

Low Carbon Transport Fuel Policy for Europe Post 2020

How can a post 2020 low carbon transport fuel policy be designed that is effective and addresses the political pitfalls of the pre 2020 policies?

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Executive Summary

Why Decarbonise Transport Fuels?

To meet the EU long-term targets to reduce transport's greenhouse gas (GHG) emissions, action will be needed to reduce the carbon intensity of the fuels consumed, to improve the energy efficiency of transport vehicles and to improve the efficiency of the overall transport system. The EU White Paper for Transport – 'Towards a competitive and resource efficient transport system' (COM(2011)144) seeks to dramatically reduce Europe's dependence on imported oil and sets the goal of cutting carbon emissions in transport by 60% by 2050 (compared to 1990 levels). There is an increasing urgency to focus on decarbonising the EU transport sector. This reflects the reality that, despite policies in place to increase efficiency and reduce GHG emission growth, the transport sector has made limited progress in reducing its GHG emissions and this trend is considered likely to continue post-2020.

The European Commission's Communication on a 2030 framework for climate and energy policies (COM(2014)15) signalled a pull back from existing quantitative targets to deliver change in the composition of transport fuels. The Commission's framework stated that it 'does not think it appropriate to establish new targets for renewable energy or the greenhouse gas intensity of fuels used in the transport sector or any other sub sector after 2020'. However, there have been some subsequent shifts in this stance as a result of Conclusions adopted by the European Council; asking that measures be examined to promote emissions reduction and energy efficiency in transport. Most recently the Commission's Energy Union Package (COM(2015)80) highlighted the need to 'speed up' decarbonisation in transport.

Important elements of the current policy framework¹ have been problematic to implement and controversial in terms of the shifts in technology and behaviour that have occurred, or conversely have failed to materialise. The level of emission savings resulting from the expanded use of conventional biofuels has been widely questioned. However, a lack of emphasis at EU level on reductions of transport fuel GHG emissions and on low carbon alternatives, corresponding to reticence to act by Member States, would arguably lead to stagnation. Were transport fuels to fail to deliver effective GHG emission reductions, the total mitigation effort needed from the transport sector would remain. This implies increased effort from other actors and wider society.

This paper is intended to contribute to the debate on future EU policy on low carbon transport fuels. It aims to provide an analysis of a range of policy tools and mechanisms that could be employed to deliver GHG emission reductions in this field, the strengths, opportunities and limitations they imply, and to explore the need for

¹ As set out by targets in the Renewable Energy Directive (Directive 2009/28/EC) for 10 per cent of energy use in the transport sector to be from renewable sources by 2020; and the Fuel Quality Directive (Directive 2009/30/EC Article 7a) for up to a 10 per cent reduction in the life cycle emissions from fuel and energy supplied to the transport sector by 2020 with a binding element of 6 per cent by 2020.

action and the EU's role within this. It takes as its starting point an analysis of the need to decarbonise transport fuels and promote low carbon alternatives, and the resulting policy priorities and changes in behaviour necessary post 2030. In the period up to 2030 policies will be needed that impact on each of the key fuel and energy sources ie fossil fuels, biofuels, electricity and hydrogen² in line with a vision to 2050.

Promoting Transport Fuel Decarbonisation – Needs and Priorities

In 2005 the European Commission put forward its justification for supporting the regulation of GHG emissions from transport fuels. Arguably these points still stand in 2015; indeed, the need may have been heightened by the lack of progress towards transport decarbonisation and controversy surrounding recent developments in biofuel use. Action to promote the decarbonisation of transport fuels and the uptake of low carbon fuels up to 2030 is, therefore, justified by:

- The **complexity** of the **transport fuel mix within the single market** and increasing choices available in terms of fuel source;
- The potential of new and emerging fuels to either **increase or decrease GHG emissions** with the characteristics of specific supply chains being critical;
- The need to account for the **full environmental impact of transport fuel** use including their GHG emissions, in a consistent and reliable way throughout the EU;
- The need to support **innovation and significant investment in the most environmentally responsible low carbon fuels**, to promote the transformation of the transport system; and
- The **expanding contribution of transport emissions to Europe's GHG footprint and the danger of transport accounting for a disproportionate share of emissions in 2050**.

To develop effective policy it is vital to examine what changes are being sought, in terms of detailed shifts in technology use, and in terms of the behaviour of key actors. A detailed breakdown of needs and priorities is a first step in building coherent policy. To achieve this, the issues set out above were broken down into priorities for low carbon transport policy. These high level priorities were then applied to the key transport fuels available up to 2030. Based on an assessment of the actors involved, the behavioural change considered possible amongst the relevant actors and the role of fuels policy as part of the wider EU policy effort to decarbonise the transport sector, priorities for EU action up to 2030 for fossil fuels, biofuels, electricity and hydrogen were determined. These priorities are summarised below:

- **Fossil fuels** – measures to **support the choice of fuels to ensure that their GHG footprint declines over time or remains static** in line with wider decarbonisation priorities and measures that can help to **promote the availability of information** to inform decision making on appropriate fuel choices based on low carbon concerns;
- **Biofuels** – measures to provide a **clear basis for differentiating between biofuels and the risk** associated with their usage on an ongoing basis; to ensure **measures promoting**

² Both electricity and hydrogen are more accurately described as being an 'energy source' rather than a fuel. However, within the remainder of this report, we use the term 'fuel' for the sake of simplicity in most cases.

biofuel uptake are not applied to high risk biofuels³ ie those that deliver no or limited emission reductions or will result in unacceptably high risks for the broader environment and/or food prices;

- **Electricity** – for the **share of electricity in transport to increase** and for **electricity in the transport sector to be progressively renewable into the future**; this entails measures to support the wider availability of dedicated charging points to actively facilitate the wider penetration of electric vehicles; and measures to support policies aimed at the wider penetration of electric vehicles and their integration with renewable energy sources;
- **Hydrogen** – for the share of **hydrogen used in transport to increase and to be progressively renewable into the future**; measures to support roll out of dedicated fuelling infrastructure as vehicles come online; and measures to support policies aimed at the wider penetration of hydrogen vehicles.

Building Blocks for Future Policy Development

Based on the priorities identified, the behaviour changes needed to deliver these amongst the key actors involved and a review of existing policy instruments in the EU and third countries (in particular the US) for delivering low carbon transport fuels, the analysis identifies a number of lessons and building blocks for policy development. These should be taken into account irrespective of the overall frame of European policies selected up to 2030.

- **Performance based standards** that set an overall emission reduction target for transport fuels are best suited to regulating fairly comparable fuel alternatives. Their ability to function effectively across multiple technologies and energy solutions ie combining fossil fuels, biofuels, electricity and hydrogen can be constrained by limitations in setting consistent performance metrics. Their utility depends on the agreement on comparable, reliable and agreed metrics that are well correlated to real world emission changes and can be applied appropriately to all the fuels and energy sources being regulated.
- **Life Cycle Assessment (LCA)** is a valuable tool for policy making. It can, however, be conceived and designed in different ways for a number of different purposes. Consequently, the choice of LCA approach must be fit for purpose; results delivered through different approaches are often not directly comparable. Care must be taken when determining the LCA basis of future policies to ensure comparability and that the approach and assumptions are as robust as possible. LCA should be used as a tool to inform decision making and can be used within a regulatory framework, but could also be supported/complemented with other analytical frameworks. The parameters modelled with LCA should be 'sense-checked' to ensure relevance to real world conditions and the overarching policy goal ie delivering GHG emission reductions.
- **Driving behavioural and technological change** towards low carbon transport fuel solutions is the ultimate goal of policies discussed in this report. To deliver change efficiently, the policy development process must clearly identify what change is desired, which actions are required by whom and in what combination to achieve that change. It is challenging to deliver the holistic regulation of low carbon transport fuels through a single performance based measure, as the desired behavioural changes, the form of regulatory support needed and the ideal choice of regulated parties vary significantly between fuel types (eg liquid fuels compared to electricity/hydrogen). As a consequence

³ For biofuels risk is predominantly linked to the feedstock material used to produce the fuel ie associated land use and indirect land use change consequences. Moreover, there is a question about the extent to which biofuels are scalable in the long term to enable the efficient replacement of fossil fuels.

targeted and differentiated but co-ordinated interventions with appropriate timescales can be particularly valuable.

- **Determining a clear basis for comparing performance** – The implementation of low carbon transport fuel provisions at EU level (notably under the Fuel Quality Directive) has been marked by political difficulties in agreeing a common, accepted methodology for comparing and defining specific emission values for different fuel pathways. This has been a highly political process exacerbated by the strong role of vested interests. It is important that commitments to achieve the targets set to 2020 on low carbon fuels are met, but also that there is a strong emphasis on reporting and monitoring. This will enable a more informed baseline for future policy making.

Future Policy Design - Differentiating Support for Technologies based on Decarbonisation Potential

Technology neutrality is often stated as a high-level policy principle to be complied with; it is commonly referenced in relation to transport fuel policy. In practice, however, achieving true technology neutrality requires more subtlety than simply applying a single instrument to multiple technologies. In the context of long-term climate goals certain technologies may require differentiated support in the short term to ensure a level playing field in the long term. Aspiring to technology neutrality should not be seen as implying that a one-size-fits-all approach to the whole suite of technologies is appropriate, but rather a policy framework that facilitates and enables the development of a range of appropriate technologies.

In the case of the multiple and varied low carbon transport fuel solutions that will be required, first to 2030 and then on to 2050, different actors, interactions, market responses and measures of performance will be needed to drive and assess decarbonisation. The different nature of the fuels and energy sources that can be encompassed by the heading 'low carbon transport fuel' will require flexible and targeted policy action. Certain goals can be achieved by generic measures that apply to transport fuels and energy as a whole; others require more specific interventions, operate to different time scales and are subject to different market dynamics.

Eight potential policy options for promoting decarbonisation in EU policy post 2020 were assessed in this report – these are set out in section 7 and summarised in table 6 of the report. Several of these mechanisms could be employed to permit differentiation in support to accommodate the different fuel types. They include:

- Three options that would rely on existing EU policy with **no specific new instruments to support low carbon fuels**. This includes an option relying on Member State implementation of existing and already proposed EU policies on climate and energy to deliver action on transport fuels, accompanied by strengthened and mandatory sustainability criteria to promote low risk biofuels and focus Member State financial support on truly low carbon biofuels (option a ii in the assessment);
- Four options considering a **single binding legislative measure at the EU level but designed to permit differentiation of fuels based on their performance**. This includes a possible Regulation that would set binding GHG intensity targets for transport fuels but allow differentiated support to promote emission reductions from fossil fuels, support for biofuels focused only on those that deliver the highest GHG savings, and a flexible mechanism that allows credits or green certificates to promote uptake of low carbon electricity and hydrogen (option e in the assessment); and

- An option that would require **a series of coordinated but disaggregated interventions targeted at specific fuels**, with binding measures at the EU level aimed at delivering specific goals and priorities identified for each of the transport fuel categories over the appropriate time horizon (option g in the assessment).

It is possible to make relatively robust estimates of the behaviour changes needed by the key actors across the different transport fuels to deliver decarbonisation post 2020. This paper examines the policy priorities and legislative options to promote these changes in the EU. Given that 2030 is a relatively short time horizon, particularly in light of comparatively long investment cycles, it would be useful to send clear signals to the key actors in the fossil fuel, biofuel, electricity and hydrogen sectors regarding what is expected of them, and to back this up with incentives and other support mechanisms sensitive to market dynamics. Setting out what individual transport fuel streams and associated actors need to deliver would increase clarity and consequently provide a basis for innovation and uptake of low carbon solutions.

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1 Purpose of this paper

This paper is intended to contribute to debate on future EU action on low carbon transport fuels. It aims to provide an analysis of a range of policy tools and mechanisms that could be employed to deliver action in this field, their strengths and limitations and to explore the need for action and the EU’s role within this. The following analysis is intended to:

- Explore the motivation for low carbon transport policy at the EU level and examine the case for continued action;
- Examine and establish the policy goals future action post 2020 would need to deliver against;
- Improve understanding of both current EU level and alternative approaches to delivering low carbon transport fuels and key lessons from these experiences;
- Explore core policy tools, based on the literature, interviews with experts and experience for delivering effective action on low carbon transport fuels;
- Set out and review the core policy options for future action at EU level in the post 2020 period.

The analysis within this report is based on literature review, interviews with key experts, a workshop with experts (January 2015) and a systematic review of policy objectives, goals, behaviour change and actors. The methodology adopted to analyse, develop and review future policy is set out below. Within this report it was felt critical to fully disaggregate and clearly set out the policy needs before developing future policy solutions. In this way preconceptions around policy tools and policy outcomes are revealed and set aside to enable an effective assessment of the best policy solutions for the future.

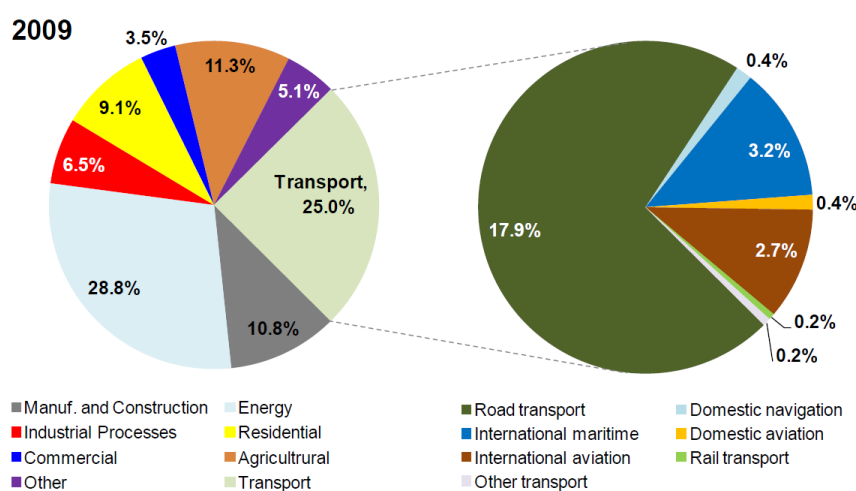
Analytical Need	Assessment Completed	Outcome
To breakdown and identify up to 2030 (and considering 2050 needs) the fundamentals of effective policy making	Review of: <ol style="list-style-type: none"> a. the case for action ie why take action on transport fuel decarbonisation; b. the high level goals and technology specific aims a policy should deliver; c. the behavioural changes required to deliver change; and d. the range of potential policy tools available 	To provide a clear picture of the policy need at EU level post 2020 ie what must policy do? And nature of the associated policy support necessary and possible for different technologies.
To set out and review potential policy options for EU level action	Building on the assessment of need and potential support mechanisms this identifies 8 potential policy options and sub options and reviews their strengths and weaknesses	To present a range of the policy options available post 2020 at EU level, their strengths and limitations to inform and stimulate further debate on policy solutions to deliver low carbon transport fuels

2 Examining the Case for Action – Why is low carbon transport fuel policy needed in the EU?

2.1 Emissions from the Transport Sector

The transport sector accounts for approximately one third of all final energy consumption and has been estimated to contribute to 25% of total CO₂ emissions in the EU.⁴ Most of EU transport emissions come from road transport, followed by international maritime and aviation transport⁵ (See Figure 1).

Figure 1 - EU-27 greenhouse emission by sector and mode of transport, 2009



Source: EEA (2012)

In the context of the overall reduction goal of decreasing greenhouse gas (GHG) emissions of 80 – 95% below 1990 levels by 2050, the EU has put in place a number of initiatives as part of the Europe 2020 strategy, including the *Roadmap for moving into a competitive low carbon economy in 2050*⁶ and the *Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system*.⁷ The former envisages for the transport sector (including international aviation but excluding maritime shipping) a target for 2030 between +20% and -9% and for 2050 between -54% and -67% compared to 1990 levels. The Transport White

⁴ European Commission (2011) Summary of the Impact Assessment accompanying the Communication on A Roadmap for moving to a competitive low carbon economy in 2050. COM(2011) 112 final, 8 March 2011, Brussels. <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011SC0289&from=EN> The calculations are based on the PRIMES model, on the basis of a 2005 baseline, and do not take into account international maritime and international aviation transport emissions.

⁵ EEA (2013) A close look at urban transport. TERM 2013: transport indicators tracking progress towards environmental targets in Europe. EEA Report No. 11/2013, p. 41,

⁶ European Commission (2011) White Paper on A Roadmap for moving to a competitive low carbon economy in 2050. COM(2011) 112 final, 8 March 2011, Brussels.

⁷ European Commission (2011) White Paper on Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. COM(2011) 144 final, 28 March 2011, Brussels

Paper took the midpoint of this range, i.e. a reduction in the sector of at least 60% by 2050 compared to 1990, as the basis of its analysis.⁸

There is an increasing urgency of debate focused on decarbonising the EU transport sector, in particular in the light of the 2030 Climate and Energy policy framework. This reflects that despite considerable success in implementing emissions reduction measures (such as efficiency standards) in the transport sector, overall emissions from the sector as a whole are not being reduced at the rate being delivered in other economic sectors. Transport is also predicted to have the highest growth rates occurring from 2010 to 2030, when compared to other energy-consuming sectors⁹. Between 1990 and 2009 GHG emissions from transport grew by between 27 and 29%,¹⁰ although emissions have begun to decline slightly in recent years¹¹ due to the implementation of environmental policies such as ambitious vehicle efficiency standards¹².

At the EU level, transport makes the largest contribution to emissions covered by the Effort Sharing Decision (ESD¹³), accounting for almost 30% of non-ETS emissions (approximately 877 MtCO₂e). Emissions from the transport sector are projected to differ by less than 1% (-28 Mton CO₂e) from 2005 levels in 2020¹⁴. To achieve a proportionate contribution from the transport sector to the overall ESD emission reduction target, further policies would need to be implemented to reach an abatement equivalent of at least 86 MtCO₂e in 2020¹⁵.

2.2 Low Carbon Fuels

The European transport sector is heavily reliant on oil imports. In 2010, approximately 94% of energy consumed in transport was from oil imported from

⁸European Commission (2011) White Paper Road Map to a Single European Transport Area – Towards a Competitive and Resource Efficient transport System, COM/2011/144 final, Brussels.

⁹ European Commission (2013) EU energy, transport and GHG emissions trends to 2050. Reference scenario 2013, p. 38.

¹⁰ AEA, CE Delft, TEPR and TNO (2012) EU Transport GHG: Routes to 2050 II. Final Report Appendix 10, p. 1.

¹¹ European Commission (2014) EU transport in figures: Statistical pocketbook 2014

¹² Miller and Facanha (2014), The state of clean transport policy: A 2014 synthesis of vehicle and fuel policy developments <http://www.theicct.org/state-of-clean-transport-policy-2014>

¹³ The Effort Sharing Decision (406/2009/EC) establishes binding annual greenhouse gas emission targets for Member States for the period 2013–2020. These targets concern emissions from most sectors not included in the EU Emissions Trading System (EU ETS), such as transport (except aviation and international maritime shipping), buildings, agriculture and waste - <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009D0406&from=EN>

¹⁴ JRC (2011) Contribution of the transport sector to the objective of the Effort Sharing Decision on non-Emission Trading Scheme sectors greenhouse gas emissions, p. 15; Ecofys, Fraunhofer and Alterra (2012) Next phase of the European Climate Change Programme: Analysis of Member States actions to implement the Effort Sharing Decision and options for further community-wide measures. Appendix 1, p. vii.

¹⁵ Ecofys, Fraunhofer and Alterra (2012) Next phase of the European Climate Change Programme: Analysis of Member States actions to implement the Effort Sharing Decision and options for further community-wide measures, Appendix 1, p. vii.

beyond the EU's boundaries, leading to economic and energy security concerns.¹⁶ The focus of this report is on the contribution of alternative, low carbon transport fuels to the decarbonisation of the sector. In so doing, this they may also help allay wider concerns.

Low carbon fuels are defined here as fuels that have lower CO₂ emission lifecycle potentials, when compared to traditional fossil fuels. The principal fuels¹⁷ considered within this definition are liquid biofuels, electricity and hydrogen used in transport.

Biofuels (although varied in their nature and the feedstock used for production) are currently the most important group of alternative fuels employed in the EU transport sector (around 4.2% in 2012)¹⁸. Advanced biofuels, such as those made from ligno-cellulosic biomass, residues, waste and other non-food biomass, may be seen as important alternatives to fossil fuels when considering the long-term decarbonisation of transport.

Electricity and hydrogen supplied from low carbon, renewable energy sources also have the potential to contribute to EU transport fuel needs. The carbon-intensity of electricity and hydrogen production will define the ultimate impact of these decarbonisation pathways. Electricity use also has potential energy infrastructure benefits, if tied to smart meters and home charging that enables their use as a form of electrical, energy store to balance periods where there may be excess supply associated with intermittent energy sources.

