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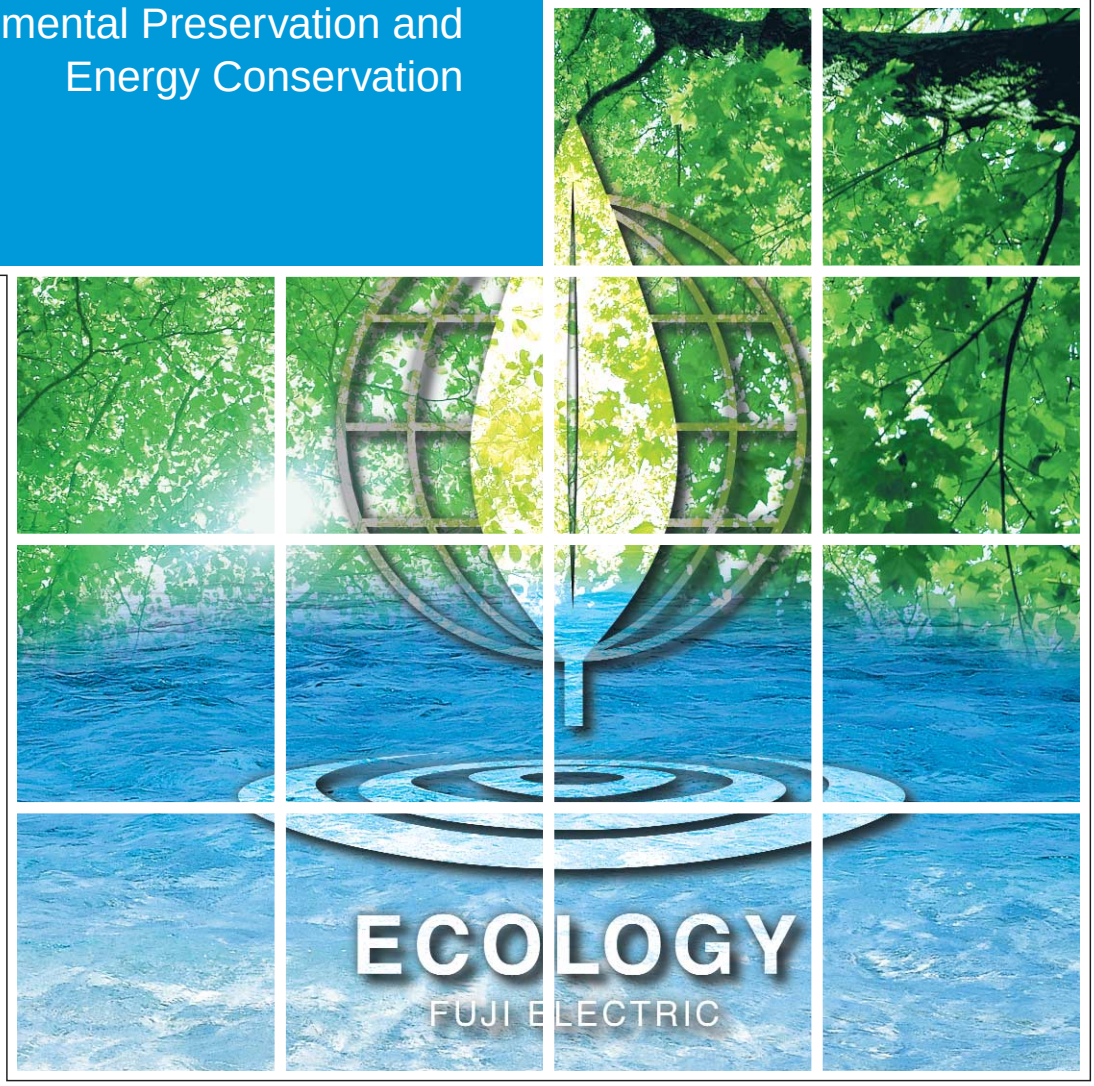
Environmental Preservation and Energy Conservation



FUJI ELECTRIC

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Fuji Electric has tackled the development of new products and technologies for the protection of global environment.

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FUJI ELECTRIC
REVIEW

3
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Environmental Preservation and Energy Conservation

CONTENTS

Cover Photo:

Human beings consumed resources and discharged wastes in the process toward prosperity, while they caused great damage to the earth that had produced life and developed human beings. The problems of global environment have become critical at an increasing tempo.

Based on its basic policy on the protection of environment, Fuji Electric offers various devices, systems, and services utilizing ample experiences and trustworthy technologies cultivated for many years as well as takes environment into consideration in its own business activities.

The cover photo, having Fuji Electric's symbol for ecology superposed on the tree and clear stream symbolic of nature, images the symbiosis of irreplaceable global environment and human society.

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Present Status and Trends of Environmental Preservation and Energy Conservation

Masakazu Usui
Kinzo Okazaki
Kazuhiko Akamatsu

1. Introduction

At the "Third Conference of Parties of the United Nations Framework Convention on Climate Change (COP3)" held in Kyoto in December 1997, the "Kyoto Protocol" was adopted, specifying the targeted reduction in greenhouse gasses for advanced countries, beginning in the year of 2000.

At the conference held in Bonn in 1999, however, agreement could not be reached among the United States, the European Union and developing countries, on how and when to ratify the pollution control agreement adopted at COP3.

At present, emissions of greenhouse gasses such as carbon dioxide are increasing in most of the advanced countries, and therefore, the drive toward global environmental preservation is making very little progress.

In Japan, the "Law for Promoting Global Warning Prevention" was enacted in April 1999 in response to the numeric targets specified at COP3. This law obligates local governments and businesses to prepare, announce and enforce a plan of emission control. In May 2000, the "Basic Law for Promoting Formation of Recycling Society" was established and the year of 2000 was positioned as the first year of the recycling society.

Japan, the presiding country at COP3, is proceeding toward an environment-oriented economy with the aim of realizing a recycling society, in line with the "Rio Declaration" which specifies sustainable development as a fundamental principle.

In response to pollution control laws and regulations established during the 1960s and 1970s, Fuji Electric was the first company to engage in an end-of-pipe type, environment-related business, such as the manufacture and sale of water pollution prevention equipment. Environmental technology in the twenty-first century is expected to aim for the zero emission of pollutants, including a reduction in greenhouse gas emission. In order to contribute to global environmental preservation, Fuji Electric is promoting a variety of technology development and businesses in new environmental fields, such as proper waste treatment, waste recycling, pollution-free energy, energy conservation and environment-related information processing.

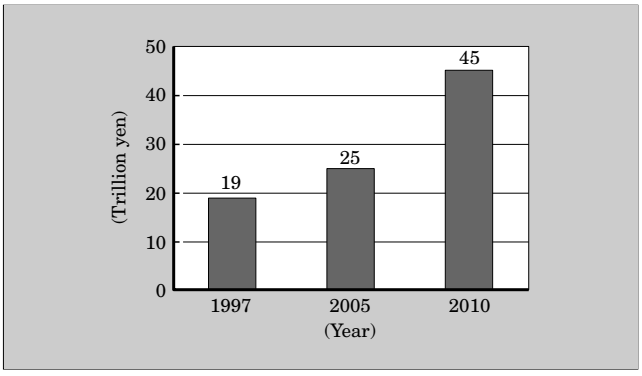
This paper introduces new trends of environmental preservation and energy conservation technology and Fuji Electric's efforts in that regard, and describes the future trends of conservation.

2. Environment-Related Budgets of Various Ministries

Global-environmental-preservation-related budgets for the fiscal year of 2000 amounted to 669.9 billion yen, a 4.1% increase over the previous year.

