Strategic Perspectives of Clean Coal Technology

referring to Efficiency, Cost and Regulatory Issues

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Political Targets in the EU 27

Energy
- 20 % Efficiency Increase
- 20 % Renewables in Energy Sector
- to be achieved in 2020
  and
- de-carbonised in 2050

Economy
- most powerful ↔ de-industrylised
Environment for Clean Technologies for Coal

- Regulatory Issues
- Characteristics coming Demand Pattern
- Development Potential
- Environmental Impact
- Economic Constraints

Criteria for Setting Priorities
EU Situation → Fossil Power Plant Efficiency

Commissioning year

Total Efficiency (%)
the conventional Power Plant Fleet in the EU 27 is aged → Need for the build-up of new Power Plants

EU 27 Structure Power Plants in terms of Age

<table>
<thead>
<tr>
<th>Year of Commissioning</th>
<th>Flexibility of new Power Plants - Comparison</th>
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</thead>
<tbody>
<tr>
<td>2005</td>
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<td>2000</td>
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<td>1995</td>
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<td>1990</td>
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<td>1970</td>
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<tr>
<td>1965</td>
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<td>1960</td>
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...are we able to cope with the challenge?

- Sprinting
- Lurking
- Gliding, diving and rising

Gas capacities offer quick start-up possibilities. Thermal load is expensive. Gas remains cool in summer peaks, even in winter markets.

New coal capacities can be dispatched with 12% of rated output. The plants can profitably react to high prices over a period of temporally high demand.

Although designed for the long-run main, nuclear plants and newighter plants can be dispatched flexibly and can be operated to provide surplus load.
Generation and Grid Interaction

Examples for different intermitting Generation Input to the System for different wind conditions

exemplary case

Source: Fraunhofer IWES
Challenges → Impact of Increase of RES for Supply System

I. very large Fluctuation Range, in the future partly Excess of Electricity

II. extremely huge Load Gradient

III. enduring „Flauten“ to be bridged

Data Source: ISET

today available Pump Storage Capability in Germany
CO₂ Efficiency, Emissions and Fuel Consumption

CO₂ reduction potential of coal-fired power plants¹ by increased efficiency

1) Average data for hard coal-fired power plants
Power Plant Concepts – an Overlook time of technical maturity & efficiency potential

<table>
<thead>
<tr>
<th>Plant Concept</th>
<th>state of the art</th>
<th>2020</th>
<th>2025</th>
<th>2030+</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Combustion</strong></td>
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<tr>
<td>conventional process</td>
<td>46</td>
<td>51</td>
<td>53</td>
<td>53+</td>
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<tr>
<td>CO₂ capture by MEA in flue gas</td>
<td>38…42</td>
<td>39…43</td>
<td>.43+</td>
<td></td>
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<tr>
<td>Oxyfuel - cryo air separation</td>
<td>39…43</td>
<td>45…48</td>
<td></td>
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<tr>
<td>Oxyfuel - membrane air separation</td>
<td></td>
<td></td>
<td></td>
<td>50+</td>
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<tr>
<td><strong>CCGT</strong></td>
<td></td>
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<tr>
<td>conventional process</td>
<td>60</td>
<td>62</td>
<td>63</td>
<td>66+</td>
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<tr>
<td>CO₂ capture by MEA in flue gas</td>
<td>48…52</td>
<td>51…55</td>
<td>56…60</td>
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<tr>
<td>O₂ combustion - membrane air separation</td>
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<td></td>
<td></td>
<td>61+</td>
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<tr>
<td><strong>IGCC</strong></td>
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</tr>
<tr>
<td>conventional process</td>
<td>43…46</td>
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<td>54…57</td>
<td>62+</td>
</tr>
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<td>50…55</td>
<td></td>
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<tr>
<td>gasification - membrane air separation</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Source: Cooretec
Efficiency increase of Power Plants

Fraction of Efficiency increase in Coal fired Power Plants in the period of 1985 - 2000

- Turbine efficiency: 2.0
- Kondensator pressure: 1.5
- Prozess optimisation (Fdw. preheating,...): 2.0
- Steam parameter: 0.4
- Feedwater temperature: 0.7
- Steam generator (Δp, P_{el}, T_{Exhaust}): 0.6

Basis: 38%


**VGB Activities**

**Technology Area**

- **Topics**
  - future Requirements for Power Plants (flexibility & more)
  - System Stability - Integration RES into the Supply System
  - Scenario Analysis Energy Roadmap 2050
  - Consolidation 600°C Materials (T24 and others)
  - COMTES+ for 700°C Technology
  - Emission Issues as Mercury, NOx and others
  - Utilisation of Biomass
  - Residuals as Gypsum and Fly Ash

- **Organisation**
  - embedded in the Committee Structure
  - activating Emax Steering Committee
Car Pilot Learning 1st Generation

