LeNa

Framework for reflection on research with societal responsibility

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Federal Ministry of Education and Research

Developed in sub-project 1 „Research with societal responsibility“ in the collaborative research project „Sustainability management in non-university research institutions“ (LeNa) in collaboration with Fraunhofer-Gesellschaft, Leibniz Association and Helmholtz Association

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Status: November 2023

www.nachhaltig-forschen.de

Disclaimer: This document is a translation of the German version “Reflexionsrahmen für Forschen in gesellschaftlicher Verantwortung”, first published in 2016 (Ferretti et al., 2016). The English translation of the Framework for reflection on research with societal responsibility is provided for informational purposes. The English text was carefully translated and reviewed for accuracy. In the event that the English and German versions permit different interpretations, the German text shall prevail.

Suggested citation: Ferretti, J., Daedlow K., Kopfmüller, J., Winkelmann, M., Podhora, A., Walz, R., Bertling, J., Helming, K. (2023): Framework for reflection on research with societal responsibility. BMBF project „LeNa - Sustainability management in non-university research institutions „, translation of the German version “Reflexionsrahmen für Forschen in gesellschaftlicher Verantwortung”, first published in 2016 (Ferretti et al., 2016). Berlin.

Acknowledgement

This framework for reflection provides a basis for research with societal responsibility in the Fraunhofer-Gesellschaft, Helmholtz Association and Leibniz Association. It is part of the handout „Sustainability management in non-university research institutions - fields of action and strategies“[1] and was developed within the framework of the BMBF-funded project of the same name (funding number 13NKE003A).
This result could only be achieved due to the cooperation of many contributors from the three non-university research institutions involved.
We would like to thank the entire consortium of the LeNa project, the Advisory Board and especially Cornelia Reimoser and Isabella Wedl from the Presidential Staff of the Fraunhofer Gesellschaft for their excellent coordination of the project.
We would like to thank the members of the „Berliner Runde“ for their numerous critical and stimulating comments and discussions on the Framework for Reflection, for their cooperation on the eight fact sheets and for coordinating and conducting the test runs:

Miriam Brandt and Kathleen Röllig - Leibniz Institute for Zoo and Wildlife Research (IZW)

Peter Burauel and Ellen Kammula - Forschungszentrum Jülich (FZJ)

Christiane Cyron - Leibniz Institute of Plant Biochemistry (IPB)

Rainer Danielzyk, Ina Peters, Lisa Marquardt and Markus Kip - Academy for Territorial Development in the Leibniz Association (ARL)

Jutta Graf and Jürgen Ortner - German Aerospace Center (DLR)

Birgit Haller - Fraunhofer Institute for Interfacial Engineering and Biotechnology (IGB)

Charlotte Knips - Fraunhofer Institute for Environmental, Safety and Energy Technology (FHG UMSICHT)

Frank Messner – Helmholtz-Centre for Environmental Research (UFZ)

Elisa Mussack - Max Delbrück Center for Molecular Medicine in the Helmholtz Association (MDC)

Alfred Olfert and Andreas Otto - Leibniz Institute for Urban and Regional Development (IÖR)
Hartmut
Pflaum - Fraunhofer Institute for Environmental, Safety and Energy Technology (UMSICHT)

Matthias Premke-Kraus - Leibniz Association, Berlin Office

Vera Rabelt – Berlin Social Science Center (WZB)

Furthermore, we would like to thank the contributors to the test runs of the Framework for Reflection for their committed participation and valuable feedback.

[1] Fraunhofer-Gesellschaft, Helmholtz-Gemeinschaft, Leibniz-Gemeinschaft (2016): Nachhaltigkeitsmanagement in außeruniversitären Forschungsorganisationen. München.

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Summary

This framework for reflection on research with societal responsibility was developed as part of the project „LeNa - Sustainability management in non-university research institutions“ funded by the Federal Ministry of Education and Research (BMBF). „Research with societal responsibility“ is understood as a component of sustainability management of research institutions at all levels.

The framework for reflection aims to support the systematic reflection of research processes with societal responsibility. This addresses „how“ research is conducted and not „what“ is the research topic. The framework for reflection consists of an introductory section (Part I) and eight criteria: ethics, integrative approach, interdisciplinarity, user orientation, reflection on impacts, transdisciplinarity, transparency and dealing with complexity and uncertainty, which are described in so-called fact sheets (Part II).

The eight criteria were identified on the basis of a literature study and a discussion process at institutions of the three research organisations involved in the project (Fraunhofer-Gesellschaft, Helmholtz Association and Leibniz Association). The framework for reflection was tested for its applicability in test runs, the results of which are presented in summary form in this report.

Implementation and institutionalisation options of the framework for reflection for different levels of the science system are outlined and critically reflected in the Outlook section.

Part I – Introduction to the Framework for Reflection on Research with Societal Responsibility

„Sustainability management in non-university research institutions“ (BMBF project LeNa)

The framework for reflection was developed as part of the BMBF project „Sustainability management for non-university research institutions“. It is part of a guideline for the integration of sustainability in research institutions, which also contains recommendations for organisational management (strategy), sustainable human resources management and sustainable construction and operation. In the medium term, framework conditions are to be established in the three-participating research organisations - the Fraunhofer-Gesellschaft, the Helmholtz Association and the Leibniz Association - that will enable the gradual application of the framework for reflection.

1 Motivation

The special responsibility that research has is based on the freedom of research guaranteed by the Basic Law. No other professional group, apart from the arts, is granted such explicit and fundamental freedom - this testifies to a great deal of trust in research. At the same time, research is caught between scientific excellence and societal relevance. Only by integrating these two aspects research can be conducted responsibly and thus contribute to sustainable development.

In business and policy, the handling of sustainability is supported by guidelines and reporting according to international standards (among others, sustainability assessment in the legal impact assessment[2], Global Reporting Initiative[3]). In research, there are no corresponding suggestions or recommendations on research with societal responsibility processes. Policy makers and research funders in Germany do not have any guidelines for science, even though the role of research, for example, in the major societal challenges has been presented in numerous policy and scientific position papers (e.g. Wissenschaftsrat 2015[4]). Accordingly, scientists and research managers are increasingly responsible for contributing to the solution of major societal challenges due to the corresponding expectations of society, politics and science itself.

[2] Cf. BMI (Bundesministerium des Innern) (2009): Arbeitshilfe zur Gesetzesfolgenabschätzung. Berlin.[3] www.globalreporting.org/Pages/default.aspx (retrieved 14.11.2023).[4] Positionspapier des Wissenschaftsrats: Zum wissenschaftspolitischen Diskurs über Große gesellschaftliche Herausforderungen, Positionspapier (Drs. 4594-15), April 2015.

In the LeNa project, eight criteria were identified that define „research with societal responsibility“. In the present working version of the framework for reflection5, they were systematically combined into a set of criteria. The question is addressed as to how a research process must be designed in order to assume responsibility for sustainable development. The set of criteria builds on the principles of good scientific practice that have already been formulated elsewhere (DFG20136) and aims to contribute to solving societal challenges (see Figure 1). It provides a framework for researchers to reflect on and reconcile both the requirements of good scientific work and the expectations of solutions to societal problems. In the LeNa project, „research with societal responsibility“ is understood as an integral part of sustainability management in research institutions.

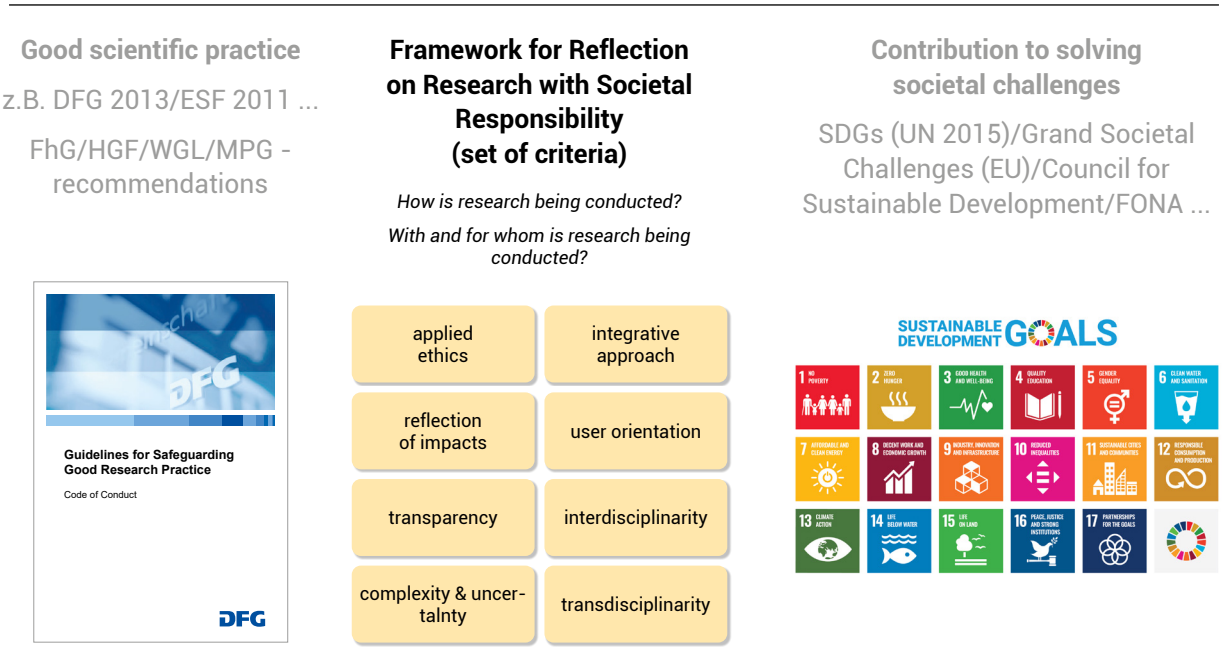

Figure 1: Embedding the framework for reflection in science-related fields of action. It characterises the societal responsible research process, builds on the requirements of good scientific practice and complements the thematic research orientation for solving societal challenges.

The framework for reflection refers to a research process based on critical and systematic reflection - in the sense of self-reflection as well as reflection in dialogue with society. Structural conditions, processes, research questions, methods and results as well as their communication, implementation and effects are to be reflected with regard to their contributions to sustainable development.

The framework for reflection with its eight criteria focuses on the research process, i.e. on „how“ research is conducted, and not on the topics of research („what“). It thus claims to be applicable to every type of research approach (basic and application-oriented), every discipline and every topic. In each case, different challenges in the individual disciplines or research approaches must be considered, which must be solved individually or in the respective disciplines.

[5] For a detailed discussion of the framework for reflection see Helming, K. & Ferretti, Johanna & Daedlow, Katrin & Podhora, Aranka & Kopfmüller, Jürgen & Winkelmann, Markus & Bertling, Juergen & Walz, Rainer. (2016). Forschen für nachhaltige Entwicklung: Kriterien für gesellschaftlich verantwortliche Forschungsprozesse. GAIA - Ecological Perspectives for Science and Society. 25. 161-165. 10.14512/gaia.25.3.6. https://www.itas.kit.edu/pub/v/2016/heua16b.pdf (retrieved 13.11.2023)

[6] DFG (Deutsche Forschungsgemeinschaft) (2013): Sicherung guter wissenschaftlicher Praxis. Denkschrift. Weinheim: Wiley-VCH.

2 Approach of the framework for reflection

This framework for reflection with eight criteria is intended to help academics and research managers to orientate research activities in line with the guiding principle of „Research in societal responsibility". The framework should be applied to all research activities (knowledge-oriented research, problem/application-oriented research). It is based on the DFG proposals for safeguarding good scientific practice (DFG2013[7]), but does not replace them. Instead, it opens up an additional dimension of research with societal responsibility. The criteria are not new in themselves, but in their holistic application they allow for a systematic description and realisation of this additional dimension of responsibility.

2.1 Development

The criteria were identified and discussed by scientists and research managers from the Fraunhofer-Gesellschaft, the Helmholtz Association and the Leibniz Association in an iterative process based on a comprehensive literature review (Daedlow et al.[8]) and in various expert workshops. Some of the criteria are already well established and have been scientifically analysed. The present framework for reflections allows for the first time a systematic, coherent characterisation of the criteria in favour of „research with societal responsibility". This lays the foundation for a research-strategic institutionalised application in scientific practice. Initial test runs have been carried out with regard to its applicability and its reflective potential on research with societal responsibility (see section 4).

