# TRENDS IN WATER SYSTEM CONTROL TECHNOLOGY INTO THE 21ST CENTURY AND FUTURE PROSPECTS

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## 1. INTRODUCTION

Many environmental problems such as global warming, deforestation, destruction of the ozone layer, and acid rain are occuring on a global scale. These phenomena are closely related to water circulation.

Water supply and sewerage systems represent one process of water circulation. When we consider the future of water supply and sewerage systems, we should not forget their connection with the above environmental problems.

Efforts are being made to improve the social infrastructure, of which water supply and sewerage systems constitute one of the most basic parts. There is a need for more sophisticated and multilaterial projects, as well as projects to maintain urban functions and improve living conditions.

In this paper we will consider changes in the environment caused by water supply and sewerage systems in terms of environmental protection and social change. We will try to sort out the Japanese government's measures and plans, and provide an overview of trends in electric and instrumentation technology which anticipate the arrival of the 21st century.

## 2. CHANGE IN THE ENVIRONMENT SURROUNDING WATER SUPPLY AND SEWERAGE SYSTEMS

### 2.1 Environmental protection and water supply and sewerage systems

Brisk manufacturing activities during the past few decades in Japan have produced environmental problems in a number. The deterioration in the quality of water in rivers and lakes due to industrial and household wastewater, and air pollution caused by emissions from factories are typical examples.

The contamination of rivers and lakes is a major factor in the deterioration in the quality of water, originaling in these bodies of water. In particular, algae that grows as a result of eutrophication are said to be the main cause of foul drinking water, and have prompted the introduction of sophisticated treatment facilities using activated carbon or ozone.

Sewerage is closely related to environmental protection in terms of prevention of water pollution. It is particularly important to treat household wastewater, which is responsible for more than half of pollution, and dispose of the sludge that is generated. Installation of good sewerage facilities, and proper treatment and disposal in each area will lead to the protection of many water sources.

A growing number of people are demanding more sophisticated water treatment processes. We must restore clean watersides by treating the water in sophisticated treatment processes to remove phosphorus, nitrogen, color and odor.

In terms of energy, we find that petrochemical materials are mainly used to power water supply and sewerage facilities, which has been an indirect cause of the generation of carbon dioxide, contributing to greenhouse effect. Therefore, such facilities are related to the problem of global warming. It is therefore necessary to look for environmentally friendly treatment systems, and conduct research on energy saving and renewable energy sources.

### 2.2 Social changes and water supply and sewerage systems

#### 2.2.1 A comfortable and safe community

In the past, projects for water supply and sewerage systems, which are a basic part of social infrastructure, have been undertaken using as guides the installation and diffusion rates.

However, as the construction of basic parts for the good life style progressed, people began to look for added value in these projects in their quest for a more affluent, comfrotable, and convenient life. Projects to build wastewater recycling systems with sophisticated treatment in which hydrophilic space is created and trees are planted above the facility are already underway, in a bid to restore nature and harmonize with the urban landscape. As part of a project to develop safer communities, there are also plans to install emergency water supply bases to secure drinking water supplies in an emergency, and construct major water supply systems deep underground.

In addition, water supply systems are becoming three-dimensional to supply water directly to buildings, improving water supply services and resolving health problems.

There are also plans to use underground sewage ducts

Table 1 Long-term plan for water supply and sewerage projects

(a) Water supply projects

| "Long-term targets of the water works adjustment plan for the 21st century" ten-year fresh water supply plan (1991–2000) | | |
|---|---|---|
| Basic policy | Targets of the water works adjustment plan | |
| 1. Water works accessible to the public | (1) Development of water resources | Preventive measures against water shortages |
| | (2) Adjustment of water supply systems | Improvement of the diffusion rate |
| | (3) Adjustment of small water supply systems | Improvement of the diffusion rate (99%) |
| | (4) Renewal of aging facilities and earthquake-proofing of mainstay facilities | Preventive measures against water measurement |
| 2. Highly-reliable water works | (5) Securing of water supply bases for emergencies | Anti-disaster measures |
| | (6) Construction of sophisticated water treatment facilities | Supply of safe and tasty water |
| 3. Safe water works | (7) Expansion of direct-link water supply systems | Improvement of water supply services resolution of sanitation problems |

