Input Paper:

Responsible Research and Innovation for the Energy Transition

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1 Project overview

The V4InnovatE research project addresses the issue of the acceptance of energy transition innovations which is key for a successful transition from fossil based towards renewable energy sources. Our objective is to contribute to shaping innovation processes in a way to increase the likelihood of social acceptance of energy transition innovations by developing a system of indicators for the initiation, selection, conduction and accompanied monitoring of research and development projects. Central idea of the V4InnovatE approach is, that by aligning innovation processes with the overall societal needs and values and involving various societal actors this can reduce the likelihood of unintended consequences for both, innovation processes and their outcomes. Therefore, V4InnovatE builds upon the concept of Responsible Research and Innovation (RRI), which deals with the question of a socially responsible design and management of research and innovation processes.

Based on the indicator system and in exchange with actors from science, business, organized civil society, and policy-supporting organizations, we propose a guideline which shows how the developed indicator system can be used as an orientation for society-friendly technology. This guideline is designed to support: (1) a better understanding of the acceptance conditions of energy transition innovations; (2) the anticipation of acceptance challenges and barriers.

V4InnovatE understands by technological energy transition innovations both, a radically new technology (e.g., new storage technologies) and an incremental improvement of an existing technology (e.g., new types of batteries). A principal challenge for governing both forms of innovation is that innovation processes are characterized by a high degree of uncertainty regarding their outcome. This limits the ability to plan and control the innovation process.

The intended users of our guideline are R&D funding organizations (government research funding and funding from private foundations) and R&D performing organizations (public and private). Our indicator system can be applied to research and development regarding the design of a technology as well as to research and development regarding the implementation of the technology (business models). The indicator system is developed based on existing literature regarding RRI operationalization and supported by case studies, simulations[1], Data-Mining approaches as well as the help of workshops with experts and practitioners. The guideline that will illustrate how the indicators can be applied has a pilot character as it is based on three unique case studies. The selected cases cover the fields of battery development, biomass use and prosumer innovations which are highly relevant to the current challenges in the implementation of the energy transition innovations. The guideline will provide also guidance on how the indicator system can be applied to other energy transition technologies.

2 Technology acceptance in the context of the energy transition

Political and diplomatic efforts have so far hardly led to significant reductions in global greenhouse gas emissions. Accordingly, hopes rest on new technical solutions that experience a high level of

[1] In addition to and as an extension of the case studies, the acceptance and, as a consequence, the diffusion of new technologies that fulfill the developed criteria to a greater or lesser extent will be examined on the basis of an agent-based simulation model (ABM).

acceptance and can thus be implemented quickly in order to effectively advance the energy transition. It is important to note, however, that acceptance is often used synonymously with acceptability. In line with other authors, we therefor distinguish between the two terms: Acceptability takes into account the judgement of experts as to whether the construction of a particular facility (e.g., a power plant or transmission line) is a reasonable burden under rational consideration of quantifiable criteria (e.g., health impact or noise). Acceptance, on the other hand, is a subjective measure of the readiness of people to accept a certain technology or even facility (in their neighborhood), regardless of rational judgements. We therefore define acceptance for the purpose of this project as the passive or active socio-political and community acceptance of (mostly) largescale energy technologies or related policy strategies, i.e. the public's passive or active approval (based on subjective valuation rather than scientific expertise) of decisions by others (Bertsch et al., 2016).

A central idea of the V4InnovatE project is that it is possible to increase the likelihood of new technologies and innovations being accepted by consumers if they are aligned more closely with societal values and needs. This will reduce the risk of energy transition innovations being developed that are not widely adopted because they contradict societal values and guiding principles, as shown, for example, by the multi-layered debate on biofuels and CCS (carbon capture and storage). Impacts of new technologies are often only identified, then regulated and mitigated after large-scale production and diffusion has started. That is, research and development (R&D) processes are often not anticipatory and are lacking the integration of, for instance, environmental and social research. In order to reduce the likelihood of unintended consequences of R&D processes, we argue for the application of an RRI indicator system. Thereby, concerns that may – directly or indirectly – affect the acceptance of a resulting innovation may be anticipated during the technology development process. Moreover, a RRI indicator system provides important guardrails to improve the innovation process and thereby informs R&D decision-makers to potentially reorient innovation processes. Technology development and diffusion cannot be viewed as an isolated process. Rather, successful technology development takes place in a systemic context in interaction with societal actors and ideas. The energy transition (in German: “Energiewende”) should thus be understood as a transformation process involving society as a whole (WBGU, 2011; Schneidewind, 2018), which is characterized by a high degree of complexity and extends beyond the implementation of purely technical solution concepts.

