ENSURING SUPPLIES IN THE GREEN TRANSITION

for renewable liquid gas

We leave no one behind in the race to green

UGI INTERNATIONAL

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UGI Roadmap 2030

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UGI ROADMAP 2030

Ensuring supplies in the green transition

UGI International has presented a plan for how we can cut carbon emissions of our customers in half by 2030. A plan that lays the foundations for becoming 100 per cent carbon neutral by 2050. We are on the way to realising our plan, as we invest heavily in transitioning away from conventional LPG to renewable liquid gas (rLG). As renewable liquid gas is a drop-in fuel ready to immediately substitute conventional fuels, our proposed energy solutions are affordable and practical, further decarbonising off-grid homes, businesses, and industries across Europe.

Already today, there are cases where renewable liquid gas is the most economically viable and climate-friendly solution. In our pathway to a sustainable future, rLG are produced from three green building blocks:

- Renewable dimethyl ether (rDME)
- Renewable/bio alcohol to hydrocarbon
- Power-to-x technology

These are sustainable energy products, which together will cover the future demand of rLG. For the transition from LPG to rLG to succeed, sufficient feedstock and the right political framework must be in place, allowing producers to secure necessary feedstock and enabling a stable business model. With these conditions in place, all of Europe's LPG market can become 100 per cent renewable by 2050.

We will demonstrate how adjusting current regulations can support an optimal utilization of feedstock. with the right regulatory framework in place and based on the current feedstock estimates, the conclusion is that it is indeed possible, to produce enough rLG to meet future demand - and beyond.

What is rLG (renewable liquid gas)?

Renewable liquid gas is a liquid fuel which resembles the same chemical and energy content as LPG and can be used as a drop in fuel. It is, however, produced through technology pathways that utilise renewable feedstocks, thus meaning it has a low carbon content when compared to conventional LPG.
UGI International has prioritised three technology pathways, as follows:

Renewable Dimethyl Ether (rDME): Renewable Dimethyl Ether (rDME) produced from organic matter is a sustainable renewable liquid gas with up to 85 per cent lower greenhouse gas emissions than fossil alternatives. rDME can be produced from sustainable feedstocks such as waste and residues, using gasification and catalytic synthesis.

Alcohol to Hydrocarbon: Renewable liquid gas from advanced bioethanol (Gen 2) derived from waste and residues.

Power to X: Power to X-technology combines captured CO2 and renewable hydrogen (made by electrolysis of water using excess renewable power) and converts to a synthesis gas; this in turn can be made into renewable liquid gas.

30%

of Europe's population are not connected to a gas grid

No Doors to Any Sustainable Energy Solutions Should be Closed

The ability for companies to provide affordable and cost-efficient energy solutions is essential if the green transition is to be realistic and inclusive for all, where no one is left behind.

