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Perspective

A Three-Stage Psychosocial Engineering-Based Method to Support Controversy and Promote Mutual Understanding between Stakeholders: The Case of CO_2 Geological Storage

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Abstract: Subsurface engineering projects with high socio-environmental impacts raise strong controversies among stakeholders, which often affects the projects' implementation. These controversies originate from a loss of public confidence in the decision-making process, lack of information about new technologies, and the desire of some promoters to avoid conflict. The lack of methodologies to structure each stage of the debate can, in this context, lead to the crystallization of the stakeholders' positions and to the failure of the project. To promote mutual understanding and constructive exchanges, this article presents a combination of methods based on psychosocial engineering principles to support debate and encourage stakeholders to participate with an openness posture. The method is based on a set of studies conducted as part of the "Social Governance for Subsurface Engineering" project and includes three stages: (1) develop stakeholders' knowledge so that they are able to participate in the debate with an informed viewpoint; (2) commit stakeholders to participate in the debate by adopting a posture conducive to constructive exchanges; and (3) structure exchanges between stakeholders through the use of cooperative methods facilitating the adoption of an openness posture.

Keywords: stakeholders commitment; knowledge development; cooperative learning; mutual understanding; openness posture; energy transition; psychosocial engineering

1. Introduction

The fifth report of the Intergovernmental Panel on Climate Change (IPCC) predicts that direct emissions of carbon dioxide (CO_2) from energy production will double or even triple in number by 2050 [1]. This increase contributes to climate change and threatens human health [2]. In response to this climate crisis, governments have repeatedly committed to reducing their greenhouse gas (GHG) emissions to keep the temperature increase below 2° Celsius. However, reaching this limit requires a decarbonization of the production processes; hence, the use of geological CO_2 storage technologies (artificial carbon sinks) cannot be avoided [3].

These technologies seem useful for their ability to restrain global warming to fewer than 2 degrees Celsius [4]. Recent research shows that it is now possible to recover CO_2 to improve the efficiency of industrial processes [5] or to inject large amounts of CO_2 into deep saline aquifers while simultaneously ensuring the safety of the storage [6]. Recent work on CCS technologies shows that, although they are increasingly being promoted, they still face technical, economic, political, and regulatory challenges, as well as challenges related to public concern and acceptability [7]. These challenges can be encountered in the implementation of these projects at local levels, with companies experiencing real difficulties in obtaining the social license to operate (SLO—[8]). However, obtaining an SLO is not only a necessity for the industry. It is also an interesting path for improving projects when energy justice principles are taken into account [9], which is, however, particularly difficult for the subsurface. According to Marshall [10], a CCS is, by nature, a social enterprise and, consequently, its establishment in a given area cannot be planned without taking account of the social context.

This article intends to research in the field of social psychology to facilitate social debate on CCS projects. The objective is to structure a series of studies carried out as part of the "Social Governance for Subsurface Engineering" (SGSE) (https://www.gefiss.eu/en, accessed on 15 February 2024) research project. SGSE focuses on the debates between stakeholders concerning subsurface engineering projects and, more specifically, CO_2 capture and storage projects.

Methods developed in the field of psychology are proposed to structure the results of scientifically validated action research to determine a solution that fosters a change in practice (e.g., [11–14]). Among these methods, the psychosocial engineering method appears particularly structured for supporting changes in practices (e.g., consultation) associated with CCS deployment projects [15]. Specifically, this method emphasizes dialogue with the stakeholders concerned by a problem in the field, in order to come up with a proposed solution that is adapted in practice. In addition, the psychosocial engineering approach allows for a step-by-step, global construction logic. According to this approach, the first phase in the work to be carried out is to assess and determine the contours of a problem in the field. In this case, the question is how to support subsurface engineering and, more specifically, CO_2 capture and storage projects. Indeed, in Europe, these projects seem to be primarily encountering social difficulties in their implementation. The second phase uses the information gathered in the first phase to propose a new action model based on a combination of laboratory and field experiments (i.e., comparison of the experimental protocol with the protocol usually used by professionals in order to identify an action model). The aim of this article is, therefore, to: (1) identify field problems and (2) articulate research findings in the service of an alternative method of action for concertation professionals.

