ELEMENTS OF OUR VISION: SUPPLY SIDE

COMPONENTS THAT ENABLE OUR STRATEGY

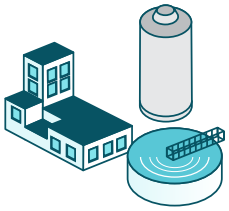
Renewable Natural Gas

Renewable natural gas turns the problem of waste into a powerful climate solution using our pipeline network already in place. RNG is considered carbon neutral because both combustion and lifecycle emissions do not contribute a net-increase in greenhouse gases into the atmosphere. It also improves local air and water quality and offers clean energy jobs for rural communities.

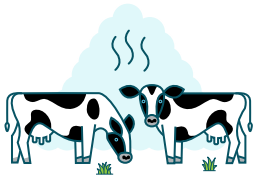
TURNING WASTE INTO RENEWABLE ENERGY

North American sources of organic waste that can be converted to RNG to displace conventional natural gas are vast—and provide similar climate benefits to wind and solar:

MORE THAN
144
MILLION METRIC TONS
of food waste produced each year



17,000
WASTEWATER FACILITIES



19,000
LARGE FARMS AND DAIRIES

4,400
LANDFILLS

Source: Coalition for Renewable Natural Gas

A 2018 report by the Oregon Department of Energy found enough potential in feedstocks for renewable natural gas supply in Oregon to meet the annual usage for every residential gas customer in the state.

GROUNDBREAKING RNG BILL

A coalition of industry, municipal and nonprofit agencies worked together with elected officials in 2019, leading to bipartisan support and passage of Oregon Senate Bill 98 (2019), and the subsequent rulemaking (finished in July 2020), which enables the development and procurement of renewable natural gas and renewable hydrogen for our customers.

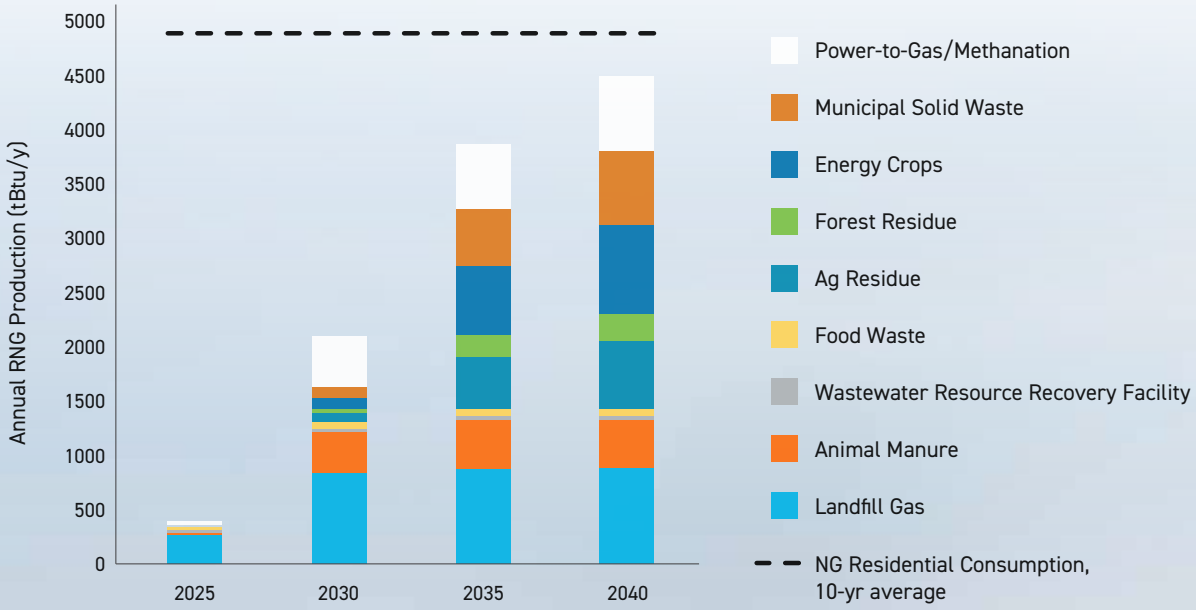
At the national level, RNG technical potential is vastly greater (see chart on page 15).

