

The Altmark Gas Field

Investigating CCS Potential under an EGR Project

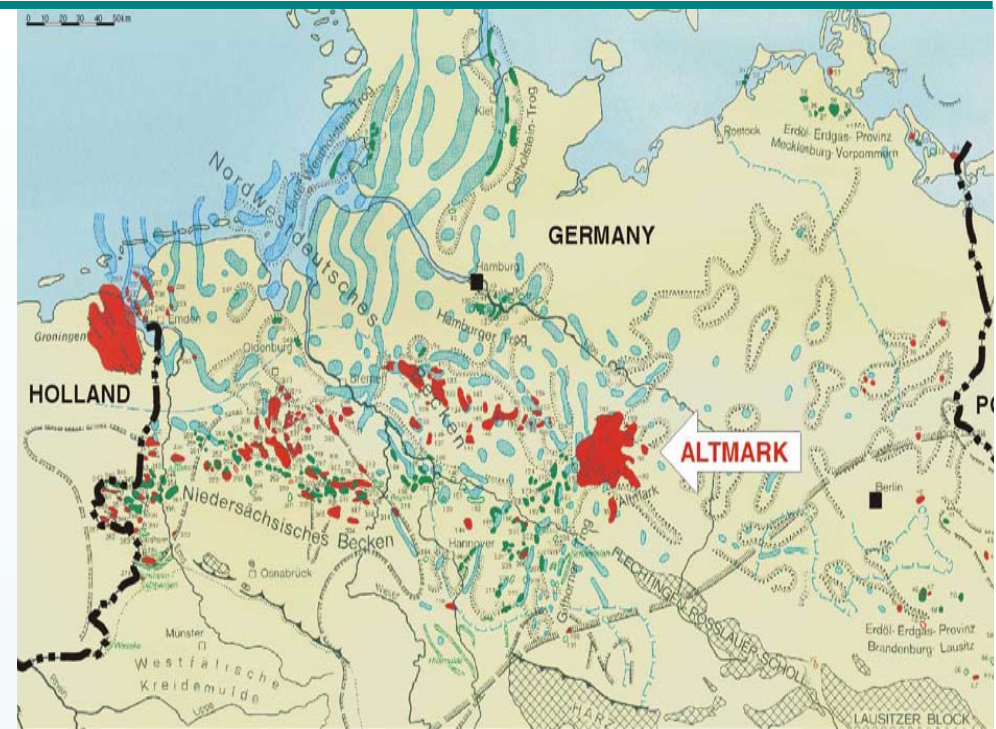
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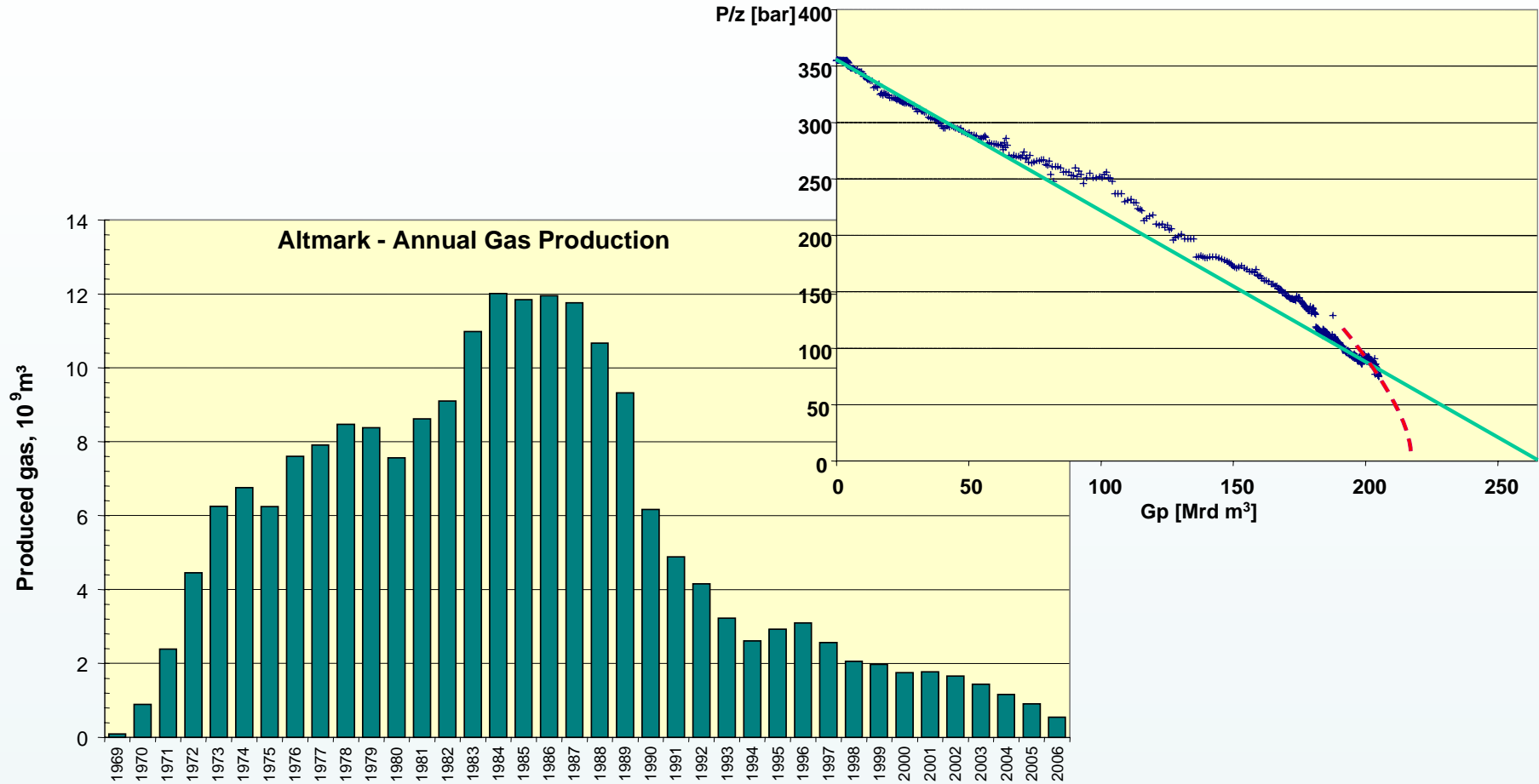
The Altmark Field

