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CCS as part of a global cultural development for environmentally sustainable energy production

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Abstract

Cultural transformation is needed to allow the world's population to make the right decisions for dealing with greenhouse gases. The authors have conducted an explorative study into the social representations and cultural models that could facilitate or hinder the necessary decisions for the implementation of Carbon Capture and Storage(CCS). Some key cultural factors have been identified with regard to the role of scientists, the relationship with the authorities, and the connection among the different social institutions. In addition it is highlighted how the research approach used can interact with and foster a new cultural representation of environmental problems and solutions.

Keywords: public perception; public awareness; CCS communication; emotional analysis; demand analysis; cultural model; social representation; public acceptance; CO2 geological storage; Carbon Capture and Storage.

1. Introduction

CO_2 is one of the main greenhouse gases whose proportions in the air have changed during the last few decades. As many a report indicates we urgently need to initiate a number of actions to quickly decrease the influence of human induced alterations of fundamental atmospheric parameters. But it is difficult for the majority of people to understand how very small changes in air composition can make a big difference to our lives and to the planet. It is difficult to understand what decisions have to be taken and how. For this reason, the influence of burning fossil fuels on the quality of the air has long been underestimated. Already in 1896 the Swedish scientist Svante Arrhenius started to quantify the contribution of carbon dioxide to the greenhouse effect and to speculate about the influence of variations in the atmospheric CO_2 concentrations on long term climate variations. After winning his Nobel prize in chemistry Arrhenius suggested that the burning of fossil fuels by humans would have doubled the pre-industrial level of CO_2 in the atmosphere. He clearly anticipated that the release of large quantities of CO_2 to the atmosphere would not be without consequences. Nevertheless man has continued for many years to burn fossil fuels without worrying about the consequences. And this is what we are still doing, because the use of fossil fuels has changed our lives to such an extent that we cannot do without them. At least until we find other more environmentally sustainable solutions.

To bridge our world to a more responsible use of resources and to the implementation of new technologies which already incorporate the concept of respect for environmental balances, we need to be ready to adopt a number of measures which might

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be costly or demand a change in our life style. CCS is one of them, a technology which gives us the time to develop new energy sources while still using fossil fuels in a more compatible way. It would seem to be common sense then, that CCS, just as many other possible solutions to reduce greenhouse gases, should be implemented without hesitation, even if there are costs or other draw-backs like energy penalties. Still, the implementation of CCS is slow, and although the world is hoping for solutions to climate change, only a very small number of people have ever heard about this technology. In Europe, for example, only 20% of the population - medium rate for 25 European countries (8) - has any knowledge of the existence of CCS. From when CCS was first proposed in 1986 by two Norwegian researchers (Erik Lindeberg and Torleif Holt) only a few industrial sites have been realized, such as Weyburn in Canada, Sleipner in the North Sea, and In-Salah in Algeria.

During the last few years things have started to speed up. The European Union has supported a number of projects in the field of CCS, and research institutes have become more and more involved in projects targeted to CCS. Projects such as the European Technological Platform for Zero Emission Power Plants - ETP-ZEP have provided the opportunity for all stakeholders to meet and discuss CCS perspectives, the role CCS can play, and how to address relevant regulatory, scientific, commercial and communication issues. While the technical side of CCS has greatly advanced, thanks to so many initiatives, the social side of CCS is only starting to be developed. Public perception and public acceptance issues with regard to CCS have been the object of a limited number of studies (1).The present work comes in this context, motivated by the need to speed up socio-cultural transformation to allow the exploitation of available scientific research and solutions to climate change.

In this paper we will document the development of the work we have been performing over the last 5 years that has been aimed at understanding how best to communicate CO_2 geological storage(CGS)/Carbon capture and Storage(CCS) to stakeholders and society. It is a work in progress, very much influenced by the atmosphere of the increased need for actions to mitigate climate change. Things are moving very quickly in specialized circles working on the issue of CCS, and there is the urgent need to facilitate the social processes that can support the deployment of the technology. We have therefore made an effort to overview the different studies we have conducted during this period, focusing on research process development, to try to highlight some relevant aspects which can be of interest for their direct practical application.

