WP3 Document

Public acceptance of CCUS technologies. A survey study in France and Spain

Release Status: UNDER EC REVIEW

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Date: 15 December 2021

Filename and version: D3.3_STRATEGY CCUS_Dic_2021_SurveyReport

Project ID NUMBER 837754

STRATEGY CCUS (H2020-LC-SC3-2018-2019-2020/H2020-LC-SC3-2018-NZE-CC)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 837754

Document History

Location

This document is stored in the following location:

Filename	D3.3_STRATEGY CCUS_Dic_2021_SurveyReport
Location	

Revision History

This document has been through the following revisions:

Version No.	Revision Date	Filename/Location stored:	Brief Summary of Changes

Authorisation

This document requires the following approvals:

AUTHORISATION	Name	Signature	Date
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Project Coordinator	Fernanda de Mesquita Lobo Veloso		20/12/21

Distribution

This document has been distributed to:

Name	Title	Version Issued	Date of Issue
		Public	00/00/0000

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Executive summary

Introduction

In this report, based on survey data in four study populations, we assess levels of awareness, attitudes towards and acceptance of carbon capture, utilization and storage (CCUS) technologies in the public in Spain and France and in a selected region in each of the two countries (the Ebro Basin and the Rhône Valley). We also identify the key individual-level determinants of acceptance of both technological options.

Design

Representative samples on the national and regional level from each country (n= 1300) took part in the survey conducted online. The sample consisted of Dynata panel members who had agreed to participate in online market and social research. The samples were representative for the age and gender groups in each study population and had an approximate distribution regarding region and education. Data was collected during summer 2021 (June to August).

We implemented a questionnaire with the following sections: i) baseline questions; ii) information about CCS/CCU; iii) awareness and overall evaluation of CCS/CCU; iv) beliefs about the attributes of CCS/CCU; v) acceptance of CCUS at the general and the local level; vi) preference for other options; vi) trust. Sections ii, iii and iv constituted the core of the questionnaire and included several items designed to measure familiarity, affects, perceived attributes, perception of benefits and costs, attitude, acceptance and support regarding the two specific applications.

Results

- Most respondents reported not having heard about CCUS technologies before participating in the study. Only around one out of ten respondents reported being familiar with CCS or CCU technologies. There were no significant differences in levels of familiarity between study populations.
- After being informed about the main features of CCS and CCU technologies, respondents in the four study populations provided a more positive evaluation of CCU compared to CCS.
- Respondents in the four study populations reported, on average, more positive emotions towards CCU than towards CCS.
- CCU was perceived as more innovative, necessary, economical, safe, less tampering with nature and more beneficial for the regional and national economies by respondents relative to CCS.
- At the national level, more than half of respondents would accept the development of CCUS technologies in their country. Acceptance levels were higher for CCU (60 per cent) relative to CCS (50 per cent). Acceptance was higher in Spain (65 per cent for CCU and 54 per cent for CCS) compared to France (56 per cent for CCU and 46 per cent for CCS).

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- Younger respondents, women and residents in small cities were, on average, less favorable to CCUS projects.
- Regarding the local acceptance of CCS and CCU projects, acceptance ranged from around 60 per cent for CCU to 48 per cent for CCS. Acceptance levels were higher for CCU projects (62 per cent in both regions) compared to CCS projects (45 per cent in France and 49 per cent in the Ebro Basin).
- Relative to CCUS technologies, respondents preferred reforestation and afforestation, having more ecological lifestyles, investing in energy efficiency, using more photovoltaic systems and in both Spanish samples also building more on-shore and off-shore wind parks.
- Levels of trust were higher, on average, for NGOs and the European Commission and lower for the Industry and the National government. Levels of public trust were, in general, lower in Spain and the Ebro Basin relative to France and the Rhône Valley.
- The main individual-level predictors of acceptance of CCS and CCU included the perception about the economic impacts of CCUS developments as well as prior pro-technology beliefs. Perceived tampering with nature predicted acceptance of CCS at the local level and acceptance of CCU at the national level. Perceived risk played a role in the acceptance of CCS and CCU at the local level. At the national level, acceptance of CCS was also related to affect and trust in energy companies while acceptance of CCU was related to the perceived seriousness of climate change.

Conclusion

Building on previous studies on the public acceptance of CCUS technologies, this report provided an overview of public attitudes towards CCS and CCUS technologies in two European countries and two potential affected regions. We found significant differences in the overall public evaluation and acceptance of CCU and CCS as well as between the four study populations. The factors predicting acceptance also varied among study populations. These results contribute to improve our understanding of public perception of CCUS technologies through cross-national research. As CCUS initiatives in Europe develop, properly engaging the public at the national and the local level will likely play a role in the success of CCUS projects.

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Table of Contents

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Public acceptance of CCUS technologies. A survey study in France and Spain

1 Introduction

The public understanding and acceptance of carbon capture, storage and utilization (CCUS) technologies has become a matter of importance for governments, the energy industry, and academics alike. There is a recognition that stakeholders and the public might affect investment and siting decisions relating to CO2 capture, storage and utilisation facilities and CO2-derived products (Jones et al., 2017) and that understanding public perceptions of CCUS technologies is a critical element in the design and implementation of effective public engagement strategies around potential CCUS projects in Europe.

Public attitudes towards CCUS technologies have received significant attention from the social research in the last 20 years. Available studies have examined public awareness, understanding and acceptance of CCS projects as well as the factors that predict support and opposition to CCUS technologies in different contexts and study populations. In general, reviews of the studies conducted have found moderate levels of public acceptance of CCUS technologies (Jones et al. 2017; L'Orange Seigo et al. 2014).

In studies that disentangle perceptions of CCU and CCS, CCU is perceived more positively than CCS (Arning et al. 2019; Linzenich et al. 2019; Whitmarsh et al. 2019) and CO_2-storage receives the lowest level of acceptance (Dütschke et al. 2016). Furthermore, the specific configuration of the application case also plays a role for public acceptance. For instance, Whitmarsh et al. (2019) found that scenarios combining CCS with bioenergy were preferred over shale gas, underground coal gasification or heavy industry; a study by Dütschke et al. (2016) found preferences for CCS in combination with bioenergy and heavy industry compared to coal-fired power plants.

Some studies have also explored whether those who are more likely to be affected by nearby CCS installations differ in their perception of the technology from the wider population. This has led to heterogeneous findings. Several studies found more scepticism towards CCS on the local level in potentially affected storage areas (Braun 2017; Schumann et al. 2014), while Whitmarsh et al. (2019) identified the same or higher acceptance levels in local samples in a more recent five-country study (CA, NL, NO, USA, UK).

More generally and as for other technologies, perceived risks and benefits are important predictors of variation in acceptance as well as trust in stakeholders (L'Orange Seigo et al. 2014; Broecks et al. 2021; Pianta et al. 2021). Potential risks include leakages or blowouts of CO2, induced seismicity, local impacts (e.g., on property value or tourism) as well as CCS representing an unsustainable solution for retaining environmentally harmful industries. On the positive side, the main perceived benefit is the contribution to climate change mitigation, but sometimes also that CCS might enable a smoother transition to a decarbonized society and bring local economic benefits. Trust in stakeholders was also repeatedly examined and found to play a role

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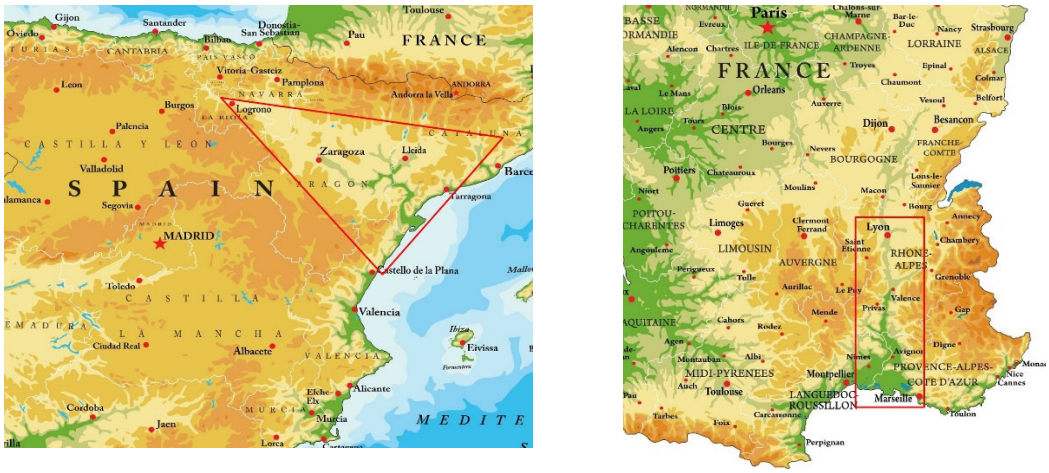
(L'Orange Seigo et al. 2014); stakeholder communication shaped trust perceptions, e.g. in how far lines of argument are perceived to be congruent with the stakeholders' interests (Vries et al. 2015). Further research has looked into the role of affect (L'Orange Seigo et al. 2011; Midden und Huijts 2009) and prior attitudes (Dütschke et al. 2016), however, relationships have not been clearly established.

The STRATEGY CCUS Project has worked to increase the understanding of cross-country differences in stakeholder and public acceptance of CCUS initiatives. In this report, based on survey data in four study populations, we assess levels of awareness and acceptance of CCUS technologies in the general public in Spain and France as well as in a selected region in each of the two countries.

Figure 1. *Maps of Spain and France showing the selected regions, Ebro and Rhône Valley, for CCUS implementation*.



Future economic scenarios on CCUS for these regions with analysis of carbon cycle (LCA) are developed in the further work packages (WPs) of the STRATEGY CCUS project. We specifically examine and compare public attitudes towards CCU and CCS in Spain and the Ebro region in Spain as well as in France and the Rhône Valley region in France (see Figure 1). This also implies that this deliverable focuses on countries that have rarely been subject to research on social acceptance, especially not recently (for exceptions see Ha-Duong et al. 2009; Oltra et al. 2012). The objectives of the study were:

a) To estimate levels of public awareness, perception of benefits and costs, overall evaluation and acceptance regarding: (1) CCS and (2) CCU
b) To identify the key individual determinants of acceptance of both technologies
c) To report on cross-country and cross-region comparisons in public attitudes and acceptance about CCUS technologies.

In the following sections, the main study variables are examined for the distinct dimensions included in the study in the four study samples: awareness, overall evaluation of CCUS technologies, affect, perception of attributes, benefits and costs, acceptance, preference over

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other technologies and trust. The variables are also cross-examined by age, sex, and urban/rural residence and income. Additional analyses are carried out to examine the determinants of acceptance of both CCU and CCS technologies. The summary and discussion section provides conclusions and implications from the study.

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2 Design of the study

The current study is based on survey data collected in Spain, France, the Ebro Basin and the Rhône Valley. A specific questionnaire implemented online to measure public attitudes towards CCUS technologies was developed by the research team. Participants, members of the general population aged 16 and over, were recruited from online panels in the four study populations.

Participants

Representative samples on the national and regional level of approximately 1300 adults from each country took part in the online survey conducted by Dynata. The sample consisted of Dynata panel members who had agreed to participate in online market and social research. The samples were representative for the age and gender groups in each study population and had an approximate distribution regarding region and education. Invitations to take part in the survey were sent to participants through the access panel system. Data was collected during summer 2021 (June to August). The socio-demographic characteristics of the sample in each country are shown in Table 1.