Second largest onshore gas field in Europe

- Southern edge of Northeast German Basin
- Gas bearing horizons in the Rotliegend
- Gas production since 1969
- 420 wells drilled (250 producers)
- Cumulative production: 206 billion m³ of gas
- Recovery factor: 78 %
- Economic gas production is nearing its end
- Possibilities for field life extension are investigated (enhanced gas recovery)



Altmark Field Production History



The EGR Project

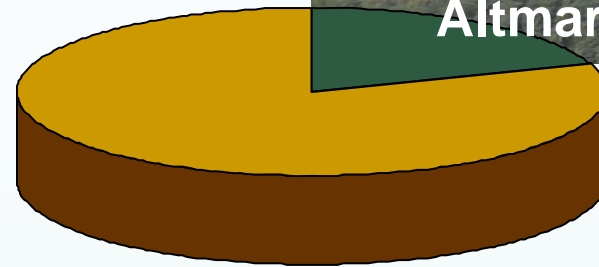
- EEG participation in CSEGR* Research Project (2005 – 2008)
 - *Carbon Sequestration with Enhanced Gas Recovery
 - joint research under the German “Geotechnologies” research program
 - partners: TU-Clausthal, Vattenfall, EEG, Wintershall, E.ON-Ruhrgas
 - fields under investigation: Altmark and Barrien (lower Saxony)
 - study of EGR potential by CO₂ injection in theory
- Test of practical feasibility of EGR by CO₂ injection within a pilot field project
- Cooperation agreement signed with industrial partner which will deliver CO₂
- The target of the pilot project is test whether gas production from the Altmark can be enhanced in a sustainable manner by CO₂ injection, and at the same time
- to clarify general questions regarding CO₂ sequestration potential.