We consider RRI a possible element of the solution for the raised problem. RRI calls, for example, for the involvement of societal stakeholders in research and innovation processes in order to align the results with society's values and needs. As also Owen et al. state: "The aim of RRI policy is that research and innovation should have a societally beneficial impact" (Owen et al. 2012). The concept of RRI gained increasing importance over the last decade, especially in the European research landscape (Schlaile et al., 2018; Stilgoe et al., 2013; von Schomberg, 2013). RRI means, among other things, (i) focusing research and innovation processes on significant socio-ecological needs and challenges, (ii) a participatory engagement to actively include and integrate stakeholders in innovation processes in order to arrive at societally relevant problem solutions through transparent and collective learning processes, (iii) a dedicated attempt, anticipate potential problems (both in the innovation process and with regard to its outcomes) at an early stage, to evaluate alternative innovation paths, and to reflect societal needs, values, and preferences, and, last but not least, (iv) the will of all actors in the innovation system to act on the basis of these principles and to continuously (adaptively) question this action (cf. for example, Wickson and Carew, 2014).

Already with the introduction of the RRI concept in the context of the European research agenda, initial discussions started on how to make the initially mainly theoretical concept operationalizable for practice and how to make corresponding efforts measurable and presentable (Monsonís-Payá et al., 2017). In this context, Wickson and Carew (2014) argued that, in particular, the formulation of both quality criteria and concrete RRI indicators is an essential necessity if the RRI concept is to be understood and practically applied in academia, science funding, innovation drivers, and by relevant stakeholders. The need for tools for practical implementation of the RRI concept resulted in first projects and publications with the aim of creating appropriate indicators (Ravn et al., 2015; Strand et al., 2015, Flipse et al., 2015). Nevertheless, Latridis and Schroeder still stated in 2016 that the development of tools and metrics in the RRI context was only in the development phase. At the same time, the literature also points to a lack of focus on context-based indicators and indicator approaches (Monsonís-Payá et al., 2017). Recent publications related to the practical use of RRI addressed this issue and already expanded the base of existing RRI indicators (Stahl et al., 2017; Yaghmaei et al., 2019; Nazarko, 2020). However, there is currently still a lack of operationalization of RRI with regard to energy transition and associated energy transition technologies.

3 Target groups: Who should use our guideline

The intended users of our guideline are R&D funding organizations (government research funding and funding from private foundations) and R&D performing organizations (public and private).

The indicator system and guideline shall help R&D funding organizations to:

- Find inspiration for funding anticipatory research on newly emerging energy transition technologies
- Identify RRI-relevant research needs and research gaps in regard to already existing energy transition technologies and set up corresponding research funding programs (e.g. with the help of expert groups and/or multi-stakeholder agenda-setting processes informed by the indicator system)
- Inform the selection of research proposals for funding and take well-grounded funding decisions
- Help communicate decision-making on proposal selection in a transparent manner.

The indicator system and guideline shall help R&D performing organizations to:

- Design research projects informed by the RRI-philosophy
- Provide timely feedback to technology developers regarding “initial material selection, energy targets, end-of-life management strategies, maintenance options, and user demands” (Wender et al., 2014)
- Help creating teams in the R&D process that are aware of the different responsibility aspects of innovation (Thorstensen and Forsberg, 2016)
- Monitor the research progress in regard to relevant RRI dimensions.

Figure 1 illustrates the basic logic of the project:

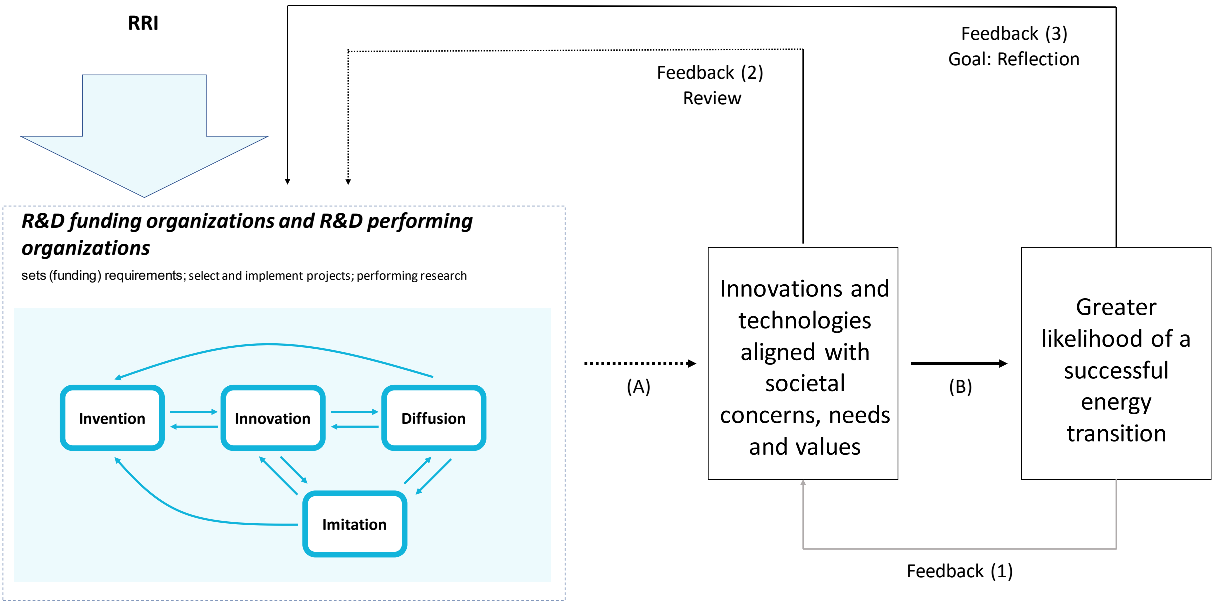

Figure 1: Project overview

4 Basic concept of the indicator system

4.1 Overview of the development of the indicator system

The development of the indicator system follows a clearly defined procedure and is based on the steps commonly found in the literature (see e.g. Meyer, 2004; Lustat, 2012). Key steps involve (1) the definition of a theoretical frame, (2) the compilation of existing indicators, (3) the collection and selection of relevant selection criteria for the indicators as well as (4) a selection based on these, (5) the development of new indicators if necessary, and (6) a final weighting and discussion. Figure 2 provides a schematic illustration of the indicator system development process. The individual steps are also briefly described in the following sections.

