



# Co-creation in practice: enabling multistakeholder collaboration in nanotechnology research and innovation

Policy and organisational opportunities and challenges  
for practically realising RRI conditions in nanotechnology  
research and innovation



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# Executive summary

Nanotechnologies and nanomaterials have served as a test field for governance approaches to emerging technologies for over 15 years. Induced and fuelled by both anticipation of new risk profiles and public concern, approaches such as Responsible Research and Innovation (RRI), i.e. innovation that is safe, ethically acceptable, and responsive to the needs and expectations of people, aim at redistributing responsibility among *all relevant* actors to align their input closer to innovation processes. Here, co-creation appears as one potential approach to the inclusion of a broader public in state-of-the-art research and innovation (R&I) activities.

Co-creating nanoproducts, as pursued in GoNano, may therefore be considered as a bridging activity between the societal realm, which has so far often been treated as distinct, research and innovation actors, and policy. Established practices of R&I are routinised within the innovation system, which means that from the point of view of industrial stakeholders and policy makers or regulators, integrating input from the broader society may appear challenging. A well-established concept for approaching activities in the innovation system is the concept of the ‘value chain’ (source). In addition to the different stages in this chain, product suggestions emerging from the co-creation process represent condensation points of discussion, rooted in actual challenges for innovation as identified by different actors. The resulting project ideas and objects may mobilise different actor groups so that they can concretely, and together, define directions of and limitations to R&I.

In order to support mainstreaming attempts to bring about co-creation, this GoNano White Paper identifies opportunities and challenges for co-creation in order to provide interested parties (e.g. industrial stakeholders or research organisations) with a hands-on treatment of what to consider when thinking about implementing co-creation.

Recommendations and insights that have emerged from the GoNano pilot experiences will help in identifying relevant preconditions and practical ways to implement co-creation in R&I following the value chain.

The six GoNano recommendations for mainstreaming and implementing a GoNano co-creation process are:

## **1. Identify needs and entry points for co-creation**

Be clear about what your co-creation experience should be about (topic) and what you are doing it for (objective).

**2. Mapping the innovation context** When you are clear about your expectations and objectives with regard to the process, map the state-of-the-art of research in the specific fields, the stakeholders in the R&I area and their interests, and contextual factors (e.g. regulations) that need to be considered.

## **3. Showcase the benefits of co-creation**

In order to get stakeholders on board who you have identified as relevant, use showcases and best practice examples of how stakeholders have benefited from co-creation. These could be, for example, networking opportunities they otherwise hardly encounter, better and more accepted products, improved market shares, or more socially robust decision-making.

## **4. Implement a structured methodology**

Co-creation requires structure and reflection when organising but allows for a degree of flexibility in implementation to account for the specificity of your own research landscape, organisation culture etc. in order to achieve your objectives. Reflect on your own requirements for co-creation beforehand and be aware of the variety of engagement practices available. Selecting a structured and suitable co-creation methodology for what you would like to achieve will make it easier. And then: do it!

## **5. Ensure understanding between societal and stakeholders'/researchers' perspectives**

Finding consensus on broad societal goals is usually rather easy – no one is against responsible innovation. However, the meanings of such terms may differ between actor groups, especially when their worlds hardly meet – as may be the case for a wider public and researchers or industries. Successful co-creation has to make sure to establish a respectful and trustful relationship between different actor groups as well as shared understanding and language.

## **6. Restructuring the environment: Create a culture of co-creation**

These tall orders as outlined above can hardly be carried out by researchers on their individual shoulders: collaboration and co-creation need to become mainstream practices in R&I and this implies overcoming a lack of incentive structures for researchers, confidentiality or IP limitations and other obstacles. So, if a change in culture is required, this needs fundamental rethinking of research practices, research funding, and incentive structures.

# Highlights from the gonano white paper series

The GoNano White Paper series highlights the conclusions derived from the co-creation activities carried out in the project. On the basis of our GoNano experience, we recommend that the following factors should be considered when planning co-creation activities:

## Knowing and reaching the target audience

- Find ways to improve the conditions to enable responsiveness on the levels of institutions, opportunities and organisational culture
- Be cognisant of what it is possible to change within the affected system
- Identify and assess issues and actors along the whole value chain for concrete scoping
- Address salient dilemmas or societal challenges to attract the attention of potential participants, using solution/opportunity-oriented framing.

## Changing perspective as a precondition or outcome of co-creation

- Foster R&I actors' appreciation of the opening up of the research process and involve perspectives not usually involved in R&I
- Challenge the ways in which (the views of) others are anticipated, simplified or ignored in relation to science/scientists, industry/industry representatives and society/citizen-consumers.

## Adopting tangible methods for co-creation

- Identify ways to empower actors to express diverse issues (enabling responsiveness)
- Balancing actors' involvement: be aware of the trade-off between specific expertise and societal inclusiveness
- Be aware of potential power differences among the participants: academics, industry representatives – and the general public.

## Increase your gain

- Share your knowledge across sectors and activities
- Improve R&I strategies and innovation trajectories
- Find new and original design and product suggestions.

# Foreword

## What are the gonano white papers?

The present publication is part of a series of three white papers developed by the GoNano project covering different aspects of co-creation in research and innovation (R&I) with a focus on nanotechnology.

The white papers are intended as a knowledge repository for further GoNano communication activities. As such, they provide relevant background information with condensed GoNano findings. They also form the basis for six industry and policy briefs outlining the topics with greatest industry and policy relevance.

The GoNano White Papers are a core part of the GoNano project<sup>1</sup>.

The three GoNano White Papers provide insights into different aspects of co-creation and responsiveness in the field of nanotechnology. Each paper addresses the question of conditions for Responsible Research and Innovation (RRI) in nanotechnology R&I from a different angle.<sup>2</sup>

- **White Paper 1** sets out why co-creation responsiveness makes sense in nanotechnology and describes conceptual and empirical aspects of *responsiveness of researchers and engineers* in co-creation processes with a focus on nanotechnology. It mainly addresses researchers, engineers and other stakeholders involved in the research system (e.g. research funding or research institutions), including the organisational structures they are engaged with.
- **White Paper 2** provides a strategic focus regarding *how to implement co-creation*, considering research as well as the innovation eco-system. It addresses industrial and business partners, research institutions, and policy makers who are active in and are influencing R&I processes.
- **White Paper 3** provides guidance on how to realise co-creation in the light of a *gender and diversity perspective*, in order to better integrate these perspectives into nano-related R&I. The main addressees of the paper are process organisers and/or researchers in a position to put co-creation into practice.

## GoNano project and goals

This white paper explores opportunities for and constraints on implementing co-creation in nanotechnology R&I practice. It builds on the findings of the GoNano project, which is built on the assumption that several types of knowledge and expertise are needed to support co-creation towards sustainable, acceptable, and desirable applications of nanotechnologies. GoNano explored approaches that could be put into practice in different application areas of nanotechnologies (Health, Food and Energy), combining face-to-face citizen consultations, stakeholder workshops and online consultations (see Figure 1).

