DfT Low Carbon Fuels Strategy: Call For Ideas
Zemo Partnership Response

Zemo Partnership, previously known as LowCVP and established in 2003, is a public-private partnership working to accelerate the transition to zero emission and sustainable transport in the UK. Around 200 organisations are engaged as members from diverse backgrounds including automotive and fuel supply chains, vehicle users, academics, environment groups and others. The Partnership became a not-for-profit company limited by guarantee in April 2009 and receives roughly half its funding as a direct grant from the DfT, together with funding directly from member companies. This response is from Zemo Secretariat to the DfT Low Carbon Fuels Strategy: Call For Ideas. Engagement has been made with Zemo's Fuels Working on formulating this response.

Executive Summary

1) Surface transport will require an estimated 73% reduction to achieve the Government's 2035 economy wide GHG emission reduction target, and the CCC's 2050 net zero pathway. The next thirteen years are critically important for accelerating the pace, and scale, of GHG emission abatement from the road transport sector.

2) The Low Carbon Fuels Strategy (LCFS) should be ambitious and lay down a roadmap, and accompanying policy framework, that stimulates the concurrent supply and demand of sustainable low carbon fuels. A priority should be to increase the current RTFO target and extend this beyond 2032. The RTFO target should evolve into a GHG emission intensity-based target over time to maximise GHG emission reduction. This will be especially important as the volume of fossil fuel decreases markedly post 2035.

3) The LCFS should pay close attention to the role of sustainable low carbon fuels in decarbonising heavy duty vehicles and off highway sectors, which are challenging to electrify in the 2022–2030 timeframe. This includes long-haul HGVs, coaches and NRMM. These sectors are high consumers of diesel. Zemo modelling has shown that limited reduction in diesel volumes will materialise in these sectors over the next decade: accelerating the uptake of higher blends of biofuels in ICE HDVs and NRMM will be a key opportunity for surface transport decarbonisation. The RTFO target must be increased for this to materialise.

4) The legacy diesel fleet will require decarbonising up to 2050 as the speed of transition to zero emission propulsion technologies will materialise a much slower pace for certain heavy duty segments. This demonstrates that a long-term vision for the use of low carbon fuels in road transport fuel will be necessary.

5) The LCFS should not neglect opportunities to scale up GHG emission reduction in the light duty vehicle ICE fleet. Whilst electrification of this sector is gaining momentum, the legacy fleet will require decarbonisation post 2030. Given the large contribution that cars and vans make to UK road transport GHG emissions, further efforts to increase the bio-content of retail petrol and diesel should be exploited. A key opportunity could be through drop-in diesel and gasoline.

6) LCFS should avoid diverting biomass feedstocks (waste lipids) from the road transport sector to SAF too quickly. Attention should be given to addressing GHG reduction in the most challenging heavy duty vehicle segments, then moving to aviation and marine.

7) The LCFS should take a technology neutral approach and recognise the WTW GHG emission performance benefits of liquid and gaseous fuel in ICE and plug-in hybrid powertrains.

8) Encouraging the expansion of supply chains for drop-in renewable diesel in the UK will be important for decarbonising HDV and NRMM, and alleviating concerns related to fuel security. This could materialise through supporting the establishment of dedicated production plants and/or producing drop-in diesel as a by-product from the manufacture of SAF.

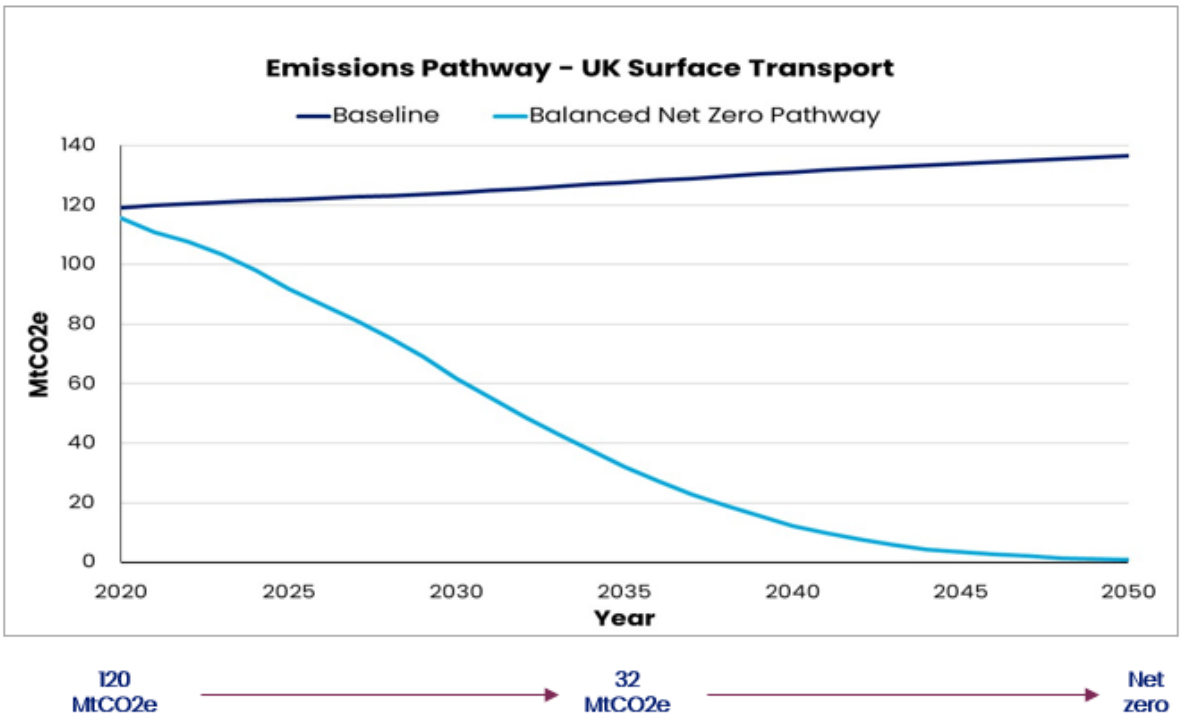
9) The LCFS should include interventions that will help alleviate various demand side barriers that are precluding the wider take up of higher blends of renewable fuels in HDV and NRMM sectors – recommendations include:

- Introducing fiscal incentives to stimulate the greater adoption of higher biofuel blends; this could be delivered through a reduction in fuel duty for higher blends of renewable diesel (HVO and FAME).
- Recognising Zemo's Renewable Fuels Assurance Scheme as a supportive mechanism working alongside the RTFO to provide assurance of the lifecycle GHG emission and feedstock sustainability of low carbon bunkered fuel used by commercial vehicles and NRMM operators.
- Collaborating with heavy duty vehicle manufacturers to expand the range of engine models that are approved for running on higher blends of biodiesel (B20/B30).
- Develop an infrastructure roadmap to support the adoption of low carbon liquid and gaseous fuels (including biofuels and hydrogen).

Chapter 1 – Introduction

Following COP26, the Government announced ambitious UK economy wide GHG emissions reduction targets for 2030 (68%) and 2035 (78%). Figure 1 shows the Climate Change Committee's (CCC) 'balanced net zero GHG emissions pathway' for UK surface transport[1], from which it can be estimated that a reduction in GHG emissions of around 73% is required between now and 2035.

