

Yokogawa's Contribution to Industrial Infrastructure for a Sustainable Society

Teruyoshi Minaki **1

Global warming is causing sea levels to rise and abnormal weather patterns. Humankind is also facing other serious problems including the depletion of fossil fuels, forests, water, and food, and must reduce the use of hazardous chemicals for the sake of humans and the natural environment. To solve these problems and achieve a sustainable society, people around the world must work together immediately to conserve energy and preserve the environment. This paper describes the global situation relating to these difficulties, and Yokogawa's efforts to solve the problems. Yokogawa's products and solutions are also outlined.

INTRODUCTION

While automobiles, electrical appliances, personal computers, mobile phones, Internet, and the like make our lives more convenient and improve the quality of our lives, global warming is actually causing damage such as rising sea levels and abnormal weather patterns. Humankind is also facing other serious problems including the depletion of fossil fuels, forests, water, and food, and must reduce the use of hazardous chemicals for the sake of humans and the natural environment. To solve these problems and achieve a sustainable society, people around the world must work together immediately to conserve energy and preserve the environment.

This paper describes the global situation relating to these difficulties, and Yokogawa's efforts to solve the problems. Specific solutions and examples, and Yokogawa's products used for such purposes, are presented in other papers in this issue.

GLOBAL SITUATION TO ACHIEVE A SUSTAINABLE SOCIETY AND YOKOGAWA'S BASIC APPROACH

Global Situation to Achieve a Sustainable Society

Global warming is recognized as a global threat to the development of humankind, according to a report of the

Intergovernmental Panel on Climate Change (IPCC) ⁽¹⁾. Under these circumstances, countries around the world joined the United Nations Framework Convention on Climate Change (UNFCCC) to address the global warming problems. The UNFCCC defined principles and measures to prevent adverse effects caused by climate changes. The Conference of Parties (COP), the supreme decision-making body of the convention, is held every year. With the regulations for 2000 and beyond being found unsatisfactory, the Kyoto Protocol ⁽²⁾ with legally binding targets was adopted at the COP3 (Kyoto conference) held in December 1997. However, since the US, which emits a large amount of greenhouse gases, did not ratify the treaty and developing countries, which think they must emit a large amount of greenhouse gases for economic development, were not involved in the treaty process, the global reduction in greenhouse gases has made little progress. On the other hand, global warming is causing abnormal weather patterns, a decline in sea ice at the South and North poles, a glacier retreat, a rise in sea levels, and so on, which require prompt action. ⁽³⁾

Under these circumstances, the International Energy Agency (IEA) released basic data in October 2009 as a special early excerpt ⁽⁴⁾ of the World Energy Outlook 2009 towards a climate agreement in the COP15 held in Copenhagen, Denmark, in December 2009.

The IEA presented a plan entitled the 450 Scenario that aims at keeping the global temperature rise within 2 °C compared with pre-industrial levels. This title was named after the greenhouse gas concentration of 450 ppm CO₂-equivalent under which the concentration needs to finally be stabilized.

*1 Executive Vice President, Chief Green Officer,
Industrial Automation Business Headquarters

This concentration is less than half that will be achieved with just the currently planned measures. Figure 1 shows estimated CO₂ emissions achieved only with the current measures and those achieved with the 450 Scenario. A decline in emissions in 2010 from those in 2007 is attributed to the effect of the financial and economic crisis since 2008. The IEA regards this financial and economic crisis as “an opportunity to put the global energy system on a trajectory to a low-carbon future.”

