A roadmap to 2050

Liquid fuel for heating

Eurofuel's contribution
to the decarbonisation of heating

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Fuelling your future heating

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Fuelling your future heating

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ABOUT EUROFUEL

Eurofuel represents organisations that promote the use of liquid fuels for domestic heating in Europe.

Our membership covers 10 European countries and over 10 000 companies. Eurofuel encourages innovation and promotes existing and new liquid fuels and techniques for heating in the domestic market. Our members are committed to ensuring the competitiveness and efficiency of heating with liquid fuels, while also reducing its environmental footprint.

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1 EXECUTIVE SUMMARY

Heating and cooling account for almost half of the EU's energy consumption and for a significant share of carbon emissions. Decarbonising the sector is key for achieving EU's climate objectives.

In doing so, on the path to energy transition, safeguarding social inclusion is paramount to ensure that no one is left behind. Consequently, it is essential to acknowledge Europe's diversity in terms of access to energy, weather conditions and types of dwellings. This demands an approach that is open to all available technologies which can provide clean, affordable, and tailored heating solutions for all EU citizens.

While technology choice is important for all households, it is especially important to provide solutions for all, including for those located in rural, off-grid areas. This is where the benefits of liquid fuels are maximised. These households (20 million homes across the European Union) represent a significant proportion of the population and one with specific needs that cannot be easily fulfilled by other energy carriers. For most oil-heated homes **it is not that easy to switch to a different heating technology and energy, be it for technical or financial reasons.** Different technologies are suitable for different buildings and different regions across the EU.

Eurofuel, who represents the European liquid heating fuel sector, is committed to ensure that liquid heating fuel users can maintain comfortable heating at an affordable cost, while also decreasing CO_2 emissions. This pragmatic approach focuses on energy efficiency, since the best energy is the one we don't consume, and the progressive inclusion of low-carbon and renewable liquid fuels.

This Roadmap describes how liquid fuels can help in reducing the emissions to 55% by 2030 and to 100% by 2050, thus contributing to the carbon neutrality objectives of the EU.

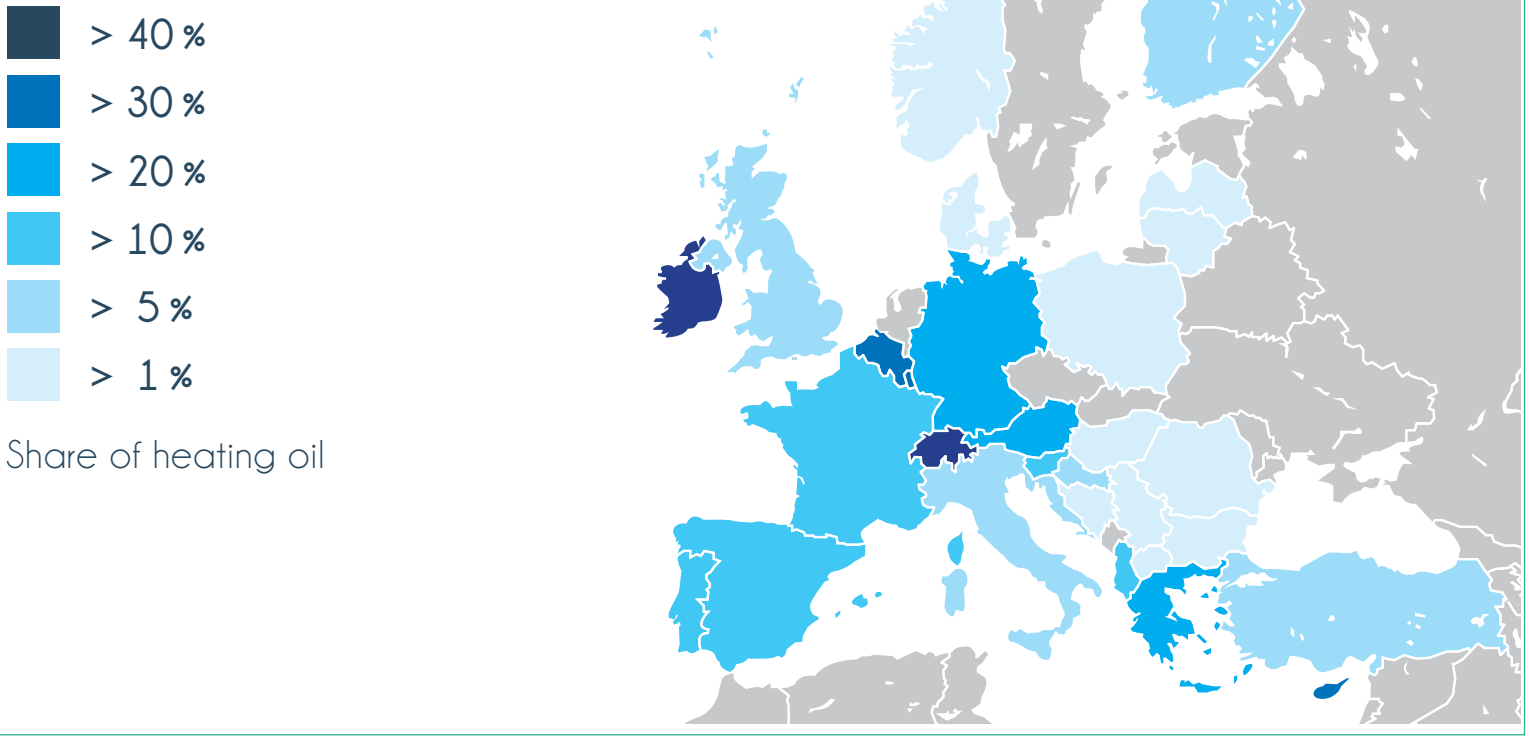
2 LIQUID FUEL FOR HEATING TODAY

In the EU, **20 million homes** rely on oil heating with most of these homes being located in rural, off-gas grid areas, where no other affordable alternatives are available, due to technical, economic, or social reasons.

At present, heating oil stored in tanks is one simple way in which homeowners can warm their house. Without liquid fuels, these families are literally left out in the cold. In some European countries, such as Austria, Belgium, Germany and Ireland, over 20% of the population relies on liquid fuels for heating.

20 million homes

heated with liquid fuels in the EU, mainly in rural and residential areas



Source: "Heating with liquid fuels: Pathway for a sustainable future" (ECFD, Eurofuel, FuelsEurope and UPEI)
https://www.eurofuel.eu/images/Heating_with_liquid_fuels.pdf

3 LOW-CARBON AND RENEWABLE LIQUID FUELS

Today, liquid fuels are used all over the world since they offer many benefits. Most of them are derived from fossil fuels and need to be replaced by low carbon and renewable alternatives. The amount of renewable energy needed for this is considerable. Renewable energy is available in considerable amounts globally, but when it comes to covering Europe's entire energy demand with locally produced green energy, such thing will not be possible. This is exactly why liquid fuels will still be needed in the future. Renewable and low carbon energy can be produced where the conditions are suitable (sun, wind), and stored and transported to Europe to cover its energy demand while existing infrastructure and technology makes it possible to ensure users have access to it.

