

The Role of Societal Acceptance in Renewable Energy Innovations' Breakthrough in the Case of Deep Geothermal Technology

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ABSTRACT

The objective of increasing the share of renewable energy is high on the policy agenda in countries around the world. Although, the current understanding of social processes affecting the societal (non-)acceptance of innovative renewable energy technologies is rather limited. The issue of societal acceptance needs to be urgently addressed to support the knowledge among the key actors in the planning and implementation procedures to develop successful diffusion strategies. Societal acceptance in its three key dimensions (1) socio-political acceptance; (2) community acceptance and (3) market acceptance (Wüstenhagen 2007) is a complex interplay between different social processes. Although deep geothermal technology seems to have a high potential for sustainable energy generation in the long-term, especially the short term effects like induced seismicity and failures in communication may create anxieties and opposition among the directly and indirectly affected people that could hinder the further development and diffusion of this technology.

How to understand, deal and communicate the risks and benefits of deep geothermal technology in society and how to overcome barriers to its societal acceptance? Within a three years public-private PhD project (2009-2011) the main processes, key actors and key structures that create or hinder societal acceptance of deep geothermal technology will be surveyed. A main focus is currently laid on the specific socio-cultural and socio-economic conditions of the target regions in Germany and relevant neighbour regions. In this paper, the development and the potential of the societal acceptance approach will be reviewed with the aim to design a comprehensive framework for the case of deep geothermal technology. We take a look at today's state of societal acceptance of deep geothermal technology in the target region outlining the main barriers currently identified and introducing specific aspects of three geothermal projects in the cross-region France-Switzerland-Germany. Finally, we draw first conclusions about the development of future improvement strategies and finish with a methodological outlook.

1. INTRODUCTION

A question that seems quite relevant to be raised in the communication between sociologists and technical engineers working together in the field of energy technology research: What exactly are the interrelations between society and technology? From a techno-sociological perspective (Degele 2002) technology is perceived as a social product that shapes societies significantly. To gain empirical knowledge on the features of society and technology we have to deal with a high grade of complexity. In terms of technology we have to consider e.g. different sectors, different states of

technological developments, or different states of diffusion of technical artifacts. And in all these different dimensions different social actors are involved.

Technology is seen as a key factor to understand the processes of social change, especially the all-encompassing change of "modernization". Modernization shows as its main mechanisms growth, acceleration, differentiation, autonomization and individualization. An important social formation in this development is the creation of networks. While until the 20th century the big networks were built (e.g. telephone network, electricity and water grids, the internet) the fusion of networks seems to be a driving force in the beginning of the 21st century. In the energy sector these are e.g. the "smart" and "intelligent" solutions combining the power grid with the internet; in the communications sector new networks are created by integrating virtual interest networks to new information platforms, mixing different competencies of scientific experts and laymen.

The interfaces to the above described tendencies become obvious in perceiving the three dimensions of technology as defined in the social sciences: (1) the material dimensions of technical artifacts; (2) the action dimension of certain methods, practices and implementation modes; and (3) the knowledge dimension in terms of certain functions and interrelations of technological elements.

Society and technology shape each other in different ways and a variety of scientific approaches try to explain this specific relationship. In this paper we will refer in some part to the agent-network-theory (ANT) with the concept of techno-economical networks¹ which seems to be a promising approach. Complementary the concept of techno-economical paradigms is considered as both approaches seems particular interesting to integrate the issue of societal acceptance. This kind of integration seems to open up a space for the development of practical solutions to current problems in innovative technology diffusion as in the case of deep geothermal technology.

Although deep geothermal technology seems to have a high potential for sustainable energy generation in the long-term, especially some of the short term effects like induced seismicity and failures in communication may create anxieties and opposition among the directly and indirectly affected people that could hinder the further development and diffusion of this technology. How to understand, deal and communicate the risks and benefits of deep geothermal technology in society and, as it seems necessary, how to improve its societal acceptance?

¹ Referring to the approach of Callon, Latour and others and the research at the Ecole de Mines de Paris, for the techno-economical networks (see e.g. Callon 1992).

In section 2 we introduce the societal acceptance approach and outline the main methodological challenges to be considered in applying it to the study's research questions. The application of the approach to deep geothermal technology in a first attempt of developing a comprehensive scheme is content of section 3. In section 4 we review current barriers to societal acceptance and have a closer look at specific aspects of three geothermal projects in the cross-region France-Switzerland-Germany. Section 5 summarizes the findings and gives first conclusions on the question how to improve societal acceptance of deep geothermal projects. The paper ends with a methodological outlook in section 6.

2. THE SOCIETAL ACCEPTANCE APPROACH

How and when did the issue of "acceptance" enter social science, what is the state-of-the-art of current approaches and how is the phenomenon of "societal acceptance" defined? Further, how can we draw a link to the case of deep geothermal technology and what should we expect to achieve with such an approach? Some answers will be given in the following sub-sections.

2.1 Why research about societal acceptance?

2.1.1 Historical tracing

In her techno-sociological review, Degele (2002) traces the roots of the issue of societal acceptance to the generation of the "68's": the debates about technology became a political issue. This initiated in the 1970s a vital discussion in science and public regarding the effects of the technological development on social structures and social behaviour. In this context some effort grew to develop sociological research approaches around an assessment of technology effects, studies on the social well-being and around societal acceptance.

This fits well to Lucke's (1995, 1998) approach in referring to the concept of a "voting society" and her thesis of "the structural change of societal acceptance". This approach derives from the recognized dynamics (in market and opinion research) of decreasing acceptance and an increasing loss of acceptance of societies' members regarding an increasing number of social issues. Her thesis refers to the context of the "legitimation crisis" and the "change of values", widely discussed in the 1970s.

The term "acceptance" arrived in the 1980s in the German Duden, until 10 years later it became "chic" and a fashion word in politics and daily speech as a prominent figure of argumentation. In the social sciences it was applied especially in market- und opinion research and the new discipline of "technology assessment"², predominantly in terms of the loss of acceptance and the attempts to create or improve acceptance.

Legitimation induced by faith and force as pre-democratic forms are more and more replaced by voting procedures. But voting is getting harder and harder as it becomes less and less clear what is "true or false", "right or wrong" or "good or bad" with a rising awareness of complexity. Thus, the issue of societal acceptance is related to a certain state of democratic development and to certain established power relations in a society.