(b) Sewerage projects

| | "How sewerage should be organized and managed in the future" | | | The 7th five-year program for sewerage construction (1991–1995) |
|---|---|---|---|---|
| | Early 21st century | The year of 2000 | Immediate future (through 1995) | |
| Population-based diffusion rate | Approximately 90% | Approximately 70% | 10% rise | 44% → 55% |
| Preventive measures against flooding | Elimination of areas prone to flooding in heavy rain, occurring approximately every 10 years | To cope with heavy rain, occurring approximately every 5 years, or in densely-populated areas, every 10 years | To cope with heavy rain in urban districts, occurring every 5 years | Rate of installation of sewerage systems for rainwater drainage 40 → 49% |
| Sophisticated treatment | Implementation of most measures | Implementation of only those measures related to areas important to water quality protection | Systematic implementation with a priority on closed water areas | Population covered by sophisticated treatment 2.3 → 7.5 million |
| Other priority measures | • Functional improvement of aging facilities<br>• Use of sewerage systems for resources and energy; efficient use of ducts and facilities | | • Rebuilding of aging facilities<br>• Efficient treatment of sewage sludge, and efficient use of resources, energy, and sewerage facilities | • Improvement of maintenance and management<br>• Promotion of multipurpose uses<br>• Promotion of large-scale sludge treatment and disposal |

to maintain urban information networks, as a means to expand utilization of sewerage facilities. Also, a scheme to lay fiber optic communications networks in the ducts is presently being conceived in some areas. District air-conditioning, utilizing thermal energy from sewerage systems is also expected.

### 2.2.2 Toward water supply and sewerage projects that meet with the approval of residents

Efforts to contribute to the development of comfortable and safe communities are heading toward water supply and sewerage projects that are open to residents. From now on, it will be increasingly important to implement projects that are consistent with the needs of residents, and undertake these projects in an efficient manner. It will also be necessary to develop technology and undertake business management research to ensure that the projects are managed in a reliable manner.

## 2.3 Long-term plan for water supply and sewerage projects

It is apparent from a public works investment program, a 430 trillion Japanese Yen project recently conceived by the Japanese government, that water supply and sewerage projects will be undertaken on a priority basis.

As the demand for supply water continues to rise, reflecting brisk economic activity and an improvement in the standard of living, it is essential to develop new water resources for tap water. The Ministry of Construction will inplement a comprehensive program, including long-range and systematic development of water resources and construction of dams to supply water in times of drought, as part of the Water Resources Development Plan for the 21st Century (1988). The National Land Agency has formulated a National Comprehensive Water Resources Plan, detailing its basic policy for the administration of water resources in the future.

In 1991, the Ministry of Health and Welfare formulated Long-term Targets for the Water Works Adjustment Plan, consistent with the 4th Comprehensive National Development Plan, detailing its basic policy for the administration of water resources in the future.

In 1990, the Central Council on City Planning, an advisory organ to the Ministry of Construction, made a recommendation entitled, "How Sewerage Should be Managed in the Future", detailing a long-term goals for sewerage management. Their recommendation became the basis of the 7th Five-Year Program for Sewerage Construction. High points of the program include raising of the diffusion rate, improvement of antiflood measures, and maintenance

of water quality through sophisticated treatment processes. It also calls for qualitative improvements in sewerage facilities through various functional improvements, energy saving, multipurpose use of facilities, and improvement in maintenance and management.

