Energy Saving Solutions for Sustainable Growth of Industry

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OVERVIEW: With the need for action on global warming becoming more urgent, further energy saving measures focused on industry in particular have become essential if Japan, a country poor in natural resources, is to recover from its recent Great East Japan Earthquake and sustain economic growth as part of the global economy. Emerging economies, meanwhile, continue to experience electricity shortages, rising electricity prices, and other side effects of economic development and are looking to measures such as enhancing energy efficiency and expanding support policies. Hitachi is involved in smart city plans which seek to achieve energy efficiency across an entire community including factories and homes while in the industrial sector it is aiming to build smart factories. In emerging economies, Hitachi is contributing to energy savings in industry through joint projects with national governments and solutions that have been developed in Japan.

INTRODUCTION

THE oil crisis of the 1970s triggered joint efforts aimed at greater energy efficiency by the public and private sectors in Japan and energy saving policies adopted since the passing of the 1979 Energy Conservation Law (Law Concerning the Rational Use of Energy) included regulations such as those obliging a reduction in energy use as well as support for the development of energy saving and other technologies. Industry has also been active in adopting energy-efficient technology. As a result energy consumption per unit of GDP (gross domestic product) in Japan is among the lowest in the world. Being poor in natural resources, Japan will need to undertake measures that build on the strengths in energy conservation it has demonstrated in the past if it is to enhance its industrial competitiveness further and achieve sustainable growth. There is also an urgent need for action to prevent global warming, not only in Japan but also in emerging economies where energy use is growing rapidly. Although industry has cooperated through measures such as cutting production to save electricity, fuel, and other resources in response to the recent Great East Japan Earthquake, the development of energy saving technology has become even more important in order to restore the previous level of convenience and industrial scale.

This article describes solutions that help save energy in industry as well as the outlook for the future.

TRENDS IN INDUSTRY

Recently, how companies manage things like energy use and CO_2 (carbon dioxide) emissions has come to be recognized as an indicator of their competitiveness and growth potential. The objectives for energy efficiency in Japanese industry have included reducing energy use by factories and offices and improving the efficiency of the products being produced based on accumulated technology at manufacturing plants. In contrast, companies in Europe and America in particular view energy efficiency as becoming an important aspect of business in its own right and are taking a more active approach to establishing businesses in this field. Emerging economies are also adopting energy saving technologies from Japan and elsewhere as well as investing policy resources into the creation of new industries that relate to energy efficiency. The following sections look at developments in Japan, China, and the nations of Southeast Asia.

Developments in Japan

With the 2010 revision to the Energy Conservation Law, the areas covered by the energy conservation rules were extended from workplaces to organizations and the scope of application of energy efficiency was expanded to include not only factories and other buildings but also areas such as factory complexes and city blocks. Examples of initiatives that have

already commenced include the centralized energy management of a large number of workplaces using an application service provider and providing a flexible mix of electric power, thermal energy, and other services for a number of factories in an industrial complex. Progress is also being made on building systems that achieve greater efficiency by coordinating the operation of equipment used for air conditioning and water heating in multiple buildings. As the widespread adoption of such systems will require the collection and sharing of information about energy supply and demand, needs include greater use of information and communication technology and reductions in the cost of measurement instruments and other systems. Although energy conservation tends to be seen as a restriction or "economy measure" in Japan, in order to become a leader in energy conservation, it is important that the country undertakes actions such as developing new energy saving systems and establishing service businesses that will stimulate domestic demand and employment.

Developments in China

The 12th Five-Year Plan for National Economic and Social Development of the People's Republic of China agreed by the National People's Congress held in March 2011 not only stipulated a 16% reduction in energy use per unit of GDP in 2015 compared to 2010, it also specified a 17% drop in emissions of CO_2 per unit of GDP during the same period, the first time such a target has appeared in a five-year plan. A growth plan for strategic emerging industries, which was presented as a fundamental reform, identified energy efficiency, environmental protection, and new energy as growth sectors. Along with this expansion in new energy and other environmental measures, the plan made clear that turning energy efficiency into an industry was something that should be forcefully pursued. To put these plans into effect, it appears likely that regulation, support, and other policies relating to energy efficiency will be forthcoming.

