Overcoming the barriers

to the development of the European Alternative Fuels market

AUTHORS

Albert Serra & Ignacio Magallon
Bax & Company
a.serra@baxcompany.com
i.magallon@baxcompany.com
+34 93 476 04 44

Maitane Berecibar & Maarten Messagie
University of Brussels
maitane.berecibar@vub.be
maarten.messagie@vub.be
+32 (0)2 629 38 34

Margarida Lozano, Ines Munoz & Javier Lebrato
Applus IDIADA Group
margarida.lozano@idiada.com
ines.munoz@idiada.com
javier.lebrato@idiada.com
+34 97 716 60 39

Overcoming the barriers

to the development of the European Alternative Fuels market

This public report on the current limitations of the development of the European alternative fuels market for the road transport sector serves as a baseline for recommendations to the European Commission and other policy making bodies. The research was conducted by members of Horizon 2020 Funded project COLHD, involving some of Europe's top universities, SMEs and engineering organisations to find alternatives to using fossil fuels in Heavy-duty Vehicles.

colhd

CONTENTS

ACKNOWLEDGEMENTS

A number of pre-selected experts from the transport and energy value chains have granted us their valuable time contributing to the elaboration of this report.

The authors would like to particularly thank the following entities: **AEBIG NEDGIA, AOGLP, AVL List GmbH, Concawe, Daimler AG, DECKERS MOBILITY CONSULTING, Eni, ENGIE, Energigas Sverige, Energy Institute Hrvoje Pozar, Matthews International Transport Ltd, European Biogas Association, FCC Acqualia, FEV Europe GmbH, GALP DOUROGÁS, GAS NATURAL FENOSA, Gasum Ltd, Gaz Réseau Distribution France (GRDF), GNVERT, IAV GmbH, Institut Català d'Energia, Institut de Recerca En Energia de Catalunya, EnergyLab, IVECO, LOGICOMPANY 3 SRL, Monfort Logística, S.L., Natural & bio Gas Vehicle Association, NATURAL SA, Rolande LNG B.V and Transports Metropolitans de Barcelona, Unipr, MAN Truck & Bus and Universitat Politecnica de Catalunya - BarcelonaTech.**

The authors would also like to thank the **16 partners in COLHD**, for all the dedicated conversations in meetings, workshops and teleconferences that have enriched the content of this report.

Finally, the authors would also like to thank all the **relevant stakeholders in Europe from the Advanced Alternative Fuels (AAFs) and Heavy-Duty vehicles (HDVs) sectors** who contributed to this research by filling out our online questionnaire.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 769974

EXECUTIVE SUMMARY

We need to achieve a net zero-emission European society by the second half of the century. The transportation sector accounts for one-third of the total emissions in EU-28 alone.

Just last year, a new EU proposal was introduced, limiting, for the first time ever, Greenhouse gas (GHG) emissions from HDVs by 15% in 2025 and by 30% in 2030. Since then, **COLHD has conducted a legislation-supporting study to identify the main barriers and propose concrete measures to further reduce emissions from HDVs.**

Mature technologies like Diesel and Natural gas powertrains, with an already existing market, experience a very different situation compared to other solutions like powertrain electrification and hydrogen fuel cells. The latest technologies are appropriate for light vehicles, but not proven feasible for HDVs in the short and mid-term. Although Natural Gas is still a fossil fuel, it generates less GHG emissions than today's widely used fuels, almost no PM and close to zero NOx. Additionally, natural gas can be completely replaced by its chemically identical biological part, Biomethane -considered a viable mid to long-term alternative to achieve net zero-emissions in freight transport.

This report presents an updated and comprehensive view on the **barriers that are still preventing the development of the Alternative Fuels (AFs) market for HDVs**, mainly focusing on Liquified Natural Gas (and Biomethane) and Liquified Propane Gas (and Bio-propane) as alternative energy carriers, as they are considered the most promising in the short-term.

The methodology includes literature research building on current state-of-the-art (SotA) from experts in the field and related H2020 projects, dedicated interviews with experts and involved a wider community of Stakeholders in the field, through an online Open Consultation.

In Europe, there is a generalised uncertainty about AFs (in terms of fuel types, necessary infrastructure, technical and economic viability, sustainability) that leads to a fragmented market with unstable conditions. The highest concern shared among all different Stakeholder groups is the economic viability of Alternative Fuel solutions given current and future market conditions, which calls for a need to incentivise the market if AFs are to take-off.

