Actions for Realizing Next-generation Smart Cities
—Working both to Protect Global Environment and Achieve Prosperous Urban Lifestyles that are Secure and Convenient—

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OVERVIEW: Successfully combining protection of the global environment with prosperous urban lifestyles that are secure and convenient is an important factor in ensuring the sustainability of cities. The social infrastructure that supports such a city is required not only to establish robust safety and security, it also needs to satisfy criteria such as enhancing urban value by overall optimization and reduction of total cost. To achieve this, parts of the social infrastructure like power, transport, and water which have been optimized independently in the past need to be comprehensively redesigned based on considerations such as environmental performance, customer service level, and operation and maintenance costs. This is one of the prerequisites for achieving what Hitachi calls "next-generation smart cities."

INTRODUCTION

THE human race has evolved by adapting to numerous environmental changes and, in particular, the rapid technological innovation that has occurred since the industrial revolution has brought us to our current prosperity. However, the growing severity of global-scale problems of climate change, resources, energy, and food leads us to reexamine what we mean by

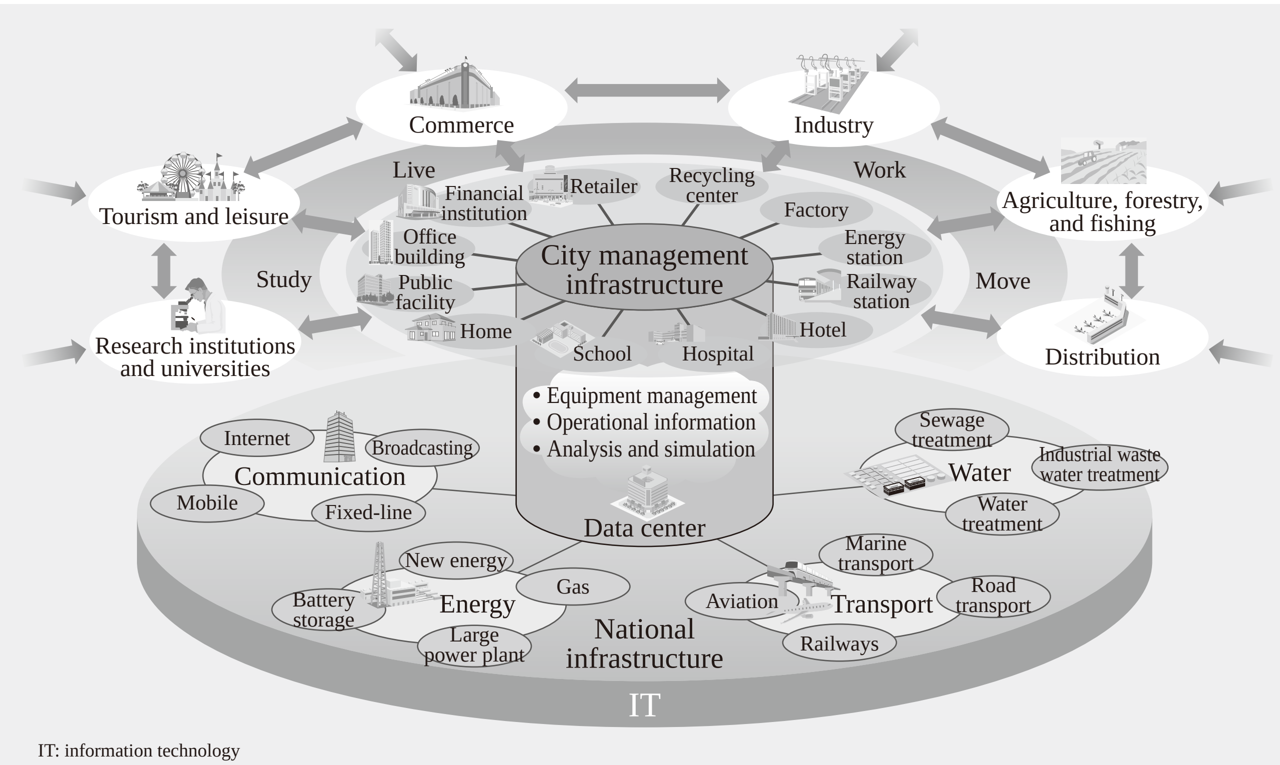

Fig. 1—Structure of Next-generation Smart City.
The city has a cluster-based structure in which IT is used to link the social infrastructure together with various everyday services so that infrastructure systems can continue to operate flexibly and respond autonomously to situations such as supply shortages while also achieving sustained growth in a way that balances concern for the environment with citizens' security and comfort.

