D6.5: Summary report on public acceptance

Findings from second survey and citizen engagement

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2. Executive summary

The **PilotSTRATEGY Deliverable 6.5** report presents the results from the citizen engagement and public perception activities conducted across three European regions—Portugal, Spain, and France—between 2023 and 2025. These activities were designed to evaluate perceptions of geological carbon dioxide (CO_2) storage (CCS) and to identify conditions under which communities might support or oppose its development. The findings provide valuable insights into the social dimensions of CCS, which alongside technical and economic considerations are essential for its successful deployment.

Methodological Approach

The engagement activities combined qualitative and quantitative methods tailored to each study region's specific context. Portugal employed format experimentation, including workshops and interactive exhibitions around a potential offshore storage site. Spain implemented reconvened focus groups in rural municipalities to enable informed deliberation over time. France adopted an organic approach, leveraging open-door meetings and community partnerships initiated during a seismic campaign to foster ongoing dialogue. Additionally, surveys were conducted across regions to assess public attitudes, familiarity with CCS, and influential factors shaping social acceptance.

Key insights include:

- Social acceptance as conditional contract: Communities tend to express conditional acceptance of CCS projects, often emphasizing the importance of safety, tangible benefits, transparency, and meaningful involvement in decision-making.
- Trust through institutional design: Building trust may require credible mechanisms such as binding agreements, oversight committees, and open communication channels to address concerns rooted in historical experiences of unmet promises.
- Territorial justice concerns: Addressing fairness issues related to the distribution of local burdens and global benefits appears to be a critical aspect for fostering acceptance in affected communities.
- Technical and social feasibility: Alignment between technical viability and community willingness is likely to be an important factor for the successful implementation of CCS projects.
- Methodological diversity: Engagement approaches should aim to adapt to regional contexts and conditions, as standardized protocols may not address local specificities effectively.
- Low initial knowledge as opportunity: Limited familiarity with CCS may provide an opportunity for meaningful dialogue before positions become entrenched.
- Sustained engagement fosters evolution: Repeated interactions over time show how meaningful dialogue requires time while all relationships take place in a larger context which may hinder or delay such dialogue.
- Tangible, verifiable, and fair benefits: Communities generally expect benefits from CCS projects to be clear, measurable, and equitably distributed, with mechanisms in place to ensure their delivery.

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- Governance design influences legitimacy: The design of governance processes, including opportunities for community involvement, may play a key role in shaping perceptions of legitimacy, though preferences may vary by region.

The findings underscore the importance of treating social acceptance as a central pillar of CCS development. Social integration should not be considered a secondary challenge to technical and financial ones but as an essential component of responsible innovation. Successful CCS deployment requires equal investment in fostering trust, transparency, and shared purpose (justification of technology and of specific infrastructure) among local communities and broader society.

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3. Introduction to overall approach and key concepts

The PilotSTRATEGY project, funded by the European Union's Horizon 2020 programme, advances the technical, economic, and social feasibility of geological carbon dioxide storage in three European basins: the Lusitanian Basin (Portugal), the Ebro Basin (Spain), and the Paris Basin (France). These regions were selected for their geological potential and diverse socioeconomic contexts, providing complementary insights into the challenges and opportunities of CCS deployment across different European settings.

Carbon capture and storage has been identified by the Intergovernmental Panel on Climate Change, the European Commission (European Commission 2024) and other key institution as an essential component of climate mitigation strategies, particularly for decarbonizing hard-to-abate industrial sectors such as cement, steel, and chemical production. However, technical and financial viability alone does not guarantee successful deployment. The social dimension—encompassing public perception, community acceptance, and territorial integration—has emerged as equally critical in shaping the feasibility and legitimacy of CCS infrastructure.

Within this framework, Work Package 6 (WP6) on 'Social Acceptance and Public Participation' in PilotSTRATEGY plays a pivotal role in bridging techno-economic assessment with the social realities of affected communities. The underlying premise is that effective public engagement is not merely a procedural requirement but a constitutive element of responsible innovation in the energy transition. Public acceptance cannot be assumed or imposed; it possibly emerges through iterative dialogue, transparent information sharing, and genuine opportunities for communities to voice concerns and shape project design. Thus, the objectives of WP6 extend beyond measuring attitudes, aiming to create spaces where citizens and stakeholders can learn about CCS technologies, deliberate on their implications and articulate the conditions under which they might consider CO_2 storage to be socially acceptable. This approach lies at the intersection of social research and civic engagement, generating empirical evidence while simultaneously promoting informed and legitimate decision-making processes.

The overall project goal of PilotSTRATEGY is to support future decision making by developing detailed insight on how geological storage sites for carbon dioxide (CO_2) could potentially take their place in five regions across Europe. This five-year international research endeavour investigates the feasibility of geological storage of CO_2 using deep saline aquifers. Building on the findings of earlier EU-funded projects, notably STRATEGY CCUS, PilotSTRATEGY carries out detailed characterization studies in three of the five countries, namely in regions situated in France, Portugal and Spain. The research undertaken in the timeframe of the projects aims to support the implementation of pilot storage sites for CO_2 in the regions studied – after the lifetime of PilotSTRATEGY, and in the case of favourable findings regarding geological, technical and economic conditions, and depending on decisions taken by political authorities.

This deliverable from WP6 contributes to the objectives of the work package by conceptualizing local acceptance as being embedded within the broader national and European context, establishing and enhancing the participation of local communities and stakeholders in the regions under study, and making initial contributions toward developing valid public engagement recommendations. It builds on the exploratory phase which took place in the first 18 months of the project. In this initial phase

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WP6 focused on analysing societal contexts for CO_2 storage by characterising the overall settings, policy frameworks (Duscha 2022), and regional profiles of six study areas across all five countries (Dütschke et al. 2022). This included document analyses, media reviews, stakeholder interviews, and a first wave of regional surveys to assess public acceptance—conceptualized as understandings, attitudes, intentions, and behaviors toward CCS. These initial steps informed the development of detailed community profiles and a preliminary understanding of societal contexts, which guided the second phase of WP6. From November 2022 onwards, the project shifted to active engagement and participation through two key strategies: (1) stakeholder engagement via Regional Stakeholder Committees (outcomes will be documented in D6.4), and (2) public engagement initiatives tailored to local cultures, traditions, and diverse demographics. The procedure for the public engagement initiatives was developed as a plan in Oltra et al. (2023) and its implementation and outcomes are now the main focus of the present report including an additional second round of surveys. By the end of WP6, recommendations will be made on sustaining engagement with local communities which will be made accessible in a final policy brief (D6.6). Figure 1 provides an overview on the steps in the WP.

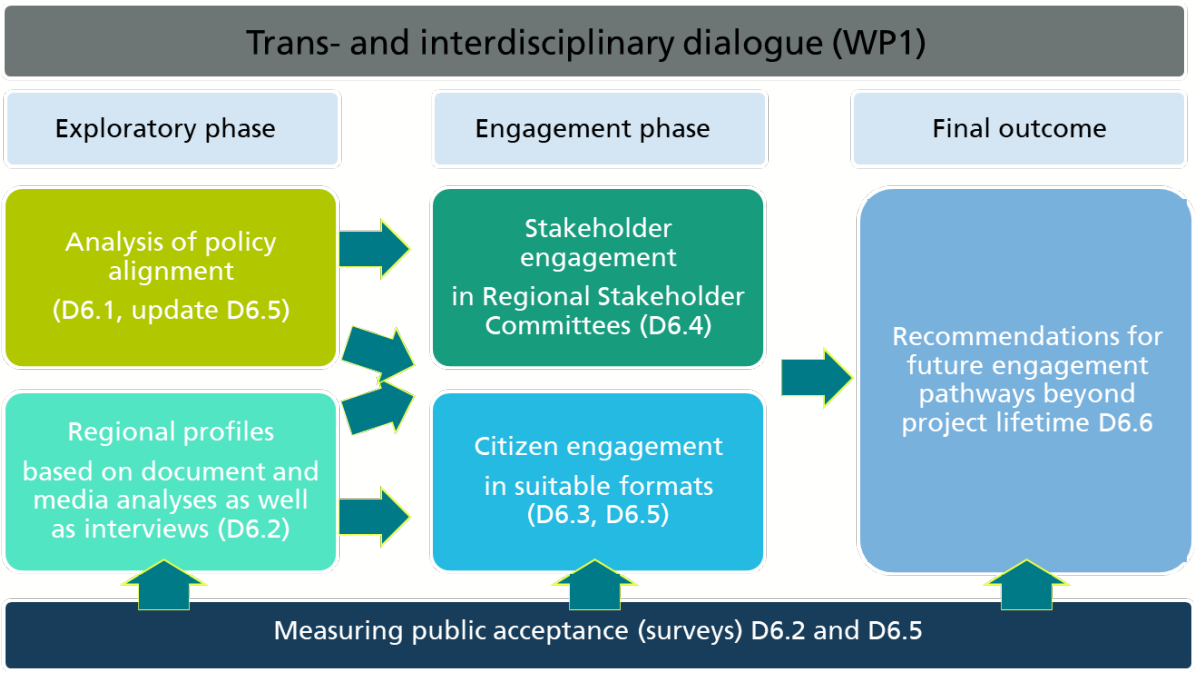

Figure 1 Concept for engagement and participation activities in WP6 in PilotSTRATEGY

The exploration phase also contributed to informing the project's choice of location for characterization in view of a pilot storage installation in Portugal and Spain where two options, one onshore and one offshore site, had been under consideration (milestones 2.1, 2.2 and 6.2 of the project). This selection process took into account technical, environmental, economic and geological factors and led to the decision to continue with the offshore option in Portugal and the onshore option in Spain.

This deliverable is structured as follows: The next subsections of chapter 3 introduce the concept of social acceptance and what is known about citizen attitudes and perceptions of CCS. Chapter 4 focuses on citizen engagement, presenting the methodologies applied in Portugal, Spain, and France,

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followed by a synthesis of regional findings and cross-regional analysis of common patterns and specific contrasts. Chapter 5 details survey research conducted across regions, including its methods, findings, and statistical analyses, with insights into how perceptions evolved over time. Finally, Section 6 provides a summary of conclusions, drawing together key findings to inform future engagement strategies.

3.1 Social Acceptance as a Concept

Social acceptance, as defined by Upham et al. (2015), describes a favorable response—encompassing attitudes, intentions, and behaviors—towards proposed or in-place technologies or socio-technical systems within a given social unit (e.g., households, communities, or nations). The concept includes several dimensions: (i) manifestations of acceptance in attitudes and behaviors, which are influenced by cognitive and emotional responses as well as external factors like social norms and situational constraints; (ii) objects of acceptance, which can range from specific storage sites to broader energy transitions, differing by development stage; and (iii) subjects of acceptance, spanning individual and collective levels that interact and influence one another, such as socio-political acceptance shaping individual decisions. Acceptance is often misinterpreted as passive compliance, but the term also reflects active roles, perceptions, and interactions. While earlier conceptualizations viewed acceptance as a top-down response to interventions, a more neutral and descriptive understanding is increasingly emphasized, particularly within European funding contexts, highlighting the societal dimension of technology adoption and transition. Public perception and engagement enable the co-development of projects, technologies and policies. Transparent communication, trust-building, and participatory processes have the potential to contribute to strengthen acceptance and create conditions for long-term legitimacy of political pathways and technologies included in them.

3.2 State of Research on CCS Acceptance

Research on social acceptance of CCS peaked 15 years ago and has regained attention with the rise of industrial carbon management. Public acceptance studies consistently reveal low awareness of CCS and CCU technologies, with moderate acceptance levels overall (Miu et al. 2024). Acceptance varies to some extent by application, for example with CCS paired with coal-fired plants being less favored than integration with heavy industries. CCU is generally evaluated more positively—seen as safer, more economical, and innovative—than CCS. National and local acceptance levels differ, and differences seem to be related to specific national contexts. Past research on CCS acceptance is sparse in PilotSTRATEGY countries (Portugal, Spain, France, Greece, Poland). Surveys from STRATEGY CCUS indicate low familiarity with CCS/CCU among the public but higher acceptance for CCU (60%) than CCS (50%), with socioeconomic benefits emerging as key predictors of acceptance (Oltra et al. 2021).

Stakeholder perspectives often align with public views, emphasizing CCS as a last-resort or bridging technology. Support varies by stakeholder group, typically with industries more favorable than environmental NGOs. Economic viability, public engagement, and government policy are identified as critical conditions for acceptance. Studies also highlight the importance of local engagement and

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participation. Successful engagement processes involve clear communication, inclusive participation, and alignment with socio-political norms.

3.3 Key insights from exploratory phase

Surveys, desk and field research during the exploratory phase (the first 18 months of the PilotSTRATEGY project, May 2021-October 2022) revealed the following main social insights for the regions in Portugal, Spain, and France (Dütschke et al. 2022; Duscha 2022).

At this point in time, regulatory frameworks for CCS remained underdeveloped across the three countries, with France and Spain demonstrating slightly more progress than Portugal. None of the countries had fully defined strategies for implementing CO_2 capture, transport, and storage as part of their decarbonization efforts. Societal awareness of CCS was low in all countries, with limited knowledge among both citizens and stakeholders. Media coverage rarely addresses domestic CCS implementation, instead framing the topic within international climate discussions. As a result, public attitudes toward CCS are not firmly established, with opinions and preferences still evolving.

In Portugal, we found that there was particularly little political or societal experience with CCS given the country's relatively low industrial emissions. While public acceptance of CCS projects in the region under study appears to be medium to high, there has been little societal debate. However, previous civic activism indicates that there is potential for engagement if CCS is perceived as a threat. This highlights the need for trust-building and careful communication. Spain has some experience with CCS initiatives and a partially developed regulatory framework. Public acceptance in the Ebro Basin, which was investigated further, was higher than in the offshore region, where trust in stakeholders and acceptance levels were notably low due to past infrastructure projects. Onshore stakeholders appear more willing to discuss CCS and negotiate acceptance conditions. France has the most advanced regulatory framework and practical experience with CCS, with ongoing activities centred around an existing capture facility. Public acceptance was moderate to high, with CCS being viewed positively for its potential to mitigate climate change. However, tensions arise from the perception that CCS primarily benefits industries and may conflict with other climate solutions. It was identified that engagement efforts need to address these concerns while navigating broader societal debates and local political dynamics.

4. Citizen Engagement

This chapter reports on the strategies and findings related to citizen engagement, highlighting the methodologies employed across the study regions. One central issue across all three study regions has been the low level of public familiarity with CCS technologies. Media analyses at the beginning of the project suggested and baseline surveys conducted in 2022-2023 confirmed that most residents had either never heard of carbon capture and storage or possessed only vague knowledge about the technology (Dütschke et al. 2022). These levels of knowledge reflect a broader European pattern: in the absence of direct experience or local controversy, CCS remains an abstract concept that fails to register in everyday civic discourse (Miu et al. 2024).

This initial unfamiliarity also represents a challenge and an opportunity. Public perceptions are not yet crystallized into entrenched positions of support or opposition. A critical window exists for

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meaningful engagement and mutual information before project development advances to stages where community input might be perceived as merely consultative rather than genuinely influential.

Recognizing this, WP6 adopted a deliberately participatory approach, designing activities that prioritize mutual learning alongside consultation.

The three study regions present markedly different profiles, each offering distinct insights into how CCS projects might be socially negotiated. The **Lusitanian Basin** in Portugal employs an offshore storage proposal approximately 12 kilometers from the coast of Figueira da Foz. Key topics include the marine ecosystems. In the **Ebro Basin of Spain**, the focus has been on two small, historically depopulated rural municipalities—Belchite and Quinto in Zaragoza province. The proposed storage site at Lopín is located far from any big industrial CO_2 emitters. The **Paris Basin** in France centres on the Grandpuits area southeast of Paris, a region with longstanding familiarity with subsurface applications through decades of oil and gas activity. The presence of a major fertilizer production plant identified as a potential CO_2 source, combined with existing industrial infrastructure, positions the project within an established industrial landscape rather than as an external imposition. These three contexts collectively provide rich comparative terrain for exploring how geological, industrial, and social variables intersect to shape community responses.

This chapter on the citizen engagement activities conducted across in the three regions between 2023 and 2025 summarizes the approaches and insights – a more detailed documentation of the engagement with citizens in each country is included in the Annex. The primary objective in this chapter is to identify common patterns, regional specificities, and actionable insights that can inform both ongoing research activities and broader strategies for public engagement in future CCS developments across Europe. Rather than simply compiling individual reports, this synthesis adopts an analytical approach that interrogates the data comparatively. The analysis aims to serve multiple audiences: it provides the PilotSTRATEGY consortium with empirical evidence for stakeholder engagement decisions; it offers policymakers insights into social prerequisites for CCS deployment; and it contributes to academic and practitioner knowledge about effective public participation models.

This chapter is structured as follows: Section 4.1 presents the methodological framework; Section 4.2 provides a regional synthesis; Section 4.3 undertakes a cross-regional comparative analysis; and Section 4.4 presents conclusions. Complete documentation is provided in annexes.

4.1 Methodological framework

The citizen engagement activities implemented across the three PilotSTRATEGY study regions employed distinct methodological approaches tailored to local contexts, institutional landscapes, and project development stages. This section describes the three primary engagement strategies and their underlying rationale, demonstrating how methodological diversity reflects adaptive responsiveness rather than inconsistency.

4.1.1 Portugal: Engagement strategy

The Portuguese engagement strategy experimented with two formats across 2024-2025, reflecting a learning process about effective outreach in a context where the proposed storage site is offshore

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and geographically distant from major CO_2 sources. The first initiative in February 2024 employed a structured workshop format at Quartel da Imagem in Figueira da Foz. Invitations were sent to

numerous local civil society organizations, science educators, and community groups, with 16 registrations and 9 attendees (five women, four men, aged 48-72, diverse professions incl. teachers, a retired merchant navy officer, a manager, a consultant).

The workshop was structured in two parts: general discussion about CCS supported by a Bellona Foundation video and a national newspaper article presenting balanced perspectives, followed by specific discussion of the PilotSTRATEGY project and the Figueira da Foz location. Participants engaged in exercises identifying benefits and concerns using color-coded post-its and completed a vignette activity positioning themselves relative to contrasting perspectives on project acceptance. The technical team from Universidade de Évora who are also part of the PilotSTRATEGY consortium was present to answer questions, which focused heavily on energy sources for capture, environmental risks, and the philosophical appropriateness of technological versus nature-based solutions.

The second initiative in September 2025 adopted a different approach: a small interactive exhibition open to the public during one afternoon at the Meeting Point venue near the beach. The exhibition combined two sections—introductory posters on climate change, CCS technology, and PilotSTRATEGY research designed by the ICS social science team, and technical exhibits including thin sections of rock under microscopes, models in jars, and a scale model of the storage site designed by the Université de Évora team. The event was extensively promoted through municipal social media channels reaching tens of thousands of followers.

The exhibition attracted 28 visitors, including 13 men and 15 women. Visitors included middle-aged and older men who came alone, older couples, and families with babies, children, or teenagers. Visitors typically engaged with exhibits and researchers for approximately one hour each. At the exit, visitors were invited to write concerns and benefits on post-its, vote on project acceptance using stars placed in labelled jars (yes/maybe/no), and leave additional comments in a "mailbox." Participant observation and team debriefing identified areas for improvement, including venue visibility, outdoor signage, more interactive experiments, and clearer role definition for researchers during visitor interactions.

4.1.2 Spain: Hybrid focus group methodology

The Spanish engagement strategy employed reconvened focus groups designed to combine research, consultation, and participation objectives. This methodology recognizes that meaningful deliberation on complex technologies requires time for information absorption and reflection between sessions. The approach was implemented first in Belchite (September 2023) with nine participants meeting twice and subsequently adapted for Quinto (June 2025) with two parallel groups of six and seven participants respectively.

Recruitment aimed for diversity in gender and age while maintaining territorial coherence within each municipality. Sessions lasted 90-100 minutes and were structured in progressive blocks: initial emotional reactions using visual emotion cards; exploration of risks and benefits through post-it exercises; examination of conditions for acceptance; and reflection on trust, legitimacy, and information needs. Between the first and second Belchite sessions, participants received

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informational dossiers containing project materials, press articles presenting diverse perspectives on CCS, and evaluation frameworks to stimulate reflection.

The methodology integrated stimulus materials including introductory videos, infographics of the CCS cycle, scale maps of subsurface geology, and vignettes presenting contrasting citizen perspectives on hypothetical storage projects. These tools facilitated discussion while providing shared reference points for deliberation. Sessions were audio-recorded, transcribed verbatim, and analyzed using hybrid thematic analysis combining deductive categories derived from literature (emotions, risk perception, benefit perception, conditions of acceptance, trust and legitimacy) with inductive subcodes emerging from participant discourse.

4.1.3 France: Organic open-door approach

The French engagement strategy emerged organically from a concrete operational necessity: the 2022 seismic 3D data acquisition campaign in the Grandpuits area. This campaign required researchers to request right-of-way access from approximately 80 landowners for temporary installation of geophones and authorization from municipal and departmental authorities for vibrator truck circulation. These negotiations constituted the first substantive contact between PilotSTRATEGY and the local community, creating a natural entry point for dialogue.

Two small meetings were organized at the Chamber of Agriculture where farmers, elected officials, and residents could learn about the project and voice concerns. Access was ultimately granted by 80% of farmers and all but one municipality. Building on this foundation, the French team organized three open-door meetings between May 2022 and May 2024 in partnership with the Community of Communes of Brie Nangissienne. These events were deliberately structured to accommodate any interested local resident rather than recruiting specific participant profiles. The format evolved across the three iterations in response to observed dynamics: the first meeting combined formal presentations with informal patio discussions; the second adopted an "apéro" (informal gathering) format but encountered confrontational dynamics with theatre-style seating; the third introduced small mixed tables where participants discussed questions collaboratively before presenting them to the plenary.

The open-door meetings attracted 25-40 participants per event, with partial renewal of attendees across editions. While demography was not formally recorded, generally the participants were to majority male, and also predominantly middle-aged to older.

The French approach emphasized co-construction of knowledge and mutual learning, with the research team adapting both WP6 scientific activities and communication strategies based on citizen input.

4.1.4 Rationale for methodological diversity

The three methodological approaches reflect different but complementary philosophies of public engagement. The Portuguese progressive model prioritizes experimentation and learning, testing different formats to identify what resonates most effectively in a context where spatial distance from the storage site challenges tangible community connection. The Spanish focus group model prioritizes depth and analytical rigor, enabling systematic comparison of responses while providing participants with structured opportunities to develop informed positions. The French open-door

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model prioritises accessibility and co-construction, creating spaces where any interested community member can participate in ongoing dialogue as the project evolves.

These differences are not weaknesses but rather strengths that emerge from contextualized responsiveness. Portugal's approach navigated the challenge of engaging communities about offshore infrastructure where risks and benefits feel abstract. Spain's approach responded to the need for rigorous social science evidence in communities with no prior CCS exposure and strong concerns about territorial justice. France's approach built naturally on the seismic campaign's concrete local presence and existing institutional relationships. Collectively, the three approaches generate complementary forms of evidence—longitudinal co-constructed knowledge (France), systematically coded qualitative data (Spain), and comparative format effectiveness insights (Portugal)—that together provide a richer understanding of public engagement possibilities than any single methodology could achieve.

4.2 Regional synthesis

This section integrates findings from citizen engagement activities in each study region, presenting key themes and evolution over time.

4.2.1 Lusitanian Basin (Portugal): Figueira da Foz Offshore

Portuguese engagement centred on a potential offshore storage approximately 12 kilometres from coast. Motivations for participants to join ranged from curiosity to concern. While prior knowledge tended to be low, several workshop participants had sought for information beforehand and few expressed clear but negative opinions about CCS on arrival. Although the potential project is offshore, many perceive it as proximate and impactful, even if not directly affecting them personally.

Benefits identified were notably fewer than concerns, focusing on atmospheric CO_2 reduction, technological advancement, and industrial accountability. Two participants explicitly did not recognise any significant benefits to CCS. **Concerns** proved extensive: seismic activity, leakages, infrastructure impacts, costs and efficacy, and long-term uncertainties. Novel concerns emerged: energy needs for capture and renewable/non-renewable sources (potentially worsening climate change), risk of misleading technology-intensive solutions instead of nature-based approaches, and greenwashing concerns. One environmental expert raised specific concerns about biomass burning in Portugal using whole trees rather than forest residue, arguing preserved trees as carbon sinks are preferable, and citing studies showing CCS requires 50-80% electrical energy.

Technical **questions** focused on storage siting, capacity, lifespan, permanence, and whether future science might identify new risks. The hypothetical rupture scenario prompted questions about consequences and accountability. Regarding business models, participants questioned cost distribution, with conviction that EU funding would be necessary.

The **acceptance conditions** exercise proved problematic because it assumed inherent project acceptance. One participant stated: "The balance between costs and benefits is negative for me"—no compensation would suffice. Others found the exercise premature given uncertainty about risks, benefits, and solution appropriateness. The vignette activity revealed three participants in total

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rejection, five adopting cautious "not ideal but potentially beneficial if well-managed" positions, and one selecting both.

The exhibition developed in September 2025 applied an adapted format: afternoon exhibition at public beach venue with introductory posters and technical exhibits (rock microscopy, jar models, scale storage model). Despite extensive social media promotion reaching 150,000+ followers and generating some controversy (three online opposition comments), only 28 visitors attended. Most stayed approximately one hour engaging with exhibits and researchers.

Post-it exercises matched 2024 concerns (safety, carbon footprint, costs, bureaucratic delays, consultation needs, emission reduction delays) and benefits (emission reduction, environmental protection, industrial accountability, economic gains). Voting showed overwhelming "yes" support (20), some "maybe" (4), one "no" (1), though this requires cautious interpretation given selection bias—possibly critical commentators did not attend. Visitor backgrounds coloured perceptions: environmentalists left feeling more informed and favourable, while discussions ranged from international CCS comparisons to impacts from local industrial dust.

The Portuguese engagement exercises provide insights into the specifics of offshore CCS engagement and demonstrate the value of experimenting with different formats. The workshop yielded rich qualitative data but limited participation and polarized positions. The exhibition increased accessibility and favourable responses but possibly suffered selection bias. Both revealed persistent concerns about technological versus nature-based solutions, energy sources for capture, and CCS philosophical appropriateness. Limited attendance despite extensive promotion might suggest that community concern is less immediate – possibly because due to the offshore location or because concrete plans do not exist at this point in time, representing both an engagement challenge (mobilizing interest) and potential advantage (lower perceived threat).

4.2.2 Ebro Basin (Spain): Belchite and Quinto

The Ebro Basin engagement focused on two small rural municipalities in Zaragoza province facing depopulation challenges. The proposed Lopín storage site is located far from significant CO_2 emitters, immediately raising territorial justice concerns about hosting externally generated emissions.

Belchite 2023 revealed a community with virtually no prior CCS knowledge. Emotional responses were ambivalent: astonishment at both the technology and the proposal for their municipality, curiosity and scepticism, and fear linked to uncertainty about leaks. A recurring theme emerged: distrust rooted in prior territorial marginalization. Participants perceived their community as receiving "facilities that nobody wants", with one stating: "That seems odd to me rather than something good being brought here for us." Trust in technical experts was distinguished from trust in political decision-makers.

Risk concerns centred on potential leaks and aquifer contamination affecting agriculture, high costs, the perception that CCS gives companies "an excuse to continue polluting", and comparisons to the controversial Castor project. The notion of being an "experimental village" storing CO_2 produced elsewhere appeared repeatedly. Perceived **benefits** focused on economic revitalization: job creation, fiscal benefits, and infrastructure improvements. Conditions for acceptance prioritized explicit local benefits and continuous information mechanisms above all else.

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Quinto in 2025 employed more research-oriented analysis with parallel focus groups (n=6 and n=7) and systematic thematic coding. Five **macro-themes** emerged: emotions, risk/cost perception, benefit perception, conditions of acceptance, and legitimacy/trust. Emotional ambivalence persisted, surprise and curiosity with "Why here?" reflecting suspicion about being selected as a "guinea pig". Risk perceptions focused on subsurface integrity, aquifer contamination, and transport logistics, framed through analogies (e.g. failed renewable development) rather than CCS-specific data.

"Territorial equity" emerged strongly: the idea that "everyone should store their own emissions" rather than concentrating emissions in vulnerable rural areas. Benefit perceptions referenced the the development of a General Motors plant in nearby Figueruelas as a precedent for positive industrial transformation, though Group 2 demanded direct financial incentives for residents rather than only municipal-level benefits. Participants showed preference for CO_2 utilization over mere storage, framing it as resource circulation rather than waste disposal.

Conditions formed a detailed implicit contract: continuous safety monitoring with accessible real-time data, "radical transparency" with regular reporting, and tangible time-bound benefits. Historical memory of broken promises from renewable energy projects profoundly shaped skepticism, generating demands for binding guarantees, reversion clauses, and independent audits. Co-occurrence analysis confirmed benefits as the central axis where communities evaluate trade-offs and assess promoter credibility.

Evolution 2023-2025 showed remarkable consistency in substantive concerns (territorial justice, historical distrust, transparency demands, tangible benefits) with significantly greater precision and nuance in Quinto's articulation of an "implicit psychological contract" specifying detailed requirements across safety, benefits, transparency, and governance.

4.2.3 Paris Basin (France): Grandpuits Area

The Paris Basin experience unfolded through initial de facto engagement during the 2022 seismic campaign, followed by three open-door meetings (2022-2024). The context differs from the other two countries: longstanding subsurface familiarity through oil/gas activity, presence of a major fertilizer plant as CO_2 source, and other existing industrial infrastructure.

Seismic Campaign 2022 required right-of-way requests from 80 landowners and municipal authorities, creating organic engagement through meetings and leaflet distribution to 20,000 households. The campaign achieved high cooperation (80% farmer access, all but one municipality) while revealing locally specific concerns. This revealed both the community's willingness to engage with research activities and the salience of locally specific concerns, such as the symbolic and practical value of ceramic drainage systems installed generations ago in agricultural fields. Most salient proved ceramic drainage systems installed generations ago—insignificant geologically but symbolically valuable as local heritage transmitted through family ties. This insight led to concrete adaptations: georadar to locate drains, stress tests, and in-depth farmer cooperation. When a commune reported water leaks after truck passage, despite uncertain causality the project team and the local government agreed to jointly fund an inspection of sewage lines, demonstrating "transdisciplinary solidarity" with public concerns.

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Early discussions about limited direct job creation prompted participants to raise the question of social recognition for communities contributing to climate mitigation. This led researchers to add survey questions already in the first round of surveys (Dütschke et al. 2022) which then received strong positive responses, depicting consensus on the need for symbolic acknowledgment beyond material compensation. Social recognition was considered somewhat to very important by around 92% of respondents (n=235), and around 84% reported they would feel somewhat to very proud if their area would contribute to climate change mitigation through CCS (n=232).

