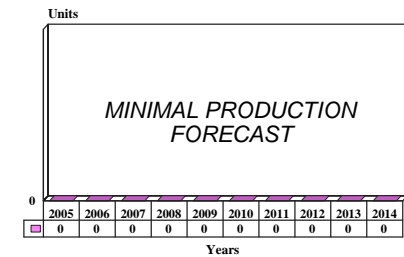


Siemens SGT-1000 - Archived 5/2006

Outlook

- The 68-MW 50/60 Hz SGT-1000 has faced competition from the Trent 50, Trent 60, and GT8C2
- Produced by Ansaldo and TPMS
- Siemens AG is well poised to take advantage of global generation capacity boom with its experience in simple-cycle, combined-cycle, and cogeneration operations, as well as steam turbines

10 Year Unit Production Forecast
2005 - 2014



Orientation

Description. The SGT-1000 (formerly the V64.3) is a large, heavy-duty single-shaft 50/60Hz industrial gas turbine machine whose power output is about 68 MW.

Sponsor. The SGT-1000 machine was privately developed by the prime contractor (identified below).

Power Class. The most current model in the SGT-1000 series, the SGT-1000F (formerly V64.3A), is base-plate rated at 68 MW.

Status. As of early March 2005, the SGT-100F was still in the Siemens portfolio and still available for order.

Total Produced. At of the start of 2005, at least 77 SGT-1000s are known to have been installed (V64.2, 2; V64.3, 45; V64.3A/SGT-1000F, 30).

Application. The current application is utility and industrial electrical generation, including simple-cycle, combined-cycle, and cogeneration installations.

Price Range. Price for the SGT-1000F (estimated in 2005 U.S. dollars) is \$14.5 million to \$15.5 million. Combined-cycle prices estimated to range between \$550 and \$560 per kW for SGT-1000F Single and between \$490 and \$500 per kW for SGT-1000F Multi.

For electrical generation, gensets prices are in 2005 calendar year U.S. dollars and include a basic electric power skid-mounted generator package, including one simple-cycle (open cycle) single-fuel gas turbine, air-cooled electric generator, skid and enclosure, air intake with basic filter and silencer, exhaust stack, basic starter and controls, and a conventional combustion system.

Competition. The Siemens SGT-1000F competes against the Rolls-Royce Trent 50 DLE and Trent 60 (water injection), and the Alstom GT8C2.

Contractors

Siemens AG, Siemens Power Generation, <http://www.pg.siemens.com>, Freyeslebenstr1, Postfach 3220, Erlangen, 91952 Germany, Tel: 49 9131 18 7034, Fax: 49 9131 18 7039, Prime

Ansaldo Energia S.p.A., <http://www.ansaldoenergia.com>, Via Nicola Lorenzo 8, Genoa, 16152 Italy, Tel: 39 010 6551, Fax: 39 010 655 6209, Email: Communication@aen.ansaldo.it, Licensee

Boldrocchi Srl, <http://www.boldrocchi.it>, Viale Trento E Trieste 93, Biassono, 20046 Italy, Tel: 39 39 2202 900, Fax: 39 39 2754 200 (Intake & Exhaust System)

Industrial Acoustics Company Inc, <http://www.industrialacoustics.com>, 1160 Commerce Avenue, New York, NY 10462-5599 United States, Tel: 1 (718) 430-4523, Fax: 1 (718) 863-1138 (Noise Suppression System)

Contractors (continued)

Maag Gear Company Limited, (a member of the F. L. Smidth Group), <http://www.aag-gear.com>, Hardstr 219, Zurich, CH 8023 Switzerland, Tel: 41 01 2787878, Fax: 41 01 2787880 (Load Gear System)

Renk AG, <http://www.renk.newsfactory.de>, Gogginger Strasse 73, Augsburg, 86159 Germany, Tel: 49 821 57 00 0, Fax: 49 821 57 00 460, Email: info.augsburg@renk.biz (Turbo Gear Unit)

Technical Data**Design Features**

Intake. Air enters radially and is turned for entry into a compressor with fixed inlet guide vanes. Intake filtration and silencing systems are available.

Compressor. The SGT-100F (formerly V64.3A) features a 17-stage axial-flow compressor with a pressure ratio of 15.8, designed for optimum flow distribution. First four guide vane stages are variable.

Combustor. The SGT-1000 has an annular combustion chamber with 24 hybrid burners; ceramic-coated heat shields are used. The two combustor silos are mounted horizontally. Hybrid burners are available to customers in countries with strict NOx limits. The machine can be equipped with a low-NOx combustion system.

