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A survey on the public perception of CCS in France

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Abstract

An awareness and opinion survey on Carbon Capture and Storage was conducted on a representative sample of French aged 15 years and above. About 6% of respondents were able to define the technology. The key question about `approval of or opposition to' the use of CCS in France was asked twice, first after presenting the technology, then after exposing the potential adverse consequences. Approval rates, 59% and 38%, show that opinion is not anchored, but there is no a priori rejection. Using 'Storage' instead of 'Sequestration' had no significant effect on approval rates, but the former word is more meaningful.

Keywords: Survey; Perception; Carbon capture and storage; France;

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1. Introduction

A survey on awareness and 'approval of or opposition to' the use of Carbon Capture and Storage in France was conducted to explore the variability of opinion to two key factors: information and semantics. The survey was designed as a split-sample, before/after experiment. To look at the effect of information, we asked about approval of / opposition to CCS twice: first after a short presentation on the technology focusing on global warming mitigation; second after explaining its potential adverse consequences. A lower approval was expected the second time, which was the case but only shows that public opinion is not anchored. Results show that there is no a priori rejection of the technology, but public trust needs to be build. The semantic effect was analyzed by splitting the sample in two: one half heard about 'Storage' (literally in French: stockage), the other half about 'Sequestration' (also: sequestration). We found no statistically significant difference in approval rates between the two terms, but respondents found the "storage" clearer.

In addition to these two core issues, respondents were asked about their awareness of various CO2 mitigation technologies. While the sample was aware of several CO2 mitigation technologies, less than a third of the respondents had heard about CO2 sequestration /storage, making this technology one of the less well known.

The outline is as follows. Section 2 presents the method. Section 3 presents results on awareness. Section 4 present results on approval, before and after the additional information focused on CCS risks. Section 5 examines the effect of semantics. Section 6 discusses the policy implications and concludes.

2. Method

TNS-Sofres, a large reputable survey institute in France, conducted the survey. Respondents were interviewed face to face at home by their network of surveyors using a computer-assisted system. The study was done on April 11–12th, 2007, between the two rounds of the French presidential election. Environment was an important issue at the time, but CCS was almost not mentioned. The questionnaire was developed iteratively starting with a pilot survey [1] inspired in part by Palmgren et al. [2]. After rewriting to consider recent research findings, budget constraints and technical specifications, the questionnaire was further refined with two rounds of pre-testing with workers in the authors' campus. The survey institute helped to simplify and shorten further the final version.

For each individual, three groups of data were collected. Twelve questions specifically related to CCS were asked, followed by 11 questions on the social and demographic characteristics of the respondent. Six additional variables describing the respondent's neighborhood were looked up in a national database.

One cannot expect respondents to know about the subject matter in this kind of survey. A key methodological issue is then to inform as well as question. Answers should not be interpreted as signs of an already existing opinion but as quick responses to a stimulus, a new idea for most respondents. Designing interviews as a two-staged process (before/after information) and structuring the survey as a split-sample (storage /sequestration) allowed us to focus on relative response and analyze the effects of information and semantics.

The sample of 1076 individuals aged 15 and above was selected by the Institute. Representativity of the metropolitan French population (in both subsamples) was achieved by using the quota method on sex, age, head of household profession/social category and through stratification on the region and the type of urban area.

The surveyors explained CCS using both a simple textual description of the technology and a graphical description. The text, see Table 2, was shown and read aloud by the surveyor. The diagram, see Figure 1, originally provided by BRGM (France) was simplified by erasing confusing elements such as text legends, chimney fumes, boat transportation and alternative storage types.

Most questions were multiple-choices, with a 'no opinion' option available. Questions numbers 4 was open-ended, asking for a CCS definition. Answers, when given, were encoded as 'Correct' (the respondent redefined 'geological storage' using his or her own words), 'Vague' (essentially not wrong, even if remotely related), or 'Wrong'. Summary results are available electronically from the TNS-SOFRES website, the complete dataset is available at CIRED [3]. Statistical results exposed below are taken from the summary tables and cross analysis tables provided by the survey institute. In addition to discussing the aggregate results, we comment on subgroups which deviate from the mean answer at a 95% confidence level. In questions 3, 4, 6, 11 the Wilcoxon rank sum test with continuity correction was used to compare the answers between the two subsamples, while differences in answers to questions 7 and 8 are tested using the Chi-squared test of the contingency table.

