SHARE

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D3.3: Report identifying and comparing international collaborative research initiatives

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SHARE
A roadmap for research in Decommissioning

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Abstract

International collaboration provides a key method to implement technology development and research, share knowledge, develop competence and harmonise practices. These collaborations ('instruments') can come in different forms, with varying arrangements and comprise of multiple partners. This paper aims to group the instruments/mechanisms that are currently in place within the science and technology field in the Nuclear, Waste Management and Decommissioning sector, and provide key characteristics and traits of each instrument.

The intention is that this report acts as a resource to SHARE Work Package 4, to list possible collaboration instruments that could be utilised by entities when fulfilling the decommissioning roadmap. It should be noted that the most proven method to further research and development of science and technology are those offered by the European Commission. For example, the Horizon 2020 programme was the largest ever European funding programme for research and innovation. Its budget of 79 billion euros aimed to ensure that Europe produces world-class science and make it easier for public and private sectors to innovate together. It offers an open, simple structure in order to provide accessible funding to remove barriers to collaborative innovation, getting new projects off the ground quickly and achieve results faster.

Deliverable content

1. Introduction

The main objective of the StakeHolder-based Analysis of REsearch for Decommissioning (SHARE) is to provide a roadmap for future developments in technical and non-technical areas including harmonisation, knowledge sharing and educational activities. This European collaboration (Horizon 2020) SHARE project aims to provide better coordination among nuclear decommissioning stakeholders, to allow stakeholders the visibility of the synergies in opportunities, challenges, and solutions to decrease costs and improve safety through collaboration.

This report provides a summary of the current (and relevant) international practice in terms of international collaborations for research, development, training, and demonstration projects. Specific consideration has been given to the role of large consortium forming mechanisms (such as Horizon 2020 and IAEA) but also ad-hoc bilateral relationships. A table for comparison of the instruments/mechanisms has been included.

The nature of the instruments for enabling collaboration identified in this report will be used to inform the development of SHARE Instruments for Implementation deliverable (4.3), SHARE Work Package 4. This deliverable will to propose appropriate and efficient mechanisms to implement the activities aimed at meeting the gaps identified in SHARE Task 3.2, Gap Identification.

2. Approach

2.1. Methodology

It is recognised that there are numerous collaborative instruments used nationally and internationally, and it would be impossible to conduct a truly exhaustive review. Therefore, Task 3.3 has focussed its attention on collaborative instruments used within the science and technology field, relevant to the Nuclear, Waste Management and Decommissioning sector. The following methodology was adopted to achieve our goal.

1. The Task 3.3 team compiled a list of collaboration instruments through an initial 'brainstorm' involving SHARE partners and 'literature' searches.
2. Each identified instrument was then reviewed by one of the project partners, based around a series of predetermined questions, either based on partners' prior knowledge or through an interview of personnel with experience within a collaboration project example.
3. This list of instruments was refined further throughout the task implementation phase as additional initiatives and suggestions arose from further stakeholder engagement.
4. The results of this analysis are summarised in Section 3 of this report.

2.2. Analysis

The instruments have been grouped under broad areas, based on the coordinating funding body for ease of interpretation. These instruments have been roughly grouped, and whilst the authors have tried to be as accurate as possible, there may be exceptions and the details may not apply to all those within the group but should be interpreted as a general classification.

The characteristics of the individual collaboration instruments have been summarised against a series of questions to help readers assess the relevance of each instrument to any specific type of project need. The aim of this is to help inform the development of the SHARE Roadmap in a subsequent task in Work Package 4, where the intention is to map actions to the most appropriate collaboration instrument.

The following characteristics were assessed based on the questions in Table 1 below.

Table 1. Questions included in the questionnaire used as a prompt in interviews to personnel with experience within a collaboration instrument example (at project level).

Characteristic	**Question**
Funding Mechanism	How is this type of collaboration funded?
Strategic Research Agenda (SRA) Action Alignment	What type of SRA action is this instrument used for? *SRA action types are identified in Figure 1 below and align with the definitions used in Work Package 4 in the SHARE SRA.*

Geography	Where is this instrument used?
Scope	Who defines the scope of the collaboration project?
Eligibility	Who can participate?
Output	Are the outputs of the project typically public or private?
Number of partners	What is a typical number of participants?
Scale of project	What is a typical project budget under this instrument?
Example project	Is there a 'decommissioning relevant' example project facilitated under this instrument?