1.1. Phase 1: Understand the Issues Related to Subsurface Engineering and CO_2 Capture and Storage

1.1.1. Contestation Related to Subsurface Exploitation and the Social Acceptability of Risks

In 2024, the Global Atlas of Environmental Justice identified 1503 cases of social conflict over subsurface projects worldwide [16]. The subsurface combines several types of challenges explaining these conflicts, which may or may not be specific to it, and all of which have to do with the notion of energy justice [17,18]. Those conflicts related to energy transition technologies can be explained by the lack of respect for the principles of procedural, distributive, and intergenerational justice [19], or the perception of this lack, but more so by the specificities of subsurface exploitation [20]. Indeed, the subsurface suffers from misconceptions of the general public operated by incomplete perceptions and ideas [21] linked to the difficulties in visualizing the subsurface and comprehending the impact and risks of the exploitation technologies. More generally, it is the social acceptability of risks that is often pointed out, and more specifically, the gap between general social acceptability regarding the sector and more local acceptability regarding a project within an identified territory [22,23]. Indeed, the risks associated with a local project, which the stakeholders are experiencing or will experience (e.g., drilling, noise, pollution, odors, etc.) often take the upper hand over global risks [24]. This confrontation between the global and the local is illustrated by the "Not In My Back Yard" (NIMBY) issue, often used by project promoters to discredit local opposition to solutions approved by the majority (see [25,26]). For stakeholders, the appropriation of these projects is built from the perception of risks, benefits, trust in the promoter, and the perception of both distributive and procedural equity [27,28].

For Wüstenhagen et al. [29], the issue of risks is directly linked to the social acceptability of energy transition technologies by communities, particularly regarding the question of trust between stakeholders. These authors highlight the necessity of considering three dimensions of social acceptability when understanding energy transition projects: (1) socio-political acceptability (i.e., the acceptability of technologies and associated policies to the public), (2) acceptability of local communities (i.e., trust, procedural, and distributive justice) and (3) market acceptability (i.e., the acceptability of the technology for investors and users). Consideration of these three types of acceptability explains the apparent contradiction for some technologies, for example, between public support and local rejection. Yet, the subsurface remains largely associated with fossil fuels, i.e., their local and global impacts and the social and geopolitical inequalities that have accompanied its exploitation [30].

1.1.2. CO_2 Capture and Storage, a "Useful" Technology Whose Legitimacy Lacks Debate among the General Public

These concerns about the subsurface are also reflected during the deployment of carbon capture and storage (CCS) technologies. These technologies, which consist of separating CO_2, most often from industrial sources, and then transporting it to a storage site, are often presented by major organizations [3,31] and by many scientists as a relevant answer to support the energy transition and address the issue of climate change [32,33].

Nevertheless, CCS remains a largely unknown technology, yet domain-specific knowledge is related to risk perception [28]. Most studies conducted between 2002 and 2018 on public perceptions report that individuals have relatively low awareness about CCS [34]. According to Huijts et al. [35], the issue of effective public awareness through the development of knowledge about the technology is decisive. Indeed, according to these authors, in the absence of sufficient information about a technology, individuals are more likely to construct their opinions according to the promoters of the project than according to the technology itself. This lack of knowledge results in risk perception relying more on trust in public authorities than on the technology itself [36].

The debate on these technologies, however, is largely insufficient. For O'Neill and Nadai [37] and Chailleux et al. [38], the scientific consensus around CCS in Europe is mostly about "technical and scientific debate arenas" involving the IPCC, the European research space, and the European GHG reduction policy. Indeed, in most cases, the general public is often not involved in debates on the legitimacy of the technology, because they are perceived as not having sufficient knowledge about CCS (e.g., [34,39]).

1.1.3. Implementing the Debate on CO_2 Capture and Storage Projects, an Insoluble Equation?

Setting up a debate during the implantation of a CCS project with all the stakeholders may seem to the promoters as particularly risky and can lead to the failure of the project (e.g., [40,41]). In response to this possibility, project promoters sometimes choose to refuse the debate, to delay it as long as possible, or to locate part of the infrastructure away from local residents—or even offshore in the case of CCS [42]. However, these elements do not enhance the trust necessary for the decision-making process (e.g., [43]).

Thus, recent years have seen most large-scale projects to implant CCS end in failure (e.g., [44]). Indeed, these projects have often been the subject of strong local contestation for their environmental and social consequences, such as the CCS projects proposed by Vattenfall in Beeskow (Germany) and by Shell in Barendrecht (Netherlands). In these projects, it was the environmental risks (e.g., integrity of the CO_2 storage site) and lack of communication and debate that led to the crystallization of stakeholder opposition and to the failure of the implementations [45,46].