2.3 Decarbonising European Transport – The Case for Low Carbon Fuels

There are in essence three high level approaches to reducing the GHG emissions of the transport sector: decarbonising the fuels and energy sources that transport uses; improving the energy efficiency of transport vehicles; and reducing transport demand. A project undertaken for the European Commission that aimed to explore how long-term GHG reduction targets for the transport sector might be achieved, developed various scenarios to explore the sensitivity of long-term targets to GHG reduction across these three broad approaches¹⁹.

A core reduction scenario was developed to meet the 2050 CO₂ reduction target of the European Commission's Transport White Paper (see Figure 2). This aimed to deliver broadly equivalent GHG emissions reductions across all transport modes. It estimated that the GHG budget for transport, i.e. the total GHG emissions that would be allowable in the transport sector, in 2050 was 545 MtCO₂e. In order to develop this core reduction scenario it was necessary to make many assumptions

¹⁶ European Commission (2013) Communication on Clean Power for Transport: A European alternative fuels strategy, COM(2013) 17 final, Brussels.

¹⁷ Both electricity and hydrogen are more accurately described as being an 'energy source' rather than a fuel. However, within the remainder of this report, we use the term 'fuel' for the sake of simplicity in most cases.

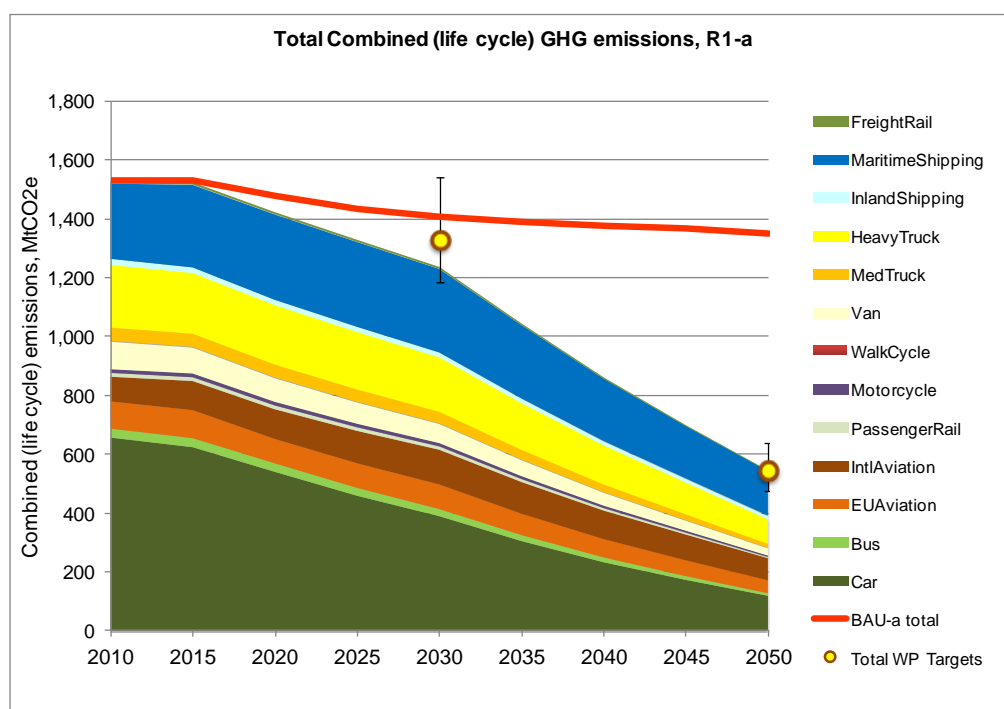
¹⁸ European Commission (2014) EU energy in figures. Statistical pocketbook 2014, p. 113. http://ec.europa.eu/energy/publications/doc/2014_pocketbook.pdf

¹⁹ Ricardo-AEA, TEPR, TNO and CE Delft (2012) « EU Transport GHG: Routes to 2050 II »; see <http://www.eutransportghg2050.eu/cms/reports/>

about the scale of GHG reductions that were necessary. Some of the most relevant assumptions in the context of this report were:

- An 80% reduction in lifecycle GHG emissions compared to 2010 for passenger cars;
- GHG savings from biofuels of 85% by 2050 (compared to 55% for 2010)
- A cap on the use of biofuels at the possible level of sustainable biofuels²⁰;
- A 50% substitution of the remaining conventional, road transport fuels by 2050; and
- A 93% reduction in the carbon intensity of electricity production compared to 1990, which is consistent with the Commission’s 2050 Roadmap.

Figure 2 - Core reduction scenario by mode (total combined (life cycle) GHG emissions)



Source: Ricardo-AEA et al (2012)²¹

- The baseline, i.e. the emissions reductions that would take place without any further policy action, is also shown in

Figure 2 (i.e. the red line).

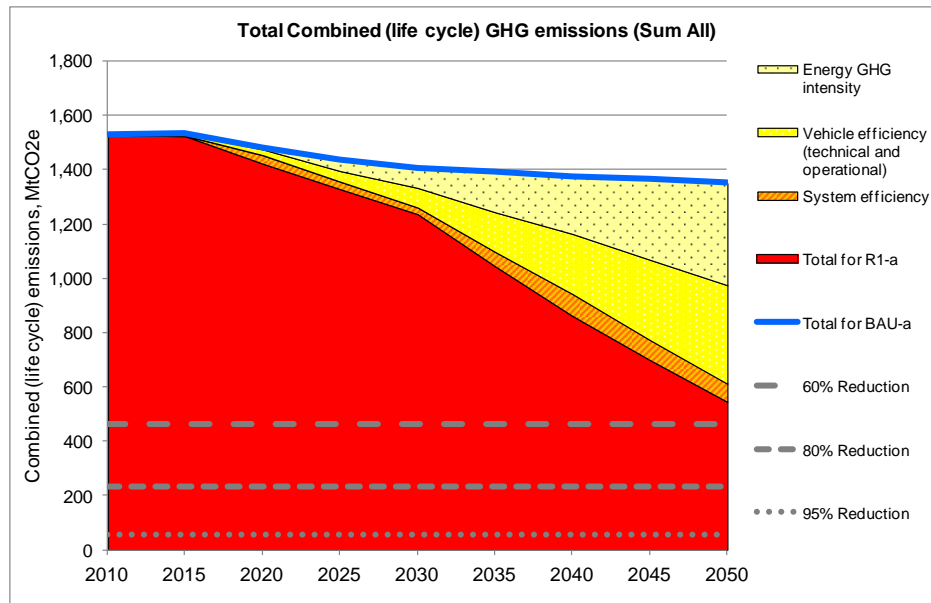
Figure 3 shows where the reductions are needed to reduce GHG emissions from the baseline to a level that is consistent with the White Paper target. As can be seen, improvements in the GHG intensity of the energy supplied to transport and improvements to vehicle efficiency contribute almost all of the necessary reductions and in roughly equal proportions. The fact that relatively lower levels of GHG

²⁰ This was based on the assessment in BIOFRAC (2006) “Biofuels in the European Union - A VISION FOR 2030 AND BEYOND”, Final draft report of the Biofuels Research Advisory Council, March 2006; see http://ec.europa.eu/research/energy/pdf/biofuels_vision_2030_en.pdf

²¹ Ricardo-AEA, TEPR, TNO and CE Delft (2012) “Further development of the SULTAN tool and scenarios for EU transport sector GHG reduction pathways to 2050”, Task 6 paper produced as part of the “EU Transport GHG: Routes to 2050 II » project for the European Commission’s DG Climate Action

emissions reduction were delivered from reduced demand (referred to as ‘system efficiency’) is linked to the consideration that, particularly at the EU level, it is easier to take action to reduce the GHG intensity of energy and to improve the fuel efficiency of vehicles than take action to reduce demand for transport. This core scenario, therefore, demonstrates the importance of improving the GHG intensity of fuels/energy carriers in order to deliver long-term GHG reduction targets.

Figure 3 - Core scenario reduction scenario by means (total combined (life cycle) GHG emissions)



Source: Ricardo-AEA et al (2012)²²

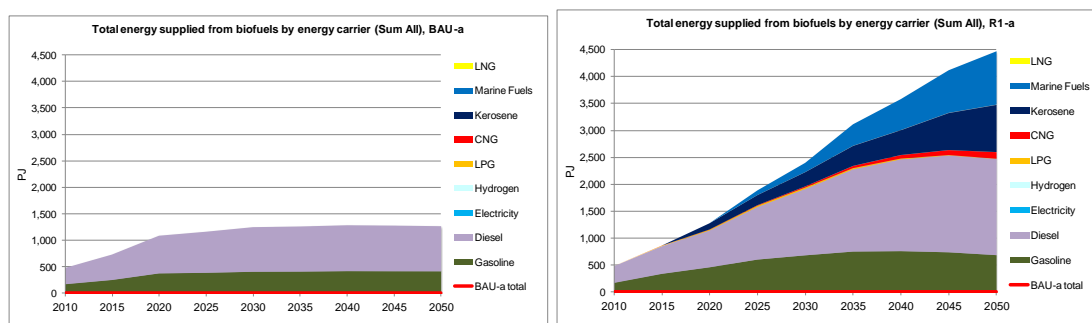
However, there is clearly the risk that it proves not to be possible to either improve efficiency of vehicles to the extent implied above, or, which is of more relevance for report, to improve the GHG intensity of transport’s energy to such levels. As demonstrated in

²² Ricardo-AEA, TEPR, TNO and CE Delft (2012)

- Figure 4, even under the core reduction scenario presented in

Figure 2 there would be an increased use of biofuels by 2050 compared to the baseline. It should be noted that this analysis does not take into account the potential for the GHG intensity of fossil fuels to also increase over time, which would impact on the level of effort needed.

Figure 4 - Biofuel use under, respectively, the baseline and the core reduction scenario (in PJ)



Source: Ricardo-AEA et al (2012)²³

In order to identify the sensitivities around the importance of various options in delivering the GHG reductions anticipated in the core reduction scenario, further scenarios were developed to explore what additional actions would be needed in the event that various options, including biofuels and electricity, did not deliver to the extent anticipated. A scenario was developed in which biofuels and electricity only delivered the following reductions:

- GHG savings from biofuels of 20% by 2050 (compared to 85% in the core reduction scenario); and
- A 65% reduction in the carbon intensity of electricity production by 2050 (compared to 93% in the core reduction scenario).

Under these assumptions, transport's GHG budget of 545 MtCO_{2e} in 2050 would be exceeded by almost 300 MtCO_{2e}. In order to make up for this short-fall, i.e. to keep the budget at 545 MtCO_{2e}, the following additional policy measures would be needed, which were not included in the core reduction scenario:

1. Driver training (road/rail)
2. Speed enforcement for road vehicles
3. Tighter speed limits for road vehicles
4. Further improvements in spatial planning
5. Tighter, new car/van GHG standards (intermediate)
6. Tighter, new truck/bus GHG standards (intermediate)
7. Further modal shift (passenger and freight) (intermediate)
8. Further maritime efficiency measures
9. Further increase in harmonisation of fuel taxes (intermediate)
10. Tighter new vehicle GHG standards for all road vehicles (high)
11. Further improvements of new ship efficiency
12. Further improvements in new aircraft efficiency
13. High levels of modal shift (passenger and freight)
14. Further increase in harmonisation of fuel taxes (high)

As an example of the stringency of the measures required, option 10 – tighter GHG standards for all vehicles – would require a 95% reduction in lifecycle GHG emissions for passenger cars compared to 2010 for passenger cars (compared to the 80% reduction required under the core reduction scenario).

²³ Ricardo-AEA, TEPR, TNO and CE Delft (2012)

Based on the analysis set out here, if the transport energy and fuel sector delivered less reduction in the GHG intensity of the energy supplied to the transport sector, much more would be needed from other sectors. Notably this would apply to vehicle manufacturers, but also to consumers of transport. There would be a need for high levels of modal shift and increases in taxation.

3 Delivering Decarbonisation - the Case for Policy Action

3.1 Legal Requirements up to 2020

There is currently a legislative framework at EU level intended to deliver low carbon transport fuels up to 2020, set in the context of the Transport White Paper's call to reduce emissions by at least 60% by 2050 from the transport sector. Article 7a of the Fuel Quality Directive (FQD) sets out in EU law the requirement to reduce GHG lifecycle emissions from transport fuels²⁴ up to 2020. In so doing it integrated the consideration of the GHG emissions from transport fuel use into existing EU legislation aimed at dealing with wider quality issues and environmental emissions linked to transport fuels. Adopted as an amendment to Directive 98/70/EC, Directive 2009/30/EC requires fuel suppliers, as of 1 January 2011, to report annually their greenhouse gas intensity of fuel and energy supplied. By 31 December 2020 'Member States shall require suppliers' to reduce life cycle greenhouse gas emissions per unit of energy from fuel and energy supplied by up to 10 %'. The binding element of this target is a 6 % reduction by suppliers by 31 December 2020 (with interim targets of 2% by 31 December 2014 and 4% by 31 December 2017); the remaining 4% are termed indicative targets.

Post 2009 the FQD provided the framework for GHG emission reduction from the transport fuel sector, although extensive negotiations have been ongoing to secure supplementary requirements to enable its implementation. In parallel EU transport fuels are also impacted on, up to 2020, by a binding target set within the Renewable Energy Directive (RED – Directive 2009/28/EC) requiring Member States to ensure 'that the share of energy from renewable sources in all forms of transport in 2020 is at least 10 % of the final consumption of energy in transport in that Member State'. While the target within the RED was not explicitly focused on GHG emission reduction, this was the indirect intention through the promotion of alternative renewable technologies. Moreover, the RED contains explicit requirements for GHG emission reductions from biofuels and bioliquids used to meet the targets of the RED, as part of wider sustainability criteria set out in Article 17. Biofuels used to meet the targets should deliver GHG emission savings of at least a 35%, rising to 50% from January 2017.

The current policy framework has been problematic to implement and controversial in terms of the shifts in technology and behaviour delivered. Implementing measures to enable monitoring and reporting, essential to the functioning of the approach and target delivery under the FQD, have been delayed repeatedly due to objections over default carbon intensity values²⁵. Moreover, ongoing debates around the carbon intensity of biofuels and the emissions associated with indirect land use change (ILUC), the use of food based biofuels and wider concerns around resource use and

²⁴ The FQD covers only fuels used in road vehicles, non-road mobile machinery, agricultural and forestry tractors, and recreational craft when not at sea.

²⁵ Implementation of the Fuel Quality Directive, Decarbonizing transport fuels, October 2013, a briefing by T&E and other NGOs http://www.transportenvironment.org/sites/te/files/publications/NGO%20Briefing%20on%20FQD%20and%20tar%20sands_T%26E.pdf

environmental consequences have resulted in mounting pressure to move away from 'volume' based targets²⁶ for renewable transport fuels (as per those set out in the RED).

3.2 Policy Commitments up to 2030

On 22 January 2014, the European Commission set out its vision for EU climate and energy policy up to 2030²⁷, including high level GHG emission reduction targets and EU level binding targets for renewable energy among others²⁸. Within this vision was included the statement that [the Commission] *'does not think it appropriate to establish new targets for renewable energy or the greenhouse gas intensity of fuels used in the transport sector or any other sub sector after 2020'*. Under this vision the current legislative framework of GHG requirements in FQD and RED transport targets would end post 2020. Under this proposal the Commission considers that no further action in the field is deemed necessary with efforts delivered via Member States under the auspices of the higher level GHG emission reduction and renewable energy targets. In addition to the ending of these measures the Commission also stated in its vision that biofuels produced from food-based feedstocks should not receive *'public support'* after 2020. The term *'public support'* is considered to extend beyond explicit subsidies for biofuel uptake to other policy mechanisms. This would potentially include policies promoting ie *'supporting'* their use to meet general EU targets for renewables and national support mechanisms including mandates and obligations.

In their resolution responding to the Commission's Communication Members of the European Parliament stated their *'regret'* at the *'Commission's lack of willingness to ensure the continuation of the Fuel Quality Directive [Article 7a] after 2020'*. They also highlighted the importance of complete carbon accounting and *'stressed'* the FQD's important role in promoting sustainable biofuels in the 2030 framework²⁹.

Heads of State adopted Conclusions on Climate and Energy Action post 2030 in the European Council meeting of the 23 October 2014³⁰. Apparently rejecting the Commission's view of no action on transport fuels post 2020, Heads of State invited *'the Commission to further examine instruments and measures for a comprehensive and technology neutral approach for the promotion of emissions reduction and energy efficiency in transport, for electric transportation and for renewable energy sources in transport also after 2020'*. This would seem to set a basis for discussion on a potential policy approach post 2020; however, the nature of the tools and policies

²⁶ While often referred to as volume based targets the targets in the RED technically refer to a proportion of energy demand.

²⁷ European Commission (2014) A policy framework for climate and energy in the period from 2020 to 2030, COM(2014) 15 final, Brussels, 22.1.2014

²⁸ For a full review of the targets and measures included within the January statement see http://www.ieep.eu/assets/1322/IEEP_Background_Paper_on_2030.pdf

²⁹ European Parliament resolution of 5 February 2014 on a 2030 framework for climate and energy policies (2013/2135(INI)) <http://www.europarl.europa.eu/sides/getDoc.do?type=TA&reference=P7-TA-2014-0094&language=EN&ring=A7-2014-0047>

³⁰ European Council (23 and 24 October 2014) – Conclusions http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/145397.pdf

that might be appropriate is unclear. Within their conclusions the Council opened up the possibility of shifting effort between EU ETS and non EU ETS sectors (that includes the transport sector); this potentially may add to uncertainty as to the role of a future EU measure on transport fuels and what it can seek to deliver.

In response to this Commissioner Cañete indicated in a speech to MEPs³¹ that he would kick off a ‘wider debate on policies for emission reductions in road transport’ focusing on bringing stakeholders together to reflect on what has worked well and what can be improved for the period after 2020. The only guiding principle set out is that of technology neutrality, which in reality can be interpreted in a number of different ways and expressed within policy very differently depending upon the approach deemed most appropriate – see Box 1.

The Commission’s position on the future of policy action to decarbonise the transport sector continues to evolve. On the 25 February 2015 the Commission presented its Energy Union Package³², offering a somewhat changed stance on support for alternative fuels. The Package highlights the need to take further action to ‘*speed up*’ decarbonisation the transport sector and the need to transform the entire transport system as well as increase development and deployment of alternative fuels. Key themes in the ‘Package’ include bolstering energy efficiency in the transport sector and the importance of electrification of the transport sector. Specifically it states that the ‘*Commission will take further action to create the right market conditions for an increased deployment of alternative fuels and to further promote procurement of clean vehicles. This will be delivered through a mix of national, regional and local measures, supported by the EU*’. Moreover, it is also stated that the new Renewable Energy Package (to be brought forward in 2016-2017) will include a new policy for sustainable biomass and biofuels. Although this falls short of explicitly supporting the continuation of the FQD post 2020 per se, it opens up the possibility of continued EU action to promote low carbon transport fuels.

³¹ European Commission RAPID Article, European Union: a Global Leader in Climate Action – Speech of Commissioner Miguel Arias Cañete before the ENVI committee of the European Parliament, November 11 2014

³² European Commission, 25.2.2015 (COM(2015)80 – Energy Union Package - Communication from the Commission - A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy http://ec.europa.eu/priorities/energy-union/docs/energyunion_en.pdf

Box 1- The concept of 'technology neutral' policy action

While policies often claim to be technologically neutral, the term is often not well defined. Work for the Commission, has sought to better understand this in practice³³. At the most basic level, the analysis noted that the term meant that legislation does not specify the technology that should be used, e.g. to meet a target. However, even if this is the case, the detail of legislation can mean that it implicitly (if not explicitly) favours a technology over alternatives. Hence, the report identified a number of different perspectives as to what might be meant by technological neutrality. A legislative measure might be considered to be technology neutral if:

- There are many technologies that can be used to meet a given target, but that the different routes would not necessarily have similar costs;
- There are many technologies that can be used to meet a given target and that these routes would incur similar costs;
- There are feasible shares of different technologies that can be used to meet a given target; and
- Different technologies are incentivised in proportion to the potential contribution that each technology might have to meeting the overall objective.

In the context of legislation that incentivises low carbon transport fuels, it would need to be considered which (if any) of these definitions might be appropriate.

3.3 The Historic Case for Decarbonising Transport Fuels In Europe

The desire to take action in this field was first officially expressed in the Commission's Communication on alternative motor fuels, COM(2001)547, where the *'possibility and desirability of promoting different alternatives to conventional transport fuels'* was discussed. One of the main reasons for an interest in alternative fuels at that time was *'if their use results in lower life-cycle greenhouse gas emissions'*. As a consequence the Commission proposed the Directive on biofuels in transport, adopted as Directive 2003/30, and action to de-tax biofuels to enable them to be 'price competitive'.

