Latest Developments in Siemens Large Gas Turbine Portfolio

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Abstract

In the light of existing CO₂ reduction policies and related addition of renewable energy the European Power Market is in a general need for highly flexible generation, especially for heavy duty gas turbines and related plants. The paper will outline how the proven heavy duty gas turbine portfolio from Siemens is meeting this demand by offering proven and reliable as well as flexible products and solutions.

New technologies are quickly and effectively validated at Siemens' own test centers and on customer sites worldwide. The test facilities of the Gas Turbine Plant Plant in Berlin (Germany), in Casselberry (U.S.A.), the Clean Energy Center in Ludwigsfelde (Germany) as well as on-site testing in cooperation with customers ensure the full testing and validation coverage and demonstrate the full functionality. With this Siemens is generating trust for its own technologies, for the insurer and of course for the customer.

The paper will highlight successful projects using Siemens technology for SGT-8000H series gas turbines and will also give an outlook on the capabilities the SGT-8000H series has to offer. This gas turbine series has not only set new standards in terms of robustness of the design and reliable operation it has become a benchmark in the industry. With low life cycle costs, high reliability and availability, operational flexibility, and low emissions it is a trendsetting solution for clean fossil power generation all over the world. With more than 80 units sold and more than 45 units in commercial operation, the SGT-8000H gas turbine series is widely accepted as a fully proven product series which is perfectly suited for power projects.
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Abbreviations

CC       Combined Cycle
CCPP     Combined Cycle Power Plant
EU       European Union
GT       Gas Turbine
GW       gigawatts
HCO      Hydraulic Clearance Optimization (system)
HRSG     Heat Recovery Steam Generator
I&C      Instrumentation & Control
MW       Megawatts
p.a.     per annum
SGT      Siemens Gas Turbine
SCC      Siemens Combined Cycle
TIT      Turbine Inlet Temperature
1. Power Market Challenges for Large Gas Turbines

Initiated by strategy of the European Union (EU) to become a low-carb region as well as by isolated activities on individual country level the share of renewable energy sources in the EU's gross final energy consumption will be more than 20% by 2030. The result is an ever-changing power market and the strong need for flexibility and back-up capacity.

Fig. 1: Power demand in Germany February 2016

2. The Siemens heavy duty Gas Turbine Portfolio

For the European 50 Hz grid Siemens offers three heavy duty frames: SGT5-2000E, SGT5-4000F and SGT5-8000H, with the standard turboset and plant portfolio spanning a power range from 187 MW to 1,335 MW.

Both SGT5-4000F and SGT5-8000H have an excellent position for meeting the European Market needs, however the SGT5-8000H with advantage for larger projects, higher fuel prices and longer operating hours p.a.. The SGT5-4000F that has been dominating the European Market for more than a decade with a multitude of installations all across the continent whereas the SGT5-2000E is the application for smaller power needs, fast installation time, open-cycle peaking and off-spec liquid or gaseous fuels with high contamination; as a result this engine plays only a niche role in the Central European Market.
3. The SGT5-8000H Gas Turbine

The Siemens SGT-8000H gas turbine series marks the top of the Siemens portfolio with high power outputs of 660MW and above in combined cycle (CC) application and allowing for net efficiencies far beyond 60%.

Fig. 3: SGT5-8000H features

This gas turbine series was from the very beginning intended to not only to achieve unprecedented efficiencies but also to meet flexibility requirements while maintaining the robustness and reliability of the existing design heritage.
After six years of commercial operation of the first commercial installation and a fleet of more than 45 engines in commercial operation the Siemens SGT-8000H gas turbine series has met its targets to the satisfaction of our customers. Such success is the outcome of a longterm effort and several hundred million Euro investments of Siemens and many of its dedicated employees. The Siemens evolutionary design approach ensures competitive products for the new unit and service business. This development philosophy is based on the proven design and the fleet experiences of more than 6,750 installed heavy duty, industrial, and aero-derivative gas turbines in more than 60 countries worldwide. Using the design circle Siemens validates new technical developments in a proven three step testing approach which fully corresponds with the Product Development Process.

![Evolutionary design circle](image)

Fig. 4: Evolutionary design circle

Upgrade components, gas turbines and technical solutions pass through a series of tests designed to meet the market needs for lowest technical and commercial risks.

1. Material and component tests for example at the Clean Energy Center (CEC), Ludwigsfelde, Germany
2. In-house full scale engine test at the test facility of the Gas Turbine Plant Berlin, Germany
3. On-site tests at customer sites for long time validation and test of gas turbine operation in interrelation to other power plant systems

Rapid engineering and prototyping through concentrated research manufacture and development capabilities are the basis of this testing approach. The close distance of manufacturing and testing at the Gas Turbine Plant Berlin and the Clean Energy Center ensures rapid prototyping and supports the time-to-market time frame. The individual testing procedure for validation of new developments, technology downloads, or incremental changes and improvements will be selected in accordance to the target group and the timeline (new gas turbine developments or service upgrades).
4. The SGT5-4000F Gas Turbine

With 128 units sold in Europe alone, this well-known gas turbine is the best-selling large gas turbine in the European Market. Since its market introduction in 1996, the machine has seen continuous development, resulting in an impressive power increase from initially 240 MW to in the meantime 329 MW for the latest version. And development efforts continue, benefitting both existing and future customers. At the same time the current models offer far more reliability than the initial model with today’s fleet average exceeding > 99% since years, making the SGT5-4000F the F-class benchmark in the industry also in this respect.

