

LGA SPECIAL INTEREST GROUP ON RADIOACTIVE WASTE MANAGEMENT AND NUCLEAR DECOMMISSIONING

Note of the meeting on Advanced Modular Reactors (AMRs), held online on 14th June 2023, 13.00 – 15.00

Present:

Cllr David Moore	Cumberland Council (Chair)
Cllr Mike Caswell	Somerset Council (Vice-Chair)
Cllr Sarah Whitelock	East Suffolk Council
Cllr Paul Thomas	Folkestone and Hythe District Council
Cllr Maggie Tyrell	South Gloucestershire Council
Cllr Richard Smith	Suffolk County Council
Jonathan Cook	Cumberland Council
Bethany Rance	East Suffolk Council
Terry Burns	Essex County Council
Linda Marsh	Folkestone & Hythe District Council
Linda Townsend	Gloucestershire County Council
Nia Bowden	Gwynedd Council
Richard Outram	Manchester City Council
John Burton	Somerset Council
Gillian Ellis-King	South Gloucestershire Council
Ross Walker	Suffolk County Council
Rachel Whaley	Westmorland & Furness Council
Angharad Crump	Ynys Mon County Council
Philip Matthews	Nuleaf
Catherine Draper	

1.	WELCOME AND APOLOGIES	ACTION
	The Chair welcomed everyone to the meeting and thanked the presenters for agreeing to participate.	

2.	INTRODUCTION TO ADVANCED MODULAR REACTORS, PRESENTATION BY THE DEPARTMENT OF ENERGY SECURITY AND NET ZERO (DESNZ)	
2.1	<p>Key points from the presentation by DESNZ are:</p> <p>2.1.1 Advanced Modular Reactors (AMRs) are Generation IV reactor designs, they use novel fuel and coolants (not water) and offer high levels of heat output.</p> <p>2.1.2 UK Government made commitments to AMR technologies in the 2020 Ten Point Plan, the 2021 Net Zero Strategy, 2022 British Energy Security Strategy and in 2023 Powering Up Britain.</p> <p>2.1.3 UK Government’s ambition is to deploy a demonstrator reactor in the 2030s. High Temperature Gas-Cooled Reactor (HTGR) design had been selected as the best technological fit for the UK, and the Department was currently going through contract award and due diligence before announcing the two designs which will go forward to the next stage.</p> <p>2.1.4 Fuel is being dealt with separately. Given the current international political situation it is important to establish sovereign capability around fuel supply. A separate announcement will be made shortly.</p> <p>2.1.5 AMRs have enhanced passive safety features both in the types of coolant and fuel used. General principles are well understood, but further R&D is required to facilitate regulation.</p> <p>2.1.6 DESNZ is developing a new nuclear NPS, which will cover the policy framework for deploying new nuclear power stations beyond 2025 and take into account the potential for deployment of SMRs and other advanced nuclear technologies. AMRs have the potential to be sited closer to industrial sites because of their passive safety features and smaller size. A siting policy consultation will be launched later in 2023.</p> <p>2.1.7 At present there are no AMR vendors going through the Generic Design Assessment (GDA) process, and Rolls Royce is the only Small Modular Reactor (SMR) being assessed by ONR and the Environment Agency.</p> <p>2.1.8 A review of UK radioactive waste policy was recently a subject of public consultation, with the view of moving to a proportionate risk-based life cycle. Any AMR vendor will need to demonstrate that it can safely and securely manage waste arisings as it develops its design and has the funding to do so.</p>	

	Decommissioning, Waste Management and Disposability Plans will be required.
2.2	The meeting opened up to questions:
2.2.1	<p><i>Q: How will the supply of helium for High Temperatures be managed in terms of maintaining sovereignty of supply.</i></p> <p>A: This is currently being considered. The Nuclear Innovation Research Office is looking at what R&D is required. Helium typically comes from areas in the world which are currently not easily accessed. There is also a need to secure supply of HALEU (fuel type).</p>
2.2.2	<p><i>Q: What levels of enrichment are required for the reactors?</i></p> <p>A: It differs between design, but it falls between 5 – 20%. This is higher than is currently used today. Most aspects of fuel supply and enrichment already exist within the UK supply chain.</p>
2.2.3	<p><i>Q: What socio-economic benefits are being considered, and what is being done to ensure that the skilled workforce is there to deliver the programme?</i></p> <p>A: DESNZ is engaging with the Nuclear Industry Association to ensure we have the necessary skills to take this forward.</p>
2.2.4	<p><i>Q: What impact could a change of political leadership have on this programme?</i></p> <p>A: It is widely recognised that nuclear power plays an important part in generating electricity and delivering the required baseload. Every party has a different stance on nuclear issues and the Civil Service will deliver on the priorities of the Government of the day.</p>
2.2.5	<p><i>Q: Will GDA apply to all technologies regardless of scale?</i></p> <p>A: The GDA is a voluntary process, so it is feasible for an approach to be made to ONR for licensing without going through GDA. However, the aim of GDA is to de-risk the design process by providing regulatory feedback as the design is develop. Any design which does not go through GDA will still be assessed before a license is granted.</p>
2.2.6	<i>Q: Will the new EN7 cover siting in the same way that EN6 did?</i>