There has been growing interest in co-creation in recent years. Generally speaking, co-creation is defined as the practice of collaborative product or service development as developers and stakeholders work together; or the joint creation of value by the company and the customer; or as allowing the customer to co-construct the service experience to suit their context.<sup>3</sup>

Co-creation as a method has been applied to research and innovation to achieve very different aims and objectives. Companies have used co-creation to encourage user-led innovation. Their aim is to put the needs of users at the heart of innovation. The Creator Space initiative by BASF for example aims to foster open innovation within the company.

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1. For more information on the overall structure of the project and our further understanding of co-creation see <http://gonano-project.eu/>.

2. For more information on the RRI framework as set out by the EC, see the website (<https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation>). For the aspect of responsiveness, see GoNano White Paper 1.

3. For further information see GoNano D2.1: [http://gonano-project.eu/deliverable-2-1/\[20-02-2020\]](http://gonano-project.eu/deliverable-2-1/[20-02-2020]) or, for an illustrative example, see the experiences of the Fonteer project: [https://www.youtube.com/watch?v=VID2EyW5W\\_k](https://www.youtube.com/watch?v=VID2EyW5W_k)

Others have used co-creation to enable more democratic decision-making in research and innovation. The EU project Making Sense EU for example helped citizens to use academic technologies to make sense of their own environments.<sup>4</sup>

Within the GoNano project, co-creation is applied to strengthen the ability of R&I processes to respond and adapt according to changing demands. The underlying assumption is that R&I will be more socially robust if societal needs and values are taken into account in the early stages of innovation.<sup>5</sup>

GoNano defines co-creation as *“activities [that] enable productive collaborations between researchers and societal stakeholders over longer timeframes, focusing on specific nanotechnology research lines, leading to tangible outcomes such as a new research avenue, proposal, product or prototype.”*<sup>6</sup>  
(Bechtold et al. 2019<sup>7</sup>)

Through the involvement of citizens and stakeholders from early stages of the innovation process, GoNano aims at anticipating contributions that can serve to make R&I more socially relevant.

To do so, co-creation approaches require new forms of collaboration that extend across different disciplines and sectors. (Figure 1)

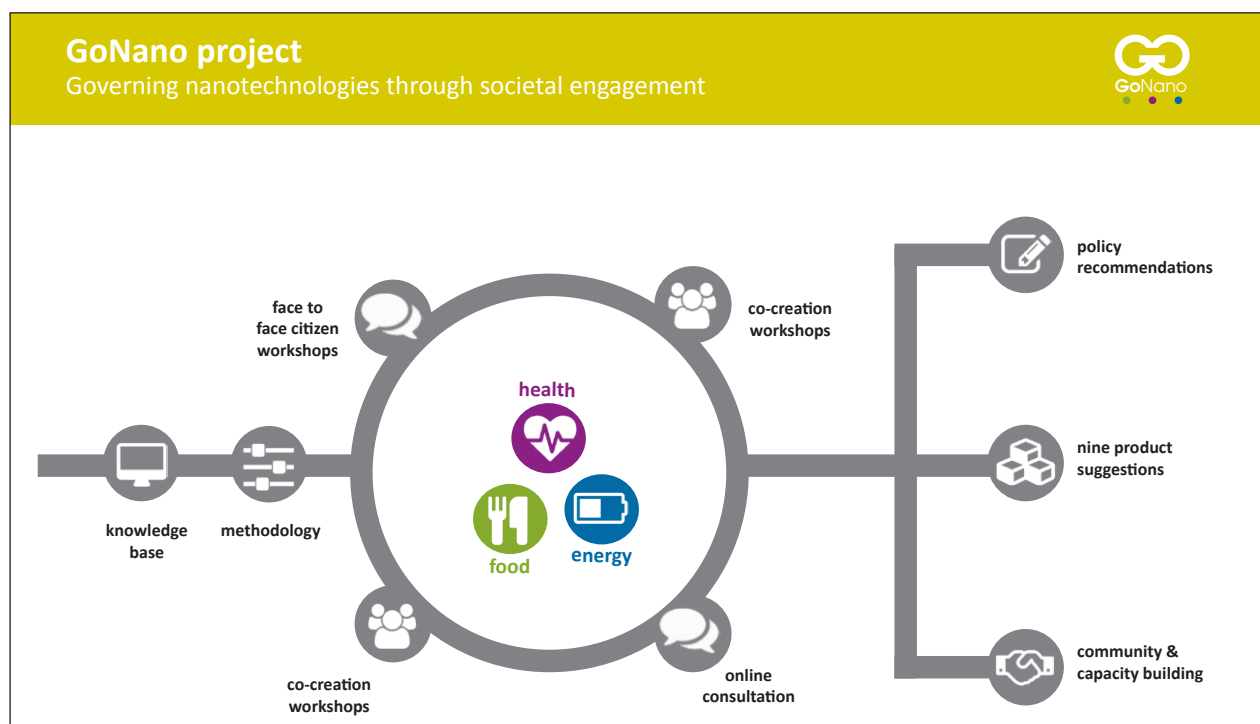


Figure 1. GoNano co-creation process

4. The Creator Space initiative brings together stakeholders with varying experience from within and outside of the company to develop concrete, challenge-based business outcomes. Originally developed as a one-time initiative to celebrate the 150th anniversary of BASF, the Creator Space now forms an integral part of the company's approach to innovation (in this Youtube video, Elise Kissling, Director of the Creator Space frontend innovation program at BASF, reports on Creator Space: <https://www.youtube.com/watch?v=Y0JuOWO0hB8>).

5. Using low-cost, open source technologies, Making Sense EU empowered citizens to discuss methodologies, devise data collection strategies for measuring air pollution, water quality or sound pollution, and interpret the results. It's a win-win project: scientists can use the datasets for their research, and citizens acquire tools to understand their environment and take appropriate action. In this YouTube video Frank Kresin, Managing Director of the Design Lab at the University of Twente, highlights the EU project Making Sense EU: <https://www.youtube.com/watch?v=au3uVptWjBU>.

6. For further information, see this earlier report on the co-creation methodology for GoNano: <http://gonano-project.eu/deliverable-2-1/>.

7. GoNano D2.1: <http://gonano-project.eu/deliverable-2-1/> [20-02-2020]

## The process in detail

GoNano has established an iterative and interactive process through which societal considerations in the area of nanotechnologies<sup>8</sup> can be integrated into R&I. In a series of citizen workshops, citizens expressed their wishes and concerns with respect to each of the application areas. In a series of stakeholder workshops, stakeholders subsequently explored ways to take these wishes and concerns into account in nanotechnology R&I.

