

Storage in Aquifers for European Industrial CCS Projects

The AQUA-CO2 initiative

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Why aquifers are so important for CCS?

■ Statements:

1. CCS needs to be widely available for deployment by 2020
2. Large-scale demos in Europe are needed for 2015

■ Where are we ? How to do it ? (from a technology point of view)

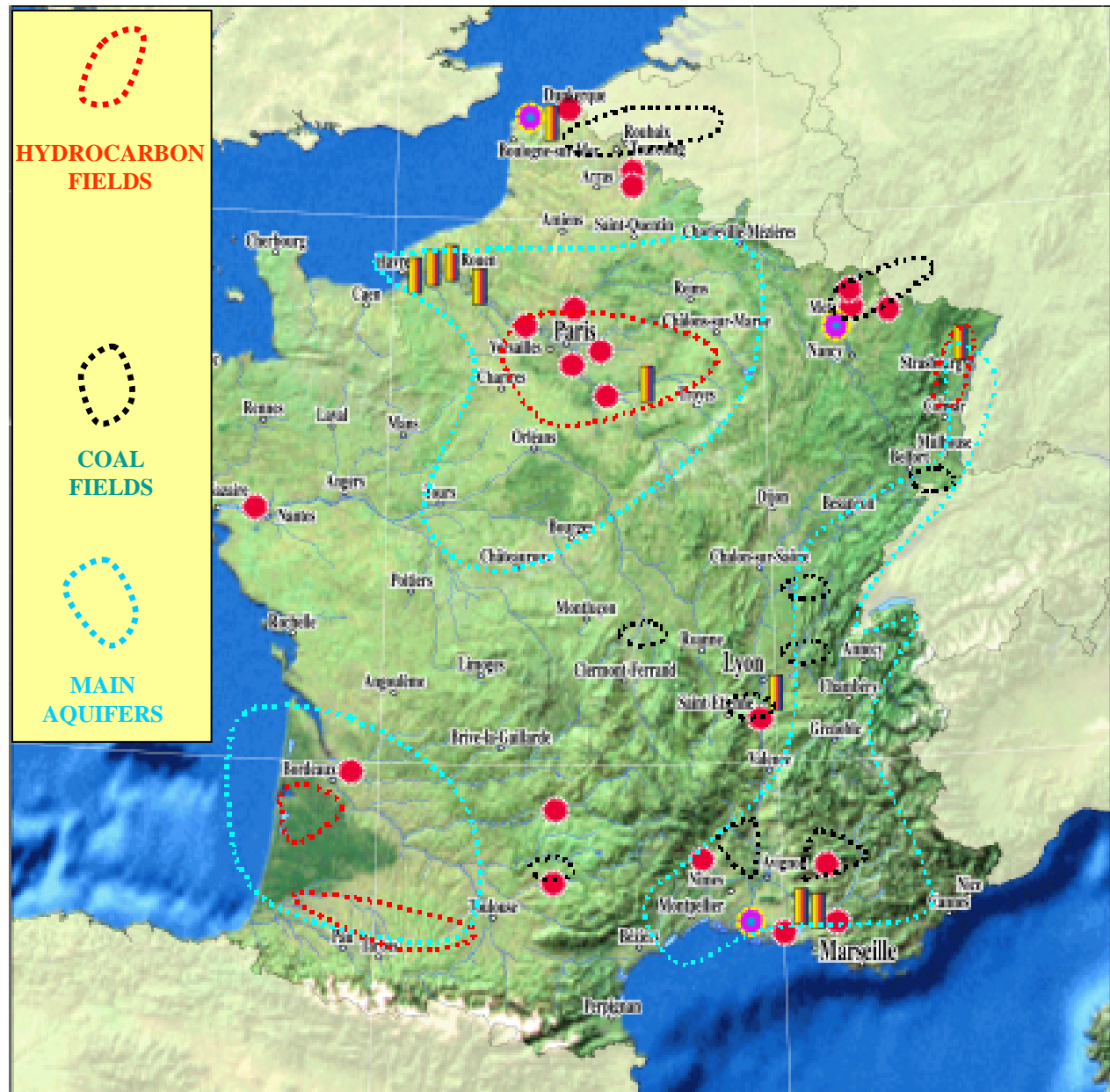
- Lowering capture costs and improvement of capture technology ? YES, but technology exists and can be used now. The 3 routes (post-, pre-, and oxy-combustion are under considerable progress)
- For storage, we can easily (?) start with depleted oil and gas fields

⇒ Is it enough (in Europe) to achieve statement 1 and 2 ?

