Introduction into the German Energy Market and Overview of flue gas cleaning technologies and recycling of residuals
Kolkata, Raipur, Hyderabad, November 2016
Dr. Claudia Weise
1. Who is VGB?

2. Framework and German energy market

3. Overview of flue gas cleaning – coal, technologies and framework

4. Overview of recycling of residuals

5. Conclusions and outlook
1. VGB PowerTech – who we are

Our mission is…

- 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 European Competence Center of Heat and Power Generators. Founded in 1920 it is based on a voluntary association of companies active in the energy business.
1. VGB PowerTech – how we work

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.
1. Long-term co-operation with India
2. Energy Policy Framework

**20/20/20 targets:** CO₂ emission reduction, efficiency increase, share of renewables by 2020

- 40% CO₂-reduction target, share of renewables of 27% of energy consumption, 27% efficiency increase by 2030 framework
- Reduction of greenhouse gases by 40% in 2020, by 80% in 2050
- Phase-out of nuclear power by 2022
- Increase of the share of renewables up to 80%, reduction of primary energy consumption by 50% and decrease of electricity consumption by 25% in 2050

Reference year for CO₂-reduction: 1990

Source: Eurostat
2. Germany as an energy role model

Power generation in Germany in 2015

- Installed capacity: 201 GW
- Gross power production: 652 TWh

- Lignite: 23.8%
- Nuclear: 14.1%
- Hard Coal: 18.1%
- Fuel Gas: 9.1%
- Fuel Oil: 0.8%
- Others: 4.0%
- Renewable: 30.1%
  - Wind: 34.2%
  - Solar: 20.5%
  - Hydro: 13.9%
  - Biomass: 27.9%
  - Waste: 3.6%

In 2015 for the second time renewables have outscored lignite as No. 1 electricity generation source.
The profitability of conventional power plants, even on marginal costs, has deteriorated because of lower prices and reduced operating hours.

Source: EEX, BDEW
2. What have been drivers in power generation?

- Economy
- Environment
- Security of Supply

Drivers over time:
- 1950
- 1960
- 1970
- 1980
- 1990
- 2000
- 2010
- 2020
3. Development of Emissions in Germany

Changes in % in emissions compared to the base line 1990/1995

Quelle: Umweltbundesamt, Nationale Trendtabellen für die deutsche Berichterstattung atmosphärische Emissionen seit 1990, Emissionsentwicklung 1990 bis 2014 (Stand 03/2016)
3. Development of Emissions in Germany

Sulfur emissions in k-tons dedicated to their originator

Quelle: Umweltbundesamt, Nationale Tendenzübersichten für die deutsche Berichterstattung atmosphärischer Emissionen seit 1990, Emissionsentwicklung 1990 bis 2014 (Stand 03/2016)
### 3. Development of emission limits of new builds

<table>
<thead>
<tr>
<th>mg/m³ N₄dry @6% O₂</th>
<th>Germany: 13th BImSchV 1983 &gt; 300 MW</th>
<th>Germany: 13th BImSchV 2004 &gt; 300 MW</th>
<th>EU: IED 2010 &gt; 300 MW</th>
<th>Germany: 13th BImSchV 2013 &gt; 300 MW</th>
<th>India: regulation as of Dec 7, 2015 &gt; 500 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM</td>
<td>50</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>CO</td>
<td>250</td>
<td>200</td>
<td>-</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>SOₓ</td>
<td>400 + 85% DR</td>
<td>200 + 85% DR</td>
<td>200 + 97% DR</td>
<td>150 + 85% DR</td>
<td>100</td>
</tr>
<tr>
<td>NOₓ</td>
<td>200</td>
<td>200</td>
<td>150</td>
<td>150 100*</td>
<td>100</td>
</tr>
<tr>
<td>Hg</td>
<td>-</td>
<td>0.03</td>
<td>-</td>
<td>0.03 0.01*</td>
<td>0.03</td>
</tr>
<tr>
<td>Dioxin/ Furan</td>
<td>-</td>
<td>0.1 ng/m³</td>
<td>-</td>
<td>0.1 ng/m³</td>
<td></td>
</tr>
</tbody>
</table>