In the Balanced and Moderate Offsets scenarios, we assumed that in 2040 NW Natural can deliver roughly half of our customers' population-weighted share of national RNG production—23 million dekatherms—for a cost of less than $20/Dth, as estimated by ICF Consulting in the 2019 *Renewable Resources & Emission Reduction Assessment*, the most comprehensive evaluation of U.S. RNG technical potential done to date. Given NW Natural's early participation in the RNG market and differences in regional policy, we consider this to be a conservative estimate of the amount of RNG that we will be able to procure for our customers.

There is rapid development and new advancements driving availability of RNG supply. For instance, a new process called "recuperative thickening" allows for much greater volumes of renewable gas to be produced at a lower overall cost. Another new technology now in use produces RNG from very dry waste streams that had previously been untapped. This is all helping drive new supply to market—from 50 RNG facilities a few years ago to more than 430 now online or in development in North America.

Assessing the availability of RNG is an important consideration in analyzing paths to achieving decarbonization for a natural gas utility. The most comprehensive study to date on the availability of RNG in the United States, *Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment*, completed by ICF for the American Gas Foundation (2019), was utilized in our analysis to determine the maximum amount of RNG that NW Natural assumed could be available for its customers. Estimates of the annual RNG production of the "High Resource Potential" scenario of the ICF study are shown in the graph below. This estimate of annual RNG production assumes that roughly one third of the total RNG technical resource potential that exists in the United States is produced in 2040.

Potential National Annual RNG Production



RNG PROJECTS ACROSS NORTH AMERICA

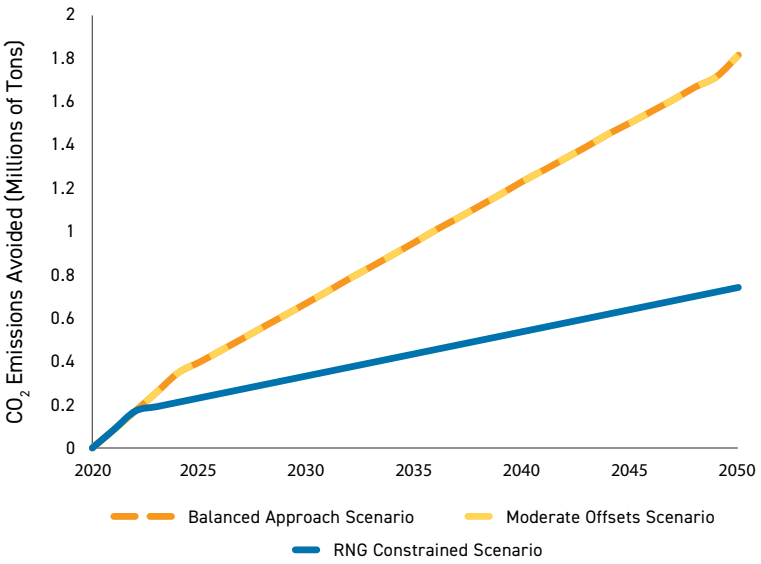
Operational: **189**
Under Construction: **146**
Planned: **95**

TOTAL: **430**

Source: 2021 RNG Coalition

The RNG Constrained scenario limits the amount of RNG available to NW Natural to 70% of our customers' population-weighted share (14 million dekatherms) of national RNG production estimated by ICF in the "Low Resource Potential" scenario. While data suggests this very low assumption of RNG supply is not likely, it was included in the assessment to show carbon neutrality can still be achieved.

Emissions Reductions from Renewable Natural Gas (RNG)



POLICY TO ACCELERATE RENEWABLES FOR THE PIPELINE

Congress started incentivizing wind and solar projects as early as 1992 through the use of tax credits aimed at bending the cost curve of the technologies until the market developed enough to make wind and solar competitive with other conventional sources of energy. This approach is working.

NW Natural has joined other utilities in asking Congress to do the same thing for renewable natural gas and renewable hydrogen to accelerate the development of renewable energy for the pipeline, and make it more affordable for gas customers across the country.

