Proven CCPP Technology with the SCC5-8000H in Samsun

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1. Introduction

During the last two decades, the Turkish electricity market has been rapidly growing, with an average annual growth rate of more than 6%. According to IEA forecasts, it is expected that electricity consumption will double by 2020. Unless major changes in electricity imports take place, this will require at least doubling the installed generation capacity within a decade, which constitutes a tremendous challenge. Since the Turkish electricity market faces strong liberalization and privatization, most of the additions will be provided by independent power producers (IPPs) which face a fully competitive electricity market with all its uncertainties regarding fuel and electricity prices. The dynamic power plant market in Turkey calls for flexible and eco-friendly power generation facilities that are cost-efficient at the same time, so that they are right at the top in the merit order. Therefore Siemens is offering its state-of-the-art H-class technology in the Turkish market and placed the first 50 Hz H-class plant outside Germany first with Cengiz Enerji with a new 580 MW CCPP in Samsun at the Black Sea coast. This success has been followed by the second order of an H-class plant in Turkey with Enerjisa’s Bandırma II project, which received notice to proceed in December 2013.

2. Turkish power market characteristics

The Turkish energy sector is characterized by an ongoing process of liberalization and privatization with a strong political target to reduce the account deficit, mainly driven by tremendous imports of oil and gas. On the one hand the privatization process in the energy sector is in full swing with the distribution networks already sold to private investors, while the sale of several older power plants – hydro and thermal – is ongoing. Since all new and privatized power plants are exposed the liberalized merchant market with volatile electricity prices, operating flexibility is an important feature to be available on demand.

On the other hand Turkey relies heavily on primary energy imports due to limited own resources. Turkey imports more than 40 bcm of natural gas, roughly half of this amount is used for electricity generation. It is the declared policy of the Turkish government to reduce this dependency on gas imports which is a key driver for highly efficient power plants.

Based on these characteristics the electricity market demands power plant solutions which fulfil both requirements at the same time: Operate at highest efficiency and flexibility. The Siemens H class gas turbine and power plant technology is designed to fulfil these requirements in the best way.

3. Siemens SGT-8000H gas turbine

3.1. H-class portfolio and core engine design

Following the merger of Westinghouse Power Generation with Siemens in 1998, the decision was made to develop a Next Generation Family of Gas Turbines and therewith widen
the existing product portfolio based on the H-class frames for 50Hz and 60Hz markets. The Siemens gas turbine range spans now from 5 MW for industrial plants to 375 MW for utility size CCPPs. The SGT-8000H series addresses the major market requirements in terms of efficiency, environmental protection, operational flexibility and economical value.

The SGT-8000H gas turbine series combines the best design features and technologies of the established product lines combining high gas turbine efficiency with maximum operating flexibility (Figure 1). The Siemens H-class gas turbine and power plants were designed from the very beginning with a strong focus on highest level of operational flexibility. The design challenge was to provide improved plant flexibility without compromising plant service life or plant efficiency. Very early during the Siemens H-class development program a key design decision was made to select from both inhouse available gas turbine cooling technologies (air and air/steam) purely internal air-cooling. Due to the heavy impact of the steam cooling on the engine operational flexibility and design complexity, the internally fully air-cooled design was selected for the SGT-8000H series. This design feature enables faster starts, since there is no need to wait for steam from the water/steam cycle. The avoidance of steam cooling and external coolers enables easier simple cycle and bypass operation, faster load following and part load operation. Design simplicity especially in terms of sealing designs provides higher engine robustness. The SGT-8000H proven design allows achieving outstanding performance and operational flexibility without the higher risk associated with the steam cooling.

Figure 1: Main efficiency and flexibility related features of SGT-8000H gas turbine series
3.2. SCC-8000H combined cycle power plant solutions

Siemens Energy offers different combined cycle power plant configurations based on single- and multi-shaft arrangements. Additionally, Siemens is unique in offering a flexible scope of supply varying between the power train components via power island scope up to the entire power plant (turnkey scope). This enables Siemens to support – depending on the project specific setup – the regional partners and local knowledge. The portfolio flexibility with regards to different arrangements and scope of supply allows a wide range of technical and commercial (risk and cost) optimizations (Figure 2).

The power plant SCC-8000H series was developed based on the SGT-8000H as prime mover, the Irsching test plant and the large F-class experience. The design principle comprising the gas turbine, the generator, the coupling and the steam turbine on a single-shaft remained the same, as this continues to offer the customer greatest economy and at the same time supreme operational flexibility. The SCC-8000H series is also characterized by its high degree of harmonization, modularization and compact design towards footprint and space requirements. Recently a multi-shaft arrangement has been developed to provide flexible solutions e.g. for small power plant sites. Both solutions for 50Hz and 60Hz markets are based on the same design principles.