The concept of GHG emission reduction targets within the FQD³⁴ was, however, originally developed as a clear concept in a Commission non-paper for discussion as part of a wider review of the FQD in 2005 – Commission non-paper 14 on carbon content of fuel. Within the non-paper it was highlighted that neither of the measures adopted in in 2003 *'distinguishes between fuels on the basis of their greenhouse gas impacts... This means that the full potential of alternative fuels to avoid transport*

³³ TNO et al (2013) *Analysis of the influence of metrics for future CO₂ legislation for Light Duty Vehicles on deployment of technologies and GHG abatement costs*, report for the European Commission's DG Climate Action (Service Request 8 under framework contract ENV.C.3/FRA/2009/004324)

³⁴ The Fuel Quality Directive is a long-standing piece of EU legislation to ensure the quality, and regulate the content of, transport fuels. It bans the use of lead in petrol and also ensured that the proportion of sulphur allowed in petrol and diesel has been progressively lowered.

greenhouse gas emissions is not being met'. The original goal of the amendment to the FQD on GHG emissions was, therefore, to fill both gaps in the coverage of the existing FQD regarding impacts on the environment of transport fuels and in the existing policy framework regarding associated GHG emissions linked to promoting alternative fuels.

By the time (January 2007) of the publication of the full impact assessment for the proposed amendment to the FQD, the argumentation had evolved to take into account that the transport fuels market was evolving and that both promoting alternatives that might deliver GHG emission reductions and avoiding alternatives that deliver increases in emissions were key. Additionally, it was noted that there was a need to drive innovation to put production of biofuels and hydrogen on a lower GHG trajectory, and to promote evolution of lower carbon alternatives, particularly 2nd generation biofuels. In parallel in January 2007 the Commission issued the renewable energy roadmap (COM(2006)848), which called for '*legally binding minimum targets for biofuels.... fixed at 10% of overall consumption of petrol and diesel in transport*'. By January 2008 this had morphed into a proposed 10% target for renewable transport fuels by 2020 accompanied by proposed environmental sustainability criteria, later adopted in the RED.

When originally developed the concept of inclusion of lifecycle GHG emissions in the FQD would have served the dual purpose of extending the remit of the European Union to limit environmental harm associated with transport fuels and filling a policy void. By the time the FQD Article 7a was formally adopted, by the Council and Parliament, it was operating in a completely different policy space, alongside a renewable transport fuel target that contained requirements on the GHG emissions associated with certain alternative fuels.

The impact assessment that justifies the inclusion of GHG lifecycle emission reductions in the FQD sets out its justification based on three premise:

- that other *polluting emissions from transport fuels are controlled under FQD but previously not CO₂* – the remit of the original Directive was 'This Directive sets technical specifications on health and environmental grounds for fuels to be used for vehicles equipped with positive-ignition and compression-ignition engines';
- that the then *biofuel Directive was in place to promote adoption based on indicative targets but that this did not take into account LCGHG emissions of fuel and the need to deliver GHG savings*; and
- that *the fuel base for transport is increasingly complex* with potential novel sources of fossil fuels, additional technologies including biofuels, hydrogen etc with very different GHG trajectories and that a mechanism was needed to promote adoption of lower GHG alternatives.

Options analysed were BAU (although it should be noted that this would differ from the proposed BAU post 2030 as the Biofuel Directive indicative targets would have been in place). Alternatives assessed were a voluntary approach, mandatory requirements or taxation-based approaches. It should be noted that the legal nature

of the mandatory approach was not discussed ie Directive or Regulation. It was concluded, however, that a mandatory approach was needed as a *'Threat of effective sanctions is needed to ensure action taken and the polluter pays'*. The IA concluded that a mandatory reduction target linked to life cycle GHG savings would respond to a number of goals established by the Commission in particular:

- delivering innovation in the sector
- encouraging the development and commercialisation of 2nd generation biofuels
- delivering and promoting GHG emission reduction within biofuel policy
- improving the implementation and effectiveness of existing policies in particular the then biofuels Directive

'The analysis shows that there could be significant benefit from requiring the reporting of life cycle Greenhouse Gas emissions for road transport fuels. However, real Greenhouse Gas reductions can only be assured if the reporting is associated with a mandatory requirement to reduce the emissions. Therefore a mandatory reduction obligation should be introduced after a trial period of operation of the reporting obligation' IA for the Amendment of the FQD to take into account GHG emissions'.

3.4 The Current Policy Situation – the successes and limitations imposed by the existing policy framework

In response to the dual adoption of the FQD GHG emission reduction targets and the parallel renewable energy target for the transport sector set out in the RED, it has been the RED target that has primarily driven action between 2009 and the present. This action has largely driven the expansion in the use of conventional biofuels ie those from sugar, starch and vegetable oils produced using conventional crops.

Implementation of the FQD has been slow partly because some core implementing measures on the carbon intensity of fossil fuels were only agreed in 2014, delayed due to intensive lobbying and divisions over the consideration of tar sands and other unconventional fuels. There have also been ongoing concerns about the indirect land use change consequences of expansion in the use of particularly crop based and/or land based biofuels. This has raised questions as to the emission reduction potential of key biofuel sources.

The majority of Member States have yet to implement the FQD, meaning that the mechanisms for determining and monitoring fuel supplier compliance are not in place. Prior to the definition of the FQD target, the baseline against which achievement should be measured, GHG values for fossil fuels and the reporting system to underpin this were not established. In part FQD Article 7a sought to address this by requiring suppliers to report annually on the greenhouse gas intensity of fuel and energy supplied within each Member State as of 1 January 2011. In theory this would allow for a period of data collection to inform delivery of the target; however, as set out above discussions on the fossil fuels' carbon intensity values have delayed the FQD implementation. Not only does this mean fuel suppliers

are not currently delivering against requirements, it also means that the data on which to base assessments of the relevance of the target into the future remains unavailable.

The overlap with the RED has in some ways undermined the FQD approach. Member States have largely been focused on delivering the RED target. The FQD target states that 'Member States should require fuel suppliers' to deliver the targets and report against a stated timeframe. Arguably the wording, by shifting focus from Member State to fuel supplier, may be seen as less empowering to the Member States than the RED. In contrast the RED very strongly highlights the Member State as the only entity responsible for target delivery³⁵. Despite both the RED and the FQD being Directives, legally binding and the Commission empowered to undertake sanctions in the event of a failure to deliver against requirements; there has been a focus on RED implementation rather than FQD. This has been compounded by the lack of binding trajectory and the absence of implementing measures for implementing the FQD target. As a consequence, Member States are able to point to renewable energy mandates as their chosen policy mechanism to deliver carbon savings. The overlap in terms of the technologies potentially pursued means that this can look compelling despite not taking account of the full range of behavioral changes envisaged by the carbon intensity focus of the FQD target. To date, only Germany has an implemented alternative fuel policy that directly regulates the carbon intensity of fuels.

A further challenge of the FQD is that it speaks to multiple different technologies, fuel suppliers and actors with a wider range of potential activities when compared to the RED. As such it provides little clarity for Member States as to how they might differentiate between the scale of action required by different actors or technologies. While overlap between complementary policy mechanisms does not necessarily lead to redundancy, and arguably the RED and FQD are compatible, the variable emphasis on targets, the role of Member States and delays in FQD implementation have resulted in FQD requirements being less of a focus and implementation deprioritised. This may change in the next few years, however, as the 2020 deadline approaches.

3.5 A Case for Action up to 2030?

As set out in section 2, there is very much still an emission reduction case for addressing the carbon intensity of transport fuels. This is relevant given the wider need to decarbonise the sector as a priority and that failure to improve fuel performance will lead to higher costs, effort and potential impacts on non-fuel actors ie vehicle manufacturers and end users.

The Commission's post 2020 commitment to remove carbon reduction requirement of the FQD and renewable transport fuel targets post 2020, results in arguably a greater policy void to fill than when GHG emissions were first proposed to be

³⁵ The RED target for the use of renewable energy in transport is phrased as follows - Each Member State shall ensure that the share of energy from renewable sources in all forms of transport in 2020 is at least 10 % of the final consumption of energy in transport in that Member State (Article 3, Paragraph 4).

included in the FQD back in 2005. While the Commission statements on a post 2020 policy framework leave the door open for advanced biofuel support, electrification and hydrogen they are silent on what mechanisms might be used to provide this support - in the absence of either carbon reduction or renewable energy targets. It is unclear whether these decisions will be deferred entirely to Member States (the Member State role will be stronger than in the 2020 period), whether the Commission will place binding restrictions on support for food-based biofuels (echoing existing distinctions as set out in State Aid Rules³⁶) or whether the Commission will in fact bring forward alternative proposals. Despite the Commission's 2030 package suggesting an end to the existing action on transport fuels, the IA supporting the 2030 package specifically highlighted that 'present policies are insufficient to deliver necessary reductions of 80-95% in 2050'. Moreover, comments by the Council and within the Communication on the Energy Union would suggest the need for a continued focus on transport fuel decarbonisation.

There remains a strong case for policy intervention at the EU level post 2030 given: the emission trajectories envisaged without transport fuel emission reductions up to 2030 and 2050; the emergence and use of fossil fuel sources with high GHG emission profiles; the continuing challenges associated with the delivery of robust and verifiable emission reductions from biofuels; and the continued need to develop low carbon alternatives to fossil fuels, in the form of electricity and hydrogen. The following list would seem to summarise the need for intervention going forward:

- The **complexity** of the **transport fuel mix within the single market** and increasing choices available in terms of fuel source;
- The potential of new and emerging fuels to either **increase or decrease GHG emissions** with the characteristics of specific supply chains being critical;
- The need to account for the **full environmental impact of transport fuel** use including their GHG emissions, in a consistent and reliable way throughout the EU; The need to support **innovation and significant investment in the most environmentally responsible low carbon fuels**, to promote the transformation of the transport system; and
- The **expanding contribution of transport emissions to Europe's GHG footprint and the danger of transport accounting for a disproportionate share of emissions in 2050.**

³⁶ Communication from the Commission, 28.6.2014 - Guidelines on State aid for environmental protection and energy 2014-2020, 2014/C 200/01, [http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0628\(01\)&from=EN](http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0628(01)&from=EN) - Paragraph 112 of the guidelines states that the 'Commission will consider investment aid in new and existing capacity for food-based biofuel not to be justified. However, investment aid to convert food-based biofuel plants into advanced biofuel plants is allowed to cover the costs of such conversion. Other than in this particular case, investment aid to biofuels can only be granted in favour of advanced biofuels'.

4 Policy Priorities – what should future action deliver?

4.1 High Level Policy Aims

Identifying clearly what objectives a policy is intended to deliver against is fundamental to understand which policy options and policy solutions will be most appropriate. The following represent the high level aims and principles that a future low carbon transport policy should seek to deliver against. Based on these requirements it is then possible to draw down and interpret these for the different technologies and pathways to inform how best to shape policy, the most appropriate instruments and how to determine what policy must achieve. The following list of high level policy aims were identified and developed based on those set out in the FQD, RED, Passenger Car CO₂ Regulation, the 2030 climate and energy package and complimentary Council Positions, the Transport White Paper and in discussion with experts interviewed as part of this analysis.

Proposed High Level Policy Aims for the post 2020 period:

1. Deliver **real world GHG emission reductions** taking into account all lifecycle emissions, by:
 - Increasing low (and zero) carbon fuels/energy sources
 - Reducing the carbon intensity of existing fossil fuels
2. Deliver **innovation and transformation** in the transport fuels/energy sectors, in line with decarbonisation goals, by providing clarity and policy certainty
3. Deliver **cost effective GHG emission reductions** by limiting inefficiencies
4. **Ensure coherence with, and if possible, a positive contribution towards other EU policy goals and targets** including:
 - Other policies targeting transport's CO₂ emissions
 - Biodiversity targets and objectives, including ecosystem services
 - Air quality targets
 - Social policies, e.g. impact on food markets and development goals
5. **Contribute to a secure, competitive and sustainable fuel/energy supply sector** by:
 - Attracting investment in low carbon fuel/energy technologies and infrastructure
 - Supporting the market uptake of these technologies

4.2 Translating Aims into Actions for Policy Delivery

To develop policy that meets the high level aims set out above it is necessary to understand how desired the changes can be achieved across the different low carbon transport fuel technologies and fuel types. The role of and type of actors that are able to deliver policy outcomes must also be taken into account, including their ability to engage with the policy process and determine the outcomes needed to deliver transformation in the transport fuel sector.

The following tables start to map out, based on more detailed analysis set out in Annex 1, the actions that would be needed to shift behaviour across the key transport fuel alternatives. These tables specifically focus on delivering against the high level aim of 'real world life cycle emission reduction'. They also aim to set out

the key actors and behavioural changes over which EU level fuels policy has the ability to most directly influence. The opportunities highlighted in blue within each technology table are identified as the most important to take forward within the development of a future fuels policy. In essence they highlight the priority needs that low carbon transport fuels policy is likely to be able to address for each technology. It is recognised that action is needed elsewhere to support some of the goals set out, but that these are not necessarily appropriate to deliver through fuels based policy.

Table 1 – Liquid Fossil Fuels – understanding how GHG reduction aims flow into potential actions and needs to inform future low carbon fuels policy³⁷. (Text highlighted in blue within the table indicates actions most likely to be possible to address in EU level low carbon transport fuels policy).

GHG Reduction Aims	Action Needed	Key Behavioural Changes needed	Issues/Opportunities for Fuels Policy
Ensure that liquid fossil fuels life cycle GHG emission trajectory per unit fuel is downwards	Reduce emissions associated with extraction and processing of fossil fuels	<ul style="list-style-type: none"> - Oil companies and refiners to develop and use fuel extraction and processing methods that reduce GHG emissions - Importers and fuel stations to supply fuels with lower associated GHG emissions 	<ul style="list-style-type: none"> - Refineries in Europe are covered by EU measures intended to deliver emission reductions (EU ETS and Industrial Emissions Directive) outside of fuels policy. - Oil companies often operate beyond the EU jurisdiction but there may be a possibility of rewarding project based efforts to improve performance, but this would require an effective monitoring and verification network
	To increase the usage of lower carbon fossil fuels in Europe and limit the use of higher carbon fossil fuel alternatives	<ul style="list-style-type: none"> - Oil companies to focus their resources on exploiting lower carbon fuels - Refiners to make use of feedstocks that have the lowest GHG ratings and in the most efficient processes possible - Importers of refined fuels and fuel stations to source the fuels based on the GHG rating 	<ul style="list-style-type: none"> - Lack of consistent and clear information on chain of custody at present may hamper the ability of importers and end users to understand the sources of feedstocks and their relative GHG consequences. While data may exist it is not necessarily available in the public domain to enable comparisons of performance of different oils. - Promoting use of lower GHG fuels by refiners and importers will likely involve fuels based policy intervention and the development of a measurement system that allows the comparison of different fossil fuels against a baseline
To reduce the demand for liquid fossil fuels and replace them in the market place with low or zero carbon alternatives	Increase the efficiency of liquid fossil fuel use in the EU	Action by vehicle suppliers to provide more efficient vehicles and users to modify driver behaviour and infrastructure such as car sharing	Taken forward by non fuel based instruments at the EU level ie vehicle performance standards
	Increase the use of low or zero carbon biofuels as a substitute for fossil fuels blended into the fuel mix	See table 2 below for discussions on the needs for biofuels	
	Promote the use of alternative low carbon energy solutions ie roll out of electricity/hydrogen	See tables 3 and 4 below for discussions	

³⁷ A similar table could be developed for gaseous fossil fuels – see Annex 1 – but is not included here, as it would be very similar.

Table 2 – Liquid Biofuels - understanding how GHG reduction aims flow into potential actions and needs to inform future low carbon fuels policy. (Text highlighted in blue within the table indicates actions most likely to be possible to address in EU level low carbon transport fuels policy).

GHG Reduction Aims	Action Needed	Key Behavioural Changes needed	Issues/Opportunities for Fuels Policy
<p>Ensure biofuels receiving policy support in Europe deliver genuine life cycle GHG savings</p>	<p>Lowering the GHG emissions associated with production of biofuel feedstocks and processing into fuels</p>	<ul style="list-style-type: none"> - Cultivators of crop based biofuel feedstocks manage production and land use questions in a way that ensures that GHG savings occur - Biofuel producers to source feedstocks and feedstocks produced in ways associated with low (or zero) GHG emissions (taking account of indirect effects). This would include the sustainable use of appropriate waste and residue materials - Biofuel producers operate and develop methods for reducing the GHG emissions associated with feedstock to fuel conversion - Fuel suppliers and importers to source fuels with lower associated GHG emissions 	<ul style="list-style-type: none"> - Feedstocks are often sourced from outside the EU's jurisdiction - To ensure delivery biofuel producers, fuel suppliers and importers require: a system of measurement as a basis to determine what the lowest GHG emission routes and feedstocks are; to assess GHG savings; and a robust chain of custody. - Incentives/policy support should recognise the range of life cycle GHG emissions that can be delivered by biofuels and support the sourcing of the best solutions/lowest risk solutions and promote best practice in the supply chain.
<p>Ensure that the emission profile of biofuels improves over time ie that biofuels that deliver the greatest life cycle GHG savings are promoted</p>	<p>Promoting innovation and adoption of biofuel feedstocks and technologies that progressively increase GHG savings to deliver low or zero GHG biofuels</p>	<ul style="list-style-type: none"> - Biofuel producers to invest in technological processes that offer the greatest GHG LC savings, taking into account emissions associated with the feedstocks production, collection and the biofuel production process - Fuel suppliers and importers to preferentially source the lowest carbon biofuels 	<ul style="list-style-type: none"> - Biofuel producers, suppliers and importers need a clear system of measurement and basis to determine what the lowest GHG emission routes and feedstocks should be - Incentives/policy support should focus on ensuring that the biofuels with the lowest GHG emission potentials are prioritised to avoid the diversion of investment into suboptimal or higher risk biofuels. This may include actions to support collection of for example certain wastes and residues

Table 3 – Electricity as a Transport Fuel - understanding how GHG reduction aims flow into potential actions and needs to inform future low carbon fuels policy (Text highlighted in blue within the table indicates actions most likely to be possible to address in EU level low carbon transport fuels policy).

GHG Reduction Aims	Action Needed	Key Behavioural Changes needed	Issues/Opportunities for Fuels Policy
Promoting the uptake of zero carbon electricity as an energy source for the transport sector	Decarbonising electricity generation	Electricity producers need to progressively decrease the carbon intensity of their electricity generation with the ultimate aim of generating all electricity from zero carbon fuels/energy sources	<p>It is unlikely that fuel policy targeting the electricity used in transport would provide a sufficient incentive to decarbonise electricity production more generally. This would need to occur as a part of the wider prioritisation of decarbonisation in the power sector(s).</p> <p>Systematically planning to deliver from low carbon and renewable resources into the future should provide clarity and support wider decisions on energy supply, investment and strategy.</p>
	Increasing the use of zero emission electricity in the transport sector	<ul style="list-style-type: none"> - Actual or potential owners of dedicated, transport electricity-charging points need to expand the network facilities available - Actual or potential owners of dedicated, transport electricity-charging points should supply electricity that has been generated from zero emission sources - Owners of electric vehicles should use zero carbon electricity when charging their vehicles, e.g. at home - Vehicle purchasers need to buy increased numbers of EVs or PHEVs - Manufacturers need to supply increased numbers of EVs or PHEVs suited to consumers requirements at sufficiently attractive prices. 	<ul style="list-style-type: none"> - Support for infrastructure investment is important but is also dealt with in other elements of EU policy. However, additional incentives from fuels policies may provide complimentary support for this. - Owners of dedicated transport electricity-charging infrastructure are in a good position to choose from where they buy their electricity - Owners of electric vehicles can choose to charge their vehicles using zero carbon electricity, but such behaviour would only be indirectly affected by EU fuel policy - Vehicle purchase is the target behaviour for drivers; however, there are more direct (and effective) means of encouraging the purchase of such vehicles than fuels policy (e.g. vehicle taxation, subsidies) - Fuel policy is an indirect way of encouraging manufacturers to supply more EVs and PHEVs. Other EU policy targeting manufacturers directly – especially CO₂ standards for cars and other vehicles - is more important in this respect

Table 4 – Hydrogen as a Transport Fuel - understanding how GHG reduction aims flow into potential actions and needs to inform future low carbon fuels policy (Text highlighted in blue within the table indicates actions most likely to be possible to address in EU level low carbon transport fuels policy).

