PilotSTRATEGY

Planning CCS deployment in the Lusitanian Basin, Portugal

Autumn webinar, 17th october 2024

UNIVERSIDADE DE ÉVORA

galp

ICS INSTITUTO DE CIÊNCIAS SOCIAIS

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

PilotSTRATEGY - CO2 Geological Pilots in Strategic Territories

May 2021 – April 2026

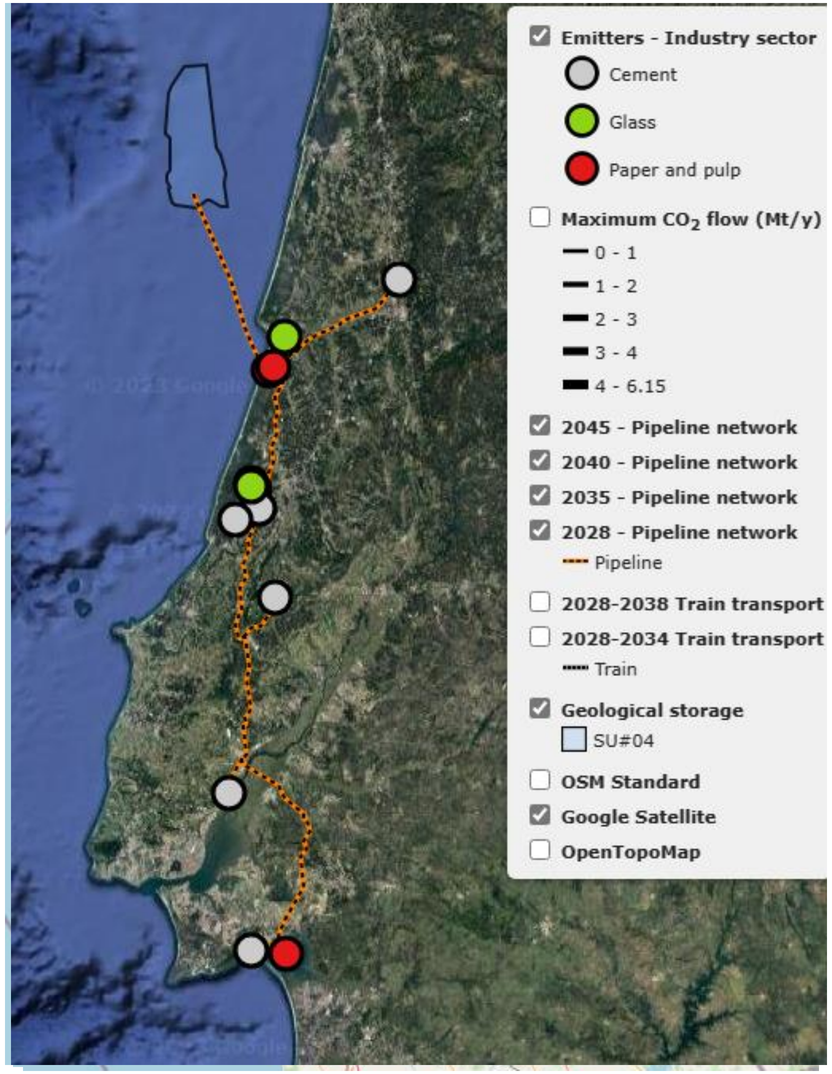
Aim: detailed characterization, feasibility studies and preliminary design or pre-FEED study - allow a FID to be made; storage permitting and approval.

- Technical evaluation
- Safety and performance risk assessment
- Legal framework
- Investment proposal and pilot life-cycle
- Social acceptance and stakeholders' participation
  - Regional Stakeholder Committee
- Communication and dissemination

PilotSTRATEGY

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

STRATEGY CCUS Scenario (2028-2050)



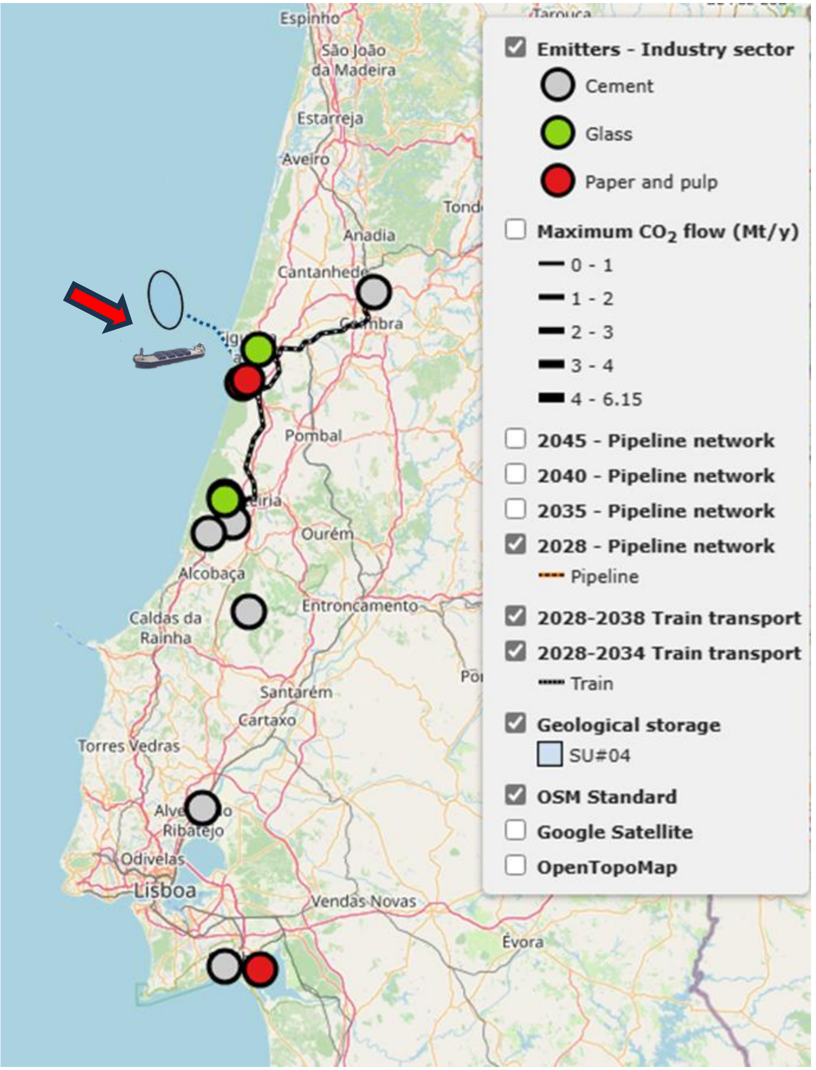
2028
2 pilots:
Cement + Glass
1 injection well
23 km pipelines
2 train connections

Annual CO_2 flux
<0.1 Mt/a
<0.1 Mt/a

Capture CO_2 ↓
93 Mt CO_2
Storage
61-70 Mt CO_2
Utilisation
22-32 Mt CO_2

Costs (full chain)
69-86 €/ton CO_2 avoided
(5% discount value)

STRATEGY CCUS Scenario (2028-2050)



2028
2 pilots:
Cement + Glass
1 injection well
23 km pipelines
2 train connections

Annual CO_2 flux
<0.1 Mt/a
<0.1 Mt/a

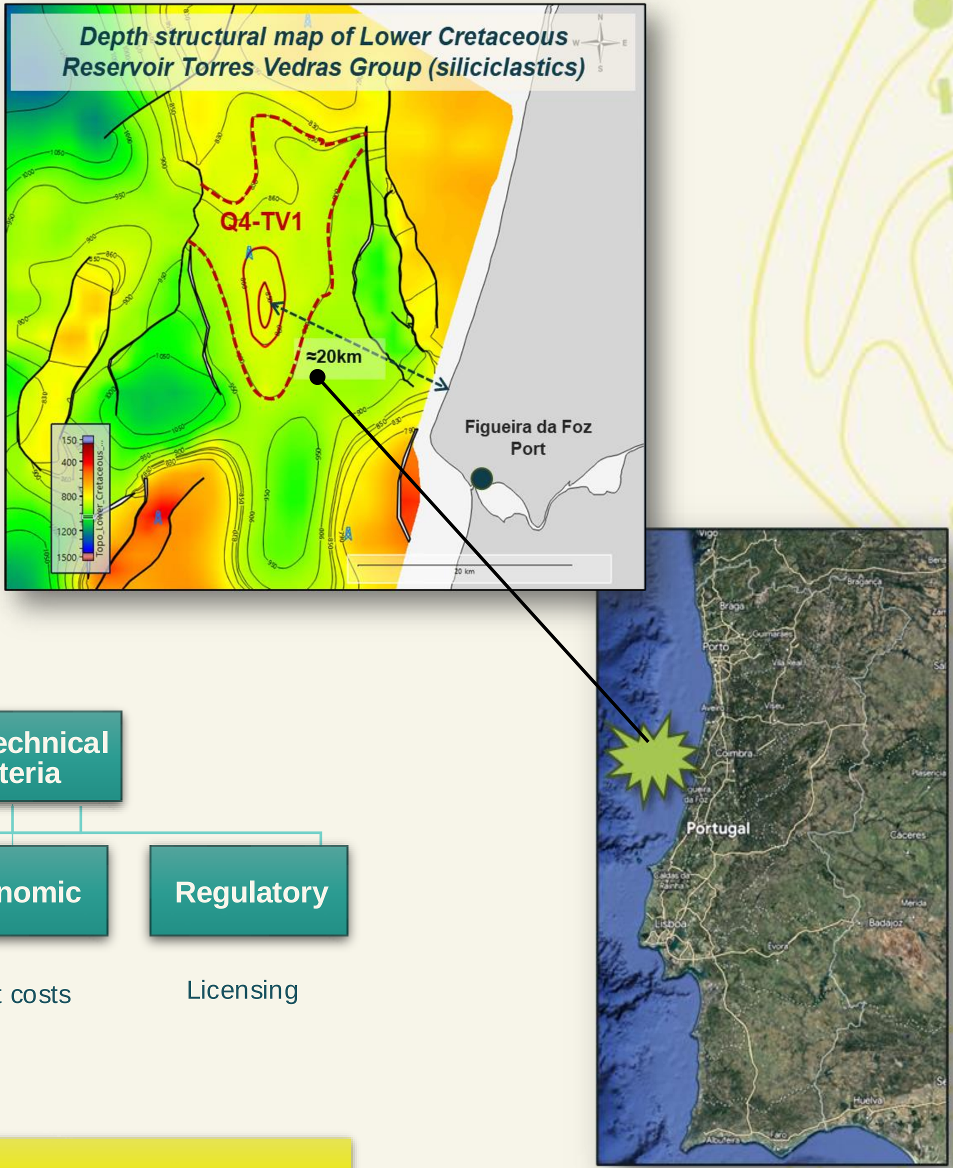
Transport by train to Figueira da Foz port:

- 65 km from BA glass factory (Marinha Grande) - **20 $KtCO_2$/yr**
- 47 km from Souselas cement factory – **58 to 64 $KtCO_2$/yr**

Key KPIs:	
Total costs (discounted)	4.64M€
Total costs (undiscounted)	7.56M€
Net CO2 transported	0.62Mt
Total costs per ton (undiscounted)	12.23€/t
Total costs per ton (discounted)	**7.51€/t**

Geological characterization

- ❑ Petrophysics from all offshore petroleum exploration wells
- ❑ Facies analysis (D2.6).
- ❑ **2D/3D Seismic interpretation for offshore LB**
- ❑ Selected deep saline aquifer from Lower Cretaceous.
- ❑ Selection of offshore structure (3 structures analyzed)
- ❑ Geological conceptual modelling
- ❑ Geochemical Assessment



Technical Criteria

- **Storage capacity**: Capacity, Injectivity, Trapping
- **Containment**: Primary seal, Secondary seals
- **Integrity**: Faults, Wells and boreholes, Seismicity
- **Location**: Mitigation, Upscale, Impacts

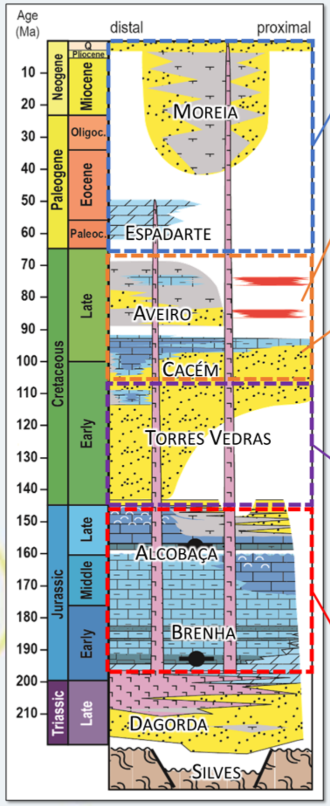
Non-technical criteria

- **Social**: Jobs created, Citizens, Private sector, Civil society, Local authorities
- **Economic**: Pilot costs
- **Regulatory**: Licensing

Data quality and coverage

Q4-TV1 Prospect – Offshore Lusitanian Basin

CO_2 Storage Complex



Overburden

Cenozoic siliciclastic deposits and dolomites (Espadarte Fm.)

Potential Secondary seal

Upper Cretaceous siliciclastic deposits and carbonates (Aveiro Group)

Primary seal

Upper Cretaceous limestones, argillaceous limestones and shales (Cacém Fm.)

Reservoir

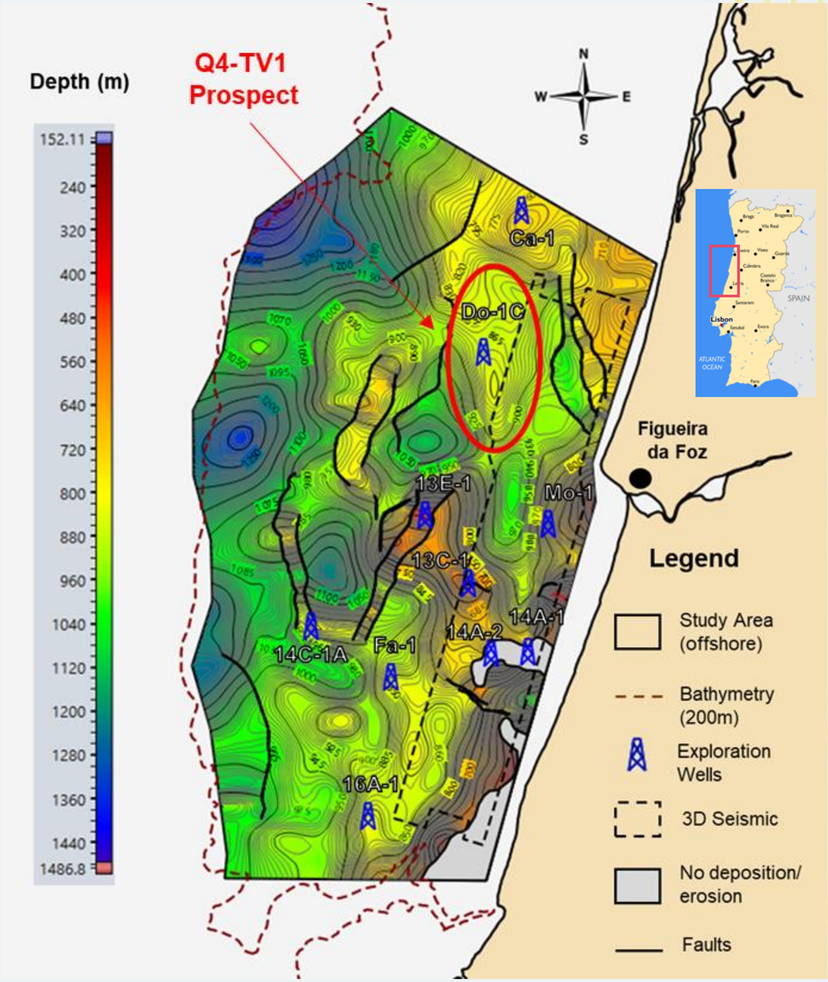
Lower Cretaceous siliciclastic deposits, with coaser sediments at the bottom evolving to sandstones and interbbeded claystones towards the top (Torres Vedras Group)

Underburden

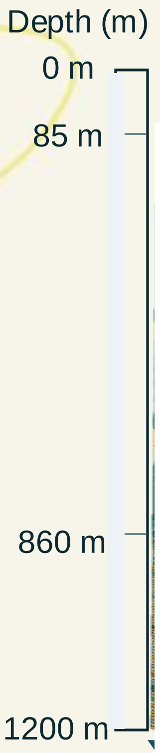
Upper Jurassic layers with intercalated sandstones/ claystones (Alcobaça Fm.) and Middle Jurassic carbonate-rich rocks (Brenha Group)

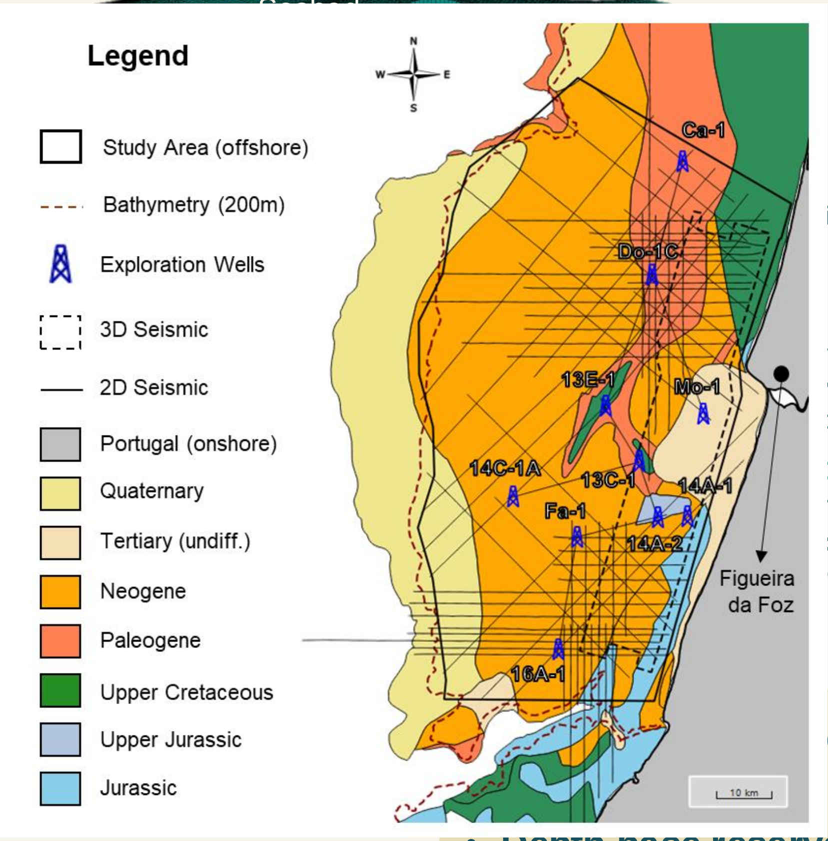
- Located in the northern area of the Lusitanian Basin, approx. **20km from the shoreline** (Figueira da Foz)
- **Target reservoir unit of Q4-TV1 prospect**: Lower Cretaceous (Torres Vedras Group)
- Main risks include the presence of a **hydrocarbon exploration legacy well** Dourada-1C (Do-1C) and faults
- Potential upside opportunity by **upscaling from pilot- to commercial-scale**