The French situation

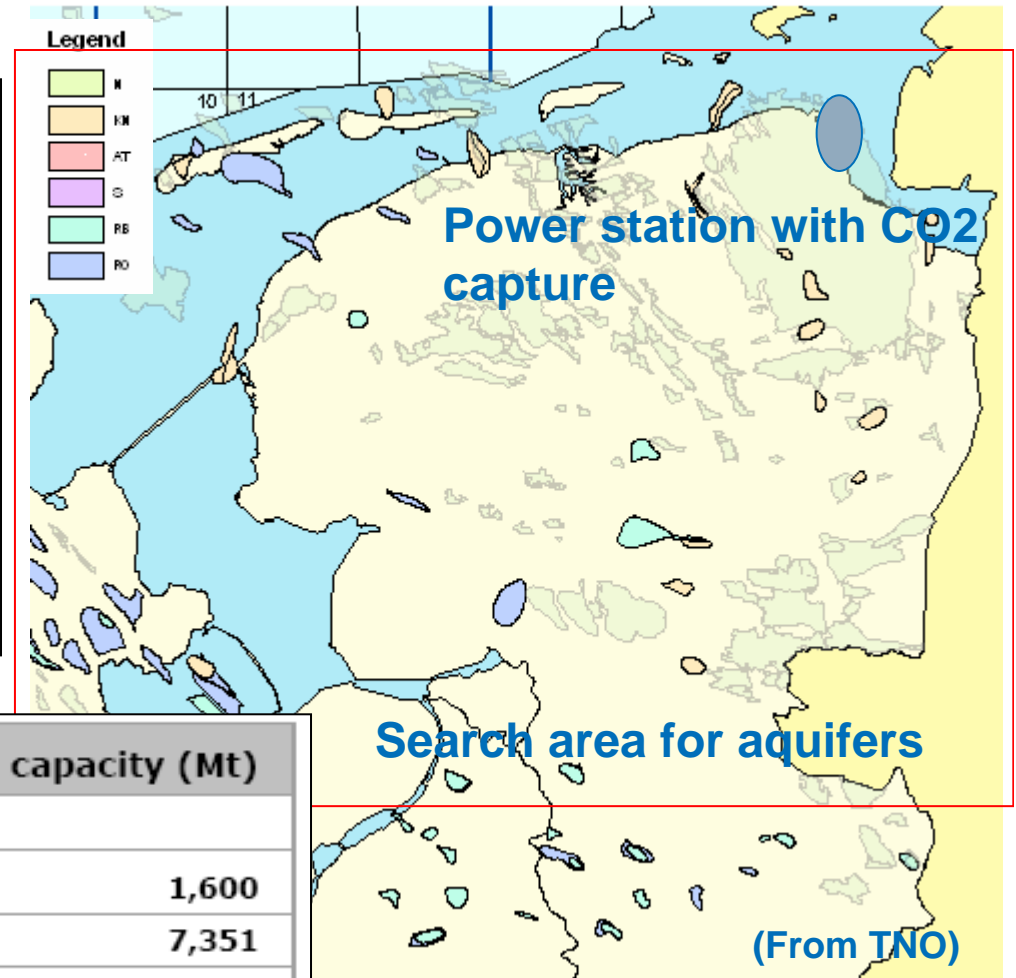
Potential Storage in oil fields: 450-650 Mt
(from PICOREF – D. Bossie Codreanu)

Potential storage in Paris Basin deep aquifers
(Dogger+Trias): 25 Gt
(from GESTCO EU project)



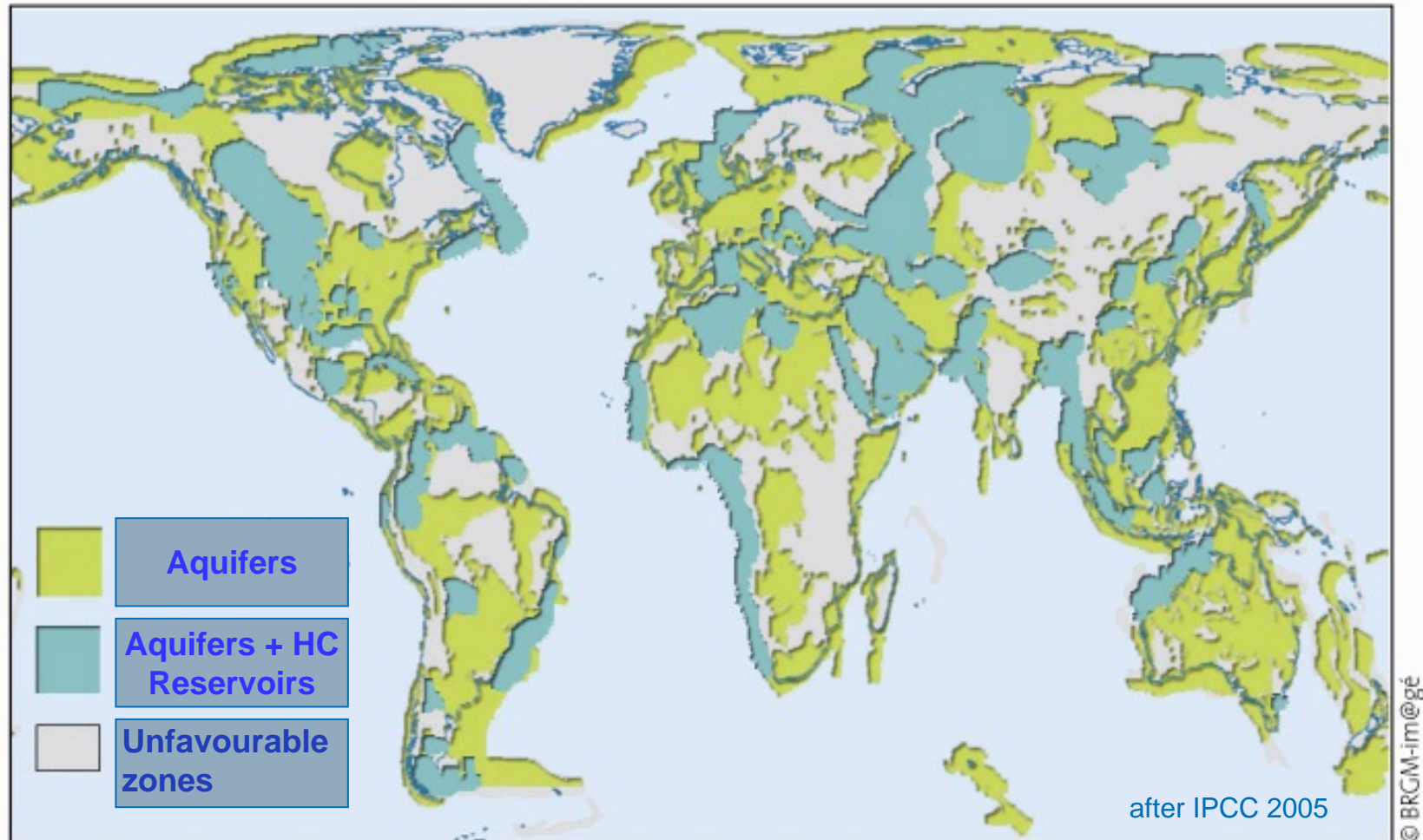
The Dutch situation (gas fields)

Class	Onshore		Offshore	
	No of fields	Storage Capacity (Mt)	No of fields	Storage Capacity (Mt)
4-15 Mt (small)	36	300	50	425
15-50 Mt (medium)	18	450	23	600
>50 Mt (large)	9	850	2	125
<i>Total</i>		<i>1600</i>		<i>1150</i>