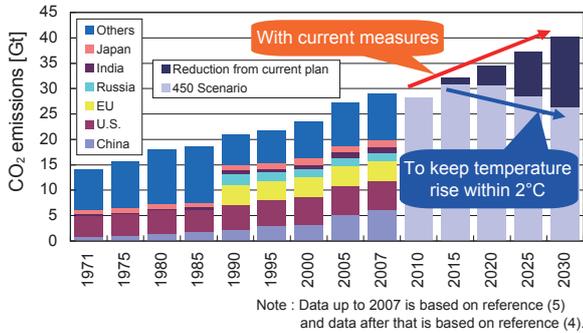


Figure 1 Global CO₂ Emissions

Figure 2 shows the CO₂ reductions by country and region and Figure 3 shows the CO₂ reductions by area in the 450 Scenario. The part of the reduction from the current plan in Figure 1 are enlarged and the breakdowns are shown. Renewable energies exist in the natural world and can be obtained almost permanently, and include the use of solar light, solar heat, wind power, water power, biomass, melting heat of snow and ice, ocean temperature difference, salt concentration difference, geothermal heat, and tidal power. Regarding CO₂ emissions by country and region, a significant reduction is required particularly for the US and China, which emit a large amount of CO₂. By area, required reduction in the energy conservation area accounts for more than half of the total reduction.

Figure 4 shows additional capital investment estimated in the 450 Scenario. Investment in the energy conservation area is huge. Additional annual capital investment, including related investment, will increase from 0.5% of the gross domestic product (GDP) in 2020 to 1.1% in 2030. This capital investment will create an energy reduction effect worth \$8.6 trillion from 2010 to 2030 and can save the cost of implementing air pollution measures by as much as \$40 billion in 2020 and \$100 billion in 2030.

Despite the proposal of the IEA and the efforts of each country, the COP15 only got to approve the Copenhagen Accord and each country was required to submit a reduction plan to the treaty secretariat by January 31, 2010. As a result, 55 countries which account for about 80% of total global CO₂ emissions, including emerging countries, the U.S., and China which are not obligated to decrease emissions by the Kyoto Protocol, agreed and submitted a reduction plan by the deadline of January 31. Negotiations over a new international framework for global warming measures (Post-Kyoto Protocol) will once again commence.

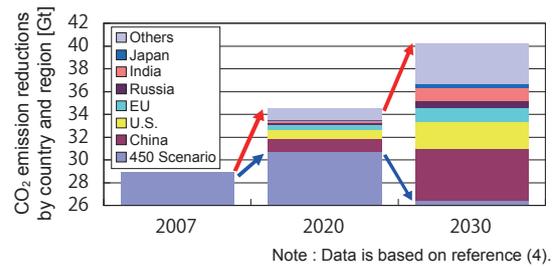


Figure 2 CO₂ Emission Reductions by Country and Region in the 450 Scenario

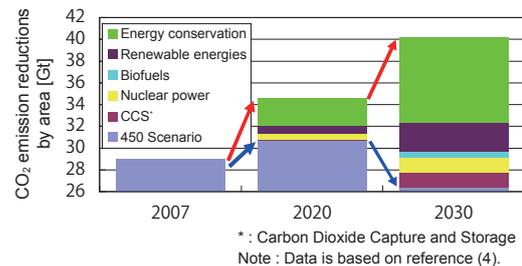


Figure 3 CO₂ Emission Reductions by Area in the 450 Scenario

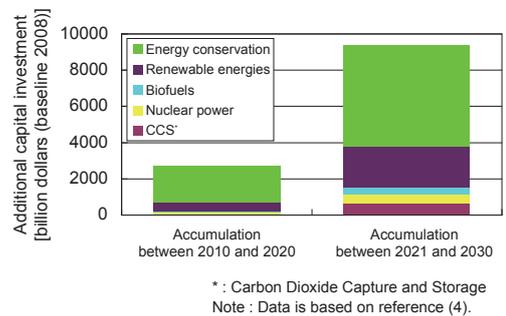


Figure 4 Additional Capital Investment Based on the 450 Scenario

So far a global situation of energy conservation and CO₂ emissions has been described. In addition, regulations in many regions and countries to prevent humans and the natural environment from being adversely affected by hazardous chemical substances are increasing. They include the Restriction on Hazardous Substances (RoHS) Directive which restricts the use of certain hazardous substances, the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) which requires manufacturers to register chemical substances, evaluate safety, restrict use, and authorize use, and the Chinese version of RoHS (Electronic Information Products Pollution Prevention Management Approach).

