Liquid Gas UK: The industry's

Journey to 2050

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Liquid Gas UK

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Authors

This report has been prepared by Gemserv Ltd on behalf of and in collaboration with Liquid Gas UK and its members.

Liquid Gas UK

Liquid Gas UK is the trade association for the liquified petroleum gas (LPG) and renewable and recycled liquid gas (RLG) industry in the UK, representing a membership of companies who are LPG and RLG producers, distributors, equipment manufacturers and service providers.

Member companies supply over 99% of the total LPG in the UK marketplace, and 100% of RLG.

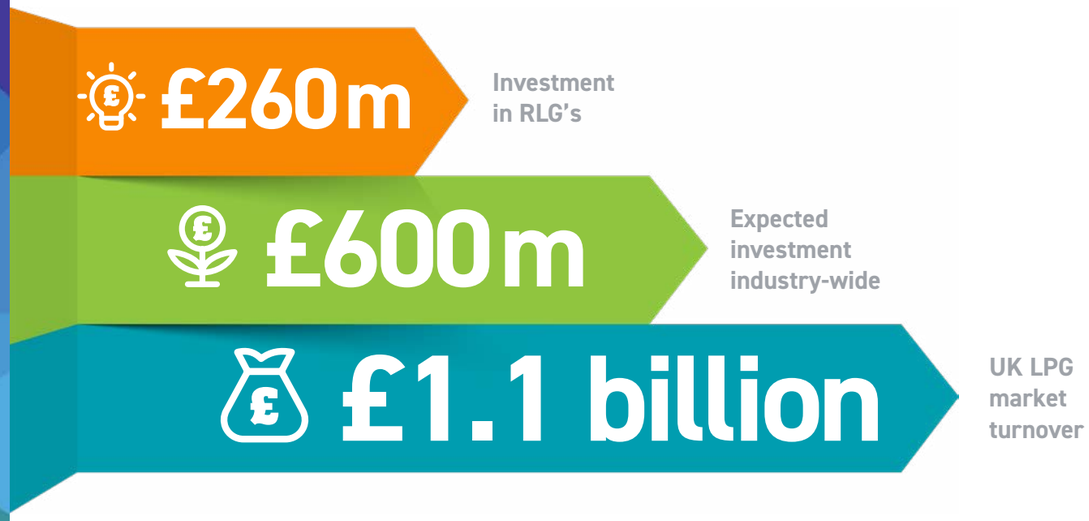
Liquid Gas UK takes a leading role in liaising and consulting with UK Government and Devolved Administrations to shape policy with respect to the decarbonisation of heat, transport and industry.

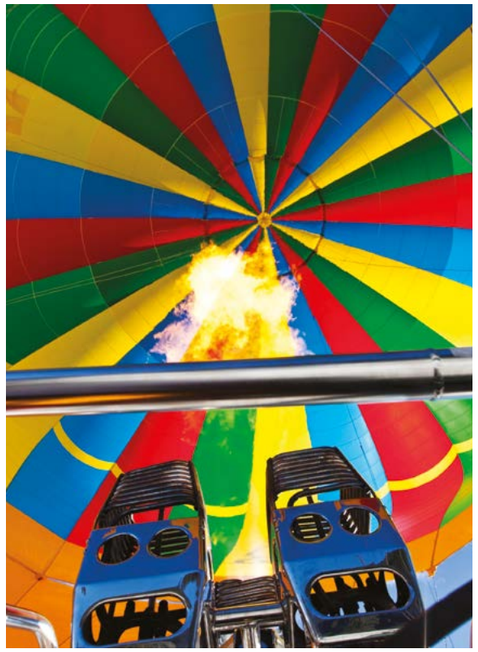
The LPG market in the UK is a £1.1 billion turnover industry and, in the run up to 2025, £600m is expected to be invested industry-wide, with £260m being invested in RLGs alone.

Gemserv

Gemserv, a Talan Company is an expert provider of professional and digital transformation services designed to accelerate the transition to a more sustainable future. Gemserv specialises in complex and highly regulated energy and environmental sectors at the forefront of a changing world, offering a comprehensive range of services for organisations in both the public and private sectors.

Our experience in the transition to low carbon heat stretches over many years. Gemserv is working with the Government, energy companies, manufacturers and trade associations as well as wider heating industry stakeholders to prepare the heating market for a low carbon transition. This includes assisting our clients with navigating the complex regulatory and policy landscape, providing insightful and informative research, economic analysis and stakeholder engagement.





1 Executive Summary

In 2019, the UK Government set a legally binding target to reach Net Zero by 2050, meaning that UK greenhouse gas emissions from the economy must be reduced to close to zero over the course of three decades. It is widely recognised that the pace of change needed to decarbonise the economy must be accelerated if the UK is to hit this goal including, critically, the phase out of unabated fossil fuel emissions. This means that new technologies and fuels will be needed to power the economy whilst mitigating against the negative impacts of climate change.

LGUK members believe that the liquid gas industry has a responsibility to lead, and support Net Zero through its own transition and innovations. The liquid gas industry recognises the need to transition to a low carbon economy and is subsequently re-setting its vision for a pathway to 2050, including a credible view on future demand for RLGs. This report provides a up to date view of the liquid gas industry's potential role in the journey to Net Zero. It sets out how the development of RLGs can support decarbonisation across multiple sectors. The report is underpinned by evidence-based economic analysis, desk-based research, and member engagement, and highlights the future role and evolution of the industry. The industry believes LPG and RLGs can contribute to the transition through the below benefits:

Paving the way for RLGs, LPG is a well-known, versatile, and reliable energy source for off-grid businesses and homes

LPG is a versatile fuel which is easily stored, transported and used. The versatility of LPG is demonstrated by its use across different sectors and in multiple applications. From static and portable space heating and hot water, to cooking appliances used in homes and businesses, through to process heat powering for industrial plants, and portable power-generation, its use is wide-ranging. LPG can also be supplied in bulk tanks or flexibly through bottled storage that is transportable, facilitating a steady and secure supply of LPG to a variety of sectors. A range of RLGs are being developed which are compatible with existing heating infrastructure within buildings, and can be transported in the same way as LPG. RLGs can also be 'dropped in' to replace LPG used in current applications. This means costly changes involved with changing heating systems can be avoided owing to RLG's adaptability, particularly for processes which require a flame to deliver varying levels of heat quickly.

A seamless transition to RLGs can be delivered through a well-established LPG supply chain

The LPG market has a strong foundation servicing off-grid homes and businesses, and a supply chain which is transitioning to RLGs. RLGs are predominately drop-in fuels which can be used as a low carbon fuel in existing appliances. The industry has committed to transition fully from LPG to RLGs by 2040. The industry has started its pathway to Net Zero, as investment in production is already underway. With the supply of RLGs set to increase, owing to the increased provision of production facilities, there has been good progress in bringing RLGs to market. However, greater policy support for RLGs is needed to drive further advancement to 100% RLGs by 2040.

Using current LPG sales data, industry insights from stakeholder engagement and general energy consumption trends outlined by the National Grid[1] and the Climate Change Committee (CCC)[2], a forecast on potential RLG demand has been conducted to identify the sectors and use cases which could benefit from RLGs. The demand modelling included domestic, industrial (manufacturing), leisure, agriculture and hospitality and catering. These selected sectors make up 657,600 tonnes (65%) of a 1,073,000 tonne LPG market today. Two scenarios were developed for each use case, the Sustained Growth (SG) (no further policy support, a conservative estimate) and the Leading the Way Scenario (LTW) (a more ambitious outlook with policy support).

Under both scenarios RLG volumes increase, signalling the scale of potential demand for off-grid renewable fuels. Under the SG scenario, volumes are estimated to increase from 648,595 tonnes to roughly 709,800 tonnes between 2025 and 2050. Under the LTW scenario, volumes also start at 648,595 tonnes but increase to approximately 1,180,000 tonnes in 2050. The carbon emission savings of displacing fossil fuels like oil, gas and coal with RLGs have been modelled, which result in carbon emissions savings between 2.0 and 3.3 Mt CO2e in 2050, depending on the scenario. Total greenhouse gas emissions in the UK currently stand at 331.5 Mt CO2e[3] .

> “The RLG industry can make a notable contribution towards achieving Net Zero by 2050 by tackling emissions in parts of the economy that are difficult to decarbonise.”

Investing in RLGs will create jobs, providing a clear career path for those working in the fossil fuel sector. Jobs growth is estimated to increase by over three-fold compared to current levels, reaching 12,500 jobs in 2045. This results in an estimated Gross Value Added (GVA) of around £1.3 billion in 2050.

1.The analysis applies general energy consumption trends outlined in the National Grid's 'Holistic Transition' scenario to the different use cases. The National Grid. 2024. Future Energy Scenarios. Available here: https://www.nationalgrideso.com/future-energy/future-energy-scenarios-fes

2. The analysis applies general energy consumption trends for agriculture and industry outlined in the Sixth Carbon Budget's 'Balanced Pathway' scenario. Climate Change Committee. 2020. Sixth Carbon Budget. Available at: https://www.theccc.org.uk/publication/sixth-carbon-budget/

3. DESNZ. 2023. 2022 UK greenhouse gas emissions. Available here: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1147372/2022_Provisional_e3missions_statistics_report.pdf

A three-fold increase in jobs is expected, reaching **12,500 jobs in 2045**

Resulting in an estimated Gross Value Added (GVA) of **£1.3 billion by 2050**

Where hydrogen or electrification prove technically or financially challenging, RLGs can provide a simple and flexible solution.

Complex-to-decarbonise homes have a wide range of locational and structural characteristics which makes their decarbonisation particularly challenging. For example, this includes large, old, off gas grid rural properties with generally poor levels of fabric efficiency, where heat pumps may be technically unfeasible or not cost-effective. Previous studies have suggested that around 20% of UK homes would fit into this category based on the technical feasibility of installing a heat pump[4] . Further analysis herein considers both the technical and cost feasibility of installing a heat pump in these homes. The analysis suggests up to 36% of homes may not be well-suited for a cost-effective heat pump installation. With LPG currently heating many of these types of homes, RLGs could act as a drop-in alternative to provide cost-effective low carbon and high temperature heat, hence removing the need for fabric and heating system changes. Switching away from LPG, oil, or solid fuel to RLGs in these homes would support the growth of the RLG industry, as RLG volumes are estimated to increase in the domestic sector by as much as 107% from 2025 to 2050.

On-gas grid properties may present an opportunity for RLGs as the gas grid is decommissioned. In hard-to-electrify areas, where options like district heating, heat pumps, or hydrogen are either technically challenging or too costly, there are properties where RLGs offer a viable cost-effective alternative. As gas prices rise with grid decommissioning, and higher costs for electrical grid upgrades, many properties risk becoming "stranded" without affordable alternatives. In the domestic sector, our LTW analysis suggests that more than 50% of future RLG demand could come from homes transitioning away from the gas grid.

There are also industrial locations requiring high temperature heat outside of planned hydrogen infrastructure. These are coined as 'dispersed sites' by the Government. Some of which will currently be connected to the gas grid, and so require low carbon alternatives. As electrification may not be cost-effective or practical for these sites, RLGs could provide reliable, low carbon, high temperature heat in a more cost-effective manner compared to electric technologies. As an example, analysis suggests that for glass manufacturing, an industrial RLG furnace would be cheaper to operate than an industrial electric furnace, achieving savings of almost £3 million in terms of annualised costs. Analysis estimates that RLGs can replace up to 40% of fossil fuel use in off-grid high-heat manufacturing.

4. BEIS. 2021. Impact Assessment on phasing out fossil fuels. Available here: https://assets.publishing.service.gov.uk/media/616d7b4d8fa8f5297cc02b5c/domestic-offgg-ia.pdf

36% of homes may not be well-suited for a cost-effective heat pump installation.

40% of fossil fuel use can be replaced by RLGs in off grid high-heat manufacturing.

RLG based heating systems are a cost-effective option in the domestic, commercial and industrial sectors.

Switching to RLGs could help industrial and commercial businesses meet environmental regulations. Many businesses located off the gas-grid use carbon intensive oil, or solid fuel as energy resources, and may need an alternative solution. Modelling suggests that RLG based heating systems can present an economically viable solution for a range of applications while achieving a considerable reduction in carbon emissions compared to fossil fuels.

In the domestic sector, the analysis compares the annualised cost of an air source heat pump to an RLG boiler in an unrenovated single family home built before 1918. The results show that owning and running an RLG boiler instead of a heat pump could save homeowners roughly £2,000 annually[5] – this underlines the significance of a multi-technology approach to decarbonise heating in complex-to-decarbonise properties. Blends of RLG and LPG could be used in cases where the annualised cost difference between installing an air source heat pump and RLG boiler is minimal, such as the case used for a Heritage Hotel. In the future, the proportion of RLG in the blend can be increased over time in response to cost changes as the market grows. Using a Heritage Hotel as an example, an RLG/LPG boiler can result in annualised savings of over £8,000 when compared with an air source heat pump.

5. A $1000/ tonne premium over the price of LPG is assumed for RLGs based on historic price data. Further explanation in chapter 7.

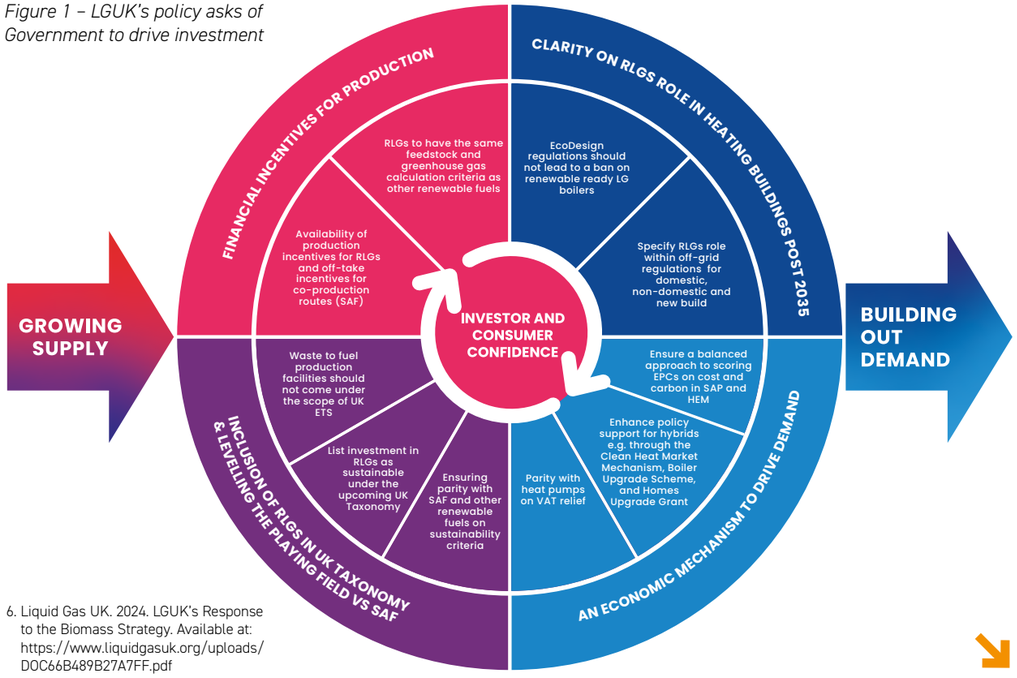
A heritage hotel using an RLG/LPG boiler could result in over **£8,000** annualised savings, when compared with an air source heat pump

2 The policy landscape needed to support the journey

This section sets out LG UK's policy asks of Government. The findings of this project demonstrate that there is a clear opportunity for RLGs to take a leading role in hard-to-decarbonise sectors. However, the commercialisation of RLGs is at an early stage and a clear, long-term policy framework that supports delivery into the UK market is needed to promote further industry investment and provide customer confidence in these new fuels. This is no different to other nascent green sectors, such as hydrogen and sustainable aviation fuel production, which have seen significant government intervention and the support necessary to enable the growth of these sectors.

LGUK is engaging with Government on all aspects of the policy framework required for the roll out of RLGs. There are a series of demand and supply side policy measures that the industry will require to quickly scale up production. These policy recommendations, set out in Figure 1, have been developed in consultation with members and informed by the findings of the previously published 'LGUK's Response to the Biomass Strategy'[6] .

Figure 1 – LGUK's policy asks of Government to drive investment



6. Liquid Gas UK. 2024. LGUK's Response to the Biomass Strategy. Available at: https://www.liquidgasuk.org/uploads/D0C66B489B27A7FF.pdf

To grow supply, members of LGUK, their parent companies, and external investors are already investing hundreds of millions of pounds into the production of RLGs and there are UK specific investment opportunities which could be harnessed with the right policy framework. The global liquid gas industry is also expected to invest £600 million between 2021 and 2025, with £300 million already spent, this includes investment in bio-propane and renewable and recycled dimethyl ether (rDME) production. Potential UK suppliers are competing globally for investment, and a lack of supply side support and other policy and investment incentives could lead to a missed opportunity.

Users have already shown great interest in RLGs which are currently supplied to a variety of forklift operators, food and drink manufacturers and off-gas grid businesses. Providing decarbonisation choices for rural communities will be crucial to drive the pace of change needed for action to meet Net Zero and to ensure collective buy-in for new technologies. For instance, in the heating sector, Government recognises that not all homes will be suitable for a heat pump, and there is a role for alternative heating systems to play[7]. RLGs are well placed to provide a reliable, cost-effective and low carbon alternative to heat pumps in these sectors. Policy incentives and regulation designed to help address off-grid and complex-to-decarbonise properties should be developed to help build further demand for RLGs. LGUK members believe the findings of this report will help provide clarity to Government on the future role of RLGs in heating buildings.

The global liquid gas industry is also expected to invest **£600 million** between 2021 and 2025

7. Liquid Gas UK. 2024. LGUK's Response to the Biomass Strategy. Available at: https://www.liquidgasuk.org/uploads/DOC66B489B27A7FF.pdf

3 Introduction

UK legislation mandates the decarbonisation of the economy by 2050. UK emissions have fallen to less than half of 1990 levels[8], but many remaining emissions come from hard-to-decarbonise areas (see Figure 2).

Within the above sectors, the use of fuel for heat and power contributes significantly to these emissions. From powering cars and forklifts, to keeping homes and businesses warm, or providing high-temperature process heat for

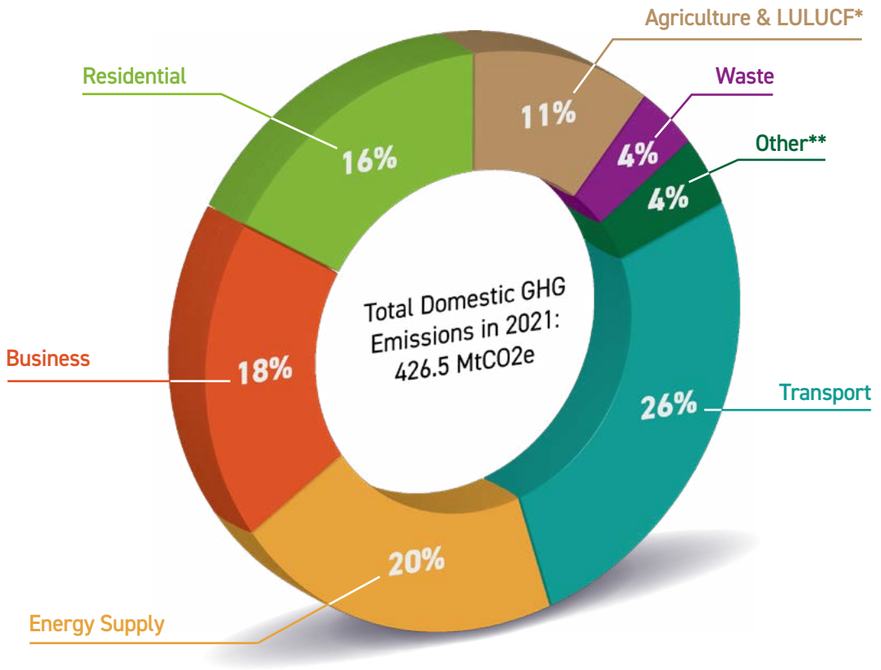


Figure 2 – Share of Greenhouse Gas Emissions by Sector in 2021[9]

8. ONS. 2021. Measuring UK GHG Emissions. Available at: https://www.ons.gov.uk/economy/environmentalaccounts/methodologies/measuringukgreenhousegasemissions#:~:text=Provisional%20estimates%20show%20that%20territorial,roughly%2039%25%20for%20since%201990

9. UK Government. 2018. Clean Growth, Transforming Heat. Available at: https://esc-production-2021.s3.eu-west-2.amazonaws.com/2021/08/decarbonising-heating.pdf

industry, fuels such as diesel, gas, and oil used within these processes contribute to higher carbon emissions. These fuels will need to be phased out to achieve Net Zero targets and avoid the worst impact of climate change, but in certain cases, there is an unclear role for suitable low carbon alternatives.

Millions of homes and businesses in rural areas off the gas grid are faced with uncertainty pertaining to the delivery plans and financing of future low carbon technologies. Over the next 20 years, the UK needs most households to transition to a form of low carbon heating. For many, a heat pump will be the practical solution provided it can be afforded. For others in complex-to-decarbonise properties or with specific requirements, alternatives may be required, particularly if heat pumps continue not to be technically suited or cost effective for these properties. Additionally, many industries requiring high temperature process heat currently use coal or oil as fuel. Industries located outside of potential future hydrogen cluster developments may experience challenges in securing a reliable low carbon fuel alternative.

Liquified gases have a wide range of uses across various industries which can support the low carbon transition. LPG is a highly versatile fuel with widespread applications across different sectors. In homes, it is commonly used for heating and cooking, providing a dependable and efficient energy source. In commercial and industrial settings, LPG powers processes like metal cutting, heating, and manufacturing. It also plays a crucial role in agriculture, supporting tasks such as crop drying, greenhouse heating, and food production.

Additionally, LPG is used in power generation as a cleaner alternative to some conventional fuels. Its relative affordability, portability, energy efficiency, and adaptability make it an essential fuel across many industries.

Industry is keen to explore and invest in RLGs, as a mechanism to help transition away from current fossil-based fuels. As such Liquid Gas UK members have publicly announced their intention to become fully renewable by 2040 in the supply of energy solutions[10]. Following the announcement in 2019, the industry has made investments in both the development and commercialisation of renewable and recycled liquid gas technologies.

To gain a comprehensive understanding of the liquid gas market, a mixed methods approach was employed in this report, incorporating both qualitative and quantitative elements. Our research is based on engagement through interviews with LGUK members, analysis of the LPG volumes sold by the UK's largest LPG suppliers, and respected industry reports. Additionally, from a supply and demand perspective, we have expanded upon forecast data previously provided by Frazer-Nash Consultancy in partnership with LGUK, aligning it with our 2050 analysis[11].

The report is structured in the following format:

1) Exploration of the existing state of the liquid gas industry;
2) The future of the renewable and recycled liquid gas industry and the exploration of novel applications;
3) The necessary policy and regulatory environment to enable RLGs to contribute to UK decarbonisation.

