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Renewable Natural Gas: A Sustainable Approach to the Energy Transition

Renewable natural gas offers a new and promising energy source that will help decarbonize a portion of Utah's energy mix.

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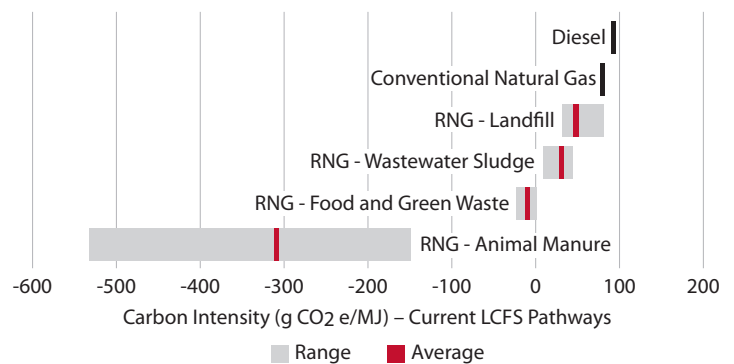
Analysis in Brief

Renewable natural gas (RNG) offers a new and promising energy source that will help decarbonize a portion of Utah's energy mix. RNG feedstocks include waste streams from livestock, landfills, and food. By recycling these waste streams Utah will avoid the release of methane, which has a climate warming potential 25–34 times greater than carbon dioxide. Analysts estimate that Utah RNG volumes could supply 4% of Utah's fossil natural gas demand. In addition, fuel switching in 2025 at the Intermountain Power Plant will increase green hydrogen availability.

Key Findings

- **RNG is a low-carbon energy source**—Generation of RNG avoids emissions of methane, a greenhouse gas with warming potential 25–34 times greater than carbon dioxide. Avoidance of methane emissions gives RNG a negative carbon intensity metric (grams CO₂ equivalent per megajoule of energy). RNG pathways involving livestock waste, food waste, wastewater sludge, and landfill all have carbon intensities lower than fossil fuels.
- **Utah has RNG resources**—Utah's current RNG sources are food waste, landfill gas, wastewater treatment plants, and livestock farms. Potential RNG production from these sources would supply about 4% of Utah's natural gas demand.
- **There are multiple pathways to RNG**—RNG feedstock sources are limited by organic waste streams generated by

Renewable Natural Gas's Carbon Intensity Is Five Times Lower Than Conventional Natural Gas



Source: World Resources Institute, Renewable Natural Gas as a Climate Strategy; Guidance for State Policymakers

the Utah population. However, another RNG pathway occurs when carbon dioxide reacts with green hydrogen created by renewable energy. Increased Utah production of green hydrogen for the Intermountain Power Plant in 2025 and 2045 will likely boost RNG supplies above current levels.

- **There are several local RNG producers**—Owners of five anaerobic digesters processing livestock waste and one anaerobic digester processing food waste fulfill a vital role in the RNG production chain. In addition, Utah has 54 landfills and 20 wastewater facilities, only some of which are capturing biogas.

Anaerobic Digestion Process



Source: Environmental and Energy Study Institute

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Climate change presents a global challenge posing risks to the environment and the economy. Companies are transitioning to low-carbon sources of energy, including renewable energies such as wind, solar, and geothermal. Nuclear technologies, now de-risked for safety concerns, will enter into Utah's energy mix in this decade.

Natural gas serves as a transition fuel to lower-carbon energy supplies due to its smaller carbon footprint than either crude oil or coal.

Interest in *renewable* natural gas (RNG) has mounted in the United States and Canada. In California, SoCalGas committed 5% of its distribution to be RNG by 2022 and 20% by 2030. In Canada, the British Columbia government will increase the percentage of its RNG distribution from the current 5% to 15% by 2030.

This report considers impacts of adding RNG into Utah's energy mix.

Introduction

RNG is a waste-derived fuel used to power homes, businesses and vehicles. RNG and the natural gas supplied to heat homes are both methane (CH₄), but their production pathways differ. RNG pathways comprise municipal solid waste landfills and anaerobic digesters, both fed by waste products. Recycling carbon already on the earth's surface avoids extraction of fossil fuels buried deep underground.

Waste products are the starting point for the RNG pathway.



Food Waste Approximately 40% of U.S. food supply is thrown away.¹ More food reaches landfills and incinerators than any other single material in our everyday trash.² Food waste constitutes 20% of landfills, where it decomposes in the presence of bacteria to methane and carbon dioxide. A more efficient food waste destination is an anaerobic digester that processes organic matter into sustainable resources such as RNG and fertilizer. Wasatch Resource Recovery's (WRR) anaerobic digester, located in North Salt Lake, processes deliveries of food waste into enough RNG to heat Bountiful and produce bio-based fertilizer³.



Livestock Waste Hogs produce between 3 to 13 pounds per day of manure capable of generating up to 5 cubic feet per day of biogas, a feedstock for RNG. Smithfield Farms in Beaver County comprises 26 family farms equipped to generate RNG. Swine manure pumped from animal barns fills high-density polyethylene basins that retain and convert manure emissions into RNG capable of heating 3,000 homes.



Wastewater Treatment Wastewater treatment plants separate sewage sludge from liquids during the treatment process. Biogas from sewage sludge could potentially meet 12% of national electricity demand.⁴ However, many wastewater treatment plants lack facilities to convert biogas into electricity, so they flare biogas instead.⁵



Crop Residues Quantities of corn stover, wheat straw, and forest product residues may co-digest with the wet wastes listed above. However, conversion of large amounts of woody biomass as a stand-alone feedstock requires thermal gasification technologies not yet fully mature.