2.2 Structure

The set of criteria comprises the two strands „How is research being conducted?" and „With whom and for whom is research being conducted?" Ideally, the eight criteria are considered in the entire research process - from strategic agenda planning, topic identification, development of the research design and methodology, implementation of the research, result identification and dissemination to monitoring and evaluation (Figure 2).

The framework for reflection stands for adaptable research. Reflection on research with societal responsibility ensures that knowledge, requirements and needs of science and society are related to each other throughout the entire research process. Overlaps between criteria are consciously accepted, as this allows different approaches to and perspectives on certain issues or problems to become clear. In total, they allow for a complex interaction, whereby they are to be regarded a priori as equally weighted. The criteria can be applied and weighted according to the research context. An individual justification and documentation of the decisions made is reasonable. The comprehensibility of results beyond a specific specialist community and thus the desired societal resonance and effectiveness can be increased in this way.

The individual criteria are explained in fact sheets (→ see part II of this document). They contain justifications and descriptions of the criteria, methodological notes on their implementation as well as selected practical examples to illustrate their implementation in research practice. Quick-check questions are intended to facilitate the application of the criteria in research practice. Since the focus is on critical reflection on research processes, the fact sheets do not contain evaluation criteria, indicators or binding checklists.

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[7] DFG (Deutsche Forschungsgemeinschaft) (2013): Sicherung guter wissenschaftlicher Praxis. Denkschrift. Weinheim: Wiley-VCH.

[8] Katrin Daedlow, Aranka Podhora, Markus Winkelmann, Jürgen Kopfmüller, Rainer Walz, and Katharina Helming. „Socially responsible research processes for sustainability transformation: an integrated assessment framework" Current Opinion in Environmental Sustainability, vol. 23, 2016. doi:10.1016/j.cosust.2016.09.004 https://www.sciencedirect.com/science/article/pii/S1877343516300604 (retrieved 15.11.2023)

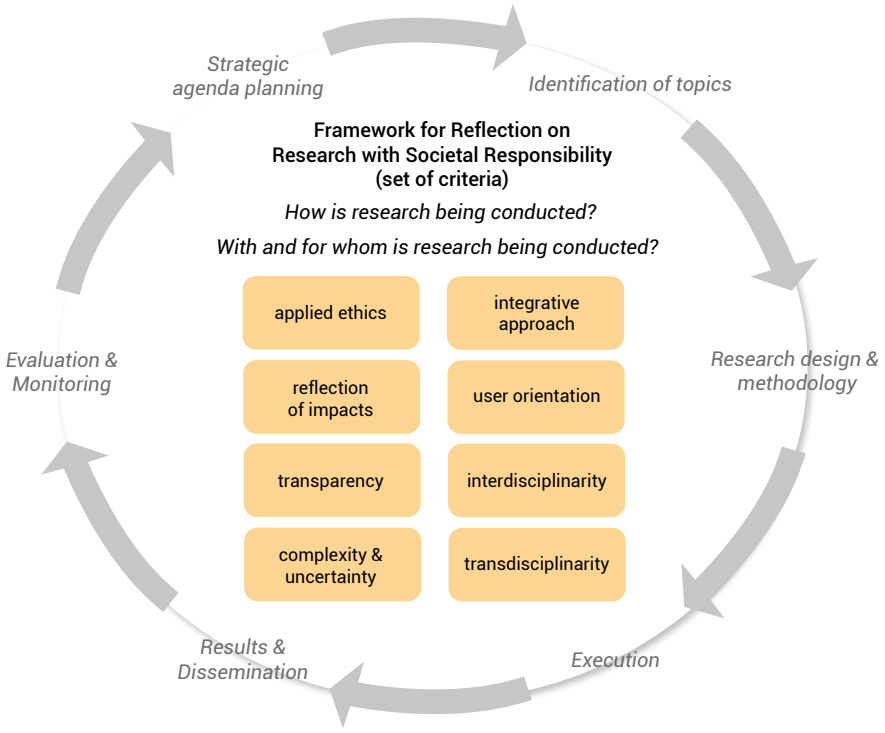


Figure 2: The framework for reflection (criteria set) on research with social responsibility". Ideally, it is considered in all phases of the process - from strategic agenda planning, topic identification, development of the research methodology, conducting the research, finding results and dissemination to monitoring and evaluation.

2.3 Application

The target groups of the framework for reflection are different stakeholder in the public research landscape: from individual researchers and research management to decision-makers in research policy. The focus here is on the use of the framework for reflection both in the context of individual projects, for example in the application process, and at the institutional level, for example in strategy or agenda processes or in research planning. This allows for linking the cognitive interest of research and societal responsibility.

2.4 Potential conflicts of objectives

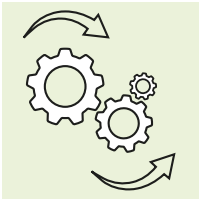
A central benefit of the framework for reflection is seen in the fact that the requirements of scientific excellence and societal relevance are better linked and integrated into the research process. However, particularly for pioneers of application, conflicting goals can arise with regard to research efficiency, competitiveness and freedom of research. Consideration of the set of criteria initially may be expected to lead to increasing use of resources (especially time) and thus, superficially, a decline in research efficiency and competitiveness. This can be counteracted by including the criteria from the outset when considering efficiency. For example, it would make sense to integrate the criteria already in the application phase (research design and methodology). In comparison with other projects and programmes, the reference to „research with societal responsibility" can bring competitive advantages. However, a prerequisite for this is that the idea is considered in corresponding organisation-specific mechanisms of research planning and evaluation. In addition, the application of the framework for reflection enables an increased awareness of the dimensions of freedom of research by making transparent the motivation for the research as well as the approaches chosen and the actors involved.

3 The eight criteria of the framework for reflection in brief

Ethics

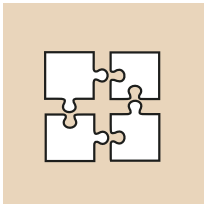
Ethics means argumentative engagement with the question of good living and acting (together). Ethical reflection includes the willingness to deal with different concepts of norms and values in the research process and to join a discourse about them. Ethical conflict may result not only from the consequences of the research results but also from the research process itself. Ethical considerations are particularly relevant in cases when ethical issues of the research goals contradict with the values of many people.

Integrative approach



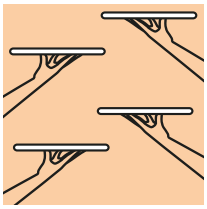
An integrative approach systematically includes the aspects and interactions relevant to the research subject. It first requires the identification of relevant elements that result, for example, from the interplay of different economic/societal subsystems as well as actors or scientific disciplines. Based on this, interactions between subsystems on the spatial and temporal, analytical or methodological level must be considered.

Interdisciplinarity



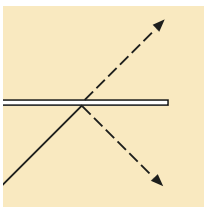
Interdisciplinary research represents a research mode that combines approaches and methods from different disciplines. It enables approaches to solving complex societal problems that would not be possible in purely disciplinary terms. Major challenges, especially when combining the expertise of the humanities and social sciences on the one hand and the natural sciences and engineering on the other, arise due to the different disciplinary paradigms and resulting technical languages.

User orientation



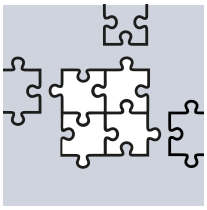
User orientation means that the needs of potential users (as a subset of stakeholders) of research results are taken into account throughout the research process. Users can be, for example, the scientific community itself, the business community, the public, or other social groups. The objective is to communicate knowledge in a user-friendly way at an early stage through communication that is as freely accessible, comprehensible and transparent as possible. This increases the applicability, transferability, relevance and legitimacy of the results.

Reflection of impacts



The potential impacts of research on society and the environment should be considered throughout the research process. This includes impacts resulting from the choice of the research object or strategy, the design of the research process, and the application of the results. The assessment of potential impacts can be carried out before or after the research process (exante or ex-post) and should include intended and unintended impacts as well as and possible consequences of not doing research.

Transdisciplinarity

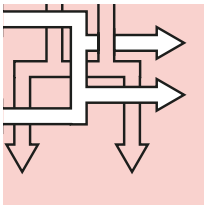


Transdisciplinary research integrates the practical knowledge of stakeholders from outside science - for example companies, the public sector or interest groups - into the research process. It strives to expand and ultimately synthesise this body of knowledge. Through the use of participatory methods and feedback from societall discourses, research needs relevant to practice are identified and appropriate solutions are developed in co-operation between academia and practitioners.

Transparency

The disclosure of the research process as comprehensive as possible includes the presentation of the normative and theoretical foundations, methodological and content- related orientation, results, consequences, scientific independence, and, if necessary, the consideration of societal interests and funding sources. The degree of transparency in everyday research is often limited by interests and rights of relevant actors.

Dealing with complexity and uncertainty



Risks and knowledge uncertainties in complex systems should be taken into account in research processes and reflected on with regard to the research question, the methods applied and the results. Dealing with uncertain knowledge can be supported, for example, by methods of modelling or scenario analysis.

4 Test applications of the framework for reflection

4.1 Goals and organisation of the test applications

The framework for reflection was tested in test runs for its applicability and reflective potential on research with societal responsibility. The test runs took place at nine research institutions and two research management institutions[9].

To derive an overview of the applicability of the criteria in different phases of the research process,
- individual interviews were conducted with scientists at different hierarchical levels (project implementation, project management, science management),
- projects of different stages, size and orientation were selected (collaborations, dissertation projects, basic research, application-oriented research).

The participants of the test runs received a short introduction to the framework for reflection and the LeNa project, in order to subsequently apply the set of criteria to their own research with the help of the fact sheets. The findings from this reflection exercise were discussed in subsequent individual interviews and summarised in reports for each institution.

[9] WGL: Academy for Territorial Development (ARL)/ Leibniz Forum for Spatial Sciences, - Leibniz Institute for Urban and Regional Development (IÖR), Leibniz Institute for Zoo and Wildlife Research (IZW), HGF: Forschungszentrum Jülich (FZJ), Helmholtz-Centre for Environmental Research (UFZ) FHG: Fraunhofer Institute for Chemical Technology (ICT), Fraunhofer Institute for Interfacial Engineering and Biotechnology (IGB), Fraunhofer Institute for Industrial Mathematics (ITWM), Fraunhofer Institute for Environmental, Safety and Energy Technology (UMSICHT). Other institutions: Project Management Jülich (PtJ), Technopolis Group.

4.2 Results and feedback

In principle, the set of criteria was evaluated in the test runs as relevant for reflecting on research processes with the aim of assuming societal responsibility. Other key findings from the test runs were:

- Above all, the systematic compilation of the criteria, some of which were classified as „intuitive knowledge“, was welcomed as it enables a structured approach.
- In order to avoid conflicts of interest (see section 2.4) in the application of the criteria and to recognise the consideration of the criteria in research processes, incentives for applying the reflection criteria are necessary.
- To support an appropriate application of the framework for reflection, the wish was expressed for stronger support on methods and strategies (for example, workshops). As far as possible, the specificities of the different disciplinary perspectives should be considered.

Some of the suggestions from the test runs have already been implemented. Others, such as the establishment of incentives, require a more comprehensive implementation process.

5 Outlook

The present framework for reflection is intended to initiate a debate on research processes with societal responsibility. A consistent implementation process of the framework for reflection will be demanding and resource-intensive. Medium- to long-term options for implementation and institutionalisation of the framework for reflection are outlined in considerations for a road map.[10] This addresses different levels of implementation (e.g. the scientific community as a whole, funding bodies, organisational development) and implementation measures (e.g. consideration of the framework for reflection in funding guidelines or internal programmes of research institutions, consideration in the remuneration of individual scientists).

In addition, the benefits and trade-offs of using the framework for reflection have not yet been fully explored. A thoughtful implementation process should therefore include the following activities:

- Development of a toolbox: It would contain training material and practice-oriented application support. A first approach is available with the fact sheets for the eight criteria. An extended toolbox should contain instruments for the implementation, monitoring and impact assessment of the framework.
- An international comparison: It could show how research with societal responsibility is defined in other countries with high-performing research, what requirements are placed on research processes in this regard, and how the effects of research are evaluated.
- Evaluation concepts developed for monitoring: Evaluation criteria would have to be developed to allow an assessment of the successful application of the framework for reflection. Furthermore, it becomes necessary to provide evaluation criteria for the process of integrating research with societal responsibility into the daily research routine of research institutions.
- An impact assessment: is necessary to test the extent to which the framework for reflection can add value and outweigh possible conflicting goals. Methods need to be developed to test ex-ante, during research and ex-post benefits, difficulties and side effects of implementing the framework for reflection in research activities of different fields, thematic orientations and time horizons.
- Piloting activities: They can support scientists and institutions in their efforts to reflect on „research with societal responsibility“. They identify obstacles, challenges, opportunities for responsible implementation and good practices for selected disciplines.

