



Characterisation of European CO₂ storage

Closing conference

F. Delprat-Jannaud





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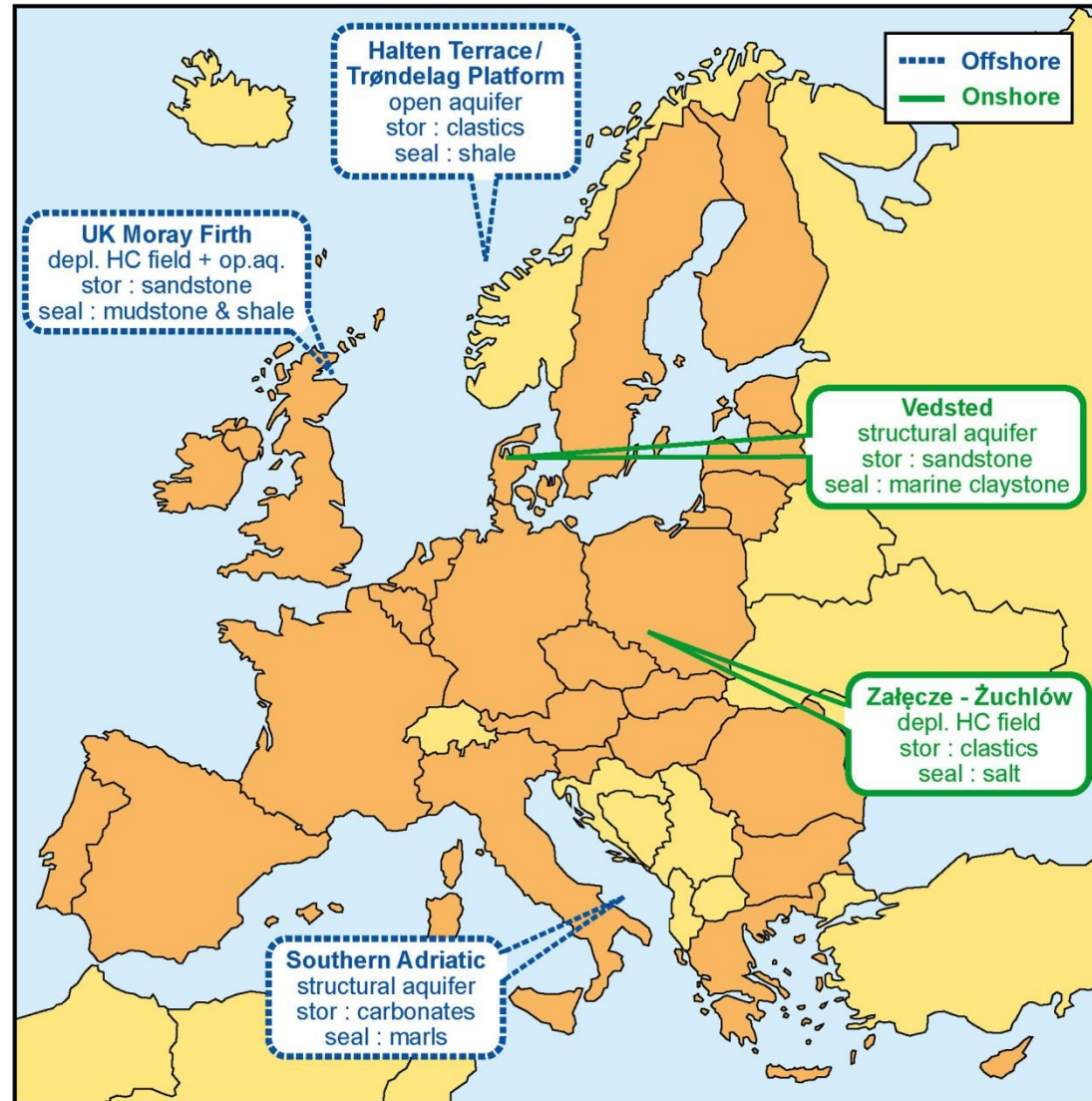
The aim of *SiteChar*

Provide the key steps required to make on-time effective large-scale implementation of CO₂ storage in Europe