	<p>A: We will consult later this year on our proposed siting strategy for determining how new nuclear developments might be located.</p>	
2.2.7	<p><i>Q: Is the current competition for SMRs and AMRs? Are you likely to select more than one technology?</i></p> <p>A: There are a wide range of nuclear technologies available for deployment in GB. We expect the competitive process to select to attract the best designs from both domestic and international vendors. As part of the market engagement process, we will engage Advanced Nuclear Technology (i.e. SMR and AMR) vendors up front to ensure the right technology for GB.</p>	
2.2.8	<p><i>Q: Will the criteria for sites change in relation to the deployment of AMRs?</i></p> <p>A: This new NPS will take into account the significant changes in the nuclear landscape since EN-6 was designated, including the potential for deployment of SMRs and other advanced nuclear technologies</p>	DESNZ
2.2.9	<p><i>Q: Do you expect any of the new reactor designs to use MOx fuel?</i></p> <p>A: At present no vendor has proposed using MOx fuel.</p>	
2.2.10	<p><i>Q: Your proposal is for the competition to conclude within this parliament. What stage will you reach?</i></p> <p>A: In April GBN launched the first phase of the competitive process to select the best SMR technologies in the form of a market engagement exercise. The second phase – the down-selection process - will be launched in the summer, with an ambition to assess and decide on the leading technologies by autumn.</p> <p>The Government will provide co-funding to be deployed by GBN to support the development of these selected technologies and will work with successful bidders on ensuring the right financing and site arrangements are in place, in line with its commitment to take two Final Investment Decisions (FIDs) next parliament. The total level of development funding will be subject to future Spending Reviews.</p>	
2.3	<p>The Chair thanked the DESNZ representatives for their presentation.</p>	

3.	ADVANCED MODULAR REACTOR TECHNOLOGIES, PRESENTATION BY NATIONAL NUCLEAR LABORATORY (NNL)	
3.1	<p>Key points from the NNL presentation are:</p> <p>3.1.2 NNL has a wide-ranging role. First and foremost, it focuses on Research and Development (R&D). It is technology neutral. It worked on the first phase of the government demonstrator programme but has also been supporting vendors in developing their technology. It also works to support the waste management and decommissioning aspects of AMR technology development.</p> <p>3.1.3 AMRs are smaller than conventional nuclear power stations. They are designed so that much of the plant can be fabricated in a factory environment and then transported to the site reducing construction costs and making them less capital intensive.</p> <p>3.1.4 Types of Generation IV reactor are:</p> <p><i>High/Very High Temperature Reactor:</i> e.g. the Dragon reactor at Winfrith. This design is deemed to be closest to market. It is suitable for the production of hydrogen, but industry could also potentially use the steam downstream.</p> <p><i>Sodium cooled fast reactor:</i> similar to that at Dounreay. Also fairly mature. The design utilises liquid sodium so the system is not pressurised which is an additional safety feature. Key technical challenges are around the corrosive aspect of the coolant. The fuel would require additional treatment following irradiation to make it safe.</p> <p><i>Lead cooled reactor:</i> there is no experience of this in the UK. Lead has improved thermodynamic ability which can help offset higher capital costs. The outlet temperature is mid-range, but it is still suitable for some downstream applications. There are also some corrosion related challenges.</p> <p><i>Molten salt reactor:</i> there is a lot of experience of this reactor type in the UK as many were in national laboratories in the 1960s. There are a number of international R&D programmes active. The challenge is on reprocessing and recycling the fuel as it becomes molten into the coolant. Although not pressurised, containment would have to be of a very high standard because of the fuel/coolant combination.</p>	

Gas cooled fast reactor: these are high temperature helium cooled reactors with a closed fuel cycle. They are in early stages of development with many unproved concepts and design features. The high temperature makes them desirable for downstream applications, however there is no experience of these reactors in the UK.

