# Nuclear Innovation and Research Advisory Board – Early Advice to BEIS

March 2022

## Context

1. The Nuclear Innovation and Research Advisory Board (NIRAB) is a group of independent experts who work in partnership with the Nuclear Innovation and Research Office (NIRO) to advise Ministers, Government Departments and Agencies on issues related to nuclear research and innovation in the UK. The third iteration of NIRAB was convened in autumn 2021 and the Board is developing a substantive programme of work. This document outlines early advice to the Department for Business, Energy and Industrial Strategy (BEIS) on the Advanced Modular Reactor Research Development and Demonstration Programme (AMR RD&D) from initial analysis. NIRAB broadly welcome the proposal for a three-phase approach to delivery, as outlined in the recent market engagement exercise[1]. However, there are several points that NIRAB advise BEIS should urgently consider within the programme.

## Early Advice to BEIS

2. The Nuclear Innovation Programme (NIP) funded by BEIS made headway in supporting the development of the nuclear sector's skills and capability for development and delivery of small and advanced modular reactors. NIRAB advise that continuous support should be maintained to ensure that this capacity is retained and built upon in order to ensure that the sector is in a position to deliver phases B and C of the AMR RD&D programme – the design and construction of a demonstrator. Any hiatus in funding will inhibit delivery to the required timescales. The UK should also invest in expertise to, at least, maintain a position as intelligent customer for other reactor technologies, which in turn will support UK membership of GIF and IAEA. Phase C activities that could be brought forward to accelerate timescales for delivery should be strongly considered. BEIS should also consider the facilities and investment that will be needed to support the programme.
3. We advise that BEIS consider fuel cycle strategy as a priority, and do so in parallel to the development of a reactor design of choice. This should include fuel supply and performance, as well as a source of appropriate fissile material (uranium of an appropriate enrichment level or plutonium). The UK is fortunate in that its indigenous supply chain has the requisite capability to support across the whole fuel cycle, and the AMR RD&D programme should facilitate this to ensure UK value and security of supply is embedded. It is noteworthy that the UK owns a one-third share of Urenco, the most credible supplier of the High Assay Low Enriched Uranium (HALEU).
4. It is essential that the use case for AMRs is understood in the context of the UK's requirements, which will differ from those of other nations with varying infrastructure and demographics. This in turn will assist in identifying the specifications for a reactor that will

---

[1] Advanced Modular Reactor Research, Development & Demonstration Programme: Indicative Programme Outline (nirab.org.uk)

best support the UK markets. NIRAB advise that the primary purpose of HTGRs should be the heat outputs (rather than electricity) and the vectors that this could potentially support, including for example the hydrogen economy, district and industrial heating, synthetic fuels and ammonia production. The AMR RD&D programme should be clear on what it will demonstrate, including demonstration that HTGRs can competitively deliver across these vectors. We suggest that a mechanism to recognise the value that nuclear energy can add to an increasingly variable energy system is developed to ensure a level playing field. Strategic coordination of relevant programmes such as R&D into hydrogen and its derivatives and UK SMR should be optimised to ensure a systematic approach, to share learning, develop skilled work forces and optimise delivery mechanisms.

5. From initial analysis that NIRAB has done to date on use case, the need to make a significant contribution to net zero by 2050 and other parameters, we advise that the demonstrator needs to be as close as possible to a first of a kind (FOAK) to support timely roll-out of a fleet, provided the demonstrator meets programme objectives and the case is made for fleet build. The chosen reactor design should be factory / modular build to support economic competitiveness, which will have an impact on the size of reactor that fits this requirement. Further analysis is needed to identify the optimal size for the UK's preferred HTGR concept since a case can be made for different sizes of reactor depending on the use case.
    a. large reactor designs with power outputs of ~600MWth are limited to large heat networks and large-scale hydrogen production, as well as probably being limited to coastal locations;
    b. mid-size reactors (200-250MWth), probably at the upper limit for modular construction of HTGRs, can be utilised for large single-user process heat or hydrogen production, or in multiple units for larger networks, with the added benefit of energy resilience for outages / refuelling;
    c. small reactors (up to 50 MWth) offer flexibility for modular construction and transport and can be utilised for single-user process heat, or multi-reactor heat networks.

    Ultimately a more detailed understanding of economic costs, siting requirements, heat offtake mechanisms and compatibility with end user requirements will impact on the choice of reactor. Since the demonstrator needs to be a 'near-FOAK' design, this work on use case and reactor size is needed urgently, and NIRAB is ready to play its part.

6. With regards to the temperature of the heat outputs, we suggest that this should be within existing limits that materials degradation can confidently withstand, noting that the majority (70%) of current UK heat demand is for temperatures < 500°C. The future temperature range for UK heat demand is uncertain, due to changes in industry for decarbonisation and innovation. Hydrogen production through steam electrolysis (HTSE) can currently be achieved in the 650-850°C region, and thermochemical water splitting technologies are in development that cover the range 550-950°C. 750°C is a common target temperature for

international HTGRs and is believed to pose lesser technological risk[2]. However, a reactor outlet temperature of 550°C could be supplemented with a heat pump to reach optimised HTSE configuration. HTGRs could reach higher temperatures, and if future developments in materials can support this, these could be pursued in the longer term if the market need can be demonstrated. This is an area where the UK R&D programme needs to be able to understand and track global technology developments.

7. The outline timetable for delivery of an AMR demonstrator is extremely challenging and any delays could significantly affect the critical path. The introduction of innovative techniques should be carefully considered and adopted only where they are of sufficient maturity to support expedited delivery. NIRAB advise that a business as usual (BAU) approach to planning, permitting and licensing is not sufficient and disruptive innovation is essential to develop and implement an alternative approach to HTGR demonstration. Two key factors will set the pace of delivery timescales: Design maturity will impact on progress through Generic Design Assessment (GDA); and operator capability will impact on progress through licensing and permitting. A priority for the AMR RD&D programme is to establish a competent authority who can own, develop and operate the demonstrator via a programmatic approach, with potential to expand to support a fleet of reactors. International collaboration could facilitate AMR development and, in some areas, may be essential.
8. Siting will also be pivotal for delivery and BEIS plays a key role in specifying site requirements. BEIS should explore the possibility of site specific but plant independent (within limits) assessments that could be carried out now to support planning consents for prospective sites in advance to accelerate the timeline for delivery. Also, since the number of sites required for nuclear generation is likely to be much larger than the eight currently nominated locations, the process needed to nominate and assess additional sites that are suitable for large, SMR and/or AMR needs to be defined. This should include sites which would not have previously been considered for nuclear deployment. This will also involve a knowledge of the likely capacity and geographical spread of heat generating sites, and this analysis is urgently required.
9. In summary, for energy security, it is imperative that the UK has a clear strategy on enrichment, fuel manufacture and qualification, reactor operation, and fuel cycle, underpinned by the UK supply chain which is well positioned to support. There is no time for delay and the UK should seek to accelerate activities that can support delivery of new nuclear, including on siting, licensing, financing, and establishing a competent authority, whilst maintaining rigour in the process with respect to safety and security. Continuous investment in R&D and capacity building is necessary to support delivery and added value for UK.

---

[2] The maximum temperature permitted by the codes and code cases for the materials acceptable for HTGR components is 760°C. Review and Assessment of Codes and Procedures for HTGR Components (NUREG/CR-6816, ANL-02/36). US NRC, 2003. https://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr6816/index.html