Moreover, fleet operators are struggling to make a positive business case for Alternative-Fuelled Vehicles (AFVs). This is due to higher vehicle purchasing costs and lower residual value, as well as higher operating costs related to limited refuelling infrastructure, despite the lower fuel prices.

Stakeholders are calling for a Europe-wide strategy with long-term policies supporting AFs in a technology neutral way, including all fuels in the Directive on Alternative Fuels Infrastructure (DAFI) and Renewable Energy Directive (RED).

In this report, we elaborate on our findings and propose measures to move forward, with a more critical view on the selection of fuel types, while incorporating a list of complementary measures to increase the GHG emissions reduction potential for HDVs transporting goods across Europe.

MOTIVATION

Objectives of this research

The present work was performed with the objective of identifying, classifying, discussing and summarising the most important barriers that could prevent wide adoption of Alternative fuel solutions in Europe, and the creation of a European AFs market to fulfil the energy needs of our transportation systems, particularly for HDVs transporting goods across European road networks.

The final goal is to gather the latest information on the current state of the market, using multiple European stakeholders all along the AFs for HDVs value chain as sources. Ultimately, this information will be analysed, processed and translated into recommendations for the elaboration of future policies and regulations.

The report's complementary goal is to inform, as openly and transparently as possible, about alternative solutions to current transport fuels, including options that are both cleaner and cheaper than diesel and petrol. The report will highlight the significant developments already achieved in bio- and synthetic fuels. These are milestones on the way to an increasingly renewable and circular economy, boosting the self-production of European energy to increase energy security for the EU's citizens and industry needs.

Context: Alternative Fuels for Heavy-Duty Vehicles

Currently, more than 90% of road transport relies on diesel and petrol to run and road transport accounts for more than 20% of the total GHG emissions in Europe. Figure 1 shows the evolution of GHG emissions in the European Union (EU) by sector. Although many solutions for AFs and powertrain technologies have been already identified and suggested, the number of Original Equipment Manufacturers (OEMs) so far involved is limited and there is still no mass adoption of these solutions.

While in other sectors the emissions are going down, transport emissions continue to increase and the trend is not set to change, with more than 70% of EU transport emissions coming from road transport. Alternative Fuelled Vehicles only represented 3.4% of the European car fleet in 2012 and the use of AFs in Heavy-Duty Vehicles is negligible, currently highly dependent on diesel. On the other hand, the share of electric vehicles in the total activity of Light-Duty Vehicles (LDV) is forecast to reach 15% in 2050[1] - **electricity, unlike Liquefied Natural Gas (LNG) or biofuels, is not considered a feasible option for alternative-fuelled road-freight in medium and long ranges[2].**

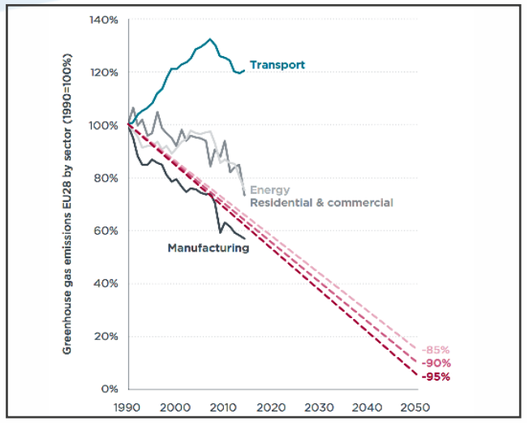

Figure 1. Greenhouse gas emissions in the European Union by sector, including linear emissions reduction trajectories (dotted lines) through 2050 [ICCT, May 2018]

1 EU Reference Scenario 2016
2 DG MOVE. "State of the art on alternative fuels transport systems"

The share of LNG in total consumption of heavy-duty trucks is anticipated to go up to 2.8% and 8.2% in 2030 and 2050, respectively[1].

There is currently a lack of attractiveness of fuel and powertrain alternatives for the general public and businesses: improvement in existing technologies is either limited in performance or still entails high operational costs; on the other hand, current Alternative fuel solutions for HDVs fail to achieve significant GHG emissions reduction. It is necessary to help remove these bottlenecks, addressing the problem through a 3-level strategy: bring new technologies to market, spur an optimised infrastructure deployment and contribute to mitigate remaining societal and economic barriers.