Three explorative studies have been performed that targeted our understanding of which issues have to be considered when planning CCS dissemination and communication strategies. The studies have involved: 1. researchers in the field, 2. a population living in an area where naturally-produced CO_2 is released to the atmosphere, and 3. primary school children.

The studies have been conducted following a psycho-sociological approach. The psychological factors that influence and shape social perception and social acceptance of CGS have been investigated, for communication, training, and education purposes. The Fluid Chemistry Lab within the Department of Earth Sciences at Sapienza University of Rome (Italy) has been working in the field of CGS from many years, and has participated in six EC projects on CO_2 geological storage, starting with Nascent in 1998. Since 2004 the Fluid Chemistry Lab has also been a partner in CO2GeoNet, a Network of Excellence funded under the European Research programme FP6. In fact, the need to disseminate scientific results and spread excellence from network joint research programs was the initial motivation for studying how to help people understand this technology. An important feature of the adopted approach is the strong collaboration between social and natural sciences. Given the very technical nature of the topic and the psychosocial nature of the task, a continuous exchange between researchers with psychological expertise and researchers working on the technical aspects of CGS has been considered fundamental within the team. As such, a thorough discussion of the technical sides of CGS has guided the design of the social research plan. Progress in research has all along informed the relationship between the team and the wider scientific community.

The psycho-social methodology used is that of ADD – Demand Analysis (2,3,7) with the support of AET – Emotional Text Analysis(4, 6). This methodology is particularly appropriate for the study of social phenomena which have a low level of clear definition and explicit sharing in the social context. It facilitates the manifestation of people's or stakeholders' own representations, reducing to a minimum the risk of researchers super-imposing their own representations on the subjects studied. Another fundamental characteristic of this methodology is that it allows the comprehension of the interaction between cognitive and emotional factors that shape consensus on a social level.

2. The relationship between researchers and the public

One main focus of the research has been the scientific community. At the beginning a small number (13) of open non-structured interviews was conducted with researchers in the field. Subsequently a great deal of material and input has come from meetings and workshops organised within the scientific community that forms CO2GeoNet.

The relationship between researchers and the public can be considered a crucial aspect of CCS communication for many reasons. Researchers are the ones who know more about the technology. Researchers are the most trusted by the public to give information on energy issues (8). CCS is a highly technical topic and very little known by the public. Even more importantly, scientists have a central role in defining standards for safe and reliable CO_2 storage and in guaranteeing the scientific foundations of CO_2 geological storage. For all these reasons it was important to first understand the outlook of scientists towards CCS, because this is going to play a primary role on how CCS will be perceived in the social context. The main finding was that

researchers seemed to be sure about the scientific foundations of CGS, "it is feasible", while at the same time there was confusion and uncertainty about its deployment. This was quite surprising especially in the context of CO2GeoNet, which is a project with a specific objective for integration of the multidisciplinary expertise needed for CGS. The analysis has subsequently proceeded through interpretative actions which have allowed the emerging of the potential critical issues in the communication process between the scientific community and the public. The main potential bias lies in the representation researchers have of themselves and their role in society.

In table 1 the stages of two different cultural representations are summarized: i) the one which was first identified, that seems to be more common and not favourable for efficient communication and ii) the one which is emerging, which manifests when the process of communication is taken care of, such as through the psycho-social work carried out in CO2GeoNet.

Table 1. The table shows how researchers view themselves and their role according to two different cultural models.