Yokogawa's Basic Approach

As shown in the company's philosophy of “As a

company, our goal is to contribute to society through broad-ranging activities in the areas of measurement, control, and information,” Yokogawa always focuses on providing excellent products and solutions in areas relating to infrastructures that serve as a foundation for industries and society. The Yokogawa Group has focused on the energy conservation and environmental preservation technologies since before the oil shock and its headquarters and plants obtained the ISO 14001 certificate in 1997. Since then, the Yokogawa Group’s environmental policy includes contributing to customers’ environmental preservation efforts through Yokogawa’s products and solutions.

As shown in Figure 5, almost all areas that emit a lot of CO₂ just involve infrastructures that serve as a foundation for industries and society. Emissions in the areas of energy and industries, in which Yokogawa has strength, account for more than half of the total emission volume. Actually, Yokogawa has already contributed to energy conservation for global warming countermeasures for many years. For example, Yokogawa’s control system, CENTUM series for saving energy and improving productivity and quality, has an installation base of more than 20,000 around the world and has a reputation for being the most reliable in the industry. Many systems are still in operation and greatly contribute to energy conservation and environmental preservation around the world. The DPharp EJA/EJX series of differential pressure/pressure transmitters, which has an installation base of more than 1.2 million, accurately measures combustion gases, exhaust gas pressure, etc. and helps conserve energy and preserve the environment.

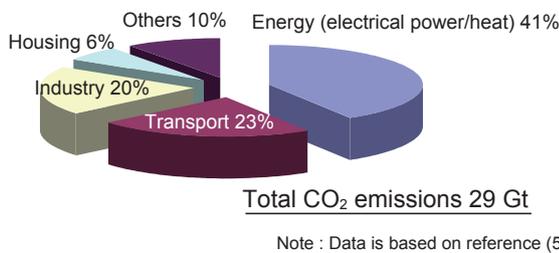


Figure 5 CO₂ Worldwide Emissions by Area in 2007

While the Japanese industry has increased international competitiveness based on the strength of high productivity and excellent quality since the oil shock, it has intensively focused on improving energy efficiency. Although the GDP increased 2.4 times and energy consumption in the areas of transport and consumer goods more than doubled for 34 years from 1973 to 2007, the industry energy consumption remained almost unchanged. (6) These efforts made it possible for Japan to keep CO₂ emissions per GDP at a very low level as shown in Figure 6.

Yokogawa, the world’s leading company in the control area, has greatly contributed to this achievement and provides products for customers around the world to help reduce global CO₂ emissions. As the IEA reported, future capital investment related to energy conservation will be huge, therefore, we are

convinced that we will be able to greatly contribute to energy conservation and environmental preservation. Yokogawa also recognizes that observing the regulations of each region and country to prevent humans and the natural environment from being adversely affected by hazardous chemical substances is a corporate obligation and encourages such observation.

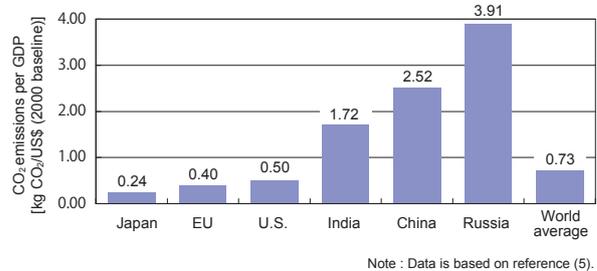


Figure 6 CO₂ Emissions per GDP in 2007

YOKOGAWA'S ACTIVITIES FOR ENERGY CONSERVATION AND ENVIRONMENTAL PRESERVATION

An ideal plant to realize the ideal operation for customers is the “VigilantPlant.” Yokogawa views energy conservation and environmental preservation as one of the most important themes and aims to achieve an earth friendly plant, which contributes to the optimization of energy for the entire plant and entire community based on the vision of a VigilantPlant and the concept of “Energy on Demand” as shown in Figure 7.

