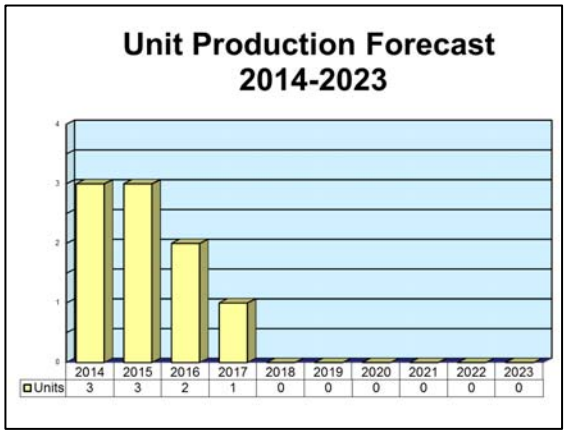
Turbomeca Makila TI

Outlook

- In the electrical generation/cogeneration arena, the Makila TI is moving aside in favor of newer machines
- Makila TI production is limited and will soon be negligible
- Sales in Asia in packaged units through IHI are minimal
- There is no emphasis on new sales



Orientation

Description. The Makila TI is a two-shaft, axial-centrifugal-flow, aero-derivative industrial and marine gas turbine machine in the 1.0-1.5 MW class.

Sponsor. The Makila TI was privately developed by the prime contractor.

Power Class. The approximate power output of the Makila TI is as follows:

Application	Power Output
Electrical Gensets	1,050 kWe
Mechanical Drive	1,550 hp (1,155 kW)
Marine Propulsion	1,600 hp (1,193 kW)

Status. In production.

Total Produced. At the start of the forecast period, at least 127 Makila TI machines had been built for electrical generation, mechanical load drive, and marine power applications by Turbomeca and IHI. This total *excludes* aviation turboshaft engines, marine drive units, and units for rail propulsion.

Application. This report focuses on three applications: 1) electrical generation and cogeneration; 2) various mechanical load drives, including pumping and compression; and 3) marine power/propulsion.

Price Range. The price of the Makila TI is estimated at $950,000-$1,020,000 in current U.S. dollars for a gas turbine-equipped electrical generating package. A mechanical drive package is estimated to cost $950,000-$1,000,000 in current U.S. dollars.

For electrical generation (simple-cycle), the genset price covers a single-fuel skid-mounted gas turbine, an electric generator, an air intake with basic filter and silencer, an exhaust stack, a basic starter and controls, and a conventional combustion system.

For mechanical drive, the price covers a gas-fired gas turbine (without driven equipment) with gearbox, skid, enclosure, inlet and exhaust ducts and exhaust silencer; basic turbine controls; fire protection; starting systems; and a conventional combustion system.

Competition. Apart from gas turbine machines manufactured for electrical generation in the Russian Federation and Ukraine, the machines that most actively compete against the Makila TI in the electrical generation arena are the Kawasaki M1A-11, Mitsui SB5, Motor Sich TV3-137, Pratt & Whitney Power Systems ST6L-813, and Solar Saturn 20.

In the mechanical drive arena, the most active competition comes from the Kawasaki M1A-11, Motor

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Sich TV3-137, and Pratt & Whitney Power Systems ST6L-90.

Contractors

Prime

Turbomeca SA	http://www.turbomeca.com, Bordes, 64511 France, Tel: + 33 5 59 12 50 00, Fax: + 33 5 59 53 15 12, Prime
IHI Corporation, Mizuho Aero-Engine Works	http://www.ihi.co.jp, 229 Tonogaya Mizuho-Machi, Nishitama-Gun, Tokyo, 190-1297 Japan, Tel: + 81 42 568 7000, Fax: + 81 42 568 7012, Licensee

Subcontractor

Defontaine SA	http://www.defontaine.com, 3 Rue Louis Renault, BP 57, Saint Herblain, 44800 France, Tel: + 33 2 406 78989, Fax: + 33 2 406 78903 (Flash Butt Welded Rings)
The Kahn Companies	http://www.kahn.com, 885 Wells Rd, Wethersfield, CT 06109 United States, Tel: + 1 (860) 529-8643, Fax: + 1 (860) 529-1895, Email: info@kahn.com (Dynamometer)

Comprehensive information on Contractors can be found in Forecast International's "International Contractors" series. For a detailed description, go to www.forecastinternational.com (see Products & Samples/Governments & Industries) or call + 1 (203) 426-0800.

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 Makila TI has the following design features:

Intake. The intake is an annular pitot type with bulletdome spinner. Hot air anti-icing is utilized.

Compressor. Three-stage axial compressor and single-stage centrifugal unit provide a pressure ratio of 9.9:1. Axial stages are of forged titanium, while the centrifugal unit is machined from a steel forging. The axial compressor nozzles are made of stainless steel. Stage 3 is an integrally cast component, consisting of a double ring of airfoils. Air flow is 12.01 lb/sec (5.45 kg/sec).