3.1 Advantages of low-carbon and renewable liquid fuels

FLEXIBILITY

- Can be supplied in all geographical areas (e.g., rural, and mountainous regions, islands)
- No need for additional infrastructure
- Renewable future fuels can be delivered individually to specific homes
- Future-proof: boilers combine well with renewable energy input like solar energy, in a hybrid system, and are ready to operate with low carbon and renewable liquid fuels

AFFORDABILITY

- Freedom to choose an individual fuel provider
- Freedom to define the time and frequency of tank refills: enabling customers to benefit from lower prices depending on the market and their personal circumstances
- Price transparency: no base fee, customers only pay for the energy they are using

RELIABILITY

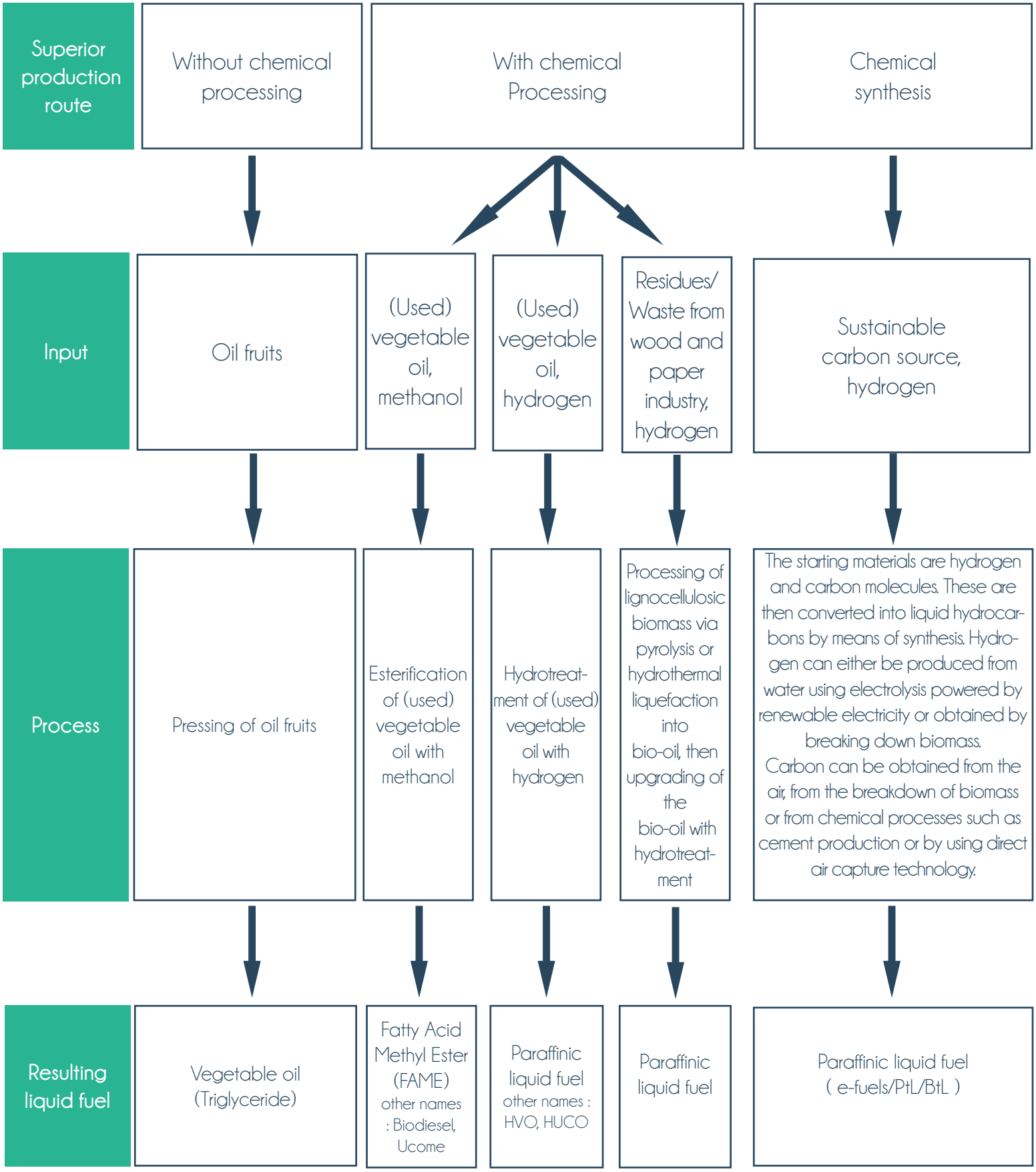
- Long term proven heating technology
- Global and reliable independent energy supply system
- Energy demand can be stored on-site
- Suitability for different building types and variable climate conditions

EFFICIENCY

- The efficiency of new heating oil systems is close to 100%
- Liquid fuel heating systems can operate in combination with other systems (hybrid systems), making them even more efficient

3.2 Manufacturing routes for renewable liquid fuels

The following table shows manufacturing routes for low carbon and renewable liquid fuels, their inputs, processes, and the resulting liquid fuels:



ESTERIFIED FUELS

FAME
Fatty Acid Methyl Ester
UCOME
from residues like
Used Cooking Oil (UCO)
or from Vegetable Oil
(e.g. Rapeseed Methy Ester - RME)

PARAFFINIC FUELS

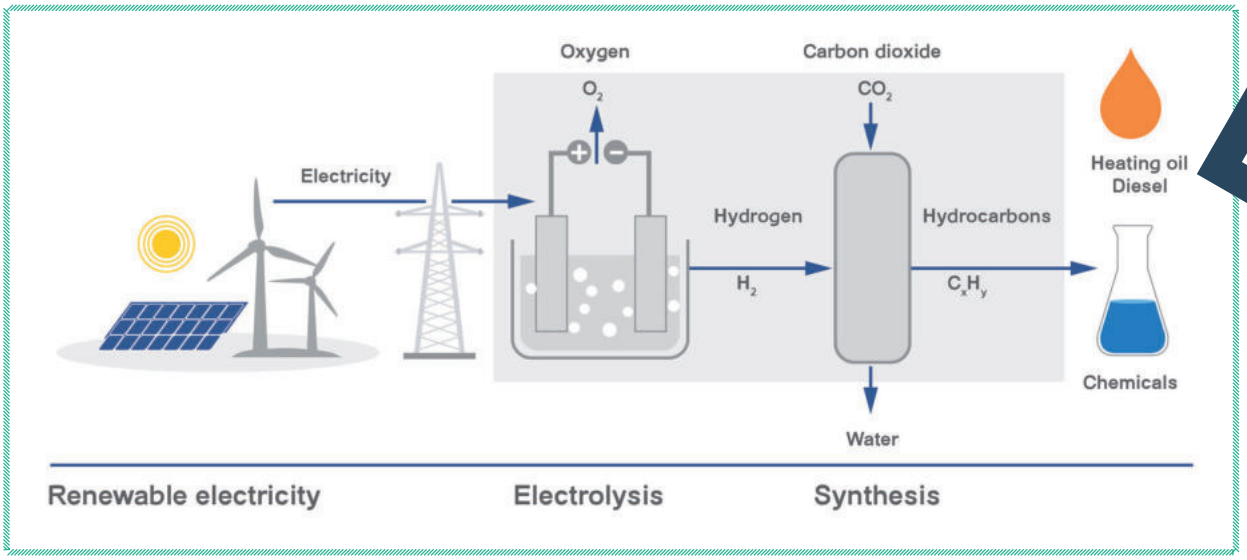
HYDROTREATED OILS
HUCO from residues like
used cooking oil (UCO)
or HVO from vegetable oil
(e.g. rapeseed oil) - and waste

E-FUEL (PtL)

based on green electricity,
e.g. produced by Fischer-Tropsh-Synthesis

Source: en2x

POWER TO LIQUID: FISCHER-TROPSCH PROCESS



Source: Eurofuel

3.3 Fuel types

Low carbon and renewable liquid fuels can be produced from different raw materials and through various processes. They are based on biomass and/or green electricity/hydrogen and a carbon source. The key feature is a closed carbon cycle, which makes the fuels carbon neutral. Therefore, the required carbon is taken from the environment - as CO_2 - directly from the air or from biomass, and in the same amount that is released again when the alternative fuels are used.

