

An overview on CCS Activities in Germany

Martin Streibel, Axel Liebscher

Centre for CO₂ Storage

GFZ - German Research Centre for Geosciences, Potsdam, Germany

European energy and climate politics set challenging targets

“We are facing worldwide climate change, a situation which calls for an effective low-carbon policy and efficient energy technologies.”

Targets to be achieved by 2020:

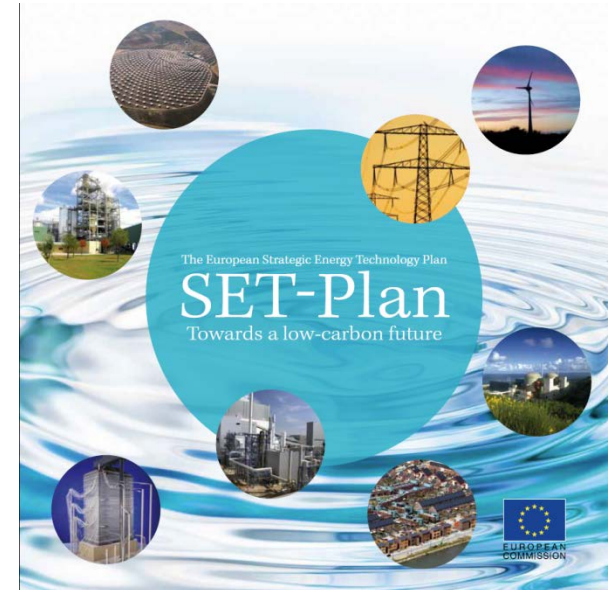
- reducing carbon emissions by 20 % (and by 30 % if conditions permit),
- increasing the share of renewable energies by 20 % and
- increasing energy efficiency by 20 %.



SET-PLAN: The European Strategic Energy Technology Plan

"We must make low-carbon technologies (bioenergy, CCS, fuel cells and hydrogen ...) affordable and competitive."

- CCS can contribute approx. 20 % of the global CO₂ emissions reductions by 2050.
- The ultimate goal is commercial viability of CCS under the EU Emission Trading Scheme by 2020.
- Investment: The cost of CCS initiatives will total approx. € 13 billion over 10 years.

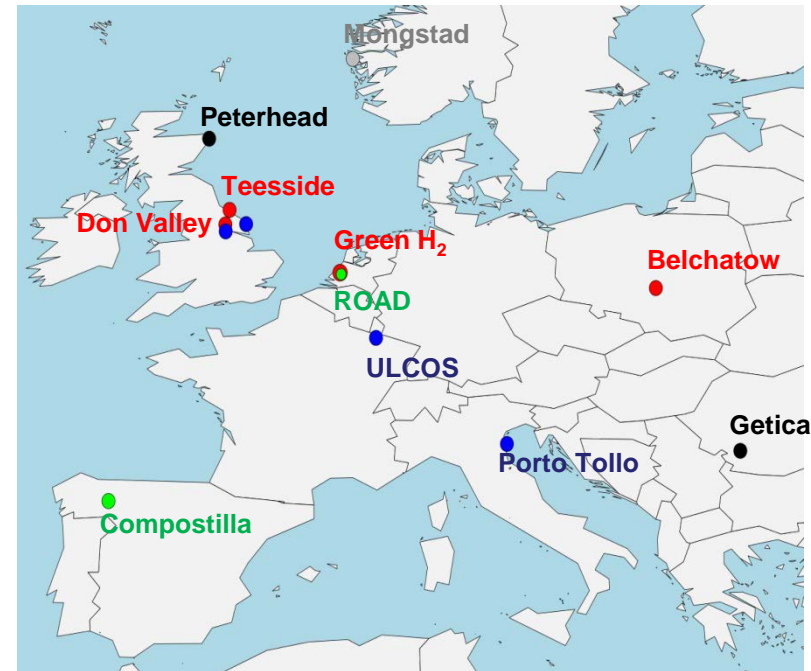


Two main European funding mechanism for demonstration projects in conjunction with national and industrial funding:

- **European Energy Program for Recovery (EEPR),**
- **NER300 - Moving towards a low carbon economy.**

Published Short list of NER-300 projects

- 79 project proposals (13 CCS and 66 RES) submitted by May 2011.
- After technical and due diligence assessment 10 CCS and 55 RES projects were shortlisted.
- Approx. € 1.3 billion available for 2-3 CCS projects.
- Decision for funding expected end of 2012.



Pre-combustion	Post-combustion	Industry	Oxyfuel
1. Don Valley - EEPR	2. Belchatow - EEPR	3. Green Hydrogen	5. UK Oxy CCS
4. Teesside	7. Porto Tollo - EEPR	8. ULCOS	
6. C.Gen	9. Getica		
	10. Peterhead		

Numbering according to ranking in NER-300 short list – projects in black are in the second row, green projects are EEPR Projects, Mongstad is an important project in Norway.

EU regulation and guidance documents define life cycle of CCS projects

- EU Directive 2009/31/EC entered into force June 2009. Guidance documents were published to provide further detail.
- The 27 member states had 2 years to transpose the directive into national law.
- Up to July 2012 not quite half of the EU countries have transposed the directive, amongst others: UK, Spain, Romania, Denmark, the Netherlands, Germany.



Transposition of the directive is much slower than anticipated due to issues with the public acceptance of on-shore CO₂ storage.

The German Energy concept pushes renewable energy sources

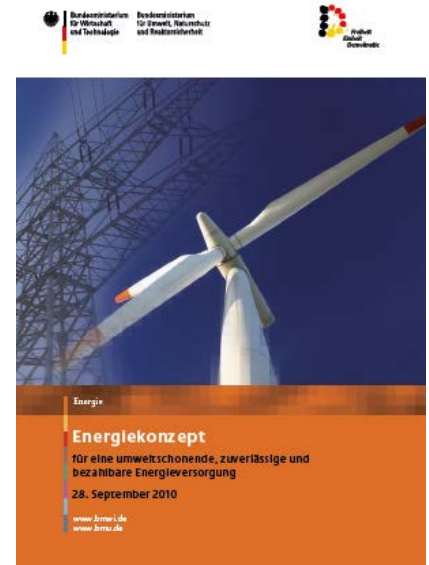
Aims for 2050:

- Reduction of green house gas emissions by 80% compared to 1990.
- Reduction of primary energy consumption by 50% compared to 2008.

Measures:

- 60% of the gross power consumption shall be provided by renewable energy sources.
- 80% of the electricity generation shall be provided by renewable energy sources.
- Increase of the energy productivity to averaged 2.1% per year.
- Shut-down of nuclear power plants up to 2025.

CCS is mentioned as a possible solution for future power plants based on fossil fuels or CO₂ of industrial sources.

