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Co-Design of a Deep Geothermal Energy Implementation Concept for the Energy Transition in Germany - the Case Study of the Karlsruhe Institute of Technology

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ABSTRACT

The co-design of a deep geothermal implementation concept with potentially affected citizens represents the first step of a planned demonstration project at the Karlsruhe Institute of Technology (KIT). The aim is to develop a societal feasible and acceptable concept for the use of deep geothermal potentials for the renewable and CO_2-neutral heat supply of KIT Campus North area and, if desired and feasible for the heat supply of neighboring municipalities. The inter- and transdisciplinary work will comprise decisive findings and contributions to the involvement of citizens in a co-designed implementation concept of a deep geothermal demonstration project and the transformation process towards climate-friendly heat production at regional level. The transdisciplinary design and demonstration character of the approach will facilitate the transfer of results into practice. In addition, EnBW Energie Baden-Württemberg AG – one of the largest energy supply companies in Germany and Europe, supplying electricity, gas, water and energy-related products and services to 5.5 million customers – will apply the criteria and conditions for societal feasibility developed together with citizens for the implementation of deep geothermal projects. Beyond that, the co-design process will contribute to an overall societal understanding of the energy transition by providing and discussing information and bringing together actors from research and society. Based on this orientation knowledge, citizens and political decision-makers can use the results to develop visions and concepts for their regional renewable energy supply.

1. INTRODUCTION

The attempts to combat climate change and reach the objectives of the energy transition are among the greatest challenges faced by society, not only in Germany, but also in Europe and all over the world. Therefore, it is an important scientific and societal issue, especially in the context of more and more energy-demanding lifestyles and consumption patterns. Sustainability research aims to solve this crucial challenge by integrating engineering and natural sciences with social and ethical sciences as well as non-academic stakeholders and citizens. This objective is reflected by the implementation of transdisciplinary research in several fields of research and transformation. The interdisciplinary approach helps in removing disciplinary barriers, but a transdisciplinary approach additionally seeks to combine expert and citizens knowledge in an integrated research design to solving complex real world problems, by engaging a broad range of citizens and stakeholders outside academia. Inter- and transdisciplinary research is a complex and demanding task, but crucial to learn about the expectations and concerns of stakeholder and citizens and to create new ideas and ways to address the challenges and tackle the trade-off of technologies and projects aiming to combat climate change. The transdisciplinary approach facilitates mutual learning and understanding and can contribute to find new or alternative ways to increase the regional production of renewable energy.

2. FROM COMMUNICATION TO PARTICIPATION

In general, the implementation of energy infrastructure and new renewable energy plants is increasingly focusing on improved public communication through more information and transparency. In addition to the legal participation requirements, this approach should lead to a broader societal acceptance and less public resistance in the surroundings of the planned plant site. However, recent publications on participation processes point out that information as such is by no means sufficient to build-up confidence in the decision-making process. Rather, changed processes and procedures are necessary that guarantee openness with regard to adaptation options or alternatives and adequately involve diverse actors such as citizens directly in the decision-making process (Renn 2013; Strömer und Trufer 2009; Mbah 2017; Kuppler 2017). It is important to consider alternative criteria and values rather than focusing on only a few criteria, e.g. increasing the share of renewable energies, as is the case with conventional planning projects (Strömer und Trufer 2009, pp. 75-76). Such an approach to infrastructure and energy plant planning can help to make robust decisions, especially in conflict-prone planning processes. Examples of this can be found in the planning of renewable energy facilities, nuclear waste repositories and transport (Bergmans et al. 2015; Römmele and Schober 2013; Brettschneider and Schuster 2013; Gohl and Meister 2012; Seidl et al. 2013).

