# Power Systems and Industrial Equipment

In the power systems and industrial equipment field, Toshiba takes on the role of a pillar supporting life lines, aiming to construct a society in which people are able to lead secure and safe lives. We have carried out large scale demonstration tests of residential fuel cells, set up a state-of-the-art steam turbine generator with large capacity and high efficiency and provide products considerate of the global environment such as advanced sewage treatment process control systems complying with the demand for both improvement of discharged water quality and conservation of energy.



## Large-Scale Field Test for 1 kW-Class Residential Fuel Cells


Residential 1 kW-class fuel cell

Fuel cells are expected to become widely used in a variety of applications, including both stationary and automotive systems, because of their high efficiency and environmental friendliness. Toshiba has been working on the development of 1 kW-class residential fuel cell systems since fiscal year (FY) 2000 with the aim of improving their performance, durability and reliability.

Toshiba Fuel Cell Power Systems Corporation has developed and deployed 125 residential polymer electrolyte fuel cell (PEFC) systems in various dwellings for a large-scale field test program funded by the New Energy Foundation that was started in FY2005.

These fuel cell systems are co-generation systems using city gas or liquefied petroleum gas as fuel. Their high efficiency (generation efficiency of 32% HHV and total efficiency of greater than 71% HHV, at rated power when operated with city gas), excellent energy-saving capability through optimum operating control, high reduction rate for carbon dioxide in actual daily operating conditions were confirmed.

The large-scale field test program will continue until FY2007. Toshiba will continue development efforts for residential fuel cell systems for commercialization in FY2008.

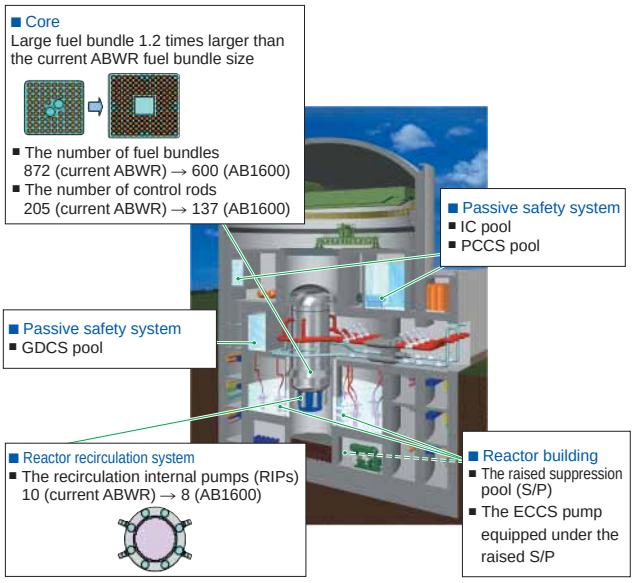
HHV: Higher Heating Value

## Development of The Next Generation ABWR (AB1600)

Toshiba is developing a next generation ABWR (Advanced Boiling Water Reactor) of 1,600 MWe, which we call AB1600. The AB1600 is an improved reactor based on ABWR-II that was developed in joint studies to improve ABWR for the first time. The target for its first commercial operation is set for the late 2010's.

In order to improve countermeasures against severe accidents (SA) as well as the economic efficiency of ABWR, the AB1600 adopts a hybrid active/passive safety system and simplified overall plant systems. Furthermore, in consideration of the necessity of maintaining a core damage frequency as low as that of ABWR, the passive containment cooling system (PCCS), gravity driven core cooling system (GDCS) and isolation condenser (IC) have been introduced. By introducing passive safety systems, the composition of the emergency core cooling system (ECCS)/heat removal system can be reduced to the two-division configuration from the three-division configuration of ABWR. This configuration change contributes to improvement in economic efficiency by resource-saving in not only the main systems but also auxiliary systems. Moreover, with the introduction of large fuel bundles, the number of fuel bundles and control rods can be reduced.

Toshiba will join the National Project developing the next generation light water reactor with the AB1600.