10. Liquid Gas UK. 2040 Pathway. Pathway to Net Zero: Delivering our 2040 Vision. Available at: https://www.liquidgasuk.org/policy/2040-pathway
11. Frazer-Nash. 2022. UK Renewable Liquid Gas Modelling. Available at: https://www.liquidgasuk.org/uploads/D0C6346A4E460BFF.pdf

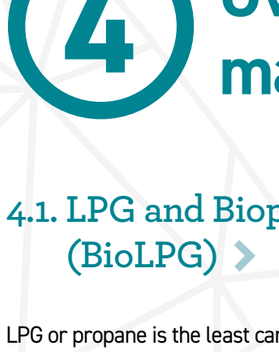
4 Overview of the liquid gas market

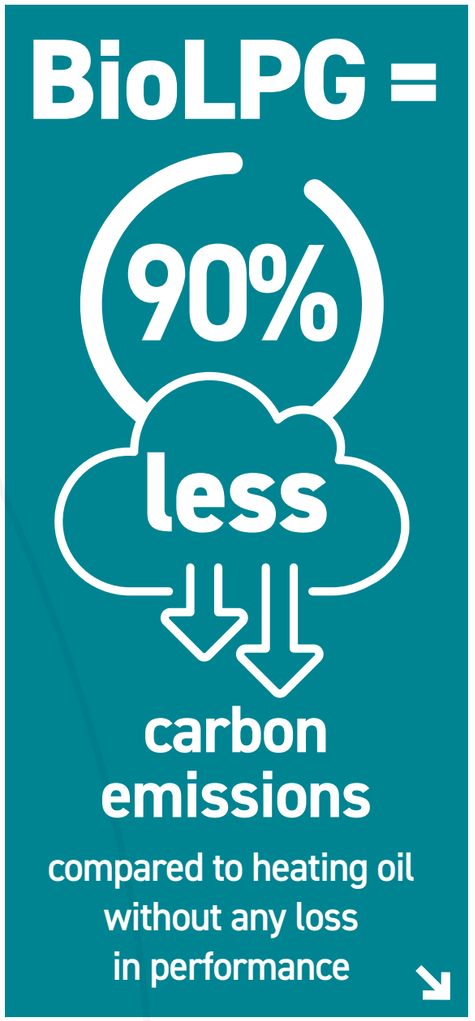
4.1. LPG and Biopropane (BioLPG)

LPG or propane is the least carbon-intensive conventional fuel source that is widely used in rural and off-grid areas. Its renewable fuel analogue, biopropane, made from non-petroleum feedstocks, can reduce carbon emissions by up to 90% compared to heating oil without any loss in performance[12].

The attractiveness of LPG is often driven by its ease of transportation and storage, providing accessible, high-utility energy in large volumes. Today, a typical biopropane mix sold by suppliers consists of 80% propane and 20% biopropane.

LPG and biopropane are versatile, high-heat energy sources, crucial for decarbonising rural, off-grid areas with hard-to-abate industries. Biopropane offers a cost-effective, low-disruption option for reducing emissions. As a 'drop-in' fuel, biopropane works in existing LPG systems like boilers, combined heat and power (CHP) units and hybrid heat pumps without modification, aiding the decarbonisation of current infrastructure.





12. WPLGA. 2020. Supporting businesses in the energy transition: the role of LPG and bioLPG in Europe. Available at: https://www.worldliquidgas.org/wp-content/uploads/2020/11/LPG-bioLPG-FAQ.pdf

Although biopropane is currently only available in limited quantities, the liquid gas industry has invested considerably in recent years to decarbonise its supply chain and overall supply. Further details on the industry's commitment and efforts to decarbonise are discussed later in the chapter.

4.2. DME and Renewable and Recycled DME

bioLPG

rDME

DME is used worldwide in industrial power generation and is complementary to biopropane for industrial decarbonisation. Chemically similar to butane and propane, its renewable or recycled counterpart, rDME, could play a role in decarbonising many off-grid energy applications currently serviced by the LPG industry. A key distinction of rDME is that it is produced from renewable or waste feedstocks such as methane, municipal waste, renewable power, and captured CO2, with a potential emission reduction of up to 85%[13].

rDME can not only help address the challenges of waste production and exportation – an issue globally – but it also supports the decarbonisation of heat applications, as mentioned above. rDME can be blended with biopropane, to alleviate any possible shortages in supply of biopropane, or used as a standalone low carbon energy source.

Similar to LPG, rDME can be utilised for heating and cooking in homes, and in industrial and commercial sectors. Like LPG and biopropane, rDME's role in the transition of both on- and off-grid sectors is supported by its ability to be used as a blend with LPG and biopropane. Although, blends with a higher proportion of rDME will require slight modifications to the heat generator, lower blends require no modifications to existing appliances and therefore can be easily integrated into existing heat infrastructure.

A key distinction of rDME is that it is produced from renewable or waste feedstocks, with a potential **emission reduction of up to 85%**

13. Liquid Gas UK. 2023. Pathways to Net Zero - Delivering our 2040 Vision. Available at: https://www.liquidgasuk.org/uploads/DOC62BED9462606B.pdf

4.3. Today's UK Liquid Gas Market

The UK currently ranks 17th globally in total LPG consumption, with the largest consumers being the USA, China, Japan and India[14]. Factors such as climate, culture and regional infrastructure influence the relative demand for LPG. Due to their versatility, liquid gases have a wide range of applications across global markets, which contributes to its varying use cases worldwide.

Historically, UK refineries have supplied the majority of the country's domestic production of LPG. However, due to insufficient investment and the closure of refineries, the UK's annual LPG output has declined by 1.4 million tonnes since 2011 with outputs at around 1.5 million tonnes in 2023[15]. Despite this, the liquid gas industry achieved a turnover of £1.1 billion and employed over 4,000 people within the UK in 2022– an increase of 600 employees from 2020[16].

The industry's primary market caters to off-takers in rural, off-grid areas. According to LGUK's Industry Census of 2022, LPG usage is highest in commercial and public buildings and in the domestic sector as shown in Figure 3[17]. Significant demand for LPG arises from warehouses, hotels, restaurants, leisure parks, and residential properties.

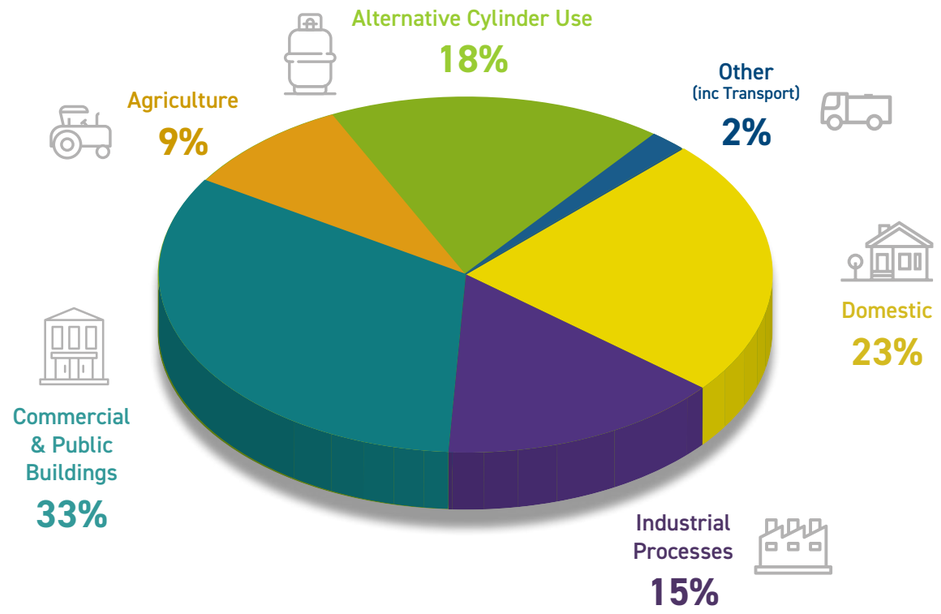


Figure 3 - Snapshot of the Market, Census 2022

14. IndexMundi. 2023. LPG Consumption by Country. Available at: https://www.indexmundi.com/energy/?product=lpg&graph=consumption&display=rank
15. Spherical Insight. 2023. UK LPG Market Insight Forecast to 2033. Available at: https://www.sphericalinsights.com/reports/united-kingdom-lpg-market
16. Liquid Gas UK. 2022. LPG Industry Census. Available at: https://www.liquidgasuk.org/uploads/DOC637B69B62F04C.pdf
17. Liquid Gas UK. 2022. Pathway to 2040. Available at: https://www.liquidgasuk.org/uploads/DOC62BED9462606B.pdf

4.4. Liquid Gas UK's Pathway to Net Zero

RLGs are the future of the liquid gas industry given the need to transition to net zero. With the industry committing to fully renewable liquids gases by 2040, investment has been made to start to future proof the industry. The UK liquid gas industry invested approximately £350 million in 2023, with an additional £5.6 million forecasted by 2025[18]. This investment covers developing renewable technologies, R&D, and enhancing energy resilience through infrastructure and storage improvements. However, a further £1 billion in investment is necessary over the coming decades to develop sufficient production capacity for RLGs[19].

The UK's Biomass Strategy marks an important development, boosting industry confidence following the recognition of the strategic value of RLGs[20]. The strategy identified the capacity of renewable and recycled liquid gases to decarbonise processes like heating. Government's acknowledgment of this potential is a positive step towards establishing the necessary framework and incentives to drive increased investment in the RLG market, which would support the UK's broader decarbonisation goals, particularly in some of the country's hardest-to-abate sectors.

The UK liquid gas industry invested approximately **£350 million in 2023** with an additional **£5.6 million** forecasted by 2025

18. Liquid Gas UK. 2022. Pathway to 2040. Available at: https://www.liquidgasuk.org/uploads/DOC62BED9462606B.pdf
19. Bioenergy-insight. 2020. Household waste could power off-grid UK homes via bioLPG, report shows. Available at: https://www.bioenergy-news.com/news/household-waste-could-power-off-grid-uk-homes-via-bio-lpg-report-shows/
20. UK Government. 2023. Biomass Strategy. Available at: https://assets.publishing.service.gov.uk/media/64dc8d3960d123000d32c602/biomass-strategy-2023.pdf

5 The off-gas grid journey

There are over four million domestic properties across the UK that are not connected to the gas grid and are therefore reliant on alternative energy solutions for heating[21]. Around half these properties can be found in urban locations and may be electrically heated flats or similar. The remainder, over 2 million are much more likely to be rural and may be considered to be truly off the gas grid.

As off-grid homes and businesses face additional challenges in moving to lower carbon heating solutions, the share of fossil fuels remains high in off-grid areas. To meet the Government's target to achieve net zero emissions by 2050, off-grid energy users will need to shift away from fossil fuels to sufficiently reduce their carbon emissions. The transition away from fossil fuels and the expected decommissioning of sections of the mains gas network are expected to reshape the off-grid market significantly over the next two decades. While existing LPG consumers are likely to switch to RLGs, a wider opportunity could open up as oil and coal powered applications need to decarbonise. The transition of the off-grid market presents both opportunities and challenges for the liquid gas industry, considering that the off-grid market is currently much larger than the LPG market. With an established and reliable network of suppliers, liquid gases are generally well suited to service customers in remote locations and off the gas grid.

Phasing out fossil fuels in off-grid areas

Off gas grid locations are usually in rural areas. Properties in rural areas are generally older, larger, and more energy inefficient. Predominantly they use fossil fuels to cost effectively meet the high heat demand of these properties, such as oil, or coal. However, these properties will need to replace their current fossil fuel heating system with a low carbon alternative. Heat pumps are the solution for most properties, however, heat pump installations in off gas grid, rural, and larger properties are likely to be costly[22], and they are not technically suitable for one in five homes[23]. These households therefore will require an alternative solution to electrification , which is both cost-effective, and technically suitable. RLGs can provide this alternative. RLGs can also be used in biofuel boilers and hybrid heat pumps, both of which are expected to play a role in the heating technology mix for the domestic sector.

Certain industrial and commercial processes using heat cannot be suitably replaced by electrification. This is because of the need for a modulating flame, and high temperature heat. Businesses located off the gas grid are unlikely to be covered by hydrogen, as infrastructure will be located

21. House of Commons Library. 2024. Households off the gas-grid. Available here: https://commonslibrary.parliament.uk/research-briefings/cbp-9838/
22. HM Treasury. 2021. Net Zero Review. Analysis exploring the key issues. Available at: https://assets.publishing.service.gov.uk/media/616eb3568fa8f52979b6ca3e/NZR_-_Final_Report_-_Published_version.pdf
23. BEIS. 2021. Impact Assessment on phasing out fossil fuels. Available here: https://assets.publishing.service.gov.uk/media/616d7b4d8fa8f5297cc02b5c/domestic-offgg-ia.pdf

around industrial clusters. This leaves a proportion of manufacturing facilities, construction sites and agricultural businesses requiring low carbon alternatives. The Government recognises deep decarbonisation of these sites is unlikely to start before 2030 because of this[24]. RLGs can provide an earlier solution for these businesses, and there is the opportunity to use bioLPG today for mobile power generation[25].

The National Grid's Future Energies Scenarios (FES) estimate that biofuels could supply around 9% of total energy demand in the industrial sector by 2050[26]. The transition to low carbon fuels in off-grid areas is however currently hindered by the lack of a clear policy framework. Whilst on-gas grid biofuels are supported by government policy (see Green Gas Support Scheme for biomethane), there is a relative lack of support for off-grid low carbon fuels. Price also currently remains a barrier. Industry stakeholders have long called for fairer pricing of hydrotreated vegetable oil (HVO). Currently, HVO benefits from reduced rates under the Renewable Transport Fuel Obligation (RTFO) 2007 for aviation and transport[27], but there is no similar support for its use in the off-grid heating sector.

Further compounding the issue is the lack of adequate policy support for off-grid low carbon fuels in existing mechanisms, such as hybrids, where RLGs could play a key role. Programs like the Clean Heat Market Mechanism, Boiler Upgrade Scheme, and Home Upgrade Grant offer only limited pathways for these fuels, further hindering their uptake.

Finally, there is a lack of long-term clarity regarding the role of RLGs within off-grid regulations for domestic, non-domestic, and new-build properties. This is a concern as the industry prepares to scale up in anticipation of potential policies, including those that could restrict or ban off-grid boiler installation, where greater clarity from government is required.

Decommissioning of the mains gas network

Parts of the gas grid will be decommissioned during the net zero transition – in certain scenarios as much as 80% of the distribution network is estimated to be dismantled by 2050[28]. With 85% of homes relying on gas for their heating, most of these homes will come off the gas grid. During this process, gas prices are expected to rise – the Office of Gas and Electricity Markets (Ofgem) suggests a rapid surge in gas bills in the 2040s[29]. Customers relying on gas for heating in the future are therefore expected to experience higher energy bills. There will therefore be properties disconnected from the gas grid, and those that disconnect owing to high costs over the next few decades. Some of these properties may experience cost or technical challenges associated with installing a heat pump and and are likely to require an alternative solution. As a drop in solution, renewable liquid gases present a great option for customers looking to switch away from natural gas without replacing their existing heating system. With minimal upgrades to their existing boiler, natural gas users can make the switch to RLGs at a low cost.

24. DESNZ. 2021. Industrial Decarbonisation Strategy. Available here: https://www.gov.uk/government/publications/industrial-decarbonisation-strategy
25. LGUK. BioLPG Powers Generators in Off-Grid Areas. Available at: https://www.liquidgasuk.org/commercial/case-studies/biolpg-powers-generators-in-off-grid-areas
26. The National Grid. 2024. Future Energy Scenarios. Available here: https://www.nationalgrideso.com/future-energy/future-energy-scenarios-fes
27. Department for Transport. 2021. Renewable Transport Fuels Obligation. Available at: https://www.gov.uk/guidance/renewable-transport-fuels-obligation
28. Frontier Economics. 2016. Future Regulation of the UK Gas Grid. Available here: https://www.frontier-economics.com/media/vfholk2g/20161013_future-regulation-of-the-uk-gas-grid_frontier.pdf#page83
29. Ofgem. 2024. RIIO-3 Sector Specific Methodology Decision. Available here: https://www.ofgem.gov.uk/sites/default/files/2024-07/RIIO-3_SSMD_Finance_Annex.pdf

6 The future of the industry

While the potential future supply of RLGs has been subject to several studies, there is little information on the future demand for RLGs in the UK. The analysis developed for this chapter aims to fill the current gap in the literature by providing an overview of how the demand of RLG could evolve between 2025 and 2050 under varying policy support scenarios.

The chapter evaluates the potential for RLG usage across different industries. To assess the future relevance of RLGs, a range of factors were considered – including the current market size, the availability of alternative low carbon technologies, and policy support for RLGs. In addition to a qualitative assessment using the below criteria, the chapter presents liquid gas demand projections in five-year increments for selected use cases.

Building on Gemserv's existing heating and archetype model, the analysis explores the economic performance and affordability of RLG fuelled systems in comparison to other low carbon alternatives through exemplary case studies. The analysis aims to demonstrate the economic viability of RLG solutions across a range of sectors and applications. Depending on the use case, the alternative heating systems considered include electric heating, air-source heat pumps and hybrid systems.

The results highlight that RLG based heating systems can present an economically viable solution for a range of applications while achieving

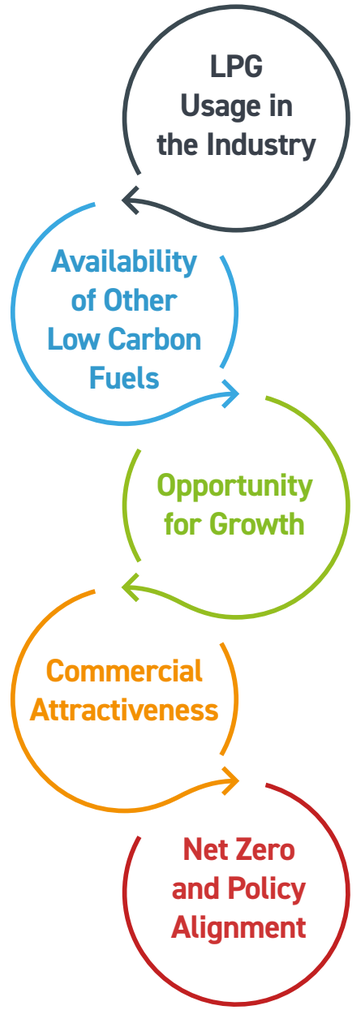


Figure 4 - Criteria to Evaluate the Future Importance of RLGs

a considerable reduction in carbon emissions compared to fossil fuels. In a detached house built before 1918 – one of the most common archetypes in the UK – running an RLG boiler is estimated to be £15,000 less expensive than a heat pump over a 15-year period. Economic viability and affordability present important elements of a fair transition to low carbon heating and should therefore be taken into account by decision makers.

Running an RLG boiler is estimated to be **£15,000 less expensive** than a heat pump over a 15-year period.

6.1. Overview of the Demand Scenario Model

Detailed demand forecasts were developed for the use cases that show the largest potential for the uptake of RLGs in the future. The table below introduces these use cases and defines the scope of the sector.

Use Cases	Definition
Domestic Heating	Includes liquid gas usage in all domestic applications, mostly consisting of space and water heating.
Hospitality and Catering	Includes liquid gas usage for heating and cooking in pubs, restaurants (including catering and street food), and hotels.
Manufacturing	Includes liquid gas usage in high-heat manufacturing processes
Leisure Sites	Includes liquid gas usage in caravans, residential parks, holiday parks and campsites.
Agriculture	Includes liquid gas usage in all agricultural applications, excluding agricultural vehicles.

Table 1 - Demand Scenario Use Cases

The volume of liquid gas supplied to the five sectors introduced above currently accounts for over 65% of the total amount of LPG used in the UK in 2023[30]. Figure 5 (opposite) presents the current market size of each sector – note that the volumes displayed represents the starting points of the modelled demand projections for the respective use case.

6.1.1. Demand Scenario Methodology

Scenario Framework

Within the quantitative analysis, each use case is modelled under two scenarios. The Sustained Growth (SG) scenario forecasts the demand of RLGs without improvements to support for RLGs, representing a more conservative demand scenario. The Leading the Way (LTW) scenario represents a more optimistic outlook, forecasting RLG demand when there is a dedicated policy framework to support decarbonisation with RLGs. The LTW scenario assumes a higher uptake of renewable liquid gases and is therefore aligned with a higher supply forecast.

