

In the power systems and power transmission and distribution systems field, Toshiba is aiming to realize both stable supplies of energy and a better global environment. To meet the growing demand for energy while reducing greenhouse gases, we are continuing our efforts to develop new energy-related technologies and to supply nuclear power generation systems with no carbon dioxide emissions as well as large-capacity and high-efficient power generation and transformation equipment.

COLA Revision Issued for STP ABWR Units No. 3 and 4; TANE in Action



New office of Toshiba America Nuclear Energy (TANE), located just outside Washington DC



TANE staff



Reception in Washington DC in December 2008

Toshiba established Toshiba America Nuclear Energy (TANE) in Falls Church, VA, in January 2008 to expand nuclear business activities in the United States. TANE supplies Toshiba's advanced boiling water reactor (ABWR) and its turbine/generator (T/G) system, as well as the T/G system for the AP1000™ pressurized water reactor (PWR).

TANE has hired U.S. staff and established its business process and licensing support organization. The TANE licensing team supported the South Texas Project (STP) in issuing the COLA revision for STP Units No. 3 and 4 (STP-3/4) in September 2008. The company also held a reception in Washington DC in December 2008, inviting U.S. nuclear industry participants to introduce Toshiba/Westinghouse Electric Company (Westinghouse) nuclear activities in the U.S.

TANE is performing the system design, layout design, and equipment design of STP-3/4. It has also started ordering the long-lead materials and formulating the construction schedule for this project, and will accelerate engineering work for both STP-3/4 and the T/G system of the AP1000™.

COLA: Combined Construction and Operating License Applications

Successful Completion of Steam Turbine Renovation



Assembly work for high-efficiency turbine

The current trend in the nuclear power industry is for nuclear power plant operators to seek ways to extend the lifetime of their plants. This often means that older steam turbines need to be replaced.

Toshiba's renovation technology enables a power plant to increase the electricity output of the generators without the need to increase the thermal output of the reactor. The replacement plan is designed to minimize the effect on other related components, as it requires almost no modification of the turbine casing and no changes to the steam supply system. This reuse of components also minimizes the radioactive waste produced in performing the replacement.

The increase in turbine performance is accomplished by optimizing the shape of the blades and the three-dimensional (3D) shape of steam passage. Our turbine renovation technology has been successfully implemented in a boiling water reactor (BWR) in Japan with a net result of about 5% increase in electricity output.

With such a significant increase in sellable electric power, we are planning to recommend this turbine renovation technology to our clients worldwide.

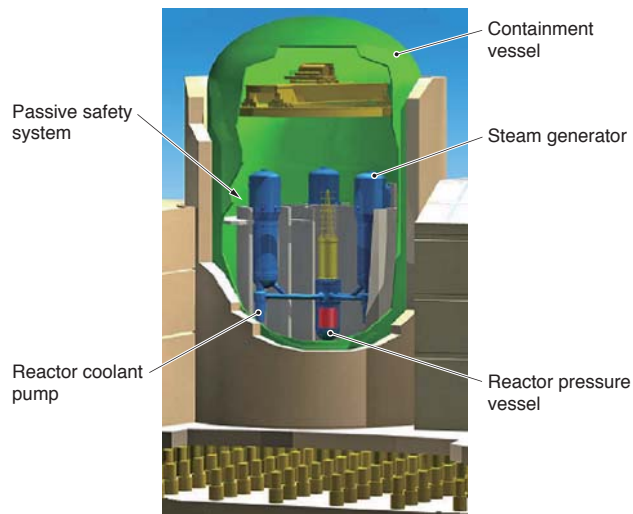
Development of Next-Generation Light Water Reactors (BWR and PWR)

Toshiba is tackling the development of next-generation light water reactors (NGLWRs), encompassing both the BWR and the PWR, in order to contribute to stable energy supplies and the prevention of global warming by cutting emissions of harmful greenhouse gases.

Toshiba is a leader in BWR technology and achieved a world-first with the completion and commissioning of the ABWR. Westinghouse, the pioneer in nuclear energy, developed a new industry standard with the AP1000™ PWR, which incorporates passive safety features. The combination of Toshiba and Westinghouse will create international-standard NGLWRs as a result of the synergies of BWR and PWR technologies.

