

CCOP – Norway Program EPPM

P2W1: Workshop on development of natural gas resources with high CO₂ & CCS in CCOP

Geological CO₂ Storage

Risks, uncertainties & the role of GS

Bali/Indonesia, March 17-20, 2009

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Some characteristics of Geological Surveys

- ▶ **advisory body to Government**
- ▶ **independant**
- ▶ **neutral**
- ▶ **broad knowledge about subsurface**
- ▶ **etc.**

Energy demand & climate protection

- ▶ World energy demand will grow by 50 % until 2030 (e.g. IEA, WEO 2006)
- ▶ Main share from fossil fuels, mainly from coal
- ▶ Consequence: Increase of CO₂ emissions

Options to react:

1. Better energy efficiency
2. Growing share of renewables
3. Cleaner fossil fuels



Preamble of the **Bali Action Plan** (2007):

„*Responding* to the findings of the Fourth Assessment Report of the IPCC that **warming of the climate system is unequivocal**, and that **delay in reducing emissions significantly constrains opportunities** to achieve lower stabilization levels and increases the risk of more severe climate change impacts.“

Bali Action Plan – Mitigation

- i. [All Developed Countries] “measurable, reportable and verifiable **nationally appropriate mitigation commitments or actions**, (...) “comparability of efforts”*
- ii. [Developing Countries] “Nationally appropriate mitigation actions (...), **supported and enabled by technology, financing and capacity building**, in a measurable, reportable and verifiable way”*
- iv. “Cooperative sectoral approaches and sector-specific actions.”*
- v. “Various approaches, including opportunities for using markets”*



Road to Copenhagen

Bali Action Plan has given mandate for negotiations to Copenhagen end of 2009

AWG LCA: Track under the convention:

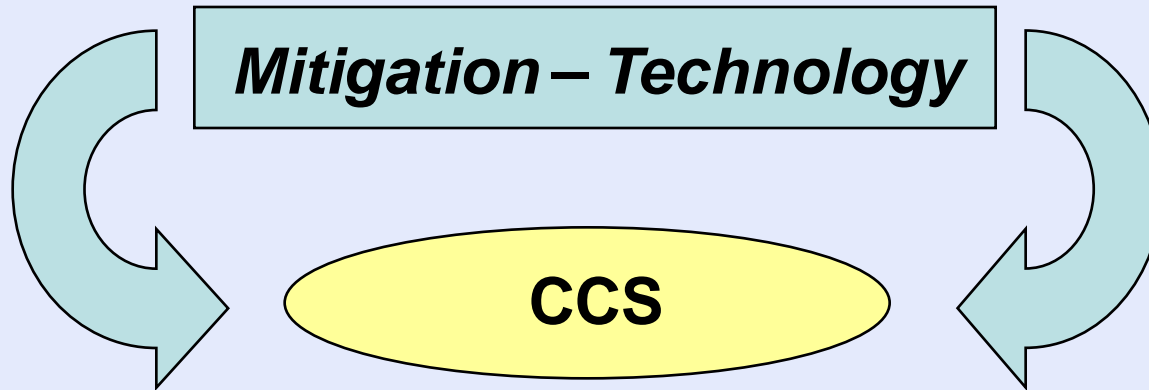
Contribution of all countries (esp. developing countries and the US)

- shared vision
- **mitigation**
- adaptation
- **technology**
- finance

AWG-KP: „Kyoto-Track“

GHG reductions of industrialised countries for the second commitment period of Kyoto: **indicative corridor**: minus 25-40% by 2020 (compared to 1990 levels)

UNFCCC Process



Some of the preconditions for CCS implementation:

Availability of suitable storage sites and capacity

Regulatories in place (for approval of projects)

Knowledge in place (for design / for approval / for control of projects)

*Input from national
Geological Surveys
necessary!*

- **Legal framework: CCS Directive agreed December 2008**
 - **national governments have to implement ≤ 2 years**
- **Demonstration programme:**
 - **10-12 demo plants by 2015**
 - **Financing & incentivisation through EU ETS**
 - **Additional finance for 5 plants proposed through Economic Recovery Plan**

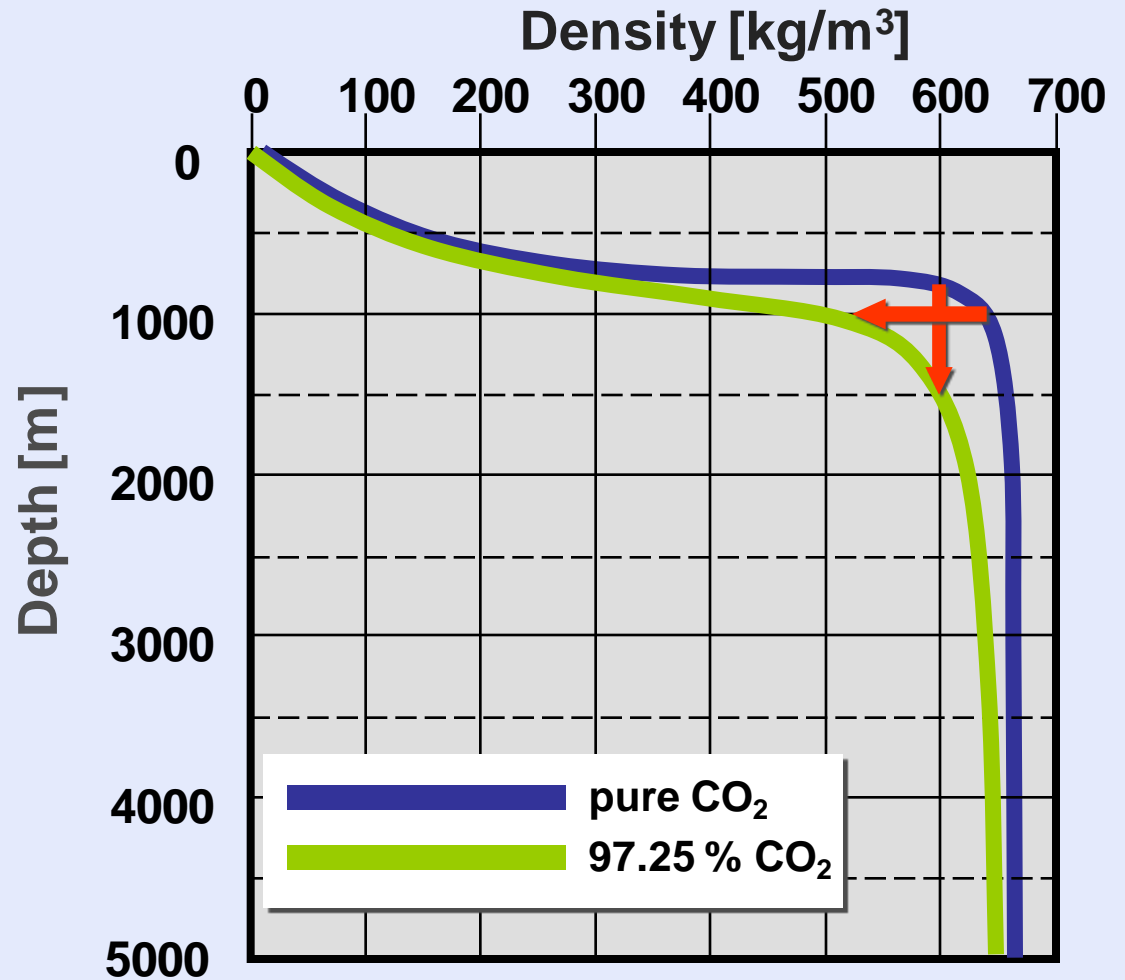
- **The importance of global demonstration: EU assistance to emerging economies and developing countries**
 - **coal to play a significant role**
 - **need to tackle emissions of fossil-fuel dependant emerging economies in order to meet 2°C objective**
 - **cooperation will be an essential element of a post-2012 agreement**
 - **not to forget: 1.6bn don't have access to electricity**