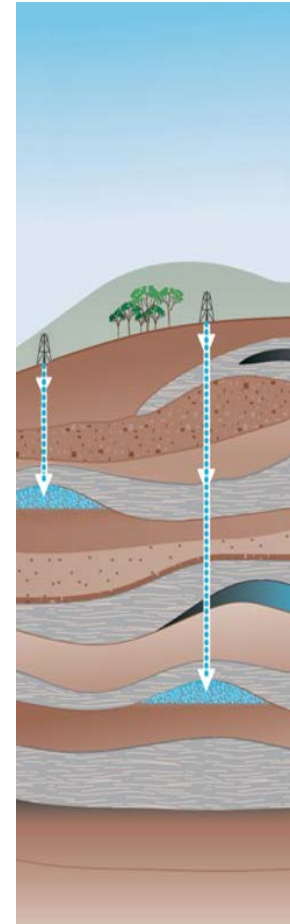


The German Law on the geological storage of CO₂ is for demo projects only

- Implementation of the EU Directive 2009/31/EG.
- The law took effect on 24.08.2012.
- The act provides framework for the transport and the storage of CO₂ (for all steps of the storage life cycle). It needs an ordinance which provides the details.
- Valid on-shore and on the German continental shelf.

Main restriction:

- Permitted 1.3 M tonnes/year up to 4 M tonnes/life time for one storage site.
- The “Länder” clause – Bundesländer have the right to deny/to allow CO₂ storage in certain regions.
- Valid for applications up to 31.12.2016.
- Evaluation of the law from 2018 onwards.



CCS related Research in Germany



CO₂ REduction TEChnologies – initiative of the Federal Ministry of Economics and Technology, funding low-CO₂-Emission power plant technologies.

- Efficient transformation of fossil fuels in power plants and capture and transport of CO₂ as part of CCS.
- From 2004 to 2011 R&D funding of 141 M€ (including 60 M€ of industrial contribution).



GEOTECHNOLOGIEN

program of the Federal Ministry of Education and Research, funding sub-surface research, 3 Phases of 3 years each from 2005 up to 2014.

- Research for Technologies for a sustainable storage of CO₂ in Geological formations.
- Approx. 30 projects in addition to the Pilot site in Ketzin with a funding of approx. 50 M€ (including funding of Ketzin and industrial contribution of more than 7 M€).

Germany's former Demonstration project

First pilot of an Oxy fuel combustion power plant at Jänschwalde, Brandenburg, Vattenfall Europe

- 30 MW_{th}, capturing more than 90% of CO₂.
- Plant to be upgraded to demonstration size of 300 MW_{th}.

Two possible CO₂ storage sites were anticipated to be

- at the Altmark in conjunction with EGR,
- in a saline aquifer at Beeskow.

Project received EEPR funds and was ranked first in first NER-300 ranking.



Demonstration sized project was cancelled by the operator in November 2011 due to missing public acceptance and lacking legal support, the pilot goes on.

Public Perception/Acceptance

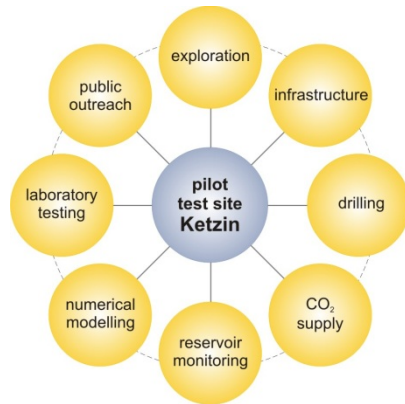
- There is a loud minority – well organised which is “fighting” the energy system/industry
- Most people do not understand the change of energy system – too complex - and are confused
- Not in my backyard part of the public
- Some are afraid...
- Some do not care
- Some accept the necessity and hence our work
- The discussion in Germany has become emotional!

Some factors of success at Ketzin:

- At Ketzin the implementation of the project is made transparent by a well organised communication.
- GFZ – the operator - is a research institute
- A research-size project, below 100.000 t CO₂, seems to be a moderate risk



Block the CO₂ repository



CO₂ Storage at the Pilot Site Ketzin

The Ketzin Team



Many project partners support the R&D activities at Ketzin since 2004



Friedrich-Schiller-Universität Jena



Universität Stuttgart

UNIVERSITÄT LEIPZIG



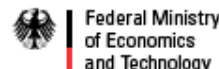
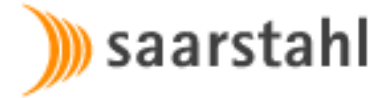
Uppsala Geophysics



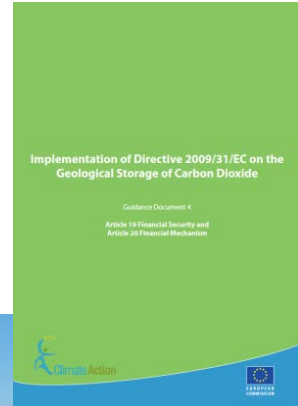
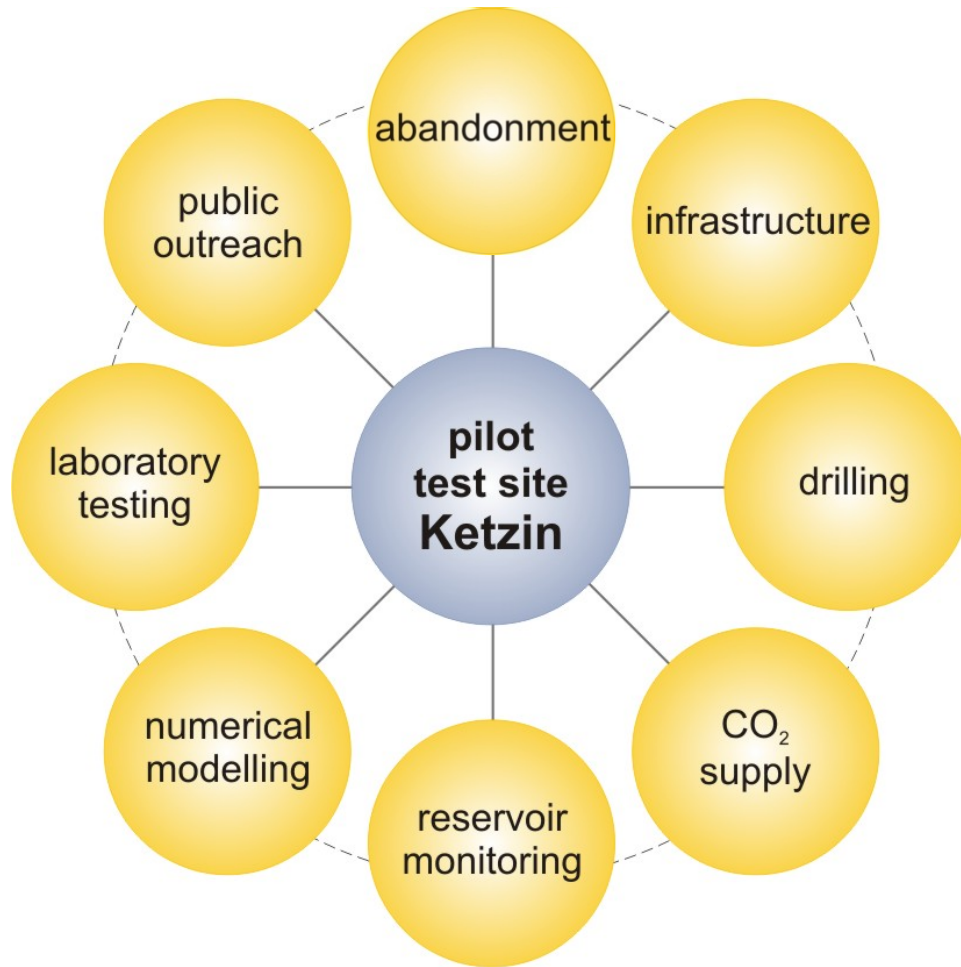
VATTENFALL