**Table 1** summarizes the content of these programs.

## 3. TECHNOLOGICAL ADVANCEMENTS AND WATER SUPPLY AND SEWERAGE SYSTEMS

### 3.1 Technological innovations and water supply and sewerage system technology

Technological innovation and commercialization of application technology are occurring quite rapidly, especially in the areas of data processing using microelectronics, optical communications, image processing, AI, and neurotechnology, as well as biotechnology, micromachines, and alternate energy sources.

Advances in microelectronics and optical communications technology has helped promote the downsizing and upgrading of equipment, and brought about remarkable improvements in the functions of EIC integrated systems and EA/OA integrated systems.

Advances in biotechnology and image processing technology have greatly expanded the range of sensor functions, and made it possible to measure various indicators on-line, replacing point measurement with area measurement. Thanks to these new types of measurement data and visual information, it is now possible to run high-quality process operations.

AI and neurotechnology have been introduced in process control, guidance, and decision making, ensuring safe and reliable facility operation and sound business management.

Alternate, new energy sources, comprising solar cells and fuel cells will play an active role in future water supply and sewerage processes as "clean energy."

**Figure 1** summarizes the relationships between water and sewerage issues and system technologies.

### 3.2 Trends in water supply and sewerage system technology and future prospects

A water and sewerage system consists of various facilities scattered over a broad area and the ducts which connect them. The system works best when each of the facilities performs its individual function properly and the system as a whole operates in a harmonious manner. The water supply and sewerage management system ensures this overall harmony. We need a technology that combines the components technology, such as electricity (E), instrumentation (I), computer network (C), and machinery (M), with engineering technology for system design, manufacturing, and construction.

The following is a discussion of characteristic items of trends in water supply and sewerage system management control technology, and future prospects.

(1) Sensor technology

Efforts to improve sensor technology are mainly centered on water quality analyzers. The traditional series, including for example coagulation sensors for sedimentation process control are how being improved or upgraded. In addition, a trihalomethane sensor and ozone sensor for high-grade water measurement, and an ammonia sensor, BOD gauge, water quality safety monitor, and bacteria counter using biotechnology have been installed in some facilities. Their installation has proven useful in increased environmental protection and quality control.

Plans have been made to revise water quality standards in the future. Added to this is an urgent need to promote research, development, and commercialization of new water quality sensors.

(2) Communication systems

We are working to develop a multimedia transmission system, fully utilizing light transmission, LAN for processing, and image compression technology. It is believed it will be easy to develop a remote control system that gives a more acute sense of presence by going one step further than the current remote monitoring operation, which utilizes only data, voice, and added image information.

(3) Image processing technology

Fuji Electric is trying to develop a flock monitoring system by using image processing in order to achieve logical operation control of the coagulation process. This technology is suitable for a wide range of uses, such as area-measuring of temperature and turbidity, and for maintaining the security of facilities by detecting transpassers and controlling visitors.

(4) AI, fuzzy logic, neuro application technology

Expert systems have been introduced to control processes such as pumping, injection of chemicals, and incineration, to detect failed generators, pumps, and motors, and to support the work of sludge treatment units and other facilities. Attempt are also being made to utilize these systems in business planning and manpower-allocation planning. It is believed that a knowledge of engineering technology will prove useful in a wide range of fields, including operation, maintenance, and management of facilities, as well as business administration.