[10] See the roadmap developed in the LeNa project, www.nachhaltig-forschen.de/roadmap/.

Part II – Fact sheets on criteria „Research with Societal Responsibility“

Structure of the fact sheets

The eight fact sheets have a uniform structure and each contains:

I. Brief description
The short description summarises the relevant aspects of a criterion in one paragraph.

II. Quick-check
The quick-check contains questions that can be used to quickly assess the extent to which the respective criterion is relevant for reflection in the respective research process.

III. Relevance
The paragraph on relevance describes what role the respective criterion plays for a research with societal responsibility process.

IV. Contents
Here, the focal points are described that are characteristic of the respective criterion in terms of „research with societal responsibility“ are.

V. Implementation
The steps for implementing or reflecting on the criterion in the reflection process are shown. The question „Which steps does the criterion include in a research with societal responsibility process?

VI. Case studies
The case studies show how the criterion can be implemented in research practice.

VII. Further information
Here users can find further information, literature and links (e.g. to guidelines for the consideration of a criterion) for a more in-depth examination of the respective criterion.

fact sheet

Ethics

Knips, C., Röllig, K., Brandt, M., Bertling, J. (2016): fact sheet Ethik. In: Ferretti, J. et al.: Reflexionsrahmen für Forschen in gesellschaftlicher Verantwortung. Verbundprojekt „Nachhaltigkeitsmanagement in außeruniversitären Forschungsorganisationen“. BMBF, Berlin.

I. Brief description

Ethics in the true sense is moral philosophy. This means the argumentative preoccupation with the question of a good life, good livingtogether and good actions. Ethical reflection includes the readiness to justify one's own actions to one's own conscience and to one's fellow human beings with arguments and to enter into dialogue about them. In doing so, values and norms are used as a basis - for example justice, human dignity, environmental and animal protection, freedom of science. Every researcher has the responsibility to deal with ethics within his or her own field of research. This fact sheet provides concrete recommendations and suggestions for dealing with ethical issues in the research process.

II. Quick-check

1. Is a research topic with obvious ethical conflict potential, such as projects in the field of genetic engineering, medical technology or defence research, being worked on? Or are there any hidden ethical challenges in the research field, such as in the areas of big data or robotics?

2. Are methods used that are ethically relevant, such as animal experiments or experiments with human subjects?

3. Are there already concrete orientation offers for the solution of possible ethical conflicts, such as codes of ethics or guidelines?

III. Relevance

The freedom of research protected in Article 5 of the German Basic Law is based on the fact that the associated responsibility for self-regulation is actively exercised by the research actors, i.e. this freedom also gives rise to a societal and ethical responsibility. Ethically responsible research, thus, goes far beyond the principles of good scientific practice and compliance with legal requirements.

On the one hand, scientific developments influence society and the environment far beyond the boundaries of the scientific enterprise, therefore research actors must also address the value framework for the society in which they live in their work (→ compare criteria „reflection on effects“ and „dealing with complexity and uncertainty“). On the other hand, methods used in the research process are also subject to ethical review. Finally, the link between these two ethical dimensions is to ensure the proportionality of the necessary means and methods in relation to the expected results of the research.

In the face of complex problems, it becomes all the more difficult to make an objectively justified decision in the case of moral conflicts - because of unclear facts (for example, if the consequences of a new technology are difficult to foresee with the current state of knowledge, which applies to nanotechnologies, for example),potential military use of a technology (dual-use problem), or because the amount of data becomes unmanageable (for example, in the case of the problems surrounding big data and digital privacy).

In addition, legislation often lags behind in new fields of research and technology due to their topicality. This means that legal regulations may be less developed than in the case of already clearly defined ethical challenges, for example experiments on human subjects or animals. Where no legal provisions or ethics committees exist, research stakeholders are therefore called upon to contribute to the resolution of ethical conflicts through voluntary self-organisation.

IV. Contents

In essence, ethically responsible research means that research actors consider the potential hazards of their research and avoid direct and indirect harm to humans and the environment as much as possible.

In conflict situations, one is therefore usually confronted with the question of how to make the right decision between different alternative courses of action. Ethical reflection can help to systematically examine eligible courses of action with regard to relevant ethical maxims and principles in order to offer orientation for a concrete decision and, at the same time, make the decision transparent and comprehensible. In cases of ethical conflict, however, it is not necessary to develop a clear, generally valid position or to make an assessment in the sense of „right" or „wrong". Rather, an attempt should be made to solve the problem specifically in each case through consideration and prioritisation, i.e. through broad ethical reflection.

For the individual, ethical responsibility also includes becoming aware of the limits of individual reflection and, if necessary, seeking help elsewhere (for example, from ethical ombudsmen or ethics committees, see below). Scientists can use the following support and institutes for ethical questions:

Codes of ethics provide a collection of principles and guiding rules agreed upon by the members of a professional group or institution. A challenge of such codes is the great generality of the rules summarised there (for example, in the „Hippocratic Oath for Scientists"). Codes of ethics must be constantly updated and adapted to changing societal conditions. Using a code of ethics as a guide is no substitute for a more in-depth study of ethics, but it can provide some initial food for thought (see below for examples).

The German Ethics Council advises and informs at national level on ethical, social, scientific, medical and legal issues, especially in the field of life sciences. It was constituted in 2008 and is composed of an interdisciplinary team of experts that organises symposia and publishes statements and recommendations on current topics. These publications are also of interest to research actors beyond the subject areas dealt with in order to learn about arguments and positions on a particular topic.

There are currently around 50 ethics committees throughout Germany, which are appointed by research institutions, the states or the federal government. They assess specific questions ethically and legally and provide advice. In the case of animal experiments or experiments on human subjects, the examination by an ethics committee is prescribed by law. Ethics committees exist primarily in the field of medical research, but since 2011 there has also been an Ethics Committee for a Secure Energy Supply at the federal level. In 2012, the Karlsruhe Institute of Technology (KIT) also appointed an internal ethics committee.

V. Implementation

The following questions and food for thought can ideally be reflected on in dialogue with those involved in the decision-making process or trusted persons:

Thinking outside the box when choosing topics and methods:

- What potential conflicts or risks of ethical disputes does the research topic entail (e.g. dual-use problems, damage to the institution‘s reputation)? On the other hand, what opportunities does it offer to contribute to solving existing ethical problems (e.g. through the development of alternative technologies, collaboration on standards)?

- What possibilities exist for cooperation in order to broaden one's own field of vision with regard to ethical questions? (→ compare criteria „interdisciplinarity" and „transdisciplinarity")?

Clarify the legal and normative basis:

- Which laws and guidelines affect my research field or my method design?

Clarify the ethical basis:

- Do codes of ethics relevant to my research area already exist (see below for more information)? If so, how can I apply them to my current research activity? If no codes exist for my field, can I transfer principles from codes of ethics of related research fields to it?

- Are there already recommendations from the German Ethics Council, existing ethics committees or other institutions regarding ethical aspects in the research question at hand (see below for web links)?

- Which values are important for me, for my institution and in the public discourse, and how do I prioritise them in my work (for example, human rights, human health, distributive justice, environmental protection, data protection, economic efficiency, etc.)?

- Are there colleagues in my professional environment who are confronted with similar ethical problems and with whom I can seek dialogue?

Sensitivity to societal debates and participation in public discourse:

- Which societal stakeholders are affected or interested? How can I involve them at an early stage if necessary (→ compare criteria „transdisciplinarity" and „user orientation")?

- How can I help shape the public discourse?

Use of counselling services to deal with conflicts at institutional level:

- Ethical concerns should be shared with trusted persons at every stage of the research process: Ombudspersons, association/ umbrella organisation (for example VDI), ethics committees, etc.

- Research actors can stimulate or collaborate in the establishment of institutional structures for addressing ethical issues.

VI. Practical examples

Equitable licensing describes a licensing model in which the patenting of research results is waived, particularly in order to facilitate access to medicines for poorer countries. The Universities Allied for Essential Medicines (UAEM) network is working with around one hundred local groups at universities worldwide to implement this model in publicly funded research. In the USA and Great Britain, the model is already widespread; in Germany, it is still in its infancy. Here, the University of Freiburg has so far adopted a voluntary commitment to societal responsible licensing in summer 2015. The driving force behind this is UAEM Germany, an initiative of students from various faculties throughout Germany.

The example illustrates the debate about the societal responsibility of publicly funded research, especially against the background of international justice, as well as the handling of conflicts between patenting and transparency, societal and financial benefits of research results.

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Codes of ethics, guidelines and institutions

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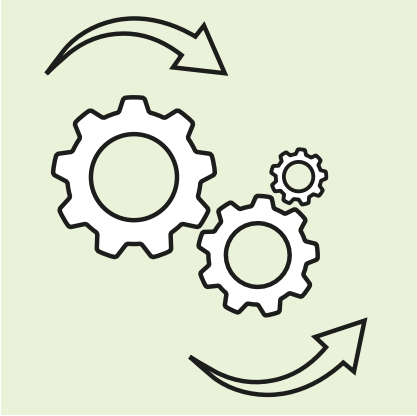
German Reference Centre for Ethics in the Life Sciences (DRZE), www.drze.de (retrieved 15.11.2023).

fact sheet

Integrative approach



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I. Brief description

The growing complexity of modern societies, the diversity of societally relevant research questions and the desire to provide decision-makers with reliable knowledge for action lead to the expectation that research should be conducted in an integrative manner. This includes taking into account as many elements as possible that are considered relevant to a research question, and also their interactions. In addition to the usually addressed scientific disciplines, economic sectors, development dimensions and stakeholders, integration here also refers to spatial, temporal, analytical and methodological aspects. This fact sheet describes the main steps of an integrative approach, which are situated in the area of tension between the need for completeness and the reduction of complexity.

II. Quick-check

1. Are there relevant elements within the scope of the subject of study that require integration (for example, spatially, temporally, etc.)? Have these already been systematically identified? Are they interrelated?

2. Do suitable methods or procedures exist to integrate the relevant elements and their interrelationships?

3. Are the necessary competences for an integrative approach available (for example in the project team)? Is the organisation of the research activity adapted to the requirements of an integrative approach?

III. Relevance

The growing complexity of modern societies and their development (→ compare criterion „Dealing with Complexities and Uncertainty“) leads to the expectation that research should look „at the full story“. In order to be better able to deal with research questions in their complexity, they should be dealt with in an „integrative“ or „integrated“ way by considering the relevant elements, their interconnections and interactions as well as synergies or conflicts.

This becomes particularly important when it comes to analysing or evaluating research subjects such as products, technologies, regions or sectors, to designing and evaluating possible future developments or to finding suitable options for action to solve problems. Here, researchers are often confronted with complex and diverse human-technology and human-nature interactions. For this reason, integrative research is not only oriented towards internal scientific paradigms when defining and addressing research questions, but also towards needs and priorities defined outside the science system.

IV. Contents

Whereas the term „integrated“ or „integrative“ had already been used in the 1970s/1980s in the field of planning, such as urban planning, it also found its way into research in the 1990s. First discussed in the context of research on global change, the attribute of “integrative” encompassed four aspects:

- economic sectors, several of which are usually responsible for the emergence of global phenomena and problems, often intertwined in many ways;

- the dimensions of societal or sustainable development in order to adopt a holistic perspective on societal, economic, ecological and socio-technical developments or even justice-related basic ideas instead of one-dimensional analyses;

- scientific disciplines, in order to incorporate or make available the scientific knowledge required to address research questions across disciplines;

- cultural attitudes in order to take cultural and normative differences into account against the background of increasing globalisation as well as societal individualisation and fragmentation.