Open-Door Meetings Evolution demonstrated adaptive learning in its format and variation of topics according to project stages. Discussions were sincere and often technically sophisticated, with citizens' questions becoming increasingly precise over time. The first meeting (May 2022, Nangis) alternated formal presentations with informal patio conversations, identifying the drain concern and social recognition theme as outlined above.

The second meeting (June 2023) with a higher attendance of 40 with "apéro" branding but theatre-style seating reported on the insights from the geological campaign. Partly a confrontational format emerged with rapid-fire questioning. Views on the possible risks of carbon storage were voiced confrontationally referred to past incidents in the region and elsewhere. Additionally, attendance by managers of the local fertilizer plant enabled much-needed direct community communication about facility uncertainty. Despite contentious dynamics, all participants stayed for buffet discussions.

The third meeting (May 2024, ~25 attendees) incorporated lessons learnt by shifting to small mixed tables for collaborative question development, producing 34 written questions spanning reservoir issues, project dependency on the CO_2 source, general CCS questions, and governance. About half were answered immediately; all questions were submitted to the regional stakeholder committee, and also shaped criteria entered in subsequent Work Package 4 modelling. Researchers noted citizens' questions were now approaching current scientific knowledge limits.

French Engagement Characteristics included organic responsiveness evolving through iterative learning, institutional partnership providing logistical support and symbolic legitimacy, genuine dialogue with researchers accepting challenges and maintaining transparency, concrete impact on other scientific activities (survey questions, stakeholder input, site modelling, risk assessment), and researcher reflexivity jointly organizing events and reflecting on how concerns should impact research. Although attendance remained modest (25-40 persons per event), the approach enabled significant shared learning and went well beyond typical consortium-community interaction.

4.3 Cross-regional analysis

This section identifies several common patterns transcending geographical differences, the regional specificities illuminating how local conditions shape responses, and the temporal evolution in perceptions where data permit.

4.3.1 Common patterns across regions

Despite markedly different contexts, citizen engagement activities revealed striking convergence on core themes, suggesting fundamental dynamics of public response to CCS that transcend local particularities.

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1. **Limited initial knowledge, strong learning capacity**. As anticipated all three regions exhibited low baseline familiarity with CCS technology. Most participants had never heard of carbon capture and storage or possessed only vague concepts. However, this did not translate into disengagement. Participants demonstrated genuine curiosity and significant learning capacity when provided accessible information. Linking engagement activities with technical information and including researchers with a technical background strongly supported this. In France, researchers noted questions becoming increasingly sophisticated across meetings. In Spain, participants moved from basic "what is this?" queries to detailed articulation of conditional acceptance frameworks. This pattern suggests initial unfamiliarity represents opportunity rather than obstacle, creating space for meaningful dialogue before crystallized opposition or support. However, it also emphasizes the need for creating opportunities for meaningful engagement.
2. **Ambivalent emotions mixing hope and fear**. Emotional responses consistently combined positive and negative valences rather than polarizing toward single affect categories. Curiosity and hope coexisted with fear and scepticism across all sites. Spanish participants expressed astonishment at both the technology and site selection. Portuguese visitors showed interest while voicing concerns about risks. French attendees engaged constructively while challenging assumptions. This ambivalence indicates neither enthusiastic embrace nor outright rejection but rather thoughtful deliberation weighing potential against uncertainty. The prevalence of mixed emotions underscores the conditional nature of acceptance and the importance of addressing both aspirational benefits and concrete risk mitigation.
3. **Safety as non-negotiable foundation**. Continuous monitoring, demonstrable safety protocols, and accessible verification mechanisms emerged as universal prerequisites. Spanish participants stated bluntly, "If it's not safe, no one will accept it." Portuguese concerns centred heavily on leaks, seismic activity, and marine ecosystem impacts. French discussions addressed risk assessment methodologies and determination of “acceptable risk”. Safety ranked consistently among top priorities in acceptance condition exercises. Importantly, communities demanded not just assertions of safety but tangible evidence: real-time monitoring data, independent audits, and institutional mechanisms ensuring ongoing oversight beyond project operators' self-reporting.
4. **Radical transparency as requirement**. All regions articulated strong demands for continuous, accessible, unbiased information throughout project lifecycles. Spanish participants explicitly invoked "radical transparency", insisting on regular updates about safety inspections, employment creation, and incident occurrence. French open-door meetings evolved toward formats enabling direct questioning and collaborative inquiry. Portuguese participants sought clarity on technical processes, business models, and governance arrangements. Transparency extended beyond information provision to genuine dialogue: communities wanted opportunities not merely to receive updates but to question and challenge assumptions. In most regions, particularly in France and the later Quinto study, this evolved into a clear preference for participation (sharing power) over mere

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consultation (seeking input). However, this was not universal, for example, the initial Belchite group prioritized receiving explicit local benefits and continuous information on active participation in decision-making.

5. **Historical distrust shaping current perceptions**. Broken promises from previous projects profoundly coloured attitudes toward CCS proposals. Spanish participants recalled wind turbines that failed to lower electricity bills as promised and solar projects that generated no local employment. This memory generated demands for binding guarantees, reversion clauses, and penalty mechanisms for unmet commitments. Portuguese commentators referenced broader patterns of communities bearing infrastructure burdens without benefits. French participants expressed scepticism about whether economic returns would materialize. This distrust is not inherent or irrational but learned from experience, underscoring that CCS projects cannot be evaluated in isolation but inherit the legitimacy debt of past failures.
6. **Conditional acceptance, not polarization**. Across all regions and methodologies, citizen positions clustered toward conditional middle ground rather than extremes. Even Portuguese participants selecting "total rejection" in vignettes often qualified their stance, and those selecting "cautious acceptance" specified extensive requirements. Spanish focus groups articulated detailed implicit contracts specifying safety, benefit, transparency, and governance conditions. French attendees engaged seriously despite expressing concerns, and participation itself signalled willingness to deliberate rather than dismiss outright. This conditionality represents both challenge and opportunity: projects must meet substantive requirements to gain support, but outright opposition is not predetermined. Social acceptance emerges as negotiable outcome of meeting community-defined conditions rather than fixed attributes to be measured.
7. **Distributive justice as critical lens**. Distributive justice encompasses multiple dimensions: spatial (location of risks vs. benefits), temporal (current burdens vs. future gains), social (which community segments gain employment, compensation), and procedural (who participates in decisions). Questions of fairness—who bears risks, who receives benefits, who decides—appeared centrally in all contexts, though with varying intensity. Spanish communities articulated this most explicitly through "territorial equity" demands and the "experimental village" framing, but similar concerns surfaced elsewhere. Portuguese offshore context raised questions about why Figueira da Foz rather than other locations, with one participant noting, "these solutions never seem to be implemented in capital cities...they're always situated elsewhere." French discussions addressed the relationship between local industrial presence (fertilizer plant) and storage proposal, reflecting on whether the community was serving external interests or benefiting from its own industrial activity.

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4.3.2 Regional specificities and contrasts

While common patterns reveal shared dynamics, regional differences illuminate how specific contexts and possibly also formats of engagement and the selection of participants mediate responses and shape the particular concerns requiring attention.

1. **Siting context fundamentally shapes perceptions**. The starkest contrast appears between Spain's onshore rural non-industrial context, France's onshore industrial context, and Portugal's offshore context. Spanish communities raised immediate questions about why their depopulated municipalities should host CO_2 generated elsewhere, with no local industrial benefit justifying the intrusion. This generated intense territorial justice concerns, comparisons to waste dumping, and demands for tangible compensation. French communities, by contrast, situated CCS within the existing industrial landscape where subsurface applications were familiar and a local CO_2 source existed. This reduced the "external imposition" perception, though concerns about legacy infrastructure (ceramic drains) and future industrial employment emerged instead. The Portuguese offshore proposal created physical and psychological distance reducing immediate threat perception but also complicating tangible community connection and mobilization of interest. These differences suggest communication strategies, benefit packages, and governance arrangements must be fundamentally tailored to siting contexts rather than applying standardized approaches.
2. **Industrial presence mediates economic expectations**. Communities with existing industrial activity (France) discussed CCS within frameworks of employment continuity and industrial transition, asking whether carbon storage could help maintain fertilizer production and associated jobs. The Spanish communities without significant industry viewed potential CCS infrastructure as possible catalyst for broader economic revitalization, invoking precedents like the General Motors plant and anticipating multiplier effects on services, housing, and population retention. In the Portuguese offshore context more abstract economic discussions emerged focusing on municipal-level infrastructure benefits and environmental impacts from industry rather than direct industrial job creation. This points out that potential benefits and concerns on economic consequences need to be seen within the local context and history.
3. **Environmental discourse varies by ecological context**. Spanish concerns centred on aquifer contamination and agricultural land protection, reflecting the centrality of farming to local identity and economy. Portuguese concerns emphasized marine ecosystem impacts, biomass energy sources, and included debates about technological versus nature-based solutions, reflecting both offshore location and strong environmental advocacy presence. French concerns addressed ceramic drains as heritage infrastructure and induced seismicity comparisons to other subsurface activities, reflecting specific regional ecological and cultural features. These variations indicate that "environmental concern" is not generic but takes locally specific forms requiring contextual understanding rather than standardized risk communication messages and emphasizes specific communication and engagement needs for project developers.

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4. **Engagement format effectiveness varies by community structure**. France's open-door approach succeeded in creating iterative dialogue within a community having existing institutional partnerships (Chamber of Agriculture, municipal groupings) and modest population density enabling repeated attendance by committed participants. Spain's focus group methodology proved effective for systematic research in small rural communities where targeted recruitment could achieve representative diversity and reconvened sessions enabled reflection. Portugal's exhibition format attracted engaged visitors in a larger coastal town where event-based formats compete with beach activities. These differences including its successes and challenges underlines that engagement strategies must match community size, institutional landscape, and project salience and the need for flexibility in engagement processes rather than assuming single best-practice format.

4.4 Summary of insights

The citizen engagement activities conducted across three PilotSTRATEGY study regions between 2023 and 2025 aimed to involve communities regarding CCS projects through region-specific methodologies. In Portugal, workshops and exhibitions focused on offshore storage in a situation where the project is not a key regional issue. Spain employed reconvened focus groups in rural areas near the proposed onshore storage site. France implemented open-door meetings and informal dialogues alongside seismic surveys in an industrial area. The formats were developed and adapted according to local conditions and context and technical project developments.

Overall the citizen engagement activities reveal a consistent pattern: social acceptance of geological CO_2 storage is neither predetermined nor impossible, but rather conditional, negotiable, and constructed through sustained dialogue addressing substantive community concerns. Across all regions, citizen participating in the events typically showed low initial knowledge but high learning capacity, with ambivalent emotions blending curiosity and concern. Common themes included demands for safety, transparency, and distributive justice, with conditional acceptance hinging on meeting community-defined benefits and risks. Regional differences in siting, industrial presence, environmental concerns, and engagement formats shaped interest and reactions, highlighting the need for tailored approaches to foster meaningful dialogue and trust.

5. Survey: insights over time and across regions

To gain a deeper understanding of current perceptions of CCS within the regions and to track changes over time, a second round of surveys was conducted in Summer 2025, building on the previous ones (2022) to foster some comparability. This chapter outlines the methodology and findings of the surveys. It is important to note that while PilotSTRATEGY involved intensive engagement and technical activities, these were relatively limited in scope and outreach: no major infrastructure developments occurred, few research activities were visible to local residents, and no key decisions regarding potential future implementation were made by promoters, authorities, or communities. As a result, the samples of local populations recruited by market research institutes for this study likely experienced minimal direct impact from the project's activities. Additionally, the

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salience of climate change and related policies has diminished recently due to the emergence of other crises, such as the energy crisis linked to the Russian invasion of Ukraine, economic recession in Europe, and broader geopolitical instability. Consequently, any changes observed between the two survey waves likely stem from a combination of factors, including sample characteristics, whereas PilotSTRATEGY project activities may have played only a minor role. Nonetheless, the survey remains particularly valuable for providing insights beyond those gained in dialogue with already interested and engaged participants in the citizen engagement activities.

5.1 Methods

This section outlines the study procedure (Section 5.1.1), the questionnaire design and sample characteristics (Section 5.1.2), and the procedure for analysing the data (Section 5.1.3).

5.1.1 Study procedure

The aim of the second wave of regional surveys was to obtain representative findings on current levels of awareness and acceptance among the general public in the main regions, as well as to evaluate potential changes over the project duration. It was planned to obtain online surveys with a sample size of 500 respondents in each of the three main regions, i.e. Portugal (offshore), Spain (onshore), and France (onshore). Participants were to be recruited through subcontracted market research institutes. However, following the definition of the affected regions and taking into account country-specific research practices and available market research services, the research team decided to implement phone surveys instead of online surveys in Portugal and Spain as already in the first survey wave (Dütschke et al. 2022). Following this decision, the survey length also had to be adjusted to the method of data collection, resulting in shorter questionnaires for the phone surveys. Moreover, the sample size in each of the three regions had to be adjusted to around 350, as service providers could not guarantee higher numbers due to low population rates or limited coverage in their contact data bases. Table 1 provides an overview of the final implementation and numbers of respondents achieved in the two survey waves. A very small number of participants in both waves were excluded from the analysis due to low-quality responses (e.g. very high rates of 'don't know' responses across all questions).

Table 1 Overview of study design and sample sizes analysed in the second wave of surveys.

Country	Storage option		Final sample size		Type of provision		Length	
	2022	2025	2022	2025	2022	2025	2022	2025
Portugal	on- & offshore	offshore	N=497	N=352	Phone		10 min	7 min
Spain	onshore		N=300	N=350	Phone		7 min	
	offshore	not investigated in the 2025 survey						
France	onshore		N=243	N=348	Online		10 min	
Poland	onshore	not investigated in the 2025 survey						
Greece	onshore	not investigated in the 2025 survey						

As in the first survey wave, representativity of the sample was aimed for in terms of age (using four categories) and gender. The soft quotas set up for this purpose were not crossed and were partly based on national statistics due to low data availability for the selected regions. Owing to this, a

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higher tolerance was set for the quota limits. In addition to the criteria mentioned above, the ratio of residents in the respective administrative units and the educational level of the participants were monitored without specific thresholds, allowing for natural variation.

For the phone vs. online survey implementation, the wording of the questions, instructions, and explanatory text had to be slightly adjusted, however were kept as similar as possible. Since both survey types were already used in the first wave, the modifications for the second wave were made in a similar way. The surveys were implemented in the respective national languages, and fieldwork for the second wave started in June 2025 and was completed in each region by July at the latest. The fieldwork for the first survey wave, detailed in Deliverable 6.2, was conducted between July and September 2022. The main descriptive findings from this wave are compared to those of the current survey wave in Section 5.2.1.

5.1.2 Questionnaire and sample

For the first wave of surveys, the research team developed a modular questionnaire that included a common identical core across all regions to allow for cross-country comparisons. This core was retained in the second wave to assess potential changes, with some modifications to account for latest developments in the main regions. As in the first wave, some region-specific questions were added, along with additional topics for the longer online questionnaire. Table 2 summarises the topics covered in each questionnaire for the main regions across both survey waves.

Table 2 Overview of survey content across both waves.

Topics in the questionnaire	Portugal		Spain		France	
	2022	**2025**	2022	**2025**	2022	**2025**
Socio-economic variables	(x)	**x**	(x)	**x**	x	**x**
Place attachment	x	**-**	(x)	**-**	x	**-**
Climate change perceptions	x	**x**	x	**x**	x	**x**
Attitudes towards industry	x	**x**	x	**x**	x	**x**
Familiarity with CCS	x	**x**	x	**x**	x	**x**
(Informed) acceptance of CCS	x	**x**	x	**x**	x	**x**
Expected benefits of CCS	x	**x**	x	**x**	x	**x**
Conditions for acceptance	x	**x**	x	**x**	x	**x**
Expectations regarding the process	-	**x**	(x)	**(x)**	x	**x**
Trust in societal stakeholders	x	**x**	x	**x**	x	**x**
Preferred involvement of societal stakeholders	(x)	**-**	-	**-**	x	**-**
Preferred involvement in the process	x	**x**	x	**x**	x	**x**

x: included in full; (x): included in abbreviated form; -: not included

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As in the first survey wave, the samples drawn for the current wave aimed at representativity but exhibited clear biases (cf.

Table 3). Only few socio-economic characteristics could be used as quota variables in the sampling (cf. Section 5.1.1), and these were only fulfilled to a certain extent. This is mainly due to the limited number of people living in the respective areas. Regarding the quotas set, the regional samples well cover the targeted gender distribution in the population, although there is some variation in Portugal. For the age distribution across four categories, representativity was partly achieved; however, the oldest category is underrepresented in Portugal and France.

In addition, the second wave of surveys focused on rather small regions (particularly when it comes to the priority zones), for which it is likely that those who agreed to participate in the survey have different opinions from those who declined or were not interested in joining the market research institutes' directories. Thus, the final numbers obtained need to be interpreted with caution. In this regard, cross-country comparisons and a multivariate analysis of influential factors for the acceptance of a potential local implementation of CCS form an important part of the interpretation. By including a broad set of structural variables, the multivariate analysis mitigates potential sampling bias.

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Table 3 Overview of socio-demographic variables and the respective shares in the final sample across both waves.

Socio-demographic variables		Portugal		Spain		France	
		2022 (on- & offshore)	2025	2022 (onshore)	2025	2022	2025
Age group (in years)	18-29	25%	**18%**	11%	**13%**	24%	**20%**
	30-49	36%	**40%**	17%	**21%**	44%	**36%**
	50-69	32%	**36%**	42%	**36%**	27%	**36%**
	70+	7%	**5%**	31%	**30%**	5%	**9%**
Gender	Female	59%	**37%**	57%	**55%**	40%	**50%**
	Male	40%	**63%**	43%	**45%**	58%	**49%**
	Non-binary	0%	**0%**	0%	**0%**	0%	**0%**
Place of residence	Selection of municipalities in the following administrative units:						
Portugal (NUTS3)	Coimbra	13%	**60%**				
	Leiria	61%	**40%**				
	Oeste	26%					
Spain (NUTS3)	Teruel			28%	**19%**		
	Zaragoza			72%	**81%**		
France (Communauté de communes CC)	Bassée-Montois						**4%**
	Brie des Rivières et Châteaux					6%	**4%**
	Brie Nangissienne					82%	**5%**
	Provinois						**8%**
	Du Pays de Montereau						**11%**
	Val Briard					12%	**8%**
	other CCs in Seine-et-Marne						**60%**
Educational level	University degree or comparable	35%	**53%**	16%	**14%**	57%	**43%**

Note: The number and selection of municipalities included in each administrative unit may differ between the survey waves, making the NUTS3 regions and CCs not directly comparable across waves.

To derive insights over time, findings from the two survey waves are compared in the descriptive analysis of the main findings. However, comparability is constrained by differences in regional composition, arising partly from project developments[1] and partly from the services available from market research companies. These could only guarantee the targeted number of respondents by expanding the regions under investigation.[2] Therefore, comparisons over time need to be

[1] In Portugal and Spain, the regional composition changed between 2022 and 2025 due to project developments. In Portugal, only those municipalities relevant to a potential offshore implementation were retained in 2025, with the inclusion of additional municipalities in the coastal area. In Spain, the analysis in 2025 focused solely on the onshore region, with a slightly modified regional composition.

[2] In France, the market research company could only guarantee a limited number of respondents from the area under investigation in the 2022 survey. Consequently, the 2025 survey's coverage was expanded to

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interpreted with caution and serve only to identify whether the patterns observed in the first wave remain consistent within the respective countries over time. They provide limited insight into how attitudes have evolved within the specific regions under study between the two waves.

5.1.3 Data analyses

Data analyses were performed using RStudio and encompassed both descriptive and multivariate methods. The descriptive analysis focused mainly on cross-country comparisons and comparisons across survey waves. This approach was taken to situate each region's results over time relative to the regions in the other countries, which is important to keep in mind for interpretation. The multivariate analysis relied on three linear regression models to discern patterns relating to influential factors in the local acceptance of a potential implementation of CCS in the study regions. As potential influential factors we distinguished between (1) prior personal beliefs about climate change and industries related to the CCS technology; (2) personal familiarity with CCS and related industries; (3) attitudes towards a potential implementation of CCS; and (4) socio-economic characteristics. The annex provides further methodological details on the multivariate analysis and presents descriptive statistics for all the variables used in the regression models, as well as detailed information on their composition.

5.2 Findings

In the following, the survey results are presented. This section is structured as follows: First, the main descriptive results are provided, covering respondents' familiarity with CCS and their (informed) acceptance of this technology option (Section 5.2.1). Section 5.2.2 then presents the findings from the multivariate analysis on the influential factors for the acceptance of a potential implementation of CCS in the study regions.

5.2.1 (Main) Descriptives including comparisons across regions and time

The summary figures below (cf. Figure 2, Figure 3, and Figure 4) illustrate the relative frequencies of response options, excluding the 'don't know' category. In the second wave of surveys, familiarity with CCS remains generally low across all regions (cf. Figure 2). Among the regions, Portugal shows the highest levels of familiarity in this second survey wave, with a statistically significant difference compared to the others. Notably, familiarity levels in Portugal are almost identical to those observed in the first wave, with 16% of respondents reporting familiarity with CCS, while the majority still indicated they had never heard of the technology. In contrast, Spain (again) exhibits the lowest familiarity levels, with 79% of respondents stating they had no prior knowledge of CCS, although this marks an increase from the first wave in 2022, when over 90% reported being unfamiliar with the technology. France shows the strongest change: Now 56% of respondents state they had never heard of CCS, a decrease in familiarity compared to the first wave, when only 25% reported unfamiliarity.

include two additional priority zones, increasing the radius by approximately 25 km. Around 37% (cf. annex) were recruited from these three priority zones. To meet the target number of respondents, the remaining respondents were sourced from the entire Seine-et-Marne department.

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It is important to note however, that the region under study had to be strongly extended for France for the second survey.

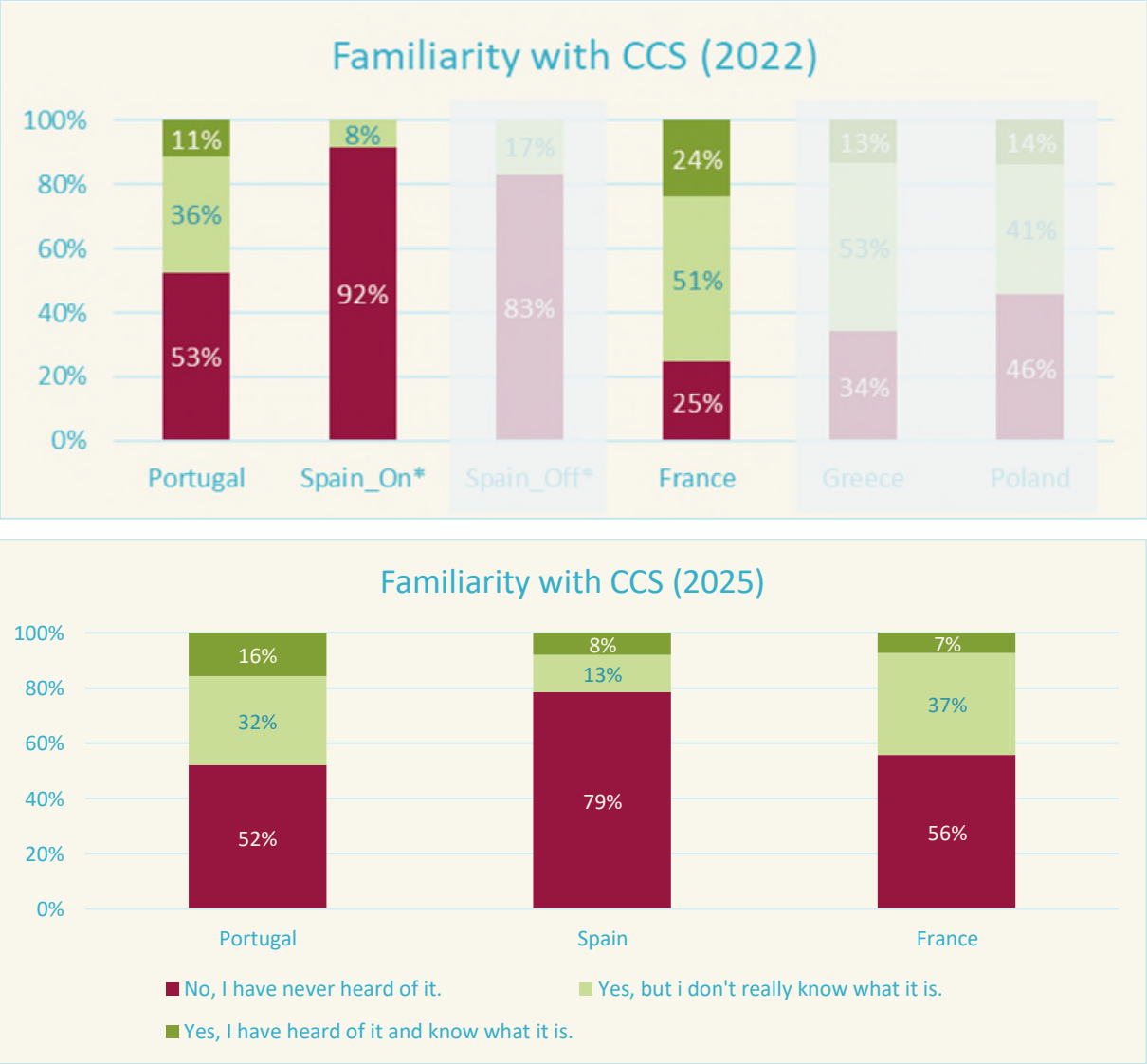

*Figure 2 Familiarity with CCS in the study regions (*in 2022, the two Yes-categories were merged into one in the Spanish sample).*

The overall evaluation of CCS as a technology option to mitigate climate change is relatively positive in Portugal (cf. Figure 3). Spanish respondents shared a similarly positive view. In both countries, more than 54% of those providing an evaluation categorised the technology as a good or very good option. In contrast, French respondents were more undecided. Around 42% rated CCS as a (very) good option and 32% as neutral. The rate of sceptical respondents is at around 26%. Compared to the first wave, where slightly above 70% evaluated the technology as a (very) good option, it was evaluated less positively in the current Portuguese and French samples. Conversely, for Spain, the evaluation in the second wave was more positive than in the Spanish onshore region of the first wave, where only around 38% rated the technology positively.

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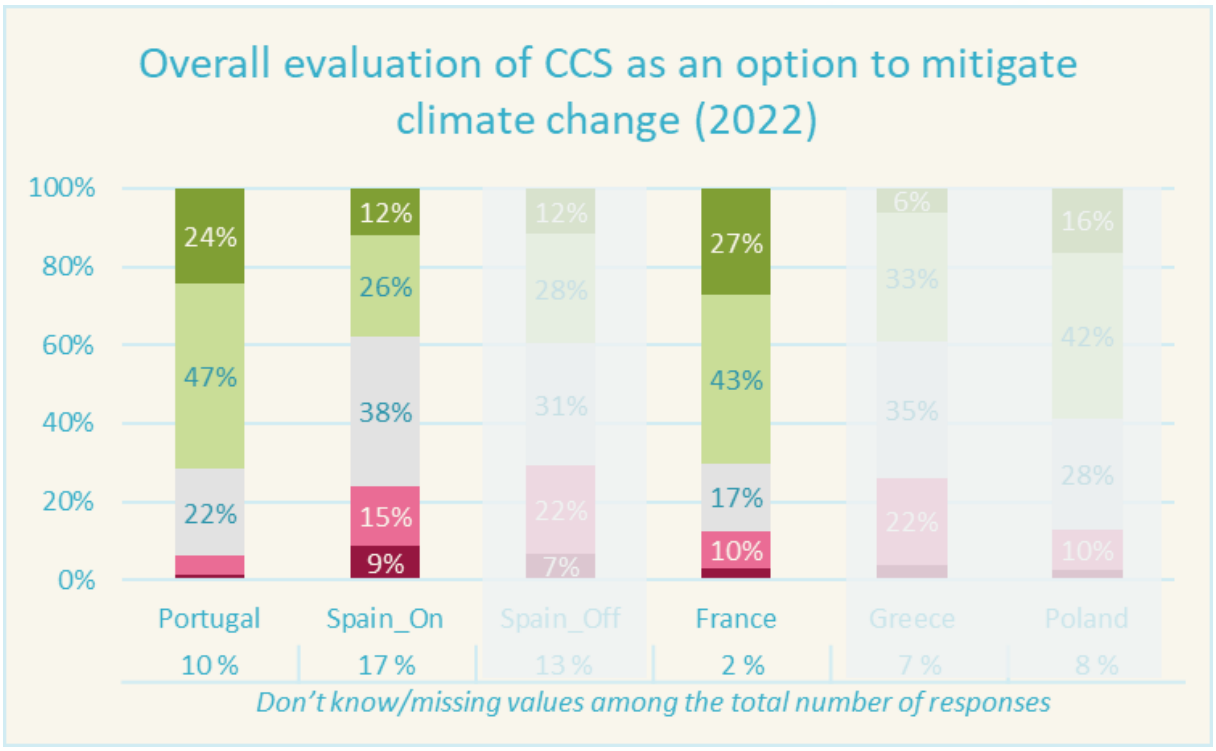

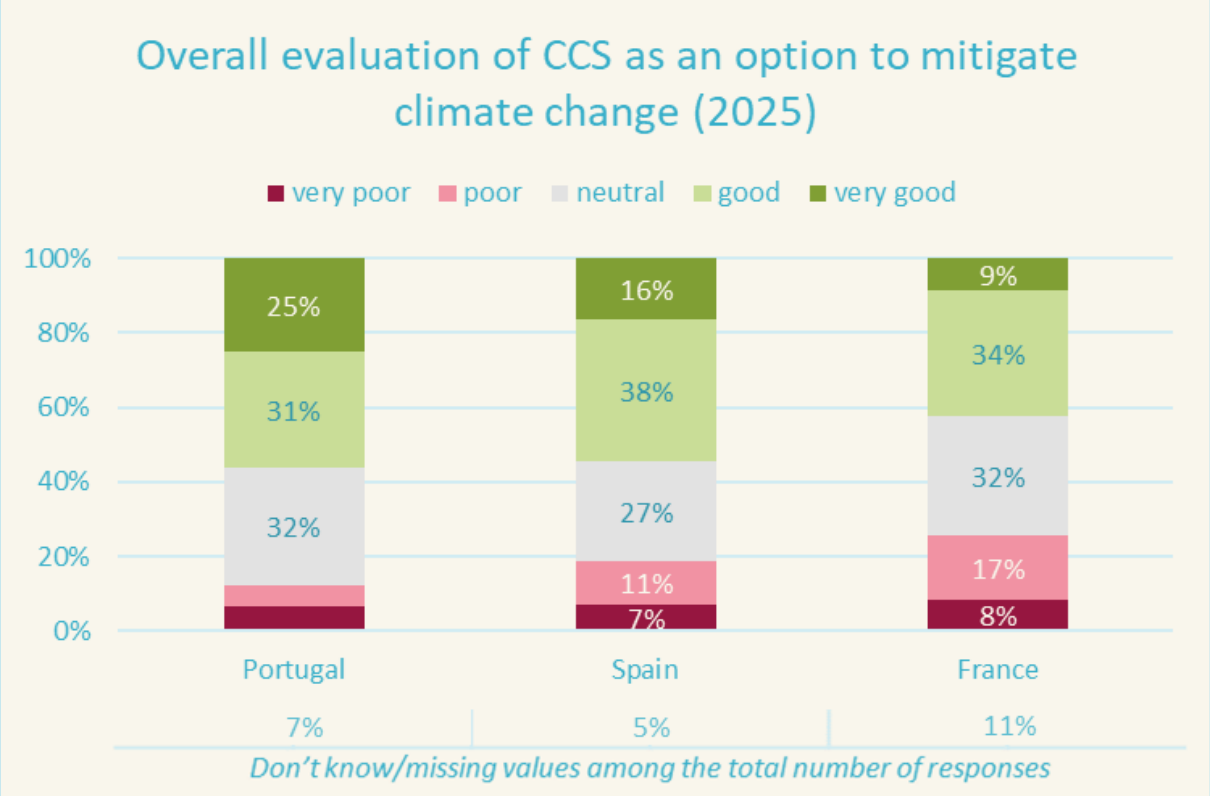

Figure 3 Overall evaluation of CCS as a technology option.