A technological factor in building a "voting society" is with no doubt the development of information and

communication technologies (ICT) and their respective networks. These technologies and the networks significantly influence decision-making procedures as they provide an abundance of alternative approaches and solutions with print, audio, visio and other medial formats. The evaluation of "facts" and the legitimization of decisions derive now from a multi-dimensional space of (competing) thinking, deciding and action alternatives strongly influenced by the "4th force" of the media.

As Ball (2000) states in referring to the findings of classical sociologist Karl Mannheim: Individuals create only in a limited sense their thoughts as they speak the language of their groups and milieus, thinking in the manner in which their groups and milieus think. And concerning the 4th force he asks:

"How, in a society flooded with mass advertising, can we hope to make decisions free from the influences of our environment?"

2.1.2 Sociological research about acceptance in practice

As stated above, acceptance research developed in the interdisciplinary field of technology research as (constructive) technology assessment (CTA, TA). The research about societal acceptance initiated other approaches like the "Leitbildforschung" or analysis of the "social well-being" and shifted lately rather into the direction of "societal acceptability" (Renn 2005). The research programme of "science and technology studies" (STS) integrates the questions about the origin, design and steering as well as the effects of technological developments and societal changes like reforms, management of crisis etc. (Degele 2002).³

Technology acceptance research is causal research, it is mainly market and opinion research moving between explanation and strategical interference; it investigates the potential of technologies' impact on societal well-being and of societal adaptation and adoption potentials; it tries to predict market chances and last but not least, deals with the questions of risks and societal risk acceptance.

Sociological fundamental research around technology acceptance addresses the dimensions, conditions and manifestations of the phenomenon "societal" or "social" acceptance. It considers the following aspects of acceptance: legitimization of acceptance; reasons and socio-cultural localization of increasing loss of acceptance; criteria and conditions of acceptance; and evaluation and development of strategies and instruments to create acceptance (Lucke 1998, Renn 2005). According to Lucke (1998) the main focus should be laid on the exploration of the interrelations between "acceptance subjects" and "acceptance objects", which will be more deeply explained in the following section. Regarding the social contexts and conditions different spheres of rationalities and existing legitimization processes, further acceptance logics and their mutual impacts should be investigated. Finally, the elaboration of strategies and instruments that improve and stabilize acceptance have been important aspects of this research field. Although, Renn (2005) states a shift to a mainly explanatory approach, in various current EU project approaches⁴ show a high interest in targeted risk and technology communication, and intervening action.

³ For a good overview of approaches dealing with the question about the potential social interference of technological developments see Grunwald 2003.

⁴ For instance the Esteem tool, see: www.esteem.org

According to Renn (2005) current technology acceptance research consists of empirical research about the acceptability of a technology including a comprehensive analysis of public opinions and positions, a normative perspective in considering ethical justifications about technology judgements, as well as constructivist concerns about references to “objective” expertise. As Grunwald (2003) argues, the ethical perspective in sociological technology assessment could only be integrated in raising the questions about societal responsibility and action potentials in technology developments by leaving the perspectives of technological determinism.

2.2 What is “societal acceptance”?

As “acceptance” is quite a fashioned expression in daily speech and in the social sciences, there still is some dust around the various terms and concepts like “social acceptance”, “social acceptability”, and “societal acceptance”. This is even more the case considering different languages in international scientific discourses⁵.

2.1.1 Definitions of social and in the broader understanding societal acceptance

The acceptance processes as described in the following consider *social* processes among social individuals or groups in the societal spheres of “community”, “market”, and “politics”. Dealing with questions that are relevant for certain parts of society we can speak of *social acceptance* as a disaggregated level of *societal acceptance*. Modern societies’ current problems, like implementing sustainable energy solutions, need rather short adaptation processes but with long-term acceptance structures. These sustainable acceptance structures will predominantly evolve if (positive) social acceptance processes take place in *all* societal spheres and mutually support each other. As technology diffusion is in the best case affecting society as a whole we should rather speak of societal acceptance as our target issue.

In the following we summarize Lucke’s and others statements (1998):

(1) Acceptance is the result of multidimensional processes that are determined by subjects (individuals or groups) and objects (e.g. geothermal power plants) and their specific conditions.

(2) Acceptance is a result of the acceptance subjects’ social constructions (interpretations of an acceptance object’s meaning; its appraisal etc.).

(3) Acceptance as a result is not inherent to the acceptance object and is not constant over time: it is a dynamic reciprocal process between the acceptance subjects and their examination with the dimensions of the acceptance object – e.g. a power plant and its operation features.

(4) Acceptance is something different than acceptability. Acceptability is the potential willingness of acceptance subjects regarding an acceptance object or in other words, the objects potential for being accepted (e.g. technical aspects).

(5) Individuals or groups can accept differently among the different dimensions of the object: conditions, motives, objectives and results. Thus, acceptance may only be partly

and for certain aspects and in time the subjects can revise their acceptance as well as in time non-acceptance can become acceptance.

(6) An acceptance typology defines a particular form of affirmation ranging from „informed consent“ to „forced compliance“.⁶

Finally, Lucke (1998) states that in speaking about “acceptance” a minimum criterion is “the subjects’ minimal understanding and belief as well as knowledge about alternatives regarding certain positions and actions that in principle could be realised” (transl. by the authors).

To step beyond the micro-level of social interactions, in referring to societal acceptance of technologies Wüstenhagen (2007) considers three key dimensions: (1) socio-political acceptance; (2) community acceptance and (3) market acceptance.

2.1.2 Acceptance subjects, acceptance objects and acceptance chains

Thus, the main elements of the acceptance process that occur in the above mentioned statements are the acceptance subjects, e.g. end-users of technology or political supporters, and the acceptance objects, e.g. a deep geothermal energy project. They build a relation in a specific social context and specific social conditions. Their relation may result in the subjects’ active or passive acceptance or non-acceptance behaviour reaching from opinions to (physical) actions.

The acceptance subjects’ decisions are linked to their interests and values, their social group and milieu features, the status they embody and their respective action frame (Ullrich 2000). Acceptance objects usually have a higher potential for interpretations and uses as conceived by their inventors and producers. Even designed for specific functions, technical artifacts typically give space for multi-functions and different parts and aspects of the object can be interpreted differently. Furthermore, historical roots of the acceptance object or some of its parts and certain interfaces and similarities with other objects shape the interpretation process and the mode of acceptance.

Conceived this way, acceptance unfolds rather as a “chain” (Müller 1998) of acceptance processes deriving from various dimensions of and beyond the object. Because oft these acceptance chains and possible acceptance fractures the process of building acceptance or non-acceptance can be highly dynamic and changing. (Non)acceptance processes may derive from competing rationalities and may transfer themselves in crossing the borders of their initial acceptance objects and their contexts. As described later in the case of geothermal energy projects some chains are reaching even topics like a tsunami.