Landfill Gas The Resource Conservation and Recovery Act of 1976 sets criteria under which landfills can accept municipal solid waste and nonhazardous industrial solid waste. Landfill gas captured from the anaerobic digestion of biogenic waste is methane and trace amounts of nitrogen and oxygen.

Decomposing waste products emit methane and carbon dioxide. RNG projects capture these gases from existing food and livestock waste, crop residues, and wastewater sludge, repurposing them as a green energy source. Recycling carbon already on the earth's surface avoids extraction of fossil fuels buried for millions of years. RNG is chemically identical to natural gas, but its production method differs from fossil fuel natural gas:

Fossil natural gas forms within the earth's organic-rich rock formations under high-temperature and high-pressure conditions. Natural gas comes to the earth's surface from depths of 8 to 12,000 feet through a well bore drilled by energy exploration and production companies.

RNG forms when waste products on the earth's surface decompose via bacteria to form methane and carbon dioxide and small amounts of hydrogen sulfide.

RNG is carbon neutral (i.e., no net release of carbon into the atmosphere) because it recycles carbon already in circulation on the earth's surface. The waste products creating RNG would have emitted methane into the earth's atmosphere by natural decay processes. Recycling carbon already on the earth's surface reduces the need to extract and combust fossilized carbon sources. Estimated RNG feedstock sources in Utah are in Table 2.

Terms Used in this Report

Anaerobic Digestion An anaerobic digester facilitates biological processes in which bacteria break down organic matter (e.g., animal manure, wastewater bio solids, and food waste) in the absence of oxygen. Combining multiple organic materials in one digester is a practice called co-digestion. Anaerobic digester outputs are biogas and digestate. Digestate finds application as either fertilizer or animal bedding.

Biogas Upgrading Biogas created by anaerobic digesters is a combination of methane (50%–60%), carbon dioxide (40%–50%), and trace amounts of other gases. Upgrading biogas separates methane from the carbon dioxide and hydrogen sulfide. The renewable natural gas could either be injected into a gas distribution network or used as a vehicle fuel.

Carbon Intensity The weight of carbon dioxide equivalent emitted per unit of energy released. Typical units for this measurement are grams of carbon dioxide equivalent per megajoule of energy produced.

Carbon Neutral A state of net-zero carbon dioxide emissions. RNG pathways for livestock, food and green waste *avoid* release of methane into the atmosphere, creating carbon offsets.

Dekatherm A unit of energy equal to 1 million British Thermal Units (BTUs) that measures the heating value of a specific volume of natural gas. A typical Utah residential customer consumes 80 dekatherms per year.

Electrolysis The electrolysis pathway for producing RNG involves electricity from renewable energies and carbon dioxide (CO₂). The first step is producing green hydrogen by using electricity generated from renewable energy sources such as wind or solar to split water into hydrogen and oxygen. The second step is methanation of hydrogen to produce renewable natural gas (CH₄) in the sequential reactions listed below.

Green hydrogen production:



Renewable natural gas production:



Livestock, food and organic waste streams currently used to produce RNG are limited. However, electrolysis may create unbounded RNG production.

Table 1: Hydrogen Feedstocks

Feedstock	Process	End Product
Water	Electrolysis	Green hydrogen
Natural gas	Steam Reforming with carbon sequestration	Blue hydrogen
Natural gas	Steam Reforming with no carbon sequestration	Gray hydrogen
Coal	Gasification	Brown hydrogen

Source: S&P Global Market Intelligence

Hydrogen A fuel having no carbon footprint, it is a transportation fuel for heavy-duty vehicles. Electricity generation plants now utilize hydrogen as a replacement fuel for coal and natural gas. Feedstocks in Table 1 produce hydrogen by chemical processes.

Life Cycle Accounting (LCA) LCA evaluates net impacts of emissions throughout a renewable natural gas pathway, including avoided methane emissions at the feedstock source, emissions from energy consumption for biogas upgrading, methane leakage, and end-use emissions. Emission impacts are compared to a reference case in which renewable natural gas is not produced and the feedstocks are managed according to existing practices.

Natural Gas Two sources for natural gas exist. First, fossil natural gas is methane (CH₄) produced by drilling operations providing a conduit from the deep geologic formations to the earth's surface. Second, renewable natural gas (RNG) is a fuel derived from waste streams. As organic waste decomposes, it releases a biogas having 50%–60% methane. This biogas can be refined to remove contaminants and increase heating value. RNG may substitute for fossil natural gas in pipelines, fueling stations, and storage tanks, or as a drop-in fuel requiring no engine modification in natural gas vehicles.

Organic Waste Ban A policy restricting food waste sent to landfills to avoid methane gas leaks to the atmosphere. Waste bans require restaurants or grocery stores to either donate food waste or recycle it via composting or anaerobic digestion.

Voluntary Green Pricing Utility customers voluntarily specify an amount of electricity or natural gas from renewable energy resources they will underwrite by means of surcharges. Only participating customers pay these surcharges.

Wastewater Treatment Plant A facility that removes contaminants from wastewater and converts it into an effluent suitable for return to the water cycle.