- *Demonstrate the level of geological characterisation and the assessment of long-term storage complex behaviour in accordance with the regulatory requirements (EU Directive)*
- *Develop a methodology for the preparation of storage permit applications, accounting for all the technical and economic data, as well as the social dimension*
- *Raise public awareness and enable informed opinion formation*

The *SiteChar* sites portfolio

- Representative EU sites providing credible options for CO₂ storage
- Allowing to test and improve the *SiteChar* methodology for site characterisation in different geological contexts



Two sites to perform a full-chain characterisation suitable for a storage permit application

The northern North Sea site, UK

A multi-store site, comprising

- A hydrocarbon field: near-term storage capability
- The host saline aquifer sandstone: greater storage potential, later in the storage cycle

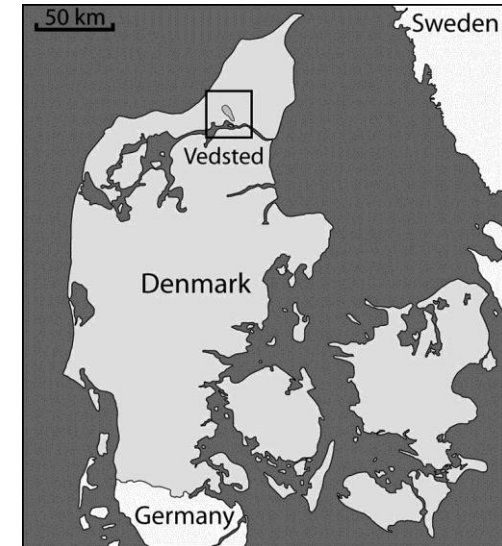


- Characterisation of a multi-store site sufficient for submission of a 'dry-run' permit application to the Scottish Government
 - *All components of a permit application developed as far as possible*
- Design of injection strategy for pressure management
- Investigation of the relationship between a producing hydrocarbon field and the host saline aquifer

Two sites to perform a full-chain characterisation suitable for a storage permit application

The Vedsted site, Denmark

An onshore saline aquifer processed by Vattenfall till late 2011 to be an industrial scale CCS demo project



- **As complete as possible techno-economic assessment to reach readiness for storage permit**
- **Incremental development proposed to supplement sparse data**
- **Special emphasis on the monitoring program to investigate the impact of CO₂ injection on the surrounding region and design the best risk management**

Three sites to overcome specific barriers related to the site characterisation methodology

The Zalecze & Zuchlow site, Poland

An onshore gas reservoir, representative of a series of natural gas reservoirs in the Polish Lowland with CO₂ storage potential

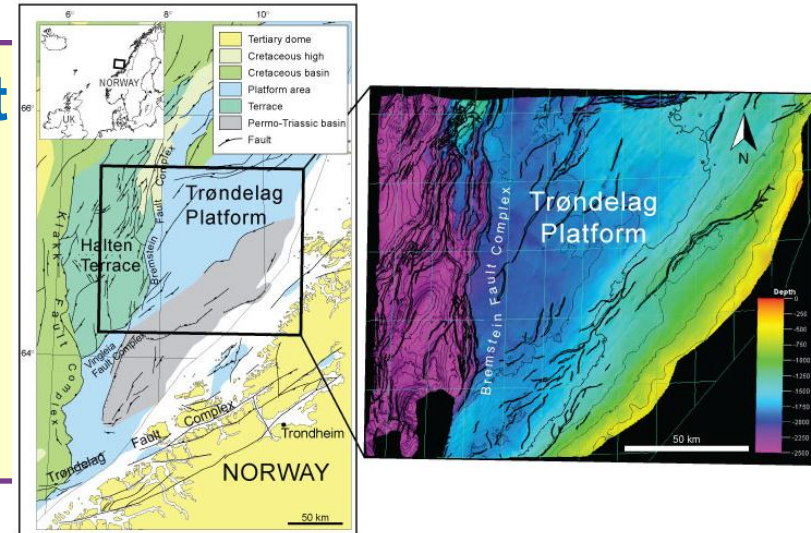


- Application of the whole workflow from the first stages through to the development of an injection strategy
- Investigation of the behaviour of the reservoir rock and the caprock during CO₂ injection by laboratory experiments and numerical simulations
- Well integrity analysis and related risk assessment, monitoring and remediation plans