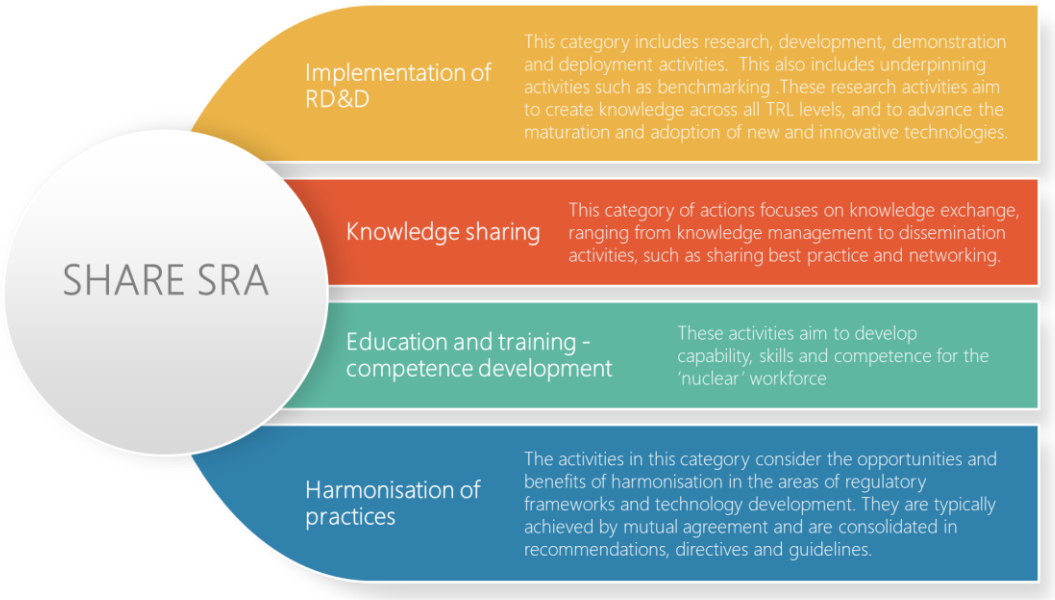

Figure 1. Strategic Research Agenda (SRA) Action Types as defined in SHARE WP4, courtesy of JRC

3. Collaborative Instrument Summary Table

Table 2 provides a summary of the different collaborative instruments identified during the analysis. Further descriptions and information regarding some of the instruments can be found in the Appendix.

Table 2. Review of the collaborative instruments available

Grouping	Instrument	Funding Mechanism	SRA Action Alignment				Geography	Who determines scope of projects	Eligibility to participate in research and development	Output Public/Private	Number of partners	Typical funding	Example if previously used for Waste Management Decommissioning Research
			Implementation	Harmonisation	Knowledge Sharing	Education and Training							
Academic/Industry	National academic research programmes	Research council and/or state level funding and/or industry					All	Proposal prepared by universities and/or industry	Consortium members	Varies	Varies	<10M Euro	KYT2022 (Finnish Research Programme on Nuclear Waste Management 2019–2022) (KYT2022, 2022) SAFIR2022 (Finnish Research Programme on Nuclear Power Plant Safety 2019–2022). (SAFIR2022, 2022) BNEN (Belgian Nuclear higher Education Network) (SCK-CEN, 2022) DISTINCTIVE (UK Research Programme on Decommissioning, Immobilisation and Storage soluTIons for NuClear wasTe InVEntories) (DISTINCTIVE University Consortium, 2022)

Grouping	Instrument	Funding Mechanism	SRA Action Alignment				Geography	Who determines scope of projects	Eligibility to participate in research and development	Output Public/Private	Number of partners	Typical funding	Example if previously used for Waste Management Decommissioning Research
			Implementation	Harmonisation	Knowledge Sharing	Education and Training							
	Challenge led innovation programme	Industry					Open	Funder sets challenge statements, followed by a call for proposals	Open	Private	Varies	Varies	Gamechangers (FIS 360 & National Nuclear Laboratory, 2022) Energiforsk research program (Energiforsk, 2022)
	University Bi-laterals	Parallel central funding in each country					Universities in the bilateral states	Joint calls for proposals	Open to academics	Public	Varies	Varies	UK - US NEUP (Nuclear Energy University Program) (UKRI, 2022)
European Commission	Research and Innovation (RIA)	Central funding					EU and associates	EC Call	Open	Public	>3	<10M Euro	Theramin (Thermal treatment for radioactive waste minimisation and hazard reduction) (VTT Technical Research Centre of Finland Ltd, 2022) MIND (Microbiology In Nuclear waste Disposal) (MIND, 2022) PREDIS (pre-disposal management of radioactive waste) (PREDIS, 2022)

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	EJP Cofund	Co-funding					EU and associates	EC Call	Mandated actors and linked third parties	Public	>3	>10M Euro	EURAD (European Joint Programme on Radioactive Waste Decommissioning) (EURAD, 2022)

Grouping	Instrument	Funding Mechanism	SRA Action Alignment				Geography	Who determines scope of projects	Eligibility to participate in research and development	Output Public/Private	Number of partners	Typical funding	Example if previously used for Waste Management Decommissioning Research
			Implementation	Harmonisation	Knowledge Sharing	Education and Training							
	Coordination and Support Action (CSA)	Central funding					EU and associates	EC Call	Open	Public	>3	<5M Euro	SHARE (StakeHolder-based Analysis of REsearch for Decommissioning) (SHARE, 2022)