30. Based on Liquid Gas UK member data

Liquid Gas demand by Use Case
Compared to the total volume in 2023

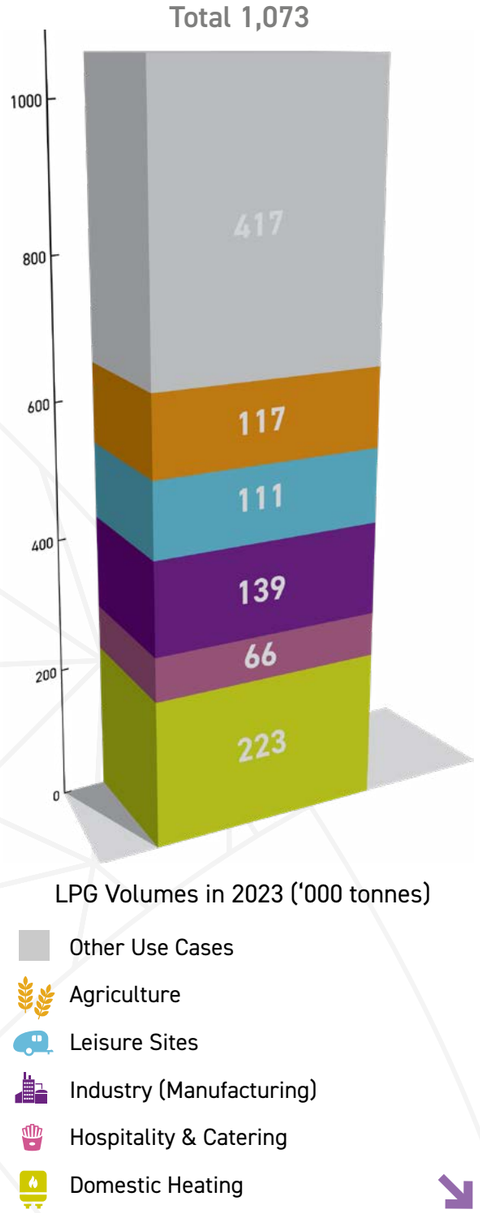


Figure 5 - Liquid Gas Volumes in 2023 by Use Case

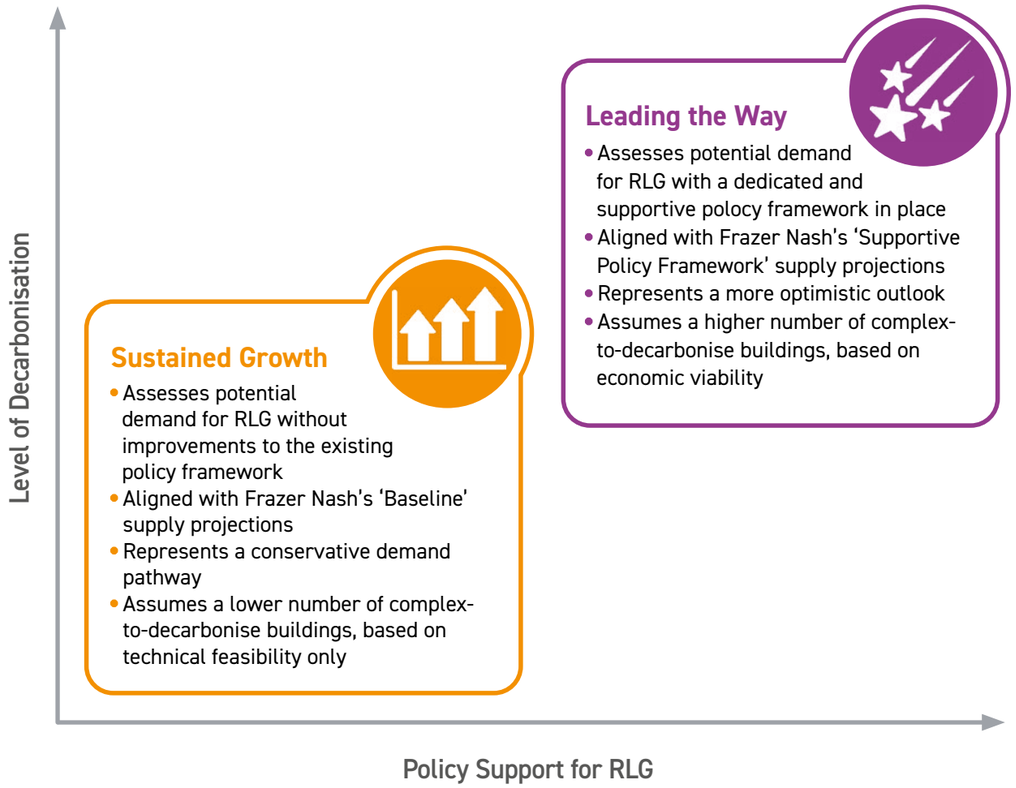


Figure 6 - Introduction of the Model Scenarios

Uptake of Renewable Liquid Gases

The consumer demand for RLGs is expected to depend on the availability, economic viability and technical suitability of alternative low carbon fuels. Customers where RLG could present an economical solution were categorised into three groups which face different challenges and requirements – existing LPG users, off-grid customers currently relying on other fossil fuels (e.g. oil or coal), and on-grid buildings currently supplied with natural gas. On the gas grid, district heating and low carbon hydrogen could offer a viable solution for applications not well-suited for a heat pump while decarbonising off-grid areas is expected to be more challenging. The uptake of RLG solutions is accordingly modelled to be higher off the gas grid. To fully capture the range of future outcomes for the industry's transition to renewable fuels, the assumptions regarding the uptake of RLGs vary across the scenarios and end use cases. The assumptions were shaped together with industry stakeholders in alignment with general energy consumption trends developed by the Climate Change Committee (CCC) and National Grid. The flowchart opposite provides an overview of the approach to developing the demand scenarios.

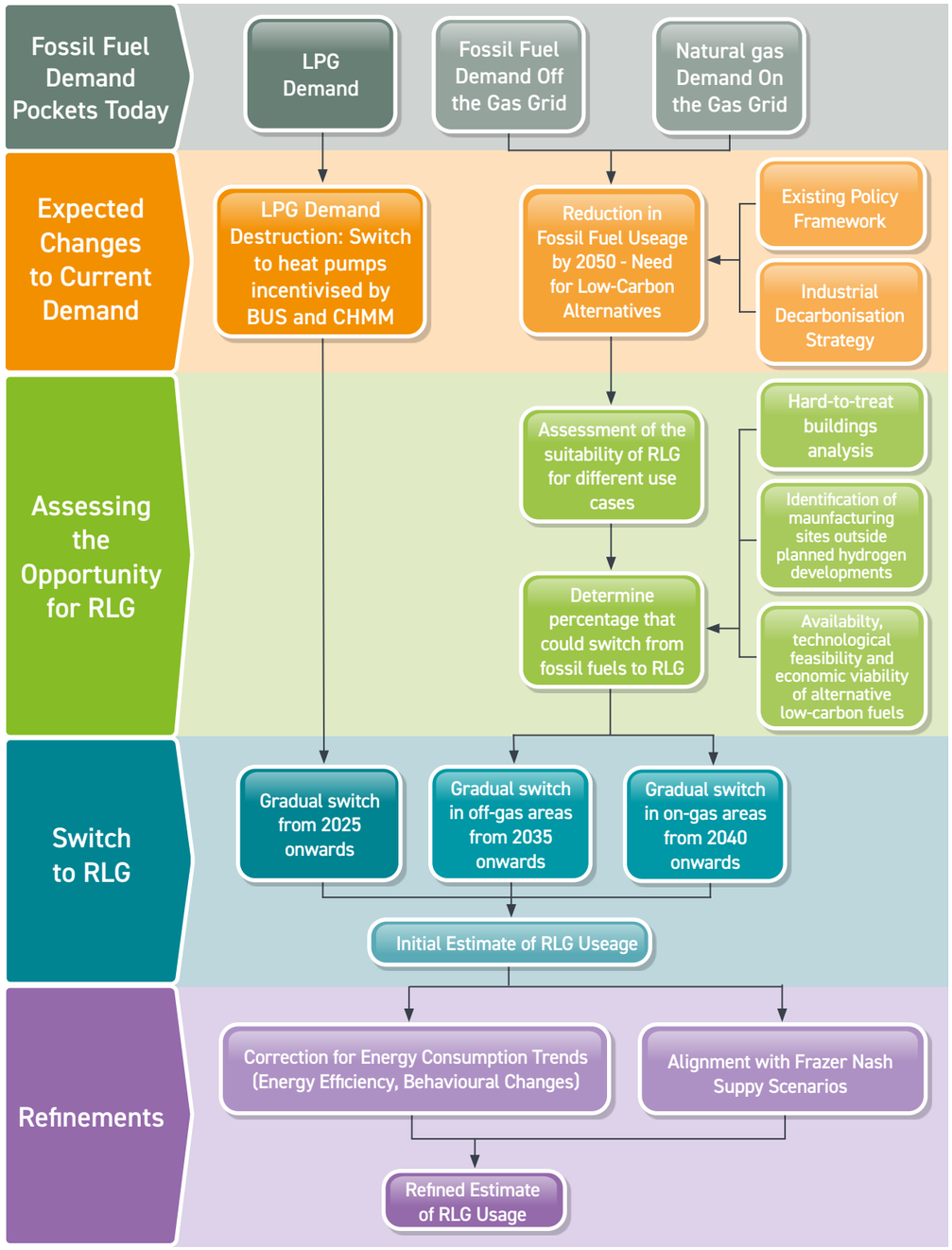


Figure 7 - Demand Scenario Modelling Approach

Supply Projections

The demand scenarios modelled for this project are based on the supply forecasts developed by Frazer-Nash Consultancy and NNFCC[31]. The Frazer-Nash report projects the supply of RLGs up to 2040 under various scenarios. For this report, the baseline scenario and the supportive policy framework scenario were used. Key trends in the data are extrapolated to extend the supply forecasts to 2050 and align the timeframe with the demand scenario model. For the Sustained Growth scenario, the Baseline supply projections are used, presenting an indication of the supply and demand for in a scenario where there is no additional policy support for RLGs. The Leading the Way scenario is based on the most optimistic supply projections as shown in the Supportive Policy Framework scenario.

6.2. Key Findings

6.2.1. Future Volumes

In the 'Sustained Growth' scenario, demand is projected to increase by circa 10% across the five modelled use cases by 2050. This is due to an increase in demand across most sectors, resulting from the growing pressure to decarbonise both on and off grid areas. Accordingly, the model assumes a gradual switch from fossil fuels and natural gas to RLG boilers in the late 2030s and 2040s within suitable buildings. Figure 8 illustrates overall demand forecasts for each use case, including the split between fossil and renewable liquid gas.

In both scenario's the industry is on track to hit its target of providing 100% renewable liquid gases by 2040, as shown in Figures 9 and 11. This is because the supply of RLGs is set to increase to 2040, owing to an increase in production facilities such as gasification and HVO[32]. This means a greater amount of feedstock can be processed for supply onto the market. The co-production of SAF also provides an opportunity for increasing the provision of renewable fuels. However, government policy support is needed to drive a higher volume of RLG supply onto the market[33].

The industry is on track to hit its target of providing **100% renewable liquid gases** by **2040**

31. Frazer Nash. 2022. UK Renewable Liquid Gas Modelling. Available at: https://www.liquidgasuk.org/uploads/D0C6346A4E460BFF.pdf
32. Frazer Nash. 2022. UK Renewable Liquid Gas Modelling. Available at https://www.liquidgasuk.org/uploads/D0C6346A4E460BFF.pdf
33. Liquid Gas UK. 2024. LGUK's Response to the Biomass Strategy. Available at: https://www.liquidgasuk.org/uploads/D0C66B489B27A7FF.pdf

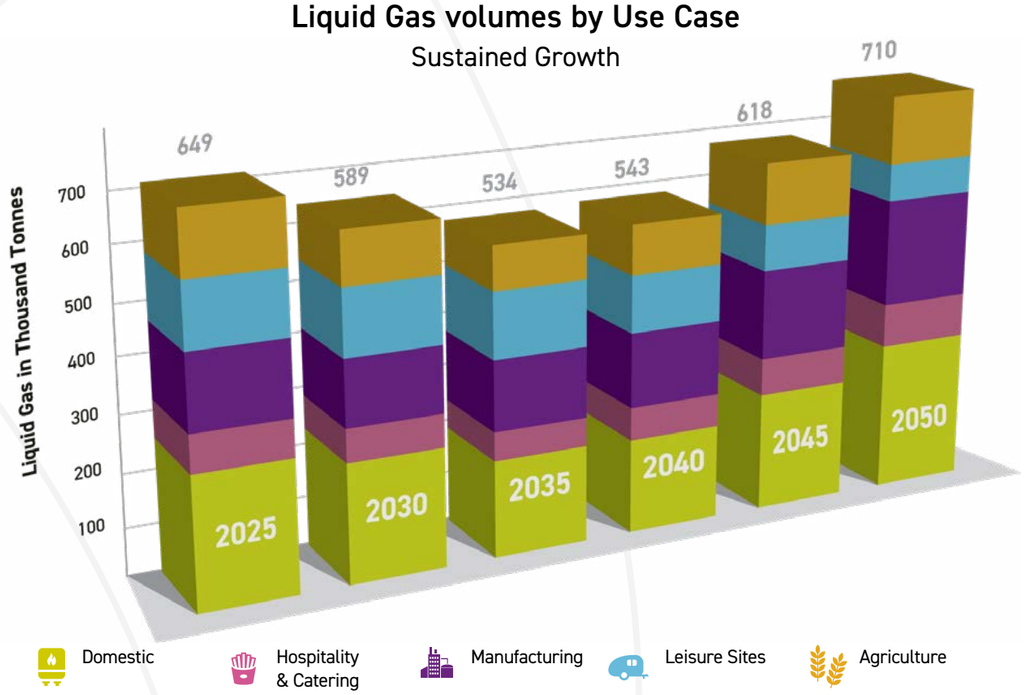


Figure 8 - Liquid Gas Demand Projections by Use Case: Sustained Growth Scenario

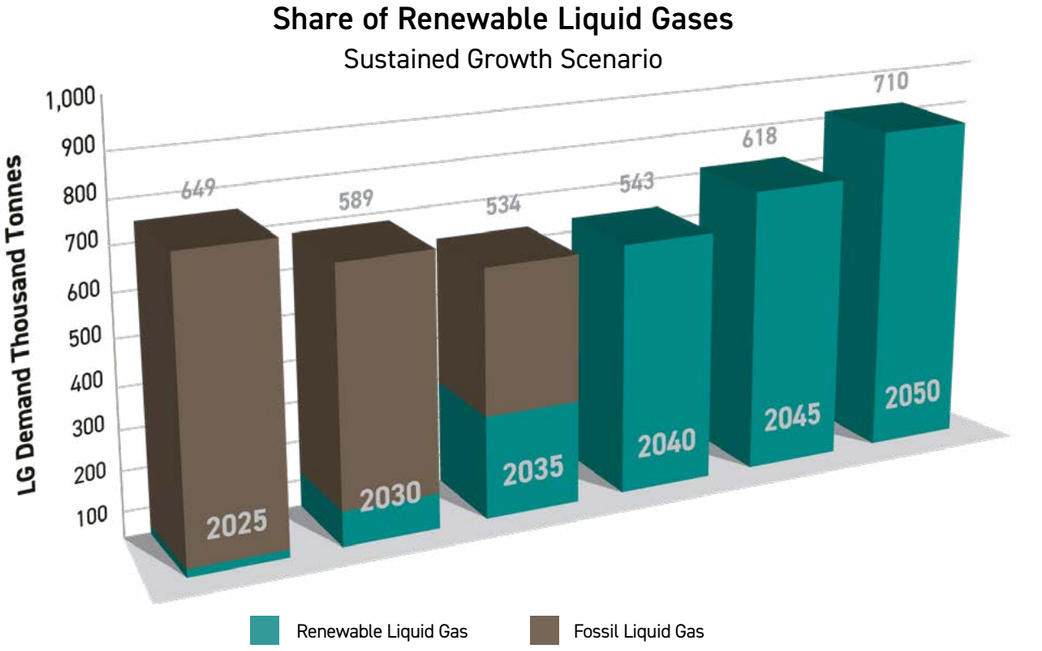


Figure 9 - Share of Renewable Liquid Gases by 2050 in the Sustained Growth Scenario

The domestic sector (i.e. homes) is currently the largest consumer of liquid gas and is projected to remain so up to 2050. Similar demand patterns occur for manufacturing, and hospitality & catering, which show slight declines in volumes up to 2035, then an increase in demand up to 2050. This is largely due to a lack of policies that incentivise consumers to switch away from fossil fuels earlier. The agricultural sector is expected to undergo significant changes associated with a decline in overall energy consumption[34]. While overall demand is expected to decline due to changes in consumer habits and energy efficiency improvements, RLGs could displace some fossil fuel applications currently prevalent in the sector. Leisure sites show the highest decline between 2025 and 2050 since many applications are expected to be suitable for electrification.

In the 'Leading the Way' scenario, demand is projected to grow by more than 80% across the five modelled use cases by 2050. The LTW scenario assumes a higher uptake of RLGs in all use cases based on a lower availability of alternative low carbon fuels and increased policy support for RLGs. The sharp increase in demand for RLGs in 2045 is due to buildings and applications switching away from natural gas from 2040 onwards. Figure 9 presents the total demand forecasts for each use case and the split between fossil and renewable liquid gas in the LTW scenario.

34. Climate Change Committee. 2020. Sixth Carbon Budget. Available at: https://www.theccc.org.uk/publication/sixth-carbon-budget/

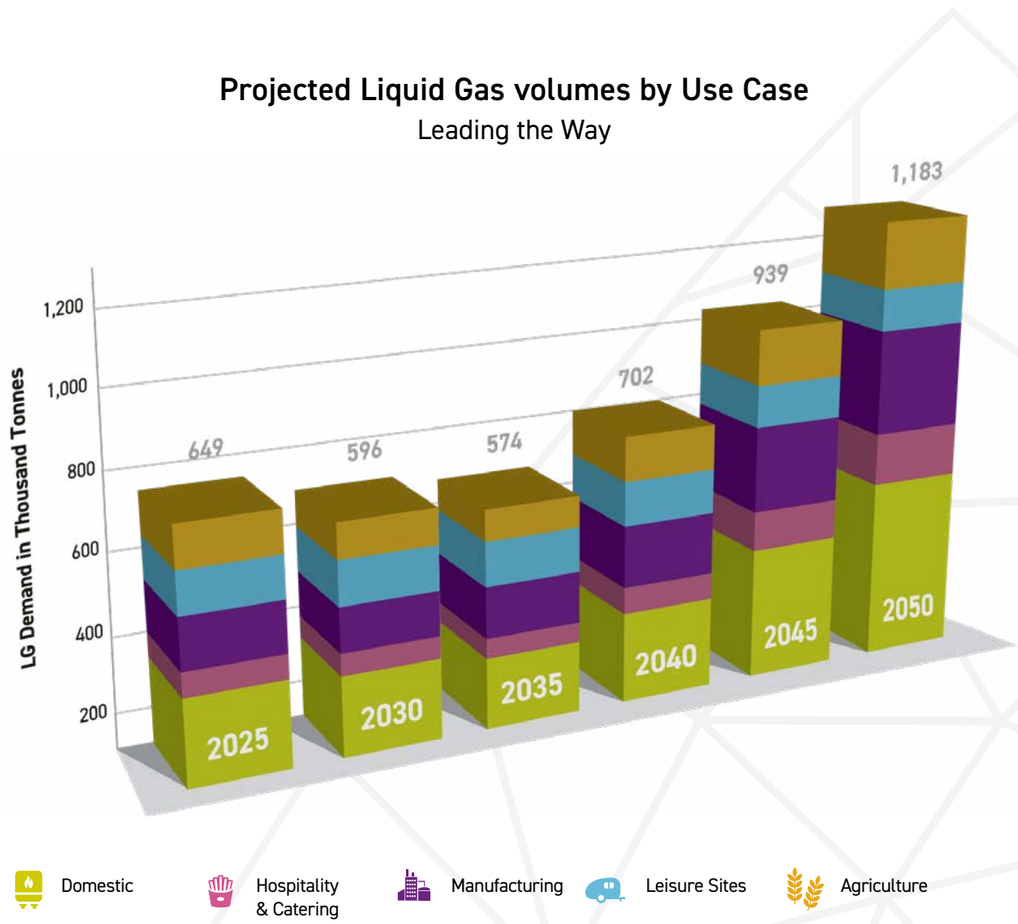


Figure 10 - LG Volume Projections by Use Case in Five-Year Increments: Leading the Way

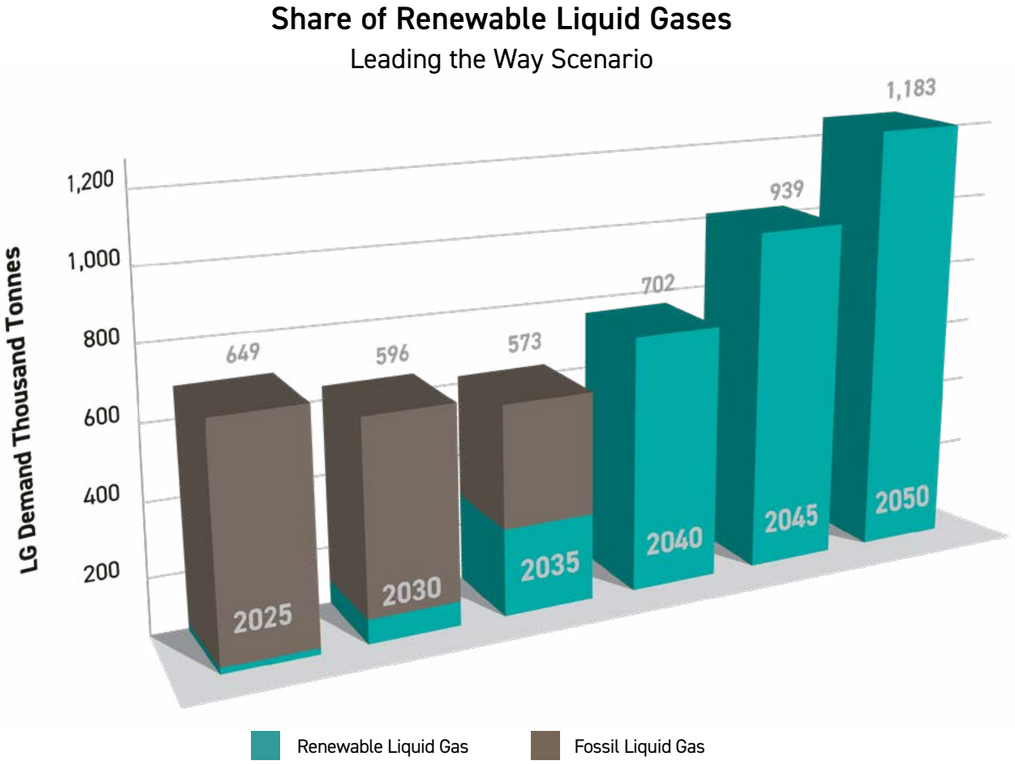


Figure 11 - Share of Renewable Liquid Gases in the Leading the Way Scenario

6.3. Carbon Emissions Savings

This section presents the emissions savings that could be achieved when switching from various fossil fuels to RLGs. The carbon saving displayed is therefore the difference between the emissions from RLGs and counterfactual heating fuels including LPG, natural gas and oil.

The RLG emission factor[35] used in this analysis represents an average over time. This reflects that the fuel will be less carbon-intensive in the future as access to sustainable feedstocks increases. The remaining GHG emission factors were sourced from the UK Government's Green Book Guidance[36], as shown in the table opposite.