DILLINGER HÜTTE



Ketzin covers entire lifecycle of a CO₂ storage project and focuses on monitoring

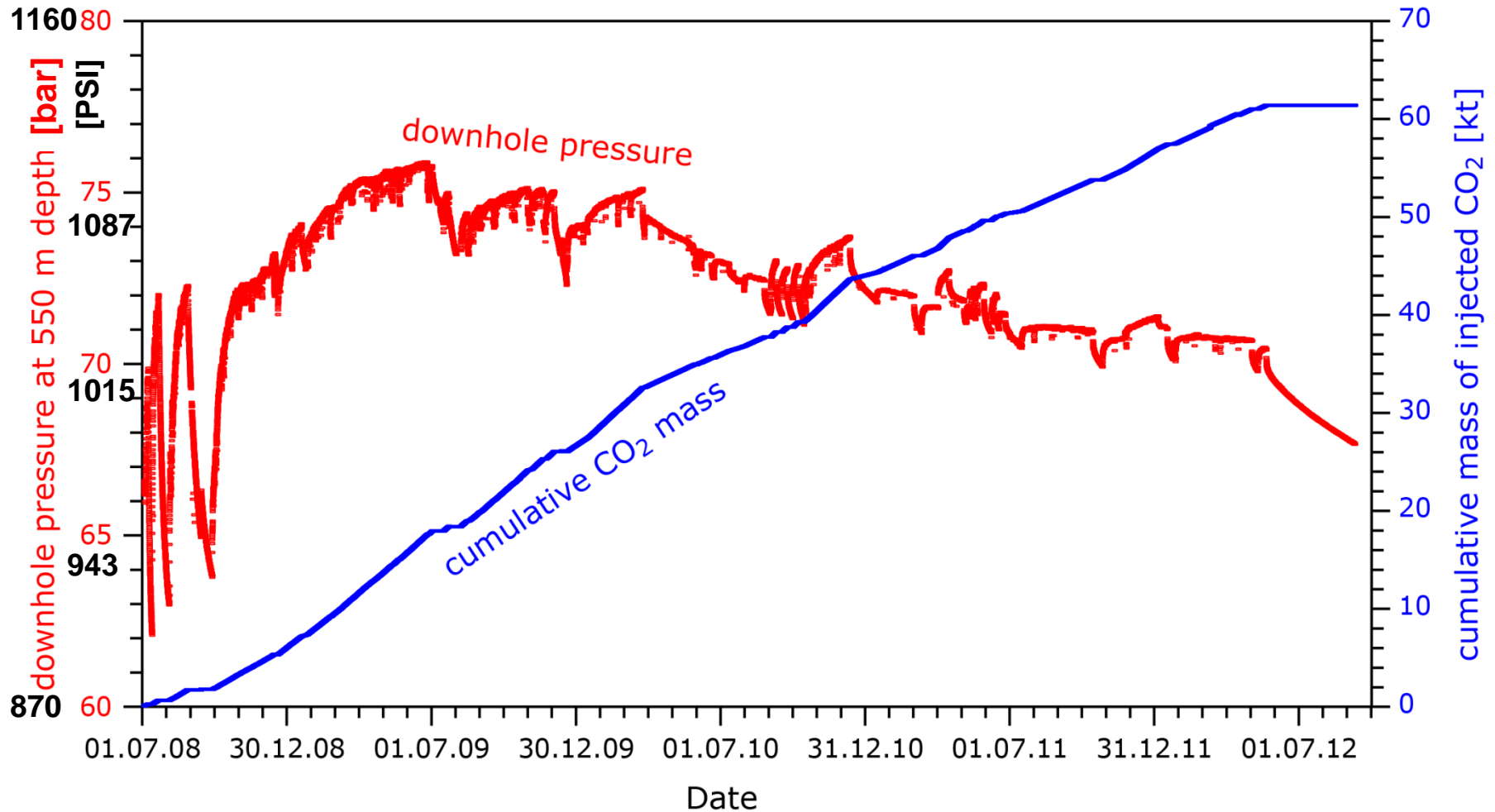


CO₂ injection runs safely and reliably

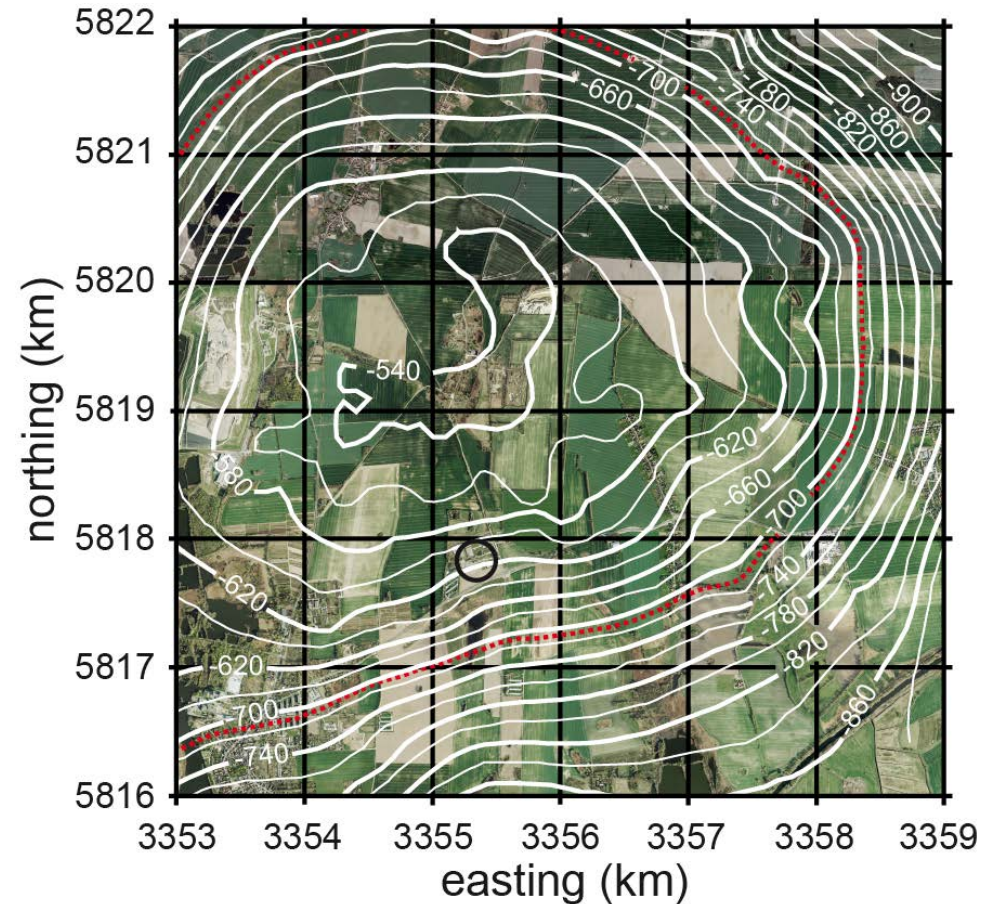
- Start of CO₂ injection: 30.06.2008
- CO₂ sources and qualities
 - Primary source: food-grade CO₂ (Linde), > 99.9%
 - Secondary source (1,515 t from May 05 to June 12, 2011): Schwarze Pumpe pilot plant (Vattenfall), > 99.7%
- Injection rates: 24 to 77 t/day (currently ~ 1 kt CO₂ /month)



