Department for
Business, Energy
& Industrial Strategy

Advanced Modular Reactor (AMR) Research, Development & Demonstration Programme

A Call for Evidence on the potential of High Temperature Gas Reactors (HTGRs) to support Net-Zero

Closing date: 9th September 2021

July 2021

Any enquiries regarding this publication should be sent to us at:
nuclearinnovation@beis.gov.uk

Contents

General information

Why we are issuing this call for evidence

We are inviting views on the UK Government's preference to explore the potential of High Temperature Gas Reactors (HTGRs) via the Advanced Modular Reactor (AMR) Research, Development & Demonstration (RD&D) Programme (the Programme). This Call builds on the commitment made in the Prime Minister's Ten Point Plan for a Green Industrial Revolution [1] and the Energy White Paper: Powering our net zero future [2] for a £170m AMR R&D Programme, with the aim of enabling an AMR demonstration by the early 2030s, at the latest, to prove the potential of the technology. The key objective for the Programme is to demonstrate that AMRs can produce high-temperature heat which could be used for low-carbon hydrogen production, heat for industrial processes and domestic use and cost-competitive electricity generation, in time for any potential commercial AMRs to support Net Zero by 2050. HTGRs are one of the main six AMR technologies considered by the international Generation IV forum [3] and based on independent reports and technical analysis, they are considered the most promising AMR technology to pursue for the Programme. As part of this Call for Evidence we also invite any new, additional evidence on other AMR technologies against the key objective of the Programme.

Call for Evidence details

Issued: 29th July 2021

Respond by: 9th September 2021

Enquiries to:

Email: nuclearinnnovation@beis.gov.uk

Consultation reference: Advanced Modular Reactor Demonstration Programme: a call for evidence on the potential of High Temperature Gas Reactors to support Net Zero by 2050

Audiences:

This will be of interest to anyone with an interest in Advanced Modular Reactor technology, in the future of innovation in the nuclear sector more generally and also the sectors that these technologies could support.

Territorial extent:

United Kingdom excl. Overseas Territories

How to respond

Please send responses to the email address below. When responding, please state whether you are responding as an individual or representing the views of an organisation. Your response will be most useful if it is framed in direct response to the questions posed, though further comments and evidence are also welcome.

Please do not send responses by post to the department, as we may not be able to access them.

Email to: nuclearinnovation@beis.gov.uk

Confidentiality and data protection

Information you provide in response to this consultation, including personal information, may be disclosed in accordance with UK legislation (the Freedom of Information Act 2000, the Data Protection Act 2018 and the Environmental Information Regulations 2004).

If you want the information that you provide to be treated as confidential please tell us, but be aware that we cannot guarantee confidentiality in all circumstances. An automatic confidentiality disclaimer generated by your IT system will not be regarded by us as a confidentiality request.

We will process your personal data in accordance with all applicable data protection laws. See our privacy policy.

We will summarise all responses and publish this summary on GOV.UK. The summary will include a list of names or organisations that responded, but not people's personal names, addresses or other contact details.

Quality assurance

This consultation has been carried out in accordance with the government's consultation principles.

If you have any complaints about the way this consultation has been conducted, please email: beis.bru@beis.gov.uk.

Introduction

This Call for Evidence invites views on the UK Government's preference to explore the potential of High Temperature Gas Reactors (HTGRs), a type of Advanced Modular Reactor (AMR) technology, via the AMR Research Development & Demonstration programme (the Programme). The key objective of this Programme is to demonstrate that AMRs can produce high temperature heat which could be used for low-carbon hydrogen production, process heat for industrial and domestic use and cost-competitive electricity generation, in time for any potential commercial AMRs to support Net Zero by 2050. HTGRs are one of the main six AMR technologies defined by the international Generation IV forum and based on independent reports and technical analysis are currently considered by Government as the most promising AMR technology to pursue for the Programme. We also invite any new, additional evidence on other AMR technologies against the key objective of the Programme.

The Prime Minister's Ten Point plan for a Green Industrial Revolution [1] and the Energy White Paper: Powering our net zero future [2] recognised the role of large reactor technology, Small Modular Rectors (SMRs) and AMRs in supporting Net Zero by 2050. For AMRs up to £170m was committed for a research & development programme with the ambition for this to lead to an AMR demonstration by the early 2030s, at the latest, to prove the potential of the technology. The key objective of the Programme is to demonstrate that AMRs can produce high temperature heat which could be used for low-carbon hydrogen production, process heat for industrial and domestic use and cost-competitive electricity generation, in time for any potential commercial AMRs to support Net Zero by 2050.

Advanced Modular Reactors is a UK term for the next generation of nuclear reactors. They use novel coolants and/or fuels and typically have higher temperature outputs (in the range of 500-950°C compared to around 300°C for Light Water Reactors (LWRs)) and have a smaller power output per unit than more conventional LWRs operational today. The international Generation IV forum classify AMRs into six main technology types with each having different characteristics and levels of maturity [3] as shown in Table 1. There is growing support that the potential of certain AMRs to generate high temperature heat could help displace fossil fuels in industrial processes and support more efficient low-carbon hydrogen and synthetic fuel production.