Storage type	Storage capacity (Mt)
Depleted gas fields	
• Onshore Non-Groningen	1,600
• Groningen	7,351
• Offshore	1,150

Aquifers worldwide (sedimentary basins)

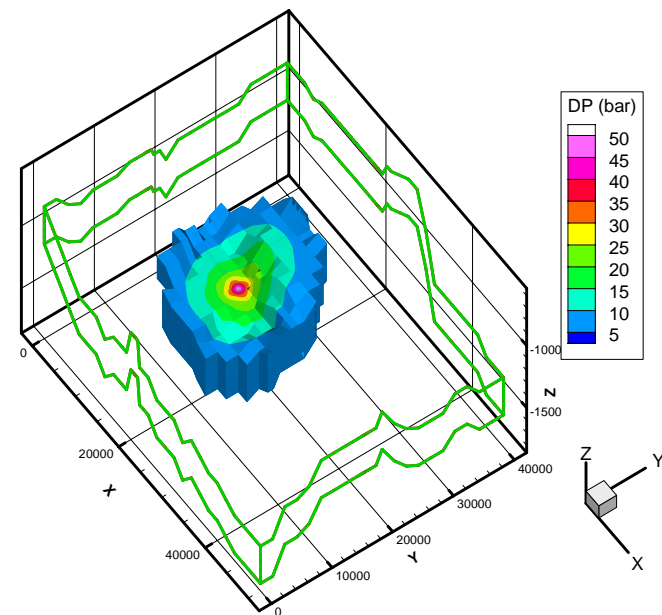
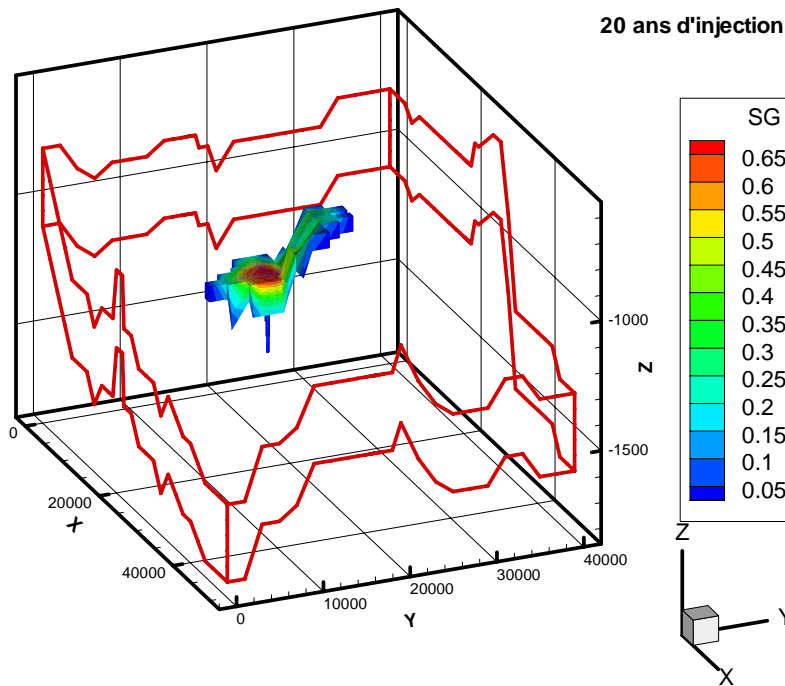
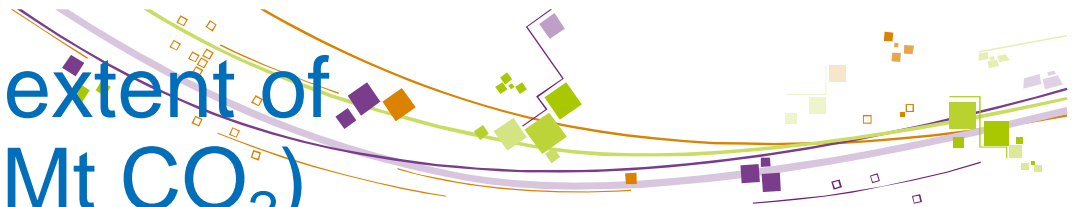




CO₂ storage in deep saline aquifers

- **The largest potential globally (IPCC 2005)**
 - **Relative potential for various storage types:**
 - 1000 Deep saline aquifer storage
 - 100 Oil & gas field use (EOR-EGR) and storage
 - 10 Deep un-mineable coal bed use (ECBM) and storage
 - 1 Mineral sequestration
- **But ...**
 - Poorly explored
 - Vertical (at least) confinement to be proven
 - Injectivity to be proven
 - Competition with other activities (geothermal, ...)

Example of lateral extent of a CO₂ plume (200 Mt CO₂)



COORES simulator (IFP) – Y. Le Gallo

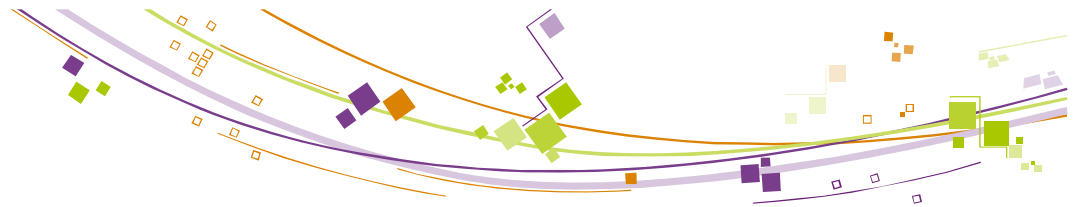


The AQUA-CO₂ initiative



- **Develop the R&D needed to enable near future implementation of industrial storage of CO₂ in saline aquifers (stepping stone to the 10-12 large-scale CCS demonstration projects in Europe)**
- **Develop a robust methodology for the qualification of saline aquifers for storage, based on a number of actual geological storage sites across Europe**
 - **Aquifer characterisation**
 - **Performance prediction**
 - **Risk & selection criteria**
 - **Technical requirements for aquifer qualification**
- **Establishment of a Regulatory Issues Communication Committee**
 - **National regulator representatives**
 - **DG ENV & DG TREN**
 - **End-users from industry partners**

Who is in ?