Figure 2: H-class power plant solutions enable different arrangements

![SCC5-8000H series performance and configuration overview](image-url)
The implementation of the FACY™ concept in combination with the hot start on-the-fly allows a hot start-up time reduction down to less than 30 minutes in comparison to “conventional” hot starts. The concept is based on a procedure for parallel start-up of gas and steam turbines, while monitoring and controlling the temperature gradients within limits acceptable for all critical plant components. Further, the design is based on a long term operation experience with different steam conditions in the Siemens turbine design. A new start-up sequence, which avoids gas turbine load hold points, was implemented. The main innovation here is the early steam turbine starting point with earlier acceleration and loading of the turbine. The FACY™ technology allows for higher number of starts and faster cycling without compromising plant lifetime consumption.

Figure 3: SCC-8000H series combines advanced water-steam cycle design with FACY™ technology for a perfect match between highest efficiency and plant operational flexibility

As H-class gas turbines provide high exhaust temperatures >620 °C, a further efficiency increase was achieved based on an advanced triple pressure reheat water steam cycle (up to 600°C inlet temperature and 170 bar inlet pressure). Despite high live steam parameters, the plant flexibility is further improved by use of a BENSON® type HRSG and condensate polishing (Figure 23). Compared to other combined cycle power plants using gas turbine steam
cooling, the number of main and auxiliary systems and their complexity are kept extremely low and therefore even the plant footprint could be reduced to the minimum.

The project specific selection of major design parameters and components is always a result of an overall life cycle cost optimization, which comprises invest, efficiency and operational flexibility aspects allowing maximization of customer’s value add and investment security. Siemens is offering a wide and flexible H-class combined cycle power plant portfolio based on long lasting experience and pre-designed and pre-optimized solutions, which provide an answer to the leading market requirements.

4. Fleet experience

4.1. References of the SCC-8000H series

With the successful conclusion of “Ulrich Hartmann” plant in Irsching (unit #4) and the related validation and testing phases, Siemens Energy is the first OEM to handover a gas turbine engine and a combined cycle plant with efficiency far beyond 60%. Siemens impressively demonstrated that world-record technology is now world wide commercially available to customers.

The next commercial success was achieved in Florida, USA, where 9 units of the SGT6-8000H were placed. All Florida Power & Light sites in Cape Canaveral (all three engines are already in commercial operation), Riviera Beach, and Port Everglades are equipped with the SGT6-8000H gas turbines in a multi-shaft configuration (3 on 1) and provide approximately 1200 MW electrical energy each (Figure 5). Prior to shipment to first customer’s site (Cape Caneveral) the full scale 60Hz engine was thoroughly tested in the Berlin test facility. At the same time period the next order from South Korea for the supply of a complete combined cycle power plant equipped with the SGT6-8000H in a single shaft configuration was placed by the independent power producer GS Electric Power & Services, Ltd. As a consortium leader, Siemens installed the 400MW class power plant Dangjin 3 as a turnkey project. In 2012 and 2013 further seven units were successfully sold in South Korea, with Ansan as a multi-shaft configuration, Andong, Posco Power 2 as a single shaft arrangement and Daegu City as a single shaft with a CHP application.

Following the success in Asia Siemens Energy has received an order for turnkey erection of the Lausward combined cycle power plant with district heat extraction in Düsseldorf, Germany. Further contract awards were recently achieved in the US in Pennsylvania with Moxie Liberty as a double unit single shaft SCC6-8000H 1S, in Turkey a 50Hz single shaft unit and in Malaysia also with a double single shaft unit in Prai. Currently several projects are in final negociation steps, confirming the world wide acceptance of the SCC-8000H power plants and customer’s trust in this proven technology.

End of 2012 Siemens received the notice to proceed for the Cengiz Samsun 600 MW CCPP which reflects another important milestone for the success of the Siemens H-class technology. With the SCC5-8000H CCPP and its core component SGT5-8000H, Cengiz Enerji will feature the most efficient fossil fired power plant in Turkey with a net efficiency of almost
61%. The power plant is configured as a single-shaft configuration and will meet all requirements for a flexible power plant with short startup times and fast load capability and will be the stable complement for the Turkish grid supply. This plant is capable of producing full load in as little as 30 minutes after eight hours shutdown. Furthermore, it reacts very quickly to grid fluctuations and can adapt its output by more than 35 MW within one minute to meet the changing power requirements. The power plant is currently under construction; all major equipment has been shipped to site, the power train has been installed in the turbine building and the HRSG is almost fully assembled. Cold commissioning has started already, first fire is scheduled for 31. August 2014.

