LIGHTHOUSE ENERGY CONSULTING

TO:	Tom Armstrong, City of Portland Bureau of Planning and Sustainability
FROM:	Ted Light, Lighthouse Energy Consulting
SUBJECT:	Natural Gas System Review
DATE:	May 13, 2022

This memo documents research and analysis related to natural gas infrastructure and proposed limits on new or expanded storage tanks within the City of Portland. A summary of key findings is provided, followed by detailed discussions of the regional and local natural gas systems, future demand for natural gas, how those future demands will be met, and implications of storage tank restrictions in Portland.

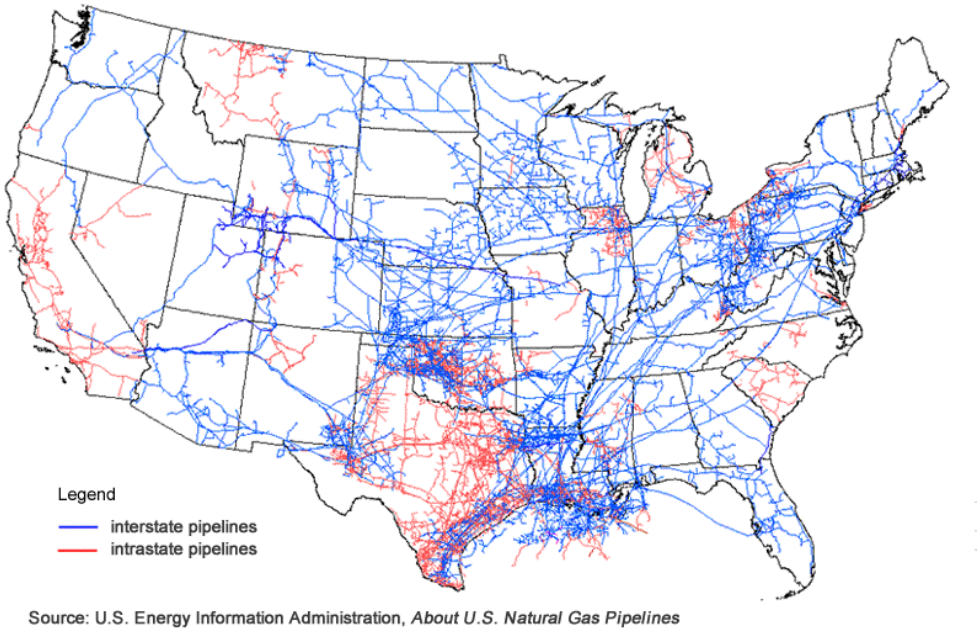
Summary

- Infrastructure needs for the local natural gas system are primarily driven by the need to match the demand for natural gas over a single peak day which is associated with extreme cold weather events.
- NW Natural's 2018 IRP considers a range of possible future demand for natural gas and in its base case predicts continued growth in peak day demands over the 20-year period covered by the IRP.
- The 2018 IRP identifies new resources that, in total, exceed NW Natural's expected future growth in peak day demand and describes other resources that, while not quantified in the IRP, could provide additional peak day capacity. None of these resources require new or expanded natural gas infrastructure within the City of Portland.
- Policies encouraging electrification, especially those covering building heating systems, will lessen peak day demand for natural gas. These policies are playing a significant role in the development of NW Natural's 2022 IRP. While subject to change, data presented thus far suggests that NW Natural may expect declining loads and peak demands in the future.

Overview of the Natural Gas System

The natural gas system in the US is comprised of a multi-step process that delivers natural gas from production and storage areas to end use consumers. Interstate and intrastate transmission pipelines make up the backbone of this system and carry natural gas at high pressures from processing plants and storage facilities. Along the way, compressor stations operate to keep the gas flowing. Figure 1 shows a map of these pipelines in the US.

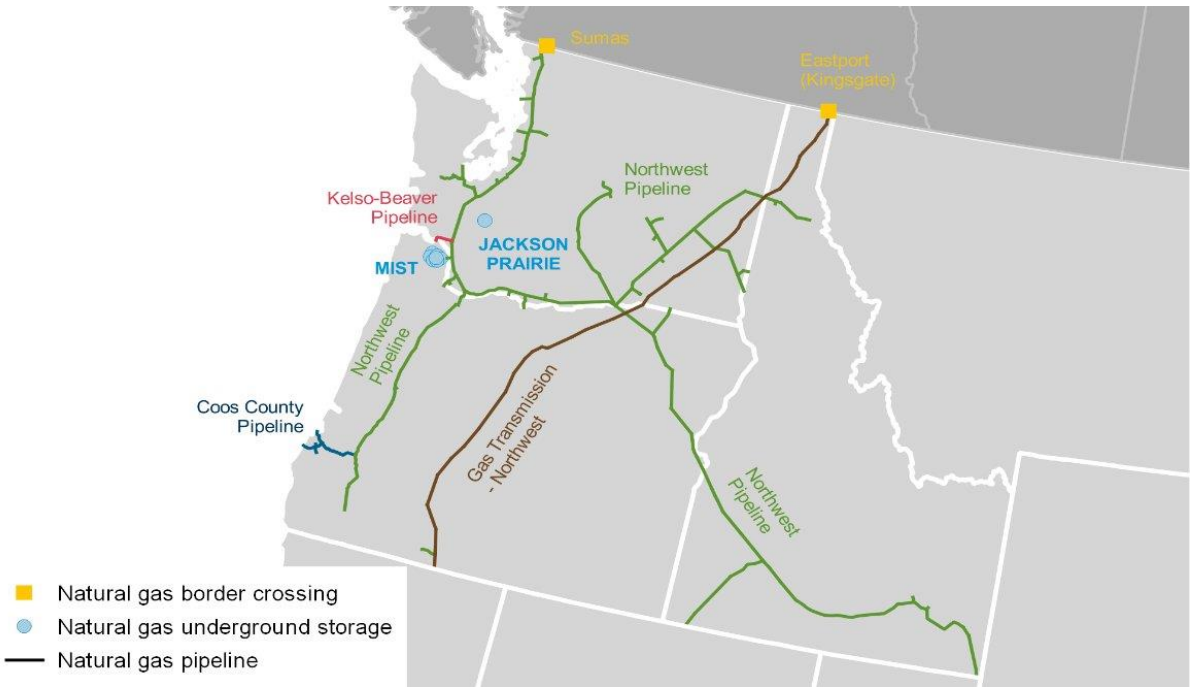
Figure 1: Interstate and Intrastate Natural Gas Transmission Pipelines in the US



