RESPONSIBLE RESEARCH AND INNOVATION IN ADVANCED BIOFUEL RESEARCH PROJECT REFOLUTION

Nina Wessberg and Hanna Saari
VTT Technical Research Centre of Finland Ltd.
Visiokatu 4, Tampere, Finland, nina.wessberg@vtt.fi, hanna.saari@vtt.fi

ABSTRACT: This paper outlines the Responsible Research and Innovation (RRI) process and framework applied to the EU-funded technology development project, Refolution studying and developing advanced biofuels to marine and aviation. The RRI process aims to systematically consider the sustainability aspects of the project, ensuring its results are comprehensible and applicable to stakeholders and society at large. By fostering communication and interaction with stakeholders, including citizens, the RRI process seeks to understand the social implications of the research and ensure the social acceptability of the outcomes, such as a new biofuel and its production processes. Additionally, the RRI approach supports the development of a sustainable business based on these results.
Keywords: sustainability, stakeholders, environmental impact, socio-economic impact

1 INTRODUCTION

This paper outlines our exploration of applying the Responsible Research and Innovation (RRI) approach in a technology research project, a novel undertaking. We share our experiences and insights into creating a systematic application process, contributing to the establishment of RRI within the scientific framework. Our focus is on understanding how RRI enhances the sustainability and responsibility of the research project and its outcomes, as well as fostering effective communication between the project and society.

While the consideration of sustainability and responsibility is not new, tracing back to the emergence of ELSA (Ethical, Legal, Social Aspects) in 1994 within the 4th EU Framework Programme, the current landscape has evolved. Contemporary EU funding initiatives, such as Horizon2020, introduce a fresh perspective encapsulated in the term Responsible Research and Innovation (RRI). Unlike its predecessor ELSA, RRI, as noted by Zwart et al. (2014), appears to emphasize social-economic impacts, including valorization, employment, and competitiveness.

The RRI keys and competences serve as the foundational elements of the RRI approach applied in research projects. This paper explores the implementation of these RRI elements in Refolution, a technology development research project focusing on pyrolysis oil refinery integration, scale-up, and certification for aviation and marine biofuels production. The project commenced in early 2023 and is scheduled to continue until the end of 2026.

Owen et al. (2021) characterizes that RRI is already institutionalized in the research area. Benefits for responsible innovation processes in industry are also considered, but the RRI concept does not yet resonate widely with business due to lack of practices such as programs, tools, and criteria for defining best practice, as well as governance mechanisms in industry not just highlighting regulation and legislation, but also customs and culture in innovation processes (Martinuzzi et al. 2018). Schuijff and Dijkstra (2018) introduce the practices of RRI approach, but they ask for further research on practices focusing on not just specific characteristics of RRI, but on the complexity of the RRI as a whole.

This paper introduces a case where Responsible Research and Innovation (RRI) approach is applied in Refinery integration, scale-up and certification for aviation and marine biofuels production (Refolution) project. We describe the RRI process, designed and conducted in and for the Refolution project. The projects targets sustainable innovations in bioeconomy heading commercial and industrial processes. Refolution project aims to develop commercial new biofuel solutions for marine and aviation industry in existing oil refineries.

Refolution project aims to conduct its optimization and validation processes in an industrially relevant environment. This means that the Research, Technology and Innovation (R&T&I) activities are designed to align with industrial practices and conditions, ensuring that the findings can be effectively implemented in real-world settings. Refolution tries to create a roadmap towards sustainable biofuel business by utilizing and repurposing the existing fossil oil refineries into biofuel production.

In the paper we describe the prerequisites and backgrounds of the RRI framework and the use and applicability of public Societal Readiness Thinking Tool (SRTT) in the Refolution project. Special focus is put on experiences and lessons learned in using the RRI approach and the named tools. Suggestions for beneficial RRI process actions and contents are given. The paper aims to create a guide how to design and conduct a good RRI process in a R&T&I project based on the experiences in innovation action projects, and to find RRI and industrial business correlations. Our research question, hence, is how to apply RRI approach in a R&T&I project in order to benefit the sustainable innovation processes and business creation.