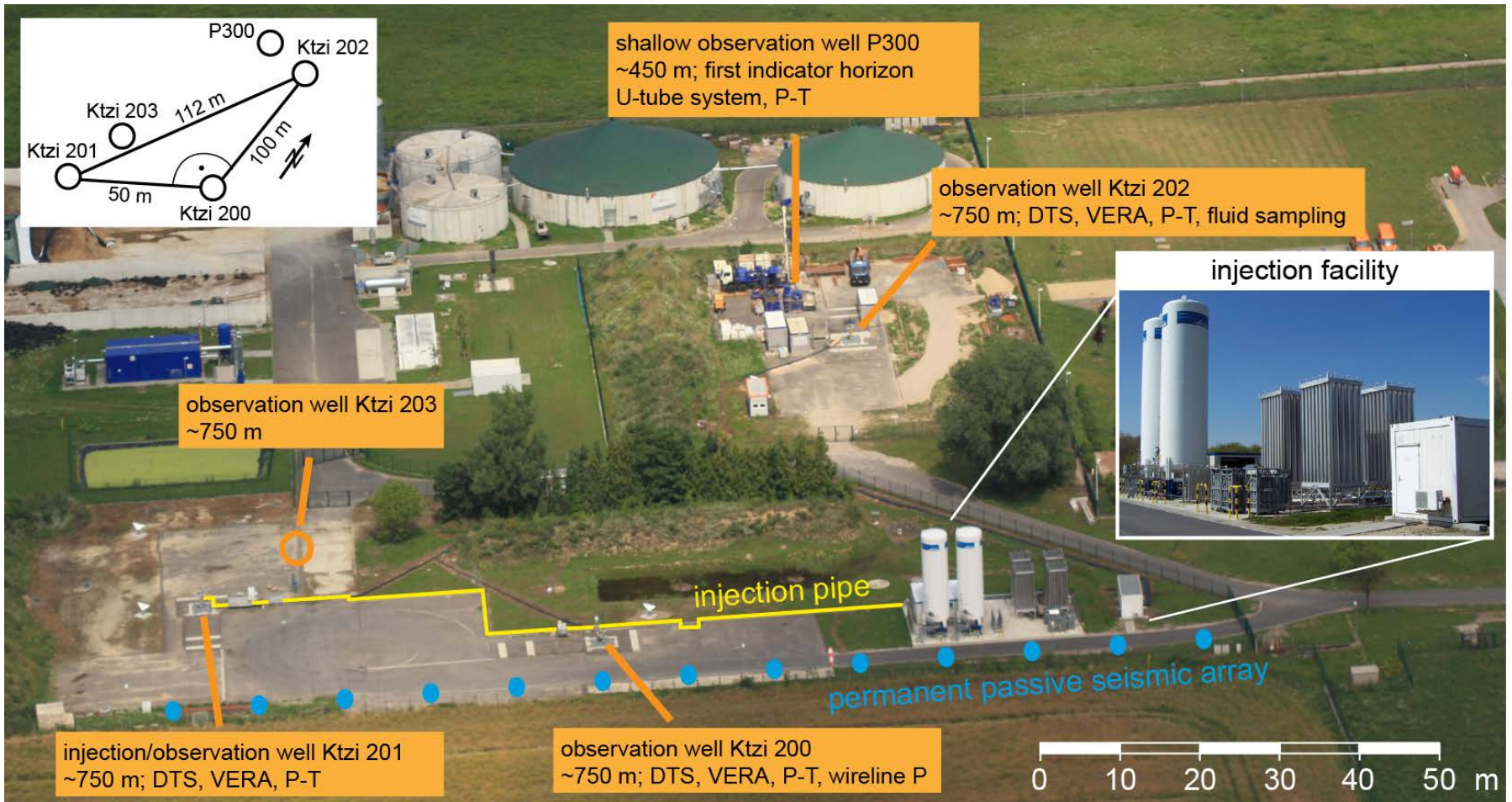
Injected CO₂ and downhole pressure



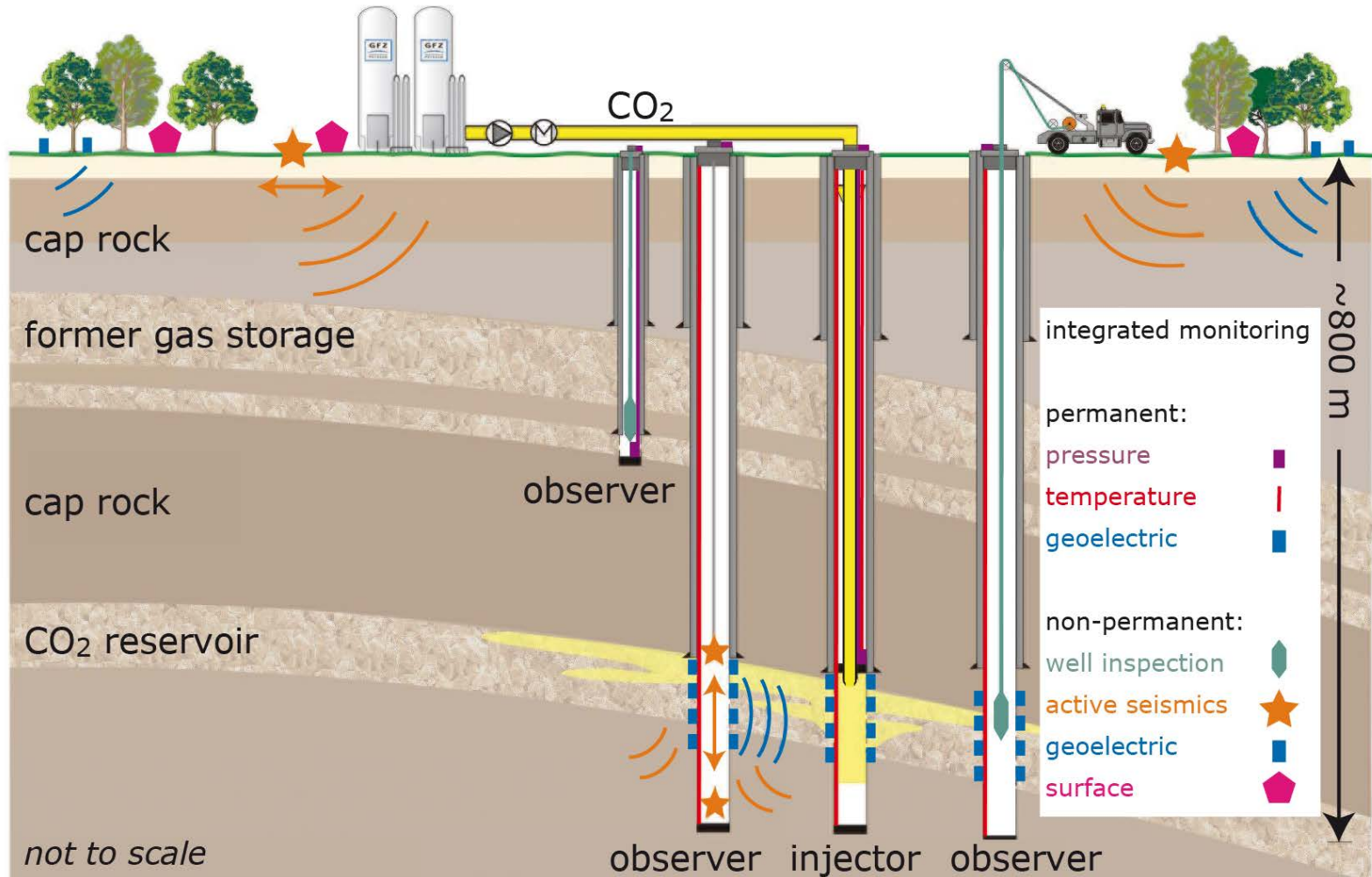
Ketzin at the SE flank of an anticline



Aerial view of installation at Ketzin site



A unique and interdisciplinary monitoring concept is applied and operated at Ketzin