Car Pilot Learning 2nd Generation

Pilot Demo

Demo HWT II ENCIO COMTES700 CC + efficiency engineering PP 700

Pilot Demo CC + efficiency efficiency

Learning process

Demonstration

Commercial Deployment

2010 2020 2030
VGB Activities

in pursuing the Development of Clean Coal Technologies

- Material Research
- NRW Reference Plant \(\rightarrow\) state of the art
- AD700/COMTES700 \(\rightarrow\) component test
- COMTES+ \(\rightarrow\) ENCIO & HWT II
- ZEP Technology Platform \(\rightarrow\) CCS Issues
Materials for Waterwalls

Mean Creep Rupture Strength Values 100,000 h

![Graph showing creep rupture strength values for different materials over temperature](image-url)
Materials for Header and Piping

Mean Creep Rupture Strength Values 100,000 h

![Graph showing mean creep rupture strength values for different materials.](image)
pulverised Coal Plant Technology

*state of the art Technology* → 600 °C

*advanced USC/Ni Alloys* → 700°C
NRW Reference Plant
principal Design Data

- Gross capacity: 600 MW
- Type of boiler: Tower-type boiler with vertical tubes and steam coil air heater
- Heat recovery: Utilization of mill air heat recuperation
- Flue gas discharge: Discharge via cooling tower
- Turbine model: H30-40 / M30-63 / N30-2 x 16 m²
- Main steam parameters: 285 bar / 600°C / 620°C
- Condenser pressure: 45 mbar
- Generator: Water/hydrogen cooling
- Feed water heating stages: 8 feed water heaters + external desuperheater
- Feed water final temperature: 303.4°C
- Feed water pump concept: 3 x 50% electric motor-driven feed water pumps, variable-speed drive with planetary gearing
Figure 8.2: Tower boiler.

Figure 8.1: MPS mill and DS burner.

- Evaporator/superheater - vertical tubing: 7CrMoVTiB 10 10
- Superheater Ü1 support tube partition: HCM 12
- Superheater Ü2: Super 304 H or TP 347 HFG
- Superheater Ü3: HR3C or AC 66
- HP outlet header: P92
- Reheater ZÜ1 Outlet: 7CrMoVTiB 10 10, HCM 12
- Reheater ZÜ2: HR3C or AC66
- Reheater outlet header: P92
Host Plant - Scholven F, E.ON

- **Net output**
  - 676 MW

- **Live-steam**
  - 220 bar (design pressure)
  - 540 °C
  - 625 kg/s (2,250 t/h)

- **Reheater-steam**
  - 44 bar
  - 540 °C
  - 568 kg/s (2,044 t/h)

- **Fuel**
  - Hard coal
Pre-Engineering Study PP 700

*Principal Objectives & Tasks*

- definition of reference case
- concentration on the 700 °C relevant issues
- implementing the experiences (AD 700, Marcko, COMTES700)
- detailed analysis where necessary
- concept ready for Demo 700 PP
- inclusive credible parts for *capture ready*
Condition for Investments in the Electricity Sector

→ influencing factors

- market regulations → PPA or spot market
- financing conditions
- cash flow
- licensing procedure
- infrastructure
- owner´s engineering
- project structure → turn-key or lot-wise
- supplier´s issues
- fuel prices → long term perspective
..which Perspective?
Politics - Investor

...to analyze/evaluate $\rightarrow$ Options of different Policies

Cost capex/opex as a f(time)
Time Line when/what/how much
RES subsidies cost (capex/opex)

$\rightarrow$ Obstacles = system stability/ transmission & distribution

★ to be identified!

GDP = Market Consequences
$\rightarrow$ Cost! Security! Affordability! Sustainability!
Impact of low Load Factor on Generation Cost

Levelised Cost of Electricity exemplarily as function of the load factor in terms of operation hours

- Impact of CO₂ Certificate Cost (=20 €/t)
- Impact of Capacity Markets

Hard Coal new (zero paid off)
lev Cost of Electricity

**conventional** Power Generation

EUR/MWh

- Gas open cycle
- Gas CC GT
- Hard coal 600
- Lignite 600
- Hard coal 700*
- Lignite 700*
- HC-700 + CCS
- HC-600 + Bio-cofiring
- Nuclear EPR 1600*
- Pumped storage**

- Invest costs
- O&M costs
- Fuel costs
- CO2 costs***

* for >2015
** without pumping costs
*** with CO2 costs 30 EUR/t
Global electricity production by fuel and scenario, 2003, 2030 and 2050

Outlook business as usual
Outlook with active measures

IEA Energy Outlook 2006
Power Plant Trends
Diverse technologies and emerging markets

Drivers leading to the “triple” investment wave - R.E.R
Replacement in established markets + Investment in Emerging countries + Renewables
Conclusion

- **even** in a RES-driven Power Generation → **Need** for back-up Power Generation
- **absolute Must** for R&D Activities for Coal
- **burden sharing** is the first Choice → Cooperation
- **Consistency** of Regulatory Framework → basis for economic Viability
Thank you for your Attention