Developments in Southeast Asia

Energy use by the Association of Southeast Asian Nations (ASEAN) is growing rapidly, at a similar rate to China and India, and the total for the six member nations already exceeds that of Japan. In recent years, countries like Malaysia, Viet Nam, and Indonesia have eliminated subsidies to publically owned power companies and raised power prices. With the price of petroleum products also rising, it is anticipated that interest in energy efficiency will continue to grow. ASEAN has also entered into free trade agreements with the European Union (EU), China, and other countries and is growing in importance as a global industrial hub. Potential local energy sources include geothermal and natural gas fields as well as biomass. In addition to developing these with the aim of stabilizing energy prices, it is expected that energy efficiency measures will be further strengthened through regulation and support targeted at users.

ACTION BY HITACHI ON ENERGY CONSERVATION IN JAPAN AND OVERSEAS

In response to the developments described above, Hitachi is working to create smart cities that seek to establish a low-carbon way of life throughout the entire community including functions like transport and distribution as well as making factories, homes, and other buildings more energy efficient. For industrial plants, Hitachi promotes energy saving solutions that create smart factories, a more advanced form of Eco-Factory. Smart factories use networking to integrate a site's equipment and information systems to give

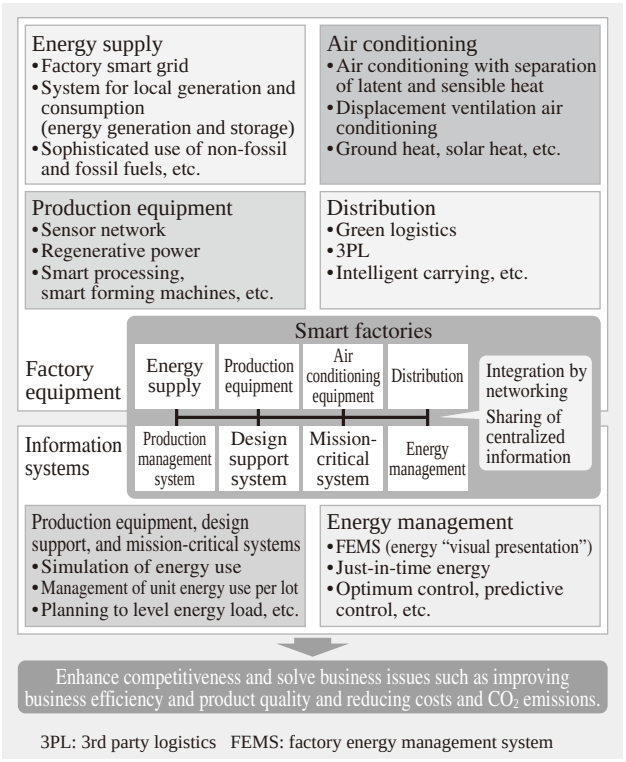


Fig. 1—Example Methods for Reducing CO_2 Emissions Based on Smart Factory Concept.
Even greater power savings and CO_2 (carbon dioxide) emission reductions are possible by using a network to integrate equipment and information systems and share centralized information.

access to various different types of information and clarify the relationships between them, allowing the sharing of centralized information by every part of the organization from administrative departments through to the factory floor. The benefits include improving administrative efficiency and product quality while cutting costs and CO_2 emissions, and the aim is to solve a range of issues faced by factory management while strengthening competitiveness. Hitachi is building CO_2 emission reduction solutions for smart factories in fields which include energy supply, production and air conditioning equipment, and energy management (see Fig. 1).

As a first step, Hitachi in Japan is developing systems such as factory smart grids (next-generation electricity networks that use information and control technologies to optimize electricity supply and demand in a factory), systems for local generation and consumption of energy, and displacement ventilation air conditioning systems. Outside Japan, it is involved in energy efficiency assessment and other similar work in Asia. The following sections give some typical recent examples.

Factory Smart Grid Trial

Hitachi supplies power plants for factories including gas engine generators and wind and photovoltaic power generation systems and is developing factory smart grids that can coordinate these so that they operate efficiently. In a demonstration at the Ohnuma Works of Hitachi Engineering & Services Co., Ltd., Hitachi has connected generation systems such as these together with a recharging station for electric vehicles, batteries, and a GCS (grid control system) to verify the practicality of cutting peak demand and minimizing fluctuations in the amount of power drawn from the commercial supply.

