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To: Department for Transport
By Email: LowCarbonFuel.Consultation@dft.gov.uk

17th June 2023

Dear Low Carbon Fuels Team,

**RE: Response to Consultation on Pathway to net zero aviation: Developing the UK sustainable aviation fuel (SAF) mandate**

Thank you for the opportunity to provide input on the development of the SAF mandate. Equilibrion is a project development and consulting company specialising in the use of nuclear energy for the decarbonisation of energy end-use where emissions are hard to abate including transport, industry and heating sectors. We have a leading position advising across the energy sector on the wider applications of nuclear energy and particularly recognise the opportunity presented for the decarbonisation of aviation.

We therefore welcome the inclusion of nuclear in the SAF mandate and our response outlines our views on how the future SAF mandate can be designed to best leverage nuclear-based solutions to achieve UK policy outcomes on climate change, energy security and socio-economic opportunity.

The UK nuclear sector currently provides well-paid jobs to 65,000 people across all areas of the UK but particularly in the North of England, making a major contribution to levelling up. In the future, nuclear deployments to support the aviation sector could double this figure, bringing much-needed employment to areas where jobs could be at risk from the energy transition, and concurrently positioning the UK as a world-leading nation on the production of power-to-liquids SAF on a large scale leveraging nuclear electricity and heat.

Our response to a subset of the consultation questions is provided below this letter and focuses on the areas where we have relevant capability and experience to provide credible and, we hope, valued input to DfT's consultation process.

We would of course be delighted to answer any clarifications or further questions that you may have.

Thank you again for the opportunity to contribute and we look forward to seeing the DfT response in due course.

Yours sincerely,

**Caroline Longman**

Director, Equilibrion Limited

**Consultation Response**

Throughout our response, Equilibrion wishes to assert the opportunity for nuclear-derived Power-to-Liquids (PtL) SAF to enable the UK to extend its position in the PtL market.

We believe that the introduction of a PtL mandate is essential to ensure this strategically important pathway to large volumes of SAF can emerge in the UK.

***3: Do you have any comments on the post 2040 proposal to legislate for targets continuing at the 2040 level, with the plan to update these when better data is available?***

Equilibrion believes there are benefits to stating a 2050 target and believes this can be underpinned by considering the opportunity that nuclear presents. We believe the PtL Mandate target could be delivered through the fleet deployment of nuclear power stations for the specific purpose of PtL production.

Nuclear projects are large capital-intensive projects that require long-term strategic thinking and benefit from the foresight of a strong pipeline of deployments. We believe that investors and project developers would welcome the extension of the target to 2050, showing a continued upward trajectory, which in turn will support fleet deployment programmes and by implication make first and second-of-a-kind projects easier to finance and deploy. Given that the targets could be adjusted in the future as new information becomes available, we see no drawbacks to stating 2050 ambitions and updating these when better data is available.

***4: What increasing trajectory to 2040 do you think strikes the right balance between ambition and deliverability? Do you have any evidence to support your position?***

Equilibrion believes that an ambitious trajectory to 2040 is the right approach to driving the development of a healthy SAF production capacity in the UK. We believe that technologies that make use of low-carbon heat and electricity can make a significant difference to the overall availability of SAF. One small modular nuclear reactor could provide 75% of the 2035 High PtL target with further deployments providing major contributions to the 2040 target.

Therefore, we suggest that Option 3, the high trajectory, is the right balance between ambition and deliverability but see credible options to increase this.

***6: Would you find it acceptable if the trajectory from 2030 onwards was set at an ambitious level and this led to high levels of buy-out and increasing costs to consumers?***

Equilibrion believes that the needs of consumers should be balanced with the needs of industry over the medium term to ensure the suitable scale-up of SAF production within the UK that can help achieve longer-term cost reduction for aviation and greater price certainty for airlines. Therefore, we believe that setting an ambitious target level that causes increased costs to consumers in the near term is appropriate to send a strong market signal for the expansion of future production capacity.