Super critical water reactors – these are high temperature high pressure light water cooled reactors which operate above the thermodynamic critical point of water. There is no UK experience of this type of reactor. The design is in early stages of development. The goal of this type of reactor is to reduce waste.

3.2 The meeting opened up to questions:

3.2.1 *Q: How much energy would an AMR produce?*

A: There is a large range in size and output from 10MW to <300MW.

3.2.2 *Q: Is it correct that some AMRs can use spent fuel to fuel the reactor?*

A: Fast reactors almost eat themselves reducing the amount of waste output through operation. There are some fuel types which could utilise legacy waste as part of their fuel.

3.2.3 *Q: Are some types of reactor more suited for specific types of site.*

A: The only differentiation is the downstream use of the steam generated. Reactors producing high temperature steam need to be located close to where the steam is used. Some reactors have a smaller footprint.

3.2.4 *Q: What steps are being taken to ensure we learn from international experience?*

A: The UK is part of the Generation 4 Forum which disseminates output from R&D. We also engage with IAEA and OECD, and there is a bi-partite agreement with Canada and with the USA. The NNL has been engaging with colleagues in Japan.

3.2.5 *Q: Can both SMRs and AMRs be used for the generation of hydrogen?*

A: Some AMRs can, these tend to be the high temperature gas and sodium cooled reactors. SMRs could be used to generate

	electricity which in turn could be used for the generation of hydrogen.	
3.4	The Chair thanked Emma Vernon for her presentation.	
4.	ONR ENGAGEMENT ON AMR TECHNOLOGY, PRESENTATION BY THE OFFICE OF NUCLEAR REGULATION (ONR)	
4.1	Key points from ONR's presentation were:	
4.1.2	ONR provided support to BEIS (as was) when their AMR technology feasibility and development project began in 2018. It provided an initial assessment of vendor submissions and subsequently held detailed discussions on regulatory matters with two vendors to help them understand the regulatory requirements. This phase of the project has now closed.	
4.1.2	ONR also has ongoing engagement with IAEA and OECD/NEA on developing regulations and safety standards for AMRs. Funding is provided by DESNZ to support this work.	
4.1.3	ONR, together with the Environment Agency (EA), engaged with four high temperature design AMR vendors, and two TRISO fuel manufacturing vendors. Vendors provided regulatory submissions and ONR and EA provided feedback to DESNZ on whether they considered the technology could meet UK regulatory expectations.	
4.1.4	The next phase will be for ONR to have detailed regulatory discussions with two reactor vendors and one fuel manufacturing vendor. At present DESNZ has not yet announced which vendors these will be.	
4.1.5	A new reactor requires a new license regardless of where it is sited. ONR issues a license specific to a reactor and the site whether that site already has a reactor of a different type on it. If a site is licensed for fuel manufacturing, the terms of that license will dictate whether or not new fuel manufacturing can be carried out there.	
4.2	The meeting opened up to questions:	
4.2.1	<i>Q: Some vendors are saying that it would be possible for them to have a reactor constructed on site within a couple of years. What is your view on this statement?</i>	
	A: The GDA is a voluntary process, so it is feasible for an approach to be made to ONR for licensing without going	

	<p>through GDA. However, the aim of GDA is to de-risk the design process by providing regulatory feedback as the design is develop. Any design which does not go through GDA will still be assessed before a license is granted.</p>	
4.2.2	<p><i>Q: When do you think an AMR will be producing electricity commercially in the UK?</i></p> <p>A: The goal of mid 2030s is challenging. However, anything is possible if adequately funded.</p>	
4.2.3	<p><i>Q: Does ONR have a preference for a vendor to go through the GDA process or to go direct for licensing?</i></p> <p>A: There is no difference from our point of view, our only issue is resourcing as we also have a mature nuclear industry to regulate.</p>	
4.3	The Chair thanked Peter Donnelly for his presentation.	
5.	RADIOACTIVE WASTE FROM SMALL MODULAR REACTORS, PRESENTATION BY CoRWM	
5.1	Key points from CoRWM's presentation are:	
5.1.1	It is important to take the opportunity now at the design stage of AMR technology to address waste management and decommissioning issues.	
5.1.2.	Factors influencing the amount of radioactive waste generated are: reactor size, fuel burn-up, coolant and moderator type and fuel type.	
5.1.3	<i>Reactor size:</i> The neutron diffusion pathway is the same length for all thermal neutrons. Consequently, there is greater opportunity in a small reactor for radioactive neutrons to hit reactor components, thus making them radioactive and increasing the amount of radioactive material present (long- and short-lived Intermediate Level Waste) which will need to be dealt with upon decommissioning.	
5.1.4	<i>Fuel burn-up:</i> most AMRs will use highly enriched fuels, which will result in a higher level of fissile material in the spent fuel which will need to be addressed during storage and disposal. The potential for criticality may require a larger GDF footprint.	
5.1.5	<i>Coolant type:</i> the new coolant types can present challenges during decommissioning. Some types present a fire risk. Lead is subject to significant regulation. Molten salts can be very	

corrosive to reactor components. New alloys are being developed to address this, but at present they remain in the R&D stage.