The GCS predicts the factory power demand and the level of generation by photovoltaic, wind, and other power sources based on weather and other data and uses this to control the output of the gas engine generator and the charge or discharge rate of the batteries. The demonstration system smoothes fluctuations based on their period, distinguishing between those of long duration (several dozen seconds to several hours) and those of short duration (several seconds to several dozen seconds). That is, the gas engine generator is used to suppress long-period fluctuations in the amount of incoming power and the batteries are used to suppress sudden or short-period fluctuations. This is because, although the gas engine generator can provide steady power generation, its output responds slowly to control. Batteries on the other hand find it difficult to sustain output over a

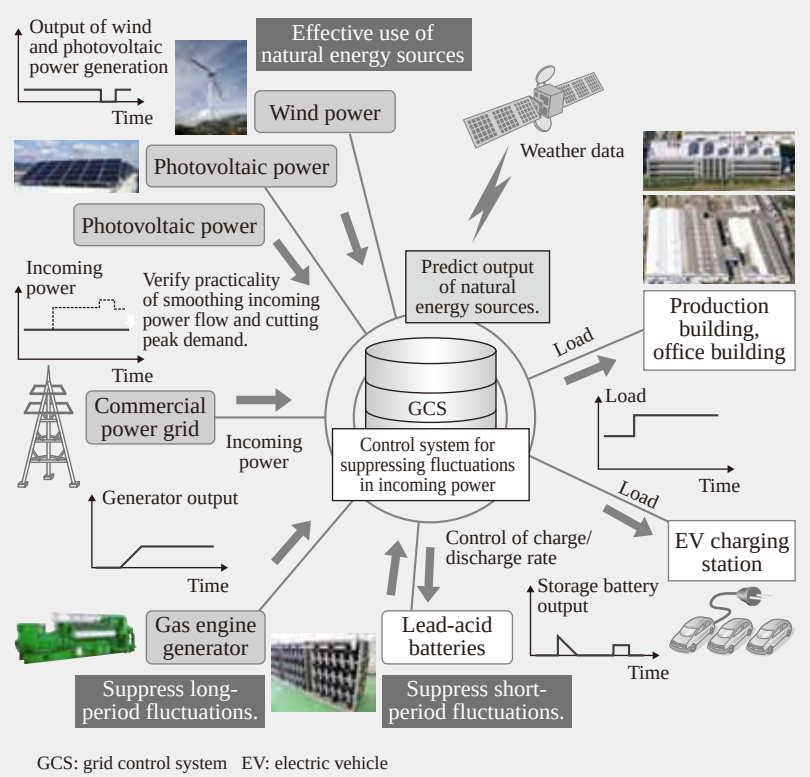


Fig. 2—Overview of Factory Smart Grid Trial. The demonstration commenced in May 2011. The GCS controls the gas engine generator and batteries to smooth the incoming power flow and cut peak demand. The graphs indicate how the output of the gas engine generator and batteries varies when the factory load increases (long-period fluctuation) or the photovoltaic and wind power output varies (short-period fluctuation). They show how the control system effectively suppresses fluctuations in the incoming power flow.

long period but have a fast response to output control (see Fig. 2).

The GCS is a key technology for factory smart grids and Hitachi plans to use this demonstration to improve its performance and other functions in preparation for commercialization.

System for Local Energy Generation and Consumption

Local energy generation and consumption systems that generate power for on-site use at a factory from clean sources such as photovoltaic power are an important energy saving solution for smart factories. Hitachi Industrial Equipment Systems Co., Ltd.'s development of local energy generation and consumption systems includes improvements to the efficiency of photovoltaic power generation systems and the development of a system for recovering unused water energy.

(1) Power conditioner for photovoltaic power generation system

Hitachi Industrial Equipment Systems has developed an industrial power conditioner (100 kW) that can convert the DC (direct current) output of solar cells to AC (alternating current) with high efficiency. Combining inverter and amorphous transformer technology, the conditioner achieves an industry-leading level of maximum conversion efficiency (96.3%) for an output of 200 V while also improving conversion efficiency in the 20% to 80% load range at which the system most commonly operates.

(2) System for recovering unused water energy

The system for recovering unused water energy uses a turbine to produce electricity from water energy sources that have been overlooked in the past such as a factory's cooling water pipe networks or air conditioning networks. As the maximum permitted size for hydro generation equipment (which are classed as general electrical devices) was raised from 10 kW to 20 kW during the fiscal year 2010, Hitachi Industrial Equipment Systems is now developing a 20-kW model to complement the existing 3-kW and 9-kW models.

(3) Charging and discharging system

A charging and discharging system is a device for converting AC to DC when charging batteries and DC to AC when discharging. Operating in conjunction with batteries, a charging and discharging system can be used to reduce the power drawn from the commercial grid by cutting or shifting peak demand and is an essential device for creating systems such as factory smart grids or systems for local energy generation and consumption (see Fig. 3).

