The New Siemens Gas Turbine SGT5-8000H for More Customer Benefit

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Power Generation Gas Turbines

SIEMENS

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Kurzfassung

Größerer Kundennutzen durch die neue Siemens-Gasturbine SGT5-8000H

E.ON Energie und Siemens realisieren am Standort Irsching in Bayern ein neues Kraftwerksprojekt, das in puncto Leistungsfähigkeit und Wirtschaftlichkeit neue Maßstäbe setzen wird. In einem ersten Schritt errichtet Siemens eine neu entwickelte Gasturbinenanlage. Mit 340 MW wird die Maschine die weltweit größte und leistungsstärkste Gasturbine sein. Nach der Testphase wird diese Gasturbinenanlage zu einem hocheffizienten Gas- und Dampfturbinen (GuD)-Kraftwerk mit einer Leistung von rund 530 MW und einem Wirkungsgrad von über 60 % erweitert. Die E.ON Kraftwerke GmbH wird die Anlage nach erfolgreichem Probebetrieb übernehmen und in den kommerziellen Betrieb überführen. Die SGT5-8000H ist das Ergebnis eines intensiven F&E-Programms zur Entwicklung einer wettbewerbsfähigen, effizienten und flexiblen vollständig luftgekühlten Gasturbine. Sie ist die erste neue Turbine, die seit der Fusion von Siemens und Westinghouse entwickelt wurde, mit dem Ziel die besten Merkmale der bestehenden Produktlinien beider Unternehmen mit moderner Technologie zu kombinieren. Der vorliegende Beitrag gibt einen Überblick über den Stand des Projektes, die Designmerkmale und die umfangreichen Designprüfungen an Komponenten und Systemen.

Introduction

Energy efficiency is one of the main objectives for the development of new power plant technology in order to reduce fuel consumption and emissions. In response to the increasing, worldwide need for reliable, low- cost and environmentally compatible generation of energy, Siemens Power Generation has developed the new generation of H-class gas turbines that sets unparalleled standards for high efficiency, low life-cycle costs and operating flexibility.

The Siemens gas turbine portfolio covers the whole range of gas turbine applications for the oil and gas industries through to the largest engines for large-scale applications. With the new SGT5-8000H gas turbine the 50 Hz product portfolio will be completed with the world´s largest exclusively air-cooled gas turbine.

The new gas turbine was developed in accordance with the well-established PG Product Development Process (PDP) to deliver a competitive product focused on market and customer requirements.

Customers expect an economic, competitive product with a high efficiency, great reliability, high flexibility and reduced service at low life-cycle costs. They judge this more and more with the net present value (NPV) of life-cycle costs determined over the lifetime of a power station. With a steady technical innovation in development, technologies, materials and manufacturing, Siemens as manufacturer takes these requirements into account.

During the development of a new gas turbine attention must also be paid to meet or even exceed the high environmental standards with regard to emissions. Only when considering all of these influences can a gas turbine be developed which increases the customer benefit optimally with regard to efficiency, reliability, flexibility in operations and use of fuel as well as in service kindness.

SGT5-8000H Completes the Siemens PG Gas Turbine Product Portfolio

The next step to the completion of our gas turbine product portfolio shall be performed now with the newly developed gas turbine the SGT5-8000H with a power output of over 340 MW (Figure 1). We can thereby accommodate all segments of the market and offer our customers the appropriate products to meet the requirements of every conceivable power plant application, from very flexible peaking application to highest efficiency combined cycle plants to coal gasification combined cycle plants.