Table 1. *Demographic characteristics of study samples*

Sample		Spain	France	The Ebro Basin	The Rhône Valley
N		1300	1300	1267	1300
Sex (% women)		51%	52%	50%	52%
Age	18-24	8%	9%	8%	11%
	25-29	6	6	6	7
	30-39	16	16	15	16
	40-49	20	17	20	16
	50-59	18	17	18	16
	60-69	19	19	26	20
	70 or more	12	16	6	13
Education	Primary	35%	18%	36%	20%
	Secondary	24	42	24	42
	Tertiary (or higher education)	41	40	40	39
Size of place of residence	<2.000	4%	19%	9%	12%
	2.000-20.000	20	31	25	35
	20.001-199.999	34	32	32	26
	200.000-1.000.000	23	10	28	16
	>1.000.000	18	8	5	10

Hard quotas were applied regarding gender and age based on national and regional population statistics. Soft quotas with broader margins were used for educational level and regional distribution (nationally and within the region, respectively). Due to challenges - especially on the regional level - to fill the quota conditions, a broader oversampling was done. Then, after excluding low quality answers (e.g. speeders and incorrect answers to the control items), the

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sample was reduced - using a random mechanism provided by Dynata to meet the intended overall participant number and characteristics. In the sample of Ebro Basin we were not able to meet the hard and soft quota and the goal of 1300 participants, thus, we have 1267 participants in this sample. All four final samples were representative regarding gender and met the soft quota regarding education and regional distribution. The Ebro Basin sample and the France sample were slightly younger than the population but still in a sufficient manner (rather soft than hard quota). A reason for this could be the online format making it more difficult to reach people older than 60 years. However, the sample of Rhône Valley and Spain met the age quotas perfectly, leading to gender and age representative samples.

Questionnaire

A specific questionnaire was developed by the research team to assess the levels of public awareness, understanding and acceptance CCS and CCU technologies. The design of the questionnaire also aimed at building a predictive model for the acceptance of CCUS. The final questionnaire included items specifically developed by the research team to measure the various dimensions of the public acceptance of energy technologies (Huijts, Molin and Steg, 2012) as well as a selection of items from previous studies on public acceptance of CCUS technologies in different countries. Table 2 gives an overview of the dimensions considered in the study.

Table 2. *Dimensions included in the questionnaire*

Dimension	Definition
Awareness	Degree to which individuals are conscious, know, have heard about CCUS
Affect	Degree in which the technology generates various emotions in participants
Beliefs	Perceptions about the attributes and benefits/costs of CCUS technologies
Overall evaluation	Personal evaluation of the technology
Acceptance	Degree in which the individual accepts further developments in the technology. Support for specific CCUS projects
Trust	Trust in industry and governments to make good decisions about the technology and to succeed
Preference for alternative options	Degree in which the individual favours alternative options (e.g., reforestation, investments in more wind parks, etc.) relative to CCUS
Prior attitudes	Aversion to tampering with nature Pro-technology attitude Environmental self-identity Perception of the economic contribution of the industry

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The questionnaire was structured in the following sections: i) baseline questions; ii) information about CCS/CCU; iii) awareness and overall evaluation of CCS/CCU; iv) beliefs about the attributes of CCS/CCU; v) acceptance; vi) preference for other options; vi) trust. Information on section ii consisted on two paragraphs explaining the basic features of CCS and CCU technologies (see Annex 1). Sections ii, iii and iv constituted the core of the questionnaire and included a number of items designed to measure familiarity, affects, perceived attributes, perception of benefits and costs, attitude, acceptance and support regarding the two specific applications.

Analysis

The data were analysed using SPSS 19 software (SPSS, Chicago, Illinois, United States) and Excel software (Microsoft, Redmond, Washington, United States). Descriptive analyses of the relevant variables were performed for the four study populations. Contingency table analyses were performed to study the relationship between responses on dependent variables and other independent variables such as age, gender, geographic region and other demographic variables. Differences in the frequencies of different survey responses were tested for significance by using a $\chi 2$ test of proportions and Anova for means. Multiple regression and path analyses were conducted to investigate associations among various dependent and independent variables, with difference tests used to make cross-country comparisons.

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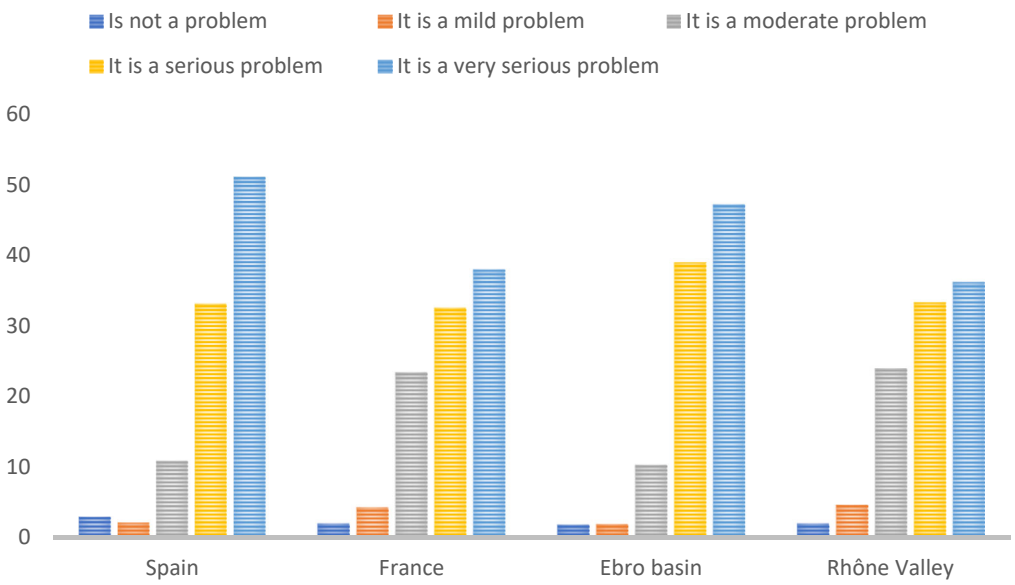
3 Results

Perception of climate change

Before introducing CCUS technologies to respondents, we asked them to evaluate the severity of climate change. As shown in figure 2, climate change was rated as a serious or very serious problem by most respondents (more than 70 per cent) in the four study populations. Less than ten per cent of respondents considered climate change as a mild or not a problem.

Figure 2. *Perception of climate change (as % of respondents)*



We found moderate differences in the evaluation of climate change across study populations. Climate change was rated as a very serious problem by 51 per cent of respondents in Spain compared to 38 per cent in France, 47 per cent in the Ebro basin and 36 per cent in the Rhône Valley. On average, therefore, respondents were more concerned about climate change in Spain and the Ebro Basin relative to France and the Rhône Valley.

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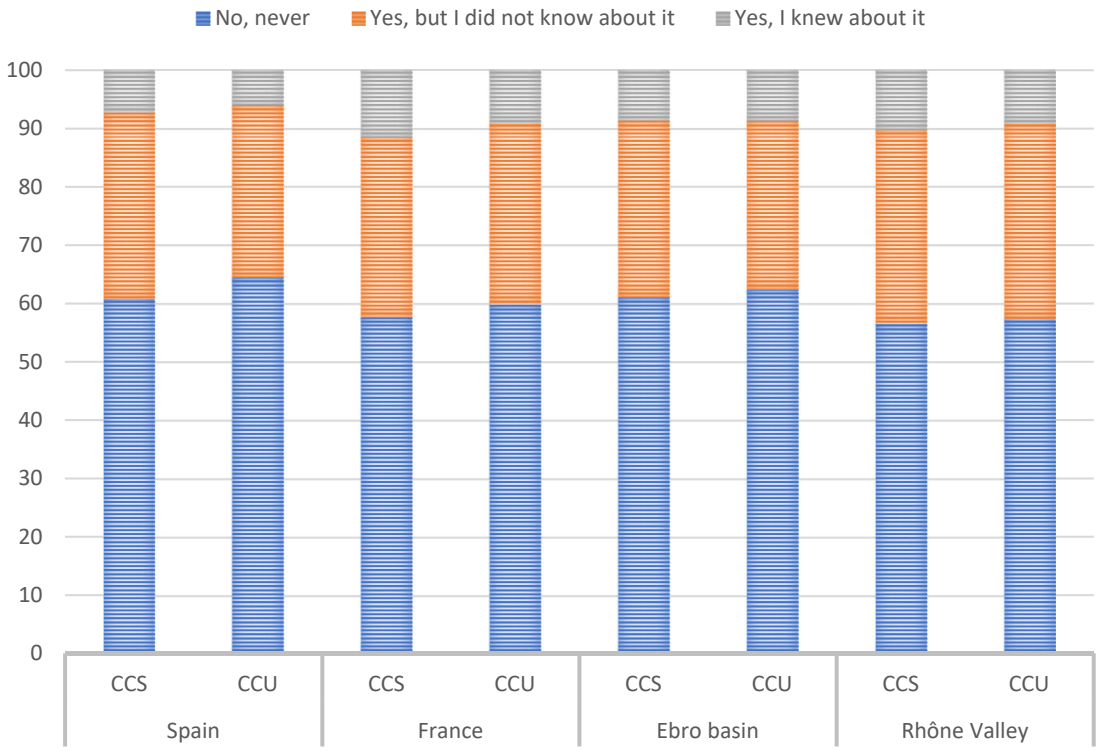
Awareness of CCUS technologies

Figure 3 displays the level of awareness about CCUS technologies in the four studied populations. The survey data showed that the majority of respondents in the four study populations had never heard about CCUS before participating in the study. Only around one out of ten respondents reported being familiar with CCS or CCU technologies. Around 30 per cent of respondents reported having heard about CCS or CCU before participating in the study and around 60 per cent reported not having heard about them. Differences among study populations were non-relevant.

Figure 3. *Awareness of CCUS technologies (answers to the question "had you ever heard about…", as % of respondents)*



Male respondents reported slightly higher levels of familiarity with CCU and CCS relative to females. Awareness was also higher for those having a university degree, as well as for those living in cities with more than one million residents and those aged 18-39 and more than 60. Differences across sociodemographic groups were significant but very weak.

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Table 3. *Awareness about CCUS according to sociodemographics*

(% of respondents that reporting knowing about CCUS by sociodemographic category)

		CCU	CCS
Gender	Male	10	13*
	Female	5	6
Age	18-39	9	11*
	40-59	6	7
	60+	8	11
Educational level	Non-university degree	4	6*
	University degree	10	12
Size of residence	<20.000	7	8*
	20.000 – 1.000.000	6	9
	>1.000.000	12	13

** Chi-square significant at the p<0.05 value*

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Informed evaluation of CCUS

After informing participants about CCUS technologies and their potential role in climate change mitigation, we asked participants to evaluate CCU and CCS as possible solutions for climate change (the specific information about CCUS we provided participants can be found in annex 1). We measured respondents' evaluation of CCUS technologies in a scale from 0 to 10 where 0 means a "very bad option" and 10 an "excellent option".

