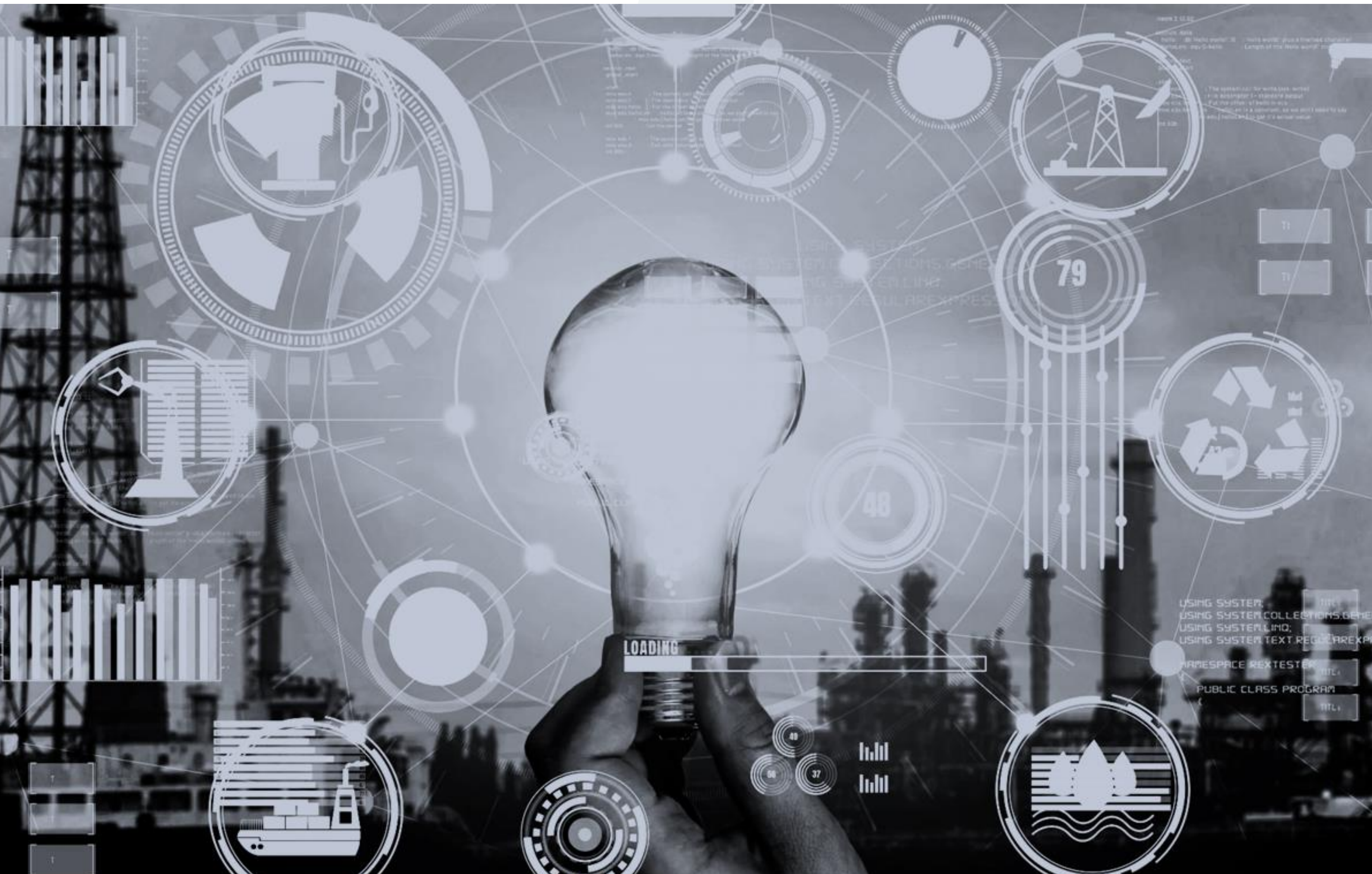
Alternative Routes to Market

Combined Consultation Response

Prepared for the Department for Energy Security and Net Zero

April 2024



Introduction to this Document

This document comprises an industry response to the Department for Energy Security and Net Zero (DESNZ) Consultation on Alternative Routes to Market.

The signatories to this document represent a wide range of businesses that will be affected by the outcome of this consultation, including those that represent the energy user community. This collective response to DESNZ is intended to support guiding the future policy pathway in the areas where a response has been provided.