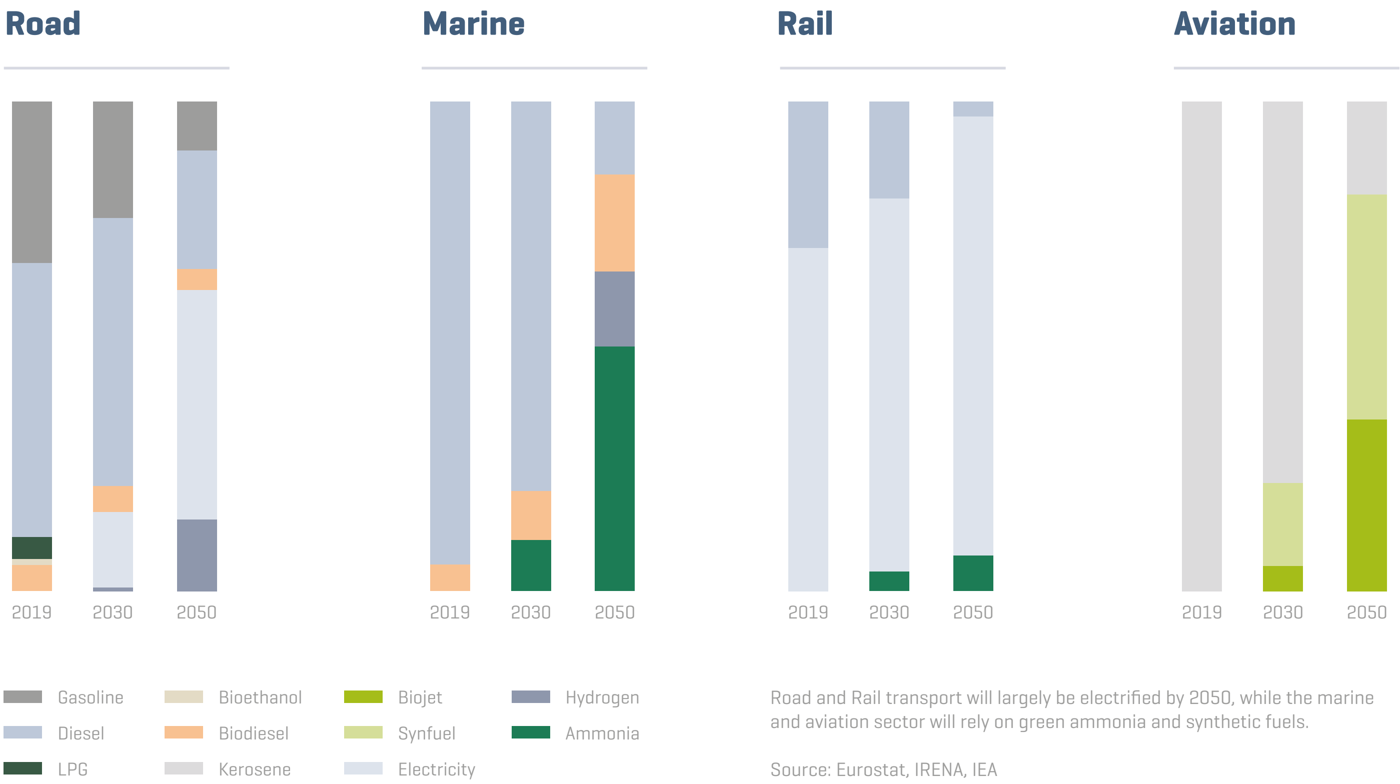
As it is difficult to predict what the world of the future will look like based on the situation today, we must at this stage, not close any doors prematurely to sustainable energy solutions such as rLG, which will benefit the total carbon footprint of a community.

It is crucial that we use the technologies that provide the most value, both in the short and long term, when we decarbonise various sectors.Therefore, it does not make sense to use feedstock for creating biofuel to be used by trains and road transport vehicles, when there are other better-suited solutions, such as electrification and hydrogen.

The maritime sector could be powered by synthetic fuels, such as green ammonia or methanol, recently supported by several of the world's largest shipping companies.

For aviation and off-grid energy consumers, electrification and hydrogen are options that are either inviable or economically inefficient. These sectors should therefore be given priority in terms of feedstock for rLG solutions.

Estimated Evolution of Transport Energy Demand until 2050



Road and Rail transport will largely be electrified by 2050, while the marine and aviation sector will rely on green ammonia and synthetic fuels.

Source: Eurostat, IRENA, IEA

rLG requires no new Infrastructure Investments by our customers

When choosing the optimal decarbonisation solutions, price must be taken into account. In this regard, electrification solutions need a closer look. Europe-wide, the total cost of electric vehicle charging infrastructure alone, as estimated by Concawe, could reach 30 billion euros per year, and a cumulative cost of 630 billion euros by 2050. These investments in enforcements of local power grids are necessary to prevent blackouts caused by electricity consumption by users charging electric vehicles and heating their homes with electric heat pumps during peak hours.

