GREA RRI plan

University of Lleida

2016-2017

Ruth Carbajo García-GREA UdL

Prof. Dr. Luisa F. Cabeza -GREA UdL

Version August 2017

RRI Plan for GREA research group

Over the last decades many efforts have tried to reduce the distance between science and society, leading to a European-wide approach in Horizon 2020 called Responsible Research and Innovation. RRI seeks to bring issues related to research and innovation into the open, to anticipate their consequences, and to involve society in discussing how science and technology can help create the kind of world and society we want for generations to come.

A normative framework for RRI includes eight normative policy keys/agendas:

- Ethics: focuses on (1) research integrity: the prevention of unacceptable research and research practices; and (2) science and society: the ethical acceptability of scientific and technological developments.
- Gender Equality: is about promoting gender balanced teams, ensuring gender balance in decision-making bodies, and considering always the gender dimension in R&I to improve the quality and social relevance of the results.
- Governance: arrangements that lead to acceptable and desirable futures have to (1) be robust and adaptable to the unpredictable development of R&I (de facto governance); (2) be familiar enough to align with existing practices in R&I; (3) share responsibility and accountability among all actors; and (4) provide governance instruments to actually foster this shared responsibility.
- Open Access: addresses issues of accessibility to and ownership of scientific information. Free and earlier access to scientific work might improve the quality of scientific research and facilitate fast innovation, constructive collaborations among peers, and productive dialogue with civil society.
- Public Engagement: fosters R&I processes that are collaborative and multi actor: all societal actors work together during the whole process in order to align its outcomes to the values, needs and expectations of society.
- Science Education: focuses on (1) enhancing the current education process to better equip citizens with the necessary knowledge and skills so they can participate in R&I debates; and (2) increasing the number of researchers (promote scientific vocations).
- Sustainability: encompasses both responsibility and energy research considerations. (1) Sustainability through inclusive and sustainable growth challenge is considered as development that meets the needs of the present without compromising the ability of future generations to meet their own needs,and (2) Sustainable development and climate changein terms of clean, reliable, and affordable (sustainable) energy, linked critically for achieving inclusive, low-emissions growth and development.
- Social justice: can be defined as (1) "an ideal condition in which all individual citizens have equal rights, equality of opportunity, and equal access to social resources" related with poverty prevention, access to education, labour market inclusion, social cohesion and non- discrimination, health and intergenerational justice (OECD, 2011), and (2) in the context of the role of science and technology in promoting social justice in terms of Relationship between the researchers and the research subjects and Participation of social groups in benefits arising from research.

1. GREA MOTIVATION TO DEVELOP AN RRI PLAN

1. 1 MOTIVATION

GREA is focused in excellence beyond standards in terms of research and innovation and subscribes the idea of excellence attached to analytical and social relevance with particular attention to improve the ways that different aspects of science and technological change are governed. RRI have potential as a transformative, critical and radical concept, to make research and innovation more efficient to solve global social problems helping to develop a more socially-dimensioned research environment. Transcending beyond RRI dimensions and attributes, implement Responsibility and Open innovation approaches in renewable energy research and applications and to be able to monitoring this implementation is also a great motivation, due to the fact that, although RRI has become an overarching trend, there is a lack of frameworks for assessing the interaction of dimensions and structural barriers in research groups regarding practical applications and researcher's awareness is also reported.

A review of motivations for arrange and subscribe Responsible Research and Innovation framework, present in literature shows different possibilities, being the aim of contribute to the development of certain discipline or area of research (Owen 2012, Ribeiro et al. 2016) with particular attention devoted to a suite of contentious and emerging areas of science and innovation, such as biotechnology, geoengineering and information and communication technologies (ICTs) (Owen et al. 2012) one of the most representative in existing practical experiences.

A desire to improve the ways that different aspects of science and technological change are governed (Ribeiro et al. 2016); engage indirectly by addressing responsibility in science and innovation more broadly and a need of implementation of novel policy and governance mechanisms is seen as important factor for the practical implementation of RRI. A recent review regarding to the RRI practices, shows that perhaps the greatest potential of RRI may be the ability to unify and provide political momentum with a wide range of long-articulated ethical and policy issues; in this terms, RRI's dynamism and resulting complexity may represent its greatest challenge (Ribeiro et al., 2016).

An unpacking process towards identification of the elements for achieve RRI goals and dimensions, GREA group shows weaknesses and strengths. Therefore, the motivation for GREA in order to arrange a RRI Plan is focused in the fact that RRI have potential as a transformative, critical and radical concept, to make research and innovation more efficient to solve global social problems helping to develop a more socially-dimensioned research environment.

Transcend beyond RRI dimensions and attributes, implement *Responsibility* and *Open innovation* approaches in renewable energy research and applications and be able to monitoring this implementation is also a great motivation, due to the fact that, although RRI has become an overarching trend, there is a lack of frameworks for assessing the interaction of dimensions and structural barriers in research groups regarding practical applications and researcher's awareness is also reported.

GREA Innovació Concurrent is located in University of Lleida, Spain and is a transdisciplinar research group focused in advanced energy research and applications. Founded in 1999, today it counts with 30 research members between permanent staff and collaborators, and research topics include Energy and Building Engineering.

The main objectives of GREA are related with the contribution to increase the competitiveness of enterprises, through the collaboration in the development of new products and with technological assessment and give an answer to the needs of specialized training and by continuous training oriented to companies. Basic research in Renewable energy technologies (RETs) and applications as well as the formation of human capital and teaching in undergraduate, graduate and posgraduate programs (Grades and European PhD programs) is also its mission.

The group collaborates with a big variety of companies, from local SME to multinationals, doing R+D+I or developing new products, in punctual or continuous collaborations. Innovation support tasks, technology transfer, and collaboration in calls of financed projects are offered. This wide group of expertise and the collaboration with other national and international research centres allows the integration of different technologies and topics to offer specialized or integral services of development and innovation to different industry sectors.

Due to the international partnership of GREA, the participation in research projects and the specific levels of governance, our aim is also to transcend from local to global and use RRI dimensions for vertebrate partnerships and future research towards more socially outcomes. GREA RRI aims to develop and implement an RRI Plan to promote institutional change and foster the uptake of the RRI approach by researchers and participants.At disciplinary level, the recognition of the interdisciplinarity and cross-cutting nature of the field of energy and its applications is also the motivation to start the implementation of RRI in a research institution (research centres, universities and the research departments as well as in industry partnerships) by the implementation around one research area, to set common strategies and tools giving answer to common working methods, problems and approaches as well as reinforce the culture of responsibility within research group. Therefore, our RRI Plan will allow us to manage research and innovation to be more efficient to solve social problems regarding with energy research trough the integration of eight key aspects of RRI in research for arrange structural changes in our research organization as well as vertebrate partnerships towards more socially outcomes and encourage awareness in researches.

The group belongs to the TECNIO network[1] created by ACC1Ó to bring together Catalan expert agents in Technology Transfer. ACC1Ó is the Agency for innovation and the internationalization of Catalan companies and is attached to the Department for Innovation, Universities and Enterprise of the Generalitat de Catalunya.

Renewable Energy Technologies (RETs) and Thermal energy storage (TES) is one of the most remarkable GREA research topics, considered by the EU Strategic Energy Technology Information Systems[2] (SETIS) as a strategic topic. TES is a technology that stocks thermal energy by heating or cooling a storage medium so that the stored energy can be used at a later time for heating and cooling applications and power generation. TES systems are used particularly in buildings and industrial processes. In

[1] The goal of TECNIO is to facilitate Catalan businesses the access to differential R&D and technology to enhance their competitiveness and their international success. TECNIO members respond to the demands of technology companies quickly and efficiently, so they can be incorporated to their products and services.

[2] SETIS plays a central role in the successful implementation of the SET-Plan by helping to identify energy technology and R&D objectives, striving to build consensus around the SET-Plan programme, identifying new opportunities, and assessing the effectiveness and efficiency of the SET-Plan in delivering energy and climate change policy goals.

these applications, approximately half of the energy consumed is in the form of thermal energy, the demand for which may vary during any given day and from one day to the next[3]. The use of RRI framework to solve research issues regarding with the social dimension of Renewable energy research and applications, social acceptance, user's knowledge and sustainability in terms of social relevance is an example of the potential of the implementation of this plan.

At disciplinary level, the recognition of the interdisciplinarity and cross-cutting nature of the field of energy and its applications is also the motivation to start the implementation of RRI in a research institution (research centres, universities and the research departments as well as in industry partnerships) by the implementation around one research area, to set common strategies and tools giving answer to common working methods, problems and approaches as well as reinforce the culture of responsibility within research group.

In this term, RRI Plan will allow us to manage research and innovation to be more efficient to solve social problems regarding with energy research trough the integration of eight key aspects of RRI in research for arrange structural changes in our research organization as well as vertebrate partnerships towards more socially outcomes and encourage awareness in researches.

1. 2 WHAT'S IS GREA ALREADY DOING THAT CAN BE CONSIDERED PART OF RRI?

The need of novel policy and governance mechanisms is seen as important factor for the practical implementation of RRI. These are decidedly diverse: *ranging from laws and regulations* (Rawlins 2014; Stahl 2012); *principles included in international declarations and protocols* (Stahl 2013); *guidelines or frameworks put forward by funding agencies* (Owen and Goldberg 2010) *or professional societies*. In these terms GREA group subscribes a series of protocols derivative from research policy regulations, higher educational institution guidelines as well as commitments that rely on founding bodies.

Also as part of TECNIO network and ACC1Ó the Agency for innovation and the internationalization of Catalan companies and attached to the Department for Innovation, Universities and Enterprise of the Generalitat de Catalunya subscribe all the mandates regarding with the accountability and liability of Catalan, Spanish and European research institutions.

The University of Lleida mission is based in their ethical and institutional values, devoted to educate professionals and citizens for contribute to social and economic a development of the territory through generation, transference, application and diffusion of scientific, technological and cultural knowledge.The institutional values composed by Social responsibility, accountability, planning and leadership are enriched by ethical values such as commitment, dialogue, efficiency , integrity , responsibility, transparency and public service vocation. Many initiatives are being undertaken to promote ethical and institutional values related with fostering gender, science

[3] TES systems can help balance energy demand and supply on a daily, weekly and even seasonal basis. They can also reduce peak demand, energy consumption, CO_2 emissions and costs, while increasing overall efficiency of energy systems. Furthermore, the conversion and storage of variable renewable energy in the form of thermal energy can also help increase the share of renewables in the energy mix.

education, inclusion, responsibility, sustainability and engagement. Regarding with research and technology transfer and under the umbrella of Social responsibility the following documents can be found in terms of Responsible Research and innovation, where dimensions of ethics, gender, engagement and open science are contemplated as shown in Figure 1.

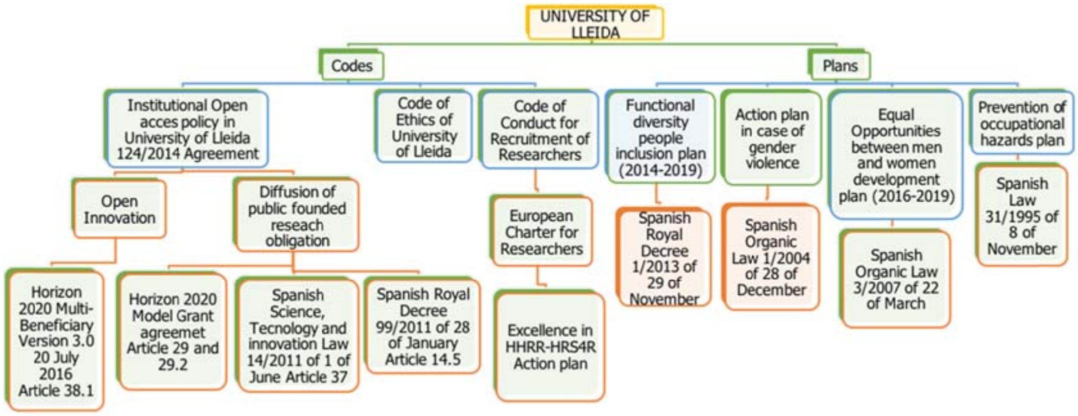

Figure 1: A summary of codes and strategies related with responsible research and innovation policies in udl structure.

The plans of prevention of occupational hazars,Equal opportunities between men and women and plan vor action in case of gender violence, as well as Inclusion of functional diversity plan covers elements of gender, ethics. Regarding to the codes, as part of a HE institution, GREA fulfils University of Lleida Ethics code (UDL Agreement no. 276/2009 of the Governing Council of 29 October 2009) regarding to the ethical values , as well as other codes and strategies related with european and supranational structures. In this terms, the code of conduct for recruitment of researchers, for susbscribe and broad, European Charter for Researchers is a proposal for improve the quality of teaching and research activities by developing the structures, facilitating the access to new methods and instruments and boosting international collaboration.Is structured in a plan that proposes a set of actions to strengthen and develop UdL's research strategy as well as to increase the visibility of UdL in the international context, by promoting the activity of individual researchers, research groups and centres in order to highlight their areas of expertise. The plan organizes the research structure of UdL in four Institutes according to the corresponding four research areas recognized as strategic for the institution: Agri-Food, Biomedicine, Sustainability, and Social and Territorial Development. Some of the main actions described include the promotion of the Institutes, the development of a complementary plan to consolidate research groups, the participation and leadership in European and national projects, the support to the recruitment of postdoctoral researchers through the participation in national and regional calls and the promotion of an institutional program of PhD students. The objectives, based in European Commission's *European Charter for Researchers* and *Code of Conduct for Recruitment of Researchers*[4] is to apply these principles within its human resource policy and to promote transparency, accessibility, equity and pursuit of excellence in the recruitment of researchers. For develope this initiative, an Action plan[5] that will cover the next two years, 2017-2018 is being proposed,mainly focused

[4] http://ec.europa.eu/euraxess/index.cfm/rights/index

a[5] http://www.udl.es/export/sites/universitat-lleida/ca/organs/vicerectors/vri/.galleries/docs/Action-Plan.pdf on the review of the dissemination rules for recruitment and selection, redefining the good practices in research and the selection and recruitment protocols, improving the research environment, promoting the career development and specific training and revising the mechanisms of complains and appeals for researchers. The action plan comprises ethical and professional aspects; Selection and Recruitment; Working conditions and social security and Training and a set of principles and actions as shown in Table 1.

TABLE 1: Action plan principles and dimensions for HRS4R-UDL inititiative.

Dimensions	Ethical and professional aspects	Selection and Recruitment	Working conditions and social security	Training
Principles	Research Freedom Ethical Principles Professional Responsibility Professional attitude Contractual and legal obligations Accountability Good practice in research Public engagement	Recruitment(letter) Recruitment (code) Selection Transparency Judging merit Recognition of mobility experience	Research environment Access to career advice Complaints/appeals	Continuous profesional development Access to research training and continuous development
Actions	Development of a code of good practices and obligations and responsibilities of researchers with the institution	Review and/or elaboration of a recruitment and selection regulations for research staff Review and/or implementation of recruitment and selection procedures for research staff	Developement of a wellcome protocol and guidance plan Professional support strategy for researchers Define an action protocol in cases of : Psychosocial risks and problems arising from intellectual property, conditions of use of acquired information, instrumentation and/or research resources	Design and implementation of a training plan for research staff that includes research management issues (such as exploitation of results, intellectual property, national and international funding, etc.)

Diffusion of the public founded reserch obligation and the participation in Horizon 2020 founding initiatives, requires to subscribe codes foused on open science and open acces policies as well as public engagement and comunication.Commitment with science education is understood from the base of been within a HE institution. As research group, GREA take part in outreach activities, and formal and informal science education initiatives. Participation in European initiatives such as a *Researchers night;* arrangement of citizen science projects as well as science shop initiatives can be consider a reinforcement of dimension of science education and engagement.

Interdisciplinary approaches of energy research in terms of ethical issues and translation of RRI dimensions in research topics with examples of sustainability and social justice dimensions are intentions to arrange. Gender dimension and the combination of science education and gender due to participation in Girl in STEM initiatives[6] are also considered.

The participation in energy agencies and plataforms such as a International Energy Agency (IEA), International Solar Energy Society (ISES), European Renewable Heating and Cooling platforms as well as the engagement with public and private SPIRE partnership also allows to GREA to reinforce concerns such as a social jutice, energy poverty, energy education, gender promotion in energy, open acces to scientific results and global development and responsibility.

1. 3 BARRIERS

Barriers for this RRI plan emerged from the evaluation of the RRI theoretical background (annex A.1 1), insights of the energy research and social science frames (annex A.3 1) as well as a diagnosis arranged with a participatory approach arranged via survey project with researchers and due to governance diagnosis performed following Res-Agora project recommendations (annex A.2.2 1.)

To settle the background of the structural barriers of GREA group, a participatory survey of researcher's awareness based in semi structured interviews and online questionaries' was arranged; and the meta governance diagnosis proposed in ReS-AGoRA Project (A.2.2 1), tested in many practical cases in research institutions in EU was performed.

Most of the insights arise from researcher's survey project regarding with practical applications are related with; researcher's awareness and disaffection, un-comfortability with philosophical approaches and plea for an interdisciplinary lecture of science, technology and innovations that shaped the background of RRI, that seems to still be present when we ask to researchers to consider RRI practices.

1.3 1 LITERATURE REVIEW OF RRI BARRIERS

RRi literature review results a series of issues not only related with the practice of RRI , but with the implementation of theoretical background of rri such as a general complexities regarding with real practice of the interdisciplinarity, especially when the collaboration is between social scientist and energy scholars and social sciences frameworks.

The hegemony of the institutions in the assignation of responsibility (Raws 1993) issued in the *Division of moral labour*[7] philosophical backgrounds (Nagel 1995, Murphy

[6] http://www.expecteverything.eu/hypatia/

[7] The division of labour also known as specialization is the separation of tasks in any economic system. Individuals, organizations, and nations are endowed with or acquire specialized capabilities and either form combinations or trade to take advantage of the capabilities of others in addition to their own. This approach is considered the driven for the economic interdependence and the design of the institutions and the solution the problem of reconciling the conflicts between the collective and the individual standpoint. The basic idea of the division of moral labour is familiar in political philosophy from the work of John Rawls, who argues that we should accept a division of moral labour in which only institutions (or more precisely the subset of institutions that here referrers to as 'the basic structure') should be assigned responsibility for realising distributive justice.

1999, Scheffler 2005 and Douglas 2014) may hinder the application and achievements of attributes such as anticipation, reflexivity, inclusion, and responsibility (Stilgoe et al., 2013) and keys recognised in RRI. In line with this; the reinterpretation of the responsibility; in the case of large research organizations, some are currently in the middle of a process of debating and discussing questions of responsibility; hence **it is too early to make any statements with regard to *responsibilisation* and deep *institutionalisation*** of RRI[8] (Goos K, Lindner R. 2015).

Responsibility is understood in some fields as a *responsibility of assumes the effects* (minimize environmental degradation and climate change, current generations to protect future ones' human and non-human) and as a recognition of the importance of more people-centric approaches (Energy justice approach, Sovacool et al., 2015, 2016).

Issues regarding with **reinterpretation** of the objectives of RRI in terms of shared theoretical backgrounds can occur. For example, regarding to the **justice/Social justice** (RRI dimension) most of the approaches regarding with science, technology and innovation interpretation are in terms of realising *distributive justice* based in equity, equality, power and need and responsibility in terms of individuals sharing resources with those who have less (Forsyth, 2006).

Another **complexity** is related with the **real practice of the interdisciplinarity**, especially when the collaboration is between philosophers/social scientists and natural and life scientists/engineers on the other. The complexities of these collaborations were sometimes underestimated, not only over methods, but also over chairs, journals, program committees, and funding opportunities (Zwart 2014).

Some of the barriers are inherent to research activities and projects. Although **early stage inclusion**, it been considered the most effective to solve issues in a societally desirable direction, it is difficult during this early stage to assess what the societal effects of the technology will be considered and which are not. The risk is that, in more advanced phases societal effects will become clearer, but there is less room for change. Lack of optimization of the **assessment frameworks for RRI and complexities for develop indicators that are dependant of primary (non existing)** and secondary (existing) data, for monitoring RRI practices it is considered one of the largest operational barriers.

Also, how RRI will translate into institutional pathways and arrangements remains to be an open question (Fisher, Rip 2013). Some others frameworks such as a Technology assessment TA or Impact assessment IA and combination of backgrounds are being used in specific fields (Rip 2011, Robinson 2010, Krabbenborg 2013, Stilgoe 2013, Van de Poel 2013 and Van der Hoever 2014) for the achievements of the goals of responsibility. The perspective of RRI implementation in current and future research varying significantly from project to project and in terms of scholarly is also a concern for some authors claiming for RRI approaches common ground (Zwart 2014).

No less important, is the fact that R&D policies often suffer from a certain amount of **disaffection and doubts** regarding to the extent the research groups involved had really 'internalised' the label, consideration that RRI in designing research is not adequately rewarded in the researcher's carers and fact that policies have been

[8] Goos K, Lindner R. Case Study Institutionalising RRI. The case of a large research organisation. Fraunhofer Society. Germany. ResAgora Project. 2015.

introduced in a top-down manner, namely, by funding agencies rather than by the research communities (Zwart and Nelis 2009).

Related with researchers also, implementation of RRI faces the **freedom of individual research activity consideration** and the autonomy of the research organizations. This is a great concern for scientists, whose claim that their commitment is to make excellent, trustworthy and reliable research, to diffuse, transmit and circulate knowledge, and to calculate how the results coming from research would produce an impact on science.

Reductionism of upstream approach is also noticed in practical applications when issues are processed for ensure de malleability. EU has been pronounced regarding to the importance of upstream engagement since first frameworks and policies for engage science with society were launched [80].

Examples can be found when developments are focus in issues, which appear to be more tractable than societal and ethical issues, or when upstream interaction arrangements are made with society for avoid to be blamed for what happens afterwards (Rip 2014).

Critical issues for practical implementation such as a **Public/stakeholder engagement** emerge as prominent and cross-cutting practical dimensions of RRI (Ribeiro et al 2016). Public acceptance for example, can suffer reductionism when efforts are focus on upstream approach to assure acceptance while the real challenges might be downstream (Rip 2014). This can affect in the preference of develop some RRI keys upon others. Also, despite **strong trend towards increased public dialogue and participation**, **mistrust to which degree and how to institutionalise this trend in detected in practical approaches (**Goos K, Lindner, 2015).

Convenience, in terms of adopting this new label that the research in question to be recognised as 'eligible for funding' and fact that some types of questions will become more important (or more difficult to ask) than others are some of other reported issues (Zwart 2014).

A review of the barriers can be found in Table 2.

1.3 2 INSIGTHS FROM SOCIAL DIMENSION APPROACH: SARTES SURVEY

Social approach of research in thermal energy storage [9] (SARTES) survey was a participatory approach was set up in order to determine awareness and definitions regarding with the social approach to scientific research in general and then focus on renewable energy study and TES. This survey was based on interviews and was designed to be executed by groups of researchers, academics and social actors that are part of institutions throughout Europe, USA and South America. Its aim was to collect impressions regarding to social approach and barriers, recommendations,

[9] SARTES and SARES 2015-2016 were a series of surveys performed based on semi structured interviews and online questionaries' designed to be executed by groups of researchers, academics and social actors that are part of institutions throughout Europe, USA and South America.

pitfalls, experiences, and expectations. Also the application of RRI (Methodologies and regulatory framework) and possible barriers was considered.

TABLE 2: review of the barriers for RRI implementation.

Barriers	Type	References
Culture of responsibility Hegemony of the institutions in the assignation of responsibility Philosophical backgrounds Absence of common ground Reinterpretations	**Foundational issues**	(Ribeiro, Smith, Millar 2016) (Raws 1993) (Nagel 1995, Murphy 1999, Scheffler 2005 and Douglas 2014) ;(Stilgoe et al., 2013) (Zwart 2014), (Rip 2011, Robinson 2010, Krabbenborg 2013, Stilgoe 2013, Van de Poel 2013 and Van der Hoever 2014) (Forsyth, 2006), (Davis, 2014)
Public/stakeholder engagement Novel policy and governance mechanisms Reductionism of upstream approach *Responsibilisation* and deep *institutionalisation* Disengagement with top-down approaches Freedom of individual research activity consideration /autonomy of the research organizations.	**Practical mplementation**	(Rawlins 2014; Stahl 2012); (Stahl 2013); (Owen and Goldberg 2010) (Rip 2014), (Goos K, Lindner, 2015). (Zwart and Nelis 2009) (Goos K, Lindner R. 2015) (Zwart 2014) (Zwart 2014)

The questions were grouped in four fields (and suggestions about the branches of social approach were indicated): Energy and Society; Communication, research and dissemination and outreach; Participatory Research or engaging research and Methodologies and regulatory framework (The extended questionnaire can found in annex

	PE subcategory 'public communication' and the SLSE subcategory 'science communication')
Data collection specifications	This section specifically addresses the procedure for collecting primary data, including collection of supplementary data when existing data has insufficient coverage. Please expand on each issue to the extent feasible in order to – as precisely as possible - direct the data collection process in task 4.
Data collection methods	Please note how data should be collected for this indicator (survey / questionnaire, data retrieved from databases,

	structured/semi- structured/explorative interviews, focus groups, desk research, document analysis, ethnographic field studies, etc.). Describe the respondents / informants, including the size of this population
Representation issues	Please reflect on the coverage of the available/proposed indicator and the potential data collection challenges that should be taken into consideration, e.g. would representative data, if relevant, be available for all European countries? How would institutions be sampled in order to be representative for a country etc.
Feasibility issues	Please address the feasibility of this indicator given the constraints on resources and time in the project
Additional points to pay attention to	
Comments/caveats	Additional comments/caveats can be specified here

A.4 3).

As main important conclusions, survey concludes that the RRI implementation needs to undertake a structural change in research organizations in order to promote its deployment. The isolate outreach actions, even if they are positive to encourage citizen participation in science and technology spaces, do not allow integration of the society in research interest. The engagement of the researchers in these activities is also necessary to result in a horizon of bidirectional participation. The absence of a clear idea about the social approach or a clear trend towards the meanings of responsibility was detected. Regarding to considerations like *open science*, several confusions regarding *open access* concept as a format of communicate research results and *open science* as initiative to generate open outreach science contents was detected. In this direction, two broad lines where been opened regarding to open access: the debate on the publication of research results in open access, intellectual property management; and the responsible conduct of the researchers, the access to social communication supports including rewards systems.

Results showed a positive bias towards the implementation of actions for pursuit the responsible approaches detected in researchers accustomed to use social research platforms. Convergence and inclusiveness of the proposed approaches was found, as well as the requirement of assets indicative techniques and factors affecting the implementation in order to generate useful tools for researchers.

2. OBJECTIVES OF THE GREA RRI PLAN

RRI potential as a transformative, critical and radical concept, for make research and innovation more efficient to solve global social problems, focused in develop a more socially-dimensioned of research environment is the inspiration for GREA for develop a RRI plan. In this terms, the objective is to develop, adopt and assess a RRI Plan around the topic of energy research and applications such as RETs and Thermal energy storage (TES) at national level within GREA group. For this purpose, we define a number of general and specific objectives. General objectives are related with the outputs of the RRI plan and specific objectives are linked with the measurement of the appropriateness of this methodology for GREA research purposes; the overcoming of barriers both related with implementations of the framework and deployment of RRI that we shall call *foundational issues*[10] as well as unravelling research issues of GREA related disciplines.

2. 1 GENERAL OBJECTIVES

The general objectives of this plan are:

- Develop a RRI plan for GREA group
- The adoption of the plan for GREA researchers
- Monitoring and assessing the implementation of the plan to evaluate the results in terms of changes in GREA group research structures and international partnerships

The flow of RRI plan is show in Figure 2:

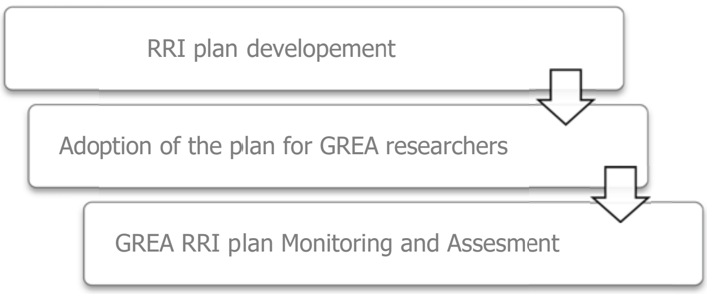

FIGURE 2: Flow of the RRI Plan

2. 2 SPECIFIC OBJECTIVES

Complexities regarding to the implementation in terms of adopting this new label and the observance of how far RRI methodology allows to achieve research and innovation goals, shape the specific objectives. For this purpose, a frame of dimension interpretations, barriers both adapted from literature and participatory approaches and RRI previous experiences is intended to arrange stated as a ***foundational issues framework.*** Also, the adaptation of responsible approach to energy field, developing frameworks and indicators for sustainability and social justice RRI dimension is consider part of the specific objectives.

---

[10] Foundational issues are broader in chapter 2.2.

In this terms, the specific objectives of the development of the RRI plan, are focused in three elements:

- Development of RRI foundational issues
- Development of the eight key aspects of RRI beyond significance and focused on research and researchers
- Adaptation of RRI methodology to energy research

In our aim to transcend from RRI dimensions and attributes and develop foundational issues, the use of approaches related with RRI are considered, such as Open innovation frame for dimension considerations and the alternative approaches of public engagement, which are considered as transversal elements to responsible approach beyond RRI.

A summary of the scope of specific objectives is show Table 3.

TABLE 3: Development of the specific objectives in terms of foundational issues of GREA RRI Plan

	Development of RRI foundational issues	**Development of the eight key aspects of RRI**	**Adaptation of RRI methodology to energy research**
GREA RRI plan Specific objectives	Translate RRI into practice	Move forward RRI dimension significance	Frame RETs and TES innovation as a Responsible innovation
	Reinforce Researchers awareness	Translate dimensions to research topics	Frame non-technological barriers for RETS and TES
	Reinforce Interdisciplinarity	Reframe responsibility and social justice dimensions for energy research	Arrange user's approach to technology transfer

2.2. 1 DEVELOPMENTS OF RRI FOUNDATIONAL ISSUES AS OPPORTUNITIES

The development of the foundational issues is framed in three elements:

- **Translate RRI into practice**
- **Reinforce researchers awareness**
- **Reinforce interdisciplinarity**

Although there seems to be a general and growing awareness of the importance of RRI, these aspects are not routinely taken into account by the research system or by markets for innovation. in fact, the research system as a whole fails to sufficiently consider such ethical and societal aspects. there are countless examples of innovations that have been contested by societal actors because this concerns and/or because of their failure to meet societal needs. grea rri aim is to **adopt the rri plan through the implementation of the RRI roadmap for energy research and applications.**

Regarding to researcher's awareness, although rri was coined as a top-down funding mechanism, the question whether and to what extent the research groups involved had really 'internalised' the label, seeing themselves as representatives of the rri-approach has been addressed at various occasions. also, in the career system of academic researchers, there are hardly any rewards for taking ethics and responsible innovation seriously and general perception that the consideration of RRI in designing research is not adequately rewarded in the careers of researchers. avoid disaffection and reinforce awareness due to practical application is our aim. educating researchers on rri implementing it at different levels (research group, department or institution level), will allow grea to learn how engage society more broadly in its research and innovation activities, increase access to scientific results and their understanding and promote formal and informal science education. arrange surveys, participatory process and training as well as integrate RRI in the ongoing education projects is also our aim.

Social sciences, Ethics and Philosophy as a central feature of RRI not least because openness, transparency, and a broader involvement in research and innovation will require methods, assumptions, and values in research to be explicit, understood, and discussed (Zwart 2014). Therefore, reinforce interdisciplinary in research practices, will allow for continue asking foundational questions (of RRI theoretical background) regarding methods and scientific assumptions. Explore approaches of strategic planning methods such as *Backcasting*[11] and *Transdisciplinarity*[12] that match RRI objectives and the development of these approaches will take into account.

Transdisciplinarity, as a culture and knowledge approach is based in a new form of learning and problem solving, involving cooperation among different parts of society and academia in order to meet complex challenges of society (Klein 2001). Can also approach for arrange public engagement challenge: users, stakeholders and researchers. Responsible approaches of energy issues such as **Energy justice framework** (Sovacool et al 2015) will also review and integrate in this objectives.

2.2. 2 DEVELOPMENT OF THE EIGHT KEY ASPECTS OF RRI BEYOND SIGNIFICANCE

Regarding to development of the eight key aspects of RRI beyond significance we focus in transcend from the keys[13] to research topics and the integration of RRI dimension and attributes in the objectives of the projects. The contextualization of the attributes and the inclusion of different approaches is going to take into account. This process is going to be focused in expansion of the attributes of RRI with frameworks of ethics in technologies and values approaches trying to broad responsibility approach. **Regarding to RRI dimension, GREA is going to focus in translate RRI dimension in research topics, reframe dimensions for its adaptation to energy research such as sustainability and social justice and reinforce the interlinkages between dimensions.**

---

[11] Backcasting is a planning method that starts with defining a desirable future and then works backwards to identify policies and programs that will connect the future to the present.

[12] Is consider an element for identify a fundamental change in the ways that scientific, social, and cultural knowledge are being produced along with the complexity, hybridity, non-linearity, reflexivity and heterogeneity. The new mode of production is "transdisciplinary" in that it contributes theoretical structures, research methods, and modes of practice that are not located on current disciplinary or interdisciplinary maps. One of its effects is to replace or reform established institutions, practices, and policies.

[13] Key and dimension is used indistinctly.

The dimensions (and actions) with special interest for this reframing process are:

- **Gender:** With actions focused in ensuring the effective promotion of both gender equability and gender dimension in research topics.
- **Sustainability:** With actions focused in assessment and developments of performance indicators.
- **Social justice:** With actions focused transcend to research topics, such as energy poverty and assessment and developments of performance indicators.
- **Science education:** With special dedication to arrange and monitoring non-conventional methodologies and alternative approaches.

Reframe sustainability and social justice RRI dimensions taking into account energy research and social sciences insights is consider also an objective derivate for deepen in the development of the eight key aspects of RRI beyond significance specific objective.

GREA RRI plan specific objectives are also related with the enrichments of the indicators for monitoring dimensions with special attention to sustainability and social justice. In this terms, the integration between dimensions in terms of indicators is also part of the assessment process.

2.2. 3 ADAPTATION OF RRI METHODOLOGY TO ENERGY RESEARCH

The adaptation of RRI methodology to energy research is going to consider three elements:

- **Explore the possibility of reframing RETs and TES innovation as Responsible innovation**
- **Use RRI for frame non technological barriers frameworks for RETS and TES.** The case study of the assessments of the public engagement in energy technologies is an example
- **Arrange user's approach to technology transfer**

For **reframing innovation** in terms of social innovation though RRI framework, it must be borne in mind that RRI, emphasize collaboration with industry to potential socio-economic benefits of scientific and technological change[14]. This efforts, not only pushes researchers into close proximity to their private-public 'objects' of research, but may also expand them with the aims and ideologies involved, such as: innovation, creating jobs and similar tangible socio-economic impacts. This path is an opportunity.

In this terms, use RRI for enable accelerated market roll-out of merging innovations, while maximising the outcome of resources invested in research is consider for RETs[15] and innovations.

---

[14] In René von Schomberg definition of Responsible Research and Innovation as a *transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products*; in order to allow a proper embedding of scientific and technological advances in our society is generally being interpreted as a plea for transparency and interactivity as important characteristics, furthermore, the importance of empathize the purpose of the process and thus the outcome in marketable solutions is not minor.

[15] Renewable energy technologies.