Turbine. The SGT-1000 has a four-stage axial-flow turbine. Turbine blades have thermal barrier coatings. The first four stationary blade rows and the first three rows of rotating blades are internally cooled.

Dimensions. The approximate dimensions and weight of a SGT-1000F (formerly V64.3A) are as follows:

	<u>Metric Units</u>	<u>English Units</u>
Length	11.0 m	36.1 ft
Width	3.96 m	13.0 ft
Height	4.8 m	15.7 ft
Weight (with gearbox)	110,000 kg	242,500 lb

Performance. The Siemens SGT-1000F (formerly V64.3A) can be supplied in various modes including Econopacs, Power Islands, or complete power plants. For gas turbine component packages, the 50-Hz Econopac V64.3A has been redesignated the SGT5-PAC 1000F; the 60-Hz Econopac V64.3A has been redesignated the SGT6-PAC 1000F.

The SGT-1000F has the following performance parameters in simple-cycle mode:

APPLICATION = SIMPLE-CYCLE MODE					
	<u>Net Power</u>	<u>Net</u>	<u>Net</u>	<u>Exhaust</u>	<u>Exhaust</u>
	<u>Output</u>	<u>Heat Rate</u>	<u>Efficiency</u>	<u>Mass Flow</u>	<u>Temperature</u>
SGT-1000F	68 MW	10,496 kJ/kWh	35.1%	190 kg/sec	586°C

The SGT-1000F (formerly V64.3A) has the following performance parameters in combined-cycle mode (standard inlet and exhaust losses; ISO ambient conditions, natural gas fuel, fuel heating value [LHV] 48,803 kJ/kg, fuel HHV/LHV 1.11, generator power factor 0.9):

APPLICATION = COMBINED-CYCLE MODE			
	<u>Net Power</u>	<u>Net</u>	<u>Net</u>
	<u>Output</u>	<u>Heat Rate</u>	<u>Efficiency</u>
SGT-1000F Single ^(a)	101 MW	6,844 kJ/kWh	52.6%
SGT-1000F Multi ^(b)	201 MW	6,601 kJ/kWh	52.5%

^(a) Single = Single Shaft (both the gas turbine and steam turbine are on the same drive train).

^(b) Multi = 2 gas turbines + 1 steam turbine on its own shaft.

Variants/Upgrades

Since the start of the Siemens SGT-1000 program (formerly V64 program), only a few variants have been produced. Siemens documentation lists only the SGT-1000F (V64.3A) as being currently available, at a base-plate rating of about 68 MW and with a net simple-cycle efficiency of 35.1 percent.

In late November 2004, Siemens redesignated its gas and steam turbine machines, using a numeric system that relates a machine model's power output relative to all other machines in the Siemens portfolio. The V64.3A is now designated the SGT-1000F.

Program Review

Background. Technology for the Siemens SGT-1000 (V64) was taken from the V94 (now the SGT5-2000/3000/4000) and the V84 (now the SGT6-2000E/-4000F) gas turbines. Their proven operational reliability and ease of maintenance were transferred in full to the scaled-down SGT-1000. In addition, the SGT-1000 now comes equipped with ceramically lined multiburner combustion chambers, a two-bearing shaft and front-end generator drive, and an intercooler that can be air- or water-cooled. Early orders for the V64 were placed by Finland, the U.S., Japan and the UAE.

The SGT-1000F prime manufacturer is Siemens AG, Erlangen, Germany. The gas turbine is produced in Berlin, Germany.

Combined-Cycle Technology. The Siemens Power Generation Group makes its gas turbine technology available under the GUD trademark (Gas und Dampf, or Gas and Steam), using steam turbines built in Mühlheim. Based on gas turbine efficiencies up to 38.2 percent, GUD plants offer new efficiencies as high as 55 percent. Major GUD projects are in Ambarli, Turkey; Damietta, Egypt; and Valladolid, Mexico.

United Technologies/KWU Early Efforts. United Technologies and KWU conducted a study of the requirements of a baseload coal-fueled gas turbine design that could meet the needs of utilities in the future. The basic design used for investigation was the KWU 100-MW simple-cycle unit, which later was a reference point for all design changes. Combining advanced aero-derivative technology with a combined-cycle system incorporating a coal gasifier, the group determined that a true high-efficiency, baseload generation plant could be developed. With no new developments in technology, the system could be competitive in terms of reliability, performance, fuel flexibility, and cost.

