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# Informing people about CCS: a review of social research studies

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## Abstract

This contribution examines studies on CCS public perception which have investigated the introduction of CCS information to the public. Studies published between 2007 and 2011 are considered and analysed with regard to research methods and tools and the construction of information. The relationship within which the communication of information takes place and content characteristics of the information emerge as two key aspects to be developed both from a methodological and an operational point of view.

## 1. Introduction

The last decades have been characterised by an intense scientific and technological development aimed at reducing greenhouse gas emissions. Many different solutions have been proposed either to reduce emissions altogether or to reduce their impact. Among them we find the capture of $CO_2$ from industrial sources and its storage in geological formations (CCS), a technology which has a significant potential for reducing emissions coming from power and industry sectors which would otherwise go unabated.

CCS is a relatively recent technology, which however has a rather consolidated background of expertise based on the oil and gas industry experience in enhanced oil recovery and natural gas storage. Its use within specialist circles has not, until very recently, implied the involvement of public opinion; therefore CCS is still little known by people who are not directly or indirectly concerned by its

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development and implementation [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11]. Once this technology has started to be used with the aim of reducing emissions and since the implementation of the first CCS plant in 1996 in Norway at Sleipner, many pilot projects have followed. Such projects have been carried out in different countries and within different social contexts so the attitude of local communities towards them has to be understood in relation to the specific contexts. Nevertheless what has clearly emerged as a more general consideration is that the implementation of CCS needs to take into account public opinion and requires the consensus of local communities. In many cases, people have manifested interest in understanding the reasons and the scenarios for the implementation of the technology, for discussing its pros and cons; they have expressed the willingness to be involved in the decision making process and have stopped projects that had not managed to find the consensus of the local community [12, 13, 14, 15, 16, 17, 18]. The need to communicate the technology, to make it understandable, to facilitate public participation in decision making processes has thus come to be recognized as an important aspect for the professional community engaged on CCS. This has given rise to efforts for finding appropriate ways and strategies for disseminating about CCS. Within this framework social research on CCS has tried to understand how public opinion on this technology forms and develops. Researchers have immediately been confronted with a lack of knowledge on the topic by the majority of the population. This has stimulated many of them to develop tools or strategies for investigating CCS public perception based on the introduction of specific information to the participants by the researchers themselves. A new research field has started to grow, experimenting with a number of ways for providing information, evaluating how the technology can be introduced, how people's perceptions build up and how understanding of CCS can improve.

This study aims at offering an overview of this body of research and at providing useful criteria for its exploitation with regard to the interaction between information provision and public perception of CCS. The objective is to learn from present research results on how to further develop social research in this domain for the benefit of all the stakeholders who are engaged in social dialogue on CCS: public authorities, companies, NGOs, the media and social researchers themselves.

## 2. Methodology

The review takes in consideration the studies published between 2007 and 2011 conducted in the following countries: Europe, Unites States, Australia and Japan. Some contributions from previous years have been also included because of their importance for subsequent studies. The articles were collected in June and July 2012 on the Science Direct search engine. Additional interesting material such as some reports has also been considered.

The studies can be grouped into 4 main categories:

- Studies which investigate the role of information in shaping people's opinions within relational contexts such as interviews and focus groups (Ashworth et al 2009; Bradbury et al, 2009; Upham et al, 2011a; Upham et al, 2011b; Wallquist et al, 2009; Vercelli et al, 2008, 2010); [20; 21, 22, 23, 24, 25, 26, 27, 28].
- Studies based on questionnaires that inform and at the same time verify the effect of the information provided (de Best-Waldhober and Daamen, 2006; de Best-Waldhober et al, 2008, 2009, 2011; Daamen et al, 2011); [29, 30, 31, 32, 33].
- Studies based on statistical analysis for the identification of relevant information factors (Itaoka et al, 2004, 2006, 2009; 2011; Tokushige et al, 2007); [7, 34, 35, 36, 37].
- Studies on particular factors such as trust that can influence the perception of information (ter Mors et al, 2009/2010; Terwel et al, 2009/2010; Wallquist et al, 2011); [38, 39, 40, 41, 42].

They have been analysed following two main criteria:
- the  research approach: methods and tools;
- the way information is constructed and communicated.

## 3. Literature review

We will now explore and analyse the studies on the communication of information on CCS following the two criteria for discussion: 1) research methods and tools; 2) information construction and communication.

### 3.1  Research methods and tools

Since explicit reference to a theoretical framework for communication was infrequent in the works examined, a first differentiation of the research works has been identified at the level of methods and tools. With regard to methods the studies can be divided based on whether they have adopted "qualitative" or "quantitative" methods. In fact, although this categorisation could rather be regarded as outdated†, it has the advantage of still being very popular and it does correspond to the material under consideration.