Sources: United States Environmental Protection Agency, How Does Anaerobic Digestion Work, <https://www.epa.gov/agstar/how-does-anaerobic-digestion-work>; Argonne National Laboratory, Greenhouse Gases, Regulated Emissions, and Energy Use in Technology model, <https://greet.es.anl.gov/>; World Resources Institute, Renewable Natural Gas as a Climate Strategy: Guidance for State Policymakers, <https://www.wri.org/research/renewable-natural-gas-climate-strategy-guidance-state-policymakers>; and Kem C. Gardner Policy Institute

Table 2: Utah Feedstocks for Renewable Natural Gas

Source		Annual RNG Feedstocks	Potential Renewable Natural Gas (billion cubic feet/yr)	Range of Feedstock Carbon Intensity (g CO ₂ e/MJ)
Animal Manure	Swine – 1MM	1.2MM tons manure	3.7	(525)–(150)
	Cows – 95,000	2.6MM tons manure		
Landfill Gas	8 landfills	2.6 billion ft ³ biogas	1.0	40–80
Wastewater	2 facilities	92,000 gallons sludge	0.7	10–40
Food Waste	Wasatch RR	1MM ton food waste	2.7	(25)–0
Total Utah RNG Production			8.1	
Utah Natural Gas Demand in 2020			211.6	

Source: American Biogas Council, Utah Geological Survey, World Resources Institute, Utah State Agricultural Review

The U.S. government’s climate plan targets carbon neutrality by 2050.⁶ Under this plan, renewable natural gas would replace fossil-fuel natural gas as a heating fuel or transportation fuel (i.e., compressed natural gas and liquid natural gas).

Renewable Natural Gas Production Cycle

RNG generates from organic waste streams with varying degrees of process control. At one end of the spectrum, organic waste brought to landfills has little processing other than hooding to capture biogas. At the other end of the spectrum, an anaerobic digester (AD) is a sealed vessel containing microbes that break down organic waste. Process controls include retention time in the AD, optimization of vessel temperatures, and maintenance of an organic waste load rate to support a healthy microbial population. Each process results in renewable natural gas (i.e., methane). Other RNG pathways are gasification and power-to-gas that rely upon chemical reactions. Gasification converts waste streams into synthetic gases leading to methane formation. Power-to-gas electrolyzes water to produce hydrogen for conversion to methane. Each RNG pathway is assessed by a life cycle emission accounting to assess its carbon intensity.

Biogas Production Landfill is the oldest and most common form of waste disposal. Landfill operators confine waste to as small an area as possible and compact the waste to reduce volume. Soil, chipped wood, or other green waste covers the compacted waste daily. Decaying organic waste creates decomposition gases such as carbon dioxide and methane, which can be collected by blanketing the landfill. Eight of 54

Utah landfills currently collect biogas. Of these eight sites, four use biogas to support on-site operations, one creates compressed natural gas for vehicles, and four flare the gases.⁷

Anaerobic digesters capture biogas from food waste, animal manure, crop residues and wastewater sludge. These digesters replicate nature’s decomposition process under optimized, controlled conditions when bacteria in an oxygen-free environment break down plant and animal matter (see Figure 1). One product is biogas, composed of 50%–60% methane and 40%–50% carbon dioxide, plus solid digested material used as soil amendment.

- Biogas may produce heat and electricity for use in engines, micro turbines, and fuel cells.
- Upgraded biogas, stripped of its non-methane components, may be injected into natural gas pipelines.

Emission Benefits When RNG replaces fossil fuel natural gas, the emissions reductions improve the environment. A metric characterizing the RNG benefit is “carbon intensity” (CI), based on a life cycle emissions accounting (LCA) approach that estimates greenhouse gas (GHG) emissions associated with producing and consuming RNG. LCA impacts are compared to a reference case in which RNG is not produced and feedstocks are managed according to existing practices. Life cycle accounting steps include:

1. Avoided methane emissions at the feedstock source
2. Emissions from energy consumption for upgrading biogas to RNG
3. Methane leakage in the pipeline transport network
4. End-use emissions

Figure 1: Anaerobic Digestion Process



Source: Environmental and Energy Study Institute

The CI metric is the net grams of carbon dioxide equivalent (CO₂e) emitted per megajoule of energy over the life cycle.

RNG feedstocks (i.e., food waste, woody biomass, livestock waste, wastewater sludge, landfill biogas) have lower CI values than fossil natural gas and diesel fuel (see Figure 2).

The animal manure-to-RNG pathway has the largest negative CI (-525 to -150 grams CO₂e per megajoule of energy) because diversion of manure from open lagoons to hooded lagoons avoids methane emissions to the atmosphere. Methane is a powerful greenhouse gas with warming potential 28–34 times greater than carbon dioxide. Avoiding these methane emissions creates a large negative CI for the animal manure-to-RNG pathway.

The food/green waste-to-RNG pathway has CI's ranging from -20 to +10 grams CO₂e per megajoule of energy. However, this CI is an order of magnitude lower than the animal manure-to-RNG pathway due to transportation emissions and inconsistent quality of the food waste. That is, emissions for delivering food/green waste from widely dispersed locations (i.e., grocery stores, restaurants, food service locations) to the anaerobic digester are large relative to collecting animal manure from a herd of livestock collocated in a barn or livestock pen.

