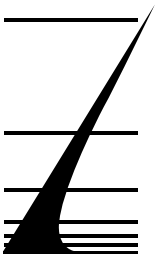
The Market for Gas Turbine Mechanical Drive Engines

Product Code #F648

A Special Focused Market Segment Analysis by:



FORECAST INTERNATIONAL

Analysis 3
The Market for Gas Turbine Mechanical Drive Engines 2010-2019

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Introduction

The majority of gas turbine-powered mechanical load drive machines are used in the oil and gas industry for such duties as pumping, injection, re-injection, and compression, as well as the transportation of oil or gas through a pipeline. Natural gas has become the primary fuel for over 90 percent of all new gas turbine-equipped power generation equipment. This shift is a certainty in the U.S., and an increasing trend worldwide, as witnessed by Endesa's recent Gas Turbine Combined Cycle (GTCC) projects in France. Primarily due to the low emissions byproducts of natural gas, this development has yielded a serious concern: whether there will be sufficient pipeline capacity, and machinery, to keep up with the dramatic rise in demand for natural gas (mainly) and oil (secondarily) for electrical generation plants. While power plants need an ever-expanding supply of natural gas, it is becoming more and more difficult to build infrastructure to pump out and then transport the amount of fuel needed for those plants.

Much of the growth in demand for natural gas for new gas turbine power plants is due to its environmental and economic advantages, as well as to the expectation that the young gas markets of emerging nations will develop rapidly in the near future. World coal use will account for a gradually decreasing share of world energy consumption, even though its use in tons is projected to grow at a rate of 1.35-1.5 percent per year through 2025. Much of the new natural gas will come from the Caspian Sea region, Russia's far eastern region, and Central/South America.

World oil consumption is projected to increase 1.7-2.0 percent annually from 2010 to 2025, from about 84-85 million barrels per day in 2010 to 120 million barrels per day in 2025.

A review of the world's generation of electricity by energy/fuel source shows that oil accounted for about 17 percent of the fuel used to generate electricity in 1990. By 2000, it accounted for only about 15 percent of the total, and in 2020 it is projected to account for 11 percent of all fuels used to generate electricity. On the other hand, natural gas accounted for about 12 percent of all fuel used to generate electricity in 1990. In 2000, it accounted for about 17 percent, and in 2020, natural gas is projected to account for about 30 percent of all fuel used to generate electricity.

In terms of U.S. fuel consumption, natural gas accounted for about 17.90 percent of all fuel used to generate electricity in 2007, a slight increase over the percentage for 2005. Forecast International projects that natural gas's share of the total will grow to 18.25 percent in 2010, 19.0 percent in 2015, 21.25 percent in 2020, and 23.5 percent in 2025.

The major original equipment manufacturers (OEMs) of mechanical drive gas turbines projected to fuel this consumption are Solar, General Electric Company (USA), and Siemens AG. These will be the top-tier major players, experiencing success both in North America and overseas, followed by GE and UTC Pratt & Whitney Power Systems.

Natural gas and oil are needed to fuel the growing demand for electricity worldwide. In 1990, the worldwide demand for electricity was about 11,860 billion kilowatt hours (kWh). In 2000, usage had grown to 15,200 billion kWh. We estimate that demand will grow to 24,000 billion kWh in 2020. While North America accounted for about 31 percent of the usage of electricity generated worldwide in 1990, we estimate that it will account for 26-27 percent in 2020. The largest growth in usage by region will be in the Asia/Pacific locale. That region accounted for about 21 percent of the usage of electricity generated worldwide in the year 2000. In 2020, we estimate its usage will increase to 37 percent of all electricity generated.

Global production of natural gas, currently about 92 trillion cubic feet (Tcf), is expected to grow to about 168 Tcf per year by 2025 – an average increase of 2.75 percent per year.

In the U.S., coal accounted for 49-50 percent of the fuel used to generate electricity in 2006. The share held by coal is expected to drop to 40.25 percent in 2025. On the other hand, natural gas, nuclear power, renewables, and wind power all should enjoy percentage gains into 2025.