Today, research is often described as „integrative" if it is inter- and transdisciplinary. In order to do justice to the complexity of many pressing research questions, a broad understanding of integration takes into account five further aspects in addition to these and those mentioned above:

- the spatial dimension, in order to identify the relevance of spatial aspects for a research question as well as the relevant scales in each case (local, regional, national, supranational or international) and to consider their manifestations and interactions;

- the temporal dimension, in order to consider the appropriate time scales for a research question and their dynamics, as well as possible conflicts, for example between short-term and longer-term perspectives or between different speeds of development;

- the analytical level, in order to address the entire breadth of a goal-, problem- and action-oriented perspective in the area of research oriented towards societal problems, as well as to consider their interconnections. Societal problems can only be identified and dealt with appropriately if development goals in the political, economic or ecological fields exist as reference points or are worked out in the research process. At the same time, the development of strategies for action should be oriented towards existing problems (perceptions) and goals;

- the methodological level, in order to define methods of analysis and combinations of methods for complex questions that cover a sufficient thematic and methodological breadth;

- the addressee-related level, which requires a systematic identification of relevant user groups or addressees. These should be integrated into the research process as early as possible in order to initiate an appropriate addressee-oriented transfer of knowledge and results.

In order for the „view of the full story" to succeed, it is first necessary to identify the aspects and elements relevant to the research activity (e.g. formulation of the research question), in order to then be able to decide which of them should be considered. Here, the right balance must be found between the extremes of an irredeemable claim to completeness and a problematic reduction of diversity and complexity (→ compare criterion „Dealing with complexity and uncertainty"). In order to be able to integrate individual elements, the aspects relevant for dealing with a research question (e.g. spatial levels, sectors, topics) are first „broken down" into distinguishable and processable parts in order to generate specific „individual knowledge" for them. This must be supplemented by „integration knowledge" about the necessities and methodological possibilities of „thinking things together". Researchers must be able to recognise conflicting goals, deal with them and weigh up individual elements. Phenomena of incompleteness and uncertainty of knowledge (→ compare criterion „Dealing with complexity and uncertainty") are of particular importance in such integrative research.

Another challenge is to assess or ensure the quality of such research. On the one hand, this requires a common understanding of definitions or methods between researchers and reviewers, and on the other hand, criteria must be defined as to how sectoral knowledge can be brought together in a suitable manner. In addition to the always necessary quality assurance based on disciplinary standards, quality assurance must be supplemented by one that is orientated towards the process of integration.

This particularly requires relevance decisions in all phases of the research process, based on both scientific criteria and normative settings.

Such integrative research with its societal (problem) reference is to be understood as a necessary complement to the established science sector, not as a substitute for it.

V. Implementation

A standardised procedure for the implementation of such research does not exist yet, therefore the steps outlined below are not to be understood as a complete list to be processed, but as a suggestion to realise the „view of the whole thing" in one's own research question:

1. **Determining the theoretical framework:** The first step is to determine the appropriate theoretical and conceptual perspective for a research question, i.e. the chosen view of the research subject. It includes basic questions about the definition of research subjects or the theoretical framing of working on research questions and thus provides a benchmark for necessary decisions about the relevance of a certain aspect of integration, as well as elements within an aspect.

2. **Relevance checks:** The aim here is to identify the relevant aspects of integration as well as the elements that are relevant in each case, which are to be taken into account in the research process. „Aspects of integration" refers to the above-mentioned scientific disciplines, social actors, addressees, the development dimensions (economic, ecological, social, etc.), economic sectors (transport, energy, agriculture, etc.) development dimensions (economic, ecological, social, etc.), as well as the spatial, temporal, analytical and methodological levels.

3. **Analysis of interactions:** In this step, it is necessary to analyse which interactions exist between which elements and how they are connected to the research question. With regard to the spatial level, the influence of national regulations on design options in municipalities or examples of synergetic as well as conflictual relationships could be relevant here. Environmental impacts that cross administrative or national borders, remote urban watersheds or the upstream/downstream problem of watercourses are also examples of issues that require spatially integrated approaches. In the temporal dimension, it is a matter of recognising and evaluating differences or conflicts between short-term and longer-term achievements, goals or cause-effect relationships. For example, cost- benefit considerations strongly depend on the choice of the time horizon if costs and benefits occur at different points in time.

4. **Pathways to integration:** Various approaches are conceivable here, which may differ depending on the aspect of integration. Especially if conflicting goals arise, it is important to consider different scales and perspectives. Criteria-based relevance decisions must be made for this. Decisions on how to deal with conflicting goals should be recognisably oriented towards the goals set and subordinations of certain elements to others should be adequately justified. The inclusion of (side) effects associated with certain processes is an important criterion here (→ compare criterion „Reflection of effects").

At the analytical-methodological level, integration can be supported by the development or application of tools or the appropriate combination of methods. For example, integrative modelling can be used to take different aspects into account in analyses, such as economic, ecological or societal aspects, to simulate and analyse complex situations and to develop heuristics for problem hierarchies. Critical reflection on the possibilities and limitations of the methods used is crucial for the development of valid, addressee-oriented knowledge for action.

A starting point for integration in the addressee-related perspective could be, for example, the active search for application contexts in basic research. There could also be a need for more in-depth scientific research on certain fundamental issues (e.g. further methodological developments, gaining knowledge about fundamental relationships in socio-ecological or socio-technical development pro-

cesses), which could also be addressed by a corresponding disciplinary expansion of the research team. In addition, the societal relevance of issues and results achieved should be considered from the outset, in order to be able to decide on this basis about the timing, form and costs of transferring results to society.

5. **Reflection and communication of results:** The complete results, i.e. also the trade-offs or model analyses as well as supplementary information - for example regarding their underlying assumptions - should be disclosed and made available to all interested parties (→ compare criterion „transparency"). This will enable users of the results to assess them and use them in their decisions.

VI. Case study

„Risk Habitat Megacity" project (2005-2010) (see www.ufz.de/risk-habitat-megacity) (retrieved 15.11.2023): The aim of this German-Chilean collaborative project funded by the Helmholtz Association was to develop goals for the sustainable development of megacities in general and the Santiago de Chile metropolitan region in particular, to identify the most pressing current and future problems and risks, and to develop corresponding practice-relevant risk management and problem-solving strategies. The project was broadly interdisciplinary and was conducted transdisciplinary with partners such as the UN Economic Commission for Latin America and the Caribbean (ECLAC). The project developed and applied an innovative integrative research approach: The theoretical concepts of sustainable development, risk and governance were applied as a common framework for the analysis of different thematic fields (energy, water, transport, land use, socio-spatial differentiation, etc.) and their interactions (water-energy, transport-land use, etc.). Scenarios and action strategies for the individual fields were developed with the involvement of various local and supra-regional groups. The governance structure of the metropolitan region itself (regional government, mayors and parliaments in the municipalities) and the national (ministries, president, etc.) and international levels (OECD, World Bank, etc.) influencing it were taken into account in their considerable complexities and interactions between the individual actors.

A platform was established for continuous interdisciplinary and intercultural learning as well as for dissemination and integration of research results into university teaching and municipal practice. This also created a suitable learning and experience environment for young German and Chilean researchers (a total of 20 doctoral students), which could be used in both countries.

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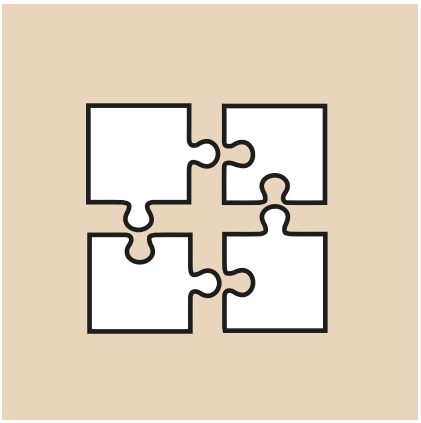
fact sheet

Interdisciplinarity



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I. Brief description

Interdisciplinary research is a coordinated work process based on different disciplinary expertise. The aim is to arrive at common approaches to problems and solutions with a high problem-solving potential, as well as new findings with regard to a given subject of research. Complex problems require contributions from different disciplines. The formulation of a common perspective requires the willingness to be open to other problem approaches and methods. Although this continuous communication process is demanding, it opens up possibilities for broadening perspectives and improving the manageability of complex issues. Interdisciplinarity enables the development of solutions that go beyond purely disciplinary approaches.

II. Quick-check

1. Which disciplines are integrated into the research project? Should other disciplines be involved to answer the research question?

2. How can misunderstandings be prevented and the understanding of the research subject between the different disciplines be guaranteed?

3. How can the interdisciplinary findings be connected to the disciplinary communities?

III. Relevance

Interdisciplinary work is a reflected communication process with the aim of achieving a better understanding of a complex research subject by combining the expertise of different disciplines.

The structuring of science into disciplines enables specialised subject discourses that are relatively homogeneous in terms of concepts, theories, problems and methodological approaches. Within a discipline, the specialisation of the range of topics allows for in-depth elaboration of individual aspects and facilitates communication (technical languages) within the corresponding specialist community through the formation of a common knowledge base.

Based on this disciplinary organisation, the integration of ways of thinking and methods of several independent scientific disciplines (e.g. engineering, natural sciences, societal sciences, humanities, economics, cultural sciences, etc.) enriches the research content and increases the connectivity of possible results to other disciplines and societal issues. For questions that go beyond conventional disciplinary boundaries, lie across subject boundaries or suggest different approaches depending on the disciplinary contexts, a convergence and (re)combination of theories and/or methods allows for gaining new insights. Especially in problem-oriented research, such as sustainability research, the need for interdisciplinary work is already given in the comprehensive idea of sustainable development.

In this respect, interdisciplinary work does not replace disciplinary specialisation, but generates additional knowledge on its basis by linking it. The early involvement of the relevant disciplines contributes to the efficient use of available resources for a given issue through a common definition of goals.

IV. Contents

Crossing disciplinary boundaries can take different forms: While multidisciplinarity describes the parallel processing of a superordinate question with the respective disciplinary theories and methods, an interdisciplinary approach is characterised by the combination of approaches from different disciplines. Here it is necessary to clarify the relationship between different disciplinary perspectives, approaches and solutions in order to ideally arrive at a new integrated view of a research subject as well as new methods. A step further represents the joint processing of a research question with the involvement of non-scientific actors. Strictly speaking, this is no longer a form of interdisciplinarity, but rather work that goes beyond the logic of scientific disciplines (→ compare criterion „transdisciplinarity").

The interdisciplinary research process involves addressing the questions of which subjects are relevant to a given research topic, which specific sub-disciplines within these subjects offer the best added value, and why a chosen combination of subjects, theories and methods is most appropriate with regard to a given goal. Interdisciplinary work therefore already begins in the run-up to the formulation of research questions and requires an ongoing communication process to develop and maintain a common perspective on a research problem. Interdisciplinary work requires a special form of project-internal communication with sufficient space for communication processes to formulate a common perspective on a research subject. The participants should gain expertise on other perspectives and approaches and be open to perspectives from other disciplines.

The different starting points of disciplines lead to different approaches to problems. Identifying a targeted thematic intersection, narrowing it down and reformulating it jointly in a way that is still compatible for the disciplines involved requires a reflected approach to specialist languages, methods and approaches.

A structural challenge of interdisciplinary work is the (still) non-existent or constantly reconstituting subject community, which means that there are no opportunities for discussion about methods and theoretical approaches as well as about the classification and weighting of results achieved, or that this is only possible for (disciplinary) sub-aspects.

Interdisciplinary work is not an end in itself. Firstly, it can serve the more adequate (re)formulation and treatment of a research subject in relation to a given goal. Secondly, an interdisciplinary approach can promote the expansion of existing disciplinary approaches. Thirdly, interdisciplinary approaches can contribute to changing disciplinary boundaries by integrating the knowledge of several disciplines. Finally, the combination and adaptation of different disciplinary approaches can contribute to the development of new methods.

Interdisciplinary work thus serves the following goals:

- Research subject: Interdisciplinarity can contribute to a more adequate (re)formulation and treatment of a research subject in relation to a given goal.

- Single discipline: An interdisciplinary approach promotes the expansion or reformulation of existing disciplinary approaches by incorporating new concepts.

- Disciplinary structuring: Interdisciplinary approaches change disciplinary boundaries by integrating the knowledge of several disciplines.

- Interdisciplinary method development: The combination and adaptation of different disciplinary approaches can contribute to the development of new methods and to an efficient use of knowledge resources.

The increased time required can be justified in view of the research subject and the expected added value of combining disciplines.

V. Implementation

Search for project partners and joint topic delimitation:

- Interdisciplinary research is usually problem-oriented, i.e. - in contrast to knowledge-oriented research - it is geared towards societal challenges. At the beginning of a concrete research project, there is a search for suitable project partners to formulate and work on an interdisciplinary topic, as well as a joint thematic delimitation and formulation of goals.