SGT5-8000H Engine Design and Features

The new SGT5-8000H gas turbine is the result of years of research and development within Siemens Power Generation. An extremely efficient and flexible, purely air-cooled engine was produced which will be highly competitive against the steam-cooled products of the competitors. This is the first new frame developed after the merger of

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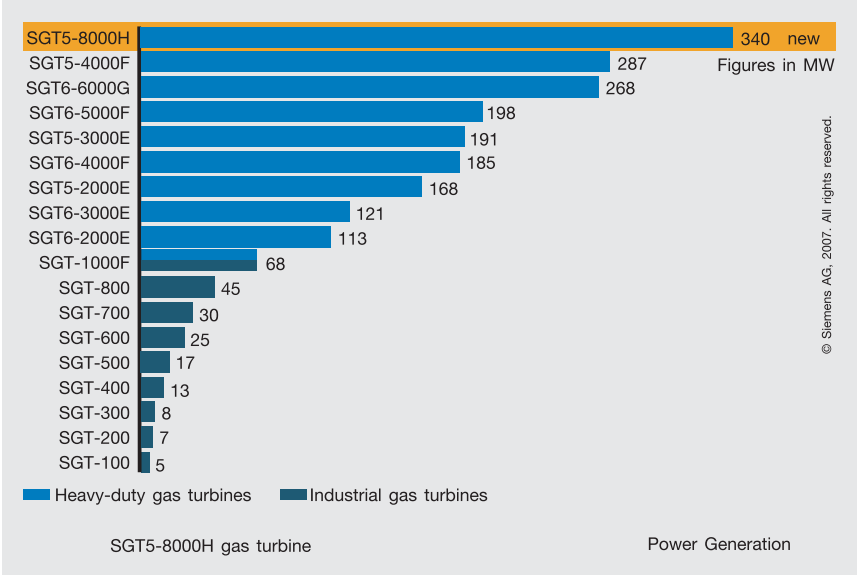

Figure 1. Siemens gas turbines - SGT5-8000H completes the product portfolio.

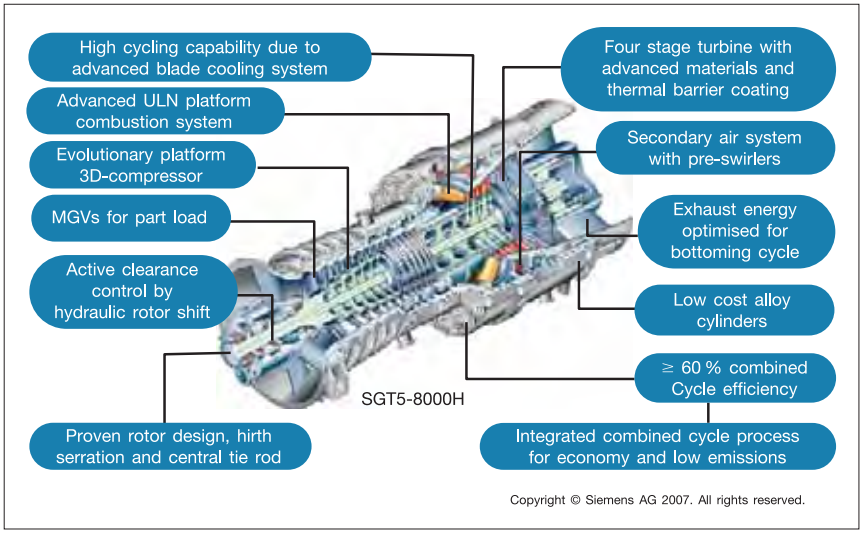

Figure 2. Innovation drives the world's most powerful gas turbine.

Siemens and Westinghouse and combines the best features of the existing product lines and advanced innovative technology. Interpretation and design of the new engine was built on the experiences of the predecessor 50 Hz and 60 Hz engines. Proven design features were applied wherever possible, and "Design for Six Sigma" tools were used consistently, to deliver a competitive product which fulfils the features described at the beginning (Figure 2).

The new SGT5-8000H engine concept has been selected out of many variants of air-cooled engine designs and out of several gas turbine cycle models after a comprehensive feasibility analysis during the conceptual design phase. The selected air-cooled concept offers best value through higher operational flexibility required in deregulated market environments.

The new gas turbine has been developed in a multi-location team structure to integrate more than 250 experts worldwide. Mainly involved have been our engineers from Erlangen, Berlin and Mülheim in Germany, and Orlando and Jupiter in Florida, USA. An additional 500 employees were involved in the manufacturing and test preparation of the prototype engine and at present about 800 people are working on the prototype test plant design and erection.