Methodology breakdown

In order to achieve the main objectives of this report, a specific methodology was defined and implemented. The steps and activities involved in it are explained below:

STEP 1
Pre-barrier identification

A first screening of results from previous projects and related literature research allowed the authors to identify and classify a preliminary list of barriers, including: 12 technical, 15 in regulation, 15 social, 9 related to market economics and 12 environmental.

STEP 2
Stakeholder identification and assessment

Relevant market stakeholders were identified and classified into 9 categories:

1. **Fleet operators/End-users**
2. **Agencies/Policy-makers**
3. **Associations/Networks**
4. **Infrastructure operators**
5. **OEMs**
6. **Industrial suppliers**
7. **Engineering suppliers**
8. **Alternative Fuels producers/suppliers**
9. **Academia/Research**

Afterwards, each one was qualitatively assessed in two dimensions: their relative importance in terms of market development influence (level of influence impact) and their associated innovation risks (impact of a potential innovation failure).

STEP 3
Open questions during phone interviews

The most relevant stakeholders were interviewed using the same 10 questions structure, giving also space to share additional information.

STEP 4
Open consultation at EU level

An online survey was created for the project website, based upon knowledge built during the previous steps and sent to the rest of identified stakeholders, as well as announced through the Twitter page and the first issue of the COLHD project newsletter.

STEP 5
Analysis of common barriers

The final step was to compile all the information, assess cross-linkages between barriers and summarise the key findings while proposing possible strategies to overcome the remaining barriers.

CURRENT LANDSCAPE

Alternative fuels market overview

Several AFs have been proposed and tested during the last years in order to decarbonise the European transport sector. Among the most promising alternatives for HDVs in the short and mid-term, biodiesel (HVO), Compressed and Liquified Natural Gas (and their biological and synthetic forms) and Liquified Propane Gas (and bio-propane) stand out. However, these solutions still struggle to penetrate the market.

In this section we summarise **the main barriers** discovered from our conversations and surveys with Stakeholders all along the value chain of these fuel alternatives, from researchers to end-users.

Main barriers identified

1. European Policy and Programmes

The Third Clean Mobility Package, proposing average vehicle emissions from HDVs to be slashed by 15% in 2025 and by 30% in 2030, has created some controversy. The targets themselves have been classified by some Stakeholders as a breaking point for technology neutrality in the EU, as they are interpreted as a way to boost and support electric mobility over the rest of the available options. It is also the first time ever that specific CO2 emission reduction targets are fixed for HDVs.

The Clean Vehicles Directive's CO2 calculation model does not consider the Well-to-Wheel (WTW) approach, but the Tank-to-Wheel (TTW) approach instead. This approach undermines the total lifecycle emissions reduction potential of biofuels , as only reduction in tailpipe emissions are considered.

The ILUC (Indirect Land Use Change) directive limits first-generation biofuels produced from food crops to 7% of the total transport fuels. ILUC is also banning public support for biofuels produced from food crops after 2020. The future biogas market development could suffer a recession without compensating governmental support for the development of 2nd generation biofuel production technologies and a common European market for biofuels.

For fuels from non-food crops (2nd generation), there is still the need to clarify which products can be considered as waste, residues or by-products. Based on the **RED (Renewable Energy Directive)**, different products used to produce biogas have to be considered separately at the time of calculating the GHG emissions. Administratively-speaking, it can represent a significant burden . It also goes against the principle of co-digestion and ultimately harms the viability of waste digestion, like manure for example, which is better treated with plant material.

Directive on Alternative Fuels Infrastructure (DAFI) sets specific targets for Member States (MS) to achieve, such as the maximum distance between LNG refuelling stations within the TEN-T network (400 km by 2025). However, to date, not all MS have submitted their National Policy Framework (NPF) and by November 2017, only 8 out of 25 NPFs fully met the NPF requirements. Only 5 NPFs estimates for future LNG HDVs deployment[5].

> "**It is very important that the EU member states make good long-term policies and all the available AFs with infrastructure are taken into account.** – Biogas association"

In view of present regulations, the Stakeholders' opinions generally point towards a lack of political commitment that leads to an uncertain legal framework in the long-term, which make viable business cases not possible. The main reasons seem to be related with the fact that there is a generalised lack of clear understanding of the role and viability of AFs in the energy for transportation market. The lack of a common long-term European policy framework to support fuel alternatives for the decarbonisation of transport leads to a general lack of political support and associated financial incentives.