Outline of the AB1600

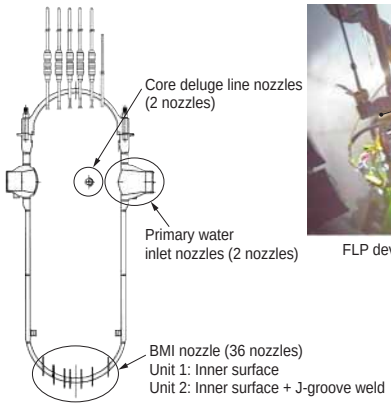
## Application of Laser Peening System for PWR Power Plants

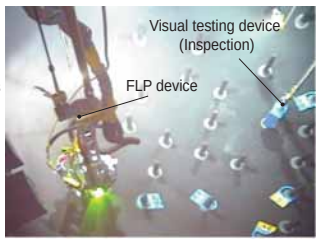
Stress corrosion cracking (SCC) is one of the major phenomena contributing to degradation in the reliability of aged reactor components. As a preventive maintenance measure to avoid SCC, laser peening (LP) could improve residual stress by converting it from tensile to compressive stress through irradiation with focused high-power laser pulses in water. Toshiba has developed fiber-delivered laser peening (FLP) systems, which have been successfully applied to operating BWR (Boiling Water Reactor) plants.

Toshiba has further applied FLP in Ikata units 1 and 2 of the Shikoku Electric Power Company Inc., marking its first application for PWR (Pressurized Water Reactor). The use of these systems has been extended to bottom-mounted instrumentation (BMI) nozzles, core deluge line nozzles and the primary water inlet nozzles of PWR plants.

The figure shows peened nozzles. For BMI nozzles, we peened not only the inner surface around the J-groove welds, but also the outer surface and the weld for Ikata unit 2. For core deluge line nozzles and primary water inlet nozzles, we were able to peen the inner surface of dissimilar metal welds, which were of nickel base alloy, joining a safe end and a low alloy steel nozzle.

For Ikata unit 1, the peening was accomplished within 18.4 days from December 2004 to January 2005. For Ikata unit 2, the critical path was 19 days from December 2005 to January 2006. Both operations were successfully completed within the scheduled deadline without any trouble. This result confirmed the reliability and the applicability of the FLP system for PWR power plants.




FLP device for J-groove welds of BMI

Peened nozzles of Ikata units 1 and 2

## In-Vessel Inspection Capability Certification by EPRI USA

Toshiba has demonstrated its in-vessel inspection (IVI) capability for ultrasonic testing (UT) instruments, UT procedures and inspectors' skills to the Electric Power Research Institute (EPRI) and successfully obtained its certification.

It was certified that the UT instruments (i.e., phased-array UT), underwater remotely operated vehicles (ROVs), and the UT detection and sizing procedures for the shroud and shroud support were of higher accuracy and also that the inspectors held a high degree of expertise in flaw (including SCC) detection in stainless steel and in flaw length and depth measurement.

Toshiba will continue to try other performance demonstrations (PD) to inspect other internals, and expand the IVI business in the USA.

SCC: Stress Corrosion Cracking

Small ROV

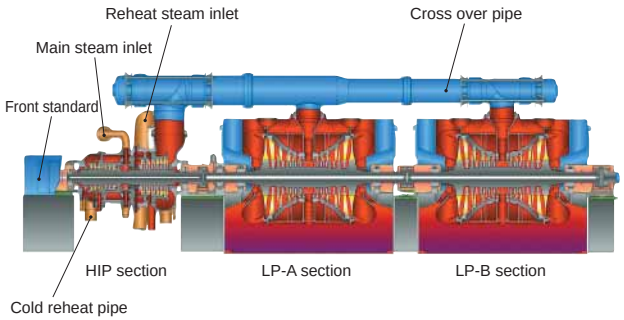
Shroud ROV

Shroud support ROV

Phased-array UT instruments

Underwater ROVs and phased-array UT instruments

## Successive Orders for Steam Turbine Generators with Advanced Technology for Fossil Fuel Power Plants in North America




Steam turbine assembly

The demand for large capacity fossil fuel power plants instead of for combined cycle power plants is increasing recently in North America.

