



Renewable energy research and technologies through responsible research and innovation looking glass: Reflexions, theoretical approaches and contemporary discourses



Ruth Carbajo, Luisa F. Cabeza*

GREA Innovació concurrent, INSPIRES Research Centre, University of Lleida, Pere de Cabrera s/n, 25001 Lleida, Spain

HIGHLIGHTS

- Responsible Research and Innovation (RRI) and Open Innovation European strategies.
- RRI policy insights construction.
- RRI dimensions beyond significance.
- Social science frameworks for energy research.
- Operational elements of responsibility in energy research.

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ABSTRACT

The increasing challenges that energy research faces as a priority in most of the global research agendas, are revealed both in terms of social and technical issues. Energy research highlights are set on the development of reliable renewable energy systems and applications; transition to decentralized systems and socio-technical, behavioural and institutional issues combination which requires the integration of both energy and research policies. Global trends in research policies showing an advocacy for responsible approaches are for example Responsible Research and Innovation (RRI) and Open Innovation European strategies which promote the development of social issues as core key of the research and innovation and the definition of the outcomes as the expression of human values such as safety, justice, sustainability and efficiency. The purpose of this article is to present a reflexion regarding to a contextualization of this approach in energy research. Therefore, a range of theoretical backgrounds, meaning making processes, historical approaches, frameworks and contemporary discourses, have been examined. Our aim is to provide a detailed review of existing literature related to the key elements of Responsible Research and Innovation. The innovative contribution is focused in the vision of these key elements applied to energy research, with particular reference to renewables and the outline of the many factors influencing the real field implementation. Results show the existence of a common ground between responsible approaches and many concepts from energy research and social sciences frames. Responsibility as understood in the RRI framework was found not deliberately represented, although, shifts towards responsible approach in social dimension treatment of renewable energy research appeared notable.

1. Introduction

Energy research has been greatly influenced by multidisciplinary efforts towards enhancing and pursuing open, participatory and responsible approaches before this concept become overarching. The integration of philosophy, ethics, communication, economy and politics, shaping energy research and social sciences approaches and the eclectic nature of the energy as a complex socio-technical system, with a

combination of a variety of technical aspects and automated processes which includes human behaviour and social factors [1] are some of the examples. Responsibility as a concept, approach and policy [2], permeates today, every scientific discipline and its insights are present in global research and energy policies, reinforced by contemporary discourses regarding to the integration of the social and human dimensions in science, innovation, economy and politics and the search for a new paradigms of governance of science. Examples of this

* Corresponding author.

E-mail address: lcabeza@diei.udl.cat (L.F. Cabeza).

integration are the sustainable global challenges development in terms of affordable and clean energy, climate action, responsible consumption, and commitments with renewable energy production. Moreover, this integration is also achieved when policy seeks for strongest partnerships between institutions to achieve those sustainable global challenges, such as gender equality, education and poverty eradication [3] among others.

Responsibility does not correspond to one fixed definition and its scope in policy is still under construction. It comprises a wide umbrella of approaches where, the preference for innovation with the ability to solve social issues, the understanding of progress and advances in terms of social commitments, as well as the management and inclusion of the diversity of stakeholders, are some of its remarkable insights. Responsibility incarnated as research and innovation policy, also comprises a broad spectrum of actions and intentions such as an interdisciplinary integration of topics [4], innovation outcomes re-interpretation as an expression of moral values, intention of broaden the impacts beyond return of investment (ROI) policies [5], and an Impact assessment (IA) process reframing with excellence redefinition both in terms of analytical and social relevance of scientific outcomes [6]. Responsible policies are present as research policies in the European Framework Programme for Research and Innovation *Horizon 2020*, identified as *Responsible Research and Innovation (RRI)*, and as cross-cutting issue in the *Open innovation, Open science, Open to the world* [7] research and innovation strategy of the European Commission [8–11]. At national level, the Dutch Responsible Innovation strategy, now integrated in EU RRI policy and considered one of RRI foundational predecessors [11,12], and the UK Engineering and Physical Sciences Research Council Delivery plan [13] are some examples where responsibility is included as a backbone.

