Future Energy Scenarios 2024 Call for Evidence

Summary

The Nuclear Institute (NI) is the professional body and learned society for the nuclear industry. Representing over 3,500 professionals at all levels across the industry, from new build and operations to decommissioning, the NI sets the standards for nuclear professionalism.

The NI is supportive of this Call for Evidence. Without nuclear technology, the route to Net Zero would be higher risk, more expensive and uncertain.

Nuclear technology can also be used to decarbonise, heat, transport and electricity through vectors such as hydrogen and synthetic fuels.

Questions responded to:

- What are your thoughts on current net zero policy and what is needed to deliver a net zero economy?
- What is the biggest challenge for the UK in meeting net zero by 2050 and what must be done to overcome it?
- What is the biggest opportunity for the UK in reaching net zero by 2050?
- What are your thoughts on current government ambitions for low-carbon hydrogen production?
- In 2035, which of these electricity supply technologies do you feel should have the highest installed capacity within GB? Rank them from greatest capacity to smallest capacity.
- In 2050, which of these electricity supply technologies do you feel should have the highest installed capacity within GB? Rank them from greatest capacity to smallest capacity.
- If you were designing the optimal route to net zero, what would you expect this to look like from an electricity supply perspective? What evidence can you point us to, to support your view?

1. ***<u>What are your thoughts on current net zero policy and what is needed to deliver a net zero economy?</u>***

This question has been answered through the lens of nuclear power, but several aspects may have synergies with other elements of the energy sector.
It is evident that nuclear policy is maturing, with the announcement of Great British Nuclear (GBN) to deliver Small Modular Reactors (SMRs) to the grid being a positive step. However, there are significant challenges ahead for the sector.

The "Delivering Nuclear Power" report (Jul '23)[1], authored by the House of Common's cross-party *Science, Innovation and Technology Committee* provides an excellent overview on the current status and gaps of energy policy in relation to nuclear power. Key recommendations to note:

- UK Government policy needs to move away from ambitions to a concrete strategy, a *Nuclear Strategic Plan* – as part of this, there needs to be an indication of how much of the 24GW ambition (25% of electricity generation being nuclear by 2050) will be accounted for by SMRs and/or large GW scale plants. The plan should also cover skills, supply chains and plans for regulation/licensing/siting.
- It is positive that GBN has been announced with support of up to £20bn for SMRs. This competition will support at least one technology vendor and at least one technology through to FID decision on their deployment within the next parliament (latest decision 2029). However, greater clarity on the role of GBN must be provided.
- What financial models are anticipated for supporting future nuclear and what are the planned routes for attracting private partnerships.

2. ***<u>What is the biggest challenge for the UK in meeting net zero by 2050 and what must be done to overcome it?</u>***

The biggest challenge for the UK in meeting net zero is two-fold: understanding how technologies can be rapidly scaled-up to meet the demands for net zero and ensuring energy security. Both factors are highly interdependent.

Scaling: there are a wide array of technologies to support meeting net-zero targets, the real challenge is ensuring that these technologies can be deployed at pace with the right enabling policy. Concerning nuclear power, and again many of these challenges are transferable to other elements of the energy sector, the two biggest challenges underpinning the issue of scaling are:

1. Robust supply chains:

   In order to meet net-zero ambitions, the energy sector supply chains need to be in place to ensure the rapid deployment of low-carbon technologies. This very closely ties into energy security.

   For the nuclear sector, there are significant challenges at present with global supply chain bottlenecks in heavy forging capabilities which could slow down the rate of deployment. This is especially pertinent as the US recently announced that 200GW of nuclear power will be required by 2050 in order for it to meet its net-zero targets[1].

   There are opportunities for the supply chain to grow in nuclear though initiatives such as the publicly funded Nuclear Advanced Manufacturing Research Centre's (NAMRC) Fit4Nuclear Programme[2] that helps manufacturers "sector-hop" and have the suitable accreditations to deliver for the nuclear sector. The centre also has similar programmes for wind power and hydrogen.