The customer requirements and with that their advantages were the essential drivers for the development of the new SGT5-8000H. The following requirements should be fulfilled:

- combined cycle net efficiency over 60 %,
- fast start capability and high operational flexibility,
- lowest life-cycle costs,
- high reliability and availability,
- low emissions and
- turndown capability with high efficiency and low emissions.

Keeping these factors in mind, Siemens PG started the internal Product Development Process (PDP) with the strategic product planning in 2000. In 2005, Siemens announced that we were developing the world's largest, most powerful gas turbine. At the end of April 2007 and right on schedule, the prototype of the SGT5-8000H was shipped to its destination, the Irsching 4 gas turbine power plant (Figure 3). The turbine and the generator are already set up on their foundations. The first firing of the engine is planned for late 2007. After extensive tests the series production release will be carried out for this new gas turbine generation in 2008. The completion of the test phase is targeted for mid-2009.

The SGT5-8000H will have a net power output of at least 340 MW and will be optimised for the combined cycle process with a net power output of more than 530 MW and a efficiency over 60 % (Figure 4).

The most important gas turbine features are:

- axial 13-stage compressor with high mass flow, high component efficiency, CDA front stages & HPA rear stages, four rows of variable guide vanes, cantilevered stator vanes (Figure 5),
- high-temperature can annular combustion system, air-cooled,
- four-stage turbine with stage 1 single crystal blades and vanes, stage 1 to 3 TBC-coated blades and vanes, air-cooled (Figure 6),
- advanced secondary air system (SAS),
- single tie bolt rotor with compressor and turbine disks including hydraulic clearance optimisation (HCO) (Figure 7)
- direct scaling for further frames e.g. for a 60 Hz gas turbine is possible.

Figure 3. The SGT5-8000H prototype – development driven by market requirements.

Fuel	Natural gas, fuel oil
Grid frequency	50 Hz
GT output	340
Weight	444 t
Length	13.2 m
Height	5.0 m

Figure 4. SGT5-8000H – key data.

Figure 5. SGT5-8000H – axial 13-stage compressor.

Features for high efficiency:

- advanced sealing system for low leakage cooling air gas turbine design,
- advanced materials to increase the firing and exhaust gas temperatures,
- new compressor with advanced blading design,
- advanced highly-efficient, high-pressure and high-temperature combined cycle process with Benson boiler, based on the high mass flow and exhaust gas temperature of the new engine.

Features for low life-cycle cost:

- over 60 % efficiency in combined cycle mode,
- low maintenance and operation costs due to less complexity in engine and parts,
- simple operational concept.

Features for advanced operating flexibility:

- air-cooled engine to assure that the cooling medium is always present at speed,
- flexibility in operation and reduced start-up times due to less complexity in engine and plant.

Figure 6. 1 stage single crystal blade of the new gas turbine.

More than 3000 measurement points will help validate the performance, the integrity of the systems and the optimisation of turbine operation.

Irsching 4 CCPP – A Two-phase Concept

The Irsching 4 combined cycle power plant will be constructed in two phases. Phase 1 is the prototype testing of the newly developed gas turbine SGT5-8000H under real operating conditions. The power plant will be constructed in a special simple cycle configuration, but prepared already for an extension to a combined cycle single shaft configuration. The prototype testing will be performed under Siemens PG's ownership (Figure 8).