These NGLWRs will provide a very high level of safety and economic competitiveness by utilizing natural forces such as gravity and natural circulation with passive safety systems. In addition, the fuel and core designs will be optimized for a 24-month fuel cycle, achieving a significant improvement in fuel cycle costs. The reactor and turbine designs will also be capable of achieving a significant improvement in overall plant efficiency.

Our goal is the development of NGLWRs that are applicable to various site conditions and country-specific regulations, such as aseismic requirements in Japan and requirements for severe accidents in Europe.



Outline of Toshiba next-generation PWR

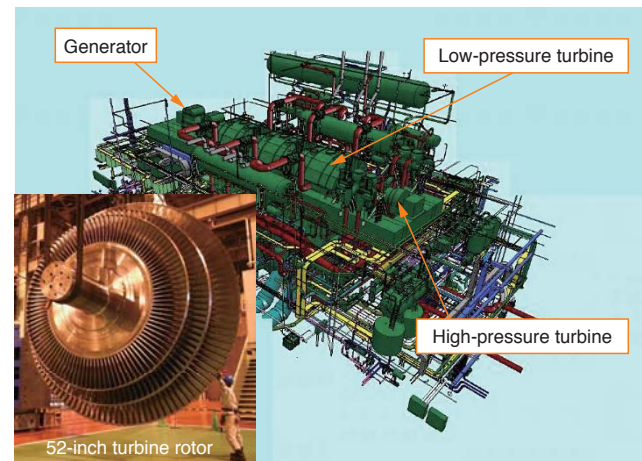
Design Work Completed for Toshiba's Turbines for AP1000™ PWRs

Westinghouse recently received contracts for six AP1000™ PWRs in the United States that will use Toshiba's steam turbine and electric generator technology. High-performance turbines with a 52-inch last-stage blade design are used for the AP1000™ that can effectively convert steam power into rotation energy using an optimized 3D shape. This blade design also has verified design integrity taking both vibration characteristics and blade stiffness into consideration.

Toshiba has designed the turbine to ensure close conformity with the nuclear island design by dispatching resident engineers to the U.S. This approach has also allowed us to better address the concerns of the end users.

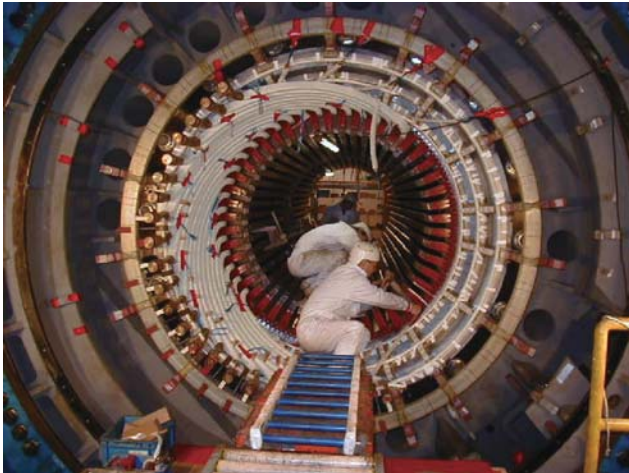
Currently, drawings and specifications for the basic engineering, such as the system specifications, system design calculations, and piping and instrumentation diagrams, are nearing finalization.

Plant physical design, such as the plant general arrangements, piping and support layout, and preliminary stress analysis, is in progress.