Source: U.S. Energy Information Administration, *About U.S. Natural Gas Pipelines*

The natural gas infrastructure in the Northwest is shown in greater detail in Figure 2 below. There are two primary pipelines operating in Oregon, each operated by a different company. The Northwest Pipeline, operated by Williams Company, runs roughly along the Interstate 5 corridor from Sumas, Washington to southern Oregon and includes branches extending along the Columbia River and into eastern Washington and Idaho. The Gas Transmission-Northwest pipeline is operated by TC Energy and is located east of the Cascades.

Figure 2: Natural Gas Infrastructure in the Northwest



Source: U.S. Energy Information Administration

Local distribution companies, including utilities like NW Natural, receive gas from these transmission pipelines at specific points called city gates or gate stations. These serve as the point where natural gas transitions from the high-pressure transmission pipelines to the lower pressures used in distribution systems. This is also the point where natural gas is odorized for safety. NW Natural receives nearly all of its natural gas through the Northwest Pipeline. A small portion is produced at its Mist facility in northwest Oregon, which operates as both a gas production field and storage facility, although its gas production is limited.

Figure 3: NW Natural System

Source: NW Natural

NW Natural is the designated regulated utility that serves western Oregon and parts of southwest Washington, as shown in Figure 3. Within the City of Portland, NW Natural is the only natural gas distribution utility. As a regulated utility, NW Natural is given a local monopoly in exchange for being regulated by Oregon Public Utility Commission. Even absent this regulation, it would be extremely difficult and cost-prohibitive for another utility to construct an equivalent system of delivery infrastructure. As a regulated utility, NW Natural is required to prepare file an Integrated Resources Plan (IRP) with the Oregon Public Utility Commission. The IRP projects demands for natural gas over a 20-year period and identifies how NW Natural will serve that demand with existing and new resources. NW Natural's most recent IRP was completed in late 2018 and is a key resource document for this analysis. NW Natural published IRP update in March of 2021, but it does not go to the same level of depth as the original IRP and any changes are inconsequential to this analysis. NW Natural has also begun developing and presenting draft material as part of the development of its 2022 IRP. While this information is preliminary and subject to change, it is discussed in this memo where relevant so that the most up to date information can be included.

Across Oregon, NW Natural has 39 city gates connecting its system to the regional transmission pipelines at various points (NW Natural 2019). NW Natural's system is composed of both transmission and distribution pipelines. NW Natural-owned transmission lines are shown in the map at the left. After travelling through these transmission lines, natural gas is delivered to end use customers through a network of smaller distribution lines.

Unlike the electric grid, the production and delivery of natural gas does not need to be coincident with its consumption. Operators of transmission pipelines and local distribution companies can rely on storage to help meet daily customer demands for natural gas and conduct arbitrage, buying when prices are low to meet demand when prices are higher. Natural gas can be stored in gaseous form, often in large, depleted oil or natural gas reservoirs, or it can be cooled and condensed to a liquid and stored as liquified natural gas (LNG). In liquified form, LNG takes up approximately 1/600th of the volume.

In addition to dedicated storage facilities, natural gas can be stored through linepack, in which additional natural gas is compressed in the distribution pipelines for later withdrawal while maintaining system pressures within defined operational ranges. This effectively serves as temporary storage.

On a typical day, NW Natural largely draws gas from the regional pipeline system to serve its customers. Demand for natural gas on cold days may exceed what NW Natural has contracted to withdraw from the regional transmission pipelines. In these situations, NW Natural has four storage resources that it can use. It owns and operates an underground storage facility in Mist, Oregon. NW Natural also contracts for underground storage at the Jackson Prairie facility near Centralia, Washington as shown in Figure 2 above. In addition, NW Natural owns two liquified natural gas (LNG) facilities in Oregon, one in Portland and one in Newport. NW Natural is the only company that operates an LNG storage facility in Portland. The City of Portland's recent zoning code amendment would allow new fossil fuel terminals with LNG storage tanks up to 2 million gallons, which is just under half of NW Natural's existing Portland LNG facility.

While the Mist, Portland, and Newport facilities are within NW Natural's system, NW Natural must procure capacity on the NW Pipeline to transport gas stored at Jackson Prairie to its system. Table 1 lists these storage facilities and provides the maximum amount of natural gas that can be withdrawn in a day as well as the overall storage capacity.

Table 1: NW Natural Firm Storage Resources

Facility	Maximum Daily Rate (Dth/day)	Maximum Seasonal Capacity (Dth)
Mist	305,000	11,382,120
Newport LNG	65,280	761,600
Portland LNG	131,880	371,902
Jackson Prairie	46,030	1,120,288
Total	**548,190**	**13,635,910**

Source: NW Natural 2018 IRP, Table 6.1

NW Natural's IRP does not discuss the amount of linepack available as storage. A study on natural gas resiliency conducted by Portland State's Center for Public Service states that NW Natural provided an estimate of one million therms or 100,000 Dth available as storage through linepack (Portland State Center for Public Service 2018).