3. Awareness of climate mitigation technologies

The first two questions focused the interest of the respondent on climate change. On question 1, most respondents (79%) recognized the seriousness of climate change and said that actions should be undertaken. Subsamples significantly more likely to support action against climate change include: respondents 18–34 years old, civil servants, higher-education graduates and those living in the Paris area. These results are confirmed by the answers to question 12, an open ended question inquiring about what respondents would like to ask if faced with climate change experts. A substantial minority (9%) of answers demonstrate skepticism about the reality of the climate change issues. Yet, most answers related to issues of mitigation (22%), impacts (21%), technologies (11%) and actors (6%). This confirms that, broadly, the French public is aware of and interested in the climate change issue.

Question 2 was about the balance between the Environment and the Economy. Again, a large majority of the sample (78%) tilted towards the former. Replies correlate strongly with the previous answer and the population was more or less divided along the same lines. The subsamples of educated, intellectuals, left-wing, richer, organic-consuming and Parisians respondents inclined relatively more towards the environment. Subsamples comprising older, retired, less educated respondents, or those living in rural areas, or in the Center of France, gave relatively more attention to the economy.

Question 3 examined awareness of various energy technologies, mostly following the list used by Reiner et al. [4]. As Table 1 below shows, nearly everybody declared having already heard about solar energy, nuclear power, wind power, biofuels and energy efficient appliances. Hybrid engine vehicles and hydrogen vehicles are also well known, albeit to a lesser extent. Less than half of the sample declared being aware of carbon sequestration by forests and of energy from biomass. Geological CO2 storage or sequestration is clearly a technology most people have never heard about. Compared to international results our findings reveal a rather high level of awareness on climate change mitigation options among the French public (or a higher self-confidence bias in France).

Respondents were asked again to compare technologies at the end of the survey. Question 13 asked to select, among the same list as in question 3, the three most efficient technological choices to fight ‘climate warming’. Despite asking the question at the end of the questionnaire, CCS remained next to the least efficient technology. It was selected in their top 3 by only 5% of the respondents. Oceans fertilization by iron remained last with 3%. Results demonstrate that the most heard-about technologies are not necessarily seen as the most efficient: ‘planting trees and preserving forests to absorb CO2 in the atmosphere’ ranked first on question 13 (57% of respondents selected it) but ‘carbon sequestration in forests’ ranked eighth on the awareness question 3. Conversely, nuclear energy ranked second on question 3, but seventh on question 13.

Question 4 asked respondents to describe the geologic storage/sequestration of CO, using their own words. At that stage, the technology had not been presented by the interviewer. The majority of respondents (72%) declined to answer, which is consistent with the result of question 3 since they have never heard about it. Other answers were categorized as exact/vague or wrong. Any reply conveying the idea that CO2 was being put underground was classified correct: 6% of respondents offered a correct definition, while 8% demonstrated a vague idea. The 14% erroneous replies mostly confused CO2 sequestration / storage with carbon sequestration in forests.

Table 1: Awareness of energy technologies relevant for climate change mitigation (SOCECO2 survey question 3). Data for other countries [4].

Technology	% of respondents having ever heard about it	
	This survey	Other countries
Solar energy	99	~ 73
Nuclear energy	97	~ 38–85
Wind energy	97	34–87
Biofuels	93	N/A
Energy saving appliances	90	40–68
Hybrid engine vehicles	80	~ 85
Hydrogen vehicles	71	26–48
Forest carbon sequestration	48	2–38
Biomass energy	40	10–54
CO2 storage	34	4–22
CO2 sequestration	27	4–22
Iron ocean fertilization	16	~ 3

