30th NENE 2021
September 6 - 9
BLED-SLOVENIA
International Conference Nuclear Energy for New Europe

Gathering of Data on the European Research Reactor Fleet as Part of the TOURR Project

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ABSTRACT

The primary objective of the Towards Optimized Use of Research Reactors in Europe (TOURR) project is to develop a strategy for Research Reactors (RRs) in Europe and prepare the ground for its implementation. This strategic goal can be divided into specific objectives: status assessment of the European RRs fleet, including plans for upgrades, evaluation of urgent European needs, developing tools for optimal use of the RRs fleet and finally, rising awareness among decision-makers on the present and future role of research reactors. The working package (WP), led by the "Jožef Stefan" Institute (JSI), aims to collect and update information on the European RR fleet and their plans in the period 2020-2030. Furthermore, gap analyses of the RR will be performed based on the collected data in science & technology, medical and industrial radioisotope production, and education & training. This paper introduces the TOURR project and the first steps– gathering data on the European RR fleet through a dedicated questionnaire. After a general overview of the project in the Introduction, the first part of the paper presents the process of shaping and distributing a dedicated questionnaire used to gather relevant information on the current status, plans and needs of the European RR fleet. In the second part of the paper, initial feedback and preliminary results of the questionnaire are presented. The preliminary results show that RRs response to the questionnaire was very high (more than 80 %), a sign that the RRs community has a keen interest in the project's outcome. In the near future, a thorough gap analysis for each of the main topics will be performed in order to identify the strengths and development shortcoming of the current European RR fleet and to identify a common strategy of optimization.

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1 INTRODUCTION

It was and still is a common practice for a country that will operate a commercial nuclear power plant to construct a Research Reactor (RR) prior to the plant. Almost all countries followed such practices. As their name suggests RRs were primarily used for education, training and technological experiments necessary for the development of commercial power reactors. Neutrons, produced in RRs, are used to study matter in physics and other natural sciences, including biology, chemistry, and material sciences. Consequently, high-performance RRs devoted solely to neutron beam experiments have been constructed. The capability to produce new materials and isotopes by bombarding materials with neutrons has become a major use case of RRs. Moreover, the production of medical radioisotopes enabled the development of new diagnosis and treatment techniques. Nuclear medicine is nowadays an established form of treatment that benefits millions of patients each month. In Europe, there is a growing demand for RR designs with specific tasks in mind, either those focusing more on irradiation of materials or beam extraction for material science purposes. This new paradigm is contrary to the previously established idea of multi-purpose reactors which were built in the decades following the Atoms for peace speech in 1953 [1].

The 25 yearlong stagnation in Europe and in the US in the research of new nuclear reactors was mainly caused by the maturity and the known technology of the Generation II and III power reactors and by the Chernobyl and the Three Miles Island accidents. The miniature nuclear renaissance in the late 2000s was stifled by the Fukushima accident. All these events had a devastating impact on the European research reactor fleet. Today, the number of RR is decreasing, with only a few being newly constructed, most notably the Jules Horowitz Reactor in France [2][2]. Furthermore, significant testing capacity has disappeared in Europe with the shutdown of research reactors, including (but not limited to) large material test reactors (OSIRIS, France and R2, Sweden), prototype fast reactors (Phenix, France), small training reactors (CONSORT, UK, FiR1, Finland) [3][4], eliminating sometimes unique capabilities in Europe or representing the only facility for training in a specific member state. This trend is alarming and calls for a joint European action to assess the impact of the decreasing number of RRs, to identify future needs and opportunities for utilization and transnational access, and to draw a roadmap for upgrading the existing RR fleet and implement new neutron sources that reflect the European needs.

Being the first-of-its-kind, well-coordinated action of European RRs to evaluate the current and future need for neutron sources in Europe is the ambition of the TOURR (Towards Optimized Use of Research Reactors in Europe) project [5]. This ambitious assessment of the current status of the European RR fleet will happen along five science and technology axes: Education and training; Fundamental research and its instruments; Medical applications, including isotope R&D as well as beam applications; Material testing, including fuel, structural material and its instrumentation and Core physics testing for reactors in "zero power" installations.