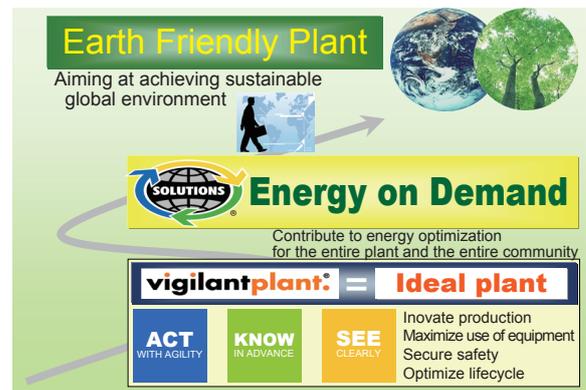


Figure 7 Earth Friendly Plant

VigilantPlant - Ideal Plant

VigilantPlant is the plant in which

- All the necessary information is given to all plant operators,
- Operators are able to quickly react to changes in the external environment while production activity runs without interruption,
- Both equipment and people are able to continue to evolve for the future,

and fully optimized operation has been achieved to enable making decisions for tomorrow.

VigilantPlant executes the following three cycles to help create an environment where both equipment and people are able to continue to evolve for the future.

- SEE clearly
 - See in every corner of plants

Accurately measuring physical quantities, such as the amount of energy and materials used, quality and amounts of products, amount of CO₂ and other emissions, and temperature, pressure, flow rate, and quality in the production process, is the beginning of all activities for energy conservation and environmental preservation.
- KNOW in advance
 - Predict future changes based on collected information

Predict and analyze to verify whether the amount of used energy and materials is appropriate to the products to be produced and whether CO₂ and other emissions are as planned.
- ACT with Agility
 - Support business growth with agile operation

Minimize energy and material waste to keep CO₂ and other emissions within the specified values. Supplying just a sufficient amount of energy where and when it is required is ultimate energy conservation.

VigilantPlant also provides a total solution that helps achieve operational excellence (OE) with the following four excellences.

- Safety Excellence (Securing safety): Maximize both safety and availability.
- Asset Excellence (Maximizing equipment use): Maximize reliability and minimize maintenance cost
- Production Excellence (Innovating production): Achieve continuous improvement of productivity
- Lifecycle Excellence (Optimizing lifecycle): Achieve improvement of operational quality.

Energy on Demand

Yokogawa helps customers reduce costs and carry out environmental management with the concept of “Energy on Demand” aiming at ultimate energy saving that supplies just enough energy where and when it is required. The current energy supply from the energy source to production process is stable and the supply and demand is well balanced. However, this supply and demand balance is based on the assumption of the waste of energy used in the production process. Yokogawa aims to achieve an ideal supply and demand balance that eliminates waste in the production process as shown in Figure 8.

As shown in Figure 9, achieving energy conservation results in not only cost reductions as the amount of energy use decreases, but also results in a reduction of equipment and buildings management costs which can directly lead to management improvement. In addition, CO₂ emissions can be reduced, resulting in the prevention of global warming.

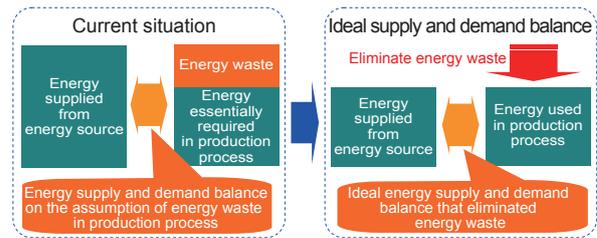


Figure 8 Energy Supply and Demand Balance in Energy on Demand

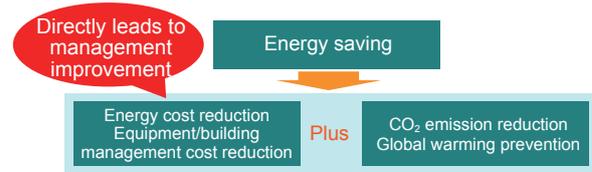


Figure 9 Energy Cost Reductions and CO₂ Emission Reductions

Yokogawa provides solutions based on the VigilantPlant cycles, “Visualize” (See clearly), “Analyze” (Know in advance), and “Solve” (Act with agility) as shown in Figure 10, for all customers from those who have just started energy conservation measures to those who are involved in advanced energy conservation activities. These cycles need to be run continuously for energy conservation measures. A sustainable society can be achieved by extending the scope of measures from a low-profile activity like turning off lights to energy saving measures for individual equipment such as boilers, pumps, and compressors, to energy management of the entire plant, and to the minimization of energy for the entire corporation, the entire industrial complex, and the entire community.

