Methodology for alternatives definition, prioritisation, and selection

WP4: Pilot development and implementation plan

Release Status: Public

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Date: 23/05/2023

Filename and Version: v1

Project ID Number: 101022664

PilotSTRATEGY (H2020- Topic LC-SC3-NZE-6-2020 - RIA)

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1. Document History

1.1 Location

This document is stored in the following location:

Filename	PilotSTRATEGY_WP4_D4_1
Location	https://pilotstrategy.eu/about-the-project/work-packages/pilot-development

1.2 Revision History

This document has been through the following revisions:

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

1.3 Authorisation

This document requires the following approvals:

AUTHORISATION	Name	Signature	Date
WP Leader	Paula Canteli		23/05/23
Project Coordinator	Fernanda de Mesquita Lobo Veloso		09/06/23

1.4 Distribution

This document has been distributed to:

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

Canteli, P.; Garcia, D.; Jannel, H. & Casacão, J. 2023. Methodology for alternatives definition, prioritisation, and selection. Deliverable D4.1, PilotSTRATEGY EU project (101022664).

Disclaimer

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

2. Executive summary

The objective of the WP4 is to provide complete information of the optimum development concept applicable to the proposed pilots of Paris Basin (FR), Lusitanian Basin (PT) and Ebro Basin (ES) to go ahead with the decision of whether this pilot is viable technically, commercially, considering social and environmental demands and in the existing European and local regulatory frame. The decision of the optimum development concept is key, and it must be based on strategic information at the very first steps of the project, when the ability to influence changes in design is high and the cost of them is low.

This approach, inspired on the front-end loading (FEL), allows to integrate progressively the information required for a complete view of each pilot (technical, environmental, social, commercial, and regulatory), from a divergent thinking to a convergent thinking, ensures consistency in the proposals, identifies improvements, and maturates them to an optimized development concept ready for final decision.

The methodology proposed for collecting this information, sorted, select several desirable alternatives (from which the optimum will be selected) is here described. It is based on "Decision Quality" approach, proposed by Society of Decision Professionals, applicated to big industries such as oil and gas, and here adapted to our objective on PilotSTRATEGY project.

The starting point is a brainstorming session(s) with all disciplines involved in the project and with the goal of clarifying objective(s) of the project (what is the main goal of our project?), limitations and givens (what cannot be change?), decisions (what must we decide now and cannot wait?), and strategies (how can we reach that?). It is fundamental that all participants have clear and common view of those elements to ensure they are all in the same page and it is understood and collected the views from all disciplines: technical, social, legal, commercial and regulatory.

Ebro Basin team, Paris Basin team and Lusitania Basin team applied this exercise during January-February 2023, in two session each, resulting a list of 5 to 6 strategies (alternatives) each of them underlining the description of a development concept. These development concept will be built for the full life cycle (wells and facilities design from task 4.2; reservoir behaviour with the support of WP3 and dynamic modelling; and WP5 for the risks evaluation), and evaluate economically (task 4.4) to priorate alternatives and select the optimum one.

Although each team worked independently and focus on their area particularities, it is concluded a lot of similarities between then. The most relevant is that was (still) somewhat unclear the main goal of the project: pilot or commercial development. After discussion, all now agree that the main goal is to design a carbon pilot injection storage site, and in the case of Spain and Portugal, to check the possibility of upgrade to commercial scale. Other relevant point is the need to qualitatively define the criteria for the pilot's success, considering non-technical Criteria (Regulatory workflow clarification; Increase subsurface knowledge & technology implementation; Regional social support) and technical Criteria (Prove reservoir deliverability – test permeability; Prove seal capacity, when subject to pressure build-up; Test maximum injectivity rate compatible with the upscaling business case).

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3. Introduction

The objective of the WP4 is to provide complete information of the optimum development concept applicable to the proposed pilots of Paris Basin (FR), Lusitanian Basin (PT) and Ebro Basin (ES) to go ahead with the decision of whether this pilot is viable technically, commercially, considering social and environmental demands and in the existing European and local regulatory frame.

To conclude whether a pilot is viable is a major decision of a project. This decision must be based on strategic information to identify and address existing risks, and to commit available resources maximizing the potential of success. Strategic information gathering is possible if a robust project´s lifecycle is built and considered from the very first steps, when the ability to influence changes in design is high and the cost of them is low. This approach, inspired on the front-end loading (FEL), allows to integrate progressively the information required for a complete view of each pilot (technical, environmental, social, commercial, and regulatory), from a divergent thinking to a convergent thinking, ensures consistency in the proposals, identifies improvements, and maturates them to an optimized development concept ready for final decision.

