Renovation, Modernization and Life Time Extension Measures on Steam Turbines
Sustainable Growth - Strategies for efficiency Increase

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Contents

- **Introduction**
  - Lifetime Extension Method
  - Modernization Technology
  - Upgrade Products
  - Upgrade References
R&M & LE are imperative in order to accommodate power demand

Installed Capacity (rounded)

2012

Coal
Gas
Nuclear
Hydro
Oil
Renewable

Additional Capacity

88 GW
Modified to 75 GW

R&M, LE or shut down

~200 GW

30 GW

Source: Siemens AG
Steam Plant Modernization
Main Market Drivers

- Improve competitiveness of plant
  Production costs and life cycle costs
- Environmental regulations/Climate change
- Increasing share of renewables
- Ageing fleet – Lifetime extension
- Availability and reliability
- Need for more capacity (MW)
- Unstable political boundaries for new power plant projects

**Main Market Drivers**

<table>
<thead>
<tr>
<th>Year</th>
<th>2008</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>TWh</td>
<td>20,300</td>
<td>33,000</td>
</tr>
</tbody>
</table>

2.3% per year

Fossil energy sources:
- Coal: 32%
- Oil: 2%
- Gas: 20%
- Nuclear: 15%
- Hydro: 15%

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Content of Presentation

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- Introduction
- **Lifetime Extension Method**
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Turbine Stress Limits

![Turbine Stress Limits Diagram]
Service concept for Turbine Components

Component Failure Probability

Operational Hours

Design
Service (NDE, RLA)
Real Life Time of Component Up To Failure

NDE – Non-Destructive Examination
RLA - Remaining Life Analysis
Lifetime evaluation

Life Time Assessment by NDT at major outages

Design Lifetime

Operational data evaluation
Future operational Scenario
Remaining Lifetime Analysis (RLA)

Repair / Replace Components
Operational Restriction, Limitation
Modernization and upgradation

Lifetime Assessment by NDT at major outages

Extended Lifetime
Fatigue of major steam turbine components

Main Steam and Reheat turbine valve casings
Low cycle fatigue due to starts and shutdowns
Creep damage due to stationary operation

LP turbine rotor
• Low cycle fatigue due to starts and shutdowns

IP/LP bypass valve casings
• Low cycle fatigue due to bypass operation

HP and IP turbine casings and rotors
Low cycle fatigue due to starts and shutdowns
Creep damage due to stationary operation
Life Time Extension of steam turbine components

Damage reduction DD and component release for the further operations based on:

• Updated computational conditions
• Local repair
• Transient and steady state operational conditions adjustment
→ Evaluation Repair vs. Replace by three steps
Steam Plant Modernization
Service Differentiation

- Investment
- Component Exchange
- Upgrade
- Inspection/Repair
- Reliability
- Efficiency
- Capacity
- Flexibility
- Lifetime
- Value to Customer
- Service Differentiation

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Steam Plant Modernization
Product Portfolio

- Upgrade solutions for fossil and nuclear steam turbines
- All power output ranges (200-1400 MW)
- HP, IP, LP turbines
- Condenser, Generator and I&C upgrades
- Siemens (incl. KWU), Parsons and Westinghouse designs (incl. license ST)
- Other OEM products
- Continuous R&D investment for technology improvements and product range enlargement
- Large list of references
- > 25 years of experience. More than 270 fossil units modernized (64 O-OEM)
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Turbine Stress Limits

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Overview of Key Technologies for Efficiency Improvements for Modernization Projects

State-of-the-art 3DS™ Drum Stage Blading

Customer Benefits
- World-class performance
- Wide range of application
- Specific design for each application within short delivery times
- Long life & high reliability
HP/IP Blading Technology
3DV™ Blading – Optimized Expansion Line

Increase of element efficiency by up to 1% compared to traditional bladepath design

- Optimized expansion
- Expansion with constant stage reaction

Δh_s

Entropy

Enthalpy

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Overview of Key Technologies for Efficiency Improvements for Modernization Projects

LP Blading Design Features

- State-of-the-art fully 3D design by means of advanced computational methods
- Optimized last stage blade size
- Optimized LP exhaust area
- New Shrouded L-2, L-1 and Freestanding or Shrouded Last Stage Blade with Trans- and Supersonic Tip Sections, 3D-Flow Design

Customer Benefits

- Improved blade efficiency by advanced 3D blade design
- Increased efficiency by shrouded rotating blades
- Reduced exhaust losses
Overview of Key Technologies
LP-Blading – Reliability Features

- Fir Tree Root Design for improved Strength and Reliability by Residual Stress Application and Control
- Highly effective Erosion Protection Measures based on extensive Experience and Use of High Alloy Materials

Customer Benefits
- Increased Reliability and Service Life due to Reduced Stress Levels and effective Erosion Protection Measures
- Reduction of Maintenance Costs
Overview of Key Technologies for Efficiency Improvements for Modernization Projects

**Optimized Sealing Concept**

- Brush Seals in Bladepath & Shaft Sealing
- Abradable Coatings in Shaft Sealing
- Spring-Backed Seal Segments

**Customer Benefits**

- Minimization of clearance losses for higher efficiency
Concepts for Efficiency Improvement
Technologies

**Blading Technology**
- Protection via coating
- Retrieve original roughness
- Application of shrouded L-1 standard stage
- Reblading 3DS