CCS in Germany

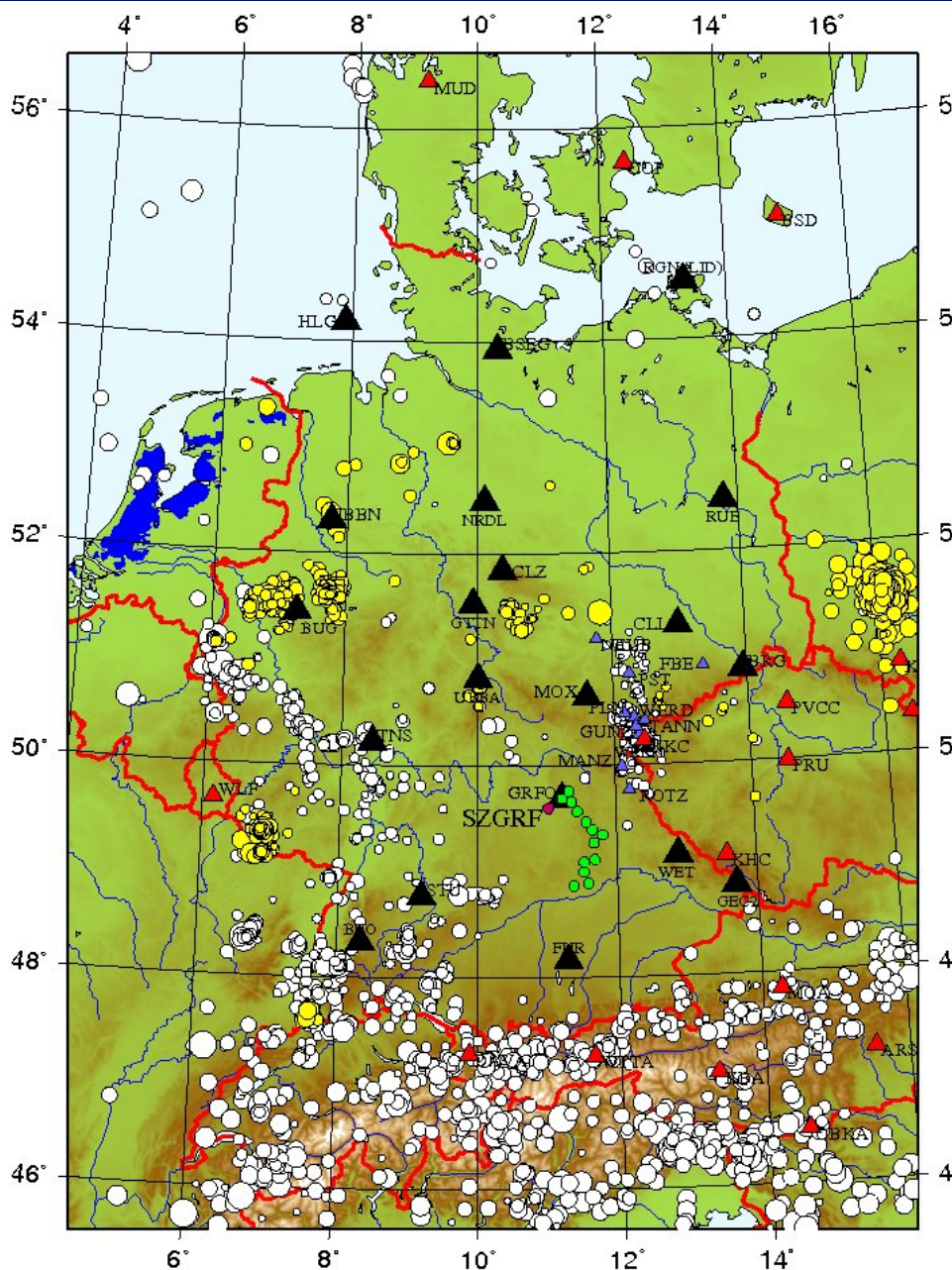
- **German CO2 Storage Act**
 - **common draft by both ministries of economics and environment next week in Cabinet**
 - **Parliament readings in April to June**
- **proposed role for BGR**
 - **elaborate intensively on national storage capacities**
 - **set-up an national register of all CCS activities**
 - **approve applications for exploration, deposition and closure of CO2 storage sites**

Boundary condition I: Depth beyond 800-1000 m

CO₂-behaviour underground



Boundary condition II: Long-term safety



Tectonic Earthquakes in Germany since 1992 (Magnitude >2)