Figure 4. *Overall evaluation of CCS and CCU (scale from 0 to 10, in %)*

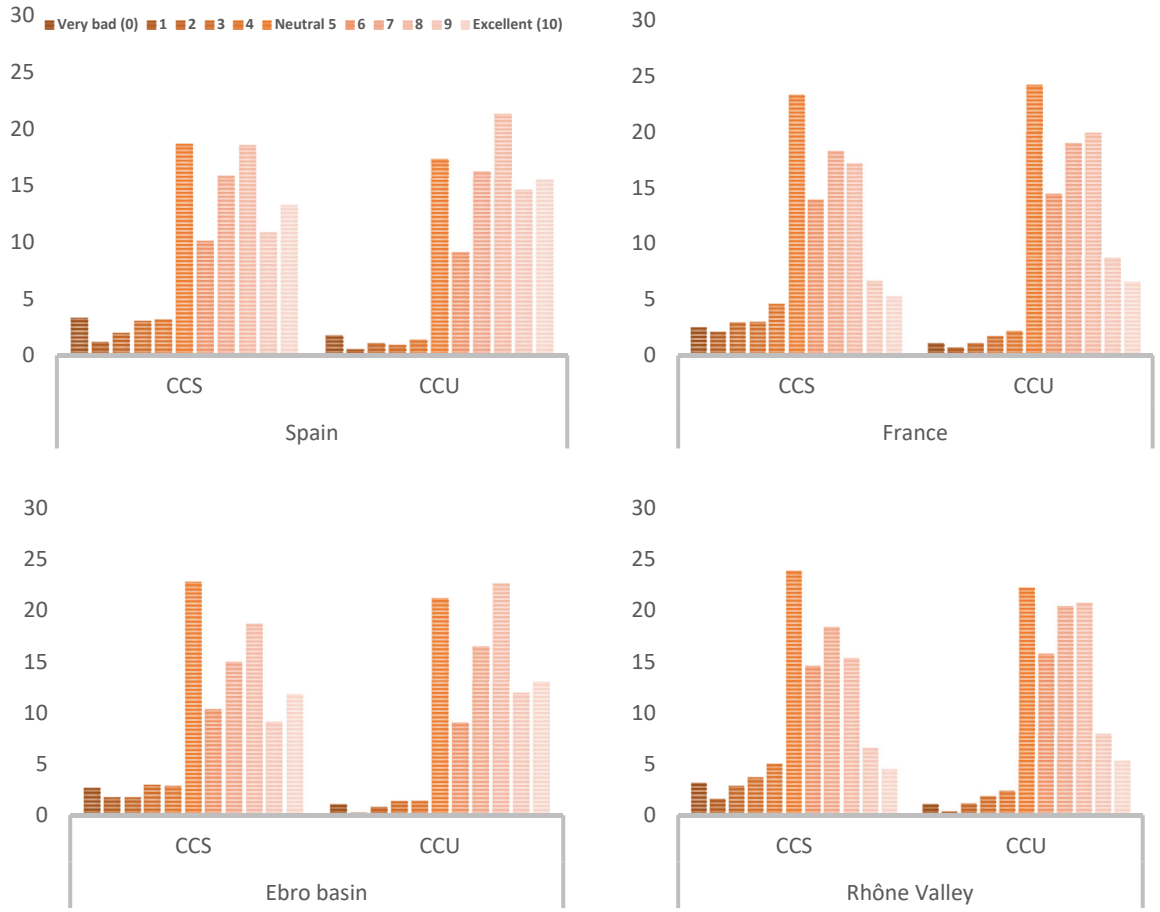

Figure 4 shows the distribution of the evaluation of CCUS technologies in the four samples. The majority of respondents in the four study populations provided a positive evaluation of both CCS and CCU (values 5 to 10).

In the four study populations, respondents evaluated CCU more positively (mean of 7.86) than CCS (mean of 7.33) as an option to tackle climate change challenges. 58 per cent of respondents in Spain rated CCS as a very good or excellent option (values 7 to 10) versus a 68 percent that rated CCU as a very good option. In France, 47 per cent rated CCS as a very good or excellent

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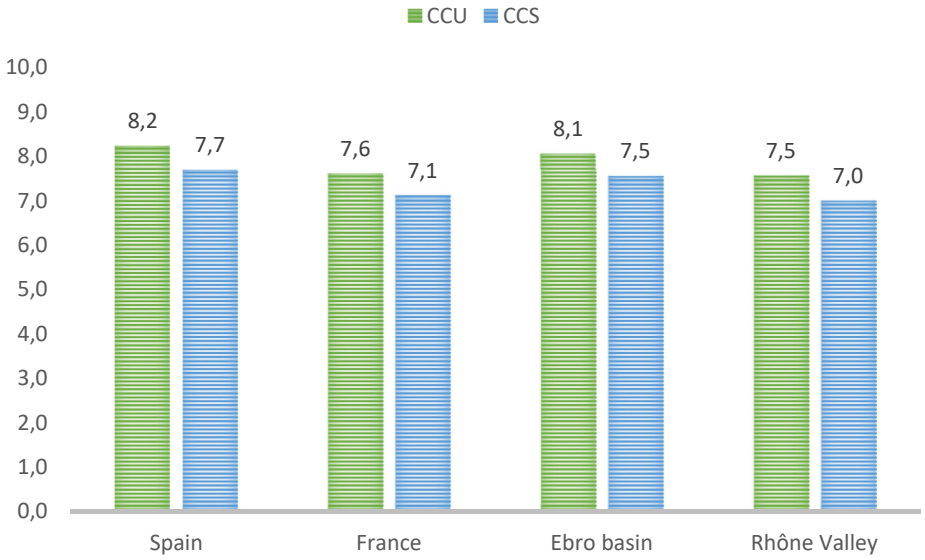
option versus 54 per cent that rated CCU as a very good or excellent option. In the Ebro Basin, 54 per cent of respondents rated CCS as a very good or excellent option versus 64 per cent that rated CCU as a very good or excellent option. In the Rhône Valley, 45 per cent rated CCS as a very good or excellent option and 54 per cent rated CCU as a very good or excellent option.

On average, participants in Spain were the most positive about both technologies (mean of 8.23 for CCU and 7.68 for CCS) followed by participants in the Ebro Basin (mean of 8,05 and 7,54 respectively), France (mean of 7,60 and 7,11) and the Rhône Valley (mean of 7,55 and 6,99).

Figure 5. *Overall evaluation of CCS and CCU (scale 0 to 10, mean)*



Respondents aged 18-39 provided a more positive evaluation of CCUS technologies relative to other age groups. Respondents living in cities with more than one million residents were, on average, slightly more positive about CCUS relative to respondents living in cities with less inhabitants.

Table 4. *Overall evaluation of CCUS technologies according to sociodemographics* (*scale 0 to 10, mean*)

		CCU	CCS
Gender	Male	7.9	7.4
	Female	7.9	7.4
Age	18-39	8	7.6*
	40-59	8	7.5
	60+	7.8	7.1
Educational level	Basic education	7.8	7.5
	High school and vocational training	8	7.4
	University degree	7.9	7.4

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Size of residence	<20.000	7.7*	7.1*
	20.000 – 1.000.000	8	7.5
	>1.000.000	8.1	7.6

** F test significant at the p<0.05 value*

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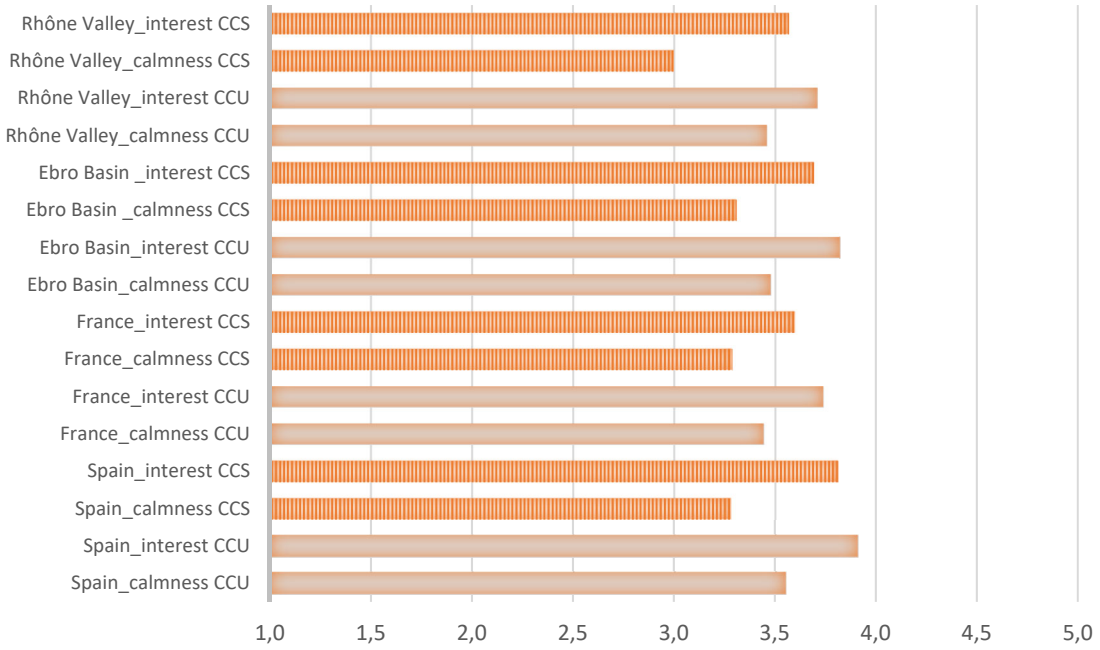
Emotional associations to CCUS

To examine the potential emotional responses of individuals to CCUS technologies, we asked respondents to what extent the technology, as presented in the information factsheet, evoked the feelings of fear and interest in them.

Figure 6. *Affect associated to CCS and CCU (mean value)*



As shown in figure 6, respondents in the four populations reported, on average, more positive emotions towards CCU than towards CCS. In a scale from 1 to 5, where 1 means "not at all" and 5 means "very much", respondents reported higher levels of interest for CCU relative to CCS and higher levels of fear for CCS relative to CCU. Self-reported emotions were, on average, more positive in Spain and the Ebro Basin compared to France and the Rhône Valley.

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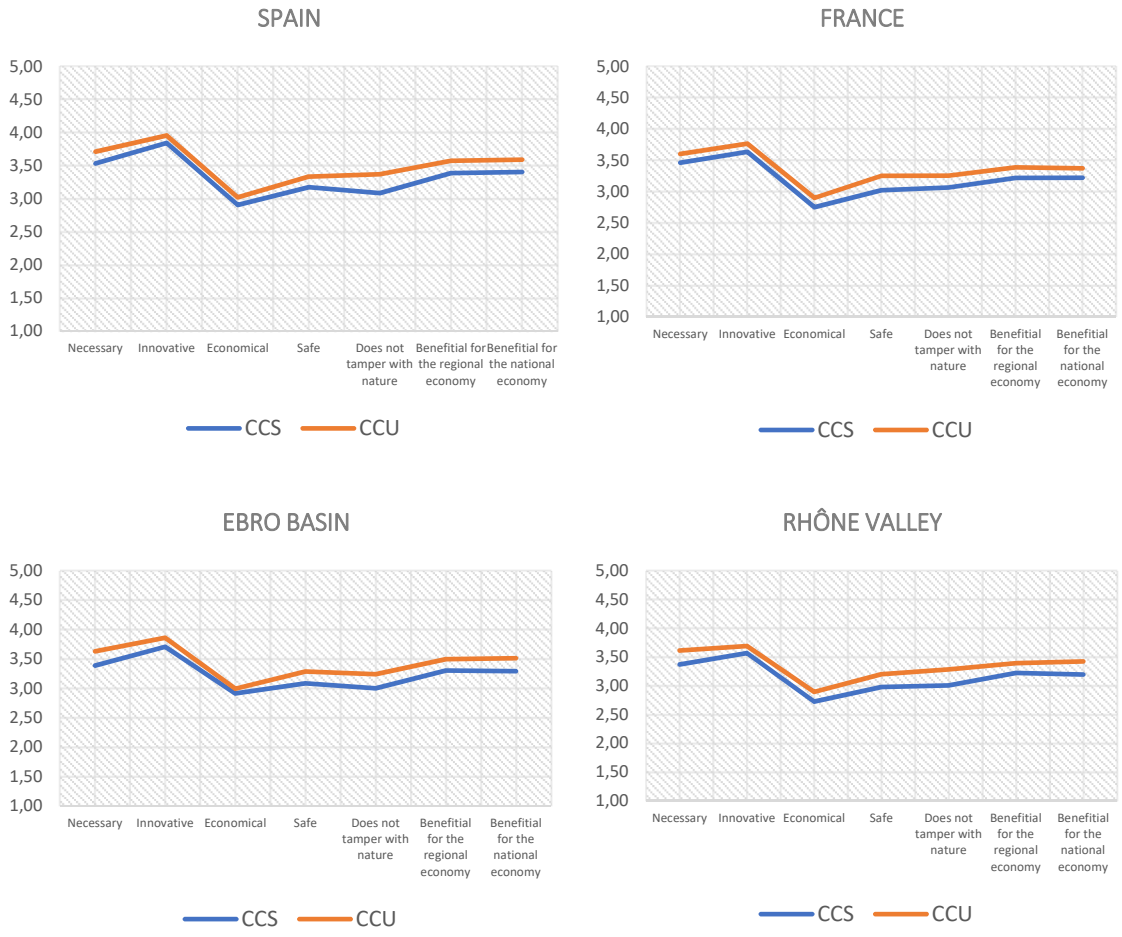
Beliefs about the attributes, benefits and costs of CCUS

Figure 7 displays the beliefs about the potential benefits and costs of CCS and CCU technologies. In general, respondents reported neutral to positive beliefs about CCUS technologies. CCUS technologies were perceived as moderately necessary, innovative and beneficial for the national and regional economies. Regarding the cost, the safety and the tampering with nature, respondents evaluated both technologies more neutrally. CCS was perceived as uneconomical in the four study populations and slightly unsafe in the Rhône Valley.