Based on this thorough evaluation, a strategy for maintaining and upgrading existing RRs and building new ones shall be proposed. It is expected that the outcome of TOURR will be an important contribution for the design of the European Research Area.

The TOURR project responds to the challenge of coordinating the optimization of the exploitation of available research reactors in Europe. Therefore, its primary objective is to develop an overall strategy for RRs in Europe and prepare the ground for its implementation. This strategic goal can be divided into six specific objectives:

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[2] The status of other neutron sources such as spallation sources and compact accelerator based sources is addressed in other European incentives such as Brigtness and Brigtness[2] (https://brightness.esss.se/).

1. Assessment of the current status of European RRs fleet
2. Estimation of future needs
3. Plan for the upgrade of reactor fleet
4. Plan to maintain the fleet
5. Developing tools for optimal use of RRs fleet
6. Rising awareness of decision makers and the public on the role of RRs

The first objective, assessment of the current status of the European RRs fleet, is a vital and critical step in the project as the real outcome of the project depends on the quality and integrity of the gathered data. More specifically, the first objective will provide an inventory database of existing European RR. It is well known that the IAEA maintains an inventory of RR, the Research Reactor Database (RRDB) [6], however the database focuses on a different kind of information rather than what is considered vital for the successful creation of a joint development strategy for the European RR fleet. It is imperative for the TOURR inventory database to include information regarding the implemented applications, scientific strength of each particular facility, user structure, instrumentation, future developing plans, actual and future needs, etc. The TOURR inventory database will gather this kind of information with a dedicated survey.

This paper presents the questionnaire that was created for the means of conducting the TOURR inventory database survey. The paper is divided in to three parts. Firstly, the process of shaping the questionnaire is presented, with an emphasis given to the specific topics it deals with. The second part of the paper presents some initial feedback, statistics and results of the questionnaire. A few concluding remarks and a glance into the future of the project is given at the end of the paper.

2 SHAPING THE QUESTIONAIRE

The TOURR project is divided into five work packages, whereas Work package 1 (WP1), Inventory of the RR fleet, is led by "Jožef Stefan" Institute (JSI). As it is envisioned that WP1 will provide crucial input data for most of the TOURR project, it was initiated with the TOURR project start in October 2020. Other contributing institutions to WP1 are ENEN (European Nuclear Education Network), CVR (Centrum Výzkumu Řež), NCBJ (National Centre for Nuclear Research), EK (Hungarian Academy of Sciences – Centre for Energy Research), SCK-CEN (Belgian Nuclear Research Centre), USTUTT (University of Stuttgart) and CIEMAT (The Center for Energy, Environmental and Technological Research). The fact that WP1 has a wide variety of contributing institutions, ranging from those focusing on Research and Development to those heavily involved in shaping the nuclear educational landscape in Europe and those operating and managing isotope production reactors, established solid foundations for the shaping of the questionnaire.

The first version of the questionnaire was created at the end of 2020. This first version was shaped mostly around the question of what information would a common strategy for the development of European RR need. This initial idea was developed over three virtual meetings in the first three months of 2021. A crucial step that was taken early on in the process of shaping the questions, was to follow a line of questioning of so-called gap analyses. With gap analysis one can identify the difference between the current status and desired status of their business, in this case the status of the RRs fleet. The easiest way to perform such analysis is to examine and assess the current performance and the desired future of the whole RRs fleet. Some general guiding questions which were used to define specific inquiries into the areas of interest were:

- What is the current status of the RR in a specific area of research/utilization?
- Would the RR like to improve/expand this field?

- If so, does the RR have any action plans already in place?
- If not, what are the main reason holding this potential expansion back?

Once these general questions were established the WP1 contributors created further specific questions for their area of expertise i.e. ENEN Education and Training, JSI Science and Technology, NCBJ Isotope production. A valuable source information for identifying different areas of technological exploitations of RRs was the IAEA report "Applications of Research Reactors" [7].

The final questionnaire was roughly subdivided into three sections: general information, exploitation, problems, and future. These sections are presented in the following sections of the paper.

