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Other Session

Outline of MEXT R&D programs for nuclear technology;
Around the International Programs

(3) An Introduction to JUNO: Japan UK Nuclear Opportunities

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1. Introduction

The UK and Japan have a long established co-operation in the field of civil nuclear energy, originating in the 1960s. The UK supplied Japan's first commercial nuclear power reactor, based on the Magnox design, which operated on the Tokai site, from 1966-1998, generating in excess of 27.7 billion KWh. Nuclear fuel from this reactor, and later Light Water Reactors in Japan, was reprocessed under contract to British Nuclear Fuels, and its successors, from mid 1970s onwards. Following the Great East Japan Earthquake, on 11 March 2011, leading to partial melt down of three Boiling Water Reactors at the Fukushima Daiici site (Units 1-3), the UK and Japan have established a strong collaboration in the field of nuclear decommissioning and waste management [1-3] The Governments of UK and Japan recognise the importance of stronger collaboration and co-operation in the field of civil nuclear energy, to address the challenges of legacy decommissioning and waste management, and exploitation of nuclear fission technology as a safe, affordable, low carbon energy supply. Accordingly, a Japan – UK framework for Civil Nuclear Co-operation was established in 2012 [1], leading to an annual UK – Japan Nuclear dialogue to strengthen bi-lateral co-operation in civil nuclear energy [4-6]. The JUNO Network for Japan – UK Nuclear Opportunities, sponsored by the UK Engineering & Physical Sciences Research Council, and led by The University of Sheffield, will build on the foundations of this bi-lateral co-operation, to facilitate, create, nurture and co-ordinate collaboration in civil nuclear energy between academic researchers in the UK and Japan, see the Network website: http://www.juno.org.uk/. The initial Network membership comprises over 80 individuals from more than 20 organisations.

2. Network aims and objectives

The overarching aim of the JUNO project is to nurture and network the UK and Japan academic communities in civil nuclear energy, leading to the collaborative development of novel methodologies and tools, to address common challenges in decommissioning and waste management, reactor safety and regulation, nuclear energy policy, public communication and engagement, and environmental safety. The JUNO Network will build on the existing portfolio of bi-lateral projects established through the EPSRC / MEXT sponsored UK – Japan Civil Nuclear Research Programme [7-9], to facilitate enhanced networking, collaboration, and annual engagement, between the UK and Japan academic communities. The Network investigators will leverage their experience and existing links to lead Network activities in their domains of expertise. Our leadership team will also enable the Network to engage and bring together key projects in the EPSRC nuclear fission portfolio on which they are leading investigators, including: the two Centres for Doctoral Training – NGN and ICO, the PACIFIC and DISTINCTIVE consortia, the UK Nuclear Champion Network, and the

National Nuclear User Facility. The priority objectives of the Network were established with due regard to development of the UK – Japan Nuclear Dialogue [4-6]:

1) To deliver an annual meeting for grant holders in the UK – Japan Civil Nuclear Research Programme, to promote collaboration and knowledge exchange between these projects.

2) To effectively network the wider UK and Japan research communities in the core themes of the Network, maintaining an agile approach to new priorities, within the framework of the UK – Japan Nuclear Dialogue.

3) To hold scientific meetings / conferences which bring together researchers in the core themes of the Network, in the UK and Japan, together with practitioners in industry and decision makers from government agencies.

4) To deliver activities and initiatives to stimulate and pump-prime innovative ideas and develop research collaborations and proposals in the challenge themes.

5) To engage and bring together, where possible, ongoing research projects, CDTs and Networks in the EPSRC nuclear fission portfolio, to enhance UK – Japan collaboration

2-1. Core Themes of the JUNO Network

The core research and capability themes of the Network seek to address the common challenges identified through the Japan – UK Framework on Civil Nuclear Co-operation [1], and the subsequent annual UK – Japan Nuclear Dialogue [4-6], which have framed the three calls for projects in the UK – Japan Civil Nuclear Research Programme [7-9].

Decommissioning and Waste Management. In this thematic area, the UK and Japan share a common need to develop the knowledge, skills and technological capability to safely decommission and manage the wastes from legacy nuclear operations. The priority generic research challenges include the need to locate and remove highly radioactive materials from facilities of uncertain structural integrity, for example the fuel debris arising from the meltdown of Fukushima Nuclear Power Plant Units 1-3 in Japan and the legacy ponds and silos facilities at Sellafield. In both cases, the development of remote sensing and robotic inspection and retrieval technologies will be required, given the high dose environment. A second priority highlighted by the International Research Institute for Nuclear Decommissioning (IRID) is treating contaminated groundwater to remove radionuclides including Cs, Sr, Co and tritium. From the perspective of waste treatment, there is a common need to efficiently manage and safely condition radioactive wastes which are heterogeneous in radiological, chemical, and physical nature, for example: high dose spent adsorbents / ion exchange materials, process sludges, soft / combustible wastes, and highly contaminated soils. This challenge should be addressed within the waste hierarchy to minimise the hazard and cost of interim storage and disposal, through innovation or decontamination, decay storage, or material reuse, recycle, and volume reduction strategies, whilst minimising secondary waste generation. A further priority challenge is the management of fuel debris material to be recovered from Fukushima NPP Units 1-3, which requires demonstration of a safe disposition route which could involve: direct disposal of the material; conversion to a waste product; or tailored “reprocessing” and waste treatment. At a smaller scale, this challenge is also of interest to the UK, from the perspective of spent fuel wastes arising from post irradiation examination.

