in the figure below which shows RNG carbon dioxide equivalent intensity by pathway[65].

(a) GWP-100, kg CO2e/GJ methane productively consumed							
system leakage (mass CH4 emitted/mass CH4 produced)	0	0.025	0.05	0.075	0.1	0.125	0.15
Path 1: Waste methane diverted from emission to atmosphere	−680	−680	−680	−680	−680	−680	−680
Path 2: Waste methane diverted from a 99% efficient flare	−7	10	29	48	68	89	112
Path 3: Intentionally produced methane used	0	17	36	55	76	97	120
(b) GWP-20. kg CO2e/GJ methane productively consumed							
system leakage (mass CH4 emitted/mass CH4 produced)	0	0.025	0.05	0.075	0.1	0.125	0.15
Path 1: Waste methane diverted from emission to atmosphere	−1720	−1720	−1720	−1720	−1720	−1720	−1720
Path 2: Waste methane diverted from a 99% efficient flare	−17	26	72	121	172	226	283
Path 3: Intentionally produced methane used	0	44	91	139	191	246	304

Figure 17: RNG Methane Emissions by Pathway

The figure above lays out the relative emissions of RNG in both a 20-year global warming potential scenario and 100-year.

- **New Infrastructure**
  If even a percentage of the potential sources for RNG were utilized, a large investment into new infrastructure **or** transportation costs would have to be made.
  If RNG is produced at the site of the feedstock production, then the resulting RNG will have to be compressed and trucked, or a pipeline built to the facility to move gas into the distribution system.
  If RNG is produced closer to a distribution system injection point, then feedstock will have to be transported from various sites.
  In both cases, new infrastructure to capture, convert, clean and compress gas will have to be installed.
- **Efficiency of Combustion vs. Flaring**: Waste methane for use in RNG systems (especially early adopters) is more likely to be diverted from a flare than from direct atmospheric release. Flaring involves burning off the methane in highly efficient combustor systems that can prevent up to 99%+ of GhG from reaching the atmosphere. This means that RNG systems need to be more efficient for the entire capture to combustion process than a flare to provide climate benefits versus the alternative management strategy of simply flaring. Given that the distance and complexity from capture to combustion in RNG use cases is much greater than capture to combustion in
- **Perpetuate Reliance on Methane**: RNG is still, essentially, methane. Regardless of source, there will be operational and distribution emissions associated with the fuel that exceed those of renewables. RNG can be a stop gap or used during a natural gas decommissioning process in small percentages to prevent the release of methane in industrial applications, but at scale does not have the effect of reducing methane reliance.
- **RNG Availability**: There have been several studies on the availability of RNG. Typically, the approach for such studies is to assess existing potential sources of biomass, calculate throughput of such sources and estimate a potential output of biogas or RNG. This final step – the estimating of potential output – relies on making assumptions about the feasibility,

[65] assumes climate-neutral combustion emissions of carbon dioxide

willingness, cost effectiveness, and timing of sources. In reality, capturable waste biogas for conversion to RNG is extremely limited[66] in availability.

We assume many utilities will substitute RNG for traditional natural gas in their future plans in order to purportedly limit the impact of their operations while continuing to operate a profitable business. The assumption that such substitution is climate friendly relies on a major condition that is unlikely to be met: namely, that RNG is manufactured from waste methane/biogas that would otherwise have been emitted to the atmosphere. At volumes projected by some of the more extreme gas utility plans, RNG would need to be intentionally manufactured from various feedstocks en masse. There are even some plans to turn hydrogen into methane. At the point where RNG is being manufactured at scale to meet these artificial volumes needed, there is very minimal benefit.

- **Potential for "Double-dipping":** When a utility distributes RNG, it can claim to have offset some of the impact of natural gas use. However, in regions where transferable carbon credits are made available, it is critical to ensure that companies are not acquiring such credits and using or selling them, while making claims regarding emissions reductions. RWA searched the Berkley Carbon Trading database project[67] that lists approximately 6,000 projects and the associated carbon credits, but SWG does not appear to be providing data to this voluntary project.
- **"Green Attribute" Transfer**: "Green Attributes" is a term that RWA has seen appearing in RNG contracts in the US. The exact definition of what comprises a green attribute varies from jurisdiction to jurisdiction, but generally is broadly defined to include most or all climate or carbon offset benefits of the product.

  Part of the economic viability of the production of RNG are the governmental/third party economic incentives to do so. The ability to claim carbon offset credits in one or more of the various programs in existence makes the business of RNG more profitable. As such, RNG producers are sometimes unwilling to grant the transfer of any of the climate-positive attributes of RNG. An example of these terms that RWA has seen in RNG contracts in other states is provided below.

No Green Attributes:	The RNG that Seller sells and delivers and Buyer purchases and receives under this Transaction Confirmation shall not have any Green Attributes. Any Green Attributes shall be retained by Seller.

Figure 18: Green Attributes of RNG Contact Example

As even the casual reader can see, from the buyer's perspective, the RNG received from the seller is indistinguishable from traditional natural gas as far as climate impact is concerned

[66] https://iopscience.iop.org/article/10.1088/1748-9326/ab9335/pdf
[67] https://gspp.berkeley.edu/assets/uploads/page/Voluntary-Registry-Offsets-Database--v4-2021-year-end.xlsx

In summary, RNG may be useful in certain circumstances to give use to captured methane where major infrastructure improvements do not need to be made. However, among other things; availability, emissions, and cost issues with RNG make this “alternate” fuel unattractive at scale.