At the start of the iterative and interactive process, the three pilot partners (the University of Twente in the Netherlands, the Technology Centre of the Czech Academy of Sciences in the Czech Republic, and the European Office of the Royal Melbourne Institute of Technology in Spain) organised a series of face-to-face citizen workshops in the Netherlands, the Czech Republic and Spain in October/November 2018.<sup>9</sup> The aim of the first round of stakeholder workshops was to come up with concrete responsive design suggestions that could be fed back into ongoing R&I activities, building on the outcomes of the citizen workshops. The design suggestions were to feed into a next round of citizen consultations, which would again feed into a second round of stakeholder workshops serving to evaluate the uptake of the responsive design suggestions of the previous round. The primary aim was to identify product suggestions which are better aligned with societal needs and values. Taken together, these iterative tasks explore the potential of co-creation in integrating societal values into R&I and provide more insight into the more actively-oriented responsiveness of business and industry.

Thus, the main findings of the GoNano process in the four steps of co-creation were:

### • Citizen workshop

Citizens appreciate the promise of nanotechnologies and connect the applications to current global issues concerning sustainable development, the environment, and health and wellbeing, but they also realise that the benefits might not follow automatically: In all pilot countries, citizens seem to put a strong emphasis on the role of scientists in the process of development and implementation of nanotechnologies, expecting that they will ensure that especially food and health related applications are safe to use – that they do not harm the environment or the human body. Citizens can provide a fresh and somehow ‘untainted’ picture of what the technology might look like.

... for more details, see Hebáková et al (2019)<sup>10</sup>

### • Stakeholder workshop 1

As it is far from self-evident how broader societal consideration can be applied meaningfully to R&I practice, the workshops succeeded in raising and fostering awareness with stakeholders that an early consideration of the needs and values of citizens and societal stakeholders can add value to innovation in nanotechnologies; however, it proved difficult to connect the general input from citizens to the research agenda and concerns of the professional stakeholders. So, connecting the ideas of citizens to the stakeholders and their agenda was the main challenge of all the activities.

... for more details, see Schuubiers et al. (2019)<sup>11</sup>

8. See GoNano Del. 1.1 (online: <http://gonano-project.eu/wp-content/uploads/2018/08/1.1.pdf> [2020-03-23]) and 2.1 (online: <http://gonano-project.eu/wp-content/uploads/2018/08/2.1.pdf> [2020-03-23]) for knowledge base and the methodology developed in earlier stages of the project.

9. See the briefing report for further information on the outcomes of the citizen workshops.

10. GoNano D3.2. Online: <http://gonano-project.eu/wp-content/uploads/2019/06/D3.2-Briefing-report-from-the-citizen-workshops.pdf> [2020-01-21]

11. GoNano D4.2. Online: [http://gonano-project.eu/wp-content/uploads/2019/07/GoNano\\_D4.2\\_Working\\_paper\\_on\\_the\\_designs\\_and\\_outcomes\\_of\\_round\\_1.pdf](http://gonano-project.eu/wp-content/uploads/2019/07/GoNano_D4.2_Working_paper_on_the_designs_and_outcomes_of_round_1.pdf) [2020-01-21]

#### • **Online Consultation**

Results of the online consultation showed that product suggestions beneficial for the whole society gain most popularity. These products would be mostly related to health application area – specifically to diagnosis of cancer and diabetes. The online consultation again proved that for health and food, the safety is the most important main need and value for the future nanotechnology applications. However, results also show that citizens can have concerns also about the solutions for the issues they raise - preferences of the wide audiences can be easily malleable and therefore unpredictable.

... for more details, see Pour et al. (2019)<sup>12</sup>

#### • **Stakeholder Workshop 2**

The second stakeholder workshop – as the final step of the co-creation process – resulted in the most sophisticated exchange of ideas and feedback on the co-creation process so far. In comparison to the first stakeholder workshop, the second workshop provided important insights into the requirements for co-creation in nanotechnologies, highlighting both opportunities for and constraints on co-creation.

... for more details, see Schuubiers et al. (forthcoming)<sup>13</sup>

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12. GoNano D3.3. Online: <http://gonano-project.eu/d3-3-briefing-report-on-the-outcomes-of-the-online-consultation/> [20-02-2020]

13. GoNano D4.2b (forthcoming).

# Finding a place for co-creation in R&I processes

Nanomaterials and nano-based technologies have experienced a rapid development and a broad diffusion due to a huge range of applications during the last 15 years. Therefore, they provide a good example of what are known as Transformative or Enabling Technologies: technologies requiring a strong knowledge base for their development, together with intensive R&I and highly skilled human resources, showing a systemic relevance for all phases of product development, with the capacity to provide pervasive innovation throughout the economy and to enable new paradigms and processes, and which are strongly multidisciplinary and trans-sectoral (DG Research and Innovation, 2018).

These characteristics make the development of Enabling Technologies, such as nanomaterials and nanotechnologies, a useful opportunity to tackle grand challenges and responses to citizens' needs. At the same time, however, the rapid and large amount of disruptive applications they can enable may give rise to new (real or perceived) problems and concerns. Typical examples of this are the safety and health issues associated with the introduction of nanoparticles in products (e.g. cosmetics or food) and the governance of possible risks for the workers at manufacturing sites producing or employing nanomaterials.

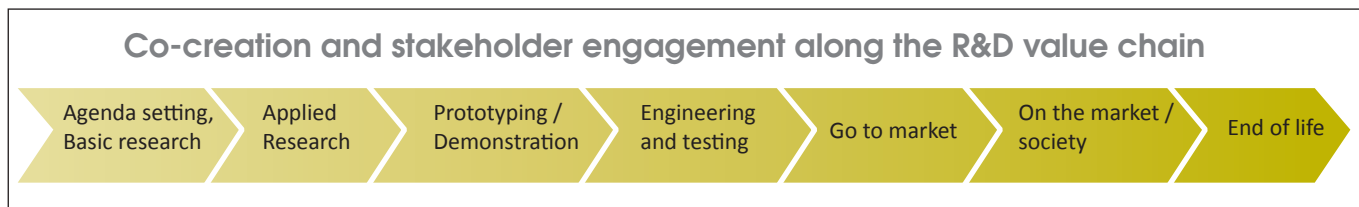
Including stakeholder engagement in the R&I process could be a useful way to exploit the opportunities provided by new technologies while taking into account societal needs and concerns. GoNano experimented with the co-creation methodology as a way to incorporate stakeholder engagement into R&I processes.

Enabling technologies are characterised by a high degree of uncertainty at different levels, including scientific, technical, legal, social and market and consumer acceptability aspects. Investing in R&I requires a huge amount of effort, and by definition its outcomes are uncertain; this implies a degree of risk. Furthermore, effecting change in the development of a new product or solution becomes increasingly more expensive when intervening further up the R&D value chain, as is known from the Collingridge dilemma (Genus and Stirling, 2017; Collingridge, 1980). Looking at RRI all along the R&I value chain is thus fundamental, and co-creation and stakeholder engagement could play a central role to this end.

