The Financial Aspects of Implementing an IGCC CCS Project in Germany

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Structure

- Potential for the reduction of CO₂ emissions via efficiency improvements and CCS
- RWE’s decision on CCS
- RWE project of a zero-CO₂ 450 MW power plant (IGCC-CCS)
- Timetable of RWE's IGCC CCS project
- CO₂ scrubbing as a retrofit option for steam power plants
- Financial aspects of implementing CCS
- New scenario study concerning the development of the German energy market by 2030 (scenario design)
- Assumption for CCS in the scenario study
- Results concerning CO₂ prices, energy mix in power generation and CCS share
- Conclusion
Zero-\(\text{CO}_2\) coal-fired power plants can slash carbon emissions further

Reference basis: units with 31% efficiency to be replaced

<table>
<thead>
<tr>
<th>CO(_2) reduction in %</th>
<th>Steam power plants with boosted efficiency</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>up to 40% through efficiency boost</td>
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<tr>
<td></td>
<td>up to 95% through carbon capture</td>
</tr>
</tbody>
</table>

2010: BoA
2015: DLG*-fired
2020: 700°C

Power plants with carbon capture

2014: 450 MW IGCC-CCS*

DLG = dry lignite
CCS: Carbon Capture and Storage

Efficiency boost also required for zero-\(\text{CO}_2\) power plant: The higher the efficiency the less carbon must be captured and stored
### Horizon 3: RWE's decisions on CCS

1. RWE Power develops and builds a **zero-CO₂ 450 MW coal-fired power plant** based on IGCC technology incl. CO₂ transport and storage; start of operation is planned for 2014.

2. In parallel, RWE will develop the technology of **CO₂ scrubbing** for future advanced coal-fired steam power plants and as a retrofit option for modern installations.
   - RWE Power will focus on CO₂ scrubbing for lignite
   - RWE npower will perform a feasibility study for a Clean Coal 1,000 MW steam power plant in Tilbury and carry out tests for CO₂ scrubbing in hard coal plants.
RWE's project of a zero-CO$_2$ 450 MW power plant with carbon storage (IGCC-CCS)

- Basic technology: IGCC
- El. capacity: 450 MW$_{\text{gross}}$, 360 MW$_{\text{net}}$
- Net efficiency: 40 %
- CO$_2$ storage: 2.3 mill. t/a in gas deposits or deep saline formations
- Commissioning: 2014

RWE Power has inhouse power plant and gasification know-how and RWE Dea has basic CO$_2$ storage know-how.
IGCC is particularly attractive for the zero-\(\text{CO}_2\) power plant and, at the same time, offers the key to other coal-derived products

- All process steps are commercially available
- Technical and economic figures are robust
- Power plant can also be operated efficiently without carbon capture
- IGCC offers additional potential for emission reduction
- High fuel and product flexibility

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**Fuel flexibility**

- Nat. gas
- Coal
- Biomass
- Residues

**Product flexibility**

- \(\text{CO}_2\)
- Electricity
- Heat
- \(\text{H}_2\)
- Synthesis gas (\(\text{CO}+\text{H}_2\))
- SNG
- Methanol
- Motor fuels (CtL)

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as an alternative or additionally
The timetable of RWE's IGCC-CCS project is ambitious and requires support by the overall environment.

RWE's IGCC CCS project:
- **Power plant**
  - Today 8/2007: Decision on fuel/location
  - 8/2008: Approval Decision to build
  - 2010: Construction, commissioning
  - 2014: Start of operation

- **CO₂ storage, pipeline**
  - Approval: Screening, exploration, approval
  - 2014: Construction, commissioning
  - Start of operation
The development of the CO₂ storage site must be step by step and on several levels