2 RRI APPROACH

RRI is characterized by transparent and interactive processes, as defined by Von Schomberg (2011), promoting responsiveness between societal actors and innovators. Its overarching goal is to ensure the ethical acceptability, sustainability, and societal desirability of the innovation process and its end-products, facilitating the integration of scientific and technological advances into society. Nieminen and Ikonen (2020) underscore the importance of stakeholder and citizen participation in the RRI approach.

Originating from the European Union research field, the RRI approach has been refined through various EU-funded projects, including Satori, Morri and SUPER Morri, and NewHoRRIzon. These projects address evaluation frameworks, societal readiness tools, and aim

to globalize RRI, fostering mutual learning and collaboration. Efforts have also been dedicated to establishing a RRI toolkit (https://rri-tools.eu/).

The RRI approach emphasizes addressing responsibility through six keys (https://rri-tools.eu/). These keys focus on the content of RRI, encompassing:

1. Public Engagement: Involves a diverse array of societal actors, including researchers, industry, policy-makers, and civil society, in the research process.

2. Open Access: Aims to enhance transparency by making research and innovation activities easily accessible to the public, utilizing open data and providing free access to publications.

3. Science Education: Focuses on enhancing society's science literacy, encouraging interest in science and technology among children, and equipping civil society actors with the skills to actively participate in the research process.

4. Gender: Promotes women's involvement as researchers and integrates a gender dimension into research content.

5. Ethics: Aims to foster research activities with high societal relevance, ensuring compliance with the highest ethical standards.

In addition to the RRI keys, the RRI approach highlights key competences (Tassone et al. 2018; https://rri-tools.eu/):

1. Anticipation: Involves carefully examining both intended and potential unintended consequences of research activities, addressing environmental, health-related, economic, and social impacts. Anticipatory processes encourage researchers to contemplate "what if..." scenarios, allowing them to prepare for and respond to uncertainties and dilemmas inherent in their work.

2. Reflexivity: Involves reflecting on the motivations, assumptions, and commitments that underpin research projects. Researchers commit to questioning and challenging ingrained assumptions, remaining open to alternative ways of framing the value and societal impact of their ideas, methods, and proposed solutions.

3. Inclusion: Closely tied to public engagement and stakeholder involvement, it involves actively involving relevant societal actors in research and innovation activities from the outset. This approach ensures an ongoing, open dialogue about both desirable and undesirable outcomes, broadening the perspectives that guide research and innovation activities.

4. Responsiveness: Focuses on aligning research and innovation activities with new perspectives, insights, and values emerging from anticipatory, reflexive, and inclusion-based RRI processes. Responsiveness requires a willingness to learn from practical experience and the ability to translate this learning into improved, more responsible research and innovation solutions.

In addition to RRI Tools (https://rri-tools.eu/), the Societal Readiness Thinking Tool (hereinafter SRTT) is a tool developed under the EU-funded project NewHoRRIzon (2017-2021, https://newhorrizon.eu/). SRTT is specifically crafted for the implementation of the RRI approach in research projects. Its purpose is to assist researchers and innovators in developing projects that align more closely with societal values, needs, and expectations (Bernstein et al. 2022). The conceptualization of SRTT by Bernstein et al. (2022) aligns it with NASA's technological readiness level (TRL) concept, where societal readiness level serves as a metric for assessing the social acceptability and relevance of research results and innovations. SRTT thus functions as a tool to foster the creation of research that is socially acceptable and relevant. Figure 1 provides an overview of the gates and the model of SRTT. The tool is freely accessible in the internet (https://thinkingtool.eu/).

Figure 1 elucidates the fundamental concept and content of SRTT. The primary aim of SRTT is to elevate the societal readiness level of the research project's impact by applying the RRI approach. SRTT divides the research project into four distinct phases, termed Gates: 1) Research design and problem formulation, 2) Implementation, data collection and testing, 3) Data analysis and evaluation, and 4) Launching and disseminating.
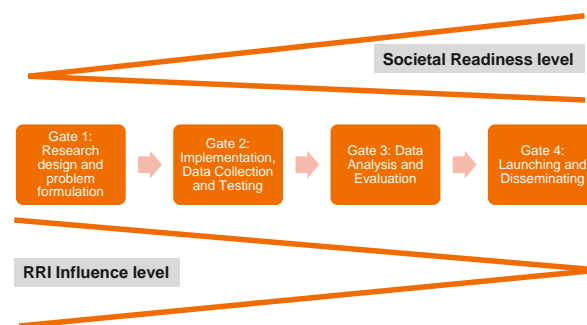

Figure 1: Societal Readiness Thinking Tool gates model (adapted from Bernstein et al. 2022).