Clean Hydrogen

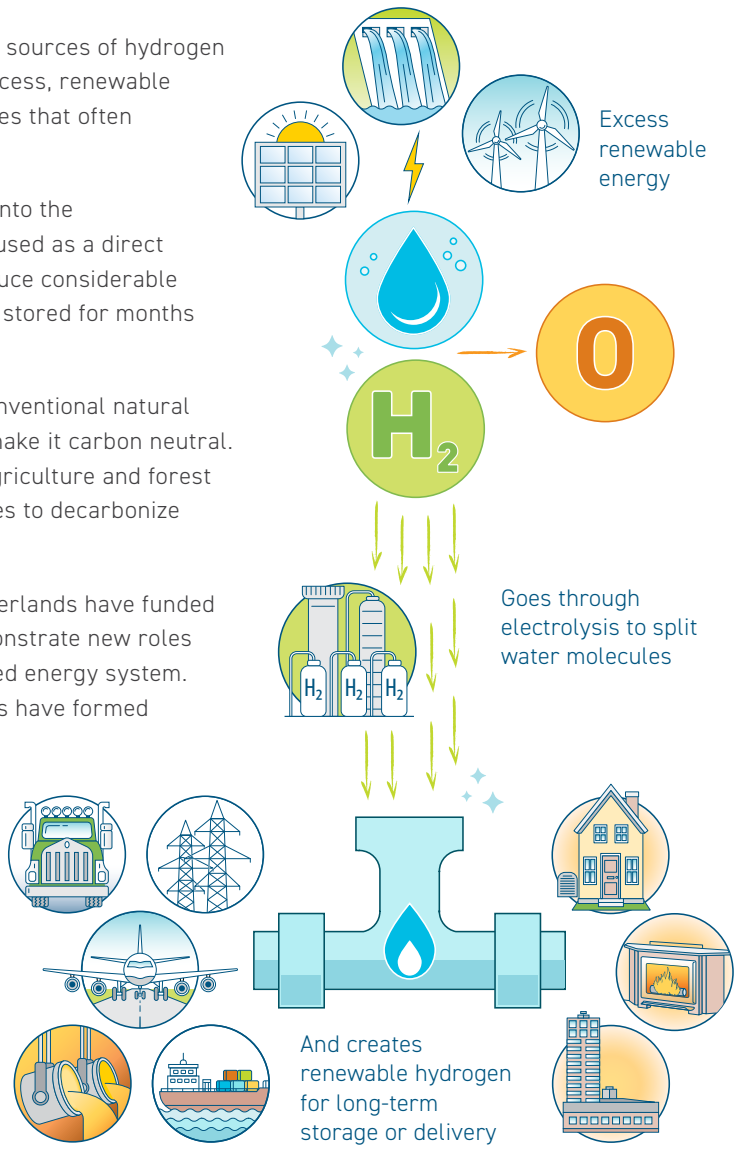
Looking ahead, we see emerging opportunities to bring low-carbon sources of hydrogen into our energy mix at a large scale. Through the power-to-gas process, renewable hydrogen can be created using wind, solar and hydro energy sources that often produce excess power at times of low demand.

Renewable hydrogen can be blended with natural gas for delivery into the existing pipeline system or converted to synthetic natural gas and used as a direct replacement for conventional natural gas. Power-to-gas can introduce considerable flexibility into the energy system since renewable hydrogen can be stored for months and then delivered to provide energy when it's needed.

Clean, low-carbon hydrogen can also be produced by reforming conventional natural gas, paired with carbon capture and storage ("blue hydrogen") to make it carbon neutral. Other options include gasification of biomass feedstocks such as agriculture and forest waste. These various technologies create even greater opportunities to decarbonize heating and industrial process loads across the economy.

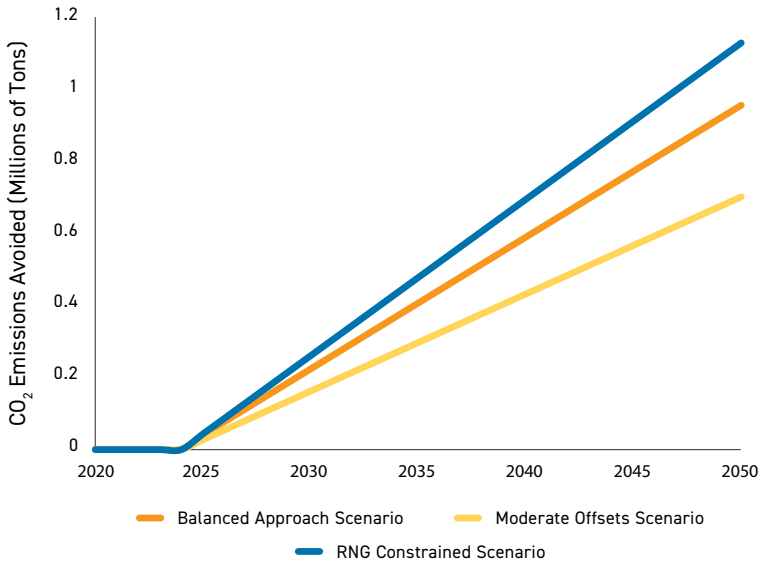
Over the past decade, countries like Germany, France and the Netherlands have funded research, developed policies, and deployed pilot projects that demonstrate new roles for natural gas infrastructure and renewable fuels in a decarbonized energy system. NW Natural and other forward-thinking North American gas utilities have formed working partnerships to apply those lessons at home.