Figure 1: CCC 6th carbon budget surface transport GHG emission projections to 2050



CCC estimates in their 6th Carbon Budget analysis, that about 96 million tonnes of GHG emission abatement is needed for UK surface transport by 2035, rising to about 136 million tonnes by 2050. This level of reduction will not materialise without bolder targets and measures related to sustainable low carbon fuels. The LCF strategy subsequently needs to be ambitious, recognising the urgency in near and medium term GHG emission reduction and the critical role of sustainable low carbon fuels in surface transport decarbonisation. Measures to de-fossilise both the light and heavy-duty fleets will be vital, exploiting conventional biofuels and more advanced low carbon fuels.

It could be highly valuable for DfT to consider the abatement required for different transport sectors to meet net zero GHG emission by 2050, and what contribution sustainable low carbon fuels make towards this reduction. The 2022–2035 period is an extremely important period for ramping up cumulative GHG emission abatement. Consideration should be given

[1] Six ways to explore the Sixth Carbon Budget dataset - Climate Change Committee (theccc.org.uk)

the CCC's carbon budgets, specifically CB5 and CB6, and exploring what contribution sustainable low carbon fuels can deliver in terms of sizable GHG emission savings. Identifying how to rapidly increase GHG emission reduction over the next decade is particularly relevant.

A 'low carbon fuels roadmap' could feature as part of the LCFS showing how a portfolio of low carbon fuels will be deployed across transport sectors and propulsion systems[2]. This needs to include higher blends of renewable fuels in incumbent ICE powertrains for different road transport sectors.

The strategy needs to take a pragmatic perspective on the speed of adoption of zero emission propulsion systems, and associated energy vector supply chains and infrastructure roll out – especially hydrogen and electricity. The strategy should reveal how the volumes of petrol, diesel and kerosene will change over the next three decades, considering the transition of different sectors to zero emission propulsion systems. This will enable the scale of fossil fuel decarbonisation to be determined, and subsequently identifying how sustainable low carbon fuels can maximise GHG emission abatement. It is essential that GHG emission reduction over the next decade is accelerated, and attention is given to road transport sectors that are challenging to electrify and have lengthy operational lifetimes, specifically long-distance HGVs, coaches and NRMM. DfT needs to be cognisant that diesel powertrains will remain operational in the road transport sector in the 2040 to 2050 timeline, and possibly longer. Decarbonising the legacy diesel fleet should feature strongly in the LCFS.

Attention should be given, as soon as possible, to easily addressable markets and transition over time as demand shifts e.g. light duty to heavy duty to aviation. The strategy should recognise that SAF plants can serve as 'sustainable fuel refineries' and produce a slate of low carbon fuels that can benefit the economy. These include drop-in diesel and gasoline, bio-naptha, bio-propane; these will vary depending on the SAF pathway. Other sectors that would value these products include the chemicals industry and off grid heating.

In preparing the LCFS DfT may wish to consider the potential risk of the transition to zero emission vehicles taking longer than anticipated. If the CCC's projections are not achieved, sustainable low carbon fuels will have a much bigger role to play in surface transport decarbonisation. Recognised battery supply chain industry experts have recently revealed the rising cost of raw materials such as lithium, cobalt and nickel, are impacting battery prices[3]. A more concerning issue is the fact that demand for electric vehicles is forecast to outpace the supply of lithium over the next 8 years. Lack of supply is not due to geological constraints, but limited investment in lithium mining[4]. There is then the issue of availability of public refuelling/charging infrastructure for both light and heavy duty zero emission vehicles (battery electric and HFC/H2ICE). Whilst this is gaining momentum for cars and vans, it is absent for HDVs.

[2] Transport Energy Network - Cross sector energy and propulsion roadmaps APC/Zemo 2020

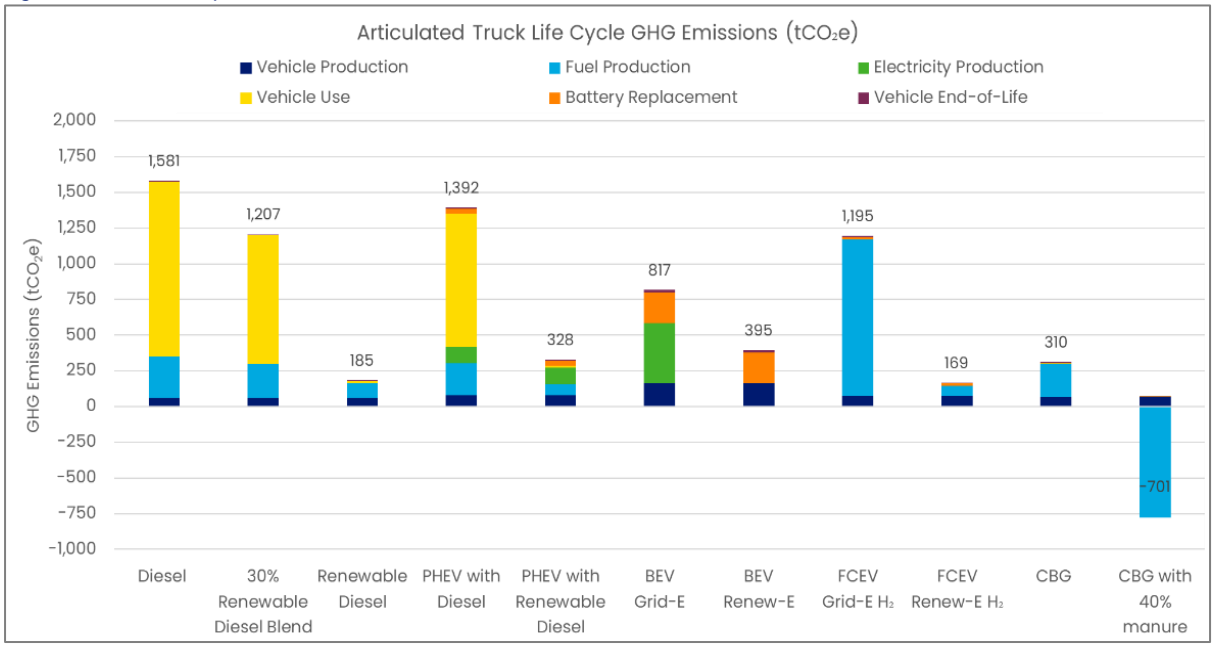
[3] Battery, EV producers grapple with record-high prices due to ongoing raw-material supply crunch - Fastmarkets

[4] Carmakers will "need to become miners" – Benchmark Minerals

Finally, it is extremely important that the LCFS recognises the WTW GHG emission performance of renewable fuels in ICE and hybrid powertrains, in conjunction with zero emission propulsion technologies. A technology neutral approach should be taken to decarbonising surface transport: a variety of technology and fuel solutions will be necessary to achieve deep cuts in GHG emissions. Figure 2 shows life cycle GHG emissions for an articulated truck. Sustainable low carbon fuels in ICE HGV, and plug-in hybrid HGV, can offer significant reductions in GHG emissions compared to a diesel truck, and can achieve similar or better performance to BEVs (Battery Electric Vehicles) using current UK grid electricity. CBG (Compressed Biomethane Trucks) using biomethane produced from manure can give negative GHG emissions by utilising manure 'credit' for methane as per REDII. Zemo members suggest the DfT should explore the integration of WTW GHG emission metrics in the HGV CO2 regulations, where renewable fuel use could be associated with carbon credits.