Common understanding:

- A common understanding of the research subject, the relevant levels of observation, the methods and the language required for description must be developed with the project partners (→ compare criterion „user orientation"). This can also mean involving other disciplines and/or reformulating problems and questions in such a way that a viable intersection for co-operation emerges.

Methods for recording and merging:

- In each case, suitable recording methods for the aspects considered relevant are to be defined, which are compatible with each other. This should enable an integrative consolidation and formulation of the results.

Quality assurance:

- Quality assurance measures are initially oriented towards the standards of the disciplines involved. If the interdisciplinary approach makes it necessary to formulate own quality criteria, these should be transparent and comprehensibly justified in order to establish connectivity in the respective subject communities.

Project management:

- Interdisciplinary cooperation places new demands on project management: Different assumptions, perspectives and methods must be identified and productively linked with each other by means of structured processes of communication and rapprochement. In addition, roles and decision-making competences should be allocated transparently and justifiably at an early stage. Finally, the delimitation of target groups, the choice of media and the form of publication of interdisciplinary results must be coordinated between the project partners.

Steadiness:

- A suitable way to disseminate interdisciplinary results and to consolidate co-operation, approaches and discussions is to form networks. Ideally, a new interdisciplinary specialist community can be established on this basis. This requires a longer-term identity-building process of integration and differentiation from other disciplines.

VI. Case study

The accompanying research project **„Bundling Knowledge - Strengthening Will - Facilitating Ability“** (https://www.fona.de/de/fona-strategie/) was part of the thematic focus „From Knowledge to Action - New Paths to Sustainable Consumption“ of the BMBF funding priority „Societal-ecological Research“ (SÖF) between 2009 and 2012. One of the declared goals of the accompanying research was to integrate the ten project networks into a process of joint formulation of the research topic „sustainable consumption“. Similarly, results were produced across individual topics and disciplines in the form of synthesis products: Ways and Beings of Sustainable Consumption (www.oekom.de/nc/buecher/buchreihen/soef/archiv/buch/wesen-und-wege-nachhaltige-konsums.html, retrieved 15.11.2023).

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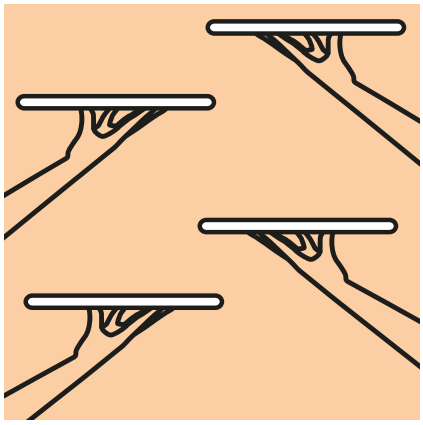
fact sheet

User orientation



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I. Brief description

User orientation in the sense of „research with societal responsibility“ means that the potential users (as a subset of stakeholders) of research results are already taken into account during the research process. Users can be science itself, the economy, politics or other societal groups. Stakeholder management methods help to identify users and to interact with them in the research process. This interaction ranges from mutual listening and informing to shaping co-operation through consultation or involvement. The aim is to communicate knowledge in a user-friendly way at an early stage through communication that is as freely accessible, comprehensible and transparent as possible. This increases the applicability, transferability and relevance of the results. In contrast to transdisciplinary research, which aims to link scientific knowledge with practical experience, user orientation focuses on the reflection of the interests and needs of potential users.

II. Quick-check

1. Are there potential users from science, business, politics and society of research results? How can I systematically identify and involve them?

2. Are expectations and needs of users adequately taken into account?

3. How is existing and newly created knowledge prepared for users?

III. Relevance

The aim of user-oriented research is to produce relevant and useful results for the respective groups addressed and to make them available in a way that meets their needs. The inclusion of a variety of interests opens up new perspectives and promotes a critical examination of one‘s own research work. It can also contribute to increasing creativity and the potential for innovation, as well as to increasing the acceptance and applicability of the results. A cross-border examination of exploitation paths can help to open up new areas of application. In addition, participating actors can act as multipliers in larger user groups. Transparent communication of research content and results also contributes to a responsible research process (→ compare criterion „Transparency“).

IV. Contents

In order to be more oriented towards the needs and priorities of potential users in the identification and processing of topics compared to previous research practice, users should be involved as early as possible. The utilisation of research results includes all follow-up processes within science, business, politics or other societal groups that are stimulated by the research. This can mean the utilisation of findings and data in subsequent research projects, the marketing or use of a newly developed product, the implementation of political or research strategic recommendations and concepts, or the stimulation of public debates on societally relevant topics.

In contrast to transdisciplinary research, which aims to develop practical knowledge and in which the involvement of external non-scientific stakeholders in the research process is a core element, user-orientation focuses on reflecting the interests and needs of potential users. This means that in user-oriented research processes the involvement of users is not a precondition, but an optional criterion. (For information on the inclusion of societal interests → see criterion „transdisciplinarity“).

The term „user“ is used here in a broad sense: Users of research results are to be understood as specific groups from society, politics or the economy, or in each case as a whole. In contrast to the criterion of transdisciplinarity, the term user also includes scientific actors. Users are understood as a subset of stakeholders (see Figure 3). Stakeholders in the research context are interest groups that are influenced by or influence the respective research process. Users may have a personal or institutional interest in the use of potential research results. They play an active role in the above-mentioned intended or unintended follow-up processes or have a significant influence on their course. Intended users are referred to as addressees. Direct interaction with the addressees during the research process is possible in many cases.

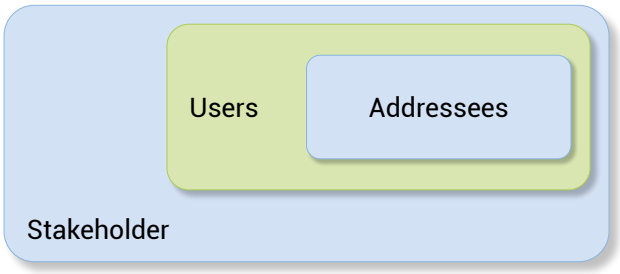

Figure 3: Users and addressees as a subset of stakeholders in the research process.

The relevance of potential users may only become apparent during or after the research process (→ compare criterion „Reflection of effects“).

Participatory methods help to achieve user orientation, but vary depending on the addressee and the research objective.

When choosing participation and communication formats, the plurality of interests, expectations and needs must be taken into account. Interests, expectations and needs may diverge between different users, but also within the selected groups. The actors involved should be understood as partners in the research process. Awareness of the respective goals and expectations should be created on both sides.

Ideally, the transfer of knowledge in the user-oriented research process should take place in parallel and mutually. Research content and results should be prepared in such a way that they are freely accessible and understandable for the addressees. Knowledge transfer also means coveying knowledge that is transferable, i.e. that can be applied to other contexts. This is supported by the intellectual transcendence of disciplinary boundaries and the consideration of systemic contexts (→ compare criteria „interdisciplinarity“ and „integrative approach“). The transferability of results to other spatial and temporal scales, for example by taking future developments into account or adapting to country-specific conditions, is also desirable (→ compare criteria „Reflection of effects“).

V. Implementation

User-oriented research begins with understanding one‘s own research as part of societal life as a whole. The classification of the research project in societal, political and economic challenges can serve as a basis for identifying the users relevant to a specific research question. In order to increase relevance and balance in the selection of users, a systematic user analysis along categories is recommended (→ see section „Methods and instruments“ and Table 1). An iterative approach to identifying users during the research process is particularly useful if objectives or result perspectives change during the course of the project. The following questions help to find the relevant users and to determine their interests:

- Who should be able to use the results or who could use them?
- How can these users use the results?
- What interests might these users have in the results?
- How can these users influence the research process?
- How do we shape the transfer of knowledge?

The interaction with the users along the research question takes place primarily during the research design and the implementation phase of the research process. The degree of interaction ranges from unilateral or mutual information regarding needs and interests, to forms of consultation, to formative cooperation (→ compare criterion „transdisciplinarity"), here for example to jointly coordinate development steps. A systematic interaction and communication strategy can help to achieve an open and constructive user orientation.

For the dissemination of results, classic forms of scientific publication play a role. In addition, there are numerous formats for user-specific communication of research content and results that support knowledge transfer during the research process. Dialogue-oriented formats in particular help to accompany use beyond the actual research process, to obtain feedback from users and to reflect evaluation results back to the users.

What methods and instruments exist for implementation?

In addition to the steps described above, the fact sheet „Transdisciplinarity" as well as guidelines and manuals on stakeholder involvement are recommended. They support the planning and implementation of participation processes (see literature).

Table 1 shows examples of user categories and groups as well as options for communication formats. From these, relevant users and formats can be selected according to the research question. The addressees are decision-makers or knowledge owners in the respective groupings who are addressed personally or via contact persons. Formats for communication and knowledge transfer range from one-sided user-oriented to dialogue-oriented types. The formats and classifications presented are suggestions and can be adapted to the phases of the research process.

Table 1: Examples of user categories and groups and corresponding formats for communication and knowledge transfer

Category	User group	Formats for communication and knowledge transfer along the research process Strategic agenda planning / Identification of topics / Research design and methodology / Execution / Result dissemination / Strategic agenda planning
Science	Scientific disciplines, research groups, individual scientists, scientific associations	Workshops interdisciplinary collaborations Publications in scientific journals contributions
Business	small/medium/large companies, industrial associations, economic development agencies, cooperatives	Industry workshops Customer discussions open source solutions Conferences Patents Technology transfer spin-offs
Politics	Governments, ministries, parties	Agenda Setting Consultations Scientific Advisory Boards Expert councils committee of inquiry Round tables Ethics committees Position papers Policy recommendations
Administration/ institutions	Schools, hospitals, other public institutions, authorities and offices at the federal / state/ local level	Workshops Student forums Committees (Computer-based) models and tools Technical/standard committees Institutional reforms School materials Publications in practical media Guidelines
Society	Municipalities, religious communities, cultural institutions, clubs, associations, non-governmental organizations	Public events Citizen Science Citizen dialogues/conferences Discourse/agenda processes FabLabs Science shops Open Innovation Web-based and social media Publications in traditional media (television, newspapers, magazines, etc.) Exhibitions
Special users	consumers, patients, local/regional groups, minorities, professional	Interviews Interviews Expert discussions

How can arising challenges be tackled?

The research process can become more complex by the need for successful interaction between science and user groups. Following the basic principle of efficient resource use, the degree of interaction that is suitable and promises benefits for research and users should be weighed up on a project- or programme-specific basis, but also on a user-specific basis. Inadequate participation processes can raise unrealistic expectations among users or lead to decisions that do not reflect the interests of the users as a whole. These challenges can be met by appropriate project planning, systematic user analysis and understanding, and early clarification of goals, expectations and communication channels. Success factors for a successful interaction include incentives for participation, meeting at eye level and mutual respect, identifying the different, individual perception filters and contexts of action, as well as a language that is understandable for the users.

VI. Case studies

- EnSign Reallabor - Climate-neutral university as a partner of the region: In order to achieve climate neutrality for the inner-city university campus of the Stuttgart University of Applied Sciences, a comprehensive implementation strategy is to be developed in the EnSign Reallabor, debated with actors from the university and the city, and implemented as an example in the first innovative projects - financed by the Landesbetrieb VermögenBau. Project launched, https://www.hft-stuttgart.de/forschung/projekte/abgeschlossen/ensign (retrieved 20.11.2023).

- DEUS 21 (Fraunhofer IGB & ISI) – Decentralised urban water management, development of a decentralised infrastructure for wastewater treatment and rainwater management, participation of residents, municipal authorities, plant constructors; two pilot sites; project duration 2003-2010.

- BalticClimate Toolkit - a tool that supports local and regional actors in finding an approach to the topic of climate change. It is aimed at three important groups of actors (political decision-makers, spatial planners and entrepreneurs), for each of whom special „toolsets" have been developed. http://toolkit.balticclimate.org (retrieved 20.11.2023).

