

Featured Articles

Overseas Involvement in Smart Energy Solutions

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OVERVIEW: Full deregulation of the supply of electric power to households commences in Japan from April 2016. Countries like the UK and Germany deregulated their retail markets in the 1990s, and more than 20 US states have done likewise (this being a decision that is left up each state in the USA). The UK is also pursuing CO₂ emission reductions in the household sector, recognizing the potential for smart energy practices. This article profiles work by Hitachi in leading overseas markets that takes account of local conditions and involves collaboration with local companies and regional governments together with the adoption of common strategies, and describes the IT systems that underpin this work.

INTRODUCTION

SHARING a common cause with the New Energy and Industrial Technology Development Organization (NEDO), and in preparation for the comprehensive liberalization of the retail electricity market in Japan in April 2016, Hitachi is conducting smart energy trials in Europe and North America (where market liberalization has already taken place) that use control technologies for aggregating electric vehicles (EVs) and batteries installed in the home so that they can operate as if they are a single power plant, and use information technology (IT) for systems such as those for coordinating supply and demand that control the operation of heat pumps and other electrical appliances during periods of peak demand. Hitachi is also participating in the provision of high-added-value services for electric power distributors in North America that combine IT and operational technology (OT).

These leading overseas markets are also home to customers who are seeking to move quickly from demonstration projects to full-scale systems.

This article presents examples of Hitachi's overseas activities and describes the Intelligent Operations Suite of IT for expediting their implementation in response to diverse customer challenges and other requirements.

MARKET DEVELOPMENTS IN THE UK AND HITACHI'S ACTIVITIES

Market Developments in the UK

The UK has set a target of reducing carbon dioxide (CO₂) emissions by 34% relative to 1990 by 2020, and reducing them by 80% by 2050. This will require a major reduction in emissions by the electricity and building sectors in particular. The expectation for the electricity sector is that these reductions will be achieved through a combination of nuclear power and fossil fuel power generation with carbon capture and storage (CCS). In the building sector, the focus is on households as well as commercial facilities. The UK has a high demand for heating during winter, with space and water heating accounting for as much as 80% of household energy consumption. It is anticipated that the use of heat pumps and other electrical appliances will reduce CO₂ emissions and these will become the predominant form of heating systems in the future. The use of electrical appliances is not without problems, however. The UK is exposed to a prevailing westerly wind that can bring sudden changes in air temperature, meaning that using electric power to meet the full heating demand during peak cold periods will require a large investment in additional generation and distribution capacity and other infrastructure solely to cover this peak. It will

also increase the risk of power outages caused by the sudden loads imposed on aging distribution networks by higher peaks in the demand for electric power or greater use of renewable energy. Overcoming this requires mechanisms and technologies for improving security of supply that control the use of electric power on the supply-side and demand-side, including demand response (DR) and demand-side management (DSM).

Involvement in NEDO Demonstration Project in UK

Under contract to NEDO, a demonstration project in Greater Manchester that combines technologies from Hitachi and Daikin Industries, Ltd. is planned to run from April 2014 to February 2017. The aim of the project is to trial technologies and systems that will help the UK to become a low-carbon society, using Hitachi information and communication technology (ICT) platform and aggregation system technologies and Daikin heat pump and water heating technologies. The project involves replacing gas water heating used for heating public housing with heat pump systems and installing an aggregation system to control the individual heat pumps. Along with adjusting power use by each household, the trial is evaluating the ability to balance supply and demand for small-scale

consumers by coordinating these adjustments. It is also evaluating the potential for using aggregation to implement DR without compromising comfort by assessing the extent to which adjustments to power use affect residents, utilizing in-home heat retention together with the hot water tanks installed along with the heat pump systems (see Fig. 1).

In addition to evaluating the effectiveness of Hitachi’s ICT platform and household aggregation functions, the project also aims to extend the scope of control by the aggregation function to include large premises such as commercial or industrial facilities, and expand its application to other locations that have a similar climate to the UK and where the same model will be applicable.