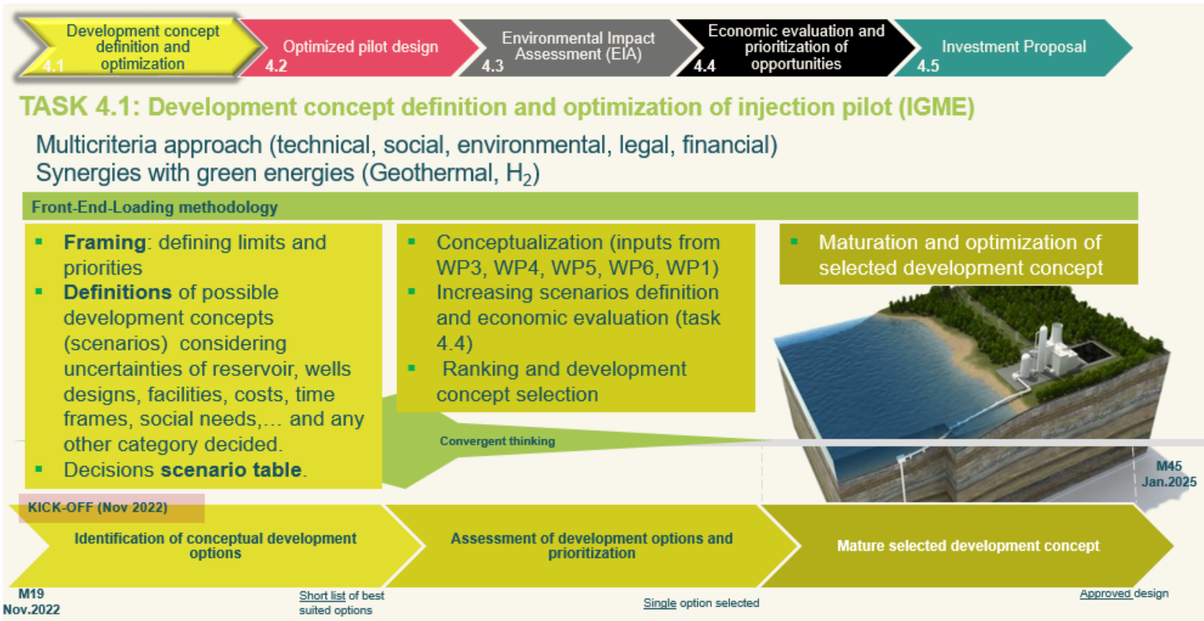

Fig. 1: Description of the task 4.1 along the pilotSTRATEGY project.

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4. Proposed methodology for alternatives definition, prioritisation and selection

The proposed methodology is based on the "Six elements of decision quality" proposed by Society of Decision Professionals (SDP)[1] and applicable to large projects such as oil and gas developments. Decision makers should make certain demands of their project teams that will set clear expectations and including their participation[2], which are formulated as six decision-makers steps:

1. Decision FRAME
2. Generating ALTERNATIVES
3. Relevant and reliable INFORMATION
4. Potential CONSEQUENCES understanding
5. LOGICAL ANALYSIS for clear conclusions
6. Commitment to ACTIONS

From C. Spetzer (2016), Decision Quality.

In particular, this approach is considered for the alternatives definition. Then, each of these alternatives will be represented by a development concept, which will be economically evaluated on task 4.4, defined the KPI and economic criteria for comparison, and final priorization. This document is focus on the first step: Decision Frame and generating alternatives.

4.1 Terminology

In the context of the PilotSTRATEGY project, some key words will be used and are defined as follows:

- **Framing session**: It is an internal project workshop where all different disciplines are represented, with the goal to identify and agree on the objectives and limitations of the opportunity. The information is collected by brainstorming, discussed if needed until achieving clear alignment, and sorted to define alternatives for the development concept. It is expected at least two session of 2-3 hours each.
- **Development concept**: a High-level description and scheme of the relevant technology and actions to be considered for the implementation of the pilot during the life cycle: source of CO_2, transport, injection facilities, wells, or any other element the team considers key for the pilot implementation.
- **Alternatives**: different possibilities of development concept applicable to our pilot and considering its particular technical, economic, environmental, social features, and team objectives, givens and decisions.
- **Objective**: what we want to achieve.
- **Givens**: features, conditions or statements that are accepted as fact in the team.
- **Decision**: a common team agreement of doing (or not to doing) something.
- **Strategy**: a portfolio of decisions intended to achieve an overall goal.

[1] https://www.decisionprofessionals.com/
[2] SPE & SDP (2016): Guidance for Decision Quality for Multicompany Upstream projects. Technical report.

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4.2 Framing session

The Framing session is the team workshop(s) where the last objective is to agree on 4 to 6 possible alternatives or proposal for our final goals in the context of PilotSTRATEGY project. The range from 4 to 6 recommended comes from the need of having different alternatives but manageable. This information can be obtained, sorted, and classified by the following steps:

1) **Brainstorming:** to create a collective view of the decision problem.
2) **Identify and classify objective, givens, and decisions.**
3) **Identify key decisions/later decisions.**
4) **Develop key decisions table options.**
5) **Define desirable strategies.**
6) **Define alternatives for each strategy.**

The goal of the Decision Framing (DF) is to identify and agree on our **OBJETIVES** (what we want to do and what we do not want to do); **GIVENS** (what I cannot change?); **DECISIONS** to be made (what I have to decide to reach my objective?), and the key **CRITERIA** to be assessed (how I will measure the result? How will I compare different possibilities?).

That means:

- Clarify the key dimensions of the problem/opportunity.
- Provide space for brainstorming of creative alternatives, and then focus the team on the most critical decisions and uncertainties. Generate creative and doable alternatives (scenarios).
- Early integrative (all disciplines involved) and iterative (to clear and simplify view) discussion between disciplines for robust project framing and planning.

