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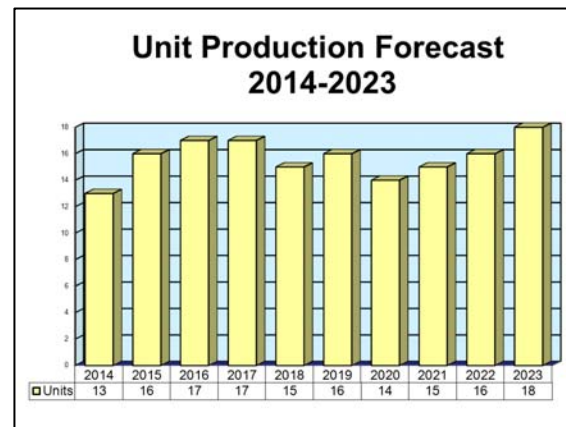
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Daihatsu DT Series

Outlook

- DT Series competes in a very crowded gas turbine machine marketplace against small/medium-size diesel engines, gas-fired engines, and fuel cells
- Virtually all production is expected to be for Japan; DT Series not believed to be exported overseas; production solely for electrical generation at this time
- DT-20W model raises TX Series generator set output to 4.0 MW



Orientation

Description. The Daihatsu DT Series machines are 50-/60-Hz single-shaft, simple open-cycle, centrifugal-flow industrial gas turbine machines with power output (single machine) in the range of 180-4,400 kW.

Sponsor. The DT gas turbine series was privately developed by the prime contractor.

Power Class. The approximate power output of the Daihatsu DT Series of gas turbine machines is 180 kW to 4,410 kW (see Performance section below).

Status. In production.

Total Produced. At the start of 2014, at least 125 Daihatsu DT Series machines of all variants had been built, including one pre-series prototype G33.

Application. Used mainly for electrical generation, including use in small generator sets. Mechanical load drive applications for pumps have been made available.

Price Range. Electrical and mechanical load drive genset prices are estimated in 2014 U.S. dollars at \$425 to \$900 per kW, depending on the model.

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

Competition. Because of the relatively wide power range of the DT Series of machines, competition comes from gas turbine models produced by Dresser-Rand, Kawasaki, Solar, Turbomeca, UTC Pratt & Whitney Power Systems (PWPS), Vericor, and Zorya-Mashproekt, among others. Competition also comes from diesel engines, gas engines, and fuel cells.

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Contractors

Prime

Daihatsu Diesel Manufacturing Company Ltd, Moriyama Factory	http://www.dhtd.co.jp, 45 Amura-cho, Moriyama City, Shiga, 524-0035 Japan, Tel: + 81 6 6454 2331, Fax: + 81 6 6454 2750, Email: sales.DDK@dhtd.co.jp, Prime
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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. Among the design features of the Daihatsu DT Series are the following:

Compressor. Single-shaft, simple open-cycle design featuring a two-stage centrifugal compressor. Main shaft speed range is 21,000-41,000 rpm. Overall pressure is 8:1 to 10:1. Mass flow is 3-20 kg/sec.

Combustor. The DT Series has a single, reverse-flow can-type combustor. Single igniter installed on combustor housing. The combustor can burn a variety of fuels, most notably kerosene, gas oil, and diesel oil.

Turbine. A two-stage/three-stage turbine arrangement is employed, depending on turbine type. EGT is in the range of 480°C to 580°C, depending on turbine type.

Bearings. Dual main bearings and thrust bearings support the high-speed rotation shaft.

Gear System. The gas turbine machine employs parallel-shaft double reduction gears. Major gears are made of wear-resistant materials.

Accessories. Electrohydraulic fuel control system. Electric starting is standard; pneumatic optional.

