Challenges and opportunities for Clean Coal Technologies in Europe and Germany

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We have **484 members in 35 countries**, over 90% are European based.

- We represent an installed capacity of **458 GW** based on this energy mix:

  - Fossil
  - Nuclear
  - Renewables

VGB is the International Technical Association for Heat and Power generation and storage. Founded in 1920 it is based on a voluntary association of companies active in the energy business.
Over 1,700 experts are active in the VGB network.

VGB facilitates the exchange of experiences between the experts and document and disseminate the results for the benefit of all members.
Agenda

1. The present: European power generation 2016

2. The future: European energy policy framework

3. The challenges: flexibility, compliance and survival

4. Conclusion
1. The present: European power generation 2016

Key changes from 2015 to 2016

1. Gas replaced coal, and hence European power sector emissions fell drastically by 4.5%.

2. Renewables increased only slightly from 29.2% to 29.6% of the electricity mix, mainly due to bad solar and wind conditions.

3. Electricity consumption rises slightly by 0.5%, with European GDP rising by 1.7%.

4. The structural oversupply of the EU-ETS has passed the landmark of 3 billion tonnes of CO2 (2016 + 255 mil. tons CO2).

5. The outlook for 2017 is for further significant falls in fossil generation – but whether this is coal or gas is uncertain.
1. The present: European power generation in 2016

- Gross power production: ~ 3.211 TWh


More than 50 % of nearly unchanged RES is coming from volatile sources. Significant shift from coal (down by 12 %) to gas (up by 20 %).
1. The present: European generation capacity in 2016

- Installed net capacity ~ 1050 GW (thereof 450 GW RES)

- In 2016 wind energy capacity has increased by 12.5 GW with investments of approx. 27.5 bill. EUR. It is followed by solar PV with + 7.3 GW.
- Coal power has seen shutdowns of 8 GW of capacity.

2007: Wind overtakes fuel oil as the 5th largest form of power generation capacity.
2013: Wind overtakes nuclear as the 4th largest form of power generation capacity.
2015: Wind overtakes hydro as the 3rd largest form of power generation capacity.
2016: Wind overtakes coal as the 2nd largest form of power generation capacity.

Source: WindEurope
1. The present: European power generation mix 2016

Based on a very heterogenous generation mix in the individual EU countries political targets and transformation speed will remain significantly different.
1. Consequences of German “Energiewende”: Profitability

The profitability of conventional power plants, even on marginal costs, has deteriorated because of lower prices and reduced operating hours.

Source: EEX, BDEW
1. Trend analysis of unavailability in HC plants > 200 MW in Germany

In Germany not postponable unavailability has seen a sharp increase but stabilizes according the latest trend. Planned measures have been reduced but recover.
1. What is VGB’s operational experience?

Example:
explosion of boiler circulation pump 12 May 2014 KW Staudinger Unit 5

1. “Gut feeling”: Increasing number of incidents and damages
2. Especially at components “inconspicuous” over decades and not in the focus of monitoring and maintenance
3. Yet no clear reference to more flexible operation. Other contributing factors could be ageing of plants and reduced maintenance efforts.
4. Other VGB-activities: R&D projects e.g. on boiler circulation systems, consultancy

source: Dr. M. Bader E.ON Anlagenservice MPA-Seminar 2015
1. The present: European power generation 2016

2. The future: European energy policy framework

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2. The future: Energy Policy Framework in Europe

<table>
<thead>
<tr>
<th>2020</th>
<th>-20% Greenhouse Gas Emissions</th>
<th>20% Renewable Energy</th>
<th>20% Energy Efficiency</th>
<th>10% Interconnection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>at least 40% Greenhouse Gas Emissions</td>
<td>at least 27% Renewable Energy Consumption</td>
<td>at least 20% (indicative) Energy Efficiency</td>
<td>15% Interconnection</td>
</tr>
<tr>
<td></td>
<td>- 43% reduction from ETS - 30% reduction from non-ETS</td>
<td>* Implies 45% RES in power generation</td>
<td>(to be reviewed by 2020)</td>
<td></td>
</tr>
</tbody>
</table>

Source: Eurostat
Reference year for CO₂-reduction: 1990

Future energy market design?
Will there be an energy-only-market or a capacity market or both?

