# Analysis of research needs in nuclear decommissioning based on stakeholders' point of views

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## 1 Introduction

Nuclear decommissioning includes all technical and management actions associated with the terminated operation of a nuclear installation and its subsequent dismantling to remove it from regulatory control while delivering an environmental friendly end-product. Therefore, enormous amount of capital is estimated to be required to decommission nuclear facilities in coming decades. In order to highlight the fact, the nuclear decommissioning service market in Europe was valued US$ 2.68 billion in 2019 and is projected to reach US$ 4.29 billion by 2027 [1]. Thus, a great deal of resources and capital will be spent in coming decades to safely decommission nuclear facilities. This leads to increased awareness and interest among a variety of stakeholders, like operators, industry, regulators, waste management companies, R&D organisations, universities, international organisations, consultants, and others. Decommissioning activities require a definite timeframe that takes place over the years. For the stakeholders, they raise not only technological challenges related to characterisation, dismantling, radioactive waste management and final remediation but also non-technological challenges associated particularly with maintaining competence, education and training, economic renewal and growth, and dialogue with regulator but also society.
The Horizon 2020 SHARE project (StakeHolders- based Analysis of REsearch for Decommissioning), funded by the European Commission, intends to provide an inclusive roadmap for joint near future decommissioning research, facilitating stakeholders to improve safety, reduce cost, and minimise environmental impact in the decommissioning of nuclear facilities. The research areas are focused on R&D, R&I, new methodologies, standards, and cross-cutting technologies in technical and non-technical areas. By the end of 2021, the aim is to develop a Strategic Research Agenda (SRA) associated with a Roadmap for the next 10-15 years to encourage coordination and harmonisation of future research activities related to decommissioning for the benefit of Member states in Europe and beyond by considering the stakeholders' needs and opinions. This should also help and support policy makers to prioritise strategically the direction of research that is recommendable for financing in the next decade. Moreover, it would benefit different types of involved stakeholders to access expertise and technology in the field of decommissioning and environmental remediation.

## 2 Concept

The overall approach of SHARE is based on a consultation process considering the needs and points of view of different stakeholders involved in the decommissioning value chain across the world. Three groups of stakeholders are involved at different levels in establishing the roadmap for decommissioning research.

- SHARE consortium members consisting of CEA/ EI/ ENRESA/ IFE/ JRC/ KIT/ LEI/ NNL/ SCK-CEN/ SOGIN/ VTT.

- An Expert Review Panel (ERP) including industry, operators, waste management organisations, research institutes, regulators beyond Europe with an interest of contributing to the process of establishing the roadmap by assessing, reviewing and complementing the overall outcome at different steps.

- A wider community of organisations across the decommissioning value chain who showed interest to SHARE initiative (answered to surveys or registered to public workshops and/ or to social media, etc.)

## 3 Methodology

As highlighted above, SHARE is built on a consultation process including the needs and points of view of different stakeholders. In this regard, a survey was set-up by keeping in consideration key thematic areas divided in sub-thematic areas. Representative stakeholders were asked to give their feedback in terms of importance and urgency of 'the need for research', in each of these sub-thematic areas, using a Likert scale from zero to 5. In parallel, a detailed assessment on literature was performed to identify existing best practices and emerging advanced techniques and solutions for decommissioning employed across the nuclear industry to meet the current and future needs. Moreover, a review of international initiatives (IAEA and NEA/OECD reports; EU projects) in relation to the thematic areas defined in the questionnaire was also performed.
Investigation of needs (issues, challenges, opportunities, etc.) was performed, followed by a gap analysis among needs, available solutions, and desired state, and by the identification of actions to fill the gaps. These proposed actions will be classified by key topics in a Strategic Research Agenda. It will be followed by a Roadmap for the next 10-15 years, with proposal of collaborative schemes for future implementation. An overview of SHARE methodology is shown in Figure 1 [2].