Dimensions. The approximate dimensions and weights of the TX Generator Set Series equipped with the Daihatsu DT Series are as follows:

	APPLICATION = GENERATOR SET DUTY						
	TX200- TX500	TX625- TX750	TX1000	TX1250- TX1750	TX2000- TX2500	TX3000- TX3500	TX4000- TX5000
Length	3,200 mm	4,000 mm	4,000 mm	5,000 mm	5,400 mm	6,000 mm	6,500 mm
Width	1,550 mm	1,800 mm	2,300 mm	2,300 mm	1,750 mm	2,800 mm	2,590 mm
Height	2,100 mm	2,520 mm	3,520 mm	3,150 mm	3,300 mm	4,800 mm	3,700 mm
Weight	250 kg	450 kg	500 kg	1,200 kg	1,750 kg	2,400 kg	3,500 kg

Performance. The approximate performance parameters of the TX Generator Set Series equipped with the Daihatsu DT Series include the following:

	APPLICATION = GENERATION SET DUTY						
Genset Model	Generator Set Output	Generator Set Fuel Consumption	Generator Capacity	Daihatsu Gas Turbine Model	Gas Turbine Output		Gas Turbine Main Shaft Speed
TX200	160 kW	160 liters/hr	200 kVA	DT-4	245 PS	180 kW	41,000 rpm
TX250	200 kW	175 liters/hr	250 kVA	DT-4	310 PS	228 kW	41,000 rpm
TX300	240 kW	180 liters/hr	300 kVA	DT-4	365 PS	268 kW	41,000 rpm
TX375	300 kW	200 liters/hr	375 kVA	DT-4	450 PS	331 kW	41,000 rpm
TX400	320 kW	210 liters/hr	400 kVA	DT-4	480 PS	353 kW	41,000 rpm
TX500	400 kW	230 liters/hr	500 kVA	DT-4	600 PS	441 kW	41,000 rpm
TX625	500 kW	310 liters/hr	625 kVA	DT-6	750 PS	552 kW	34,200 rpm
TX750	600 kW	340 liters/hr	750 kVA	DT-6	900 PS	662 kW	34,200 rpm
TX1000	800 kW	460 liters/hr	1,000 kVA	DT-4W	1,200 PS	883 kW	41,000 rpm
TX1250	1,000 kW	610 liters/hr	1,250 kVA	DT-10	1,500 PS	1,103 kW	25,000 rpm
TX1500	1,200 kW	680 liters/hr	1,500 kVA	DT-10A	1,800 PS	1,324 kW	25,000 rpm
TX1750	1,400 kW	800 liters/hr	1,750 kVA	DT-14	2,100 PS	1,546 kW	23,300 rpm
TX2000	1,600 kW	1,000 liters/hr	2,000 kVA	DT-20	2,400 PS	1,765 kW	21,000 rpm

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APPLICATION = GENERATION SET DUTY

Genset Model	Generator Set	Generator Set Fuel Consumption	Generator Capacity	Daihatsu Gas Turbine Model	Gas Turbine Output		Gas Turbine Main Shaft Speed
	Output						
TX2500	2,000 kW	1,140 liters/hr	2,500 kVA	DT-20	3,000 PS	2,206 kW	21,000 rpm
TX3000	2,400 kW	1,360 liters/hr	3,000 kVA	DT-10AW	3,600 PS	2,648 kW	25,000 rpm
TX3500	2,800 kW	1,600 liters/hr	3,500 kVA	DT-14W	4,200 PS	3,089 kW	23,300 rpm
TX4000	3,200 kW	2,000 liters/hr	4,000 kVA	DT-20W	4,800 PS	3,529 kW	21,000 rpm
TX4500	3,600 kW	2,140 liters/hr	4,500 kVA	DT-20W	5,400 PS	3,971 kW	21,000 rpm
TX5000	4,000 kW	2,280 liters/hr	5,000 kVA	DT-20W	6,000 PS	4,412 kW	21,000 rpm

Notes: Gas turbine performance is at 40°C ambient temperature.

Generator Set Fuel Consumption is calculated using kerosene as the main fuel (tolerance +5 percent).

