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Public Awareness and Perceptions of Carbon Dioxide Capture and Storage (CCS): Insights from Surveys Administered to Representative Samples in Six European Countries

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Abstract

The representative survey studies provide a comprehensive database on the public awareness and perception of CCS in six selected European countries. Our results provide insights into the public understanding and knowledge of energy related issues and CCS topics. The embedded experimental research provides insights into how information affects CCS perceptions. The results discuss implications for CCS communication methods.

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1. Introduction

Previous research has indicated that public awareness of CCS is currently low and that public opinions are rather unstable [1-3]. While in some European countries representative public opinion survey studies regarding CCS have been conducted, in several other European countries, for instance Greece and Romania, no surveys on the public perception of CCS have yet been carried out. Even countries like Norway which are performing numerous CCS-related activities, are in possession of hardly any representative results regarding public perception and awareness of CCS.

Against this background and given the fact that research and development activities on CCS are continuously increasing, it is important to continue and advance the assessment of public perceptions of CCS in Europe. The presented paper contributes to this field of research, summarising the results of representative surveys in six European countries - Germany, Greece, the Netherlands, Norway, Romania and the United Kingdom (UK). So, this study fills a gap by including three countries for which no public opinion data were available up to now (i.e., Romania and Greece). The random sample of each survey consists of over thousand respondents (i.e., N varied between 1000 and 1109) so that data of more than 6100 interviews are now available. To ensure comparability between all the countries, the questionnaire includes a set of core questions on CCS awareness and perceptions and was administered in a similar manner in each country. All survey data were collected from the last quarter of 2009 to January 2010, final reports on all results were conducted in March 2010.

All surveys contained a general and a specific section. Within the general section attitudes on energy and environmental issues were measured in addition to the media preferences of the respondents as well as their trust in information sources in terms of energy related issues. Furthermore data on the general knowledge on environmental issues and estimates on the contribution of certain activities for CO₂ reduction were gathered.

The second CCS-specific section focuses on the awareness of CCS and encompasses an initial evaluation of the contribution of CCS technologies to CO₂ mitigation. Since previous studies pointed out that only a small share of the public is aware of CCS technologies, the respondents received a brief and easily understandable information text on CCS. Afterwards the respondents were asked to evaluate the CCS technologies again. A matter of particular interest within the CCS-specific section of the study is that the survey included an experiment investigating whether different information content affects the public perception of CCS.

2. Public Awareness and initial perceptions of CCS in six European Countries

60% of all respondents indicated to have never heard about CCS before participating in this study. The public awareness of CCS in the six European countries is quite different (cf. Table 1). It can be assumed, that the level of awareness increases with the actual existence or plans for CCS activities in a specific country.

Table 1: Percentages of self-reported awareness of CCS specified per country

Country	Never heard about CCS	Heard a little bit	Heard quite a bit
Germany (N=1017)	61.9	28.3	9.7
Greece (N=1000)	76.5	18.7	4.8
The Netherlands (N=1109)	50.0	44.5	5.5
Norway (N=1000)	37.4	45.2	17.4
Romania (N=1002)	75.7	21.4	2.9
UK (N= 1040)	61.9	31.8	6.3
Total	60.4	31.9	7.7

The vast majority of respondents in Greece and Romania (just over 75%) indicated never having heard of CCS technologies. The respondents in Norway and the Netherlands expressed the highest level of awareness of CCS, 62.6% of the Norwegians had heard a little bit or quite a bit, while in the Netherlands half of the population had heard about CCS. Chi-square tests revealed that there is a significant difference between female and male respondents regarding the level of awareness on CCS in Germany, the Netherlands, Norway and the United Kingdom ($p = .00$). Male respondents generally indicated a higher level of awareness on CCS than female respondents in all six countries. Furthermore, with the exception of Greece and Romania, analysis of variance (Kruskal-Wallis test one-way) showed that there is a significant difference between the levels of awareness in different age groups². The oldest age groups³ from the Netherlands and Norway indicated a lower level of awareness on CCS technologies than younger respondents. The middle-aged⁴ groups in Germany and the United Kingdom showed the highest level of awareness on CCS compared to other age groups. There is also a significant difference regarding the awareness on CCS between groups of different educational levels (apart from Romania), revealed by analysis of variance (Kruskal-Wallis test one-way)⁵. More precisely, respondents with a higher level of education also showed a higher level of awareness on CCS.

In sum, CCS awareness differs strongly across national borders as well as within each country. The result leads to the assumption that information and education strategies regarding CCS technologies must be tailored to the specific context of each country and group being targeted.

