# Harnessing Renewable Natural Gas for Low-Carbon Fuel: A Roadmap for Washington State


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# 1. Executive Summary

Renewable natural gas (RNG), also called biomethane, is produced by removing carbon dioxide ($CO_2$), trace gases, and contaminants from biogas. Biogas is produced naturally through anaerobic decomposition of organic materials in landfills and in anaerobic digesters located at wastewater treatment plants (WWTPs), food processing facilities, and farms. The benefits of producing and using biogas and RNG are measured in many ways, including:

- Attracting millions of investment dollars
- Creating hundreds of clean energy jobs in Washington state
- Producing renewable energy and low-carbon fuels for use directly in homes, businesses, transportation, and to generate electricity.
- Improving resiliency in local communities
- Eliminating millions of tons of greenhouse gas (GHG) emissions each year
- Reducing air pollution by displacing petroleum fuels in transportation
- Extending the life of regional landfills by diverting food waste and other organics to digesters
- Offering valuable energy options for woody materials generated by forest health, harvest, and fire reduction activities
- Protecting natural gas consumers by diversifying supplies
- Providing value-added waste management solutions

Residents and businesses in Washington consume 308 trillion British thermal units (BTU) of natural gas annually. [1] That is equivalent to 308 billion cubic feet. In Washington natural gas is primarily used to heat homes and businesses and provide energy for food processing and manufacturing. Of the 308 billion cubic feet consumed, about 14% is used to produce electricity.

With no in-state production of natural gas, Washington currently relies upon supplies from Canada and the Rocky Mountain states. This can make the state's utilities and consumers vulnerable to fluctuations in supply and price.

The analysis completed for this report finds that maximizing yields of RNG from the most common public and private sources in Washington with existing technology could replace 20 to 26 trillion BTU, or about 20 to 26 billion cubic feet, of fossil natural gas—roughly 8% to 10% of the natural gas currently consumed directly by Washington homes and businesses. If the RNG were converted to vehicle fuel it could displace roughly 198 million gallons of diesel—about 20% of current diesel consumption.

In the future, processing urban wood waste through thermal gasification could expand the supply of RNG past 50 trillion BTU or 370 million diesel gallon equivalents. That represents nearly 19% of direct natural gas consumption or 37% of diesel consumption. The supply could be expanded even further by adding more feedstocks (e.g., forestry or agricultural crop residues) or using advanced technology such as "power-to-gas" systems now under development.

Federal, state, and local governments have programs and policies that can spur development of RNG resources. However, development has been slow or stalled in many areas. For example, no new dairy digester has been added since 2012. This report details the size of the opportunity and the benefits of policy-driven RNG development in Washington.

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[1] Data from 2015. U.S. Energy Information Administration, 2017. Washington State Profile and Energy Estimates.

Support is needed for small- and medium-scale projects at public landfills and WWTPs. Providing specific support (e.g., feed-in tariff for power or fuel) to projects using dairy manure and/or municipal or industrial food scraps will achieve immediate reductions in methane emissions. Supporting RNG use in transportation, especially for heavier vehicles otherwise fueled by fossil natural gas, further reduces GHG and air pollution emissions.

Most biogas and RNG projects provide multiple benefits, with capital investments typically involving local construction companies. Several companies leading the development of biogas and RNG technology in the U.S. are based in Washington.

To provide support for projects that supply biogas and RNG:

- Reinstate sales and property tax incentives, and expand their application to support a broader array of potential projects and value-added co-products.
- Fund a complimentary study to characterize specific opportunities along major natural gas corridors.
- Provide resources to state agencies to coordinate development of a voluntary RNG quality standard with natural gas utilities to enhance access to the natural gas pipeline grid.
- Consider a range of policy options that would significantly increase market demand for RNG, including carbon pricing programs (e.g., carbon tax, cap and trade), a clean fuel standard, and a renewable portfolio standard targeted to natural gas supplies.
- Direct state agencies to coordinate and provide technical and financial assistance to foster RNG development.
- Fund research and development of technological innovations that broadly expand the potential supply of RNG and build markets for value-added co-products.

# 2. Introduction

Biogas, a mixture of methane, carbon dioxide ($CO_2$), trace gases, and contaminants, forms naturally from the anaerobic decomposition of organic materials. If the methane is separated from the other gases, the term "biomethane" applies. When taken from ancient underground reserves we call it "natural gas" (also known as fossil or geologic natural gas). When it is produced from landfills or in anaerobic digesters at wastewater treatment plants (WWTPs), food processing facilities, or dairy farms, the purified biogas, known as biomethane, is commonly called renewable natural gas (RNG). Natural gas and RNG are effectively the same. Whether the raw gas is taken from underground reserves or produced from organic materials, both must be processed to meet standards for transport in pipelines or use in boilers, engines, and other equipment.

How the State of Washington will incorporate RNG and natural gas into its energy and fuel mix in the coming decades is being actively discussed. The state's natural gas utilities express support for further development of RNG. Dan Kirschner, Executive Director of the Northwest Gas Association, describes the value of natural gas infrastructure as a vehicle for RNG. According to Kirschner, "Natural gas makes possible the renewable power we care so deeply about. Natural gas vehicles and RNG present our region with terrific opportunities."[2]

This discussion is important because the impacts of investment decisions can last for decades. Under Governor Inslee, Washington state has made commitments to significantly reduce greenhouse gas (GHG) emissions to achieve targets set by the legislature and more recently by the Paris Climate Accord. In a 2016 report to the legislature, *Washington Greenhouse Gas Emissions Reduction Limits*, the Washington Department of Ecology (Ecology) documented the scientific basis for updating the state's existing limits on GHG emissions.

To further develop the state's plans the Governor commissioned a study, *Deep Decarbonization Pathways for Washington*, which analyzed options for achieving reductions proposed by Ecology's report. Among the scenarios described is the "renewable pipeline," in which buildings and industrial consumers continue to use pipeline gas that has been decarbonized with a mix of biogas, synthetic natural gas, and/or hydrogen.

The biogas industry in Washington has been through many stages of development. Some landfills and WWTPs have used biogas productively on site for decades, while others simply flare the biogas. In the past, Washington's dairy industry was the primary target for digester developers, but new development in this sector has stalled. With changes in power and gas markets, new emphasis on climate action and decarbonization, and desire for greater resiliency in Washington communities, it is valuable to reconsider the state's policies and incentives as they apply to biogas and RNG development.

This study provides a detailed review and analysis of data and information about the sources, costs, and challenges of producing RNG and the opportunity for Washington state to gain significant economic, social and environmental benefits from RNG.

As this report details, RNG can offer numerous benefits to residents and businesses in Washington. As a locally produced energy source, RNG will keep dollars circulating in the state and support a variety of good paying jobs. As detailed later, when used in transportation, RNG can significantly reduce air pollution. Support for RNG is also tied to reducing GHG emissions. After transportation, the residential, commercial, and industrial sector is the second largest source of GHG emissions in Washington. Most of

[2] Kirschner, Dan, 2017. "The power of natural gas in the war on carbon emissions," Seattle Times.

the emissions from this sector results from the use of fossil natural gas to heat water and buildings and for industrial processes.[3] Livestock manure management is another important source of GHG pollution.

In 2008, the Washington legislature set ambitious goals for reducing GHGs. Based on the most recent scientific findings, Ecology now recommends expanding these goals:[4]

- Reduce statewide GHGs to 1990 levels by 2020.
- Reduce statewide GHGs to 25% below 1990 levels by 2035 (Ecology recommends expanding this goal to a 40% reduction below 1990 levels).
- Reduce statewide GHGs to 50% below 1990 levels by 2050 (Ecology recommends extending this goal to an 80% reduction below 1990 levels).

The Clean Air Rule, established by Ecology in 2016 to address carbon pollution in Washington, addresses these targets and sets aggressive limits for various fossil fuels.[5] For natural gas, the department calls for GHG emission reductions of 1.7% every year from the baseline.[6] The rule provides a variety of compliance options, including reductions in natural gas use, greater efficiency, and the incorporation of RNG into the natural gas market. These measures also match the clean energy priorities that Governor Inslee is seeking to advance, including greater energy efficiency in the built environment, improved integration of all renewables, greater resiliency across the state, and an advanced natural gas policy.

Finally, the Pacific Coast Collaborative (PCC) brings together executive leadership in Washington with counterparts in Oregon, California, and British Columbia to find ways to cooperate to address key challenges. The potential for alignment of policies related to natural gas and RNG takes many forms and offers multiple, enhanced benefits. For example, the PCC calls for a Pacific "Green Highway" with infrastructure for alternative fuels including natural gas and RNG. They also seek to share standards and best practices for alternative fuels. California, Oregon, and British Columbia all share policies described in this report that support advances in the development of RNG. These include carbon pricing programs (e.g., cap and trade, carbon tax), clean fuel standards, and grant programs to support RNG investments. More important than any difference in market conditions, these policies have resulted in development of many more biogas and RNG projects, especially in agriculture and municipal waste handling, than in Washington.

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[3] Washington State Department of Ecology, 2016. Report to the Legislature on Washington Greenhouse Gas Emission Inventory: 2010-2013.
[4] Washington State Department of Ecology, 2016. Washington Greenhouse Gas Emission Reduction Limits.
[5] In December, 2017, Thurston County Superior Court Judge James Dixon ruled that the state cannot require gasoline and natural gas distributors and similar businesses that do not themselves burn fuels to comply. A written ruling was not yet available when this report was prepared.
[6] Washington State Department of Ecology, 2016. Washington Greenhouse Gas Emission Reduction Limits.

# 3. Biogas and RNG: Versatile Renewable Energy

Biogas can be used to produce many forms of energy. With minimal conditioning (i.e., removing water and hydrogen sulfide), raw biogas has the characteristics of a medium-BTU gas, providing about 500-600 BTU per cubic foot. Biogas with minimal conditioning can be burned directly in heaters, stoves, or boilers to provide useful thermal energy, or converted by various types of generators, turbines, or fuel cells into renewable heat and electricity (also called combined heat and power, or CHP). The methane in the biogas can be further separated from $CO_2$ and other gases into an upgraded, high-BTU gas (biomethane or RNG) that can be injected into the natural gas distribution system or used to fuel natural gas vehicles.

As renewable energy sources, biogas and RNG are highly versatile. Biogas is already produced and captured by public entities and private companies throughout Washington, including all territories served by natural gas utilities, as well as areas without natural gas service. Biogas can be produced at all levels, from small-scale mobile and on-farm digesters to community-sized facilities. Heat and power produced from biogas can be used as an off-the-grid resource. More commonly the power is added to the electricity grid through net metering or power purchase agreements (PPAs) with local utilities.

Using biogas from landfills, wastewater treatment plants, or dairy farms is a cost-effective way of reducing methane emissions. Anaerobic digestion or gasification technologies used to produce RNG are adaptable to both dilute, wet organic materials and drier, high-solids organics, even woody, cellulosic materials. Materials headed to compost facilities could be digested first to recover renewable energy, then composted aerobically to become soil amendments. This combination of anaerobic treatment of organic wastes followed by aerobic processing has higher capital and operating costs, but is gaining support as the value of RNG increases. This pathway also offers composters improved management of odors, pathogens, and vermin.

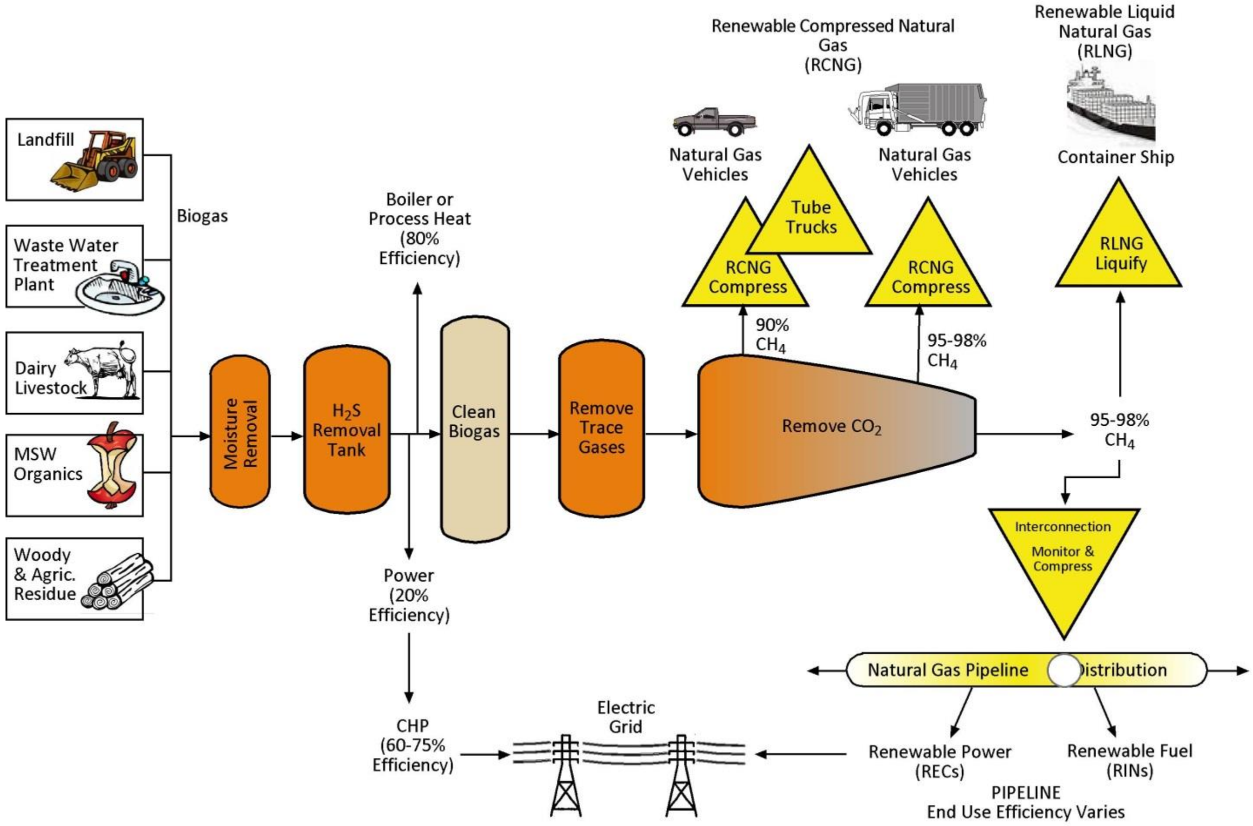
Because most biogas sources produce biogas on a consistent basis, biogas can be a valuable source of predictable baseload power. This sets it apart from intermittent sources of renewable energy, such as wind and solar.

