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25th March 2024

By email to nrmm.cfe@energysecurity.gov.uk

Response to: Non-road mobile machinery decarbonisation options: call for evidence

Dear Sir or Madam

Fuels Industry UK represents the eight main oil refining and marketing companies operating in the UK. The Fuels Industry UK member companies – bp, Essar, Esso Petroleum, Petrolneos, Phillips 66, Prax Refining, Shell, and Valero – are together responsible for the sourcing and supply of product meeting over 85% of UK inland demand, accounting for a third of total primary UK energy (based on the Department of Energy Security and Net Zero Digest of UK Energy Statistics 2022).

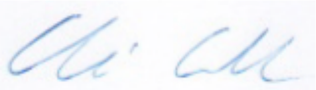
The refining and downstream oil sector is vital in supporting UK economic activity. It provides a secure supply of affordable energy for road and rail transport, aviation, and marine applications, as well as for commercial and domestic heating. It also supplies base fluids for use in lubricants, bitumen for use in road surfacing, and graphite for use in electric vehicle batteries and as electrodes in steel and aluminium manufacture.

Fuels Industry UK welcomes the opportunity to respond to the Non-road mobile machinery decarbonisation options: call for evidence.

Company number: 01404376 – a company limited by guarantee

Our responses to the questions posed in the consultation are given in Attachment 1.

Yours sincerely



Chris Gould

Energy Transition Lead, Fuels Industry UK

Appendix 1: Fuels Industry UK Response

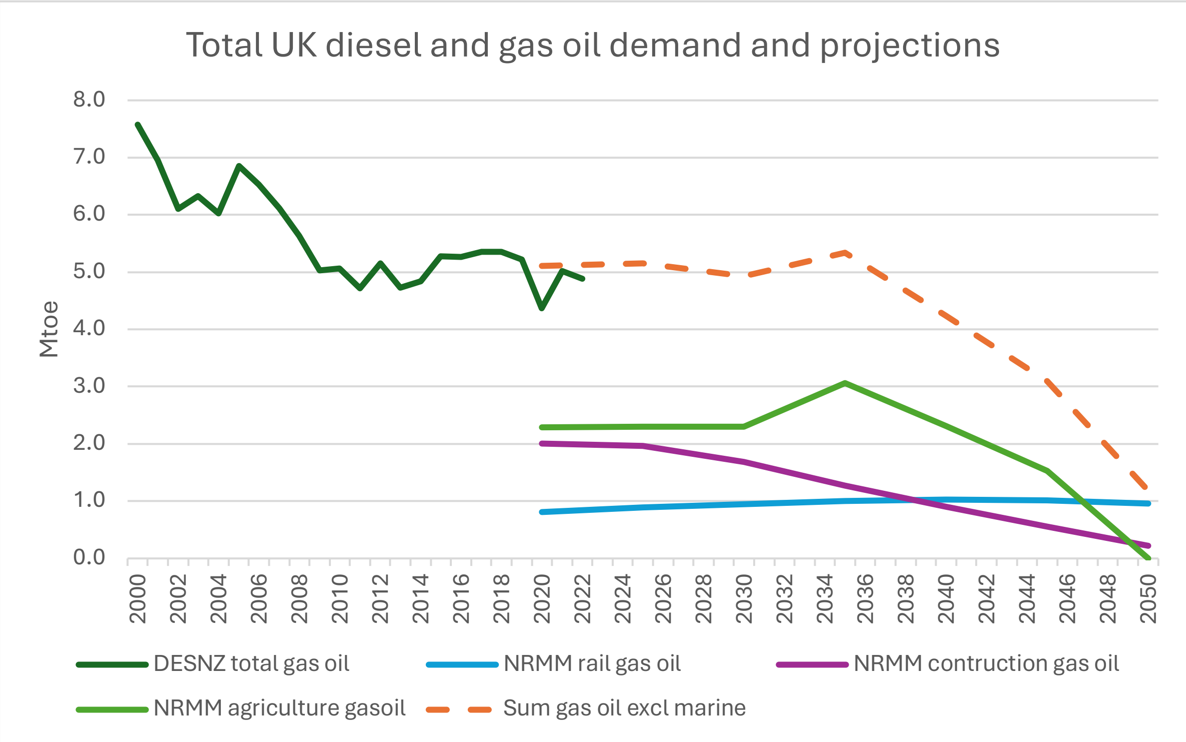
Question 1 to 11 is summarised in the cover letter attached.

