AMERESCO REPORT

Beyond Hydrogen:
Renewable Natural Gas and Deep Decarbonization

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INTRODUCTION

Shifting sentiment on fossil gas

The urgent need to develop alternatives to fossil gas is underscored on a near-daily basis. Russia's invasion of Ukraine, for example, prompted the European Union to pledge a two-thirds reduction in its purchases of Russian gas by the end of 2022. The U.S. Congress also voted to ban imports of Russian gas, although the shale boom has made America a net exporter of fossil gas, also known as natural gas.

Energy security and diplomatic maneuvers to punish Russian aggression are perhaps the most recent obvious drivers of increased interest in developing cost-effective and decarbonized gas options.

Even before the war on Ukraine began, the International Energy Agency stated in 2021 that there should be no new development of oil, coal or gas projects if the world wants to reach net-zero emissions by 2050. Earlier this year, the Los Angeles City Council voted to ban fossil gas appliances in new homes. Other cities have taken similar actions, including over 50 California municipalities and other major U.S. cities, including New York, Denver and Seattle. And as the escalating climate crisis is felt everywhere in the form of heat waves, wildfires, floods and storms that are made worse by climate change, the task of building local, resilient energy options has also taken on new urgency.

Many decarbonization goals also depend on reductions in methane emissions, the primary component of fossil gas. At last year's COP26

gathering in Glasgow, over 100 countries, including the U.S., signed on to the Global Methane Pledge to reduce emissions by 30 percent from 2020 levels by 2030. The focus on reducing methane emissions is because of its outsized warming potential, which is 25 to 34 times that of carbon dioxide, according to the U.S. Environmental Protection Agency. In particular, capturing methane from sources where it would otherwise end up in the atmosphere is critical.

A nascent market ready for rapid growth

Renewable and clean gas options available today represent a tiny fraction of the overall market for fossil gas. To achieve ambitious decarbonization goals set forth by countries, states, municipalities and corporations, alternative fuels need to scale quickly.

That conviction is gaining traction. In its recently released plan to achieve carbon-neutrality by 2045, the California Air Resources Board repeatedly highlighted the importance of zero- or low-carbon gas as a tool to decarbonize industrial facilities. Emerging alternatives to fossil gas include green hydrogen and biomethane, the latter of which is also known as renewable natural gas (RNG).

Green hydrogen, which uses renewable energy to power the electrolyzers that split water into hydrogen and oxygen, is a particularly hyped technology of late. Green hydrogen can also be produced from steam reforming of RNG.

Dozens of countries, including the U.S. and China, have developed strategies for the development of green hydrogen as a way to achieve net-zero targets. In June 2022, the Biden administration announced that $8 billion from the Bipartisan Infrastructure Law will be invested in developing regional hydrogen hubs.

This substantial base of support means that hydrogen will likely play a major role in the energy transition. But the reality is that green hydrogen is a decarbonization tool that faces a number of hurdles before it becomes widely adopted. By contrast, RNG is an alternative fuel option for fossil gas that is already in use today, particularly in transportation. Not only does RNG have the capacity to scale quickly, but it also has the potential to augment and support the development of green hydrogen.

This paper will explore:

- The current and future market prospects for RNG, including essential policy drivers.
- How RNG can complement and help drive the coming green hydrogen boom.
- The benefits and long-term implications of an RNG project in Phoenix, Arizona.
- The lessons for RNG that can be drawn from the growth of solar and battery energy storage.