Although deep geothermal energy use is classified as very conflict-prone due to possible seismic risks, so far hardly any participation procedures have taken place within the framework of planning and implementation of geothermal energy plants. In the case of geothermal projects, participation is usually limited to informing the public, which in some cases takes place only after a project has been approved (Kunze and Pfeiffer 2018). Besides the accident risk, controversially discussed issues in the use of deep geothermal energy, which are particularly taken up by actors and citizens, are primarily the cost issue and the contribution to the energy transition (cf. Benighaus and Bleicher 2019; Kunze and Pfeiffer 2018). It can be assumed that citizens' risk perception of geothermal plants is high since media heavily reported on unintended consequences of geothermal energy use, respectively with regard to the lifting cracks in the city of Staufen in South-West Germany (Kunze and Hertel 2017). Therefore, a significant conflict potential and low public acceptance has to be expected for deep geothermal energy in general and the planned plant at KIT Campus North respectively.

Due to the very small body of social science literature and the lack of geothermal case studies in the state of Baden-Wuerttemberg, , many questions of participation in the context of geothermal projects cannot yet be answered satisfactorily. With this transdisciplinary co-design approach, we would like to contribute to closing this research gap in the field of renewable energies. The focus on the use of deep geothermal energy at KIT (North Campus) in the Upper Rhine Valley is for two reasons. Firstly, this expanded perspective gives the participating citizens the opportunity to discuss opportunities and possible disadvantages or even risks associated with the technology and shape the design of the implementation process and the utilization concept. Secondly, it will enable the transfer of the experiences gained within the case study to start the energy dialog between scientists and citizens on how to achieve a climate-friendly heat supply in the region and beyond.

3. THE CONCEPT OF TRANSDISCIPLINARY RESEARCH

A inter- and transdisciplinary research concept for the implementation of a deep geothermal demonstration project is developed and will be outlined here (see Figure 1). This project aims to contribute to the transformation of the heat supply system of the Karlsruhe Institute of Technology (KIT), one of the biggest research institutions in Europe, and to make KIT a climate-friendly institution with role model function. The concept comprises two objectives: The first objective is the inter- and transdisciplinary development of criteria and scenarios for the use of deep geothermal energy at the North campus of KIT with scientific experts and citizens living in the neighboring municipalities. The second objective is the identification and analysis of conditions for societal feasibility and acceptability, which are the cornerstones of a successful use of deep geothermal energy and long-term orientation towards the common good in the region of the Upper Rhine Valley, Germany. Through the transdisciplinary approach, relevant influencing factors on the chances and challenges as well as opportunity and risk perceptions of citizens regarding deep geothermal energy can be recognized and regional scenarios for a renewable energy supply can be developed. In such a transdisciplinary process, citizens reflect on the role of deep geothermal energy for the energy transition at regional scale and on conditions for its long-term use. The findings of the project will improve the scientific reflection on transdisciplinary research and give valuable insights in conditions required for the successful implementation of renewable energies in general.

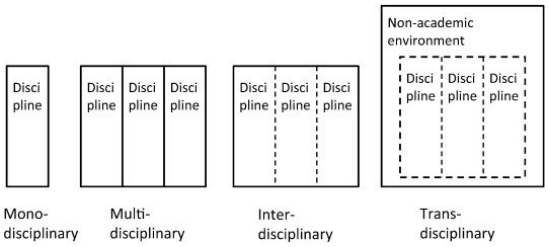

Figure 1: The concept of transdisciplinary research

In principle, the use of deep geothermal plants in the Upper Rhine Valley is associated with uncertainties, as knowledge and experience about their use and the possible unintended impacts on humans and the environment are limited to a period of about 20 years. Thus, the question arises how it can be ensured that energy infrastructure with a long service life, such as geothermal plants, are operated in the long term in the interest of society and the common good (cf. Kuppler and Hocke 2018). Experiences from other regions and research fields show that not only the design of the plant itself must be taken into account. Beyond that, the best possible integration of this plants in the energy transition and new system as well as accompanying processes, such as the monitoring of the plants by public authorities, are needed in order to enable long-term use and acceptability without undesirable side effects (Hocke et al. i.E.).