4.2.1 Brainstorming

It is fundamental to ensure the participation of all key decision-makers that are impacted by the project in the relevant business value chain, or those that can influence the outcome of the project, are aligned with the frame. We try to answer questions such as:

- Do we have a clear view of what we want to achieve/deliver?
- Do we know what is in/out of the scope of the project?
- What are our priorities?
- What is a success for us?
- How can we measure this success?
- What is critical for our success?
- Do we know and understand our key stakeholders?
- What are the limitations of the project?
- What are the main uncertainties?
- What are the main challenges?

If participants can be in the same room, classical post-its session is possible, but if it is an online or hybrid session, try using existing online tools or blackboards (MS Teams, Slido or Miro for example but no limited to this). It must to be ensure that all participants contribute since it is key to cover all different topics.

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4.2.2 Objectives, Givens and Decisions

When all the ideas are collected, now they must be classified and grouped as:

- Objectives:
  - What we want to achieve/delivery
  - How & when we want to deliver
- Givens:
  - Things that cannot be changed
  - Decisions already made
  - Assumed expectations of others (society, shareholders, government…)
- Decisions
  - a common team agreement of doing (or not to doing) something

4.2.3 Decision hierarchy

The list of decisions should be sorted in order of priority, which are the most important decisions to be made soon versus decisions that are dependent on additional data or can be differed without affecting the project value and overall objectives.

Decisions can be "strategic" or "tactic", that is:

- Strategic or focus decisions, if we need to decide before next phase.
- Tactic or later decisions, the rest which can wait for later stage of the project

4.2.4 Decision table

Create a table with 5 to 7 columns and 4 to 6 files, and:

a) FOUCS Decisions: Include possible "options" for EACH "decision". Options@column A are independent of Options@column B. Recommended no more than 6.

	CO_2 source	Transport	Number of wells	Facilities	Synergies with green energies	Green Energies

This is just an example!

b) Options: For each of the columns = Decisions), identify no more than 4 or 5 alternatives independently of the other decisions. It is not necessary to have the same number of alternatives for each decision but at least two (it we can only identify one alternative, then it is a given).

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	CO2 source	Transport	Number of wells	facilities	Synergies	Green Energies
	PEPE Industry	pipeline	1	close to wellhead	YES	Geotherm al energy
	Buy CO2	train	2	Shortest distance to main road	NO	Wind power
	Cluster Cement ind.	truck				Solar panels
						H2

4.2.5 Desirable strategies

A portfolio of desirable achievements based on the objectives of the project, identified during brainstorming. Recommended 3 or 4. It is not necessary to have as many distinct strategies as the number of "options".

Minimum visual impact						
Minimum cost						
Shortest time of implementation						
Maximize Green energy use						

4.2.6 Define alternatives

One by one, selecting the option that best fits to each strategy in the decisions columns:

Decisions / Strategies	CO2 source	Transport	Number of wells	facilities	Synergies	Energies
Minimum visual impact	Industry PEPE	pipeline	1	close to wellhead	YES	Geothermal energy
	Buy CO2	train	2	Shortest distance to main road	NO	wind
	Cluster Cement ind.	truck				Solar panels
						H2

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And do the same for each alternative, for example:

STRATEGIES	CO2 source	Transport	Number of wells	facilities	Synergies	Energies
Minimum visual impact ▲	Industry PEPE	pipeline ●	1 ▲ ●	close to wellhead ▲	YES ▲	Geothermal energy ▲
Minimum cost ●	Buy CO2 ▲	train	2	Shortest ● distance to main road	NO ●	wind
Shortest time of implementation	Cluster ● Cement ind.	truck ▲				Solar panels
Green energy						H2

4.3 Expected results

1. Clear and well-defined boundary conditions -what is part of the problem, what is not- for all team participants. (Will we include capture plant or not? Are we thinking in a pilot to evaluate the technology or a commercial possibility to develop? Do we have any specific limitation/constrain to consider?)
2. Clear and well-defined final objective(s) of the project (To verify technology in the area? To help future investors evaluating opportunities? To engage society demonstrating that is safe? To pave the path for future permits?)
3. Set of alternatives, to be used in the next step (next step: alternatives evaluation, prioritization, and selection of the optimum one).

4.4 Session preparation and implementation.

Before the Framing session, a presentation was carry out explaining the objectives, procedure and key definitions to ensure the participant be familiar with the methodology. Before this meeting, it was provided the presentation and the document “SPE & SDP (2016): Guidance for Decision Quality for Multicompany Upstream projects. Technical report.”

Local teams meetings was done individually and in their local language. Results have been collected in English and shared with the other local teams. WP4 leader or coleaders acted as facilitator.

Results from each team have been collected and they are presented in the annex 1.

5. Conclusions

This methodology was applied by Ebro Basin team, Paris Basin team and Lusitania Basin team during January- February 2023. Initially, it was planned in a brainstorming session; however, most of the session was spend in the 3 regions around the main objectives of the project, longer than expected, and another session was planned in the 3 teams. After that, all reached the final table with defined alternative for future evaluation. For the first session, at least one of the leaders/coleaders of WP4 acted as facilitator to help the local teams during the process.

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Other relevant point is the need to qualitatively define the criteria for the pilot's success, considering non-technical Criteria (Regulatory workflow clarification; Increase subsurface knowledge & technology implementation; Regional social support) and technical Criteria (Prove reservoir deliverability – test permeability; Prove seal capacity, when subject to pressure build-up; Test maximum injectivity rate compatible with the upscaling business case).