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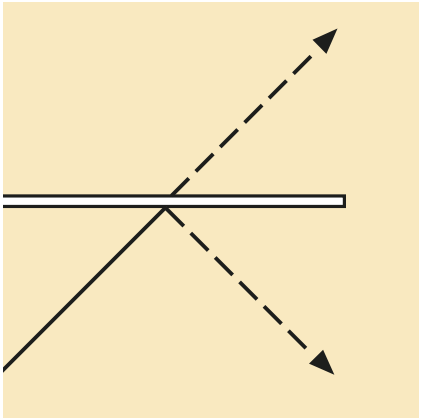
fact sheet

Reflection of impacts



Walz, R., Podhora, A., Helming, K., Kopfmüller, J., Winkelmann, M., Daedlow, K. (2016): fact sheet Reflexion von Wirkungen. In: Ferretti, J. et al.: Reflexionsrahmen für Forschen in gesellschaftlicher Verantwortung. Verbundprojekt „Nachhaltigkeitsmanagement in außeruniversitären Forschungsorganisationen“. BMBF, Berlin.

I. Brief description

Responsible research means reflecting on possible impacts for society and the environment (impact assessment). This refers to impacts that may result from the choice of the research subject or strategy, the design of the associated research process and the application of the results. These impacts can be considered at different points in time - before, during and after the research process. At the same time, different types of positive and negative implications need to be analysed: direct and indirect, intended and unintended, short-term and long-term. Impact assessment involves defining and delimiting the system whose impacts are being studied and selecting the relevant topics for analysis. This is followed by the selection of appropriate indicators and the method of analysis. The results of the impact assessment are evaluated in terms of their relevance, followed by the disclosure of the results. Because the estimation of impacts is associated with considerable uncertainties, it is often helpful to show different options (for example with the help of scenarios) and to analyse them comparatively.

II. Quick-check

1. For the research question, have I systematically identified the intended impacts on society and the environment before, during and after carrying out the research activity?

2. In addition to the desired and obvious effects, are there also unintended consequences of the implementation of the research results that may only occur in the long term and have an indirect effect?

3. Can the impacts be determined quantitatively and/or qualitatively and what limitations in the robustness of the results of the impact reflection are associated with the chosen methods for estimating the impacts?

III. Relevance

With an impact assessment, research actors can provide themselves, but also the users of research results, with clarity about the possible consequences of their research for politics, the economy, civil society and the environment. Impacts of research can arise both through the research process itself and in the application and utilisation of research results. Impact assessments provide guidance and decision support. Furthermore, scientifically justifiable alternative development paths, context- and actor-specific future references, possible critical thresholds, unexpected effects and possible societal risks can be adequately considered.

IV. Contents

In Germany, no generally accepted procedure for conducting an impact assessment of research has yet been established. Standardised impact assessments regulated by legal provisions have existed for some time, for example in planning processes (environmental impact assessment). There is also a great deal of experience with technology or regulatory impact assessment. For example, the European Commission carries out a binding sustainability assessment in policy development, in which the respective impact areas of the economic, societal and ecological sustainability dimensions are analysed. Reflection on impacts should accompany research as an ongoing process.

Only if the potential effects are identified early on in the research process it is possible to adapt the research in time or to take accompanying measures to increase positive effects and minimise negative ones.

The associated increase in the relevance of the results also ensures the efficient use of resources in the research process. Three stages of impact assessment can be distinguished:

before (ex ante) the development phase of research projects or strategies,

during their term for the purpose of possible adaptation,

after (ex post) completion of the project or strategy for final reflection.

It is not possible to consider all potential impacts for all conceivable levels and topics. Therefore, decisions on system boundaries and analytical foci must be made in each phase of the impact assessment. The central criterion here should be the relevance of the impacts for society. The following aspects are important when reflecting on possible positive or negative impacts:

a. ***Intended and unintended effects:*** In addition to an assessment of intended effects, it is also necessary to consider unintended effects. Which side effects and/or synergies, for example, that only result from the implementation of research results or strategies are possible?

b. ***Direct and indirect impacts:*** Direct impacts arise from the research process and the immediate application of the research results and strategy. In addition, indirect impacts that can result from the interaction with other upstream or downstream processes or during and after the implementation of research results must also be taken into account. This also reflects the consequences that arise over the entire life cycle of an implementation. For example, technical innovations can also lead to economic, societal or ecological effects. An interdisciplinary approach to impact assessment is therefore essential (→ see criterion „Interdisciplinarity“).

c. ***Small-scale and large-scale, short-term and long-term impacts:*** All impacts should be considered at the relevant spatial (local to global) and temporal (short-, medium-, longer-term, cross-life-cycle, future) scales. With globalisation, the spatial scope of the implementation of research results has increased significantly. It must also be taken into account that the algebraic sign of effects can change from the small to the large scale or from the short to the long term, which means, for example, that short-term positive effects can have long-term disadvantages and vice versa.

d. ***Impacts of alternative actions:*** Especially in view of the uncertainties associated with impact assessments, a comparative reflection of the consequences is recommended. This comparison can be carried out with regard to the choice of topic as well as the approach and the research process. When considering options for action, the effects of inaction should also be included, for example: What happens if I do not conduct research on this topic? The comparative view allows for weighing up the options for action, and it becomes easier to define the analytical framework and to classify the estimated effects in terms of their significance.

e. ***Conflicts of objectives:*** Existing or possible conflicts of objectives can be identified with an impact assessment or anticipated at an early stage. Conflicts of objectives can relate to the research subject and the research result, and are reflected in the different objectives of various societal groups. However, conflicting goals can also arise with regard to the research process and affect the goal system of the research organisation.

f. ***Sustainable development as a framework for reflection:*** In the sense of „research with societal responsibility“, the objective, i.e. the future orientation and the interacting societal, ecological and economic dimensions of sustainable development, should form the evaluation framework for the impact assessment.

This also makes the initially abstract concept of sustainable development graspable for the respective research context and takes account of the fact that sustainability in impact assessments is context dependent and must be defined on a case-by-case basis.

V. Implementation

The implementation of an impact assessment depends on the context. Specific approaches to impact assessment have already been developed for various topics (e.g. technology and regulatory impact assessment, environmental impact assessment, societal impact assessment, health impact assessment, gender impact assessment). However, these approaches have mainly emerged in the evaluation of political measures and strategies and are not tailored to research projects and strategies. Nevertheless, they are fruitful as an initial orientation for reflecting on the impacts of research.

The following ideal steps are recommended:

1. ***Preliminary assessment and definition of the scope of the assessment (screening and scoping):*** First, the aspects to be considered in the impact assessment are identified (screening). Screening is particularly important in the impact assessment of research. This is because the essence of research is to be directed towards the new, the undiscovered. Therefore, no list of predefined potentially relevant effects can be used, which would then only have to be checked for their relevance to the application. Rather, the identification of intended and unintended effects requires context-specific, individual reflection. In the best case, this step is carried out in co-operation with various actors, including those external to the research, in order to identify the relevant aspects from different perspectives (→ compare criteria „inter- and transdisciplinarity"). Thereupon, the aspects can be concretised with regard to the specific research question and substantiated with indicators for the evaluation (scoping). This includes system delimitation, i.e. the selection of the relevant temporal and spatial scales, and the determination of the necessary depth of analysis.

2 . ***Estimation of impacts:*** This step involves the empirical determination of indicators to measure intended and unintended impacts. Depending on the focus and the availability of methods and data, more qualitative or quantitative methods can be used and, if necessary, combined:

   - *Qualitative methods:* Expert assessments, interviews, focus groups, for example with research actors, civil society groups and potential users of the results (→ compare criterion „transdisciplinarity");

   - *Quantitative methods:* statistical tests, simulation models to illustrate different futures (see below), cost-benefit analyses, cost-effectiveness analyses or multi-criteria analyses.

Due to the many uncertainties about the interrelationships of effects and the numerous assumptions that have to be made within the framework for the impact assessment, these assessments can be made in the form of scenarios that illustrate different plausible „futures", i.e. development options.

3. ***Evaluation of the impacts of different options for action:*** Here, a comparative assessment is made of the possible impacts of different research topics, results or approaches, including the option of inaction. The relevance of the identified impacts can be assessed against corresponding standardised reference values and/or against each other in a comparative manner. Such assessments take place in an area of tension in that they should not be carried out solely from the perspective of research, but should also include the perspective of other actors and interest groups, as in Step I (screening and scoping). The comparative consideration allows for weighing up options for action.

4. ***Disclosure of results:*** The results of the impact assessments are made available to all interested parties in an easily understandable form (→ compare criterion „transparency").

This should also address the underlying assumptions, reference values and uncertainties that still exist.

VI. Case study

Employment effects of renewable energies: The EU has set itself the goal of promoting the expansion of renewable energies. The aim is to reduce greenhouse gas emissions and increase security of supply. Such a strategy is also likely to have an impact on employment in Europe. But how can the net employment effects be determined and what restrictions are imposed on the robustness of the results by the methods used to estimate them? In the project **„Support Activities for RES modelling"** of the Fraunhofer ISI the proceeding was as follows:

- The effects depend on assumptions about the framework conditions, such as the existing energy prices, but also on the different policy measures used to achieve the targets. Therefore, different scenarios were formed, each of which depicts different assumptions in this regard.

- The impulses emanating from an expansion of renewable energies are very different: investments in renewable energies can on the one hand increase demand, but on the other hand also lead to higher costs; imports of fossil energy sources are avoided and, if necessary, exports of renewable energy technologies are stimulated due to their pioneering function. Thus, several impulses have to be taken into account.

- Stimuli emanating from the expansion of renewable energies can trigger different impact mechanisms. Different economic models depict the impact mechanisms in quantitatively different ways. In order not to be dependent on the results of one model, two different models were used in parallel.

The results show a range of possible effects. An expansion of renewable energies to 30 percent of energy consumption in Europe in 2030 would lead to net employment effects of 90,000 to 720,000 additional employees. The complexity of the effects allows for giving precise figures. On the other hand, the analyses show that even under unfavourable conditions the employment effects of an expansion of renewable energies would be small, but still positive. Under favourable conditions, the increase in employment is significantly greater, but at the same time it is clear from the magnitude that the expansion of renewable energies is not a panacea for solving all employment problems in Europe.

VII. Further information

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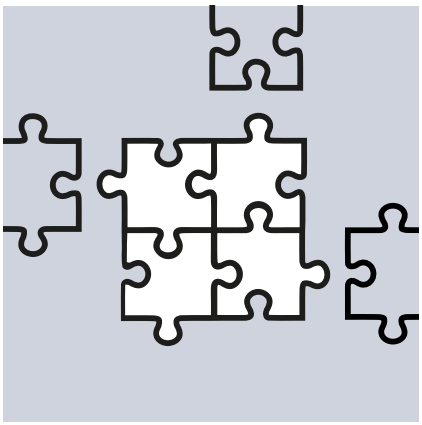
The following page provides various tools and data, for example for impact assessment and, if necessary, correction of innovations, www.rand.org/pubs/tools/TL159.html (retrieved 22.11.2023).

fact sheet

Transdisciplinarity



Winkelmann, M., Kopfmüller, J., Kammula, E., Knips, C., Marquardt, L. (2016): fact sheet Trans- disciplinarity. In: Ferretti, J. et al.: Reflexionsrahmen für Forschen in gesellschaftlicher Verant- wortung. Verbundprojekt „Nachhaltigkeitsmanagement in außeruniversitären Forschungsorganisationen“. BMBF, Berlin.

I. Brief description

Transdisciplinarity is the linking of scientific knowledge with practical experiential knowledge. This enables an effective connection of research processes and results to societal discussions through direct feedback of knowledge production to relevant discourses and problems. The involvement of actors external to science in the research process is a fundamental element of transdisciplinary work. Transdisciplinary projects require continuous exchange with the actors involved in order to develop and maintain a common understanding of the research subject, the research process and the intended goals.

II. Quick-check

1. Are there actors outside academia who can contribute practical or non-scientific knowledge to the research activity?

2. Are forms of interaction with practitioners (participation) envisaged in relation to the formulation and treatment of the research question?

3. Are research results formulated and accessible in a way that relevant actors outside academia can find and understand them?

III. Relevance

Transdisciplinarity is the joint processing of a question with the involvement of actors external to science (e.g. administrations, associations/chambers, companies, NGOs, etc.). In contrast to interdisciplinary research, transdisciplinary research topics do not exclusively involve scientific actors (→ compare criterion „interdisciplinarity“). Transdisciplinary work strives for a synthesis between scientific disciplines on the one hand and practical knowledge on the other. This enables the enrichment of disciplinary (as well as interdisciplinary) knowledge with empirically valid - because applied - experience and corresponds to the basic principle of efficient use of resources by increasing the relevance of results.

It also enables complex societally relevant problems to be adequately addressed that transcend conventional scientific disciplinary boundaries (for example, globalisation, climate change, demographic development, transformation of the energy system; → compare Criterion „Dealing with complexity and uncertainty“).