Hitachi is building systems such as factory smart grids and systems for local energy generation and consumption in which these devices and the GCS described above play a central role.

Displacement Ventilation Air Conditioning

Displacement ventilation air conditioning is a cooling technique which blows very-low-velocity chilled air into a room at close to floor level and

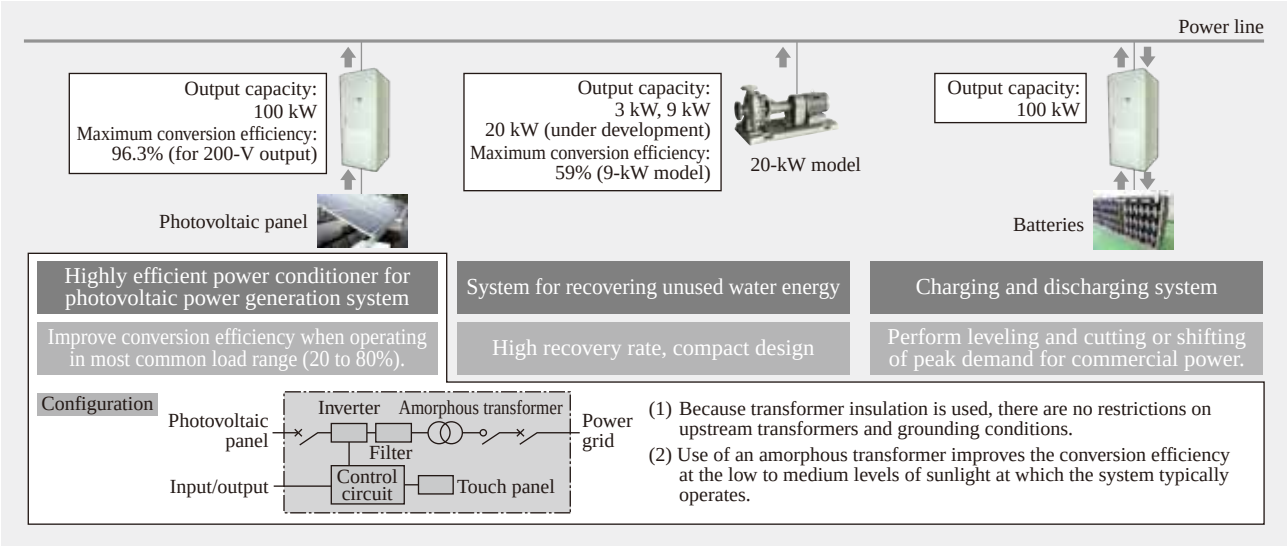


Fig. 3—Equipment for Local Energy Generation and Consumption Systems.
Hitachi is developing a range of systems essential for saving energy in industry, including a power conditioner (100 kW) for a photovoltaic power generation system which achieves high efficiency under actual operating conditions, a system for recovering unused water energy (20 kW), and a charging and discharging system (100 kW).

extracts it from the ceiling, taking advantage of the updraft caused by the heat coming of people and machinery. Because this technique can be targeted at work areas that require air conditioning, it achieves both higher energy efficiency and greater comfort than previous methods, particularly in large spaces with a high ceiling. Working with The Tokyo Electric Power Co., Inc., Hitachi Appliances, Inc. has jointly developed a package air conditioning system which uses displacement ventilation air conditioning. The product features are as follows.

(1) Energy savings of approximately 40% compared to previous methods

(2) Three operating modes: internal recirculation, external air inflow, and mixed operation

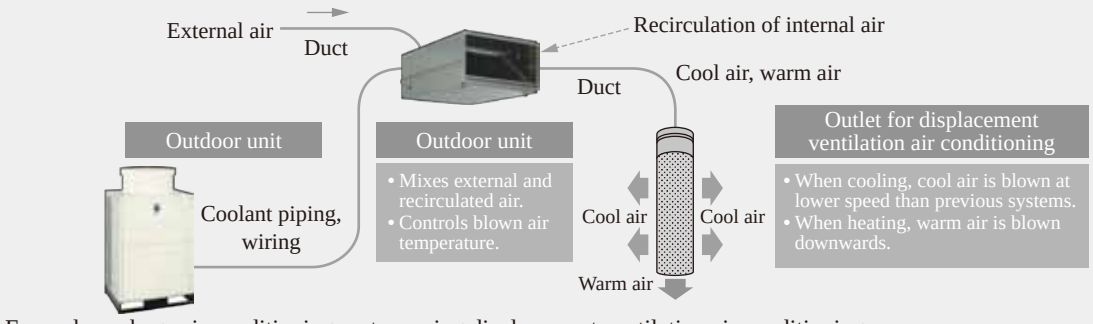
(3) Blown air temperature control suitable for displacement ventilation

Fig. 4 shows the temperature distribution inside a factory building that has installed this system. The results show the temperature rising from floor to ceiling while the work area (up to 2 m above the floor) is kept at 28°C or below. Hitachi intends to continue developing air conditioning systems for smart factories including the use of renewable energy and the development of new techniques like the package air conditioner which uses displacement ventilation air conditioning.