(5) Sophisticated information systems

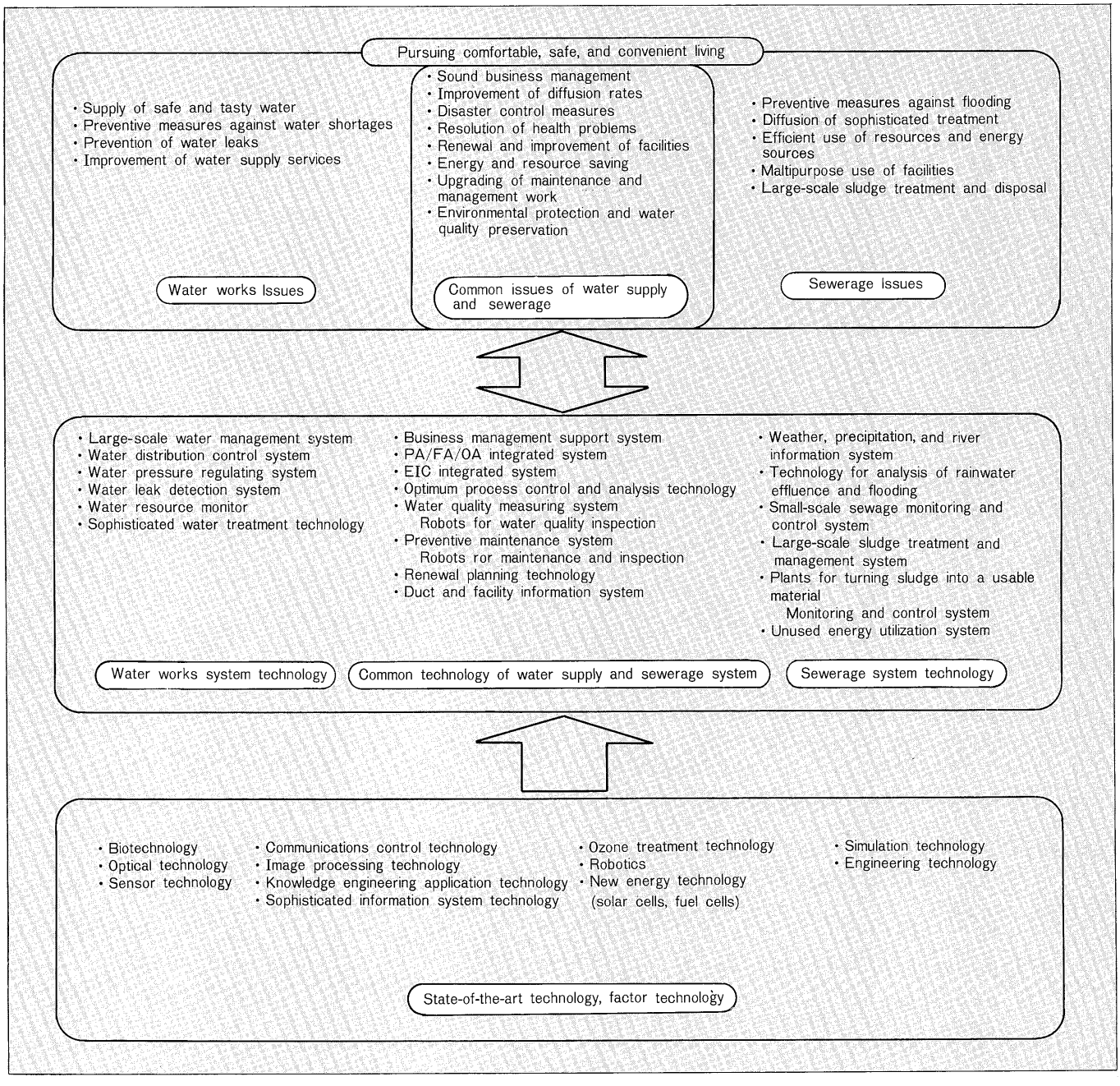
CIM (Computer Integrated Management) is a sophisticated information system for improving the quality and efficiency of business services and improving working environments. Fuji Electric plans to begin large-scale installation of a CIM system in a few years.

The CIM system uses state-of-the-art technology such as computer technology and networking technology to totalize functions such as general facility operation, facility information management, and business administration, i.e., functions that are related to the operation of water and sewerage operations. In the future, the CIM system will develop into a general control system for public facilities, including water and sewerage systems, rivers, harbors, roads, and parks.