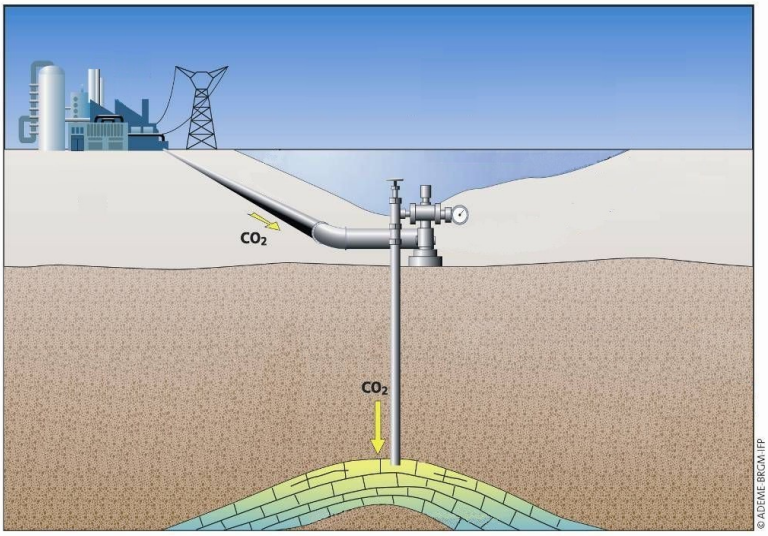

Figure 1: Diagram used to help explain CCS in the SOCECO2 survey. Simplified from BRGM/IFP/ADEME original, with permission.

Table 2: (a) Translation of the text used to explain CCS in the SOCECO2 survey. [sequestration — storage] is a placeholder for either 'stockage' or 'séquestration'. (b) Translation of the text used to expose respondents to CCS risks in the SOCECO2 survey.

(a) Here is a text presenting the principle of CO2 geological [sequestration — storage]. We will read it together before going on with the questionnaire.

CO2, also called carbonic gas, is found naturally in the earth's atmosphere. Plants require it to growth and to produce the oxygen in the air we breathe.

However, when there is too much CO2, temperatures rise on the surface of the earth. Today there is 30% more CO2 in the atmosphere than 100 years ago, this is mostly due to energy production (burning coal, oil and natural gas). This increase in CO2 is the main cause of climate change which might have important consequences for the environment and human health. To fight against climate change, we must therefore reduce CO2 emissions. To do so, some political and technical measures should be considered. Among them, one solution has already been experimented in North America, Norway and Algeria. It consists in capturing the CO2 and injecting it deep into the underground instead of letting it go away in the atmosphere. This method is called geological CO2 [sequestration — storage]. The principle already exists in nature since there are a lot of natural underground reservoirs, which have kept CO2 there for thousands of years.

(b) Here is a second text about the consequences of geological [sequestration — storage]. We will read it together.

The goal of geological [sequestration — storage] is to postpone and limit the effects of climate change. Notwithstanding the difficulties involved in finding appropriate underground locations, scientists question themselves about:

- Leakages by which CO2 might go back into the atmosphere and cause environmental damages.
- Sudden leakages that might impact on human and animal health.
- Increasing the pressure underground could cause gentle ground motion that might damage buildings.
- The possibility that CO, a weak acid, contaminates underground rocks and pollutes water.

These effects are not well known yet, this is the reason why:

- Long term permanent monitoring of [sequestration — storage] sites is planned.
- If problems developed, there are solutions to take back most of the CO2 injected underground.

4. Approval of or opposition to the use of CCS

Basic information on the principles and the role of CCS in reducing CO2 emissions were provided as shown in Table 2a and Illustration 1. We then asked question 9 about support of / opposition to the use of CCS in France, using a 4-point scale in order to purposely force an informative answer.

A majority of respondents (59%) were positive, 48% being rather supportive and 11% strongly supportive. The rate of approval was significantly higher among respondents aged 15–17 (73%), respondents living in the North of France (69%), those identifying politically at the right (66%) and those working in the trade sector (71%). Rate of approval was significantly lower in the subsample of respondents with elementary education only (51%) and those living alone (48%).

Less than a quarter (21%) were opposed to the use of CCS in France: 14% rather opposed, 7% strongly opposed. Opposition was significantly higher than average among respondents with middle-scale professions (32%), and lower than average among those identifying politically at the right (15%).