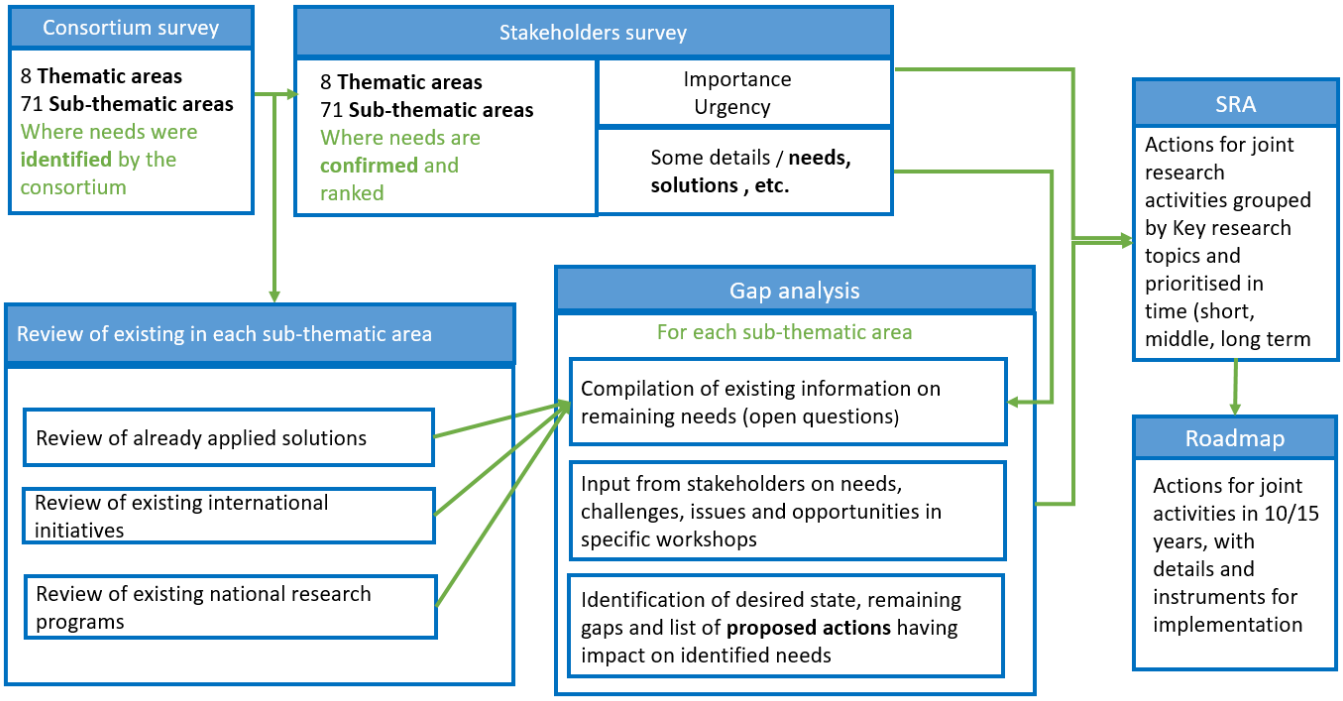


*Figure 1: SHARE project methodology*

## 4 Stakeholders survey

### 4.1 Survey results

In order to achieve the stakeholders' involvement, the consortium set up a survey based questionnaire with well-known 8 thematic areas and further divided into 71 sub-thematic areas as having major research needs. The list of thematic areas can be seen in the Table 1.

*Table 1: List of thematic areas*

| ID | Thematic areas |
|---|---|
| Q1 | Safety and radiological protection aspects |
| Q2 | Project management and costing |
| Q3 | Human resources management |
| Q4 | Characterisation during decommissioning |
| Q5 | Site preparatory activities |
| Q6 | Dismantling |
| Q7 | Environmental remediation and site release |
| Q8 | Management of material and radioactive waste from decommissioning |

Questionnaires were sent to 650 stakeholders from across the decommissioning value chain in Europe and worldwide. Respondents were asked to assess their needs for enhancement of the current situation for each sub-thematic area, evaluating each topic in function of importance and urgency, using a 5-point scale with 5 expressing the highest need or the highest urgency. Additionally, no answer was required if a sub thematic area was not relevant for a stakeholder. Respondents were given the possibility to add any missing topics through text-boxes for open questions.

With 34.5% response rate, 224 full answers were received and analysed. The stakeholders prioritised different thematic and sub-thematic areas in terms of importance and urgency by scoring them. Figure 2 highlights the global survey results for the main thematic areas expressed as the percentage of respondents for each point (stacked bar chart) in the scale and by the Top N 2 Scores that is the percentage of respondent's positive answers means scoring 'high' or 'very high' (red circle) [3].