(6) Ozone treatment technology

Water pollution is posing an increasingly serious ploblem. Thus, removal of the odor and organic substances,

Fig. 1 Issues for water supply and sewerage, and system technology




and reduction of trihalo methane are current issues urgently requiring attention. The conventional solid-liquid separation method is not effective enough to eliminate these impurities entirely. Therefore, more sophisticated treatment processes such as ozone treatment and biologically active carbon treatment are receiving greater attention. These processes require the use of optimum control technology, which has already been developed and is now being used commercially. It has been demonstrated that ozone treatment is effective in the reuse of secondary treatment of water from water supply and sewerage systems. We are conducting research in this area along with research on sophisticated water treatment.

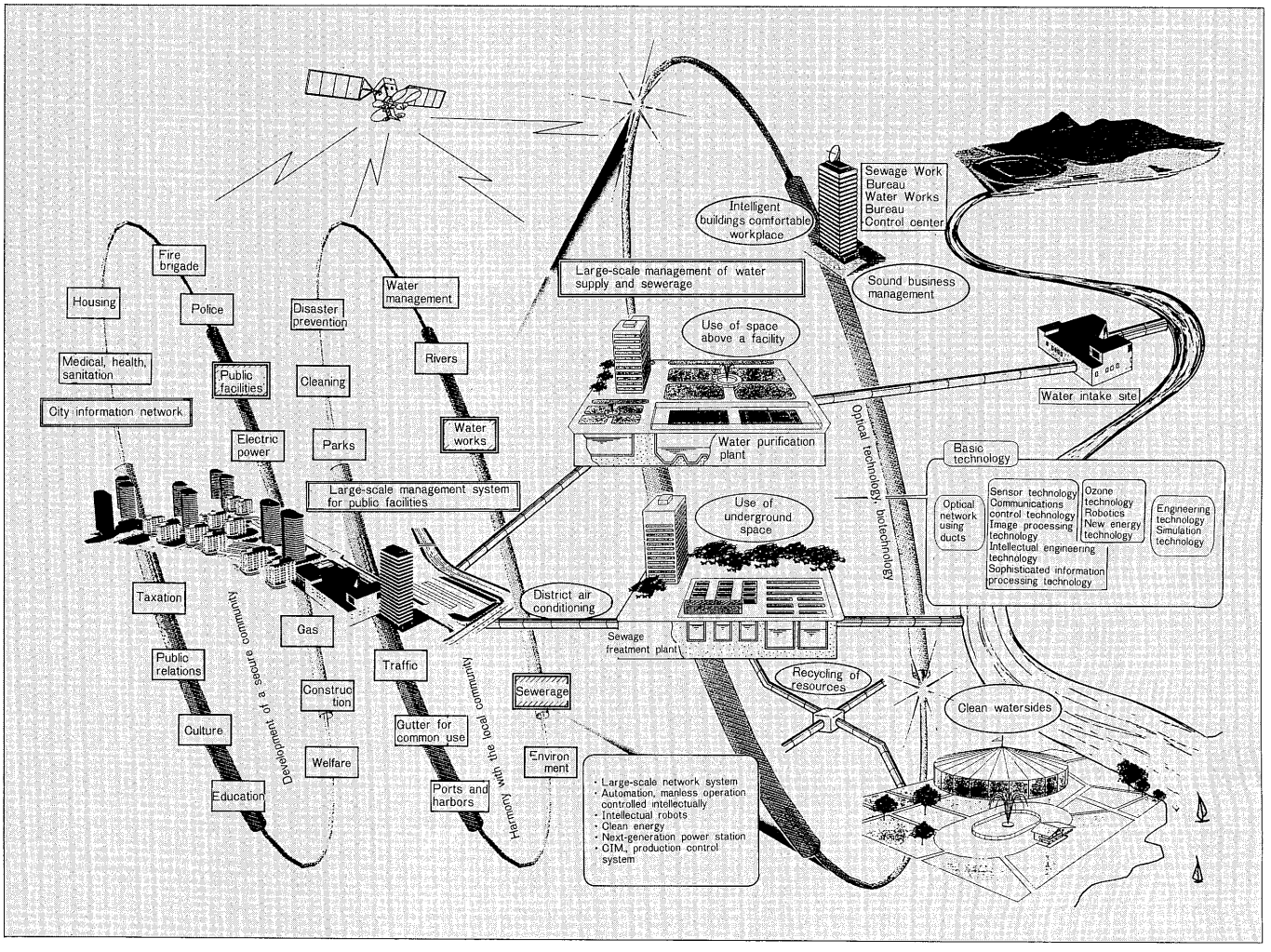
(7) Robotics

We are also conducting research to develop a number of robots, particularly maintenance-and-control robots to replace humans in maintenance and inspection work, and robots to automate water quality inspection.

(8) Making intelligent of Electric Facilities

Making intelligent of equipment is in progress, as can be seen in the transformation of mechanical equipment into electrical equipment and the use of microcomputers in control circuits. Various sensors for preventive maintenance of electric facilities have been developed, and maintenance support systems using knowledge engineering based on the technology are being introduced.

Fig. 2 Information-oriented city and large-scale management water supply and sewerage system




## 4. OUTLOOK FOR THE 21ST CENTURY

**Figure 2** shows an overall picture of new water supply and sewerage systems. From this, we can infer how the new water and sewerage systems designed for the 21st century will look. We can see that the benefits of technical innovation in water supply and sewerage systems are enormous. Here, we will try to visualize these systems and predict how they will operate in the 21st century. As is illustrated in the figure, water purification plants and treatment sites have made headway in the use of underground and aboveground spaces, and intelligent buildings and parks have been installed, playing an important role in the improvement of urban landscape.