When methane is isolated from biogas to make RNG, the BTU content rises to 985 BTU per cubic foot or greater, equivalent to fossil natural gas. This high-BTU RNG can be used in a wider variety of equipment and vehicles or injected into the natural gas pipeline grid.

RNG offers substantial carbon emission reductions for utilities looking to lower the carbon intensity of their fuel mix. It also provides utilities and local communities with a resilient source of fuel or power that can continue to produce energy during emergencies.

As shown in Figure 1, producers use a sequence of upgrading steps to remove moisture, hydrogen sulfide, $CO_2$, and other trace gases from biogas. The resulting biomethane or RNG becomes interchangeable with fossil natural gas. RNG can be used in the same appliances, equipment, engines, and vehicles that use natural gas. RNG can be pressurized into renewable compressed natural gas (RCNG) or renewable liquefied natural gas (RLNG) for even more versatile uses, especially in transportation to fuel cars, vans, trucks, or marine vessels.

**Figure 1. Biogas Upgrading and End-Use Pathways**




*Washington State University Energy Program, 2017*

RNG that meets prescribed quality standards can be injected into the natural gas pipeline grid. This makes RNG available to every natural gas user. As the uses for natural gas expand in industry and transportation, the same infrastructure for storage and distribution of natural gas can be used for RNG.

Though recent technological advances have reduced costs and improved efficiencies, conditioning biogas into RNG remains a costly process. Unless prices for fossil natural gas increase, direct competition as a market commodity does not by itself support investments in RNG. RNG developers must find multiple sources of revenue to be successful. This includes securing markets that monetize RNG's environmental benefits or require its use to bridge the gap between the cost of fossil natural gas and the cost to develop RNG production facilities.

# 4. RNG Provides Numerous Benefits

Developing RNG will provide Washington residents and companies with a number of significant economic, environmental, and social benefits.

## Develop Local Resources

Petroleum fuels and natural gas must be imported into Washington. While organic materials that can be used to produce RNG are found in every community in the state, putting these waste materials in landfills can cost $100 or more per ton. Retaining and processing these materials into renewable energy and other beneficial co-products can spark new economic activity. The energy can offset electricity and fuel costs for government and local businesses, and the nutrients and soil amendments can offset the costs of imported fertilizers that have been mined or produced from fossil fuels.

**Washington Businesses Make a Strong RNG Industry**

Anaerobic digestion, RNG, and the industry's co-products support many local companies. These are just some examples of Washington-based companies that are active in the anaerobic digestion/RNG sector:

- Biogas Energy, Seattle
- Cedar Grove Composting, Seattle
- DariTech, Lynden
- Edaleen Cow Power, Lynden
- Environmental Energy & Engineering, Olympia
- Farm Power NW, Arlington
- FPE Renewables, Lynden
- IGI Resources, Kirkland
- Impact Bioenergy, Shoreline
- Organix, Walla Walla
- Promus Energy, Seattle
- Regenis, Ferndale
- Raincountry Industrial, Arlington
- Trident Processes, Sumas
- Vaughan Company, Montesano
- Whole Energy Fuels, Bellingham
- Yield Biogas Solutions, Blaine

## Investment Success and Jobs

RNG projects are gaining traction at Washington landfills and at some WWTPs and dairy farms. To profit from RNG these projects require millions of dollars of investment in facilities and equipment. The state's largest landfills are investing more than $50 million to achieve the highest and best use of their RNG resource. WWTP systems can cost $10 million to $30 million. Biogas digesters on Washington dairy farms typically cost $3 million to $4 million to construct with the work provided by local contractors and equipment dealers. Projects serving large or multiple dairies or producing pipeline quality RNG, can require investments reaching $10 million to $25 million.

The job creation potential from RNG development is significant. An analysis by the American Gas Foundation found biogas projects in the U.S. could provide up to 83,000 direct jobs, which rises to more than 257,000 jobs when applying the average indirect jobs multiplier of 3.1 for this industry group.[7] A 2017 report evaluating the economic impact of developing RNG for fueling 172,000 to 516,000 natural gas trucks in California estimates creation of up to 134,000 jobs in the production of 500 million diesel gallon equivalents of RNG.[8]

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[7] American Gas Foundation, 2011. The Potential for Renewable Gas: Biogas Derived from Biomass Feedstocks and Upgraded to Pipeline Quality.

[8] ICF, 2017. Economic Impacts of Deploying Low-NOx Trucks Fueled by Renewable Natural Gas.

Numerous Washington companies have built their futures on supplying systems and equipment for anaerobic digestion or thermal gasification, and gas cleaning and conditioning equipment. Many of these companies are already making names for themselves in other states. The graphic sidebars show the types of jobs and the Washington businesses that can be supported by such new investments.

## Reduce Air Pollution Health Impacts

Diesel fuel is a major source of air pollution, smog-forming gases, and fine particulate matter. In 1998, the California Air Resources Board (CARB) identified diesel pollution as both a source of toxic air contaminants and a significant cancer risk. Despite having a number of programs designed to reduce sulfur levels in diesel and retrofit or retire the most offending engines, CARB estimates that thousands of people still die prematurely each year from excessive exposure to diesel particulate pollution. Nationally, the U.S. Environmental Protection Agency (EPA) attributes 63,000 to 80,000 premature deaths each year to diesel pollution.[9] The Lung Association of Washington has identified similar health concerns, especially from diesel pollution along major freight corridors. This pollution has its biggest impacts on more marginal communities (e.g., minorities, the poor) who live close to these corridors.

Natural gas and RNG are relatively clean fuels, especially when used for vehicles. Compared to conventional gasoline and diesel vehicles, the reported reductions offered by natural gas vehicles are striking[10]:

- Carbon dioxide ($CO_2$) reduced 10% to 30%
- Carbon monoxide (CO) reduced 70-90%
- Nitrogen oxide (NOx) reduced 75-95%
- Particle matter (PM) reduced up to 90%
- Sulfur oxide (SOx) reduced up to 99%
- Volatile organic compound (VOCs) reduced 89%

### Examples of Jobs in RNG

**Collection, Hauling, Processing**

- Facility operators
- Farm system managers
- Wastewater technicians
- Landfill engineers
- Mechanical engineers
- Processing equipment operators
- Mechanics
- Equipment production workers
- Chemical engineers
- Chemical application specialists
- Chemical production workers
- Biochemists
- Agricultural engineers

**Conversion of Feedstocks to RNG**

- Microbiologists
- Industrial engineers
- Chemical & mechanical engineers
- Digester operators
- IT and process control specialists

**End Use of RNG and Co-products**

- Station workers
- Construction workers
- Codes & standards developers
- Regulation compliance officers
- Consultants
- Chemists

**Materials and Product Transport**

- Truck drivers
- Filling station workers
- Pipeline operators
- Barge and railcar operators

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[9] California Air Resources Board , 2010. Staff Report: Initial Statement of Reasons for Proposed Rulemaking. Proposed Amendments to the Truck and Bus Regulation, the Drayage Truck Regulation and the Tractor-Trailer Greenhouse Gas Regulation.

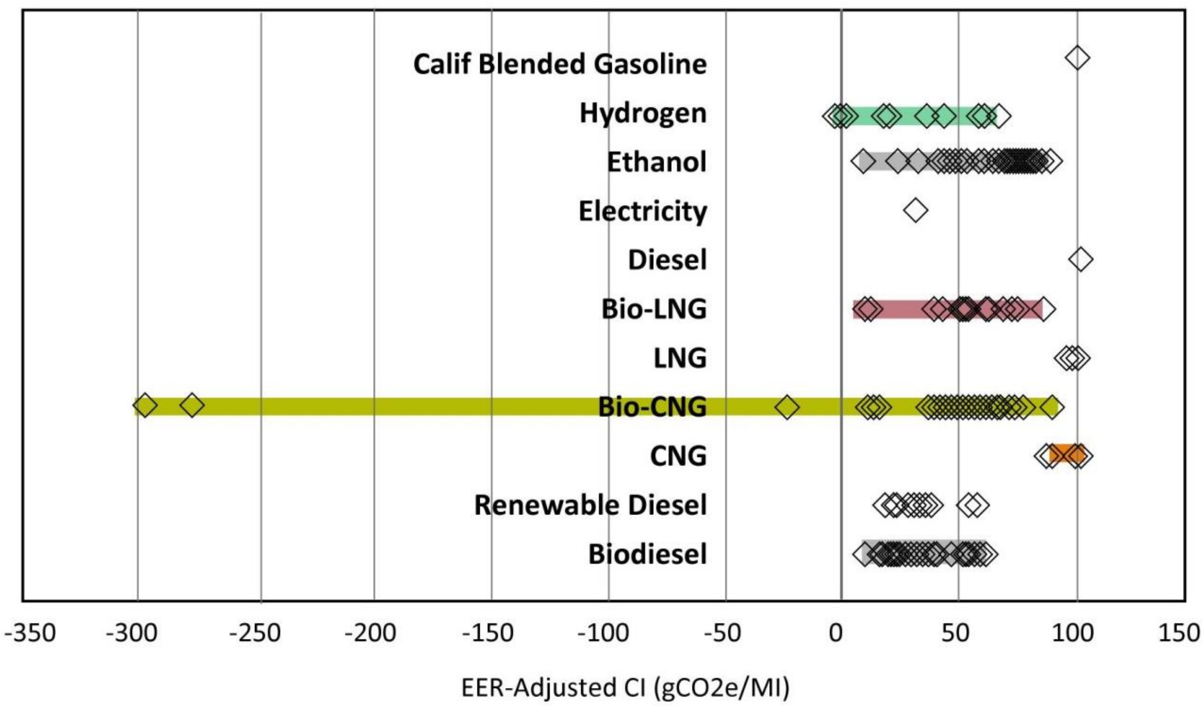
[10] U.S. Environmental Protection Agency and U.S. Department of Energy data as reported in Chesapeake Energy, 2017. Natural Gas Vehicles Improve Air Quality and Achieve Emissions Compliance.

## Support a Lower-Carbon Energy Future

Methane, the chief constituent of both fossil and renewable natural gas, is a potent GHG. The global warming potential of methane is more than 20 times greater than $CO_2$ when measured on a 100-year scale. On a shorter 20-year scale, methane has 84 to 87 times the global warming potential of $CO_2$.[11] As a result, methane released from landfills or dairy manure storage lagoons pose a GHG risk. Capturing methane, while producing and using RNG, provides major GHG reduction benefits.

The GHG impact of fuels is commonly assessed in terms of carbon intensity (CI) as measured in grams of carbon dioxide equivalent gases per megajoule of energy ($gCO_2e/MJ$). California and Oregon use CI calculations for transportation fuels to manage their Low Carbon Fuel Standard programs. Figure 2 shows the CI values calculated for different fuels by the California Air Resources Board.

**Figure 2. Carbon Intensity Values of Current Certified Pathways**




*California Air Resources Board, 2017. [LCFS Pathway Certified Carbon Intensities](LCFS Pathway Certified Carbon Intensities).*

The only fuels with CI values less than zero are bio-CNG (compressed RNG). Production and use of RNG provides multiple GHG emission reduction benefits. For example, RNG from a dairy farm digester produces biogas from manure previously stored in lagoons where it released methane into the air. If this low-carbon RNG is used to replace diesel fuel in a truck, the GHG-reducing benefit is magnified. Taken together, the GHG emissions reduction is greater than the emissions resulting from the RNG project, making the RNG fuel "carbon negative." Figure 2 illustrates the significance of the market advantage that projects with low or negative CI ratings can have.

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[11] U.S. Environmental Protection Agency, 2017. Understanding Global Warming Potentials.

## Support Alternative Fuel Use in Vehicles

Nationally, natural gas is already an important fuel in some heavy-duty markets. For example, 20% of transit buses operate on natural gas, and more than 50% of new orders for refuse trucks are now for CNG vehicles.[12] Increasingly strict emissions rules for diesel engines have prompted advances in efficiency and emissions controls and increased use of natural gas in medium- and heavy-duty engines. School buses, trucks of all sizes, even farm tractors come in natural gas-fueled versions. Because the fueling infrastructure is RNG-compatible, vehicles that use natural gas can easily use RNG. There are also aftermarket dual-fuel engine technologies that use natural gas or RNG to displace diesel.

For companies that collect municipal waste or recyclables and also operate or partner with waste processing or landfill facilities, the value proposition of producing renewable fuel for their vehicles is very attractive. Similarly, towns or cities that operate wastewater treatment digesters or landfills can align their plans for converting fleet vehicles to alternative fuels with the opportunity to produce RNG.

## Stabilize Fuel Price Volatility and Resiliency

Oil and gas prices have a long history of price volatility, especially when observed over decadal timelines. Leading or partnering on development of RNG production facilities can provide cost assurance over a long 10- to 20-year horizon. This is another potential win for businesses or municipal governments that have control over organic materials and the means of producing RNG.

Finally, another important consideration is the value of alternative-fueled vehicles for resiliency during emergencies. Since no natural gas is produced in Washington, RNG could provide valuable fuel for CNG vehicles in disaster scenarios. For example, alternative-fueled vehicles were found to be critical resources after Hurricane Sandy.

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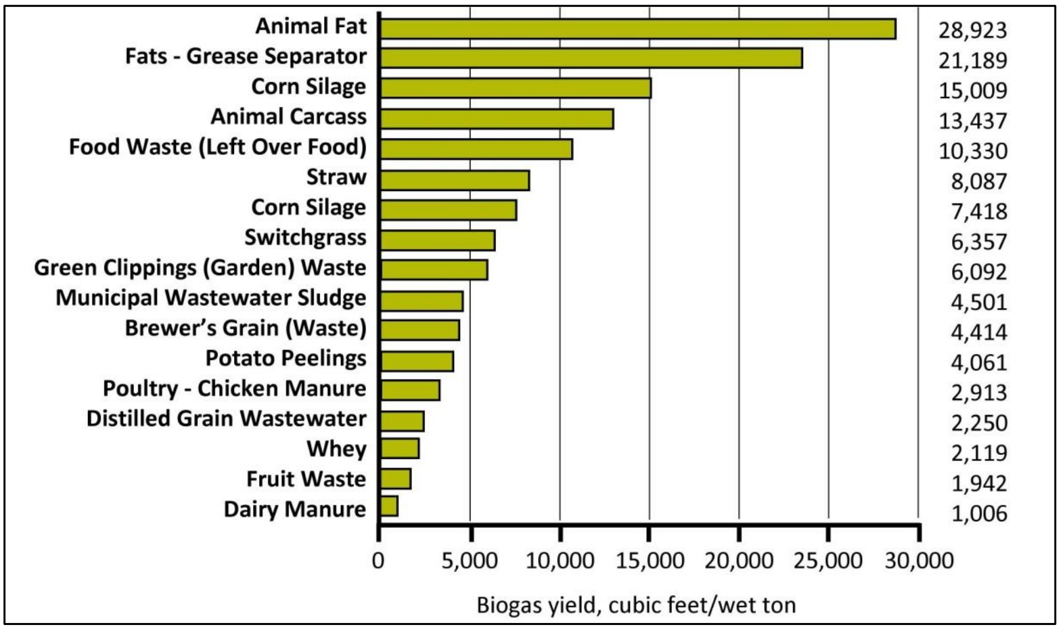
[12] Burnham, Andy, M. Mintz, and M. Rood, 2015. Status and Issues for Natural Gas in the United States: Alternative Fuel and Advanced Vehicle Technology Market Trends. U.S. Department of Energy—Clean Cities.