Model 1	Model 2
1. The researcher only concentrates on its own field of expertise	1. The researcher finds added value in interdisciplinary exchange and coordination
2. Isolation	2. Integration
3. Somebody else takes care of how to use the knowledge that has been produced	3. The researcher reads his/her own work as related to the scientific and social context
4. Research might remain unexploited if there is no one from outside the research world to pick it up or if only too few understand what is its use	4. The researcher is aware of the meaning of his/her own work for society, he/she feels the need to communicate it
5. The researcher has to be objective and impartial, must not express his/her point of view	5. The researcher is objective and impartial when clearly stating his/her own point of view from a scientific perspective

We can describe the presence of these two cultural patterns as being indicative of a process of cultural transformation which is related to new information needs arising in our society. The high complexities of science and the extreme importance of technological choices for our life on the planet make people very sensitive to scientific issues and the demand for clarity and for somebody to trust as a guide to make the best choices is pressing. This is one of the reasons why scientists are more and more being asked to spread excellence, to disseminate, to bring their knowledge to the people. This is new and not so easy. The way researchers look at themselves, the way they have been taught to consider their role in society follows the lines of model number one, which does not encourage researchers to communicate with society: "it is not our role, it is a nuisance, we have to work". Model number two on the contrary motivates researchers to communicate with society, because they understand that this is going to be not only useful but also stimulating: "I want to express my point of view, I want people to understand my work, I want to learn how to better communicate". This will be particularly relevant for CCS dissemination; the work done to raise awareness within the scientific community enables researchers to express their potential, to fulfil their role in society, to answer to the information needs coming from stakeholders and society. This in fact has started to happen within CO2GeoNet, with a number of new initiatives for training, dialogue and direct communication to the public, like the recently published brochure on "What does CO_2 geological storage really mean?".

3. Researchers go to school

An important part of our work on how to better disseminate CGS research has been through a two year study of primary school children. The objectives of this study were to: experiment teaching materials, identify favourable/unfavourable concepts to learning, identify emotional patterns, and disseminate to children and through them to adults –teachers and parents. The study has seen the involvement of three schools in Rome for a total of 13 classes of 9 to 10 year old children. Working with the children has given us the opportunity to investigate CGS perception at different levels, and, particularly interesting, at a symbolic level through the children's drawings. The inputs received from the children have had a great impact on our own vision of CGS/CCS. As we had expected, children helped us to simplify our concepts and see more clearly the role of CCS in the wider context. The drawings produced by the children very clearly pointed to the problem we are facing, having heavily polluted our world and having put at risk the survival of animal species and of humanity too. This is a strong message coming from the children, telling us to look at reality, to face it, to stop denying what in fact is in front of our eyes. At the same time they clearly expressed the need for solutions, finding healthier ways to live, produce energy, and enjoy life, which is a simple and straightforward message coming through all the practical complexities of remediation action.. No matter how difficult finding solutions can be, since

climate change is perceived as a life/death issue, engagement to find and implement solutions is seen as vital. One of the main findings in terms of the emerging cultural representation can be visualized in fig.1.

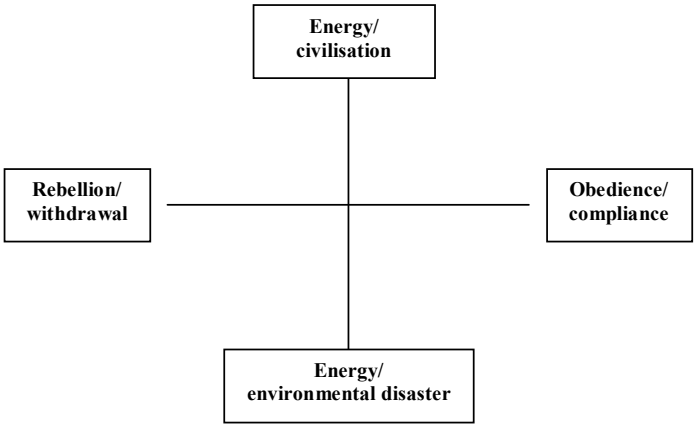

Figure 1. The scheme shows the articulation of the emotional pattern activated by the concept of energy

A scenario related to the representation of energy can be delineated. Energy has a positive dimension, bringing advantage to society and representing a civilisation factor. At the other end of the spectrum it is linked to the destruction of the balance of natural environment, to environmental disaster, and to death for biological systems. This axis is associated with a range of attitudes towards authority, spanning from obedience and/or compliance to rebellion and/or withdrawal towards actions, decisions or demands coming from the authority. The factor that seems to play the most critical role is the process followed by the authority in taking decisions. If the decision is perceived as an imposition it can elicit refusal to learn about the technology or refusal of the technology altogether.