Figure 10 illustrates the emission savings in five-year increments for the two modelled scenarios. Across both scenarios, the analysis finds a strong upward trend in emissions savings up to 2050 which is largely due to an increase in demand for RLGs across most use cases. Significant savings occur especially for those switching away from highly polluting fuels such as coal and oil. Note that the carbon emissions savings achieved in the supportive policy scenario are over 65% higher than in the 'Sustained Growth' pathway

	kgCO2e / kWh
Natural Gas	0.183
Oil	0.247
Petroleum	0.245
Industrial Coal	0.323
LPG	0.214
Evolving RLG (avg.)	0.023

Table 2 - Emission Factor Comparison

35. Gemserv's model on emission factor projection for liquid gas.
36. UK Government. 2012. Green Book Guidance. Available here: www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

Carbon emissions savings achieved in the supportive policy scenario are **over 65% higher** than in the 'Sustained Growth' pathway

Annual Carbon Emissions Savings in Different Scenarios

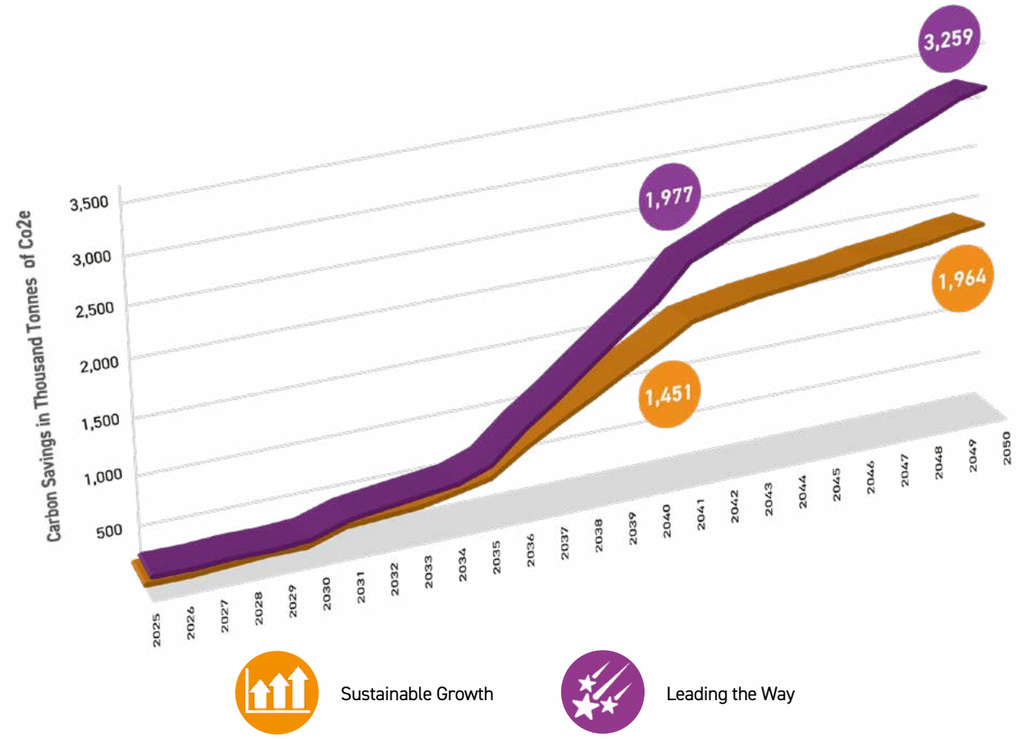


Figure 12 – Carbon Emissions Savings of Both Scenarios in Specific Years

7 A vision of liquid gas and renewable liquid gas demand – use cases

The tables below provide an overview of all existing use cases. Those most relevant to this study are detailed in the following sections, and the remaining use cases are in Annex A. These are divided into existing sectors and novel applications that could play a role in the future. To determine the potential relevance of RLG in the future, the use cases were scored against the five criteria introduced in the previous section. The highest scoring use cases and appliances were included in the quantitative demand forecasts.

	SIZE OF THE MARKET Based on volumes supplied in 2023.	RELEVANCE IN THE FUTURE Relevance based on the availability of competing low carbon fuels.	GROWTH OPPORTUNITY Assessing the potential of the market sector	COMMERCIAL ATTRACTIVENESS Based on maturity and market potential.	GOVERNMENT ALIGNMENT Existing support for the uptake of RLG in this market segment.
DOMESTIC	HIGH	HIGH	HIGH	HIGH	MEDIUM
INDUSTRIAL PROCESSES	HIGH	HIGH	HIGH	HIGH	MEDIUM
FOOD/DRINK PRODUCTION	MEDIUM	MEDIUM	MEDIUM	HIGH	HIGH
HOSPITALITY	MEDIUM	HIGH	HIGH	HIGH	HIGH
LEISURE	MEDIUM	MEDIUM	LOW	HIGH	MEDIUM
AUTOGAS	LOW	LOW	LOW	MEDIUM	LOW
FORKLIFT TRUCKS	MEDIUM	LOW	LOW	MEDIUM	LOW
AGRICULTURE	MEDIUM	MEDIUM	MEDIUM	HIGH	LOW

Table 3 - Qualitative Assessment of the Relevance of RLG in Existing Sectors

	SIZE OF THE MARKET Based on volumes supplied in 2023.	RELEVANCE IN THE FUTURE Relevance based on the availability of competing low carbon fuels.	GROWTH OPPORTUNITY Assessing the potential of the market sector	COMMERCIAL ATTRACTIVENESS Based on maturity and market potential.	POLICY & REGULATORY SUPPORT Existing support for the uptake of RLG in this market segment.
FUTURE OFF-GRID DOMESTIC (Current on grid buildings that become off grid)	LOW	HIGH	MEDIUM	HIGH	MEDIUM
HYBRID HEATING SYSTEMS (with HPs)	LOW	HIGH	HIGH	MEDIUM	MEDIUM
FUTURE OFF-GRID INDUSTRIAL (Current on grid buildings that become off grid)	LOW	MEDIUM	MEDIUM	HIGH	MEDIUM
BACK-UP POWER GENERATION	LOW	MEDIUM	HIGH	MEDIUM	HIGH

Table 4- Qualitative Assessment of the Relevance of RLG in Novel Applications

7.1. Domestic Cooking and Heating

The domestic sector primarily uses fuel for space and water heating, relying typically on gas, oil, electricity, and LPG. The domestic use of fuel furthermore covers cooking appliances such as stoves, ovens and BBQ grills. Due to its reliability and ease of use, LPG is often the preferred option for outdoor applications. In addition to heating and cooking, fuel is required to heat approximately 210,000 domestic swimming pools in the UK[37]. Whilst public data on the fuel used to heat swimming pools is sparse, there could be an opportunity for the liquid gas industry in off-grid areas, as LPG is generally well-suited for this application.

7.1.1. Market Size

The domestic sector is currently the largest market for the liquid gas industry, accounting for over 23% of total demand in 2023[38]. The analysis completed for this report shows that RLGs could play a significant role in the decarbonisation of domestic appliances as households start switching away from fossil fuels. As of today, LPG is particularly well suited to off-gas grid customers, servicing around 300,000 homes in the UK[39]. However, the liquid gas market could change in the future as the on gas grid market transitions.

37. Latimer Hinks. 2016. Making a splash: does a swimming pool add value? Available at: https://www.latimerhinks.co.uk/news/making-splash-does-swimming-pool-add-value
38. Liquid Gas UK member data, independently collected
39. ONS (2023). Central heating. Available at: https://www.ons.gov.uk/datasets/TS046/editions/2021/versions/4

7.1.2. Industry Future & Sector Growth

Role of Alternatives

There are many forms of low carbon heating technologies available to the domestic sector. Heat pumps are expected to be the mass market solution as evidenced by the Government's goal of installing 600,000 heat pumps per year by 2028[40], and support for heat pumps through the Future Homes Standard. However, heat pumps remain prohibitively expensive[41] for many households due to high upfront costs, especially in complex-to-decarbonise homes where substantial investments to improve fabric efficiency are essential in achieving suitable heat pump performance.

Heat pumps remain prohibitively expensive for many households

The ongoing high cost of electricity, which has not yet benefited from levy rebalancing, further exacerbates this issue. With air source heat pump installation costs remaining high under the Boiler Upgrade Scheme between 2022 and 2024[42], their cost shows little sign of coming down.

Where standalone heat pumps do not present a viable solution, district heating could be well suited to decarbonise dense urban areas. However, for rural areas or less dense urban areas, district heating may not present an economically valuable solution either.

The electricity network also requires capital investment and technical upgrades to enable the effective integration of heat pumps, and electric vehicles. Projections from the National Grid[43] suggest that by 2030, the UK needs to build five times more high voltage transmission lines than have been built in the last 30 years. Currently, it takes 12 to 14 years to build new electricity transmission lines[44]. Even if this timeframe could be halved, grid constraints could still present a challenge as many households increase their electricity demand. While current constraints are estimated to cost £500 million per year, National Grid modelling suggests these costs could peak between £1 billion to £2.5 billion annually before eventually decreasing.

Government was previously considering how hydrogen can play a key role in the decarbonisation of domestic heating. However, given the pausing of hydrogen home heating trials, such as Redcar[45], and low projections of hydrogen usage in the domestic sector, there is considerable uncertainty about its future role.

40. National Audit Office. 2024. Low heat pump uptake slowing progress on decarbonising home heating. Available at: https://www.nao.org.uk/press-releases/low-heat-pump-uptake-slowing-progress-on-decarbonising-home-heating
41. National Audit Office. 2024. Decarbonising Home Heating. Available at: https://www.nao.org.uk/reports/decarbonising-home-heating/
42. DESNZ. 2024. Collection. Boiler Upgrade Scheme Statistics. Available at: https://www.gov.uk/government/collections/boiler-upgrade-scheme-statistics
43. National Grid. 2023. Delivering for 2035. Upgrading the grid for a secure, clean and affordable energy future. Available at: https://www.nationalgrid.com/document/149496/download
44. Energy Systems Catapult. 2023. Electricity Networks Commissioner - Companion Report Findings and Recommendations. Available at: https://esc-production-2021.s3.eu-west-2.amazonaws.com/wp-content/uploads/2023/08/03165030/Electricity-Networks-Commissioner-Companion-Report-by-ESC.pdf
45. Hydrogen Insight. 2023. UK cancels controversial hydrogen heating trial in Redcar due to 'lack of H2 supply'. Available at: https://www.hydrogeninsight.com/policy/uk-cancels-controversial-hydrogen-heating-trial-in-redcar-due-to-lack-of-h2-supply-/2-1-1571341

The Government's announcement on the role that hydrogen is expected to play within home heating is set to be announced in 2026[46].

There are approximately 4.4 million off-grid homes in the UK[47], many of which are heated by high carbon fuels such as oil and solid fuel. Although there is a low carbon alternative for oil – HVO – a large share of HVO is expected to be required in the transport sector due to the Renewable Transport Fuel Obligation (RTFO) and the Sustainable Aviation Fuel (SAF) mandate. For households currently reliant on LPG, RLGs present a drop-in solution, and therefore a quick and easy way to reduce carbon emissions. For off-grid homes currently using oil or solid fuel heating, upgrading boilers to run on liquid gas could be more cost effective than installing a heat pump.

Growth

While new builds will need to meet specific energy efficiency requirements under the 2025 Future Homes Standards, many existing homes will be complex-to-decarbonise (CTD) because of the technical and financial constraints they face to realising energy efficiency improvements[48]. For those off the gas grid, only a small portion are currently using lower carbon solutions like LPG (10%) and electrification (18%)[49]. Accordingly, there remains a substantial potential market that includes properties relying on the most carbon intensive fuel sources such as heating oils (55%) and solid fuels (11%)[50].

In addition, there are close to 380,000 listed buildings in England (and more across the UK) for which deep retrofits, and changes to the external appearance of the building might be restricted[51]. The installation of a heat pump often requires building fabric upgrades and the situation of an outdoor unit which may be undesirable or prohibited.

There are approximately **4.4 million off-grid homes** in the UK

On Grid Properties

Once new properties are no longer connected to the gas grid, the cost for those remaining on the gas grid is expected to increase. With the cost of using natural gas likely to rise rapidly beyond 2040[52], on-grid households are incentivised to switch to a renewable heating system. Considering the high cost of heat pumps, local electricity network constraints, and the limited access to district heating, some homes risk becoming stranded without affordable alternatives.

46. UK Government. 2024. Hydrogen heating: overview. Available at: https://www.gov.uk/government/publications/hydrogen-heating-overview/hydrogen-heating-overview--2
47. House of Commons Library. 2024. Households off the gas-grid and prices for alternative fuels. Available at: https://commonslibrary.parliament.uk/research-briefings/cbp-9838/
48. DC Cities. 2023. Considering people, not just properties: when it comes to decarbonisation, what makes a home 'hard to treat'?. Available at: https://www.dgcities.com/blog/hardtotreathomes
49. Hansard. 2023. Heating Rural Homes. Available at: https://hansard.parliament.uk/commons/2023-06-13/debates/63E77ECB-8586-44B0-98F9-284651A03DA5/HeatingRuralHomes
50. Hansard. 2023. Heating Rural Homes. Available at: https://hansard.parliament.uk/commons/2023-06-13/debates/63E77ECB-8586-44B0-98F9-284651A03DA5/HeatingRuralHomes
51. Historic England (2024) Listed building dataset. Available at: Listed building Dataset | Planning Data
52. Ofgem. 2024. Sector Specific Methodology Decision for the Gas Distribution. Available at: https://www.ofgem.gov.uk/decision/riio-3-sector-specific-methodology-decision-gas-distribution-gas-transmission-and-electricity-transmission-sectors

Especially CTD households might switch to RLG once the cost of remaining on the grid outweighs the cost of switching. In the 'Sustained Growth' scenario, approximately 45% of the demand in 2050 is projected to come from households currently connected to the gas grid. This share increases to 50% in the Leading the Way scenario as a larger number of CTD buildings is assumed. As such, our analysis suggests that the largest RLG customer segment in the future could be those switching away from the gas grid.

Off Grid Properties

There are currently approximately 300,000 homes heated with LPG[53] for which RLGs could be the most cost-effective solution to decarbonise. With the relevant infrastructure in place, a majority of current LPG users is expected to switch from LPG to RLGs once available. Some demand destruction due to initiatives like the Clean Heat Market Mechanism and the Boiler Upgrade Scheme, must however also be taken into account.

Most off-grid dwellings currently reliant on oil boilers are expected to switch to heat pumps, but an opportunity for RLGs could emerge in dwellings that are not well-suited for a heat pump installation. The share of dwellings not suitable for heat pumps is assessed in more detail in the "Complex-to-decarbonise Homes" analysis discussed in section 7.1.4. In the Sustained Growth scenario, 20% of homes are considered CTD. This share is increased to 36% in the Leading The Way scenario. The share of CTD properties has a strong impact on the uptake of RLGs and highlights the number of households that could require a non-electric heating solution. The consumer pathways considered in the analysis are illustrated in Figure 11.

53. ONS (2023). Central heating. Available at: https://www.ons.gov.uk/datasets/TS046/editions/2021/versions/4

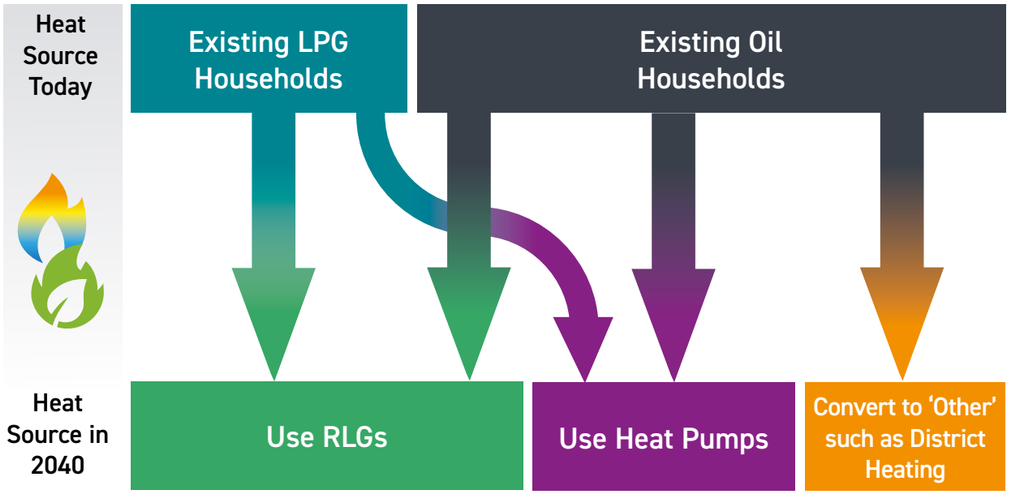
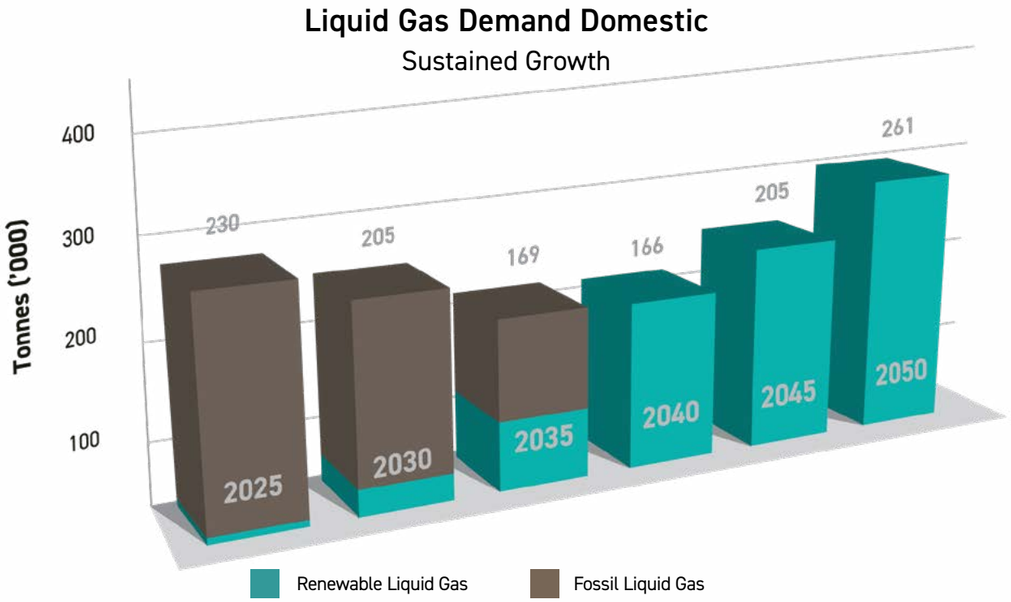


Figure 13: Transitional visualisation of current fuel source (LPG and Oil) to projected heat sources in 2040

Irrespective of the carbon emission reduction potential, households are assumed to transition to RLG boilers only when their current heating technology is no longer cost effective, or when fossil fuel boiler installations are banned. Considering the lack of a stringent policy framework to drive the uptake of low carbon heating solutions, the switch to RLG boilers is expected to be slow in the next decade. The model assumes a gradual uptake of RLG boilers from 2035 and 2040 onwards for on-gas-grid and off-gas-grid areas, respectively.



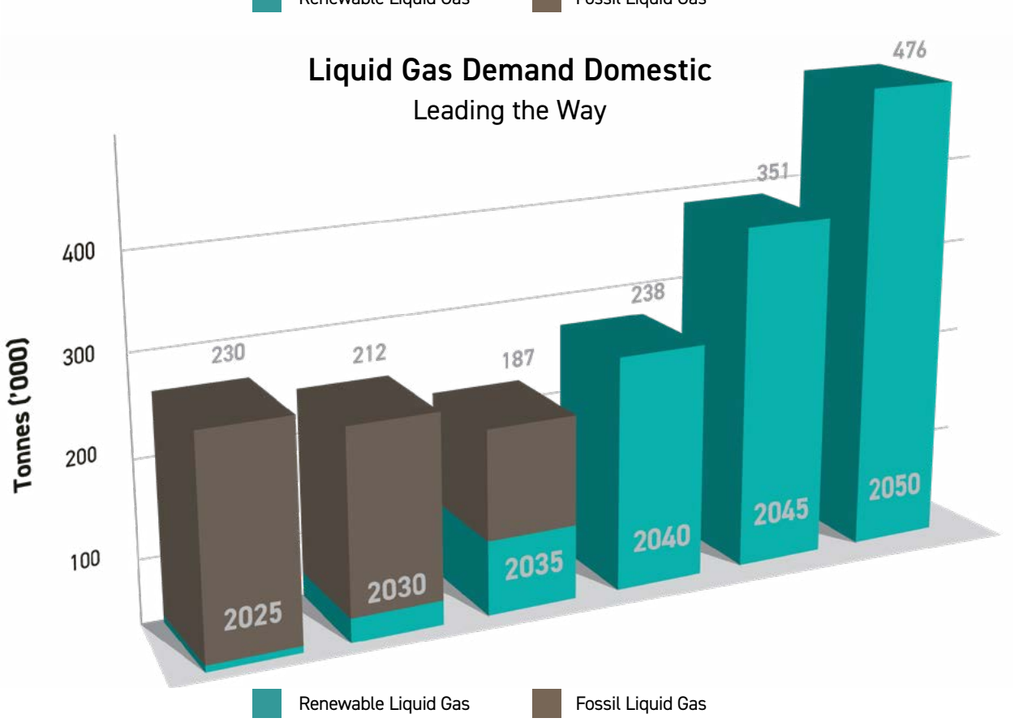


Figure 14 - Liquid Gas Demand in Domestic Space and Water Heating

7.1.3. Alignment with Government Policy

Policymakers continue to emphasise the decarbonisation of domestic properties due to the emissions they produce; ~17% of UK heating emissions come from households[54]. With no clear commitment from the current Government on the phase out date for new boilers, a clear decision is needed on the role of RLGs in the domestic sector, to provide the necessary signals for industry to invest in scaling up production.

In the long term, we consider government recognition of RLGs in the Biomass Strategy as critical for the industry's development and sustained growth. The electrification of the domestic sector will be fundamental to achieving interim decarbonisation targets. Where electrification is not a viable option, RLGs could play an important role in decarbonising a considerable amount of the domestic stocks' heat emissions.

A clear and holistic government strategy, set out in coordination with the liquid gas industry, is key to maximising the economic and environmental benefits of RLG. It is crucial for the Government to continue engaging with the liquid gas industry on feedstock security, and to explore long-term policy initiatives to fully realise the potential of RLGs.

7.1.4. Complex-to-Decarbonise Homes

This section explores the hard-to-treat (now coined complex-to-decarbonise) segment in greater detail, exploring the potential number of complex-to-decarbonise houses and their potential demand for RLG.

Complex-to-decarbonise (CTD) homes face challenges in decarbonising their heating due to various factors including infrastructure, fabric efficiency and household demographics. For instance, an old dwelling with poor fabric efficiency located off the gas-grid is likely to be CTD, especially for low-income households. Limited access to renewable technologies could furthermore be amplified by a lack of skilled installers that have experience with novel heating technologies[55]. Skill shortages are unlikely to be an issue when switching to RLG – as a drop-in solution for LPG and other gas boilers, the technology has access to an experienced installer base.

Calculating the exact number of CTD dwellings is challenging, given the number of factors that contribute to the definition. The number of listed properties in the UK provides an indication of the minimum number of CTD properties, totalling approximately 435,000 buildings – with 379,000 in England[56], 47,000 in Scotland[57] and 9,000 in Northern Ireland[58]. Households that are defined as CTD will need to decide on whether to commit to a deep retrofit or to use the existing infrastructure to run on a low carbon fuel, such as RLG.

54. BEIS. 2022. Decarbonising heat in homes. Available at: https://committees.parliament.uk/publications/8742/documents/88647/default/
55. DESNZ. 2024. Defining and identifying complex-to-decarbonise homes. Available at: https://assets.publishing.service.gov.uk/media/65819bc3fc07f3000d8d44a5/complex-to-decarbonise-homes-report.pdf
56. Historic England. 2024. Listed building dataset. Available at: https://www.planning.data.gov.uk/dataset/listed-building
57. Historic Environment Scotland. 2024. Living in a Listed Building. Available at: https://www.historicenvironment.scot/advice-and-support/your-property/owning-a-traditional-property/living-in-a-listed-building/
58. Historic Environment. 2024. Listed Buildings – An Introduction. Available here: https://www.communities-ni.gov.uk/articles/listed-buildings#:~:text=There%20are%20over%208%2C900%20Listed%20Buildings%20in%20Northern%20Ireland.