![Samsun 600 MW CCPP – Turbine hall view January 2014](image)

Figure 4: Samsun 600 MW CCPP – Turbine hall view from January 2014

In December 2013 Siemens has received the order for the turnkey construction of the Bandirma II CCPP in Turkey. The purchaser is Enerjisa, a joint venture of Sabanci Holding and E.ON. Following the Samsun project, which is currently under construction, Bandirma II will be the second power plant in Turkey to be powered by an SGT5-8000H gas turbine, marking the sale of 28 of this model of gas turbine by Siemens worldwide. These gas turbines, which have proven themselves in commercial operation since 2011, have now clocked up more than 70,000 equivalent operating hours at an availability of more than 97 percent. Upon completion in the spring of 2016, this plant will have an installed capacity of close to 600 MW and an efficiency of over 60 percent.
4.2. Operational experience

Since “Ulrich Hartmann” handover in July 2011, SCC5-8000H has achieved in the Irsching 4 power plant in sum more than 16,000 equivalent operating hours and more than 450 starts. Depending on the grid dispatch requirements the unit is running in a daily start / stop and load following mode according to the dispatch requirements.

Several planned short time outages were performed and allowed a visual inspection of the hot gas path and confirmed the anticipated excellent engine conditions. The combustor inspection took place at 12,000 equivalent operating hours (EOH) outage in May 2012. The engine conditions and the hot gas path components were found to be in excellent condition. Further opportunistic inspections were done, the latest in August 2013. The results are more than satisfying, as the engine and the overall plant components are in an excellent shape, confirming accordingly the expected lifetime prediction (Figure 6). The intensive monitoring of “Ulrich Hartmann” shows also outstanding plant availability and starting reliability, which is necessary for a daily cycling operating regime.
In 2013 the first four 60Hz H-class power plants achieved commercial operation successfully and ahead of schedule. The units are running at base load and provide the fleet with very positive feedback in terms of performance and of course reliability and availability. The overall SCC-8000H fleet has today exceeded 70,000 EOH and in 2015 the 250,000 EOH mark will be surpassed.

Figure 6: Ulrich Hartmann (Irsching unit #4) inspection summary
5. References


6. Summary

The Turkish electricity market faces two main challenges: On the one hand the majority of electricity generation is still based on gas fired power plants which rely on expensive imports from several countries around Turkey. On the other hand the privatization and liberalization is progressing fast, reflected in volatile electricity prices exposing the several generating companies to a challenging market environment. To cope with these challenges the new CCPPs have to be highly efficient and flexible at the same time – requirements which can be fulfilled by the Siemens SCC5-8000H power plants in an excellent way.

This paper provides an overview of the Siemens SCC-8000H gas turbine, which is meanwhile recognized as fully proven technology. The main design features displaying the outstanding efficiency and operating flexibility of the SGT-8000H gas turbine series are presented. Siemens’ H-Class product portfolio is based on single shaft and multi shaft arrangements with optimized water / steam cycle and live steam parameters up to 600°C and 170 bars. The wide range of different solutions is based on pre-engineered and pre-optimized designs. The product portfolio offers several solutions with a flexible scope of supply and covers all relevant applications for 50Hz and 60Hz, e.g. Cogeneration.

In order to achieve highest operational efficiency without compromising the plant efficiency and its service life, Siemens Energy Solutions based all development activities on a global integrated approach, where all plant components besides the gas turbine are considered and optimized at the same time. This is possible, since Siemens Energy Solutions has all required engineering competencies and major components inhouse. The global solution design approach enables the achievement of outstanding performance, flexibility and reliability results as it has been impressively demonstrated in Ulrich Hartman plant, our H-class front runner. Finally Siemens Energy Solutions global approach leads to economically viable and sustainable answers, which drastically reduce life cycle cost and hence maximize customer’s value add.

The commercial success of the SCC-8000H series provides numerous proof points of Siemens Energy Solutions’ philosophy. The worldwide acceptance of this product line from Asia over Europe to the United States shows our customer’s trust. Latest project awards provide references for all different plant configurations from 1 on 1 up to 3 on 1 arrangement, from a daily cycling plant up to purely baseload plant, from 100% condensation operation up to large steam extraction.

This paper emphasizes the lighthouse projects Cengiz Samsun 600 MW CCPP and Enerjisa’s Bandırma II CCPP which will be the benchmarking CCPPs in Turkey in terms of efficiency and operating flexibility in the near future.
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