However, the challenge of co-creation is significant. All participants come to the table with their own assumptions and standard repertoires, which can compromise the willingness and thus the opportunities for mutual learning and co-creation. Such approaches provide the opportunity to broaden one's perspective beyond individual opinions by interaction. As a result, they may contribute to overcoming the widespread prejudice which perceives ethics or broader issues as hindrances to innovation processes (even if this is mistaken) (Tuncak, 2013).

As such, RRI and associated calls for responsiveness challenge the roles and responsibilities of researchers and redefines the boundary between science and society. In a sense, RRI - and the responsiveness that it purports to advance - can be viewed as a social innovation that is "gradually being articulated" (Rip, 2014). The innovation is visible in the call for researchers to extend their roles and responsibilities to consider input from outside the R&I ecosystem and to actually act on this input, in order to adapt - and potentially reconsider - the direction and trajectory of the R&I process itself.

In order to align innovation with societal values and bring more value to people it is important to adopt a life cycle view, considering the entire R&I value chain, from the lab to the market and the end of life of a product (see Figure 2). Alignment to societal values calls for R&I processes that are able to look beyond the primary use and market and consider the entire product life cycle (GoNano D5.1, 2018; GoNano D5.2, 2019).



**Figure 2. Co-creation and stakeholder engagement along the R&D value chain**

Enabling technologies such as nanotechnologies are expected to have huge impacts on society, but this doesn't necessarily guarantee that the overall impact will be positive, that supposedly disruptive technologies will effectively succeed, or that companies bringing these solutions to the market will effectively reap commercial reward from it: their success will depend on their ability to provide real benefits for all. Including all stakeholders' views in the development of technological innovations could be an effective method to ensure their overall success by increasing acceptability among potential users.

In all phases of the R&D process, there could be positive implications to be further exploited or negative ones to be avoided from the societal, sustainability or economical point of view. Co-creation has the potential to foresee many of these implications, or at least identify them in a timely manner. Despite these added values of co-creation to connect and bring into contact multiple stakeholders, GoNano identified structural and economic issues that prevent the creation of productive connections between the stakeholders along the R&I value chain and impede the bridging of the gaps in the innovation process. This is a crucial point for policy and funders of R&I activities.<sup>14</sup>

This White Paper proposes an overall framework to pursue the GoNano vision of co-creation (Figure 3) that identifies three levels of analysis:

- **essential elements for co-creation uptake in R&I**, as identified by GoNano experience
- **current conditions, barriers and challenges** in nanotechnology development that co-creation approaches could help to address
- **recommendations** to promote and perform co-creation in the R&I process

Objective of co-creation		
Aligning innovation with societal needs through more participatory and responsive approaches		
Elements for co-creation uptake in R&I	Gaps and challenges for co-creation in Nanotech R&I	Recommendations for co-creation in R&I
<p><b>Interact with the Innovation ecosystem</b></p> <ul style="list-style-type: none"> <li>• Enable citizens participation</li> <li>• Ensure awareness of participants</li> <li>• Provide feedback to stakeholders</li> <li>• Ensure responsiveness towards public and stakeholders concerns</li> </ul>	<p><b>With regard to Nanotechnologies</b></p> <ul style="list-style-type: none"> <li>• Safety</li> <li>• Transparency</li> <li>• Acceptability</li> <li>• Trust</li> </ul> <p><b>With regard to co-creation</b></p> <ul style="list-style-type: none"> <li>• Added value</li> <li>• Methodologies</li> </ul>	<p><b>Mapping the innovation context</b></p> <ul style="list-style-type: none"> <li>• Identify needs and entry points</li> <li>• Fostering confidence</li> <li>• Implement a structured methodology</li> <li>• Ensure appropriate translation of different perspectives</li> <li>• Create a reward structure</li> <li>• Create a culture</li> </ul>

**Figure 3. The framework identified in this White Paper to align nano-enabled innovation with societal needs through co-creation**

14. Initiatives such as the report from the project Value4Nano (NANO futures, European Technology Integrating and Innovation Platform on Nanotechnology, 2015) and the Re-finding Industry report have recommended the creation of clusters based on a European value chain approach (European Commission - Directorate General for Research and Innovation, 2019). Similar observations have been made by others.

# Essential elements for co-creation uptake in R&I

## .... as identified by GoNano experience

Co-creation is a form of collaborative innovation where ideas are shared and improved together (GoNano D2.1, 2018). Essential actions/elements to obtain tangible outcomes from co-creation are:

- **multi-actor engagement**, to gather different perspectives in the R&D value chain and get access to the diverse range of skills needed to develop complex solutions based on enabling or disruptive technologies
- **citizen participation**, in order to reassure citizens that their concerns matter and that their visions are important for the development of solutions
- the consideration of the whole **innovation ecosystem**, including the stakeholders involved and their roles and relationships
- instruments to provide **feedback** to the stakeholders involved, so they can appreciate the responsiveness of other stakeholders and the added value of the co-creation process
- the **awareness** of the participants and their willingness to continue participating during the process
- the **responsiveness** of innovators to the concerns, positions and perspectives of all other stakeholders.

Even when these essential elements are already present co-creation may be a challenging exercise, as shown by telling examples from the GoNano experience below.

*“We knew what we wanted to do but didn’t always manage to put it into practice, e.g. stakeholder workshops in Spain were attended by mostly researchers, despite seeking participation of all stakeholder groups.”*  
(co-creation pilot on energy, Spain)

*“It takes quite some time to understand the specific take on the development of nanotechnology in regard to expertise of the stakeholders, and the different aspects and views that these stakeholders bring to the table.”*  
(co-creation pilot on food, Czech Republic)

*“GoNano partners managed to bring stakeholders together with different backgrounds (research, industry, policymaking, CSO, and citizens) at the workshops, as they were interested in meeting other stakeholders or learning more about the co-creation process. However, it was difficult to ensure responsiveness, in a way that the suggestions that were being made during the workshops were taken up by them. Most of the stakeholders did not feel a sense of problem-ownership.”*  
(co-creation pilot on healthcare, the Netherlands)

*“Although some steps of the co-creation process at some point seem to bring less tangible results than the others, in the end all the results play similarly important role in making the process more valuable and useful for the stakeholders, citizens, and researchers behind the methodology.”*  
(co-creation pilot on food, Czech Republic)

*“During the Citizen workshop we had a first session about data management: ownership, sharing etc. We had a second loop during the first stakeholder workshop and we continued this topic a third time during the second stakeholder workshop. Then we focused more and more on data and diabetes 1. This iteration process was very effective”*  
(co-creation pilot on healthcare, the Netherlands)