Combustor. Single annular combustor is standard. Fuel is injected into the combustor via a single centrifugal injector located in the shaft. Turbomeca injectors and ABG-SEMCA or EYQUEM ignition units with EYQUEM or Smiths igniters have been employed.

Compressor/Generator Turbine. A two-stage gas producer/compressor turbine, with separate uncooled blades, drives the gas generator, at approximately 33,350 rpm. Turbine inlet temperature (TIT) is approximately 2,200°F (1,204°C). Gas producer turbine Stage 1-2 blades cast in MAR-M002.

Power Turbine. A two-stage PT drives the rear-mounted output shaft at 22,850 rpm (100 percent power turbine speed). The PT blades are not tip-shrouded. There are two nozzles made of HS 31 (X-40) cobalt-base alloy, and Stage 1-2 blades of MAR-M004 (IN713LC + Hf). Power output is 14,000-23,000 rpm.

Accessories. A top-mounted accessory gearbox is driven via a shaft from the compressor rotor. Electric or pneumatic starting is available. The Digital Engine Control Unit (DECU) is derived from the ELECMA Full Authority Digital Engine Control (FADEC) system. Industrial integrated reduction gear train with output power drive shaft; output speeds are available at the following rpm settings: 22,850, 6,300, 6,000, 5,000, 3,600, 3,000, 1,800, and 1,500. Five borescopic inspection points are provided, plus three magnetic plug oil inspection points.

Modular Construction. The Makila TI is designed for easy maintenance, with modular construction. The five basic modules are the auxiliary gearbox, axial compressor, gas generator, nozzle guide vane segment, and power turbine module.

Dimensions. The approximate dimensions and weight of a complete Turbomeca Makila TI electrical genset are as follows:

	Metric Units	U.S. Units
Length	6,000 mm	19.68 ft
Width	1,800 mm	5.91 ft
Height	2,100 mm	6.89 ft
Weight	9,000 kg	19,842 lb

Performance. A Makila TI-equipped simple-cycle genset package has the following performance parameters (ISO conditions, no losses):

	Metric Units	U.S. Units
Power Output	1,050 kWe	1,408 hp
Specific Fuel Consumption	13,273 kJ/kWe-hr	12,580 Btu/kW-hr
Efficiency	27.1%	27.1%
Pressure Ratio	9.6:1	9.6:1
Exhaust Gas Temperature	505°C	941°F
Mass Flow	5.45 kg/s	12.01 lb/s
Turbine Speed	1,500/1,800 rpm	1,500/1,800 rpm

Variants/Upgrades

No information has been released regarding variants or upgrades of the Turbomeca Makila TI. It should be noted here that the Makila TI-equipped electrical generating package is referred to as the TM 1000 Makila TI or, more commonly, the TM 1000.

Program Review

Background. The Turbomeca Makila TI is an industrial and marine gas turbine variant of the popular Makila aviation turboshaft engine. Development of the machine began in 1975 to meet the expected demands for aircraft efficiency and power of the 1980s. After 58 months of testing, Makila certification for aviation uses was awarded by the Direction Générale de l'Aviation Civile (DGAC) in April 1980. Work on series-production turboshaft engines began in October 1979.

In the U.S., the Makila aviation engine is certified under U.S. FAA Type Certificate No. E12NE, issued April 13, 1981; Revision # 4 is dated December 6, 2002, for the Makila 1A, 1A1, and 1A2. The most recent updates to the Type Certificate were announced in March 2007.

Derived from the aero Makila, the Makila TI was designed for the power generation (including cogeneration) and drive requirements of railways and naval vessels, and for various duties in the oil and gas industry.

With the wide customer base of the Makila aviation turboshaft engine, the offering of an industrial and marine variant was considered to be a natural evolution, especially considering the synergy of the two programs. Since its introduction, the Makila TI has made a penetration into the 50-Hz and 60-Hz power generation/cogeneration arena.

Makila TI Packaged Design Versions

Standard Versions. The Makila TI machines serve as centrifugal pump drives for water injection and turbopump firefighting applications, and as propulsion units for high-speed trains and surface vessels/fast boats. When equipped with an integral reduction gearbox, the output shaft speed of these machines is in the range of 4,000-6,000 rpm.

Direct Drive Versions. The Makila TI machines serve as high-speed centrifugal compressor drives for gas gathering and gas pipeline boosting, and as direct output prime movers for high-speed drive applications. Output shaft speeds are in the range of 14,000-23,000 rpm.

Power Drive Versions. The Makila TI machines serve as electric generator drives for baseload power generation or peaking and for cogeneration plants, and as reciprocating compressor drives for gas lift and gas injection. When equipped with an integral reduction gearbox, the output shaft speed of those machines is in the range of 1,000-3,000 rpm.

