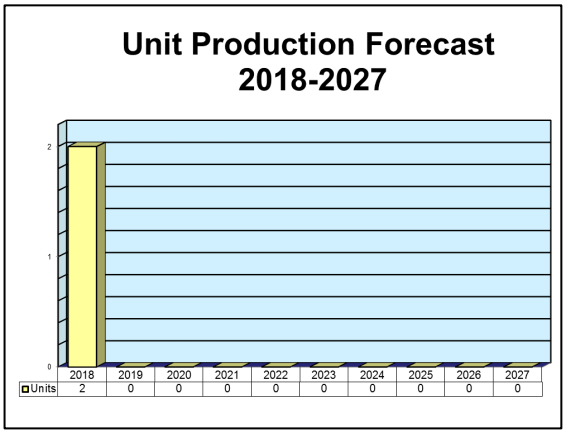
Siemens SGT-200

Outlook

- Position challenged by Siemens' acquisition of Rolls-Royce aeroderivatives
- Mechanical drive for pipeline and compressor use is major part of total production
- As of August 2018, Siemens has removed the SGT-200 from its product line



Orientation

Description. The Siemens SGT-200 (formerly Siemens Tornado, and earlier, Alstom Tornado) is a single-shaft/twin-shaft axial-flow industrial gas turbine machine in the 6- to 7-megawatt class.

Sponsor. The SGT-200 was privately developed by Ruston Gas Turbines Ltd, which later became a part of European Gas Turbines Ltd. EGTL was later incorporated into Alstom.

Power Class. The power output/rating of the SGT-200 is 6.75 MWe for electrical generation and 10,300 bhp (7,680 kW) for mechanical load drive duty.

Status. In production.

Total Produced. By 2017, more than 430 units had been sold, with more than 30 million equivalent operating hours.

Application. The SGT-200 is employed for electrical generation, including cogeneration and mechanical load drive duty – including gas compression and pumping.

Price Range. Estimated prices are approximately $3.77 million for an SGT-200-equipped gas turbine generator package and $4.8 million for a gas turbine-equipped mechanical drive package.

For electrical generation, the genset price is for a basic electric power skid-mounted generator package that includes one simple-cycle (open-cycle) single-fuel gas turbine, an air-cooled electric generator, a skid and enclosure, an air intake with basic filter and silencer, an exhaust stack, a basic starter and controls, and a conventional combustion system.

For mechanical drive gas turbines, the price covers a natural gas-fired, skid-mounted, simple-cycle (open-cycle) gas turbine prime mover (without driven equipment) with a gearbox, a skid, an enclosure, inlet and exhaust ducts, and an exhaust silencer; a conventional combustion system; fire protection and starting systems; standard engine controls; and the basic auxiliaries needed for an operational installation.

Competition. The Siemens SGT-200 competes in the electrical generation arena against the Kawasaki M7A-02, Solar Taurus 70, and Zorya-Mashproekt UGT-6000.

In the mechanical load drives arena, the Siemens machine competes with the Solar Taurus 70.

Siemens SGT-200

Contractors

Prime

Siemens, Siemens Industrial Turbomachinery	http://www.energy.siemens.com, Ruston House, Waterside S, Lincoln, United Kingdom, Tel: + 44 1522 584000, Fax: + 44 1522 584900, Prime
Siemens, Energy	http://www.energy.siemens.com/us/en/charlotte/products-services.htm#content=Gas%20Turbines, 5101 Westinghouse Blvd, Charlotte, NC 28273 United States, Tel: + 1 (704) 551-5100, Email: support.energy@siemens.com, Second Prime

Subcontractor

Altair Clean Air Technology	http://www.altair-srl.com, Via Caselle, 113, Leinì, Italy, Tel: + 39 119973113, Fax: + 39 119988546, Email: direzione@altair-srl.com (Acoustic Equipment)
Voith Turbo GmbH & Co KG	http://voith.com/en/group/organization/group-divisions/voith-turbo-164.html, PO Box 1555, Crailsheim, Germany, Tel: + 49 7951 32 0, Fax: + 49 7951 32 500, Email: industry@voith.com (Type PT 90 SP Gear Unit)
Wood Group Fuel Systems	http://https://www.woodgroup.com, 66 Prospect Hill Rd, East Windsor, CT 06088 United States, Tel: + 1 (860) 292-3115, Fax: + 1 (860) 292-1305 (Fuel Nozzle)