A further analysis of the data also suggests that the choices and behaviours that have brought the world to such a severe situation as climate change might have originated within the framework of such a negative relationship with the authority. The inability to understand the destructive potential of certain energy policies, of burning fossil fuels without taking adequate measures to prevent environmental damage, could be linked to a relationship with authority that does not allow enough space for independent thought and decision. This finding, which needs to be further investigated, appears quite helpful for understanding many public opinion phenomena of reactions and opposition to technologies or decisions concerning the environment. It has great implications for the whole issue of educating young generations to more responsible behaviours with regard to environmental problems, but it also sheds light on more general issues of public acceptance of energy technologies and policies. If a feeling of being imposed on is at the origin of contrasting behaviour, then it will be crucial to adopt decision making procedures that seriously and systematically allow for collaboration and participation at all social and political levels. Concerning CCS, the involvement of civil society at an early stage, preferably before decisions are taken, will be a priority of any project or policy that does not want to run the risk of being suddenly stopped by public opinion opposition. But what will be the specific concerns of people when coming to learn about CCS?

4. CGS at the level of local implementation

CO_2 geological storage is considered a safe technology based on the knowledge of gas behaviour in the underground. A well designed storage site is expected to contain injected CO_2 for thousands to millions of years, the same way natural oil and gas fields have existed for millions of years. Nevertheless when considering the possible impacts of the technology the potential of any release of CO_2 from the well or the reservoir needs to be taken into account. Health and safety of humans and biological systems will be the primary concern of local populations dealing with CGS installations. To address this concern research is needed to understand how the public will perceive CGS and which specific issues will be raised. In the absence of a population already experimenting life with CGS and the impossibility to investigate representations of CCS in the public due to the generally very low knowledge about CCS, a study has been conducted on a population living near natural CO_2 emanations, assuming that the issues to be found in such a situation could possibly be similar to those that could be raised by any population living near a CO_2storage site.

Ciampino is a small town a few kilometres away from Rome situated in a volcanic and seismic area. The presence of natural CO_2 emanations includes a large gas vent which releases up to 7 tons of CO_2 per day, with houses only thirty meters away. The population of about 38,000 inhabitants lives on an area of 11 square kilometres. Interviews have been made with local authorities and with persons responsible for local civil protection. A survey has also been conducted on a sample of 309 inhabitants. Two thirds of the population knew about gas emanations, while one third had no knowledge. The latter group was asked if they wanted information on the phenomenon and what kind of information. Concern about possible consequences for health was the main focus of requested information. This result gives an important indication as to which could be the concerns of populations who for the first time hear about CGS: would it be dangerous for health? It thus suggests that a specific involvement of medical institutions would be advisable. Two aspects have to be taken into account: the preparation of medical doctors to answer people's questions and concerns; and epidemiological monitoring to complement geological and biological monitoring for impact assessment of CGS. But even more interesting were the results from the interviews and the survey sub-group of the population which knew about the gas emanations. Generally gas emanations were not regarded as a main source of worry; the population appeared much more worried about the pollution coming from the nearby airport, and from car, lorry and train traffic. The main emerging needs are to know exactly where the possible danger is and what are the mechanisms that regulate gas flow. This need has been partially answered by the scientific studies commissioned by the city council, studies which could probably be further disseminated. In the case of storage sites a preparatory study of the baseline gas values and the geological structure of the area, in conjunction with a clear explanation of gas behaviour in the underground, would seem to have a fundamental role in the perception of local communities. What emerged as a very characteristic feature, at the level of social atmosphere, was the strong collaboration of local institutions with university and research centres. The numerous initiatives taken by the Ciampino municipality to study the phenomena and to inform the population seems to have produced a favourable social climate for understanding what gas emanations are and what measures have to be taken to avoid any danger. This seems again an advisable choice for any local authorities interested by CGS projects. The interaction and collaboration with scientific institutes can provide not only instruments to address local concerns but, even more importantly, can facilitate a correct approach and a positive social climate that will enable the community to make choices which find consensus at all levels.

