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Enhanced Coal Bed Methane Recovery with CCS: Limitations and Possibilities

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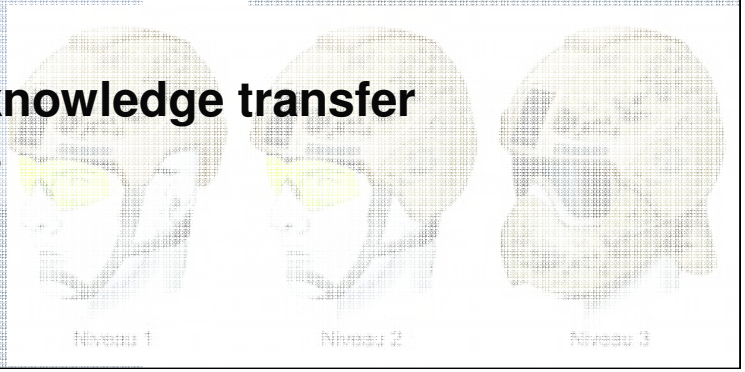
TNO: Netherlands Organization for Applied Scientific Research

- Founded in 1932 by act of parliament (*TNO law*)
- US$ 800 M (m€ 600) turn-over; 4.600 staff

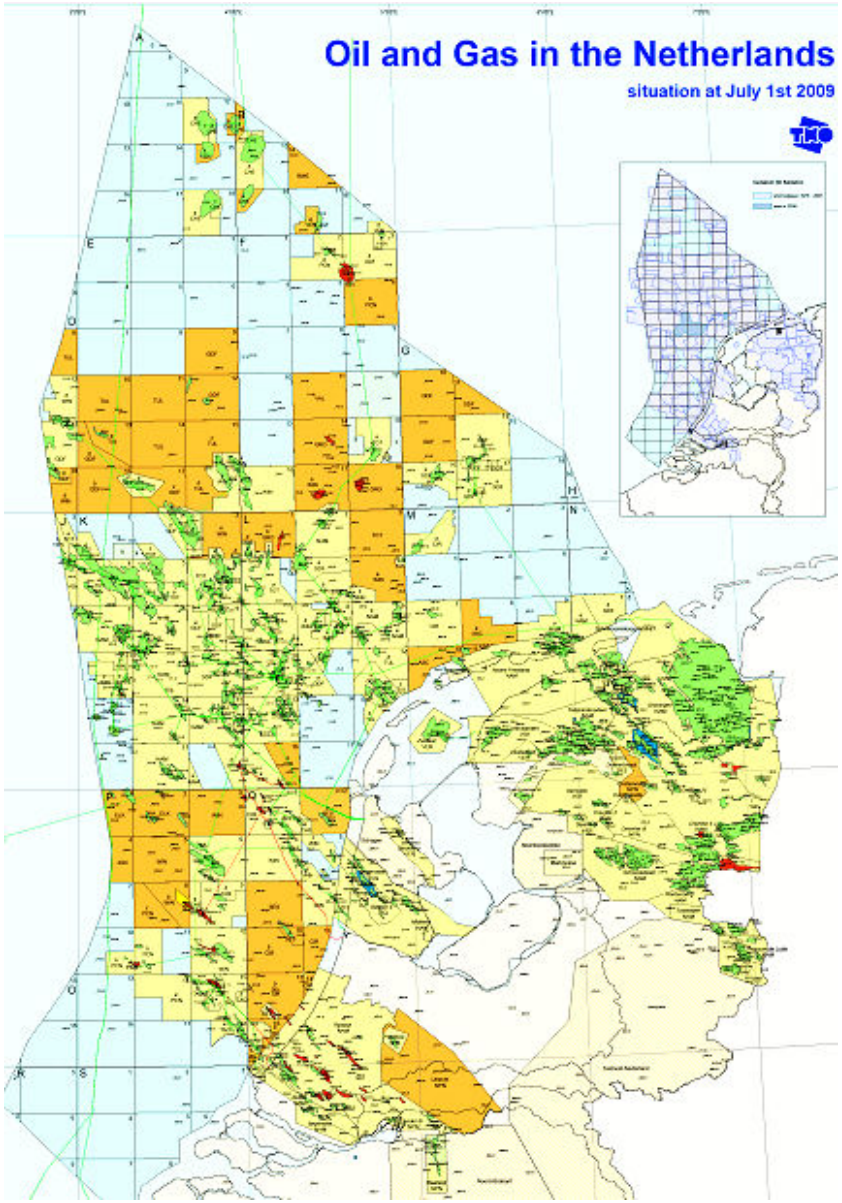
- *Applied* R&D organization
  - technology development
  - contract R&D
  - non-routine consulting
  - special tasks (*Geological Survey of The Netherlands*)

- Independent, transparent, not-for-profit
- Focus on fundamental understanding & knowledge transfer
- *Comparable to IFP, SINTEF, CSIRO, KISR*



CCS and the Netherlands

- Availability of (clustered) large CO_2 point sources
- Large storage capacity (1500 Mt in gas fields, excl. Slochteren and aquifers)
- Relatively short transport distances
- Extensive knowledge of gas and CCS (technology, infrastructure etc.)
- Long production history of gas (1959 -)
- Long academic history on CCS (1990 -)
- Serious business interests and commitment of relevant parties



CATO-2 in a glance

- Applied and scientific research
- Complete CCS Chain
- Demand driven & flexible program
- 60 M€ (50% government)
- Coordination: TNO
- 2009-2014
- Partners from industry, SME, university, NGO