	Expand the scope of measures		
	Optimize individual equipment	Optimize entire plant	Optimize entire community
Visualize	Install measuring instrument, and monitor and record energy of individual equipment to make it visible.	Monitor energy in entire plant to make it visible.	Make energy used in each plant in community visible.
Analyze	Quantify waste by per unit production management of energy of individual equipment.	Quantify waste by per unit production management of energy in entire plant.	Analyze type and quantity of energy that can be transferred between plants using up-to-date control technology.
Solve	Eliminate waste and minimize energy consumed by individual equipment.	Eliminate waste and minimize energy consumed in entire plant.	Use advanced control technology, etc. and minimize energy consumed in entire community.

Figure 10 Cycles for Energy Saving Measures

Products and Solutions to Achieve Energy Conservation and Environmental Preservation

Yokogawa provides customers with many products and solutions to achieve energy conservation and environmental preservation. The following provides an overview of some of them. Annexed Table 1 shows Yokogawa’s major products for customers to achieve energy conservation and environmental preservation in their plants corresponding to each of the

VigilantPlant cycles. Annexed Table 2 shows an overview of the major types of business and solutions provided by Yokogawa.

■ Field Instruments, Analyzers, and Measuring Instruments

All activities for energy conservation and environmental preservation at the production site start with accurately measuring physical quantities such as temperature, pressure, and flow rate. Optimal control requires measuring in real-time not only the amount of energy and materials to be used, the quality and amount of products, and the amount of CO₂ and other emissions, but also the temperature, pressure, flow rate, quality, etc. in the production process.

A variety of field instruments, analyzers, and measuring instruments provided by Yokogawa, such as DPharp EJA/EJX Differential Pressure/Pressure Transmitters, TDLS200 Tunable Diode Laser Gas Analyzer, and POWERCERT Power Monitor, are able to measure various physical quantities of such as combustion gas, exhaust gas, water, wastewater, and electricity and can be used as key components for solutions to achieve energy conservation and environmental preservation.

■ Control and Production Systems

Distributed control systems (DCSs) using IT technology, such as CENTUM VP Integrated Production Control System and STARDOM Network-based Control System, serve as a foundation for energy conservation and environmental preservation for not only individual equipment but also for the entire plant and the entire community. In many cases, DCSs are used intending to improve quality and increase productivity, but they always help conserve energy regardless of the purpose.

Since DCSs allow easy changes of PID tuning parameters, control methods and control loop configurations without changing or adding any hardware, they enable continuous improvements to achieve more stable and efficient operation. Improving just one control loop can save significant energy. Adding a feedforward control for load fluctuations is one example of a very effective measure. Even if improvement of individual loops is small, improvement of hundreds and thousands of control loops leads to a drastic improvement.

DCSs maintain and manage a wide range of data necessary for further improvements and provides a uniform access method for that data. Upper layers such as Manufacturing Execution System (MES), Supply Chain Management (SCM) and Enterprise Resource Management (ERP) are able to access and use the data for energy conservation and environmental preservation for the entire plant, the entire corporation, and the entire community.

■ Advanced Process Control Packages

Advanced process control can save energy in oil, chemical, power, iron & steel and other plants using the MES layer packages, such as the Exasmoc Multivariable Model Predictive Control Package and the Exarque Robust Quality Estimator Package. The basic concept of the

advanced process control is to produce products meeting the product specifications with the smallest amount of energy and materials, and the shortest time within the given device limitation, exhaust gas limitation, economic limitation, and other limitations.