The LCFS should aim to drive on-going improvements in life cycle GHG emissions associated with biofuel, RFNBO and RCF supply chains, and maintaining robust sustainability performance criteria for renewable fuel feedstocks. The LCFS should lay the foundations for a harmonised approach for measuring and reporting fuel life cycle GHG emission metrics, and sustainability criteria. This should be reflected in cross cutting Government policy areas related to low carbon fuels.

Figure 2: Zemo life cycle GHG emissions for an articulated truck



Chapter 2 – LCF Demand

Over the past two years Zemo has maintained strong engagement with HDV and NRMM stakeholders, with regards to understanding key market barriers, interventions and current adoption rates of different renewable fuels. This includes individual fleet operators, and trade bodies and forums such as Logistics UK, Road Haulage Association, Constructure Plant Hire Association, the Retail Energy Forum, CPT. The following information could be valuable for DfT to consider in the development of the LCFS.

- Approximately 1500 gas trucks running on biomethane are operational across the UK, with public infrastructure expanding year on year. There is growing demand for biomethane in the long-haul truck market: it is perceived as a cost-effective decarbonisation solution. The LCFS should recognise biomethane as a viable solution for decarbonising HGV and see the added value of manure as a feedstock, in terms of HGV achieving net zero today. The commitment to reduce fuel duty for methane should be maintained to 2032. Government could consider a lower price differential for biomethane to reduce fossil methane use.

- Approximately 70% of RTFO approved HVO is being deployed in the NRMM sector, mainly construction equipment, with the remaining used in HGVs. There is growing demand for drop-in fuel such as HVO in the HGV and NRMM sectors. With regards to HVO there are concerns regarding the security of supply in the UK and its cost premium. There is also some unease regarding feedstock sustainability. Very few companies, and local authorities, are aware of the RTFO and its associated sustainability criteria for low carbon fuels.

- The UK coach market is struggling to find cost effective decarbonisation solutions at present, sustainable low carbon fuels are a key opportunity. There is strong demand for drop-in renewable diesel. HVO is the only product on the market, but this is perceived as being too expensive and lacks any financial support for commercial fleet operators by Government.

- The NRMM sector is very challenging to decarbonise, with limited affordable technology options on the market. Equipment lifetimes can be lengthy, over 20yrs. Sustainable low carbon fuels are therefore a key opportunity for this sector. There is an absence of low carbon policy direction for this sector, the LCFS could help fill this gap.

- Small operators in the HGV, coach and NRMM sectors run their businesses on very low financial margins. They require financial assistance to decarbonise their vehicle and equipment fleets. At present the absence of any fiscal incentive for renewable diesel from Government is impinging their ability to move away from diesel.

- There is continued demand for information pertaining to fuel lifecycle GHG emissions performance, and feedstock provenance of biofuels. Scrutiny of product supply chains is increasing, both in private and public sectors. This includes the use of renewable fuels in organisation's own and contractor's vehicle fleets and equipment (NRMM). Zemo's Renewable Fuels Assurance Scheme[5] is playing a pivotal role in assuring claims made by renewable fuels suppliers (biofuel and hydrogen) with regards to their low carbon fuel supply chains. Zemo would like to propose that the LCFS acknowledges RFAS. The demand of sustainable low carbon fuels is highly influenced by fleet operators having confidence in these fuels in terms of their environmental performance.

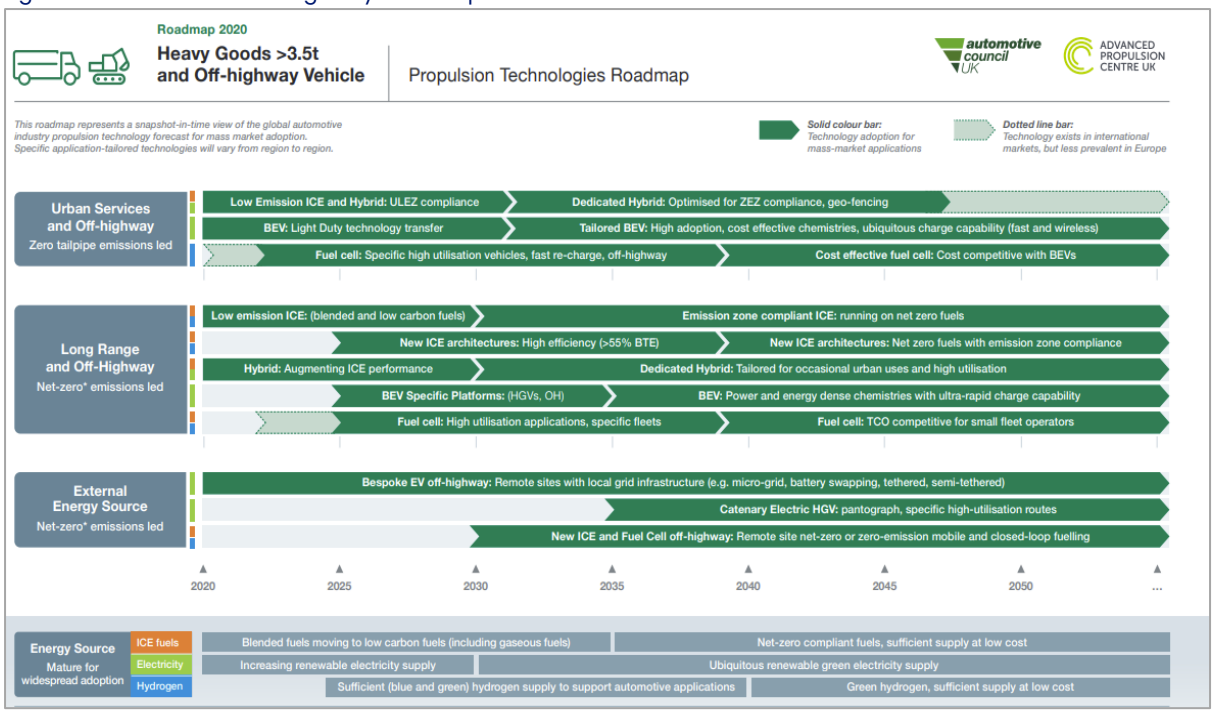
- HDV and NRMM stakeholders perceive sustainable low carbon fuels to offer valuable opportunity for surface transport decarbonisation, especially as the market for zero emission technologies, and associated infrastructure, is in its infancy. Low carbon fuels are not considered a competing solution, on the contrary, a complimentary pathway in the roadmap to meeting net zero. The lengthy timeline for switching to zero emission vehicles has frequently been cited, and the subsequent need for an affordable, and easily deployable, interim solution to reduce GHG emissions. This point is extended in the next section.

