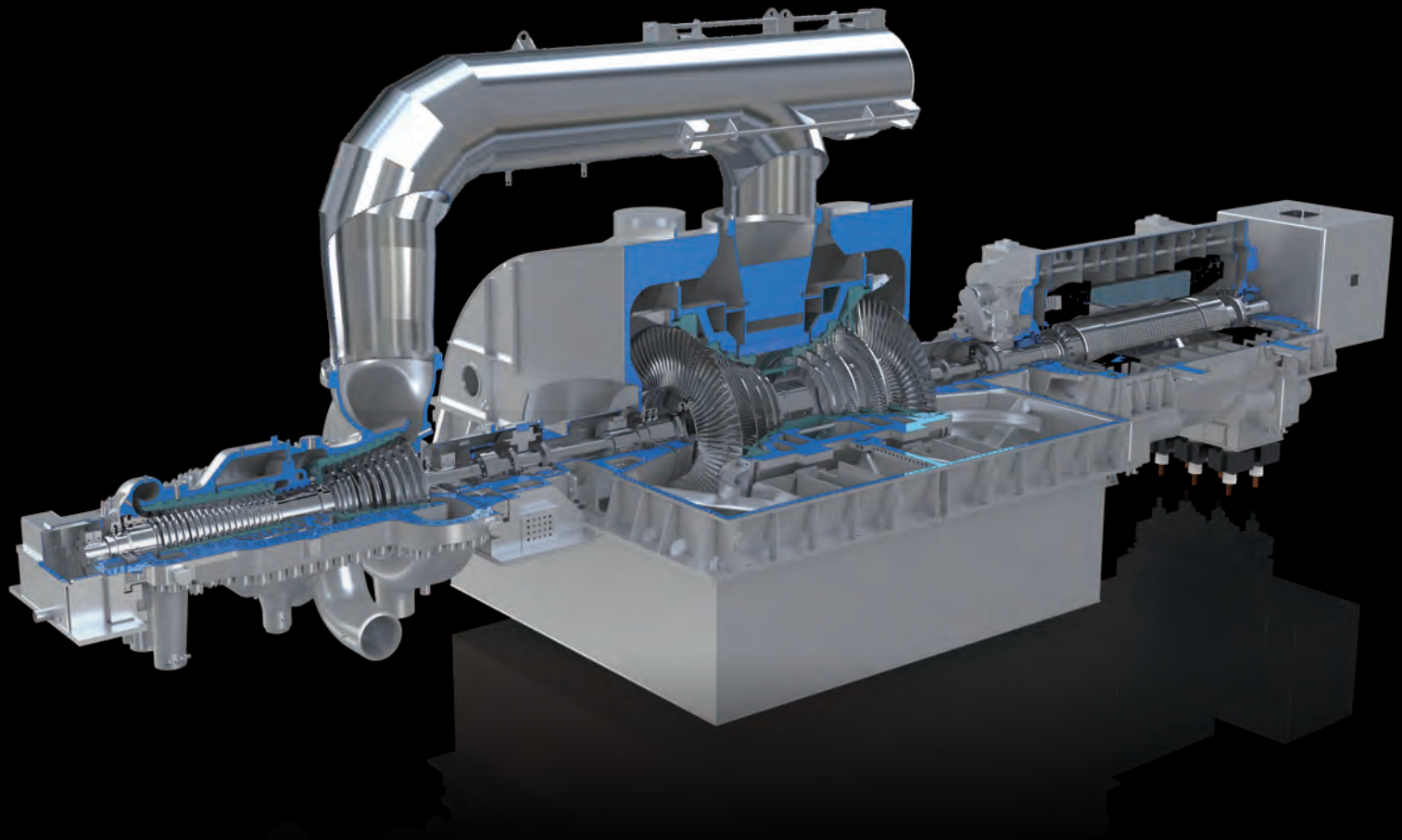
TOSHIBA

STEAM TURBINE GENERATORS



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PHILOSOPHY

Toshiba is renowned worldwide for delivering innovative, reliable and energy efficient solutions that lead to a better world, a planet that's safer and cleaner, a society that's both sustainable and dynamic and a life that is as comfortable as it is exciting.

Our 80+ years of experience in the field of thermal power generation combined with a flair to imagine and innovate empowers us to provide solutions that are economical, reliable, and eco-friendly. Toshiba endeavors to achieve a future where people everywhere have access to the energy they need to improve their quality of life.

These abilities and commitments raise Toshiba above the crowd. Our beliefs that there are no challenges too great, nor promises we can't fulfill allow us to deliver superior solutions to you.

Customer Centric

Toshiba's ability to customize and align steam turbine designs with customer needs ensures that a Toshiba solution is available for a wide range of steam conditions and uses.

Economical

Cost-Efficient Solutions

Toshiba's deep understanding of customer requirements helps us provide equipment solutions that offer an ideal balance of performance, reliability, life expectancy and cost.

Lean Construction

Our wealth of project experience guides us in providing product solutions with short construction times, optimized shipping logistics and improved constructability leading to considerable project cost savings.

Reliable

Proven Technology

Since the production of its first steam turbine in 1927, Toshiba has manufactured and delivered over 1,900 turbine and generator equipment sets worldwide, with cumulative installed capacity surpassing 200 GW -a true testament of the trust bestowed upon us by our customers.

Uninterrupted Operation

Toshiba's robust steam turbine designs offer excellent performance and class-leading reliability. Typical of Toshiba's strong record of reliability, an Australian steam turbine and generator set achieved 99.6% reliability. This superior level of reliability is driven by our diligent pursuit of Japanese philosophies of “Monozukuri” - the art, science, and craft of engineering and “Kaizen” - the concept of continuous self-improvement.

Eco-Friendly

Our pursuit of high efficiency directly translates to reduced CO_2 emissions per unit of power produced. This contributes to the global objective of achieving a carbon-neutral society which aligns with Toshiba's goal of playing a critical role in realizing a sustainable society.