For example, with a distillation column in oil refinery, reducing the reflux ratio as low as possible, in other words, reducing the temperature for distillation as low as possible within the product specifications can save the use of fuel significantly. There is an example where more than 20% fuel reduction was achieved.

Another example is replacing quality measurement using an analyzer with estimation using a model, which can perform real-time feedback control using estimated quality values and prevent production of out-of-spec products and reduce operation losses. The measurement delay time can be reduced by more than one hour.

■ Energy Management and Control Systems

● Individual Equipment Energy Saving Control

The Econo-Pilot Series is a package to control energy for individual equipment. For example, the Econo-Pilot Water Pump Energy Saving Control System and the Econo-Pilot HSP Heat Source Water Pump Energy Saving Control System help save a lot of energy for cool/hot water pump systems in buildings, plants, and commercial facilities. In many cases, flow rate control for pumps is performed by controlling return valves, but operating return valves can save only a small amount of electrical power. However, since required electrical power is proportional to the cube of the number of revolutions, changing return valve control to motor revolution control can save the use of electrical power significantly. For example, reducing the revolutions to 60% leads to $(0.6)^3=0.216$, which means saving approx. 80%. The smaller the average flow rate compared with the maximum allowable flow rate, the larger the saving effect.

● Energy Management for Entire Plant and Entire Community

The InfoEnergy Energy Management System and the Enerize E3 Factory Energy Management System are packages to manage energy for the entire plant and the entire community. The newly developed Enerize E3 integrates the energy and production information to help save energy in the production process. The conventional production process increased productivity, resulting in energy saving and performing per unit production management (managing energy use per product or product unit quantity) at the factory as a whole. However, to save energy further, it is necessary to identify where in production process energy is wasted, and it is also necessary to manage energy in real-time by product, lot, and process. The Enerize E3 is a system that can perform all of these to achieve the real energy on demand.

● Optimal Operation

The Enemap Energy Prediction and Optimization System is a software package to predict the energy demand load based on past operation data and weather forecast and create an optimal operation plan to meet the demand load.

Combining with a DCS, advanced process control package, or the like make it possible to build a system capable of optimal operation. It can be used for solutions such as that for private power generation equipment and contributes to achieving energy conservation in the area of process control.

■ Solutions to Achieve Energy Conservation and Environmental Preservation

Yokogawa provides customers with solutions that can be reused for as many types of business as possible quickly and at low cost. Factory Energy Saving Diagnosis Solution in Annexed Table 2 proposes customers energy saving measures based on the above procedure of cycles for energy saving measures.

Energy Conservation and Environmental Preservation Measures in Yokogawa's Products

With respect to Yokogawa's hardware product development, the Yokogawa Group has established design standards with regard to saving power consumption, reducing weight for conserving resources, and reducing and eliminating hazardous substances, and is actively committed to energy conservation and environmental preservation for the company's own products.

Activities at Yokogawa's Plants

Yokogawa contributes not only to energy conservation and environmental preservation in the plants of customers but is also actively committed to energy conservation and environmental preservation in its own plants. In October 2009, Kofu Plant's project "Using IT to Eliminate Energy Waste in Production Lines" won the prize of Minister of Economy, Trade and Industry in the Green IT Awards 2009 sponsored by the Green IT Promotion Council. The project was recognized for the great results achieved by taking measures to increase the efficiency of equipment and enhance the initiatives to turn off lights, making visible the energy amount to promote further energy saving, and participating of all members in the activity to "eliminate energy waste in the production lines."

YOKOGAWA'S FUTURE ACTIVITIES

Yokogawa focuses not only on the area of energy conservation but also on the areas of clean renewable energies and biofuels expected to grow significantly in the

future. Yokogawa's control systems and field instruments are already producing results in many plants for solar generation, wind generation, dimethyl ether (DME) production, DME cogeneration, and so on.

Yokogawa plans to further focus on energy conservation and environmental preservation, continuously develop products and solutions, and strengthen functions, and hopes that they will be utilized around the world. In particular, Yokogawa has high expectations in energy conservation measures to reduce greenhouse gas emissions generated as the economies of emerging countries develop. With respect to environmental preservation, Yokogawa will also actively commit itself to green and water conservation and food shortage in addition to the reduction of greenhouse gas emissions through energy conservation, and wishes to contribute to solving global social problems such as environmental sanitation and hygiene, and poverty.