Contractors are invited to submit updated information to Editor, International Contractors, Forecast International, 22 Commerce Road, Newtown, CT 06470, USA; rich.pettibone@forecast1.com

Technical Data

Dimensions

Siemens SGT-200

	GENERATOR SETS	
	Metric Units	**U.S. Units**
Length (with package-mounted controls)	12.5 m	41 ft
Length (without package-mounted controls)	10.9 m	35.75 ft
Width	2.4 m	7.83 ft
Height (to top of enclosure)	3.3 m	10.83 ft
Weight	56,250 kg	124,000 lb

Siemens SGT-200-2S

	COMPRESSOR PACKAGES		PUMP PACKAGES	
	Metric Units	**U.S. Units**	**Metric Units**	**U.S. Units**
Length	10.5 m	34.41 ft	10.4 m	34.08 ft
Width	2.4 m	7.83 ft	2.4 m	7.83 ft
Height (to top of enclosure)	3.4 m	11.16 ft	3.4 m	11.16 ft
Weight	43,000 kg	94,798 lb	38,000 kg	83,775 lb

Performance

	ELECTRICAL GENERATION		MECHANICAL LOAD DRIVE	
	Metric Units	**U.S. Units**	**Metric Units**	**U.S. Units**
Output (ISO baseload)	6.75 MWe	9,050 shp	7,680 kW	10,300 shp
Heat rate	11,419 kJ/kWh	10,824 Btu/kW-hr	10,745 kJ/kWh	7,595 Btu/hp-hr
Pressure ratio (ISO)	12.3:1	12.3:1	12.6:1	12.6:1
Speed	11,050 rpm (a)	11,050 rpm (a)	11,500 rpm (b)	11,500 rpm (b)
Air flow (ISO)	29.0 kg/s	63.9 lb/s	29.45 kg/s	64.9 lb/s
Exhaust temperature	466°C	871°F	489°C	913°F

(a) Compressor nominal speed.
(b) Turbine speed.

Siemens SGT-200

Design Features. The SGT-200 design employs a single rotor with heavy-duty casings, allowing full site maintenance to be carried out. The single-shaft arrangement is achieved by fitting a coupling between the compressor turbine and power turbine rotor, and is intended for generator drive with output shaft speeds of 1,800 rpm and 1,500 rpm to suit 60- and 50-Hz-cycle machines. The output shaft speeds of the two-shaft engine are designed to drive gas compressors in the range of 7,500 rpm to 12,000 rpm and to drive centrifugal pumps at 3,000 rpm, 3,550 rpm, or 6,000 rpm.

Axial Compressor. A 15-stage axial-flow compressor of subsonic design provides a pressure ratio of 12.3:1 for the single-shaft model and 12.6:1 for the twin-shaft model. Compressor blades and stator vanes are of 17-4 PH steel, while the discs are forged of Jethete 152 material (1.5 percent Ni-Cr-Mo steel). Cast-iron compressor casing is horizontally split for easy access and maintenance.

The gas turbine has variable inlet guide vanes and stators for smooth startup and reliable part-load performance. Segmented compressor turbine stators are provided for the single-shaft model. Power turbine stator stages are cast as a complete ring.

Combustor. The combustor has eight reverse-flow tubular combustion chambers that are positioned circumferentially to allow easy removal. The combustor casing is split vertically to provide access. Chambers are made of Nimonic 75 and use film cooling. For the conventional combustion arrangement, there are two retractable high-energy igniters, and cross lighting between chambers is featured.

For the dry low emissions (DLE) combustion arrangement, there are high-energy igniters in each combustor. For the single-shaft machine, steam injection is an option for power enhancement.

Turbine. The turbine features a two-stage, high-efficiency design. Both versions have a two-stage overhung compressor turbine in which the first two blade rows are air-cooled.

