Featured Articles

Energy Infrastructure and ICT Systems

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OVERVIEW: While nations around the world consider what constitutes the best mix of electric power sources given the adoption of renewable energy, and with both developed and emerging economies facing their respective workforce and equipment challenges, electric power infrastructure needs to remain in continuous operation with safety as its top priority. To support the energy infrastructure, Hitachi supplies solutions that improve the value of power systems to customers by making the best possible use of ICT based on highly reliable plant control technology built up over time. This involves working closely with customers to assess what is happening in the workplace and identify challenges in order to use ICT to implement total solutions for the electric power business that extend from improving the operational efficiency of equipment and optimizing maintenance to speeding up business operations.

INTRODUCTION

AS exemplified by such initiatives as Industrie 4.0 and the Industrial Internet, advances in information and communication technology (ICT) are accelerating the pace of innovation in industry. By giving access to previously unavailable information and other data and providing greater processing capacity, this has opened up extensive possibilities, including expanding the scope of optimization, sophisticated processing, the dissemination of better practices, and the integration of industries from different sectors[(1)]. This has been accompanied by dramatic growth in the number and range of stakeholders, equipment, and other factors involved in the operation and control of specific processes. In place of past operating practices based on information and data from a limited range of sources, the requirement now is for machinery, equipment, organizations, and industries to deal with information and data from a much wider scope. When this happens, it opens up the potential for innovation in ecosystems made up of traditional stakeholders[(2)].

Nations around the world are responding to the problem of global climate change by looking at what constitutes the best mix of energy sources in their electric power systems, including the adoption of renewable energy. Meanwhile, developed economies are having to deal with aging equipment and falling numbers of skilled staff, while emerging economies face the challenges of establishing infrastructure and recruiting skilled staff. Compounding these challenges, the energy infrastructure is an essential service that needs to remain in continuous operation with safety as its highest priority[(3)].

Given these circumstances, the key to the safe and reliable maintenance of operational continuity together with ongoing sound management is the use of ICT and its potential for bringing innovation to the industry.

This article covers the current state of electric power systems and presents examples of new solutions that use ICT, together with the new challenges facing the industry and the outlook for its future.

ICT SYSTEMS OFFERING NEW POSSIBILITIES FOR ENERGY EFFICIENCY

Increasing Importance of ICT

Hitachi interprets the plan, do, check, act (PDCA) cycle used to optimize operations in the electric power business as follows (see Fig. 1).

Plan: Formulate plans for equipment operation, shutdowns, maintenance, and upgrades that optimize performance at a system-wide level.

Do: Follow sound operation and maintenance practices based on the plans.

Check: Monitor equipment efficiency and problems, analyze and assess equipment data, and conduct internal audits and management reviews.

Act: Improve maintenance practices, reprioritize work, remedy equipment problems, take preventive measures, and train staff.