12. Do you represent or hold expertise on a specific machine type(s) or technology? If so, please specify.

No

13. Do you hold data on NRMM used in the UK which you would be willing to share with government? We are particularly interested in sales, usage, and ownership fleet data, although please highlight any other data that you think might be useful. In your response, please provide specifics about the data that you hold and would be willing to share.

Below, we have analysed a net zero pathway for gas oil consumption by type in the UK using the ETI Clockwork scenario. The modelled results were then compared to historical consumption using DESNZ Energy Trends 3.13 data [1][2].



[1] https://www.gov.uk/government/statistics/oil-and-oil-products-section-3-energy-trends

[2] https://es.catapult.org.uk/report/options-choices-actions-how-could-the-uk-be-low-carbon-by-2050/

Chapter 1 – The role of NRMM in the economy

14. Are you able to provide any additional information regarding the NRMM product lifecycle?

Fuels Industry UK is unable to provide any further information on this question.

15. Are you able to provide any additional information regarding how NRMM is used in the sectors presented in Table 1?

Refineries and terminals may be covered under the "Manufacturing" category. In addition to the NRMM types listed, they make extensive use of lighting towers powered by portable generators, and cranes of a number of sizes during routine maintenance activities (known as Turnarounds or Shutdowns). Additionally, backhoes, rollers and excavators are heavily used in refineries to maintain internal roads, tank bases, plant construction, and embed/repair/maintain pipelines.

16. Are there any sectors not listed in Table 1 that constitute a significant source of NRMM use and/or are particularly dependent upon NRMM for their operations?

Fuels Industry UK is unable to provide any further information on this question.

17. If you own, rent, or lease, and/or operate NRMM, what are the main considerations when deciding what machines to procure and whether to buy outright or rent/lease?

Fuels Industry UK members typically use third party companies for Turnarounds as discussed in our response to Q15 and so do not generally own the equipment. However, the ready supply of fuel is often an advantage in the equipment used; for refineries and terminals this is currently often diesel but may move to hydrogen or low carbon fuels in the future.

18. DESNZ commissioned research suggests that around 33% of construction machinery is owner operated versus 67% which is either hired or leased. How does this compare to the sector(s) in you are interested?

As discussed above, typically refiners and terminals use 3rd party supplied equipment so for them the figure would be 100% hired or leased.

Chapter 2 – Decarbonisation options

19. Are there any additional efficiency measures that have not been included in this section relevant to the NRMM type(s) and/or sector(s) that you are interested in?

Fuels Industry UK has no significant comment on the efficiency measures laid out in the consultation document.

20. What efficiency measures have been implemented in the machine type(s) and/or sector(s) that you are interested in? What were the impacts that you observed?

NA

21. Do you agree with the estimated emissions saving range of the different efficiency measures as set out above [on page 15]? Please explain your reasoning.

Fuels Industry UK has no data to support or contradict the numbers given. However, many of the efficiency measures listed likely have already been implemented if there is a cost advantage for operators to do so.

22. To what extent do you think these efficiency savings will be realised through market forces?

Some efficiency measures on a macro level are likely to be observed already such as the optimisation of NRMM use schedules and optimum routes between destinations, due to the incentive to minimise operational cost by the business operator. The relaxation of red diesel usage on many of these applications during the last 12 months and the rise in prices of fuel, especially where derv reached £2 per litre, will have already focussed operators on efficiency gains. Since the loss of red diesel sales has been offset by the sales of un-marked derv. However, there have yet to be any major efficiency improvements observed in the sector.

Efficiency measures may be less closely observed by individual operators of NRMMs. These efficiency measures may be less significant compared to planned efficiency measures if not enforced by the company. Therefore, the likely future efficiency gains are expected to be minimal.

23. Can you identify any process change(s) for the NRMM type(s) or sector(s) that you are interested in? What do you see as the abatement potential (possible emissions saving range) for these?

NA. Fuels Industry UK are unable to comment on specific efficiency savings from NRMM operations.

24. What process change(s), if any, has been attempted in the company or sector(s) that you are interested in with the intention of decarbonising NRMM? Did you observe any impacts?

NA.

25. Has fuel switching been attempted in the NRMM type(s) or sector(s) that you are interested in? If so, please list the alternative fuels that have been switched to.

NA

26. Where fuel switching has been attempted, what have been the outcomes?

NA

27. Are there any promising fuel switching options that have not been included in this section relevant to the NRMM type(s) and/or sector(s) that you are interested in?

NA

28. What do you see as the necessary fuel switching options for the NRMM type(s) and/or sector(s) that you are interested in?