This document was brought together by Equilibrion, who has also guided and facilitated the response.

DESNZ should note that for convenience, this submission has also been made through the online portal under the name of Caroline Longman. It is distinctly different from the submission by Philip Rogers, which represents Equilibrion's own, specific corporate submission.

Question 1: Are there any uses for nuclear energy (beyond those in the consultation document) that you believe government should be considering? If yes, please explain what they are.

The categories of potential new uses of nuclear energy listed in the consultation document adequately cover the spectrum of potential uses with the addition of:

- methanol production;
- desalination;
- carbon capture;
- medical isotopes;
- Desalinisation.

DESNZ may also wish to consider two areas where approaches to deployment and financing may be required:

- Data centres specifically are set to increase in size, potentially to more than 1000 MW, and there is predicted to be a very large growth in energy demand from the sector overall. Some states in the USA have already rejected the building of new data centres due to the inability to provide suitable energy supplies. The primary demand for energy

Reverse Osmosis Desalination Plant

at data centres is electricity, but there is also a need for heat and hydrogen.

- Ports are another sector that DESNZ may wish to consider specifically due to the diverse energy needs and potential for production and use behind the meter.

However, we believe an all-encompassing approach can best enable nuclear to realise its potential in net zero and that a definitive, prescriptive list of applications, set into policy or legislation could be counter-productive.

We also believe that all nuclear technologies should have access to alternative routes to market, noting the giga-watt (GW) reactors as well as ANTs can deliver the uses outlined in the consultation and listed above. Therefore, it is important that technology selection is applied to achieve the optimum outcome of the solutions.

A key challenge for DESNZ and the wider energy sector is how to adequately model nuclear in the energy system for all noted applications and relevant deployment models; for example, direct coupling reactor-end use coupling, behind the meter, or grid supply. None of the current UK energy system models suitably cover the available options, which limits the visibility of how nuclear can contribute to net zero and potentially constrains investor appetite. This also creates an uneven playing field with other energy sources that are more completely modelled.

DESNZ should therefore consider developing new modelling capability, which would provide policymakers with a reliable, informed evidence base covering the full range of potential applications for nuclear energy.

Question 2: To what extent do you agree that advanced nuclear can be a valuable energy source when combined with a Thermal Energy Storage System or for cogeneration? Please provide an explanation for your response.

Strongly Agree

Nuclear energy can contribute to a flexible electricity system by compensating for the inherent intermittency of renewable energy, increasing grid resilience and adding important inertia to the grid; a service not offered by renewable generation. Variable output also acts to reduce the volumes of energy storage required compared to an energy system based only on variable energy sources.

We encourage DESNZ to include the value of inertia and reduced storage as part of engagement across the department. This applies in policymaking by both nuclear and non-nuclear teams to ensure all factors are considered when making value assessments between different net-zero energy system models. This is valuable for deployment at industrial sites/clusters where energy demand may not be level.

Nuclear is best operated at constant, full power, to utilise thermal energy storage or enable the electricity supplied to the grid to reduce by directly feeding power to electrolysers for hydrogen production.

Indeed, modelling by the Energy Systems Catapult to support nuclear for net zero showed that nuclear operated in flexible electricity/hydrogen cogeneration mode is highly valuable to the energy system. In particular, the model demanded mainly electricity from the nuclear power station with a smaller proportion of hydrogen, before transitioning to higher outputs of hydrogen as demand increased towards 2050.

In the instance of cogeneration of hydrogen and electricity, electrolysers are best operated at a high-capacity factor to reduce the overall price of hydrogen, so the design of projects and systems will need to be carefully considered to ensure economic viability. DESNZ may wish to work with the Future Systems Operator (FSO) to consider how to appropriately recompense a nuclear power station operator for offering these services.

Question 3: To what extent do you agree that advanced nuclear could be a valuable energy source for large-scale industry. Please provide an explanation for your response.

Strongly Agree

We agree that ANTs could provide an essential energy source for large-scale industries. All reactor technologies, including GW reactors, can decarbonise industrial operations through direct heat (up to 300°C for Light Water Reactors) and produce cost effective electricity and hydrogen production, where hydrogen can be utilised as both a feedstock (synthetic fuels, ammonia, methanol, direct reduction iron for green steel production) and for flexible backup electricity production itself. Additionally, the high temperatures of AMR's could unlock cost effective hydrogen production through supporting additional technologies such as thermo-chemical water splitting.

