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Special Reports

Smart Grid Technologies to Support Future Energy Infrastructure

Highest Priority for Energy Infrastructure
TAKENAKA Shoji

Smart Grid Technologies Supporting Electric Power Infrastructure for New Era and Toshiba's Efforts
KAMITAKE Takashi
To fulfill the heightened expectations placed on smart grids following the Great East Japan Earthquake of March 11, 2011, it is necessary to develop smart grid technologies for the introduction of renewable energy sources and improvement of energy usage efficiency. The Energy and Environment Council established by the Japanese government has decided to deploy core components of smart grids such as smart meters, rechargeable batteries, renewable energies, and so on. Smart meters and demand response programs, which constitute a new electricity supply and demand scheme, have already been put into practical use in the United States and will also be evaluated in the Yokohama Smart City Project (YSCP) in Japan.
Toshiba has developed battery energy storage systems for both utility grid and home use applying its SCiB$_{TM}$ batteries in order to adjust the balance of power supply and demand. Furthermore, as renewable energies are expected to be important energy resources to ensure national energy security, we are offering various solutions including photovoltaic, solar thermal, wind, hydroelectric, and geothermal power plants utilizing our core technologies acquired through the development of electric power systems.

Trends in Standardization of Smart Grids and Toshiba's Approach
SHOBATAKE Yasuro / TANAKA Tatsuji / HAYASHI Hideki
With the aim of widely diffusing renewable energies and enhancing the efficiency of electric power transmission and distribution, smart grid systems applying information and communication technologies (ICTs) and other state-of-the-art technologies, such as distributed energy resource systems and wide area monitoring, protection, and control (WAMPAC) systems, have recently been attracting worldwide attention. As interoperability of these technologies is required in order to realize new smart grid services incorporating demand response (DR) functions, standardization to ensure interoperability is currently being promoted by Japan, Europe, the United States, and international standards organizations.
Toshiba has been actively participating in these international standardization activities and contributing to the development of international standards for smart grid systems in various areas, including communications systems and cybersecurity.

Community Energy Management System to Connect Utility Customers Using Web Service Technologies
MATSUZAWA Shigeo / YAMADA Takahiro / MIYAZAKI Kazuhiko
Demand is emerging for a community energy management system (CEMS) that can manage energy usage through community-level connections with users including houses, buildings, electric vehicles, and so on, in order to make more effective use of photovoltaic power generation, wind power generation, and other renewable energies. To establish close cooperation between the CEMS and a diverse range of utility customers, visualization of both energy consumption and the demand response (DR) function as well as the standardization of interfaces are required for the CEMS.
Toshiba has developed a CEMS that can connect utility customers using a newly developed community energy management unified interface applying global-standard Web service technologies.

BEMS Technologies Contributing to Electricity Supply and Demand Adjustment through Demand Response
MITSUMOTO Kenji / ISHIYAMA Masahiro / TOYODA Isamu
To reduce greenhouse gas emissions, there is an increasing need for energy management and improvement of the electricity consumption of buildings, particularly small- and medium-scale buildings that have not been equipped with a building energy management system (BEMS). Expectations are also rising for smart grid technologies that can maintain the balance of electricity supply and demand in electric power grids because of the tight electricity supply and demand situation caused by the Great East Japan Earthquake. BEMS with demand response (DR) functions for adjustment of electricity supply and demand have been attracting considerable attention as a solution to this issue.
Toshiba has been developing and releasing BEMS for large-scale buildings since the 1970s. We have now developed a Web service system to provide various BEMS functions for small- and medium-scale buildings as a remote monitoring service, and a BEMS function validation and evaluation environment that can simultaneously assess electricity consumption and comfort in a building under DR control.

HEMS for Optimizing Operation of New Energy Equipment Introduced in Homes
MURAI Masahiko / DOI Yusuke / TAKAGI Yasuo
New energy equipment such as photovoltaic (PV) generation systems and so on are expected to be introduced to many homes from now on. The home energy management system (HEMS), which connects these types of new energy equipment with existing home appliances via communication networks and controls each piece of equipment in cooperation with electric power systems, contributes not only to home energy conservation and carbon dioxide emissions reduction but also to optimal efficiency of operation and reduction of the social cost of electric power systems.
Toshiba has been developing functions for the HEMS corresponding to new energy equipment and has developed both an HEMS evaluation system and a DC power supply system for home use as part of its in-house integrated evaluation system for smart grids. We have also been promoting the international standardization of home appliance network technologies and utilization technologies.

Integrated Smart Grid Evaluation System
TOBA Koji / MIYAZAKI Yasuyuki / YURINO Shinji
For the development of smart grid technologies, it is necessary to verify cooperative functions between the power system network and customer systems including smart meters, home energy management systems (HEMS), and building energy management systems (BEMS).
Toshiba has developed an in-house integrated smart grid evaluation system consisting of the following equipment: (1) a distribution network simulator that offers users increased efficiency and flexibility in setting up the configuration of a power supply system and the connection of dispersed sources, storage batteries, and power loads; (2) a micro energy management system (μEMS) that can improve power supply reliability for smart grids; (3) an advanced metering infrastructure (AMI) system to realize interactive communication between customers and power supply systems; and (4) customer load simulators. This system makes it possible to evaluate the cooperative control performance of entire smart grids between the power system and customers such as HEMS and BEMS via the AMI system installed in a newly developed smart grid simulator.