*Netherlands)*

*“To discuss the topic of data management and diabetes 1, we not only have to talk with ICT technology people, but also with clients/customers, health insurance companies, doctors, and lawyers to assure that all specific elements are taken into account. Organize a co-creation workshop is complex and time consuming” (co-creation pilot on healthcare, the Netherlands)*

*“The first stakeholder workshop included a number of various stakeholders from different backgrounds. It proved quite difficult to manage the expectations of all these actors. Moreover, it seemed challenging to manifest the added value of the initial input from citizens. A more focused approach, and a more sophisticated input – in the form of the results of the online consultation – seemed to be the key to manage the expectations and to bring more focused results during the second Stakeholder workshop.” (co-creation pilot on food, Czech Republic)*

# Current conditions in nanotechnology development

## ... that co-creation approaches could help to address

Based on an in-depth desk analysis and interviews with stakeholders GoNano identified the main characteristics of nano-enabled innovation, including critical aspects that are still unresolved<sup>15</sup>(GoNano D5.1, 2018, GoNano D5.2, 2019). Table 1 shows a selection of these major issues and gaps in nanotechnology development in different areas that need to be considered when designing and performing co-creation for this technology, and highlights options for improvements (in italics).

Areas	Specific challenges and potential anchor points for improvement
<b>Regulatory and safety aspects</b>	<ul style="list-style-type: none"> <li>• Standardisation, classification and definitions of nanomaterials</li> <li>• Health and environmental impacts</li> <li>• <i>Regulatory preparedness: discrepancy in pace between technology development and safety testing/risk assessment of nanomaterials and a resulting lack of regulation</i></li> <li>• Lack of social debate on regulatory and safety aspects</li> </ul>
<b><i>Ethical, social and environmental aspects</i></b>	<ul style="list-style-type: none"> <li>• <i>Acceptability, risk perception, sociological aspects</i></li> <li>• <i>Equity and justice in access to new technologies</i></li> <li>• <i>Environmental and sustainability aspects</i></li> </ul>
<b>Strategic and systemic aspects</b>	<ul style="list-style-type: none"> <li>• <i>Structural, cultural and economic issues preventing connection of stakeholders along the R&amp;I value chain and impeding the connection from research to market (e.g. how to support SMEs in open innovation processes)</i></li> <li>• Mainstreaming of RRI (innovation eco-system)</li> </ul>
<b>Communication aspects</b>	<ul style="list-style-type: none"> <li>• <i>Absent or misleading information on nanotechnology; fear of nanotech; considering cultural differences. How to provide balanced information to citizens on use of nanotechnology</i></li> <li>• Tangibility of nanodebate: Avoidance of negative effects of a single nanomaterial could influence reputation of nanotechnology as a whole</li> <li>• <i>Distinction between nanomaterials and nanotechnology in public debate</i></li> </ul>
<b>Institutional and policy aspects</b>	<ul style="list-style-type: none"> <li>• International harmonisation</li> </ul>
<b>Scientific and technological aspects</b>	<ul style="list-style-type: none"> <li>• Challenges of collecting adequate scientific data for characterisation and safety</li> <li>• Sharing of scientific data, including sharing and harmonisation of modelling tools</li> </ul>
<b>Economic and market aspects</b>	<ul style="list-style-type: none"> <li>• Cost-effectiveness of the fabrication and scale-up of nanomaterial-based technologies</li> <li>• Affordability of technologies and innovation</li> </ul>

**Figure 4. Major issues and gaps in nanotechnology development**

15. With reference to the topics included in this section, it is important to underline that three large EU projects (Gov4Nano, Nanorigo and RiskGone) are now exploring a harmonised approach to these aspects with the aim of developing a European Framework for Risk Governance of Nanomaterials associated with a unique portal and establishing a European Council for the Risk Governance of Nanomaterials (for further information see GoNano D5.2).

Co-creation is not expected to contribute to all these areas, but this provides an idea of the innovation context for nanotechnology and of the different issues that various stakeholders may have to deal with. Co-creation could become a useful methodology to address some of these issues, for example helping to achieve regulatory preparedness by bringing together disparate fields of expertise or developing adequate nanotechnology risk governance by improving collaboration along the value chain (between producers, downstream users, risk researchers, regulators and civil society). A clear identification of the innovation context for nanotechnologies, together with the interaction with various stakeholders, enabled us to identify specific challenges for co-creation. As indicated in the table above not all of the areas are likely to be improved by co-creation, but they nevertheless fundamentally define the context or final outcome of R&I processes (e.g. strictly scientific and technological aspects, economic and market aspects or institutional and policy aspects).

# Specific challenges for co-creation

## ...with regard to nanotechnologies

Based on the issues outlined above, nanotechnologies and nanomaterials are considered differently across sectors and by different stakeholders. Therefore, a common understanding needs to be established in terms of:

- how to deal with uncertainties, mainly related to technical and scientific aspects, normative issues, ethical, social and environmental implications, and strategic and systemic aspects of R&I that all stakeholders along the R&I value chain face to some extent
- the state of the art of research activities and debate around the safety of nanomaterials and a normative framework for nanotechnologies
- the ambiguity of the debate around nanotechnologies, which is probably due to gaps in sharing of information among the different actors of the R&I value chain and to a shortage of reliable and acknowledged sources of information in the field (transparency)
- the difficulties in expressing, understanding and considering the needs, concerns and expectations (and perception of risks) of stakeholders (in particular citizens) in the course of nanotechnology development. This holds especially true for materials which involve radical innovations and are likely to have a significant impact on people and society (e.g. healthcare). In short, the issue of trust in nanotechnology innovation (by citizens, as well as by partners, suppliers, business operators and other stakeholders along the R&I value chain).

A lack of consideration of these aspects can easily polarise debate, hamper the relationships between stakeholders or cloud the dialogue with citizens. As a result, innovations can experience a slowdown or be sidelined. While there might be other reasons to be considered here (as required under RRI), the most important ones may come from the innovation stakeholder perspective.

## ... with regard to co-creation

The GoNano experience shows that there are challenges related to the implementation of a co-creation approach as such. In particular:

- a lack of awareness about the potential benefits of co-creation, which is associated with a lack of convincing and inspiring examples of including societal aspects and stakeholders' views in the development of new innovations in a direct manner and the related communication challenges. This then frequently results in overconfidence in one's own perspective and capacity to assess all aspects of the innovation process. The issue is therefore how to demonstrate the added value of co-creation approaches for innovation, in order to persuade R&I actors to use and implement such an approach.
- another aspect is the lack of acknowledged and good practices for co-creation.<sup>16</sup> Providing ambassadors (who have already experienced co-creation) or good examples could reduce initial scepticism and improve stakeholders' confidence, and it could also reduce the likelihood of barriers and expectations regarding co-creation being either underestimated or overestimated.

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16. For more information see White Paper 1.

