Promoting Renewable Natural Gas in Washington State

A Report to the Washington State Legislature

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905 Plum Street SE, P.O. Box 43165, Olympia, WA 98504-3165
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1. Executive Summary

In 2018, the Washington Legislature passed HB 2580, supporting production of renewable natural gas (RNG) and requesting this study from the Washington State University Energy Program and the Washington Department of Commerce. RNG is produced by separating methane from raw biogas created through decomposition of organic wastes at landfills, wastewater treatment plants (WWTPs), livestock farms and other locations. In their request, legislators described a specific public policy objective – “to stimulate investment in biogas capture and conditioning, compression, nutrient recovery, and use of renewable natural gas for heating, electricity generation, and transportation fuel.”

This report builds on the 2017 study “Harnessing Renewable Natural Gas for Low-Carbon Fuel: A Roadmap for Washington State,” which developed hypothetical estimates of current and future RNG production. This new report responds to the Legislature’s expressed objective by providing a more detailed inventory of the most practical opportunities and associated costs for RNG production through anaerobic digestion. It describes potential uses of RNG by state agencies and offers recommendations for limiting the carbon intensity of RNG. It also explores issues surrounding policy options, specifically a renewable portfolio standard supporting RNG.

Three large biogas projects already produce enough RNG to offset 1.3 percent of current fossil natural gas consumption in Washington. At present, this RNG is being sold into the California market due to the significant value available under that state’s low-carbon fuel standard. Detailed analysis has identified hundreds of additional locations where RNG could be produced in proximity to the natural gas pipeline grid. However, significant investments are needed to condition the biogas to pipeline-quality standards as well as construct new pipelines and inject the RNG into the pipeline grid.

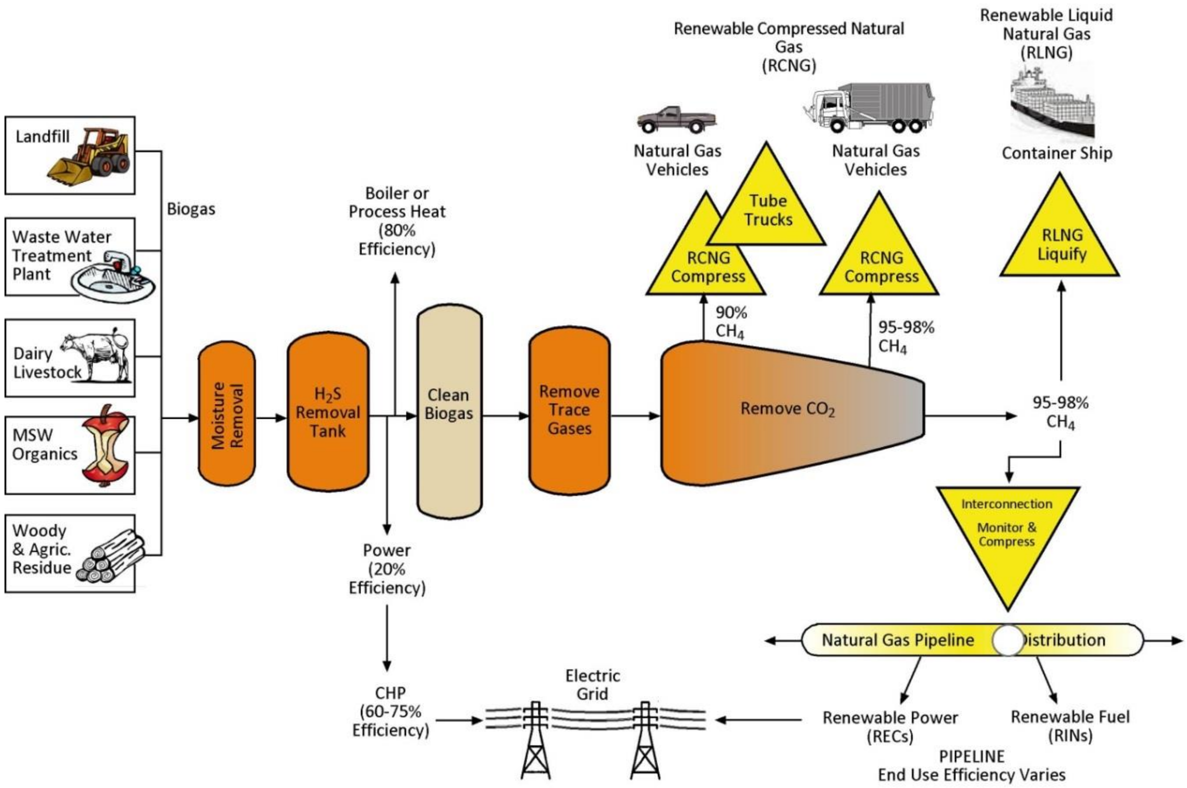
This study finds that even though the direct cost to produce, clean and deliver RNG into a natural gas pipeline often falls in the range of $10 to $20 per MMBtu, the total project value required to attract private investment can be $20 to $30 per MMBtu. Significant economies of scale exist throughout the RNG supply chain, making it valuable to arrange RNG projects in chains or clusters that can share gas conditioning and pipeline infrastructure. Various policies that subsidize RNG development or provide credits for the environmental and economic benefits of RNG can further mitigate high development costs. Public sector preferential purchasing policies and programs can also increase demand for RNG.

The analysis performed demonstrates that adequate opportunities exist for RNG production equivalent to 3 percent to 5 percent of current natural gas consumption in Washington. The timeline for achieving a 3 percent to 5 percent RNG production goal can be accelerated with support from natural gas utilities through a Renewable Portfolio Standard (RPS). Designing an RPS that takes carbon emissions into consideration would accelerate projects that produce RNG from dairy manure and food waste. Lifecycle greenhouse gas emission reductions can be further enhanced by adopting a complementary clean fuel standard (CFS) that prioritizes natural gas for transportation over other uses.

2. Background

RNG, also called biomethane, is produced by removing carbon dioxide, other gases, and various contaminants from biogas that results from the natural, anaerobic decomposition of organic materials in landfills and anaerobic digesters located at wastewater treatment facilities, food processing plants, and farms. Biogas can be used in its raw form (generally 40 percent to 70 percent methane, depending on source) to generate power and heat, or it can be conditioned as RNG to meet quality specifications like those applied to fossil natural gas (at least 97 percent methane). RNG can then be distributed and used for the same array of applications, from power generation and heating to transportation fuel.

Figure 1. Schematic of Typical Production, Upgrading and Distribution Pathways for RNG



This report updates and refines estimates for RNG production in Washington from a wide range of sources, building on information presented in two previous studies:

- "Biomethane for Transportation: Opportunities for Washington State"[1]
- "Harnessing Renewable Natural Gas for Low-Carbon Fuel: A Roadmap for Washington State"[2]

Until recently, biogas use has largely been limited to heating and power generation. Numerous factors are now driving biogas into new markets, especially as transportation fuel. These factors include:

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[1] *Biomethane for Transportation: Opportunities for Washington State*, Western Washington Clean Cities, 2011, revised 2013
[2] *Harnessing Renewable Natural Gas for Low-Carbon Fuel: A Roadmap for Washington State*, WSU Energy Program, 2017

- Increasing value of renewable fuels under federal and state renewable fuel standards
- Maturation of state Renewable Portfolio Standard (RPS) requirements for electrical utilities
- Improvements in biogas conditioning and RNG compression technologies
- High operating and maintenance costs for electrical generators

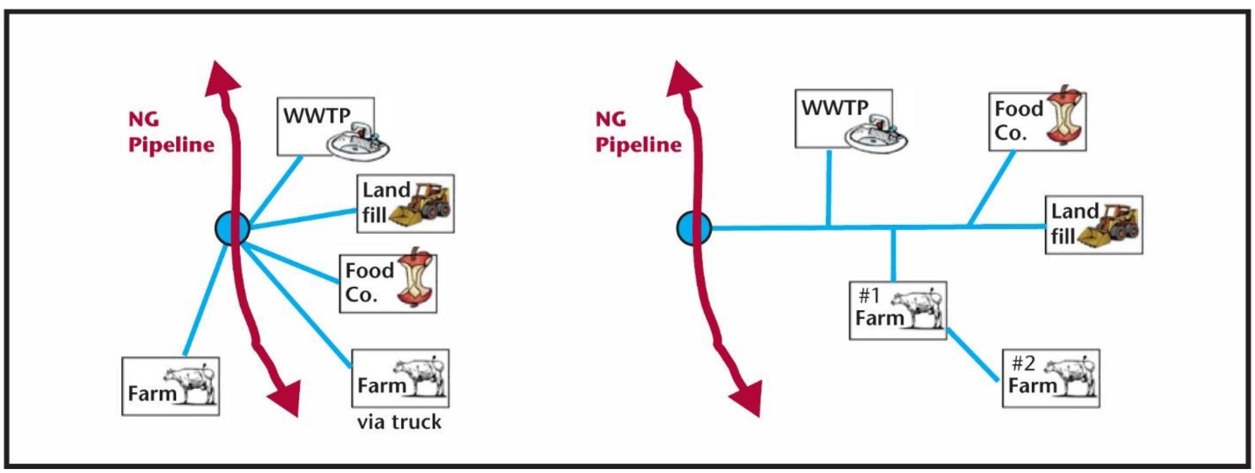
As a result, RNG developers are shifting away from power sales through interties to the electrical grid and toward natural gas pipeline interconnections to tap more diverse markets. An important component of this report is the identification of organic waste sources and waste management facilities that would be good candidates for production and distribution of RNG due to their proximity to the natural gas pipeline grid.

RNG can be directly injected into an interstate or local distribution pipeline through an interconnection at or near the point of production (typically less than 5 miles). The RNG will be tested and must meet standards established to both preserve the integrity of the pipeline grid and ensure the quality of gas delivered to customers. These standards are currently set on an ad hoc basis by the receiving pipeline company. During 2019, the Washington Department of Commerce will coordinate a voluntary conversation with gas utilities and regulators regarding development of a common standard or quality tariff for pipeline injection of RNG.

In addition to direct pipeline injection by a single facility, RNG developers are looking for opportunities to share biogas upgrading, compression, and injection infrastructure among multiple producers. RNG from more remote locations could also be compressed into tube trucks and delivered to injection points.

When exploring potential RNG locations, this study considered producers large enough to be stand-alone facilities and more modestly sized facilities that could be part of hub-and-spoke or chain clusters.

Figure 2. Hub-and-Spoke and Chain Models for Sharing Interconnection Costs



To address the difference between the cost of producing RNG in smaller, distributed quantities and extracting natural gas from large underground reserves, this study reviews policy mechanisms that monetize social and environmental attributes of RNG. The federal Renewable Fuel Standard and California's Low Carbon Fuel Standard are currently the key market drivers for RNG development.

3. Inventory of Opportunities

Building on previous work, this study updates and refines estimates for production of RNG from landfills, WWTPs, agricultural producers, food processors, municipal solid waste handlers, and other sources of organic wastes. It identifies where existing facilities are close enough to the natural gas distribution system to be candidates for production of RNG that can be injected into the pipeline grid. Modeling RNG potential is challenging due to the dynamic nature of biogas sources. Landfill gas (LFG) quantities evolve over time, WWTPs serve changing populations, and dairy farms expand or close. This inventory is a snapshot in time of RNG resources in Washington.

3.1 Methodology

The project team considered RNG resources from two perspectives: 1) sources of organic residuals, and 2) existing waste management infrastructure that might host an RNG facility. The data search started with updates from sources used in previous surveys, such as U.S. Environmental Protection Agency's (EPA) Landfill Methane Outreach and AgSTAR programs, wastewater permits in the National Pollution Discharge Elimination System, and livestock manure data from state and federal departments of Agriculture. New data resources were found based on various permitting and reporting requirements, including Washington Department of Ecology's (Ecology) Permit and Reporting Information System.