3.1 Comprehensive involvement of citizens in the co-design

The involvement of citizens living in the neighboring municipalities is required to get insights into local knowledge and values, which need to be incorporated into the implementation concept prior to an official approval procedure. The objective is to identify, analyse and discuss disagreements and points of conflict at an early stage, so that adjustments in the design of the plant and the implementation process can be made if possible or that alternative or even new solutions to combat climate change at the regional scale can be developed. Citizens based changes and improvements in the concept and design of an energy plant can increase the acceptability of the project (Stelzer 1993, 1994, Ketzer et al. 2018). Since infrastructure and energy plants are designed for long periods of time no robust statements or predictions can be made about future developments of energy plant operation in the context of potentially changed environmental conditions and societal values. Although uncertainties cannot be completely dispelled a decision must be taken, preferably one that promises to have no obvious or less undesired side effects in the long term compared to the alternative.

Up to now, projects in the field of renewable energy plants are mainly carried out in the classical way, i.e. the participation of citizens is often only achieved through information and consultation. It is clear from literature, that citizen participation, which only serves the purpose of getting public acceptance for the construction of a specific infrastructure or energy project, usually does not achieve the desired result (cf. Bock et al. 2017; Krütli et al. 2012; Renn et al. 2014; Schnelle and Voigt 2012). Rather, research indicates that early and comprehensive involvement of both stakeholders and citizens, going beyond mere information, is more effective (cf. Benighaus et al. 2016; Drazkiewicz et al. 2015). Prerequisites for a successful participation process are, for example, openness to other interests and the willingness of all participants to consider alternatives and conceptual changes and to make compromises (Bergmann et al. 2018). In a participatory project, disagreements and conflicts can be addressed and dealt with at an early stage and thus lead to an overall improvement of the project (Geißel 2009, pp. 403-404; Schweizer 2008, pp. 26-27; Kamlage et al. 2017). However, public participation does not guarantee the successful development of a concept that meets acceptability.

In order to make these findings fruitful, an inter- and transdisciplinary co-design is needed for the elaboration of an implementation concept for deep geothermal energy. The co-design process, however, is about further participation by developing a potentially possible implementation concept for a deep geothermal plant together with social actors. The aim is the transdisciplinary development

of an implementable concept that is supported by citizens, respectively those living in the surroundings of the planned plant at Campus North of KIT. A further innovation is that the focus is not only on the current and regional conditions for societal feasibility and acceptability of deep geothermal energy plants, but also on factors that can ensure long-term governance of supplying deep geothermal energy once the plant is in operation.

The results of such a co-design concept can be used for scientific reflection on successful conditions for the implementation of geothermal energy in the Upper Rhine Valley and beyond as well as its long-term orientation towards the common good. The deep geothermal energy plant for the climate-friendly heat supply of KIT (North Campus) is considered to be part of a regional energy transition. As such, it cannot be developed and implemented independently of the knowledge, values and goals of society For this reason, the co-design approach is intended to involve local actors and citizens in the research process at an early stage. Therefore, from the beginning of the research process citizens have to be included in the research design and involved in the elaboration of the implementation concept and the discussion of the results (Bergmann et al. 2010; Defila and Di Giulio 2016; Pohl and Hirsch Hadorn 2006).

3.2 Requirements for transdisciplinary research

According to Krohn et al. (2017) and Pohl and Hirsch Hadorn (2006), the first important prerequisite for a transdisciplinary research process is the recognition of real-world conditions. This refers above all to the social and technical complexity in the field of renewable energies. Secondly, contingencies must be taken into account, i.e. there should be a fundamental openness to changes and an adequate handling of uncertainties (cf. Wulf 2015). This leads to the third point, the changeability of boundary conditions that can influence the overall project. Fourthly, an open approach to one another is indispensable, i.e. the recognition of others and the questioning of one's own points of view. Fifthly, those involved in the research process must have sufficient flexibility and reflection to make the involvement of social actors fruitful and to be able to guarantee recursiveness, i.e. to revise the problem definition or to adapt the research design. Therefore, a transdisciplinary research process involves different phases of collaboration. Initially, the research process should be more transdisciplinary. This is followed by phases with a stronger disciplinary and interdisciplinary orientation, in order to once again experience a transdisciplinary opening in which the implementation concept is evaluated and, if necessary, changed by the citizens.