Increasing biodiesel blends for use in existing equipment is an achievable and suitable intermediate step to fully decarbonise NRMMs. HVO is a drop-in alternative to diesel and is readily available and compatible with current NRMM technologies, supported by the RTFO. This will be a useful lower-carbon fuel as the sector explores the feasibilities of other powertrain types. Similarly, alcohol-to-jet technologies also have considerable potential to be used as a low-carbon drop in fuel, supplementing the limited supply of HVO. In the short term, the main requirement is the supply of drop-in biofuels. The limited availability of HVO will require market participants to find alternative low-carbon drop-in fuels.

NRMMs tethered to the mains power may still be required for operating larger electric NRMMs where current battery technology and capacity are not suitable for larger machinery. This may require further health and safety considerations. For smaller NRMMs, many electric versions have been in the market for several years, therefore technology is not the main barrier to the adoption of ZE NRMMs, but rather its other disadvantages such as cost and convenience.

29. If you own, rent/lease, and/or operate NRMM, have you at any point decided to reduce emissions from these machines? If so, what were your main considerations when doing so? If not, why have you not sought to do so?

In the case of refineries operating NRMMs, the readily available fuel to power NRMMs on-site is a convenient advantage for refinery operators. It is uneconomical to invest in infrastructure to power alternative zero/low carbon NRMMs when there is a convenient, cheap, and readily available fuel on-site that can be used. Thus there is a unique advantage for refiners which provides a very significant disincentive to change.

Chapter 3 – Deployment considerations

30. Do you agree that these are the main opportunities and potential co-benefits to the deployment of NRMM decarbonisation options?

Fuels Industry UK agrees with the opportunities listed. (evidence wanted for lower noise pollution).

31. Are there any other opportunities and/or potential co-benefits?

Potentially increase safety without the need to handle flammable liquid fuels, if replaced with battery packs. Non-ICE NRMMs may be more versatile and be able to operate where there is a lack of oxygen (i.e. underground, and locations in high altitudes). The use of electrical NRMMs would also reduce the amount of ventilation equipment needed compared to ICE NRMMs. Electrification also brings greater control for certain applications as motors are much easier to regulate speed electronically than ICE engines.

32. Do you agree that these are the main technical barriers to the deployment of NRMM decarbonisation options? If not, which barriers listed do not apply and/or what additional significant technical barriers exist?

Fuels Industry UK agrees with the main technical barriers listed. Additional battery packs may be needed for electric NRMMs where access to charging facilities is not available or when the battery capacity is limited. This would add additional complexity to maintain the continuous operation of an NRMM.

Limited availability of different raw material feedstocks for alternatively powered NRMMs (i.e. lithium, biomass). Similarly, in the case of hydrogen, the lack of hydrogen available in the wider market to power ZE NRMMs will discourage any operators from adopting hydrogen NRMMs. In this case, the wider hydrogen infrastructure and available supply of hydrogen must become more accessible before the adoption of hydrogen NRMMs is considered.

33. Do you agree that these are the main financial and economic barriers to the deployment of NRMM decarbonisation options? If not, which barriers listed do not apply and/or what additional significant financial and economic barriers exist?

Fuels Industry UK agrees with the barriers listed. Limited UK and international demand for low-carbon NRMMs, would result in a niche manufacturing capacity compared to conventional powered NRMMs, likely leading to higher costs for low-carbon alternatives, without government policy. The lack of an international market would limit incentives to develop this technology in the UK.

34. Do you agree that these are the main infrastructure and fuel supply barriers to the deployment of NRMM decarbonisation options? If not, which barriers listed do not apply and/or what additional significant infrastructure and fuel supply barriers exist?

Fuels Industry UK agrees with the barriers listed. E-fuels/RFNBO (Renewable Fuels of Non-Biological Origin) should not be considered unless the grid is fully decarbonised. We would support RFNBO's for decarbonisation provided it meets the RFNBO criteria specified under the RTFO, rather than creating additional restrictions for individual transport modes.

35. Do you agree that these are the main operational barriers to the deployment of NRMM decarbonisation options? If not, which barriers listed do not apply and/or what additional significant operational barriers exist?

Significant vibrations when operating some NRMMs may hinder the operation of hydrogen fuel cell machinery. Increased weight of low and zero-emission NRMMs may be barriers for projects where the weight loading of the equipment is a significant factor. [1] For example, there are a lot of 2-stroke petrol items – designed specifically for the low weight of this type of engine. The increased weight of alternative ZE NRMMs would also increase logistical issues.

Fuels Industry UK largely agrees with the other operational barriers listed.

[1]https://www.sciencedirect.com/science/article/abs/pii/S0013935119301501#:~:text=The%20proton%20exchange%20membrane%20fuel%20cell%20(PEMFC)%20in%20fuel%20cell,during%20the%20development%20of%20FCVs.