1. Biodiesel/FAME/UCOME

Biodiesel (FAME - Fatty Acid Methyl Ester) is based on vegetable oil, which is processed with methanol into a liquid fuel. It is suitable for oil heating systems designed for this type of fuel. Usually, Biodiesel/FAME is used as admixture in other fuels. In several European countries, a share of appr. 7% Biodiesel is included in the diesel at each petrol station. Many modern condensing boilers for liquid fuels are approved for up to 20% or 30% Biodiesel/FAME, specific ones are approved for up to 100% Biodiesel/FAME.

2. Biomass-to-Liquid Fuels

The fuel is derived from different types of vegetable raw materials or waste and residues of biogenic origin. In a first step, the raw material is split into molecules. In a second step, the hydrogen and the carbon molecules are put together in a synthesis process to build hydrocarbons with the desired parameters. The final products are paraffinic liquid fuels like gasoline, diesel, or heating oil.

3. Hydrotreated Fuels (HVO/HUCO)

The bases for hydrotreated fuels are biogenic wastes or other biomass such as: used cooking oil, biogenic waste, or vegetable oils. The process of producing paraffinic liquid fuel is a mature technology and the fuel is available on an industrial scale.

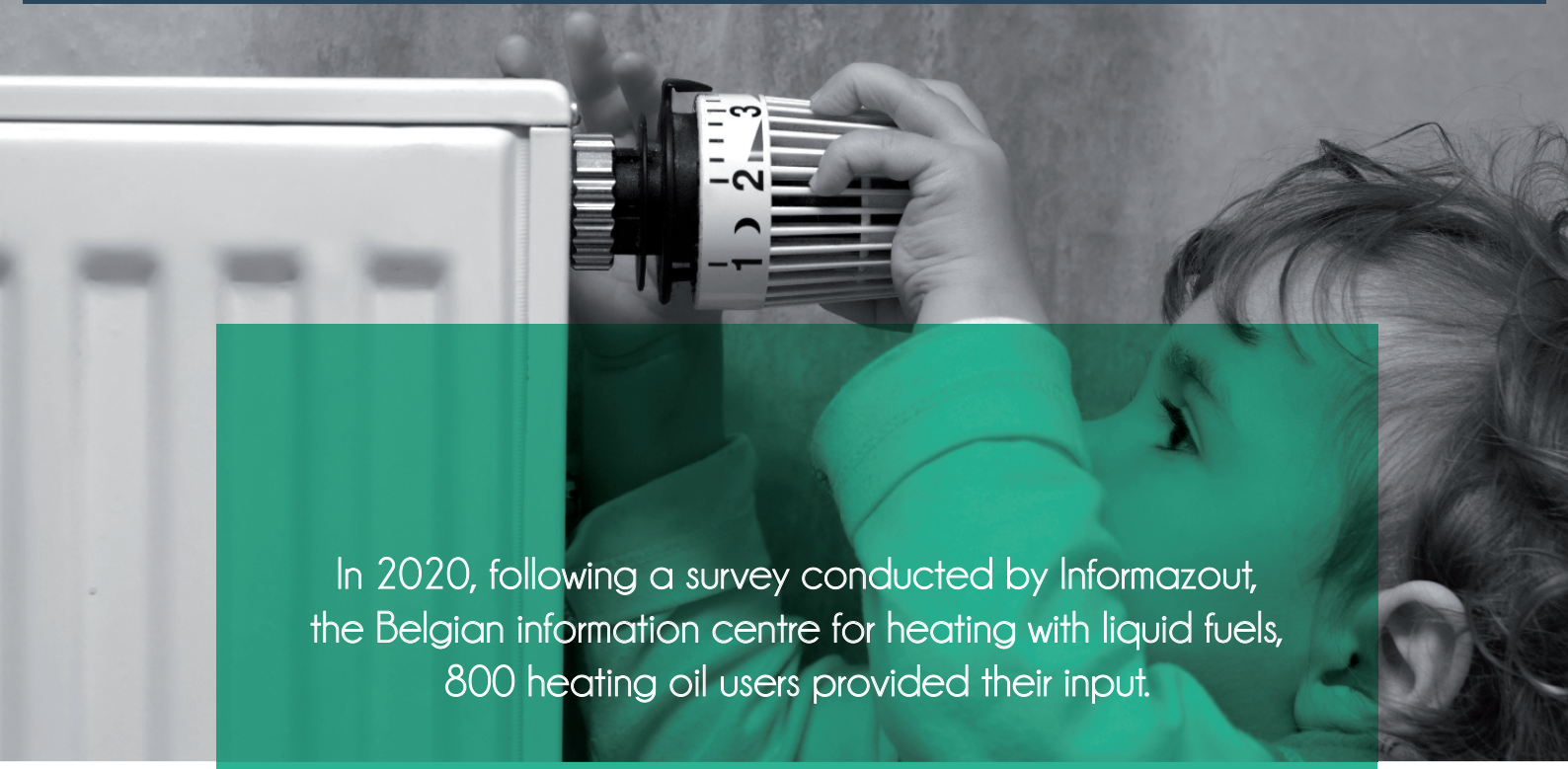
4. E-fuels / Power Fuels / Power-to-Liquid Fuels

The production of e-fuels is based on the synthesis of hydrogen and carbon. As opposed to the BtL-process, the hydrogen input is derived from the electrolysis process. If the electric energy used for this process comes from wind or solar energy plants and the necessary carbon is not fossil (e. g. from the ambient air or biomass), e-fuels are carbon-neutral and a viable solution to reduce greenhouse gas emissions via a closed carbon cycle while keeping the fuel in liquid form. E-fuels, which are paraffinic liquid fuels, are synthesized in a catalyst driven process called the "Fischer-Tropsch" process.

5. Blends

Whatever the type, renewable fuel can be used as a pure product, as well as in blends with conventional gasoline or diesel. The blend can also be made of several components. For instance, R33 in Germany is made of 67% domestic heating oil + 7% FAME + 26% hydrotreated products.

3.4 What do customers think about renewable fuels?



In 2020, following a survey conducted by Informazout, the Belgian information centre for heating with liquid fuels, 800 heating oil users provided their input.

Main conclusions from the survey are as follows:
20% of the respondents would like to use low-carbon and renewable liquid fuels as heating fuel for their home in a relatively short term.
60% are interested but would rather wait.
Only 20% considered renewable liquid fuels are out of potential' and will therefore not opt for the low-carbon variant of heating oil.

The majority would accept the product to cost 10% more than conventional heating oil.

3.5 Affordability

One of the obstacles to the development of these new fuels has been their production cost – which is for the moment higher than that of conventional fuels. These costs would, of course, be reflected in the consumer prices, making their uptake difficult. Today, a few types of mainly first and second-generation biofuels have production costs relatively close to the price of conventional heating oil. This is, for instance, the case of hydrotreated oil (HVO/HUCO), which can have production costs lower than € 1 per litre. Favourable taxation treatment for low-carbon and renewable liquid fuels can make this renewable fuel a competitive option, especially when blended with heating oil.

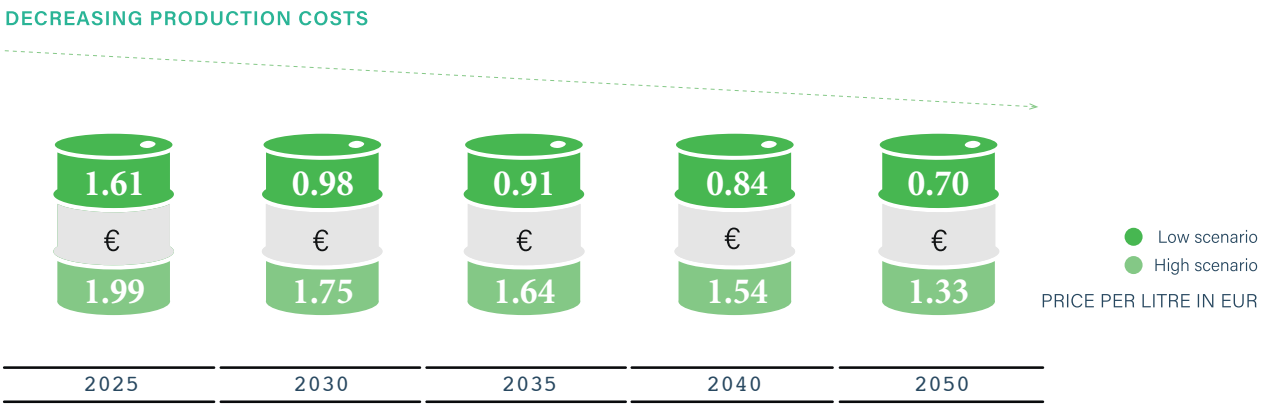
The most advanced alternatives, in particular fuels generated with Biomass-to-Liquid and Power-to-Liquid (PtL) technologies, are today too expensive to offer a viable substitute to conventional liquid fuels in the context of the current regulations.