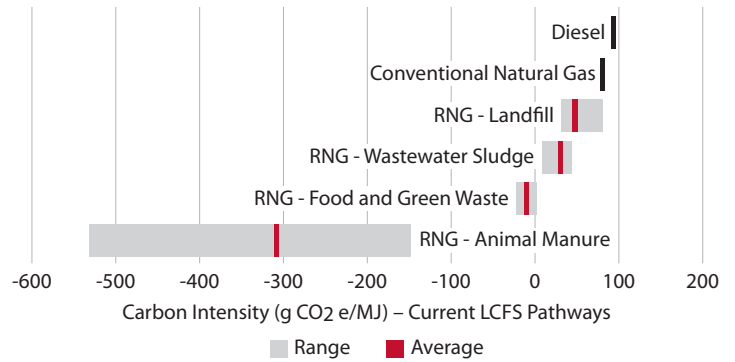
Renewable natural gas offers potential benefits in decarbonizing Utah's energy mix. However, some raise questions about 1) RNG's scalability to cover Utah's natural gas demand, 2) the economics of producing RNG, and 3) overall greenhouse gas impacts.

Scalability to Meet Demand Utah consumed 211 billion cubic feet of natural gas in 2020, with the residential sector accounting for one-third of total natural gas consumption (see Figure 3). Natural gas heats 4 in 5 Utah households.⁸

Utah's current RNG feedstocks could cover about 4% of Utah's natural gas consumption, approximating the starting points of the RNG mix ratio by both California and British Columbia utilities cited in the Overview.

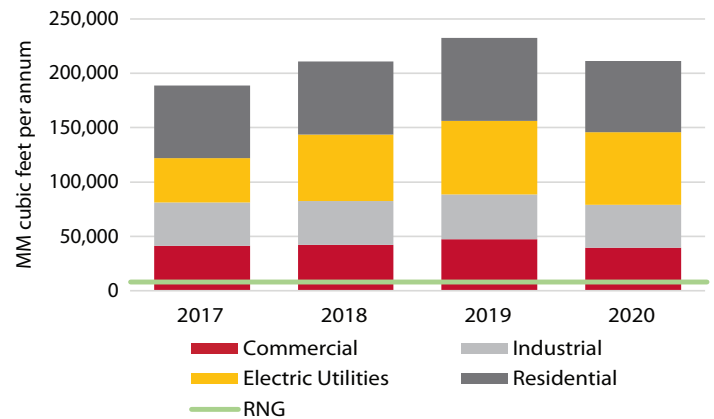
RNG production levels are currently limited by landfill, livestock, and food waste streams. However, future RNG production levels may increase when new technologies such as power-to-gas and thermal gasification are considered.

Figure 2: Carbon Intensity of RNG Feedstocks



Source: World Resources Institute, Renewable Natural Gas as a Climate Strategy; Guidance for State Policymakers

Figure 3: Utah Natural Gas Consumption, 2017–2020



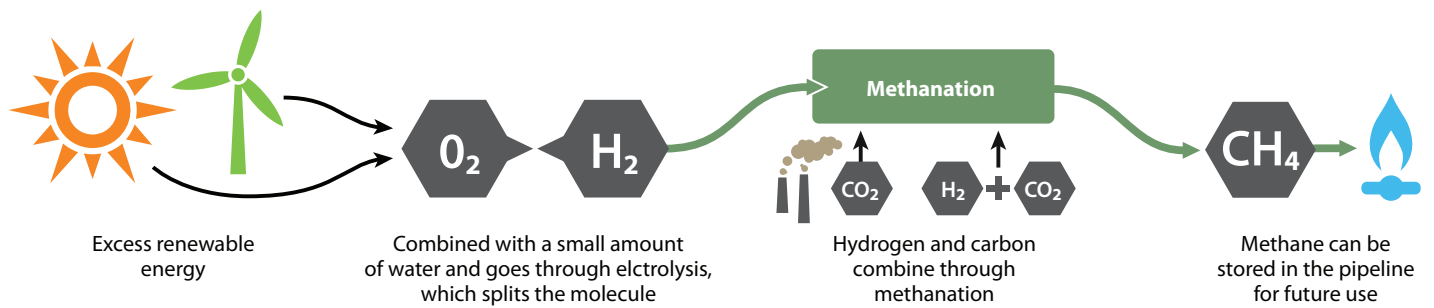
Source: Utah Geological Survey; Consumption of Natural Gas in Utah

Power-to-Gas Electricity produced from wind or solar is frequently surplus to utility system requirements because of renewable energy's intermittent generation. Utilizing this surplus renewable electricity in an electrolyzer creates oxygen (O₂) and green hydrogen (H₂). In the third unit of Figure 4, green hydrogen and carbon dioxide flow into a reactor, creating renewable natural gas (RNG) having no carbon footprint.

Green hydrogen, generated from renewable energies such as solar or wind, has no carbon footprint, whereas hydrogen from fossil fuels has higher carbon intensity. Figure 5 displays the pathways to gray, brown and blue hydrogen.

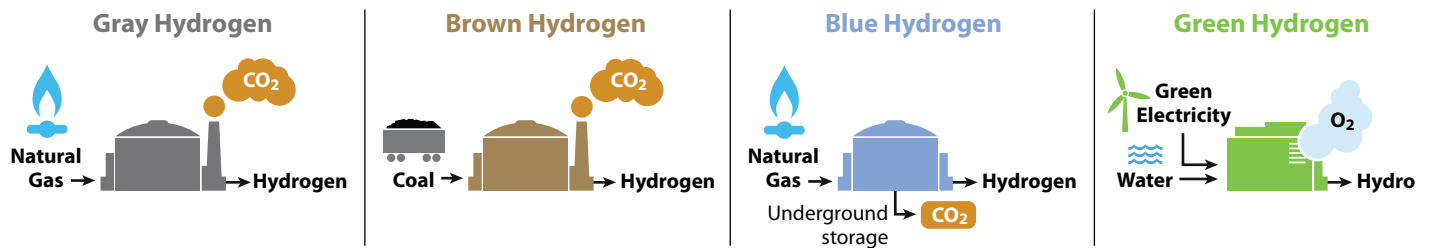
Green hydrogen will feature prominently in Utah's energy transition to lower-carbon-intensity fuels. The Intermountain Power Project (IPP) in Delta, Utah will fuel switch from coal to a mix of 70% natural gas and 30% green hydrogen in 2025. By 2045, green hydrogen will be the sole feedstock for IPP.