Figure 7. *Perception of attributes, benefits and costs associated to CCUS (mean value in a differential semantic scale from 1-negative to 5-positive)*



Respondents' beliefs about CCU were slightly more positive compared to CCS. On average and in the four populations, CCU was perceived as more innovative, necessary, economical, safe, not tampering with nature and more beneficial for the regional and national economies. The differences in perception between both technologies were higher in terms of tampering with nature and safety. The differences in perceptions between CCS and CCU were higher in the Ebro Basin and the Rhône Valley compared with Spain and France.

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On average, respondents' beliefs about CCUS technologies were slightly more positive in Spain and the Ebro Basin compared to Paris and the Rhône Valley.

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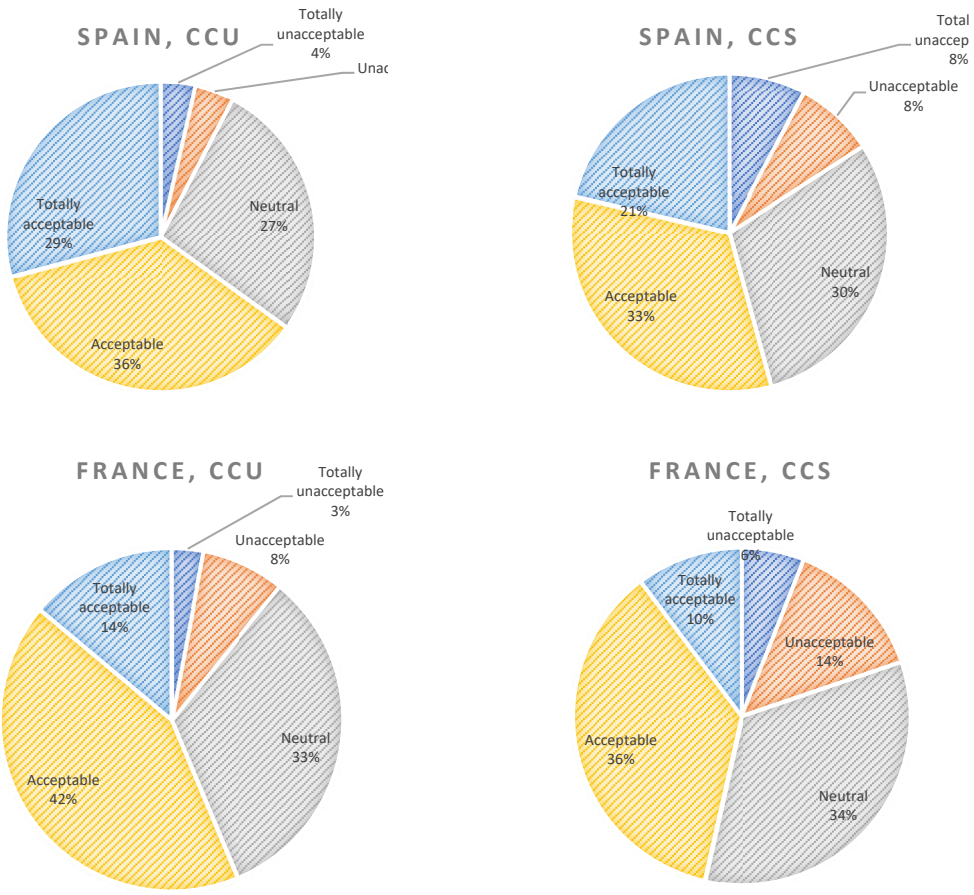
Acceptance and support

After having measured respondents' beliefs, affects and overall evaluation of CCUS, we introduced two items to measure the general and local acceptance of CCUS projects.

Regarding the general **acceptance** of CCUS technologies, the figure below shows the distribution of the answers to the question "*How acceptable do you consider the development of Carbon Capture and Utilization (CCU)/Carbon Capture and Storage in Spain/France*?"

Acceptance of CCUS technologies ranged from 46 (CCS in France) to 65 per cent (CCU in Spain). Acceptance levels were higher for CCU (56 per cent in France and 65 per cent in Spain) compared to CCS (46 per cent in France and 54 per cent in Spain). Levels of acceptance were moderately higher in Spain, where 65 per cent of respondents accepted the development of CCU projects and 54 per cent accepted the development of CCS projects, than in France, where only 56 per cent accepted the development of CCU projects and less than 50 per cent of respondents accepted the development of CCS projects.

Figure 8. *General acceptance of CCU and CCS (in % of respondents)*



Regarding the local acceptance of CCS and CCU projects, the figure below shows the distribution of responses to the question measuring acceptance: *How acceptable do you consider*

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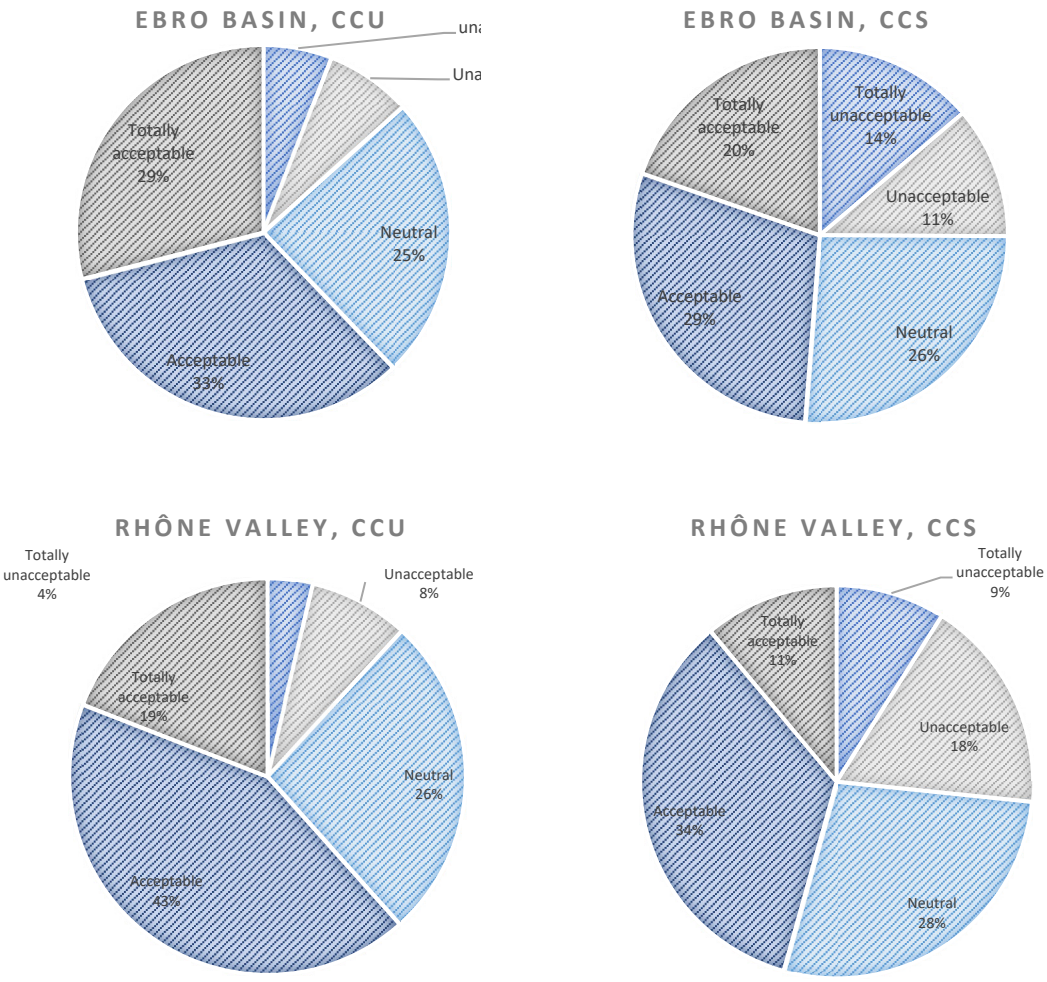
the Carbon Capture and Storage (CCS)/Carbon Capture and Utilization (CCU) ***project*** *in the region of Ebro Basin/Rhône Valley?*

Local acceptance of CCUS technologies in the Ebro Basin and the Rhône Valley ranged from 45 (CCS in the Rhône Valley) to 62 per cent (CCU in the Ebro Basin). Acceptance levels were higher for CCU (62 per cent in both regions) compared to CCS (45 per cent in France and 49 per cent in the Ebro Basin). Levels of acceptance were moderately higher in the Ebro Basin, where 62 per cent of respondents accepted the development of CCU projects and 49 per cent accepted the development of CCS projects, than in the Rhône Valley, where 62 per cent accepted the development of CCU projects and only 45 per cent of respondents accepted the development of CCS projects.