However, if, as expected, the cost of synthetic fuels falls due to economies of scale and lower electricity prices[1], these fuels will become a credible medium- to long-term solution. A study by Frontier Economics anticipates some PtL products will achieve a product price of 5 to 10 cent per kWh, i.e., close to the anticipated price of conventional fuels, by 2050.

eFuel generation costs

(PtL syncrude as a crude oil substitute)

for large-scale industrial production in wind- & sun-rich regions of the world



Lower cost path of eFuels: cost-effective international provision with optimal site conditions for renewable power generation and better electrolysis efficiency

Higher cost path of eFuels: international provision with a not always optimal choice of location for renewable power generation and slower increase in electrolysis efficiency

Source: Source: UNITI-informiert_Bezahlbarer_Klimaschutz_EFuels.pdf

1. TU Bergakademie Freiberg: Production of GHG-reduced liquid fuels, 2017 https://www.eurofuel.eu/images/Study_on_Liquid_Fuels_with_Reduced_GHG_Emissions_-_EN.pdf

3.6 Environmentally sound

Renewable and low-carbon liquid fuels are sustainable liquid fuels from non-fossil origin, with **no or very limited net CO_2 emissions during their production and use, compared to fossil-based fuels[2], due to their** closed carbon cycle.

To be considered renewable, biofuels like FAME and HVO/HUCO must meet sustainability criteria relative to the feedstock, in line with the Renewable Energy Directive[3]. The main crops used to produce biofuels in Europe are rapeseed and sunflowers[4]. The blend stocks might be certified in the future by specific schemes.

2. Clean Fuels For All - https://www.cleanfuelsforall.eu
3.Directive (EU) 2018/2001 - https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG&toc=OJ:L:2018:328:TOC
4. Bringing biofuels on the market - Options to increase EU biofuels volumes beyond the current blending limits Delft, CE Delft, July 2013

4 FUTURE FUELS IN OPERATION

To assess the compatibility between existing boilers and different blends of products, Eurofuel and the European Heating Industry (EHI) run field tests[5] .
In total, about more than two hundred family homes across Europe were involved in the field tests.
Due to regional requirements, different types of liquid fuels were used.
Some minor technical adjustments may be needed, depending on the fuel mix and boiler, but the preliminary results show that compatibility can be achieved at a minimal cost for consumers: the existing equipment is future-proof. The results are promising, all appliances are running well, and commercial scale-up is under discussion. Finland is one step ahead since 2021, with a 100% renewable product (HVO) which is available for heating and mobility use.

GERMANY

Renewable heating oil "33" (67% DHO + 7% FAME + 26% hydrotreated products)
In Kirchdorf

The Federal Association of the German Heating Industry (BDH) and the business association fuels and energy "en2x" are jointly making field tests with a new variant of low-carbon and renewable liquid heating fuel. As part of a practical test lasting for at least two years, 21 residential buildings are being supplied with a 33% renewable blended fuel, one third of which consists of low-carbon and renewable component. The aim is to prove their readiness for use.
26 % of the R33 blend used in the new joint project consists of second generation hydrotreated biofuel derived from waste material, which does not compete with food cultivation, and a 7% share of esterified bio-oils (FAME).

The business association fuels and energy "en2x" has already been using such paraffinic fuels without any problems since 2017 as an admixture to classic heating oil in a smaller number of its own model projects.

The field test is part of an international project involving the European umbrella organization of the heating industry EHI (Association of the European Heating Industry) and the European heating oil association Eurofuel.

5. https://www.eurofuel.eu/publications/position-papers/item/462-eu-field-tests

5 HEATING TECHNOLOGY

Situations vary greatly from one country (or even one region) to the other, depending on the climate, the type of dwelling, the family composition... But reducing CO2 emissions is always possible.
Here are two examples:

5.1 Example from UK

In the UK[6] , more than two thirds (68%) of rural homeowners state that £2 500 is the maximum amount they would be willing to spend on energy efficiency upgrades, with over a third (35%) unwilling to spend anything.

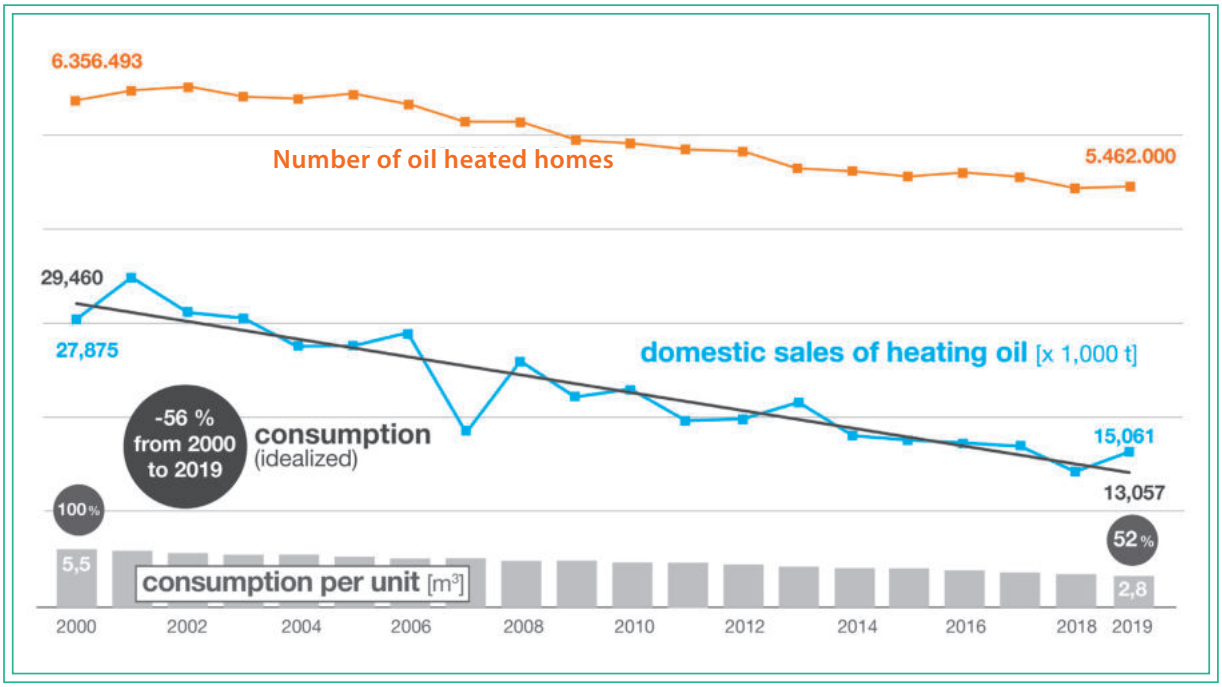
While subsidies are available for the purchase of new systems, situations vary widely depending on the member states and running costs, which need to be considered as well.