The integration of societally reflected practical knowledge renders orientation towards the wants and needs of potential users possible. User orientation (→ compare criterion „User orientation“) is therefore always a motivation of transdisciplinary work, as long as the users are not scientists (in this particular case → compare criterion „Interdisciplinarity“).

In addition, the translation work that researchers have to perform in transdisciplinary processes in order to make specialist discourses generally comprehensible contributes to the better visibility and acceptance of research results.

IV. Contents

In order to link scientific discourses with everyday knowledge, both actors from relevant scientific disciplines (→ compare criterion „interdisciplinarity“) and suitable practice partners must first be found, based on the research question. In the case of the so-called co-design approach, the question is already formulated together with the actors involved.

As soon as a viable mixture of actors from both fields interested in the content has been found, a process of communication can begin for the linguistic and conceptual rapprochement of subject matter and problem definitions with practical logics of experience and implementation. The central point is the formulation of problems and solutions that are compatible with both scientific discourse and the everyday practice of the non-scientific actors involved.

The organisation of transdisciplinary research processes is, therefore, a continuous problem-oriented process of approach and consideration to integrate perspectives from science and practice. The process requires moderation, time and the openness of those involved to change approaches and ways of thinking.

In order to realise this linkage of different forms of knowledge and experience, participatory processes are indispensable. Participation is understood here as the planned and controlled inclusion of actors external to science in parts of the research process. In most cases, the possibilities of influence are controllable by the scientific side moderating the process. The various forms of interaction between researchers and involved actors differ essentially with respect to the possibility and degree to assume responsibility. Participation is, thus, a necessary but not sufficient element of transdisciplinarity. Participation in itself (in contrast to transdisciplinarity) is not linked to the fact that scientific actors are part of a process.

Efforts to derive, substantiate and communicate research questions and results in a generally understandable way, as well as the resulting approaches to solutions, serve to improve the perception of research and the ability to discuss research processes in society.

V. Implementation

1. Joint identification of research needs:

Already in the run-up to the formulation of a concrete research question/research activity, it should be examined to what extent topics can be explored more comprehensively through the integration of practitioners and thus be worked on more purposefully.

2. Agreeing on expectations and goals:

Once this need for research has been identified, goals of and funding opportunities for a research project should be clarified. In this phase, it makes sense to discuss expectations and goals with all participants (including potential funding bodies) in order to develop a common understanding of the subject under consideration, the use of available resources and the envisaged results. Agreeing on a common language concerning the subject of consideration and comparing the underlying concepts avoids irritations and contributes to the development of a compatible perspective.

3. Establish continuous communication during the research process:

The respective benefit of participation must be recognisable for all actors involved (→ compare criterion „user orientation“); the results should, therefore, always go beyond purely scientifically usable findings.

The meaningful linking of knowledge interest with possible positive effects outside the scientific logic (for example, public attention, network formation, practical implementation possibilities, etc.) requires a continuous communication process. The distribution of roles, tasks, resources and decision-making competences between the project partners must be clearly regulated in advance. The purpose and sequence of the process steps, the function of the actors involved as well as deviations, problems and changes in the research design should be transparent for all participants (→ compare criterion „Transparency"). The actors' possibilities to influence the respective phases of the process as well as the weighting of the goals should also be clearly communicated.

4. Formulation and transfer of research results:

The actors involved should also agree on the formulation and dissemination of results and combine the knowledge and experience gained to a consensual synthesis. The type, content and form of joint results and products should be appropriate for the intended target groups and address the expectations originally formulated by the project partners.

5. Reflection on the research process:

It is desirable to document experiences, achieved effects and impacts both during and after the active research phase in order to enable learning processes in follow-up projects. The documentation requires sufficient detail and appropriate abstraction to make clear both, situational differences and overarching commonalities. This is all the more important because transdisciplinary research projects are usually not carried out within the framework of stable structures, but rather in collaborations that are limited in time and geared towards concrete individual goals, and are therefore transferable to other circumstances only to a limited extent.

VI. Case studies

- The project **„Bürger schaffen Wissen (GEWISS)"** (**Citizens create knowledge**) is a joint project of various scientific institutions with the declared aim of strengthening Citizen Science in Germany. The aim is to record, network, develop strategies and support citizen science activities with the help of materials, information and an online platform. https://www.buergerschaffenwissen.de (retrieved 22.11.2023).

- The **Climate Adaptation Santiago** (CAS) project was an official project of the UN Decade of Education for Sustainable Development (ESD) from 2005 to 2014. The project was funded by the International Climate Initiative (IKI) of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and ran from 2009 to 2012. The aim was to forecast effects caused by climate change and to support adaptation processes, as well as to find concrete solutions for changes already taking place in the Santiago metropolitan region. To this end, researchers from two science centres of the Helmholtz Association worked together with local and regional actors on the ground as part of a participatory process in order to both gain a deeper understanding of ongoing and potential changes and to build up the corresponding skills for adaptation among local partners. www.ufz.de/climate-adaptation-santiago (retrieved 22.11.2023).

VII. Further information

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fact sheet

Transparency

Daedlow, K., Podhora, A., Helming, K., Knips, C., Röllig, K., Brandt, M. (2016): fact sheet Transparenz. In: Ferretti, J. et al.: Reflexionsrahmen für Forschen in gesellschaftlicher Verantwortung. Verbundprojekt „Nachhaltigkeitsmanagement in außeruniversitären Forschungsorganisationen“. BMBF, Berlin.

I. Brief description

Transparency is an essential element of all other seven criteria for „research with societal responsibility“, because it is indispensable for an exchange within science and between science and society. Transparency, as it is understood here, goes beyond the presentation of methodology or making available selected data and research results. Rather, it includes transparent communication with society that is coordinated with and accompanies the research process. This includes the disclosure of the following areas as comprehensive as possible: (a) the initial situation of research, (b) the methodological and content-related orientation as well as the results achieved and their consequences, (c) the degree of scientific freedom and its use, (d) the integration of interests, (e) the institutional embedding and financing of research, including possible requests of research funders. In order to ensure comprehensive transparency, the communication of these focal points can be user group-oriented according to different research phases and contents. Possible limits to the degree of transparency can also arise in the process. Critical reflection and consideration are therefore always necessary.

II. Quick-check

1. Is transparency towards certain addressees (not) guaranteed within the framework for the research activity and why?

2. Which contents are (not) transparent in which phase of the research process?

3. Which communication channels are (not) used in which phase of the research process?

III. Relevance

Transparency in research is a self-evident part of good scientific practice. Efforts to make individual elements of the research process transparent have so far mainly been aimed at comprehensively presenting and critically reflecting on the methods used and the results achieved, especially afterwards in scientific publications and lectures.

If one goes beyond a primarily scientific user group, transparent research can facilitate the transfer of research planning and results to society by research actors reflecting throughout the research process about which interim results, decisions and methods they can present transparently to which addressees and in which way (→ compare criterion „user orientation“).

Transparency is the basis for exchange between research, politics, business and civil society about research content, goals and results. In this context, it is important to reflect on whom, when and how one wants to be, should be or even must be transparent (→ compare Criterion „ethics“). On the basis of this openness, societal groups, for example, can influence topics relevant to them and contribute to the definition of new research goals (→ compare criteria „transdisciplinarity“ and „user orientation“). Transparency also enables civil society, politics and the economy to better understand the decisions of researchers and to better track and verify the implementation and effects of research (→ compare criteria „reflection of effects“).

Transparency can also help to ensure that research investments in redundant projects are avoided if, for example, research funding organisations communicate projects and their results publicly using databases. This can lead to an increase in efficiency with regard to the use of resources in research.

IV. Contents

After critical reflection and consideration, transparent research with societal responsibility is characterised by the disclosure of the following focal points as comprehensive as possible:

- **Initial situation of the research:** The choice of normative assumptions, guiding principles and theoretical foundations that have an influence on research results must also be presented transparently beyond the publication in scientific articles. This enables, for example, a comparison or an evaluation of the chosen research bases with societal models (→ compare criteria „transdisciplinarity" and „reflection of effects").

- **Methodological and content-related orientation of the research as well as the results achieved and their consequences:** Research is societally responsible, among other things, if it communicates transparently what content and methods were chosen and why. This also includes disclosing the interim and final results achieved as comprehensive as possible. It is also important to explain the extent to which the results achieved are presented selectively (for example, due to limited resources or requirements for secrecy or confidentiality, etc.). Furthermore, content- related and methodological risks, unsuccessful research approaches, ignorance and uncertainties regarding the validity of the results can be communicated in order to also highlight limitations and challenges (→ compare criteria „Reflection on impacts" and „Dealing with complexity and uncertainty").

- **Degree of usability of scientific freedom:** Scientific freedom, the openness of research results and the independent decision of scientists for new content-related and methodological approaches are central to societal development. In this way, for example, research topics can be opened up that are not (yet) or only marginally recognised in civil society, the economy or politics. When planning research programmes and projects, the decision-making processes regarding the trade-off between societal needs and the necessary scientific independence can take place in a transparent manner. The relationship between individual and institutional freedom of research could be disclosed in connection with certain funding sources or funding channels.

- **Integration of interests:** Ideally, societal responsible research considers the range of societal interests equally. In addition, it can be explained what kind of knowledge (e.g. origin, degree of accuracy or empirical basis) is generated or which topics were contributed by which actors (→ compare criterion „transdisciplinarity"). Differences and areas of influence in this regard should also be reflected and communicated. This creates the basis for a broad public discussion about who influences and legitimises the interpretative sovereignty of the research results, for example with regard to their societal relevance.

- **Institutional embedding and funding of research, including possible requests of research funders:** Funding and the associated requests for research projects and strategies can influence individual assumptions, theoretical foundations, the content orientation of research and, consequently, the results that can be used by society. The same applies to institutional embedding, i.e. scientists are influenced by the specific thematic or methodological orientations of the research institutions or professional networks in which they work. In this context, conflicts of interest that arise on the basis of the funding and organisational embedding of the research projects can also be consciously addressed in the research team and, if necessary, made public (→ compare criterion „ethics").

- **Limits to transparency:** Certain results and steps in the research process may contain sensitive information, which makes it difficult to proceed transparently. Reasons for this can be, for example, the high competition for research funds (danger of idea theft in the application phase) or research aspects that are controversial in certain cultural circles or parts of society or concern national security issues. After the end of the project, issues of intellectual property rights in the context of the exploitability of research results may stand against complete transparency. Scientists must be aware of the limits of possible transparency in their case and assess the consequences for future

research (e.g. lack of funding, decrease or increase in research intensity on a certain topic) and for society. Considerations of the limits of transparency therefore require critical reflection (→ compare „Reflection of effects“).

V. Implementation

Transparency as a criterion of a societally responsible research process can be addressed to different user groups before, during and after the actual research process (→ compare criterion „user orientation“). The implementation depends on the research context and may also require that certain steps cannot be made fully transparent. Ideally, the project‘s own limits of transparency are defined:

- Project start: At the beginning of the research process, it can be communicated who is funding the planned research, what is actually being researched and who can be involved (→ compare the criteria „transdisciplinarity“ and „interdisciplinarity“). In this phase, this can be particularly important in relation to research funding institutions, for example in the context of coordination meetings and other involved actors from business and civil society.

- Research process: Transparency in the further course of research concerns, for example, the composition of the research team and the disciplines of the team members. Furthermore, transparency can be created through a (step-by-step) publication of methodological approaches and the research data generated with them, if applicable interim results, positions and suggestions for user groups or funding institutions.

- Communication of results: The dissemination of results can go beyond the general reporting obligation to funding institutions and include user-group-specific communication of results to scientific colleagues, involved actors, experts and the interested public (→ compare the criteria „transdisciplinarity“, „user orientation“ and „interdisciplinarity“). So-called policy briefs or strategy papers have become established for communication with policy-makers. For civil society and economic user groups, methods of transdisciplinarity and user orientation can be applied, for example through the dissemination of user-specific information in various media, flyers, websites, expert excursions and workshops. After the end of the project, the final disclosure of research results, methodological approaches, ethical challenges (→ compare criterion „ethics“), decisions and research steps can be due as comprehensive as possible, as long as this has not already been done during the project.

- Continuity: In the follow-up , the medium- and long-term effects of research can be identified, evaluated and communicated with the help of a transparent monitoring approach, for example via freely accessible user-oriented electronic evaluation systems.