Geophysical methods with different spatial resolution are applied

active seismic methods

surface-surface:
3-D (grid), 2-D star (red lines)

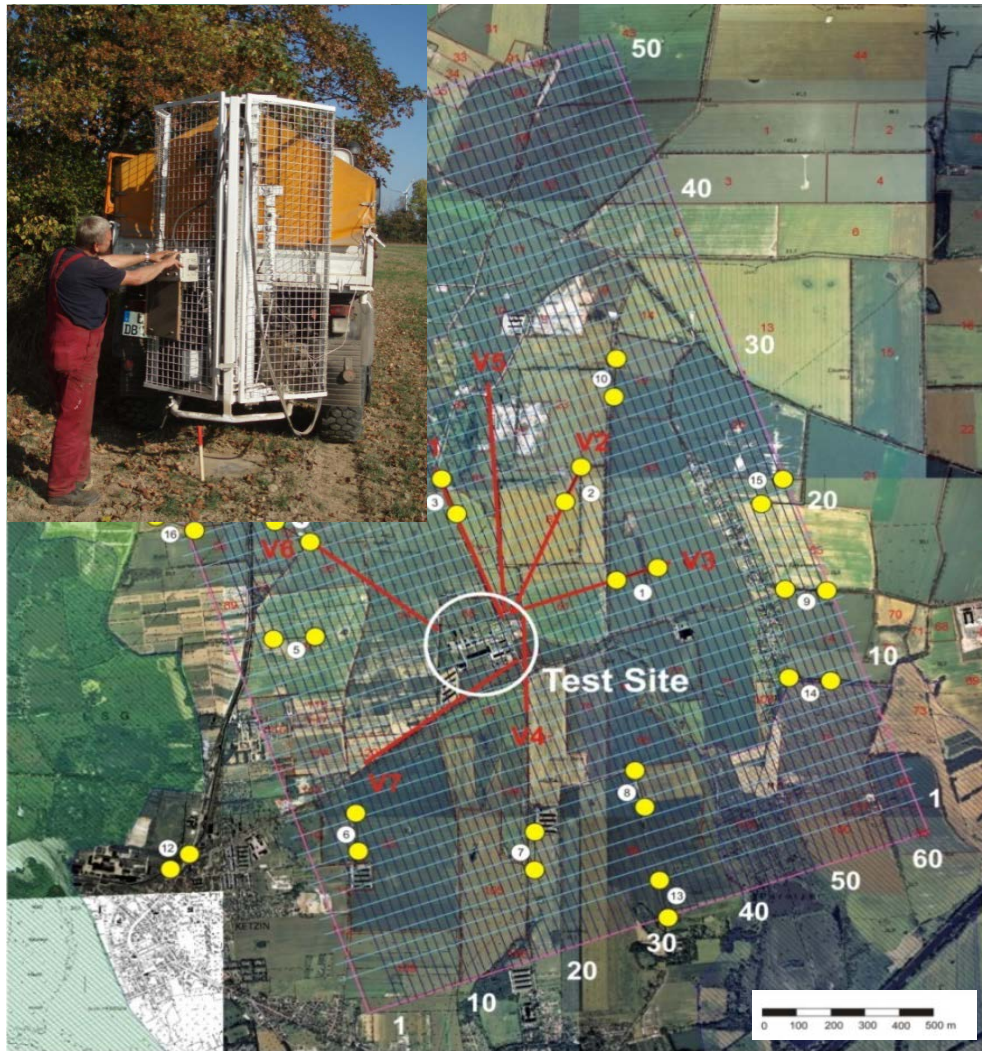
surface-downhole:
vertical seismic profiling VSP
moving source profiling MSP

cross-hole (white circle)