- **Maturity of Technological Processes:** While methane from biomass has been captured for combustion for nearly 40 years, the technology to produce RNG at scale is not available. The first RNG facility opened in 1982 at the Fresh Kills Landfill on Staten Island. Over the next 40 years, only about 230 facilities nationwide have opened despite increasing push from natural gas companies. To supply RNG at scale, tens of thousands of RNG facilities would be needed – along with the associated supply chain, production capabilities, and improved technology itself.

8.2 Hydrogen

8.2.1 Use cases for Hydrogen

Hydrogen is generally utilized in one of two ways in the natural gas industry: Blended Fuel combustion and “Power to Gas” (P2G),

Blended fuel combustion refers to the combustion of hydrogen and methane together. In this use case, hydrogen from various sources is injected into the system by a distribution company (like SWG) and is carefully blended at carefully controlled percentages and then sent to end use customers to use just like regular natural gas would be.

The National Renewable Energy Laboratory, at the request of the Department of Energy, conducted an assessment of the relative risk of various percentages of hydrogen-natural gas blends using data gathered by GTI. That assessment suggested that higher concentrations up to 50% present only a minor increase in overall risk (in both probability and severity of impact). However, in services, the risk is much higher at those concentrations due to the potential for confined spaces and trapped gas. The blending threshold at which the increased risk transitions from minor to moderate is at approximately 20% hydrogen. Higher concentrations of Hydrogen would require further technical studies before implementation.

Power to Gas (P2G) is the process whereby electrical power is used to convert hydrogen to natural gas. This process is expensive today and largely deployed at research and demonstration scale, with limited commercial scale deployments. This is sometimes touted by natural gas utilities as a way to utilizes renewable energy and hydrogen in a way that avoids the concerns of hydrogen distribution. However, it appears that given the costs, and additional steps needed to convert hydrogen into methane, that this technology currently appears to hold little practical use in a natural gas utility’s portfolio.

8.2.2 Hydrogen Production

Hydrogen for distribution can come from various sources. There are three typical pathways that result in hydrogen:

1. **“Brown” Hydrogen** is the result of using coal or similar feedstock in a high heat steam environment with the addition of oxygen to gasify the volatiles in the feedstock which are then filtered and cleaned to produce hydrogen.

This approach is less common when looking at hydrogen for distribution and is sometimes used in conjunction with carbon capture solutions.

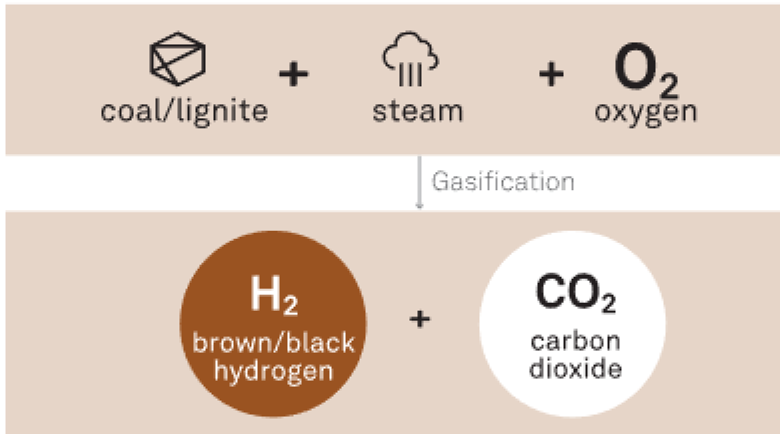

Figure 19: "Brown" Hydrogen[68]

2. **"Grey" Hydrogen**, or as the gas industry prefers "Blue" hydrogen, is produced by the reaction of methane with steam and other catalysts in a process known as steam reformation to produce hydrogen. There is an emerging technology called methane pyrolysis[69] which may be a more attractive method of transforming methane to hydrogen. This technology produces hydrogen from natural gas and generates a solid carbon as the only by-product, which facilitates separation and collection of the fossil fuel's carbon component after the process. The first at-scale project just went operational at the end of 2021 and results of its efficacy are pending.[70]
   Many in the natural gas industry prefer this pathway to hydrogen in that it provides ongoing demand for natural gas and can be seen as a less harmful use for natural gas. Use cases include the conversion of captured methane emissions into hydrogen.
   Typical issues with this pathway to hydrogen is the energy required, emissions produced[71], and the fact that high-efficiency flaring is often a more cost effective way of reducing emissions.

[68] Graphics from S&P Global research
[69] https://pubs.acs.org/doi/10.1021/acs.iecr.1c01679
[70] https://monolith-corp.com/methane-pyrolysis
[71] https://theicct.org/sites/default/files/publications/lca-biomethane-hydrogen-eu-oct21.pdf, pg. 29

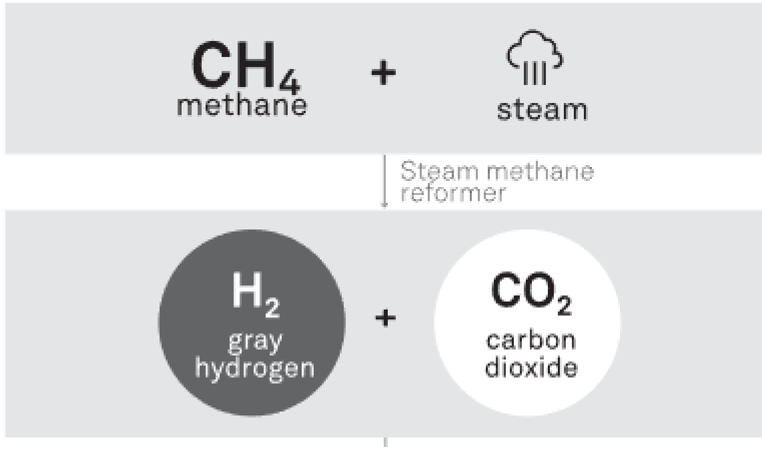

Figure 20: "Grey"/"Blue" Hydrogen

3. **"Green Hydrogen"** is produced by a process called electrolysis in which water is split into oxygen and hydrogen using electricity. This process, when done using renewably-sourced power is typically the idea pathway to hydrogen production but can be difficult to achieve at scale.
   Use cases for this pathway to hydrogen are often focused on the conversion of excess renewable energy (i.e. peak afternoon solar or high wind production periods) into hydrogen as a means of energy storage to optimize the renewable energy source.