Three sites to overcome specific barriers related to the site characterisation methodology

The Trøndelag platform, Mid Norway

An offshore multi-compartment saline aquifer presenting possible storage sites in saline formations and dry structures



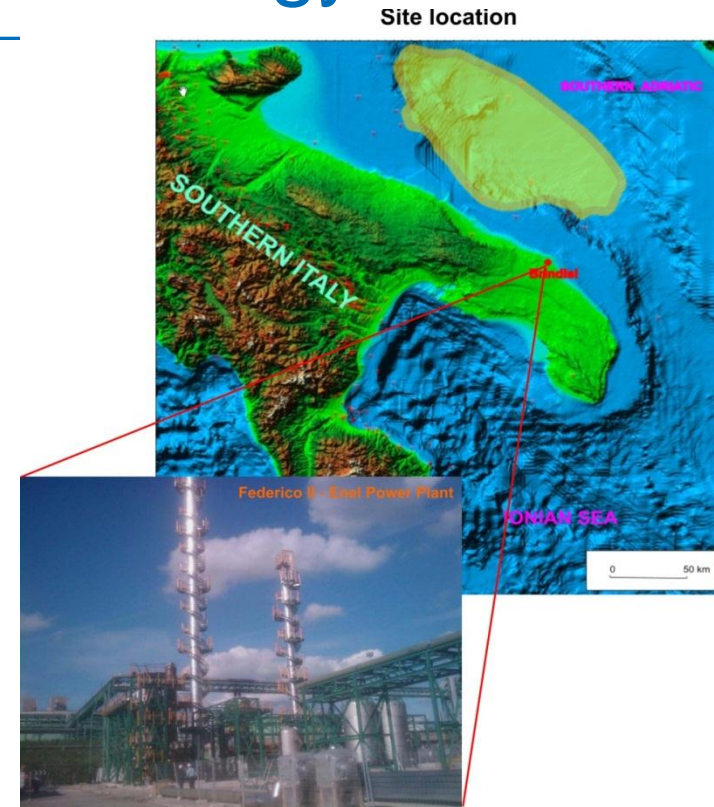
- Virgin area characterised on the basis of public data
- Basin to individual CO₂ storage compartment assessment
- Comparison of different modelling approaches to simulate injection strategy with emphasis on storage capacity optimisation
- Monitoring and remediation strategies

Three sites to overcome specific barriers related to the site characterisation methodology

The South Adriatic site, Italy

A structural trap in a offshore carbonate saline aquifer, located in a relatively stable area

- Qualitative assessment of the southern Adriatic offshore area for CO₂ geological storage based on public data
- Simulation of the geomechanical and dynamic behaviour of the storage complex due to the CO₂ injection



The *SiteChar* public engagement activities

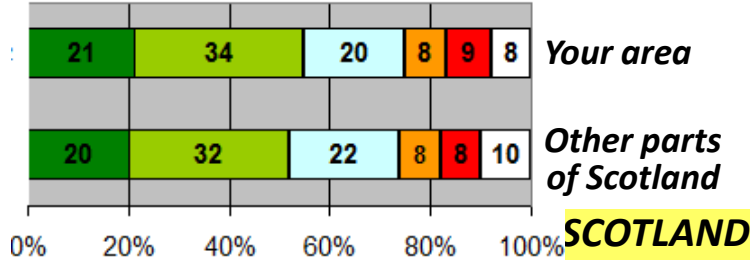
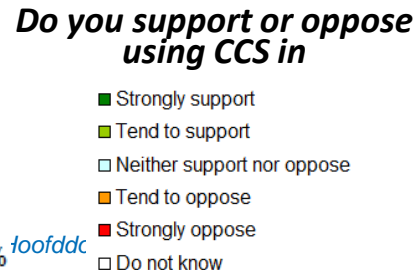
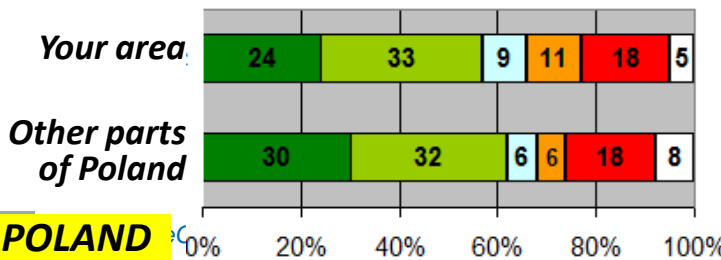
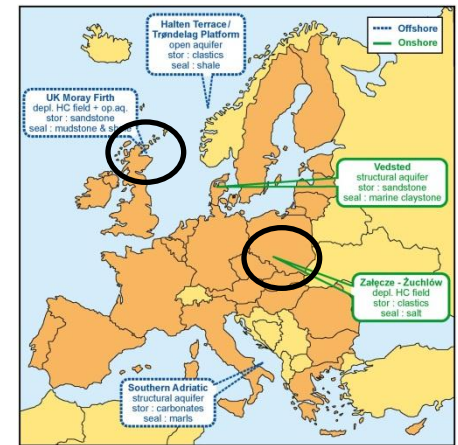
Social site characterisation & advancing public awareness