BImSchV: Bundes-Immissionsschutzgesetz-Verordnung (German immission legislation)
DR: Deposition Rate
IED: Industrial Emission Directive
EU: monthly average; Germany: daily average but * means annual average
India: units installed **after Jan 1, 2017**
## 3. Future challenges: BREF LCP 1/2

### Requirements for the use of solid fuels in existing Large Combustion Plants

<table>
<thead>
<tr>
<th>Air pollutant mg/m³</th>
<th>IED Annex V</th>
<th>Preliminary-Draft 06/2015 BAT-AEL (YA) &gt;300 MW</th>
<th>Preliminary-Draft 06/2015 BAT-AEL (DA) &gt;300 MW</th>
<th>India: regulation as of Dec 7, 2015 &gt;500 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO₂</td>
<td>200</td>
<td>Pulverised coal: 10 – 130</td>
<td>Pulverised coal: 25 – 165</td>
<td>200 / 200</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FBC: 20 - 180</td>
<td>FBC: 50 - 220</td>
<td></td>
</tr>
<tr>
<td>NOₓ</td>
<td>200</td>
<td>FBC, lignite: 85 – 175</td>
<td>FBC, lignite: 140 – 220</td>
<td>600 / 300</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other: 65 - 150</td>
<td>Other: 80 – 220</td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>no limit value</td>
<td>FBC, lignite: 5 – 100</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hard coal: 5 – 100</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CO just indication, no BAT-AEL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM</td>
<td>20</td>
<td>300 – 1000 MW: 2 – 12</td>
<td>300 – 1000 MW: 3 – 20</td>
<td>100 / 50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 1000 MW: 2 – 12</td>
<td>&gt; 1000 MW: 3 – 14</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt; 2 – 8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

YA = yearly average, DA = daily average
### 4. Future challenges: BREF LCP 2/2

#### Requirements for the use of solid fuels in existing LCP

<table>
<thead>
<tr>
<th>Air pollutant</th>
<th>IED Annex V &gt; 300 MW</th>
<th>Preliminary-Draft 06/2015 BAT-AEL (YA) &gt;300 MW</th>
<th>India: regulation as of Dec 7, 2015 &gt;500 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia</td>
<td>no limit value</td>
<td>&lt; 1 – 10</td>
<td></td>
</tr>
<tr>
<td>HCl</td>
<td>no limit value</td>
<td>&lt; 1 – 5</td>
<td></td>
</tr>
<tr>
<td>HF</td>
<td>no limit value</td>
<td>&lt; 1 – 3</td>
<td></td>
</tr>
<tr>
<td>Mercury</td>
<td>no limit value</td>
<td>Hard coal (YA): 1 – 4 µg/m³ Lignite (YA): 1 – 7 µg/m³</td>
<td>0.03 mg/m³</td>
</tr>
</tbody>
</table>

**Notes:**
- 
- 

### 3. Coal composition used in German power plants

<table>
<thead>
<tr>
<th>Type of coal</th>
<th>Calorific value [kJ/kg]</th>
<th>Ash content [%]</th>
<th>Water content [%]</th>
<th>Sulphur content [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lignite – GER Rhineland</td>
<td>7,800 – 10,500</td>
<td>2.5 – 8.0</td>
<td>50 – 60</td>
<td>0.15 – 0.50</td>
</tr>
<tr>
<td>Lignite – GER Lusatia</td>
<td>7,800 – 9,500</td>
<td>2.5 – 16.0</td>
<td>48 – 58</td>
<td>0.30 – 1.50</td>
</tr>
<tr>
<td>Lignite – GER Central Germany</td>
<td>9,000 – 11,300</td>
<td>5.0 – 20.0</td>
<td>40 – 50</td>
<td>1.00 – 3.00</td>
</tr>
<tr>
<td>Hard coal</td>
<td>~25,000</td>
<td>7.0 – 15.0</td>
<td>9.0 – 12.0</td>
<td>&lt; 1.0</td>
</tr>
</tbody>
</table>

**Differences to Indian coal:**

- lower ash content
- calorific value in the same range
- less water content
3. Flue Gas Cleaning Technologies

Best Available Technology

Steam Generator

NH₃ -Dosing

DENOX Plant

Air Heater

Stack

Dust Removal

Regenerative Gas Heater

FGD

Power Plant with SCR „high dust“, dust removal and FGD
3. Examples of VGB-work / Flue gas cleaning

