

General Electric GE-10

Outlook

- Production reportedly ceased some years ago
- No active market for GE-10 at this time
- Most machines sold for mechanical drive duties

Orientation

Description. The GE-10 is a single-shaft (GE-10-1) and two-shaft (GE-10-2) machine designed and developed by GE Oil & Gas for power generation (including industrial cogeneration) and mechanical load drive applications. Emphasis was placed on the design of a dry low NO_x (DLN) system for NO_x reduction to meet current and future standards for pollutant emissions.

Sponsor. The GE-10 is derived from the Nuovo Pignone SpA (now a part of GE Oil & Gas) PGT10.

Power Class. The power output of the GE-10 machine is in the 10- to 12-MW class.

Status. The GE-10 is no longer produced by GE in the Americas.

Total Produced. GE states in its corporate documentation that about 200 GE-10/PGT10 machines have been manufactured and installed for customers in 21 countries and territories worldwide.

Application. Current applications include mechanical load drive duty and electrical generation duty, the latter including cogeneration plants.

Price Range. The GE-10's price in current-year U.S. dollars is estimated at \$5.5 million for a gas

turbine-equipped package and \$6.7 million for a gas turbine-equipped mechanical drive package.

For electrical generation, the genset price covers 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 gearbox, skid, enclosure, inlet and exhaust ducts, and exhaust silencer; a conventional combustion system; fire protection and starting systems; standard engine controls; and the basic auxiliaries needed for an operational installation.

Competition. In the electrical generation and mechanical drive arenas, the GE-10 competes with the MAN TURBO THM 1304-11 and the Solar Mars 100.

A machine that indirectly competes with the GE-10 is the Zorya-Mashproekt UGT-10000.

General Electric GE-10**Contractors****Prime**

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Subcontractor

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Technical Data**Dimensions.**

	GENERATOR DRIVE DUTY		MECHANICAL LOAD DRIVE DUTY	
	<u>Metric Units</u>	<u>U.S. Units</u>	<u>Metric Units</u>	<u>U.S. Units</u>
Length	9.0 m	29.5 ft	10.5 m	34.3 ft
Width	2.5 m	8.2 ft	2.5 m	8.2 ft
Height	6.0 m	19.6 ft	6.0 m	19.6 ft
Weight	34,000 kg	74,950 lb	38,000 kg	83,775 lb

Performance.

	GENERATOR DRIVE DUTY		MECHANICAL LOAD DRIVE DUTY	
	<u>Metric Units</u>		<u>Metric Units</u>	<u>U.S. Units</u>
Electrical Output				
GE-10/1	11,250 kWe		Not applicable	
GE-10/2	11,690 kWe		11,690 kW	15,675 shp
Heat Rate	11,481 kJ/kWh		11,059 kJ/kWh	7,816 Btu/shp-hr
Pressure Ratio	15.5:1		15.4:1	
Turbine Speed	11,000 rpm		7,900 rpm	
Exhaust Flow	47.5 kg/sec		46.9 kg/sec	103.5 lb/sec
Exhaust Temperature	490°C		490°C	

Design Features. The GE-10 is offered in both an indoor and outdoor configuration, with modularized enclosures and silencing equipment for different sound attenuation levels. The package includes the gas turbine; inlet module with air filter, silencer, and ventilation system; and the exhaust module with silencer. Due to the modular layout, the gas turbine can be serviced applying either the traditional on-site

maintenance cycle or the flange-to-flange shop maintenance cycle used for aero-derivative gas turbines.

Compressor. The GE-10 has an 11-stage axial-flow compressor (first three stages have variable geometry). The PGT10 has a 17-stage axial-flow compressor. The compression ratio of the GE-10 is 15.5:1; the compression ratio of the PGT10 is 14.1:1.

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Combustor. A single slot-cooled combustion chamber assembly. The single combustor (virtually identical to that of the MS1002) is designed for low NOx emissions and can burn a wide variety of gaseous and liquid fuels.