From a budgetary viewpoint, budgets for the "Campaign to realize a sustainable domestic society" and for "Investigation, research, observation and monitoring" increased 17% and 11%, respectively. The budget for measures against global warming is 553.1 billion yen, including budgets for support of local activities of promoting alternative energy and energy saving (Ministry of Economy and Industry), development and upgrade of a physical distribution system to reduce environmental impact, reduction in environmental pollution resulting from road maintenance and management work (Ministry of National Land and Transport), promotion of research and development of global climate change forecast (Ministry of Education, Science and Technology) and promotion of research on

Fig.1 Environmental business market size (The Ministry of Economy and Industry: Industrial environment vision)



the global environment (Ministry of the Environment). This trend of expanding global-environmental-preservation-related budgets is expected to continue in the future.

According to the "Study report on environment-related business" conducted by the Japan Machine Industry Association, it is expected that the size of the environment-related business market will reach 45 trillion yen in 2010. Figure 1 shows the size of the environmental business market.

3. Environment-Related Law and Regulations

In Japan, the "Basic Law for Environmental Pollution Control" was intended to address the pollution issues of the 1970s. As environmental issues became global issues, the "Basic Environment Law" was established in November 1993, specifying the basic philosophy and an overall framework for basic environmental policy. In December 1994, the "Environmental Basic Plan" was prepared, prescribing that most all waste be recycled to the extent possible instead of merely burning them, and that the heat generated during incineration be utilized.

The following laws related to environment and energy were prepared and enacted: the "Law for Partial Amendment of the Law of Rationalized Use of Energy" (Revised Energy Conservation Law), the "Law of Environmental Impact Assessment", the "Law for Promoting Separate Collection and Recycling of Containers and Packages" (Containers and Packages Recycling Law), and the "Law for Recycling Specific Consumer Electric Appliances" (Electric Appliance Recycling Law). Local governments are also vigorously preparing environment preservation measures in response to the above-mentioned laws. Based on Japan's envisioned concept of sustainable cities, several ministries announced their own plans and the intent to realize them in order to build environment-oriented cities and towns, such as "Ecocity" and "Ecoport" (Ministry of National Land and Transport), "Ecotown." (Ministry of Economy and Industry) and "Ecopolis" (Ministry of the Environment).

Development of new technologies and new businesses related to environmental preservation and energy conservation is strongly required for such new efforts as mentioned above.

4. Fuji Electric Group's Commitment to Environmental Business

In line with a new trend of environmental preservation that began in the 1990s, Fuji Electric Group formulated its "Environmental preservation basic plan" and strengthened its environmental preservation activities with the catchword "ECOLOGY*ing*." Fuji Electric Group applies useful environmental preservation technologies obtained during these activities to various fields, such as energy, water environment, atmospheric environment, zero emission, recycling and environmental information systems, and provides a wide range of comprehensive solutions for environmental preservation. Figure 2 lists Fuji Electric's technologies and products related to environmental preservation and energy conservation, and Fig. 3 depicts their application.

4.1 End-of-pipe

The technology to treat hazardous substances at drain openings is known as "end-of-pipe." End-of-pipe technology has developed in Japan as a measure against environmental pollution since the 1960s. Fuji

Fig.2 Fuji Electric's technologies and products related to environmental preservation and energy conservation

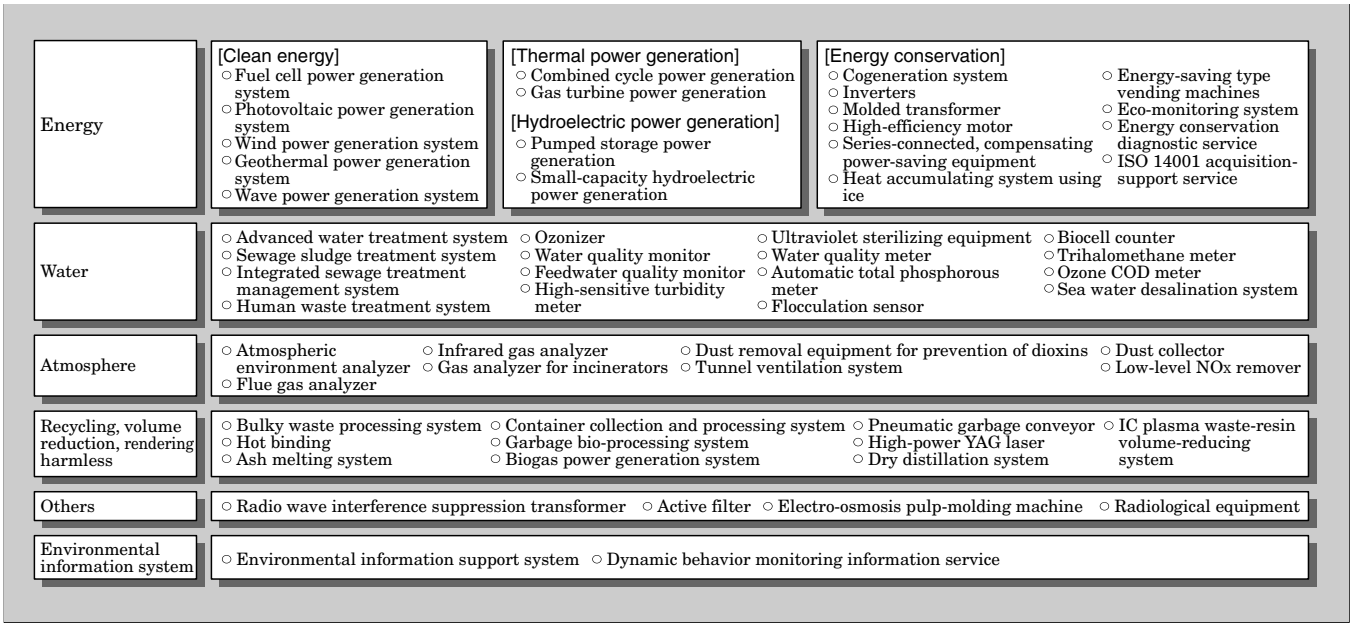
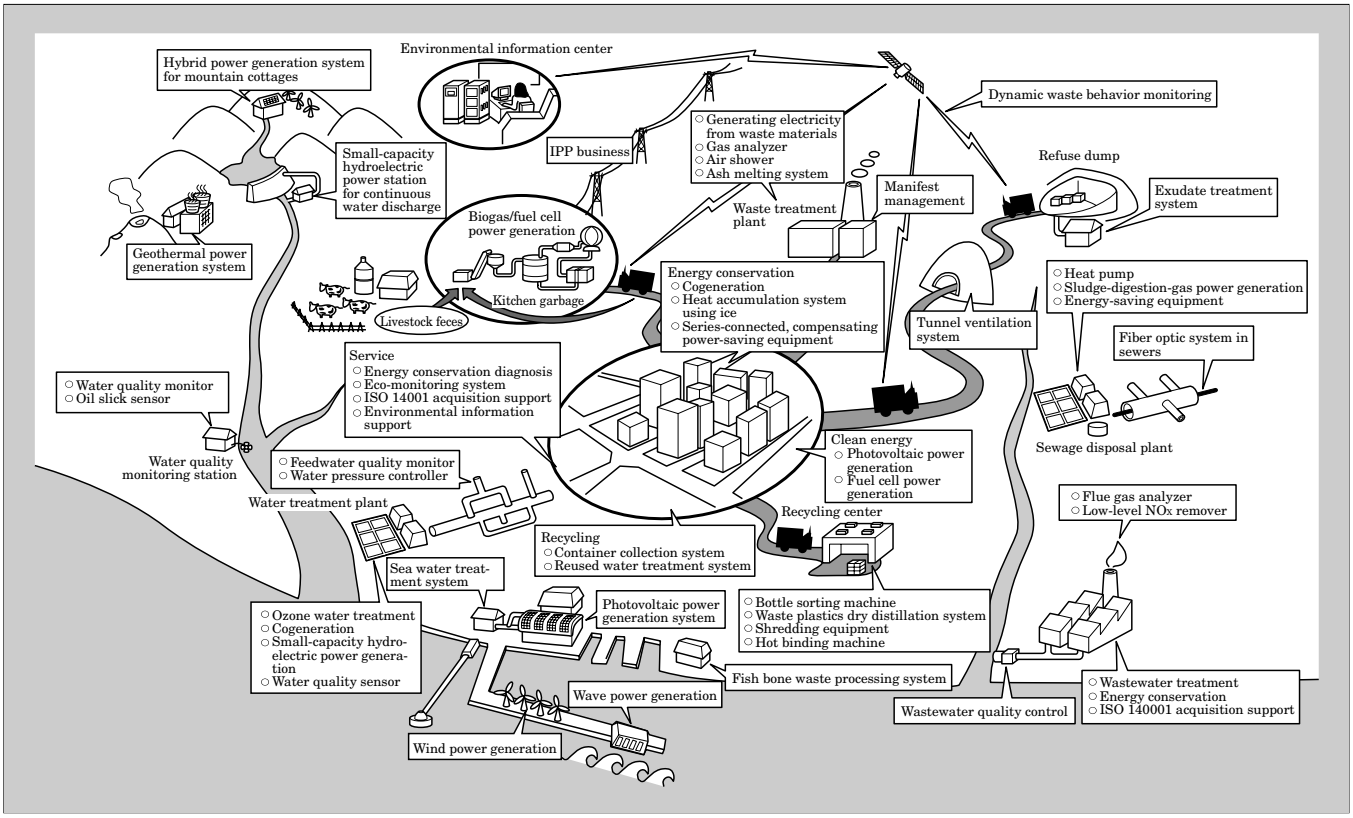