To highlight the uncertainty related to the share of CTD homes, two scenarios with a varying share of CTD households have been modelled. The 'Sustained Growth' scenario is based on the 20% figure published in a BEIS impact assessment that focuses on the technical feasibility of heat pump installations[59]. The 'Leading the Way' scenario assumes that 36% of households are CTD based on Gemserv's calculations on the economic viability of heat pumps in different UK archetypes[60]. This means that 20% and 36% of households are assumed to require an alternative low carbon source of heating in the respective scenario.

7.1.5. Hybrid Heat Pumps with RLG boilers

Market Size

Since hybrid heat pump installations are uncommon to date, the number of RLG hybrid systems in use is small. However, the technology is ready to be scaled up and RLGs can be substituted into hybrid systems which currently utilise LPG.

Future Relevance

The Government recognises that not all homes will be suitable for a heat pump, and that there is a role for alternative heating systems, particularly for off-grid, and complex-to-decarbonise homes. There are many technologies other than heat pumps that could be considered.

Oil, and solid fuels are currently used in off grid complex-to-decarbonise properties. While they can meet the heating demand, they are carbon intensive and result in air pollution through emitting NOx (Nitrous Oxide), particulate matter (PM) 2.5 and PM 10[61]. While direct electric heating presents a low carbon alternative, it is an expensive option that puts pressure on the electrical grid in off gas areas. This means that costly grid upgrades and a scale-up of the associated electrical infrastructure would be required, which takes several years to build. Additionally, these technologies are unlikely to cost-effectively heat complex-to-decarbonise off grid properties, particularly for larger homes with higher heat demand[62]. However, for smaller homes, and off grid flats and tower blocks they can be a more attractive option.

Considering the limitations of the heating technologies discussed, a role for RLG hybrids emerges. A hybrid heating system using a heat pump and boiler powered by RLG is a cost-effective, low carbon, and energy efficient option for complex-to-decarbonise off gas grid properties[63].

Considering the limitations of the heating technologies discussed, **a role for RLG hybrids emerges**

59. BEIS. 2021. Impact Assessment on phasing out fossil fuels. Available at: https://assets.publishing.service.gov.uk/media/616d7b4d8fa8f5297cc02b5c/domestic-offgg-ia.pdf
60. Based on Gemserv's heating and archetype modelling (2024)
61. Liquid Gas UK. 2021. Opportunities to Decarbonise the Non-Domestic Off-Grid Sector with LPG and bioLPG. Available here: Opportunities to Decarbonise the Non-Domestic Off-Grid Sector with LPG and bioLPG
62. Based on Gemserv's heating and archetype modelling (2024)
63. Liquid Gas UK. 2024. LG UK's Response to the Biomass Strategy. Available at: https://www.liquidgasuk.org/policy/2024-report-lguk-response-to-biomass-strategy

Growth

The industry expects domestic heating to be a key growth area[64]. Whilst growth in heat pump numbers is expected, the Government's annual heat pump installation target of 600,000 by 2028 seems optimistic given current deployment (60,244 in 2023[65]), with a circa ten-fold increase in installations needed between 2024 and 2028 to meet the objective. Therefore, exploring alternative technology options, for homes where heat pumps are not the most cost effective or technically feasible option, is key.

Hybrid heat pumps have the advantage of scaling the installation of heat pumps whilst overcoming restrictive cost, space, and reliability issues associated with installing a standalone heat pump and hot water cylinder in certain archetypes. In older properties with larger rooms and poor fabric conditions, fabric and air tightness measures would be costly to install[66]. Heat pumps may still not be able to provide a consistent and comfortable indoor air temperature owing to its low flow temperatures, particularly during the winter. Hybrid systems, using a heat pump and RLGs could help resolve this issue in off-gas grid areas, as recognised by the CCC in their Progress Report to Parliament[67], and provide additional resilience if one of the heating systems is unavailable or faulty.

Figure 13 illustrates the number of RLG hybrid heat pump systems and the volume of RLG associated with them. The projections are adopted from the National Grid's FES 2024[68] and show a ratio of biofuel to electricity of around 1:11 kWh. The projected uptake is promising, peaking at 282,000 hybrid systems in 2042, with an RLG demand of 9,306 tonnes. As hybrids primarily run on electricity, the demand for RLG is relatively low, amounting to roughly 4% of total RLG demand in 2040 in the LTW scenario. Hybrids have not been considered in the 'Sustained Growth' scenario because of the limited number of installations currently.

64. Liquid Gas UK. 2022. Industry Census. Available at: https://www.liquidgasuk.org/uploads/D0C637B69B62F04C.pdf
65. HPA. 2024. Heat Pump Sales in the UK. Available at: Statistics - Heat Pumps
66. Gillott et al. 2016. Improving the airtightness in an existing UK dwelling: The challenges, the measures and their effectiveness. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0360132315300986
67. Climate Change Committee. 2023. Progress in reducing emissions - Report to Parliament. Available at: https://www.theccc.org.uk/wp-content/uploads/2023/06/Progress-in-reducing-UK-emissions-2023-Report-to-Parliament-1.pdf
68. The National Grid. 2024. Future Energy Scenarios. Available here: https://www.nationalgrideso.com/future-energy/future-energy-scenarios-fes

RLG Hybrid Heat Pump Projection

National Grid Holistic Transition Scenario

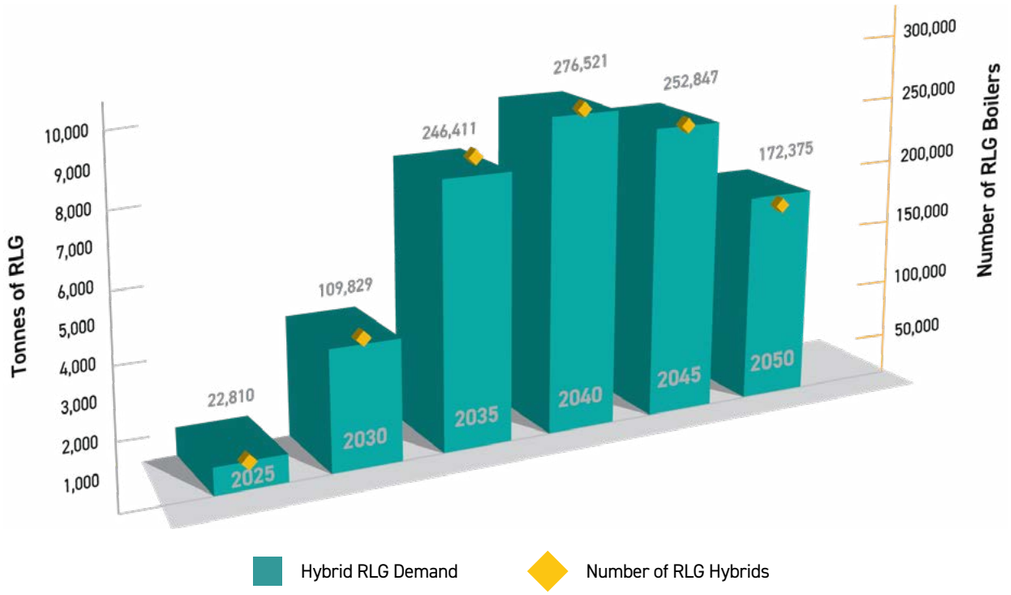


Figure 15 - RLG Hybrid Heat Pump Projection under FES Holistic Transition

7.1.6. Alignment with Government Policy

Hybrids in the domestic sector enjoy policy support through the Clean Heat Market Mechanism and the Social Housing Decarbonisation Scheme, but more support is needed for their benefits to be realised. Hybrids can be a solution for decarbonising CTD homes while supporting progress towards the Government's target of 600,000 heat pump installations by 2028. Therefore, there is a clear opportunity for hybrids in the Net Zero transition.

Consumers in the Netherlands have driven a growing market for hybrid installations following the announcement of the mandate on renewable heating systems from 202613. Hybrids, recognised to be the solution where standalone heat pumps are not suitable, have been an eligible measure and have contributed to accelerating the installation of heat pumps, and providing carbon emissions savings. Forecasts estimate that hybrids could make up to 65% of the Dutch heat pump market by 2030[69], demonstrating how they are an attractive technology for the Net Zero transition. This highlights how the UK can capitalise on the opportunity of hybrids to deliver policy objectives.

69. Dutch New Energy Research. 2024. The 2024 National Heat Pump Trend Report. Available at: https://www.greenheatingsolutions.nl/trendrapport/

7.1.7. Economic Benefits- Single Family Home Case Study

Building on Gemserv's existing heating and archetype model, this analysis compares the economic performance and affordability of RLG powered heating systems with other low carbon alternatives. To determine cost efficiency, the model estimates the annualised cost of different heating systems in the respective archetype. The annualised cost metric considers upfront and running costs[70] across the technology's lifespan and is a widely accepted metric to compare the cost of different technologies.

Single Family Home (pre-1918) without Major Renovations

This case study assesses the annualised cost of different heating systems in one of the most common archetypes across the UK. Single family homes built before 1918 make up around 16% of properties and are considered a representative example of the challenges homeowners face in terms of decarbonisation.

Table 5 illustrates relevant financial metrics associated with owning and running four low carbon heating technologies in the specified archetype. The retail price of LPG is based on the bulk price data submitted by LGUK members. The reported bulk price was adjusted for the difference in wholesale and retail price observed in the recent past. Argus was consulted to estimate the premium on RLG which stood at $1,000/MT over the price of propane during the first half of 2024[71]. The argus premium equates to a 60% markup over LPG which is used in this report.

The results highlight that air-source heat pumps (ASHPs) present an expensive option in terms of upfront costs. The analysis finds that owning and running an RLG boiler instead of a heat pump in a large, detached house without renovation can save homeowners roughly £15,000 throughout the 15-year lifetime[72] – this underlines the significance of a multi-technology approach to decarbonise heating.

Although extensive renovation measures could enable homeowners to cost-effectively run a heat pump, most households are unable to afford the upfront cost associated with installing a heat pump and energy efficiency measures. The cost of the renovation measures required to make the archetype heat pump ready is estimated at just under £26,000. Adding the upfront cost of an ASHP to the renovation costs results in a total upfront cost of roughly £45,000 – a figure that substantially exceeds the median disposable household income of £32,400[73].

70. All fuel prices and technology costs as of 2023.
71. Barchart. 2024. Mini European Propane CIF ARA Argus Futures (Final Sale Price). Available here: Mini European Propane CIF ARA Argus Futures Nov '22 Futures Price - Barchart.com
72. Difference in net present costs of the two heating systems.
73. Office for National Statistics. 2022. Average Household Income FY21/22. Available here: https://www.ons.gov.uk/peoplepopulationandcommunity/personalandhouseholdfinances/incomeandwealth/bulletins/householddisposableincomeandinequality/financialyearending2022

Detached House – No Major Renovations		
ASHP	Upfront Cost (£)	18,270
	Annual Running Cost (£)	5,489
	Annualised Cost (£)	**7,495**
Direct Electric Heating	Upfront Cost (£)	2,731
	Annual Running Cost (£)	11,430
	Annualised Cost (£)	**11,730**
RLG Boiler	Upfront Cost (£)	2,483
	Annual Running Cost (£)	5,571
	Annualised Cost (£)	**5,843**
LPG RLG Blend (50/50)	Upfront Cost (£)	2,483
	Annual Running Cost (£)	3,862
	Annualised Cost (£)	**4,134**

Table 5 - Annualised Cost of Low Carbon Solutions in a Single Family Home (pre 1918)

7.2. Industrial Demand

As a versatile and reliable fuel, LPG is used in a variety of industrial applications. Its high calorific value makes it suitable for powering high-temperature processes with a relatively low volume of fuel. Since electrifying high-temperature processes (especially >1000°C) is challenging[74] , many industries like the cement, glass and mineral sector rely heavily on fossil fuels like oil and natural gas.

In the food and drinks industry, heat is used in cooking, baking, pasteurization, drying, brewing, and distilling. While high-temperature processes are less common in this sector, many production sites are located in rural and remote areas with limited access to renewable fuels and technologies. As a portable and flexible fuel, RLGs could be well-suited to supply energy to dispersed sites off the gas grid.

74. DESNZ. 2023. Enabling Industrial Electrification. A call for evidence on fuel- switching to electricity. Available at: https://assets.publishing.service.gov.uk/media/64c0c6961e10bf000d17ce97/industrial-electrification-call-for-evidence.pdf

7.2.1. Market Size

The industrial sector including high-heat processes, manufacturing, construction, mining, and aggregates is responsible for 14% of total emissions in the UK[75]. In 2022, the sector's energy consumption was distributed among various sources as follows: natural gas accounted for 39%, electricity for 33%, oil for 13%, bioenergy & heat for 11%, and coal for 5%[76]. As per government modelling, industrial emissions must be reduced by two-thirds by 2035 and by 90% from 1990 levels by 2050 to achieve net-zero targets. The manufacturing sector also presents one of the largest markets for the liquid gas industry, accounting for roughly 14% of total LPG demand in 2023[77].

7.2.2. Industry Future & Sector Growth

Role of Alternatives

Electrification is a competitor to liquid gases in low and medium heat applications, but technology for high-heat applications remains less applicable. According to our stakeholder engagement, electric heating technologies are not suited to processes that require quick modulation in temperatures usually provided by a flame.

In addition to the technical suitability of electrical solutions, industrial sites off the gas grid face another key challenge in the form of grid constraints. Parts of the electricity network in rural areas are not prepared for high levels of electrification and are likely to require significant grid upgrades first. This causes long waiting times to connect with some customers being offered connection dates as late as 2030[78]. The Government recognises that grid connection delays present one of the most common barriers to industrial electrification, with industrial sites waiting on average 5 years for an upgraded connection[79]. As a result, it is likely that fringe areas with low grid capacity will need interim non-electrical solutions.

Considered a 'low regret' technology, hydrogen has garnered government support, including subsidies for developing hydrogen infrastructure when costs are prohibitive for industry[80]. Hydrogen networks are expected to develop in industrial hotspots with four low carbon clusters targeted by 2030 and one Net Zero cluster by 2040[81]. The Government has characterised hydrogen as a leading solution for the decarbonisation of high-temperature heating processes, however, there are locations outside of planned hydrogen networks which will require an alternative solution[82]. Therefore, there remains an opportunity for RLGs outside of industrial clusters, where hydrogen infrastructure is not available. Accordingly, the availability of low carbon hydrogen across the UK determines the uptake of renewable liquid gases in the manufacturing industry in our analysis.

75. UK Government. 2022. UK GHG Emissions, Final Figures. Available at: https://assets.publishing.service.gov.uk/media/65c0d15863a23d0013c821e9/2022-final-greenhouse-gas-emissions-statistical-release.pdf
76. DESNZ. 2023. UK Energy in Brief. Available at: https://assets.publishing.service.gov.uk/media/664c827ff34f9b5a56adcb5d/UK_Energy_in_Brief_2023.pdf
77. Liquid Gas UK Member Data
78. DESNZ and OFGEM. 2023. Connections Action Plan. Speeding up connections to the electricity network across Great Britain. Available at: https://assets.publishing.service.gov.uk/media/6581730523b70a000d234bb0/connections-action-plan-desnz-ofgem.pdf
79. DESNZ. 2024. Enabling Industrial Electrification. Available here: https://assets.publishing.service.gov.uk/media/66e013650f4ba0621b086702/electrification-call-for-evidence-formal-summary-of-responses.pdf
80. DESNZ. 2021. Industrial Decarbonisation Strategy. Available at: https://www.gov.uk/government/publications/industrial-decarbonisation-strategy
81. DESNZ. 2021. Industrial Decarbonisation Strategy. Available at: https://www.gov.uk/government/publications/industrial-decarbonisation-strategy
82. DESNZ. 2023. Enabling Industrial Electrification. A call for evidence on fuel- switching to electricity. Available at: https://assets.publishing.service.gov.uk/media/64c0c6961e10bf000d17ce97/industrial-electrification-call-for-evidence.pdf

Alongside cost, one of the primary barriers to scaling hydrogen projects is the relatively low maturity of the technology, which presents an opportunity for liquid gases. As the development and deployment of hydrogen progress slowly, liquid gases offer an immediate solution to replace existing boiler infrastructure in high-heat applications or provide a lower-carbon alternative.

Growth

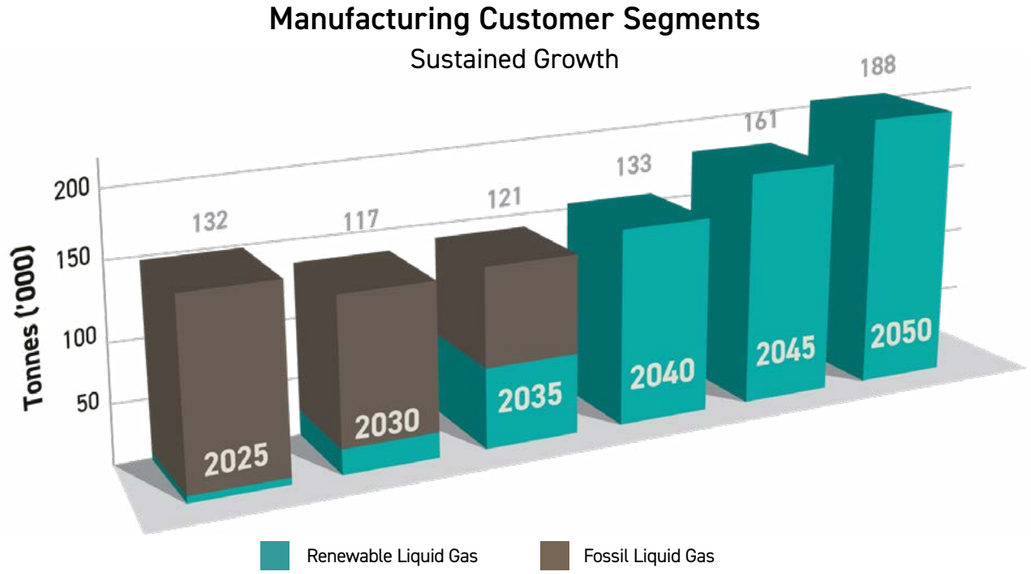
The pressure to decarbonise energy and carbon intensive manufacturing processes – driven in large part by the price of carbon – is modelled as creating an increase in the demand of renewable liquid gases from 2030 onwards. As one of few mature technologies suitable for processes that require high-temperature direct heating, the liquid gas industry is in a good position to tap into a new customer base both on and off the gas grid.

To reflect the uncertainty associated with the hydrogen rollout, two demand scenarios have been modelled to account for a varying degree of access to hydrogen. While hydrogen is expected to be critical, the demand scenarios recognise that other technologies like Carbon Capture, Utilisation and Storage (CCUS) could also play a role in decarbonising high heat industrial processes[83]. As such, the uptake of RLG outside of hydrogen clusters is estimated at 30%.

The 'Sustained Growth' scenario shows how the demand for RLGs could evolve in a situation with widespread access to low carbon hydrogen. The scenario assumes that Track 1 and 2 hydrogen clusters[84] are fully operational by 2040. Analysis based on the Net Zero Industrial Pathways model shows that the energy demand of manufacturing sites outside of Track 1 or Track 2 hydrogen networks makes up 33% of total energy demand from manufacturing. Those sites are likely to require alternative low carbon technologies and present an opportunity for renewable liquid gases. Figure 14 visualises this opportunity for growth, suggesting that the market could grow by over 40 percent by 2050 even though low carbon hydrogen is widely available.

The 'Leading the Way' scenario assumes a larger share of manufacturing sites that are located outside of future industrial clusters. Assuming that only Track 1 hydrogen clusters are in operation by 2040, nearly half of the energy demand from manufacturing is related to sites that are not connected to a hydrogen network. Therefore, a larger proportion of the market is expected to switch to RLGs once the use of natural gas and other fossil fuels becomes prohibitively expensive. As shown in Figure 14, the limited availability of low carbon hydrogen combined with the lack of suitable alternatives could lead to a demand of over 280,000 tonnes of RLG in 2050, equating to around 40% of fossil fuel use in off-grid high-heat manufacturing, and so highlighting the opportunity for RLGs.

83. DESNZ. 2021. Industrial Decarbonisation Strategy. Available at: https://www.gov.uk/government/publications/industrial-decarbonisation-strategy
84. Including HyNet (Merseyside) and East Coast (Teesside and Humberside) clusters



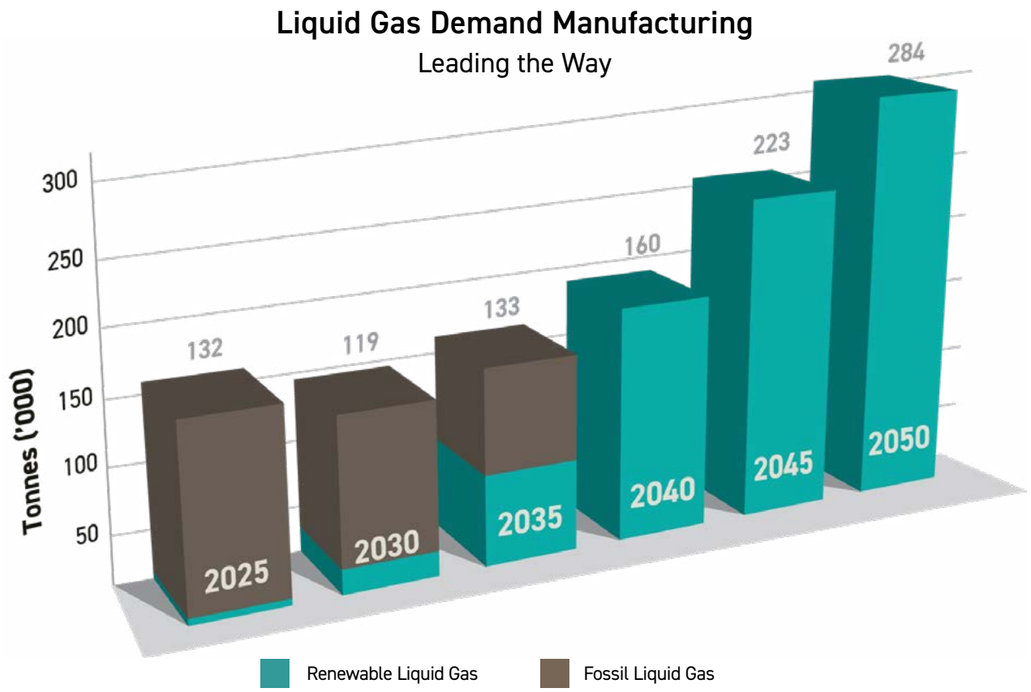


Figure 14 - Liquid Gas Demand in Domestic Space and Water Heating

7.2.3. Alignment with Government Policy

Although initiatives like the Industrial Energy Transformation Fund are not compatible with liquid gas funding, public procurement offers a valuable opportunity for the liquid gas market. To win a government contract in sectors like construction, companies must demonstrate their decarbonisation efforts, especially for contracts exceeding £5 million per annum. One effective way to achieve carbon reductions is by using RLG on-site. Given that the Government is a major customer in sectors like construction, this presents an opportunity for the sector moving forward, particularly considering the lack of mature alternative technologies for high-heat industries and applications.