CO_2 capture: from lab to pilot

Lab testing: Solvent screening

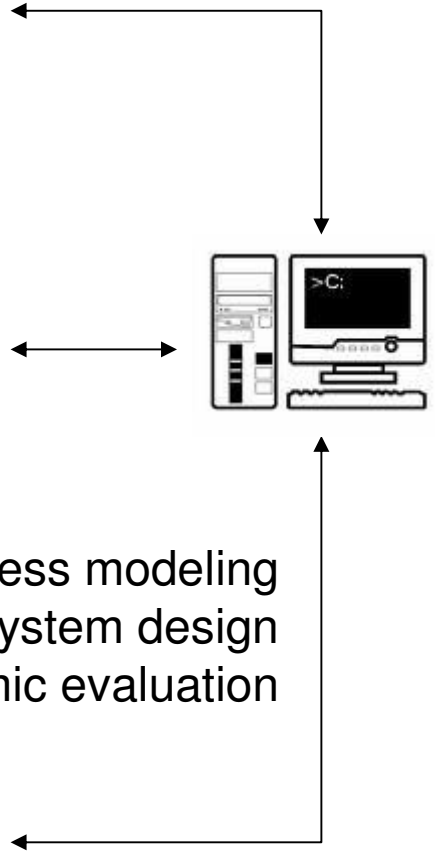
- Thermodynamics
- Kinetics
- Stability

Cont. process micro-plant

- Process development
- Model validation
- Scaling-up

Pilot-scale

- Industrial conditions
- Model validation
- Long term effects



CO_2 transport: CO_2Europipe

- Aim
  - Define requirements for development of future, large-scale CCS transport network in Europe
    - EU, national initiatives / regulations
    - Timeline for policies / regulatory frameworks to be put in place
- Method
  - Define future large-scale CCS transport requirements
    - CO_2 volumes: what, where, when?
    - Network lay-out ((inter)national, simple or complex)
    - CO_2 management (cross-border issues)
    - Regulations (CO_2 as waste?)
- Timeline
  - April 2009 through October 2011

CO_2 storage: involvement in first storage fields

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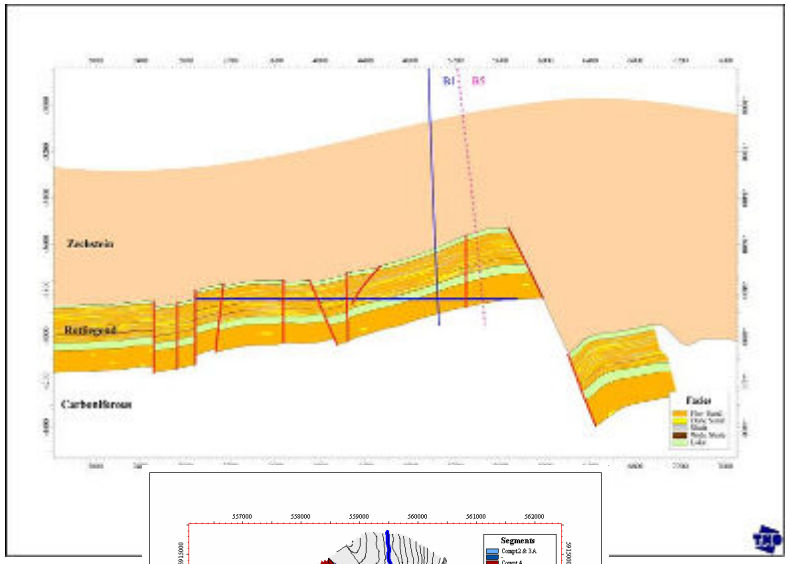