# 5. Pathways to RNG

The potential pathways to producing biogas/RNG include, in no particular order: landfills, WWTPs, and anaerobic digesters processing agricultural, food processing, and/or municipal organic materials. A load of fruit waste will produce biogas whether it is buried in a landfill, flushed to a wastewater plant, fed to a dairy manure digester, or digested with other food waste in a specialized digester. Figure 3 shows the wide range of biogas yields possible from different organic materials. Which pathways make most sense is influenced by many factors, including markets, location, available facilities, and government policies. For example, the volume of RNG available on dairy farms and the benefits of developing this resource in rural Washington can make sense even though the biogas yield from dairy manure is relatively low.

**Figure 3. Biogas Yield from a Variety of Organic Feedstock Materials**




*TetraTech, 2011.* *Tillamook County Bioenergy Feasibility Study Report.*

Depending on the pathway chosen, the resulting biogas will have varying energy values (as measured in BTU) and complex mixes of other trace gases, reflecting the wide range of materials used in its production. Table 1 shows common sources of biogas and the different gases or contaminants that can be found. Such variations can complicate the possible end uses for biogas.

**Table 1. Characteristics of Biogas Produced from Different Source Pathways**

| Sources | Common Characteristics |
|---|---|
| Landfills | Methane ($CH_4$), carbon dioxide ($CO_2$), hydrogen sulfide ($H_2S$), water vapor, other sulfides and mercaptans, siloxane, nonmethane organic compounds, oxygen, nitrogen, ammonia, and other trace gases |
| Wastewater treatment plants | $CH_4$, $CO_2$, $H_2S$, water vapor, siloxanes, and possibly traces of nitrogen and ammonia |
| Dairy manure | $CH_4$, $CO_2$, $H_2S$, and water vapor |
| Food processing byproducts | $CH_4$, $CO_2$, $H_2S$, and water vapor |
| Municipal organic wastes | $CH_4$, $CO_2$, $H_2S$, water vapor, siloxanes, other gases in trace amounts |

*Western Washington Clean Cities, 2013.* *Biomethane for Transportation.*

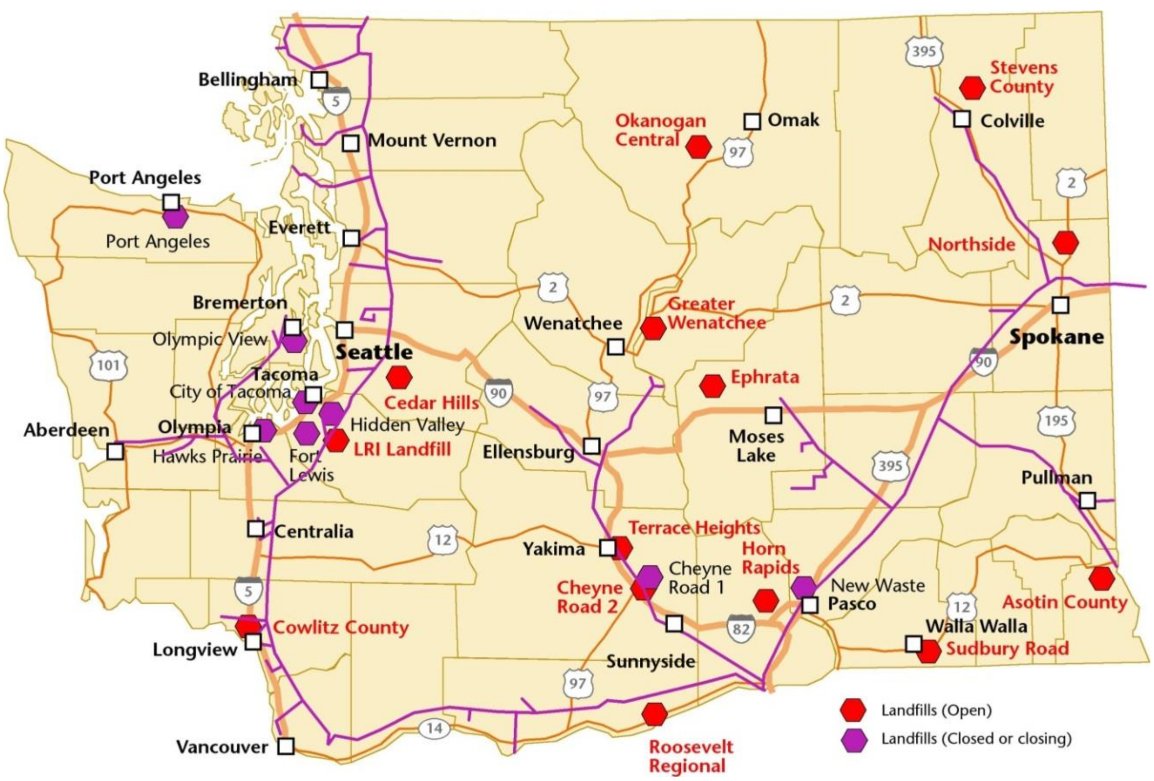
The desired end use for RNG guides the extent of scrubbing or upgrading required of the raw biogas. In general, the energy value of biogas and RNG is measured in British Thermal Units (BTUs). Fossil natural gas is 95 to 100% methane with amounts of ethane, propane, butane, and/or inerts. To be transported in a pipeline, it needs to have an energy value of 985 BTU per cubic foot or greater. Specifications among natural gas utilities and pipeline companies may vary, but to mix with other gas in transmission pipelines, an RNG product would typically need 985 BTU per cubic foot or greater and meet thresholds for a number of specific contaminants. For direct use in vehicles, RNG would have to be scrubbed of hydrogen sulfide, siloxanes, and other trace gases, but engines can tolerate some nitrogen and as much as 10% carbon dioxide so the required upgrade may only be to 900 BTU per cubic foot.

## Landfills

Landfills generate raw biogas from the decomposition of organic materials deposited as waste. Some materials, such as food scraps and grass clippings, are highly putrescible and decompose rapidly. Other materials (e.g., garden debris, tree and shrub prunings, lumber, woody materials, paper and cardboard, some textiles, even disposable diapers) decompose over a longer period of time. All can lead to biogas composed of 50% or more methane.

Between 1991 and 2014, the amount of disposed refuse in Washington increased from 3.9 million to 5.4 million tons, while the number of open landfills decreased from 45 to 14 (11 public and 3 private). The share of refuse managed at private landfills shifted markedly during the past 25 years, from 31% in 1991 to 66% in 2017.[13] Figure 4 shows landfills of significance in Washington and their location relative to the major natural gas pipelines in the state.

**Figure 4. Washington Landfills and Major Natural Gas Pipelines**




13 Washington State Department of Ecology, 2015. Solid Waste in Washington State: 24th Annual Status Report.

In the past, landfills were simply open unlined pits, which allowed methane to seep into neighboring homes and businesses with potentially hazardous consequences. Now, federal and state regulations require landfills to comply with operating standards based on their size and level of risk. For example, landfills must cover each day's refuse, install liners to control leachate, and use biogas collection systems and flares to control methane leakage. These systems can keep much but not all of the methane-rich landfill gas from escaping into the atmosphere. According to the EPA, municipal solid waste landfills are still the third largest source of human-related methane emissions in the U.S, accounting for 15.4% of emissions in 2015.[14] In Washington, landfills account for 2.54 million metric tons of GHG emissions each year.[15]

Landfill gas collected from landfills is highly variable, occurring at different rates throughout the lifespan of the landfill. It also contains a greater variety of contaminants and trace gases than other sources of biogas. Until recently, much of the gas collected at landfills was destroyed in flares. This was convenient because it could effectively manage all the different trace gases found in landfill gas. However, the volumes of gas produced by larger landfills are staggering in comparison with other sources. For these reasons, fully capturing landfill gas during the entire lifespan of the landfill and cleaning that gas to RNG standards often makes an excellent business case. Table 2 details RNG opportunities at landfills.

**Table 2. RNG Opportunity at Landfills**

| | |
|---|---|
| **Potential number of projects** | 8 to 12 |
| **Total estimated RNG potential** | 16,519,219 MMBTU/yr |
| **Electricity – Megawatt hours per year** | 1,738,865 MWh/yr |
| **RNG Fuel – Diesel gallon equivalents** | 122,364,586 DGE/yr |

*Note: Heat rating for power 9,500 BTU/kWh, Fuel factor 135,000 BTU/DGE*

## Wastewater Treatment Plants

The Department of Ecology lists more than 300 WWTPs in Washington, serving small towns and cities in every corner of the state. They use a variety of mechanical, biological, and chemical methods to separate and remove organic waste materials and contaminants so the water can be discharged into the environment. Larger WWTPs that receive hundreds of thousands to millions of gallons of wastewater daily often use anaerobic digesters as a cost-effective part of the treatment process.

Plant operators often burn the biogas produced to provide heat for the digester and plant facilities, and in a few cases, to dry the facility's treated biosolids to make them easier to transport and use as fertilizer. Biogas also powers generators that produce both heat and electricity. That energy can offset much of the energy needs of the facilities. Larger treatment plants even produce surplus electricity that goes onto the grid through power purchase agreements with local utilities. These larger plants can also be in a position to scrub biogas to RNG quality standards. With RNG they can fuel fleet vehicles, or depending on their location, inject it into distribution or interstate gas pipelines. Figure 5 shows major WWTPs in Washington and their location relative to the major natural gas pipelines in the state.

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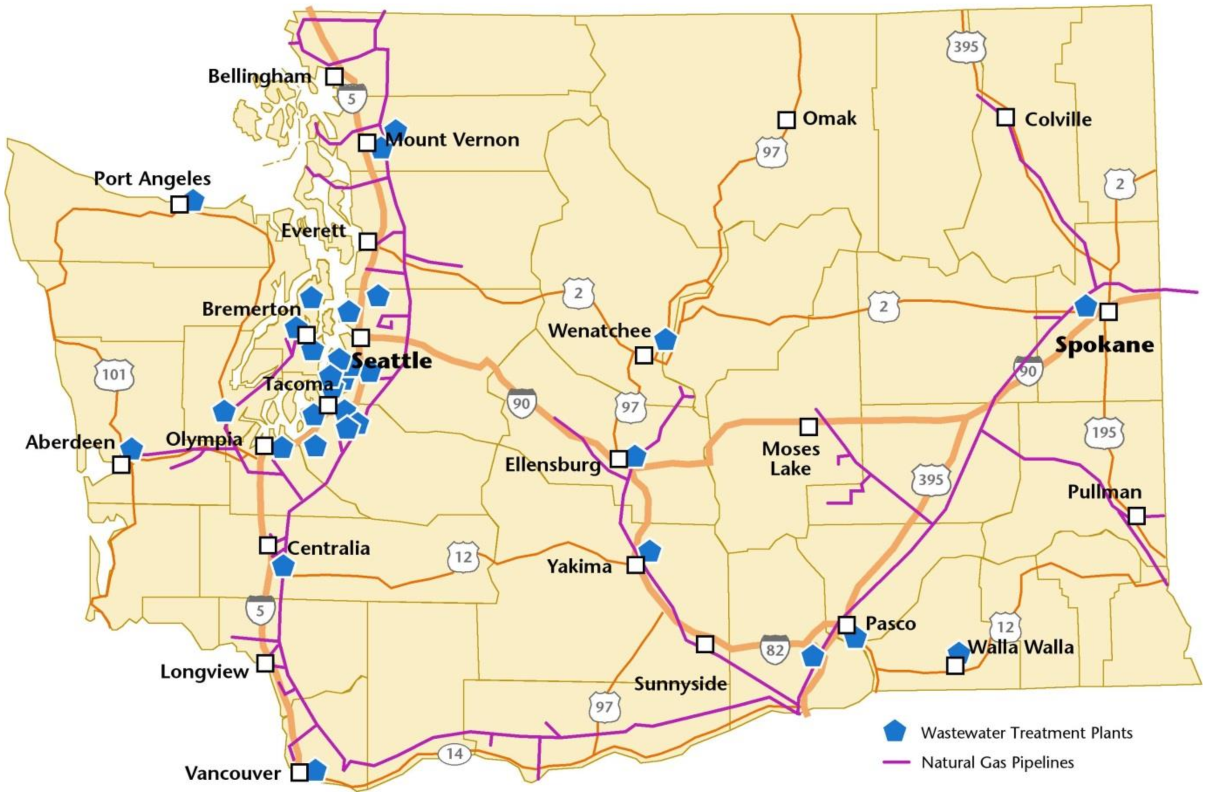
[14] U.S. Environmental Protection Agency, 2017. Basic Information about Landfill Gas.

[15] Washington State Department of Ecology, 2016. Report to the Legislature on Washington Greenhouse Gas Emission Inventory: 2010-2013.

**Figure 5. Washington WWTPs and Major Natural Gas Pipelines**




The organics category known as fats, oils, and greases (FOG) describes many materials with a high potential for physical and chemical contamination. FOG often ends up at local WWTPs, or is collected directly from grease traps in restaurants and other facilities. Much of what is currently collected is used to produce biodiesel. It also has a high capacity to produce biogas, so it may play a role in some digestion projects in the state. The 20-million-gallon-per-day WWTP in Gresham, OR, began receiving FOG in 2012. They observed that addition of just 10,000 gallons per day of FOG increased biogas production by 50-60%.[16] Table 3 details RNG opportunities at WWTPs.