A more specific example regarding the cost of electrification infrastructure required for heat pumps is provided by an Imperial College London study, which estimates that 5.7 million heat pumps installed by 2035 would require the reinforcement of 42% of the distribution network in the UK at a cost of £40.7 billion. That's £1,500 per electricity consumer. According to the report, the high cost of reinforcing underground network lines accounts for around two thirds of the cost of reinforcing distribution networks. Costs of overhead lines and transformers make up the remainder. The Imperial College London study also states that meeting net zero emissions targets may require an accelerated approach to the electrification of heat. The study estimates that accelerated electrification could involve the installation of up to 2 million heat pumps in the UK by 2025, rising to 15 million by 2035. In this perspective, rLG seems a more cost-effective solution than electrification for decarbonising heating, as the infrastructure investments would not be required.

In political terms, the cost of electrification infrastructure may also become a hot topic in the coming years, as the implications of the green transition become clearer.

https://www.concawe.eu/wp-content/uploads/RD18-001538-4-Q015713-Mass-EV-Adoption-and-Low-Carbon-Fuels-Scenarios.pdf
https://www.theccc.org.uk/wp-content/uploads/2019/05/CCC-Accelerated-Electrification-Vivid-Economics-Imperial-1.pdf
https://www.dr.dk/nyheder/regionale/trekanten/elbiler-og-varmepumper-udfordrer-elnettet-der-skal-investeres-milliarder

Short Term Demand for Organic Feedstock

Today, there is a rising demand for liquid biofuels from several sectors. Therefore, there is a need to take a closer look at the feedstock supplies for these renewable fuel products. This way, we can ensure that feedstock is being used where it has the most cost-effective impact on the green transition. Most actors within the LPG sector have chosen organic feedstock for their immediate decarbonisation pathways, leading to a short-term peak in demand for this feedstock.

In the short to medium term until 2030, rLG volumes are expected to come mainly from renewable alcohol to hydrocarbon and renewable dimethyl ether. The feedstock for these products consists mainly of agriculture residue, energy crops, forest residue, municipal waste, sewage sludge and animal waste.

From 2030 onwards, when derived products from power-to-x technologies are expected by the European Commission to mature and begin penetrating the European market, the supply of feedstock for renewable liquid gas will be plentiful and primarily dependent on the availability of renewable electricity and the efficiency of DAC (Direct Air Capture) or CO2 capture. This means that to ensure the right level of rLG supply until power-to-x technology is ready, it is vital that the feedstock is directed towards where it is the most cost-effective for communities and the green transition.

“As the findings of reports referred to in this paper show, feedstocks will have the greatest economic and environmental impact when used for the production of rLG in order to decarbonise off-grid homes and businesses. The following pages will further explore how the development of feedstock availability for rLG is foreseen until 2030 and beyond.