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>2008</th>
<th>Phase 2</th>
<th>2010</th>
<th>Phase 3</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Screening:</strong></td>
<td></td>
<td><strong>Exploration:</strong></td>
<td></td>
<td><strong>Construction:</strong></td>
<td></td>
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<tr>
<td>▪ Screening of potential reservoirs</td>
<td>▪ Exploration (3D seismics)</td>
<td>▪ Drilling of wells and construction of storage facility</td>
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<tr>
<td>▪ Evaluation and feasibility study for 2 – 3 sites</td>
<td>▪ Selection of storage site</td>
<td>▪ Surface installations</td>
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<td>▪ Approvals</td>
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</table>

The following tasks must be tackled in parallel:

▪ Development of standards for the evaluation of CO₂ storage sites and their long-term tightness

▪ Creation of underlying legal and regulatory conditions
  – Legal norm must be defined
  – Regulatory frameworks below the law level must be created

▪ Reaching public acceptance

⇒ Joint tasks of companies, policy-makers and authorities
Parallel RWE programme on the development of CO₂ scrubbing for steam power plants

This opens up the retrofit option

RWE involvement:
- First pilot plant for HC in operation at the Esbjerg power plant (DK) as part of the EU CASTOR project

RWE developments:
- RWE Power for lignite:
  - until 2008: pilot project
  - from 2009: demonstration plant
- RWE npower for hard coal:
  - Pilot test plant
  - Study for 1,000 MW Tilbury plant with CO₂ scrubbing

Currently formation of partnerships with plant makers and chemical industry

Budget: ~ €90 million
Comparison of power generation costs for various technologies

![Comparison of power generation costs for various technologies](image)

**Power generation costs for newbuilds in €/MWh**

- **Steam power plants**
- **IGCC-CCS**
- **Renewables**

Source: VGB (German Technical Association of Large Power Plant Operators), supplemented by CO$_2$ allowances costs of €20/t and plants with carbon capture.
Scenario design in the EWI/EEFA study

Scenario 1: Consideration of the stipulations made by the European Council in March 2007 with regard to the reduction of greenhouse gas emissions in the EU-27 (-20% by 2020 over 1990) with unchanged energy policy conditions in Germany.

Scenario 2: Equal consideration of supply security, economic efficiency and environmental compatibility/backing of market mechanisms (no restrictions for nuclear energy use, EU-wide harmonized funding model for renewable energies, free allocation of CO₂ certificates based on fuel-specific benchmarks).

Scenario 2a: Like Scenario 2, but 100% auctioning of CO₂ emission allowances after 2012.

Scenario 3: Priority on environmental protection and nuclear phase-out (100% auctioning of CO₂ certificates after 2012 – as in Scenario 2a).
### Overview of policy scenarios (1)

<table>
<thead>
<tr>
<th></th>
<th>Scenario 2</th>
<th>Scenario 2/2a</th>
<th>Scenario 3</th>
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<tbody>
<tr>
<td><strong>GHG reduction</strong>&lt;sup&gt;1)&lt;/sup&gt;</td>
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<tr>
<td><strong>EU</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>- 8 %</td>
<td>- 8 %</td>
<td>- 8 %</td>
</tr>
<tr>
<td>2020</td>
<td>- 20 %</td>
<td>- 20 %</td>
<td>- 30 %</td>
</tr>
<tr>
<td>2030</td>
<td>- 25 %</td>
<td>- 25 %</td>
<td>- 40 %</td>
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<tr>
<td><strong>DE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>- 21 %</td>
<td>- 21 %</td>
<td>- 21 %</td>
</tr>
<tr>
<td>2020</td>
<td>- 25 %</td>
<td>- 25 %</td>
<td>- 40 %</td>
</tr>
<tr>
<td>2030</td>
<td>- 30 %</td>
<td>- 30 %</td>
<td>- 50 %</td>
</tr>
<tr>
<td><strong>NAP</strong></td>
<td>Unchanged NAP II after 2012</td>
<td>100 % auctioning after 2012</td>
<td></td>
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<tr>
<td><strong>JI/CDM</strong>&lt;sup&gt;2)&lt;/sup&gt;</td>
<td></td>
<td>max. 50 % of each reduction (stipulated by EU Commission)</td>
<td></td>
</tr>
</tbody>
</table>