Although multi-determined, these failures can, therefore, be understood by the fact that the issue of CCS, and more generally of subsurface exploitation, has rarely been debated with all stakeholders. There has been insufficient politicization of the debate with the public [47], and the absence of debates has not met the strong contestations relating to the social and environmental risks that subsurface exploitation may generate [48]. However, these debates can be useful for projects because they bring together, in a given social context, stakeholders to build common exchange criteria [49], which could allow energy justice principles to be respected [17]. Therefore, the discussion of these projects with all stakeholders (e.g., [50]) appears necessary in order to make the deployment of this technology possible.

1.1.4. Setting Up a Debate on CO_2 Capture and Storage Projects, a Profound Change

Setting up debates during implementation projects implies a profound change comparable to a translation process as developed by the sociology of the network actor [51]. According to this model, the setting up of this network is not linear, but involves contributions from divergent points of view. The stakeholders will "translate" the points of view of the others into their own reference system and then work together to elaborate, in successive steps, an innovative common position that is the result of a co-construction (e.g., [52]). This requires that all stakeholders in a project recognize the validity of each other's opinions and enter into a process of mutual understanding. A number of authors (e.g., [53,54]) argue that it is possible to promote the inclusion of different individuals' perspectives in a discussion. These authors share the idea that constructive dialogue and co-construction depend on individuals' abilities to engage in specific behaviors necessary for mutual understanding. This principle is considered essential to enabling the development of CCS [55]. However, if mutual understanding seems to be the keystone of a debate so that individuals can take the other's point of view into account, the conditions in favor of considering the point of view of others are not always achieved. This is due in particular to the wide diversity of concertation practices [56], which are sometimes aimed at simply transmitting information to citizens [57] or at legitimizing projects and decisions that have already been made [58].

Although the scientific literature has already drawn on these principles to encourage industry to be transparent in its processes [59], and has developed methodologies for identifying and engaging stakeholders [60], there is no real method to promote the deployment of debates. Thus, Mark Reed, in a review of different methods of stakeholder engagement, identified the need for clear methods of stakeholder engagement in the debate without actually proposing them [60]. In the absence of a methodology to accompany the debates, the diversity of the stakeholder's positions appears to be very difficult to reconcile and can lead individuals to crystallize their positions and, thus, to bring the debate to a dead end, leading to the failure of the project.

2. Phase 2: A New Action Model for Practitioners: Three Research Actions to Structure a Method

This article intends to build on the second stage of the psychosocial engineering method [15] to articulate the results produced by the research team as part of the Social Governance for Subsurface Engineering (SGSE) project. This project is the result of a collective, multi-disciplinary approach (e.g., psychology, educational science, geography, sociology, etc.) and is based on the following observations: the question of social acceptability; the need to engage stakeholders in informed debate on underground engineering in the decision-making process for projects, and on the conditions for their implementation; and the need to think about a shared, coordinated use of underground resources and other potentialities to support the energy transition. To address these issues, the members of the SGSE project have set themselves the objective of engaging all stakeholders in an informed dialogue on the exploitation of subsurface resources as part of the energy transition.

To achieve this objective, three social psychology research actions in the SGSE project aimed to propose new ways of mobilizing stakeholders, in participative forms, to encourage an informed dialogue around projects to exploit subsurface resources and the conditions under which they are carried out. These three research actions aimed to encourage stakeholders to move beyond their points of view by opening up to the arguments of others. Thus, to ensure that the debate is not merely consultative, but promotes mutual understanding and constructive exchanges, it was proposed that the conditions that would enable each stakeholder to adopt an openness posture, which seems to be the key to the success of a cooperative debate, be evaluated. In this project, the openness posture was defined through different behaviors based on Habermas' theory [53] and work concerning cooperative skills (e.g., [54]). The openness posture refers to (1) expressing one's opinions as clearly as possible so that they are accessible to others and (2) supporting the consideration of other people's points of view. The aim of adopting the openness posture is to foster behaviors essential for mutual understanding of individuals in a debate setting: arguing one's ideas, listening to and taking into account the point of view and arguments of others, accepting different opinions, listening and debating with respect, and expressing oneself clearly.