In 2021 we joined the Low-Carbon Resources Initiative, a joint effort by the Electric Power Research Institute and the Gas Technology Institute to accelerate development and demonstration of low- and zero-carbon energy technologies. This five-year initiative, which has surpassed $100 million in funding, is targeting fundamental advances in a variety of low carbon technologies, providing scientific credibility and objectivity to the global decarbonization effort.



Hydrogen pathways can deliver clean energy to multiple industries via pipeline infrastructure

Emissions Reductions from Clean Hydrogen



ELEMENTS OF OUR VISION: DEMAND SIDE

Gas Heat Pumps

Of all the available natural gas technologies, natural gas-powered heat pumps offer the single greatest opportunity to reduce natural gas consumption while maintaining equipment performance in cold weather, a challenge for electric heat pumps.

A 2019 American Gas Foundation report prepared by Enovation Partners indicates that these new technologies have the potential to reduce energy use by 40% or more, while still serving customers' energy needs.

In late 2019, we co-founded the Gas Heat Pump Collaborative with local distribution companies, representing 31% of North American customers, to help reduce carbon through deployment of highly efficient space and water heating equipment.

We are working with nonprofit organizations like the Gas Technology Institute, Low Carbon Resources Initiative, and Northwest Energy Efficiency Alliance to encourage innovation through new products like gas heat pumps and other progressive technologies that use less energy.

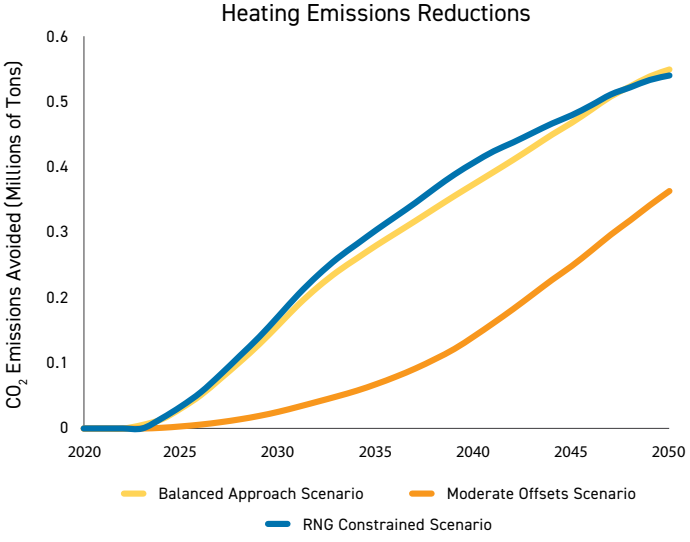
Hybrid Heating Systems (Electric Heat Pump with Gas Furnace)

Hybrid or dual-fuel heating systems rely on an electric heat pump under more moderate temperatures but is supplemented by a natural gas furnace when temperatures fall below a threshold (or a balance point temperature) where the heat pump is unable to serve the building's heating needs effectively or efficiently.

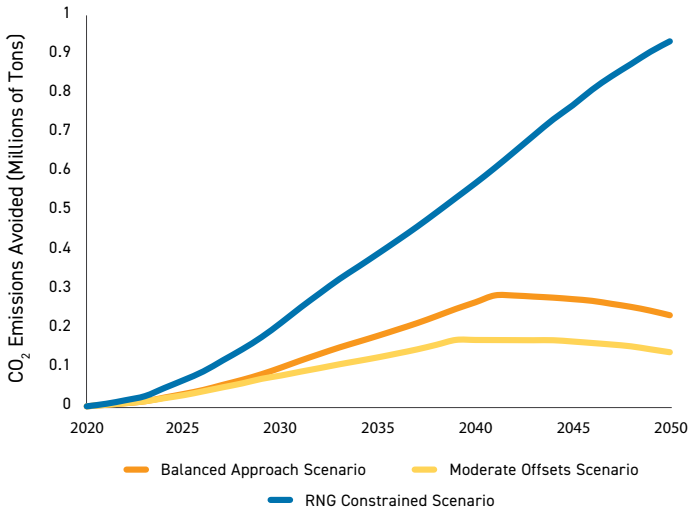
The need for supplemental heating is dependent upon installation practices, the balance point temperature, and climate. For the weather in NW Natural's service territory and the temperatures typically experienced during a heating season, the natural gas component of the hybrid system is estimated to use slightly less than 100 therms per year.