Demonstrating the critical role of low carbon fuels in decarbonising HDVs and NRMM

There are significant challenges in electrifying HGVs, coaches and NRMM sectors in the short to medium term, a portfolio of technological solutions will be required for different applications over the next three decades. The timelines for commercialisation are important. Figure 3 shows that long range HGVs and off-highway applications will take longer to switch to zero emission propulsion technologies. The same issue applies to coaches who share similar duty cycles, and product development, to HGVs. Although the Government has announced phase out dates for non-zero emission HGVs (2035 for rigid trucks and 2040 articulated trucks), significant volumes of diesel will remain in the HGV fleet over the next ten years. This presents a prime opportunity for sustainable low carbon fuels in terms of GHG emission reduction. A key pathway is exploiting the use of higher blends of biofuels in ICE HGV. This includes biomethane in artic gas HGV, FAME and paraffinic fuels in diesel HGVs. It is also worthwhile highlighting that diesel HGVs will remain in the UK fleet beyond 2040: tackling the legacy diesel HGV will be vital for longer term GHG emission reduction in road transport.

[5] Renewable Fuels Assurance Scheme | Fuels | Zemo Partnership

Figure 3: APC HGV and off-highway roadmap to 2050



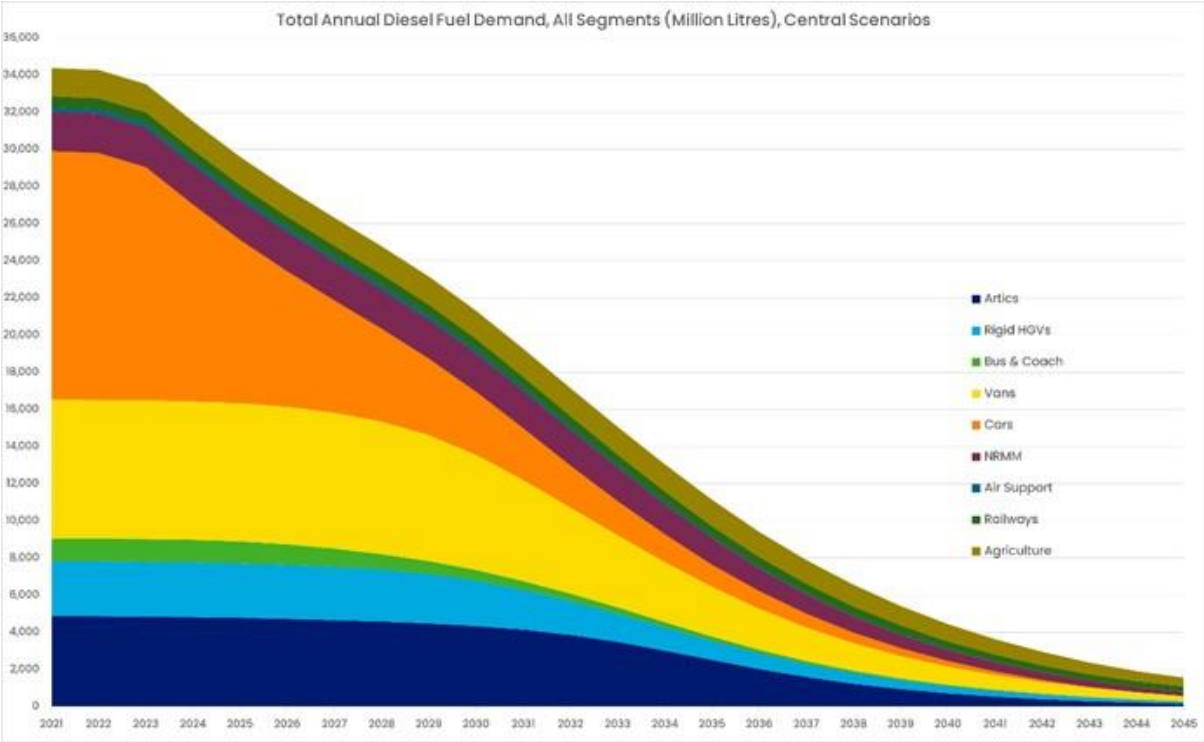
Zemo has developed a fuel demand model to determine how much diesel fuel is currently used in the HDV and NRMM sectors (plus agriculture, rail and air support), and how that demand will reduce over time as zero emission technologies permeate the fleet. This has formed part of Zemo's work related to developing a proposal for a renewable diesel fiscal incentive for HDVs and NRMM (near completion). The modeling work accounted for diesel ICE phase out dates and vehicle / plant lifetimes, as well as considering three scenarios for new ZEV sales: market enthusiasm, a central scenario and market reluctance. Zemo is open to sharing their model, and background assumptions, with DfT for any analysis related to the LCFS development.

Figures 4 illustrates the outputs of the HDV fuel demand model (central scenario). In total, annual diesel fuel demand across the nine sectors is projected to fall from its current 34 billion litres to between 20 and 24 billion litres in 2030, and then more steeply to around 8-14 billion litres by 2035, just 2–7 billion litres by 2040 and 1–3 billion litres by 2045. The analysis reveals that from 2022 to 2032 a colossal volume of diesel remains in the HDV fleet. For HGV's an estimated 8 billion litres of diesel will remain in the fleet over this period. Sustainable low carbon fuels (biomethane, higher blends of biodiesel, and drop-in paraffinic diesel) offer an immense opportunity to reduce GHG emissions in the incumbent heavy duty ICE fleet.

To completely 'de fossilise' the HGV, coach and NRMM sectors, sustainable low carbon fuels will need to play a long-term role in road transport decarbonisation. Whilst the CCC, and Government, highlight the need to reserve biomass resources for the aviation sector (and BECCS), care needs to be exercised to avoid creating stranded assets for UK biofuels suppliers. The LFC strategy should additionally avoid creating a policy landscape that diverts biogenic waste lipid feedstocks from renewable fuels used in road transport to SAF

too quickly. The most effective use of this biomass resources over the next decade is to mitigate GHG emissions from HDV, and NRMM sectors.

Figure 4: Zemo modelling of diesel demand across different road transport sectors