The search for organic residuals included sources already producing biogas as well as ones that don't. The wastewater, biosolids, and greenhouse gas reporting systems used by EPA and Ecology contained helpful data. Whenever possible, specific waste data for each facility was noted or an estimate of the potential available RNG was calculated. Not all identified sources show residual volumes because available data might be dated, incomplete or highly seasonal in nature. Some sources only show levels of business activity (e.g., gross sales, number of employees). Particular attention was given to high-volume sources, especially those with strong energy potential (e.g., seafood, oils). The search explored:

- Landfills
- Wastewater treatment plants
- Composters
- Food processors (including milk, meat and poultry processors)
- Dairies
- Nondairy animal feeding operations
- Egg producers
- Fish hatcheries
- Renderers
- Tree fruit packers
- Vineyards
- Breweries and distilleries
- Commercial feed and pet food

The inventory also identified locations close to gas pipelines that have or had a waste-handling purpose that might be repurposed as host sites for RNG development. Examples include closed landfills, waste transfer stations, compost facilities, and WWTPs (municipal and industrial) that might be smaller in capacity or do not currently have anaerobic digesters.

Distance to natural gas pipelines was assessed in three ways:

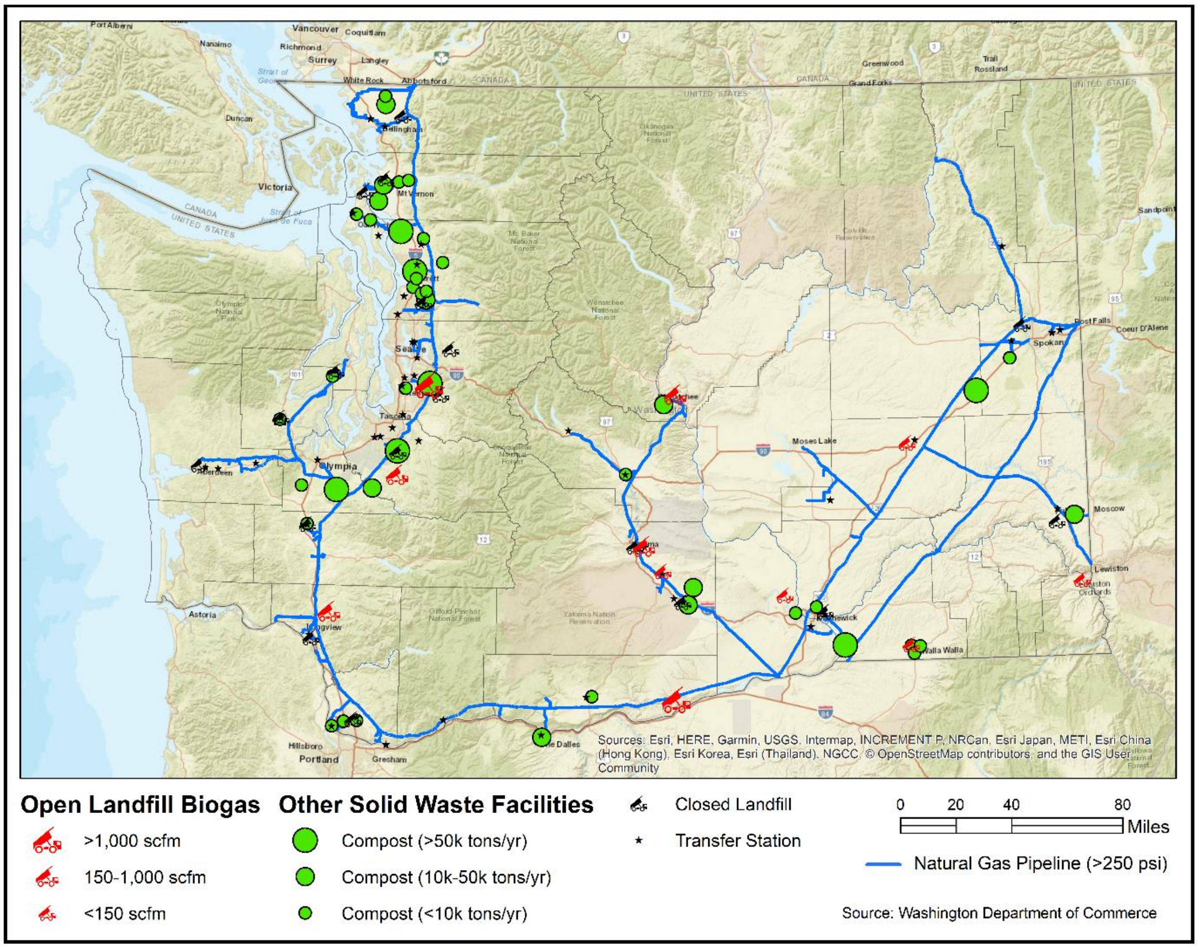
1. High-volume organic waste management infrastructure within 10 miles
2. Secondary infrastructure and biogas and feedstock sources within five miles
3. High-volume and high-energy content feedstocks within a 30-mile haul radius

Five counties fell outside the search area, including Clallam, Jefferson, Okanogan, Pacific and San Juan.

After a lengthy search, the team incorporated location data for facilities and feedstocks into a geographic information system (GIS) used to then calculate distances to pipelines. The GIS data for the natural gas grid was provided by the Washington Utilities and Transportation Commission, which regulates pipeline safety for portions of the gas grid operating at 250 psi and above. Therefore, the study does not show smaller portions of the grid that deliver gas to many residential and commercial customers. It might be possible to also inject RNG into these portions of the grid at specific locations.

3.1.1 Landfills

Figure 3. Organic Solid Waste Management Facilities in Proximity to Natural Gas Pipeline Grid

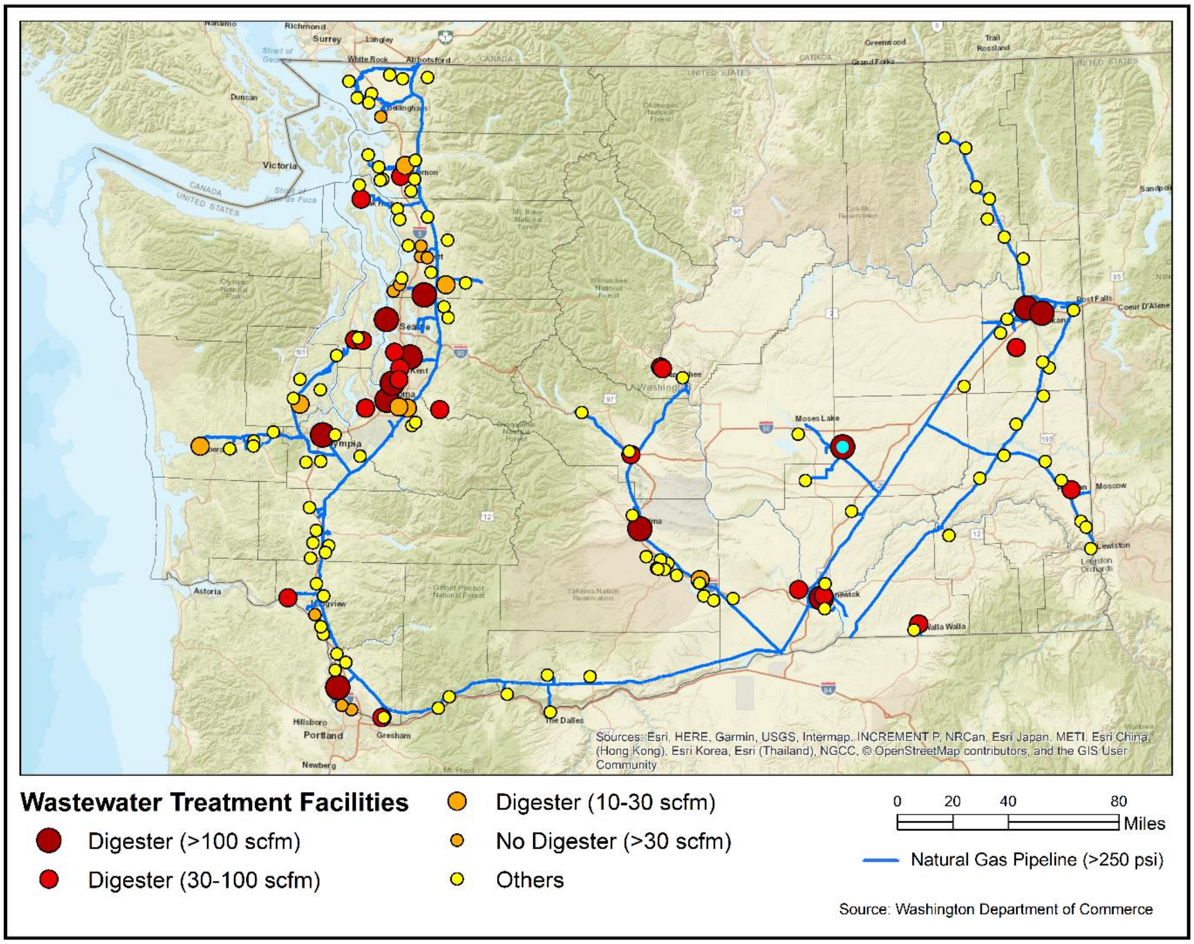


For an estimate of RNG potential from landfill resources, this study looked at 11 landfills with the potential to yield substantial biogas. Those with gas collection systems already in place were considered more likely candidates. The project team supplemented previously gathered data on greenhouse gas emissions from Ecology and EPA with direct reports from facility operators.

Landfills generate raw biogas as organic materials decompose. Some highly putrescible materials, such as food scraps and grass clippings, decompose rapidly. Woody or fibrous materials decompose over longer periods. As a result, landfill gas is generated at varying levels over time. Most landfills suitable for RNG production are required to collect and destroy biogas. EPA estimates landfill gas collection systems can effectively collect about 75 percent of the methane generated by decomposition.[3]

3.1.2 Wastewater Treatment Plants

Figure 4. Wastewater Treatment Plants with Significant Potential Biogas Yields



WWTPs use a variety of treatment methods to produce biosolids and treated water for discharge to the environment. Anaerobic digesters needed to capture biogas are most often used at larger WWTPs to further treat biosolids. This study focused on facilities with digesters and larger facilities without digesters that have the potential to generate significant enough quantities of biogas. Of the nearly 300 WWTPs in Washington, at least 65 operate with digesters. Another nine have the potential to generate enough biogas to consider incorporating digesters into their operations.

For this study, the number of customers was used to model likely wastewater inflows and resulting biogas production. RNG production from WWTP digesters varies as many facilities burn the biogas,

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[3] *LFG Energy Project Development Handbook (Chapter 2: Landfill Gas Modeling)*, U.S. EPA, 2017