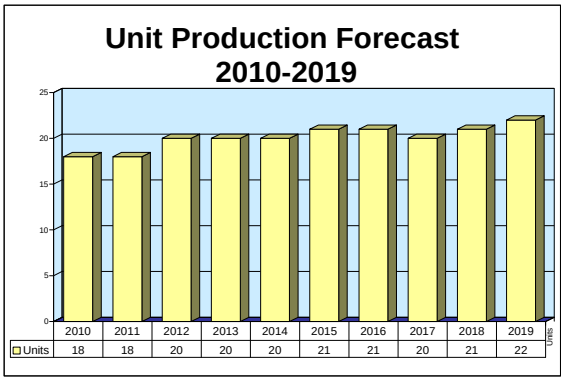
In the forecast decade, the geographic areas expected to require the largest number of mechanical drive gas turbines for use in the oil and gas industries (onshore as well as offshore) are: 1) the Caspian Sea area; 2) the Middle East; 3) Western Russia; 4) Central and South America (most notably Brazil, Peru, and Colombia); 5) Africa, most notably offshore the Niger and Congo deltas and offshore Northern Africa in the Mediterranean Sea; 6) the Gulf of Mexico (deepwater areas); 7) the U.S. (the Rockies region and Northern Alaska); 8) offshore Australia, especially Northern Australia; and 9) Canada (Western Canada and the Atlantic region).

* * *

General Electric GE-10

Outlook

- Machine is well-sized as a driver for compressors in gas and oil industry applications
- GE-10 can easily replace older MS3002E machines
- KOBELCO and CAGT relationships in Asia expected to eventually generate a moderate number of sales



Orientation

Description. The GE-10 is a single-shaft and two-shaft, axial-flow, high-efficiency industrial gas turbine machine in the 10-12-MW class.

Note: *Although the PGT10 is no longer in regular production, it can be manufactured to a customer's requirements.*

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 10-12 MW class (see Performance section, below).

Status. The GE-10 is in production.

Total Produced. As of the current production year, at least 200 GE-10/PGT10 machines had been manufactured and installed for customers in 21 countries and territories worldwide. At least 86 of these were of the current production standard (see note above on PGT10).

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 $4.6-$4.9 million for a gas turbine-equipped package, and $3.8-$4.3 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 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 UGT10000.

General Electric GE-10

Contractors

Prime

China Aviation Gas Turbine Co Ltd, (Shenyang Co)	http://www.china5e.com/information/cagt, No. 6 Dongta St, Dadong District, Shenyang, 110043 China, Tel: + 86 24 2483 1945, Email: shenyang@cagtc.com, Packager
GE Oil & Gas, (formerly Nuovo Pignone)	http://www.gepower.com/geoilandgas, Via Felice Matteucci, 2, Florence, 50127 Italy, Tel: + 39 55 423 211, Fax: + 39 55 423 2800, Second Prime
General Electric Co	http://www.ge.com, 3135 Easton Tpke, Fairfield, CT 06828-0001 United States, Tel: + 1 (203) 373-2211, Prime
Kobe Steel Ltd	http://www.kobelco.co.jp, 9-12, Kita-Shinagawa 5-chome, Shinagawa-ku, Tokyo, 141-8688 Japan, Tel: + 81 3 5739 6000, Fax: + 81 3 5739 6903, Email: admin@kobelco.co.jp, Packager

Subcontractor

Engelhard Corp	http://www.engelhard.com, 101 Wood Ave, PO Box 770, Iselin, NJ 08830 United States, Tel: + 1 (732) 205-5000, Fax: + 1 (732) 205-6711, Email: info@engelhard.com (Oxidation Catalyst)

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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

Design Features. The GE-10 has the following design features (data on the PGT10 are included for added clarity):

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.

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 (CRT) 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.

Dimensions. The dimensions and weights of a GE-10 for generator drive duty and for mechanical load drive duty are as follows (GE-10 generator drive package excludes generator and filters):

	GENERATOR DRIVE DUTY		MECHANICAL LOAD DRIVE DUTY	
	Metric Units	U.S. Units	Metric Units	English Units
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. The GE-10 gas turbine machine has the following performance parameters (for mechanical load drive, metric equivalents are in parentheses):

	GENERATOR DRIVE DUTY	MECHANICAL LOAD DRIVE DUTY
Electrical Output		
GE-10/1	11,250 kWe	Not applicable
GE-10/2	11,690 kWe	15,675 shp (11,690 kW)
Heat Rate	11,481 kJ/kWh	7,816 Btu/shp-hr (11,059 kJ/kWh)
Pressure Ratio	15.5:1	15.4:1
Turbine Speed	11,000 rpm	7,900 rpm
Exhaust Flow	47.5 kg/sec	103.5 lb/sec (46.9 kg/sec)
Exhaust Temperature	490°C	914°F (490°C)

Variants/Upgrades

GE-10. 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 DLN system for NOx reduction to meet current and future standards for pollutant emissions.