**Sealing Technology (Shaft & Blading)**
- Improved seal strips
- Advanced segment design
- Abradable coating
- Brush seals
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Steam Plant Modernization
Typical Upgrade Scope

- Modernization of HP, IP and LP Turbines, Condenser
- Exchange of bladepath components: Rotor, blading, inner casing
- Newest blading and sealing technology
- Outer casing, auxiliary systems, interfaces to foundation etc remain unchanged
- For Other OEM an upgrade study with adaptation measurement is mandatory
### Products for Mods&Ups Market in India

<table>
<thead>
<tr>
<th>Frame</th>
<th>Turbine</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LMZ 200 / 210 MW</td>
<td>HP</td>
<td>K-200 HP</td>
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</tr>
<tr>
<td></td>
<td>IP</td>
<td>K-200 IP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LP</td>
<td>N30-2x5m²</td>
<td></td>
</tr>
<tr>
<td>KWU 200 / 210 MW</td>
<td>HP</td>
<td>H30-25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IP</td>
<td>M30-25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LP</td>
<td>N30-2x5m²</td>
<td></td>
</tr>
<tr>
<td>KWU 500 MW</td>
<td>HP</td>
<td>H30-63</td>
<td>H30-100</td>
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<tr>
<td></td>
<td>IP</td>
<td>M30-50</td>
<td>M30-63</td>
</tr>
<tr>
<td></td>
<td>LP</td>
<td>N30-2x10m²</td>
<td></td>
</tr>
</tbody>
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Turbine Stress Limits
Upgrade References

Ibbenbüren (Germany) – Upgrade of fossil OEM-Turbines & Condensers

- Hard coal-fired HP-IP-LP-LP configuration with approx. 838 MW (after Retrofit)

- Extended upgrade scope: all turbine sections + condenser + bearing
Upgrade References
Overview Total Scope

Offset-halves bearings

Reinforced connection bearing pedestal to foundation

HP
IP
LP1
HP
IP
LP1
Condenser 1
Condenser 2
LP2
Upgrade Reference
Conclusions

✓ Performance increase of **86MW**
  (43 green MW due to increased thermal efficiency)

✓ Up to 260,000t CO₂ reduction p.a.

✓ All requirements fulfilled for characteristics such as
  • Heat rate
  • Swallowing capacity
  • Rotor & Bearing Vibrations
  • Start up and shutdown times
  • Noise Emissions

✓ Total retrofit time 72 days

✓ Commissioning without any obstacles and delays
Experiences with Fossil Turbine Modernizations

Experiences with fossil turbine modernizations over the last 20 years

<table>
<thead>
<tr>
<th>Fossil Fleet</th>
<th>No. of Units</th>
<th>Rating (MW)</th>
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<tbody>
<tr>
<td>Siemens*</td>
<td>214</td>
<td>88250</td>
</tr>
<tr>
<td>GE</td>
<td>2</td>
<td>1200</td>
</tr>
<tr>
<td>Alstom</td>
<td>2</td>
<td>650</td>
</tr>
<tr>
<td>MHI</td>
<td>4</td>
<td>1700</td>
</tr>
<tr>
<td>LMZ</td>
<td>32</td>
<td>7120</td>
</tr>
<tr>
<td>Skoda</td>
<td>1</td>
<td>120</td>
</tr>
<tr>
<td>Chinese</td>
<td>23</td>
<td>4950</td>
</tr>
<tr>
<td><strong>Σ 278</strong></td>
<td></td>
<td><strong>Σ 104 GW</strong></td>
</tr>
</tbody>
</table>

* includes Westinghouse and Parsons Steam Turbines
Upgrade References

Kardia, Greece – 300 MW LMZ Steam Turbine Upgrade

Fig. 1: Cross section of the HP turbine.

Fig. 2: Rotor cooling system for the IP section of the IP / LP turbine.

Fig. 3: Cross section of the double-flow LP steam turbine.

Fig. 4: HP turbine with new rotor and inner casing.
Upgrade References

Syrdarinskaya, Uzbekistan – 300 MW LMZ Steam Turbine Upgrade

Scope of the upgrade:

**IP/LP Cylinder:**
- IP section: Installation of a rotor cooling system
- LP section: Renewal of the shrunk-on disks, including rotating blades and diaphragms

**LP Cylinder:**
- New rotor, inner casing and blading.
Upgrade References

Loy Yang Power, Australia – 500 MW SIEMENS / KWU Steam Turbine Upgrade

*Customer benefits*
- Increased power output by almost 10%
  to more than 545 MW
- Improved efficiency.

*Awards celebration*
The outage has set an international benchmark for outage management and sustainable plant enhancement and has been therefore cited with two Engineering Excellence Awards.

- *Ausindustry Excellence Award* for Industrial Development
- *Victorian Workcover Excellence Award* for Workplace Practice.
Steam Plant Modernization – Fossil Plants
Customer Benefits

Improvement of turbine efficiency
- Higher load output, “GREEN MW”
- Lower CO₂ emissions
- Lower production costs
- Improved profitability

Improvement of total plant efficiency
- Through boiler and condenser upgrade
- Increased mass flow, steam parameters

Lifetime Extension – ageing fleet
- Reduced maintenance costs
- Improvement of availability and reliability

Improved Operational Flexibility – Flex Power
- Faster start up/load changes
- Flexible use of lifetime
Thank You
for Your Attention!
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