DEPARTMENT OF GEOLOGY

SHOGENERGY
Consulting & Solutions for future energy sector
CCUS /H_2/Energy storage /Geothermal energy recovery
SYNERGY CONCEPTS

CCUS ZEN

A framework for the selection of promising CCUS value chains in the Baltic and Mediterranean regions

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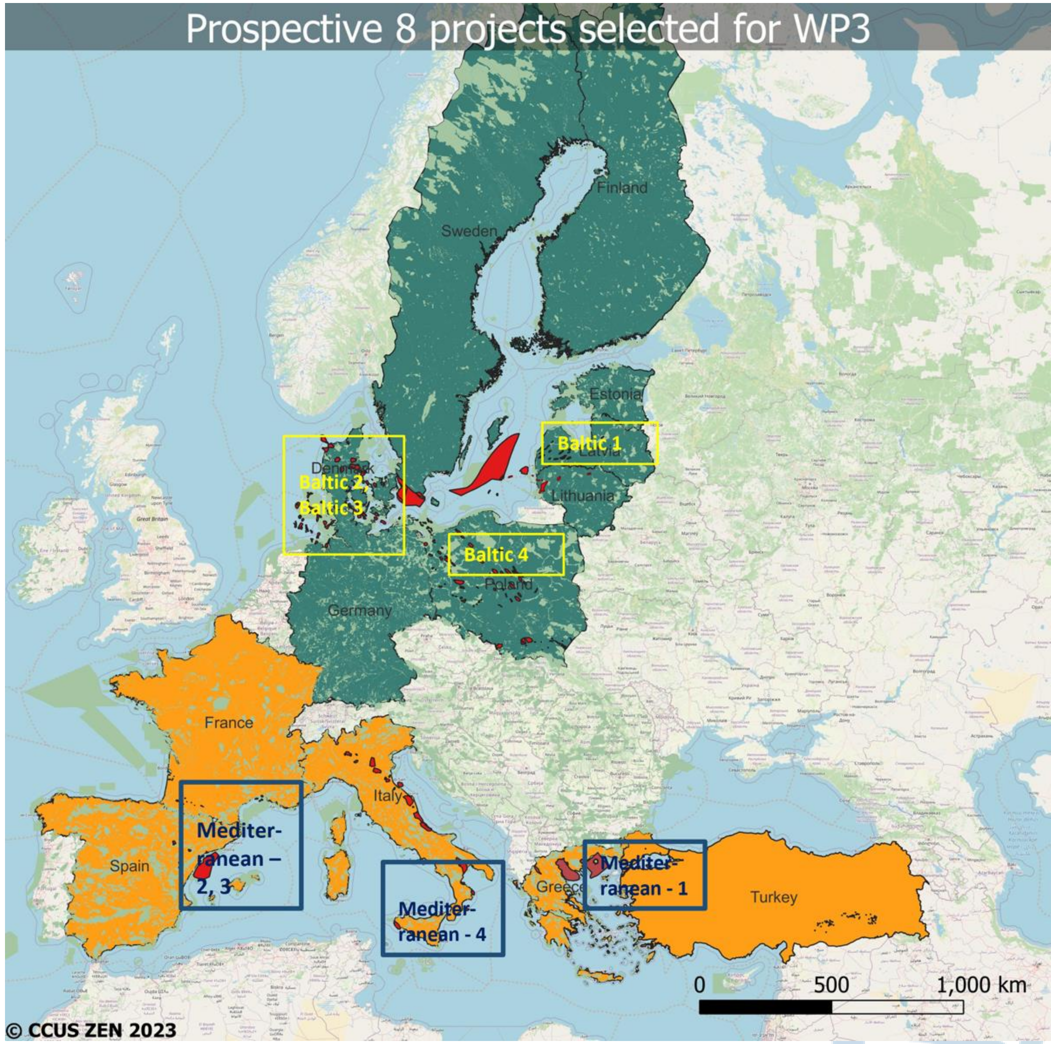
Summary

- **The objective of this study is to propose a framework for the selection of national and cross-border CCUS value chains and to apply it to eight case studies in the Baltic and Mediterranean regions studied by the Horizon Europe CCUS-ZEN project.**
- Technical and non-technical data were first collected and integrated into a common GIS project for eight countries in the Baltic region and five countries in the Mediterranean region.
- To apply SWOT analysis to the prospective CCUS cluster projects, internal and external groups of parameters were first developed.
- Internal technical groups (strengths and weaknesses) include 1) CO_2 emission plants, 2) CO_2 storage sites, 3) available and planned infrastructure, and 4) CO_2 use options.
- An external technical group includes 1) characteristics of the area around the storage site, and non-technical external groups include 1) social, 2) political development, 3) international and national regulations, 4) MRV (Monitoring Reporting and Verification), 5) financial, 6) Readiness of CCUS value chain, which were analysed for opportunities and risks.
- The developed framework includes 24 internal quantitative technical parameters and 14 external qualitative parameters, which were collected for eight CCUS value chains.
- For qualitative parameters, questions with numbers were developed to be able to include external parameters in the quantitative SWOT analysis.
- However, offshore and onshore CCUS projects must adhere to different regulatory frameworks and some other studied issues. Despite these differences, it is possible to perform a unified quantitative analysis for all projects (both onshore and offshore) by utilizing common internal technical factors and a streamlined list of external technical and non-technical parameters.
- **Here, we reported the qualitative results of analysis and the framework for the quantitative SWOT analysis, which will be performed at the next step of this study using statistical multivariate analysis.**

INTRODUCTION

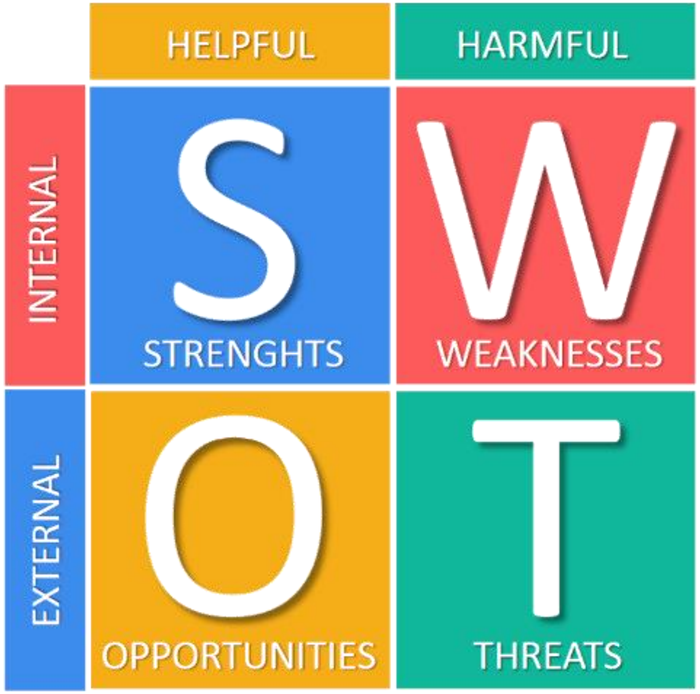
- Today, CCUS projects around the world inject about 50 Mt of CO_2 annually. To achieve climate neutrality, we must increase CO_2 storage from millions to billions of tons per year. One effective way to accelerate this necessary scale-up is by implementing CCUS clusters and hubs.
- The application of CCUS clusters and hubs offers many advantages:
  - ✓ faster scaling
  - ✓ lower unit costs
  - ✓ reduced investment
  - ✓ reduced cross-chain risks
  - ✓ governmental support
  - ✓ the creation of new jobs
  - ✓ potential revenues from CO_2 utilization
  - ✓ synergies with renewable energy sources and CO_2-negative technologies
  - ✓ increased public awareness
  - ✓ improved public perception
- This study proposes a framework for selecting national and cross-border CCUS clusters and hubs (value chains)
- The framework is applied to eight case studies in the Baltic and Mediterranean regions (12 countries involved) and has been developed by the Horizon Europe CCUS-ZEN project
- Technical and non-technical data were first collected and integrated into a unified GIS project for 6 countries in the Baltic region and 5 countries in the Mediterranean region.



Location of the studied value chains in the Baltic and Mediterranean Regions. Storage sites are shown in red. The green colour is for the Baltic, and the orange is for the Mediterranean Region.

Methodology

- SWOT analysis, which stands for strengths, weaknesses, opportunities, and threats, is a strategic planning technique used to assess various factors related to project planning
- To quantify the SWOT analysis, we will apply the methodology established by Chang & Huang (2006) at the next step of this study.
- The Quantified SWOT analytical method incorporates the principles of Multiple-Attribute Decision Making (MADM), using a multi-layered approach to simplify complex issues.
- Since we need to analyse both quantitative and qualitative data, a statistical methodology is necessary.
- In this study, it was suggested that the weights of internal and external factors be treated equally. The weights of the key factors will be calculated using the Analytic Hierarchy Process (AHP), as proposed by Saaty (1980), and applied to the SWOT analysis by Chang & Huang (2006).
- This methodology could be applied at the final step of this study, after clarifying how many parameters (technical and non-technical could be analysed together statistically for all the proposed CCUS projects)



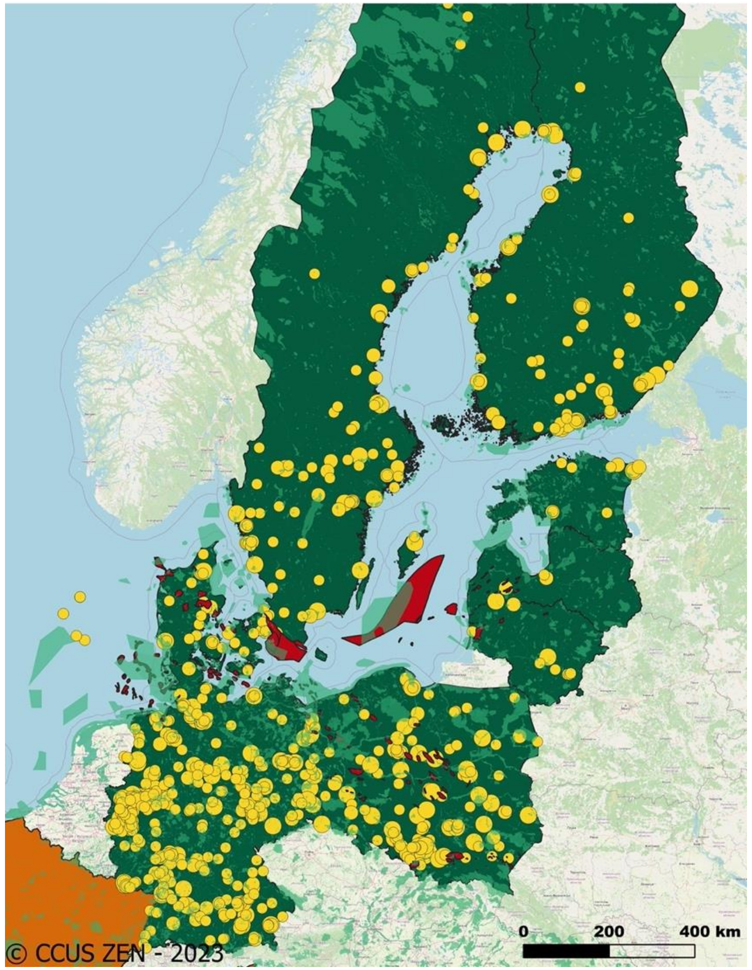
Multivariate SWOT analyses of CCUS value chains

Technical and non-technical data
for two regions were collected and integrated into GIS

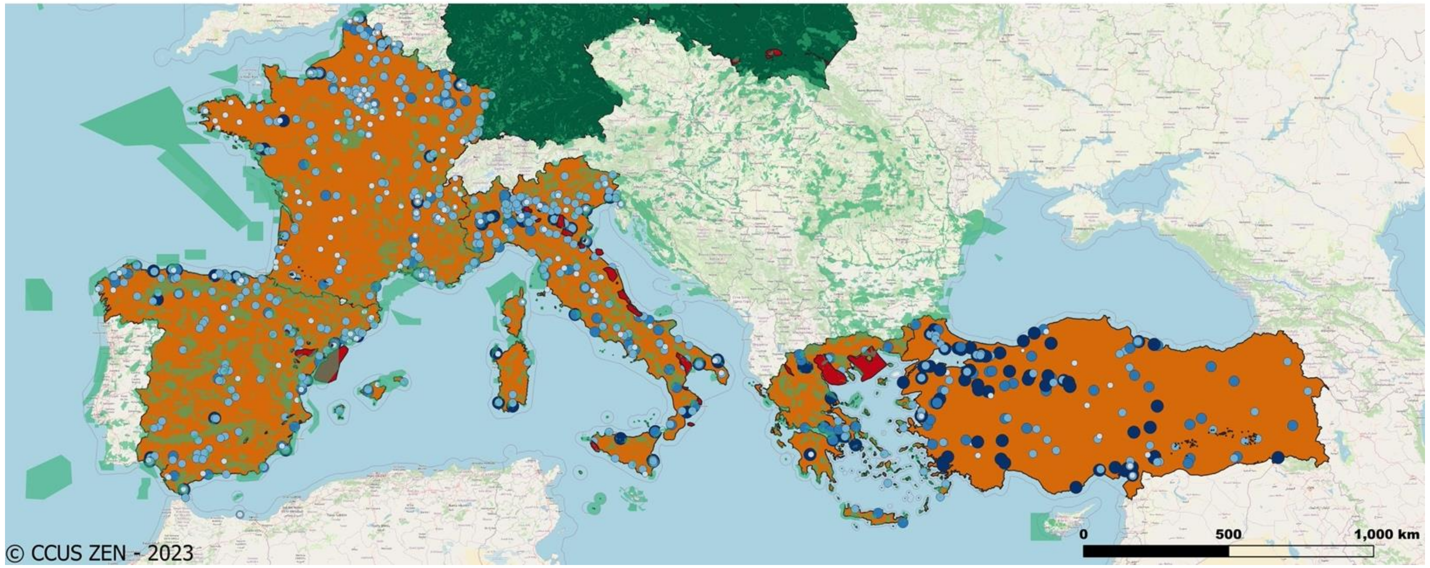
Collected Layers:

- CO_2 emission sources (yellow and blue circles)
- CO_2 storage sites (red polygons)
- Natura 2000 areas (Light green areas)
- Available infrastructure (pipelines, ship routes)

Baltic technical data



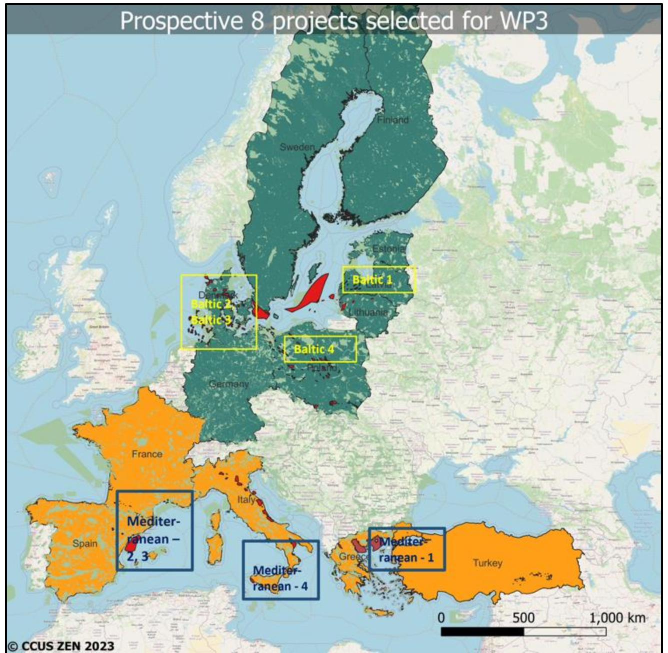
Mediterranean technical data



Parameters of the studied value chains in the Baltic and Mediterranean Regions

M-1–M-4 - Mediterranean-1–Mediterranean-4, respectively

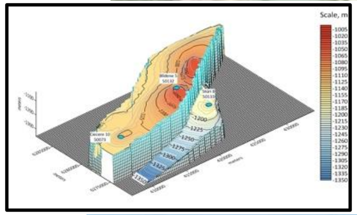
8 large CCUS cluster projects were selected, with 4 projects from each studied region for the more detailed technical analysis, integration with CO_2 use options and consideration of non-technical parameters

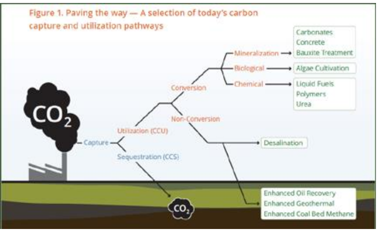


Project ID	Value chain name	Involved countries	N. of countries	Total produced CO_2 emissions, Mt/y	N. of emission sources	N. of emission clusters	Storage sites	N. of storage sites	Total CO_2 storage capacity, Mt	Total years for storage	Distance emission sources - storage sites, km
Baltic-1	Baltic Lat-Lit-onshore	Latvia Lithuania	2	4.25	6	2	North Blidene, Blidene and Dobele	3	403	> 40	9-150
Baltic-2	DE DK SWE Jutland network Onshore & offshore transport & storage	Germany Denmark Sweden	3	22.66	33	9	Gassum, Voldum, Jammerbugt Inez, Bifrost, Greensand, Lisa, Thorning	8	928	> 40	5-750
Baltic-3	Copenhagen	Germany Denmark Sweden	3	5.9	16	4	Rødby, Havnsø, Stenlille	3	657	> 40	5-115
Baltic-4	North Poland onshore	Poland	1	8.19	11	4	Konary J, Kamionki K	2	381	52	4.2-38.2
M-1	Soma - İzmir Aliağa - Prinos	Türkiye Greece	2	40.0	16	2	Prinos	1	1000	25	120-360
M-2	Ebro offshore	Spain and France	2	23.82	32	3	Castellon	1	200	20	50-470
M-3	Beaucaire onshore	France	1	1.17	2	1	Haut d'Albaron	1	34	29	27
M-4	Southern Italy network and Athen, Greece	Italy and Greece	2	41.1	32	6	Bradanica	1	344-1376	7.8 -19	50 - 450
Total range for all clusters		**11**	**1-3**	**1.2-40**	**2-33**	**1-9**		**1-8**	**34-1400**	**8-> 40**	**5-750**

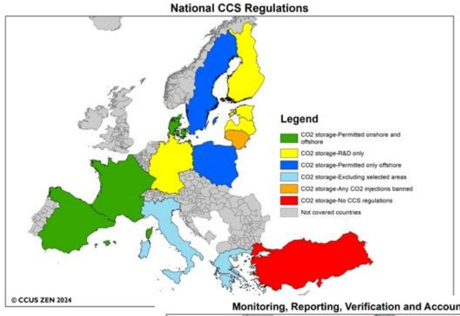
SWOT analyses
of CCUS value chains

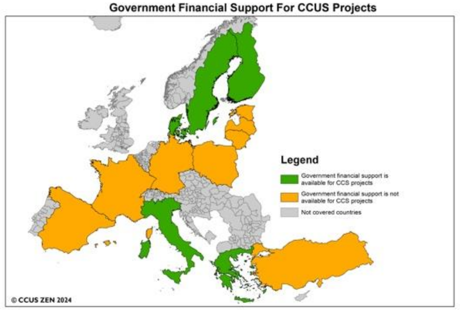
A qualitative SWOT analysis was applied to prospective CCUS cluster projects, evaluating technical and non-technical parameters





INTERNAL FACTORS Strength and Weakness	EXTERNAL FACTORS Opportunities and Risks	
Technical	**Technical**	**Non-technical**
CO_2 emission plants	The area surrounding the storage site	Social considerations
		Political development
CO_2 storage sites		Regulatory requirements
Infrastructure (available and planned)		MRV (Monitoring Reporting and Verification) processes
CO_2 use options		Financial parameters





INTERNAL GROUP FACTORS

EXTERNAL GROUP FACTORS

INTERNAL GROUP FACTORS

Technical (24 factors)

CO_2 emission plants

(I1) Number of countries
(I2) Number of clusters
(I3) Number of plants
(I4) Fossil CO_2 emissions (Mt)
(I5) Bio CO_2 emissions (Mt)
(I6) Captured CO_2 emissions (Mt)
(I7) Number of plants planned CO_2 capture
(I8) Number of plants planning H2 production

CO_2 storage sites

(I9) Number of storage sites
(I10) Porosity of the reservoir rocks (average, decimal)
(I11) Permeability of the reservoir rocks (average, Md)
(I12) Well injectivity (Mt/y)
(I13) Thickness of primary cap rocks, m
(I14) CO_2 storage capacity (total, Mt)
(I15) Storage Readiness Level (SRL) (1-9)

Infrastructure

(I16) Transport distance (max, km)
(I17) Transport distance (total, km)
(I18) Total CO_2 emissions per distance unit (t/km)
(I19) Number of wells in operation
(I20) Number of old abandoned wells
(I21) Number of planned PCI projects

CO_2 use options

(I22) Number of CO_2 use projects in operation, or R&D
(I23) Longevity of CO_2 use products (years)
(I24) Bio-CO_2 to be used (Mt)

EXTERNAL GROUP FACTORS

Technical (5)

The area in and around the storage site

(E10) Storage site located in the densely populated area (Low – 1, medium – 2, 3, high – 4)
(E11) Storage site area belonging to landlords (Yes - 4, No -1)
(E12) Storage site located in seismic risk area (no seismic risk – 1, low seismic risk – 2, seismic risk in the neighbouring region – 3, average seismic risk – 4, high seismic risk – 5)
(E13) Storage site located in Natura 2000 area/other protected area (100% located in the protected area - 5, 50% located in the protected area -4, 25% -3, 10% -2, not located -1)
(E14) Transport routes are going through Natura 2000 area/other protected areas (100% located in the protected area - 5, 50% - 4, 25% - 3, 10% -2, no located - 1)

Non-technical (9)

Social

(E1) Level of public acceptance (low - 1, medium - 2)

Political development

(E2) Political development
Favourable (4-5), Business as usual (2-3)
Unfavorable (1)

International Regulations

(E3) London Protocol (LP):
Non-member - 1, Member of London Convention - 2
Member of LP - 3
Amendment to Article 6 to LP implemented - 4
Provisional Application of Article 6 to LP - 5

National Regulations

(E4) EU CCS Directive implemented:
Any CO_2 injection banned (1)
CO_2 storage permitted for research (2)
CO_2 storage permitted offshore or onshore (3)
CO_2 storage permitted onshore and offshore (5)
No CCS Regulations (0)

MRV (Monitoring Reporting and Verification)

(E5) MRV Readiness
Low (1), Medium (2), High (3)
(E6) Accounting Readiness
Low (1), Medium (2)

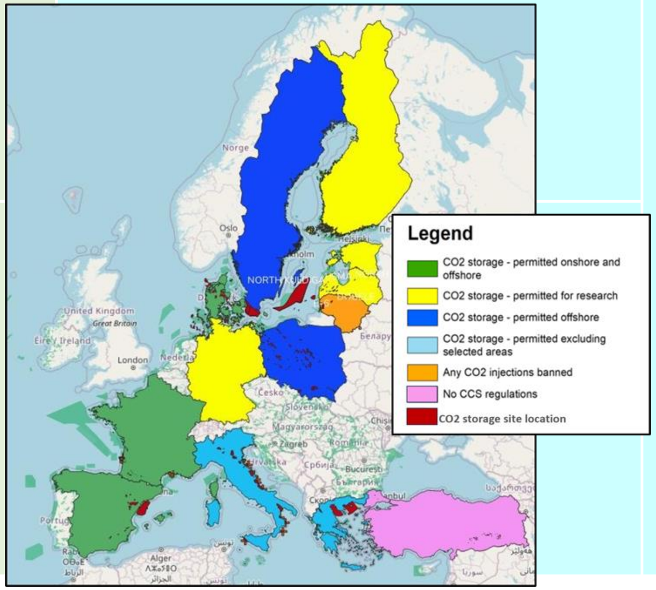
Financial

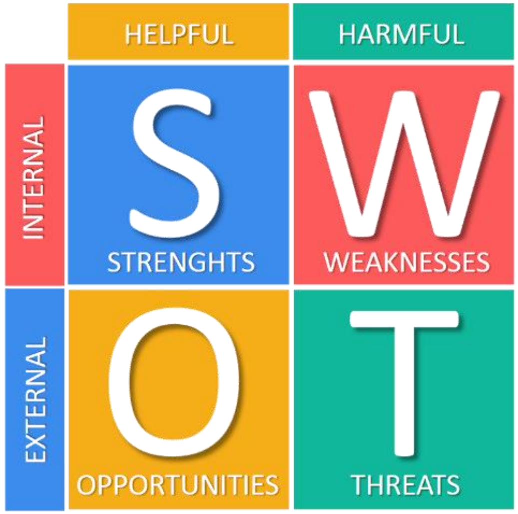
(E7) Governmental financial support for CCUS projects
Not available (0), available (3)

Readiness of CCUS value chain

(E8) Value chain readiness
Developing Capture (1), Capture available (2)
Developing Capture & Transport (2)
Capture and transport available (4)
Developing Capture, transport and storage (3)
Capture, transport and storage available (6)
Capture in development, storage is available (3)
None (0)
(E9) CCUS in Industrial strategy/plan
Yes (3), No (1), No strategy/plan (0)

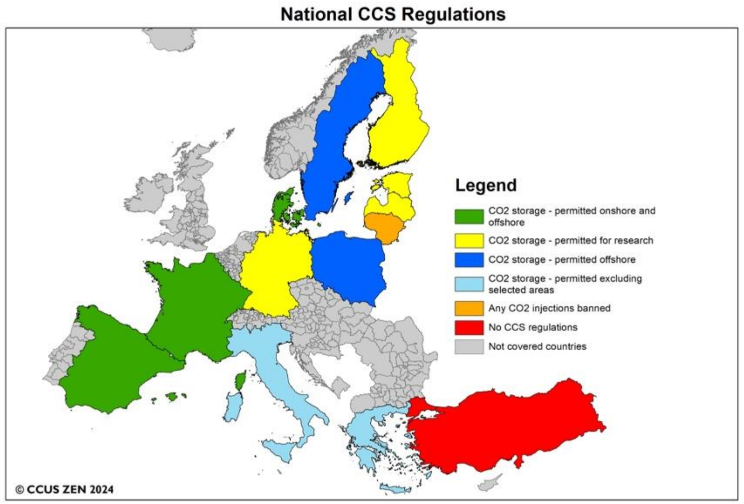
National Regulations combined with CO2 Storage Sites