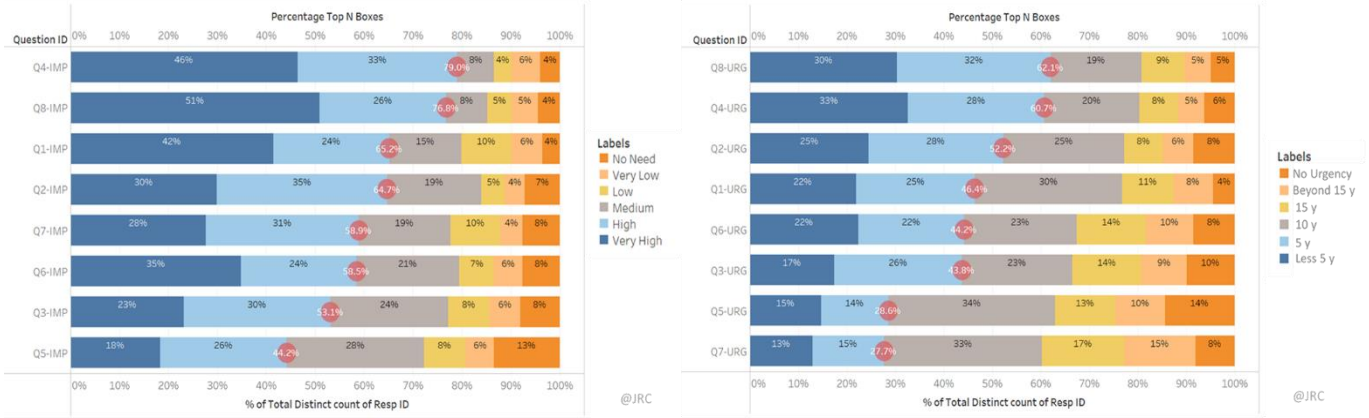


*Figure 2: General Overview of the Thematic Areas for Importance (left figure) and Urgency (right figure)*

As it can be seen in Figure 2 the thematic areas, "Characterisation during decommissioning" (Q4) and "Management of material and radioactive waste from decommissioning" (Q8) received the highest percentages of respondents' positives answers followed behind for "Safety and radiological protection aspects (Q1) and "Project management and costing" (Q2). Site Preparatory activities received the lowest percentage of respondents' positive answers. In terms of Urgency, (Q8) "Management of material and radioactive waste from decommissioning" and (Q4) "Characterisation during decommissioning", received the highest percentages of respondents' positives answers followed by (Q2) "Project management and costing" and (Q1) "Safety and radiological protection aspects". There is a change in order of prioritisation for the two pairs with respect to the importance.

Similarly, Figure 3 shows the importance (X-axis) versus urgency (Y-axis) for top 15 sub-thematic areas with higher percentages of respondents' positive answers for both importance and urgency. In the scatterplot, the 45-degree line is indicating where urgency is equal to importance. The differences between importance and urgency vary between -5 and -23 % [3]. The importance prevails over urgency and there is no obvious trend showing than the most important sub thematic areas are also the most urgent.

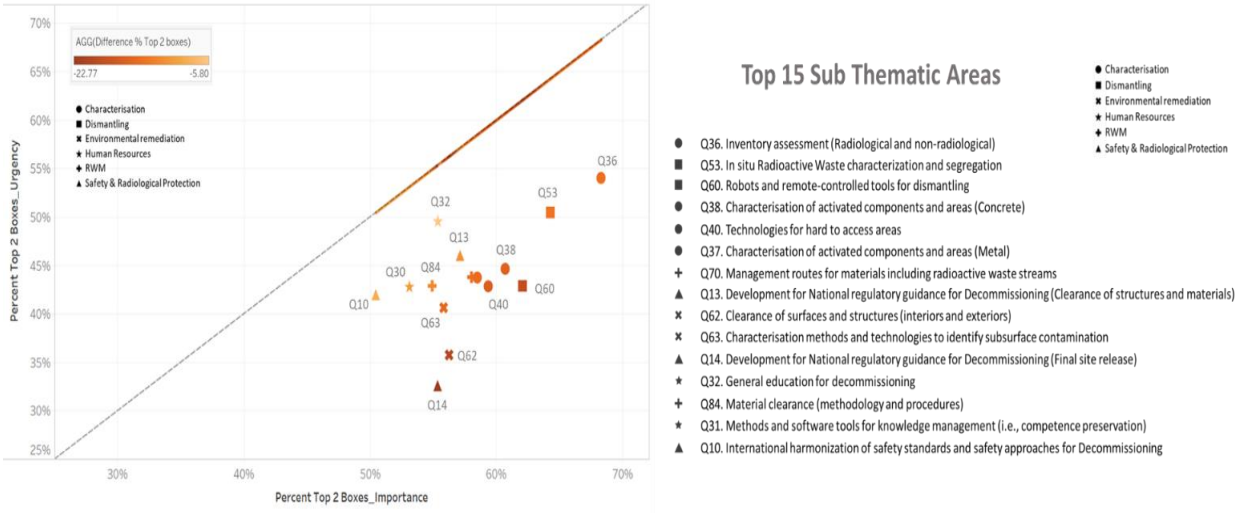


*Figure 3: General Overview of top 15 Sub-Thematic Areas for Importance and Urgency*

Within the scope of survey, a detailed analysis was also made by considering type of stakeholders, country, type of facility, and status of decommissioning project.