CONCLUSION

This paper described energy conservation and environmental preservation to achieve sustainable society as problems to be addressed immediately by all people around the world working together, and how Yokogawa contributes to solving these problems in the present and the future.

Yokogawa regards it as its mission to utilize its technologies cultivated in the areas of measurement, control, and information over many years for global energy conservation and environmental preservation, and wishes to work together with customers to contribute to achieving a sustainable society.

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Annexed Table 1 Yokogawa's Major Products to Achieve Energy Conservation and Environmental Preservation

Cycle	Product Name	Description
SEE clearly	Tunable Diode Laser Gas Analyzer TDLS200	A spectroscopy analyzer to measure various gas concentrations under harsh conditions with high speed and high precision using a tunable diode laser
	Zirconia Oxygen Analyzer ZR402, ZR22	A measuring instrument to measure oxygen concentrations in equipment such as a furnace and boiler using a zirconia sensor
	Infrared Gas Analyzer, Near Infrared Analyzer IR400, NR800	A spectrometer to measure concentrations of gases such as NO, SO ₂ , CO ₂ , and CO using infrared or near infrared lights
	Continuous VOC monitor VM500	A measuring instrument to continuously and automatically measure hazardous volatile organic components (VOCs) such as benzene and trichloroethylene
	Right Angle Scattered Light Turbidity Analyzer TB700, TB750G	A measuring instrument to measure the turbidity of water, wastewater, etc.
	Fiber Optic Distributed Temperature Measuring Unit AQ8920	A measuring instrument to measure temperature distribution over a distance of up to 2 km using optical fiber and laser light
	Power Monitor POWERCERT	A measuring instrument to continuously measure electrical power consumed in plants and buildings
	Digital Power Meter /Power Analyzer WT/PZ Series	A measuring instrument to measure power consumption of electrical equipment for research and development, production line, etc. of electrical appliances, lighting equipment, industrial equipment, etc.
	Gas Density Meter GD410	A measuring instrument to perform continuous, high-speed, stable measurement of the calorific value of gas using the correlation equation between gas density and calorific value
	Differential Pressure/Pressure Transmitter DPharp EJA/EJX	A measuring instrument to measure the flow rate, liquid level, density and pressure of liquid, gas, and vapor using a silicon resonant sensor
	Magnetic Flow Meter ADMAG AXR/AXF	An instrument to continuously measure the amount of fluid flowing through a tube using electromagnetic force
	Vortex Flowmeter digital YEFWLO	An instrument to continuously measure the amount of fluid, gas, and vapor flowing through a tube using Karman vortex street
KNOW in advance	Plant Information Management System Exaquantum	An information management system to collect and analyze various information throughout the plant and help achieve safe, optimum operations
	Distributed SCADA system FAST/TOOLS	A distributed Supervisory Control and Data Acquisition (SCADA) system based on open architecture
	Paperless Videographic Recorder DXAdvanced	A paperless data acquisition station with network function and advanced information processing capability
	Consolidated Alarm Management Software CAMS for HIS	An alarm management system to inform only required alarms to only the operator who needs to know at the optimum timing
	Plant Simulator Visual Modeler	A simulator to simulate plant behavior at high speed using models with plant-level details
	Robust Quality Estimator Package Exarqe	A package to estimate online the quality of products and interim products based on the temperature, pressure, flow rate and other data
	Energy Management System InfoEnergy	A management and analysis system to reduce use of energy by using collected data on electrical power, operation conditions of equipment, flow rate and amount of heat, etc.
	Energy Prediction and Optimization System Enemap	A system to predict the energy demand load based on the past operation data and weather forecast information and create an optimal operation plan
ACT with Agility	Factory Energy Management System Enerize E3	A system to help save energy in the production process by integrating the energy and production information
	Integrated Production Control System CENTUM VP	A production control system to serve as a core for achieving the optimal plant operation with high reliability and high efficiency
	Network-based Control System STARDOM	A production control system to allow for building systems in a flexible and scalable manner using network technologies
	Safety Instrumented Systems Prosafe-RS	A safety system for the purpose of preventing plant accidents and preventing the damage from spreading if an accident occurs
	Film/Sheet Thickness Measurement and Control System WEBFREX3	A system to optimize the quality of packaging films, sheet materials for electric and electronic use, paper and pulp, etc. and the operation of their production plants
	Multivariable Model Predictive Control Package Exasmoc	A control package for advanced process control in order to keep plant operation in optimal condition
	Integrated Plant Asset Management System PRM (Plant Resource Manager)	A package to manage various plant resources, including field instruments such as transmitters and control valves
	Operation Efficiency Improvement Package Exapilot	A package to increase operation efficiency by standardizing and automating operations according to the high levels of operation of experienced operators
	Real-time Plant Optimizer Exaspot	An online real-time optimizer to calculate and set the optimal operation parameters according to the operation requirements
	Water Pump Energy Saving Control System Econo-Pilot	A system to control for saving energy in the secondary water pumps of the cold and hot water for air-conditioning in buildings and plants
Heat Source Water Pump Energy Saving Control System Econo-Pilot HSP	A system to control for saving energy in the primary cold and hot water pumps around the heat source and cooling water pumps in heat transfer systems in plants and commercial facilities	