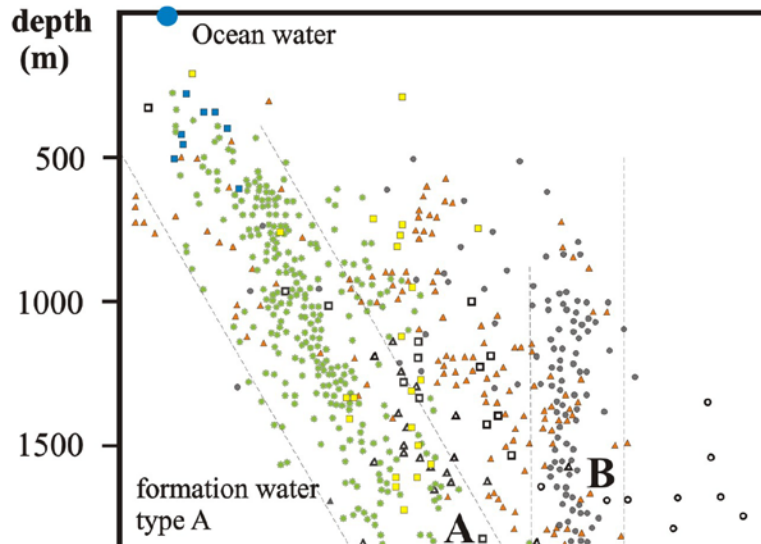
- Tectonic earthquakes (since 1992)
- Induced earthquakes (since 1992)
- ▲ Seismometer station

Boundary condition II: Long-term safety



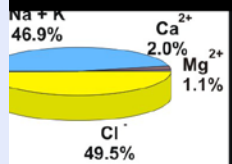
Gas “monitoring“ in previous times

Boundary conditions III: Protect potable water

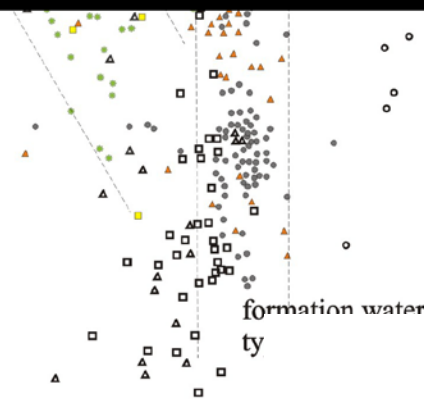


Chemical properties of the brines from the geothermal heating plants in Neubrandenburg and Neustadt-Glewe (Hoth&Seibt 1999)

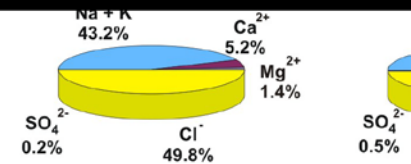
	Neustadt-Glewe	Neubrandenburg
typ	anoxic Na-Cl-brine	
temperature [°C]	99	54
pH	5.3	6.1
density [g/cm ³]	1.147	1.089
total dissolved solids [g/l]	216	137



2000
2500
3000

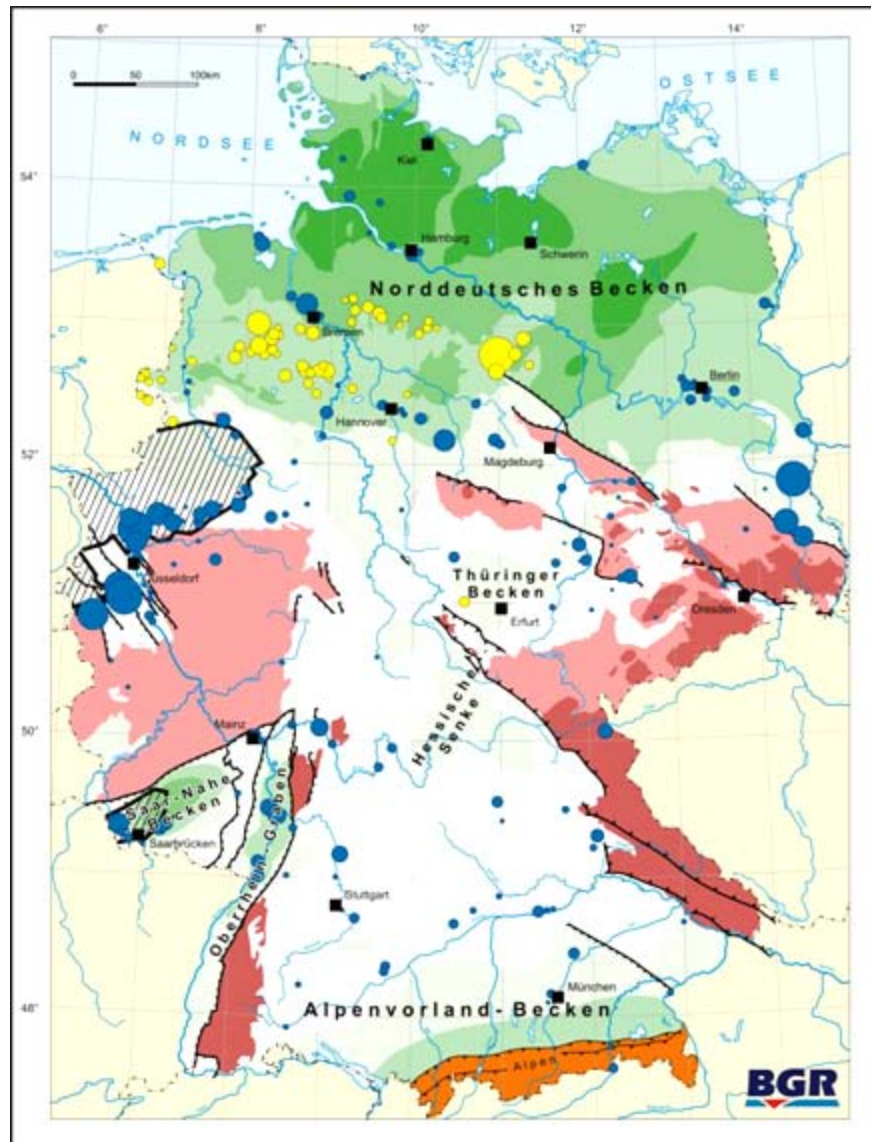


cationics and anionics [mmol(eq)-%]



gas-water-ratio 1:10
carbon dioxide [vol.-%] 94

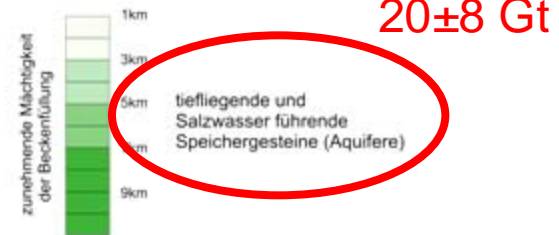
Storage Potential: current knowledge (1)