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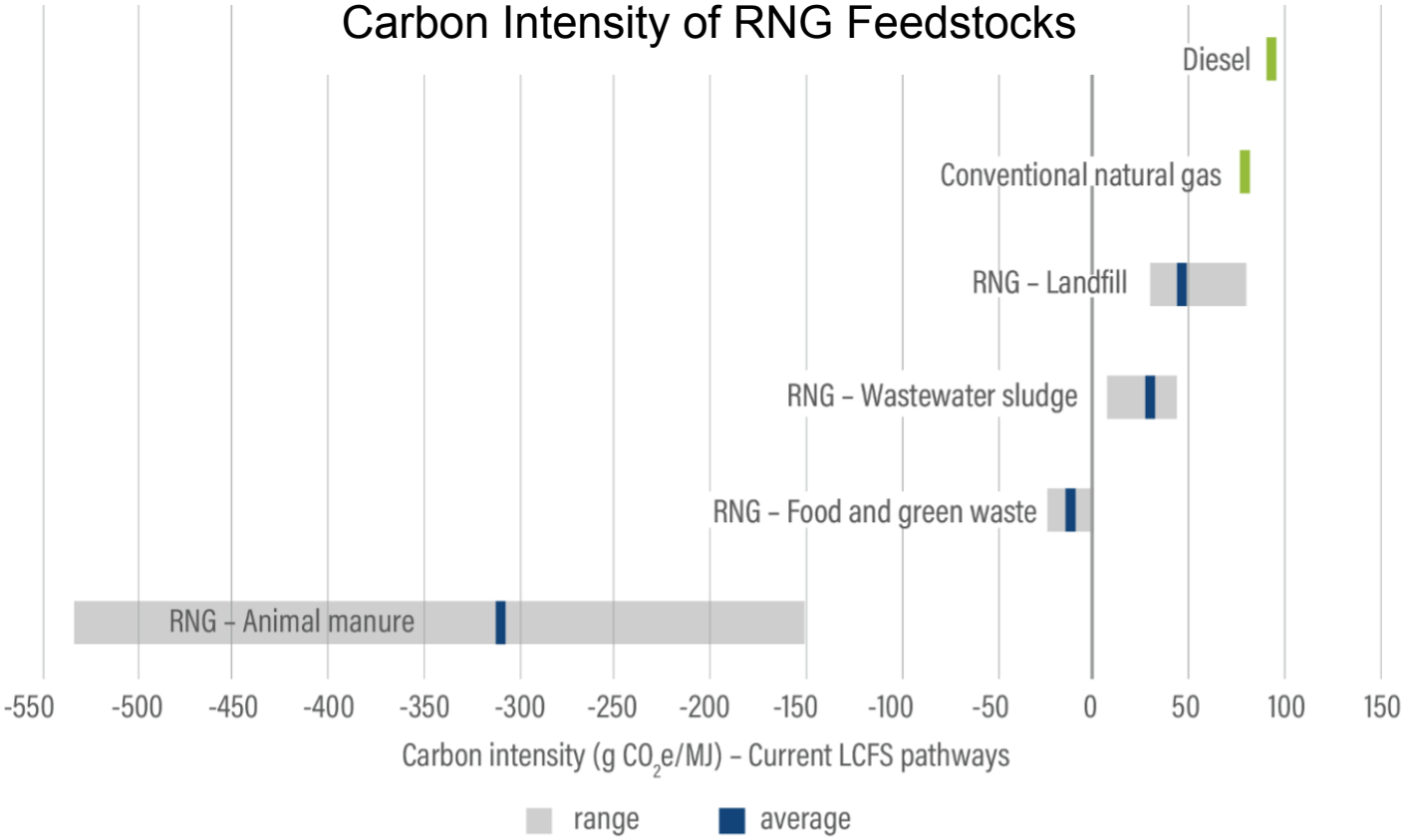
The basics of renewable natural gas

RNG is an alternative to fossil gas. It is produced by refining biomass and other renewable resources into gas (composed primarily of methane) that can be used in existing natural-gas pipeline networks. The feedstock for RNG can be found in landfills, livestock farms, wastewater treatment facilities and food waste.

The natural decomposition of organic waste at these facilities releases methane into the atmosphere. The U.S. Environmental Protection Agency reports that nearly 30 percent of human-caused methane emissions in the country come from organic waste at water resource recovery facilities, landfills and farms, so capturing it is a crucially important component of reducing carbon emissions.

The process for producing RNG takes organic waste, an existing source of methane that would otherwise be released into the atmosphere, and captures it to make RNG. The treatment process for creating RNG involves removing moisture, particulates, carbon dioxide and contaminants, as well as reducing nitrogen and oxygen levels. The finished product can then be transported in the existing pipeline infrastructure. Depending on the source, RNG can have a negative carbon-intensity — a measure that takes into account emissions from production through consumption — and all RNG has a lower carbon-intensity than fossil gas, according to the World Resources Institute.