Figure 9. *Local acceptance of CCU and CCS (in % of respondents)*



As seen in the figure below, CCS local projects were least accepted in the Rhône Valley and the Ebro Basin, relative to Spain and France and relative to CCU projects. Interestingly, respondents in the two regions (Ebro Basing and Rhône Valley) and contrary to respondents in Spain and

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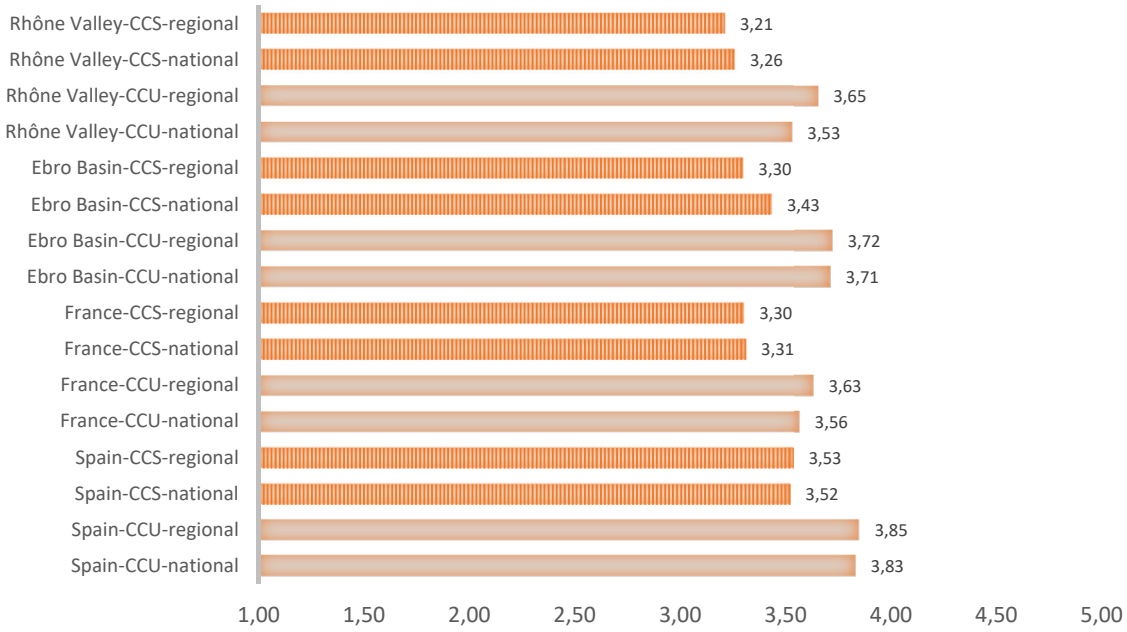
France, accepted to a greater extent CCU local projects than CCU national projects. The contrary was observed regarding CCS projects (the expected Nimby effect). The lowest levels of acceptance were found in France, the Ebro Basin and Rhône Valley regarding CCS projects. The highest levels of acceptance were found in Spain and in The Ebro Basin and the Rhône Valley regarding CCU local projects.

Figure 10. *Acceptance of CCU and CCS (mean value)*



Male respondents were more likely to accept the development of CCUS technologies relative to female respondents. Respondents aged 18-39 were less likely to accept the development of CCUS. Respondents living in cities with less than 20.000 inhabitants were less likely to accept the development of CCUS technologies.

Table 5. *Acceptance of CCUS according to sociodemographics (% of "totally acceptable")*

		CCU	CCS
Gender	Male	27*	17*
	Female	18	14
Age	18-39	18*	13*
	40-59	23	19
	60+	23	14
Educational level	Basic education	22	18*
	High school and vocational training	22	15

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	University degree	21	15
Size of residence	<20.000	19	13*
	20.000 – 1.000.000	23	18
	>1.000.000	25	17

** Chi-square test significant at the p<0.05 value*

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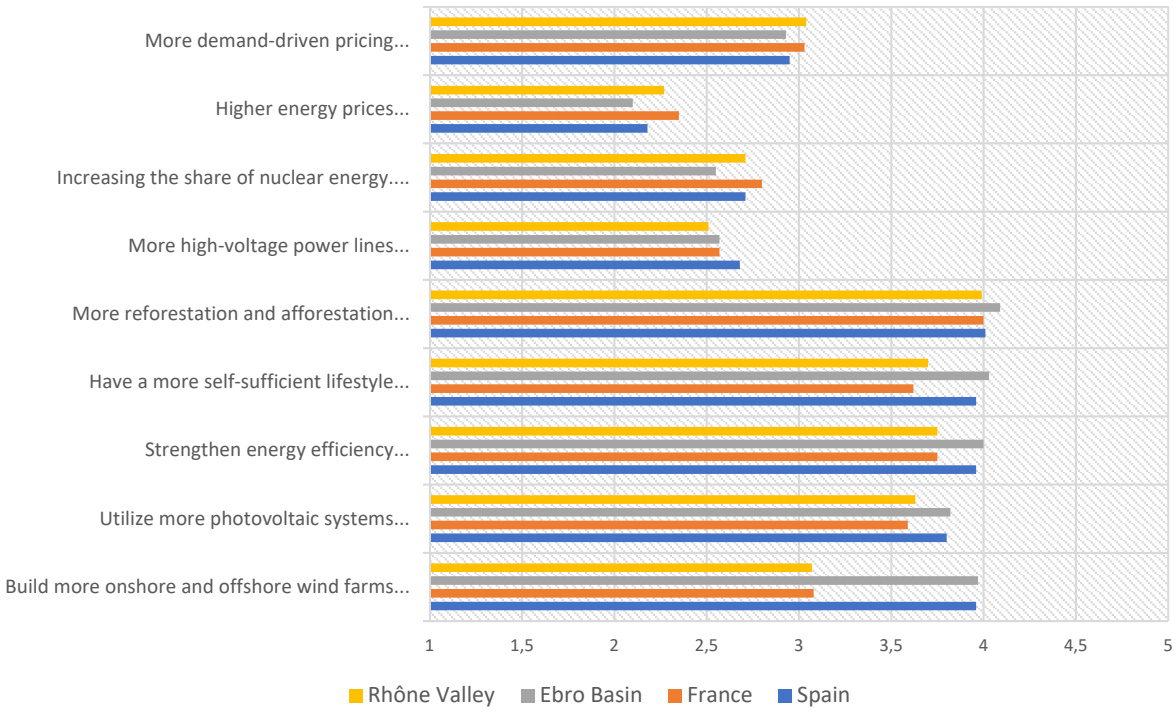
Preference for other technologies

To understand the preference for CCUS technologies compared to electricity generation systems, we asked respondents to rate a set of alternative technologies (wind parks, photovoltaic systems, higher energy prices, etc.) as a worse, about the same or a better option than CCUS.

Figure 11. To what extent do you consider the following options more suitable for tackling climate change (compared to CCU and CCS)? (From 1-is a worse option to 5-is a better option)

Figure 11. *Preference for alternative decarbonization options (mean value, scale from 1-is a worse option to 5-is a better option)*



As shown in the figure above, preferred options, relative to CCUS, were reforestation and afforestation, having more ecological lifestyles, investing in energy efficiency, using more photovoltaic systems and - in Spain and the Ebro Basin - building more on-shore and off-shore wind parks. Respondents reported a lower preference (relative to CCUS) for higher energy prices, increasing the number of high-voltage power lines and increasing the share of nuclear energy and a similar preference for more demand-driven pricing.

We found significant differences between the study populations regarding investing in wind parks and changing habits and lifestyles, which were much more preferred options in Spain and the Ebro Basin compared to France and the Rhône Valley.

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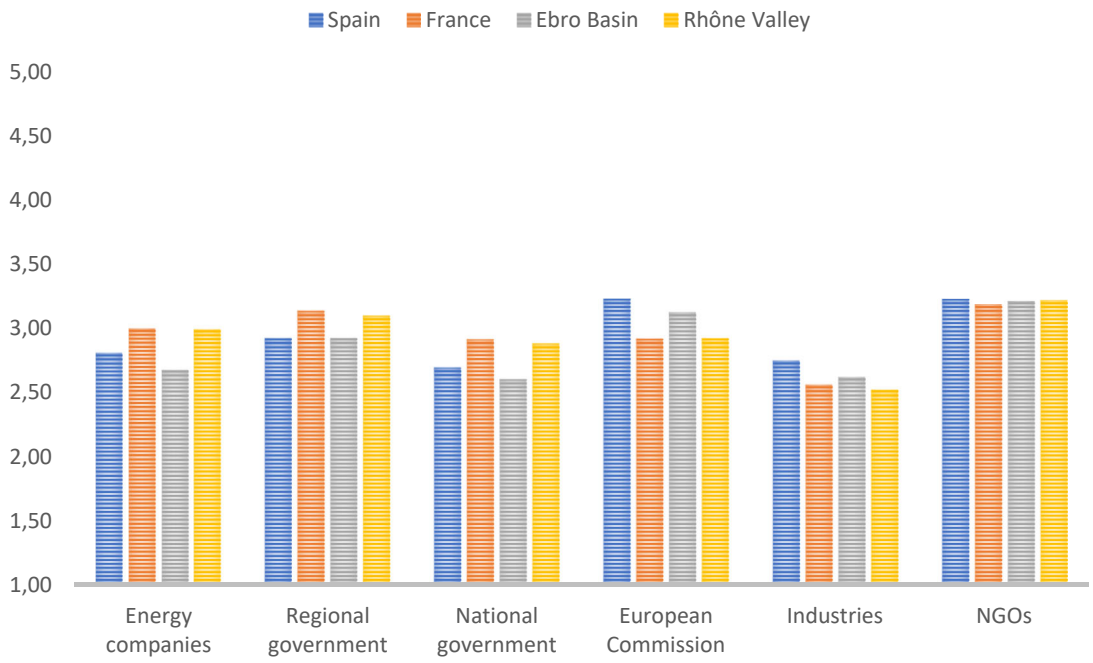
Trust

Finally, we asked respondents about their levels of trust in the various actors involved in the development of CCUS technologies. As shown in Figure 12, levels of trust were higher, on average, for NGOs and the European Commission and lower for the Industry and the National government. Levels of public trust were, in general, lower in Spain and the Ebro Basin relative to France and the Rhône Valley.

Figure 12. *How much do you trust the following actors in your country and region to make good decisions about CCS and CCU? (mean value, scale from 1-not at all to 5-completely)*



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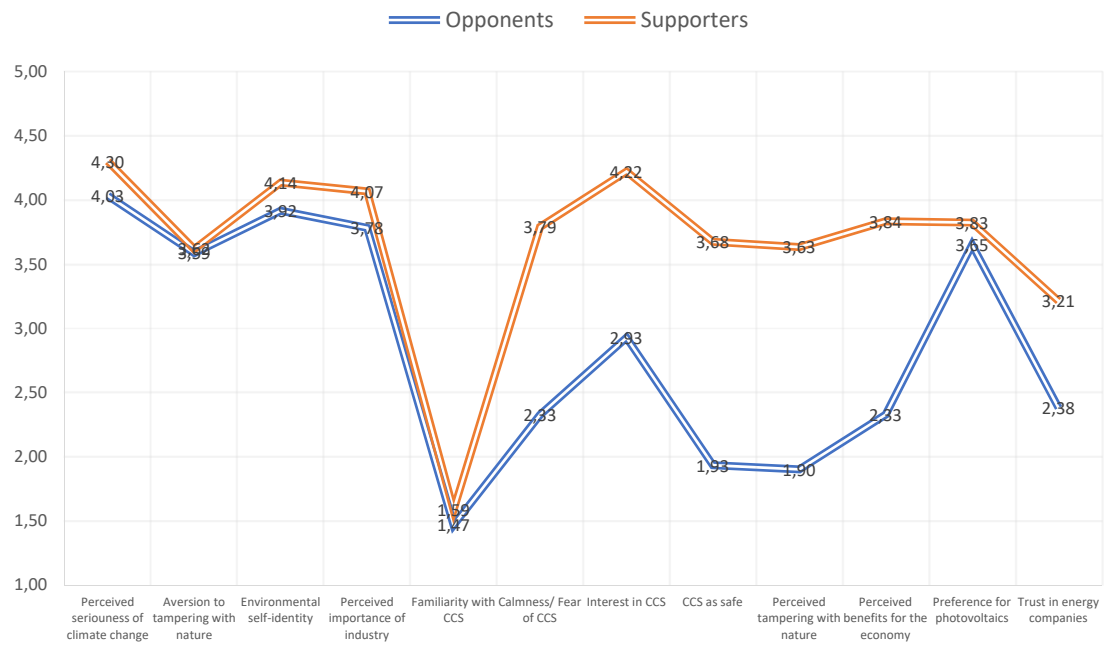
Determinants of acceptance of CCUS technologies: bivariate analysis

To explore and examine the factors underlying public acceptance and opposition to CCUS technologies at the individual level, we conducted two types of analysis. First, a bivariate analysis involving acceptance and a set of attitudinal and sociodemographic variables was conducted to stablish the possible factors associated with acceptance and opposition to CCUS. Second, a more complex regression analysis was conducted to model the net effect of a set of factors on acceptance

Supporters and opponents to CCS at the national level

If we consider specifically the sample of respondents in Spain and France and the attitudes towards CCS, around 50 per cent of respondents were supporters of CCS compared to around 20 per cent of respondents opposed to CCS.