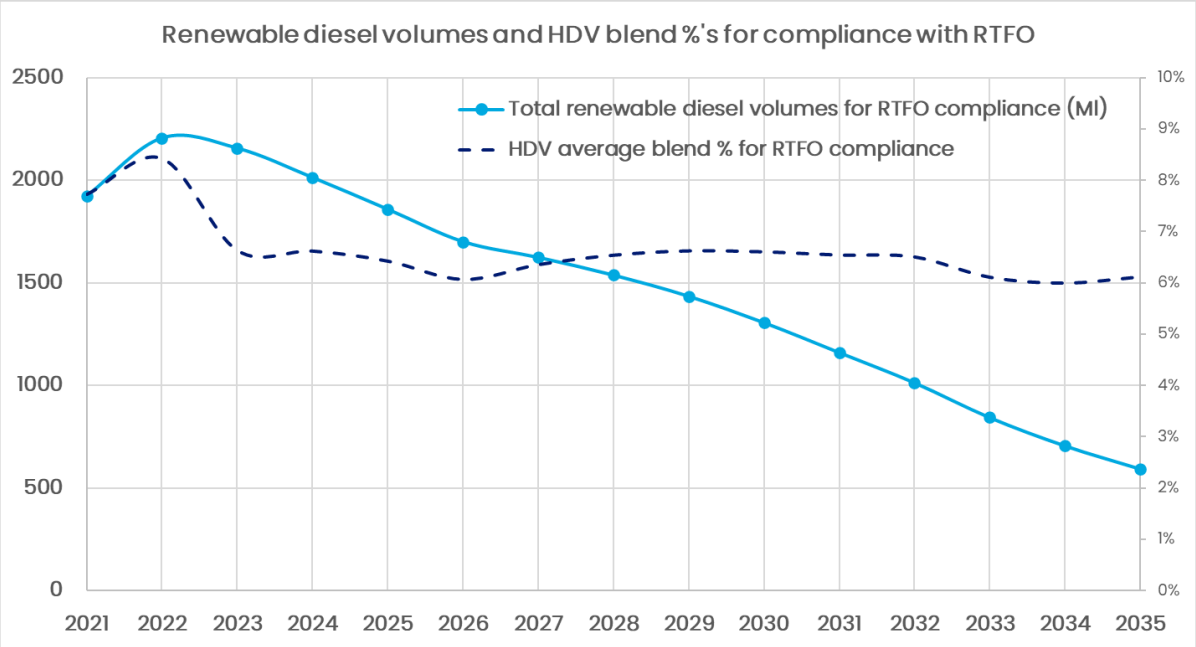


Exploring opportunities for higher blends of renewable fuels

Impact of current RTFO target

Zemo have used their fleet model to assess the effect of the RTFO on the overall supply of renewable diesel. Our modelling (Figure 5) suggests that the current RTFO targets, even as they gradually rise in percentage terms between now and 2032, are likely to lead to an immediate and gradual decline in overall volumes of renewable diesel supply. In effect and in simple terms, the rate at which cars will cease to need diesel fuel (as they rapidly transition to non-diesel alternatives) looks set to out-pace the quite modest increases in the RTFO target percentages. The figure also shows how demand remains for renewable diesel in the heavy-duty vehicle and NRMM fleet (after allowing for E10 petrol and B7 diesel for all light-duty vehicles and some growth in bio-methane usage for articulated HGVs) represents only around 6-7% average blend over the modelled period. In effect, this modelling strongly indicates that the existing RTFO target will be met simply through E10 petrol and B7 forecourt diesel; there is little or no incentive currently to go beyond B7 in the heavy-duty vehicle and/or NRMM fleets.

Figure 5: Zemo modelling of HDV renewable diesel % blends and volumes to comply with the RTFO target



Our engagement with freight transport operators and users of NRMM, however, suggests there is a significant appetite amongst them to make more extensive use of renewable diesel fuels as part of their decarbonisation strategies. Any diesel-powered vehicle or machine can make use of HVO without modification, as this is a warrantied drop-in substitute for conventional diesel fuel. Many can also run without modifications on FAME biodiesel blends of up to B20. B30 blends can be used with generally only quite minor modifications to vehicles/machines and fuel storage infrastructure. Blends up to B100 (fully renewable biodiesel) are also possible in many cases, albeit with generally more extensive modifications to vehicles and infrastructure being required.

Scenarios for increasing renewable diesel take up

Zemo have modelled four alternative scenarios for increasing the uptake of renewable diesel in the HDV and NRMM fleets. The results are presented here in terms of both overall supply volumes (in millions of litres, Ml) and average blend percentages for HDV/NRMM fleets. It is important to note, however, that these average blend percentages do not necessarily mean all such vehicles would run on a blend of that percentage, i.e. for example a 20% average blend does not mean all vehicles would run on B20. The model simply presents the overall fleet average; individual fleets may use B20, B30, HVO, B100 or B7 or any combination of those. (Within our analysis we have assumed that 15% of new artic HGVs switch to gas trucks running on 100% biomethane by 2032; this was agreed Zemo members).

The average blend percentages for each scenario are presented in two ways. First, assuming the renewable fuel is used across all the modelled HDV and NRMM sectors (HGVs, buses, coaches, air-support vehicles and NRMM) and second assuming it is just used by HGVs (and the other HDV/NRMM sectors use pump-average B7 only).

The first two of these scenarios (labelled Scenarios 1A and 1B) are based on retaining or slightly increasing the overall supply volumes, largely by assuming the renewable fuel volumes no longer needed for light-duty vehicles (as the B7 blend wall is reached and overall volumes needed by such vehicles decline) are re-assigned to the HDV and NRMM sectors. These scenarios effectively ignore any constraints imposed by the RTFO, other than using the existing RTFO to define a sustainable level of overall renewable diesel supply volumes.

For Scenario 1A, the peak volumes of renewable diesel to be supplied under the existing RTFO described in the preceding section (2,200 Ml in 2022) are then held constant throughout the remaining modelling period, to 2035. Any "spare" renewable diesel not needed for B7 compliance in the light-duty vehicle fleets (cars and vans) is then modelled in terms of its effective average blend percentage if fully used by the HDV and NRMM fleets. Scenario 1B goes slightly further by assuming a gradually increasing additional supply of HVO into the UK market. There are already plans in place to increase the supply of HVO for the European market by 5 billion litres over the next five years or so. Scenario 1B assumes that the UK can ultimately capture up to 10% of this additional supply capacity. On top of the 2,200 Ml of renewable diesel assumed for Scenario 1A, Scenario 1B increases this in 100 Ml increments from 2023 to 2,700 Ml in 2027. Supply is then held constant at this level until 2035.

The second set of scenarios (labelled Scenarios 2A and 2B) assume that higher levels of renewable diesel fuel supply can be achieved through further modifications to the RTFO, i.e. increasing the targets. In scenario 2A, we model the RTFO targets to increase from their current 11% in 2022, in 1% increments to 21% in 2032 (and then remain at 21% until 2035). Scenario 2B uses exactly the same RTFO targets out to 2032 but then assumes they continue to increase between then and 2035, and at a faster rate; 25% in 2033, 30% in 2034 and 35% in 2035. These Scenario 2B target values have been chosen to align with a trajectory that would ultimately mean full diesel fuel decarbonisation of the HDV and NRMM fleets by 2040 (the phase-out date for all new non-zero emission HGVs), i.e. sufficient renewable diesel supply to mean no fossil-derived diesel fuel would be needed for such vehicles/machines by that time. This would be a full decade ahead of the full fleet decarbonisation that would be achieved relying solely on the uptake of new zero emission equipment from 2040.
The above four scenarios modelled are summarised in Table 1.