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Regarding a potential local implementation (cf. Figure 4), a comparison across regions reveals that respondents from Portugal are rather accepting.[3] Their acceptance evaluations are also relatively consistent with their overall evaluation of CCS as a technology option to mitigate climate change. Specifically, 53% [48%; 58%][4] support a potential local implementation, with a significant share (i.e. 33% [28%; 38%] of those providing an evaluation) selecting the highest option. In Spain, statistical tests indicate that respondents are less positive about a potential local implementation of CCS than they are about the technology itself. Around 56% [50%; 61%] consider a local implementation acceptable or totally acceptable, with 12% [8%; 15%] choosing the highest option. The remainder are evenly split between neutral and negative responses (about 22% each). Conversely, responses to a potential local CCS implementation in France are more favourable than evaluations of the technology as an option to mitigate climate change. Around 48% [42%; 53%] rated a potential local CCS implementation as (rather) acceptable. 28% [23%; 33%] provide neutral responses. However, around a quarter are negative about a potential CCS implementation.

While the answering patterns of the two survey waves and samples do not differ statistically for Portugal and the Spanish onshore region, the current responses from France are less supportive of a potential CCS implementation than in 2022.[5] The first French survey relied on a smaller number of respondents, but at the time the market research company involved allowed for a recruiting approach that was more focused on the small-scale region where geological characterisation studies were conducted by PilotSTRATEGY.

[3] Acceptance scores in Portugal are statistically significantly higher than in France. Regarding Spain, however, clear evidence of its position relative to the other two regions is lacking due to differences in the wording of the scale for this question. A comparison based on the combination of the two highest and two lowest categories, respectively, revealed no statistically significant differences between responses in Spain and the other regions.

[4] All confidence intervals (CIs) reported are 95% CIs, indicating the range within which the true population value is likely to fall with 95% confidence.

[5] For Portugal, the 2025 acceptance results are compared with the 2022 offshore acceptance results. To account for the variation in wording between the two survey waves, we treated the two highest and two lowest categories as one, respectively.

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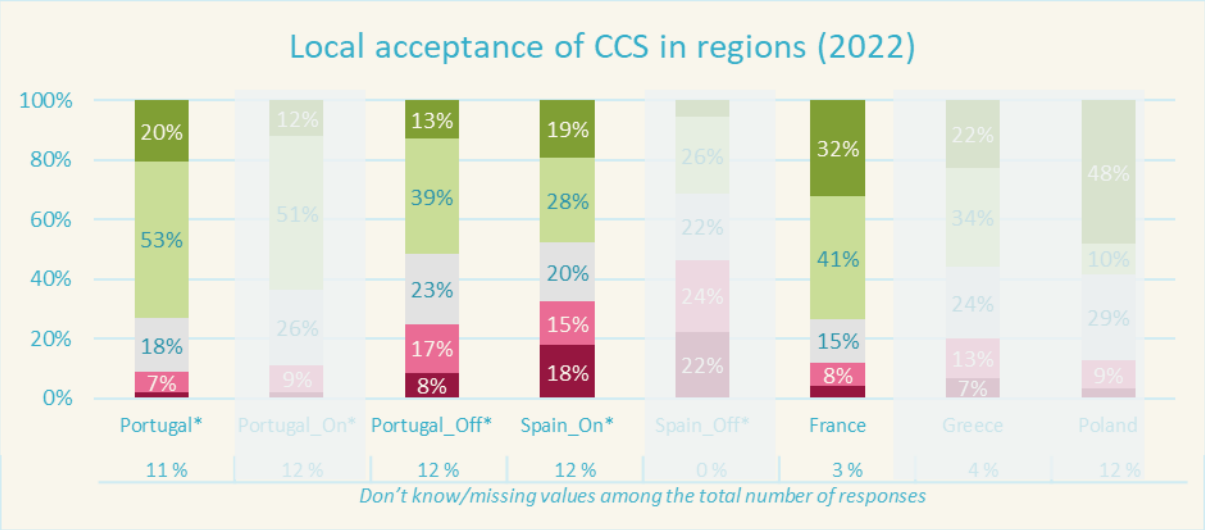

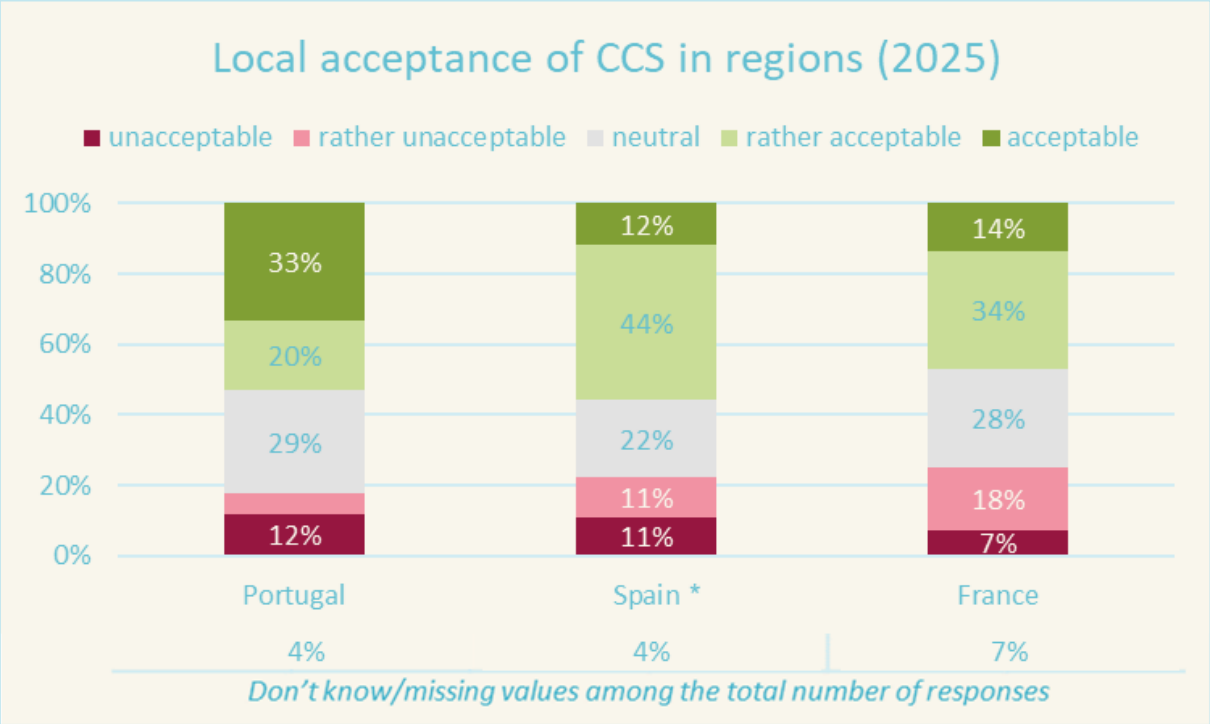

*Figure 4 Local acceptance of CCS in the respective study regions (*in Spain and the Portuguese sample from 2022, the wording of the scale was slightly different ranging from 'totally unacceptable' to 'totally acceptable').*

With regard to further topics covered in the survey (cf. annex), respondents across the three main regions generally consider climate change an important problem, especially in Portugal and Spain. Here, >79% consider it to be a (very) severe problem, with >43% selecting the highest option. Attitudes towards industries potentially involved in CCS deployment in the respective regions are also generally favourable. This particularly applies to Portugal, where 40% regard these industries as very important and another 23% as important. However, trust in industry actors in general is highest in Spain, where around 54% stated to be fairly or very trusting in local industry. Notable differences between trust in local and external industry actors appear in Portugal and Spain, where respondents

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trust local industries more than external ones (around 38% and 54% versus 28% and 41%, respectively). In France, no statistically significant difference is observed in this regard.

Compared to the other regions, French respondents are the least optimistic about the changes resulting from a potential CCS implementation in their region. Across the three categories of environmental, economic, and societal benefits, their responses are mixed, with being >34% positive, >30% neutral, and >21% negative. By contrast, the majority of Spanish respondents express (very) positive views, especially regarding economic (around 78%) and societal benefits (around 69%). In both the Portuguese and the French region, economic benefits are also expected to be the most positive, with close to half of respondents expecting (very) positive changes. Regarding the perceived legitimacy of a potential CCS implementation process, Portuguese respondents' expectations are the highest. Around 44% expect the process to be (very) fair, and another 39% expect it to be moderately fair. Expectations around process legitimacy are more mixed in the other two regions.

Finally, given that CCS is an unfamiliar topic, it is also relevant to look into the shares of respondents answering 'I don't know'. Across all regions, between 4-11% of respondents chose this option in the CCS-related questions. These responses are not counted in the shares outlined above (cf. Figure 3 and Figure 4), thus, decreasing them relatively. The share of respondents opting for the *don't-know* option is highest in France, with up to 11% for the question on the overall evaluation of CCS as a technology option.

5.2.2 Regression models

Table 4 summarises the key findings of our regression models, highlighting the statistically significant correlations between the local acceptance of a potential CCS implementation in the study regions and potentially influential factors. Detailed documentation of the findings of the multivariate analysis can be found in the annex.

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Table 4 Influential factors in the acceptance of a potential local CCS implementation.

	Acceptance in Portugal	*Acceptance in Spain*	*Acceptance in France*
Prior personal beliefs			
problem perception	n.s.	n.s.	n.s.
importance of related industries	**positive correlation**	n.s.	n.s.
Personal familiarity			
familiarity	n.s.	n.s.	n.s.
employment in related industries	n.s.	n.s.	n.s.
Attitudes towards the implementation of CCS			
environmental benefits	**positive correlation**	**positive correlation**	**positive correlation**
economic benefits	**positive correlation**	n.s.	**positive correlation**
societal benefits	n.s.	n.s.	**positive correlation**
process legitimacy	**positive correlation**	**positive correlation**	**positive correlation**
trust in local industry actors	n.s.	n.s.	n.s.
trust in external industry actors	n.s.	n.s.	n.s.
Socio-economic characteristics			
female	n.s.	n.s.	n.s.
50 years or older	n.s.	n.s.	n.s.
university degree	n.s.	n.s.	n.s.
high income	n.s.	n.s.	n.s.
primary place of residence	n.s.	n.s.	**positive correlation**
# of observations	257	219	216

n.s. Results are not statistically significant.

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Table 4As summarised in Table 4, the regression results show that respondents' prior personal beliefs are associated with the acceptance of a potential local implementation of CCS in one of the three models. While respondents' problem perception regarding climate change does not feature a statistically significant correlation in any model, the perceived importance of related industries is positively and statistically significantly correlated with acceptance in the Portuguese sample. However, this relationship is not particularly strong compared to other covariates.[6]

The surveys also examined the respondents' personal familiarity with CCS and related industries. In this regard, neither *familiarity* with CCS as a technology option to mitigate climate change nor *employment in related industries* (such as energy-intensive industries that are likely to be involved in CCS development in the study regions) appears to be related to any of the three dependent variables. Although familiarity with the regions was not directly assessed in the second wave of surveys, the multivariate analysis controlled for regional variation by including covariates related to the respondents' place of residence. This revealed that, in France, acceptance levels are higher among respondents primarily residing within the region compared to those primarily residing outside of it. There is also evidence of relevant variation between administrative units in the Spanish and French samples, but not in Portugal.

With regard to respondents' attitudes towards a potential implementation of CCS in their respective region, the technology's expected benefits for the region appear to be highly relevant for acceptance by the local public, particularly expected environmental benefits. These show strong positive, and statistically significant correlations with all three dependent variables (cf. annex). Thus, respondents expecting environmental benefits also demonstrate higher levels of acceptance. For each one-point increase in *environmental benefits* on the 5-point Likert scale, the acceptance score is expected to increase by up to 0.562 points on the same scale, as indicated by the respective (unstandardised) coefficients. By contrast, the identified statistically significant relationships between the expected economic and societal benefits of a potential local CCS implementation and the dependent variables are weaker, with standardised coefficients of up to 0.159. Both are nonetheless relevant factors for local CCS acceptance. Expected *economic benefits* are positively and statistically significantly related with local acceptance in Portugal and France, while the same is true for expected *societal benefits* in France. In Portugal, the coefficient for *societal benefits* is just shy of statistical significance (p-value of 0.052).

Process legitimacy, captured through expectations regarding the fairness of CCS implementation decisions in the respective study regions, constitutes another important influential factor for local CCS acceptance. The correlations between *process legitimacy* and acceptance are positive and statistically significant across all models, with comparatively high effect strengths (cf. annex). For each one-point increase in *process legitimacy* on the 5-point Likert scale, the acceptance score is expected to increase by up to 0.276 points on the same scale. In contrast, trust in industry actors related to a potential CCS implementation in the respective study region – whether local or external – does not show statistically significant correlations with acceptance in any sample.

[6] This interpretation is based on the standardised regression coefficient (*ß*), i.e. the expected change in the dependent variable in standard deviation units for a one standard deviation increase in the independent variable (with all other variables held constant).

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Finally, none of the socio-economic characteristics examined, i.e. gender (*female*), age (*50 years or older*), level of education (*university degree*), and household income (*high income*), is significantly related to any of the three dependent variables, all else being equal. Thus, no evidence was found that the socio-economic characteristics of the respondents are influential for their level of acceptance of a potential local CCS implementation.

5.3 Discussion including limitations

The findings from the second wave of surveys provide valuable insights into public perceptions and acceptance of CCS technology across the study regions of Portugal, Spain, and France. Public familiarity with CCS remains generally low with Portugal demonstrating slightly higher levels of awareness compared to the other regions. Changes in familiarity and acceptance between survey waves varied notably between countries, with France showing a decline in familiarity and Spain showing an increase. Despite these trends, overall evaluations of CCS as a technology option to mitigate climate change were relatively positive in all regions, with Portugal and Spain demonstrating higher levels of enthusiasm than France. Local acceptance of CCS implementation followed similar patterns, with Portugal showing the highest levels of support, Spain demonstrating moderate acceptance, and France exhibiting mixed attitudes.

Quantitative measurement in this study faces inherent limitations, particularly regarding sample composition and representativity. The recruitment process relied on market research institutions, which needed to expand the target regions to achieve sufficient sample sizes, thus introducing variability in regional composition in comparison to the first wave. Additionally, quotas for age and gender were partially met, but broader socio-economic characteristics could not be fully controlled, leading to potential biases. As such, cross-country comparisons and analyses over time must be interpreted cautiously, as they provide snapshots rather than definitive trends. Furthermore, the relatively small population sizes in the study regions and the lack of direct exposure to CCS activities likely influenced the observed attitudes, with respondents likely having limited interaction with project-related developments.

The surveys' findings also highlight the impact of broader contextual factors. While PilotSTRATEGY activities focused on citizen engagement and technical research, their visibility and outreach were limited. External factors such as the energy crisis, economic recession, geopolitical instability, and various local events likely shaped public attitudes and contributed to variations between survey waves. This underscores the complexity of isolating project-specific impacts from their context and from broader societal trends.

The multivariate analysis provides additional valuable insights into the factors related to local CCS acceptance. Key determinants include expectations about environmental, economic, and societal benefits, as well as perceptions of process legitimacy. Environmental benefits emerged as the strongest predictor of acceptance across all regions, while expected economic and societal benefits also played a role, particularly in Portugal and France. Process legitimacy, defined as the perceived fairness of decision-making processes, significantly influenced acceptance across all regions, highlighting the importance of transparent and inclusive engagement strategies.

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Overall, these findings underline the need for tailored engagement strategies that address regional specificities while fostering trust, transparency, and public understanding of CCS technology. The results also highlight the importance of framing CCS as an integral part of broader climate and industrial transition efforts that align with local priorities and concerns. Future research should continue to explore how societal attitudes evolve as CCS projects progress and as engagement efforts deepen.

6. Conclusions

The citizen engagement activities conducted across three PilotSTRATEGY study regions and the insights from the survey point out that social acceptance of geological CO_2 storage is neither predetermined nor impossible, but rather conditional, negotiable, and constructed. This concluding chapter synthesizes the findings and reflects on their implications for CCS development more generally.

1. **Social acceptance as conditional contract**. The most significant finding across all regions and methodologies is that communities do not evaluate CCS projects through binary accept/reject frameworks. Instead, they articulate detailed conditional acceptance: "We might support this if safety is continuously demonstrated, if tangible benefits materialize with verification mechanisms, if we have genuine voice in decisions, and if transparency is maintained throughout the project lifecycle." Survey results further corroborate this conditionality, showing that respondents' acceptance is closely tied to their expectations of environmental, economic, and societal benefits, as well as the perceived fairness of the decision-making process. This conditionality should be viewed as an opportunity rather than an obstacle. If they aim for acceptance of a suggested project, the challenge for developers and policymakers is not to overcome opposition, but to credibly meet the conditions that communities reasonably articulate.
2. **Trust must be built through institutional design**. Historical experiences with broken promises from previous infrastructure projects might shape current scepticism toward new proposals. This distrust is not inherent prejudice but learned caution based on experience. In line with this observation from the citizen engagement activities, survey findings suggest that expectations around process legitimacy—perceived fairness in decision-making—play a critical role in shaping public support and should therefore be prioritized in institutional designs. What can potentially restore or create workable levels of trust are institutional mechanisms enabling verification, e.g. binding benefit-sharing agreements with enforcement clauses, citizen oversight committees with real authority. Trust is likely to emerge as an outcome of credible institutional design and open communication between researchers, project developers and industries, communities and other stakeholders.
3. **Territorial justice concerns require explicit attention**. The spatial concentration of risks in specific communities while benefits accrue more diffusely generates fundamental fairness questions that cannot be resolved through better technical communication alone. Addressing territorial justice requires acknowledging the scalar mismatch between local burdens and global benefits.

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4. **Technical viability and social feasibility are equally critical**. PilotSTRATEGY's comprehensive assessment across geological, engineering, economic, and social dimensions confirms that identifying suitable storage reservoirs represents only partial feasibility. A technically sound storage site in a community unwilling to host it remains infeasible. Conversely, community willingness without geological suitability obviously provides no path forward. This means that social and technical assessment need to be developed hand-in-hand.
5. **Methodological diversity reflects context responsiveness**. The three regions' distinct engagement approaches— Portugal's format experimentation, Spain's rigorous focus group methodology, France's organic open-door evolution —underline the need for flexible contextual adaptation rather than standardized protocols. The lesson for future projects is not to replicate any single approach but to begin with careful context assessment.
6. **Low initial knowledge creates opportunity windows**. The low baseline CCS familiarity across all regions initially appeared as both - a challenge and an opportunity. Communities had not yet formed entrenched positions, creating space for meaningful dialogue before polarization occurs. However, this opportunity comes with a responsibility to engage with people, providing balanced information to enable them to make informed judgements, rather than running information campaigns.
7. **Sustained engagement enables evolution and sophistication**. Where longitudinal data exist—particularly France's three meetings over two years—clear progression emerged in citizen question sophistication. Initial basic inquiries evolved into complex technical and governance questions approaching current scientific knowledge limits. This progression validates investment in repeated engagement opportunities rather than one-time consultations. Meaningful dialogue requires time for information to be prepared and to be absorbed and debated, for reflection, and for trust-building.
8. **Benefits must be tangible, verifiable, and fairly distributed**. Abstract promises of economic revitalization or environmental contribution generated scepticism. Survey findings emphasize this point, with respondents across all regions identifying economic benefits as a key factor in their acceptance of CCS projects. Critically, the implementation of such benefits requires verification and enforcement mechanisms to be reliable and credible —third-party audits, penalty clauses for non-delivery, reversion provisions if commitments unmet. Thus, a possible way to solve this is for projects to conceptualize benefits not as aspirational goals but as contractual obligations with the same rigor applied to technical specifications and safety protocols.
9. **Governance design determines legitimacy**. In most regions, participants demanded more than simple information provision or consultative input—they sought genuine influence over decisions. These demands were core requirements for legitimacy, particularly where historical distrust was high. While the demand for continuous information and verifiable benefits was universal, the prioritization of active governance varied slightly; for instance, one early focus group (Belchite) ranked direct participation as less important than securing tangible local benefits and safety monitoring. Therefore, projects must gauge the specific local desire for active governance versus compensatory and informational mechanisms.

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10. **Cross-regional patterns suggest generalizable dynamics**. Despite markedly different contexts—offshore vs. onshore industrial versus onshore rural, different national governance traditions, different engagement methodologies—striking convergence emerged on core themes: limited initial knowledge with strong learning capacity, ambivalent emotions mixing hope and fear, safety as non-negotiable foundation, transparency demands, historical distrust shaping perceptions, conditional acceptance rather than polarization, and distributive justice concerns. Survey findings further reinforce these patterns, revealing and confirming common themes such as the importance of environmental benefits and process legitimacy as drivers of acceptance across regions. Despite differences in familiarity and local contexts, the surveys also show that communities share similar concerns and expectations regarding CCS implementation. This convergence suggests that insights from PilotSTRATEGY have applicability beyond the specific study regions. European CCS development can learn from these experiences, recognizing both common patterns requiring attention in any context and regional specificities requiring tailored approaches.

The PilotSTRATEGY citizen engagement experience demonstrates that meaningful public participation in complex energy infrastructure decisions is both possible and valuable. Communities across diverse European contexts proved capable of engaging thoughtfully with technical complexity, articulating sophisticated requirements for project acceptability, and participating constructively in dialogue with researchers and developers. What worked was commitment to transparency, respect for community concerns as legitimate rather than obstacles to overcome, flexibility to adapt approaches based on learning, and recognition that social acceptance cannot be manufactured but must be earned through credible institutional design and demonstrated accountability.

The success of European CCS deployment will ultimately depend not only on identifying geologically suitable reservoirs, developing effective capture technologies, and finding viable business models, but also on fostering social relationships of trust, reciprocity, and shared purpose to establish and maintain societal legitimacy both within the local communities hosting this infrastructure and in society at large. This requires treating social integration not as a peripheral challenge to be managed but as a core dimension of responsible innovation deserving equal investment to technical research and development.

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Summary public acceptance

Survey 2 & citizen engagement

- Annex -

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A. Annex

A.1. Citizen Engagement

A.1.1. Portugal: First meeting Report, Figueira da Foz, 3rd February 2024

A.1.1.1. Introduction

The PilotSTRATEGY project aims to promote local engagement activities in three study areas: the Paris Basin (France), the Lusitanian Basin (Portugal), and the Ebro Basin (Spain). In the early stages of the project, researchers characterized the overall setting in which CO_2 storage discussions take place. This involved analysing the policy framework, developing regional community profiles, and conducting a questionnaire survey to explore community acceptance.

The project identified a need for social science research to understand public perceptions of CO_2 storage at the local level and to open up pathways for the participation of affected communities in project development. Given the low level of familiarity with carbon capture and storage (CCS) technologies among citizens in the study communities, the project team recognized that such work could be carried out using a hybrid (research and engagement) group-based methodology. This would enable groups of lay citizens to engage with issues related to CO_2 storage in their communities, to learn about CCS technologies, and to express their views and concerns.

The research team designed a hybrid consultation and research strategy to be implemented in the study regions. The aim was to gather local public views on CCS technologies and a potential CO_2 storage project in the region, and to improve the quality of public engagement with CCS projects. The specific objectives were to:

- Gather data on citizens' views and attitudes towards a hypothetical CCS pilot project in the region (research and consultation).
- Engage the public in learning about PilotSTRATEGY, CCS technologies, and the implementation of future CCS projects (to address their concerns and aspirations).
- Gain methodological insights into the implementation of hybrid group-based methods for future public engagement activities on CCS.

Hybrid engagement activities with citizens in Spain were conducted in September 2023, which formed the blueprint for similar activities in Portugal. In this section, we report the main results from this activity in Portugal in February 2024.

A.1.1.2. Method

In Portugal, with the study site defined in offshore near the city of Figueira da Foz, the research team decided to carry out a one-time activity that included a diverse group of local community representatives.

The session was scheduled outside of regular working hours, specifically on Saturday from 2:30 to 4:30 p.m., at Quartel da Imagem located at Figueira da Foz. This timing was chosen to ensure that members of the community could participate. Quartel da Imagem is a municipal facility, that includes exhibition and meeting spaces, centrally located, well-known by the community.

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The session aimed to gather citizens' views on different aspects of CCS technologies, its implications, and the possible implementation of a project in the offshore of Figueira da Foz. It was structured into two main parts: the first focused on a general discussion about CCS, and the second was dedicated to the PilotSTRATEGY project and the specific location at Figueira da Foz.

It included reading or viewing specific information, discussing among participants, and taking part in exercises. These objectives were attained through facilitated group discussions, the provision of stimulus materials, and activity-oriented exercises. PilotSTRATEGY facilitators encouraged a safe, open, and non-judgmental discussion. The session was audio-recorded.

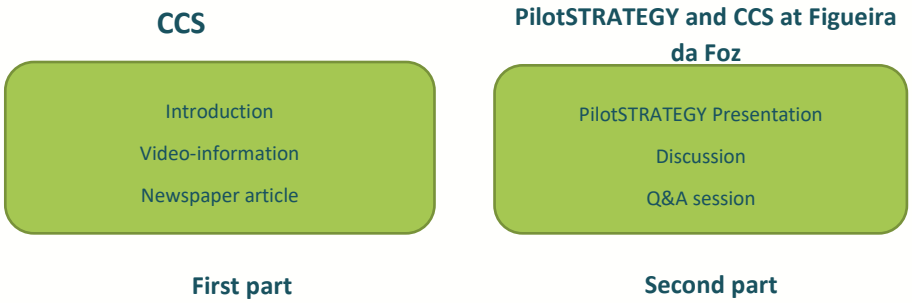

Figure 1 Session overview

The event was followed by a coffee break, in which participants had the opportunity to ask additional questions to the PilotSTRATEGY team members.

Recruitment

Recruitment was conducted through invitations sent via email to numerous local civil societies organisations, including scout groups, local parishes, community organizations such as the Lions Club and the Rotary Club, science high school teachers, members of the Ciência Viva club, libraries, museums, and local newspapers. In total, invitations to 20 organisations were sent. Registration to attend the event was done by filling out an online form.

Participants

Sixteen participants signed up for the event. Each individual received an email confirmation of their registration, which included details about the venue and a note encouraging them to share the invitation with others interested in the topic. Among the registrants was an individual affiliated with a local Association for the Development of the Sea Economy. Given this connection, the PilotSTRATEGY team recognized him as a specialized stakeholder and invited him to join the Regional Stakeholder Committee instead. On the day of the event, nine registered participants attended, comprising five women and four men, aged between 48 and 72 years. The group's professional backgrounds were diverse, featuring several teachers, a retired Merchant Navy officer, a manager, and a consultant (Figure 2).

The team consisted of two researchers (sociologists) from ICS and three researchers (geologists) from Universidade de Évora.

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Figure 2 Participants at the citizen engagement event at Figueira da Foz

A.1.1.3. Results

FIRST PART

A.1.1.3.1. Awareness and knowledge

The session began with a general introduction, during which participants were inquired about their familiarity with CCS and their motivations for attending the event. Most participants mentioned having heard of CCS and/or having researched the topic before their attendance. Some expressed interest in learning more about the technical details of CCS, others were more curious about the potential site location for CCS in Figueira da Foz, and a few stated that they attended the consultation due to concerns related to CCS. Below are some illustrative statements made by the attendees during the session:

> *"This issue scares me. From what I've read, obviously, and also from a brief search I did on the Internet, I understood what the location was… so I'm curious, obviously, but mainly curiosity with rationality."*

> *"I have some curiosity for technical clarifications about this project, as I have a background in biology and geology, I am curious to know something more, what is it that is proposed?"*

> *"I'm a person linked to these environmental issues. I'm working here in Figueira, (...) but I'm here as a citizen. With this environmental vein of mine... this [CCS] is something that's now getting a lot of attention. There's a lot of research around this and I'm curious to understand this project.*

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One participant stated that she had already heard about geological carbon storage as a method to mitigate climate change, but she had many concerns about the topic. She also mentioned that she had prepared a written statement on her position, which she would leave with the team at the end of the event.

A.1.1.3.2. Perceptions associated to the CCS

Following the introduction participants were presented with some informative materials on CCS:

1) A video from the Bellona Foundation explaining the technical aspects of CCS.
2) An abridged version of a recent article from the national newspaper, Público1, that offered both positive and critical perspectives on CCS.

Participants were then asked to write on post-its of different colours what they considered the benefits of CCS, as well as their concerns with the technology. They placed their notes on a wall, allowing everyone to view each other's' contributions (Figure 3). A member of the PilotSTRATEGY team roughly organized these post-its into themes, aiming to identify the primary ideas shared among participants.