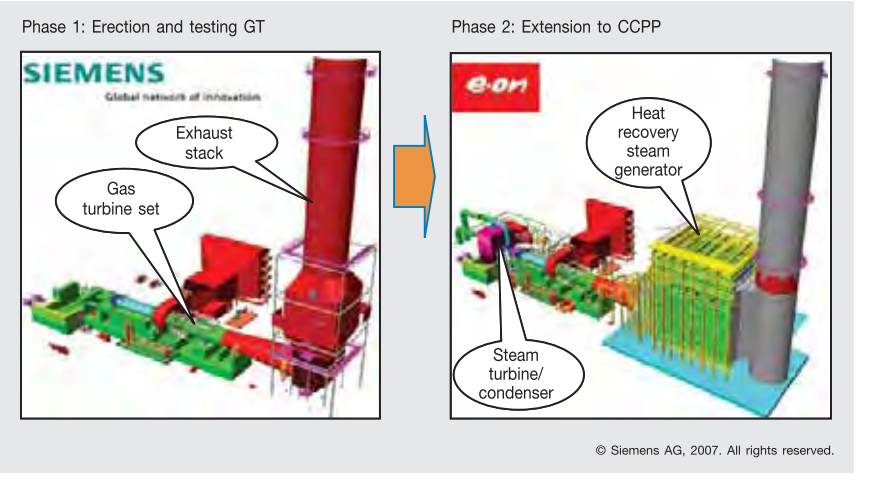

Figure 7. The CCPP Irsching 4 – two-phase concept.

The simple cycle prototype test plant will be equipped in phase 1 with the following new/approved technologies and components:

- a single-shaft arrangement, ready for the planned installation of the steam turbine, water steam components, and piping,
- the new Siemens gas turbine SGT5-8000H,
- a Siemens water-cooled generator SGen5-3000W,
- an exhaust stack,
- fuel gas supply system connected to the E.ON Ruhrgas gas pipeline grid,
- auxiliary systems for gas turbine and generator,
- a unit transformer connected to the E.ON high-voltage grid,
- electrical auxiliary power supply, I&C, and control room for gas turbine operation,
- control centre for testing,
- turbine building with heavy-load cranes.

Upon successful completion of the test phase, the plan is to extend this simple cycle prototype test plant to a high-efficiency combined cycle plant in phase 2. The gas turbine will be rebuilt from a fully instrumented to a com-