Some of the examples for application of this approach that have been take into account in GREA RRI plan are:

- Significant time lag between a technical discovery and the stage when the product reaches the market
- Difficulties to predict what is the society perception of the technology
- The impact of technology might have on the society

Both RETs and **TES technologies face some barriers** to greater market penetration and often the research are focused in overcome these barriers. In most cases, cost is the identified or recognised barrier, but greater deployment in the market face other barriers such as **social acceptance, social and practitioners' knowledge, or recognition of the fact that TES is an enabling technology and** early societal intervention can enable anticipation of positive and negative impacts.

Use RRI for shape **users approach to technology transfer is the last target related with adaptation of the frame to energy research.** Users approach is also related with public engagement and social acceptance framework, however, public participation is only and edge of the public engagement dimension.

Incorporating RRI in RETs and TES R&D, will allow to obtain relevant knowledge on the consequences of the outcomes of their actions and on the range of options open to them, to effectively evaluate both outcomes and options in terms of ethical values (including, but not limited to well-being, justice, equality, privacy, autonomy, safety, security, sustainability, accountability, democracy and efficiency), and to use these considerations as functional requirements for design and development of new research, products and services. **Alternative technology assessment approaches** such as a **Value sensible design (VSD)** (Correljé, Cuppen and Dignum, 2015) will be re-examined.

3. ELEMENTS FOR THE GREA RRI PLAN

3. 1 INDICATORS FRAMEWORK PROPOSAL

The indicators theoretical frameworks of GREA RRI plan are based in intervention logic model based on the explanatory idea that complex policy problems are characterised by a series of issues or problems that need to be addressed. For this purposed a set of inputs which are applied to a series of activities is develop; which generate outputs which lead in turn to outcomes considered the resolution of the problems (Meijer AI, Mejlgaard N, Lindner R, Woolley R, Rafols I, Griesler E, et al. 2016).

The imputs are going to translate in activities and immediate results of those activities are going to become in outputs, leading to outcomes for reaching long term achievements as shown in Figure 3.

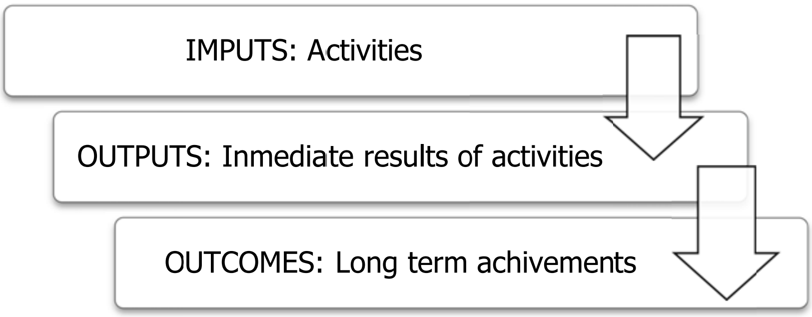

FIGURE 3: Categories for the performance indicators.

To evaluate the continuity of the plan implementation**, the main source of theoretic** indicators for RRI eight key areas are EC RRI process indicators[76] which depends both on the processes that promote RRI activities and on the effects that these processes have (outcome). Those set are distributed in **processes indicators, their outcomes**, and how such processes and **outcomes are perceived** (perception) as shown in Table 4.

Perception indicators are going to be considering as an outcome indicators and process indicators since belong usually to structural mandates are only consider when they can be considered measurable.

Due to the complexities and interlinks between dimensions and in order to include as much information as possible for each dimension indicators, several approaches and sources are considered. In the following chapters, the description for each dimension and attributes of RRI from GREA perspective is indicated, as well of the sources and approaches for consider the indicators.

3. 2 DIMENSION AND INDICATORS PROPOSAL FOR GREA RRI PLAN

3.2 1 PUBLIC ENGAGEMENT

Engagement of all societal actors (researchers, citizens, policy makers, business stakeholders) and their joint participation in the R&I process in accordance with the value of inclusiveness, is reflected in the Charter of Fundamental Rights of the European Union. EU advocate to mutual learning process and agreed practices needed to develop joint solutions to societal problems and opportunities, and to preempt possible public value failures of future innovation.

TABLE 4: European Commission RRI process indicators[76]

Criteria	Performance indicators		Perception indicators
	Process indicators	Outcome indicators	
Public engagement	Number and degree of development of formal procedures for citizens' involvement (consensus conferences, referendum, etc.) Number of citizen science projects, discriminating from those supported by institutions and those that are created at grassroots level, by field	Number (absolute and percentage with respect to the total) and the percentage in terms of funding of projects and initiatives (a) led by citizens or civil society organisations and (b) including research done by citizens or civil society organisations (citizen science) Number of advisory committees including citizens and/or civil society organisations Percentage of citizens and civil society organisations with special responsibilities within advisory boards, committees and consultant bodies (chair, rapporteur, etc.) Number of citizens engaged in citizen science projects	Degree of public interest in science and technology issues: percentage of the total population declaring themselves interested; percentage of citizens indirectly showing interest in science and technology (percentage visiting science centres, percentage participating in demonstrations about scientific issues, etc.) Expectations of responsible science: percentage of population that sees science as part of the solution rather than the problem; percentage of population with high expectation
Gender equality	Percentage of research institutions that document specific actions that aim to change aspects of their organisational culture that reinforces gender bias	Percentage of women that are principal investigators on a project Percentage of women that are first authors on research papers Percentage of research projects including gender analysis/gender dimensions in the content of research	
Science education	The inclusion of an initiative or requirement for RRI-related training in a research strategy/call/work programme, etc. (yes/no, percentage)	At the level of R & I projects, whether they encourage or require young researchers to take RRI-related education/training and to apply it in the project (e.g. in an integrated ELSA model) Percentage of research projects with at least one educational resource deliverable	
Open access	Inclusion of open science measures in research policies and calls for proposals	Percentage of research projects that report real added value by an open science mechanism (for themselves and/or other actors)	The extent to which members of the public have visited vital virtual project environments and found them useful
Ethics	ect component ponent that and ethical ency; qualitative	ch or older of best	
Governance	nformal networks of oth the national and		e,

Our definition of engagement dimension is based in a two-way commitment where on one hand the public agrees to participate in the previous debate and decision-making regarding to research; and on the other hand researchers are committed to carrying out socially relevant research and accompany citizens in their participatory process.

Within the public engagement (PE) dimension, PE mechanisms and initiatives have been classified according to the degree of socio technical integration and the direction of the flow of information following MoRRI project approach (annex A.2.3). In these terms, the indicators for each division are:

- The degree of "socio-technical integration"(EC2013) and the kinds of engagement (Rodriguez et al. 2013) relating to a different category of actors: **Socio technical actors involved**, **stakeholders involved, general public involved** and **socioeconomic actors involved in activities.**
- MoRRI indicators with distention between direction of the flow of information; and horizontal (culture-oriented activities) and vertical (policy-oriented) engagement.

A summary of indicators is shown in Table 5.

TABLE 5: Public engagement dimension indicators for GREA RRI Plan.

Public engagement	Degree of socio-technical integration/ socio technical actors	Direction of the flow of information
	Socio technical actors	PE1 - Models of public involvement in S&T decision making
	Stakeholders involved	PE2 – Policy- oriented engagement with science: number of citizens in advisory committees
	General public involved	PE3 – Citizen preferences for active participation in S&T decision-making: number of citizen engaged in citizen science projects
	Socioeconomic actors involved in activities	PE4 – Active information search about controversial technology
		PE5 – Public engagement performance mechanisms at the level of research institutions: (number and degree of development of formal procedures for involvements for example referendums, conferences)
		PE6 – Dedicated resources for PE (in terms of number and percentage of funding projects and initiatives a-led by citizens or civil associations, b-citizen science initiatives)

3.2 2 SCIENCE EDUCATION

Europe must not only increase its number of researchers, it also needs to enhance the current education process to better equip future researchers and other societal actors with the necessary knowledge and tools to fully participate and take responsibility in the R&I process. GREA shares the aim to boost the interest of children and youth in STEM, so they can become the researchers of tomorrow and contribute to a science-literate society.

The Indicators for Science literacy and scientific education[16] for GREA RRI plan, adapted from MoRRI and EC2015 are:

- SLSE 1 - Importance STEM and RETS in science curricula for 12-18 year olds
- SLSE 2 – Inclusion of RRI related training (i.e. ethical, economic, environmental, legal and social aspects) in a research strategy, call or work programme included in the training of young researchers
- SLSE 3 – Encourage or require young researchers to take RRI related education and to apply to the project (for example an integrated ELSA model)
- SLSE 4 - Citizen science activities

[16] As specified in the analytical report covering this dimension, 'science literacy as it is defined in the context of the MoRRI project is generated through activities aiming to provide citizens with a deeper understanding of science, to shape their attitudes towards science and to develop their abilities to contribute to science and science-related policy-making. Including the co- production of knowledge in the dimension of SLSE, alters the way we think about the public and its role in science and innovation, from a mere receiver and customer to an active agent of change'.

Data collection for indicators, following this approach is costly and could prove rather challenging due to varying educational systems across country. For this purpose, GREA RRI plan consider the arrangement of science education advisory board and educators and researchers focus groups for help in the achievement of this data. The description of this efforts is broader in activities (Section 3.5 7).

3.2 3 GENDER DIMENSION

The dimension of gender equality is defined according to a '*three-dimensional construct'*[76] addressing: ***The (under-) representation of women in research and innovation with the objective to reduce gender segregation; The structural and organisational changes in research institutions with the aim to break down structural gender barriers (by means of action plans, gender budgeting, among others actions)*** and ***the inclusion of gender in R&I content.***

As specified in the analytical report[17] covering this dimension, gender equality has been perceived as closely connected with the ethics and governance dimension, moderately interlinked with science education and non-reciprocally connected to public engagement, whereas no connection exists to the open access dimension[76].

While most large-scale data sets provide information on gender (e.g the gender of respondents), explicit gender issues are rarely included in the content (e.g. gender differences in stem research as an indicator).

The indicators for grea plan are:

- GE1- Institutional measures for engagement in GE: (Percentage of actions that aim to change aspects of their organizational culture that reinforce gender bias)
- GE2 – Percentage of women that are PI
- GE3 – Percentage of women that are first authors on research papers
- GE4 - Promoting gender content in research. (Number of actions to ensure the integration of the gender dimension in research content)
- GE5 – Percentage of research projects including gender analysis in the content of research. (for example Pollution from cooking stoves posing greater risk to women than men, perception of comfort in heating and cooling)
- GE6 - Glass Ceiling Index addresses the issue of vertical segregation, by measuring women's chances of reaching the highest academic ranks relative to men's
- GE7- Gender Pay Gap measures gender variations with respect to annual earnings, and will be used as a proxy for gender equality in the non- academic research sector
- GE8 – Share of female heads
- GE9 – Share of gender-balanced recruitment committees
- GE10 -number and share of female inventors and authors

A special effort for wide the presence of gender topics in research initiatives is the commitment of GREA as seen in GE4 and GE5 indicators. GE8 to GE10 suggested to be measured by surveys and qualitative research.

---

17 https://ec.europa.eu/research/swafs/pdf/pub_gender_equality/meta-analysis-of-gender-and-science-research-synthesis-report.pdf

3.2 4 ETHICS

GREA share the idea that European society is based on shared values. In order to adequately respond to societal challenges R&I must respect fundamental rights and the highest ethical standards. Beyond the mandatory legal aspects, RRI aims to ensure and increased societal relevance and acceptability of R&I outcomes. Applied ethics as a theoretical basis of the RRI approach also serves as a reference when setting attributes of anticipation, inclusion, responsibility and reflexivity, concepts related to the establishment of values and expectations management for achieving a socially relevant impact.

GREA RRI plan considerations for this dimension is based in the fact the ethics dimension covers both epistemic and moral considerations. For moral consideration we are taking into account *Ethical framework of experimental technologies* (Van de Poel, 2015) which proposes a set moral obligations to follow based one or a combination of the four bioethical principles most commonly used. The proposed moral obligations are: **Non-maleficence; Beneficence; Respect for autonomy** and **Justice** (definition of each moral obligation is developed in annex A.1.2 1).

This framework also defines Responsibility as element of reinforcement in the cases, in which one moral principle did not cover the specific obligations and need to be added as an another moral principle that until all obligations were covered. In this frame **Responsibility, indicates that a specific group or person has a duty or responsibility with respect to a certain moral obligation**.

For epistemic considerations, within the dimension of research and innovation ethics, the indicators follow the following conceptual approaches[83]:

- **Ethical governance** or "institutionalising ethics"
- **Ethical deliberation**, or policies for example Technology Assessment (TA) (or ethical constructive Technology Assessment (eCTA))
- **Ethical reflection** that stresses the public engagement aspect in deliberations on S&T ethics [78]

The indicators are show in Table 6.

TABLE 6: Ethics indicators for GREA RRI Plan

Ethics	Institutional ethics	Indicators
	Ethical governance	E1 – General ethics: Number of ELSA project component, trasdisciplinarity component or existing frameworks for address social relevance and acceptability.
	Ethical deliberation	E2 - Ethics Committees: Documented change in ethics committee towards RRI
	Ethical reflection	E3 - Research Funding Organizations Ethics Index will capture national variations in the input, output and context of mechanisms dealing with ethics and societal implications in public and private RFOs
		E4 - R&I ethics priorities (ethics first): Documented changes in R&I priorities attributable to multi-stakeholder and transdisciplinary process of appraisal of social relevance and ethical acceptability, qualitative descriptions and best practices

3.2 5 OPEN SCIENCE

GREA share the approximation of RRI that calls for a new definition of excellence in terms of an analytical excellence and social relevance. This approach also needs to be applicable to the impact assessment for example in the seeking for alternative systems of impact assessments (IA), not based in bibliometric indicators such as the number of citations and indexed publications as well as in economic indicators such as the ability to obtain financial resources in public calls, the degree of internationalization, the number of patents, etc.

In GREA RRI plan, distinctions between open access, open science and open digital science have settled in order to move beyond the dimensions of RRI and based in Open innovation EU strategy framed in annex A.1.4 1.

The considerations for indicators on GREA RRI plan came from:

- MoRRI criteria: Open Access /Open science indicators
- EC Open science indicators
- Open innovation, open science, open to the world EU policy integration
- Open Digital Science project experiences

The indicators are shown in Table 7.

TABLE 7: GREA RRI Plan indicators for open innovation

Open innovation	Open access	Open science	Open digital science
	OA1 - Open Access Literature: number of publications in OA	OS1-Percentage of research projects/research with daily laboratory notebooks online. (outcome indicator)	ODS1-% of peer reviews that include reproducibility and transparency as review criteria
	OA2 – Percentage of research projects reporting added value using open acces	OS2-Percentage of research projects with a virtual environment that is updated and actively used with a threshold frequency (outcome indicator)	ODS2-data communication recognised as criterion for career progression (yes/no)
	OA3 - Social media outreach : measured by the use of social media tools in disseminating OA publications and Open Research data by combining data from Web of Science, Scopus, Mendeley and Altmetric	OS3-Percentage of research projects that report real added value by an open science mechanism (for themselves and/or other actors) (outcome indicator)	ODS3-% of research personnel / research disciplines skilled in OS
	OA 4 - Public perception of Open Access by researchers and public. Extend of public visiting projects virtual enviroments, numbers of members of the public founding contends useful	OS4-The extent to which members of the public has visited such environments and found them useful (Perception indicator)	ODS4-% of research personnel active in OS
	OA 5 - Funder Mandates in institution regarding with OA and support structures for researchers in open access	OS 5- Citizen science projects	ODS5-% of curricula that include OS skills (also prior to higher education)
	OA6.-.Participation in crowdsourcing teams	OS 6-increase in % of citizens engaging in open science	ODS6-% of research personnel aware of standards (is there a standard (relevant to open science), how to adhere to it, etc.)
		OS 7-% of crowdsourced projects	ODS7-% of research personnel aware of standards (is there a standard (relevant to open science), how to adhere to it, etc.)
		OS 8-increase in % of citizens engaging in open science	ODS8-circulating and communicating research results outside the academia is standard (yes/no)
			ODS9-circulating and communicating research results outside the academia is standard (yes/no)

3.2 6 GOVERNANCE

RRI proposes that the different stakeholders work together throughout the research process to increase the relevance of policies. Around this dimension, the RRI takes many practices coming from existing methodologies such as Anticipatory governance, constructive governance and other forms of technological enhancement as value sensitive design (VSD).

The approach of governance in the RRI looking that it can include concepts such as uncertainty, purposes, motives and political and social complexion along with possible paths of research and innovation (Stilgoe, Owen, & Macnaghten, 2013).

Governance dimension is interlink with gender, public engagement, open access, and ethics and this relations provide an evaluation of member state governance systems against a qualitative typology of governance approaches of:

- Institutionalization of governance indicators in terms of RRI dimensions
- Existence of previous governance structures
- Share of research funding and performing organisations promoting RRI (congruent with the present H2020 Key Performance Indicator for SWAFS[39])

The indicators for GREA RRI plan are shown in Table 8.

TABLE 8: GREA RRI Plan governance indicators

Approach	Indicators
GOV1- Institucionalization of governance	Number of RRI formation Number of RRI protocols or frameworks Number of projects adopting RRI framework Number of RRI agreements with companies and private founding organizations Number of RRI agreements with companies and private founding organizations
GOV 2 – Existence of formal governance structures for RRI for RRI within research funding and performing organisations will determine whether RRI is seen as a priority issue for organisations and is supported by a formalised governance structure.	
GOV 3 – Share of research funding and performing organisations promoting RRI. The indicator is congruent with the present H2020 Key Performance Indicator for SWAFS[39].	

3. 3 SUSTAINABILITY AND SOCIAL JUSTICE FRAMEWORKS

Aspects of sustainability and social justice/inclusion deserve special attention, not only because the EU has committed itself to these aspects on the most general level (in the Charter of Fundamental Rights) but also because they are central to the Europe 2020 strategy of smart, inclusive and sustainable growth' to which Horizon 2020 (and, consequently, RRI policy) is a means[18].

Both dimensions also speak to the political guidelines for the EU Commission, which present an agenda for jobs and growth that has a clear eye for fairness and democratic change. The rationale of the Europe 2020 strategy is to address and overcome the shortcomings of the current growth model in order to achieve smart, sustainable and

[18] European Commission (2010), Europe 2020 — A strategy for smart, sustainable and inclusive growth, COM(2010) 2020 final.

inclusive growth. To this end the strategy includes headline targets in five areas: employment, research and development, climate/energy, social inclusion and poverty reduction.

Despite the importance of sustainability and social justice for achieve RRI goals, both are not included in EC RRI concrete indicator proposals due to the **joint process nature**. Also, no metrics and indicators or methodological specifications for indicator selection is recommend in MoRRI assessment framework.

While many, perhaps all, of the six original RRI keys are to some extent related to aspects of inclusion and sustainability, indicators for these keys cannot answer by a simple question such as a: ***What extent does a research field, a research programme or an RRI initiative contribute to inclusive and sustainable growth, and how can this be assessed and monitored?***

Coming up next an adaptation of policy recommendations as well theoretical indicators frames are presented for GREA plan, highlighting the interconnection of both dimensions through inclusive and sustainable EU growth challenge.

Social justice interlinks with inclusion RRI attribute is also take into account. Sustainability and energy justice, share the seeking for **Good governance** in terms of the right to all people to have access to high-quality information about energy and the environment. Information, accountability, and transparency have become a central element of promoting "good governance" throughout a variety of sectors, a term that centres on democratic and transparent decision-making processes and financial accounting, as well as effective measures to reduce corruption and publish information about energy revenues and policies.

In GREA RRI plan, both dimensions will be treated from the point of view of the responsible approach and from the application of the energy study as a discipline.

3.3 1 SUSTAINABILITY DIMENSION AND INDICATORS

The considerations for Sustainability in GREA RRI plan are going to encompass both responsibility approach and energy research considerations. Sustainability through inclusive and sustainable growth challenge is considered as *development that meets the needs of the present without compromising the ability of future generations to meet their own needs*[19] Brundtland Commission[20] termed understand this dimension as the duty of states to ensure the sustainable use of natural resources. It means that countries have sovereign rights over their natural resources, that they have a duty not to deplete them too rapidly, and that they do not cause undue damage to their environment or that of other states beyond their jurisdiction.

Energy research reinforce sustainability dimension in terms of clean, reliable, and affordable (sustainable) energy, linked critically for achieving inclusive, low-emissions growth and development (Sovacool et al., 2016). Sustainable energy can influence human progress; creating jobs and economic competitiveness, empower women

[19] World Commission on Environment and Development (WCED). Our common future. Oxford: Oxford University Press; 1987. p. 43

[20] European Commission (2010), Europe 2020 — A strategy for smart, sustainable and inclusive growth, COM(2010) 2020 final.

(Eberhard et al., 2011); lead to new global markets for goods and services (Bairiganjan et al., 2010); alter regional energy trades (Saadi, Miketa and Howells, 2015) and help to ensure that environmental impacts of economic development are minimized (Birol, 2014).

Sustainable development and climate change, including information on the amount of climate change related expenditure is considered as Indicators for monitoring Horizon 2020 Cross-Cutting Issues. This was implicitly recognised when Horizon 2020 set out specific priorities, such as 'societal challenges', and specific objectives for these priorities, such as 'secure, clean and efficient energy' and others.

Indicators framework for sustainability dimension, based in Eurostat's indicators for research and development[21] they are mostly concerned with the headline target for R & I. They do present one indicator more directly targeted towards sustainability, namely the number of patent applications of technologies or applications for mitigation or adaptation against climate change. The Sustainable Development Indicators (SDIs) SDI framework additionally includes a theme of 'socioeconomic development', which focuses on the key objective of economic prosperity, and a theme on 'good governance' related to the guiding principles of the EU SDS and other cross-cutting issues[22]. The most recent changes to the indicator set followed the adoption of the Europe 2020 strategy[18] and its eight headline indicators, which have been integrated into the SDI framework in the themes 'socioeconomic development', 'social inclusion' and 'climate change and energy'.

For GREA RRI plan, climate change and energy theme is going to take into account in terms of:

- Sustainable transport
- Natural resources
- Global partnership
- Good governance

In this terms qualitative indicators are set up monitoring the number of projects with thematic related with these topics.

Report of Indicators for promoting and monitoring Responsible Research and Innovation[23] (EC 2015) indicate that since the nature of process and perceptions indicators lays in milestones and specific pathways that have effect on specific interactions between renewable and non-renewable resources and consumption and regeneration (annex **A.2.4 2**), meanwhile both milestones and pathways are still under construction, as of today there is no obvious place for such indicators in current policy practice.

Qualitative indicators in terms of *what extent does a research field, a research programme or an RRI initiative contribute to inclusive and sustainable growth, and how can this be assessed and monitored*? Are proposed.

[21] http://ec.europa.eu/eurostat/help/first-visit/content

[22] 2015 monitoring report of the EU Sustainable Development Strategy2015 edition from http://ec.europa.eu/eurostat/documents/3217494/6975281/KS-GT-15-001-EN-N.pdf

[23] Indicators for promoting and monitoring Responsible Research and Innovation, Roger Strand, Jack Spaapen, Martin W Bauer, Ela Hogan, Gema Revuelta, Sigrid Stagl Contributors: Lino Paula, Ângela Guimarães. EC2015

Adapting Kettner, Köppl and Stagl (2014) proposal perception and process indicators for sustainability as a dimension of RRI for GREA RRI plan are:

- **Perception indicators:** What is the anticipated effect of this research contribute to sustainable development? How the anticipated research will contribute to sustainability by RETs and TES
- **Process indicators:** Defined to monitor the efforts and developments being made towards the expected outcomes and can be defined in terms of milestones on specified pathways
- **Number of projects with thematic related with** Sustainable transport; Natural resources; Global partnership and Good governance

When taken together, perception and process indicators may provide a basis for RRI governance in the sense of improved responsiveness and accountability among R & I actors.

3.3 2 SOCIAL JUSTICE DIMENSION AND INDICATORS

Social justice is approached in GREA RRI plan in terms of RRI recommendations thought the interlinks of inclusion attribute and though energy research integration.

Social justice can be defined as 'an ideal condition in which all individual citizens have equal rights, equality of opportunity, and equal access to social resources' (Maschi and Youdin, 2012) and National social justice policies are focus on investing in achieving inclusion rather than compensating for exclusion. The effectiveness of such policies is measured by monitoring progress in six elements : **poverty prevention, access to education, labour market inclusion, social cohesion and non- discrimination, health and intergenerational justice** (OECD, 2011).

The role of science and technology in promoting social justice is very important. Social justice, although not explicit, is a transversal theme running through most, if not all, societal challenges of the Horizon 2020 framework. However, to date no attempts to measure how social justice is actually addressed through R & I activities have been observed.

The connection between science and technology and social justice is recognised through acknowledging the role of **science and technology education** (Dy, 1994) and **technological developments**, especially in the area of information and communications technology (ICT), in promoting social justice (Vrasidas, Zembylas and Glass, 2009), as well as the consideration of ethical issues and values in the design, development and implementation of new technologies[24].

In the last decade growing attention has been given to distributional justice issues[25] in energy matters, with a body of work of **Energy justice** emerging with connections to previous social, environmental and spatial justice work (Sovacool and Dworkin, 2014, Sovacool et al., 2013 and Bickerstaff et al., 2013).

[24] Ageing project: incorporating European fundamental values into ICT for ageing: a vital political, ethical, technological, and industrial challenge (http://www.value-ageing.eu)

[25] Distributive justice concerns the nature of allocation of goods in a society.

Formulations of distributional social justice have been drawn on to inform work beyond that traditionally considered as the concerns of social justice such as an environmental justice, where the distribution of environmental hazards and goods across social groups is of concern (Yenneti and Day, 2016). A development of the concepts of procedural, distributive and energy justice framework are explained in annex A.3.2 1.

Examples to distributional justice in renewable energy technologies are for example the **observed perception that environmental and social impacts**, such as noise, visual impacts, and **land and habitat loss**, occur mostly at the local level where projects are hosted (Mallon, 2006). Some studies have also connected distributional fairness and its perception with the extent to which procedural justice[26] is seen to be done, through transparent and open decisions making (Gross, 2007 and Zoellner et al., 2008); echoing the wider environmental and energy justice literature on the connection and complementarity between procedural and distributional justice (Shrader-Frechette, 2002 and Walker and Day, 2012).

In the case of social justice, since indicators are measuring by level of commitment and qualitative indicators for identify best and worst practices, substantial resources are required in order to meaningfully monitor the indicators. Only within fields where the link between research and social justice is found to be evident or at least relevant (several scientific fields may be excluded here) is required (annex A.2.4 3).

Social justice directly in the context of research activities can be considered from two perspectives. These two perspectives are key to developing indicators to address social justice issues in the context of R & I:

- **Relationship between the researchers and the research subjects**
- **Participation of social groups in benefits arising from research**

Relationship between the researchers and the research subjects, concerned with researchers unfairly taking advantage of research subjects and imposing unfair burdens on them for their own benefit or the benefit of others. This relationship lies firmly within the field of research ethics and should be incorporated in the indicators for the **ethics key**.

Participation of social groups in benefits arising from research, involves the potential unfair exclusion of particular groups from either participation in research and/or access to benefits arising from research (European Commission, 2010). This indicator encourages equal participation of social groups in benefits arising from research goes beyond what is usually included in the ethics key as currently practiced.

From energy justice framework, **qualitative** are included regarding to:

- **Good governance:** All people should have access to high-quality information about energy and the environment. Information, accountability, and transparency have become a central element of promoting "good governance" throughout a variety of sectors, a term that centres on democratic and transparent decision-making processes and financial accounting, as well as effective measures to reduce corruption and publish information about energy revenues and policies.

[26] Procedural justice is the idea of fairness in the processes that resolve disputes and allocate resources.

- **Responsibility:** This element of energy justice is perhaps the most controversial and complex, as it blends together four somewhat different notions of "responsibility": Responsibility of governments to minimize environmental degradation; Responsibility of industrialized countries responsible for climate change to pay to fix the problem (the so-called "polluter pays principle"); Responsibility of current generations to protect future ones and Responsibility of humans to recognize the intrinsic value of non- human species, adhering to a sort of "environmental ethic.

Activities and their contribution in achieving social justice/inclusion are going to be proposed for this dimension.

3. 4 TRANSVERSAL ATTRIBUTES DESCRIPTIONS

Transversal attributes of GREA RRI plan, consider attributes of RRI such as Anticipation, reflexivity, responsiveness and inclusion together with ethical frameworks for technology and responsibility consideration for energy research and social sciences frameworks.

The assessment of the transversal elements is going to arrange thought indicators of impact following Stilgoe (Stilgoe et al. 2013) recommendation and clarification of the RRI dimensions at university governance level[27]. The indicators for attributes are going to be measured by the numbers of applied indicative techniques and approaches vs factors affecting implementations. For GREA RRI plan proposal, the interconnections between dimension is going to take into account in terms of indicators.

In the case of the attributes, rather than indicators, initiatives applied in the process, factors affecting the implementation and actions for foster are proposed.

The descriptions of attributes for GREA RRI plan are described in below chapters.

3.4 1 ANTICIPATION

Anticipation is considered as an inclusion of new perspectives in the research and innovation process as well as to think through various possibilities to be able to design socially robust agendas for risk research and risk management. Is consider a mix between prediction and participation and it differs from the prediction for its explicit recognition of the complexities and uncertainties of the evolution of science in society (Barben et al., 2008).

Anticipation also emerges as an alternative to remove barriers to interdisciplinarity (Guston, 2012). This is an attribute on which they have built methodologies as Constructive Technology Assessment (CTA) (Rip et al., 1995), Real-Time Technology Assessment (RTTA) (Guston and Sarewitz's (2002) and the Upstream public engagement (Wilsdon and Willis, 2004) involving discussions and design of future scenarios that fall within the concept anticipatory or anticipatory governance.

[27] Concept paper for the 20th STI 2015 ENID Conference Lugano, 2-4 September 2015 Responsible Research and Innovation and the science-society link: new tools and approaches for the evaluation of universities.

Factors affecting the implementation for inclusion are:

- Engaging with existing imaginaries
- Participation rather than prediction
- Plausibility Investment in scenario-building
- Scientific autonomy and reluctance to anticipate
- Rethinking

3.4 2 INCLUSION

The rise of demystifying the authority of the expert and the proliferation of top-down methodologies has been considered as an increase in inclusion. The inclusion goes beyond the participation of stakeholders and gradually included in discussions about governance to the general public.

The tools considered for foster inclusion are considered citizen's juries, participatory conferences, working groups and roundtables that in many cases allow a debate 'upstream' technology generated in the scientific process. They can also consider the generation of multi-sector consortia, including external members on scientific committees giving place to the approach of inclusive governance.

The considerations to achieve this attribute are not exempt to controversy and often considered short-termed. *"Technically is political, politics should be democratic and democracy should be participatory"* (Moore, 2010, p. 793) is one of the consideration regarding with this issue. To overcome this consideration of strengthens the debate and public participation, as a beneficial element for society not as a tool to achieve governance objectives (Chilvers, 2009) is recommended. Inclusion is also associated with diversity and both elements are included in the RRI approach, understanding society as a whole where special attention to minorities and underrepresented groups.

The practical implementation of inclusion is related the consideration of inclusion attribute, as involvement of diverse stakeholders (such as users, NGOs, etc.) in the process to broaden and diversify the sources of expertise and perspectives.

Factors affecting the implementation are:

- Questionable legitimacy of deliberative exercises
- Need for clarity about, purposes of and motivation for dialogue
- Deliberation on framing assumptions
- Ability to consider power imbalances
- Ability to interrogate the social and ethical stakes associated with new science and technology
- Quality of dialogue as a learning exercise

3.4 3 REFLEXIVITY

Reflexivity is an attribute with different meaning depending on the proximity with other approaches. Which is closer to **governance**, reflexivity is considered as an act of revising the actions with the awareness of the limits of knowledge and encouragement to think about their own ethical, political or social assumptions to enable them to consider their own roles and responsibilities in research and innovation as well as in public dialogue.

Related with **ethics**, it is considered as an element for connecting external value systems with scientific practice (Stilgoe et al, 2013). In this terms, mechanisms such as a codes of conduct, adoption of standards and regulations are considered useful for achieving these attribute elements.

In the context of **research**, reflexivity focuses on awareness after an action. Reflexivity is an attribute that expresses a consciousness researcher, talking about its connection with the status of research and denotes a process in which the researcher reflect him/herself to critically examine the effect on the study and the impact of interactions with participants. The reflective process permeates all levels of a research study and is present in all phases from the research question to fieldwork, data analysis to the final preparation of the report.

Factors affecting the implementation are:

- Rethinking moral division of labour
- Enlarging or redefining role responsibilities
- Reflexive capacity among scientists and within institutions
- Connections made between research practice and governance

3.4 4 RESPONSIVENESS

This attribute is associated in the RRI approach to adaptation and inclusion considered as the ability to change, redirect and adjusted to meet the actors involved transcending the epithets of beneficiaries, users, managers, decision makers when it notes that there is insufficient control and knowledge. The capacity to change its direction or shape when it becomes apparent that the current developments do not match societal needs or are ethically contested, referring to the flexibility and capacity to change research and innovation processes according to public values.

In the RRI approach, responsibility means answering to emerging perspectives, viewpoints and regulations and to be placed in a governance environment and policies where outputs and purposes that transcend the Great challenges at are the same level (Lund Declaration, 2009) to the challenges of society (Von Schomberg 2013).

To achieve this attribute, studies indicate that it is necessary to foster a deliberative scientific culture, a thoughtful and responsible science education, a culture of openness and operational transparency, creativity, interdisciplinarity, experimentation and risk-taking, leadership and commitment to citizen participation in terms of taking into account the public interest.

Responsibility also has been linked to the products obtained and the results that may be unacceptable and harmful (Stilgoe 2013) for both people and the environment. This approach requires the definition of values in terms of socially acceptable and relevant impact.

Factors affecting the implementation are:

- Strategic policies and technology 'roadmaps'
- Science-policy culture Institutional structure
- Prevailing policy discourses
- Institutional cultures
- Institutional leadership
- Openness and transparency

- Intellectual property regimes
- Technological standards

A summary of the recommendation for foster attributes and factors affecting implementation is show in Table 9. There is and extensed literature reporting the use of this methods , often considered as a RRI background techniques.

Table **10** shows the background techniques of responsibility approach related with theoretical concepts, practical objectives and governance attributes of RRI policy.

Table 9: Recommendation for foster attributes and factors affecting implementation

Attributes	Fostering frameworks and resources	Number of initiatives applied in the process	Factors affecting the implementation
Anticipation	Foresight Technology assessment Horizon scanning Scenarios techniques Vision assessment Socio-literary techniques	A1-Foresight Technology assessment A2-Risk scenarios A3-Horizon scanning Scenarios A4-Vision assessment A5-Socio-literary techniques A6-Integration the result of anticipation techniques in research activities	- Engaging with existing imaginaries - Participation rather than prediction - Plausibility Investment in scenario-building - Scientific autonomy and reluctance to anticipate - Rethinking
Inclusion	Consensus conferences Citizens' juries and panels, Focus groups Science shops Deliberative mapping Deliberative polling User-centred design processes	I1- Citizens' juries and panels I2-Focus groups I3-Science shops I4-Deliberative mapping I5-Deliberative polling I6-Lay membership of expert bodies I7-User-centred design I8-Open innovation I9-Including the participation of non-academic stakeholders from very beginning of the research projects	- Questionable legitimacy of deliberative exercises - Need for clarity about, purposes of and motivation for dialogue - Deliberation on framing assumptions - Ability to consider power imbalances - Ability to interrogate the social and ethical stakes associated with new science and technology - Quality of dialogue as a learning exercise
Reflexivity	Multidisciplinary collaboration and training Embedded social scientists and ethicists in laboratories Ethical technology assessment	RF1-Multidisciplinary collaboration and training RF2-Embedded social scientists and ethicists in laboratories RF3-Ethical technology	- Rethinking moral division of labour - Enlarging or redefining role responsibilities - Reflexive capacity among scientists and within institutions - Connections made between research practice and governance

	Reframe Codes of conduct	assessment RF4-Codes of conduct RF5-Guides and standards RF6-Moratoriums RF7-Conections between external expectations	
Responsiveness	Constitution of grand challenges and thematic research programmes Regulation Standards Open access and other mechanisms of transparency Alternative TA methods such as a Value-sensitive design and Stage-gate Alternative intellectual property regimes	RS1-Constitution of grand challenges and thematic research programmes RS2-Regulation Standards RS3-Open access RS4-Mechanisms of transparency RS5-Niche management RS6-Value-sensitive design RS7-Moratoriums RS8-Stage-gate RS9-Changing the directions of the activities under development when the knowledge and control on possible effect are insufficient RS10-Alternative intellectual property regimes	- Strategic policies and technology 'roadmaps' - Science-policy culture Institutional structure - Prevailing policy discourses - Institutional cultures - Institutional leadership - Openness and transparency - Intellectual property regimes - Technological standards

Table 10: Background techniques of responsibility approach related with theoretical concepts, practical objectives and governance attributes of RRI policy.