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.

PGT10. The PGT10 is a two-shaft machine designed and developed by Nuovo Pignone SpA (now a part of GE Oil & Gas) for shaft outputs in the range of 9,500-15,000 horsepower at ISO conditions. It was introduced in 1988.

Program Review

Background. The GE-10 gas turbine machine is a derivative of the Nuovo Pignone (now an entity of GE Oil & Gas) PGT10, a second-generation, high-efficiency, two-shaft industrial gas turbine machine 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.

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.

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

At least 125 PGT10s and 18 GE-10s have been ordered and installed for mechanical drive duty.

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.

General Electric GE-10

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.

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 papermaking 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.

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.

Affiliated Companies. Firms formerly or currently affiliated with GE Oil & Gas include Kobe Steel Ltd (KOBELCO), 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

Timetable

Month	Year	Major Development
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
Thru	2019	Continued production/aftermarket support of GE-10

Worldwide Distribution/Inventories

Currently, at least 200 GE-10/PGT10 machines had been built and installed for customers in 21 countries and territories worldwide. Eighty-six were of the current production standard. These machines are the most prominently featured in **Algeria** (24 machines), **Italy** (26), **Mexico** (28), the **Russian Federation** (24), and the **U.S.** (13).

Forecast Rationale

The GE-10 gas turbine is becoming a popular machine for mechanical load drive and electrical generation duty; its regenerative cycle mode offers an attractive option for continuous service applications.

For mechanical load drive duty, the machine's speed has been optimized for direct coupling to pipeline, injection, and process compressors. The machine is projected to be more popular in the mechanical load drive arena due to its similarity to the venerable MS3002. With new GE-10 technology (along with technology from the PGT10), customers of the older MS3002s can upgrade their machines easily and quickly without the cost of

acquiring a new machine. (More than 800 Frame 3s were installed for mechanical load drive duty.)

In addition, the sales and marketing support of the General Electric Company (USA) parent group and its after-sale division should boost machine sales, particularly in the oil sector, but also in the electrical generation sector.

Considerable support for this gas turbine machine will come from GE Oil & Gas in Italy. A potentially large market for this particular gas turbine is the retrofit and upgrade of older gas turbines, including machines installed by Nuovo Pignone in such countries as Algeria and the Russian Federation.

Given the ongoing need for machines in the power output class of the GE 10 – not only in the mechanical load drive sector but also in the electrical generation sector – we project that, in the coming decade, GE Oil & Gas will build 197 machines – 147 for use as mechanical load drivers. Meanwhile, the mechanical drive applications field should remain active for the foreseeable future.

An additional 54 machines are projected to be produced for industrial and utility power generation installations, including cogeneration. For electrical generation, the gas turbine machines are expected to be used chiefly in either a simple-cycle or an integrated regenerative-cycle mode of operation.

The GE Oil & Gas GE-10 machine, even with the muscle and weight of General Electric Company (USA) behind it, will continue to face stiff competition from Solar Gas Turbines and MAN TURBO, two well known and well respected entities in the gas turbine arena that continue to display strength and ingenuity in generating orders.

While it is too early to see any results from the relationships between GE Oil & Gas and Kobe Steel and China Aviation Gas Turbine Company, we believe that they will eventually result in sales in that region. One machine has already been ordered by CAGT for generation duty in China.

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.

The PGT10 machine itself may be sporadically produced in the forecast period, with manufacturing taking place to fill an order or two for that model.

Ten-Year Outlook

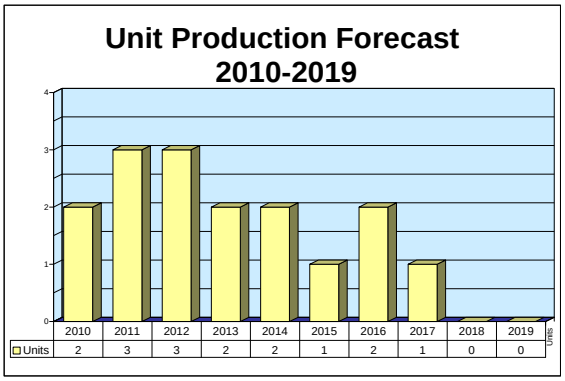
ESTIMATED CALENDAR YEAR UNIT PRODUCTION

Designation or Program	High Confidence				Good Confidence			Speculative			
	Thru 2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
GE Oil & Gas												
GE-10 -1 <> MW 10.0 to <20.0 <> Industrial Power Generation												
	29	5	5	6	6	5	5	6	5	5	6	54
GE-10 -2 <> SHP 10,000 to <20,000												
	57	13	13	14	14	15	16	15	15	16	16	147
Subtotal	86	18	18	20	20	20	21	21	20	21	22	201
Total	86	18	18	20	20	20	21	21	20	21	22	201