Bedeutende CO₂ - Quellen

- Kraftwerke, Hütten- und Zementwerke, Raffinerien u. a.
- 0.2 → 20 Mt/a

Regionen mit Speichermöglichkeiten



Steinkohle - Flöze

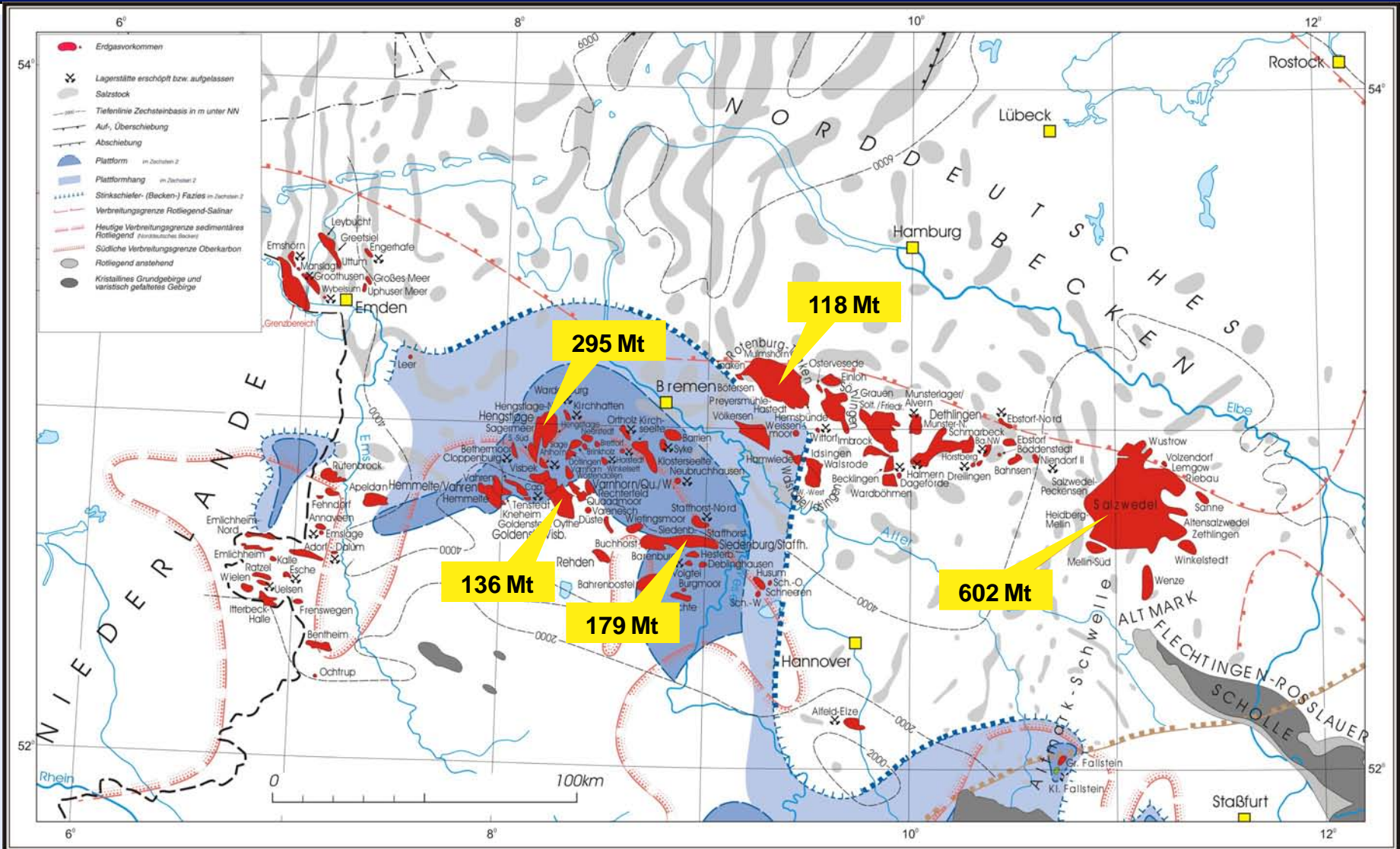
Erdgas - Felder

2.75 Gt

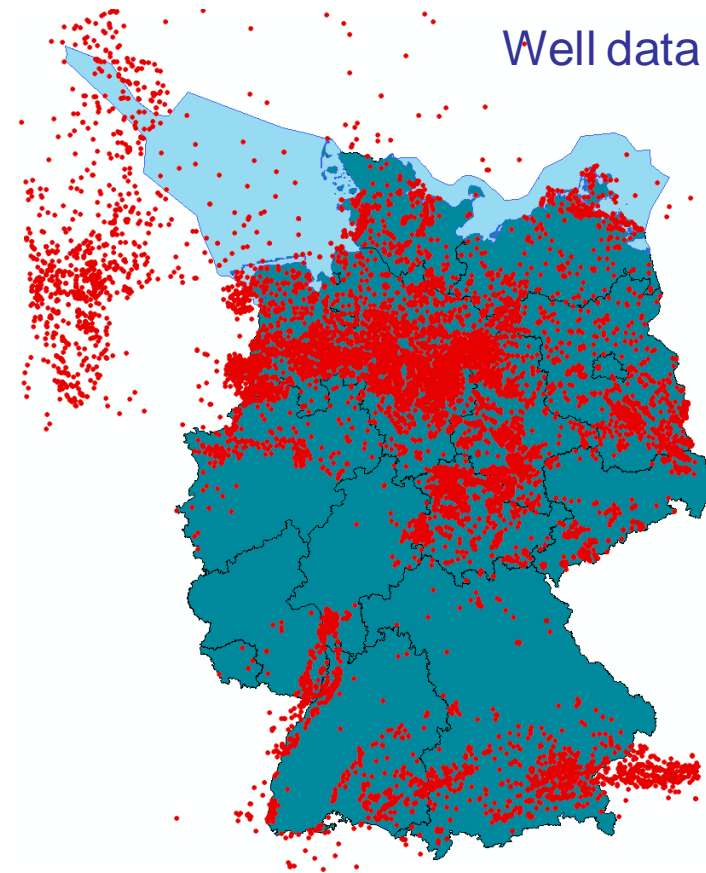
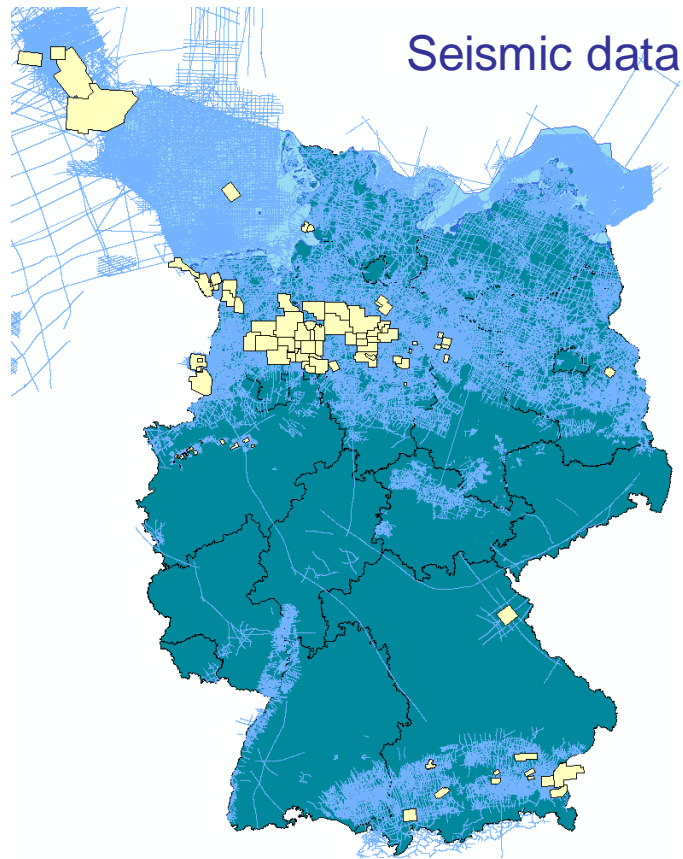
Regionen ohne bedeutende Speichermöglichkeiten

- metamorphe Gesteine
- magmatische und hoch-metamorphe Gesteine
- Speichergesteine nicht oder in zu geringen Tiefen vorhanden

Natural gas fields are premium options



Storage Potential: current knowledge (2)



- ▶ Property of E&P-industry, with own interest
- ▶ regional geological expertise with SGD

Underway: Catalogue of CO2 Storage Sites

► Partnership:

BGR (project leader) plus Geological Surveys (SGD) of all Federal States



► Funding: public (COORETEC) plus industry consortium (EnBW, E.ON, Vattenfall Europe Mining)

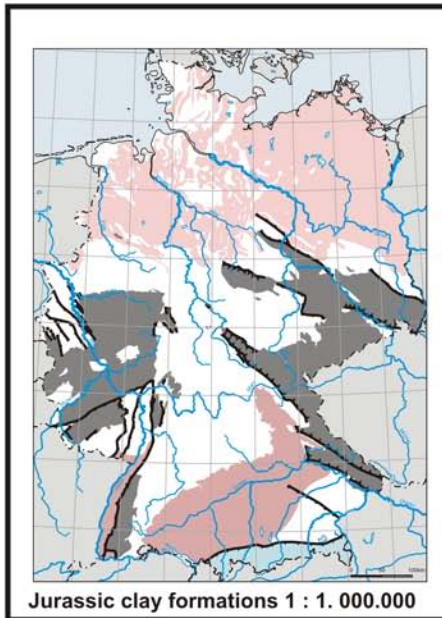
► Time frame: 2008 bis 2011

► Reference: Integrated Energy- and Climate Program of the Federal Government

Catalogue: Work programme