Nuclear Policy. A key part of the work of the JUNO collaboration will be policy-oriented. The themes of nuclear safety and regulation, public communication and environmental safety all relate to important dimensions of public policy. The intention is to build upon an existing track record quantitative approaches to strategies in the face of uncertainty and the economic advantages of technological flexibility. Such approaches relate to the world of “real options” – where “real” relates to physical or tangible as in the phrase “real estate”. The options are akin to financial options. For example extra money might be spent up front on project engineering to allow decision makers to delay a

decision on which of two long-term solutions to deploy. Noting the importance of discounted cash flow for the net present value (or cost) of a proposition, it can be beneficial to buy the option to delay expensive decisions. Also, delay can allow uncertainties to be resolved via the emergence of new information.

Nuclear Safety & Regulation. Understanding the state of a nuclear reactor core following a severe nuclear accident like that at Fukushima is of great importance for the planning of its safe decommissioning. Due to limited access for on-site monitoring there is a strong need for computational models to provide information of the core's likely state. This can range from partially melted fuel pins to fully melted corium that forms stratified layers in the lower vessel head or surrounding containment buildings. Existing numerical simulation technologies cannot simulate this phenomena fully. This is due to the complexity of physics involving nuclear heating, through thermal radiation, decay and possible re-criticality, solid-structures and their interaction, melt progress, multi-phase flows and complex chemical reactions. In this thematic area, key nuclear safety issues that arise during both accident progression and the core's decommissioning will be addressed by researchers in UK and Japan through the use of detailed computational models. Challenge areas include: determining the re-location of molten nuclear materials; quantifying the likelihood and repercussions of re-criticality during re-flood or by moving materials during decommissioning; decay heat removal; and atmospheric radioactive dust dispersion and mitigation that is released during the material cutting stages of decommissioning. The development of high detailed models using advanced numerical methods, providing unrivalled resolution of the multi-physics (neutronics, multi-phase fluids, solid) processes of accidents and decommissioning procedures will be the principle component of this Network.

Public communication. The importance of fostering effective public (and wider stakeholder) communication and engagement has been recognised as an integral component of the ongoing UK – Japan Nuclear Dialogue following the Fukushima accident. This is pertinent due to the fact that public and broader social (e.g. market, political) acceptance of nuclear power generation (and waste-management and decontamination activities) is currently, and will continue to, shape the future of the technology in both countries (and further afield) at strategic/national, regional and local levels. For instance, following the Fukushima accident, publics have generally responded differently to nuclear power in the UK vs. Japan; with an erosion of public trust in Japan resulting, in part, from failures of operators and regulators to adequately and appropriately address public concerns regarding risk and uncertainty. This situation contrasts markedly with the relative stability of public opinion that occurred in the UK following the accident; providing valuable opportunities for international comparison of the specific factors influencing public responses to nuclear power following such accidents. This thematic area will pool expertise and advance contemporary understandings of the complexity of factors (e.g. technical, cultural, demographic, psycho-social, etc.) affecting attitudes and responses to nuclear power generation and related activities (including nuclear facility siting, waste processing and disposal, etc.). It will provide a structured and interdisciplinary forum for theoretically-driven discussion and knowledge exchange, with a focus on policy and on prospective public (and stakeholder) engagement and communication strategies and practices.

Environmental safety. There is a shared need to develop the knowledge, skills and technological capabilities to enable assessment, monitoring and minimization of environmental contamination and risk during the whole decommissioning process, from planning to site end use. The decommissioning process itself can increase, in the short term, the risk of contaminant release. The key challenge is minimizing the risk of further environmental contamination during the decommissioning of damaged and/or deteriorating infrastructure with uncertain structural integrity, such as Fukushima Nuclear Power Plant Units 1-3 in Japan and the legacy ponds at Sellafield. Priority research areas to address this challenge are the development of: (1) technologies for monitoring and analysis - to enable assessment of

contamination during planning and rapid monitoring of contaminants and structural integrity during decommissioning; (2) technologies for stabilisation and restoration of the contaminated environment; in particular technologies that can be rapidly deployed under conditions of weakened structural integrity to limit contamination release in the event of, for example, a leak during decommissioning. Novel smart materials could combine sensors within the barrier materials to enable ongoing monitoring.

2-2. Maintaining an agile thematic approach.