Vericor ASE8

Outlook

- The venerable ASE8 machine is well-sized for DG and CHP schemes
- Its sales opportunities in the 500-550-kW class are being challenged by diesel engines, gas engines, microturbines, and fuel cells
- This unit will most likely see maximum production of three per year; production will wind down and then cease in the next 10-15 years



Orientation

Description. The ASE8 is a single-shaft, open-cycle, centrifugal-flow aviation derivative industrial and marine gas turbine machine in the 500-550 kW class.

Sponsor. The IE831/ASE8 was privately developed. The ASE8 traces its history back to the (then) AiResearch Manufacturing Company of Arizona, a division of (then) Garrett Corporation.

Power Class. The approximate power output of the ASE8 is 525 kW (704 hp).

Status. The ASE8 is in low-level production for electrical generation and is offered for mechanical load drive duty.

Total Produced. At this time, about 383 ASE8 gas turbines have been installed worldwide, including machines installed by packagers.

Application. Applications of the ASE8 are electrical generation, including small-scale cogeneration, CHP schemes, and marine auxiliary power generation. The machine is available for mechanical load drives (including duty as compressor and pump drivers) on special order.

Price Range. The ASE8's price, in current U.S. dollars, ranges from $435,000-$475,000 for a basic gas turbine-based electric power-generating package. For the ASE8 in a mechanical drive package, the cost is estimated at $360,000-$380,000.

For electrical generation, the genset prices cover 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 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 basic auxiliaries needed for an operational installation.

Competition. In the electrical generation and mechanical load drive arenas, the ASE8 competes with the UTC Pratt & Whitney Power Systems ST6L-721. Machine models whose power output is slightly above or below that of the ASE8 include those from Daihatsu and Kawasaki Heavy Industries (KHI).

Vericor ASE8

Contractors

Prime

Shinko Engineering Co Ltd (Toyohashi Plant)	http://www.shinko-elec.co.jp, 150 Azo-Motoyashiki, Sannya-cho, Toyohashi, 441-3195 Aichi Prefecture, Japan, Tel: + 81 532 41 2121, Fax: + 81 532412179, Licensee
Vericor Power Systems Inc	http://www.vericor.com, 3625 Brookside Pkwy, Suite 500, Alpharetta, GA 30022 United States, Tel: + 1 (770) 569-8800, Fax: + 1 (770) 569-0399, Prime

Subcontractor

Coen Co Inc	http://www.coen.com, 1510 Rollins Rd, Burlingame, CA 94010-2306 United States, Tel: + 1 (650) 697-0440, Fax: + 1 (650) 686-5655 (Specialized Combustor)
Goodrich Engine Components	http://www.goodrich.com, 811 Fourth St, PO Box 65100, West Des Moines, IA 50265-0100 United States, Tel: + 1 (515) 274-1561, Fax: + 1 (515) 271-7201 (Exciter)
Unison Industries	http://www.unisonindustries.com, 7575 Baymeadows Way, Jacksonville, FL 32256 United States, Tel: + 1 (904) 739-4000, Fax: + 1 (904) 739-4093 (Exciter)
Wood Group Fuel Systems Ltd	http://www.woodgroup.com, Wellshead Industrial Ctr, Dyce, Unit 22, Aberdeen, AB21 7GA Scotland, United Kingdom, Tel: + 44 1224 771 133, Fax: + 44 1224 725 275 (Fuel Nozzle)

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Technical Data

Design Features

Intake. Screened annular type. Intake can be rotated 90°.

Compressor. Two-stage centrifugal compressor with two radial impellers provides a pressure ratio of approximately 10.5:1. The radial compressors are machined from high-strength forged titanium billets, and provide improved resistance to foreign object damage and contaminant buildup on the blades. Casings are cast iron. Engine rotor speed is 41,730 rpm.

Combustor. The single offset cannular combustor uses a dual-orifice fuel nozzle. Dual-fuel option is available, with automatic switchover. Combustor is designed for easy maintenance and replacement in the field. All combustor material is Haynes 188.