VI. Case studies

In the following, case studies are presented that show how scientists can make research processes and research content transparent:

The project „**Hochschulwatch**“ by Transparency International Deutschland e. V., the taz daily newspaper Berlin and Freier Zusammenschluss von Studentenschaften (FZS) aims to disclose and make transparent economic research funding. It is intended to show which economic institutions support which research or scientists and thus anchor certain interests and positions in research projects, strategies and programmes in Germany. The published information usually refers to the entire research process or the entire funding period.

Up to now, transparency in research funding has not been mandatory and can also be denied to participating researchers, as an example at the University of Mainz shows. Here, a staff member and the Ombudsperson for Transparency were denied access to the contracts between the University of Mainz and the Boehringer Ingelheim Foundation. The contracts show, among other things, that the foundation has influence on personnel decisions and important organisational issues in the research project and can thus control research content and research results. The question who can determine who can take insight how extensively into certain research contracts is controversial and often has to be clarified legally (source for this example: https://www.spiegel.de/lebenundlernen/uni/geheimvertrag-in-mainz-wie-transparent-muss-forschung-sein-a-1037579.html, Spiegel Online of 08 July 2015, retrieved 22.11.2023).

An exceptional and innovative example of comprehensive content transparency is the project „**Open doctoral thesis**" (http://offene-doktorarbeit.de/, retrieved 22.11.2023). The topic of the doctoral thesis is „From Open Access to Open Science: On the Transformation of Scientific Communication". Here, the public can participate in the dissertation throughout the research process and use the results. In this case, „openly authoring" means that the work is published directly and immediately at the time of writing, freely accessible to everyone at all times under a free licence (CC-BY-SA). The current status of the work corresponds at all times to the status of the blog on the work. Transparency of content is thus ensured throughout the entire research process.

Transparent communication channels that promote societal responsible research are, for example, superordinate databases and information systems in which individual project results are prepared for specific user groups (for example www.engagedata.eu). In addition, the platform „**Science in Dialogue**" (www.wissenschaft-im-dialog.de, retrieved 22.11.2023) is a very diverse initiative to communicate research transparently to society. It is committed to discussion and exchange about research in Germany and integrates different user groups into research processes through various projects. Communicators create this integration in various ways, for example in the format „Citizens Create Knowledge" through a crowdfunding platform, surveys on research, discussion series and the Citizen Science Lab „Hack your City". In this way, social groups can view and influence different phases of a research process.

VII. Further information

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Focus: Contains, among other things, extensive information on attempts to define the concept of transparency in various scientific disciplines and in business.

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Focus: Problem-orientated approach in which a lack of transparency is seen as a deficit in the current science system.

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Focus: Transparency is the content of principle no. 5 in this article, which primarily emphasises the need to publish data and research results and make them accessible to the public.

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Focus: Position paper on the social responsibility of science with a focus on transparency in 1) project funding, 2) presentation of results, 3) in the university, and 4) through communication/discourse with the public.

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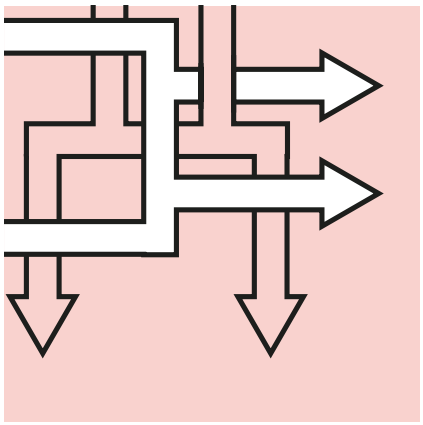
fact sheet

Dealing with complexity and uncertainty



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I. Brief description

The development of modern societies is increasingly characterised by complexities. Reasons for this are the growing diversity of sectors, institutions and stakeholders, the dynamic changes in their natural and social „environments“, and the diverse interactions between these elements. Cause-effect relationships are often indirect, time-delayed, interconnected and not directly assignable; feedback or amplification effects occur. Therefore, society - and thus also research - is confronted with considerable uncertainties and ambivalences of the knowledge required to analyse, evaluate and control such complex processes. Responsible research means recognising these complexities and uncertainties in the definition of the research subject, the design and implementation of the research process as well as the communication and application of research results, assessing their relevance and dealing with them in an appropriate manner.

II. Quick-check

1 . Have the relevant elements of the subject of study or the research question been identified and how are they linked together?

2. Are uncertainties (related to assumptions made or to be made, analytical methods used, validity of results obtained, etc.) identified and described?

3. Can appropriate methods be used to deal with complexities and existing uncertainties?

III. Relevance

Natural, technical or social systems are indicated as complex if they consist of several individual elements that exhibit a variety of interdependencies and the system characteristics cannot be fully explained by the characteristics of its sub-elements. The term „system“, which originates from system theory, refers to entire units of elements that are interconnected and interact for a specific purpose.

The complex situations or systems that are characteristic of modern societies are hallmarked above all by non-linear and dynamic interactions between their sub-elements and with their „environments“, by indirect, interconnected and not clearly assignable cause-effect relationships as well as feedback and reinforcement effects. This makes, for example, the appropriate reflection of various kinds of effects more difficult (→ compare criterion „reflection of effects“). Examples of such complex systems are the climate system, the transport system, the energy system, the health system or the financial system. Acting under conditions of complexity requires more and different knowledge, which, however, is only available to a limited extent and is often uncertain. Ignorance or knowledge uncertainties result primarily from:

(i) a long-term perspective - as necessary, for example, for climate-related issues - which prevents reliable knowledge, for example with regard to the future behaviour of actors;

(ii) limited knowledge of cause-effect relationships, dynamics and threshold values as well as future developments, for example of technologies or societal values;

(iii) different types of knowledge required, distinguishable in explanatory/system knowledge, orientation/target knowledge and action/transformation knowledge;

(iv) the large number of actors involved or affected;

(v) the contradictory nature of scientific and non-scientific evaluations and statements.

Accordingly, complex systems are difficult to understand and predict in their development, and their control is associated with considerable uncertainties. Although decision-makers in business, politics and administration have increasingly recognised the need for holistic approaches that take complexity into account, in practice an isolated treatment of individual issues still dominates. This is also due to the fact that complexities and uncertainties are often insufficiently considered and communicated in research. Examples of this are: not environmentally sound use of arable land for reasons of food or income security, resulting in increasing soil degradation; water use from groundwater reservoirs that is higher than the regeneration volume; and dam projects that contribute to energy security but also entail changes in land use or biodiversity as well as resettlement with a wide range of negative consequences.

IV. Contents

The following deficits in dealing with complex issues are frequently mentioned:

(a) a non-systemic consideration or setting of goals for a system, for example by focusing on sectoral sub-goals instead of goals that address the overall system's ability to develop;

(b) a non-systematic application of methods, for example in data collection, ignoring or misjudging interdependencies or system boundaries, lack of consideration of buffers to create error-friendliness in analyses, or a mere extrapolation of past trends into the future, etc.;

(c) a non-systemic analysis or development of strategies for action, if, for example, interactions between factors are faded out or problem repair instead of prevention of causes is preferred.

The analytical-methodological challenge therefore consists of, on the one hand, finding an appropriate balance for the respective research subject and process between excessive reduction of complexity - with the consequence of only limited relevance of results - and excessive demands for complexity - with the consequence of more difficult processing of research questions. On the other hand, researchers need to be willing and able to recognise and overcome these deficits.

V. Implementation

A standardised, generalisable procedure does not exist. In the following, ideal-typical steps are outlined that are considered necessary for a rational-pragmatic, goal-oriented and context-related handling of complexities and uncertainties.

I. Identification of relevant elements:

a. Determine the system boundaries relevant to the research question;

b. Investigate possible facets of complexity (spatial, temporal, thematic, actor-related);

c. Identification and analysis of the manifold factors and elements characterising a research subject, which are part of or influence a system;
d. Assessing the relevance of these factors and elements and deciding which of them can be considered.

II. Analysis of the interconnections:

a. Identification and analysis of the manifold interrelationships and interactions between these factors and elements to create the necessary basis for integrated considerations and decision support based on them (→ same criterion „integrative approach“);

III. Setting and analysing goals:

a. Identification, discussion or definition of status or development goals for a system, oriented to the respective issue;

b. Involvement of relevant actors (→ compare criteria „transdisciplinarity“ and „user orientation“);

c. Identify and analyse conflicting goals and actively seek approaches to help resolve or reduce them.

IV. Identification of existing uncertainties:

a. Assessment of existing or expected knowledge and resulting action uncertainties in their extent and relevance for the quality of results and their communication for the different phases of the research process; reflection on the analytical methods used, to what extent they contribute to the emergence of uncertainties. It should also be considered that the perception of the extent and relevance of uncertainties can differ between individuals or groups of actors.

b. Weighing up between uncertainties that are in principle reducible through research or the use of alternative methods („not-yet-knowledge“) and those that are assessed as irreducible („impossible knowledge“).

V. Methods:

a. Development and application of models useful to analyse natural or social processes and their interactions in a selective and complexity-reducing form (for example, agent-based models attempt to analyse the behaviour of actors);

b. Application of methods for determining and weighting such interactions, for example the cross-impact analysis that is used above all in the field of indicator and scenario analysis;

c. Application of the scenario method. In contrast to forecasts, scenarios do not predict future developments, but describe possible options in terms of an „if-then logic“ that are analysed using quantitative and qualitative methods.

d. Reflexive, i.e. problem-oriented modelling, transparent and carried out in dialogue with relevant actors, which contributes to the production of societal robust knowledge.

The methods used depend, among other things, on the degree of uncertainty. In the field of quantifying methods, simulations are used, for example, if the probability of occurrence of certain phenomena can be calculated or estimated (e.g. Monte Carlo method). The same applies to sensitivity analyses, which are used to determine how a system reacts to changes of influencing factors. Both are often used in combination with the scenario method.

I. Reflection:

a. Ensuring a reflexive research process that is capable of learning and adapting. This includes an appropriate inclusion of actor knowledge, the reaction to changes in important data and boundary conditions, the disclosure of assumptions made in analyses, or the assessment of methods used with regard to the uncertainties associated with them.

II. Communication:

a. Comprehensible formulation and availability of results for all interested parties, for example of model or simulation analyses, as well as of information on assumptions made or existing uncertainties;

b. Addressee-specific communication and dissemination of results (→ compare criterion „transparency").

The basis for all these steps is both, the respective scientific state of knowledge and the knowledge available among non-scientific actors. In order to be able to implement the steps mentioned, it is also necessary to implement the other criteria on „research with societal responsibility". In particular, an integrative approach, i.e. the consideration of relevant elements of the different facets of complexity, an inter- and transdisciplinary approach in order to be able to bring together the necessary scientific as well as practice-related knowledge, and the reflection of effects that result from development processes or interventions within and outside of a system are to be mentioned here. It is not least the lack of application of these criteria that leads to the deficits mentioned above. In this context, a major challenge is to organise and implement strategic agenda planning and the research process in such a way that the steps mentioned can be realised. Although it is certainly not always possible to completely and unambiguously assign the individual phases of the research process, steps I to III are likely to play a role primarily in the phases of topic identification, research design, methodology and implementation, steps IV and V more in the context of research methodology and implementation, and steps VI and VII primarily in the phases of result dissemination, monitoring and evaluation.

VI. Case study

Project „**ENERGY-TRANS** - Future energy supply infrastructures. Towards sustainability and social compatibility" (2011-2016) https://www.ufz.de/index.php?de=35950, retrieved 06.12.2023): In this Helmholtz Alliance project (i.e. a cooperation between Helmholtz institutes and university and non-university institutions), the analysis and evaluation of the transformation of the German energy system, in particular the interfaces between energy technology, planning procedures and consumer behaviour, are at the forefront of the research interest. The work in the various sub-projects attempts to describe and analyse the energy system as a socio-technical system with its complexities, interfaces and interactions between demand behaviour and technical developments better than in previous research practice. Against the background of the politically set energy transition targets, sustainability analyses and systemic risks and analyses of governance strategies for alternative transformation paths are carried out. Scenarios are developed, modelled and evaluated for the national level, but also for example regions and evaluated that take into account behaviour and acceptance patterns in relation to energy infrastructures and their interactions with transport infrastructures. Overall, the results should provide decision-makers with the knowledge they need to transform the energy system in an effective, efficient, socially acceptable and sustainable manner,

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Fraunhofer-Gesellschaft

Helmholtz-Association

Leibniz-Association

ISBN: 978-3-943679-54-0