Although each team worked independently and focus on their area particularities, it was concluded important similarities between then, which gave us the opportunity of exchange procedures and information.

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6. Annex 1: Application and results

6.1 Lopín onshore Ebro Basin (Spain)

6.1.1 Framing session: dates, organization and participants.

Meeting Subject: pilotSTRATEGY- WP4- Framing session Ebro Basin
Meeting Date: 26/01/2023 09:30 (first session) and 3/02/2023
Location: Microsoft Teams/IGME hybrid (first session) and online (second session)
Participants from WP2, WP3, WP4, WP5 and WP6.

6.1.2 Brainstorming: goals, givens, and decisions

Following an open discussion initiated by the list of questions, post-its, initially no sorted, have collected answers and possible outcomes. In a second step, that post-its were grouped as objectives, givens and decisions, reviewed each group and combining post-its (ideas) when it was possible. Final lists of those are as follow:

OBJECTIVES
Quality Deliverables
Finding a positive narrative
Opportunity to involve local citizens and their waste
Demystification of CO2 storage in communities
Engaging stakeholders in the project
Proposal for compensation to local governments
Selection of a feasible development concept within budget
Offering presentations to citizens about the pilot and commercial study
Generating interest in research and industry
Approval for the next funding - constructing the pilot
Local and political support
Conducting risk assessments
Applying Economies of Scale in the evaluation
Having sufficiently mature documentation for the pilot to move to the next phase
Identifying technical and legal gray areas
Identifying sources of CO2 (emitters, markets, etc.)

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DECISSIONS
Source of dry CO2 with sufficient pressure and low cost close to the pilot well
Transportation method (truck, pipeline)
Order of magnitude of CO2 injection
Continuity vs discontinuity of CO2 injection
Monitoring systems (seismic, observation well, DAS)
Synergies with blue hydrogen production / renewable power generation
Well design (vertical, deviated, number of sections, appropriate metallurgy, etc.)
Modes of pilot funding (EU, private financing search, consortium)
Involving the capturer in economic analysis
Duration of the pilot project

GIVENS
Stakeholders
Data Availability
Social and Environment: Areas with environmental limitations
Limited Local Knowledge of CCS (Carbon Capture and Storage)
Weak Project Narrative
Pilot-scale Project (maximum 100kt)
Administrative Support/Neutrality
Industry with poor public perception
Technical Standards
Unfamiliarity with Administration
Lack of clarity in regulatory framework
Pilot without scale for capture - interest in pilot plant?
Storage capacity of selected site
Cost and availability of equipment and service companies.

6.1.3 Results: defined alternatives

Finally, five (5) alternatives have been defined according to 5 desirable strategies following the proposed methodology:

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- Minimum investment
- Social engagement and local development
- Regulatory gaps identification for best practices and recommendations
- Enhance commercial development (potential commercial development after pilot)
- Minimum uncertainty on HSE risks (well-known practices)

STRATEGIES	CO2 source	Transport	CO2 Quantity	Supply continuity	Monitoring	Power supply	Well	Pilot duration	Project budget
Minimum investment	Market	pipeline	100 kt	Continuo	Seismic 4D	Power grid	vertical	5 years	Up to 20 M€
Social engagement	Valorisation plant	Truck	Min for monitoring	Intermittent	New monitoring wells	Solar/wind	deviated	Min* for monitoring	No limit
Gaps understand	Paper plant				Legacy observation wells	Geothermal		No limit	
After pilot, commercial development	Other								
Limit HSR risk									

6.1.4 Learning and recommendations

Although it was discussed several times before the framing session, to define and agree on the final objectives and limits (what is included and what is not part of this project) needed almost the first session. It was needed time to be sure next steps we are all on the same page but unexpected as this time of the project.

It is possible than some alternatives look to similar when they be evaluated and reduced the final number of possible scenarios. It would be also interesting to compare Ebro Basin results with the other two local teams to agree on similarities and differences, and perhaps review the final table.

6.2 Paris Basin (France)

6.2.1 Framing session: dates, organization and participants

Meeting Subject: pilotSTRATEGY- WP4- Framing session Paris Basin (FR)
Meeting Date: 03/02/2023 (first session) and 3/03/2023 (close-out session)
Location: Microsoft Teams for both sessions