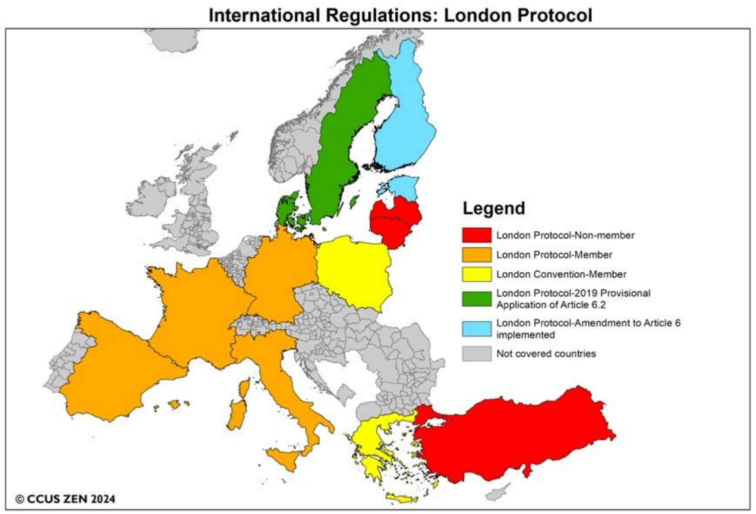


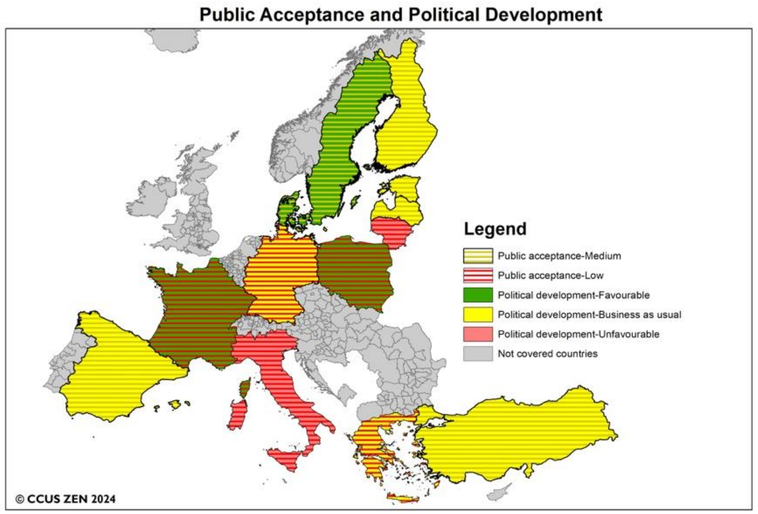


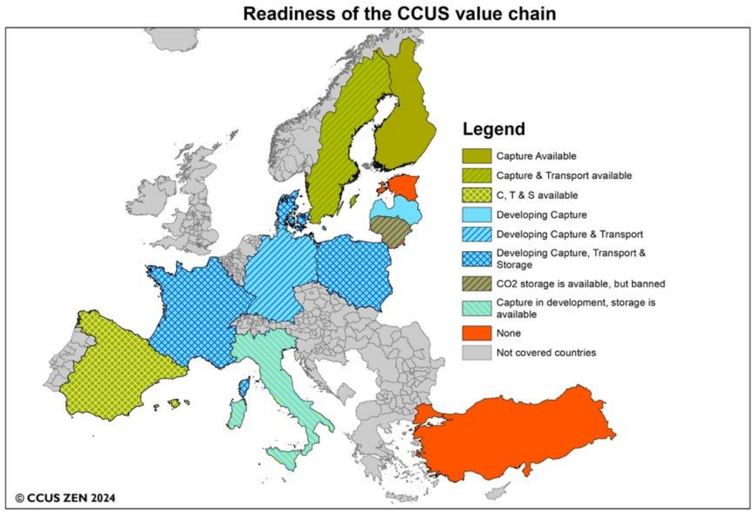
Multivariate SWOT analyses of CCUS value chains

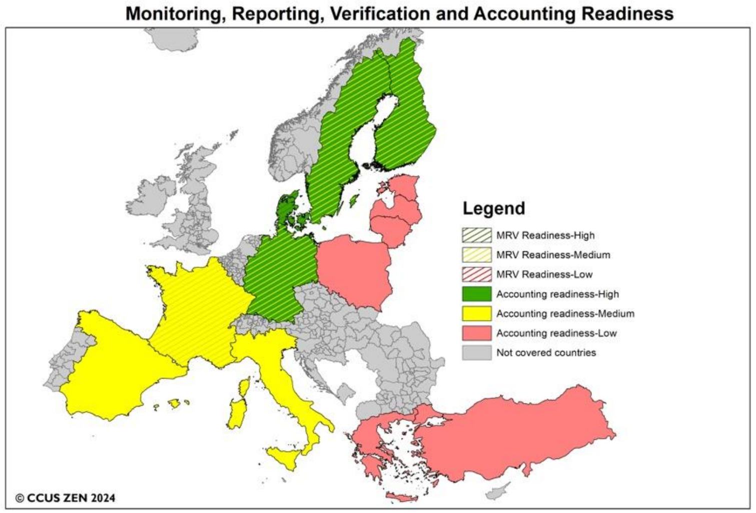
Non-technical layers in GIS

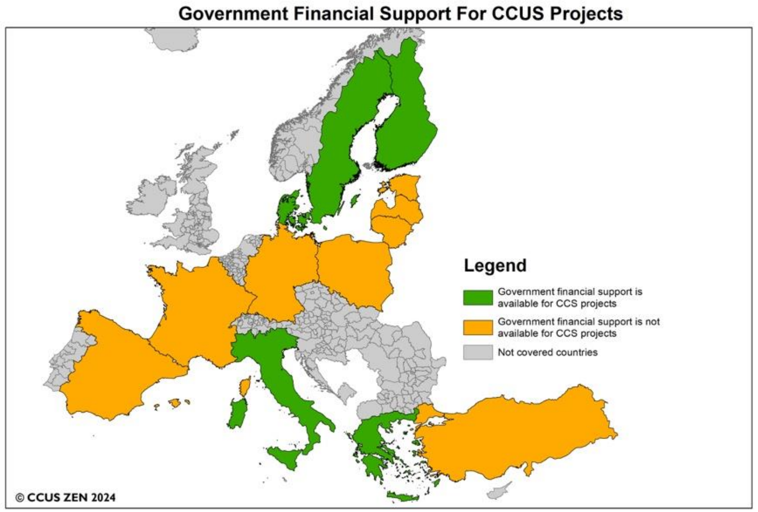




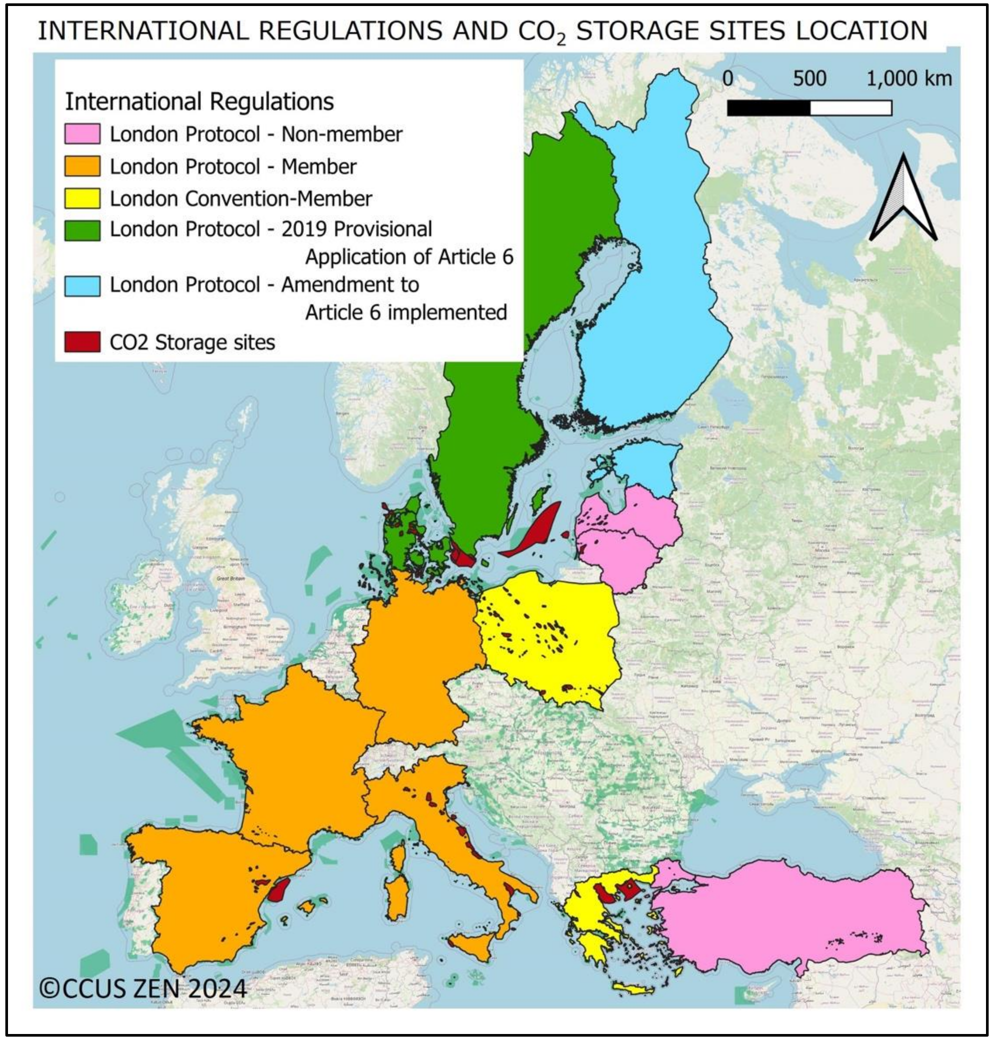


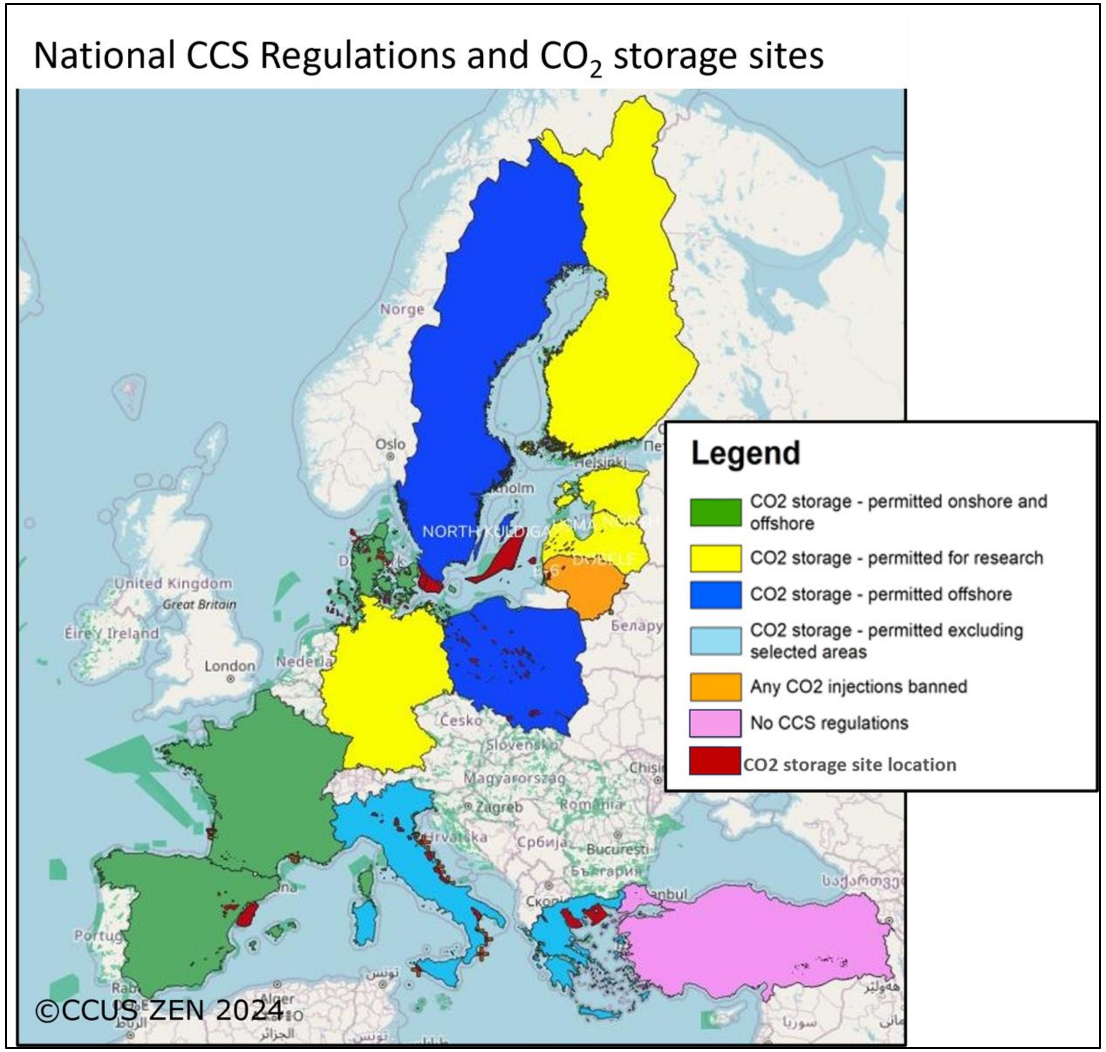






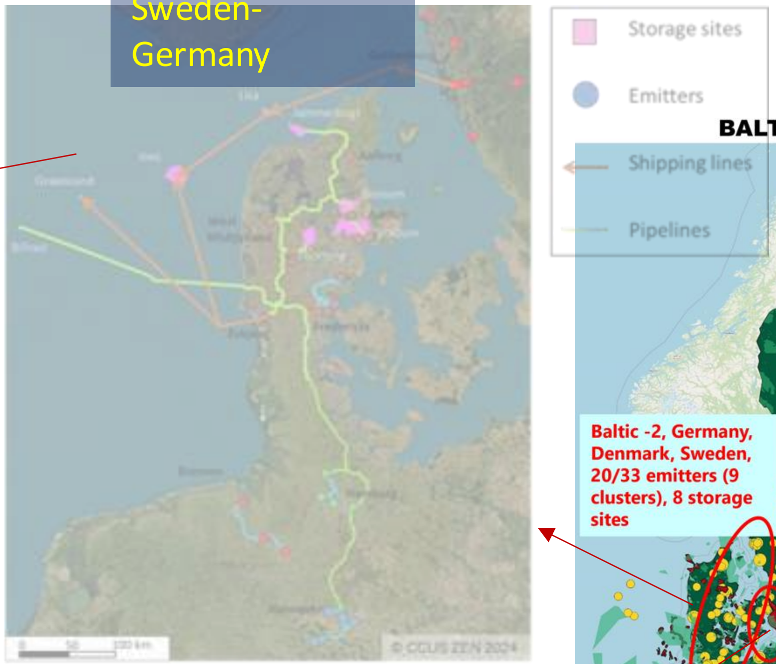
Non-technical data combined with technical data