2.1 General information

Significant thought and deliberations were dedicated to the introduction and the platform on which the questionnaire will be distributed to RRs around Europe. Initially there was a strong push to make the questionnaire an online and interactive form. However, this idea was soon scrapped as none of the online providers of such tools could guarantee security (at least to the best of the knowledge of the questionnaire authors). As some of the questions, particularly those dealing with isotope production, are sensitive, it was decided to make the questionnaire in an editable but protected Microsoft word format. Because of the security concerns and to encourage the response rate, the questionnaire was designed in such a way to have the option to leave questions blank. Of course, the goal of the survey is to gather as much information as possible, but not at the expense of not actually getting any results. The questionnaire also falls under ENEN's GDPR privacy policy for the need of handling personal confidential data.

As the IAEA database contains most general information on the reactors, i.e. date of construction, type of reactor, location, fluxes, irradiation positions etc., it did not make sense to ask for this information again. However, there is an option to mention information missing from the IAEA database and is considered crucial at the end of the questionnaire. Since it was difficult to find the right people to address the questionnaire during the creation and distribution of the questionnaire, up-to-date contact information was also asked for.

2.2 Exploitation

As previously mentioned, the central part of the questionnaire consists of questions on the exploitation of the reactors, structured so that gap analysis can be conducted. The Exploitation sections begin with questions on the principal use of the reactor and then continues further in to the scientific and technological utilization of the RR. There are 19 subcategories of RR utilization in the field of science in technology, ranging from Neutron activation analysis to Instrument development, testing, and calibration. An example of a structured question with gap analysis in mind for Radiation hardness exploitation is given in Figure 1. The Education and training part of the Exploitation section has 7 subcategories. The subcategory questions are structured in the same way as the example in Figure 1. Moreover, the Medical and industrial radioisotope production of the RR part of the section utilizes the same question structure but adds some additional questions to clarify particular areas of interest from the field of Radioisotope production.

The Exploitation part of the questionnaire is complemented by questions on the number of users per field the RR accommodates and their primary affiliation i.e. academia, research institutions, industry etc. An important question on the ability to meet demands which transitions the questionnaire into the next section about the sustainability and future of the RR concludes the section on Exploitation.

3. ☐ **Radiation hardness testing**

To what degree do you think this application is exploited at the RR of your institute:

☐ Low ☐ Medium ☐ High

Would your institute like to expand the utilization of your RR for this application?

☐ YES ☐ NO

If NO, can you briefly describe the reason:

Click or tap here to enter text.

If YES, what obstacles are preventing your institute to do so:

☐ No obstacle, the expansion is already taking place
☐ Lack of manpower
☐ Lack of financial resources
☐ Lack of customers
☐ Lack of time
☐ Lack of expertise
☐ Other (please specify)
Click or tap here to enter text.

☐ Is there an existing action plan to address any of these obstacles?
Click or tap here to enter text.

Figure 1: Example of a structured question with gap analysis in mind.

2.3 Sustainability and future

The questions of sustainability and future plans are considered as the most sensitive but do provide the most significant insight into the status of the European RR fleet and thus form the basis for a joint development strategy. Because questions on sustainability can have broad answers these questions were conceived as open-ended, where RRs can respond in any form they felt comfortable. To guide and help with the answers a few general sustainability issues were listed based on the experience of the WP1 collaborators operating RR themselves. These issues included: material ageing, cost of fuel, fuel availability, lack of funding, lack of human resources, national policy etc. All sections included the option to add “other” answers, in case a specific aspect was not explicitly mentioned in the questionnaire already. As mentioned above, these questions might be sensitive, and RRs had the option not to answer them, but in that case, we asked for a brief explanation why that was so.

Much like the sustainability questions, the questions about the future of the RR were also open-ended. The questions were structured so that the RR could answer on the current implemented scenario, approved scenario and long envisioned scenarios for current operation, new research, upgrades possible shutdown or even plans for building new reactors. A part of the questions on the future of RR, there was also a question on the biggest envisioned problems and obstacles the RR are expecting in the future. To conclude the questionnaire, a completely open question for the future of RR in the next 5, 10 and 30 years was posed, as it was recognized that major changes in RR operation or building new RR can take significant time.