Hybrid systems can provide a cleaner, more comfortable, and cost-effective way to serve colder weather than the typical electric heat pump installation in our region, which relies on inefficient electric resistance as the backup heating source. Hybrid systems also help address the grid capacity shortfall challenges in the Northwest. These hybrid heating systems are

Natural Gas Powered Heat Pump Heating Emissions Reductions



Hybrid Gas-Electric Heating Emissions Reductions



available today in the U.S. and elsewhere. Industry groups and advisers like the Northwest Power Pool and Energy+Environment Economics (E3)[6] have considered these systems an important option to decarbonizing energy in the region.

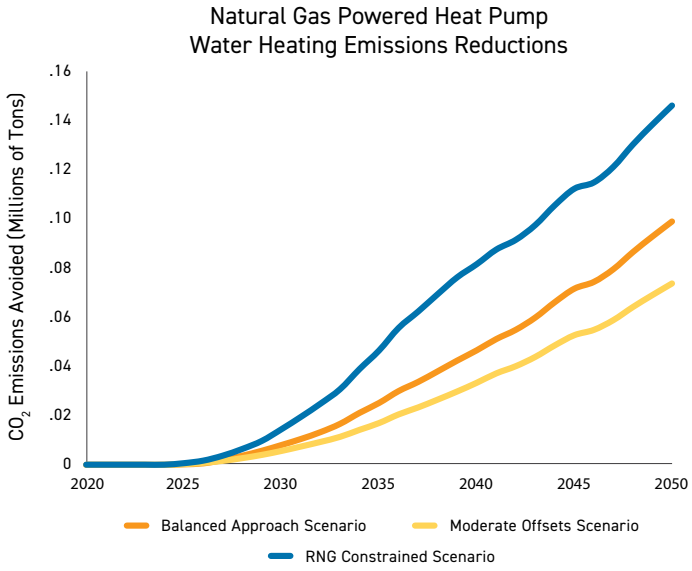
ENABLING POLICY NEED

A hybrid heat system can leverage the strengths of both the gas and electric systems. For example, during periods of peak heating demand, gas service is a lower cost resource than electricity. In many markets, customers pay electric providers a "capacity charge" to ensure that they have power during periods of peak usage, when system operators may rely on more expensive battery storage, standby generation or other ancillary energy services.[7] With hybrid heat, the gas system is basically serving as a low cost, high-performing battery.

To enable hybrid heating solutions, NW Natural and others are contemplating the policy implications. We know that the gas system in the Pacific Northwest has far greater capacity to deliver energy than the electric system—which means leveraging it in new ways provides a faster climate solution with a significant cost savings for rate payers.

Water Heating Equipment

The projected greenhouse gas savings from use of natural gas heat pumps for water heating can be seen in the below chart for Balanced Approach, Moderate Offsets and RNG Constrained scenarios.



[6] This E3 report discusses the emissions-reduction potential for dual-fuel systems and the lack of alignment with climate reduction goals under current market conditions, pp. 81-83: https://www.ethree.com/wp-content/uploads/2020/11/E3-EFI_Report-New-England-Reliability-Under-Deep-Decarbonization_Full-Report_November_2020.pdf.

[7] For a discussion on the use of battery storage as an ancillary service, see this U.S. Energy Information Administration article, "Battery storage applications have shifted as more batteries are added to the grid," https://www.eia.gov/electricity/monthly/update/archive/september2021/.

Enhanced Building Shell Energy Efficiency Measures

Through Energy Trust of Oregon, NW Natural supports energy-efficiency improvements such as cost-effective equipment upgrades, insulation and building improvements that last for many years.