Fig.3 Fuji Electric's measures for environmental preservation and energy conservation



Electric Group has utilized its excellent proprietary water treatment technology, water and air analysis technology and electrostatic precipitation technology, to provide end-of-pipe systems that include advanced water treatment systems, sewage sludge treatment systems, tunnel ventilation systems, atmospheric environment analysis equipment, final waste disposal plants, etc.

In recent years, with strengthened anti-pollution laws and regulations, such as the "Waste Disposal and Clean-up Law," "Revised Air Pollution Control Law" and "Environmental Impact Assessment Law," advanced techniques related to environmental measurement and purification treatment are increasingly required.

To meet these demands, Fuji Electric has developed and commercialized water quality sensors that utilize bioassay technology, compact environment-resistant sensors, and eco-monitoring systems that utilize radio transmission. Fuji Electric has also developed a system to compile a database for environmental information management using aggregated data.

4.2 Waste recycling

Waste recycling, sometimes described as a "vein-like industry", is the most important element in structuring a zero emission industry. Recycling requires technologies for reduction in volume, sorting, disassembly, reuse, recycling and effective use of energy.

Fuji Electric Group has, in the past, provided technologies and products for reduction in volume, sorting and disassembly, such as shredding equipment for bulky waste and induction heating equipment for waste plastics. Based on these experiences, and placing new emphasis on material recycling and thermal recycling, Fuji Electric Group is vigorously working to promote reuse and recycling by developing can, glass bottle and PET (polyethylene terephthalate) bottle recycling systems, ash melting systems and waste plastic dry distillation systems, and by developing energy utilizing RDF (refuse derived fuel) power plants, garbage-fermented methane gas power plants and other systems.

4.3 Clean energy and energy conservation

The introduction of clean energy and promotion of energy conservation is gaining attention as a means to reduce greenhouse gasses to prevent global warming.

Fuji Electric Group was one of the first companies to develop solar battery and fuel cell technology, and has provided a variety of power generation systems including wind, geothermal, wave and hybrid power generation systems for a variety of customers such as IPPs (independent power producers) and remote mountain cottages. For energy conservation, Fuji Electric provides energy conservation systems, such as inverters, power-saving equipment, high-efficiency motors, and energy conservation systems, such as cogeneration and heat accumulating systems using ice. Based on

the results from its own energy-conservation activities, Fuji Electric Group provides energy-conservation diagnostic service and ISO 14001 acquisition-support service.

4.4 Environmental information support system

With enactment of the Revised Energy Conservation Law and Environmental Impact Assessment Law, measures to preserve environment and conserve energy have become imminent. First of all, it is important to collect and utilize environmental information. Fuji Electric Group provides an environmental information support system comprised of environmental sensors and an information processing system. The support system features integrated support for a variety of application services utilizing flexible environmental sensors with wireless communication and advanced IT (information technology). The support system allows preparation of environmental reports, implementation of environmental accounting and connection to networks, such as the Internet, facilitating the disclosure of environmental information.

5. Fuji Electric's Efforts to Preserve Environment

In 1992, Fuji Electric formulated "Fuji Electric's environmental preservation basic policy" shown in Fig. 4 and is determined to do business in all fields by establishing specific targets for environmental preservation based on symbiotic relationships with the global environment.

5.1 Acquisition of ISO 14001 certification

In 1998, all of the Fuji Electric factories completed acquisition of the international standard ISO 14001 certification for environmental-management systems with the aim of understanding and reducing the environmental impact resulting from business activities. As a citizen of the global environment, Fuji Electric is continuously and systematically improving its environmental management as well as performing activities to reduce environmental impact.

5.2 Action programs

(1) Recovery of chlorofluorocarbons (CFCs) to protect the ozone layer

The use of CFCs and 1,1,1-trichloroethane, which had been used for many years as refrigerant in vending machines and open refrigerated cabinets, is completely banned. For CFCs still used in products on the market, Fuji Electric is considering recovering them in cooperation with local governments and parties concerned.

(2) Promotion of energy conservation for global warming prevention

With enactment of the Revised Law Concerning the Rational Use of Energy, the company established an energy conservation target to reduce energy per basic unit output by at least 1% per year. To be specific, the company has worked diligently to increase efficiency and decrease energy consumption of various facilities including air-conditioning systems, substations and heat treatment furnaces, and to introduce alternative energy and energy assessment at the time of investment in plants and equipment.

(3) Reduction in volume of industrial waste

While making every effort to reduce the volume of industrial waste, such as wastepaper, wood chips, waste plastics, sludge, waste oil, waste acid and waste alkali, the company thoroughly performs sorted collection of wastes and has organized disposal procedures for reuse and recycling after the sorted collection. The company also designs easy-to-disassembly products and uses recyclable materials, leading to an improved recycling rate of products.

(4) Product assessment of main products

During the development stage of a product, the company implements a rigorous product assessment of

Fig.4 Fuji Electric's environmental preservation basic policy

In promoting global environmental preservation and environmental pollution protection, Fuji Electric Group is determined to follow the following basic policy, understanding its responsibility to the global society as a citizen.
The whole Group is determined to do its very best, through its sound business activities, to strengthen the bond of trust with local communities, customers and business partners and to achieve harmony with the environment.

1. Reduction in environmental impact throughout products' life cycle
In providing its products to the market, Fuji Electric Group shall reduce the environmental impact as much as possible throughout products' life cycle from development, design, manufacturing, packaging, distribution, use to disposal.

2. Technology and products useful for global environmental preservation
Fuji Electric Group shall positively contribute to environmental preservation through providing the market with products in its areas of expertise, such as energy-saving equipment, alternative energy equipment, environmental measuring instruments and pollution prevention equipment, and their technologies.

3. Promotion of global warming prevention
To promote global warming prevention, Fuji Electric Group shall further reduce energy consumption and carbon-dioxide emission in-house, through encouraging energy-saving activities.