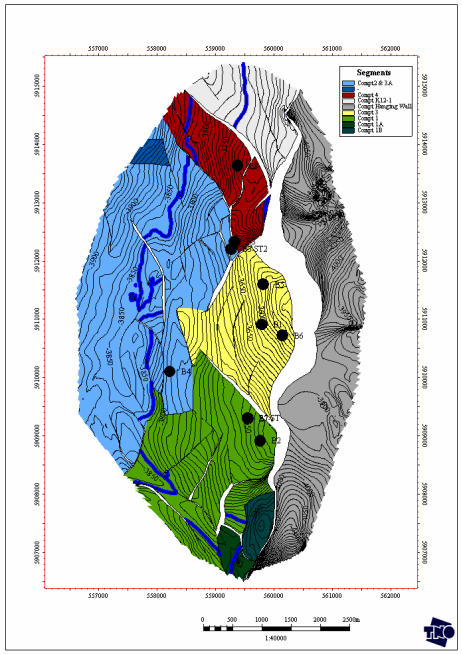

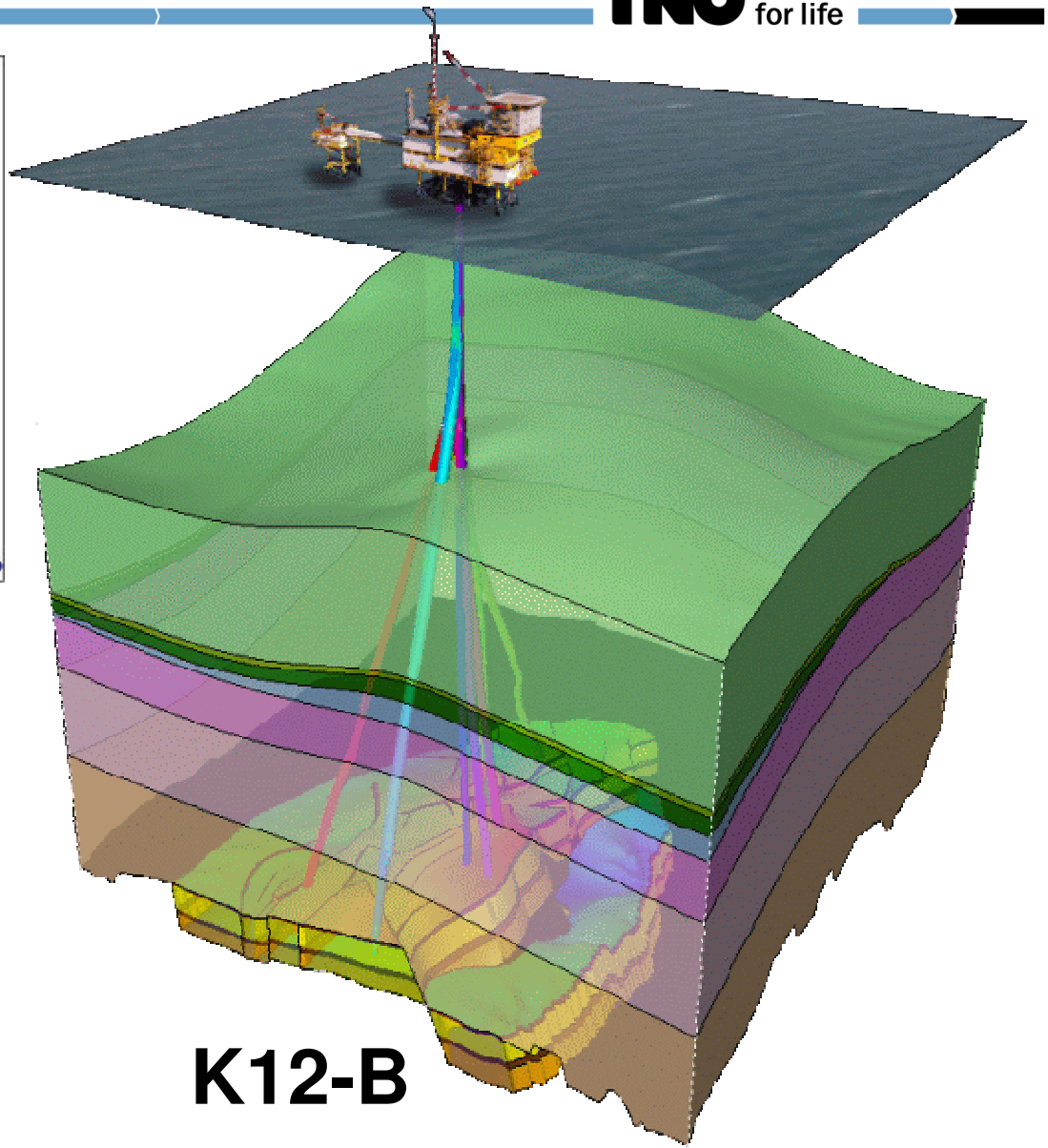

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Research and involvement in all CO_2 storage options

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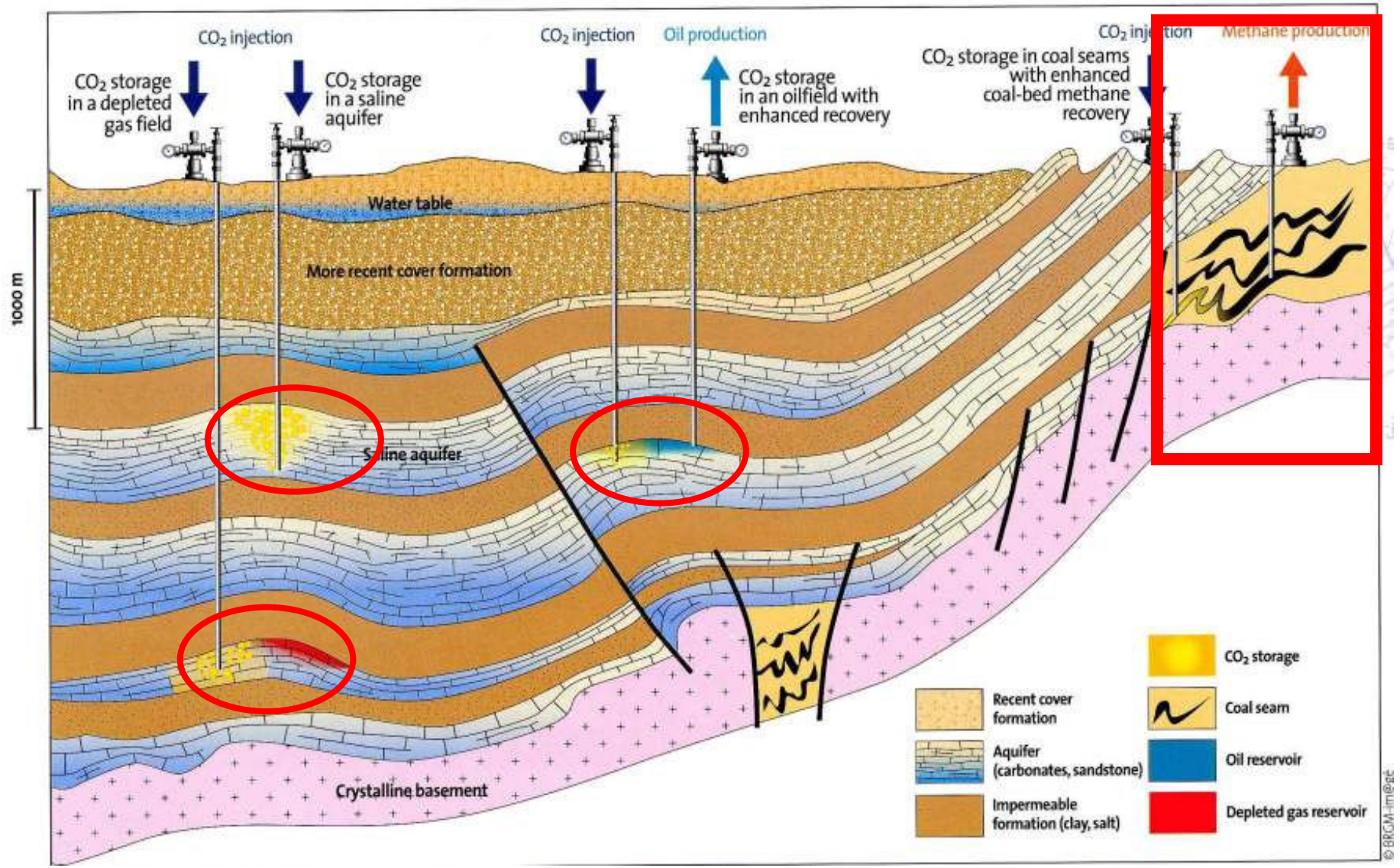

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CO_2 enhanced coalbed methane production (CO_2-ECBM)