In 1997, AlliedSignal began to offer a dry-low emissions combustion system for the ASE8/IE831-1000 (see **Program Review**, below).

Turbine. A three-stage uncooled axial turbine drives the compressor section. Shaft, discs, blades, and vane are of IN738; casings are ductile cast iron. Marinized variants use aluminized coatings to reduce corrosion of hot-end components.

Gearbox. The heavy-duty gearbox is driven by an extension of the compressor rotor shaft and provides output speeds of 3,600, 1,800, or 1,500 rpm, depending on the application. The gearbox also contains the drive pads for the starter, oil and fuel systems.

Bearings. One tapered land thrust and 10 fluid film journal bearings (seven journals in gearbox).

Controls. Honeywell supplies a wide range of controls for the ASE8, including speed, oil pressure, and temperature sensors; engine monitoring units; and automatic startup and shutdown systems. Automatic dual-fuel switchover available.

Accessories. AC electric start. DC electric start or pneumatic start options.

Vericor ASE8

Dimensions. The approximate dimensions of a Vericor ASE8-equipped VPS1 genset are as follows (natural gas fuel):

Note: *Genset weight has not been disclosed.*

	Metric Units	English Units
Length	4.27 m	14.0 ft
Width	4.29 m	14.1 ft
Height	2.59 m	8.5 ft

Performance. The Vericor ASE8 (simple-cycle performance) powering a VPS1 genset has the following performance parameters (ISO conditions, no duct losses, natural gas fuel):

	APPLICATION = SIMPLE-CYCLE PERFORMANCE	
	Metric Units	English Units
Output	487 kW	487 kW; 653 shp
Heat Rate	17,676 kJ/kWh	16,754 Btu/kW-hr
Thermal Efficiency	20.4%	20.4%
Fuel Flow (LHV)	180 kg/h	397 lb/h
Heating Value (LHV)	47,786 kJ/kg	20,548 Btu/lb
Fuel Pressure Required (a)	250/300 psig	1,723/2,068 kPA
Exhaust Gas Flow	3.56 kg/s	7.8 lb/s
EGT	489°C	913°F

(a) Minimum/maximum.

The Vericor ASE8 (CHP performance) has the following performance parameters (ISO conditions, inlet duct loss 3" [76.2mm] and exhaust duct loss 10" [254mm]):

	APPLICATION = CHP PERFORMANCE	
	Metric Units	U.S. Units
Output	506 kW	506 kW; 678 shp
Fuel Flow (LHV)	180 kg/h	397 lb/h
Fuel Flow (LHV)	8.7 x 10^6 kJ/kWh	8.2 MMBtu/h
Heat Rate (LHV)	17,008 kJ/kWh	16,122 Btu/kW-h
Efficiency	21.2%	21.2%
Exhaust Flow	3.6 kg/s	7.9 lb/s
Exhaust Gas Temperature	491°C	916°F
Fuel Gas Pressure	14.06 kg/cm^2	200 psig
ASE8 Steam Generation		
Unfired	2,045 kgh	4,500 lb/h
Fired to 1,600°F/812°C	4,545 kgh	10,000 lb/h
Duct Burner Fuel Flow (LHV)	5.7x10^6 kJ/h	5.4 MMBtu/h
Fired to 2,200°F/1,204°C	7,273 kgh	16,000 lb/h
Duct Burner Fuel Flow (LHV)	12.1x10^6 kJ/h	11.5 MMBtu/h

The Vericor ASE8-equipped VPS1 mechanical drive package has the following performance parameters (ISO conditions, 3"/4" inlet/exhaust losses, gear losses included, natural gas fuel):

	VPS1 MECHANICAL DRIVE	
	Metric Units	U.S. Units
Output	513 kW	688 shp
Heat Rate (LHV)	16,792 kJ/kWh	15,917 Btu/kW-h
Thermal Efficiency	21.4%	21.4%
Fuel Flow	180 kgh	397 lb/h
Heating Value (LHV)	47,786 kJ/kg	20,548 Btu/lb
Fuel Pressure Required	250/300 psig	1,723/2,068 kPA
Exhaust Gas Flow	3.54 kg/s	7.8 lb/s
Exhaust Gas Temperature	489°C	913°F

Vericor ASE8

Variants/Upgrades

IE831. The IE831 was an early version in this gas turbine family; it was rated at 400 to 690 horsepower.