4 Baltic projects

Baltic-2 (B-2) Denmark, Sweden-Germany

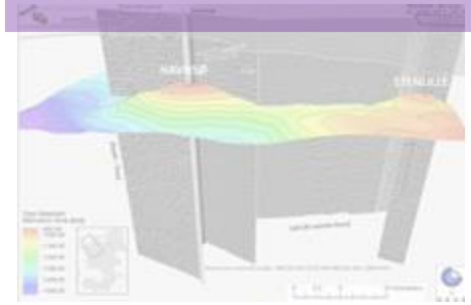


Advantages (B-2 & B-3)

- ✓ High storage capacity
- ✓ favourable CCS policies and regulations
- ✓ financial governmental support in Denmark

Challenges (B-2 & B-3)

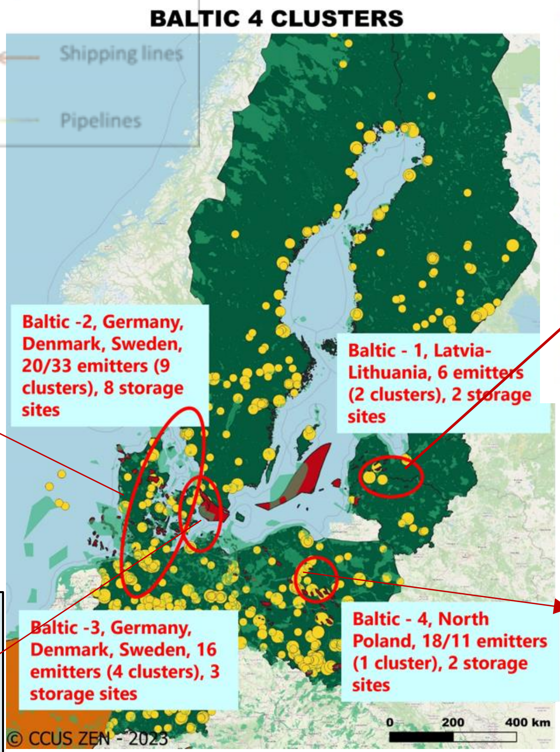
- Regulatory in Germany
- Complicate transport structure and long distances

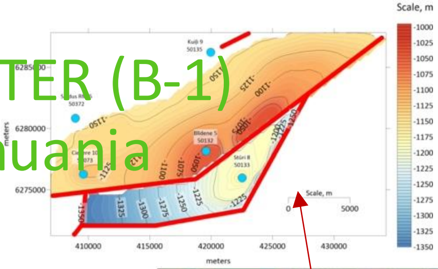


Map of the Top of Gassum formation for Stenlille and Havsno structures. Source: Gregersen et al, 2023

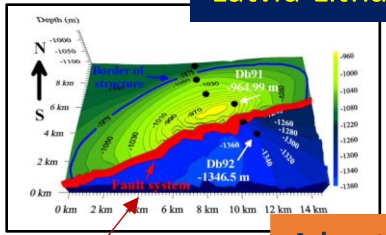
Baltic-3 (B-3)-Denmark, Sweden-Germany

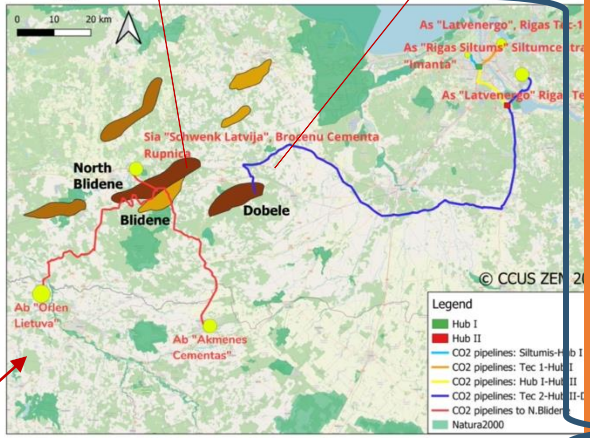
Baltic-1 CLUSTER (B-1) Latvia-Lithuania





Baltic-1 (B-1) Latvia-Lithuania



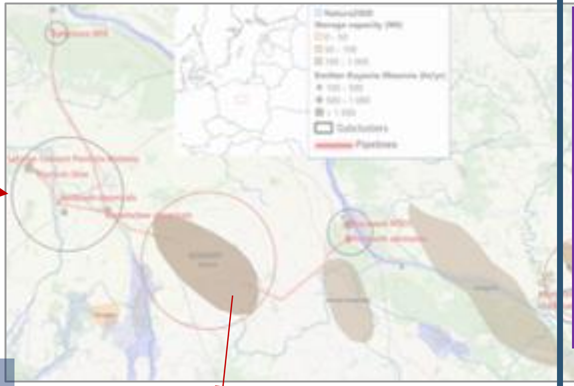


Advantages (B-1 & B-4)

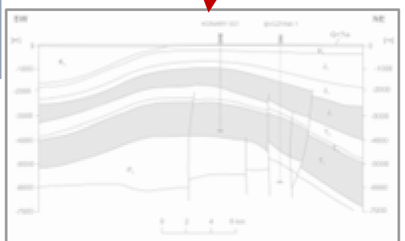
- ✓ High storage capacity,
- ✓ Close location of emitters to storage sites,
- ✓ 3 PCI projects in Baltic-1 and Baltic-4
- ✓ Onshore-economic

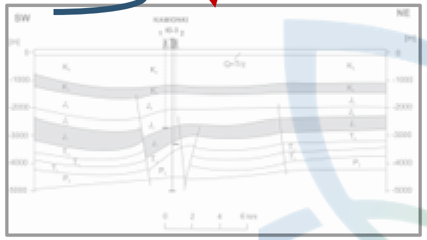
Challenges (B-1 & B-4)

- ➢ Regulatory
- ➢ Social - landlords
- ➢ No yet governmental support



Baltic-4 (B-4) Poland



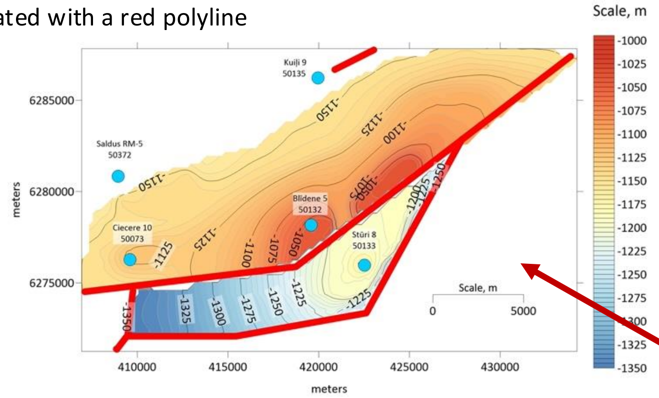


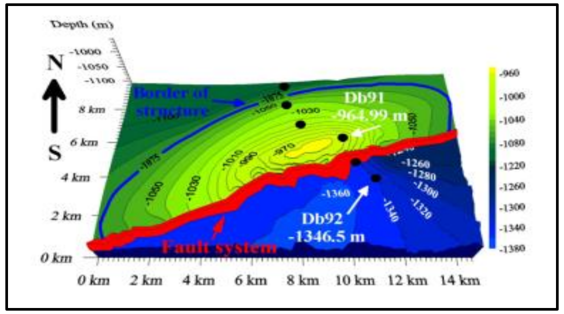
Baltic project

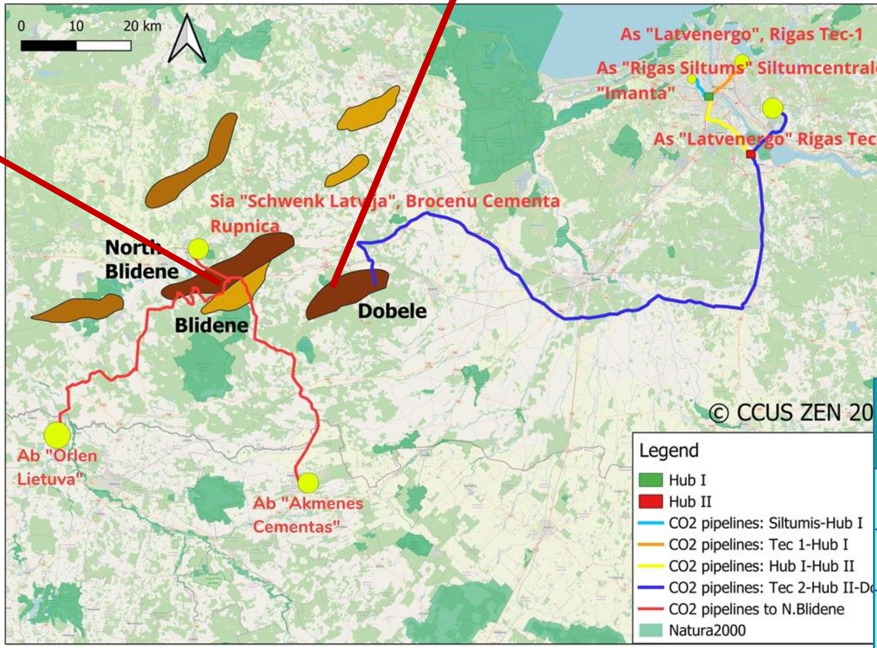
Baltic-1 CLUSTER (B-1)

Latvia-Lithuania

Contour maps of the top of the Cambrian Deimena Formation in the North Blidene (left) and the Blidene (right) structures. The fault line is indicated with a red polyline







Advantages

- ✓ High storage capacity (0.4 Gt CO_2)
- ✓ Close location of emitters to storage sites,
- ✓ 2 PCI projects in the Baltic-1
- ✓ Onshore- economic

Challenges

- ➢ Regulatory
- ➢ Social - landlords
- ➢ No yet governmental support

Latvian CO_2 emitters (4):

- Latvenergo PP (2 plants)
- Rigas Siltums Thermal Plant
- “Schwenk Latvia” SIA (Cement plant)

Lithuanian CO_2 emitters (2):

- Orlen refinery
- Akmenes cement plant (acquired by SCHWENK)

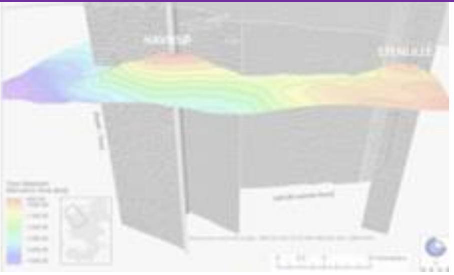
Total CO_2 emissions, Mt/y	Storage sites	CO_2 Storage Capacity, Mt	Distance from emission to storage site, km	Transport options
3.25	North Blidene & Blidene	297	9-70 km	pipeline
1.00	Dobele	106	150 km for Latvenergo Tec-2	pipeline
Total: 4.25	North Blidene, Blidene and Dobele	Total: 403	9-150 km	pipeline

Baltic project

Baltic-2 CLUSTER (B-2)
Germany-Denmark-Sweden

Advantages (B-2 & B-3)
- ✓ High storage capacity
- ✓ favourable CCS policies and regulations
- ✓ financial governmental support in Denmark

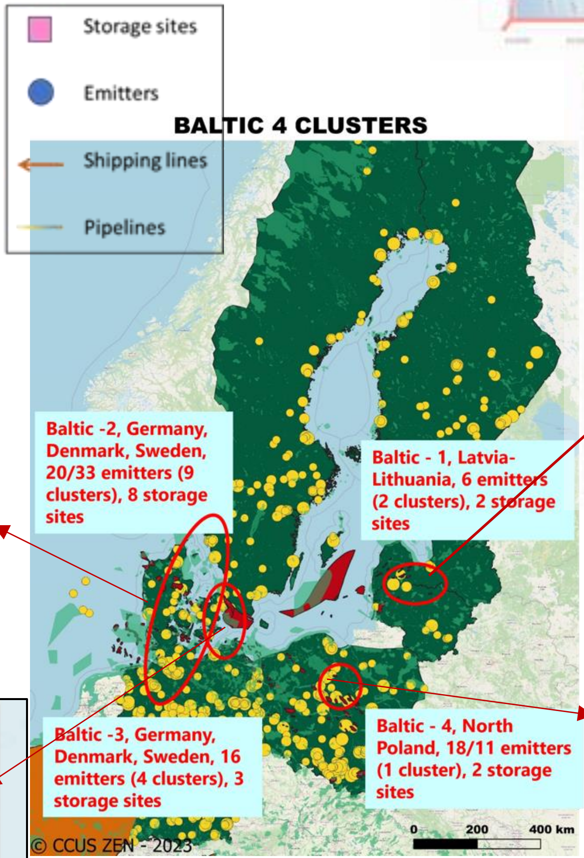
Challenges (B-2 & B-3)
- Regulatory in Germany
- Complicate transport structure and long distances