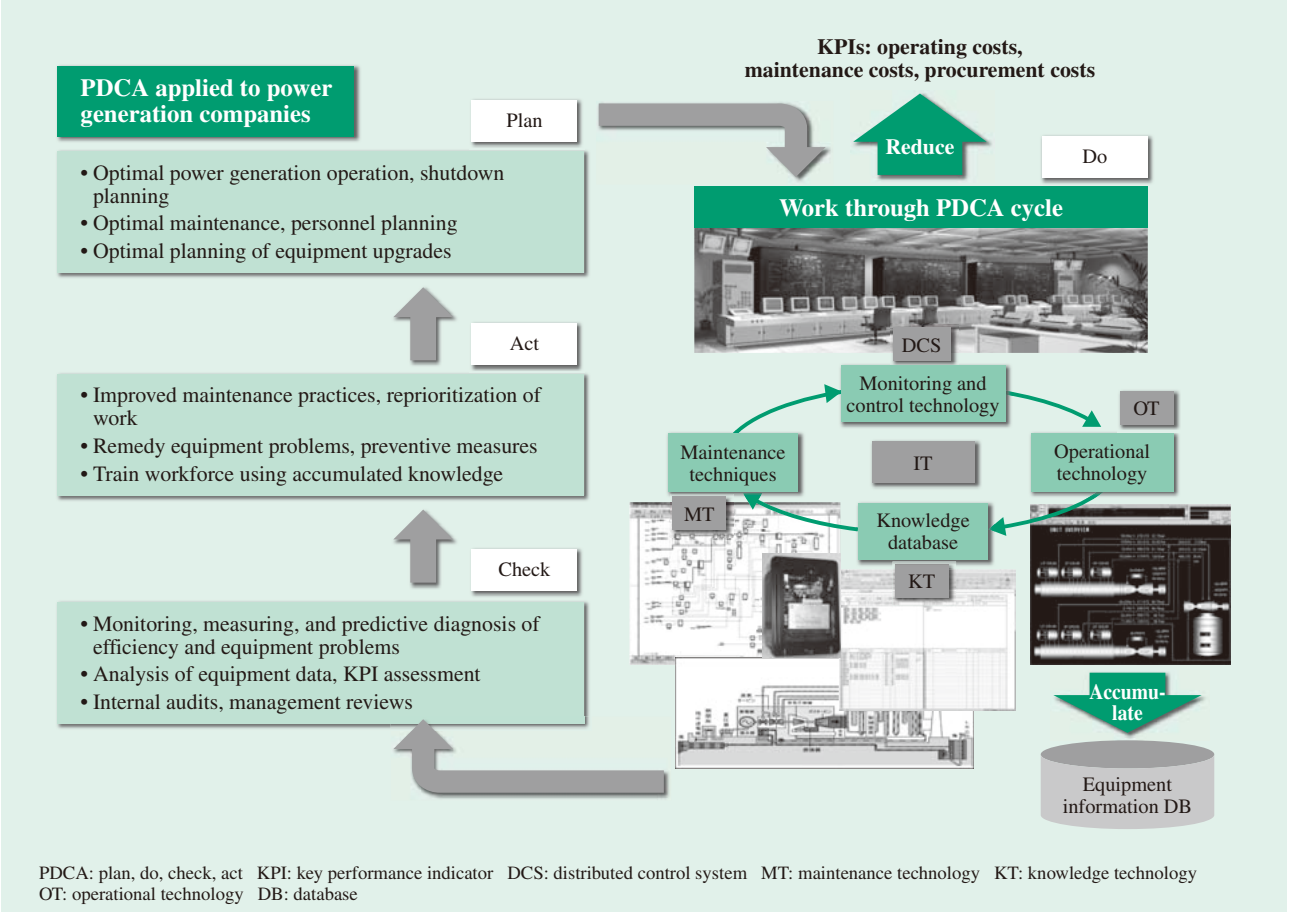

Fig. 1—PDCA for Optimal Operation of Electric Power Businesses.
Working through the PDCA cycle effectively and efficiently requires accurate decision making based on extensive operational experience and knowledge.

In the case of a power plant, for example, working through the PDCA cycle effectively and efficiently requires accurate decision making based on extensive operational experience and knowledge, while also making effective use of plant data items numbering anywhere between several hundreds and several tens of thousands together with a wide variety of information about equipment and machinery. The major challenges to achieving this include obtaining and rapidly up-skilling highly skilled staff.

In the future, use of ICT that supplements human skills will become an increasingly important factor in overcoming these challenges. In response, Hitachi has been developing new solutions that will improve the overall efficiency of the energy infrastructure through a fusion of control and ICT. The following are some notable examples.

(1) System for cost-based analysis of operational efficiency

To quantify improvements in operational efficiency at power plants, Hitachi has developed a system that takes maximum advantage of large amounts of collected sensor data and other maintenance information to analyze current costs and forecasts.

(2) Support system for optimizing operation and maintenance

Hitachi is currently developing a system that supports optimal operation by automatically determining operation patterns under different operational circumstances from plant data items that number in the tens of thousands, and assessing the benefits based on the results of simulation using physical plant models (see Fig. 2).

A feature of the system is that, by plotting information such as the results of potential fault detection and the modeling of plant data on a fault tree analysis (FTA) diagram, it presents information about maintenance, operation, and other procedures, and about the associated background factors, in a form that makes sense to operators and other staff, while also building up knowledge in the form of FTA itself.