The perceptions regarding CCS within this study are “initial perceptions” in the sense that they are reported by respondents with very limited information about CCS technologies. As shown previously, 60% of all respondents indicate never having heard about CCS before participating in this study. Hence, while evaluating the initial perceptions regarding CCS, respondents were only given a very brief description of what CCS entails (i.e., “CO₂ capture and storage: Capturing carbon dioxide from power plants exhaust and storing it in underground reservoirs”). This brief description was embedded in the interrogative questioning

² Risk of errors: 0.3% for Germany, 0.1% for the Netherlands, 0.1% for Norway, 0.0% for the UK, significance level $p = .05$.

³ The oldest age groups range from 65 to 79 years old and more than 80 years old.

⁴ The middle-aged groups range from 25 to 49 years old and from 50 to 64 years old.

⁵ Risk of errors: 0.0% for Germany, Greece, the Netherlands, Norway, the UK, significance level $p = .05$.

about the use of CCS technologies and other energy related technologies (in particular: Energy Efficient Appliances, Nuclear Energy, Solar Energy and Wind Energy) to address global warming⁶.

The initial perceptions in the six countries range from a more or less neutral to a slightly positive evaluation regarding the use of CCS technologies, revealed by mean values and standard deviations (cf. Table 2). Greece and Romania would, on average, slightly support the use of CCS technologies to address global warming; these are also the countries with the lowest awareness on CCS. Germany, the Netherlands, Norway and the United Kingdom are on average essentially neutral regarding the use of CCS, although the Germans are the most sceptical of all respondents. The German sample also presented the highest rate of respondents who would definitely not use CCS technologies to address global warming (16.2% = score 1), all counterparts indicated lower percentages within this score.

Table 2: Means and Standard Deviations on initial perceptions towards the use of CCS technologies

Country	Means	Standard Deviations
Germany	3.99	1.93
Greece	4.97	1.96
The Netherlands	4.20	1.61
Norway	4.14	1.63
UK	4.49	1.54
Romania	5.03	1.86

Compared to the use of other energy related technologies, the use of CCS technologies was evaluated much less positively, only Nuclear Energy received lower rankings. In general, to address global warming, Renewable Energy Technologies and Energy Efficiency Technologies were the responses most frequently given by respondents.

3. Change of initial perceptions: the influence of information

Initial perceptions of CCS can be expected to be strongly influenced by new information because they are reported by people who have very little knowledge about the technology (cf. section 2). Hence, future communications about CCS can be expected to heavily influence the initial perceptions people hold [4,5]. The impact of communication about CCS on initial perceptions is exactly what we examined by means of an experiment included in the representative surveys. More specifically, by means of an experiment we examined whether presenting people with positive or negative information about CCS would change their initial perceptions. Our assumption was that initial perceptions regarding CCS would become more negative after the respondents were being presented a short negative text about CCS, while being presented a short positive text about CCS would lead to more positive perceptions. In order to examine this, after respondents had indicated their initial perceptions regarding CCS they were randomly assigned to one of two experimental conditions: half of the respondents in each country received positive information about CCS, while the other half of respondents in this country received negative information about the technology⁷. Afterwards we asked them again whether they would use CCS to address global warming. This question was identical to the one we had asked the respondents before they had read the information text⁸. In our analysis we focused on the degree and direction of change between respondents' pre- and post-information perceptions.

⁶ The question was as follows: The following technologies have been proposed to address global warming. If you were responsible for designing a plan to address global warming, which of the following technologies would you use? The respondents had to express whether they would use the different technologies on a scale ranging from 1 (=definitely not use) to 7 (=definitely use).

⁷ The positive and negative information texts comprised five lines each.

⁸ As mentioned with possible answers to this question ranging from 1 (=definitely not use) to 7 (=definitely use).

Table 3: Means and (Standard Deviations) for change in initial perceptions

Experimental condition		Pre-information perception	Post-information perception	Perception Change
Germany	Positive CCS information (N=507)	4.07 (1.93)	4.03 (1.89)	-.04 (1.94)
	Negative CCS information (N=510)	3.91 (1.93)	3.70 (1.91)	-.21 (1.85)
Greece	Positive CCS information (N=500)	5.03 (1.94)	5.48 (1.74)	.45 (2.01)
	Negative CCS information (N=500)	4.92 (1.99)	4.42 (2.12)	-.50 (2.29)
The Netherlands	Positive CCS information (N=572)	4.14 (1.58)	4.35 (1.64)	.21 (1.55)
	Negative CCS information (N=537)	4.28 (1.63)	3.86 (1.63)	-.42 (1.49)
Norway	Positive CCS information (N=502)	4.12 (1.65)	4.47 (1.72)	.35 (1.42)
	Negative CCS information (N=498)	4.16 (1.61)	4.02 (1.75)	-.14 (1.47)
UK	Positive CCS information (N=506)	4.57 (1.51)	4.81 (1.68)	.24 (1.54)
	Negative CCS information (N=534)	4.42 (1.57)	3.71 (1.84)	-.71 (1.76)
Romania	Positive CCS information (N=496)	4.95 (1.92)	5.52 (1.76)	.57 (1.66)
	Negative CCS information (N=506)	5.10 (1.81)	5.30 (1.85)	.20 (1.60)