> "**At the moment, the Agency of Energy is preparing a national plan in order to coordinate the different alternatives (Biomethane, HVO, Electricity…) and make a projection of the future infrastructure needed.** – Gas association"

> "**Bureaucratic procedures in order to get funds and subsidies are extremely time-demanding.** – Biogas association"

2. LNG related technologies

There are several aspects of LNG technologies currently under development and in need for improvement. Some concrete examples are listed below:

LNG engines need to achieve higher injection efficiencies and more homogeneous combustions[6].

Effective after-treatment technologies need to be designed and developed in order to cope with the fact that the content of sulphur decreases their durability[7].

Different parts of LNG trucks do not last the same. For instance, cryogenic pumps have a shorter lifetime than the trucks.

Fugitive emissions along the LNG supply chain need to be addressed, as they have a much higher global warming potential than CO2. For instance, fugitive emissions from LNG tanks during venting need to be effectively recovered through boil-off recovery systems[8].

Some stakeholders have reported their concerns about the possible effects of different fuel blends and dual-fuel use in the engines.

3 Consultation on an EU strategy for liquefied natural gas and gas storage. European Commission 2015
4 Bio surf project D3.2 | Proposal on cross-border biomethane administration

5 Communication from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions towards the broadest use of alternative fuels - an action plan on alternative fuels infrastructure under article 10(6) of directive 2014/94/eu, including the assessment of national policy frameworks under article 10(2) of directive 2014/94/eu
6 Alternative Fuels Expert group report European Commission directorate - general for research and innovation
7 State of the Art on Alternative Fuels Transport Systems in the European Union FINAL REPORT. EC
8 LNG Blue Corriors D3 10 - Design solutions to minimise Boil-off

3. Production of Biofuels: Biogas, Bio-methane, Bio-propane & HVO

Nowadays, the majority of biogas produced in Europe comes from anaerobic digestion plants using 1st generation feedstocks, which will progressively be phased-out. There are other production technologies under development, which use 2nd generation feedstocks (Advanced biofuels). One is the biomass gasification process that generates bio-SNG. This technology offers larger production capabilities than anaerobic digestion processes, but it is still under development and there are only a few pilot plants in Europe[9]. Another possibility is to use power-to-gas (Syngas) processes, in which the excess of solar and wind energy is used to produce synthetic gas. The future development of these two processes will influence the European production capabilities[10] of renewable gas and has to evolve together with gas powered vehicles.

At present stages of market development, the production of biofuels tends to be more expensive than conventional fuels, except for some cases like HVO. Neste Oil is the biggest producer of HVO in Europe and lately it has also started producing Bio-propane. The advantages of these two fuels over other fuel alternatives are their reduced price and market readiness. HVO can directly substitute diesel as a drop-in fuel, using the same available infrastructure and without requiring any additional engine modifications. Bio-propane is chemically identical to regular propane, thus being directly applicable to any powertrain running with Liquefied Petroleum Gas (LPG) and able to use the same LPG infrastructure with no modifications.

> **“Production of HVO does not require expensive technology investment, while other biofuels do.** – Fuel suppliers ”

4. Lack of Infrastructure & Fuel quality standards

There are standards that, due to their absence or need for modifications, can create barriers in the supply chain of fuel alternatives. Below some examples:

There is no International or European Standard that ensures the compatibility of LNG nozzles and receptacles. At the moment, there is a proposal for a standard – ISO/DIS 12617, that will be incorporated into the R110 regulation.

There is no official certification at European level for ensuring a homologated and recognised training programme for operating and refilling LNG HDVs. This means that training certificates obtained in some countries might not be recognised in others.

> **“If you provide safety training in one Member State, it might not be recognised abroad and then it is of no use when you pass the border.** – Fleet operator ”

There is no common standardisation for LNG supply infrastructure specifications. This generates a discrepancy between stations in different Member States in terms of delivery pressure and temperature of the fuel as well as other interoperability issues (e.g. payment).