Excellent Customer Support

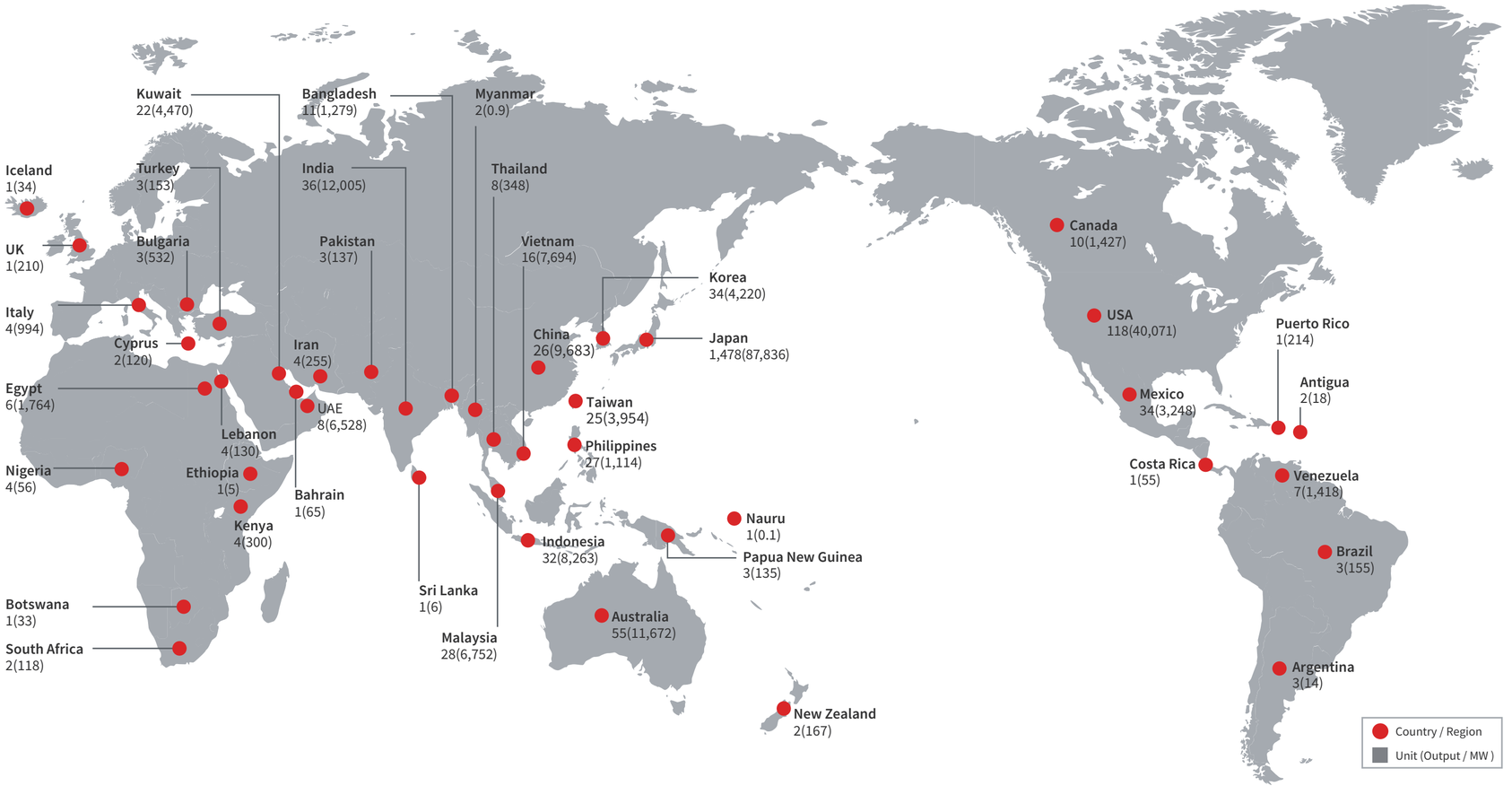
We place the highest priority on customer satisfaction. Our dedicated customer support teams ensure that customer needs are promptly and satisfactorily resolved. Our teams work closely with our clients from concept design, construction to lifetime operations, providing timely responses drawn from our experience and our extensive knowledge of turbine technology.

TOSHIBA HAS DELIVERED MORE THAN 200 GW OF TURBINE POWER GENERATION CAPACITY

Since Toshiba's first turbine delivery in 1927, we have never looked back, continuously aiming to innovate and raise industry standards. The testament being our delivery record of more than 2,000 successful turbine deliveries. This is a reflection of the faith customers have in the quality of Toshiba products and the capability of our state of the art manufacturing facilities : Keihin Product Operations in Yokohama, Japan and Toshiba JSW Power Systems Factory in Chennai, India.

Toshiba's cumulative delivery record from 1927 to Dec 2023 : 2,038 units / 217,652 MW

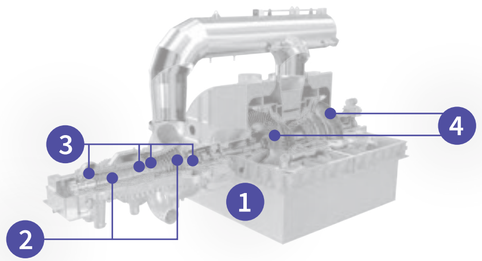


Latest supply record

STEAM TURBINE PRODUCT LINE-UP

Features



1 Exhaust Hood Options

2 High Performance Steam Path

3 Advanced Seals

4 High Efficiency & Reliable Last Stage Blade

State-of-the-art technologies are applied to each Toshiba steam turbine, providing the highest performance and reliability.

STG Output (MW)

0 200 400 600 800 1000 1200 1400 1600 1800

tandem compound Six Flow **TX-10**	
Tandem Compound Four Flow **TX-8**	
Tandem Compound Four Flow **TX-6**	
Tandem Compound Double Flow **TX-4**	
Tandem Compound Single Flow **TX-2**	
Tandem Compound Geared Single Flow **TX-2G**	
Single Casing Single Flow **TX-1**	

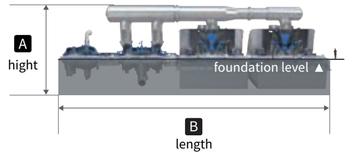
Specifications

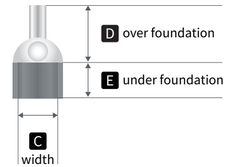
turbine pressure ● high ● high-Intermediate-low ● high-intermediate ● intermediate ● intermediate -low ● low

TX-10	A 10.1	B 55.1	C 12.8	D 6.6	E 3.5	1 + 3 double flow
TX-8	A 11.5	B 42	C 10	D 8.3	E 3.2	1 + 1 + 2 double flow
TX-6	A 11.5	B 33	C 10	D 8.3	E 3.2	1 + 2 double flow
TX-4	A 11.5	B 20	C 10	D 8.3	E 3.2	1 + 1 double flow
TX-2	A 6.5	B 36	C 10	D 4.2	E 2.3	1 + 1 single flow
TX-2G	A 6.5	B 23	C 8.2	D 4.2	E 2.3	1 + 1 single flow
TX-1	A 6.5	B 14	C 8.2	D 4.2	E 2.3	1 single flow

Scale

Toshiba's product lineup is a reflection of our deep understanding of the STG market enabling us to offer innovative customized solutions to meet customer specific requirements. Whether energy is needed for industrial applications or for public electricity generation, we possess all the capabilities needed to meet your exact energy demands. We look forward to assisting you with your custom STG needs.





Note: Dimensions vary on a Case to Case basis.
Only for Reference.

unit : meter

TX-10

Tandem Compound Six Flow

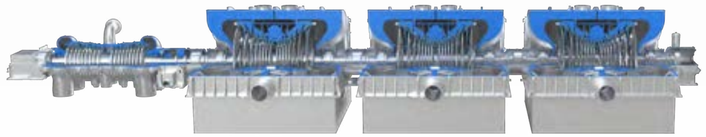
The TX-10 series steam turbines offer the highest capacity from our steam turbine product line-up for nuclear power plant applications.

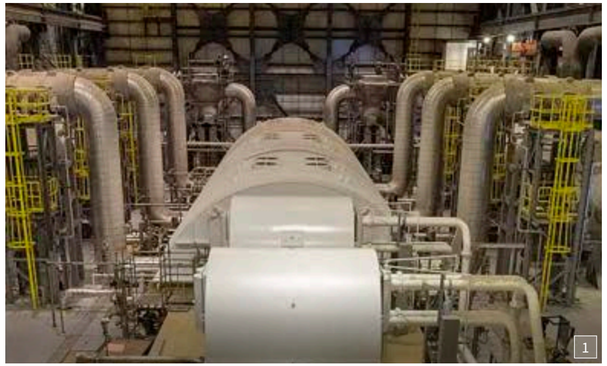
The TX-10 is a tandem compound, reheat downward-exhaust steam turbine whose power train consists of single double flow high-pressure turbine and three double flow low -pressure turbines.

Toshiba's nuclear turbines, including the TX-10 series, have been delivered with a total capacity exceeding 20GW worldwide, earning significant praise and trust from our customers.