Figure 4: Power-to-Gas Creation of RNG



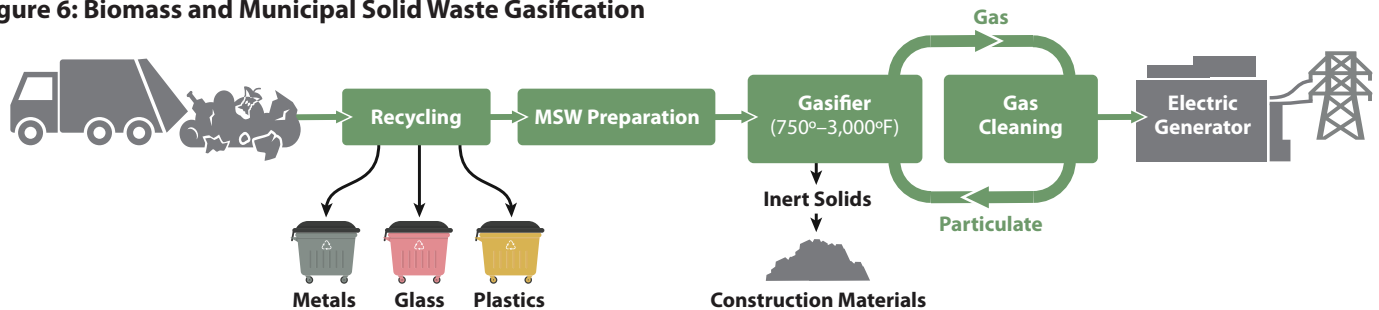
Source: SoCalGas; Imagine the Possibilities

Figure 5: Colors of Hydrogen Generation



Source: S&P Global Market Intelligence

Figure 6: Biomass and Municipal Solid Waste Gasification



Source: Zafar, Salman. (2009). Gasification of municipal solid wastes. *Energy Manager*, 2, 47-51; https://www.researchgate.net/figure/Schematic-of-MSW-Gasification-and-Power-Generation-Plant_fig1_285295261

Currently North America's only green hydrogen supplier, located in eastern Canada, produces 8,000 kilograms of green hydrogen per day. However, announced green hydrogen projects in North America will ramp up production to 290,000 kilograms per day by the middle of the decade.⁹

Mitsubishi Power, Magnum and Chevron formed a joint venture to produce, store and transport green hydrogen in the western United States. The joint venture, situated adjacent to IPP, will generate green hydrogen via electrolysis. This green hydrogen will be stored in an existing underground salt dome beneath IPP.

Thermal Gasification Gasification converts carbon-based raw materials such as biomass or waste products in a high-temperature/-pressure vessel into synthetic gas, an intermediate in the production of hydrogen and carbon dioxide (see Figure 6). Gasification is the leading technology for converting forest waste products and coal into hydrogen. While few gasification projects are in operation globally, this technology has potential to be a dominant waste-to-energy process. Challenges to thermal gasification include high capital costs, high operating costs, and the large scale required.

RNG's Role in Reducing Greenhouse Gas Emissions

This section examines how RNG deployment as a heating source for the residential and commercial sectors may decrease greenhouse gas emissions. The trend towards building electrification will be evaluated. Finally, RNG's utilization in heavy-duty vehicle fleets will be reviewed.

Heating Fuel in Commercial and Residential Sectors RNG diverts waste product-produced methane from entering the atmosphere, turning it into a usable energy source. Current Utah RNG potential feedstocks total about 4% of the state's natural gas demand. Injecting RNG into the natural gas stream delivered to industrial, commercial and residential sectors lowers the carbon intensity of fuel delivered by the gas utility.

Reducing carbon is a national policy interest. Natural gas delivered to commercial and residential buildings accounted for 11% of Utah's greenhouse gas emissions in 2018 (see Figure 7).

Municipalities and cities in other states have recently passed ordinances to electrify new buildings instead of delivering natural gas. Building electrification is a strategy to convert fossil fuel-based elements of daily activities to run on electricity so benefits of lower-carbon fuels are realized. However, electrification as a decarbonization strategy depends upon using electricity generated by low-carbon sources.

Comparison of electricity feedstocks in the western states illustrates how building electrification may have carbon

benefits for states with low-carbon-intensity electricity, but no carbon benefits for states with higher carbon-intensive electricity (see Table 3).

In Utah, electricity is 65% coal-fired. In this situation, building electrification in Utah would increase carbon emissions relative to buildings fueled by natural gas. Utah's electricity carbon intensity emissions factor is 1.65 lbs. CO₂ per kWh, compared with the natural gas emissions factor of 0.91 lbs. CO₂ per kWh.