**Table 3. RNG Opportunity at Wastewater Treatment Plants**

| | |
|---|---|
| **Potential Number of Projects** | 30-40 |
| **Total Estimated RNG Potential** | 1,716,062 MMBTU/yr |
| **Electricity – Megawatt hours per year** | 180,638 MWh/yr |
| **RNG Fuel – Diesel gallon equivalents** | 12,711,571 DGE/yr |

*Note: Heat rating for power 9,500 BTU/kWh, Fuel factor 135,000 BTU/DGE*

[16] Goldstein, Nora, 2015. "Oregon WWTP's Energy Net Zero Journey," BioCycle. 56:3.

## Agriculture

Livestock production generates tons of manure suitable for anaerobic digestion. While Washington has little swine production, there are roughly half a dozen poultry farms producing eggs or broiler birds that might co-digest manure with other materials. Horse manure with bedding, on the other hand, may be more suitable for composting. For this study, the spotlight is on dairy manure. Milk is the second largest agricultural commodity in Washington, contributing more than $1.1 billion in farm gate revenue.[17] Counting the land, facilities, equipment, and cows themselves, even small dairies are multi-million dollar enterprises that provide jobs in rural areas. Medium and large dairies support as many as 10 to 20 employees each, and even more at the largest facilities.

Milk cows produce large volumes of manure and wastewater, most of which is stored in lagoons during wet months before being land applied during the growing season. Liquid manure storage releases methane equivalent to 4 to 5 tons of $CO_2$ for each cow per year. That is about the same GHG impact as an average passenger car. Because methane is a short-lived GHG, the impact is multiplied.

In 2017, the Washington Department of Agriculture (WSDA) identified 144 small dairies (<200 milk cows), 121 medium dairies (200 to 700 milk cows), and 106 large dairies (>700 cows) in the state. While the number of dairies continues to decline, the total number of mature cows in Washington has stayed at roughly 275,000 head. Figure 6 shows locations of dairy farms relative to major natural gas pipelines.

**Figure 6. Washington Dairies and Major Natural Gas Pipelines**


[17] Washington State Department of Agriculture, 2017. Value of Washington's 2016 Agricultural Production Totaled $10.6 Billion.

Yakima, Grant, Franklin, and Adams counties in eastern Washington host the largest dairies, making these areas prime candidates for significant biomethane development. These dairies represent 59% of the biomethane potential on farms characterized as having large herds, more land, and dryer conditions.

In Western Washington, dairy producers in Whatcom, Skagit, and Snohomish counties offer the most significant opportunities for RNG development. Digester and RNG project developers could be attracted by the proximity of these farms to major urban centers, interstate highways, and major natural gas pipelines. Together they represent 27% of the biomethane potential for dairies.

Covered lagoons and free-standing anaerobic digesters are cost-effective options for mitigating GHG emissions. With 242 anaerobic digesters operating on livestock farms in the U.S., the appropriate technologies and methods are well established. Dairy farm digesters have good track records for cutting odors, reducing pathogens, and enhancing the value of the digested manure.

Table 4 details RNG opportunities at dairy producers. For policy-makers looking to support near-term projects, dairy manure management through anaerobic digestion offers excellent projects with multiple benefits, including rural development and resilience, job creation and retention, and improved nutrient management for the environment and neighboring communities.

**Table 4. RNG Opportunity in Agriculture**

| | |
|---|---|
| **Potential Number of Projects** | Hundreds (small, medium and large) |
| **Total Estimated RNG Potential** | 3,011,250 MMBTU/yr |
| **Electricity – Megawatt hours per year** | 316,974 MWh/yr |
| **RNG Fuel – Diesel gallon equivalents** | 22,305,566 DGE/yr |

*Note: Heat rating for power 9,500 BTU/kWh, Fuel factor 135,000 BTU/DGE*

## Source-Separated Organics

Organic materials found in the municipal solid waste stream—food scraps of all types, grease, yard and garden debris, woody materials, low-grade paper, and even disposable diapers—will produce biogas or RNG along any of several pathways. They might be buried in a landfill or converted to biogas in a variety of anaerobic digestion facilities. Based on the most recent statewide waste composition study, Ecology estimates that more than 770,000 tons of food wastes and 260,000 tons of yard and garden debris in Washington are disposed of in landfills. This represents nearly a quarter (22.7%) of the disposed wastes in Washington.[18]

Landfills, however, are not the most efficient method of extracting biogas from municipal organic wastes. They have a defined lifespan, and significant quantities of biogas may not be collected at the beginning or end of a landfill's life. On a daily basis, methane produced from highly putrescible materials, such as food waste or grass clippings, may be lost because they decompose prior to gas collection. Critics also point to contaminants in landfill gas as sources of pollution and greater gas cleaning costs.[19]

Better pathways exist for capturing the RNG potential of source-separated organic materials. For example, diversion of food scraps to anaerobic digesters located at WWTPs or farms is an established practice. Co-digestion is popular for many digester operators because gas production is boosted

[18] Cascadia Consulting Group, 2016. 2015-2016 Washington Statewide Waste Characterization Study.
[19] Ewall, Mike, 2007. Primer on Landfill Gas as "Clean" Energy, Energy Justice Network.

significantly. At a Washington dairy digester, WSU researchers found that co-digestion of manure with 16% food waste more than doubled biogas production and nearly quadrupled project revenues.[20]

Food scraps from the industrial or food-processing sector is another source of digestible materials. According to WSDA, the food processing and manufacturing industry has gross annual sales greater than $17 billion and employs more than 40,000 people.[21] Food processing is the second largest user of electricity in the Northwest, and energy generation and fossil fuel use account for the vast majority of GHG emissions in the sector.

Industry interest in anaerobic digestion exists because of the potential to digest single-source, easy-to-collect, pre-consumer vegetative materials free of contaminants. Digester projects, such as JR Simplot's facility in Moses Lake, benefit from digesting on-site food scraps. Other scraps, including fish and seafood processing wastes, can super-charge biogas yields at existing facilities. Liquid waste streams (e.g., dairy products, whey, brewery or distillery by-products, off-date beverages) are very compatible with typical anaerobic digesters.

Information about organic residuals in the food processing industry is scarce because data may be considered proprietary. Solid waste experts believe that many food manufacturers avoid the costs of conventional solid waste handling by distributing their organic residuals for livestock feed or direct land application as soil amendments. Table 5 details RNG opportunities from source-separated organics.

**Table 5. RNG Opportunity from Source-Separated Organics**

| | |
|---|---|
| **Potential number of projects** | Several large facilities and/or hundreds of smaller ones |
| **Total estimated RNG potential** | 5,430,198 MMBTU/year |
| **Electricity – Megawatt hours per year** | 571,600 MWh/yr |
| **RNG Fuel – Diesel gallon equivalents** | 40,223,692 DGE/yr |

*Note: Heat rating for power 9,500 BTU/kWh, Fuel factor 135,000 BTU/DGE*

## Innovative Technology for RNG Production

Technological innovations currently in development could significantly increase the long-term availability of RNG. Thermal gasification systems use low-moisture, fibrous and/or woody materials to produce a synthesis gas (syngas) composed of hydrogen, carbon monoxide, $CO_2$, water vapor, methane and trace gases. Syngas can be upgraded to RNG by removing $CO_2$ and other gases and converting hydrogen and carbon monoxide to methane. Existing gasification plants have used wood chips, woody biomass, crop residues, and even purpose-grown energy crops. In British Columbia, an analysis of RNG potential found gasification of available forestry debris nearly doubled their potential volume of RNG.[22] In Washington, forestry debris and purpose-grown poplar trees were the targets of major recent studies about producing biojet fuel for the aviation sector. Other sources of fibrous or woody materials include crop residues, perennial grasses, and construction and transport packaging residuals from municipal solid waste. Table 6 details RNG opportunities from thermal gasification of urban woody residuals.

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[20] Yorgey, Georgine, et al., 2011. Anaerobic Co-Digestion on Dairies in Washington State. WSU Extension Fact Sheet FS040E.

[21] Washington State Department of Agriculture, 2015. AGRICULTURE – A Cornerstone of Washington's Economy.

[22] Hållbar Consulting and Research Institute of Sweden, 2017. Resource Supply Potential for Renewable Natural Gas in British Columbia.

**Table 6. RNG Opportunity from Innovative Technology Developments**

| | |
|---|---|
| **Potential Number of Projects** | Unknown |
| **Total Estimated RNG Potential** | 23,376,197 MMBTU/yr |
| **Electricity – Megawatt hours per year** | 2,460,652 MWh/yr |
| **RNG Fuel – Diesel gallon equivalents** | 173,157,015 DGE/yr |

*Note: Heat rating for power 9,500 BTU/kWh, Fuel factor 135,000 BTU/DGE*

Another RNG innovation currently in research and development is "power-to-gas." Now being studied by the National Renewable Energy Lab (NREL) and others, it would use renewable electricity from intermittent sources like wind and solar to produce hydrogen that is combined with waste $CO_2$ to produce RNG. The estimate in this study is based on the impact thermal gasification could have in producing RNG from woody materials derived from urban waste streams. It does not represent the full opportunity that could be realized from uses of these innovative technologies.

## Summary

The results of this analysis (Table 7) suggest that in the near term, maximizing RNG opportunities in Washington using existing technologies could produce on the order of 20 to 26 trillion BTUs of RNG each year. This could displace roughly 8% to 10% of the natural gas currently consumed directly by residents and businesses in the state. If it were all converted and used as transportation fuel it could displace 198 million gallons of diesel fuel or about 20% of the state's annual consumption.

**Table 7. Summary of RNG Opportunities**

| RNG Source | Energy MMBTU/yr | Electricity MWh/yr | Fuel DGE/yr |
|---|---|---|---|
| **Landfills** | 16,519,219 | 1,738,865 | 122,364,586 |
| **Wastewater Treatment** | 1,716,062 | 180,638 | 12,711,571 |
| **Agriculture** | 3,011,250 | 316,974 | 22,305,566 |
| **Source-Separated Organics** | 5,430,198 | 571,600 | 40,223,692 |
| **Thermal Gasification** | 23,376,197 | 2,460,652 | 173,157,015 |

*Note: Heat rating for power 9,500 BTU/kWh, Fuel factor 135,000 BTU/DGE*

Continued development and deployment of innovative RNG technologies could lead to much stronger results. Converting urban woody debris to RNG through gasification could push the total contribution of RNG past 50 trillion BTUs or 370 million diesel gallon equivalents. That represents nearly 19% of direct natural gas consumption or 37% of the current diesel consumption. This estimate can grow further with gasification of forest or agricultural residues or innovations like power-to-gas.

While analyzing the opportunity represented by RNG in Washington, it is also important to consider the impacts of population growth on future opportunities. According to the Office of Financial Management, the population of Washington state as of April 2016 was 7,183,700.[23] Estimated low, medium, and high population growth curves over the next 25 years range from roughly no change to increases of 2 million to 3.5 million more residents by 2040.[24]

Because most organic waste streams change with population (e.g., municipal solid waste, wastewater, food processing wastes), projected population growth could potentially expand the RNG opportunity by 25% to 40%.

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[23] Washington Office of Financial Management, 2016. State of Washington 2016 Population Trends.
[24] Washington State Office of Financial Management, 2012. County Growth Management Population Projections by Age and Sex: 2010-2040.

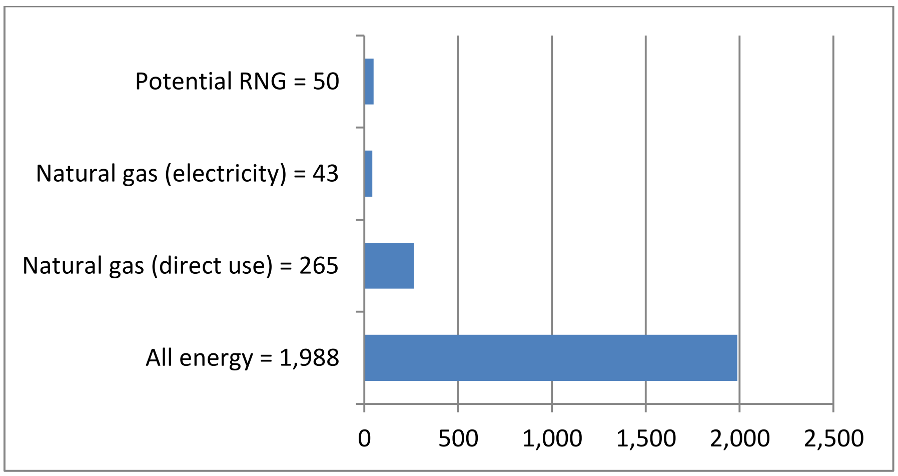
# 6. Natural Gas Infrastructure and Markets

To fully appreciate the opportunities and challenges facing RNG development in Washington, it is valuable to review the basics of natural gas infrastructure and markets and the utilities currently providing natural gas to customers.

## Consumption

According to estimates by the U.S. Energy Information Administration (EIA), Washington residents used 1,988 trillion BTU of energy in all forms in 2015. Total annual per capita energy consumption is estimated at 278 million BTU. Total consumption of natural gas in Washington was reported as 308 trillion BTU, equivalent to 308 billion cubic feet. Figure 7 shows the split between direct use of natural gas by residents and businesses versus the use for electricity generation. The overall potential of RNG to provide upwards of 50 trillion BTU of energy is also shown.[25]

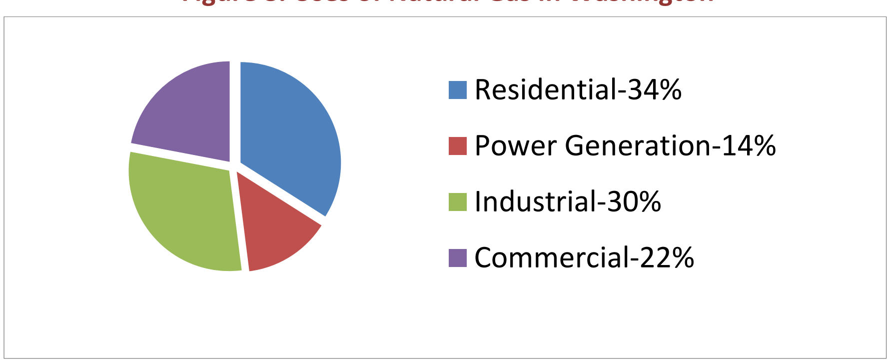
**Figure 7. Energy Consumption in Washington (trillion BTU)**




*U.S. Energy Information Administration, 2015. Washington State Profile and Energy Estimates.*

The major uses of natural gas in Washington are residential and commercial cooking and heating, industrial energy, and electricity generation. Figure 8 shows the relative distribution of natural gas to these various end users. Very little natural gas (<1%) is currently used for transportation in Washington.