Toshiba has a great deal of experience and a long history in supplying steam turbine generators (STGs) in North American power plants. After the award of a 500 MW STG in March 2002, Toshiba has received orders for STGs in combined cycle power plants instead of for fossil fuel power plants. However, the order for a 600 MW super critical STG in October 2004 led to a further four orders for sub-critical STGs, 240 MW in March, 720 MW in May, 800 MW in September and 230 MW in October, for fossil fuel power plants. This is the fruit of our supply of STGs with safe operation for fossil fuel power plants in many countries in the world as well as in Japan. The high regard of the customers has led to these successive awards.

## State-of-the-Art Steam Turbine Generator Shipped and Installed at the Sumitomo Metals Kashima Thermal Power Plant

Generator

A state-of-the-art 507 MW steam turbine together with a 563.334 MVA large-capacity hydrogen gas-cooling synchronous generator for the Sumitomo Metals Kashima thermal power plant were completed and shipped.

This steam turbine aims at improving efficiency by adopting a three-dimensional fluid design, which is a well-tested state-of-the-art performance enhancement technology.

Moreover, a large-capacity, high efficiency indirect hydrogen gas-cooled generator was accomplished by taking advantage of the latest available cooling technology and analysis technology, and employing high-thermal conductivity insulation on the stator winding.

This plant is currently under construction with commercial operation scheduled for 2007.

Array of snubber buckets for steam turbines

## Operation of Toshiba Hydro Power (Hangzhou) Co., Ltd. Begins

In January 2005, Toshiba Corporation and Sinohydro Corporation, the world's largest dam construction company, established Toshiba Hydro Power (Hangzhou) Co., Ltd. (THPC) in Hangzhou City, China.

China has been the largest hydro equipment market for the past ten years and will continue to be so. From design to manufacture, THPC is a fully integrated hydro equipment manufacturer, successfully receiving an order for Dayingjian Power Plant (178.6 MW, 4 sets of hydro turbines and generators) etc.

With Toshiba's other Japanese operations, THPC will be a mutually supportive and fully integrated hydro equipment company for the Chinese market, as well as a manufacturing base for the global market including pumped storage equipment manufacturing.


Toshiba Hydro Power (Hangzhou) Co., Ltd. (THPC)

75 MW Kaplan turbine shop assembly at THPC

## Renovation of Control Systems for Steam Turbines and Generators for the Republic of South Africa Completed

Digital control system for steam turbine and generator

Two sets of EHC (Electro Hydraulic Control) system, AVR (Automatic Voltage Regulator) and GPR (Generator Protection Relay) for the steam turbine and generator for a factory in the Republic of South Africa, that were installed in the early 1980s, were upgraded successfully with state-of-the-art-digital technology in May 2005.

The new upgraded control system shows remarkably improved performance in supervising function compared with the old system by using a color display based operation and monitoring system.

Furthermore, optimal load sharing of each generation unit is realized by implementing coordination control function in the unit control system of the D-EHC (Digital-Electro Hydraulic Control) system. On the other hand, in order to perform the upgrade work on both units at the same time for the minimum period, full consideration was given to the re-use of existing cables and minimization of the use of new cables at the basic design stage.

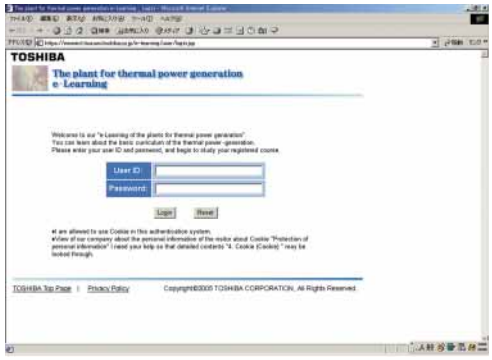
As a result, the upgrading and commissioning work on the two units was achieved successfully within the expected period and it has been confirmed that their performance fulfills the set requirements, and the new D-EHC, D-AVR (Digital-Automatic Voltage Regulator) and GPR have been handed over to the customer as planned.