NW Natural has another storage-like resource that it can tap to address peak demand —through negotiated agreements, NW Natural can access the gas supplies of industrial customers, operators of gas-fired power plants, and gas suppliers for short periods of time. These are called "recall agreements" and currently total an additional 39,000 Dth per day that NW Natural can use to meet short periods of high demand (NW Natural 2019). These agreements are limited in the amount of natural gas that NW Natural can access, so they are akin to other storage resources.

Natural Gas Customers

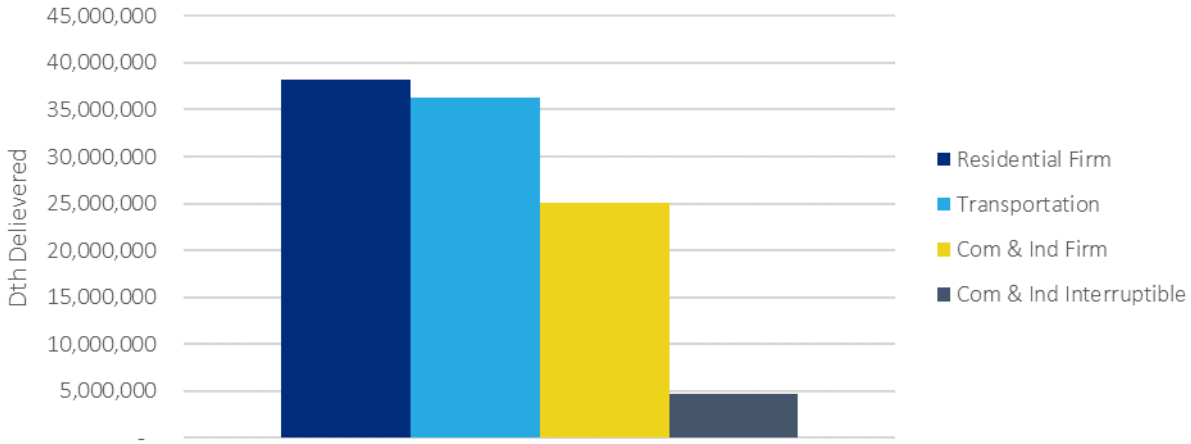
In addition to the different types of infrastructure used to supply natural gas to customers, another important distinction is the different types of natural gas customers. NW Natural's customers generally can be divided into one of three categories:[1]

[1] Note: Natural gas-fired power plants are also consumers of natural gas, but there are no facilities within the City of Portland and these facilities are not dependent on NW Natural's distribution system or LNG storage facilities.

1. **Firm service** customers include all residential and most commercial customers. NW Natural provides these customers with a reliable supply of natural gas throughout the year.
2. **Interruptible service** customers include larger commercial and industrial customers who elect to pay a reduced rate in exchange for allowing NW Natural to interrupt their service if needed. Interruptible customers must have end uses that are flexible or that can shift to other fuels in the event of a service interruption.
3. **Transportation service** customers procure their own natural gas, including the delivery on transmission pipelines up to the point where it is delivered into NW Natural's system. They pay NW Natural only for local delivery of the natural gas through their distribution system to their facility. Transportation service customers ensure that the timing of natural gas deliveries to NW Natural's distribution system meets their demands, so no storage of this natural gas is required by NW Natural. Note that the use of the term "transportation" in this context does not have any connection to vehicle transportation. Transportation service customers are typically the very largest industrial consumers who use natural gas for industrial processes and dedicate staff resources to the procurement of natural gas.

A breakdown of NW Natural's 2020 deliveries of natural gas by these customer types is provided in Figure 4, based on data provided in the 2020 Oregon Utility Statistics Report, published annually by the Oregon Public Utility Commission. Residential firm service customers are the largest group, followed by customers receiving transportation service. Commercial and industrial customers receiving firm service makeup the third largest group, with interruptible customers making up approximately 5% of 2020 natural gas deliveries.

Figure 4: 2020 Natural Gas Deliveries by Customer Type



(Oregon Public Utility Commission 2021)

Demand for Natural Gas

NW Natural must plan to meet customer demand across multiple time horizons. It must ensure that it has a sufficient supply across the months of a year, including the heating season when demand for natural gas is higher. According to NW Natural's 2018 IRP, more than 90% of customer accounts are residential and most of its load is driven by space heating equipment.

NW Natural must also ensure that its infrastructure is sufficient to meet the demand for gas over the course of a single day to ensure the reliability of its service, especially during short periods of high demand driven by cold weather events.