"prosperity." Also, safety and peace of mind broke down to a certain extent when the Great East Japan Earthquake struck eastern Japan on March 11, 2011. Hitachi has taken this seriously and reinforced its resolve that it needs to work toward restoring safety and security while also doing everything in its power to help affected areas recover and rebuild.

This article explains what Hitachi means by "next-generation smart cities" and what it is doing to make these a reality.

WHAT HITACHI MEANS BY NEXT-GENERATION CITIES

The many challenges faced by the human race include the severe effects of global warming, depletion of energy and other resources, rapid population growth, aging populations with a declining birth rate, and urbanization. Further, these problems do not exist independently of one another but are closely interlinked meaning that we need to find solutions that incorporate measures that move us closer to a low-carbon society that minimizes global warming.

Up until now, people have sought to make the things around us more convenient and built a prosperous way of life that utilizes a range of different types of energy. As we steer ourselves toward a low carbon society, there is no doubt we would find it extremely difficult to sacrifice our prosperous way of life and abandon the civilization we have built up over time. What is recognized as being needed is that we should seek the successful combination of environmental protection with economic progress by balancing protection of the global environment with prosperous urban lifestyles that are safe, secure, and convenient. In other words, to achieve this by maintaining an ideal relationship between people and the global environment.

STRUCTURE OF NEXT-GENERATION CITIES

The primary elements that make up a city are its homes, offices, hotels, factories, and schools, while commercial activity includes industry, commerce, ports, airports, research institutions and universities, agriculture, forestry, and fishing. Hitachi's idea of a "next-generation smart city" is one in which these primary elements combine with commercial activity in accordance with distinctive local characteristics to form a cluster structure where these components interlink both physically and functionally, with the infrastructure of city management playing a central role.

This involves consolidating common functions shared by different elements as well as the logical unification of information. If urban development can be done in a way that adds elements characteristic of the combination of these individual functions, it results in next-generation cities that facilitate progressive functional enhancement and improvement. On the other hand, in the event of some functions being lost in a disaster or other emergency, the damage can be contained and normality restored quickly by changing the way in which these interact. Examples of this include control of supply and also demand prioritization in the event of an electricity shortage.

Hitachi is seeking to create "next-generation smart cities" by integrating IT (information technology) into existing control technologies based around the city management infrastructure systems that form the foundations of these next-generation cities (see Fig. 1). The following section gives an overview of city management infrastructure.

City Management Infrastructure

Consider the situations in which this infrastructure is used. For example, feed-in tariffs offering a guaranteed purchase price represent one approach to introducing renewable energy to achieve a low-carbon society. It is anticipated that such a policy would accelerate the integration of renewable energy sources into electricity distribution networks[*1]. However, being dependent on the natural environment means that the output of renewable energy is variable and not necessarily available when demand is high. Further, there are many systemic and technical issues with directly controlling output from the supply-side. Accordingly, it is recognized that, if large amounts of renewable energy are to be connected to distribution networks, the effect on the core electricity grid as well as on these distribution networks will need to be considered.

In a smart city, it is possible to buffer the fluctuating output of local renewable energy sources and minimize their impact on the core electricity grid by sharing the information output by regionally located DER (distributed energy resource) monitoring and control systems based on local weather information to manage demand within the region through measures such as adjusting the heating times of domestic water heaters or encouraging the charging of EVs (electric vehicles) and PHEVs (plug-in hybrid EVs).

*1 The operation of power generation equipment connected to power company transmission lines or distribution lines. Power sources such as household photovoltaic power generation systems are typically connected to low-voltage distribution lines whereas wind, biomass, and other similar power generation systems are connected to high-voltage transmission lines.

Similarly, it is also possible to maintain city services at a reduced level in the event of a fall in the supply of power from the core electricity grid due to a natural disaster or other emergency by controlling demand based on the prioritization of city functions. This allows everyday life to continue with a degree of safety and security while accepting a lower level of service in order to share with other regions the burden of coping with the supply shortage.

This approach is supported by the concept of a CEMS (community energy management system) platform and a city management infrastructure system is the result of extending this concept to a large number of different applications. Such a system can be used to balance supply and demand through a variety of effects by integrating many different systems for both users and the service providers who form the foundations of society.