As affirmation is given in between the limits and demands of certain social (e.g. the economical, political) sub-systems, often acceptance includes an affirmation in a sub-system and a rejection of another system’s logic. To apply this to the case technology of deep geothermal energy projects, it may occur that acceptance is reached at the level of perceiving it as a “green”, renewable and innovative technology (“green voters”) and reaches non-acceptance at another level for instance regarding the choice of the site of a power plant (people from the neighbourhood), the social and environmental side effects (Greenpeace members) and the type of operation or certain actors involved (community members).

⁵ German: „Akzeptanz“ und „Akzeptabilität“; French: „acceptabilité“, ...

⁶ Lucke (1995) introduces 12 types of acceptance

2.1.3 Factors of societal (non)acceptance

Although highly dynamic and varying in different parts and sub-systems of a society, the acceptance processes and strategies to maintain acceptance show similar conditions and basic structures: According to Lucke (1998) the main acceptance criteria are credibility, responsibility and accountability. Differences can be observed in specific areas of acceptance and in varying weighting criteria.

The probability of acceptance differs regarding the way how people are objectively or subjectively affected of related risks and regarding the (assumed or actual) interference and prevention of hazardous incidents. Differences can be identified in prevalent rationalities (about pragmatism, theory, materiality, formalisation or ethics) and social awareness patterns of certain situations.

An important factor in the creation of acceptance is the balance between knowledge and trust. This is particularly true in dealing with risks. We are all confronted with the complexity in our world of living. Thus, in creating acceptance, little knowledge about an object calls for more trust. And vice versa, the more (reliable and understandable) knowledge exists the less trust may be needed. As Lucke (1998) points out, the more willingness for acceptance is based on trust, the less dissemination of knowledge is necessary.

As democracy is a highly participative form of societal organisation the factor "participation" seems highly relevant in the creation of societal acceptance. Although, the question of "who to involve when and how?" so far is not solved sufficiently. This question appears e.g. in asking why elections are not necessarily creating social or societal acceptance. We find some arguments in Ball (2000) that even if choices are made through "democratic" elections their results may not meet societal acceptance because of narrow majorities, questioned statistical counting of the votes, etc. A lack of societal belief or consensus is a seed for non-acceptance and a potential for future changes.

In studying social acceptance processes of nuclear energy technology Müller (1998) refers to the "change of values" hypothesis in arguing that obstacles to acceptance appear if values and societal perceptions or goals linked to specific technologies can be questioned from a majority of society's members.

Single serious and sometimes even quite trivial incidents can mobilize large proportions of public opinion (Ball 2000). Marketing strategies can stabilize acceptance in linking separate objects e.g. "nature and automobiles" (Müller 1998). To achieve a loss in acceptance this strategy can be used as well in "anti"-campaigns. As Müller (1998) concludes, incidents may falsify political or economical information policies and lead to a loss of trust and acceptance not only regarding the acceptance object but also regarding the sources of information and the transmitting institutions.

The loss of acceptance of public authorities is aggravating further losses of acceptances to other objects. Müller (1998) outlines general communication failures between economical, political and civil society actors. In referring to the Tschernobyl accident, he identifies lacks in providing clarifying data and information in the situation of an acute incident. The problems are caused by an abruptly created public interest, the high pressure of fast actions and decisions and the resulting contradictions of the proposed solutions. In this kind of situation the acceptance subjects

are exposed to a high degree of uncertainty. Considering for instance the "2020" goals as a reaction on climate change, today's politicians and experts face as well the problems related to time pressure.

2.3 Societal acceptance of innovative renewable energy technologies

2.3.1 Technology and society

Where are actually the borders and interfaces between technology and society? And what questions arise out of the particular relation(s) that characterises both, society and technology.

To outline the technological dimensions that have to be considered in coming closer to answer this paper's leading question, we want to shortly come back on the general question of "what is technology" focussing on energy technologies. Taking up the extreme positions of technology determinism and social determinism we can raise the two questions:

1. What does technology do *to* and *with* society?
2. What do social actors do *to* and *with* technology?

Some resulting questions are: How is technology changing social behaviour and structures? How are social structures inscribed in technological artefacts? How do consumers use and multi-use technology, e.g. change the initial foreseen function? And how do social actors interpret technology?

In the case of energy technologies we can observe the following example features:

- (i.) They supply people with energy, implying the uses of electricity and heat in daily living, consumption, life-style, work, etc.
- (ii.) Renewable energy technologies try to meet the sustainability needs: for instance the reduction of CO₂-emissions and being "a renewable".
- (iii.) Energy technologies secure or challenge power structures: e.g. of state and markets.
- (iv.) Energy technology innovations bear certain (economical, technological) risks as well as they shape the context of societal risks.

2.3.2 Methodological challenges

The dimensions of societal acceptance on the one hand and of technology on the other hand and their respective complex structures lead to a number of theoretical and empirical challenges.

Generally, the discontinuity between the individual level and the societal level has to be considered especially in attempts of extrapolating findings from assessments at a project level or at the level of one specific technology into general conclusions. In this respect each approach has to be clearly allocated to the target scope: e.g. the project level and its specific needs and conditions or the breakthrough of a technological innovation on more global level.

To explain and assess current states or dynamics of social or societal acceptance appropriate indicators have to be discovered or developed. These indicators can range from

individual opinions to public actions e.g. according the implementation of power plants.

Theoretical challenges

From a theoretical point of view, the issue of societal acceptance is confronted with different theoretical approaches concerning theories about social subjects or actors as well about the acceptance objects and the interrelations between these two. Furthermore, theoretical approaches differ in their scope ranging from the micro via the meso to the macro level.

For instance, from the systems theory point of view the issue of societal acceptance is perceived on the result level: the existence of a legitimized acceptance object is already including societal acceptance, whereas non-acceptance would automatically lead to (a long-term) non-existence of that object. From the social action theory point of view, societal acceptance is conceived as a product of social action with a focus on the social interactions that build the acceptance structures.

As Ullrich (2000) identifies, different definitions and operationalizations concerning the interpretation of the subjects' interests and values exist in social science. This can lead to different results in determining particular decisions. For instance are political or general values and orientations associated with ideology, orientations of justice, affiliations to political parties or with a materialism / post-materialism index.

Empirical challenges – How to measure societal acceptance?