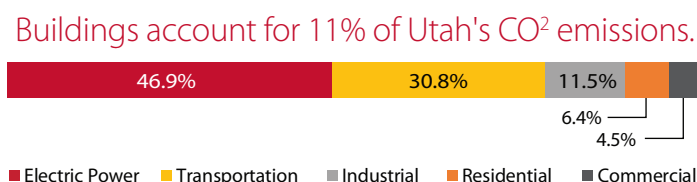
By contrast, Idaho's electricity comprises 76% renewables, the highest percentage among the western states, and 24% natural gas, long considered a transition fuel to achieve a smaller carbon footprint. More importantly, natural gas covers Idaho's baseload electricity demand when renewable energy sources become intermittent.

While newly built all-electric homes and buildings may be cost-competitive with homes using natural gas, retrofits can be considerably more expensive, depending on existing heating and cooking systems plus the cost of effectively converting them. In San Francisco, a recent study estimated costs for retrofitting a quarter million housing units using natural gas. Estimated retrofit costs ranged from \$14,000 to \$25,000 per unit.¹⁰

An alternative to the building electrification strategy has arisen. Modifying the utility natural gas streams to include RNG achieves carbon reduction. A Navigant Consulting study found that if 46% of SoCalGas natural gas delivered to residential customers were RNG, the emissions reduction would equal that achieved with building electrification.¹¹

Transportation Fuel RNG also serves as a vehicle fuel occupying the same market niche as fossil-fuel natural gas. RNG converts to either compressed natural gas (CNG) or liquefied natural gas (LNG), which are both interchangeable with fossil natural gas in servicing the heavy-duty vehicle market. LNG is more expensive to produce and store than CNG, but its higher

Figure 7: Commercial and Residential CO₂ Emissions in Utah, 2018



Source: U.S. Energy Information Administration

Table 3: Western States Electricity Feedstocks, 2019

State	Coal	Renewables	Natural Gas	Petroleum	Nuclear	Total	Pounds CO ₂ per kWh
Idaho	0%	76%	24%	0%	0%	100%	0.22
Washington	7%	70%	15%	0%	8%	100%	0.29
California	0%	48%	43%	0%	8%	100%	0.39
Oregon	4%	62%	34%	0%	0%	100%	0.40
Nevada	7%	28%	65%	0%	0%	100%	0.75
Arizona	20%	11%	41%	0%	28%	100%	0.82
New Mexico	42%	24%	34%	1%	0%	100%	1.26
Colorado	45%	25%	30%	0%	0%	100%	1.27
Utah	65%	11%	24%	0%	0%	100%	1.65
Montana	71%	7%	10%	0%	12%	100%	1.66
Wyoming	84%	13%	3%	0%	0%	100%	1.88

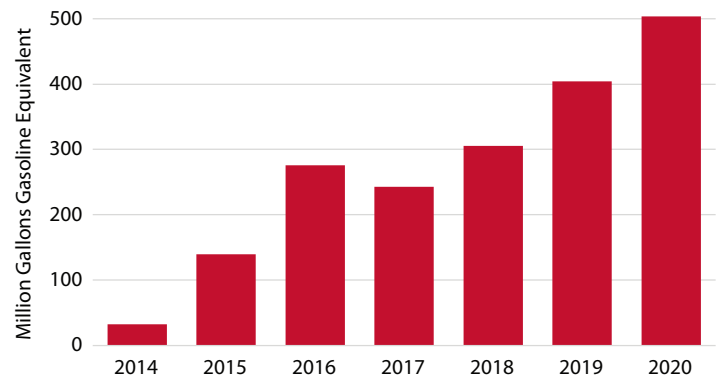
Note: Carbon intensity emissions factors are 2.21 lbs. CO₂ per kWh for coal, 0.91 for natural gas, and 2.13 for petroleum.

Source: US Energy Information Administration

density makes it preferable for long-distance travel. LNG and CNG are well suited to heavy-duty fleet vehicles refueling at a base location. About 9% of all U.S. heavy-duty trucks operate on natural gas.¹²

The Renewable Fuel Standard, created by the U.S. Congress in the 2005 Energy Policy Act, incentivizes blend stocks that lower greenhouse gas emissions. RNG's growth coincided with technical issues that prevented cost-effective cellulosic conversion of crop residues into liquid fuels. To fill this low-carbon fuel production gap created by technical issues, EPA administrators permitted RNG to receive incentives associated with the cellulosic category, spurring a rapid production increase from 2014 to 2016 (see Figure 8).

Figure 8: Renewable Natural Gas as a Transportation Fuel, 2014–2020



Source: U.S. Environmental Protection Agency, Public Data for the Renewable Fuel Standard

Community Benefits of Renewable Natural Gas

Benefits of renewable natural gas from waste products accrue to local and municipal operations in communities in Utah. Using biogas to generate electricity defrays operating expenses. Waste products that previously held no value are now converted into revenue streams by means of supplying renewable natural gas (e.g., Smithfield Hog Farms), transportation fuel (e.g., Bayview landfill), or electricity (e.g., Ballard, Sunderland, and Wadeland dairies).

Landfill Gas The Environmental Protection Agency's Landfill Methane Outreach Program (LMOP) tracks active landfills as well as landfills closed after 2000, since landfills continue to emit significant volumes of methane for over 20 years after closure. The LMOP database reveals the following about Utah:

- 27 of the 54 Utah landfill sites are operational.
- Eight sites collectively capture 7 million cubic feet of biogas per day, generating 10 MW electricity supporting on-site operations.
- The Bayview landfill site in Elberta will sell RNG into the transportation market starting in November 2021.