The average cost to install an air source heat pump is nearly £11 000 and, for a biomass system, over £16 000. Consumers in poorly insulated homes may also have to fund the additional energy efficiency improvements needed for their homes so that heat pumps can work effectively. Figures suggest 65% of oil heated properties fall into the lowest energy efficiency bands (E to G). The government estimates the average cost to upgrade EPC Band E homes to an acceptable Band C standard is £12 300 and, for Bands F and G homes, £18 900.

6. https://www.oftec.org/news/2021/04/13/government-green-heating-plans-unworkable-survey-finds

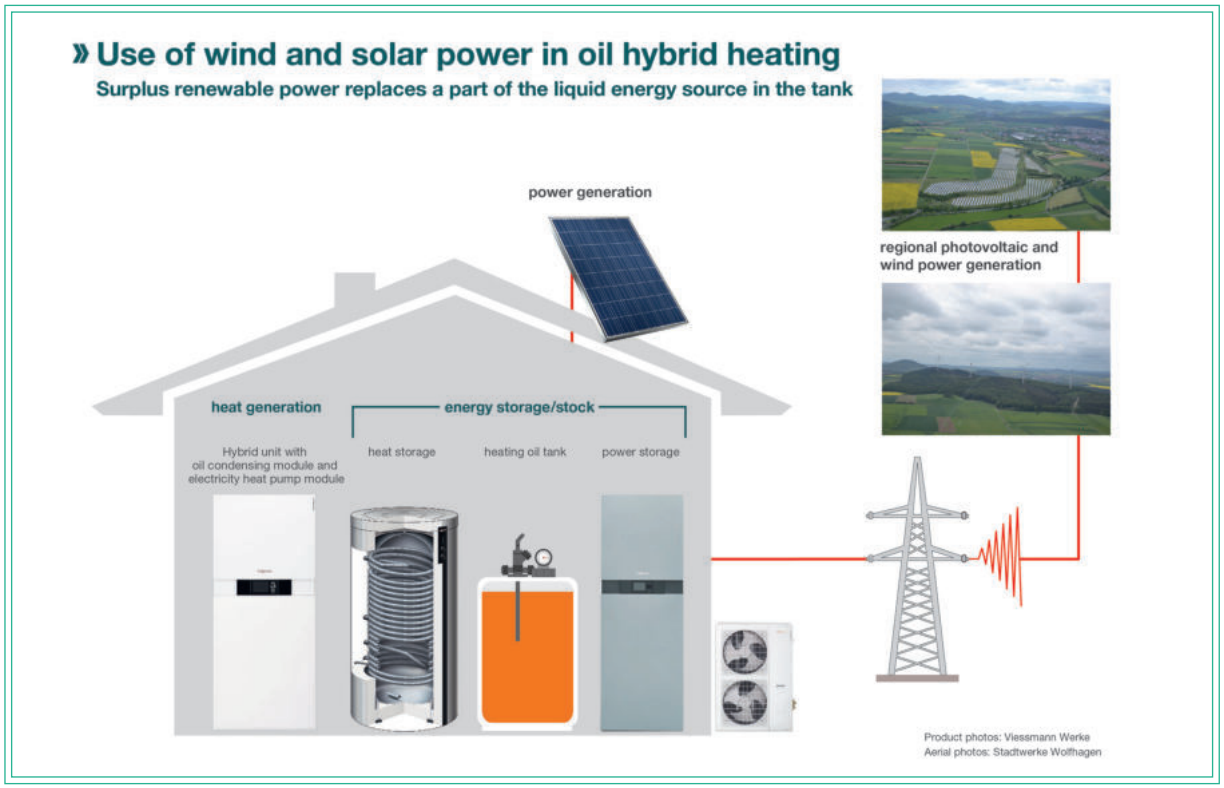
5.2 Example from GERMANY

Example for halved consumption



Source: BAFA, ZIV, en 2x

Example for a hybrid system



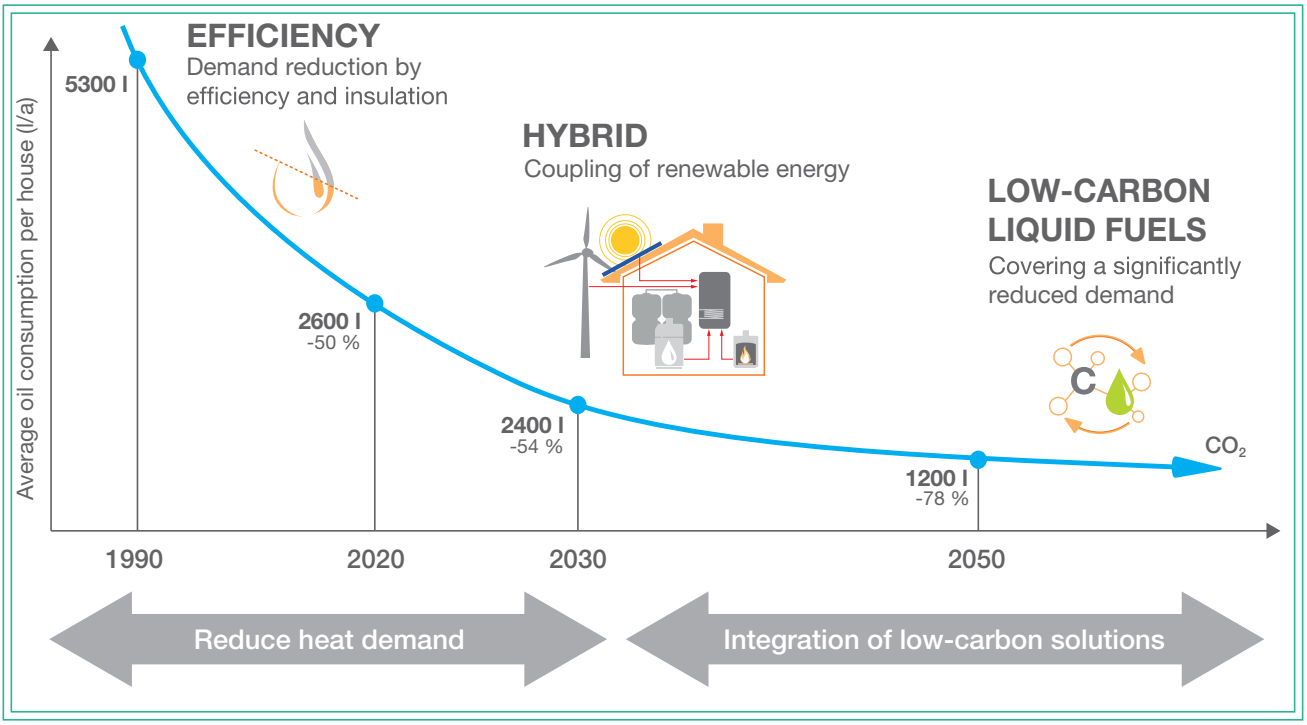
6 EUROFUEL'S STRATEGY TO GUIDE THE HEATING SECTOR INTO A CARBON NEUTRAL FUTURE

The targets have been set out by the EU: a 55% reduction (compared to 1990 levels) of CO_2 emissions by 2030, and net-zero emissions by 2050.

This will require considerable effort across all sectors – heat, energy, and transport.

6.1 The three-step approach

Eurofuel is committed to technology-oriented solutions in the heating sector which ensure that people have affordable ways to save energy. With highly efficient heating technology, increased use of renewable energy sources, a targeted reduction in consumption through thermal insulation, and liquid fuels that will reduce greenhouse gases in the long term, the goal is to reach the target by 2050.



STEP 1 - MAXIMISE EFFICIENCY

Installing modern condensing boilers in all buildings would have immediate benefits. Improved building insulation and highly efficient condensing boilers reduce both fuel oil consumption and greenhouse gas emissions. Today's condensing boiler technology is ready for the use of renewable liquid fuels.