## Development of EHC/AVR E-Learning System on the Web for a Thermal Power Plant Completed

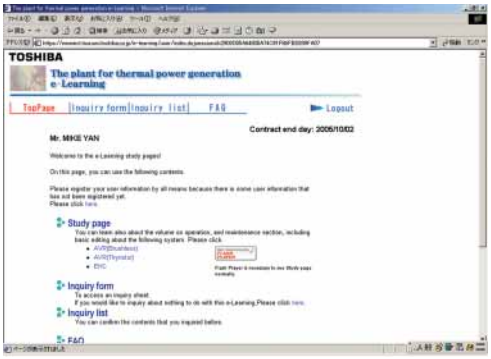
Toshiba has completed the development of an e-learning system concerning the operation and maintenance of EHC/AVR which is the primary control equipment for overseas thermal power plant customers.

Content can be selected from EHC, AVR (brushless type) and AVR (thyristor type). Since there is a test at the end of each chapter, the customer is able to carry on learning while confirming comprehension at each stage. Through these studies, the customer is able to understand the basic configuration, operation and maintenance of EHC/AVR.

Toshiba also gives courses on these units. This web site is provided as an educational system via the Internet for acquisition of basic knowledge before attending courses or for the many customers who are unable to attend the courses.




User authentication page




Front page

## Consecutive Energization of Two Large 400 kV Substation Projects for Abu Dhabi Water & Electricity Authority

Site test of 400 kV gas-insulated switchgear (GIS) at Abu Dhabi Umm Al Nar IWPP Substation

Toshiba has successfully energized two large 400 kV substations in succession for Abu Dhabi Water & Electricity Authority in the United Arab Emirates. The first substation serves Umm Al Nar Thermal Power Station IWPP (Independent Water and Power Project); the second substation completes stage one of the E48 Grid Station Project. Both projects are Full Turn Key contracts and include the supply of the entire substation equipment including 400 kV and 132 kV gas-insulated switchgear (GIS), power transformers, digital substation control and monitoring systems, protection systems, and include all civil and erection works and the testing and commissioning of all primary and secondary apparatus. These projects were executed in tandem, and despite the extremely short project delivery period of twenty-two months, Toshiba was able to successfully complete and energize both substations on target utilizing its in-house project management expertise.

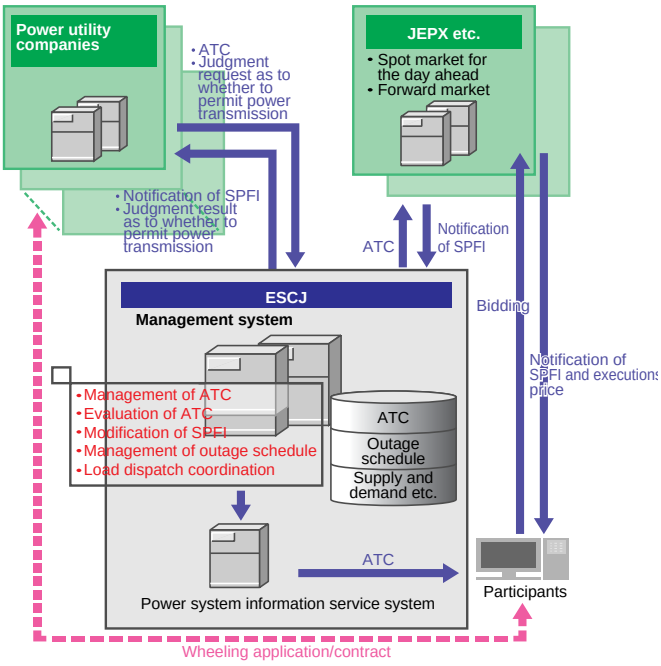
Toshiba maintains its international competitiveness utilizing state-of-the-art technology products, which typically include 420 kV single break gas circuit breaker technology complying with the latest IEC (International Electrotechnical Commission) standard.