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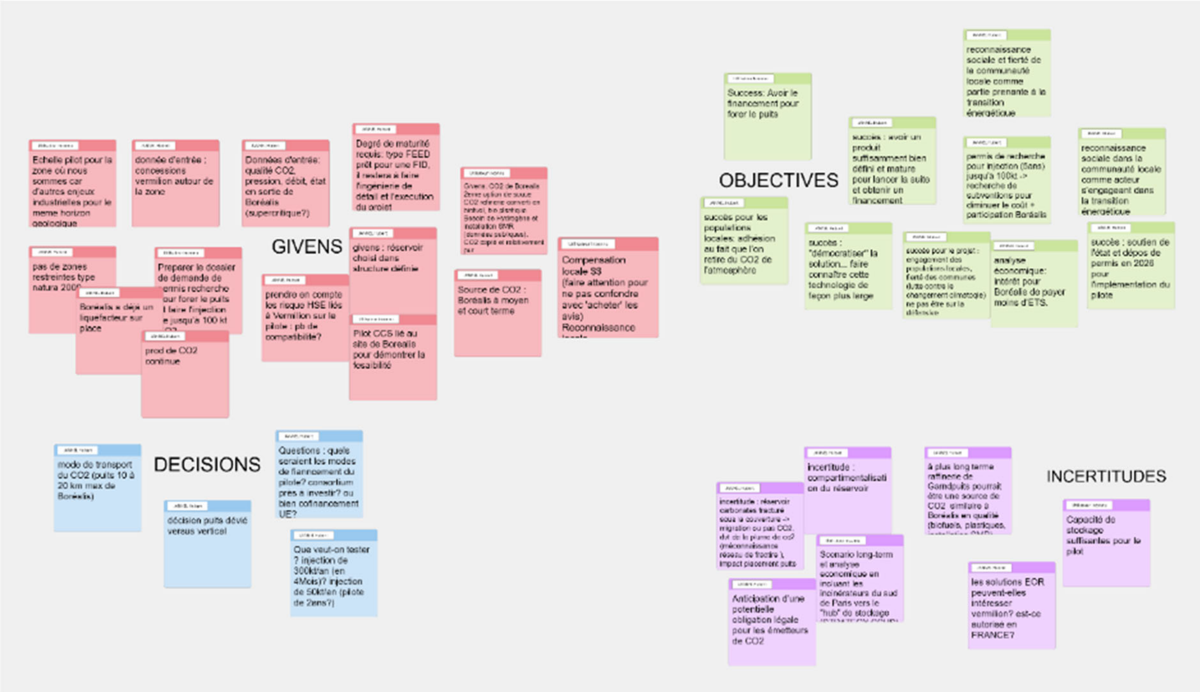
Participants from WP2, WP3, WP4, WP5 and WP6.



6.2.2 Brainstorming: goals, givens, and decisions

The France team carried out both session online and using the MS Teams blackboard for exchange and collected ideas, and then sorted and grouped on Objectives, Givens, Decisions and Uncertainties. The list of outcomes are:

<u>**OBJECTIVES**</u>

Our customer - EU/Horizon2020 R&D program

To show case CCS solutions and associated advantages.

To find attractive prospects that could be developed on a commercial scale in the midterm.

To demystify CCS solutions in the public.

To increase the probability of having at least one site in operation before 2030 in Europe.

Borealis - potential future user

From Borealis' point of view: opportunity to reduce ETS purchasing.

From Borealis' point of view: to anticipate a legal framework evolution regarding industrial CO2 emissions.

Nearby communities - contributors to this initiative

From communities' point of view: recognition and pride to be part of the energy transition.

Pilotstrategy project participants

To provide new technical and societal research and insights on geological storage of CO2 in five regions in Europe.

To deliver high quality decision support package with reduced uncertainty to secure financing to execute the pilot.

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Active engagement and visible/transparent strategy to secure stakeholders' support to the project
To secure state support to submit request for “permis de recherche” in 2026 for pilot implementation.
To secure “permis de recherche” for 5 years / 100 kt with support from public / private actors.
To select a development concept achievable within approved budget/time
To study applicability of CCUS for small-medium emitters through a pilot scale.

DECISIONS

CO2 transport solution knowing that the well will likely be located < 10 km max. away from Borealis.
Well design: vertical well versus deviated well (potentially drilled from Borealis site).
To define injection strategy: maximise injection rate over a short period of time or inject at low rate over the entire duration of the “permis de recherche”?
Project financing through EU funds? State support? Private consortium?
Economic analyses considering long-term scenario including waste incinerators nearby Paris (STRATEGY CCUS).
To select surveillance / monitoring strategy (4D seismic, induced seismicity, monitoring wells, DAS)
CO2 capture to be considered or not in the economic assessment
Continuity of CO2 supply/injection.
Pilot injection duration

GIVENS

Project frame

Aiming for pilot-scale (as opposed to commercial-scale) due to multipurpose nature of geological horizon of interest (multiple users)
Required level of project maturity: FEED level studies i.e. readiness for final investment decision (FID)
Out of scope: detailed engineering and project execution
High-level screening of CCUS potential of the five regions carried out as part of STRATEGY CCUS
PilotSTRATEGY project relates to work programme ‘Secure, clean and efficient energy’, focusing in ‘Building a low-carbon, climate resilient future (LC)’

Site location

CO2 storage location defined with specific area and geological horizon (77 - Seine et Marne)
Source of CO2: Gas CO2 capture plant already operational at Borealis, with continuous stream of gas (short term). A small fraction of CO2 is arealdy liquefied and sold.
Source of CO2: Total’s Grandpuits Steam Methane Reforming plant (biofuels, hydrogen prod., etc) -> long term

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Sufficient CO_2 storage capacity in targeted geological horizon

Stakeholders

nearby communities

EU / Horizon 2020 - Research and innovation Program

Pilot Strategy Project Participants

Local and National Authorities

Data Availability

Vermilion's licensed blocks to be considered

Technical support from Vermilion regarding G&G data

Input data for the project: CO_2 specifications, operating pressure, flowrates, thermodynamic state

Social and Environmental Aspects

No record of restricted areas e.g. Natura 2000, natural reserves, etc.