Fig. 2 shows a specific example consisting of a CEMS platform that deals primarily with electric power. The systems connected to the CEMS include the power company's EMS (energy management system), regional DER monitoring and control systems (DER controllers), consumer HEMSs (home EMSs), FEMSs (factory EMSs), BEMSs (building EMSs), EV charging systems, and other service provider systems. The EMSs and EV charging systems operated by consumers are connected via HEMS center, BEMS center, EV charging center, and other similar systems. The HEMSs and BEMSs also monitor and control photovoltaic power generation systems installed on homes or offices.

In other areas such as transport, the key to achieving smart transport systems is a mechanism that balances supply and demand in which, rather than being demand-driven, demand is managed in accordance with limitations on capacity and other supply constraints by utilizing IT-based systems such as satnav and EV-based green mobility. The same applies to water resources where advanced water management IT systems for using rain water, recycled water, and other water sources are important.

Tasks that utilize these IT systems include information management, data analysis, and planning. Rather than performing these independently of each other, what is desirable from the perspective

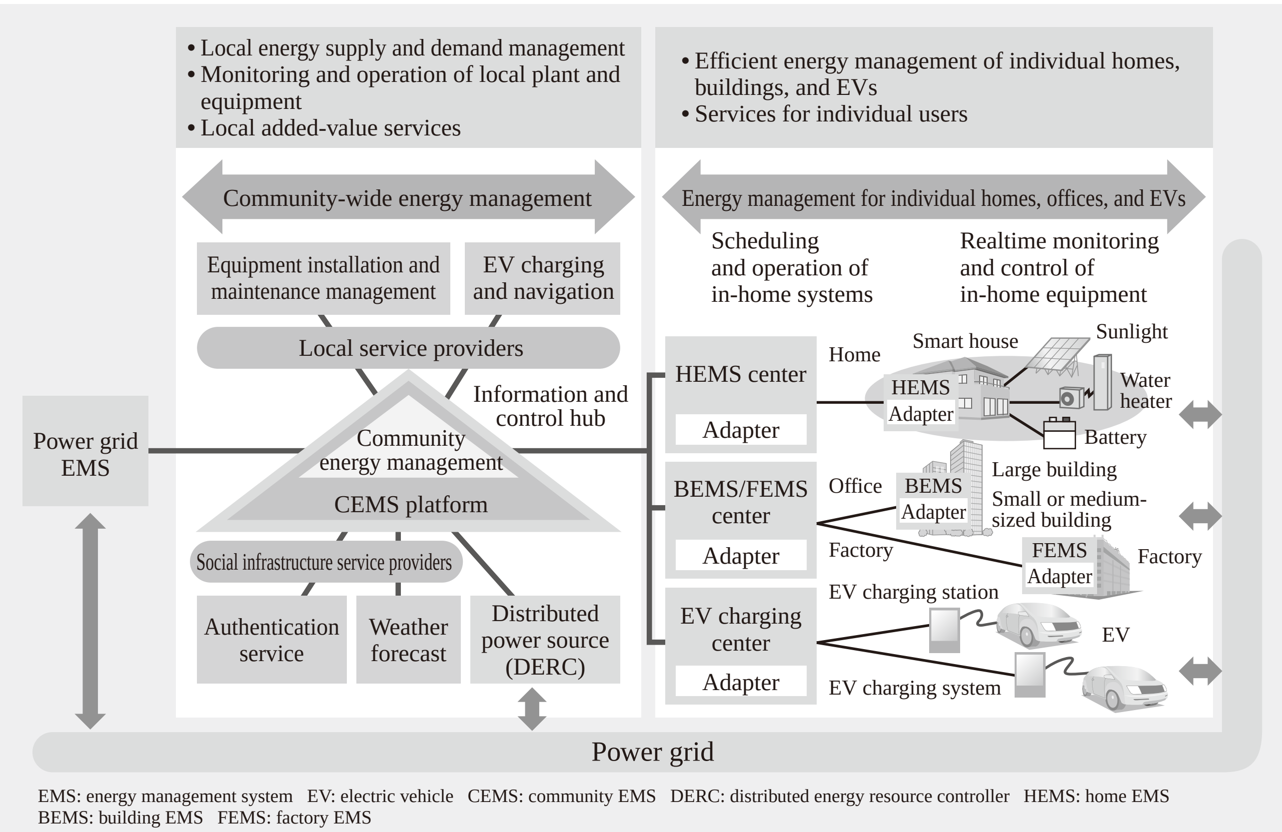

Fig. 2—Overview of CEMS Platform.
The community energy management system platform connects the power grid EMS to the consumer EMSs (home, building, EV charging station, etc.) to allow balancing of supply and demand.

of efficiency is to have a common platform for providing these functions. Also, Hitachi believes that a core mechanism in the form of a city management infrastructure system that works by incorporating functions for coordinating across different fields is an effective approach to building “next-generation smart cities.”