Bird's-eye view of turbine, generator, and auxiliaries layout and photo of 52-inch turbine rotor of AP1000™ PWR

Generator Maintenance Contract for French Nuclear Power Station



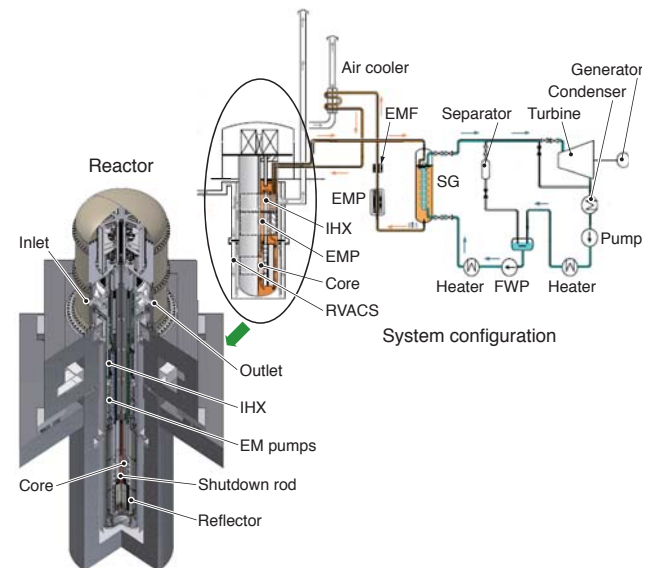
Stator coil rewinding for turbogenerator

The Toshiba-Westinghouse consortium has been awarded a long-term contract for turbogenerator stator coil rewinding for the Électricité de France (EDF) nuclear power station, covering 10 units or more during the coming 10 years. Toshiba will manufacture durable stator coils with advanced brazing technology.

Toshiba was awarded the joint work with Westinghouse, which has site administration capability at the French nuclear site. We will work with Westinghouse to provide higher plant availability, and are planning further deployment of generator maintenance service business to other utilities.

Development of 4S Small Fast Reactor

Toshiba and the Central Research Institute of Electric Power Industry (CRIEPI) have been developing a small, liquid-sodium-cooled fast reactor with inherent safety and excellent nuclear nonproliferation characteristics named 4S (Super-Safe, Small and Simple), which can generate electric power of 10 MW to 50 MW (thermal power 30 MW to 135 MW) without refueling for up to 30 years. Toshiba has teamed up with the CRIEPI to proceed with the pre-application review by the United States Nuclear Regulatory Commission (NRC) in cooperation with the Argonne National Laboratory and Westinghouse toward submitting the application for design approval by the NRC. Four public meetings with the NRC were completed in August 2008. Toshiba also studied the verification test program necessary for design approval submission to the NRC using the phenomena identification ranking table (PIRT) method, which has been reviewed by both U.S. and Japanese experts. We will submit the technical reports of the safety analysis and PIRT that were discussed at the public meetings to the NRC.



EM: Electromagnetic
 IHX: Intermediate heat exchanger
 EMP: Electromagnetic pump
 EMF: Electromagnetic flowmeter
 SG: Steam generator
 FWP: Feedwater pump
 RVACS: Reactor vessel auxiliary cooling system

Structure and system configuration of the 4S reactor

FPGA Technology for Next-Generation Safety-Related Instrumentation and Control System



Neutron monitor using FPGAs

Toshiba has developed the world's first fully field programmable gate array (FPGA)-based neutron monitoring system for a boiling water reactor. Through the use of FPGAs, a type of LSI, in digital signal processing, this new monitoring system has resolved long-term issues for application regarding signal drift, logic verification, and product lifecycle that exist in the conventional analog-based or CPU-based systems.

In addition, the monitor is designed in accordance with the regulatory requirements of the NRC, since it is used for the monitoring system essential for safety in a nuclear power plant. We have recently confirmed that the monitor conforms with the U.S. regulatory requirements from the results of temperature tests, humidity tests, radiation exposure tests, and electromagnetic compatibility (EMC) tests. It has been decided that the monitor will be applied to the safety-related monitoring system of currently planned plants. We are now working toward obtaining NRC approval.

LSI: Large-scale integration
CPU: Central processing unit

Japan's First Environmentally Conscious H-System™ Combined-Cycle Thermal Power Plant



Overview of Futtsu Thermal Power Station of The Tokyo Electric Power Company, Inc.

Power train of Futtsu Thermal Power Station Unit 4-1

The first H-System™ combined-cycle (C/C) power plant in Japan is under construction and commissioning at Futtsu Thermal Power Station Group 4 of The Tokyo Electric Power Company, Inc. (TEPCO).