STEP 2 - MOVE TO HYBRID HEATING SYSTEMS

The next step is to further reduce the fossil fuel requirements of oil-fired condensing boilers. Hybrid heating systems, which combine heating oil with renewable electricity, solar heat, or biomass, guarantee a reliable supply of heat. These hybrid systems are suitable for the modernisation of old buildings which have higher heating needs. The technology is suitable for well-insulated buildings as well. In addition, the integration of renewable electricity with innovative power-to-heat technology is also possible. If enough renewable energy is available, it can be converted into heat by means of a heat pump or a heating element in a buffer tank. This further reduces the consumption of heating oil, increases the share of renewable energy in the heating supply and helps to stabilise the electricity grids.

STEP 3 - INTRODUCE LOW-CARBON AND RENEWABLE LIQUID FUELS

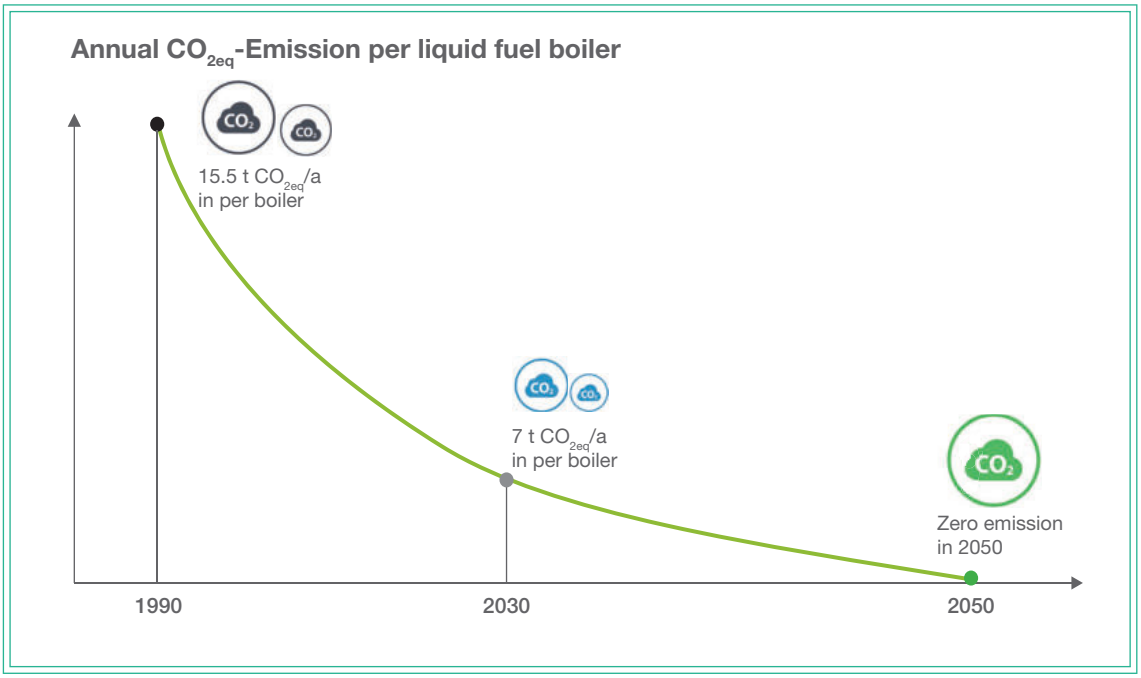
However, highly efficient heating technology and the integration of renewable energy into the heating s upply are not sufficient on their own to reduce greenhouse gas emissions to zero. Low-carbon liquid fuels can cover the remaining energy demand and follow at the same time the climate protection targets.

6.2 Example calculation: liquid fuel for heating in Europe until 2050

To estimate future developments in the heating oil market, Eurofuel has carried out the following model calculation with two different scenarios.

Goal to be achieved / basis of consideration

According to European legislation, greenhouse gas emissions must be reduced drastically. While an average heating boiler still emitted app. 15.5 t/y of CO_2eq in 1990, this value must be reduced to 7 t/y in 2030 and drop to zero in 2050.



Scenarios under consideration

To assess the future of liquid fuels for heating, we have considered two different scenarios, which are illustrated in the following graphs.

RESTRICTIVE SCENARIO

- This scenario is likely to happen in a framework which favours other technologies rather than liquid fuels
- Low carbon or renewable liquid fuels for heating are not accepted as a solution to reduce CO2 emissions
- No level playing field for the different low carbon energy solutions
- Bans, restrictions, and no legal or financial incentives for CO2 reduction with liquid fuels

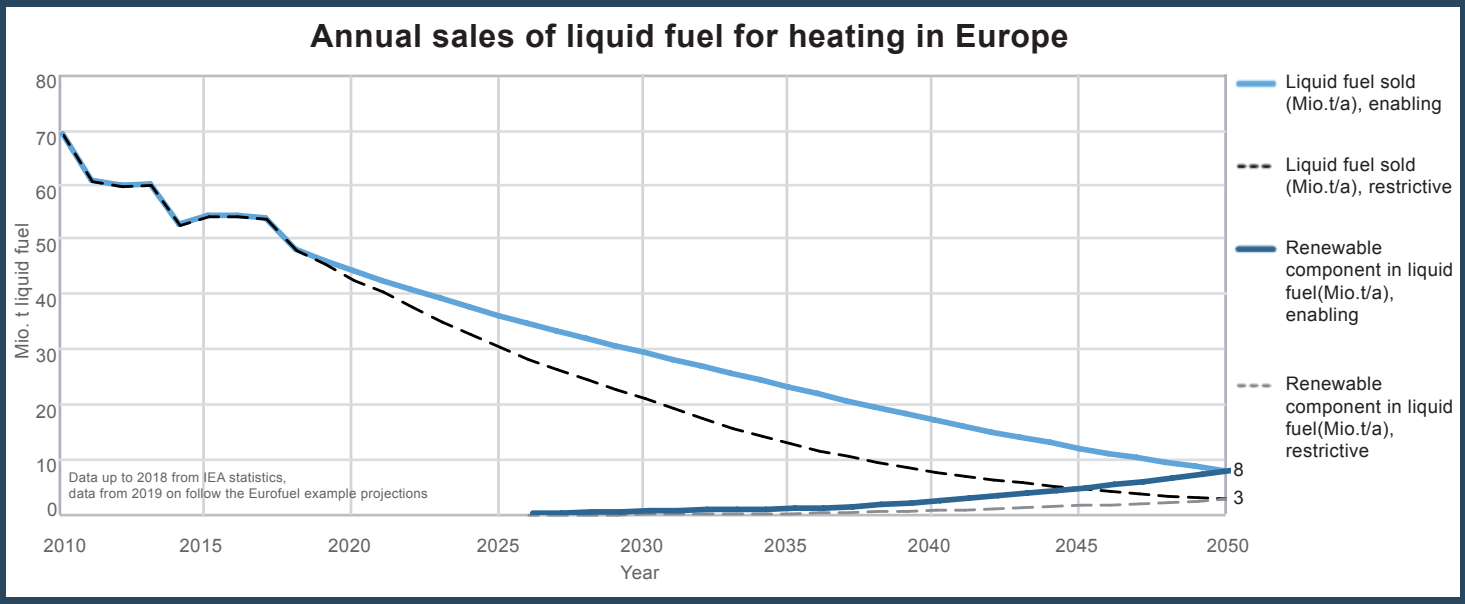
ENABLING SCENARIO

- Low carbon or renewable liquid fuels are recognised as a tangible solution to meet the climate targets
- Incentives for the use of renewable and low carbon liquid fuels are created, helping to build a "business case" for these products (e.g., energy tax according to CO_2 emission)
- Through a technology-open approach, liquid fuels can make a significant contribution to the reduction of greenhouse gas emissions