4. Promotion of resource saving and recycling
To effectively utilize the limited resources on the earth, Fuji Electric Group shall reduce the amount of materials used in its products and in manufacturing and packaging, and also reduce and recycle waste materials to the extent possible.

5. Improvement in working environment
To enhance employee health and safety, a precondition for active workplaces, Fuji Electric Group shall improve the working environment and facility safety, enhance workplace amenities and introduce advanced technologies at an early stage.

6. Environmental assessment during site selection of a new factory
When selecting a site for a new factory, Fuji Electric Group shall conduct an appropriate environmental assessment in advance, in consideration of environmental preservation.

7. Compliance with regulations and standards related to environmental pollution
Fuji Electric Group shall strengthen its management to obligate its employees to more strictly comply with regulations and standards for environmental preservation.

8. In-house audit
Fuji Electric Group shall perform an in-house audit of its environmental preservation activities to verify whether they are satisfactorily conducted.

certain items to determine the extent of a product's environmental impact throughout its life cycle from design, manufacturing, and use to disposal.

5.3 Fuji Electric Group's environmental logo

Fuji Electric Group adopted the environmental logo shown in Fig. 5, to express its commitment to environmental preservation.

6. Conclusion

This paper described Fuji Electric's environmental-preservation and energy-conservation technology development and its commercialization of that technology.

This paper does not cover the whole range of the company's activities related to environmental preservation and energy conservation. For further details refer to separate papers in this special issue.

The papers listed below describe Fuji Electric solutions to environmental preservation and energy conservation that are not covered by this paper.

Fig.5 Fuji Electric Group's environmental logo

(1) Fuji Electric Review: Water management technologies, Vol. 45, No. 4 (1999)
(2) Fuji Electric Review: General-purpose inverters and servo systems, Vol. 46, No. 2 (2000)
(3) Fuji Electric Review: Fuel cell generation, Vol. 4 7, No. 1 (2001)

Reference

(1) JAPAN TECHNICAL INFORMATION CENTER: American Environmental News, Vol. 8, No. 12 (2000)

Solutions for Waste Recycling and Zero-Emission

Masuhisa Hayakawa
Kiyomi Wada
Kazuteru Shinkai

1. Introduction

As we enter the 21st century, we inherit responsibility for important worldwide issues such as environmental problems. In order to attain a sustainable civilization where the global societies will maintain their existence and their economies will continue to function, we must change our vantagepoint and course of thinking to solve the problems.

In this paper, a general overview of the present situation of environmental issues in Japan will be reported. Next, the main products and systems of Fuji Electric related to recycling, resource recovery and the zero-emission of waste will be also described.

2. Environmental Issues and the Present Situation in Japan

Among the various environmental issues on the global scale such as ozone depletion and acid rain, the most important issues are global warming and the disposal of waste and toxic chemical materials. Needless to say, there are also many other important issues.

2.1 Countermeasures for global warming

The Kyoto Protocol was adopted at the COP3 (Third Conference of Parties of the United Nations Framework Convention on Climate Change at Kyoto) held in December 1997, to deal with the problem of global warming. The target of reducing each country's green house gas emissions was adopted, and Japan committed to reduce its emissions by 6% compared to 1990 levels, during the 5 years between 2008 and 2013. The achievement of this target depends on the degree of reduction of CO_2 emission, the main component of green house gas. Therefore, means to achieve these goals are being promoted through governmental instruction, guidance and regulation including a nationwide energy conservation campaign.

As a measure to promote these activities, the so-called "Revised Energy Conservation Law" was enacted and a novel competition principle, the so-called "Top Runner Principle" was introduced as a new philosophy. New products must now be designed in consideration of energy conservation and recycling principles. In addition, the promotion of clean energy with less emission of CO_2 has been requested.

2.2 Waste issues

Wastes issues include the overflow of discharged waste in residential areas and the subsequent deterioration of residential environment condition. Japan is now in a critical situation. The final landfill sites for municipal waste and industrial waste will remain only for several more years, and therefore this is one of our most urgent issues. Furthermore, environment pollution due to the dioxins generated at incineration plants has become a reality, and in response our government has enacted regulations.

In order to find a solution to the waste issues, it is required for every company, every municipal and every local community to implement a "zero-emission policy" to bring the discharge of waste to zero without exemption. Such a zero-emission policy aims for a society in which no waste will be discharged over the life cycles of all productive operations, all service operations and all products. To that end, in the case of manufactured products as an example, strategies to "Reduce" (reduce waste generation), "Reuse" (reuse products and parts) and "Recycle" (resource recovery) shall be considered at each stage of design, manufacturing, distribution, consumption and disposal. This concept shall be realized not only within each company at the intra-company level, but also among companies at the inter-company level, at the local community level (an Eco-town plan, for example), and further on the global level. This concept is shown in Fig. 1.

2.3 Toxic chemical material issues

Toxic chemical material problems occurred frequently in the 1960s and 1970s as a result of "environmental pollution" in a specific area and due to a specific cause. However, because various types of chemical products have become common today, toxic chemical material issues have recently become broad issues not limited to a specific area and specific cause. The total quantity of toxic chemical material released or leaked into the environment by all the companies

Fig.1 New concept of recycling

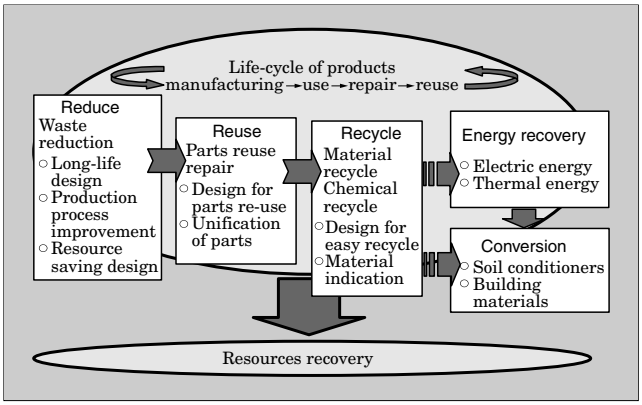
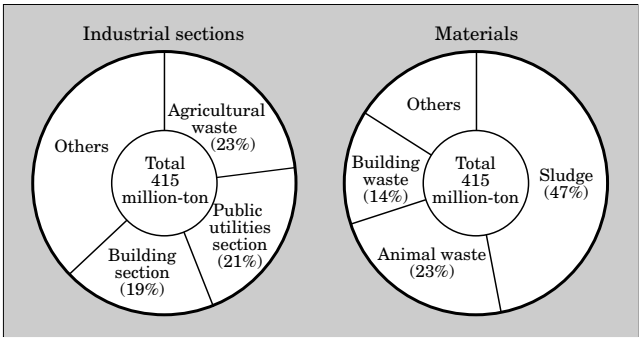


Fig.2 Industrial waste distribution in Japan



engaged in production and service operations, as well as by consumers, has created serious environmental issues. Many chemical substances are extremely toxic to the human body even in minute quantities, such as polychlorinated biphenyl or dioxins.

In order to cope with these issues, the "Law of Pollutant Release and Transfer Register" has been legislated and enacted from early this year. This law requires that the transfer and release of toxic chemical material must be registered and officially announced. Furthermore, the "environmental endocrine" problem is one of the toxic chemical material issues. It was learned recently that when this endocrine, even in extremely small quantities, affects a living organism for a specific period during the growth of that organism, normal hormone action is disrupted and the generative function and other functions are seriously affected. This is an important issue for which scientists shall endeavor to put forth a scientific explanation.

2.4 Present situation of waste discharge in Japan

The quantity of waste discharge in Japan is 50 million tons of "municipal waste" annually discharged from residences and offices, and 400 million tons of "industrial waste" annually discharged. These amounts have remained almost constant during the last 10 years.