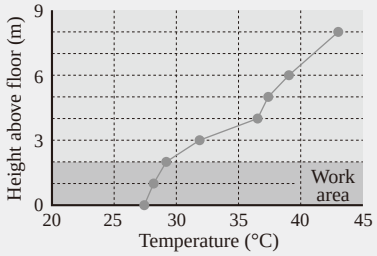
Overseas Activities

Hitachi is also undertaking a wide range of business activities that relate to energy efficiency outside Japan. These include energy infrastructure such as smart grids and megasolar (large-scale photovoltaic power generation) and businesses that utilize new practices such as bilateral credit arrangements (a system whereby CO_2 emission reductions in the partner country are counted as Japanese reductions within the terms of a bilateral agreement). In relation to saving energy in industry, Hitachi is seeking to utilize energy efficiency solutions that it has developed for Japan, mainly in Asian countries. As an example of this, the following section describes what Hitachi is doing in China.

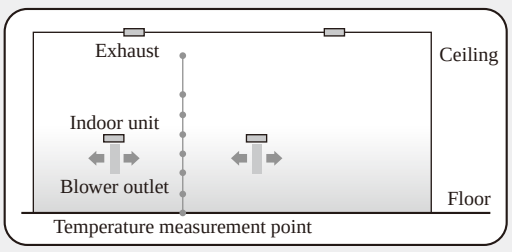
Hitachi undertakes a wide range of activities in China, including involvement in joint Sino-Japanese projects, factory energy efficiency proposals for Japanese-owned companies, and EMC (energy management company) businesses. In joint projects, Hitachi is installing high-voltage inverters for the drives used in the large plants of steel and chemical companies in Yunnan Province[2] and undertaking energy efficiency assessments for small and medium-sized factories in Ningbo City, Zhejiang Province. Meanwhile, the demand from Japanese-owned companies for factory energy efficiency has increased



Example package air conditioning system using displacement ventilation air conditioning



Steady-state temperature at measurement point



Layout diagram of blower outlets for factory building displacement ventilation air conditioning system

Fig. 4—Temperature Measurements for Displacement Ventilation Air Conditioning System.
The graph shows the measured temperature distribution when operating a package air conditioner that uses displacement ventilation air conditioning in a factory building. The temperature rises from floor to ceiling while the work area (up to 2 m above the floor) is kept at 28°C or below (measured on August 28, 2010).

over the last few years. The reasons for this are believed to include the strengthening of regulations, support, and other Chinese policies that relate to energy efficiency, and the fact that the plant used in many of the factories built when companies first moved into China is now coming due for replacement.

The number of companies in China considering installing energy management systems has also been growing in recent years and EMC business [a Chinese version of ESCOs (energy service companies)] is expanding. This business provides services to customers who have installed energy saving equipment, including monitoring operating conditions, verifying energy savings, and suggesting ways of improving operating practices. Hitachi works with EMC businesses on activities such as conducting energy efficiency assessments, supplying equipment, and collecting data via monitoring systems.

In other Asian countries outside China, while Hitachi's activities already include joint energy centers for industrial complexes[3] and photovoltaic power generation for islands or other remote locations, its work in the field of saving energy in industry is only now getting started with factory energy efficiency assessments providing a way into the market. Hitachi's approach is to use energy efficiency assessments to gain an understanding of local conditions along with measures such as finding local partners and identifying which solutions to offer in order to provide energy saving solutions that suit the characteristics of each region.

CONCLUSIONS

This article has described solutions that help save energy in industry as well as the outlook for the future.

To save energy in industry, Hitachi is working on developments which include factory smart grids and systems for local production and consumption of energy. It is also pursuing activities in Asia including factory energy efficiency assessments and working on joint projects with national governments. For the future, Hitachi intends to accelerate development to help create smart factories while expanding the geographic scope of its activities, primarily in emerging economies, and contributing to saving energy in industry.

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