36. Do you agree that these are the main regulatory barriers to the deployment of NRMM decarbonisation options? If not, which barriers listed do not apply and/or what additional significant regulatory barriers exist?

Fuels Industry UK agrees with the regulatory barriers listed. In addition to unharmonized global standards, a lack of urgency to decarbonise NRMMs in other jurisdictions will hinder the market incentives to invest in certain low and zero-carbon NRMM technologies. Policy should be developed not to be a barrier to using conventional NRMMs but to enhance the viability of alternative low-carbon NRMMs. Any policy developed should be technology-neutral and consider all options for decarbonisation.

37. Do you agree that these are the main knowledge and information barriers to the deployment of NRMM decarbonisation options? If not, which barriers listed do not apply and/or what additional significant knowledge and information barriers exist?

Since NRMMs are a subset of different types of machinery and equipment used across all sectors, there is a lack of data collected on NRMM uses and types across the country. NRMMs are also not featured in most whole system energy models such as the UK Times model [1] as NRMMs would be an additional granularity in the model which does not exist. However, the observation of gas oil use trends in energy system models may indicate the current demand for NRMM gas oil use, as much of the demand for gas oils is derived from NRMMs. However, the reform of red diesel and other rebated fuel entitlements in late 2021 which restricted the use of gas oil by some NRMMs may complicate these modelling assumptions.

Typically, a lack of knowledge by one company may be mitigated with interactions with clients and partners. For example, the news that one company decided to use an effective new zero-emission NRMM alternative will most likely be spread by word of mouth. Others may therefore be more interested in investigating the use of ZE NRMMs for their operations.

Fuels Industry UK agrees with the other knowledge and information barriers to deploying NRMM decarbonisation options. Fuels Industry UK are happy to discuss more about modelling this scenario in UKTM or connect DfT with the UKTM modelling team at DESNZ if desired.

[1] https://www.ucl.ac.uk/bartlett/sustainable/news/2021/dec/uk-times-model-underpins-government-climate-policy

38. Are there any barriers to the adoption of decarbonisation options for the NRMM type(s) and/or sector(s) that you are interested in which have not been included in this section?

Fuels Industry UK agrees with the barriers listed and has no further comment.

39. For the NRMM type(s) or sector(s) that you are interested in, please score each barrier category (e.g. financial and economic) in terms of its impact on the deployment of decarbonisation options using the scale below. Please provide a rationale for any scores of 4 and 5, noting where applicable any variation by NRMM type, sector, or decarbonisation option.

0 = Don’t know / not applicable

1 = Not at all important

2 = Slightly important

3 = Moderately important

4 = Important

5 = Extremely important

Fuels Industry UK is interested in the supply of fuel to NRMM equipment, rather than specific NRMM types of sectors (with the exception of NRMM used in refineries as outlined in our response to Q15). As such we have answered this question from the perspective of fuel supply in its own right.

Technical barriers – 4

The technical obstacles to be overcome are significant and have issues such as energy density as mentioned in the consultation that are challenging to overcome, even with significant research and development. For example, hydrogen is challenging to manufacture, store and transport either in compressed gaseous or liquified. This is the case for the supply of hydrogen, forms as it is currently unavailable as well as it's use in NRMM equipment.

Some improvements may be possible with efficiency gains, but often these are related to thermodynamic, or materials issues so again could potentially be difficult to overcome. While research and development is to be strongly encouraged, there needs to be a recognition of the inherent difficulties of these fuels in the establishment of decarbonisation policies.

Financial and economic barriers – 4

There is a risk of a classic "chicken and egg" situation developing with fuel supplies; in the absence of strong demand signals fuel suppliers are unlikely to invest in the supply of these fuels. Similarly, unless fuel supplies are available, NRMM is unlikely to transition to low carbon alternatives.

There needs to be a clear government strategy for NRMM decarbonisation; the example of the ZEV mandate in passenger cars is a clear example of this, creating the framework for the transition of the UK car fleet over time. Similarly, the RTFO creates a framework for low carbon fuels used in NRMM but at this time does not provide specific clarity on NRMM to drive the transition. However, the NRMM sector probably does not require separate legislation as being largely diesel-based will naturally follow the path taken for other road fuels, therefore support policies for diesel/gas oil would in part support NRMMs.

As with the technical barriers described above, government policy needs to recognise that for a number of technical reasons, low-carbon fuels are extremely likely to cost more than their fossil fuel equivalents, mainly due to both thermodynamic as well as efficiency reasons. While research and development are to be strongly encouraged (and can potentially solve efficiency and usability issues), this high-cost base is likely to remain the case for the foreseeable future and needs to be solved.