## Operation of Management System (Load Dispatching Coordination System) for the Electric Power System Council of Japan Started

Toshiba has developed a management system (load dispatching coordination system) for the Electric Power System Council of Japan (ESCJ), which started operation in April 2005.

This system bears the load of the dispatching coordination function, which is one of the businesses under ESCJ newly established under the revision of the Electricity Utilities Industry Law, and this system is an online system that operates continuously 24 hours a day, connecting the power system operation sections of nine power utility companies, the trading system at JEPX (Japan Electric Power Exchange), and the power system information service system at ESCJ.

Not only does this undertake the "load dispatch coordination" function etc. from CEPC (Central Electric Power Council) to ESCJ but also Toshiba has developed the new features of "wheeling management", "evaluation of ATC (Available Transfer Capability)", and "modification of SPFI (Schedule of Power Flows of Interconnections)".



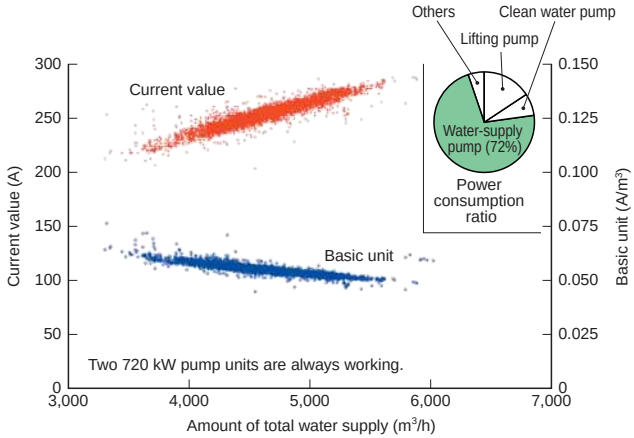

Configuration of the management system (load dispatching coordination system) for ESCJ

## Energy-Saving Diagnostic Technology

The Law Concerning the Rational Use of Energy aims at reducing energy consumption per basic unit by an average of 1% per annum, and requests the continued reduction in energy usage. Water-and-sewage plants are also subject to this revision of the law. Toshiba is working on a reduction in the amount of energy use with the customer.

The engineers and persons qualified in energy management who are experts on the equipment we deliver participated in "energy-saving diagnostic business" entrusted from Wakayama City. After performing measurement and analysis of plant power consumption, they carried out a quantitative study, and created an energy management regulation standard, a periodical report and a medium-to-long term plan.

On the basis of the plant operation analysis as in the analysis example, we will make every effort to further reduce the amount of the energy used with the customer including efforts to study the introduction of energy-saving apparatus.




### Example analysis of water-supply pumping equipment

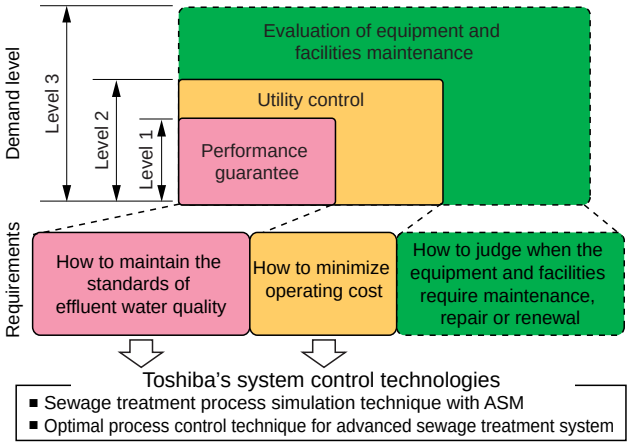
In the example analysis of the water-supply pump that accounts for 72% of power consumption, it is understood that the basic unit goes up as the amount of total water supply falls. Consequently, it can be said that rotational speed control rather than the currently used exhalation valve control is preferable.