R&D

IFP (FR)
GEUS (DK)
GFZ (DE)
TNO (NL)
SINTEF (NO)
BGS (UK)
BGR (DE)
BRGM (FR)
OGS (IT)
Heriott Watt (UK)
INIG (PL)
IGME (SP)
ELGI (HU)

Energy Companies

STATOIL (NO)
SUEZ (BE)
DONG ENERGY (DK)
SHELL (NL)
RWE (DE)
VATTENFALL (SE)
BP (UK)
Gaz de France (FR)
TOTAL (FR)
ENEL (IT)
ENDESA (SP)

Service & Supply

GEOSTOCK (FR)
SCHLUMBERGER (FR)
DNV(NO)

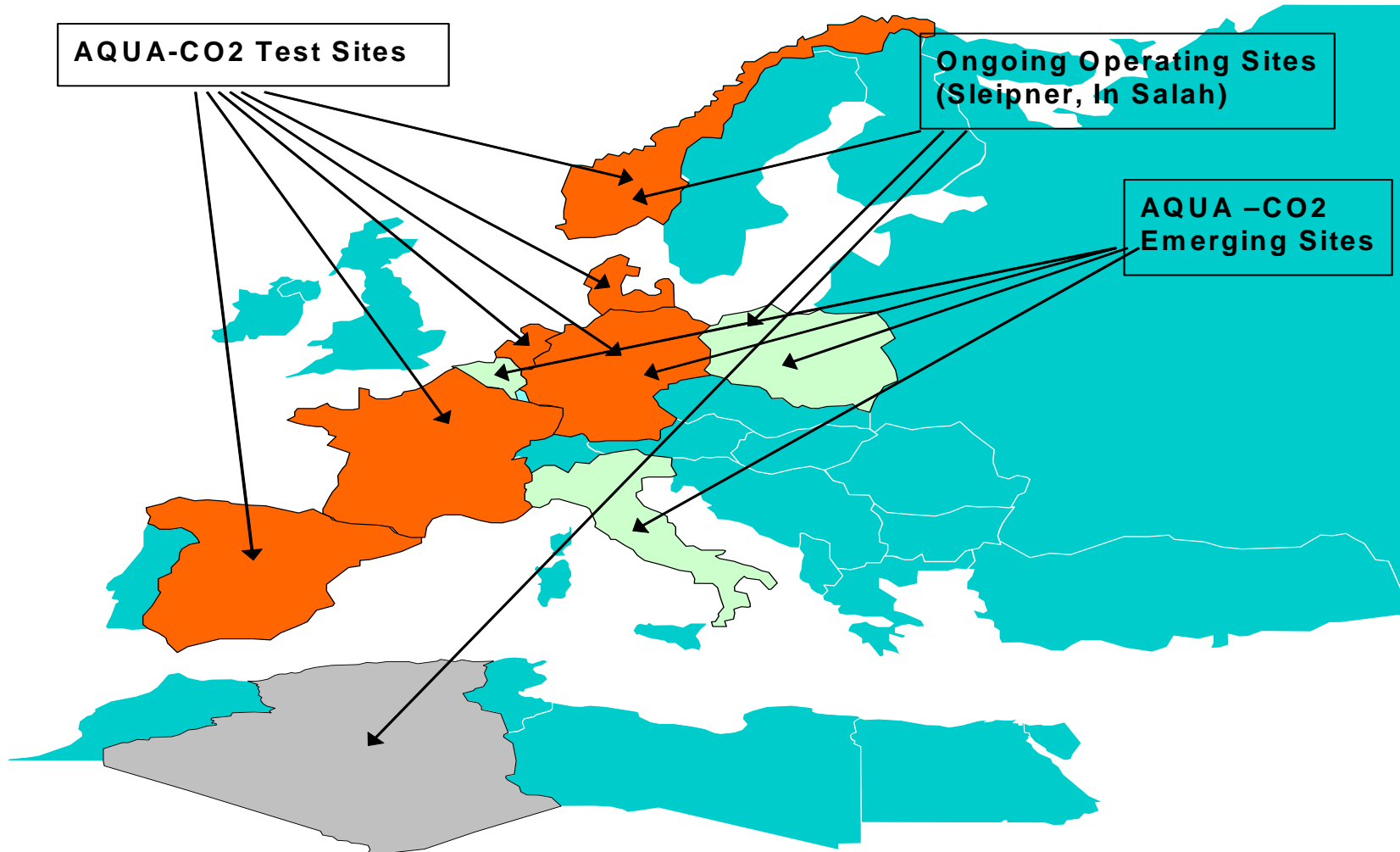
International Programs

IEA-GHG (UK)

Other end-users knocking at the door: POWEO (FR), Wintershall (DE), NUON (NL), ...