Features

- **Applicable for both BWR and PWR**
- **Class-leading availability and reliability**
- **Advanced blade & steam path design, leakage mitigation technologies**
- **Optimization with wide line-up of last stage blades**
- **Mono-block rotor to mitigate SCC risks and shaft vibration**
- **Moisture extracting blades and blade hardening as countermeasures for wet steam conditions**
- **Interchangeable design among LP rotors as an option**





1 2 4 Plant Vogtle, Nuclear Power Plant, Georgia, USA

3 Barakah Nuclear Energy Plant, UAE

Main Steam Pressure	up to 75 bara / 1088 psia	**Main Steam Temperature**	up to 290℃ / 554F		
Reheat Tempreture	up to 280℃ / 536F	**Output**	up to 1800 MW	**Frequency**	50 Hz or 60 Hz

TX-8

Tandem Compound Four Flow

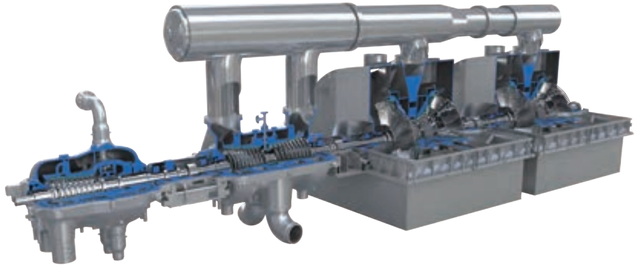
Toshiba's TX-8 series steam turbines are the highest capacity offering from our steam turbine product line-up, providing output of more than 1,100 MW.

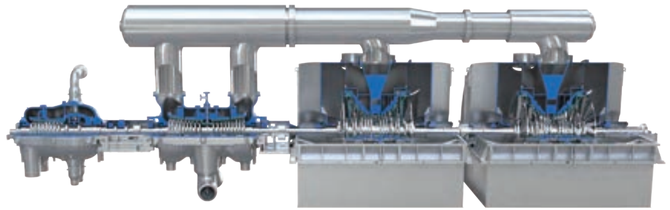
The TX-8 is a tandem compound, reheat downward- or side-exhaust steam turbine whose power train consists of a high-pressure turbine, a double flow intermediate-pressure turbine and two reverse double flow low-pressure turbines.

Worldwide installed capacity of more than 60 GW is a testament to the confidence entrusted to Toshiba by our TX-8 customers.

Features

- **Down- or side-exhaust options.**
- **Ideal solution for base load power demands.**
- **Equipped with latest supercritical technology.**
- **Dynamic steam path design for enhanced performance.**
- **Class-leading availability and reliability.**





1 Jimah Coal-Fired Power Plant, Malaysia

2 Coal Fired Thermal Power Plant, North Carolina, United States

3 Coal Fired Thermal Power Plant, Illinois, United States

4 Hekinan Thermal Power Station, JERA, Japan

Main Steam Pressure	up to 271 bara / 3,930 psia	**Main Steam Temperature**	up to 600 °C / 1,112 °F		
Reheat Tempreture	up to 630 °C / 1,166 °F	**Output**	up to 1,200 MW	**Frequency**	50 Hz or 60 Hz

TX-6

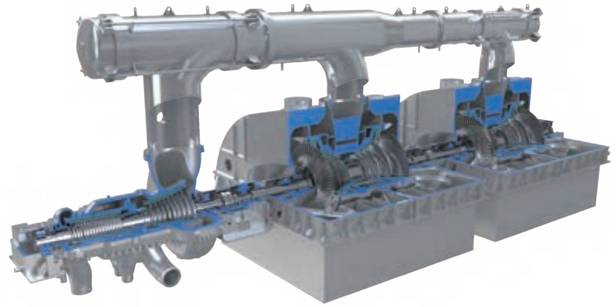
Tandem Compound Four Flow

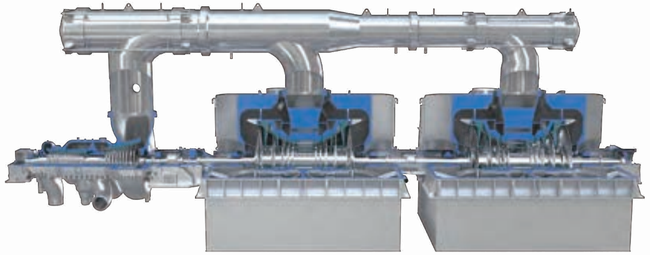
The TX-6 steam turbine power train consists of one reverse flow high-pressure / intermediate-pressure (HIP) turbine and two double flow low-pressure turbines, featuring 3 casings. The TX-6 gives customers the option to choose between down- and side-exhaust, providing additional degree of overall plant design flexibility.

TX-6 steam turbines find applications in both combined cycle power projects and conventional coal- or gas-fired steam power plants. With more than 2.5 million reliable hours of cumulative operating time, the TX-6 product line has the demonstrated experience you can count on.

Features

- **Down- or side-exhaust options.**
- **Best-in-class efficiency as a result of innovative, leading-edge technologies such as an optimized high-performance steam path, advanced seals and other advanced features.**
- **Short start-up times and flexible start-up modes.**
- **Class-leading availability and reliability.**
- **Equipped for handling supercritical steam conditions.**





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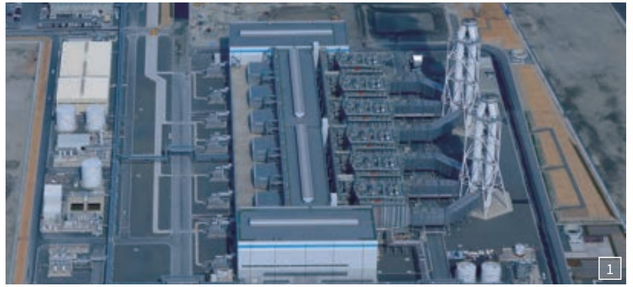

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1 Nishi-Nagoya Thermal Power Station, JERA, Japan

Main Steam Pressure	up to 271 bara / 3,930 psia	**Main Steam Temperature**	up to 600 °C / 1,112 °F		
Reheat Tempreture	up to 620 °C / 1,148 °F	**Output**	up to 800 MW	**Frequency**	50 Hz or 60 Hz

TX-4

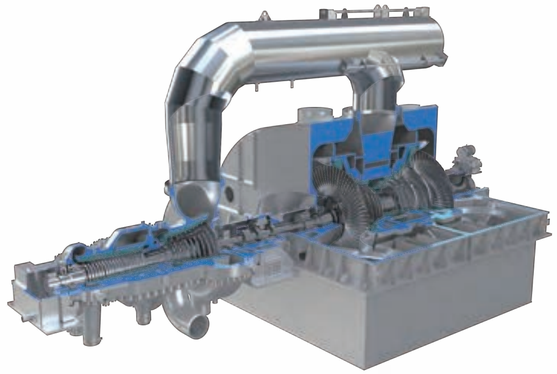
Tandem Compound Double Flow

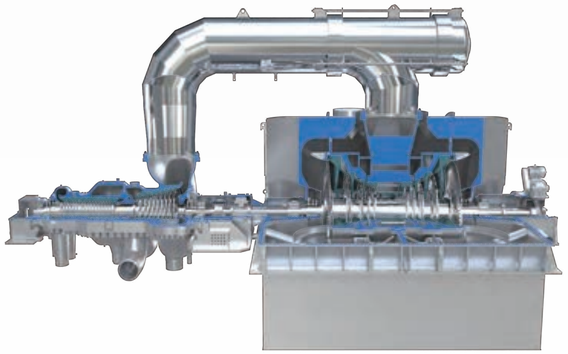
The TX-4 is a tandem compound reheat unit. The power train is comprised of two casings housing a high-pressure / intermediate-pressure (HIP) turbine and a double flow low-pressure turbine that can either be downward- or side-exhausting. The TX-4 series offworld class efficiency with output power ranging from 130 MW to 700 MW.