Theoretical concept	Background techniques/ Operational elements	Objective	Related RRI attribute
Action of consider the contingency of the products, process and purpose of STI involving systematic thinking for increasing resilience, and revealing new opportunities for innovation	Foresight Upstream public engagement Horizon scanning Constructive Technology assessment Cost-benefit analysis Impact assessment Life-cycle assessment Risk assessment	Identification and appraisal of risks, potential positive and negative impacts of research and innovation	Anticipation
Multifaceted concept related with the researcher evaluation as an organising principle of science and moral responsibilities	Multidisciplinary Transdisciplinarity Ethical technology assessment Codes of conduct Moratoriums Midstream modulation	Socio-technical integration and interdisciplinarity in research and innovation	Reflexivity
Public and stakeholder engagement with research and innovation, for the inclusion of new voices in the governance of science and innovation as part of a search for legitimacy	Consensus conferences Citizens' juries Focus groups Science shops Citizen science Participatory research Deliberative mapping Deliberative polling User-centred innovation Open source innovation Participatory innovation Constructive TA Co- evolutionary approaches Backcasting Multi-stakeholder	Public and stakeholder engagement with research and innovation	Inclusion

	partnerships Participatory agenda setting Upstream engagement Crowdsourcing		
Process for assessment products, and outcomes and modulate the process of research in STI in the case where insufficiency of knowledge and control is detected	Regulation Standards Codes of ethics Research integrity Niche management Value-sensitive design Stage-gates Alternative intellectual property regimes	Identification and appraisal of ethical and societal aspects of research and innovation	Responsiveness

Source: Adapted from (Stilgoe 2013 andRribeiro et al. 2015) and enriched by the authors.

3. 5 ACTIVITIES

3.5 1 THEORETICAL CONSIDERATIONS FOR ACTIVITIES FRAMEWORK

As seen in dimension description and contextualization, there are several methods for arrange activities for reach[13] the objectives of RRI approaches. These methods are developed in annex A.2 and A.3.

A review of the methods connected to RRI in the academic literature (Ribeiro et al. 2016) is show in Table 9 and Table 10.

Also the barriers regarding to the RRI implementation collected in Section 1. 3 indicate:

- **Lack of practical experiences**
- **Low level of researcher's awareness**
- **Implication of *Foundational issues***
- **Absence of standard Monitoring frames and indicators**

In this terms and for the successful implementation of the RRI plan, a series of **drivers** are going to arrange indicating the RRI dimension and attribute that it intends to cover as well as the theoretical framework and recommendation taken into account for each activities[28], as well the description of the activities.

[28] The activities are actions that will be produce tangible and measurable results in term of organisational process and structures of all the project partners. The selection of the activities will be done based on the RRI defined keys following the criteria expressed in background and to facilitate its later monitoring.

The proposal of activities is going to follow the same structure of the proposed objectives in terms of general and specific objectives developed in Table 3. The creation of a Science shop will allow to vertebrate initiatives for achievement the objectives of the plan as well be the host of the activities.

The drivers and activities are developed in following chapters.

3.5 2 DEVELOPMENT OF FOUNDATIONAL ISSUES RELATED ACTIVITIES

Some activities were proposed in order to identify the dimensions and attributes of RRI and evaluate the relationships between science and society for GREA. Those activities were conducted previous to the RRI plan arrangement.

- **Identify good practices**
- **Analyse the internal governance and the decision-making to identify barriers for the implementation, based Res-Agora project de facto Governance appraisal and MoRRI project appraisal**
- **Identify dimensions**
- **Identify interlinks within dimensions**
- **Identify interpretations for renewable energy research context**
- **Identify public engagement frame for Energy research**
- **Identify Sustainability frame for Energy research**
- **Identify Social justice frame for energy research**
- **Identify Open access/open science dimension for researchers**
- **Identify transversal attributes**
- **Multidisciplinary advisors panel arrangement: Science education dimension advisory board and interdisciplinarity panel**
- **Arrange public advisory boards**

Also, applied ethics and humanities activities are comprised in this driver. It will focus mainly on the review of policies, standards and methodologies as well as in assessing the impact of all actions taken:

- **Generation and implementation of ethics committees and best practice guidelines**
- **Ethics frame identification**
- **Training in open access content and responsible for intellectual property management and RRI for researchers**
- **Generation and implementation of tools for assessing the impact of actions associated with RRI and moral and social dimensions of research**

Also, initiatives for reinforce researcher's awareness are comprised in the development of foundational issues. Activities regarding with reinforce researcher's awareness examples are:

- **Integrate RRI formation in PhD programs**
- **Training and educating researchers on RRI implementing at different levels (research group, department or institution level)**
- **Promote formal and informal science education programs**

3.5 3 GREA SCIENCE SHOP[29]

Science Shops are small entities that carry out scientific research in a wide range of disciplines – usually free of charge and – on behalf of citizens and local civil society[30]. The fact that Science Shops respond to civil society's needs for expertise and knowledge is a key element that distinguishes them from other knowledge transfer mechanisms. A Science Shop provides independent, participatory research support in response to concerns experienced by civil society and is considered a driver for achieve public and stakeholder engagement with R&I.

Different types of interfaces exist between researchers and society, one of which are 'Science Shops', organisations created as mediators between citizen groups (trade unions, pressure groups, non-profit organisations, social groups, environmentalists, consumers, resident's association etc.) and research institutions (universities, independent research facilities). Science Shops are also, important actors in community-based research (CBR).

As a mission statement, Science Shops seek to:

- Provide civil society with knowledge and skills through research and education
- Provide their services on an affordable basis
- Promote and support public access to, and public influence on, science and technology
- Create equitable and supportive partnerships with civil society organisations
- Enhance understanding among policymakers and education and research institutions of the research and education needs of civil society
- Enhance the transferable skills and knowledge of students, community representatives and researchers

Science shops are considering a powerful interface of researchers and society and has been tested in many Universities fruitfully.

The GREA science shop will develop activities focused in fostering RRI dimensions with core activities for **public engagement, science education and open science keys.** GREA science shop will be the meeting point between students, researchers and citizens who come to launch projects and will be focused on generating creative and divergent

[29] Science shops are considered one of the first attempts to conciliate science and citizen participation and emerged in various European universities, especially in the Netherlands throughout the 70 Initiated by groups of students and university staff ideologically connected with movements May 1968, its creation coincided with the demand for college education models project-based learning (PBL) and an emerging environmental awareness in society. From the 80s is beginning to develop science shops in Germany, France, Denmark and Belgium.

[30] http://www.livingknowledge.org/science-shops/about-science-shops/

thinking in the public about scientific issues, creating communication links between researchers and citizens, stimulating an awareness among researchers about the problems of the community and the establishment of closer relations between scientists and the general public.

Examples of actions for arrange in the science shops are:

- Advice for the implementation of projects of local and regional interest, with particular interest and gender minorities and advice to entrepreneurs and start-ups about European funding routes.
- Entrepreneurship projects, Think Tank and Challenges for municipalities and the region with transnational projection, as to the energy challenges, sustainable mobility, supply, energy poverty, and sustainability and innovation in general.
- Review and strengthen the multidisciplinary approach within the institution for vertebral projects of this nature.

Science shops is going is going to represent a physical place for researcher's and citizen's interchanges and the *home* of the RRI plan. This physical space, is necessary for arrange most of the activities regarding to bridge stakeholder's diversity.

3.5 4 USERS APPROACH TO TECHNOLOGY ACTIVITIES

Methodological approaches followed in the participatory processes contribute to addressing the challenges of different "languages" between different actors: by involving designers and using creative methods as translators between non-experts and expert's communication issues have diminished. In fact, what is practiced within the RRI unit can be classified as what Fisher et al. call "**midstream modulation**" (Fisher et al. 2006).

The main focus lies on fostering knowledge transfer between actors from within and without the science system, in this case part of the work that is done within the GREA. Develop, evaluate and apply **participatory foresight processes** and user oriented processes of technology transfer is the objective. Participatory foresight process aims to "foster technology transfer, [...] defined [...] as the exchange of ideas, findings, and methods of production and management among research institutions, industry, and the public with the purpose of making scientific and technological advances accessible and appealing to a wider range of potential users such as consumers and licensees" (Schraudner/Wehking 2012).

The focus lies on interdisciplinary idea generation and evaluation to shape research agendas and to support spin offs resulting from those ideas. They are mainly characterised by a strong emphasis on translation efforts between the actors involved: by giving designers an important role as translators between non experts and experts, an effort is made to avoid the premature closing down of discussions and misunderstandings.

Very briefly, the approach followed consists of various stages:

- First, people unfamiliar with but interested in a specific field are brought together to brainstorm and generate ideas, supported by a creative and inspiring environment.
- In a second step, these ideas are visualised by designers, for instance by designing prototypes or developing small business cases.

- In a third step, these materialised ideas are discussed and evaluated by experts in the field in order to assess feasibility and novelty.

This activity will focus in PE, open access and governance dimensions and are going to take place in GREA science shop.

3.5 5 ADAPTATION OF RRI METHODOLOGIES TO RESEARCH AND INNOVATION SOLUTIONS ACTIVITIES

The proposed activities for adaptation of RRI methodologies are

- **Explore the possibility of reframing RETs and TES innovation as Responsible innovation**
- **Use RRI for frame non technological barriers frameworks for RETS and TES.** The case study of the assessments of the public engagement in energy technologies is an example
- **Translate RRI dimensions in energy research topics**

Some examples of this activities are:

- Responsible Industry collaborations
- **Market roll-out initiatives of merging innovation**
- **Arrange international RRI instances**

Regarding to **use RRI for frame non technological barriers frameworks for RETS and TES, an experience with** the assessments of the public engagement in energy technologies is proposed. **Public participation as only and edge of the public engagement dimension and all the aspects of this dimensions and the relation with the non-technological barriers of RETs is going to arrange.**

Regarding with the generation and fomentation of research topics including the RRI dimension variable and inclusion in advanced energy research is one of the aims and transcend beyond RRI dimension definition. Social science approach regarding with contemporary energy research production, advocate for reduce disciplinary bias, strength scientist's collaboration beyond their fields and approach energy research more problem-oriented, including social perspectives and neglected topics (Sovacool, 2014) as:

- Gender and identity
- Philosophy and ethics
- Communication and persuasion
- Geography and scale
- Social psychology and behaviour
- Anthropology and culture
- Research and innovation
- Politics and political economy
- Institutions and energy governance
- Energy and development
- Externalities and pollution
- Sociology of technology

For this reinforcement a **Panel/advisors group with educators and sociologies is going to arrange.**

3.5 6 COMMUNICATION AND TRANSMEDIA CULTURE ACTIVITIES

Generation and coordination of the contents of external and internal communication as well as actions to promote scientific culture through the use of artistic and cultural resources will arrange in order to archive interdisciplinarity and open science dimensions. A drive to promote the use of non-conventional platforms and social outreach and advise researchers to enable them to carry out content.

Exhibitions, debates, science cafes and participation of researchers in existing initiatives such as the night of researchers, will support and arrange. **This activity will focus in PE, open science and interdisciplinarity.**

One example of this activity is the continuous celebration of the Researchers night at the University of Lleida.

Some more examples of activities regarding to scientific communication are:

- How to communicate climate change? forum with journalist and educators
- Researchers night at the University of Lleida

3.5 7 SCIENCE EDUCATION ACTIVITIES

Shares in science education are divided into those associated with formal and non-formal education. *Formal education,* include the promotion of scientific careers in STEM[31] in school and improving the current education of future researchers so that they can be really able to participate fully and take responsibility representing research and innovation throughout the process. In both cases it should be noted the development of this dimension to be like in bidirectional process where both researchers and citizens to benefit from the scientific, participatory education, with initiatives such **citizen science** and general outreach activities such as a science fairs, open laboratories, science cafes, scientific events and festivals, enrichment educational programs. *Formal* education initiatives are structured through primary and secondary schools, higher education institutions, and university and participatory activities as educational enrichment programs and residential programs for young researcher's pre-university or college.

In the case of *non-formal* education, the same can be done from the universities through units of Creating STEM education programs for children, adults, Lifelong learning and citizen science activities and integration RRI in the ongoing education projects.

The proposals for science education activities are:

- GREA Energy school: Initiative consisting of training students and all actions aimed at promoting science education in the town of Puigverd de Lleida and citizen participation in space science and technology.
- Girls in Energy: Fostering STEM education for girls.
- **GREA Citizen Science pilot:** The pilot projects will be based on citizen science projects about energy consumption and efficiency.
- Research in school forum
- Reflexions about Capital science concept forum

[31] STEM corresponds to Science Technology, Engineering and Maths.

The focus in interlinks between PE, open science as well as gender and science education. This driver comprises the arrangement of a focus group of educators and school professors and its consolidation a science education dimension advisory board.

3.5 8 OPEN SCIENCE/ICT ACTIVITIES: CITIZEN SCIENCE AND CROWDSOURCING COMMUNITIES

The increasing importance of open science and the related fields is evidenced by a growth of open data and open access sources as well as an increase in the use of the related terms by scientists world-wide is one of the most important insights of the open science strategies. Open science dimension shares important characteristics with information and communication technologies (ICT) that are going to take into account for arrange these activities.

The massive use of new ICT in research with the example of MOOCs.

Open science based in ICT allows to transcend from the researchers to the society and explore innovative methods for arrange initiatives. Some of the examples, based in ODS project are:

- **Use personal devices for open science and interchange activities.**
- Trend towards storing data in a cloud of internet-based servers
- **Mobile computing, internet-of-things**
- Open and do-it-yourself approaches
- Converged and integrated systems
- ICT innovation in renewable energies
- **Crowdsourcing research pilot**

An important driven for open science dimension is the increase of ICT in renewable energies and the shift in citizens from consumers to producers of energy is dramatically changing energy networks. Rifkin, (Rifkin 2008) calls this development the 'third industrial revolution' based on an 'internet of energy'. As example, the transcendence of smart meters regarding with public engagement dimensions is going to evaluate.

An example of a ict activities related with researchers, is a **Crowdsourcing research pilot.** In the case of the reported project applying crowdsourcing research, the methodology proposed is based in the participation of diverse teams, instead of the single team which takes the multiple roles of create ideas and hypotheses; scrutinize the data in search of confirmation and try different approaches to reveal flaws in the findings. Alternative set-up, implies for example conformation of findings conducted by other research teams with alternative approaches. Silberzahn et al. (silberzahn and eric l. Uhlmann, 2015) approached the data with a wide array of analytical techniques, and obtained highly varied results followed by organized rounds of peer feedback, technique refinement and joint discussion to see whether the initial variety could be channelled into a joint conclusion. They found that the overall group consensus was much more tentative than would be expected from a single-team analysis.

Following Silberzahn and Eric L. Uhlmann methodology we will arrange a crowdsourcing research pilot with the following steps:

- Set up one research question
- Select research teams

- Organize rounds of peer feedback
- Technique refinement
- Joint discussion to see whether the initial variety could be channelled into a joint conclusion
- Invited all the researchers to discuss the results
- Exchange reports in light of others' work (in other words, to express doubts or confidence about their approach)
- Presented the teams' findings in a draft manuscript, which the participants were invited to comment on and modify

Also, GREA RRI plan will participate in the **Pilot on Open Research Data Open data** is free to use, reuse, and redistribute. As part of this experience the initiatives are:

- Develop and update regularly a Data Management Plan (DMP)
- Deposit our data in a research data repository
- The data and metadata will be stored on the Universitat de Lleida server, which obeys the law of data protection in Spain "Ley orgánica 15/1999, de 13 de diciembre, de protección de datos de caracter personal"
- Make sure that third parties can freely access, mine, exploit, reproduce and disseminate it
- Make clear what tools will be needed to use the raw data to validate research results (at this stage none has been yet selected)
- The Intellectual Property Rights of the data collected will be held by the members of the group; they will share those rights in the same way as the results

The strategy for knowledge management and protection are:

- **Basic Principle for the Management of Intellectual Property Rights (IPR):** Basically, the general principles for Intellectual Property Aspects will apply, as set out by the EC. Existing know-how (such as background or pre-existing intellectual property) of a specific partner shall be made available on transfer conditions to the partner(s) within the consortium that need this information for the proper execution of their tasks within the scope of the project. The use of such existing know-how is strictly limited for use to the achievement of the project goals and for the duration of the project.
- **Foreground:** (e.g. results, including intellectual property generated during the project) shall be owned by the partner or partners who developed the results. Each partner is responsible for taking the appropriate steps for securing intellectual property of the knowledge or results created during the project (e.g. filing of patent applications).
- **Results:** (resulting from the project) owned by one or more of the partners shall be licensed to other partners of the consortium on favourable conditions to the extent necessary to enable these partners to exploit their own results.
- **Publication of results:** The participating academic partners are entitled to use knowledge or results from the project that either have been published or have been declassified, for research and teaching purposes.

One of the pages of the website will contain an overview and archive of all published information: scientific articles, publications, press releases, conference papers, etc.

Citizen science activities will cover science educations, public engagement, ethics and open science dimensions.

A summary with the activities and drivers is shown in Table 11.

TABLE 11: summary of GREA RRI Plan activities and driver's proposal

Drivers	Activities
Development of foundational issues activities	**Identify good practices** ▪ To analyze the internal governance and the decision-making to identify barriers for the implementation, based Res-Agora project de facto Govenance appraisal and MoRRI project appraisal. ▪ To identify dimensions, interlinks within dimensions. interpretations for the renewable energy research context, the public engagement framework for Energy and ICT research, the sustainability framework for Energy and ICT research, the social justice framework for Energy and ICT research, the open access/open science dimension for researchers, transversal attributes. ▪ To engage a multicisciplinary advisors panel: science education dimension advisory board. ▪ To arrange public advisory boards. **Applied ethics initiatives** ▪ Generation and implementation of ethics committees and best practice guidelines. ▪ Ethics framework identification. ▪ Training activities in Open Access content and responsibility for intellectual property management and RRI for researchers. ▪ Generation and implementation of tools to assess the impact of actions with RRI and moral and research social dimensions. **Reinforce researcher's awareness** ▪ To integrate RRI training in PhD programs. ▪ To train and educate researchers on RRI implementation at different levels. ▪ To promote format and informal science education programs.

GREA Science shop	▪ To advice in the implementation of projects of local and regional interest, with particular focus on gender minorities and to advice to entrepreneurs and start-ups about European funding routes. ▪ To implement entrepreneurship projects, Think Talk, and challenges for municipalities and the region with transnational projection. ▪ To review and strengthen the multidisciplinarity approach within the institution for vertebral projects for this nature.
Users approach to technology transfer and public engagement activities	**Midstream modulation pilot**
Adaptation of RRI methodologies to research and innovation solutions activities	**To explore the possibility of reframing RETs and TES innovation as Responsible innovation** ▪ Responsible industry collaborations. ▪ Market roll-up initiatives of merging innovation. ▪ To arrange international RRI instances. **To use RRI to framework non-technological barriers for TETS, TES and ICT** **To develop the case study of the assessment of the public engagement in energy technologies as example.** **To translate RRI dimensions in energy research topics.**
Communication and transmedia culture activities	**Researchers night at the University of Lleida** **Communication forums** ▪ How to communicate climate change? forum with journalist and educators
Science education activities	▪ GREA Energy school: This initiative consists of training students and all actions aimed at promoting science education in the town of Puigverd de Lleida and citizen participation in space science and technology. ▪ Girls in Energy and ICT: Fostering STEM education for girls. ▪ GREA Citizen Science pilot: The pilot projects will be based on citizen science projects about energy consumption and efficiency. ▪ Research in school forum ▪ Reflexions about Capital science concept forum
Open science/ ICT activities: Citizen science and Crowdsourcing communities	**Citizen science activities** ▪ To use personal devices for open science and interchange activities. ▪ To go towards storing data in a cloud of internet-based servers. ▪ Mobile computing, internet-of-things. ▪ Open and do-it-yourself approaches. ▪ Converged and integrated systems. ▪ ICT innovation in renewable energies **Crowdsourcing research pilot** **Pilot on Open Research Data Open data**

3. 6 MONITORING

It is important to note that since the RRI methodology is still under construction, reviewing methodologies for finding the social dimension of research that have resulted and it is necessary. For the monitoring RRI plan, a chart with RRI dimensions and the structural changes arranged will arranged as see in Table 12 and Table 13.Pre Assessment for GREA will arrange with the ReS Agora and MoRRI projects frameworks. The indicators proposed in **¡Error! No se encuentra el origen de la referencia.** and 3. 3 chapters are going to take into account and at least **3 main changes in each partner** implementing the RRI plan will be achieved.

TABLE 12: RRI dimensions pre assessment chart

RRI dimension	Pre assessment for GREA	Outcomes after RRI deployment
Governance		
Gender		
Ethics		
Public Engagement		
Science education		
Open access		
Open science		
Social justice		
Sustainability		

TABLE 13: RRI dimensions and the structural changes arranged evolution chart

RRI dimension	Indicators for RRI plan	RRI deployment	Outcomes after RRI plan for next 2 years
Governance			
Gender			
Ethics			
Public Engagement			
Science education			
Open access			

Open science			
Social justice			
Sustainability			

4. REFERENCES

- Beck and Natan Sznaider, Unpacking cosmopolitanism for the social sciences: a research agenda. The British Journal of Sociology 2006 Volume 57 Issue1
- Boucher, P. (2015). 'You wouldn't have your granny using them': Drawing boundaries between acceptable and unacceptable applications of civil drones. Science and Engineering Ethics. doi:10. 1007/s11948-015-9720-7.
- Caprile, M., Addis, E., Castano, C., Linge, I., Larios, M., Moulders, D. & Vazquez-Cuperio, S. (2012). Meta-analysis of gender and science research – Synthesis report. Luxembourg: European Union, Directorate-General for Research and Innovation.
- Edler, J., Randles, S., Gee, S. Kuhlmann, S.& Walhout, B. (2014) Responsible Research and Innovation in a Distributed Anticipatory Governance Frame. A Constructive Socio-normative Approach, Governance Situations and Challenges. Conceptualising variety to underpin a socio-normative RRI governance framework.
- European Commission (2010), Europe 2020 — A strategy for smart, sustainable and inclusive growth, COM(2010) 2020 final.
- European Commission (2014). European Research Area: Progress Report 2014.
- European Commission (2015): Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI): Analytical Report on the Dimension of Citizen Engagement and Participation of Societal Actors in Research and Innovation. Sub-task 2.5, deliverable D.2.1.
- European Commission (2015b): Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI): Analytical Report on the Gender Equality Dimension. Sub-task 2.5, deliverable D.2.3.
- European Commission (2015c): Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI): Analytical Report on the Dimension of Science Literacy and Scientific Education. Sub-task 2.5, deliverable D.2.2.
- European Commission (2015): Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI): Analytical Report on the Dimension of Open Access. Sub-task 2.5, deliverable D.2.4.
- European Commission (2015): Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI): Analytical Report on the Dimension of Research and Innovation Ethics. Sub-task 2.5, deliverable D.2.4.1.
- European Commission (2015): Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI): Analytical Report on the Dimensions of Research and Innovation Governance. Sub-task 2.5, deliverable D2.4.2.
- European Commission (2015): Indicators for promoting and monitoring responsible research and innovation: Report from the expert group on policy indicators for responsible research. DG Research and Innovation: Brussels.
- European Commission 2012 Monitoring Policy and Research Activities on Science in Society in Europe (MASIS). doi 10.2777/79320
- European Union (2012): Responsible Research and Innovation. Europe's ability to respond to societal challenges. Available at: http://ec.europa.eu/research/sciencesociety/document_library/pdf_06/responsible-research-and-innovation-leaflet_en.pdf
- Glerup, C., & Horst, M. (2014). Mapping "social responsibility" in science. Journal of Responsible Innovation, 1(1), 31–50.
- Grinbaum, A., Groves, C., 2013. What is "responsible" about responsible innova- tion? Understanding the ethical issues. In: Owen, R., Bessant, J., Heintz, M. (Eds.), Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society. Wiley, London, pp. 119–142.
- H. Chesbrough, From Open Science to Open Innovation, Science|Business Publishing 2015 http://www.sciencebusiness.net/eventsarchive/OpenScience/
- Hagendijk, R., & Irwin, A. (2006). Public deliberation and governance: engaging with science and technology in contemporary Europe. Minerva, 44(2), 167-184.

- Hertog, den P., Jager, C.-J., te Velde, R., Veldkamp, J., Aksnes, D.W., Sivertsen, G., et al. (2012). Science, Technology & Innovation Indicators 2014. Dialogic. Utrecht. Retrieved April 18 2015: http://dialogic.nl/documents/other/sti2_themepaper1.pdf
- Jaap Voeten. Responsible Innovation. 2012. doi: 10.1002/9781118551424.
- Koops BJ, Oosterlaken I, Romijn H, Swierstra T, van den Hoven J, Sciences S. Responsible innovation 2: Concepts, approaches, and applications. 2015. doi:10.1007/978-3-319-17308-5.
- MORRI Proposal (2014). Monitoring the evolution and benefits of Responsible Research and Innovation. Technical Proposal following Call for Tenders Nr. RTD-B6-PP- 00964-2013.
- Open, innovation, open science, open to the Word. A vision for europe, Directorate-General for Research and Innovation Directorate 2016; doi:10.2777/061652
- Owen R., "Responsible research and innovation: From science in society to science for society, with society" *Science and Public Policy* 39 , pp. 751–760 (2012).
- Pellizzoni, L., 2004. Responsibility and environmental governance. Environmental Politics 13, 541–565.
- Randles S., Youtie J., Guston D., Harthorn B. , Newfield C., Shapira P. , Wickson F. , Rip A., Von Schomberg R. ,Pidgeon N., A "Transatlantic Conversation on Responsible Innovation and Responsible Governance", Study of Nanoscience and Emerging Technologies Conference. May 2011.
- Ribeiro BE, Smith RDJ, Millar K. A Mobilising Concept? Unpacking Academic Representations of Responsible Research and Innovation. Sci Eng Ethics 2016. doi:10.1007/s11948-016-9761-6.
- Silberzahn R. Many hands make tight work. Nature 2015;526:189–91.
- Socientize Project. White paper of citizen science. 2011. http://www.socientize.eu/sites/default/files/white-paper_0.pdf.
- Sovacool B.K., "Energy studies need social science" *Nature*, 511, pp.529-530 (2014).
- Sovacool B.K., Ryanb S.E., Sternc P.C., Jandad K., Rochline G., Sprengf D.,Pasqualettig M.J., Wilhiteh H., Lutzenhiseri L., "Integrating social science in energy research",*Energy Research and Social Science* 6, pp 95-99, (2015).
- Special Eurobarometer 401: Responsible Research and Innovation (RRI), European Commission, Directorate-General for Research & Innovation, 2013 . Available at: http://ec.europa.eu/public_opinion/index_en.h
- Special Issue"Interdisciplinarity". Nature, 525, pp. 305 (2015).
- Spreng, Transdisciplinary energy research-reflecting the context, *Energy Reseach and Social Science* 1 pp. 65-73 (2014).
- Stilgoe J, Owen R, Macnaghten P. Developing a framework for responsible innovation. Res Policy 2013;42:1568–80. doi: http://dx.doi.org/10.1016/j.respol.2013.05.008.
- Van Noorden R., "The scientists who get credit for peer review" *Nature News*, (2014).
- Von Schomberg, R. (Ed.), 2011. Towards Responsible Research and Innovation in the Information and Communication Technologies and Security Tech- nologies Fields. European Commission, Brussels, Downloaded from: http:// ec.europa.eu/research/science-society/document library/pdf 06/mep-rapport- 2011 en.pdf (01.02.13).
- Von Schomberg, R., 2011. Prospects for technology assessment in a framework of responsible research and innovation. In: Dusseldorp, M., Beecroft, R. (Eds.), Technikfolgen Abschätzen Lehren: Bildungspotenziale Transdisziplinärer. Vs Verlag, Methoden, Wiesbaden.
- Von Schomberg, R., 2011. On identifying plausibility and deliberative public policy. Science and Engineering Ethics 17, 739–742.
- Von Schomberg, R., 2013. A vision of responsible research and innovation. In: Owen, R., Bessant, J., Heintz, M. (Eds.), Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society. Wiley, London, pp. 51–74
- World Commission on Environment and Development (WCED). Our common future. Oxford: Oxford University Press; 1987. p. 43

- Zhao Y, Zhu Q. Evaluation on crowdsourcing research: Current status and future direction. Inf Syst Front 2014;16:417–34. doi: 10.1007/s10796-012-9350-4.
- Zwart H, Landeweerd L, Van Rooij A. Adapt or perish? Assessing the recent shift in the European research funding arena from "ELSA" to "RRI." Life Sci Soc Policy 2014;10:11. doi:10.1186/s40504-014-0011-x.

ANNEX 1 RRI BACKGROUND

A.1. 1 RRI IN CONTEXT

There are multiple and overlapping ways in which 'science' and scientific actors could proceed in socially responsible ways (Ribeiro, Smith, Millar 2016), for example ascribing to rigorous levels of research conduct; providing solutions to societal problems and delivering (socially) useful outcomes; by reflecting on their motivations and methods or by opening up knowledge production, through oversight and assessment, to a broad range of societal actors (Glerup and Horst 2014, p. 35). Similar approaches have been applied to the responsible development and deployment of (potentially controversial) emerging technologies. Boucher (Boucher 2015), for example, emphasises that new technologies should be made acceptable to citizens, ideally by embedding societal expectations and visions — for instance around acceptable and unacceptable use — in their development.

In addition, the governance of emerging science and innovation is being consider a major challenge for contemporary democracies (Stilgoe J, Owen R, Macnaghten 2013) from the basis that science and technology are powerful engines of change, although generate both controversies and high expectations.

Combinations of Technology assessment methodologies dominated early approaches of governance of innovation, major concern of research policies; although were show by many as a technical form of research, conducted by science and technology experts and tools to solve certain problems. Many of these approaches exemplify a transition from analysing how science and technology are shaped by societal factors to actively supporting ways to integrate science and technology in society.

Notions of responsibility as applied to techno-scientific developments have broadened in recent years (e.g. Briggle 2012), embodied in the development of support mechanisms to facilitate greater societal scrutiny, ethical reflection and appraisal (Forsberg et al. 2015). But responsibility has been present since the first discussions related with research efforts dealing with ethical and social aspects and socio-technical integration appears (Ribeiro, Smith, Millar 2016).

Its application to scientific fields is rooted in several disciplines such applied ethics, moral philosophy as well as emergence of social movements for mainstreaming public participation in institutions and activism.

At policy level, responsibility is present in approaches of Technology Assessment[32] (TA), Science, Technology and Society studies[33] (STS) and Ethical, Legal and Social

[32] TA is the interdisciplinary and interested in the societal dimension technology development. It originated in the 1950's from a demand from different institutions such as governments and corporations to anticipate the potential consequences of new technologies, especially relying on forecasting techniques (see Schot and Rip 1996). As a whole, more recent incarnations of TA have tended towards more participatory and reflexive approaches aimed at fostering positive impacts of technologies (see Genus 2006).

[33] STS is an interdisciplinary field of research focused on the social dimensions of science, which has developed over the last three decades making significant contributions to the analysis of public engagement in science (see Delgado et al. 2010), the production of scientific knowledge (e.g. Nowotny et al. 2003), and the broad societal aspects of scientific and technological change (see Bijker 1995), including their governance aspects (see Jasanoff 1990).

Aspects approaches [34] (ELSA) and recently in Responsible Innovation [35] (RI) and Responsible Research and Innovation (RRI) frameworks in EU.

Ribeiro et al. suggest that theoretical backgrounds of RRI are based only in three main important backgrounds, STS, TA, ethics or a combination of both (Ribeiro, Smith, Millar 2016) as show in

Table **1**.

In ethics and moral philosophy approach, responsibility involves both moral and epistemic dimensions (Grunwald 2011) where *moral dimension* is related with how an action can be deemed responsible or irresponsible and where quality of methods, approaches, and framework of research, determines quality of knowledge and Epistemic *dimension* is related with the quality of knowledge of the subject of responsibility, which in this context is scientific knowledge (Oftedal 2014).

TABLE 1: RRI UNPACKING PROCESS RESULTS (ADAPTED FROM RIBEIRO ET AL. 2016)

Motivations	**Theoretical conceptualizations**	**Translation into practice**
Develop better or novel practice	Emerging specialized RRI literature	Integrated approaches
	Ethical tradition	
Deliver societal benefits	Science and technology studies	Evaluation or assessment
	Technology assessment	
Grasp the impacts of technologies	Management, organization and governance studies	Policy and governance structures and mechanism
Promote public acceptance	Public engagement and science communication	
Public policy as a driver	Risk assessment	
	Sustainability studies	

RRI approach also collects experiences of previous models. In special ELSA in EU and the conflicts in the role of bioethics acting both on behalf of morality and as an institutional parameter and criticism regarding to the duty of bioethicists becoming facilitators of science and technology rather than critical assessors of societal impact (Eckenwiler and Cohn 2007).

[34] ELSA, ethical, legal and social aspects of emerging sciences and technologies approach emerged in Europe, in the context of the 4th EU Framework Programme launched in 1994 to frame societal issues and to finance research, stakeholder dialogues, education and other activities to address them. In the same line, ELSI, which refers to research on ethical, legal and social implications of emerging life sciences, notably human genomics, was a program funded by National Institution for health and Human genome project in the U.S.

[35] The practical relevance of moral philosophy with the firm belief that philosophy, ethics and humanities more generally, can be highly relevant to policy making was the core of the program on Responsible Innovation in The Netherlands emerged out of discussions organized by the Dutch Research Council (DRC) between 2003 and 2007. The program was the result of a collaboration in the applied ethics of technology of DRC with several ministries, private sector partners, university based research groups and representatives of and representatives of NGO's and was a successor to the Applied Ethics Program (*Ethiek en Beleid*) active until the late 1990s. The program runs from 2009 to 2014 when the European Horizon 2020 Program with Responsible Research and Innovation included as launched.

Depletion of ELSA and bioethics model is consider one of the starting points for the development of Responsible Research and Innovation models (Zwart 2014) which arise developments of responsibility models following two currents: the ***Public participation paradigm* focussed on involving (future) stakeholders and various 'publics' (plural)** in reflections on new technologies (Broerse 2011, Zwart 2014) and ***empirical and participatory approaches of bioethics***, notably between researchers from the humanities and social sciences with natural and life scientists embedded in ELSA approaches.