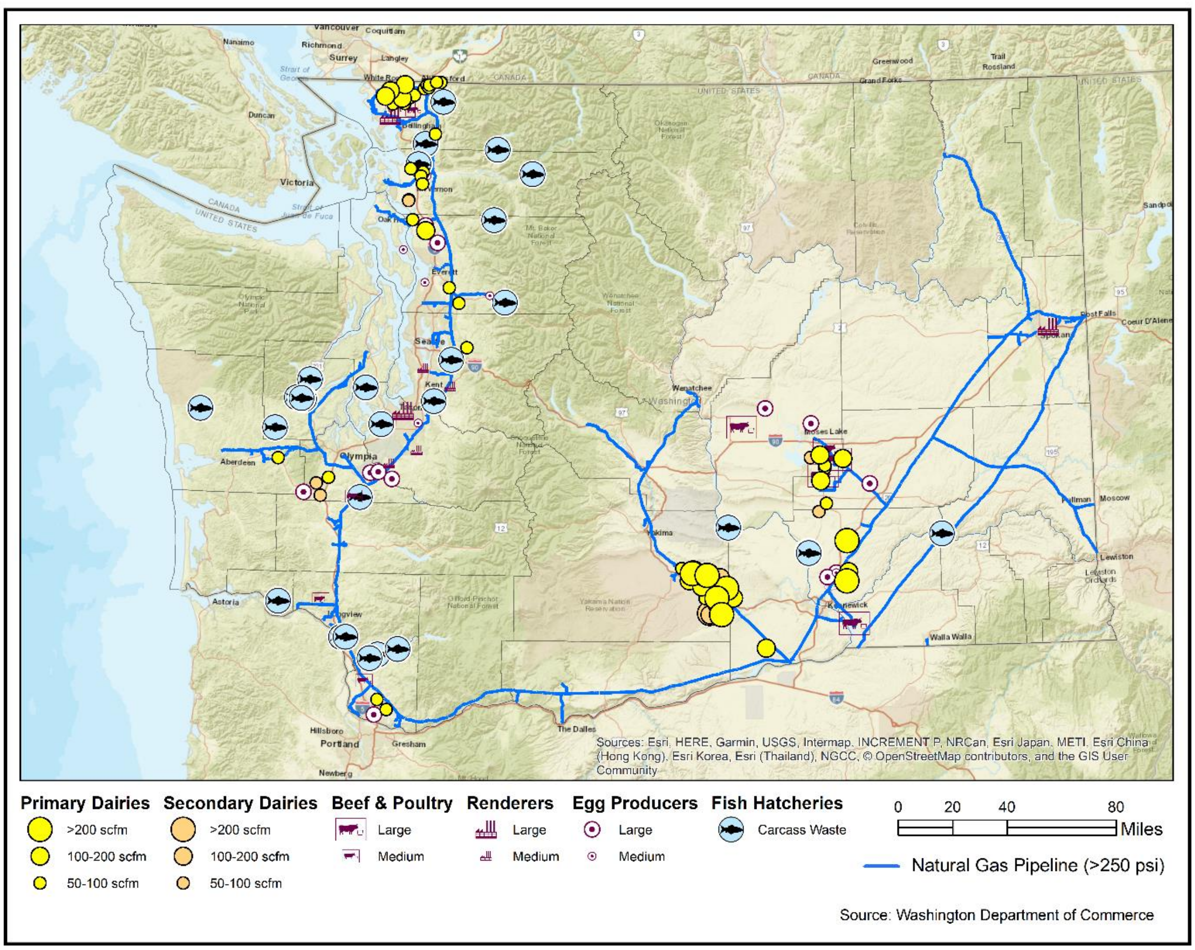
either for heat to keep digesters operating at optimum temperature or to dry biosolids for use as fertilizer. Many others generate electricity to offset operational needs, with surplus power sold to the local utility. Biogas in excess of thermal and electrical needs could be redirected to RNG.

3.1.3 Livestock Agriculture

Livestock producers generate manure, wastewater and other materials suitable for anaerobic digestion. Although Washington has little swine production, there are roughly 350 dairy farms, 10 beef and poultry farms, a few rendering facilities, and a couple dozen egg producers of adequate size to consider hosting a digester or contributing feedstock to nearby digesters. Horse manure, which is usually mixed with bedding, is more suitable for composting than anaerobic digestion, so it was not included in this study. Given dairy privacy concerns, the data about their RNG potential is only presented in aggregate form.

In the following graphic, primary dairies are within five miles of the major pipeline grid and secondary dairies are further from the grid but still within five miles of a primary dairy. The opportunity here is that dairies might be able to run manure slurry lines, or low-pressure biogas lines, to common facilities for digestion, biogas capture, gas conditioning and pipeline injection.

Figure 5. Significant Sources of Animal Waste Within 30 Miles of Natural Gas Pipeline Grid



3.1.4 Source-Separated Organics

Organic materials found in municipal and industrial solid waste streams — such as food scraps of all types, non-recyclable paper and compostable products, yard and garden debris, and fats, oils and greases — can be converted to biogas and RNG in a variety of anaerobic digestion facilities. Based on Ecology's most recent "Washington Statewide Solid Waste Characterization Study,"[4] an estimated 770,000 tons of food waste and 260,000 tons of yard and garden debris are disposed of in Washington landfills each year. With further development of high-solid digestion systems, RNG can be produced from the biogas captured through decomposition of yard and garden debris and other organic residuals collected in Washington communities.

Though biogas yields at landfills will likely decrease when organic wastes are diverted, the reduction will not be proportionate to the reduction in tons landfilled since the rapid aerobic decomposition of energy-rich materials such as food waste occurs prior to landfilling and creation of an anaerobic environment equipped with landfill gas capture. The efficiency of biogas production and capture, as well as opportunities for nutrient recovery, will improve with direct diversion of food waste to above-ground digesters. The resulting digestate can then be composted with the added benefit of improved odor and vermin control.

3.1.5 Food and Beverage Processing

Significant quantities of food and beverage processing residuals are available in a variety of sectors. Food processing ranges from agricultural products handled near the fields to manufactured products for supermarket distribution. Residuals also come from processing milk and other common beverages as well as breweries and distilleries. The project team identified hundreds of such businesses throughout Washington. However, little data was available regarding actual volumes of waste. Instead, the study prioritized high-energy content foods and relied on indicators of business activity, such as gross sales and employment levels, to identify potential high-volume waste streams.

3.1.6 Additional Organic Residuals

Other potential sources of residuals include upland fish hatcheries, tree fruit packers, and vineyards. However, tapping these high-quality, high-volume sources can be challenging given their seasonal nature. Commercial animal feed and pet food manufacturers could also be good sources, but no data is currently available regarding their waste generation.

Many organic residuals already have existing uses or markets. The extent to which they might contribute to RNG production will depend largely on the market value for RNG and the resulting competitive value of desirable feedstocks.

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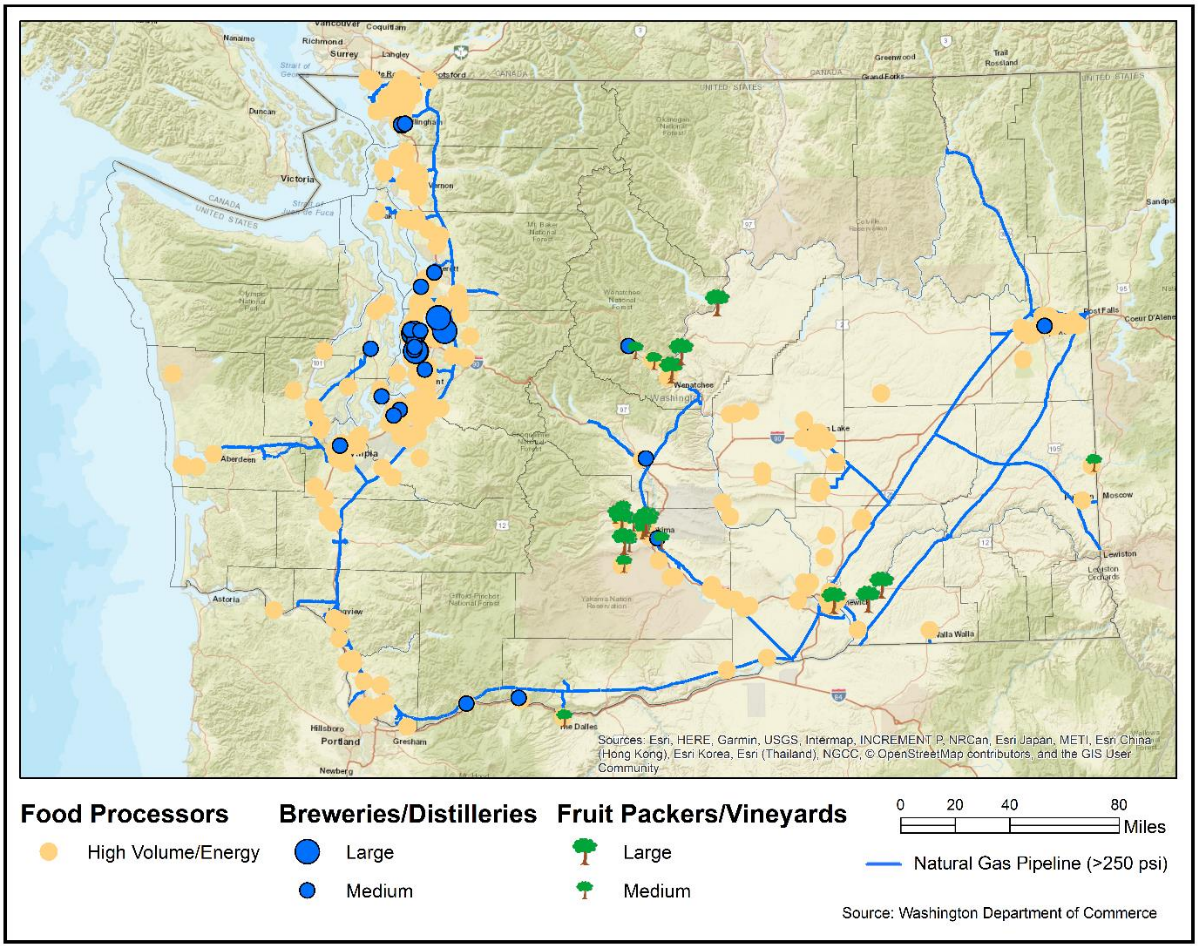
[4] *2015-16 Washington Statewide Waste Characterization Study*, Washington Department of Ecology, 2016, revised 2018

Figure 6. Primary Sources of High-Energy-Content Organic Wastes from Food Processing



3.2 Results

The development of RNG resources in Washington is well underway. The best opportunities for near-term production of significant volumes of RNG lie with open landfills, major WWTPs, clustered dairy operations, and redirecting existing biogas facilities away from power generation toward biogas conditioning and pipeline injection.

3.2.1 Current RNG Pipeline Projects

The two largest landfills in the state and a major metropolitan wastewater treatment facility are already upgrading their biogas to RNG and injecting it into the natural gas pipeline grid. This RNG is being sold out of state due to valuable clean fuel standard credits in neighboring states. According to the U.S. Energy Information Administration, the volume of natural gas delivered annually to end users in Washington state between 2013 and 2017 averaged 300 million MMBtu. So taken together, RNG from these three facilities would be equivalent to 1.3 percent of current consumption.

Table 1. Existing RNG Production Facilities Intertied with Natural Gas Pipeline Grid

Facility (Owner/Operator/Utility)	Type	RNG (MMBtu/yr)	Gas Market (%)
Cedar Hills Landfill (King County) Bio Energy WA/Puget Sound Energy	LFG	1,600,000	0.5%
Roosevelt Landfill (Republic Services) Klickitat County PUD	LFG	2,102,400	0.7%
South Treatment Plant (King County) Puget Sound Energy	WWTP	300,000	0.1%
TOTALS		**4,002,400**	**1.3%**

Given that these projects are subject to long-term, out-of-state supply contracts, this study excludes them from additional consideration as instate RNG opportunities. This relationship could change in the future, though, if contracts are altered due to new economic or regulatory considerations.

3.2.2 Near-Term RNG Opportunities

Several smaller facilities — one landfill, two WWTPs and eight dairies — currently use their biogas to produce renewable electricity. With conversion to RNG, these projects could produce about 1.3 million MMBtu per year, or about 0.4 percent of current natural gas consumption in Washington. Other RNG-to-pipeline projects already in the development process include Tacoma's Central Wastewater Treatment Plant and a dairy-based project Promus Energy is developing in Yakima County.

Several other RNG projects at landfills and WWTPs, and in the agricultural sector, could be developed in the near-term, or on about a five-year time horizon. These opportunities feature resources producing at least 100 scfm of biogas. Further geographical analysis found most of these facilities to be in proximity (within five miles) of major gas pipelines. Near-term opportunities include:

- Facilities in King, Pierce and Thurston counties already generating power from biogas that could be converted into RNG
- Landfills in Chelan, Cowlitz and Yakima counties
- Wastewater treatment plants with anaerobic digesters in Benton, Clark, Grant, King, Snohomish, Spokane and Yakima counties

Table 2. Near-Term Opportunities for RNG Production at Existing Waste Management Facilities

Facility (Location)	**Type**	**Biogas (scfm)**	**RNG (MMBtu/yr)**
LRI (Graham)*	LFG	4,138	985,500
Cowlitz Headquarters (Castle Rock)	LFG	2,170	513,248
Greater Wenatchee (East Wenatchee)	LFG	1,140	299,592
Terrace Heights (Yakima)	LFG	1,017	240,541
West Point (Seattle)*	WWTP	938	295,798
Warden Industrial (Warden)	WWTP	700	265,428
Brightwater (Woodinville)	WWTP	310	97,877
Riverside Park (Spokane)	WWTP	291	91,837
Central (Tacoma)	WWTP	282	88,851
Yakima Regional (Yakima)	WWTP	151	47,639
LOTT Regional (Olympia)*	WWTP	148	46,629
Salmon Creek (Vancouver)	WWTP	137	43,309
Lakota (Federal Way)	WWTP	128	40,461
Spokane County (Spokane)	WWTP	126	39,727
Kennewick (Kennewick)	WWTP	106	33,530
TOTALS (* = existing biopower generation)		**11,782**	**3,129,967**

The project team also identified 27 dairies, including eight currently generating renewable electricity, that could be developed as RNG projects during this time frame, either separately or in clusters or chains with other dairies or biogas sources. Dairies using open lagoons to store manure before land application have a significant biogas resource that is currently lost to the atmosphere. By sharing biogas upgrading and pipeline injection infrastructure with other dairies, these RNG resources could be readily developed. Whatcom and Yakima counties, and to a lesser extent Skagit and Grant counties, have many such dairies as well as major pipelines traversing their counties.