In energy research and policy, many authors agree that the path of responsibility needs to be led by social sciences. This is due to its ability, as cross-cutting issue, to highlight its role in solving energy-related challenges regarding social, economic and ecological concerns [14,15]. Social science contribution to the treatment of the non-technical issues has long been recognized, despite critical voices stating that social sciences adapt to technology and not the other way around. Social sciences are accused of being easily amenable to a managerial implementation approach and closely related to a particular technological development [16]. In energy policy, meanwhile, its presence is still marginal [15,17–19], being this concern often justified by the fact that the funding is dominated by techno-economic interests [15] and the prevalence of economics upon other social sciences and humanities. The widespread of social sciences in research policies through early applications to the technical disciplines has not been free from controversy. What is perceived as an expression of interdisciplinarity and responsibility and is accepted as one of the most unanimously recognized early approach of RRI, it is considered by other authors not inclusive and insufficient to encourage policy to transcend from traditional social science topics to tackle neglected issues [18], such as gender and identity. For instance, broadening the spectrum to other disciplines such as philosophy, ethics, anthropology, and culture manifestations is mentioned as a recommendation to transcend from the simple application of the social sciences when it comes to achieving responsibility. Similarly, the moderation in the use of methodologies, such as impact assessment and risk management is recommended in responsible approaches. This is due to the fact that these methodologies are considered top-down, and that adversely neglect the human dimension [17].

It is also subject of discussion of this paper the shift between social dimension approaches related with issues being considered social rather than concerns of society *per se*. Examples such as risk assessment, costs analysis and increase of public acceptance of achievements of science and technologies [20] towards responsibility approach, with the focus in reframing of the process of production of scientific knowledge [21] and how this shift is represented in energy research, are included.

Many factors influence the real field implementation of the responsibility approach. Contextual variation between research fields and research ecosystems are responsible of the insights which modulate societal impact, governance and responsibility. Perhaps it is difficult to apply Responsible approaches and RRI elements as a general research policy to all the practices and disciplines. Other constraints, such as the time for research outcomes to become in applications and contributions of acknowledgment when innovation is in result of a network of interactions between a variety of stakeholders, are some of the many factors influencing the real implementation and the reach of responsibility goals in terms of the insights shown above. Moreover, the interpretation of these insights becomes more complicated, when the considered research fields integrate historically their own societal dimension, governance and responsibility considerations.

The role of researchers also has to be taken into account as factor for implementation: researchers awareness and disaffection, convenience, un-comfortability with social sciences approaches and complexities regarding real practice of the interdisciplinarity, as well as the guarantee of the freedom of individual research activity consideration and the autonomy of the research organizations, are some of the examples.

Energy research and policy have their own interpretation regarding the concept of responsibility, which is present in several aspects of its policy agendas. For example, the concept of responsibility in energy policy is included in the effect of technology outcomes on society, the well-being of the community, the consequences that changes in norms, values and beliefs have on the society, and in the enactment of government as well as policies and regulations [1]. Responsibility as approach can be found, also, in the treatment of social issues and concerns, and in the socio-political impact approaches that are engaged with reframing energy decisions in terms of ethical concerns, such as justice and values [22,23]. It is widely recognized that in the case of renewable energy some projects implementation and assessment follow the bottom-up. This process is guided by the collaboration between relevant stakeholders in terms of the processes and their outcomes and how such processes and outcomes are perceived.

Contextual variation between research fields and research ecosystems are also important. RRI defines key elements, such as engagement and gender, in a generic way, while different scientific disciplines are used to tackle those questions in their specific way. Participation, for example, can be addressed through researcher engagement in policies, evolving citizens through participatory research methods [24], through stakeholders engagement, through social activism, or through citizen science. Moreover, those approaches change over time. Another example is public engagement, which was already present in some social dimension approaches and transcended to RRI. The traditional objective of public engagement was to create *consensus* around *upstream engagement*, which assumes that agreement between diverse *stakeholders* is desirable and possible [25]. Today public engagement considers that stakeholders replace social actors and that a *upstream process* involves methods such as focus groups, citizen juries, and other forums for participatory discussions [6,26]. This is reflected in new models of anticipatory governance [6,27] and Constructive Technology Assessment [28,29] as methods for practical applications in disciplines such as renewable energy research. These models can be considered tools to achieve operational elements of RRI and will be discussed throughout the paper. The importance of the users, as a ramification of participation based in the premise that invention becomes an innovation only if users become a part of the value creation process, is also another example. The integration of the users in RRI and the Open innovation framework is conducted via methods such as *User innovation* in terms of the role of citizens and users in the innovation processes as *distributed* sources of knowledge. In this context, the term *open* is used as a synonym for *user-centred*. Open science, citizen science, and crowdsourcing are also elements of this approach.

Thereby, this paper explores the responsibility understandings of the energy research in terms of the Responsible Research and

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