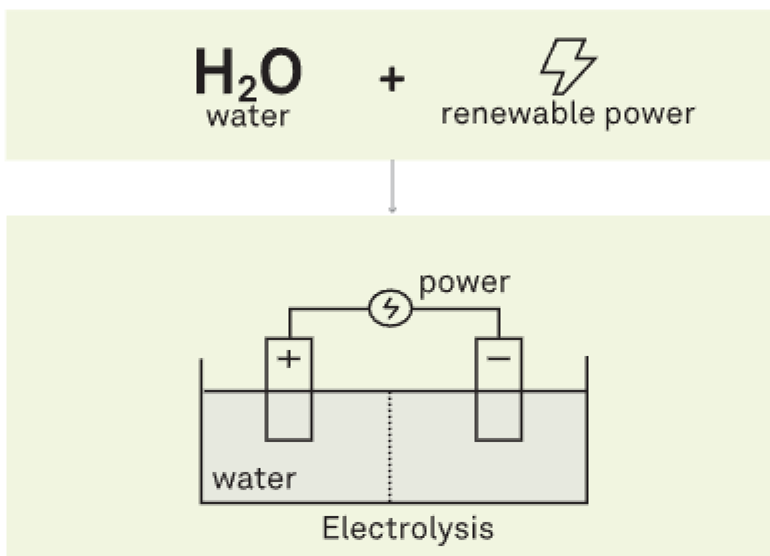

Figure 21: "Green" Hydrogen

8.2.3 Hydrogen Availability[72]

S&P Global has compiled a list of active hydrogen producing facilities in the US. These facilities are summarized in the figure below:

[72] https://www.spglobal.com/commodity-insights/en/products-services/oil/platts-world-refinery-database

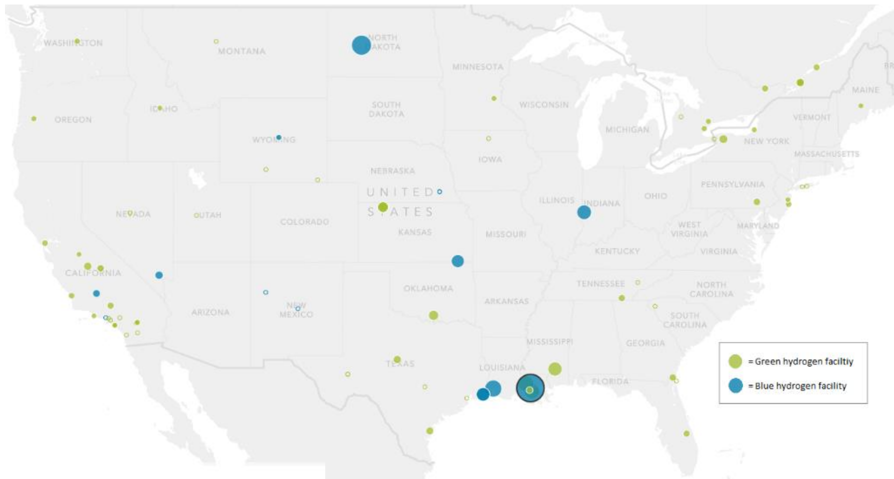

Figure 22: Hydrogen Production Facilities - US

These facilities are clustered in California and Texas, however, there does appear to be one facility that SWG may currently have access to on the outskirts of Las Vegas[73]. This facility is owned and operated by Air Liquide, a multinational gas-producing company. While the original press release appears to have been removed from the website, an archive[74] of it appears to indicate that this facility is currently producing hydrogen from natural gas using a P2G process.

8.2.4 Practicality of Distributing Hydrogen

Distribution and transmission of hydrogen in the United States is currently limited to large corporate-owned hydrogen merchants and are closed loops. When looking at options for developing a more robust hydrogen transmission and distribution network, the best example would be Europe's network.

The first European natural gas pipeline was converted and put into commercial service by Gasunie in the Netherlands in November 2018.[75] This prompted a collective of natural gas operators in Europe to propose the European Hydrogen Backbone (EHB) initiative in 2020[76] that plans for an eventual 39,700 km of pipelines across twenty-one countries by 2040. Of this proposed network, 69% would be repurposed natural gas pipelines and 31% newly built hydrogen pipelines.

To mimic such a system, densely populated portions of the country such as the eastern and western coasts, as well as the east-central US could implement a similar network. For more rural and sporadically populated areas of the country like NV and AZ, single trunk lines to move gas from city-to-city may be more feasible. This, of course, would come at massive up-front capital cost – particularly since dedicated hydrogen pipelines are often made of more expensive types of materials.