Most importantly for the liquid gas sector, the Biomass Strategy has recognised that RLG can contribute to decarbonising high-heat industrial processes, though Government support is still in its early stages[85] . Future measures, such as carbon pricing, could benefit the liquid gas sector. While the existing UK Emissions Trading Scheme (ETS) is currently limited in scope, the government is likely to expand its reach as part of its Industrial Decarbonisation Strategy[86].

7.2.4. Economic Benefits – Glass Manufacturing Case Study

The glass production process is an energy-intensive procedure that relies on high-temperature direct heating. Heat pumps are not suitable to provide heating without reducing process efficiency. Thus, the current availability of low carbon technologies suitable to power high heat manufacturing processes remains low, presenting a considerable barrier for reaching Net Zero targets. The UK's glass manufacturers require a unique solution to decarbonise process heating requirements. Outside of hydrogen clusters, RLGs could present a cost-effective decarbonisation pathway for high heat manufacturers as it requires minimal changes to the existing infrastructure.

Glass manufacturing requires extremely high temperatures and thus the annual heat demand was estimated at 48,341 MWh per year for a typical manufacturing site that produces approximately 110,000 tonnes of glass per year[87]. Assuming 1,705 working hours per annum, the size of the furnace needed was estimated at 28,000 kW.

The analysis suggests that an industrial RLG furnace is cheaper to operate than an industrial electric furnace, achieving savings of over £3 million in terms of annualised costs. This is mainly due to the difference in lifetime of the furnace types. According to technology cost data published by the Sustainable Energy Authority of Ireland (SEAI), an industrial electric furnace is expected to last only 8 years, whereas an industrial biofuel furnace can last up to 25 years[88].

The findings discussed in this section suggest that RLG based heating systems can present an economically viable and technically feasible solution for the manufacturing sector. As such, the demand for RLG is expected to increase between 42% and 128% from 2025 to 2050, depending on the availability of low carbon hydrogen.

85. DESNZ. 2023. Biomass Strategy. Available at: https://assets.publishing.service.gov.uk/media/64dc8d3960d123000d32c602/biomass-strategy-2023.pdf
86. DESNZ. 2021. Industrial decarbonisation strategy. Available at: https://ww.gov.uk/government/publications/industrial-decarbonisation-strategy
87. Carbon Trust. 2004. A Study of Balance Between Furnace Operating Parameters and Recycled Glass Melting Furnaces. Available here: https://www.glass-ts.com/site/assets/files/1015/2004_-_a_study_of_the_balance_between_furnace_operating_parameters_and_recycled_glass_in_glass_melting_furnaces.pdf
88. Sustainable Energy Authority Ireland. 2022. Low Carbon Heating and Cooling Technologies. Available here: https://www.seai.ie/data-and-insights/national-heat-study/low carbon-heating-and-co/

Glass Manufacturer		
Industrial Electric Furnace	Upfront Cost (£)	6,381,470
	Annual Running Cost (£)	9,088,033
	Annualised Cost (£)	**10,016,388**
Industrial RLG Furnace	Upfront Cost (£)	6,381,470
	Annual Running Cost (£)	6,410,987
	Annualised Cost (£)	**6,798,177**
Industrial RLG/LPG Furnace	Upfront Cost (£)	6,381,470
	Annual Running Cost (£)	4,505,207
	Annualised Cost (£)	**4,892,397**

Table 6 - Annualised Cost of Different Heating Systems in a Glass Manufacturing Plant

7.3. Leisure Sites

7.3.1. Market Size

The leisure sector accounts for approximately 11% of LPG demand, equivalent to 111,000 tonnes[89]. Currently, liquid gas is used in caravans, holiday parks, and campsites in over 6,250 locations in which LPG plays a major role in delivering heating requirements[90].

7.3.2. Industry Future & Sector Growth

Leisure sites in the UK are typically located in rural areas and off the gas grid. Concerns about gas grid decommissioning and the shift toward hydrogen are therefore less relevant to this industry.

89. Liquid Gas UK Member Data – Independently sourced
90. British Holidays & Home Parks Association. 2019. Pitching the Value – 2019 Economic Benefit Report: Holiday Parks and Campsites UK. Available at: https://www.bhhpa.org.uk/system/files?file=misc-documents/sc6407-00-holiday-park-econ-impact-uk-final-report-2.pdf

While decarbonisation efforts in the sector focus on electrification, there is uncertainty regarding the economic and technological feasibility of electric solutions for leisure site appliances. Leisure sites often require portable, flexible and reliable energy sources such as liquid gas.

The limited capacity of the electricity network in remote and rural areas presents an additional challenge to large-scale electrification in the short and medium term. The British Holidays and Home Parks Association has called on the Government and distribution network operators to address grid capacity challenges which is affecting many sites[91]. As a reliable source of energy that is well placed to address fluctuations in energy consumption, RLG presents an interim low carbon solution.

The growing need for backup power given increasingly variable weather patterns, and the requirement for touring pitch visitors to travel between sites with a reliable energy supply, highlights the importance of liquid gases in this industry. In such situations, liquid gases remain the primary solution for both site owners and consumers.

The demand pathways displayed in Figure 15 illustrate the impact of electrification on the future demand for RLG in the leisure sector. The 'Sustained Growth' scenario assumes that electric solutions will support 50% of the energy demand by 2050, in alignment with the National Grid's 'Holistic Transition' pathway. The 'Leading the Way' scenario assumes a lag in decarbonisation in the leisure sector compared to other commercial sectors, and therefore a lower rate of electrification leading up to 2050. With many leisure site visitors not being permanent residents, mostly visiting in the warmer months, this is considered a reasonable assumption.

The lower rate of electrification of only 15% is sufficient to sustain the current liquid gas demand in the sector in the LTW scenario. If the rate of electrification reaches 50%, a decline in the demand for liquid gas is to be expected. By 2050, this will be nearly half of today's output at 64,000 tonnes of LPG.

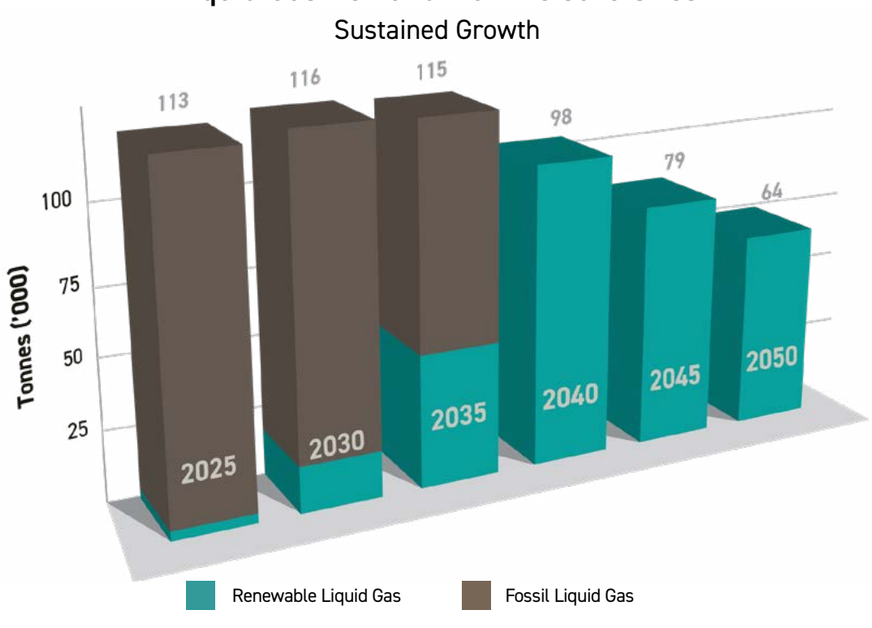
7.3.3. Alignment with Government Policy

Although tourism is an important contributor to the UK economy, leisure sites have not been a direct focus of Government policy. Instead, it is the strengths of liquid gas that make it a favourable option for those operating within this sector. The provision of heat from RLGs is particularly relevant for the industry and aligns well with the government's focus on heat decarbonisation.

RLGs provide a safe, secure, and reliable energy supply for those on the road, as an emergency backup, or for situations where the energy efficiency of static homes or the high capital cost of heat pumps makes liquid gas the most suitable alternative.

An important consideration for static homes, particularly when privately rented, is the requirement to have an Energy Performance Certificate (EPC) in certain instances. With changes like the introduction of a minimum EPC rating by 2030 and calls for EPC criteria to be reformed to reflect carbon savings, as already seen in Scotland[92], LPG technologies at present, and RLGs in the future, could play a key role in helping landlords ensure compliance.

91. British Holidays & Home Parks Association. 2024. BH&HPA Manifesto 2024. Available at: BH&HPA Manifesto 2024 | BH&HPA (bhhpa.org.uk)
92. Scottish Government. 2023. EPC Reform Consultation. Available at: https://www.gov.scot/publications/energy-performance-certificate-epc-reform-consultation/



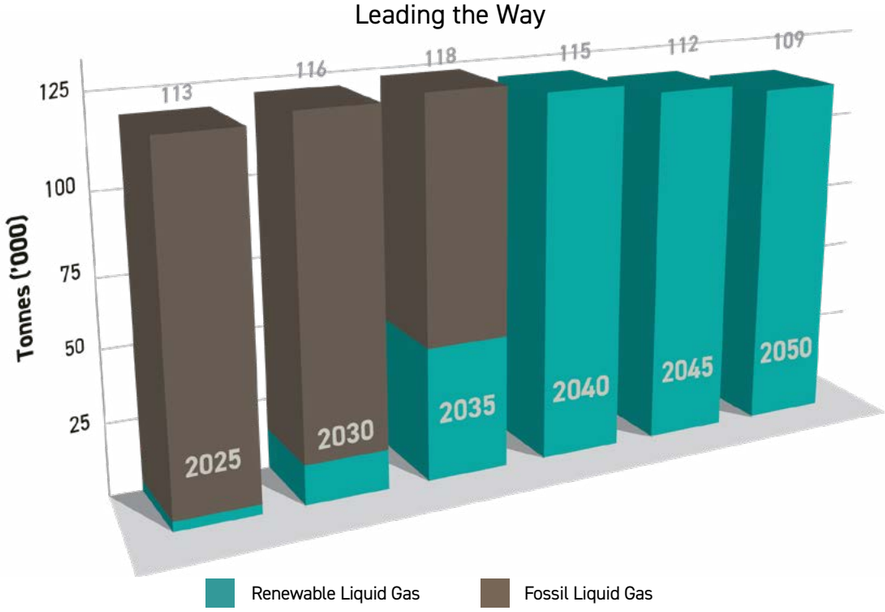


Figure 17 – Liquid Gas Demand from Leisure Sites in Different Scenarios

7.4. Agriculture

The agricultural sector uses heat in many different settings, including livestock facilities, food processing, crop drying, greenhouses, and on-site energy generation for other needs. The diversity of uses across the agricultural sector aligns with the versatility, portability and flexibility that RLGs can provide.

The diversity of uses across the agricultural sector aligns with the **versatility, portability and flexibility that RLGs can provide**

7.4.1. Market Size

The agricultural sector presents one of the most important markets for the liquid gas industry, accounting for roughly 12% of the total LPG consumption in 2023[93]. Farms and other agricultural businesses are typically located off the gas grid and in remote areas where the availability of low carbon fuels is limited. The industry's current reliance on fossil fuels presents an opportunity for the liquid gas industry to displace traditional power sources like diesel and solid fuels where electrification does not present an economically viable option. With a large supply network and expertise in servicing off-grid customers, the liquid gas industry is in a good position to not only maintain its current market share but to service new customers that are looking to decarbonise their operations.

93. LGUK member data, independently collected

7.4.2. Industry Future & Sector Growth

Role of Alternatives

Although electrification is expected to play an important role in cutting carbon emissions from agricultural buildings and appliances, a technology-agnostic approach is required. Based on the CCC's Balanced Pathway scenarios, electricity is projected to make up circa 50% of energy demand in 2050, with a small share of fossil fuels remaining[94]. This indicates that there remains great potential for alternative low carbon fuels including RLGs.

Growth

The 'Sustained Growth' and the 'Leading the Way' demand scenarios project the demand of liquid gases under varying degrees of electrification and other competing fuels in the agricultural sector. This reflects the uncertainty related to potential grid constraints, the availability of low carbon technologies in remote locations and the prevalence of complex-to-decarbonise applications in the agricultural industry.

The RLG demand pathway presented in the 'Sustained Growth' scenario assumes that 20% of fossil fuel powered appliances will gradually switch to RLGs from 2035, with a share of fossil fuel remaining by 2050. This percentage is increased to 36% in the 'Leading the Way' scenario, demonstrating the potential demand for RLG when the uptake of electrification and other competitor fuels is low. Figure 16 shows how the demand for liquid gases is projected to develop under our scenarios.

The CCC's Balanced Pathway scenario projects that the overall energy consumption attributed to this sector halves by 2050[95]. This is based on an expected increase in energy efficiency measures and behavioural changes affecting the demand of resource intensive products such as meat and dairy. Without a firm policy framework in place, there is limited incentive to switch away from fossil fuels currently, leading to a decrease in liquid gas demand until 2035 in both scenarios. After 2035, the pressure to decarbonise is expected to increase creating new markets for the liquid gas industry, both on and off the gas grid. The renewable liquid gas demand from customers switching away from fossil fuels could lead to an overall increase in demand to 175,000 tonnes of RLGs in 2050 in the more optimistic 'Leading the Way' scenario. This is equivalent to decarbonising the energy of around 25,000 farms in the UK.

94. Climate Change Committee. 2020. Sixth Carbon Budget. Available at: https://www.theccc.org.uk/publication/sixth-carbon-budget/

95. Climate Change Committee. 2020. Sixth Carbon Budget. Available at: https://www.theccc.org.uk/publication/sixth-carbon-budget/

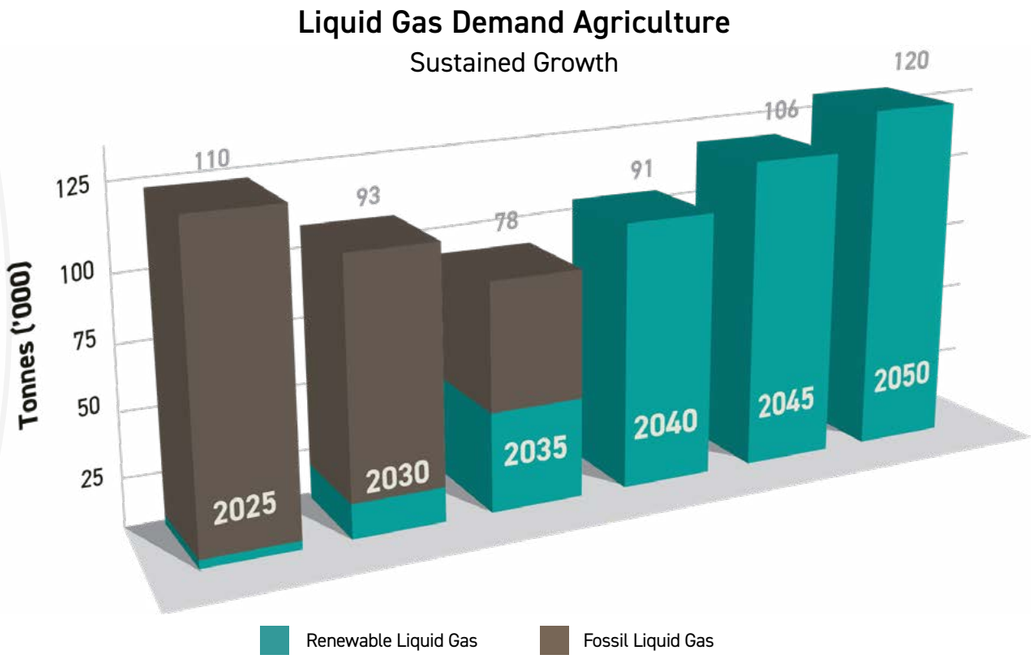


Figure 18 - Liquid Gas Demand from Agriculture in Different Scenarios

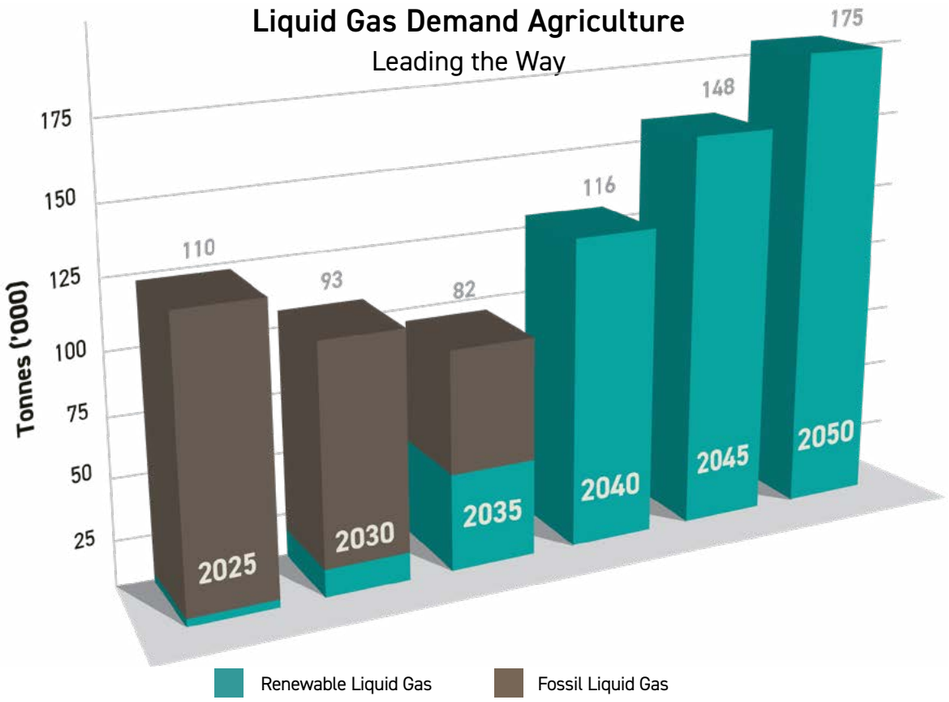


Figure 18 - Liquid Gas Demand from Agriculture in Different Scenarios

7.4.3. Alignment with Government Policy

Agriculture is a critical sector facing challenges due to the substantial emission reductions needed to meet interim net-zero targets. Adopting renewable liquid gases across the many processes used within the agricultural sector would reduce greenhouse gas emissions.

In addition, propane is a by-product of both Sustainable Aviation Fuel (SAF) and biodiesel production. As the government and industry place greater emphasis on decarbonising sectors such as aviation, there is a growing opportunity for cross-sector collaboration. Leveraging these synergies can help ensure timely and adequate capacity to meet future RLG requirements.

Although current policies and regulations are lacking in driving agricultural decarbonisation, the eventual need to reduce emissions, combined with the versatile utility of RLGs in applications like space and water heating for livestock facilities or crop drying, could play an important role in facilitating easy, on-site transitions to cleaner energy sources in agriculture.

The findings discussed in this sub-chapter suggest that RLG based heating systems can present an economically viable and technically feasible solution to satisfy space and water heating demands in the agricultural sector. This is particularly relevant for buildings and applications that are unsuitable for electrification. While electrification is expected to play an important role in the sector, the demand for RLG still shows potential to grow between 9% and 59% from 2025 to 2050.

7.5. Hospitality and Catering

The hospitality, catering, and street food industry encompasses restaurants, pubs, hotels, and the growing trend of street food in the UK. The sector is one of the largest contributors to the UK economy.

7.5.1. Market Size

In 2023, LPG demand in the hospitality and catering sector accounted for roughly 7% of total LPG demand in the UK[96]. Restaurants, pubs, and hotels are frequently found in rural areas which are not connected to the gas-grid – resulting in reliance on higher emitting fuel sources such as heating oil and fossil LPG. Recent statistics suggest there are 88,310 restaurants, bars and pubs in the UK[97] and 9,955 hotels in the UK across on-and off-grid areas[98].

Street vendors are an important and growing sector with an estimated 8,000 businesses which are, by definition, almost all entirely disconnected from the mains gas supply[99].

96. Liquid Gas UK Member Data, independently collected
97. Office of National Statistics. 2020. Number of restaurants, takeaways, cafes, bars, and pubs in the UK. Available at: https://www.ons.gov.uk/aboutus/transparencyandgovernance/freedomofinformationfoi/numberofrestaurantstakeawayscafesbarsandpubsintheuk
98. Office of National Statistics: 2020. UK Hotels in 2019 and 2020. Available at: https://www.ons.gov.uk/aboutus/transparencyandgovernance/freedomofinformationfoi/ukhotelsin2019and2020
99. LGUK. 2021. Opportunities to decarbonise the non-domestic off grid sector. Available at: https://www.liquidgasuk.org/uploads/DOC60193EF45014F.pdf

7.5.2. Growth

Rural hospitality businesses, such as pubs, restaurants and hotels, occupy buildings with a similar age distribution and fabric efficiency as rural residential properties. Consequently, this demand modelling has assumed the same proportion of CTD properties as in the domestic analysis. This classification limits some of the opportunity for electrification but creates potential for RLGs. Within off gas or rural settings, business owners are likely to have limited low carbon alternatives, including biomass boilers and hybrid systems.

A key advantage of RLGs in this context is their suitability for kitchens, where a high-heat, controllable flame is frequently preferred. Additionally, RLGs offer a reliable and effective heat source for maintaining thermal comfort for guests across all types of properties. Compared to low carbon technologies like heat pumps, which operate at constant low temperatures and are not as effective in thermally inefficient properties, RLGs may seem to be a more appropriate choice for consumers. However, for those in the hospitality and catering sector, the cost-effectiveness of the energy source is crucial due to high operational costs and reduced margins. Where costs can be kept competitive, in which adoption of a bulk supply is to assist in affordability, there exists considerable potential for growth from the hospitality and catering sector.