GHG Reduction Aims	Action Needed	Key Behavioural Changes needed	Issues/Opportunities for Fuels Policy
<p>Promoting the uptake of zero carbon hydrogen as a energy source for the transport sector</p>	<p>Decarbonising hydrogen production</p>	<p>- Hydrogen producers need to progressively decrease the carbon intensity of their hydrogen generation with the ultimate aim of producing all hydrogen from zero carbon fuels/energy sources</p>	<p>It is unlikely that fuel policy targeting the hydrogen used in transport would provide a sufficient incentive for hydrogen production more generally. Clarifying that only Hydrogen from low carbon sources would be acceptable for use in the transport sector into the long term would help provide greater certainty when developing investments.</p>
	<p>Increasing the use of zero emission hydrogen in the transport sector</p>	<p>- Owners of dedicated, transport hydrogen filling stations should supply hydrogen that has been generated from or zero emission sources - Vehicle purchasers need to buy (and manufacturers need to supply) increased numbers of FCEVs</p>	<p>- Owners of dedicated transport hydrogen filling infrastructure are in a good position to choose from where they buy their hydrogen - Vehicle purchase is the target behaviour, not vehicle use; there are more direct means of encouraging the purchase of such vehicles than fuels policy, such as CO₂ standards for cars and other vehicles</p>

Table 5 – A summary of the priorities and needs from low carbon transport fuel policy for the key low carbon fuel sources identified in tables 1 – 4 to deliver real world emission reductions post 2020

Fuel/Energy Source	Priority/Aim	Key Issues for EU Fuels Policy
Fossil Fuels	Ensure that liquid fossil fuels life cycle GHG emission trajectory per unit fuel is downwards or static	<ul style="list-style-type: none"> - Oil companies often operate beyond the EU jurisdiction but there may be a possibility of rewarding project based efforts to improve performance. This would require an effective monitoring and verification network - Lack of information on chain of custody and limitations to public data availability at present may hamper the ability of importers and end users to understand the carbon footprint of feedstocks. - Promoting use of lower GHG fuels by refiners will likely involve fuels based policy intervention and the development of a metric that allows the comparison of different fossil fuels against a baseline
	To reduce the demand for liquid fossil fuels and replace them in the market place with low or zero carbon alternatives	<ul style="list-style-type: none"> - Promote the uptake of alternative liquid fuels or energy sources by fuel suppliers and vehicle users
Biofuels	Ensure biofuels receiving policy support in Europe deliver genuine life cycle GHG savings	<ul style="list-style-type: none"> - Biofuel producers, suppliers and importers need a clear metric and basis to determine the lowest GHG emission routes and feedstocks. - Incentives/policy support should focus on ensuring that the biofuels with the lowest GHG emission potentials are prioritised to avoid the diversion of investment towards suboptimal or higher risk biofuels
	Ensure that the emission profile of biofuels improves over time ie that biofuels that deliver the greatest life cycle GHG savings are promoted	<ul style="list-style-type: none"> - Biofuel producers, suppliers and importers need a clear metric and basis to determine what the lowest GHG emission routes and feedstocks. - Incentives/policy support should focus on ensuring that the biofuels with the lowest GHG emission potentials are prioritised to avoid the diversion of investment into suboptimal or higher risk biofuels
Electricity	Promote the uptake of low carbon electricity as a energy source for the transport sector	<ul style="list-style-type: none"> - Noting the aspiration to deliver from low carbon and renewable resources into the future may provide clarity and support wider decisions on energy sourcing. - Support for infrastructure investment is important but is also dealt with in other elements of EU policy. However, additional incentives from fuels policies may provide complimentary support. - Owners of dedicated transport electricity-charging infrastructure are in a good position to choose from where they buy their electricity
Hydrogen	Promote the uptake of low carbon hydrogen as a energy source for the transport sector	<ul style="list-style-type: none"> - Clarifying that only Hydrogen from low carbon sources would be acceptable for use in the transport sector into the long term may help provide greater certainty when developing investments. - Owners of dedicated transport hydrogen filling infrastructure are in a good position to choose from where they buy their hydrogen

5 Learning the Lessons from Alternative Policy Action

5.1 Alternative Policy Approaches to Transitioning Transport Fuels towards Low Carbon – An Introduction

Globally, there are a variety of different types of policy instruments and policy frames that are applied in an attempt to promote low carbon alternative transport fuels. This section provides an introduction to certain key policies in order to inform understanding and provide context for later discussions within the report. Policies operating to deliver low carbon transport fuels essentially fall within the three categories set out below.

1. **Mandated targets for market adoption** – where a minimum amount of renewable fuel to be used in the transport sector is specified. This can be based on either the volume of fuel to be supplied or the amount of energy to be provided. Historically in Europe there were mandates that did not impose performance expectations; however, these have been overtaken by hybrid policies as a consequence of wider concerns regarding the need to demonstrate tangible savings and environmental protection largely linked to the evolution of the debate on biofuels.
2. **Hybrid policies** – these are essentially mandates that set targets for market adoption, most commonly of renewable transport fuels (often taken as short hand for biofuels, renewable electricity and renewable hydrogen), but in so doing also impose performance expectations ie fuels used to comply with the target have to meet minimum GHG savings/environmental compliance standards and/or different thresholds of performance to qualify for additional support. This implies a mechanism for determining compliance with the performance standards and measuring GHG savings. Policies covered in this section relevant to this category include: the RED, RTFO and RFS.
3. **Performance-based standards** – often referred to as ‘low carbon fuel standards’ or technology neutral approaches, these set a target for a carbon intensity reduction in transport fuels. The technologies to be used to deliver compliance, however, are not necessarily specified meaning in theory a whole suite of emission reduction approaches can be applied to transport fuels to deliver reductions. This implies a robust mechanism for determining the relative and comparable performance, in terms of GHG emission reduction, of all the different types of compliance activities that might be employed to meet the standard. Policies covered in this section relevant to this category include: FQD and LCFS.

Both performance based standards and mandated targets can operate as fixed requirements or be subject to flexible mechanisms to allow the trading of credits to facilitate compliance with the target (the RTFO, RFS and LCFS operate credit trading to enable the regulated parties to comply with the targets by purchasing credits from other producers or selling credits if they have an excess of supply). Delivering robust hybrid policies and performance-based standards implies reliable measurement systems to ensure that GHG savings are delivered. In performance-based standards, where multiple compliance pathways may be permitted and need

to be compared, selecting the appropriate system of comparable measurement is of significant importance to enable different compliance approaches to be promoted equitably.

5.2 Key Mechanisms in Place to Support Low Carbon Transition in Transport Fuels

5.2.1 European Policies – EU and National Level Action

At the EU level there are two very different legislative measures in place that seek to promote alternative transport fuels: the Fuel Quality Directive, Article 7a; and the Renewable Energy Directive. They seek to achieve a shift in transport fuel use by: setting a performance based standard to deliver a target for the reduction of the carbon intensity of all transport fuels placed on the market by fuel suppliers of at least 6 per cent by 2020 (FQD); and separately via a mandated requirement setting the level of energy to be delivered ie 10 per cent of energy from transport fuels to be renewable by 2020 (RED)³⁸. Biofuels used under both targets must deliver against certain environmental and GHG saving parameters. This represents two different policy design models operational at the EU level, which deliver different outcomes and potentially promote transformation of the transport fuel sector but along different pathways.

Within Europe at the national level there are policy tools that are also used to promote a shift in transport fuel use towards alternatives, and simultaneously deliver the against the EU targets. For example, the Renewable Transport Fuel Obligation (RTFO – see box 2) requires fuel suppliers in the UK to demonstrate that biofuel (in compliance with the environmental and GHG sustainability criteria set out at EU level) has been supplied to cover a set proportion of overall transport fuel. Compliance is demonstrated via redeeming Renewable Transport Fuel Certificates (RTFCs). While there are other obligation/mandate based models operating in EU Member States, the RTFO is of particular interest as it operates a flexible mechanism. This allows RTFC's to be traded between suppliers to demonstrate compliance and additionally suppliers are offered the opportunity to buy-out of their obligation, ie paying a set buy-out price for every litre of biofuel for which they have not redeemed an RTFC.

³⁸ Following the agreement of the Council and the Parliament on proposed changes to the RED to better take into account concerns regarding Indirect Land Use Change associated with biofuel and bioliquid use, there are in essence subtargets and caps under the 10 per cent target relating the use of particular biofuels – limiting use of conventional and land based biofuel feedstock's and promoting alternative sources primarily from wastes and residues.

Box 2 – Renewable Transport Fuel Obligation (RTFO)³⁹

The RTFO requires that a certain percentage of fuel is renewable. The scheme started in 2008 and was amended in 2011 to implement mandatory sustainability criteria for the biofuels supplied.

The RTFO operates with tradable certificates. These are called Renewable Transport Fuel Certificates (RTFCs) and are awarded to suppliers of sustainable biofuel. In order to receive the certificates the supplier must provide information which demonstrates their fuel meets the sustainability requirements. They must also have this data and the evidence supporting it independently verified. One RTFC is issued per litre of liquid biofuel derived from crop based feedstocks. Biofuels produced from waste material and certain other sources have an increased incentive of 2 RTFCs per litre. This is intended to reflect the lower risk that these materials will cause undesirable impacts such as indirect land use change.

The RTFO operates on an annual basis starting each year on 15 April. Each supplier of fuel to the UK market is required to demonstrate that biofuel has been supplied to cover a set proportion of their overall fuel supply. For the 2013-14 year, this proportion was 4.75%. Suppliers can meet this obligation by redeeming certificates that they have received for their own biofuel supply, or by redeeming certificates that they have bought from other suppliers of biofuel.

Suppliers also have the option to buy-out of their obligation, paying 30 pence per litre of biofuel for which they have not redeemed an RTFC. This is intended to protect consumers from excessive increases in fuel prices by setting a maximum value for RTFCs. Any money received from suppliers buying out is distributed between suppliers who have redeemed RTFCs and those who have chosen to surrender additional RTFCs for this purpose. Fuel suppliers can meet up to 25% of their obligation with certificates issued in the previous year. This reduces the impact of unexpected events and provides some protection against year to year volatility of fuel prices.

5.2.2 Policy Development in the USA – Federal and State led

Policies to promote the use of low carbon transport fuels and renewable transport fuels are also in operation, and under development, in countries beyond the EU. Some key policy innovations have been occurring in the USA, where the most developed and long standing policies are: the Renewable Fuel Standard (RFS), in operation at the federal level; and the Low Carbon Fuel Standard (LCFS), in operation in the state of California.

The Renewable Fuel Standard (RFS)^{40 41 42}

³⁹ Renewable Transport Fuel Obligation, Annual Report 2013-14, March 2015 - https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/415132/cm-9026_accessible.pdf

The RFS was established in the Energy Policy Act of 2005 (EPAAct) and significantly expanded in the Energy Independence and Security Act of 2007 (EISA). The RFS requires the use of renewable biofuels in transportation fuel. It applies to producers and importers of gasoline and diesel in the USA; however, it does not regulate petroleum-based fuels. It sets out to mandate the use of 36 billion gallons of renewable fuel by 2022.

Nested inside this overall mandate there are sub-mandates (sometimes referred to as ‘carve-outs’), requiring that certain volumes of the overall mandate are delivered by advanced biofuels; and within the advanced biofuels sub-mandate further sub-mandates for biomass based diesel and cellulosic fuels. For each of these categories certain characteristics and GHG savings must be delivered – as set out below. The volume of fuel within each mandate is determined on an annual basis by the EPA, and progressively the goal is to steadily increase the overall volume and proportion of fuels delivered under the advanced and cellulosic mandates, with 21 billion gallons of the 36 billion delivered in 2022 delivered by advanced biofuels.

- **Cellulosic biofuel:** renewable fuel obtained from cellulose, hemicellulose and lignin that decreases life cycle GHG emission by 60% as compared to gasoline and diesel
- **Biomass-based diesel:** biodiesel, non-ester renewable diesel and other diesel derived from biomass. Biomass-based diesel must reduce life cycle GHG emissions by at least 50%
- **Advanced biofuel:** renewable fuel other than corn ethanol that reduces life cycle GHG emissions by 50% as compared to gasoline or diesel
- **Other renewable fuels:** renewable fuels in a motor vehicle that reduce the quantity of fossil fuel used in a fuel mixture used to drive a vehicle (e.g. conventional ethanol). These are required to meet a 20% reduction in life cycle GHG emissions

To determine whether a biofuel can qualify as a renewable fuel and in what category, the carbon intensity of that biofuel is compared with the carbon intensity of baseline gasoline or diesel. Lifecycle analysis was used to specify the carbon intensity with emissions with ILUC taken into account within the methodology. In addition to the fuel specific criteria, obligated parties also have to demonstrate that the feedstock used for biofuel production is renewable and grown in cleared or cultivated lands that were either fallow or actively managed prior to the enactment of EISA.

The RFS is a market compliance scheme with obligated parties (generally refiners and/or terminal operators) required to submit credits, known as Renewable Identification Numbers (RINs), to cover their obligations. A RIN is attached to each gallon of renewable fuel under the RFS and they can be traded to ensure obligated

⁴⁰ Analysis of Renewable Identification Numbers (RINs) in the Renewable Fuel Standard (RFS), Congressional Research Service, July 22, 2013 - <http://www.fas.org/sgp/crs/misc/R42824.pdf>

⁴¹ <http://www.epa.gov/oms/fuels/renewablefuels/>

⁴² Cellulosic Biofuel Standard Guidance, Issued by the Office of Air and Radiation, Office of Transportation and Air Quality, EPA, March 2015 - <http://www.epa.gov/otaq/fuels/renewablefuels/documents/420b15027.pdf>

parties have sufficient quantities to surrender. It should be noted that the nested nature of the mandates means that RINs for the fuels that fall into the different categories trade at different prices. This is because, for example, a cellulosic RIN can be used to comply with the cellulosic mandate, the advanced biofuel mandate and the overall mandate. In contrast, for example, a RIN for conventional ethanol can only be used to comply with the overall renewable fuel mandate. There is generally considered to, therefore, be a hierarchy of price signals associated with the RINs ie cellulosic, biodiesel, advanced biofuels, other renewable transport fuels.

During implementation of the scheme there have been challenges associated with setting appropriate levels for the different mandates, in particular over ambition in terms of ability to deliver cellulosic fuels. As a result the 'cellulosic waiver credit' applies. Rather than delivering compliance with the cellulosic mandate through RIN purchase, obligated parties can buy cellulosic waivers and retire these – the level of waiver availability is determined by the EPA based on the difference between the volume of cellulosic biofuel required by the statute books and the volume anticipated to be produced in a given year. There have also been concerns regarding speculation on the RIN market pushing up prices for compliance.

The Low Carbon Fuel Standard (LCFS) - California

The LCFS is a performance-based system, requiring regulated parties – fuel producers and importers to California – to reduce the carbon intensity of their fuel mix by at least 10% in 2020, relative to 2010 levels. The standard requires progressive reductions of the carbon intensity (CI) of California's transportation fuel mix below CI baselines established for conventional gasoline and diesel fuels sold in California. Based on life cycle emissions (ie the sum of GHG emissions connected to the production, transportation and deployment of transport fuels – this is based on both direct emissions from CA-GREET model and indirect emissions from GTAP modeling) a 'carbon intensity score' is applied to each type of transportation fuel. The regulated party is required to ensure that the overall CI score for its fuel pool meets the annual CI target for a given year.

The LCFS does not emphasise volume of fuel placed on the market but rather it requires that the overall CI of fuels used for transportation decrease by a certain percentage each year compared to the baseline. Thus, the prescribed CI for a given year can be achieved by using a combination of fuel blends, alternative fuels, and credits. A regulated party's fuel pool can include gasoline, diesel, and their blendstocks (eg bio-based fuels) and substitutes (eg hydrogen or liquified gas). Unlike the RFS, the LCFS does regulate petroleum-based fuels.

The LCFS is conceived as a market based mechanism where by, depending on the CI rating of a fuel, a credit or debit is generated. A fuel that has a CI that is below the target in a given compliance period generates credits (1 credit is equivalent to 1 metric ton (MT) of CO₂e reduction below the annual LCFS standard); conversely, a fuel with a CI above the target will generate a deficit. For a given annual compliance

period⁴³, a regulated party's overall credit balance is determined by adding up all the quarterly deficits and credits applicable to that party. If an overall negative balance results at the end of the year, the shortfall needs to be reconciled. Reconciliation can be accomplished by purchasing credits from the market or surrendering credits that the regulated party already has in hand.

The LCFS Regulation⁴⁴ sets out the coverage of the LCFS, the national carbon intensity baselines, annual targets for emission reduction to 2020 and the respective carbon intensity score for relevant fuels (participants can choose to use these default values or pursue customised pathways with CARB). The Regulation covers low carbon fuels including biofuels (conventional ethanol, biodiesel and cellulosic bioethanol), natural gas, LPG, hydrogen and electricity. The LCFS specifically exempts a number of lower carbon fuels deemed to meet the carbon intensity target though to 2020 including electricity and hydrogen. However, providers of these fuels can opt into the LCFS programme and become regulated parties. In so doing they are able to access credits from the LCFS market for the fuels they supply and hence generate financing to support investment in transportation uses of these fuels.

The LCFS is overseen by the California Environmental Protection Agency's Air Resources Board (CARB). CARB has been the agency involved in developing, overseeing compliance and trading under the LCFS Regulation. According to CARB, mid-west corn ethanol is projected as the major fuel in the early part of the program with cellulosic and advanced renewable fuels dominating in the latter part of the program. Hydrogen and electricity use (in alternative fuel vehicles, plug-in hybrid electric vehicles, and battery-electric vehicles) is expected to increase gradually.

⁴³ Regulated parties (fuel producers and importers) must meet the overall carbon intensity target in a given year, with progress assessed in quarterly reports plus an annual compliance report.

⁴⁴ The LCFS was introduced by the California Assembly Bill AB 32, as part of the Global Warming Solutions Act of 2006. The system contributes to the overall GHG emission reduction goals under the Global Warming Solution Act. The Governor's Executive Order S-01-07 initiates the requirement to develop the LCFS to deliver a 10 per cent reduction in GHG emissions by 2020 in California's transport fuels and empowered the Californian Air Resources Board (CARB) to work with University of California, the California Energy Commission and other state agencies to develop and propose a draft compliance schedule to meet the 2020 target. Subsequently the LCFS Regulation was adopted as part of the Californian Code of Regulations.

6 Elements of an EU low carbon transport fuels policy framework

It is important to reiterate that the ultimate aim of any EU policy framework on low carbon transport fuels and energy sources is to deliver real-world reductions in the GHG emissions associated with the fuels and energy sources used by transport. EU legislation to reduce the GHG emissions from the combustion of fossil fuels is, however, already in place for cars and vans (i.e. the passenger car and van CO₂ Regulations⁴⁵), and further improvements to these Regulations are the most appropriate, efficient and effective means of delivering improvements in vehicle efficiency and in increasing the supply of electric and hydrogen vehicles. Consequently, the aim of any EU policy framework on low carbon transport fuels should be:

To reduce the net global GHG emissions associated with the production, processing and distribution of the fuels and energy sources used in the transport sector in the EU in line with the long-term objectives of EU climate policy.

The implications of this for various potential elements of an EU policy framework on low carbon transport fuels are discussed in this section. Within this section the core fundamentals of any regulatory framework are discussed ie the basis for target setting including who would be the regulated party, the development of effective measurement tools and the role of Life Cycle Assessment within this, and the implications for monitoring, reporting and verification systems. This analysis draws on Section 4, which set out the actions that a potential EU low carbon transport fuels policy framework should deliver, and Section 5 that provided an overview of relevant experience elsewhere in the world. Section 6.1 identifies the most appropriate actions that such a policy framework should aim to incentivise and the implications of this for the target setting. This section also draws on experience from other relevant policy instruments to identify how frequently targets might be set.

Section 6.2 explores more detailed issues that will inform the levels of such targets, as well as the details of the policy framework, that need to be considered in order to ensure that the ultimate aim of the policy framework, as noted above, is delivered. This includes a discussion of the potential beneficial role of LCA, along with associated challenges and the implications of these for a low carbon transport fuels policy framework. Section 6.3 concludes the section with some observations on the implications for monitoring, reporting, verification and enforcement. Lessons and best practice messages in terms of approaches to their use and integration into EU law are in many ways separate to the wider more politicised debate on the best policy mechanism or instrument at EU level – this is the focus of section 7.

⁴⁵ Regulation 443/2009, amended by Regulation 333/2014 sets out emission performance standards for new passenger cars as part of the community's integrated approach to reduce carbon dioxide emissions from light duty vehicles; sets targets for emission reductions for cars up to 2020 however the Regulation contains no incentives to decarbonise transport fuels but is successfully promoting more efficient, hybrid, electric and hydrogen based vehicles.

6.1 Target Setting to Deliver Emission Reductions

This section covers generic issues of relevance to the setting of the targets, i.e. who are the most appropriate regulated entity, the most appropriate metric for the targets and some lessons that might be drawn from other relevant policy instruments.