The various IT systems that support social infrastructure must also be capable of flexible expansion, upgrade, and reorganization to suit the development and other characteristics of the city. For social infrastructure like energy, water, and transport, in addition to each part of the infrastructure being flexible and expandable on its own, it is also important that the overall infrastructure be able to grow, change, develop, and become more sophisticated as an interlinked system. Accordingly, it is essential that social infrastructure systems, including city management infrastructure systems, evolve along with the growth and development of the city.

Features of City Management Systems

City management infrastructure systems only become effective for tasks like information processing, analysis, and planning when they can acquire data from the “real world” (control systems) and are ultimately put to work in ways that have an effect on the real world. That is, what is required to solve the numerous problems that cities face and create a “next-generation smart city” is a city-wide optimization system that fuses information and control systems.

What is important here is a recognition of the differences between the IT used in control systems and information systems. Because control systems are designed for safety, reliability, and realtime performance to operate physical equipment accurately and safely and are intended to remain in service for decades or more, most of them have a vertically integrated and overlapping system structure.

In the case of information systems, on the other hand, rapid advances are being made in improving the speed and volume of data processing to handle the explosive growth in information flowing from the Internet and mobile networks in particular. Many information systems work on the “best effort” principle and are adopting horizontally distributed open designs to cope with the steady stream of new services appearing.

Although they both require 24-hour operation, in contrast to information systems that perform transaction processing in which data may under no circumstances be lost, the emphasis with control systems is on fail-safe operation and ensuring real-world safety which means they must under no circumstances cause a major accident, and if something happens they should shut down the equipment being controlled so that the safety of people and society is protected. The difference also extends to how realtime performance is treated, with control systems emphasizing “hard realtime performance” which guarantees that processing will always complete within the allocated time whereas information systems are typically designed with an emphasis on throughput and other measures of average execution time.

Because of these different system requirements, the evolution of the information technologies used in information and control systems has followed very different paths. In the future, Hitachi believes it will be necessary to treat an entire city as a single social infrastructure system by “fusing information and control” such that these two different types of IT system work much more closely together than they have in the past and to achieve city-wide optimization in response to the various issues faced by the city.

However, it remains unclear who will bear the cost of this city-wide optimization and who will manage the process. Meanwhile, action on reducing carbon emissions will not wait until the answers to these questions become clear and it is necessary to investigate potential operational models in parallel with the implementation of technical measures. Further, in addition to subsidies that support the installation of such systems like those currently available, what is also in prospect is the establishment of methods that utilize pricing mechanisms through new policies such as carbon taxes or resource taxes[*2].

ACTIONS FOR CREATING SMART CITIES

Action by Hitachi can be divided into those actions that deal with smart cities directly and action on IT that will grow in smart cities. This section describes the directions being taken by Hitachi to help make smart cities a reality, and provides actual examples.

Action on Smart Cities

Hitachi’s activities that deal with smart cities directly can be broadly divided into three parts.

The first involves packaging the advanced infrastructure of environmentally progressive

*2 A taxation method that boosts the relative value of iron produced from scrap obtained from the collection of home appliances and similar products by taxing the production of pig iron.

Japan and its global and horizontal deployment in collaboration with local partners. This is not undertaken by Hitachi on its own but through the formation of consortiums of companies with strengths in the various different elements that make up the package and is carried out in a comprehensive way extending from infrastructure development planning through to operation and maintenance services.

The second category is those activities aimed at expanding Hitachi's service business, including operation and maintenance services, with involvement from the concept-stage consulting and planning work by growing its PPP (public private partnership)*3 business. This approach supports urban development by undertaking everything from investment in infrastructure through to operation and maintenance in cases when sufficient capital cannot be raised for investment in the infrastructure and other costs associated with the creation of smart cities.

Finally, there are activities that draw on Hitachi's strengths to take a developmental approach to utilizing and supplying a core of existing products that have already built up an extensive record of success in Hitachi's social infrastructure business aiming for realization of smart cities. While this approach is positioned as a way of expanding uses for existing commercial resources, rather than just supplying equipment, it offers proposals based around how to solve problems from the customer's perspective.

