Investment in Coal-Fired Power Generation

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Significance and Characteristics of Coal-Fired Generation in Europe (1)

Coal's role in the long-term power generation energy mix

Europe: EU 15

2000 2020

0.8 bn tce + 22 % 1.0 bn tce

Coal 43 % 40 %

Hydro/Other 10 % 13 %

Oil 9 % 6 %

Gas 20 % 29 %

Nuclear 19 %

0.3 bn tce 0.4 bn tce

World

2000 2020

5.3 bn tce + 53 % 8.1 bn tce

Coal 29 % 22 %

Hydro/Other 9 % 13 %

Oil 6 % 6 %

Gas 15 % 27 %

Nuclear 41 %

1.5 bn tce 1.8 bn tce

Coal will go on being a crucial pillar of power generation in the long term.
Significance and Characteristics of Coal-Fired Generation in Europe (2)

Age structure and demand for new plants

Share of coal plants older than 20 years

<table>
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<th></th>
<th>World</th>
<th>Europe</th>
<th>Germany</th>
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<tbody>
<tr>
<td>60 %</td>
<td>70 %</td>
<td>60 %</td>
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Demand for new plants in EU 15

- Installed capacity in GW
- Replacement demand
- Growth demand

Substantial replacement investment in coal-fired generation is required to avoid capacity shortages
Changed Boundary Conditions of Coal-Fired Generation

- Liberalization of energy markets
  - Revenue erosion suffered by power plants (in Germany: up to 40%)
  - Higher demands on flexibility of power plants
  - Replacement/new construction of power plants hardly feasible under economic efficiency aspects

- Stricter environmental standards and regulations
  - Insufficient European harmonization of environmental standards
  - One-sided CO₂ penalty through emissions trading

- State interference and support programs in favour of non-coal technologies and generation capacities
  - Further increase in cost pressure and flexibility requirements of conventional power plants

Serious deterioration in boundary conditions of coal-fired generation through full liberalization on the one hand and state control at the expense of coal on the other
Development, State of the Art and Prospects of Coal-Fired Generation (1)

- Comprehensive flue gas cleanup is standard today in coal-fired generation

- Existing power plants across Europe upgraded by retrofits
  
  Example: Emission reduction through retrofit of the Rhenish lignite mining area's 10,000 MW power plant portfolio (1983 - 92)

Nitrogen oxide: - 72 %
Sulphur dioxide: - 93 %
Particulate matter: - 93 %
Development, State of the Art and Prospects of Coal-Fired Generation (2)

Efficiency

- Breakthrough in efficiency increase during the 90s thanks to supercritical power plant technology; efficiency of new plants:
  - 70s/80s: 36 - 38%
  - since 90s: 43 - 48%

- CO₂ reduction through replacement of all power plants that are older than 20 years by state-of-the-art plants: CO₂ emissions of European power plants in bn t/a:

<table>
<thead>
<tr>
<th>Plant Age</th>
<th>Current Efficiency</th>
<th>CO₂ Emissions</th>
</tr>
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<tbody>
<tr>
<td>&gt; 20 years</td>
<td>η = 31%</td>
<td>0.9</td>
</tr>
<tr>
<td>&lt; 20 years</td>
<td>η = 36%</td>
<td>0.4</td>
</tr>
<tr>
<td>Status quo</td>
<td>η = 36%</td>
<td>1.3</td>
</tr>
<tr>
<td>State-of-the-art plants</td>
<td>η = 45%</td>
<td>0.6</td>
</tr>
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</table>

Already today, modern coal technology opens up the largest global CO₂ reduction potential.
Development, State of the Art and Prospects of Coal-Fired Generation (3)

Focuses of further development

**Efficiency**
- Target: efficiency > 50% by 2015/20
  - New materials / 700 °C power plant
  - Lignite pre-drying

**Competitiveness**
- Cut in investment costs
  (standardization, capacity increase)
- Increase in availability

**Flexibility**
- Increase in controllability and application range

Ambitious development targets of coal-fired generation contribute to environmentally compatible and low-cost power supply.
Power Plant Renewal Program of RWE Rheinbraun (1)

**RWE Rheinbraun:**
- Lignite-fired power generation capacity of 10,000 MW at 4 locations, producing some 70 TWh/a of base-load power
- Integrated operation of opencast mines and mine-mouth power plants
- Entire value chain, i.e. from mine to terminal, under one roof
- Comprehensive retrofit measures
  - 80s: flue gas cleanup
  - 90s: turbine upgrade