Annual sales of liquid fuel for heating in Europe until 2050

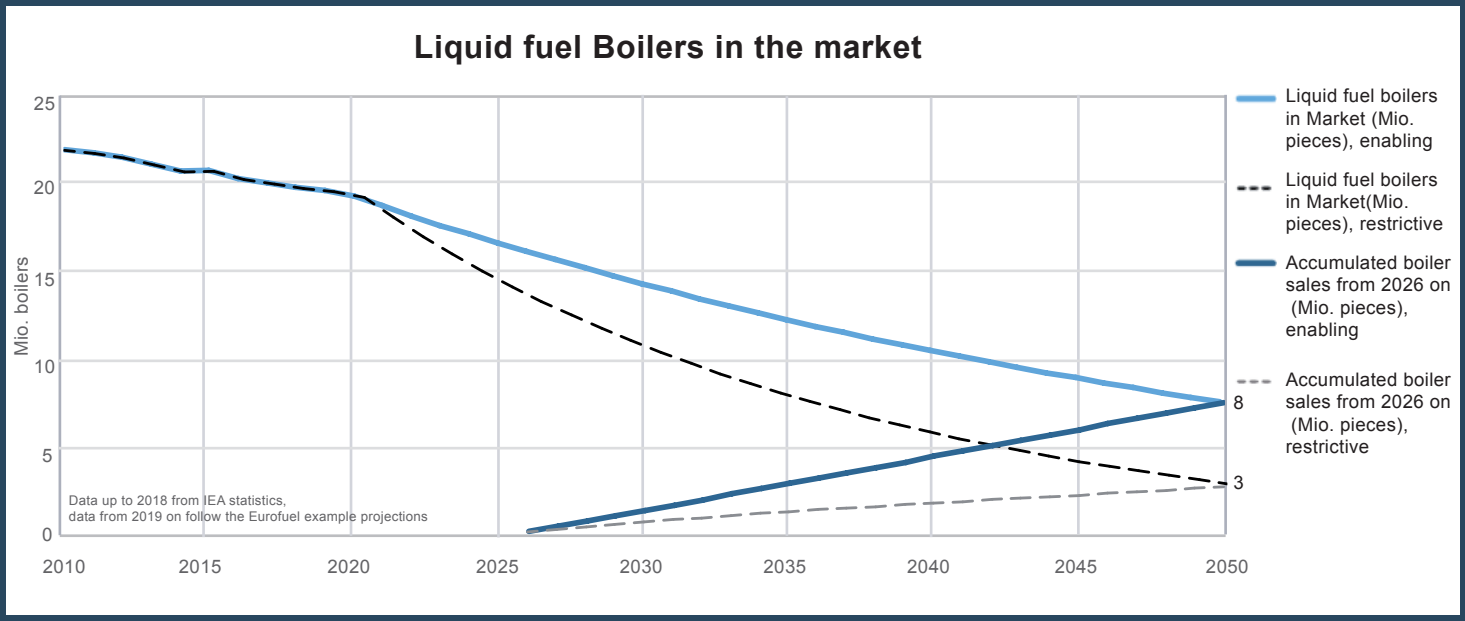
Due to energy efficiency measures in building insulation, heating technology and the introduction of renewables in hybrid systems, the sales of liquid fuels for heating are reduced drastically.

For the following model calculation, we assume that this will take place while we increase the share of alternative liquid fuels up to 2050 to about 100%. In 2050 the liquid fuels for heating will be 100% renewable. We anticipate the decrease of heating oil sales from 87 million t/y in 1990 to 3 or up to 8 million t/y in 2050 depending on chosen scenario.



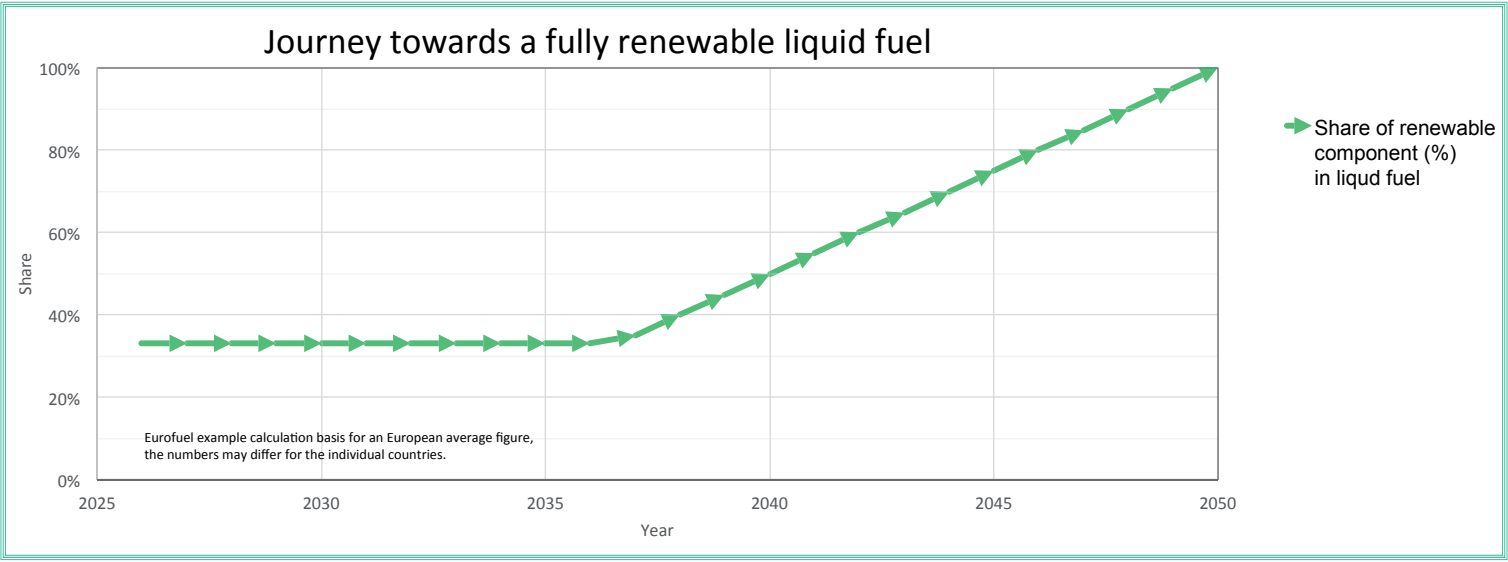
Boilers for liquid fuel in the market until 2050

Depending on the chosen scenario we anticipate a total number of 3 up to 8 million boilers in 2050.



Share of renewable component in liquid fuel sold to boilers installed from 2026 on

We assume that starting from 2026 liquid fuels with 33% renewable components are used in heating systems installed from 2026 on. Then, the share of the renewable components will increase. In 2050 a fully renewable product will be sold.



Summary of example calculation

Compared to 1990 emissions, this will allow each boiler to decrease its emissions by 55% in 2030, and by 100% in 2050, thus in line with the EU targets.
It appears that the "enabling" scenario would lead to 8 million boilers, 8 million tons of liquid fuel and 0 greenhouse gas emissions.

The restrictive scenario would lead to 3 million boilers, 3 million tons of liquid fuel and 0 greenhouse gas emissions.
An enabling policy framework would allow 8 million houses to use alternative liquid fuels for heating and provide a significant contribution to achieve climate neutrality by 2050.

Our example models reflect what we expect at "average" European level: some member states will go faster (for example Finland, where there is already an uptake of renewable paraffinic fuels for heating), others will go slower depending on the national legislation such as the authorisation to put the product on the market.
Please note that the mentioned example calculations strongly depend on the assumed legislation. These may change with the political regulations, as well as the market developments.