Grouping	Instrument	Funding Mechanism	SRA Action Alignment				Geography	Who determines scope of projects	Eligibility to participate in research and development	Output Public/Private	Number of partners	Typical funding	Example if previously used for Waste Management Decommissioning Research
			Implementation	Harmonisation	Knowledge Sharing	Education and Training							
	Innovation Action (IA)	Central funding					EU and associates	EC Call	Open	Public	>3	<10M Euro	Inno4graph (INNOvative tools FOR dismantling of GRAPHite) (INNO4GRAPH , 2022) MICADO (Measurement and Instrumentation for Cleaning And Decommissioning Operations) (MICADO Project, 2022)

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			Implementation	Harmonisation	Knowledge Sharing	Education and Training							
	Marie Skłodowska-Curie Actions	Central funding and Co-funding					International	EC Call	Open	Public	>3	8.82M Euro	(European Commission, 2022)
	Public Procurement Calls	Central funding					International	European Commission, DG Energy (ENER)	Open	Public	>1	Varies	Gap Analysis of Earned Value Management Systems in Use by Operators Under the Nuclear Decommissioning Assistance programmes (TED eTendering, 2022)
	European Research Council	Central funding					EU and associates	ERC Calls	Open		ERC grants support projects carried out by an individual researcher	1.5M Euro	
	European Innovation Council	EIC Fund (mix of grant and investment)					EU and associates	EIC Calls	Innovators, start-up and SMEs, and small Mid-caps,	Private	Varies	between 0.5M and 15M Euro	

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EURAMET	European Metrology Programme for Innovation and Research (EMPIR)	Central funding					EU and associates	EMPIR Call	Open	Public	>3	600 M Euro (Total EMPIR Budget)	METRODECOM METRODECOM II (Metrology for Decommissioning Nuclear Facilities) (EMPIR project, 2022)
International Open	Network	Volunteering					UN members	IDN members	Open but may require country approval	Public	Many	Limited funding for specific countries	IAEA – IDN (International Decommissioning Network) (IAEA, 2022)
	IAEA CRP	Mutual Cooperation					UN members	Call from IAEA - then mutual contribution of research and development	Based on research and development contribution	Public	Varies	Limited funding for specific countries	CRP T13017 on the management of high alpha wastes (IAEA, 2022)
	IAEA CC	Internal investment					Global	Agency's Collaborating Centres Scheme, obtained via formal written expression of interest sent by a Member State institution	Based on promoting knowledge transfer, education & training and research & development contribution	Public	1	Varies	HALDEN IAEA CC (IAEA, 2022) SOGIN IAEA CC (IAEA, 2022)

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Membership Model	SNETP	Membership					Europe	n/a	Membership fee (7000 EUR) targeted to owners (NPPs) and research entities	Private	Many	None	SNETP (Sustainable Nuclear Energy Technology Platform) (SNETP, 2022)
	WENRA	Membership					Europe	Members	Association of regulators	Private	Many	None	WENRA (Western European Nuclear Regulators Association) (WENRA, 2022)
	ETSON	Membership					Europe	n/a	Association of TSO (technical support organizations)	Private	Many	None	ETSON (European Technical Safety Organisations Network) (ETSON, 2022)
	EPRI	Membership					Global	Members	Commercial contracted research and development	Private	Implemented by contract	Varies	EPRI (Electric Power Research Institute) (EPRI, 2022)

Grouping	Instrument	Funding Mechanism	SRA Action Alignment				Geography	Who determines scope of projects	Eligibility to participate in research and development	Output Public/Private	Number of partners	Typical funding	Example if previously used for Waste Management Decommissioning Research
			Implementation	Harmonisation	Knowledge Sharing	Education and Training							
	EERA	Membership					Europe	Members	Membership fee (8000 EUR)	Private	>10	Varies	JPNM-EERA (The Joint Programme on Nuclear Materials of the European Energy Research Alliance) (EERA, 2022)
	Cogentus (professional support and advice provided by third party)	Subscription					All	n/a	All	Private	n/a	n/a	Cogentus (Cogentus, 2022)
	Candu Owners Group (COG)	Member's investment					Global	Members	CANDU Operators	Private	10	47M EUR	COG (CANDU Owners Group (COG), 2022)
NEA	Nuclear Education, Skills and Technology (NEST)	National level funding					Global	Members	NEA Member countries	Private	15	Varies	NEST (Nuclear Education, Skills and Technology) (NEA, 2022)
OECD	NEA projects	Membership at State Level					Global	Members	NEA Member countries	Private	Varies	Varies	TDB (Thermochemical Database) (NEA, 2022)