In these three research projects, the idea was to highlight the criteria for establishing a posture of openness during a consultation process in the context of subsurface engineering projects. To accomplish this, each of these research projects started from a problem in the field and worked towards a proposed solution (e.g., [14]). The first research project was based on the observation that individuals have little knowledge of CCS technologies. The project was, therefore, intended to understand and then develop a methodology to enable stakeholders to increase their knowledge of subsurface technologies. The second research action was based on the observation that people no longer make the effort to take part in debates. The project therefore set out to determine the conditions for stakeholder engagement to develop a methodology to ensure their participation in the debate. Finally, the third research action was based on the observation that consultation spaces were not structured in such a way as to enable individuals to adopt a posture of openness.

Thus, adopting a psychosocial engineering approach [15], it was proposed that we structure the results of the three research actions carried out as part of the SGSE project in order to propose a series of steps that form an alternative method for supporting debate professionals. This method aims to encourage and support the effective implementation of an openness posture (i.e., behavior) and is sequenced in three stages, starting with a problem in the field and working towards a proposed solution to the identified problem: (1) developing stakeholders' knowledge and enabling them to participate in the debate with an informed point of view; (2) committing stakeholders to participate in the debate by adopting an openness posture; and (3) structuring exchanges between stakeholders using cooperative methods.

2.1. Stage 1: Develop Stakeholders' Knowledge and Enabling Them to Participate in the Debate with an Informed Point of View

2.1.1. How Does the Social Relationship between Stakeholders and Objects Determine How They Appropriate Projects?

The first step is to understand how the information conveyed about projects can affect the attitudes and knowledge of stakeholders. In France, a survey conducted in 2009 showed that only 4% of respondents were able to explain what CCS was [61]. However, people's attitudes towards objects are constructed based on their own beliefs and the information available (e.g., [62,63]). Thus, communication in the context of the energy transition must be adapted to the channel (e.g., press, social networks, etc.) and to the audience, as well as to respond to several issues such as human nature, partisan identities, and media fragmentation [64]. Geologic hazard communications face the same challenges, but also face specific obstacles such as the difficulty of identifying the target audience or the complexity of the language used by geoscientists [65]. However, the provided scientific and technical information partly focuses on the potential hazards of a technology (e.g., the risks of nuclear accidents are statistically low) without really taking into account how people are likely to interpret it [66]. When communication is made to the public, the assumption is that well-targeted information to the public will lead them to the same conclusions as the experts: the technology is reliable, it is practically risk-free, etc. [67]. However, there is a contrast between experts and non-experts. From the expert's point of view, the danger can be statistically quantified; however, the risk perception is socially constructed [68], mainly because the information is perceived through the filter of the social relationship that the individual has with the object (e.g., [69,70]). Individuals as social agents (e.g., residents, politicians, or project leaders) have a specific social relationship with the objects. As a result, they will appropriate information and perceive risk based on their socio-cultural values [71], beliefs, knowledge, representation of context (e.g., trust in experts), emotions, or social affiliations [72]. These individual and collective filters contribute to the construction and dissemination of risk through interpersonal and media communication and enable stakeholders to interpret, process, and adapt to emerging threats (e.g., [73,74]). One study in the research program looked at how a stakeholder can seize information about an underground project. A survey was conducted during the first implantation phase of a helium (He) and carbon dioxide (CO_2) valorization project [75]. This study was conducted with people living in two geographical areas, one affected by the project and the other one unaffected. The results suggested that the appropriation of perceptions and knowledge of He and CO_2 were influenced by socio-professional categories, general attitudes, environmental attitudes, and geographic location. In particular, the representation of He (i.e., a little-known gas) is structured according to geographical location, i.e., proximity to the project, whereas that of CO_2 (i.e., a very well-known gas) transcends geographical aspects since the representation existed before the project was implemented. This differentiated appropriation of information could have an impact on discussions during debates. The issue is that the stakeholders do not have the opportunity, prior to the debate, to become aware of others' points of view. Consequently, they are not aware of the stakes and constraints. Without this necessary prerequisite, each party speaks from its point of view, but does not meet the others' understanding of the phenomenon. As a result, each stakeholder cannot adopt an openness posture during the debate. These elements support the idea that, before a debate, it is necessary to identify the stakeholders in relation to a project and then to assess their knowledge and perceptions of the technologies, especially in the case of CCS, which remains unfamiliar to the general public.