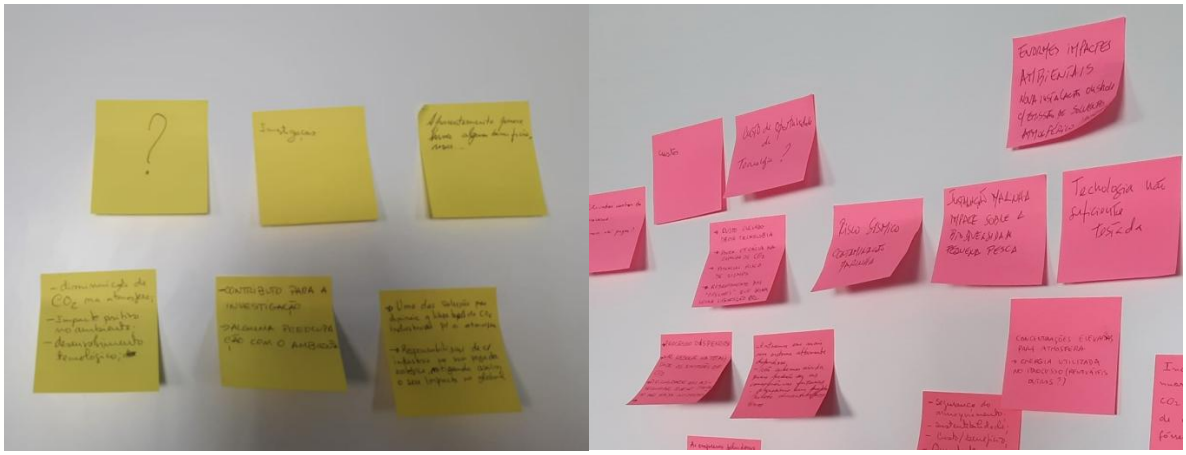

Figure 3 Exercise about benefits (in yellow post-its) and concerns (in pink post-its) regarding CCS

Benefits

Overall, participants recognized fewer benefits than concerns regarding CCS. Identified benefits were associated with its environmental role in reducing CO_2 in the atmosphere, its link to technological advancement and research, and its potential to foster greater accountability within the industrial sector. Two participants utilized post-its to express their uncertainty or lack of knowledge about possible benefits associated with the technology. The classification of the benefits identified during the exercise is presented in Table 1.

[1] https://www.publico.pt/2023/01/22/azul/reportagem/noruega-quer-enterrar-co2-fundo-mar-europa-2033033

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Table 1 Classification of the benefits identified during the exercise

Environmental	• Some concern for the environment Reduction of CO_2 in the atmosphere • Positive impact on the environment • One of the solutions to reduce the release of industrial CO_2 into the atmosphere
Accountability	• Holding each industry accountable for its ecological footprint, thereby mitigating its overall impact
Tecno-Scientific advancement	• Technological development • Research • Contribution to research
Unknown	• It seems there might be some benefit, but... • ?

Concerns

Participants identified numerous concerns regarding CCS (Table 2). These were predominantly related to environmental and security risks, such as seismic activity, potential leakages, and the safety of storage solutions, and to environmental impacts stemming from the required infrastructure, including pipelines and onshore/offshore facilities. Moreover, they raised issues about the technology's cost (and who will pay them) and its efficacy in tackling the problem. Uncertainties regarding technological aspects and long-term effects were also a subject of concern. Novel concerns, not present, for instance, in the engagement with stakeholders, also emerged, widening the discussion around CCS: the energy needs of carbon capture and how they will be met (with renewable or non-renewable sources, worsening climate change) and the risk of CCS being a misleading solution (relying on technology intensification instead of nature-based solutions) and a form of greenwashing (allowing CO_2 emissions to continue growing).

Table 2 Classification of the concerns identified during the exercise

Environmental/security risks	• Potential risk of earthquakes • Bursting of pipelines that would lead to the release of CO_2 • Difficulty in ensuring that there are no incidents in the process • Seismic risk • Environmental contamination • Storage safety • High concentrations for the atmosphere
Environmental impacts	• Marine installation impact on biodiversity and small-scale fishing • Huge environmental impacts • New onshore installation with atmospheric solvent emissions, landscape • Impact on the environment surrounding the chosen locations to store CO_2/all the environmental space for the passage of piping to the chosen locations • Distance between the factory and storage locations
Efficacy	• Low efficacy in capturing CO_2 • Does not completely resolve CO_2 emissions • A pilot project is necessary for a few years • Energy used in the process (renewables or others?)

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	• Sustainability
Cost	• High cost of this technology • Costly process • We enter another highly costly system • Cost/benefit • Opportunity cost of the technology? • High process costs • Who pays? • Costs
Uncertainty	• How long to increase the efficiency of the process without emitting CO_2? • Technology not sufficiently tested • Poorly explained chemical transformation
Long term impacts	• We still do not know what the future consequences might be • Creates another problem for future generations to solve
False tecno-solutionism	• Existence of other alternatives. • Gives the false impression that technology will always solve the environmental problems created. • Does not solve the problem. • Devalues more environmentally safe solutions as a way to decarbonize. • Burying the CO_2" is like "burying one's head in the sand", attacking/hiding a symptom and letting the serious disease continue to manifest and claim victims.
Greenwashing	• Another "greenwashing" Project • Incentive to continue producing CO_2 with the burning of fossil fuels • What is the source of energy for the process in Portugal? Will it be biomass or bioenergy? What is already happening is the burning of tree trunks to produce electricity, the depletion of our tree heritage, and its consequences. An absurdity that cannot be called "green energy". It is also serious that the emissions from the said burning are not accounted for when the goal is to produce electric energy. • Polluting companies in this and other location emit various gases and fine particles, not just CO_2. Capturing and storing CO_2 is to continue to allow to have a license to pollute with negative consequences for public health and the environment. We need a systemic solution, not piecemeal measures.

Participants were inquired about which of the identified issues during the exercise concerned them the most. One participant answered that the uncertainty of the future worries them, specifically the unknown outcomes related to all the CO_2 put into storage. Another participant questioned the location of the pre-treatment plant, asking if it would be situated near the cellulose industry. Yet another participant emphasized that this approach would be a piecemeal measure, pointing out that nature already offers solutions to these problems.

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A.1.1.3.3. Perspectives on the Project PilotSTRATEGY

The second part of the session started with a short presentation by Maria Helena Caeiro from the Universidade de Évora, who introduced the PilotSTRATEGY project and elaborated on the reasons for selecting Figueira da Foz as a pilot site. One exemplificative slide is presented in Figure 4.

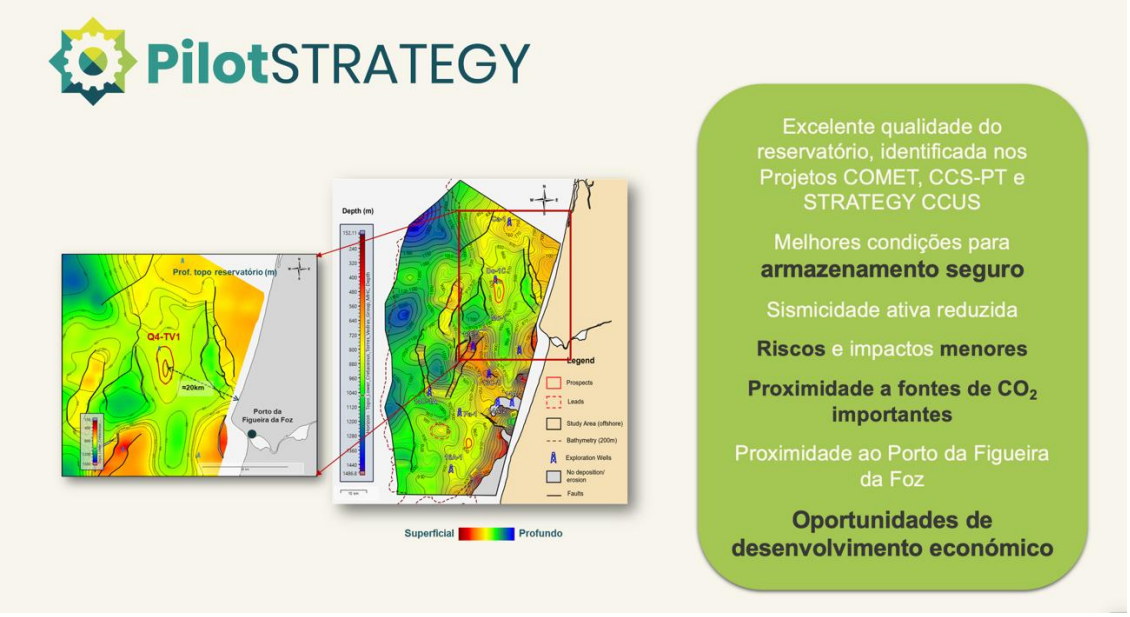

Figure 4 Slide from the Universidade de Évora presentation outlining the reasons for selecting Figueira da Foz.

After the presentation, there was a group discussion where participants were asked for their opinions on the project's development in Figueira da Foz and its potential impact on the local community. However, participants primarily had questions regarding the project and the technology. In response, the technical team made themselves available to clarify any doubts they might have.

The initial questions raised touched upon various concerns, starting with whether the boat tasked with transporting CO_2 to the offshore drilling site would operate on fossil fuels. Another point of discussion was the choice of Figueira da Foz as the location, specifically if it was due to its unique geological conditions within the Portuguese maritime area. There was also a request for more details regarding the precise site and whether this might overlap with protected Natura 2000 areas or conflict with existing offshore wind farms. Further inquiries were directed at understanding the logistics of how CO_2 would be transported from different factories. Questions were also posed about the engagement with environmental associations in the context of the project Regional Stakeholder Committee. Additionally, there was curiosity about the reference to cement production and what was the connection to the area of Figueira da Foz. Lastly, when risks were mentioned, it was clarified whether these were exclusively geological or also environmental, and it was noted that both types of risks are being taken into account.

One participant in particular raised a question about the energy source for the entire process of CCS. When it was explained that it would be the energy currently used by industrial facilities—such as gas or hydrogen—she answered that in the case of the pulp and paper industry, biomass would likely be the source, especially since these facilities already have biomass boilers. The participant expressed a concern that in our country, the energy should come from the burning of forest residue, from

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forestry or agricultural activities, but instead, many trees are being used in this burning for producing energy, including cork oaks and holm oaks, which should not be the case. She pointed out that in Portugal, as in Europe, the burning of trees for energy is problematic. Each tree, with its biomass, contains about 80% carbon, making them the true carbon sinks. The participant argued that the path forward should be to preserve the ecosystems we have and restore those that are degraded. This, she stated, is how we truly decarbonize. She also mentioned a detail from a study from the University of Utah in the United States, noting that CCS requires between 50 and 80% of electrical energy. Therefore, the participant concluded the implementation of a CCS process might lead to freeing up more land to grow exotic species, which would then be cut down and burned to produce electricity, a process where emissions are not properly accounted for.

Another participant agreed but also pointed out that pulp and paper industries do not solely depend on biomass; they utilize various energy sources, including solar panels and that certain industries are proactively planting new trees to compensate for their CO_2 emissions. While this approach doesn't entirely solve the problem, it represents an additional method worth considering. Stating that he was speaking from a forester's perspective, he noted that planting a single tree is a heroic act, so industries planting thousands is commendable. It is the same with CCS although he expressed concern over CCS not being a solution. His concern was that CCS, akin to storing nuclear waste, doesn't truly solve the underlying issue but merely stores the problem away, potentially with risks of its own.

A different participant commented that with CCS we are merely addressing a symptom. Industries engage in these practices because of carbon credits, which the participant dismissed as ineffective, allowing them to emit even more CO_2.

"We're treating a symptom. Industries do this, and it has to do with carbon credits, its bullshit, they do it so that they can emit more CO_2."

Instead, he argued in favor of nuclear energy, advocating for it as the cleanest solution. He critiqued other approaches as mere patches, capturing only about 1% or 2% of emissions, drawing a parallel with electric cars as another example of insufficient solutions. Another attendee added that industries release more than just CO_2, implying that pollution will remain an issue.

Another participant expressed that while she somewhat agrees with these views, she finds the debate highly political and holistic. She emphasized that what is being discussed is just one of many possible solutions that aim to contribute to the same goal of environmental preservation.

> *"I somewhat agree with these opinions; I am very objective and, although I agree with you, I think this is a very political, very holistic discussion. And what we're talking about here is one of the 500 solutions that exist. I think that the solutions that exist are not divergent. They all want to contribute to the same end.*

The conversation then shifted to a discussion of several technical aspects related to the project and safety issues. A participant inquired about the three distinct phases of carbon capture, transport and storage and asked whether the study only addressed the optimal location for storage including the siting, the risks and potential outcomes related with storage.

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Questions about the storage facility's capacity and lifespan were raised, along with the permanence of the stored carbon and the potential for future scientific developments to identify new risks. Following the technological team's clarifications, a participant reflected on the longevity of the sequestered carbon. He noted that while current scientific knowledge suggests that it should not pose problems indefinitely, future scientific theories may contradict this, and the evolving nature of technology could present unforeseen risks. He highlighted that there is no absolute certainty in safety, just a current assurance.

> *"So, the scientific knowledge that exists at the moment allows us to say that there will never be any problems. In short, ad aeternum. But another scientific theory may come along that contradicts it. It evolves, doesn't it? I'm talking about the risks that technology could make happen in the future. We don't [know], but it could happen. "*

The conversation shifted to the hypothetical scenario of a catastrophe involving the 30 million metric tons of stored carbon, with one participant questioning the consequences of a potential rupture, the affected area, and whether these risks have been studied. Lastly, concerns were raised about the possibility of seismic activity induced by CCS and the accountability issues if a leak were to occur, questioning which company would be responsible for the damages. The discussion also covered the business model and financing of CCS technology. One participant raised the question of who would bear the costs of capture, transportation, and storage. He was unsure whether it would be the collective responsibility of various producers or a national investment.

Another participant stated that he is convinced that CCS funding will come necessarily from European funds. He believes that the capture at factories will likely be entirely funded by the EU, implying that factories will not undertake such measures if they have to pay for it themselves.

> *"It will be financed, for now, it'll be European funds, that much we know. I'm pretty sure. Capture in factories. I'm pretty sure it's going to be 100% financed projects. The factories wouldn't do it if they paid for it themselves".*

Another participant, however, highlighted that factories might have reasons to make such investments if the cost of emitting CO_2 becomes higher than the long-term investment in CCS technology. This is considered a strategic component of the CCS business model.

When Júlio Carneiro from the Universidade de Évora mentioned that only the initial, demonstrative installations of CCS might eventually be eligible for funding, another participant agreed, emphasizing that these demonstration projects are a part of scientific progress.

Another participant questioned the stance of the IPCC regarding CCS, noting that the panel has deemed the effectiveness of CO_2 capture in combating climate change to be of little significance and has raised awareness about the various associated risks. When Júlio Carneiro answered that the reports have included this solution along with many new others due to the increasing challenges of meeting climate goals, the participant emphasized her belief that there is a misguided focus on technology-driven solutions at present.

> *"Technology, technology, I understand, technology replacing natural processes, I understand."*

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Finally, when Júlio Carneiro explained that certain sectors, such as the cement and lime industries, have no alternative to carbon capture because even if they use renewables, they still emit a significant amount of CO_2, which is inherent to their industrial process, a participant noted that this is due to the current "*development paradigm*."

An additional question was about the Torres Vedras geological formation and its suitability for storage in Torres Vedras. Júlio explained that the term "Torres Vedras formation" is used by geologists to describe a geological layer from a specific era with somewhat consistent characteristics, though these can vary significantly from the location where it was characterized to others. He noted that storage in this formation near Torres Vedras would not be possible due to its shallow depth. A participant commented that it is probably also because it is near Lisbon:

> *"It's curious how these solutions never seem to be implemented in capital cities or similar locations; they're always situated elsewhere. If there was a viable option in Lisbon, they would claim there was nothing there, it always seems to go that way."*

This a common grievance in discussions on the siting of technological infrastructures in Portugal, such as windfarms. Another participant responded that the goal is also to promote decentralization.

A.1.1.3.4. Conditions of acceptance

In the exercise on "acceptance conditions" we showed participants a list of conditions for acceptance of CO_2 storage in their community (Figure 5) and asked participants to select those they would consider more important.

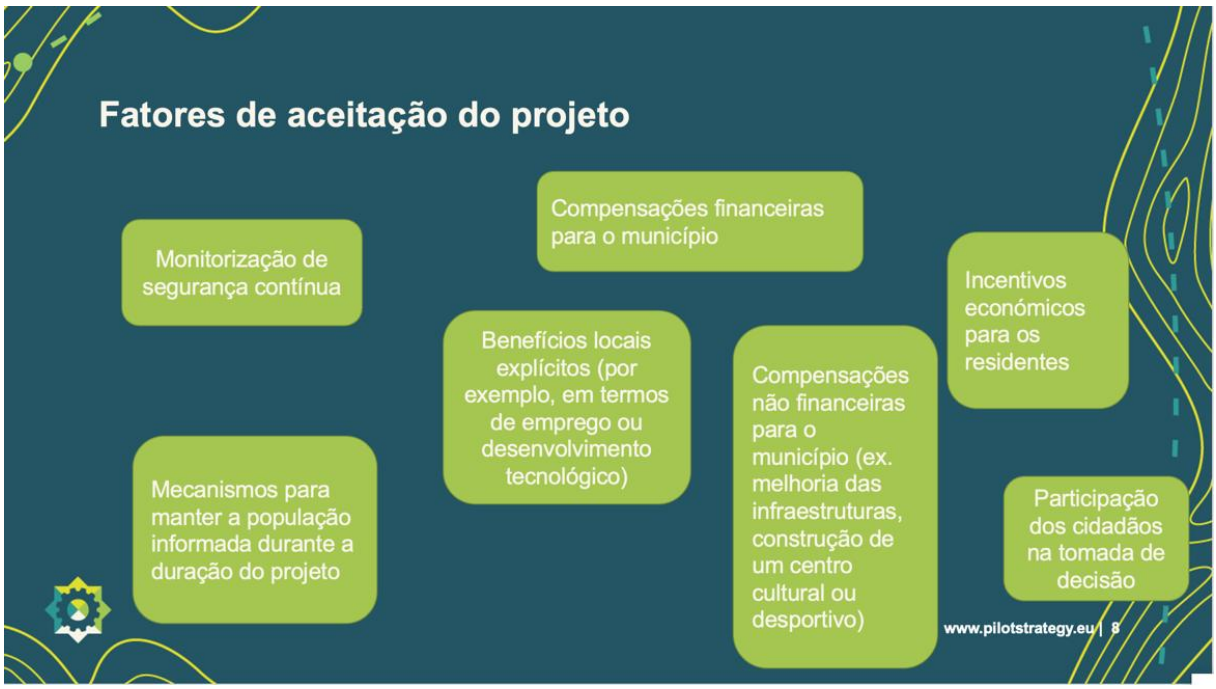

Figure 5: List of conditions of acceptance of the project presented to the participants.

Presented alternatives were:

- Continuous security monitoring
- Financial compensations for the municipality

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- Mechanisms to keep the population informed during the duration of the project
- Explicit local benefits (e.g., in terms of employment or technological development)
- Non-financial compensations for the municipality (e.g., improvement of infrastructure, construction of a cultural or sports center)
- Economic incentives for residents
- Citizen participation in decision-making

Several participants began to emphasize the necessity for monitoring, considering it an evident requirement. One of the participants also expressed that she considered possible non-financial compensations for the municipality important:

> *"I think the development here in the municipality, I think the non-financial compensations for the municipality in terms of informal infrastructures, territorial development would be an added value here for the municipality of Figueira da Foz."*

However, most of the participants considered that this was a difficult exercise, given it assumes an inherent acceptance of the project. One participant promptly asserted that her opposition to the technology meant that no compensation would be sufficient.

> *"The balance between costs and benefits is negative for me; therefore, I do not accept any kind of compensation."*

Other participants were less definitive but echoed the sentiment that discussions on conditions of acceptance are premature. They highlighted the prevailing uncertainty concerning the project's risks and benefits, as well as doubts about the suitability of this solution in tackling current challenges. Some of the statements were as follows:

> *"I think all of this relates to risk analysis and the level of risk that this can have. This will influence, let's say, this compensatory system, right? There is the possibility of more employment. There will be more people working in this area, there could be more research at this level too, all right, but I think first we need to know what the actual potential risk is."*

> *"I think this [exercise] starts from a premise... Acceptance factors. If I don't accept, I don't even answer, right? But of all these that are here the most important is citizen participation in decision-making, isn't it? But the rest are obvious, meaning 4 out of the 7 are related to financial and economic issues. It makes sense... It's a framework, ultimately, for gauging a group's opinion, right? But I will not respond to any at the moment, because I am not yet sufficiently convinced that the project brings more benefits than, well, the risks or damages that have been listed here."*

> *"I am also still not convinced of the effectiveness of this project. I think the solution cannot always be to try to solve problems of technology with more technology and to always be a flight forward with more technology. We have, perhaps, to re-naturalize a bit. We are creating a problem for the next generations, we are leaving them to solve another one, just like radioactive waste, just like filling the country with landfills, when only now are we taking the steps to selectively collect the*

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organic waste that filled the landfills for decades. We opted for one thing when perhaps we should have opted for another way. If [this project] is until 2050, after 2050 will we have to find another place to store more carbon? What has this solved? In the meantime, we are just postponing solutions for the future."

A.1.1.3.5. Position towards a potential CCS project at Figueira da Foz

At the concluding segment of the event, each attendee was provided with a sheet featuring a vignette activity in which they were asked to choose which stance regarding a prospective CCS project at Figueira da Foz they identified with the most (Figure 6). The participants gravitated towards two main viewpoints. Three individuals declared their total rejection of CCS, resonating with the "Natália" stance, which contends that "I don't think this is an appropriate technology to fight against climate change to me. I would be against any carbon capture and storage project in Portugal." Meanwhile, five participants adopted a more cautious approach, aligning with the "Paula" perspective, asserting that "Carbon capture and storage is not the ideal option to mitigate climate change. But a well-managed project, with responsible promoters, could be beneficial for the planet and for the local community." One participant signaled both options.

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 Rui Carbon capture and storage is an essential option for mitigating climate change. All regions that have suitable conditions should promote CCS projects.	0
 Pedro Even though carbon capture and storage may have some potential, I am skeptical that a CO_2 storage project in my region would be conducted with transparency and with the community's well-being in mind	0
 Maria Carbon capture and storage is a good option, but I don't think it should be done in my region	0
 Natália I don't think this is an appropriate technology to fight against climate change to me. I would be against any carbon capture and storage project in Portugal	4
 Paula Carbon capture and storage is not the ideal option to mitigate climate change. But a well-managed project, with responsible promoters, could be beneficial for the planet and for the local community	6

Figure 6 Vignette activity on position towards a potential CCS project at Figueira da Foz

A.1.1.4. Final remarks

After the debate, the participants were invited to have some refreshments in a nearby room. The conversation between team members and participants continued in an amicable mode and the Universidade de Évora team replied to further questioning and comments from participants.

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The PilotSTRATEGY team ensured participants that they would receive a brief report on the event and updated information about the project regularly.

The citizen engagement meeting was very useful to gauge the perceptions and attitudes of the community and to find ways to address their needs and concerns about the project. We believe that neared the end of the project a more open event with the local community will be necessary.

A.1.2. PilotSTRATEGY — Mini-report Portugal 2025 (Ana Delicado, Joana Sá Couto, Jussara Rowland)

A.1.2.1. Introduction

In line with Task 6.5 aim of generating direct interactions with local communities in order to obtain a deeper understanding on the findings of the survey and promote further local engagement, as well as investigating their perceptions of the costs and benefits of CO_2 storage, their impacts, any changes impinged upon their daily lives, we organised a citizen engagement initiative named "CO_2 Storage off the cost of Figueira da Foz: a small interactive exhibition". It took place at Figueira da Foz, the closest town to the study area, on the 13th September 2025, during the afternoon (Figure 7).

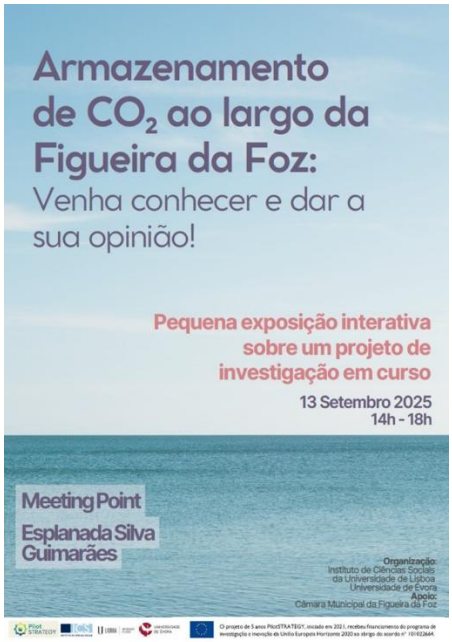

Figure 7 Poster for the exhibition

A.1.2.2. Method

Since the workshop format we used for the first initiative of citizen engagement in February 2024, was qualitatively rich, but had a limited impact and participation (just nine citizens present), for the second round we opted for a more open format, an exhibition held during one afternoon at a public place in Figueira da Foz, with the presence of the research team to interact with visitors.

The exhibition was held at "Meeting Point", a space owned by the Municipality of Figueira da Foz, close to the beach and underneath the Esplanada António Silva Guimarães, a focal point of the town (Figure 8). It is used as an exhibition gallery but also for other events, such as book fairs.

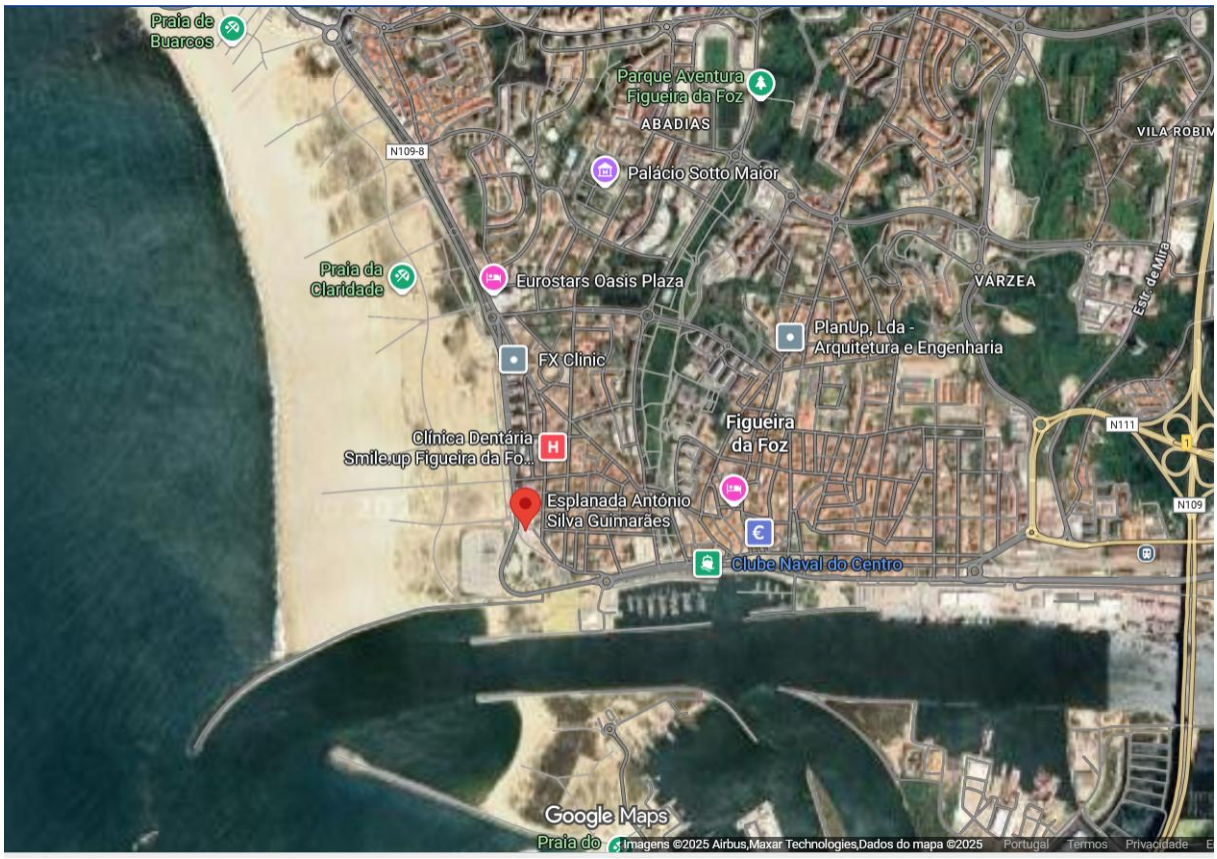

Figure 8 Location of the exhibition

Crucial for the success of the citizen engagement event was to disseminate it as widely as possible, to guarantee that the exhibition had as much visitors as possible. For that purpose, we wrote email invitations to local and regional stakeholders from the Regional Stakeholders Committee (RSC) and to all local civil society organisations (including media) identified for the first workshop, asking them to publicise the event among their members. We also wrote to all participants who had registered for the first workshop (even those who had not attended). We created an event in the Facebook of our Research Group at ICS ULisboa (2,100 followers) and shared it. We also counted on the support of the Municipality for the dissemination of the event (Figure 9), who also shared it in their Facebook account (72,000 followers) and Instagram account (35,000 followers), as well as in the Facebook page *Figueira na Hora* (56,000 followers), also affiliated to the municipality.

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Figure 9: Post in the Facebook profile of the municipality of Figueira da Foz

Dissemination in social media spurred a small controversy, with a few citizens (three) commenting on the municipality's post expressing their opposition to the project, which was included in the data analysis below.

The exhibition had two sections, one devised by the social sciences team (ICS ULisboa), the other by the technical team (University of Évora).

The first section consisted of a series of six introductory posters, with very simple messages, describing the project and the technology (see Annex 1). The posters addressed the following topics:

- The problem (climate change, hard to abate emissions)
- One of the solutions (CCS)
- Risks of CCS
- Benefits of CCS
- What is being studied at Figueira da Foz
- What PilotSTRATEGY is researching

The second section was more technical and revisited some of the topics presented in the initial posters but provided more detailed information and included audio-visual and interactive exhibits (Table 3). It was composed of six distinctive topics, where different content was explained and illustrated though the exhibits.

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Table 3: Contents and formats of the second section of the exhibition

Topics	Content	Format/Exhibits
1	CO_2 emissions by country and per capita Our daily lives and our emissions	Two balloons (volume of 1 kg of CO_2 before and after storage) PowerPoint presentation Poster Leaflet
2a	CCS technology	Video PowerPoint presentation Poster
2b	Use of CCS technology in the world	Poster
3	Geological requirements and how it works	Video Leaflet Models: jars with pebbles, sand and silicone simulating the geological layers Microscope and rock samples
4	Offshore potential at Figueira da Foz	Photos of the seal and reservoir Rock samples
5	Projects PilotSTRATEGY and CTS	Posters model of the storage site
6	The pilot at Figueira da Foz	Poster (timeline) Video of the model

Upon entering the exhibition, participants were greeted and invited to begin their visit in the first section, which provided an overview of the problem and the project. They then proceeded to the second part of the exhibition, where representatives from the University of Évora were on hand to explain the different devices, answer visitors' questions, and discuss the topic with them. Throughout the entire event, researchers from both the University of Évora and ICS were available to answer questions and guide participants. The scheme of the exhibition can be seen in Figure 10 and some photos in Figure 11.