Grouping	Instrument	Funding Mechanism	SRA Action Alignment				Geography	Who determines scope of projects	Eligibility to participate in research and development	Output Public/Private	Number of partners	Typical funding	Example if previously used for Waste Management Decommissioning Research
			Implementation	Harmonisation	Knowledge Sharing	Education and Training							
	NEA Committee	Membership at State Level					Global	Members	NEA Member countries	Private	Varies	Varies	CSNI (Committee on the Safety of Nuclear Installations) (NEA, 2022)

Grouping	Instrument	Funding Mechanism	SRA Action Alignment				Geography	Who determines scope of projects	Eligibility to participate in research and development	Output Public/Private	Number of partners	Typical funding	Example if previously used for Waste Management Decommissioning Research
			Implementation	Harmonisation	Knowledge Sharing	Education and Training							
	Joint projects	Membership at State Level					Global	Funders via programme committee	Approval required from partners	Private	>15	Varies	Halden Reactor Project (HTO since 2021) (OECD-NEA, 2022)
Other	SITEX	Closed Grouping of TSO s					Global	Members	Approval required from partners	Private	15	Varies	SITEX (Sustainable network for Independent Technical EXpertise on radioactive waste management) (SITEX Network, 2022)
	Commercial	Funded					n/a	Funder	Open	Private	Varies	Varies	
Regional	Regional action	State Level cooperation					Regional	Funders	State companies with support from subcontractors	Public	Varies	Varies	Norwegian Government's Action Plan for Nuclear Safety and Security in Russia, Ukraine and other countries in Eurasia (DSA Norwegian Radiation Protection Authority, 2022) NKS (Nordic Nuclear Safety Research) (NKS, 2022)

Grouping	Instrument	Funding Mechanism	SRA Action Alignment				Geography	Who determines scope of projects	Eligibility to participate in research and development	Output Public/Private	Number of partners	Typical funding	Example if previously used for Waste Management Decommissioning Research
			Implementation	Harmonisation	Knowledge Sharing	Education and Training							
State / Commercial	Bilaterals	Mutual cooperation					Closed	Mutual agreement	Closed	Private	2 countries / organisations	Varies	NNL (UK) - JAEA (Japan)

4. Discussion

Over recent years, the experience in developing multi-national collaborations has increased, aided by the digitalisation of the workplace. A number of collaboration mechanisms exist, and these have been grouped for convenience in Table 2, by the nature of the 'organising/coordinating body' associated with the instrument as listed below:

- Academic/Industry
- European Commission
- International Open (IAEA)
- Membership Model
- OECD-NEA
- Other
- Regional
- State / Commercial

The key themes emerging from the review are detailed below, whilst further details are available in the appendix (Section 7) and on the associated 'instrument' or collaboration websites see References (Section 6).

The adoption of the different mechanism/instrument for a specific collaboration is influenced by many factors including:

i. the mandate of the organising body,
ii. the financial model,
iii. the nature of the collaborative activity (i.e. the action type as defined in Figure 1),
iv. the eligibility to participate in the collaboration (is participation open or constrained by regional limitations, or membership of an organisation),
v. the scale of the project (e.g. number of partners to participate, total collaboration budget),
vi. if the output of the collaboration is public or private.

Therefore, the preference for utilising a particular instrument for a specific collaboration will be contingent upon these factors and depends on the intended end goal and associated action it is aiming to resolve (action type). It should be noted that the instruments reviewed in Table 2, showed that different instruments were relevant to each of the action types; some instruments covered more than one action type.

From the international collaboration practises considered, the most proven method to further research and development of science and technology, are those offered by the European Commission (Section 7.1) For example, the Horizon 2020 programme was the largest ever European funding programme for research and innovation at the time. Its budget of 79 billion EUR aimed to ensure that Europe produces world-class science and make it easier for public and private sectors to innovate together. It offers an open, simple structure in order to provide accessible funding to remove barriers to collaborative innovation, getting new projects off the ground quickly and achieve results faster. Individual Member States have the influence of providing feedback on the programme's scope and can

iterate the periodic calls. Therefore, the project calls are related to the campaigning and requests from the Member States (and organisations like SNETP) that can influence the program content.

The Horizon Europe programme will play a pivotal role in accomplishing the actions listed in the SRA and/or roadmap (WP4), however the best-fit instrument for each activity will depend on the action types.

Membership groups

European Technology Platforms, such as SNETP, have a pivotal role in networking similar organisations, so that members can harmonise practises across the nuclear decommissioning industry. Other groups, such as EPRI, are more focused to leverage funding for research linked to the development and demonstration of technology.

OECD-NEA

OECD-NEA has several initiatives aimed at sharing knowledge and training throughout Member States. The fee of involvement depends on the project; however organisations are able to leverage the funding for research, which in some cases may be at the fundamental level which would otherwise struggle for national/commercial investment without the other partners involvement.

IAEA

Involvement in the IAEA's decommissioning activities are suited to the harmonisation of advice to organisations, release of benchmarking documents such as 'state of the art reviews' and permitting networking between nations, to flourish the growth of capability. The IAEA has the influence to drive organisations and governing bodies to follow the guidance.