Figure 13. *Attitudinal differences between supporters and opponents to CCS developments (mean value, scale from 1-not at all to 5-completely)*



As shown in the figure above, supporters and opponents of CCS differed substantially in their affects and their beliefs regarding CCS technologies but very weakly in their prior attitudes. Opponents reported less interest in the technology and more fear, relative supporters. They perceived CCS as more dangerous compared to supporters and perceived, to a greater extent, that CCS tampers with nature. They perceived that CCS was less beneficial for the economy as compared to supporters of the technology. They tended to have a lower level of trust in energy companies. Supporters and opponents were only weakly different in terms of their perception of climate change, their aversion to tampering with nature, their environmental self-identity, the perceived importance of the industry in the country, their preference for photovoltaics or their level of prior familiarity with CCS technologies.

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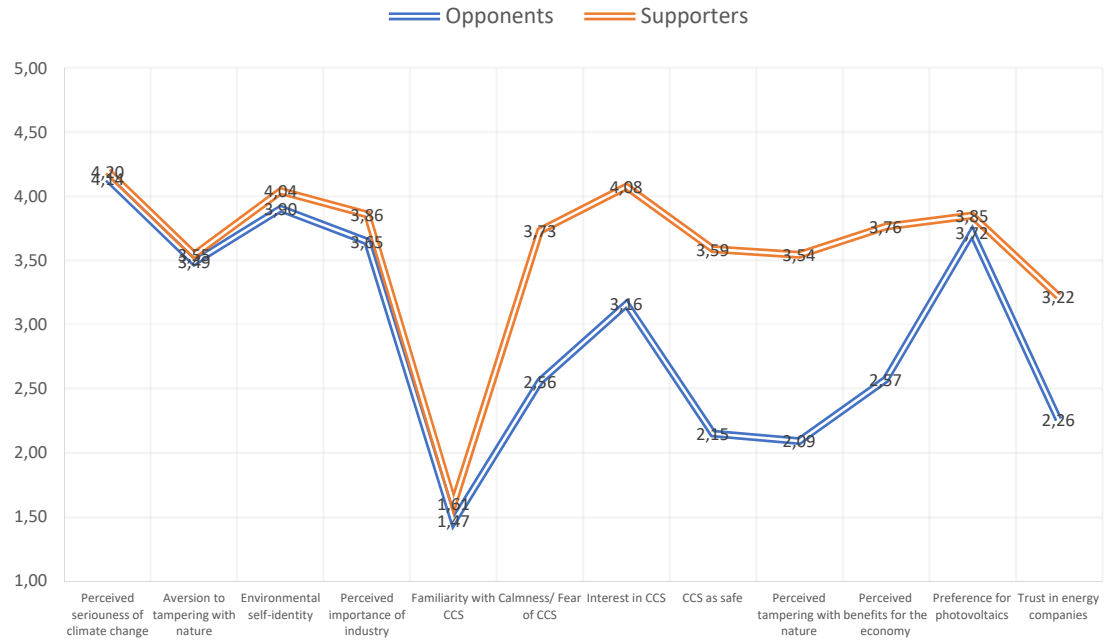
Supporters and opponents to CCS at the local level

If we consider specifically the sample of respondents in the Ebro Basin and the Rhône Valley, 47 per cent of respondents were supporters of a CCS project in the region compared to around 25 per cent of respondents opposed to a CCS project.

Figure 14. *Attitudinal differences between supporters and opponents to CCS developments at the regional level (mean value, scale from 1-not at all to 5-completely)*



The differences between supporters and opponents at the regional level in the main study variables were very similar to the ones found previously. Opponents at the regional level reported less interest in the technology and more fear, relative to supporters. They perceived CCS as more dangerous compared to supporters and perceived, to a greater extent, that CCS tampers with nature. They perceived that CCS was less beneficial for the economy as compared to supporters of the technology. They tended to have a lower level of trust in energy companies. Supporters and opponents were, again, only weakly different in terms of their perception of climate change, their aversion to tampering with nature, their environmental self-identity, the perceived importance of the industry in the country, their preference for photovoltaics or their level of prior familiarity with CCS technologies.

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Determinants of acceptance of CCUS technologies: multivariate analysis

With the aim of examining the direct and indirect **individual-level determinants** of **acceptance** of **CCS technologies at the national and the regional levels**, four path analysis models were estimated for the two samples (national and regional). Figures below display the causal models. Tables show the direct and indirect standardized effects of the independent variables over the main dependent variable (acceptance of CCS/CCU at the national and at the local level).

A model of general public acceptance of CCS

Regarding the acceptance of CCS at the national level, results from the path analysis show, first, that trust, affect and perceived benefits/costs had a moderate direct influence on acceptance. Affect (fear and interest) was the main determinant of acceptance of CCS technologies (beta of .27-.30). Those who reported positive emotions regarding CCS technologies tended to report a higher level of acceptance of the technology. Trust was the second most influential variable in the model. The effect was positive (.12), meaning that the more trust in energy companies, the more the technology is accepted. The perception about the impacts of CCS on the economy was the third most influential variable on acceptance (.10). Other variables with a direct but a very small effect on acceptance were perceived risk, perceived tampering with nature, pro-technology belief and perceived seriousness of climate change.

Table 6. *Direct and indirect standardized effects of the independent variables over acceptance*

	Direct effect	**Indirect effect (one step)**	**Total effect**
Trust in energy companies	0.12		0.12**
Perceived risk	0.05		0.05
Perceived tampering with nature	0.05		0.05
Perceived benefits for the economy	0.10		0.10**
Fear	0.30		0.30**
Interest	0.27		0.27**
Perceived seriousness of climate change	0.05	0.06	0.11**
Aversion to tampering with nature	--		--
Pro-technology beliefs	0.04	0.10	0.14**
Environmental self-identity	--	0.07	0.07
Familiarity with CCS	--	0.09	0.09

*** p value of less than 0.01*

Second, according to the model presented, variables indirectly related to acceptance such as familiarity, prior pro-technology beliefs, perceived seriousness of climate change and environmental self-identity had a significant effect on acceptance. After controlling for other variables, endorsing a pro-technology belief was positively associated with acceptance (.14),

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given its influence on trust and affect, which means that those who endorsed pro-technology beliefs had, on average, more positive affect and beliefs regarding CCS as well as higher levels of trust in CCS promoters, which in turns, resulted in a more positive attitude towards the technology. Perceived seriousness of climate change, environmental self-identity and familiarity with CCS technologies had a small indirect effect on acceptance (.11, .07 and .09 respectively).

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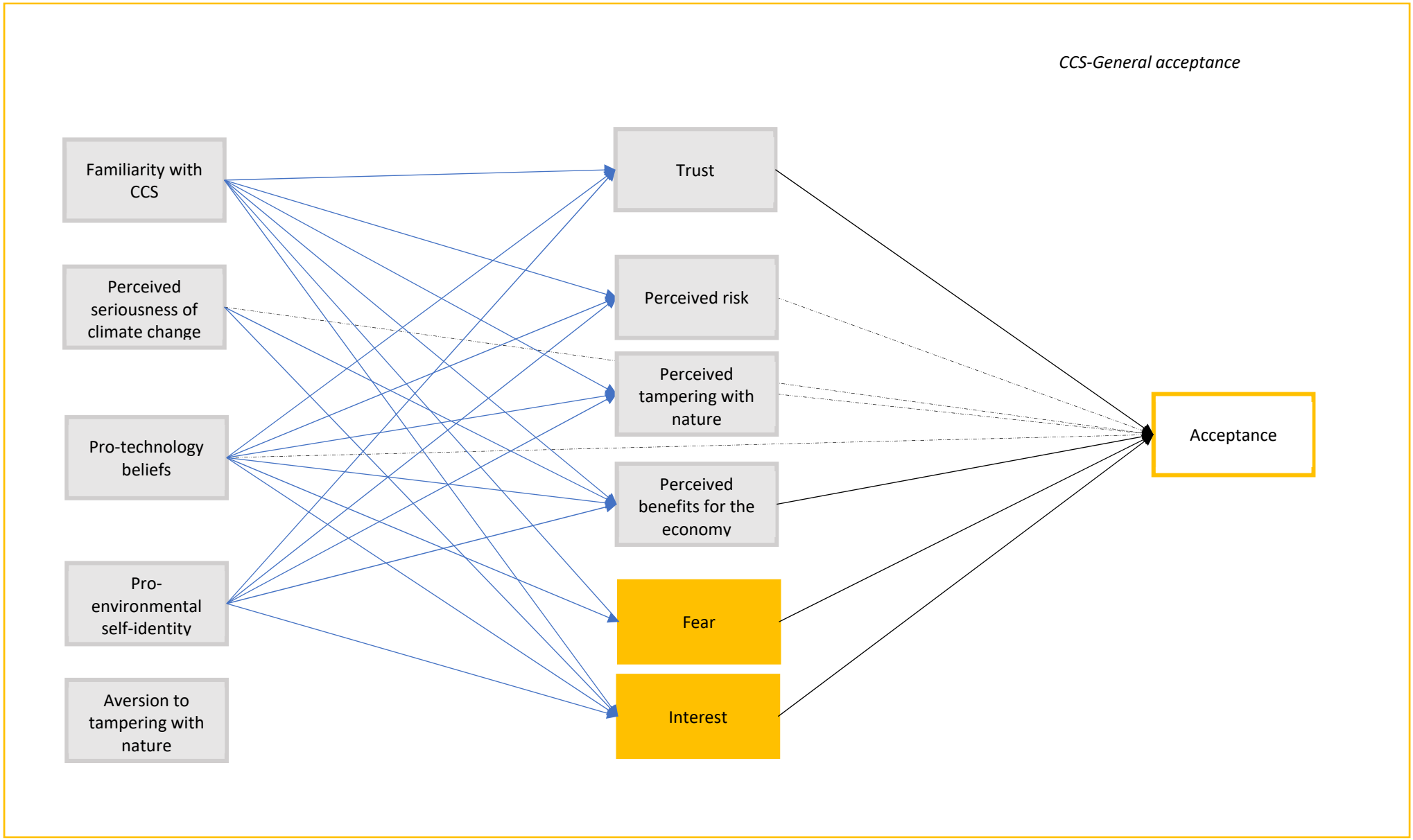
CCS-General acceptance
Familiarity with CCS
Perceived seriousness of climate change
Pro-technology beliefs
Pro-environmental self-identity
Aversion to tampering with nature
Trust
Perceived risk
Perceived tampering with nature
Perceived benefits for the economy
Fear
Interest
Acceptance

A model of local public acceptance of a CCS project

We developed a second path analysis model to examine the individual level determinants of acceptance of CCS at the local level. Results show, first, that perceived risk and perceived tampering with nature were the main determinants of acceptance of CCS (.20). Those who perceived CCS technologies as more dangerous and as tempering with nature to greater extent tended to report lower levels of acceptance. Perceived benefits for the regional economy and trust were also important determinants of acceptance (.18 and .13 respectively). Other variables with a direct but a less relevant effect on acceptance were interest and fear, pro-technology beliefs, perceived seriousness of climate change.