A Significant Sequestration Potential

Total potential
in depleted gas fields in Germany:

2563 Mt

Altmark: 508 Mt

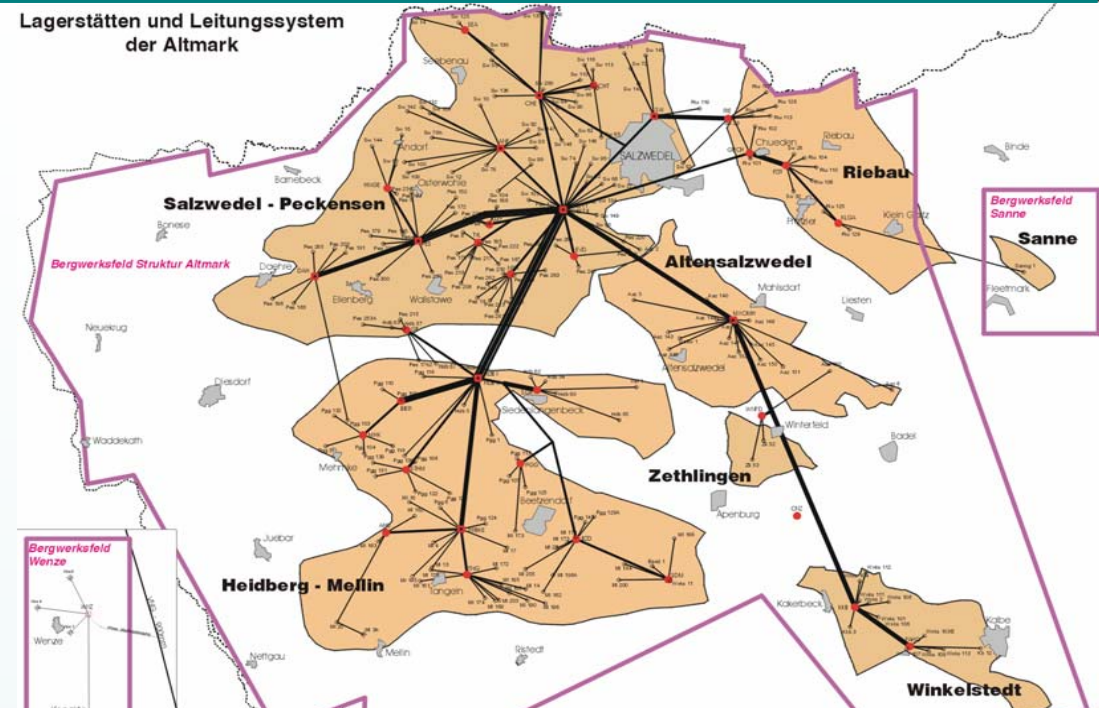


the only depleted gas field which can store the entire CO₂ emitted from a large-scale power plant throughout its entire life cycle




World wide CO₂ sequestration potential in depleted gas fields: ca. 600-700 Gt


Favorable Conditions for CO₂ Sequestration

- Very large sequestration volume
- Well explored reservoir
- Proven seal integrity (Zechstein salt)
- Low reservoir pressure
- > 200 wells available
- Existing infrastructure (>1000 km flowline)
- Tailend phase of production
- Possible combination with EGR



Basic Data of the Pilot Phase

-  3 year period: (2008-2011)
-  Total injection volume: ca. 100,000 tons of CO₂.
-  Process:
 - capture of CO₂ from a pilot power plant
 - transport of the liquefied CO₂ by trucks to the Altmark
 - injection into one compartment of the Altmark field

-  The pilot injection project shall include:
 - the completion of 2 existing wells for injection,
 - the design and construction of a pilot injection facility,
 - the implementation of a comprehensive monitoring program, and
 - the implementation of a joint R&D program with partners & research facilities.