## An Optimal Control System for Advanced Biological Sewage Treatment Process

Due to the stringent standards recently introduced for effluent water quality in Japan, sewage treatment plants are now required to remove nitrogen and phosphorus as well as organic matter. At the same time, the plants also need to reduce operating costs such as energy costs associated with aeration and/or pumping. In the control strategy, however, it is often a difficult task to determine the optimal setting value for the actuators such as blowers and pumps, due to the tradeoff between the need for higher effluent water quality and operating costs, and the highly complex nature of enhanced activated sludge processing.

Toshiba has developed an optimal process control system for advanced sewage treatment process that optimizes the setting value for actuators. In this system, we have introduced a total cost index that considers the effluent water in terms of cost so that it can be evaluated in the same way as operating costs. We have also developed a novel algorithm to calculate the optimal operating conditions based on the total cost index, by combining process simulation techniques with ASM (Activated Sludge Model), a heuristic search algorithm, and nonlinear programming.

With this system, it is possible to both reduce operating costs and maintain higher standards of effluent water quality in the sewage treatment plant. We hope that this system will play an important role in meeting the performance specifications required for sewage treatment plant operation.




System control technologies required in meeting the performance specifications required for sewage treatment plants in Japan

## Ultrasonic Gas Meter for Residential Use

Toshiba has jointly developed a new ultrasonic gas meter utilizing ultrasonic waves for measuring gas flow volume for residential use, with Tokyo Gas Co., Ltd., Toho Gas Co., Ltd. and Aichi Tokei Denki Co., Ltd.

Compared with the existing diaphragm gas meter, the new ultrasonic gas meter has some notable features such as smaller-size, lighter-weight, lower-price as well as more advanced measuring and safety functions. It is scheduled to be introduced in a pilot scheme in 2007.

The main features are as follows:

- Wide range ability (3 L/h to 12,000 L/h)
- Realization of instantaneous gas flow measurement of gas usage flow volume
  - Advanced monitoring of abnormal gas consumption is possible.
- Simplified gas flow path structure
  - Small size, light weight and low cost are realized.
- Establishment of high precision ultrasonic flow measurement technology at low power consumption
  - Operational life of ten years with batteries is achieved utilizing low power consumption technology.
- Realization of LSI for ultrasonic flow measurement circuit
  - Both cost reduction and high reliability are achieved by reducing the number of parts.


Ultrasonic gas meter

## Propulsion System for Electric Multiple Units for Rio de Janeiro, Brazil

Traction motor

VVVF inverter

Auxiliary power supply unit

Major 3,000 Vdc electrical equipment for electric multiple units

Toshiba has developed and manufactured a traction system, including VVVF (Various Voltage Various Frequency) inverters, APUs (Auxiliary Power supply Units) and traction motors for 20 new trains (80 cars) for CENTRAL (Companhia Estadual de Engenharia de Transportes e Logística).

Electric units are compliant with 3,000 Vdc of catenary. We were especially keen to achieve high efficiency and downsizing, and adopted a forced air cooling method to maintain sufficient performance and reliability in a high ambient temperature.

The adoption of insulation bearings to prevent electrolytic corrosion, and inertial filters to separate dust from the cooling air has contributed to the achievement of a maintenance-free traction motor.

## 1 Gbit/s Optical Ethernet Module for Railroad Vehicles

The ubiquitous network society is being built. In order to respond to the needs of network infrastructure construction in the severe environmental conditions of railroad vehicles, Toshiba has developed a 1Gbit/s optical Ethernet module for railroad vehicles, which is excellent in terms of maintenance performance, quality, and high-speed.

The optical fiber transmission technology, which is not influenced by electromagnetic environmental conditions, and 1-Gbit Ethernet technology have been applied in this module. This module enables not only mass transmission use, but also applications in the vehicle control field, which requires information on a constant cycle, by adding a constant periodic transmission function and a function to check the amount of optical power.

Thereby, not only improvements in data utility such as picture and sound, but also applications in optimal control through the network between the control apparatus of a vehicle system are attained, and improvement in railroad transport service is expected.

1 Gbit/s optical Ethernet module for railroad vehicles