CBM in Europe

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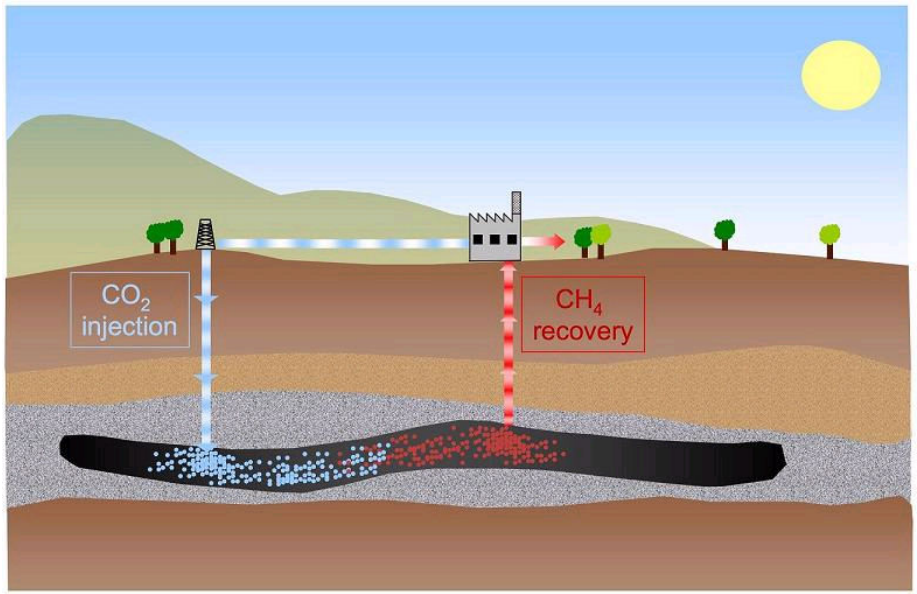
- Comparison studies showed that Europe is also rich in CBM resources
  - Compared to Black Warrior Basin, five Variscan foredeep basins in Germany and UK showed thicker coal-bearing sequences, more numerous beds, greater net coal thickness (Fails, 1996). Also, gas content of the coal was confirmed.

- Nevertheless, CBM appeared sub-economic when tested
  - Other factors than thickness and gas content play a role
    - Ability to dewater the seams, depositional setting, coal distribution, tectonic and structural setting, coal rank and gas generation potential, permeability, gas content (Scott, 2002)

- Many hoped that ECBM would change this situation

Enhanced Coalbed Methane

- Basic principle:
  - Inject CO_2 in subsurface coal seam
  - CO_2 replaces adsorbed methane on the coal surface
  - Released methane can be produced
  - CO_2 is stored as an adsorbed phase on the coal



http://www.ipe.ethz.ch/laboratories/spl/research/adsorption/project03

Enhanced Coalbed Methane

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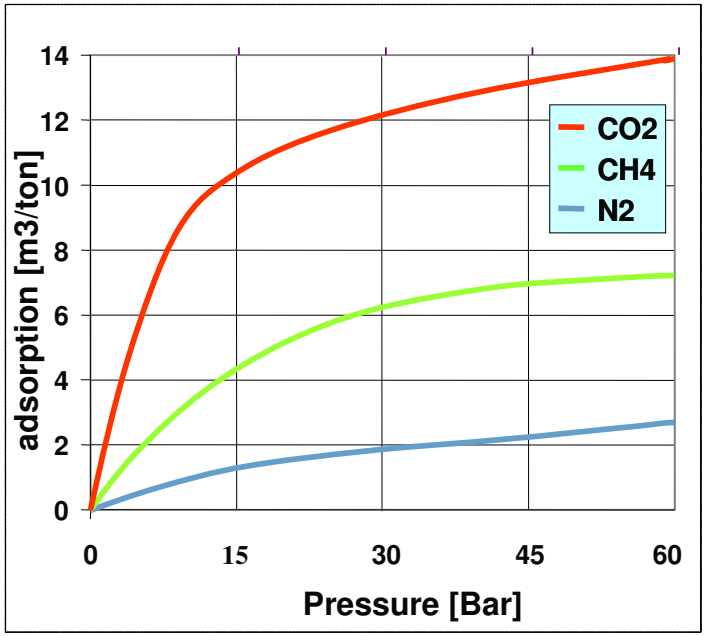
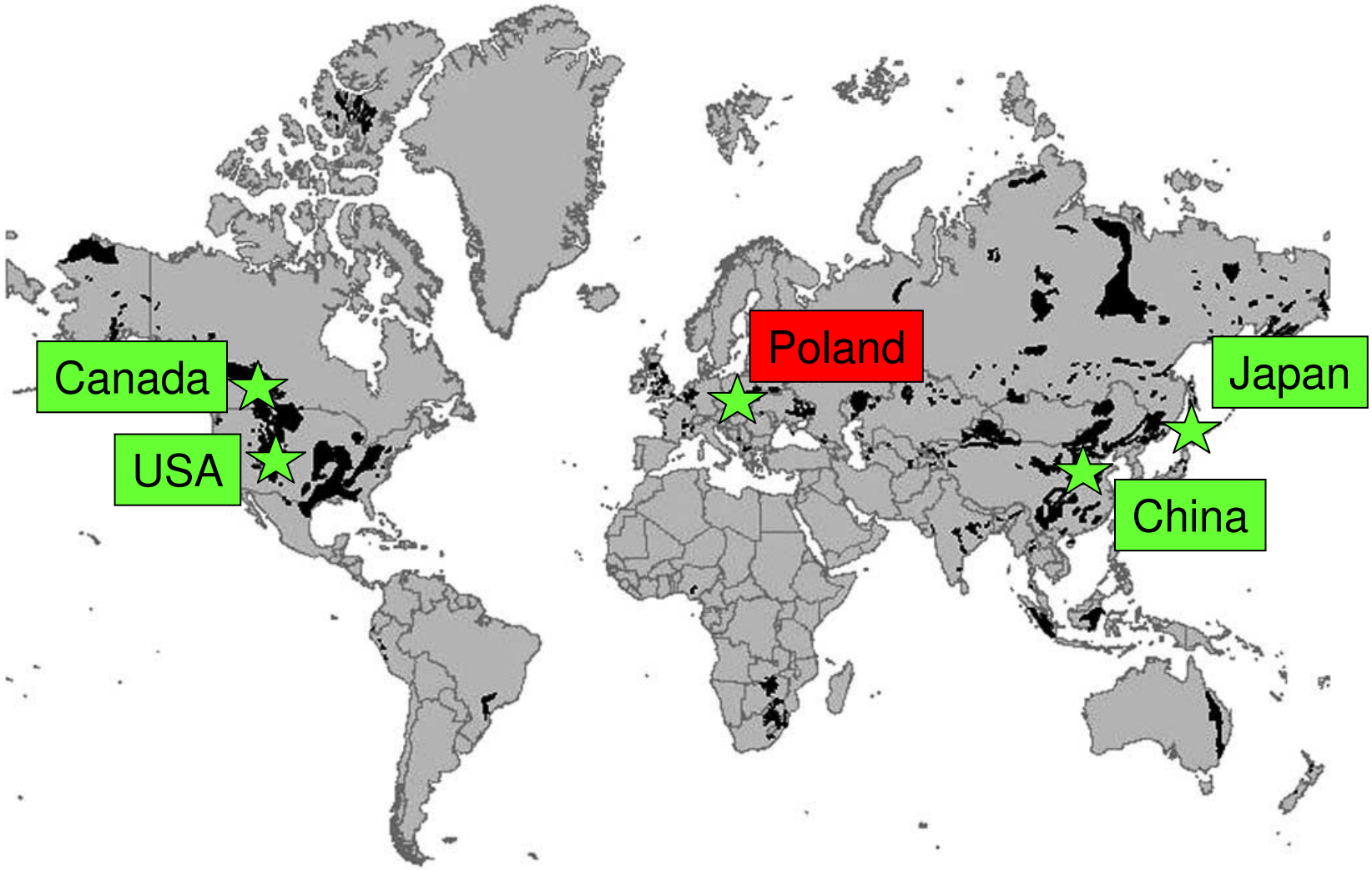
- Suggested since beginning of 1990's, following laboratory experiments
  - Both N_2 and CO_2