What can and what should be measured and how should the results be interpreted? Societal acceptance as a whole can hardly be measured, but we can find quantitative and qualitative indicators to make assumptions on the state of acceptance regarding parts or levels of the acceptance object.

The first problem occurs in determining the boundaries of the acceptance object: what *is* or what aspects belong to for instance a deep geothermal project or *the* deep geothermal technology? This problem evolves in considering the multi-dimensional character of a technology from the idea until the artefact.

In opinion polls or face-to-face interviews we find different types of *subjective indicators*, e.g. direct opinion on existing features of the acceptance objects dimensions/areas; or general preferences towards the underlying problems that the acceptance objects try to solve. Examples of subjective acceptance indicators are e.g.: the societal value given to the acceptance object (good, bad); or preferences for certain revenues (who should pay for occurring costs).

To explain acceptance opinions as key factors mainly consulted are e.g. socio-demographic factors of the acceptance subjects; the status of the acceptance subjects related to the problematic in discussion; and the awareness of personal and societal benefits (Ullrich 2000).

Although, the interpretation of results contains some traps. Firstly the given opinions are given in a specific situation of the investigation, they are subjective and they must not even be true. Furthermore and secondly, people announce one intention in opinion polls one day and then go and do the opposite the other day. Last-minute events can change everything from one minute to the other (accidents, terrorist

incidents, newly published scientific results, etc.). Finally, in measuring changes in acceptance behaviour, sometimes the acceptance values refer to another way of measuring as done in the base case and the results are not related to an actual change of acceptance.

The often applied "NIMBY" approach ("not in my back yard") in opinion questions may not be a sufficient indicator for a general acceptance but rather for the grade of acceptability of an acceptance object.

What is more difficult and still lacks development is research involving *objective indicators* to assess societal acceptance. Here, the challenge is to empirically operationalize an acceptance object in a comprehensive way and find appropriate ways of measuring the indicators. These indicators may hardly be disconnected from their specific acceptance object and show restricted potential of transferability to other fields. Quantitative approaches may be applied in working with data of historical analysis and longitudinal analysis.

2.4 An interdisciplinary approach of medial range

The complexity of the research subject calls for the development of creative research methods and instruments. The dimensions where technology meets society in the case of deep geothermal technology are multi-scaled and are subject of different disciplines such as technical engineering, geology, geography, economy, sociology, political sciences, information and communication sciences, law, to name just the most obvious ones. Taking into account a cross-regional application of this approach it seems important to integrate the knowledge of comparative cultural sciences.

In developing methodologies to define indicators and identify explanatory factors for social and societal (long-term) acceptance of sustainable technological solutions deeper knowledge is needed. With this knowledge we may and should not directly influence societal acceptance regarding acceptance objects like a deep geothermal technology project. But we can help identifying barriers and give support in finding solutions to overcome these barriers.

Coming back to the initial question of this paper: "What is the role of societal acceptance in renewable energy innovations breakthrough?" we have to draw the link to innovation theories and strategies.

2.4.1 Techno-economical networks and paradigms

In enhancing classical innovation theories (e.g. Rogers 2003) with sociological theories of technological innovation, currently the perspective shifts from the concept of a "state of innovation breakthrough⁷" or an "evolution of an innovation⁸" to mutually supporting "techno-economic networks (TEN⁹)" on the micro-level and to macro-level approaches like trajectories of techno-economic paradigms (TEP¹⁰). As Green et al (1999) outline, both TEN and TEP show a lack of explaining particularly the aspect of "decisions" in innovative processes.

⁷ Jolivet, Laredo and Shove 2003

⁸ Nelson and Winter 1982

⁹ Callon 1992

¹⁰ Perez 1983

The approach of “techno-economic networks” deriving from the agent-network-theory (ANT) tries to cross the boundaries of traditional subject-object relations and seem to be a promising way to address the interdependencies between technological and social developments. The “techno-economic paradigms” integrate the aspect of “change of values” in innovation processes. We think that the issue of “societal acceptance” can enhance the further development of innovation theories. On the other hand an integrative approach of this kind would also support a further understanding to the question on barriers to societal acceptance.

Facing the high grade of complexity of such a theoretical and empirical integrative approach, new methods and instruments in problem solving and simulation should be considered (e.g. TRIZ and multi-agency-modelling). Furthermore, interdisciplinary approaches like discourse analysis seem particularly promising in further developing the societal acceptance approach.

2.4.2 Theoretical and empirical limits

Social or societal acceptance yet seems to create a strong limit concerning the location of the acceptance objects. Thus, a starting point of any analysis should be specific regional settings.

3. SOCIETAL ACCEPTANCE OF DEEP GEOTHERMAL ENERGY PROJECTS

What benefits provide the approach of “societal acceptance” to the field of deep geothermal technology? We might find some answers in identifying the current difficulties in the pathway of the (technological and societal) breakthrough of this promising innovative technology.

Renewable innovative energy technologies are getting more and more mature from a technical perspective. But as stated by experts on EU or national level, in coping with time pressure in dealing with energy scarcity and climate change the aspect of social acceptance becomes more and more important. Particularly investors’ and end-consumers’ acceptance is crucial and a minimum condition for the needed fast and wide-spread dissemination of new technological solutions.

3.1. Current situation

In a paper of the ENGINE¹¹ project called “Non-technical Barriers preventing a Further Use of Geothermal Energy”¹² the authors derive from the general assumption that in general there is a broad acceptance of plants using renewable sources of energy by the public at present which evokes the question: “Why does this not count for geothermal projects?”

The authors shift the focus to organisational and perception challenges that have been identified along financial as well as legal and administrative issues in geothermal projects. They identify delays, modifications and failures as negative

¹¹ ENGINE was a European project in FP6 (2005-2008) for coordination action. The acronym stands for: Enhanced Geothermal Innovative Network for Europe. In the frame of the project a best practice handbook with a special focus on EGS technology was published.

¹²http://engine.brgm.fr/Deliverables/Period2/ENGINE_D36_WP5_NonTechnicalBarriers_IE_29102007.pdf

factors for acceptance and cite as reasons: funding difficulties; administrative difficulties; organisational difficulties (lack of resources) and insufficient perception and acceptance.

They point out the complexity of this type of technology as it isn’t a “one-way technology”, specific local contexts had to be considered and expert networks were crucial for a successful project implementation. Further a vicious circle is outlined: That on the one hand a market for geothermal energy was needed but had to be created in the first hand.