Notes: "Green waste" in the above pathway refers to yard clippings, grass, leaves, and brush (e.g., from residential curbside pickup programs that is codigested with food waste).
g CO_2e/MJ = Grams of carbon dioxide equivalent per megajoule.
Source: Based on raw data from CARB (2020a), modified by WRI.

The potential to reduce emissions by expanding RNG production and consumption is notable. According to WRI, existing organic waste streams are sufficient to produce enough RNG to replace up to 7 percent of the fossil gas consumed in the U.S. The report also notes that in all scenarios, RNG has a lower carbon-intensity than fossil gas, especially when it is made from diary manure. Like fossil gas, however, the carbon-intensity of RNG depends on many factors, including the feedstock and pipeline infrastructure.

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RNG: A complement to other low-carbon fuel sources

Green hydrogen

The momentum of green hydrogen production strongly indicates that it will play a role in the future of energy. But “future” is the operative word here. Bloomberg New Energy Finance forecast in its 2021 New Energy Outlook that hydrogen made from any type of power, clean or dirty, would account for 22 percent of final energy consumption in 2050, compared to just .002 percent today. Still, despite hydrogen’s significant long-term role in reducing emissions, RNG is poised to have a more substantial impact in the short and medium term. That’s because RNG can be distributed using existing fossil gas pipes and hydrogen cannot. In order to transport hydrogen, extensive pipe retrofits will have to be undertaken, and optimal hydrogen blending rates will have to be determined, both of which will require a substantial investment of time and money.

Other issues could also come into play that could limit the potential of green hydrogen. One constraint is the process of electrolysis, a method used to make green hydrogen using renewable electricity. Electrolysis uses electricity to split water into hydrogen and oxygen. In drought-stricken states across the Western U.S., it’s hard to imagine there will be much appetite for using copious amounts of water to make green hydrogen. Currently, the cost of producing green hydrogen using electrolysis is falling, but it is still much higher than the cost of conventional fuel sources.

Another method for making green hydrogen could benefit from RNG. Steam methane reforming (SMR) technology creates hydrogen from a methane source with the help of steam and a catalyst. RNG can be used as a base feedstock for green hydrogen without overtaxing limited water resources. According to the U.S. Department of Energy, most of the hydrogen produced in the U.S. today is made using SMR technology in tandem with non-renewable electricity and fossil gas.

Biomethanol

Hydrogen is not the only future fuel source that RNG could complement. Methanol, an essential and versatile chemical element used in gasoline, solvents and antifreeze, is now manufactured using fossil gas. But if the fossil gas used in the manufacturing process is replaced with RNG, conventional methanol becomes biomethanol, also known as renewable methanol. What's more, the carbon dioxide captured during the RNG upgrade process can be put to use to produce biomethanol when hydrogen is used as a feedstock.

The right policy supports are vital to unlock the benefits of RNG

RNG alone can't get us to economywide decarbonization — but it is a vital piece of the puzzle. However, with smart policy in place, RNG can play an important role alongside renewable energy, energy efficiency, green hydrogen and other solutions to drive cost-effective decarbonization for governments and businesses.

The growth of solar over the past decade demonstrates how clean technologies can scale with targeted support. According to the National Renewable Energy Laboratory, utility-scale fixed-tilt solar projects cost $4.75 per watt to install in 2010. By 2020, the cost per watt had declined to less than $1.

Government incentives that encouraged solar installations in the U.S. and globally were able to increase demand while spurring massive expansions in manufacturing capacity that drove down costs. With a beneficial policy environment in place, RNG and green hydrogen could also follow this growth trajectory. In fact, this is already happening in states such as California and New Hampshire that are showcasing pathways forward that other states could duplicate.

Lessons from Arizona

Even today, RNG is already being used to support the potential development of green hydrogen. In Phoenix, Arizona, biogas culled from one of the country's largest wastewater treatment facilities is being used to create 693,500 dekatherms of RNG annually that are injected into a nearby commercial natural-gas pipeline. The Phoenix RNG processing facility, which is owned and operated by Ameresco, is the largest of its kind in the U.S. and is expected to reduce the equivalent of nearly 45,000 metric tons of carbon dioxide annually while also creating jobs.