Bi-laterals

Bi-laterals are suited to a small number of organisations (or countries) with an interest in sharing information and developing and implementing the technology.

5. Summary

Many different vehicles have been identified in Section 3 that have been used or could be used to facilitate collaboration in decommissioning development. Indeed, this work has also shown that these instruments have been used to facilitate collaboration on each of the different classes of action, as defined in the SHARE SRA, namely:

- Implementation of research, development, demonstration and deployment,
- Knowledge sharing,
- Education and training – competence development, and
- Harmonisation of practices.

European instruments led by the European Commission such as Horizon Europe will continue to be the key facilitating instruments for open collaborative Research, Development & Demonstration (RD&D) across Europe, aided by European networks notably SNETP, Nugenia and ETSON. However, other international organisations including OECD-NEA and IAEA are also facilitating co-operation beyond Europe and remain important instruments for collaboration and networking in the nuclear sector.

This report and analysis of potential instruments for collaboration is used to inform the development of SHARE project Strategic Research Agenda into the SHARE project Roadmap (WP4).

6. References

CANDU Owners Group (COG). (2022, January 31). *CANDU Owners Group (COG)*. Retrieved from http://www.candu.org/SitePages/Home.aspx

Cogentus. (2022, January 31). *Cogentus*. Retrieved from https://www.cogentus.co.uk/

DISTINCTIVE University Consortium. (2022, January 28). *DISTINCTIVE*. Retrieved from http://distinctiveconsortium.org/

DSA Norwegian Radiation Protection Authority. (2022, March 09). *About the nuclear action plan*. Retrieved from https://dsa.no/en/the-nuclear-action-plan/about-the-nuclear-action-plan

EERA. (2022, March 09). *The Joint Programme on Nuclear Materials of the European Energy Research Alliance (EERA-JPNM)*. Retrieved from http://www.eera-jpnm.eu/

EMPIR project. (2022, January 31). *MetroDecom II*. Retrieved from http://empir.npl.co.uk/metrodecom/

Energiforsk. (2022, March 09). *Nuclear Power – Outlook and Technology Development*. Retrieved from https://energiforsk.se/en/programmes/nuclear-power-outlook-and-technology-development/

EPRI. (2022, January 31). *Nuclear*. Retrieved from https://www.epri.com/research/sectors/nuclear

ETSON. (2022, March 09). Retrieved from ETSON: https://www.etson.eu/

EURAD. (2022, January 28). *EURAD*. Retrieved from https://www.ejp-eurad.eu/

European Commission. (2013). *EU Decommissioning Funding Data.* Brussels: SWD(2013) 59 final .

European Commission. (2021). *Horizon 2020, Work Programme 2021-2022, 19. General Annexes.* European Commission Decision C(2021)1940.

European Commission. (2022, March 09). *Horizon Europe*. Retrieved September 28, 2021, from https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

European Commission. (2022, March 09). *Marie Skłodowska-Curie Actions: Commission supports researchers and organisations with €822 million in 2021*. Retrieved from European Commission: https://ec.europa.eu/commission/presscorner/detail/en/ip_21_3057

European Commission. (2022, March 09). *What is Horizon 2020?* Retrieved September 28, 2021, from https://ec.europa.eu/programmes/horizon2020/en/what-horizon-2020

FIS 360 & National Nuclear Laboratory. (2022, January 28). Retrieved from Game Changers : https://www.gamechangers.technology/

IAEA. (2022, January 31). *Active IAEA Collaborating Centres sorted by topic.* Retrieved from https://www.iaea.org/sites/default/files/20/01/collaborating-centres.pdf

IAEA. (2022, March 09). *Coordinated Research Projects*. Retrieved September 27, 2021, from https://www-amdis.iaea.org/CRP/

IAEA. (2022, January 31). *IAEA International Decommissioning Network - IDN*. Retrieved from https://nucleus.iaea.org/sites/connect/IDNpublic/Pages/default.aspx

IAEA. (2022, January 31). *Management of Wastes Containing Long-lived Alpha Emitters: Characterization, Processing and Storage*. Retrieved from https://www.iaea.org/projects/crp/t13017

INNO4GRAPH . (2022, January 28). *INNO4GRAPH – INNOvative tools FOR dismantling of GRAPHite moderated nuclear reactors*. Retrieved from https://www.inno4graph.eu/

KYT2022. (2022, March 09). *Finnish Research Programme on Nuclear Waste Management (KYT2022) 2019-2022*. Retrieved from KYT2022: http://kyt2022.vtt.fi/index_en.htm

MICADO Project. (2022, January 28). *MICADO*. Retrieved from https://www.micado-project.eu/

MIND. (2022, January 28). *MIND*. Retrieved from https://mind15.eu/

NEA. (2022, January 31). *Committee on the Safety of Nuclear Installations (CSNI)*. Retrieved from https://www.oecd-nea.org/jcms/pl_24829/committee-on-the-safety-of-nuclear-installations-csni