The social concept of responsibility from the scope apart from research and technology development is focused in the evolution of the responsibility as a concept and its evolution through *language of responsibility* (Rip, 2014). A brief look shows an evolution that transits from duties evolving social order and agreements in terms of "social contract" (Guston and Kenniston 1994, Rip 2014) and "moral division of labour"(Rawls 1993, Nagel 1995 Murphy 1999, Scheffler 2005 and Douglas 2014) towards a "prudential acquiescence" (Rip 2011) related to the powers that scientist may manage; "ivory tower" ideal vision (Nelson 2014), "republic of the science" (Polanyi 1962, Stilgoe 2013) regarding with the autonomy of science management and subsequent phases of claims of socially responsible proceed present in contemporary discourses of participation of society in science and innovation arenas.

Interest in public engagement and the actual and possible role of citizens and consumers often remains within traditional divisions of moral labour by positioning members of the public as articulating preferences which may then be taken up in decision making as additional strategic intelligence (Rip 2014).

Responsibility regarding to assessment of societal dimensions of science and technology involving 'third' parties besides scientist's trough the inclusion of legal and ethical experts, NGO's, policy makers and a variety of 'publics' (Zwart 2014) is know from early approaches. Collaborative interactions with relevant stakeholder representatives as alternative to the 'expert' model (Zwart 2014), broaden the expert approaches even the waning the authority of the experts (Stilgoe, 2013) are exponents of features of contemporary discourse.

Broaden the concept of expertise towards societal expertise (represented by future users) and alternative technology assessment methods such Constructive Technology Assessment (CTA) (Rip, 2010, Robinson 2010, Krabbenborg 2013) where social scientists, play the role of mediators, 'bridging' different stakeholders and ethics are integrated in science and technology processes in an early stage, with ethical considerations taken into account in the design-phase of innovation trajectories or approach - "ethics first "approach -(Moor and Weckert 2003, Van de Hoven 2013) are part of new 'upstream innovation' approach.

The newness of RRI, regarding with some early approaches such as ELSA is that places more weight on the process of research and innovation and social-economic impacts such as valorisation, employment and competitiveness (Zwart 2014). It also comprises a transit from the mainly external and theoretical approaches to more integrated science research projects and considers the entire innovation process, from research and development to production and distribution. Also, RRI no longer see the ethical aspects of new technologies as constraints but as an opportunity (Von Schomberg, 2012).

A.1. 2 RESPONSIBILITY FRAMEWORKS

A.1.2. 1 RESPONSIBLE INNOVATION (RI)

The inclusion of the moral values in terms of responsibility shapes the first policy approach of **Responsible Innovation** (RI), a form of technology assessment (TA) devoted to look to the best solutions on basis in this values and amplifying the set of obligations. RI suggest that for the design of the values is necessary to obtain the relevant knowledge regarding to consequences of the outcomes and a range of the actions, evaluate both outcomes and options in terms of the relevant moral values and use these considerations as requirements of design and development this technology. Therefore, RI process enables previous unknown design and functionality to expand feasible options regarding to solving a set of moral values.

In RI, the appraisal of the technology is in terms of the values that support and embody. When moral overload -so many values at the same time or necessity of choose from one to another, values being compromised, or more moral obligations that the situation allow us to satisfy- strikes, RI consider this situation as an opportunity to trigger creativity and smart design and innovations instead of a pitfall to overcome.

RI also covers the moral and regulatory assessment of new technologies and their impact on society through the development of ethical frameworks that shifted from trying to predict or anticipate social consequences - to use these as a basis for moral and regulatory appraisal - towards the introduction of new technologies into society as a social experiment, where potential social changes induced by technological development are taking into account.

A.1.2. 2 ETHICAL FRAMEWORK FOR EXPERIMENTAL TECHNOLOGY

The ethical frameworks for the acceptability of such social experiments are developed based on the bioethical principles for experiments with human subject's specification of the four moral principles[36] or moral obligations: non-maleficence, beneficence, respect for autonomy, and justice approaches (Van de Poel 2015). This framework based in ethical assessments suggests that Responsible experimentation needs to meet both **epistemological** (are important to ensure learning from social experiments) and **ethical** constraints (are important because these experiments take place in society and may seriously harm individuals as well as society as a whole).

It is based in general set of ethical principles that have been articulated in bioethics (medical experiments and other experiments with human subjects) such as non-maleficence, beneficence, respect for autonomy, and justice:

- **Non-maleficence:** Obligations relating to doing no harm, including obligations to minimize risks, or to take precautions against possible risks or harms from the experiment.
- **Beneficence:** Obligations to do good, including obligations to take away existing harm, or to prevent harm or risks that do not originate in the experiment, to

[36] These principles came into across in the main codes in the domain of clinical experimentation and experiments with human subjects: The Nuremberg code, the Helsinki Declaration and the so-called Common Rule in the US (in particular its codification in the US Code of Federal Regulations, Title 45 (Public Welfare), Part 46 (Protection of Human Subjects).

produce more good than harm, to create or increase benefits.

- **Respect for autonomy:** Obligations relating to protecting and guaranteeing the autonomy, including the autonomous choice, of individuals and groups.
- **Justice:** Obligations relating to issues of distributive justice, to special protection of vulnerable groups, to avoiding exploitation, but also to procedural justice (just procedures).

Responsibility in this terms does not add substantial moral obligations to the ones covered by non-maleficence, beneficence, respect for autonomy and justice. Rather it specifies who has a duty or is responsible for living by or upholding these moral obligations. So while responsibility adds a moral dimension that is not covered by the four bioethical moral principles, it does not add substantive moral obligations not covered by the four principles.

A.1.2.3 TRANSDISCIPLINARITY

Transdisciplinarity approach, based in a new form of learning and problem solving involving cooperation among different parts of society and academia in order to meet complex challenges of society (Klein 2001) is also a contribution of a social science towards seeking the human dimension of research. It was proposed as a broad-based scientific and cultural approach with multiple lectures: long-term dialogue between specialists informed by the new worldview of complexity in science facilitator process (Nicolescu 1987), methodology for identify a fundamental change in the ways that scientific, social, and cultural knowledge are being produced in terms of complexity, hybridity, non-linearity, reflexivity, and heterogeneity (Gibbons, et al. 1994).

A.1. 3 RRI IMPORTANCE FOR EC

A.1.3 1 RRI IN POLICY CONTEXTS

Responsible Research and Innovation (RRI) framework is a wide umbrella connecting different aspects of the relationship between R&I and society: public engagement, open access, gender equality, science education, ethics, and governance[37]. The concept of RRI has been put forward by the European Commission as a key element of the Horizon 2020 programme, in which the trifold ambition of 'excellent science, competitive industry and a better society' calls for a normative and comprehensive governance framework for RRI (Walhout B, Kuhlmann S, Edler J, Randles S. 2014).

Responsibility in governance has historically been concerned with the impacts and limitations by market choice leading risk-based regulation and responsibility in terms of accountability and liability (Pellizzoni, 2004; Grinbaum and Groves, 2013). In response to this, sensitivity to societal issues, particularly within the life sciences, has increased over the years and has become a standard feature of funding programs (Zwart 2014).

In Europe, there is a wide tradition in efforts towards framing societal issues and to finance research, stakeholder dialogues, education and other activities to address them such as ethical, legal and social aspects **ELSA** of emerging sciences and technologies

[37] From RRI Tools http://www.rri-tools.eu/

and Responsible Innovation[38]. Responsible innovation, emerged for approach a world where technology is never neutral and it is always value laden and needs to be the expression of moral values such as safety, health, accountability, wellbeing, justice, equality, privacy democracy, autonomy, sustainability and efficiency (Van den Hoven 2012, 2015).

Responsible research and Innovation policy framework (Von Schomberg 2011, 2012, 2013; Owen et al. 2012), crystalizes in EU upon the process for arrange Framework Programmes for Research. The Lund Declaration of 2009, based on encouraging European research force to assume "Grand Challenges"*...moving beyond current rigid thematic approaches and involving public-private stakeholders in transparent processes and global dimension fostering excellence in knowledge institutions* ... maximising economic and societal impact of new knowledge and with a risk-tolerant and trust-based approach in research funding (Lund Declaration 2009); the Vilnus Declaration of 2013, devoted to integrate Social Science and Humanities (SSH) in policy–making for resilient partnership with all relevant actors with Innovation serving to societal expectations, values and demands and solving "Societal Challenges" *...fostering the reflective capacity of society ...*through innovative interdisciplinary participatory approaches (Vilnus Declaration 2013) and the Rome Declaration of 2014 which finally declares RRI framework as "useful and institutional tool for respond to Social Challenges" as the on-going process of aligning research and innovation to the values, needs and expectations of society (Rome Declaration 2014) are the most remarkable preceding.

Perhaps, Von Schomberg`s definitions in terms of a "*transparent and interactive process where actors share responsibilities and work together to achieve important positive impacts, ethical acceptability, sustainability and societal desirability of research and innovation" is* the most used and inclusive one (Von Schomberg`s 2013).

Contributions from Owen et al. (2012) and Stilgoe et al. (2013) deserve attention here as they offer some of the **most precise specifications of RRI** in the literature sample. In these complementary works the authors articulate **three main purposes for RRI:**

- To promote a shift in research and innovation governance away from the avoidance of negative impacts, towards an 'opened-up' democratic process that explicitly engages with 'questions of intent' in research and innovation;
- To foster an integrated, participatory, reflexive and responsive process of deliberation about the uncertainties and potential unintended consequences of research and innovation;
- To extend the notion of responsibility in research and innovation as something that stretches significantly farther than just scientists, and to foster incarnations that move away from consequentialist rule-based embodiments towards a collective duty of care.

---

[38] The practical relevance of moral philosophy with the firm belief that philosophy, ethics and humanities more generally, can be highly relevant to policy making was the core of the program on Responsible Innovation in The Netherlands emerged out of discussions organized by the Dutch Research Council (DRC) between 2003 and 2007. The program was the result of a collaboration in the applied ethics of technology of DRC with several ministries, private sector partners, university based research groups and representatives of NGO's and was a successor to the Applied Ethics Program (*Ethiek en Beleid*) active until the late 1990s. The program runs from 2009 to 2014 when the European Horizon 2020 Program with Responsible Research and Innovation included as launched.

A.1.3 2 RRI DIMENSION AND ATTRIBUTES

RRI is along with European Research Area (ERA) an indicator for monitoring Horizon 2020 Cross-Cutting Issues[39]. The Commission originally recognised six key areas for the application of RRI (EC 2012): **public engagement; gender equality; science education; open access; ethics; and, governance. Two additional areas of relevance to RRI, which have been highlighted recently, are sustainability and social justice** (EC 2015). These 'thematic' areas have been used to guide the formulation of indicators for RRI.

Sustainability and social inclusion/justice dimension are framed in the consideration of the interface between R & I and the society in which it takes place, and hence we have considered indicators both of actors and action within the R & I sector, but also the perception by other actors and society in general. This dimensions deserve special attention, not only because the EU has committed itself to these aspects on the most general level (in the Charter of Fundamental Rights) but also because they are central to the Europe 2020 strategy of smart, inclusive and sustainable growth' to which Horizon 2020 (and, consequently, RRI policy) is a means.

Additional keys of the RRI are also characterized by assumptions of attributes such as anticipation, reflexivity, inclusion, and responsibility (Stilgoe et al., 2013). These attributes are more related with the development of ethical approaches and ethical frameworks for evaluating experimental technology. A brief description of this attributes for researchers and innovators (Hoven et al. 2013) illustrates:

- **Anticipation** as inclusion of new perspectives in the research and innovation process and to think through various possibilities to be able to design socially robust agendas for risk research and risk management.
- **Inclusion** as involvement of diverse stakeholders (such as users, NGOs, etc.) in the process to broaden and diversify the sources of expertise and perspectives.
- **Reflexivity**, as a encouragement to think about their own ethical, political or social assumptions to enable them to consider their own roles and responsibilities in research and innovation as well as in public dialogue.
- **Responsiveness, as** the capacity to change its direction or shape when it becomes apparent that the current developments do not match societal needs or are ethically contested. Hence, responsiveness refers to the flexibility and capacity to change research and innovation processes according to public values.

A.1. 4 OPEN INNOVATION POLICY AND RRI INTEGRATION

Open innovation in Europe is a series of initiatives proposed from Research and innovation General Directorate in 2016, in order to get integrate a new series of goals for EU research and innovation policy, summarised as ***Open Innovation, Open Science and Open to the World***. These goals, show how research and innovation

[39] Horizon indicators for Research and Innovation. EC 2015. doi:10.2777/71098.

contribute across the European Commission's political priorities. They do not represent a new policy initiative or funding programme as such, but they are a way to reinforce existing programmes, such as Horizon 2020 (where RRI policy is located), and reinforcement for the existing policies such as the European Research Area[40]. As a framework, compresses insights of Responsible Research and Innovation such as public engagement, open science and participation in innovation sphere mechanisms such as citizen science as shown in Figure 4.

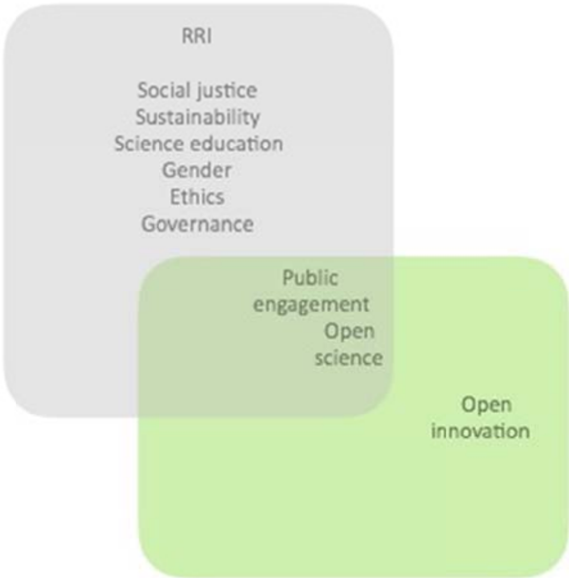

FIGURE 4: Insights of Responsible Research and Innovation and Open Innovation

Open innovation in EU advocate for making the most of its innovation talent and create an ecosystem where innovation can flourish with the premise of open up the innovation process to all active players so that knowledge can circulate more freely and be transformed into products and services that create new markets, fostering a stronger culture of entrepreneurship. One of the most important insight is that specific innovation can no longer be seen as the result of predefined and isolated innovation activities but rather as the outcome of a complex co-creation process involving knowledge flows across the entire economic and social environment. The co-creation process takes place in different parts of the innovation ecosystem and requires knowledge exchange and absorptive capacities from all the actors involved, whether businesses, academia, financial institutions, public authorities or citizens.

A.1.4 1 OPEN INNOVATION 2.0

The dimension of Open Innovation is constantly evolving and is moving from linear, bilateral transactions and collaborations towards dynamic, networked, multi-collaborative innovation ecosystems and cannot be defined in absolutely precise terms.

[40]For example, the Open Innovation goal has led to a debate on a possible European Innovation Council and the creation of a Seal of Excellence to facilitate links between Horizon 2020 and other funding programmes. The Open Science goal is materialising in the development of a European Science Cloud and greater openness to scientific data generated by Horizon 2020 projects.

It may be better to think of it as a point on a continuum: there is a range of context-dependent innovation activities at different stages, from research, to development through to commercialisation, where some activities are more open than others.

The definition[41]of Open innovation, considered as Open Innovation 2.0, combine two main elements[42]:

- **Users**
- **Innovation eco-system**

The importance of the users is based in the premise that invention becomes an innovation only if users become a part of the value creation process. The integration of the users in this framework is conducted via notions such as *user innovation* in terms of the role of citizens and users in the innovation processes as *distributed* sources of knowledge.

This approach in terms of **public engagement** is one of the aims of the Responsible Research and Innovation where the term *open* is used in this contexts as a synonym for *user-centric.*

Regarding to a well-functioning eco-system that allows co-creation; in this eco-system relevant stakeholders are collaborating along and across industry and sector-specific value chains to co-create solutions for socio-economic and business challenges.

The most important insight of the Innovation ecosystem is related with its role as a driver for the transition from linear knowledge transfer towards more dynamic knowledge circulation which also integrate socio-economic value as shown in Figure 5.

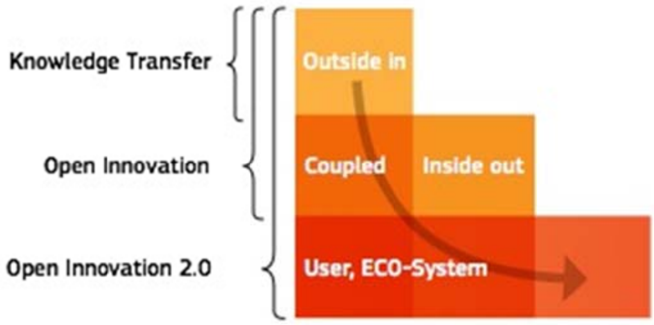

Figure 5: relation between knowledge transfer and open innovation. *Source:* DG Research and Innovation, Knowledge transfer and open innovation study (on-going)

41 Open innovation is a term promoted by Henry Chesbrough, though the idea and discussion about some consequences such as an interfirm cooperation in R&D. The term refers to the use of both inflows and outflows of knowledge to improve internal innovation and expand the markets for external exploitation of innovation. The concept is also related to user innovation, cumulative innovation, know-how trading, mass innovation and distributed innovation. The concept of Open Innovation is constantly evolving and is moving from linear, bilateral transactions and collaborations towards dynamic, networked, multi-collaborative innovation ecosystems, EU highlight three important elements of this approach as an expression of: *Open innovation; Open science and Openness to the world*. Contemporary discourse of open innovation is related with open science, citizen science and Crowdsourcing applied to research and innovation.

42 Independent Expert Group Report on Open Innovation & Knowledge Transfer, Directorate-General for Research and Innovation, 2014; Cf. also Open Innovation Strategy and Policy Group (OISPG).

A.1.4 2 OPEN SCIENCE

Open Science represents a new approach to the scientific process based on cooperative work and new ways of diffusing knowledge by using digital technologies and new collaborative tools.

The idea captures a systemic change to the way science and research have been carried out for the last fifty years: shifting from the standard practices of publishing research results in scientific publications towards sharing and using all available knowledge at an earlier stage in the research process. However, open science in embedded in research and innovation process current practices as seen in Figure 6.

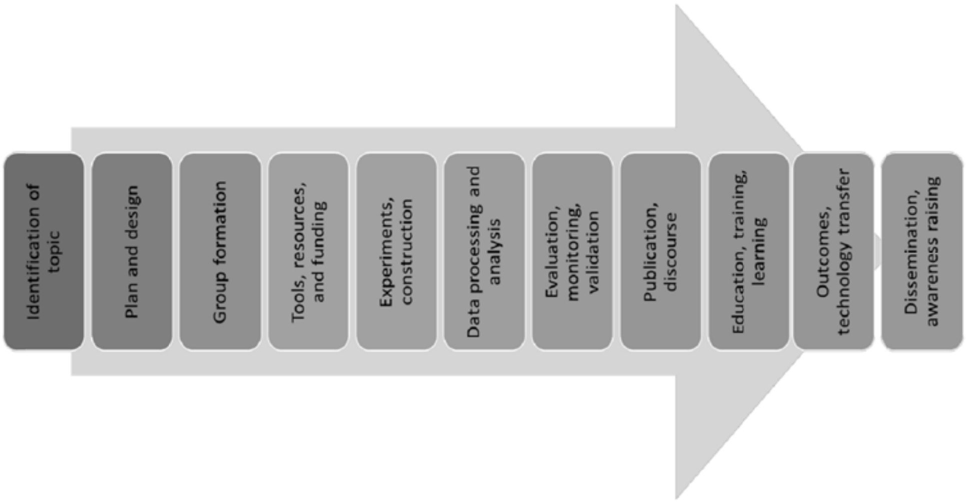

Figure 6: Current open science practices in research process. Source E. Prem, F.S.Sanz, M. Lindorfer, D. Lampert, J. Irran, Open Digital Science (SMART 2014/0007) Final Report, 2016.

Open Science, related to the users is to science what Web 2.0 was to social and economic transactions: allowing end users to be producers of ideas, relations and services and in doing so enabling new working models, new social relationships and leading to a new modus operandi for science. Open Science is as important and disruptive a shift as e-commerce has been for retail. Just like e-commerce, it affects the whole 'business cycle' of doing science and research – from the selection of research subjects, to the carrying out of research and to its use and re-use - as well as all the actors and actions involved up front (e.g. universities) or down the line (e.g. publishers).

The European Commission's 2014 public consultation on '*Science 2.0: Science in Transition*'[43] sought the views of major stakeholders to gain a better understanding of the full potential of 'Science 2.0' and to assess any need for action. Stakeholders preferred the term 'Open Science' to describe the transformation of scientific practice.

The background paper that served as the basis for the public consultation[44]described

[43] http://ec.europa.eu/research/consultations/science-2.0/

[44] http://ec.europa.eu/research/consultations/science-2.0/background.pdf

Open Science as '*the on-going evolution in the modus operandi of doing research and organising science*'. This evolution is enabled by Big Data and digital technologies and is driven by both the globalisation of the scientific community and increasing public demand to address the societal challenges of our times. Open Science entails the ongoing transitions in the way research is performed, researchers collaborate, knowledge is shared, and science is organised.

Open science is a wide umbrella which compresses various approaches such as**:**

- **Open access**
- **Open digital science**
- **Citizen science**
- **Crowdsourcing**

Open access in open science:

Open access to research results, an essential part of Open Science, which aims to make science more reliable, efficient and responsive, is therefore the springboard for increased innovation opportunities, for instance by enabling more science-based start-ups to emerge.

Prioritising Open Science does not, however, automatically ensure that research results and scientific knowledge are commercialised or transformed into socio-economic value. In order for this to happen, Open Innovation must help to connect and exploit the results of Open Science and facilitate the faster translation of discoveries into societal use and economic value (Chesbrough**,** 2015).

Figure 7 shown the open science taxonomy developed by the European-funded project FOSTER (Facilitate Open Science Training for European research developed as an attempt to map the open science field:

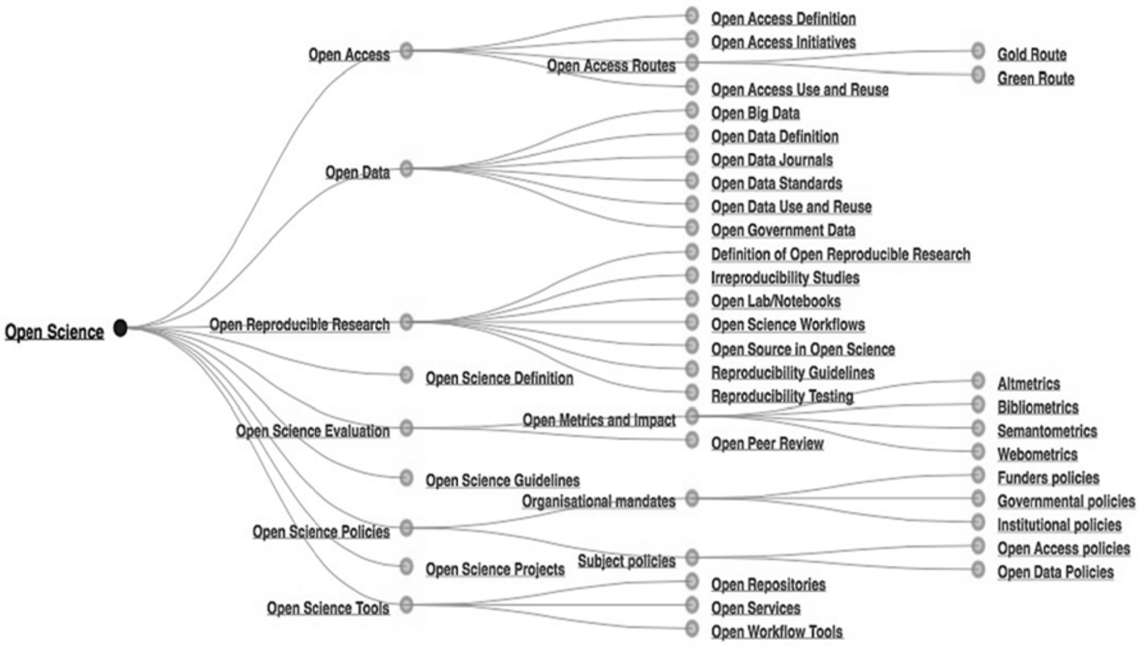

FIGURE 7:Open Science taxonomy. Source https://www.fosteropenscience.eu

Open Science permits knowledge to circulate more quickly and be more freely available, however, does not mean 'free science'. It is essential to ensure that intellectual property is protected before making knowledge publicly available in order to subsequently attract investments that can help translate research results into innovation. If this is taken into account, fuller and wider access to scientific publications and research data can help to accelerate innovation. In this context, Open Access can help overcome the barriers that innovative companies, in particular SMEs, face in accessing the results of research funded by the public purse.

Open Science has an impact on the entire research cycle, from the inception of research to its publication, and on how this cycle is organised. The outer circle in Figure 8 shows the new interconnected nature of Open Science, while the inner circle shows the entire scientific process, from the conceptualisation of research ideas to publishing.

Each step in the scientific process is linked to on- going changes brought about by Open Science, such as the emergence of alternative systems to establish scientific reputation, changes in the way the quality and impact of research are evaluated, the growing use of scientific blogs, open annotation and open access to data and publications.

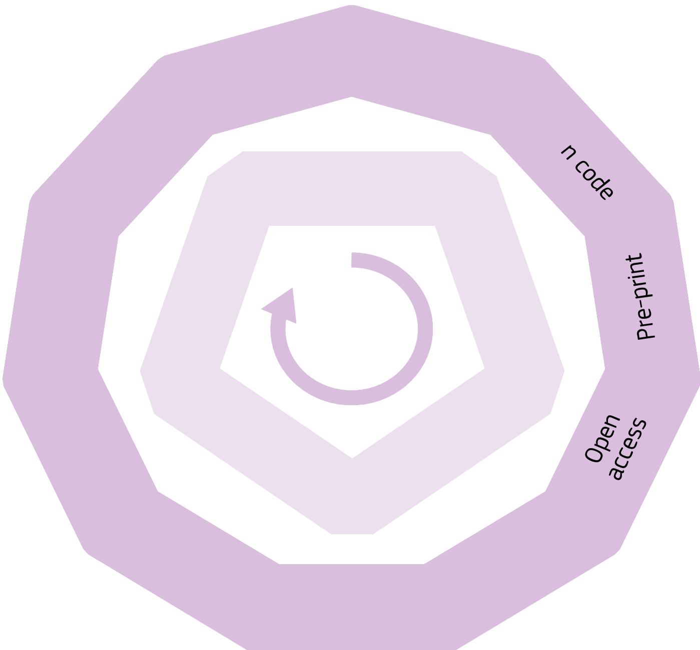

FIGURE 8: Open Science in the research process.

Source: http://ec.europa.eu/research/consultations/science-2.0/background.pdf

Open digital science:

Open Digital Science (ODS) in terms of Open Science, describes new and open practices in science, research and innovation that make extensive use of digital technologies and fits with the EU goal of merging the digital into societal challenges.

Europe must act now to harness the potential of digitisation for its citizens, to tackle societal challenges effectively, and to boost its businesses and industries.

The opportunities and challenges in this area are growing. EU science, research and innovation policy plays an important part in merging the physical and digital worlds by exploiting the potential of digital technologies, such as big data analytics and the Internet of Things to deliver innovative solutions to societal challenges in areas like health, energy, food and water. These four areas are the priorities for action. Actions should also help create new business models and adjust existing ones, as 'physical-digital' innovations often entail new value-streams that blur the lines between products and services, consumption and production, online and offline. The overall aim is to increase the impact of Europe's investments on its innovation capacity, so as to better tackle societal challenges, increase our competitive advantage and create jobs.

The use of digital technologies facilitates openness regarding data, methods, results, actors or publications with an emphasis on scalability of the approach in terms of data, access or computation. Open science is considered a powerful element for changing the relation of science and society[45].

Digital Science (DS) should be distinguished from other terms such as open science (which includes also being non-digital), digital science and science 2.0 (where the emphasis is on digital tools), e-science (which often focuses on high-performance computation and other e-infrastructure), **citizen science** (which engages the general public in research) and open access (which means online and usually free access to publications).

Being digital in nature, ODS shares important characteristics with information and communication technologies (ICT). This includes features of group-forming networks, zero marginal costs effects and the power of formal modelling and simulation, but also the bi-directionality of communication and the ability to work over long distances.

Although this concept emphasizes the role that digital technologies play without any doubt in the current transformation of scientific processes, it is neither broadly accepted nor is it widely used. Open Digital Science (ODS) is embedded in a global context where science is faced with increased fragmentation, internationalization and a strong emphasis on innovation and application. Apart from the open data movement, there are new trends in opening various points in the scientific workflow to a broader public.

One trend that seems to be clear as of now is the increasing interest of a new generation of researchers in making the best use of digital technologies for research, publication, and dissemination of many aspects of their work. These aspects not just include research results and data, but also methods ('open methods'), software ('open software'), and even lab books ('open notebook science').

New (and perhaps more importantly old) generations of researchers now require additional training on digital tools for science, open science etc. New initiatives, including those of the European Commission[46] provide such training in the various elements.

[45] Open Digital Science (SMART 2014/0007) Final Study Report by E. Prem, F.S.Sanz, M. Lindorfer, D. Lampert, J. Irran.2016.

[46] FOSTER – facilitate open science training for European research. https://www.fosteropenscience.eu/

At European scale, we are observing a diverse set of initiatives promoting the uptake of ODS for research and innovation in the context of European Research Area[47] and Digital Agenda for Europe[48].

Some examples are:

- Open Science
- E-Infrastructures[49]
- Collective Awareness Platforms[50]
- Citizen Observatories[51]
- Global System Sciences[52]
- Digital Social Innovation [53]
- Responsible Research and Innovation
- Smart Cities[54]
- Citizen Science[55]

Citizen science:

Relation of open science in terms of encourage the inclusion of non-institutional participants, in the scientific process via Citizen science[56] and the links with outreach activities, **science education or various forms of public engagement is part of open innovation consideration for citizen science witch can contribute to the Commission's goal of Responsible Research and Innovation, as it reinforces public engagement and can re-direct research agendas towards issues of concern to citizens is notable**. Citizen scientists are also collaborating globally to address societal challenges such as climate change or food security.

This kind of citizen science is increasingly on the agenda and it is planned that future work programmes of Horizon 2020 will continue to support relevant initiatives at EU level. For instance, the continuation and upscaling of various citizens' observatories initiatives are foreseen, including an inducement prize for new products and services that will harness the data produced.

Citizen Science is considered as a *mainstream science* representation covering DIY Science (Do It Yourself Science) amateur, 'garage', 'citizens', 'extreme citizen' and activism and a form of 'direct' interaction at stake, recognising that citizen scientists are also collaborating globally to address societal challenges such as climate change or food security.

---

[47] http://ec.europa.eu/research/era/index_en.htm

[48] http://ec.europa.eu/digital-agenda

[49] https://ec.europa.eu/digital-agenda/en/e-infrastructures

[50] http://ec.europa.eu/digital-agenda/en/collective-awareness-platforms

[51] http://www.citizen-obs.eu/

[52] http://global-systems-science.eu/

[53] http://digitalsocial.eu/

[54] https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/citizen-science-and-smart-cities

[55] http://ec.europa.eu/digital-agenda/en/citizen-science

[56] Scientific work undertaken by members of the general public, or in collaboration with or under the direction of professional scientists and scientific institutions. Oxford English Dictionary List of New Words". Oxford English Dictionary. Retrieved 13 September 2014.

Crowdsourcing:

Both citizen science and open innovation are considered under the umbrella of ***crowdsourcing***[57]. Shaped by crowd's wisdom (Surowiecki 2004) and collective intelligence (Gregg 2010; Leimeister 2010; Lévy 1995) approaches, a wide range of academic disciplines have begun to experiment with 'crowdsourcing' - creating or mobilising online communities of volunteers to assist them in their research. Academic crowdsourcing projects may have more in common with other kinds of participatory research initiatives. The participation can be arranged by other scientist of different disciplines sharing databases or divergent approaches for same research questions, (Silberzahn and Eric L. Uhlmann, 2015) or due to Citizen science, as "the involvement of volunteers in science"; term which is sometimes used interchangeably with 'crowdsourcing' as a label to describe research projects, which involve an online, open call for participation, by the public.

In the case of the reported project applying crowdsourcing research, the methodology proposed is based in the participation of diverse teams, instead of the single team which takes the multiple roles of create ideas and hypotheses; scrutinize the data in search of confirmation and try different approaches to reveal flaws in the findings. Alternative set-up, implies for example conformation of findings conducted by other research teams with alternative approaches. Silberzahn et al. (Silberzahn and Eric L. Uhlmann, 2015) approached the data with a wide array of analytical techniques, and obtained highly varied results followed by organized rounds of peer feedback, technique refinement and joint discussion to see whether the initial variety could be channelled into a joint conclusion. They found that the overall group consensus was much more tentative than would be expected from a single-team analysis.

Two broad lines of crowdsourcing projects are being developed recently:

- **Crowdsourcing academic communities**
- **Crowdsourcing citizen communities**

Successful initialization and sustainable development of crowdsourcing communities largely depend on mass participation. Thus, it is of great importance to explore what motivates the crowd to participate in problem-solving activities. Some critical aspect to the crowdsourcing applied to research (Zhao and Zhu, 2014) are the authorship and audience management, theoretical foundations for apply crowdsourcing such as a Game theory or strategic management theories (SMT), empirical or non-empirical research methods such as the use of focus groups and research focus.

Crowdsourcing can provide individuals in the crowd opportunities for working with large or small organizations to increase exposure and working experiences, and has allowed people to tap, explore, and turn their hobbies into something more beneficial. Participation in crowdsourcing projects can provide individuals with more chances to get noticed, sharpen their creative skills, and strengthen a sense of community. Hence, from a crowd's perspective/participant's perspective, future researchers might want to pay more attention to the directions outlined below.

For many research problems, crowd- sourcing analyses will not be the optimal solution. It demands a huge amount of resources for just one research question. Some

[57] 'Crowdsourcing: a definition' by Jeff Howe (2006) from http://crowdsourcing.typepad.com/cs/2006/06/crowdsourcing_a.html

questions will not benefit from a crowd of analysts: researchers' approaches will be much more similar for simple data sets and research designs than for large and complex ones. Importantly, crowdsourcing does not eliminate all bias. Decisions must still be made about what hypotheses to test, from where to get suitable data, and importantly, which variables can or cannot be collected.

Finally, researchers may continue to disagree about findings, which makes it challenging to present a manuscript with a clear conclusion. It can also be puzzling: the investment of more resources can lead to less-clear outcomes. Still, the effort can be well worth it.

Crowdsourcing research can reveal how conclusions are contingent on analytical choices. Furthermore, the crowdsourcing framework also provides researchers with a safe space in which they can vet analytical approaches, explore doubts and get a second, third or fourth opinion. Discussions about analytical approaches happen before committing to a particular strategy. In our project, the teams were essentially peer reviewing each other's work before even settling on their own analyses. And we found that researchers did change their minds through the course of analysis.

Crowdsourcing also reduces the incentive for flashy results. A single-team project may be published only if it finds significant effects; participants in crowd- sourced projects can contribute even with null findings. A range of scientific possibilities are revealed, the results are more credible and analytical choices that seem to sway conclusions can point research in fruitful directions. What is more, analysts learn from each other, and the research community and the public can better appreciate the creativity required to construct analytical methodologies. The transparency resulting from a crowdsourced approach should be particularly beneficial when important policy issues and advice policy makers and public.

Open science for better science:

The potential interventions build on the expectation that Open Science will eventually lead to better science, by making science more credible (addressing scientific integrity), reliable (better and more transparent verification of data), efficient (avoid duplication of resources) and more responsive to societal challenges as shown in Figure 9.