Regarding fuel quality standards for alternative fuels, there are still gaps to be covered, as not all the standards for AFs include all relevant parameters, some limits being different between

9 Meijden, Christiaan. (2010). Development of the MILENA gasification technology for the production of Bio-SNG
10 Manuel Götz, Jonathan Lefebvre, Friedemann Mörs, Amy McDaniel Koch, Frank Graf, Siegfried Bajohr, Rainer Reimert, Thomas Kolb, Renewable Power-to-Gas: A technological and economic review, Renewable Energy, Volume 85, 2016, Pages 1371-1390

standards or even using different measuring units. As it has been pointed out during the interviews, some standards are also considered to be very restrictive, like the regulations limiting mix of Hydrogen (H) with Methane (CH4) and the efficiency of biomethane production.

5. Market instability: variability of AFs availability and prices in the market

Incorporations of AFs have resulted in localised and sometimes discontinued use. Some alternatives survive in specific countries over periods when prices for conventional diesel and gasoline are higher, or thanks to strong governmental support.

> **“A while ago we tried biodiesel (B-30) in a complete fleet, but it stopped being interesting when the financial incentives finished.** – Transportation service provider ”

Without stable market conditions for fuel alternatives favoured by a long-term policy framework and favourable market regulations, the uncertainty and thus the risk of investing in Alternative fuel solutions, together with the impossibility of making reliable market predictions for economic amortisations leads to poor market adoption and, ultimately, market failure. Nowadays, AF markets in Europe are fragmented, leading to some paradoxes like the importation of a final product being cheaper than buying the local raw material to produce it. The steps of the value chain in which you place certain regulatory requirements and/or incentives influence drastically the market behaviour. Not harmonising the requirements and financial support to AFs in Europe can create some competition between domestic and external biogas production, hindering the future market development (Double Biomethane subsidising)[11]. Interviewed Stakeholders have put emphasis on having a common European approach in order to avoid these conflicts.

> **“Inside one Member state you can find financial incentives for biogas production and feed in the gas grid but no incentives for using it as transportation fuel. I think this is a lack of coordination because different government departments make the policy.** – Fuel suppliers ”

In terms of availability, there is a limited production capacity of fuels coming from renewable sources. This is related to the availability of feedstocks and regulations limiting the production of first-generation biofuels. In this sense, there is a strong market competition between HVO, regular biodiesel and LBM, both as fuel alternatives and for the feedstock. In the case of LNG, the limit is more related to the capacity of the liquefaction plants and the availability and prices of imported supplies.

6. Higher investments and operational costs

Besides some exceptional cases like natural gas (CNG) fuelled vehicles in Italy, most AFs have higher operational costs, with business models relying on subsidies and financial incentives. For this reason, only cheaper and subsidised fuel alternatives that can cut down on operational costs over time are considered as viable substitutes to conventional fuels (e.g. LNG trucks are 30-35% more expensive than their diesel cousins). Additionally, the residual value of diesel trucks

11 Bio surf project D3.2 | Proposal on cross-border biomethane administration

after 2-3 years of use is around 40-50% of the initial price, while for LNG/LPG trucks, the residual value is less than 10%. This represent business expenses that, at the end, need to be covered by the reduction in fuel consumption along these 2-3 years of operation, which in some cases is not sufficient.

> **Limited benefits of biomethane fuel compared to its associated costs. In some Member states it is currently more beneficial to produce electricity from biogas and trade with it.** – OEMs

In the case of biomethane, it can be directly mixed with natural gas, which is an added advantage if natural gas supply infrastructure is already in place. However, bringing biomethane to the refilling stations could be more challenging and expensive, depending on the supply channels used. Having a reliable biomethane grid-injection policy would make supply operations much cheaper where natural gas supply infrastructure is already in place. However, without sufficient AFs refilling infrastructure in place, customers don't buy AFVs, so vehicle manufacturers do not make any manufacturing investments. And the other way around, if there are no (or very few) vehicles available in the market, investing in the related infrastructure is not attractive. Nowadays, in the case of LPG there is more infrastructure available than vehicles that run with this fuel, while for LNG/LBM is the opposite.

> **To overcome the chicken-or-the-egg problem, one of the keys is increasing infrastructure roll-out with financial incentives support. In that way, truck companies start manufacturing or even converting vehicles. If there is no infrastructure, there is no interest in putting on the market gas vehicles.** – Engineering suppliers

Around 90% of fleet operators make the transition towards AFs powered vehicles because of the financial incentives associated, which builds a positive business case for them. However, there is still a bit of social fear regarding the possible rise of Alternative fuel prices due to changes in regulations, which will in turn destroy the projected business models relying on cheaper (incentivised) fuel options.