Co-creation projects are still in their infancy as a means of developing knowledge for social purposes. Most existing co-creation projects work on a local scale, seeking practical solutions that work for a specific product and service and for a specific organisation.

The following section identifies some of the existing conditions that make a case for increased efforts to introduce co-creation and stakeholder engagement approaches along the value chain on both organisational and systemic levels. These conditions are summarised in the second column of Figure 1.

In order to identify the areas of action for co-creation, there is a need for changes at the level of internal activities of organisations (e.g. commitment, relationships or procedures<sup>17</sup>), of cooperation throughout the innovation ecosystem (e.g. through policies or relationships involving more stakeholders or the public), and of policy actions. Suggestions from the GoNano experience are reported in the next section.

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17. See also GoNano White Paper 1: Rule of thumb 'Enhance potential for recognition of opportunities'.

# Recommendations for actions to establish co-creation

Moving on from the challenges identified in the nanotech field, this section identifies recommendations designed to realise co-creation processes along the R&I value chains, increase added value for all the stakeholders involved, and facilitate RRI-friendly conditions, in particular with respect to the inclusiveness and responsiveness dimensions, thus focusing on co-creation and stakeholder engagement.

As co-creation is a complex approach requiring synergies between different functions of the organisation and stakeholders, adopting a structured management approach could help to deal with it. The following steps should be considered:

- Understand the issues at stake
- Plan actions
- Implement changes
- Ensure long-term sustainability

GoNano has developed the following recommendations to introduce co-creation in R&I processes in line with this approach.

RECOMMENDATION

1

**identify needs  
and entry points  
for co-creation**



## WHY?

It is important to collect, understand and consider the needs and views of the different stakeholders who are to be involved in the co-creation from the very early stages of the process, as the goal is to provide concrete added value to each stakeholder, thus motivating them to take an active part in the co-creation process. This will also make it possible to provide a better focus for the different phases of the process.



## HOW?

Each organisation along the value chain should identify the R&I topics and motivations that are a priority for co-creation purposes, selecting areas where the organisation could provide valuable inputs to the co-creation process and areas where the organisation needs to receive data and information from the co-creation process.

Specific recommendations to identify needs and areas of action for co-creation are:

- Highlight the most interesting points to debate for each stakeholder (e.g. interests, needs and concerns)
- Identify criteria to prioritise topics/areas for stakeholder engagement
- Identify where in the value chain the co-creation could be most useful
- Select stakeholders to be involved in different co-creation phases
- Provide clear indications about the focus and priorities of co-creation actions

Initially, GoNano consulted selected stakeholders (interviews) about their needs and views in order to inform the co-creation process. This action explored aspects related to the most significant ethical and social issues to debate, the added value of co-creation, and the type of stakeholders to involve. Most of the results of this exercise are quite specific for the type of application and sectors considered. The needs and concerns of stakeholders identified in the case of application of nanotechnologies in the health sector are reported in the figure below.

Moving to a systemic level, this will make it possible to draw up a list of key areas or topics that are relevant for the solutions being developed and for the stakeholders involved, and will help identify those most relevant for the debate. A set of criteria could serve to prioritise the topics.

Stakeholder engagement should cover the whole R&I value chain and may have different purposes for and involve different stakeholders. There could also be, for example, different sessions along the same co-creation process targeted to different steps of the value chain.

At a systemic level, it should always be made clear to which stage of the value chain the respective stakeholder engagement is referring, while each organisation should clearly identify the important value chain steps to select the appropriate session or initiative.

***The GoNano experience with one of the stakeholder workshops (GoNano D4.2, 2019) in the Dutch pilot highlighted that in that case participants had difficulty distinguishing the prototyping session from the ideation process, while in another workshop the purpose of the session was not clear. Such confusions can be avoided. In order to move the co-creation session forward from the ideation phase to the prototyping phase, a specific problem or goal should be defined. Preparation is crucial in this regard, and interviews with stakeholders before the workshop could help to establish a framework in which stakeholders are asked to come up with suggestions for action.***

RECOMMENDATION

# 2

## mapping the innovation context

*“To map the innovation context seems to be crucial as the first step of the co-creation process – to be able to identify the application areas that seem to be most promising to be used in the near future. However, even in these specific areas, their perception may be ambivalent. On one hand, the nutrition/novel foods application area was perceived as the most promising area connected to many expectations (Citizen workshop). On the other hand, the very same application area was connected to the highest safety risks and difficult implementation into concrete products during the second Stakeholder workshop.”*

*(co-creation pilot on food, Czech Republic)*



## WHY?

In order to contextualise innovation, it is crucial to first identify the R&D priorities of the sector in question. This can both provide a general idea of what innovators are considering at the present time and inspire possible future scenarios in the sector. The GoNano literature review and experience with stakeholder interviews and with citizen and stakeholder workshops confirmed that nanomaterials and nanotechnologies can contribute to providing solutions and products to address societal challenges as well as public and stakeholders' needs in the three areas considered: Food, Health and Energy. The specific applications and R&D priorities that were identified in (GoNano D1.3, 2018, GoNano D5.1, 2018), are shown in Figure 5.

<b>Nanotech R&amp;D priorities</b> Emerged from GoNano literature review, interviews and workshops		
<b>Food</b> <ul style="list-style-type: none"> <li>• Packaging</li> <li>• Safety &amp; Security</li> <li>• Nutrition</li> </ul>	<b>Health</b> <ul style="list-style-type: none"> <li>• Therapeutics: targeted and personalized drug delivery and theranostics</li> <li>• Diagnostic/imaging: efficient fast and site-specific monitoring</li> <li>• Regenerative medicine</li> </ul>	<b>Energy</b> <ul style="list-style-type: none"> <li>• Energy storage</li> <li>• Advanced photovoltaics and CPV</li> <li>• Wind</li> <li>• Renewable heating and cooling</li> <li>• Multi-application components</li> </ul>

Figure 5: Nanotech R&D priorities (see GoNano D1.1 and 1.3)



## HOW?

The innovation eco-system in which co-creation is taking place should be carefully analysed. GoNano used a context analysis to inform and inspire both the planning and the implementation phase of the co-creation process. Context analyses need to explore a series of elements, such as the ones outlined in the table below as used in the GoNano project.

Specific recommendations on how to analyse the context in the sector where innovation is being promoted are:

- Identify R&I priorities in the field
- Identify the R&I value chain
- Map the stakeholders in the innovation ecosystem (including endusers)
- Highlight type of business, market aspects, trends and consumer attitudes
- Identify relevant regulatory aspects

As a value chain approach is recommended, it is also crucial to identify and map all stakeholders (including the endusers) in the respective innovation ecosystem, i.e. highlighting their interests, relations, needs and concerns. It could also be useful to consider the type of business, the specific market characteristics, the trends and the consumer attitudes at the present time (or, in other cases, recent developments). Specific attention should be paid to identifying and analysing the regulatory aspects that could influence the innovation.