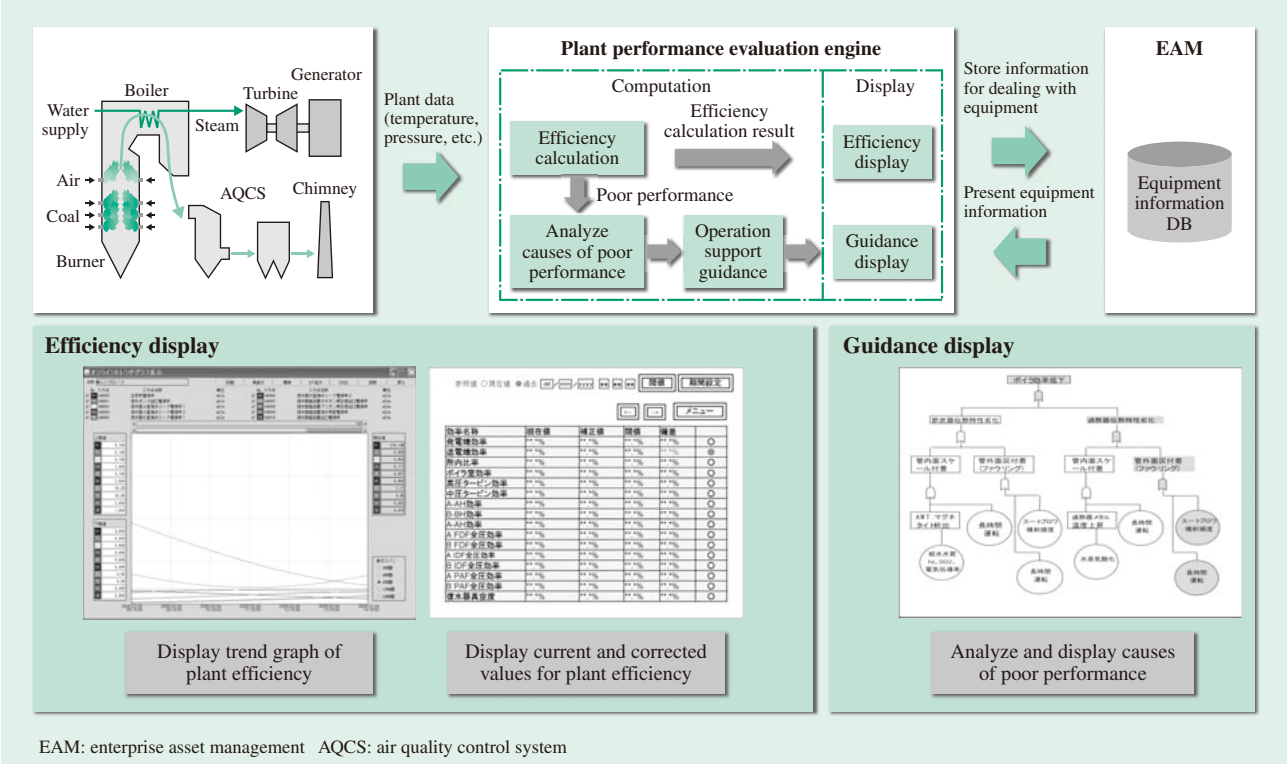

Fig. 2—Example Solution for Evaluating Plant Performance.
Hitachi is developing systems that perform realtime analyses to determine the causes of poor performance from large amounts of plant data and provide guidance on optimal operation.

(3) Visualization tool for management key performance indicators (KPIs) and risks

Hitachi is developing management improvement solutions that include a tool for improving power generation efficiency, incorporating analysis of the causes of poor power plant efficiency, improvements to boiler combustion efficiency, and reductions in the load on the environment, and a plant diagnosis tool that uses a proprietary clustering technique. These solutions are marketed together with consulting on installation.