The results will be developed in a transdisciplinary research process. Building on this, the aim is to derive transferable conditions for success for the use of deep geothermal energy in the Upper Rhine Valley. In addition, conditions for societal feasibility and acceptability are derived, which relate to the long-term use of geothermal energy for the common good, which should be reflected in the utilization concept. The aim to implement an utilization concept for KIT, which is at the same time for the benefit of neighboring municipalities, refers to the fact that the results (criteria and scenarios) to be developed within the framework of the process must not be limited to advantages for a few individuals or specific groups, but to all potentially affected. This working definition of the concept of the common good is reviewed and, if necessary, adapted in the course of the process in line with the co-design approach.

3.3 The process of transdisciplinary research

The first step in the co-design process is to investigate, analyze and reflect the state of research on the involvement of social actors in the project planning or approval of renewable energy projects and if available geothermal plants respectively. Therefore, existing, planned and failed geothermal projects has to be identified in which citizen participation has more or less taken place (e.g. Staufen, in Baden-Wuerttemberg, Landau in the Palatinate and St. Gallen and Basel in Switzerland). With a view to the participatory format of the process, literature review will provide a differentiated and understandable picture of the opportunities and challenges of citizen participation in infrastructure planning projects such as deep geothermal energy plants. Based on these findings and the transferable results from the case studies, the methodic approach of the criteria workshops and the strategy for the selection of the workshop participants as well as the processing concept has to be designed. The participants of the workshops should be compiled in different group constellations to discuss the aspects of deep geothermal energy that they consider relevant at regional scale. An explorative approach needs to be pursued, i.e. both topics and their weightings has to be negotiated in a discussion process and condensed into as consensual (partial) result as possible. From the point of view of a co-design process, relevant topics need to be identified in advance on basis of the literature study and need to be discussed at the workshops.

A broad range of stakeholders and citizens have to be invited and involved to develop relevant criteria (see e.g. Benighaus et al. 2016) for a deep geothermal project as part of the energy transition at regional scale, which promises to be managed sustainably in the long term and to fulfil the conditions for societal feasibility and acceptability. The initial aim is to identify relevant (positive and negative) aspects at different levels (economic, ecological, and social), from which in a second step criteria for the acceptability of both the specific project and further deep geothermal projects will be developed. The participants have to be selected in such a way as to represent as many different groups of the population and societal actors as possible. Therefore, a part of the participants needs to be selected and invited by means of a random sample based on the official population registers. A second group of participants should be selected by means of targeted invitations (e.g. to citizens' initiatives or environmental non-governmental-organizations, school representatives and students as well as scientists) or by their own expressions of interest based on a call for participation in the respective local newspapers and media. This ensures that those actors and citizens who have a particularly strong interest in the energy transition and renewable energy technologies as well as the co-design process or are skeptical or critical are involved.

If possible, general and context-specific disadvantages and risks of regional deep geothermal energy use should also be deliberately discussed. However, it cannot be assumed that full representativeness will be achieved by the chosen method, since experience has shown that interest in this type of topic is higher in some population groups than in others (Geißel 2012, 210ff). The criteria workshop serves the explorative development of relevant criteria by the participants. The methodological approach should ensure openness and flexibility in order to be able to react to the input of citizens itself and, if necessary, make adjustments. The results of citizens' involvement and engagement have to be analyzed, evaluated and summarized by means of a qualitative content analysis and given to the participants of the co-design process for reflection and commenting in order to ensure that the input of the citizens has actually

been taken into account and is also presented and interpreted in a comprehensible way. Engineers and technical scientists in cooperation with social scientists will identify criteria for the development of socio-technical scenarios for deep geothermal heat supply as part of the energy transition.

