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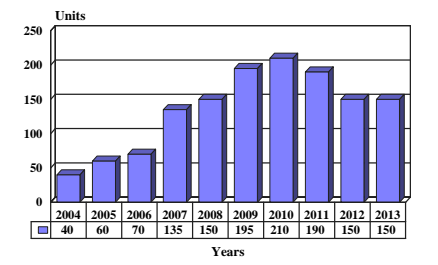
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## Kawasaki Microturbines - Archived 6/2005

### Outlook

- Deregulation of the worldwide power utility market has opened wide-ranging opportunities for low-power-output machines
- For CGT302, almost all customers expected to be located in Asia
- At 300 kW, machine competes against the newly announced Niigata RGT-3R

10 Year Unit Production Forecast  
2004 - 2013



### Orientation

**Description.** The Kawasaki Heavy Industries (KHI) CGT302 is a recuperated twin-shaft microturbine (with a recuperator) intended for cogeneration duty, rated at about 300 kW. The machine has been designed for a wide range of partially loaded conditions.

**Note:** *We are treating the CGT302 machine as a microturbine since we believe that the CGT302 functions more as a microturbine than as a traditional small gas turbine machine for electrical generation.*

**Sponsor.** Much of the effort to develop a ceramic gas turbine in Japan has been sponsored by the Japanese government (see **Program Review** section below).

The current major contractor/manufacturer is identified as the "prime" in the **Contractors** section below.

**Power Class.** The KHI CGT302 operates at 300 kW (see the **Performance** subsection below).

**Status.** In production. Production began in 2002.

**Total Produced.** At the start of 2004, fewer than 60 complete machines are estimated to have been installed for electrical generation.

**Application.** Electrical generation, including cogeneration and distributed generation schemes.

**Price Range.** Estimated in 2004 U.S. dollars at US\$210,000, or about US\$700 per kW, for early-production units. The price is expected to drop as high production volume is attained.

**Competition.** At 300 kW, the CGT302 faces competition in the microturbine-based electrical generation arena from the Niigata RGT-3R machine.

In the sphere of small gas turbine machines for electrical generation, the CGT302 faces competition from Daihatsu which offers its DT-4 small power generation gas turbine machine series for duty as low as 180 kW.

### Contractors

Kawasaki Heavy Industries - Gas Turbine Division, Akashi Works, <http://www.khi.co.jp/hangas>, 1-1 Kawasaki-cho, Akashi City, Hyogo, 673-8666 Japan, Tel: 81 78 921 1335, Fax: 81 78 913 7344, Prime

### Technical Data

**General.** The KHI CGT302 advances the use of ceramics and has a conventional components layout, a blisk-type turbine rotor, and a triple casing to minimize heat radiation loss.

Ceramic wave rings and Si<sub>3</sub>N<sub>4</sub> coil springs are employed.

**Design Features.** Among the design features of the KHI CGT302 gas turbine machine are the following:

Compressor. Single-stage centrifugal compressor made of titanium alloy. Pressure ratio about 8.0:1. Outer diameter is about 158 mm.

Combustor. A single-can combustor is standard.

Gasifier Turbine. A single-stage axial turbine unit, featuring an all-ceramic design, is standard. Speed is about 64,000 rpm. Outer diameter is about 142 mm.

Power Turbine. A single-stage axial/hybrid power turbine is employed; speed is about 47,800 rpm. Outer diameter is about 190 mm.

Heat Recovery System. KHI has adopted a heat recovery system consisting of a plate-fin-type counter-flow recuperator made of heat-resistant metal.

**Dimensions.** The dimensions and weights of the KHI CGT302 were not available at the time of this report.

**Performance.** The KHI CGT302 for electrical generation has the following performance parameters:

#### **ELECTRICAL GENERATION**

	<u>Metric Units</u>	<u>English Units</u>
Power Output (Base Rating)	300 kW	402 shp
Thermal Efficiency (a)	42.1%	42.1%
Recuperator Efficiency	82%	82%
Tit	1350°C	2,462°F
Output Shaft Speed	3000/3600 rpm	3,000/3,600 rpm
Pressure Ratio	8.0:1	8.0:1

(a) At 1396°C (2,545°F).

## Variants/Upgrades

At the start of 2005, no variants or upgrades of the KHI CGT302 were reported to be in development.

## Program Review

**General.** The prime manufacturer of the CGT302 is Kawasaki Heavy Industries Limited, Industrial Gas Turbine Division; Hyogo, Japan. Kawasaki's gas turbine machine is produced at its facility in Hyogo.

Firms that are currently affiliated with KHI on the CGT302 program are Kyocera Corporation (Kyoto, Japan) and Sumitomo Precision Products Company Limited (Hyogo, Japan).