The top three industries that produce industrial waste are construction, agriculture and public utilities. A breakdown by material type of industrial waste shows that sludge is ranked as the most prevalent type of waste, animal waste is ranked second and construction waste is ranked third.

Figure 2 shows the industrial waste distribution in Japan.

Recycling and resource recovery are indispensable future themes in Japan, in particular, drastic measures are needed to counter the tremendous amounts of industrial waste. On the other hand, recycling of the most voluminous containers and packages has become an issue in municipal waste.

2.5 Policies and regulations aiming for zero-emission

Various bills relating to environmental issues have been approved in the Diet of Japan in recent years.

A system of governmental laws aiming for a "society that recycles" and for zero-emission has being prepared through successive enactment of the "Dioxins Law", "Building Materials Waste Recycling Law", "Food Waste Recycling Law", "Containers and Packages Recycling Law", "Pollutant Release and Transfer Register Law", and "Home Electronics Recycling Law."

In addition, some cities have started planning locally to realize the concept of an "Eco-town", targeting resource recovery and the recycling of waste. Future developments can be expected.

3. Efforts of Fuji Electric to Provide Systems, Equipment and Services to Realize Zero-Emission

In order to realize the zero-emission society that aims to be without waste, Fuji Electric Group endeavors to incorporate the concept of zero-emission from all aspects.

The systems, equipment and services utilized for the treatment and resource recovery of discharged waste are provided in connection with the following fields in each phase of a product's life cycle:

(1) Waste collection, crushing, and size reduction system
(2) Waste separation system
(3) Waste resource recovery system
(4) Waste energy utilization system
(5) Clean energy system
(6) Waste management service system

3.1 Hot bind

In order to treat plastic waste, size reduction is required first due to the bulkiness and very small apparent specific gravity of the waste. The "Hot Bind" system reduces the waste size by the method of induced heating, rather than incineration, and enables the formation of cubes with side dimensions of 40, 50 or 70 cm. The bulky waste plastic is reduced in size by approximately 1/15 to 1/20. The cubic shape facilitates stacking; this is highly advantageous for the effective

use of space, since cubic blocks can be stacked in an orderly manner whether at a landfill site or temporary depot.

Figure 3 shows an example of the apparatus.

3.2 Ash melting system

This is an ash melting system in which the incinerated ash is reduction melted in an electric resistance reactor to make harmless materials. The ash is reproduced into harmless, high-purity and high-grade slug. Artificial sand with good quality suitable for building materials can be obtained through further thermal treatment. A demonstration test with 12 tons/day has already been performed.

Figure 4 shows general idea of this system.

3.3 Dry distillation system

In the case of treatment of waste containing plastic, because such waste may contain polyvinyl chloride, there is the possibility that dioxins may be generated if incinerated. However, this problem is solved by the dry distillation system (thermal decomposition without oxygen).

Through the dry distillation of waste containing plastic, the waste is separated into carbonaceous residue and decomposed gas. The decomposed gas can be converted into oil by re-cooling. Differing from the incineration, dioxins are not generated even in a chloride atmosphere because oxygen is not supplied; consequently, this is an environmental friendly system. The product of carbonaceous residue and distilled oil can be recycled effectively.

Fuji Electric developed the original induction heating system, instead of an oil burning system, as a heating source for dry distillation. Because the induction heating system can precisely control temperature, it has various merits such as clean heating, high efficiency of input energy and an optimal decomposition process corresponding to the type of waste plastic.

Fig.3 Waste plastics treatment system

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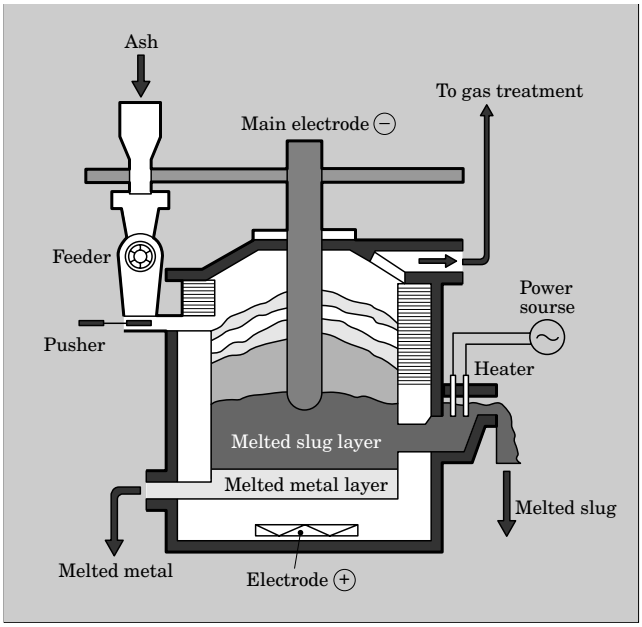
Fig.4 Ash melting system



3.4 Recycle plaza

Waste collected from residences and from the streets is processed with an intermediate treatment (crushing, separation) at the treatment plants and then recycled at so-called recycle plazas or recycle centers.

These plants are comprised of a crushing system, a glass bottle separation system, a steel and aluminum separation system and a plastic size reduction system.

Figure 5 is a photograph of a typical plant.

3.5 Final landfill site system

After the waste is recycled and treated intermediately, the final residues are deposited at a landfill site. At a final landfill site, the dirty water is treated into a suitable state as prescribed by environmental regulations through aeration, coagulating sedimentation, high-grade treatment with active carbon and/or sand filtering.

Figure 6 is a photograph of a typical system.

Fig.5 Recycle center

Fig.6 Landfill water treatment system

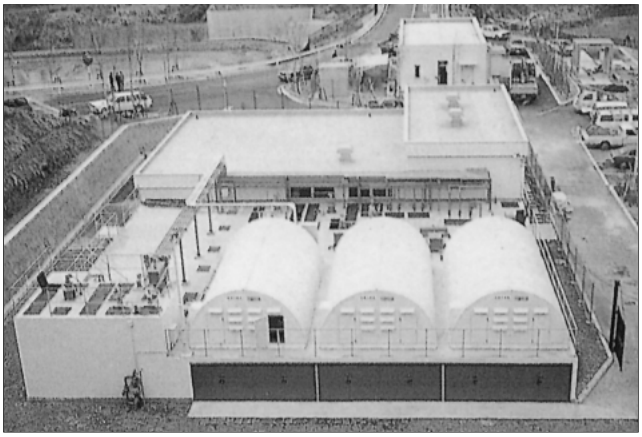


Fig.7 Fuel cell for biogas

3.6 Solid waste fuel (RDF) power generation system

RDF (refuse derived fuel) is solidified waste fuel and has enhanced transferability and storability characteristics. For this purpose, the municipal waste generated in each local area is processed into RDF; then the RDF collected from numerous bases over a wide area is concentrated at a single site, and burned. As such, this system makes possible a highly efficient system of power generation from waste.

3.7 Biogas power generation system

A biogas power generation system utilizes methane gas to generate electric power. The methane gas is generated by the anaerobic fermentation of organic waste such as raw organic waste and animal waste. The types of waste applicable to biogas power generation systems cover a wide range and include organic waste from residential and restaurant kitchens, food waste from food markets and factories, animal waste, agricultural waste, and sewage sludge. The available power generation systems are gas engines, gas turbines and fuel cells. Cogeneration is also possible.

Fuji Electric has demonstrated and is promoting practical applications of a 100kW-class power generation system equipped with phosphoric acid fuel cells that utilize fermented methane.

Figure 7 is a photograph of a typical system.