- Flow Correlated Positioning of Spray Nozzles in Flue Gas Scrubbers
- Description of the Interaction of Liquid Layer and Flue Gas Flow on the Walls and Inserts of Flue Gas Desulphurisation Plant Scrubbers
- Optimisation of Wet Hg Capture from Flue Gases of Coal-fired Power Plants in the Case of Co-combustion of Mercury-rich Secondary Fuels
- Optimisation of a Condensing Wet Electrostatic Precipitator for Particulate Matter and Aerosol Separation

- VGB-Guideline R 302: Guideline for the testing of DENOX-catalysators
- VGB-Standard S 015: Type, Operation and Maintenance of Flue Gas Desulphurisation Plants (FGD)
- VGB-Standard S 014: Type, Operation and Maintenance of Flue Gas DENOX Plants (only in German)
3. Mercury-debate in Germany

VGB-Initiative „Hg^{cap(ture)}“

Further reduction of mercury emissions from coal-fired power plants

The VGB Initiative Hg^{cap} pools know-how and ensures transparency by:

→ Objectifying the debate

→ Public relation and transfer of information

→ Development of further reduction technologies for mercury emissions

→ Joint activities for the research and testing of new and existing removal technologies

→ Ensuring knowledge and experience exchange with science and politics

→ Professional support of the legal implementation for setting future limits on the basis of BREF-LCP with reasonable period for the implementation of appropriate and effective procedures
4. Recycling of residuals – an overview

The majority of the residuals (boiler slag, bottom and flue gas ash, gypsum) is utilised in construction and building value chains.
4. Recycling of residuals – an overview

Utilisation, temporary stockpile and disposal of residuals of coal fired power plants in Europe (EU 15) in 2013
4. Recycling of residuals – fly ash quantities

Development of fly ash production from hard coal and lignite in Europe (EU 15) from 1993 to 2010

22.8 Mio tons in 2014 in German coal fired plants
Utilisation of fly ash in the construction industry and in underground mining in Europe (EU 15) in 2013
4. Recycling of residuals – gypsum utilization

Utilisation of FGD Gypsum in the construction industry in Europe (EU 15) in 2013 in million tonnes

- Plaster Boards: 62.9%
- Projection Plaster: 8.9%
- Set Retarder: 8.5%
- Self Levelling Floor Screeds: 16.1%
- Gypsum Blocks: 3.2%
- Other: 0.5%

(total utilisation 8.2 million tonnes)
4. Examples of VGB-work / Utilisation of residuals

- Avoidance of Alkali Reactions by Fly Ash – Examinations of concretes during long-term storage
- Avoidance of Alkali Silica Reaction (ASR) by Fly Ash due to External Alkali Supply - long term behaviour
- Further Investigations of the Sulphate Resistance of Fly Ash Concrete
- VGB runs the secretariat of the European Coal Combustion Products Association e.V

- VGB-guideline M701e: Analysis of FGD-gypsum
- VGB-work is considered in relevant norms and standards such as:
  - EN 197-1 Composition, specifications and conformity criteria for common cements
  - EN 450-1 Fly ash for concrete: Definition, specifications and conformity criteria
  - EN 13282 Hydraulic road binders : Rapid hardening hydraulic road binders - Composition, specifications and conformity criteria
5. Program of the workshop

- Dr. Dirk Porbatzki, Uniper
- Matthias Schneider, Steag

- Dr. Annette Ziemann-Nöthe, Doosan
- Dr. Frank Delle, Steinmüller Babcock
5. Conclusions and outlook

→ Flue gas cleaning technology has been in operation for decades in Germany: wet FGD and ESP are the most common technologies in Europe

→ The majority of residuals (ash and gypsum) is utilised in the construction and building industry

→ Solid framework regarding legislation, norms and industry guidelines are essential

→ EEC is an ideal platform to share experiences and lessons learnt; e.g. guideline for implementation of FGD in existing plants, reference concepts for new builds; train-the-trainer programs would also provide valuable assistance

VGB is eager to support these activities together with the EEC as an important platform generating solutions for the Indian power sector.
धन्यवाद

Thank you for your interest!

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