Reservoir Top Depth



WP3: Static model completed





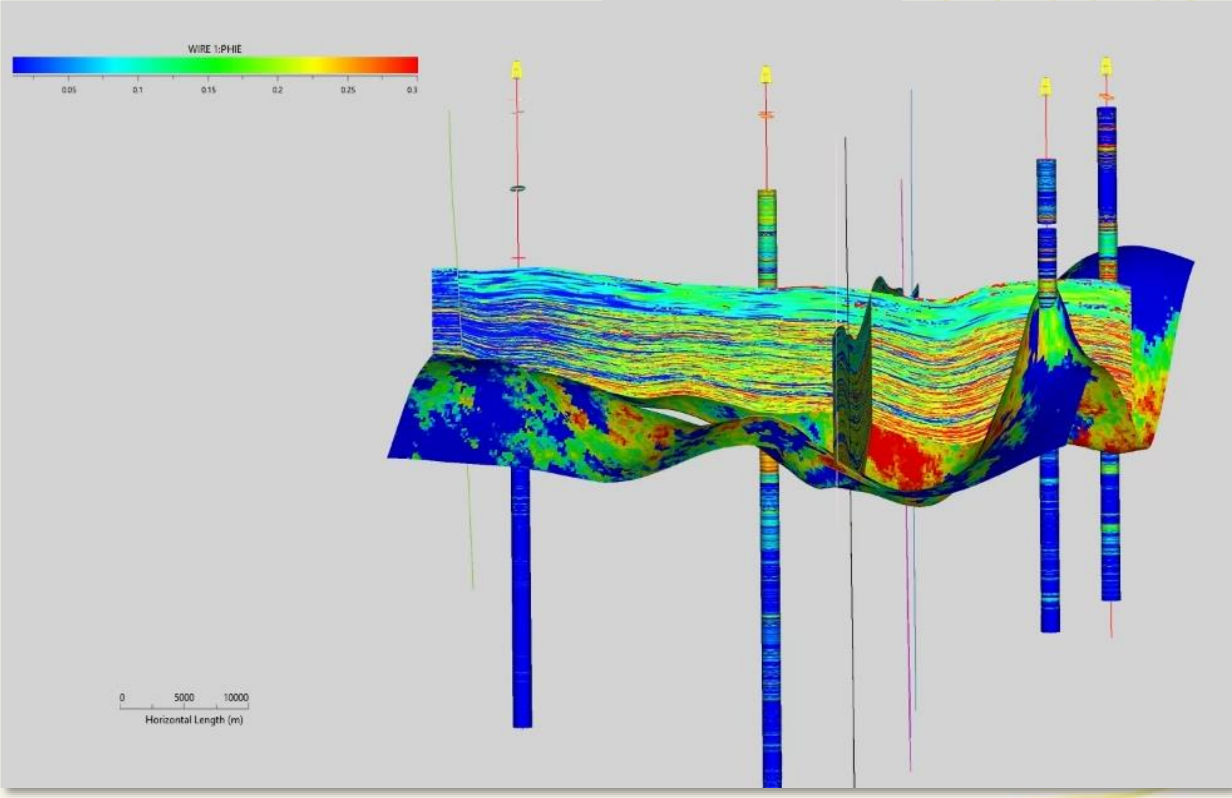
rden
15%
ility: 3mD

m Cacém)
: 7%
bility: 0.04 mD

oir
res Vedras)
: 22%
ility: 229 mD

th: 85 m
r : 860m
- **Depth base reservoir**: 1200m

Static model (offshore) Prospect Q4-TV1



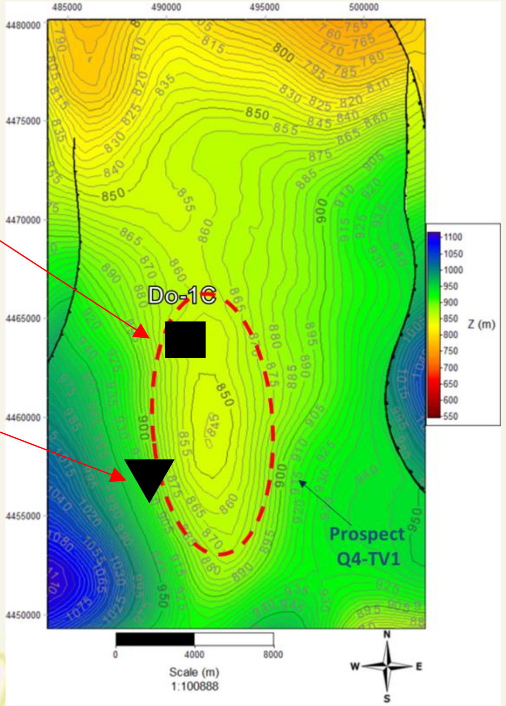
Static simulation software – SKUA GOCAD (ASPENTECH)

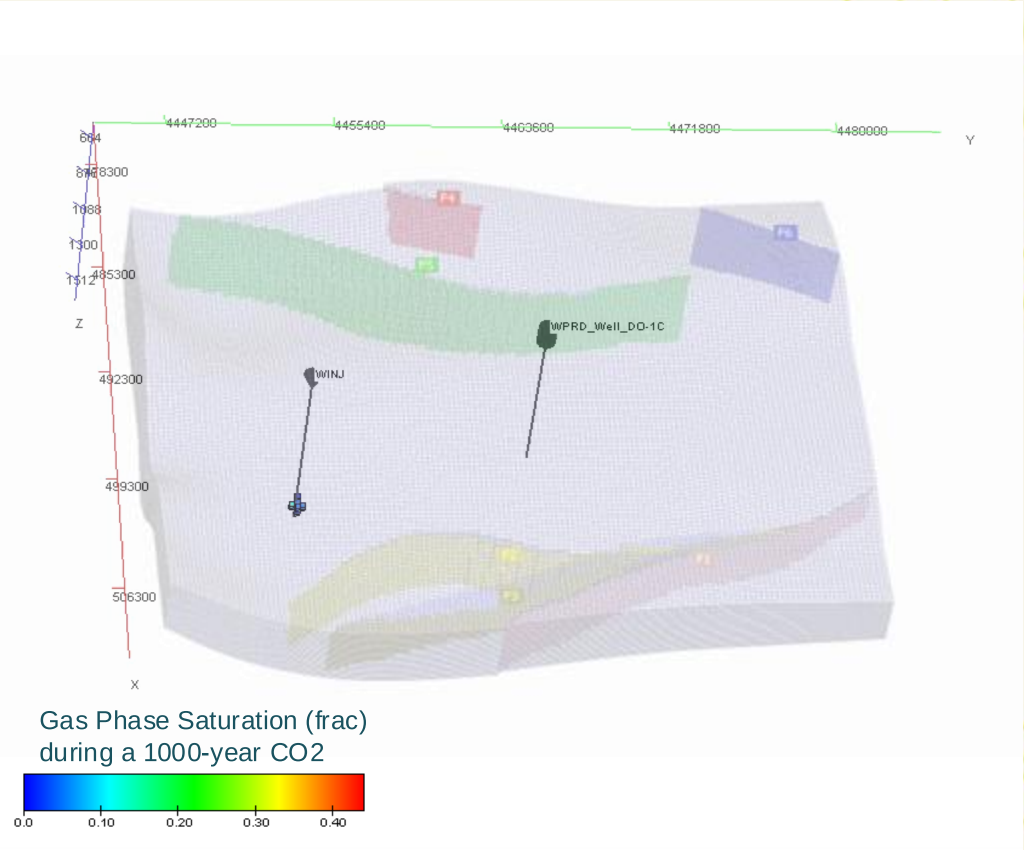
Optimization of well location

- **Objective**: maximizing CO_2 storage capacity (up to 100,000 tons, over 36 months), minimizing the risk of leakage
- **Risk Factors**: Analyze the potential leakage of CO_2 on the fault and prevent plume migration towards the existing well (Do-1)
- **Injection Parameters**: Focus on injection flow rate, pressure rate and downhole pressure
- **Long-Term Safety**: Ensure long-term CO_2 plume containment, avoid escape areas, and optimize well location

Legacy well
(Dourada-1C)

Injection well
(Piloto de CO_2)



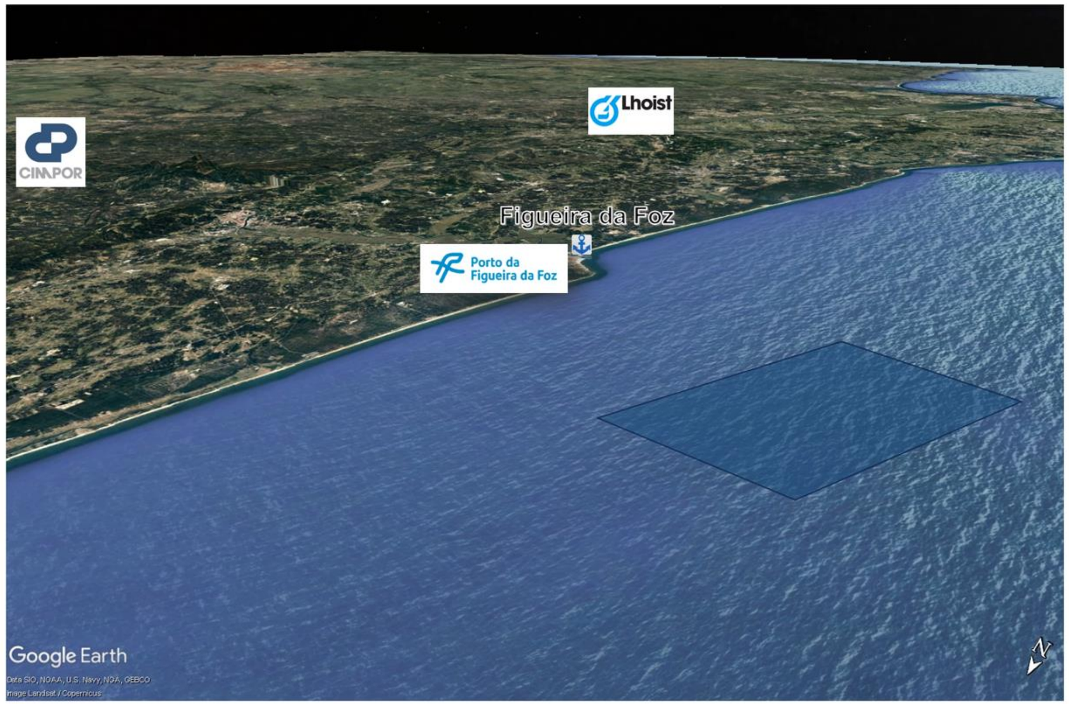


Gas Phase Saturation (frac)
during a 1000-year CO2

Barriers and challenges for the offshore option

- Regulatory aspects more challenging
- Social acceptance slightly best for the onshore
- Cost for a storage pilot higher than onshore
- Economy largely based on maritime activities (tourism, shipping and fishing)
- Restriction and impact of site implementation and monitoring (platform, pipelines, protection zone …)