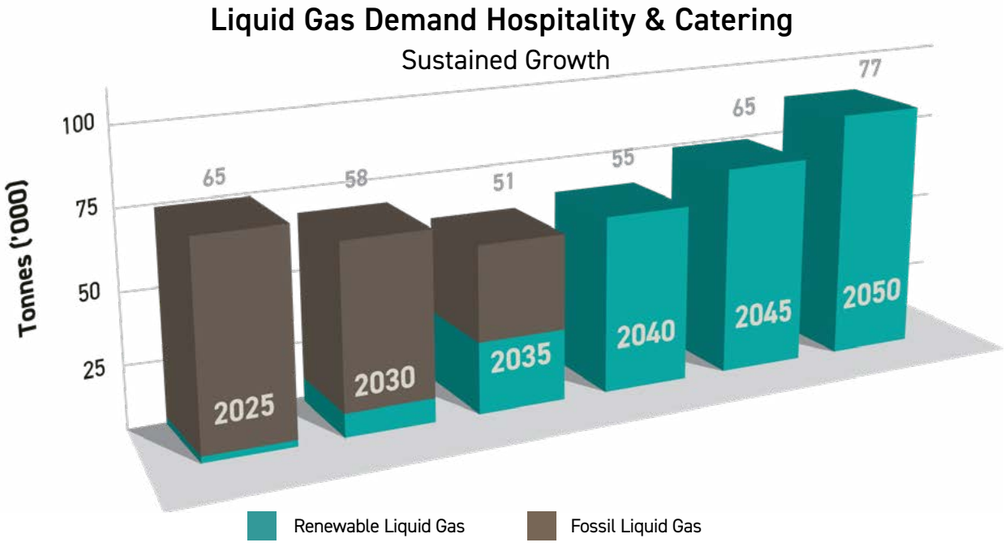
Modelling

The 'Sustained Growth' and 'Leading the Way' scenarios support the 20% and 36% adoption rates equivalent to the assumed prevalence of complex-to-decarbonise homes (see domestic section). A key difference between the hospitality & catering sector and the domestic sector, however, is the level of electrification. Given considerations of gas preferences in commercial kitchens, as well as the assumption that street vendors will be dependent on LPG cylinders, the modelling has separated catering, hospitality and mobile catering into three different sections within the demand modelling.

With approximately 8,000 street food vendors in the UK, we estimate that consumption was around 486 tonnes of LPG in 2023[100] . Where electrification is particularly challenging for street food vendors, vendors that use LPG will naturally switch to RLGs given its simplicity as a drop-in fuel. Given the nature of mobile street food vendors, which are typically operating sporadically (e.g. during the summer months in attendance of food, drink and music festivals) cylinders of liquid gas are likely to be in high demand for this sector as opposed to bulk purchases.

Within the broader hospitality and catering sector, we found demand trends similar to those in the domestic sector. As oil boilers are phased out, many CTD properties will be required to transition towards alternative fuel sources. Apart from heat pumps, district heating is recognised as one of the most important technologies to decarbonise heating in the commercial sector, with National Grid's 'Holistic Transition' scenario predicting that 50% of energy requirements in the public and commercial sector will be covered by district heating. However, district heating is only well suited for heat dense areas and is therefore unlikely to play a role in remote and rural areas. Accordingly, there could be an important role to play for RLGs in the commercial sector as well. By 2050, half of the RLG demand is likely to come from previous off-grid properties that transitioned from fossil heating technologies like oil boilers, whilst approximately 35,000 tonnes of RLG demand is expected to come from properties which were originally using LPG. Under the LTW scenario, RLG volumes in 2050 can decarbonise the energy of 9500 off-grid hospitality businesses.

100. Liquid Gas UK Member Data, independently collected



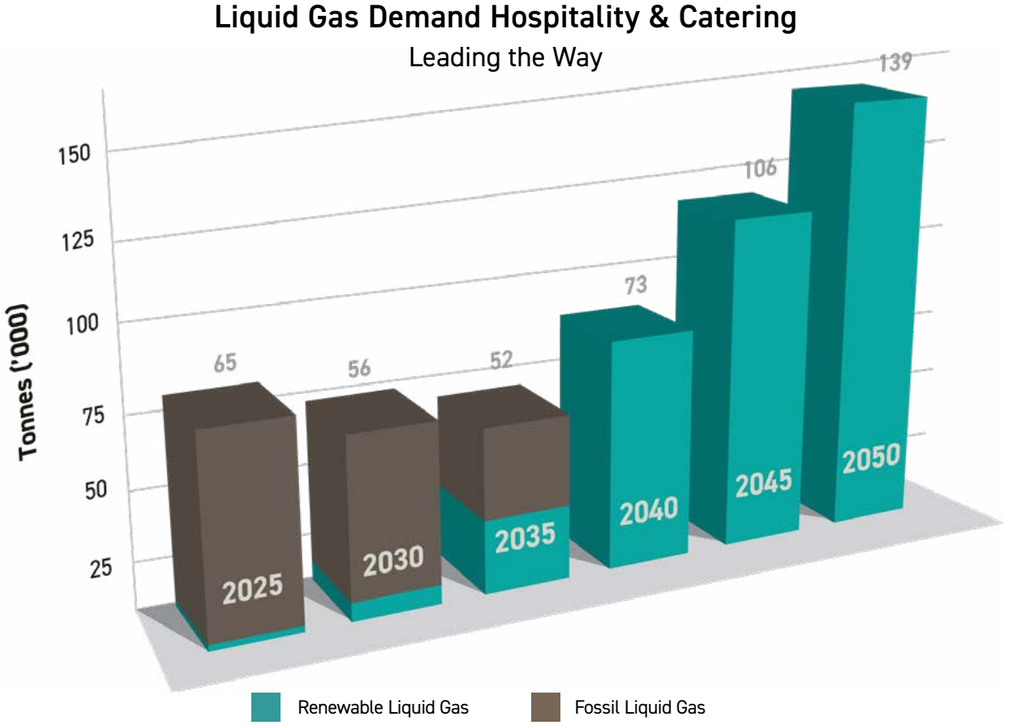


Figure 14 - Liquid Gas Demand in Domestic Space and Water Heating

7.5.3. Industry Attractiveness

The well-established and relatively easy transition from oil heating systems to LPG/RLG makes this pathway highly attractive, offering an easy change and a large pool of potential adopters. Similarly, street vendors have limited alternatives, which provide the required operational versatility. Amongst a set of persistent economic challenges for chefs and prospective restauranteurs, including rising rents and labour shortages, more entrepreneurs are turning to street-food-style businesses. This trend suggests promising future market prospects for the liquid gas industry. With a large supply network and expertise in servicing off-grid customers, the liquid gas industry is well-positioned not only to maintain its current market share but also to service additional RLG demand.

7.5.4. Government Alignment

Attempts by the previous government to phase out the installation of fossil fuel heating systems in businesses and public buildings off the gas grid appear to have stalled. However, with 1.7 million non-domestic buildings and heat accounting for nearly 40% of emissions, government action soon will likely be necessary to ensure heat decarbonisation gains momentum in this transition.

For smaller companies in the hospitality and catering sector operating on low margins, price concerns are central. These businesses are likely awaiting greater clarity on the boiler phase-out and other regulatory changes before committing to new investments.

7.5.5. Economic Benefits – Heritage Hotel & Rural Pub Case Study

Heritage Hotel

Hotels typically have a high energy demand, having to power a variety of applications including space and water heating, catering and leisure facilities. Many hotels will face technical and economic constraints when evaluating heat decarbonisation options, especially older hotels located in off-grid areas. Hotels with limited access to low carbon fuels are expected to be eager to capitalise on cost-efficient options to decarbonise. RLG systems could provide a flexible alternative that reduces the need to consider costly energy efficiency upgrades or renovations that could result in temporary closure of the business. As a drop in solution, RLG can be used in existing gas condensing heating systems without impacting performance[101].

For this illustrative case study, the analysis was based on the archetype model of a pre-1918 detached house with solid wall insulation as a proxy. The hotel is based on a domestic archetype due to a lack of data specific to commercial archetypes, and hotels in particular. The total annual heating demand was estimated at 247 MWh, with half of the heating requirement for space heating, and half for hot water demand. In this instance, the RLG boiler is estimated to be significantly cheaper than direct electric heating, saving business owners over £37,000 annually. Although RLG boilers are only marginally less expensive than ASHP in terms of annualised cost, the upfront cost of a heat pump system is expected to present a barrier in terms of affordability.

101. Liquid Gas UK. 2021. Opportunities to Decarbonise the Non-Domestic Off-Grid Sector with LPG and bioLPG. Available here: Opportunities to Decarbonise the Non-Domestic Off-Grid Sector with LPG and bioLPG.

Heritage Hotel		
ASHP	Upfront Cost (£)	77,455
	Annual Running Cost (£)	34,424
	Annualised Cost (£)	**41,149**
Direct Electric Heating	Upfront Cost (£)	23,600
	Annual Running Cost (£)	75,149
	Annualised Cost (£)	**77,198**
RLG Boiler	Upfront Cost (£)	6,794
	Annual Running Cost (£)	39,273
	Annualised Cost (£)	**39,862**
LPG RLG Blend	Upfront Cost (£)	6,794
	Annual Running Cost (£)	31,976
	Annualised Cost (£)	**32,566**

Table 7 - Annualised Cost of Different Heating Systems in a Heritage Hotel

Rural Pub

There are around 46,800 pubs operating across the country[102]. Many are located in rural areas and continue to rely on fossil fuels for space and water heating. Owners and customers of rural pubs are often drawn to older and heritage buildings which could be challenging to retrofit. However, reports have found that many small and medium sized businesses in the hospitality sector continue to struggle after the COVID-19 pandemic[103], putting affordability at the forefront of potential decarbonisation plans. Rural pubs and restaurants therefore require easily accessible decarbonisation methods that are suitable for buildings with poor thermal efficiency levels at a competitive cost.

This case study explores whether RLG can provide a cost-effective solution for decarbonising heating in a rural pub in the UK. The pub itself is modelled as a detached building built before 1900. The model considers the energy requirement for space and hot water heating, which is estimated to reach around 53 MWh per year.

The analysis finds that direct electric heating is by far the most expensive heating technology to own and operate. Both the RLG solution and the LPG / RLG blend have also been found to be more cost-efficient than heat pumps in this non-residential building type, saving £400 and £2,000 per year, respectively.

102. The Guardian. 2023. Is the party over for the UK's pubs and clubs? Available here: https://www.theguardian.com/business/2023/oct/08/its-soul-destroying-to-have-one-customer-on-a-saturday-is-the-party-over-for-the-uks-pubs-and-clubs.
103. Liquid Gas UK. 2021. Opportunities to Decarbonise the Non-Domestic Off-Grid Sector with LPG and bioLPG. Available here: Opportunities to Decarbonise the Non-Domestic Off-Grid Sector with LPG and bioLPG.

Rural Pub		
ASHP	Upfront Cost (£)	29,293
	Annual Running Cost (£)	6,723
	Annualised Cost (£)	**9,267**
Direct Electric Heating	Upfront Cost (£)	9,200
	Annual Running Cost (£)	16,136
	Annualised Cost (£)	**16,935**
RLG Boiler	Upfront Cost (£)	4,627
	Annual Running Cost (£)	8,433
	Annualised Cost (£)	**8,834**
LPG RLG Blend	Upfront Cost (£)	4,627
	Annual Running Cost (£)	6,866
	Annualised Cost (£)	**7,268**

Table 8 - Annualised Cost of Different Heating Systems in a Rural Pub

8 Supply of renewable liquid gases

8.1. Securing RLG Supply for the Transition to Net Zero

This section provides an overview of the evolving supply of RLGs in the UK. The supply of renewable and recycled fuel will be key in helping sectors to decarbonise. With RLGs at the start of their journey, and the industry ready to invest in scaling up the production in response to clear government signals, there is an opportunity to support the growth of associated technologies.

The demand scenarios modelled for this project are based on the supply forecasts developed by Frazer-Nash Consultancy and NNFCC[104]. The Frazer-Nash report projects the supply of RLGs up to 2040 under various scenarios. For this report, the baseline scenario and the supportive policy framework (SPF) scenario were adopted. Key trends in the data are extrapolated to extend the supply forecasts to 2050 and align the timeframe with the demand scenario model. Both supply projections are compared in Figure 18 below.

In addition to extending the timeframe to 2050, the Frazer-Nash supply scenarios were adjusted in response to recent developments impacting the production capacity of RLG in the UK. Due to the cancellation of a planned rDME production project, owing in part due to lack of funding, and lack of policy clarity on the role of RLGs, the annual supply forecasts were reduced by 50,000 tonnes

The Baseline scenario projects RLG supply volumes between 2024 and 2040, assuming that there is no further policy support for RLGs. The baseline supply scenario represents low technology readiness levels of the production pathways to reflect a natural pace of innovation without policy intervention.

The Supportive Policy Framework (SPF) is the most optimistic scenario for the supply of RLG in the UK. The SPF scenario is based on a favourable policy framework that supports the production of and the demand for RLG in the UK through an obligation similar to the RTFO. In the long term, there will be a variety of feedstocks and production pathways. This will support the stability of RLG production into the future. The SPF scenario supports long term growth, and also assumes a higher technology readiness levels than the baseline model.

104. Frazer Nash. 2022. UK Renewable Liquid Gas Modelling. Available at: https://www.liquidgasuk.org/uploads/D0C6346A4E460BFF.pdf

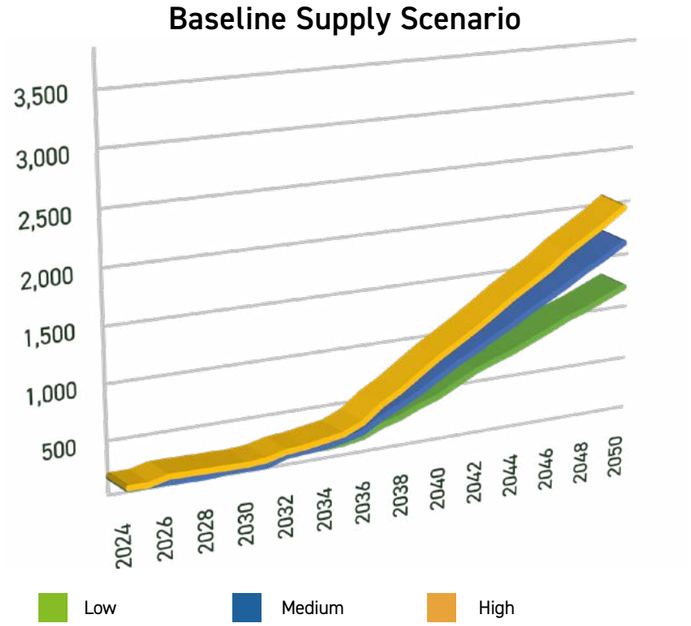


Figure 20 - The Projected Supply of RLG (rDME and Biopropane) under Different Pathways

8.1.1. Key Trends

From the supply data from both scenarios, rDME production increases every five years by 50,000 tonnes and so is well established by 2040. The production methods with the most prominence in and growth to 2050 are expected to be flash pyrolysis, gasification and Fischer Tropsch, and ethanol to gasoline. This is because these processes can utilise a variety of different feedstocks, which mitigates against individual feedstock shortages providing continuity in supply. Therefore, the availability of these production facilities will influence the supply of RLGs onto the market. However, the level of competition for feedstocks, their availability, and level of policy support also influence RLG provision. Other methods are set to increase such as HVO and Power-to-X, but at a lower rate.

Under the SPF scenario, government policy support will drive a higher level of RLG supply onto the market. With the lowest SPF scenario, nearly achieving the same level of supply as the baseline scenario's highest estimation, there is a clear benefit of creating policy to support the supply of RLGs onto the market. This could lead to an additional 1 million tonnes of RLG per annum under the most optimistic scenario, which is sufficient to supply around 1.3 million households[105].

8.2. The Current State of the Supply Chain

LGUK commissioned a report which investigated the existing literature to determine the current state of RLG supply, and the level of RLG supply that could be realised in the future. It covered key areas influencing supply: feedstocks, processes, and SAF and co-production. The below summarises the key sections from this report to highlight the current state of the supply chain for the RLG industry.

8.2.1. Feedstocks and Production

The report found that all feedstocks assessed can contribute to the future RLG supply mix to varying degrees. With the right policy and economic conditions all feedstocks can be highly available, apart from bio-based oils and wood, which are found to have medium availability over the short- and medium-term. It is unlikely that the UK will experience challenges with securing feedstock. However, an appropriate market mechanism stimulating investment into RLG feedstocks is needed to further increase availability and enhance resilience.

Several production pathways for RLGs exist and are each at different stages of commercialisation. Increased demand for biofuels alongside government funding and policy mechanisms can drive an increase in production development and capacity. For example, the RTFO and the SAF mandate (in combination with a revenue certainty mechanism), provide good examples of policy initiatives that can support RLG production. UK Government has also provided grant funding to seven different Power-to-Liquid projects, four Gasification and Fischer Tropsch projects and five Alcohol to Jet projects . This demonstrates that with Government support biofuel producers can be encouraged to invest in scaling up production process technologies to support greater supply onto the UK market.

105. ONS. 2023. Central heating. Available here: https://www.ons.gov.uk/datasets/TS046/editions/2021/versions/4
106. Liquid Gas UK. 2024. LG UK's Response to the Biomass Strategy. Available on request.
107. Six feedstocks were reviewed including (1) bio-based oils, (2) municipal solid waste, (3) wood and forestry waste, (4) sewage and landfill gas, (5) bioethanol, (6) low carbon hydrogen and carbon dioxide
108. See Table 9

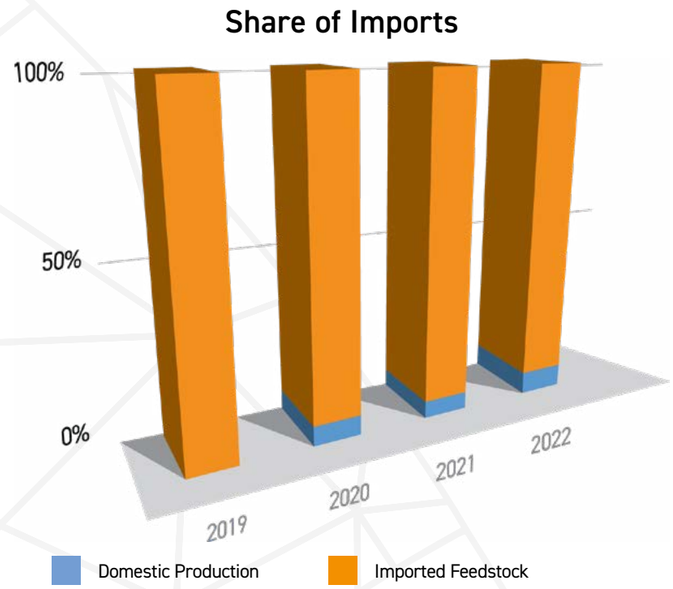


Figure 21 - Share of Imported Biopropane under RTFO[109]

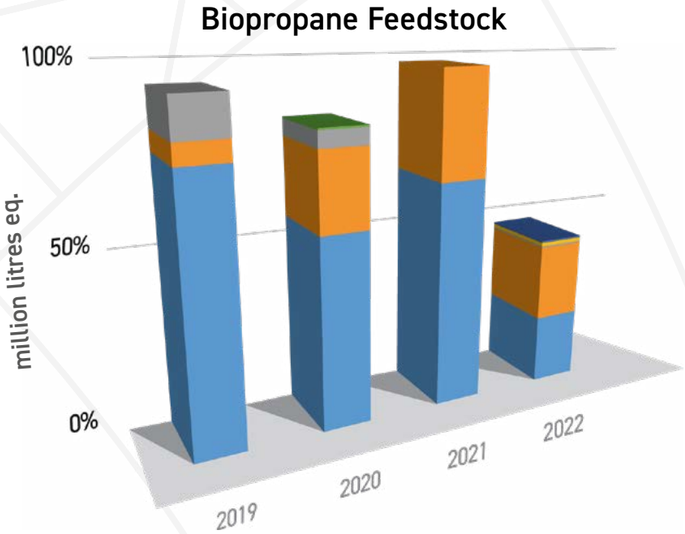


Figure 21 - Share of Imported Biopropane under RTFO[110]

109. Department for Transport. 2024. Supply of Renewable Fuels. Available at: https://www.gov.uk/government/statistics/renewable-fuel-statistics-2023-first-provisional-release
110. Department for Transport. 2024. Supply of Renewable Fuels. Available at: https://www.gov.uk/government/statistics/renewable-fuel-statistics-2023-first-provisional-release

Additionally, there are existing HEFA and HVO production facilities in Europe which can supply RLG to the UK market, as it is produced as a by-product. These include:

- NESTE– Operator of the Rotterdam and Porvoo biorefineries - have transitioned to using waste and residues, which now account for over 90% of total raw material input globally[111]. The plant in Rotterdam has a production capacity of 2.7 million tonnes per annum, and Porvoo plant has a capacity of 2.9 million tonnes per annum[112], with NESTE expecting production capacity globally to increase to 6.8 million tonnes by 2027[113], contributing to domestic and global biofuel demand. Around half of the capacity of the Rotterdam plant is expected to be used for SAF.

- Eni – Operator of the Venice and Gela biorefineries – has stopped supplying palm oil to its European HVO production facilities as of October 2022 and is now utilising wastes – such as used cooking oil, animal fat and other biomass - as the principle raw materials in their processes[114]. The Venice plant is expected to contribute to SAF production once permits have been approved. Its biofuel production capacity is 600,000 tonnes per year[115] by 2024, the Gela refinery processes 470,000 tonnes of biofuel in 2023[116].

Both of the above examples demonstrate the potential a UK biorefinery could have on supplying fuel onto the market. However, there is also potential to import RLGs from the exporters such as the United States, given import facilities and storage terminals at Canvey, Immingham[117] and soon to be Avonmouth[118].

111. NESTE. Renewable raw materials in our portfolio today. Available at: https://www.neste.com/renewable-raw-materials
112. https://www.ieabioenergy.com/wp-content/uploads/2020/11/1-AFF_IEABio_SuccessStories_Neste_HVO.pdf
113. NESTE. Neste invests in its world scale renewable products refinery in Rotterdam. Available at: https://www.neste.com/news/neste-invests-in-its-world-scale-renewable-products-refinery-in-rotterdam#:~:text=Neste%20currently%20has%20a%20renewable,of%203.3%20million%20tons%20annually.
114. Eni. Bioenergy, energy from biogenic raw materials. Available at: https://www.eni.com/en-IT/actions/energy-sources/bioenergy.html
115. Eni. n.d. Our activities in Venezia Porto Marghera. Available at: https://www.eni.com/en-IT/actions/global-activities/Italy/venice-porto-marghera-bio-refinery.html
116. Eni. n.d. Gela, Europe's most innovative biorefinery is Italian. Available at: https://www.eni.com/en-IT/actions/global-activities/Italy/gela.html
117. Calor. The right energy for off-grid industry. Lower carbon, lower cost and sustainable. Available at: https://www.calor.co.uk/-/media/sites/greatbritain/pdfs/lng-overview-brochure.pdf
118. Flogas. Flogas Avonmouth LPG Storage Terminal. Available at: https://avonmouth.flogas.co.uk/

8.2.2. Sustainable Aviation Fuel Production

RLG from SAF production has the potential to reach 20% to 55% of total RLG demand associated with off-grid commercial and domestic heating markets by 2040[119]. The supply is anticipated to be driven by the SAF mandates in the UK and EU, as RLG is a byproduct of SAF production. However, for a secure supply of RLG from SAF production, producers will need to be encouraged to supply the RLG into the market. This is because currently, there is limited commercial incentive to supply the fuel onto the market given the lack of firm policy support for RLGs by government. Selling biopropane onto the market comes at an additional cost to SAF producers (for example storage and distribution costs) as well as forgoing the cost reduction in plant heating and hydrogen production which can be realised from its use in the internal process of SAF manufacture, and so needs to be incentivised. This is an opportune moment to incorporate an adjustment of this nature through a legislative update to complement the UK's SAF mandate. A strong UK SAF industry, alongside incentives for the SAF producers to sell more biopropane onto the market, will maximise the availability and security of supply of biopropane within the UK.

