CCS

Technological Achievements and Political Challenges

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Vattenfall: a European energy company

- Europe’s fifth largest generator of electricity and the largest producer of municipal heat
- Net sales 2009: 19.85 billion €
- Operations in Sweden, Finland, Denmark, Germany, Poland, the Netherlands, Belgium and UK
- 7.4 million electricity customers
- 5.6 million network customers
- Business along the entire value chain
- 40,000 employees
- 100 % owned by the Swedish state
- Core businesses: Electricity, Heat, Gas
Vattenfall's target: climate neutral by 2050

Carbon dioxide reduction

- **EU-Target**: Emission reduction by 20% until 2020
- **Vattenfall - Target I**: Emission reduction by 50% until 2030
- **Vattenfall - Target II**: CO₂ neutrality until 2050

Basis: EU & Kyoto
Various technologies – one strategy

- Wind Energy
- Biomass
- CCS
- Nuclear

[Diagram showing the energy mix for 2008 and 2030, with percentages for each category: Fossil-based 47%, Wind 1%, Hydro 24%, Nuclear 28%, Coal 20%, Fossil-based with CCS 16%, Gas 4%, Ocean 8%, Bio 6%, Nuclear 22%.]
Why do we need CCS?

- The world will not stop using fossil fuels.
- Coal is the one fossil fuel which combines availability with cost-efficiency.
- CCS is **THE** key technology for developing a CO$_2$ lean energy system based on the reality of fossil fuels – especially coal.

Global electricity supply - 2008

- Fossil fuels 66.1%
- Nuclear 15.7%
- Hydro 16.1%
- Others 2.1%

[Diagram showing global electricity supply with percentages for different sources including fossil fuels, nuclear, hydro, and others.]
Does the technology work?

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  CO₂ capture for many decades in industrial processes
  - 3100 km CO₂ pipelines in USA transport 30 m. tonnes per year
  - Sleipner (Norway) since 1996; approx. 12 m. tonnes of CO₂ in the Utsira formation
  - CO₂SINK-project Ketzin: start 2004; Vattenfall partner of the research project led by Geo-forschungszentrum Potsdam; 40,000 tonnes CO₂ stored
  - Pilot plant Schwarze Pumpe: since 2008; demonstration of the entire process chain; approx. 5,000 tonnes CO₂ captured

Weyburn: picture of a transferpipeline for distribution; transportpipeline 1.50 meter under surface
Roadmap for implementing carbon capture

- Feasibility studies
  - Theoretical studies

2001

2004
- Research
- Fundamental principles
- Combustion characteristics

2008
- Demonstration of the entire process chain
- Interplay of components
- Validation of results gathered with the test rigs
- Investigation of scale-up criteria

2015
- Verification and optimisation of the selected components
- Risk mitigation
- Proof of commercial operability (subsidising still required for this step)

2020
- Economically viable and competitive power plant concept
- No subsidies needed

Test rigs: 0.1 – 0.5 MW<sub>th</sub>

Pilot plant: 30 MW<sub>th</sub>

Demonstration plant: 250-500 MW<sub>el</sub>

Commercial-scale PP: 500 - 1000 MW<sub>el</sub>
The CCS pilot plant: successful testing of CO$_2$ capture

Facts and figures:
- Capacity: 30 MW$_{\text{thermal}}$
- CO$_2$ capture rate: + 90%

Results of operation:
- Operating hrs since Sept. 2008: 8,000 hrs
- CO$_2$ quantity captured: 5,000 t

- The CCS pilot plant serves the purpose of testing CO$_2$ capture according to the Oxyfuel process.
- The obtained results of operation meet the expectations regarding CO$_2$ capture.
- Further potential for technical optimisation is available, and is being tested continuously.
Locations of European CCS projects under EEPR

- Hatfield, UK
- Rotterdam, NL
- Compostilla, ES
- Porto Tolle, IT
- Bełchatów, PL
- Jänschwalde, DE
CCS projects under EEPR

**Rotterdam (Netherlands)**
Project developer: Maasvlakte CCS Project C.V.  
Partners: E.ON Benelux, GDF SUEZ  
Post-Combustion, 250 MWel  
1.1 m t CO\(_2\) stored per annum  
Pipeline: 25 km  
Storage: depleted gas reservoirs, off-shore