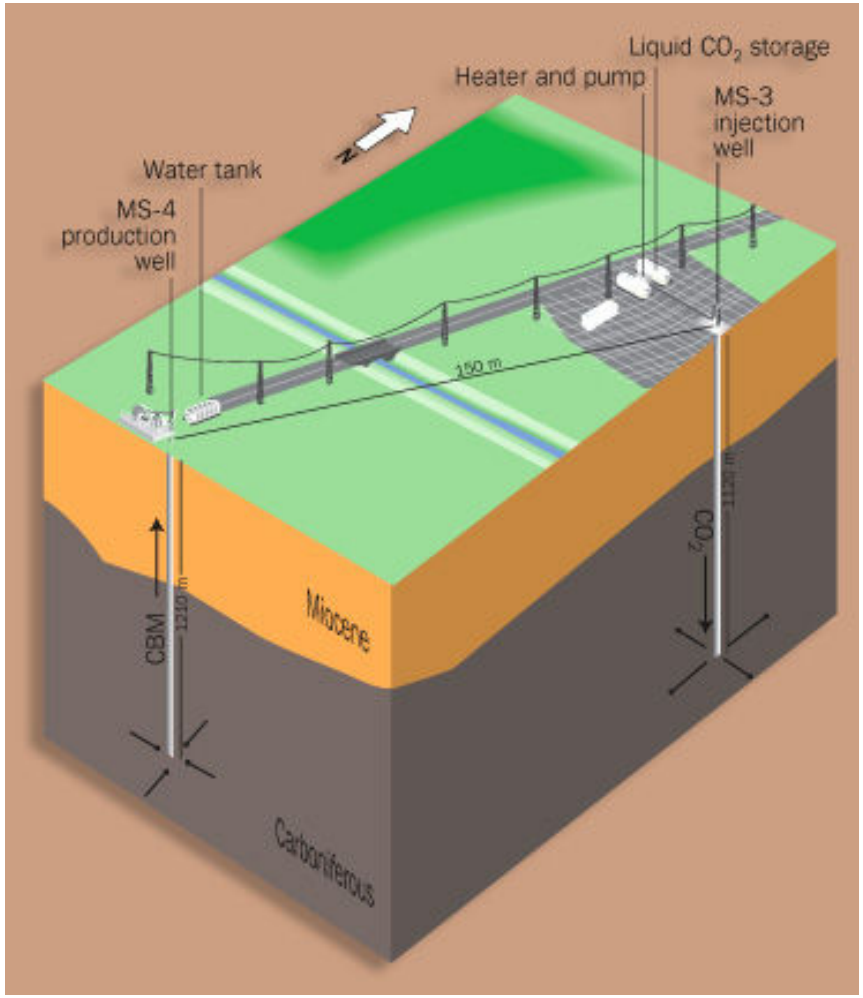


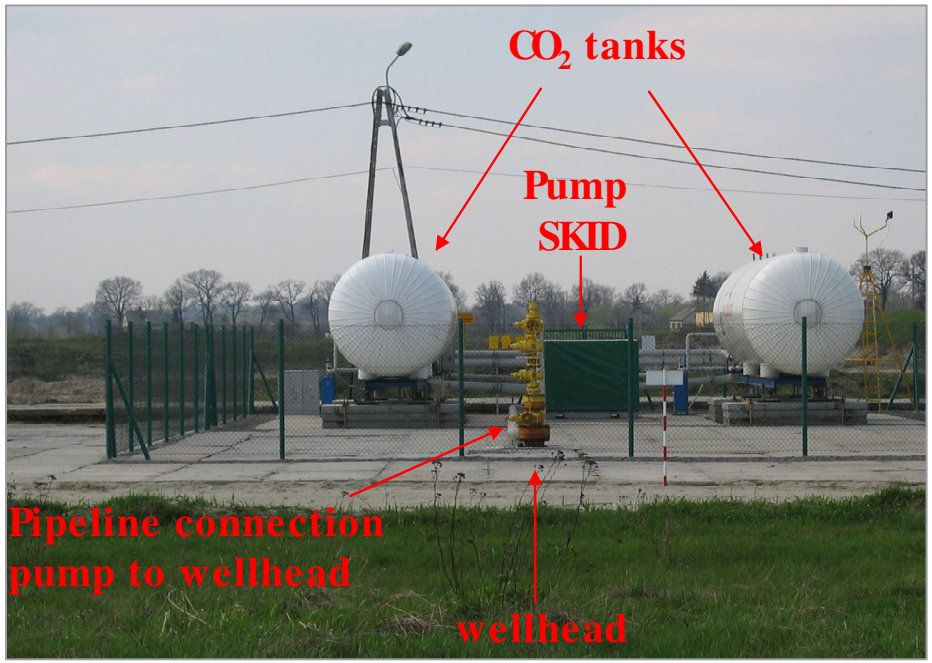
- Field experiments (Allison and Tiffany Units) in San Juan Basin (USA) in second-half of 1990's
  - Considered successful but too expensive to continue
    - CO_2 stored in the reservoir was considered a loss
- Idea of storing CO_2 to reduce CO_2 emissions was appealing to researchers in Canada, Europe and Japan
  - ECBM as CCS option

Field pilots before 2005