Projects to digest municipal food waste for RNG are another short-term opportunity. Digesting half of the municipal food waste from King, Snohomish and Pierce counties could generate nearly 400 million cubic feet of RNG each year. Even though biogas yields at landfills will likely decrease when organic wastes are diverted to other processing pathways, the overall efficiency of biogas capture would improve.

Combined, these various near-term RNG resources could displace about 1.8 percent of current fossil natural gas consumption by end users in Washington.

Figure 7. Near-Term Opportunities for RNG Production at Existing Waste Management Facilities

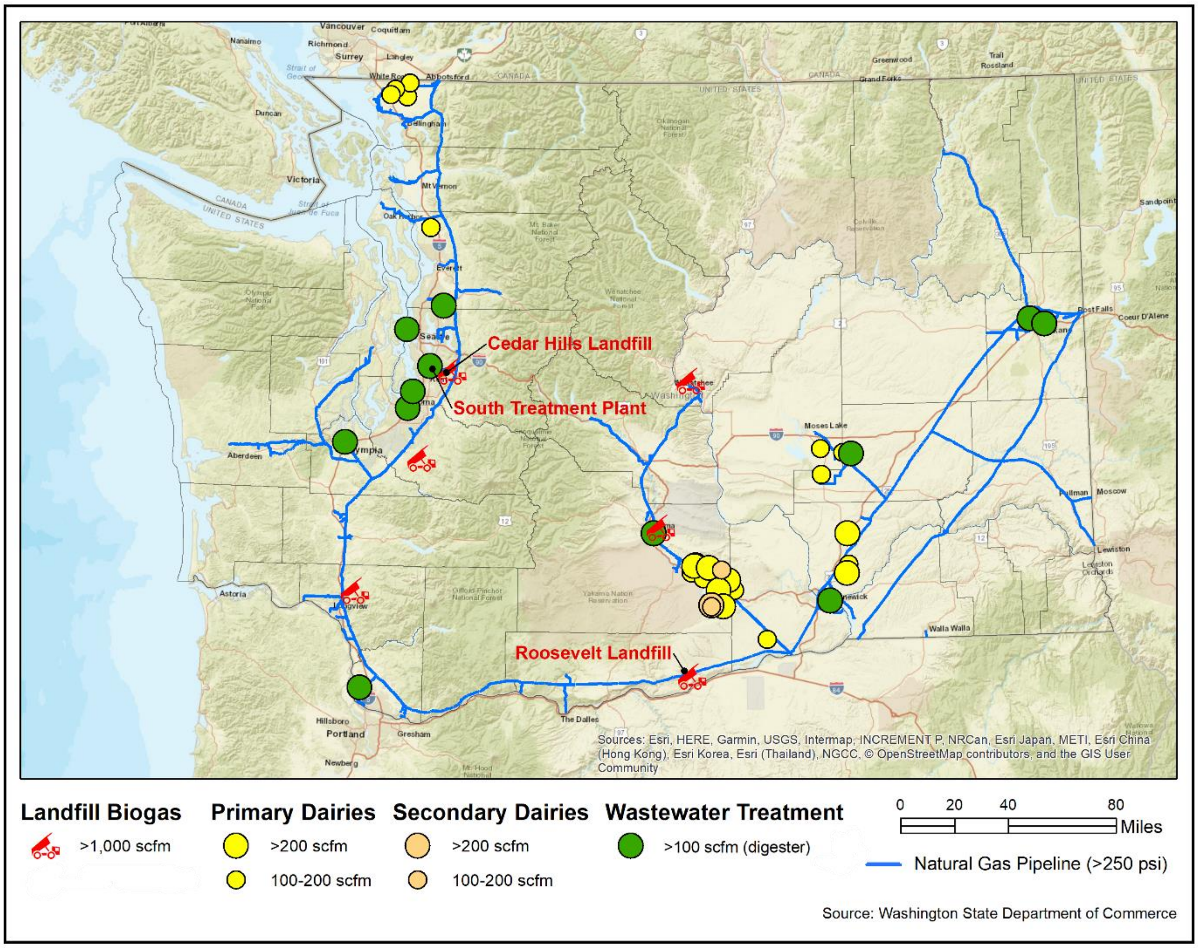


Table 3. Summary of Near-Term RNG Projects by Sector

Near-Term Projects	RNG (MMBtu/yr)	Gas Market (%)
Landfills	2,038,881	0.68%
Wastewater treatment plants	1,091,086	0.36%
Dairy digesters	1,866,113	0.62%
Municipal food waste digesters	398,930	0.13%
TOTALS	**5,395,010**	**1.79%**

3.2.3 Medium-Term RNG Opportunities

Additional projects equivalent to another 1.9 percent of current gas consumption in Washington could be developed over five to 10 years. These opportunities represent smaller, more distributed biogas resources that could be developed with improvements in technology and/or as clusters of facilities with shared infrastructure. Such medium-term projects could include landfills in Asotin, Benton, Grant, Yakima and Walla Walla counties.

Table 4. Medium-Term RNG Projects at Landfills

Facility (Location)	Biogas (scfm)	RNG (MMBtu/yr)
Horn Rapids (Richland)	399	94,286
Ephrata (Ephrata)*	388	91,839
Cheyne Road (Zillah)*	326	77,081
Sudbury Road (Walla Walla)	200	47,304
Asotin County (Clarkston)	150	35,478
TOTALS (* = no current landfill gas capture)	**1,463**	**345,988**

Among WWTPs, 27 facilities that have digesters could each provide at least 3,000 MMBtu per year of RNG and nine WWTPs without digesters could each produce at least 10,000 MMBtu per year of RNG if digesters were added.

Table 5. Medium-Term RNG Projects at Wastewater Treatment Plants

Facility (Location)	Biogas (scfm)	RNG (MMBtu/yr)	Facility (Location)	Biogas (scfm)	RNG (MMBtu/yr)
Everett (Everett)*	147	46,226	Midway (Des Moines)	43	13,430
Marine Park (Vancouver)*	137	43.309	Lake Stevens (Everett)*	42	13,116
Vancouver West (Vancouver)*	126	39,844	South Kitsap (Port Orchard)	38	12,126
Post Point (Bellingham)*	114	36,104	Ellensburg (Ellensburg)	36	11,412
Pasco (Pasco)	94	29,730	Puyallup (Puyallup)	35	9,462
Three Rivers (Longview)*	91	28,800	Camas (Camas)	32	9,996
Marysville (Marysville)*	89	28,188	Oak Harbor (Oak Harbor)	31	9,660
Richland (Richland)	73	22,977	Sumner (Sumner)	26	8,146
Salmon Creek (Burien)	69	21,736	Redondo (Redondo)	26	8,045
Edmonds (Edmonds)*	56	17,711	Monroe (Monroe)	25	7,752
Wenatchee (Wenatchee)	55	17,304	Aberdeen (Aberdeen)	22	7,040
Bremerton (Bremerton)	53	16,705	Sunnyside (Sunnyside)	22	6,990
Lynnwood (Lynnwood)*	50	15,889	East Wenatchee (East Wenatchee)	19	5,849
Stella (Longview)	50	15,800	Enumclaw (Enumclaw)	16	5,001
Mount Vernon (Mount Vernon)	47	14,725	Cheney (Cheney)	16	4,946
Chambers Creek (University Place)	44	13,981	Shelton (Shelton)	13	4,234
Walla Walla (Walla Walla)	44	13,820	Central Kitsap (Poulsbo)	13	4,202
Pullman (Pullman)	43	13,698	Burlington (Burlington)	12	3,711
** = No digester at present*			**TOTALS**	**1,849**	**538,399**

This phase of RNG development would require the following:

- Collaborating extensively with the dairy community to establish digesters to serve the more than 200 dairies in Washington with significant biogas potential

- Capturing biogas from the balance of food waste generated in King, Snohomish and Pierce counties as well as food waste from the 14 counties with the next highest RNG potential
- Diverting food processing residuals from the 16 counties that have the greatest number of sources exceeding 50 scfm of biogas potential (likely in combination with other digester developments in clusters or chains of RNG projects)
- Generating biogas through integration of anaerobic digestion of food with other organic wastes at compost facilities before sending residual solids to aerobic composting operations

Combined, these diverse resources would generate enough RNG to offset another 1.9 percent of current natural gas consumption in Washington.

Figure 8. Medium-Term Opportunities for RNG Production at Existing Waste Management Facilities

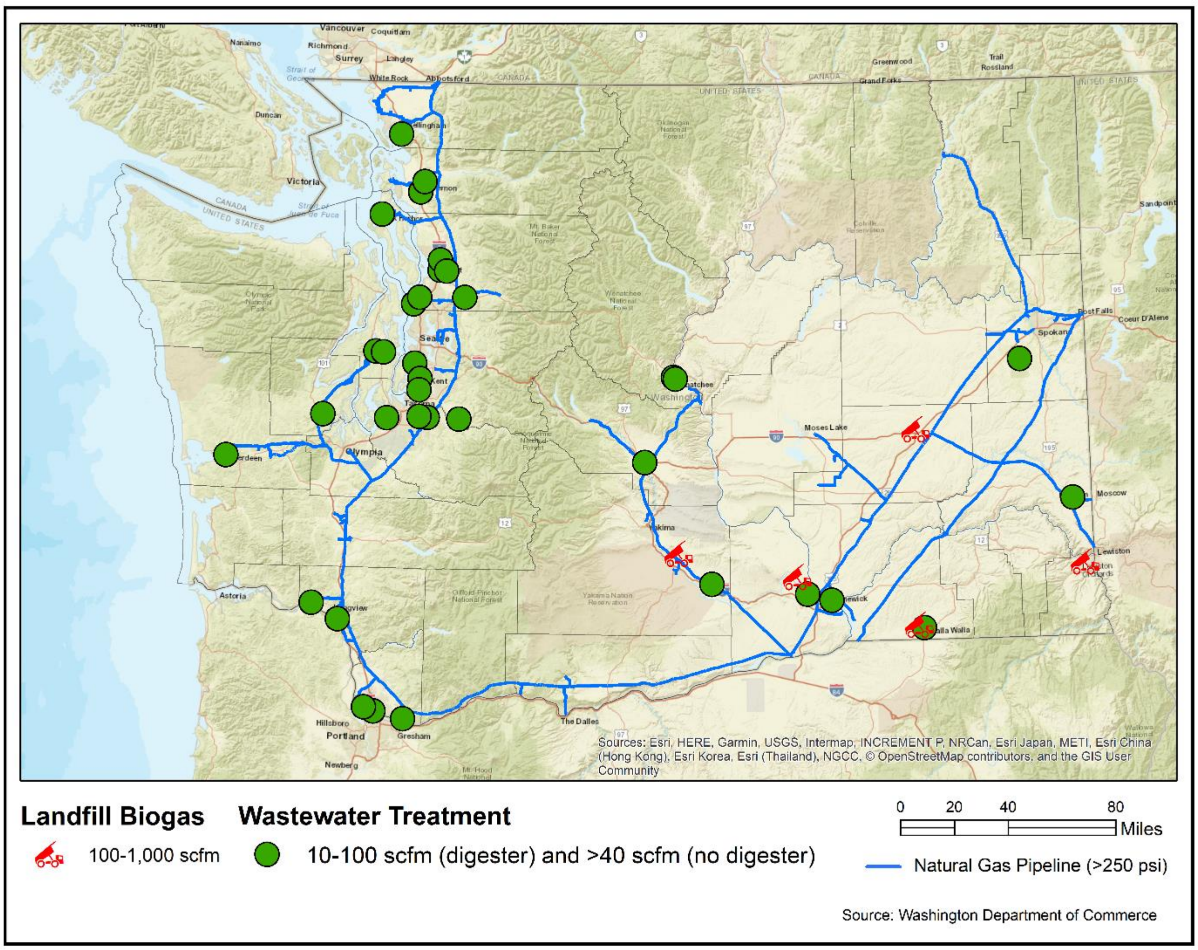


Table 6. Summary of Medium-Term RNG Projects by Sector

Medium-Term Projects	**RNG (MMBtu/yr)**	**Gas Market (%)**
Landfills	345,988	0.12%
Wastewater treatment plants	538,399	0.18%
Dairy digesters	1,851,170	0.62%
Municipal food waste digesters	1,067,152	0.36%
Food processing residuals	1,142,846	0.38%
Food processed at compost facilities	783,455	0.26%
TOTALS	**5,729,010**	**1.92%**

3.2.4 Other RNG Opportunities

Further opportunities can be developed by redirecting organic wastes away from existing disposal markets to production of RNG. For example, fats, oils and greases used to produce biodiesel or rendered products have been targeted by some wastewater treatment facilities to enhance biogas output.