Concerning the tools used in the studies to communicate information and for data collection, keeping in mind that their choice appears to have been guided by coherence with the method used, we have identified: on one side, explorative studies that use mainly focus groups and interviews, on another side, studies directed to the verification of consolidated categories that use tools like structured questionnaires with closed questions (can't remember how you say in English). Based on this distinctions we can classify the studies as:
- "qualitative" based on the use of interviews, focus groups and direct interaction with or among participants, integrated with quantitative data collection before and after the interaction [20, 21, 24, 25, 26, 27, 28];
- "quantitative" that use structured questionnaires to inform and at the same time to assess how the communication of information deemed relevant affects opinions [29, 30, 31, 32, 33, Wallquist et al, 2011a];
- "quantitative" focused on statistical methods for data analysis to inform and identify the factors that contribute to the formation of perceptions on the topic [7, 34, 35, 36, 37];
- "experimental or quasi-experimental" directed to the verification of how some specific factors can influence information perception  [38, 39, 40, 41, 42].

Taking into account that the relationship between "quantitative" and "qualitative" can be questioned, we will now examine the contribution by the different articles in terms of methods and tools adopted. If for instance the research starts at a level in which the possible categories are little known to the researcher, the goal of the study could often become to build/validate some categories or frameworks for situating the

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† It is in examining the same texts written by the most important proponents of this polarization between "qualitative" and "quantitative" that we can easily fragment it [43]. As Lucidi et al, remind us, at the extremes of this qualitative quantitative issue, we can quote Fred N. Kerlinger on the one hand - when he affirms that there is no such thing as qualitative data and anything is 1 or 0 - and on the other hand Donald T. Campbell, who reminds us that all research, ultimately has at its base a qualitative foundation. Krippendorf [44] summarizes: "I question the validity and usefulness of the distinction between quantitative and qualitative content analyses. Ultimately, all reading of texts is qualitative, even when certain characteristics of a text are later converted into numbers. The fact that computers process great volumes of text in a very short time does not take away from the qualitative nature of their algorithms: On the most basic level, they recognize zeros and ones and change them, proceeding one step at a time. Nevertheless, what their proponents call qualitative approaches to content analysis offer some alternative protocols for exploring texts systematically." (p. 16).

phenomenon under study. In some cases these categories can already have been consolidated by previous research; in this case the study can become a verification of how they are distributed within groups of the population, verification that could allow inferences on the population itself. Furthermore, on a "quantitative" level the phenomena can be measure in different and possibly progressively complex ways: by the type 0/1 (present, missing) data gathering, by frequency count and the use of descriptive statistics, by multivariate statistics, based on the analysis of correspondences and correlations, by factor analysis statistics, cluster analysis, up to variance and regression analysis.

Usually the more qualitative studies place more attention on the exploration and identification of the factors that contribute to the building up of public perception, starting from what people say in interactive situations like interviews, focus groups and workshops. Through an exploration process they try to identify ideas, opinions, uncertainties, worries in addition to perceived advantages and disadvantages. Questionnaires can be used to detect the way qualitative data are distributed in a group/population, while focus groups offer more in depth material, for detecting new elements and understanding the reasons of people's choices.

In particular, "qualitative" studies have contributed to the identification of:

- relevant factors influencing the construction of public perception of CCS in 3 key areas of public questions management: 1) "How can we have a say in what happens? Who is in charge? Will the process be fair and will anyone listen to us?", 2) "What will happen if something goes wrong? Can we trust the project developers and the government to take care of any problems – what have our previous relationship with this entities shown us?", 3) What is the benefit to our community? How does the proposed project fit into or improve our way of life?" [21];
- factors related to the perception of geological and ocean storage of $CO_2$, noting that people do not speak of technical aspects only but rather place their considerations in relation to socio-economic issues [28];
- aspects that orient the acceptance of various energy technologies and the effectiveness of the information communicated through the large group process [20], demonstrating how the attention to the construction of the interactive process can influence people's attitude towards the technology;
- thoughts and emotions people feel related to CCS, highlighting how collaborative learning in a trusting environment can stimulate people to a positive attitude looking for solutions [27];
- the perception of benefits and risks by stakeholders, noting how it can change by participating in a workshop [24];
- how opinion develops, for instance after showing an informative video on CCS and analysing the themes emerged in the discussion following it [25].