3.8 Management of waste through "SCM" system

It is possible to manage electronic manifest data by utilizing communication satellites and the global positioning system ("SCM" system). Through enabling the real-time monitoring of waste transportation routes, this system makes it possible to verify that waste is being treated legally and it facilitates management of car operation. Since this system communicates via satellites, all the land in Japan, including the mountainous areas, are included in the service area. This service is operating from a network center based in Tokyo.

4. Conclusion

In this paper, the present situation of environmental issues in Japan as well as the main products, main systems and services provided by Fuji Electric have been presented.

Last year (in the year of 2000), various bills related to environmental issues, including global warming and the waste problem, were approved in the Diet of Japan. Some of them have been enacted as of 2001. At the beginning of the 21st century, we are entering the real environmental age, and therefore the residents, companies, public utilities and government administrations must make every effort to cooperate in these efforts.

Waste Treatment Using Induction-Heated Pyrolysis

Katsuhiro Nakanoh
Shizuo Hayashi
Kiyonori Kida

1. Introduction

Japanese waste treatment policy has been developed with emphasis on incineration, aiming to reduce the quantity of waste at final landfill sites. Although incineration has been the major waste treatment method until now, the recent increase in quantity and diversification of types of waste are forcing a shift in policy from the exclusive promotion of waste incineration to policy that also promotes reduction of waste generation itself as well as reduction of waste quantity through reuse of the waste and its restoration as a resource.

Also, the negative environmental impact of emissions from incineration, including atmospheric and soil pollution, has become problematic and advanced technologies are required especially to limit the generation of dioxins.

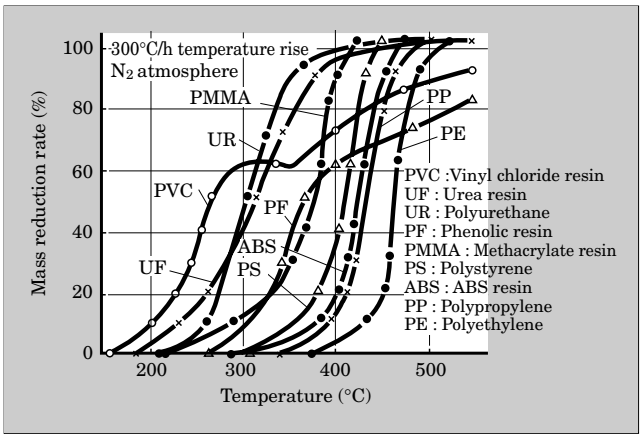
At present, 50 million tons of general waste is generated annually (including about 4 million tons/year of waste plastics), of which about 75% is incinerated. Associated with this incineration are important issues that must be resolved.

As an alternative to incineration, pyrolysis technology was developed in the 1970s to limit the generation of dioxins. This is a technology for decomposing organic materials into gases, liquids and solids by heating them in an atmosphere where there is little or no oxygen content. Its practical use and popularization in the future is expected.

Heat sources generally utilize combustion heat (as hot air, steam, exhaust gas etc.) of fossil fuels (oil, gas, coal etc.). Heating of the pyrolysis tank by electric resistance heaters is also utilized.

Fuji Electric has manufactured an induction-heated kiln type continuous pyrolysis demonstration apparatus, as an alternative to combustion type equipment, and performed experiments for treating waste plastics. An overview of this newly developed pyrolysis apparatus is presented below.

Fig.1 Pyrolysis temperatures and mass change of various types of plastics



2. Pyrolysis of Plastics

2.1 Mechanism of pyrolysis

It is well known that plastics in general decompose into oil and gas when isolated from air (oxygen) and heated to 200 to 400°C. The progress of pyrolysis differs considerably depending upon the type of plastic and the pyrolysis temperature. An example is illustrated in Fig. 1. Polyvinyl chloride (PVC), for example, decomposes at 200 to 250°C primarily and at around 350°C secondarily, generating hydrogen chloride, hydrocarbons (gases and liquids) and solid (cinders). The decomposition is completed by most polymers at 250 to 450°C.

The combustion of organic compounds in the presence of air or oxygen generates carbon dioxide, steam and cinders (ashes) and, furthermore, combustion of plastics that contain chlorine such as PVC generates the problematic dioxins. Performing pyrolysis on these materials in an environment isolated from air (oxygen) causes dechlorination, breaking of C-C bonds and C-H bonds, or recombination with various ratios of generated gases, liquids and solids depending upon the different chemical structures and size of molecules and the pyrolysis temperature and speed. The resultant generated gases include carbon, hydrogen and hydrogen chloride and generated liquids include benzene and toluen, but no dioxins, which are compounds containing oxygen. The chemical structure of dioxins are shown in Fig. 2.

Fig.2 Chemical structure of dioxins

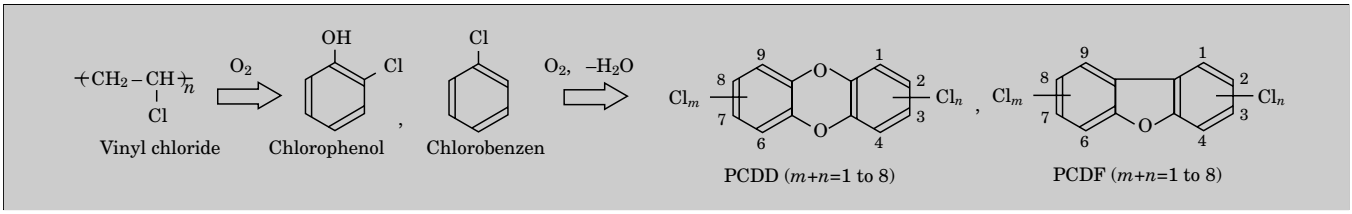
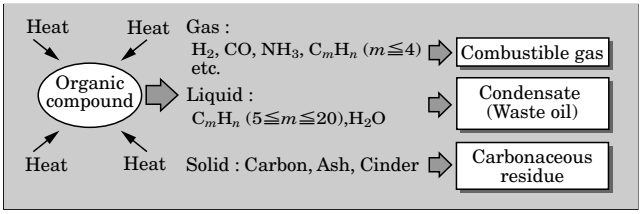


Fig.3 Pyrolysis process



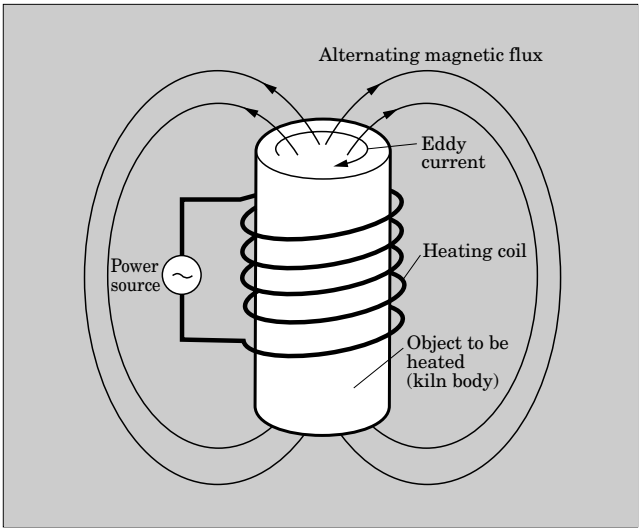
The apparatus reported herein, a so-called dry distillation device, decomposes organic compounds by heating them in an environment isolated from gases such as oxygen, air, carbon dioxide and steam that contain oxygen, a factor which causes the generation of dioxins. "Dry distillation" is a process for decomposing organic compounds by heating them under no or lean oxygen conditions into the three flows of gas, liquid and solid respectively. The term "dry distillation" is used as a synonym for pyrolysis. Figure 3 shows the pyrolysis process.