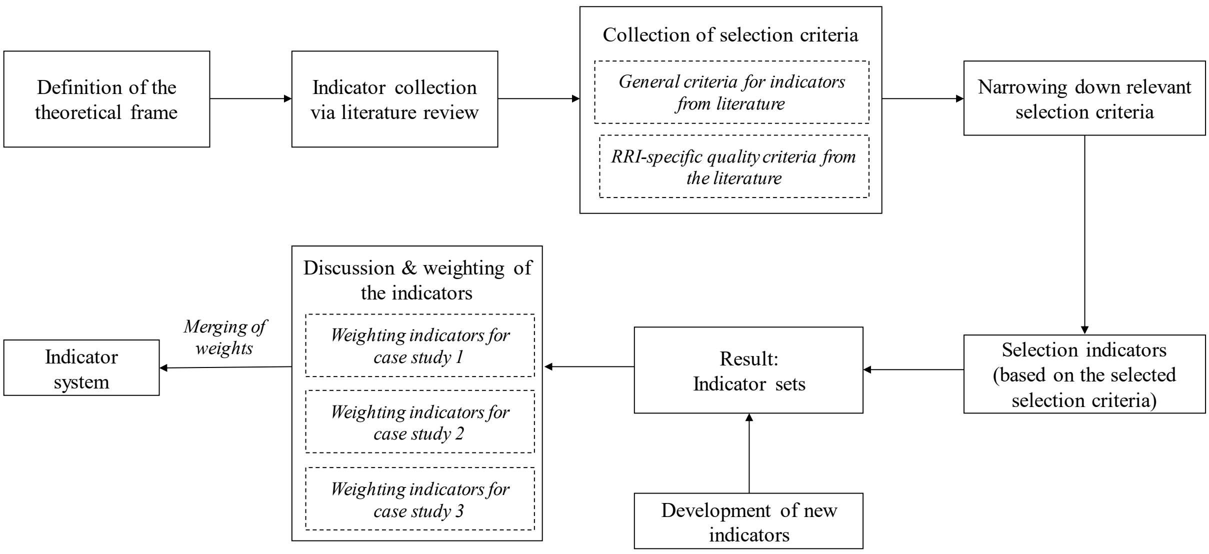

Figure 2: Schematic illustration of the indicator system creation process

4.2 Collection of existing Indicators in literature

The specification of the theoretical frame, illustrated in the previous chapters, is followed by a comprehensive collection of the measures already identified or proposed in the RRI literature. As a result of increasing operationalization efforts in the field of RRI, various RRI assessment methods and metrics have been developed, especially in recent years. These can serve as a valuable basis for the development of the indicator system. Table 1 provides an overview of recent publications regarding RRI assessment and measurement. It can be seen that previous indicator compilations differ significantly in terms of their unit of assessment, the aim of assessment, the underlying dimensions of observation, type of measurement and scope of application.

Table 1: Overview on RRI-assessment in Literature. Table based on van de Poel (2019) and own additions

Reference	Unit of assessment	Assessor	Aim of assessment	Indicators	Type of measurement
Ravn, Nielsen and Mejlgaard (2015)	Country	Independent assessor	Monitoring; comparison	36	Quantitative
Strand et al. (2015)	RRI initiatives	Independent assessor	Monitor and assess the impacts of RRI initiatives	83	Quantitative
Flipse et al. (2015)	Project (within a company)	Self- assessment	Monitoring; decision support for managers	30	Qualitative
Stahl et al. (2017)	Company	RRI researchers; Self- assessment	Assessing RRI level, monitoring	14	Qualitative
Heras & Ruiz-Mallén (2017)	Research/Teaching Institutes	Self- assessment	Monitoring; comparison	86	Qualtitative
Otero-Hermida & García-Melón (2018)	Research Institutes	Self- assessment; Independent assessor	Monitoring	23	Quantitative
Tharani et al. (2019)	Company	Self- assessment	Learning	43	Qualitative
Verburg, Rook, and Pesch (2019)	Employee (in a company)	Self- assessment	Assessing RRI level	7	Qualitative
Yaghmaei et al. (2019)	Project	Self- assessment	Monitoring	43	Qualitative
Nazarko (2020)	Company	Self- assessment	Monitoring; decision support for managers	53	Qualitative/ Quantitative
V4InnovatE	R&D funding programmes R&D projects	Self- assessment; Independent assessor	Improving (RRI-oriented) design/performance of renewable energy innovations; decision support for research funders and researchers	x	Qualitative/ Quantitative

4.3 Collection of selection criteria

Based on the compilation of potentially relevant indicators, a selection must be made for reasons of practicability, compatibility and applicability. In the context of indicator selection, Meyer (2004) proposes a comparison of the collected indicators according to several, well defined selection criteria in order to determine which indicators should be retained, further developed or rejected. Therefore, as part of the indicator selection process, general requirements for indicator were collected from literature. These are illustrated below in Table 2.

Table 2: General Selection criteria for indicators. Own compilation according to Atkinson et al., 2002; Coenen, 2000; Joumand & Gudmundsson, 2010 and Noll, 2002

Scientific criteria	Data quality; transparency in the face of uncertainty; Accuracy; Representativeness and relevance for the target system (validity); Reproducibility of results (reliability); Sensitivity; Balanced representation of different dimensions (on set/system level); Balanced weighting and coherence of the indicators among each other (at set/system level).
Requirements-based criteria	Significance in an international, national or regional context; High acceptance; Normatively clear interpretation; User-adequate condensation of information and clarity; Comprehensibility for politics, administration and the public; Target reference
Functional criteria	Suitability for recording trends; Early warning function; Not manipulable; Sensitivity to changes over time; Comparability
Practicability criteria	Data availability; Manageability; Possibility of regular updating; Reasonable effort for data acquisition

Notably, this is an ideal-typical presentation. On the one hand, not all of the indicators satisfy all of the criteria, and on the other hand, not all of the criteria are ultimately relevant for the indicator set or system. With regard to its requirements in general and the individual indicators in particular, it therefore makes sense to select a subset of the criteria shown in Table 2.