Promote Integration and local development

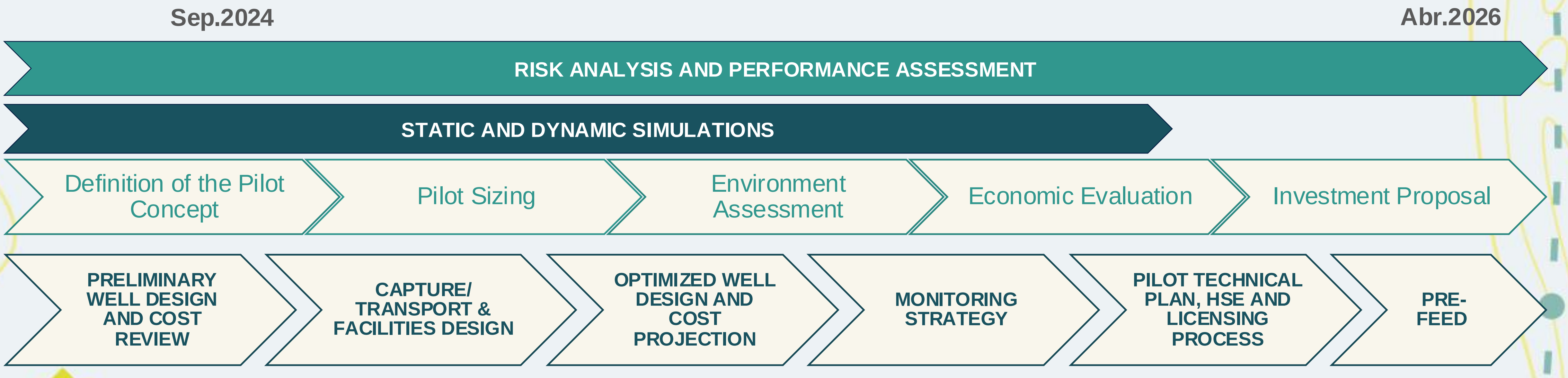


Connection to projects **CTS** – *CO_2 Transport and storage directly from ship* - and **MOTECH -** *innovative techniques for monitoring offshore CO2 storage.*

Progress Overview of the Project Technical Work

- **Analysis and quantification of risks** through dynamic reservoir simulation studies to evaluate **reservoir performance and containment** at both pilot- and commercial-scales.

- **Development of strategies and scenarios** for designing the offshore pilot storage site, addressing **environmental** and **economic assessments**, as well as the **investment proposal**.



Lusitanian Basin, Portugal

Thank you!

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

PilotSTRATEGY

WP4 – Pilot Development and Implementation Plans

Portugal Team

17th October 2024

Webinar

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

PilotSTRATEGY Project Framing

Pilot Phase: <100 kton CO_2

- Design a **carbon pilot injection storage site in the Lusitanian Basin** (~25 km offshore Figueira da Foz) to allow **safe storage** over 5 years
- Consider **CO_2 sourcing & transport** options
- Develop **business cases** that consider **commercial upscaling**
- **Mature storage site** to allow future investments from public and private sectors

- Define **injection strategy** – Injection intermittence helps to preserve optimal pressure gradient & control CO_2 plume
- **Inject CO_2 in liquid/supercritical phase**
- **Volumes, rate and duration** of pilot injection
- **Define baseline monitoring** – 3D seismic
- **Propose other monitoring** techniques in the well & surrounding environment

Pilot scale: Up to 100 kton CO_2 injected

Subsurface modeling and **above-ground characterization** (CO_2 capture out-of-scope)

1 injection well (Pilot Phase)

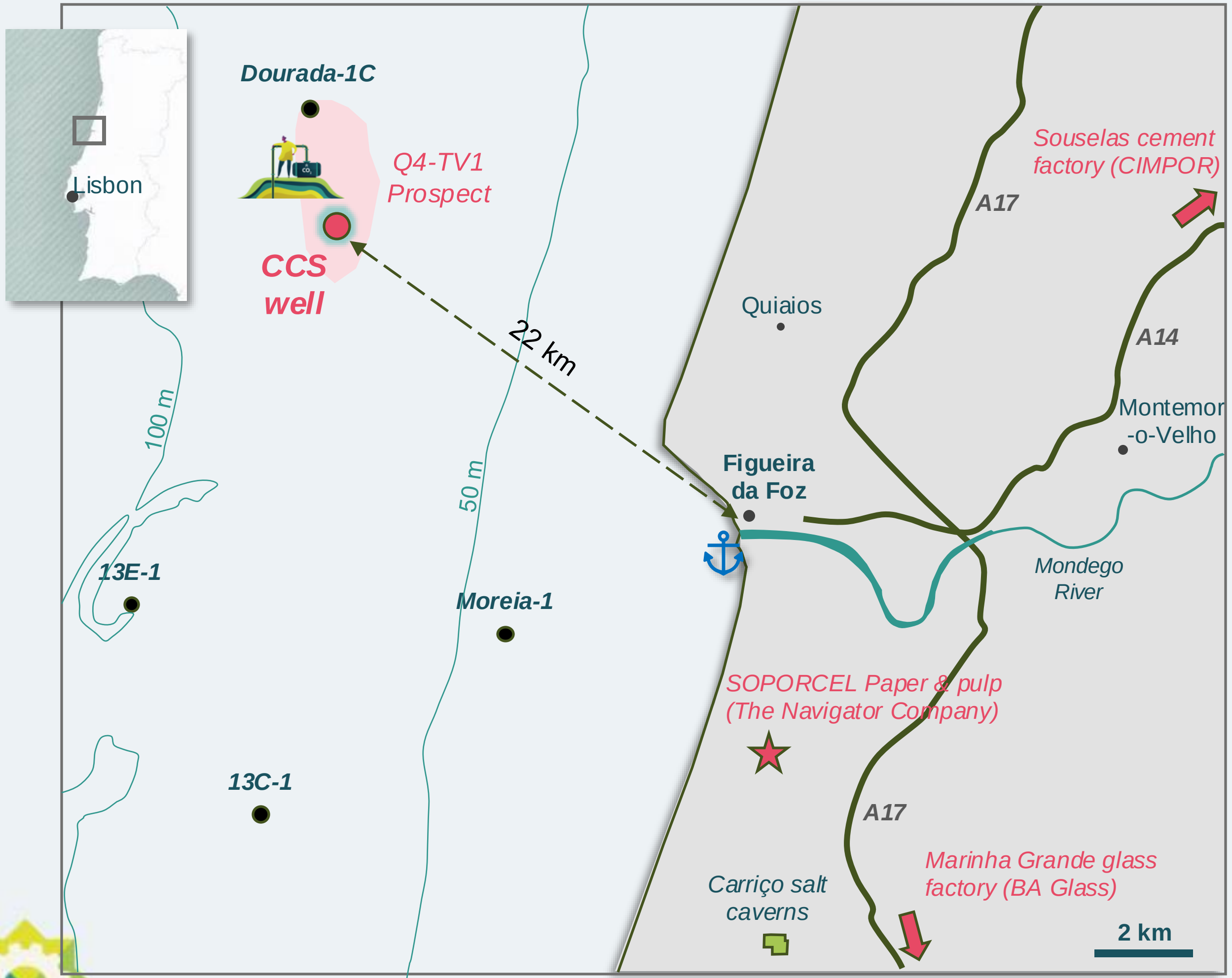
Pipeline to wellhead (+ transport to offloading facility)

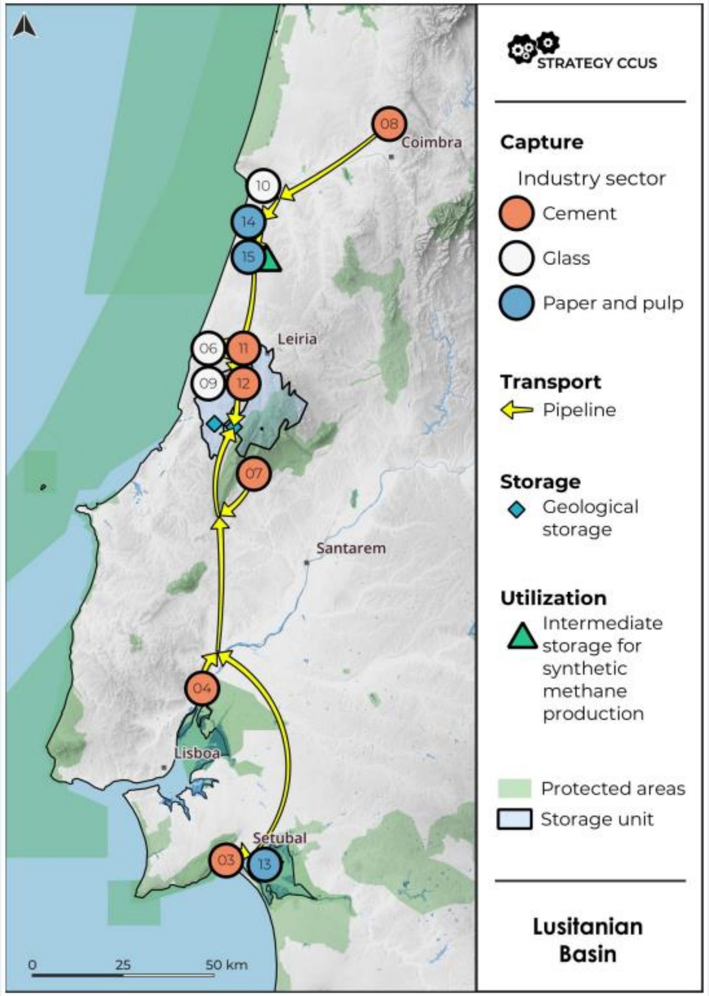
Infrastructural support (Figueira da Foz port)