Turbine. For the single-shaft GE-10, the turbine has three reaction stages, with the first two stages cooled. For the two-shaft GE-10, the HPT has two reaction stages (both cooled), and the LPT and the two-shaft PGT10 turbine model have two reaction stages as well.

Bearings. The HP rotor rests on two tilting-pad bearings, with the thrust bearing at the forward end of the compressor.

Control System. Turbine control panel is an NP integrated-microprocessor-based SUMIVAC 8000 system. A color cathode ray tube display is standard; a diagnostic system is optional.

Accessories. The lube oil tank is fabricated as an integral part of the baseplate of the gas turbine. Lube oil pumps, hydraulic oil pumps, filters, pressure-regulating valves, and control devices are mounted on the baseplate. In addition to the normal configuration, an optional separate lube oil console is available.

The auxiliaries are installed on a separate baseplate bolted to that of the gas turbine to form a single lift on which the sound-insulated enclosure is mounted.

Operational Characteristics.

Mechanical Load Drive Installations. GE-10 two-shaft gas turbines are typically used for natural gas compression such as by centrifugal pump drives, and

are also used for processing applications. In mechanical drive configuration, the machine's speed has been optimized for direct coupling to pipeline, injection, and process compressors. Speed range is 50-105 percent for optimized compressor or pump control.

Generator Drive Installations. The GE-10, when coupled to a synchronous generator, is a very efficient (≥ 31.4 percent) unit for power generation, and also for cogeneration applications, due to the constant maximum exhaust temperatures achievable at part loads. At least 42 PGT10 and 15 GE-10 machines have been ordered and installed for generation duty.

Combined-Cycle Plants. Turbotecnica (Florence, Italy) was set up by Nuovo Pignone as its main producer of turbine-generator units and complete power plants under turnkey contracts. The company constructed power plants with turbine-generator units in the power range of 34-480 MW. Combined-cycle systems supplied by Turbotecnica utilized components largely manufactured by Nuovo Pignone.

Using twin GE-10Bs, Turbotecnica made available the CC-201 combined-cycle plant, having a net electric power rating of 34.4 MW (23.4 MW from the gas turbines) at an efficiency of 44-45 percent.

IGCC. Using the same combined-cycle technology for Integrated Gasification Combined-Cycle (IGCC) systems that it uses for conventional systems, GE reportedly offers extensive experience and a high level of reliability. The GE-10 model, which can be integrated efficiently with IGCC plants, has a syngas power rating of 10 MW. The net plant output power is 14 MW.

Variants/Upgrades

GE-10-1. The single-shaft GE-10-1 has three reaction stages, with the first two stages cooled.

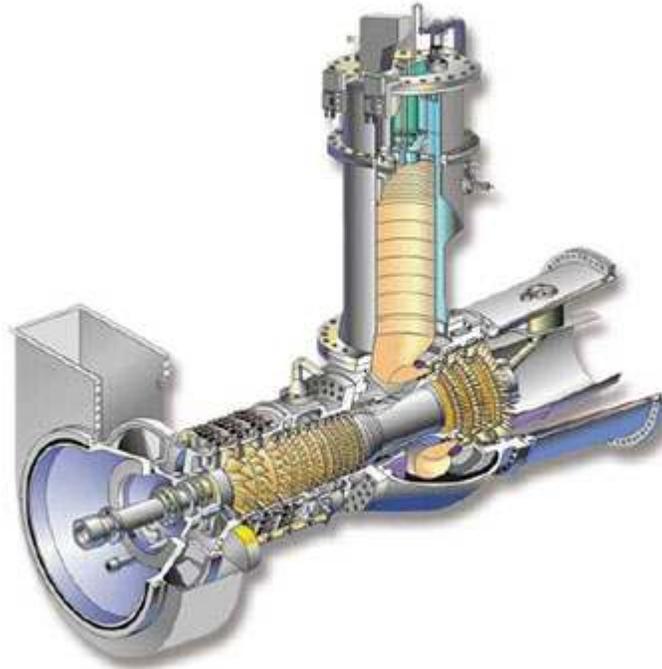
GE-10-2. The two-shaft GE-10-2 has two reaction stages (both cooled). The two-shaft PGT10 turbine model has two reaction stages as well.

