The Nuclear Institute welcome the opportunity to respond to the call for ideas related to the Low Carbon Fuels (LCF) and recognise the role that Low Carbon Fuel can play in meeting our national and global Net Zero aims.

We are pleased to see the high-level recognition that nuclear power can play as highlighted in Figure 1 of the call for ideas. Our observation is that the document presently understates the importance of the need for large quantities of low carbon heat and power to underpin the strategy. This can only economically be provided by renewables and nuclear in particular, with respect to low carbon heat in the future. We wanted to highlight that the call for ideas does not include all the benefits nuclear energy can provide for low carbon fuels.

There are three areas that we would like to highlight:

1. The major part it will provide creating the original energy vector that powers the production of LCFs
2. The conversion of that energy into LCFs
3. The important part that low carbon heat will play systemically

The growing amount of new low carbon energy required:

The base energy required to create Low Carbon Fuels will be substantial and beyond reach of solar and wind combined with energy storage. This is highlighted in the Climate Change Committee which envisions that electricity demand will approximately 550 – 680 TWh by 2050 and all pathways considered by the Climate Change Committee show that variable renewable energy (including wind and solar) is unable to meet the required demand with 60 – 75 GW of electricity from other sources required[1]. This covers electricity demand alone and does not include low carbon heat required for other sectors such as heavy industry.

Nuclear power not only provides low carbon, reliable electricity - it is also able to act as a low carbon heat source for low heat (~300ºC) or high heat (~700ºC) purposes where required. This heat can be provided at a cost that is relatively similar to burning fossil fuels (historically) and used to produce low carbon fuels in an efficient manner.

The conversion of energy into LCF:

A number of the processes for LCF development highlighted in Figure 4 and Figure 5 may benefit from heat produced by nuclear with respect to improving the efficiency of the process.

Almost certainly, a future LCF system will require readily available large quantities of both hydrogen and heat. Note that this hydrogen is used not just as a fuel but as a chemical agent. Overtly or tacitly, hydrogen is needed for the production of many of the LCFs. Nuclear provides that low

[1] Data from Table A 3.4a of Climate Change Committee Sixth Carbon Budget – Electricity Generation - https://www.theccc.org.uk/wp-content/uploads/2020/12/Sector-summary-Electricity-generation.pdf

carbon base energy generation (heat and electricity) for the low cost production of hydrogen that will be the basis for many of the low carbon fuels.

Figure 5 in the supply chapter does not highlight the role nuclear power can play for hydrogen production:

Some illustrative examples:

- On a pure electrical basis, nuclear can provide electricity to support electrolysis from water in a similar manner to renewables with an additional advantage that the electricity will be firm power which will ensure more cost efficient production.
- Hybrid basis where technologies such as solid oxide steam electrolysis can use waste nuclear heat and generate hydrogen more efficiently (~10% boost to energy efficiency). In this instance, the heat is effectively used directly as the energy vector. Higher temperatures using advanced reactors will yield even greater efficiencies.
- Chemical production of hydrogen where water is 'cracked' using heat and recycling chemical processes. This is being developed in Japan and Canada with a watching brief by the National Nuclear Laboratory in the UK. If successful in the future, this will produce very low cost hydrogen.

Examples of the systemic advantages of nuclear energy for LCFs:

- Hydrogen fuel: Highly capitally intensive electrolysers will need to be operated equally intensively to generate the hydrogen at a price required for fuels. This can only reasonably be achieved through non-intermittent power sources, either nuclear or CCUS with nuclear likely to be the most economic option going forward
- Biofuels (and agriculture generally): Will require low carbon fertilizers which will be derived using low carbon energy alternatives. CCUS and nuclear can [in the future] provide the energy feedstock for these chemicals.
- Synthetic Aviation Fuels (SAF): Aircraft will need a 'slot in' fuel. It is envisaged that nuclear heat can provide the energy for making SAF in the future. Nuclear energy can also provide the stable, low carbon electricity needed to power direct air capture processes which could be used to create SAF.
- Synthetic fuels can also be deployed to support marine, vehicle and rail transport as required and would benefit from the low carbon electricity and heat nuclear power can provide.
- Carbon efficient chemical reforming generally: Where low carbon heat from a nuclear reactor can be used to recycle long chain molecules and make fuels thus avoiding the need to burn valuable fuel to make the process heat.

The important part that low carbon heat will play systemically

Heat generally is not transported and used in the UK. High temperature heat is generally created locally through fuel combustion and this will not be as available in a Net zero future. Note that it is possible to derive nuclear heat at a similar cost to natural gas (historic price) without the carbon penalty. The nuclear industry is progressing lower cost advanced reactors. In the future, a new breed of High Temperature Gas Reactors (HTGR) will have the capacity to generate large quantities of 600 – 900^{o}C heat that will replace burners. This heat will be used to power industry.

Examples that illustrate how nuclear heat will be used:

- Biorefineries for instance could use nuclear derived heat in the form of high temperature steam rather than burning valuable bio-molecules to process LCFs
- Heat will be a useful energy vector in the future of Fischer–Tropsch processes to make synthetic fuels such as SAF
- Heat and hydrogen contribution to Haber–Bosch process for making ammonia. Ammonia is used for fertilizers for agriculture and biofuels production and has the potential to support marine propulsion.

While nuclear power is recognised by UK government as a key part of meeting our Net Zero goals as highlighted by the 10-point plan and Energy White Paper, its connection to LCF cannot be taken for granted and would be a strategy omission not to highlight its importance underpinning LCF production and ensure it is supported.

Summary:

LCF production will require significant quantities of energy (electricity and heat) which need to be low carbon and affordable. This needs to be considered in the context of the increase low carbon energy demand required to meet our net zero goals and support areas such as Electrical Vehicle charging, heating of homes via electric heat pumps or hydrogen and decarbonisation of heavy industry. Considering the challenge ahead, we hope that the DfT will continue to advocate for an increase in all low carbon technologies including Nuclear power and renewables to ensure the requirements for low carbon fuel are met.

Should the DfT wish to learn more about how nuclear can support its Net Zero targets, we are happy to discuss further.

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