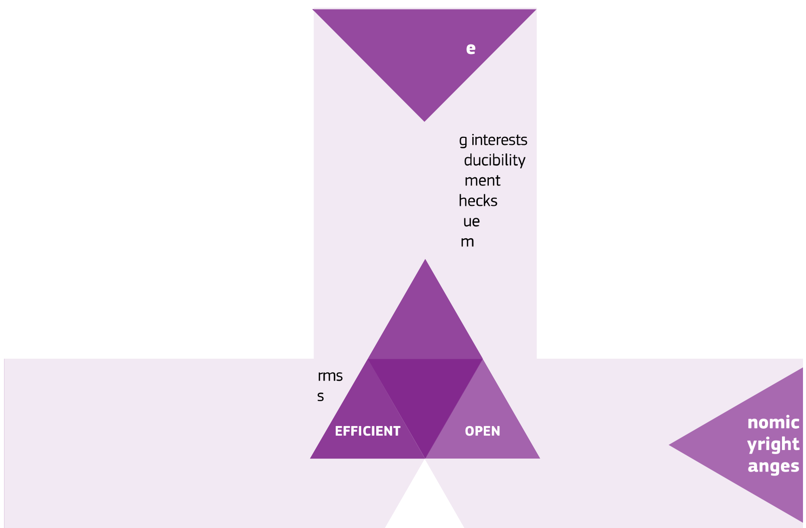

FIGURE 9: Open Science to Better Science.
*source:*http://blogs.lse.ac.uk/impactofsocialsciences/2015/11/11/101-innovations-in-scholarly-communication/

European Commission identified five lines of potential policy actions to support the development of Open Science in Europe[58].

The five lines of potential policy actions for are:

- *Fostering and creating incentives for Open Science*, by fostering Open Science in education programmes, promoting best practices and increasing the input of knowledge producers into a more Open Science environment (citizen science).
- *Removing barriers to Open Science:* this implies, among other issues, a review of researchers' careers so as to create incentives and rewards for engaging in Open Science.
- *Mainstreaming and further promoting open access policies* as regards both research data and research publication.
- *Embedding Open Science in society as a socio- economic driver*, whereby Open Science becomes instrumental in making science more responsive to societal and economic expectations, in particular by addressing major challenges faced by society.
- *Developing research infrastructures for Open Science*, to improve data hosting, access and governance, with the development of a common framework for research data and creation of a European Open Science Cloud, a major initiative to build the necessary Open Science infrastructure in Europe[59].

A.1.4 3 OPEN TO THE WORLD: INTERNATIONALIZATION AND GLOBALIZATION

RRI framework *from local to* global insight is remarked in Open innovation framework regarding to the aim of develop an open innovation based in the *Open to the world* premise with can be translated in leading multilateral initiatives and working with international organisations to tackle global societal challenges

Fostering international cooperation in research and innovation is a strategic priority for the European Union so that can access the latest knowledge and the best talent worldwide, tackle global societal challenges more effectively, create business opportunities in new and emerging markets, and use science diplomacy as an influential instrument of external policy. While the globalisation of research and innovation is not a new phenomenon, it has become increasingly visible, particularly in terms of collaborative research, international technology production, and the worldwide mobility of researchers and circulation of knowledge.

As more research and innovation is performed outside Europe, the EU will need to

[58] http://europa.eu/rapid/press-release_SPEECH-15-5243_en.htm

[59] The European Open Science Cloud aims to create a trusted European environment for hosting and processing research data to help maintain the world-leading role of European science. It will be achieved by creating a world-class scientific infrastructure, which will help ensure that European stakeholders reap the full benefits of data- driven science and services for the digital economy and wider society. This initiative is part of Europe's ambition to support the transition to Open Science in the context of the Digital Single Market. It aims to meet an urgent need of the scientific community to increase access to and re-use of data, and to reduce the cost of data storage and high-performance analysis by pooling existing capacity and by aggregating demand, initially by researchers in the public sector.

access this knowledge. And to remain a major global player, the EU must promote itself as an attractive location for carrying out research and innovation and be successful in the global competition for talent, while at the same time preserving its economic interests, notably as regards intellectual property rights and standards.

A.1. 5 SCIENCE COMMUNICATION

Science communication is part of Research and Innovation challenge of open innovation and open science. Grant Agreement 38.1 states the obligations of communicate and efforts like *Open innovation, open science, open to the world vision of Europe* as well changes in Grant Agreement for embrace open innovation and science were proposed in H2020 Programme Multi- Beneficiary General Model Grant Agreement[60] (H2020 General MGA— Multi) Version 3.0 20 of July 2016 are part of the efforts related with the science communication transcending from the press release.

The changes in the agreement are focused in this premise, Science communication is not dissemination, shaping the framework for foster communication in research projects. Science communication is related with promoting actions and its results by providing targeted information to multiple audiences including **media and public** in a strategic and effective manner and possible engaging in two-way Exchange, while science diffusion is related with peer review actions, exploitation of the results and communication between users of the results.

Recommendation for Science communication are related with the needs to be devoted to inform but also to inspire and engagement needs to be a two-way exchange based in delivering and receiving, and needs to be visual and personal with emotions more than evidences.

The suggested resources for participation are School science competitions, multimedia platforms, science fairs, interactive online science, and citizen science, Gaming/ animation (f.e Pokemon GO), exchange of experiences of relevant persons, personal histories, inclusion of drama, visual arts, poetry or residence of artist in research institutions (CERN cosmic piano, Come Be Biz).

In this science communication frame, social media is suggested as platform for meet media and public but also we were warned regarding to the hazards of spread of information with no insights and the necessity of reinforce synergies of media supports.

The European Commission’s perspective is focused in the fact that research and innovation is founded by tax payers; communication build trust and good communication strategies may improve the rate of success. In this terms, 38.1 (38.1.1) must be taken as a strategy rather than a check list with this recommendations:

In conclusion, the re-framing of return of investing (ROI) is proposed, more based in outcomes not just the outputs and with the communication strategies that:

- Communicate with purpose
- Go beyond audiences

[60]http://ec.europa.eu/research/participants/data/ref/h2020/mga/gga/h2020-mga-gga-multi_en.pdf

- Inform and reach out society
- Choose targeted audiences
- Is included in the strategic plan from the start of the project
- Match channels and activities to targeted groups
- Builds measurable outcomes
- Engage scientists in communication
- Communication needs to be framed in a strategic plan as well as in a WP
- Communication strategy needs to start before the rest of the proposal
- Is necessary to promote your project and its results beyond the project own community
- Is necessary to choose few messages and targets (stakeholders) without understanding this as narrowing the dimension of the public
- Communicate in the way of all of the audiences can understand
- The strategic communication plan needs to answer to the questions: What we want to archive? For who? How?

A.1. 6 EXPERIENCES IN RRI

A.1.6 1 PREVIOUS EXPERIENCES IN RRI PROJECTS

Regarding to the projects overview, there are three distinctions. Projects intended to map RRI dimensions as show in Table 14; devoted to foster the keys and attributes and mainstream the concepts as show in

Table **15** and more disciplinary related project focused in develop research topics under the framework of RRI as show in Table 16.

TABLE 14: key focused RRI projects (2013-2015)

ACRONYM	PROJECT	RRI KEY
CIPAST	Citizen Participation In Science And Technology	PE, Governance
ESCITY	Europe Science And The City: Promoting Scientific Culture At Local Level	PE
ESCW	The European Science Communication Workshops	PE
MESSENGER	Media, Science And Society: Governance And Engagement In Europe	PE
ACCENT	Action On Climate Change Through Engagement, Networks And Tools	PE, science education
CASC	Cities And Science Communication: Innovative Approaches To Engaging The Public	PE
PE2020	Public Engagement Innovations For Horizon 2020	PE
SEISMIC	Societal Engagement In Science, Mutual Learning In Cities	PE
PRAGES	Practising Gender Equality in Science	Gender Equality
GENDERA	Changing the Gender Balance in Research Organisations	Gender Equality
GENSET	Increasing Capacity for Implementing Gender Action Plans in Science	Gender Equality
MOTIVATION	Promoting positive images of SET in young people	Science Education

SIS CATALYST	Children as Change Agents for the future of Science in Society	Science Education
ETHICSWEB	Inter-connected European information and documentation system for ethics and science: European ethics documentation centre	Ethics
PRESCIENT	Privacy and emerging fields of science and technology: Towards a common framework for privacy and ethical assessment	Ethics
FOSTER	Facilitate Open Science Training For European Research	Open Access
RISKBRIDGE	Building Robust, Integrative interdisciplinary, Governance Models for Emerging and Existing risks	Governance
SIAMPI	Social impact assessment methods for research andfunding instruments through the study of productive interactions between science and society	Governance
Responsible Industry	Implementation Plan of Responsible Research and Innovation (RRI) in Industry focus on the grand challenge of health, demographic change and wellbeing.	(RRI) in Industry

TABLE 15: General RRI projects (GO4 AND 2015-2017)

ACRONYM	PROJECT	DIMENSION
RESPONSIBILITY	Global Model and Observatory for International Responsible Research and Innovation Coordination	RRI Keys
NUCLEUS	New Understanding of Communication, Learning and Engagement in Universities and Scientific Institutions	RRI dimensions and HE
RRI-Tools	Develop a set of digital resources to raise awareness, educate, disseminate and implement the RRI in Horizon 2020	RRI keys and atributes outreach
Res-AGorA	Responsible Research and Innovation in a Distributed Anticipatory Governance Frame. A Constructive Socio-normative Approach	Governance and Global potential
GREAT	Governance for Responsibl innovation	Empirical and theoretical governance model development
PERARES	PERARES. Public Engagement with Research And Research Engagement with Society	PE
ProGReSS	Global network on responsible research and innovation (RRI) involving academia, SMEs, international organisations, policy advisors, research funders, NGOs and industry	Global potential and networks
HERRI	Higher Education Institutions &Responsible Research and Innovation	Foster RRI in HE
ERRICH	Enhancing Responsible Research and Innovation through Curricula in Higher Education	Foster RRI in HE
SCIENTIX2	SCIENTIX 2. The community for science education in Europe	Science education
IRRESISTIBLE.	Including Responsible Research and innovation in cutting Edge Science and Inquiry-based Science education to improve Teacher's Ability of Bridging Learning Environments	Inquiry-based Science education to Learning Environments
SATORI	Stakeholders Acting Together On the ethical impact assessment of Research and Innovation	PE, Stakeholders
MORRI	Metrics and Indicators of Responsible Research and Innovation	RII Assesment

TABLE 16: Disciplinary RRI projects

ACRONYM	PROJECT	DISCIPLINE
SYNENERGENE	Engaging with New and Emerging Science and Technology in Responsible Governance of the Science and Society Relationship	Synthetic biology
CRM-EXTREME	Solutions for Critical Raw Materials Under Extreme Conditions	Solutions for Critical Raw Materials
NanoDiode	Developing innovative outreach and dialogue on responsible nanotechnologies in EU civil society	Nanotechnologies

A.1.6 2 RRI EXPERIENCES IN SPAIN

In Spain, the regulation of RDI system experienced recently some strong changes in Spain (mainly represented by The Science Act of 2011 that replaces the one from 1986) and new and fresh ideas have reached more recent plans, strategies and programs, including some issues related with the concept of RRI. The 2011 Science Act contains numerous references to those 6 concepts considered by the European Union as key elements of RRI – public engagement, science education (formal and informal), gender equality, open access, governance and ethics – as well as other elements that we can also consider as consubstantial to RRI, such as inclusiveness, sustainability, cooperation, transparency, and a focus on future.

A report for existing RRI projects overview regarding with Spanish RRI[61] explicitly mentioned in the strategic documents of the selected universities performed by Gema revuelta, Octavi Planells and Núria Saladié[62] regarding to Res – Agora RRI project based in the review of the most recent strategic plan document available on each university website in addition to the relevant institution latest annual report and website shows that RRI is not featured in any of these strategic plans as part of the challenges and objectives of the university. Neither is RRI specifically referred to in any section of these documents. Some of the key elements of RRI considered by the EU are not new for the Spanish system and had a relatively solid structure and regulation, even before the 2011. Table 17 shows the main important findings regarding to issues related with RRI concepts.

[61] Revuelta G. Overview on Spanish National Policies towards Responsible Research and Innovation. Res-AGorA MoRRI 1st Ctry Rep Spain 2013:1–6.

[62] Res –Agora reports http://res-agora.eu/assets/Res-AGorA_321427_Del_2-2_updated.pdf

TABLE 17: findings regarding to issues related with RRI concepts. Adapted from Revuelta G. Overview on spanish national policies towards Responsible Research and Innovation. Res-Agora MORRI 1st Report for Spain 2013:1–6

RRI dimension	Findings
Ethics	- The 2007 biomedical research law - The science act 2011 - Programs also describe the ethical dimension of the spanish rdi system according to precise national, european and international laws, as well as to general and specific issues.
Gender	*"relevance of gender issues "is considered in all aspects of the process".* Additional provision of the law of science, technology and innovation (14/2011), the national plan 2013-2016 - The 2011 law on science - The strategy 2013-2020 - The national plan 2013-2016 - The handbook of gender in research (2011) , spanish version of the handbook of gender in research from the european commission published and distributed in spain by the women and science unit (wsu) from the former ministry of science and innovation - White paper on the position of women in science in spain (libro blanco sobre la situación de las mujeres en la ciencia española) 2011
Public engagement public participation	*Emphasizes the importance of society as a recipient and beneficiary of scientific activity with "citizen participation", one of the main goals of this act".*the new law on science, technology and innovation Althougth , conventional approach of "participation", oriented to the promotion of science and scientific culture, the social acceptability of science, and the shaping of a positive image of spanish rdi system is remining. - Science act 2011: - The 2013 -2016 r&d&i national plan 11 and 10 objectives centred in the promotion of scientific culture while objective 11 seems to follow a more participatory approach despite this general trend, there are some notable exceptions. - 2013 call of the national program of scientific and innovation culture. - Bottom-up approachs: the open letter for science 2012 arranged by a collective of scientists and labour union representatives and the second open letter published in 2013, with more types of stakeholders. Both letters are mainly centered on the economic aspects, but they also include some claims about the role of rdi in politics, and the need for an independent agency for the management of funding.
Open acces	- Article 37 of the science, technology and innovation law of 14 /2011 of 1 june, "scientific publications resulting in whole or in part, of the funding under this call shall be available in open access. To do this, the authors may choose to publish in open access journals, or to self-archiving in institutional or subject open access repositories, those scientific papers that have been accepted for publication in serial or periodical journals". - The spanish council of research (csic) and many universities and public organisations are developing measures to guarantee that their researchers know the current mandates about open acces facilitating one or those alternatives (or both).

However, the **Social Responsibility (SR)** of the university does feature in all documents as a challenge or objective. This concept involves a collection of a number of aspects, which vary greatly between universities, some of which fall into the definition of RRI, such as gender equality, ethics and participatory dialogue within the social environment. In the majority of the documents, SR also includes other more transversal aspects, such as sustainable development, international cooperation, economic transparency and emphasis on physical and mental diversity.

For example, the Strategic SR Challenge within the UPV 2020 Strategic Plan prioritises the commitment to: "being aware of the challenges facing society, those requiring solutions and responses". Similarly, in its 2012-2017 Strategic Plan, the UPV/EHU defined certain objectives and actions under the umbrella of 'Social Commitment' many aspects of which overlap with RRI. Specifically, the UPV/EHU emphasises: Participation, Ethics Dissemination and Gender issues.

It should also be noted that in the conceptualisation of SR contained in the sampled university strategic plans there was no specific mention of open access or of the promotion of scientific vocations among young people - issues covered in the definition of RRI.

There was no specific reference to RRI found on the websites of the universities studied, except in certain exceptional cases. One such exception is that of the UB Unit for Scientific Culture[63], expresses its wish to: "**start working towards an RRI approach** in which citizens play a more active and participatory role in research".

Other specific mentions of RRI can very occasionally be found on the websites of the sampled universities advertising events in which RRI is being discussed or describing projects or lines of research focused on that particular area of study.

Table 18 lists the documents referred to and links to the corresponding university websites concerned.

Regarding with RRI dimensions implicitly emerging in strategic University documents, broadly speaking, almost all the dimensions of RRI emerge implicitly in the majority of the strategic plans reviewed with the exception of those of the UCA and the UIB.

The commitments, goals, challenges, intentions, etc. reflected in the strategy documents for each institution in the sample are summarised below, in relation to the six dimensions of RRI:

- **Ethics:** Ethics is mentioned in the majority of the universities' documents but is only included among the strategic activities for three institutions – the UPV, the UPV/EHU and the USAL. In the rest, where mentioned, it appears as one of the university values but not as a strategic objective.
- **Science and society/Engagement:** Communication and outreach regarding the university's research activities are featured as a common objective in the majority of the strategic plans studied. Many of these documents express the university's commitment to social return on public investment in the area of research. This is manifested, for example, by the USC in its Strategic Plan.

[63] http://www.ub.edu/laubdivulga/club

- **Governance:** On governance issues, only the strategic documents of the UB and the UPV/EHU reflect the need to contribute to political and other administrative agendas and decisions. In other universities, the documents reviewed refer only to the self-governance of the institution, which does not appear to reflect the perspective of RRI.

TABLE 18: RRI related concepts in spanish universities strategic plans. ADAPTED FROM 2nd report in RRI in Selected Research Funding Organisations, Universities and Companies 2nd report from https://rritrends.res-agora.eu/reports/second/from Author: Gema revuelta, Octavi Planells, Núria Saladié.2015

University	Document	Link
UAM	CEI UAM+CSIC 2015 Strategic Plan	http://bit.ly/1ErC2Ub
UB	UB Horizon 2020 Framework Plan	http://bit.ly/1LkfYg1
UCA	UCA 2015-2020 Strategic Plan II	http://bit.ly/1y8NM6Q
UIB	UIB 2012-2014 Action Management Plan	http://bit.ly/1LkhTRO
UM	2007-2012 Institutional Strategic Plan	http://bit.ly/1ErCUrS
UPNA	2011-2014 Strategic Plan III	http://bit.ly/1CgUXQN
UPV	UPV 2015-2020 Strategic Plan	http://bit.ly/1HioVH6
UPV/EHU	UPV/EHU 2012–2017 Strategic Plan	http://bit.ly/1Bt4b6X
USAL	2013-2018 General Strategic Plan	http://bit.ly/1K9E7SY
USC	USC 2011-2020 Strategic Plan	http://bit.ly/15XrGwZ

- **Scientific vocations/science literacy/Science culture/Science education:** This RRI dimension is not specifically featured in any of the strategic objectives of the universities in the study, at least with regard to those documents reviewed, with the exception of the UB. It should also be noted that, in this specific case, the document focuses on attracting prospective students to the university and on improving their ability to obtain good results in their studies. The document does not make any reference to specific subjects (i.e. it does not specifically mention vocational activities geared towards scientific studies).
- **Gender:** All the universities in the study – with the exception of the UB, the UCA and the UIB – include specific instruments – entities, plans or strategies – that deal with the issue of gender equality. In some cases there is a commitment towards the establishment of such instruments, while in others the document refers to strengthening activity in this area. **Beyond their strategic plans, gender is the best-represented dimension of RRI in the universities studied.**
- **Open Access:** Four universities (the UM, the UPNA, the UPV and the USC) cover the creation of an academic open access repository in their strategic plans, both for academic documents and for scientific information and results. The other universities make no reference to this RRI dimension in the documents reviewed.

A.1.6 3 RECOMMENDATIONS FOR PRACTICAL IMPLEMENTATION

The RRI therefore fits with the prominent objectives of EU such as development of public engagement agendas, socio-technical integration, research ethics and integrity, enrolments of different actors, stakeholders and public and new forms of assessment, but at operational and disciplinary level, RRI in context can lead to certain ambiguities and the meaning and application **often** was found loosely articulated (Owen et al. 2012, Bensaude-Vincent 2014).

Clarification on what RRI **has to offer in practice — beyond what has been offered to date** — is still needed (Ribeiro et al. 2016), **as well as more explicit engagement with research and institutional culture of responsibility.**

At level of practical implementation, several authors have made attempts to translate the concept into practice, but there are noticeably few reports on real-world experiences and no single approach to practice dominates (Ribeiro, Smith, Millar 2016).

RRI experiences regarding to **traslation into practice** recommend:

- Early stage implementation of mechanisms avoiding time delays between innovation and regulation.
- To explore the complex dynamics behind innovation and their evolving landscapes (industrial, market, society, regulation, research etc.).
- Facilitate the construction of more pluralistic visions of technology futures.

This recommendations are related with **"socio-technical integration"**(EC2013) and the integration in RRI due to four kinds of engagement (Rodriguez et al. 2013) each relating to a different category of actors:

- Socio-ethical.
- Stakeholder.
- Socio-economic and industrial.

Recommendations and critical issues for arrange dimensions and attributes can found in studies regarding to implementation of techno-integration and responsible innovation as show in

Table **19** and

Table **20**.

TABLE 19: Indicative techniques and factor affecting in the case of the attributes application. Adapted from J. Stilgoe et al. / Research Policy 42 (2013) 1568– 1580 1573.

Dimension	Indicative techniques and approaches	Factors affecting implementation
Anticipation	Foresight Technology assessment Horizon scanning Scenarios Vision assessment Socio-literary techniques	Engaging with existing imaginaries Participation rather than prediction Plausibility Investment in scenario-building Scientific autonomy and reluctance to anticipate Rethinking
Reflexivity	**Multidisciplinary collaboration and training** Embedded social scientists and ethicists in laboratories Ethical technology assessment, **Codes of conduct** , Moratoriums	Rethinking moral division of labour Enlarging or redefining role responsibilities Reflexive capacity among scientists and within institutions Connections made between research practice and governance
Inclusion	Consensus conferences **Citizens' juries and panels** **Focus groups** **Science shops** Deliberative mapping Deliberative polling Lay membership of expert bodies **User-centred design** **Open innovation**	Questionable legitimacy of deliberative exercises Need for clarity about, purposes of and motivation for dialogue Deliberation on framing assumptions Ability to consider power imbalances Ability to interrogate the social and ethical stakes associated with new science and technology Quality of dialogue as a learning exercise
Responsiveness	Constitution of grand challenges and thematic research programmes Regulation Standards **Open access and other mechanisms of transparency** Niche management **Value-sensitive design** Moratoriums **Stage-gate** **Alternative intellectual property regimes**	Strategic policies and technology 'roadmaps' Science-policy culture Institutional structure Prevailing policy discourses Institutional cultures Institutional leadership Openness and transparency Intellectual property regimes Technological standards

TABLE 20: Approaches and methods connected to RRI in the academic literature (adapted from Ribeiro et al. 2016).

Approaches and methods	Objetive of approaches and methods
Codes of conduct; codes of ethics; **constructive ethical TA; ethical impact assessment; ethical TA;** ethics review; **research integrity;** value- sensitive design	Identification and appraisal of ethical and societal aspects of R&I
Constructive TA; cost-benefit analysis; foresight; **horizon scanning; impact assessment; life-cycle assessment; risk assessment; risk management; scenario planning; socio- literary techniques; technology assessment; vision assessment**	Identification and appraisal of risks, potential positive and negative impacts of R&I
Constructive TA; ethical parallel research; **ethnographic studies; foresight activities; horizon scanning;** midstream modulation; **real-time TA; scenario planning;** technology assessment	**Socio-technical integration and interdisciplinarity in R&I**
Anticipatory governance; citizens' juries/panels; consensus conferences; constructive TA; co- evolutionary scenarios; deliberative mapping; deliberative polling; focus groups; **foresight activities; horizon scanning;** hybrid mechanisms (e.g. lay members on scientific advisory committees, stakeholders advisory boards)**; interactive learning and action (ILA) approach; multi-stakeholder partnerships;** open access; **participatory agenda setting;** participatory forums and workshops; participatory research projects **(e.g. community-based approaches, CBL, CBR); participatory TA;** public advisory boards; public opinion polling; **roadmapping,** multi- level analysis **and** socio- technical scenarios (as pre- engagement tools)**; scenario planning;** science cafes; science shops; upstream engagement; user-centred design	Public and stakeholder engagement with R&I

ANNEX 2 REVIEW ON RRI EVALUATION METHODS

A.2 1 INTRODUCTION TO METHODS, CRITERIA AND SOURCES OF INDICATORS

Measurements and development of indicators for assessment RRI dimension is a challenge while many, perhaps all, of the six original RRI keys are to some extent interrelated and generally cannot answer the following question *what extent does a research field, a research programme or an RRI initiative contribute to a particular dimension and how can this be assessed and monitored?*

The construction of outcome indicators for socioecological metabolism is a research field of its own. Most of the suggested methods are based in intervention logic model, based on the explanatory idea that complex policy problems are characterised by a series of issues or problems that need to be addressed; a set of inputs which are applied to a series of activities, which generate outputs which in turn lead to outcomes or the resolution of the problems (Meijer AI, Mejlgaard N, Lindner R, Woolley R, Rafols I, Griesler E, et al. 2016). Inputs are translated in activities and immediate results of those activities become in outputs, leading to outcomes for reaching long term achievements.

The most used criteria are based in the statement of performance indicators; which are divided in process indicators and outcome indicators and perception (how such processes and outcomes are perceived) indicators. **Perception indicators** for RRI dimensions, can easily be defined by inquiring into different actors' sociotechnical imaginaries (Jasanoff and Kim, 2009) with respect to the R & I activity in question. One could simply ask: *what is the anticipated effect of this research development on gender for example?* For instance, both research funding programmes and research proposals make frequent claims on how the anticipated research will contribute RRI dimensions.

Process indicators otherwise, can be defined to monitor the efforts and developments being made towards the expected outcomes. When taken together, perception and process indicators may provide a basis for RRI governance in the sense of improved responsiveness and accountability among R & I actors.

For appraisal purposes, process indicators can be defined in terms of milestones on specified pathways that have an effect on specified dimensions and R&I actors' perceptions may be indicated in terms of their anticipation and imagination of pathways, milestones and the ultimate effect on above specified dimensions. Perception indicators are going to be considering as an outcome indicators and process indicators since belong usually to structural mandates are only consider when they can be considered measurable.

Regarding to operationalization of monitoring, efforts have been made with projects such as a Res-AGorA[62] and MoRRI [74] focused in developing indicators for monitoring RRI practices as shown in chapters below. Ravn, T., M.W. Nielsen, and N. Mejlgaard suggested that despite RRI key dimensions' indicators can measured with existing data (secondary data), moderated set require (primary) data collection.

To collect primary data, different approaches have been suggested. These include: desk research, register-based data collection, surveys and interviews. To establish the subsequent process of identifying and constructing indicators, the research design for collecting primary data therefore requires a set of well-defined methods taking into consideration criteria such as appropriateness of methods (individually and collectively), issues of relevance, robustness, richness as well as feasibility concerns/data administration matters (Ravn, T., M.W. Nielsen, and N. Mejlgaard 2015).

The indicators that are more broadly represented are those corresponding to dimensions such as a gender, ethics and governance, presents in early predecessor's approaches of RRI such as an ELSA and Impact assessment/Technology assessment methods. Open science, has had a great development in the last times, featuring projects and initiatives like EU Open innovation initiative (annex A.1.4 1).

Dimension such as a sustainability and social justice, needs to be developed more interdisciplinary as well as considerations regarding to the interlinks of RRI dimensions in terms of indicators.

A.2.1 1 SOURCES OF INDICATORS FOR RRI DIMENSIONS

The main source of indicators for RRI eight key areas are EC RRI process indicators[76] which depends both on the processes that promote RRI activities and on the effects that these processes have (outcome) and are described in Figure 10. These indicators were proposed for six's initial dimensions.

Criteria	Performance indicators		Perception indicators
	Process indicators	Outcome indicators	
Public engagement	Number and degree of development of formal procedures for citizens' involvement (consensus conferences, referendum, etc.) Number of citizen science projects, discriminating from those supported by institutions and those that are created at grassroots level, by field	Number (absolute and percentage with respect to the total) and the percentage in terms of funding of projects and initiatives (a) led by citizens or civil society organisations and (b) including research done by citizens or civil society organisations (citizen science) Number of advisory committees including citizens and/or civil society organisations Percentage of citizens and civil society organisations with special responsibilities within advisory boards, committees and consultant bodies (chair, rapporteur, etc.) Number of citizens engaged in citizen science projects	Degree of public interest in science and technology issues: percentage of the total population declaring themselves interested; percentage of citizens indirectly showing interest in science and technology (percentage visiting science centres, percentage participating in demonstrations about scientific issues, etc.) Expectations of responsible science: percentage of population that sees science as part of the solution rather than the problem; percentage of population with high expectation
Gender equality	Percentage of research institutions that document specific actions that aim to change aspects of their organisational culture that reinforces gender bias	Percentage of women that are principal investigators on a project Percentage of women that are first authors on research papers Percentage of research projects including gender analysis/gender dimensions in the content of research	
Science education	The inclusion of an initiative or requirement for RRI-related training in a research strategy/call/work programme, etc. (yes/no, percentage)	At the level of R & I projects, whether they encourage or require young researchers to take RRI-related education/training and to apply it in the project (e.g. in an integrated ELSA model) Percentage of research projects with at least one educational resource deliverable	
Open access	Inclusion of open science measures in research policies and calls for proposals	Percentage of research projects that report real added value by an open science mechanism (for themselves and/or other actors)	The extent to which members of the public have visited vital virtual project environments and found them useful
	mponent t that thical qualitative	r r t	
nance	al networks of e national and		

FIGURE 10: Indicators for promoting and monitoring RRI. European Commission 2015.

Regarding to sustainability and social justice, both dimensions are not included in EC concrete indicator proposals due to the joint process nature of both indicators. Also, no metrics and indicators or methodological specifications for indicator selection are recommend in existing RRI monitoring projects such as MoRRI. In the case of sustainability, the report of Indicators for promoting and monitoring Responsible Research and Innovation[64] (EC 2015) indicate that since the nature of process and perceptions indicators lays in milestones and specific pathways that have effect on specific interactions between renewable and non-renewable resources and consumption and regeneration (stock- flow interactions), meanwhile both milestones and pathways are still under construction, as of today there is no obvious place for such indicators in current policy practice.

In the case of social justice, since indicators are measuring by level of commitment and qualitative indicators for identify best and worst practices, substantial resources are required in order to meaningfully monitor the indicators. Only within fields where the link between research and social justice is found to be evident or at least relevant (several scientific fields may be excluded here) is required. However, as noted above, the expert group (EC 2015) has found it reasonable also to take into account what we consider to be likely future developments of the concept of RRI by including reflections on design principles for such indicators and focus efforts only within fields where the link between research and social justice is found to be evident or at least relevant (several scientific fields may be excluded here).

Other sources of indicators are:

- Horizon 2020 indicators for Research and Innovation of 2015, RRI, gender, science communications and sustainability Cross-Cutting Issues indicators
- Pilot on Open Research Data[65] suggestions
- Open Digital Science project[66]
- Open innovation initiative (A.1.4 1)
- Eurostat's indicators for research and development[67] , mostly concerned with the headline target for R & I

Recommendations for extended energy research policy literature in terms of barriers of technology penetration, sociotechnical integration (Rodriguez 2013), public participation in energy research (Bidwell 2016) and integration of social sciences in energy research frameworks (Sovacool 2014, 2015, 2016) will be considered for special frameworks of sustainability and social justice framework proposal for GREA RRI plan.

A.2 2 RES-AGORA PROJECT: META GOVERNANCE APPROACH

This Project main goal is to develop a normative and comprehensive governance framework for Responsible Research and Innovation (RRI). The Res-AGorA framework proposed to build new monitoring toolkits based on existing RRI governance practices

[64] Indicators for promoting and monitoring Responsible Research and Innovation, Roger Strand, Jack Spaapen, Martin W Bauer, Ela Hogan, Gema Revuelta, Sigrid Stagl Contributors: Lino Paula, Ângela Guimarães. EC2015

[65] https://www.openaire.eu/opendatapilot

[66] E. Prem, F.S.Sanz, M. Lindorfer, D. Lampert, J. Irran, Open Digital Science (SMART 2014/0007) Final Report.2016

[67] http://ec.europa.eu/eurostat/help/first-visit/content

across and beyond Europe. The project[68] provides precious information regarding to comparative analysis of a diverse set of existing RRI governance arrangements their theoretical/conceptual underpinnings across different scientific technological areas and detected the existence of multiple governance arrangements working towards objectives as stated in definitions of RRI.

The Res-AGorA framework suggests that the 'success' of any new RRI governance framework will depend on the way it relates to already existing governance practices or *de facto* governance. To translate this *de facto* to *de jure* in terms of governance arrangements project first suggest to learn from the dynamics in *de facto* RRI governance, by using a **meta-governance' approach**.

The *de facto* governance of RRI was analysed through the model of looking for processes of '**RRI in the making'**. This framework is valid for diagnosis the state of an institution in order to arrange RRI practices. Two research questions are proposed for this evaluation:

- How is 'RRI in the making' conditioned?
- Are there building components for a socio-normative governance framework?

RRI in the making' is conditioned by RRI policies, characterised by structural aspects such as a modes of regulation (e.g. hard/soft), type of responsibility (e.g.prospective/retrospective), type of (ethical principles) and the relative position within the broader landscape of R&I and RRI governance arrangements.

The building components are linked to the demonstrated 'success' or 'failure' in the case studies.

The steps of the meta governance approach are:

- **Research questions and model**
- **Assessments of *de facto* governance**
- **Operationalisation model for the pilot case studies**

A.2.2 1 RESEARCH QUESTIONS AND MODEL

Research model reflects the de facto element of RRI governance in distinguishing three overlapping dimensions conditioning 'RRI in the making', proximate to the notions of structure, agency and their dynamic interplay in governance practices. For build the components of the framework, research strategy in search of component for the RRI governance framework is suggested, focused in:

- RRI governance arrangements
- Actors involved
- De facto practices of governance

A.2.2 2 ASSESSMENT OF *DE FACTO* GOVERNANCE

The steps for the facto governance are:

[68] Res-AGorA partners are Fraunhofer Institute for Systems and Innovation Research, University of Twente, Netherlands, University of Padua, Danish Board of Technology, Denmark, Institut für Höhere Studien, Austria, University of Manchester, University of Aarhus, Denmark and Université Paris-Est Marne-la-Vallée, France / IFRIS.

- Evaluation of *responsabilization* and *managing contestations*
- Level of constructive /productive interactions

The key factors contributing to the well-doing of the de facto governance of RRI can be grouped under the headings of **'responsibilisation'** and **'managing contestation' and the** understanding of 'well-doing' in the context of de facto governance as emerging from or produced by interactions, can be assessed to what extend these are **'constructive'** and/or **'productive'**.

Project use **'well-doing'** as an overarching notion for assessing the de facto governance of RRI in the same way as, for example, the notion of 'good governance' is used and the appraisal.

Specification of factors contributing to 'well-doing' is arranged as descriptors in ReS-Agora project. **Constructive input requirements** descriptors are actors' inclusion, robustness of the knowledge base, capacities of learning and **Productive outputs** are considered actors change behaviour and governance changes

For evaluate this factors the framework defines the concepts:

- **Responsibilisation**: About the governance of (self-) stimulating actors to care for their duties of being anticipatory, reflexive, responsive, etc... by drawing on a clear under- standing of their responsibilities and un-coerced application of values.
- **Managing contestation**: is about the governance of deliberating and negotiating competing claims of responsibility, effectiveness and legitimacy, being the result of different understandings, framings and evaluations of the need for and processes and instruments by which normative objectives are to be accomplished (whether or not specifically articulated as RRI).
- **Constructive interactions**: can be characterized by an adequate (evaluated by the actors themselves, and evaluated by the researcher) treatment of the issue(s) under discussion (including the framing of the problem)) and mobilization of resources (from mental to financial) and by process requirements perceived as legitimate by the involved actors.
- **Productive interactions**: bring about transformation, either in the behaviour or attitude of actors, in line with new understandings of responsibility, working towards a higher level of shared understanding of responsibility or in responsive/reflexive improvement in the governance arrangement itself.