1) over 1990  
2) optionally: over base year, 2004 or forecast, if appropriate  
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## Overview of policy scenarios (2)

<table>
<thead>
<tr>
<th>Renewable energies targets(^1)</th>
<th>Unchanged Renewable Energies Act</th>
<th>Market economy integration model of the EU</th>
<th>Forcing Renewable Energies Act</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EU</strong> (2010)</td>
<td>17 %</td>
<td>17 %</td>
<td>22 %</td>
</tr>
<tr>
<td>(2020)</td>
<td>22 %</td>
<td>22 %</td>
<td>30 %</td>
</tr>
<tr>
<td>(2030)</td>
<td>27 %</td>
<td>27 %</td>
<td>35 %</td>
</tr>
<tr>
<td><strong>DE</strong> (2010)</td>
<td>13 %</td>
<td>13 %</td>
<td>15 %</td>
</tr>
<tr>
<td>(2020)</td>
<td>20 %</td>
<td>Market result</td>
<td>25 %</td>
</tr>
<tr>
<td>(2030)</td>
<td>26 %</td>
<td>Market result</td>
<td>35 %</td>
</tr>
<tr>
<td><strong>CHP</strong></td>
<td>Unchanged CHP Modernization Act</td>
<td>Production discontinued</td>
<td>Ratio: Doubling of CHP power generation by 2030</td>
</tr>
<tr>
<td><strong>Nuclear energy</strong></td>
<td>Phase-out</td>
<td>No restrictions</td>
<td>Phase-out</td>
</tr>
</tbody>
</table>

\(^1\) Share in gross power consumption

**Crude oil price**

*High-price and low-price path*

Gas prices free power plant
Low and high price, intermediate and peak load

**Real \( \text{CO}_2 \) prices in scenarios**

*Price basis 2005, high price*

![Graph showing real \( \text{CO}_2 \) prices in different scenarios](image)

Real CO₂ prices in scenarios
Price basis 2005, low price

### Assumptions concerning costs and efficiency of newbuild coal-fired plants

<table>
<thead>
<tr>
<th></th>
<th>Hard coal</th>
<th>Lignite</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Investment costs in € mill./MW(_{el})</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>without CCS</td>
<td>1.20</td>
<td>1.35</td>
</tr>
<tr>
<td>with CCS</td>
<td>1.68</td>
<td>1.75</td>
</tr>
<tr>
<td><strong>Efficiency after 2020 in %</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>without CCS</td>
<td>52</td>
<td>51</td>
</tr>
<tr>
<td>with CCS</td>
<td>44</td>
<td>43</td>
</tr>
</tbody>
</table>

An emission reduction of 90\% was assumed for plants with CCS. The costs of transport and storage are based on an aggregate amount of €14/t CO\(_2\).

Source: EWI/EEFA "Energiewirtschaftliches Gesamtkonzept 2030" (Overall Economic Energy Policy Concept), 23/05/2007
Net power output in Germany/CO₂ emissions from power generation, year 2020

Source: EWI/EEFA study: “Energiewirtschaftliches Gesamtkonzept 2030” - overview of scenarios - status: 23/05/07
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**Net power output in Germany/CO₂ emissions from power generation, year 2030**

Source: EWI/EEFA study: “Energiewirtschaftliches Gesamtkonzept 2030” - overview of scenarios - status: 23/05/07

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Main findings:

- Coal will remain an important pillar in the energy mix.
- Increase in efficiency and CCS are the decisive levers for securing the future of coal-based electricity generation.
- Technological solutions for CCS can be made available.
- Politicians have to create the legal framework for CO$_2$ transport and storage.
- RWE is willing to make the necessary investment using own funds for their large-scale demonstration project.
- CCS can be made available at competitive conditions from 2020 onwards – depending on gas and CO$_2$ prices.
- Incentives to promote CCS are necessary, in particular appropriate rules as part of the ETS.