The non-response rate was 20%. It was significantly higher among the respondents aged 62 and older (32%), with elementary education only (30%), living alone (28%), retired (27%), in Paris area (27%) or in communities with lots of social housing (25%). It was significantly lower for respondents in the trade sector (7%), those living in the North of France (10%), in a family of four (12%), high-school-only graduates (12%).

After two questions on semantics, discussed below, we presented information on the potential consequences of CCS, see Table 2b. The word 'Risk' was purposefully avoided as we believed it would strongly bias the results. Given the scientific uncertainties and the need for simplicity, we did not present any quantification of the effects or of their likelihood. Remediation measures were presented.

Question 9 tested how respondents reacted to this shortlist of potentially negative consequences of CCS. The no-reply rate was rather low (10%). Most respondents (63%) considered that more research was needed.

A small minority (9%) already considered that uncertainties could be controlled enough so as to ensure a good security. This point of view was significantly more frequent among organic product consumers (20%), inhabitants of the North of France (16%), executives (16%) and higher-educated people (13%). It was significantly less frequent among respondents aged 18–24

A larger minority (18%) answered that the uncertainties are too large and that this technology should not be used. Nearly a third (29%) of those who believed that concerns about climate change are not justified pointed out that CCS should not be used. In short, skepticism on the climate change issue tends to imply opposition to CCS. This intuitive result was already apparent in the pilot survey and in the previous literature, see for example Itaoka et al. (2004). However, there are subsamples in which this a priori rejection of the technology is less frequent. They include executives (7%), parliamentary right sympathizers (13%), families of 5 or more (11%), incomes above 3.000 euros (10%) and Parisians (10%).

Question 10 was a choice between two propositions. Proposition one framed CCS positively, stating that it allows us to benefit from the existing coal and oil reserves. Proposition two depicted CCS as a moral hazard, stating that it potentially discourages the development of renewable energy technologies. The response rate was lower than at question 9, with 21% of no-opinion. This is not surprising since the question was more complicated. But as a way to focus the respondent's attention on the main CCS pros and cons, we felt that asking this question was probably more efficient than an academic standalone explanation. Only an 18% minority balances towards the idea that CCS is a good transition technology. This rate was significantly higher among teen-agers (32%), respondents living in the North of France (30%), consumers of organic goods (29%). It was lower (9%) among young adults aged 18–24. Most respondents (61%) rather inclined towards the idea that 'CCS could be an excuse to avoid changing the way we produce energy'. Dispersion between subsamples is larger than for other questions. The use of CCS tended to be seen as an ecological alibi particularly by members of consumer groups (84%), ecologists (77%), adults 18 to 49 years old (77% of the 18–24 age class, 70% of the 25–49), respondents with high levels of income (75%) and highly graduated (72%), executives middle-managers and employees (72%). The older, retired or elementary education only subsamples were significantly less likely to support this point of view and much more likely to have no opinion. This confirms the salience of the moral hazard shown by Itaoka et al. [6]. This is also important in NGOs' discourse, many arguing that financial public support should be used to promote energy efficiency rather than CCS.

At this stage, question 11 repeated the text of question 6 on approval of or opposition to the use of CCS in France. Compared to the initial reactions when the principle of the CCS was presented, lower approval rates could be expected and have been found.

On the whole, the approval rate was 38%, down from 59% in question 6. As previously, it was significantly higher (50%) among respondents aged 15–17 and those identifying politically at the right (47%). It was also significantly higher among executives and intellectuals (48%), and non working persons in the highest income bracket considered (50%). The rate of approval was significantly lower in the 35–49 years age range (31%), for ecologists (26%) and respondent without a political preference (31%). The opposition rate was at 42%, compared to 21% in question 6. Opposition was stronger among ecologists (60%), lower income respondents (55%), workers (54%) employees (52%), respondents aged between 35 and 49 years old (53%). Opposition rates were lower in Paris (33%) and in urban areas with low unemployment (33%), as well as for respondents identifying politically at the right (34%) and non-working persons in the highest income bracket (24%). The rate of no-reply was comparable for questions 6 and 11, about 20%. Respondents retired, aged over 65 or living in two-persons households were relatively more likely to give no answer (30, 34 and 26%, respectively), and less likely to oppose CCS (32, 33 and 34%).