A feature of Hitachi’s technology used in the project is that the ICT platform consolidates the technologies and services needed to engage in trading on the UK electricity market, combining the distributed power supply to several hundred homes into a bundle large enough to trade on the market. As an aggregation technology, it identifies which orders for the sale or purchase of electric power from aggregators dealing in electricity trading can be accepted and which are most profitable, and calculates and orders trades so that trades do not go unexecuted. It calculates the

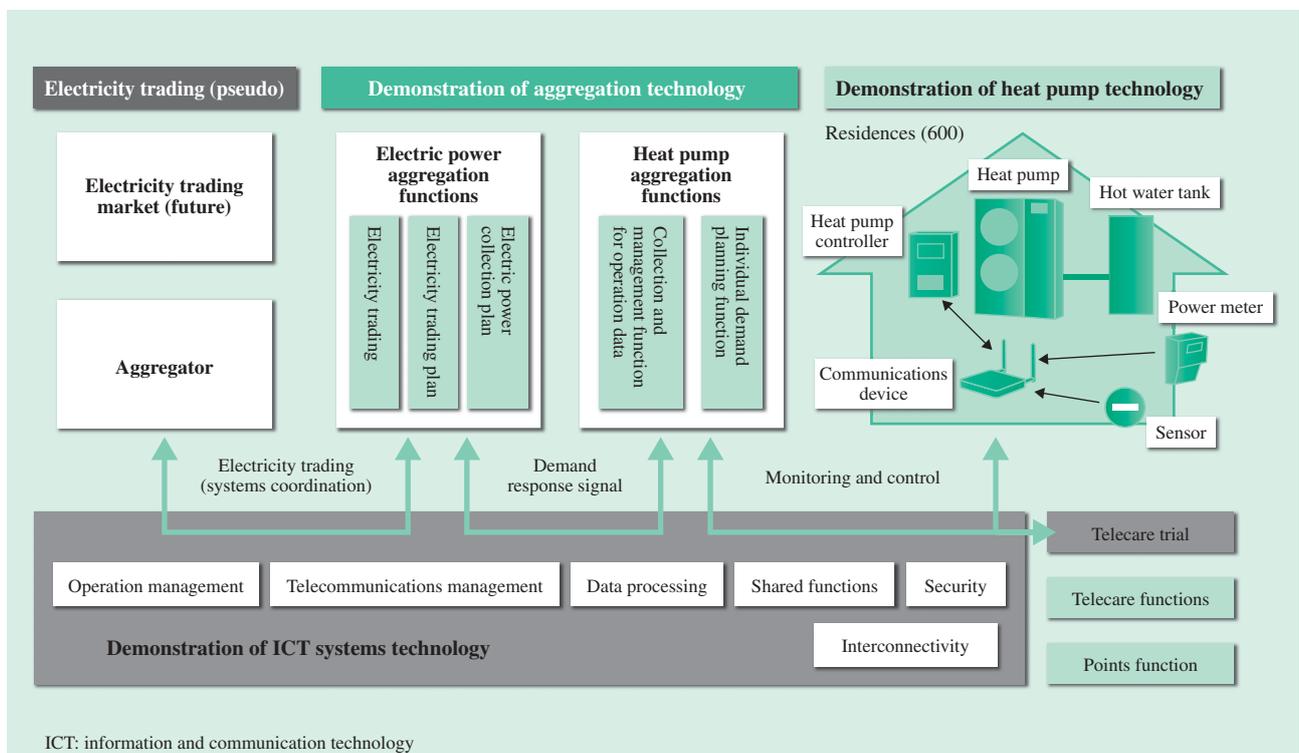


Fig. 1—Block Diagram of UK Demonstration System. The figure shows an overview of the system to be trialed in Manchester in the UK and its functions.

optimal amount by which to cut consumption based on the future price of electric power. It collects data from the electricity meters installed in each household to implement optimal DR in accordance with the current situation and past performance.

For the ICT platform, technology that is able to provide simple and secure communications with other companies' aggregation systems was reviewed and selected. Communication equipment was also given encryption capabilities in recognition of the potential for data from sensors installed in people's homes to be accessed by third parties.

MARKET DEVELOPMENTS IN THE USA AND HITACHI'S ACTIVITIES

Market Developments in the USA

Investment in power distribution infrastructure in the US market reached 20.8 billion dollars in 2013. It is also anticipated that North American utilities will continue to increase expenditures on both capital (capex) and operation and maintenance for electric power distribution.

This is because power distribution in North America experienced growth in suburban housing driven by population increases in the 1960s and 1970s, together with the installation of distribution infrastructure with a large capacity and geographical scope based on the industrial policy of the time, meaning that this extensive and high-capacity infrastructure is now reaching the end of its life. Furthermore, the maintenance staff recruited to maintain all of this distribution infrastructure when it was first installed is now approaching retirement. This distribution equipment was installed at high cost, and measures for dealing with aging infrastructure are also needed so that it can withstand natural disasters such as the frequent tornados that have been occurring recently as a result of climate change.