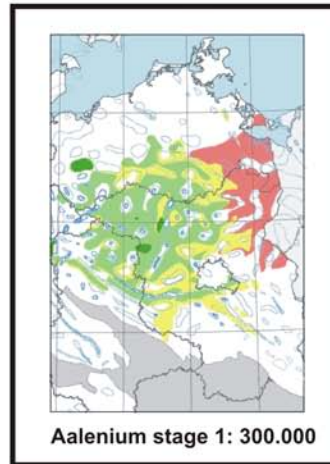
Step 1

Distribution of Reservoir and Barrier Rocks



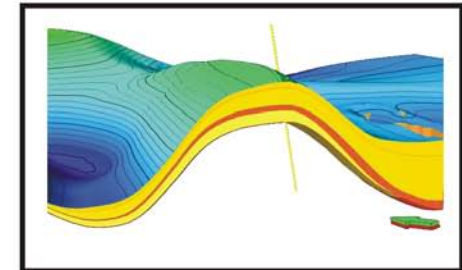
Step 2

Classification of Reservoir and Barrier Rocks



Step 3

Evaluation and Documentation of Individual Structures



I n c r e a s i n g I n c o r p o r a t i o n o f D a t a



Qualification

Quantification

Major Reservoir & Barrier Rocks

System	Serie	Stufe / Folge	
Quartär			
Neogen	Pliozän <small>ca. 1,8</small>	Ober	
		Unter	
	Miozän	Ober	
		Mittel Unter	
Paläogen	Oligozän	Chattium	
		Rupelium	
	Eozän	Ober	
		Mittel	
		Unter	
	Paläozän <small>ca. 65 Ma</small>	Ober	
Unter			
Kreide	Oberkreide <small>ca. 65 Ma</small>	Maastrichtium	
		Campanium	
		Santonium	
		Coniacium	
		Turonium	
	Unterkreide	Cenomanium	
		Albium	
		Aptium	
		Barremium	
		Hauterivium	
Jura	Oberjura (Malm) <small>ca. 142 Ma</small>	Valanginium	
		Berriasium	
		Thitonium	
		Kimmeridgium	
	Mitteljura (Dogger)	Oxfordium	
		Callovium	
		Bathonium	
		Bajocium	
	Unteljura (Lias) <small>ca. 200 Ma</small>	Aalenium	
		Toarcium	
Pliensbachium			
Sinemurium			
Hettangium			