6.1.1 Identifying the regulated entities

In order to identify how targets might be set, and what other elements might be necessary for an EU policy framework on low carbon transport fuels, it is important to consider the roles of the relevant actors, and particularly the behaviour that the policy framework might change. On the basis of an assessment of the potential behaviours or roles of the various stakeholders that such a policy framework might want to encourage (see Annex 1 and summary in Section 5), the most appropriate appear to be the following, set out by fuel/energy source:

- **Liquid fossil fuels:**
 - Upstream oil producers decisions relating to which new oil sources they invest in, and how they extract oil.
 - Refiners' decisions relating to the choice of the crude oil that they buy.
 - Refiners' choices with respect to how they refine the oil, either in the EU or (for imported refined product) in other regions.
 - Importers and fuel stations to supply fuels with lower associated GHG emissions
- **Biofuels:**
 - Cultivators of biofuel feedstocks, as these can choose which feedstocks they grow and/or producers of biofuels feedstock in the context of wastes and residues.
 - Biofuel producers, as they can choose which feedstocks to buy and how they process these.
 - Biofuel blenders, as they can chose which biofuels to buy.
 - Biofuel suppliers, as they can choose to supply fossil fuels with high biofuel blends.
- **Electricity:** Owners of dedicated transport electricity charging points, as they can choose how to source their electricity.
- **Hydrogen:** Owners of hydrogen filling infrastructure, as they can choose how to source their hydrogen.

It is worth noting that in all cases, the identified behaviour would be undertaken by the entity that supplies the fuel to the transport sector. However, the entities are different in terms of their position on the supply chain. For the fuels that are not currently used extensively in the transport sector, and so for which there already exist suppliers to the wider economy, ie gas, electricity and hydrogen, the identified behaviour would be undertaken by the entity that effectively diverts the fuel to the transport sector. This is because, for these fuels, the transport sector would be one among several sectors using the fuel and also that the fuel would be supplied in the same specifications for use in the transport sector as in other sectors. For liquid

fossil fuels on the other hand, two of the identified behaviours are at the refinery level, which is again where oil is transformed into a fuel to be used mainly by the transport sector, but is further upstream in the production process. The other behaviour mentioned – ie upstream oil producers decisions relating to which new oil sources they invest in, and how they extract oil – will only be indirectly affected by any low carbon transport fuels policy, but is a behaviour that it is important to influence.

For biofuels, it is more complicated, and so more entities would be targeted for behavioural change. This is because biofuels can be diverted for use in the transport sector in different ways. Biofuels can be either supplied directly to the users of dedicated biofuels vehicles, or most commonly blended into fossil fuels further upstream. Moreover, the range of ‘cultivators’ or ‘producers’ of biofuel feedstocks is increasing as investment expands in the advanced biofuel sector to include wastes, residues and other ligno cellulosic material. Similarly, in line with the approach for liquid fossil fuels, the ultimate behaviour that has to be influenced, ie cultivators’ choices around feedstock production, will only be indirectly affected by any low carbon transport fuels policy, although the signal is likely to be stronger for biofuels than for liquid fossil fuels, as it is EU policy that drives the market for biofuels in the EU transport sector.

Any legislative framework that aims to improve the carbon performance of fuels will have indirect impacts on suppliers of gas, electricity and hydrogen, as it will affect the amount of these fuels used in the transport sector. However, clearly this will also depend on the presence on the market of vehicles that are able to use these fuels and energy sources, which highlights once more the importance of other legislation, such as the passenger car CO₂ Regulation, to ensure that manufacturers develop and supply such vehicles to the market. Currently, as transport uses a relatively small amount of such fuels, low carbon transport fuels legislation is probably not the most direct or the most effective way to improve the carbon performance of these fuels. For liquid fossil fuels and for biofuels, a low carbon transport fuels policy could have a more significant, but still indirect, impact on upstream oil producers and biofuel feedstock producers. A low carbon transport fuels policy framework could also be used to encourage the purchase of, for example, electric vehicles, hydrogen vehicles and dedicated biofuel vehicles, eg by enabling purchasers to benefit from the value of any credits produced. However, there is already existing EU action in the form of the passenger car and van CO₂ Regulations to improve the fuel efficiency of light duty road vehicles, which is encouraging the development and purchase of such vehicles. Furthermore, other measures, such as vehicle taxation, can also more directly influence vehicle purchase decisions than would a low carbon transport fuels policy. Hence, it needs to be remembered that any future EU-level low carbon transport fuels policy does not have to – and indeed should not – attempt to decarbonise the transport sector on its own; different policies will be more appropriate for targeting fuels, vehicles and vehicle use.

As the actors listed above are those whose behaviour the policy would aim to influence, it would make sense – at least in the first instance – to consider the above

to be the potential 'regulated entity' within any policy framework, ie those to which targets or any linked credits for positive action might be attributed. Of course, the format of the policy, e.g. a target, standard or credit, and the associated details, will also influence the choice of regulated party.

6.1.2 The most appropriate metric for the target(s)

On the basis of the discussion in the previous section, it appears that potential GHG reduction targets might relate to:

- **Liquid fossil fuels:** Average GHG emissions associated with extraction and transport of crude oil, and the production of transport fuels.
- **Biofuels:** Average GHG emissions associated with the biofuels produced (including the direct and indirect emissions associated with the cultivation of the feedstocks), blended and supplied.
- **Electricity:** Average GHG emissions associated with the electricity sold to the transport sector at dedicated transport electricity charging points.
- **Hydrogen:** Average GHG emissions associated with the hydrogen sold to the transport sector at dedicated transport hydrogen filling stations.

The above list might be considered a preferred approach of differentiating between the sub-elements, actors and fuels that together form the basis around which low carbon fuel policy should be delivered. An implication of the analysis of the different possible behaviours and actions needed by the different actors relevant to the different fuels is the emerging perception that emission reduction could be best promoted by using a suite of differently focused targets to collectively provide a policy designed to clearly and effectively bring down emissions across the different fuel sectors and actors. If the LCFS is analysed in detail it is clearly possible to see differentiation in the approach to the different fuels and actors to deliver the overarching goals (see section 5).

There is a challenge, however, with respect to how best identify equivalent targets across the various fuels and energy sources. This is at least partially due to the fact that the challenges that are faced with respect to decarbonising the different fuels vary, as do the ultimate objectives. For example, there is a limit to the extent that liquid and fossil fuels can be decarbonised (without biofuels); indeed the risk is that the carbon intensity of liquid fossil fuels increases as a result of the use of more higher GHG intensity oil feedstocks, such as oil sands and heavier crudes. Hence, the focus of policy on liquid fossil fuels might be to prevent the carbon intensity of such fuels increasing. For biofuels, policy needs to ensure that the right type of biofuels are used, ie those that deliver GHG emissions reductions (taking account of indirect impacts), so some types of biofuel should be discouraged, while others should be encouraged. In the longer-term, both electricity and hydrogen need to be zero carbon, but in the short-term this is not possible, particularly for electricity. Hence, having a zero, or even a low, carbon requirement for these two energy sources in the short-term might disincentivise the development of the respective technologies. In the short-term, therefore, it might be appropriate to encourage the use of such fuels, even if they are not currently sufficiently low carbon.

A low carbon transport fuels policy would need to recognise such diversity and put in place the appropriate incentives or requirements. Such complexity might suggest that the most appropriate approach is a differentiated one that differs by fuel. This, of course, raises questions as to the extent to which such a differentiated system could respect the principle of technological neutrality. Technological neutrality is still considered to be an important underlying principle of the EU's GHG reduction policy in the transport sector, as noted in the most recent conclusions on climate policy for 2030 from the European Council. However, this statement itself demonstrates the inherent challenges with a technologically neutral approach, as it calls for such an approach while simultaneously calling for more electricity and more renewable energy sources to be used in transport post 2020 (see Section 2).

Furthermore, as a result of the effects of carbon leakage, a nominally technology neutral system may in fact be very much biased towards certain technology solutions – specifically, towards any apparent emission reduction opportunity that is most subject to leakage. Hence, achieving true technology neutrality will require either that the full consequences of each fuel choice are captured (which may be analytically difficult and uncertain, as noted above) or that the emissions savings apparently delivered by different options should be differently valued. That is to say that the only way to make policy [relatively] technology neutral in reality may be to make it technology biased in form (see box 1, section 3.2 for more details). Of course, applying this sort of market correction by 'picking winners' requires that a policy maker has a good sense of the relative leakage likely in different pathways, which brings the methodological challenges back to the fore.

Arguably the most important consideration with respect to technology neutrality is that policy should not require the regulated parties to implement expensive technologies to achieve the stated objective where there are cheaper options for achieving the same target. Hence, policy should enable industry to choose the most cost-effective approach from their perspective to achieve the aims of the policy. However, this assessment of cost-effectiveness can only be robust if the tools used to compare options are equally robust.

6.1.3 Lessons from other relevant policy instruments

In the US, it is worth noting that some of the low carbon transport fuel policies have **regular, e.g. annual, targets**, which decline year-on-year as set out at the start of the scheme. Declining, annual targets have benefits over a single target for the end of a longer period as they require consistent progress and enable the regulator to intervene earlier in the event that requirements are not being met. In addition, where credits are linked to annual targets, these provide incentives for early action and also financially support low carbon fuel suppliers, for which cash flow can be a problem. Effectively, anything that delays the issuance of credits and the opportunity to sell credits will weaken the investment signal. Ideally, credits should be awarded promptly, and obligated parties should have reasons to buy relatively early in the year. Such annual targets are also important if a scheme is to have a trading element (see below).

It is interesting to note in this respect that the passenger car CO₂ Regulation also effectively has annual targets. While the targets are effectively set for 2012 and 2020⁴⁶, the target for 2012 applies from 2012 through to 2019, and the target for 2020 applies from 2020 onwards. Hence, the Regulation has annual targets – it is just that these do not decline between 2012 and 2019.

Box 3 – Selection of legislative measure, adopting a Directive or a Regulation?

There are three types of legally binding Community ‘legislation’ set out in Article 288 of the Treaty on the Functioning of the European Union⁴⁷: Regulation; Directive; and Decision. In the context of this analysis the most relevant are the Regulation and Directive options. At present GHG emission reductions are contained within the Fuel Quality Directive, but action in the related field of performance standards for CO₂ emissions for passenger cars is set out in a Regulation.

A **Regulation** is a directly applicable law and is mostly used for rather precise purposes. They are increasingly used to set binding performance standards for products on the EU market place. A Regulation also creates the possibility for creating a penalty structure that applies at EU level, rather than at the national level. A **Directive** is binding as to the results to be achieved, but leaves to the Member States the choice of form and methods, which means that it has to be transposed in national legislation. It is therefore the most appropriate instrument for more general purposes; particularly where some flexibility is required to accommodate existing national procedures, or where progress depends to some extent on national infrastructure choices. For this reason, it is the instrument most commonly used for environmental matters⁴⁸.

In terms of future action on low carbon transport fuels, the question is whether requirements best sit within a Directive⁴⁹ (whether this be a new measure or the existing fuel quality Directive framework that predates the GHG emission reduction requirements) or within a new Regulation. One of the current limitations of the Directive approach is that it in essence requires action of fuel suppliers, but has to do so in a roundabout way stating that ‘Member States require fuel suppliers to reduce lifecycle GHG emissions’. However, there is a lack of clarity on what policy options are potentially open to Member States to drive the necessary behaviour change. Moreover, most suppliers span multiple Member States.

Setting out requirements within a Regulation (assuming requirements are clear and transparent) into the future could have the benefit of being directly binding on the fuel suppliers, more akin to a product based standard ie requiring a certain compliance with GHG emission targets of the products placed on the EU market place. Larger fuel suppliers may benefit given that they would only need to deal with one system, rather than multiple interpretations of approach. It would also reduce administrative burden on member states. However, the variation in the nature of the fuel suppliers active in low carbon transport fuels means that for some, engagement may be challenging ie fuel suppliers for electricity and hydrogen would be those actually delivering the fuel to the end users and are likely to be smaller scale operators.

⁴⁶ Although, as a result of the details of the Regulation, they do not come fully into force until 2015 and 2021, respectively.

⁴⁷ <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:12012E/TXT&from=en>

⁴⁸ Manual of European Environmental Law, Chapter 1.9 – Environmental Policy Making, IEEP, 2012 - <http://www.ieep.eu/publications/2014/10/chapter-1-policy-framework>

⁴⁹ Directive 2009/30/EC amends Directive 98/70/EC

There are other elements that might be included within a policy framework that might be used to improve its flexibility and cost-effectiveness. The first of these is **credit trading**, where a credit relates to an over-achievement (and a debit for under-achievement) of a target, standard or mandate. Credit trading introduces flexibility into the system, as it requires that the industry as a whole meets the requirements of the legislation, rather than each company. This is considered to be more cost-effective, as it allows the regulated industry, with the support of the market, to meet the legislative requirement in the most cost-effective manner, rather than having the policy framework exclusively impose the respective targets for different regulated entities.

The inclusion of trading, however, does make a system more complex and so less easy to communicate to a wider audience. Additionally, the increased complexity – particularly in relation to compliance – makes the scheme more challenging and time-consuming from an administrative perspective. The approach in California and British Columbia is administratively intense, and require independence and consistency. In these systems, the engagement with stakeholders is high. As an organisation, CARB has the independence to make the necessary quick decisions (eg to update carbon intensity values) for the purpose of the LCFS, and is also able to provide a consistent message. These issues might be more challenging in the European context, as a result of the role of the Commission, the different DGs within it, and the various national administrations that would need to be involved.

The trading of credits is part of various low carbon fuel schemes around the world – both those that have a volumetric mandate and those that have a low carbon fuel standard. In a volumetric mandate without trading, every supplier would be obligated to supply at least a certain physical volume of biofuel (essentially a blend mandate). Shifting to a system of crediting gives suppliers more flexibility in the way they comply with the regulation, allowing some to over-comply in terms of physical volume and others to under-comply. In a system without credits, the price of the fuel itself should move to reflect its value as a compliance option under a policy. With credits, the value of compliance should in principle be reflected by the value of the credit, and the value of the fuel itself can reflect the underlying energy value. This provides a clearer indication to potential market entrants of the value of a unit of compliance, rather than requiring them to unpick the value of compliance from the value of the fuel. Credit trading also provides comparable value signals across different fuels and other compliance options. Under a system such as the FQD that allows divergent compliance options ie you can use very different technologies and methods to deliver your emission reductions, a credit trading system would allow a carbon price to be transmitted across different markets.

One challenge for systems based on mandates is what will happen in the event that the supply of fuels (and hence credits) is inadequate to meet compliance obligations. One answer to this risk would be to argue that obligated parties should simply have done more to ensure that compliance would always be possible, and to apply the full weight of compliance penalties regardless. However, in practice this may not be politically or practically desirable. In the event that additional units of compliance

become exceedingly expensive it may not be considered constructive to force obligated parties to pay indefinite rates for additional credits, especially when that cost will be at least partly passed along to consumers. There may also be cases when events well beyond the control of regulated parties interrupt the supply of compliance credits. As an alternative to seeking compliance penalties through the courts in such situations, some regulations have allowed for the use of **alternative compliance mechanisms**.

Essentially, these involve setting some sort of defined payments incumbent upon obligated parties in the event that fuel volumes or overall carbon savings do not meet targets. Under the RFS, there is the cellulosic waiver credit. Under the RTFO, there is the buy-out price (see Section 5). While these mechanisms cap the potential value of a unit of compliance, they can also steer the market by providing a defined indicator of the marginal value of a unit of compliance. If this helps to add transparency to the future value of compliance, it may be possible to achieve a virtuous situation where capping the cost of credits actually supports rather than deters investment. In California, an analogous system is currently under discussion for an end-of-year credit clearance market, in which out-of-compliance regulated parties would be forced to buy any available credits left over at year-end for a defined price. This would help provide a value marker for the marginal unit of compliance, while limiting costs to suppliers.

Another relevant issue that needs to be addressed is the **predictability of the value** of compliance credits. Several of the ultra-low carbon alternative fuel pathways that regulators and NGOs are interested in seeing develop have a relatively high perceived technology risk and high capital costs as compared to operational costs. Where large facilities take years to build and potentially months to bring up to full production speed, investment is determined not by the value of a compliance credit (or other policy) now but by the expected value of a compliance credit several years in the future. Even in the best case, that government support is considered completely reliable and has a well-defined value, it will be discounted by investors because it will only be received several years hence, generally only when production starts. If the long-term support for a policy is unclear, or if the value of credits is hard to predict, investors are likely to discount support much further.

In the US, for instance, there is a cellulosic biofuel tax credit in place that is worth \$1 per gallon of fuel produced. However, because the policy has to be renewed every year by an unpredictable congress, investors are unwilling to rely on the credit remaining in place several years down the line. As a result investors often discount the tax credit to zero when considering investments. In this case, the credit is unlikely to be effective at driving fuels to market, and essentially becomes a windfall to companies that would have developed plants anyway/or were well developed in terms of this process. Such policies are inefficient as drivers of transformational market change. Even without the unpredictability of political institutions, credit based programs do not generally give clear future value signals for investment especially in the high-risk early stages of rolling out new technologies. Policies that

are consciously designed with the intention of giving value certainty may be disproportionately more effective at supporting technology commercialisation.

6.2 Measuring performance against GHG reduction targets - Life Cycle Assessment its role and limitations

6.2.1 LCA Approaches

Given the stated goal of low carbon transport fuel policy (stated in section 6.1) ie to reduce the net global GHG emissions associated with the production, processing and distribution of the fuels and energy sources used in the transport sector in the EU in line with the long-term objectives of EU climate policy. An important challenge in regulatory terms is to develop an appropriate metric that is a good proxy for real-world GHG reductions. Simply identifying the metric, however, is not sufficient. It is also important that the metric is: easy to manage; that it can be evaluated consistently and is not vulnerable to gaming; with limitations that are well understood.

The standard approach to estimating real-world GHG emissions reductions delivered by a low carbon fuels policy framework is to compare the lifecycle emissions of alternative fuels with the lifecycle emissions of the fossil fuels they replace. Lifecycle emissions are defined as the sum of all of the GHG emissions associated with fuel production, and can be identified by undertaking an appropriate lifecycle analysis (LCA). However, it is not always straightforward to assess these emissions, and different techniques will show different levels of correlation to real-world emissions reductions achieved as a result of implementing a policy.

The RED and FQD, as they stand, are based on attributional lifecycle analysis. Attributional LCA (see Box 4) involves summing the emissions associated with producing all of the inputs to a fuel manufacturing process together with the emissions from the manufacturing process itself. It is a relatively well-defined task, giving results that tend to be less subject to uncertainty than those from alternative 'consequential' approaches (also see Box 5). This is partly because attributional methodologies tend to exclude the most difficult questions from the system boundary, for instance indirect land use change emissions.

While attributional LCA is a relatively well-defined analytical exercise, the values given by attributional LCA do not capture any changes beyond the system boundary ie emissions that might result from changes in behaviour that will be caused by a new policy framework. For instance, attributional LCA has traditionally treated land as a resource the use of which has no fundamental carbon cost (unless a specific land use change has been observed on that parcel of land). This ignores the reality that land is a limited resource and that there is an opportunity cost associated with using it for one purpose rather than another. A simple example is that most farmland, if abandoned, would start to revert to a natural state, normally with higher persistent carbon stocks than farmland. Some authors have argued that there is, therefore, a foregone carbon sequestration associated with using farmland (even if not currently in agricultural production) for biofuel feedstock cultivation. Similarly, using a land parcel for this purpose means that no food is produced from that land.

This causes indirect land use change as the agricultural economy adjusts to a new supply-demand equilibrium.

In some cases, the results of attributional LCA can give an entirely misleading impression about the environmental benefits of increased consumption of a certain fuel, making consequential LCA seem appealing. However, in practice it can be challenging to identify with certainty a single value for the consequential lifecycle emissions associated with the various changes, as the necessary methods may be incomplete and the results are dependent on the scenarios assumed (Plevin et al. 2013). Given that attributional and consequential LCA both have strengths and limitations, care should be taken in choosing which framework is best applied to a given question. In some cases, there may be considerable value in considering the results of more than one LCA approach.

LCA can also have an important role in assessing choices for alternative vehicles. LCA has been used in the past to investigate differences in embedded emissions from the manufacture of different vehicle types, such as electric vehicles and hydrogen vehicles. As with assessing the carbon intensity of liquid fuels, LCA can be applied to the carbon intensity of alternative energy carriers such as electricity and hydrogen. For a comprehensive comparison of the carbon impact of an electric vehicle vs. a conventional petrol vehicle, it is necessary to assess energy for manufacture (and expected vehicular lifespan), energy losses in transmission, relative energy efficiency of drivetrains, carbon intensity of fuel production.