Infrastructure and fuel supply barriers - 5

We agree with the infrastructure and fuel supply barriers outlined in the response and that they are a real impediment to the development of low carbon NRMM technology.

These need to be systematically addressed in order to enable the transition. We note and welcome the work and investment that DESNZ have made on the hydrogen and CCUS business models and expect that this will lead to the start of the development of these sectors in the UK.

Similarly, we welcome the recent work on streamlining the approvals process for new EV infrastructure as outlined by the DfT at the Zemo passenger car working group meeting on the 16th of January 2024.

Similar initiatives should be introduced in the NRMM sector to reduce the barriers and start the transition to low carbon alternatives.

A particularly high barrier exists for hydrogen introduction. The current fuel supplies businesses (refineries etc) handle liquids and have tanks, pipes and tanker infrastructure to handle such materials. Hydrogen (or ammonia) is a compressed gas with separate expertise required to handle such materials.

Operational barriers - 3

We note the operational barriers discussed in the consultation and agree that they are material for operators of NRMM.

However, they represent user barriers rather than fuel supply ones, and so we have ranked this of lower importance to avoid overly prioritising all factors simultaneously.

Regulatory barriers - 4

For fuel suppliers the regulatory barriers are very significant, particularly relating to approval by competent authorities such as the HSE or EA.

Whilst we recognise that approvals would not necessarily be unduly withheld, the timescales and resource requirements concerned are very significant, and can lead to delays in approving Final Investment Decisions, starting project construction and ultimately the delivery of low carbon NRMM fuel solutions.

Knowledge and information barriers – 3

In our view, whilst important, the other barriers described above are more significant in the transition of the NRMM sector. There are existing, significant, networks already in place such as Zemno, or the Catapult centres to share technical knowledge and expertise in a timely and effective manner. These should continue to be supported and encouraged to assist the transition over the medium term.

40. How does the current usage and ownership structure of NRMM in the UK present opportunities and/or challenges for decarbonising NRMM?

Currently, there is a vast range of different NRMMs used across different industries. In order to be effective, policies must address NRMM usage across all sectors. Policies may be directed at the source of the fuels to decarbonise NRMMs, large operators or leasers of NRMMs.

Chapter 4 – Policy considerations

41. Do the policies contained in Tables 2 and 3 provide sufficient support for NRMM decarbonisation? If not, what are the gaps in the current policy landscape?

Fuels Industry UK welcomes the outlined and proposed policies in Tables 2 and 3. However, the stated policies are heavily focused on market certainty and supply-side support for both low-carbon fuels and low-carbon NRMMs but lack the demand-side support policies which would require operators to decarbonise by operating lower emission NRMMs. 'Stick' policies may be adopted to mandate users to operate a certain number of low-carbon NRMMs or face a penalty.

However, a market-driven approach as seen in the ETS may be very challenging as there is very little information to quantify GHG emissions from all NRMM types which might be required to build such a 'stick' policy. DfT may want to investigate how building and transport emissions are being considered for the EU ETS. [1]

Some types of NRMMs have also been excluded from supply-side support policies in Tables 2 and 3 (i.e. hand-held machinery, generators, other heavy equipment, etc.). There is also a potential risk for stranded conventional NRMM assets if conventional fuels are phased out before the transition to zero/low carbon emission NRMMs.

Government should focus support on the wider adoption of alternative fuels such as hydrogen and electrification. This in part would support the adoption of ZE NRMMs. Currently, there are few usable alternative power supplies/fuel supplies available for alternative NRMMs. The fundamental driver of adopting ZE NRMMs is to have an ample supply of alternative fuels such as hydrogen and enhanced grid capacity in a timely manner. Aggressive policies such as the DRTFO which incentivised buyouts should be avoided as this does not encourage decarbonisation.

[1] https://sustainablefutures.linklaters.com/post/102ipy5/european-renewable-energy-directive-red-iii-updated-ambitious-targets-to-boost

42. Are you aware of any other policies (either current or in development) that could positively or negatively impact NRMM decarbonisation?

The upcoming DfT Low-Carbon Fuel Strategy will also help the industry understand how the UK government intends to expand this sector which would provide businesses with more information when making investment decisions. However, Fuels Industry UK along with other industries have collectively expressed concerns about the significantly delayed publication.

43. Are the IDS policy principles appropriate in relation to NRMM decarbonisation?

Fuels Industry UK broadly agrees with the IDS policy principles.