Trias	Keuper	O	k6 - "Rhätkeuper"	
			k5 - "Steinmergelkeuper"	
			k4 - "Oberer Gipskeuper"	
		M	k3 - "Schilfsandstein"	
			k2 - "Unterer Gipskeuper"	
			U	k1 - "Lettenkeuper"
	Muschelkalk		Oberer	
			Mittlerer	
			Unterer	
	Buntsandstein	O	s7 - "Röt-Folge"	
			s6 - "Solling-Folge"	
			s5 - "Hardeggen-Folge"	
		M	s4 - "Detfurth-Folge"	
			s3 - "Volpriehausen-Folge"	
s3 - "Quickborn-Folge"				
s2 - "Bernburg-Folge"				
U	s1 - "Calvörde-Folge"			
	z7 - "Mölln-Folge"			
Perm	Oberperm (Zechstein) <small>ca. 251 Ma</small>	z6 - "Friesland-Folge"		
		z5 - "Ohre-Folge"		
		z4 - "Aller-Folge"		
		z3 - "Leine-Folge"		
		z2 - "Staßfurt-Folge"		
		z1 - "Werra-Folge"		
		Unterperm (Rotliegend)	Oberrotliegend	
	Unterperm (Rotliegend)	Unterrotliegend		

 Main reservoir rocks
  Main barrier rocks

Storage and Barrier Rocks in NGB: correlation

Periode/Epoche	Alter/Formation	NW		NI		SH		MV		BB		ST		Grenzen
		Speicher-Komplex	Barriere-Komplex	Speicher-Komplex	Barriere-Komplex	Speicher-Komplex	Barriere-Komplex	Speicher-Komplex	Barriere-Komplex	Speicher-Komplex	Barriere-Komplex	Speicher-Komplex	Barriere-Komplex	
Quartär														
Tertiär	Pliozän ca. 1,8													
	Miozän													
	Oligozän Chatt													
	Eozän Rupel													11 Top Rupel Basis Rupel
	Paläozän ca. 65													
Kreide	Maastricht													
	Campan													
	Santon													
	Coniac													
	Turon													
	Senoman													
	Alb													
	Apt													
	Barrême													
	Hauterive													10 Top Unterkreide-Sandsteine
Valangin														
Berrias / Wealden													9 Basis Kreide	
Jura	Oberjura (Malm)													
	Kimmeridge													
	Oxford													
	Mitteljura (Dogger)													
	Callov													
	Bathon													
	Bajoc													8
Aalen														
Unterjura (Lias)	Toarc												7 Basis Dogger - Top Lias	
	Pliensbach													
	Sinemur													
	Hettang												6 Basis Lias	
Trias	ca. 205													5 - Top Rhatkeuper
	O	Rhatkeuper												Basis Rhatkeuper
		Steinmergelkeuper												
		Oberer Gipskeuper												
	M	Schilfsandstein												Berücksichtigung als potenzielles Speichergestein in der Phase 2 des Projektbearbeitung von Teilget
		Unterer Gipskeuper												
		Lettenkeuper												
		Ob. Muschelkalk												Berücksichtigung als potenzielles Speichergestein in der Phase 2 des Projektbearbeitung von Teilget
		Mittl. Muschelkalk												
		Unt. Muschelkalk												4 Top Röt - Basis Muschelkalk
Buntsandstein	O	Röt												ca. Basis Röt - Top Mittlerer Buntsandstein
		Solling-Folge												
		Hardegsen-Folge												
	M	Detfurth-Folge												3
		Volpriehausen-Folge												
		Quickborn-Folge												
		Bernburg-Folge												Basis Mittlerer Buntsandstein
U	Calvörde-Folge												ca. Basis Buntsandstein - Top Zechstein	
Perm	ca. 250													
		Fulda-Folge												
		Friesland-Folge												
		Ohre-Folge												
		Aller-Folge												2
		Leine-Folge												
		Stäufurt-Folge												
		Werra-Folge												
	Rotliegend												1 ca. Basis Zechstein - Top Oberrotliegend II	
Karbon	Oberkarbon													Basis Oberrotliegend II (Havel & Elbe Sub-Gr.)

Süßwasser-Aquifere

Key criteria for reservoir/barrier rocks have to be defined ...

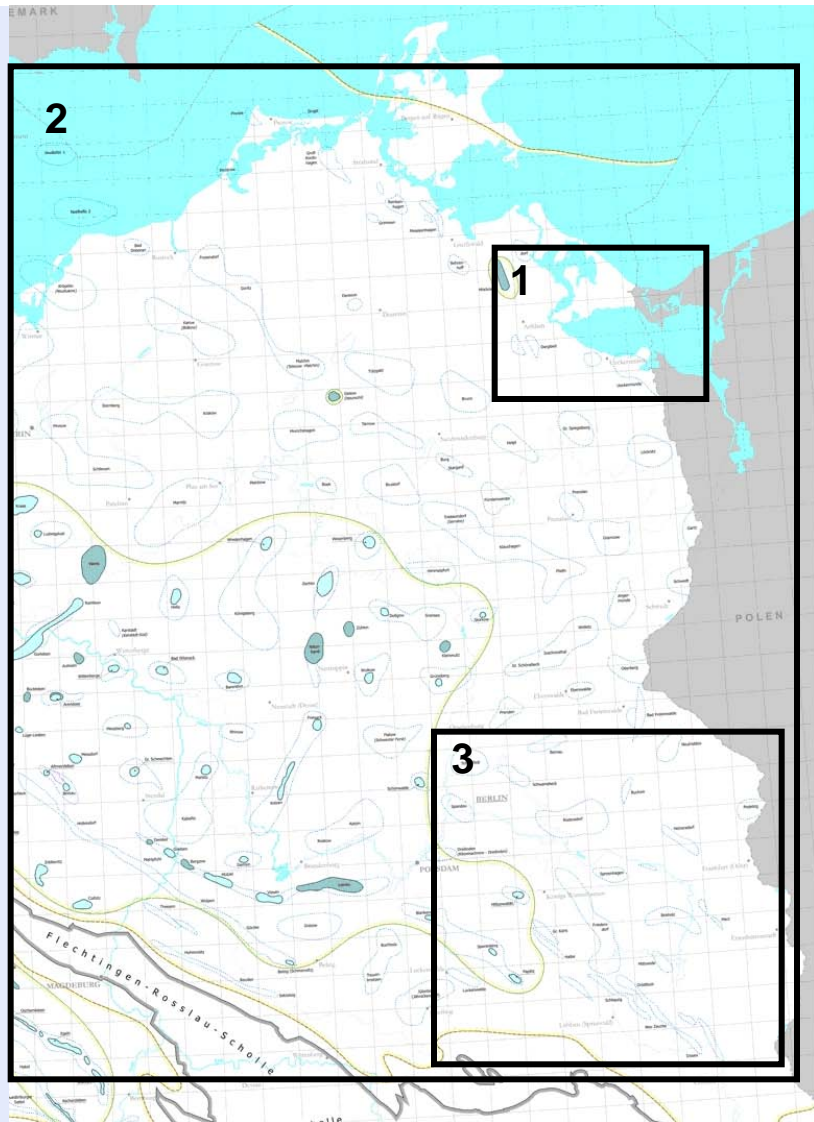
- **distribution**
- **thickness (>10m)**
- **depth (>800m)**
- **reservoir/barrier properties (Poro; Perm; geochemistry)**
- **lithofacies**
- **spatial characteristics**
- **etc.**