In addition to the general criteria, there are also specific criteria in the literature that should be considered in the selection process. In particular, the quality criteria developed by Wickson & Carew (2014) and Kupper et al. (2015), shown below in Table 3, should be mentioned here. They provide an overview of aspects that "'good' science and 'responsible' research and innovation should entail" (Wickson & Carew, 2014, p. 261). The quality criteria were specifically developed as assistance and as a possible basis for the development of tools for monitoring, assessment and (self-)evaluation in the RRI context (Kupper et al., 2015). Since there are a large number of quality criteria, which in turn can be broken down into several sub-criteria or components, a selection of particularly relevant criteria is required. Such an approach is also explicitly desired, since the used quality criteria should always be adapted to the respective project or the respective evaluation task (Wickson & Carew, 2014). Within the project, the identification is based i.a. on the knowledge gained within the three case studies, which enables the consideration of energy transition relevant aspects in the criteria selection process.

Table 3: Overview on RRI quality criteria in literature

	Quality Criteria	**Sub-criteria/ Components**
Kupper et al. (2015)	Engaging a variety of stakeholder groups	4
	Variety of means of stakeholder engagement	3
	Engagement of public(s)	3
	Institutional diversity	2

	Attention for appropriate R&I models and methods	2
	Honest and clear (re)presentation of the practice details	5
	Open and clear communication about the processes of deliberation and decision-making	2
	Open and clear communication about the results of the practice	3
	Appropriate means and content of communication and education per actor	2
	Openness to critical scrutiny from all stakeholders	1
	Analysis of the background, current situation and context of the (planned) research or innovation	5
	Envisioning of plausible futures	3
	Variety of impacts	5
	Facilitating deliberation on values, perceptions, needs, interests, choices and definition of the problem at issue in the practice	2
	Addressing roles in RI trajectories	2
	Structure for seeking and incorporating feedback	2
	Flexible process management	4
	Development and implementation of evaluation strategies	5
	Flexible attitudes to revise views and actions	2
	Changing responsibilities	2
	Application of results	2
Wickson & Carew (2014)	Socially relevant and Solution oriented	2
	Sustainability centered and Future scanning	3
	Diverse and Deliberative	3
	Reflexive and Responsive	4
	Rigorous and Robust	3
	Creative and Elegant	3
	Honest and Accountable	5

4.4 Indicator selection, clustering and weighting

Based on the chosen criteria a selection of relevant indicators takes place. For this, we first made a broader pre-selection based on the general selection criteria due to the large number of potential indicators already available in the literature. The remaining indicators are then further narrowed down by assignment to the selected quality criteria. It may happen that a high number of possible indicators can be assigned to the respective quality criteria. In this case, further narrowing down may be necessary in order to reduce the number of indicators to a feasible level. At the same time, it is possible that no suitable indicator can be assigned to relevant criteria. In this case, it is necessary to develop new indicators that both covers the relevant quality criterion and satisfies the chosen general selection criteria.

In the following step, a thematic clustering of the ultimately selected indicators is advisable, since the indicators sometimes cover clearly different areas and this also allows better analysis. In the RRI context, a differentiation with regard to the affiliation of individual indicators to existing RRI-dimensions formulated in the literature makes sense. Conveniently, Kupper et al. (2015) already assign possible RRI-dimensions to the quality criteria they formulate, which allows the indicators to be clustered accordingly. The dimensions considered here cover both an adapted version of the AIRR dimensions (Stilgoe et al., 2013) and the RRI-Keys formulated by the European Commission (European Comission, 2012, 2014).

Depending on the context under consideration, the indicators are not always of equal importance, which is why a weighting of the indicators seems appropriate in a final step which can be done by context experts prior to the application of the indicator system. In fact, the literature points to a lack of weighting or hierarchical ordering of indicators as one of the central weaknesses of existing measurement concepts in the field of RRI (Monsonís-Payá et al., 2017). Of the many different methods available, the Analytical Hierarchical Process (AHP) (Saaty, 1990) is a suitable multicriteria analysis technique. This method has already been successfully used in the RRI context (Monsonís-Payá et al., 2017). For a more detailed description of the method, see Saaty (1990). The final weighting of the indicators within the framework of the project can, for example, be carried out generally in relation to energy transition technologies. However, in our case it might be advisable to carry out the weighting for various representative case studies and then combine them. This makes it possible to better reflect the diversity of RRI requirements in the overall area of energy transition technologies.