   Supply chain growth to meet demand does need policy support, however.

2. Enabling policy:

   There remain challenges in policy around siting, licensing and regulation. Reforms are required in order to meet the pace at which new low-carbon energy technologies need to be deployed to meet net-zero.

   At present in the nuclear sector, further clarity is required on where responsibility sits for these activities – GBN or Dept. for Energy Security and Net Zero.

Energy Security: many technologies are reliant on raw materials and manufacturing capabilities in potentially hostile countries to the UK, and as such, there is an increasing need to develop a domestic or Western supply chain for low-carbon technologies. The Energy Security Strategy Plan

(Mar '23)[3] goes some way to providing clarity on this matter, but again how this translates into actionable interventions remains uncertain.

Further Comments: It is also important to recognise that there are still many hard to abate sectors, such as foundation industries, aviation and so forth. It remains a challenge to decarbonise these sectors without alternative fuels such as synthetic aviation fuels, ammonia, or hydrogen. There will need to be a rapid scale-up of fuel production and in order to so in an economical and low-carbon manner, it is inevitable that nuclear technologies will have to underpin these industries. The reason for this, taking hydrogen as an example, is that the economics of producing hydrogen are more favourable if there is a continuous (high-capacity factor) production process. This will be more difficult to achieve with renewables without increasing system balancing/storage costs. Nuclear power in contrast can offer localised cogeneration at high-capacity factors (>90%), with the potential to simultaneously increase the efficiency of electrolysis processes by utilising heat from steam off-takes[4].

The relationship is complimentary – nuclear can help support a growing hydrogen economy, whilst hydrogen co-generation itself can improve the economics of nuclear power in the context of a high-renewable energy mix[5].

Challenges remain to produce fuels from nuclear power, in terms of licensing the colocation of nuclear and hydrogen/ammonia/syn-fuel sites, financial models and regulation. It is noted that Frazer-Nash Consultancy, on behalf of BEIS, has undertaken an analysis which indicates the suitability of sites for nuclear cogeneration with hydrogen.

References:

1. https://www.energy.gov/lpo/articles/sector-spotlight-advanced-nuclear#:~:text=The%20United%20States%20will%20likely,to%20meet%20national%20decarbonization%20targets.
2. https://namrc.co.uk/services/f4n/
3. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1148252/powering-up-britain-energy-security-plan.pdf
4. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1158090/HYS2153_FNC_Final_Feasibility_Report__Public_.pdf
5. https://www.oecd-nea.org/jcms/pl_73133/the-role-of-nuclear-power-in-the-hydrogen-economy

3. ***What is the biggest opportunity for the UK in reaching net zero by 2050?***

The challenges outlined in question two above can be converted into opportunities, especially regarding supply chains and nuclear cogeneration, provided the appropriate enabling policy is in place.
The following report also provides an in-depth energy system model including the role of nuclear cogeneration: https://www.nnl.co.uk/2021/06/nnl-publishes-energy-system-modelling-report/.

4. *What are your thoughts on current government ambitions for low carbon hydrogen production?*

This question is answered through the lens of the nuclear sector.

The government's intent and targets for hydrogen are ambitious (10GW by 2030 with 50% from electrolytic sources and 20-30% of energy consumption by 2050 or 250-460TWh[1]) – this is no bad thing, but does pose serious challenges for how it with be practicably realised as it is a significant ramp up given 96% of hydrogen is from fossil fuels at present[2].

Whilst nuclear is unlikely to play a significant role within the 2030 timeframe, noting the timeframe for first SMRs deployment being the 2030s, there is significant opportunity beyond this with numerous hydrogen-nuclear cogeneration highlighting the realistic feasibility and beneficial economics in doing so[2][3].