More than 170 TX-4 series steam turbine units have been successfully installed worldwide to date.

Features

- **Down- or side-exhaust options.**
- **Best-in-class efficiency as a result of innovative, leading-edge technologies such as an optimized high-performance steam path, advanced seals and other advanced features.**
- **Short start-up times and flexible start-up modes.**
- **Class-leading availability and reliability.**
- **Equipped for handling supercritical steam conditions.**





1 Gas Turbine Combined Cycle Power Plant, Kentucky, United States

2 TPP Maritsa East 2, Bulgaria

Main Steam Pressure	up to 271 bara / 3,930 psia	**Main Steam Temperature**	up to 600 °C / 1,112 °F		
Reheat Tempreture	up to 620 °C / 1,148 °F	**Output**	up to 700 MW	**Frequency**	50 Hz or 60 Hz

TX-2

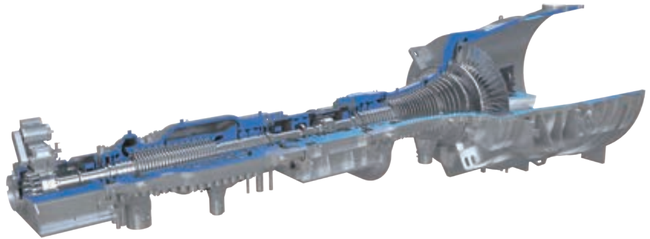
Tandem Compound Single Flow

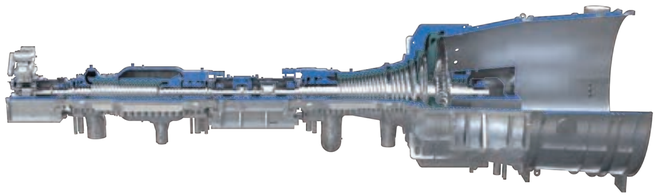
The TX-2 series steam turbine consists of two casings that house one high- and intermediate-pressure turbine (HIP) and a single-flow low-pressure (LP) turbine.

TX-2 series turbines are available in both down- and axial-exhaust configurations, wherein the axial-exhaust design allows for centerline height reduction, allowing for a reduced construction area and more economical plant construction costs.

Features

- **Down- or axial-exhaust options.**
- **High-performing, high-efficiency turbine with single-flow exhaust.**
- **Short start-up times and flexible start-up modes.**
- **Class-leading availability and reliability.**





1 Gas Turbine Combined Cycle Power Plant, Ohio, United States

2 Gas Turbine Combined Cycle Power Plant, North Carolina, United States

3 Kashima Thermal Power Station, JERA, Japan

Main Steam Pressure	up to 175 bara / 2,538 psia	**Main Steam Temperature**	up to 600 °C / 1,112 °F		
Reheat Tempreture	up to 600 °C / 1,112 °F	**Output**	up to 300 MW	**Frequency**	50 Hz or 60 Hz

TX-1

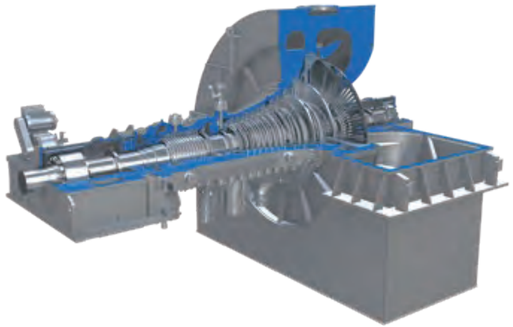
Single Casing
Single Flow

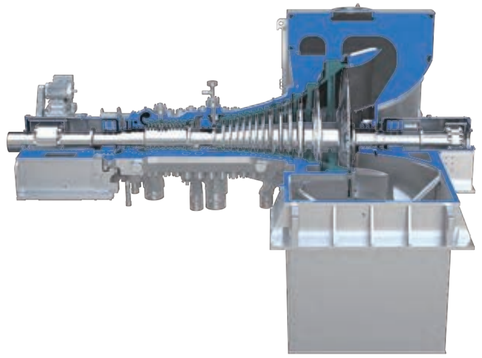
The TX-1 series steam turbine consists of a single casing which houses an HP turbine, IP turbine and LP turbine. The TX-1 is available in down - or axial-exhaust configuration, resulting in a tailored, extremely compact design.

The single casing construction allows for a simplified design which offers great performance in an extremely cost-efficient system..

Features

- **Down- or axial-exhaust options.**
- **High availability and reliability.**
- **Simplified design tailored for compact solutions.**
- **Ease of maintenance due to compact size and single-casing design.**
- **Class-leading availability and reliability.**





1 Sakaide Thermal Power Station, Shikoku Electric Power Co., Inc., Japan

2 Mindanao Coal-Fired Thermal Power Plant, Philippines

Main Steam Pressure	up to 170 bara / 2,466 psia	**Main Steam Temperature**	up to 585 °C / 1,085 °F		
Reheat Tempreture	up to 585 °C / 1,085 °F	**Output**	up to 220 MW	**Frequency**	50 Hz or 60 Hz

TX-2G

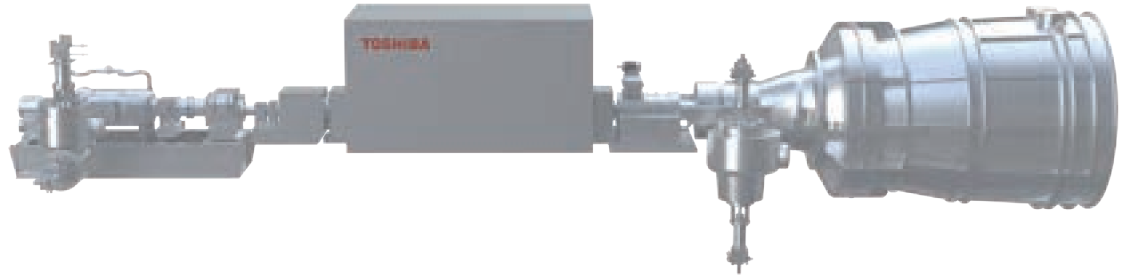
Tandem Compound Geared Single Flow

The TX-2G geared turbine consists of two casings and incorporates one high-speed, high-pressure turbine and one intermediate / low-pressureturbine (ILP). A reduction gear between the turbines reduces the rotational speed of the high pressure turbine to 3,000 rpm (50 Hz) or 3,600 rpm (60 Hz).

The TX-2G turbine system offers benefits not possible with a traditional turbine. One benefit is quick start-up and fast response making the TX-2G a perfect choice to complement variable output of alternative energy sources such as solar energy and wind energy. Additionally, the high speed of the high-pressure turbine reduces the footprint of the TX-2G without sacrificing performance, leading to constructability benefits and construction cost savings.

Features

- Down- or axial-exhaust options.
- High performance and efficiency in a single-flow exhaust.
- Compact high-speed, high-per modularized high-pressure turbine.
- Short start-up times and flexible start-up modes.
- Class-leading availability and reliability.