For the single-shaft SGT-200, the power turbine is mechanically coupled to the compressor turbine.

For the two-shaft machine, the SGT-200 has a two-stage, high-efficiency free power turbine in which the Stage 2 rotor blades have interlocking shrouds for mechanical integrity. The power turbine rotates in a counterclockwise direction when viewed from the driven equipment end.

Fuel System. Both variants of the SGT-200 can operate on natural gas or distillate fuel, with a dual-fuel capability available. The ability to burn nonstandard fuels is optional. The machine variants have an automatic changeover capability, allowing a change from primary to secondary fuel at any load.

Exhaust Emissions Control. The SGT-200 is available with a single- or dual-fuel DLE combustion system, with VGV modulation for part-load emissions control. DLE NOx levels are <25 ppm on gas fuel. Steam or water injection can also be used for emissions control on conventional combustion.

Bearings. Tilting pad journal and thrust bearings are standard.

Gearbox. The single-shaft SGT-200 features hot-end drive via an integral speed-reducing gearbox. Output speeds of 1,500 rpm and 1,800 rpm are available to meet the needs of 50-Hz and 60-Hz operation. For the two-shaft SGT-200, there is direct drive of compressors without a gearbox for full load speed from 8,000 rpm to 11,500 rpm. Gearbox options are available for other mechanical drive applications. The auxiliary gearbox is mounted directly off the compressor inlet bearing housing.

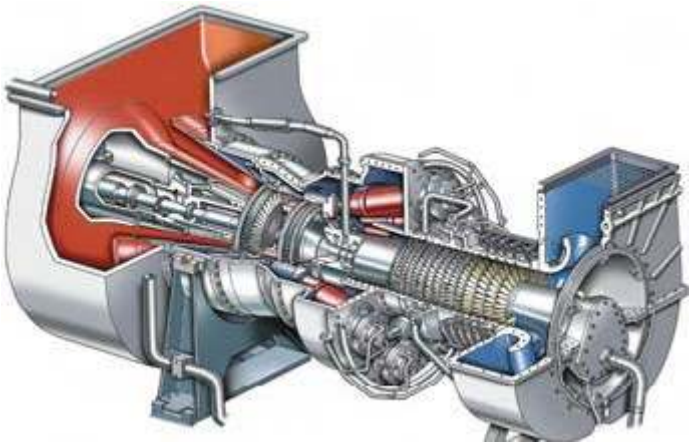
Lubrication. Standard equipment includes an integral lubricating oil system, a gearbox-driven pump, an AC-motor-driven pump, and a DC-motor-driven emergency pump.

Starting. Starting is normally accomplished using a variable-speed AC motor.

Control System. The machine is equipped with a Rustronic Series 3000 PLC-based system, with local control and processing capability installed on the under-base structure.

Operational Characteristics. The power turbine has a maximum continuous design speed of 11,525 rpm and a minimum design speed of 7,000 rpm. Flexible coupling joins the compressor turbine and power turbine assemblies. The two-stage power turbine has solid blades cast of IN713LC; the blades are unshrouded. Segmented nozzles are standard, with four vanes per segment. Discs are of austenitic chrome steel (FV 488E) and are connected by a single center bolt. Nozzle segments are cast in IN713LC.

Siemens SGT-200



SGT-200 Gas Turbine Cutaway View

Source: Siemens Energy

Variants/Upgrades

The SGT-200 is available as a single-shaft version for power generation with a power output of 6.75 MW, and as a twin-shaft turbine with output of 7.68 MW for mechanical drive. The SGT-200 operates with various gaseous and liquid fuels, and is available as a factory-assembled package.

Power Generation. The SGT-200 is well suited for industrial power generation, particularly in cogeneration or combined heat and power. In applications where the SGT-200's high-temperature exhaust is passed through a waste heat recovery unit or boiler, overall thermal efficiency of up to 95 percent can be achieved. The steam or hot water generated is used in industrial process or district heating schemes. The steam raised may also be used in small-scale combined-cycle applications in conjunction with a steam turbine. Alternatively, exhaust heat may be utilized for the drying of industrial products.