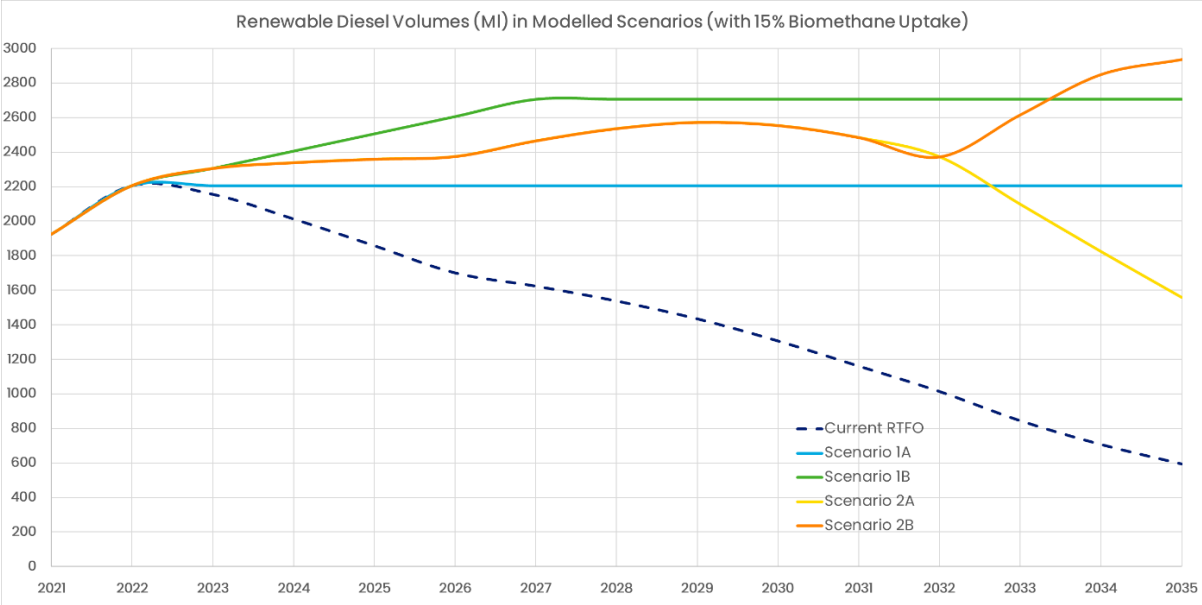
Table 1. Alternative scenarios for increasing uptake of renewable diesel fuel

Scenario	Description
Scenario 1A	Peak supply volumes determined by current RTFO (2,200 Ml) held constant to 2035
Scenario 1B	As 1A but with additional 500 Ml of supply, based on 10% of new European HVO capacity
Scenario 2A	Increase RTFO targets, ultimately to 21% in 2032 (15% under current RTFO)
Scenario 2B	As 2A but increase targets further after 2032, ultimately to 35% in 2035

Modelling results from alternative scenarios

The modelled volumes of renewable diesel to be supplied under each scenario (for all road transport not just the HDV and NRMM sectors) are shown in Figure 6.

Figure 6. Overall renewable diesel supply volumes, modelled scenarios



Supply volumes under all the modelled scenarios do not exceed 3 billion litres in the period modelled to 2035, meaning even under the most ambitious scenario (2B) volumes in 2035 amount to no more than 50% above the volumes already being supplied to the UK in 2021/22. With the assumption that these current volumes are entirely sustainable and involve no major conflicts for bio-energy resources with alternative usage sectors, this modest level of increased supply, over a period of more than a decade, should, we believe, also be readily achievable sustainably. The highest growth rate for renewable diesel supply derives from Scenario 1B (rising by 100 Ml per year to 2.7 billion litres in 2027). This, too, is believed to be wholly achievable in a sustainable way; renewable diesel supplies, for example, are reported by the RTFO[6] to have grown by roughly double this amount in the five-year period from 2014 to 2019, so our modelling is not suggesting anything outside of the bounds of what has already recently been achieved.

The effects of these modelled overall supply volumes on average blend percentages within the HGV and/or HDV & NRMM sectors (with all other diesel-consuming sectors assumed to be fixed at B7) are shown in Figures 7 and 8.

If all "spare" renewable diesel is directed specifically at the HGV sector (Figure 7), average blend percentages would increase under Scenarios 1A, 1B and 2B to somewhere in the range 50–65% by 2035. In Scenario 2A, which freezes the 2032 RTFO target out to 2035, the average blend gets to a little under 25%. While the modelling does not distinguish between FAME biodiesel and HVO, these high average blends in the early 2030s suggest either a

[6] https://www.gov.uk/government/collections/renewable-fuel-statistics

widespread uptake in drop-in HVO usage or a significant programme of vehicle and infrastructure modifications would be needed across the HGV operator community to accommodate biodiesel blends of B30–B100, or some combination of the two. In all the modelled alternative scenarios, average blend percentages in the 2020s increase quite modestly, to around 20-25%.

If the additional renewable diesel volumes are used over a wider market, embracing all heavy-duty vehicles and NRMM sectors, the average blend percentages would, naturally, be slightly lower than for the HGV sector alone. For this situation, Scenario 2A would achieve an overall average blend of only around 18% in the 2032-35 period. In the other scenarios modelled, the blend percentages increase to more like 35–45% by 2035 (Figure 8).

Figure 7. Modelled average blend percentages for increasing supplies of renewable diesel to HGVs only