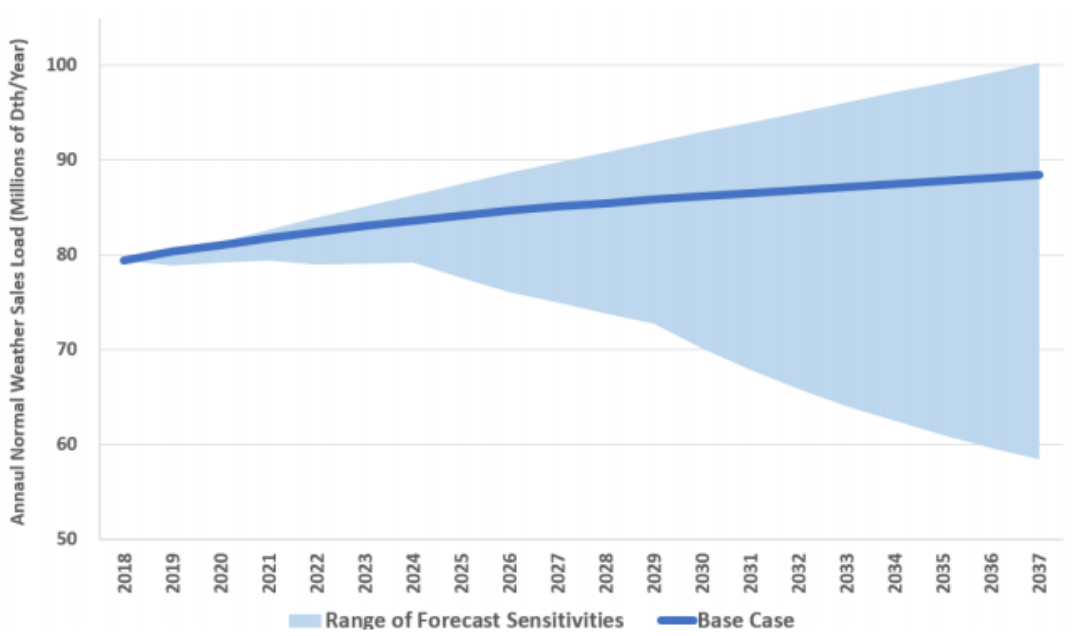
Through the IRP planning process, NW Natural ensures that it is prepared to meet these future demands for the next 20 years. These demands for natural gas are related but can be driven differently by distinct factors. For example, while the number of customers and saturation of end use equipment fueled by natural gas can affect both the overall annual load and peak daily demand, climate change may result in a net reduction in annual loads while peak daily demand depends on the severity and duration of short duration cold weather events and the number of customers using natural gas for space heating.

While the overall amount of natural gas NW Natural has delivered to its system is determined by the longer-term seasonal demand for natural gas, the infrastructure needs are primarily driven by the requirements to meet short term peak day demands.

Annual Demand

As shown in Figure 5 below, NW Natural's 2018 IRP projects their base case annual sales to increase from approximate 79 million Dth in 2018 to approximately 88 million Dth in 2037. This total includes sales to firm and interruptible customers only and excludes natural gas delivered to transportation service customers.[2] The forecast reflects a compound average annual growth rate of approximately 0.6% per year. NW Natural also includes a range of forecast sensitivities, varying from a decrease to under 60 million Dth to an increase to more than 100 million Dth.

Figure 5: NW Natural 2018 Annual Load Forecast

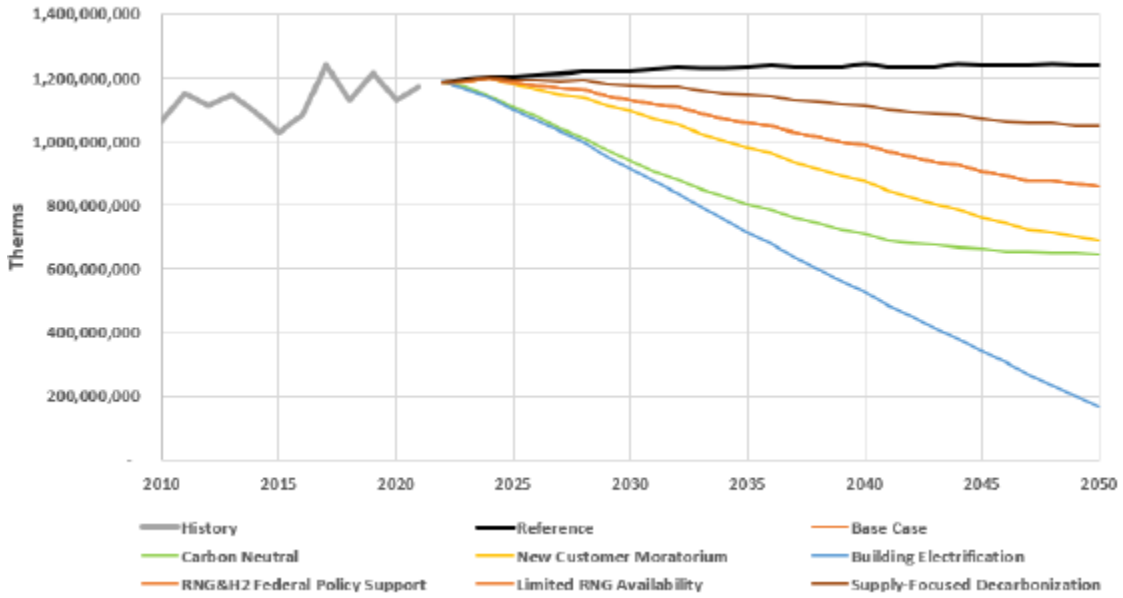


Source: NW Natural 2018 IRP

[2] Because transportation service customers procure their own gas and its delivery to NW Natural's system, NW Natural does not need to plan for this gas consumption as part of its IRP.

In materials presented as part of the development of their 2022 IRP, NW Natural extends their forecast horizon out to 2050. The extended "business as usual" Reference case load forecast shows a similar trend of flattening load growth that has reached a steady state by 2050 (Figure 6). However, NW Natural acknowledges that the reference case is not likely to reflect future conditions, but instead merely the continuation of the past, and the scenarios that NW Natural proposes for consideration in their 2022 IRP all feature declining loads due to various assumptions about future technology and policy developments (NW Natural 2022). Note that the overall level of the load shown in Figure 6 is higher as it includes all natural gas flowing through NW Natural's system, including both transportation customers, whereas Figure 5 does not include loads from transport customers.