passive seismic methods

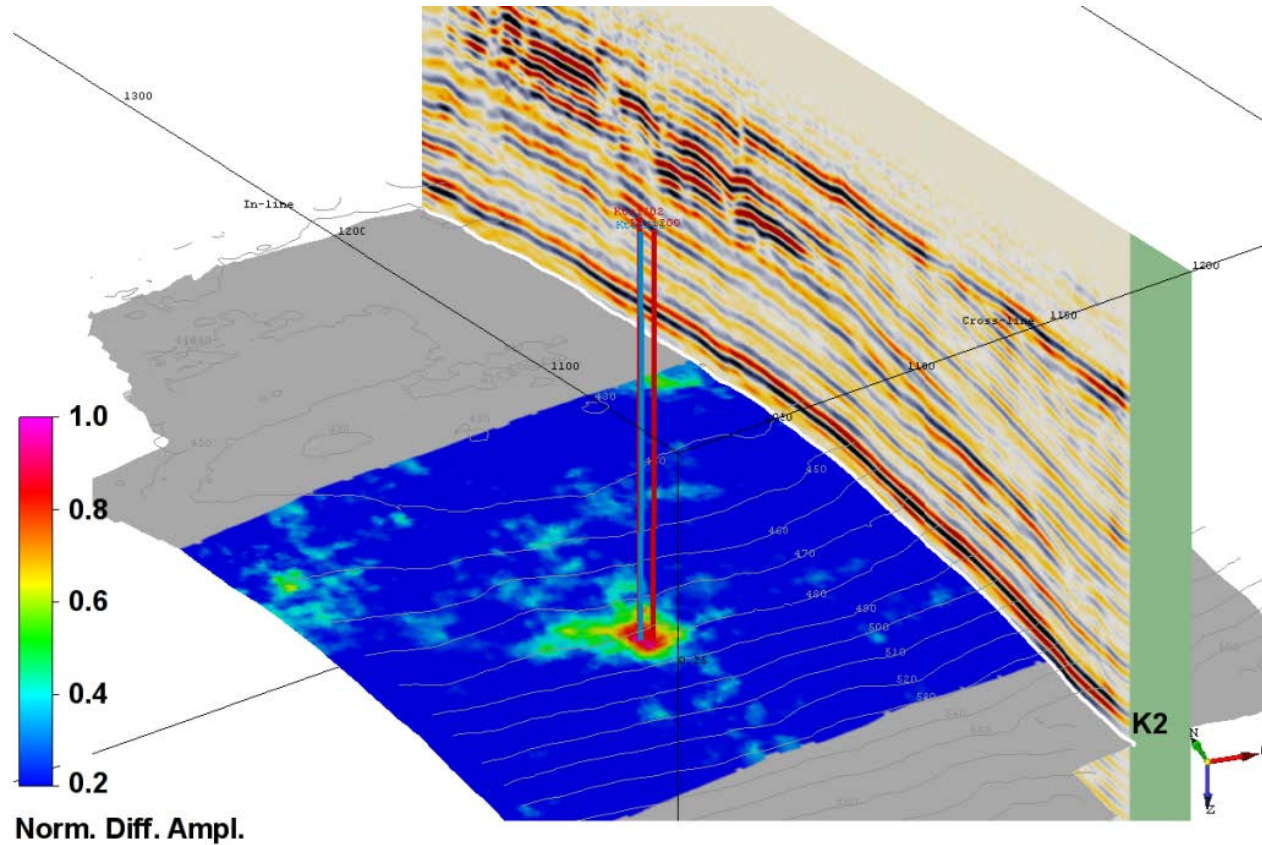
geoelectric methods

surface-downhole (yellow dots)
cross-hole (white circle)



3D seismic provides CO₂ signature in subsurface

Changes in reflection amplitude between 3-D baseline (2005) & repeat (2009)