Development of the Emission Trading Scheme?
Will the introduction of a market stability reserve revive the CO₂-market?

Increased importance of security of supply?
Is there a conflict between the dependence on gas and European foreign policy?

The EU reference scenario based on the 20/20/20 climate targets is showing a significant decrease of coal based generation until 2050 from 24 to 7%.
Based on typical life times approx. 50 % of the European power plant fleet will be decommissioned until 2035 (>2%/a). Shutdowns due to missing economics will add on. Current new build projects only cover approx. 60 % of this capacity loss.
2. The future: VGB Project 388 – Necessary investments until 2045

Significant need for investments of up to 40 bill. EUR/a until 2025 and 40-80 bill. EUR/a until 2035. (40 bill. EUR ~ 5.165 bill. Yen)

Major share of wind and PV but significant investments in gas-fired backup plants necessary. Nuclear and CCS as alternative options in some countries.
2. The future: One Europe – different countries

- **Coal**
  - EXIT in UK, Denmark (conversion to biomass), Netherlands (?), Germany (?)
  - SUPPORT in (South) Eastern Europe e.g. Poland, Czech, Serbia, Turkey
  - BAN for new build after 2021 (EURELECTRIC initiative 2017)
  - STOP of major R&D initiatives for A-USC technologies

- **Nuclear**
  - EXIT in Germany
  - SUPPORT in Finland, France, Switzerland, SEE e.g. Poland, Turkey

- **RES**
  - SUPPORT in all countries but very different supporting schemes, speed, shares

- **CCS**
  - SUPPORT e.g. Norway, Netherlands, UK (few projects progressing)
  - BAN in Germany for storage, shift towards CCU and other industries

- **IGCC**
  - no major projects under development due to market conditions
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4. Main challenges for coal fired power generation

1. Increase flexibility of equipment and plants to better backup fluctuating RES generation.

2. Comply to further stringent emission reduction directives, e.g. new BREF LCP ELV’s from 2021 on.

3. Adapt maintenance strategies to reduce costs for improving plant position in merit order and thus increase operating hours.

4. Implement new skills and training concepts to ensure efficient and optimized operation and maintenance.

5. Prepare for implementing technologies to further increase of efficiency and stabilizing availability & reliability.
Achieving system stability is key to a successful energy transition. Therefore a flexible conventional power plant fleet is essential.
### 4. Flexible operation – new technologies, processes and skills

**Technology:**
- ensure proper instrumentation and condition monitoring
- implementation of advanced control and diagnostics
- adjustment of the key components or systems
- replacement or modification of components or systems

**O&M:**
- new control and data strategies
- new operation regime affecting all areas of the plant
- need to develop preservation concepts
- adjustment of maintenance strategies
- adjustment of shift-planning, staffing and organisation
- re-assessment of coal-supply and by product strategies

**Skills:**
- flexible technologies and processes go along with high level of automation – training is essential
- familiarise the staff with new requirements arising from flexible operation
- define new requirements and re-work job profiles
- long-term training strategies need to be developed for all types of personnel

Flexible operation has an impact on all aspects of power plant operation. A high level of automation with advanced control is key for any efforts towards flexibilization.
4. What does flexible operation mean?