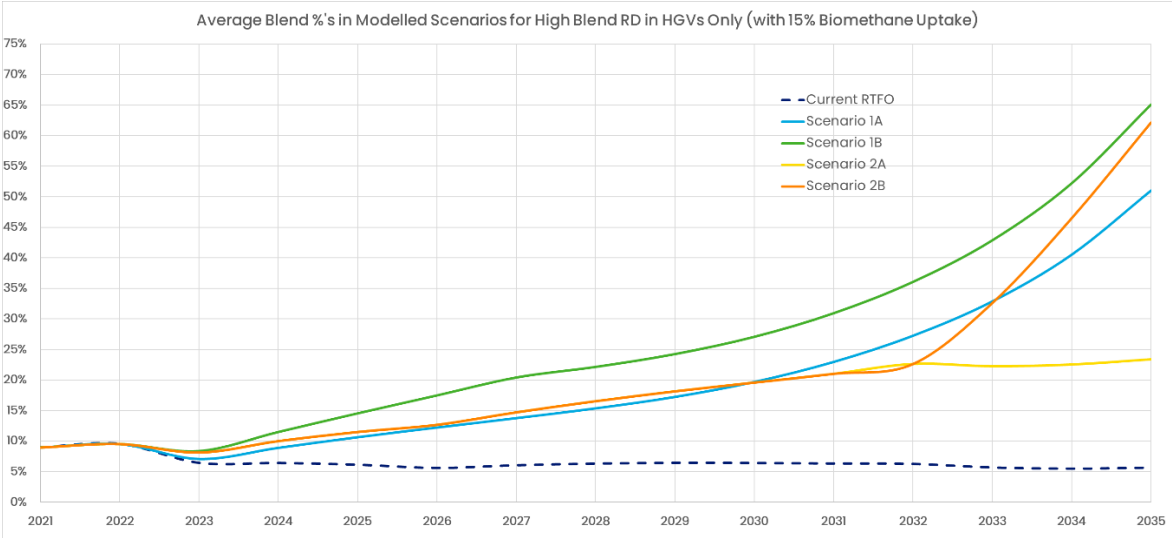
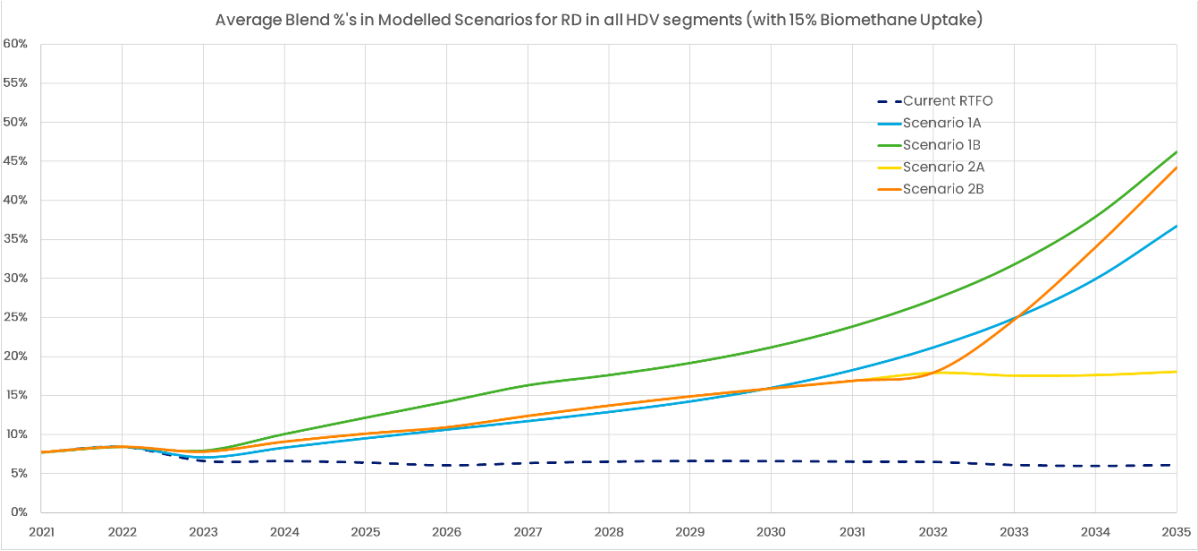
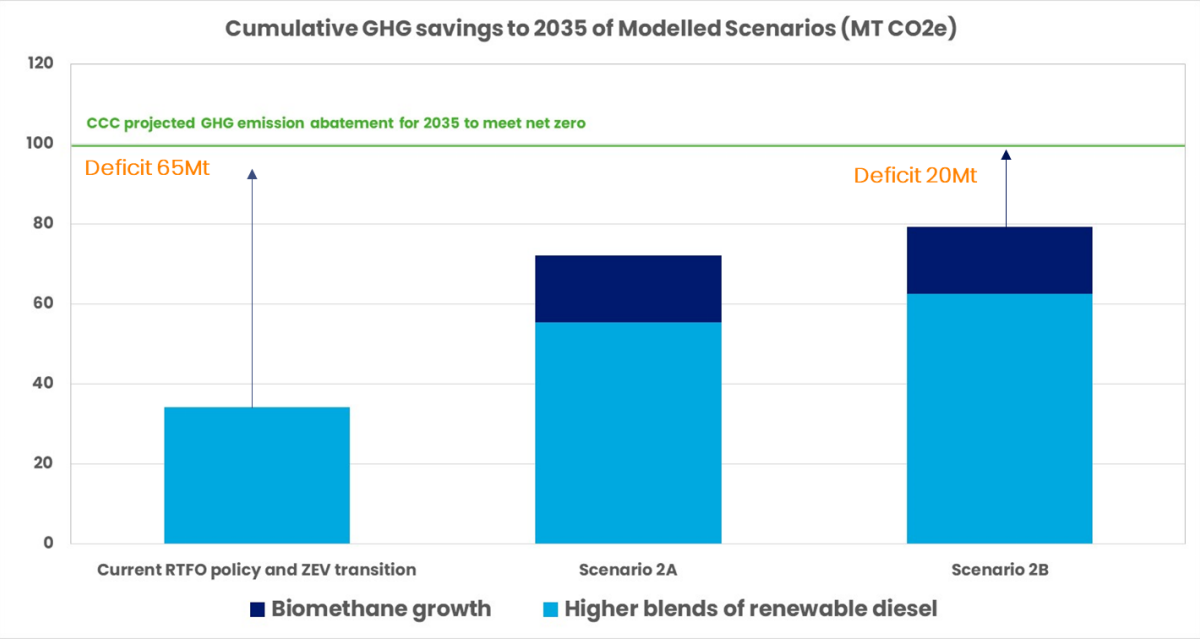


Figure 8. Modelled average blend percentages for increasing supplies of renewable diesel to HDV & NRMM



The adoption of higher blends of renewable fuels (biomethane and renewable diesel) in HGVs could deliver significant additional GHG savings over the next 13 years, see Figure 9. CCC's projected GHG emission abatement for HGV (100mt) by 2035 will be challenging to achieve without low carbon fuels. Zemo strongly suggests DfT includes demand side analysis scenarios that include higher blends of renewable fuels in HGVs.

Figure 9: Maximising GHG emission reduction in HGVs using higher blends of renewable fuels



Zemo recommends development of the LCFS demand scenarios consider the following -

- Take insights from industry led technology and product roadmaps (e.g. APC HGV and off highway product roadmaps) for different transport sectors between 2020 and 2050 to determine realistic commercialisation rates for zero tailpipe emissions technologies. This should also include 'end of sale' dates for ICEs for different vehicle and equipment segments. This will form the basis of determining how the volume of diesel, petrol and kerosene will change over the next three decades.

- Be ambitious and determine the cumulative GHG emission savings that could be achieved by 2030, 2040 and 2050. It is essential that demand scenarios account for the full spectrum of road transport applications that use fossil fuels, in particular focus on hard to 'electrify' sectors e.g. long distance HDVs (coach, trucks), NRMM.

- Account for a range of sustainable low carbon liquid fuels to decarbonise diesel use in HDV and NRMM including biodiesel, paraffinic fuels (HVO, BTL) and recycled carbon fuels in the 2022 to 2050 timeframe. Work undertaken by Zemo suggests DfT should explore demand scenarios for higher blends of renewable diesel across HDV and NRMM, ranging up to an average 18% by 2032 and 50% by 2040.

- Account for increased demand of biomethane in artic HGVs. Work undertaken by Zemo, and engagement with members, suggests 15% of new artic HGV sales could shift to biomethane trucks by 2030.

- Determine the volume of renewable hydrogen required to achieve CCC's 6th Carbon Budget scenarios e.g. hydrogen vehicles 7% new vehicle sales by 2030 and 33% 2040. Consideration should be given to H2ICE as well.

Chapter 3 LCF Supply

The LCFS should explore the following items with regards to stimulating low carbon fuel supply chains for road transport.

Opportunities for UK production of drop-in renewable diesel
Increase opportunities for domestic supply chains of drop-in renewable diesel, this could be via SAF roll out. Other opportunities could exist through RCF and renewable synthetic fuels (e-fuels). Legacy diesel HDVs and NRMM, would be a key market for drop-in diesel, all be it the numbers of diesel vehicles will significantly reduce from 2040 onwards.