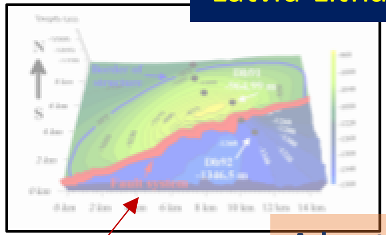
Map of the Top of Gassum formation for Stenlille and Havsno structures. Source: Gregersen et al, 2023

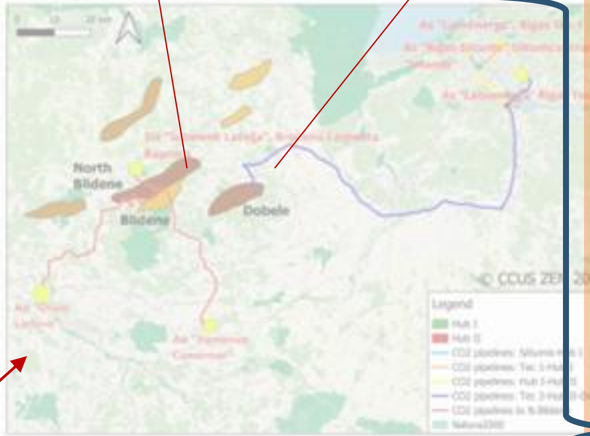
Baltic-3 (B-3)-Denmark, Sweden-Germany

Baltic-2 (B-2) Denmark, Sweden-Germany

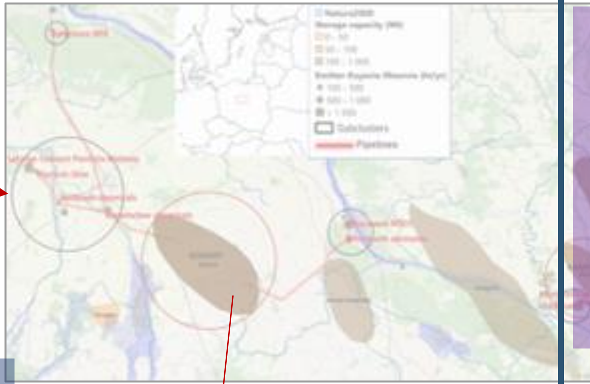


Baltic-1 (B-1) Latvia-Lithuania



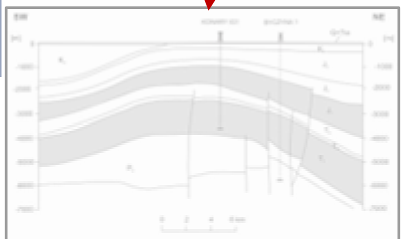


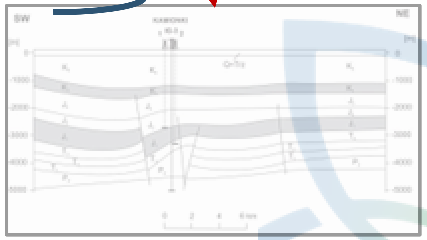
Advantages (B-1 & B-4)
- ✓ High storage capacity,
- ✓ Close location of emitters to storage sites,
- ✓ 3 PCI projects in Baltic-1 and Baltic-4
- ✓ Onshore-economic



Challenges (B-1 & B-4)
- ➢ Regulatory
- ➢ Social - landlords
- ➢ No yet governmental support

Baltic-4 (B-4) Poland





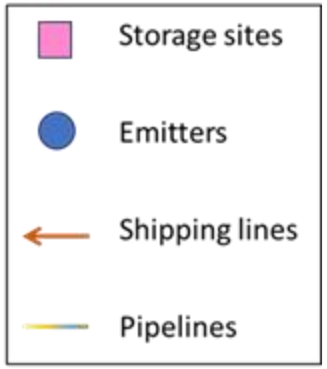
Baltic project

Baltic-2 CLUSTER (B-2)

Germany-Denmark-Sweden

Advantages
- ✓ High storage capacity
- ✓ favourable CCS policies and regulations
- ✓ financial governmental support in Denmark

Challenges
- Regulatory in Germany
- Complicate transport structure and long distances

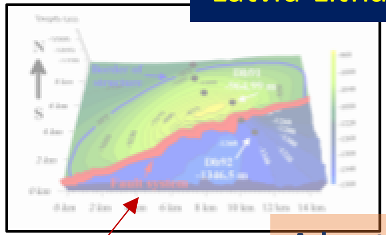


- 33 significant emitters with a capture capacity of about 22,66 Mt of CO_2 annually
- 20 of them have a high potential to adopt CO_2 capture
- Eight geological storage sites in Denmark onshore and offshore with a mean capacity of around 928 Mt
- Among these, Bifrost and Greensand
- Six projects with CO_2 use options elaborating CO_2 conversion into methanol with a conversion rate of up to 72%
- 30% of captured CO_2 could be used and 70% stored
- 15.1 Mt CO_2 could be injected annually
- 6 Mt CO_2 could be used annually within 15 CCU plants

Baltic project

Baltic-3 CLUSTER (B-3) Germany-Denmark-Sweden

Baltic-1 (B-1)
Latvia-Lithuania



Baltic-2 (B-2)
Denmark,
Sweden-
Germany

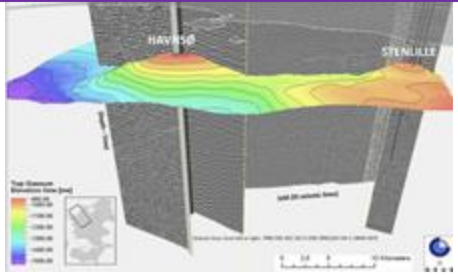
www.projectgreensand.com

Advantages (B-2 & B-3)

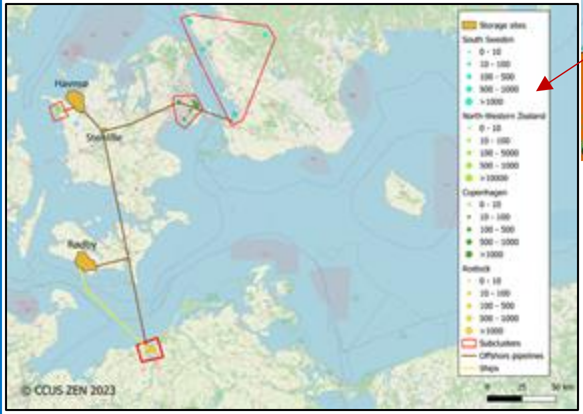
- ✓ High storage capacity
- ✓ favourable CCS policies and regulations
- ✓ financial governmental support in Denmark

Challenges (B-2 & B-3)

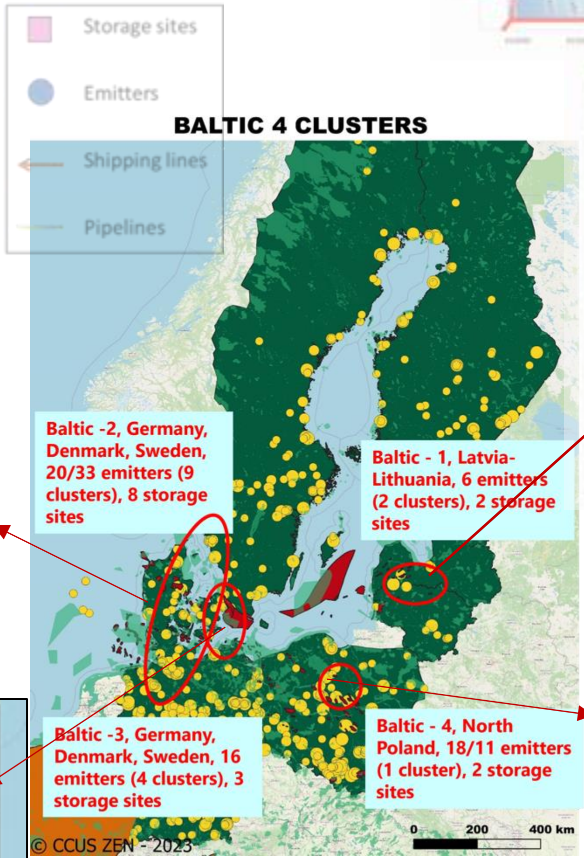
- Regulatory in Germany
- Complicate transport structure and long distances

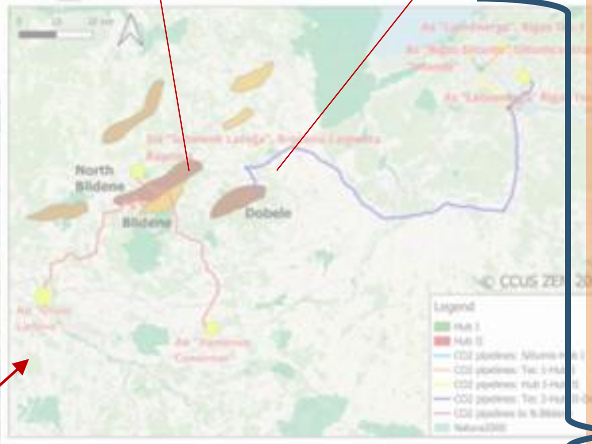


Map of the Top of Gassum formation for Stenlille and Havsno structures. Source: Gregersen et al, 2023



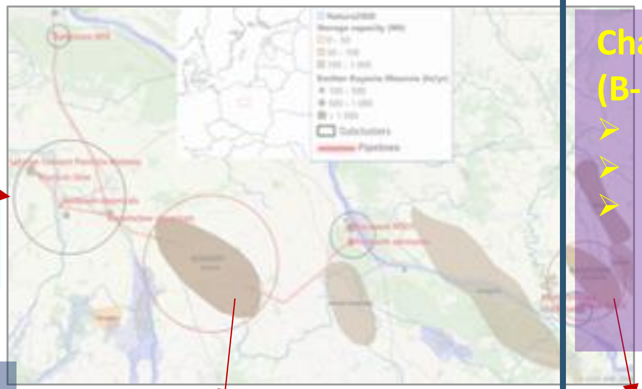
Baltic-3 (B-3)-Denmark, Sweden-Germany





Advantages (B-1 & B-4)

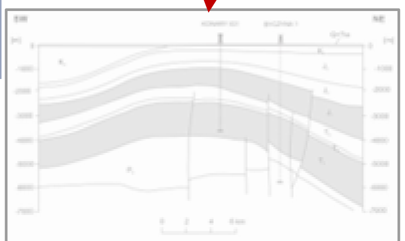
- ✓ High storage capacity,
- ✓ Close location of emitters to storage sites,
- ✓ 3 PCI projects in Baltic-1 and Baltic-4
- ✓ Onshore-economic

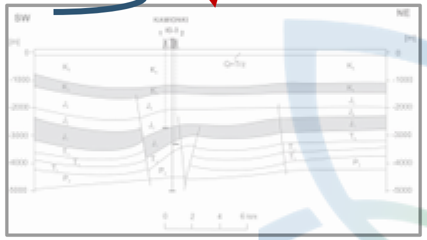


Challenges (B-1 & B-4)

- ➢ Regulatory
- ➢ Social - landlords
- ➢ No yet governmental support

Baltic-4 (B-4)
Poland

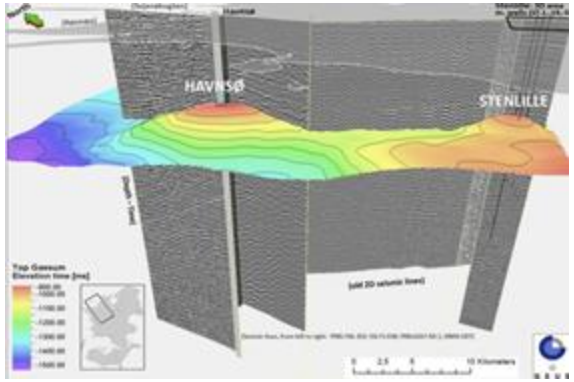




Baltic project

Baltic-3 CLUSTER (B-3)

Germany-Denmark-Sweden



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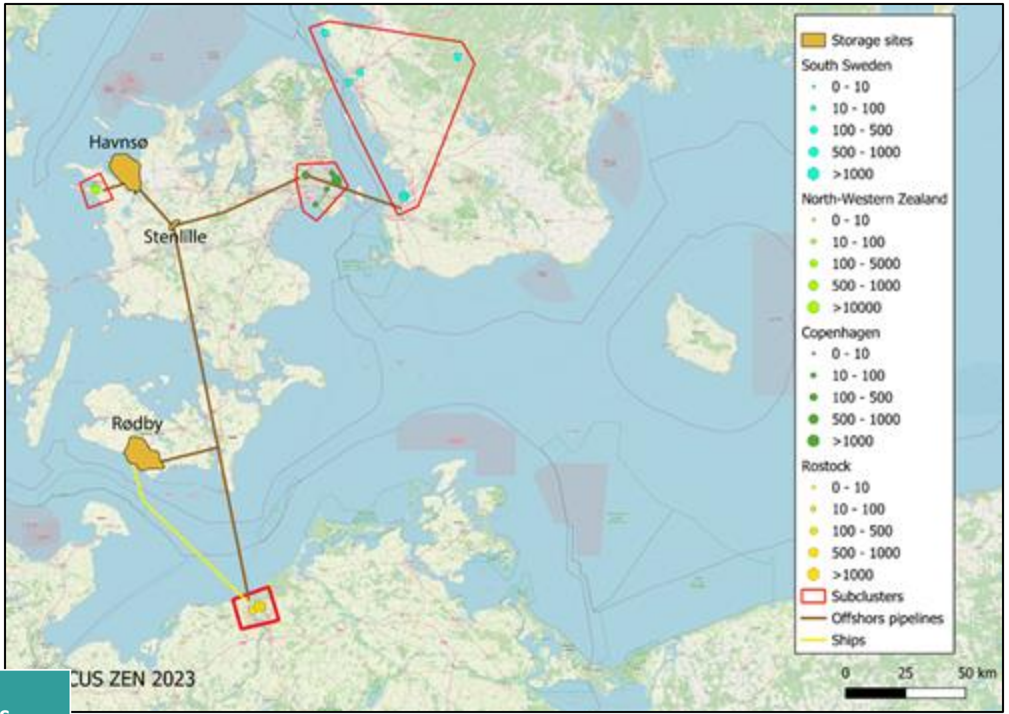