Table 7. *Direct and indirect standardized effects of the independent variables over acceptance*

	Direct effect	**Indirect effect (one step)**	**Total effect**
Trust in energy companies	0.13		0.13**
Perceived risk	0.20		0.20**
Perceived tampering with nature	0.20		0.20**
Perceived benefits for the economy	0.18		0.18**
Fear	0.10		0.10**
Interest	0.09		0.09
Perceived seriousness of climate change	--	0.02	0.02
Aversion to tampering with nature	--		--
Pro-technology beliefs	0.08	0.10	0.18**
Environmental self-identity	--	0.05	0.05
Familiarity with CCS	--	0.09	0.09

*** p value of less than 0.01*

Second, according to the model presented, variables indirectly related to acceptance were endorsing a pro-technology belief, familiarity with CCS technologies and environmental self-identity (total effect of .18, .09 and .06 respectively).

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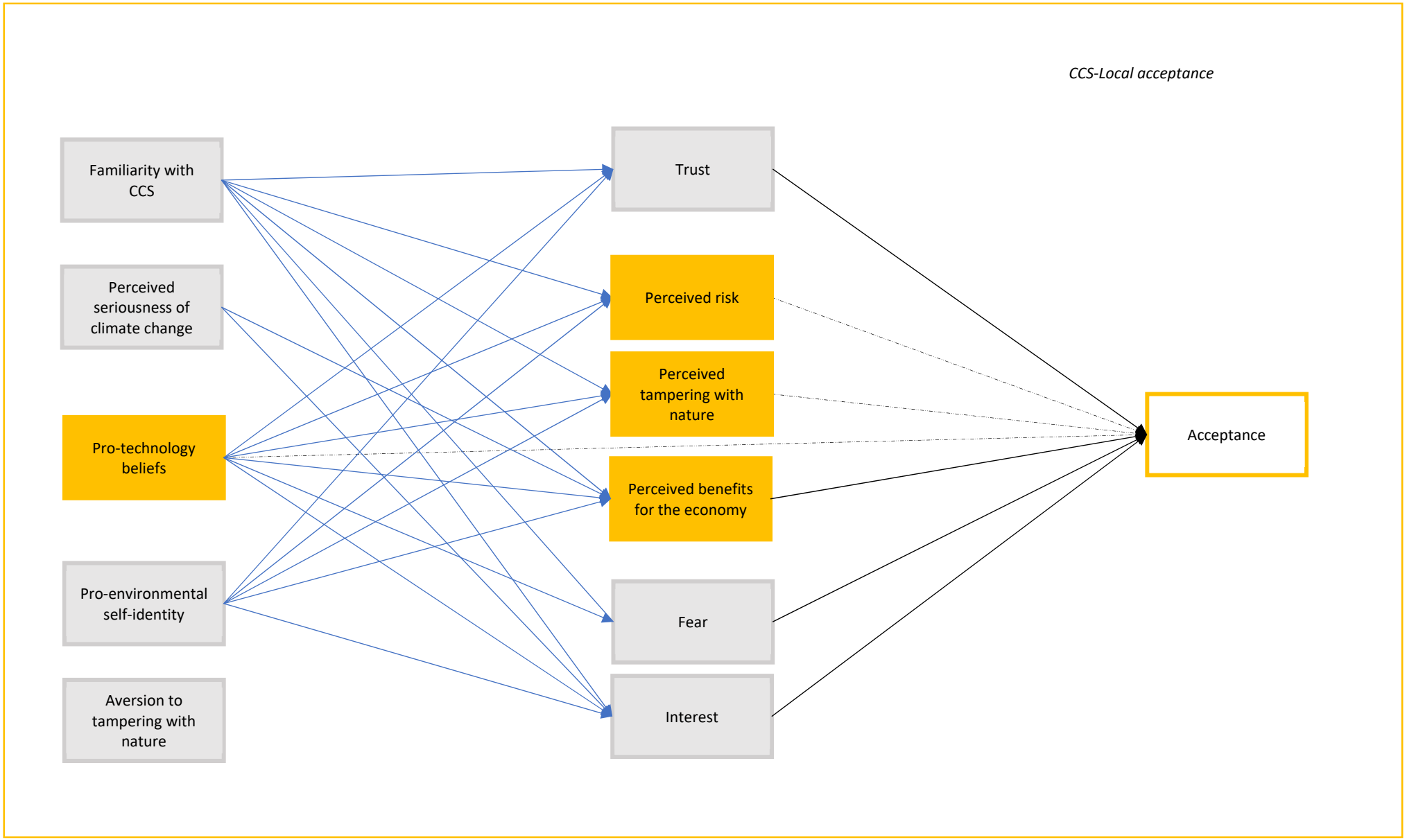
CCS-Local acceptance
Familiarity with CCS
Perceived seriousness of climate change
Pro-technology beliefs
Pro-environmental self-identity
Aversion to tampering with nature
Trust
Perceived risk
Perceived tampering with nature
Perceived benefits for the economy
Fear
Interest
Acceptance

A model of general public acceptance of CCU

Regarding the acceptance of CCU at the national level, results from the path analysis show, first, that the perceived benefits for the economy was the main direct determinant of acceptance of CCU technologies (beta of .22). Those who perceived that CCU technologies might have a positive impact on the regional economy tended to report a higher level of acceptance of the technology. Interest about CCU and perceived tampering with nature were also relevant determinants of acceptance. Other variables with a direct but a smaller effect on acceptance were fear, perceived risk and perceived seriousness of climate change.

Table 8. *Direct and indirect standardized effects of the independent variables over acceptance*

	Direct effect	**Indirect effect (one step)**	**Total effect**
Trust in energy companies	0.07		0.07**
Perceived risk	0.11		0.11**
Perceived tampering with nature	0.16		0.16**
Perceived benefits for the economy	0.22		0.22**
Fear	0.12		0.12**
Interest	0.16		0.16**
Perceived seriousness of climate change	0.12	0.08	0.20**
Aversion to tampering with nature	--	--	--
Pro-technology beliefs	0.08	0.12	0.20**
Environmental self-identity	--	0.07	0.07
Familiarity with CCS	--	0.07	0.07

*** p value of less than 0.01*

Second, after controlling for other variables, pro-technology beliefs and perceived seriousness of climate change had a moderate indirect effect on acceptance (total effect of .20).

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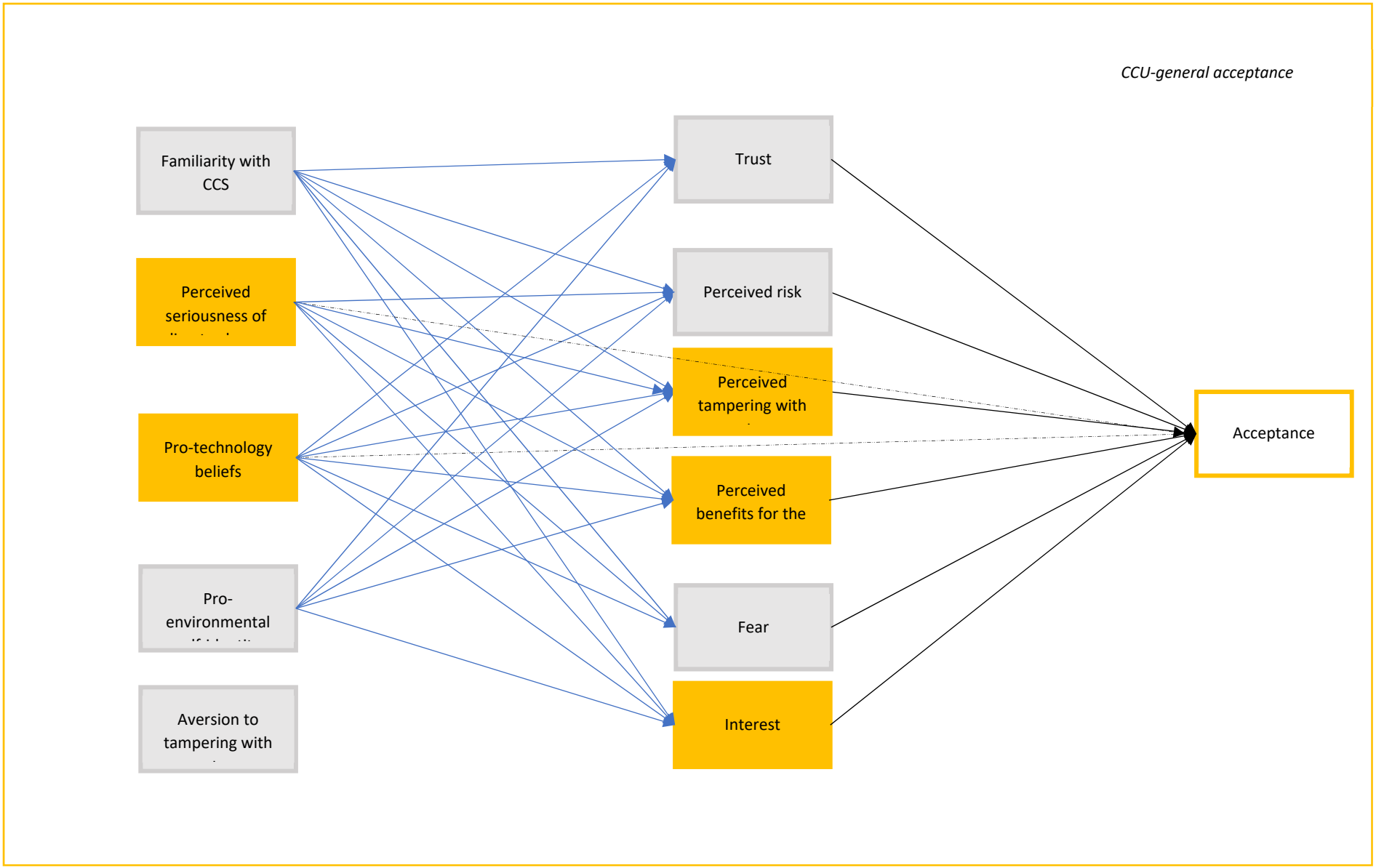
CCU-general acceptance
Familiarity with CCS
Perceived seriousness of
Pro-technology beliefs
Pro-environmental
Aversion to tampering with
Trust
Perceived risk
Perceived tampering with
Perceived benefits for the
Fear
Interest
Acceptance

A model of local public acceptance of CCU

Regarding the acceptance of CCU at the local level, results from the path analysis show, first, that the perceived benefits for the economy was the main direct determinant of acceptance of CCU technologies (beta of .19). Those who perceived that CCU technologies might have a positive impact on the regional economy tended to report a higher level of acceptance of a potential CCU project. Perceived risk associated to CCU technologies and perceived tampering with nature were also relevant direct determinants of acceptance at the local level (beta of .16 and .15 respectively). Other variables with a direct but a smaller effect on acceptance were fear and interest, perceived seriousness of climate change and pro-technology beliefs.

Table 9. *Direct and indirect standardized effects of the independent variables over acceptance*

	Direct effect	**Indirect effect (one step)**	**Total effect**
Trust in energy companies	0.09		0.09
Perceived risk	0.16		0.16**
Perceived tampering with nature	0.15		0.15**
Perceived benefits for the economy	0.19		0.19**
Fear	0.10		0.10**
Interest	0.10		0.10**
Perceived seriousness of climate change	0.07	0.04	0.11**
Aversion to tampering with nature	--	0.01	0.01
Pro-technology beliefs	0.08	0.11	0.19**
Environmental self-identity	--	0.04	0.04
Familiarity with CCS	--	0.09	0.09

*** p value of less than 0.01*

Regarding the indirect and total effects, pro-technology beliefs had a moderate effect on acceptance at the local level (total effect of .19). Perceived seriousness of climate change had also a relevant indirect and total effect on acceptance. Other variables such as familiarity with CCU and environmental self-identity had a weaker indirect effect on acceptance.