Besides performance improvement also the operational flexibility has been focus of recent years. Based on the inherent design advantages (rotor, design, HCO, turbine cooling - see below), improvements in many aspects (fuel flexibility, load gradients, turn down etc.) have been made.

As a result a SGT5-4000F will safeguard the plant investment and competitiveness of any project for years to come.

Fig. 6: SGT5-4000F features
5. Operational Flexibility

The Siemens SGT5-4000F and SGT5-8000H share some common design features that allow for inherent operational flexibility:

- **Rotor design**
  The rotors consist of individual discs being spanned to a stiff rotor by a central tie rod. The individual discs are aligned with the so-called Hirth-serration on their interface areas which allows for self-centering of the rotor discs during assembly and high torque transfer through the rotor while avoiding individual discs slipping and resulting rotor imbalance. It also allows for internal cooling air passages from compressor to turbine section, which ensure fast thermal response of the rotor in case of high load transients, fast cold starts and alike, basically eliminating the lifetime impact on rotor for such operation.

- **Hydraulic Clearance Optimization (HCO)**
  One of the major concerns for flexible operation with fast load transients are the clearances between stationary and rotating parts in a gas turbine, mainly in the turbine section. Due to faster thermal response of the rotor, especially during the start-up of a gas turbine, the clearances get reduced and even rubbing may occur - with impact on performance (degradation) and potentially also hardware integrity. As a result, this transient state normally defines the width of the clearances for thermally stable operating condition. With the HCO system a Siemens gas turbine will have large enough clearances to avoid any rubbing in the turbine for startup. During stable condition the system will then push the rotor a few mm’s towards the compressor end, reducing the turbine clearances due to the conical flow-path to the design value. So the system avoids the effects on degradation and hardware integrity.

The operational flexibility of the SGT5-8000H is displayed in the following graph and has been demonstrated at the Lausward Power Plant. It is important to note that the gas turbine capability alone is not sufficient. The whole plant - turboset, I&C system, auxiliaries, HRSG etc. - needs to be designed to cope with such capabilities. As a result, Siemens plant solution has developed corresponding plant operation concepts. These concepts combine a set of engineering ideas into a single integrated plant concept with the aim to design a plant for an increased number of starts and to reduce startup times. Hold points at which a plant waits until certain steam parameters have been reached were eliminated as part of the shortened startup procedure. The steam turbine is now started up parallel to the gas turbine using the first steam which becomes available after a hot start, reducing the start-up time to below the 30-minute mark.
Fig. 7: CCPP Hot-start

Shortening startup times and improving the starting reliability while increasing the number of starts is only one of many requirements regarding plant flexibility. The SGT5-4000F capabilities and related plant concepts have been demonstrated in various applications already. On the SGT5-8000H the flexibility needs were a main design target for gas turbine and plant design and have been thoroughly validated.

6. Siemens overdelivers on Promise in Egypt Megaproject

In June 2015, Siemens was awarded its single biggest order ever for the expansion of the Egyptian power supply. 18 months after the signing of the contract, Siemens has set a new worldwide benchmark for the execution of fast-track power projects. The first phase of the megaproject in Egypt has been finalized.

Fig. 8: Site photo of the Beni Suef Power Plant
The promised goal of bringing 4.4 GW of new capacity to the grid has even been exceeded, and 4.8 GW are already connected to the grid. After completion in May 2018, the three power stations will be the largest gas-fired, combined cycle power plants ever built and operated in the world.

Together with local Egyptian partners Elsewedy Electric and Orascom Construction, Siemens is supplying on a turnkey basis three natural gas-fired combined cycle power plants, each with a capacity of 4.8 GW, for a total combined capacity of 14.4 GW. The three power plants – Beni Suef, Burullus and New Capital – will be powered by 24 Siemens H-Class gas turbines, selected for their high output and efficiency. The scope of supply also comprises twelve steam turbines, 36 generators, 24 heat recovery steam generators and three 500 kV gas-insulated switchgear systems. The dimensions of the megaproject are enormous: More than 20,000 workers are engaged at the construction sites during implementation. Over 1.6 million tons of material is being handled.

![Fast track at Egypt megaproject](image)

7. Conclusion

All in all Siemens offers various gas turbines with proven and reliable technologies for different application that support the European customers to provide an answer for the highly flexible market environment and requirements.

Both SGT5-4000F and SGT5-8000H with their proven air cooled technology have an excellent position for meeting the European Market needs, however the SGT5-8000H with advantage for larger projects, higher fuel prices and longer operating hours p.a.. The SGT5-4000F offers reliability constantly exceeding > 99% since years, making the SGT5-4000F the F-class benchmark. The SGT5-8000H is well received by customers as demonstrated in the latest project success in Egypt and has globally collected more than 400,000 operating hours of fleet experience.

Siemens gas turbines: proven, efficient, flexible, reliable, cost efficient, and with upgrade possibility. The right choice for Europe.
References

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