The studies that we have here classified as "quantitative" have mainly used structured questionnaires as tools for giving information and verifying its impact. The data collected are processed with descriptive statistical analysis and integrated with covariance structure analysis [37], exploratory factor analysis [7], regression analysis [31], correlation coefficient [30], to identify factors that might be relevant in the construction of public perception and acceptance of the technology. Among these studies we find:

- the ICQ (Information-Choice Questionnaire) whose objective is to understand how the provision of information can influence CCS perception, through the communication of information deemed relevant for forming an opinion [29, 30, 31, 32, 33]. This kind of tool has been developed by Saris, Neijens and De Ridder [45, 46] for evaluating the preferences of the Dutch population concerning energy production. ICQ is not just designed to collect data on people's opinions on the given topic, but rather it aims at supporting people in forming an opinion on the different options. For instance, what would be the best CCS option for the Netherlands to cut 20% emissions before 2030 [29], or what would people consider to be the preferred options for ensuring energy supply in 2030 cutting $CO_2$ emissions by 50% [31];

- studies that aim at the identification of the elements that influence public perception, through factor analysis statistics, have shown that: on one hand, understanding of technological efficacy is a factor that influences positively CCS perception, while risks and possible leakage contribute to the forming of a more negative opinion [7]; on the other hand, the perception of benefits and the contribution CCS can give in the fight against global warming are factors that favour positive perception of the technology. Furthermore a reduced perception of risk and information on natural analogues facilitate public acceptance[37];

A different approach has been taken by other researchers who have developed experimental or quasi-experimental research designs: to assess how trust in the stakeholders [40, 41], collaborative communication between stakeholders [39] and information provision by experts [42] might influence the perception and acceptance of the technology:

- the findings from Terwel et al, [40, 41] point to the importance of trust in stakeholders for the evaluation of information on benefits and risks of CCS. The same type of information will elicit different responses depending on the recognition of the presence (or lack of) competence and integrity of the information provider;
- Ter Mors et al., [39] found that people perceived factual information from collaborative stakeholders to be of higher quality than when the same information was provided by individual stakeholders;
- Wallquist et al, [42] compared the effect of basic versus extensive expert information. After the provision of expert information respondents perceived significantly lower risks and higher benefits from CCS compared to the respondents receiving only the basic info.

### 3.2 Information construction and communication

Reviewing the literature and focusing on how information has been given to the participants in the studies, two key issues can be identified: the first one concerns the relationship between who gives and who receives the information and the context within which this happens. The second one concerns the content of information, the effort to produce balanced and "neutral" information and how the content has been put together. Let us now take these key issues in consideration.

### 3.2.1 The relationship within which the communication happens

We can define communication as a process which connects various subjects through the sharing of contents that are mediated by emotional and context related dimensions. If on one hand communication is a natural process, so much that it is impossible not to communicate [47], on the other hand it is also true that communication is a complex phenomenon, which compels setting aside any linear cause and effect idea in favour of a vision that recognizes the concepts of field, context and co-construction.

In the literature we are considering, communication is thus characterised as a relationship within which there is an exchange among the participants mainly based on contents. Some of the authors assume that the content of information plays a central role in the construction of public opinion, so much that many studies place their focus on how different kinds of information can favour or not the public acceptance of the technology [7, 29, 30, 31, 32, 34, 35, 36, 37].

If content contributes to the construction of an opinion on the technology, it is also important to underline that it is not the only factor in this process, but rather it is one of many factors operating within a certain context. Based on this premise other studies have used information as an input for setting up a dialogue between experts and the public, where opinion is seen as something being constructed through exchange among the participants.

Tools like the large group process, the workshops and focus groups have allowed the creation of interactive situations in which the participants could build up their opinion through dialogue and verbal exchange, in addition to being presented some piece of content. The large group process, in particular, has been tested in the workshops organised by CSIRO [20]. Participants had the opportunity to meet experts and exchange with them on CCS.

A similar approach based on dialogue and interactive communication has also been adopted by Upham & Roberts [25], who organised focus groups that included discussion sessions following the provision of video, text and graphic information. The objective of the study was to analyse how opinion on CCS develops when people are exposed to new information.

A focus on the construction of a participative context has also been placed by Vercelli [27], who has studied how new information can influence motivation and thus the attitude towards new technologies on a group of elementary school students.

Other approaches have given more relevance to the information content offering people the possibility of forming an opinion through written information proposed in the questionnaires. The relationship within which communication happens is intended here in a completely different way with respect to the interactive model referred to in workshops, focus groups and the large group process. The communication model used, holds the transfer of information to the individual as central and sufficient for the person to elaborate his/her own evaluations on which subsequent choices will be made. In a figure/background interplay, information is here considered as the central element, therefore the "figure" and the people implied come to be considered the background. The effectiveness of communication is related to content effectiveness, with the disadvantage of neglecting elements such as the relationship, expectations, motivations, values and the ways peculiar to individuals in constructing a conceptual map on a given topic. The advantage of this approach is that it can propose a number if issues which are unknown or little known to many people and assess the preferences, as for instance with the ICQ or with the questionnaires from Tokushige et al., [37] and Itaoka et al. [7, 35]. The last studies of this kind conducted in 2010 [36], have tried to overcome the limits of this approach integrating data collection from a national survey with two focus groups. The authors have then used the outcomes from the focus groups to integrate the interpretation of the statistical data collected with the survey.