ASE8. The ASE8 (formerly IE831-1000) is the current offering of the IE831 in the power generation and mechanical drive arenas. It is rated at 525 kW/704 shp for electrical power generation, with an efficiency of 21 to 22 percent. The machine's pressure ratio is about 10.5:1.

IM831-800. The IM831-800 is the previous production model, rated at 518 to 548 kW continuous duty. It replaced the earlier IE831 model.

ME831-800. The ME831-800 is a variant of the IE831 adapted for marine duty.

Program Review

Background. The ASE8 marketer-distributor is Vericor Power Systems, Alpharetta, Georgia. Vericor is a subsidiary of MTU Aero Engines, a DaimlerChrysler company. The engine is manufactured and serviced at Vericor's facility in New Orleans, Louisiana.

The AlliedSignal Garrett IM831 was introduced in the mid-1960s as the IE831, and incorporated much of the same technology found in Garrett's aircraft propulsion engines of the same era, notably the TPE331. The IM831, as the small industrial engine was later designated, was adapted to a host of electric power and mechanical drive applications, including marine auxiliary power generation and standby electric power generation. It is used in compression and lift modules for platforms and oil field service, and in water injection pumps and fuel pumps.

In its history, the ASE8 has been referred to as the Series 831, Model 831, IE831, and 831. Among the more important marine power applications for the engine has been the naval surface combatant. The former U.S. Navy Patrol, Hydrofoil, Missile (PHM) boats each utilized an IM831 for onboard electric power generation. Additionally, the ASE8 engines have been considered to power auxiliary generators aboard a number of new U.S. Navy mine countermeasures vehicles (see below) and non-U.S. surface combatants.

Fluid Coupling Option. For electrical generation and other non-surge applications, the Series 831/ASE8 machine can be supplied with a standard direct-coupled gearbox connection. However, Voith has offered a special fluid coupling to adapt the engine to pipeline pumping and compression duties where variations in load are encountered. Under a NATO contract, at least 20 fluid-coupled units were ordered for use as emergency pumpers. Those portable units were envisioned as capable of being installed on pipelines that transfer aviation or other critical fluids in the event of a pipeline malfunction or main pump system breakdown. Units are equipped with bypass lines and all required hardware for rapid installation.

Cheng Cycle. The Cheng Cycle is a patented thermodynamic power cycle of International Power Technology. It combines Brayton and Rankine cycles, utilizing the exhaust mass flow to produce superheated steam that is then re-injected into the gas turbine, greatly increasing the power output.

In 1983 and 1984, International Power Technology conducted an evaluation of an Onan-packaged IM831 gas turbine equipped with a heat recovery steam generator (HRSG). The IM831 produced essentially the same power output as the simple-cycle machine, 500 kW, but at a greatly increased thermal efficiency of 27 percent – 5 full percentage points higher than the simple-cycle machine. IPT officials indicated at that time that an optimized Cheng Cycle IM831 set could produce a power output of 1.1 MW at thermal efficiencies of 34 percent.

Emissions Control. The IE831/ASE8's dry low emissions (DLE) system produces NOx levels well below 30 ppm and is available on new units or can be retrofitted onto previous IE831 models. It consists of a gas nozzle system using two separate gas flows, one for a pilot burner and one for a main burner. Gas is injected through holes in the vanes.

The optional dry-low NOx combustor is only available for use with natural gas fuel.

VOC Reduction. AlliedSignal/Honeywell's VOC (volatile organic compound) technology can help reduce fuel emissions and fuel costs, and can meet electrical and thermal requirements at a given power plant. The VOC technology has destruction efficiencies that can be well above the current U.S. standard.

VOC reduction technology has been installed at the Tempo Plastics facility in Visalia, California. The polystyrene producer has realized a 96 percent reduction in VOC while saving 25 percent in energy costs since the system was installed in 1993.

Packagers. The IE/IM831 and the follow-on ASE8 have been packaged by a number of original equipment manufacturers (OEMs) for generation and mechanical drive applications. The companies mate the gas turbine to driven equipment of their own design per customer specifications, with the packaged units including accessories and controls. A brief discussion of the major packagers follows:

Commercio e Industria Induco. Brazil's efforts toward wider use of alcohol-based fuels were seen as possibly opening new niches for the 831. Developments in the combustion of alcohol fuels impacted the sales potential in this region through the late 1980s and 1990s.

Hibiya Engineering. Among the more recent packagers of the IE/IM831, Hibiya of Japan is believed to have sold machines to commercial establishments in Japan and the Middle East. The units are believed to have been generation sets, designated HGT 625, installed as standby/baseload systems.