Advantages

- ✓ High storage capacity
- ✓ favourable CCS policies and regulations
- ✓ financial governmental support in Denmark

Challenges

- Regulatory in Germany
- Complicate transport structure and long distances

- ▷ 4 clusters with 13 emitters
- ▷ Maximum emission volume: 5.7 Mt annually
- ▷ 3 storage sites
- ▷ Maximum storage volume: approximately 456-882 Mt
- ▷ Possible transport infrastructure includes pipeline and ship

Country	Cluster	Total CO_2 emissions [Mt/yr]	Emitters number
Germany	Rostock Cluster	2.5	3
Denmark	Copenhagen Cluster	1.2	3
	North-western Zealand Cluster	0.53	1
Sweden	South Sweden Cluster	1.5	6
Total		5.7	13

Storage name	On / offshore	Capacity mean (million tonnes)		Status
		P90	P10	
Havnsø	Nearshore	204	423	Seismic campaign
Rødby	Onshore	242	449	Seismic campaign
Stenlille	Onshore	10 (mean)		Seismic campaign finish ed

Baltic project

Baltic-4 CLUSTER (B-4) POLAND

Baltic-1 (B-1)
Latvia-Lithuania

www.projectgreensand.com

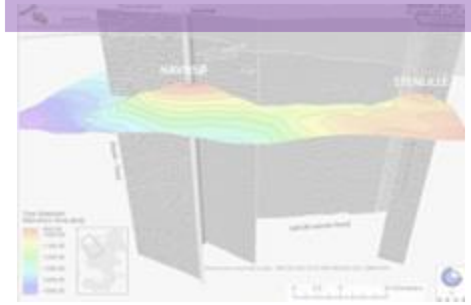
Baltic-2 (B-2)
Denmark,
Sweden-
Germany

Advantages (B-2 & B-3)

- ✓ High storage capacity
- ✓ favourable CCS policies and regulations
- ✓ financial governmental support in Denmark

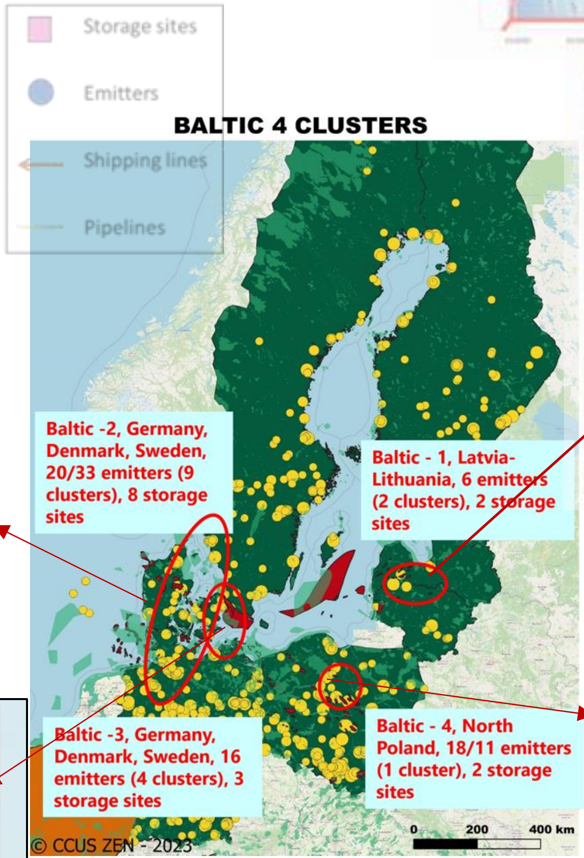
Challenges (B-2 & B-3)

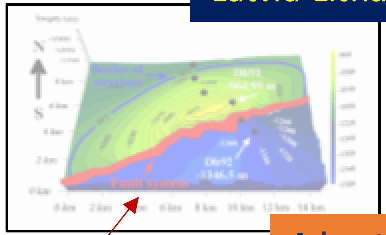
- Regulatory in Germany
- Complicate transport structure and long distances

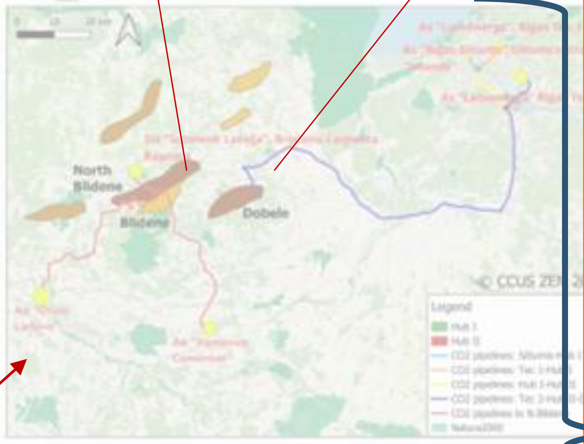


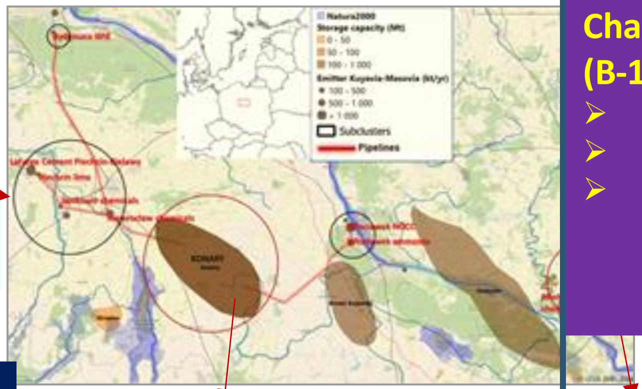
Map of the Top of Gassum formation for Stenlille and Havsno structures. Source: Gregersen et al, 2023

Baltic-3 (B-3)-Denmark, Sweden-Germany









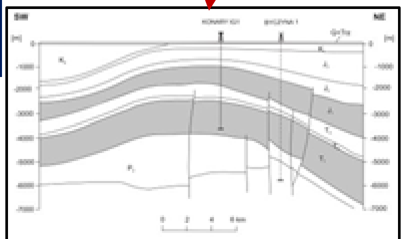
Advantages (B-1 & B-4)

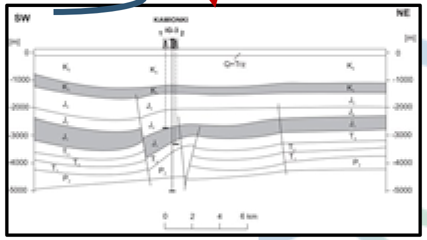
- ✓ High storage capacity,
- ✓ Close location of emitters to storage sites,
- ✓ 3 PCI projects in Baltic-1 and Baltic-4
- ✓ Onshore-economic

Challenges (B-1 & B-4)

- ➢ Regulatory
- ➢ Social - landlords
- ➢ No yet governmental support

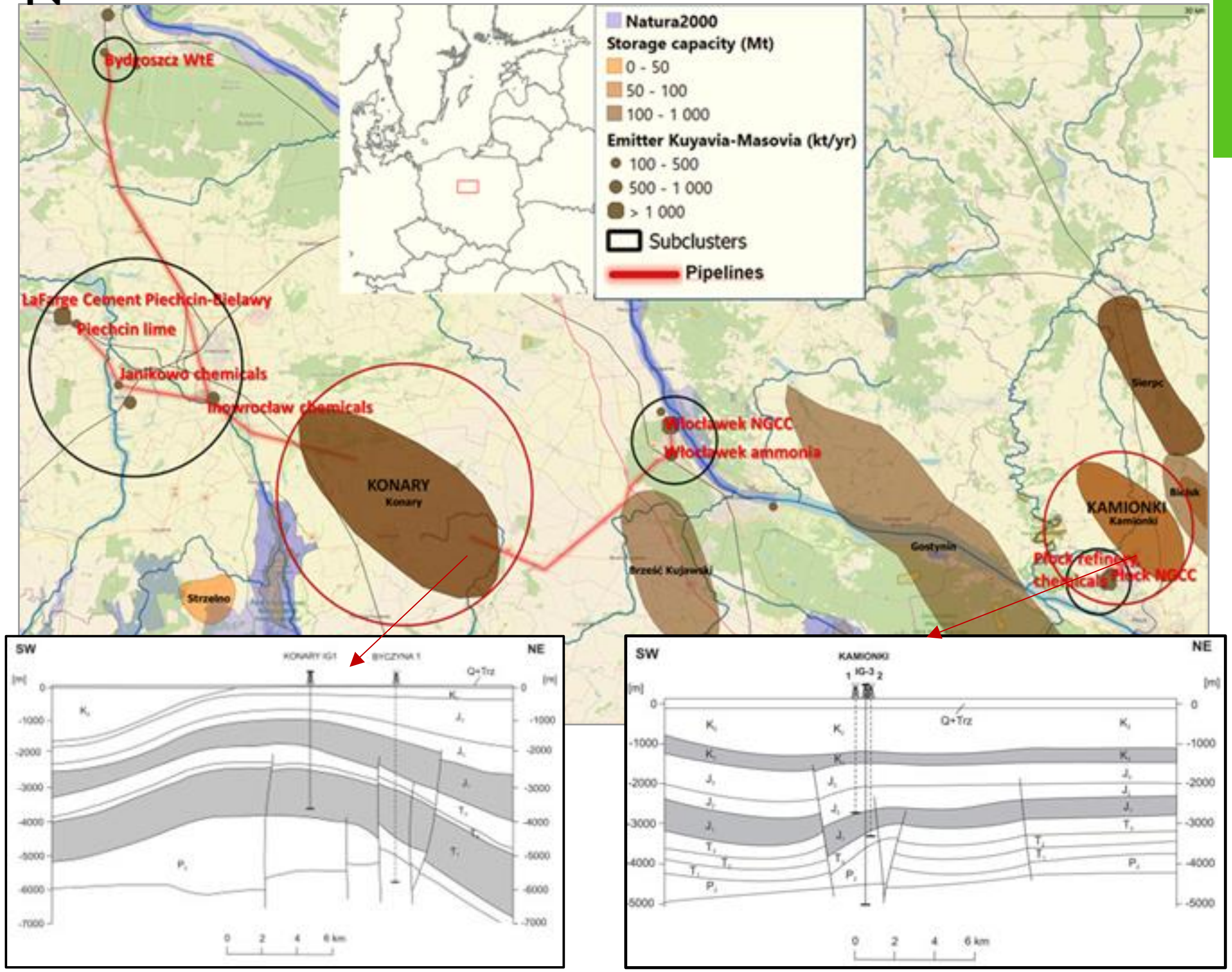
Baltic-4 (B-4)
Poland





Baltic project

Baltic-4 CLUSTER (B-4)
POLAND



Advantages

- ✓ High storage capacity,
- ✓ Close location of emitters to storage sites,
- ✓ 2 PCI projects in Baltic-4
- ✓ Onshore- economic

Challenges

- ➢ Regulatory
- ➢ Social - landlords
- ➢ No yet governmental support

- ▷ 4 sub-clusters with 11 emitters
- ▷ Maximum emission volume: 8,2 Mt annually
- ▷ 2 storage sites
- ▷ Maximum storage volume: approximately 381 Mt
- ▷ Total pipeline length 108 km

Regulatory readiness
of the analysed value chains: Baltic Region

Among higher-readiness value chains are

CCUS projects with CO_2 emission sources in Denmark, Sweden and Germany and CO_2 storage in Denmark (Baltic-2 and Baltic-3).