In all cases, the issue of whether demand-driven infrastructure or infrastructure-supplied availability comes first will be at the forefront and is a classic chicken-and-egg problem. Natural gas utilities

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[73] https://goo.gl/maps/E3g6vwVzG3gqVXuj8
[74] https://web.archive.org/web/20210313171321/https://www.airliquide.com/united-states-america/air-liquide-committed-producing-renewable-hydrogen-west-coast-mobility-market
[75] https://www.gasunie.nl/en/news/gasunie-hydrogen-pipeline-from-dow-to-yara-brought-into-operation
[76] https://gasforclimate2050.eu/sdm_downloads/extending-the-european-hydrogen-backbone/

efforts to create demand for hydrogen, and thus stimulate the production side of the hydrogen economy may face challenges in regulatory environments given the upfront capital costs required which most investor-owned utilities would prefer to be paid for by ratepayers. This large capital outlay would also be in competition with other, potentially more climate-beneficial, projects.

8.2.5 Risks of distributing hydrogen

Hydrogen in the distribution system, blended or pure, poses a challenge when assessing the relative safety of the addition to end users/the public. Hydrogen shares many risk factors with natural gas such as:

- Susceptibility to leaks in old main,
- Need for leak prevention and detection systems,
- High-consequence in the event of an incident, etc.

However, Hydrogen also differs from natural gas in that it has a larger set of conditions in which ignition is possible. Also, having a molecular weight of almost 1/16th that of methane, Hydrogen is more susceptible to leaking at mechanical joints and via permeation through the walls of pipe. A study assessed the following risk areas[77]:

- **Gas buildup**: Gas buildup behavior of blends was similar to that of pure natural gas – no separation. In general, the concentration following a release is only slightly higher for blends of up to 50% hydrogen, but concentration increases become more significant for hydrogen blends greater than 70%. Concluding that at lower, sub-20% concentrations, hydrogen does not increase the risk of gas buildup.
- **Explosions in Enclosures**: The relative increase in the severity of confined vented explosions was modest for blends with less than 20% hydrogen and more significant for blends over 50%. Concluding that there is a moderate increase in risk of explosions from leaks in confined spaces.
- **Risk from Hydrogen in Transmission lines**: Risk is spatially proportionate – closer to incident location = higher risk. Higher percentage hydrogen blends disperse faster lowering the radius of risk but increasing the risk at the site. Inversely, lower percentage hydrogen blends disperse slower, increasing the radius of risk, but lowering the risk at the site of the leak. The figure below illustrates the relative risk of injury to a person with differing blends. The vertical axis is a measure of the relative chance of becoming a fatality in a given year – the higher the value, the more probability exists.

[77] Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues, NREL, 2019

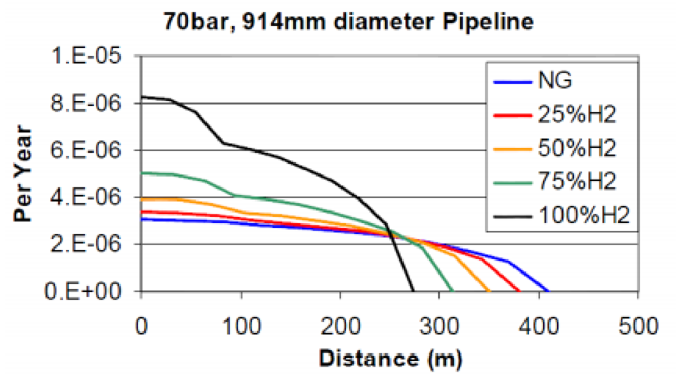

Figure 23: Hydrogen Risk Curve

8.2.6 Embrittlement concerns

The use of hydrogen in steel pipe can present some embrittlement concerns.[78] Embrittlement of steel occurs in the presence of hydrogen in steel reduces the tensile ductility and causes premature failure under loads that depend on the stress and time. This phenomenon is known as hydrogen embrittlement.

While we do not know with complete certainty the mechanism by which hydrogen embrittles steel, all theories agree on several key points. Embrittlement is exacerbated by increased pressure and concentration of hydrogen in a mixed gas. These concerns are mostly present at injection sites where the concentration of hydrogen is much higher and there is more potential for higher pressure as the injection of compressed hydrogen gas meets the relatively lower pressure distribution system.

Thankfully, these concerns can be mitigated by instituting blending processes that prevent higher than normal pressures and higher hydrogen concentrations in excess of 50%.

Any hydrogen program utilizing natural gas infrastructure must account for the potential for embrittlement. To this end, PHSMA is actively pursuing research into this and other hydrogen-related topics[79][80]. The US DOE is also performing ongoing research and development regarding hydrogen compatibility/impact on infrastructure with $15M in funding expected to be spent from 2021-2023 through the HyBlend initiative[81]. The DOE initiative in particular will provide the public with publicly accessible tools that:

- Characterizes the costs of blending hydrogen and its potential to reduce emissions relative to alternative pathways, and
- Assesses the risks of blending to a pipeline system given the materials in use, age of the system, and blend concentration.

[78] Hydrogen Embrittlement of Pipeline Steels: Causes and Remediation (energy.gov)
[79] https://primis.phmsa.dot.gov/meetings/MtgHome.mtg?mtg=153
[80] https://sam.gov/opp/2bac8152ac6746b6a578a0760d4c795d/view#general
[81] https://www.energy.gov/sites/default/files/2021-08/hyblend-tech-summary.pdf

8.2.7 Permeation concerns

Hydrogen is more mobile than methane in many plastics including the plastic pipes and elastomeric seals used in natural gas distribution systems.