AQUA-CO2 Aquifer Sites

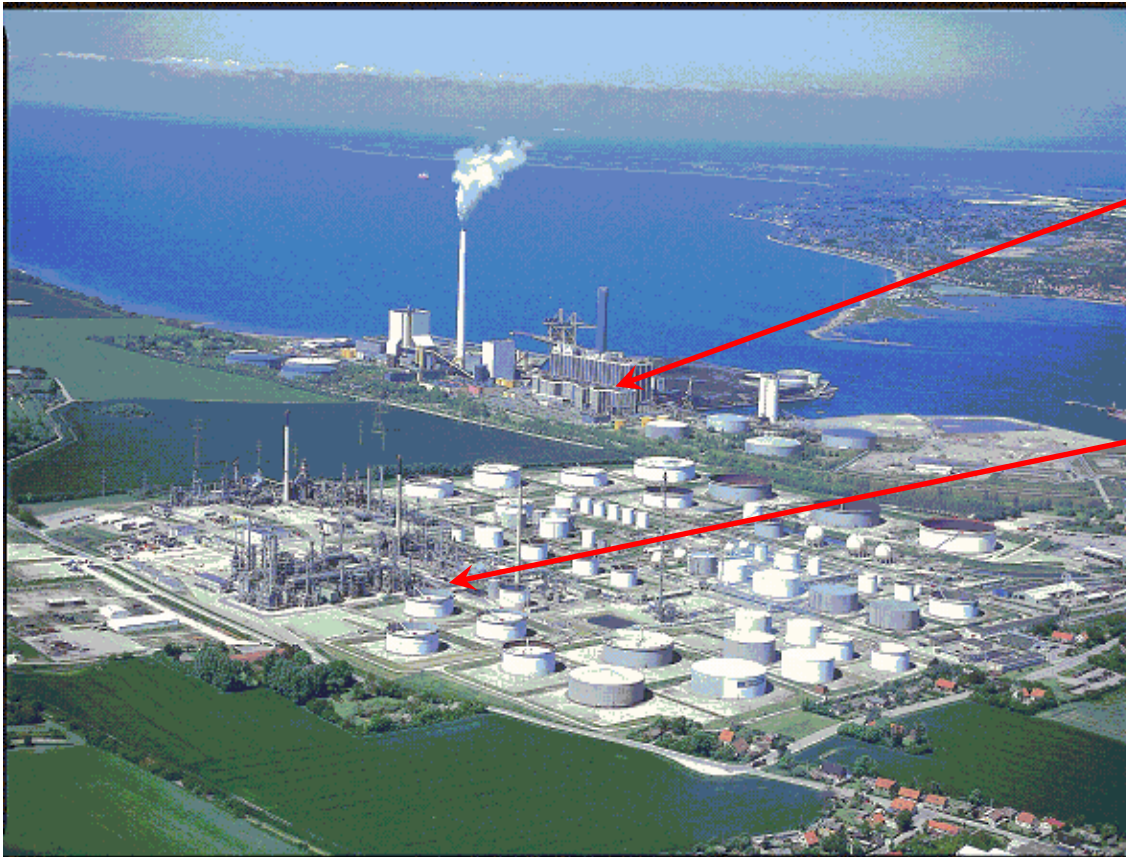




Technical scope and sites

- Exploring for aquifer storage sites (*Cases: Regional– Northern Europe & Sedimentary Basin - Spain*)
- Selecting offshore aquifer storage sites (*Case: North Sea - Norway*)
- Delineating and testing aquifer storage structure (*Case: Onshore/offshore aquifer – Denmark*)
- Preparing for onshore injection demo (*Case: Paris Basin – France*)
- Assessing trap integrity (*Case: Testing fault sealing – the Netherlands*)
- Post-injection and abandonment (*Case: Ketzin site – Germany*)
- Emerging European sites (*Possible input from Italy, Poland, Belgium, Hungary, UK...*)

The Danish Case ("kalundborg")