Box 4: Types of LCA

There are two main types of LCA:

- **Attributional LCA**, in which all emissions within a defined system boundary are 'attributed' to the production of specified products. In some cases, where only a single product is produced by the system, then all emissions would be attributed to that product. If many co-products are produced, then the emissions may be attributed to the co-products based on some defined proportion. In principle, if a consistent attributional LCA was applied to all final products and activities in the world, the sum of the attributed emissions should match the sum of all human emissions. This type of LCA is particularly well suited for comparing the emissions associated with two or more similar processes occurring in similar contexts. For instance, for two wheat ethanol plants purchasing feedstock from the same market, attributional LCA would be well equipped to identify which was the most energy efficient. However, this approach is insensitive to the consequences on the larger global system as a whole as a result of, for example, the implementation of a new policy.
- **Consequential LCA** is, in contrast, designed to identify changes in net emissions across a larger system that can be associated with a given signal, such as increasing or decreasing the use of a given product. Consequential analysis requires that emissions in some scenario where the signal has happened are compared to emissions in a case that is set as the baseline. Hence, consequential LCA is better suited to analysing whether the implementation of a given policy, or change in demand for a given product, is likely to reduce or increase net global emissions. Consequential considerations could include, for example, the impact of increased demand on land use change and impact of carbon pricing on upstream practices in fossil fuel production. In practice, elements of attributional and consequential LCA are sometimes combined, such as by using the consequential 'system expansion' approach for co-product accounting in attributional LCA, or by adding iLUC factors to attributed lifecycle carbon intensities.

6.2.2 Fossil fuel displacement, rebounds, leakage and shuffling

Calculating the carbon saving delivered by increasing use of a particular fuel requires identifying not only a carbon intensity value for the fuel being added to the mix, but also identifying the amount and carbon intensity of fuel that is displaced. It is generally assumed in analysis of low carbon fuel policies that each extra megajoule of an alternative fuel supplied will automatically result in one less megajoule of fossil fuel being consumed, but this assumption need not be correct. The 'rebound effect' is a term used to describe the conventional economic expectation that increased energy supply in one region will lead to a reduced global market price for energy, which could result in increased energy consumption elsewhere. In the case of alternative fuels, this could happen if reduced demand for fossil fuels in Europe results in a reduced global crude price leading to increased fossil fuel consumption in

third countries. Analysing the rebound effect is complicated by the fact that the nature of any global rebound is highly dependent upon the form that policy takes. In general, policy that protects fuel consumers from the cost of increased alternative fuel supply will have a larger global rebound effect than policy that increases costs to fuel consumers. This is because increased costs to consumers will tend to reduce fuel demand in the jurisdiction in question. This can offset potential increased fuel consumption elsewhere.

Estimates for the magnitude of the rebound in the liquid fuels market vary considerably. A representative estimate from the literature for the rebound from a biofuel mandate would be 33%⁵⁰ (ie supplying a megajoule of alternative fuel could only result in a reduction of fossil fuel consumption by two thirds of a megajoule). Depending on the carbon savings anticipated from the alternative fuel's use, this rebound could undermine the ability of a policy to deliver sufficient emission savings in the global context.

A second and related concern is that 'carbon leakage' within a low carbon fuel policy can arise if additional demand for biofuels in one region resulted in reduced use of biofuels in a second region. This could occur, for instance, if Europe imported sugarcane ethanol from Brazil, but total sugarcane ethanol production did not increase enough to meet this new demand. If one result of EU biofuels policy is that Brazilian drivers use lower blends of ethanol (ie Brazilian drivers consume some of the petrol that has been displaced in Europe), then as in the case of the rebound, the rate of displacement of fossil fuels for the system as a whole would be much less than 1:1.

A third risk is 'shuffling' within product categories. An example of shuffling could occur if, in the previous example, instead of Brazilian drivers replacing sugarcane ethanol with gasoline American corn ethanol is imported for use in Brazil. Assuming that US ethanol production increases to meet the new demand, the total displacement of fossil fuel at a global level may not be affected. It would, however, be incorrect to use a lifecycle assessment of sugarcane ethanol to estimate the carbon benefits of a policy that has the overall effect of increasing corn ethanol production. In the crude oil supply chain, a comparable issue could arise if a reduction in high carbon oil demand in Europe resulted to some extent in a 'swap' of oil imports between Europe and other countries; ie the higher carbon oil is still used but not in Europe.

In reality, various combinations of these effects could occur in response to a policy change in one region such as Europe. In all cases, these chains of consequence would not be effectively captured within most LCAs with strong attributional characteristics. As a consequence, the real emission savings of a policy based on such an LCA (that might assume 1:1 displacement), would be more limited than the methods employed presume. Reliance on over-simplistic analysis risks over-

⁵⁰ Eg Stoff, S. (2009). The Global Rebound Effect Versus California's Low-Carbon Fuel Standard. *Global Energy Policy Center Research Paper*, (09-04).; Chen, X., & Khanna, M. (2012). The market-mediated effects of low carbon fuel policies.

incentivising fuels that are subject to rebounds, carbon leakage or are at risk of shuffling. The risk of substantial errors in setting levels of incentives is great in cases where an inappropriate LCA is used, but will vary in scale depending on the nature of a fuel source, linkages between markets etc. Where such errors in incentivisation occur, this impacts detrimentally on emission savings and the technology neutrality of the policy.

6.2.3 Applying LCA within Policy Making

LCA is a useful decision support tool but, for the reasons set out above, should not be relied upon to the exclusion of other analytical approaches. It can inform and support important quantitative and qualitative judgements, policy approaches, boundaries and critical decision points but should be coupled with other tools and sensible and informed consideration of the overall parameters affecting policy choice.

This coupling of LCA with a broader range of policy considerations and value judgements regarding future needs, innovation etc can be seen both in Europe and the US. The original European Commission draft of the 'iLUC proposal'⁵¹ contained a simple example of this type of approach. Under this proposal, the value accorded to fuels in the Renewable Energy Directive would have varied between advanced fuels from wastes and residues, advanced fuels from energy crops, first generation fuels from wastes and residues and other first generation fuels. The distinction assumed differences in value regarding long-term GHG emission reductions. While the proposed system for differentiating value (double and quadruple counting) was not taken on as originally proposed in the positions of the Parliament or Council, the principle of providing enhanced incentives for certain fuel types based on a judgment of their potential benefits to the environment and society was accepted.

A similar hierarchy of value is applied under the US RFS and within the US tax system. A gallon of cellulosic fuel supplied in the US is eligible for support through the cellulosic RIN (provided EPA assesses that it delivers a 60% carbon saving or better), and also for the second-generation biofuel producers' tax credit. In contrast, corn ethanol is eligible for a less valuable renewable RIN, and no longer receives any tax credit. Even in California, where alternative fuels are regulated through the performance-based LCFS, the eligibility of fuels for federal incentives means that cellulosic fuels benefit from an overall policy incentive greater than that derived directly from their assessed potential to deliver carbon savings. There are also limits on which types of carbon savings are eligible for credit within LCFS (eg upstream emissions reductions in the oil industry can only be accounted if considered 'innovative'). These are practical examples in which the overall relative value of

⁵¹ European Commission (COM(2012)595) proposal for a Directive of the European Parliament and of the Council amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources

different fuels is based on a combination of LCA and of broader category assessments.

The fact that there are challenges and limitations in applying LCA as a regulatory tool does not devalue LCA. It does, however, suggest that it is important to be cautious in the way that LCA results are applied and interpreted. In particular, one should be cautious about assigning equal value in policy to carbon savings estimated on different bases. This risk is particularly high when making comparison between very dissimilar emissions reduction strategies. For instance, there is likely to be a higher risk of miscalibrated incentives when regulating both fossil fuel pathways and alternative fuel pathways under a single piece of legislation than in regulating the two groups of fuels separately.

One approach to dealing with these limitations of LCA is to focus on cases in which many of the uncertainties can be avoided or cancelled out because the baseline and scenario emissions can be fairly compared. For instance, when assessing emissions reductions delivered by specific new projects, it may be possible to be relatively assured that carbon leakage is avoided. For fossil fuels, methodologies to calculate upstream emissions reductions from specific targeted projects are designed to answer a simpler and more tractable question than a full carbon intensity evaluation (what level of emissions would there be in a world with that specific project versus a world without the project) and thus these carbon savings may be identified with relative confidence. For relatively comparable alternative fuels pathways such as different technologies for producing biofuels from the same crop, attributional LCA can be well suited to identifying comparative efficiency.

In general, the 'direct' LCA approach gives the most accurate results when used to assess entirely new production systems. If an uncultivated parcel of land is converted to grow bioenergy crops, and a new production facility is built to process them, then assessing the change in carbon stock on the land, the carbon intensity of feedstock production and the carbon intensity of processing should give a relatively accurate assessment of the change in carbon emissions across the system. Where, in contrast, changes in production capacity, feedstock source, land use change and so on are market mediated, the results of direct LCA may be a poor proxy for the real carbon intensity of a system (eg if sugarcane ethanol imports increase but it is unclear whether global sugarcane production or ethanol processing has also increased). Consequential models can give insight into, and estimation of, the carbon implications of these changes, but the results are subject to considerable uncertainty. In either case, rebound effects could undermine the extent to which increased alternative fuel supply reduces global oil consumption.

6.3 Implications for monitoring, reporting, verification and enforcement

Clearly, the details of the monitoring, reporting and verification requirements will depend on the form and content of the policy options, not least the choice of regulated entity, as discussed above. However, there are some common issues in relation to monitoring, verification and reporting that are relevant to this section.

First, it is clear that there will need to be verifiable means of:

- Assessing the GHG emissions associated with fossil fuel and biofuel feedstocks and the associated production techniques; and
- Tracing the origins of fuels and energy sources, along with their associated GHG emissions.

As discussed in earlier sections, the first of these can be challenging.

As noted above, in the Californian and British Columbia systems, the responsibility for reporting falls on the regulated entities. Compliance is demonstrated when a regulated entity has the same number (or more) credits than deficits. Reporting is required every quarter in order to ensure that the regulated entities are on course to meet their requirements of the system (which could be through trading).

The targets under the passenger car CO₂ Regulation are enforced through financial penalties imposed on manufacturers in the event of non-compliance in any particular year. Currently, the Californian system under LCFS does not have a system of defined financial penalties in place; instead CARB is able to take enforcement action in the case of non-compliance. An option that has been suggested in California is to introduce something similar to the RTFO's buy-out mechanism, which would force regulated parties to buy any credits available on the market (at a defined price), rather than impose further penalties. The idea is that this would preserve the marginal incentive to comply by one extra tonne, while avoiding excess fines or onerous and demanding court actions.

6.4 Key emerging questions, issues and political decision points

This section has outlined some of the considerations of relevance to the development of an EU policy framework for low carbon transport fuels and energy sources. It is clear that the overall objective of such a policy should be “to reduce the GHG emissions associated with the production of the fuels and energy sources used in the transport sector in the EU in line with the long-term objectives of EU climate policy”. One of the challenges is, however, to identify an appropriate metric that is a good enough proxy for the purpose of delivering real-world GHG reductions. Not only should this be reliable but also easy to manage and for which its values can be calculated with relative certainty. As discussed, LCA techniques can support the identification of a metric and its value, but LCA is not a panacea and should not be relied upon to the exclusion of other analytical approaches. It can inform and support important quantitative and qualitative judgements, policy approaches, boundaries and critical decision points but should be coupled with other tools and sensible and informed consideration of the overall parameters affecting policy choice.

The assessment of the most appropriate behaviours that should be changed by a low carbon transport fuels policy framework concluded that it was the behaviour of the entity that diverts each fuel or energy source to the transport sector should be altered, which implies some form of differentiation within a policy that were to truly deliver certainty, investment and emission reductions across this varied group.

Consequently, the most appropriate targets would require each of these entities to reduce the average GHG emissions associated with the products that they supply to the transport sector.

Flexible mechanisms, offer a potential approach to delivering alternative compliance pathways (hence flexibility) and greater clarity around the costs of compliance, for example through systems whereby regulated parties can trade to ensure their compliance with the target set. In such cases, regular reporting would be required to ensure compliance within the system and to facilitate trading. The regulated entities not in compliance could be required to make defined payments, which both cap the value of a unit of compliance and also make the value of compliance transparent, and thus support investment. Such values need to be set at the start of the period in which the mechanism is to operate, and need to be adhered to throughout, in order to provide a consistent investment signal. Credits also enable different targets or approaches to be set for different fuels, e.g. to reduce the risk of carbon leakage, as they enable the over- or under-compliance of the different targets to be traded. In this way, cost-effective reductions can be delivered efficiently across the whole mechanism. However, the systems that are in place in California and British Columbia are administratively intense, and require independence and consistency, which might be a challenge in the EU, as a result of the various EU level and national administrations that would need to be involved.

7 Potential policy mechanisms and legislative approaches

7.1 Designing Policy to Deliver Against Priorities and Needs

This section of the report sets out potential options for low carbon transport fuel policy in Europe post 2020. This is informed by the analysis undertaken and the alternative approaches examined in sections 2 to 6, building lessons from policy making in the EU and third countries. Most importantly it tries to take into account the key needs identified within the analysis on policy priorities. The key priorities and needs per fuel/energy were identified in section 4 and are translated into the list of priorities per fuel type listed below. It should be noted that these are the elements identified for which the goals can be advanced effectively through transport fuel policy only. What is also clear from the analysis in section 4 is the need for parallel efforts on vehicle standards to deliver efficiency and vehicles suited to alternative low carbon energy sources, and also on infrastructure development to support low carbon fuel delivery. A full spectrum of policy measures is needed to support reduction in the use of liquid fuels and the roll out of alternative low carbon energy sources ie electricity and hydrogen.

The following summarises the needs identified for the key transport fuels that low carbon transport fuel policy should secure:

- **Fossil fuels** – measures to *support the choice of fuels to ensure that their GHG footprint declines over time or remains static* in line with wider decarbonisation priorities and measures that can help to *promote the availability of information* to inform decision making on appropriate fuel choices based on low carbon concerns;
- **Biofuels** – measures to provide a *clear basis for differentiating between biofuels and the risk associated with their usage* on an ongoing basis; to ensure *measures promoting biofuel uptake are not applied to high risk biofuels*⁵² ie those that deliver no or limited emission reductions or will result in unacceptably high risks for the broader environment and/or food prices;
- **Electricity** – for the *share of electricity in transport to increase and for electricity in the transport sector to be progressively renewable into the future*; this entails measures to support the wider availability of dedicated charging points to actively facilitate the wider penetration of electric vehicles; and measures to support policies aimed at the wider penetration of electric vehicles and their integration with renewable energy sources;
- **Hydrogen** – for the share of *hydrogen used in transport to increase and to be progressively renewable into the future*; measures to support roll out of dedicated fuelling infrastructure as vehicles come online; and measures to support policies aimed at the wider penetration of hydrogen vehicles.

These policy priorities lead to a number of potential policy options and routes that might be explored at the EU level. Several characteristics are particularly desirable in any the policy mix that is selected:

- To be designed to be effective both in *driving emission reduction and driving investment into truly low carbon solutions*;

⁵² For biofuels risk is predominantly linked to the feedstock material used to produce the fuel ie associated land use and indirect land use change consequences. Moreover, there is a question about the extent to which biofuels are scalable in the long term to enable the efficient replacement of fossil fuels.

- To enable ***policy certainty and clarity***, which is necessary to ***secure investment and innovation*** within the low carbon fuel technologies to support long term transition of the transport sector; and
- To include a ***transparent and verifiable system for monitoring and reporting using an agreed and consistent system of measurement*** to ensure that there is high certainty of delivering tangible emission reductions.

7.2 Policy Options and Alternatives

Based on the analysis conducted specifically into the success of the current policy approaches in the EU, the policy priorities for action, alternative approaches to low carbon transport policies and consideration of appropriate policy tools and approaches the following set of 8 options have been defined. The following options would be focused at the EU level. It is believed that the EU has the right under subsidiarity principles to act in this field. This is based on the analysis of the original case for action in support of the FQD and the premise that the need to reduce emissions from the transport fuel sector remains unchanged. Table 6 summarises the options presented. These are then systematically explained and examined with an initial summary of potential issues, and the associated strengths and limitations set out.

Table 6 – Summary of the policy options reviewed within this report and the nature of interventions proposed

Option	Type of Intervention	Description of Measure
a (i)	Reliance on existing EU policy with no specific, new instruments to be put in place post 2030 to deal with low carbon transport fuels	Reliance on high level targets for GHG reduction and renewable energy promotion to deliver low carbon transport fuel options via Member State led actions
a (ii)		Reliance on high level targets for GHG reduction and renewable energy promotion to deliver low carbon transport fuel options but coupled with measures to enhance coordination on low carbon fuel issues, provide guidance on priorities to Member States and promote positive investment through EU funding routes and state aid rules. Anticipated ‘governance’ measures could reinforce the leverage exercised by high-level targets.
b		Integration of transport fuels within the EU ETS
c	Options for a single, binding legislative measure at the EU level post 2030 to deliver low carbon transport fuels within an integrated framework but applying variable approaches to differentiation based on relative ‘performance’ of fuel technologies.	Binding legislation setting out a single high level GHG intensity target for the transport fuel sector as a whole, akin to the current approach in Article 7a FQD
d		Binding legislative measure setting an overarching ambition in terms of GHG intensity of transport fuels, but containing differentiated targets and caps applicable to delivery by different technologies and sectors involved.
e		Binding legislative measure setting a high level target for GHG intensity but utilising a flexible mechanism to demonstrate compliance enabling alternative compliance approaches for eg electricity and hydrogen, similar to approaches adopted in California under LCFS
f		Binding legislative measure based on nested targets for delivery of low carbon fuels. Different target would be set within a whole with support level dependent on performance of the fuel against carbon intensity and other core parameters for society.
g	Coordinated but disaggregated, binding interventions at the EU level to deliver specific priorities applicable to the different low carbon transport fuel technologies	Goals/targets for delivery up to 2030 by the low carbon fuels sector would be identified but specific requirements for each of the low carbon fuel/energy sources would be set, allowing a differentiated approach reflecting the needs identified for each fuel . Action to include: potential binding emission limits or reduction targets; binding monitoring and reporting requirements; and rules on appropriate sourcing and production.

a – No specific EU level legislation for low carbon transport fuels up to 2030 or for the delivery of GHG emission reduction from transport fuels

There are two sub-options considered here. The first would rely completely on the high level system of targets up to 2030; the second would supplement this with non-legislative action and guidance to provide coordination to try to achieve the needs identified in 7.1 for the different fuel options.

- a (i) – **reliance on high level targets for renewable energy (binding at the EU level) and GHG emission reduction rather than specific transport fuel actions.**

Given the shift in the renewable energy target from binding national targets to a binding EU level target with no national targets, it is as yet unclear what impact the target will have on adoption of renewable energy technologies post 2020. While potentially some conventional biofuels are market ready and may well continue to be used by Member States, *there is a question as to whether a high level target would encourage and drive forward innovation and the evolution of renewable energy technologies to deliver the transformation needed in transport fuels needed up to 2050.* Moreover the RED transport target in place up to 2020 failed to effectively differentiate between the best technologies that maximised emission reduction and wider benefits to society and less sustainable technologies and feedstocks.

In reality the loss of nationally binding renewable energy targets, to be replaced by one binding at the EU level only, increases uncertainty as to how Member States and the EU will drive progress up to 2030; hence potentially weakens signals for investment in novel renewable energy solutions. In their recent review of energy policies for the EU, the IEA raised questions around who would have responsibility for delivering the renewable energy target up to 2030 and how renewable energies will develop in the transport and heat sectors⁵³. In the absence of EU level action up to 2030 there is an opportunity for Member States to take forward action independently, however, this could result in a fragmented approach to the fuels market in Europe. It is also difficult to see how the Commission would monitor progress towards an EU target on renewable energy without a common definition of what constitutes a renewable energy source in the transport sector.

Member States will also be bound by binding national GHG emission reduction targets set for 2030; these comprise the EU-level requirements for the sectors covered by the Emissions Trading System, and the Member State level targets for emissions from the remainder of the economy. The latter will include emissions from the transport, agriculture and building sectors. The transport sector is responsible for the highest proportion of these non-ETS emissions, and alternative fuels may assist in delivering national targets. The current policy framing does not, however, provide a basis for promoting the technologies that deliver the greatest GHG benefits (ie all biofuels and bioenergy are treated equally as delivering zero emissions within the present accounting system). Moreover, proposals put forward by the European Council in October 2014 would potentially permit shifting of effort between the EU ETS and non ETS sectors, further complicating the identification and delivery of efforts in the transport sector and potentially reducing the incentive to act on transport in several Member States.