The criteria elaborated need to be sharpened and further developed by being underpinned by scientific findings. One example could be the criterion ‘transparency’, which would require a more precise definition of the challenges that a transparent procedure has to take into account. Qualitative interviews with different actors and citizens can help to gain insights into different mind settings, expectations and concerns. Therefore, interviews need to be conducted with non-governmental-organizations or civic interest groups and, if necessary, one or two independent scientists or municipal citizens' representatives (cf. Lamnek and Krell 2016). In addition, expert interviews with for example scientists have to be conducted to prepare the scenario workshop (cf. Meuser and Nagel 2009; Lauth et al. 2015, 176ff). In these interviews, for example, questions can be clarified with regard to relevant technical or political-institutional aspects, which can be made available as background information for the development of scenarios by the actors and citizens if required.

For the transdisciplinary discussion of the results, a scenario workshop (see e.g. Nanz and Fritsche 2012, pp. 74-76) has to be organized with the citizens involved in the first workshop, at which the scenarios prepared will be discussed, modified, further developed and evaluated in small groups. The aim of the second workshops is to develop qualitative socio-technical scenarios. Possible future scenarios will be developed, discussed and evaluated with the participants based on the previously defined criteria. As a basis for the development of the scenarios, information will be provided by the scientists (e.g. on the usable heat quantity, costs, technology specifics) in order to support the regional citizens and relevant stakeholder groups in the development of qualitative socio-technical scenarios. This ensures that the resulting scenarios are defined with the help of all participating knowledge sources.

The specific questions, the relevant key factors and the selection of participatory methods have to be based on the results of the criteria workshops. Methods such as for example World Cafés, visual approaches (such as visual facilitation) or argument mapping can be envisaged. Contents to be addressed are the retention of the structure of the previous heat supply as well as possible alternative heat generation such as the planned deep geothermal energy, but also the use of biomass and large-scale solar thermal energy. The final definition of the workshop concept should take place in consultation with scientists and the energy supplier of the region. In the case study the energy supplier will be EnbW Energie Baden-Württemberg AG, one of the largest energy supply companies in Germany and Europe, supplying electricity, gas, water and energy-related products and services to 5.5 million customers. The outcome of second co-design workshop should be at least two scenarios, which are societal feasible and address the prerequisites for acceptability from the point of view of citizens. These scenarios contribute to define conditions in the sense of minimum requirements for the design of an implementation concept for the successful use of geothermal energy in the Upper Rhine Valley, in particular at KIT (Campus North). A compulsion for the agreement on scenarios is not exerted; a goal of the workshops is consensus-orientation, for all involved criteria and scenarios. Any dissent will be clearly addressed in the results and project decisions will refer to them in specific terms.

3. CONCLUSUONS

Shifting from inter- to transdisciplinary research comes along with the challenge to connect with a wider community of stakeholders and citizens. Beyond that, scientific system and orientation knowledge must be combined with non-academic knowledge types such as traditional and regional knowledge to achieve a more effective interface between science, policy and society and to merge both knowledge types to knowledge for action to achieve the ambitious targets of the German energy transition and to combat climate change. Perception and acceptance of new infrastructures and technologies, even for the ‘good’ renewable energies, which replace ‘bad’ fossil energy technologies, however, are not only influenced by the specific design of the technology and implementation concept, but also by institutions responsible for governance and by culture and patterns of behavior. These non-technical issues must be addressed, and the installation and operation of the deep geothermal plant must be tailored to reflect regional conditions and values. Thus, it is critical not only to look at the physical, economic and social issues, but also to focus on people themselves and to involve citizens in the design and implementation of renewable energy plants at an early stage.

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