3.1.1 Review of current (general) barriers to societal acceptance

Concerning societal acceptance the ENGINE paper addresses some important aspects, although lacking a comprehensive approach. The identified aspects are cited below:

- (1) “People who are not familiar with the opportunities and benefits from the use of geothermal energy and who have only little knowledge about technology tend to have prejudices [...]”
- (2) “Often these people have had, or have heard about, negative experiences of not-comparable projects and transfer this experience to new geothermal power and/or CHP plants. [...]”
- (3) “Renewables are often related to subsidies which finally have to be paid by the public not knowing that this is also considerably true for fossil fuel energy (in the past and still in the present) [...]”
- (4) “[we need to consider the] perception of public and politicians and of local authorities and plant affected people [...]”
- (5) “[...] so far the role of deep geothermal energy is perceived as playing a small role compared to solar and wind.”
- (6) “[...] lack of awareness of the benefits [...]”
- (7) “[A project] affects mobility, health, environment, labour market, attractiveness/image of a community.”
- (8) “[...] weighing pros and cons is dependent on present situation and given alternatives [...]”
- (9) “Adequate communication is crucial – not too early and not too late.”
- (10) “[...] bottom-up projects with local participation seem to be (more) successful.”
- (11) “The public trustworthiness of the plant owner and operator can play a central role in the acceptance of a geothermal plant and the acceptance of the energy delivered to the community from this owner / operator.”
- (12) “The acceptance of geothermal energy in the public and by politicians and administrative facilities needs to be improved [...]”

Considering the experiences of the latest conferences in Germany on geothermal energy, we can confirm lacks of

political and market acceptance deriving mainly from the risk awareness of politicians and investors regarding the reservoir finding and economical exploitation. The factor of uncertainty is still a variable in the main fields of action in deep geothermal technology that can be identified e.g. in accounting procedures, exploration tools like seismic metering and computed simulation models, concerning long-term plant operation as well as in understanding the different types of deep geothermal technologies (EGS, Hot-dry-rock, Hydrothermal etc.). So far civil society was hardly presented in the conference topics but certain problems were already raised such as the effects of seismicity on residential areas and general communication problems.

3.2 Development of a comprehensive approach

To develop improvement strategies further questions arise out of this first analysis:

- i. Which are the partial acceptance structures and which discourses can be identified in which groups of actors? (For instance which negative experiences, subsidy policies, etc.?)
- ii. Are there regional differences in the findings?
- iii. In which way should which parts of the public be integrated or informed in the project phases (planning, implementation, operation)?
- iv. How to deal with technology related risks?
- v. Which methodology and what kind of indicators were found to be most useful in this assessment?

To better allocate the issues and questions raised so far we developed the following scheme that links the main technological dimensions that are important in the analysis of societal acceptance.

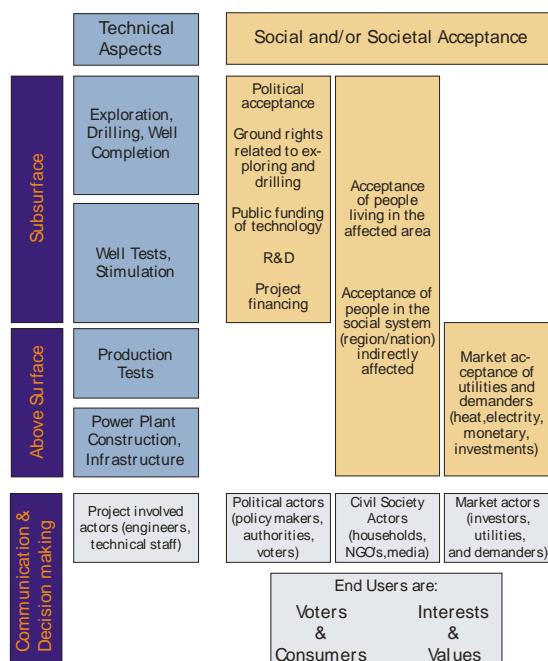


Figure 1: Societal acceptance spheres of deep geothermal technology projects

Fig. 1 shows the main acceptance spheres and how they could be linked to different steps and technological aspects in the case of a deep geothermal technology project. Although an enhanced conceptual frame would as well have to consider the ideas and pre-technical aspects of a technology like technology concepts, technological paradigms and scientific pre-studies on technical issues. As the starting point for this paper were certain implementation features we developed this frame on a rather project focused perspective.

3.2.1 The acceptance subjects of deep geothermal projects

With their embodied roles as voters and consumers, the direct or indirect end-users of the technology output (heat, electricity, monetary investments) have an important role in creating societal acceptance of a new energy technology.

Regarding the acceptance potential we should differentiate into the “hardware” dimension and the “software” dimension. In the first dimension, strongly related to the physical aspects of technical artifacts, the main questions are:

- i. Where are the technical artifacts located? Or: How are they (dis-)integrated in residential areas?
- ii. Which effects are produced by the technical artifact for the social, ecological and economical environments?
- iii. What are the socio-cultural and socio-economical characteristics of the affected people (knowledge, power, specific interests, values and needs etc.)?
- iv. Which are the measurable (direct and indirect) benefits and disadvantages of these direct effects for which actors?

The second dimension deals with the communication flows and the ways in which objective facts and subjective knowledge are integrated in producing the respective energy technology discourse. The following questions seem to be highly considerable:

- i. What is the state of knowledge in the different acceptance spheres (political, communal, and economical)?
- ii. Which links and interfaces to other technologies, aspects of those technologies, and/or technology related social, ecological and/or economical dimensions can be identified influencing opinions and decisions?
- iii. Which communication strategies can be identified inside and in between these spheres (type of information, time and way of dissemination)?
- iv. Which positive and/or negative impacts do these communication strategies show in terms of driving or hindering the further development and dissemination of this energy technology?

These questions should be the starting point in identifying further explanatory factors for social /societal acceptance.

As technological Innovations are characterized of certain degrees of uncertainty and insecurity, the risk awareness and risk perception of different acceptance subjects should be well addressed in both, the “hardware” and the “software” dimension.

4. GEOTHERMAL PROJECTS IN THE CROSS-REGION FRANCE, SWITZERLAND AND GERMANY

In this section we present the main findings of a site visit to the EGS-project in Soultz-sous-Forêts (France) and an interview with the scientific coordinator and the project seismologist. In the cases of the EGS-project in Basel and the heat pump project of Staufen we carried out a short analysis regarding type of communication concerning seismicity in the main news accessible currently in the internet. Even if not a deep geothermal technology project, we included the case of Staufen to find out about the above described "chains" that build new links between similar but not actually comparable acceptance objects with the result of common interpretation patterns.