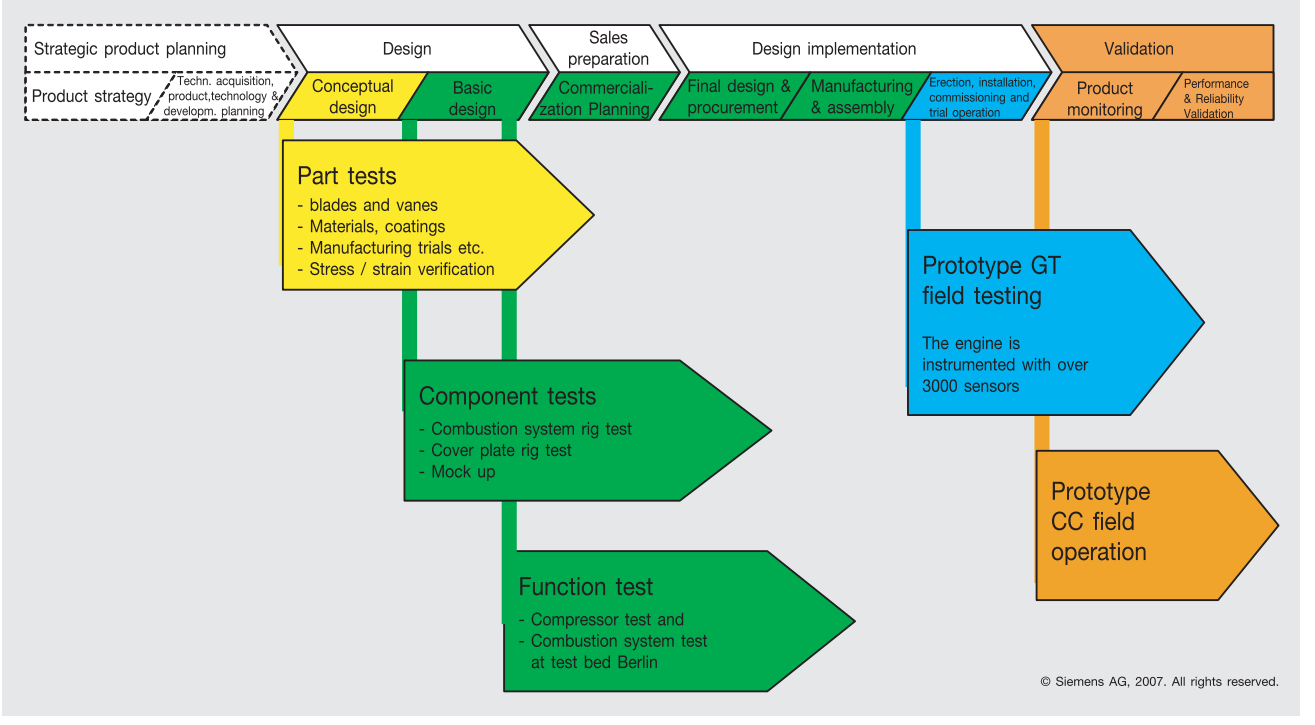

Figure 8. Testing and verification steps along the product development to ensure lowest customer risk.

mercial engine. With the successful completion of the test phase 1, the ownership for the plant will be transferred to the customer, E.ON Kraftwerke.

The extensive testing in simple cycle operation under real grid conditions ensures that subsequent commercial product lines will be introduced to the market with an adequate testing history and commercial release will occur only after successful completion of the prototype testing. Siemens believes that this advanced approach maximises the quality and reliability of the products that we ultimately bring to market to also reduce the risk for our customers.

After start-up, part load and base load validation operation of the plant, a comprehensive endurance testing phase will be conducted. With this extended testing phase, the overall validation program will cover approximately 18 months.

The combined cycle plant, the SCC5-8000H-concept is characterised through:

- advanced power plant design in a single-shaft combined cycle arrangement,
- Benson boiler for steam generation (HRSG),
- water-cooled generator,
- two-casing steam turbine with double-flow low-pressure section.

Gas Turbine Test and Field Validation Approach

For minimisation of customer risk during the introduction of a new product, extensive tests which are completed by prototype tests, were carried out on parts, components and finally on the whole engine in all stages of the development. The individual components, subsystems and engine tests were carried out in the Siemens Berlin Test Centre or at special development sites. The prototype gas turbine, however, will be tested under real power plant conditions with connection to the electrical power grid in a hosting agreement with E.ON Kraftwerke at the Irsching 4 site.

All key gas turbine components are already pre-validated in several sub-system tests. The results of the tests are very promising.

The technology was validated through test rigs before prototype engine testing. The compressor tests in Siemens PG test bed on the new compressor have been carried out successfully at our manufacturing plant in Berlin in 2005. Combustion test have been carried out at several development sites: High-pressure combustion tests were realised at Enel, Italy and DLR, Germany. The catalytic combustion test rig at Pittsburgh/USA was also used. Aerodynamic and heat transfer tests have been performed at the Mülheim Factory Labs and the University of Central Florida as well as at the Florida Turbine Technologies. Atmospheric combustion ignition testing has been carried out at SPC Inc. Casselberry Lab, Orlando, Florida.

Highlights of the validation project:

- test plant operation and testing at the Irsching 4 customer site (E.ON) exclusively by Siemens AG under Siemens PG field test management,
- extensive field testing and validation.
- prototype engine equipped with about 3000 sensors for monitoring,
- commercial release of the new SGT5-8000H will be made only after successful completion of the prototype gas turbine testing.

After a successful test conclusion, the simple cycle test plant will be converted into a combined cycle plant with optimised water steam cycle components.

Improvements from the prototype test plant operations will be considered for implementation in a world-class, highly-efficient combined cycle plant that can be offered after serial release.

Construction of the prototype plant in Irsching 4 is under progress. The SGT5-8000H gas turbine and the generator are already delivered and set up on their foundations. The first firing of the engine is planned for late 2007. Completion of the test phase is targeted for mid-2009.

Summary

A major benefit for the customer is the high efficiency of 60 %. Efficiency not only plays an important role with respect to environmental aspects, but also for the profitability of the power plant. As fuel is the largest single cost item for running a power plant, an increase of two percentage points can save the operator millions of Euros over the entire life cycle of a combined cycle power plant with a capacity of 530 MW.

The gas turbine will initially target the 50Hz markets in Asia and Europe and is being developed for use with natural gas and fuel oil. A scaled 60Hz SGT6-8000H gas turbine will be released after the 50Hz engine verification. □

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