Stakeholders' support to the project is NOT a given: MUST be secured with active engagement and visible/transparent strategy

Regulatory framework

"Permis de recherche" to drill a well and inject up to 100 kt in total over 5 years

EU/FR/Industry technical standards

UNCERTAINTIES

Geology & Geophysics

Reservoir compartmentalisation.

Carbonate reservoir with fractures below the seal with uncertainty on CO_2 migration, gas cap development, impact on well placement, etc.

Interest of Vermilion in EOR solutions (EOR is possible in France).

Surface facilities

Cost and availability of equipment and utility companies.

6.2.3 Results: defined alternatives

Five strategies were agreed and defined corresponding scenarios according to the following tables:

1) Pilot fast-track development at minimal cost to prove technical feasibility
2) Prepare/develop pilot for commercial development (e.g. attract project developers)
3) Minimise project footprint on local communities
4) Foster local economy, nearby communities' development
5) Show case CCS solutions and associated advantages e.g. build world-class CCS demonstrator

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STRATEGIES	DECISIONS										
	CO_2 Source	*CO_2 Transport solution*	*Continuity of supply*	*Total CO_2 quantity to be injected*	*Injection plant / surface facilities*	*Power supply*	*Well design*	*Monitoring strategy*	*next phase Funding*	*Project duration*	*Project budget*
Pilot fast-track development at minimal cost to prove technical feasibility	Borealis	Onsite (injection well within CO_2 plant)	Continuous	Research permit (< 100 k tons)	No facilities i.e. manifold hooked up to injection well	power grid	Vertical, basic completion	4D seismic	UE	5 years	< 10 M€
	Total Grandpuits	Road (Truck)	Intermittent	Min. to obtain meaningful results (~30 k tons)	Temporary surface facilities with reduced footprint	solar / wind	Deviated, enhance completion design	DAS	State initiative	Minimum to obtain results (30ktons) i.e. 3 years / check Quest	< 20 M€
	Waste incinerators, large CO_2 emitters nearby Paris (as identified in Strategy CCUS)	Railway (Train)		Amount to achieve commercial scale ("autorisation environnementale unique")	Permanent injection facility	geothermal		New surveillance wells	consortium public/private	Commercial design life e.g. 30 years	Commercial scale (~100 M$)
	Distant CO_2 emitters (e.g. steel industry in Northern France)	Pipeline						legacy O&G wells	Private equity		
	CO_2 market										

STRATEGIES	DECISIONS										
	CO_2 Source	*CO_2 Transport solution*	*Continuity of supply*	*Total CO_2 quantity to be injected*	*Injection plant / surface facilities*	*Power supply*	*Well design*	*Monitoring strategy*	*next phase Funding*	*Project duration*	*Project budget*
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Minimise project footprint on local communities	incinerators, large CO_2 emitters nearby Paris (as identified in Strategy CCUS)	Railway (Train)		Amount to achieve commercial scale ("autorisation environnementale unique")	Permanent injection facility	geothermal		New surveillance wells	consortium public/private	Commercial design life e.g. 30 years	Commercial scale (~100 M$)
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STRATEGIES	DECISIONS										
	CO_2 Source	*CO_2 Transport solution*	*Continuity of supply*	*Total CO_2 quantity to be injected*	*Injection plant / surface facilities*	*Power supply*	*Well design*	*Monitoring strategy*	*next phase*	*Project duration*	*Project budget*
	Borealis	(injection well within CO_2 plant)	Continuous	Research permit (< 100 k tons)	manifold hooked up to injection well	power grid	Vertical, basic completion	4D seismic	UE	5 years	< 10 M€
	Total Grandpuits	Road (Truck)	Intermittent	Min. to obtain meaningful results (~30 k tons)	Temporary surface facilities with reduced footprint	solar / wind	Deviated, enhance completion design	DAS	State initiative	obtain results (30ktons) i.e. 3 years /	< 20 M€
	Waste incinerators, large CO_2 emitters nearby Paris (as identified in Strategy CCUS)	Railway (Train)		Amount to achieve commercial scale ("autorisation environnementale unique")	Permanent injection facility	geothermal		New surveillance wells	consortium public/private	Commercial design life e.g. 30 years	Commercial scale (~100 M$)
Foster local economy, nearby communities development	Distant CO_2 emitters (e.g. steel industry in	Pipeline						legacy O&G wells	Private equity		
	CO_2 market										

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STRATEGIES	DECISIONS										
	CO2 Source	*CO2 Transport solution*	*Continuity of supply*	*Total CO2 quantity to be injected*	*Injection plant / surface facilities*	*Power supply*	*Well design*	*Monitoring strategy*	*next phase Funding*	*Project duration*	*Project budget*
	Borealis	Onsite (injection well within CO2 plant)	Continuous	Research permit (< 100 k tons)	manifold hooked up to injection well	power grid	Vertical, basic completion	4D seismic	UE	5 years	< 10 M€
	Total Grandpuits	Road (Truck)	Intermittent	Min. to obtain meaningful results (~30 k tons)	Temporary surface facilities with reduced footprint	solar / wind	Deviated, enhance completion design	DAS	State initiative	obtain results (30ktons) i.e. 3 years / check Quest	< 20 M€
	Waste incinerators, large CO2 emitters nearby Paris (as identified in Strategy CCUS)	Railway (Train)		Amount to achieve commercial scale ("autorisation environnementale unique")	Permanent injection facility	geothermal		New surveillance wells	consortium public/private	Commercial design life e.g. 30 years	Commercial scale (~100 M$)
	steel industry in Northern France)	Pipeline						legacy O&G wells	Private equity		
Show case CCS solutions and associated advantages e.g. build wordl-class CCS demonstrator	CO2 market										

6.2.4 Learning and recommendations

One of the main learnings is related to the fact that the process should be conducted in two phases as pointed out above (Lopín onshore Ebro Basin (Spain)) and below (Lusitanian Basin (Portugal)).