The first unit, No. 4-1 (rated output: 507 MW), started commercial operation in July 2008. It is expected to become a main force for the next generation of C/C systems, which is characterized by high efficiency and power with a low nitrogen oxide (NOx) emission level. Group 4 consists of three units. The main contractor is General Electric Company (GE). Toshiba is taking responsibility for the design and manufacturing of the steam turbines and generators for Units 4-1 to 4-3, and for manufacturing of the gas turbine compressors for the same units under a manufacturing partnership agreement with GE. We are also responsible for the design and manufacturing of auxiliary equipment for Units 4-1 and 4-2, and for construction and commissioning of those units under a contract with TEPCO.

It is necessary for large-capacity thermal power plants to achieve reductions in fuel consumption as well as in carbon dioxide (CO₂) and NOx emissions to address environmental concerns. We believe that the H-system™ will contribute to the realization of an environmentally conscious C/C power plant.

The second unit, No. 4-2, is currently under construction.

Successful Completion of High-Efficiency Multishaft Combined-Cycle Power Plant in Malaysia



Multishaft combined-cycle power plant for the Port Dickson Rehabilitation Phase 2 Project

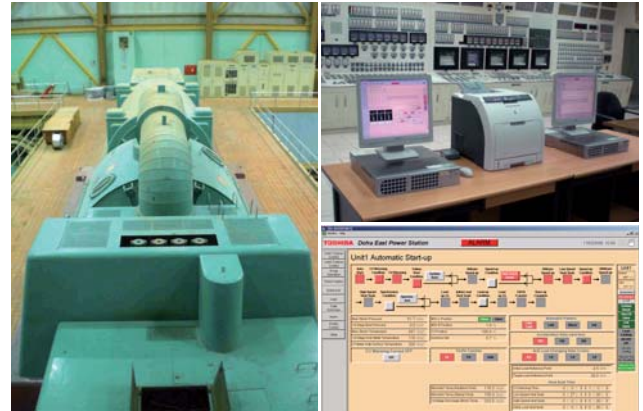
The multishaft combined-cycle power plant for the Port Dickson Rehabilitation Phase 2 Project in Malaysia was successfully completed at the end of December 2008 and has started commercial operation. This power plant, comprising two dual-fuel-capable gas turbines, two triple-pressure reheat type heat-recovery steam generators (HRSGs), one reheat type condensing steam turbine, associated balance-of-plant (BOP) equipment, and a 132 kV gas-insulated switchgear (GIS) substation, has a total gross power generation capacity of 750 MW.

Toshiba was responsible for engineering, procurement, construction, and commissioning of the power units, and also served as the contractor's technical leader of the overall project.

The gas turbines are fitted with dry low NO_x (DLN) combustors, making the plant environment-friendly. The HRSGs, steam turbines, and steam cycles without a bypass stack were designed to improve the efficiency of power generation and for quick startup. Moreover, Toshiba's state-of-the-art distributed control system provides a fully automatic plant control system envisaging single-pushbutton plant startup and operation with a minimal number of plant operating personnel.

During the design phase, emphasis was placed on achieving high reliability and availability with adequate redundancy and system optimization. The result was aptly demonstrated by successful passing of the stringent technical requirements of the Malaysian Grid Code and a successful reliability run test for 30 days continuously.

Mechanical Governor to EHC Conversion for Steam Turbines



Turbine, EHC operator station, and its display at the Doha East Power Station, Kuwait

Conversion from mechanical governor control to electrohydraulic control (EHC) is in progress for seven power generation units at the Doha East Power Station, Kuwait. The conversion has been completed for six units and they are operating satisfactorily.

This EHC conversion project has been performed together with other steam turbine generator rehabilitation tasks including the replacement of turbine blades and generator stator coils. The mechanical governors have been replaced with digital controllers and associated devices, thus realizing easier maintenance of the mechanical parts of the turbines, easier operation by screen-based procedures, and additional automatic operating functions such as automatic turbine startup and automatic generator load control.

Lifetime extension and functional improvement of the more than 30 years old turbine generators have been achieved by this conversion and other rehabilitation work. This conversion will be performed for the remaining turbine generator unit utilizing the annual maintenance period in financial year 2009.