Early in 2022, Ameresco announced its participation in a pilot project to scale clean hydrogen by leveraging RNG. It will investigate the use of RNG produced at Ameresco's Phoenix facility as a feedstock to make low-carbon hydrogen for use in heavy-duty trucking transport along the I-10 corridor between Southern California and Phoenix. Adding steam methane reforming to existing RNG production facilities could help speed up clean hydrogen production for transportation and other uses.

Recent policy changes, corporate imperatives spur RNG

In California, the switch to RNG is already underway, and the use of natural gas as a transportation fuel has declined as RNG has replaced it, according to the state's Air Resources Board. Because of its climate benefits compared to fossil gas, RNG is eligible to participate in California's Low Carbon Fuel Standard program. Incentives such as LCFS and the federal government's Renewable Fuel Standard have helped steadily grow the market for RNG as a transportation fuel over the past several years. In 2021, RNG made up 64 percent of all on-road fuel used by the 175,000 natural-gas-powered vehicles in the U.S., according to industry group NGV America.

RNG holds immense potential to replace fossil gas as a transportation fuel in natural-gas-powered vehicles. But RNG's potential stretches far beyond the transportation sector. In fact, transportation consumes just 3 percent of natural gas in the U.S., according to the U.S. Energy Information Administration, with electric power production followed by industrial processes using the majority of gas supply.

The growing recognition of RNG as a tool to help drive deep decarbonization across the entire economy has led to a flurry of recent policy and regulatory measures that could help dramatically scale its deployment across the country. In February 2022, for example, California approved biomethane procurement targets as part of the state's goal to

reduce methane emissions by 40 percent by 2030. By that same year, the investor-owned gas utilities in California regulated by the state's Public Utilities Commission will be required to procure nearly 73 billion cubic feet of RNG annually, an amount equal to about 12 percent of the fossil gas usage by those utilities' residential and small-business customers in 2020.

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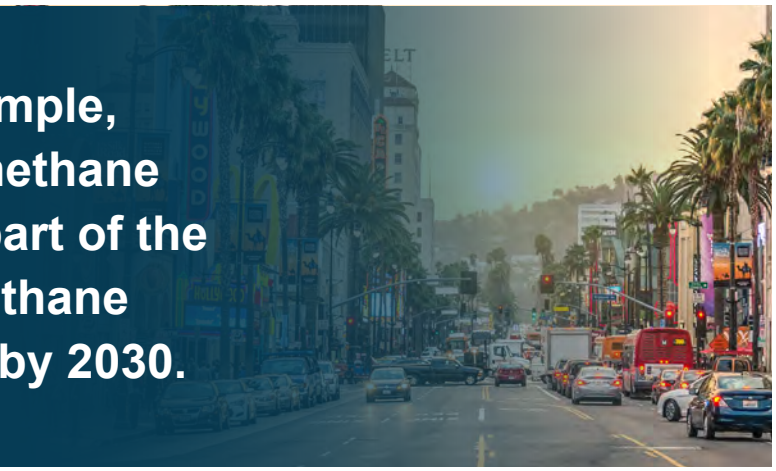
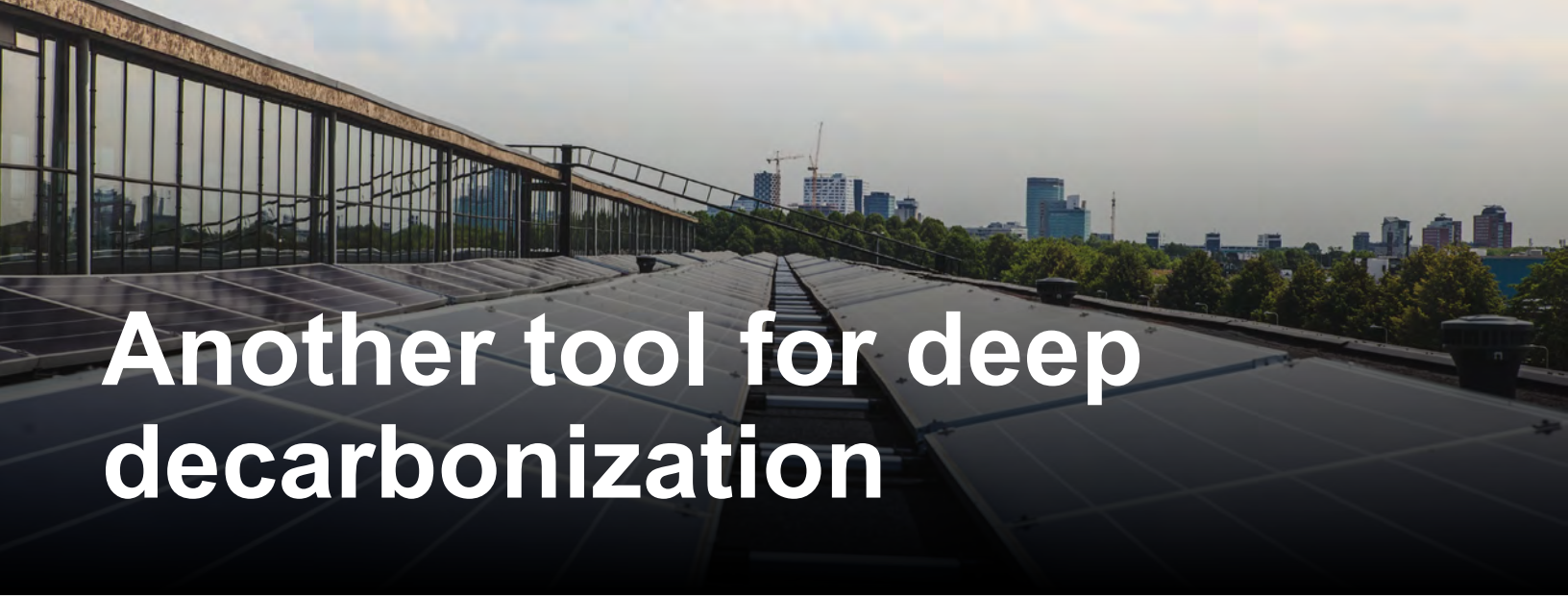


