CEAP | CLEAN ENERGY ACCOUNTING PROJECT

CLEAN FUELS IN THE RESIDENTIAL AND COMMERCIAL SECTOR

Background Report | August 2024

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Key Takeaways

- The residential and commercial sector contributes significantly to greenhouse gas (GHG) emissions. Heating and cooking are typically the main fuel consuming activities within the sector.
- There is increasing interest and support for clean fuels such as biomethane and bioLPG in this sector, evident from their adoption in countries like the UK and other European nations. Large corporations are also actively supporting the expansion of bioLPG.
- Many fuels used in the residential and commercial sector can be blended with conventional fuels to reduce overall GHG emissions, but wide adoption of this method is limited by cost and infrastructural challenges.
- While there is a lack of comprehensive regulations and initiatives at the federal level, various U.S. states and regions are implementing programs to incentivize the adoption of clean fuels such as biomethane and green hydrogen.

1. Introduction

The residential and commercial sector is largely dependent on fossil fuel use and contributes to a significant portion of annual global GHG emissions. Roughly two thirds of heating around the world is still powered by fossil fuels.[1] In 2010, the residential and commercial sector accounted for 6% of the total global GHG emissions.[2] Decarbonization in this sector has been advanced through two primary methods: electrification and a shift towards clean fuels. One of the main constraints to a more rapid decarbonization of this sector is the need for widespread infrastructural modifications to the appliances that currently operate using fossil fuels in homes and buildings. As many regulations and initiatives in this sector are still in their beginning stages, the information of market-based instruments to account for clean fuels is limited. However, certificate-based systems are being considered by several programs as an instrument to track and account for clean fuels in the residential and commercial sector.

This document includes a summary of the residential and commercial sector's key fuel consuming scale and scope, production and distribution characteristics of the clean fuel types available, and examples of relevant regulations and initiatives.

2. Residential and Commercial Sector Overview

This document focuses on heating and cooking, the highest fuel-consuming activities in this sector, and specifically their consumption of natural gas and petroleum-based fuels.[3] Innovative technologies, like geothermal heat pumps, along with the transition to clean fuels will play an important role in decarbonizing the residential and commercial sector.

Heating

While alternative heating methods like geothermal heat pumps are becoming more widely available, most heating worldwide still relies on fossil fuels. Heating in this sector can include gas powered water heaters, fireplaces, and fire pits, but the most common conventional fuels that are used for residential and commercial heating are natural gas and propane (LPG). Natural gas is generally distributed to homes and buildings through designated pipeline systems,[4] while propane is more commonly delivered to end-use customers in trucks.[5] One alternative method for heating that doesn't require infrastructural modifications is the blending of clean fuels into existing pipelines to lower the volume of fossil fuels distributed to homes and buildings.

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[1] IEA. Heating. https://www.iea.org/energy-system/buildings/heating
[2] US EPA. Global Greenhouse Gas Emissions Data | Greenhouse Gas (GHG) Emissions | US EPA. (n.d.). https://climatechange.chicago.gov/ghgemissions/global-greenhouse-gas-emissions-data
[3] US EPA. Sources of greenhouse gas emissions. https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions
[4] ,U.S. EIA. Delivery and storage of natural gas - U.S. Energy Information Administration (EIA). https://www.eia.gov/energyexplained/natural-gas/delivery-and-storage.php
[5] U.S. DOE. Propane Production and Distribution. https://afdc.energy.gov/fuels/propane_production.html

There are several low carbon fuels that can be blended into existing natural gas carrying pipelines at low volumes. Biomethane[6] and bioLPG[7] are low carbon drop-in fuels that can used interchangeably with natural gas and propane respectively. Hydrogen can also fuel heating activities, though this method is not currently widely used due to associated costs and lack of compatibility with existing infrastructure and equipment.[8]

Cooking

Cooking appliances in residential and commercial settings, like stoves and ovens, are typically either gas or electric powered. Gas powered cooking appliances operate using the same fuels as heating appliances: natural gas and propane.

3. Clean Fuels in this Sector

The primary clean fuels used in the residential and commercial sector are biomethane and bioLPG. Hydrogen as a clean fuel in this sector is not widely used because many existing gas-powered appliances are not hydrogen-compatible. Hydrogen can be blended with natural gas at low volumes and fuel many existing natural gas-powered appliances.[9] Hydrogen, along with several other alternative fuels, is being considered internationally in the residential and commercial sector as a potentially promising alternative to natural gas and propane which are currently the two most widely used conventional fuels in this sector.