3 INITIAL FEDBACK AND RESULTS

To decide to whom send the questionnaire, the starting point was represented by the information found in the IAEA RR database [6]. This information is public. For the task scope, facilities have been selected using the following filters: western Europe + eastern Europe + operational.

The project partners support was precious when looking for a contact person in each facility. In fact, although a contact email address is present in the IAEA database (per each facility) a rection was not always received. Thanks to personal and professional connections, it was possible to finally reach out to 25 RR facilities which led to 19 questionnaires filled and sent back to us. 19 out of 25 translates into 76% of response rate. On top of those, there are 2 small assemblies for which a dedicated questionnaire has not been received but still, the operator provided some generic information. If these 2 extra entries are considered it yields to 21 out of 25 which gives an 84% as response rate.

The questionnaire has been sent out until covering the whole geographical Europe. At the end of the gathering process however, all the received answers are from EU RR. Data received are from: Austria, Belgium, Czech Republic, France, Germany, Hungary, Italy, The Netherlands, Poland, Romania and Slovenia.

In terms of distribution strategy, at first, at the end of April 2021, an email was sent to a list of contacts put together merging the contact details found on the IAEA RR database and project partners' connections. Moreover, an invitation to take part in this initiative was published both on [5] and on the www.tourr.eu website. The same initiative has been advertised on ENEN social channels, and all project partners have been invited to take actions in order to maximize the outreach. The above response rate describes the reactions received at the time of the paper preparation.

Some preliminary results are presented hereafter, in Figure 2, Figure 3 and Figure 4.

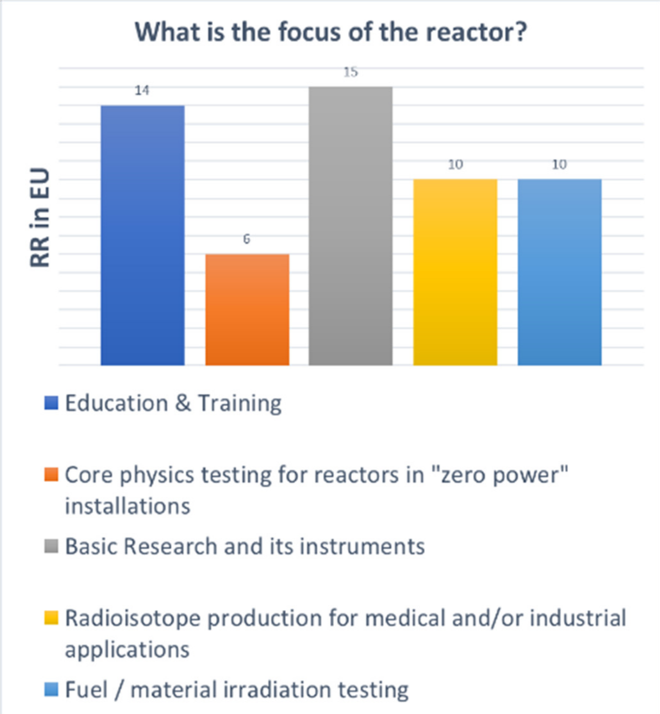

Figure 2: Assessment of the current status of the European RR fleet will along the science and technology axes previously defined.