Field injectivity test in Poland (RECOPOL)





RECOPOL results

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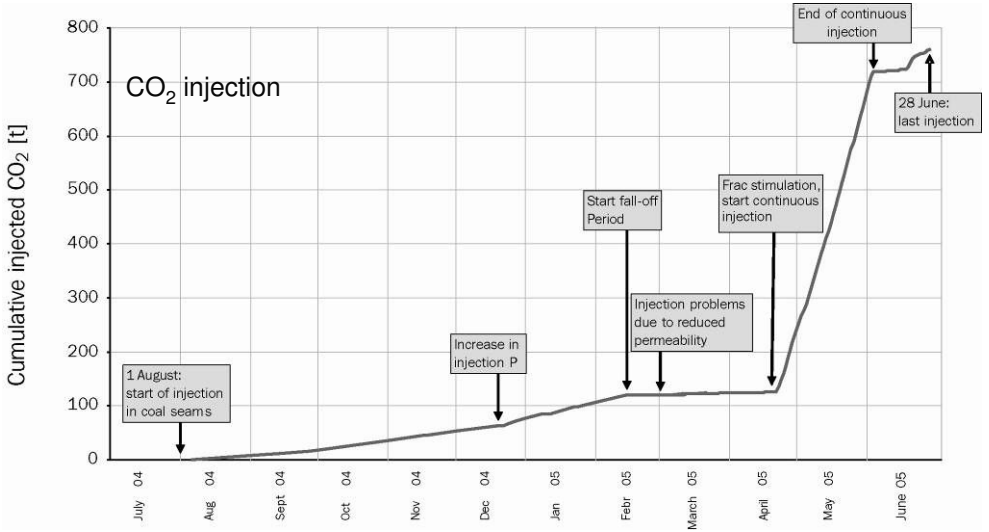
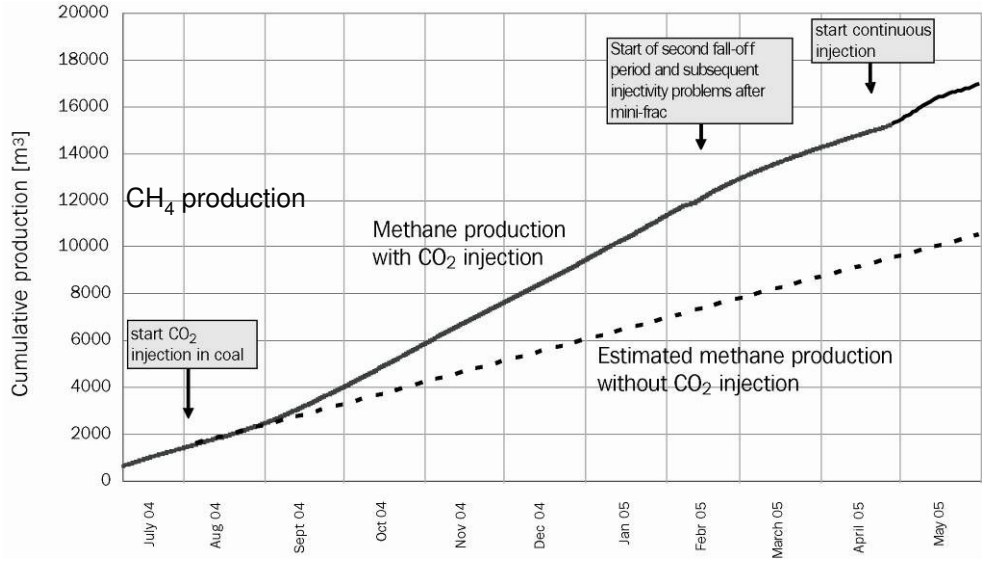
- Injection in coal seams is not trivial !
  - Coal is swelling, thereby reducing the permeability
- Although gas production is enhanced, gas production rates are lower than expected (probably related to matrix diffusion)