Water supply and sewerage public works are collectively operated by information control offices in competent metropolitan government agencies, as well as their local organizations. The advent of networking technologies such as ISDN and satellite communications has led to a trend in which public works try to broaden their operations spatially and in an interdisciplinary manner by working closely with each other. This collaboration allows the organizations involved to be in close contact with each other, enabling them to operate their businesses more efficiently, cooperating with into other public service activities such as electric power, gas, roads and water supply and sewerage. Water supply and sewerage organizations will increasingly share manpower and other corporate resources with one another in operation of their water and treatment facilities. The beneficiaries, the residents and the public works themselves can communicate both ways, providing one another with various services, using different forms of communications media.

Hyper-parallel computers are also making an appearance, while neuro-computers are being used routinely, demonstrating their capabilities in the control of water purification plants and treatment facilities. Intellectual control of facilities has progressed to the point where most operations can be controlled without humans. To relieve personnel from routine operations and dangerous work, various intellectual robots have been developed and are working hard in the two areas of factory and laboratory automation. Thus, ongoing efforts are being made to automate operations and reduce manpower requirements.

Photovoltaic power generation and fuel cells are

clean energy source used to power facilities. The power stations are maintenance free, and are known as next-generation power stations, meaning they are environmental friendly and nonpolluting. Also, it has become standard pratice to utilize unused energy, and district air-conditioning using treatment water as a source of heat and low-head water power generation, have been introduced.

Water supply and sewerage operations contribute to the recycling of resources. Fertilizers and construction materials are being produced using sludge, and the CIM-controlled treatment facilities reflect a new era in modern factories.

## 5. CLOSING REMARKS

Water supply and sewerage operators not only have a vital role in the recovery of the environment, but must have the business knowhow to respond promptly to social change and to the needs of residents. Both these areas raise a number of issues that require.

Fuji Electric will continue to work hard to contribute to the development of water supply and sewerage systems for the 21st century. Fuji Electric hopes to be able to contribute, even in a small way, to making a more affluent society by developing technology and offering new products. We would appreciate it if you could continue to share your opinions with us in the future as you have in the past.