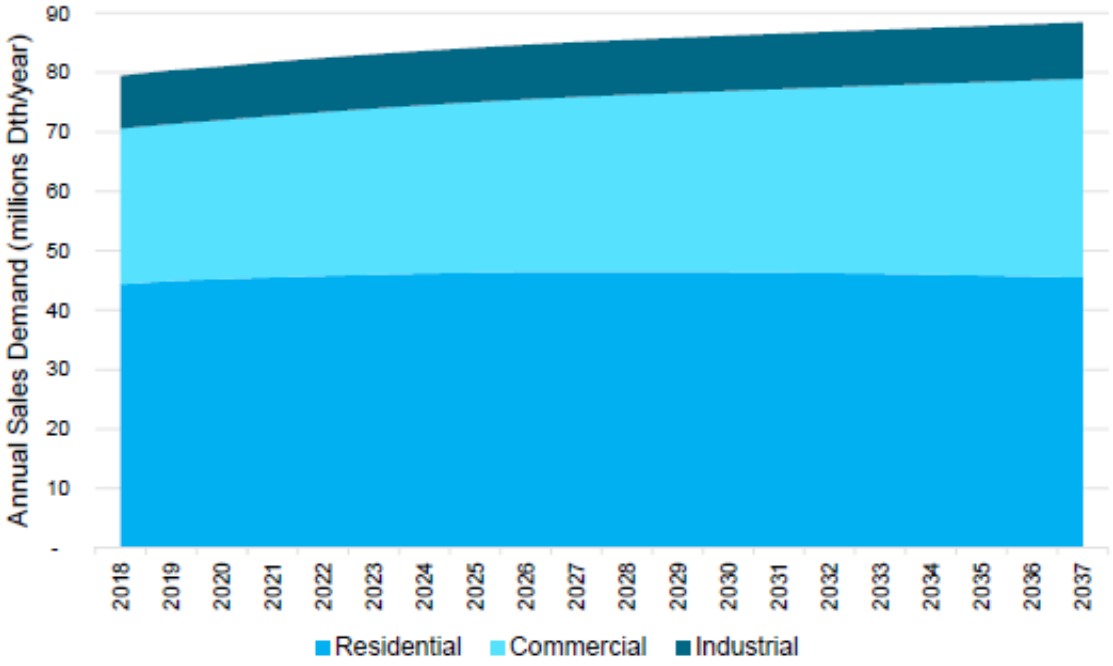
Figure 6: Draft Load Projections by Scenario for 2022 IRP



Source: Load Forecast for the 2022 IRP – Technical Working Group Presentation

The breakdown of this forecast into customer sectors is shown in Figure 7 below. The residential sector grows slightly in the initial years of the forecast but subsequently declines. This is driven by growth in the number of customers but declines in the use per customer. In the commercial sector, NW Natural forecasts growth throughout the 20-year study period, driven by increasing customer counts but slower declines in the use per customer, resulting in growth in the overall load. Industrial demand (including only the firm and interruptible service customers) is projected to be relatively constant based on the input of a panel of subject matter experts assembled for NW Natural's 2018 IRP.

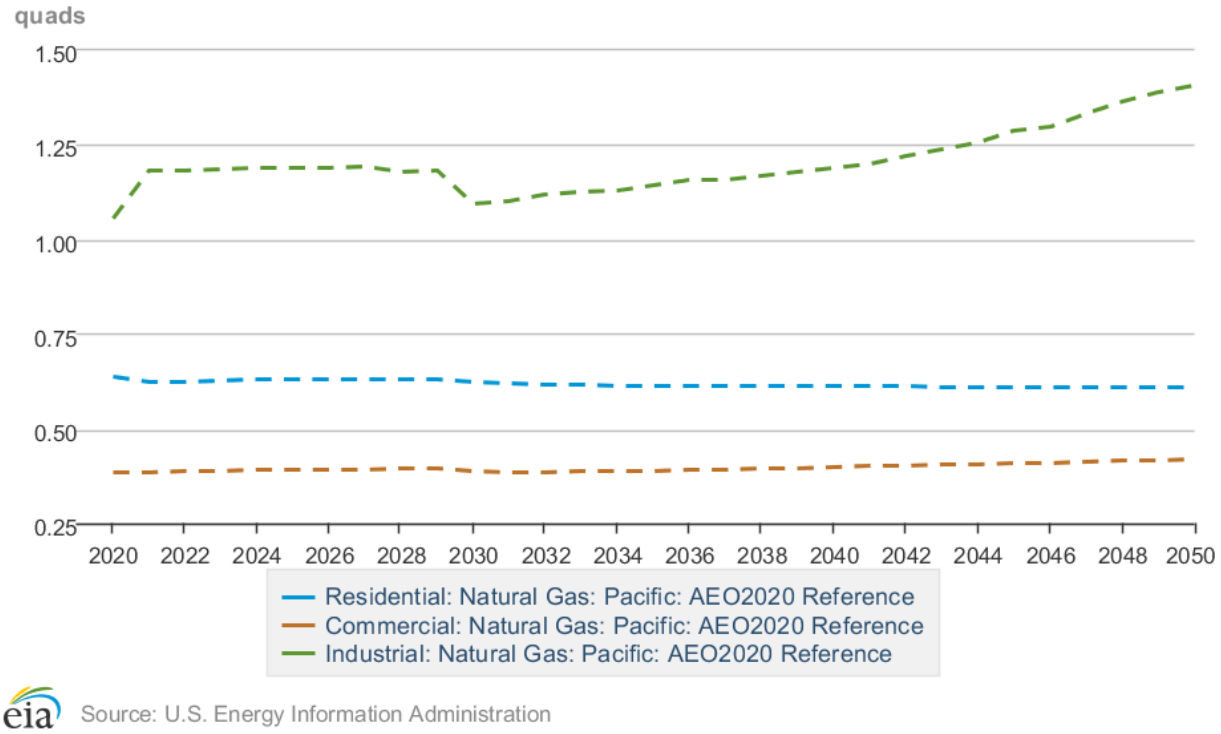
Figure 7: NW Natural 2018 Annual Load Forecast by Sector