**Power Plant Renewal Program:**
- Agreement with the state of North-Rhine/Westphalia: Successive replacement of old plants until 2030 by eco-friendly and climate-sparing state-of-the-art power plants
- In 2002, the first 1,000 MW BoA*) unit of the Niederaussem power plant went on stream
  - global frontier technology in coal-fired power plant engineering
  - net efficiency of more than 43 %

*) BoA = lignite-fired power plant with optimized plant engineering
Power Plant Renewal Program of RWE Rheinbraun (2)
Successive renewal of the 10,000 MW power plant portfolio

- Substantially aggravated boundary conditions for BoA 2 already
- Program can only be implemented if long-term planning and investment certainty is given
Consequences of Changed Boundary Conditions (1)
Serious deterioration in investment conditions,
Comparison: BoA 1 and BoA 2

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<tr>
<th></th>
<th>BoA 1</th>
<th>BoA 2</th>
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<tbody>
<tr>
<td>Project start</td>
<td>1995</td>
<td>2002</td>
</tr>
<tr>
<td>Electricity prices</td>
<td>€ct \approx 4.0 /kWh</td>
<td>€ct 2.3 /kWh</td>
</tr>
<tr>
<td>CO₂ penalty</td>
<td>-</td>
<td>EU Directive</td>
</tr>
<tr>
<td>Environmental regulations</td>
<td></td>
<td>Stricter environmental and emission regulations</td>
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<tr>
<td></td>
<td></td>
<td>EU Large Combustion Plant Directives</td>
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<tr>
<td></td>
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<td>EU Waste Incineration Directives</td>
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The pressure of liberalization is incompatible with the non-uniform and unpredictable regulations in the fields of environment and climate.
Consequences of Changed Boundary Conditions (2)
Significantly increased risks in the liberalized market

**Former regulated market:**
Full costs were passed on to the customers via prices
⇒ very limited investment risks

**Today's liberalized market:**
⇒ Wide range of investment risks
  - Electricity price development risks
  - Fuel price development risks
  - Environmental legislation risks
  - CO₂ penalty risks

For coal, the situation is aggravated by
  - Long financing periods
  - High capital expenditure

New instruments required for risk management
Consequences of Changed Boundary Conditions (3)
New instruments for risk analysis and risk evaluation of investment at RWE Rheinbraun

- Power generation market model
  used to calculate developments in wholesale prices by simulation of the European producer market as a pool market.

  Basis:
  - Range of products including all power plants and options for new plants in Europe with their costs (capital, operation, fuel)
  - Demand curve as identified by separate forecast
  - Fuel prices as identified by separate forecast

  Result:
  - Wholesale prices resulting from a capacity-driven determination of the intersections of supply and demand (hourly)
  - Utilization ratio of the various power plants
  - Shutdown and construction of new plants (The power plant with the highest ROI is built.)
Consequences of Changed Boundary Conditions (4)
New instruments for risk analysis and risk evaluation of investment at RWE Rheinbraun (2)

Corporate planning
Planning calculations performed for the company covering a period of up to 50 years (corresponding to the life of the mines and power plants) in the form of external accounting, i.e. including
- income statement
- balance sheet
- cash flow statement
and including/excluding the new investment project.

Risk management
Permanent process covering all risk factors that are relevant to lignite production and power generation in the form of continuous monitoring and evaluation of the defined risks.
Conclusions: Demands on Energy Policy

- Support necessary a power plant renewal in order to prevent capacity shortages
  - Investment leeway restricted by liberalization must not be further reduced by additional state control
  - Political boundary conditions must be created to ensure long-term planning and investment certainty

- Give CO₂ reduction a sustainable shape through balanced targets geared to market conditions
  - Efficiency increase is the best route towards CO₂ reduction
  - New technology for old power plants brings max. reduction, not the latest and highest-cost frontier technology
  - Innovative technologies need financial support
  - One-sided CO₂ penalty favours gas and nuclear energy but does not solve the problem of energy supply

- Ensure fair competition through uniform European environmental standards and regulations
  - Power is freely transportable; therefore, uniform environmental boundary conditions are especially important to avoid misallocation