> **The final consumer is the one who decides which fuel to use. You need to incentivise the final user to buy the fuel and the rest of the market will organise.** – Transportation service providers

End-users of commercial transportation, which are different from fuel consumers (fleet operators) are increasingly putting pressure on their fleet contractors to reduce the total emissions derived from their services. The problem is that they are not directly the fuel consumers, and fleet operators need to pay the extra fuel costs. There are also examples where the transportation end-users are also fleet operators, which makes them care about fuel prices and can result in interesting cases like the one a Spanish public service provider in charge of residual waste-waters and garbage trucks shared with us. They convert the waste resulting from their waste-water treatment into biomethane to fuel their own garbage trucks, resulting in a positive business case for them.

> **We use the biomethane we produce for our own fleet of service trucks, following the principles of self-consumption, circularity of waste and reducing our operation costs (reduction of 7€/100km), the taxations and our carbon footprint.** – Public service provider

7. Environmental concerns

Advanced biofuel research is being pushed in order to play a key role in decarbonising the transport sector, in which HDVs have an impact[12]. The main reasons to move away from current biofuels towards Advanced biofuels is the negative environmental impacts that biofuels, especially those coming from food-crops, can have when considering their full lifecycle emissions (WTW), some of them having even higher Global Warming Potential (GWP) than fossil fuels. Biofuels can potentially create a shift in the environmental burden and create new by-products with significant impacts. Biofuels can decrease the climate change impact that conventional fuels create during the TTW part, but system-wide environmental consequences should be considered. Potential burden shifts could be manifold, however, the ones to consider at first are linked to the agricultural process (land use changes and agricultural intensification, fertilisers, water usage, pesticides...) and the air quality effects of burning the fuel (in terms of PM and NOx emissions) in the engine.

In the case of biomethane, its characterisation shows that the infrared radiative forcing ability of this molecule is up to 25 times stronger than carbon dioxide. This means that potential methane leakages throughout the supply chain and in the engine due to incomplete combustion might lead to an increased impact on climate change compared to conventional fossil fuels.

12 Transport & Environment, Fixing Europe`s clean fuels policy

WAY FORWARD

Raise awareness

In order to convince decision makers to take action and the population of the advantages that each fuel alternative can bring to the overall transportation system, proper information well backed-up with experimental data needs to be transmitted, including the pros and cons of each fuel alternative. In this way, it is most likely that well-informed decisions are taken. Also, education and training programs for end-users and administrations should be put in place.

Set ambitious targets

Initiatives such as fixing targets for the reduction of emissions and incentivising or penalising the use of different fuel alternatives helps accelerate the process and build 'eco-conscious' societies. In Sweden, for example, the government has fixed a 70% GHG emissions reduction target by 2030. To help reach this goal, fossil fuels are charged with CO2 taxes and biofuels like bio-methane are exempt, increasing the economic advantages of using less pollutant fuel alternatives.

Incentives that help stabilise prices of AFs in the market and accelerate investments in Alternative fuels Infrastructure (AFI), while stopping subsidies to the production and import of fossil fuels.

Launch campaigns to facilitate the introduction of AFV and replace old ones. Make use of smart financing mechanisms and business modelling strategies to solve business case challenges of fleet operators, like the price gap between AFV and diesel ones and their lower residual value. Increase the economic support to those companies making huge efforts in reducing their carbon footprint, as a means for accelerating change through rewarding best practices.

Find a common approach to the AFs market

Standardise AFs and related technologies and procedures across Member States to avoid market fragmentation. Having harmonised market rules and political support across all countries will have a positive impact in the AFs market development, especially for HDVs transporting good across different EU countries. Nowadays, the lack of coordination between MS limits the uptake of Alternative fuel solutions.

Promoting cross-border trade will be significantly beneficial to the AFs market. One important step in that direction would be to harmonise, all over Europe, the criteria and requirements of guarantees of origin and voluntary certification schemes applied to AFs. This would allow the bio-methane trade market to flourish, as the European gas grid could be treated as one administrative unit with a unique European registration system. Additionally, two more steps would be necessary to allow cross-border bio-methane trade. The first one would be to modify the mass balancing approach of the RED directive. The second one would be to harmonise the gas quality standards applicable to bio-methane.

All Member States have to follow the directives placed by the Commission, like providing the necessary refuelling infrastructure as stated in the DAFI. Otherwise, a common European approach will not be feasible.