The large variation between the answers to questions 6 and 11 shows that opinions are not firmly anchored. Approval rates decline when the respondent's attention is focused on the uncertain local consequences rather than on the global climate benefits.

5. Semantics: Storage vs. Sequestration

The word 'stockage' (storage) was used for half the sample, and in the other we used 'sequestration'. Question 7 and 8 made it clear to the respondents that we were interested in the semantics, even if the questionnaire did not ask for a straight comparison between the two words.

First, does the degree of approval change with the word used to describe the technology? The pilot survey found that the word 'sequestration' tended to arouse higher rates of approval. In this survey when basic information was provided the approval rate for 'sequestration' was 60%, against 58% only for 'storage' (question 6). The difference was even larger at the end of the questionnaire: 40% versus 35% for the 'storage' half of the sample (question 11). The balance tilted in the same direction.

But the difference between the two halves of the sample was not statistically significant. On question 6 (ex ante opinion), approval rates differed by only 2%. The hypothesis that 'the semantics has no effect' easily passes the two-sided Wilcoxon rank sum test (p=0.2004). On question 11 (ex post opinion), we tested the one-sided hypothesis that approval rates in the half-sample with 'sequestration' was larger than in the half-sample with 'storage'. Here again, p=0.1376 is large so that the hypothesis does not hold. We conclude that statistically, the semantics does not influence significantly the respondent's degree of approval.

Considering the effect of the semantics elsewhere in the questionnaire, storage appears clearer than sequestration. Answers to question 3 (awareness) shows that people were more aware of storage than sequestration. The difference is statistically significant (Wilcoxon rank sum test with continuity correction, one sided, p=0.0386.) Moreover, question 4 (open ended, CCS definition) shows that people were able to provide a better description of the technology when it was called carbon storage than carbon sequestration (Wilcoxon rank sum test with continuity correction, one sided, p=0.0796.) Since that question had a lot of no replies, 72%, we conducted the same test in the subsample that provided a definition. The difference here is even more statistically significant (p=0.0006). This is congruent with the result from question 7, where more people faced with 'stockage' considered that the name of the technology helped to understand what CCS is about (62% versus 48% in the 'sequestration' subsample). The difference is significant (Chi-squared test for independence between the semantic and the reply to question 7).

On Question 8, more people faced with 'stockage' considered that the name of the technology gave a good image of it (44% versus 33% in the 'sequestration' subsample). Here again the difference is significant (Chi-squared p=0.000197). This contradicts the survey result, that sequestration arose higher rates of approval (questions 6 and 11, although this result is not statistically significant). Either the public is not a reliable assessor of its own opinion, or although we intended 'a good image' to mean *favorable*, most respondents interpreted it as *clear*.

6. Discussion and conclusion

Miller et al. [7] found that the Australian public lacked knowledge about CCS but was willing to engage and learn about the technology. Compared to men, women were less accepting of CCS and more concerned about safety, risk and effectiveness. Those with a higher education were more aware of the greenhouse gas debate and supportive of CCS, whilst younger Australians were more trusting that information providers 'told the truth' about CCS.

In the SOCECO2 survey, gender and the opinion on CCS are significantly not independent (Chi-squared test, p=0.011 for question 6, p=0.037 for question 11.) Results show that women tend to be less accepting than men, as in the Australian survey. This does not mean that women are more opposed but that they more frequently abstain from giving an opinion. As with the Australian survey, women tend to be more concerned about uncertainties.

Education level and age are also very much correlated. We found that aged or retired respondents as well as respondents holding no or an elementary degree tended more often to abstain from giving an opinion. Accordingly, they are less often supportive of the technology, but also less often opposed to it.

With respect to other factors, occupation and income are influential. Respondents holding executive positions or intellectual jobs were more frequently supportive of the technology than those in other job categories. This is also true for respondents in the highest income bracket. This holds for both ex-ante and ex-post opinions (questions 6 and 11), even the deviation is not always significant at a 95% confidence level.