As an illustrative example FNC's cogeneration study indicated that SMRs could achieve a levelized cost of hydrogen of £2-6/kg, which has the potential to be cost competitive with gas with carbon capture[2]. As per the report, there is also a significant market opportunity: *cogeneration by 2050 could be 28 RR-SMRs (assuming ramped up production capacity in the 2040s), two MSRs and two HTGRs dedicated to hydrogen production, providing an output of 2.5 Mt H2 per year (>10% of UK hydrogen requirements by 2050). This is not including the potential of the hydrogen export market, which is estimated to cover 25% of global hydrogen demand."*

Note there is reference to multiple technologies; SMRs which are forecast for first deployment in the 2030s, as well as Molten Salt Reactors (MSRs) and High Temperature Gas Reactors (HTGRs). The latter two of these operate in temperatures greater than 600^{oC} and therefore could provide high-grade heat for chemical production of hydrogen, far more efficient than electrolytic conversion. Dept. for Energy Security and Net Zero currently has a Programme underway to develop the first test reactor for HTGRs by the 2030s[4]. This technology is therefore likely for first deployment towards the back end of the decade.

It is evident that nuclear co-generation can support the development of a hydrogen economy at scale – what needs to be seen to enable this is targeted policies relating to siting (when considering co-location of nuclear sites with production facilities), licensing and building of supply chains. Further work is required by government to provide this clarity.

References:

1. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1166666/hydrogen-investment-roadmap.pdf
2. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1158090/HYS2153_FNC_Final_Feasibility_Report__Public_.pdf
3. https://www.nnl.co.uk/2021/06/nnl-publishes-energy-system-modelling-report/.
4. https://www.gov.uk/government/publications/advanced-modular-reactor-amr-research-development-and-demonstration-programme-phase-b-competition

5. ***In 2035, which of these electricity supply technologies do you feel should have the highest installed capacity within GB? Rank them from greatest capacity to smallest capacity.***

It is evident that a mix of technologies is required to achieve net-zero; The Government's target of at least 24 GW of new nuclear technology by 2050 is highlighted and the Technology Innovation Needs Assessment[2] has also indicated the opportunity for up to 40-50 GW of UK energy generation to come from nuclear power.

This highlights the need for a pipeline of nuclear projects through 2035 and into 2050.
At present the opportunities for 2035 are as follows noting that the majority of the current fleet will be taken offline by 2030[3]:

- Hinkley Point C to come online adding 3.2GW to grid. Sizewell C, which is to be an almost identical design to HPC (again 3.2GW) is currently projected to be online by the mid-2030's.
- Sizewell B is the only operating reactor that has the potential for a life extension beyond the 2020's. EDF are targeting extending it's life from 2035 to 2055. Capacity 1.2GW.[4][5]
- Great British Nuclear SMR competition – intention to commit £20bn to at least one SMR vendor for multiple units from 2024 onwards, within latest date for FID in 2029[6]. SMRs can be commissioned, licensed and built in shorter timescales than traditional nuclear providing opportunity for multiple SMRs to be on-grid by 2035. Indicative and credible capacities per reactor for these SMRs are between 300MW (GE Hitachi)[7] – 470MW (RR SMR)[8].
- Additionally, several private investors are seeking to develop SMRs without the need for government intervention with the opportunity for further reactors to be built before 2035.
- In all, noting the above numbers, there is feasible potential for 9-10GW of nuclear power to be on-grid by 2035.

References:

1. https://www.gov.uk/government/news/nuclear-energy-what-you-need-to-know
2. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/593463/Refreshed_Nuclear_Fission_TINA_Summary_Report_February2016.pdf
3. https://publications.parliament.uk/pa/cm5803/cmselect/cmsctech/626/report.html#:~:text=The%20UK%27s%20current%20nuclear%20power,be%20shut%20down%20by%202028.
4. https://www.edfenergy.com/media-centre/news-releases/sizewell-b-starts-review-extend-operation-20-years
5. https://www.bbc.co.uk/news/uk-england-suffolk-66240489
6. https://www.gov.uk/guidance/small-modular-reactors-competitive-technology-selection-process
7. https://nuclear.gepower.com/bwrx-300
8. https://www.rolls-royce-smr.com/why-rolls-royce-smr