An assessment was done on Hydrogen leakage in PE80 plastic pipe at 58, 116, and 174 psi. using a 10% Hydrogen blend. The findings were:

- The hydrogen permeation coefficient is four or five times higher than that of methane.
- The permeation rate of methane and hydrogen increases with pressure at a similar rate.
- The aging of pipelines has no apparent significant effect on permeation coefficients.

The general conclusions regarding hydrogen permeation concerns are:

- The gas lost via permeation exponentially scales with the percentage of Hydrogen present at all pressures that have been studied.
- Hydrogen blends under 20% see steady but reasonable increases in permeation. Blends over 20% begin to increase permeation exponentially.

8.2.8 End use equipment concerns

The primary concerns for end use equipment are twofold:

- Firstly is residential equipment, which makes up a large percentage of end use equipment by volume. Specific items of concern include air mixing equipment on heating and cooking appliances, impact of blended fuel on risk of leaks.
- Secondly is high-volume industrial equipment. This category of equipment can be very sensitive to changes in the fuel, and blended fuel applications **must** consider the impact to these customers or include a way for such customers to opt out.

From available research which includes pilot programs in various European countries, it does not appear that blends under 20% caused issues with end-user residential equipment. There does not appear to be a reliable source of data on impacts to industrial equipment by industrial customers as the equipment in question varies widely in sensitivity to fuel mixture.

Blends that contain hydrogen content over 20% will quickly have greater and greater impact to end use equipment. At some yet-undetermined threshold, the hydrogen blend will contain too much hydrogen for typical residential heating and cooking equipment to function and new equipment would be required. This would cause obvious cost and feasibility issues.

The final concern with the use of blended-fuel in end-use equipment is that it does not eliminate the health concerns of gaseous fuel combustion. This concern is twofold:

- While hydrogen does not have any carbon atoms and thus, there are no carbon-based pollutants such as carbon dioxide or carbon monoxide, hydrogen combustion in atmospheric air results in the production of an oxide of nitrogen known as nitrous oxide (NOx). As such, hydrogen combustion is not a truly zero-emission fuel, but rather is a low-emission fuel. This is the reason that some hydrogen combustion engines use exhaust gas recirculating to reduce emissions[82]- something that is not possible with today's residential and commercial cooking and heating equipment.

- Secondly, the vast majority of the blended fuel is still methane. A 20% blend of hydrogen/methane still results in approximately 80% methane being burned which has known health and safety concerns.[83]

8.2.9 Conclusions

Blending hydrogen into natural gas pipeline networks at low concentrations (less than 20%) has the potential to increase utilization and/or energy storage of renewable energy production facilities in the near term. When coupled with renewable or low-carbon energy sources, hydrogen can potentially have a net positive climate impact.

The 20% delineator is supported by an industry-leading study performed by the National Renewable Energy Laboratory (NREL)[84], which in itself includes a study done by the Gas Technical Institute (GTI). This percentage is quicky becoming the industry standard for proposed hydrogen pilot programs in the US.

In the longer term, blending may provide an economic means of hydrogen delivery when the hydrogen is injected upstream and then extracted downstream for use in fuel cell electric vehicles (FCEVs) or stationary fuel cells. This technology is not currently implemented in the field and has more barriers to overcome than simple blending for combustion.

The risk:reward ratio and impact on infrastructure & consumer appliances becomes more acceptable in the 5-15% hydrogen blend range. Targeted applications of blended fuel can further improve this ratio and further research can better support the ideal percentage for each application.

This is a transitionary period, in which much research and many pilot programs are ongoing, and the technical merits of hydrogen are still being studied. It is crucial to understand the acceptable hydrogen percentage that can be blended into natural gas without negatively impacting the lifetime of the infrastructure, safety of the system and cost-effectiveness of any program. This is currently best done via a practical pilot program study or through the meta-analysis of many other pilot programs. Careful attention to emerging research and development, as well as other pilot programs will allow a utility to effectively pilot hydrogen blending in a laboratory setting or in isolated portions of its system to best study the impact.

Large capital expenditures into hydrogen distribution may be inefficient in the long run as alternative non-gaseous energy sources ramp production and the capital costs for building and maintaining hydrogen infrastructure become cost-ineffective. Care must also be taken when making capital investments into hydrogen infrastructure to assess the expected lifespan of these assets and understand that there may not be a cost effective use for these assets for the entirety of that lifespan.

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[82] https://www.researchgate.net/publication/223080548_NOx_emission_and_performance_data_for_a_hydrogen_fueled_internal_combustion_engine_at_1500rpm_using_exhaust_gas_recirculation

[83] Methane and NOx Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes | Environmental Science & Technology (acs.org)

[84] Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues, NREL, 2019

8.2.10 What are SWG's plans for hydrogen?

In its 2021 sustainability report, SWG lays out some of its plans to utilize hydrogen.

These plans focus on around partnering with Arizona State University (ASU) and the University of Nevada, Las Vegas (UNLV) on two hydrogen blending pilot projects that begin in early 2022.[85]

As part of the program with UNLV, Southwest Gas will use the university's electrolyzer to test the production, blending, distribution and end-use of hydrogen blend. Green hydrogen will be blended with natural gas at ratios of 5%, 10% and 50%.

The study with ASU will use pre-purchased hydrogen bottles and will blend up to 20% hydrogen with 80% natural gas. The first phase of programs will last several months and will serve to shape subsequent phases.

There does not appear to be any status updates or information on these programs aside from the press release. There also do not appear to be any other active plans, programs, or actions that SWG is taking to implement hydrogen blending into its operations.

9 Fuel Switching/Electrification

9.1 State initiatives

9.1.1 Arizona

The Arizona Corporation Commission ordered the state's Public Service Corporations to develop a strategic, long-term Transportation Electrification (TE) plan for Arizona.[86] This largely focuses on switching from gasoline and diesel use to electric.