5. Evolving perspective: dissemination, public acceptance, public awareness, communication

In this section we would like to focus on how the developments of research and research findings have affected our own perspective on the research itself ,and on CCS and its role in our society. This is an essential element of the cultural transformation process that this kind of research intends to facilitate.

When we first started to research CGS dissemination we were not aware of how far this would have brought us. It seemed a scientific topic like any other, very little known by the public, which needed to be explained and communicated. But we soon realised that CGS was part of a much bigger picture, that related to climate change. A picture which at the time was even more difficult to see than it is now, a picture involving many controversial issues, political conflicts, economical and social problems.

We immediately moved from dissemination to public acceptance: we have a good technology which can help the world face climate change, but nobody knows about it, so the risk is that when we go to deploy it, people will not understand it and possibly refuse it. And for some time this was the perspective we worked from.

Then, as our study and experience within the Network proceeded, it became more and more clear that what we were dealing with was much more than a problem of public acceptance. In fact the term "public acceptance" was easily misleading, in that it implies the existence of someone detached from the public who can determine what is good, what is the solution and then public acceptance needs to be gained, to support decisions, to allow the implementation of the chosen solution. This point of view, although it may be supported by collaborative approaches like upstream engagement (5), is still an approach that does not fully recognize the role of the public in relation to the process of development of important social decisions, nor does it recognize all the complex socio-cultural aspects that support innovation and problem solving at the social level.

Thus from a cultural perspective we rather preferred to look at the problem as one of public awareness, assuming that the problem we were dealing with was not just a problem "of the public", the public who doesn't know, the public who could react negatively, the public who does not have a sufficient educational background, etc. The problem to face was instead involving all the stakeholders together with the public, it was a shared socio-cultural asset to which CGS/CCS posed a challenge. To be able to incorporate CCS into our way of thinking we need to make a change. And the change in our way of thinking is not only an individual one, it is a collective one in that we all participate in a common cultural milieu.

Raising awareness in turn is a process which implies both cognitive and emotional factors, which we had already assumed to be involved with regard to learning about CCS as a new technology, when our approach was strictly focused on dissemination. Evolving towards a wider public awareness perspective, the role of educational backgrounds together with feelings, emotions, previous experiences and cultural specificities came to have an even greater relevance. What is more, we realized that all the work done from the dissemination point of view, and particularly the work with the children, was feeding and supporting the understanding of the social processes that underline the development of the image of CCS in our society.

What we would like to point out is that the specific approach used will influence not only the outcomes but also both the researchers themselves and the people involved or touched by the research; in our case, through the process of social elaboration enabled by the structure of the studies and the social lab context of the Network, many aspects of the collective representations which could be relevant for CCS have started to make sense, stimulating a different level of awareness which is bound to trigger socio-cultural transformation. It can be hypothesized that a wider application of similar research experiences, in addition to bringing new findings, can also have an important role in encouraging a higher awareness and new and more appropriate ways of thinking with regards to environmental issues such as CCS. Cultural transformation, if left to itself, is usually very slow because the sedimentation of innumerable experiences emotionally connoted in the individual and collective cultural heritage, tends to be stable to protect us from unwanted experiences. If we bring this to light and analyse it with respect to the new challenges, like CCS, then we might speed up desirable transformations of the way we collectively behave and feel with regard to CCS. And now we come to a further conceptual step of our work, from the perspective of public awareness to communication. Communication is a term with thousands meanings, what we intend here is that, while the social processes involved to help the development of public awareness are multilevel and require that the complexities are identified and taken charge of by the appointed responsible entity (in our case: regulators must make good legal frameworks, industry must set out appropriate procedures for site selection and handling of all those aspects which are relevant to the public opinion, scientists must elaborate and organise knowledge in the field to make it exploitable, understandable, easily accessible, etc.) at the same time we have identified the need to shift to a very direct and simple communication level, which drawing on the characteristic of the relationship with the people involved in the research, succeeds in finding the essential messages that the collusive cultural environment still hides. Bringing this messages out in a suitable way, with different means, targeted to the stakeholders, can enable the public to have a clear view, overcoming the feeling of excessive complexity, allowing awareness on a global level, allowing society to take appropriate, long-sighted decisions.