Photo: Unsplash

Liquid Gas Europe Overview of rLG production processes

TECHNOLOGIES & PROCESS		POTENTIAL BIOLPG YIELD (OF TOTAL FUEL)	TECHNOLOGY READINESS	EXAMPLES OF EXISTING PRODUCERS OR PROJECTS*
BIOREFINING				
Lipid hydrotreatment	Most bioLPG today is produced as a co-product of the hydrogenated vegetable oil (HVO) process, where vegetable oils are treated with hydrogen to produce renewable diesel or aviation fuel.	**7%**	**Demonstration/pilot phase**	**Eni (Italy), Global Bioenergies (France), Neste (the Netherlands), PREEM (Sweden), Repsol (Spain), Total (France)**
Transesterification	FAME biodiesel and glycerine can be produced through transesterification of oils. Glycerine can be used as a feedstock and reacted with hydrogen to yield bioLPG and water.	**70%**	**Commercial phase**	**Hulteberg (Sweden)**
Fermentation	Biorefineries transform biomass into a wide spectrum of products and energy carriers. In biorefineries producing ethanol, sugars are fermented. Such alcohol can be further converted into drop-in jet fuels. BioLPG is a by-product of this process.	**100%**	**Pilot phase**	**Byogy (USA), Gevo (USA), UOP (USA), Vertimass (USA)**
PYROLYSIS				
	Pyrolysis is a process of thermal decomposition in the absence of oxygen. In fast pyrolysis, biomass rapidly decomposes to generate vapours, aerosols, gases, including bioLPG, and some charcoal. At the next step, after cooling and collection, a dark brown mobile liquid is formed, pyrolysis oil. Through catalysis cracking, it can be transformed into bioLPG.	**5%**	**Demonstration phase**	**BTG (the Netherlands), Gas Technology Institute (India), UPM (Sweden)**
GASIFICATION				
Thermal gasification of biomass (followed by methanation)	Gasification is a complete thermal breakdown of the biomass particles into syngas, volatiles and ash in an enclosed reactor (gasifier) in the presence of any externally supplied oxidizing agent (air, O2, H2O, CO2, etc.). Syngas through methanation is transformed to SNG, which can be futher synthesised to bioLPG.	**20%**		
Fischer-Tropsch (FT) synthesis of syngas followed by hydrocracking	Alternatively, syngas goes through a cleaning stage to remove impurities before the gas can be used in Fischer-Tropsch (FT) synthesis. The FT process means producing liquid fuels from syngas using catalysts. The intermediate product is a solid mixture of hydrocarbons, known as FT wax. It then goes through a process of catalytic cracking to produce drop-in fuels such as petrol, diesel and jet fuel, as well as LPG.	**5%**	**Commercial /demonstration phase**	**BioTFuel project by Total (France), Cadent (UK), Enerkem (the Netherlands), Fulcrum (USA), Red Rock (USA)**
Methanol synthesis from syngas	Syngas can be also synthesised to methanol. In the next step, methanol can be used to produce gasoline. BioLPG would be a co-product in significant quantities of this process.	**8%**		
ANAEROBIC DIGESTION				
Oligimerisation of biogas	Anaerobic digestion is a fermentation process, which takes place in a closed airtight digester where organic raw materials such as manure, food waste, sewage sludge and organic industrial waste are converted into biogas and digestate as products.	**90%**	**Research & development phase**	**Alkcon (USA), PlasMerica (USA)**
POWER-TO-X				
Methanation of CO2 by electrolytically obtained hydrogen	Power-to-x is a technology that converts captured CO2 and hydrogen made from water by electrolysis using renewable electricity into gas or, after further synthesis, fuel. Both syngas and synthetic methane can be further synthesised to renewable LPG.	**10%**	**Research & development phase**	**(Nordic Blue Crude (Norway), Sunfire (Germany), Synhelion (Switzerland), Repsol (Spain))**
FT synthesis of syngas	Renewable LPG would also be a co-product of Fischer-Tropsch synthesis of syngas for synthetic fuels (e-fuels).	**10%**		
Methanol synthesis from syngas	Synthetic methanol can be produced using hydrogen made with renewable electricity and captured CO2. Further it can be used as a feedstock to produce gasoline and bioLPG as a co-product.	**10%**	**Pilot/demonstration phase**	**Carbon Recycling International (CRI) (Iceland)**

*Process Technologies and Projects for BioLPG (2018) E. Johnson

Link to overview in report: https://www.liquidgaseurope.eu/news/biolpg-pathway-decarbonisation-2050 Liquid Gas Europe Report 'BioLPG – A Renewable Pathway Towards 2050'

Situations where feedstock should be directed towards rLG in Sectors, without viable decarbonisation alternatives

As highlighted in a January 2021 report by Liquid Gas UK, a key advantage of using rLG in rural and off-grid areas, given the low population and business density, is that local electricity grids would not be overburdened by sudden increases in electrified heating solutions, potentially causing localized blackouts. As rural electricity grids may need costly reinforcements to accommodate a surge in electrified heating solutions, choosing an rLG solution may save taxpayer money and hassle for citizens, as no infrastructure upgrades would be needed.