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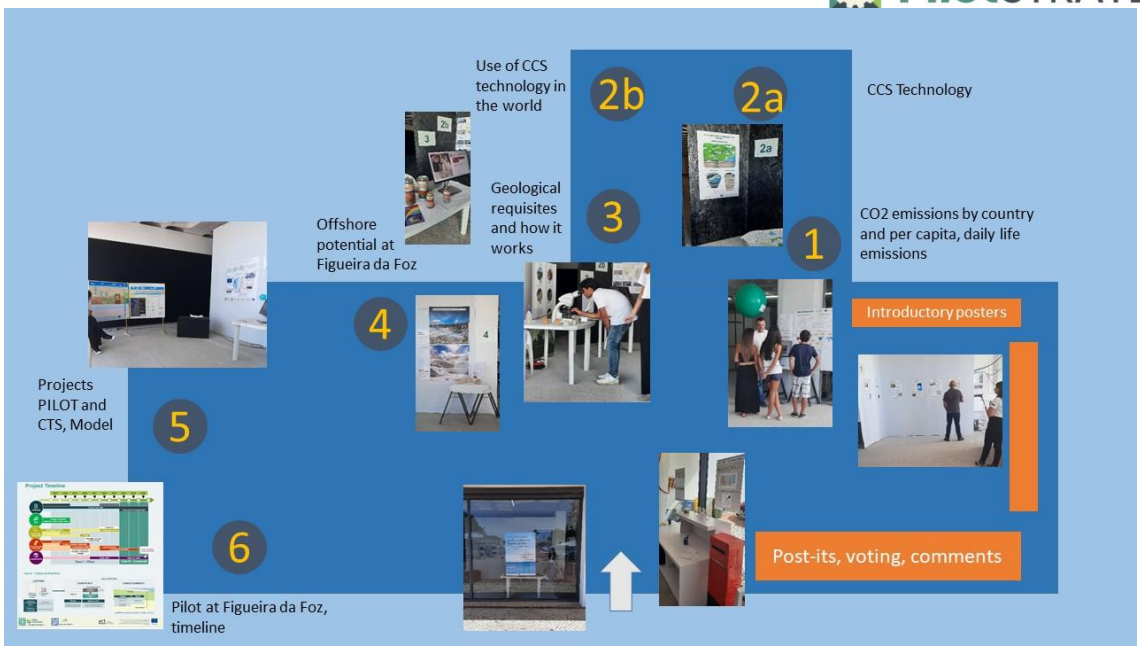
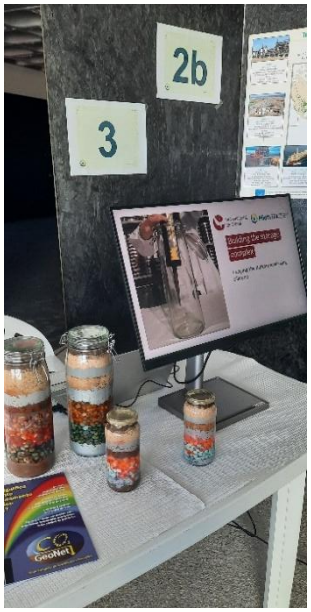


Figure 10 Exhibition scheme



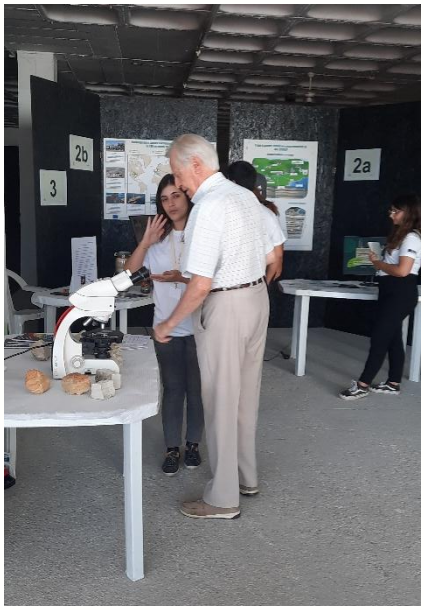


Figure 11 Photos from the second section of the exhibition

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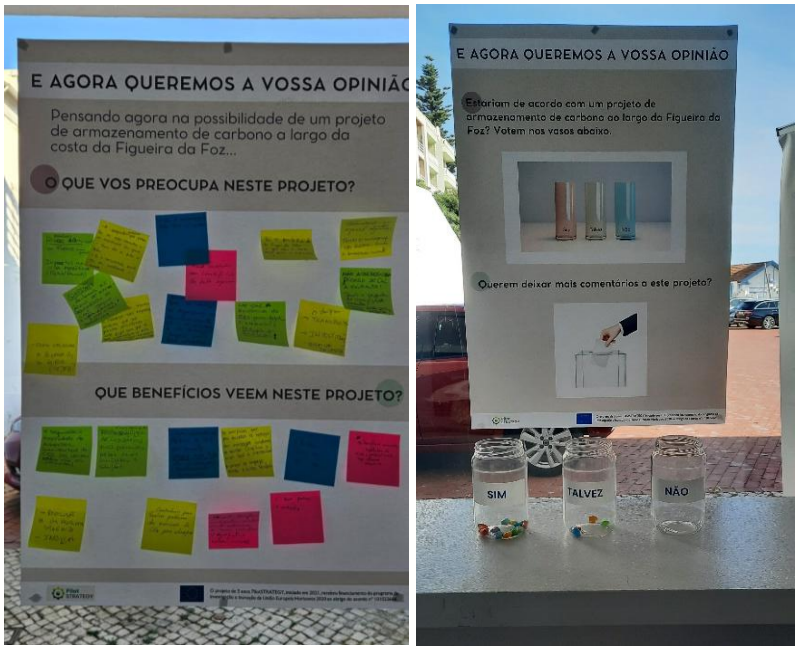
At the exit of the exhibition, there was a final stand where visitors were asked to share their opinions on the project. Specifically, they were asked what concerned them about the project and what benefits they saw (by writing on post-its). They were also asked to vote on whether they agreed with a CCS project offshore at Figueira da Foz (by placing a little paper star on jars labelled 'yes', 'maybe' and 'no') and to share any other comments on the project (by writing in 'postcards' and placing them on a "mailbox").

Data collection during the event consisted of not just the collection of post-its, voting and comments (Figure 12), but also participant observation by one member of the ICS ULisboa team (who followed visitors and took notes of their questions and comments) and written recollections from the University of Évora team members.

Figure 12: Post-its left by visitors and voting station



Overall, we had 28 visitors to the exhibition, 13 men and 15 women. Some came alone (middle age and older men), others in couples (mostly older), some with families (with babies, children or teenagers). Not all of them left their impressions at the end of the exhibition. The majority of visitors remained at the exhibition close to one hour, observing every exhibit and talking with the team members. Although we did not collect systematic sociographic data about the visitors, some information was registered. Some of the visitors were connected to institutions that participate in the RSC: the municipality, the port authority, the MARE research centre. One of the visitors was the former mayor of Figueira da Foz. Some visitors were not permanent residents but had second homes at Figueira da Foz. Two of the visitors were connected to environmental NGOs. None of the more critical social media commentators visited the exhibition.

In general, the number of citizens reached by this initiative was smaller than intended. The location, though very central, was somewhat hidden so we barely had any incidental visitors who had no previous knowledge of the event. The weather was more suitable for beach-going

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than to visit an exhibition. The dissemination was extensive enough, but the topic does not seem to have generated a lot of interest, which is perhaps to be expected.

A.1.2.3. Results

The results of the exhibition can be gleaned from the written materials collected, from the ethnographic notes and from the impressions of the team members.

Regarding the concerns/benefits post-its exercise (Table 4), the results match closely those achieved at the workshop one year ago but also issues discussed during the Regional Stakeholders Committee meetings. On the side of concerns are mentioned safety issues (earthquakes, leaks, environmental contamination, transportation), the carbon footprint of the project itself, the costs (and who will fund them) and bureaucratic delays, the need for consulting the community, and the risk of delaying or foregoing the reduction of climate change causing emissions. Regarding benefits, reducing emissions and protecting the environment are the most often mentioned, followed by accountability of industries, economic gains and job creation.

Table 4: Post-it exercise on concerns and benefits from a CCS project at Figueira da Foz

Concerns	Benefits
Possible seismic risks or leaks (in general), impacts on marine life (flora/fauna)	Responding to the need to increase CO_2 sinks (natural ones may not be sufficient)
Suggestion: declare CO_2 storage areas as marine 'sanctuaries' or reserves	It is a way of holding the most polluting industries accountable for their emissions and solutions
How to calculate the CO_2 footprint of the project itself	Solving an urgent problem; Innovation
The negative impacts it may have on marine life and the general population; How the tests will be carried out; Whether the general community will be consulted and heard	Contributing to solving the problem of CO_2 emissions into the atmosphere
CCS may stifle innovation in companies and sectors that are major polluters, causing them to commit to this technology and not invest in improving their processes	The benefits are clear: reducing emissions, in line with climate agreements, at local and international level; the creation of green jobs is another benefit
Ensure that storage is carried out in excess.	High environmental benefits that could eventually be extended to various industries with significant emissions
Tectonics: safety conditions for storage in terms of seismicity retention must be thoroughly studied.	Removing CO_2 from the atmosphere
Risks involved with CO_2 release due to lack of safety.	It is good for the environment
Do not use CCS to avoid doing what is essential: reducing emissions!	The environmental benefits outweigh the risks and may even bring economic returns

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Concerns	Benefits
There is a possibility of CO_2 leakage, which is not very good for the environment Clarify: transport, research, who will invest? Do not add to the existing CO_2 footprint. What is the footprint of storage? How can this footprint be reduced? Transport: particularly safety issues; Time required to complete the project, due to inherent bureaucracy	

Regarding the overall acceptance of the project, when asked whether they accepted a CCS project offshore in Figueira da Foz, the overwhelming majority of visitors (20) voted "yes", some voted "maybe" (4) and only one voted "no" (1).

However, these results should be interpreted with caution. As seen above, although there was a social media controversy about the event and the more critical voices decided not to attend the exhibition.

As to the two comments left in the mailbox, they were also overwhelmingly positive, concerning both the climate impact of the project and the information provided at the exhibition:

> *Congratulations on taking on this challenge, which will help Portugal achieve its European carbon neutrality targets. Best of luck!*

> *Congratulations to the whole team for providing such comprehensive information, explained in a simple and accessible way. Well done. ☺Keep up the good work, for all of us and for our home planet.*

A close observation of the visitors and their interactions with team members yields more information on the doubts and opinions of visitors. Table 5 summarises the questions asked by visitors to team members, which can be aggregated in four types: technical, environmental, economic and procedural.

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Table 5: Questions asked by visitors

Technical	What is the storage capacity of the project? What conditions does the storage area have? Where is CO_2 captured? Is capture the most complicated part of the process? How many wells will be necessary per tonne? Is that enough for the industries? How will the CO_2 be transported? Will pipelines be built? Can trains be used for transport? What substance is the seal made of? How is CO_2 injected? Once stored, can the CO_2 be used? Are there CCS projects already running in the world? Is CCS going to be done offshore because it is not possible onshore? What connection is there with the offshore wind project?
Environmental	How much greenhouse gas emissions will be caused by the transportation of CO_2? What consequences will CCS have on marine animal and plant life? Can the storage area be turned into a protected area? What are the landscape impacts? Is there a risk of leaks? How much energy is necessary and from what source?
Economic	Is the project economically viable? Which are the costs? Who will pay the costs, the government or private companies? Will the industries at Figueira da Foz benefit from the project? Are the industries interested in the project? What impact will the project have on fishing activities? How much will a tonne of CO_2 cost?
Procedural	Who is going to carry out the project? Who will capture and condense the CO_2? Are there third-party industries interested in carrying out this task? Why is the project being done at Figueira da Foz?

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	Are there similar projects being done in other places in Portugal? Were environmental organisations contacted for giving an opinion on the project?

Comments made by visitors reflect their own backgrounds:

> *two environmentalists had some concerns about the technology but left feeling more informed and with a more favourable opinion ("I have come to hear (…) I have been reading about climate mitigation and geoengineering scares me but this seems more benign");*
>
> *a visitor originally from South Africa showed interest on CCS projects in his country and the possibility of storing carbon from SA industries in Mozambique;*
>
> *a young geologist working in a museum had only just heard about CCS from an oil industry engineer who had written a book about the topic;*
>
> *an older visitor with a holiday home at Figueira da Foz noted that pollution from the local industries was noticeable in the grey dust that covered his balcony every day and hoped CCS would put a stop to that;*
>
> *a young woman who had been reading the information thoroughly explains to her brother "'Haven't you read it?' and explains 'they take the smoke from the factories and put it under water, but I don't understand where' and she then asks some questions and comments at the end 'very interesting'.*

Other topics that come up in the discussions are the severity of climate change ('*I think we are happily walking towards ultimate disaster*'), renewable energies (positive and negative impacts), the hurdles of hydrogen, the problem of big carbon emitters such as India and China, the possibility of storing CO_2 from Portugal in Norway

Several visitors commended the willingness of the research team to engage in dialogue and explain the project in an event open to the public, since such projects often lack transparency. Most thanked the team for their explanations.

Vignette 1 delves in more detail the observed experiences of one of the visitors, highlighting the questions and comments he made during the visit.

Vignette 1

A male member of the public enters, aged between 45 and 55 years old, a resident of Coimbra with a determined and curious demeanour. He photographs all the panels, inside and outside. He begins to view the exhibition from the beginning, with great attention. A team member from University of Évora accompanies him through their part of the exhibition. In the first section, the visitor immediately points out that the increase in consumption mentioned in the video does not necessarily refer to a problem of consumerism, but rather to the improvement of living conditions for many populations. Even so, he makes critical comments about the capitalist system and the consumerism it promotes, which he considers '*cannot be stopped with renewables, only with systemic changes*'. Continuing on the issue of emissions, he refers to the emissions caused by fires, '*and this year there were a few more tonnes*'.

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Vignette 1

He praises the project for seeking to reduce emissions without major disruptions. He asks about storage capacity and greenhouse gas emissions caused by transport to the carbon storage area: '*all things considered, is it feasible?*' The team replies that it is up to the industries to answer that question. *'I'm asking questions, I don't have a fixed position, I came to listen*,' which indicates that he came on purpose to the event.

He explains that he reads literature on systemic alternatives, since climate change affects everything. He criticises the lack of reference to the seismic safety of the exhibition panels. '*People don't know that renewable energies cannot be 100% clean and demand this without realising it and with naivety, it's a whitewashing of reality*,' he comments on large-scale solar farms, which he considers having the same logic as fossil fuels. '*It pains me greatly because there is nothing on roofs, there are no panels in cities*.'

He mentions that the first section of the exhibition lacked a historical map of emissions and something to clarify that the Chinese and Indians emit much more than we do but notes the '*very interesting maps*'. He tries to start a conversation about the problem caused by overpopulation, but the team member chooses not to engage in that specific discussion.

In front of Panel 3, he asks how CO_2 was used in the video (creation of model bottles), to which another team member explains that it was dissolved. He apologised before asking a question about the consequences of this type of project on marine fauna and flora, and also asked whether it would be possible to create a specific status for the area where it is stored, transforming it into a protected area and '*combining the two concerns*', giving the example of offshore wind farms, which he considers to function as marine sanctuaries. He believes that poster 2B, with examples of the technology in various locations, '*helps to think*'.

He asked about the possible storage capacity of this project and whether they had spoken to any activists, mentioning that the photographs he is taking will be shared with a WhatsApp group of activists, although he noted that '*this generation is completely demobilised*'. He carefully wrote several post-its on concerns and benefits.

At the end of the visit, he was asked to vote on the acceptability of the project but says he needs to read more about the subject before voting. He said he was '*positively pleased*' with the '*possibility of dialogue*', the fact that the people involved in the project were on the ground, willing to explain it at an event open to the public, considering the lack of transparency that usually surrounds such projects. He says he has been reading books on these matters, on reducing the impact of climate change, even though he is afraid of geoengineering. Considering other things he has read, he considers this project '*the most benign*'.

Insights from the team members from Évora also help compose the picture of the event. There is general high satisfaction with the design of the exhibition and the response of the public: curiosity, interest, open-mindedness, perceived relevance of the topic in view of climate change, perceived positive environmental, economic and social impacts over local development, understanding of the need for urgent decisions and of the nuances of the solutions. The public seemed particularly taken with the opportunity to observe the thin sections of rock under the microscope and compare them with the samples they were holding on their hands, as well as with the models in jars and the scale model of the storage site. Some suggested these activities should be done also in schools and in more exhibitions.

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Team members also noted that visitors, particularly residents, asked often why had Figueira da Foz been chosen for the project; that they showed concerns with risks for the biosphere and geosphere and impacts over humans and daily life; that they inquired about the safety of storage, the efficacy of the seal in containing CO_2 without leaks and impacts on marine life.

Nevertheless, some aspects could be improved:

- The location was not ideal, a more visible venue would have attracted more visitors;
- Some potential visitors came closer to the exhibition hall but did not enter, they might have been enticed by bigger outdoor posters or an advertisement saying the event was open to all;
- The exhibition space should have wider and more open, so that people could approach the posters and read the information more comfortably;
- The exhibition should have been more dynamic and interactive, to enhance knowledge transmission, with experiments that enable a better understanding of concepts relevant to the project such as porosity, permeability, injection pressure;
- The role of the team at the event should have been more well defined in advance, a clearer division of labour in explanations (with experts on each topic explaining it), a previously prepared script for each topic to make sure all relevant aspects were covered;
- Visitors also commented that they missed information on current emissions in Portugal by sector, in order to understand the magnitude of the problem and the impact of the proposed solution.

Finally, since it also represents an outcome, it is worth analysing the comments left on the Facebook post promoting the event. In this case, attention is given to the arguments of those who did not attend the event but nevertheless criticised the project publicly.

Examining the comments left in the social media post in the Facebook profile of the municipality of Figueira da Foz, it is noticeable that some of the commentators has attended the February 2024 workshop, so they already had detailed knowledge of the project. Nevertheless, their objections remained. Their comments highlighted the following concerns:

- Risks: leaks, acidification of water with negative impacts on marine life, threat to human life
- High costs of the project (transportation, storage), low efficiency
- Corporate interests, as CCs is perceived as a strategy for companies to continue emitting CO_2
- Local pollution issues. Arguing thar CCS does not solve the problem of emissions of small particles from local industries that cause respiratory diseases, that should be monitored more closely
- Natural alternatives, as CCS It seen as a worse option than natural carbon capture by land and marine vegetation and soil and ecosystems, that should be protected and restored
- Concerns with the energy demands and source for CO_2 capture, in particular if biomass is to be used, since it contributes to deforestation

The commenters supported their stance on information from the IPCC and likened CCS to “burying your head in the sand” or “hiding a symptom letting the disease roam wild and making victims” or “continuing a license for polluting”. One comment stated, “we need systemic solutions and not isolated measures such as ‘sinking’ CO_2 that worsen the problems that already exist”.

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A.1.2.4. Conclusion

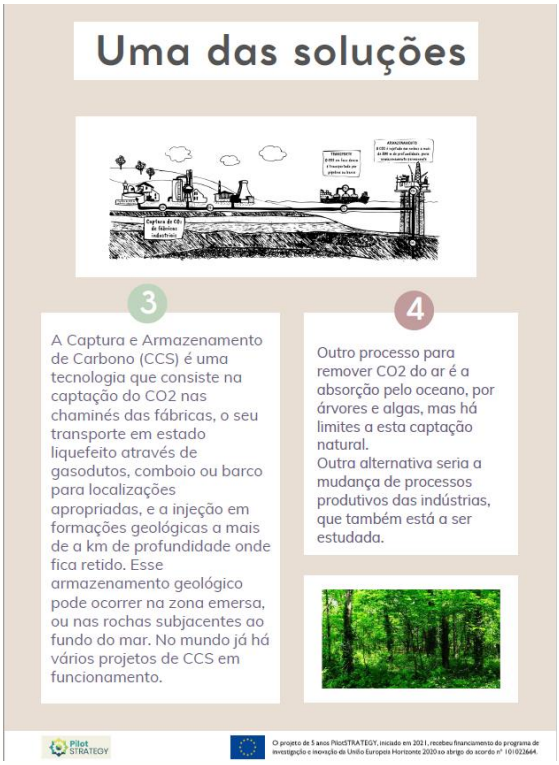
In general terms, the second citizen engagement activity in Portugal accomplished the objectives that were defined in the Task description. We managed to consult local communities on the development of CCS in Figueira da Foz, by providing extensive information about the technology and the project and creating opportunities to express their opinion. We achieved the aim of having a diverse audience in terms of gender and age. Through multi-method data collection, we were able to gather information on public perceptions, concerns and positions.

Visitors showed curiosity and interest on the technology by reading the available information, looking at the exhibits in display and engaging the scientists in conversation. Opinions were overall positive regarding CCS and this particular project at Figueira da Foz, commending their role in climate change mitigation and generating positive economic impacts, but some expressed concerns regarding safety issues, the carbon footprint of the project, the costs (and who will pay them), the need for consulting the community, and the risk of delaying or foregoing the reduction of climate change causing emissions.

Direct observation of visitor behaviour yielded a list of questions they asked researchers regarding technical, environmental, economic and procedural doubts, as well as an illustration on how their personal circumstances coloured citizens' perceptions of the technology and the project.

Nevertheless, the limited number of attendants precludes wider generalisations, and the chosen format (exhibition) does not allow for a more in-depth analysis of citizens' opinions.

A.1.2.4.1. Annex 1



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Os riscos da CCS

5

Os principais riscos associados à CCS são a possibilidade de fuga de CO2 e a sismicidade induzida.
Uma fuga nestes reservatórios subterrâneos poderia significar a libertação de CO2 na atmosfera, anulando os benefícios ambientais do armazenamento, afetando aquíferos de água potável ou mesmo causando problemas de saúde a pessoas e animais.

6

O risco de sismicidade induzida está, por sua vez, associado à possibilidade de ocorrência de sismos causados pelo aumento de pressão no subsolo. No entanto, a probabilidade destes riscos é muito baixa e a experiência internacional não tem registado casos relevantes. Outras dúvidas em relação a esta tecnologia prendem-se sobretudo com os seus custos.

O projeto de 5 anos PilotSTRATEGY, iniciado em 2021, recebeu financiamento do programa de investigação e inovação da União Europeia Horizonte 2020 ao abrigo do acordo nº 101022664.

Os benefícios da CCS

7

O principal benefício da CCS é evitar que o carbono seja libertado para atmosfera, contribuindo dessa forma para a mitigação das alterações climáticas.
Em determinadas circunstâncias, ainda a serem desenvolvidas, o CO2 pode também vir a ser utilizado para produzir produtos, como plástico ou combustíveis, ou recuperado como fluido para armazenamento de energia ou recuperação de calor geotérmico

8

A implementação da CCS permite gerar empregos e manter a atividade de indústrias difíceis de descarbonizar.

Imagem: Os operários, pintura de Tarsila do Amaral

O projeto de 5 anos PilotSTRATEGY, iniciado em 2021, recebeu financiamento do programa de investigação e inovação da União Europeia Horizonte 2020 ao abrigo do acordo nº 101022664.

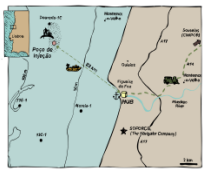
O que está a ser estudado na Figueira da Foz

9

O subsolo no mar ao largo da Figueira da Foz apresenta as características mais adequadas para o armazenamento de CO2 em Portugal. Os estudos feitos indicam que tem boas condições de segurança e está localizado perto das indústrias emissoras.

10

Numa fase piloto, o CO2 seria transportado por comboio, por exemplo, da fábrica de cimento em Souselas até ao porto da Figueira da Foz, e posteriormente transportado por navio de até um furo a 15km da costa, e injetado a 1250 m de profundidade. Mais tarde, num projeto comercial, a injeção seria feita a partir de um gasoduto submarino, provavelmente partindo da zona a sul da Figueira da Foz



O projeto de 5 anos PilotSTRATEGY, iniciado em 2021, recebeu financiamento do programa de

O que o projeto PilotSTRATEGY investiga

11

O projeto de investigação europeu PilotSTRATEGY tem como objetivo dar apoio a tomada de decisões futuras através da recolha e desenvolvimento de conhecimento detalhado sobre potenciais locais de armazenamento geológico de CO2.
Não será feito armazenamento de carbono no âmbito deste projeto.

OBJECTIVOS

- **Estudar os aquíferos salinos profundos que proporcionam grande capacidade de armazenamento de CO2**
- **Identificar locais piloto de armazenamento seguros e eficazes**
- **Envolver os cidadãos e as partes interessadas e investigar a aceitação social da CCS**

12

Em Portugal, os parceiros do projeto são a Universidade de Évora, responsável pelas tarefas de geocaracterização, análise de risco e análise de segurança e desempenho, e o Instituto de Ciências Sociais da Universidade de Lisboa, responsável pelo estudo da aceitação social da captura e armazenamento de carbono e pelo processo de envolvimento da comunidade.
O projeto conta também com o apoio técnico e operacional de um parceiro industrial - a GALP.

O projeto de 5 anos PilotSTRATEGY, iniciado em 2021, recebeu financiamento do programa de investigação e inovação da União Europeia Horizonte 2020 ao abrigo do acordo nº 101022664.

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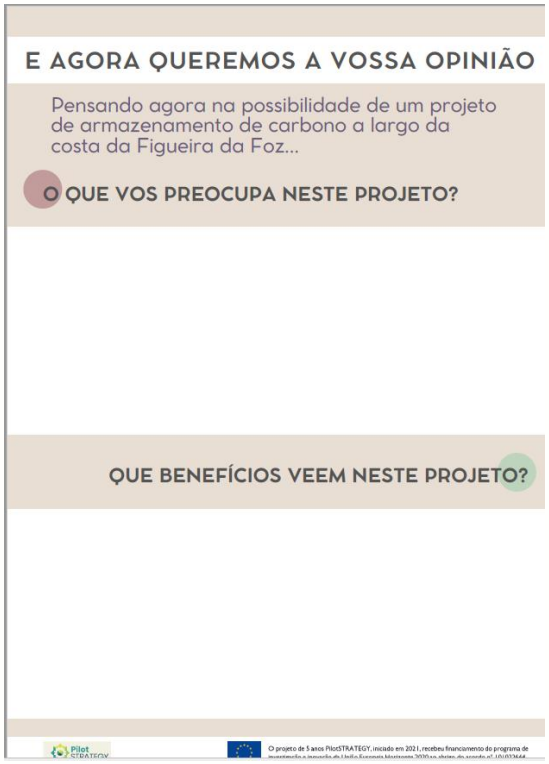

A.1.3. First Meeting Report Spain

A.1.3.1. Introduction

The PilotSTRATEGY project aims to promote local engagement activities in three study areas: the Paris Basin (France), the Lusitanian Basin (Portugal), and the Ebro Basin (Spain). In the early stages of the project, researchers characterized the overall setting in which CO_2 storage discussions take place. This involved analysing the policy framework, developing regional community profiles, and conducting a questionnaire survey to explore community acceptance.

The project identified a need for social science research to understand public perceptions of CO_2 storage at the local level and to open up pathways for the participation of affected communities in project development. Given the low level of familiarity with CCS technologies among citizens in the study communities, the project team recognized that such work could be carried out using a hybrid (research and engagement) group-based methodology. This would enable groups of lay citizens to engage with issues related to CO_2 storage in their communities, to learn about CCS technologies, and to express their views and concerns.

The research team designed a hybrid consultation and research strategy to be implemented in the study regions. The aim was to gather local public views on CCS technologies and a potential CO_2 storage project in the region, and to improve the quality of public engagement with CCS projects. The specific objectives were to:

- Gather data on citizens' views and attitudes towards a hypothetical CCS pilot project in the region (research and consultation).
- Engage the public in learning about PilotSTRATEGY, CCS technologies, and the implementation of future CCS projects (to address their concerns and aspirations).

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- Gain methodological insights into the implementation of hybrid group-based methods for future public engagement activities on CCS.

Hybrid engagement activities with citizens in the three study areas were conducted from September 2023 to October 2025. In this section, we report the main results from this activity.

A.1.3.2. Method

As described in D6.3, we conducted hybrid (research, consultation and participation) reconvened focus or discussion groups in the different study sites. Reconvened focus groups are discussion groups of 6 to 10 participants that meet twice, with an interval between meetings to allow participants to absorb new information and reflect on the issues raised at the first meeting.

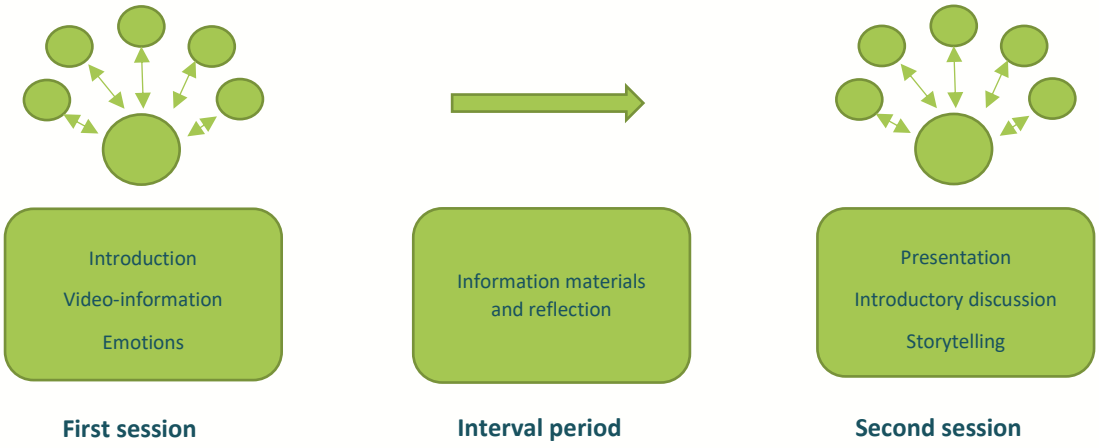

Figure 13 Methodology flow chart

Each group session lasted between one and a half and two hours. During the group sessions, participants were encouraged to reflect on the issue under discussion (in our context, a carbon capture and storage project) by reading or listening to specific information, taking part in exercises and discussing with others. These objectives were achieved with structured facilitation, stimulus materials and exercises or activity-oriented questions. Between the two sessions, the participants received a dossier filled with different materials in order to stimulate the discussion for the second session (Annex 1. Information packet). Group facilitators encouraged a safe, open and non-judgmental discussion and learning environment and interaction between participants. Group sessions should be audio recorded. Observational notes by a member of the research team may also be useful for data analysis.

