Economic Power Plant Operation by post-engineering, efficient O&M and advanced monitoring – Experiences in the European power sector

4th EU - South Africa Coal and Clean Coal Working Group Meeting

Dr. Jens Reich
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Our expertise

Planning – operating – supplying – marketing – recycling

Project development, planning, operation and supply of power plants …

… in Germany and …

… abroad …

… on the basis of fossil …

… and renewable energy sources.

Marketing of electricity and district heat, and …

… recycling of power plant By-Products.

Key figures (as at Dec. 31, 2011) Sales revenue € 3,067 million Employees 5,766
Overview of O&M Services
STEAG group

O&M of STEAG assets:
– More than 20 units with a capacity of 9,000 MW
– 2 industrial power plants with 8 steam boilers rated 100 t/h
– 221 decentralized power plants with a capacity of 360 MW

O&M for third parties:
– Large power plants with a capacity of 4,500 MW
– Thereof 3 coal-fired power plants with a capacity of 3,750 MW

Total O&M Services within STEAG group: 14,000 MW
Economic Power Plant Operation means

- aiming for efficiency
- chasing the state-of-the-art
- fighting comfort, laxness and habits
- establishing improvement processes

Efficiency is a key word in context with climate change:

- Utilities (carbon footprint and capacity building / „white MW“)
- Municipal utilities (generation assets and customers)
- Industry (cost reduction)

Driven by

- economical forces (power generation costs)
- post-Durban activities
- positive „charisma“
1. Short / medium term approach
   • Optimization of operation (processes, habits)
   • Minor engineering modifications

2. Medium / long term approach
   • Optimization by implementation of monitoring systems
   • Optimization of maintenance

3. Long term approach
   • Major boiler / turbine / flue gas treatment retrofits
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1a) History and actual plant status

- **Measurement** of the unit’s characteristics like turbine and plant efficiency on a time to time basis
- **Documentation** of expended lifetime for components subject to creep rupture

Plant history forms the basis for further investigations
1b) Simulation with reference model

- **Reference heat and mass balance** of the unit’s actual state of the water-steam cycle
- **CFD-Model** of flue-gas ducts ESP and FGD in order to get flow behaviour and losses
- Reference **heat surface model** for simulation of the heat transfer behaviour of the steam generator

Reference model of the plant allows before / after comparison
2) Evaluation of plant improvement potential

- Improvement of the circuit with state-of-the-art turbine efficiencies (manufacturer’s figures)
- Improvements of preheating train and/or adjustments of boiler configuration
- Consideration of eventually decreasing auxiliary power demand due to optimized components e.g. feed water pumps

Comparison of plant improvements under consideration of side effects secures techno-economical project decision
STEAG’s participation in Energy Efficiency program of power plants in South Africa

Short / medium term approach

Quick-win heat rate improvement:

- Define baseline and refine target based on one lead plant
- Identify full set of improvement levers including operations & maintenance, minor engineering modifications.
- Determine mindsets and capability readiness to implement improvements
- Roll-out approach and improvements across fleet in waves, now in process
Plant performance is often affected by lack of maintenance, poor or non-design coal quality and habitual operating practices

**Boiler**
- Optimising of combustion process according to coal input
- Optimising of mill utilisation according to coal input
- Optimising of steam-air preheater utilisation
- Reducing of stack losses

**Auxiliary steam system**
- Reducing leakages by improved maintenance
- Optimising operation of auxiliary steam consumers

**Auxiliary steam system**
- ensuring sealing of vacuum systems
- reducing steam losses via operational drains
Economic Power Plant Operation
Wide field of range of opportunities acting

1. Short / medium term approach:
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   • Optimization of maintenance

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## 2. Medium / long term approach
Optimization of maintenance

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<th>Monitoring / Training</th>
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<td>Interface handling:</td>
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<td>Identify</td>
<td>- operations,</td>
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<td>Maintenance</td>
<td>undetected defects</td>
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<td>Budgeting</td>
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</table>

- Subsequent assessment of improvements
- Theoretical training
- Simulator training
- Practical training on the job
2. Medium / long term approach
Optimization of maintenance

Training designed on three pillars:

Know How

- Train the trainer principle, multiply efforts and enhance communication skills
- Hands on instructions at system checks and commissioning
- Theoretical classroom training
- Final evaluation of training success during overhauls / revisions of STEAG plants

Do How

- Proactive maintenance for critical equipment
- Fault clearance
- Optimization of maintenance schedules

How to do

- Motivation, Team Integration, Team Development,
- Communication, Delegation and Responsibility,
Energy Management Systems