Combine fuel alternatives in a technology neutral way

Replacing conventional fossil fuels for AFs will most likely require a share of different alternatives available in the energy mix. In the case of HDVs transporting goods over long distances across Europe, electric and hydrogen technologies are not feasible yet, while other AFs solutions are. Several stakeholders declared HVO, CNG/LNG and LPG as the most feasible solutions for the short and mid-term. To help define the best policies and associated financial incentives, different aspects need to be considered. These aspects include the adequacy of each Alternative Fuel to each transport mode, the foreseen future availability of each fuel type and the infrastructure required for each fuel option. Feedstock availability, sustainability and economic constraints will also limit the supply potential of each fuel alternative, thus requiring a mix between different AFs. To be able to make well-informed decision, proper information well-backed up with experimental data needs to be transmitted in an open and transparent way.

Using a TTW approach distorts the true view on alternatives. Using WTW CO2 emissions is the most holistic methodology to assess the real environmental impact of different fuel solutions and hence it is an important tool for choosing the best Alternative Fuel for each particular context. In the analysis shown below, which we use as an example, full-cycle emissions (WTW) of different powertrain alternatives – taking C-category vehicles from 2014 as examples – are presented. The WTW analysis includes same type of fuels coming from different sources (as HVO from different feedstocks and electricity produced by different means) to highlight the important differences when comparing CO2 emissions from a full cycle perspective instead of only taking into consideration tailpipe emissions. Among the options with fewer emissions there is biogas from waste (2nd generation), electricity from renewables and HVO.

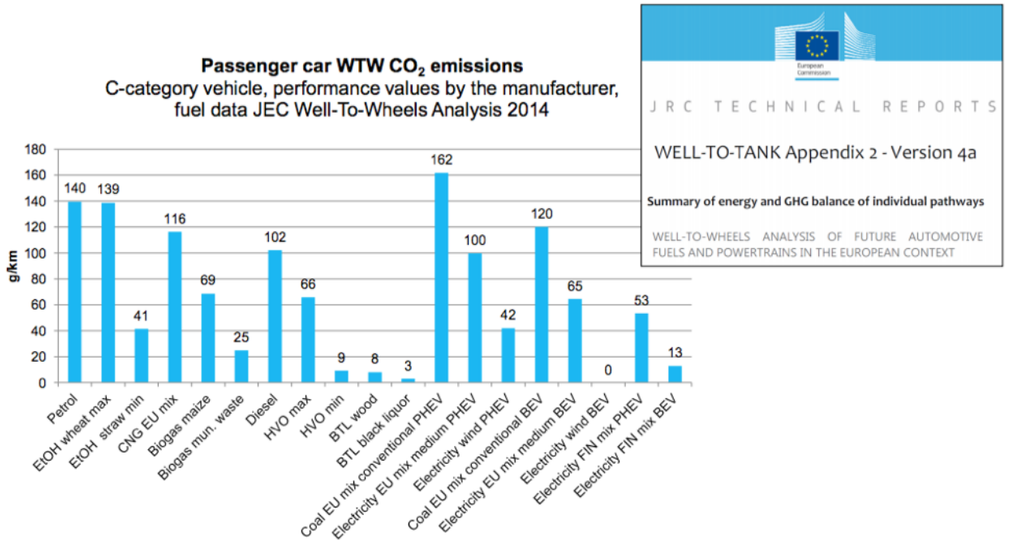

Figure 2. WTW CO2 emissions by passenger car [Source: JRC technical reports]

Improve truck and powertrain design

Besides incorporating AFs, it is important to combine all GHG emissions reduction strategies in the design of new HDVs in order to achieve the required targets recently set by the European Commission. Within these strategies, improving vehicle aerodynamics, lightweighting, ITS for monitoring and mandatory eco-drive mode are of great importance.

Promote the use of already available alternative powertrain technologies and alternative fuels for HDVs to speed-up transport decarbonisation in the short and mid-terms, while maintaining research and development investments in future technologies: Hydrogen, electrification, Advanced biofuels…

Look for pollution mitigation strategies in a holistic way

Achieving proposed GHG reduction targets in transport will not come solely from switching to lower emission fuels and improving truck design, but from leveraging also complementary technologies like (Cooperative)-Intelligent Transport Systems ((C)-ITS) and automation. These technologies offer multiple ways of optimising transport consumption, from increasing vehicle utilisation rates and reducing the total number of Vehicle Kilometres driven, to reduce fuel consumption through automated driving modes, truck platooning and other automation strategies.