⁵³ International Energy Agency, Energy Policies for IEA Countries, European Union, 2014 Review <http://www.iea.org/Textbase/npsum/EU2014SUM.pdf>

- a (ii) – **reliance on high level targets for renewable energy and GHG emission reduction, accompanied by non legislative support to promote innovation in the transport fuel sector**

The EU has an established role in acting in non legislative ways to promote research and development and controlling the way in which funding and support is offered at the national level ie through state aid rules. To counter concerns around divergent Member State support mechanisms a **technology development strategy** for low carbon transport fuels could be put in place to set out guidance on the appropriate development routes for low carbon fuels, coordinate funding for EU level research and also ensure that Member States are only providing financial support for the development of truly low carbon transport fuels. It might also provide a space for the active sharing and coordination of Member State action, through facilitating Member State engagement and exchange. This would not provide the clear drivers for investment that a legislative measure might ie the guarantee of market share that is often felt needed to secure market roll out and return on investment, nor the push to act. It would, however, provide a basis for revealing and understanding the state of action and providing coordination at the EU level to monitor consequences and ensure learning between Member States.

Critical Issues and outstanding questions	
It is unclear whether the loose EU level framework of targets for the non-ETS sectors would drive effective action on low carbon transport fuels, particularly action requiring infrastructure investment.	
Given uncertainty over the nature of Member State level action there is no guarantee that the full range of low carbon fuel technologies ie from biofuels to hydrogen would be explored and approaches to support for different technologies would vary country by country.	
Member States may be able to independently promote low carbon fuel alternatives	
Pros	Cons
Provides the opportunity for more flexible and innovative approaches to fuels at the national level.	There is little guarantee of action taking place holistically in the low carbon transport field and little certainty provided by the high level EU targets that Member States will effectively take transport into account.
	Significant risk of delayed action in the transport fuel sector, leading to higher costs of abatement in the longer term.
	Member States are able to implement GHG reduction and renewable energy policies based on their own priorities potentially leading to market fragmentation and loss of the EU's innovative and competitive advantage

b - Integration of the transport fuel sector into the EU ETS ie instead of a dedicated policy focusing on transport fuels these are integrated into the EU ETS with the fuel supplier as the trading entity.

Under current proposals from the European Council, up to 2030 Member States would be able to transfer effort between EU ETS and non ETS and/or request transport as a sector to be included within the EU emissions trading system at the national level. There is also the potential for wider inclusion of transport fuels within the EU ETS, which has been mooted by some Member States and interest groups. Option b could represent the alternative approaches to EU ETS/transport integration: reliance on national level driven trading; or the wider integration of transport fuels into the EU ETS.

There are some fundamental challenges associated with the inclusion of transport fuels into the EU ETS. From a logistical perspective fuel suppliers would be the most logical trading entity; however, this would **not be consistent with the principle of direct emissions** ie that trading entities are directly responsible for emissions and in the case of transport this would be the end user rather than the fuel supplier. Moreover, fuel suppliers would have limited options to reduce fuel use, although they could choose to supply lower carbon fuels (however, the ability to promote low carbon fuels beyond biofuels is questionable given the nature of the fuel supplier, the different infrastructure required for electric and hydrogen roll out and the current low price of carbon under the ETS).

The ***influence on fuel usage and end users would be dependent on whether costs associated with the EU ETS are passed on to end users*** and in reality there is a risk that such a price change would neither be significant enough to drive behavioural change, nor be clearly signalled. Critically there are concerns about the ability of inclusion into the EU ETS to drive GHG emission reductions in transport and deliver the transition and investment in innovative solutions needed. While inclusion in the EU ETS would have the benefit of tightening the market (assuming abatement remains more expensive in the transport sector than in the energy sector); that benefit could be dissipated unless the political will exists for more demanding targets to be imposed on the EU ETS sectors. Emission reductions from the transport sector are seen as more expensive than those in other sectors and so inclusion into the EU ETS may stimulate additional behaviour to reduce emissions in other sectors rather than action on transport. Moreover, there is already a high level of taxation in place in the transport sector (equivalent to 200 EUR/tonne), additional price rises generated in the EU ETS (of currently 6 EUR/tonne or even an aspirational 30 EUR/tonne) will have a muted, comparative impact on price. ***As a consequence action within the transport sector would be deferred***^{54 55}.

⁵⁴ European Parliament Policy, Department Economic and Scientific Policy, A study requested by the European Parliament's committee on Industry, Research and Energy (ITRE). The future elements of the EU Emission Trading Scheme, 2008 – Authors - Mr. Mark Johnson, Mr. Ian Skinner, Mr. Michael Harfoot., Dr. Ian McCubbin

<i>Critical Issues and outstanding questions</i>	
Questions around the practical implications of incorporating fuel suppliers into the EU ETS as trading entities when they are not direct emitters	
Questions around whether this could drive action across the wider sphere of technologies needed for a low carbon transport transition and in fact whether supplementary measures would always be needed to support innovation and emission reductions.	
<i>Pros</i>	<i>Cons</i>
Utilises an existing policy framework and fuel suppliers, at least of fossil fuels, have some experience with the system	Requires a fundamental shift in the principles of applying the EU ETS to trading parties that could have implications for the robust nature of the scheme. Moreover fuel suppliers as the trading entity have limited ability to influence infrastructure development or end user actions.
	Higher abatement costs in the transport sector would tend to mean emission reduction takes place in other sectors first leading to action and transformation of the transport sector being deferred and higher costs of decarbonisation given the need to transition the transport system to meet long-term GHG targets.

c – Legislative measures to reduce the GHG intensity of fuels placed on the EU market (similar to the current FQD approach)

This would be akin to the approach currently under the FQD ie a target would be set that specifies a level of GHG emission intensity reduction to be delivered from transport fuels by 2030. This would address in its approach some of the core existing challenges within the FQD around appropriate comparable measurement of emissions from different fuels; lack of driver given the overshadowing of action by the parallel RED approach; and lack of effective enforcement. ***Under c only a high-level national binding emission reduction target would be set.*** Were a Directive based approach pursued it would be up to Member states to translate this to different sectors. Were a Regulation adopted it would be the fuel suppliers who would be responsible for this interpretation. Under either legislative approach, ***it***

⁵⁵ These messages regarding inclusion in the EU ETS have been highlighted in a number of publications including the briefing by T&E, Three reasons why road transport in the ETS is a bad idea, September 2014. However, concerns regarding the ability to drive innovation, emission reduction and the appropriateness of fuel suppliers as the trading entity predate this paper.

would likely be unclear for fuel suppliers what technologies they have to use to deliver the reductions. The high level target would apply to renewable transport fuels including electric, hydrogen and fossil fuels but with no differentiation in terms of the share of emission reductions delivered from the different technologies.

Critical Issues and outstanding questions	
Whether the approach should best be taken forward as a Directive, i.e. prolonging the current FQD based framework, as a new measure; or as a Regulation. If it took the form of a Directive Member States could be explicitly empowered to set out mandates or requirements to ensure a mix of technologies are promoted.	
Presumes technology neutrality as it does not require action within any particular technology sphere, but in reality may lead to particular technologies that are the most market ready dominating, as alone it does not provide sufficient clarity to support investment decisions. Were a Directive adopted this would rely on Member State implementing measures to provide clarity.	
It is fundamentally linked to an LCA based approach and it has proved politically difficult to have a robust LCA framework that deals with all the elements required.	
Pros	Cons
In theory technology neutral, ie does not specify any defined routes for delivering emissions reductions hence has the potential to promote action across technologies.	The lack of differentiation in terms of delivery technologies could lead to confusion as to how best to deliver the target meaning lack of clear investment signals and a lack of clarity as to what each technology needs to deliver.
The focus of the target is on direct GHG reductions in the fuel sector and reducing the GHG intensity of transport fuels on the market.	

d – A GHG emission intensity led approach that explicitly requires contributions from specific technologies and sectors to deliver an overarching target – a differentiated target

This option would ideally take the form of a **Regulation that imposes a generic target for GHG emission reductions from transport fuels by 2030 but below this sets out a number of subtargets or caps relevant to different delivery streams and technologies.** The latter would be based on a dialogue with experts and stakeholders regarding delivery potentials and potential emission reductions underpinned by independent evidence and research. To recognise the diversity of action needed across the different low carbon fuel actors and the market readiness of different technologies this option would set a series of caps/targets underneath the overall GHG emission intensity reduction target relevant to the different sectors covered. The intent is to provide investment certainty and clarity over the contribution to emission reduction from each of the core sectors within the transport fuel subgroups. Hence, under an overall target a number of different caps and targets

would operate to deliver both actions across the different fuels and technologies and promote market transition.

<i>Critical Issues and outstanding questions</i>	
There needs to be a clear understanding of the ability of different technologies and sectors to deliver change over a given time period, but also a willingness to encourage/enable emergence of new technologies	
There would need to be a willingness from the industry to engage in a positive debate around promoting and facilitating transition in the fuels market	
<i>Pros</i>	<i>Cons</i>
Should provide clarity for the different sectors on the nature and level of their contribution anticipated to deliver low carbon fuel targets providing space for less established sectors to develop	It presumes that for example, electricity and hydrogen can be driven through a fuel-based measure and that the barrier to roll out is the lack of commitment to fuel use rather than for example, effective infrastructure or uptake of vehicles. Additional action (continuation of cars and CO ₂ standards, infrastructure build-up, further standardisation of charging points) will be needed to enable these industries to drive change through a fuels based measure to deliver a target.
Provides a basis for potentially limiting the contribution of the less innovative or less effective fuels or pathways, in some ways mimicking the approach to ILUC set out in current proposals ie a set of caps and subtargets to deliver the whole. However, thought would need to be given to how such an approach would operate in a carbon intensity rather than energy quantity driven instrument	Fixed targets may be inflexible and become politically unsustainable if they are out of kilter with what industry is actually capable of delivering and if it is not open/ambitious enough it may be restrictive to emerging technologies. However, this could be addressed by adding some form of flexible mechanism (see options e and f)
Since the approach is GHG based it would still: encourage additional GHG savings, discourage high carbon intensity fossil fuels and be open enough to allow space to new technologies.	Would require accompanying action by Member States to facilitate infrastructure shifts necessary for longer-term decarbonisation options – but provides no incentives for Member States to do so.

e – Legislative measure that sets a GHG intensity target for transport fuels but allows flexible mechanisms to be employed to demonstrate compliance

This measure would set a target to be met at the Member State level by transport fuels and delivered by fuel suppliers; however, the regulated parties would be able to trade or retire emission credits. **As such it would require a system of annual targets to demonstrate compliance and facilitate the trading system. Given the establishment of a trading system,** it offers the possibility of setting out alternative compliance pathways for, in particular, electricity and hydrogen. **These sectors might, for example, receive particular credits for investment in new infrastructure that supports decarbonisation.** For such a scheme to operate there would be a need for **fossil fuel based emissions to be held static at a particular or falling level of carbon intensity, with credits potentially available for project based improvements.** Without this it would be difficult to judge the baseline for compliance and the credit and debit system. This would build from the LCFS approach; however, issues around the intensity of operation and management would need to be resolved before implementing at an EU level.

<i>Critical Issues and outstanding questions</i>	
There would need to be a clear metric defined in advance as a basis to monitor success and the ability to gain credits for specific actions. This would need to be developed in advance of 2020, ideally the implementation of current instruments would provide the data and knowledge to provide a basis for this definition. This would need to consider the base year for calculation, the ability of different biofuel technologies in particular to deliver, the approach to LCA adopted and the consideration of ILUC and ILUC impacts within the system. It would also need to be clearly set out how the different fuel types feed into the overall trading and compliance system.	
There are issues potentially regarding the high engagement and management needed to deliver the LCFS, careful consideration and resourcing would need to be put in place to provide the necessarily infrastructure to manage this approach.	
<i>Pros</i>	<i>Cons</i>
Provides a differentiated approach to the different sectors and technologies that need to be dealt with within the low carbon transport fuel sphere including fossil fuels.	Requires a clear metric and the policy making, enforcement and verification infrastructure for implementation at the EU level, without these will not function effectively
Allows the promotion of electricity and hydrogen in a differentiated way and crediting may provide a new investment pathway and certainty	Relies largely on biofuels as the core delivery technology with additional credits gained from other technologies, therefore, may be less relevant to longer-term decarbonisation choices.
	Requires a high level of political commitment to set the bounds of the

	<p>scheme appropriately in order to provide an appropriate level of credit for emission abatement.</p>
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- f – An overarching target based on energy volume delivered by low carbon transport fuel technologies but determined by a series of nested targets based on ‘performance’ of a fuel against GHG and other parameters.

This option could take the form of a nested target (similar to the US RFS approach and the current RED, as reformed by the ILUC proposal but broadened to consider non biomass/renewable elements), with progressive tiered groups of fuels, each with their own target, used to meet the overall commitment. The best performing category of fuels would have a target set at a given mandated level. The next best performing fuels then also have a given mandate sitting below the first, until you reach a mandate for fuels deemed to be the least best (but still in compliance with criteria required to receive policy support eg sustainability criteria). The best fuels would be used to meet the first tier mandate, and if sufficient quantities are available could also contribute to meeting a mandate in the next best tier ie the use of the best fuels would be allowed to expand across the other tiers if and when able to compete on price; this means that their target does not also operate as a cap. Fuels from both first and second tiers could be used to meet a third tier mandate and so forth. ***This is intended to maximise the contribution of fuels considered to be the ‘best performing’ and limit the contribution of those that offer the most limited benefits.***

Within such a scheme the tier within which a given fuel would fall would be determined based on an independent assessment of their performance. This ***measure of ‘performance’ could be set on a wider basis than simply a calculation of carbon intensity*** (although this would be an important consideration), but could also take into account other concerns to society such as long term need to support transition to a low carbon future, consequences for land use and food prices, the ability to deliver co-benefits such as reduced urban air pollution.

<p><i>Critical Issues and outstanding questions</i></p> <p>The approach would require a clear definition of both carbon intensity considerations and the wider parameters for defining the ‘performance’ of a given fuel and where the boundaries between the tiers in performance sit. This should consider not just a given technology stream but differentiate between subgroups of a given technology eg differentiating between renewable and non-renewable hydrogen. Moreover, it would require that the performance of different fuels and feedstocks are possible to determine in an overarching manner ie rather than being case or location specific.</p> <p>There is a question as to whether such a system could or should be tied to some form of flexibility between the tiers, for example, to allow lower performing fuels to be counted towards higher tiers based on, for example, a set fee when sufficient quantities of the best fuels are unavailable. Such an approach would have to take</p>

into account that lower tier fuels are likely to be cheaper than the higher tiers hence clear rules would be needed around buy out price and potential limits on the ability of fuels to 'jump upwards'. Alternatively, the lower tiers can be used as an implicit cap ie with no permeability between tiers upwards meaning if the best options are not brought forward in essence the quantity of energy delivered from low carbon technologies would default to a lower level.

<i>Pros</i>	<i>Cons</i>
It enables the consideration of both carbon intensity benefits, and wider societal benefits and negative impacts to be taken into account. This includes consideration of land use consequences of action	The core challenge is in setting the nested targets at the appropriate levels taking into account the need to develop specific technologies, and the extent of market penetration that is likely and realistic. RFS in the US has suffered from over ambitious targets in excess of the ability of, for example, the cellulosic fuels sector to deliver.
It enables the promotion of a number of different technologies and a clear hierarchy of desirability for promotion to provide more clarity for investment.	While allowing the broader societal impacts of different fuels to be taken into account and those with positive benefits to be promoted, this does not necessarily seek to directly drive the industry in a particular direction of wider environmental sustainability or GHG reduction and there is a danger it is perceived as an alternative to more formal sustainability constraints. Moreover, this does not specifically address questions around the GHG intensity of fossil fuels.
	Performance indicators would need to be carefully defined, and a structure for review clearly in place, to avoid a repetition of the problems associated real world emission reductions resulting from biofuel use in the pre 2020 period as a result of failing to consider ILUC.

g – Coordinated but disaggregated interventions, binding measures at EU level to deliver specific goals for the different low carbon transport fuels

This option would effectively entail a ***different, separate approach for each of the likely core fuels and energy sources*** that might supply the transport sector in the period up to 2030, ie liquid fossil fuels, biofuels, electricity and hydrogen. Despite acknowledging the need for coordinated reference points, and an ability to

understand the collective consequences of action; this option would see a differentiated approach to these fuels and technologies based on the needs identified (see section 7.1).

There may be the possibility of amending existing measures to accommodate these technology specific requirements. This ***could arguably include action on fossil fuels and biofuels sitting within the FQD, but in a more differentiated way than currently set out in Article 7a.*** As highlighted in 2005, as part of earlier policy development processes, the FQD is the logical home for action that impacts on the GHG performance of petrol, diesel and gas oil and its direct substitutes, given its regulation of the quality of fuels and other associated environmental impacts. The original remit for this Directive is that it *'sets technical specifications on health and environmental grounds for fuels to be used for vehicles equipped with positive-ignition and compression-ignition engines'*

Based on the actions and needs identified in section 4 and 7.1, Box 5 presents the type of actions that might be encompassed within a differentiated approach to each fuel type post 2020. This represents an initial scoping of issues based on the analysis conducted for this report and discussions with experts.

Box 5 – Scoping policies to take forward differentiated action on low carbon transport fuels post 2030

For **fossil fuels** there are two, in many ways interlinked, elements required to minimise the carbon footprint of the fossil fuel supply chain. Firstly, there is a need to improve understanding of the nature of the fossil fuels market place through more effective monitoring. Secondly, there is an opportunity to create pressure so that the emission trajectory for fossil fuels remains static or downward. A policy targeting the delivery of lower carbon fossil fuels would arguably need to contain the following elements to address the needs identified in 7.1.

- A ***basis for improved supply chain reporting*** in the fossil fuel sector ie. a legally binding reporting system that may build on effort up to 2020 to implement the reporting requirements set out in the FQD. The aim would be to establish better chain of custody, develop an understanding of the evolution of the fossil liquid fuel sector and identify opportunities to reduce carbon intensities in the fossil fuel supply.
- To develop a ***standard*** for the carbon intensity of fossil fuels in transport. Such a standard could require that there was no increase in the carbon intensity of fossil fuels, or require a downward trajectory. A fully disaggregated assessment of the carbon intensity of all fuels may introduce concerns of shuffling and/or carbon leakage. The risk of shuffling could be reduced by targeting only specified categories of high carbon crude (for instance by distinguishing tar sands crude from kerogenous crude from conventional crude) and to approach the regulation of fossil resources through credits for specific emissions reduction projects.

For **biofuels**, there is a need to provide a basis for differentiating between biofuels based on their GHG saving potential and wider risks associated with their usage. On this basis it is then possible to promote innovation and secure market pressure to adopt biofuels that deliver the highest GHG savings with the lowest risk of failure. The following three policy elements have been identified as key when supporting biofuels that have the greatest low carbon potential.

- A **support mechanism to drive forward the use of the lowest carbon biofuels** is necessary if these are to be brought forward; however there are some fundamental questions around EU level regulation to be clarified before the final nature of such a scheme can be determined. Essentially this focuses around how to address ILUC into the future. There are a number of ways to address ILUC in policy either by: developing a measure that allows ILUC to be appropriately apportioned to different fuels based on performance; or to put in place a barrier to entry on the market that in essence negates the need for a metric and avoids the use of the highest risk fuels ie current Commission proposals to prevent policy support for crop based fuels post 2020. The decision as to what biofuels will be eligible for policy support post 2020 will impact on the nature of the policies needed to regulate biofuels and promote the best solutions post 2020.
- **Sustainability criteria** exist for biofuels up to 2020, to limit the consequences of their use upon the environment and to secure a minimum level of GHG savings per unit fuel. The existing set of criteria focus predominantly on land based biofuel production, and within this the use of conventional crops to provide biofuel feedstocks. As biofuel technologies are now coming on-stream and being promoted through policy that are based on alternative ligno-cellulosic based feedstocks, including wastes and residues, there is a need for sustainability criteria to be made fit for purpose for the post 2020 period. This implies not only the consideration of the coverage in terms of feedstocks but also how compliance (including chain of custody) might be demonstrated by a different and wider array of actors.
- Given the increasing complexity of feedstock mixes, and associated consequences for emission profiles, there is a need to **improve monitoring and reporting** around the use of feedstocks by biofuel producers and importers. This will enable understanding of the types and quantities of material being used.