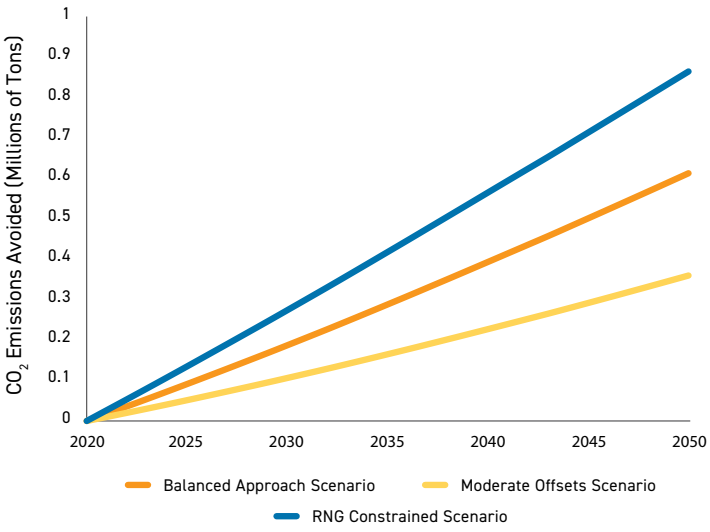
More than half of the gas sold to NW Natural's customers is used for space heating. Buildings with better insulation, windows, and other shell improvements require less energy to heat and cool, thus reducing energy consumption and emissions for both gas and electricity. Building shell improvements for new construction are continually progressing, with structures becoming increasingly efficient.

Retrofits of existing buildings can deliver greater savings at lower costs by addressing multiple opportunities that might not prove cost-effective as a stand-alone measure. A project that begins with plans to replace a large boiler may incorporate a suite of additional improvements as part of a whole-building assessment: sealing ducts to prevent the loss of conditioned air, improving exterior shell insulation, upgrading windows to double- or triple-pane, and installing advanced heating controls.

These improvements can deliver benefits beyond energy cost savings, including increased occupant comfort, building marketability, and a lower carbon footprint overall.

For the Vision 2050 scenarios, we considered efficiency gains beyond Energy Trust's projections, focused on building shell improvements and industry-sector efficiency measures in new and existing structures. These are additional to assumptions for space and water heating equipment upgrades. Note, however, that building shell retrofits and equipment upgrades have an interactive effect, combining to reduce overall energy demand. Below are the projected greenhouse gas emissions avoided through building shell improvements in the three scenarios analyzed.

Building Shell Improvement Emissions Reductions



Valley Milling and Lumber, courtesy of Energy Trust of Oregon

Industrial energy efficiency supports strategic growth for Eugene company

Valley Milling & Lumber is one NW Natural customer that's already seeing the benefits of industrial energy efficiency. The Eugene-based company and its 30 employees produces wood stakes for multiple industries, manufactures building materials, and processes large, exposed timbers for ceilings, lodges and bridge work. In 2020 the company purchased a new kiln, as part of a strategic business decision to increase its in-house production capacity and add more services to its material processing for customers.

To meet the kiln's energy needs, the company installed a new natural gas boiler and added piping insulation for improved efficiency. Incentives from Energy Trust of Oregon helped to offset nearly 70% of the cost of the boiler upgrade. The company expects to save more than 64,000 therms annually (a $49,000 value), thanks to those incentives and technical assistance. Working with its local electric provider, the mill also invested in variable controls for the kiln fan motors for additional energy savings. Today, Valley Milling and Lumber is building on its legacy in an environmentally sustainable way.

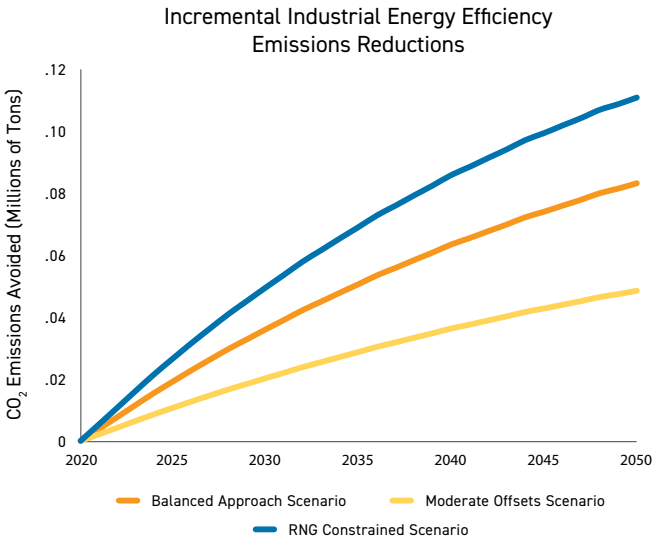
Learn more: **https://blog.energytrust.org/wood-products-manufacturer-heats-up-energy-savings/**

Industrial Energy Efficiency

Another opportunity to realize additional natural gas savings can be found in the industrial sector. Many deep decarbonization studies assume industrial gas efficiency gains as high as 30% by mid-century. It's a group that, though small in number, comprises roughly half of NW Natural's gas delivery volumes annually. These types of essential sectors and organizations include pulp and paper, semiconductors, university campuses and hospitals.