However, there may be some portions of this plan that relate to natural gas. Arizona has enacted a number of policies that aim to support transportation electrification in the state, as well as the increased use of alternative fuel vehicles (AFVs) more broadly. Most statutes define an AFV to include vehicles fueled by propane, natural gas, electricity, hydrogen, or a blend of hydrogen with propane or natural gas.

It seems likely that SWG will make an effort to acquire transportation customers in the same way it has in Las Vegas to secure additional end users for its natural gas in a way that is deemed more environmentally friendly than the alternative (Gasoline or Diesel).

9.1.2 Nevada

In 2021, Clark County adopted its first ever Sustainability and Climate Action Plan.[87] The stated goal of this plan is to demonstrate commitment to a healthy, sustainable community for all its current and

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[85] https://www.swgasholdings.com/wp-content/uploads/2021/12/SWGH-Sustainability-Rep-2021.pdf
[86] https://illumeadvising.com/files/Arizona-Phase-1-TE-Report-Final.pdf
[87] https://files.clarkcountynv.gov/clarknv/Environmental%20Sustainability/Sustainability/Sustainability%20and%20Climate%20Action%20Plan_FINAL.pdf?t=1636995195328&t=1636995195328

future residents by addressing climate change risks and contributions within the County's own operations.

This plan does not explicitly lay out plans for natural gas distribution beyond generally calling for a reduction in the percentage of electricity generation from natural gas and to generally electrify operations where possible. There is no mention of hydrogen, CNG, or RNG in the plan.

Additionally, The PUCN opened an investigation for the long-term planning of fossil gas utility services in the state in May 2021.[88] This investigation is split into three Phases:

- Phase 1 requested an inventory of the uses of natural gas in Nevada, associated GhG emissions, and alternative fuels.
- Phase 2 requested comments to evaluate the impacts of decarbonization on the electric system
- Phase 3 requested comments to evaluate the costs, planning, and mitigation measures required

This investigation is groundbreaking and asks many questions that get at the heart of the electrification issue such as "If natural gas sales decline, at what point does the gas system become operationally and financially unviable?." While the future of this investigation is uncertain, the results will likely drive all gas-related climate goals and inform SWG's decisions.

9.1.3 Costs & Impacts of Electrification

9.1.3.1 General

Electrification refers to the replacement of fossil-fuel end uses in buildings and transportation with electricity-based alternatives as well as the potential replacement of upstream electric generation with other non-fossil fuel sources. In buildings the end uses in question include building heating, water heating, clothes drying, and cooking.

While SWG does provide some natural gas for transportation in the form of CNG vehicles, the largest impact to SWG will be the electrification of buildings.

There are an incredible number of factors to consider when attempting to determine the relative cost of fuel switching.

Generally, the high-level goal of fuel-switching is to reduce reliance on natural gas and do so in a relatively cost effective manner **to the end use customers**. To achieve this, there are operational and economic factors that must be considered.

9.1.3.2 Operational Considerations

The process of electrifying a natural gas system that results in partial or complete shutdown of the gas system is not one that is well defined or standardized. Additionally, RWA is not aware of any natural gas system that has fully electrified. However, partial electrification where the goal is to incrementally move customers from natural gas to electricity is being discussed and is ongoing in the US and worldwide.

[88] https://www.documentcloud.org/documents/21172753-21-05002-order#document/p1/a2071915

In order to accomplish this in a safe and effective manner for a natural gas system, the reduction in load or shutdown of sections of the system will have to be done both intentionally and incrementally.

This process would likely involve sectionalizing the system into many distinct sub-sections and then systematically transitioning each section off of gas to electricity. To do this safely, and without compromising the reliability of gas service to the remainder of the system that is still active, each system operator would have to consider things like:

- The location and needs of large commercial and industrial customers
- The location and needs of electric generation facilities
- The location of interconnects with various gas supply sources
- The pressures that each section of the system can sustain
- The hydraulic design of each section of the system, and the changing hydraulic design of the system as a whole as each section is removed.
- The readiness of the electric grid to take on additional load
- The fuel costs passed on to remaining customers in late stages as the utility purchases less gas
- The percentage of customers who are willing to switch fuels in each area

This process is aided by the existing shutoff valves in each system that are required under federal code[89] to reduce the time to shut down a section of main in an emergency. This process may also be aided by the geographic clustering of aging infrastructure in certain systems. If one segment of a system contains a large percentage of the system's leaks and/or aging infrastructure, then that portion may be a good candidate for initial shutdown assuming existing users are ready to switch fuels. In addition to infrastructure condition, other factors that may help with sectionalizing a system include geographic portions of the gas system that:

- Have an electric system capable of accepting new load,
- Are isolated from the rest of the system already, or are connected by a small number of main gas lines,
- Are already being electrified to a high percentage,
- Are a defined municipality, subdivision, area, or other group that wish to electrify as a whole, or
- Are in an area that costs considerably more to serve with gas.

9.1.3.3 Economic Considerations

Economic considerations regarding electrification in the SWG service territory are two fold – those that pertain to natural gas customers and those that pertain to the gas utility itself.

Economic impact to end use customers is often the most-talked about topic in electrification. The goal is to create a means for customers to switch fuels in a cost-effective manner and the conversation typically centers about how to induce consumer behavior and energy consumption changes all while impacting those consumers financially as little as possible.