Potential Storage Sites across the border

Poland

Source: <http://www.pgi.gov.pl>

CO₂-studies in NE Germany



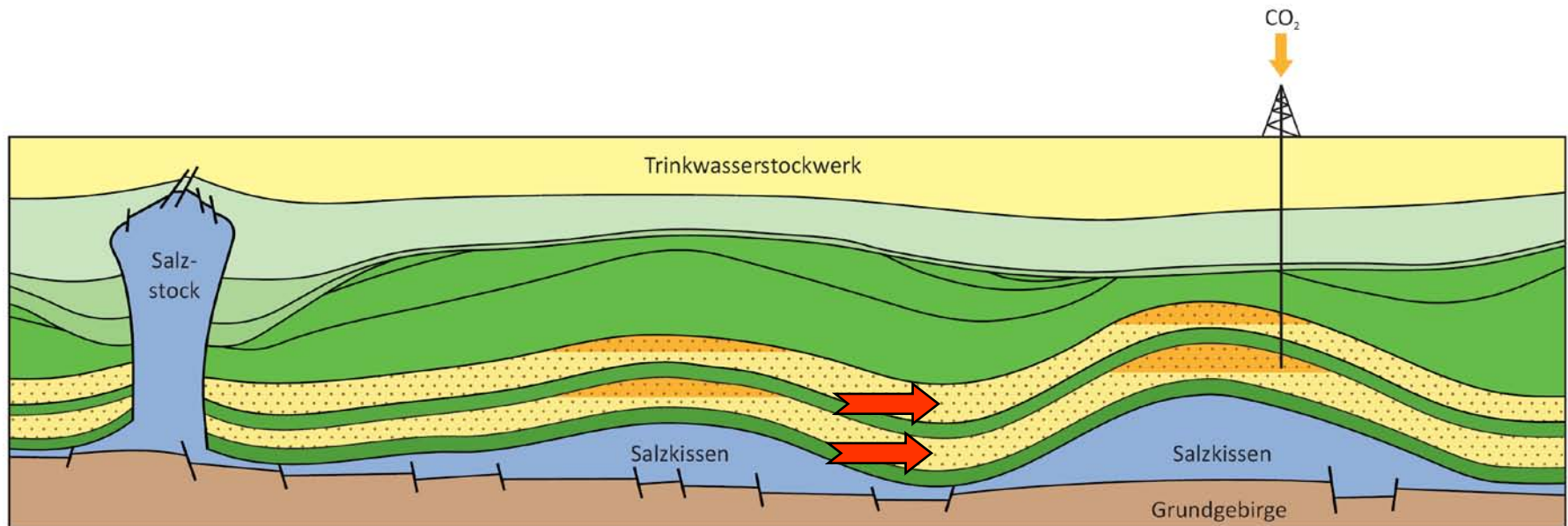
Different CO₂-storage capacity studies in East Germany:

1. GESTCO project (2004)
2. CO₂Store study (2003)*
3. Other industry studies (2007/2008)*

*unpublished

Different injection strategies:

- in anticlines
- in synclines



Competing interests on deep subsurface targets

- ▶ **Mining: coal, salt, oil, gas**
 - ▶ formation water from HC-production
 - ▶ waste from salt mining / processing
- ▶ **Nuclear waste**
- ▶ **Gas storage (natural gas, compressed air?, hydrogen?)**
- ▶ **Deep geothermal energy**
- ▶ **Geological CO2 storage**

Site-specific national R&D projects (GEOTECHNOLOGIEN/BMBF)

- ▶ CLEAN – CO2 storage in a gas field (Altmark) :
 - ▶ Bundle of projects; national partners only; started in late summer 2008
 - ▶ R&D Coordinator: GFZ Potsdam
 - ▶ Industry: Gaz de France Suez + Vattenfall

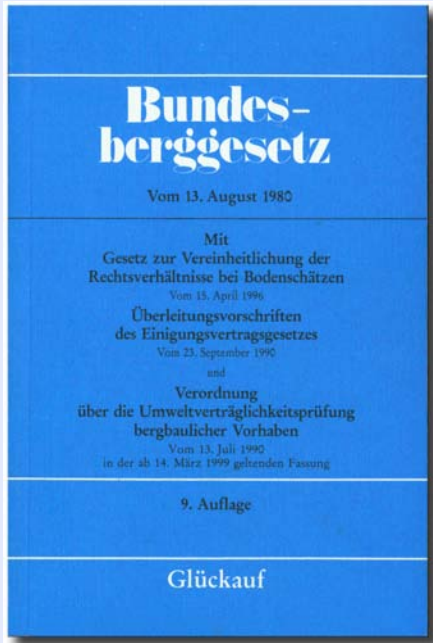
- ▶ COAST – CO2 storage in a saline aquifer :
 - ▶ Bundle of projects; national partners only; will probably start in August 2009
 - ▶ R&D Coordinator: BGR
 - ▶ Industry: RWE

What else is missing ?