Based on control technology and packaged as systems or services along with information technology (IT) business systems, these solutions can improve workforce skills and deliver efficient power plant operation by offering all-in-one know-how that covers everything from energy system planning to maintenance. Hitachi is currently marketing the solutions to customers in Japan and elsewhere by offering to tailor them to the specific challenges facing each customer (see Fig. 3).

Symbiotic Autonomous Decentralization with Advanced ICT

Hitachi has in the past promoted the concept called autonomous decentralization, which refers to systems that can respond rapidly to changes such as internal faults or new functions[4]. Systems that adopt autonomous decentralization can establish relationships between themselves autonomously through the hierarchical addition or removal of autonomous components whenever a fault occurs or a new feature is added. This makes the overall system capable of rapid and ongoing expansion[5].

In the case of systems that support social infrastructure, Hitachi believes that the following ICT elements are required for symbiotic autonomous decentralized systems that incorporate ICT while still following the autonomous decentralization concept.

(1) ICT for system-wide connectivity

This means serving as a platform for the exchange of information and data. This interconnects information systems belonging to a large number of stakeholders, collecting information and data from the individual systems and providing information and data from the platform to them.

(2) ICT for system-wide coordination and optimization

This relates to the overall operation of social infrastructure with consideration for its system-wide efficiency. Explicit instances of this sort of ICT can serve as optimization or management centers, or it

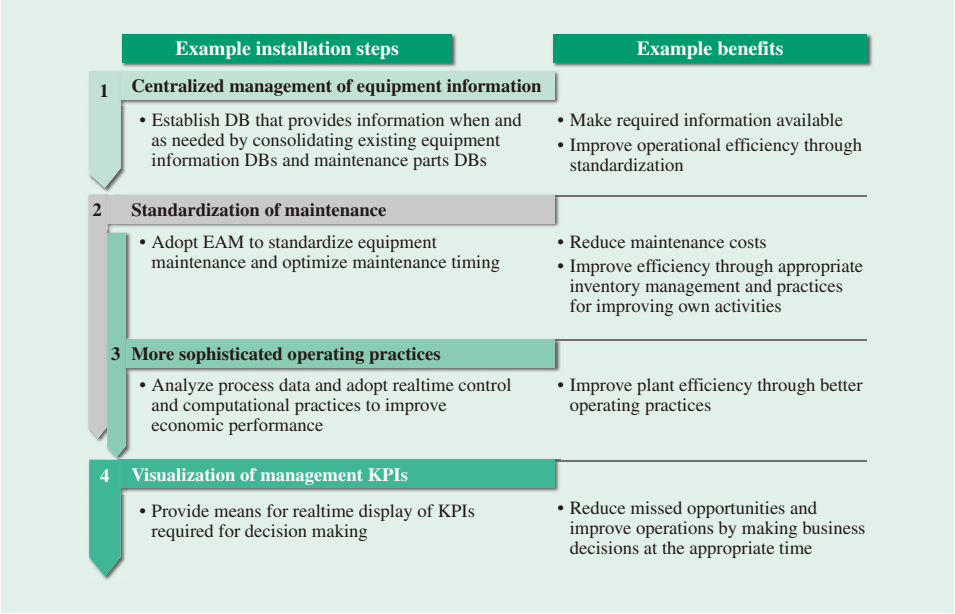

Fig. 3—Example Installation of Solution for Working Closely with Customers.
Hitachi is consulting with customers about their specific challenges and, based on a common understanding of their current situations, is marketing solutions that suit their budgets and the issues they face.

can operate implicitly whereby matters are handled through individual autonomous decision making. In the latter case, some form of mechanism is required to guide these decisions, such as a formal system, market rules, or business model.

(3) ICT for individual businesses

This element of ICT integrates with cooperating fields (shared access platforms) to supply or retrieve information and data in these cooperating fields.

(4) ICT associated with operations at individual businesses

This ICT element includes functions for interoperating with other businesses through these businesses making their own autonomous decisions, and functions for businesses to make optimal use of their own resources.

Along with serving as a platform for the electric power business, the application of symbiotic autonomous decentralized systems in the energy infrastructure is also becoming a core technology that will make a major contribution to the development of this business.