**Compostilla, León (Spain)**
Project developer: Endesa Generacion  
Partners: CIUDEN (Spanish government), Foster Wheeler Oy  
Oxy-combustion (CFB)  
323 MW\(_{el}\) gross capacity  
2 m t CO\(_2\) stored per annum  
Pipeline: ~ 135 km  
Storage: deep saline aquifer, on-shore

**Porto-Tolle, Veneto (Italy)**
Project developer: Enel  
Post-Combustion  
264 MWe  
Up to 1 m t CO\(_2\) stored per annum  
Pipeline: ~100 km  
Storage: deep saline aquifer, off-shore
### CCS projects under EEPR

#### Hatfield, Humberside (UK)
- Project developer: Powerfuel Power Ltd.
- Partner: National Grid Carbon
- Pre-Combustion, 900 MW<sub>el</sub>
- Up to 5 MtCO<sub>2</sub> stored per annum
- Pipeline: ~175 km
- Storage: depleted gas reservoirs, aquifers. off-shore

#### Jänschwalde (Germany)
- Project developer: Vattenfall
- Oxyfuel 250 MW<sub>el</sub>
- Post-Combustion 50 MW<sub>el</sub>
- 1.7 MtCO<sub>2</sub> stored per annum
- Pipeline: 50-300 km
- Storage: Natural gas field, deep saline aquifer, on-shore

#### Bełchatów (Poland)
- Project developer: PGE Mining and Conventional Power J.S.C.
- Support from: Alstom, The Dow Chemical Co., Polish Geological Institute, Schlumberger
- Post-Combustion
- 260 MW<sub>el</sub> gross capacity
- 1.8 MtCO<sub>2</sub> stored per annum
- Pipeline: 60-140 km
- Storage: deep saline aquifers, on-shore
## CCS-demonstration project Jänschwalde

### Capture

| Block G (Oxyfuel) | Capacity gross: 250 MW | Capacity net: 167 MW | Production: 1.3 TWh | Efficiency net: 36% | Coal consumption: 1.5 mill. t | Emission total: 1.4 mill. t | Emission captured: 1.3 mill. t | Capture rate: 93% |
| Block F (PCC) | Capacity gross: 534 MW (thereof PCC: 50 MW) | Capacity net: 494 MW | Production: 3.5 TWh | Efficiency net: 36% | Coal consumption: 4.1 mill. t | Emission total: 3.9 mill. t | Emission captured: 0.4 mill. t | Capture rate: 10% | Capture rate (treated flue gas): 90% |

### Transport

- **Capture**: 60 km
- **Storage**: 300 km

### Storage

- **Block G (Oxyfuel)**: 130 km
  - Storage capacity: up to 100 mill. t
  - Storage type: Saline formation

- **Block F (PCC)**: 60 km
  - Storage capacity: up to 100 mill. t
  - Storage type: Saline formation

- **Altmark** (owned by GDF)
  - Distance: 300 km
  - Storage capacity: ~450 mill. t
  - Storage type: Gas reservoir

Two capture technologies as part of Demo plant

Three alternative storage locations being explored in parallel
Challenge # 1: public perceptance

- Political support and public acceptance → you cannot enforce CCS
- Aggressive citizen movements at the exploration sites against survey and research
- Regional Advisory Council initiated by Brandenburg Ministry of Economy to include all stakeholders in a dialogue on how to proceed
Challenge # 2: legal framework

• CCS investment decisions need legal and regulatory clarity asap
  – Transposition of EU Directive still missing in most states
• Widespread deployment post 2020 depends both on legal framework and global carbon/climate policy
  – Shape of Post-Kyoto and carbon markets highly uncertain
• German CCS-law pending
  Draft version shows a need for action:
  **Timetable**
  • Extensive and time-consuming licensing procedures, lack of instruments for acceleration
  • Downstream powers to issue ordinances delay legal certainty
  • Validity of the law limited to storage applications filed until 31 December 2015
  **Costs**
  • Total costs of financial security and after-care incalculable, especially in view of the development of emission allowance trading