***10: At what level do you think a PtL mandate should be set to strike the right balance between ambition and deliverability? Do you have any evidence to support your choice, in particular considering low carbon electricity and hydrogen production, as well as carbon capture requirements?***

Equilibrion believes a PtL mandate should be set with Very High ambition in order to provide a strong demand signal to the market on the importance of PtL. Our preliminary calculations show that one small modular nuclear reactor deployment with an associated PtL production facility could deliver 0.75% of the UK's aviation production use. We believe that 2035 is achievable for a first-of-a-kind commercial facility, which could include one or multiple units to increase the scale of PtL production accordingly. There are therefore credible pathways to increasing the PtL mandate target from 2035 onwards.

In this example, the nuclear reactor provides heat and electricity to the entire lifecycle of PtL production including desalination in coastal areas, direct air capture, hydrogen production, fuel synthesis and upgrading. The only input feedstocks would be nuclear fuel, water and air providing significant scale-up opportunities with feedstocks that do not constrain the scale of production that can be achieved in the future.

Based on this information, we encourage DfT to review this target as part of ongoing considerations and regularly thereafter, including consideration of raising the target based on the increasing maturity of high-capacity PtL production systems.

***11: In which year do you think it would be most appropriate for a PtL mandate to start and how quickly do you think ambition should ramp up?***

Development of PtL facilities that maximise the value of low carbon heat and electricity will require an extended lead time, and therefore Equilibrion proposes the introduction of a PtL mandate from 2030 onwards to allow time for the introduction of suitable facilities. Ambition should then be ramped up from 2035 onwards, where greater confidence in the availability of high-capacity production systems is available.

Based on our experience we believe 2035 is a credible date by which nuclear-derived PtL could be operational, however, there are steps that could be taken to bring this forward including:

1. Early identification of sites and carrying out of relevant planning and site assessment activities;
2. Leveraging existing infrastructure and sites including in regions where nuclear is not currently an established employer;
3. Inclusion of nuclear for PtL production as part of the considerations for Great British Nuclear;
4. Ability to agree to long-term offtake agreements with suppliers and airlines. Longer offtake agreements will support the high capital expenditure, and therefore borrowing, requirements related to the nuclear plant;
5. Accelerated regulatory approval of nuclear technologies.

***13: Do you agree or disagree with the proposed use of the medium buy-out price of £2.75 per litre or £3,525 per tonne for the PtL mandate, and do you have any evidence to support your response?***

Equilibrion agrees with DfT's proposal to use a separate buy-out price for the PtL mandate, reflecting the lower commercial maturity of PtL production. This recognises that the PtL market is likely to be much larger than the Bio-fuels market in the longer term and a higher buy-out price will support the UK as the best place to invest in first-of-a-kind deployments. Furthermore, we agree with the proposal to use the medium buy-out price of £2.75 per litre, which aligns with pessimistic production cost estimates for PtL fuels. This balances the demands of the consumer with the ability of the industry to deliver novel projects that can deliver a long-term reduction in the production cost of PtL synthetic fuel.

However, as PtL is strategically important for the UK with very few production pathway opportunities, it would be non-ideal to set the buy-out price at a level that is subsequently found to be below what producers can achieve and we recommend that this figure is kept under review as more information becomes available.

***16: Do you agree or disagree with our proposed flexible approach to review timelines?***

Equilibrion agrees with DfT's proposed flexible approach and timeline for review of the SAF mandate and encourages these to be aligned with the emergence of new information.

***20: Do you agree or disagree with the proposed definition of fuels that will be eligible for PtL certificates to be redeemed against the PtL obligation?***

Equilibrion is supportive of DfT's proposed definition of fuels that will be eligible for PtL certificates, including the recognition of nuclear heat and electricity as suitable low-carbon energy inputs to the production of PtL. We agree that no energy content should be contained in PtL feedstocks.

We agree that CCUS-enabled hydrogen and biomass-produced electricity should not be qualifying feedstocks and have provided further information in our response to the Call for Evidence further down this response.