5 Prototype of the indicator system

In the following section, the procedure described in the previous section gets illustrated by means of an example. It should be noted that the illustrations only serve to exemplify the principle concept and that the work on indicator selection and evaluation as well as the implementation of the case studies is yet not completed. For our case studies we will predominantly work with publicly available information on the different technologies (including required resources, work conditions etc.) and project reports of German publicly funded projects. These reports rich information about project participant, goals, processes etc., that is we conduct a retrospective analysis to develop the indicator system. In contrast, the actual application of the indicator system will be conducted by a prospective analysis.

5.1 Possible evaluation scheme

Table 4 below shows a possible collection of indicators that could result from the indicator selection process. The compilation comprises a total of ten selected quality criteria, which can be assigned to four RRI dimensions listed by Kupper et al. 2015. From the available collection of indicators identified in the RRI literature, a possible indicator was assigned to each of the quality criteria. The indicators listed here as examples are of a qualitative nature, which means that the resulting system can be used primarily in the context of self-assessment. Furthermore, it is also possible to link the selected quality criteria to the RRI keys of the European Commission. The individual indicators can be evaluated, for example, on the basis of the given evaluation scale.

The process allows some adaptations. For example, quantitative indicators would be assigned to the selected quality criteria for an independent, external evaluation. In this case, a corresponding adjustment would be necessary with regard to the evaluation. For the presentation of the prototype, we refer to the evaluation scheme shown in Table 4.

Table 4: Exemplary evaluation scheme

Criteria		
	Fully met	100
	Well met	75
	Halfway met	50
	Barely met	25
	Not met	0

Dimension	ID	Quality Criteria	Possible Indicator (qualitative)	Value
Diversity and Inclusion	DI1	Engaging a variety of stakeholder groups	Engagement of relevant stakeholders in the innovation process (civil society organizations, local government, education community, customers, patients, Families, etc.)	
	DI2	Variety of means of stakeholder engagement	Within this project we use a systematic approach (specified how, when, and why) from the beginning to include various stakeholder viewpoints on a wide set of values (technical, social, ethical, legal, etc.)	
Openness and Transparency	OT1	Open and clear communication about the results of the practice	We organise science communication/education activities aimed at educating citizens and generating awareness of aspects/issues of the innovations we are working on	
	OT2	Openness to critical scrutiny from all stakeholders	Within our project we use tools and mechanisms for organising dialogue with stakeholders on appraisal/ethical acceptability	
Anticipation and Reflection	AR1	Variety of impacts (Society)	Societal values (privacy, safety, health, security, data ownership, etc.) are actively included in the design process of this project	
	AR2	Variety of impacts (Ethics)	We use ongoing, continuous monitoring of ethical aspects in this project	
	AR3	Variety of impacts (Environment)	This project provides substantial environmental benefits to society compared to available alternatives	
	AR4	Envisioning of plausible futures	We continuously consult other researchers and research projects to signal new and future technological trends	
Responsiveness and Adaptive Change	RAC1	Structure for seeking and incorporating feedback	Within our project we use tools and mechanisms for organising dialogue with stakeholders on appraisal/ethical acceptability	
	RAC1	Flexible process management	Within this project we adopt a learning approach to adapt the research programme according to the viewpoints and ideas of other stakeholders.	

5.2 Example – Battery Technology

5.2.1 Characterization of the technology

Batteries and especially lithium-ion batteries (LIBs) are particularly employed for mobile applications. As a prominent case, experts expect that we will see up to 200 million electric vehicles on the road by the year 2028. However, there is also an increasing need for LIBs in stationary applications, for instance to stabilize the energy system. LIBs are currently considered the most advanced battery technology regarding their energy and power performance. However, further innovations in battery technologies are required to foster the energy transition that is needed for realizing a carbon neutral society [3]. LIBs have been first commercialized in 1991 by Sony and since then continuously improved. Improvements concern energy density (Wh/l), which is linked to driving range of electric vehicles, and specific energy (Wh/kg) but also safety, cost and charging speed. In particular, costs are expected to drop during the next years due to economies of scale and the application of materials that are less expensive than cobalt. Thereby, growing customer acceptance for electric vehicles is expected. Thus, related to batteries there is also the case for indirect acceptance that concerns appliances powered with batteries (Zubi et al., 2018).