The GoNano project performed an in-depth analysis of the regulatory framework for nanomaterials with a specific focus on the three target sectors (Food, Health, Energy), as reported in (GoNano D5.1, 2018) and (GoNano D5.2, 2019). The need to prepare the policy and regulatory framework for the introduction of new technologies (such as nanotechnology), in order to ensure that safety and risk governance are in place and also to reduce (regulatory and financial) uncertainty when investing in innovation, was confirmed as a crucial aspect by the majority of the stakeholders involved and for each of the three target sectors. A summary of the output of the context analysis for the application of nanotechnologies in the health sector is reported in figure 5.

RECOMMENDATION

3

## Showcase benefit of co-creation

**Make transparent how individual researchers can  
benefit from broadening their perspectives.**

*“One of the important points to emphasize seems to be that nanotechnology in itself is connected to various fields of expertise: from biotechnology, materials science, conservation of food to circular economics. If not for anything else, the main benefit is that there is a topic which brings all these actors to one table and ensures that there is a possibility to come up with as complex solutions to current problems as possible.”*

*(co-creation pilot on food, Czech Republic)*



## WHY?

Research suggests that individual researchers can benefit from opening up to broader perspectives. Extending consortia beyond the usual suspects to include a broader range of stakeholders could both create new business opportunities and function as early warning for potential problems further down the line. It also allows these partners to modulate research trajectories as they unfold, rather than after they are established (for more information see the GoNano Website).<sup>18</sup>



## HOW?

In order to deal with potentially limited interest, particular strategies may be deployed in relation to less experienced stakeholders. However, the challenge in this process is to educate/inform the participants without undermining their values and concerns.

*“Stakeholders repeatedly emphasised that the main benefit of the co-creation process is that they can meet and discuss ideas or products they work on with experts with a completely different perspective, and that these meetings and exchanges of ideas are something they lack. During one of the workshops, a representative of a state said that this was the first time they had met at one table various actors actually engaged in the development of specific products.”* *co-creation pilot on food, Czech Republic)*

*The GoNano stakeholder workshops do, in some cases, suggest added value for the researchers involved. According to the developer of the artificial pancreas, for which a data-management plan was formulated, the outcomes of the workshop “improved the foundation of their product as there were some new aspects discussed they hadn’t thought of before”.<sup>19</sup> The developer of the early diagnostic device for which an implementation plan was discussed evaluated the outcome as something that supported their initially somewhat vague ideas, which had since become much clearer. They thought the discussion with participants from different backgrounds was “very stimulating and motivating”. Another example was derived from collaboration with a post-doctoral researcher at the start of their research trajectory who was focusing on the diagnosis of cancer based on specific proteins. By discussing their proposal with different stakeholders along the value chain, the researcher got new insights into how to further develop their research. These included reshaping the demand for their research by talking to other stakeholders. For the post-doc researcher, the workshop exceeded their expectations as they got a “more concrete understanding of what steps to take and what steps not to take during the rest of their research”, which helped them “to build the next three years of my research life”.<sup>20</sup>*

In addition to this, some agreements about future collaboration were reached with the participants present at the workshop.

Two points can be summarised here:

- Researchers should be informed as to the rationale of co-creation, that is, why they should be involved in co-creation exercises. Innovators, including researchers, may be unaware of the implications of demands for sustainable, desirable and acceptable advances in science and technology for their innovations and processes. Co-creation events offer opportunities for the articulation and deliberation of the needs and concerns of society and contribute to the development and embedding of new, more desirable advances.
- Provide examples in order to clarify how stakeholder engagement can enhance both the quality and the societal value of R&I. Additional efforts are needed to make existing experience more accessible and actionable, with respect to when and where stakeholder engagement makes sense and how it can be organised.

18. [https://www.youtube.com/playlist?list=PLI2-pUcVlb7PQI76LYATbGkY2P\\_PU\\_m-d](https://www.youtube.com/playlist?list=PLI2-pUcVlb7PQI76LYATbGkY2P_PU_m-d) [2019-01-16]

19. [https://www.youtube.com/playlist?list=PLI2-pUcVlb7PQI76LYATbGkY2P\\_PU\\_m-d](https://www.youtube.com/playlist?list=PLI2-pUcVlb7PQI76LYATbGkY2P_PU_m-d) [2019-01-16]

20. [https://www.youtube.com/watch?v=1UbBVtbiNdM&list=PLI2-pUcVlb7Mub\\_FgxtwLpQZCzbHHZBOW&index=4&t=1s](https://www.youtube.com/watch?v=1UbBVtbiNdM&list=PLI2-pUcVlb7Mub_FgxtwLpQZCzbHHZBOW&index=4&t=1s) [2020-01-21]

RECOMMENDATION

# 4

## Implement a structured methodology for co-creation

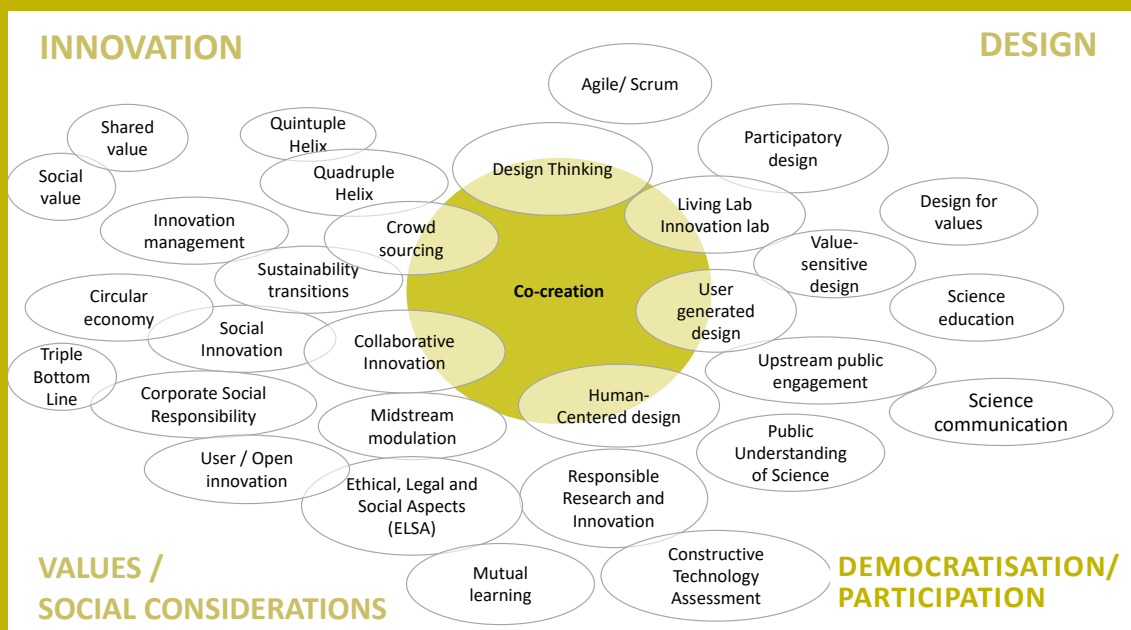


Figure 6. Positioning of the concept of co-creation between all existing methods of public and stakeholder involvement

## WHY?

Stakeholders will discuss a lot of different issues about the specific technology or innovation that is at the core of the co-creation process. This means that the organisation should avoid any issue about the co-creation process itself, which needs to have a structured and well-defined methodology before it is started. The objective of the process is to bring together very different views and perspectives from people who often speak different ‘languages’. Accounting for the various perspectives, in a space where all stakeholders feel safe to express their views and where these views are heard and considered, requires deliberate consideration of obstacles and the limitations and interests of all groups involved, which, in turn, requires approaching the process with a clear sense of how to overcome these hurdles.