- Raising public awareness and enabling informed opinion formation
- Making available and comprehensive site-specific information

On two sites

- The *offshore* Scottish site
- The *onshore* Polish site

Fieldwork from early 2011 to mid-2012





The *SiteChar* techno-economic analysis

➔ Address the storage part on the full-life time of the storage

- All CAPEX and OPEX to be mobilized over the project life

	UK North Sea <i>UK</i>	Vedsted <i>Denmark</i>	Trøndelag Platf. <i>Norway</i>	South Adriatic <i>Italy</i>
Context	Offshore	Onshore	Offshore	Offshore
Reservoir type	Depl. HC field & Deep Saline Aquifer	Deep Saline Aquifer	Deep Saline Aquifer	Deep Saline Aquifer
Injection/Project life (y)	20 / 40	40 / 70	40 / 70	10 / 40
CO ₂ stored (Mt) / Rate (Mt/y)	100 / 5	60 / 1.5	40 / 1	10 / 1
Nb. Inject. / Product. wells	5 / 1	1 / 0	1 / 0	1 / 0
Estimated costs	599 M€ / 11.4 €/t	29 M€ / 3.2 €/t	159 M€ / 26.6 €/t	97 M€ / 28.8 €/t
Share of estimated costs				

➔ No meaningful average cost for CO₂ storage

- Very heterogeneous structure of costs
- Site/Project dependent
- Choice of economic parameters