### 4.2 Further Stakeholders Involvement

In order to share the first results of the project and to perceive from and coordinate with other ongoing international initiatives in the field of decommissioning; including legacy waste management, robotics for characterisation and dismantling, and environmental remediation on nuclear sites, a workshop was organised in October 2020 where 50 participants from SHARE consortium and ERP took part [4]. Moreover, a review of international best practices and available advanced technologies in relation to the thematic areas defined in the survey questionnaire was also shared to get their feedback.

Similarly, another online workshop was held in December 2020 to hear stakeholders' voices by firstly investigating together with them issues, challenges, and opportunities in research and secondly sharing status and results of on-going developments. A wider stakeholder community of 317 members of different type registered for this workshop. The distribution of registered participants by the type of stakeholder is given in Figure 4 [5].

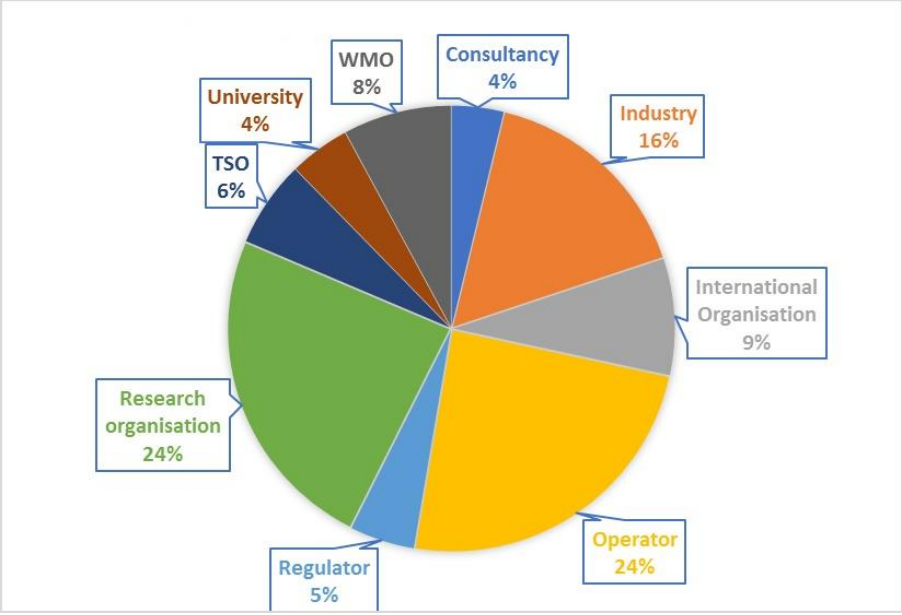


*Figure 4: Distribution of registered participants by stakeholders' type for December 2020 Workshop*

For this, a virtual brainstorming post-it sessions were facilitated by SHARE consortium team as shown in Figure 5. Different break-out sessions were organised according to sub-thematic areas, where variety of stakeholders participated according to their topic of interest. Stakeholders pointed out numerous needs in different sessions including sharing experience, advancements in technologies, and best practices among the different organisation involved in decommissioning. The data collected during this workshop was further used for consolidating the knowledge about the available solutions and on-going activities, as starting point for the subsequent gap analysis [6].