<table>
<tr><td>Main Steam Temperature</td><td colspan="3">up to 170 bara / 2,466 psia</td></tr>
<tr><td>Main Steam Pressure</td><td colspan="3">up to 585 °C / 1,085 °F</td></tr>
<tr><td>Output Tempreture</td><td colspan="3">up to 585 °C / 1,085 °F</td></tr>
<tr><td></td><td>up to 220 MW</td><td>Frequency</td><td>50 Hz or 60 Hz</td></tr>
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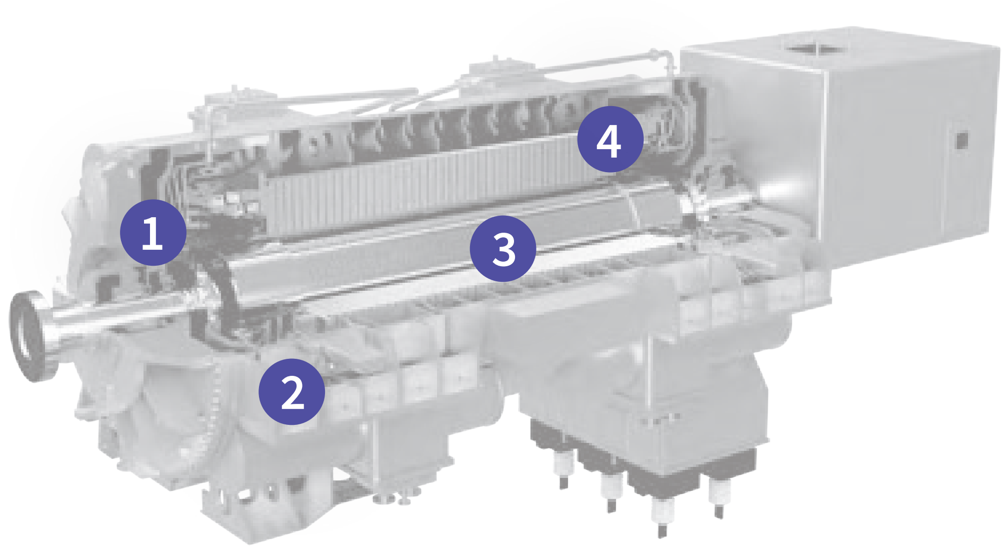
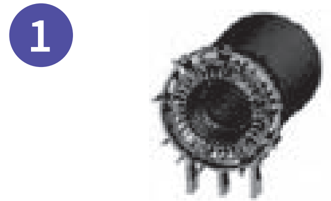
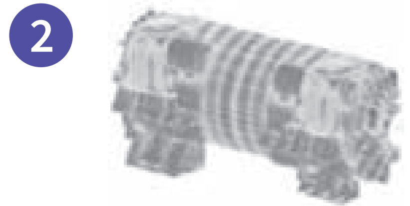
TURBINE GENERATOR PRODUCT LINE-UP

Features





Stator End Winding Support System

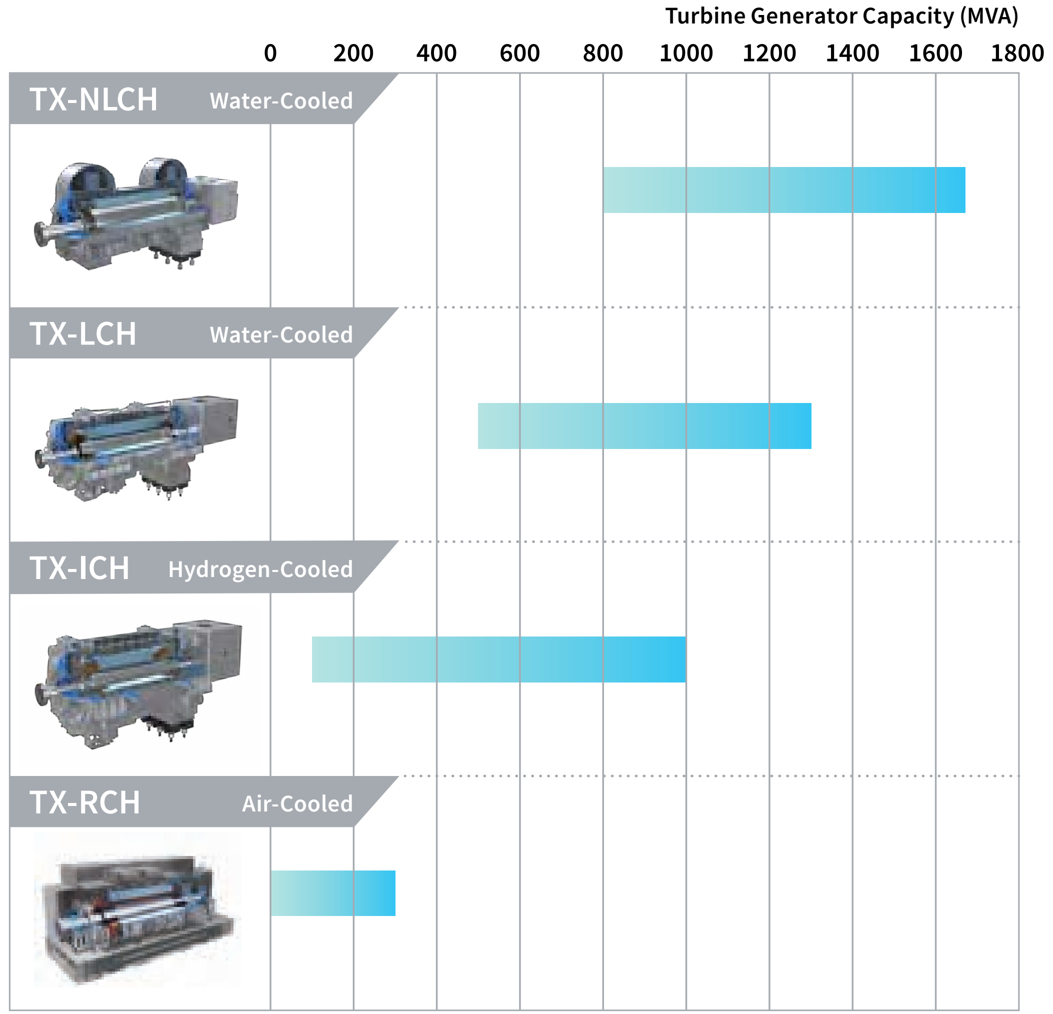


Stator Frame Stress Analisis

CED Analisis of Cooling Flow

Magnetic Flux Analisis at Stator End

Optimized design through computation analysis provides high performance and high reliability.



Toshiba's 2-pole turbine generators are available in a variety of types to meet prime mover requirements in a wide range of applications encompassing, combined-cycle power plants, conventional power plants and geothermal power plants. Water-cooled, hydrogen-cooled, and air-cooled generators are available. The capacity range of each generator, regardless of cooling design, is continuously expanded by Toshiba's developments and advances in its design and manufacturing technologies. Toshiba's generator design, based on abundant experience, emphasizes high efficiency, high quality, compactness, and easy maintenance.