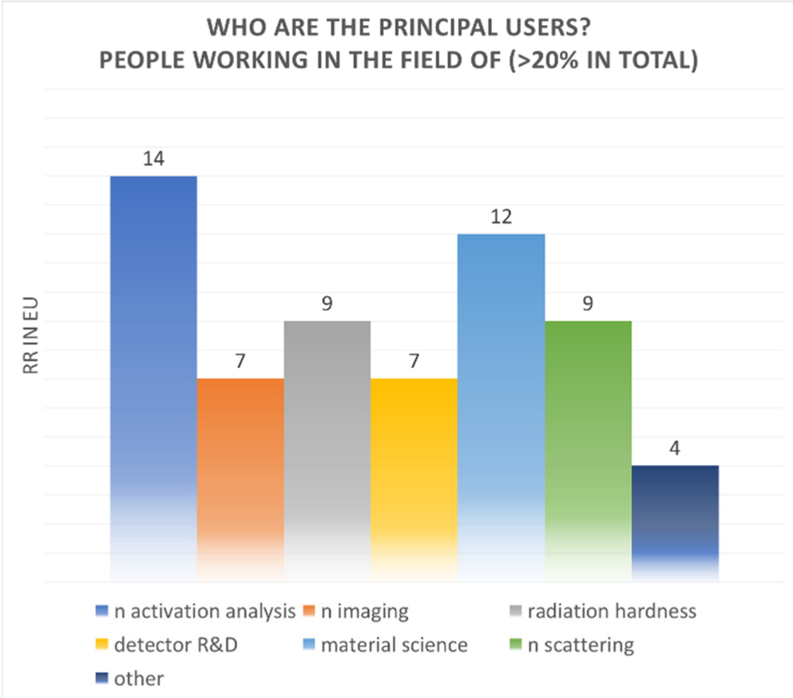

Figure 3: RR users population, providing information about how many RR receive users from some specific macro categories.

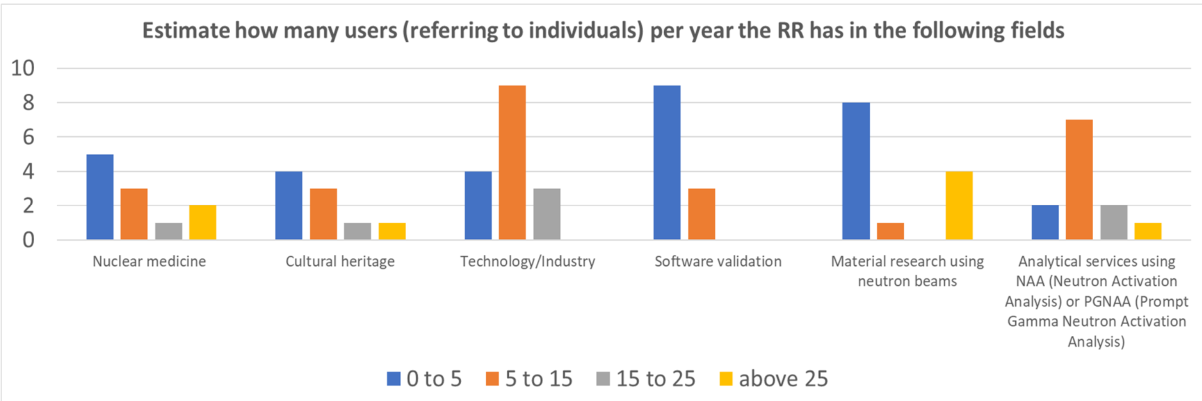

Figure 4: RR users distribution counting individuals

4 CONCLUSION

The TOURR project aims to develop a common strategy for the future of the RR fleet in Europe and prepare the ground for its implementation. The first step of this ambitious and far-reaching project was to develop, disseminate and analyse a questionnaire which assesses the current situation and the near future of the European RR fleet.

In the first part of this paper, it was shown that there is a clear need for a common strategy for the development of the European RR fleet. It was established how the TOURR project will address this. The second and central part of the paper presents the process of shaping and designing the questionnaire, which aims to gather crucial information that will be used throughout the TOURR project. The main parts of the questionnaire and the reasoning behind specific questions was presented. The third part of the paper contains initial feedback and statistics on the answers received from 21 RR from 11 countries in Europe. The preliminary feedback and analysis confirmed that the main focuses of RR in Europe are Basic Research and Education and Training applications, the majority of RR welcome users involved in the field of neutron activation analysis and material science whilst the highest number of individuals reaches out to RRs in order to perform software validation. Data are presented generically only, to ensure the confidentiality of the responders.

Based on the information gathered, gap analyses in the areas of science & technology, medical and industrial radioisotope production, and education & training will be performed later in 2021. It is predicted that the thorough gap analysis for each of the main topics will identify the strengths and shortcoming of the current European RR fleet and identify a common development strategy for the period until 2030 and beyond.

ACKNOWLEDGMENTS

This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement N° 945269.

The authors would also like to acknowledge the TOURR project advisory board for the valuable suggestions and insight on shaping the questionnaire.

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