6. ***In 2050, which of these electricity supply technologies do you feel should have the highest installed capacity within GB? Rank them from greatest capacity to smallest capacity.***

It is evident that a mix of technologies is required to achieve net-zero; NI wishes to highlight that it is government policy ambition to achieve 24GW of nuclear power by 2050, or 25% of electricity generation[1]. The Technology Innovation Needs Assessment[2] has also indicated the opportunity for up to 40-50GW of UK energy generation to come from nuclear power.

NI believes that SMRs will provide a strong avenue to achieving the 24GW by 2050 with LCOE figures cost-competitive with renewables (e.g., indicatively RR SMR's LCOE is £50-75/MWh in 2023 prices[3]) and avoiding some of the wider systems balancing/storage costs that are not reflected in traditional LCOE values for renewables. Again, not only is government policy maturing in this area, but private investors are lining up to invest in nuclear without the need for public finance.

Beyond the direct opportunities for nuclear generation to grid, there are numerous opportunities for:

- Hydrogen Co-Generation
- Synthesis of synthetic fuels (e.g., Sustainable Aviation Fuels) / ammonia
- Industrial Heat
- Providing electricity for off-grid / remote locations
- Providing electricity direct to industrial consumers such as data centres
- Direct Air Carbon Capture

Several relevant papers/articles are referenced below and discussed against the other questions in this document.

References:

1. https://www.gov.uk/government/news/nuclear-energy-what-you-need-to-know
2. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/593463/Refreshed_Nuclear_Fission_TINA_Summary_Report_February2016.pdf
3. TBC

Other References:

- https://www.niauk.org/forty-by50-the-nuclear-roadmap/#:~:text=This%20report%2C%20compiled%20by%20the,steps%20required%20to%20deliver%20them.
- https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1158090/HYS2153_FNC_Final_Feasibility_Report__Public_.pdf
- https://www.nnl.co.uk/2021/06/nnl-publishes-energy-system-modelling-report/.

7. ***If you were designing the optimal route to net zero, what would you expect this to look like from an electricity supply perspective? What evidence can you point us to, to support your view?***

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Importantly, it is worth recognising that the most economical way to operate nuclear power is in baseload capacity and avoids the price cannibalisation effects faced by renewable vendors. Capacity factors upwards of 90% are achievable for nuclear (based on data from US nuclear fleet operators), especially SMRs. There are also ways to compliment the intermittency of renewables using nuclear – SMRs designed specifically for hydrogen cogeneration can divert steam offtake (ranging from 0% (full electricity generation) to 100% (full thermal transfer)) from turbines and electricity to hydrogen-processes; in doing so, providing heat and electricity for the electrolytic generation of hydrogen.

Note a government feasibility study into nuclear-hydrogen cogeneration[4] indicated that: *By 2050, the UK aims to have met its Net Zero targets, with 20-35% of energy requirements needing to be met by low carbon hydrogen. Using estimates obtained as part of this work, a potential scenario for cogeneration by 2050 could be 28 RR-SMRs (assuming ramped up production capacity in the 2040s), two MSRs and two HTGRs dedicated to hydrogen production, providing an output of 2.5 Mt H2 per year (>10% of UK hydrogen requirements by 2050).*

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The remainder of the grid would be supported by renewables, biomass, gas with CC etc.

References:

1. https://www.gov.uk/government/news/nuclear-energy-what-you-need-to-know
2. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/593463/Refreshed_Nuclear_Fission_TINA_Summary_Report_February2016.pdf
3. **TBC**
4. **https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1158090/HYS2153_FNC_Final_Feasibility_Report__Public_.pdf**

Other References:

- https://www.niauk.org/forty-by50-the-nuclear-roadmap/#:~:text=This%20report%2C%20compiled%20by%20the,steps%20required%20to%20deliver%20them.
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