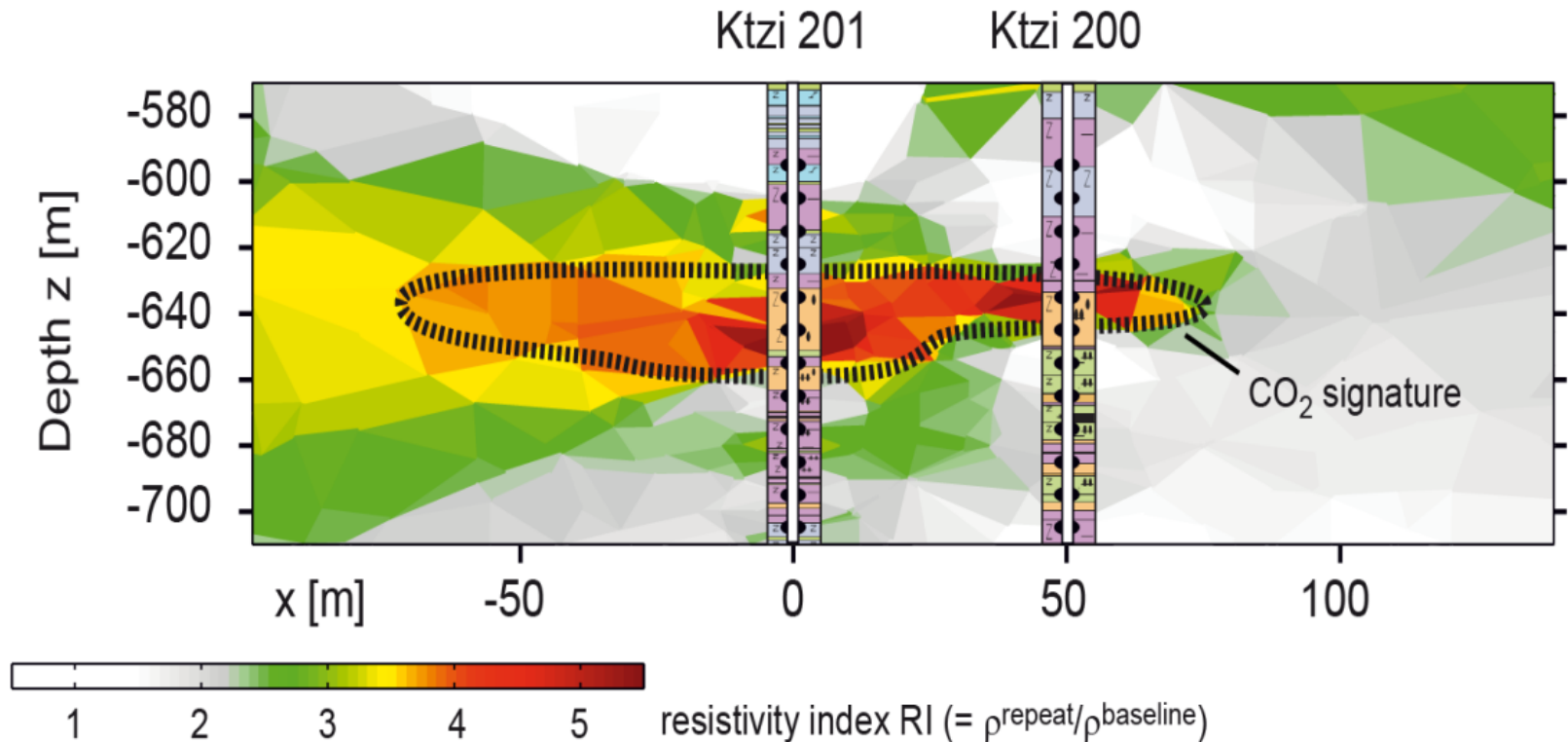


3D-Repeat 10/2009 ~22 kt CO₂ injected

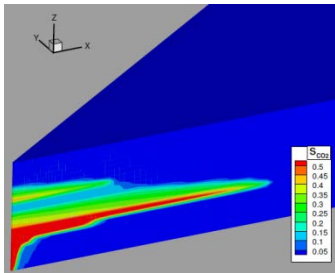
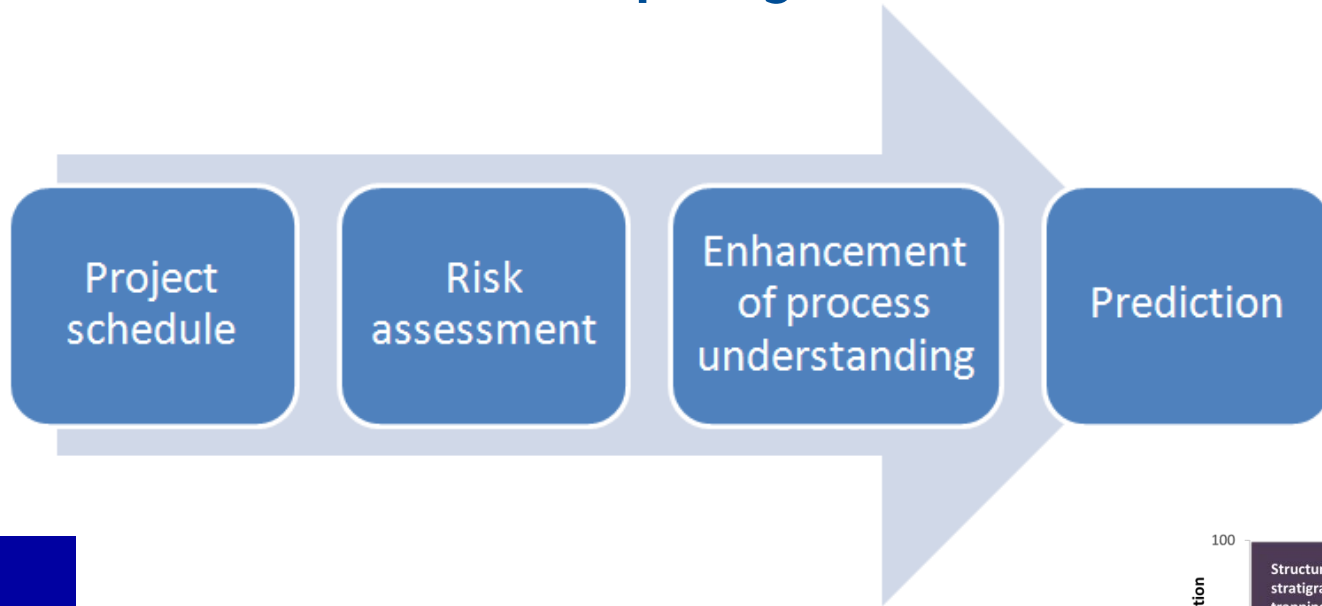
Geoelectric measurements show resistivity increase and give tomographic information

Vertical profile Ktzi 201-Ktzi 200

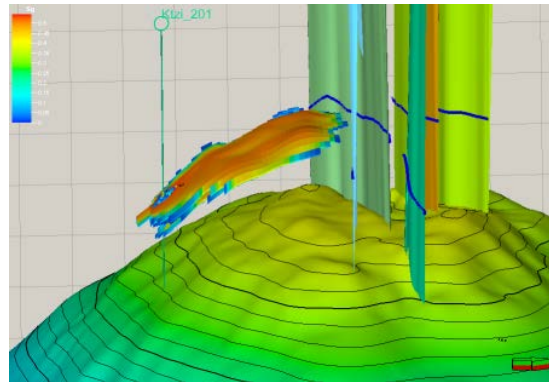
Relative resistivity change after 13,5 kt CO₂



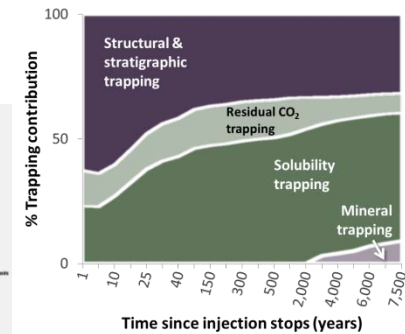
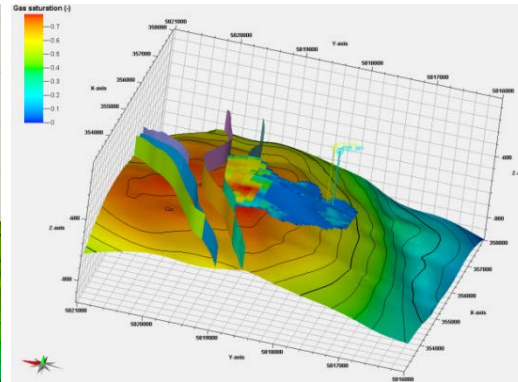
Modelling and simulation accompany the overall Ketzin project lifetime



Bielinski (2007)
Kopp et al. (2008)