A.2.2 3 OPERATIONALISATION MODEL

For operationalisation for the pilot case studies project has developed a tool for arrange assessment of RRI practices based in Co-construction method[69], which is located in **Responsibility Navigator tool**[70]. The purpose is to encourage reflective processes to help diverse and contesting stakeholders make research and innovation more responsible and sustainable in Europe.

[69] The Co-construction method was developed by Danish Board of Technology designed in collaboration with Institut für Höhere Studien, Vienna, University of Twente, Mandl, Lüthi and Partner and Fraunhofer ISI.

[70] http://responsibility-navigator.eu/navigator/

The Responsibility Navigator supports the identification, development and implementation of measures and procedures that can transform research and innovation in such a way that responsibility **becomes an institutionalised ambition.** Is based in ten principles of governance as shown in Table 21, where governance principles are divided in three dimensions of *Ensuring Quality of Interaction; Positioning and Orchestration* and *Developing Supportive Environments*.

TABLE 21: Ten principles of governance for Responsible Navigator Tool.

Dimensions	**Ensuring quality of interaction**	**Positioning and Orchestration**	**Developing Supportive Environments**
Principles	1- Inclusion	4-Modularity and flexibility	7-Capabilities
	2-Moderation	5-Subsidiarity	8- Capacities
	3-Deliberation	6-Adaptability	9-Institutional entrepreneurship
			10-Culture of transparency, tolerance and rule of law

Case studies for developed a RRI unit embodied in a large research organisation[71] and the integration of RRI policy in roadmaps[72].

A set of questions is included for arrange *responsabilization* diagnosis in order to arrive at practices and directions that are widely accepted. The questions can be found in annex A.4 1.

A.2 3 METRICS AND INDICATORS OF RESPONSIBLE RESEARCH AND INNOVATION PROGRESS (MORRI) PROJECT

Metrics and Indicators of Responsible Research and Innovation Progress (MoRRI) RRI project, aims to construct, identify, and specify relevant metrics and indicators to be used in the subsequent RRI monitoring.

The broad objective implies a cascade of work that includes conceptualising and operationalizing, developing a sound data collection approach before data can be collected and analysed, and conclusions and recommendations can be drawn (MORRI Proposal 2014) [73].

The project[74] provides a core set of RRI indicators, detailed descriptions of each indicators and a data guiding for the data-collection.

[71] From Goos K, Lindner R. Case Study Institutionalising RRI – The case of a large research organisation 2015.Fraunhofer Institute for Systems and Innovation Research ISI, 2015

[72] Doren D Van. Case Study: Integration of RRI in policy advice – A review of the UK synthetic biology roadmap 2014

[73] From http://www.isi.fraunhofer.de/isi-de/t/projekte/rl-MoRRi.php

[74] Ravn, T., M.W. Nielsen, and N. Mejlgaard (2015). Metrics and Indicators of Responsible Research and Innovation Progress Report D3.2 - Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI). 92 pp

Data is considered from two sources**, primary data,** which **must be found** and for which the project suggest the use a mix of methods such as a literature review; interviews, case studies, survey which must be founded, visioning workshop and discuss and **secondary data**, from existing RRI practices for example Reports targeting each of the RRI dimensions can found in European Commission[80].

MoRRI also highlight the interlinkages among RRI (sub-) dimensions/categories and suggest to take into account to further guide the collection of primary and secondary data. Ensuring consistency across the six RRI dimensions at different, levels, a separation between existing and potential interlinkages of RRI dimensions and sub-dimensions is arranged as show in Figure 11.

The direction of the arrows indicates whether the interrelations are reciprocal or non-reciprocal. Several of the indicators addressing the public communication aspect of pe, for instance, bear clear relevance to, and reveal actual overlaps with, the slse (science literacy-science education) sub-category of science communication. The coloured arrows reflect whether interlinkages are directly addressed (green) in the existing set of indicators, whereas the purple arrows display that could be further explored.

For example, PE, activities aiming "to inform and/or educate citizens' (public communication), for instance, often share objectives and features with those related to the dimension of science literacy and scientific education.

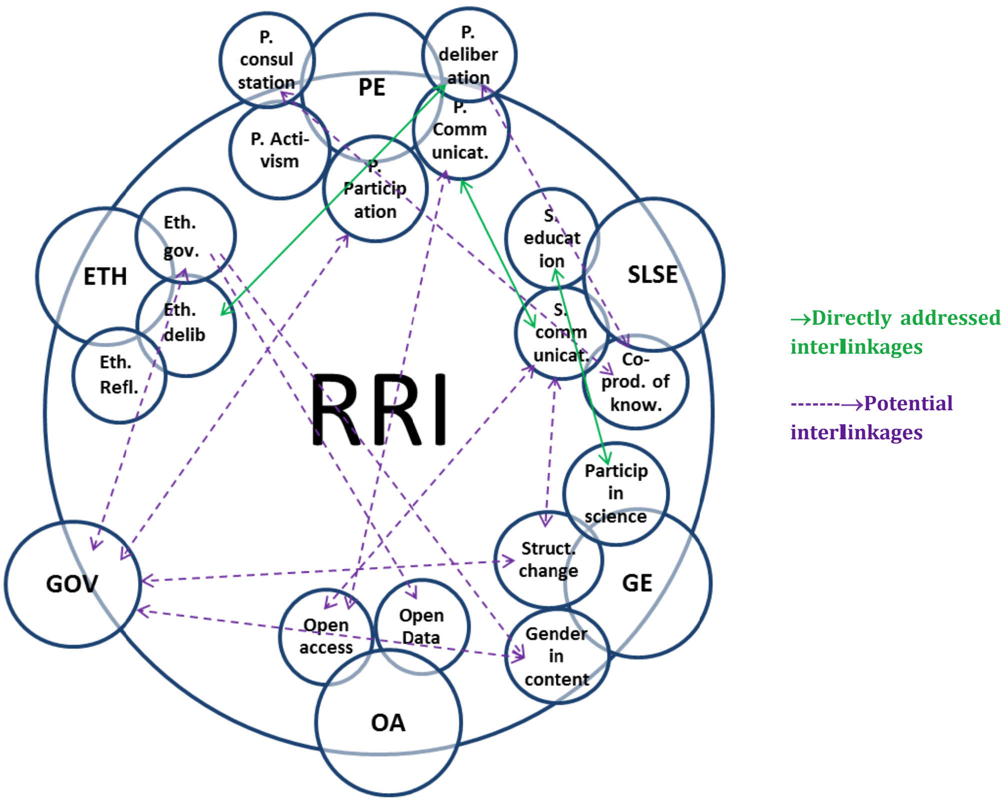

FIGURE 11: Existing and potential interlinkages/overlaps between RRI dimensions/sub-dimensions Source: MoRRI proposal 2014 deliverable 3.1

A.2.3 1 METHODOLOGICAL SPECIFICATIONS FOR INDICATOR SELECTION

To develop a solid conceptual framework capable of addressing the complex nature of RRI in the best possible manner, the MoRRI project borrows ideas from the evaluation literature and introduces the **intervention logic model** [75] The indicators of the intervention logic model are based on the explanatory idea that complex policy problems are characterised by a series of issues or problems that need to be addressed; a set of inputs which are applied to a series of activities, which generate outputs which in turn lead to outcomes or the resolution of the problems (Meijer AI, Mejlgaard N, Lindner R, Woolley R, Rafols I, Griesler E, et al. 2016). Inputs are translated in activities and immediate results of those activities become in outputs, leading to outcomes for reaching long term achievements.

Before define performance and perception indicators, MoRRI first state:

- **Context indicators**: Which provide information on the environment and overall situation in a country and across countries.
- **Input indicators**: Which concern the activities carried out, measures taken, structures created and resources allocated to promote RRI. Moreover, this type of indicators focuses on the system and consistency of the RRI related initiatives.
- **Output indicators**: Which are defined to address the immediate and direct results of these activities, while indicators of outcome scrutinize the more far-reaching and long-term achievements and perceived benefits of the RRI work.

Perception indicators are going to be considering as an outcome indicators and process indicators since belong usually to structural mandates are only consider when they can be considered measurable.

Another important classificatory scheme applied in the identification and assessment, concerns the determination of the **level of analysis or degree of aggregation characterising the available indicators**.

The MoRRI project distinguishes between the following **levels of aggregation**:

- **The global**: Which concerns indicators and data types that exceed the national level as the smallest unit of analysis, includes countries not associated with the EU, or data that cannot be specified in terms of national, regional and institutional variation.
- **The national level**: Which covers indicators providing information on country-level variations among the EU member states and associated countries.
- **The institutional level:** Which comprises all data types and indicators enabling analysis of variation on RRI parameters across institutions (e.g. research performing organisations, research funding organisations).
- **Programme/Project level:** has been used to classify data on RRI accessed via research programmes and projects (e.g. the EU FP7 framework).
- **Individual level:** covers information related to citizens' individual performance (e.g. in the PISA studies) and perceptions or opinions (e.g. in the Eurobarometer) on RRI related issues.

[75] http://ec.europa.eu/europeaid/how/evaluation/methodology/impact_indicators/wp_meth_en.pdf

MoRRI project also introduces three main parameters of assessment developed with the purpose of providing a systematic overview of the identified indicators (and data sources), in terms of their capacity, coverage and applicability in measuring and capturing aspects of RRI on various dimensions and levels of analysis.

The parameters are:

- **Relevance/Proximity:** The question of relevance/proximity concerns the relevance of the identified indicators and data sources in measuring RRI related aspects, and their proximity to the core content of the RRI concept.
- **Robustness/Quality:** The parameter of robustness/quality concerns the validity and reliability of the identified existing indicators in measuring specified dimensions and analytical levels of RRI.
- **Richness of data:** The parameter of richness of data concerns the potential capacity of the available data collected on the basis of the indicators in covering the conceptual categories carved out for each of the six RRI dimensions. In opposition to the above-mentioned parameters (i.e. relevance and robustness), this assessment only took place at aggregated levels (i.e. the four dimensions of the intervention logic and the six levels of aggregation).

In this terms, the dimension of logic intervention model is structured in the following analytical steps. The coverage of the four dimensions of the context, input, output, and outcome as the first step; the coverage of the six analytical levels of aggregation: global, national, regional, institutional, programme/project, and individual and the parameters for capturing aspects of RRI on various dimensions and levels of analysis.

A.2.3 2 THEORETICALLY-DERIVED DIMENSION-SPECIFIC CONCEPTUAL CATEGORIES

A number of theoretically derived sub-dimension or specific conceptual categories have been fixed out to conceptualise and operationalise each RRI dimension. These categories enable a systematic and functional approach to the monitoring of RRI. MoRRI suggests using this sub dimensions in assessing the coverage and relevance of promising indicators connected to each of the six RRI dimensions.

The project suggests to develop each dimension and conceptual categories according factors like their objectives in relation with RRI general approach; horizontal (culture-oriented activities) and vertical (policy-oriented) nature of the actions and interlinks between dimensions. Most of the insight for arrange the sub classifications came from theoretical conceptions. For example, in the case of public engagement mechanisms and initiatives have been classified according to their aim/objective; the direction of the flow of information and interlinks with other dimensions such as science education. This consideration leads to a frame were Public engagement is consider in terms of Public communication (with the aim to inform and/or educate citizens and with one-way flow of information from sponsors to public representatives); Public activism, with the aim to inform decision-makers and create awareness to influence decision-making processes and one-way information flow conveyed in communication from citizens to sponsors but not on the initiative of the sponsors; which characterise the 'public consultation' category. Public consultation, Public deliberation and Public participation are also framed under this consideration.

Most of the theoretical considerations are taking into account in the assessment of the indicators and the theoretically-derived dimension-specific conceptual categories for the MoRRI project is developed in each dimension proposal framed above.

Each dimension contends:

- **Theoretically-derived dimension** (specific conceptual categories)
- **Interlinks between dimensions**
- **Indicators proposal**
- **Data collection suggestions**

A.2.3 3 PUBLIC ENGAGEMENT DIMENSION

Within the public engagement (PE) dimension, PE mechanisms and initiatives have been classified according **to their aim/objective and the direction of the flow of information** in terms of Theoretically-derived dimension/specific conceptual categories as show in Other theoretical distinction to take into account is the **division between horizontal (culture-oriented activities) and vertical (policy-oriented) engagement** which lead us to a typology also indicative of possible intersections with other RRI dimensions. Apart for motioned public engagement and science education, the categories of public activism, public deliberation and public activism interrelate with aspects of participatory governance of research and innovation .

For the Public Engagement dimension a set of **10 indicators has been established**.

The indicators based in existing secondary data of MoRRI proposal are (in bold the selected for GREA RRI plan):

- **PE1 - Models of public involvement in S&T decision-making.**
- **PE2 – Policy- oriented engagement with science.**
- PE3 – Citizen preferences for active participation in S&T decision-making.
- **PE4 – Active information search about controversial technology.**
- **PE5 – Public engagement performance mechanisms at the level of research institutions.**
- **PE6 – Dedicated resources for PE.**
- **PE7 – Embedment of public engagement activities** in the funding structure of key public research funding agencies.
- **PE8 – 'activism' dimension**. This dimension has not been given priority in the development of the set, due to considerations of both relevance and feasibility in terms of data collection.
- PE10 – National infrastructure for involvement of citizens and societal actors in research and innovation are all focused on the sub-dimension of 'participation' in the conceptual specification of PE.

Indicator to be measured are (primary data):

- PE9 – R&I democratization index.

Table 22.

Other theoretical distinction to take into account is the **division between horizontal (culture-oriented activities) and vertical (policy-oriented) engagement** which lead us to a typology also indicative of possible intersections with other RRI dimensions. Apart for motioned public engagement and science education, the categories of public activism, public deliberation and public activism interrelate with aspects of participatory governance of research and innovation [76].

For the Public Engagement dimension a set of **10 indicators has been established**.

The indicators based in existing secondary data of MoRRI proposal are (in bold the selected for GREA RRI plan):

- **PE1 - Models of public involvement in S&T decision-making.**
- **PE2 – Policy- oriented engagement with science.**
- PE3 – Citizen preferences for active participation in S&T decision-making.
- **PE4 – Active information search about controversial technology.**
- **PE5 – Public engagement performance mechanisms at the level of research institutions.**
- **PE6 – Dedicated resources for PE.**
- **PE7 – Embedment of public engagement activities** in the funding structure of key public research funding agencies.
- **PE8 – 'activism' dimension**. This dimension has not been given priority in the development of the set, due to considerations of both relevance and feasibility in terms of data collection.
- PE10 – National infrastructure for involvement of citizens and societal actors in research and innovation are all focused on the sub-dimension of 'participation' in the conceptual specification of PE.

Indicator to be measured are (primary data):

- PE9 – R&I democratization index.

TABLE 22: Public engagement categorisations based in theoretically-derived dimension. Source: European Commission (2015): Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI): Analytical Report on the Dimension of Citizen Engagement and Participation of Societal Actors in Research and Innovation. Sub-task 2.5, deliverable D.2.1; the categorisation was originally developed by the PE2020 project (see www.pe2020.eu).

Public engagement theoretically-derived dimension	Aims	Flow of information	Examples
Public communication	Inform and/or educate citizens	One-way communication from sponsors to public representatives, and no specific mechanisms exist to handle public feedback	Public hearings, public meetings and awareness raising activities
Public activism	Inform decision-makers and create awareness to influence decision-making processes	One-way communication from citizens to sponsors but not on the initiative of the sponsors, which characterise the 'public consultation'	Demonstrations and protests

[76] European Commission (2015): Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI): Analytical Report on the Dimension of Citizen Engagement and Participation of Societal Actors in Research and Innovation. Sub-task 2.5, deliverable D.2.1.

		category	
Public consultation	Inform decision-makers about public opinions on certain topics	Opinions are sought from the sponsors of the PE initiative and no dialogue is implemented. Thus, in this case, the one-way communication is conveyed from citizens to sponsors on the initiative of sponsors	Citizens' panels, planning for real, focus groups and science shops).
Public deliberation	facilitate group deliberation on policy issues, where the outcome may impact decision-making	Two-way communication flow and Information is exchanged between sponsors and public representatives and a dialogue is facilitated.	'mini publics' such as consensus conferences, citizen juries, deliberative opinion polling
Public participation	to assign partly or full decision-making-power to citizens on policy issues	Two-way communication flow and Information is exchanged between sponsors and public representatives and a dialogue is facilitated	co-governance and direct democracy mechanisms such as participatory budgeting, youth councils and binding referendums

This indicator will be a composite measure based on a limited number of survey questions all tapping into the role and responsibilities – or degrees of engagement - of citizens and societal actors in research and innovation processes. The specific items need to be tailored and tested ahead of fielding the survey, but preliminary question formulations include: 1) mechanisms for efficiently involving citizens in decisions around research and innovation at the national level are in place, 2) civil society organisations are formally involved in decisions about research and innovation at the national level' and similar items with 5-point response scales.

This is a fairly high number of indicators for this dimension, but as many as seven of these (PE1, PE2, PE3, PE7, PE8, PE9, PE10) relate to the Governance dimension, which has a limited set of targeted indicators. Hence, we consider it useful to sustain a broad range of indicators for PE, which on the conceptual level are closely related to governance.

A.2.3 4 SCIENCE EDUCATION DIMENSION

Theoretically-derived dimension leads specific conceptual categories. In this terms, science education is split in **science literacy** and **scientific education**[77]**:** The science literacy and scientific education (SLSE) dimension applies a tripartite

[77] As specified in the analytical report covering this dimension, 'science literacy as it is defined in the context of the MoRRI project is generated through activities aiming to provide citizens with a deeper understanding of science, to shape their attitudes towards science and to develop their abilities to contribute to science and science-related policy-making. Including the co- production of knowledge in the dimension of SLSE, alters the way we think about the public and its role in science and innovation, from a mere receiver and customer to an active agent of change'.

categorisation to operationalise the multifaceted field of science literacy. Three aspects are identified within this general notion[78]:

- **Science education:** Science education aims at educating (especially young) citizens about scientific facts (textbook knowledge), the norms of science and the way science is 'done' as well as at conveying a positive 'image' of sciences. However, it also provides the opportunity to reflect and question science and the 'truths' it produces critically. It takes place in institutions in early childhood education and care, the school system, higher education, vocational education and training as well as in lifelong-learning. Science education is the basis for science literacy.
- **Science communication:** Science communication activities aim at educating citizens of all ages about science and generating awareness of science-related issues and a positive image of/attitude towards science. These activities can take direct forms (for instance through open days, museums or science centres) or be more indirect with mediators between the scientists and the public (e.g. via science journalists and their products such as TV programmes or media articles etc). Public relations activities of research institutions are excluded for our definition of science communication. Science communication produces linkages between science and society by creating or enabling transmission of knowledge about science and technology. This transmission can be both one-way (for instance in pure information formats) and two-way (e.g. in dialogue-oriented formats).
- **Co-production of knowledge:** Co-production of knowledge is a relatively new aspect of science literacy. It is characterised by a co-creation of knowledge through cooperation of scientific experts and non-experts. One well-known example is Citizen Science. This type of coproduction has been defined as 'research collaborations between scientists and volunteers, particularly (...) to expand opportunities for scientific data collection and to provide access to scientific information for community members' (The [79] Cornell Lab of Ornithology, 2015). Other types of co-production include open-innovation, crowd science, or user-driven innovation.

The aspect of co-production of knowledge is clearly interlinked with mechanisms and activities carried out within the field of public engagement. Crowd-sourcing, science shops, open innovation (e.g. co-creation spaces) are examples of PE mechanisms with co-production of knowledge as distinct objectives.

For the dimension of Science Literacy and Science Education **four final indicators have been proposed**. The following indicator will be therefore, based on primary data collected are:

- SLSE 1 - Importance of societal aspects of science in science curricula for 15-18 year olds. Data collection by this approach is costly and could prove rather challenging due to varying educational systems across countries. This renders the

[78] European Commission (2015): Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI): Analytical Report on the Dimension of Science Literacy and Scientific Education. Sub-task 2.5, deliverable D.2.2.

[79] European Commission (2015): Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI): Analytical Report on the Dimension of Science Literacy and Scientific Education. Sub-task 2.5, deliverable D.2.2.

indicator inappropriate for repetitive data collection. Hence, it is considered very useful as a one-off source.

The indicators based in existing secondary data of MoRRI proposal are:

- **SLSE 2 - RRI related training** (i.e. the second science education indicator) focuses on young researchers in research performing organisations. The indicator provides information on whether and to what extent RRI-related aspects (**i.e. ethical, economic, environmental, legal and social aspects (EEELSA),** are included in the training of young researchers.
- **SLSE 3 - Science communication.** This indicator uses secondary data from the MASIS project [80] to illuminate variations in the overall national science communication culture across EU28.
- **SLSE 4 - Citizen science activities in RPOs** or sub-dimension of co-production of knowledge. This indicator aims to capture information about citizen science projects performed in RPOs within and across countries. The indicator is well suited repetitive data collection, and within an emerging field such as citizen science, changes may be considerable also in shorter periods of time.

As science education is considered the most important aspect of this dimension, two indicators are allocated to this sub-category. For each of the other two sub-dimensions one indicator is presented. **These four** indicators cover all three sub- categories of SLSE: science education, science communication and co-production of knowledge.

A.2.3 5 GENDER DIMENSION

The dimension of gender equality is defined according to a *three-dimensional construct* [81]addressing three pillars:

- **Horizontal and vertical participation of women in research:** the first pillar comprises measures to promote women in fields, where they are underrepresented as well as to increase female participation in management and decision-making positions. The goal here is to reduce gender segregation and (under-) representation of women in research and innovation.
- **Structural change in institutions:** the second pillar comprises structural measures aimed at revising existing organisational arrangements to progressively eliminate barriers impeding women's advancement to top positions and factors inducing women to drop out of science. The aim is to break down structural gender barriers by means of action plans, gender budgeting, among others actions
- **Gender in research content**[79]**:** the third pillar of gender equality – the integration of a gender dimension in research and innovation content – is legitimised by the gender mainstreaming strategy on the one hand and by quality standards in science and research on the other (caprile et al. 2012).

[80] MASIS: European Commission. 2012. "Monitoring Policy and Research Activities on Science in Society in Europe (MASIS). Final synthesis report.

[81] European Commission (2015): Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI): Analytical Report on the Gender Equality Dimension. Sub-task 2.5, deliverable D.2.3.

Gender studies and gender and sex analysis are now either well-established or at least partly in place in almost all fields of research. Indeed, it is argued that research results are not valid or reliable if they only consider male research subjects.

As specified in the analytical report covering this dimension, gender equality has been perceived **as closely connected with the ethics and governance dimension, moderately interlinked with science education and non-reciprocally connected to public engagement, whereas no connection exists to the open access dimension**[81].while most large-scale data sets provide information on gender (e.g the gender of respondents), explicit gender issues are rarely included in the content (e.g. Gender differences in stem research as an indicator).

The availability of indicators on the sub-dimensions of structural change and gender in research content is modest. In 2013, efforts were made by the ERA group to collect cross-institutional and cross-national data on these matters[82] but these surveys will not be continued.

The following seven indicators will therefore be based on primary data collected via **Research Performing Organisations (RPO)** and **Research Funding Organisations (RFO)** surveys with full EU28 coverage and a possibility for repetitive data collection:

- **GE1- Share of RPOs with gender equality plans**: measures institutional engagement in GE work.
- GE2 - Share of female researchers by sector: accounts for the gender distribution of researchers across sectors (i.e. higher education, government and non- profit sectors), hereby providing basic information on sectorial variations with respect to women's opportunities and barriers.
- **GE3 – Share of RFOs promoting gender content in research.**
- GE4 - Dissimilarity Index comprises information on the horizontal gender segregation of researchers in the higher education and government sectors.
- GE5 – Share of RPOs with policies to promote gender in research content investigate the extent to which RPOs and RFOs take actions to ensure the integration of the gender dimension in research content.
- **GE6 - Glass Ceiling Index** addresses the issue of vertical segregation, by measuring women's chances of reaching the highest academic ranks relative to men's.
- **GE7 - Gender Pay Gap** measures gender variations with respect to annual earnings, and will be used as a proxy for gender equality in the non- academic research sector.

The indicators based in existing secondary data of MoRRI proposal are:

- **GE8 – Share of female heads of RPOs.**
- **GE9 – Share of gender-balanced recruitment committees.**
- **GE10 - Number and share of female inventors and authors** illuminates

[82] European Commission (2014). European Research Area: Progress Report 2014.

developments in women's representation across fields and sectors over time, on the basis of bibliometric data and patent counts.

A.2.3 6 ETHICS DIMENSION

Within the dimension of research and innovation ethics, three conceptual aspects have been identified[83]: **ethical governance; Ethical deliberation and Ethical reflection as show in** A final set of three indicators has been proposed for the dimension of Research and Innovation Ethics. The rationale underpinning this composition of indicators is the idea that every European country has its own ethics landscape, which is expressed in the existence and characteristics of the ethics infrastructure **in Research Performing Organisations (RPO) and Research Funding Organisations (RFO)** and ethics deliberation organizations.

Important selected aspects of this landscape can be captured by the following indicators:

- **E1** - **Ethics at the level of Universities** is an index-measure using primary data collected via the RPO survey and a survey addressing national research integrity offices to investigate the ethics performance of European universities. The indicator aims for full EU28 coverage and includes the possibility of repetitive data collection. More specifically, this measure has been designed to provide information on the level of mechanisms that should safeguard the observance of ethical standards in research ethics and research integrity implemented within universities at the country level.

[83] European Commission (2015): Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI): Analytical Report on the Dimension of Research and Innovation Ethics. Sub-task 2.5, deliverable D.2.4.1.

Table 23.

A final set of three indicators has been proposed for the dimension of Research and Innovation Ethics. The rationale underpinning this composition of indicators is the idea that every European country has its own ethics landscape, which is expressed in the existence and characteristics of the ethics infrastructure **in Research Performing Organisations (RPO) and Research Funding Organisations (RFO)** and ethics deliberation organizations.

Important selected aspects of this landscape can be captured by the following indicators:

- **E1** - **Ethics at the level of Universities** is an index-measure using primary data collected via the RPO survey and a survey addressing national research integrity offices to investigate the ethics performance of European universities. The indicator aims for full EU28 coverage and includes the possibility of repetitive data collection. More specifically, this measure has been designed to provide information on the level of mechanisms that should safeguard the observance of ethical standards in research ethics and research integrity implemented within universities at the country level.

TABLE 23: Conceptual aspects and definition for ethics dimension in MoRRI. Adapted from MoRRI proposal and European Commission (2015): Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI): Analytical Report on the Dimension of Research and Innovation Ethics. Sub-task 2.5, deliverable D.2.4.1.

Ethics theoretically-derived dimension	Definition	Examples
Ethical governance	Related with the main instruments being ethical commissions, ethical codes and soft law	Institutionalising ethics debate in terms of the implementation of standards in research ethics in science, technology and innovation policies
Ethical deliberations	The use of Technology Assessment (TA) or ethical constructive Technology Assessment (ECTA)	Institutionalising ethics debate that raise issues in science and technological developments in science, technology and innovation policies
Ethical reflection	Reflections that stresses the public engagement aspect in deliberations on S&T ethics	Institutionalising ethics debate that support critical reflection and engagement in debates on research standards, emerging technology issues and social justice in science, technology and innovation policies

- **E2 - National Ethics Committees** – is a composite-measure drawing on secondary data sources (i.e. MASIS, EPOCH and SATORI RRI projects[84]) to capture cross-country variations in national ethics committee infrastructure. The available data are qualitative (but can potentially be quantified) and include ample information for measuring the existence, output, impact and quality of national ethics committees across EU28 countries. Whereas time-series data would be possible via primary data collection, this would only make sense in large intervals because institutional changes on this matter are suspected to happen slowly.
- **E3 - Research Funding Organizations Ethics Index** will capture national variations in the input, output and context of mechanisms dealing with ethics and societal implications in public and private RFOs. This indicator is based on primary data to be collected through a survey covering a representative sample of RFOs in the EU 28 countries. Repetitive data collection is possible.

A.2.3 7 OPEN ACCESS

Despite open access embedded in Open science concept in most of the frameworks, MoRRi project consider two broad lines: ***Open access (OA) and Open Data (OD)*** under the umbrella of Open Research Data. This is a relatively new and emerging field of scholarship, and systematized data sources are still fairly scarce compared to the data availability on issues related to Open Access. Research on open research data and data sharing have mainly been conducted as case studies, but growing efforts are made to systematise such sources with the objective of developing data metrics[85].

[84] http://www.rri-tools.eu/search-engine

[85] European Commission (2015): Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI): Analytical Report on the Dimension of Open Access. Sub-task 2.5, deliverable D.2.4.

Open access (OA) is the idea of making research results freely available to anyone that wants to access and re-use them. One of the main drivers of the OA idea is to make publicly funded research accessible to the general public. The term Open Access originally referred to the provision of free access to peer-reviewed academic publications.

Meanwhile, the term open access also encompasses the free access to the research data that underpins publications or research projects, also referred on its own as **Open Research Data (OD).** Open Research Data is usually distributed with requirements of attribution and share-alike (copies or adaptations of the data need to be shared using the same principles as the source). Presently, the term open access also encompasses the free access to the research data that underpins publications or research projects, also referred on its own as Open Research Data (OD). Open Research Data is usually distributed with requirements of attribution and share-alike (copies or adaptations of the data need to be shared using the same principles as the source)[85].

The indicators are considering jointly for open access (OA) and open research data (OD). For the Open Access dimension, a final set of **six indicators has been proposed**.

Together this selection of indicators provides a combination **of output, outcome and context,** covering both global up until institutional analyses. The two primary paths in OA, gold and green (annex A.1.4 2) are taking into account for the data collection methods. For the gold (i.e. OA journals) the implementation is simple (basically crossing lists of journals) but this is not the case for the green path (i.e. self-archived publications). Therefore, the green approach is crucial. The proposed solution will be to harvest publications in order to find self- archived copies anywhere online. The method will combine data collections about OA evidence from different sources: Gold OA (all possible/available sources, e.g. DOAJ, etc.), and Green OA. The green OA is the most difficult one and would be based on the querying of scientific publications in different sources that can provide information on the availability of OA versions of the articles.

These sources include Mendeley, Altmetric.com, Arxiv.org, PubMedCentral and OpenAIRE. The advantage is that this process can be applied systematically to any set of publications (so it can be 'easily' updated and also applied to different collections of papers, e.g. individual countries, institutions, scientific journals, etc.).

From a 'responsible' point of view, data citations are important because this measure informs the attribution in the use of published datasets. This indicator will also inform the 'reputation' of a particular dataset (and by aggregation, those of a country). The Web of Science Data Citation Index (DCI) provides a single point of access to quality research data from repositories across disciplines and around the world. DCI fully indexes a significant number of the world's leading data repositories that are of interest to the scientific community, including over two million data studies and datasets. The records for the datasets, which include authors, institutions, keywords, citations and other metadata, are connected to related peer-reviewed literature indexed in WoS. Drawing on DCI, the idea is to create an indicator for data publications and citations providing specifications on country and year.

Indicators are:

- **OA1 - Open Access Literature.**
- OA2 - Data publications and citations per country: Data publications (i.e. datasets) are the basic unit in sharing and reusing data. When monitoring Open Research

Data, it is important to know the volume of data made available across countries.

- **OA3 - Social media outreach** will measure the use of social media tools in disseminating OA publications and Open Research data in Europe by combining data from Web of Science, Scopus, Mendeley and **Altmetric**. Measuring the number or proportion of papers/data disseminated in this way will capture take-up or outreach, but in a different way than (plain) citation.
- **OA 4 - Public perception of Open Access** has been included for various reasons. It provides information on how the European public perceives the issue of open access of research results.
- **OA5-Funder Mandates** covers an important aspect of OA, i.e. funder/institutional mandates and their numbers in the EU Member States. These mandates facilitate access to research results. Since 2009, Web of Science has included funding acknowledgments as part of its registration of publication data, which makes it possible to investigate the presence and application of funding mandates for OA, allowing for additional time points after 2011. The funder mandate information could be organized through the EC- OpenAIRE project (CWTS is partner in that project), but may involve additional surveys via National Contact Points (NCPs) for a governance perspective.
- **OA 6 - RPO support structures for researchers** as regards incentives and barriers for data sharing will use survey data collected as part of the MoRRI project to capture practices and perceptions of the incentives and barriers for and against data sharing in RPOs. The indicator is based on indicator proposals with regard to open access and open science presented in the report 'Indicators for promoting and monitoring Responsible Research and Innovation. Report from the Expert Group on Policy Indicators for Responsible Research and Innovation'[86]

Four out of six indicators have some overlap with other RRI dimensions, although the overlap is sometimes weak. Two indicators (OA5 and OA6) are directly linked to governance. Dissemination via social media is in principle related to public engagement, as this is open to the wider society. Similarly, via social media there is more opportunity for scientific literacy, although the actual scientific education is not necessarily enhanced.

A.2.3 8 GOVERNANCE DIMENSION

Typology of governance approaches helps to structure discussions about changing governance. In this regard, it is important to note that incentives and moves to democratise governance of science and innovation must be understood in the context of other moves and pressures to close down governance in discretionary, corporatist and market ways'[87].

The categorization of governance for MoRRI project based in Hagendijk and Irwin (Hagendijk and Irwin 2006) is:

---

[86] European Commission (2015): Indicators for promoting and monitoring responsible research and innovation: Report from the expert group on policy indicators for responsible research. DG Research and Innovation: Brussels.

[87] European Commission (2015): Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI): Analytical Report on the Dimensions of Research and Innovation Governance. Sub-task 2.5, deliverable D2.4.2.

- **Discretionary governance**: Based in policies in this category are made without explicit interaction with 'the public'. Governance is presented primarily as a matter for government, which is seen as serving universal goals of progress.
- **Corporatist governance**: Involves a formal recognition of differences of interest as an input to negotiation. As negotiation takes place within a closed or highly regulated space, the decisive feature of this mode is the admission of stakeholders.
- **Educational governance**: This assumes that policies for science and technology have foundered on the shoals of public ignorance. Hence, it is necessary to create an informed citizenry.
- **Market governance**: Science and technology are best regulated by demand and supply. The value of science comes from the surplus value created through its commercialization and contribution to the generation of wealth. The public participates as customers and consumers.
- **Agonistic governance:** This form of governance occurs in a context of confrontation and adversity. The storage of nuclear waste in the UK is a case where policy seems to have stalled in the face of public opposition: opposition to GM foods has also taken agonistic form.
- **Deliberative governance:** This rests on the assumption that open debate and engagement can create a satisfactory foundation for decision-making. In this mode, the public are not consumers of science, but rather 'scientific citizens'.

The indicators for research and Innovation governance are:

As mentioned earlier, the dimension of Research and Innovation Governance assumes a double role in the MoRRI project. It both represents a separate dimension and an overarching 'umbrella' concept for the remaining dimensions[88]..

- GOV 1 –Governance for responsible research and innovation will bring together the above-mentioned indicators on gender, public engagement, open access, and ethics in research and innovation to provide an evaluation of member state governance systems against a qualitative typology of governance approaches.
- **GOV 2 – Existence of formal governance structures for RRI within research funding and performing organisations** will determine whether RRI is seen as a priority issue for organisations and is supported by a formalised governance structure.
- GOV 3 – Share of research funding and performing organisations promoting RRI will assess how widespread RRI governance is through national research and innovation systems. The indicator captures the extent to which organisations explicitly apply and promote the RRI framework as stipulated through this report.

Governance indicators (GOV3) are congruent with the present H2020 Key Performance Indicator for SWAFS[89] and the required data are Number of occurrences of actions to

---

[88] European Union (2012): Responsible Research and Innovation. Europe's ability to respond to societal challenges.