5.1.6 *Moderator type:* these can generate some significantly long-lived radioactive materials. TRISO fuel uses graphite which is bonded to the fuel and cannot be separated. Compared to a Pressurised Water Reactor (PWR) such as Sizewell B, the volume of spent fuel per unit of energy generated is significantly higher. The Carbon 14 content of the graphite may be too high for it to be incinerated and so require a novel form of waste management. Volumes of waste generated and associated packaging will require larger stores and disposal facilities.

5.1.7 *Fuel type:* Current reactors use Uranium Dioxide fuel which is chemically inert and does not need to be reprocessed prior to disposal, though reprocessing is possible. The UK has considerable experience in handling this form of fuel. AMRs will use a range of novel fuel types which are chemically reactive, and which will require reprocessing prior to disposal. There is currently no waste management solution for these fuel types in the UK at present.

5.1.8 It is difficult to make an informed assessment of the waste management implications until AMR designs are published.

5.2 The meeting opened up to questions:

5.2.1 *Q: What are the merits of SMR v AMR from the perspective of waste generated?*

A: The Rolls Royce SMR produces waste very similar to that of an AGR reactor, so the waste arisings are understood and there are waste disposal routes available.

5.2.2 *Q: It has already been mentioned today that fast breeder reactors can use spent fuel as fuel, why is this type of reactor not being pushed?*

A: Depending on the design, the result is not always less spent fuel at the end of the reactor's life. There can also be challenges with dealing with the coolant. It is difficult to comment on this without seeing the reactor design.

5.2.3 *Q: Does the Generic Design Assessment consider waste issues?*

A: The methodology for decommissioning a reactor will be considered as part of the GDA process. Any vendor wishing to

	license a reactor has to show that their technology can be decommissioned and the waste disposed of using current technology.	
5.2.4	<p><i>Q: Will the type of AMR affect the decisions about the Geological Disposal Facility?</i></p> <p>A: The GDF design has been amended to reflect the uplift from 16GW to 24GW. Policy is that it will take waste from the new reactors. There has to be flexibility because the nature of materials arising from these is not yet known. Nuclear Waste Services will need to have early discussions with reactor vendors, and this is already taking place in some instances.</p>	
5.2.5	The Chair commented that the above needed to be raised with those communities engaged in the GDF siting process, as at present only legacy waste were being discussed.	
5.4	The Chair thanked Claire Corkhill for her presentation.	
6.	ADVANCED MODULAR REACTORS, ARE THEY A REALISTIC OPTION, PRESENTATION ON BEHALF OF NFLA.	
6.1	Key points from the NFLA presentation were:	
6.1.1	Much of the terminology used around AMRs and SMRs is PR related rather than meaningful. For example, there is no reason why passive safety features should make reactors simpler.	
6.1.2	The Generation III reactors, which were based on previous Pressurised Water Reactor (PWR) and Boiling Water Reactor (BWR) designs failed to live up to the expectations made for them, all running over budget and taking longer to build than promised.	
6.1.3	The fast breeder reactors included in the Generation IV designs require reprocessing of spent fuel to produce fissile material. The technical and economic record of fuel reprocessing is poor.	
6.1.4	Recent research by a former Nuclear Regulatory Commission (USA) Commissioner suggests that the Generation IV reactor designs will create a greater waste problem than earlier designs.	
6.1.5	The Generation IV designs are technically and economically unproven, and experience indicates that they are unlikely to be.	

6.1.6	It is unclear when the legislation necessary for new reactor designs will be passed into law and when it will become functional.	
6.1.7	There is little chance that AMRs will be operational before 2040, if ever.	
6.2	The meeting opened up to questions:	
6.2.1	<p><i>Q: Is it your opinion that no Generation IV design will come to fruition?</i></p> <p>A: The Generation III+ designs failed to deliver on their promises. The issue is about the credibility of the new Generation IV reactor designs.</p>	
6.3	The Chair thanked Stephen Thomas for his presentation and there being no further questions the meeting closed at 15.16.	