[89] CFR § 192.181

How much does it cost to heat a hospital or apartment complex with gas vs. electricity? Who pays to replace the cooktop, hot water heater and clothes dryer? Who pays for an industrial plastics factory going to adjust their equipment and processes to account for the fuel change? What is a cost effective way to electrify old midcentury homes? These and more questions must be addressed in an electrification plan.

While these challenges appear daunting, the solutions to solve them exist or are coming soon. As solutions are developed in various areas of the country, they are being ported to other applications. SWG in particular serves an area with minimal winter space heating load – relative to much of the rest of the country.

Thus, as far as end users are concerned, the challenge is not one of technological barriers but one of economics and pace. How quickly can end users be convinced that making the switch is economic.

Regarding the economic concerns facing natural gas utilities, the most obvious economic concern that natural gas utilities will face is that of profitability. Most natural gas utilities are investor owned or privately owned companies. The profit-driven incentives in such a company are often in opposition to the entire concept of electrification – hence the attempts of utilities to invest in anything remotely “green” like RNG or hydrogen that allows them to continue selling gas. There is no easy way to align these incentives with a large-scale electrification effort but understanding the motives and drivers of these companies can be helpful when pursuing policy options or working in regulatory proceedings. For example, a utility may be more willing to accept the concept of electrification of isolated residential developments at the end of a main line than the entire downtown of Phoenix or an area containing several industrial high-volume customers. In an environment in which electrification is not widely supported, understanding these nuances can help stakeholders come to agreements with all parties and maximize impact.

Secondary economic concerns are the potential for stranded assets as discussed in more detail further in this report. Regulatory agencies will eventually need to develop policy to manage the handling of cost recovery for assets who were prematurely removed from service due to electrification. This has the potential to result in significantly higher gas costs for end users, which has the side effect of accelerating the economic viability of fuel switching but has the potential to harm certain demographics.

9.1.4 Electrification Policy options

- Intervening in the current and future SWG rate cases in both Arizona and Nevada will be an excellent way to collect information and affect policy decisions. For example, the ACC was recently persuaded to discontinue SWG’s accelerated replacement of steel facilities by third parties.
- Watching for new regulation proposals. SWG in both states takes an unusual tact in that it has proposed new regulations to the state regulators. The language of such regulations is likely very much so in favor of the utilities and should be scrutinized. That is not to say that all regulation should be opposed outright. For example, SWG’s RNG-related regulations in Nevada give the Company a way to engage in RNG-related activities, but also require them to demonstrate the benefits of the activities.
- Develop and pursues cooperative agreements at the municipal level with SWG. This idea stems from the MOU discussed in the franchise agreements section of this report and appears to be a

potential leveraging mechanism. This could be leveraged via franchise agreements, rate cases, or any other regulatory mechanism in which mandated compliance with this MOU could be used as a bargaining chip.

- Nevada's Future of Gas Investigation may or may not result in policy changes but will definitely be a critical exercise in understanding the PUCN, utilities and other parties' goals, direction, and willingness to participate in climate action and/or regulatory/operational changes.
- Clark County, NV which encompasses Las Vegas and houses over two-thirds of Nevada's population has developed a "Sustainability & Climate Action Plan" that it calls "All In".[90] This plan seeks to reduce emissions and prepare for upcoming changes to the county's climate. Out of this plan came several initiatives including:
    - An inventory of the County's greenhouse gas emissions
    - A climate vulnerability assessment, and
    - The creation of Phase II of the Sustainability & Climate Action Plan

  Phase II of this process is ongoing until the end of 2022 and the latest step was a roundtable with the local and regional energy partners whose goals were to:
    - Review top priorities and concerns of organizations working in the energy sector in Southern Nevada, both generally and with regards to addressing climate change,
    - Learn about energy sector's future plans, goals, and technology deployment,
    - Discuss potential challenges in implementing climate/sustainability programs or regulations,
    - Identify opportunities to maximize co-benefits from climate or sustainability programs or regulations, and
    - Confirm areas for collaboration between energy sector and All-In.

  This process will be ongoing for some time, and early and consistent involvement with the County's team that is leading this effort could be a beneficial path to securing commitments from the state's largest population cluster regarding operational and policy direction going forward.

- The City of Phoenix has established a Climate Action Plan.[91] The City has previously invested $25 million in a biogas facility, and in this plan intends to advance this type of program by repurposing landfill gas that is currently being captured and flared for conversion into renewable natural gas. This facility will be operational by 2023 according to the plan. It is unclear what options exist for third parties to become involved in this established and ongoing plan, but it is clear that the city is investing ongoing funds into RNG.

[90] https://files.clarkcountynv.gov/clarknv/Environmental%20Sustainability/Sustainability/Sustainability%20and%20Climate%20Action%20Plan_FINAL.pdf?t=1636995195328&t=1636995195328
[91] https://www.phoenix.gov/oepsite/Documents/2021ClimateActionPlanEnglish.pdf

10 System Resiliency

10.1 Threat Analysis

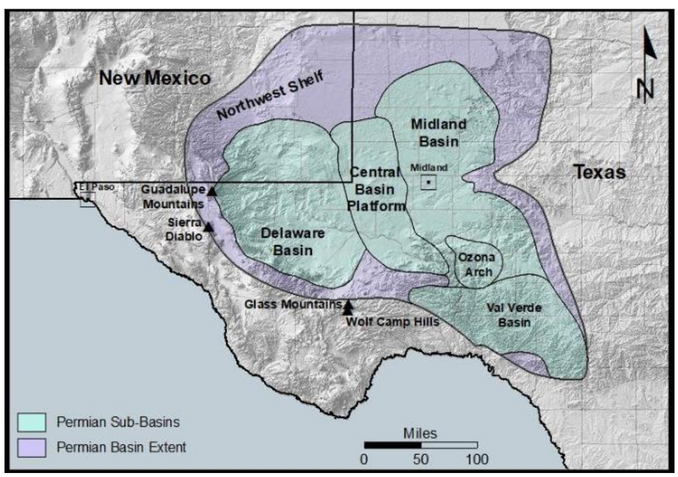
10.1.1 Resiliency to Load Spikes

SWG's system appears to be relatively resilient to load spikes. The infrastructure is modern, outages appear limited, and there is likely a large stable base load vs. severe seasonal swings.