Targets of the Pilot Phase

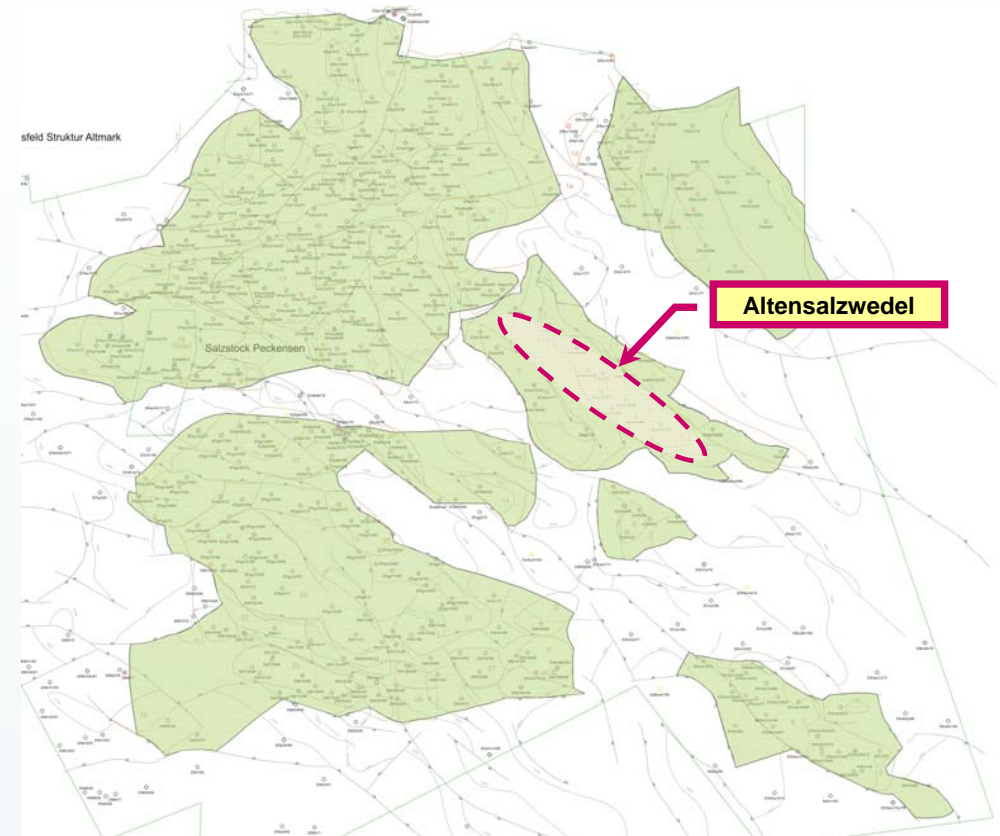
- gain knowledge on enhanced gas recovery
- better understand the reservoir behavior in case of CO₂ injection
- better define the seal integrity of the cap rock to CO₂
- provide criteria for future site selections
- help to generate specific HSE procedures
- develop and optimize the most suitable technologies and injection regimes
- test and refine the monitoring program



Demonstrate the technical and economic feasibility of Enhanced Gas Recovery and CO₂ injection into the Altmark

Site Selection for Pilot Phase

- Small area, isolated from other compartments
- Depleted natural gas reservoir
- Weak to no water drive
- Good reservoir quality
- Wells for injection, observation & production
- Infrastructure in place
- Representative Altmark conditions