Increase stakeholder awareness on CCS

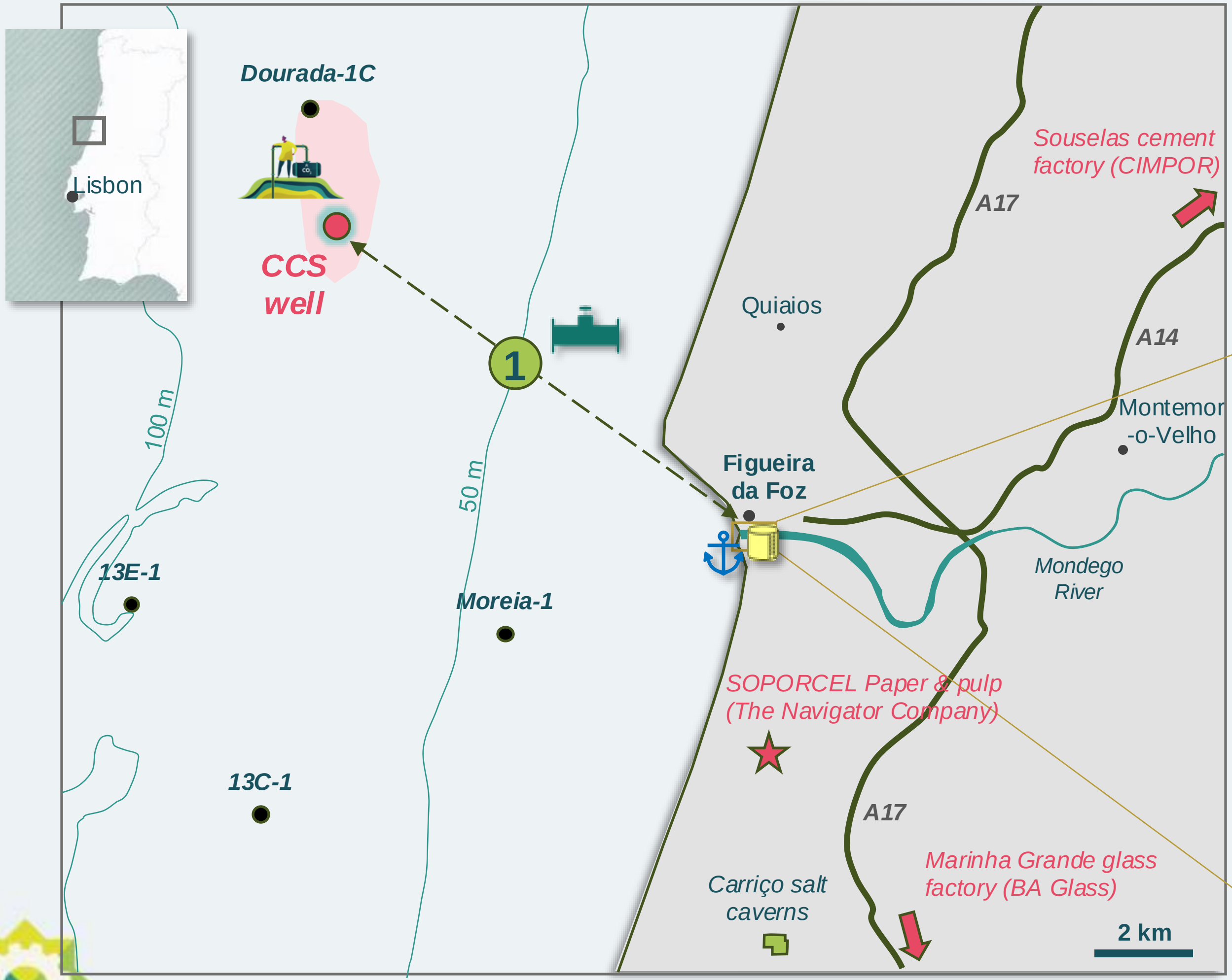
Project Basics → Offset Wells Data → Well Prognosis → Temperature and Pressure Profiles → CO_2 composition and Corrosion Assessment → Wellhead Pressure Estimation

CO_2 point sources





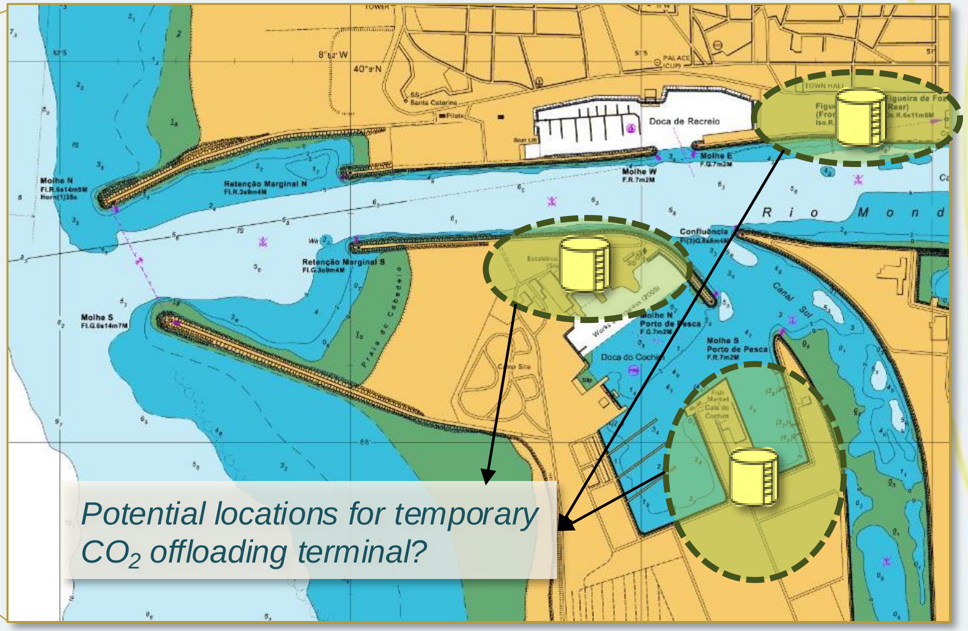
Pilot concept scenario



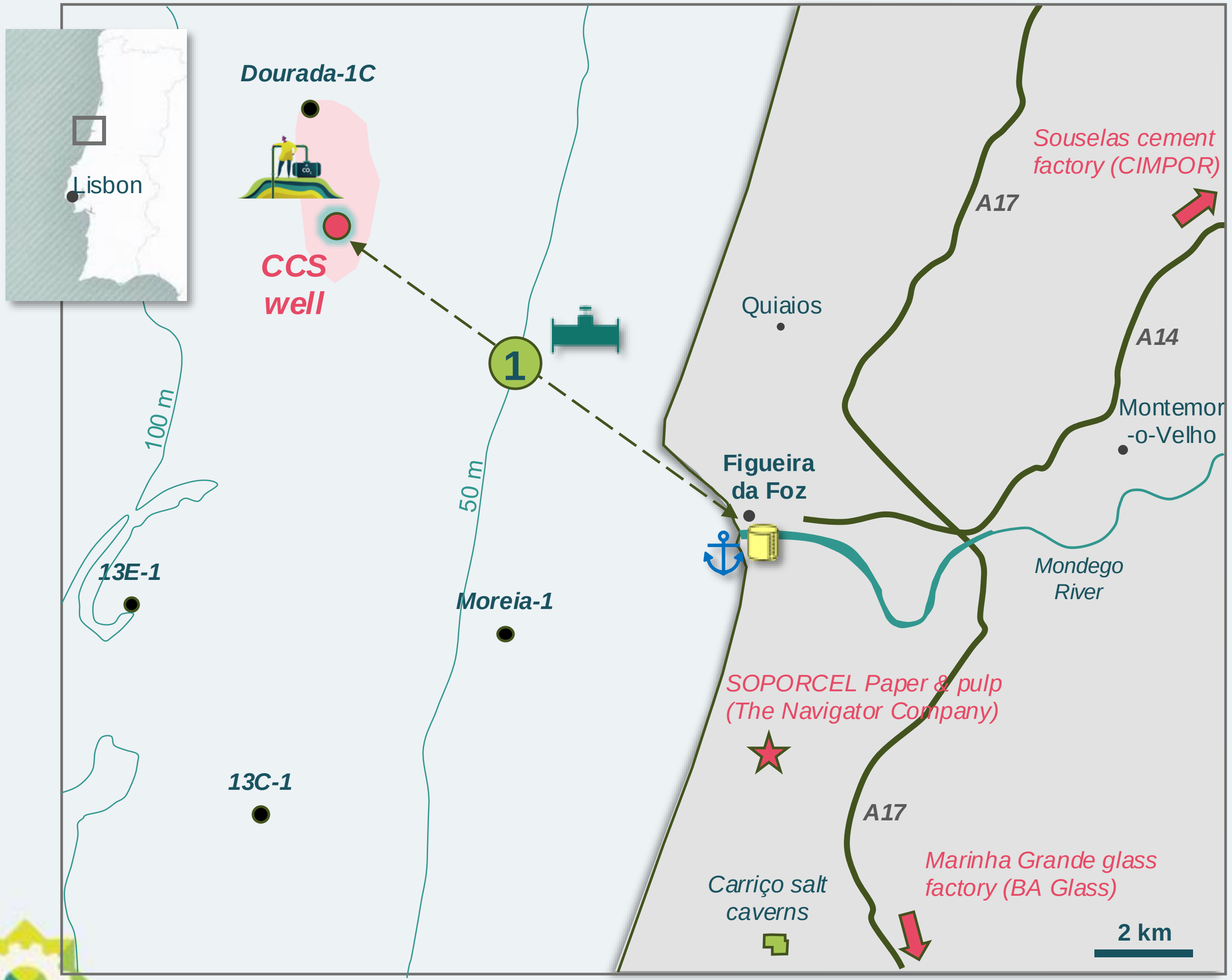
1 — Pipeline from Figueira da Foz loading/offloading terminal – CO_2 sourced by local industry