The approximate performance parameters of the Daihatsu DT Series gas turbine machines for drive power duty (mechanical drive) are as follows:

APPLICATION = DRIVE POWER DUTY

	Power Output	Gas Turbine SFC	Main Rotor Speed	Output Speed	Exhaust Gas Mass Flow	Engine Dry Weight
One-Axis Type						
DT-4	367 kW	469 g/kWh	41,000 rpm	1,500-1,800 rpm	7.25 m ³ /sec	750 kg
DT-6	551 kW	469 g/kWh	34,200 rpm	1,500-1,800 rpm	10.58 m ³ /sec	1,150 kg
DT-4W	735 kW	469 g/kWh	41,000 rpm	1,500-1,800 rpm	14.50 m ³ /sec	1,700 kg
DT-10	919 kW	490 g/kWh	25,000 rpm	1,500-1,800 rpm	18.66 m ³ /sec	2,700 kg
DT-10A	1,103 kW	465 g/kWh	34,200 rpm	1,500-1,800 rpm	19.91 m ³ /sec	2,700 kg
DT-14	1,250 kW	440 g/kWh	23,300 rpm	1,500-1,800 rpm	24.66 m ³ /sec	2,850 kg
DT-10W	1,838 kW	490 g/kWh	25,000 rpm	1,500-1,800 rpm	37.33 m ³ /sec	4,900 kg
DT-10AW	2,206 kW	465 g/kWh	34,200 rpm	1,500-1,800 rpm	39.80 m ³ /sec	4,900 kg
DT-14W	2,500 kW	440 g/kWh	23,300 rpm	1,500-1,800 rpm	49.33 m ³ /sec	5,200 kg
Two-Axis Type						
DF-4	367 kW	490 g/kWh	41,000 rpm	800-1,200 rpm	7.25 m ³ /sec	1,000 kg
DF-6	551 kW	490 g/kWh	35,000 rpm	650-1,000 rpm	10.58 m ³ /sec	1,600 kg
DF-10	919 kW	490 g/kWh	25,000 rpm	650-1,000 rpm	18.66 m ³ /sec	3,000 kg
L-Type						
DFL-4	367 kW	503 g/kWh	41,000 rpm	200-300 rpm	7.83 m ³ /sec	N/A
DFL-6	551 kW	503 g/kWh	35,000 rpm	200-300 rpm	11.66 m ³ /sec	N/A
DFL-10	919 kW	503 g/kWh	25,000 rpm	200-300 rpm	20.33 m ³ /sec	N/A

Notes: Output rating is based on operation at 150 meters, 40°C on intake duct.

SFC is based on operation with kerosene as main fuel.

Dry weight total includes reduction gear.

Generator set output is at 40°C air temperature.

N/A = Not Available

Variants/Upgrades

Daihatsu has made numerous models of its DT Series of gas turbine machines available, with all machines having the same basic configuration. The DT Series gas turbine machines were previously designated TS Series machines, with particular emphasis on the TS-22 and TS-33 Series of machines.

Drive Power Machines. The current Drive Power machines have the following design features:

One-Axis Type. The One-Axis variant has a single-stage radial compressor, a single-can combustor,

and a two-stage axial gas turbine; it has a counterclockwise rotation.

The reduction gear is a two-stage reduction type with parallel shaft.

Two-Axis Type. In the Two-Axis variant, this gas turbine type has a single-stage radial compressor, a single-can combustor, and a two-stage axial gas generator turbine and a single-stage power turbine. It has a clockwise rotation.

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In this variant, rotational speed control is possible. Clutch and fluid coupling is not required.

L-Type. In the L-Type machine variant, this gas turbine type has a single-stage radial compressor, a single-can combustor, and a two-stage axial gas

generator turbine and single-stage power turbine. It has a counterclockwise rotation.

This machine type can be operated with sound attenuation and low vibration. A bevel gear speed reducer is not required. The height of the housing has been reduced.

Program Review

Background. The engines of Daihatsu Diesel Manufacturing Company Ltd are employed for marine auxiliary use, marine propulsion use, and land- and sea-based industrial power generation. Its land and marine engines span the power range of 73-6,325 kW, and its marine propulsion engines span the power range of 441-8,826 kW. The latter engines weigh 2.25-144 tons.