**Figure 8. Uses of Natural Gas in Washington**

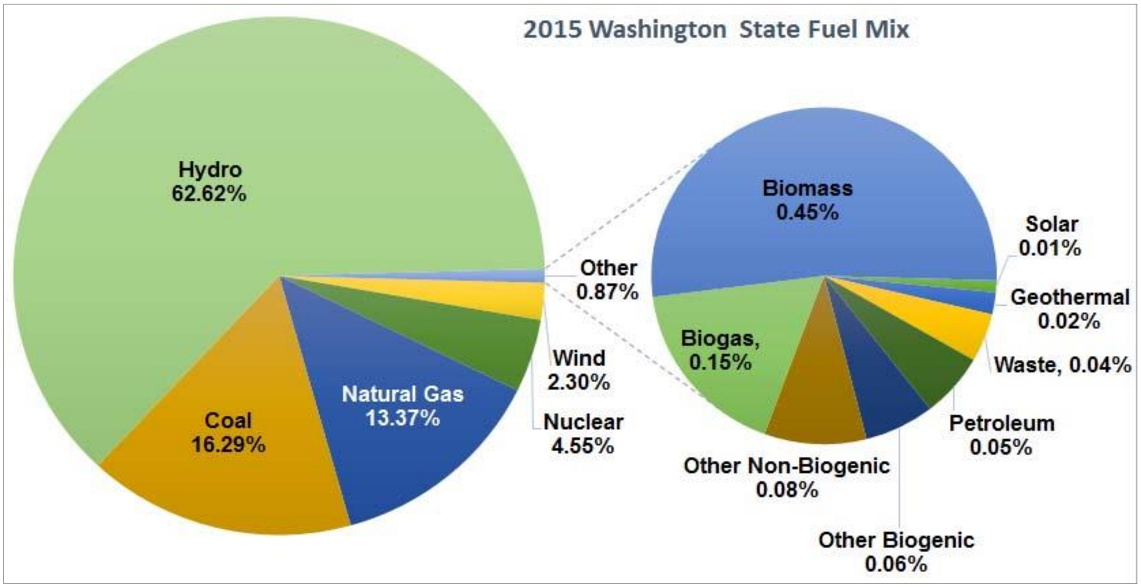



*U.S. Energy Information Administration, 2015. Washington State Profile and Energy Estimates.*

[25] Data from 2015. U.S. Energy Information Administration, 2017. Washington State Profile and Energy Estimates.

According to the Washington State Department of Commerce, natural gas is used to produce 13.5% of the electricity consumed in Washington. This use of natural gas has stayed fairly steady in recent years, from 10,088 thousand megawatt-hours (MWh) in 2013 to 10,791 thousand MWh in 2017.[26] Figure 9 shows the mix of fuels used to produce Washington's electricity supply in 2015.

**Figure 9. Washington State Electricity Fuel Mix**




*Washington State Department of Commerce, 2017. [Washington State Electric Utility Fuel Mix Disclosure Reports for Calendar Year 2016](#).*

The share of electricity produced by natural gas may change in the near future if it continues to substitute for electricity produced from coal. The Centralia Power Plant, owned by TransAlta, produces about 10% of the state's electricity. Per the TransAlta Energy Transition Bill, one generator is scheduled for transition to natural gas by 2020, the other by 2025.

The other major sources of Washington's electricity from coal are the Colstrip Steam Electric Station in Montana and the Jim Bridger plant in Wyoming. Puget Sound Energy, Avista, and PacifiCorp receive electricity in varying percentages from these sources. Plans are underway to close these sources, raising questions regarding how long this will take and how much demand will be offset by increases in efficiency or power from natural gas, RNG, wind, solar, or other renewable sources.

Very little natural gas is currently used for transportation in Washington. However, among the more advantageous uses of natural gas and RNG is the displacement of gasoline and diesel fuels in vehicles. Because of the increasing emphasis on electrifying transportation, industry observers suggest the best opportunity to use RNG in transportation is through fuel substitution in local fleets, heavy-duty over-the-road vehicles, and marine and rail vehicles.[27] By nearly any measure, trucks play an outsized role in GHG emissions. They comprise just 4.3% of vehicles in the U.S., and 9.3% of all miles driven each year, yet consume more than 25% of the fuel burned annually.[28]

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[26] Ibid.
[27] Center for Climate and Energy Solutions, 2013. Leveraging Natural Gas to Reduce Greenhouse Gas Emissions.
[28] Davies, Alex, 2015. Making Trucks More Efficient Isn't Actually Hard to Do. *wired.com*.

Such a transition will not be easy. Excitement for using natural gas in transportation has arisen multiple times. During the 1980s-90s, various fleets switched to compressed or liquefied natural gas. Enthusiasm waned as operational challenges presented themselves, followed by a few high-profile failures. Optimism rose again in the early 2000s with the large drop in prices due to natural gas fracking. However, the dreams for big increases in the use of CNG and LNG in vehicles have yet to be realized.

Natural gas vehicles have a higher incremental cost compared to diesel and gasoline vehicles due to the expense of specialized fuel systems and fuel tanks. The engines of heavy-duty natural gas trucks can cost as much as 30% more than comparable diesel engines, and fleet operators have to consider added fueling infrastructure costs due to the lack of commercial stations.

In a full economic analysis, natural gas vehicles enjoy economic advantages over comparable diesel and gasoline vehicles. The low cost of natural gas fuel relative to diesel and gasoline shorten the payback period and newer natural gas engine technology is associated with lower maintenance costs. However, the first costs and the limitation of refueling infrastructure availability have slowed broad adoption of CNG/RNG in heavy-duty fleets.

At the same time, new diesel engine efficiency is increasing. The federal government is currently following strict mileage standards for diesel trucks set during the Obama administration. Current standards requiring a 20% reduction in fuel consumption were introduced in 2011 and took effect in 2015. Phase Two rules introduced in 2015 will apply to semi-trucks, large pickup trucks, vans, and buses built between 2021 and 2027. They require another 24% fuel reduction based on 2018 numbers.[29]

Though natural gas prices remained low and the reliability of natural gas engines is improving, the price of diesel followed the drop in natural gas prices. This may not last over the long term, but the current effect is to slow fleet conversions to natural gas platforms. As evidence of this, the number of public CNG fueling stations in Washington declined from 16 in 2012 to only 6 in 2017.

## Market Trends

The 2017 market outlook published by the Northwest Gas Association predicts one of the slowest rates for growth in the last 15 years, only 0.8%. Near-term growth in industrial, commercial, and residential uses looks flat as increases in population and expanding residential and commercial use may be offset by increased efficiency in building designs and natural gas appliances.

Across the nation, natural gas prices have shifted strongly over the past 15 years. With the advent of hydraulic fracturing methods, domestic natural gas prices fell from above $10 per MMBTU to below $5 per MMBTU, and often as low as $2 to $3 per MMBTU. In recent years, natural gas prices for residential customers in Washington have reflected this new market, falling from $13.02 per MMBTU in 2013 to $10.26 per MMBTU in 2017.[30] According to the industry's latest analysis, prices are not expected to rise above $5 per MMBTU (in 2015 dollars) for many years (Figure 10). The Northwest Power and Conservation Council aligns with this trend in its Fuel Price Forecast for the Seventh Northwest Power Plan.

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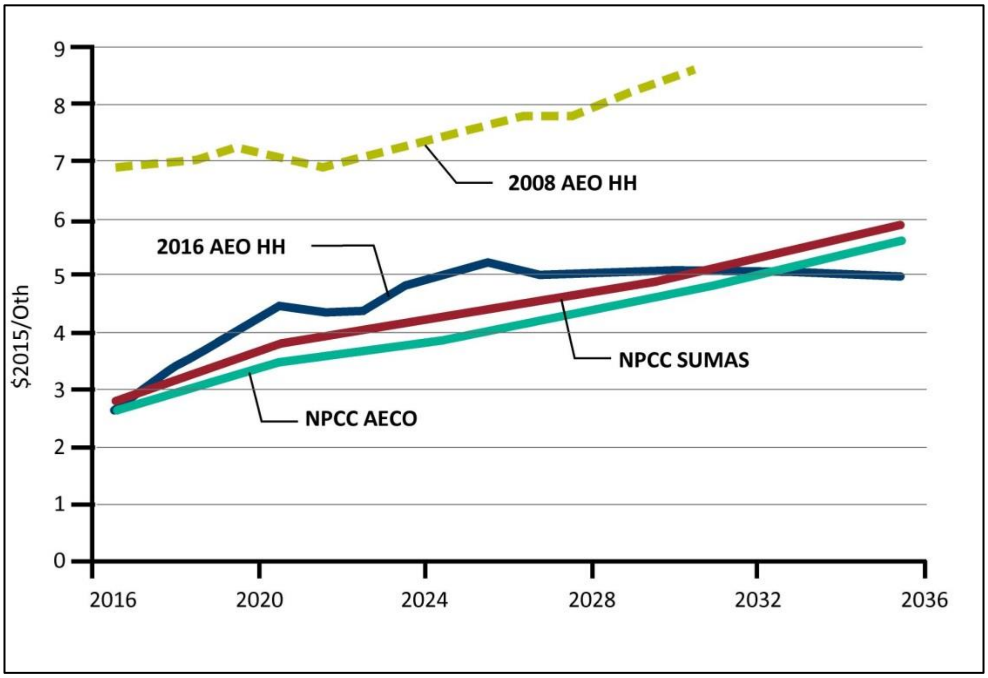
[29] Ibid.

[30] City gate prices as reported by U.S. Energy Information Administration, State Energy Data System

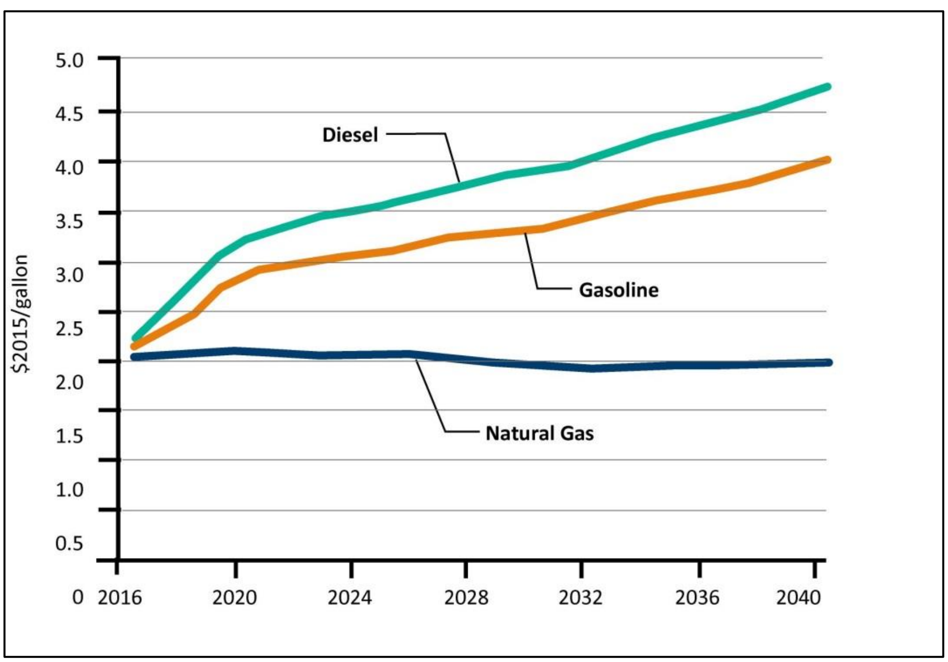
**Figure 10. Natural Gas Spot Price Forecast Comparisons**




*Northwest Gas Association, 2016. [2016 Gas Outlook: Natural Gas Supply, Demand, Capacity, and Prices in the Pacific Northwest, Projections through October 2026](#).*

Despite recent decreases in petroleum prices, natural gas maintains a roughly 3:1 price advantage over oil on a BTU basis. According to the industry, natural gas is expected to become even more price competitive as a transportation fuel when compared with diesel and gasoline (Figure 11).

**Figure 11. Transportation Fuel Price Forecast to 2040**



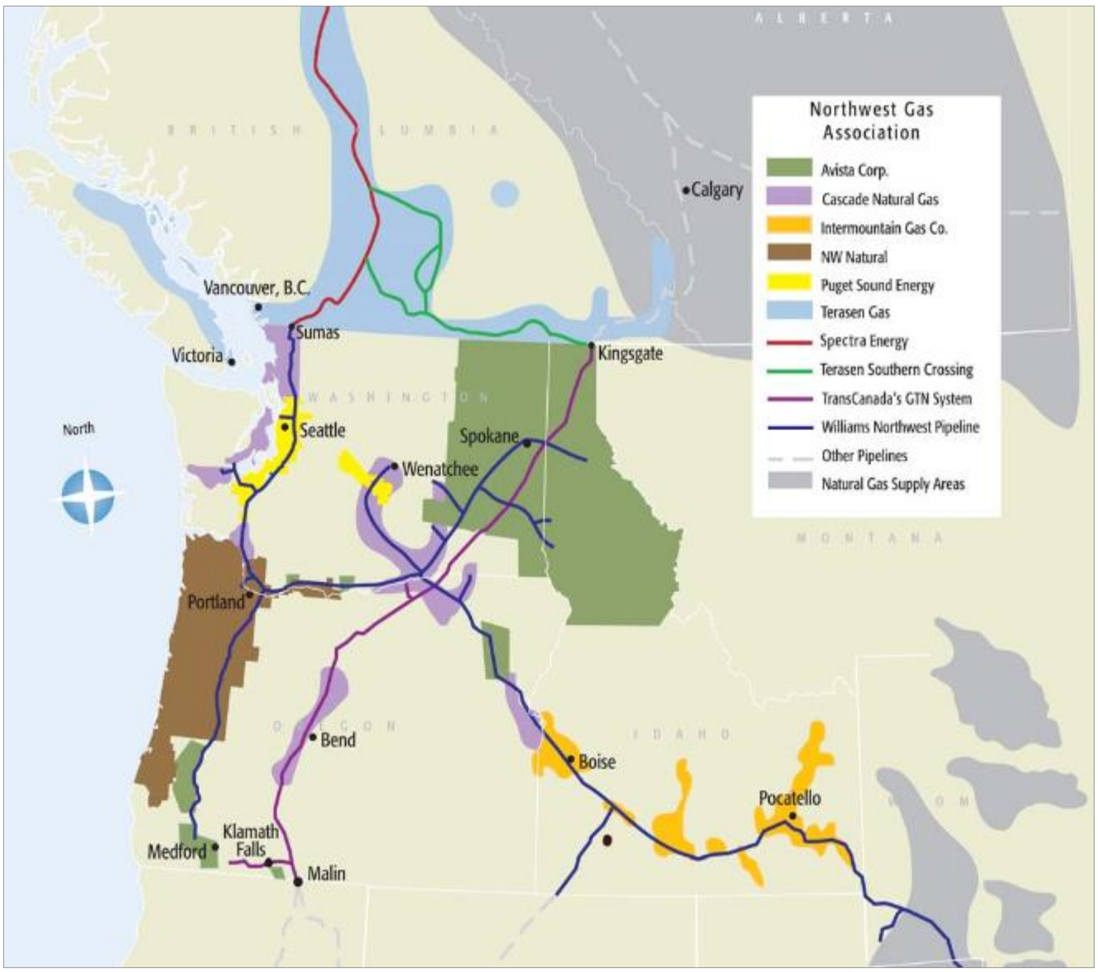

*Northwest Gas Association, 2016. [2016 Gas Outlook: Natural Gas Supply, Demand, Capacity, and Prices in the Pacific Northwest, Projections through October 2026](#).*

## Supply and Infrastructure (Pipelines)

Washington produces no fossil natural gas of its own. The natural gas consumed in Washington is imported from British Columbia and Alberta (Western Canadian Sedimentary Basin, approximately 60%), and Wyoming, Utah, and Colorado (Rocky Mountain Basin, approximately 40%). It has been estimated that half or more of the current imported supply is from operations that use hydraulic fracturing (fracking) methods.