Current status of ECBM

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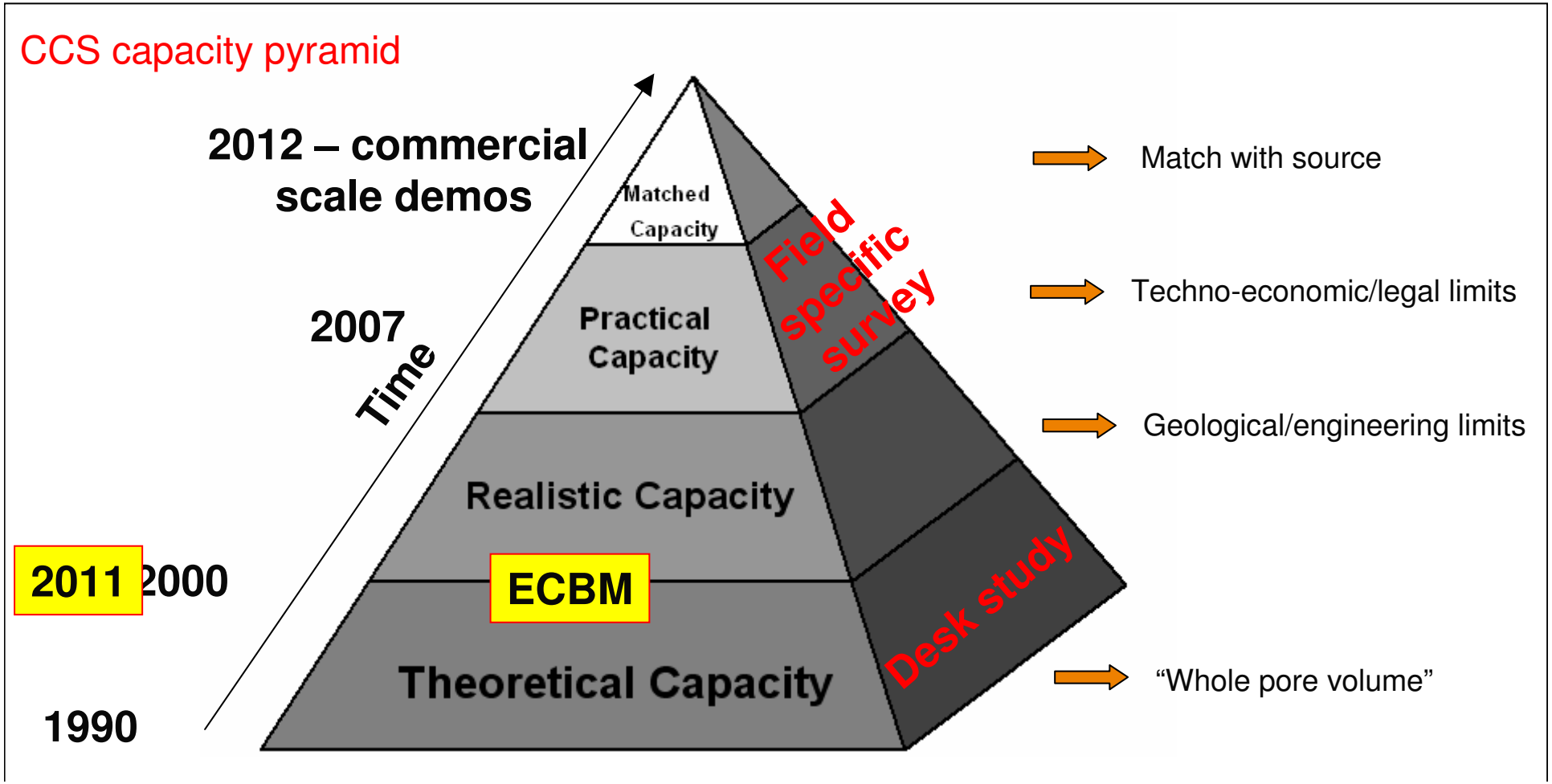
- Limited follow-up on “first generation tests” after 2005
  - DOE sponsored tests in the U.S.A.
  - drilling program in Brazil, with plans for an injectivity test
  - injectivity test in China in 2010
  - other?
- All relatively small-scale, without real new ideas or concepts tested
- However, desk/laboratory studies were continued

ECBM from a CCS perspective

- Technology not well enough matured to control uncertainties
  - Mismatch with the targeted time line for CCS implementation (20/2020)



ECBM from a CCS perspective

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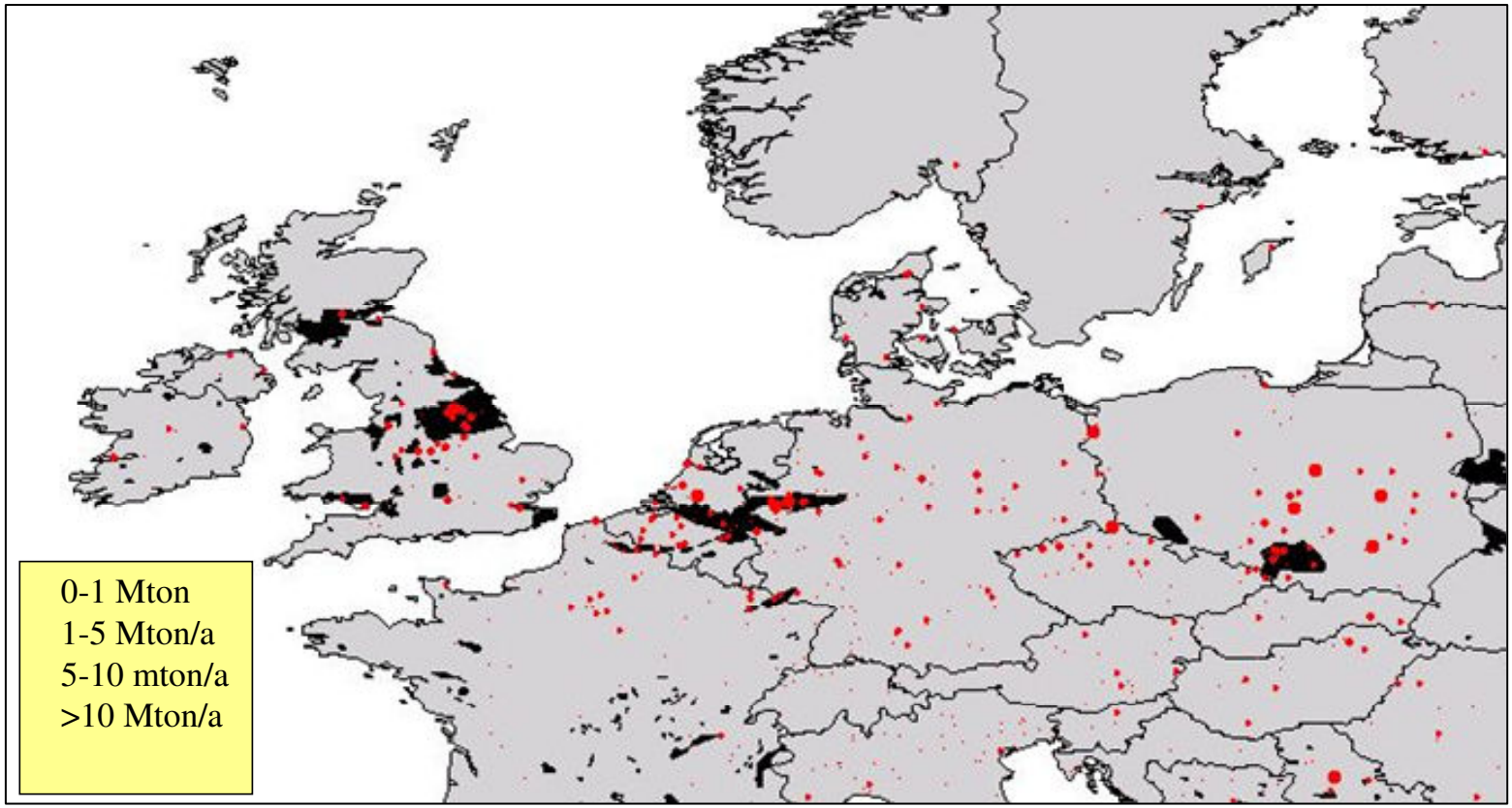
- The total storage capacity is expected to be limited compared to other options
  - Relative low permeability limits injectivity
    - Probably < 100 t/d per vertical well
  - Relatively large number of wells required