Makila TI Applications

Train/Rail Propulsion. Early Makila TI engines were used to power a French railway turbotrain. The engines

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are nominally rated at 1,200 kW ISO continuous, burning distillate fuel, and were shipped in 1988.

Cogeneration. Cogeneration is usually achieved by heating water, and is suitable for use by industrial or tertiary sectors to produce space heating, air conditioning (absorption units), and district heating, and heat for industrial processes. Cogeneration can also be applied to heat domestic water and swimming pools.

Turbomeca lists the following cogeneration data for the Makila TI:

Parameter	Recovery without Supplemental Firing	Recovery with Combustion at 1,000°C
Hot Water Flow with Temperature Raised	95,000 kg/hr	217,000 kg/hr
Production of Saturated Steam	3,300 kg/hr	5,850 kg/hr
Fuel Consumption	4,120 kW/hr	7,080 kW/hr

Some of the first machines produced were for an industrial cogeneration facility in Japan, where the gas turbine was installed with an unfired waste heat recovery boiler. The gas turbine produces 6,000 lb/hr (2,721 kg/hr) of steam at 1,200 kPa, burning natural gas. Machines were shipped in 1988.

Mechanical Drive. Makila TI machines have been packaged by IHI in Japan.

Marine Propulsion. Makila TI is employed in marine propulsion; it features corrosion-resistant materials to withstand the marine environment. The engine is offered for both main propulsion and shipboard power generation duties, and can be arranged in both twin-shaft and single-shaft configurations.

The Makila TI was selected as the powerplant for Arnold Transit Co's (Mackinac Island, Michigan) $3 million vessel *Straits Express*, a 99-foot (30.17-m) catamaran capable of carrying 400 passengers at 38 knots (70.4 kmph). The vessel, built by Marinette Marine Corp (Marinette, Wisconsin), is powered by two Makila TI machines (with ZF BW 465 marine gears and two Wadsworth Water Jet Model 3000 waterjets).

Allen Industries furnished all auxiliary equipment for the engines, including batteries, inlet filters, output flanges, and final reduction gear.

Allen estimates the MTBO to be about 15,000 hours, which compares favorably with the 5,000-hour overhaul schedule typical for diesel engines.

TM 1800 Machine. Turbomeca has worked on a gas turbine capable of competing with diesel engines in terms of ownership costs and operating economies. The machine, the TM 1800, was initially intended for onboard electrical power generation in all-electric-vessel projects. Should that model ever attain production status, Turbomeca could adapt it for stationary power generation (standby duty, cogeneration sets) and for railway traction duty. The TM 1800 would be rated at about 1,800 kW with a heat-recovery system, and 2,200 kW without a heat-recovery system.

Funding

No recent funding from the French government for the Makila TI has been identified.

Contracts/Orders & Options

No military contracts for the Makila TI have recently been announced.

Timetable

Month	Year	Major Development
Apr	1988	Makila TI program officially unveiled
Sep	1988	First Makila TI installed for rail propulsion/power
Nov	1988	First Makila TI installed for cogeneration
Late	1989	IHI becomes TI packager; IHI TI package design completed
Nov	1989	First European machine becomes operational
Q1	1991	Start of installation of IHI TI packages
Late	1992	PEMEX order for Makila TI-based turbopumps announced
	1993	Makila TI ordered for use in U.K. hospital
	1995	Makila TI ordered for marine propulsion duty
Thru	2022	Continued aftermarket support of Makila TI

Worldwide Distribution/Inventories

At the start of the forecast period, at least 127 Makila TI I&M machines had been built *(excluding* the Makila aviation turboshaft engine, marine drive units, and units for rail propulsion). Worldwide, this machine is most widely used in **France**, **Germany**, **Italy**, **Japan**, **Mexico**, **Spain**, the **U.K.**, and the **U.S.** Machines have been installed in Japan by IHI Corp.

Forecast Rationale

In the industrial drive and electrical generation arenas, the Turbomeca Makila TI is produced in only limited numbers, and production is likely to cease altogether in the next few years.

With several variants of the aviation engine in production, there is no indication that there will be any problems with service, overhaul, or parts availability. In fact, new units could be manufactured with little difficulty as required.

Neither Safran nor IHI continues to advertise the Makila TI for new installations. Current annual production is limited to several units for repair and replacement for existing clients.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR UNIT PRODUCTION												
Designation or Program	**High Confidence**					**Good Confidence**			**Speculative**			
	Thru 2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**Total**
Turbomeca SA												
Makila TI <> MW 0.2 to <3.0 <> Industrial Power Generation												
	93	2	2	1	0	0	0	0	0	0	0	5
Makila TI <> SHP 2,500 to < 3,000 <> Mechanical Drive (Pumps & Compressors)												
	34	1	1	1	1	0	0	0	0	0	0	4
Subtotal	127	3	3	2	1	0	0	0	0	0	0	9
Total	127	3	3	2	1	0	0	0	0	0	0	9