Lithium ion batteries contain so called critical metals such as cobalt and graphite. Critical refers to the problem that the supply risk is high. The concept of 'criticality' is usually calculated from a combination of the economic importance of the raw materials, the difficulty of substituting another raw material, and the supply risk (European Commission 2014; British Geological Survey 2016). Despite increasing use of all kinds of appliances that use lithium ion batteries, the total needed amount is often only on the tens to thousands of tons a year which is way less compares to other metals such as copper. Consequently, a few large mines can be sufficient for the total supply but also the choice of mines is limited. Moreover, the recycling rates are still very low. Since many of these critical metals are required for appliances that are designed to produce green electricity it is straightforward to make sure that their production is also environmentally friendly, but also does neither harm people that produce them nor the local communities. Therefore, (Wall et al., 2017) use the concept of 'responsible mining' which they define as "minimising the negative effects of mining and maximising the positive outcomes". Responsible sourcing is about all of these issues and how we, as final consumers, can be assured that the supply chains, including the ultimate sources, for our goods meet acceptable standards (Wall et al., 2017).

Batteries that are more sustainable throughout their life cycle are critical to achieving the goals of the European Green Deal and contribute to the zero emission target. That is, batteries should have the lowest possible environmental impact and at the same time, required materials are obtained in full compliance with human rights and social standards. Batteries must be durable and safe, and at the end of their life they should be reused, remanufactured or recycled, returning valuable materials to the economy. Yet, recycling has not yet played a significant role in lithium production, although it would theoretically be possible. This is because resources seem to be available in sufficient quantities and the raw material is relatively cheap to extract (British Geology Survey 2016: p. 25). However, the production of lithium requires enormous amounts of water, releases environmentally harmful chemicals, the evaporation ponds and processing plants consume land, and the chemical waste is not disposed of in an environmentally friendly manner. The salt lakes, however, form an extremely fragile ecosystem with water as a key component. Thus, there is a large container of problems that potentially influence the acceptance of the technology and more research on how to address them early in R&D processes is needed.

5.2.2 Implementation of the analytical hierarchy process

The following explanations illustrate the weighting process using the analytical hierarchy process, taking the indicators for the dimension "Anticipation and Reflection" as an example. Figure 3 shows a comparison of the individual indicators within the dimension. The individual indicators are now evaluated in terms of their relative importance, with a value of 1 representing equal importance and a value of 9 representing absolute dominance. The relative importance can be further graded using various intermediate values.

From Your Point of View, Which Indicator Is More Important in the Context of the Case Study										
AR1: Societal values (privacy, safety, health, security, data ownership, etc.) are actively included in the design process of this project	9	7	5	3	1	3	5	7	9	**AR2**: We use ongoing, continuous monitoring of ethical aspects in this project
AR1: Societal values (privacy, safety, health, security, data ownership, etc.) are actively included in the design process of this project	9	7	5	3	1	3	5	7	9	**AR3**: This project provides substantial environmental benefits to society compared to available alternatives
AR1: Societal values (privacy, safety, health, security, data ownership, etc.) are actively included in the design process of this project	9	7	5	3	1	3	5	7	9	**AR4**: We continuously consult other researchers and research projects to signal new and future technological trends
AR2: We use ongoing, continuous monitoring of ethical aspects in this project	9	7	5	3	1	3	5	7	9	**AR3**: This project provides substantial environmental benefits to society compared to available alternatives
AR2: We use ongoing, continuous monitoring of ethical aspects in this project	9	7	5	3	1	3	5	7	9	**AR4**: We continuously consult other researchers and research projects to signal new and future technological trends
AR3: This project provides substantial environmental benefits to society compared to available alternatives	9	7	5	3	1	3	5	7	9	**AR4**: We continuously consult other researchers and research projects to signal new and future technological trends

Figure 3: AHP-evaluation scheme for the dimension ‘Anticipation and Reflection‘ (depiction adapted from Monsonís-Payá et al., 2017)

An exemplary evaluation of the relative importance of the individual indicators is illustrated below in Figure 4. Furthermore, the weightings calculated from the evaluations using the analytical hierarchy process are also shown.

Exemplary evaluation

	AR1	AR2	AR3	AR4		**Resulting Weights**
AR1	1	1/7	5	1/3		22%
AR2	7	1	1	1	→	30%
AR3	1/5	1	1	5		29%
AR4	3	1	1/5	1		19%

Figure 4: Exemplary weighting for the dimension Anticipation and Reflection based on AHP

5.2.3 Filling in the evaluation scheme (Exemplary)

Table 5 below shows the evaluation results of the different RRI indicators for the self-assessment of an exemplary, (imaginary) research project. The indicators of the dimension 'Anticipation and Reflection' are additionally assigned the weights determined in the previous section (for reasons of simplification, a comparable importance is assumed for the indicators of the other dimensions, respectively). Based on the respective evaluations and weights, the last column shows the results for each considered dimension.