Meanwhile, along with interest in installing more renewable energy to diversify the energy supply, reducing CO₂ emissions, introducing EVs and other next-generation vehicles, and encouraging energy savings through more efficient use prompted by rising awareness of global environmental problems, progress is being made on the installation and operation of new distribution systems (commonly referred to as smart grids) in accordance with recent industrial promotion measures. As a result, distribution systems are becoming more diverse and there is a need to establish new maintenance and management practices.

Involvement in NEDO Demonstration Project in Maui

Under contract to NEDO, Hitachi, Ltd., Cyber Defense Institute, Inc., and Mizuho Bank, Ltd. are jointly participating in the Japan-U.S. Island Grid Project in Maui, Hawaii (JUMPSmartMaui), which runs from 2011 to the end of FY2016. Hitachi has been acting as project coordinator, building the NEDO Maui project site in collaboration with the State of Hawaii; County of Maui; Hawaiian Electric Industries, Inc.; The University of Hawaii; and American national research laboratories as well as Cyber Defense Institute and Mizuho Bank.

An EV Energy Control Center was set up at the project site to enable construction of the EV-based island smart grid with the aim of improving usage of renewable energy, and a trial of integrated energy management on the island conducted by coordinating its operation with the distributed management system (DMS) installed in the Kihei district and the energy management system (EMS) that balances supply and demand on the Maui Electric Company grid (see Fig. 2). Through this project, Hitachi is engaging in the construction and maintenance of more diverse electric power distribution systems.

The following are four technical features of Hitachi's participation in the project.

- (1) Implementation of advanced load sharing to improve usage of the large installed capacity of renewable energy
- (2) Management of electric power use by EV chargers and other home appliances to deal with the sudden fluctuations in supply and demand that are a characteristic of renewable energy
- (3) Installation of fast chargers and associated support systems to establish the infrastructure for widespread use of EVs
- (4) Cybersecurity to ensure secure system operation

Involvement in North American Power Distribution

One of the challenges for North American electric power distributors regarding the maintenance of distribution equipment installed over a wide area is that the increasing size and diversity of equipment means that a run-to-failure (RTF) policy of reactive maintenance (repairing equipment as it fails) is approaching its limit. For this reason, they are implementing measures for conducting maintenance in ways that do not impact the distribution of electric power by monitoring and managing equipment condition and performing repair or replacement pre-emptively when indicators of a

potential fault are present. Use of information and associated operation technologies is seen as having the potential to overcome challenges like this. Hitachi is already working to overcome these challenges in Japan through collaboration with Tokyo Electric Power Co., Inc., which uses advanced maintenance techniques and systems that utilize collected and analyzed data on distribution systems and equipment failures, and THE Power Grid Solution Ltd., a joint venture with Hitachi. Consultations with North American power distribution companies that focused on maintenance services like these for dealing with the aging of distribution equipment, which is the greatest challenge in North America, identified the following problems.

(1) Patrol and inspection

There were inadequate maintenance criteria, variability in the data, and inaccuracies in the collected data.

(2) Responding to outages and other faults

There was inadequate root cause analysis and traceability of data items, and inaccuracies in information on outages and other faults.

(3) Responding to tornados

The prioritization of restoration was unsystematic and lacked clarity.

These problems have resulted in cases where the identification of repeated instances of faults due to the same cause has been inadequate.

Hitachi has collated use cases that are useful for the steps from identifying to resolving workplace problems like these, and believes it is possible to combine them with decision support systems (DSSs) and other IT to establish OT that is tailored to the characteristics of particular regions. Hitachi also believes that machine learning techniques are useful for further tuning of the knowledge required for such