Daihatsu's venture into gas turbine engines began in 1980 with the early G33 machine; one G33 was built in 1981. In 1984, ongoing efforts in gas turbine technology resulted in the production of a new series of machines: the TS Series. The TS-22/22W and TS-33/33W Series machines were manufactured almost exclusively for use in small generator sets.

In 1987, Daihatsu revealed its TX-02 gas turbine, capable of developing 370 kW. The TX-02 was rated at 265 kW for the TX250 generator set, at 294 kW for the TX300, and at 368 kW for the TX375/TX400 generator sets. The TX Series of gas turbine machines were then designated TS-22, TS-01A, and TS-01B, respectively.

In late 1996/early 1997, Daihatsu changed the designation of its TS Series gas turbines to a DT Series designation. Previous emphasis had been on the TS-22 and TS-33 models.

The Japanese firm has been awarded certification to EN ISO9001, JIS Z9901, and BSEN ISO9001 standards. The compliance audit was performed by Lloyd's Register Quality Assurance Ltd in January 1994.

Funding

No Japanese government funding for the Daihatsu DT Series of gas turbine machines has been identified.

Contracts/Orders & Options

No major military contracts pertaining to the Daihatsu DT Series of gas turbine machines have been awarded in the recent past.

Timetable

Month	Year	Major Development
	1980	Daihatsu G33 program begins
	1981	First G33 fabricated
	1984	TX Series launched
Feb	1985	First installation
Mid-	1987	TX-02 introduced
Jan	1994	Daihatsu awarded certification to EN ISO9001, JIS Z9901, and BSEN ISO9001 standards
	1995	Daihatsu further simplifies machine designation system
	1996/97	Daihatsu changes designation from TS Series to DT Series
Thru	2023	Continued production of the DT Series of gas turbine machines

Worldwide Distribution/Inventories

At the start of 2014, at least 125 Daihatsu DT Series gas turbine machines had been fabricated. They are primarily installed in **Japan** (including Okinawa).

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Forecast Rationale

Daihatsu advertises the DT Series gas turbines as being compact, lightweight, quiet, and easy to operate and maintain. They require no cooling water, have minimum vibration and clean exhaust, and have a high-level fuel control system. It should be noted that for machines up to 3,100 kW for land and sea power generation, Daihatsu also offers diesel models in its DC, DK, DL, and M Series; those machines are larger and heavier than the DT Series of gas turbine machines.

For orders that are in the offing, Daihatsu's gas turbines compete against gas turbines from several firms located in the Asia/Pacific Rim area and against machines of

other configurations, including small diesel engines, small gas-fired engines, and fuel cells.

With several economies in the region becoming increasingly more robust, sales of the DT Series – the larger DT-14W and DT-20W machines in particular – could become stronger later in the forecast period.

Daihatsu does not seem to be actively promoting the DT Series in the North American market at this time, instead focusing on its diesel engines for generation and marine propulsion. Daihatsu Diesel North America has been contacted for comment on their availability.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR UNIT PRODUCTION												
Designation or Program	High Confidence					Good Confidence			Speculative			Total
	Thru 2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	
Daihatsu Diesel Manufacturing Company Ltd												
DT Series <> MW 3.0 to <10.0 <> Industrial Power Generation												
	36	4	4	5	5	4	3	2	2	3	4	36
DT Series <> SHP 2,500 to <3,000 <> Mechanical Drive (Pumps & Compressors)												
	25	3	4	6	5	6	7	6	6	6	5	54
DT Series <> SHP 3,000 to <10,000 <> Mechanical Drive (Pumps & Compressors)												
	17	2	2	2	3	2	3	2	3	3	4	26
DT Series (Up to 3 MW) <> MW 0.2 to <3.0 <> Industrial Power Generation												
	47	4	6	4	4	3	3	4	4	4	5	41
Subtotal	125	13	16	17	17	15	16	14	15	16	18	157
Total	125	13	16	17	17	15	16	14	15	16	18	157