Fossil natural gas is imported into Washington along one of two major interstate pipeline routes as shown in Figure 12. The Northwest Pipeline (also known as the Williams Pipeline) supplies natural gas from Canada, the Rocky Mountain region, and the San Juan Basin in the U.S. Southwest. TransCanada's Gas Transmission Northwest pipeline enters the state from Idaho, bringing natural gas primarily from western Canada. It continues through Washington and Oregon to California.

**Figure 12. Pacific Northwest Natural Gas Pipelines**




*Northwest Gas Association, 2016. [2016 Gas Outlook: Natural Gas Supply, Demand, Capacity, and Prices in the Pacific Northwest, Projections through October 2026](#).*

The Jackson Prairie Gas Storage Facility in Lewis County is the 14th largest natural gas storage reservoir in the nation. The facility can store 44 billion cubic feet of natural gas and be accessed by a network of 45 wells.

A $275 million LNG facility at the Port of Tacoma currently being developed by Puget Sound Energy will be capable of producing up to 293,881 metric tons of LNG annually. It will also be capable of storing as much as 12,882 metric tons onsite. Planned to begin operations in 2018, a primary purpose of the port-based facility is to provide cleaner natural gas fuel to otherwise diesel-dependent marine vessels. TOTE, a shipping company that operates large vessels between Puget Sound and Alaska, is expected to be a major customer. The facility will also be able to supply LNG fuel to many other third-party customers in the region.

Distribution can be extended by compressing natural gas and delivering it in tube trailer trucks to customers outside existing service areas. This is the concept being used by XNG in Satsop to deliver compressed natural gas to industrial customers on the Olympic Peninsula, with Port Townsend Paper Company serving as their anchor customer. Because they are served by a pipeline connection, XNG could provide RNG through this same service.

## Utilities

Four investor-owned natural gas utilities, regulated by the Utilities and Transportation Commission, operate in Washington. Table 8 shows the number of customers and area served by each of these utilities. Two public utilities also provide natural gas to customers in Enumclaw and Ellensburg.

The map in Figure 12 also shows the service areas for each of the major gas utilities in Washington. Service areas are closely associated with the interstate natural gas pipeline network. As a result, vast areas of Washington, including many whole counties, have no natural gas service.

**Table 8. Private Regulated Natural Gas Utilities in Washington**

| Utility | Gas Customers | Territory |
|---|---|---|
| Puget Sound Energy, Bellevue, WA | 790,000 | Central Puget Sound region |
| Avista, Spokane, WA | 300,000 | Eastern Washington and northern Idaho |
| Cascade Natural Gas, Kennewick, WA | 282,000 | Scattered among NW, central, and southern Washington counties |
| Northwest Natural Gas, Portland, OR | 730,000 | Western Oregon and southwest Washington |

# 7. Bringing RNG to Market

Each of the pathways used to produce and market RNG come with their own opportunities and challenges. Here is some of what has been learned by observing RNG development in Washington and how policy-driven support could spur increased production and use of RNG.

## RNG Projects in Washington

Biogas yields from landfills vary widely due to the volume and composition of materials accepted, closure dates, rainfall and/or groundwater conditions, and biogas capture infrastructure performance. At least five existing landfills have found it viable to produce electricity with their landfill gas resources. These included the City of Tacoma, Hidden Valley, and LRI landfills in Pierce County; the Cedar Hills Landfill operated by King County; and the Roosevelt Regional Landfill in Klickitat County. Together they can generate more than 30 MW of power on a regular basis. Electricity production is being considered at other Washington landfills, most notably the Greater Wenatchee Regional Landfill in Douglas County, operated by Waste Management, Inc. Most other landfills flare the biogas they collect.

King County's Cedar Hills Landfill was the first Washington landfill to develop an RNG project in 2009. King County contracted with Bio Energy Washington (BEW) to clean and market the landfill gas. BEW in turn contracted with Puget Sound Energy (PSE) to accept the gas into its distribution pipeline for electricity production. In recent years, with the emergence of the federal Renewable Fuel Standard (RFS) and the California Low Carbon Fuel Standard, the project evolved to focus on transportation. Recently, IGI Resources joined the project group. IGI is owned by British Petroleum, which has a partnership agreement with Clean Energy. Clean Energy markets RNG in California under the *Redeem* brand. This makes the RNG produced in King County and then sold and transported by pipeline into California eligible for compliance credits under the California Low Carbon Fuel Standard (LCFS) in addition to the federal RFS program.

Klickitat County is home to the Roosevelt Landfill, the state's largest refuse landfill. Klickitat PUD has already developed 26 MW of power generation at the facility. Following legislative action in 2015 requested by the Klickitat PUD, public utility districts may now produce and distribute RNG resources. As a result, Klickitat PUD has invested $35 million to developing a large RNG project. The Klickitat PUD has signed a long-term off-take agreement with IGI Resources. IGI Resources will market the RNG and resulting credits. With a connection to an interstate natural gas pipeline, the project will be positioned to take advantage of the high values offered by the federal RFS program and the California LCFS program.

The LRI Landfill in Pierce County is owned by Waste Connections, which has a long-term agreement with Biofuels Energy LLC to develop its gas resources. The first phase of the project produces clean RNG used to produce electricity for the grid. Subsequent phases of project development have been stalled. The landfill is more than 10 miles from the interstate gas pipeline that would make it feasible to transfer RNG to the most lucrative markets. The pipeline required to make the interconnection would cost more than $10 million. Transferring the gas to the pipeline via tanker trucks would be as expensive considering fuel, labor, and fleet maintenance costs.

Finally, the City of Richland's Horn Rapids Landfill in Benton County began looking at options for producing RNG in 2017. Hoping to take advantage of the federal and out-of-state credits for RNG, the city has hired a consultant-developer to further investigate the feasibility of a landfill gas-to-fuel project.

At WWTPs, anaerobic digestion has been a part of most large operations since its first application in the 19th century. Today, about one-quarter of Washington WWTPs use anaerobic digesters to treat wastewater and produce biogas. Plant operators flare the resulting biogas or use it on-site for digester operation, facility heating, or to dry biosolids.

Wastewater treatment is highly energy-intensive so much of the heat and power by burning the biogas would be consumed by the facility itself, especially during winter months. Larger facilities may have enough biogas to consider upgrading to RNG. Biogas yields from wastewater are generally low due to dilution, but can be enhanced significantly through the targeted addition of other organic waste streams, especially pre- and post-consumer food waste.

Three WWTPs currently use biogas to produce electricity. One facility—King County's South Treatment Plant in Renton—has been cleaning the biogas to pipeline-quality RNG for over 30 years. Under a new agreement with PSE and IGI Resources, the RNG is prioritized to be sold to natural gas vehicle fueling locations contracted to purchase IGI's gas within King County. Surplus RNG produced beyond King County's vehicle fleet demand is marketed to other locations in Washington State. The County and IGI share different parts of the revenue generated by the gas and the RFS and LCFS credits.

Based on industry rules of thumb for economic viability, an additional six WWTP facilities could realistically consider investments in RNG, while eight more could consider projects if gas cleanup technology became viable at smaller scale. Many others could produce power and heat.

One new RNG project is being developed at Tacoma's Central WWTP. Located in the port area, the plant already uses biogas to provide heat for the digester and facility buildings. Working with PSE and IGI Resources, county officials expect to produce RNG that can be transported through local distribution pipelines to the city's fleet of solid waste and recycling trucks. While sacrificing LCFS credits, this approach would still generate RFS credits, reduce fuel costs, and keep the RNG in local use.

The VanderHaak Dairy in Lynden built the first dairy digester in Washington in 2004. Photo: WSU Energy Program.

Everett is evaluating the addition of anaerobic digestion at their treatment facilities, in which case their biogas production might justify exploration of RNG.

On farms, anaerobic digesters are viewed much like other farm equipment. The dairy producer asks, "How does this improve my dairy business? How does it result in more milk, or make the cows more comfortable, or lower the costs of doing business?" Digesters can improve manure management by reducing pathogens and limiting odors. They can also use manure to produce revenue-generating electricity or fuel. The key challenge has been how to ensure the overall cost-effectiveness of digesters.

Biogas capture for power generation has been a successful model for eight dairy-based anaerobic digesters in western Washington. These projects have proven viable due to state and federal grant programs, PSE's willingness to provide supportive power purchase agreements, an initial array of value-added co-products (fiber and nutrients), tipping fees for accepting food processing waste, and beneficial tax incentives (deferred property tax and sales tax exemption).

The existing eight dairy biogas projects were developed to produce electricity. One of these projects can no longer afford to produce electricity given the low price offered by the local utility. They have joined forces with Promus Energy to develop the first dairy-based RNG project in the Yakima Valley. They plan to connect into the Williams interstate natural gas pipeline, making it possible to take advantage of the low-carbon transportation markets for RNG in California and top-tier federal renewable fuel credits resulting from manure-only, ultra-low carbon intensity rating.

Using source-separated organic materials works for both large and small anaerobic digestion projects. Impact Bioenergy, an award-winning Washington start-up, is developing small-scale anaerobic digestion systems that can serve small communities, campuses, hospitals, schools, and similar local needs. They are building projects on Vashon Island and at the Microsoft campus in Redmond.

While successfully developed in California, Oregon, and British Columbia, large-scale anaerobic digestion plants dedicated to processing source-separated organic materials have not yet succeeded in Washington. Composting operations work hard to effectively handle the current influx of organics under source-separated organics collection programs. Some of the largest food waste composters in the state have expressed interested in anaerobic digestion as a means of densifying waste streams, controlling odors and vermin, producing onsite heat and power, and upgrading biogas to RNG. To date, their efforts have met with resistance from neighboring communities perhaps unaware of the multiple benefits provided through digesters. Examples of municipal-scale source-separated organics digestion projects that have stalled in the Pacific Northwest include:

- Cedar Grove, Everett, WA
- PacifiClean, Cle Elum, WA
- Columbia Biogas, Portland, OR

Developers of these projects point to multiple factors that contributed to the failure of efforts to incorporate anaerobic digestion at these sites. These include cumbersome and time-consuming regulations, financial uncertainties caused by lack of long-term off-take agreements for end products, uncertainty about markets for environmental attributes, and community opposition.

Interest in large-scale municipal digester development persists. The King County Solid Waste Division recently completed an engineering analysis of the potential for capturing biogas from source-separated organics. The study looked at various digestion scenarios, including smaller-scale distributed digesters, co-digestion at the Renton WWTP, and dedicated digesters located in the county. They also explored different types of public-private partnerships that could facilitate development. They found that each scenario was technically feasible. Net costs ranged from $180 to $300 per ton of material processed.

Anaerobic treatment of industrial food organics, especially for food and beverage processing wastes with high energy potential, offers considerable biogas potential. Digesters limited to pre-consumer organic wastes also benefit from the absence of contaminants that increase the cost of biogas conditioning equipment at municipal WWTPs and landfills. Two successful projects in Washington— Agri Beef in Toppenish and JR Simplot in Moses Lake — provide valuable offsets for internal energy demand. They show the way for success in this sector.

## Costs of RNG Development

At a meeting of EPA's Landfill Methane Outreach Program in March 2017, Evan Williams, Chair of the Coalition for Renewable Natural Gas, described the cost per MMBTU of taking two million cubic feet per day of landfill gas that was already being collected and processing it to RNG:

- Plant capital amortization = $1.80
- Operation and maintenance for processing plant = $2.20

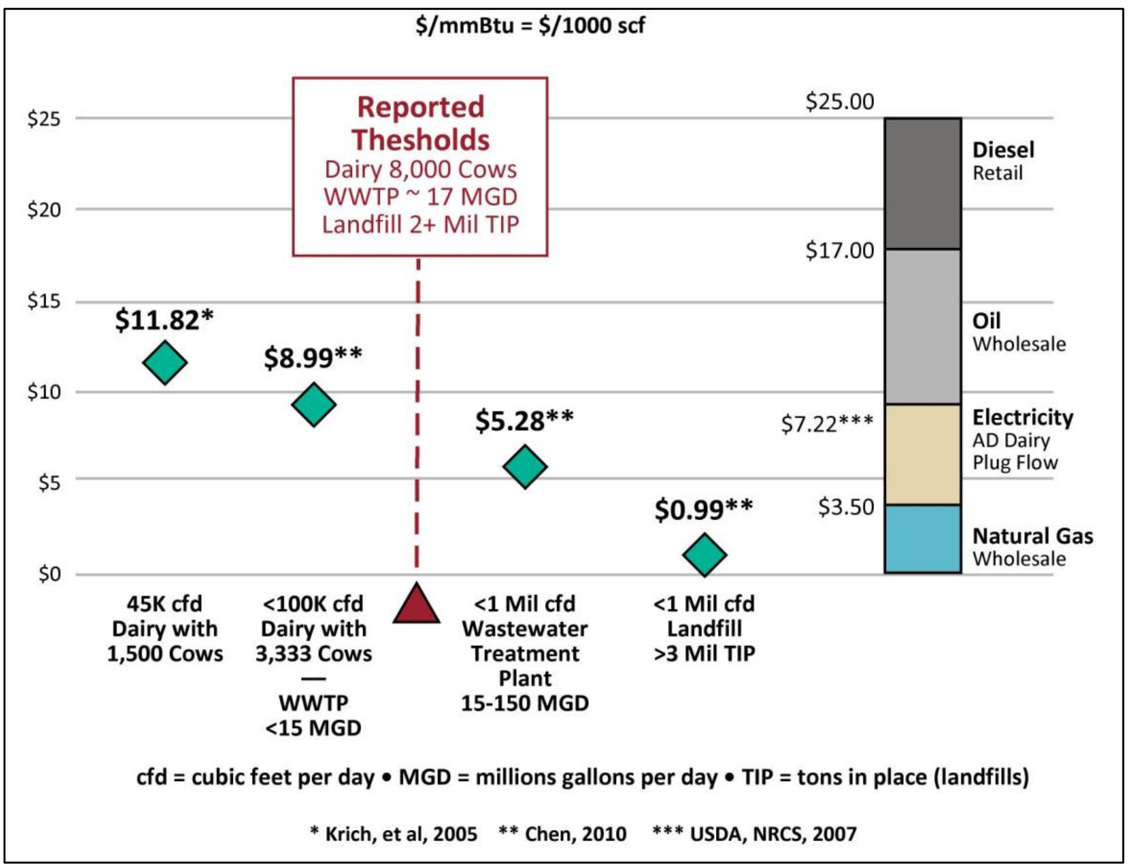
- Collection system expansion per year = $0.38
- Collection system operation & maintenance per year = $0.61
- Initial collection system and flare capital amortization = $0.49
- Royalty to landfill owner = $0.78

The estimated cost to produce RNG from this landfill example would equal $6.18 per MMBTU. This is higher than the wholesale cost of fossil natural gas but often lower than the price charged to retail customers. As transportation fuel, this would be less than $1 per diesel gallon equivalent.