Indeed, the role of nuclear should be considered from the perspective of its ability to decarbonise current operations, providing existing industries with credible decarbonisation pathways, but also future industries. The latter could include green steel, synthetic fuels, hydrogen and carbon capture and therefore integrating planning for these with the demand for nuclear is essential.

A significant portion of industrial heat demand is challenging to electrify, particularly at higher temperatures. The higher temperature output of some AMRs (e.g. ~700 – 950°C for High-Temperature Gas Reactors as opposed to ~300°C for conventional light-water reactors) could support the supply of heat to hard-to-electrify sectors. Work today carried out by industry provides evidence that advanced nuclear can provide direct process heat to decarbonise a wide variety of industrial processes creating highly efficient decarbonisation solutions.

Siting nuclear in a location with access to CO_2 storage and transportation infrastructure can provide additional opportunities to provide the energy source that can remove CO_2 from the atmosphere and contribute to reducing the effects of climate change through negative emissions. Where this is not possible then CO_2 can be stored and transported by rail or road meaning any nuclear power station could deliver carbon-negative output.

Studies carried out on the decarbonisation potential of a typical ANT demonstrate that the full capacity of these systems can be utilised to support the decarbonisation of industrial clusters. Amongst the six biggest UK industrial clusters, there is a low carbon energy requirement that can support multiple reactor deployments. Even on dispersed sites, additional functionality such as district heat and low carbon fuel production can support localised ANT deployment.

We also believe there are similarities between demands from energy-intensive industries and data centres and DESNZ could consider these demands in combination.

Question 4: In your opinion, what further measures should government take to enable industrial applications of advanced nuclear? Please provide an explanation of the type of support required.

Implementation of a favourable siting policy is required to enable flexible deployment of ANT to locations where the energy is needed. Rapid implementation will provide confidence to private investors. In addition, ensuring nuclear is considered on a level playing field when considering the appropriate business models required to stimulate investment, such as the SAF Mandate is essential. Nuclear must also be fairly represented in assessments against other energy sources, considering the wider decarbonisation challenge which is often extraordinarily under-represented.

To illustrate with an example, baseline projections against which the Net Zero Strategy indicative delivery pathway to 2037 do not include data centres and the future enormous energy demand for artificial intelligence. Therefore, future energy demand and the demand for heat are significantly under-represented.

The ability to decarbonise transport is another area where energy demand, that can be met with nuclear, is vastly under-estimated.

DESNZ could consider how to effectively support privately financed and funded projects, particularly in their earlier stages and where they are reliant on single or multiple power purchase agreements. These projects could fail to emerge if appropriate early-stage support and longer-term protections are not in place.

Question 5: To what extent do you agree that advanced nuclear could be a valuable energy source for hydrogen and synthetic fuel production? Please explain your answer.

Strongly Agree

We agree that energy from advanced nuclear is an ideal energy source to produce hydrogen and synthetic fuels. Production of hydrogen and synthetic fuel from nuclear benefits from the reliability and high-capacity factor of nuclear energy along with the ability to provide low-carbon electricity, heat and hydrogen from a very small land area. Many of these processes need constant power, so nuclear has an inherent advantage and can reduce all costs associated with grid reinforcement, energy storage and backup generation that are often hidden for other technologies.

Preliminary economic assessment shows that fuels produced from electricity and heat inputs from nuclear energy could be lower cost and at a greater scale than some other routes including from variable renewables.

The Climate Change Committee (CCC) states that to reach net zero we will need 270TW of hydrogen. This is far more than can be provided by renewables and electrolysis alone and so relies on Carbon Capture Utilisation and Storage (CCUS) enabled hydrogen and the continued need for less secure fossil natural gas. The CCC does not consider nuclear-enabled hydrogen-coupled systems.

Synthetic fuels also have a future demand that far outweighs the ability of any renewable energy source to produce them at the scale needed in the UK. The UK used 15 Mega tonnes of aviation fuel in 2019. If this volume was produced sustainably it would require

Data Centre

energy inputs equivalent to approximately 49 GW of directly supplied nuclear energy, approximately 150 GW of wind energy plus large storage and transmission infrastructure, or over 400 GW of solar. This is around three times the UK's peak nuclear capacity, 28 times the peak offshore wind capacity and 60 times the peak solar capacity. For the UK to be a producer of Sustainable Aviation Fuel (SAF) at any significant scale it is therefore highly likely to require nuclear energy due to grid-connected systems being costly and likely limited in scale. Direct renewable energy supplied systems are expected to be uncompetitive on cost due to energy storage demands.