Annexed Table 2 Major Solutions to Achieve Energy Conservation and Environmental Preservation

Type of Business Solution	Oil	Chemical	Iron & Steel	Paper & Pulp	Energy	Solution Outline
BTG Optimization Solution	✓	✓	✓	✓	✓	Operate boilers, turbines and generators (BTG) automatically and stably by improving the control and controlling the number of units for load sharing, and achieve cost cutting, energy saving, and reducing of CO ₂ emissions.
Oil Refinery Optimization Solution	✓	✓				Perform advanced process control of oil refineries utilizing model predictive control, quality prediction, real-time simulation, etc., and achieve cost cutting, energy saving, and reducing of CO ₂ emissions.
Optimized Combustion Control Solution	✓	✓	✓	✓	✓	Control combustion in boilers and other equipment applying furnace temperature control, air-fuel ratio control, furnace pressure control, etc. to improve combustion efficiency, reduce CO ₂ emissions, and minimize the supply of fuel, and achieve cost cutting, energy saving, and reducing of CO ₂ emission.
Heat Transfer Pump Energy Saving Solution	✓	✓	✓	✓	✓	Control the primary, secondary, and cooling water pumps in heat transfer pump systems in plants, commercial facilities, etc., utilizing Yokogawa's proprietary pipe friction predictive control method, and achieve cost cutting and energy saving.
Compressed Air Compressor Energy Saving Solution	✓	✓	✓	✓	✓	Control the unnecessary air pressure of multiple compressors and the number of units in operation utilizing Yokogawa's proprietary load predicting control method and control of the number of units with different capacities, and achieve cost cutting and energy saving.
Optimized Tuning Solution	✓	✓	✓	✓	✓	Diagnose the control conditions of equipment in plants, and propose optimization of the control to cut costs, increase productivity, and improve quality.
Factory Energy Saving Diagnosis Solution	✓	✓	✓	✓	✓	Diagnosis services to save energy in plants. The services consist of an initial diagnosis to propose Yokogawa's products to help customers take energy-saving measures and make them visible, and an advanced diagnosis to help customers promote specific energy-saving measures.

* CENTUM, DPharp, VigilantPlant, Energy on Demand, TDLS, POWERCERT, STARDOM, Exasmoc, Exarqe, Econo-Pilot, InfoEnergy, Enerize, Enemap, ADMAG, AXF, AXR, YEWFLOW, Exaquantum, FAST/TOOLS, DXAdvanced, ProSafe-RS, WEBFREX, PRM, Exapilot, and Exaspot are registered trademarks or trademarks of Yokogawa Electric Corporation.