NEA. (2022, January 31). *Nuclear Education, Skills and Technology (NEST) Framework*. Retrieved from https://www.oecd-nea.org/jcms/pl_21786/nuclear-education-skills-and-technology-nest-framework

NEA. (2022, January 31). *Thermochemical Database (TDB) Project*. Retrieved from https://www.oecd-nea.org/jcms/pl_22166/thermochemical-database-tdb-project

NKS. (2022, March 09). *NKS*. Retrieved from This is NKS: https://www.nks.org/en/this_is_nks/

Nuclear Energy Agency. (2022, March 09). *What we do*. Retrieved from https://www.oecd-nea.org/jcms/pl_36847

OECD. (2022, March 09). *Who we are*. Retrieved from OECD: https://www.oecd.org/about/

OECD-NEA. (2022, March 09). *Halden Reactor Project*. Retrieved from Halden Reactor Project: https://www.oecd-nea.org/jcms/pl_24970/halden-reactor-project

PREDIS. (2022, January 28). *The pre-disposal management of radioactive waste – PREDIS*. Retrieved from https://predis-h2020.eu/

SAFIR2022. (2022, March 09). *The Finnish Research Programme on Nuclear Power Plant Safety 2019 - 2022*. Retrieved from SAFIR2022: http://safir2022.vtt.fi/

SCK-CEN. (2022, March 09). *Belgian Nuclear higher Education Network* . Retrieved from https://bnen.sckcen.be/

SHARE. (2022, January 28). *SHARE*. Retrieved from https://share-h2020.eu/

SITEX Network. (2022, March 09). *SITEX . Network*. Retrieved from https://www.sitex.network/

SNETP. (2022, January 28). *The Sustainable Nuclear Energy Technology Platform* . Retrieved from https://snetp.eu/

SNETP. (May 2010). *Deployment Strategy.*

TED eTendering. (2022, March 09). *Gap Analysis of Earned Value Management Systems in Use by Operators Under the Nuclear Decommissioning Assistance programmes (NDAP)*. Retrieved from Europa: https://etendering.ted.europa.eu/cft/cft-display.html?cftId=5103

UKRI. (2022, January 28). *Research nuclear energy with a US partner: 2022*. Retrieved from https://www.ukri.org/opportunity/research-nuclear-energy-with-a-us-partner-2022/

VTT Technical Research Centre of Finland Ltd. (2022, January 28). *Theramin*. Retrieved from http://www.theramin-h2020.eu/

WENRA. (2022, March 09). *WENRA's mission*. Retrieved from https://www.wenra.eu/about

7. Appendix

Technical co-operation has been a major feature of the nuclear landscape and, given the resource constraints faced by institutions, it will continue to be a significant modality for aid in the future. The principal advantage in collaborating includes the increased cost-effectiveness of research spending, allowing for the shared financial risk in overcoming an action. Collaboration may also allow faster technical progress, due to the sharing of resources throughout the organisations involved.

Research collaboration is often difficult to achieve in practice, due to the perception that an organisation's technological advantage may be lost due to the sharing of knowledge and skills. However, many developments have occurred in the global landscape for promoting an increase in international co-operation in science and technology. This includes the evolution in the practice of scientific research, notably the digitalisation of scientific discovery; the increase in actors; the advent of the United Nations 2030 Agenda and the Sustainable Development Goals; as well as the growing importance of scientific integrity.

Previous and current collaborative activities have focussed on either implementation, harmonisation, knowledge sharing, and education and training, or multiple initiatives. The definition of these themes used in the context of this report are defined in Figure 1. The instruments listed in Table 2 can be grouped to be achieving one or more of these themes. Discussion around the details of some of the grouping is considered below.

7.1. European Commission[1]

The European Commission funds several scientific research programs integrating the scientific resources of the European Union (EU). Since its inception in 2000, the structure has been concentrated on European cooperation in the fields of medical, environmental, industrial, and socioeconomic research.

Horizon 2020 was the biggest EU Research and Innovation programme ever with nearly €80 billion of funding available over 7 years (2014 to 2020) – in addition to private investment (European Commission, 2022). Horizon 2020's focus was on innovation, delivering economic growth faster, and delivering solutions to end users that are often governmental agencies. The successor of the Horizon 2020 programme, Horizon Europe, was launched in 2021 with a budget of €95.5 billion as a is a planned 7-year European Union scientific research initiative (European Commission, 2022).

When launched, Horizon Europe calls had different types of action (funding schemes). The type of action specifies the scope of what is funded and the reimbursement rate (i.e. available funding).

It should be noted that not all these actions advocate collaboration, and some may provide a more commercial or financial intention. For example, the nuclear decommissioning assistance programmes

[1] Large segments of this section are direct quotes taken from (European Commission, 2022).

concentrate on co-financing the decommissioning of first-generation Soviet-designed nuclear reactors that were not considered safe to continue operation in the EU.