**Background.** Part of the Kawasaki CGT302 effort was done under the New Sunshine Project, a Japanese national project for developing new energy, energy-saving, and environmental protection technologies. In 1988, the New Energy and Industrial Technology Development Organization (NEDO) started the Ceramic Gas Turbine (CGT) project. The effort, which was originally expected to take nine years, was extended by two years to develop three different types of CGTs: the CGT301, CGT302, and CGT303. That work was done under a contract with the Agency of Industrial Science and Technology of the (then) Ministry of International

Trade and Industry (MITI), now known as the Ministry of Economy, Trade and Industry (METI). The development objective was to achieve a 42-percent thermal efficiency (lower heating value) at 1350°C TIT.

In terms of ceramic components, other goals of the 300 kW CGT program were a minimum guaranteed strength of 400 MPa at a temperature of 1500°C, a Weibull Modulus (Reference) of at least 20 at a temperature of 1500°C, and a fracture toughness at room temperature of at least 15 MPam<sup>1/2</sup>.

With reference to NO<sub>x</sub> emissions, KHI's testing confirmed 9 ppmv by rig tests and 31.7 ppmv (O<sub>2</sub> at 16 percent) by the engine test at 1350°C TIT.

**Parallel Efforts.** Paralleling the CGT302 effort originated by the MITI/NEDO as part of the 300 kW CGT program is the development of a single-shaft CGT with recuperator also intended for cogeneration. The machine is designated the CGT301. Also being developed is the CGT303, a two-shaft CGT with recuperator intended for mobile power.

## Funding

Japanese government funding, if any, specifically pertaining to the KHI CGT302 gas turbine machine has not been identified.

## Recent Contracts

No major identifiable military contracts specifically pertaining to the KHI CGT302 gas turbine machine have been awarded or received in the recent past.

Recent major sales of the CGT302 gas turbine machine outside the military arena have not been publicized by KHI.

## Timetable

<u>Month</u>	<u>Year</u>	<u>Major Development</u>
	1988	New Sunshine Project begun NEDO started nine-year CGT project
Mid	1989	900°C MGT development begun
Mid	1994	1350°C Pilot CGT development begun
	1997	NEDO CGT project extended by two years
Early	1999	300-kW CGT development project officially completed KHI conducted further CGT302 development and testing
	2002	CGT302 production begun
Thru	2014	Continued production/availability of KHI CGT302 machine projected

## Worldwide Distribution

At the start of 2005, fewer than 60 machines are estimated to have been installed for electrical generation. All machines are assumed to be in **Japan**.

## Forecast Rationale

Kawasaki and its team on the CGT302 have dedicated time and expense to the microturbine gas turbine machine, going beyond that of the IHI-led team (CGT301) and the Yanmar Diesel Engine Company-led team (CGT303). Kawasaki has been involved in promoting the machine for electrical generation, including combined heat and power (CHP) and distributed generation (DG) duty.

In the electrical generation marketplace, durable materials and well-thought-out technologies are strong selling points for the CGT302 for simple-cycle duty and cogeneration duty. The CGT302, with a simple-cycle efficiency exceeding 42.1 percent, can easily be fitted into a cogeneration package.

Kawasaki has long had a position of prominence in the high-performance, low-power-output gas turbine marketplace, and is no stranger in the arena of small aviation engines. Similar to Pratt & Whitney Canada and UTC Power PWPS, it has a large base of low-power-output industrial engines and aero engines.

The GTC302 goes one step further in that it has taken the best technology not only from aero engines but also from turbochargers and from automotive engines (some of which feature a high percentage of components made from advanced ceramic materials).

With a strong movement afoot in the microturbine arena for electrical generation, including CHP and DG duty — and despite a less than lackluster program of publicizing its well-qualified machine — we project that, in the decade extending through the year 2013, KHI will build 1,350 CGT302 gas microturbine machines for electrical generation for customers worldwide. Virtually all of the customers of those machines are expected to be located in Asia, especially in Japan and China.

The GTC302 systems, because of their power output, will be used in particular by small to mid-sized businesses, health facilities, data centers, and large residential complexes such as high-rise apartment buildings.

## Ten-Year Outlook

### ESTIMATED CALENDAR YEAR PRODUCTION

<u>Engine /Machine</u>	<u>Application</u>	<u>thru 2003</u>	<u>High Confidence Level</u>			<u>Good Confidence Level</u>			<u>Speculative Level</u>			<u>Total</u>	
			<u>2004</u>	<u>2005</u>	<u>2006</u>	<u>2007</u>	<u>2008</u>	<u>2009</u>	<u>2010</u>	<u>2011</u>	<u>2012</u>		<u>2013</u>
KAWASAKI HEAVY INDUSTRIES CGT302	GENERATION	58	40	60	70	135	150	195	210	190	150	150	1350