6. Conclusions

Burning fossil fuels without worrying about the consequences on the environment has lead the world to the brink of catastrophic changes to the natural equilibrium. The studies conducted suggest that more than anything climate change is placing humanity in front of a huge cultural challenge: will we manage to understand the problem we are facing, in all its facets and to take the appropriate decisions to solve it?

A number of factors have been identified which could facilitate comprehension of CCS, and the role it can play in the context of environmental policies:

1. there is a gap that needs to be filled between CCS progress at the technical and social levels: if social culture does not develop in parallel with technology, when CCS will reach the commercial stage it might be felt as an imposition and thus refused;
2. work is needed to raise awareness of stakeholders directly involved in CCS; as the work with researchers points out, becoming aware of how they view their own work and its role for society helps the emerging of more functional cultural patterns;
3. the importance and value of public opinion is probably underestimated in current social representations;
4. the involvement of the population should be primary and not secondary to decisions being taken by companies and authorities to facilitate social consensus and avoid feelings of powerlessness and of being imposed on;
5. CCS is better understood placed in the context not only of climate change but also of responsible use of fossil fuels. The link with climate change does not in fact fully explain the logics of CCS. CCS is a direct measure to take care of environmental impacts linked to the use of fossil fuels. CCS is a measure to remediate previous uncaring behaviour in burning fossil fuels. Just as we have learned to reduce other pollutants we need to learn to reduce CO_2;
6. planning is needed for actions at the social level that can pave the way for the smooth transition to CCS equipped power plants: raising awareness at the level of the different stakeholders, medical doctors, young generations, etc.; communication actions that potentially involve the whole population;
7. regulatory frameworks: as seen in the case of Ciampino, collaboration of the authorities with scientific institutions and a good communication channel with the population set the scene for good regulation and easy implementation of the necessary measures;
8. health and safety impact: again, as seen in Ciampino, respect and consideration of information needs of the population should inform communication activities to create the conditions for a positive dialogue between citizens and the authorities. This will better be achieved through a direct relationship with the population and testing approval for information plans before implementing them;
9. a contemporary action to raise awareness and share meaning within the different stakeholders contexts (research institutes, companies, European, national and local institutions, etc.) can greatly enhance and speed up the social processes that bring to clearer and more focused social objectives. As seen within CO2GeoNet, activities that imply

integration and sharing on the meaning of the work done together with respect to the wider social context raise awareness and the capacity of researchers to address those issues which are more relevant and useful to society.

CCS implementation is much more than dealing with technical issues about capture and storage. It is much more than choosing sites and gaining public acceptance. It is much more than disseminating knowledge and educating young generations. CCS implementation calls for a deeper understanding of the meaning of single actions with respect to the challenge of climate change, for understanding how they are all linked together, influencing one another and in which direction, wanted or unwanted. A global cultural development is needed to produce a new way of thinking that will support the necessary decisions to save the world from climate changes. From the study in primary schools very simple messages are coming through whose complex implications we need to take charge of. "No more smoking chimneys" is a simple concept that to be realized needs a great number of coordinated actions. Planning them will be a social engineering task which will be only thinkable and realizable once we start to share a new way of thinking, a new culture for environmentally sustainable energy production.

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