Horizon Europe programme grants are given to specific projects that relate to EU policies, usually following a public announcement known as a call for proposals. The call for proposals is based on guidance obtained from a strategic programming exercise by the European Commission. Eligibility for a grant is open to businesses or related organisations (business associations, business support providers, consultants, etc.) that runs projects that further the interests of the EU, or those that can contribute to the implementation of an EU programme or policy.

The list below gives a short overview of the Horizon Europe types of actions that can be used for collaboration and their funding rates. (European Commission, 2021)

7.1.1. Research and Innovation (RIA)

Research and Innovations Actions (RIA) are activities that aim primarily to establish new knowledge or to explore the feasibility of a new or improved technology, product, process, service or solution. This may include basic and applied research, technology development and integration, testing, demonstration and validation of a small-scale prototype in a laboratory or simulated environment. (European Commission, 2021)

7.1.2. Innovation Action (IA)

Innovation actions (IA) are activities that aim directly to produce plans and arrangements or designs for new, altered or improved products, processes or services. These activities may include prototyping, testing, demonstrating, piloting, large-scale product validation and market replication. (European Commission, 2021)

7.1.3. Coordination and support actions (CSA)

Coordination and support actions (CSA) are activities that contribute to the objectives of Horizon Europe. This excludes R&I activities, except those carried out under the 'Widening participation and spreading excellence' component of the programme (part of 'Widening participation and strengthening the European Research Area'). Also eligible are bottom-up coordination actions which promote cooperation between legal entities from Member States and Associated Countries to strengthen the European Research Area, and which receive no EU co-funding for research activities. (European Commission, 2021)

7.1.4. Programme co-fund actions (CoFund)

Programme co-fund actions (CoFund) is a programme of activities established or implemented by legal entities managing or funding R&I programmes, other than EU funding bodies. Such a programme of activities may support: networking and coordination; research; innovation; pilot actions; innovation and market deployment; training and mobility; awareness raising and communication; and dissemination and exploitation. It may also provide any relevant financial support, such as grants, prizes and procurement, as well as Horizon Europe blended finance or a combination thereof. The

actions may be implemented by the beneficiaries directly or by providing financial support to third parties. (European Commission, 2021)

7.1.5. Innovation and market deployment actions (IMDA)

Innovation and market deployment actions (IMDA) are activities that embed an innovation action and other activities necessary to deploy an innovation on the market. This includes the scaling-up of companies and Horizon Europe blended finance. (European Commission, 2021)

7.1.6. Training and mobility actions (TMA)

Training and mobility actions (TMA) are activities that aim to improve the skills, knowledge and career prospects of researchers, based on mobility between countries and, if relevant, between sectors or disciplines. (European Commission, 2021)

7.1.7. Pre-commercial procurement actions (PCP)

Pre-commercial procurement actions (PCP) are activities that aim to help a transnational buyers' group to strengthen the public procurement of research, development, validation and, possibly, the first deployment of new solutions that can significantly improve quality and efficiency in areas of public interest, while opening market opportunities for industry and researchers active in Europe. Eligible activities include the preparation, management and follow-up, under the coordination of a lead procurer, of one joint PCP and additional activities to embed the PCP into a wider set of demand-side activities. (European Commission, 2021)

7.1.8. Public procurement of innovative solutions actions (PPI)

Public procurement of innovative solutions actions (PPI) are activities that aim to strengthen the ability of a transnational buyers' group to deploy innovative solutions early by overcoming the fragmentation of demand for such solutions and sharing the risks and costs of acting as early adopters, while opening market opportunities for industry. Eligible activities include preparing and implementing, under the coordination of a lead procurer, one joint or several coordinated PPI by the buyers' group and additional activities to embed the PPI into a wider set of demand-side activities. (European Commission, 2021)

7.1.9. Marie Skłodowska-Curie Actions

The Marie Skłodowska-Curie Actions are the European Union's reference programme for doctoral education and postdoctoral training. They contribute to excellent research, boosting jobs, growth and investment by equipping researchers with new knowledge and skills. They foster research cooperation across borders, sectors and disciplines. (European Commission, 2022)

7.2. International Open

The International Atomic Energy Agency (IAEA) is an international organisation whose main function is to: encourage and assist research, development and practical application of atomic energy for peaceful uses throughout the world. As a general rule, the IAEA does not pay for external organisations

time nor travel and accommodation expenses for participants and contributors to groups, but some limited funding may be made available under some circumstances.

Participants are representatives from the Member States, and information is made publicly available.

7.2.1. IAEA International Decommissioning Network (IAEA – IDN)

IAEA International Decommissioning Network (IAEA – IDN) seeks to promote safe and efficient practices in the execution of decommissioning programmes by bringing together organisations and individuals involved in the decommissioning and dismantling of radioactive facilities, facilitating the sharing of practical decommissioning experiences and lessons learned and bringing together existing decommissioning initiatives inside and outside the IAEA to enhance cooperation and coordination.