Power Generation in the Oil and Gas Industry. The SGT-200 is employed on offshore platforms and floating production storage and offloading (FPSO) vessels worldwide. Onshore, the SGT-200 can be used as a power generator for oil field service, refinery applications, and emergency and standby power generation. Cogeneration in the oil and gas industry provides efficient solutions for crude oil and glycol heating as well as steam generation.

Dry Low NOx. Alstom had for several years been working on a dry low NOx combustor system for all of its small industrial machines. Its system was a hybrid premix combustor that could meet current and planned EU NOx emission standards. More than 600 hours of rig testing were carried out in 1993 on wet/dry low NOx systems. High-pressure rig and engine testing continued through 1994, with the Typhoon becoming the first EGTL machine to be sold with the DLN system, in 1994. Sales of the DLN system on the Tornado began in 1995.

Tornado Mobile Power Package. In 1979, Ruston introduced the mobile power station incorporating its already popular TB5000. The Nomad 10, which used a single Tornado gas turbine machine, had a rating of 5.9 megawatts. The Lincoln, U.K.-based firm launched the Nomad 10 with an eye to the market in southern Asia for mobile power generation.

Steam Injection. EGTL/Alstom developed steam injection systems for several of the machines in its product line, including the Tornado and TB5000. The systems were originally designed to reduce NOx emissions levels from exhaust gases through the introduction of high-pressure steam into the gas turbine's combustion chamber. EGTL's work demonstrated that improvements in performance could be achieved: up to a 55 percent increase in power, with efficiencies of approximately 40 percent. In addition to steam injection for the SGT-200/Tornado and TB5000, water injection systems are available.

The 6.75-MWe SGT-200 unfired heat recovery steam generator (HRSG) has an exhaust gas mass flow of 29 kilograms per second at 472°C. The gas temperature leaving the boiler is 120°C. The mean specified heat is 0.26 kcal/kg/°C.

Mechanical Drive. The mechanical drive package is very compact, providing a small footprint and a high power-to-weight ratio. The twin-shaft configuration

reportedly provides excellent speed and load turndown characteristics to allow maximum flexibility of operation.

Compressor Applications. Siemens offers a completely integrated gas compression package with common control and auxiliary systems. Alternatively, SGT-200 driver packages are available for customer integration. Due to the high output speed of the power turbine and its ability to operate at full load at reduced speed, most compressor drive applications can be met without the need for a speed-changing gear between the power turbine and gas compressor.

Pump Applications. The SGT-200 gas turbine is well suited for pumping applications. These include crude oil and product transmission and water injection. Drive from the power turbine is usually via a speed-reducing gearbox. The manufacturer reports that the load-speed characteristics of the SGT-200 provide operators with maximum flexibility for flow turndown and pressure control.

Licensees/Packagers. Japanese company Hitachi has installed at least eight SGT-200 machines in Japan, all for generation duty. Takuma has installed two machines in Japan. Stewart & Stevenson (now merged into General Electric Company) installed 19 machines, including eight machines in Brazil.

Program Review

Background. Ruston Gas Turbines began developing the Tornado in 1977. The Tornado is a two-shaft machine that can easily be converted to a single-shaft unit for generation applications. It borrows heavily from the design of the TB5000 series, with the exception of the freestanding accessory gearbox (included are air-cooled turbine components to achieve higher turbine inlet temperatures and improved efficiency).

In April-August 2003, the Siemens Power Generation Group (PG) acquired the light industrial turbine business of Alstom SA, Paris, France. This, together with a number of other corporate acquisitions at the time, made the nomenclature of the company products unwieldy. As a result, in 2004, the entire accumulated product range was renumbered in a logical and consistent series. Under this system, the Tornado became the SGT-200.