California isn't alone in adopting policies to encourage the broader use of RNG. New Hampshire also recently passed legislation that allows utilities to procure up to 5 percent of their total gas supply from RNG. Washington and Oregon also have programs similar to California's Low Carbon Fuel Standard program, and a handful of other states have low-carbon fuel goals that include RNG. In some cases, utilities are voluntarily targeting RNG goals that exceed policy mandates; SoCalGas in California plans to replace 20 percent of its gas supply with RNG by 2030.

Another significant driver of RNG development came to pass in March 2022 when the U.S. Securities and Exchange Commission released a draft rule requiring companies to disclose greenhouse gas emissions as well as "actual or likely material impacts" that climate-related risk will have on their business. This rule has already prompted many corporations to evaluate RNG as a solution to reduce or eliminate carbon emissions and risk from their balance sheets. Additionally, the recently passed Inflation Reduction Act includes tax credits for certain biogas facilities and for using RNG as a feedstock for hydrogen production.



Another tool for deep decarbonization

For many stakeholders, the interest in RNG is how it pencils out economically as a cost-effective decarbonization solution. Although RNG remains more expensive than traditional fossil gas, corporations are shifting their priorities and looking for low-carbon solutions in all aspects of their business given the focus on environmental, social and corporate governance. In a push to move away from fossil fuels, corporate buyers of RNG are seeking the lowest-cost ways to remove each ton of carbon dioxide emissions from their balance sheet.

For companies whose operations currently involve burning fossil gas, RNG may be both the lowest-cost and most immediately viable pathway toward decarbonization. In a report ICF produced for the American Gas Association, ICF found the per-ton cost of reducing emissions with RNG is less than that of electrification.

It will take all commercially available solutions to tackle decarbonization in this decade. Innovation of existing technologies and the inclusion of renewable gas options could present an enormous opportunity for carbon reduction through alternative fuels. We need to work together and utilize all of the tools available, including RNG, to scale quickly enough to reach the ambitious decarbonization goals that can help mitigate climate change.

Get started today with RNG:

www.ameresco.com/renewable-natural-gas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