IDN members direct the scope of the network.

7.2.2. IAEA Coordinated Research Projects (IAEA - CRPs)

IAEA Coordinated Research Projects (CRPs) bring together scientists representing institutes from IAEA's Member States to collaborate on a focussed research topic that is of shared interest and is important to the mission of the Agency. A CRP is normally approved for a period of 3-5 years and typically involves 8-15 laboratories, research teams or institutions. Most CRPs involve 3 Research Coordination Meetings (RCMs) where participants are brought together. The IAEA supports the cost of the RCMs, but only very limited funds are available for direct research support, and this only for participants from developing countries (IAEA, 2022).

7.3. OECD

The Organisation for Economic Co-operation and Development (OECD) is an international organisation that works to improve policies internationally. Their goal is to shape policies that foster prosperity, equality, opportunity and well-being, by working with governments, policy makers and citizens. The OECD establish evidence-based international standards and finding solutions to a range of social, economic and environmental challenges. They provide a unique forum and knowledge hub for data and analysis, exchange of experiences, best-practice sharing, and advice on public policies and international standard-setting. (OECD, 2022)

7.3.1. Nuclear Energy Agency (NEA)

NEA aims to assist its member countries in maintaining and further developing the scientific, technological and legal bases required for a safe, environmentally sound and economical use of nuclear energy. They aim to provide reliable assessments and to increase common understandings on key issues as input for nuclear energy policy and to the broader OECD analyses, in areas such as energy and the sustainable development of low-carbon economies.

To fulfil its mission the NEA currently work within the following sector-specific activities: nuclear safety research, nuclear safety regulation, nuclear economics, radioactive waste management, radiological protection and public health, nuclear law and liability, nuclear science, the data bank, and information

and communication. Within these topics, the NEA conduct a number of activities such as committees, NEST projects, joint projects and events. (Nuclear Energy Agency, 2022)

7.4. Academic/Industry

Academic and industrial funding instruments can be used to directly advance research in decommissioning processes and services. These are financed by commercial organisations, governmental ministries, academic funding bodies or business development bodies to promote technologies, offerings or competences.

7.4.1. National academic research programme

Each country appears to have their own academic hub, based on their own unique research interests associated to decommissioning. The research is conducted via a group of PhDs and Post-doctoral researchers, with guidance from industry as to ensure the research's relevance to industrial application. The programmes may be funded centrally from a national programme, through research councils, or from industry (or a combination from such routes).

For example, the Finnish research programme on nuclear waste management (KYT2022) is based on Finland's Nuclear Energy Act (990/1987) according to which the aim of research is "ensuring that the authorities have such sufficient and comprehensive nuclear engineering expertise and other facilities at their disposal that are needed for comparisons of the various ways and methods of carrying out nuclear waste management". The research emphasis on the research programme is on nationally central research topics, with the long-term aim of KYT2022 to maintain and advance national know how and infrastructure in nuclear waste management and to promote collaboration between authorities, nuclear industry, and scientists. (KYT2022, 2022) The funding of the research programme is provided by the State Nuclear Waste Management Fund (VYR) into which those responsible for nuclear waste management pay annually 0.08 % of their respective assessed liability. The current level of annual funding is c.a. 1.9M Euro. In addition to VYR funding, research organisations may direct own funding into their research projects. (KYT2022, 2022)

7.4.2. Challenge led innovation programme

Game Changers is a UK innovation programme that identifies and develops cutting-edge technologies that could provide significant advances in nuclear science and engineering, facilitating innovative solutions and their implementation in the industry. The IP remains with the innovation owner/developer, and the solution is developed for commercialisation with the caveat e.g. for no license to be required for use on Sellafield site (if Sellafield Ltd is the sponsor).

Ideas are submitted through an application process and the best projects are selected for funding. Applications are usually submitted in response to specific challenges (such as leak prevention or minimisation) but can be accepted at any time for any idea. Game Changers publish details of challenges on behalf of partner organisations, such as Sellafield Ltd, NNL and Dounreay. The challenges are then open to anyone from any sector who can offer a viable solution, from small and medium-sized enterprises to universities and large corporate organisations, to apply.

Funding is available in two phases through Game Changers:

- Feasibility grants of up to £10,000 support an initial exploration of ideas and concepts
- Ideas showing early promise are awarded larger proof of concept grants

The Game Changers programme is an Innovus initiative, and the sponsor (financier) is not restricted to be the challenge owner, but can be a partner in the programme instead.

7.4.3. University bilateral

Bilateral agreements are a reciprocal agreement signed between at least two universities to permit a joint research venture, restricted to only those involved. The location of the universities is not restricted, with specific details of the arrangement (such as financier and programme value) varying between each contract.

This approach has previously been utilised to allow research in decommissioning, such as between the UK and Japan, and the UK and South Korea.