Highly Flexible Fossil Power Plants as Backbone for Future Generation Portfolio

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Energy Research in Europe: Germany’s Contribution to the SET-Plan
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Agenda

- Flexibility challenge in today’s and future market
- Status:
  Operational flexibility of fossil power plants
- Way forward:
  Storage application as innovative approach to enhance flexibility
- EU dimension
R&D for Products and Solutions to Manage the Whole Energy Matrix

Central Power Plants
- Large power plants provide back-up for intermittent wind and solar
- Greater efficiency of conventional fossil power plants to meet supply gaps

Grids
- Renewable power requires stronger transmission infrastructure

Distributed Power Generation
- Innovative technologies at manifold feed-in-points
- Improved control software for market integration
- Adapted to local conditions

Prosumers
- Households both produce and consume power as small-scale market players
- Rooftop PVs and electric cars set for global breakthrough

Storage
- Key enabler for integration of renewables
- Avoid shutdowns and enhance grid stability
## Boundary Conditions and Challenges in Today’s and Future Energy Generation Portfolio

### Market Trends *)
- Aim to increase share of renewable energies to 35% in 2020, 80% in 2050
- Phase out of nuclear energy by 2022
- Proposed reduction of renewable subsidies

*) typical for Germany

### Technical Challenges
- Fluctuating renewable sources
- Lack of dispatchability
- Not continuously available
- Challenge of forecast accuracy

### Economic Perspective
- High price fluctuations daily and over the year

### Market Trends
- Continuous increase of renewable Fleet
- Continuous demand for reliable fossil generation backbone
- Challenge to flexibility and profitability of fossil power plants

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*EEX price €/MW (July 16, 2011)*

*EEX price €/MW (Feb. 6, 2012)*

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*Energy Research in Europe: Germany’s Contribution to the SET-Plan, 19 Mar 2012, Dr. Vortmeyer*
Combined Cycle Power Plants – Operational Flexibility at Highest Efficiency

- Highest efficiency throughout the whole load range
- Optimized start up and shutdown operation

- Fast starts
- Load ramps
- Park load

- Load ramps
- Stable operation in case of grid incidents
- Backup power

- More than half a GW in less than half an hour
- Down-load to minimum or shut-down in less than 30 minutes
- Load changes of more than 200 MW in less than 7 minutes
Steam Power Plants –
Change in Design Philosophy

Leaving Base Load ...
Future Steam Power Plants will be operated mainly in part load (~ 50 to 90%).

Component and plant design to achieve highest efficiency not longer focused on 90 to 100% load.

Measures to increase part-load efficiencies are available, e.g.
- Part-load design applying modifications at ST
- Increasing main steam temperatures at part load (@ constant mechanical load of piping, casing, valves, etc.),
- Increasing the final boiler feed water temperature (additional pre-heating at part-load operation),
- Combustion control (mitigation of CO peaks at part-load)

Principle potential also for retrofitting.
<table>
<thead>
<tr>
<th>Large-scale electricity storage options and technical feasibility</th>
<th>Concepts to integrate storage and existing fossil plant infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Compressed Air (CAES)</strong></td>
<td>✓ combination questionable?</td>
</tr>
<tr>
<td></td>
<td>✓ loss of power plant functionality (no fossil operation)</td>
</tr>
<tr>
<td><strong>Hydrogen</strong></td>
<td>✓ use of CCPP for re-electrification</td>
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<tr>
<td></td>
<td>✓ store hydrogen into natural gas grid</td>
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<tr>
<td><strong>Electrochemical (Battery)</strong></td>
<td>✓ optimize load behavior of power plant</td>
</tr>
<tr>
<td></td>
<td>✓ higher flexibility: peak power and ramp rates</td>
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<tr>
<td><strong>Thermal</strong></td>
<td>✓ use of existing steam cycle</td>
</tr>
<tr>
<td></td>
<td>✓ steam / heat for co-generation application (CHP)</td>
</tr>
</tbody>
</table>

**Very expensive as stand-alone storage solution**

**Cost reduction by combining storage with existing fossil power plants**

*(add-on: increasing flexibility of conventional fleet)*
Hydrogen Production and Re-electrification in Existing Power Plants

Siemens PEM electrolyser
- Highly dynamic for fast response on fRE (300% over-load)
- Pressurized system for optimal storage/direct use (50 bar)
- 100 kW demonstrator(s) in 2012
- 10 to 100 MW units in 2016-2018

Storage in
- Tanks, caverns, chemicals
- Natural gas grid (current discussion of limits for all consumers – DENA, EU-Turbines)

Re-electrification by co-firing in existing gas turbines together with
- natural gas in conventional technologies (up to recent generations)
- synthesis gas in IGCC and IGCC with CCS

Applications for mobility/ industrial/ chemical processes (e.g. for fuels in combination with CO₂)
Combination of CCPP with Electrochemical Energy Storage Offers Added Customer Value

- Shorter response time of the CCPP
- Higher system flexibility
  - peak power
  - faster ramp rates
- Negative balancing power

Technical solution by innovative less-expensive electrochemical batteries required, e.g. rechargeable metal/air
Thermal Storage –
Use of Existing Plant Components

Generator in fossil power plants can be operated as electrical motor.

When turned by generator in motor operation, turbomachinery losses cause conversion of electrical energy into hot gas turbine exhaust (with efficiencies close to 100%).

- Negative energy for grid stabilization
  - Renewable power
  - Low cost electricity

Exhaust gas heat stored in a simple way; online and time-shifted use.

- Combined heat and power
- Power/efficiency boost of CCPP in generation mode
- Increased system flexibility (faster plant start-up)
Co-operation –
A Must for National and International R&D Projects

Successful innovation projects ...
... have to carefully consider
- technology
- cost
- demonstration and market introduction

... need close co-operation between
- power plant operators
- suppliers and
- research

... should be supported by
- policy decision makers
- public/private risk sharing
  (e.g. by funding)
- incentives for demonstration plants
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