Maximise the implementation of alternatives to optimise logistic operations also through the unification of logistic networks and spatial planning strategies, like reducing HDVs flows through urban consolidation centres.

We advise to also consider less conventional approaches like E-roads, road pricing strategies and modal shift from road transport to others like rail and inland waterway barge transport.

Progressive deployment of Alternative Fuel solutions

Where electrification proves not feasible, switching from Diesel to Compressed Natural Gas and Liquified Natural Gas (for heavier trucks and longer routes) and progressively to Advanced biofuels, Bio-Methane, Synthetic gas and, ultimately, Hydrogen. We strongly advise to well-align AFs deployment with infrastructure deployment, taking into account the complementarities that exist between already existing and future necessary infrastructure; bio-methane can be mixed with natural gas and use the same infrastructure, while hydrogen, despite requiring some infrastructure upgrades, could also use the widely available natural gas infrastructure.

CONCLUSION

More than 90% of road transport relies on fossil diesel to run, accounting for almost 20% of the total GHG emissions in Europe. Although many solutions for AFs and powertrain technologies have been identified and suggested, the number of OEMs involved so far is very limited, hindering the mass adoption of these solutions. AFV only represented 3.4% of the European car fleet in 2012 and the use of AFs in HDVs still remains negligible.

In an attempt to tackle this reality, an analysis of the barriers preventing wide adoption of AFs solutions in Europe was conducted. Through in-depth interviews and an online open consultation to Stakeholders, we gathered the latest information on the AFs market, to identify, classify, and discuss the most important barriers.

Our research shows there is no common European support strategy towards AFs, and a clear lack of political and financial support, together with the discontinuity of policies and low economic appeal of Alternative fuel solutions.

Moreover, there are very few refilling stations along the European road networks, largely because of limited availability of brands and models of AFV in the market. On the other hand, existing AFV or AFs stations are hindered by a lack of standards or **standardisation inconsistencies in manufacturing and deployment, fuel quality requirements, interfaces between AFV and filling stations and EU training guidelines for Alternative Fuel drivers.**

Other common barriers include high capital costs and long investment return periods for investing in AFI, limited cost/benefit trade-off of Alternative Fuel solutions perceived by the end-users and low economic viability of biofuel use in transportation.

In order to tackle these main barriers, we have elaborated strategies and recommendations to move forward with the development of the AFs market. They are summarised below:

- More dissemination, training and awareness for public administrations and end-users
- Fix ambitious targets in policy framework, together with long-term incentive schemes to help achieve them
- Find a common European approach to AFs market
- Combine different available fuel alternatives in a technology neutral way
- Improve truck and powertrain design
- Look for pollution mitigation strategies in a holistic way
- Progressive deployment of AF solutions, starting with more mature technologies

Clearly, regulatory and economic barriers are the major factors hampering the potential development of the AFs market. Throughout the consultation, and reflection on the results, one key recommendation was prevalent: **with a strong regulatory framework following clear long-term objectives, supported with financial incentives and a common European approach, we will overcome the remaining barriers.**

For that reason, we have addressed this report to the EC to encourage a thorough assessment of policymaking in Europe. The COLHD team are hopeful that together, we can tackle the main barriers slowing down the development of this high-potential industry.

GLOSSARY

AAFs	Advanced Alternative Fuels
AFI	Alternative Fuels Infrastructure
AFVs	Alternative-Fuelled Vehicles
AFs	Alternative Fuels
CNG	Compressed Natural Gas
SNG	Synthetic Natural Gas
CCP	Climate Change Package
EC	European Commission
EU	European Union
FQD	Fuel Quality Directive
GHG	Greenhouse Gas(es)
GWP	Global Warming Potential
HDVs	Heavy-Duty Vehicles
HVO	Hydrogenated Vegetable Oil
ICE	Internal Combustion Engine
ICEV	Internal Combustion Engine Vehicle
ILUC	Indirect Land Use Change
LDV	Light-Duty Vehicle
LBM	Liquefied Biomethane
LPG	Liquefied Petroleum Gas
LNG	Liquefied Natural Gas
NPF	National Policy Framework
OEMs	Original Equipment Manufacturers
RED	Renewable Energy Directive
SotA	State of the Art
WTW	Well-To-Wheel
TTW	Tank-To-Wheel