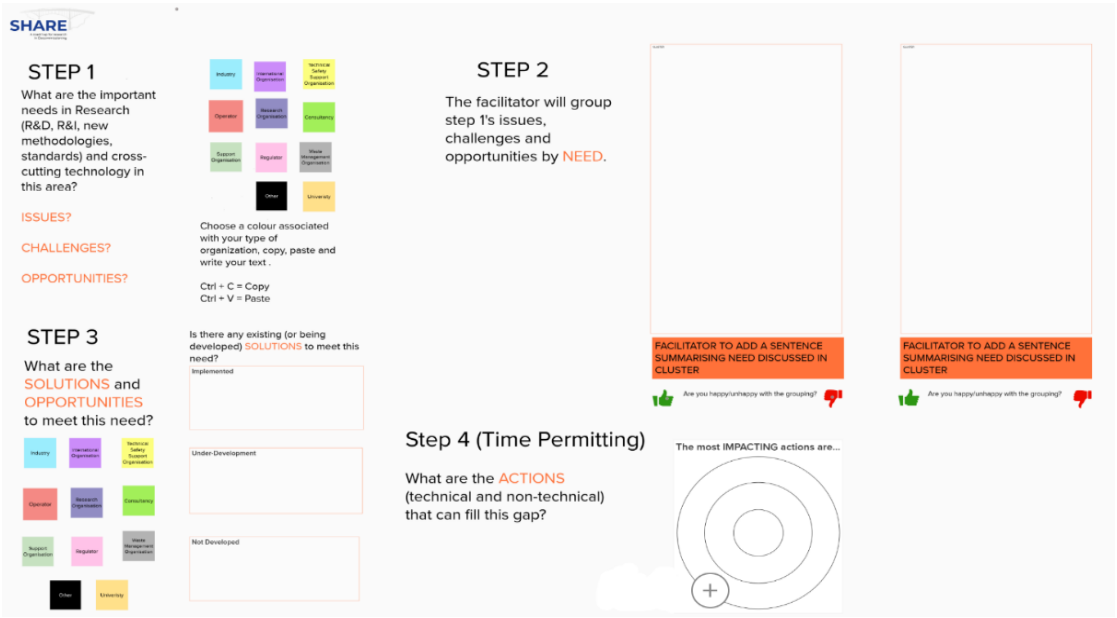


*Figure 5: Virtual post-it board during break-out sessions*

## 5 Gap analysis

Gap analysis was performed to compare the technologies and possible on-going and under development initiatives, against the results of the needs known by the questionnaire survey and research needs highlighted by the stakeholders in the second workshop. This process focused on gaps in technology/ work practices and identified a list of potential actions that will impact the identified needs by considering research, development, guidance, and demonstration of innovative solutions for every sub-thematic area. These actions will be further grouped and introduced as key research topics for future SRA and Roadmap in the next phase of the project.
In the scope of the SHARE project, once again priority was given to the involvement of stakeholders. In this regard, outcomes of gap analysis in terms of proposed action having an impact on identified needs were presented during DigiDECOM 2021 workshop [7]. Stakeholders approved of proposed actions and also provided feedback in terms of new actions focusing on training, knowledge management, and education in decommissioning. Figure 6 shows an example in a very condensed display of different types of actions impacting the highlighted needs and challenges for particular sub-thematic areas.

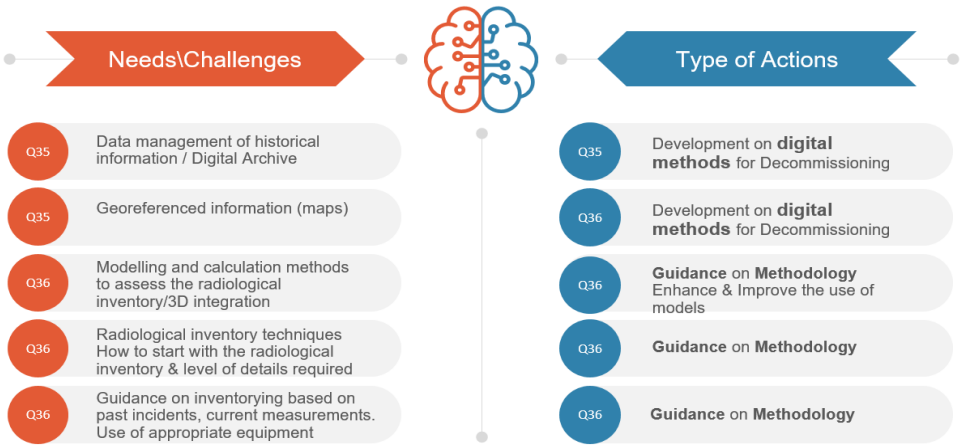


*Figure 6: Different type of actions impacting identified needs for sub-thematic areas*

## 6 Conclusion and Outlook

In the scope of the SHARE project, the key objective of stakeholders' involvement to recognise and understand issues and challenges they are facing and their needs and opportunities for enhancement of decommissioning activities is achieved by collecting their opinions through questionnaire and workshops. After analysing all the inputs from stakeholders by performing gap analysis, the SHARE team will propose actions that can impact the needs and challenges highlighted by the stakeholders. Moreover, these actions will be prioritised according to the survey results per sub-thematic areas and classified by key topics in a Strategic Research Agenda (SRA) by the end of 2021. Furthermore, the SHARE roadmap will organise the topics identified in the SRA in such a way that those relevant for joint activities are addressed in time according to the requirements. This will show how topics could be implemented and deployed. The identification of the most promising research topics will support EU and stakeholders in their understanding and evaluation of the topics to be recommended for financial support in the next decades.

## 7 Note of Thanks

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