44. What additional policy principles should government consider with regards to NRMM decarbonisation?

Recommendations are the same as the ones listed in question 41.

Due to the strong link to the fuels for road transportation, policies addressing road fuels would ultimately address issues with ZE NRMMs. Due to the limited NRMM market, it is essential to standardise ZE NRMMs in order to increase its accessibility. When considering policy, the government must consider the typical life cycle of the conventional technology (typically 20+ years), high capital cost, and how this would affect the motivations for operators to switch to ZE NRMMs.

45. How could government best contribute to establishing optimum market conditions to increase the rate of NRMM decarbonisation?

The government may also help with the adoption of low and zero-emission NRMMs by enhancing the demonstration program of these new technologies and providing information on the technology to allow operators to adapt to the new NRMMs operating patterns (ie, more frequent refuelling, extended refuelling time, and access to new infrastructure to refuel NRMMs). The government may choose to enhance the tax regime for high-blend biofuels. Zemo has previously investigated the use of high-blend renewable fuels in decarbonising heavy-duty vehicles [1], which in theory could be replicated for NRMMs. Alternatively, the government should encourage the road sector to define workable strategies to replace diesel, which in turn would decarbonise NRMMs. This is particularly pertinent since currently refineries and fuel suppliers provide the refuelling infrastructure through their diesel systems which are common for both road and NRMM systems. There is no economic justification for providing different systems to different sectors. Therefore, focussing on NRMM as a separate topic is not optimal. Instead, the focus should be on fuel types e.g. diesel users, for which the road systems are the largest.

[1] https://www.zemo.org.uk/work-with-us/fuels/projects/2020-high-blend-biofuels.htm

46. How might the role of government change over time in aid of NRMM decarbonisation?

Government intervention may be required as long as there is a significant premium between operating low/zero emission NRMMs compared to their fossil equivalence. Demonstrations and best practices of using low/zero emission NRMMs may be of higher demand at the initial stages of adoption while the knowledge base in industry is still lacking. Government departments may wish to work collaboratively with trade associations across industries to share best practices and demonstrations of using a low/zero emission road and NRMM applications, to reach a wider audience.

Fundamentally, there are currently no practical alternative fuels for many NRMMs. Any policies developed to incentivise the use of ZE NRMMs must consider whether the ZE fuels are widely available for use in ZE NRMMs. Therefore, increasing the ample supply of alternative fuels should be the initial step to supporting ZE NRMMs.

47. What factors should we consider when assessing the suitability of different policy options?

While government should consider using biofuels widely to decarbonise across all sectors, DfT must also consider the optimum allocation of limited biomass feedstock and the sectors which may be best to utilise it. We expected the Low Carbon Fuels Strategy to cover this. [1]

[1] https://www.fuelsindustryuk.org/media/x1ag3ob0/ukpia-low-carbon-fuels-strategy-call-for-ideas.pdf

48. Are there any existing models or international examples of policy that government could implement to incentivise NRMM decarbonisation?

European Renewable Energy Directive (RED III) aims to increase the share of renewable energy consumption to 42.5% by 2030, with a further indicative target of 2.5%. The UK could also implement more ambitious renewable fuel blending targets.

Improving the understanding and data available associated with NRMM scope 3 emissions would enable a better understanding of how to decarbonise NRMMs. DESNZ has recently released a call for evidence regarding UK greenhouse gas emissions reporting: Scope 3 emissions [1]. This is a good initial step to developing an effective standardise emissions report, but it is unclear how this will develop at this stage.

Government could arrange a collaboration with other countries to pool resources to deliver technology improvements, including staff from big industries, start-ups, and academia. Prior examples exist: Horizon EU, Manhattan Project, Iter, Euratom (Nuclear fusion), and Nasa (ISS). Other countries are already doing so, e.g. the Belgian "Moonshot" programme, organised by Catalisti.be, however these projects heavily focus on academia and technologies with low TRL levels and thus does not support existing industries to adapt. In the UK, we have minimal suitable pilot facilities available in the area of fuels, to drive technological advances with urgency. Thus policies should support more industrial projects in conjunction with the private sector.

[1] https://www.gov.uk/government/calls-for-evidence/uk-greenhouse-gas-emissions-reporting-scope-3-emissions

49. Is there any further relevant information that has not been asked about which you would like to submit?

NA

Part II – Industrial NRMM detailed modelling assumptions

Please only respond to this part of the call for evidence if you have experience relevant to the content of this section.

1. Can you provide evidence as to the typical hours and pattern of usage of any of the machine types listed in Annex A across an average monthly period? Please specify the sector and situation of use.