Available at: http://ec.europa.eu/research/science-society/document_library/pdf_06/responsible-research-and-innovation-leaflet_en.pdf

[89] SWAFT, Science with and for society KPI corresponds with Science with and for Society and is measured by number of institutional change actions promoted by the programme. This indicator is not mentioned in the Annex II of the Council Decision, but as SWAFS was introduced as a specific objective of Horizon 2020 during the negotiations, the

promote institutional change towards Responsible Research and Innovation at Member State- level, at RPO-level and at individual scientist level.

Indicators interlinking with the Governance dimension are: GE1, GE3, GE9, PE1, PE2, PE3, PE7, PE8, PE9, PE10, OA4, OA5, OA6, E1, E2, E3 (MoRRi deliverable 3.2).

A.2.3 9 MORRI LIMITATIONS AND DATA COLLECTION RECOMMENDATIONS

Despite MoRRI project provides an important advance for the development of indicators some limitations are reported such as s the lack of frameworks for **sustainability and social justice** dimensions and the necessity of obtain primary data for indicators.

The recommendation of methods data collection that MoRRI suggested for primary data indicators are:

- Science in Society actor survey: PE9, PE10
- RPO-survey: GE1, GE5, GE8, GE9, SLSE2, SLSE 4, PE5, PE6, OA6, E1, GOV2, GOV3
- RFO-survey: GE3, PE7, PE8, E3, GOV2, GOV3
- Register data (database): GE10, OA1, OA2, OA3
- Qualitative approaches, desk-research: SLSE1

Secondary indicators are:

GE2, GE4, GE6, GE7, SLSE3, PE1, PE2, PE3, PE4, E2, OA4, OA5, GOV1. GOV1 is a composite indicator based on secondary analysis of data collected throughout other dimensions.

Indicators depending of secondary data are obtained mainly from the existing reports targeting each of the RRI dimensions that can found in European Commission publications[36-43]. The six reports collectively form the main output of first overview of MoRRI and have resulted in a tentative list of indicators / data sources considered potentially useful in measuring and capturing core aspects of RRI. A summary of MoRRI indicators and considerations can found in

Commission has to provide a performance indicator also for this objective.

Table **24** and

Open Digital Science project (2016) suggest a series of indicators that encompasses various research aspects namely: conceptualisation & data gathering/creation, data analysis, diffusion (publication), review and evaluation, reputation system & trust, open science skills and awareness; and science with society. (E. Prem, F.S.Sanz, M. Lindorfer, D. Lampert, J. Irran, Open Digital Science (SMART 2014/0007) Final Report.2016).

In order to be responsible, R&I must be both transparent and accessible. This means giving free online access to the results of publicly funded research (publications and data). This will boost innovation and further increase the use of scientific results by all societal actors.

This approach considers the universality of knowledge and the return to a more humanistic version of the researcher promoting collaboration, interdisciplinary and altruistic communication of results. Although is necessary to establish the boundaries between this dimension and the management of intellectual property as well as assessment of research impact.

The indicators for open Digital Science project are (Consecutive numbers to MoRRI open science have been used to avoid lead to confusion):

- OS7-% of peer reviews that include reproducibility and transparency as review criteria
- OS 8-data communication recognised as criterion for career progression (yes/no)
- OS 9-% of research personnel / research disciplines skilled in OS

Table 25.

A.2 4 PROPOSALS FOR SPECIFIC DIMENSION ASSESSMENTS

A.2.4 1 OPEN DIGITAL SCIENCE

The approximation of RRI calls for a new definition of excellence in terms of an analytical excellence and social relevance that also needs to be applicable to the impact assessment. The seeking for alternative systems of impact assessments (IA), not based in bibliometric indicators such as the number of citations and indexed publications as well as in economic indicators such as the ability to obtain financial resources in public calls, the degree of internationalization, the number of patents, etc. is one of the aims of the open science approach of this project.

TABLE 24: Primary and secondary indicators and sources for MORRI

Primary data	Source
PE9, PE10	Science in Society actor survey
GE1, GE5, GE8, GE9, SLSE2, SLSE 4, PE5, PE6, OA6, E1, GOV2, GOV3	RPO-survey
GE3, PE7, PE8, E3, GOV2, GOV3	RFO-survey
SLSE1	Qualitative approaches, desk-research
Secondary data	Source
GE2	Eurostat
GE7	MORE2
SLSE3, PE1, and E2	MASIS
PE2, PE3, PE4 and OA4	Eurobarometers
E2	EPOCH, SATORI
OA5	Openaire.eu

Open Digital Science project (2016) suggest a series of indicators that encompasses various research aspects namely: conceptualisation & data gathering/creation, data analysis, diffusion (publication), review and evaluation, reputation system & trust, open science skills and awareness; and science with society. (E. Prem, F.S.Sanz, M. Lindorfer, D. Lampert, J. Irran, Open Digital Science (SMART 2014/0007) Final Report.2016).

In order to be responsible, R&I must be both transparent and accessible. This means giving free online access to the results of publicly funded research (publications and data). This will boost innovation and further increase the use of scientific results by all societal actors.

This approach considers the universality of knowledge and the return to a more humanistic version of the researcher promoting collaboration, interdisciplinary and altruistic communication of results. Although is necessary to establish the boundaries between this dimension and the management of intellectual property as well as assessment of research impact.

The indicators for open Digital Science project are (Consecutive numbers to MoRRI open science have been used to avoid lead to confusion):

- OS7-% of peer reviews that include reproducibility and transparency as review criteria
- OS 8-data communication recognised as criterion for career progression (yes/no)
- OS 9-% of research personnel / research disciplines skilled in OS

TABLE 25: RRI dimension indicators summary.

RRI Dimensions	Theoretically derived dimension	Indicators proposals
Public engagement	Public communication Public activism Public consultation Public deliberation Public participation	PE1–Models of public involvement in S&T decision-making PE2–Policy- oriented engagement with science PE3–Citizen preferences for active participation in S&T decision-making. PE4–Active information search about controversial technology PE5–Public engagement performance mechanisms at the level of research institutions PE6–Dedicated resources for PE PE7–Embedment of public engagement activities in the funding structure of key public research funding agencies PE8–Activism dimension PE9–R&I democratization index PE10–National infrastructure for involvement of citizens and societal actors in research and innovation
Science education	Science education Science communication Co-production of knowledge	SLSE 1–Importance of societal aspects of science in science curricula for 15-18 year students SLSE 2 - RRI related training SLSE 3 - Science communication. SLSE 4 - Citizen science activities in RPOs
Gender	Horizontal and vertical participation of women in research Structural change in institutions Gender in research content	GE1–Share of RPOs with gender equality plans GE2–Share of female researchers by sector GE3–Share of RFOs promoting gender content in research GE4–Dissimilarity Index GE5–Share of RPOs with policies to promote gender in research content GE6–Glass Ceiling Index GE7–Gender Pay Gap measures gender variations GE8 – Share of female heads of RPOs GE9 – Share of gender-balanced recruitment committees GE10 -Number and share of female inventors and authors
Governance	Discretionary governance Corporatist governance Educational governance Market governance Agonistic governance	GOV1–Governance for responsible research and innovation GOV2–Existence of formal governance structures for RRI GOV3–Share of research funding and performing organisations promoting RRI
Ethics	Ethical governance Ethical deliberations Ethical reflection	E1–Ethics at the level of Universities is an index E2 - National Ethics Committees E3 - Research Funding Organizations Ethics Index
Open access	Open access (OA) Open Data (OD	OA1–Open Access Literature. OA2–Data publications and citations per country OA3–Social media outreach OA4–Public perception of Open Access OA5–Funder Mandates OA6–RPO support structures

- OS 10-% of research personnel active in OS
- OS 11-% of curricula that include OS skills (also prior to higher education)
- OS 12-% of research personnel aware of standards (is there a standard (relevant to open science), how to adhere to it, etc.)
- OS 13-increase in % of citizens engaging in open science
- OS14-circulating and communicating research results outside the academia is standard (yes/no)
- OS 15 % of crowdsourced projects

A.2.4 2 SUSTAINABILITY

The rationale of the Europe 2020 strategy is to address and overcome the shortcomings of the current growth model in order to achieve smart, sustainable and inclusive growth. To this end the strategy includes headline targets in five areas: employment, research and development, climate/energy, social inclusion and poverty reduction. While sectorial strategies have been formulated for each of these areas, they are clearly not independent. Measures in one sector addressing one headline target will frequently, if not always, have direct or indirect effects relevant to other headline targets.

Sustainability indicators can found in Eurostat's indicators for research and development[90] mostly concerned with the headline target for R & I. The Sustainable Development Indicators (SDIs) are used to monitor the EU Sustainable Development Strategy (EU SDS) in a report published by Eurostat every two years. They are presented in ten themes. The SDI framework covers ten thematic areas belonging to the economic, the social, the environmental, the

- Global and the institutional dimensions:
- Socioeconomic development,
- Sustainable consumption and production,
- Social inclusion,
- Demographic changes,
- Public health,
- Climate change and energy,
- Sustainable transport,
- Natural resources,
- Global partnership,
- Good governance

Each theme is further divided into subthemes and includes three different levels of indicators. The main body of the current EU SDS, essentially unchanged since 2006, is built around seven key challenges, with corresponding operational objectives and targets as well as associated actions and measures[91]. In addition, a number of key objectives and policy guiding principles serve as a basis for the strategy. SDI

[90] http://ec.europa.eu/eurostat/help/first-visit/content

[91] The topics 'social inclusion, demography and migration' are considered together in one EU SDS key challenge, but are represented by two separate themes ('social inclusion' and 'demographic changes') in the SDI framework. This division reflects the different nature of these two issues.

framework additionally includes a theme of 'socioeconomic development', which focuses on the key objective of economic prosperity, and a theme on 'good governance' related to the guiding principles of the EU SDS and other cross-cutting issues[92].

The most recent changes to the indicator set followed the adoption of the Europe 2020 strategy[18] and its eight headline indicators, which have been integrated into the SDI framework in the themes 'socioeconomic development', 'social inclusion' and 'climate change and energy'.

However, this indicator is more directly targeted towards sustainability, namely the number of patent applications of technologies for example the applications for mitigation or adaptation against climate change and there is a knowledge gap between the headline targets for inclusive and sustainable growth, measured at a societal level of aggregation, and the performance indicators for R & I.

RRI as a policy principle is concerned with and addresses this knowledge gap. The 'Science with and for society' programme, as did its predecessors, sets out to provide research-based knowledge and best practices for more dynamic governance that will align R & I better with societal needs and goals. RRI as a cross-cutting principle throughout Horizon 2020 is intended to contribute to such governance by the actual development of RRI agendas. This important function of RRI should be reflected in RRI indicators and monitoring practices.

While many, perhaps all, of the six original RRI keys are to some extent related to aspects of inclusion and sustainability, indicators for these keys cannot answer the following questions: to what extent does a research field, a research programme or an RRI initiative contribute to inclusive and sustainable growth, and how can this be assessed and monitored?

The topic is extremely important — essential for the future wealth and health of the planet and its people. However, to answer it, original research is needed — a task beyond the remit of our expert group. A useful first approximation to the topic is provided by Kettner, Köppl and Stagl (2014). Below, we will only draw upon the conclusion of their work, in terms of the type of indicator framework that is needed. A comprehensive implementation of such a framework would amount to a number of requirements:

- Monitoring of stocks (renewable and non-renewable resources)
- Monitoring of flows (consumption and regeneration of stocks)
- Mapping and monitoring of stock-flow interactions
- Mapping of fund elements (labour and technology) and how they influence the stock-flow interactions
- Monitoring of ecosystem services and their effect on human well-being

This proposal is the base for the frameworks for sustainability indicators as summary in:

- **Perception** indicators can easily be defined by inquiring into different actors' sociotechnical imaginaries (Jasanoff and Kim, 2009) with respect to the R & I

[92] 2015 monitoring report of the EU Sustainable Development Strategy2015 edition from http://ec.europa.eu/eurostat/documents/3217494/6975281/KS-GT-15-001-EN-N.pdf

activity in question. One could simply ask: what is the anticipated effect of this research development on stock-flow interactions? For instance, both research funding programmes and research proposals make frequent claims on how the anticipated research will contribute to sustainability by resource and energy decoupling.

- **Process** indicators can be defined to monitor the efforts and developments being made towards the expected outcomes. They also can be defined in terms of milestones on specified pathways that have an effect on specified stock-flow interactions, while R & I actors' perceptions may be indicated in terms of their anticipation and imagination of pathways, milestones and the ultimate effect on specified stock-flow interactions.

When taken together, perception and process indicators may provide a basis for RRI governance in the sense of improved responsiveness and accountability among R & I actors. Ex ante sustainability assessments and sociotechnical imaginaries (promises) may be held accountable by process results.

As of today there is no obvious place for such indicators in current policy practice. However, as noted above, the expert group has found it reasonable also to take into account what we consider to be likely future developments of the concept of RRI by including reflections on design principles for such indicators.

A.2.4 3 SOCIAL JUSTICE/INCLUSION

Social justice can be defined as 'an ideal condition in which all individual citizens have equal rights, equality of opportunity, and equal access to social resources' (Maschi and Youdin, 2012). National social justice policies focus on investing in achieving inclusion rather than compensating for exclusion. The effectiveness of such policies is measured by monitoring progress in six dimensions (OECD, 2011): **Poverty prevention; Access to education; Labour market inclusion, Social cohesion; Non-discrimination; Health and Intergenerational justice.**

The role of science and technology in promoting social justice is very important. Social justice, although not explicit, is a transversal theme running through most, if not all, societal challenges of the Horizon 2020 framework. However, to date no attempts to measure how social justice is actually addressed through R & I activities have been observed. The connection between science and technology and social justice is recognised through acknowledging the role of science and technology education (Dy, 1994) and technological developments, especially in the area of information and communications technology (ICT), in promoting social justice (Vrasidas, Zembylas and Glass, 2009), as well as the consideration of ethical issues and values in the design, development and implementation of new technologies[93].

Social justice directly in the context of research activities can be considered from two perspectives:

- **Relationship between the researchers and the research subjects:** Concerned with researchers unfairly taking advantage of research subjects and imposing unfair burdens on them for their own benefit or the benefit of others.

[93] See for instance the value Ageing project: incorporating European fundamental values into ICT for ageing: a vital political, ethical, technological, and industrial challenge (http://www.value-ageing.eu)

- **Participation of social groups in benefits arising from research:** Involves the potential unfair exclusion of particular groups from either participation in research and/or access to benefits arising from research (European Commission, 2010).

These two perspectives are key to developing indicators to address social justice issues in the context of R & I. The first perspective — the relationship between the researchers and the research subjects — lies firmly within the field of research ethics and should be incorporated in the indicators for the ethics key. The second perspective of equal participation of social groups in benefits arising from research goes beyond what is usually included in the ethics key as currently practiced. In what follows we suggest initial steps towards a set of specific indicators that would enable monitoring of the progress of R & I activities and their contribution in achieving social justice/inclusion. One possibility would be to include such aspects in institutional ethics practices such as ethics reviews.

The issue that should be monitored is the impact of research and its effects on social justice/inclusion. **Monitoring could/should answer questions such as the following (non-exhaustive list):**

- Is the new technology/product accessible/affordable to wide variety of different social groups?
- Is the research problem addressing an access problem of a disadvantaged social group, such as disabled people, illiterate people, migrants, elderly people, etc.?
- Does the research have the potential to impact negatively on some social groups? Measuring the impact should focus on two issues: (a) whether researchers consider at all the impact of their research on social justice; and (b) whether they have taken any steps to either extend the impact of their research to a larger population or to minimise potential unintended negative consequences in relation to social justice.

Following this argument, a next step towards indicators could be to pursue the following directions.

In this terms, **process indicators** are proposed as:

- The number/percentage of funding calls that explicitly require impact statements to consider social justice/inclusion issues (if percentages are used they should be the percentage of calls in homogenous scientific areas to allow meaningful comparisons).
- The percentage of research institutions that have procedures that encourage/oblige researchers to consider the impact of their research on social justice/inclusion, in regard to both the participation of excluded groups in the research and the potential research impact on such groups (e.g. training, ethics reviews).
- The percentage of research institutions that have mechanisms that assist researchers in the recruitment of research participants from socially excluded groups (e.g. databases of potential participants, strong links with representative bodies).
- The number of stakeholders who actively review/show interest in research results that have an impact on social justice. Qualitative indicators should

also be used to examine the use of such results for policymaking processes.

The **outcome indicators** proposed are:

- The percentage of research proposals considering the impact of the research on different aspects of social justice (six dimensions used for social justice indicators could be used here: poverty prevention, access to education, labour market inclusion, social cohesion and non- discrimination, health and intergenerational justice).
- The percentage of research projects that modified their methodology/implementation of research to improve their impact on social justice (e.g. including research participants from a wider social grouping to address broader perspectives/needs).
- The percentage of projects that may have unintended negative effects on social justice (e.g. . projects that have benefits for only small portion of the general population or projects that may create additional barriers). Qualitative measurement may be employed to identify potential unintended negative effects on social justice to inform future funding calls/policymakers.

The **performance indicators** should measure the level of importance together with commitment and the proposed are (qualitative indicators should be employed to identify best and worst practices):

- The percentage of researchers/research institutions who believe that it is important to consider/address issues related to social justice/inclusion in their research in regard to research methodology and implementation.
- The percentage of researchers/research institutions who believe that it is important to consider/address issues related to social justice/inclusion in their research in regard to research results.
- The percentage of public that believes that research actively promote/contribute to achieving social justice/inclusion.
- The percentage of public that believes that research activities have a negative effect on social justice.

Table **26** shows a summary of the indicators proposal for social justice. The indicators listed above require substantial resources to be monitored and can be meaningfully monitored only within fields where the link between research and social justice is found to be evident or at least relevant (several scientific fields may be excluded here). For this reason, the expert's committee don not include the concrete indicator proposals into overall RRI indicators.

TABLE 26. Social justice indicators proposal.

Dimension	Performance indicators		Perception indicators
	Process indicators	**Outcome indicators**	
	The number/percentage of funding calls that explicitly require impact statements to consider social justice/inclusion issues	The percentage of research proposals considering the impact of the research on different aspects of social justice	The percentage of researchers/research institutions who believe that it is important to consider/address issues related to social justice/inclusion in their research in regard to research methodology and implementation
	The percentage of research institutions that have procedures that encourage/oblige researchers to consider the impact of their research on social justice/inclusion, in regard to both the participation of excluded groups in the research and the potential research impact on such groups	The percentage of research projects that modified their methodology/implementation of research to improve their impact on social justice (e.g. including research participants from a wider social grouping to address broader perspectives/needs)	The percentage of researchers/research institutions who believe that it is important to consider/address issues related to social justice/inclusion in their research in regard to research results.
Social justice	The percentage of research institutions that have mechanisms that assist researchers in the recruitment of research participants from socially excluded groups	The percentage of projects that may have unintended negative effects on social justice	The percentage of public that believes that research actively promote/contribute to achieving social justice/inclusion.
	The number of stakeholders who actively review/show interest in research results that have an impact on social justice		The percentage of public that believes that research activities have a negative effect on social justice.

ANNEX 3 RRI AND ENERGY RESEARCH

A.3 1 HISTORICAL CONTEXT

Last decade, one of the most dominant public debates relating to the role of science in society across Europe have revolved around energy and climate change (EC2012, MASIS 2012). Across Europe, the role and potential of science and technology within a context of resource depletion and global warming has been a major issue and the demand for scientific advice and evidence in energy and climate policy making along with demand for alternative, sustainable technologies for climate change mitigation, have been important issues in most EU countries. The climate change challenge has also to varying degrees such as a: affected public engagement with science and invoked new formats for public participation in decision making, the raising of questions related to governance of science, trust in scientists and expertise, and funding of research and development.

Specific discussions related to the environment are similarly widespread across the European public. Most of them are played out in the public arena, with citizens taking an active role in several countries. The high visibility of scientists, in the Climate Change public debate, has been an element connecting science with society, and the discussions relating to sustainable developments and renewable energy have involved stakeholders in both academic, political, and broader public arenas[80].

The pursuit of this social dimension is not new. Energy research has been greatly influenced by multidisciplinary efforts towards define and pursue social dimension. Philosophy, ethics, communication and economy, politics and management, shaping approaches of *Energy and society*[94] are some of the remarkable historical approaches at a glance. However, those approaches were based almost exclusively in issues been considered historically social such as the management of the sources, economy and geopolitics and consumption and behavioural studies related with energy.

There are some examples of alternative approaches in energy research both historic and contemporary that fits with the goals of RRI in roder to transcend from the purposes and outcomes. *"Soft energy path*[95] *"* (Lovings 1976) assuming that energy is but a means to social ends, and is not an end in itself involving efficient use of energy, diversity of energy production methods and Renewables[96], is one of the early approaches and application of Transdisciplinarity to energy research in order to "Tackling Long-Term Global Energy Problems" (Thomas Flüeler, David Goldblatt, Jürg Minsch, Daniel Spreng, 2007) also came across also as a theoretical approach that match RRI objectives.

Contemporary discourses towards responsibility in energy policies can found in alternative technology assessment methods such Constructive Technology Assessment (CTA) and Responsible Innovation approaches to stakeholder management in Energy

---

[94] Energy and society transcend from sup topic of energy studies towards became a recognisable approach.

[95] A.B. Lovins Energy strategy: the road not taken? Foreign Affairs, 55 (1) (1976), pp. 65–96 and A.B. Lovins Soft energy paths: toward a durable peace. Ballinger, Cambridge, MA (1977).

[96] Lovins argued that the United States had arrived at an important crossroads and could take one of two paths. The first, supported by U.S. policy, promised a future of steadily increasing reliance on dirty fossil fuels and nuclear fission, and had serious environmental risks. The alternative, which Lovins called "the soft path," favoured "benign" sources of renewable energy like wind power and solar power, along with a heightened commitment to energy conservation and energy efficiency.

Projects via Value sensible design (VSD) (Correljé et al, 2015) and *Backasting* settled as an alternative to *supply-demand* management model developed as a methodology to build desirable futures or scenarios from the future back to the present.

In Backcasting we found one of the first examples of balancing process and outcomes with great emphasis on economic efficiency, environmental protection, and alternative governance. Soft paths and Backcasting has been used[97] for the development of Canada Water Strategy[98] and National Solar Energy Strategy for Chile[99] for energy policy arrangements.

Arguments for the inclusion of social sciences into energy research and energy policy (Spreng 2012, 2014 and Sovacool, 2014, 2015) can be consider a shift to responsibility approach, despite are still based in the consideration of energy systems as socio-technical systems, embedded into society.

This consideration suggests that its yet marginal participation in energy research is often justified by the fact that the funding is dominated by techno-economic interests (Spreng, 2012).

A.3 2 RESPONSIBILITY FRAMEWORKS FOR ENERGY RESEARCH

The search for responsible approach in energy research and projects is related with social science approaches. Regarding with RRI dimensions and objectives, sustainability and social justice approaches can be found as well as relations with inclusion, anticipation and responsibility attributes. A deep review to responsibility concepts shows that despite the RRI responsibility definition is not present in energy research frameworks, is possible to find correlate insights.

Regarding to the energy field, **Sustainability** refers to what the Brundtland Commission termed[19] understand as the duty of states to ensure the sustainable use of natural resources and *development that meets the needs of the present without compromising the ability of future generations to meet their own needs*[100].

It means that countries have sovereign rights over their natural resources, that they have a duty not to deplete them too rapidly, and that they do not cause undue damage to their environment or that of other states beyond their jurisdiction.

Also, access to sustainable (clean, reliable, and affordable) energy is critical for achieving inclusive, low-emissions growth and development (Sovacool et al., 2016). Sustainable energy can influence human progress, creting job and economic

---

[97] Backcasting from Sustainability Principles, or System conditions of sustainability is a key concept of the 'Framework for Strategic Sustainable Development' pioneered by Karl-Henrik Robèrt, founder of The Natural Step, an international nonprofit organization dedicated to applied research for sustainability, in cooperation with a global academic Alliance for Strategic Sustainable Development which links universities which cooperate with businesses, and other NGOs.

[98] The POLIS multidisciplinary academic research and community action Project on Ecological Governance is a research-based non-profit organization based at the University of Victoria devoted to dismantle the notion of the environment as merely another sector, and to bring it into the mainstream where it belongs, as a core value in all aspects in society.

[99] ENERGY 2050. Route map of energy policy in Chile/ ENERGÍA 2050.Hoja de ruta de política energética de Chile.

Available at: http://www.energia2050.cl/uploads/libros/hojaderuta.pdf (Accessed December 5, 2015).

[100] World Commission on Environment and Development (WCED). Our common future. Oxford: Oxford University Press; 1987. p. 43

competitiveness, empowering women (Eberhard et al., 2011), leading to new global markets for goods and services (Bairiganjan et al., 2010), alter regional energy trades (Saadi, Miketa and Howells, 2015) and help to ensure that environmental impacts of economic development are minimized (Birol, 2014).

In the last decade growing attention has been given to distributional issues in energy matters, with a body of work on **Energy justice** emerging with connections to previous social, environmental and spatial justice work (Sovacool and Dworkin, 2014, Sovacool et al., 2013 and Bickerstaff et al., 2013).

Formulations of distributional social justice have been drawn on to inform work beyond that traditionally considered as the concerns of social justice such as an environmental justice, where the distribution of environmental hazards and goods across social groups is of concern (Yenneti and Day, 2016).

Examples to distributional justice in renewable energy technologies are for example the observed perception that environmental and social impacts, such as noise, visual impacts, and land and habitat loss, occur mostly at the local level where projects are hosted (Mallon, 2006), given the fact that renewable energy projects contribute to achieving economic development and climate change targets at regional, national and international level (Yenneti and Day, 2016).

Some studies have also connected distributional fairness and its perception with the extent to which procedural justice is seen to be done, through transparent and open decisions making (Gross, 2007 and Zoellner et al., 2008), echoing the wider environmental and energy justice literature on the connection and complementarity between procedural and distributional justice (Shrader-Frechette, 2002 and Walker and Day, 2012).

Sustainability and social justice, share the seeking for **Good governance** in terms of the right to all people to have access to high-quality information about energy and the environment. Information, accountability, and transparency have become a central element of promoting "good governance" throughout a variety of sectors, a term that centres on democratic and transparent decision-making processes and financial accounting, as well as effective measures to reduce corruption and publish information about energy revenues and policies.

A.3.2 2 SOCIAL-SCIENCE RESEARCH ON LONG-TERM ENERGY OPTIONS

The Relevance of social-science research to energy policy considered essential in order to tackle the upcoming energy challenges in a sustainable way (Spreng 2012,2014) is the core of (Spreng et al, 2007, 2012) an integrative framework for energy research, which classifies global energy-related problems into four challenge categories[101]:

- Security and Access
- Climate Change and other Environmental Impacts
- Economic and Social Development
- Knowledge Management

[101] ASRELEO: Agenda for Social-Science Research on Long-term Energy Options International Energy Workshop 2007, Stanford Thomas Flüeler, David L.Goldblatt, Jürg Minsch, Daniel Spreng Energy Science Center, ETH Zurich.

This framework was undertaken to examine which R&D was most needed and fruitful and how the related social-science research field might be structured, and was stimulated by a request from the European Fusion Development Agency for a review of its commissioned social-science research, initiated in mid-2005. Contribution to the question of participatory approaches in the field of energy system research is arranged based in massive literature reviews of articles published in the journal *Energy Policy.* The contributions were classified according to three perspectives: the number of disciplines involved, the type and scope of participating actors as well as the nature of the research question.

It was found that topics have been relatively well explored that are easily amenable to a managerial implementation approach and closely related to a particular technological development.

The framework, advocate for the social sciences as well as the humanities been called upon for more requests than advice concerning public acceptance of new technologies or the support of the market introduction of new technologies through specific promotion mechanisms. Even if, consider the central functions of social-science energy research in Reflection, Analysis and Design/Realization.

Despite that this work was based in energy policy improvements due to the positive influence of the social sciences, it includes some recommendations that can be consider an evolution of social dimension approach in terms of social science integration and perhaps an example of methodological responsible approach for energy research with practical recommendations for researchers.

To structure a **research agenda for social-science energy research** in a way meaningful to and adaptable by scientific communities, the framework proposes three "descending" levels of discourse, from abstract to concrete, in parallel **with an interaction level where researchers meet practitioners and end-users** (Spreng, 2007):

- Energetic behaviour
- Paradoxes of energy efficiency
- Climate change and energy systems
- Energy visions
- Policy measures to limit energy use
- Investment behaviour of house owners with respect to their buildings' energy use
- Socio-technical infrastructure design
- Sustainability assessment
- Commercialization of new renewable energy technologies
- Involvement of end-consumers

The construction and practice of energy markets with the focus on ethical considerations, ethnographic analysis, relating developments of political and social changes and policy recommendations derived from gender-specific changes or individual needs.

A.3.2 3 PUBLIC ENGAGEMENT WITH ENERGY TECHNOLOGIES

Walker (2011) developed a descriptive conceptual framework based on multiple European case studies on public engagement with renewable energy projects as shown in Figure 12. This framework schematically shows how public engagement with renewable energy projects results from the interaction between project developers and public stakeholders who have varying expectations of the technology, of each other, as well as of the process through which the project will be developed.

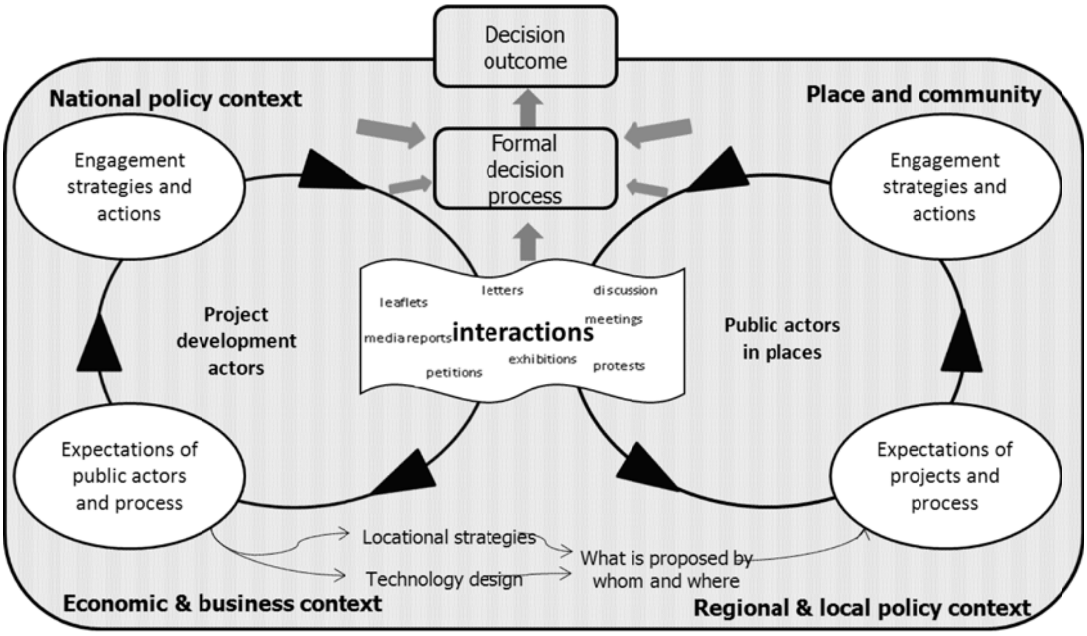

FIGURE 12 :Public engagement with energy technologies. Source Walker 2011.

The framework suggests four characteristics critical to understanding the process of values specification in the interaction between actors:

- First, the framework is dynamic "over time, anticipations and expectations evolve and that both the details of proposed projects and the currents of local debates can shift considerably" (Walker et al., 2011).
- Second, the framework describes **public engagement as a symmetrical process** (Walker et al., 2011) that gives equal attention to the stakeholders involved in promoting the project – who can be seen as the project stakeholders – and to the local community, i.e. the 'public'.
- Third, the framework **identifies expectations and anticipations** as shaping local acceptance of projects (Walker et al., 2011).
- Fourth, the framework acknowledges the influence of contextual factors on public engagement (Walker et al., 2011). Four types of context are distinguished: 1) characteristics of place and community, 2) regional and local policy, 3) national policy, and 4) business.

The management of expectations and anticipations are keys for manage the complex social dynamics in controversial energy projects. Walker et al., identify four types of expectations that public stakeholders may have:

- Expectations about the form and impact of a project;
- Expectations about the project developer;

- Expectations about the process;
- Expectations about the proper and appropriate distribution of costs and benefits of a project.

These expectations articulate specific values and therefore need consideration in the value-sensitive design of energy projects. For instance, imagine that a project developer announces his plan in a local newspaper, and citizens may respond to that plan based on their expectations of what the project entails and the consequences it may have to their living environment (decision-making processes, and how the project will be realized in their community distributional justice issues), whether they would have a voice in the (procedural justice issues).

A.3.2 4 RESPONSIBLE INNOVATION IN ENERGY PROJECTS THOUGH VALUE SENSIBLE DESIGN (VSD): STAKEHOLDERS INVOLVEMENT

The VSD approach was originally developed to target the incorporation of a diverse range of values in information technology (Friedman and Kahn, 2000). The aim of this reframe is to extend the scope of VSD, not only by relating it to other technologies, but also by applying it to the institutional context in which such new technologies are implemented and/or used. This methodology has been tested in in energy projects that individually have a local impact, such as a wind park or a gas storage or production facility. VSD aims to incorporate the values of all relevant stakeholders in the design process. For example, it includes the values that are articulated by local stakeholders regarding a specific project as well as possible large societal benefits or concerns.

Value sensitive design[102] aims at systematically incorporating diverse human values in the design of new technologies. VSD as a tripartite iterative method that integrates **conceptual, empirical and technical investigations**:

- Conceptual investigations involve a philosophical questioning of the values such as which values are affected in what way by technological design? Who is affected? How to engage in trade-offs among values?
- Empirical investigations are aimed at social- scientific understanding of experiences of people affected by technological design.
- Technical investigations analyse the technical artefact or system to assess how they support or undermine certain values and inspire the development of alternative technical solutions.

VDS to energy projects propose to apply methodologies not only in the case of the technological design of energy systems but also in institutional design and in designing public participation. Following Van de Poel's approach for translating values into design requirements, we will distinguish between three different levels in a **"value hierarchy"** (van de Poel, 2015):

- At the highest – most abstract - level, there are fundamental values someone may hold paramount such as **safety, environmental friendliness, economic efficiency** and so forth. Contestations do not (often) arise from what constitutes

[102] This method has been primarily introduced and developed in information technology and for designing human computer interaction (Friedman and Kahn Jr, 2000, Friedman and Kahn Jr, 2002, Van den Hoven, 2007), but later it has been elaborated to address the inclusion of moral values in other domains of technological design (Nissenbaum, 2005, Van de Poel, 2009b, Van den Hoven e t a l., 2015, Taebi and Kloosterman, 2015).

a value. Everybody will supposedly endorse abstract values like safety, equity, efficiency, etc.). Rather, controversy arises from how the value is specified into norms.

- Norms are located at the second level of hierarchy and form 'prescription for or restriction on' actions (van de Poel, 2015). Such norms may include objectives (like **"maximize safety", "safeguard environment" or "minimize costs"** without a specific target) that specify a more tangible target, and c on ts that set boundary or minimum conditions.
- The bottom level goals of a value hierarchy, which is also the most concrete one, indicates the technical and institutional hierarchy.

A.3.2 5 ENERGY JUSTICE FRAMEWORK

Pending consequences of climate change and structures of the global energy system as central contemporary justice issues, with implications in human dimension and concern such as happiness, welfare, freedom and equity is the core of Energy justice framework proposed for Sovacool et al. (Sovacool 2015, 2016).