Kongsberg Vapenfabrikk. Kongsberg Vapenfabrikk (now a part of Dresser-Rand) has been successful in marketing the KG831 series for generation applications; the firm has sold many units to U.S. and overseas customers. Some have been installed as standby generators for businesses, while a number are in use on offshore platforms.

North American Energy Systems. In 1996, AlliedSignal signed an agreement with North American Energy Systems to package the IE831 into a portable enclosure.

Shinko Engineering. Shinko has operated in the Japanese emergency/standby market with the IE/IM831, recording sales of just over 100 units. The package, designated GX625, has also been offered for customers in the Middle East. The firm has also provided gas turbine generation sets for the Japanese Navy's Hatsuyuki and Hatakaze class ships.

Note: *Shinko Engineering is part of the Kobe Steel group of companies.*

Stewart & Stevenson. This Houston-based firm, now a part of General Electric Co (USA), was one of the most active packagers of gas turbine machines of all sizes. In the 60-Hz generator-set market, its packages used the IE831 as its smallest offering, at 515 kW (base). Aside from small gensets powered by the IE/IM831, the Houston-based entity also offered a twin version as the IM2-831-1600, rated at 1,600 shp or 1,000 kW. In 1998, Stewart & Stevenson International completed the sale of its Gas Turbine division to the General Electric Company (USA).

Triveni Engineering & Industries. In December 1998, AlliedSignal concluded a deal with Triveni Engineering & Industries of Bangalore, India, for the marketing, sale, and packaging of gas turbines in that market. The first contract awarded under that arrangement was the December 1999 sale of two ASE8s for a hotel in India.

Triveni deals in the small gas and steam turbine and high-speed gearbox markets in India.

Industrial Applications. The IE831/ASE8 has been popular in the small generator market, especially in the standby/emergency power segment. Its compact, low-noise/emissions capabilities, coupled with simplified sitting requirements, make it very adaptable to this market. The packaged genset is also available in a quick-start configuration with 10-second capability.

Among the more notable installations, 29 sets were installed on the Alyeska Pipeline driving Electric Machinery 500-kVA generators. Those units are equipped for remote, fully automatic operation, and are fitted with weatherproof enclosures. The Delco battery starting systems are equipped with La Marche battery chargers.

Cogeneration. Model IM831/ASE8s are performing admirably in various cogeneration applications around the world. As an example, an IM831 supplied by Kongsberg to a German brick and tile plant has produced thermal efficiencies of 90 percent.

Stewart & Stevenson sold two IE831 units to support a 1-MW cogeneration system that supplies steam and electricity for the Queen Mary Hotel/Spruce Goose exhibit complex in Long Beach, California.

The IE831-1000/ASE8's low turbine inlet temperature and relatively low pressure ratio make it an excellent choice for situations requiring industrial heat. Heat recovery steam generating superheated or saturated steam can be provided at a rate of approximately 4,000 lb/hr (1,814 kg/hr). This model can also produce hot water for space heating or other heating needs.

VOC Destroyer. In 1998, AlliedSignal began marketing the IE831-1000 package as one suitable for VOC destruction in industrial and oil and gas applications. It was marketed as a low-polluting solution that also provided cost savings. The first such application was at the Tempo Plastics facility in Visalia, California (producer of expanded polystyrene). The system reportedly has yielded a 96-97 percent reduction in the facility's VOC emissions, while saving 25 percent in energy costs.

Vericor ASE8

In the system, the turbine package is attached to a reaction chamber and combustor, where the VOC/air combination is compressed to a pressure of 120 psi.

Marine Applications. The Model IM831 is used aboard various naval combatants and light force ships for onboard electrical generation, as follows:

U.S. PHM Class Vessels. The 235-240-ton PHM class Missile Hydrofoil Patrol Boats utilized the Series 831. Six authorized PHMs were built and commissioned between July 1977 and November 1982. Each vessel used twin 548-kW ME831-800 machines to power its twin generators. In 1993 and early 1994, the vessels were taken out of U.S. service due to budgetary constraints.

U.S. MSB 29, MSB 5 Class Vessels (Minesweeping Boats). Prior to 1990, the U.S. Navy operated several wooden-hulled MSB-type minesweepers for use in mine countermeasure operations. In September 1982, Garrett received a contract to supply four IM831 gensets for a trial retrofit aboard two 44-ton MSBs; each vessel had two ME831-800 generator sets. In the period from 1990 to 1992, the U.S. Navy took 17 MSO vessels and seven MSB vessels out of service. None of these vessels remain in U.S. service.