Regarding known recent load spikes, in its 2021 base rate case in Arizona, SWG references the February 2021 winter weather event known as Winter Storm Uri which cause massive outages across much of the south-central US.[92]

Although the center of this storm was somewhat distant from SWG, cold temperatures from this winter weather event caused what is most likely the largest load spike in recent history on SWG's systems – particularly in Arizona.

SWG claims that a portion of their gas supply comes from the Permain Basin – one of the country's richest deposits of shale gas.



It was not clear from the filing the percentage of gas that SWG planned to receive from suppliers drawing from the Permain Basin, or other regions strongly affected by winter storm Uri. However, regardless of that, SWG did state that as a result of shortages in supply and the necessity of buying natural gas at vastly inflated spot prices during that week, SWG incurred gas costs of $191m in the month of February 2021, as compared to the gas costs of $133m for the year of 2020.

This proceeding is ongoing, and the prudence of SWG actions are still under review. The debate regarding balancing the costs of storm-hardening a system with the benefits gained during a 1 in 100 year storm is ongoing, not just for SWG, but for utilities all along the southern half of the US.

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[92] http://docket.images.azcc.gov/E000016855.pdf?i=1649873056955 Direct Testimony of John R. Olenick, pg. 8

Regardless, as far as resiliency to outages is concerned, it does not appear that SWG experienced widespread outages or loss of service to customers during a storm that, for all intents and purposes, can be used as a benchmark for system performance for all utilities affected by it.

10.1.2 Resiliency to Decay

As discussed in the infrastructure overview section of this report, the SWG distribution system is comprised entirely of plastic and cathodically protected and coated steel pipe. These materials, as a category, are among the most resilient to decay of all materials used in gas distribution for the reasons discussed above. Below are comments on the various materials that do exist in the SWG system, and potential threats to those materials.

Steel Pipe: The corrosion process that takes place on a piece of uncoated steel is very complex. Factors such as variations in the composition/structure of the steel, presence of impurities, uneven internal stress, and/or exposure to non-uniform environment all affect the corrosion process. Generally, corrosion will occur faster steel pipe that is uncoated and exposed to electrically-conductive environment (such as wet, mineral-rich soil), or when there is an electrical difference between the pipe and something the pipe is in contact with (such as the ground).

Given the arid, dry climate of most of the SWG systems, environmental corrosion risk is already at a lower level, and all of SWG's steel pipe is coated to prevent contact between the steel and anything else. To prevent electrolytic corrosion, SWG has placed cathodic protection nodes along all of the steel pipe in its system. This protection typically uses sacrificial pieces of metal to divert the corrosion potential away from the pipes.

Plastic Pipe: Plastic is immune to the corrosion issues that befall steel. However, there are some environmental factors that can increase the degradation of plastic pipe. Exposure to sunlight, exposure to extreme heat, and decay due to inferior plastics are all known issues on plastic gas pipe.

To combat this, SWG (and all system operators) bury their plastic pipe in the ground to protect it from UV damage from the sun (as well as accidental damage). SWG further has been replacing its older plastic pipes made of materials such as PVC, a plastic called Aldyl-A, and several other vintage plastics that are known to be more susceptible to degradation or to be less heat-stable. As a result, the current SWG system is at relatively minimal risk of degradation to its plastics pipe as evidenced by the decreasing leaks on the system.

10.1.2.1 Driscopipe

This plastic piping material in particular has been the subject of recent efforts by SWG in NV for en masse replacement. The rationale that SWG relies on is that there was an advisory bulletin from PHMSA alerting operators to potential issues with Driscopipe in hot, arid climates.

However, based on our research, Driscopipe does not appear to expose the utility to risk at the same level as other pipe types replaced in the past (including PVC). Further, PHMSA's treatment of this potential risk factor (Driscopipe in hot, arid environments) is very mild in comparison to the language used by them for other pipe types with higher incidence and severity.

In order to mitigate the risk of potential issues with Driscopipe, RWA agrees with the advice of PHMSA and the pipe manufacturer and suggests that SWG continue their advanced leak surveys and replacements where issues are found.

10.1.3 Resiliency to Fire

When evaluating the risk of fire damage to natural gas infrastructure, the primary variable that impacts relative risk is frequency of fire. That is to say that there is very little variation in gas infrastructure that affects risk, and the risk of outages due to fire is minimally connected to variables within the utility's control.

A review of all natural gas reportable incidents in the US from 2010-2021 resulted in only three incidents that mentioned wildfire as a contributing cause. In all cases, the damage to the gas system was on an above-ground service riser going into a customer's house. These incidents mostly involved steel risers.

Actions that a utility could take to mitigate risk of fire damage to the system include burying any above ground pipe that exists (if any), contributing to preventative measures in their services areas, clearing land of combustibles around critical regulator stations and other facilities, and working to have a thorough, annually reviewed emergency response plan. Additionally, mock emergency activities benefit utility employees, local first responders, media, and the public and could include a fire-related incident if reasonable for the operating area.