TX-NLCH

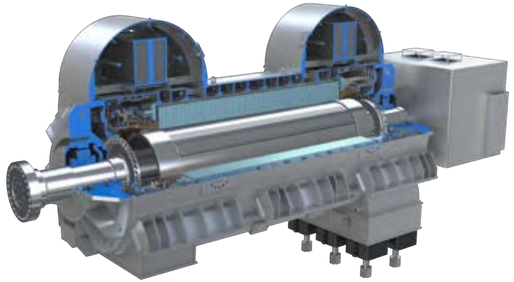
Water-Cooled 50Hz / 60Hz

TX-NLCH refers to a 4P nuclear power generator based on the TX-LCH, which is designed for 2P thermal power

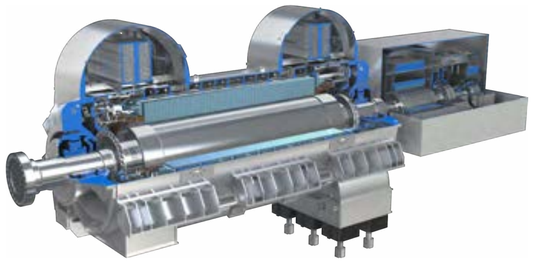
Features

- **The thyristor-excited TX-NLCH generator has been supplied to numerous nuclear power plants both domestically and internationally.**
  4P-60Hz 1389MVA(1,250MW) generator was shipped in 2012, followed by a 4P-50Hz 1690MVA(1,521MW) generator in 2013.
  These reliable generators have since commenced commercial operation.
- **The TX-LCH generator is compatible with both thyristor excitation and brushless excitation methods. For the brushless excitation method, the verification of the excitation machine has been successfully completed.**

Power Factor	0.85 or 0.9	**Efficiency**	up to 99.0%
Capacity	up to 1700MVA	**Terminal Voltage**	up to 30kV



Generator with thyristor excitation



Generator with brushless excitation

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1 4P-60Hz 1389MVA Generator (USA)

2 4P-50Hz 1690MVA Generator (UAE)

3 Plant Vogtle, Nuclear Power Plant, Georgia, USA

4 Barakah Nuclear Energy Plant, UAE

TX-ICH

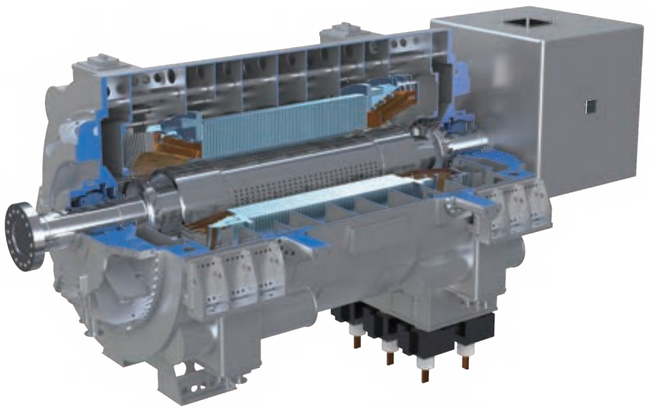
H_2 Hydrogen-Cooled 50 Hz / 60 Hz

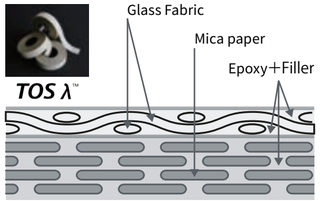
Toshiba offers hydrogen-cooled generators with a wide range of capacity options designed to meet Customers' needs. By utilizing hydrogen gas for cooling, generators are able to achieve high operating efficiencies.

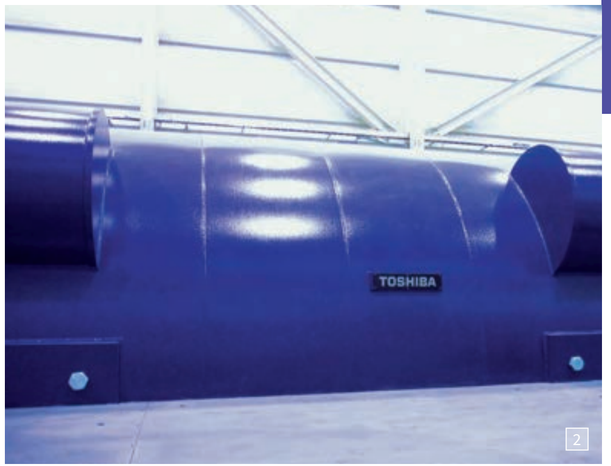
Features

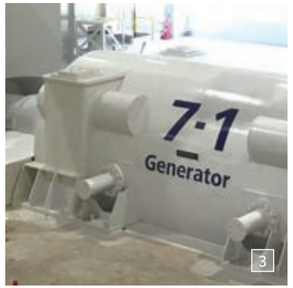
- **The hydrogen-cooled generators do not require deionized water auxiliary systems. This allows easier operation and lower maintenance costs.**
- **Toshiba developed the insulation system for indirect hydrogen cooling stator bars. The insulation system has excellent high thermal conductivity technology which allows the generator stators to be more compact than those units using water cooling.**
- **Toshiba's hydrogen-cooled units are available in capacities up to 1,000 MVA.**
- **Indirect hydrogen cooling improves the efficiency of a generator, compared to water cooling.**

Power Factor	0.85	**Efficiency**	up to 99.1 %
Capacity	up to 1,000 MVA	**Terminal Voltage**	up to 22 kV









1 Gas Turbine Combined Cycle Power Plant, Indiana, United States
2 Gas Turbine Combined Cycle Power Plant, Kentucky, United States
3 Nishi-Nagoya Thermal Power Station, JERA, Japan
4 Noshiro Thermal Power Plant, Tohoku Electric Power Co., Inc., Japan
5 Gas Turbine Combined Cycle Power Plant, North Carolina, United States

TX-LCH

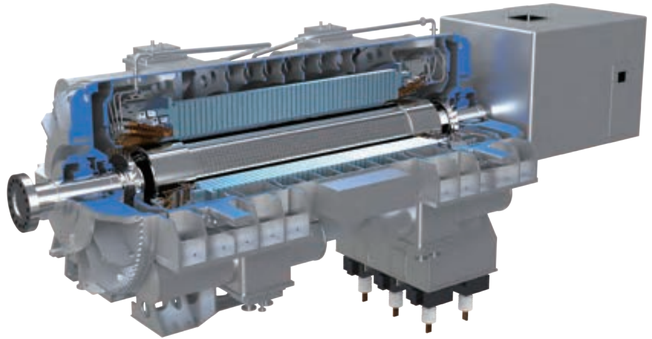
Water-Cooled
50 Hz / 60 Hz

Toshiba's water-cooled generators are exceptionally well suited for large capacity thermal power plants. Stator coils are cooled by water while rotor and stator core are cooled using hydrogen gas.

Features

- **Toshiba shipped water-cooled generators of 2P-60 Hz 1,120 MVA (1,000 MW) starting in 2001 and continues to ship reliable generators of more than 1,000 MW.**
- **The high capacity range has been continuously expanded through ongoing developments in design and manufacturing technologies.**
- **The technologies developed and applied to large capacity generators are also applied to smaller generator size ranges to realize unit compactness and reliability.**
- **Water-cooled stator coils are manufactured under strict quality control standards.**

Power Factor	0.85	**Efficiency**	up to 99.0 %
Capacity	up to 1,300 MVA	**Terminal Voltage**	up to 30 kV



1 Vinh Tan 4 Thermal Power Plant, Vietnam

2 Coal Fired Thermal Power Plant, North Carolina, United States

TX-RCH

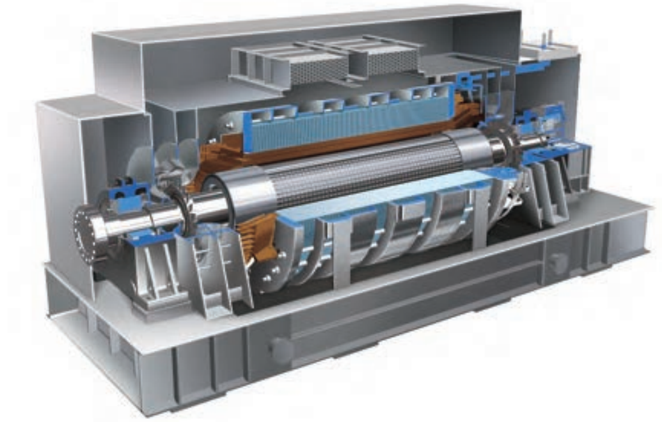
Air-Cooled
50 Hz / 60 Hz

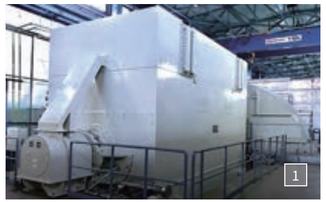
Air-cooled generators are designed for small capacity thermal power plants. They are designed based on cooling stator and rotor by air. Air-cooled generators do not require complex sub-systems (such as water cooling or hydrogen cooling systems) for their proper operation.