Community benefits include defraying landfill operating expenses by creating electricity and transportation-grade fuels.

Animal Manure Biogas from animal manure has high potential monetary value because its large negative carbon intensity creates credits in the federal Renewable Fuel Standard program and California's Low Carbon Fuel Standard program (see Figure 2 on page 4).

Prior to 2005, customary farm practice was to allow livestock manure to accumulate in an open lagoon, releasing methane vapors into the atmosphere. However, after Congress enacted the Energy Policy Act of 2005, programs at the federal and state level incentivized capture of methane vapors.

- **U.S. Renewable Fuel Standard (RFS)** The RFS credit for methane produced by animal manure from waste digesters was \$22 per MMBTU during early 2021.¹³ In July 2021, natural gas traded at \$3.75 per MMBTU, so the RFS credit was five times the market price of fossil natural gas.
- **California Low Carbon Fuel Standard** The California credit for RNG was \$45 per MMBTU in 2019,¹⁴ also a large multiple of the market price of fossil natural gas.

RNG volumes sold into California's transportation market attract stackable federal and state credits. These stackable credits create large incentives to generate motor fuels from RNG created from animal manure. However, this course of action is moderated by the following factors:

- California's natural gas transportation market will eventually saturate with new supplies of RNG.
- Financing RNG projects dependent upon federal and state credits may deter financing sources averse to regulatory and market risks.

Utah currently has five farm-related operational anaerobic digesters (see Table 4).

Farms with anaerobic digesters accrue the following benefits:

- Revenues diversify because spare digester capacity may attract non-farm organic waste deliveries with the farm gaining "tipping fees" for each delivery.
- Digesters improve soil health by converting nutrients in manure into a more accessible form for plants to use.
- RNG production converts into electricity powering on-farm needs, diminishing out-of-pocket expenditures for utility electricity.
- Digesters reduce odors from livestock manure, lessening negative impacts of farm operations on local communities.

Table 4: Utah Agricultural Anaerobic Digester Facilities

Name	City	Biogas Use	Attributes
Ballard Hog Farms	Benson	Cogeneration	Animals: 650 swine Electricity: 297 MWh/year
Smithfield Hog Production	Milford	Pipeline Gas	RNG production: 240,000 dekatherms
Sunderland Dairy	Chester	Electricity	Animals: 750 dairy cows Electricity: 369 MWh/year
Wadeland Dairy	West Weber	Cogeneration	Animals: 1,200 dairy cows Electricity: 823 MWh/year
Blue Mountain Biogas	Milford	Electricity	Animals: Swine Electricity: 3.2 MWh/year

Source: US Environmental Protection Agency, AgSTAR Livestock Anaerobic Digester Database

State Policies Supporting Renewable Natural Gas

The U.S. federal government recently rejoined the Paris Climate Accord and aims for carbon neutrality by 2050. Several states have assumed leading roles in adoption of RNG initiatives. This section examines financial incentives for anaerobic digesters, organic waste bans, and addition of RNG into fossil natural gas supplied by utilities.

Financial Incentives States have created financial incentives for capital equipment such as anaerobic digesters and pipeline infrastructure needed to inject RNG into existing natural gas infrastructure. Incentives include:

1. Direct state payments to defray capital expenditures. California SB457's monetary incentive program supports dairy cluster projects needing interconnecting pipelines to reach natural gas infrastructure.¹⁵
2. Tax exemption for RNG equipment. Washington State grants a 75% exemption on sales taxes for anaerobic digesters,¹⁶ effectively reducing the sales tax rate from 6.5% to 1.6%. The capital cost of an on-farm anaerobic digester ranges from \$400,000 to \$5 million depending on the number of livestock and technology.¹⁷ However, on the assumption that a typical on-farm anaerobic digester costs \$1.2 million pre-tax, the tax savings in Washington would amount to roughly \$60,000 per anaerobic digester.
3. Cost recovery of RNG capital equipment. Oregon's SB98 instructs the public utility commission to "ensure recovery of all prudently incurred costs," contributing to a laddered progression of RNG goals through 2050 set by lawmakers, starting at 5% in 2024 and peaking at 30% in 2050. Oregon's public utility commission confirmed the economic feasibility of Oregon utility ratepayers funding the buildout of RNG infrastructure.

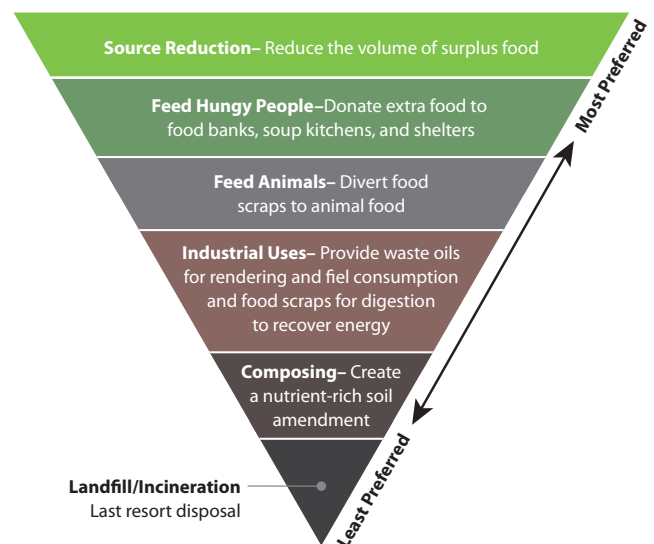
Wastewater Treatment Plants Utah has 20 wastewater treatment plants. The Central Valley Reclamation Facility (Salt Lake County) and the North Davis Sewer District (Davis County) use methane from anaerobic digesters to supply heat and power for plant operations. Each location has approximately 3,300KW of power demand. Electricity generated on-site covers approximately 85% of power demands, with the balance supplied by the local utility. Both locations provide bio-solids to fertilize alfalfa hay crops and turf grass production.