Source: NW Natural 2018 IRP

NW Natural's overall forecasted growth rate of 0.6% is higher than the trends predicted by the US Energy Information Administration (U.S. EIA) in its 2020 Annual Energy Outlook, whose Reference case features a compound average growth rate of 0.5% for the US as a whole and 0.3% for the Pacific region, which includes Washington, Oregon, California, Alaska, and Hawaii, over the 2020-2050 time period. In the AEO reference case forecast for the Pacific region, shown in Figure 8 below, the residential demand for natural gas declines slightly, while commercial increases slightly, and industrial grows after a period of relatively stable demand. While the trends are different, differences between NW Natural's customer base and the Pacific region as a whole may account for the differences. For example, since NW Natural's service territory has a different mix of customers and different macro-economic trends than other areas included in the EIA's Pacific region, the trends for natural gas demand may vary from sector to sector.

Figure 8: US EIA Pacific Region Forecast of Natural Gas Demand for the Residential, Commercial, and Industrial Sectors



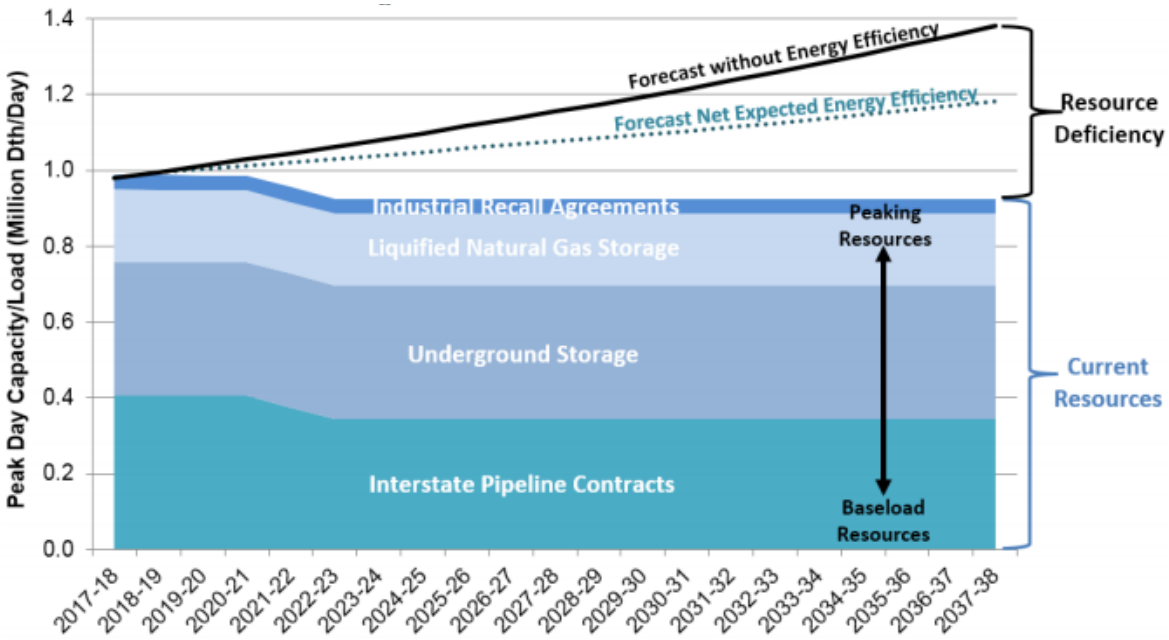
eia Source: U.S. Energy Information Administration

Peak Demand

NW Natural must also forecast the peak daily demand for natural gas to ensure that its system is sufficient to meet the maximum possible demands from its customers. In its forecast of peak pay demand, NW Natural only includes the customers receiving firm service. Customers receiving interruptible service are assumed to have their service interrupted on peak days in order to help NW Natural meet the demands of its firm service customers. The customers receiving transportation service are also not included in this forecast. Since transportation customers are responsible for the delivery of the natural gas they purchase to NW Natural's system, NW Natural does not need to consider this customer segment in its supply planning, whether through storage or regional pipeline capacity. NW Natural is responsible for ensuring that their distribution system is capable of delivering natural gas to transportation service customers during peak demands.

In its 2018 IRP base case, NW Natural projects that its peak daily demand for natural gas will grow from just under 1 million Dth/day to just under 1.2 million Dth/day over a similar time period after accounting for expected energy efficiency savings. NW Natural's current resources that can be used to meet peak demand include interstate pipeline capacity, underground storage, LNG facilities, and recall agreements. Together, these facilities total nearly 1 million Dth/day in the near term, with LNG facilities comprising only approximately one-fifth of the total. Capacity on interstate pipelines and NW Natural's underground storage make up the largest share of peak day resources. The growing demand results in a projected resource deficiency of approximately 250,000 Dth/day in 2038, as shown below in Figure 9.

Figure 9: NW Natural Peak Daily Demand and Capacity



Source: NW Natural 2018 IRP

At the time of this memo, NW Natural has not produced an updated figure comparing projections of peak demand and capacity for its 2022 IRP. Given the projections of declining loads discussed above, the needs for future capacity are likely to be smaller.