The Network research themes map directly onto the shared research and development priorities identified in the UK / Japan Nuclear Dialogue. We recognise that the relevance of these themes may evolve over the lifetime of the Network and new priorities may emerge. The Network will maintain an agile approach to balancing and expanding its thematic priorities, in the following ways: 1) Through direct engagement with the UK / Japan Nuclear Dialogue we will be positioned to adapt the Network to embrace new thematic priorities; 2) Our leadership team and initial membership comprises research leaders from institutions that are key stakeholders of EPSRC's nuclear fission portfolio, which will allow us to identify and engage new Network members working in emergent themes; 3) Our governance structure provides a decision making framework to adapt the balance of resources deployed by the Network to promote and support emergent themes.

3. JUNO Network activities

The Network will deliver activities and interventions at several scales to stimulate, nurture and support UK – Japan collaboration in the core themes of the Network. An initial networking and collaboration building visit to Japan was organized in March 2017, in partnership with EPSRC and the Science & Innovation Network in Japan. The aims were: 1) to review existing UK / Japan research projects sponsored by EPSRC / MEXT under the UK Japan Civil Nuclear Energy programme, with a view to identifying research impacts and best practice; and 2) to forge new links between leading research actors in the UK and Japan and identify the priority actions for future collaborations, through a networking workshop. Future Network activities will include:

- **Managed events:** focusing on knowledge exchange, deriving research questions, developing collaborative projects, and disseminating experience and outcomes.
- **Annual Network Meeting**: this will serve as the primary forum to stimulate engagement between the research communities in the UK and Japan,. The annual meeting will engage current and previous joint UK / Japan grant holders – both UK and Japan collaborators – who will provide updates on project progress and outcomes. Attendance will also be open to Network members in the UK and Japan, through invitation or an application / selection process.
- **Theme cluster meetings:** a series of one-day symposia will disseminate research outcomes in each thematic area, with discussion on shaping and developing future research to fit with common UK – Japan priorities. This will allow the Network to recruit new members and support them in developing UK – Japan collaborations, enabling Network sustainability.

4. Pump-priming collaboration activities

The Network will manage award of pump-priming resources to establish and develop UK – Japan research collaborations within the core themes, at three levels of investment, through an open and competitive process, with appropriate peer review scrutiny. Mechanisms will be open to application from established and early career researchers; applicants must register as Network member to submit a proposal. Expenditure should primarily support UK beneficiaries, however,

funds may support, for example, travel and subsistence of Japan counterparts if well justified. Three levels of pump-priming activity are initially envisaged:

- Collaboration building, meeting or public engagement fund: one-off scientific meetings, short collaboration forming visits, of up to one month duration, or public engagement activities.
- Collaboration development fund: secondment visits of up to 3 months to an external organisation to undertake a defined piece of collaborative research or policy study, preference will be given to international visits.
- Collaboration pilot research fund: to pump prime a collaborative pilot research project or policy study up to 6 months, with the intent of producing original research that could form or contribute to a peer reviewed journal publication or grant proposal.

Monitoring of collaborations supported through pump-priming mechanisms will be through submission of short pro-forma reports tailored to the scale of the investment. Each project will be required to produce a poster report of outcomes, using a pro-forma template, for dissemination via the Network website and meetings.

5. Conclusions

The JUNO Network for Japan –UK Nuclear Opportunities, sponsored by the UK Engineering & Physical Sciences Research Council and led by The University of Sheffield, will build on the foundations of strong bi-lateral co-operation, to facilitate, create, nurture and co-ordinate collaboration in civil nuclear energy between academic researchers in the UK and Japan. These aims will be achieved by consolidating existing collaborations and forging new links through knowledge exchange at an annual conference and themed meetings. The Network will pump prime and develop new collaborations by awarding seed-corn financial support at three scales of activity, with appropriate peer review of proposals. Membership of the JUNO Network is open to researchers in the UK and Japan, please contact the author for more details and refer to the website: http://www.juno.org.uk/.

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7. References.

1. Japan-UK Framework on Civil Nuclear Co-operation, 2012 (link).
2. UK – Japan Joint Statement, 2014 (link).
3. UK – Japan Joint Statement on Climate Change and Energy Cooperation, 2014 (link).
4. Second Annual UK-Japan Nuclear Dialogue, 2013 (link).
5. Third Annual UK-Japan Nuclear Dialogue, 2014 (link);
6. Fourth Annual UK-Japan Nuclear Dialogue, 2015 (link).
7. UK Japan Civil Nuclear Research Programme, 2014 (link).
8. UK Japan Civil Nuclear Research Programme Phase 2, 2015 (link).
9. UK Japan Civil Nuclear Research Programme Phase 3, 2016 (link).
10. H.M. Government, Nuclear Industrial Strategy -The UK's Nuclear Future (2013).
11. EPSRC Independent Review of Fission and Fusion, 2016 (link).