For **electricity and hydrogen**, the focus is on the additional benefits and the added value a low carbon fuels policy framework can deliver, given existing EU measures ie the Regulation to reduce emissions from new passenger cars and vans and Directive on alternative fuels infrastructure. Taking this into account, approaches focusing on these two energy sources might include:

- Providing some sort of **incentive for owners of electricity charging points and hydrogen filling infrastructure that divert these energy sources for use by transport**. If this incentive took the form of a credit, it would require that the approach taken for electricity and hydrogen to be linked to a wider low carbon transport fuels policy framework, and so would be covered in option e, above. If such an incentive was not linked to a wider policy framework, which is the aim of option g, it is not clear what form this incentive might take other than being a direct subsidy or tax break, which is probably more appropriately implemented at the national or sub-national level.
- Setting out a **future intention** that by a specified date (which might be different for electricity and hydrogen) action would be considered at the EU level **to decarbonise the electricity and hydrogen supplied to the transport sector**, if insufficient progress was being made in this respect. Ideally, a specified decarbonisation trajectory would be set out and action instigated if this was not being met. The detailed specification of such a trajectory is likely to be challenging given the linkages to the wider decarbonisation of the power sector. It is important, however, that action does not inhibit the wider electrification and vehicle infrastructure as decarbonisation of electricity supply and electrification of transport will most likely occur in parallel.

<i>Critical Issues and outstanding questions</i>	
A basis for ensuring effort is coordinated and that it is understood how the separate activities and requirements combine to deliver a holistic picture of action on low carbon fuels would be needed. This is important so as not to send the message that low carbon fuel action has been de-prioritised but that up to 2030 more targeted action is deemed effective while key technologies such as electricity and hydrogen expand. Into the future the policy needs may alter as the transport system transitions and fossil fuels play a more limited role.	
There is a potential for some form of guidance document or Commission Communication that would set out actions across different legislative measures to deliver a picture of low carbon fuels. Ideally this would also set out the way in which measurement should be developed to enable some form of comparability to assess whether transport fuels are actually transitioning to a lower carbon base.	
<i>Pros</i>	<i>Cons</i>
Allows differentiated action to be targeted at the key needs for the different technologies allowing for streamlining between goals and outcomes. Provides clarity for industry and actors supporting the development of relevant technologies of the expectations and opportunities providing increased certainty.	GHG mitigation will only be achieved if there is effective oversight to ensure the ambition of the different elements. Moreover, effective monitoring of efforts as a whole and within the wider lens of delivering low carbon transport is needed to ensure that action is delivered effectively.
Avoids the pitfalls and inaccuracies in trying to account for multiple technologies in a single system	Requires an appropriate legislative home to be identified for the different actions.
	By differentiating your approach to fuels, it also becomes more explicit what is being promoted by a given policy. How the question of biofuels support is addressed is potentially politically more sensitive in this open frame.

7.3 Determining an Appropriate Legislative Approach

Policy options a to g represent a spectrum of EU level approaches to policy making to promote lower carbon transport fuels post 2020. There is a need to decarbonise the transport fuels sector and deliver transformation in the transport sector to deliver goals up to 2050; only by breaking down the actions needed from the different low carbon transport fuel technologies and energy sources is it possible to reach a conclusion as to the policy priorities for 2030 that can deliver this higher level goal. This analysis has sought to systematically breakdown policy need, the types of behavioural change needed by key actors and shifts in fuel use patterns necessary to deliver low carbon transport fuels in line with a 2050 vision. This has

informed the development and assessment of the pros and cons for each policy option.

An effective policy option should be able to deliver against all the policy priorities set out for the different technologies in section 7.1. It should, however, be noted that there are challenges associated with potentially trying to integrate the multiple priorities across the suite of different technologies and pathways required to address low carbon transport fuels holistically. Those identified in this report include:

- the ***different nature and ability of the actors*** involved to influence the GHG intensity of the end use;
- that the ***needs and actions required for the different fuels*** to deliver decarbonisation vary, meaning that it is difficult to determine a single target that is equivalent across the various fuels;
- that the ***challenge of developing a comparable system of measurement*** for the analysis and fair application of a performance based target increases with the variation in the technologies; hence there is an increasing risk of inappropriately incentivising behaviour as the number of non linear technology solutions expands;
- that ***driving innovation***, desirable to deliver fuels in a low carbon way, requires clear signals to support innovation and investment.

These differences lead to a questioning of whether it is possible to place all low carbon transport fuels within one framework or one comparable performance based standard. The delivery of long term climate goals may require differentiated support in the short term to ensure a level playing field for technologies into the longer term ie developing a policy that facilitates and enables the development of a range of technologies based on their potential to decarbonise the transport fuel sector. Options c to g seek to consider how differentiation might be applied within future EU policy. Option g would provide for a completely disaggregate approach to the fuels with clear actions by the different fuel and technology streams, albeit to meet an overarching goal. Options c to f differentiate in terms of compliance pathways but in essence within a single policy framework. These approaches, while potentially effective, could add complexity both in establishing the policy framework and overseeing compliance.

The analysis has identified key actions and policy needs for the different low carbon fuel subsets, these are summarised below. Low carbon transport fuel policy adopted up to 2030 should be able to demonstrate how it will address these needs identified for the different fuel subsets. Importantly, however, it is not just future policy that is of importance. Improved understanding of the state of action and the basis for developing future metrics for assessment is needed. This could in part be addressed by ensuring monitoring and reporting requirements under Article 7a of the existing FQD are effectively implemented. Without the information base, policy making and decision making around appropriate policy action is made more complex and open to error.

For **fossil fuels**, there are two parallel axes of action available into the future. On the one hand, there is an imperative to reduce reliance on fossil fuels implying behavioural change and support of alternative fuel sources. Many of the measures

to achieve this are beyond the scope of low carbon fuels policy. On the other hand, there is an imperative to minimise the carbon footprint of the remaining fossil fuel supply. The latter will require both the monitoring and reporting infrastructure to achieve this and some form of standard against which fossil fuel carbon intensity can be measured and regulated to remain either static or decline over time.

For **biofuels** the challenges are multiple including: the need for innovation in and the deployment of the best low carbon solutions; avoiding the use of biofuels for which there is a high risk of failure to deliver emission reduction; and developing a basis for ensuring it is possible for actors on the market place to differentiate and support the lowest carbon and lowest risk fuels. For the period up to 2030 there are some fundamental questions around the entry point to the market ie what fuels are permitted and in what quantities post 2020. These need to be addressed before policy can be established. To support delivery of low carbon goals there is also a need for improved rules to ensure the sustainability of biofuels on the market place and more detailed monitoring around the use of different feedstocks and biofuel technologies. Finally there is a need for a mechanism bringing together all these elements to drive the adoption of, and focus innovation and investment on, low carbon biofuels and those that encompass the lowest risk of negative carbon consequences.

For **electricity and hydrogen**, the question is what additional requirements or incentives might a low carbon transport fuels policy framework contain that bring sufficient added value. In this respect, it is important to recall that the passenger car and van CO₂ Regulations set targets for the CO₂ emissions from new passenger cars and vans and that the Directive on alternative fuels infrastructure sets out qualitative (but not quantitative) requirements on Member States for the development of *inter alia* electricity and hydrogen infrastructure for transport. The most appropriate regulated party from the perspective of decarbonising the electricity and hydrogen supplied to the transport sector was considered to be the owners of the dedicated electricity charging points and hydrogen filling infrastructure that diverted these energy sources for use by transport. Similarly, the most appropriate metric for any associated target should ideally be the average GHG emissions associated with the electricity and hydrogen sold at these dedicated recharging/refuelling points. It was noted that putting low carbon requirements on these energy sources in the short-term risks disincentivising the development of the respective technologies, however, in the longer-term the two energy sources would need to be produced using low (or ideally zero) carbon methods.

8 Conclusions - How can a post 2020 low carbon transport fuel policy be designed that is effective and addresses the political pitfalls of the pre 2020 policies?

This report seeks to systematically identify the basis for policy making on low carbon transport fuels post 2020, to answer the question of how such a future policy might be designed. In so doing the policy priorities, behavioural changes required amongst key actors, approaches to measurement and policy design have been systematically reviewed and analysed. Based on this analysis some needs that can be met through low carbon fuel policy, rather than through other legislative measures ie on infrastructure or vehicle standards, have been identified for the main transport fuel options up to 2030. Arguably to be effective low carbon fuels action in Europe should deliver against the following list, no matter what the final nature of the policy framework.

- **Fossil fuels** – measures to *support the choice of fuels to ensure that their GHG footprint declines over time or remains static* in line with wider decarbonisation priorities and measures that can help to *promote the availability of information* to inform decision making on appropriate fuel choices based on low carbon concerns;
- **Biofuels** – measures to provide a *clear basis for differentiating between biofuels and the risk* associated with their usage on an ongoing basis; to ensure *measures promoting biofuel uptake are not applied to high risk biofuels* ie those that deliver no or limited emission reductions or will result in unacceptably high risks for the broader environment and/or food prices;
- **Electricity** – for the *share of electricity in transport to increase and for electricity in the transport sector to be progressively renewable into the future*; this entails measures to support the wider availability of dedicated charging points to actively facilitate the wider penetration of electric vehicles; and measures to support policies aimed at the wider penetration of electric vehicles and their integration with renewable energy sources;
- **Hydrogen** – for the share of *hydrogen used in transport to increase and to be progressively renewable into the future*; measures to support roll out of dedicated fuelling infrastructure as vehicles come online; and measures to support policies aimed at the wider penetration of hydrogen vehicles.

The types of action on fuels listed above are often very different in terms of the change in behaviour necessary by key actors, the nature of the actors involved and the most appropriate monitoring basis for demonstrating compliance. As a consequence it is highlighted by this study that one single performance based measure covering all the different technological and fuel solutions is likely to be limited in its ability to consistently support a low carbon transition across the suite of fuels. The different nature of the fuels and energy sources that can be encompassed by the heading ‘low carbon transport fuel’ means that regulation with one tool and one associated system of measurement can prove problematic. In future there is a need to promote differentiation in the treatment of technologies and pathways to enable the whole suite of potential low carbon action in the transport fuel sector to be brought forward.

There are different mechanisms that could be employed at the EU level to address the question of how you might, therefore, allow for differentiation across the fuels

and the technologies encompassed within low carbon transport fuels. One option would be to provide a high level target, but express this in such a way that enables Member States to put in place a framework for support that facilitates differentiated compliance. There may, however, still be limitations including the ability to measure the comparability of approaches both across technologies and pathways, and across Member States.

Alternatively it could be imagined that a single binding requirement could be adopted at EU level but with differentiation based on the performance of fuels. The latter might be achieved by a number of means including: linking a credit/debit system to a target to provide increased flexibility and an alternative compliance pathway for specific fuels and technologies; or applying a system of multiple caps and targets based on delivery against a specific definition of 'performance'. Operating such systems at EU level could represent a regulatory challenge, however; examples internationally demonstrate the high level of intervention, support infrastructure and regulatory effort needed to administer such approaches.

A more direct way to deliver the needs and behavioural changes identified up to 2030 could be to avoid trying to integrate measures into one binding requirement for all low carbon transport fuel solutions. Instead coordinated but disaggregated intervention targeted at specific fuels could be required. Binding measures at the EU level would be aimed at delivering specific goals and priorities identified for each of the transport fuel categories over the appropriate time horizon

It is possible to identify, relatively robustly, the changes needed across the different fuels to deliver decarbonisation post 2020 and the policies needed to promote this. Given that 2030 is a relatively short time horizon, particularly in light of comparatively long investment cycles, it would be useful to send clear signals to the key actors in the fossil fuel, biofuel, electricity and hydrogen sectors regarding what is expected of them. This should be backed up with incentives and other support mechanisms sensitive to market dynamics. Setting out what individual transport fuel streams and associated actors need to deliver would increase clarity and consequently provide a basis for innovation and uptake of low carbon solutions.

Annex 1 - Exploration of the types of behaviour that would contribute to reducing the GHG emissions associated with the production of transport fuels and energy sources

The tables in this Annex support the discussion in sections 4.2 and 6.1. Table 7 provides an overview of the main actors involved, which could contribute to reducing the GHG emissions associated with the production of transport fuels and energy sources.

Table 7: Actors whose change in behaviour has the potential to reduce the GHG emissions associated with the production of transport fuels and energy sources

	Producer	Supplier	Seller	User
Fossil fuels	Company responsible for extraction of oil	Refiner; Importer	Fuel stations	Vehicle purchaser or user
Biofuels	Biofuel producer	Fossil fuel supplier (see above); Blender; Biofuel supplier (if not blended)	Fossil fuel seller (see above); Owners of biofuel filling stations	Vehicle purchaser or user; Purchaser or user of dedicated biofuel vehicle
Electricity	Electricity producers	Those providing electricity to dedicated, transport electricity-charging points	Owners of dedicated, transport electricity-charging points	EV purchaser or user; PHEV purchaser or user
Hydrogen	Producer of hydrogen	Those supplying hydrogen to dedicated, transport hydrogen filling stations	Owners of dedicated, transport hydrogen filling stations	FCEV purchaser or user

Table 8 contains, for each of the fuels and energy sources that are considered likely to play a role in powering the transport sector in the foreseeable future, associated GHG reduction objectives, the main behaviours that could deliver this behaviour and issues with regulating the respective behaviours in an EU policy framework for low carbon transport fuels and energy sources. This draws on the identification of the respective actors in Table 7. The issues do not cover those linked to identifying and measuring lifecycle emissions, as these were addressed generally in Section 6.2.

Table 8: Overview of the behaviours that have the potential to reduce the GHG emissions associated with the production of transport fuels and energy sources

	Objective	Behaviour	Issues
Liquid fossil fuels	Lowering the GHG emissions associated with fuel extraction and transport prior to refining	1) Oil companies to extract fuels using extraction techniques that emit fewer GHG emissions 2) Refiners to use feedstocks with lower	1) Activities largely undertaken outside of the EU, so direct regulation difficult 2) Refiners are in a position to choose from where they buy their crude oil 3) Not clear that there is sufficient information for fuel stations to make such choices.

		<p>associated GHG emissions</p> <p>3) Fuel stations to supply fuels with lower associated GHG emissions</p> <p>4) Importers to supply fuels with lower associated GHG emissions</p>	<p>4) It might be challenging for importers to identify the GHG emissions associated with the fuel that they purchase in the absence of improved information</p>
	<p>Lowering the GHG emissions associated with fuel production</p>	<p>1) Refiners to take action to refine fuels in ways that emit fewer GHG emissions</p> <p>2) Fuel stations to supply fuels with lower associated GHG emissions</p> <p>3) Importers to supply fuels with lower associated GHG emissions</p>	<p>1) Refiners are in the best position to affect how they refine crude oils</p> <p>2) Not clear that there is sufficient information for fuel stations to make such choices.</p> <p>4) It might be challenging for importers to identify the GHG emissions associated with the fuel that they purchase in the absence of improved information</p>
	<p>Reducing the use of liquid fossil fuels in the long-term</p>	<p>1) Users purchase less fossil fuels</p> <p>2) Users purchase more low (or zero) carbon biofuels</p> <p>3) Manufacturers to supply more fuel efficient vehicles, including vehicles capable of using electricity and hydrogen</p>	<p>1) Any action that makes fossil fuel vehicles more efficient or enables (or incentivises) these vehicles to be used less would indirectly deliver this behaviour; achieving this is probably best delivered by other policy mechanisms, not by fuel policy</p> <p>2) Users purchase dedicated biofuel vehicles, which is probably best stimulated by other policy mechanisms; action to increase the amount of low (or zero) carbon biofuels (see below)</p> <p>3) Fuel policy is an indirect way of encouraging manufacturers to supply more efficient vehicles, including EVs and PHEVs. Other EU policy targeting manufacturers directly – especially CO₂ standards for cars and other vehicles - is more important in this respect</p>
<p>Biofuels</p>	<p>Lowering the GHG emissions associated with production of biofuel feedstocks</p>	<p>1) Biofuel producers to source feedstocks produced in ways associated with low (or zero) GHG emissions</p> <p>2) Fuel stations to supply fuels with lower associated GHG emissions (as a result of its biofuels content)</p> <p>3) Importers to supply fuels with lower associated GHG emissions</p>	<p>1) Biofuel producers are in the position to choose feedstocks that have been produced in ways associated with low (or zero) GHG emissions</p> <p>2) Not clear that there is sufficient information (or indeed if it is possible) for fuel stations to make such choices</p>

		emissions	
	Lowering the GHG emissions associated with biofuel production	<p>1) Biofuel producers to take action to produce biofuels in ways that emit fewer GHG emissions</p> <p>2) Fuel stations to supply fuels with lower associated GHG emissions (as a result of its biofuels content)</p> <p>3) Importers to supply fuels with lower associated GHG emissions</p>	<p>1) Biofuel producers are in the best position to affect how they produce biofuels</p> <p>2) Not clear that there is sufficient information (or indeed if it is possible) for fuel stations to make such choices</p>
	Increasing the use of biofuels with low (or zero) associated GHG emissions	<p>1) Those responsible for blending biofuels with fossil fuels should use biofuels that have been produced in a low (or zero) carbon manner</p> <p>2) Owners of filling stations (including dedicated biofuel filling stations) should supply fuel that has low (or zero) associated GHG emissions (as a result of the blending of sustainable biofuels)</p> <p>3) Vehicle purchasers need to buy (and manufacturers need to supply) increased numbers of dedicated biofuel vehicles</p> <p>4) More biofuel with low (or zero) associated GHG emissions needs to be used in the transport sector</p>	<p>1) Biofuel blenders are in the best position to make choices about which biofuels they blend with fossil fuels</p> <p>2) Not clear that there is sufficient information (or indeed if it is possible) for fuel stations to make such choices</p> <p>3) Vehicle purchase is the target behaviour, not vehicle use; there are more direct means of encouraging the purchase of such vehicles than with fuels policy</p> <p>4) Short-term targets for such fuels might be appropriate, as they can displace fossil fuels in conventional vehicles; requirement would probably have to be on fuel suppliers</p>
Electricity	Decarbonising electricity generation	Electricity producers need to progressively decrease the carbon intensity of their electricity generation with the ultimate aim of generating all electricity from zero carbon fuels/energy sources	It is unlikely that fuel policy targeting the electricity used in transport would provide a sufficient incentive for electricity production more generally. However, being explicit that the aspiration to deliver from zero carbon and renewable resources into the future may provide clarity and support wider decisions on energy sourcing.
	Increasing the use of zero emission	1) Owners of dedicated, transport	1) Support for infrastructure investment is important but is also dealt with in other

	electricity in the transport sector	<p>electricity-charging points need to expand the network facilities available</p> <p>2) Owners of dedicated, transport electricity-charging points should supply electricity that has been generated from zero emission sources</p> <p>3) Owners of electric vehicles should use zero carbon electricity when charging their vehicles, e.g. at home</p> <p>4) Vehicle purchasers need to buy increased numbers of EVs or PHEVs</p> <p>5) Manufacturers need to supply increased numbers of EVs or PHEVs</p> <p>6) More (low or zero emission) electricity needs to be used in the transport sector</p>	<p>elements of EU policy. However, additional incentives from fuels policies may provide support for this.</p> <p>2) Owners of dedicated transport electricity-charging infrastructure are in a good position to choose from where they buy their electricity</p> <p>3) Owners of electric vehicles can choose to charge their vehicles using zero carbon electricity, but such behaviour would only be indirectly affected by EU fuel policy</p> <p>4) Vehicle purchase is the target behaviour, but there are more direct means of encouraging the purchase of such vehicles than fuels policy, eg subsidies or vehicle tax policy</p> <p>5) Fuel policy is an indirect way of encouraging manufacturers to supply more EVs and PHEVs. Other EU policy targeting manufacturers directly – especially CO₂ standards for cars and other vehicles - is more important in this respect</p> <p>6) Targets for the use of (low or zero emission) electricity in transport could be achieved either by having more vehicles or for the vehicles that exist to be used more; the former is probably best achieved through more direct means of encouraging the purchase of such vehicles than with fuels policy, while the latter is not necessary once the vehicles have been purchased</p>
Hydrogen	Decarbonising hydrogen production	Hydrogen producers need to progressively decrease the carbon intensity of their hydrogen generation with the ultimate aim of producing all hydrogen from zero carbon fuels/energy sources	It is unlikely that fuel policy targeting the hydrogen used in transport would provide a sufficient incentive for hydrogen production more generally.
	Increasing the use of zero emission hydrogen in the transport sector	<p>1) Owners of dedicated, transport hydrogen filling stations should supply hydrogen that has been generated from zero emission sources</p> <p>2) Vehicle purchasers need to buy (and manufacturers need to supply) increased numbers of FCEVs</p> <p>3) More (low or zero emission) hydrogen</p>	<p>1) Owners of dedicated transport hydrogen filling infrastructure are in a good position to choose from where they buy their hydrogen</p> <p>2) Vehicle purchase is the target behaviour, not vehicle use; there are more direct means of encouraging the purchase of such vehicles than fuels policy, such as CO₂ standards for cars and other vehicles</p> <p>3) Targets for the use of (low or zero emission) hydrogen in transport could be achieved either by having more vehicles or for the vehicles that exist to be used more; the former is probably best</p>

		needs to be used in the transport sector	achieved through more direct means of encouraging the purchase of such vehicles than with fuels policy, while the latter is not necessary once the vehicles have been purchased
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