The results of the experiment confirm the assumption that initial perceptions of lay persons who have very few information about CCS can be strongly influenced by new (and even short) information. Multiple t-tests revealed that the change in perception scores differed significantly from zero, all p s = .00 (except from Germany). Secondly, the results confirmed our hypothesis that initial perceptions of lay persons change in a negative direction after presenting negative information and in a positive direction after presenting positive information (with notable differences from Romania and Germany). In the Romanian data set the analysis indicated that initial perceptions changed in a positive direction in spite of presenting negative information. In contrast, the initial perceptions in Germany changed in a negative direction after presenting positive information.

4. The impact of pre-existing attitudes towards certain energy sources on initial perceptions of CCS

It can also be assumed that initial perceptions regarding CCS are influenced by pre-existing attitudes such as the respondents' attitudes on energy issues. The respondents' attitudes on energy issues were measured by their preferences regarding the use of different sources of electricity in their countries⁹. Regression analysis showed that different attitudes towards the use of electricity sources caused different initial perceptions regarding CCS. There are notable differences between the six countries. More than half of all respondents from Germany, the Netherlands and the United Kingdom who were in favour of the use

⁹ The question was as follows: Using a scale from 1 (=opposed) to 7 (=in favour) please indicate the extent to which you are in favour of or opposed to the uses of these different sources of electricity in your country (Solar Energy, Wind Energy, Hydroelectric Energy, Biomass Energy, Coal, Natural Gas and Nuclear Energy).

of Nuclear Energy would also use CCS technologies. Beyond that we revealed that the initial perceptions of the use of CCS were influenced by the respondents' attitudes regarding the use of Natural Gas, especially for the countries Greece, Germany and Norway. Different attitudes regarding Renewable Energy Technologies caused different initial perceptions regarding CCS (for the Netherlands, Norway and the United Kingdom). To summarize, the results revealed that the respondents' attitudes towards energy issues had a significant impact regarding the perceptions of the use of CCS-technologies. Natural Gas and Nuclear Energy, as conventional energy technologies, exhibit a significant impact on perceptions towards using CCS in the majority of all countries. The impact of perceptions regarding CCS caused by attitudes regarding Renewable Energy Technologies was mainly concentrated on two sources of electricity: Hydroelectric Energy and Biomass Energy.

Furthermore, regression analysis revealed that also the level of awareness, general knowledge on environmental issues/science and knowledge on CCS caused different initial perceptions regarding CCS. Yet again, there are strong differences within the different countries.

5. Conclusion

Public awareness and perception of CCS in the six European countries differ quite a lot. Three-quarters of Romanian and Greek respondents have never heard of CCS, but even in Norway, which has longstanding involvement on the subject, almost 40% had never heard of CCS. In all six countries the majority of respondents would support the use of CCS as part of a strategy to address global warming, but in all cases it is clear that support is generally weak, built on a low base of awareness. Moreover, support for CCS does not automatically rise with a higher level of awareness, in the four countries where there was the highest awareness of CCS (Germany, the Netherlands, the United Kingdom and Norway) initial levels of support were lower compared to Romania and Greece, showing the lowest level of awareness of CCS.

This study shows that socio-demographics, new and short information on CCS technologies and pre-existing attitudes on energy issues are responsible for variations within the public awareness and perception of CCS. Women, younger and also older people and those without a higher education indicate lower levels of awareness. Future information on CCS should be targeted towards these populations, by choice of information channels and content. More research must be conducted on how best to target and engage these subgroups.

Moreover, the results concerning the change in perception due to different information contents illustrate that initial perceptions are not very well suited to predict future public support or opposition to CCS. Thus, based on the results of the representative surveys (for further details cf. Pietzner et al. 2010 [6]) and the comparison of communication methods (for further details: cf. Terwel et al. 2009 [7]) recommendations were derived concerning how to communicate CCS in order to enable the public to develop well-informed and well-considered opinions which are valuable predictors of future public acceptance of CCS.

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