In addition to food residuals in municipal solid waste streams, other organics can contribute to RNG production through high-solids anaerobic digestion.

Finally, gasification of wood and other fibrous materials from forests, fields and urban areas represents a significant resource, with the capacity to more than double overall RNG production in the state. However, this opportunity is subject to development of commercial-scale gasification technologies that are cost-effective in the American market.

4. Economics of RNG

As noted in "Harnessing Renewable Natural Gas for Low-Carbon Fuel," numerous benefits result from using RNG. However, at present, producing RNG, especially in small volumes at distributed locations, is more expensive than extracting fossil natural gas from underground reserves. The equipment to upgrade raw biogas to natural gas standards can be expensive, and the cost of pipeline interconnection facilities can be millions of dollars. This study details factors affecting the cost of RNG projects. This study does not address the incentives provided to conventional natural gas producers in the form of research grants, tax incentives and property rights that are not currently afforded to RNG.[5]

4.1 Capital Investments

The costs to build RNG projects for pipeline injection depend on many factors, including the type and size of project, biogas characteristics, and ownership. Distance to the pipeline and the type and pressure of the required interconnection have significant impact on capital costs. Public projects have different cost structures and sources of capital from private ones. Landfills and wastewater treatment plants might already produce and capture raw biogas as part of their regulated activities or business. If so, the added cost of producing RNG is largely limited to upgrading the biogas to meet quality standards and injecting it into a pipeline. Other facilities have the materials to produce biogas for RNG, but they require construction of material processing and new anaerobic digestion facilities in addition to the rest of the biogas upgrading and RNG injection infrastructure.

The combined capital investment for the three existing pipeline-intertied RNG projects in Washington has been reported by facility operators to be between $80 million and $100 million. Landfills, with their sizable RNG resources, often require the greatest capital investment. However, they offer excellent economies of scale. For example, owners of a 2,500-scfm (1.3 million MMBtu per year) landfill project in Oregon estimated their total capital investment at $26.9 million.

Recent RNG projects for larger WWTPs in Washington and Oregon cost between $9 million and $12 million to build, with each producing 100,000-340,000 MMBtu of RNG per year.

Washington has not had a new dairy digester since 2012. However, many new dairy digester projects that upgrade their biogas and inject it into the pipeline grid have been built elsewhere in the U.S.

Several Washington dairy projects have developed estimates of the capital investment needed to either add RNG to existing digesters or construct new digesters dedicated to RNG production. In the case of retrofits for existing digester projects, analyses found estimated capital costs of $4.1 million and $5.4 million for projects that would generate 184,000 to 158,000 MMBtu of RNG annually. Annual operation costs would range from $230,000 to more than $1 million. These estimates demonstrate the highly unique, nonlinear relationship of capital or operation costs, depending on RNG project alternatives.

[5] *Progress Report on Fossil Fuel Subsidies*, U.S. Department of the Treasury, 2015

Private data from digester developers in Washington suggest the following costs for construction of new digesters with RNG production. One analysis looked at a project serving 2,000 milk cows and producing 64,500 MMBtu of RNG annually for pipeline injection. It estimated the capital cost at $7.5 million and annual operation costs of $323,270. Another larger project producing 165,000 MMBtu annually was found to have a capital cost of more than $18 million, including pipeline and injection. One additional analysis found that building a new dairy digester to produce 473,040 MMBtu per year RNG could cost almost $25 million, with operation costs of $2.2 million per year.

Large-scale municipal digesters can be developed along with smaller-scale, distributed digesters for food residuals collected on streets from homes and businesses or at food processing facilities. Recent engineering analysis by King County of the potential for capturing biogas predicted net capital costs ranging from $180 to $300 per ton of processed material, depending on the type of digester system and public-private partnership used. This is equivalent to $52 to $86 per MMBtu capacity.[6] Put another way, a municipal food waste digester project producing a desirable 1,000 scfm of biogas would require a capital investment of $25 million to $45 million.

The $80 million to $100 million invested to achieve the current level of RNG production in Washington was for projects that might be considered the highest value (or low-hanging fruit) opportunities for the state. The next likely group of RNG projects would involve somewhat smaller projects built at landfills, WWTPs and dairy farms. The projects would include new digester construction for many dairies and substantial digester capacity for food residuals in the Puget Sound region. The project team estimates that capital investment in the different categories of near-term RNG projects could reach $600 million to $700 million.

Table 7. Potential Capital Requirements for Near-Term RNG Project Development

Project Type	Number of Projects	Estimated Capital Investment
Landfills	4	$110 million
WWTPs	9	$80 million
Dairies	27	$400 million
Food residuals digestion	3 or more	$100 million

4.2 Production Costs

After accounting for the cost of capital and operations, the cost of producing RNG is often reflected on a per-MMBtu basis. A previous report[7] about RNG for Washington looked at costs reported from various studies for producing RNG from different types and sizes of projects and compared them on a MMBtu-equivalent basis. On the low end of the scale, some large landfills can produce RNG for less than $1 per MMBtu. Large WWTP facilities handling 15 million to 150 million gallons per day might produce RNG for

[6] *Anaerobic Digestion Feasibility Study*, King County Solid Waste Division, 2017

[7] *Biomethane for Transportation: Opportunities for Washington State*, Western Washington Clean Cities, 2011, revised 2013

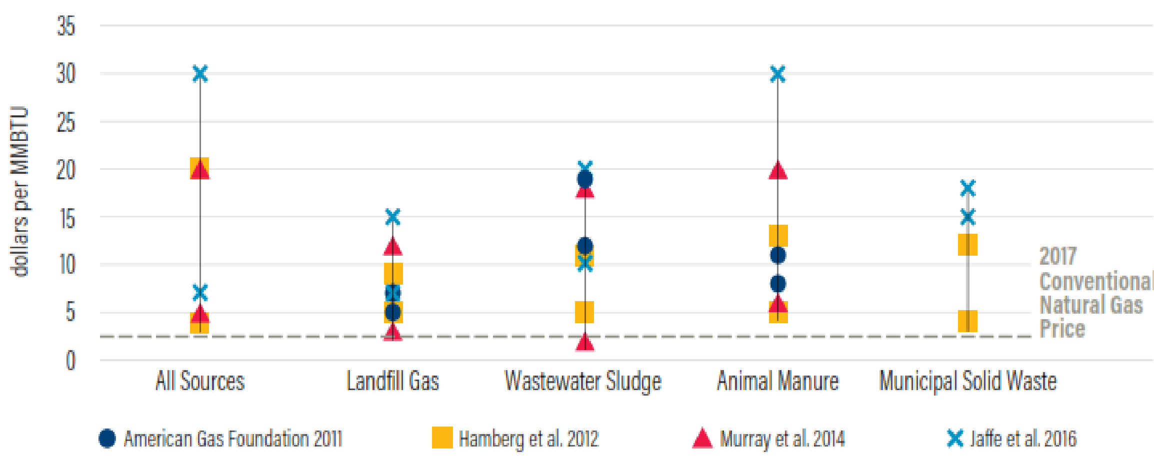
as low as $5.28 per MMBtu. Small WWTPs and large dairies could find production costs around $9 per MMBtu. Small dairy costs could approach $12 per MMBtu.

In 2017, the World Resources Institute (WRI) aggregated RNG assessments[8] to look for trends in the costs of producing RNG. It gathered synthesized data from four studies of RNG:

1) In 2011, the American Gas Foundation used cost data from available literature and its own estimates to model two RNG market penetration scenarios for average RNG production costs.
2) In a 2012 paper, Hamburg published RNG production cost estimates from various other studies.
3) A team led by Murray in 2014 calculated national RNG supply curves with project data and cost estimates for technology provided by various equipment vendors.
4) A California study published in 2016 by Jaffe and others developed supply curves for California using project and literature data, plus information available from the California Public Utility Commission.

WRI found RNG production cost estimates ranging from $3 to more than $30 per MMBtu. The sources of RNG in these studies included landfill gas, wastewater sludge, animal manure, and organics diverted from municipal solid waste. WRI concluded that a significant portion of the RNG could be produced at $10 per MMBtu. However, once early projects are completed the study concluded the cost of production will rise significantly without technological improvements or better economies of scale. Figure 9 shows the various production cost estimates the referenced studies developed.

Figure 9. Estimated RNG Production Costs from Anaerobic Digestion of Wet Waste Sources



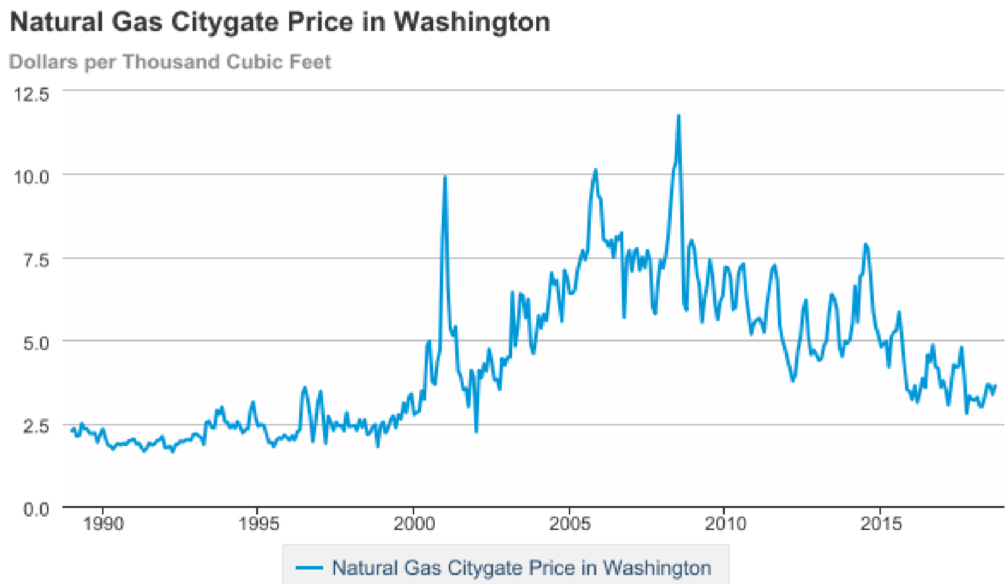
Each of these production cost estimates would need to account for the additional cost of accessing and injecting RNG into the pipeline grid. It's reasonable to assume about $3 per MMBtu for that amortized cost. Together, these production and access/injection costs represent a break-even figure for developing RNG. The ultimate price for RNG, which project developers would need to charge above these costs,

[8] *The Production and Use of Renewable Natural Gas as a Climate Strategy in the United States*, World Resources Institute, 2017, revised 2018.

would reflect developers' tolerance for risk and their requirements for return on investment. This is why private project developers often mention RNG prices in the $20 to $30 per MMBtu range. Public facilities might be able to accept prices closer to their break-even estimates.