The *SiteChar* workflow

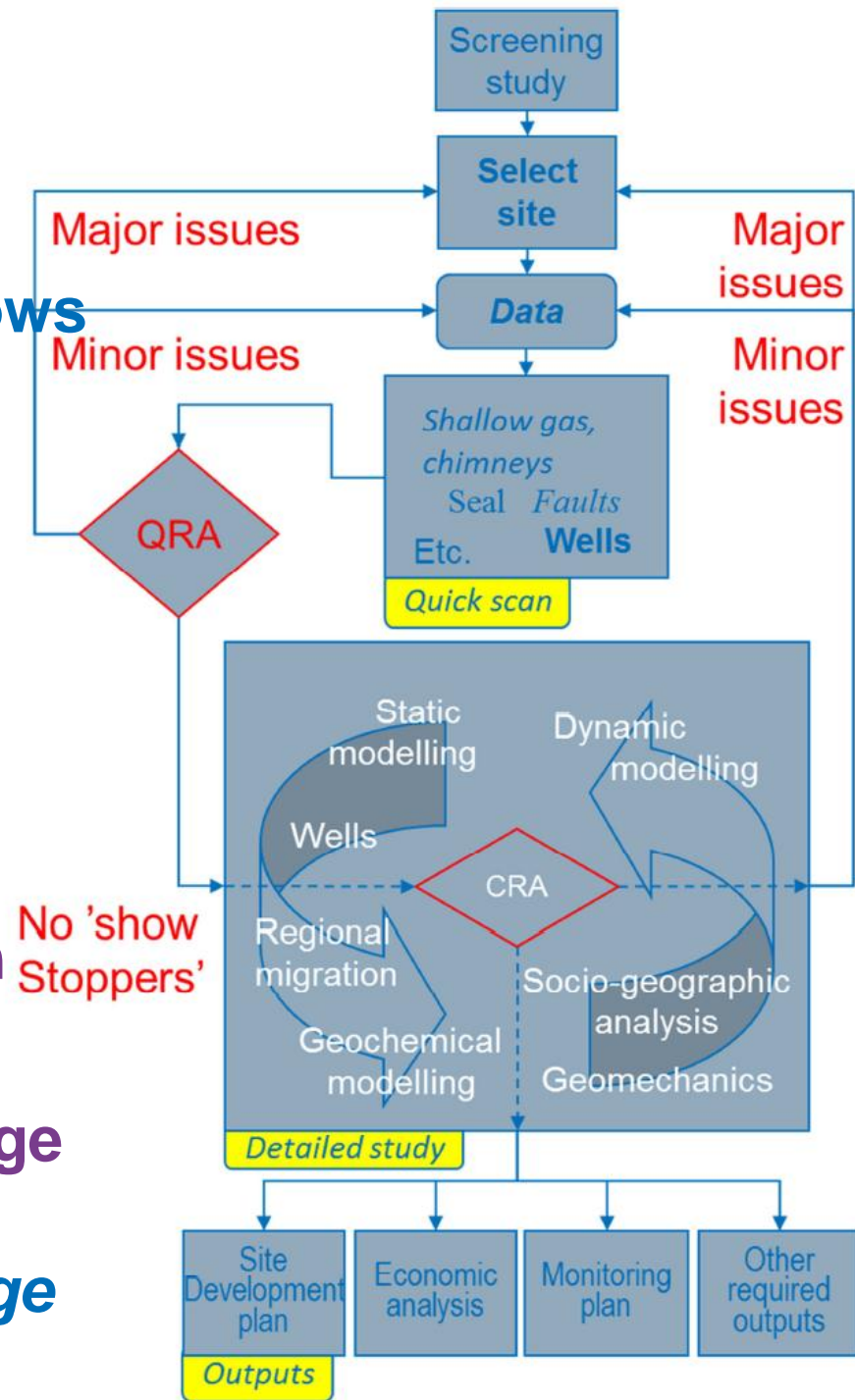
Consolidation of existing workflows

- In line with EC storage directive 2009/31/EC
- Validated from insight from research on the *SiteChar* sites portfolio

➤ So as to support

- An uniform characterisation of a storage complex
- An assessment of the storage security

Pursuant to the EC CO₂ Storage Directive



	UK North Sea		Vedsted	Załącze-Zuchłów	Trøndelag Platform	Grazia
	North Sea UK		Denmark	Poland	Norway	Italy
Geology	Offshore		Onshore	Onshore	Offshore	Offshore
	Depl. oil reserv. & Host sal. Aqu.		Saline aquifer	Depleted oil reservoir	Saline aquifer	Saline aquifer
Reservoir	Sandstone		Sandstone	Clastics	Clastics	Carbonates
Seal	Mudstone/Shale		Marine clayst.	Salt	Shale	Marls
Main objectives	H.C. fields & host saline aquifer relationship Risk-led site characterisation		Ways to supplement sparse data Impact on surroundings	Whole workflow through to the development of an injection strategy	Basin & compartment scale evaluation	Characterisation of carbonate Fm Geomechanical behaviour
Step of the workflow addressed						
1-	Risk assessment	✓	✓		✓	
2-	Static modelling	✓	✓	✓	✓	✓
3-	Dynamic mod.	✓	✓	✓	✓	✓
4-	Geomechanical mod.	✓		✓		
5-	Geochemical mod.	✓	✓	✓		
6-	Well integrity	✓	✓	✓		
7-	Migration path	✓			✓	
8-	Monitoring	✓	✓		✓	
9-	Social accept	✓		✓		
10-	Economic eval.	✓	✓		✓	✓
14-	Regul. compliance	✓	✓			