Asnæsværket 1300 MW
coal and oil fired
power plant operated by
DONG Energy

Statoil refinery

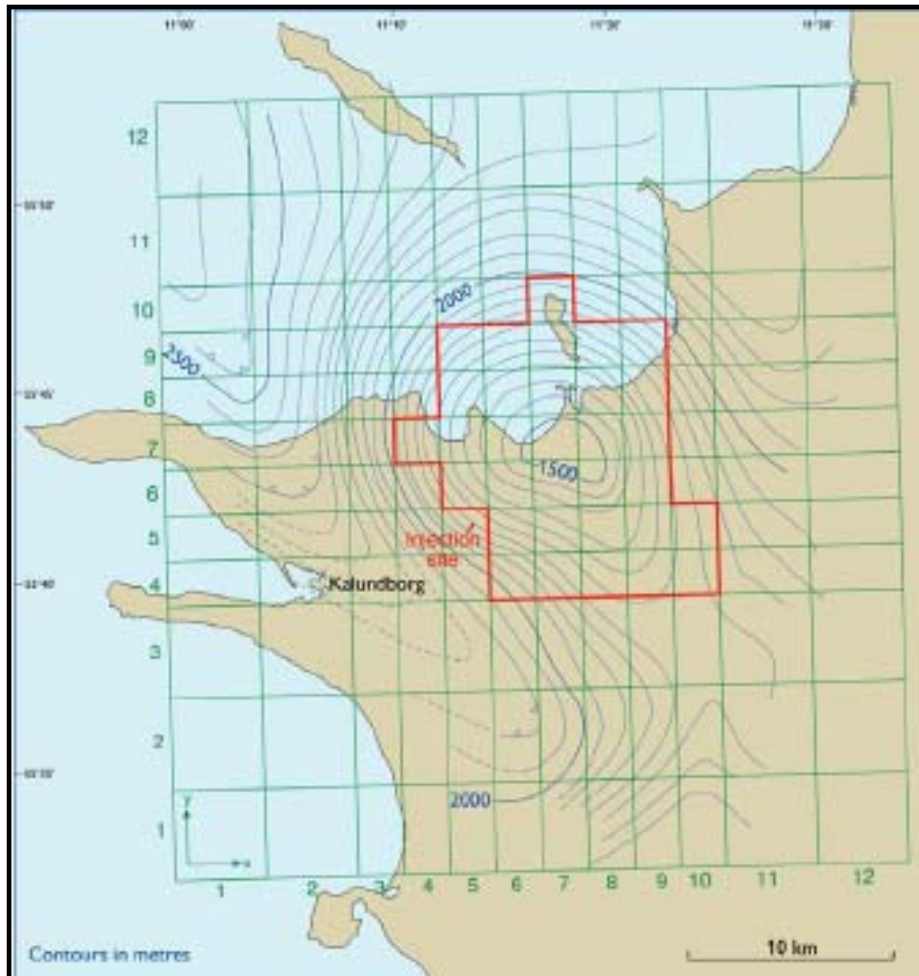
About 6 Mt CO₂ / year

DONG
energy

 **STATOIL**


Innovation
Energy
Environment

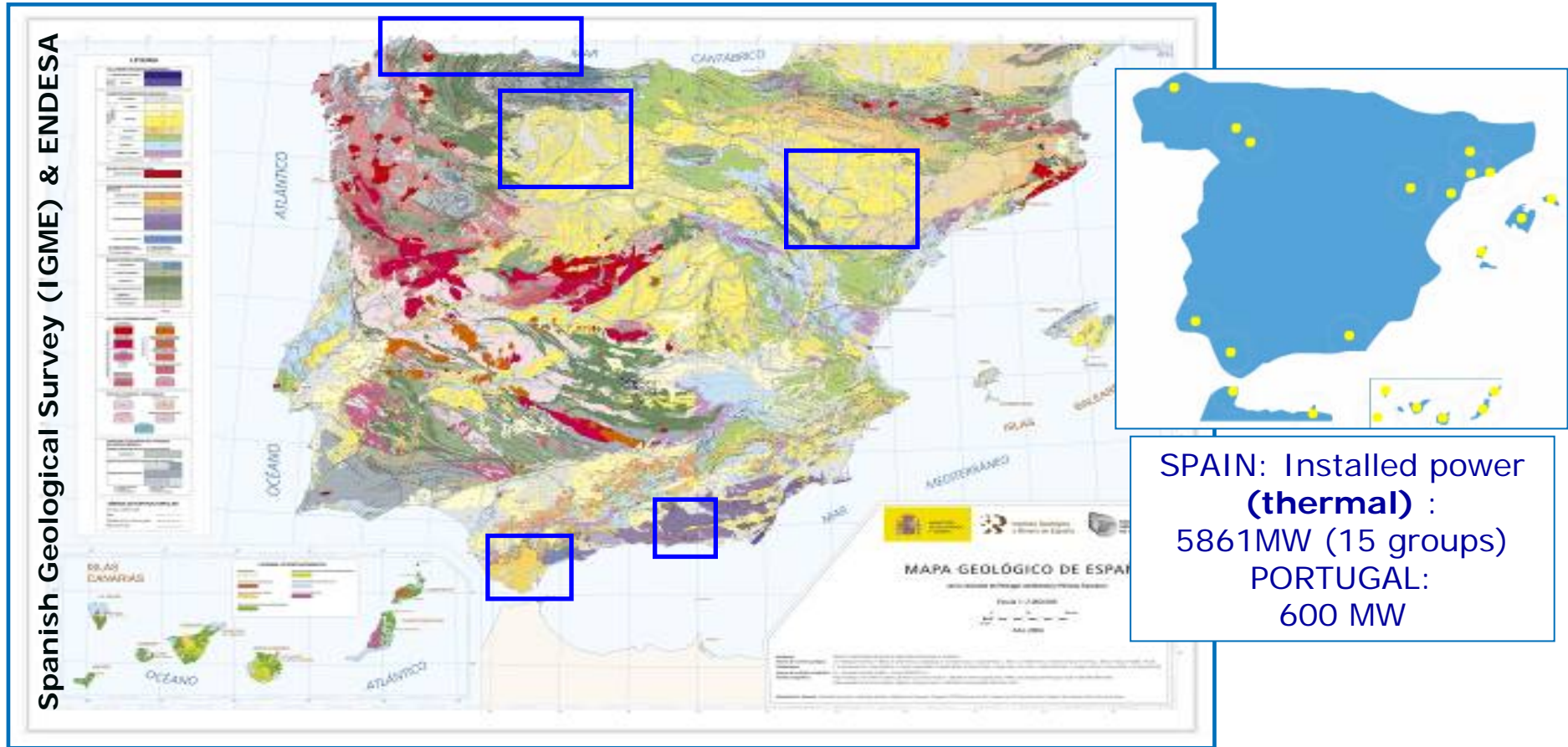
The Danish Case ("Kalundborg")



Scope: delineation and test of storage aquifer structure

1. Acquire seismic data (develop smart acquisition & monitoring system)
2. Test well and model forward behaviour
3. Design future site testing (validation of structure's suitability) with CO₂, up to 100 000 pa from refinery.
4. Outline plan and permitting requirements for million tonne pa operation

The Spanish (ENDESA) case



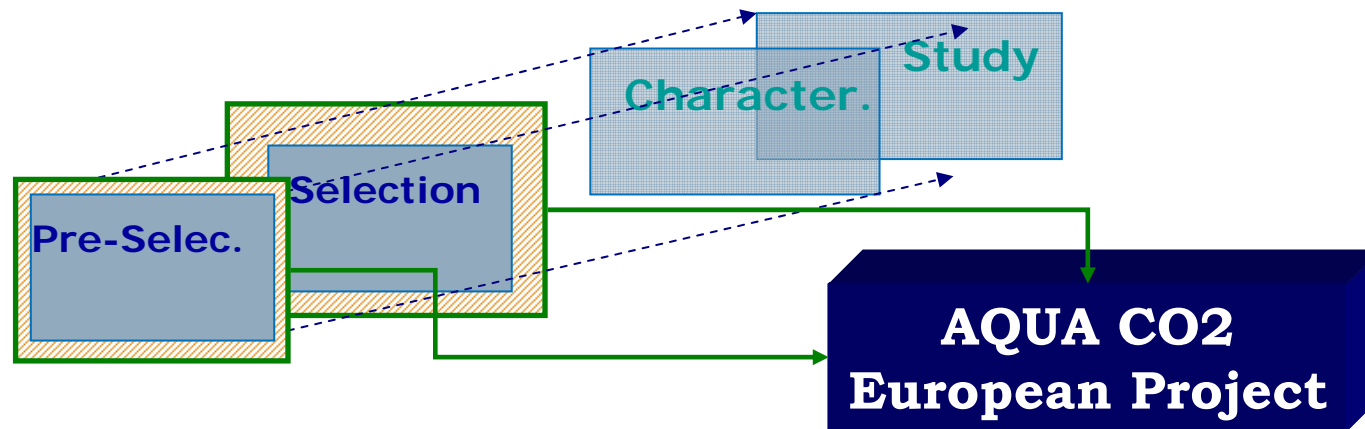
R&D Spanish Project: CENIT CO₂



The Spanish case



- **CO2 Storage: locations and development of suitable structures**
- **Phases of CENIT CO2**
- **Possible connection with future European Project**