Figure 10 shows historical citygate prices for fossil natural gas in Washington. Citygate prices record costs for natural gas at a measuring station where local distribution companies receive gas from a pipeline company or transmission system.

Figure 10. Washington Citygate Price, 1989 to 2018 (U.S. Energy Information Agency)



The price of fossil gas has decreased dramatically over the last decade largely due to two factors: first, the oversupply created by hydraulic fracturing, which has significantly reduced the cost of natural gas extraction from marginal wells; and second, the choice of natural gas producers to disconnect the historic ratio pricing between natural gas and oil to support penetration into the transportation sector.

4.3 Value of RNG

The business case for RNG cannot be based solely on the market price of fossil natural gas. Anaerobic digestion projects generate a variety of revenue streams and cost-savings, including tip fees, enhanced waste management and revenue from production and sale of digester co-products such as biofertilizer.

RNG is a locally produced, renewable fuel that has added value for the environment and host communities. Unlike many other renewable energy supplies, RNG is easily stored and can be made available on-demand. Finally, RNG projects reduce greenhouse gas emissions by avoiding fugitive methane emissions and offsetting conventional energy sources used for heat, thermal processing, power and especially transportation when replacing gasoline or diesel fuel. Quantifying and capturing these values to support RNG production is a role for policy.

As detailed by the California Air Resources Board and elsewhere, the cumulative value of RNG varies by its production and use pathway, which determines its carbon intensity as a renewable transportation fuel. In a 2017 presentation[9], SoCalGas described three components when valuing WWTP RNG:

1) Commodity value of RNG ($3.18 per MMBtu)
2) Value of low-carbon fuel standard (LCFS) credits ($6.45 per MMBtu)
3) Value of credits under the federal Renewable Fuel Standard ($37.14 per MMBtu)

Those components produce a total value of $46.77 per MMBtu.

Under the California LCFS program, the value of RNG produced from a dairy farm project could rise to $36.36 per MMBtu due to the fuel's much lower carbon intensity value. In this case, the total value could rise to $76.68 per MMBtu. Due to this high potential value, the WRI report cites several case studies with payback periods ranging from immediate to about 10 years.[10]

4.4 Barriers to Development

The Oregon Department of Energy recently completed a study of RNG potential,[11] including a survey of industry experts. It found that the most often mentioned barriers to development include:

- Access to project financing
- Higher capital cost of gas upgrading equipment to remove impurities and increase heat content of RNG to meet utility pipeline standards
- High cost of pipeline interconnection and testing
- High production and capital costs with no valuing of environmental benefits
- Perception of risk due to unfamiliarity with the technology, fuel sources, and fuel supply chain
- Existing state rules that prevent Oregon utilities from making ratepayer-funded capital investments in RNG infrastructure or purchasing or selling RNG
- Inability to use most food waste streams in the state
- Lack of financial incentives for natural gas fueling infrastructure and vehicles
- Limited number of RNG production sites close to natural gas pipelines

Not all barriers to RNG development are strictly related to costs, though nearly all have economic consequences. Many physical, geographic and demographic factors influence the success of RNG development in Washington, including the widely distributed nature of organic residuals, limited pipeline infrastructure, and the lack of a sense of urgency to address environmental issues, especially if household energy or waste management costs increase. There is also a lack of natural gas vehicles and the refueling infrastructure needed to consume RNG as vehicle fuel.

Additionally, there is uncertainty over the value and duration of state and federal policies that monetize the environmental benefits associated with RNG. And because RNG facilities involve processing or

[9] Jim Lucas, *Renewable Natural Gas and Interconnecting to the SoCalGas Pipeline*, PR1118.1 Working Group, 2017
[10] *The Production and Use of Renewable Natural Gas as a Climate Strategy in the United States*, World Resources Institute, 2017, revised 2018.
[11] *Biogas and Renewable Natural Gas Inventory*, Oregon Department of Energy, 2018

treatment of organic “wastes”, objections from neighboring communities can be a significant obstacle to project development. Given these findings, the keys to lowering the cost of RNG development can be summarized as:

- Advocating for and educating about effective public policy regarding environmental and economic benefits
- Creating, supporting or expanding public policies regarding existing and future RNG markets
- Enabling access to stable RNG markets that can predictably support project development
- Achieving the highest and best end use for biogas or RNG
- Location, location, location: Choosing projects with ready access to feedstocks and markets
- Spending extra capital on pipeline connections that can move RNG to the most valuable markets
- Monetizing environmental benefits, including carbon and fuel standard credits, for all end uses
- Adding value through commercialization of co-products
- Coordinating with local natural gas distribution companies
- Securing strong, flexible sources of private financing
- Maximizing state and local support for the project
- Having a good story to tell, which can help make other projects easier to develop and sustain

5. Expanding Public Sector Use

In 2018, the Washington Legislature requested information about opportunities to expand public sector use of RNG. This section considers ways to use RNG throughout state government.

5.1 State Agency Consumption

As in the rest of Washington, the primary use of natural gas by state agencies is for space and water heating in buildings. Local governments make limited use of compressed natural gas (CNG) in some transit and public works fleets. At present, the state does not own or operate any CNG vehicles. The Washington Department of Transportation continues to monitor opportunities to use alternative fuels in heavier vehicle classes, but the agency does not anticipate acquiring any CNG vehicles in the foreseeable future. Washington State Ferries considered the use of liquefied natural gas (LNG) but recently shifted its focus to battery electric and electric-diesel hybrid conversions for its next generation of vessels.

For state agency buildings and campuses, data from the Washington Department of Enterprise Services (DES) show that universities and colleges are among the largest consumers of natural gas. The quantity of gas they annually consume is equivalent to at least 3.72 million MMBtu, or about 1.2 percent of the state's average natural gas consumption.

Table 8. Natural Gas Consumption in 2017 by Select Washington Colleges and Universities

Institution	**Natural Gas Demand** (MMBtu)
University of Washington	1,799,055
Washington State University	1,434,286
Eastern Washington University	252,434
Spokane Community College	97,460
The Evergreen State College	93,637
Seattle Community College	41,162
Total	**3,718,034**

Data not provided for Western Washington University or Central Washington University

Other agencies consuming significant quantities of natural gas include the departments of Corrections (~700,000 MMBtu), Social and Health Services (~325,000 MMBtu), Enterprise Services (~133,000 MMBtu), and Transportation (~75,000 MMBtu) as well as the Washington State Patrol (~40,000 MMBtu). When added to universities and colleges, total annual consumption by these agencies is about 5 million MMBtu. Together, they account for more than 99 percent of state government demand. This demand is about 1.7 percent of average annual natural gas consumption in Washington. If the state were to purchase RNG for these facilities, it would more than double the existing production demand. Using RNG for transportation would also reduce greenhouse gas emissions, but the state does not anticipate procuring any natural gas vehicles in the foreseeable future.

5.2 Potential Agency Projects

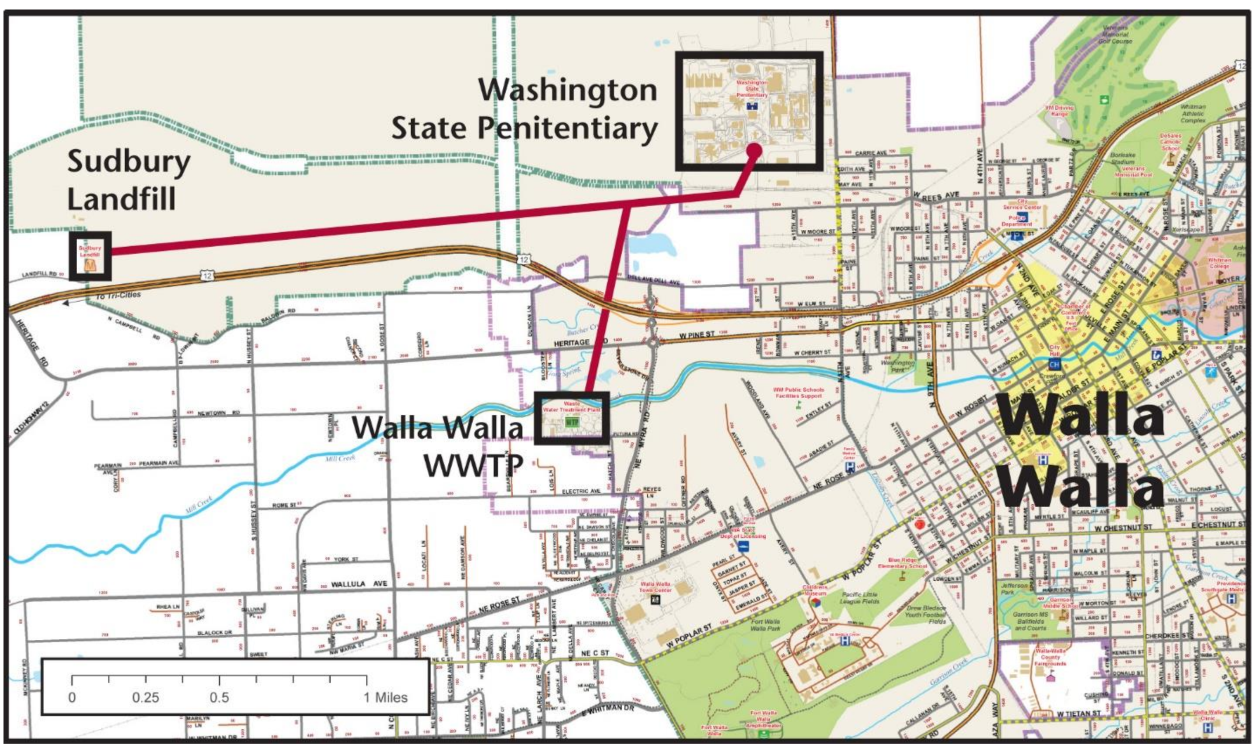
One approach for the state to consider would be a more thorough assessment of the feasibility of using RNG at various state facilities. What would be the net costs and benefits in job creation, overall economic activity, waste management, and reduction in greenhouse gas emissions? What advantages or challenges are associated with using operating funds to purchase RNG at a price higher than fossil natural gas versus appropriating capital funds for the infrastructure needed to effectively buy RNG upfront from targeted projects at a more competitive price?

Additional analysis could focus on the feasibility of using RNG at specific locations, such as at the Capitol campus. According to the state Department of Enterprise Services, the current retail cost of natural gas for Capitol facilities is about $8 per MMBtu. At that price, what would be the net impact of securing supplies of RNG to meet campus demand?

Other projects have explored use of biogas or RNG at Washington correctional facilities, including the Monroe Correctional Complex, Washington Corrections Center in Shelton, and Washington State Penitentiary in Walla Walla. Given their generally rural locations, correctional facilities are often in proximity to nearby farms, landfills and other waste management facilities.

For example, Figure 11 shows that the Washington State Penitentiary is only a short distance from the Sudbury Landfill and the Walla Walla WWTP. Partially conditioned biogas could be directly delivered in a low-pressure pipeline for space and water heating.

Figure 11. Washington State Penitentiary and Neighboring Organic Waste Management Facilities



5.3 Preferential Purchasing

Multiple laws and executive orders require Washington state agencies to expand their purchases of environmentally preferred products to reduce energy and water use, greenhouse gas emissions, and use of equipment, supplies and other products that contain toxic chemicals. Most energy-related policies affecting public sector facilities focus on energy efficiency. Directives regarding use of RNG can be found in statute and orders that address broader sustainability goals:

- RCW 39.26.160(3) (Procurement of Goods and Services): "In determining the lowest responsive and responsible bidder, an agency may consider best value criteria, including but not limited to … (d) Whether the bid considers human health and environmental impacts; (e) Whether the bid appropriately weighs cost and non-cost considerations; and (f) Lifecycle cost."
- RCW 39.35D (High Performance Public Buildings): This statute requires that all new state-funded facilities larger than 5,000 square feet meet green building criteria. Major office and higher education facility projects are required to achieve LEED Silver certification. New K-12 schools are required to meet the Washington Sustainable Schools Protocol or achieve LEED certification. Scoring criteria include reductions in greenhouse gas emissions, promoting sustainable resource cycles, and supporting local economies through use of Washington state-based resources and materials.
- Executive Order 18-01 (State Efficiency and Environmental Performance): "When making purchasing, construction, leasing and other decisions that affect state government's emissions of GHGs or other toxic substances, agencies shall explicitly consider the benefits and costs (including the social cost of carbon) of available options to avoid those emissions. Where cost-effective and workable solutions are available that will reduce or eliminate emissions, decision makers shall select the lower-emissions options."
- Executive Order 13-03 (Requiring Consideration of Lifecycle and Operating Costs in Public Works Projects): This order requires that agencies consider operating and lifecycle costs when planning a building, and it directs the Department of Enterprise Services to develop sustainable design principles that "optimize lifecycle costs, pollution, and other environmental and energy costs associated with the construction, lifecycle operation, and decommissioning of the facility."