In 2016, the Australian Ichthys LNG project took a major step forward when the Central Processing Facility (CPF) and FPSO facility safely started up their main power generators in the South Korean shipyards where they are being constructed. At the Samsung Heavy Industries shipyard in Geoje, the CPF's three generators, run by 25-MW dual-fuel gas turbines, energized the facility's distribution network. This followed the July startup of the FPSO facility's main turbo-generators at the nearby Daewoo Shipbuilding & Marine Engineering yard in Okpo. Following the successful firing of the main power generation units, the focus will be on load testing, synchronization, and commissioning of the power distribution systems for both offshore facilities. This will allow the permanent utilities on board each facility to be made fully available.

The CPF and FPSO facility will be permanently moored for 40 years of operation in the Ichthys field, which is located in the Timor Sea about 220 kilometers (137 mi) offshore Western Australia. Gas will undergo initial processing at the CPF to extract condensate and water and remove impurities in order to make the gas suitable for transmission. Most condensate will be transferred from the CPF to the nearby FPSO facility for offshore processing, with the remainder sent to Darwin along with the gas via the project's 890-kilometer (553 mi) gas export pipeline. More condensate will be extracted from the gas at the onshore plant in Darwin. Once in the field, the FPSO and CPF will be linked by an electric cable, allowing power supply to flow from each facility as a contingency measure as required.

Related News

Efficiency Is the Keyword – Turbine Efficiency, which is based in Lincoln, England, was established in 2000 and today has more than 80 employees. The company says that since early 2017 it has won six long-term service agreement contracts and has carried out "numerous" overhauls on Siemens SGT-100, SGT-200, and SGT-300 turbines. It has also completed overhauls of three Ruston TA1750 gas turbine packages. The company adds that it has received "significant investment" from London-based private equity investment group Core Capital Partners LLP. (Diesel & Gas Turbine Worldwide, 8/17)

Siemens SGT-200

Funding

Development of what is now known as the SGT-200 was originally undertaken by Ruston Turbines, which later became a part of European Gas Turbines Ltd. EGTL was later incorporated into Alstom. Any future developments will be funded by Siemens.

Contracts/Orders & Options

Contractor	Award ($ millions)	Date/Description
Siemens	44.70	Feb 2003 – Follow-on total of 15 Tornado gas turbine pump drivers for delivery to six stations on the OZ2 pipeline in northern Algeria (for Phase II of the project).
Siemens	2.46	Jun 2003 – One Tornado gas turbine compressor set for a Polysonic Wind Tunnel project in St. Louis, MO. The order was placed by The Boeing Company.
Siemens	3.57	Mar 2010 – Two Tornado gas turbine generator sets for Scottish & Southern Energy project at Barrow-in-Furness, Cumbria, U.K.
Siemens	3.60	Jun 2011 – Two SGT-200 gas turbine compressor sets for IPSA Group project in South Africa. The order was placed by Newcastle Karbochem.
Siemens	N/A	Sep 2011 – Two SGT-200 gas turbine compressor sets for FPSO available for the North Sea and Gulf of Mexico. The order was placed by Bluewater Industries.

N/A = Not Available

Timetable

Month	Year	Major Development
	1977	Development of Tornado machine
	1981	Contract placed for first machine
	1982	First production machine operational
	1983	GEC Ruston formed
Jul	1984	First order from USA
Apr	1985	First U.S. machine commissioned
Early	1990	EGTL formed
	1996	Tornado offered with low NOx burners
Mar	1999	Alstom and ABB merge power-generation businesses
May	2000	Alstom and ABB split; Alstom Power remains in turbine business
	2001	Several orders placed for Tornado gensets for FPSO vessels
Sep	2001	Three Tornado generating sets begin commercial operation at oil field in western Siberia
Nov	2001	Alstom wins $36 million contract for 15 gas turbines for major pipeline in Algeria (Phase I)
Jan	2002	Tornado machines ordered for Iran's Dorood Project on Kharg Island
Jun	2002	Alstom wins third successive order for gas turbines for FPSO vessels
Feb	2003	Alstom wins EUR40 million follow-on contract for 15 gas turbines for major pipeline in Algeria (Phase II)
Apr-Aug	2003	Siemens PG acquires part of the gas turbine business of Alstom SA
Jun	2003	Siemens awarded contract by The Boeing Company for Tornado compressor set for a Polysonic Wind Tunnel project in St. Louis, MO
Nov	2004	Siemens redesignates its entire product line; Tornado name changed to SGT-200
By end of	2004	Algeria takes delivery of 35th SGT-200 machine
Dec	2012	Wood Group GTS awarded maintenance contract for units at Sakhalin Energy
Aug	2013	Wood Group GTS provides repair and overhaul support for SGT-200 (Tornado)