In a previous assessment of biomethane potential for Washington, the cost of producing RNG for transportation from dairy digesters was described as follows: "The economics of biomethane can be summarized as somewhere in the middle, between natural gas and diesel fuel. In other words, producers contend that bio-CNG can be produced for around $2.00 per diesel gallon equivalent (DGE)."[31]

The report used the following illustration (Figure 13) to show the relative position of various RNG production pathways on an MMBTU-equivalent cost basis. The figure shows the significant cost reductions possible by economies of scale at larger projects. The reported threshold sizes (from RNG literature) assigned a level at which the project could produce RNG at a price comparable with electricity production. Only the largest projects would compete with current wholesale prices of fossil natural gas.

**Figure 13. Comparison of RNG Production Costs**




*Western Washington Clean Cities, 2013. Biomethane for Transportation.*

[31] Western Washington Clean Cities, 2013. Biomethane for Transportation.

The Port of Seattle has developed experience with RNG procurement and costs. According to their Energy Portfolio Study that looked ahead 25 years, 75% of their increased energy demand from airport expansion and other factors must be met by renewable energy sources.[32] The Port believes RNG to be "an essential component to our strategy, both in terms of energy load and GHG reductions, but it is a high-risk strategy." Their in-house search for RNG to meet up to 30% of Port energy use has been impacted by higher value markets for RNG in California and the lack of regional sources of RNG. They are currently projecting delivered costs of between $10 to $15 per MMBTU for large volumes of regionally sourced RNG that might otherwise go to the California vehicle market.

In summary, the argument for RNG cannot be based solely on economics. RNG is a locally produced, renewable fuel that has added value to the environment and host communities. Unlike many other renewable energy supplies, RNG is easily stored and can be ready on demand. Capturing these values to support RNG production is a role for policy.

## Challenges and Obstacles

Many physical, geographic, and market forces influence the success of RNG development in Washington. A primary market reality is that fossil fuel energy in Washington and around the U.S. is relatively low cost when compared to other countries or renewable energy technologies. Low-cost fossil fuels remain a major obstacle in justifying investments in RNG.

The limited pipeline infrastructure in Washington is another barrier. Entire counties and regions of the state are not served by natural gas. On the other hand, potential sources of biogas/RNG are scattered throughout the state. This means they must produce electricity, fuel local vehicles, or truck RNG to a pipeline interconnection.

For many project developers policy uncertainty and unpredictability are significant obstacles:

- Tax law changes recently adopted by Congress could upset many of the economic factors for renewable energy, waste management, or business in general.
- Changes to EPA regulations for landfills, WWTPs, or vehicles, or to EPA programs such as the federal Renewable Fuel Standard, which require annual determinations of market size, could put a significant damper on progress toward developing RNG resources.
- U.S. Department of Energy programs that provide financial and technical assistance are uncertain and underfunded compared to the need and interest.
- U.S. Department of Agriculture programs that provide financial and technical assistance for farm producers in rural America are similarly uncertain and underfunded compared to the need and interest.

NIMBY ("Not in my backyard") objections are discussed frequently as obstacles to project development, especially for those that manage organic waste resources, which some opponents simply call garbage. According to David Biderman, Executive Director and CEO of the Solid Waste Association of North America, a new form of opposition has risen to trouble project developers. The term BANANAS is used to describe people who want to "build absolutely nothing anywhere near anybody." Because these can be large, complex projects that handle "waste" materials, substantial fear, uncertainty, and doubt can be generated to slow down or stop RNG progress.

Another major obstacle affecting RNG projects is the lack of any effective national or regional standards for the quality of RNG required for pipeline injection. Utilities want to assure safety and reliability to

[32] Port of Seattle, 2016. Developing the Port of Seattle's Energy Portfolio: Final Recommendations.

protect their customers and pipeline system, while developers seek to avoid onerous capital and operating costs. The standards required for high-volume interstate gas pipelines may be different from standards required for injection into local gas distribution lines.

Other obstacles described by potential project developers include:

- Cost, in dollars and time, of permitting and environmental review processes
- Matching off-take agreements for sales of energy and co-products to the financing schedules of the facility
- Federal tax incentives (e.g., investment tax credit, production tax credit) and many state and local incentives often target renewable power, and may not include RNG used as fuel.
- While the highest return is available for RNG used in transportation, the CNG vehicle market is still fairly small and may soon be saturated with RNG use.

Finally, there may be geospatial constraints, primarily when the source of RNG does not match up with the most valuable end use. Given the limited natural gas pipeline infrastructure in Washington, the ability of RNG producers to access pipelines is limited.

## Keys to Success

The keys to success for RNG developers include:

1. Effective public policy advocacy and education about the environmental and economic benefits of RNG.
2. Public policies that create, support, or expand existing and future RNG markets.
3. Access to stable RNG markets that can predictably support project development.
4. Achieve the highest and best end use for your biogas or RNG.
5. Location, location, location: choose projects with ready access to feedstocks and markets.
6. Spend the extra capital for a pipeline connection if possible, preferably an interstate pipeline that can move the RNG to the most lucrative markets.
7. Monetize environmental benefits, including carbon and fuel standard credits, for all end uses of RNG.
8. Add value through commercialization of co-products.
9. Coordinate with local natural gas distribution companies.
10. Secure strong, flexible sources of private finance.
11. Maximize state and local support for the project.
12. Have a good story to tell; this can help make other projects facing these requirements easier to develop and sustain.

# 8. Policy Action to Support RNG

Marketplaces are shaped by many influences, including market conditions, investor interest, and government policies. RNG is a locally produced renewable fuel. It generates economic activity and jobs, improves human and environmental health, and enhances community resiliency. These benefits are not directly monetized as products of an RNG project. To fully realize the benefits available from development of Washington's RNG resources, public support through government policy is necessary.

The following section looks a wide array of policy options organized by how they might affect the opportunities for RNG:

- Increase demand for RNG
- Encourage RNG production and supply
- Enhance market access
- Strengthen value of RNG products
- Provide technical assistance
- Support research and innovation

Some general policy objectives are recommended to assure the full impact of RNG development around the state. These include:

- Provide support for both supply and demand
- Recognize incentives for RNG use in transportation (RINs, LCFS) and electricity generation (RECs) should extend to RNG used directly by homes and businesses
- Support off-grid and on-grid use
- Prioritize RNG development that also reduces fugitive methane emissions, i.e., methane production with animal manures and organic materials such as food waste
- Provide incentives for both fuels and vehicles when targeting RNG for transportation uses
- Provide incentives to offset the high cost of interconnecting RNG projects to pipelines
- Support CNG/LNG fueling stations along major freight corridors

## Increase Demand for RNG

Governmental and private sector policies intended to increase demand for renewable energy usually take the form of purchasing preferences, content requirements, and/or emissions limits or taxation structures designed to reduce environmental impacts.

### Renewable Fuel Standard

At the federal level, the Renewable Fuel Standard (RFS) was established to spur development of domestic fuel industries, including ethanol, biodiesel, biomethane, and advanced forms of cellulosic fuels. The RFS was established by Congress through the Energy Policy Act of 2005. It was later updated in the Energy Independence and Security Act of 2007. Referred to now as RFS2, the 2007 update sets annual targets, known as Renewable Volume Obligations (RVO), for four types of alternative fuels. The RVO targets are reviewed each year for each fuel type. Changing RVO levels can greatly impact supply and production and are hotly debated by advocates each year.

The nation's refiners and fuel marketers are responsible for making sure the appropriate percentage targets for alternative fuels are met. This is accomplished through a credit marketplace consisting of Renewable Identification Numbers (RINs) — individual numbers for every gallon or gallon-equivalent of alternative fuel sold. RINs have different values based on supply and demand for each alternative fuel.

The way EPA determines how renewable fuels are categorized is through the assignment of "pathways" based on lifecycle assessments (LCA) of the feedstocks and processes used to produce the fuels. RNG is commonly identified as an "advanced biofuel," with a D5 designation. However, if the RNG is produced with a high percentage of cellulosic material (e.g., landfill waste, dairy manure), the fuel is identified as a cellulosic fuel with a D3 designation. Currently, the D3 category of RINs is trading at more than three times the value of the D5 category.

As a federal program, the impact of changes to the RFS can affect markets across the country. Some of the current issues surrounding the RFS2 program include:

- Continue or extend the RFS program past the original targets established through 2022.
- Establish progressively greater RVOs for RNG categories.
- Support development of LCAs for additional production pathways.
- Support for "eRINs" for RNG projects that produce electricity for transportation.

### Alternative Fuel and Vehicle Purchase Requirements and Incentives

In 2007, the state legislature directed the Washington Department of Commerce to develop rules for procurement of electric vehicles and biofuels by agencies and local governments, "to the extent practicable."[33] Commerce adopted such rules for agencies in 2013[34], and local governments in 2016[35]. Agency rules went into effect in 2015, and local government rules will become effective July 1, 2018.

Most progress toward meeting these rules has been accomplished through purchase of electric vehicles and biodiesel. While agencies currently use little if any natural gas as a transportation fuel, many local governments have natural gas vehicles in service, especially for transit and public works fleets. The local government procurement rules require purchase of RNG when available at or below that price of fossil natural gas. Additional policy support for RNG production would assist local government efforts to meet these requirements, especially since they may be able to produce their own fuel at municipal WWTPs, landfills and digesters supplied with local organic waste streams.

Greater use of natural gas or RNG is also supported by the state's Alternative Fuel Commercial Vehicle Tax Credit.[36] Businesses may earn credits against public utility or business and occupation tax liabilities by purchasing commercial vehicles that use primarily natural gas/RNG, propane, hydrogen, dimethyl ether or electricity. Credit amounts may be up to 50% of the incremental vehicle cost depending on the gross vehicle weight rating. This credit can also support EPA-certified, after-market conversion of vehicles to use these alternative fuels. The conversion credit can fund up to 30% of the cost up to $25,000, depending on the size of the vehicle. Credits may be earned until January 1, 2021.

### Carbon Pricing

Economy-wide carbon pricing policies (e.g., carbon tax, cap-and-trade) monetize the impacts of GHG pollution by applying those costs to emission sources as a price per metric tonne of $CO_2$ equivalent gases. This pricing mechanism provides a cost signal to market decisions that can also be roughly translated on a per gallon or MMBTU basis. The price signal moves the market toward cleaner, lower-carbon energy sources based on their relative GHG reduction potential. RNG in all forms and uses would be a major beneficiary under such a policy, especially when used to displace gasoline or diesel fuel.

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[33] RCW 43.325.080
[34] WAC 194-28
[35] WAC 194-29
[36] RCW 82.16.0496

The state has analyzed various carbon pricing models in recent years, including Commerce's 2012 State Energy Strategy[37] and a 2014 report from the Carbon Emissions Reduction Task Force established through a gubernatorial executive order.[38] Governor Inslee subsequently directed Ecology to prepare a Clean Air Rule restricting the total volume of GHG emissions allowed in the state and imposing the cost of permitted emissions across all fuels and providers. While still subject to ongoing litigation, implementation of the Clean Air Rule or similar carbon pricing mechanisms would greatly incentivize use of low-carbon energy. Many of the RNG projects described in this report, whether for power generation or use as transportation fuel, would offer valuable offset opportunities given their low carbon intensity.

Adopting economy-wide carbon pricing policies would also align Washington with its Pacific Coast Collaborative partners. California has had an active cap-and-trade system for nearly a decade, British Columbia has a carbon tax, and the Oregon legislature is considering legislation that would cap carbon emissions, apply a carbon tax, and invest the proceeds in programs to lower carbon emissions. Similar revenues raised in Washington could offer significant investment opportunities for RNG production and distribution infrastructure.

### State Clean Fuel Standards

As the name suggests, low-carbon or clean fuel standards target changes in the supply of transportation fuels due to the economic and environmental costs associated with the use of imported petroleum. The low-carbon/clean fuel standards established in California and Oregon have similar elements:

- They establish targets for lowering the carbon intensity (CI) of all fuels, including transportation and heating fuels
- They include gaseous and electric transportation fuels
- Each provides some mechanism for trading offsets or credits, allowing projects not directly connected to energy grids to receive credit for RNG

Assessments of such policies show moderate economic impacts. According to the Northwest Gas Association, an Oregon study of the impacts on gross state product (GSP) from eight low-carbon fuel scenarios found that overall GSP changes were positive, indicating that the policy helped drive economic growth.[39] Establishing a Washington clean fuel standard would further align the state with Pacific Coast Collaborative priorities and help harmonize West Coast fuel markets subject to carbon policies.