Retrofitting of Other-OEM Steam Turbines in North America



Installation of low-pressure (LP) turbine rotor

Two projects for the retrofitting of other-OEM steam turbines in the United States have been successfully completed.

Reverse engineering using dimension measurements is essential in retrofitting other-OEM steam turbines. Dimension measurements were carried out on two 800 MW units in Pennsylvania and a highly efficient steam path based on Toshiba's latest technology was designed to fit into the existing outer shell, resulting in the retrofitting projects being awarded to Toshiba. Manufacturing and installation were implemented on schedule, and an approximately 18 MW increase in electrical output was achieved through the retrofit without an increase in fuel or steam.

The retrofitting of existing power plants as in this project greatly contributes to the reduction of CO₂ emissions and extension of a plant's life. We are focusing our attention on further proposals and the execution of similar retrofitting projects.

Other OEM: Products of an original equipment manufacturer other than our company

DCS Replacement for Shajiao B Power Station in China



Previous plant control board



DCS operator station and large screen system

A distributed control system (DCS) replacement project is in progress for the Shajiao B Power Station (2 × 350 MW) and common facilities in China. This is the first project launched by Toshiba in cooperation with Toshiba Xingyi Control System (Xian) Co., Ltd. (TXCS), which was established in August 2007.

The existing equipment for plant control and monitoring was configured with a plant control board, an electrical mimic board, a computer system, and a control system including a boiler modulating control system and a burner management control system originally supplied by another manufacturer. All of these pieces of equipment were replaced with the TOSMAP-DS™ series Toshiba DCS.

The new DCS provides the operators with stable, high-performance plant operations including fully automatic unit startup and shutdown, and also provides the engineers with powerful and dependable user support services.

The replacement work for Unit No. 1 and the common facilities was accomplished and the new DCS with D-EHC, D-AVR, and TSI successfully commenced operation at the beginning of March 2009. The new DCS for Unit No. 2 will be ready in March 2011.

D-EHC: Digital electrohydraulic control
 D-AVR: Digital automatic voltage regulator
 TSI: Turbine supervisory instrument

3×170 MW Teesta Stage V Project, India in Operation



View of Teesta Stage V Power Station

The 510 MW (3×170 MW) Teesta Stage V Project in the state of Sikkim in India has been successfully completed and has been in operation since April 2008.

This project, one of the largest hydroelectric power plants in India, represents yet another in a long line of success stories for the Toshiba Group in the international arena.

The electrical and mechanical equipment was designed, manufactured, supplied, installed, and commissioned by member companies of the Toshiba Group consisting of Toshiba, Toshiba India Private Limited (TIPL), Toshiba Plant Systems & Services Corporation (TPSC), and TPSC (India) Private Limited.

The scope of supply and ratings are as follows:

- Turbine rating: 173.5 MW-197 m-214.3 min⁻¹
- Generator rating: 208 MVA-13.8 kV-50 Hz
- Main inlet valve: Diameter 3.8 m, biplane type
- Main transformer rating: 9×13.8/420/√3 kV-70 MVA-1 Ph
- GIS: 420 kV, sulfur hexafluoride (SF₆) type
- Control system, power house equipment

The completion of the Teesta Stage V Power Station has greatly contributed to the power supply for the eastern region of India.

Completion of Runner Refurbishment Projects in Various Hydroelectric Power Stations



Chuncheon Hydroelectric Power Station, Korea

Runner refurbishment projects have been completed in four overseas and two domestic power stations, which have been reentered commercial operation.

The refurbished power stations are as follows:

- Murray 2 Power Station (157.4 MW, Unit No. 1, Australia)
- Tumut 3 Power Station (254.3 MW, Unit No. 3, Australia)
- Chuncheon Power Station (31.88 MW, Unit No. 1, Korea)
- Siguragura Power Station (73.2 MW, Unit No. 2, Indonesia)
- Totsugawa No. 2 Power Station (61.5 MW, Unit No. 1, Japan)
- Kabe Power Station (38.8 MW, Unit No. 1, Japan)

Each project has upgraded the turbine output and efficiency by replacing the runner with a newly designed one, which was developed using advanced hydraulic design technologies including the latest computational fluid dynamics (CFD).