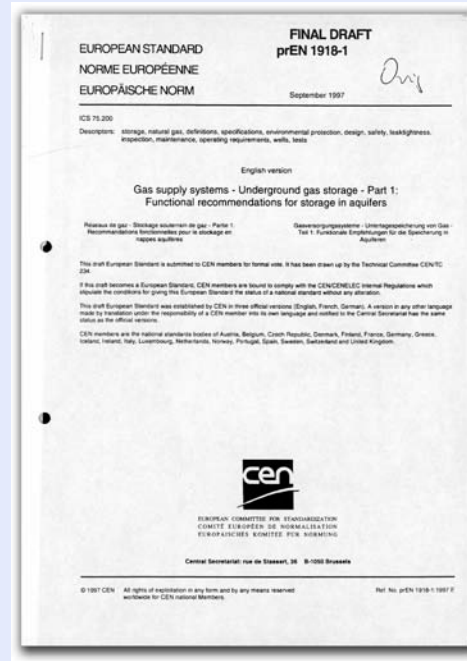
- ▶ Legal framework → EU, national: on the road
- ▶ Technical regulation
- ▶ STABILITY:
 - ▶ two persons (4/2008), continuously
 - ▶ goal: development of concepts & criteria regarding site selection, abandoned wells, longterm security, and monitoring
- ▶ TF „CO2 storage in geological formations“:
 - ▶ under the auspices of DGG and DGGT (geo-scientific organisations)
 - ▶ goal: define reg framework with all actively involved stakeholders
 - ▶ UGS as „quarry“
 - ▶ STABILITY is „backoffice“

Transfer of regulation from UGS

Federal Mining Act



EU/DIN standard UGS



Handouts from Mining Authorities



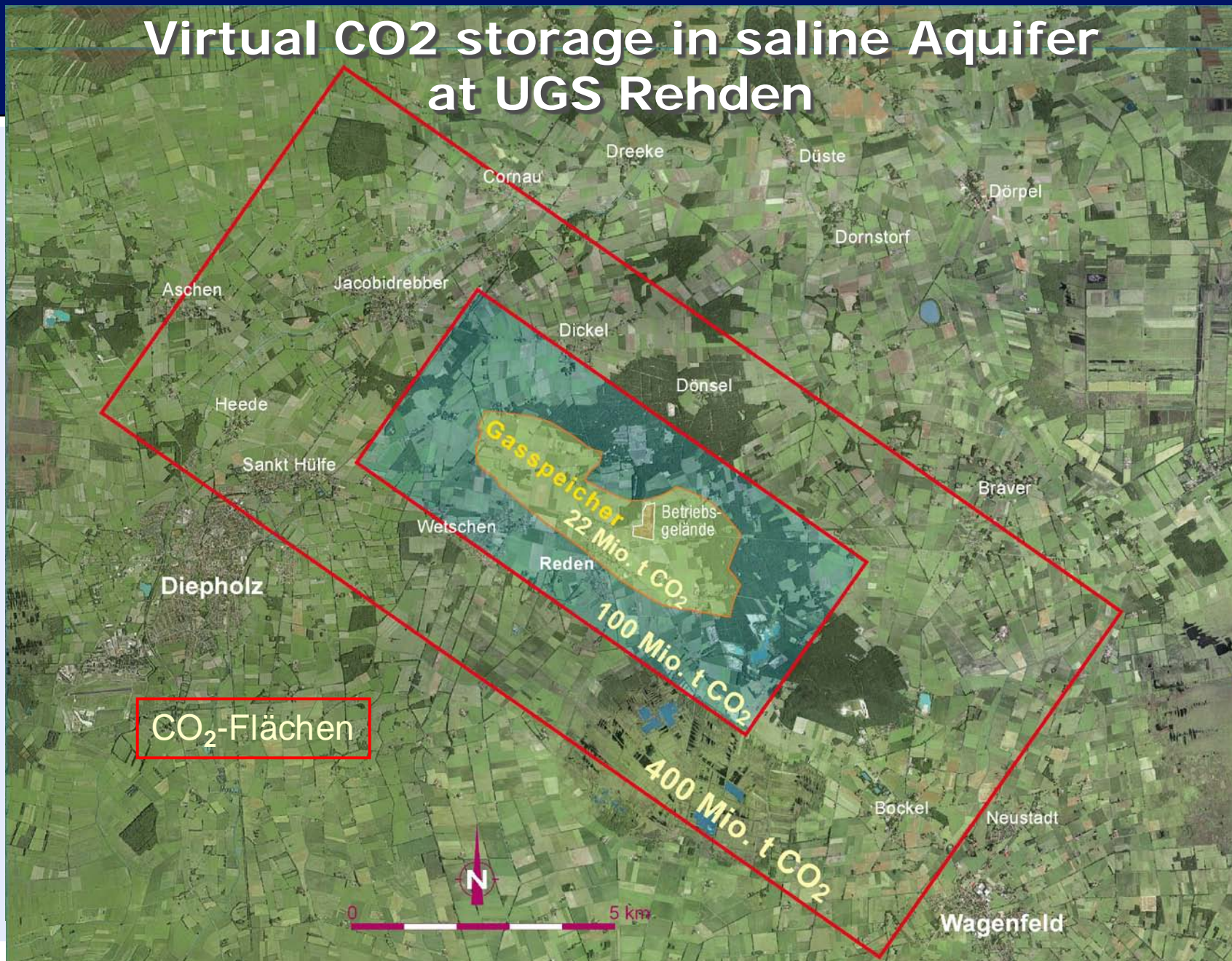
- Federal Mining Act (**BBergGesetz**) only relevant in case of enhanced oil/gas recovery

CCOP workshop on „Geological storage of CO₂“

- ▶ time : June 2009
- ▶ duration : 5 days (Monday til Friday)
- ▶ location : Bangkok
- ▶ sponsor : German government
- ▶ lectures : BGR, CO2GeoNet,
- ▶ input : national perspectives from participants

	Morning	Afternoon	Evening
Monday	Opening/ Intro	WS T1	Icebreaker-Party
Tuesday	WS T2	Input 1	
Wednesday	WS T3	Social Programme	
Thursday	WS T4	Input 2	
Friday	WS "Road Map"		

Virtual CO₂ storage in saline Aquifer at UGS Rehden



Quelle: Sedlacek 2007

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Thank you for your attention !