NA

2. We are interested in the impact that the duration of a site has on the ability of the NRMM used on it to decarbonise. We assume that the construction sector is the only industrial sector to have temporary sites (and that seaports, waste, manufacturing, and mining/quarrying sectors are all located on sites intended for long-term or permanent use). Can you provide any evidence or data covering the duration and location of sites or projects within the construction sector?
NA

3. ERM's research suggests that short-term sites will have fewer fuel switching options due to infrastructure availability, particularly outside urban areas. Are there other barriers related to site duration?
NA

4. It is assumed that the machines within an archetype share similar characteristics, and are used in a broadly similar manner, such that the decarbonisation options available are the same for all machines within the archetype. This assumption is important to ensure modelling feasibility. Do you think that the industrial NRMM archetypes set out in Table 4 form an appropriate grouping for this purpose? If not, why not?
NA

5. Do you agree or disagree with the assessed suitability of the alternative powertrains for the archetypes set out in Table 5? If you disagree, please provide explanation and provide evidence where possible.

DfT should have laid out clearly the exact definitions and examples of the type of NRMMs under each of the categories given in Table 5.

6. Do you agree with the years of availability assumed for each archetype? If not, please provide evidence to the contrary.

It is unclear why the assumptions for hybrid medium-sized mobile machinery have a yellow TRL rating, different from that of other hybrid mobile machinery of different sizes.

Due to the general categorisation of NRMMs, the model assumptions fail to highlight some significant advances in certain types of H2 fuel cell mobile machinery such as H2 fuel cell Trams recently developed by Hyundai [1], with the development of the tram is expected to finish at the end of 2023/early 2024 [2]. With H2 fuel cell trains also in the development and trial phase, H2 fuel cell trains and trams seem to warrant a 4-5 TRL rating.

[1] https://tech.hyundai-rotem.com/en/green/hydrogen-fuel-cell-tram-to-run-in-an-eco-friendly-hydrogen-society/

[2] https://www.railway-technology.com/news/hyundai-rotem-hydrogen-tram-south-korea/?cf-view

7. Do you agree with the assessment of the efficiency of the powertrains listed? If not, please provide evidence to the contrary.

Diesel ICE efficiency of 33% in the call for evidence seems lower than the value given by other sources online, where they are generally given in a range of between 35% to 40%. [1][2]

[1] https://www.genpowerusa.com/blog/diesel-generator-vs-gas-generator-which-is-more-efficient/#:~:text=Typically%20a%20diesel%20generator%20will,units%20are%20delivered%20as%20output.

[2] https://www.fwi.co.uk/arable/analysis-electric-technology-set-kill-off-diesel-tractors#:~:text=A%20diesel%20engine%20achieves%20about,have%20an%20efficiency%20of%2090%25.

8. Do you agree with this definition of 'hard to deploy'? If not, what other characteristics should we take into account?

Fuels Industry UK agrees with the definitions outlined. Additional reasons such as duration of usage limitations for different powertrains (ie battery/hydrogen supply capacity) and refuelling periods may affect the machinery usage patterns and may be unsuitable for certain cases.

9. Do you agree with these estimates of the percentage of hard to deploy machinery across different industrial sectors? Please clearly specify the sector(s) that your answer relates to and provide any specific evidence that can validate your view.

NA

10. Do you agree with the assumption that fuel switching options within the 'hard to deploy' category will face a delay to becoming commercially available and that 10 years is a reasonable assumed time period for this delay?

10 years for deployment of these technologies is a reasonable assumption with the current understanding of the market.

11. Do you have any comments to make about the calculation used to determine the CAPEX of a machine and about the costs set out in Table 7? Where possible, please provide evidence to support your view.

The assumed value for battery electric storage seems higher than other sources found online. Figures found by BloombergNEF suggest that battery storage would cost $151 kWh in 2023 (in 2022 $ value) [1].

The cost difference between different power rating machines of the same type likely does not increase linearly. The calculations imply this linearity with a constant Powertrain cost in £/kW. However, for simplicity's sake, it is understandable to have this approach.

[1] https://about.bnef.com/blog/lithium-ion-battery-pack-prices-rise-for-first-time-to-an-average-of-151-kwh/

12. Latest research suggests that tethered-electric machines would require a cable estimated to cost £1,200 (cable is assumed to be around 20 metres long). It is assumed that this cost would remain constant up to 2050. Do you consider these assumptions to be fit for purpose in assessing the relative costs of different options? If not, please provide evidence to the contrary.