2.2 Electric heating process for pyrolysis

Fuji Electric has been manufacturing electric heating systems for various types of heating processes. In the treatment of waste plastics, which has become a serious public concern, the problems are how to reduce waste volume while preventing the generation of dioxins, as well as how to progress toward the recovery of valuable materials and toward zero emission. Due to the present societal concerns, it is expected that practical application of pyrolysis technology to waste plastics will be realized. For wastes such as commercial waste having evident properties and consisting of a single type of waste, the treatment can be optimized by selecting a heating process suitable for the waste properties. But municipal waste involves different treatments for different types of waste, and this is why pyrolysis is needed. Electric heating is optimal for the required heating process, and induction heating is the most reasonable technology.

The principle of induction heating is shown in Fig. 4. When a metal body (kiln body) is inserted into a coil connected to an alternating power source, alternating magnetic flux flows through the kiln body. This flux induces electromagnetically an eddy current in the kiln body, which creates Joule heat, raising the temperature of kiln itself. This is induction heating. As the conditions of the enclosed atmosphere to be heated can be maintained at will, and temperature can

Fig.4 Principle of induction heating



be rapidly controlled, it is an excellent heating process for preventing dioxin generation.

3. Induction-Heated Kiln Type Continuous Pyrolysis Apparatus

3.1 Construction of apparatus and outline of system

The construction of the pyrolysis apparatus used for the demonstration test is shown in Fig. 5, the external view of the demonstration test apparatus in Fig. 6 and its specifications in Table 1. The demonstration test apparatus was manufactured for the purpose of treating waste plastics while suppressing the generation of dioxins. The plastics waste, which is collected in cities and towns, is fed into the input mouth and first compressed to a volume of about 1/15 through a screw feeder and then transferred to the kiln. The feeder is constructed such that the air from input mouth is automatically shut off and sealed by the compressed plastics waste. The kiln is constructed such that its interior is maintained at a very low oxygen condition by introducing N_2 gas into it and being insulating from the external atmosphere. As induction heating coils are installed at the periphery of the kiln body, the kiln body is heated by the induced heat directly, which heats up the input plastics waste. The temperature at certain points inside the kiln is measured by means of thermocouples, and feedback control is applied to maintain a predetermined temperature. The input plastics waste is heated up very

Fig.5 Construction of pyrolysis apparatus

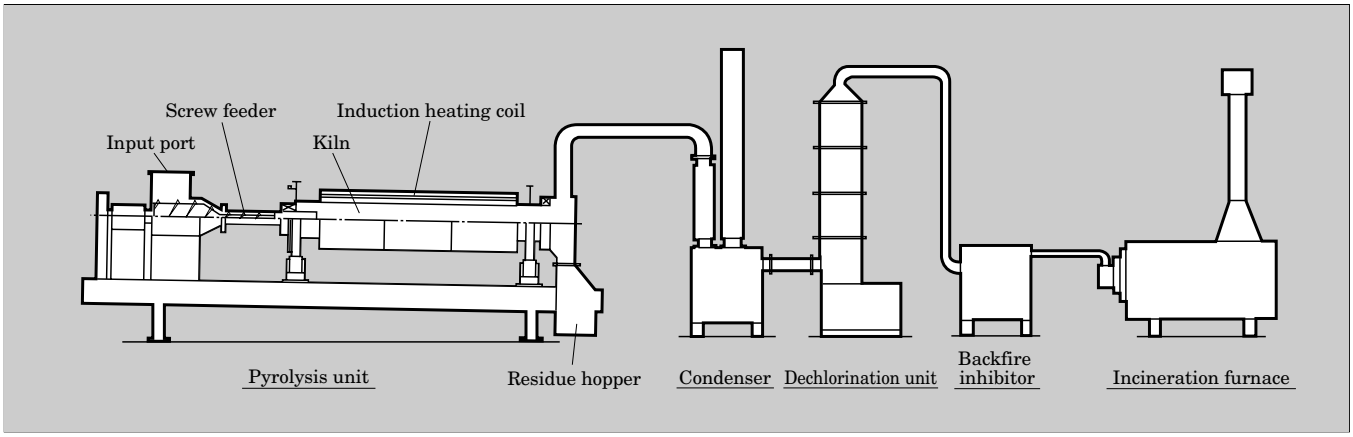


Fig.6 External view of demonstration test apparatus

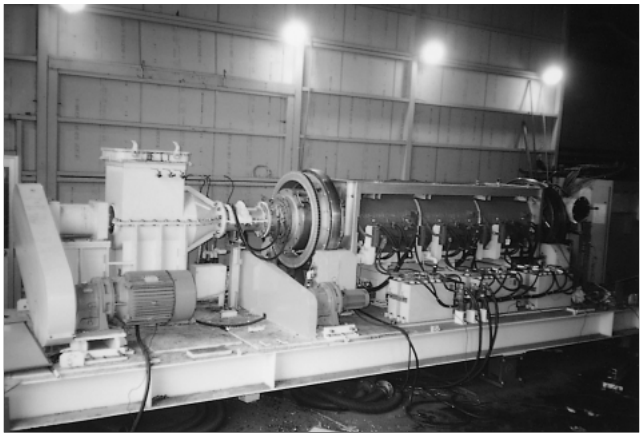


Table 1 Specifications of demonstration apparatus

Item	Specification
Waste plastics treatment capacity	100 kg/h
Kiln heating temperature	450 to 700°C
Pyrolysis temperature	500 ± 50°C
Heating method	Induction heating
Waste plastics input method	Screw feed mechanism
External dimensions of kiln	ø500×3,500 (mm) long
Atmosphere in kiln	Filled with N_2 gas
Dechlorination	Treated in later stage after heating in kiln
Heating power source capacity	100 kW

quickly in the closed space, kept at a high temperature of 500 ± 50°C, decomposed by pyrolysis in a very short time, and separated into carbonaceous residue and gas. The carbonaceous residue is fed to a hopper at the exit of the kiln. The gas is cooled in a condenser and separated into condensate and a combustible gas. The condensate is collected in a storage tank and the combustible gas is fed into a combustion furnace via a dechlorination unit and a backfire inhibitor.

3.2 Advantages of the apparatus

The apparatus has many advantages owing to the use of induction heating.

(1) Heating treatment method having a low possibility of dioxin generation

The generation of dioxins becomes prominent in an oxidizing atmosphere. As this method indirectly heats waste in a sealed inactive gas atmosphere without applying combustion flames directly to the waste to be treated, dioxin generation resulting from the existence of oxygen is extremely low in this treatment.

(2) Rapid heating and easy temperature control

The rapid heating property of induction heating makes rapid passing through the low temperature region (200 to 300°C) possible, where dioxins are apt to be generated. Furthermore, because induction heating has good temperature response characteristics, the apparatus is able to control temperature accurately and to keep the heated region at its required temperature.

(3) High energy efficiency

Induction heating has a heating efficiency of 85%, which is higher than that of other methods which use the kiln itself as the heat generating body. Furthermore, there is no decrease in efficiency caused by the adhesion of soot, as is seen in the combustion type.

(4) No restriction in the types of waste to be treated

Even in cases where scrap cans, dirt and sand are mixed into the plastics waste, treatment is possible without any problem; namely, any type of dust can be treated.

(5) Various operations are possible, ranging from continuous operation to batch operation

This apparatus is compatible with various operations ranging from continuous operation for 24 hours/day to batch operations, in which daily heating and cooling are repeated, and thus may be set up for a wide range of applications, from company use to personal use.