For example, by providing a capability for integrated management by sharing the results of efficiency analyses conducted for individual power plants across a number of such plants at different locations, rather than limiting them to single plants, or by providing a capability for the organic combination of management information on such things as fuel markets, consumers, or the redistribution of electric power, which have not been managed at power plants in the past, and simulating business scenarios in cyberspace, it is possible to improve value to customers in ways not possible in the past by adopting autonomous decentralization over a wide area (see Fig. 4).

Hitachi has built up capabilities in the control field for coordinating and maintaining high system reliability, and for resolving operational problems. The aim is to combine these with ICT to supply systems or services that help solve operational problems while maintaining close relationships with customers to

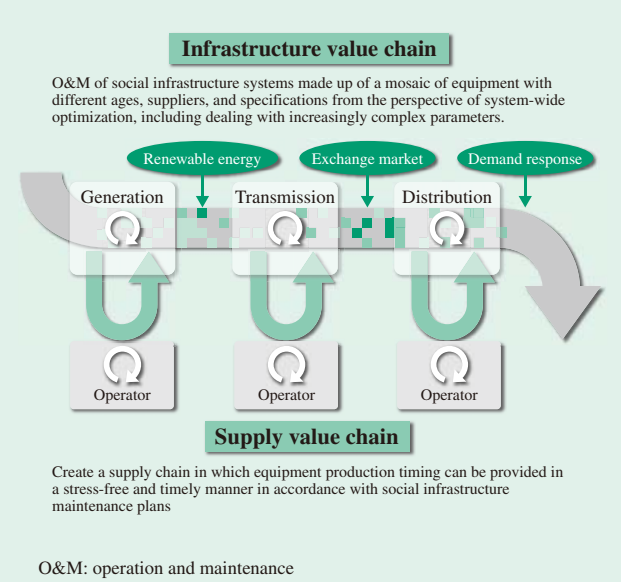

Fig. 4—Use of Symbiotic Autonomous Decentralized Systems in Energy Infrastructure.
The aim is to increase value to customers by adopting autonomous decentralization over a wide area.

deal with management challenges such as delivering best practices in a timely manner or making decisions (choosing between tradeoffs) in a variety of different situations that in the past have been difficult or time-consuming due to uncertain information.

USE OF OODA LOOP TO ENHANCE SECURITY

In addition to compliance with international and industry standards, it is important for new electric power businesses in particular to implement required security measures, and to determine the level of security in accordance with the importance (safety or extent of damage) of the equipment concerned.

The electric power business requires both physical security measures that counter the security threats that arise from the installation of machinery and all forms of electrical and control equipment, such as power plants and substations; and cybersecurity measures that counter threats to information and control systems that use ICT. Furthermore, because growth in the sophistication and scope of services means that they now have an influence on the operation and management of power generation, transmission and distribution, and retailing, there is also a need for measures to deal with an even wider range of security threats. Due to the use of ICT practices, it is expected that threats like these will have impacts that occur quickly and over a wide range, and that they can affect all aspects of the business.

To repel the sophisticated cyber threats that now exist, rather than only providing adequate security functions during the development phase, security measures for the operational phase are growing in importance. In the operational phase, the security of a system is assessed by collecting and analyzing data from various different points within the system with the aim of maintaining the security features incorporated during development. As a result, problems that arise are detected and dealt with quickly. That is, in addition to the PDCA cycle that covers activities from planning to improvements and repair, quick and accurate decision making together with faster and stronger security measures can be achieved through use of the observe, orient, decide, act (OODA) loop[6, 7].

CONCLUSIONS

While this article has presented examples from the energy infrastructure, all social infrastructure systems require the same sort of sustainable systems in the sense of being able to expand and grow in stages. Sustainability is achieved by natural world systems that go through a repeated process of construction and decay, followed by regeneration.

To achieve sustainable growth of the social infrastructure, Hitachi ICT systems seek not only to provide appropriate operation, but also to establish a cycle in which reinvestment in the social infrastructure is facilitated by supporting investment decisions and enabling appropriate cost recovery. Hitachi intends to provide sustainability in ways that make economic sense throughout social infrastructure systems.

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