Table 5: Exemplary project evaluation

Dimension	ID	Quality Criteria	Value	Weight	Result
Diversity and Inclusion	DI1	Engaging a variety of stakeholder groups	100	**0,5**	**0,625**
	DI2	Variety of means of stakeholder engagement	25	**0,5**	
Openness and Transparency	OT1	Open and clear communication about the results of the practice	50	**0,5**	**0,375**
	OT2	Openness to critical scrutiny from all stakeholders	25	**0,5**	
Anticipation and Reflection	AR1	Variety of impacts (Society)	50	**0,22**	**0,573**
	AR2	Variety of impacts (Ethics)	50	**0,3**	
	AR3	Variety of impacts (Environment)	75	**0,29**	
	AR4	Envisioning of plausible futures	50	**0,19**	
Responsiveness and Adaptive Channge	RAC1	Structure for seeking and incorporating feedback	100	**0,5**	**0,75**
	RAC1	Flexible process management	50	**0,5**	

5.2.4 Transfer into graphical representation

For better clarity and comparability, the results will be transferred to a graphical representation in a further step, as shown in Figure 5. This enables a better assessment of the project under consideration with regard to individual RRI dimensions. At the same time, several different projects can be compared against each other.

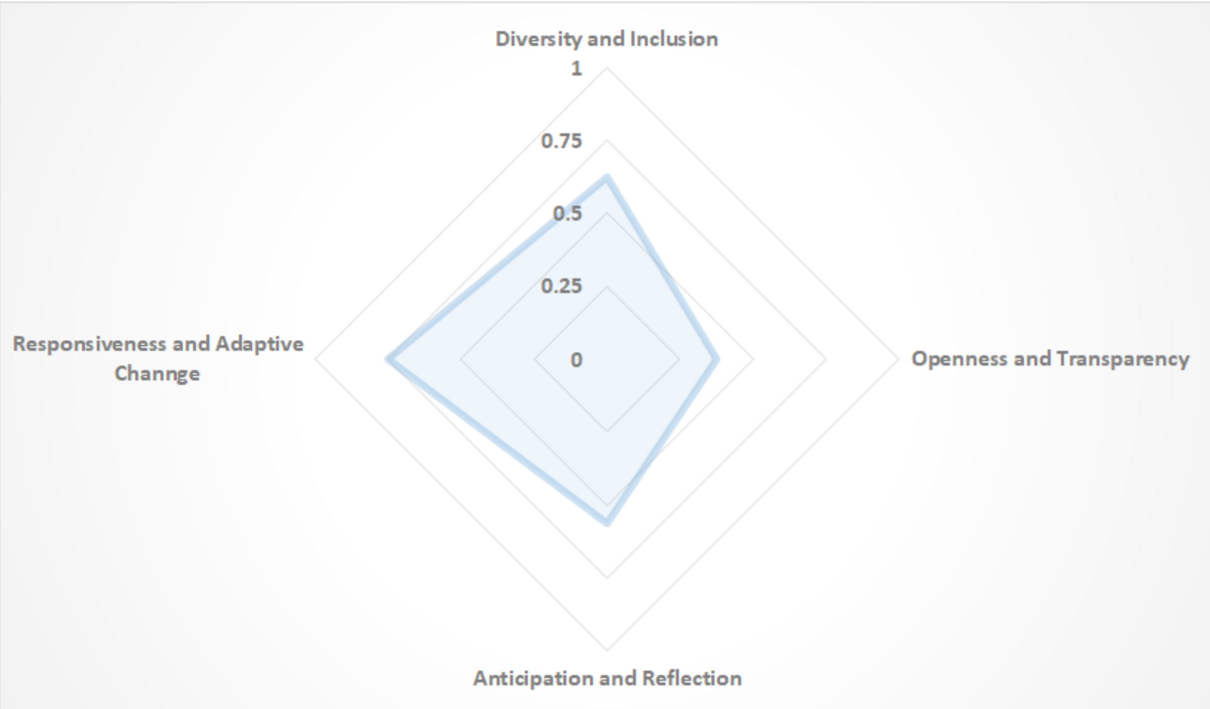

Figure 5: Graphical representation of the results

6 Literature

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