Many organisations in the UK have had grant funding for projects developing progress towards SAF production capabilities, which produces biopropane as a byproduct. With further support and investment, these projects can act as a foundation to support SAF production within the UK. See Annex B for examples of key facilities which have the estimate supply of biopropane available from production when live[120].

119. See Table 9 section for further insight into these figures.
120. Full list is available in LG UK. Response to the Biomass Strategy. Available at: https://www.liquidgasuk.org/uploads/DOC66B489B27A7FF.pdf

9 The growth of green jobs

This chapter presents a high-level assessment of the number of green jobs that could be supported by additional government investment in the production of RLGs in the UK. Green employment opportunities include indirect jobs along the supply chain and direct jobs in the construction and operation of biorefineries. Currently, the LPG industry supports roughly 4,000 full-time employment opportunities[121] which could be at risk if the RLG industry is not supported by the Government.

To project the number of green jobs that could be created, the model estimates the costs related to the production facilities required to supply the RLG volumes predicted in the Frazer Nash baseline scenario[122]. Based on existing literature that assesses the cost structure of biofuel refineries[123], the costs related to building, operating, and maintaining the required production sites are presented in the table below:

	2030	2035	2040	2045	2050
Capital Cost (£m)					
Equipment Cost	72	199	294	245	123
Construction	127	348	514	430	215
Engineering	20	54	79	66	33
Operational Cost (£m)					
Biomass cost	86	179	486	819	1,153
Repair and maintenance	16	57	177	293	404

Table 9 - Capital and Operational Costs of Required Biorefineries (£m)

121. Liquid Gas UK. 2022. LPG Industry Census 2022. Available at: https://www.liquidgasuk.org/uploads/DOC637B69B62F04C.pdf
122. Frazer Nash. 2022. UK Renewable Liquid Gas Modelling – Supply and heating demand pathways for bioLPG and rDME. Available at: https://www.liquidgasuk.org/uploads/DOC6346A4E460BFF.pdf
123. Giwa et al. 2023. Techno-economic assessment of an integrated biorefinery producing bio-oil, ethanol, and hydrogen.

The different cost elements are then mapped to the respective Standard Industrial Classification (SIC) codes as defined by the Office for National Statistics[124] - each of which is assigned to a labour intensity assumption. Using the cost estimates in combination with the labour intensity, it is possible to calculate the approximate number of full-time jobs required. Figure 21 shows the total jobs that could be created in the respective year, reaching a peak of over 12,500 jobs in 2045. While the number of jobs in operations continues to increase, employment opportunities in the construction of biorefineries will tail off after 2045.

Note that the employment created will not necessarily result in a net positive number of overall jobs, as opportunities in the fossil fuel industry are expected to decrease in the future. We therefore expect a number of jobs related to the production of fossil fuels to transition to renewable and low carbon energy, including the production of RLGs.

By creating employment opportunities as well as goods and services, the RLG industry is furthermore expected to make a positive contribution to the UK economy. Our analysis suggests that the gross value added (GVA) could reach around £1.3 billion in 2050, as displayed on the secondary axis in Figure 21.

124. Office for National Statistics. 2022. Labour productivity tables. Available at: https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/labourproductivity/datasets/labourproductivitytables110andr1

Total Jobs and GVA Created in the RLG Industry

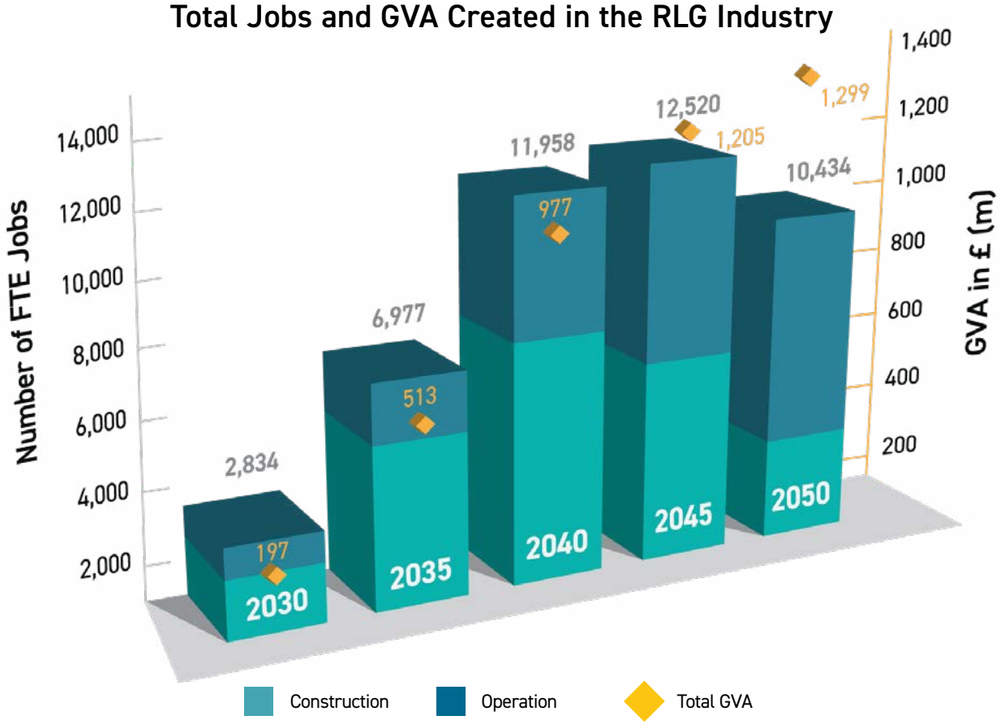


Figure 23 - Total Jobs and GVA Created in the RLG Industry

10 Conclusion

The transition to a low carbon economy requires innovative and scalable solutions, which are cost-effective, technically feasible, and easy-to-install in existing applications to enhance decarbonisation efforts. RLGs align with these principles as evidenced by their potential for decarbonising heat and power across a range of applications across the domestic, commercial, industrial, and agricultural sectors. In particular, this applies to off-gas grid locations, where portable fuels are needed, electrification is difficult or costly, and buildings are complex-to-decarbonise. This also extends to dispersed industrial sites, which are outside of planned hydrogen networks, but require high temperature heat for applications.

The insights and analysis within this report indicate growth for the industry, and an increased provision of RLGs, achieving 100% of the market in 2040. This supports a fully renewable and low carbon fuel in replacement of the familiar LPG used today. The current off grid sector is expected to benefit from the use of RLGs the most, with increased liquid gas volumes expected to be needed from 2025 to 2050 within the domestic, industrial, agricultural, and hospitality and catering sectors, RLGs can displace high carbon fuels such as oil, gas, and coal, resulting in carbon emissions savings.

The cost-effectiveness of boilers using solely RLGs, and separately blends was evaluated. The modelling suggests that that RLG based heating systems can present an economically viable solution when compared to air source heat pumps, and direct electric technologies in specific applications. As RLG supply is set to increase owing to the scaling up of production plants globally, there is an opportunity a greater number of users to reap the cost-effectiveness of using RLG.

The scenarios suggest that with the right policy interventions, RLGs can experience a strong increase in demand, and maximise carbon savings. With this, the industry is estimated to experience increased jobs, providing a potential career path for those in the fossil fuel sector, and drive economic growth. This means to secure the benefits of RLGs for the UK economy, a supportive policy framework is vital.

The findings of this report demonstrate the clear role that RLGs can play in decarbonising the economy, whilst providing a cost-effective, versatile solution for complex-to-decarbonise sectors in off gas grid locations. With the right policy framework, the well-known versatility, and reliability of liquid gases today can be saved for tomorrow.

A Annex 1 – qualitative assessment of remaining sectors

Annex 1.1 Biomethane (Agriculture)

Biomethane is a renewable fuel produced from organic materials such as manure, plant material, food and agricultural waste. As the agricultural sector produces many of these organic materials from food and drink, and livestock processes, there is an opportunity for the sector to generate its own feedstocks for biomethane. By capitalising on this, agriculture can contribute to a more circular liquid gas sector as users transition to liquid gases. Additionally, sectors like food and drink, which generate substantial organic waste, can also play at role in this initiative.

Technically, biomethane is nearly identical to natural gas[125], with comparable methane content. However, it may not always be as energy-rich as natural gas and to meet the stringent requirements for grid injection within a cost-effective manner, biomethane typically needs to be "boosted" with LPG or biopropane to ensure it is grid-compliant[126].

Biomethane enjoys increased recognition from government compared to that of renewable liquid gases within the Biomass Strategy, with the 2021 Heat and Building Strategy going further, highlighting an interim role in facilitating gas grid decarbonisation[127].

At present, biomethane benefits from financial incentives for new anaerobic digestion projects through the Green Gas Support Scheme[128], which supports the growth of the liquid gas industry. As noted earlier in the report, government recognition of the role of RLGs in the transition to net-zero is a crucial step for boosting investor confidence and attracting subsequent investment.

Annex 1.2 Transport

For the LPG sector, the fuel has primarily been used in the UK to power forklift trucks and cars/vans as Autogas, in a transport setting. Forklift trucks are powerful vehicles typically used in the industrial sector, including warehousing, construction, and quarrying. Autogas, on the other hand, is a fuel used in internal combustion engines and is considered a greener alternative to petrol and diesel, offering CO2 emission reductions of up to 12%. It remains the third most popular road fuel globally[129].

125. IEA. 2020. Outlook for Biogas and Biomethane. Available at: https://iea.blob.core.windows.net/assets/03aeb10c-c38c-4d10-bcec-de92e9ab815f/Outlook_for_biogas_and_biomethane.pdf
126. Department of Energy & Climate Change. 2014. RHI Evidence Report: Biopropane for Gas Injection. Available at: https://assets.publishing.service.gov.uk/media/5a7ebfc8e5274a2e8ab47f43/RHI_Evidence_Report_-_Biopropane_for_Grid_Injection__2___2_.pdf
127. UK Government. 2021. Heat and Building Strategy. Available at: https://www.gov.uk/government/publications/heat-and-buildings-strategy/heat-and-building-strategy-accessible-webpage
128. UK Government. 2024. Green Gas Support Scheme: mid-scheme review. Available at: https://www.gov.uk/government/consultations/green-gas-support-scheme-mid-scheme-review
129. European LPG Association. 2016. AEGPL response to Commission's consultation. Available at: https://climate.ec.europa.eu/system/files/2016-11/aegpl_en.pdf

Market Size

Currently, the demand for LPG in forklift trucks (FLTs) and non-road mobile machinery (NRMM) is relatively low and has decreased in size, from 8% of the liquid gas volume in 2018 to less than 5% in 2023[130]. In 2023, nearly all of the demand from NRMM was for Propane, totalling around 50,000 tonnes, with 65% of this demand coming from bulk propane. Meanwhile, although Autogas has a sizeable market presence in countries like Turkey and South Korea, it accounts for only around 0.2% of road fuel demand in the UK[131].

The future of Autogas

With a strong push for electrification within the industry and the anticipated, though unconfirmed, role of hydrogen, the Autogas market is not large enough to remain competitive in the long term. Reflecting this reality, the UK's largest forecourt provider, The Motor Fuel Group, has decided to phase out its supply of Autogas across its 1,000 stations in favour of EV rapid charging points and other alternative services[132].

Both the lack of government alignment and commercial viability will likely render the Autogas industry obsolete in the future. While some consumers may continue to use Auto-LPG, especially as carbon taxes on more carbon-intensive fuels like diesel and petrol are introduced, this market is expected to remain particularly small and will likely shrink further due to the decreasing availability of Autogas at forecourts. Autogas will not play a major role in a decarbonised future beyond its existing market.

Role of Alternatives and Industry Growth of FLTs

Forklift trucks typically use three types of fuel: diesel, LPG, and electricity. As the industrial sector shifts towards electrification, there has been a drive to electrify forklift fleets. This trend is supported by internal data showing a decline in LPG demand, with fleet electrification likely playing a contributing role, along with microeconomic factors such as domestic practices moving overseas.

Companies using LPG-based forklift trucks can switch to a biopropane mix without modifying their machinery. However, the liquid gas market has limited growth potential if electrified forklift trucks become competitively priced. This could also deter conversions from diesel to LPG for companies looking to avoid high capital expenditure associated with expensive battery or fuel cell solutions. Beyond supplying LPG to existing users—especially those unable to electrify or needing continuous operation—growth opportunities in this market are limited.

Alignment with Government Policy:

While the incentives provided by CBAM and ETS align with government policy and offer some benefits to the liquid gas market, the domestic push towards electrification in the Industrial Decarbonisation Strategy presents challenges for the future role of liquid gases in forklift truck operations. Although liquid gases could contribute to decarbonisation and improving on-site air quality, the government's Industrial Decarbonisation Strategy and its associated funding do not prioritise liquid gas in this context.

130. Liquid Gas UK Trend Quarterly Data (Submitted to DESNZ by LG UK members) contact for further information: oil.stats@energysecurity.gov.uk
131. Argus Media. 2020. Autogas hit by UK 2030 ban on gasoline, diesel engines. Available at: https://www.argusmedia.com/en/news-and-insights/latest-market-news/2161933-autogas-hit-by-uk-2030-ban-on-gasoline-diesel-engines
132. Forecourt Trader. 2022. MFG reveals it is pulling out of auto-LPG because it is no longer commercially viable. Available at: https://forecourttrader.co.uk/latest-news/mfg-reveals-it-is-pulling-out-of-auto-lpg-because-it-is-no-longer-commercially-viable/666173.article

Despite achieving some recognition in the Biomass Strategy, the focus is primarily on heat decarbonisation, resulting in limited alignment with government policy regarding the use of liquid gases in the forklift industry.

Annex 1.3 Back-Up Power Generation

Market Size

Back-up power generation is used in a variety of settings to ensure seamless continuity of power. Liquid gas can be used within the industry through fuel stored in built in tanks, which can support combined heat and power and through mobile LPG generators. However, the current size of the market is small for the liquid gas industry.

For portable back-up power diesel generators are mainly used. Diesel contributes to higher PM, Volatile Organic Compounds (VOCs), NOx and Sulphur Dioxide (SOx) than LPG and is a key contributor to greenhouse gas emissions. RLGs could provide a portable, scalable and readily available solution to greening back-up power generation when compared with diesel. This can be naturally replaced by RLG as a drop in fuel as policy drives supply increases.

Microgrids provide a decentralised and distributed energy resource for buildings seeking full or partial independence from the grid. These systems are increasing in the UK, and LPG can provide a role in providing back up power when solar energy and batteries fall short of power. There are reports of up to 3,000 community energy projects, including microgrids, operational in the UK as of 2021. There are currently 4,475 microgrid projects in various stages of development, from proposal to deployment, across a range of applications[133]. Microgrids can be supported by stored LPG tanks providing heat director or through CHP systems. This can be used by larger industrial users where decentralised generation powered by LPG in small self-containing generators and CHP, can provide a clean-burning, flexible, and versatile fuel to power operations. Particularly in circumstances where industries re-opening at less than full capacity but require immediate fuel.

Future Relevance

Increased extreme weather is a characteristic of climate change. The UK is expected to have wetter, hotter, and stormier weather[134]. Extreme weather disrupts infrastructure, such as power and transport. Critical services, such as the internet, emergency services, will need powering to keep the country running. There will therefore be an increasing need for emergency and back-up power.

There is a need for an energy source which can provide high and consistent heating temperatures required for business continuity in the event of power cuts. Alternative options for backup power include lithium-ion batteries, which are heavy, have a finite capacity, and experience energy storage degradation over time[135], and hydrogen fuel cells, which are costly and rely on an unreliable fuel supply. HVO can be used as an alternative to diesel. However, with increasing need for HVO in transport fuels, supply issues could occur- creating a clear potential role for RLGs.

133. GlobalNewswire. 2023. UK Microgrid Industry to Grow at CAGR 12.9% from 2022 to 2027. Available at: https://www.globenewswire.com/en/news-release/2023/05/11/2666335/0/en/UK-Microgrid-Industry-to-Grow-at-a-CAGR-12-9-from-2022-to-2027.html#:~:text=According%20to%20the%20UK%20Energy,to%20an%20independent%20research%20centre.
134. Met Office. n.d. Climate Change in the UK. Available at: https://www.metoffice.gov.uk/weather/climate-change/climate-change-in-the-uk
135. Faraday Institution. 2021. Why Batteries Fail and How to Improve Them: Understanding Degradation to Advance Lithium-Ion Battery Performance. Available at: https://faraday.ac.uk/wp-content/uploads/2021/04/Faraday_Insights_10_web_FINAL.pdf

Countries across the world recognise the role LPG can play in back-up power generation and have used regulation to secure back-up supplies when emergency power is needed. In Japan, the Government secures 95 days' worth of strategic LPG stockpiles for emergencies[136]. This provides a contingency for power generation in circumstances where natural disasters create power and supply issues. Stockpiles can also be used to take pressure off the electrical grid in times of high demand and provide a timely response to demand shocks.

The UK has experienced major increases in gas demand from freak weather occurrences such as during the "Beast from the East" cold wave in 2018. As the UK imports most of its natural gas and so is subject to volatile gas prices, LPG stockpiles can help alleviate high energy prices for households and businesses. Additionally, LPG can provide a reliable back up in the case of power cuts, which happen frequently during storms, as evidence by Storm Lilian[137]. As the UK transitions to net zero, RLGs can provide a low carbon, renewable replacement for LPG stockpiles.

Growth

The UK uninterrupted power supply market is projected to grow at a compound annual growth rate of 1.6% between 2022 and 2028[138]. This is expected to be driven by the growth of the IT industry, particularly datacentres, and plans to build new NHS hospitals. Many businesses use back-up power to avoid the sudden interruption of operations and financial losses. Currently, a large amount of portable back-up power generators are fuelled with diesel. As a lower carbon fuel, there is an opportunity for LPG to replace diesel in mobile generators which can eventually switch to biopropane to decarbonise further. Replacing fossil fuels in back-up power applications is therefore a potential area of growth for RLGs.

Alignment with Government Policy

Providing low carbon fuel is crucial for the continuity of the economy in the event of emergencies. Government recognises this and has recently outlined proposals for improving energy security[139] and is has a page for advising households and businesses on best practice in the event of emergencies through their "Prepare" campaign[140]. Integrating LPG and eventually RLG into stockpile policy can ensure a low carbon fuel supply, which provides versatility and reliability cost effectively.

136. Japan LP Gas Association. n.d. Industry Information. Available at: https://www.j-lpgas.gr.jp/en/industry/index.html
137. BBC. 2024. Storm Lilian causes power cuts and travel delays. Available at: https://www.bbc.co.uk/news/articles/cjdk109jgjlo
138. 6WResearch. 2022. United Kingdom UPS Systems Market Outlook (2022-2028) Forecast. Available at: https://www.6wresearch.com/industry-report/united-kingdom-ups-systems-market
139. Department for Energy Security & Net Zero. 2023. The role of gas storage and other forms of flexibility in security of supply. Energy security plan update. Available at: https://assets.publishing.service.gov.uk/media/656fae319462260721c56977/gas-storage-and-flexibility-update.pdf
140. UK Government.Prepare. Available at: https://prepare.campaign.gov.uk/

A Annex 2 – UK grant funded SAF production facilties

WINNER	OVERVIEW	IMPLICATION
Fulcrum BioEnergy Ltd	The Fulcrum NorthPoint project, in Ellesmere Port, will use Gas + FT technology to convert residual waste into SAF. The plant is expected to be operational in 2027 and produce 83.7 kt/y of SAF when at full operational capacity. The company already has a commercial SAF plant in the US producing SAF with the same technology.	Has the potential to produce an estimated 6.3kt of biopropane annually (assuming a 7.5% yield rate).
Lanzatech UK Ltd (DRAGON)	Funding will support a Lanzatech facility, in Port Talbot, South Wales. It is developing a commercial scale plant that converts steel mill off-gases into ethanol and then uses AtJ technology to produce SAF. The plant is expected to be operational in 2026 and produce 79 kt/y of SAF when at full operational capacity.	Has the potential to produce an estimated 7.1kt of Biopropane annually (assuming a 9% yield rate).
Nova Pangaea Technologies (UK) Ltd	This feasibility project is a partnership between British Airways, LanzaJet and Nova Pangaea Technologies. It will study the optimal design to construct a facility that produces more than 100 million litres a year using UK woody residues and the integration of Nova Pangaea's REFNOVA® and LanzaJetTM's AtJ fuel technology.	If the project goes beyond design stages it has the potential to produce an estimated 9 million litres of biopropane annually (assuming a 9% yield rate).

Table 10 - UK Grant Funding for SAF production[141]

141. Department for Transport. December 2021. Green Fuels, Green Skies (GFGS) competition: winners. Available at: https://www.gov.uk/government/publications/green-fuels-green-skies-gfgs-competition/green-fuels-green-skies-gfgs-competition-winners
Department for Transport. January 2024. Advanced Fuels Fund (AFF) competition winners. Available at: https://www.gov.uk/government/publications/advanced-fuels-fund-competition-winners/advanced-fuels-fund-aff-competition-winners

WINNER	OVERVIEW	IMPLICATION
Velocys Projects Ltd	The Altalto, developed by Velocys and British Airways, to build a commercial waste-to-SAF plant in Immingham. Altalto will take hundreds of thousands of tonnes per year of black bag waste and convert it into SAF using Gas + FT technology. The plant is expected to be operational in 2028 and produce 37.4 kt/y of SAF when at full operational capacity.	Has the potential to produce an estimated 2.8kt of biopropane annually (assuming a 7.5% yield rate).
OXCCU Tech (OXEFUEL BIOGENIC)	Based in Sheffield's Translational Energy Research Centre. The project is developing a demonstration plant that uses PtL technology to convert biogenic CO2 and low carbon hydrogen into SAF. The project also includes the design of a commercial scale plant, expected to be operational in 2026 and produce 7.4 kt/y of SAF when at full operational capacity.	Has the potential to produce an estimated 0.74kt of biopropane annually (assuming a 10% yield rate).
Zero Petroleum (PMZ.2)	This project is developing both a demonstration production module operating in Orkney and a commercial scale plant that uses PtL technology produce SAF. The commercial scale plant is expected to be operational in 2026 and produce 6.1 kt/y of SAF when at full operational capacity.	Has the potential to produce an estimated 0.61kt of biopropane annually (assuming a 10% yield rate).

Table 10 - UK Grant Funding for SAF production[141]

END.

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