(ALTERNATIVE) Shipping from Figueira da Foz loading/offloading terminal – CO_2 sourced by local industry

Figueira da Foz port



CCS Basis of Concept – Pipeline



1 *Pipeline from Figueira da Foz loading/offloading terminal – CO_2 sourced by local industry*

Basis of design:

- 100,000 t CO_2/day
- 30 km (assumed P/L equivalent distance from CO2 industrial sources
- 22 km (offshore)
- 150 bar – CO_2 compression at industrial site battery limit
- 1 bar/km (max. acceptable pressure drop; injection done always above dense phase (P> 100 bar); fluid assumed to be pure CO_2)

Pilot (100,000 ton, 3-5 years):

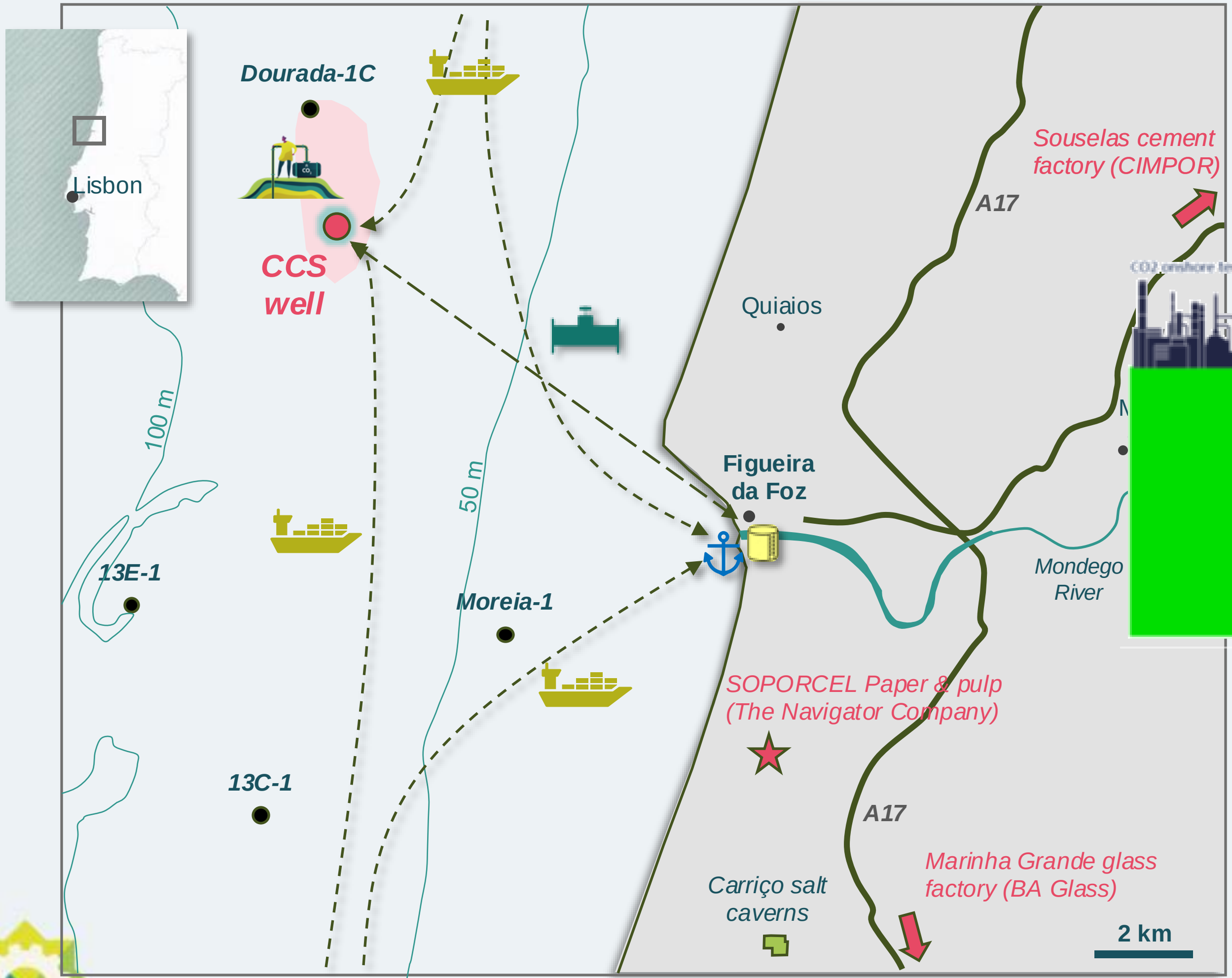
Onshore dense phase – from Figueira da Foz port to storage site (minimum operation pressure ~90bar)

- Offshore pipeline: **22 km (~~4" or~~ 8")**
- Manifold & wellhead: Subsea wellhead
- Wells: 1

Commercial (0,5 mton/yr, over 30 years):

- Offshore pipeline: **22 km (8")**
- Manifold & wellhead: Subsea wellhead
- Wells: 1 (+1?) – 1 well per 1Mtpa

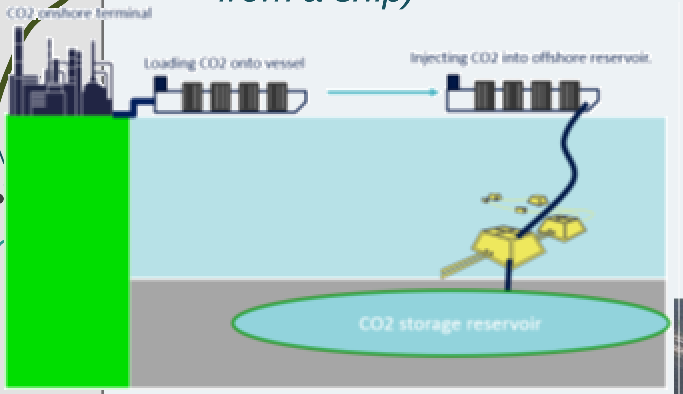
Alternative concept – Shipping



2 **Shipping** (regional CO_2 sources):

- To Figueira da Foz loading/offloading terminal
- Direct injection *(tbd)*

- **CTS project** *(CO_2 Transport and Storage directly from a ship)*

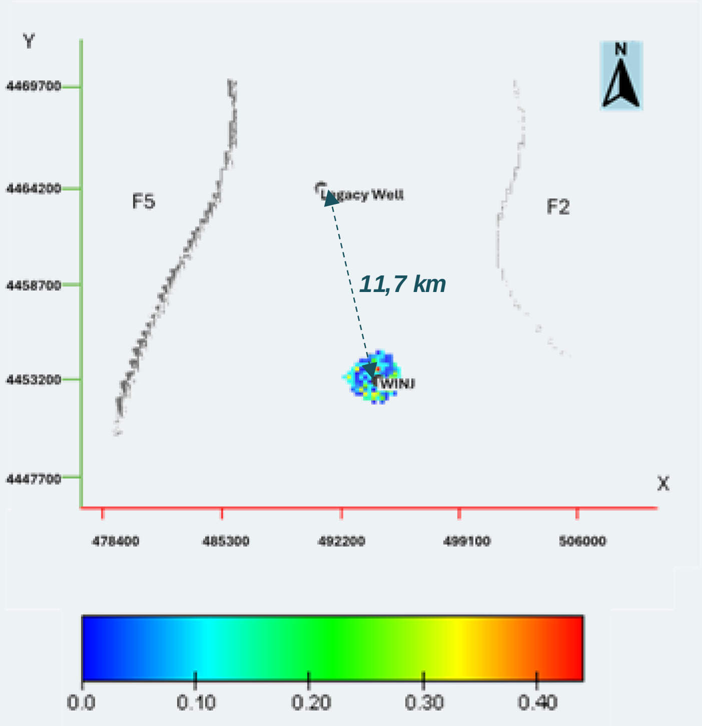


- Shipping liquefied CO_2 enables flexibility and scalability
- Pipeline from intermediate onshore storage to offshore reservoir (?)
- Identification and clustering of CO_2 sources and sinks

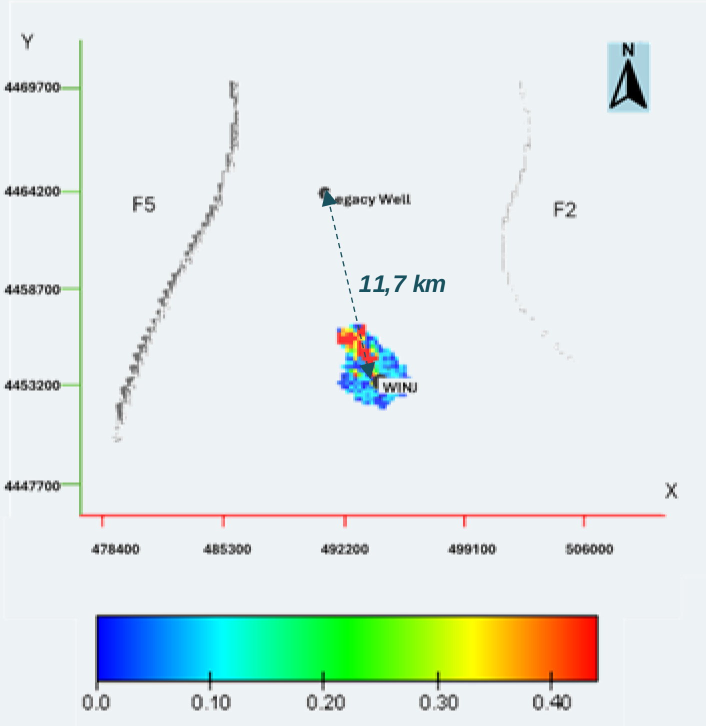
Above-ground to Subsurface

Optimal scenario:

- Well positioned further South of the legacy well (11,7 km) and away from faults (8,7 km from F2), enhancing safety
- **Simulations** over short (**30 years**) and long (**1,000-year** post-injection) periods of time suggest **CO_2 plume does not extend to the Dourada-1C legacy well**



Gas Phase Saturation (frac)
after a 30-year CO2 injection (optimization)



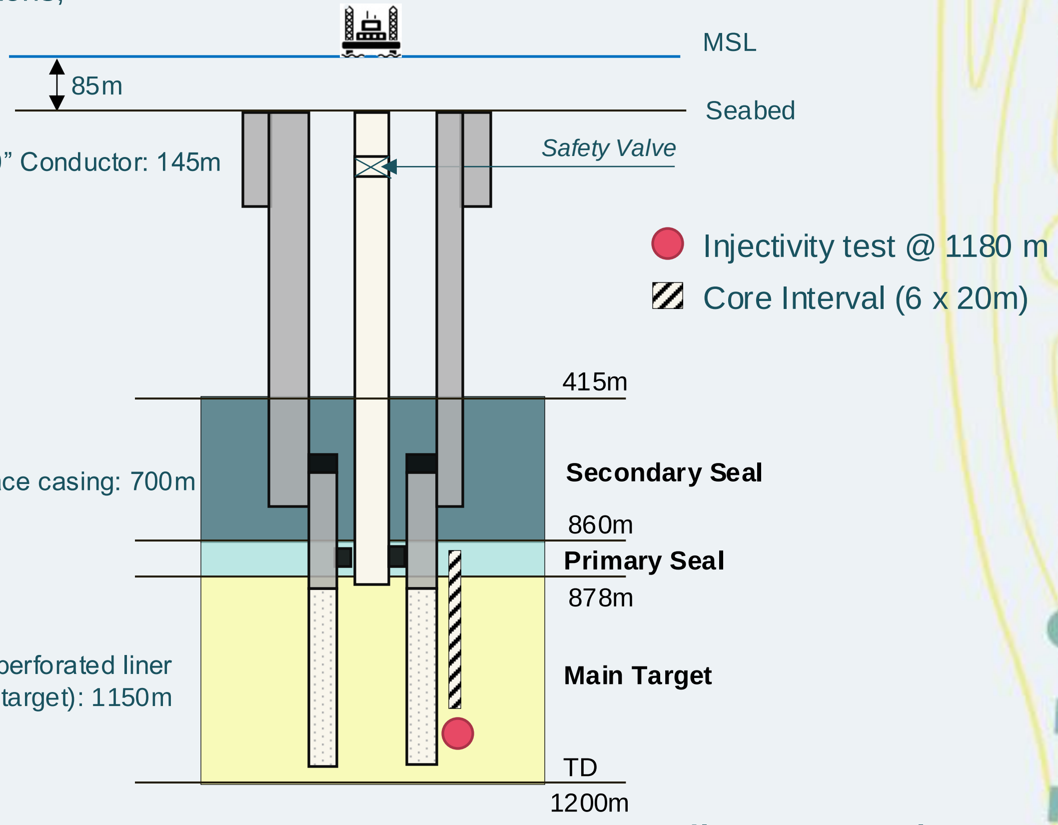
Gas Phase Saturation (frac)
after a 1000-year CO2

Well Assumptions (preliminary)

Casing Size (")	MD (m)	OH (m)
WD	85	
20	145	60
13 3/8	700	555
9 5/8"	1150	450
TD	1200	50

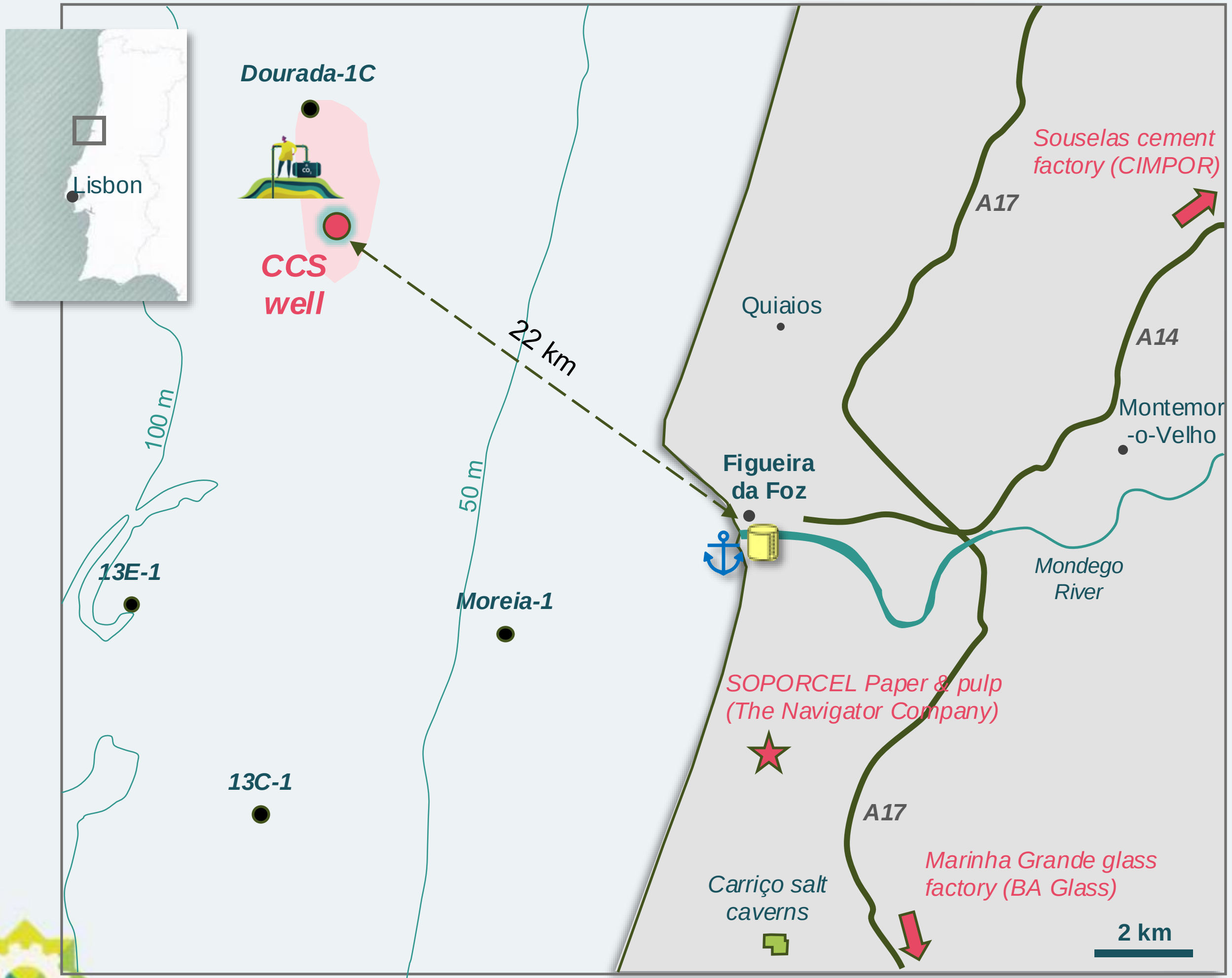
- **Rig rate**: Jack-up for shallow water depth (85m)
- **Service rate**: Includes logistics – project in Europe region with nearby service provider facilities
- **Rig mob**: a Dry Tow vessel (assuming mobilization from the North Sea to Portugal ~7days)
- **Subsurface hazards**: No HP/HT expected, stability to be achieved with regular operations, flat bathymetry, low seismicity
- **Wireline**: 3 days; **Completion**: 7" slotted liner

e.g. Jack-up drilling rig

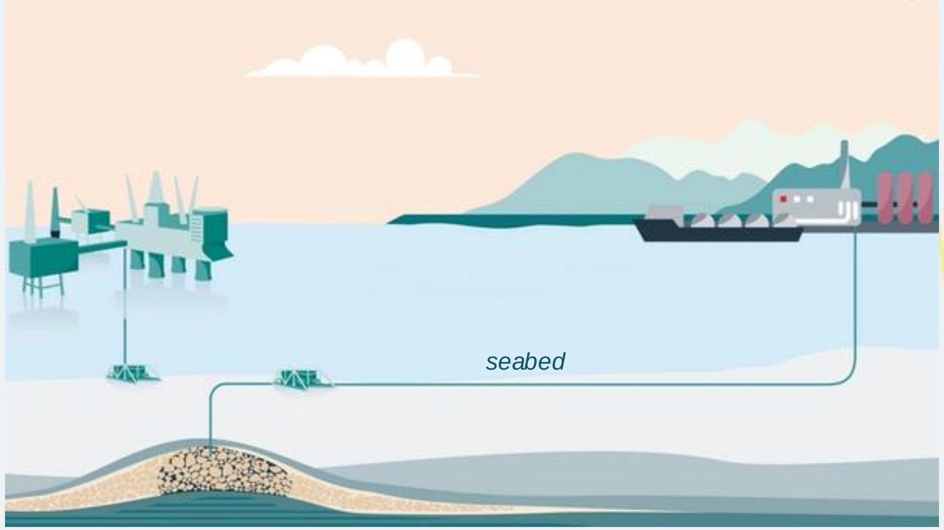


Mob/demob: 2 x 7 days x (150 (rig) + 150 (tug) + 40 (fuel));

Local Infrastructure



e.g. CCS Northern Lights infrastructure



PilotStrategy vs. Northern Lights concept

	Northern Lights (Phase I)	PilotStrategy (Phase I & II)
Capture	-	-
***Transport** to temporary offloading onshore facility*	**Yes** (shipping – 7500 m^3 LCO_2/ship, 18 bar-g @ -26ºC)	**Out of scope** – may be included in development costs
Onshore facilities	Jetty for mooring system 12 storage tanks Pump system	Storage tanks (*tba* – 1 or 2, depending on injection capacity) Pump system
Pipeline	**110 km** pipeline (12" @ 50 bar), single-phase liquid CO_2 (Phase II increase up to 20" ?)	**22 km** pipeline (4" Phase I; 8'' Phase II), single-phase liquid CO_2
Water Depth	300 m	85 m
Injection Wells	1 (+2 backup wells) (Phase I)	1 (+1?) – 1 well per 1 Mtpa
Subsea	Connecting pipeline, umbilical and wellheads	Connecting pipeline, manifold & subsea wellhead
Injection Rate	20-300 ton/h	
Injection Depth	2700 m	1180 m
Volumes CO_2	**1,5 mton/year** (Phase I); **5 mton/year** (Phase II)	**100 kton** (Phase I – 3 to 5 years); **16 mton max.** capacity over 30 years **(0,5 mton/year)**
Power	Umbilical to Osberg field	*tba* (connection to offshore wind farm?)