AMI Evaluation System for Smart Grids
OSAKI Yoshiro / KUMAZAWA Toshimitsu / MATSUI Teruhisa
An advanced metering infrastructure (AMI) system, which is being developed based on automated meter reading (AMR) systems, is one of the core technologies for smart grids to realize interactive communication between users, including homes, office buildings, factories, and so on, and power suppliers. It will realize effective control of a whole power system through cooperative control between the users and the power suppliers, in addition to conventional control of power in the power supply system itself.
Toward the realization of the AMI system, Toshiba has constructed an AMI evaluation system in its in-house integrated smart grid evaluation system, which allows the assessment of cooperation among the micro energy management system (μEMS) that manages whole power systems and other local EMS such as home EMS (HEMS) and building EMS (BEMS), and confirmed the effectiveness of this evaluation system.

Fixed-Type Battery Energy Storage Systems to Ensure Stable Power Supplies
MONDEN Yukitaka / KUBOTA Masayuki / YAMAGISHI Masayuki
Expectations are rising for the expansion of renewable energy sources such as photovoltaic power generation and so on. However, the connection of large amounts of power generated by distributed renewable sources to an AC power network may cause anomalies, including rises in the grid voltage due to changes in the direction of power flow. A stable power supply system applying storage batteries is under consideration as a solution to this issue.
Toshiba has developed battery energy storage systems for both utility and home use for the realization of grid stabilization and load peak shifting, as well as emergency power supply during blackouts. We have confirmed the effectiveness of these systems through the in-house integrated smart grid evaluation system, as well as the adequate performance of the system for home use in the event of sudden load changes of DC-powered home appliances and during the restriction of reverse power flow through a DC power supply system.

Static Synchronous Compensator for Effective Use of Renewable Energies in Smart Grids
KUZUMAKI Atsuhiko / MOCHIKAWA Hiroshi / MURAO Takeru
In response to growing concern over environmental issues, grid-connected distributed power systems using renewable energy sources such as photovoltaic (PV) power generation have been increasingly installed in recent years. With the expansion of renewable energy penetration to grids, however, the grid voltage might deviate from the stipulated voltage.
Toshiba has developed a new static synchronous compensator (STATCOM) that makes it possible to maintain the grid voltage within the proper voltage level. The newly developed STATCOM is about half the overall size and achieves one-quarter the power loss compared with conventional products by using silicon carbide (SiC) devices with low loss and high-speed switching characteristics.

Feature Articles

High-Speed Lithography Simulation Technology to Promote Shrinkage of Semiconductor Devices
MAEDA Shimon / NOJIMA Shigeki
Simulation technologies for the lithography techniques that are used to print an image of a circuit pattern with a pitch shorter than the wavelength of light on a silicon wafer are a strong driver of the high integration and shrinkage of semiconductor devices. However, with the expanding scale and complexity of such lithography techniques in recent years, lithography simulation technologies have become increasingly important for the realization of advanced semiconductor manufacturing processes.
In order to promote and accelerate the shrinkage of semiconductor devices, Toshiba has been developing a new computational lithography simulation technology incorporating image processing techniques to overcome the tradeoff between processing time and accuracy.

Superconducting Receiving Filter for 9 GHz-Band Weather Radars Contributing to Efficient Use of Frequency Resources
KAWAGUCHI Tamio / SHIOKAWA Noritsugu / KAYANO Hiroyuki
With the increase in natural disasters caused by local torrential downpours in recent years, weather radars have become essential for speedy and precise precipitation forecasts. The number of weather radar sites in Japan is increasing, reflecting the need for the introduction of a nationwide natural disaster network. However, the frequencies that can be assigned to 9 GHz-band weather radars are becoming depleted due to the increase in the number of installations.
Toshiba has developed a high-temperature superconducting (HTS) receiving filter with steep and narrow bandwidth characteristics for 9 GHz-band weather radars, which makes it possible to allocate more channels in the 9 GHz radar band compared with conventional products and contributes to the efficient use of limited frequency resources.

Railway Station Service Equipment for "manaca" IC Card System
NAKAO Masahiro / TAKAHASHI Atsushi / YAMASHITA Yuki
A study on the introduction of integrated circuit (IC) cards for railway and bus services in the Chubu region was initiated in 2006, leading to the launching of the "manaca" IC card service in February 2011.
Toshiba participated in the development of the manaca IC card system in the specification study phase, and delivered the railway station equipment including automatic ticket gates, ticket issuing machines, and card processing machines to the Nagoya Railroad Co., Ltd. This equipment provides the following unique functions for the manaca IC card service: (1) mileage point services, (2) transit discount services, and (3) railway and bus season ticket services.

Battery-Powered Electromagnetic Flowmeter Offering New Solutions for Wide-Area Infrastructure of Water Supply
HIGUCHI Takashi / IIJIMA Takuya / IKEGAMI Soichiro
Electromagnetic flowmeters have superior features including higher accuracy compared with other types of flowmeters, as well as high reliability due to the absence of moving parts inside the measuring pipe. However, the necessity of power sources and the costs of wiring between power sources and flowmeters limit the use of electromagnetic flowmeters in the field of wide-area infrastructure systems such as water supply networks relative to rotary-type flowmeters. On the other hand, there is growing demand for accurate monitoring as a countermeasure against water leakage in water utilities, particularly in developing countries.
In response to this situation, Toshiba has developed a high-performance battery-powered electromagnetic flowmeter that offers new solutions for the wide-area infrastructure of water supply services. This flowmeter can operate for up to nine years powered by its internal battery, and achieves almost the same accuracy as mains-powered electromagnetic flowmeters.

Frontiers of Research & Development