Rather than conflicting, carbon pricing and clean fuels standards can work together to reduce emissions from the transportation sector. These programs are often promoted as multi-faceted approaches, e.g., reducing carbon intensity of fuels, increasing vehicle efficiency, and decreasing vehicle miles traveled. Clean fuel standards create specific demands that help spur long-term investments in RNG facilities. This complements the carbon pricing signal placed on carbon emissions by supporting alternatives fuels needed to reduce GHG emissions.

### Renewable Portfolio Standard (I-937) for Electricity

Renewable portfolio standards (RPS) are another mechanism for supporting renewable energy demand. Washington, D.C., 29 states, and three territories have adopted RPS requirements for their electricity sectors. An additional eight states and one territory have set renewable energy goals.

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[37] Washington State Department of Commerce, 2012. 2012 Washington State Energy Strategy.
[38] Carbon Emissions Reduction Taskforce, 2014. Carbon Emissions Reduction Taskforce Report to the Washington State Governor's Office.
[39] Northwest Gas Association, 2013. Natural Gas Vehicles: Seizing the Opportunity.

In Washington, the RPS for electricity was established by passage of the Energy Independence Act (I-937) through voter initiative in 2006.[40] The Act requires the state's largest utilities to acquire both cost-effective energy efficiency and new renewable energy resources. The Act specifically recognizes the benefit of small-scale distribution generation systems rated at five megawatts or less, such as most anaerobic digesters, by providing a double credit toward a utility's renewable energy obligations. As a result, the Act increased interest in the development of digesters during the early years of compliance. More recently, most electrical utilities have met or are exceeding their RPS compliance requirements. As a result interest in power generation from digesters has plateaued.

Important features of the Act include:

- Targets for renewable power procurement top out at 15% in 2020.
- Eligible resources include wind, solar, and geothermal energy; biogas from landfills, sewage treatment, and animal manure; wave, ocean, or tidal power; biodiesel; and some forms of hydro and biomass energy.
- Environmental attributes for methane reduction versus $CO_2$ reduction are treated separately.

### RNG Portfolio Standard for Natural Gas

Similar to an electricity RPS, a portfolio standard or content requirement for RNG in the natural gas supply system would require regulated gas utilities to provide certain percentages of RNG to their customers. One advantage of a portfolio standard for natural gas would be that benefits are shared across the entire spectrum of natural gas uses—heat, electricity, and transportation—and at different scales of deployment. Similarly, any added costs are spread evenly across the rate base of the gas utility, unless other measures are taken to lower the cost or impact on certain consumer groups or businesses. Current policies at the federal and state level currently drive RNG toward power generation through Renewable Energy Credits and increasingly toward use in transportation through the generation of RINs. There is no policy instrument that directs the displacement of fossil natural gas with RNG for the industrial, residential, and commercial sectors. The advent of such a policy would create economic incentive to use RNG for all end uses.

Legislative proposals being considered in California would set a low initial target (1% to 2%) that increases over time to 5 or 10% by 2030. Allowing utilities to earn or buy credits for projects that are not grid-connected would provide significant support for RNG development at different scales and in areas not served by natural gas pipelines.

Portfolio standards or fuel content requirements can be effective at increasing demand and establishing a new market for alternative fuels. In the case of biodiesel, California, Oregon, and British Columbia all have requirements that biodiesel comprise 5% of the diesel fuel sold in their markets. Washington has a similar policy, but only in the form of a statewide goal that is largely ignored by fuel distributors. As a result, biodiesel is now well integrated into the fuel economies along the West Coast, except in Washington. While there was initially great excitement and private investment in Washington's biodiesel industry, the lack of an enforceable fuel content requirement left the industry weakened, leading to several facility closures.

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[40] Text of Initiative I-937.

## Encourage RNG Production and Supply

These policies are designed for a specific purpose to encourage RNG production and supply.

### Federal Regulations/PURPA

Congress enacted the Public Utilities Regulatory Policies Act (PURPA) in 1978 to assure independent power producers have access to utility-controlled electricity grids. PURPA requires utilities to purchase qualified energy and capacity, including renewable energy and cogeneration, at their incremental or avoided cost.

A recent review of PURPA found that many independent power producers have not fully benefited from PURPA due to the complexities of avoided cost ratemaking. Under PURPA, states have broad discretion to set avoided cost rates so there is potential for encouraging power production from biogas and RNG through modifications to PURPA:

- Improve the definition of cogeneration technologies to clarify which systems qualify
- Identify which avoided cost methodologies are most favorable to small power producers
- Consider the full range of avoided cost options, including line losses, externalities and environmental costs associated with renewable energy production
- Offer the option of 5-, 10-, and 15-year levelized rate contracts

A full report on the various methodologies, models, and policy choices regarding PURPA can be found in the report, *Reviving PURPA's Purpose*.[41]

### State Industry and Facility Regulations

Several state agencies have regulatory authority over industries and facilities that could be participants in the RNG marketplace. These include the Washington Utilities and Transportation Commission (UTC), and the departments of Ecology, Agriculture, Revenue, and Enterprise Services.

Their roles include setting industry standards, establishing rules for businesses, regulating emissions, controlling materials flows, creating product standards, monitoring compliance, and more. RNG sources such as landfills, WWTPs, dairies, and waste management facilities must comply with a variety of regulations. For example, dairies must manage manure according to a nutrient management plan. If they have a digester they are restricted to accepting a maximum 30% pre-consumer food or beverage waste for co-digestion. WWTPs must meet quality standards for their biosolids products that could be affected by their digester operations. The UTC is reviewing quality standards for RNG looking to access natural gas pipelines.

A coordinated review of the impacts of these regulations on RNG development would be valuable.

### MSW Material Regulations

Because state and local jurisdictions control the flow of source-separated organic residuals, they must:

- Tighten source-separation regulations to discourage contamination.
- Consider organic material bans or processing requirements, especially for larger commercial and industrial facilities, similar to those established in several eastern states.
- Support RNG production in waste disposal and recycling contract specifications.
- Set goals and rules for material handling at WWTPs.
- Revise rules regarding permitting of essential public facilities to encourage RNG.

[41] Carolyn Elefant, 2011. Reviving PURPA's Purpose: The Limits of Existing State Avoided Cost Ratemaking Methodologies In Supporting Alternative Energy Development and A Proposed Path for Reform.

- Offer regulatory exemptions for on-site or campus-style digester projects.
- Offer grants or other forms of financial support and risk mitigation for projects that offer cost-savings to public entities.

### State Tax Incentives for RNG Development

Various tax exemptions for equipment and facilities have been a popular method of providing support for renewable energy projects in Washington. Two valuable incentives targeted digesters—a sales and use tax exemption and a six-year property tax exemption—have expired. These should be extended to encourage RNG development.

At the same time, limitations under the previous sales tax incentive should be expanded to include not just the digester vessel itself, but the equipment needed to bring RNG and value-added coproducts to market (e.g., biogas conditioning, nutrient recovery, power generation). Similarly, restrictions in various incentive programs that target only animal manure digesters need to be eliminated. RNG development will be significantly enhanced by expanding incentives to include digesters that process the full array of organic waste feedstocks.

### Grants and Funding Opportunities for RNG Development

The state Clean Energy Fund managed by Commerce is a key funding source for development of clean energy technology, including RNG-related projects. The program supports capital projects that benefit the public through development, demonstration, and deployment of clean energy technologies that save energy and reduce energy costs, reduce harmful air emissions or otherwise increase energy independence for the state.

The program has provided support for at least two projects that support advancement of RNG:

- Installation of nutrient recovery equipment at Edaleen Dairy's digester in Whatcom County to enhance the long-term viability of their manure management program
- Installation of a community food waste digester system for Vashon Island

The Community Economic Revitalization Board is another potential source of state support, especially for RNG projects located at WWTPs, landfills and food processing facilities. CERB could provide more effective support if their loan limit was expanded from $5 million to $50 million.

Given restrictions on use of these two existing funds, the most valuable source of additional financial support for RNG development would be competitively awarded matching grants for feasibility studies and financial support for pipeline infrastructure supporting RNG development. In addition, incorporate the value of RNG environmental credits when considering funding requests.

## Enhance Market Access

These policies focus on the goal of enabling RNG producers to access the electrical grid and natural gas distribution systems, primarily pipelines.

### Interconnection Standards

Quality standards must be met before renewable energy projects can be connected into the electrical grid system or natural gas supply system. In the case of electricity generation, the technical requirements for interconnection are defined by WAC 480-108. According to some project developers, the existing standard has created electrical safety redundancy, higher insurance requirements, and a lack of uniform utility procedures and agreements, all of which can hinder new project development. Proposed rule changes are addressing many of the problems associated with interconnection standards; however, there are still topics needing to be addressed that inhibit digester development.

In 2016, the UTC began a review process for establishing a pipeline injection standard for RNG following a tariff request from Puget Sound Energy. This process was suspended after the commission found certain agencies, specifically air quality authorities, had not been adequately involved. The RNG quality standard proposed at the time followed a single standard promulgated in California that many developers consider too costly and restrictive to support the full range of potential RNG projects. Published reports suggest that costs in some states for integrating RNG into gas pipelines are under $300,000, while total costs for integration under the California rule are estimated to be between $1.5 million and $4 million. Additional annual costs can reach $400,000.[42] RNG developers in Washington have said adoption of a multi-stakeholder, UTC-supported injection standard is likely the most important step required for greater RNG development.

One step would be to engage the UTC; departments of Commerce, Ecology, and Health; air quality authorities; natural gas utilities; and other industry stakeholders in a facilitated process to establish a voluntary Renewable Natural Gas Quality Standard for the state. The desired standard would need to ensure health, safety, and pipeline integrity while providing reasonable and predictable access to transmission and distribution pipelines. Establishment of such a standard would help producers market RNG and generate greater consumer awareness.

### Purchase Agreement Standards

Power Purchase Agreements are powerful tools for developing new renewable energy resources. These contracts between power producers and purchasers, typically a utility, establish agreed upon pricing, locations, and time periods. Each utility in Washington has unique contract terms and processes, which can create a wide range of uncertainty and disparity from the producer's perspective.

Standardizing basic elements of purchase agreements would strengthen access to markets for RNG power or fuel. For example, digesters could be recognized as part of the regional power supply rather than specific to the utility in whose territory the project is located. Extending the initial purchase term to ten or twenty years would provide stability for digester project financing. Contracts could also recognize the full value of a digester project by including the value of power factor support, voltage support, high-efficiency load center energy generation, the virtual ability to store energy during times of surplus generation, deferred maintenance for the grid system, and so on.

Gas purchase agreements between RNG producers and utilities would have similar needs. Standard features could address contract length, contract price, and the size of qualifying projects.

### Expand Net Metering

Net metering is an electricity policy that allows an on-site generation system to run their electric meter backwards during periods when production exceeds load. This policy values excess electricity production at retail rates and removes the need for on-site electricity storage. Although net metering can be applied to any type of electricity generation, including fossil fuels, most states, such as Washington, limit the policy to renewable sources. Some adjustments to current net metering programs would support new RNG development:

- Expand net metering to include natural gas utility customers that use natural gas while also producing RNG.

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[42] Renewable Natural Gas Coalition, 2017. And Johnston, Marsha, 2014. "Breaking Down Renewable Natural Gas Injection Barriers," *BioCycle*, Vol. 55, No. 8.

- Increase the overall electrical system size limit from 100 kW to no more than 100% of the total electric load at a given location (this would directly encourage the design of systems tied to on-site needs, and help to attain the benefits of efficient delivery).
- Allow net-metered systems to roll over excess credits for more than one year.

### Infrastructure: Pipeline and Fueling Station Construction

Infrastructure improvements are an essential component of renewable energy development. RNG projects often have special infrastructure needs, especially when a community is involved in the project. If public resources (e.g., bonding, grants) are used for pipeline or fueling infrastructure that serves public purposes, more RNG projects could be developed and connected to the natural gas grid.

In a similar way, expansion of Washington's Green Highway Program to include natural gas fueling stations could be driven by public-private partnerships, much as electric vehicle charging infrastructure now serves a broader purpose. Coordination between the Green Highways Program, other infrastructure planning work and the UTC would help ensure that refueling infrastructure developed both by natural gas utilities and other developers will meet the most important state needs, as outlined in the plans.

## Strengthen the Value of RNG Products

Feed-in tariffs provide price support for new renewable energy development. They require regulated utilities to purchase a qualified renewable energy product at set prices. Feed-in tariffs are specifically designed to lift up a particular form of renewable energy. Though they have been used primarily for electricity, the concept could also apply to prices paid for RNG injected into the pipeline system.

Feed-in tariffs have been established in more than 60 jurisdictions around the world. They are credited with being the main force behind the success of renewable energy markets in Europe.[43] States around the country have used feed-in tariffs to support digester development, often for an important agriculture sector. Vermont established the Sustainably Priced Energy Enterprise Development (SPEED) program with a special feed-in tariff for electricity produced by dairy farm-based digesters. In North Carolina, the legislature created a feed-in tariff to support digester construction on swine farms.

In addition, diversifying the revenues from RNG digester projects can greatly increase the economic viability, and private financing, of such projects. For example, preferential state agency purchase of recovered nutrients and fiber from dairy digester projects would help to increase contracted (i.e., "bankable") revenue from these low carbon, renewable co-products.

## Provide Technical Assistance

Because of its versatility, the development of biogas and RNG resources offers positive benefits to all areas of the state. To maximize these benefits, extension-like technical assistance could be provided for RNG development, especially in small communities and for rural sources of digestible materials. Without adequate staff or expertise these opportunities can be lost.

State and local economic development and environmental management plans can also incorporate local RNG opportunities. Agencies with permitting authority can be encouraged to increase their technical knowledge of RNG and streamline associated permitting processes.

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[43] Klein, Arne, et al., 2010. Evaluation of different feed-in tariff design options - best practice paper for the International feed-in cooperation. 3rd edition. Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

## Support Research and Innovation

Since the 2007-09 biennium, the Washington Legislature has consistently funded important biofuels research, including topics related to biogas and RNG. Specific support for near-term applied research has brought new anaerobic digester technologies and systems to the market, especially for digesters located on dairy farms. Research completed by the WSU Energy Program has supported advancements in digester technologies and systems, pretreatment of feedstocks to improve digestion, and biogas recovery and purification. Additional support was provided to improve output of valuable digester co-products and advance nutrient recovery technologies that make use of the energy and chemistry of the digester system.

Continued support of basic research and technology development is needed to expand RNG markets and encourage investments in Washington. To achieve the highest production and use of RNG in Washington advances in both biomass gasification technologies and power-to-gas systems could play an important role and bear further investigation.