## HOW?

Although there are many methods out there (see figure 5), the right choice and implementation is crucial and hence needs adequate consideration. The notion of stakeholder engagement is an umbrella term that groups together a wide range of activities on different levels, from formal social dialogues at the European level to living labs at the local level or human-centred design in industry, just to provide some examples.

The organisation (or organisations) aiming to implement co-creation approaches should analyse and identify the most suitable methodologies for the specific R&D value chain stages and actors. GoNano explored a series of methodologies for co-creation provided in the literature and used by different stakeholders, and also tested its own specific methodology.

Recommendations about the methodology that emerged from the GoNano experience are:

- Define a structured methodology
- Include experts in the definition of the co-creation methodology

The GoNano project designed a recruitment strategy, workshop manual, and information material tailored to the needs of citizens and stakeholders (GoNano D3.2, 2019).

This suggests that it is important to have a structured methodology to follow in a stakeholder engagement process. The methodology could be developed by the organisation itself, but the advice of external experts is recommended in order to focus the objectives and maximise the outputs, in particular when the number of stakeholders to be involved or their heterogeneity increases.

Experts could be, for example:

- A facilitator who understands the topic, the process and how to facilitate open and constructive discussions
- An organiser, who has a broad network and is creative in combining the very best stakeholders for this methodology
- Co-creation experts, who understand the process and know which tools are available and suitable for various steps of the workshop and how get the most out of it
- Experts from other fields, such as an illustrator to make visual notes who is able to translate and visualise the various steps for final presentation, for next steps and/or for dissemination activities.

RECOMMENDATION

5

**Ensure  
understanding  
between societal  
and stakeholder/  
researchers  
perspectives**



## WHY?

Translation of needs and perspectives of stakeholders within and between different stakeholder groups such as researchers, industry, and citizens is the key to identifying potential social impacts of R&I, and translating them into research questions to address.

It is important to consider how to translate societal considerations into information that can have a bearing on concrete research decisions, as societal feedback might not fit frictionlessly into research scope, either because it is frequently not concrete enough or because it might lead to contradictory responses.



## HOW?

From the citizens' side, insight into the individual, day-to-day decisions being taken in nanotechnology R&I is required (and respect for the limited room for manoeuvre at that level). From the researchers' side, an understanding of public perceptions of and attitudes towards nanotechnologies is important, as well as an understanding of the rationales underpinning them. From the industrial side, it is important to clearly communicate what information can be shared with others and what cannot be shared, e.g. due to confidentiality issues, to understand public perceptions with respect to the industrial development process and its mission and values, and also to assign the right priority to citizens' requests.

It is crucial for the process to allow participants to build a relationship and develop a shared language in which their contribution to the problems at hand can be meaningfully expressed. Similarly, the capacity to translate needs and concerns from the social realm into practical options in the technological realm in real time is essential to the success of the process.

These are tall orders indeed, but this is exactly what needs to happen to realise the policy prescriptions underlying the notion of Responsible Research and Innovation and the Science in Society movement in general: *“to encourage actors in their own disciplines and fields to participate in developing Science in Society perspectives from the very beginning of the conception of their activities.”*<sup>21</sup>

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21. European Commission. (2007). Work programme 2007, Capacities, Part 5, Science in Society. C(2007)563.

RECOMMENDATION

6

## Create a culture of co-creation

**In order to facilitate the changes necessary to promote the consideration of ethical and social impacts, and to pursue co-creation, changes need to be made to research cultures and to the incentive structures of researchers. This point is crucial in research organisations (public or private) as well as in industry.**

## WHY?

The RRI-Practice project<sup>22</sup> has looked at the current landscape of RRI in research funding and research performing organisations and reflected on the barriers and drivers regarding RRI in these organisations. The project found that, while responsibility norms associated with research (e.g. research ethics, integrity and open access) were, generally, established and codified in most of the organisations, the additional responsibility implied by RRI – including responsiveness – tended to be poorly articulated and codified in the organisations. There was “very little evidence of knowledge co-creation and co-production that accord with the EC’s broader definition of and ambition for RRI” (Owen et al., 2019, p. 3). Although there was evidence of some “small scale, creative and inspiring experiments, these tend to be modest, time-limited and not routinely or systematically embedded and sustained in organisations” (p.3).

This was due to a number of major barriers including entrenched norms, political pressures and priorities, de facto reward structures that do not take this kind of work into consideration, and a lack of training and infrastructure. At the same time, one sees the introduction of external forms of responsibility thinking (around integration and other similar notions) into organisations via specific organisational activities, projects or funding initiatives without significant conflict, while internal orientations rooted in the “republic of science” model remain dominant in overall practice, structures and cultures (Hennen et al., 2019).

Another important finding of the RRI-Practice project concerns notions of excellence and impact that condition performance evaluation and criteria for career progression at organisational and national levels (Owen et al., 2019).

The project encountered narrowly defined understandings of research quality and excellence that are at odds with calls to do RRI or to be ‘responsive’, as RRI is viewed as diverting attention and time from the pursuit of excellence. It is important to identify and highlight the added value for each stakeholder in the innovation ecosystem. Inside the single organisation, the individual evaluation should include criteria that include the ability to integrate different perspectives and being responsive.

## HOW?

A tension exists between the de facto incentives and disincentives that form the basis of the science system and new funding mechanisms that promote efforts to address grand societal challenges through interdisciplinary and cross-sectoral research, including co-creation. While research funders continue to promote such collaborative initiatives, evaluations of researchers and research are still predominantly based on criteria of scientific excellence or the marketability or valorisation of research (van den Hoven et al., 2013). Thus, funders have a key role to play in reconfiguring both the incentive structure and the corresponding evaluation mechanisms in the research system.

Currently, there is no reward for engaging stakeholders in the research system (van den Hoven et al., 2013). Without a clear mandate or obvious benefits, it may prove difficult to embed stakeholder engagement in the everyday practice of European R&I.

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22. <https://www.rri-practice.eu/>

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