Considering that the difference between questions 6 and 11 arises only because respondents have been informed about the technology might suggest that acceptability decreases when information increases. Yet, this would implicitly reduce information to a quantitative asset, neglecting that its content (quality) as well as the type of situation in which it is provided are decisive. In other words, our results do not mean that withholding information might increase the acceptability of CCS projects. On the contrary, many reasons suggest that transparency is necessary in project development. We will only explore a few of them in what follows before discussing our result as regards to the impact of information.

Our survey has studied CCS as a generic technology. As in the case of other technologies, such as wind power for instance, the acceptance of local projects might be very different than that of the generic technology. At the local level, NIMBY concerns, environmental justice, planning procedures and specific features of the local project can drive opposition to or approval of it.

Information is not the only factor influencing people's opinion. Huijts et al. [8] have shown that trust in professional actors is particularly important. NGO's were found to be trusted most and industry least by the general public. Trust was found to depend on perceived competence and intentions. However, perceived intentions were more important than perceived competence when it came to trusting industrial actors.

Questionnaire-based surveys create very artificial communication situations. In reality, people form opinions by dialogue. Actual opinions are diverse, volatile, history and situation-dependent. 'Public opinion' is a statistical social construct, as is the half male, half female 'average individual'. A known bias is that when answering a questionnaire, people tend to pay more attention to what they have heard last. Accordingly, answers to question 11 are influenced by risk considerations and oriented towards a negative view of CCS. For these reasons, the average answer to question 11, that is a rate of approval at 38%, is not a better approximation of a pre-existing 'public opinion' than the 59% average answer to question 6. These might only be seen as a range, which can be compared to other ranges obtained in other surveys that ask similar 'approval of/opposition to' questions.

The difference in information between questions 6 and 11 is not only quantitative, but also qualitative: we initially exposed the necessity of CCS, then the risks associated with it. To some extent our approach to the formulation of information was driven by a technical and precautionary acception of 'objectivity', implicitly believing that informing about risks might contribute to objectivity. The shift from 59% to 38% can be read as the effect of a technical / precautionary approach to information provision.

The scientific literature about the effect of information provision on CCS approval is ambiguous. Palmgren et al. [2] found that interviewees' initial dislike for geological and oceanic carbon sequestration relative to other carbon management options seemed to increase with the provision of more detailed information. On the contrary, Itaoka et al. [6] found that the more information respondents obtained about CCS, the more likely they were to support those storage options except for the onshore geological storage. In a similar way, Shackley et al. [9] reported that in the absence of information, the majority of people either do not have any opinion about carbon storage or are somewhat skeptical about it. Once (even limited) information is provided as to its role in reducing CO2 emissions, opinion shifts considerably towards a slight support for the concept.

The two surveys reported by Curry et al. [10] also showed a significant impact of information. Respondents in the United States were asked to choose one energy technology to address global warming. Half of the sample received no information and the other half received information about the various technologies, such as: their costs, their efficiency in reducing emissions CO2 and their current share in electricity production. Informed respondents more frequently chose CCS than uninformed respondents, at the expense of renewable energies. But these findings can hardly be compared with those from our study, because qualitatively different information was presented. In the study of Curry et al, the information provided was strictly focused on relative costs aspects. It included much less information on the principle of CCS and its risks than the SOCECO2 survey. Thus, respondents who selected CCS among other technological choices did so based on a differently incomplete information package.

Our survey shows that climate change is largely recognized by the French public as a serious problem calling for action. Overall, the sample said that the environment/economy balance tilts toward the former term. Yet, several alternative sources of energy remain unknown and the request for information is real, in particular about the causes of climate change and the solutions to be brought. This depicts a general background in which the idea of carbon capture and storage could potentially fit positively. However, this technology is not known by the large majority of the French public. Only about a third of the population declared having heard about it and only one in twenty respondents were able describe its principle correctly.

How the public learns / might learn about CCS appears to be a significant stake. The rate of approval was insignificantly higher when 'sequestration' was used to describe the technology, compared to the same description using 'storage'. But the word 'storage' appeared clearer than the word 'sequestration', even if it does not convey the idea of monitoring and irreversibility.

Overall, this study reveals that French public is not strictly opposed to carbon capture and storage, but rather suspicious than supportive. Support is conditional at best, its level depends critically on technical risks and the political use of this technology.

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