4.1 Results on the site visit to Soultz-sous-Forêts

In Soultz the EGS project affected the natural and social environment in three areas: (1) seismicity, (2) noise at the project site during drilling and during power production and (3) bacteria in the reinjected cooling water in a nearby lagoon.

The problem of noise had to be treated within regulative thresholds. During the first years (end of the 1980s) the noise was an effect of the drilling phase. The project management received complaints from the neighbourhood towns' population. People called directly the project management or complained by local authorities, e.g. the mayor. Project personnel answered the phone with a strategy of being honestly transparent. The communication at the beginning of the project was not very much advanced as it is today.

Altogether four hydraulic stimulation tests were carried out in the projects lifetime: 2000, 2003, 2004 and 2005. In June 2003 an earthquake with the magnitude of 2.9 had a first effect on the population. There was no material damage but people were shocked. They were not prepared of such an incident. According to the seismologist, the risk of damage at such a level of seismic action is very low. From a town 15 km away the Soultz project management received peoples' feed-back that objects in the houses were moving. People seem to be particularly sensitive when seismicity occurs in the evening and night time. In the case of the 2.9 earthquake it happened between 20-21 hrs. In total 30 people claimed damages induced by the earthquake. The damages were evaluated by impartial experts of the insurance companies. The evaluation did not verify a relation to the project's induced earthquake.

Since 2006 chemical-acid stimulations were carried out to reduce the effects of seismicity. But this method is less effective, as it stimulates only local effects of cracking the rock. To have enhanced effects the amount of acid had to be increased but so far not tested. There was no seismic action in 2006 but after the Basel incident people were getting upset and the Soultz project received many reactions from the population as well as from political actors with questions like: "Do you do the same to us here?" or "What did you do in Basel?" After the earthquake in Basel the local and regional authorities created an expert panel to exchange about and evaluate stimulation plans with the project management.

The social acceptance of the project has increased until today but so far no assessment on this issue has been carried out. Indicators from the project's view are fewer complaints and less negative articles reacting on the projects activities. The temporary dislike of the population had not much impact on the projects activities but partly raised the costs

e.g. a noise-preventing wall. The impact of negative reactions of the public and authorities modified the project procedures in three ways:

- (1) development of better communication strategies and tools – on the basis of "transparency on actions and risks and effects"
- (2) scientific research on solving physical qualities related to the action to reach a high grade of controlled actions
- (3) alternative technical measures such as chemical-acid stimulations

As noted in outside communication so far the project's output of producing electricity is hardly recognized and some people think the project produces heat. In terms of risk-prevention no explicit communication strategy exists at present.

The communication is related to project knowledge and advertising information events at the project site. Politicians are invited and the population especially of the neighbourhood region. The project is present in newspapers (from local to international press) and in TV (e.g. Discovery Channel). As Soultz was from the beginning a European pilot project, at the site frequently guided tours and regular public information events are offered to the public. As noted in comments of visitors or at public events, this publicity makes people in the region proud of "their" geothermal project.

Concerning the question of positive effects for the population the benefit is not local "green electricity" as it is injected in the main grid and people don't even know about the electricity production as much. The positive effect for the public is mainly perceived as the immaterial benefit of publicity that seems to balance out the negative effects such as the earthquakes.

In the meanwhile (since almost 10 years) people became familiar with being exposed to the earthquakes.

Concerning the environmental impact of the cooling water, since the discovery of the bacteria, they were deleted with injected sodium hydroxide and regular controls have been carried out to evaluate the water quality.

4.2 Results of the news analysis of the Basel earthquake

4.2.1 Starting point: induced seismicity in 2006

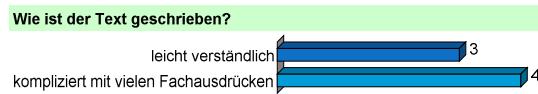
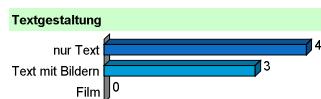
Following the Soultz experiences a new EGS project was planned in Basel (Switzerland). Financed by a Swiss-German consortium the first of three boreholes has been drilled down to 5.000 m and first stimulations have been carried out in December 2006. The stimulation tests have been stopped after a seismic event exceeded a magnitude of 3.2 during the tests. Afterwards, another three seismic events occurred with magnitudes higher than 3.0. As a consequence the project has been decommissioned by the local authorities and a risk analysis is carried out in recent days.

4.2.2 News Analysis

In the case of Basel we analyzed 2 newspaper articles, 2 expertise and 3 press releases with the following titles:

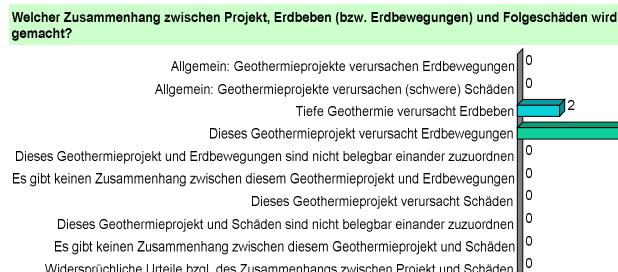
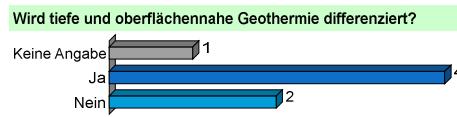
„Pilotprojekt Geothermiekraftwerk Basel: Aufarbeitung der Gründe für die ausgelösten Erschütterungen“ (09/12/2006)
„Menschengemachtes Erdbeben bei Basel“ (13/12/2006)
„Erneut Erdbeben am Bohrloch von Basel“ (14/12/2006)

„Das Deep Heat Mining-Projekt in Basel“ (16/01/2007)
 „Genaue Abklärungen zu Deep Heat Mining“ (11/02/2008)
 „Das Deep Heat Mining-Projekt in Basel, aktuelle
 Meldungen“ (20/01/2009)
 „Geothermie“ (n.n.)



The target regions reached with this news were specifically Basel, Switzerland and Germany. Additional “voices” are given from the author to politicians (1 case) and to experts (2 cases). Expert statements are part of the content in 3 out of 7 cases with the functions of project leaders, investigators, public health service, crisis management, president of association. Cited politicians (2 cases) were at the deputy level.

The most frequent signal words in the news were “fear”, “risk” and “shock”.



Concerning related technologies the news refer in 1 case to another regional geothermal technology project and at international scale in 5 cases to fossil fuel or gas technologies (2 cases), mining (2 cases) and heat production/heat pumps (1 case).