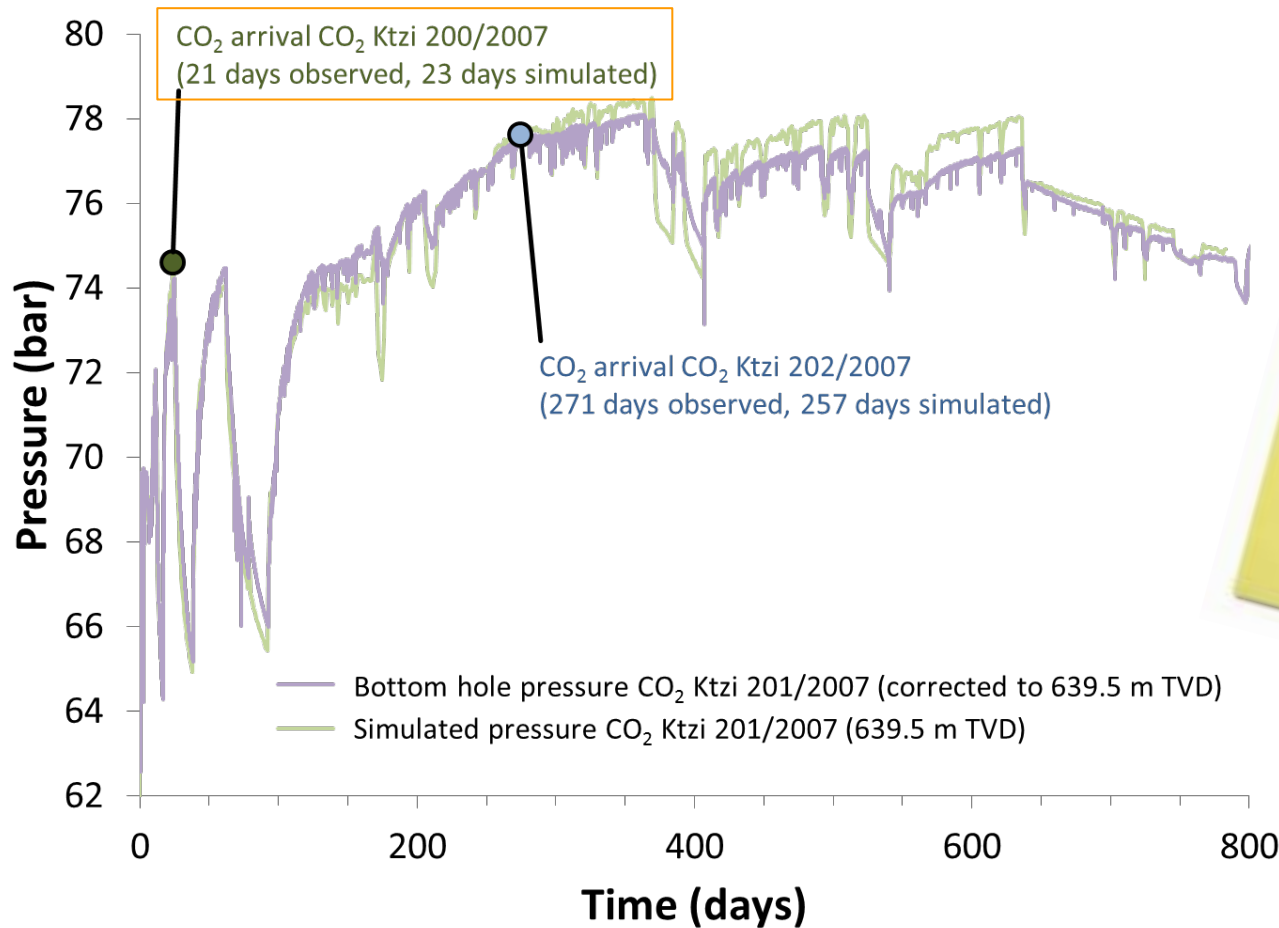


Frykman (2008)



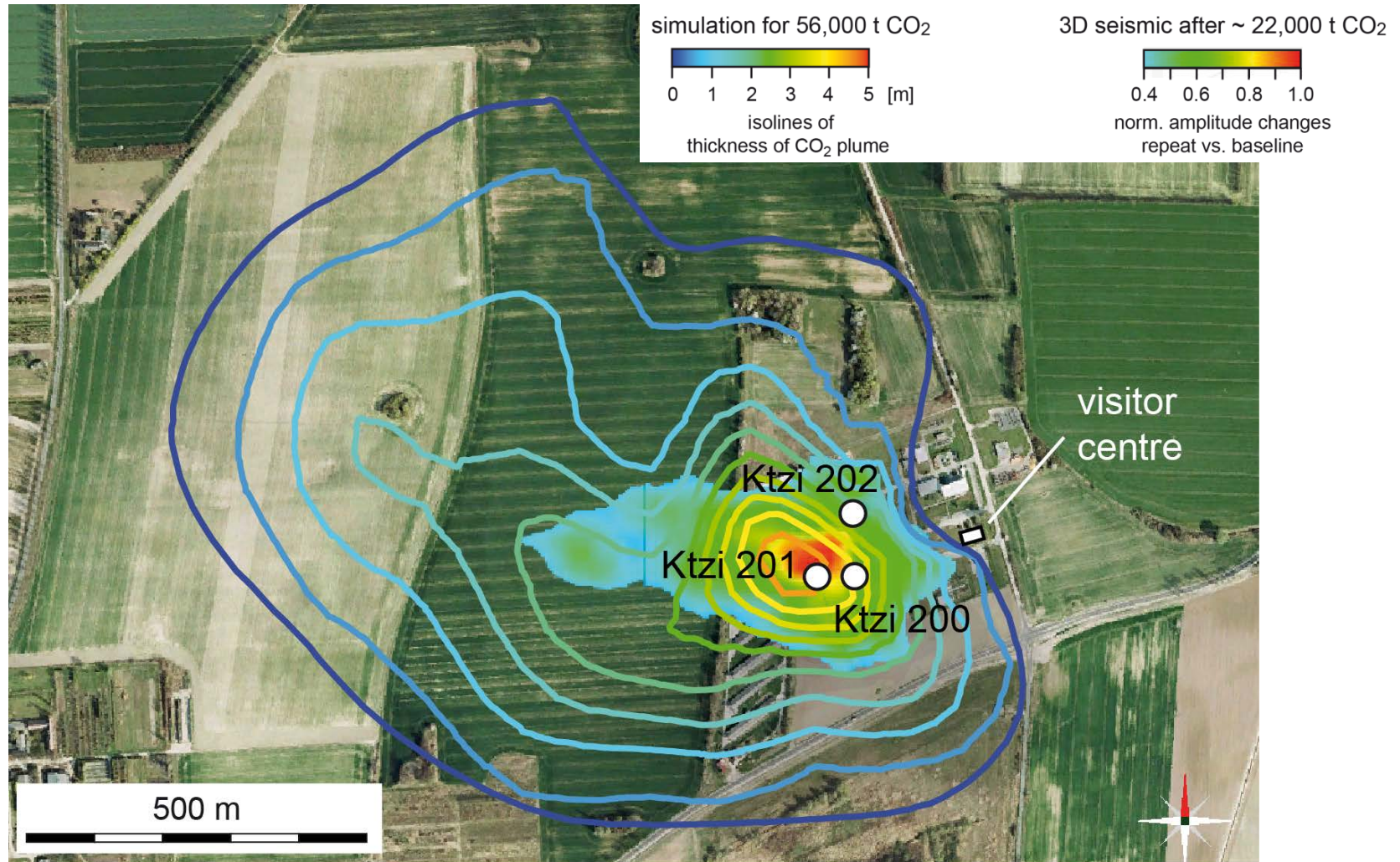
CO₂MAN &
CO₂CARE (2009-12)

Static geological Ketzin model validated by dynamic simulations



"Match the history of observations to be able to trust your predictions."

Simulated CO₂ distribution supports operational schedule and monitoring



Results from Ketzin emphasize deployment of demonstration sites in Europe

- The **Ketzin** project demonstrates successful CO₂ storage in a saline aquifer on a **research scale**.
- **Injection** operation since June 2008 is **safe and reliable** (> 61,000 t).
- **Geophysical monitoring** detects the CO₂ signature on **various - even very small - scales**.
- Dynamic **model matches** arrival / travel times and observed reservoir pressure.
- **Next** step will be the **abandonment phase**.



www.co2ketzin.de