The SRTT systematically introduces pertinent questions at each phase of the research process. It organizes these questions into RRI keys, competences, and entry points, with variations across different gates. In Gate 1, the entry points prompt reflection on responsibility within the project and its plan, inclusive identification of partners, and addressing societal challenges and trends such as the UN Sustainable Development Goals (SDGs).

Moving to Gate 2, the entry points encompass questions related to engaging stakeholders, communicating with advisory groups, developing ethics, creating plans for dissemination, communication, gender, and data management. It also encourages a reconsideration of the project plan through the lens of RRI. Gate 3 entry points emphasize communication surrounding uncertainties, involving stakeholders and the public in analysis, reassessing analyses from an RRI perspective, and ensuring transparency. In Gate 4, the focus shifts to reflecting on the research process, effectively communicating results, initiating public discussions, and contemplating follow-up projects.

Users have the option to respond to these questions using the online tool and can generate a PDF report from their answers. The tool allows for the selection of only relevant questions or the inclusion of all provided questions. Additionally, users have the flexibility to generate new questions within the tool.

3 RRI IN REFOLUTION ADVANCED BIOFUEL DEVELOPMENT PROJECT

To initiate the RRI process in the technology project Refolution, we conducted an internal RRI workshop.

During this workshop, we introduced the RRI approach and engaged in initial discussions with the project's scientists to explore specific and relevant ways to address sustainability and responsibility. These discussions resulted in the creation of a detailed description of the biofuel value and production chain, illustrated in Figure 1. The value and production chain illustrates the different points in which responsibility considerations are relevant in the specific case of biofuels, offering an overview of possible points of intervention.
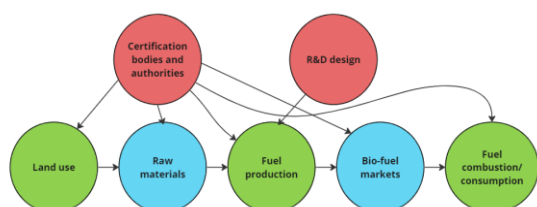

Figure 2: Refolution biofuel value chain – working version.

At a practical level, the project developed a specific RRI framework as the main systematic tool for responsibility reflections. This framework, detailed in

Tables I and II: Refolution RRI Framework.

Table 1, integrates RRI elements and the biofuel value chain. It comprises reflexive questions designed to guide discussions within the consortium and with broader stakeholder groups. The framework has proven effective as a discussion tool within the consortium, yielding promising results.

In addition to Refolution's RRI framework, we utilize the SRTT (2018) so that we chose specific questions tailored to Refolution, supplementing the more sector-specific questions. The selected SRTT questions are detailed in Table 2. By using SRTT we ensure that all the RRI relevant aspects are covered in our RRI process. In practice, the SRTT questions picked from the online tool have also proven valuable and useful in the RRI process within the consortium.

The RRI approach adopted in Refolution brings responsibility questions to the fore, leaning to the scientific expertise of the scientists developing the biofuel to explore the most relevant responsibility topics for the specific application area. Through structured reflexive discussions, the topics are explored and shared understanding is created.

