Latest Developments in Siemens Large Gas Turbine Portfolio

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8000H Product Manager
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Challenging energy market in Germany:
February 2016

High ramps
High power output

Import Balance
Load
Intraday Continuous 15 minutes High Price (right axis)
Conventional > 100 MW
Intraday Auction 15 minutes call (right axis)

Wind
Intraday Continuous 15 minutes Average Price (right axis)
Solar
Intraday Continuous 15 minutes Low Price (right axis)

https://www.energy-charts.de/price.htm
The Siemens gas turbine portfolio:
The right engine for every requirement

<table>
<thead>
<tr>
<th>Model Code</th>
<th>Power (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGT5-8000H</td>
<td>450</td>
</tr>
<tr>
<td>SGT5-4000F</td>
<td>329</td>
</tr>
<tr>
<td>SGT5-2000E</td>
<td>187</td>
</tr>
<tr>
<td>SGT6-8000H</td>
<td>310</td>
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<tr>
<td>SGT6-5000F</td>
<td>250</td>
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<td>SGT6-2000E</td>
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<td>SGT-A65 TR</td>
<td>53 to 66</td>
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<tr>
<td>SGT-800</td>
<td>48 to 54</td>
</tr>
<tr>
<td>SGT-A45 TR</td>
<td>39 to 44</td>
</tr>
<tr>
<td>SGT-750</td>
<td>40 / 41</td>
</tr>
<tr>
<td>SGT-700</td>
<td>33 / 34</td>
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<tr>
<td>SGT-A30 RB</td>
<td>27 to 37</td>
</tr>
<tr>
<td>SGT-A35 RB</td>
<td>28 to 38</td>
</tr>
<tr>
<td>SGT-600</td>
<td>24 / 25</td>
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<tr>
<td>SGT-400</td>
<td>13 to 14</td>
</tr>
<tr>
<td>SGT-300</td>
<td>8 / 8 to 9</td>
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<tr>
<td>SGT-100</td>
<td>5 / 6</td>
</tr>
<tr>
<td>SGT-A5 AE</td>
<td>4 to 7</td>
</tr>
</tbody>
</table>
Siemens SGT-8000H series: Reliable, flexible, and proven in commercial operation

**Rotor**
- Proven rotor design with internal cooling air passages for world-class fast (cold) start and hot restart capability
- Easy rotor de-stacking on site due to disc assembly with Hirth serration and central tie rod

**Compressor**
- Variable inlet guide vanes and three stages of fast acting variable-pitch guide vanes (VGV) for improved part load efficiency and high load transients
- High efficiency due to evolutionary 3D blading
- All rotating compressor blades replaceable without rotor lift or rotor de-stacking

**Bearings**
- Active clearance control with Hydraulic Clearance Optimization (HCO) for reduced degradation and clearance losses

**Combustion**
- Advanced can annular combustion system

**Turbine**
- High cycling capability due to fully internally air-cooled turbine section
- 3D four-stage turbine with advanced materials and thermal barrier coating
- Shorter outages: All turbine vanes and blades replaceable without rotor lift; vane 1, blade 1 & 4 replaceable without cover lift

61% efficiency in combined cycle

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Fränkle / Siemens AG
Siemens evolutionary design circle ensures competitive products based on proven design

3-step testing approach
- Component/ rig testing
- Full scale engine testing
- Site testing

Based on field experience

Incremental changes & improvements

Technology download

Pre-testing and validation

Fleet experience by Digital Services

Evolutionary design circle

Retrofittable

Robust design
New technology developments to further enhance customer value of air-cooled gas turbines

Advanced Coatings
Firing Temperature Increase

Super-efficient internal cooling features for blades and vanes
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
Evolutionary Upgrade Steps based on “built-in” Engine Growth Potential

- As tested, Irshing 2nd build
- 95% compressor mass flow

- 100% compressor mass flow

- Increased mass flow
- Increased TIT
- Reduced cooling & leakage flow

- 375MW / 40%
- 570MW / 60%
- 600MW / >60%
- 400MW / >40%
- 450MW / 41%
- 665MW / 61%

- Increased mass flow
- Increased TIT
- Reduced cooling & leakage flow

2007 Market introduction
2013 uprate
2016 1st upgrade
20xx

Next step: Currently in preparation

- Upgrades are retrofitable
- Further upgrades are in development

Siemens continues to invest in retrofittable upgrade of its existing fleet
The Siemens SCC5-8000H series
Flexibility defined

- Power
  - 3%/s GT Gradient
  - 10% rated load jump
  - Purge after shutdown
    - 55 MW/min GT start up gradient, also for cold start
  - Grid Sustaining at under-frequency
  - Fast Start Up
  - Primary Frequency Response
  - Secondary Frequency Response
  - Manual Operation
  - BLOC
  - Peak Power
    - Extra power by
      - Evap. cooler
      - Inlet chilling
      - Suppl. firing
  - Part Load
    - Lower Minimum Turndown
  - Fast Shut Down
    - 55 MW/min transient gradient

Extra power by:
- Evap. cooler
- Inlet chilling
- Suppl. firing
CCPP Lausward test results
Hot Start

![Graph showing the performance of CCPP Lausward test results for Hot Start. The graph includes various parameters such as GT Speed, ST Speed, Plant Output, GT Load, and ST Load, with specific events like ignition, HP B/P open, IP B/P open, IP B/P close, and HP B/P close marked at different time intervals.]
CCPP Lausward test results
Ramp with +/- 70 MW/min

Time [min]

Plant Output
GT Load
ST Load
HP Steam Flow
SH Outlet
HRH Steam Flow (calc.)

[MW]

[kg/s]
Early Power to Grid 4.8GW achievement

20,000 manpower on the 3 sites (> 95% Egyptian nationals)

Nov. 2016
Synchronization of Beni Suef
1st unit GT42 which produces 400MW

67 Mio man-hours since start of projects

1,762 suppliers worldwide and > 16,000 workers involved

Synchronization of 7 units
+ 5 units in Beni Suef
+ 1 unit in Burullus
+ 1 unit in New Capital
in total 2.8GW

773 local suppliers and subcontractors

Jan. 2017
Synchronization of 4 units
+ 3 units in Burullus
+ 1 unit in New Capital –
400MW more than promised
in total 1.6GW

4.8GW achieved on Jan 22, 2017 connected to the grid in only 18 months after signing the contract
Thank you for your attention

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