Minimum load operation
- important for the provision of residual load and for fast start up in case of high demand (e.g. two-shifting)
- more economic than shut-down of the whole plant

Advanced dynamics by high ramp rates
- high ramp rates ensure a fast reaction to changed market condition
- power plants with dynamic cycling abilities can participate in different markets

Short start-up and shut-down
- Short start-up and show-down times are beneficial to quickly respond to according market requirements (e.g. two-shifting)
- thermal stress during start and stop are most severe and causes life time consumption

Flexible operation aims at achieving low minimum load, high ramp rates and fast start and stop time. According measures might contribute to one or more targets.
4. Flexibility parameters of thermal power plants

Main flexibility contributors are: **high load gradients, low minimum load, short ramp-up times**

<table>
<thead>
<tr>
<th>Plant type</th>
<th>Hard-coal</th>
<th>Lignite</th>
<th>CCGT</th>
<th>Gas Turbine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load gradient [% / min]</td>
<td>2 / 4 / 8</td>
<td>2 / 4 / 8</td>
<td>4 / 8 / 12</td>
<td>8 / 12 / 15</td>
</tr>
<tr>
<td>in the load range [%]</td>
<td>40 to 90</td>
<td>50 to 90</td>
<td>40* to 90</td>
<td>40* to 90</td>
</tr>
<tr>
<td>Minimum load [%]</td>
<td>40 / 25 / 15</td>
<td>60 / 40 / 20</td>
<td>50 / 40 / 30*</td>
<td>50 / 40 / 20*</td>
</tr>
<tr>
<td>Ramp-up time Hot start &lt;8 h [h]</td>
<td>3 / 2 / 1</td>
<td>6 / 4 / 2</td>
<td>1.5 / 1 / 0,5</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>Ramp-up time Cold start &gt;48 h [h]</td>
<td>7 / 4 / 2</td>
<td>8 / 6 / 2</td>
<td>3 / 2 / 1</td>
<td>&lt; 0.1</td>
</tr>
</tbody>
</table>

*Source: VDE and own studies
usual value / state of the art / potential
*as per emission limits for NOx and CO

Thermal power plants are able to significantly contribute to a modern energy system. Technology development is focused on realising the flexibility potentials.
### 4. Market driven impacts on O&M strategies

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Must-run (contractual)</th>
<th>Market follower</th>
<th>Reserve</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>operation according to customers' needs for electricity and/or heat</td>
<td>market prices rule the power operation</td>
<td>operation on demand of the TSO</td>
</tr>
<tr>
<td>Availability</td>
<td>&gt; 90 %</td>
<td>&lt; 80 %</td>
<td>not important</td>
</tr>
<tr>
<td>Utilisation</td>
<td>70 – 80 %</td>
<td>35 – 50 %</td>
<td>1 – 5 %</td>
</tr>
<tr>
<td>Maintenance approach</td>
<td>• preventive maintenance in wear-intensive areas (mills, boiler, FG-cleaning)</td>
<td>• risk-based maintenance</td>
<td>• condition based maintenance</td>
</tr>
<tr>
<td></td>
<td>• condition based maintenance</td>
<td>• advanced condition monitoring</td>
<td>• frequent plant tests and start-ups to secure reliable operation if requested</td>
</tr>
<tr>
<td></td>
<td>• overhaul cycles and durations are time-dependent</td>
<td>• overhaul cycles are cost-optimised and based on equivalent operating hours</td>
<td>• long stand-stills</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• longer stand-stills</td>
<td>• need for a concept to maintain know-how</td>
</tr>
</tbody>
</table>

Source: VGB based on Uniper

The operational regime remains stable over the contractual period for must-run and reserve power plants. Market followers suffer from increased lifetime consumption.
4. Conclusion

→ European energy politics are reducing the share of coal fired generation in the upcoming decades in favour mainly of gas and RES.

→ Coal new build have become very unlikely in the future. CCS will be only an option in some countries and some industries.

→ A changed market environment is leading towards a significant more flexible operation regime of conventional power plants. Flexible technologies are available for new builds as well as for existing assets.

→ VGB statistics up to now are showing only rudimental consequences on availability of plants and reliability of components.

→ VGB experiences nevertheless reveal an increasing number of incidents and damages. In most cases an unambiguous assignment to more flexible operation could not be construed. Ageing plants and cut O&M budgets are other potential contributing factors.

→ Further R&D efforts in conventional generation technology are necessary to better understand the effects of flexible operation and further reduction of emissions.
Thank you for your interest!

ご清聴ありがとうございました。

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