The German (Vattenfall) case



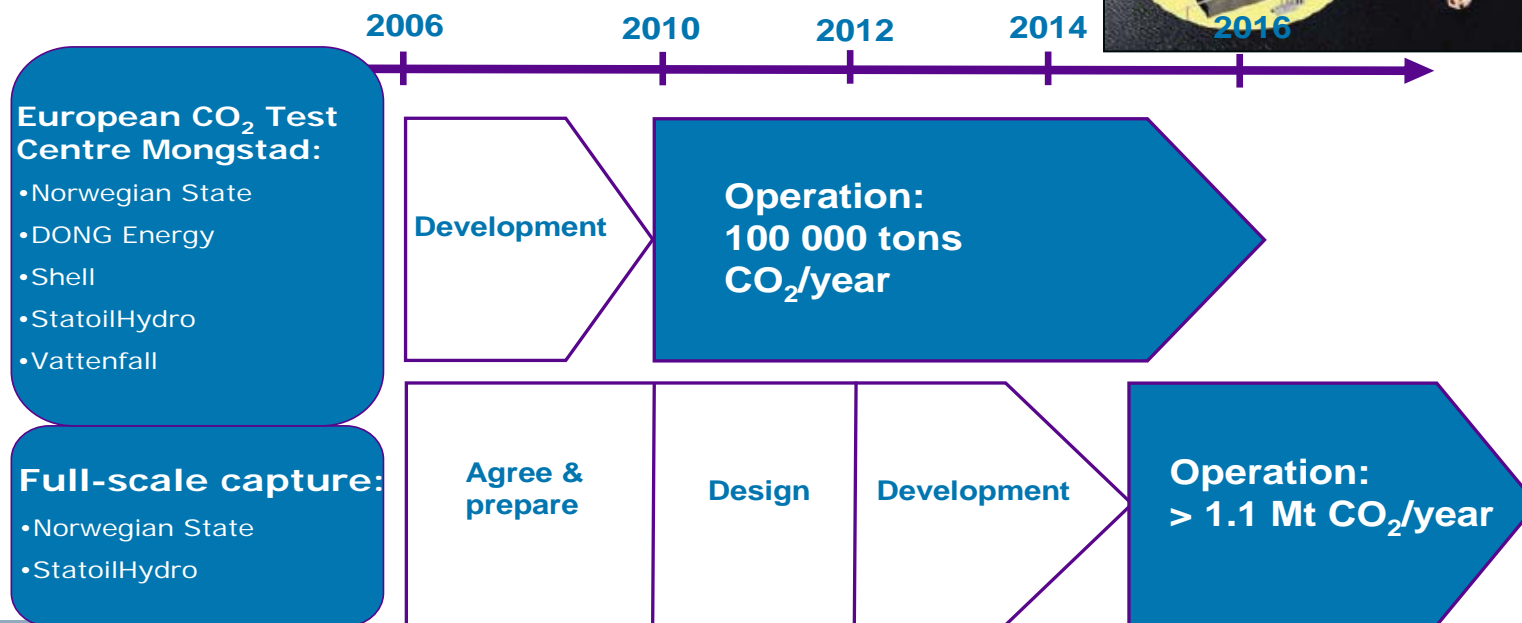
- Vattenfall's pilot plant projects will be in operation in 2008 and 2010:
 - **The 30 MW Oxyfuel Pilot plant in Germany.**
 - **The co-funded Mongstad Post-combustion pilot plant in Norway**
- The next step is Demonstration power plants of sufficient size to demonstrate that the concepts are commercially feasible.
- Vattenfall's Demonstration power plant project includes the design of one or several 250–350 MW electricity power plant(s), with transportation and storage of the captured CO₂.
- The Demonstration power plant(s) is/are targeted to be taken in operation by 2015. The critical line is development of storage and transport concepts.
- A number of candidate aquifer storage sites are being investigated. The storage structure must be tested and validated in order to receive corporate go-ahead as well as regulator's permission to store
- In the AQUACO2 project, Vattenfall governs two candidate aquifers to be explored for CO₂ storage: Northeast Germany and Denmark