Features

- **Toshiba's air-cooled generators are designed utilizing abundant manufacturing and operating experience.**
- **High performance is provided by effective cooling and loss reduction techniques.**
- **Air-cooled generators do not require hydrogen gas supply. This minimizes auxiliary equipment and reduces operating costs.**
- **Toshiba's design is robust resulting in easy maintenance.**

Power Factor	0.85	**Efficiency**	up to 98.8 %
Capacity	up to 300 MVA	**Terminal Voltage**	up to 20 kV





1 Mindanao Coal-Fired Thermal Power Plant, Philippines

2 Manzhouli Dalaihu Project for 2 X 200 MW Cogeneration Power Plant, China

TURBINE & GENERATOR CONTROLLER

TOSMAP-DS™/LX

Toshiba's package includes TOSMAP-DS™/LX, (Toshiba Microprocessor Aided Power system control-Dynastream) controller hardware, a state-of-the-art microprocessor based controller specifically developed for steam turbine and generator control, to ensure stable and reliable STG operation. More than 350 D-EHC and over 500 D-AVR systems have been successfully installed worldwide to date.

D-EHC Digital Electro-Hydraulic Control System

The D-EHC is a key control and safety component of a power plant. The role of the D-EHC is to control the steam turbine operation from start-up to shut-down as well as to provide protection throughout its operating range.

Toshiba's many years of steam turbine control system design and manufacturing experience provide us with the technological foundation to develop the latest generation of the D-EHC control system. We offer the most advanced, sophisticated solution for steam turbine control and protection available today.

Features

- **Powerful and reliable controllers**
- **Improved monitoring and operability**
- **Fully automatic turbine startup control**

D-AVR Digital Automatic Voltage Regulator

The D-AVR contributes to the grid power stability improvement of system network by voltage control and reactive power control.

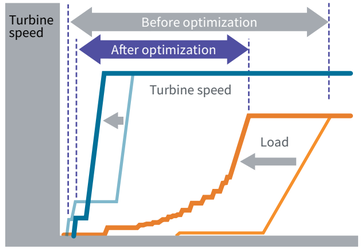
Toshiba has more than 100 years of experience in design and manufacture of control systems for synchronous generators. We have incorporated this extensive experience and technical expertise into the design of our latest generation Toshiba excitation system.

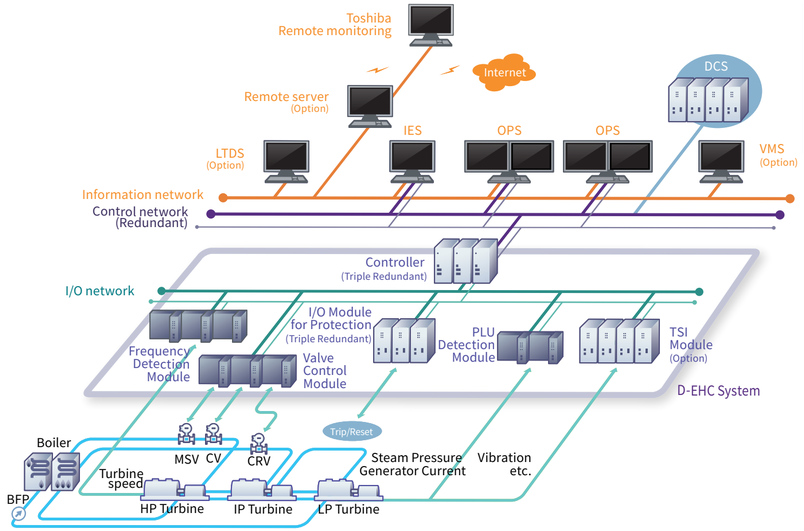
Toshiba's expertise in generator control enables us to provide highly sophisticated, reliable and profitable D-AVR not only for Toshiba turbine generator but also for generators of other manufacturers.

Steam Turbine Optimized Start-up Control

Optimized Start-up Control is a predictive model for rotor thermal stress that can be applied to the steam turbine start-up procedure in order to reduce start-up and loading time. This start-up method modulates the turbine acceleration and loading rate to maintain optimum rotor surface temperature. Optimized Start-up Control is outlined in the figures below.

Start-up Curve





Typical D-EHC System Configuration

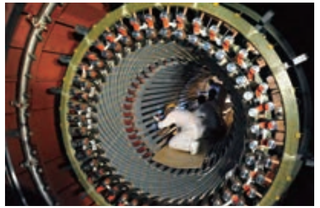
HMI : Human Machine Interface
OPS : Operator Station
VMS : Vibration Monitoring System
DCS : Distributed Control System
IES : Integrated Engineering Station
LTDS : Long Term Data Server
TSI : Turbine Supervisory Instrument
PLU : Power Load Unbalance

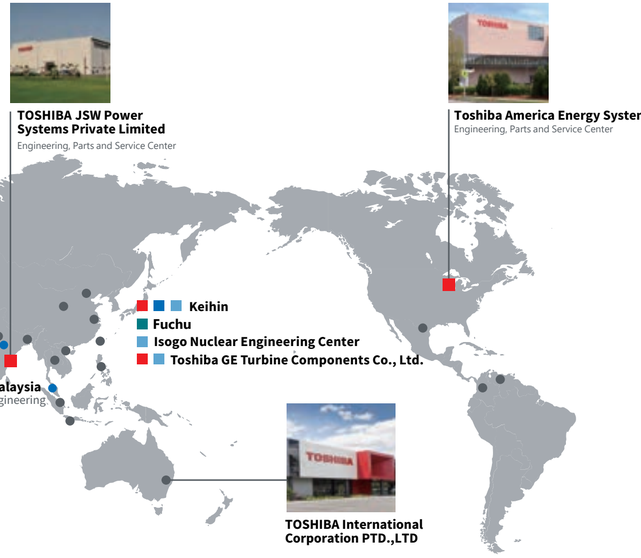
TOSHIBA STEAM TURBINE AND GENERATOR MAINTENANCE AND SUPPORT SERVICE

Toshiba's Preventive maintenance technology offers steam turbine and generator service solutions that stabilize turbine generator operations, and enable ease of analysis, inspection, and diagnosis on a day to basis, boosting the plant efficiency and reliability.

Steam turbine and Generator maintenance services mainly include the following four activities:

- **Support for operator's periodic inspection**
- **Support for developing maintenance plans**
- **Investigate the deterioration of facilities and replace spare parts**
- **Retrofit and improve performance, functionality and reliability by applying cutting edge technologies**





Global Service Network

CONTINUOUS SERVICE AGREEMENTS (CSA)

Toshiba also offers Continuous Service Agreements (CSA) which include Long Term Service Agreements (LTSA) and IoT technical support. Customer benefits include stable operation of the plan, marked improvements in reliability and performance, levelized minimized maintenance costs, among others.

