Applicability of Large Gas Turbines for the Asian Energy Market

Axel Felderer,
Product Portfolio Manager Large Gas Turbines and Generators

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siemens.com/power-gas
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

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Siemens supplies high performance combined cycle power plants for customer value

<table>
<thead>
<tr>
<th>Year</th>
<th>Efficiency</th>
<th>Turbine</th>
<th>Projects</th>
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<tbody>
<tr>
<td>1992</td>
<td>52%</td>
<td>SGT5-2000E</td>
<td>Killingholme (2x 470 MW, 2x (1x1))</td>
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<tr>
<td>1996</td>
<td>56%</td>
<td>SGT5-4000F</td>
<td>Didcot B 1&amp;2 (702 + 710 MW, 2x (2x1))</td>
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<tr>
<td>2001</td>
<td>58%</td>
<td>SGT5-4000F</td>
<td>Mainz-Wiesbaden (&gt; 400 MW, (1x1))</td>
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<tr>
<td>2011</td>
<td>60.75%</td>
<td>SGT5-8000H</td>
<td>Irsching 4 (&gt; 545 MW, (1S))</td>
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<td>2016</td>
<td>61.5%</td>
<td>SGT5-8000H</td>
<td>Fortuna-Lausward (&gt; 603 MW, (1S))</td>
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</table>

Major milestones in new technology introduction
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 MWₘₚ net 
Total power output

61.5 % net 
plant efficiency

85 % 
fuel utilization

Customer: Stadtwerke Düsseldorf
Commercial operation: January 2016
300 MWₜₜ, 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

**Direct Scale 50Hz → 60Hz**

**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>
<td>50Hz</td>
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<td>60Hz</td>
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</table>

- **First Fire** GT Testing
- **CC Extension**
- **CC Validation**
- **CC Commercial Operation**

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
Reference Power Plant: Andong (South Korea)
SCC6-8000H 1S

Project details

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

Siemens AG
Freyeslebenstraße 1
91058 Erlangen
- Germany -

Mobile: +49 (152) 01654518
E-mail: axel.felderer@siemens.com

siemens.com
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