Clean Coal for Europe
Making CCS Work

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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
Various Technologies – One Strategy

- Wind Energy
- Biomass
- CCS
- Nuclear

Chart showing energy sources from 2008 to 2030:
- Wind: 1%
- Hydro: 24%
- Nuclear: 28%
- Fossil-based: 47%
- Coal: 20%
- Fossil-based with CCS: 16%
- Ocean: 8%
- Gas: 4%
- Bio: 6%
- Wind: 12%
- Hydro: 12%
• The world will not stop using fossil fuels.

• Coal is the one fossil fuel which combines the greatest potential with the strategic optimum

• CCS is **THE** key technology for developing a CO$_2$ lean energy system based on the reality of fossil fuels – especially coal

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**CCS – A Global Perspective**

**global electricity supply - 2008**

- Fossil fuels: 66.1%
- Nuclear: 15.7%
- Hydro: 16.1%
- Others: 2.1%
- Fossil fuels: 66.1%
Developing CCS

Capture
CO₂ Sequestration

Transport
CO₂ Pipeline

Storage
Geological Storage

Target: Parallel development of technology for carbon dioxide capture and storage.
**Roadmap for implementing carbon capture**

- **Test rigs:** 0.1 – 0.5 MW<sub>th</sub>
- **Pilot plant:** 30 MW<sub>th</sub>
- **Demonstration plant:** 300 MW<sub>el</sub>
- **Commercial-scale PP:** 500 - 1000 MW<sub>el</sub>

**2001**
- Theoretical studies

**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
Roadmap for implementing carbon storage

**Screening**
- Ongoing R&D injection projects (Sleipner, In Salah)

**Pilot phase**
- EGR / CO₂ injection of 100,000 t

**Demo phase for storage**
- CO₂ injection of >1 m t

**2001**
- Theoretical studies
- Ongoing R&D injection projects (Sleipner, In Salah)

**Feasibility studies**
- Screening
- Research
- Fundamental principles
- Pipeline model computations

**2004**
- Screening
- Research
- Fundamental principles
- Pipeline model computations

**2010 / 2011**
- Altmark project
- Demo: EGR
- Demonstration of the full process chain
- Operating experience with injection
- Research

**2015**
- East Brandenburg aquifer project
- 1st step: repository exploration
- Qualification of reservoir structures
- Opening-up of the reservoir
- Pipeline construction
- Operation over 15 – 20 yrs

**2020**
- Economically viable and competitive transport and storage infrastructure
The CCS pilot plant: Successful testing of CO₂ capture

Facts and figures:
- Capacity: 30 MW<sub>thermal</sub>
- CO₂ capture rate: > 90%

Results of operation:
- Operating hrs since Sept. 2008: 6,000 hrs
- CO₂ quantity captured: 3,100 t

- The CCS pilot plant serves the purpose of testing CO₂ capture according to the Oxyfuel process.
- The obtained results of operation meet the expectations regarding CO₂ capture.
- Further potential for technical optimisation is available, and is being tested continuously.
**CCS-Demonstration Project Jänschwalde**

### 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

### Storage

#### Birkholz
- **Distance:** 60 km
- **Storage capacity:** up to 100 mill. t
- **Storage type:** Saline formation

#### Neutrebbin
- **Distance:** 130 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

**Three alternative storage locations being explored in parallel**

**Two capture technologies as part of demo plant**
The CCS power plant: Advancing the concept

Previously: Retrofitting unit F:
- Oxyfuel 250 MW
- PCC 125 MW

Now: New unit:
- Oxyfuel 250 MW
- Retrofitting unit F:
  - PCC 50 MW
Advancing the concept - Key results of the technical modifications

<table>
<thead>
<tr>
<th></th>
<th>Previous concept</th>
<th>Current concept</th>
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</thead>
<tbody>
<tr>
<td>Efficiency (Oxyfuel)</td>
<td>28 %</td>
<td>36 %</td>
</tr>
<tr>
<td>CO₂ emissions per kWh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Oxyfuel</td>
<td>145 g/kWh</td>
<td>78 g/kWh</td>
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<tr>
<td>- PCC (rel. to treated flue gas)</td>
<td>149 g/kWh</td>
<td>107 g/kWh</td>
</tr>
<tr>
<td>Captured CO₂</td>
<td>2.7 Mt/a</td>
<td>1.7 Mt/a</td>
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</tbody>
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Use of best practice in power plant technology
- *highest possible power plant efficiency for a CCS demo plant*
- *lowest possible CO₂ emissions per kWh: Oxyfuel less than 25% of BAT gas-fired power plant*
Permits for exploration of the Birkholz-Beeskow and Neutrebbin storage structures have been received. Main plan for operations, and special plan for seismic operations, submitted for Birkholz-Beeskow to authority LBGR. Main plan for operations currently in the phase of public participation.
Next step: exploring the geological formation

Vattenfall needs to explore the potential storage sites

- to be able to evaluate the suitability of the geological formations;
- to be able to answer open questions on a valid basis;
- as an essential step towards a permit procedure for later CO$_2$ storage.
Transposition of the EU Directive into German law

- CCS Directive is an element of the EU's "Green package"
- Publication of the "Green package" in the EU Gazette on 05 June 2009
- **Enforcement of the Directive** after 20 days, i.e. on **25 June 2009**
- **Deadline for transposition of the Directive into national law:** **after two years**

- The EU CCS Directive must have been transposed into national law by 25 June 2011
- CCS bill presented on 14 July 2010 (joint press conference of the Federal Ministries for the Environment and Economics)
- To be followed by a reconciliation process in the parliament (final decision in Q1 2011)
- Law can be enforced in summer 2011 at the earliest
Preconditions for implementing the project

Implementation of the CCS demo project in the German state of Brandenburg

Subsidies
Legal Framework
Public Acceptance
Public Acceptance: Dialogue and Transparency

**DIALOGUE**

- Community information office opened 07 / 2009
- Regular information events on CCS
- Regional contacts programme (regular talks with regional political and media stakeholders)
- Regular talks with regional associations ("regulars‘ table“)
- Regional Advisory Board (initiator State of Brandenburg; sort of “social dialogue”)

**TRANSPARENCY**

- Extensive distribution of info materials
- Telephone hotline for community questions
- Regular newsletter on project progress
- Placement of information ads

*We take people’s fears in connection with CO2 storage seriously.*

*We fully rely on open and direct communication with the public.*
Conclusion:

• CCS is one of the technologies with crucial importance for climate protection from a sustainability angle.

• Germany – specifically Brandenburg - and Vattenfall are among the technology leaders, but losing momentum.

• The development of CCS will sustain important industries, and the resulting value creation and employment situation.

• Major prerequisites to its successful rollout are an investment-friendly legal framework and political support.
Thank you for your attention!