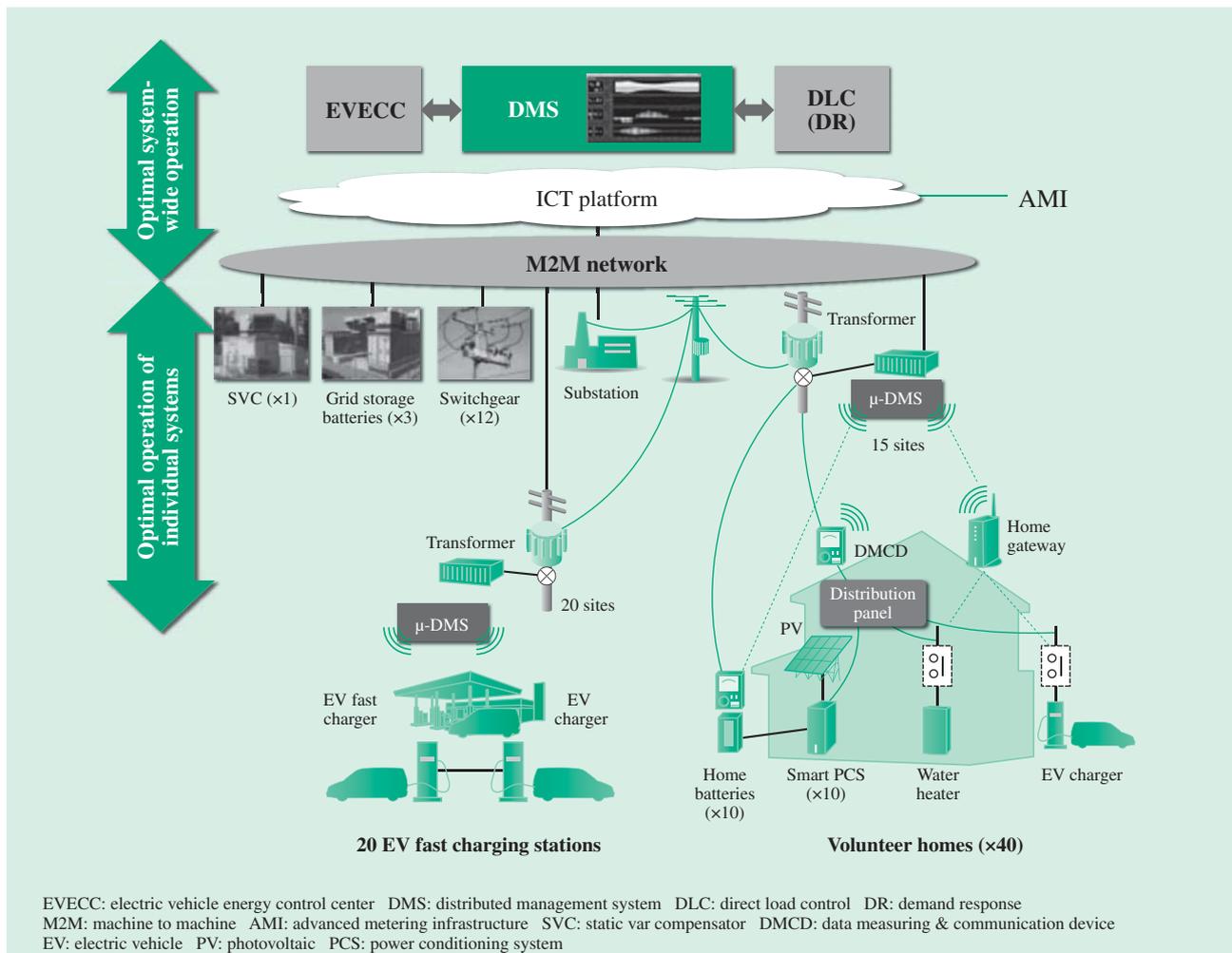


Fig. 2—Block Diagram of Demonstration System in Maui.

The trial is evaluating the ability to maintain grid stability using a tiered control architecture that combines a DMS for optimal system-wide operation with μ-DMSs for optimal operation of individual systems.

initiatives. Hitachi is currently deploying these in North America, including a consultation service that extends as far as management decision-making on measures for resolving problems, and is working on things like building smart grids and activities aimed at ensuring the secure supply of electric power.

IT SYSTEMS FOR SUPPORTING ENERGY SOLUTIONS

As noted in the above overseas examples, supplying energy solutions to customers requires both a high level of control technology for the stable operation of power systems and advanced IT for the optimal exchange of information between energy suppliers and consumers. This section presents an overview of Hitachi’s IT system technologies for energy solutions.

IT System Requirements

Hitachi has collated IT system requirements through the demonstration projects described above. The main requirements are as follows.

(1) Dealing with diversity (interoperability)

The capability is required to link together the varied equipment and diverse information and control systems belonging to energy suppliers and consumers, and to supply users with integrated services.

(2) Dealing with reliability

There is a need to implement systems that can be used safely and securely so that services are not

interrupted during emergencies and are trouble-free during normal operation, and also a high level of security so that information can be shared and used safely and securely.