When successful, efficiency investments for industrial use can deliver large energy savings while also enabling companies to expand and pursue new growth strategies.

In assessing the potential for these scenarios, NW Natural subject matter experts balanced the opportunity for savings against the specific and relatively complex nature of equipment used by companies across sectors, as well as the significant capital investments required. Below are the projected greenhouse gas emissions avoided through industrial energy efficiency in the three scenarios analyzed.



ELEMENTS OF OUR VISION: OFFSETS, CARBON CAPTURE AND NEGATIVE EMISSIONS TECHNOLOGIES

Reducing greenhouse gas emissions to net-zero will require deploying new technologies, policies and approaches that cut across regional economies and industry sectors. Carbon capture, utilization, and storage (CCUS), direct air capture, carbon offsets, and other approaches all have the potential to deliver real reductions.

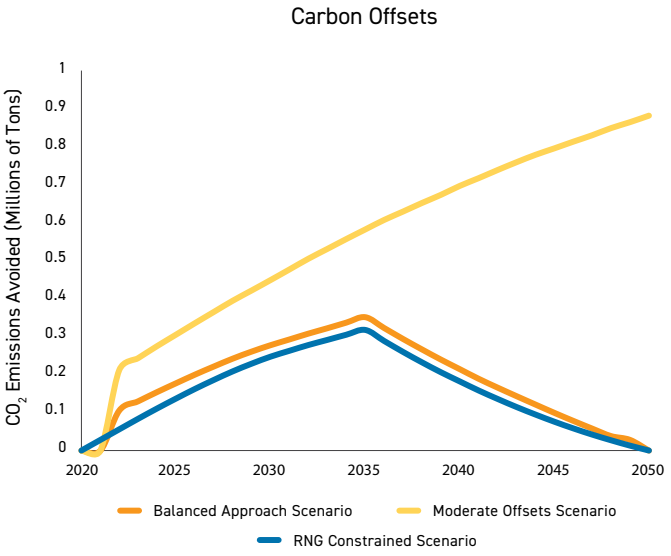
Uncertainties exist with respect to timeframes to deployment, policy frameworks needed, costs and market structures, and technology options. However, much of this work will require the safe and reliable capture, storage and movement of a resource from one place to another—something that aligns well with the natural gas workforce, knowledge base, skill set and infrastructure.

We've reflected this in our Vision 2050 work with two components: verified carbon offsets and a new carbon capture technology currently in the pilot phase, which serves as a useful proxy as this category matures.

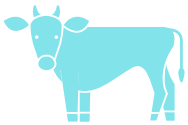
Carbon Offsets

Carbon offsets offer another mechanism for lowering carbon emissions. An offset certificate represents one metric ton of carbon dioxide emissions that has been eliminated. Offsets can be generated in a variety of methods from a variety of projects.

NW Natural's approach to date has been an emphasis on projects in our region tailored to reduce methane emissions. Since 2007, NW Natural has offered customers a voluntary carbon offset program called Smart Energy that enables them to offset some or all the emissions associated with their natural gas consumption.



Making carbon offsets at a dairy farm



1. Manure from dairy cows can release methane, a greenhouse gas 25 times more potent than CO_2, into the atmosphere.

2. The dairy farm diverts manure to an anaerobic digester, where methane is captured and prevented from entering the atmosphere.

3. Captured methane can be used as an on-demand renewable energy source to heat and operate homes and businesses.

The Smart Energy program has purchased offsets from 14 innovative projects across the Pacific Northwest, California and Utah. These include projects like biodigesters on family-owned dairy farms that capture methane from cow manure, keeping this potent greenhouse gas from entering the atmosphere and harnessing it as a renewable energy source.

These offsets are a valuable tool to effectively lower emissions and are verified by The Climate Trust to ensure that only high-quality offsets are purchased and retired for the Smart Energy program. Since its inception, the program has funded over 1.5 million metric tons of emissions reductions. Today, over 67,000 customers are enrolled.

We believe that carbon offsets have a useful role as an interim tool and economical option to reduce emissions. To that end, carbon offset projections increase over time in our Balanced Approach and RNG Constrained scenarios. Offset use peaks in 2035 and is then gradually phased out by 2050.