Meeting Demand for Natural Gas

As discussed above, NW Natural has multiple resources available to help meet customer demand for natural gas. These resources include:

- Gas withdrawn from storage located within its service territory
- Gas effectively stored through linepack in its distribution system
- Gas procured through recall agreements
- Gas from outside its service territory and brought to NW Natural gate stations via NW Natural contracted capacity on transmission pipelines
- Citygate deliveries, which are gas supplies delivered to NW Natural's system via pipeline capacity owned by other entities

Some of these resources, such as in-system storage, linepack, and customer recall agreements, are better suited to serve short term peak demands as their overall capacity is limited. Similarly, the longer-term customer demand for natural gas over the months of a year is best met through gas delivered to its system on pipeline capacity contracted by NW Natural, as the NW Natural's volume of natural gas storage is insufficient to meet more than a few months of customer demand.

NW Natural's 2018 IRP base case forecast identifies both a growing annual demand for natural gas and a growing peak daily demand. In addition to NW Natural's current pipeline supply contracts and storage facilities, the IRP considered the following new resources to meet the peak demands identified in Figure 8:

- Acquiring additional capacity on interstate pipelines
- Additional storage capacity at its Mist facility
- Increased ability to withdraw gas from its Newport LNG facility
- Renewable natural gas added from within NW Natural's system

The specific pipeline capacity and storage resources considered by NW Natural are described further in Table 2 below. In addition to these resources, NW Natural also included a small amount of renewable natural gas, produced within NW Natural's service territory.

Table 2: Potential Future NW Natural Supply Resources

Capacity Resource	Description
Mist Recall	Transferring Mist storage from interstate customers to core utility
North Mist II	Completing new storage wells and building southbound pipeline capacity
North Mist III	Completing new storage wells and building northbound pipeline capacity
Local Pipeline Expansions	An expansion of the Northwest interstate pipeline specifically for NW Natural
Regional Pipeline Expansions	Expansion of the Northwest interstate pipeline and other expansions for multiple shippers
Central Cost Feeder 1-3	Projects to increase the withdrawal capacity from NW Natural's Newport LNG facility

Source: NW Natural 2018 IRP, Table 7.1

While no daily capacity figure is provided for the potential regional pipeline expansion project, the NW Natural IRP assumes 30,000 Dth/day are available through a local pipeline expansion project. In addition, the IRP states that the Mist Recall could provide approximately 220,000 Dth/day, North Mist II & III could produce 100,000 Dth/day, and the Central Coast Feeder would provide approximately 40,000 additional Dth/day. In total, these resources provide nearly 390,000 Dth/day, far in excess of the 250,000 Dth/day peak day resource deficiency identified by NW Natural and shown in Figure 9 above. Figure 9 above projects annual growth in peak demand of approximately 0.9%. If peak day demand for natural gas were to continue to grow at the same rate until 2050, NW Natural would have a capacity shortfall of approximately 389,000 Dth/day, so the additional resources identified in the IRP are likely sufficient to meet peak demand in 2050 without the need to expand LNG storage tank capacity in Portland.

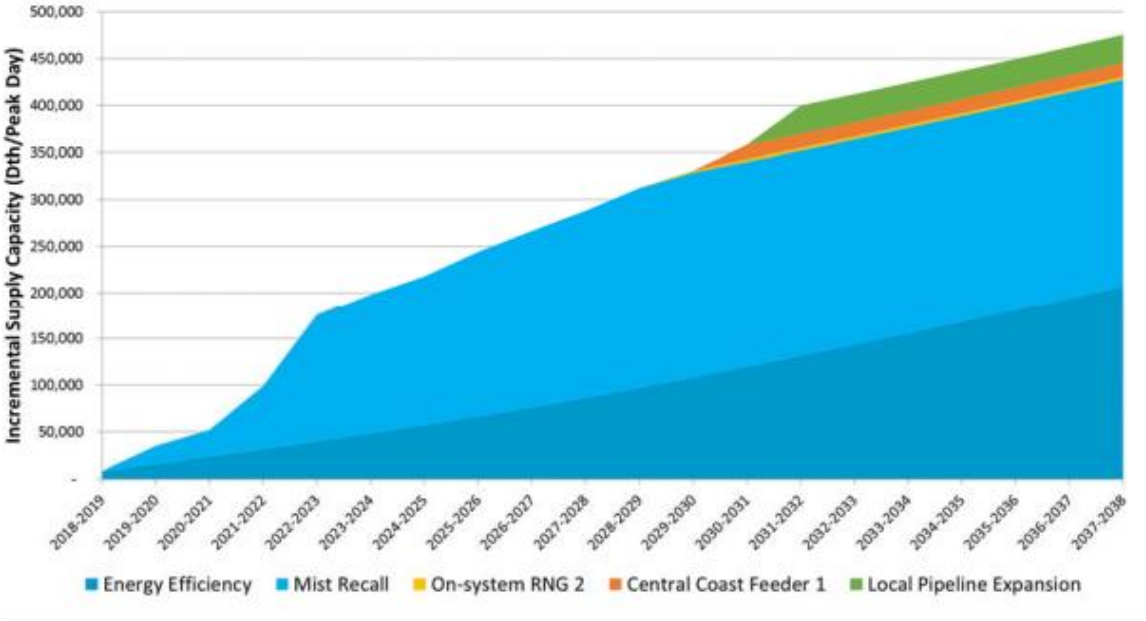
In addition to these resources, NW Natural has other resources available in the future to help meet peak daily demands for natural gas. All of the following were discussed in the 2018 IRP:

- Additional Mist expansion: The 2018 IRP describes that the facility has the potential for additional capacity expansions beyond the North Mist II & III projects described in the IRP.
- Additional interruptible customers: In the 2018 IRP, NW Natural describes a proposed change in rate design that, while ultimately not approved, could have attracted additional customers to interruptible rate schedules. NW Natural's IRP does not discuss or estimate the total customer load at facilities where interruptible schedules may be acceptable.
- Additional recall agreements: As with moving additional customers to interruptible schedules, NW Natural's IRP discusses that they have approached additional industrial customers about recall agreements but has not identified any willing to commit for similar levels of cost.
- Hydrogen blended with natural gas: Hydrogen gas, potentially produced with excess renewable energy, can be blended with natural gas in small volumes

As shown in Figure 10 below, NW Natural's 2018 IRP ultimately concludes that, after accounting for energy efficiency, the base case resource portfolio should largely rely on additional storage from its Mist facility to meet the resource deficiency. Smaller amounts of demand are met through renewable natural gas produced within their service territory, increases to the delivery capacity from the Newport LNG facility, and the local interstate pipeline expansion project. With these additional resources, NW Natural projects that it will be able to meet the peak daily demands of its firm service customers through 2037— the end of their IRP study period. If peak capacity demands continue to increase beyond the IRP's study period, NW Natural would likely use a similar mix of these strategies to meet the projected demand growth. None of these strategies require facilities located in Portland.