The main internal strengths of these two value chains:

- The high storage capacity associated with the very good reservoir properties, the large thickness of primary cap rocks
- CO_2 capture and use options are under development
- Many CCUS research and demo projects in Denmark

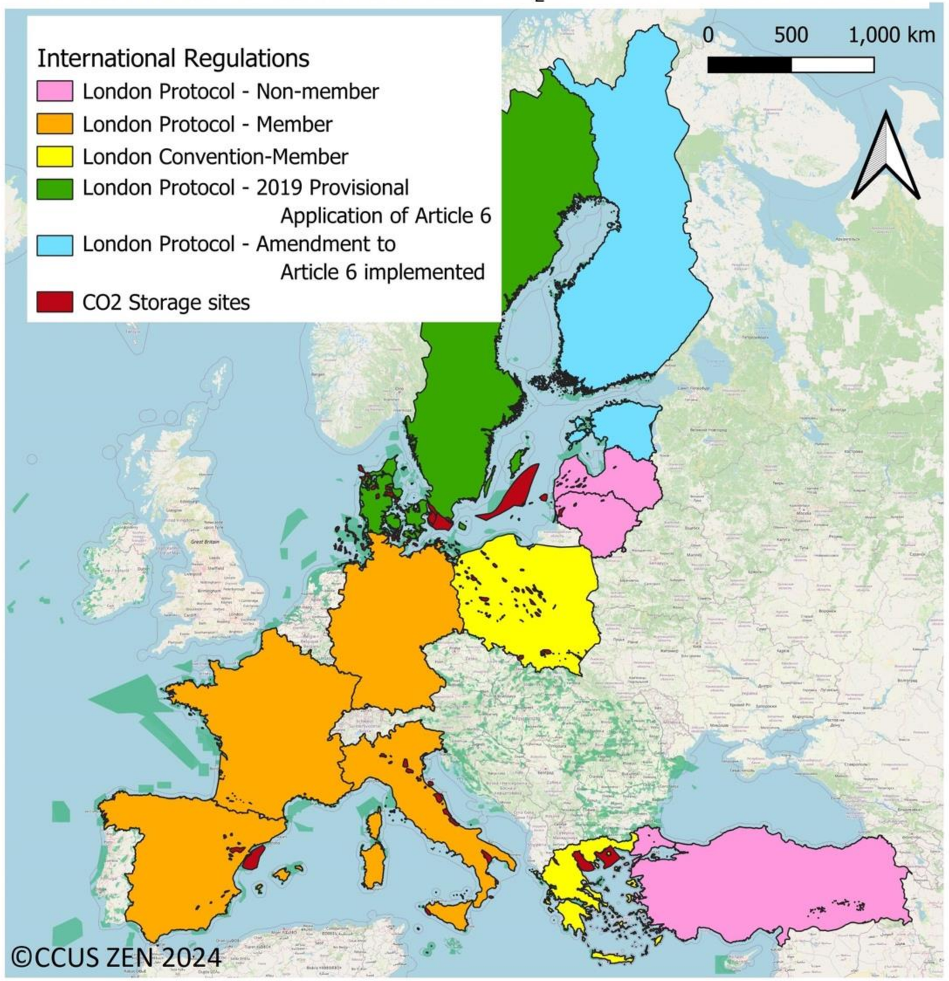
Their main external opportunities are

- The favourable CCS policies and regulations and financial governmental support in Denmark, where CO_2 storage sites are located
- Sweden and Denmark have deposited a declaration of provisional application of Amendment to Article 6 of the London Protocol

The main risks

- Among the risks for Baltic-2 and -3 is German international regulations
- Germany has not deposited a declaration of provisional application of Amendment to Article 6 with the IMO. This, in addition to a bilateral agreement, is needed before the export of CO_2 for offshore storage

INTERNATIONAL REGULATIONS AND CO_2 STORAGE SITES LOCATION



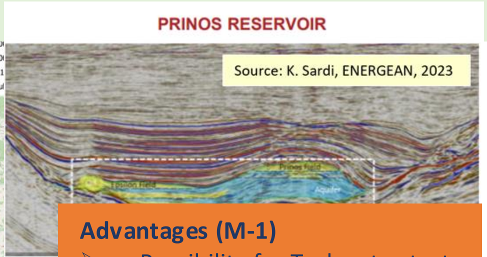
4 Mediterranean projects

Prinos Basin
Areal extent: 800km^2
Saline aquifer
Rock type: Sandstone
The thickness of the reservoir: 260 m
Depth: 1-3.5 km (2.4 km)
Geothermal gradient: 78°C/km
Porosity: 15-20% (Avg. 18%)
Permeability: 50 mD
N/G=0.8
Storage capacity: 1000 Mt

Challenges in M-3
- Shallow CO_2 storage site in France - Top reservoir at 200 m
- Protected areas around – Natura 2000, Bird protection area

Challenges in M -1
- CO_2 emission database not available in Turkey
- Seismic active countries
- Infrastructure is not available
- International and national CCS regulations are not available in Turkey

Mediterranean-1 (M-1) Turkey & Greece

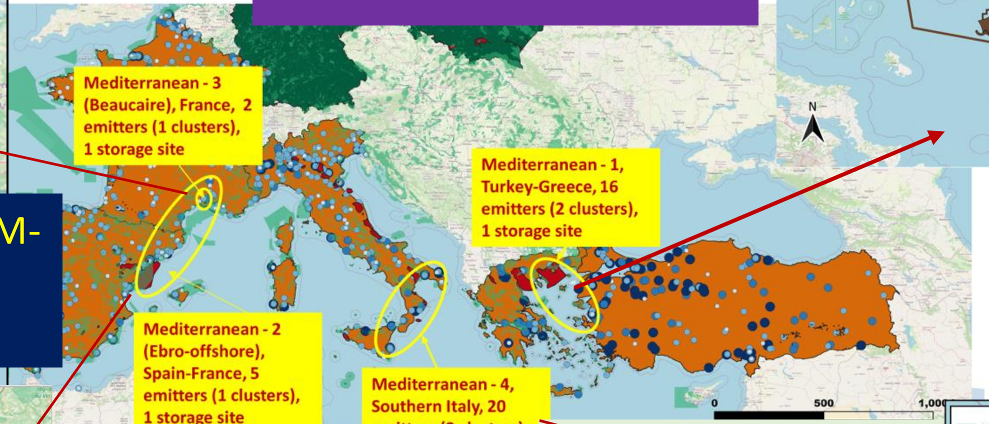


Advantages (M-1)
- Possibility for Turkey to start CCUS activities and implement policies

Advantages (M-3)
- ✓ Close location to storage site
- ✓ Onshore- economic
- ✓ Capacity is enough for 2 emitters

Advantages (M-2)
- Emission clusters located close to the Ports
- CO_2 storage is permitted in Spain

Mediterranean-3 (M-3) France

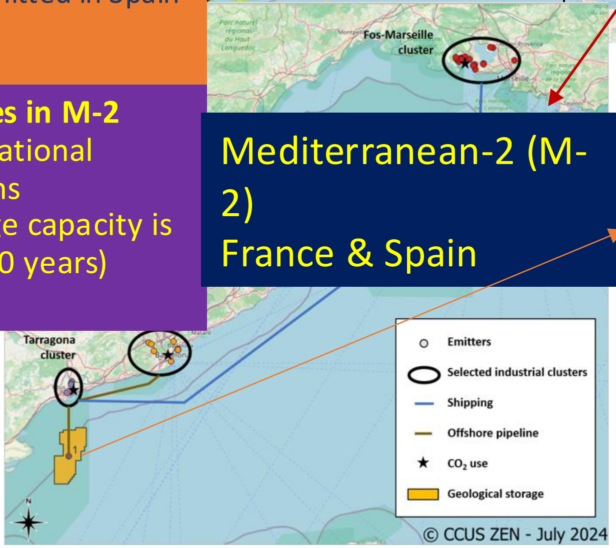


Advantages (M-4)
- CO_2 storage site with high capacity and good cap rocks
- Cross-border clusters from Greece and France can be included

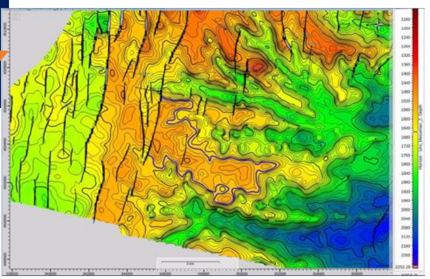
Challenges in M-4
- Seismic risks in Italy
- Densely populated area and Natura 2000 within the storage site

Challenges in M-2
- International regulations
- Storage capacity is limited (20 years)

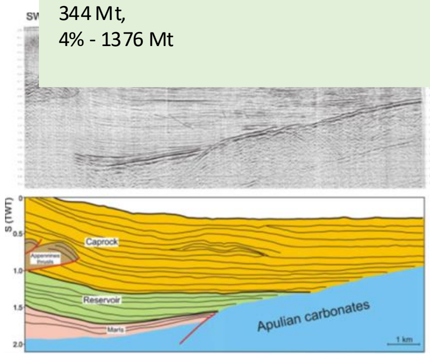
Mediterranean-2 (M-2) France & Spain



Structural map of the Castellon storage site (Gravaud et al, 2023)



Bradanica storage site:
- Reservoir: Late Pliocene sands and silty sands with marl, up to 800 m thick,
- Caprock: Clay and silty clay up to 1500 m thick
- Storage capacity: with efficiency of 1%- 344 Mt, 4% - 1376 Mt



Mediterranean-4 (M-4) Italy & Greece

Mediterranean project

Mediterranean-1 CLUSTER (M-1)
Turkey & Greece

Advantages

✓ Possibility for Turkey to start CCUS activities and implement policies

Challenges

- CO_2 emission database not available in Turkey
- Seismic active countries
- Infrastructure is not available
- International and national CCS regulations are not available in Turkey

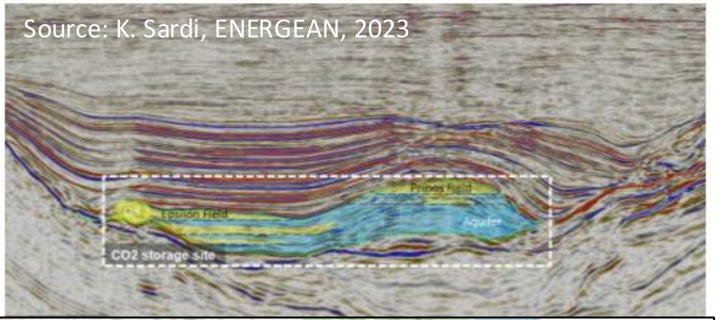
CO_2 emissions:

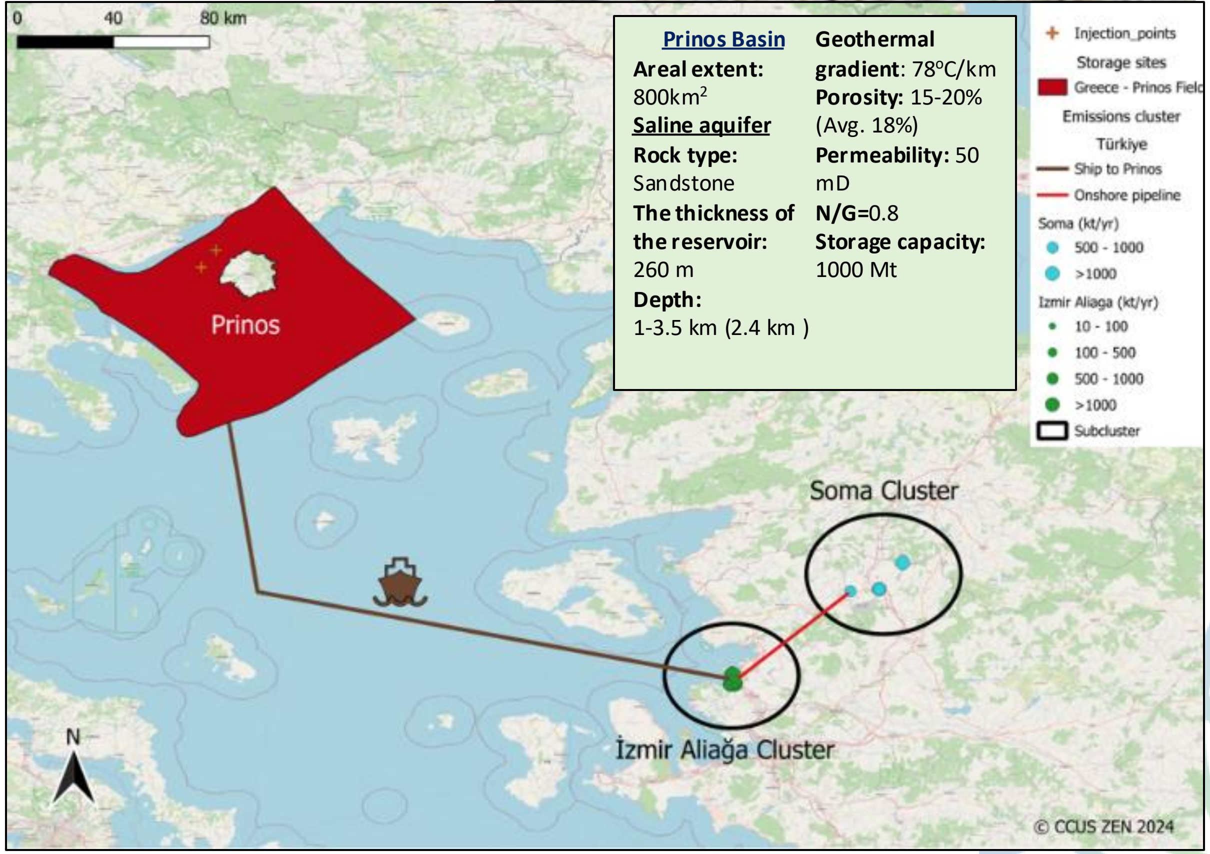
- Soma cluster and İzmir Aliağa cluster – a total of 16 emitters produced 40 Mt CO_2

Transport routes

- Onshore pipeline - 120 km
- Ship transport - 360 km from İzmir-Aliağa port
- Prinos storage site in Greece with 1Gt of storage capacity
- The CO2Fokus project suggests that CO_2 could be used to produce dimethyl ether (DME) in the Aliağa region.