Carbon Capture Equipment

Emerging technologies can play a role in decarbonizing non-renewable gas supplies through the direct capture of carbon dioxide at the point of combustion. These emissions can be sequestered or utilized, giving rise to the category of CCUS.

We've represented a modest savings potential from CCUS, using a market-ready technology now in the pilot phase of deployment among a handful of natural gas utilities, including NW Natural.

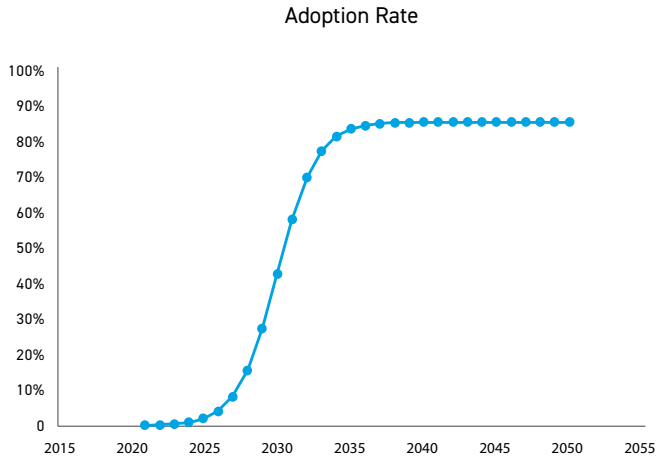
The CarbinX unit, manufactured by the Canadian-based CleanO2 firm, draws a fraction of the flue gas from natural gas-fired appliances, and mixes that gas with potassium hydroxide to produce potassium carbonate.

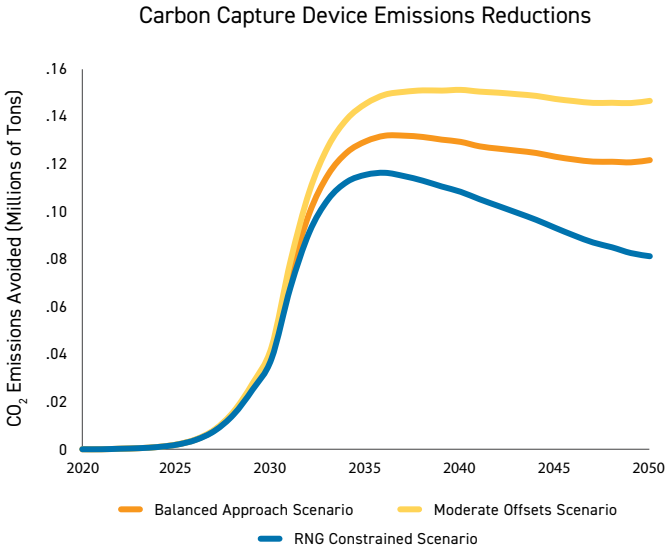
Several other direct capture technologies are approaching commercialization as the business case for carbon capture evolves. We've considered the CarbinX as a useful proxy for this market segment, based on applicability and capture effectiveness.

Assumptions were also developed on the CarbinX's ability to capture CO_2 in the coming years. The initial model is expected to capture 20% of the CO_2 in the flue stream and eventually rise to 100% in 2030. For a more conservative estimate, we discounted these rates by 25%, so the effective capture rates modeled start at 15% in 2021, rising to 75% by 2030.

The CarbinX device is best suited for a customer whose gas consumption falls within a certain range and remains relatively constant throughout the year. Examples include indoor aquatic and recreation centers, or hotels with on-site laundry—larger facilities that use relatively stable amounts of natural gas. That is, facilities that have a load factor of at least 75% (ratio of peak demand compared to average demand) and use at least 65,000 therms of natural gas annually.

We assumed that 85% of customers who fit this profile would eventually install this technology, following a typical S-curve of adoption rates shown in the graph. While early in the curve we have a small number of first-movers and a slower rate of adoption, later in the decade the rate ramps up as more users become familiar with the technology and its benefits.





The graph shows volumes of natural gas combusted, with emissions captured by the device. We assumed the same adoption rate across all scenarios. In the case of the RNG Constrained scenario, increased energy efficiency and adoption of hybrid heating equipment is assumed to result in lower volumes of gas consumed overall, and in turn, lower volumes of gas captured by carbon capture units.

Most of the carbon captured here comes from conventional natural gas. However, as the remaining conventional supplies are replaced by renewable natural gas, the carbon captured by the units will be from biogenic (organic) sources. At this point, this equipment begins to lower overall atmospheric carbon levels, creating a carbon-negative pathway.