SR::EPOS is the SR product for process quality monitoring and unit optimization

– Cyclically monitors the power plant process in technical and economic terms (every five minutes)
– Assesses plant components online and supplies
– Data for condition-based maintenance
– Suggests optimal modes of operation from an economic point of view
– Considers the influence of different, varying ambient conditions
– Optimizes the unit operation and increases its efficiency - typically by 0.1-0.3 %-points.
Economic Power Plant Operation
Wide field of range of opportunities acting

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3. Long term approach
Retrofits

**Water Steam Cycle:**
- Turbine / Condenser
- Preheating Train
- Feed Water Pumps

**Steam Generator:**
- Exchange of Heat Surfaces
- Firing System
- Mills / Classifier
- Fuel Drying Systems

**Others:**
- Cooling Tower
- Dynamics of Operation
- Frequency Control

**FGD:**
- S-Removal
- Pressure Drop
- Demister

**ESP:**
- Dust Removal
- Pressure Drop
3. Long term approach
Retrofits

**Motivation**
- original design - efficiency not state of the art, *but*
- remaining life time sufficient for further operation *or*
- life time extension of parts possible by overhaul
- gouvermental standards require process improvements

**Objectives**
- improvement of unit efficiency
- increase of power output at constant fuel input with low specific costs
- reduction of plant emissions like CO2, NOx, SOx, dust
- reduction of operation and maintenance costs

**Requirements**
- quick implementation of project
- realization during a normal long-time shut-down (maintenance) of the unit
- short payback-time
- success of measure
## 3. Long term approach

### Retrofits: Water Steam Cycle - Steam Turbines

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>Herne 3</th>
<th>Lünen 150 MW</th>
<th>Lünen 350 MW</th>
<th>West 1+2</th>
<th>Weiher 3</th>
<th>Bergkamen</th>
<th>Bexbach</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>- Installed capacity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ three-phase (TPC)</td>
<td>MW</td>
<td>300</td>
<td>150</td>
<td>350</td>
<td>2 x 350</td>
<td>680</td>
<td>747</td>
<td>773</td>
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<tr>
<td><strong>- Steam capacity</strong></td>
<td>t/h</td>
<td>910</td>
<td>520</td>
<td>940</td>
<td>980</td>
<td>2130</td>
<td>2280</td>
<td>2250</td>
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<tr>
<td><strong>- Steam conditions</strong></td>
<td>bar/°C</td>
<td>182/525</td>
<td>183/525</td>
<td>190/525</td>
<td>197/530</td>
<td>175/525</td>
<td>190/530</td>
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<tr>
<td><strong>- Measures on turbine</strong></td>
<td></td>
<td>HP/IP</td>
<td>HP</td>
<td>HP/IP</td>
<td>HP</td>
<td>LP</td>
<td>HP/LP</td>
<td>LP</td>
</tr>
<tr>
<td><strong>- Additional measures</strong></td>
<td></td>
<td>steam cond. (540 / 535 °C)</td>
<td>HP heaters</td>
<td>steam cond. (530 / 540 °C)</td>
<td>boiler-modification</td>
<td>Feed water pumps</td>
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<tr>
<td><strong>- Blading</strong></td>
<td></td>
<td>Impulse (I)</td>
<td>Impulse (I)</td>
<td>W1:R / W2:I</td>
<td>W1:R / W2:I</td>
<td>Reaction (R)</td>
<td>Reaction (R)</td>
<td>Reaction (R)</td>
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<tr>
<td>▪ before retrofit</td>
<td></td>
<td>Reaction (R)</td>
<td>Reaction (R)</td>
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<td>Reaction (R)</td>
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<td>▪ after retrofit</td>
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<td></td>
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<tr>
<td><strong>- Load increase (at 100 % load)</strong></td>
<td>MW</td>
<td>7</td>
<td>7</td>
<td>15</td>
<td>8 (each)</td>
<td>17</td>
<td>30</td>
<td>7.2</td>
</tr>
</tbody>
</table>
3. Long term approach
Retrofit of Herne unit 4 (500 MW) in 2012

Simultaneous Retrofit – Projects:

- Retrofit / Exchange HP Turbine
- Refurbishment DCS System
- Refurbishment Coal Burners
- Retrofit of Hot-Gas Generator
- Automisation of De-Ashing System
- Retrofit of a new heat extraction station
Economic Power Plant Operation requires continuous improvement

STEAG follows an integrated operation approach

- Post-Engineering: Process, Mechanical, Electrical, I&C, Project Management, QA/QC
- Operation: Maintenance Procedure and Process, training, Overhaul optimization, Virtual-Task-Force
- Systems: Monitoring of Power Plants

This integrated approach is relying on:

- Long-term Engineering know-how and expertise
- Its own experience in power plant operation and maintenance,
- Know-How in consultancy, training and engineering,
- International network, Virtual-Task-Force, Know-How exchange, e.g. VGB-PowerTech (Society of European Power Plant Operators).
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