2.1.2. Experiential Communication Devices to Facilitate the Adoption of an Openness Posture

As shown in the previous section, stakeholders' appropriate information through different filters. Therefore, to enable dialogue and understanding between stakeholders during a debate, each of them must be able to understand the social relationship that the other stakeholder has with the project. The challenge is, therefore, to deploy communication dedicated to this appropriation. The first step should be to assess the prior knowledge and perceptions of risk of each stakeholder. The challenge would be to provide key points for designing communications based on the prior knowledge and psychological and social anchors of project stakeholders.

This stage should develop knowledge without affecting representations or judgments (it is not about convincing regarding the credits of the project) through explicit learning using didactic presentations or implicit learning, which can include, e.g., virtual reality (VR) or serious games (SG—[76]). These tools respond to the principles of experiential learning theorists (e.g., [77]), who postulate that there is no better learning than that which involves action. Thus, knowledge is developed in a process of appropriation of lived experiences without changing the beliefs or judgments of the stakeholders. These tools also have the advantage of responding to the specific problems of projects related to energy transition. For example, SG allows a wide variety of stakeholders to be brought together around a common project [78]. VR allows for the exploration of objects that are often difficult to apprehend, such as the subsurface, notably through a better contextualization of the characteristics of these objects [79]. Two experiments in the research project conducted with civil society participants sought to test the effects of explicit (i.e., didactic video) and implicit (i.e., SG and VR) learning on stakeholders' knowledge acquisition and appropriation [80]. Three measurement periods were carried out: before the experiment, just after the experiment, and two weeks afterwards. Overall, the results showed that both explicit and implicit learnings were equally effective in terms of knowledge acquisition and had no effect on individuals' opinions. Explicit learning, as the first information device, seems better suited to enabling less informed audiences to acquire knowledge. Finally, implicit learning, such as SG, appears to be valuable for maintaining knowledge over time, in particular for people with prior knowledge and a relative interest in CCS.

The appropriate knowledge constitutes a shared foundation that allows each stakeholder to develop what seems desirable to them while taking into account the constraints of other stakeholders. In the case of CCS technologies, it is therefore important to develop communication adapted to the characteristics of the project's stakeholders, while at the same time using methodologies that enable them to develop their skills (e.g., SG, VR). While this first step could be a facilitating condition for stakeholders to adopt a posture of openness during the debate, it does not guarantee that they will adopt the expected behaviors during debates.

2.2. Stage 2: Commit Stakeholders to Participate in the Debate by Adopting an Openness Posture

2.2.1. Encouraging Stakeholder Participation to Come to a Debate?

Stakeholders' presence must first be guaranteed before they can adopt a posture that promotes constructive debate. Citizens seem to have lost confidence in their ability to step into arenas of democratic debate [81]. Thus, they sometimes appear skeptical about the real impact of participatory processes [82]. This has a direct impact on their actual participation in debates. The stakes are high since the majority of citizens seem to refuse to participate, which was the case for The British Columbia Citizens' Assembly on Electoral Reform where only 4% of those invited committed to participating [83]. Indeed, often, the organizers of consultations use a strategy aimed at delivering information to convince citizens to come to debates. However, many studies show the limits of this strategy in terms of convincing people to do what is expected of them (e.g., [84]). Although information is a lever for changing knowledge or representations, it has little effect on behavior [85].

In line with Lewin's work [13], the theory of commitment [86] has shown, on numerous occasions (e.g., [87]), its effectiveness in "leading people to do of their own free will what is expected of them" ([88], p. 29). According to this theory, human beings are rationalizing individuals who do not commit themselves according to what they think, but according to the conditions in which they act. Certain characteristics of the situation (e.g., the behavior is carried out in complete freedom; the behavior is irrevocable) will be conducive to commitment, and, in this case, "the realization of an act can only be attributable to the person who carried it out" ([88], p. 60). In the context of subsurface engineering projects, these action strategies guarantee a significant increase in the probability of participation in debates.

In the research program, one study tested the effectiveness of a commitment technique to increase the probability of individuals participating in the debate compared to a "normal" situation, without a commitment technique [89]. To test this hypothesis, two studies mobilized the technique, known as the Four Walls technique (FW—[90]). This technique consists of convincing the subject to answer "Yes" to several successive questions before submitting a final request (i.e., to participate in a debate). According to Cialdini and Sagarin [90], the procedure is based on the principle of consistency, which can be summarized as follows: "after committing one should be more willing to comply with requests for behaviors that are consistent with that position" (p. 152). Following this principle, the individual would successively answer "yes" to some questions concerning the necessity of participating in this type of debate. Thus, in one case, participants could answer questions about citizen participation (e.g., "is it important to encourage citizen participation for our democracy?") or in relation to the target request (i.e., "do you agree to participate in a debate?"), and in the other situation, called the control, participants were answering the target request (i.e., "do you agree to participate in a debate?"). The results of both studies showed that performing a pre-participation behavioral commitment using FW, quadrupled the percentage of individuals agreeing to attend a debate (a success rate of 50%) compared with the control condition (a success rate of up to 15%). In these studies, the project was intended to ensure the effective participation of all stakeholders in a debate without trying to convince them of the interest of a project or a technology.