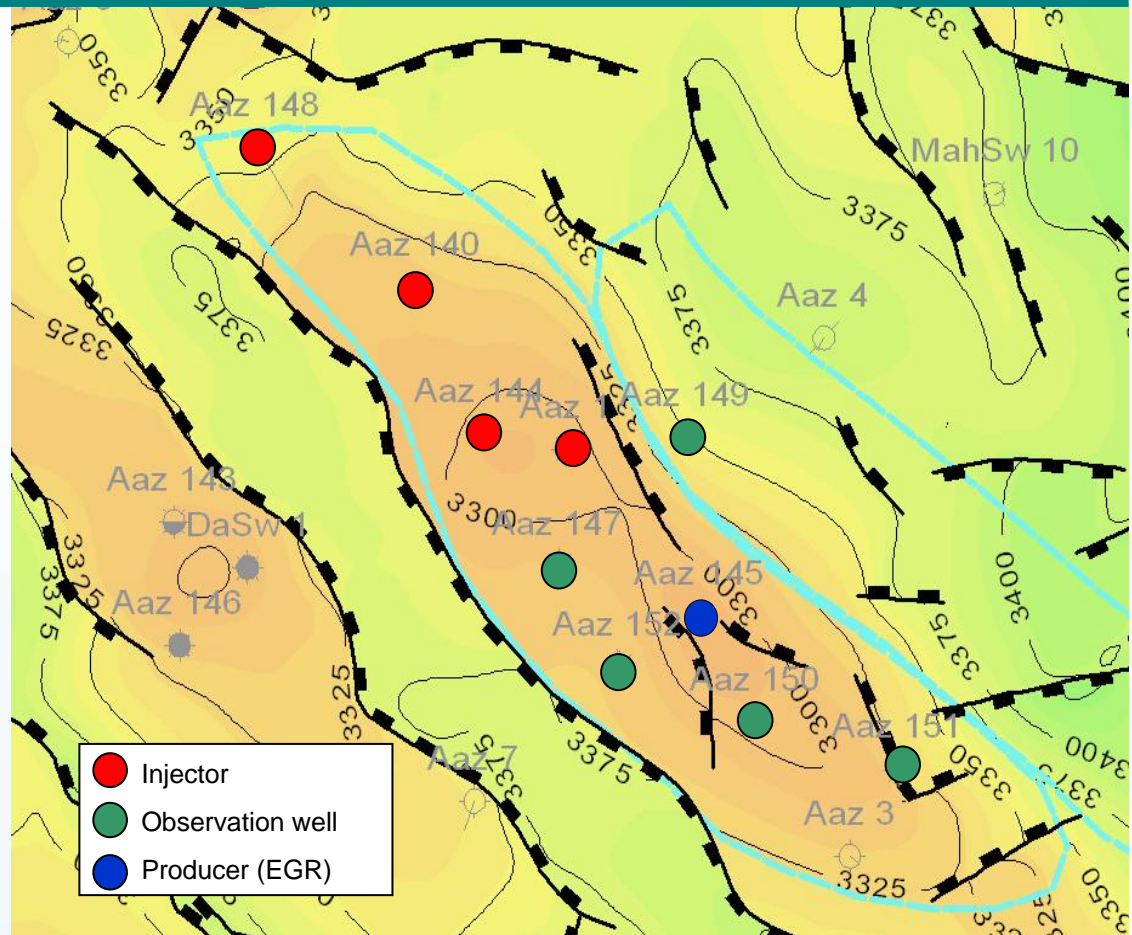


Site Selection for Pilot Phase

Available Well Portfolio:

- 10 open wells: 8 producers
2 suspended

- Well scenario for injection:
 - 4 injectors (2 firm, 2 optional)
 - 5 observation wells (reservoir)
 - 1 producer (EGR)



Research/Technology/Monitoring Program

MONITORING

Surface

- Monitoring of well parameters and environmental impact (e.g., soil air)
- Remote sensing (stress and deformation monitoring – radar interferometry, GPS)

Subsurface

- Monitoring of shallow aquifers (geochemistry, hydraulics)
- Monitoring of overburden with focus on caprock/overburden interface (geochemistry of formation water, pressure monitoring)
- Monitoring within the reservoir
 - Seismic (microseismicity, time lapse VSP)
 - Tracer to track CO₂ migration
 - WL-logging (p & T-profiles, saturations, flow allocation)
- Run different injection regimes: injection of gaseous, supercritical and liquid CO₂ at different wellhead pressures and rates
- Well integrity surveys (corrosion, cement)
- Sampling of reservoir fluids

Research/Technology/Monitoring Program

APPLIED RESEARCH

Well Integrity

- Investigate technical status of wellbores
- Develop well abandonment strategies with regard to CO₂ injection
- Calculate CO₂ influenced lifecycle for existing wells
- Estimate near-wellbore stress field (rock-cement-casing)

Reservoir

- Identify reservoir rock parameters
- Study rock mechanics (reservoir, caprock, overburden)
- Assess CO₂ induced rock alteration and its influence on rock parameters
- Perform 3D-geomedelling & hydraulic numerical simulation
- Optimize process parameters for enhanced natural gas recovery
- Describe coupled THMC processes

Surface injection facility

- Test injection technologies (e.g. HP pumps vs. compressors) and material
- Optimize CO₂ injection regimes



Outlook

Next steps:

- Coordination of research program
- Coordination with authorities, clarification of legal questions
- Development of PR concept (gain public acceptance for the project)
- Preparation for implementation of pilot phase (ca. 15 months)

Target for the year 2012:

- Reliable statement on the suitability of Altmark for large-scale CO₂ sequestration