3.1. Biomethane (RNG)

Production Process and Feedstocks

Biomethane, or renewable natural gas, is primarily produced through anaerobic digestion or gasification. To produce biomethane, conventional natural gas must go through a purification process called upgrading.[10] The most common feedstocks used in biomethane production are animal manure, organic municipal solid waste, and wastewater sludge.[10]

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[6] IEA. An introduction to biogas and biomethane. https://www.iea.org/reports/outlook-for-biogas-and-biomethane-prospects-for-organic-growth/an-introduction-to-biogas-and-biomethane
[7] SHV Energy. (n.d.-a). BioLPG. https://www.shvenergy.com/what-we-do/sustainable-fuels/biolpg
[8] Guardian News and Media. (2023, December 13). UK government backs plan to ban gas and "hydrogen-ready" boilers. https://www.theguardian.com/business/2023/dec/13/uk-government-backs-plan-ban-gas-hydrogen-ready-boilers-newbuilds-2025
[9] U.S. DOE. Hyblend: Opportunities for hydrogen blending in natural gas pipelines. https://www.energy.gov/eere/fuelcells/hyblend-opportunities-hydrogen-blending-natural-gas-pipelines
[10] IEA. An introduction to biogas and biomethane. https://www.iea.org/reports/outlook-for-biogas-and-biomethane-prospects-for-organic-growth/an-introduction-to-biogas-and-biomethane

Distribution Networks

Biomethane is generally distributed via dedicated biomethane pipelines or existing natural gas pipelines.[11] In the residential and commercial sector, biomethane can be used in its pure form or as a blend with natural gas in conventional natural gas-powered appliances.

Biomethane is commonly used as an alternative to natural gas across European countries. Denmark has already displaced a large portion of natural gas on the national gas grid with biomethane and aim to completely transition to 100% biomethane by 2030.[12]

3.2. Renewable Hydrogen

Production Process and Feedstocks

The two most common methods for producing hydrogen are natural gas reforming (also known as steam methane reforming or SMR) and electrolysis.[13] Natural gas reforming is currently used to produce approximately 95% of the hydrogen in the world.[14] For hydrogen to be considered "renewable", the production process must be powered by renewable resources.[15]

Recent policy such as the United States Inflation Reduction Act (IRA) Section 45v and the European Union Hydrogen Directive have proposed a three-pronged approach for determining the "cleanness" of hydrogen production. These three pillars are Incrementality/Additionality (is the clean energy used for hydrogen production new or would it have gone online without this incentive?), temporal matching (matching the hour of generation of the renewable source to the hour of hydrogen production), and deliverability/geographical correlation (how close the renewable source is to the hydrogen facility).

Distribution Networks

Distribution networks for hydrogen are still largely undeveloped. In the United States, the majority of hydrogen is currently distributed through high-pressure tube trailers, and liquefied hydrogen tankers.[16] Due to the lack of infrastructure for hydrogen distribution in the United States, the fuel is generally used close to the production sites.[16] Hydrogen can be transported in existing natural gas pipelines at low volumes,

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[11] Storage and Transportation of Biogas and Biomethane. https://suscon.org/pdfs/cowpower/biomethaneSourcebook/Chapter_4.pdf
[12] Robb, S. (2022, December 15). Denmark heads for 100% biomethane by 2030. Free. https://www.farmersjournal.ie/more/climate-and-environment/denmark-heads-for-100-biomethane-by-2030-740055
[13] U.S. DOE. Hydrogen Basics. https://afdc.energy.gov/fuels/hydrogen_basics.html
[14] Methane Steam Reforming. https://www.sciencedirect.com/topics/engineering/methane-steam-reforming
[15] Electrolysis using renewable electricity demonstrated through the retirement of renewable energy certificates (RECs) is the primary method for producing renewable hydrogen.
[16] U.S. DOE. Hydrogen production and distribution. https://afdc.energy.gov/fuels/hydrogen_production.html

though the logistics of this delivery option are still being researched. In cases where hydrogen could be delivered in natural gas pipelines, the molecules would not be disaggregated at the site of consumption; rather, hydrogen and natural gas would be used as a blend.[17] Hydrogen delivery through natural gas pipelines could present an opportunity for market-based accounting in the residential and commercial sector.