*3.2.2 The content of information*

The content of information plays an important role in public perception formation and many studies have focused on the effects of different kinds of information pieces. Generally speaking, the preparation and/or selection of contents requires a careful evaluation process to make the content fit for communication with the participants whilst also enabling researchers to test the effects of the specific chosen material. From this point of view we can distinguish studies that have used available scientific materials deemed fit for purpose and studies that have prepared their own specific materials.

For instance for the ICQ [29, 30, 31, 32, 33], information content has to comply with specific requirements which are met through a long an complex preparation process involving a number of stages and expertise validation checks from internal and external experts. In addition the content is translated into non technical language and selected to avoid excess information that would be difficult to assimilate. The authors explain that this tool can be used only to get input on issues of limited complexity.

Wallquist et al. [42], have also proposed materials expressly prepared for the research study. Information has been "carefully worded, written in informal language and approved by several experts" and they have asked participants "to rate technical and socioeconomic concept and beliefs related to $CO_2$ and CCS which had been identified in previous research" [28].

Ashworth et al. [20], have proposed information gathered with the help of an advisory body representing a range of stakeholders deemed relevant to ensure objectivity of the final content. They also gave the participants the opportunity to ask the experts for further information.

Other studies, instead, have used already existing information.

Tokushige et al [37] for instance, comparing the effects of information on natural analogues and on demonstration projects, have used available information on natural analogues from the FP5 NASCENT project and on demonstrations project information taken from the websites of the projects (Sleipner, Weyburn, Nagaoka and Gorgon Project). Itaoka et al [7] have used contents from different sources to evaluate how the source of information influences public evaluation of the technology. The reference sources being: 1) newspaper articles; 2) IPCC report on $CO_2$ Geological Storage [48]; 3) IPCC plus a message from scientists; 4) IPCC plus information on natural and industrial analogues; 5) IPCC plus description of European plans for CCS implementation.

Wallquist et al [28] used a mixture of tools: a 5 minute video on Sleipner shown on TV the previous week; a comprehensive chart on the CCS process, figures and schemes illustrating storage., This information, given before the interviews, was chosen in an attempt to be as neutral as possible and to avoid influencing the interviewees. Upham & Roberts [25] proposed video, text and graphic materials. They also aimed at neutrality, by them intended as coherence with the prevailing scientific thinking on the subject and thus referring to IPCC [48, 49]. In the work of Bradbury et al. [21], the focus group discussions were supported by information sheets approved by the US Department of Energy. In the case of Ter Mors et al. [39] and Terwel at al. [40, 41], by contrast, one and the same piece of information was presented to all participants as having been produced by different stakeholders.

As can be seen, a wide range of materials has been used by the researchers, from official documents to newspaper articles, from carefully and specially elaborated information to videos shown on television. Nevertheless, common to most has been the intention of providing "neutral" information. We agree with the authors that the presentation of one content or another will influence the perception of the technology. But it should not be forgotten that people in a natural context are not involved in such controlled and controllable interactions and messages. They also follow other criteria for forming an opinion as is clearly shown in the studies by Ter Mors et al. [39] and Terwel at al. [40, 41], such as trust in who has produced the information and the quality of the information when considered as resulting from the collaboration among stakeholders. Making a further step, we can perhaps recognize in the concept of "neutrality" an expression of the line of thought which refers back to the mathematical theory of communication [50]. Within this theoretical framework, the importance of the message and of eliminating any possible "noise" disturbing the signal is central. But remembering that this theory was originally developed in relation to the man – (computer)machine communication, would it not be advisable to give up the "comfort" of assuming an identical communication code shared by the "transmitter" and the "receiver" in favour of a more complex dimension where the linear cause-effect reasoning is replaced by the idea of a shared field, a concept of co-construction and context? These considerations are meant to raise a question for future research on the topic: what are the terms for considering a piece of information as neutral and objective? What could be the advantages of operating within a different paradigm?

## 4. Conclusions

Informing people about CCS has been up to now a necessary task for social researchers working on CCS public perception. Most studies have undertaken this task placing a lot of attention on the selection and preparation of information. It nevertheless emerges from the research that information is only one element of the complex life situation that influences the way CCS is perceived. From this point of view the effort to provide "neutral" information for research purposes could perhaps shift its focus to more content

related investigations, since content more than neutrality appears to be influencing perception [7, 37, 42]. From a different perspective, the importance of the relational context within which the information is communicated suggests that this aspect should be prioritised in the development of investigations tools.

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