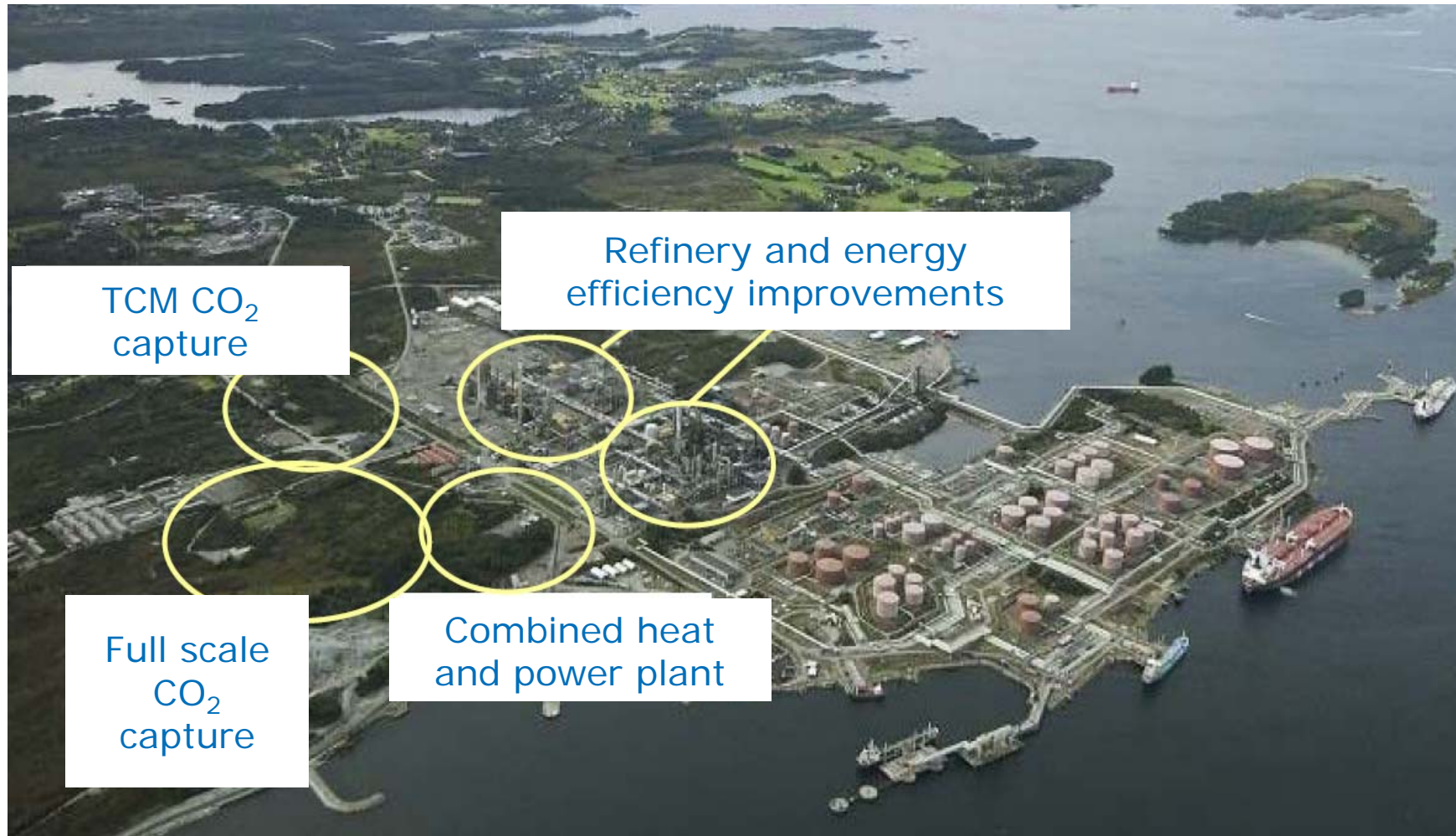
The Norwegian case (StatoilHydro)

The Mongstad project: A two-staged approach to CO₂ capture

Possible storage in aquifer



The Norwegian case (StatoilHydro)



The Norwegian case (StatoilHydro)

Power stations with CCS 2012-14

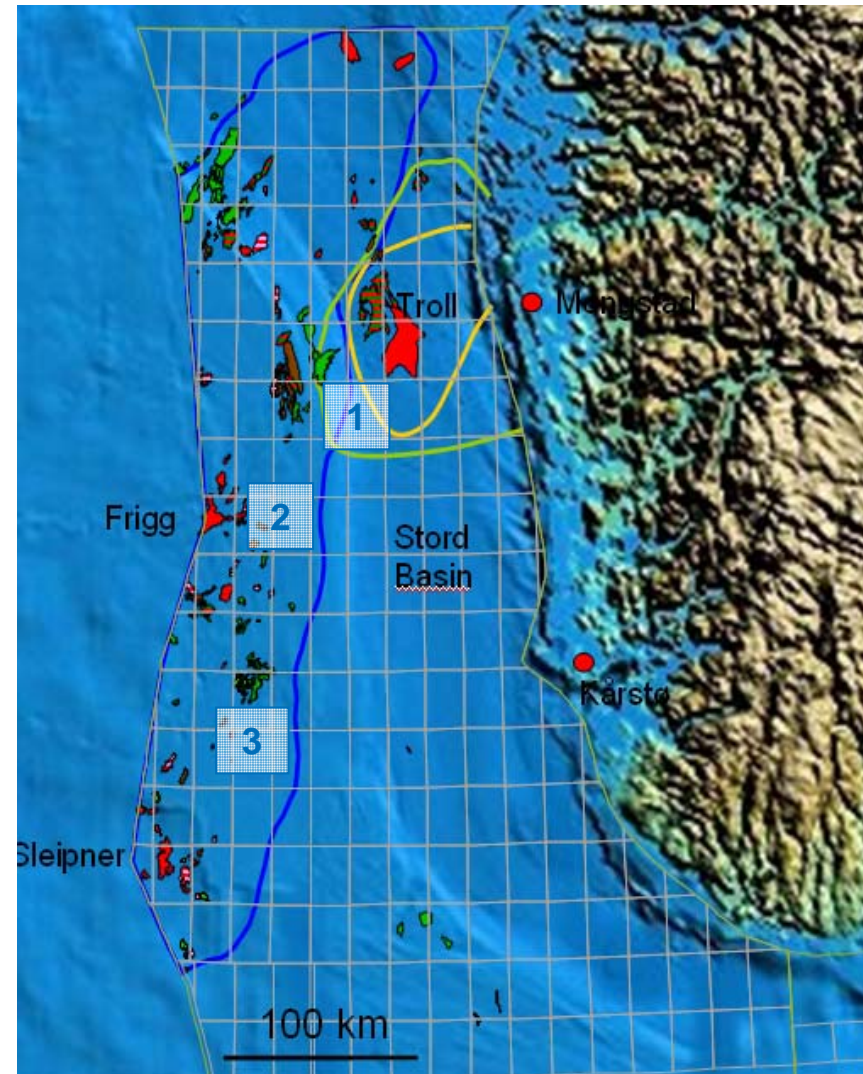
Site characterisation:

■ New sites

- Aquifer formation west of Mongstad
- Extend mapping of Utsira fm.
- Transport with pipe and/or ship

■ CO₂ from

- Kårstø : 1.1 Mt/year
- Mongstad 2,2 Mt/year
- + extra volumes?



Energy
Environment



Conclusion – The (green) way forward

- **CO₂ storage in deep saline aquifers is still largely non demonstrated. Important efforts are needed:**
 - **Site characterisation and qualification**
 - **Regulatory framework**
 - **Public acceptance**
- **The first industrial initiatives (AQUA-CO₂) will be a crucial step in the "storage-ready" concept to enable the large-scale demos in Europe around 2012-2015**
- **AQUA-CO₂ provides an important means of building confidence in Europe in how to qualify aquifers for CO₂ storage**

**This is a real challenge ... and we
have to start NOW !**