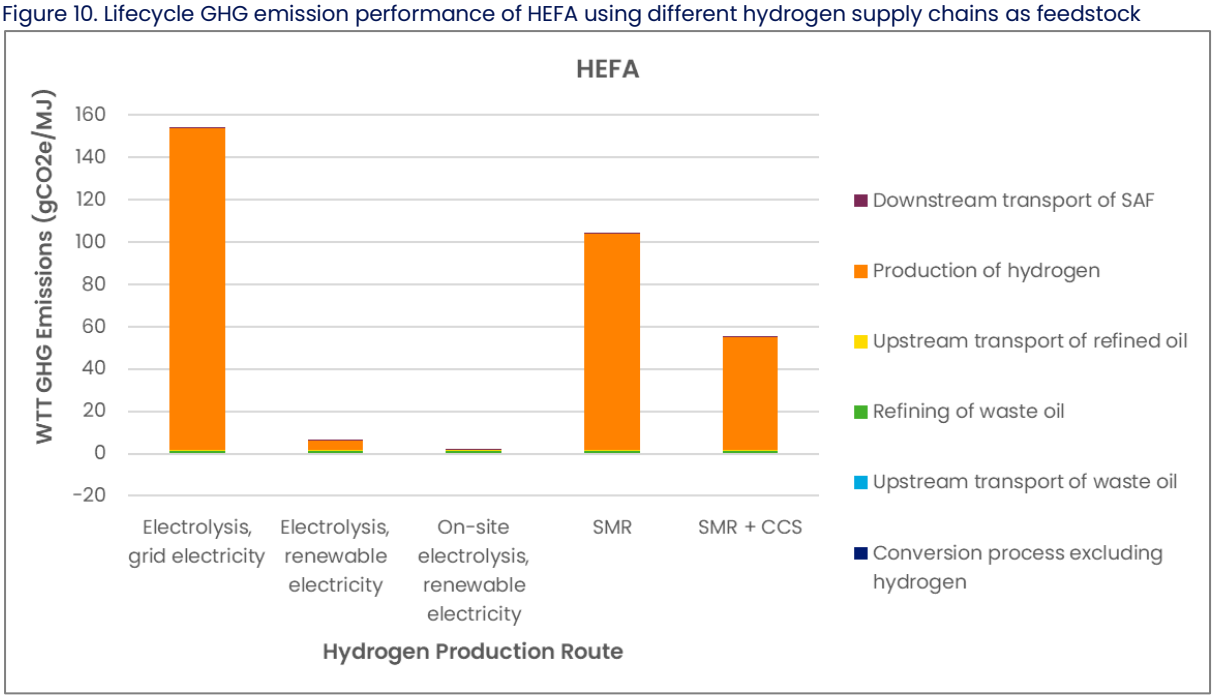
Opportunities local biomass feedstocks
Most biomass in the UK is sourced from overseas. The LCFS should look at what can be done in the UK, particularly localised energy sources such as small dairy farms (manure) and fats/greases. These bioresources are going to waste and should be harnessed now.

Maxisimising the bio-content of gasoline through advanced gasoline
Bio-derived gasoline can be made through ethanol-to-gasoline or methanol-to-gasoline type processes. Increasing the bio-content of petrol can be materialised beyond the blend wall through the use of advanced gasoline (a drop-in fuel). Opportunities should be explored to establish such production plants in the UK.

Hydrogen use for SAF production and demand in road transport
DfT should ensure that SAF pathways requiring hydrogen as a feedstock provide evidence of the use of 'low carbon hydrogen'. Zemo has undertaken a high-level analysis of the impact of different hydrogen supply chains on the life cycle GHG emissions for HEFA. We have used hydrogen GHG emission data from Zemo's WTT Low Carbon Hydrogen Pathways Study and JEC Concawe data for HVO production. Hydrogen is assumed to be delivered to the SAF plant unless stated as 'on-site'. As Figure 10 shows low carbon hydrogen is imperative for HEFA to achieve SAF status.

Zemo would like to propose DfT introduces a GHG emission threshold for low carbon hydrogen used in SAF, this should be based on a lifecycle metric (not just production). Zemo suggests a threshold being a 65% GHG emission saving compared to a fossil fuel comparator of 94gCO2e/MJ (lifecycle methodology). The hydrogen should also demonstrate 'additionality' with regards to use of renewable electricity if classed as RFNBO.

Figure 10. Lifecycle GHG emission performance of HEFA using different hydrogen supply chains as feedstock



UK supply chains of low carbon hydrogen are currently in their infancy and will require significant expansion to meet demand in HFC HDVs. Using the Innovate UK projections[7] of HFC HGV fleet penetration, (which match CCC's six carbon budget analysis values) Zemo has estimated hydrogen demand in 2030 and 2040 – see Table 3.

Table 3: Zemo estimations of low carbon hydrogen demand for HFC HGVs projections

	2030	2040
Innovate UK projections % share of FCEV	7%	33%
Estimated annual FCEV fleet H_2 consumption (tonnes)	462,000	1,930,500

LCFS development could consider exploring how much of this demand can be achieved through the RTFO development fuel sub-target. DfT is recommended to determine how much low carbon hydrogen will be required for SAF by 2030 and 2040. Follow on from this determine if the use of low carbon hydrogen for SAF production compete with renewable H_2 required for road transport.

Chapter 4 – Policy Framework

Increasing the RTFO Target

The RTFO target should be increased and extended beyond 2032 to facilitate the supply of higher blends of renewable fuels (renewable diesel and biomethane) for commercial fleets. The RTFA (2021) have suggested the 2032 target could increase to 21% by volume, without impacting supply of sustainable biomass.

[7] UK TRANSPORT VISION 2050: investing in the future of mobility, Innovative UK 2021

GHG emission intensity target should be reinstated into the RTFO

The RTFO volume based renewable fuels target should transition to a GHG emission intensity threshold. This will align with the proposed SAF mandate that is likely to be GHG emission intensity based. (Further it will ensure the UK aligns with Europe as numerous members states have introduce GHG thresholds.) Adopting such a threshold could be beneficial in reducing the risk of lower quality renewable fuels (GHG savings and sustainability) being directed to the UK market. Furthermore, to stimulate improvements in the lifecycle GHG emission performance of low carbon fuels, and maximizing GHG emission savings, a regulatory landscape which incentivises the best performing supply chains should be introduced.

Introduce a fiscal incentive for higher blends of renewable diesel in HDVs and NRMM

Currently, there is an absence of any fiscal incentive for fleet operators in relation to low carbon liquid fuels. Government could introduce a fiscal incentive for fleet and NRMM operators to encourage wider use of higher blends of renewable diesel (e.g. FAME/HVO). Zemo is working on a proposal with UKPIA and RTFA. A fuel duty incentive could help stimulate supply chains for drop-in renewable fuels either through encouraging investment in domestic production and/or encouraging international supply chain into the UK.

Collaborating with OEMS to encourage wider approval for B20/B30

It is recommended that Government raise awareness to fleet operators that an EU fuel quality standard exists for B30 and paraffinic fuels (HVO/BTL) and work with automotive manufacturers to approve a wider range of Euro VI, and Euro VII, engine models to use of B20/30. To raise confidence in the market, Government could also run a Low Carbon Fuels HGV/Coach demonstration programme to showcase the successful deployment of higher blends of renewable fuels in terms of operation, GHG performance and whole life costs.

Infrastructure for high blends of renewable diesel and hydrogen

The bunkered HGV refuelling network will need to accommodate infrastructure for B20/30 and paraffinic fuels such as HVO. Collaboration with downstream fuel suppliers will be required to determine the practical implications of higher blends of renewable diesel at HGV refuelling sites – an infrastructure roadmap could be created.

Refuelling infrastructure for low carbon hydrogen will also be required to support the roll out of HFC and H2ICE in the 2030 to 2050 timeline. Zemo published a series of 'Transport Energy Infrastructure Roadmaps 2050' in 2016, which included hydrogen. DfT could consider revising this roadmap. It is worth highlighting that biomethane refuelling stations (CNG/LNG), current expanding across the UK, could evolve to hydrogen refuelling stations given their strategic positioning to maximise use by HGV freight operators. DfT could explore a future 'retofit infrastructure' strategy.