Hydrogen distribution networks in European countries like Germany and France are also being constructed. Hydrogen is commonly distributed in Europe through dedicated hydrogen pipelines. Europe plans to develop cross-border hydrogen distribution networks, like the proposed hydrogen pipeline through Spain, France, and Germany.[18] The market for transacting green hydrogen in Europe is still being developed and is largely dependent on funding for the infrastructure programs.[19]

3.3. BioLPG

Production Process and Feedstocks

BioLPG is a clean drop-in fuel that can be used in place of liquefied petroleum gas (LPG).[20] LPG is a term that can be used for both propane and butane.[20] While conventional LPG is derived from natural gas, bioLPG uses renewable feedstocks in its production process. The primary feedstocks in bioLPG production are renewable waste materials including vegetable oils, waste materials from food processing, and waste fat from fish processing.[20] BioLPG is generally produced through a process of hydrotreating vegetable oil (HVO).[21]

Distribution Networks

Like conventional propane, bioLPG is mainly transported in trucks rather than pipelines and can be used with compatible appliances in either its pure form or blended with conventional LPG.[20]

Other Key Facts

BioLPG is becoming more common in the UK and in European countries including France and Sweden with large corporations like La-Roche-Posay and Circle K supporting the clean fuel's expansion.[21]

4. Regulations and Initiatives

[17] U.S. DOE. Hyblend: Opportunities for hydrogen blending in natural gas pipelines. https://www.energy.gov/eere/fuelcells/hyblend-opportunities-hydrogen-blending-natural-gas-pipelines
[18] Offshore. Hydrogen pipelines start to materialize in France, Germany and Spain. Offshore. https://www.offshore-mag.com/regional-reports/north-sea-europe/article/14292219/rystad-energy-hydrogen-pipelines-start-to-materialize-in-france-germany-and-spain
[19] The value of green hydrogen trade for Europe. RMI. https://rmi.org/insight/the-value-of-green-hydrogen-trade-for-europe/
[20] BioLPG. https://www.wlpga.org/wp-content/uploads/2021/03/BioLPG-Charter-of-Benefits.pdf
[21] SHV Energy. BioLPG. https://www.shvenergy.com/what-we-do/sustainable-fuels/biolpg

Regulations and initiatives specifically supporting clean fuels in the residential and commercial sector are limited. Biomethane is more commonly used as an alternative to natural gas across European countries. Denmark has already displaced a large portion of natural gas on their grid with biomethane and aim to reach 100% biomethane by 2030. In the United States, the U.S. Department of Energy's HyBlend initiative is the most prominent regulation in the sector. However, there are several programs that are in the process of being established by U.S. states that support the injection of clean fuels onto local gas grids. There are also several regulations that have been introduced by local governments limiting the use of conventional gas-powered appliances.

4.1. HyBlend (U.S. Department of Energy)

The HyBlend initiative was established by the U.S. Department of Energy in 2021 and functions in collaboration with several industry partners including the National Renewable Energy Laboratory (NREL) and Argonne National Laboratory[22]. The initiative aims to support the expansion of hydrogen in the United States specifically through pipeline distribution.[22] There is currently over 1,600 miles of dedicated hydrogen pipeline in the United States and roughly 3 million miles of natural gas pipeline.[22] The initiative does not require any minimum percentage of hydrogen to be blended into natural gas pipelines; instead, the goal of HyBlend is to research and develop the logistics of hydrogen blending in natural gas pipelines and provide more certainty for future use.

4.2. Green Gas Certification Scheme (UK)

The Green Gas Certification Scheme (GGCS) is a program in the United Kingdom that promotes clean fuels by issuing Renewable Gas Guarantees of Origin (RGGOs) to green gas producers. RGGOs are certificates that are distributed to producers that inject green gas, or clean fuels, into the UK gas grid.[23] The primary gas that is supported through the program is biomethane, though the GGCS plans to incorporate other clean fuels, like green hydrogen, into the program in the future.[24] RGGOs are tracked through the program's registry and can be transacted by producers to ultimately be retired by gas consumers to offset their gas consumption.[24] RGGOs do not track the actual molecule of biomethane put onto the grid; rather, they represent the environmental attributes of the clean fuel used to generate the certificate.