RRI (Responsible Research and Innovation)		Raw materials, land use	Fuel production	Bio-fuel markets	Fuel combustion/ Fuel consumption
	Anticipate & Analyze Opportunities: Foresight Horizon scanning Scenarios	Which raw materials are likely to be available, inexpensive and sustainable in the future?	How can we ensure that biofuel production is possible and will be accepted in existing refineries with Refolution methods in the future?	What is likely to be the role of biofuels in the future sustainable fuels markets?	How should the infrastructures in transportation, airports, ports etc. change in the future to facilitate for growing usage of sustainable fuels?
	Reflect & Reason Consideration: Ethical assessment Multidisciplinary	How could intense competition between different uses of raw materials be avoided or dealt with?	How is the energy intensity of production methods likely to influence biofuel production? How could this challenge be tackled?	How should the public discourse around biofuels change? What new knowledge and information could we bring to the public awareness?	Do we know enough about the overall environmental impacts of burning biofuels (accounting for CO_2 & non-CO_2 emissions, biodiversity, pollution, etc.)?
	Engage & Include Alternatives: Open innovation Focus groups	Could dialogue be established about the different uses of biomass raw materials? Who could be included in such conversations?	How can we ensure acceptability of biofuel production, especially locally near sites of production?	Which stakeholders are important in ensuring a sustainable production chain of biofuels with Refolution methods?	How could we work towards making fuel sustainability a selection criteria for travellers?
	Act & Respond Capacities: Regulation Standards Societal challenges	How do we ensure that the processes developed in Refolution can be used with the most sustainable raw materials possible to produce good quality fuels?	What can we do to ensure that switching from traditional fuels to biofules is possible fast enough? What is needed from other stakeholders?	How are the regulations that affect biofuel production and market price changing?	What is and/or should be done in Refolution to ensure the safety of the produced fuel, making sure it does not cause any dangers during storage or usage or harm the engines?

Societal Readiness Thinking Tool	Anticipate & analyse	Reflect and Reason	Engage & Include	Act & Respond
Impacts	How may the results of this project be used in the education of future generations of researchers and engineers?	Is it possible to change the problem formulation or project design in response to changing stakeholder viewpoints or unforeseen ethical issues arising throughout the project?	At which phases in the project will stakeholder involvement have the most crucial impact, and why?	To what extent will you be able to predict the long-term societal outcomes of the project?
Transparent documentation & open access publishing	How may your results contribute to the public interest in and understanding of science?	How do you plan to communicate the uncertainty of your research?	What do people not participating in the project (teachers, students, museums, civil society organizations) need to know about the data analysis and evaluation of project results to learn about/engage with the outcomes of your work?	Did you document your data analysis / evaluation in an intelligible and transparent way, and how?
Relevance of the project	Can you think about beneficial applications of results beyond the original scope of your work?	Why should this project be done?	How can you ensure that interested stakeholders understand the purpose and approaches of the project?	With whom do you plan to share the results of your work?
Risks	Can you imagine possible scenarios of misuse of your results? Can you imagine possible scenarios where the outcomes of your project may be misrepresented or misinterpreted in the public discussion?	What are the potential barriers to making documentations of data collection and testing publicly accessible (e.g. intellectual property rights, competing interests)?	Have the results been discussed with different types of stakeholders to allow for alternative interpretations?	Does your project involve any risks of negative impacts, and which?

The RRI process has been a participatory co-creation process from the onset. Scientists with deep understanding of biofuel development, production and the whole value chain have been building the evaluation framework with the social sciences partners from drafting the value chain, naming the most important responsibility questions related to each phase and discussing possible solutions.

An overview of the RRI process can be seen in Figure 2.

Figure 2: Refolution RRI process methodology.

The RRI process described above is still on-going and comprehensive conclusions can not be drawn at this point. However, the process shows promising initial results. The reflexive and co-creative approach has lead to high involvement from partners, and topics uncovered through the RRI framework have been taken into action in the project. Now, the RRI process will widen the sphere if engaged stakeholders based on the stakeholder

mapping executed as part of the project internal RRI process.

4 DISCUSSION AND CONCLUSIONS

Biofuels presents a complex issue in terms of sustainability, highlighting the importance of inclusive discourse on the topic. Depending on the perspective, biofuels might pose different sustainability challenges while from other perspectives also offering opportunities for huge sustainability achievements, as fossil fuels can be replaced. The RRI framework is a great tool for tackling these complexities, since it encourages multitude of perspectives and allows for a safe environment to examine paradoxes and contradictions that might arise.

For an RRI framework such as the one presented here to be comprehensive and efficient, expertise on sustainability and responsibility should be combined with sector-specific expertise in a co-creative manner. RRI expertise brings in the process the multitude of sustainability perspectives spanning from social sustainability to environmental responsibility with all their many sub-themes, and invites sector-specific exploration. This invitation is presented here as open-ended reflexive responsibility discussions guided by the RRI framework.