Enterprise Services uses master contracts to procure most of the goods and services required by agencies and made available to local governments. One exception is utility service, which is generally purchased on a retail basis at each facility. Absent policy requiring RNG content in the general natural gas supply, agencies and local governments would need to work with the Utilities and Transportation Commission and natural gas utilities to establish a voluntary offering of RNG similar to electric utility Green Power programs.

6. Carbon Intensity

Carbon intensity (CI) is a measurement of lifecycle greenhouse gas emissions. CI is usually expressed in grams of carbon dioxide equivalent gases per megajoule of energy consumed, or gCO_2e/MJ. These calculations play a vital role in the administration of low-carbon fuel standards (LCFS) in states like California and Oregon. The fees assessed, or costs encountered, are based on CI measurements, with low CI values reflecting low total greenhouse gas emissions over the lifecycle of each fuel.

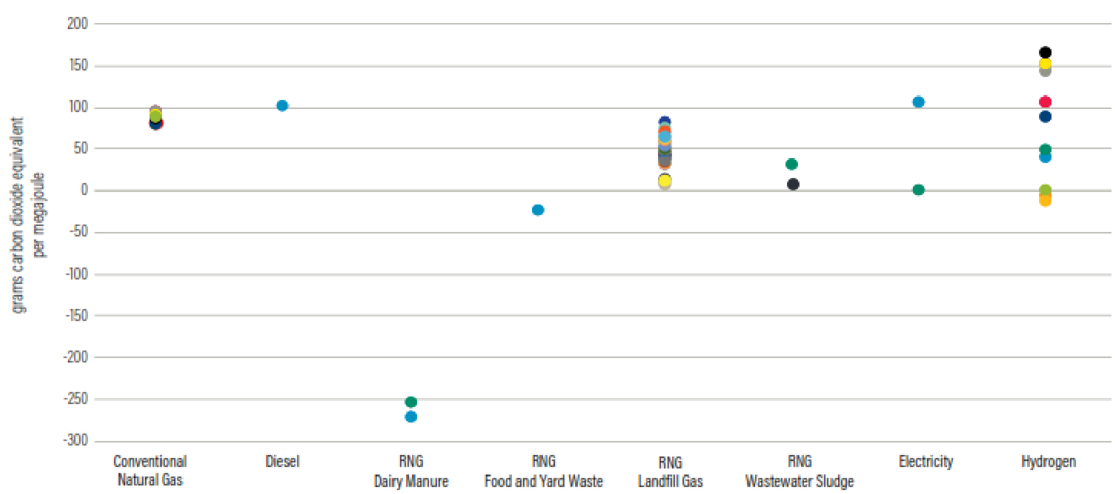
CI values are based on a lifecycle analysis (LCA) of the production, distribution and use of each fuel, from well to wheels (for petroleum or natural gas) and from field, farm or landfill to wheels (for biofuels such as ethanol, biodiesel and RNG). An LCA identifies and quantifies all material and energy flows in a fuel's lifecycle. It measures a range of direct and indirect greenhouse gas impacts and considers all carbon emissions, including carbon dioxide, methane and nitrous oxides. LCAs are conducted according to a set of ISO 14000 international environmental management standards, guides and technical reports.

A CI calculation involves multiple elements, including:

- Feedstock production (e.g., drilling and pumping for petroleum or natural gas, crop production for ethanol, and collection of wastewater, manure or food residuals for RNG)
- Feedstock transportation, storage and distribution
- Fuel production (e.g., gasoline refining, ethanol fermentation, and anaerobic digestion for RNG)
- Production of coproducts, such as biofertilizers from anaerobic digesters
- Finished fuel distribution, including transportation and storage
- Fuel use in vehicles

Figure 12 shows the relative CI calculations for a wide variety of fuels used in the California LCFS program. Most RNG fuel types have lower CIs than conventional petroleum or natural gas fuels.

Figure 12. Lifecycle Carbon Intensities of RNG and Other Fuels Under California LCFS Program



Source: California Air Resources Board 2017d.

RNG from dairy manure achieves a low, even negative CI because it is a low-carbon fuel when compared to gasoline or diesel and it also captures methane emissions previously escaping from open manure pits. This reduction of a highly destructive greenhouse gas can lower a CI score dramatically.

In light of energy and material inputs required to produce and deliver RNG to end users, the emphasis for producing low-CI fuels should be on conservation, efficiency and use of renewable energy for delivery. For example, reducing truck hauling of feedstocks or finished fuels would be important. Manure or food wastes delivered to a digester via pipeline would have lower impacts than the same materials delivered by truck. Using renewable fuels in the supply chain would also lower the CI.

Sharing infrastructure would be another excellent way to reduce the cost and CI of a finished fuel. Much of the equipment for producing biogas, cleaning it to pipeline-quality RNG, and compressing and injecting it into the pipeline could be shared among multiple facilities.

Considering the length of pipeline from the injection point to the eventual end user is another factor in CI calculations, as is the amount of leakage in the supply and distribution chain. Using RNG as locally as possible, therefore, would raise the carbon benefit.

7. Policies to Promote RNG

Previous studies regarding RNG for Washington, as cited on page 2, described policies and programs that could support the development of RNG at federal, state and local levels. In requesting this report, the state Legislature specifically requested information on establishment of a renewable portfolio standard (RPS) for natural gas. Such a law would require natural gas utilities to incorporate specified levels of RNG into the natural gas supply, a policy similar to requirements in place for large electric utilities in the state. At present, nearly all Washington dairy-based anaerobic digesters are generating electricity from their biogas for sale to Puget Sound Energy to support that utility's voluntary Green Power programs.

7.1 Renewable Portfolio Standard

Natural gas plays a significant role in the heating of Washington homes, institutions and businesses. An industry study[12] suggests natural gas offers greenhouse gas reduction advantages over heating with electricity, so many gas industry experts encourage using RNG for heating, not just transportation. A different study[13] finds methane emissions from U.S. oil and gas operations are 60 percent higher than previous estimates from the federal government. Regardless, use of natural gas does offer economic advantages through reduced peak electric load.

Use of natural gas for transportation in Washington is currently limited to a few transit, public works and long-haul trucking fleets. Only five retail compressed natural gas (CNG) and liquefied natural gas (LNG) refueling stations are currently operating in the state. Meanwhile, most RNG is flowing south to California due to the high demand for low-carbon fuel credits under state clean fuel standard programs.

An RPS would support all existing RNG projects as well as new or expanded uses of RNG. The volume of readily available RNG would cover a fraction of all existing uses of natural gas, so new natural gas RPS requirements could be met within the existing natural gas demand profile. From the perspective of economic transformation, an RPS policy would allow investments to be focused on development of new RNG resources and infrastructure for integrating RNG into the natural gas grid (i.e., pipeline access and injection) without necessitating additional investments in new natural gas vehicles and refueling and maintenance infrastructure.

7.1.1 Policy Framework

The best example of a state-level RPS for natural gas is one recently adopted in California. SB 1440, approved in 2018, requires the California Public Utility Commission (PUC) to consider adopting specific biomethane procurement targets for each natural gas utility. Advocates are urging the PUC to require that utilities pursue 32 billion cubic feet of annual RNG procurement by 2030. That represents about 5 percent of California's current gas demand.

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[12] *Dispatching Direct Use*, American Gas Association, 2015
[13] *Assessment of Methane Emissions from the U.S. Oil and Gas Supply Chain*, Science, 2018

An RPS for natural gas in Washington could be similarly constructed, including the existing requirement that gas utilities show prudent discretion in their procurements of both fossil natural gas and RNG. Some potential questions about a natural gas RPS include:

- Would enough RNG opportunities exist to meet the RPS targets?
- What would be an appropriate price cap for RNG?
- Would adequate opportunities be available for all gas utilities to meet their targets?
- What would it mean to involve the utilities as active participants in these markets?
- Would RNG projects achieve the market values and rates of return needed to support development by public and private entities?
- What credits or other incentives should accompany an RPS requirement?
- How should RNG claims be tracked across RPS, voluntary market and LCFS uses to protect against double-counting and to facilitate exchange of renewable attributes?

To determine what level of RPS is realistic for Washington state, both the scale of natural gas consumption and the available inventory of RNG sources would need to be considered. According to the U.S. Energy Information Agency, average annual natural gas consumption by end users in Washington state between 2013 and 2017 was 300 million MMBtu.[14] The current annual supply of pipeline RNG in Washington is an estimated 4 million MMBtu, equivalent to 1.3 percent of natural gas consumption in the state. Not accounting for future changes in demand, an additional 3 million MMBtu of RNG is required to offset every 1 percent of fossil natural gas.

If the three existing pipeline-intertied projects selling RNG into the California transportation fuel market were redirected to RPS compliance in Washington, a 3 percent renewable portfolio threshold could be reached by converting existing biogas-to-power facilities to pipeline injection and then developing the resources identified in the "Near-Term RNG Opportunities" section of this report. Developing the projects identified in the "Medium-Term RNG Opportunities" section would enable the state's natural gas utilities to comply with a 5 percent standard based on current consumption. The inventory of potential RNG projects found numerous opportunities in each utility service territory.

If existing out-of-state RNG sales were not to qualify for RPS compliance, an additional 4 million MMBtu of RNG would be needed to meet a 5 percent threshold. This could be accomplished through more advanced technologies, such as gasification of wood waste, or by purchasing from out-of-state sources.

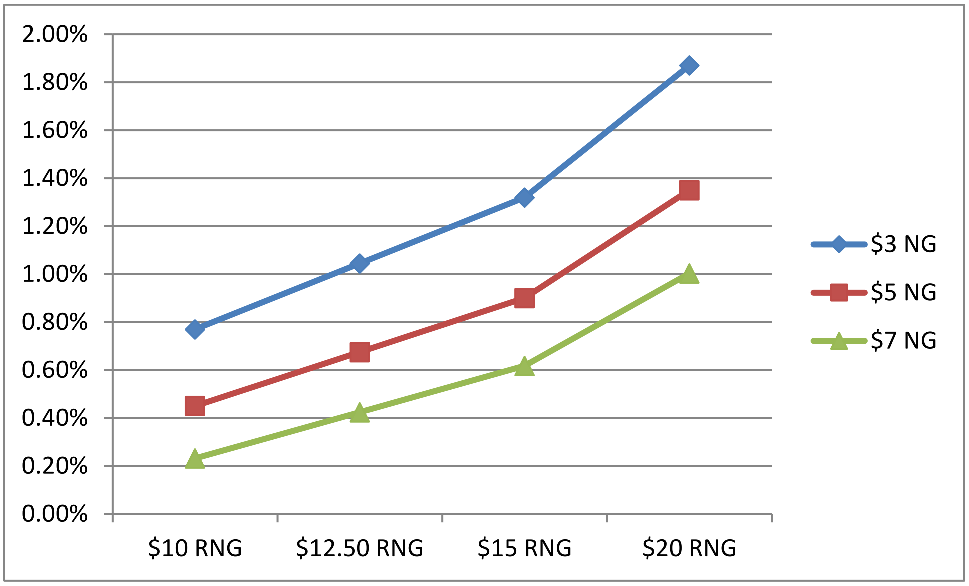
7.1.2 Policy Impacts

Figure 13 illustrates the potential change in retail natural gas prices from each 1 percent of RNG delivered into the pipeline system at base costs of $10, $12.50, $15 and $20 per MMBtu. Even though the cost of RNG might be higher than the price of fossil natural gas, the impact on retail gas prices would be mitigated because the wholesale cost of gas accounts for only about one-third of the retail price.