(3) Dealing with ongoing growth (sustainability)

The capability is required to supply services over the long term in step with the incremental growth of systems, while also being able to maintain harmony even when additions or repairs are made to parts of the system.

(4) Dealing with system-wide optimization (total optimality)

So that the different systems used by energy users and suppliers can coexist, there is a need for mechanisms that are aimed at optimizing the overall system by having individual systems interoperate and resolve their respective issues by having a positive impact on each other.

IT Systems for Energy Solutions

Hitachi is making progress on putting together its Intelligent Operations Suite of ideal IT system “patterns” that draw on its past experience supplying IT systems to customers and its knowledge of how to use various different solutions to provide total support across the customer’s system life cycle, from planning through to design, implementation, operation, and maintenance. To satisfy the IT requirements described above, Hitachi is also working on the deployment of symbiotic autonomous decentralized system platforms

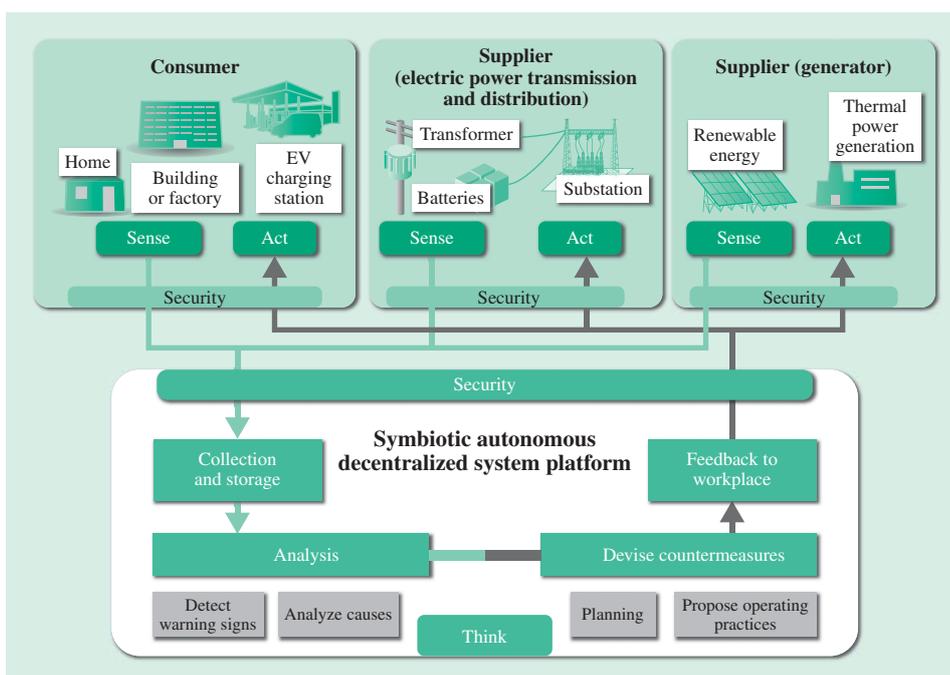


Fig. 3—Block Diagram of Symbiotic Autonomous Decentralized System Platform. The aim is to achieve system-wide optimization by linking a number of independent systems together so that they can interoperate via a hub for inter-system data sharing.

that seek to provide system-wide optimization by linking a number of independent field control systems in such a way that the systems can interoperate via a common hub for data sharing (see Fig. 3). These symbiotic autonomous decentralized system platforms collect and store different types of data from the systems, and analyze the collected data to obtain status information. They also devise ways of overcoming the challenges faced by each system and provide the results of this back to the workplace as feedback in order to optimize key performance indicators (KPIs) across all systems, not just individual systems.

By using loose coupling to enable field systems to interoperate smoothly, symbiotic autonomous decentralized system platforms provide an environment in which individual systems can coexist while still remaining independent of each other. Furthermore, combined with the security, network, and other solutions collected together in the Intelligent Operations Suite, they maintain the security of the systems, machinery, and equipment belonging to customers and enable highly reliable communication and interoperation between different systems, machinery, and equipment.

CONCLUSIONS

As noted in this article, Hitachi is helping make energy smarter through the implementation of demonstration projects and commercial systems, not only in Japan, but also in the countries of Europe and North America where energy deregulation is well-advanced. Hitachi's IT covers a wide range, of which the examples in this article have only touched on a small part. By combining this IT, the OT of partners, and other elements, Hitachi intends to continue contributing to the realization of a global low-carbon society.

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