We note that the consultation omits to refer to the use of direct heat for PtL production and we strongly encourage DfT to explicitly introduce this to future publications. The use of direct heat from nuclear power stations for downstream industrial processes such as PtL production is proven and can improve production efficiencies by a large margin, reducing costs and promoting the UK as a leader in PtL production. The UK is currently seen as the best place to deliver such first-of-a-kind projects, with supportive nuclear and SAF policies and alignment in ambition between the two. Industrial solutions are emerging that have credible timescales to start of production.

Direct supply, low-carbon heat can improve the efficiency of a PtL system in the following ways:

- Higher efficiency hydrogen production with steam electrolysis. Hydrogen production accounts for circa 90% of the total energy use in a PtL system. Steam electrolysis can be up to 40% more efficient than traditional low-temperature routes providing a marked improvement in the yield of PTL product from the same energy input.

- Higher efficiency direct air capture. Heat is required to regenerate many of the sorbents used in direct air capture. This heat would traditionally be provided by burning natural gas, along with post-combustion CCS, or possibly hydrogen in the future. Using direct heat from nuclear, which can be provided within the required range for most DAC systems, provides marked system, efficiency and cost benefits.
- PtL production requires large volumes of water, which can place a strain on local water resources. The heat from nuclear is proven to drive desalination processes, which can improve the overall environmental performance of the system and reduce the costs of purification for hydrogen production.
- Hydro-treating the output from the Fischer-Tropsch process requires a high-grade heat input, and providing this from nuclear energy can further improve the efficiency of this step.

There are numerous examples from around the world and in the UK of providing direct output heat to industrial processes, and indeed on nuclear power stations used solely for electricity production, a significant percentage of heat and steam produced is used for on-site steam supply. This is a proven technology.

The temperatures required for the PtL sub-processes (DAC, hydrogen production, desalination, hydro-treating) are achievable with today's Light Water Reactor technology and small modular reactors. Advanced modular reactors operating at a higher temperature can provide further system efficiency improvements and may provide options for flexible siting.

It is essential that heat is explicitly referred to in every instance whenever and wherever the feedstocks for PtL are mentioned in SAF mandate text.

***21: Do you agree or disagree that the SAF mandate should adopt the criteria concerning additionality for RFNBOs that aligns with the RTFO?***

Equilibrion believes additionality should be an unambiguous requirement as this will promote the build-out of primary energy production capacity and the development of whole-system solutions that take account of their energy input and ensure real-world decarbonisation without shifting emissions to other areas of the energy system.

***22: Do you agree or disagree that additionality rules should be introduced for nuclear power that follow the same principles as those currently applied to RFNBOs in the RTFO?***

Please refer to the response to question 21.

Equilibrion agrees that the additionality rule should also apply to nuclear power.

Nuclear in the UK is currently operating 24/7 delivering electricity to reduce the carbon intensity (CI) of our national grid. Diverting this for another purpose is counter to delivering low-cost, secure, low-carbon electricity to consumers. Retrofitting PtL production is also highly unlikely to be a credible option for operating plants with limited lifetimes, and as new nuclear build of small modular reactors could be achieved on appropriate timelines (i.e. 2035), there should be no requirement to utilise existing generation. Additionality rules will promote new nuclear deployments and overall support a stronger pipeline of primary energy production from nuclear to deliver real-world decarbonisation of our energy system.

***23: Do you agree or disagree that, where hydrogen is used as a feedstock, eligibility should be limited to biohydrogen derived from wastes or residues and electrolytic hydrogen derived from renewable and nuclear power (when legal powers allow)?***

Equilibrion agrees with the approach to align feedstocks to biohydrogen, and electrolytic hydrogen derived from renewable and nuclear power.

***24: Do you agree or disagree that the contribution of energy content from hydro-processing should be calculated?***

Equilibrion agrees that the contribution of energy content from hydro-processing should be calculated and included within the SAF mandate.

***25: What level should the maximum CI threshold be set to maintain high sustainability credentials while ensuring enough flexibility to allow a wide range of SAF to be developed? Please provide evidence to support your answer.***

Equilibrion believes that the maximum CI threshold should maintain high sustainability credentials while ensuring enough flexibility to allow a wide range of SAF to be developed. This includes enabling the use of hydrogen with the maximum intensity allowed by the LCHS (notwithstanding the exclusion of blue hydrogen).