In addition to the above projects, Unit No. 1 of the Noxon Rapids Power Station in the United States and Unit No. 1 of the Benmore Power Station in New Zealand are planned to be commissioned in 2009.

Development of Residential Fuel Cell CHP System



1 kW-class residential fuel cell CHP system

Many efforts for the research and development of fuel cells have been promoted in Japan with the expectation of reducing CO₂ emissions because of their advantages in terms of high efficiency and environmental friendliness.

Toshiba Fuel Cell Power Systems Corporation (TFCP) has been engaged in the development of residential fuel cell combined heat and power (CHP) systems since 2000. In a large-scale field demonstration test conducted as a national project from fiscal years 2005 to 2008, a total of 748 TFCP residential fuel cell systems were installed throughout Japan and their performance and reliability were verified. Efforts have continued to further upgrade performance and reduce costs, and the results obtained have been incorporated into a new model that has been commercialized in the Japanese market since June 2009. This new model is a 1 kW-class CHP system that uses city gas or liquefied petroleum gas as a fuel, and can supply electricity and hot water to a house with high efficiency (36% power generation, 86% or higher total efficiency^(*1)). The system has a learning-control program that analyzes the demand pattern and performs optimal operational control, thereby maximizing the energy-saving rate for each house.

The system is designed so as to be quiet, compact, and lightweight, with consideration given to easy installation and maintenance. Installation of the system will reduce CO₂ emissions by about 1.2 tons/year^(*2) for a standard house. We intend to contribute to the prevention of global warming by promoting the dissemination of such fuel cell systems.

(*1) The value for efficiency is based on the lower heating value (LHV) at rated power operated by city gas.

(*2) The CO₂ reduction rate depends on the demand for electricity and the thermal load.

Matrixeye™ 3D Ultrasonic Inspection System for Spot Welds



Matrixeye™ EX



Probe for spot weld inspection

Toshiba has developed the Matrixeye™ 3D ultrasonic inspection system for spot welds. The ultrasonic probe of this system has 64ch piezoelectric elements arranged in an 8×8 matrix array. This system can visualize a spot welded area three-dimensionally by the synthetic aperture focusing technique (SAFT) imaging method.

Matrixeye™ can automatically measure the maximum and minimum diameters of a welded area from the synthesized 3D image. It can also precisely detect not only blowholes but also spatters in the welded area. This image processing technology thus makes it possible to accurately evaluate the condition of spot welds in a nondestructive manner.

Matrixeye™ can be applied to spot welds on high-strength steel sheet and aluminum structures, and Japanese automobile manufacturers have recently begun using it for nondestructive inspections. With its convenience of use and high sensitivity, this system is expected to contribute to the improvement and maintenance of quality of spot welding carried out in the automotive industry worldwide.

SMES Commercialized for Compensation of Voltage Dips

Toshiba has commercialized a superconducting magnetic energy storage (SMES) system with a capacity of up to 10 MVA. SMES systems are utilized in such facilities as semiconductor or liquid crystal display (LCD) manufacturing plants for compensation of instantaneous voltage dips caused by lightning and so on.

SMES systems with a capacity of 5 MVA and 10 MVA were developed in collaboration with Chubu Electric Power Co., Inc. The system (10 MVA) was installed in a large-scale LCD plant in July 2007, and have successfully protected the power lines of the plant from instantaneous voltage dips more than 10 times since their installation.

Compared to competitive devices, the SMES system has the following advantages:

- Large electrical capacity and power sufficient to cover the critical equipment of a plant.
- Long life of the storage part, which is mainly composed of a superconducting magnet.
- Less environmental burden from waste products, because it is unnecessary to replace the storage part.

The capability of the SMES system to compensate for instantaneous voltage dips has been proven. We are now promoting the wide dissemination of this product in manufacturing plants.