2.2.2. Commit Stakeholders in the Debate by Adopting an Openness Posture

The theory of commitment has proven to be effective in ensuring that different stakeholders come to the debates. However, ensuring their presence does not guarantee that the exchanges during the debate will be constructive. Therefore, the commitment strategy can encourage individuals to adopt an openness posture, beyond encouraging participation. The consistency principle on which the FW technique is based [90] has helped to address this problem. It was hypothesized that, to be consistent with the questions they just answered (i.e., the importance of participation, openness posture behaviors), individuals would be more likely to go into the debate with a willingness to adopt an openness posture.

To test this assumption, two studies were conducted [89] to test the effects of the FW technique [90] on attitude strength (i.e., the importance of this attitude and the certainty of this attitude for the participants [91]). Participants were asked to rate their willingness (or unwillingness) to adopt an openness posture in a debate situation involving nuclear waste disposal. Two situations were compared. In one situation, participants were asked questions about citizen participation (e.g., "Is encouraging citizen participation important for our democracy?") and about the different behaviors of the openness posture as defined in this article (e.g., "Do you think it is important to take into account the point of view of others?") before answering questions about the strength of their attitude. In the other case, participants were simply asked to answer questions about the strength of the attitude. The results of both studies showed that FW mobilizing the openness posture increases attitude, its importance, and the certainty of adopting an openness posture in a future debate. Thus, the commitment strategy of mobilizing both questions about the interest of participation and those about the behaviors of the openness posture could be a prerequisite for engaging individuals over the long term [92], and thus have an impact on the discussions during debates. The proposed commitment procedure is a preliminary step that seems necessary for mutual understanding between individuals. However, if this step can be a prerequisite for increasing the probability that individuals will adopt an openness posture, the creation of a social context in favor of the effective implementation of openness behaviors during the debate also seems necessary.

2.3. Stage 3: Structure Exchanges between Stakeholders Using Cooperative Methods

2.3.1. Encouraging Controversy between Stakeholders during the Debate

The results of the previous sections have highlighted the possibility of understanding how stakeholders can appropriate knowledge while encouraging their engagement and the adoption of a posture of openness in the debate. The task is now to facilitate the effective adoption of this openness posture during the debate. However, these debates are not structured to encourage this attitude of openness (e.g., [56–58]) and are aimed more particularly at avoiding controversies, as they are seen by project leaders as elements that could threaten the projects [40]. However, according to some researchers, conflicts and controversies are inevitable in public debates, but they can be potentially beneficial for decision making and developing solutions for project implementation [93]. These conflicts can be opportunities to highlight social issues underlying projects, provide spaces for previously ignored stakeholders to express themselves, and even foster social innovation, making the consultation process more democratic [94]. However, for these benefits to be effective, stakeholders must engage in structured debates that encourage constructive exchanges. In this line, research on socio-cognitive conflict showed that conflicts in interactions can lead to profound cognitive changes that are beneficial for learning new knowledge and improving the quality of social interactions (e.g., [95,96]). This type of conflict, common in energy transition debates, arises when stakeholders confront divergent points of view. This divergence of conflicting points of view ideally leads to cognitive imbalances that promote (1) awareness about the existence of other points of view, (2) the development of cognitive instruments and social skills through the argumentation and discussion of these points of view, and (3) knowledge elaboration and restructuring [97]. However, the benefits of social–cognitive conflict depend strongly on how the interactions are regulated [98,99]. Research findings have indicated that social–cognitive conflict can be regulated in two distinct ways, each with diametrically opposed effects on learning and social relationships (e.g., [95]). Conflict regulation is epistemic when individuals are focused on the task and on the validity of their position and others' positions. They elaborate upon or coordinate their actions and ideas to arrive at a more acceptable and consensual representation. Conflicted participants seek to make sense of an epistemic conundrum regarding the existence of an object and two different answers [95]. This regulation is accompanied by the benefits sought in contrast to relational regulation [100,101]. Relational regulation occurs when individuals are more concerned with the social comparison of their competence at the expense of their differing positions on the object of study. In such cases, the conflict becomes a source of threat, leading each participant to cling to their position and reject opposing viewpoints, or to adopt an opposing viewpoint in an apparent submission to avoid any conflict. In either case, this relational regulation of the conflict is accompanied by negative effects on learning, exchanges, and relations between participants. It is understandable that conducting a public debate can be complex, and it is often challenging to achieve constructive interactions. If stakeholders remain firmly rooted in their disagreements, this may be due to relational regulation, where confrontations have negative effects on the debate outcome. The question remains as to how epistemic regulation can be promoted in debates concerning subsurface exploitation. An interesting answer is provided by the cooperative learning approach, in particular the cooperative controversy [102]. This approach suggests structuring debates to facilitate the adoption of an openness posture and promote epistemic regulation of socio-cognitive conflicts.