In addition, ensuring that there was enough diversity within the team with most disciplines represented during the discussions proved to be critical to produce meaningful results and to capture all the dimensions of the project.

To conclude, significant efforts were required to clarify the ultimate goal and the vision for the project. However, they may evolve over time as more data becomes available and as the project is further matured. It is currently assumed that the main goal is to design a CO_2 injection pilot in the Paris basin, which would allow to safely store up to 100 kton over the course of 5 years.

6.3 Lusitanian Basin (Portugal)

6.3.1 Framing session: dates, organization and participants

Meeting Subject: pilotSTRATEGY- WP4- Framing session Lusitanian Basin offshore
Meeting Date: 27/02/2023 14:00 (first session) and 23/03/2023 14:00 (second session)
Location: Microsoft Teams online
Participants from WP2, WP3, WP4, WP5 and WP6.

6.3.2 Brainstorming: goals, givens, and decisions

Following the proposed methodology, those are the resulting tables:

Goals
General: Design a carbon **pilot injection storage site** in the Lusitanian Basin (offshore Portugal), which would allow safe storage of **up to 100 kton** over the course of 5 (?) years
Specific: **Mature storage site** to allow future investments from the public/private sector
Specific: Consider **CO2 sourcing & transport** in business scenarios
Develop a business case that would consider **upscaling** a site into a commercial project - NEED FOR A **PIPELINE**
Givens

Project on a pilot scale: Up to 100 kton CO2 injected volume
Data availability for model building
Offshore setting - Stakeholder management & lack of regulation for CCS in this context
Limited knowledge of CCS by local parties
1 development/injection well
Out-of-scope capture & transport Pilot?
Shipping (& transport to shipping facility)
Infrastructural support by the port of Figueira da Foz
Decisions (critical decisions in green)
Project initiation - consider all circumstances (e.g. source of CO2, available infrastructures, regulation, carbon credits, time-to-inject)
Volumes, rate and duration of pilot injection
Source of CO2 (considering the offshore setting for transportation)
Onshore transport from source (by railway, road/truck)
Inject CO2 in liquid/supercritical phase. Injection facility (compression station on site?)
Injection intermittence helps to preserve optimal pressure gradient & control CO2 plume - Define an Injection strategy
3D seismic for baseline monitoring - TO CONFIRM with regulatory requirements
Other monitoring techniques available in the well & surrounding environment & frequency; Post-injection monitoring?
Solutions for CO2 sources
The Navigator Company is planning to implement carbon capture in their plant (Figueira da Foz) - Transport is the transversal issue for mainland Portugal
Shipping: what are the options? ALTERA? STELLAMARIS? Some projects will start offering transport solutions by 2026
Coupled transport & injection shipping
Buy CO2 from external parties
Access to CO2 sourced from mainland Portugal (Souselas, BA Glass & Navigator with railway access to Fig. Da Foz)

What defines the pilot's success:	
Non-technical Criteria	**Technical criteria**
Regulatory workflow clarification	Prove reservoir deliverability (test permeability)
Increase subsurface knowledge & technology implementation	Prove seal capacity, when subject to pressure build-up
Regional social support	Test maximum injectivity rate compatible with the upscaling business case

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6.3.3 Results: defined alternatives

As results of the discussion, six (6) strategies and corresponding alternatives have been defined:

1) Minimum cost
2) Social engagement, awareness, local development
3) Regulatory gaps understanding and research
4) Schedule and accelerating the pilot development
5) Enhance the commercial development
6) Limit HSE risk and reduce territorial impacts

The following tables of alternatives were built for each of topics defined above, and we highlighted with a different colour the best option(s) for each one of these:

Strategy	Decisions							
	CO_2 Source	*Transport (onshore to port/offshore)*	*CO_2 Quantity*	*Supply continuity*	*Monitoring*	*Power Supply*	*well design*	*project duration*
Minimum Cost	market	pipeline/ship	100kt (permit max)	**intermitent**	4D seismic (to monitor CO_2 plume)	**power grid**	**vertical**	monitoring during injection, monitoring post-injection
	cement & lime plant	**truck/ship**	CO_2 availability at the source		**monitoring along well**	Renewable: offshore wind	deviated	**min. for monitoring (30ktons): 3 years (check QUEST)**
	pulp plant	**train/ship**	**min. for monitoring (<100 kton)**		**near-seabed (e.g. piston cores, ROV inspection)**			Upscale to commercial storage site
	glass industry							
	refinery							
	others							