Organic Waste Bans New York's legislature passed the 2019 Food Donation and Food Scrap Recycling Act, a step forward in preventing food waste, rescuing surplus wholesome food for those in need, and recycling any remaining food scraps.

Forty percent of food in the U.S. is wasted. Food amounts to 18% of the solid waste streams sent to landfills, where decomposing organic materials release methane into the atmosphere. If global food waste were a country, it would be the third largest emitter of methane after the United States and China.¹⁸ Redirecting food waste to anaerobic digesters avoids methane release and creates RNG.

The Environmental Protection Agency frames the food waste issue in humanitarian terms. Ideally, food production would match demand, thereby saving land, water, and energy tied to food waste. The next highest priority is alleviation of hunger, while creation of energy is the lowest priority (see Figure 9).

Figure 9: Recovery of Food Waste



Source: Natural Resources Defense Council

State Legislatures and Public Utility Commissions Adding RNG into fossil natural gas deliveries to rate-paying utility customers would incur additional costs such as biogas upgrading and interconnections services from a cluster of hog farms to the utility pipeline.

Two regulatory principles potentially impede RNG integration into fossil natural gas delivered to ratepayers. Public utility commissions govern utility rates, allowing utilities to recover capital asset investments with an associated rate of return. The “least cost” regulatory principle requires utilities to demonstrate their investments represent the lowest-cost option while maintaining reliable service. The “used and useful” principle requires assets be physically used and useful to current ratepayers before those ratepayers pay the costs associated with them.

State legislatures have introduced innovative policies by issuing instructions to the public utility commission, implementing pilot programs to include environmental benefits in the assessment of the “least cost” determination, or allowing ratepayers to self-select for higher utility payments.

Issuing Instructions When Oregon’s legislature passed SB98 in 2019, the legislature instructed the public utility commission to adopt a statewide rule to implement RNG target goals while providing a ratepayer protection plan against higher costs due to biogas conditioning and interconnection services. SB98 states that the natural gas utility’s incremental annual costs may not exceed 5% of “total annual revenue requirement,” thereby protecting Oregon ratepayers from excessively higher costs.

Pilot Programs Utilities may narrowly define an RNG pilot program in order to gain flexibility on the “least cost” regulatory principle. Nicor Gas, an Illinois natural gas utility, obtained pilot program approval from the state’s public utility commission to interconnect RNG into Nicor’s natural gas distribution system.

Conclusion

Renewable natural gas facilitates decarbonization of Utah’s energy mix. RNG feedstocks comprise waste streams from livestock, landfills and food. Recycling these waste streams avoids the release of methane, which has warming potential 28–34 times greater than carbon dioxide. Life cycle accounting of RNG pathways enables policymakers to assess environmental benefits.

Utah RNG volumes could supply 4% of Utah’s fossil natural gas demand. Blending Utah’s current RNG production volumes with fossil natural gas would approximate the starting point for RNG introduction set by California and British Columbia utilities.

Power-to-gas and thermal gasification technologies could enable RNG growth. Power-to-gas is likely in Utah because fuel

Table 5: Vermont RNG Adder Costs

Blend Ratio with Fossil Natural Gas	Annual Cost
10%	\$112
25%	\$280
50%	\$559
100%	\$1,118

Notes: Annual residential natural gas consumption is 90,000 cubic feet. The fossil natural gas price was \$13.14 per thousand cubic feet. Source: Vermont Gas

The Illinois ruling permits capital investment up to \$16 million and allows Nicor Gas to collect an associated tariff.

Voluntary Green Premium Program Making an RNG program voluntary allows self-selection by individual ratepayers for higher costs, avoiding the “least cost” regulatory requirement for this subset of ratepayers willing to pay a “green premium.” Vermont Gas allows residential and commercial ratepayers to select an RNG blend percentage. Participants pay an “adder” price based on the difference in cost between fossil natural gas and RNG. Ratepayers choose RNG program participation at various tranches (e.g., 10%, 25%, 50%, and 100%) of their monthly natural gas usage. Table 5 shows levels of estimated “adder” costs for the Vermont program.

Dominion Energy initiated its own voluntary green premium program, GreenTherm, in 2020. Ratepayers elect a number of green attributes added as a surcharge to their monthly gas bill. A green attribute certifies production of RNG and the surcharge acknowledges environmental benefits from carbon-free fuels. A typical Utah residential customer consuming 80 dekatherms per annum would pay \$400 annually for RNG attributes. By capturing methane released from organic waste and repurposing it as RNG, the program reduces contributions to climate change and improves air quality.

switching in 2025 at the Intermountain Power Plant will increase green hydrogen availability.

State policies and local utility actions in Oregon, Washington, California, Illinois and Vermont facilitate RNG growth by offering financial incentives for investment in anaerobic digesters. Cooperation between the state legislatures and public utility commissions has facilitated commingling of renewable natural gas and fossil natural gas while providing ratepayer protection against higher costs due to biogas upgrading and interconnection to utility pipelines.

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