- Despite similarities, there are several technical differences, mostly related with **legacy infrastructures, dimensioning, subsurface uncertainties** and **project scale**

Social acceptance: methodology

Media and document analysis

+

Interviews with stakeholders at the national and local level

+

Survey of the local population

(beginning and end of the project)

+

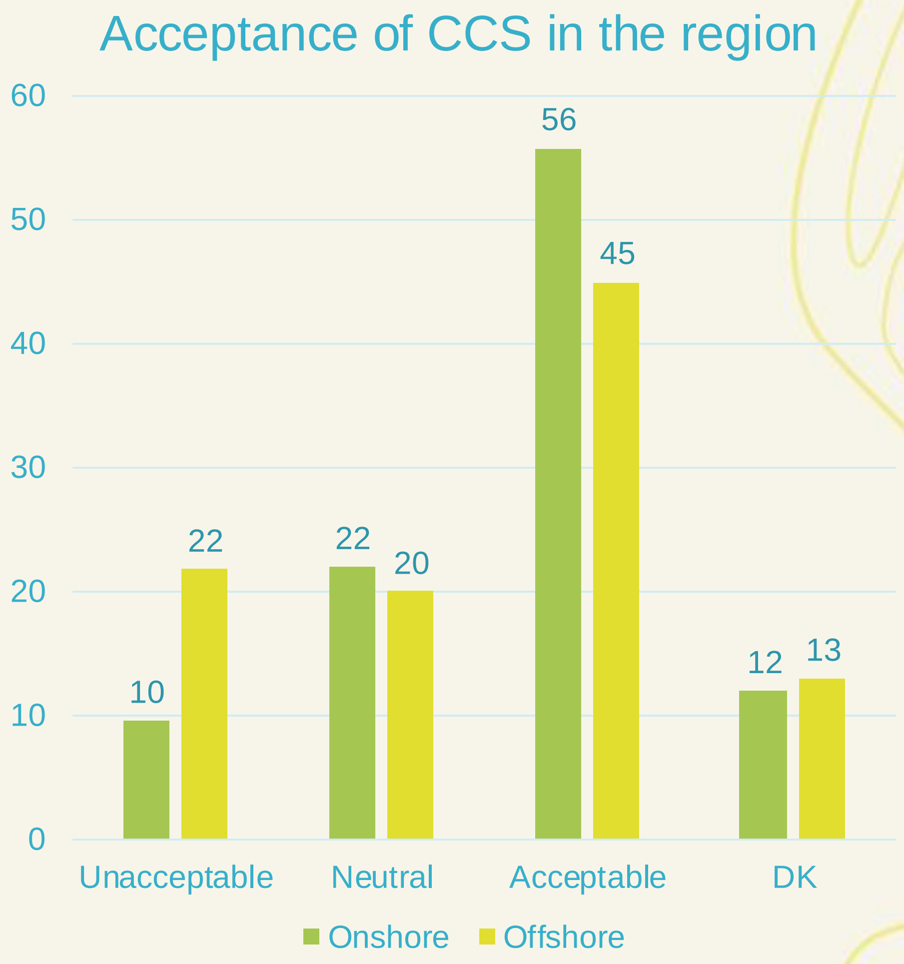
Regional Stakeholder Committees

+

Citizen engagement

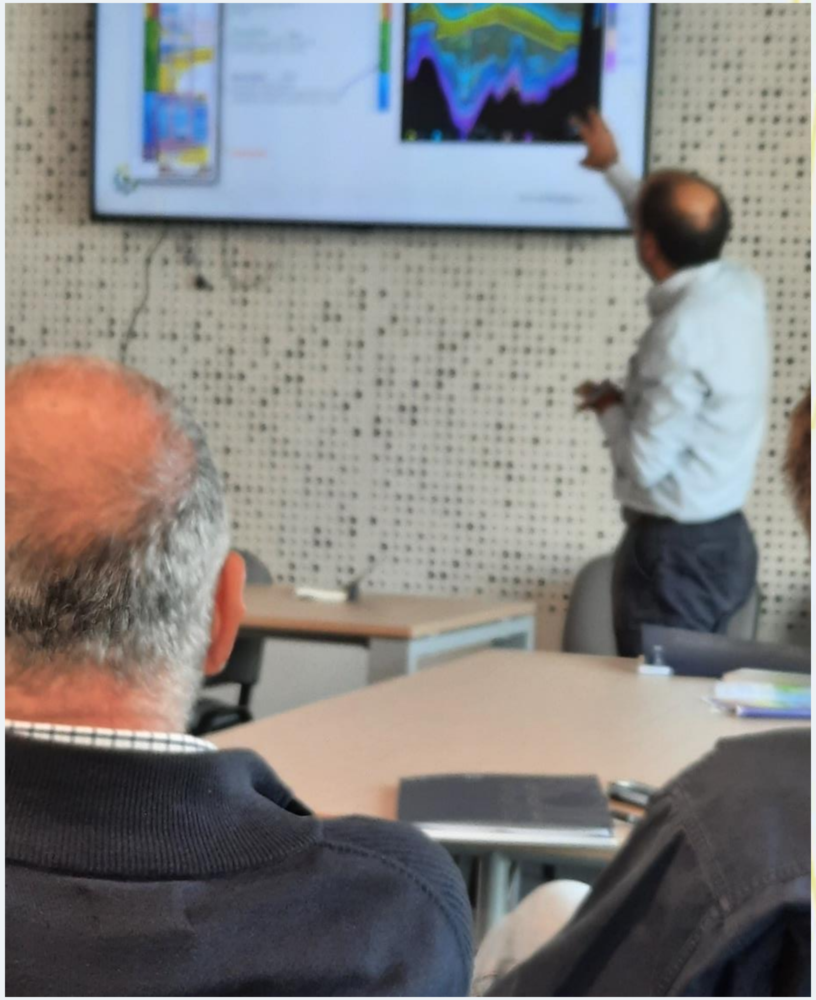
Public opinion survey

- Close to 90% of the sample do not know what CCS is
- After a brief explanation, 63% agree that CCS is a good solution for climate change
- Acceptance of CCS in the region is over 55% onshore and 45% offshore
- 52% believe in positive economic impacts, 47% in positive environmental impacts
- 80% want citizen participation in decision, 71% economic compensation
- Higher levels of trust in scientists and NGO



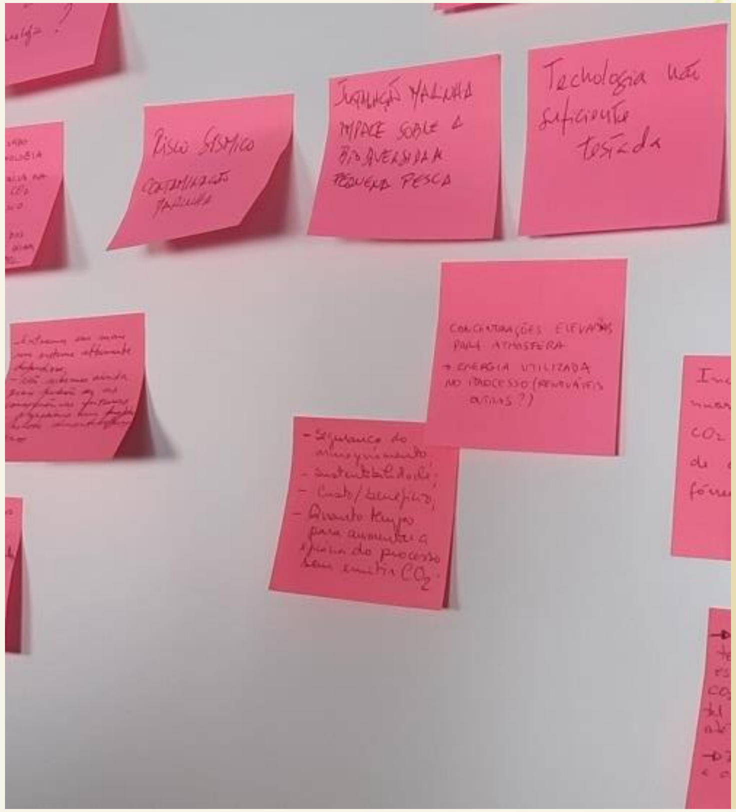
Stakeholders

- Government: absence of specific regulation or policies, noncommittal in RSC meetings
- Industry (emitters): interested, active in meetings and in between meetings
- Local authority: supportive (local development, investment in R&I)
- Local economic actors (e.g. port authority): interested in business opportunities
- Environmental NGO: against CCS as an expensive distraction from other climate solutions and some concern with risks for marine ecosystems
- Local associations (fishermen): not against, but have concerns regarding seismic monitoring (and a bigger battle with offshore wind)



Residents

- Small, non-representative sample participated in workshop (although invitations were wide-ranging)
- Well-prepared, did their ‘homework’
- Some very vocal against CCS: technosolutionism, greenwashing, energy needs, risks
- Divided between being completely contrary to CCS and accepting it as a not ideal solution for climate change but tolerant of a well-managed project



Next steps

- Online RSC meeting in November 2024
- Face to face RSC meeting in Spring 2025
- Second round of public opinion survey in Spring 2025 (more localised in the area of Figueira da Foz)
- Citizen engagement with a wider sample (format to be decided)

PilotSTRATEGY

Acknowledgements

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