This framework background is based in several efforts for integrate, redefine and revealing the value of social sciences in energy research (Sovacool et al., 2015), the issues regarding to depletion and energy poverty as well as excess of energy arising waste, over-consumption and pollution (Wilkinson, Smith, Joffe and Haines, 2007) generating a perspective of the word climate and energy dilemmas[103] (Sovacool, 2016) and the utility of concepts from ethics and justice as an reframing elements of the discourse were been proposed in this work (Sovacool, 2014, 2015, 2016).

Energy justice framework is focused in five contemporary energy problems: **nuclear waste, involuntary resettlement of populations due to the energy infrastructures, energy pollution, energy poverty and climate change** (Sovacool et al, 2016) and builds the conceptual frame in principles such as a:

- Availability
- Affordability
- Due process
- Transparency and accountability
- Sustainability
- Inter and intra generational equity
- Responsibility

In Energy justice frame Responsibility is understood as a responsibility **of assume the effects** (minimize environmental degradation and climate change, current generations to protect future ones human and non-human) and as a **recognition of the importance of more people-centric approaches for energy use**, understanding the human dimensions of energy as promise of generating valuable insights about energy culture, historical and future shifts in energy practices, sources of variation in energy-use patterns, and effective mechanisms for transforming how people, organizations and societies use energy.

---

103 Energy dilemma is often represented by triangle with a energy law and policy is in the center and on the three vertices of the triangle economics (for example, energy finance), politics (for example, energy security) and environment (for example, climate change mitigation) are located.

Responsibility also is seen as element of the social justice, along with individualism, universality and identity shaping the approach of *cosmopolitan justice*[104], which understands social justice from an anthropogenic point of view as it (Sovacool et al, 2016), consider all ethnic groups belonging to the same community shared collective morality (Beck and Natan Sznaider, 2006). **The use of energy justice framework as an analytical tool is focused** in the connections between energy justice frame and energy policy and technology; thought eight philosophical concepts, influences, applications, injustices, and solutions summarized in reframing **eight distinct energy problems as justice themes**: **virtue, utility, human rights, and procedural justice** come primarily from classical theorists**,** and **welfare, freedom, posterity, and responsibility,** come from modern thinkers**.**

According to this analytical view, the problem of efficiency becomes reframed not as an **economic or technical issue, but one of virtue**. Human becomes reframed not as an economic or technical issue, but one of virtue, hence *Externalities* can be considered Human rights abuses and poor social and environmental impact assessments. Energy poverty becomes immoral because it interferes with human beings' ability to achieve functions and capabilities. Subsidies, intriguingly, can be viewed as an affront to individual liberty and personal property. The depletion of resources can be reframed as an issue about present versus future generations and climate change becomes a moral issue concerning responsibility, fairness, and the duty to respond to it**.**

Reframing five energy problems as justice concerns arise a:

- **Involuntary resettlement as a violation of procedural justice** with interrelated justice issues such as a *who gets to decide and set rules and laws, which parties and interests are recognized in decision-making, by what process do they make such decisions as well as how impartial or fair are the institutions, instruments and objectives involved.*
- **Fossil fuel pollution became a human rights concern** due to the unevenly distribution of the effects and inequitable impacts on children and minorities. Such pollution can be reframed not only as a health concern, but also one of justice and human rights.
- **Energy poverty is reframed under energy justice frame as a violation of distributive justice** due to the unequal distribution of modern energy services in terms of dealing with what goods, such as wealth, power, respect, food or clothing, *are to be distributed* and *Between what entities are they to be distributed* and *what is the proper mode of distribution.*
- **Nuclear waste as an insult to future generations.**
- **Climate change as contravened responsibility.**

Energy justice frame argues that we need to start making energy decisions that promote:

[104] Cosmopolitan philosophy is the belief in that we are all 'world citizens'. With the advent of clear and visible effects of climate change the approach to environmental protection is being seen more in the light of cosmopolitan philosophy. Cosmopolitism has of course a distinctly long history in global justice thinking. From this perspective, we build on environmental and climate justice demands for a collective approach to resources. The focus here, however, is targeted on energy resources in an attempt to achieve a meaningful global change specifically in energy behaviours and attitudes.

- **Availability:** Availability is the most basic element, for it involves the ability of an economy, market, or system to guarantee sufficient energy resources when needed. It therefore transcends concerns related to security of supply, sufficiency, and reliability, and it encompasses a range of different dimensions. It includes the physical resource endowment of a particular country or region, as well as the technological solutions that region utilizes to produce, transport, conserve, store, or distribute energy
- **Affordability:** Affordability thus encompasses stable prices (minimal volatility) as well as equitable prices that do not require lower-income households to expend dis- proportionally larger shares of their income on essential services. Implicit with this criterion is the idea that highly available energy fuels and services is meaningless unless households and other consumers can afford to access and utilize them.
- **Due process:** Due process seeks to ensure that the potential for stakeholder participation in the energy policymaking process at least roughly matches the importance (in aggregate and to each person affected) of the matter at stake and the irrevocability of any decisions that may be reached. More specifically, the decision-making principle suggests that communities must be involved in deciding about projects that will affect them; they must be given fair and informed consent; environmental and social impact assessments must involve genuine community consultation; and neutral arbitration should be available to handle grievances.
- **Good governance:** All people should have access to high-quality information about energy and the environment. Information, accountability, and transparency have become a central element of promoting "good governance" throughout a variety of sectors, a term that centres on democratic and transparent decision-making processes and financial accounting, as well as effective measures to reduce corruption and publish information about energy revenues and policies.
- **Sustainability:** Sustainability refers to what the Brundtland Commission termed[19]. In an energy context it refers to the duty of states to ensure the sustainable use of natural resources. It means that countries have sovereign rights over their natural resources, that they have a duty not to deplete them too rapidly, and that they do not cause undue damage to their environment or that of other states beyond their jurisdiction.
- **Intergenerational equity:** present people have a right to access energy services fairly. This approach, finds its roots in modern theories of **distributive justice.** Philosophers call it "distributive" justice because it deals intently with three aspects of distribution: *What goods, such as wealth, power, respect, food, or clothing, are to be distributed? Between what entities are they to be distributed? What is the proper mode of distribution-based on need, based on merit, based on property rights-, or something else?*
- **Intragenerational equity:** Instead of emphasizing distributive justice between different communities in the present, intergenerational equity is about distributive justice between present and future generations. It holds that future people have a right to enjoy a good life just like us contemporaries, yet one undisturbed by the temporal damage our energy systems will inflict over time.

Consequently, each of us has a moral responsibility to ensure that today's children and future generations inherit a global environment at least no worse than the one we received from our predecessors—and that **responsibility** extends to preventing climate change and making strategic investments in something known as **"adaptation"** to increase the needed resilience of communities.

- **Responsibility:** holds that nations have a responsibility to protect the natural environment and minimize the production of negative externalities, or energy-related social and environmental costs.

Responsibility in energy justice framework blends together four somewhat different notions of" responsibility**"**:

- **Responsibility of governments to minimize environmental degradation**,
- **Responsibility of industrialized countries responsible for climate change to pay to fix the problem** (the so-called" polluter pays principle**"**),
- **Responsibility of current generations to protect future ones**,
- **Responsibility of humans to recognize the intrinsic value of non-human species, adhering to a sort of" environmental ethic"**

A summary of the insights of energy frameworks is shown in Figure 13**:**

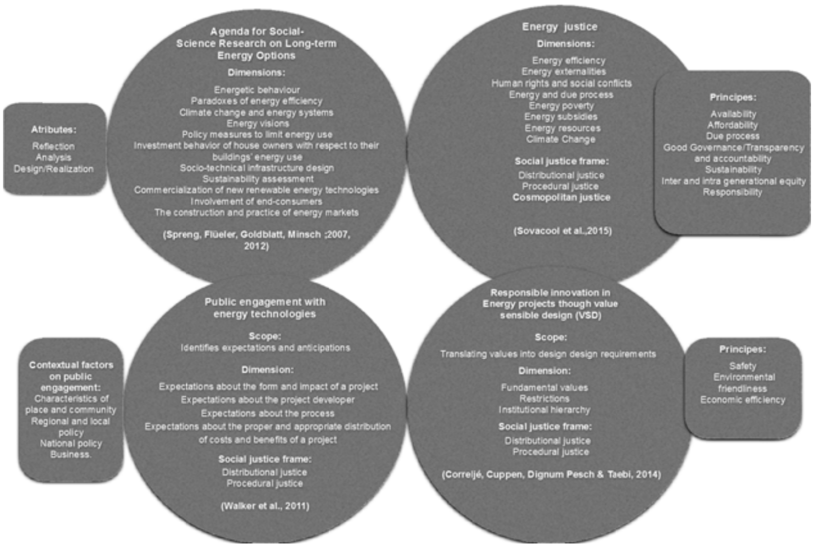

FIGURE 13: Elements of social sciences frameworks for energy research comparison.

A.3 3 RESPONSIBILITY APPRAISAL FOR RENEWABLE ENERGY RESEARCH AND APPLICATIONS

Some authors **express that the path of responsibility in energy research needs to be leaded by social sciences** owing to the ability and responsibility, as a cross-cutting issue, to concrete role in solving energy-related challenges regarding social, economic and ecological problems are raising. Social sciences in energy research field are progressively strengthened devoted to encourage contemporary energy research to transcend from traditional social science topics to neglected issues (Sovacool, 2014) such as gender and identity as well as philosophy, ethics anthropology and culture. In this terms the responsible approach of energy research can be consider from the elements of the social dimensions.

Although, worrying trends are being detected concerning to the interpretation of inclusion of social sciences in energy research such as a: an undervaluation of the influence of social dimensions on energy use; a bias towards science, engineering and economics over other social sciences and the humanities; a lack of interdisciplinary collaboration; and the under-representation of female authors or those from minority groups (Sovacool 2014 and Sovacool et al., 2015). Those trends match with the objectives of the RRI in action.

The importance of multidisciplinary and the inclusion of social topics in research and in researchers are also inferred from these trends. Social science approach regarding with contemporary energy research production, advocate for reduce disciplinary bias, strength scientist's collaboration beyond their fields and approach energy research more problem-oriented, including social perspectives and neglected topics (Sovacool, 2014).

Despite this historical and contemporary efforts towards the shaping social dimension of energy research, Responsibility as understand in RRI framework was found not deliberately represented in energy research, although, shifts towards Responsible approach in social dimension issues treatment appeared notable. Most of the responsible approaches were found related with energy policy rather than with energy research and innovations.

In the case of Renewable energy research, an evolution is noticed, even thought, most of the overarching approaches seems to be leveraged in traditional frames of socio technical and human dimension in most, without recognizable elements proposed in RRI Responsible approach.

It is inferred from these trends also the importance of multidisciplinary and the inclusion of social topics in research and in researchers. Social science approach regarding with contemporary energy research production, advocate for reduce disciplinary bias, strength scientist's collaboration beyond their fields and approach energy research more problem-oriented, including social perspectives and neglected topics (Sovacool, 2014)

Social science approach regarding with contemporary energy research production, advocate for reduce disciplinary bias, strength scientist's collaboration beyond their fields and approach energy research more problem-oriented, including social perspectives and neglected topics (Sovacool, 2014) as shown in Table 27.

Despite this historical and contemporary efforts towards the shaping social dimension of energy research, **Responsibility as understand in RRI framework was found not deliberately represented in energy research, although, shifts towards Responsible approach in social dimension issues treatment appeared notable**. Most of the approaches were related with energy policy rather than with energy research and innovations. Even though Renewable energy research is evolving, seems to be leveraged in historical approaches of socio technical and human dimension in most of research efforts, without embracing RRI Responsible approach.

TABLE 27: Neglected topics rarely consider in energy research (Adapted from Sovacool, Nature volume 511, 2014)

Social Sciences neglected topics in energy research	Examples
Gender and identity	Pollution from cooking stoves posing greater risk to women than men
Philosophy and ethics	Future generations bearing the burden of pollution
Communication and persuasion	Energy information changing individual or firm behaviour
Geography and scale	Mismatching the size of energy systems to patterns of demand
Social psychology and behaviour	Shaping energy choices by trust, control and denial
Anthropology and culture	Temporal and regional differences in conceptions of energy services
Research and innovation	How people, markets and institutions drive innovation
Politics and political economy	Resources contributing to conflict or stymying growth
Institutions and energy governance	Evolving rules and norms to address collective energy problems
Energy and development	Energy use contributing to economic growth and falling poverty
Externalities and pollution	Costs to society of erosions of environmental and ecological capital
Sociology of technology	Economic, political and social drivers of energy consumption

The coverage of social issues such a as ethics, gender contemporary considered as a dimensions of RRI and necessary expression of the values of innovation, its seems to be more related with evolution of social approaches of energy studies than with embracement of Responsible Research and innovation Framework.

A.3.3 1 RENEWABLE ENERGY TECHNOLOGIES RETS

Overall consideration, shows that Renewable energy research does not seem very influenced by RRI approach when we considered globally, however develop RRI in dimension allows finding more correspondences. RRI dimensions of science education, gender, governance, sustainability, ethics, open access, engagement and social justice have been treated in Renewable energy research in varying degrees, emphasizing ethics, science education, sustainability and governance. Several interconnections between RRI and evolved and traditional social inputs from energy research heritage were found.

Correlations between RRI dimensions in energy studies were found. From education with public engagement towards gender and public participation, despite gender and engagement are represented but focused on the relationship with technology. New paradigms in Energy research contemporary approaches such as Energy justice and

Public participation/ engagement are some of the most remarkable ones. A Public consultation[105] on the Renewable Energy Directive for the period after 2020 (EC 2016 energy) arranged for the EC for preparation new renewable energy directive period after 2020 focused in the analysis of stakeholder views, shows that despite there is a strong support for additional EU action for empowering energy consumers and local authorities, the vast majority of replies (84%) support stronger EU rules guaranteeing that consumers have the possibility to produce and store their own renewable heat and electricity. Also, the necessity of tabling measures to improve public acceptance of renewables was addressed by key stakeholders.

Half of the respondents mention the importance of involving citizens and local communities in the development of renewable energy projects, also through awareness campaigns and public dialogue emphasising the contribution of renewables to achieving climate goals, energy security, and local growth.

Social justice in terms of energy justice is been recently developed in a promising recent works (Sovacool et al 2015, 2016) but as a development contemporary global energy systems issues and social concerns related with, not as responsible approach application.

The evolution of the social dimension differs from responsible approaches, despite both are contemporary. A review of Energy justice frame (Sovacool et al, 2016) in terms of responsible approach indicates that although the same terms are used, the concepts and contexts embodied are not exactly the same. Responsibility is understood in Energy justice framework as a responsibility of assumes the effects (minimize environmental degradation and climate change, current generations to protect future ones' human and non-human). Also, Responsibility approach as a recognition of the importance of more people-centric approaches for energy use, understanding the human dimensions of energy (as promise of generating valuable insights about energy culture, historical and future shifts in energy practices, sources of variation in energy-use patterns, and effective mechanisms for transforming how people, organizations and societies use energy).

A.3.3 2 THERMAL ENERGY STORAGE (TES) APPLICATION

The assumption that a single energy technology cannot emerge as the ultimate solution to Europe's energy challenges, as well as the fact that transition to zero carbon energy solutions in EU needs to address a wide range of **technological issues**, but also socio-**economic issues** is supported widely in numerous reports describing possible future scenarios of the European energy system.

In this landscape, energy storage will be required in the sustainable energy system and this assumption furthermore depend on many aspects of the energy system such as penetration of renewables, electricity transmission capacity across Europe, penetration

[105] This public consultation was launched on 18 November 2015 and remained open until 10 February 2016. A total of 19 national governments and 22 regional or local authorities also participated in this consultation. It is worth to note the significant participation by individual citizens, energy cooperatives and NGOs (EC2016).

of demand side management and alternative back-up power availability[106].

The Strategic Research Priorities for Cross-cutting Technology [107] in storage calls for understand its cross-cutting nature in terms of involvement of a large range of topics, from thermal energy production to its consumption, including customer relations, networks management and integration; found close relation with other stakeholders, like the renewable energy industry (solar, geothermal, biomass, incl. waste), building owners, operators and users, industrial facilities and the service sector, but also with urban planners, local authorities and assume challenges of the environmental policy complexity as well as ever faster societal changes over time as shown in Figure 14.

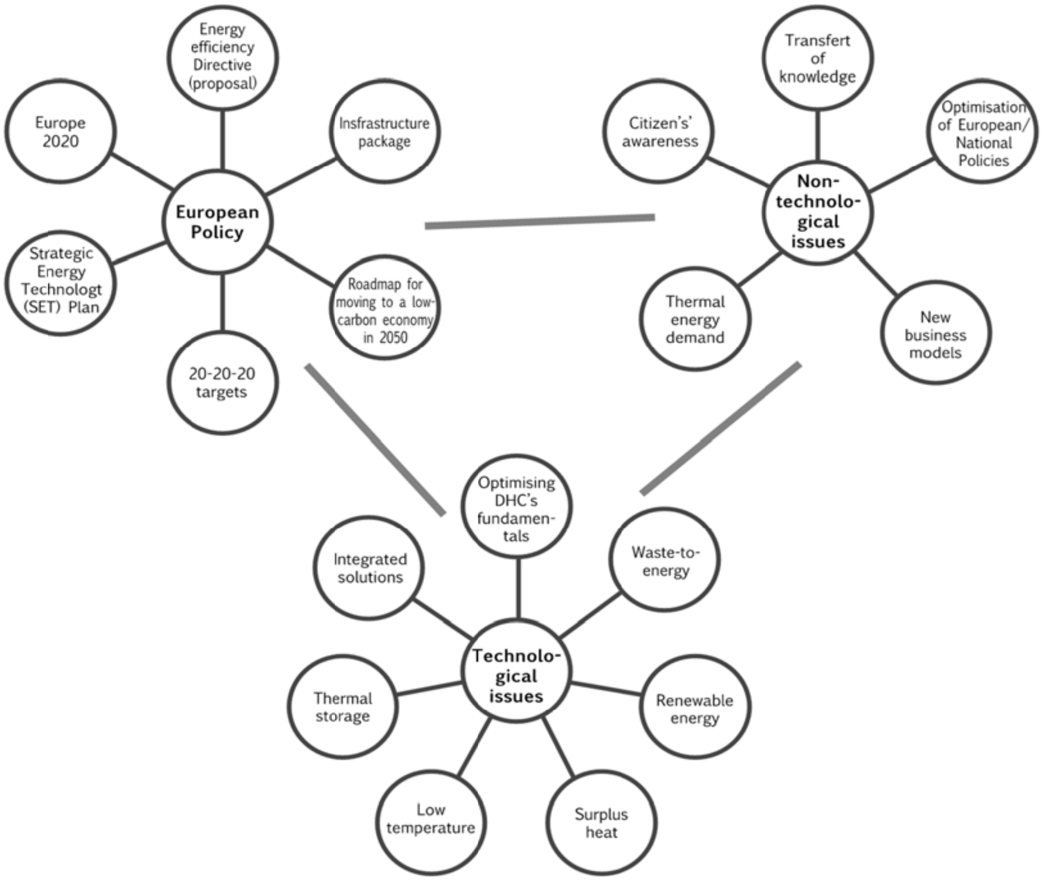

FIGURE 14: Interrelated issues for energy storage (Source: Cross Cutting Technology RHC platform 2015).

Regarding with non-technological priorities where rri can help to arrange a framework are transfer of knowledge, education and training and public awareness and efforts for enabling research areas. Computer tools, assessment techniques and design guides are required that are easy to understand but do not simplify things to an extent that installation and operation are compromised by lack of knowledge. Knowledge of tes

[106] European Energy Storage Technology Development roadmap towards 2030. The European Association for Storage of Energy (EASE) and EERA, the European Energy Research Alliance, leading organisations in the eld of energy research. 2015.

[107] Strategic Research Priorities for Cross-cutting Technology European Technology Platform on Renewable Heating and Cooling, 2016.

principles should become a standard part of energy education in schools and university curriculum. Vocational training programmes in any renewable heating and cooling technologies should include a component of tes.

Also, in order to deploy tes at large scale, reinforce public awareness it's critical to raise awareness on the existence and benefits of integrating tes into the energy system. Therefore, a broad range of actors should be addressed: architects and engineers, installers, manufacturers, policy makers and the public.

Value laden technology such as smart meters interchanging information provided by ict systems and tools can be strategic to raise acceptance levels or to refusal in communities and central role in the smart cities and communities development creating stronger links with current and potential customers are issues where rri approach could help.

The integration of information and communications technology and the power system, (smart grid) and demand side management (dsm) technologies [108] becoming increasingly feasible and being considered as a key aspect of many future energy system scenarios [109] are also important challenges for 2020 (technology roadmap energy storage international energy agency 2016). Although, substantial public engagement and further policy development is required for widespread dsm implementation (spence, demski, butler, parkhilland pidgeon, nature climate change 2015).

Engagement with communities and end user is also a priority. Clear understanding of the uses of research facilities and plants, in order to avoid nymbyrims occurring when installations are perceived as invasive and hard to accept for local residents.

End users can change behaviour raising the awareness of the impact of their behaviour on their energy consumption (particularly for heating and cooling systems).

The involvement of end user communities can also be stimulated by implementing social network tools (or extending existing ones) for the dissemination of information about best practices and results obtained by virtuous behaviour.

To give communities the possibility to choose the best energy mix, evaluate new installations and adopt the most energy efficient behaviour, appropriate tools and equipment must be developed. Given their intrinsic functional complexity, additional research is needed on tools that provide a flexible user interface tailored to different stakeholder groups: operators/utilities, user communities, escos, and financial institutions. Each group requires a different "view" (focus, detail level) of the common underlying information (production and consumption information, user profile, social aspects, demographics, economics, business models, etc).

[108] DSM is known, as is the modification of consumer demand for energy through various methods such as financial incentives and behavioural change through education. Usually, the goal of demand side management is to encourage the consumer to use less energy during peak hours, or to move the time of energy use to off-peak times such as night-time and weekends.

[109] National Grid UK Future Energy Scenarios: UK Gas and Electricity Transmission (UK Government, 2013).

ANNEX 4 DATA COLLECTION

A.4 1 RES-AGORA PROJECT: DE FACTO GOVERNANCE OPERATIONALISATION MODEL

TABLE 28: De facto governance operationalisation model for the pilot case studies (Adapted from Walhout B, Kuhlmann S, Edler J, Randles S. Responsible Research and Innovation in a Distributed Anticipatory Governance Frame. A Constructive Socio-normative Approach. Deliverable D2 . 2 – update Research heuristic and key concepts 2014).

1) Situate the R&I characteristics in your case.
- Research (public and/or private founded)
- Experimenting with new technologies in public settings (e.g. fracking, products entering practices or market introduction)
- Regulating market dynamics or value chains? If applicable

2) Describe the governance arrangement(s):
- Purpose (e.g. outcome objectives such as ensuring safety, protecting equity, increasing societal relevance; or principal/procedure objectives such as ethical acceptability, public participation or stimulating reflexivity)
- Policy instruments (e.g. law, soft regulation, codes of conduct, hybrid organised)
- Systems of enforcement/implementation (procedures, informal/formal institutional structures)

3) Describe how the RRI governance arrangement(s) are positioned in the wider R&I & RRI governance landscape
- Vertical: relation to overarching frameworks or treaties
- Horizontal: relation/competition to co-existing RRI arrangements

4) Describe the (key) actors involved, in terms of:
- Organisation (e.g. Single Companies, Universities, CSOs, Ministries, business associations, professional associations, charitable foundations, media)
- Roles and relations (e.g. (in) formally, hierarchical, in competition, collaborative, ...
- Relevant problem frames (ethical, economical, etc...), related interests (values, normativity's) and power (resources, capabilities to frame the problems in de facto governance practices)
- Capacities and capabilities of actors to relate to the dimension of responsibility and to engage in debates and negotiations (level of awareness, underlying training, ability/readiness to learn, resources to be invested etc.)

5) De facto practices of RRI governance
- Characteristics of the places and spaces of interaction, whether or not linked to the RRI governance arrangements
- How actors are mobilized: agenda setting, resource provision, capacity building
- How responsibilities are constructed, negotiated and taken up (including modes of enforcement / incentivizing)
- If actors use the (soft and hard) instruments incorporated in the governance arrangement and if so in which ways (e.g. to comply with or as conversational/reflexive tool; to implement or to experiment, etc...)
- How are interests played out, value clashes modulated and competing claims about effectiveness and legitimacy aligned

6) Assess extent *responsibilisation* and managing contestation are *'doing well'*:

- **Describe and assess the actual transformation:**
  - o Is there a development of shared (or a sufficient level of complementary) under- standings of the governance challenges (as for "responsibilisation") and how these are to be addressed?
  - o Is there a change of behaviour and attitudes, if so in how far is there a change their behaviour in line with new understandings of responsibility (not only compliance, but also change of attitudes)? ?
- **What are the constructive quality of interactions?**
  - o The capacities for learning (reflexive actors)
  - o Embedding of responsibilities (think of addressing various levels within organizations instead of only having 'spokespersons' involved).
  - o Are the 'right' set of actors involved (think of different problem types requiring different modes and scope of participation), in a way that is perceived as meaningful and fair?
  - o What level of trust is built up as regards the governance arrangements and practices, in how far are procedures or 'rules of the game' accepted (including issues of transparency and inclusivity) and what is the stakeholder's acceptance of (con- tested) outcomes ?
  - o What is the level of (perceived) robustness of the knowledge base (as far as the level of uncertainty of the issue allows, social acceptance of including the state of the art knowledge and accepting its limitations)?

7) Situate your case in terms of level of perceived locality vs globality

- Research vs. innovation
- Technoscience domains / cross-domain issues
- General purpose technology vs. specific application
- Range and variety of actors involved
- Uncertainty about (the kind of consequences), e.g. market uncertainty, regulatory un- certainty. etc.

Assisting transversal analysis:

8) How can they be modified, extended (internal view, organisation & coordination)?

9) How can RRI governance arrangement better be positioned in hierarchical landscape (external view, meta-governance)

10) When/how would RRI need to be differently understood? (framings, in relation to construction of responsibilities)

11) We then can expect building components to be found in all sorts of 'conflict management' strategies, playing out at different levels (think of conflicting logics, framings, interests, ...).

12) In addition, do we see common dominant values and normativity's related to the emerging technologies domain we are focusing on (e.g. strong democratic principles), reflected in the empirical cases? Or are they underpinned by other dominant values and normativities?

13) What are lessons in terms of the interactions and inter-penetrations of multiple-level analysis:

- EU (policy and programmes)
- Member states institutional framing conditions
- Hybrid (multi-stakeholder)
- Single organization types (Such as multinationals, universities, charitable foundations),
- Individuals (formation of more reflexive and societally conscious/learning individuals, presence/absence of Champions/Institutional Entrepreneurs)

A.4 2 MORRI PROJECT DIAGNOSIS SHEET

TABLE 29: Collection data sheet template (Source Ravn, T., M.W. Nielsen, and N. Mejlgaard (2015). Metrics and Indicators of Responsible Research and Innovation Progress Report D3.2 - Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI). 92 pp.)

Information item	Description
Indicator characteristics	This section includes general indicator specifications
Name of indicator	Please state an informative short name for the indicator
Primary/secondary data	Please state whether this indicator is based on secondary (already existing) data or on primary data that we will need to collect
Need for supplementary data collection	Please note if the indicator is based on secondary data with insufficient coverage, thus requiring supplementary data collection. A typical example would be non-exhaustive coverage of EU28 countries
Description	Please provide an accurate and thorough description of the indicator (what is it an indicator of, how does it capture information about the RRI dimension in question, in which context was the indicator developed (if secondary data) etc.)
Qual / Quant	Please specify whether the basic data are of quantitative or qualitative. In some cases, the basic data will be qualitative (interview transcripts, national reports or similar) which require coding / categorisation in order to be useful for monitoring purposes. Please specify
Source of data (specific references, page numbers, links, exact tables etc.)	If indicator is based on secondary data, please state the data sources for the indicator, including specification of database, specific page numbers, exact tables etc. If possible please provide direct links to the data source in question
Date	If indicator is based on secondary data, please note in which year data was most recently collected
Time-series	Are time-series data available? Please specify by yes/no and note the actual years for which data are available
Potential time series data	Could the indicator be a potential candidate for longitudinal data collection? Please specify. We hope that 2-3 out of 10 indicators for each dimension would potentially be interesting for over-time data collection
Measurement level	Please state the level of measurement (scales of measure), e.g. nominal, ordinal, interval
Unit of analysis	Please state the basic unit of analysis (e.g. countries, citizens, publications etc.)
Coverage (specific	If the indicator is based on secondary data, please

countries, institutions etc. covered)	state the specific data coverage. For instance, specify the actual countries covered, or institutions covered
Attributes	Please describe the specific indicator attributes
Assessment of RRI indicators	This section assesses the indicator on the basis of the analytical distinctions and quality parameters specified within the context of the MoRRI project
Analytical level (logic model)	Please specify the analytical level in the intervention logic model at which the indicator is oriented (i.e. context, input, output, outcome). Note that we aim for INPUT and OUTPUT indicators
Analytical level (aggregation)	Please specify the level of aggregation for the indicator (i.e. global, national, regional, institutional, project/programme, individual). Note that we aim for NATIONAL level indicators, but that the basic unit of analysis does not need to be countries. Individual level data could, e.g., be aggregated to the national level
Is indicator based on aggregation/disaggregation	Please state whether the indicator is based on aggregation or disaggregation of data
Sub-categorisation from dimension typology (functional vocabulary)	Please specify whether the indicator addresses a particular sub- category within the dimension typology (e.g. the 'public participation' category within the public engagement dimension). Furthermore, please state if the indicators internally relates to other sub-categories within the same dimension.
Interlinkages with other RRI dimensions	Please indicate to which extent the indicator directly relates to or overlap externally with other (sub)dimensions (e.g. an indicator measuring visits to science museums could be an indicator for both the

TABLE 30: Collection data example for open access indicator (Source Ravn, T., M.W. Nielsen, and N. Mejlgaard (2015). Metrics and Indicators of Responsible Research and Innovation Progress Report D3.2 - Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI). 92 pp).

Information item	OA3
Indicator characteristics	
Name of indicator	Social media outreach/take up of Open Access Literature and open research data
Primary/secondary data	Primary data (i.e. Web of Science or Scopus data - and data collected in OA1 and OA2) + other secondary data (i.e. Mendeley and Altmetric.com)
Need for supplementary data collection	Need of data collection as decided in OA1 and OA2.
Description	This indicator will inform how OA European publications and data publications are being disseminated across social media tools.
Qual / Quant	Quantitative
Source of data	CWTS counts with the following databases: Web of Science. Mendeley. Altmetric.com. Open Access databases (based on Crossref, DAOJ and ROAD), and potentially all the information collected in OA2.
Date	From 2012 onwards.
Time-series	Yes, from 2012 onwards.
Potential time series data	Yes
Measurement level	Raw counts, shares and ratios.
Unit of analysis	Countries, regions, institutions and authors.
Coverage	All countries, institutions, authors with OA publications in the Web of Science (and with a DOI or other identifiers) and Open research data publications in the DCI
Attributes	Counts, ratios and shares.
Assessment of RRI indicators	
Analytical level	Outcome
Analytical level	Global, national, regional, institutional, project/programme and individual.

Is indicator based on aggregation/disaggregation	The indicator(s) is(are) based on raw and aggregated data.
Sub-categorisation from dimension typology (functional vocabulary)	Open Access
Interlinkages with other RRI dimensions	Public Engagement (PE)
Data collection specifications	
Data collection methods	Bibliometric and altmetric data collection. CWTS has already developed methodologies to implement this. It would be necessary to experiment with the altmetric approaches.
Representation issues	Similar representation (and biases) as regarding the use of the Web of Science and altmetric databases.
Feasibility issues	Medium feasibility. In so far as OA1 and OA2 is done, data collection will be easy
Additional points to pay attention to	
Comments/caveats	Caveats related with bibliometric and altmetric indicators also apply here. This indicator requires both standardized procedures and data collection and also more exploratory approaches.
	PE subcategory 'public communication' and the SLSE subcategory 'science communication')
Data collection specifications	This section specifically addresses the procedure for collecting primary data, including collection of supplementary data when existing data has insufficient coverage. Please expand on each issue to the extent feasible in order to – as precisely as possible - direct the data collection process in task 4.
Data collection methods	Please note how data should be collected for this indicator (survey / questionnaire, data retrieved from databases, structured/semi- structured/explorative interviews, focus groups, desk research, document analysis, ethnographic field studies, etc.). Describe the respondents / informants, including the size of this population
Representation issues	Please reflect on the coverage of the available/proposed indicator and the potential data collection challenges that should be taken into

	consideration, e.g. would representative data, if relevant, be available for all European countries? How would institutions be sampled in order to be representative for a country etc.
Feasibility issues	Please address the feasibility of this indicator given the constraints on resources and time in the project
Additional points to pay attention to	
Comments/caveats	Additional comments/caveats can be specified here

A.4 3 SOCIAL APPROACH OF RESEARCH IN RENEWABLE ENERGY SURVEY SARRES AND SOCIAL APPROACH OF RESEARCH IN THERMAL ENERGY STORAGE SURVEY SARTESS QUESTIONNAIRE

TABLE 31: Questionarie template

Question	Dimension
What is your opinion regarding with this statement? Energy studies needs the insights of the social sciences.	**Energy and Society**
What is your opinion regarding with this statement? Energy studies would benefit from the insights of the social sciences.	
Regarding with the implementation of the social sciences in TES, which are the most significant applications in the context of your research?	
How would you understand or describe energy studies and TES with a social focus or social approach?	
What would count as research with social approach in your field? Kindly describe this with reference to your role, institution, country, region and state. Are you aware of any research trends or practices that can be linked to this social approach?	
In the context of your work, which aspects come under the areas of divulgation?	**Communication, research and dissemination and outreach**
In the context of your work, which aspects come under the areas of communication?	
Do you know any remarkable initiatives and platforms related with TES communication? Please, suggest examples.	
Do you know any remarkable initiatives and platforms related with TES communication? Please, suggest examples.	
Do you use non-conventional, social or open platforms to communicate your research activities?	
Would you say that you have the right skills / tools to prepare and disseminate content for communication / dissemination purposes?	
Are you aware with the concept of participatory research/engagement research?	**Methodologies and regulatory framework**
Do you consider that there are differences between participation research and engagement research?	
Are you aware with the concept of responsibility regarding to research? Please, select related options.	
Do you use the concept "responsible/responsiveness" in your TES research?	
Are you aware with the following concepts regarding with your research? Please select correspondences.	

Anticipation Reflexivity Inclusion Responsiveness	
Are you aware with the following concepts regarding with your research? Governance Gender equality Scientific education Engagement Ethics Open access	
In your field of work / research, what is considered engagement?	
In your field of work / research, what is considered science education?	
Regarding with TES research, what is your consideration regarding with the target audience of science education?	
Which of the definitions below will most closely match your understanding of the term "open science"?	
What is your view in the current state of the field of "open science"? Kindly note below any gaps, dangers, needs, controversial positions, red lines, critical issues, challenges and trends that in your opinion will define the "open science" now and in the near future.	
What are your considerations regarding the publication of results in open access?	
Do you think that citizens can contribute to scientific research?	
In the context of your research, how would you describe your relation with the society at large?	
Are you aware with the concept of "citizen science"?	
Are you aware of any initiatives or examples of the "citizen science" projects? Please, describe examples.	
What are your reflexions regarding to the following concepts?	
Are you aware of any of the following methodologies?	
In the context of your institution what are the measures considered necessary to carry out an integration of methodologies for integrate social approach in TES research?	
Do you think that any implementation of this methodologies and	

regulatory frameworks in your institution will have an impact on your work?	