- Definition of unminable coal is still matter of debate
  - generally considered to be seams at >1000 m depth, but this varies per location

… but …

1. **There is a clear need for CO_2 storage options in coal basins with heavy industry**
   - The occurrence of large CO_2 point sources in coal basins, while there is a lack of alternative storage options, is still attractive
   - Alternative for long-distance transport



… but …

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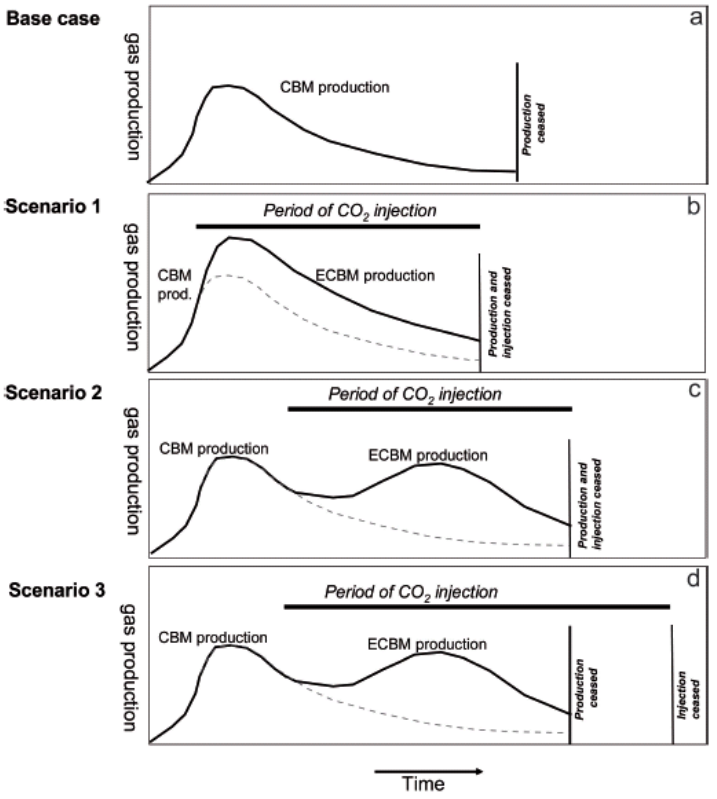
2. CBM fields are being developed rapidly

- ECBM as a secondary production phase
  - With conventional techniques there will be remaining gas in coal after production, which will still be a resource
  - ECBM techniques may be applied to tap these resources in a secondary production phase



… but …

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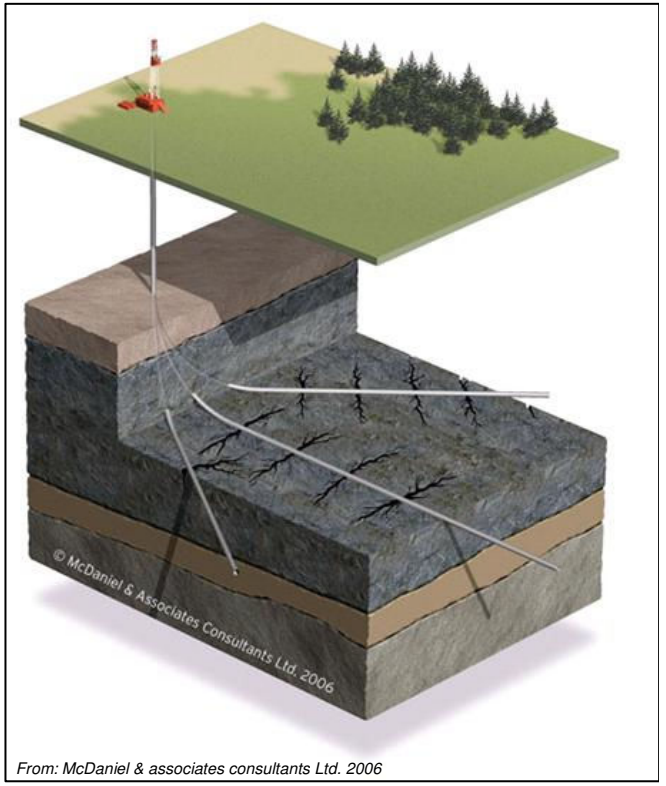
- **2. Technology developments go rapidly**
  - Horizontal drilling, also for injection



From: McDaniel & associates consultants Ltd. 2006

- **4. Research is advancing to obtain a better understanding of the process**

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