The UK is ideally placed to take a leading role in developing the role of nuclear-enabled hydrogen and synthetic fuels. We can develop our supply chains and build the capacity, capability and knowledge to expand the role of nuclear beyond electricity.

Ultimately, what differentiates nuclear technology is the high-capacity factor and the ability to use both heat and electricity to drive down costs, addressing the intermittency of renewables therefore nuclear has the potential to enable hydrogen and synthetic fuels to reach the right price points by which it can displace oil and gas.

Question 6: To what extent do you agree government should explore the opportunity of using nuclear plants to provide district heating to help decarbonise our domestic and commercial buildings? Please provide an explanation and include suggestions on mitigating any potential barriers.

Strongly Agree

Waste heat from nuclear power stations to supply district heating systems with energy is proven globally, with multiple operating plants providing low-grade heat to energise local district heating networks. District heating can provide valuable ancillary revenue for nuclear reactors and the government should further explore how the technical and regulatory barriers can be overcome to enable any nuclear new build project to additionally support district heating. Siting of new nuclear power stations should consider access to current or potential future district heat networks.

There is extensive experience from around the world of the practical use of nuclear for district heating which provides a high confidence of the value of in this application with a high technology and regulatory readiness level.

Question 7: What do you think are the opportunities and challenges associated with other potential uses for nuclear power? Please explain your answer.

The scale of decarbonisation required for transport, heat and industry can be underestimated. The ability of nuclear energy to provide the energy source to deliver solutions that decarbonise these sectors at scale, together with the socio-economic benefits associated with nuclear development are the key opportunities that will deliver vast economic benefits to the UK.

Additionally, global expertise in the integration of these systems, if developed in the UK, can deliver a global future export opportunity where many other countries are also considering this opportunity.

HMG should consider setting and working towards longer-term decarbonisation targets in these sectors. Many departments and teams have targets for 2030, which means projects seeking to deploy in the 2030s are disadvantaged. Delivering short-term solutions only risks locking in imperfect solutions.

Solutions that rely on nuclear energy require a level playing field and must be fairly considered when compared with other renewable generation sources in the context of the energy system decarbonisation.

Our response to question 1 covers the other potential uses and we would add that:

- For desalination, the UK is due to be in water debt with an increasing demand for clean water for hydrogen production. This presents an opportunity for power stations located on the coast;
- For direct air capture, there is an opportunity for all nuclear power stations to be carbon-negative;
- For data centres, the opportunity is to consider siting of new nuclear to meet their needs;
- For medical isotopes, the opportunity is for DESNZ to review and support technologies that can support the UK's medical isotope demand.

The main challenge is how DESNZ can be prepared to support developers with the right incentives and frameworks across the whole range of applications and be prepared to negotiate contracts when these projects come forward.

Question 8: To what extent do you agree that the current regulatory pathways cover new uses? Are there any areas that are not covered? Please explain your answer.

Undecided

In principle, the goal-setting approach applied in UK nuclear regulation provides flexibility for innovative technologies and applications to be regulated. Therefore, we agree that the current regulatory pathways cover new uses to a suitable extent.

However, we believe the capacity and experience of both the regulator and regulated entity restrict the deliverability of these pathways. Firstly, the ability to apply proportionate regulation within the regulator is dependent on the experience of individuals within the regulators, of which there are few with specific operational experience of novel nuclear technologies and applications. This can drive an overly cautious approach.

Secondly, in the UK regulatory regime, a significant regulatory burden is applied to the regulated party which can present an onerous demand for innovative organisations seeking to disrupt the sector with novel technologies and applications. This occurs both because of the need for the organisation to demonstrate relevant organisational capacity combined with the cost burden associated with being regulated. In summary, whilst an appropriate regulatory framework exists to support novel technologies and applications, its accessibility and flexibility are yet to be demonstrated. Beyond nuclear regulation,

DCO and local planning processes important to power and decarbonisation UK could be simplified to derisk potential marginalised voices stopping any new build projects.

Question 9: What, if any, are the main opportunities and challenges for streamlining regulation while maintaining high standards of safety, security and environmental protection? Please explain your answer.

A key opportunity is increased collaboration with international equivalent regulators to apply equivalent learning and experience. Fleet build cost savings will not be delivered unless regulators are willing to accept prior good practice as a basis for approval.