As the majority of electrical cables are made from copper or aluminium, the price of the cables will be heavily correlated to the price of these two commodities. With electricity demand, subsequently, the grid and electrical cable demand is set to increase considerably in the coming years as western countries electrify and emerging economies develop [1][2]. This in part will exacerbate the current copper supply issues resulting in a likely increase in commodity prices [3].

[1] https://www.grandviewresearch.com/industry-analysis/wire-and-cable-market-analysis-market

[2] https://www.businessresearchinsights.com/market-reports/extension-cables-market-109805

[3] https://www.mining.com/copper-prices-may-jump-20-aluminum-by-36-as-demand-outpaces-supply-forecast/

13. Latest research suggests that on-site hydrogen infrastructure costs will start at £7/kg of hydrogen (delivered to the machine) in 2020 and decline linearly to £2/kg in 2050. Do you consider this assumption to be fit for purpose in assessing the relative costs of different options? If not, please provide evidence to support your view.

It is unclear from the call for evidence how such a complex process has been condensed into a single cost figure. The figures in Table 8 do not indicate what the figure contains, and it is unclear how all the various parameters have been consolidated (ie. Transportation type, the cost associated with the distance transported from production to need user, H2 storage cost, etc.).

The Hydrogen transport and storage cost analysis published by DENZ highlights some key cost assumptions for this process [1]. In Figure 3 of the analysis, a present cost varying from approx. £2/kg to £5/kg of H2 transportation is given, with breakdowns of the distance, capacity, method, and frequency of transportation. It is unclear whether the same assumptions were made in the NRMM study.

[1] https://www.gov.uk/government/publications/hydrogen-transport-and-storage-cost

14. Latest research suggests that battery infrastructure costs will start at £500/kW of charger power output in 2020 and decline linearly to £350/kW in 2050. Do you consider this assumption to be fit for purpose in assessing the relative costs of different options? If not, please provide evidence to the contrary.

The figure provided in Table 8, like the answer in question 13, does not address whether this figure includes cost associated with distance, capacity, technology type, and frequency. There have been extensive studies regarding the cost of battery electricity however a comparison cannot be made without the knowledge of what the figure in table 8 consists of. Some alternative studies are listed here [1][2][3].

[1] https://www.nrel.gov/docs/fy21osti/79236.pdf

[2] https://about.bnef.com/blog/lithium-ion-battery-pack-prices-rise-for-first-time-to-an-average-of-151-kwh/

[3]https://spiral.imperial.ac.uk/bitstream/10044/1/50848/10/20170620_FINAL_ExpCurves_Main.pdf

15. It is assumed that machines will have at least 8 hours to charge overnight and that a suitable battery size will be selected such that a full day's work can be performed without needing to recharge during the day. Do you consider these assumptions to be fit for purpose in assessing the feasibility of different options? If not, please provide evidence to support your view.

This may only be applicable to larger machines where the size of the battery storage device is not as restricted. For heavy-duty small machinery/hand-held machinery, it is unlikely a single charge will be sufficient for a full day's work. Additional replaceable power banks will be needed to enable the continuous operation of the machinery. For example: a battery-powered jackhammer with a calculated power rating of 1.1kW [1], with a recommended powerpack capacity of 260Wh [2], will only last approximately 13 minutes of continuous usage of the machine before the depletion of the battery pack.

[1]https://www.hilti.co.uk/c/CLS_POWER_TOOLS_7124/CLS_DEMOLITION_HAMMER_BREAKER_SUB_7124/CLS_CORDLESS_BREAKERS_7124/r13250322

[2]https://www.hilti.co.uk/c/CLS_CORDLESS_TOOLS_7123/CLS_CORDLESS_BATT_CHARGE_7123/CLS_CORDLESS_BATTERIES_7123/r13250381

16. What do you see as the plausible pathways for the decarbonisation of industrial NRMM within the sector(s) that you are interested in? (Where multiple sectors are relevant to you, please clarify if your response varies by sector).

NA

17. Do you have any comments to make on the pathways presented in Chapter 5 of the ERM study?

The assumption made in section 5.1.2, 'Biofuels are modelled to have zero TTW emissions' fails to consider the origin of FAME, which is derived from methanol. [1]

[1] https://www.crownoil.co.uk/guides/fame-biodiesel-guide/

18. Are there any other comments or evidence that you would like to provide in response to the content and findings of the ERM study published alongside this call for evidence?

The call for evidence does not address the vast differences between NRMMs in the subcategories listed. Even within the mobile machinery category of the same size listed in Table 5, the actual types of machinery and decarbonisation options may vary, such as for trams and haul trucks. Table 60 in the ERM study where example machineries have been listed, would have been useful if it was in the call for evidence document.