Worldwide Distribution/Inventories

According to Siemens, more than 430 SGT-200 units have been sold. Of these, 266 have been positively identified. The balance of 164 are believed to be mostly mechanical drive units or used for FPSO vessels and other maritime requirements.

Country	Year Installed	Total
Power Generation		
Australia	1983 (1), 1988 (1), 1991 (1), 1993 (1)	4
Bangladesh	1991	1
Canada	1992	1
Chile	1988	1
China	1986 (2), 1987 (1)	3
Denmark	1989 (1), 1990 (1), 1997 (2)	4
Finland	1997	2
France	1995 (2), 2000 (2)	4
Germany	1983 (1), 1990 (2), 1991 (1), 1992 (2), 1994 (1)	7
India	1997	1
Indonesia	1993	1
Iran	1994	2
Ireland	1997	1
Japan	1988 (1), 1992 (1), 1995 (2), 1996 (2), unspecified (8)	14
Libya	2003	6
Luxembourg	1995	1
Netherlands	1981 (2), 1982 (2), 1983 (1), 1984 (2), 1985 (2), 1986 (1), 1987 (1), 1988 (1), 1990 (3), 1995 (1), 1997 (2)	18
Pakistan	1999	1
Qatar	1992	1
Russia	2001 (3), 2002 (3)	6
South Africa	2007 (2), 2011 (2)	4
Spain	1989 (1), 1990 (4), 1991 (2), 1992 (1), 1994 (1)	9
Turkey	1994 (2), 1995 (2), 1997 (6)	10
UAE	1984	4
U.K.	1985 (2), 1987 (4), 1989 (2), 1990 (3), 1992 (3), 1993 (2), 1994 (4), 1995 (1), 1996 (2), 1997 (1), 1998 (3), 1999 (2), 2010 (2)	31
USA	1975 (1), 1984 (1), 1985 (9), 1986 (1)	12
Total		**149**
Mechanical Drive		
Algeria	2001 (15), 2003 (15), unspecified (10)	40
Brazil	Unspecified	8
France	Unspecified	6
Gabon	1995	3
Iran	Unspecified	10
Japan	Unspecified	6
Myanmar	1985	1
Russia	2001 (3), 2002 (1), unspecified (3)	7
U.K.	1988 (6), 1991 (1), 1992 (6), 1997 (4)	17
USA	1986 (6), 1987 (4), 1988 (1), 1995 (1), 1999 (2), 2003 (1), 2011 (2), 2014 (2)	19
Total		**117**
Grand Total		**266**

Siemens SGT-200

Forecast Rationale

Siemens' acquisition of Rolls-Royce and its aeroderivative turbines has put the SGT-200 under threat, so much so that it appears the SGT-200 is no longer in the product line. The former Rolls-Royce 501-K is now the Siemens SGT-A05 AE, which is in the power range of the dated SGT-200 and a fitting replacement for that turbine.

As it currently stands, the SGT-200 is no longer available for purchase, although there might be some undisclosed orders that have not been fulfilled. This report will be archived in 2019 if the situation remains the same.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR UNIT PRODUCTION												
Designation or Program	High Confidence					Good Confidence			Speculative			
	Thru 2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Total
Siemens												
SGT-200 (Tornado) <> MW 3.0 to <10.0												
	217	1	0	0	0	0	0	0	0	0	0	1
SGT-200 (Tornado) <> SHP 10,000 to <20,000												
	236	1	0	0	0	0	0	0	0	0	0	1
Subtotal	453	2	0	0	0	0	0	0	0	0	0	2
Total	453	2	0	0	0	0	0	0	0	0	0	2