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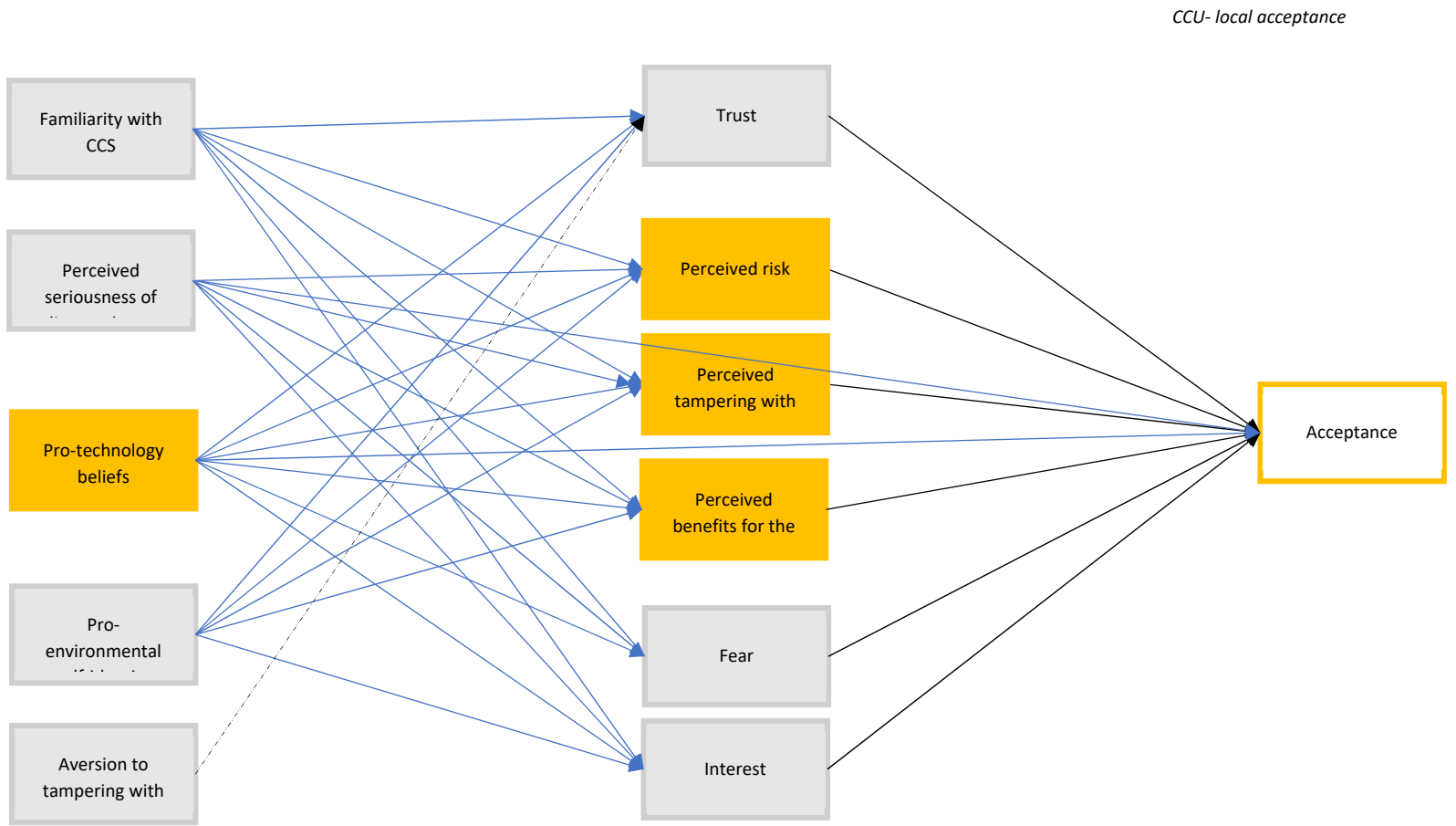

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4 Summary of results

This report has examined public awareness, attitudes and acceptance of CCUS technologies in two countries (Spain and France) and two regions within these countries (Ebro Basin and the Rhône Valley) potentially affected by CCUS developments. The analysis has been based on survey data collected from a representative sample of approximately 1300 residents in the four study populations and specifically examines the differences in awareness, affects, beliefs, attitude and acceptance of CCUS. The analysis conducted here includes descriptive statistics as well as correlational models based on path analysis. The data allows for comparisons between the samples as well as between CCU and CCS as different application cases.

- The majority of respondents (60 per cent) reported not having heard about CCUS technologies before participating in the study. Only around one out of ten respondents reported being familiar with CCS or CCU technologies. Thus, overall familiarity was **low**. There were no significant differences in levels of **familiarity** between study populations.
- After being informed about the main features of CCS and CCU technologies, respondents in the four study populations provided a more positive **evaluation** of CCU compared to CCS. On average, participants in Spain were the most positive about both technologies (mean of 8.23 in a 0 to 10 scale for CCU and 7.68 for CCS) followed by participants in the Ebro Basin (mean of 8,05 and 7,54 respectively), France (mean of 7,60 and 7,11) and the Rhône Valley (mean of 7,55 and 6,99). These overall evaluations of the technology ranged between neutral and positive.
- Respondents in the four study populations reported, on average, more positive **emotions** towards CCU than towards CCS. Self-reports of interest were the highest in Spain regarding CCU. Self-reported fear was the highest in the Rhône Valley regarding CCS.
- Regarding the **perception of the attributes and potential benefits** of CCUS technologies, on average and in the four populations, CCU was perceived as more innovative, necessary, economical, safe, less tampering with nature and more beneficial for the regional and national economies by respondents relative to CCS.
- An **acceptance** measure referred to the degree that respondents supported further developments of CCUS technologies. At the national level, more than half of respondents would accept the development of CCUS technologies in their country. Acceptance levels were higher for CCU (60 per cent) relative to CCS (50 per cent). Acceptance was higher in Spain (65 per cent for CCU and 54 per cent for CCS) compared to France (56 per cent for CCU and 46 per cent for CCS).
- Younger respondents, women and residents in small cities were, on average, less favorable to CCUS projects.
- Regarding the local acceptance of CCS and CCU projects, acceptance ranged from around 60 per cent for CCU to 48 per cent for CCS. Acceptance levels were higher for CCU projects (62 per cent in both regions) compared to CCS projects (45 per cent in France and 49 per cent in the Ebro Basin).

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- Relative to CCUS technologies, respondents preferred reforestation and afforestation, having more ecological lifestyles, investing in energy efficiency, using more photovoltaic systems and in both Spanish samples also building more on-shore and off-shore wind parks. The options evaluated as similarly attractive to CCUS were, in the four study populations, increasing the number of high-voltage power lines, increasing the share of nuclear energy and more demand-driven pricing plus increasing wind energy in the French samples. Higher energy prices were seen as less favorable then CCUS.
- Levels of trust were higher, on average, for NGOs and the European Commission and lower for the Industry and the National government. Levels of public trust were, in general, lower in Spain and the Ebro Basin relative to France and the Rhône Valley.
- Opponents to CCUS developments (around 20 per cent respondents) reported less interest in the technology, as well as a higher level of fear associated to CCS relative to supporters. They perceived CCUS as riskier compared to supporters and perceived, to a greater extent, that CCUS tampers with nature. They perceived that CCUS was less beneficial for the economy as compared to supporters of the technology. They tended to have a lower level of trust in energy companies. Supporters and opponents were more similar in terms of their perception of climate change, their aversion to tampering with nature, their environmental self-identity, the perceived importance of the industry in the country, their preference for photovoltaics or their level of prior familiarity with CCS technologies.
- The main individual-level **predictors of acceptance** of CCS and CCU included the perception about the economic impacts of CCUS developments as well as pro-technology beliefs. Perceived tampering with nature predicted acceptance of CCS at the local level and acceptance of CCU at the national level. Perceived risk played a role in the acceptance of CCS and CCU at the local level. At the national level, acceptance of CCS was also related to affect and trust in energy companies while acceptance of CCU was related to the perceived seriousness of climate change.

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5 Conclusion

There are relatively few studies combining cross-national and regional comparable data on public acceptance of CCS and CCU. Yet, it is important for governments and the industry to understand public beliefs and attitudes regarding both technologies given their potentials socio-economic and environmental impacts. Moreover, hardly any recent study exists targeting the public acceptance in the countries under research in this deliverable and in the focus of the STRATEGY CCUS project.

Findings from this report show that, based on self-reporting, just under 10% of the population in the two countries and regions under study consider themselves familiar or knowledgeable about CCUS technologies. These results are very similar to previous recent reports by Broecks et al. (2021) or Whitmarsh et al. (2019).

In general, the results show that the majority of the population in the four studied populations have a positive *attitude* towards CCUS technologies. However, we found significant differences between the evaluation and acceptance of CCU relative to CCS as well as between the evaluation and acceptance of both technologies in the regional samples compared to the national samples. On average, respondents evaluated CCS more negatively than CCU which is in line with findings by Linzenich et al. (2019). CCS was considered slightly more dangerous, less innovative and less beneficial for the economy relative to CCU. The differences in the evaluation of both technologies were weak but significant and resulted in different levels of acceptance (60 per cent versus 48 per cent in terms of local acceptance of CCS projects and CCU projects respectively).

In general, the attitudes towards CCUS technologies were more positive in Spain relative to France and in the Ebro Basin relative to the Rhône Valley. In both regions and regarding CCS, respondents reported lower levels of acceptance in the regional samples compared to the two country-level samples which is in line with earlier research (Braun 2017). A higher public concern with safety and tampering with nature associated to local CCS projects in the regions and to less extent to CCU seems to be behind this difference.

Another key observation of the study is the existence of internal variations in attitudes to CCUS. Younger respondents, women and residents in small cities were, on average, less favourable of CCUS technologies. Apart from the differences between the sociodemographic categories, the data suggest that acceptance of CCUS technologies varies according to individuals' perceptions and affects about the technology as well as to individuals' prior orientations. Opponents to CCUS at the national level tended to report less interest in the technology, as well as a higher level of fear associated to CCS relative to supporters. Opponents perceived CCS to be more dangerous and less beneficial for the economy as compared to supporters of the technology. They tended to have a lower level of trust in energy companies.

Interestingly, we found that the most explanatory individual-level factors of acceptance were not the same at the local and the national level. Acceptance of CCS technologies at the national level is partially determined by positive and negative affect, the perception of benefits and costs of the applications, trust and prior pro-technology attitudes. However, the main individual-level predictors of acceptance of CCS at the local level are the level of perceived risk and perceived tampering with nature, the perception about the benefits for the regional economy of CCS and prior pro-technology attitudes. How dangerous the CCS project is perceived to be and to what extent it is perceived to

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tamper with nature seems to play a critical role at the local level where the impacts of a CCS project are, perhaps, seen as closer to respondents' daily life than at the national level. Trust in the promoters of CCUS technologies, the emotions associated to CCUS and the perceived regional economic impacts of CCUS were also important determinants of acceptance in the four study populations. The model in this study does not fully explain acceptance of CCUS technologies but helps understanding the components of acceptance. Other factors not included in the study might explain acceptance of CCUS applications. Additionally, attitudes and opinions might be unstable and also easily affected by contextual factors.

This report, building on previous studies on the public acceptance of CCUS technologies, provided an overview of public attitudes towards CCS and CCUS technologies in two European countries and two potential affected regions. These results contribute to improve our understanding of public acceptance of CCUS technologies through cross-national research. As CCUS initiatives in Europe develop, properly engaging the public at the national and the local level will likely play a role in the success of CCUS projects. Acceptance of CCUS will likely vary across time, countries and regions and segments of the population. This report not only provided a picture of the current levels of public acceptance but also contributed to understanding the individual-level determinants most likely to play a role in citizens' future reactions to CCUS projects.

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 837754

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 837754