2.3.2. Cooperative Controversy in the Context of the Energy Transition Debate

The cooperative controversy is based on a confrontation of ideas, where participants must exchange polarized viewpoints and defend their positions to reach an informed decision that considers the various viewpoints of stakeholders. In the cooperative controversy, individuals (1) prepare to defend their position, (2) engage in a collective exchange to critically analyze and discuss all stakeholder positions, (3) defend a position that contradicts their own to decentralize and appropriate a different viewpoint, and (4) collectively synthesize all positions into a shared conclusion that satisfies all stakeholders. By structuring debates in this way, individuals are encouraged to develop and refine their arguments in defense of their viewpoints [102], to analyze situations from different perspectives, to decenter from their position, and to think more complexly. For the stakeholders, it encourages cognitive restructuring by exposing individuals to divergent viewpoints. Thus, structuring the debate through the use of cooperative controversy is a method of creating constructive conflicts by promoting their epistemic regulation [98,101]. This approach serves as a source of motivation for individuals to learn new information about the topic under discussion.

Socially, it contributes to positive stakeholder relationships, positive attitudes toward others, and social skill development [102]. As part of the research program, a study carried out between 2021 and 2022 with civil society participants evaluated the effects of a debate on deep geothermal energy, structured according to the cooperative controversy method, compared to a traditional debate on knowledge and on the intention to adopt an openness posture [103]. Two measurement periods were conducted, before and after the debates, testing the effect of structured debates on knowledge and openness posture. The results show that both types of structuring proved to be effective in developing people's knowledge of geothermal energy. However, the results showed that only the debate structured using the cooperative controversy method predicted the intention to adopt an openness posture in a subsequent debate.

For energy transition debates, the use of the cooperative controversy method principles (e.g., defend a position that contradicts their own to decentralize and appropriate a different viewpoint) would be likely to prevent the crystallization of the debate by creating favorable conditions for an openness posture. It would also facilitate the epistemic regulation of conflicts, which is essential for constructive exchanges that are indispensable for the informed and equitable involvement of all stakeholders in the decision-making process.

3. Discussion

This article aimed to propose a structured method based on psychosocial engineering principles to support debates. This method favors the commitment and participation of stakeholders based on a posture that promotes constructive exchanges and mutual understanding: the openness posture. This method appears to be particularly well suited for debates organized during the implementation of subsurface engineering projects or within the broader context of energy transition.

The proposed method for supporting debates (Figure 1) is based on the openness posture, defined through different behaviors that promote mutual understanding [53,54]. The method consists of three stages. The first aims to involve stakeholders in the debate using experiential communication devices, encouraging the development of a common base of knowledge about the topic of the debate [76] to experience the perspectives and social relationships that others have with the project (e.g., [69]). The second stage aims to commit stakeholders to coming to the debate with a will to participate in a constructive way. Based on the commitment theory [86] and the Four Walls technique [90], this stage leads individuals to be more likely to come to a debate with a willingness to adopt an openness posture. The third stage aims to structure the social interactions between the stakeholders during the debate to take advantage of socio-cognitive conflicts by using cooperative controversy [104]. The aim is to take advantage of these results in the context of debates on important issues related to the energy transition, the urgency of which has once again been underlined by the latest IPCC report [1].