Independent reports from the Royal Society [4] the Energy Systems Catapult [5] Nuclear Innovation Research Advisory Board (NIRAB) [6] and the University of Manchester Dalton Nuclear Institute [7] all recognise the potential role of AMRs in supporting a future clean energy system, highlighting that the unique characteristic of certain AMRs is the high temperature heat that could help unlock the decarbonisation of several energy vectors such as low carbon hydrogen production and process heat in industrial processes. The independent NIRAB and University of Manchester Dalton Nuclear Institute specifically noted HTGRs as the most promising AMR technology to support Net Zero due to the maturity of the technology, synergies with UK technical experience & historical operating experience [6, 7]. The Royal

Society highlighted that the high temperature requirement could be satisfied by HTGRs due to their ability to reach temperatures >600°C [5].

Table 1: Summary characteristics of AMR reactor technologies [3]

System	Neutron Spectrum	Coolant	Outlet Temp (°C)	Fuel Cycle	Technology Readiness Level * [8]
HTGR / VHTR High / Very High Temperature Gas Reactors	Thermal	Helium	700 – 950 [9] 900 – 1000+	Open	7 / 5
SFR Sodium-Cooled Fast Reactors	Fast	Sodium	500 – 550	Closed	7
SCWR Supercritical Water-Cooled Reactors	Thermal / Fast	Water	510 – 625	Open / Closed	2
GFR Gas-cooled Fast Reactors	Fast	Helium	850	Closed	2 [10]
LFR Lead-cooled Fast Reactors	Fast	Lead	480 – 570	Closed	4
MSR Molten Salt Reactors	Thermal / Fast	Fluoride Salts	700 – 800	Closed	4 Thermal 3 Fast

Technical analysis by the Nuclear Innovation Research Office (NIRO)[1] has assessed the six main AMR technology types with respect to high-level criteria and sub-criteria, that are relevant for the Programme. The analysis, which draws on several techno-economic studies of AMRs, indicates that HTGRs are consistently the preferred technology option, with respect to the key objective of demonstrating the ability to generate high-temperature heat which could be used for low carbon hydrogen production, process heat for industrial and domestic use and cost-competitive electricity generation in time to support Net Zero by 2050.

Underpinned by this body of evidence, UK government's preference is to explore the potential of HTGRs via the Programme. It should be noted that this preference is for the Programme only [2], and will complement the UK government's wider activities on nuclear policy and broader AMR technologies.

Call for Evidence

The key objective of the Programme is: to demonstrate high temperature heat production which could be used for low-carbon hydrogen production, process heat for industrial and domestic use and cost-competitive electricity generation, in time for any potential commercial AMRs to support Net Zero by 2050.

We invite views and evidence on the following:

1. **Do you agree with the UK Government's preference to explore the potential of High Temperature Gas Reactors (HTGRs) to meet the key objective of the Programme?**

2. **Whether there is any new, additional evidence on other AMR technologies that could meet the key objective of the Programme?**

3. **How the capability of the UK supply chain could support the Programme?**

In your response to 1. and 2. you may wish to include detail and associated evidence against the criteria noted in Table 2 of the technical research paper.

We welcome views and information from a range of stakeholders with an interest in AMRs and innovation in the Nuclear sector. The information collected will support the development of the Programme and BEIS will make an announcement later in the year.

[1] https://www.gov.uk/government/publications/advanced-modular-reactors-amrs-technical-assessment
[2] Government continues to support developing advanced nuclear technologies of all types as part of wider programmes. That includes opening the Generic Design Assessment process to advanced nuclear technologies, developing a siting approach for further nuclear developments as well as plans to pilot an Advanced Nuclear Skills and Innovation Centre to help develop and commercialise advanced technologies. An AMR demonstration will also generate strong synergies and benefits across multiple AMR technologies, including in common areas of interest such as exploring the scope for co-generation as well as addressing shared technology and engineering challenges.

References

[1] BEIS, UK Government, “The Ten Point Plan for a Green Industrial Revolution”, November 2020.

[2] BEIS, UK Government, “Energy White Paper - Powering our Net Zero Future”, December 2020.

[3] Generation IV Technology Systems, https://www.gen-4.org/gif/jcms/c_40486/technology-systems (accessed 06/07/2021).

[4] The Royal Society, “Nuclear Cogeneration: civil nuclear in a low-carbon future”, UK, October 2020.

[5] Energy Systems Catapult, Nuclear for Net Zero, https://es.catapult.org.uk/reports/nuclear-for-net-zero/ (accessed 06/07/2021).

[6] NIRAB, “Achieving Net Zero: The role of Nuclear Energy in Decarbonisation”, December 2020.

[7] Dalton Nuclear Institute, University of Manchester, “Nuclear energy for net zero: a strategy for action”, June 2021.

[8] NNL, “Addendum to NNL(11)11620 - Assessment of advanced reactor systems against UK performance metrics, NNL (11) 11620 ADDENDUM Issue 1 DE06742/06/09/02”, March 2012.

[9] J. M. Beck and L. F. Pincock, INL, “High Temperature Gas-cooled Reactors Lessons Learned Applicable to the Next Generation Nuclear Plant”, April 2011.

[10] Idaho National Laboratory, “Gas-Cooled Fast Reactor Research and Development Roadmap: Draft for Public Comment”, May 2018.

This consultation is available at: www.gov.uk/government/consultations/potential-of-high-temperature-gas-reactors-to-support-the-amr-rd-demonstration-programme-call-for-evidence

If you need a version of this document in a more accessible format, please email enquiries@beis.gov.uk. Please tell us what format you need. It will help us if you say what assistive technology you use.