The SiteChar workflow for integrated and accountable site characterisation

14:00-14:20	<i>F. Neele</i>	The SiteChar workflow to answer the requirement of characterization	<i>Chair F. Delprat- Jannaud</i>
14:20-14:40	<i>A. Lothe</i>	Estimating the storage capacity: the first but still challenging step	
14:40-15:00	<i>V. Volpi</i>	Evaluating the storage geomechanical stability	
15:00-15:20	<i>S. Nagy</i>	Assessing the well integrity	
15:20-15:40 Break / Poster session			
15:40-16:00	<i>S. Brunsting</i>	Public engagement activities to inform development of a storage permit	<i>Chair J. Pearce</i>
16:00-17:00	<i>Panel of experts W. Hull V. Kougionas O. Tucker D. Taylor C. Skriung</i>	<i>How to prioritise risk reduction and balance characterisation with costs? How to define an effective cost-reduction strategy? Role of operators and state authorities in supporting site characterisation? How to get a 'social ticket to ride'?</i>	<i>Moderator J. Pearce</i>
17:00-17:15	<i>F. Delprat-J. F. Kalaydjian</i>	Key learning of the projects / Next steps required for the deployment of CCS	
17:10-18:30 Poster session / Cocktail			

Site characterisation in the purpose of a storage permit








- **Demonstrate understanding of the site for a CO₂ storage**
- **Convince Competent Authority that**
 - Permit applicant has sufficient understanding of the site
 - Proposed site operation will securely contain CO₂
- **Comply with regulatory issues**



The *SiteChar* 'dry-run' permit applications

- Develop dry-run permit applications and undertake independent reviews of these applications
 - Identify the best approaches to site characterisation to enable robust and defensible permit applications to be developed by *operators*
 - Help *regulatory authorities* to identify the necessary levels of evidence required to assess safety, containment and capacity

The *SiteChar* Advisory Panel on Regulation

 Australian Government Department of Resources Energy and Tourism	Australia	Geoscience Australia RET	<i>Greg Leamon</i> <i>Steve Tantala</i>
	Germany	BGR	<i>Franz May</i>
	UK	BP	<i>Stephen Cawley</i>
	The Netherlands	Shell	<i>Owain Tucker</i>
	Spain	CIUDEN	<i>Fernando Recreo Jimenez</i>



The *SiteChar* 'dry-run' permit applications

■ Two contrasting storage sites

UK North Sea

- Offshore
- Hydrocarbon field within the host saline aquifer
- Identified from previous regional reviews of UK northern North Sea storage targets
- 'Theoretical' study
- Sufficient publicly available data

Vedsted

- Onshore
- Saline aquifer
- Previously applied for permit prior to Directive to promote dialogue with Regulators
- Real project, now stopped
- Sparse data

■ But a common approach

→ *A fit for purpose characterisation driven by risk assessment*



The *SiteChar* benefits

Key learning's and technical recommendations for storage site characterisation

Best practice guidance for storage permitting from the perspective of both applicant and regulator

For further use by storage site operators and regulatory bodies

www.sitechar-co2.eu



Site characterisation for storage permitting

8:30-8:50	<i>F. Kalaydjian</i>	Welcome address	
8:50-9:20	<i>F. Delprat-Jannaud</i>	The SiteChar project	<i>Chair</i> <i>H. Pagnier</i>
9:20-9:30	<i>S. Mc Kay</i>	Statement of Support from the Scottish Government	
9:30-10:00	<i>M. Akhurst</i>	Developing a storage permit: A risk assessment led characterisation	
10:00-10:30	<i>C. Nielsen</i>	Developing a storage permit for an onshore aquifer	
10:30-10:50	Break / Poster session		
11:50-11:20	<i>J. Pearce</i>	Dry-run storage permit applications Lessons learned from the perspective of operators and regulators	<i>Chair</i> <i>F. Kalaydjian</i>
11:20-12:20	<i>Panel of experts</i> <i>L. Perrette</i> <i>A. Kneppers</i> <i>H. Hoyadalsvik</i> <i>F. Dalhoff</i> <i>Rune Thorsen</i>	<i>What is good enough to gain a storage permit?</i> <i>What issues regarding storage permits still require clarity from the regulatory perspective?</i> <i>Which criteria to assess long-term security and support liability transfer?</i>	<i>Moderator</i> <i>F. Kalaydjian</i>