In this article, a psychosocial engineering method (e.g., [11–15]) has been proposed to support the presentation of the research results produced as part of the SGSE project. The results of this research and the model derived from it can be used to define an alternative action model for the professionals concerned. Nevertheless, although this method is based on scientifically proven knowledge, its overall coherence remains to be tested in the application contexts for which it is intended. In line with this psychosocial engineering approach, it seems to us that a third phase should enable the debate support method to be deployed in the context of a CCS implementation project.

It remains to be seen what links exist between this method and the one developed by Batellier and Maillée [105]. These authors intend to support major energy transition projects throughout the concept of social acceptability, combining dialogue, trust, and collective consent. For dialogue to exist in CCS projects, it seems that the emphasis should rather be placed on trust (e.g., [106]), which should be considered as an inherent aspect of social relations [107]. Moreover, the principles of the right to "Free Prior and Informed

Consent" (FPIC—[108]) seem to offer some guidelines that can help to establish a climate of trust between stakeholders.

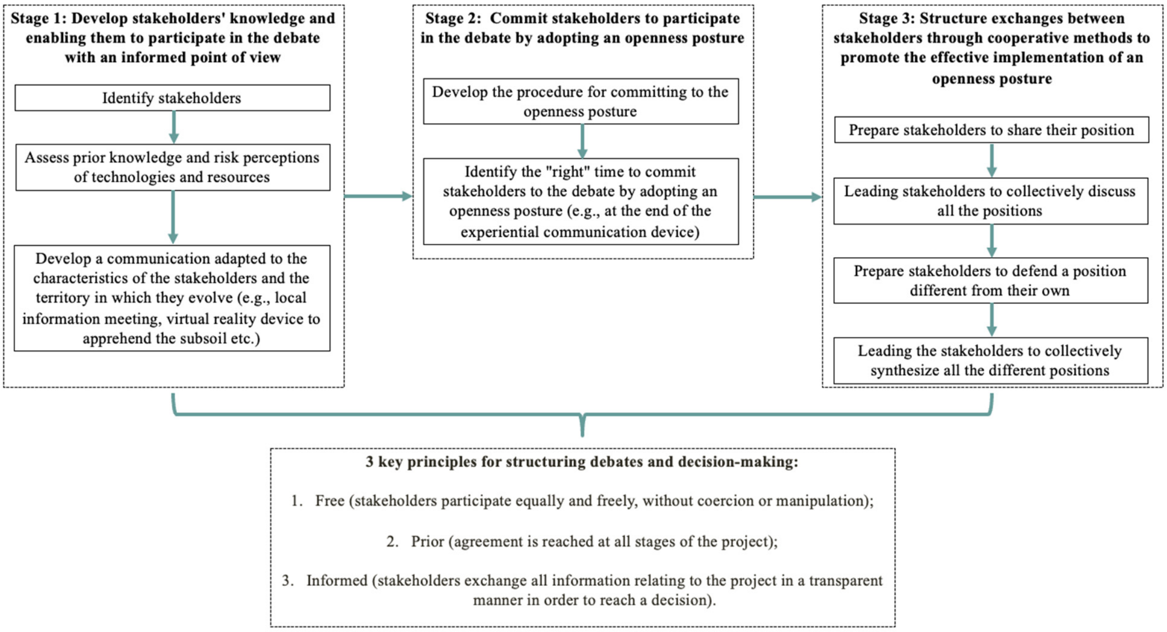

Figure 1. A three-stage method to support debate and encourage an openness posture.

4. Conclusions

Engaging stakeholders to open up to controversy is a way to politicize (i.e., in the sense of res publica: the public thing) the debate on the energy transition and subsurface exploitation technologies. The politicization of the debate involves three stages, as presented in this article. Each stakeholder participates with full knowledge of the issues at stake and adopts a position with full transparency (i.e., support, oppose, etc.). Thus, depending on their attachment to the project, each stakeholder can become involved in the social consultation process. According to Moscovici and Doise [109], the decision-making process is focused on the search for a common agreement, rather than suppressing or neglecting dissension. By making it the core of the debate, stakeholders manage to forge a "convergence of minds and interests" (ibid., p. 272), even if this convergence may not necessarily result in acceptance of the project.

This space for expression, where consensus and dissensus would have their rightful place, would be a source of social innovation for all the stakeholders, and in particular the stakeholders who have been overlooked until now. Individuals would recognize and commit to it, which would help to make the consultation process not only more democratic, but also more engaging for stakeholders. Therefore, the engagement of all stakeholders appears to be a key determinant of the success of debate in CCS projects.

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