Strategy	Decisions							
	CO_2 Source	*Transport*	*CO_2 Quantity*	*Supply continuity*	*Monitoring*	*Power Supply*	*well design*	*project duration*
	market	pipeline/ship	**100kt (permit max)**	**intermitent**	**4D seismic (to monitor CO_2 plume)**	power grid	**vertical**	**5 years (injection, monitoring during injection, monitoring post-injection)**
Social Engagement, Awareness, Local development	cement & lime plant	truck/ship	CO_2 availability at the source		**monitoring along well**	**Renewable: offshore wind**	**deviated**	min. for monitoring (30ktons): 3 years (check QUEST)
	pulp plant	**train/ship**	min. for monitoring (<100 kton)		**near-seabed (e.g. piston cores, ROV inspection)**			Upscale to commercial storage site
	glass industry							
	refinery							
	others							

Strategy	Decisions							
	CO_2 Source	*Transport*	*CO_2 Quantity*	*Supply continuity*	*Monitoring*	*Power Supply*	*well design*	*project duration*
	market	**pipeline/ship**	**100kt (permit max)**	**intermitent**	**4D seismic (to monitor CO_2 plume)**	power grid	vertical	monitoring during injection, monitoring post-injection)
	cement & lime plant	truck/ship	CO_2 availability at the source		**monitoring along well**	**Renewable: offshore wind**	**deviated**	min. for monitoring (30ktons): 3 years (check QUEST)
Regulatory Framework Gap Understanding / Research	**pulp plant**	train/ship	min. for monitoring (<100 kton)		**near-seabed (e.g. piston cores, ROV inspection)**			**Upscale to commercial storage site**
	glass industry							
	refinery							
	others							

Strategy	Decisions							
	CO_2 Source	*Transport (onshore to port/offshore)*	*CO_2 Quantity*	*Supply continuity*	*Monitoring*	*Power Supply*	*well design*	*project duration*
	market	pipeline/ship	100kt (permit max)	**intermitent**	4D seismic (to monitor CO_2 plume)	**power grid**	**vertical**	5 years (injection, monitoring during injection, monitoring post-injection)
	cement & lime plant	**truck/ship**	**CO_2 availability at the source**		**monitoring along well**	Renewable: offshore wind	deviated	**min. for monitoring (30ktons): 3 years (check QUEST)**
	pulp plant	train/ship	min. for monitoring (<100 kton)		near-seabed (e.g. piston cores, ROV inspection)			Upscale to commercial storage site
Schedule & accelerate the pilot development	glass industry							
	refinery							
	others							

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Strategy	Decisions							
	CO2 Source	*Transport*	*CO2 Quantity*	*Supply continuity*	*Monitoring*	*Power Supply*	*well design*	*project duration*
	market	**pipeline/ship**	100kt (permit max)	**intermitent**	**4D seismic (to monitor CO2 plume)**	**power grid**	vertical	5 years (injection, monitoring during
	cement & lime plant	truck/ship	**CO2 availability at the source**		monitoring along wel	Renewable: offshore wind	**deviated**	min. for monitoring (30ktons): 3 years
	pulp plant	train/ship	min. for monitoring (<100 kton)		near-seabed (e.g. piston cores, ROV			**Upscale to commercial storage site**
	glass industry							
Enhance the commercial development	refinery							
	others							

Strategy	Decisions							
	CO2 Source	*Transport*	*CO2 Quantity*	*Supply continuity*	*Monitoring*	*Power Supply*	*well design*	*project duration*
	market	pipeline/ship	100kt (permit max)	**intermitent**	4D seismic (to monitor CO2 plume)	**power grid**	**vertical**	5 years (injection, monitoring during injection, monitoring post-injection)
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	pulp plant	**train/ship**	**min. for monitoring (<100 kton)**		**near-seabed (e.g. piston cores, ROV inspection)**			Upscale to commercial storage site
	glass industry							
	refinery							
Limit HSE Risk & Reduce territorial impacts	others							

6.3.4 Learning and recommendations

As stated in the Grant Agreement, the main goal of this early phase of WP4 was to conduct a Framing Session, in order to identify, discuss, and agree/align on the problem/opportunity to be solved, the Given decisions, the Decision to be made, and the key Criteria to be assessed.

The Framing Session occurred in two moments, to have a complete discussion and alignment. These two meetings were very productive and very useful, so that every participant had the chance to express their views, and in the end, we got to a very clear idea of the assumptions and goals of our CCS project.

Some of the main highlights consider the goal definition, which was somewhat unclear from the start of the project. After discussion, we can now assume that the main goal is to design a carbon pilot injection storage site in the Lusitanian Basin (offshore Portugal), which would allow the safe storage of up to 100 kton over the course of 5 years. Specifically, the Portuguese team will 1) mature the storage site characterization to allow future investments from the public/private sectors; 2) consider CO_2 sourcing and transport in business scenarios; and 3) develop a commercial business case that would contemplate injection upscaling (a pipeline would be an assumption for this).

Several Givens were specified, and some of the critical Decisions to be made until the end of project consider the volumes, rate, and duration of the pilot injection, as well as the source of CO_2.

Besides this, we discussed internally the need to qualitatively define the criteria for the pilot's success. This would consider Non-technical Criteria (Regulatory workflow clarification; Increase subsurface knowledge & technology implementation; Regional social support) and Technical Criteria (Prove reservoir deliverability – test permeability; Prove seal capacity, when subject to pressure build-up; Test maximum injectivity rate compatible with the upscaling business case).

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