Applicability of Large Gas Turbines for the Asian Energy Market

Axel Felderer, Product Portfolio Manager Large Gas Turbines and Generators
Siemens is the world leader in advanced air-cooled gas turbine technology

Siemens experience covers today:

- more than 2,250 GTs worldwide
- more than 260,000 MW output
- more than 750,000 GT starts
- more than 61M EOH (equivalent operating hours)
Continuously enhanced technologies proven in the field

Worldwide growing fleet

more than 1,300 LGT units sold until today

SGT5/6-2000E  SGT5-4000F  SGT6-5000F  SGT5/6-8000H

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Siemens supplies high performance combined cycle power plants for customer value

Major milestones in new technology introduction

<table>
<thead>
<tr>
<th>Year</th>
<th>Plant Location</th>
<th>Output</th>
<th>Turbine Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>Killingholme</td>
<td>2 x 470 MW, 2x (1x1)</td>
<td>SGT5-2000E</td>
</tr>
<tr>
<td>1996</td>
<td>Didcot B 1&amp;2</td>
<td>702 + 710 MW, 2x (2x1)</td>
<td>SGT5-4000F</td>
</tr>
<tr>
<td>2001</td>
<td>Mainz-Wiesbaden</td>
<td>&gt; 400 MW, (1x1)</td>
<td>SGT5-4000F</td>
</tr>
<tr>
<td>2011</td>
<td>Irsching 4</td>
<td>&gt; 545 MW, (1S)</td>
<td>SGT5-8000H</td>
</tr>
<tr>
<td>2016</td>
<td>Fortuna-Lausward</td>
<td>&gt; 603 MW, (1S)</td>
<td>SGT5-8000H</td>
</tr>
</tbody>
</table>

Efficiency:
- 1992: 52%
- 1996: 56%
- 2001: 58%
- 2011: 60.75%
- 2016: 61.5%
Three world records in one CCPP: Lausward, Block “Fortuna“ SCC5-8000H 1S

Siemens sets new performance and efficiency world records

- Gas turbine type: SGT5-8000H
- Steam turbine type: SST5-5000
- Generator type: SGen5-3000W
- Ramp-up to full load in less than 25 minutes after a hot start

>600 MW\textsubscript{el} net Total power output

61.5 % net plant efficiency

85 % fuel utilization

Customer: Stadtwerke Düsseldorf

Commercial operation: January 2016

300 MW\textsubscript{th} district heating

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The 8000H Validation and Market Introduction Approach

### SGT5-8000H Validation in Irsching
- Testing in simple & combined cycle …
- … under full Siemens control
- … with commercial grid boundaries
- … gas turbine thoroughly tested in simple cycle
- … BOP validated subsequently

### SGT6-8000H Validation in Berlin Test Facility
- Testing in controlled environment …
- … grid independent (e.g. frequency)
- … with fuel gas and fuel oil

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</tr>
</thead>
<tbody>
<tr>
<td>50Hz</td>
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<td></td>
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<tr>
<td>60Hz</td>
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</tr>
</tbody>
</table>

- **50Hz**: GT Testing, CC Extension, CC Validation, CC Commercial Operation
- **60Hz**: First Fire, Testing in Test Bed

8000H has passed a Comprehensive Testing before shipping to a customer site …
… even the 60Hz version as a true scale
Siemens has 79 H-class turbines under contract with 27 units in commercial operation. This adds up to a fleet experience of more than 270,000 fired hours globally.
Leader in advanced air-cooled gas turbines
Reliable, flexible and proven in commercial operation

Compressor
- Evolutionary 3D blading
- 4 stages of fast acting variable-pitch guide vanes (VGV) allowing for improved part load efficiency and high load transients

Proven rotor design
- Hirth serration, central tie rod, internal cooling air passages for world class fast (cold) start and hot restart capability

Turbine
- 3D Four stage turbine with advanced materials and thermal barrier coating
- High cycling capability due to fully internally air cooled turbine section

Bearings
- HCO for reduced clearance losses
- Transient protection of clearances for reduced degradation with hydraulic clearance optimization (HCO) active clearance control

Combustion
- Advanced can annular combustion system
- 61.5% combined cycle efficiency

SGT-8000H series
- Performance
- Flexibility
## Project details

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>Andong, South Korea</td>
</tr>
<tr>
<td><strong>Customer</strong></td>
<td>KOSPO</td>
</tr>
<tr>
<td><strong>Total power output</strong></td>
<td>415 MW net</td>
</tr>
<tr>
<td><strong>Plant efficiency</strong></td>
<td>&gt; 60 % net</td>
</tr>
<tr>
<td><strong>Generator type</strong></td>
<td>SGen6-2000H</td>
</tr>
<tr>
<td><strong>Steam turbine type</strong></td>
<td>SST6-5000</td>
</tr>
<tr>
<td><strong>Date of order</strong></td>
<td>April 2012</td>
</tr>
<tr>
<td><strong>Commercial operation</strong></td>
<td>August 2014</td>
</tr>
</tbody>
</table>

## Project specifics

- Designed for 250 starts per year
- Fast start capabilities: Only 30 min for hot start
- Fast track project: 24 months

### Power Plant Awards
- 2014 Top Plants: Gas
- Fast-Track Power Plant of the Year Silver Award
New technology developments to further enhance customer value of air-cooled gas turbines

Advanced Coatings
Firing Temperature Increase

Mikro Systems
Cooling Air Reduction

Advanced Blades
Aero-Efficiency

Major technology levers to achieve new benchmarks in performance

Firing Temperature Increase
Emissions Reduction

Sealing Optimization
Whole Engine Modeling

Aero-Efficiency Increase
3-D Blading Design
Summary & Conclusion

Siemens experience covers today:

… being the **fleet leader** in H-class air-cooled gas turbines.

… setting milestones in **new technology** introduction.

… ensuring economic and competitive products based on **proven design**.

… being **your partner** for reliable and efficient power generation.

… **Passion generates trust**.
Thank you for your attention!

Axel Felderer
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