Efficient Lignite Power Plants

Mission 6.2: Energy Efficiency

Development of Energy Efficiency

Source: RWE Power; Das Vorhaben BoA 2/3 Neurath, 2006
**EU-Twinning Project SL04/EN/01**

**Integrated Pollution Prevention and Control (IPPC)**

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Ljubljana, 13 -15 March 2006

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### Full Load Hours of Power Stations in Germany (2004)

<table>
<thead>
<tr>
<th>Power Station Type</th>
<th>Full Load Hours (2004)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear</td>
<td>7260</td>
</tr>
<tr>
<td>Lignite</td>
<td>7240</td>
</tr>
<tr>
<td>Coal</td>
<td>4500</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>2100</td>
</tr>
<tr>
<td>River run water</td>
<td>5620</td>
</tr>
<tr>
<td>Wind</td>
<td>1400 - 1700</td>
</tr>
</tbody>
</table>

Source: VGB, Essen.

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### Further Developing Power Plant Technology

- Medium-term developments until approx. 2015/20

#### Efficiency in %

- **Coal**
  - **HC = Hard coal**
  - **L = Lignite**

**Technology lever lignite drying**

- **HC + 4 % pts.**
- **L + 8 % pts.**

**Technology lever 700 °C KW**

- **L > 50 %**

**Technology lever lignite pre-drying**

- **50 % efficiency threshold can be reached by 2020.**
- **Pre-drying can compensate for lignite’s efficiency drawbacks compared to HC.**
- **Natural gas CC plants can reach 63% efficiency.**

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Possible Efficiencies Today

Lignite

Coal

Natural Gas

Possible Improvements of the BoA Process
Basics for Lignite Drying

• Typical Analysis of Lignite
  \( H_u = 10000 \text{ kJ/kg}; \) water content 53 mass %, Ash content 14 mass-%

• Result: A share of the fuel energy is used to evaporate the water content in the fuel

• Aim: Recovery of the required evaporation energy

• Solution: Drying of lignite before combustion in the boiler. Recovery of drying energy by condensation of the vapours from the drying process

Milenstones for Efficiency Increase

**2015:** Lignite pre-drying
- Efficiency: +4% points
- **today:**
  - WTA prototype
  - Testing of full-scale drier

**2020:** 700C power plant
- Efficiency: +4% points
- **today:**
  - COMTES700 etc.
  - Manufacturing and testing of all important components
Increase in Steam Parameters

The increase in steam parameters from 280 bar/600°C to 350 bar/700°C calls for the use of a new material generation, especially for:

- Final superheater outlet headers, steam pipes to turbine
- Final superheater banks
- Membrane walls

Integrated projects for material qualification and component demonstration have been launched:

- Component testing plant, Scholven PP
  (EU project - COMTES 700)
  **Goal:** Testing of major components.
  **Budget:** € 15.3 mill., start of operation: 2005
- Weisweiler, Esbjerg and Komet 650 test rigs
  **Goal:** Qualification of potential materials.
  **Budget:** approx. € 2.0 mill., already started.

The technical feasibility of the 700°C power plant and reaching economic efficiency are enormous challenges.

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**Energetic drawbacks:**
- Drying at **very high** exergy level
- **No utilization** of vapour energy

**Energetic improvement:**
- Drying at **low** exergy level (low-pressure steam)
- **Utilization** of vapour energy

Efficient lignite pre-drying permits efficiency advantages of some 4 percentage points.
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WTA Process Diagram

- Raw lignite 0 - 80 mm
- Fine raw lignite milling
- External steam for heating
- Drier
- Dry lignite cooler
- Steam fluidized bed
- Vapour ESP
- Vapour from coal water
- Feed water
- Vapour condenser
- Vapour condensate
- Circulation blower
- Dry lignite 0 - 1 mm
- Condensate
- Dry lignite secondary milling
- Raw lignite 0 - 80 mm
- Raw lignite bunker

Source: RWE Power; Dr. Ewers

Mass and Energy Balance at Standard Operation of BoA Niederaußem

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Emission Limits

- $\text{SO}_2$
  - 200 mg/m$^3$ and a minimum separation rate of 85%  
  (achieved by wet flue gas cleaning and gypsum production; capturing also HCL and HF)

- NOx
  - 200 mg/m$^3$ (achieved using specialized burners)

- CO
  - 200 mg/m$^3$ (achieved using specialized burners)

- Dust
  - 30 mg/m$^3$ (achieved using electrostatic filters; capture rate 99.8%)

Economic Considerations

- Efficiency Increase: About 4 %-points
  - 10 % reduced resource consumption
  - 10 % reduced CO₂-Emissions compared to today's most modern lignite power plants
- Increase in Investment: About 5 %
  - Add costs for Drying plant
  - Reduce cost for flue gas cycling and coal mills. (smaller components in the flue gas path)

Based on the development of the market for CO₂ certificates the lignite power plant with pre-drying has equal or smaller power generation costs.

The Importance of the CO₂ Certificates market

- \( \text{C} + \text{O}_2 \rightarrow \text{CO}_2 \quad [12 + 32 = 44] \)
- \( \text{CO}_2/\text{C} = 44/12 = 3.67 \)
- 1 t coal for power generation costs about € 70
- 1 t coal = 0.75 t C
- 0.75 t C = 2.75 t CO₂
- 2.75 t CO₂ = 2.75 Emission Certificates
- 2.75 Certificate x 20 €/Certificate = 55 €

- The costs for disposal approach the costs for supply
Comparing Efficiencies and costs for different generation technologies

<table>
<thead>
<tr>
<th></th>
<th>KW ohne CO2-Abtrennung</th>
<th>KW mit CO2-Abtrennung</th>
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<tbody>
<tr>
<td></td>
<td>Referenz-kW</td>
<td>BoA-Plus</td>
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<tr>
<td>Wirkungsgrad [%]</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>43</td>
<td>47</td>
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<tr>
<td>Spez. Investkosten [EAW]</td>
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<tr>
<td></td>
<td>1120</td>
<td>1160</td>
</tr>
<tr>
<td>Stromerzeugungskosten [%]</td>
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</tr>
<tr>
<td></td>
<td>190</td>
<td>190</td>
</tr>
</tbody>
</table>

* inkl. CO₂-Vendichtung, Vorwärmung and 500 km Transport
** inkl. Vollmacht, d.h. rd. 4 % Pkwa. Vertiefung gegenwärtiger Rohstoffkraft berücksichtigt

- Starkere Wirkungsgradanbauten bei CO₂-Abtrennung vor allem bei konv. Technik heißt: Ressourcenverbrauch steigt drastisch
- Massiver Erhöhung der Stromerzeugungskosten durch CO₂-Abtrennung

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Stop global warming!

Fight green house effect

Should we not better save the environment in July

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