H Class High Performance Siemens Gas Turbine (SGT-8000H)

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Manager, Engineering
8000H Gas Turbine Validation

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Agenda

1. SGT-8000H: Portfolio Overview
2. GT Design Overview
3. Comprehensive Validation and Testing Concept
4. Demonstrated Operational Capabilities
5. Summary
Siemens Gas Turbine Portfolio

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Type</th>
<th>Power Output (MW)</th>
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<tbody>
<tr>
<td></td>
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<td>25</td>
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<tr>
<td>50 Hz or 60 Hz</td>
<td>SGT-100</td>
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<tr>
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<td>SGT5-4000F</td>
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<td>60 Hz</td>
<td>SGT6-2000E</td>
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<td>SGT6-5000F</td>
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<td>SGT6-8000H</td>
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Siemens extensive Gas Turbine product portfolio covers both Industrial & Large Scale applications
The SGT-8000H

Solutions For Customer Needs

SGT-8000H developed in response to customer needs, based on latest advanced technology and fully validated before commercial market launch

- Advanced thermal performance
- Operational flexibility (fast start-ups and high part load performance)
- High availability
- Reduced Life Cycle Costs

- "On-board" Air Cooling (no external cooling systems)
- Based on proven Siemens design principles
- Design for serviceability

- Integrity and Performance validated before series release
- Comprehensive Validation in a Siemens controlled environment
- 3,000 points of measurement
SGT6-8000H
Efficient & Flexible

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

HCO for reduced clearance losses

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

Advanced Can Annular combustion system

> 60% combined cycle efficiency

3D Four stage turbine with advanced materials and thermal barrier coating

High cycling capability due to fully internally air cooled turbine section

Performance features
Flexibility features

Designed for >60% efficiency in combined cycle and best in class operational flexibility
SGT-8000H
Scaling and Validation Approach

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

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

Scaling rules  
50Hz → 60 Hz

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<thead>
<tr>
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<th>50Hz</th>
<th>60Hz</th>
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<tbody>
<tr>
<td>Speed</td>
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<tr>
<td>Dimensions</td>
<td>÷ 1.2</td>
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<td>Power, Mass Flow</td>
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<tr>
<td>Stresses &amp; Temperatures</td>
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<tr>
<td>Efficiency</td>
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Siemens philosophy is to conduct thorough validation for a new engine platform like 8000H – even for the scaled engine
Comprehensive Validation and Testing Concept

Validation of advanced technologies in test rigs before prototype engine testing

<table>
<thead>
<tr>
<th>Strategic Product Planning</th>
<th>Design</th>
<th>Sales Preparation</th>
<th>Design Implementation</th>
<th>Validation</th>
</tr>
</thead>
</table>

Parts tests
- Casting blades & vanes
- Materials, coatings
- Manufacturing trials, etc.
- Stress / Strain verification

Component tests
- Combustion system rig test
- Cover plate rig test
- Mock up

Systems tests
- Compressor test
- Combustion system test at Berlin test bed

Prototype
- GT field validation
- CC field operation

Siemens has spent >10 years with significant investment to create a robust product and confirmed its integrity to ensure lowest customer risk
SGT5-8000H The World’s Most Powerful Gas Turbine

CC Power : 578 MW
CC\textsubscript{net} efficiency : 60.75%
NOx emissions : <25 ppm
CO emissions : <10 ppm

Independent body verified and certified our test & operation results
1st Combustor Interval Inspection completed

2013-05-15
### SGT6-8000H Manufacturing & Validation

#### 2011

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<thead>
<tr>
<th>Q3</th>
<th>Q4</th>
<th>2012</th>
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<td>1st Baseload</td>
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**SGT6-8000H validation completed in Berlin Test Facility and First Customer Site in Commercial Operation**
SGT6-8000H at Berlin Test Facility (BTF)

Operation Overview

- Fully instrumented engine test: with ~1900 sensors in operation
- EBH: ~300, Starts ~137

Demonstrated:
- Verification of engine performance and emissions compliance
- Fuel oil operation and fuel transfer between gas and oil
- Typical start up (ignition to FSNL) at about 5~6 minutes
- Nominal (12.5 MW/min) and fast ramp (up to 29MW/min)
- Trips from load, Spin cooling, and Hot restart
- LLCO system operation and benefit
- Advanced combustion system validation
- Serviceability

SGT6-8000H operation was fully demonstrated at BTF
SGT6-8000H Validation

Accomplishments

- FSFL on heated / unheated gas
- FSFL on fuel oil
- Thermal paint test to map hardware
- Teardown inspection post test
- Engine refurbished / shipped to customer

Current Status @ 1st Customer Site

- First fire
- Completed grid sync and initial loading
- Completed commissioning
- Commercial Operation

Next Steps

- Field follow-up program

SGT6-8000H Started Commercial Operation on April 24, 2013
Thank You / Questions