PGT10. The PGT10 is a two-shaft machine designed and developed by Nuovo Pignone SpA for shaft outputs in the range of 9,500-15,000 hp at ISO conditions. It

was introduced in 1988. Although the PGT10 is no longer in regular production, it can be manufactured to a customer's requirements.

Affiliated Companies. Firms formerly or currently affiliated with GE Oil & Gas include Kobe Steel Ltd (KOBELCO) of Tokyo, Japan, and the China Aviation Gas Turbine Company Ltd (CAGT), with most of the latter's engine work done at CAGT's Shenyang Company in the People's Republic of China.

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GE10 Gas Turbine Power Generation System

Source: General Electric

Program Review

Background. The GE-10 gas turbine machine is a derivative of the Nuovo Pignone (now part of GE Oil & Gas) PGT10, a second-generation, high-efficiency, two-shaft industrial gas turbine designed for mechanical drive and electric power generation. The machine's development was based on the two-shaft GE Model 3000, to which it retains striking similarity in general structural layout.

The GE-10 is suitable for driving compressors and pumps at variable operating speeds. With the addition of the advanced electronic control system and variable nozzle, it can also serve as a generator drive at constant speed. In a regenerative-cycle configuration, using Nuovo Pignone regenerators, an efficiency of 31-32 percent is attainable.

In 1989, Turbotecnica/Nuovo Pignone reported a contract from Cartiera Lucchese for the supply of an 11-MW combined-cycle cogeneration plant at the paper manufacturer's facility in Porcari, Italy. The cogen plant has a 9.9-MW-rated PGT10, an unfired heat recovery boiler, a 1.2-MW backpressure steam turbine generator, and a reciprocating air compressor. The steam turbine is mounted to a 1.2-MW electric generator. The gas and steam supply all of the plant's electric power, while the boiler and compressor provide steam and air for paper-making and -drying.

In October 1992, the municipality of Cremona opened a PGT10-based combined-cycle cogeneration plant. The plant was designed for continuous operation providing heat in the winter and electricity in the summer. It was designed to produce up to 12 MW of electricity and 11.6 MW of heat. Nuovo Pignone's Turbotecnica was selected as the prime contractor.

License Production Agreements

In July 2010, GE signed an agreement for the servicing of GE's fleet of oil and gas turbomachinery equipment installed in the Republic of Kazakhstan. GE Oil & Gas and JSC ZKMK announced the formation of a technology transfer and licensing partnership that enables ZKMK to manufacture GE-10 advanced technology gas turbines in Kazakhstan. Under the agreement, ZKMK manufactures, supplies, tests, and services GE's advanced technology GE-10 gas turbine units for deployment in critical infrastructure projects in Kazakhstan.

In December 2011, China Aviation Gas Turbine (CAGT) signed an agreement with GE to continue supplying GE-10-1 gas turbine engines and control panels for use in power generation in oil and gas plants and coke oven gas applications in China and abroad.

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through customers whose headquarters are in mainland China.

This agreement was the start of an extended policy by GE to establish a capability for the maintenance and repair of all gas turbines, rather than just its own production.

This strategy gained momentum in July 2015 when General Electric announced plans to use the \$10 billion acquisition of Alstom SA's energy assets as a way of leveraging its way into the lucrative business of maintaining and repairing competitors' turbines. This new business strategy takes direct aim at Siemens AG and other companies as GE looks to expand its power division, which is already the company's largest unit.

