Future Power Plant Requirements

2nd Colloquium of the Munich School of Engineering
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Structure

1. Current situation and future development
2. Future power plant requirements
3. Role of the electricity market
4. Flexibility of power plants
5. Challenges in energy supply
6. Conclusion
1. Current situation and future development
1. Current situation and future development

Capacity and power generation in Germany 2010

- Nuclear: 13%
- Coal: 33%
- Gas: 14%
- Oil: 1%
- Pump storage: 1%
- Other: 3%
- Renewable: 3%

Sum = 168 GW

- Nuclear: 16%
- Coal: 23%
- Gas: 14%
- Oil: 1%
- Pump storage: 1%
- Other: 16%
- Renewable: 42%

Sum = 621 TWh

Power plant characteristics:

Full load hours (calculated): 3705 h/a

Utilisation: 42 %/a

Source: BMWi

Speaker: Christian Schuhbauer, Institute for Energy Systems
1. Current situation and future development

Source: BMWi, Bundesnetzagentur

Speeker: Christian Schuhbauer, Institute for Energy Systems
2. Future power plant requirements
2. Future power plant requirements

Frequency stability

1) Power decrease
2) Frequency deviation
3) Primary controlling power  →  Stabilisation of frequency
4) Secondary controlling power  →  Reset the frequency to 50Hz
2. Future power plant requirements

Development of the residual load until 2020

Summer week 2011 (top)
contra
Summer week 2020 (bottom)

onshore wind: 27,2 GW → 33,3 GW
offshore wind: 0 GW → 7,6 GW
photovoltaic: 17,3 GW → 33,3 GW
2. Future power plant requirements

- Residual load decrease to 1 GW
- Increase of 3.5 GW/h
- Power plants at 30% load
  → Reserves reached after 40 minutes

More capacities are needed after 40 min without accurate prediction!!
3. Role of the electricity market
3. Role of the electricity market

Merit-Order-Effect:

1) Increase of renewables leads to lower market clearing price (MCP)

2) Load volume for conventional power is decreased
   → No more classic base load
   → Full load hours decrease
4. Flexibility of conventional power plants
4. Flexibility of conventional power plants

<table>
<thead>
<tr>
<th></th>
<th>Nuclear</th>
<th>Coal</th>
<th>Gas-CCP</th>
<th>Gasturbine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load change</td>
<td>4 – 5 %/min</td>
<td>2 – 6 %/min</td>
<td>4 – 9 %/min</td>
<td>15 %/min</td>
</tr>
<tr>
<td>During load</td>
<td>50 – 100 %</td>
<td>40 – 100 %</td>
<td>40 – 100 %</td>
<td>50 – 100 %</td>
</tr>
<tr>
<td>Primary control</td>
<td>60 %/min</td>
<td>&gt;60 %/min</td>
<td>180 %/min</td>
<td>180 %/min</td>
</tr>
<tr>
<td>Minimum load</td>
<td>20 – 35 %</td>
<td>20 – 40 %</td>
<td>15 – 50 %</td>
<td>50 %</td>
</tr>
<tr>
<td>Minimum operating</td>
<td>24 h</td>
<td>3 – 5 h</td>
<td>1 h</td>
<td>15 min</td>
</tr>
<tr>
<td>duration</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum down time</td>
<td>24 h</td>
<td>3 – 8 h</td>
<td>1 h</td>
<td>15 min</td>
</tr>
<tr>
<td>Hot start-up</td>
<td>60 – 120 min</td>
<td>80 – 150 min</td>
<td>30 – 60 min</td>
<td>A few min</td>
</tr>
<tr>
<td>Warm start-up</td>
<td>2 – 3 h</td>
<td>3 – 5 h</td>
<td>1 – 1,5 h</td>
<td>A few min</td>
</tr>
<tr>
<td>Cold start-up</td>
<td>15 – 20 h</td>
<td>5 – 10 h</td>
<td>2 – 3 h</td>
<td>Ca. 15 min</td>
</tr>
</tbody>
</table>

Source: Balling 2011 (Siemens); Steck und Mauch 2008
4. Flexibility of conventional power plants

Condensate stop for primary control

Indirect method:
- Choking condensate pump and / or condensate valves
- slower but no additional costs

Direct method:
- Additonally closing the bleeder valves
- Very quick but additional costs

Source: Zehner 2009
4. Flexibility of conventional power plants

Advantages:

- Short start-up time
- Higher load change gradients

→ BENSON Once-through operation leads to higher flexibility

Source: Siemens (Irsching)
5. Challenges in energy supply
5. Challenges in energy supply

KW 21 – BY5DE: Dynamic of the 700°C hard coal-fired power plant

- Higher electrical efficiency: Increase from 46 % to 50 %
- Higher pressures and temperatures: live steam parameters 365 bar / 705 °C
- New materials: Ni-base alloys instead of ferritic steels

Focus on:

- Influence of flue gas imbalances and fouling
- Transient behaviour during load changes and start-ups
- Durability decrease of thick-walled components caused of start-ups

Project partners:

- E.ON Energy AG
- Alstom Power Systems
- Bayerisches Staatsministerium für Wissenschaft, Forschung und Kunst
5. Challenges in energy supply – Video: Temperatur as f(boiler height)
6. Conclusion

Conventional power generation still needed for frequency stabilisation!

- Storage technologies are going forward → takes time
- Electricity network expansion too slow

Electricity market problematic for the future:

- Capacity market would be one possibility
- CCPs only economical if the provided capacity is paid

Dynamic and flexibility of conventional power plants has to be further improved to meet the necessary requirements for the future!
Backup
1. Current situation and future development

Source: Bundesnetzagentur, BMWi

Net trade in Germany 2011

Import/Export

Year

Current [TWh]

2008
2020
2030
2040
2050

import/export
conventional
renewable
consumption

Speaker: Christian Schuhbauer, Institute for Energy Systems
3. Role of the electricity market

Comparing the flexibility and costs of hardcoal-fired and combined cycle plants

Source: Jeschke 2011 (Hitachi Power)
4. Flexibility of conventional power plants

More flexibility through indirect firing
Feeding out of coal silos → mills inertia is omitted

Source: Alstom Power