A.1.3.3. Participants

A reconvened focus group was convened in Belchite, Zaragoza in September 2023. The group comprised nine participants, exhibiting a diverse mix in terms of both gender and age, to ensure a multi-faceted representation of perspectives. Two sessions were held, each designed to delve into various aspects of CCS technology, its implications, and public sentiment.

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A.1.3.4. Results

FIRST SESSION

A.1.3.4.1. Awareness and knowledge

Regarding the knowledge of the participants about the CCS technology, many of them considered they do not have any prior knowledge, and even after the introductory video and presentation (Annex 2. Introductory materials), some participants still do not understand fully the technology. Others affirm that they know something about CCS. Even one of the participants mentions that he listened something about a technique that consisted in putting filters in industries that capture the CO_2 and transform it to a solid waste or material.

Another question asked by the participants was if CCS technology is already applied in other countries and if exist CCS storage facilities there.

Another participant asks about the machinery needed to capture and storage CO_2, its complexity and its industrial process.

The moderator asks them if they know what kind of industries emit more CO_2 and therefore could be more benefitted with the implementation of CCS storage. Some participants do not know the answer but others consider the cement factories and quarries are the most CO_2-pollutant industries.

Another doubt among the participants is where the exact location of the potential CCS storage is, as they have doubts if it is in the municipality of Belchite or another neighbouring town.

A.1.3.4.2. Emotions associated to the CCS project

A specific exercise was conducted to elicit emotional responses associated to CO_2 storage among participants (Table 6). The exercise consisted in a list of emotions written in cards and presented to every participant. They had three cards with positive emotions and three cards with negative emotions and they were asked to select the emotions they feel when thinking about CCS technology and tell why they selected these emotions.

Astonishment was the most mentioned emotion by the participants (four mentions). They report to feel astonishment due to different reasons, like the lack of awareness about CCS technology and the astonishment it produces to them to know how it works. An additional element arises from the notion that sequestering CO_2, typically considered an air pollutant, might also have adverse effects on the soil, leaving certain participants in a state of astonishment.

Both curiosity and scepticism received three mentions each one. Curiosity was chosen to describe the emotion some participants feel when thinking in the operation of a CCS storage site due to the lack of awareness about this technology from the majority of participants. Another attendee found this technology to be rather odd, expressing curiosity about the process of storing CO_2 underground.

Regarding scepticism, some participants considered they could take different individual actions to reduce air pollution although they consider big companies and rich people would continue polluting much more and therefore, their individual actions would have a negligible effect. Another

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participant reports the results and consequences could be good, bad, same as now, but as he/she does not know them, he/she feels sceptic. Another participant believes that the environmental benefits would be relatively minimal given the significant economic investment required for the project. As an alternative, he suggests redirecting these funds towards other projects.

Fear was mentioned in two occasions, mainly related with the uncertainty and the lack of awareness of the technology. One of the participants mentioned indirectly fear, citing that he does not feel fearful but the need to find solutions to mitigate climate change, and CCS could be a step, although completely unknown for them and therefore considered fearful by some participants.

One participant mentioned hope as an emotion because she considers it could be a useful technology to mitigate climate change and therefore it could have a universal benefit.

Table 6: Emotional responses associated to CO_2 storage

Emotion	Number of mentions	Comments and quotes
Astonishment	4	• *For me it has been a new thing* • *The first thing I thought was that if it's bad for the environment, for the atmosphere, then it's also bad for what's underground.* • *I didn't expect that you can take carbon dioxide out of the air, put it underground and it's going to be fine.*
Curiosity	3	• How it could work and how can it be done. • *Interest because of the little knowledge I have of the subject.* • *I find it odd, rather than interesting*
Scepticism	3	• *We will do things to mitigate the contamination but the big companies will continue polluting, rich people will still travel with private jets.* • *We will do our bit, but the big industries will continue to do nothing.* • *Because maybe it is still the same, maybe it is not the only solution, maybe it can be good, or not, we do not know.* • *I think that from an environmental point of view, the profit is probably going to be small. I think that the money that is being spent, that is going to be spent by the companies and by the community, on this thing, well, surely if it were spent on other things, it would be more profitable.*
Fear	2	• Fear caused for uncertainty regarding the storage and if it will have good or bad consequences. • Fear for the unknown • *Not fear, I understand that something has to be done, I don't know if this is the solution or one of the solutions, but something has to be done, the way we are, we are going from bad to worse.*
Hope	1	• *Yes, I think this gives me hope too, that it is for the good of all.*

Other emotions that arised during the session were, among others, trust. Some participants believe that if CCS would be a good technology they will not bring it to a depopulated territory with scarcely no industry. They tend to think they only receive the facilities that nobody wants in their territory.

That seems odd to me rather than something good being brought here for us.

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Another debate about trust arises regarding little confidence in authorities and experts reported by some participants. They exemplify this remembering a natural disaster that affected an unoccupied school in the region in the past, considering there were building constructed in flood risk areas and therefore having a lack of confidence in exert decisions. Other participants say they trust the experts and technicians, with one of them specifying that the lack of trust is directed to authorities and politicians, but no to experts, as he considers politicians are the ones that take the decisions to implement anything.

> *No, the experts don't fail, what fails is the political decision, in other words, 50% of Spanish buildings are in flood risk areas, so what do you do?*

One of the participants believe big companies would use the reduction of CO_2 emissions as an excuse to emit more CO_2.

One participant reports she was confused when she discovered Repsol was a project partner. She thought they act like a sponsor and had some initial doubts about potential industrial interests unknown by the community, although she felt mostly trustful in the project.

A.1.3.4.3. Perception of benefits and costs from the project

As with emotions, benefits and costs appeared during the entire discussion and a specific activity about potential benefits and costs was carried out. The exercise consisted in each participant thinking individually some benefits and costs, global or local, that the installation of a CCS storage in Lopín would have. The participants were suggested to write the benefits in one post-it and the costs in another post-it. The transcription (translated in English) of the Post-its is presented in Figure 13.

Regarding the **negative impacts**, one type are the impacts related to risks and its associated fear. One of this fears arised with the possibility of a potential leak in the storage site. Some participants claim the lack of awareness they have to this technology makes them think about potential safety threats and unknown impacts.

Other type of risk mentioned is related to environmental risks. Some participants consider this technology is not environmentally committed and carries a potential risk to the flora and the fauna. Another idea is that CCS storage technology could give companies an excuse to continue polluting.

Regarding the risk and safety, the participants consider that before injecting CO_2 underground they have to be sure the risk is very low and is not worse putting it underground than in the air. This kind of implementation problems could carry associated protests from the affected citizens. Other participants remain also uncertain about the safety of this procedure and ask if there are studies from experts assuring the safety of this action. Regarding its safety, they are not only worried for the safety for people, but also what could be the consequences of a possible incident for the flora and the fauna, or the soil, as many people works in the agriculture in the area. They want also to know what would be the consequences of a leak.

One participant also reports the situation that happened in the Mediterranean coast due to Castor platform and its associated earthquakes and the opposition that emerged in the affected communities.

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Economical risks have been mentioned and among this, a high cost to implement a CCS storage have been mentioned. In addition, the high transport costs of bringing the CO_2 from the emitters to the storage site have been reported too. In the economical field, also has been reported the potential economic loss if the project fails and has been reported that the potential economic gains will be for the big companies but not for the community.

There also have been trust aspects mentioned in the exercise. One participant considers there is not a transparent geological study done. Another worry mentioned by the participants is placing the storage site in a depopulated area and needing to transport the CO_2, giving a sense of distrust, as they feel there are risks and therefore, they put it in a depopulated area. In this same sense, some participants also feel distrust when they consider they do not generate much CO_2 and their territory do not have industry, but the CCS storage would be located in their area. One participant compares it somehow with the case of electronic waste dumped in Africa, where it was neither produced nor used.

Another reported cost is the uncertainty of the project, regarding its success and if it could improve the atmospheric situation or even worsen it.

Regarding the **positive impacts**, one of the aspects mentioned is that if CCS is considered safe is better than doing nothing although may not be considered as a perfect solution.

Another positive aspect mentioned is the capacity to reduce emissions to the planet and to reduce global warming. Some participants put into context that this will be only a global benefit because in the area of Belchite there are no large factories that emit big quantities of CO_2 and therefore not implying local benefits.

Another reported benefit is the possibility the installation of a CCS storage site would bring job opportunities in an area where there is an historical lack of work and industry-related jobs. Another related economic benefit would be the possibility of fiscal benefits for the citizens in the area.

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Figure 13: Main benefits and costs from a CCS project as perceived by participants

SECOND SESSION

A.1.3.4.4. Initial reactions after the informative materials

Initial discussions illuminated a spectrum of perceptions, from cautious optimism to scepticism, regarding CCS. Predominant themes revolved around safety, economic implications, transparency, and community engagement. These were some of the key themes identified in the first part of the second session of the engagement activity:

1) Cost concerns:
   - The high initial expenditure associated with CCS was a recurrent concern among participants.
   - The balance between the investment in CCS and its perceived benefits in terms of carbon reduction was questioned, indicating a need for clearer economic justifications.
2) Safety and risks:
   - Participants voiced apprehensions regarding the potential for induced seismic activity and accidental CO_2 leakage.
   - They sought clarifications about the overall safety protocols and potential environmental consequences.
3) Local impact:
   - The effects of CCS on local communities, particularly in relation to property values, emerged as a primary concern.
   - Participants deliberated the fairness of situating CCS facilities in less densely populated regions, fearing disproportionate burdens on such communities.
4) Awareness and understanding:
   - A segment of participants felt they had gained insights into CCS after their research, but still harboured questions.
   - The complexities inherent to the technology appear to challenge its comprehension among the general public.
5) Comparison with other regions/countries:
   - References to the CCS practices in countries like the USA and Norway suggest a desire to understand best practices and benchmarks in the global context.
6) Long-term concerns:
   - Participants pondered the sustainability of CCS, especially the long-term viability of aquifers as storage solutions and the implications after their proposed life spans.
7) Alternative solutions:
   - A sentiment emerged advocating for exploring alternative solutions (renewables and energy saving) rather than solely relying on underground storage.
8) Trust and credibility:
   - Participants expressed reservations about the portrayal of CCS in the media and potential biases.
   - The apparent dichotomy between the regions producing the CO_2 and those storing it fostered feelings of being potentially exploited.

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9) Infrastructure concerns:
   - The need for extensive infrastructure, like pipelines, and the implications of long-distance CO_2 transportation were topics of concern.
   - Capacity and viability:
   - There was uncertainty regarding the sufficiency of storage sites to accommodate large industrial emissions.
10) Location and rationale:
   - Participants questioned the criteria for site selection, seeking clarity on the rationale behind specific choices.
11) Environmental and economic impacts:
   - A perceived imbalance between the volume of carbon captured and emitted was highlighted.
   - Job opportunities related to the CCS industry were discussed, with a focus on high qualification jobs and their accessibility to local residents.
12) Transparency and trust:
   - A clear demand for more transparent communication about CCS projects was articulated, emphasizing unbiased information.
13) Involvement of authorities and governance:
   - The role of local and regional authorities in decision-making processes was a central concern, especially their alignment with community interests.
14) Community engagement:
   - The need for wider discussions that encompass all potentially affected regions was evident.

A.1.3.4.5. Position towards a potential CO_2 storage: the vignette exercise

In the vignette activity (Figure 14), participants aligned with two primary perspectives - those resonating with "Pedro" and those aligning with "Pilar". Some participants displayed ambivalence, finding elements of both perspectives to be relatable.

Those who identified with Pedro's stance expressed skepticism about the intentions behind a CO_2 storage project benefiting the local community. One participant echoing this sentiment remarked, "I resonate with Pedro's viewpoint. While the CAC may possess potential, I remain doubtful about the transparency of a storage project here and its genuine intentions for our well-being."

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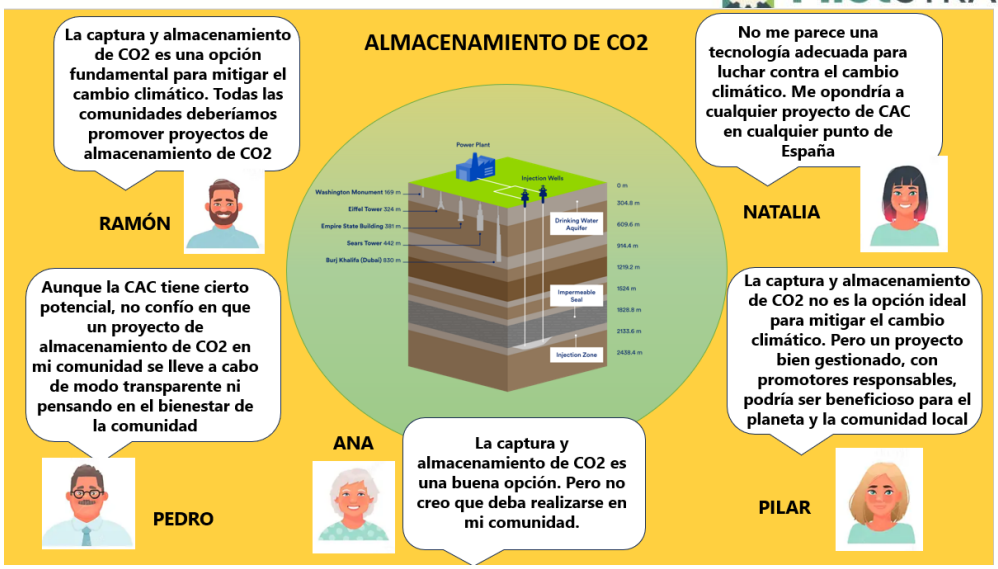

Figure 14 Vignette used in the activity.

On the other hand, participants in agreement with Pilar's viewpoint believe that a CO_2 storage project, when executed properly, could yield significant benefits both globally and locally.

Finally, some participants showcased a mix of both views. One of them commented, "I see validity in both Pedro's and Pilar's perspectives. I am torn between the two and resonate with aspects of both positions."

Various ideas appeared in the discussion regarding the acceptance of a potential CO_2 storage in the local area. One of the main aspects mentioned by the participants is the fact that the Lopín area is not an industrial zone. Therefore, most of the participants show reticence about the potential installation of a CCS storage. One of the arguments is that the CO_2 would be transported from the emitter site to the storage site, with pollution produced in the transport phase and therefore reducing the mitigation effects the technology could have. Although is not an industrial area, there are some industries to the vicinity that could benefit from CCS, and therefore, the community could be benefited. Some other participants believe that there will not be any benefits for the community, only costs like the CO_2 transport.

The depopulation of the area plays another key factor in the siting acceptance, linked to the fact is not an industrial area. Some participants distrust the fact that the storage site would be installed in an area with few population and they think it could be for reasons like having less opposition and less protests or even, another participant believes that they put it there in the case some incident happens, the population affected would be less. This is linked to the perception that industrial or big projects never came there and always went to big industrial areas.

Some participants point an example occurred in a nearby village, where an industry dedicated to the recycle of lead batteries faced a great initial opposition from the village citizens, with protests and other actions but afterwards not only they accepted it, but many people from the village want now to work there and the plant has been recently expanded. Asked why this change of opinion, the participants believe the strong opposition was due to the health risks people associated to lead batteries but after seeing the workers are healthy, they perceive the benefits of an industry like this for the community.

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In acceptability field, one of the participants puts the example of Nuclear Power Plants and the difference between Spain and France. While in France the government is supporting nuclear energy and benefitting of producing their own energy and having energy independence and in the case of a potential incident, the radiation contamination could arrive to Lopin area, depending on the wind speed and direction. With this, he wants to highlight that in Spain, we do not support nuclear energy and therefore we are not supporting energy independence while we are equally exposed to risks. He extrapoles this to the CCS storage site as he considers there is a need to change peoples' mentality and if we want to have a high living standard this technology, although maybe not perfect, is necessary to reduce emissions until other cleaner energies are available. He considers the safety of the technology to be high, and he cites the learning from past events, for example, people who work with asbestos who in the past used to get exposed to carcinogenic particles but nowadays work protected with PPE.

A.1.3.4.6. Conditions for acceptance

In the exercise on "acceptance conditions" (Figure 15), we asked participants to rank the following conditions based on the importance they gave them for the acceptance of CO_2 storage in their community.

Continuous safety monitoring	**Financial compensation to municipalities**	**Mechanisms to keep the population informed throughout the life of the project**
Citizen participation in decision-making	**Non-financial compensation to municipalities (e.g., infrastructure improvements, cultural center, etc.)**	**Explicit local benefits (e.g., local employment, technological development)**
Economic incentives for residents		

Figure 15 Acceptance conditions.

Local participants prioritized:

- Explicit local benefits from the project: This means that the project should provide clear and tangible benefits to the local community, such as jobs, infrastructure, or improved services.
- Mechanisms to keep the population informed throughout the project: This means that the project team should communicate regularly with the local community about the project's progress, plans, and potential impacts.

Participants considered the following also important:

- Safety monitoring: This means that the project team should take steps to ensure the safety of the local community during the project.
- Financial compensation to the municipality: This means that the project team should provide financial support to the local government to help offset any costs or impacts associated with the project.

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- Non-financial compensations: This could include things like training, job opportunities, or access to resources.

Participants considered the following to be less important:

- Economic incentives for the residents: This could include things like tax breaks or discounts in the electricity bill.
- Citizen participation: This means giving local residents a say in how the project is planned and implemented.

The following issues were raised in the discussion:

1. Information and transparency:
   - Emphasis on the need for proper, timely, and accurate information dissemination.
   - Continuous updates on safety measures.
2. Economic aspects:
   - Need for improvements for local benefits, especially in areas like employment and technological development.
   - Economic compensation and benefits for the local community.
   - Mention of other projects like aerogenerators which bring economic benefits.
   - Distinction between compensation to municipalities and incentives for individual residents.
   - Debate over long-term benefits versus short-term payouts.
3. Safety concerns:
   - Continuous safety controls as a priority.
   - General emphasis on the importance of safety in the project.
4. Property and land rights:
   - Concerns about land ownership, especially regarding public vs. private lands.
   - Discussions about property expropriation in the interest of the community.
   - Comparison with other projects like wind turbines (aerogenerators) and the economic implications of land ownership vs. leasing.
5. Role of businesses and government:
   - Mention of businesses' economic strategies, including their decisions to lease rather than buy land.
   - Discussions on what happens when agreements between businesses and landowners end.
   - Mention of the role of municipalities in managing compensation and benefits.

A.1.3.4.7. Final issues

Several issues were discussed in the final section of the group discussion.

1) Technical details about Capture and Storage of CO_2: The conversation revolves around the methods and technology for capturing CO_2 and storing it underground. The expert from the local team provided a clear and detailed explanation of the process, emphasizing the transformation of CO_2 into a liquid state for more efficient transportation and storage. The participants delve into technical aspects of CO_2 storage, such as the depth at which CO_2 is stored and its behaviour at various pressures and temperatures. Paula explains how the CO_2 behaves when it's stored

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deep underground, emphasizing its transformation into a liquid-like state that moves rapidly, its interaction with saline water, and its eventual settling due to the concentration gradient. There's a recurring theme of miscommunication or misunderstanding, particularly concerning the duration of CO_2 storage. Paula and others correct these misconceptions and emphasize the importance of clear communication, especially when discussing complex technical topics with the general public.

2) Understanding of the General Public: The participants reveal a limited understanding of the topic at the outset, with many expressing surprise, curiosity, and misconceptions about the process. Throughout the conversation, Paula seeks to correct these misunderstandings and provide accurate information.
3) Desire for More Information and Transparency: Participants showed an interest in understanding more about the project, evident from the inquiries about how to keep updated on the project's progress. There was a clear desire to have an ongoing dialogue, with comments on the ability to get in touch with the project leads through email.
4) Feelings of Hope: Several participants expressed hope related to the project. One woman mentioned that it gives her hope because solutions are being researched, even though the world is faced with the threat of climate change.
5) Concerns about risk and safety: Many participants mentioned words like "uncertainty and concerns about whether the CO_2 storage solution is safe, reliable, and the right choice. There is an evident feeling of scepticism about the project and its feasibility. Safety concerns regarding CO_2 storage are addressed. Paula explains the regulations in place to ensure the stored CO_2 does not escape, with monitoring occurring before, during, and after the storage process. There's also mention of the legal responsibility for monitoring shifting from the company that stored the CO_2 to the Ministry or relevant administration after 25 years.

Concerns were raised about the site's location, its safety, and whether the project will be abandoned later on.

6) Economic concerns: The perceived high costs associated with the project were a common concern. Participants questioned if there might be other, cheaper alternatives available.
7) Communication: The method of communication and who would update the participants was also discussed, reflecting the community's desire to remain involved and informed.
8) Trust and scepticism: A sentiment of mistrust or scepticism was mentioned, with one participant referencing the term "scepticism" that was brought up in a prior discussion. Another participant mentioned the rich potentially leaving the planet, reflecting a broader societal mistrust in the wealthy or powerful. Some participants express a level of resignation, with phrases like “It's always the same” and the suggestion that their opinion might not be heard or matter.
9) Personal Experience and Curiosity: Many participants express their surprise at the new information they are learning, revealing that CO_2 capture and storage is not a widely understood topic among the general public. This curiosity and eagerness to understand demonstrate the importance of outreach and education on environmental topics.

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A.1.3.5. Conclusion

The PilotSTRATEGY project's engagement activities in the Paris Basin (France), the Lusitanian Basin (Portugal), and the Ebro Basin (Spain) provided invaluable insights into community perceptions and concerns regarding carbon capture and storage (CCS). A few overarching themes emerge from the findings:

- Awareness and education: A significant knowledge gap about CCS technology was evident among participants. While efforts made during the sessions resulted in improved understanding, it highlights the critical need for clear, accessible, and transparent information dissemination about such projects to the broader public.
- Economic and local impacts: The community is naturally concerned about the economic implications of CCS projects. There's a clear desire for tangible local benefits, both in the form of infrastructure enhancements and direct economic benefits.
- Safety: Safety remains paramount. Concerns ranged from potential seismic activities, CO_2 leakage, to the overall environmental consequences of the projects. This underlines the importance of robust safety protocols, transparent communication about these protocols, and regular monitoring.
- Trust and transparency: Scepticism about the actual benefits and intentions behind the CO_2 storage project was evident. The need for unbiased, transparent, and consistent communication throughout the project lifecycle was emphasized time and again.
- Community engagement: The communities expressed a strong desire to be actively informed about the project that may impact them. They also valued platforms where they could voice concerns, ask questions, and be genuinely heard.

The findings underscore the importance of early, consistent, and transparent engagement with communities for future CCS projects. Adopting a hybrid research and engagement model, as used in PilotSTRATEGY, offers a replicable and effective strategy. It ensures communities are informed, their concerns are addressed, and they are genuinely involved in the decision-making processes. Moving forward, lessons from PilotSTRATEGY can be instrumental in shaping more inclusive, transparent, and successful CCS projects globally.

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A.1.3.6. Annexes

A.1.3.6.1. Annex 1. Information packet

PilotSTRATEGY

Materiales informativos

Proyecto PILOT-STRATEGY

Proyecto PILOT-STRATEGY
13-9-2023

Figure 16 Information packet front cover.

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PilotSTRATEGY

Índice

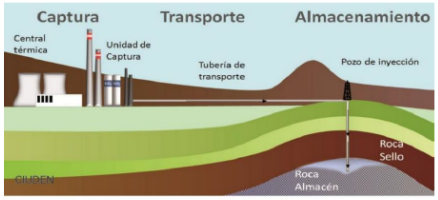
Figure 17 Information packet Table of Contents.

¿Qué es la CAC?

La Captura y Almacenamiento de CO2 (CAC) es una forma de reducir las emisiones de CO2, lo que podría ser clave para combatir el cambio climático. Es un proceso de tres pasos que implica: **capturar** el dióxido de carbono producido por la generación de energía o la actividad industrial, como la fabricación de acero o cemento; **transportarlo** por barco o por tubería; y luego **almacenarlo** a gran profundidad en formaciones geológicas.

¿Cómo puede la CAC ayudar a prevenir el calentamiento global?

El Panel Intergubernamental sobre Cambio Climático (IPCC) destacó que, si queremos alcanzar las ambiciones del Acuerdo de París y limitar los futuros aumentos de temperatura a 1,5°C, debemos hacer más que simplemente aumentar los esfuerzos para reducir las emisiones. La CAC es una de estas tecnologías y, por lo tanto, puede desempeñar un papel importante en la lucha contra el calentamiento global.



SISTEMA DE CAPTURA Y ALMACENAMIENTO DE DIÓXIDO DE CARBONO EN UNA INSTALACIÓN INDUSTRIAL

¿Cómo funciona realmente la CAC?

Hay tres pasos para el proceso CAC:

1. **Capturar** el dióxido de carbono. El CO2 se separa de otros gases producidos en procesos industriales, como los de las centrales eléctricas alimentadas con carbón y gas natural o las fábricas de acero o cemento.

2. **Transporte**. Luego, el CO2 se comprime y se transporta a través de tuberías, transporte por carretera o barcos hasta un lugar para su almacenamiento.

3. **Almacenamiento**. Finalmente, el CO2 se inyecta en formaciones rocosas a gran profundidad para su almacenamiento permanente.

¿Dónde se almacena el CO2?

Los posibles sitios de almacenamiento de emisiones de carbono incluyen acuíferos salinos o depósitos de petróleo y gas agotados, que normalmente deben estar a 1 km o más bajo tierra.

A modo de ejemplo, un sitio de almacenamiento para el proyecto Zero Carbon Humber es un acuífero salino que se encuentra en el sur del Mar del Norte, a unos 90 kilómetros de la costa. El almacenamiento se encuentra aproximadamente a 1,6 km (1 milla) por debajo del lecho marino y tiene el potencial de almacenar grandes cantidades de CO2.

¿Es seguro almacenar carbono como parte de la CAC?

Según el organismo industrial Global CCS Institute, la CAC es "una tecnología probada que ha estado en funcionamiento seguro durante más de 45 años". Añade que todos los componentes de la CAC son tecnologías probadas que se han utilizado durante décadas.

¿Dónde se está utilizando ya la CAC?

Según el informe de 2019 del Global CCS Institute, en ese momento había 51 instalaciones de CAC a gran escala en todo el mundo, 19 de las cuales se encontraban en operación, 4 en construcción y el resto en diversas etapas de desarrollo.

Fuente: Elaboración propia a partir de diversas fuentes

Figure 18 Carbon Capture and Storage brochure

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Acuíferos salinos pueden almacenar durante 60 años el CO2 generado en 2021

CAPTURA CO2

Madrid, 9 feb (EFE).- España dispone de hasta "103 acuíferos salinos profundos con potencial para almacenar durante 60 años el CO2 producido durante 2021" en el país, ha asegurado hoy el presidente de la Asociación de la Plataforma Tecnológica Española del CO2 (PTECO2), Pedro Mora.

AGENCIAS

09/02/2023 18:30

Madrid, 9 feb (EFE).- España dispone de hasta "103 acuíferos salinos profundos con potencial para almacenar durante 60 años el CO2 producido durante 2021" en el país, ha asegurado hoy el presidente de la Asociación de la Plataforma Tecnológica Española del CO2 (PTECO2), Pedro Mora.

Mora, que ha participado en una 'Jornada sobre almacenamiento y captura de CO2' organizada por su entidad y la Asociación de Periodistas de Información Ambiental (APIA) en el Instituto Geológico y Minero de España, considera que las tecnologías de captura, transporte, almacenamiento y usos del CO2 (CAUC) "son la única alternativa para los sectores con emisiones de carbono".

Se trata de almacenar los excedentes de este gas en "acuíferos salinos profundos, porosos y permeables" para alcanzar los objetivos climáticos establecidos por los tratados internacionales y ayudar a frenar el aumento de temperaturas.

Mora ha reconocido que "invertir en captura es carísimo, pero el almacenamiento geológico es la única solución madura que podemos adoptar" en este momento y ha subrayado que esta medida ya se ha implantado en otros países europeos como Holanda, Italia, Noruega y Dinamarca.

Entre otros expertos, en la jornada también ha participado Paula Fernández-Canteli, líder del grupo de trabajo de Almacenamiento en PTECO2, quien ha recordado que, según las estimaciones de la Comisión Europea, sería necesario almacenar entre 300 y 640 millones de

Figure 19 Press article: Saline aquifers can store CO_2 generated in 2021 for 60 years (La Vanguardia)

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Captura y almacenamiento de CO2: ¿Salvavidas medioambiental o cheque en blanco para contaminadores?

04/11/2022

El 'Northern Lights' en Oygarden cerca de Bergen, Noruega, es uno de los proyectos de almacenamiento de CO2 más avanzados de Europa © Alexiane Lerouge / AFP

Texto por:Grégoire Sauvage

5 min

Las tecnologías de captura y almacenamiento de CO2 están cobrando impulso mientras el mundo lucha por reducir las emisiones lo suficiente como para evitar una catástrofe climática. Algunos activistas del clima se muestran escépticos y consideran que esta tecnología es una excusa. Pero otros dicen que su uso podría ser necesario.

Durante años, la captura y el almacenamiento de carbono (CAC) estuvieron fuera de la escena, obstaculizados por los costos prohibitivos y la falta de apoyo político. Pero ahora la industria de la CAC está en auge.

En un informe de 2021, el Instituto Francés de Relaciones Internacionales contabilizó un récord de 76 proyectos de CAC en marcha en Europa.

"Actualmente, la CAC avanza por dos vías en Europa; hay mucho entusiasmo en el norte de Europa y mucho menos en el sur, donde falta voluntad política para implantar estas tecnologías", afirma Thomas Le Guénan, geólogo de la Oficina de Investigación Geológica y Minera de Francia.

Según la empresa noruega de investigación 'Rystad Energy', se prevé que el mercado de equipos de captura y almacenamiento de CO2 se cuadruplique en los próximos tres años y alcance unos 50.000 millones de dólares en 2025. Gracias al aumento de las inversiones en Europa y Norteamérica, la industria de la CAC debería ser capaz de capturar 150 millones de toneladas al año, frente a los 40 millones actuales. Sin embargo, esto es una gota de agua en el océano si se compara con los 38.000 millones de toneladas de CO2 emitidas por el ser humano en 2019.

El proyecto 'Northern Lights', dirigido por las grandes petroleras Total, Shell y Equinor, pretende

Figure 20 Press article: CO_2 capture and storage: Environmental lifeline or blank check for polluters? (France24 in Spanish)

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¿Qué consecuencias tendría implementar la Captura y Almacenamiento de CO2?

La implementación de tecnologías de captura y almacenamiento de carbono (CAC) puede tener una serie de consecuencias ambientales, económicas y sociales.