Related News

GE Upgrades Oregon Power Plant to Prepare for Seasonal Demand Challenges – GE's Power Services has completed a gas turbine upgrade project in Oregon at a time when U.S. utilities continue to increase the efficiency and flexibility of their older combined-cycle power fleets. The project with Avista's Coyote Springs Power Generation Facility comes as today's power plants need to be able to respond more quickly to changing energy demands to improve local grid reliability. "This upgrade project was a crucial part of our commitment to continue providing reliable supplies of energy to our customers in the Pacific Northwest," said Jason Thackston, Avista's senior vice president of energy resources. "This upgrade project made sense because a more flexible combined-cycle plant allows us to better respond to increased energy demands during the winter months and support regional grid stability. Increasing the capacity of our existing facilities also reduces the urgency to build new generating capacity in the region."

The project is the latest in a series of combined-cycle upgrade projects for GE's Power Services business in North America. GE recently announced that Dynegy Inc, an independent power producer with 35 power stations in eight states across the competitive power generation sector, is installing GE hardware and software equipment to upgrade and modernize four of its power plants, three of which the company recently purchased. Dynegy is upgrading the plants to enhance their reliability and increase their output by a total of 210 MW. (GE 6/16)

Timetable

<u>Month</u>	<u>Year</u>	<u>Major Development</u>
Nov	1985	PGT10 unveiled
Mid-	1986	First PGT10s begin full-load factory testing
	1988	First regenerative-cycle and simple-cycle installations
	1989	Installation in Japan
	1993	GE-10 first equipped with a DLN system
	1997	PGT10B variant launched
Jul	1997	First orders placed for PGT10B
Apr	1999	First Xonon-equipped PGT10B sales announced
Mar	2003	KOBELCO becomes packager of GE-10-1 in Japan and Southeast Asia
		CAGT issues first purchase order for GE-10-1 suitable to burn coke oven gas fuel for the Xu Zhou Power Station
Sep	2003	CAGT becomes packager of GE-10 for industrial power generation in China
Mar	2005	GE Oil & Gas and CAGT extend their cooperative agreement for small gas turbines in the industrial power generation sector
Nov	2010	GE and ZKMK localize oil and gas turbine manufacturing in Kazakhstan
Dec	2011	GE Oil & Gas renews an agreement with CAGT to continue supplying GE-10-1 gas turbine engines
Jan	2012	GE Oil & Gas signs compressor supply agreement with Shell

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Country	Year of Installation	Total
Power Generation		
Algeria	1994 (2), 2004 (1)	3
China	2004 (1), 2006 (1)	2
India	1998	4
Italy	1986 (1), 1988 (3), 1989 (2), 1990 (1), 1991 (1), 1992 (3), 1995 (1), 1999 (2), 2003 (2), 2009 (1), 2010 (1)	18
Japan	1989 (2), 1996 (1)	3
Spain	1988 (1), 1989 (3)	4
United States	1995 (2), 2001 (10), 2002 (4), 2013 (1)	17
Total		51
Mechanical Drive		
Algeria	Unspecified	21
Italy	2011 (2), Unspecified (7)	9
Mexico	2004 (6), Unspecified (22)	28
Russia	Unspecified	24
Tunisia	1997	2
United States	1998 (1), 2001 (1), 2008 (1), Unspecified (10)	13
Total		97

At least 200 GE-10/PGT10 machines are reported to have been built and installed for customers in 21 countries and territories worldwide. Of these, 148 machines have been identified (as shown above). The balance are believed to be gas compression units.

Forecast Rationale

An examination of the recorded inventory of the GE-10 machines shows that production ceased some years ago, although the equipment remains available for sporadic production in the event of an order or two for a GE-10-1 or GE-10-2.

GE Oil & Gas continues to view the Russian Federation and other countries of the former Soviet Union as a potentially viable market, especially for mechanical drive duty, both for replacing older Russian-design

machines and for new installations. However, political developments and the availability of competitive equipment from Russian suppliers do make the prospect of such orders tentative at best.

Beyond this, FI does not project any significant additional sales of the GE-10. No forecast can be made at this time. Unless there is a significant change in the situation, this report will be archived.

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