7 POLICY RECOMMENDATIONS

To allow a fair transition towards a decarbonised heating, and in particular to allow the uptake of low carbon and renewable liquid fuels in heating, Eurofuel recommends:

7.1 A technology open approach

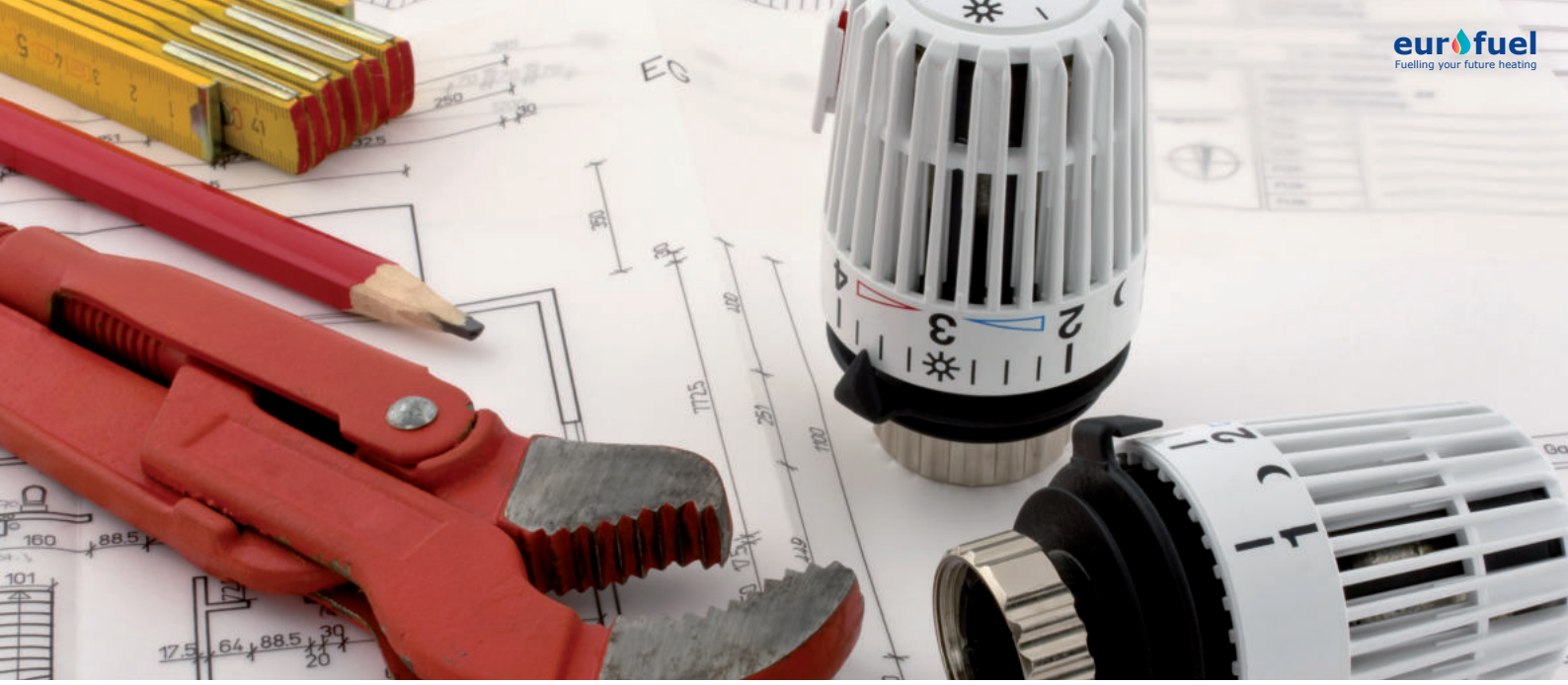
The principle of 'technology neutrality', that is the freedom of individuals and organisations to choose the most appropriate and suitable technology for their needs is a basic principle in the European Union's climate and energy policy.

EU Member States face different challenges in reducing emissions from heating. It's therefore important to offer a wide range of affordable heating alternatives. Consumers should be able to choose the most appropriate technology for their dwelling.

7.2 Introduction of renewable and low-carbon liquid fuels

Policymakers acknowledge the role of low-carbon and renewable liquid fuels in the future energy mix. However, while the focus is too often on the decarbonisation of "hard to abate sectors" such as aviation or the maritime sector, these fuels are also well-suited for heating.

The large-scale deployment of renewable and low-carbon liquid fuels will enable a more affordable introduction of these products. A political will to deploy these products for different markets and sectors will further trigger investment from producers.



7.3 Fit for 55 Package – Policy recommendations

The European liquid heating fuel sector highlights some key considerations concerning the "Fit for 55 Package".

Energy Taxation Directive

- Eurofuel agrees to use carbon content as a reference for energy taxation.
- To ensure an affordable energy transition, tax reduction should be ensured to protect vulnerable consumers, especially in a context of rising energy market prices. In addition, flexibility should be given to off-grid areas where customers choice is limited to certain heating options which might not be the less carbon intense.
- Introducing fiscal incentives to transition to low carbon and renewable liquid fuels would help their uptake.fuels would help their uptake.

Renewable Energy Directive

- The Directive needs to acknowledge the potential of low carbon and renewable liquid fuels for heating vulnerable households and off-grid communities[7].

As "drop-in" fuels, they can be used without major alterations in existing heating systems, greatly improving their efficiency with minimal costs. This technology neutral approach should be reflected throughout the text, avoiding discrimination between heating systems leading to ineffective technology bans that would disproportionally affect certain countries/regions.

- There is no fossil fuel system as such, as its nature depends on the type of energy (e.g. fossil or renewable) used to power it. Efforts should be done to decarbonise the energy source and increase the efficiency of all heating systems instead of banning them, which would be disproportionate and discriminatory since there is a lack of recognition for low-carbon and renewable fuels for heating.

7https://www.eurofuel.eu/images/Heating_with_liquid_fuels.pdf

Energy Efficiency Directive

• We are encouraging the modernisation of heating systems with more performing, condensing boilers, and informing our customers about the various options at their disposal to increase the energy performance of their heating systems and buildings, therefore reducing their energy bills.

• Energy savings from all technologies – such as renewable ready combustion technologies – should be fully accounted under the annual energy savings obligation.

Emission Trading System

• If pursued, the extension to buildings should be coherent with the existing framework and related reforms.

• The framework should cover all energies and fuels used (i.e. liquid fuels, gaseous fuels, electricity), with renewable and carbon neutral energies counted with an emission factor of 0.

Energy Performance of Buildings Directive

• The definition of "energy from renewable sources" should be expanded as to include renewable and low-carbon liquid fuels.

• The definition of available energy sources to cover the energy needs of an efficient building should be widened as to respect a technology-neutral approach and ensure all low carbon technologies can play a role in decarbonising the EU's building sector.

• Appropriate incentives should be put in place to allow a level playing field among the technological low carbon solution available for decarbonising the building sector.

•Member States should be mandated to set requirements for heat generators based on greenhouse gas emissions alone, without banning technologies and/or fuels.

8 GLOSSARY

BtL	Biomass-to-liquid – a paraffinic liquid fuel, typically out of a Fischer-Tropsch synthesis
CO_2	Carbon dioxide
DHO	Domestic heating oil – a mineral oil-based mixture of around 75% paraffinic and 25% aromatic components
e-fuel	Power-based fuel – a paraffinic liquid fuel, typically out of a Fischer-Tropsch synthesis
ETS	Emission Trading System
FAME	Fatty acid methyl ester – an esterified liquid fuel
GHG	Green House Gas
HUCO	Hydrotreated used cooking oil – a paraffinic liquid fuel
HVO	Hydrogenated vegetable oil – a paraffinic liquid fuel
LCLF	low carbon liquid fuel
PtL	Power-to-Liquid – a paraffinic liquid fuel, typically out of a Fischer-Tropsch synthesis
SAF	Sustainable aviation fuel
toe	Tonne of oil equivalent
Mtoe	Million tonnes of oil equivalent
PtL	Power-to-Liquid

eurofuel
Fuelling your future heating

Thanks

Eurofuel would like to thank all those who contributed to this document:
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