Energy storage part of SMES system



Magnet of SMES system

Commencement of Commercial Operation of 400/220 kV Sweihan Grid Station in UAE



Completed building for 220 kV GIS

The Abu Dhabi Water & Electricity Authority (ADWEA) in the United Arab Emirates (UAE) is developing a 400 kV power system to improve its power system stability and reliability. As part of this, installation of a new 400 kV power system and extension of the 220 kV power system were successfully carried out at the existing 220 kV/33 kV Sweihan Grid Station by Toshiba. The Sweihan Grid Station not only connects the capital city of Abu Dhabi and the satellite city of Al Ain but also will connect to the Fujairah Grid Station (under construction by Toshiba) with a 400 kV overhead transmission line and will play an important role in the stable supply of electrical power.

In spite of the many difficulties involved in extension of the existing in-service 220 kV substation and integration and diversion of several remote end substations, etc., the new 400 kV system of the Sweihan Grid Station was eventually energized in May 2008. Subsequently, commercial operation of the 220 kV system started in February 2009. This successful outcome demonstrates the high technical level of Toshiba's substation project management and engineering activities.

This project was contracted on a full-turnkey (FTK) basis, including the civil engineering work along with the construction of buildings and provision of engineering services related to electrical and mechanical equipment for this grid station. The engineers locally employed by Toshiba Abu Dhabi greatly contributed to the success of this project.

Site Maintenance and Inspection of 400 MVA Gas-Insulated Transformer at TransGrid Haymarket Substation, Australia



Members of the M&I team



TransGrid Haymarket Substation GIT/GIR

Toshiba has supplied large numbers of gas-insulated transformers (GITs) and gas-insulated reactors (GIRs) to overseas customers. We supplied a GIT having the world's largest capacity of 330 kV-400 MVA (gas pressure: 0.43 MPa-gauge, fill gas: high-pressure type) for the TransGrid Haymarket Substation in Australia in 2003. This time, we carried out the first periodical maintenance and inspection (M&I) for this large-capacity GIT and GIR with associated training for the customer.

The overall maintenance program was originally planned so that the customer could carry out the necessary M&I work by itself in line with our maintenance criteria for the transformer main tank, water cooling system, gas blower, etc. Toshiba has supplied many large-capacity gas transformers with a high-pressure vessel to Japanese customers, and the experience thus obtained has also been extended to GITs overseas. As a result of the inspection, no gas leakage was observed at any of the connection points in accordance with the accumulated methodologies even after five years of operation. However, fouling and dust were found on pipes, radiators, fans, and pumps for the water cooling system, and these were removed and cleaned in the maintenance work. Since the customer has little experience in M&I, especially for a water cooling system, the training provided during the M&I work gave the customer valuable experience of the GIT and was highly appreciated.

Through this M&I carried out together with the customer's maintenance team, details of the procedures were prepared accompanied by photographs to create records and useful instructions for future M&I work. This M&I work is considered to be a typical case of that required for large-capacity GITs overseas.

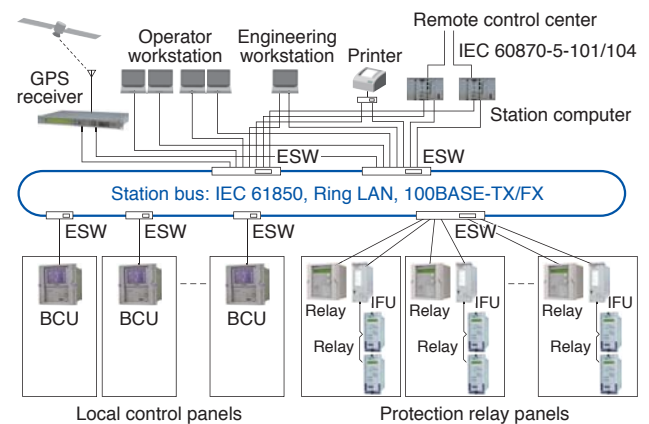
GSC1000 IEC 61850-Based Substation Automation System for Project in Abu Dhabi, UAE

Toshiba has developed the GSC1000 substation automation system (SAS) based on the IEC 61850 standard for a new 400/132/33 kV substation under construction in Abu Dhabi, UAE. The system is ready for shipment.