One of the most significant aspects of RRI approach

is stakeholder co-operation and communication. In our context, a significant question concerning stakeholder communication is how to enhance collaboration with the industry in the future. This is what Martinuzzi et al. (2018) also ask for. According to their analysis key aspect of the context that needs to be considered refers to the actions, not only including regulation and legislation, but also customs and culture, which can shape the way RRI is perceived and implemented. It is easier to arrange actions within the research project consortium together with the researchers, but to integrate also outside stakeholders into the RRI process presents a greater challenge.

In Refolution project we will invite stakeholders to answer the RRI framework questions in stakeholder workshops. First year of the project we focused on internal RRI workshops by discussing the RRI framework questions with the Refolution researchers. In the second year of the project we open up the discussions to researchers and experts from outside of the Refolution project. In the third year we will engage other citizens into the discussions, including travelers using air- and marine transport.

Collaboration with consumers and citizens should be a crucial aspect, albeit challenging. Regarding biofuels, there is a danger for green washing with inappropriate data and knowledge for the sustainability of the raw materials and the whole product. Martinuzzi et al. (2018) suggest that future work might examine the interfaces and value chains where industry and societal groups jointly negotiate the meaning of responsibility. This would be a key question for future developments, and forms also a guiding suggestion in on-going Refolution project.

Using the outlined value chain, we conducted an online workshop to identify crucial sustainability questions, involving the project's scientists and key stakeholder groups. This approach transformed the RRI framework into a context-specific working strategy, fostering a shared understanding of the diverse sustainability aspects of biofuel production and responsible practices. Recognizing common sustainability questions within the biofuel sector, the Refolution RRI framework extends beyond the project's impacts to encompass sector-wide impacts, risks, and opportunities. The project's goal is to pioneer new practices addressing these broader issues on a project level.

Refolution's RRI approach will evolve throughout the project's duration, gradually involving various stakeholder groups in a phased process. Initial outcomes are encouraging, indicating that the RRI approach aligns effectively with the responsibility objectives of a biofuel-focused technology project. Early indications suggest that employing this process holds the promise of generating more sustainable and responsible biofuel value chains.

5 NOTES

https://satoriproject.eu/
https://cordis.europa.eu/project/id/824671
https://super-morri.eu/
https://newhorrizon.eu/
part of the EU Horizon CL5 2022 D3 01 program

6 REFERENCES

[1] Martinuzzi, A., Blok, V., Brem, A., Stahl, B. and Schönherr, N. Responsible Research and Innovation in Industry—Challenges, Insights and Perspectives. Sustainability 2018, 10, 702; doi:10.3390/su10030702 www.mdpi.com/journal/sustainability.

[2] Nieminen, Mika and Ikonen, Veikko. (2020) A future-oriented evaluation model for Responsible Research and Innovation. In: Yagmhmaei, E. and van de Poel, I. (eds.) (2020) Assessment of responsible innovation. Methods and practices. Routledge, Taylor&Francis group.

[3] Owen, R., von Schomberg, R. and Macnaghten, P. (2021) An unfinished journey? Reflections on a decade of responsible research and innovation. JOURNAL OF RESPONSIBLE INNOVATION 2021, VOL. 8, NO. 2, 217–233. https://doi.org/10.1080/23299460.2021.1948789 . Routledge.

[4] Societal Readiness Thinking Tool (2018). [https://www.thinkingtool.eu/]

[5] Tassone, V.C., O'Mahony, C., McKenna, E. et al. (2018) (Re-)designing higher education curricula in times of systemic dysfunction: a responsible research and innovation perspective. High Educ 76, 337–352 (2018). https://doi.org/10.1007/s10734-017-0211-4

[6] Von Schomberg, R. (Ed.). (2011). Towards Responsible Research and Innovation in the Information and Communication Technologies and Security Technologies Fields. Luxembourg: Publication Office of the European Union. Retrieved from https://op.europa.eu/en/publication-detail/-/publication/60153e8a-0fe9-4911-a7f4-1b530967ef10

[7] Zwart, H., Landeweerd, L. and van Rooij, A. (2014). Adapt or perish? Assessing the recent shift in the European research funding arena from 'ELSA' to 'RRI'. Life Sci Soc Policy. 2014 Dec; 10: 11. doi: 10.1186/s40504-014-0011-x

7 ACKNOWLEDGEMENTS