Hitachi sees these activities not as mutually exclusive but rather as approaches that can be combined as required. Hitachi is also working on validating the technology through individual demonstrations described later in this article as well as testing it in the form of models.

Action on IT

Companies in the past have installed their own IT equipment such as server and storage systems and incorporated IT into their businesses by operating these systems at each company workplace. Unfortunately, system administration is becoming progressively more complicated. In addition to connecting any number of sensors located all across the city and processing the huge volumes of data, the city management infrastructure for smart cities also requires progress on improving the environmental performance of the IT equipment itself and on ensuring compliance with various regulations, security measures, and business continuity, including disaster preparedness.

Further, because it is anticipated that the number of devices installed in data centers will grow and the density with which they are housed will increase, also needed will be the supply of products such as IT equipment as well as air conditioning and other utilities whose efficiencies are improved, and also engineering and other services that support the effective design and operation of this equipment.

To resolve these issues, Hitachi has accelerated progress on the technologies and products it has been developing through its data center energy efficiency improvement project which has been running since 2007 by establishing the Supervisory Office for Business Coordination, a division to manage the fusion of information, power, and industrial systems in April 2009. Hitachi is working together as a group to expand its environmentally conscious data centers, targeting various regions including Europe and China as well as North America and Asia.

Case Study of Smart City Trial

At Rokkasho Village in Aomori Prefecture, Hitachi is participating in a household-based smart grid trial using the world's first wind farm to incorporate large-scale battery storage. The aims are to test efficient energy use and help realize a low-carbon society. The functions being demonstrated include energy management for the entire area covered by the project and the balancing of demand and supply using a natural energy source.

EVs are essential to reducing carbon emissions and another example of action by Hitachi is a project that entered service in Okinawa February 2011. This involves the use of EVs as tourist rental cars and the plan is to install about 50 charging units for these vehicles around the main island of Okinawa over the next three years. It is anticipated that the EVs will be sold on to local residents after they end their rental lives and the aim is to install charging infrastructure all around the main island of Okinawa and establish a privately run Okinawan model for the introduction of EVs that is unlike any found elsewhere.

Hitachi's role in the project is to supply an EV charging management solution. Specifically, Hitachi is supplying touch panel operation consoles that customers can use to operate the charging units to which they are connected and a system that links

*3 A business involving a partnership between the public and private sectors. An example of a PPP would be if a private-sector company supplied not only preliminary consulting, design, and installation but also services like operation and maintenance for a water supply business operated by local government.

together multiple operation consoles to perform batch processing and remote monitoring. These products are also seen as having potential for deployment in other countries.

An example from outside Japan is the Sino-Singapore Guangzhou Knowledge City, an advanced city to be developed on the outskirts of Guangzhou in Guangdong Province, China. This project intends to build a city with a population of approximately 500,000 people by around 2030 on a 123 km^2 site and is led by the Knowledge City Administration Committee of the government of Guangzhou in Guangdong Province and Singbridge International Singapore Pte. Ltd., an investment company of the Singaporean government. This initiative is being undertaken based on the concept of seeking to create new businesses, generate economic activity, and achieve sustainable development by bringing together talented people and attracting research and development capabilities, creative industries, educational facilities, healthcare, and global knowledge-oriented companies with advanced technologies including IT, biotechnology, and new energy and other environmental technologies.

Hitachi is the first Japanese company to be part of this project and it has already started work with the aim of supplying solutions in fields such as energy management, renewable energy, IT platforms, and next-generation transport as well as setting up a development base to facilitate progress, having commenced a feasibility study of these objectives.

Elsewhere in China, Hitachi is supplying smart city technologies for the Sino-Singapore Tianjin Eco-city on the outskirts of Tianjin while in Dailian City it is involved in a joint venture for smart city construction that includes water treatment and home appliance recycling.

Hitachi intends to use these major Chinese projects as a centerpiece around which it can supply solutions and other advanced technologies in fields such as power, water treatment, security, and urban transport in the Asian Belt zone.

CONCLUSIONS

This article has explained what Hitachi means by "next-generation smart cities" and what it is doing to make these a reality.

Next-generation smart cities are supported by a high level of social infrastructure. The creation of smart cities demands an all-embracing redesign of the power, transport, water and other parts of the social infrastructure which have evolved independently in the past to achieve sustainable growth that supports people's way of life over the long term.

By supplying evolving social infrastructure systems, Hitachi intends to help restore Japan's social infrastructure damaged by the earthquake, build social infrastructure for new cities in emerging nations, and make the existing cities of developed nations smarter.

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