We believe that this should be kept under review to drive technology developments that overall continue to reduce the CI of flying and that ultimately a very low CI can be achieved. We believe that nuclear-derived PtL could have a CI of 5-6 $gCO_{2e}/MJ_{fuel}$, more than five times less polluting than the proposed CI threshold would allow.

***26: Do you agree or disagree that the minimum CI reduction should be increased over time? If so, how should it evolve?***

Equilibrion agrees that the low-carbon SAF mandate should target an increase in CI reduction. Timing of reductions should reflect the evolution of technology to deliver large volumes of SAF, including the commercial readiness of PtL facilities that can deliver significant emissions intensity reductions.

***27: Do you agree or disagree that the GHG methodologies used in the RTFO should be adopted in the SAF mandate?***

We foresee no major challenges to this approach and advocate for an approach that is consistent for all technologies. For example, we believe that emissions associated with:

1. Embedded materials including those associated with overbuilding to accommodate low capacity factors of renewables;
2. Mining of feedstocks;
3. Decommissioning and long-term safe storage of all waste including remediating the site back to a green field. We note that the costs and CI calculations of nuclear power generation include all these costs already;

4. Emissions associated with backup generation, battery and/or heat energy storage to account for the variability of renewables. This includes accounting for the embedded emissions in all backup systems considering the capacity factors of these. So for example, if a fossil fuel-fired backup generator operates only intermittently, the CI of the generated output should be increased proportionately;

If not done already, DfT should look closely at the supporting documentation for the low carbon hydrogen standard (LCHS) as the CI calculations exclude:

1. Embedded emissions;
2. Construction and decommissioning emissions.

The effect of this is that hydrogen from electrolysis with renewable electricity is allocated a carbon intensity of 0 $gCO_{2e}/MJ_{LHV}$ hydrogen, which is clearly inaccurate and the approach is not consistent with the RTFO. This approach also neglects to account for the impact of overbuilding, or low-capacity factor effects and drives disparity with other technologies that have a higher capacity factor.

We also note that the calculation for CI of hydrogen produced from nuclear electricity is inexplicably high compared to other reference sources. The LCHS does not provide a reference for the 14 $gCO_{2e}$/kWh electricity that it uses for the output from nuclear. This figure is significantly higher than the advisory position from E4Tech in the work to assess options for the LCHS (Options for a UK low carbon hydrogen standard (publishing.service.gov.uk)).

Equilibrion therefore believes that CI values from the LCHS should not be used in CI calculations for the SAF mandate.

***28: Do you agree or disagree that only disaggregated default values will be provided for downstream emissions while the rest of the SAF lifecycle will require the use of actual GHG values?***

Equilibrion agrees that disaggregated default values should be provided for downstream emissions, whilst the rest of lifecycle emissions will require the use of project-specific GHG values.

***30: Do you agree or disagree that upstream and operational emissions should be included for nuclear power generation at the point of delivery? If yes, please provide evidence of what figure could be used for the default value.***

We agree that upstream emissions should be included, and the following references provide guidance that the figure should be 5-6 gCO2/kWh:

- szc_epd_style_doc_final_v02-00_29.10.21.pdf (edfenergy.com) and
- Current and future lifecycle emissions of key low-carbon technologies and alternatives - Climate Change Committee (theccc.org.uk).

We request that DfT clarifies its proposed approach to calculating CI figures when hydrogen is both produced and consumed within the fuel production system boundaries. There is currently uncertainty on whether the figures within the LCHS should be used in these instances, or whether the RTFO calculation route is the sole method.

We see that DfT has two options:

1. Consider the CI for the hydrogen produced within the PtL system in line with the LCHS. CI associated with other energy requirements from the system calculated according to the RTFO.
2. Hydrogen is considered as internal to the system and therefore the LCHS does not apply. The RTFO calculated figure applies to all energy input to the system, including that used for hydrogen production.

In both cases there will need to be a specific statement on the approach for calculating the CI of heat, relative to the CI of electricity. Typically figures are available for the CI of electricity, and the heat CI can be derived from this based on electricity production efficiency. This efficiency will change depending on the particular nuclear reactor system being deployed, so this will also need to be taken into account.