[14] *Natural Gas Consumption by End Use*, U.S. Energy Information Administration, 2018.

For example, adding 1 percent RNG at prices ranging from $10 to $20 per MMBtu to the current $3 per MMBtu cost of fossil gas would result in retail price increases of 0.77 percent to 1.87 percent. If natural gas prices were to increase to $7 per MMBtu, the gas price would then represent about half the retail cost. In this case, adding 1 percent of RNG at various prices would result in retail price adjustments ranging from 0.23 percent to 1 percent. In other words, even at today's low prices for natural gas, the impact on retail prices of adding enough RNG at prices as high as $20 per MMBtu would be an increase of less than 2 percent.

Figure 13. Impact of Adding 1 Percent RNG at Various Values on Natural Gas Retail Prices



Three other cost considerations should be kept in mind.

1) According to the Northwest Gas Association's "2016 Gas Outlook,"[15] fossil natural gas prices are predicted to approximately double over the next decade.
2) Natural gas prices can demonstrate striking volatility.
3) Experts believe the cost of RNG production is likely to fall with increased demand and anticipated advances in gas conditioning technologies.

Combined with shared infrastructure for gas pipeline access and injection, the cost differential of RNG could be partially mitigated.

An RPS supporting RNG development might have additional cost benefits, such as:

- Providing access to RNG across the entire natural gas value chain, extending renewable energy and pollution reduction benefits to all customers

[15] *Natural Gas Supply, Demand, Capacity and Prices in the Pacific Northwest, Projections through October 2026*, Northwest Gas Association, 2016.

- Incentivizing new utility investments, especially in RNG infrastructure, by allowing for financing at guaranteed prices
- Spreading investment cost and risk across customer base (residential, commercial, industrial)
- Involving the Washington Utilities and Transportation Commission (UTC) in accounting for costs and providing utilities with authorized rate of return for RNG investments

An important value of policy is to mitigate and distribute risk for society and markets. The technology for RNG production and pipeline injection is low risk and well-established. Anaerobic digestion and biogas upgrading are well-established industries, and gas transfer and distribution is safe and reliable. Common agreement on quality standards for RNG injected into the fossil natural gas grid would still be needed to clarify which technologies developers would need to deploy to ensure gas quality. These standards vary widely by region and could feature requirements that exceed those for fossil natural gas.

The primary risk of RNG systems is economic. Current economics rely heavily on environmental credits as major revenue sources for investment recovery. The risk sits solely with RNG project developers and their investment partners. Engaging the natural gas utility infrastructure as the key pathway to expansion of RNG markets could have great value to the state, just as electrical utility infrastructure has been at the forefront of developing renewable electricity in Washington.

An RPS for the natural gas market could align this fuel source with electricity policy. It could bring thermal uses of natural gas alongside potential transportation benefits. It could also direct natural gas utilities to expand their leadership role in reducing greenhouse gas emissions and supporting creative and valuable organic waste management solutions for public ratepayers and private business interests.

7.1.3 Feasibility of an RPS

This study found a broad distribution of RNG development opportunities in each of Washington's natural gas utility service territories. An important consideration in development of an RPS program would be how gas utilities would be expected to meet requirements. For example, under the RPS, utilities might be required to meet specific RNG volume targets through a system of credits for production of RNG from qualified projects. Additionally, each of Washington's natural gas utilities have potential RNG sources in their service territories, but trading or procurement of RNG resources and/or compliance credits from outside a service area, or even outside the state, could be allowed.

7.1.4 Portfolio Versus Clean Fuel Standards

An RPS could engage utilities in new market sectors, allowing for new investments and diversified sources of authorized profit. Action would be required of the four investor-owned retail natural gas utilities regulated by the UTC: Puget Sound Energy, Avista, Cascade Natural Gas, and NW Natural. UTC staff members review rates, revenues, expenses and programs to ensure a fair balance among corporate needs, ratepayer needs, and broader public interests. Only two municipalities — Ellensburg and Enumclaw — regulate rates and service quality for publicly held natural gas distribution systems. It is presumed they are too modest in scale for inclusion in an RPS program.

Adoption of a carbon-weighted clean fuel standard (CFS) in Washington, similar to those in California and Oregon, would support RNG use from pipelines and directly from RNG sources (i.e., public works trucks fueled at a landfill). In contrast to other demands for natural gas, transportation currently accounts for only 1 percent of natural gas use in the state. New transportation use would require additional investments in suitable vehicles plus new fueling and maintenance infrastructure.

As noted previously, RPS compliance could be met within the existing natural gas demand profile. For a CFS to meaningfully support RNG development, new investments in natural gas vehicles and refueling infrastructure would be needed to take advantage of fuel standard values. Even though a CFS could complement an RPS in supporting RNG development, the key would be in how the two policies were to interact in the marketplace to achieve relative carbon pollution reductions.

Because gasoline and diesel emit 30 percent to 35 percent more carbon dioxide than natural gas when burned, using RNG to offset petroleum-based transportation fuels would reduce greenhouse gas emissions more than using RNG to offset other natural gas uses. Calculating the total carbon pollution benefits of using RNG in any scenario would require an in-depth analysis of carbon intensity values for various sources of RNG.

Ensuring these policies are complementary would require additional modeling to prevent bidding wars between natural gas utilities seeking to comply with an RPS and fuel suppliers complying with a CFS. Perhaps utilities could receive RPS credits for handling RNG on its way to an end user claiming clean fuel credits. An RPS would get RNG into the pipeline at a base value, engaging the sector knowledge and investment capacity of natural gas utilities in a productive manner. Meanwhile, a CFS could provide significant monetary returns for emission reductions in transportation, where demand is more limited.

7.1.5 Carbon-Weighted RPS

Methane is a well-known Short-Lived Climate Pollutant (SLCP). On a 100-year time scale, the global warming potential (GWP) of methane is roughly 28 to 36 times greater than carbon dioxide. However, much of methane's GWP impact is felt in the near-term. On a shorter, 20-year time frame, methane's GWP is about 84 to 87 times greater than carbon dioxide.[16]

Short-term global warming impacts should play a role in the policy debate about RNG. For example, significant differences exist in pollution prevention benefits for RNG produced from biogas that is already captured compared to capturing fugitive sources of methane escaping to the atmosphere from human activities (landfills, WWTPs, agriculture, and oil and natural gas production and distribution).

Targeting SLCPs for reduction would prioritize capturing biogas from wastewater and agricultural lagoons, diverting organic wastes from landfill disposal toward anaerobic digestion, and placing and/or enhancing biogas capture systems on all landfills. SLCP policy options have already been adopted in California and are under discussion in other states, provinces and nations.

[16] *Understanding Global Warming Potentials*, U.S. EPA, 2018

An emphasis on SLCPs could influence the design of an RPS for RNG. Conventional RPS policies are based on volumetric percentages, while CFS policies are based on carbon intensity ratings. Credits for fuels with lower carbon intensity ratings have greater value in the CFS marketplace.

An RPS policy for RNG in Washington could be improved by incorporating a carbon intensity factor. Instead of percentage requirements based strictly on volume, consideration could be given to requiring a targeted reduction of the same percentage in the carbon intensity of the gas supply. This would provide a valuable incentive to capture fugitive methane sources and align the policy with CFS goals. As with a CFS program, an RNG project developer or utility could reach its revenue or emission reduction goals faster by engaging with dairy or food waste digester projects and directing that RNG toward replacing diesel fuel emissions in transportation. Further, a carbon-weighted RPS would support co-digestion projects, not discourage them, as the current federal renewable fuel standard program does. Finally, a carbon-weighted RPS would incentivize greater efficiency in the use of natural gas and reward utilities that reduce gas leakage in the storage and distribution system.

7.2 Other Policy Considerations

The "Harnessing Renewable Natural Gas for Low-Carbon Fuel"[17] report explored a wide variety of policy options for encouraging development of RNG. Two topics not addressed are potential tax incentives for RNG sales and distribution, and backstopping the value of environmental credit programs.

7.2.1 RNG Sales and Distribution

HB 2580, adopted by the Washington Legislature in 2018, restored and expanded several tax incentives supporting production of RNG and associated co-products. The bill did not address the broader tax environment for RNG sales or whether similar incentives might be appropriate.

Under Washington code, natural gas sales are subject to either Business and Occupation Tax (B&O) or Public Utility Tax (PUT) on gross income, depending on whether the utility is privately or publicly owned. The current B&O rate for wholesale transactions and manufacturing is 0.484 percent. In contrast, the PUT rate is typically 3.852 percent.

Per RCW 82.16.310, sales of natural gas by public utilities are exempt from PUT as long as the gas is used as transportation fuel. However, per RCW 82.04.310, such sales remain uniquely subject to B&O tax. Therefore, the tax on sales of natural gas by public utilities for purposes other than transportation fuel is nearly eight times greater than that applied to private utilities.

This discrepancy was not a concern until recently, because major public utilities had yet to enter the business of natural gas sales. With Klickitat Public Utility District now providing RNG production and distribution services to the Roosevelt Regional Landfill, it might be appropriate to standardize tax liabilities across all utilities. In addition, preferred tax rates specific to RNG sales could be considered, regardless of end usage, perhaps in conjunction with adoption of an RPS for natural gas.

[17] *Harnessing Renewable Natural Gas for Low-Carbon Fuel: A Roadmap for Washington State*, WSU Energy Program, 2017

7.2.2 Credit Enhancement

The value of compliance credits created by policies such as a renewable fuel standard can be highly volatile, especially when markets are first being established. Such instability can be a major deterrent to capital investment in projects designed to ultimately benefit from these policies. Using public funds to guarantee a minimum credit value, with any loans repayable once future values increase, would mitigate much of the risk inherent in new project development.

8. Conclusions

HB 2580 directed the Washington State University Energy Program and Washington Department of Commerce, in consultation with the Washington Utilities and Transportation Commission, to present recommendations to the Governor's Office and the energy committees of the Legislature regarding:

- How to promote the sustainable development of RNG, including a detailed inventory of practical opportunities and costs associated with RNG production
- Specific opportunities for state agencies and public facilities to take advantage of RNG
- Recommendations for limiting the lifecycle carbon intensity of RNG
- Whether to adopt a procurement standard for RNG

This study details our findings and demonstrates that a great future could exist for RNG in Washington.

The amount of RNG already injected into the natural gas supply system from existing projects represents 1.3 percent of the state's current consumption of fossil natural gas. This study found several RNG projects being planned or already in development. It also found dozens of potential additional projects throughout the state, including each gas utility service territory, that could be developed with policymaker support.

The current cost of production varies depending on scale and access to the natural gas pipeline grid. The capital expense of existing RNG projects has been estimated at $80 million to $100 million. Total investment needed to double RNG production would probably be five to six times higher.

Across the various sectors that could produce RNG, a net project value of $15 to $30 per MMBtu would likely be required to support development of pipeline RNG. Sharing RNG infrastructure among multiple projects of different sizes would lower overall project costs and optimize opportunities for production.

The carbon intensity of RNG projects could be reduced — thereby increasing greenhouse gas emission reduction benefits — by embracing conservation and efficient use of energy and materials in the development process as well as the use of renewable energy in project operations. Focusing on Washington-based projects and local uses also could contribute to lower carbon intensity.

A renewable portfolio standard (RPS) to support injection of RNG into the natural gas supply could be justified for targets of 3 percent to 5 percent. State agency use alone could generate demand for RNG equivalent to 1.7 percent of current statewide consumption.

A low-carbon or clean fuel standard would also support RNG development but would require significant investment in new vehicles and refueling infrastructure. Combining a fuel standard with an RPS for natural gas could increase carbon pollution reduction benefits by driving demand for RNG.

For the greatest greenhouse gas reduction benefits, it is critical to focus on existing sources of fugitive methane. Adopting an RPS policy focused on lowering the carbon intensity of the natural gas supply, versus requiring targeted percentages of RNG, would provide added incentive to capture the most damaging sources of methane pollution. This could include targeted incentives or support for livestock manure digesters as well as diversion of food waste from landfill disposal.