In a presentation to its Technical Working Group on January 14, 2022, as part of the development of its 2022 IRP, NW Natural noted that updated load projections resulted in no Mist recall being needed for the 2020-21 or 2021-22 gas years. NW Natural relied instead on lower cost citygate deliveries of 5,000 Dth per day (NW Natural 2022). This indicates that the growth in peak day demands may not rise as quickly as NW Natural forecasted in its 2018 IRP.

Figure 10: NW Natural 2018 IRP Incremental Capacity Additions



Source: NW Natural 2018 IRP

Changes in Demand for Natural Gas

While not shown in Figure 9 above, NW Natural's peak daily demand has uncertainties that may impact its future growth. Since NW Natural's demand is primarily driven by space heating requirements, the daily peak demand is largely driven by the number of customers using natural gas for space heating and the size of those space heating needs during a short term extreme cold weather event.

Future policies requiring residential and/or commercial buildings electrification could reduce the number of customers using natural gas for space heating, which would in turn reduce NW Natural's peak daily demand. For example, the City of Seattle recently approved changes to energy codes covering commercial and large multifamily buildings that prohibit the use of natural gas for space and water heating (Bernton

and Gutman 2021). The City of Tacoma has prohibited new city-owned buildings from using fossil fuels and will study retrofitting its existing buildings (Needles 2021).

Other potential future policy changes would have minimal, if any, impact on the future peak daily demand for natural gas.

NW Natural looked at future loads related to compressed natural gas as a transportation fuel in its 2018 IRP, estimating that it would comprise 0.6% of firm sales in 2038. This estimate was based on the use of compressed natural gas (CNG) as a replacement for diesel in commercial fleet vehicles. Further, since the demand for transportation is expected to be uniform across the seasons and not weather-dependent, NW Natural describes the impact on the peak day demand as "miniscule." Because the load is not seasonally driven, any additional demand for CNG would likely be best served by regular deliveries of natural gas to NW Natural's system, as its storage resources are best used in meeting seasonal peak demands and not demands that are consistent throughout the year.

While building electrification or the electrification of vehicles will result in increased demand for electricity, and natural gas is used as a fuel to generate electricity, there is no natural gas-fired generation within the City of Portland. The recently passed Oregon HB 2021, which takes effect on September 25, 2021, also prohibits new and expanded power plants using fossil fuels, including natural gas.

Impacts of Limitations on New or Expanded Natural Gas Infrastructure

In the list of potential capacity resources considered by NW Natural's 2018 IRP and shown in Table 2, none of the resources required new or expanded infrastructure within the City of Portland. These resources were found to provide capacity for peak day demands in excess of the 20-year needs identified in NW Natural's 2018 IRP.

The additional resources identified but not considered in the IRP would also not require infrastructure within the City. If all of these resource options were exhausted and a peak day demands for natural gas continued to grow, additional demand could be met by new storage facilities, but there is nothing that would require the facility to be located within the City of Portland. Absent other restrictions or requirements, locating such a facility outside of Portland would likely be more economical due to the cost and availability of land.

The only other element of local natural gas infrastructure not discussed above is the smaller capacity distribution pipelines used to deliver natural gas to homes and neighborhoods. Occasionally, these pipelines become constrained in their ability to meet additional loads due to load or customer growth and need to be replaced with larger capacity pipelines. It is difficult to predict whether any such projects would be required in Portland, as publicly available information on current system conditions is limited. That said, such projects seem unlikely as they are primarily driven by large increases in load growth associated with new housing development at the ends of NW Natural's distribution system. Such increases seem unlikely within Portland, where added loads often come from the addition of natural gas service to existing homes that are within NW Natural's existing distribution system. Growth in Portland is included in NW Natural's 2018 IRP and there are no projects identified as necessary. Further, NW Natural's IRPs from 2014, 2016, and 2018 did not discuss any such projects within the City of Portland. These pipeline capacity expansions are not subject to the proposed limits on new or expanded storage tanks.

The zoning amendments limiting the development of new or expanded storage tank capacity are applicable to current and any potential future purveyors of natural gas. There are no other purveyors of natural gas within Portland, and it seems impractical that another purveyor of natural gas would enter the market, as that purveyor would need to establish an equivalent distribution system of pipelines. An entity wishing to sell compressed natural gas for vehicle transportation would ultimately rely on NW Natural's distribution system for their supply of natural gas and this use of natural gas is considered in NW Natural's IRP and is discussed above.

Any new large industrial customers not considered in NW Natural's IRP would need to work with NW Natural in advance to arrange for firm service to ensure it was available or contract for its own natural gas supply and arrange for transportation service with NW Natural. It is unlikely that new or expanded storage facilities would be used to serve these hypothetical customers as natural gas use by industrial customers is typically consistent throughout the year and best served by long-term pipeline capacity as opposed to the storage facilities dedicated to meeting peak day demands.

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