The Green Gas Certification Scheme registry ensures that there is no double-counting of the certificates.[24] The RGGOs also contain information about the vintage of the gas

[22] U.S. DOE. Hyblend: Opportunities for hydrogen blending in natural gas pipelines. https://www.energy.gov/sites/default/files/2022-12/hyblend-tech-summary-120722.pdf
[23] Green gas. Green Gas - Green Gas Certification Scheme. (n.d.). https://www.greengas.org.uk/green-gas
[24] About renewable gas guarantees of origin (RGGOs). Certificates - Green Gas Certification Scheme. https://www.greengas.org.uk/certificates

(the month and year of production), and in which part of the UK the gas was produced.[25]

4.3. Colorado's Clean Heat Plan

The Clean Heat Plan (CHP) of Colorado was launched in 2023 and aims to work with public gas utilities to reduce the state's GHG emissions. The CHP is multifaceted, but one of the methods that utilities can implement for lowering their emissions is injecting clean fuels, including biomethane and green hydrogen, into Colorado's gas grid.[26] The CHP has set targets for 2025 and 2030 for emissions reductions that utilities must comply with. The plan is mandated through the state and gives utilities some freedom to create individual proposals for how they plan to comply with the targets, though the program is still being developed and there is some ambiguity regarding the purchasing of certificates or carbon offsets by utilities to meet compliance with the program.[27]

4.4. Clean Heat Standard (Vermont and Massachusetts)

Vermont and Massachusetts are both developing Clean Heat Standards (CHS) to reduce GHG emissions associated with residential and commercial heating. Vermont approved the initiative in 2023 while in Massachusetts a CHS is still being proposed.[28]

The CHS will work with public gas utilities to incentivize the injection of clean fuels into the state's gas grid. In Massachusetts and Vermont, a CHS would involve the implementation of a clean heat credit market, where credits can be earned by parties based on their contributions to the state's emissions reductions.[29] The list of eligible actions for earning credits is still being defined in both states. Credits could be traded between parties and retired within each respective state in order to meet compliance with the state's Clean Heat Standard.[30]

4.5. Zero-emission Appliances (CARB)

The California Air and Resources Board is considering a set of zero-emission standards that would limit the use of gas appliances in California. The regulation would require

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[25] Shukla, S., Pinter, P., & Morini, V. (2021, September 9). UK "Green Gas" tariffs reliant on carbon credits as biomethane, certificates supply remains short. S&P Global Commodity Insights. https://www.spglobal.com/commodityinsights/en/market-insights/blogs/electric-power/090921-uk-green-gas-tariffs-carbon-credits-biomethane

[26] Learn about clean heat plans. Public Utilities Commission. https://puc.colorado.gov/cleanheatplans

[27] DiChristopher, T. (2023, November 13). Xcel Drops Certified Gas, carbon offsets from Colo. Clean Heat Plan. S&P Global Homepage. https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/xcel-drops-certified-gas-carbon-offsets-from-colo-clean-heat-plan-78391280

[28] Massachusetts clean heat standard. Mass.gov. (n.d.). https://www.mass.gov/info-details/massachusetts-clean-heat-standard

[29] Clean heat standard. Public Utility Commission. (n.d.). https://puc.vermont.gov/clean-heat-standard

[30] Better Buildings Residential Network - Department of Energy. (n.d.-a). https://www.energy.gov/eere/better-buildings-residential-network/articles/understanding-clean-heat-standards-what-lay-land

all new appliances purchased beginning in 2030 to be zero-emission units.[31] The California Public Utilities Commission has already developed monetary incentives for residents that switch to electric heat pump water heaters.[32] The specifics of the standards are still being developed by CARB and the regulation has not yet been proposed or finalized.

5. Summary

The residential and commercial sector is moving away from conventional fuels, like oil and natural gas, as alternative methods to power appliances are continuing to evolve. A transition towards electrifying fuel powered appliances in this sector is promising, but will require ample time and resources. The use of clean fuels is promising in the short-term decarbonization of this sector due to their drop-in compatibility with existing fuel powered appliances. Many regulations in the residential and commercial sector are still undeveloped and have not released sufficient information detailing the logistics of the programs. Despite the limited information available relating to this sector, regulations utilizing market-based accounting systems are being considered on a national scale. As other sectors continue to drive the expansion of clean fuels, the demand for these fuels in the residential and commercial sector will likely increase correspondingly.

[31] California Air Resources Board. Zero-emission appliances. https://ww2.arb.ca.gov/our-work/programs/building-decarbonization/zero-emission-appliance-standards/faq

[32] Melillo, G. What does a ban on natural gas appliances mean for homeowners? https://thehill.com/changing-america/sustainability/energy/3663271-what-does-a-ban-on-natural-gas-appliances-mean-for-homeowners/