The SAS is widely used for the control, protection, monitoring, communication, and supervision of various types of equipment in a substation to improve the reliability of the power system. Although hard-wired control utilizing a simple communication method has been used in the past for SAS, systems employing information technology such as Ethernet LAN have recently become more common. IEC 61850 is an international standard defining protocols for communication within substations.

All devices used in the SAS such as bay control units (BCUs) and protection relays have been certified to conform with IEC 61850 by KEMA. The new SAS is equipped with all of the essential functions required for application at all voltage levels, and in addition provides advanced functions such as automatic synchronization for split power systems, power quality monitoring, and power apparatus monitoring in order to enhance the security and reliability of the power system.

IEC: International Electrotechnical Commission
KEMA: N. V. Tot Keuring Van Electrochnische Materialen (Laboratory and Research Center Arnhem Netherlands)



ESW: Ethernet switch
IFU: Interface unit

System configuration of GSC1000

Phase-Shifting Transformer Protection and Control System for TransGrid, Australia in Commercial Operation



132 kV phase-shifting transformer at Armidale Substation



Protection and control equipment for phase-shifting transformer

Toshiba supplied a phase-shifting transformer together with associated protection and control equipment for network reinforcement on the TransGrid system in Australia. The equipment has been in commercial operation since February 2009.

The phase-shifting transformer is used to control secondary current and voltage by phase shifting and voltage tap change selection. It is therefore necessary to include tap change transitions in the design of the protection and control system.

The configuration and setting coordination of the protection function is especially important in that it must not maloperate for normal in-service operation during tap transitions and must operate without delay in the case of a fault within the transformer.

The control system also features automatic control of taps, resulting in reducing operator's work.

Replacement of Control and Protection Systems in Pole 1 of Hokkaido-Honshu HVDC Link

The Hokkaido-Honshu High-Voltage Direct Current (HVDC) Link is a 600 MW bipolar system connecting the Hakodate Converter Station in Hokkaido and the Kamikita Converter Station in Honshu with a 167 km DC transmission line (including 43 km of submarine cable). Pole 1 started commercial operation in 1979 and Pole 2 in 1993. Electric Power Development Co., Ltd. developed the link.

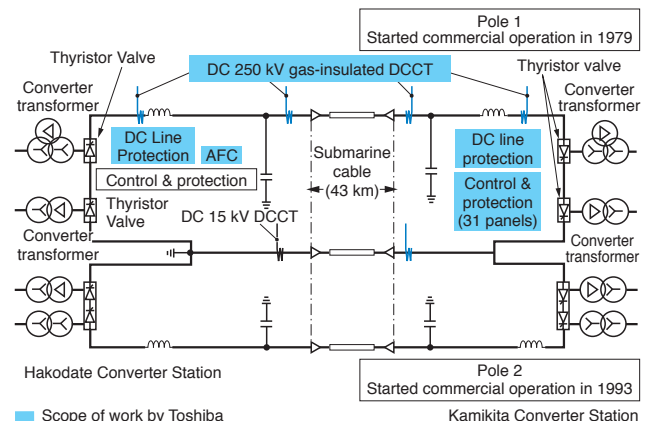
After almost 30 years of operation, the control and protection facilities of Pole 1 showed a risk of numerous problems occurring, and it was therefore determined that those facilities should be replaced. The main circuit equipment such as thyristor valves and converter transformers was to be used as before. This was the first HVDC system updating project with partial replacement carried out in Japan.

Toshiba supplied, installed, and commissioned the following equipment for this project:

- 31 control and protection panels at the Kamikita Station
- Automatic frequency control system at the Hakodate Station
- DC 250 kV gas-insulated direct-current current transformer (DCCT) at both stations
- DC line protection system at both stations

Because existing facilities were to be used as before, the field verification test period was reduced to meet the need for a short outage of around one month (usually a period of several months is required). Toshiba carried out a functional test using a Real Time Digital Simulator[®] (RTDS, Electric Power Development Co., Ltd.) for two months before installation at the site and solved many problems beforehand. The updated facilities started service in April 2008.

HVDC: High-voltage direct current



Replaced equipment in Hokkaido-Honshu HVDC Link