Concerning related seismic incidents the news refers to regional earthquakes (4 cases) and an international tsunami (1 case).

4.3 Results of the news analysis of the Staufen earth movement

4.3.1 Starting point: Earth movement 2008

The town hall in the village Staufen – located in the SW of Germany – has been refurbished. To finalize the restoration a ground coupled heat pump system including seven borehole heat exchangers was planned to provide heating and cooling energy. Approximately six months later first cracks occurred in several buildings in Staufen centre and first investigations found out, that the village is lifted up with a ratio of 12 cm per year.

Cracks in buildings are known in Staufen since decades, but first expertises said, that there is a link between the recent

uplift and the drillings near the town hall caused by Anhydrite rocks in the ground and artificial groundwater pathways.

Different from induced seismicity the cracks in Staufen are “visible” and a huge number of TV and magazine reports published the Staufen story. And although the linkage between the boreholes and the uplift in Staufen is not yet confirmed by final investigations, the public is already convinced by this cause-and effect-chain.

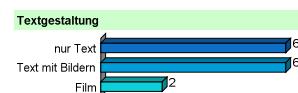
4.3.2 News analysis

In the case of Staufen we analyzed 7 newspaper articles, 1 blog, 3 forum contributions, 1 press release and 2 video contributions with the following titles:

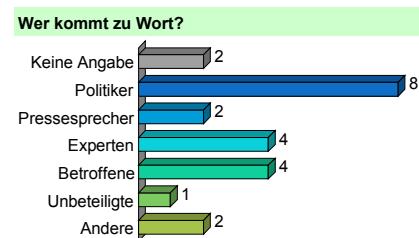
- „In Staufen der “Herr der Risse“ (05/03/2008)
- „Nach Erdwärme-Bohrung: Eine Stadt zerreißt“ (11/11/2008 und 31/12/2008)
- „Im süddeutschen Staufen hebt sich der Boden“ (08/11/2008)
- „Ein Riss geht durch Staufen“ (12/11/2008)
- „Staufen! Nichts als Vermutungen!“ (15/11/2008)
- „Ende einer Idylle - Die Stadt Staufen zerreißt“ (15/11/2008)
- „Geothermie verursacht massive Schäden in Staufen“ (16/11/2008)
- „Land zahlt Ursachenforschung“ (18/12/2008)
- „Staufen gerät aus den Fugen“ (22/12/2008)
- „Schneller als Venedig“ (09/02/2009)
- „Baden: Rissige Häuser durch Geothermie“ (21/04/2009)
- „Dossier: Chronik der Risse in Staufen“ (25/05/2009)
- „Eine Stadt zerreißt“ (n.n.)

Some of the news citing other articles including:

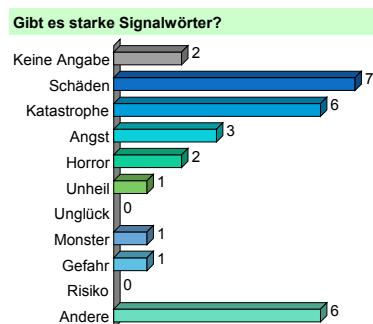
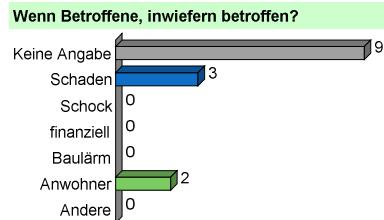
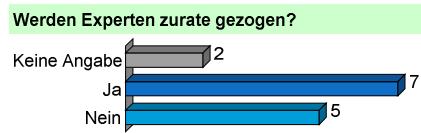
- „Eine Stadt gerät aus den Fugen Geothermie Bohrung lässt Altstadt sinken Mit Staufen geht's bergab“
- „Eine Stadt zerreißt Erneut Erdbeben am Bohrloch von Basel“
- „Nach Erdwärme-Bohrung: Eine Stadt zerreißt (Jens Lubbadeh); Staufen geht hoch: Fotostrecke (spiegel-online)“
- „http://de.wikipedia.org/wiki/Schlammvulkan_auf_Java“
- „Leitfaden zur Nutzung von Erdwärme mit Erdwärmesonden“



The target regions for this news were Germany, Baden, Brühl, Stuttgart, Southwest-Germany and Basel.

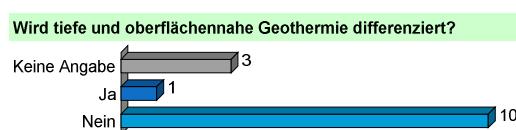


Others: members of the forum

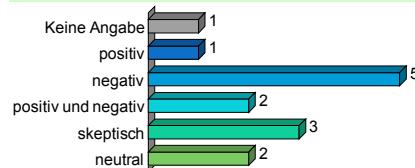


Other signal words were:

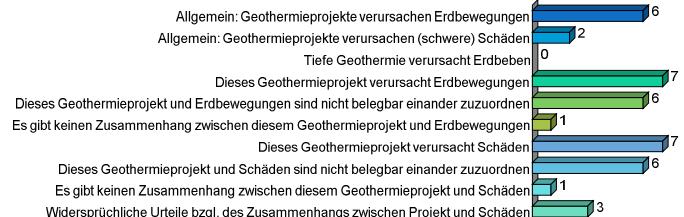
„unheimliche Vorgänge“
 „Spektakel“
 „Einsturz“
 „Unfug“
 „Ökofreaks“
 „tektonische Kriegsführung“
 „Selbstauslöschung“
 „Schreckensmeldung“
 „Ökowahn“
 „Störfall“
 „Schutt und Asche“
 „gigantische Risse“
 „dramatisch“ und „fatal“
 „die Erde spielt verrückt“



Wie wird die Geothermie bewertet?



Welcher Zusammenhang zwischen Projekt, Erdbeben (bzw. Erdbewegungen) und Folgeschäden wird gemacht?



Concerning related technologies the news refer to regional mining (2 cases), cross-regional geothermal project (1 case), international geothermal projects (2 cases) and the Basel project (5 cases).

Concerning related seismic incidents the news refers to regional earthquakes (2 cases), a cross-regional earthquake (1 case) and at an international level to an earthquake (1 case) and a volcanic eruption (1 case).

4.4 First results considering a societal acceptance approach

Regarding the hardware dimension:

(1) Some technical aspects of deep geothermal plants (like drilling and production) still have problematic impacts on the ecological and the social environment (noise, seismicity, etc.).

(2) Yet a risk management and the development of “emergency” action plans are still not enough considered in the management of deep geothermal projects.