Japanese Hatsuyuki Class Guided Missile Destroyers. The 11 3,800-ton Hatsuyuki class vessels (DD-122 through DD-132) of the Japan Maritime Self-Defense Force each have three Shinko Engineering-supplied GX625 gensets on board. The vessels were launched from November 1980 through October 1985.

Japanese Hatakaze Class Guided Missile Destroyers. The two 6,400-ton Hatakaze class vessels (DDG-171 and DDG-172) are each equipped with a gas turbine generator set using IM831s produced in Japan. Three generating sets are assumed to be employed on each vessel. The vessels were launched in November 1984 and January 1987, respectively.

Timetable

Month	Year	Major Development
	1961	Series 831 development begins
	1962	First prototype built
	1963	First production unit in operation
Late	1982	Garrett announces work on IE831-1600
Jun	1987	Stewart & Stevenson becomes exclusive distributor
Late	1996	North American Energy Services becomes packager
Jun	1999	AlliedSignal, Honeywell merge: Honeywell International adopted as name
May	2005	Vericor partners with SAE of Canada for assembly and testing
Mar	2006	Vericor and TUBA of Germany sign service agreement
Thru	2019	Continued production/aftermarket support of ASE8 (and its predecessors)

Worldwide Distribution/Inventories

As of the present time, about 383 ASE8 series machines of all marks and variants have been built, many of which were shipped to packagers for final processing and mating with the packagers' equipment prior to shipment. Major customer nations include **Japan** (through Shinko), **Saudi Arabia**, and the **U.S.** (Altogether, these machines have been installed in 12 nations.)

Forecast Rationale

The dramatically growing demand for distributed generation (DG) and CHP schemes resulting from market deregulation and the urgent need for electrical power generation (especially in the western part of the U.S.) are combining to generate sales opportunities for the Vericor ASE8. The venerable small-power-output workhorse, still referred to in gas turbine circles as the 831, will be available for several more years. While much of the electrical generation market is currently centered on machines of much higher power output, the 500-525-kW power range of the ASE8 can still cater to end users who are interested in producing power at about 500 kW and/or steam on-site – customers whose immediate concerns do not include overall machine efficiency, but who instead desire power apart from local (and often unreliable) electrical grids.

With interest in DG growing almost geometrically, the ASE8 continues to be appealing in countries where

environmental regulations and fuel emissions levels are not necessarily as stringent as those in developed nations, and where the level of technical sophistication may not be as high. We believe that countries in Central and South America continue to be the most likely customers for this practical machine.

Despite the above, Vericor has not publicized any recent orders for this machine.

While our projection for the coming decade calls for production of just 16 machines, specific applications such as VOC destruction in chemical plants and the production of electricity in small facilities such as hotels (e.g., the Indian contract in 1999) are examples of how this tried-and-true machine can find unexpected applications.

We project that Vericor will produce six of these machines for its New Orleans (Louisiana) facility, all for electrical generation. As the decade covered by our forecast progresses, we believe that Vericor will concentrate on its larger ASE40 and ASE50 machines, leaving the lower end of the power spectrum to the new wave of microturbines and, later, fuel cells, and to other small CHP power sources such as small diesels, which are gaining acceptance and orders at a healthy pace.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR UNIT PRODUCTION

Designation or Program	High Confidence				Good Confidence				Speculative			
	Thru 2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
Vericor Power Systems Inc												
ASE8 <> MW 0.2 to <3.0 <> Industrial Power Generation												
	383	2	3	3	2	2	1	2	1	0	0	16
Total	383	2	3	3	2	2	1	2	1	0	0	16

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(Purchase Order # and Signature Required)
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☐ VISA ☐ MasterCard
☐ American Express

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DVD	$50	$95
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Binder	$1,440	$2,720
DVD	$50	$95
Civil/Commercial Library		
Binder	$360	$680
DVD	$50	$95
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Aerospace		
Binder	$360	$680
DVD	$50	$95
Electronics		
Binder	$360	$680
DVD	$50	$95

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Governments & Industries		
Binder	$540	$1,020
DVD	$50	$95
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DVD	$50	$95
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Binder	$90	$170
DVD	$50	$95
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Binder	$90	$170
DVD	$50	$95
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Binder	$180	$340
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