Long Term Service Agreement (LTSA)

As an OEM of steam turbine and generators, Toshiba has the expertise to deliver a full range of service support under a Long Term Service Agreement (LTSA) structure. Toshiba offers a wide-range of LTSA plans such as Spare Parts, Outage Execution, Asset Management, Availability and Performance Optimization. Toshiba will work closely with you to custom-tailor the LTSA based on your needs.

With our LTSA, you gain the advantage of Toshiba's technical knowledge to provide assistance for your short and long term planning needs, as well as immediate support in times of emergency.

Regularly scheduled customer site visits and communication
LTSA Manager (single point of contact)

Prompt data analysis and support
Remote Monitoring System (24/7 monitoring)

Coordinated planning and scheduling of maintenance outages
OEM Certified Outage Management and Technical Support during maintenance outages

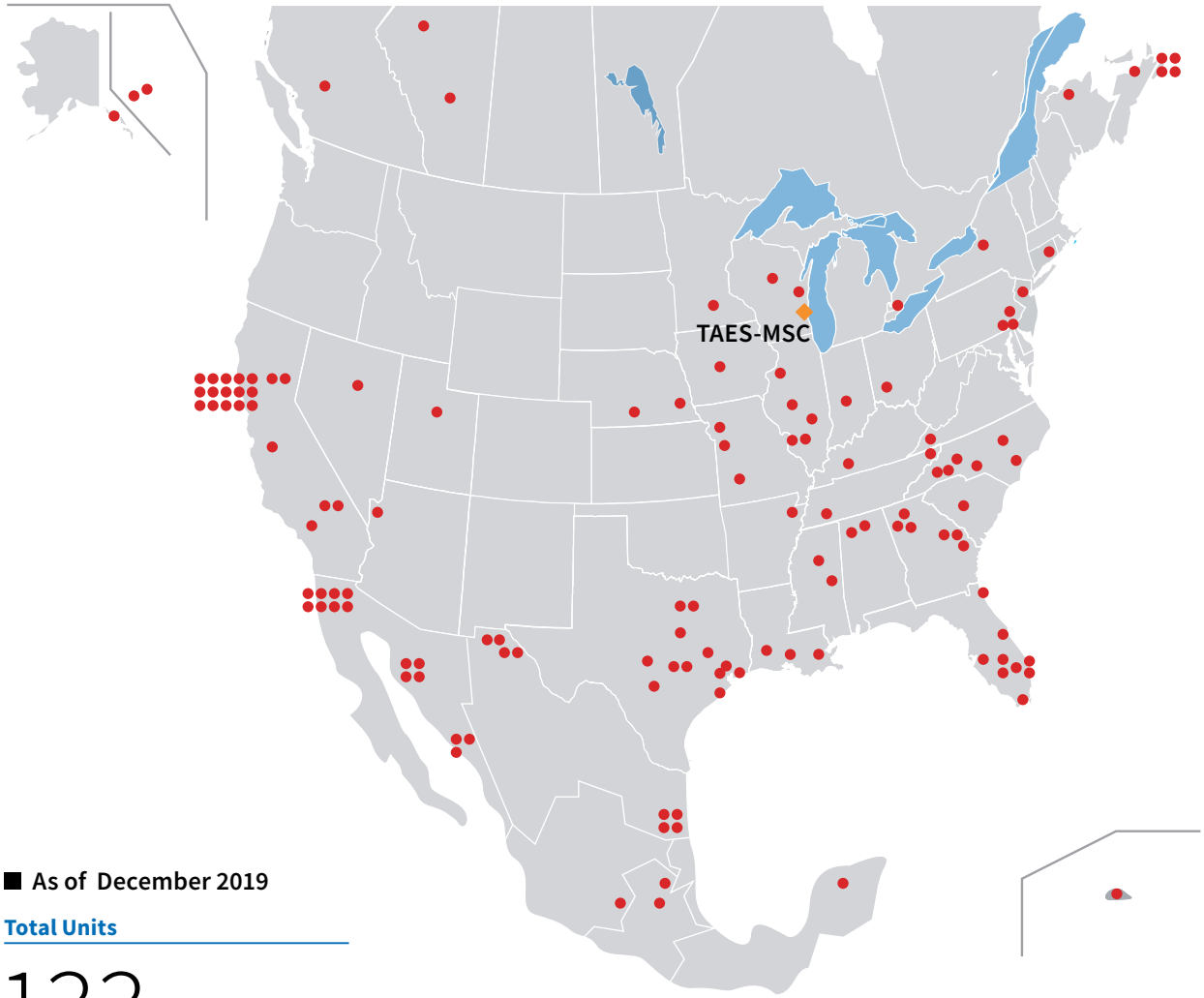
Toshiba IoT Service portfolio

We offer comprehensive digital O&M services to deliver strong performance for power plants

	SERVICE DETAILS		OUTCOMES			
			Availability	Fuel Cost	O&M Cost	Safety
A	**AX Platform with Dashboard (AX w/ D)**	Seamless access to digital information stored in separated databases				
B	**Optimal Power Generation System (OPGS)**	The most efficient loading across all units using real-time big data and advanced analytics		↓		
C	**Thermo-dynamic Performance Monitoring & Optimization (TPMO)**	Effective instructions to raise thermal efficiency based on actual situation and data analysis results		↓		
D	**Equipment Predictive Analysis (EPA)**	Timely alerts and effective recovery instructions utilizing engineering expertise	↑		↓	
E	**Advanced Maintenance Planning Support (AMPS)**	Optimal maintenance plan considering best balance of failure risk and maintenance cost	↑		↓	
F	**Quick Ramp-Up (QRU)**	Minimum ramp-up/down time by sophisticated control	↑			
G	**Boiler Combustion Optimization (BCO)**	Optimized control to avoid slagging and clinkering		↓		
H	**Field Worker Support (FWS)**	Field work supports through a dashboard to realize effective and reliable operations			↓	↑
I	**Knowledge Transfer Support (KTS)**	Knowledge transfer contents with virtualizing technologies			↓	↑

TOSHIBA'S PRESENCE IN NORTH AMERICA

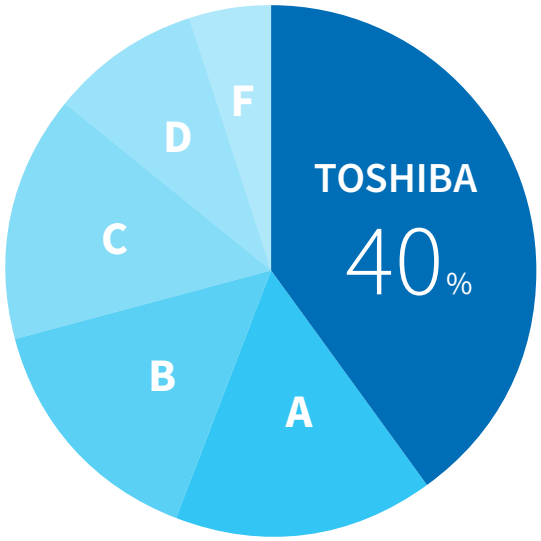
Since our first North-American delivery in 1967, Toshiba has successfully delivered 133 STG units, having 37.5 GW of cumulative capacity.



No.1 share in North America

for capacity of large STG units

from 2005 to 2019



Source : Toshiba Company Data (ST Output range 200 MW and above)

■ As of December 2019

Total Units

133 37.5 GW

1967~2019

*Units in storage and cancelled are excluded.
*Other OEM refurbishment units are excluded.

■ MILWAUKEE SERVICE CENTER

Our Milwaukee Service Center(MSC) is always ready to promptly respond to any customer service demands that might arise.

TOSHIBA

Toshiba Energy Systems & Solutions Corporation

www.global.toshiba/ww/company/energy.html