As for other alternatives on the heating market:

- hydrogen, while still a premature energy source for the mass market, would most likely only be an option for customers already connected to the gas grid.
- Electrification, for the reasons explained above, is not a solution for all businesses and property types.
- Biomass can create air quality issues, be expensive, difficult to store and it needs investments in new equipment.

As argued, rLG will have the most cost-effective impact as a solution for residential and commercial buildings – such as hotels, bars and restaurants – that require a low-carbon, convenient, off-grid solution that works for their budget and building, as well as industrial applications. Therefore, feedstock should be managed and directed towards production of rLG in order to enable its optimal cost-effective usage where alternatives are not feasible.

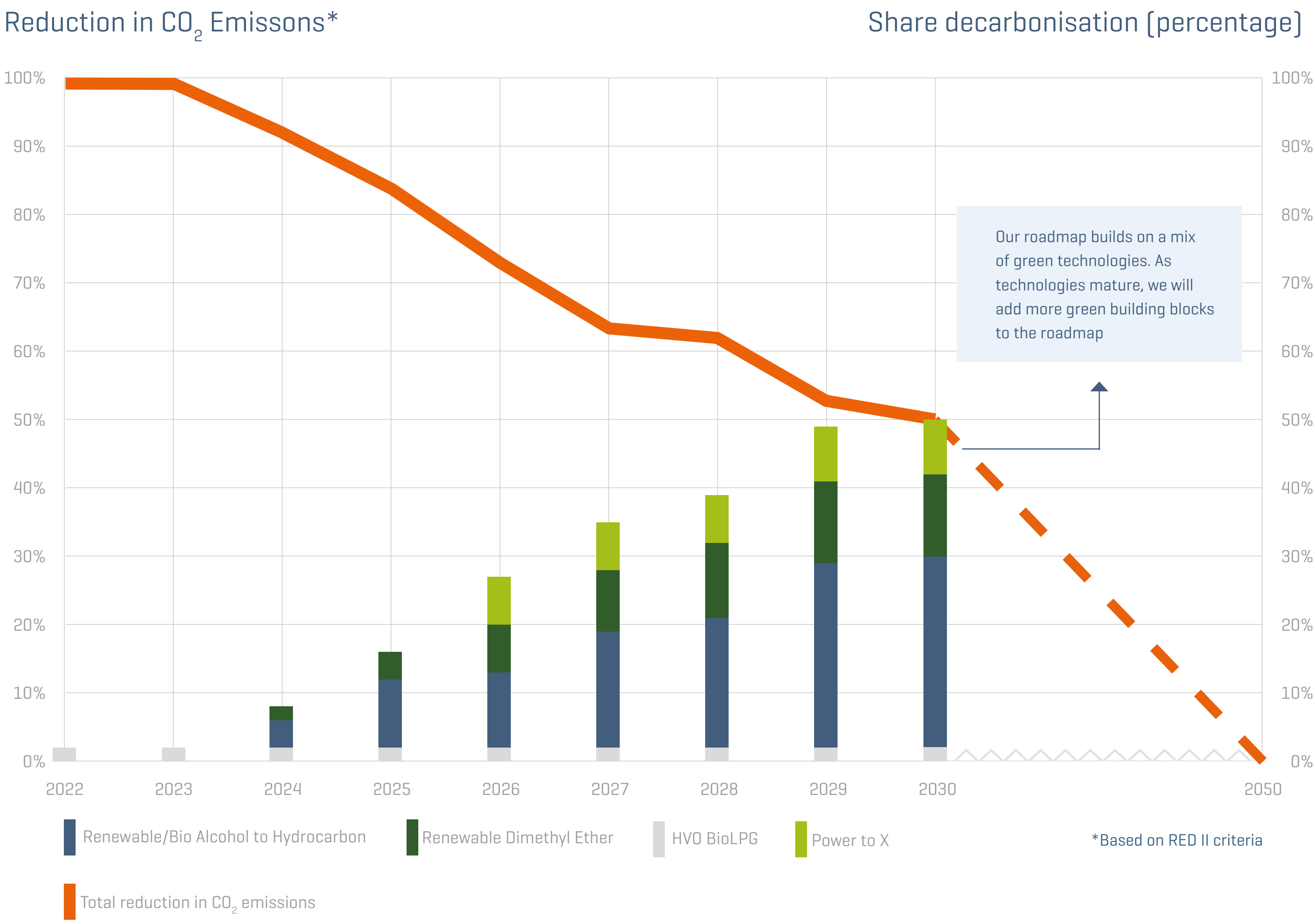
Future Demand for rLG

Demand for conventional LPG in Europe is expected to decline by 25-50 per cent from today's 16 million tons in the next 30 years. This development is due to overall trends in European energy demand, where final energy consumption is expected to decline by around one-third by 2050. Electrification will rise almost as sharply, mainly displacing liquid fuels in transport and space heating and cooling. Solid fuels will mostly disappear due to electrification of other sectors.

With this development in mind, rLG will therefore be able to replace the demand currently fulfilled by LPG. In order to ensure this transition from LPG to the more environmentally friendly rLG, the necessary feedstocks must be available.

https://www.liquidgasuk.org/uploads/DOC60193EF45014F.pdf

With our Roadmap 2030, we will be able to serve our customers with a renewable alternative to conventional LPG



Increased Demand for Biojetfuel from the Aviation Sector and Blending Obligations for Land Transport

Large-scale production of liquid biofuels will result in better affordability and drive their increasing use, especially in relation to biojet and land transport fuel blending obligations and increase demand for low-carbon fuels for off-grid energy supplies. As mentioned earlier in this paper, given that there are other ways to decarbonise land transport, fuel blending obligation for this sector is not seen as a cost-effective measure of decarbonisation, and should therefore be limited.

Proposed Policy Measures