Regarding the software dimension:

(3) Different actors have to be considered in different decision making processes along the phases of planning, implementation and operation of a deep geothermal project.

(3) Communication plays a crucial role in societal acceptance processes. The media analysis showed a difference in controlled vs. not controlled communication around a project: As Basel applies a highly controlled information politics to the public the interpretations of the incident in the news were rather limited. Whereas in Staufen the unexpected event showed a high potential for dramatization and link people's evoked emotions with geothermal technology.(4) Regarding the issue of acceptance chains the news analysis shows that people think all the geothermal projects are somehow connected. In general people do not seem to consider the differences between different types of technologies as well as they have difficulties to evaluate the related effects and risks. Events like (induced) seismicity stimulate “waves” of reactions, especially to people being sensitive of this topic because they have in some way related experiences.

Regarding the research methodology

(5) To support the technology dissemination process a comprehensive approach of societal acceptance of deep

geothermal technology is still lacking and should be further developed considering specific technological aspects and respective local or regional contexts.

(6) The findings of this short news analysis are at present qualitative and show a need for further quantitative analysis. A quantitative analysis could give insights regarding the spread and speed of information in different social spheres and regarding the impact of specific information and respective interpretations.

5. IMPROVING SOCIETAL ACCEPTANCE OF DEEP GEOTHERMAL PROJECTS – SUMMARY AND FIRST CONCLUSIONS

As elaborated in this paper, social or societal acceptance is the state of passive or active affirmation of a society's members or groups of members regarding e.g. a technological innovation. Research about the technological and economical potential of deep geothermal energy should be complemented by integrating further research on social issues in order to develop sustainable technical solutions.

Improving societal acceptance

(1) Acceptance by itself can't and should not be controlled as it is an element of democratic decision making. Although, confronted with complexity in all spheres of social life, people's decisions depend on transparent dissemination of knowledge. Thus, the information and communication strategies play a crucial role in creating (non)acceptance. Rather than aiming at creating or improving social or societal acceptance the knowledge and communication about an acceptance object should be targeted. Societal acceptance will be achieved indirectly, if the benefits as well as the risks are transparently communicated to the relevant societal target groups assuming that the features of the acceptance object meet general societal needs and demands.

(2) A specific problematic in the case of deep geothermal projects seems to be the variety of techniques and respective outcomes on the one hand, on the other hand the R&D is limited derives of projects that exist for sometimes more than 30 years. Results are related to the type of wells that were needed in the state of technology of the past. Changes and improvements in the above ground technologies lead to modified requirements (e.g. a lower depth) for underground techniques, but due to extensive costs the research stays in the conditions of each project and its historical development. Results seem sometimes worse to outside observers (investors, political actors) than what they actually imply for future projects.

(3) Usually we won't identify just one factor to control or to overcome in the case of non-acceptance but a variety of interrelated factors linked through interpretations and acceptance chains. In addressing the issue of societal acceptance these interrelations have to be analysed in creating adequate information and communication strategies. This should include experience of other technological innovations with the issue of societal acceptance¹³.

(4) Decisions, the fundamental driving force in acceptance processes, are made on the base of different beliefs and convictions. In the dissemination of energy technology innovations the cost argument and different types of

accounting (short term, life cycle analysis, externalities, including alternatives and business as usual, etc.) have an impact on the acceptance behaviour of politicians, investors and end-users.

(5) Besides or additionally to technical failures, lacks of proper communication concepts lead to failures in achieving social or societal acceptance if information is disseminated to the wrong target groups, at the wrong time or in an inappropriate way.

(6) In general social acceptance calls for certain social interests and values such as trustworthiness, security and fairness. Non-acceptance grows adversely to indicators of reasons for distrust, insecurity or unfairness. Taking into account the risk dimension of technological innovations (and especially in the case of an emergency) strategies would have to include: insurances, "plan-Bs" and strategically information and communication plans.

(7) Communication should be based on information that is based on socially trusted expertise.

Acceptance subjects

(8) If we are looking on the micro level at the end-users of deep geothermal energy technology we can identify their two key roles as voting subjects: first they are political voters and second they are consumers on the demand side of the market. In both roles their voting behaviour results from their socio-economic background and the concrete location of their living. The impact of their behaviour highly depends on their power in the social system where the innovation is to be implemented.

(9) Project complementing strategies of integrating and informing different social actors can support positive acceptance processes.¹⁴ Communication to different actors should be differently addressed in the different phases of technological development of deep geothermal technologies from basic research (exploration and simulation) until the project level. Communication to different actors about projects as testing sites or business projects should be considered detailed in their planning, implementation and operation phases.

6. METHODOLOGICAL OUTLOOK

The specific technical, economic, social and political issues targeted in this paper are complex and of interdisciplinary nature. Many researchers have repeatedly highlighted the tendency of a quantitative increase of the problems and their considerable complexity in the modern world. Another apparent regularity is the emergence of new instruments and creative methods for solving these complex, multi-disciplinary, non-typical and non-standard problems.

The theory of TRIZ – a Russian acronym for "The Theory of Solving Inventive Problems" – provides a fundamental approach to develop practical instruments for solving non-typical complex multi-disciplinary and complicated problems. The "General Theory of Powerful Thinking" OTSM enhances the TRIZ approach to the construction and analysis of network problems and offers a multidimensional picture of the research situation («Big picture»). The "network of problems" as a TRIZ-OTSM instrument includes a problem field, e.g. geothermal technology and its

¹³ For instance experience in wind energy (Laborgne and Jobert 2006).

¹⁴ For instance the ESTEEM tool developed in the frame of the EU FP6 project „Create acceptance“, see www.createacceptance.net.

social aspects, as well as problematic fields of the conduct of research and the implementation process.

The versatility and practical value of the TRIZ-OTSM tools are achieved by combining the most general and therefore the universal instruments in a particular system of application that provides a reasonable and objective assessment of the satisfactory conceptual solutions of a given problematic situation and supports its implementation (Altshuller 1992, 1999; Khomenko 1997-2000; Kaikov 2004).

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We would like to mention the fruitful discussions of the EFONET15 workshop on “New technologies and barriers related to social acceptability” that took place May 28-29 2009 in Paris. It helped a lot to clarify some points that have been raised in this paper as well as it opened our minds to new important questions on the topic of societal acceptance of innovative energy technologies. Further we would like to thank Dr. Albert Genter and Nicolas Cuenot for their friendly disposition to discuss with us and support us with information materials while the site visit in Soultz-sous-Forêts.

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¹⁵ www.efonet.org