Developers of all technologies in any sector seek global markets to maximise the return on investment for design and development. Whilst global markets for most technologies have experienced significant progress in aligning regulatory regimes in recent decades, collaboration and alignment between global nuclear regulators is still limited. In our view, one of the key opportunities for the UK to streamline regulation whilst maintaining high standards of safety, security and environmental protection is to proactively recognise equivalent regulation as applied by equivalent regulatory regimes in partner countries. Such recognition can speed up regulatory pathways whilst reducing the overall regulatory burden. Further to this, regulators will need to recognise the application of prior good practice in equivalent installations across the UK if fleet build cost savings are to be achieved.

There are also considered to be innovations in the UK's regulatory arrangements to streamline the process whilst maintaining standards. These include, but are not limited to:

- The concept of a generic site assessment;
- Increasing the modularity of the regulatory process so that it aligns better to the development, manufacturing, construction and commissioning process;
- Reducing the administrative burden to developers by creating one nuclear regulator that covers safety, security, environmental protection (including habitats), safeguards, planning;
- Formalising arrangements for lead item regulatory oversight.

Question 10: Following the government's streamlining work to date, do you agree the next phase should focus on improving the efficiency of existing processes? Please explain your answer.

Agree

Streamlining and building capacity in the planning system will be critical to enabling projects to come forward.

Question 11: To what extent do you agree that advanced nuclear technologies and new uses of nuclear are accommodated within the existing legal landscape? Please explain your answer.

Agree

Agree. Advanced nuclear technologies and new uses of nuclear are appropriately accommodated within the existing legal landscape. We further note however that one of the challenges for deployment of advanced nuclear technologies and applications is the complexity of the legal landscape in comparison to other clean energy technologies. We, therefore, encourage the government to proactively support developers to navigate the legal landscape and reduce barriers to entry for new project developers.

Question 12: What are the opportunities and the challenges of the proposed engagement approach? Please explain your answer.

Outputs of early engagement need to be recognised within formal regulatory reviews for benefits to be realised.

Question 14: What else should the government do to ensure that new nuclear projects can be brought to market? Please explain your answer.

One of the challenges to delivering privately led nuclear projects is perceived conflicts with the role of Great British Nuclear (GBN) as a state-owned entity in the development of all new nuclear infrastructure in the UK. This could lead to a delay in privately funded projects coming forward while they wait for the position of GBN to be clearer.

For privately developed projects not to be stalled in this way requires the publication of a clear GBN roadmap, so that it is clear what its responsibilities and actions shall be beyond the current SMR competition. Furthermore, clarity on priorities for access to regulatory and policy support between GBN and non-GBN projects is required.

Nuclear projects need a competent operator for the lifetime of the project, which encompasses a vastly different organisational capability to a project developer. The government should consider the options for future operator entities which could include utilising existing UK operator capability or setting up an operator entity that can grow and flex to support the operation of privately funded projects. The forthcoming closure of the Advanced Gas Reactor sites provides an opportunity for HMG to access relevant capabilities to build a national operator.

Through this consultation and follow-up work, HMG is already recognising the diversity of opportunities for nuclear and the equally diverse demand within the energy system. However, noting that this consultation covers ANTs, while GW reactors also can support many or all of the applications noted, HMG could consider avoiding prescriptive language in its policy and favouring inclusive approaches that keep options open.

HMG should also consider a specific focus on building cross-Whitehall engagement and collaboration on the opportunity for nuclear to deliver on policies of multiple departments and teams.

Intervention from government is required for first of a kind (FOAK) deployments. However, industry require clarity on government’s role for private deployment of next of a kind (NOAK) projects.

Question 15: What, if any, structures do you think are appropriate for advanced nuclear technologies? Please explain your answer.

In the electricity domain, there are different business models, for example, CfD and RAB, for nuclear compared to other technologies. This enables policymakers to ensure that the UK has the most secure and lowest-cost energy system available. Where nuclear has the potential for other outputs, for example, hydrogen and synthetic fuels, so far as these are recognised in policy to deliver net zero, HMG should consider similarly specific business models for nuclear. The risk is that business models for new applications will be geared towards other technologies, reducing or removing the ability of nuclear to support the energy transition in these areas and constraining HMG's ability to deliver on its policies.

Noting the Hydrogen Auction Rounds are now forecasting into the 2030s, we would look for an approach that considers allocations for projects that inherently take longer to first operation with a longer-term horizon (and longer-term benefits).