PRINOS RESERVOIR





Mediterranean project

Mediterranean-2 CLUSTER (M-2)

France & Spain

Geoscience for a sustainable Earth

brgm

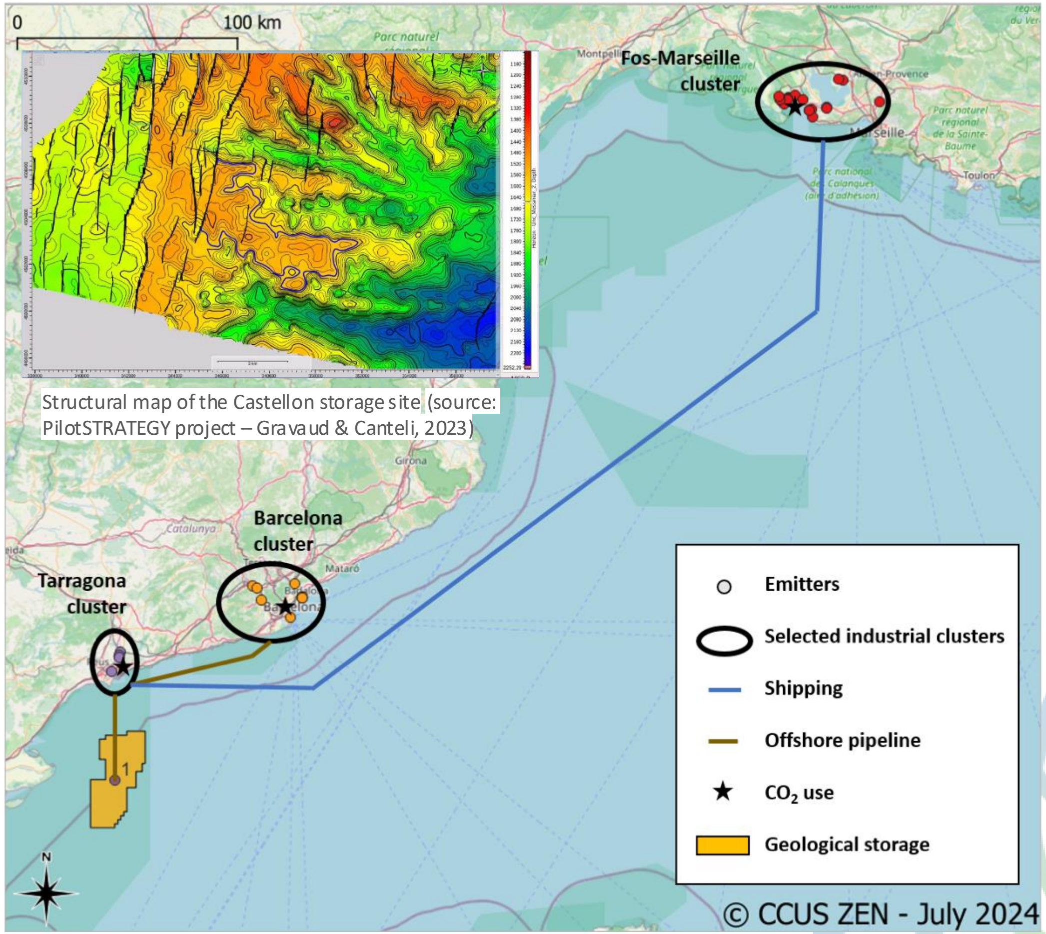
Advantages

- ✓ Emission clusters located close to the Ports
- ✓ CO_2 storage is permitted in Spain

Challenges

- ➢ International regulations
- ➢ Storage capacity is limited (20 years)

- ▷ The Mediterranean-2 project comprises 3 clusters of large emitters (32 emitters, producing 23.8 $MtCO_2$) and one storage site offshore in Spain The industrial clusters:
  - Tarragona - Spain
  - Barcelona - Spain
  - Fos-Marseille cluster in France
- ▷ The geological storage site Castellon is located offshore Tarragona in the Ebro Basin (capacity - 200 Mt CO2)
- ▷ Various CO_2 utilization options are considered on the base of CCU feasibility projects in France and Spain
- ▷ It is assumed that 9.8 Mt CO_2 will be captured, from which 6.7 Mt stored and 3.1 Mt CO_2 used



Mediterranean project

Mediterranean-3 CLUSTER (M-3)

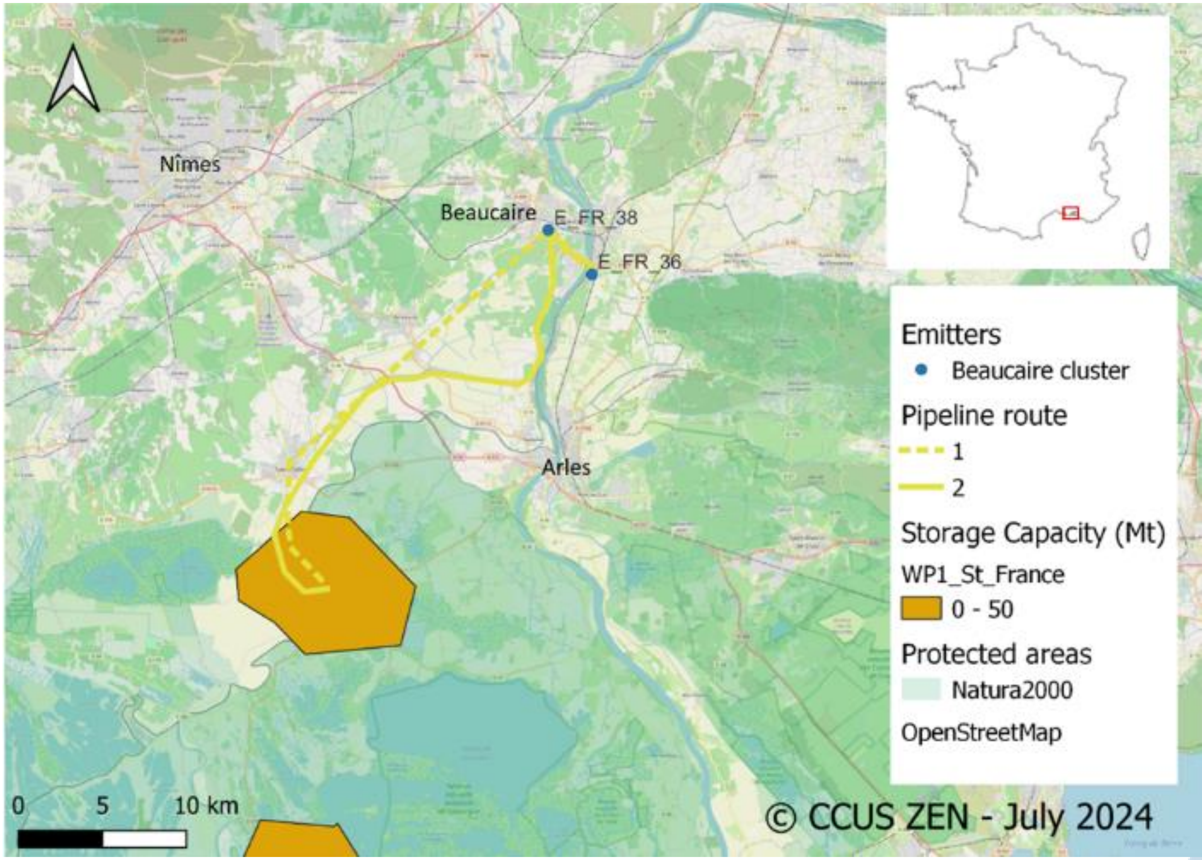
France

Advantages

- ✓ Close location to a storage site
- ✓ Onshore - economic
- ✓ Capacity is enough for 2 emitters

Challenges

- ➢ Shallow CO_2 storage site in France - Top reservoir at 200 m
- ➢ Protected areas around – Natura 2000, Bird protection area



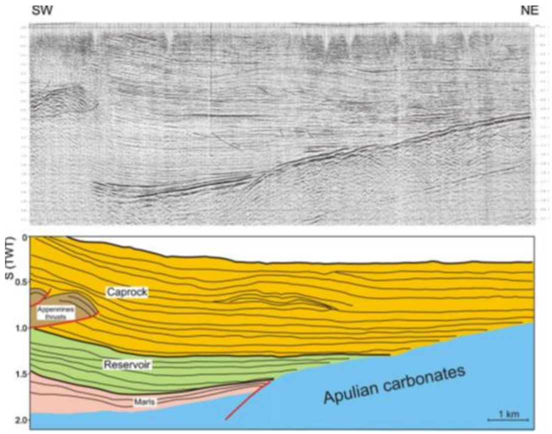
- ▷ The Beaucaire value chain is a local-scale scenario with two emitters (a paper plant and a cement plant) emitting 1.17 Mt/y
- ▷ The storage is onshore saline aquifer site Haut d'Albaron, with a storage capacity of 34 Mt
- ▷ The onshore pipeline has a total length of 32.6-38.5 km
- ▷ Proximity to the protected area is taken into account
- ▷ In the Beaucaire area, using CO_2 for catalytic methanol production, with a potential of 200 kt CO_2/y, can be considered

Mediterranean project
Mediterranean-4 CLUSTER (M-4)
France

Advantages
- ✓ CO_2 storage site with high capacity and good cap rocks
- ✓ Cross-border clusters from Greece and France can be included

Challenges
- ➢ Seismic risks in Italy
- ➢ Densely populated area and Natura 2000 within the storage site

Bradanica storage site:
- •Reservoir: Late Pliocene sands and silty sands with marl, up to 800 m thick,
- •Caprock: Clay and silty clay up to 1500 m thick
- •Storage capacity: with efficiency of 1% - 344 Mt, 4% - 1376 Mt



- ▷ CCUS value chain from Southern Italy, with 6 clusters, 32 emitters produced 41 Mt/y of CO_2
- ▷ Transport to an onshore storage site Bradanica by pipelines
- ▷ Ship transport from France and Greece is proposed, with a harbour in Brindisi
- ▷ Transport distance 50 - 450 km

Readiness
of the analysed value chains:
Mediterranean Region

Mediterranean-2, 3 and 4 value chains, which include emission sources and storage sites in Spain (M-2), France (M-3) and Italy (M-4), are assessed as more ready at the regulatory side than Mediterranean-1.

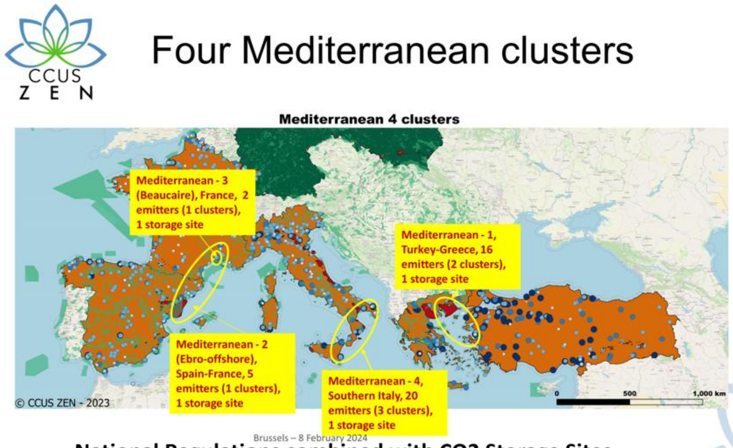
- Mediterranean-1 including CO_2 emissions from Türkiye and CO_2 storage in Greece as less ready, considering the regulatory risks:
- There is a lack of CCS regulations and CO_2 capture and transport infrastructures in Türkiye
- Türkiye and Greece are not Contracting Parties to the London Protocol and are therefore not bound by its requirements for cross-border CO_2 transport
- Italy is planning to implement an Amendment and provisional application to Article 6

However, the technical parameters of the storage site in France (M-3) (Haut d'Albaron) are not qualified for the needed requirements.

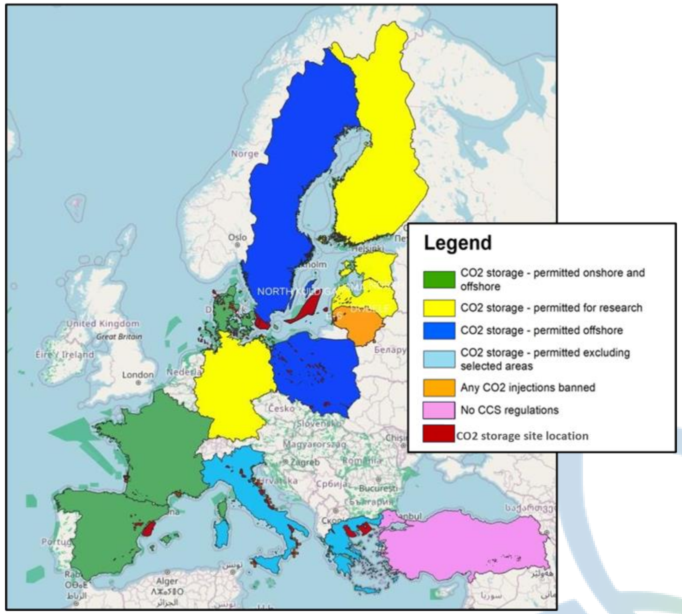
- **Technical risks for the area around the storage site (external group 1):**

In Italy and Greece, seismic risks should be checked for the storage site areas.

Most countries have risks connected with the location of Natura 2000 areas close to the storage sites or intersected with storage sites.



National Regulations combined with CO2 Storage Sites



CONCLUSIONS

- Integrated quantitative analysis can be conducted for both offshore and onshore CCUS projects. However, these projects must adhere to different regulatory frameworks—international, regional, and national regulations for offshore projects and bilateral national regulations for onshore projects
- Despite these differences, it is possible to perform a unified quantitative analysis for all projects (both onshore and offshore) by utilizing common internal technical factors and a streamlined list of external technical and non-technical parameters
- One area with significant uncertainty involves CO_2 utilization options. This uncertainty arises from the lack of established regulations for Bio-CO_2 emissions, the early stages of project piloting and demonstration, and the uncertain market conditions for CO_2-based products

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CCUS ZEN

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DEPARTMENT OF GEOLOGY

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SYNERGY CONCEPTS

Thank you for your attention!

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