Siemens/Bharat Agreement. In September 1989, the Siemens PGG Group signed a long-term cooperation and licensing agreement with Bharat Heavy Electricals Limited (BHEL) in India for the manufacture, marketing, and support of KWU-designed gas turbines in India. The agreement involved the V94 immediately,

the V64 by the end of 1990, and the updated follow-on to the V94 at the end of 1992. The Indian firm was already licensed to manufacture Siemens steam turbine generators up to 1,000 MW.

BHEL's products include the V64.3 in the V64 series.

First V64.3 GUD. The first combined-cycle (GUD) power plant to be operated in conjunction with a refuse incineration plant was built in the Netherlands. Three 60-MW V64.3 units and one 180-MW steam turbine are utilized. The plant went on-line in late 1996 and has a rated capacity of 339 MW.

In addition to generating electricity for the public grid, the Siemens-built plant supplies process steam to a nearby chemical plant. This means that almost 70 percent of the energy contained in the natural gas is utilized. The steam produced by the refuse incineration process is passed via an integrated steam, condensate, and feedwater cycle to the heat-recovery steam generators of the GUD cycle. The use of steam from the refuse incineration plant reduces the GUD plant's fuel consumption by 40 million cubic meters of natural gas per year, thereby also decreasing CO₂ emissions by almost 100,000 tons.

Ansaldo Energia. Ansaldo Energia is offering the model TX71/1C reduction gearbox manufactured by Flender Graffenstaaden as an auxiliary to the SGT-1000F gas turbine developed cooperatively with Siemens KWU of Berlin, Germany.

The quillshaft gear was originally designed for the Siemens KWU V63.3 gas turbine, a machine rated at 62.5 MW and the gears dimensioned for 75 MW to provide an adequate safety margin. To maintain this safety margin and load on the geared wheels when used in conjunction with the 68 MW-rated V64.3A gas turbine, Flender Graffenstaaden has increased the width of the two wheels in order to up its rating to 80 MW. The new wheels are assembled inside the same casing, and all other components remain unchanged, including the TX71/1C designation.

The use of the quillshaft design is standard for Flender Graffenstaaden high-speed gearboxes with a 30 MW

rating or higher. The company maintains that this type of construction has superior built-in safety margins and that the five-bearing layout is beneficial when coupled to single-bearing generators. The weight of the rotor is absorbed by the fifth bearing at the end of the quillshaft, leaving the remaining four only to maintain the position of the bull and pinion gears.

As a licensee/builder of the V64.3 and SGT-1000F, Ansaldo has installed at least 21 V64 machines to customers in eight countries. The leading customer nation is Italy, with seven machines delivered. It delivered the two V64.2s known to have been installed.

The V64.3A. In early 1996, Siemens and Ansaldo Energia revealed their joint effort on the V64.3A (now the SGT-1000F), rated at about 68 MW. The Ansaldo Energia contribution for the new model was concentrated in the design and successive manufacture

of the stator compartment, turbine cases, annular combustion chamber, and fuel burners. The new machine was developed for enhanced power output and efficiency, and for reduced environmental impact.

The earliest order for the V64.3A came from Neckarwerke Elektrik for topping duty in Germany: that machine was ordered in November 1994. In 1998, Ansaldo shipped a 125-MW Effasu barge-mounted gas turbine power station for the Ghana National Petroleum Corporation; the barge has two V64.3A machines.

It should be noted that instead of the traditional Siemens silo-type combustors, the V64.3A gas turbine uses annular combustion chambers. That method allows for a more compact layout, a reduction in cooling air consumption, and a more uniform gas temperature distribution to the Stage 1 turbine inlet.

Funding

No German government funding pertaining to the Siemens SGT-1000 series machines has been identified.

Recent Contracts

Recent non-military contracts/sales pertaining to the V64.2, V64.3 and V64.3A/SGT-1000F include the following:

<u>Contractor</u>	<u>Award (millions)</u>	<u>Date/Description</u>
PLN (Indonesia)	IDR2.6	Apr 2003 – Six V64.3A 2+1 Multi blocks (12 gas turbines) for the expansion of the Muara Tawar power plant in Bekasi, West Java, Indonesia.
Midor Electric (Egypt)	N/A	May 1999 – Three V64.3 gas turbines for a 180-MW simple-cycle gas turbine power station. The contract also included plant operation and maintenance for 10 years.