Our preference is option 2, as this considers the PtL system as an integrated system and avoids the potential for differences between the CI calculation route for the LCHS and RTFO.

Where DfT considers option 1 to be necessary, there should be consistency over the CI figure used for nuclear electricity and heat. Currently the figure for 'electrolytic hydrogen using nuclear electricity' uses a CI value for nuclear electricity (14 gCO2/kWe) that is not referenced and is nearly three times higher than other available reference sources (see above). This requires clarification with DESNZ as this figure would have a significant impact on the CI of the resulting PtL. Furthermore, if option 1 is selected we recommend that the project developer has the option to adjust the default LCHS value where evidence can be presented for an alternative CI figure.

***41: Do you agree or disagree with the calculation of certificates set out above?***

Equilibrion agrees with the proposed continuous approach for the calculation of certificates. This would ensure full recognition for technologies that achieve CI figures lower than the threshold and encourage the take up of the lowest carbon technologies through the life of the SAF mandate.

***45: In your view, should GHG reductions from CCS be rewarded under the SAF mandate? If so, should the reward extend to net negative emissions (i.e. less than 0 gCO2e/MJ on a lifecycle basis), or should these be supported by an alternative GGR policy or a combination of policies?***

Equilibrion believes that other GGR policies, including those for direct removal and sequestration of carbon dioxide, will be better placed to support GHG emissions reductions from net negative emissions. Therefore, we believe it is important for the SAF mandate to not preclude the application of a combination of policies to best incentivise the development of novel, large-scale production facilities.

***56: Do you agree or disagree that excess PtL certificates can be used to fulfil the main obligation?***

Equilibrion agrees that excess PtL certificates should be eligible to be used to fulfil the main obligation.

**Call for Evidence**

***4. The Department would welcome evidence on the use of blue hydrogen in SAF production:***

- ***Existing industry plans to use blue hydrogen in SAF production***
- ***How the capital and operational costs of blue hydrogen compares to proposed eligible hydrogen production routes and the impact this would have on the price of SAF***
- ***How the use of blue hydrogen versus proposed eligible hydrogen production routes will impact production capacity and whether eligibility of blue hydrogen is required to meet UK SAF targets***
- ***How the use of blue hydrogen versus proposed eligible hydrogen production routes will impact lifecycle CI of resultant SAF***

Equilibrion is of the view that solutions that do not use unsustainable feedstocks should be prioritised and where this is unavoidable there should be a clear pathway to reducing reliance on these feedstocks. While we recognise that during the energy transition, there is a risk that perfection can be the enemy of the good we feel strongly that there are better solutions to blue hydrogen using mature technology that will be available on a reasonable timescale. Racing to imperfect solutions that lock in emissions should be avoided.

Proposals for nuclear-derived PtL offer a lower carbon, more sustainable large-scale solution, and nuclear energy can also be a low-carbon source of hydrogen for partnering with biofuel routes with lower emissions than blue hydrogen production pathways.

Where DfT considers blue hydrogen to be a near-term option for hydrogen production, this could be explicitly limited to biogenic-based SAF production and should absolutely not apply by implication to PtL production pathways. DfT should continue to exclude blue hydrogen from PtL pathways whatever the case, as there are lower carbon, more sustainable options available that can provide the volumes of hydrogen needed on the required timescales and this would significantly dilute the value of PtL fuels.

In the instance that DfT support blue hydrogen for biogenic SAF production, this will need to consider the lifecycle impact including fugitive emissions, the potential for price fluctuations and shocks, and the need to reduce this reliance in the near term when other options are available.

***6. The Department would welcome evidence of the impact of CCS on lifecycle GHG savings that can be achieved by SAF, including the potential for negative emissions***.

Nuclear can be used to drive oversized DAC systems where carbon storage infrastructure is in place with a small but significant impact on the volume of fuel produced. How much oversize the DAC systems would be will depend on the price of carbon versus the price of fuel. Producing carbon-negative nuclear-derived PtL is credible and deliverable in locations that have access to carbon transport and storage infrastructure.