Given the demand-supply situation concerning feedstocks for rLG outlined in this paper so far, it should be highlighted that there is currently a lack of political support and recognition for rLG in Europe. The key to enabling investment in supply and production of rLG is a supportive political framework oriented towards the long-term benefit of many families and businesses in off-grid locations seeking a cost-effective and convenient decarbonisation solution.

UGI would welcome the opportunity to discuss appropriate policy instruments to encourage the production, and supply of rLG. Amongst the measures proposed by UGI, are the following:

1. Introduction of a Cost-Efficiency-First Principle: If rLG is determined to be the most cost-effective decarbonisation solution for a sector, then feedstock should be ensured for rLG production for this purpose, going where it is most economical for taxpayers. For rLG to be a viable alternative to electrification for off grid-heating, support actions must enable sufficient feedstock allocation.
2. Blending-Obligation-Principle for land transport fuel (bio-diesel, bio-petroleum): Electrification and hydrogen are viewed as the most effective energy solutions for decarbonising land transport, and should therefore be prioritised. Given this development, blending obligations for fossil fuels should be limited in scope and duration, as it is not a viable long-term solution, while also taking up organic feedstock needed to produce rLG in the short term.

As an example of a promising technology for producing sustainable jetfuel, the California-based technology company Vertimass, which UGI has entered into a 15-year cooperation agreement with, should be mentioned.
UGI together with Vertimass plan to jointly produce sustainable aviation fuels and renewable propane from renewable ethanol. The aim is to have the first production facility ready in 2024, targeting an annual production of 189 million litres of renewable fuels.

Conclusion

As seen with various social protest movements around the world in recent years, an affordable energy bill for all families and businesses is key if the green energy transition is to succeed. As highlighted in this paper, electrification is not always economically and technically feasible, especially not in the short term. Investing in expensive heat pumps and energy renovations is simply not a realistic option for many families and small businesses. Given that sustainable heating options have historically been financially supported by governments, choosing a cost-effective and sustainable energy solution such as rLG, would not only be good for citizens' finances, but also a wise use of taxpayer money.

UGI Roadmap 2030

– a pathway to a more sustainable future with liquified gas

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