Timetable

<u>Month</u>	<u>Year</u>	<u>Major Development</u>
Early	1988	V64 introduced, at 50 MW
Mid	1988	V64 ordered by Helsinki Energy Board
Mid	1988	Siemens, TPMS agreement concluded
Sep	1989	Siemens, Bharat agreement concluded
Oct	1990	First pair of V64.3s placed in trial service in Finland
Jun	1991	V64s ordered by Dubai Electricity Company
3Q	1991	Third V64.3 placed into commercial operation in Denmark
		V64.3s ordered by Kamine Development/Besicorp, through UTC TPMS, for use in USA
Early	1992	V64s ordered by Fuji Kawas in Japan
Jan	1994	V64.3 ordered for Europe's first combined-cycle (GUD) plant in the Netherlands
	1994	First V64 installed by Ansaldo
4Q	1994	Development of V64.3A/V84.3A/V94.3A variants announced
Nov	1994	V64.3A ordered by Neckarwerke Elektrik for duty in Germany
Late	1997	Test program of V64.3A on natural gas completed in Berlin
Apr	1999	Ansaldo obtained ready-to-ship certificate for V64.3A-equipped power barge for Ghana National Petroleum Corporation

<u>Month</u>	<u>Year</u>	<u>Major Development</u>
Apr	2003	12 V64.3As ordered for expansion of the Muara Tawar power plant in Indonesia.
Nov	2004	Siemens redesignates entire product line
Thru	2014	Continued production/aftermarket support of V64 series projected

Worldwide Distribution

As of the start of 2005, at least 77 Siemens V64.2/V64.3/V64.3A/SGT-1000F machines are known to have been installed in 20 countries worldwide, including 21 machines installed by Ansaldo Energia. Major customer nations include **Germany** (16 machines), **Indonesia** (12), **Italy** (7), **United Arab Emirates** (8), and the **U.S.** (5).

Forecast Rationale

The 50/60Hz Siemens SGT-1000F (formerly the V64.3A) machine, in comparison to the earlier V64.3, offered a notable increase in efficiency and a reduction in emissions due, in large part, to an annular combustion chamber featuring a hybrid burner ring: that feature has enabled the machine's NOx emissions to be kept quite low. These features have added to the attractiveness of this capable and well-positioned (power-wise) machine. At over 35 percent efficiency, the machine was able to hold its own against the GE Model 6000 produced by GE Energy and others. In addition, the V64.3A has operated effortlessly in GUD applications, most notably in Europe.

The SGT-1000F has been made available in several modes, including Econopacs, Power Islands and complete power plants, and could easily be incorporated into an overall power installation with other Siemens lower-output machines.

The recent lull in gas turbine orders, however, has taken its toll on the SGT-1000F. The venerable machine is still in the Siemens AG power portfolio, however, and available for order.

At this time, we believe that Europe will remain the prime electrical generation sales region for this machine, with other sales possible in Asia and the Middle East.

We will retain this report for another year in case additional orders should arise. While it is difficult to predict how many additional machines might be built by Siemens and Ansaldo, some possible future orders placed with Siemens might be fulfilled by Ansaldo. Production of the V64 by Bharat in India could also take place, although the Indian company has, as of the date of this report, installed only 12 V94 machines from the V64/V94 product line.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR PRODUCTION

Engine/Machine	Application	High Confidence Level			Good Confidence Level			Speculative Level			Total 2005-2014		
		thru 2004	2005	2006	2007	2008	2009	2010	2011	2012		2013	2014
SIEMENS AG, POWER GEN GROUP													
SGT-1000F (V64.3A) (a)	GENERATION	27	0	0	0	0	0	0	0	0	0	0	0
V64 (THRU V64.3)	GENERATION	27	0	0	0	0	0	0	0	0	0	0	0
SUBTOTAL		54	0	0	0	0	0	0	0	0	0	0	0
ANSALDO ENERGIA SPA (Licensee)													
SGT-1000F (V64.3A) (a)	GENERATION	3	0	0	0	0	0	0	0	0	0	0	0
V64 (THRU V64.3)	GENERATION	18	0	0	0	0	0	0	0	0	0	0	0
SUBTOTAL		21	0	0	0	0	0	0	0	0	0	0	0
TURBO POWER & MARINE SYSTEMS (Associate)													
V64 (ALL)	GENERATION	2	0	0	0	0	0	0	0	0	0	0	0
TOTAL PRODUCTION		77	0	0	0	0	0	0	0	0	0	0	0

(a) The V64.3A was redesignated the SGT-1000F in November 2004.