Question 16: What are some key areas the government should consider in a potential business model to bring a first-of-a-kind project to market? Please explain your answer.

Port Ecosystem

Nuclear projects are an exemplar of the challenge of delivering capital-intensive solutions to the energy sector. With significant upfront investment and the majority of project risk loaded into the build stage, the overall risk picture can drive investors away from nuclear investments. Distribution of this risk equitably throughout the value chain will be critical to enabling the deployment of first-of-a-kind projects.

The value chain for advanced nuclear applications incorporates everything from the nuclear reactor, through production and distribution processes to the end user. Many deployment options would avoid the production of grid electricity and instead use nuclear heat and electricity to generate other products that support energy system demands directly. Downstream processes require distinct organisational capability compared to nuclear power plant operations and are most likely to be developed and operated by independent parties. Furthermore, existing incentives for the deployment of clean energy solutions across the economy focus on usage incentive mechanisms. For example, the RTFO mandates a minimum proportion of biofuel within forecourt fuel supplies across the UK, aiming to drive investment in upstream production.

When looking at business models for advanced nuclear deployment and delivering FOAK projects, the government should therefore consider how to ensure downstream incentives would impact on upstream risk. For example, by ensuring that green fuel levies have an appropriate time horizon that can support the development of nuclear technology. Further to that, it should consider how business models can appropriately share risk between all stages of a value chain.

Question 17: How do you think the support required for projects should differ for later, nth-of-a-kind projects compared with a first-of-a-kind project? Please explain your answer.

The scale of demand for clean energy solutions is set to accelerate through the coming decades to deliver the 2050 Net Zero target. When designing support mechanisms for nth-of-a-kind projects, the government should consider how the risk profile will change compared to first-of-a-kind projects. Deployment risks will be reduced as a result of learning from experience. As confidence increases in the deployment of advanced nuclear projects, HMG support to projects is likely to need to transition to focus on mechanisms that encourage the acceleration of deployment.

Question 20: What support infrastructure, or other enablers, would help bring projects to market, in addition to those highlighted above? Should the government introduce measures to help private developers bring projects to market? Please explain your answer

Private developers need fair and equal access to regulatory and government support alongside government-driven initiatives, for example, GBN.

Question 21: To what extent do you agree that the government will always need to put measures in place to protect citizens, consumers, and taxpayers, even where a nuclear project is entirely privately financed? Please explain your answer.

Strongly Agree

There will always be a need for government engagement in privately financed projects, including long-term financial risks of decommissioning. DESNZ may wish to consider how it can facilitate risk sharing between multiple projects. For example, where twenty projects are being progressed in the UK, HMG may consider a percentage of these to require intervention to ensure all through-life costs are appropriately covered and could therefore make arrangements for risk sharing.

Question 22: To what extent do you think companies wishing to negotiate with government should be tested against suitability criteria before entering negotiations? Please explain your answer.

Strongly Agree

We agree that tests should be proportionate to the level of associated risk at the point of negotiation and the associated long-term risk that the government could be exposed to.

However, we encourage informal engagement between HMG and industry as part of the natural course of HMG activities and criteria should not be set to inhibit this process.

Question 24: What further steps should the government take to support R&D for Advanced Nuclear Technologies? Please explain your answer.

R&D support needs to cover all aspects of the value chain, interfacing fully with R&D support for downstream applications. To date, the focus has been on the nuclear technologies themselves, but there is significant scope to increase the efficiency of outputs of the products from nuclear systems and R&D programmes must cover the entire value chain and the integration of such to accelerate the path to commercialisation.

R&D should have a real-world application and ideally be associated with a longer-term vision or deployment project to ensure that the value of HMG investment in R&D is maximised through commercialisation.

Question 25: To what extent do you agree that there are current or future gaps or constraints in the UK R&D landscape for Advanced Nuclear Technologies, either for that high TRL R&D and demonstration or earlier stage R&D? Please explain your answer.

Strongly Agree

The answer is the same as the above, that R&D must focus on delivering the full systems rather than the individual reactor technologies in isolation. Engagement between the nuclear and non-nuclear sector teams is therefore essential to enable cross-cutting projects that cover both the energy source and the end user needs.

A significant limitation of some non-nuclear sector innovation programmes is that they do not adequately require bidders to consider the low-carbon energy source required for their project. This leads to HMG funding projects that do not have a pathway to being operational, which creates an uneven playing field for projects that rightly cover their energy needs but are more complex as a result. This can lead to poor value for the taxpayer.

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