Consecuencias ambientales:

1. Reducción de las emisiones de gases de efecto invernadero: la CAC puede reducir significativamente la cantidad de emisiones de dióxido de carbono de las centrales eléctricas y las instalaciones industriales, ayudando a abordar el problema del cambio climático.

2. Impactos en los recursos terrestres y hídricos: El almacenamiento de dióxido de carbono bajo tierra puede tener impactos en los recursos hídricos, la estabilidad del suelo y la actividad sísmica.

3. Posible liberación de CO2: Existe el riesgo de fuga de dióxido de carbono desde los sitios de almacenamiento, lo que puede tener impactos ambientales dañinos.

Consecuencias económicas:

4. Coste de implementación: Las tecnologías CAC pueden ser costosas de implementar y requieren inversiones significativas en infraestructura y tecnología.

5. Creación de empleo y beneficios económicos: La implementación de tecnologías CCS puede crear nuevos empleos en áreas como construcción, operación y mantenimiento, lo que potencialmente generará beneficios económicos para las comunidades.

Consecuencias sociales:

6. Aceptación pública: La implementación de tecnologías CAC puede enfrentar oposición de las comunidades locales debido a preocupaciones sobre los impactos ambientales, los riesgos potenciales para la salud y los valores de las propiedades.

7. Regulación y gobernanza: El desarrollo y la implementación de tecnologías CAC requerirán marcos regulatorios y mecanismos de gobernanza efectivos para garantizar que se minimicen los impactos ambientales y sociales.

Fuente: Elaboración propia a partir de diversas fuentes

Figure 21 Brochure about the consequences of CCS implementation

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Pilot STRATEGY
Accelerating CO_2 storage for a sustainable future

CO_2 geological storage in strategic territories Building a low-carbon, climate-resilient future: secure, clean and efficient energy

Coordinator: Dr Fernanda M.L. Veloso, BRGM (f.veloso@brgm.fr)

Captura y Almacenamiento de Carbono (CAC)

La Captura y Almacenamiento de Carbono (CAC) es el proceso de captura, transporte y almacenamiento en formaciones geológicas profundas, a largo plazo, de dióxido de carbono (CO_2). Según el Panel Intergubernamental del Cambio Climático (IPCC) y la Comisión Europea (CE), estas tecnologías tiene un papel crucial en el cumplimiento de los compromisos climáticos, y en particular en la viabilidad futura de las regiones industrializadas de Europa. Sin embargo, la superación de este reto depende de que se identifiquen estructuras geológicas seguras para el almacenamiento CO_2 ya desde el año 2030.

Proyecto PilotSTRATEGY

El proyecto europeo de investigación PilotSTRATEGY (2021-2026) "Pilotos de almacenamiento geológico de CO2 en territorios estratégicos", coordinado por el Bureau de Recherches Geologiques et Minieres (BRGM, Francia), tiene como objetivo contribuir a la mitigación del cambio climático, proporcionando apoyo para la futura toma de decisiones sobre la viabilidad de un posible almacén, basado en un conocimiento detallado, tanto geológico como ambiental, técnico, económico y social.

PilotSTRATEGY está financiado por el programa de investigación e innovación Horizonte 2020 de la UE y comenzó oficialmente en mayo de 2021. Expertos en geología, ingeniería, ciencias ambientales y sociales, investigarán la tecnología de almacenamiento a escala piloto, en colaboración con los usuarios finales y con los actores sociales clave.

El estudio se centrará en cinco regiones del sur y el este de Europa (Francia, Portugal, España, Grecia y Polonia) y en su capacidad de almacenamiento en los acuíferos salinos profundos seleccionados.

Desde un enfoque transdisciplinar e interdisciplinar, **PilotSTRATEGY** promueve un modelo ético de investigación e innovación responsable. La investigación y el desarrollo de tecnologías sostenibles no es sólo una tarea técnica, sino que implica procesos sociales en el contexto más amplio de la concienciación sobre el cambio climático. Por ello, PilotSTRATEGY tiene en cuenta a los actores sociales clave y a las comunidades locales en el proceso de investigación a través de diálogos y talleres, para garantizar que sus perspectivas estén plenamente representadas. Los resultados obtenidos se harán públicos, como en cualquier investigación financiada por la UE.

El equipo de **PilotSTRATEGY** se ha comprometido a crear una plataforma en la que agencias nacionales, organismos de investigación, industrias locales y representantes de las comunidades locales puedan examinar las percepciones sobre las tecnologías CAC y valorar juntos las posibles decisiones y soluciones.

Principales objetivos de PilotSTRATEGY:

- Estudio de los acuíferos salinos profundos por su gran capacidad de almacenamiento de CO_2.
- Apoyo de proyectos piloto de almacenamiento seguros y eficaces.
- Entendimiento de los factores que afectan a la percepción de la CAC e implicación de los ciudadanos y actores sociales clave.

The PilotSTRATEGY project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101022664

Pilot STRATEGY

Accelerating CO_2 storage for a sustainable future

CO_2 geological storage in strategic territories
Building a low-carbon, climate-resilient future:
secure, clean and efficient energy

Coordinator: Dr Fernanda M.L. Veloso, BRGM (f.veloso@brgm.fr)

PilotSTRATEGY en España

La zona Cuenca del Ebro es el área española seleccionada para el proyecto PilotSTRATEGY. El equipo de trabajo está formado por organismos de investigación –en particular, el Instituto Geológico y Minero de España (IGME-CSIC), coordinador y responsable de la caracterización geológica, y viabilidad técnica y normativa; y el Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), que contribuye al análisis de los riesgos, la seguridad, y el rendimiento, así como al estudio de los procesos de percepción social e implicación con la comunidad-, y tal como recomienda la Comisión Europea, por un socio industrial –en nuestro caso, REPSOL- que facilita la transferencia de tecnología mediante su apoyo técnico y operativo.

Siguiendo la misma aproximación que nuestros socios, el objetivo de PilotSTRATEGY es estudiar en detalle una determinada estructura, para poder tomar la decisión de si es adecuada y segura para el almacenamiento geológico de CO2, incorporando su análisis geológico, técnico, ambiental, económico y social. Este análisis servirá de guía a futuros estudios y aplicaciones.

Para este estudio se ha incluido un acuífero salino profundo caracterizado por depósitos de arenas triásicas sellados por facies arcillosas. Se han definido como ámbito geográfico de interés dos comarcas de Zaragoza (Campo de Belchite y Comarca Central- excluyendo ciudad de Zaragoza) y dos comarcas de Teruel (Andorra-Sierra de Arcos y Cuencas Mineras).

Esta región se caracteriza por su constante despoblación, que se ha exacerbado luego del cierre de las minas y de la central eléctrica de Andorra. Se destaca por su diversidad de espacios naturales, tales como: la cuenca del río Aguasvivas, el Monumento Natural de Órganos de Montoro, el Parque Cultural del Maestrazgo y la reserva natural del Galacho de la Alfranca de Patriz, La Cartuja y El Burgo de Ebro, entre otros.

Objetivos de la investigación social en PilotSTRATEGY:

- Comprender las actitudes, preocupaciones y necesidades de la población local y de los principales actores sociales en relación con el almacenamiento geológico de CO_2.
- Contribuir a la selección de los emplazamientos específicos
- Conceptualizar la percepción local de la tecnología CAC en el contexto nacional y europeo.
- Establecer y reforzar la participación de las comunidades locales y de las partes interesadas.
- Desarrollar recomendaciones válidas de implicación ciudadana.

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The five-year PilotSTRATEGY project, which commenced in 2021, has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 101022664.

pilotstrategy.eu
info@pilotstrategy.eu @PilotSTRATEGY /pilotstrategy pilotstrategy

Figure 22 PilotSTRATEGY project brochure

Evalúa la Captura y Almacenamiento de Carbono en las siguientes dimensiones:

Selecciona un valor entre el 1 y el 7

Innecesaria	1	2	3	4	5	6	7	Indispensable
Convencional	1	2	3	4	5	6	7	Innovador
Muy costosa	1	2	3	4	5	6	7	Muy económica
Peligrosa	1	2	3	4	5	6	7	Segura
No altera la naturaleza	1	2	3	4	5	6	7	Altera la naturaleza
Nada beneficiosa para la economía local	1	2	3	4	5	6	7	Muy beneficiosa para la economía local.

Figure 23 CCS evaluation in the following dimensions

Comentarios

Escribe, si lo consideras oportuno, cualquier aspecto o idea que te parezca relevante sobre la Captura y Almacenamiento de Carbono

Figure 24 CCS evaluation: open question

The PilotSTRATEGY project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101022664

A.1.3.6.2. Annex 2. Introductory materials

Figure 25 Front cover of the presentation

TECNOLOGÍAS CAC | ¿En qué consisten? ¿Qué podemos hacer con el CO2?

Figure 26: CCS introductory video

The PilotSTRATEGY project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101022664

A.1.4. Second Meeting Report Spain (Christian Oltra, Lila Gonçalves, CIEMAT), June 2025

A.1.4.1. Introduction

The PilotSTRATEGY project, funded by the Horizon 2020 programme, is investigating the technical, economic, and social feasibility of CO_2 storage in three strategic European basins: the Paris Basin (France), the Lusitanian Basin (Portugal), and the Ebro Basin (Spain). The consortium recognizes that, beyond geological and engineering aspects, the success of any carbon capture and storage (CCS) infrastructure depends crucially on its social integration.

Within this framework, Work Package 6 (WP6), focused on "Social Acceptance and Public Participation," seeks to incorporate empirical evidence on the attitudes, emotions, and interpretive frameworks of the local population. The ultimate goal is to translate this information into operational recommendations that improve public participation, risk and benefit communication, and project engagement channels. This approach is aligned with action research: generating useful knowledge while creating spaces for dialogue that reinforce the project's legitimacy.

In its initial phases (2023-2024), the project developed community profiles, stakeholder interviews and general acceptance surveys, revealing low familiarity with the technology and marked caution regarding perceived risks. To meet the objectives of WP6, a hybrid consultation and research methodology was designed in 2022 and implemented first with residents in the town of Belchite, in the Ebro Basin, in 2023, and with residents in the town of Quinto in 2025. This methodology combines face-to-face focus groups with stimulus materials—which facilitate mutual learning and the expression of concerns—with a thematic analysis that integrates deductive categories (derived from literature and previous surveys) and inductive subcodes emerging from local discourse. In this way, the qualitative data not only describe current attitudes but also reveal the conditions under which the community might view CO_2 storage as an opportunity, while also identifying critical points that could hinder its acceptance.

The social science literature applied to emerging energy technologies highlights five essential analytical dimensions: perceptions of risks and benefits and their equitable distribution, emotions, conditions of acceptance, perceived process legitimacy, and trust. This theoretical framework has the potential to serve as a basis for linking empirical findings with communication strategies based on proactive transparency and participatory governance and institutional design tools (such as citizen committees or local benefit funds).

This report summarizes the findings of the qualitative phase, providing the PilotSTRATEGY consortium with a precise tool to assess communication risks, design benefit packages, and establish engagement mechanisms that credibly and verifiably meet the expectations of Quinto and the Ebro Basin as a whole.

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A.1.4.2. Method

General Design

An applied qualitative exploratory design was used to capture the diversity of perceptions, emotions, and judgments of Quinto residents regarding the potential implementation of a geological CO_2 storage site. This study is conceived as an "instrumental case study": focus groups are not an end in themselves, but a means to identify critical factors that can guide the European consortium's communication and participation strategy.

Data collection technique

Two face-to-face discussion groups, each lasting 90–100 minutes, were held at the Casa de Cultura in Quinto during the second half of June 2025. The dynamics included semi-structured questions and the use of visual stimuli (emotion cards, infographics of the CCS cycle, and a scale map of the subsoil), following the moderation protocol agreed upon by the research team. All sessions were audio-recorded, transcribed verbatim, and anonymized using alphanumeric codes. The moderator's field notes complemented the verbal records.

Sample

Participant selection was purposive and stratified by sex, age range (18-35, 36-55, >55). Group 1 (n= 6) included young and middle-aged individuals employed in the service sector and agriculture. Group 2 (n= 7) was composed of older participants, neighborhood leaders, and two individuals associated with nearby farms. This sampling sought to maximize discursive heterogeneity without compromising territorial coherence.

Protocol

The sessions were structured in four progressive blocks, designed to explore participants' perceptions in depth:

- Initial emotional reactions to the idea of CO_2 storage.
- Exploring risks and benefits
- Conditions of acceptance.
- Reflection on trust, legitimacy and information needs.

Each block included open-ended questions to encourage discussion and prioritization activities (e.g., "Choose and justify the three emotions that best describe your feelings").

Hybrid thematic analysis

Transcripts were processed using NVivo 14 software, applying a hybrid deductive-inductive approach to thematic analysis.

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Five deductive macro-themes were derived from the specialized literature and the project objectives:

Macro-theme	Current sub-codes (examples)
Emotions	Fear, Curiosity, Hope, Restlessness, Skepticism
Perception of risks and costs	Leaks, Aquifer contamination, Overpressure explosion , Affected underground fauna, “Experimental project”, Distributive justice
Perception of benefits	Local employment, Economic revitalization, Taxes and infrastructure, Global climate benefit, Municipal reputation/visibility
Conditions of acceptance	Control and monitoring, tangible compensation, citizens' committee, territorial equity, right to veto, information and transparency.
Legitimacy & trust	Distrust in government/business, Transparency of permits, Comparison with failed renewables, External audits

During an immersive reading of the material, additional, inductive sub-codes emerged (e.g., "Distributive Justice," "Information & Transparency"), which were incorporated into the framework after reaching consensus on inclusion/exclusion criteria. The analytical process followed the six phases of Reflexive Thematic Analysis. Braun and Clarke analysis: familiarization with the data, initial coding, search for themes, review, definition and naming of themes, and production of the report, adapted to an applied context.

A.1.4.3. Results

The first table presents the conceptual structure of our analysis: each macro-theme groups a set of sub-codes that capture the nuances of local discourse. Thus, *emotions* combine feelings ranging from fear and anxiety—predominant when evoking leaks or explosions—to curiosity and hope linked to hypothetical benefits. *Perception of risks* and costs branches into technical risks (leaks, overpressure), ecological risks (aquifer contamination, effects on underground fauna), and sociopolitical risks (the idea of an "experimental village" and distributive justice). Symmetrically, *the perception of benefits* encompasses both "hard" returns (employment, taxes, infrastructure) and symbolic gains (climate reputation, external visibility).

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Macro -theme	Subcodes- emerging	Definition operational	Literal example
Emotions	• Fear (safety, unknown, leaks) • Curiosity • Hope • Wonder (why here?) • Skepticism / Concern	Explicit affective reactions to the project.	"If a large volume is concentrated and there is a leak, it can still be quite dangerous" (G1)
Perception of risks and benefits	• Risk of leak -/explosion • Contamination of aquifers • Long-term risk/"experiment" • Local economic benefit • Employment and population retention • Global environmental benefit	Cognitive evaluations of negative or positive consequences.	"The simplest benefit is the economic one… rentals, bars, it gives life to the town" (G1)
Conditions for acceptance	• Continuous safety and monitoring • Financial compensation/infrastructure • Local participation and veto rights • Preference for CO_2 use over mere storage • Territorial equity	Stated requirements to support or tolerate the project.	"Continuous safety monitoring… if it's not secure, no one will accept it" (G2)
Legitimacy & trust	• Distrust in companies, government, and technology • Comparison with failed renewable projects • Transparency regarding permits and profit sharing	Judgments on the fairness of the process and the credibility of the actors involved.	"If they don't see money in one of those three legs, they'll back out" (G2)

The *conditions of acceptance* macro-theme acts as a hinge between risk and opportunity: the community explicitly sets out control and monitoring requirements, demands tangible compensation, and elevates the demand for information and transparency to the rank of a key sub-code, along with the creation of a citizens' committee, the right to veto, and territorial equity. Finally, *legitimacy & trust* revisits the local history of broken promises—particularly in renewable energy—and translates it into demands for external audits and transparent administrative

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processes. Overall, this hybrid taxonomy (deductive + inductive) ensures that no significant nuance is left out of the analytical framework.

A.1.4.3.1. Emotions

The dominant affective reaction is ambivalent. Technological innovation arouses curiosity and hope, especially in Group 1, who envisions opportunities for community revitalization. However, these positive emotions alternate with a fear of the unknown. This fear is not expressed as immediate panic, but rather as concern about long-term escape or accident scenarios, reflecting "conditioned optimism."

For example, one participant from Group 1 combines hope, curiosity, and fear in a single statement, basing his optimism on the possibility of "more services and housing" but acknowledging his concern about unforeseen events. This nuanced discourse contrasts with the intensity of another participant from Group 2, who explicitly lists the explosion, contamination, and uncertainty about the location as direct sources of fear.

In Group 2, skepticism quickly emerges and mingles with astonishment, leading to the implicit question: "Why here?" This surprise translates into suspicion that the town may be a "guinea pig," reinforcing the negative emotional charge. Despite this, both groups demonstrate the ability to rationalize fear ("every project has a residual risk") and relegate it to the background when they perceive tangible benefits.

Finally, emotions serve as discussion triggers. The use of emotion cards during the dynamic facilitated the transformation of fear into technical questions and curiosity into concrete proposals (such as visits to similar projects or on-site demonstrations).

Macro-theme	Sub-code	Cluster	Literal quote
Emotions	Curiosity / Hope	G1	“It could be interesting… I imagine it would have a positive impact on money… then curiosity about the risks, and in the end, a little fear because you never know what's going to happen.”
	Fear + Skepticism + Wonder	G2	“Fear, fear at first… Skepticism and astonishment, because here they said it would have to be in areas near the sea.”

A.1.4.3.2. Perception of risks and costs

The risks mentioned by participants focus on three main areas: subsoil integrity (leaks, overpressure explosions), aquifer contamination and its direct impact on agriculture, and logistical risks associated with CO_2 transport. Group 2, in particular, emphasizes environmental impacts ("underground fauna," "aquifers for sure"), while Group 1 introduces the idea of an "experimental village," alluding to a reputational risk in addition to a physical one.

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One participant in Group 1, for example, expresses concern by imagining CO_2 infiltrating aquifers through the rock, insisting that "you can't isolate that." Group 2 amplifies this concern, adding impacts on underground fauna—a less obvious but symbolically potent risk—as one participant points out.

It's important to emphasize that most fears are articulated through analogies (butane, renewables that never came online, slurry pits) rather than specific data on CCS. This indicates a lack of concrete information but also suggests effective communication channels.

Finally, the discussion reveals a perceived risk of inequity: the idea of "everyone stockpiling their own." When risk is perceived as imported from other regions, local resistance increases.

Perception of risks and costs	**Leaks / Water Contamination**	**G1**	**"I'm afraid it'll go into the water; that can't be isolated."**
	Water Pollution + Fauna	G2	“Groundwater will be contaminated no matter what… and so will underground wildlife.”

A.1.4.3.3. Territorial equity and distributive justice

A recurring theme is the feeling of being an "experimental village" or of being burdened with foreign CO_2. This perception transcends the risk/benefit logic and is situated within the realm of spatial justice:

- "They'll take advantage of us because we're a small town; they'd face more opposition elsewhere." – G1·Or. 6
- "Why here and not at sea?" – G2·Or. 3

This discourse includes sub-codes such as "let everyone store their own," comparisons with coastal areas, and concerns about reputational risk or stigma.

A.1.4.3.4. Perception of benefits

Benefits act as a narrative pivot: they are invoked to justify the project's acceptance ("it gives life to the town"), but also to assess the developer's legitimacy. Group 1 imagines a pull effect similar to that of the GM plant in Figueruelas, anticipating indirect employment, increased rents, and the maintenance of local services. In contrast, Group 2 adopts a more transactional stance, prioritizing direct incentives for residents and questioning whether the money is diluted within the municipality without directly reaching families.

For example, for one participant in Group 1, the Figueruelas case legitimizes the promise of urban transformation—paved streets, a new swimming pool—and serves as a precedent to which Quinto aspires. In Group 2, one participant takes a more direct approach, conditioning project acceptance on "if there are any benefits" for the residents and the creation of tangible jobs.

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Both "soft" benefits (climate reputation, local pride) and "hard" benefits (jobs, infrastructure) emerged in the discourse. The notion of net benefit also stands out: the community accepts the risks if it perceives the overall equation to be positive and verifiable. Therefore, the proposal for "benefit packages" with time-bound milestones aligns well with community logic.

An important strategic nuance is that part of the discourse suggests a preference for using CO_2 (for e-fuels and materials) over simple storage. Integrating recovery pathways—even in the medium term—would add considerable symbolic power to the project's benefit argument.

Perception of benefits	**Local economic revitalization**	**G1**	**“The simplest benefit is economic… rent, bars, everything. Those things give life to the town.”**
	Direct incentives to residents	G2	“As long as it's safe, I'm more inclined to go for the money. Financial incentives for residents... I'm happy.”

A.1.4.3.5. Conditions of acceptance

Both groups construct a conditional checklist: strict safety, information transparency, tangible benefits, and an active citizen voice. Group 1 delves deeper into the concept of "continuous safety monitoring," even discussing the implementation of sensors and external audits. Group 2, meanwhile, adds the requirement for binding participation, exemplified by the demand for citizen committees and the right of veto.

Local voices develop a true psychological contract. One participant from Group 1 summarizes the fundamental condition: "If it's not safe, no one will accept it," linking continuous monitoring with possible compensation. Another participant from Group 2 adds the procedural dimension, emphasizing that the city council "will have to require the company to report on all inspections."

These conditions function as uncertainty reduction mechanisms. Promises are not enough; those interviewed want institutionalized processes that will last "the entire life of the project." The idea of a "local fund" managed by a joint body (city council, residents, and technicians) is seen as a practical solution to align the project's safety, benefits, and legitimacy.

It's important to emphasize that conditionality is dynamic. If trust diminishes, the demands become tougher (more compensation, greater oversight). Therefore, the engagement strategy must include periodic monitoring of the social climate and the flexibility to renegotiate commitments as community perceptions evolve.

Much of the debate revolves around how, when, and who should provide data on safety, controls, and project phases. The central demand is "radical transparency":

- "...damn transparency. Let's not let two months go by without knowing if there are jobs or if there's been a leak." – G2·Or. 2

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- "The important thing is to inform, to inform transparently, openly... factions, networks, plenary sessions" – (Summary of the G2 demands by the moderator)
-

Conditions of acceptance	Continuous safety monitoring	G1	"Continuous safety monitoring… mechanisms to keep the population informed throughout the life of the project"
	Community participation	G2	"The city's participation in decision-making… we are the ones at risk."

A.1.4.3.6. Legitimacy and trust

The underlying mistrust in the community stems from previous experiences with renewable energy projects and unfulfilled political promises (e.g., electricity bills, local employment). Institutions are perceived as distant actors, and the developer as primarily profit-oriented. In this context, the project's legitimacy is built on two fundamental ingredients:

1) Radical transparency: Access to open monitoring data and clear public contracts.
2) Fair distribution: Clarity on who benefits, how much and when.

One participant from Group 1 fears that key data will be withheld "because it's not convenient at the time" and demands absolute transparency. In Group 2, another participant cited the example of dead projects of renewable energy plants to justify his skepticism, arguing that if the three "pillars" (business, administration, politics) don't see a clear benefit, they will halt the project.

Comparisons with these projects that did not succeed fuel the idea that initial announcements don't guarantee tangible results. Therefore, participants are demanding binding guarantees: reversion clauses, penalties if the promised benefits don't materialize, and independent external audits.

At the same time, a moral judgment emerges in the community: "the polluter pays." In the eyes of residents, storing foreign CO_2 without fair compensation would be unacceptable. To strengthen legitimacy, the consortium should prioritize local emissions in the initial phase of the project and explain clear criteria for the admission of foreign CO_2.

In short, community trust is fragile, but not nonexistent. It thrives on consistency between rhetoric and action and can be cemented if the decision-making process incorporates citizen oversight mechanisms from the outset of the project.

Legitimacy & trust	Broken promises (cost-benefit)	G1	"A council member told me the windmills would lower the electricity bill… they've been there for days and it hasn't gone down."
	Comparison with failed renewables	G2	"It'll be like in many renewable energy areas... lots of job opportunities, but then nothing was activated or done; it's just sitting there, it's disgusting."

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A.1.4.3.7. Co-occurrence patterns

In addition to presenting the thematic findings individually, it is essential to examine how they interrelate within the community discourse. Co -occurrence analysis, based on a matrix that cross-references each pair of macro-themes and sub-codes across the transcripts, allows us to identify the moments in which residents connect, within a single intervention, risks and benefits, conditions and trust, or emotions and attributions of justice. Co -occurrences and their practical implications for the project's communication and governance strategy are summarized below:

Pair of macro-themes	Number of occurrences	Applied reading
Benefits × Risks	**21**	The “cost/benefit balance” debate typically arises when someone raises the question “jobs vs. pollution leakage.”
Benefits × Conditions	**16**	“If tangible benefits come (taxes, housing), we accept.”
Benefits × Legitimacy	**14**	Distrust about **who** controls and distributes the benefits.
Benefits × Emotions	**13**	Hope/local pride versus fear.
Conditions × Legitimacy	**11**	Request for citizen committees as a guarantee of transparency.
Risks × Emotions	**9**	Explicit fear linked to leaks and explosion.

- Benefits as a central axis: Most thematic connections emerge when discussing benefits. This is the point where the community contrasts "what I gain" with the perceived risks (leaks, explosions), the conditions of acceptance (requirement of technical guarantees), and the legitimacy of the promoter. This confirms the central role of benefits, acting as a discursive hinge between the economic and sociopolitical dimensions, as the conceptual map already suggested.

Applied reading: The debate focuses on a "cost/benefit balance," where the community evaluates the equation "employment vs. leakage/pollution."

- Risk-emotion relationship: Mentions of leaks or explosions are almost always accompanied by intense emotional language (fear, amazement). This connection has a double effect: it intensifies attention to the risk and raises questions about the fairness of the location ("Why here?"). For the communication strategy, differentiating emotion from technical assessment—for example,

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through visual simulations that reduce uncertainty—will help moderate the perception of danger.

Applied reading: Explicit fear is directly linked to concerns about leaks and explosions.

- Conditions and legitimacy: Binding participation and full transparency appear repeatedly linked in the discourse. This suggests that it's not just about informing, but about who controls the information and how. Designing a citizens' committee with access to raw data and symbolic veto power could provide a simultaneous and robust response to both demands.

Applied reading: The request for citizen committees is perceived as a fundamental guarantee of transparency.

- The memory of past promises: The intersection of benefits and legitimacy reveals how memories of failed energy policies (e.g., unused wind turbines or solar panels) erode the project's current credibility. The practical message is clear: every promise of local returns must be accompanied by concrete verification mechanisms and defined timelines to avoid the narrative of "just another project selling us smoke."
- Cost/Benefit balance as a dominant narrative: When the same participant states a benefit and, in the same sentence, a risk ("we'll make money, but if it leaks, we're lost"), it demonstrates that social valuation is simultaneous, not sequential. This implies that the communication should reflect this logic, presenting safety and trade-offs in an integrated manner (e.g., on the same slide or fact sheet) to reinforce the perception of coherence.

The examples mentioned illustrate how codes interact within real-world discourse and underscore the need for communication interventions—and governance design—that address code pairs in an integrated manner, rather than in thematic silos.

Code pair (macro-topic → sub-codes)	Fragment in which they co - occur	Analytical reading
Perception of benefits (economic revitalization) × Perception of risks and costs (leakage + water)	"The simplest benefit is economic... rent, bars, everything; now, if it leaks into the water, we're lost, because that can't be isolated."	In a single turn, the speaker weighs the immediate economic gain against the threat to the aquifers, illustrating how residents calculate a cost/benefit balance before forming their attitude.
Perception of benefits (direct incentives) × Conditions of acceptance (demonstrable safety)	“If they give me money, I’ll be delighted… as long as it’s safe and there are controls we can see.”	Money only works as an incentive if it's accompanied by visible technical guarantees; the "control we can see" condition acts as a safeguard for the incentive.

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Code pair (macro-topic → sub-codes)	Fragment in which they co - occur	Analytical reading
Perception of benefits (municipal revitalization) × Legitimacy & trust (unfulfilled promises)	"They say they'll paint the town like they did in Figueruelas , but they already promised us cheap electricity with the windmills, and it didn't happen."	Projected profits are reversed when a previous failed commitment is recalled: the memory of unfulfilled promises erodes the legitimacy of new offers.
Perception of risks and costs (leak + explosion) × Emotions (fear + astonishment)	"Fear of an explosion and of water pollution; also, astonishment that they're bringing it here instead of to the sea."	Emotion (fear/wonder) intensifies the perception of physical risk and at the same time legitimizes the question “why here?”, connecting affect and attribution of intentions.
Conditions of acceptance (binding participation) × Legitimacy & trust (full transparency)	"The city council will have to require the company to report all inspections to a committee that includes us."	The participant merges the need for transparency with the institutional design of participation, showing that both codes reinforce each other: without citizen voice, declared transparency is not credible.

A.1.4.4. Conclusion

The qualitative analysis of citizen perceptions in Quinto regarding the CO_2 geological storage project reveals a scenario of conditional and pragmatic acceptance, far from outright opposition or unconditional support. The community does not evaluate the project in the abstract, but rather through a rigorous cost-benefit analysis where the promises of local development must outweigh the perceived risks and a historical distrust of large energy projects.

The results demonstrate that, while legitimate fears exist—focused on subsoil safety and aquifer contamination—citizen discourse is largely dominated by the expectation of tangible benefits. Economic revitalization, job creation, and infrastructure improvements act as the main drivers of potential acceptance. However, this favorable disposition is subject to a set of non-negotiable conditions that constitute a true implicit social contract between the project and the territory.

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This contract is based on three fundamental pillars:

1) Safety and transparency: The community demands verifiable technical guarantees and continuous, accessible monitoring. It's not enough to simply claim that a project is secure; it's essential to consistently demonstrate this and allow for public scrutiny through mechanisms such as citizen committees with access to real-time data.
2) Distributive justice and verifiable benefits: Skepticism, fueled by previous experiences with broken promises, requires that any benefit package be concrete, time-bound, and include compliance clauses. The perception that Quinto could take on disproportionate risks ("experimental village") must be countered with fair benefit sharing and a narrative that positions the community as a partner, not a mere location.
3) Earned legitimacy: Trust is not a starting point, but an outcome. It must be actively built by devolving power and control to the local sphere. The creation of binding participatory bodies, respect for a potential veto right, and transparency in all administrative processes could be crucial to transforming distrust into legitimacy.

In short, the success of the PilotSTRATEGY project in the Ebro Basin will depend not only on its technical solvency, but also on its ability to design and implement a territorial integration strategy that credibly responds to these three demands. The Quinto case offers a clear roadmap: social acceptance of CO_2 storage is not imposed, but rather negotiated and built through evidence, equity, and genuine participation. The operational recommendations derived from this study should provide the consortium with the precise tools to initiate this process, turning social uncertainty into an opportunity for the co -creation of a socially robust and legitimate project.

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A.1.5. France (Marc Poumadère & Claire Mays, Symlog)

A.1.5.1. Context

In France, the citizen engagement task adopted a specific format and started early in the project to accommodate a particularity of the French research context: the seismic 3D data acquisition campaign of May-June 2022. Conducted in a region containing generally familiar subsurface applications (oilfields), these geophysical studies materially involved pertinent local actors and the general population of the study zone (a 10x10km area).

The local acquisition campaign was significant from several perspectives: the data was vital to achieve PilotSTRATEGY's subsurface geophysical characterization in France and at the same time, this first appearance of PilotSTRATEGY in the community promised to be highly visible to a variety of local people over the course of five weeks. Small captors (geophones) had to be inserted in agricultural fields and later retrieved, and conspicuous vehicles (heavy, slow-moving trucks producing unusual although not severe vibration) would circulate on local roads. Perhaps most significantly, the implementation of the campaign required local individuals to make a concrete decision in the very short term (practically immediate): whether or not to grant right-of-way.

As an impactful local intervention, the campaign was accompanied by primary project information. This framed the research by climate change mitigation, and explained the seismic 3D data collection approach. The information was imparted in an operational goal: researchers had to request access to farm fields and along roads. This dynamic of information and permission was conducted through two-way dialogue with landowners, elected and administrative officials; furthermore, collective presentations were hosted by the local Chamber of Agriculture, enabling small group and bilateral conversations. These exchanges allowed all parties to become acquainted, to trade information and requests, expectations or demands, and in particular to air local stakeholders' questions, opinions, and evaluations.

In this way, citizen engagement around real decisions relevant to geological carbon storage was *de facto* undertaken in this very interactive and locally meaningful context. It was decided to continue along this vector in the French study region, creating periodic opportunities to share the scientific knowledge of the area gained through research, and to foster exchanges with any and all interested local stakeholders and residents[2]. The informative content would reflect advances in project study activities, and thematic discussion would be guided by participants' interests and concerns.

Importantly, the events would be organized with the neutral support of local institutions (chamber, municipal groupings and town halls). Without pronouncing a "for or against" judgment with respect to project activities or any future pilot installation, these institutions provided rooms and publicity, viewing as their mission and responsibility to keep the local population well-informed and to enable

[2] As such, the citizen engagement events in France would not closely match those organized in Spain: formally structured, repeat focus groups with targeted exercises and participants recruited from "naïve" populations. The France and later Portugal events would be more comparable, with well-disseminated invitations opening doors to any interested visitors, with interactions around exhibited materials and formal talks, and gathering diversified feedback from the participants. The French formula also increasingly laid the accent on interactions among citizen participants.

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debate. This effective partnership demanded a similarly high level of transparency and responsibility on the part of researchers.

This chapter briefly recounts the first engagement with citizens in the context of the French data acquisition campaign. Then, it provides some detail on the three "open door" meetings organized subsequently in the French study zone. It shows the influence of the organic engagement on other project activities, interprets the findings, and includes examples of citizen output from the earliest and the final meeting.

The first *de facto* engagement with citizens took place in France during the preparation of the extensive 2022 seismic data acquisition campaign (pilotstrategy.eu/news/blog-3d-seismic-acquisition-grandpuits-france). This non-destructive approach commonly used in oil and gas exploration detects subsurface geometry and petrophysical characteristics. It relies on geophones, captors of vibrations emitted to the ground by trucks and reflected back to the surface. The seismic waves (vibrations) reach a depth of hundreds of meters and return carrying an image of the underground layers that successively interrupt and reflect back part of the transmitted energy.

Informal and formal permission was requested of two categories of actors. Some 80 landowners were asked to allow the temporary installation in their fields of geophones (totaling about 5000 units). Administrative and elected officials were asked to authorize vibrator trucks to circulate. In this goal, direct contacts took place between researchers and local actors (farmers, municipalities, and road administrations). Through emails, phone calls and face-to-face exchanges, these stakeholders were informed in detail about the project and the campaign. In parallel, to inform the larger general population notification leaflets were prepared with a short presentation of the project, announcing and describing the research technology that would be applied over the course of 5 weeks, framed by climate change mitigation goals. The leaflets were distributed to household mailboxes in the communities touched by the central study zone (potentially reaching more than 20,000 inhabitants).

Two small meetings were organized at the Chamber of Agriculture, with technoscience and social science researchers providing information and available for dialogue. Farmers, elected officials, and other interested residents attended. Local perspectives and comments were gathered, including reasons for granting or refusing right-of-way (see Annex I: Categories of arguments to refuse or grant right-of-way). In fine, access would be granted by 80% of the farmers, as well as by all municipalities except one, and by all departmental authorities (for the main roads). The overall experience was described and interpreted in two internal reports prepared by the social science partners, shared and reflexively discussed among the French team.

This concrete and organic experience of preparing a field intervention suggested that an open-door format would be well-adapted to continue engagement with the local citizens, enabling discussion between researchers and citizens, and also among participants themselves on the basis of project information.

The first open-door meeting took place in Nangis, the capital town of the Community of Communes of Brie Nangissienne (CCBN), on May 13, 2022. It coincided with the seismic data acquisition field operations, which involved significant local activity in May and June as detailed above. The meeting was organized in cooperation with the president of the CCBN which provided a room. Interactions

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alternated between formal presentations and informal conversations, with subgroups forming and discussions continuing in the outside patio.

Two significant issues emerged from the discussions, which would have follow-on implications for the conduct of the campaign and other project activities.

One recurring concern was the potential impact of vibrator trucks on ceramic drains in the fields. This issue had consistently appeared in previous meetings with the Chamber of Agriculture and individual talks with 80 farmers to obtain right-of-way on their properties. It was unclear on the face of it why this issue would be so salient. Although a subsurface object, the drains are hardly an issue from a geological perspective as they are located between 60cm to 1m underground. From an economic standpoint, the cost of ceramic drains is low and any damage would be covered by the 3D seismic research company's insurance. Following the open-door meeting, an interdisciplinary discussion within the French team brought into consideration the symbolic dimension of the drains: they are part of local heritage and have a historic and sentimental value (as well as practical), in that the ceramic drains were installed several generations ago in fields transmitted through family ties. This collective insight led to the integration of the drains as a new and legitimate PilotSTRATEGY research object, enabling additional technical actions specifically centered upon the drains (georadar to locate and avoid them; stress tests), and cooperation in depth with the concerned local elected people and farmers to reach a mutually satisfactory solution. The care shown by the research team for the drains as a socially valued local entity can be seen in this context as a reciprocal gesture, matching the attention and adaptation requested from this population confronted by a complex, localized technoscientific research project[3].

Another topic concerned the economic benefits the community could expect from any future geological CO_2 storage. As direct job creation appeared limited[4], the question of *social recognition* for a community contributing to climate change mitigation was raised. This discussion led the researchers to include an unanticipated question in PilotSTRATEGY's local population opinion survey of Summer 2022: "In your view, how important is it to grant social recognition to the local community for their contribution to climate change mitigation?" Another related question was added: "To what extent would you feel proud if your area contributed to climate change mitigation through underground CO_2 storage?" These questions garnered a strong majority of positive responses from among the approximately 235 local residents who replied (see Annex II: Local

[3] This learning experience proved useful when later a commune reported leaks in its water network following the passage of the vibrator trucks. A meeting was organized with the mayor of the commune, technicians, and water utility. Uncertainty prevailed at the end: leaks are common in the water network, the vibration levels would not normally damage such infrastructure, and the trucks' route was at a distance. Evidence of a causal link was not found, but concern associated with the uncertainty remained. It was therefore decided to take into account the disquiet caused by the PilotSTRATEGY field work, and to perform a video inspection of the sewage network, sharing the moderate cost three ways among the project coordination, the 3D seismic data collecting company and the municipality. Possible fissures were sought in order to anticipate any delayed consequences, in that leaks would be less apparent in the short term because unlike the water distribution network, sewage lines are not pressurized. The inspection revealed no damage. This cooperation amounted to a reduction of uncertainty through a combined technical and transdisciplinary solidarity approach.

[4] During later meetings, discussion about economic and social benefits considered how industrial activity and employment in the area might possibly be maintained through carbon storage service provision, along with royalties per ton of injected CO_2 by analogy with the geological storage of natural gas.

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population survey results for additional questions regarding social recognition), depicting a striking and unexpected consensus.

Thus, this first period of citizen engagement and interdisciplinary reflection enabled PilotSTRATEGY partners to better understand, acknowledge and adaptively act upon the concerns of the farmers about an unexpectedly salient feature of their subsurface: the ceramic drains. Additionally, discussions with participants about potential future benefits led to the inclusion of a previously unplanned dimension in the opinion survey (social recognition and pride), building a bridge between citizen engagement and the quantitative survey approach.

The second open-door meeting took place on June 8, 2023. Following discussions with elected officials after the first meeting about attracting more attendees (as their own public meetings had limited audiences), it was jointly decided to hold the meeting in the large communal multipurpose venue. Furthermore, the meeting would be called “Apéro - Portes Ouvertes”, implying snacks and drinks, and moreover a friendly and informal gathering (as per the French expression “apéro,” short for *apéritif*). The commune added their network to the project’s mailing lists to send invitations, and the event was announced on the municipal website.

The meeting aimed to present the project progress, including results obtained from the 3D seismic data acquisition campaign (after lengthy analysis of the 10 terabytes of acquired data). Each major project activity was highlighted in a dedicated large poster and some written summaries were printed, as well as a sign-up sheet to join the PilotSTRATEGY regional stakeholder committee. A more diverse audience of 40 persons attended. They included members of a small local NGO (which had previously distributed two leaflets opposing CCS and declined to join the regional stakeholder committee) as well as a journalist from the local newspaper who subsequently published an article on the project and the exchanges. The participants were seated theater-style in rows facing the project speakers.

This second experience showed lively and confrontative engagement from citizens, disrupting the planned schedule of plenary presentations to be followed by parallel discussions grouped around the diverse posters. The presentations were interrupted by audience questions, rapid-fire and sometimes called out before previous questions were fully answered.

Views on the possible risks of carbon storage were voiced confrontationally, referencing the 1986 natural disaster at Lake Nyos, Cameroon and a local well historically used (under permit) for industrial wastewater underground storage. A reply describing the project’s approach to risk assessment for CO_2 storage leaks prompted a discussion about who decides what constitutes an acceptable risk.

Local industry representatives, particularly from the local CO_2 emitter company, attended, facilitating discussions about its future, as the local population expressed concerns regarding rumors about the fertilizer plant's closure.

Such direct communication between local industry and the community was much needed, and the PilotSTRATEGY meeting unexpectedly enabled it. The research team showed flexibility, adapting to the audience’s demands. Besides scientific content, the meeting allowed for free expression of local concerns and opinions. All attendees stayed for the buffet and discussions continued.

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The **third open-door meeting** occurred on May 31, 2024, at the same location with the same communal partners as the previous meeting, again featuring the “apéro” format. About 25 people took part: local residents, farmers, elected representatives and administrators from various townships, environmental associations, and industrialists. On hand to present the work and to exchange ideas were 12 researchers from three PilotSTRATEGY technoscientific and social science partners. In addition, a French co-author of the 6th report by the Intergovernmental Panel on Climate Change (IPCC) presented the findings of this United Nations body, prompting many questions and in-depth discussion.

The program included a review of CCS's worldwide role in mitigating the climate crisis, of geological storage in deep saline aquifers, and PilotSTRATEGY’s goal to study all parameters for evaluating storage feasibility in the Grandpuits area. The project timeline (ending in April 2026) was positioned in regard to a private operator's contemporaneous initiative to request a research permit from the French administration, which, if obtained (after 1-2 years), would pursue an exploratory pilot with the goal of eventual CO_2 injection (after several more years of permit development). The IPCC presentation drew attention to global climate issues and the panel’s views on CCS.

Based on internal team follow-up reflection on the confrontative nature of the second meeting, a different approach was taken to adapt to the room's large dimensions. A very large projection screen was added for better presentation visibility, and a new communication dynamic was introduced. Participants were seated not in rows, but at small tables. They were invited after the presentations to discuss, in the resulting 6 small mixed groups, the questions they wanted to ask. This format encouraged more sustained thoughtful interactions among participants and with the project staff seated with them and led to the formulation of 34 written questions (see Annex III: Questions gathered from citizen participants in the third open door meeting). About half of these could be answered immediately by the research team, but there was not time to address all.

The questions were later fed back to the regional stakeholder committee to indicate the issues brought up by the local population. The committee meeting itself, in November 2024, was consequently focused on deepening insight into the actual application of CCS worldwide, and reviewing the diverse criteria and methods used to optimize the siting of injection wells. The latter discussion shaped the modeling subsequently deployed by PilotSTRATEGY Work Package 4.

During the internal team debriefing after the third open-door meeting, researchers noted that citizens’ questions were becoming more precise and sophisticated with each meeting, and increasingly challenging to answer; one researcher reflected that at some point there might be questions we cannot answer.

A.1.5.2. Conclusions

The citizen engagement task was approached in France through an open-door format, responding to the experience of the concrete local interactions and decision making stimulated by the 3D seismic data acquisition in the study area. An open-door format allowed real time, co-creative follow-up of the project and its impacts, with respect both to local citizens’ everyday life and to pertinent issues in their context, such as the uncertain destiny of the local fertilizer plant, identified by PilotSTRATEGY as the target CO_2 source/emitter.

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The open-door format had a variety of organic and evolving features, such as the diverse seating arrangements for citizen participants, and diverse roles for research personnel, between formal presenter and participant-observer. In each venue most of the dialogue was sincere and authentic; researchers reflexively highlighted their commitment to transparency and accepted lively challenges; stakeholder posturing was infrequent and easily identified by all when it occurred. The different actors co-constructed research questions and understanding with a high degree of concentration and cooperation, without relinquishing their specific interests.

Although limited in attendance (25-40 persons joined each meeting, with some renewal of participants over the three editions), this organic approach led to significant shared learning. Remaining informal with adaptative changes (such as introducing small group discussion workshops in the third event), the Work Package 6 citizen engagement complemented and influenced other project activities: two questions were added to the survey; concerns were fed back to the regional stakeholder committee; a desired range of criteria were integrated into site concept modeling by Work Package 4; and finally, all records of the French stakeholder meetings were analysed by Work Package 5 to inform the risk analysis and the measurement, monitoring and verification (MMV) plan.

The open-door meetings created an additional mode of dialogue-based interaction with the local population, and also within the research team itself. Indeed, the French research team cooperated to inform and consult with local elected officials to jointly organize this citizen engagement; to create highly accessible, pertinent and interesting scientific information about the project and its advancement; to analyze the input from citizens and provide feedback; and to reflect on how their concerns and perceptions could or should impact the ongoing research conduct.

All in all, effective and sustained reciprocal engagement with citizens around concrete, symbolic, and transdisciplinary objects was a major feature of the French PilotSTRATEGY research lifecycle. The events and exchanges had measurable impacts on other scientific activities, surpassed the plans laid at proposal stage, and probably went well beyond typical levels of consortium-community interaction in the context of a research project.

A.1.5.2.1. Annex I: Categories of arguments to refuse or grant right-of-way

Table 7 Categories of arguments to refuse or grant right-of-way

Collected arguments of *refusal* to grant right-of-way for seismic data acquisition (#)
EQUITY AND BALANCE OF POWER (7)
(NON)JUSTIFICATION OF LOCAL CO_2 STORAGE (5)
UNCERTAINTY AND RISK (4)
RISK OF EXPROPRIATION (LOSS OF LAND AND PROPERTY) (3)
NUISANCES (3)
VICTIMIZATION OF FARMERS (2)

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Collected arguments of *refusal* to grant right-of-way for seismic data acquisition (#)
PERCEIVED TECHNICAL INCOMPETENCE OR USELESSNESS (2)
THREAT TO ECONOMIC AND SYMBOLIC ENTITY: UNDERGROUND POTTERY DRAINS (2)
EFFECTS ON AGRICULTURE (1)
ABSENCE OF NUISANCE (2)
JUSTIFICATION OF DATA ACQUISITION AND CCUS (2)
POSITIVE INTERPERSONAL RELATIONS (1)

A.1.5.2.2. Annex II: Local population survey results for additional questions regarding social recognition

The first open-door meeting in May 2022 discussed the need for social recognition of a community that would play a role in climate mitigation. The French research team requested that two questions be added to the PilotSTRATEGY public opinion survey instrument due to be applied shortly after the seismic 3D data acquisition campaign (Summer 2022). The replies revealed an unexpected and very clear picture of consensus on the importance of such recognition (somewhat to very: 92%, 235 respondents), and also of the pride to be felt by members of the contributing community (somewhat to very: 84%, 232 respondents). This sample probably mixes a relative minority of persons who personally experienced the seismic 3D data campaign, and a majority of persons living some few kilometers from the study zone.

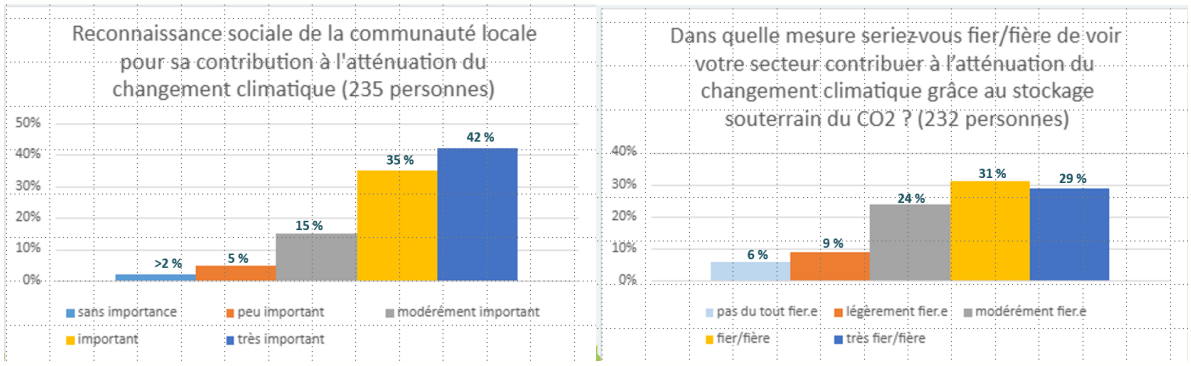

Figure 19 Local population survey results for additional questions regarding social recognition

A.1.5.2.3. Annex III: Questions gathered from citizen participants in the third open door meeting

At the 3rd open-door meeting (May 2024), the scientific presentations were followed by time for the approximately 25 participants to develop their questions and comments. Six small groups mixed different stakeholder categories (farmers, NGO members, local residents, representatives of diverse local industry and commerce, elected and administrative officials) with project personnel. They

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prepared and presented a total of 34 questions, of which 17 were answered by the PilotSTRATEGY team during the ensuing plenary. The questions could be organised into 12 categories as shown below.

Categories of questions asked by PilotSTRATEGY local French stakeholders (# of questions/34)
Reservoir and storage (9)
Dependency of the project on the CO_2 source factory (5)
General questions about CCS technology and potential (5)
CO_2 emission sources (3)
Wells (3)
CO_2 capture (2)
Post-project perspectives (2)
Competition with geothermal potential (1)
Local benefits (1)
CO_2 reuse (1)
Research governance (1)

Following are the 34 questions as they were written down (in French) by the respective small groups (A-F) during their discussions. Of note, these questions were not dictated or recorded by project professionals, but formulated and written down by the attendees, reflecting not only their interests and concerns, but also their diverse levels of local knowledge and expertise.

A-If a site were to be built, where would it be? Exact location.
A-Are we going to store in existing boreholes?

B-Inertia of the clay. What about the swelling of the clay?
B-Is CO_2 injected in purely gaseous form, or is it the effect of pressure that transforms it into a supercritical substance?
B-Estimate the total storage potential of the Paris Basin in relation to France's emissions tonnage?
B-Who are the CO_2 producers other than [the fertilizer producer] in the area?

C-What is the future of the former [fertilizer production] site? Following the definitive closure of this plant
C-What does 100,000 tons of CO_2 represent?
C-What does the project represent in France? Europe? And planet?
C-What are the other projects in Europe?
C-One talks about storage, but what about capture?
C-Financial interest for the commune or community of communes?
C-What's the point of pursuing such a project in 2024 in terms of the [source] site's future?
C-What are the biggest CO_2-producing sites in France - how are they organized to deal with the issue?
C-Density of CO_2?
C-How will the storage facility be supplied, assuming that the storage facility is in Grandpuits and the product comes from elsewhere?
C-Can CO_2 be used for other purposes?

D-Does storage depend exclusively on [the fertilizer company/CO_2 source]?

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D-What is its future if [the fertilizer production site] closes in 5 years?
D-What is the impact of CO_2 mineralization over the very long term?
D-What is the impact of making rock less porous?

E-Why did you focus your research directly on a saline aquifer and not on the territory's oil wells at their end of life? In other words, why try to recreate a borehole when there are already so many in the area?
E-What about the sustainability of CO_2 production with changes in the refinery's activities? Or of [the fertilizer producer]
E-What other sources of CO_2 could be stored here? Use of the [existing] pipeline? Or already dismantled?
E- How likely is it that this research project will come to fruition?
E-What is the possibility of reversing the use of this aquifer for geothermal energy if the need arises on the surface?
E-How long will it be before CO_2 is injected here on an industrial scale?
E-What happens if there's a non-referenced open-air well in the injection zone?

F-Capture CO_2?
F-Injection suppression?
F-Long-term monitoring?
F-Injection depth?
F-Salinity levels?

Extra (during plenary discussion): What does it mean to spend public money on research and make results available to private operators?

These questions further served to help set the themes to be addressed in the 3rd regional stakeholder committee meeting held in November 2024. They were also consulted by Work Package 5 to check local demands pertinent to the formal risk analysis.

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A.2. Citizen Survey

A.2.1. Descriptive statistics

Table 8 Descriptive statistics for all variables used in the multivariate analysis (sample sizes are shown in parentheses).

Variables	Description	Median/Share[a]		
		PT	ES	FR
acceptance in Portugal [b] (S)	5-point Likert scale ranging from 1 (unacceptable) to 5 (acceptable)	4 (339)		
acceptance in Spain [c] (S)			4 (335)	
acceptance in France [d] (S)				3 (322)
problem perception (S)	5-point Likert scale ranging from 1 (not a problem) to 5 (a very severe problem)	5 (352)	4 (350)	4 (340)
importance of related industries (S)	5-point Likert scale ranging from 1 (unimportant) to 5 (very important)	4 (343)	4 (332)	4 (278)
familiarity (D)	1 if participant has heard of CCS	0.48 (352)	0.21 (350)	0.43 (348)
employment in related industries (D)	1 if participant or a member of the participant's family is/has been employed in related industries	0.13 (352)	0.14 (350)	0.18 (348)
environmental benefits (S)	5-point Likert scale ranging from 1 (very negative) to 5 (very positive)	3 (325)	4 (288)	3 (303)
economic benefits (S)		4 (313)	4 (335)	3 (306)
societal benefits (S)		3 (333)	4 (321)	3 (292)
process legitimacy (S)	5-point Likert scale ranging from 1 (unfair) to 5 (very fair)	3 (331)	3 (301)	3 (282)
trust in local industry actors (S)	5-point Likert scale ranging from 1 (no trust) to 5 (complete trust)	3 (344)	4 (333)	3 (313)
trust in external industry actors (S)		3 (325)	3 (309)	3 (307)

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Variables	Description	Median/Share[a]		
female (D)	1 if participant is female	0.37 (352)	0.55 (350)	0.50 (348)
50 years or older (D)	1 if participant is 50 years or older	0.42 (352)	0.66 (350)	0.44 (348)
university degree (D)	1 if participant has an university degree or comparable	0.53 (352)	0.14 (350)	0.43 (348)
high income (D)	1 if participant is managing very comfortably on the household's current income	0.57 (352)	0.37 (350)	0.27 (348)
primary place of residence (D)	1 if the participant's primary place of residence is in the area	0.93 (352)	0.97 (350)	0.97 (348)
NUTS3 Coimbra[b] (D)	1 if participant's place of residence is in the respective administrative unit(s)	0.60 (352)		
NUTS3 Leiria[be] (D)		0.40 (352)		
NUTS3 Teruel[c] (D)			0.19 (350)	
NUTS3 Zaragoza[ce] (D)			0.81 (350)	
priority zones 1-3[d] (D)				0.37 (348)
rest of Seine-et-Marne[de] (D)				0.63 (348)

[a] S: score, D: 0/1-dummy. We report the median for score variables and the shares for dummies.
[b] Only used in the survey in Portugal.
[c] Only used in the survey in Spain.
[d] Only used in the survey in France.
[e] To prevent singularity of the regressor matrix, this variable was dropped from the analysis.
[f] In Spain, the wording of the scale was slightly different ranging from 'totally unacceptable' to 'totally acceptable').

A.2.2. Regression model

A.2.2.1. Details on the methodology of the multivariate analysis

The multivariate analysis relied on three linear regression models to discern patterns relating to influential factors in the local acceptance of a potential implementation of CCS in the study regions. The models were estimated using maximum likelihood estimations. The dependent variable, i.e. local acceptance of a potential implementation of CCS in the respective study region, was measured

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via a 5-point Likert scale. The covariates of the multivariate analysis distinguished between (1) prior personal beliefs about climate change and industries related to the CCS technology, (2) personal familiarity with CCS and related industries, (3) attitudes towards a potential implementation of CCS, and (4) socio-economic characteristics.

Respondents' prior personal beliefs (1) were assessed through their *problem perception* with regard to climate change and the perceived *importance of related industries* – that are relevant to CCS implementation – in the respective study region. Regarding personal familiarity with CCS and related industries (2), respondents' self-reported *familiarity* with the technology and their *employment in related industries* was used. Attitudes towards the implementation of CCS (3) were measured through variables relating to the expected benefits of a potential CCS implementation for the study regions, in terms of *environmental benefits*, *economic benefits*, and *societal benefits*. Furthermore, *process legitimacy*, i.e. the expected fairness of decisions about implementing CCS in the respective study regions, was assessed. In addition, respondents' *trust in local industry actors* and *trust in external industry actors* to make good decisions in this regard was assessed. The socio-economic variables (4) included gender (*female*), age (*50 years or older*), educational level (*university degree*), and household income (*high income*). Finally, the models controlled for respondents' place of residence by accounting for both their primary residence location and the administrative unit in which they currently live.

A.2.2.2. Detailed findings of the multivariate analysis

Table 9 presents the results of the three linear regression models, each using acceptance of a potential CCS implementation in the respective study region as the dependent variable.[5] Since the estimated models are all significant at the 0.01 level, the null hypothesis that all coefficients are jointly equal to 0 can be rejected. The adjusted R^2 values indicate that the models explain a substantial share of the variance in acceptance (between 37% and 55%), with the models for Spain and France demonstrating the strongest explanatory power.

[5] Individual variance inflation factors (VIFs) vary between 1.045 and 3.135. Thus, the covariates do not appear to be highly inter-correlated.

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Table 9 Influential factors in the acceptance of a potential local CCS implementation (OLS estimations).

	Acceptance in Portugal		*Acceptance in Spain*		*Acceptance in France*	
	B	*ß* (95% CI)	*B*	*ß* (95% CI)	*B*	*ß* (95% CI)
Prior personal beliefs						
problem perception	0.017	0.013 (-0.121;0.156)	0	0 (-0.129;0.13)	0.063	0.062 (-0.034;0.161)
importance of related industries	0.159*	0.121 (0.024;0.295)	0.079	0.074 (-0.03;0.188)	-0.056	-0.049 (-0.166;0.053)
Personal familiarity						
familiarity	0.117	0.045 (-0.157;0.391)	-0.04	-0.014 (-0.296;0.216)	-0.17	-0.073 (-0.395;0.054)
employment in related industries	-0.113	-0.03 (-0.492;0.266)	0.112	0.033 (-0.212;0.436)	0.185	0.067 (-0.092;0.462)
Attitudes towards the implementation of CCS						
environmental benefits	0.261**	0.214 (0.104;0.418)	0.562***	0.528 (0.425;0.699)	0.331***	0.312 (0.175;0.487)
economic benefits	0.189*	0.138 (0.024;0.353)	0.071	0.05 (-0.112;0.255)	0.161*	0.146 (0.02;0.302)
societal benefits	0.176	0.135 (-0.002;0.355)	0.066	0.053 (-0.11;0.241)	0.173*	0.159 (0.007;0.339)
process legitimacy	0.276**	0.215 (0.101;0.451)	0.217***	0.232 (0.11;0.324)	0.209**	0.221 (0.083;0.335)
trust in local industry actors	0.048	0.045 (-0.123;0.219)	0.02	0.023 (-0.093;0.133)	-0.024	-0.024 (-0.185;0.137)
trust in external industry actors	0.076	0.067 (-0.101;0.252)	0.041	0.047 (-0.079;0.161)	0.071	0.076 (-0.074;0.216)
Socio-economic characteristics						
female	-0.113	-0.041 (-0.402;0.175)	-0.003	-0.001 (-0.232;0.225)	-0.186	-0.079 (-0.41;0.038)
50 years or older	0.028	0.01 (-0.251;0.307)	0.051	0.021 (-0.215;0.317)	0.134	0.057 (-0.109;0.377)
university degree	-0.095	-0.036 (-0.38;0.189)	-0.062	-0.018 (-0.405;0.281)	-0.127	-0.054 (-0.358;0.104)
high income	-0.013	-0.005 (-0.28;0.254)	0.058	0.023 (-0.179;0.294)	0.196	0.075 (-0.054;0.446)
primary place of residence	-0.378	-0.074 (-0.889;0.133)	0.047	0.007 (-0.588;0.681)	0.892*	0.126 (0.193;1.59)
admin. unit	Yes		Yes		Yes	
constant	-0.126	(-1.144;0.892)	-0.256	(-1.32;0.808)	-0.114	(-1.08;0.851)
# of observations	257		219		216	
F	F(16;240) = 10.52***		F(16;202) = 17.88***		F(16;199) = 16.47***	
Adjusted R^2	0.373		0.553		0.535	

B = coefficient, *ß* = standardised coefficient, CI = Confidence Interval. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

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For the comparison of the strength of associations between the dependent variables and the covariates in the multivariate analysis, we use the standardised regression coefficient (*ß*). This allows for meaningful comparisons across covariates that differ in their coding. To understand how a one-unit change in each covariate corresponds to a one-unit change in the dependent variables, however, we rely on the unstandardised regression coefficient (*B*), as this offers clearer and more intuitive interpretability.

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