(6) Low equipment cost

There is no need to install a high temperature flue gas duct, as is required for large scale treatment

Table 2 An example of demonstration test results

Item	Measurement	After post-treatment
Waste plastics input quantity	300 kg	
Pyrolysis temperature	520°C	
Generated carbonaceous residue quantity	32.9 kg (10.9%)	
Carbonization degree of carbonaceous residue	96.0%	
Chlorine concentration in carbonaceous residue	62 g/kg	
Dioxin concentration in the residue	Not more than 0.016 ng-TEQ/kg	
Oleaginous condensate quantity	182.8 kg (60.9%)	
Oleaginous condensate property	Specific weight: 0.87 crude oil level	
Chlorine concentration in oleaginous condensate	218 mg/L	4.5 mg/L
Dioxin concentration in oleaginous condensate	Not more than 0.040 ng-TEQ/g	
Calorific value of oleaginous condensate	12,000 kcal/kg	
Combustible gas quantity	84.3 kg (28.2%)	
Dioxin concentration in exhaust gas from combustible gas combustion	Not more than 0.98 ng-TEQ/m^3N	

facilities, and there is also no increase of exhaust gas generated by burner. These simplify the post-treatment, resulting in lower total equipment costs.

3.3 Demonstration test results

The demonstration tests using waste plastics provided by city A and city B are still ongoing, but the test results up through the present are reported as follows. An example of the test results is shown in Table 2, the test materials (input plastics) and test products are shown in Fig. 7, and the concept and material flow of the induction-heated pyrolysis apparatus are shown in Fig. 8.

The reduction in volume and weight of waste plastics for a pyrolysis temperature range of 500 ± 50°C resulted in carbonaceous mass being reduced to 1/10; a carbonization level of 96.0% was achieved and a dioxin level of lower than the specified value was secured. The generation rates of oleaginous condensate and combustible gas change remarkably depending upon the pyrolysis temperature; the generated quantity of combustible gas increases dramatically at temperatures above 550°C. The oleaginous condensate has a specific weight of 0.87, which is the level of crude oil, and has a calorific value of 12 kcal/g. The chlorine concentration is a little high, but can be reduced by post-treatment with alkaline water. It is very likely that the condensate will be used as recycled oil or fuel oil. The combustible gas is combusted secondarily; however, dioxins generated in exhaust gas are below the specified value. This is likely to be used as a fuel

Fig.7 Test samples and test products

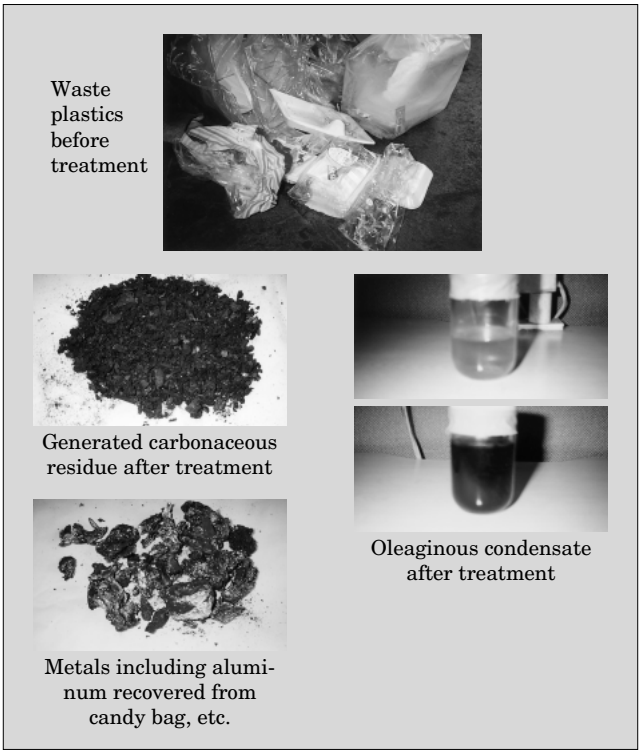
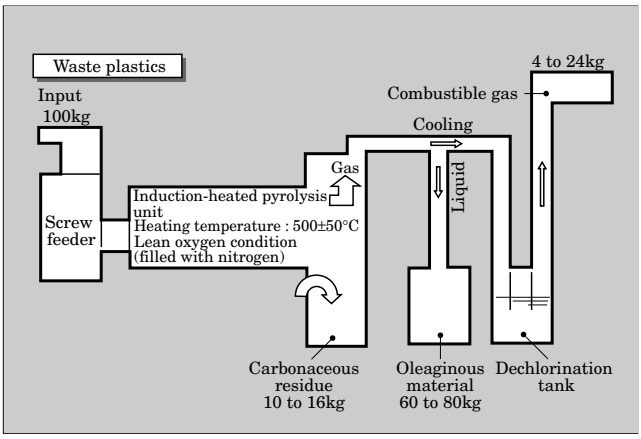


Fig.8 Concept and material flow of induction-heated pyrolysis apparatus

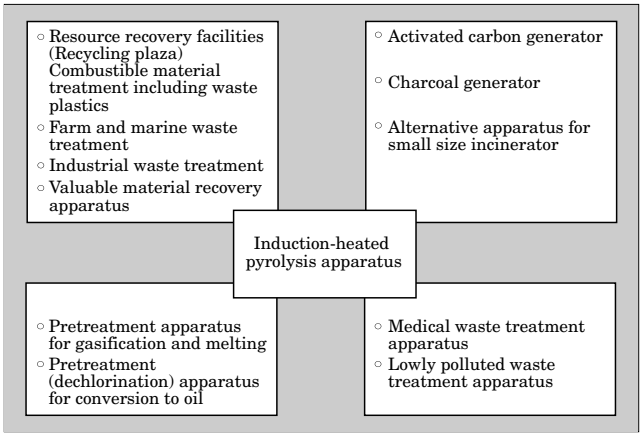


for small size boilers, etc. The residual metals, mainly aluminum, in the carbonaceous residue are interesting. Very thin film materials used for food packaging can be recovered as metal without oxidation.

4. Application Area of Induction-Heated Pyrolysis Apparatus

This pyrolysis apparatus, which suppresses the generation of dioxins, has a wide range of applications such as to waste treatment equipment and recycling equipment. With its temperature- and atmosphere-control characteristics, we are convinced that this pyrolysis apparatus will contribute to our environment-conscious society, which is struggling with many

Fig.9 Scope of application of dry distillation apparatus



problems in waste treatment. Such contributions will include its application as waste treatment apparatus and pre-treatment apparatus for recycling. The possible application range of the technology is shown in Fig. 9.

5. Conclusion

Tests using the induction-heated kiln type continuous pyrolysis demonstration apparatus have been almost completed and we believe that the initial targets of suppression of dioxins and weight and volume reduction of waste plastics have been achieved. On the basis of these results, we are going to design practical apparatuses, through which we hope to be able to contribute to the areas of waste treatment and recycling, which have become serious problems in our environmental-conscious society.

Waste Transportation Tracking and Monitoring Service Using Satellite Communications

Kohichiroh Muneki
Mitsuhiro Nakamura

1. Introduction

Speculation is abounding about environmental pollution due to the illegal dumping of industrial waste. In response, the National Police Agency has ordered a strict crackdown on acts that harm the environment as "environmental crimes." A movement toward clarifying waste-emitting companies' responsibility for violations, such as the commissioning of waste-disposal to unauthorized enterprises, is growing in intensity day by day.

Meanwhile, the problem of general waste being illegally transported to low-cost trash incineration plants in other municipalities is becoming increasingly serious. The municipality that receives the waste is forced to bear a large amount of the disposal cost, and the result imposes an economic burden on the residents. Moreover, as in the case of deadly poisonous dioxin, serious health and environment problems can also arise.

To improve and modernize the waste-disposal industry, NISSCOM Inc. started commercialization of the "Industrial Waste's Electronic Manifest Data Management System" in September 1997. Fuji Electric entered into a business tie-up with NISSCOM Inc. in 1998, and based on the system, developed a new application system. Now, both companies are jointly promoting their environmental information service, "SCM (satellite communications management) Information Service", which utilizes the new system. This paper introduces that service.

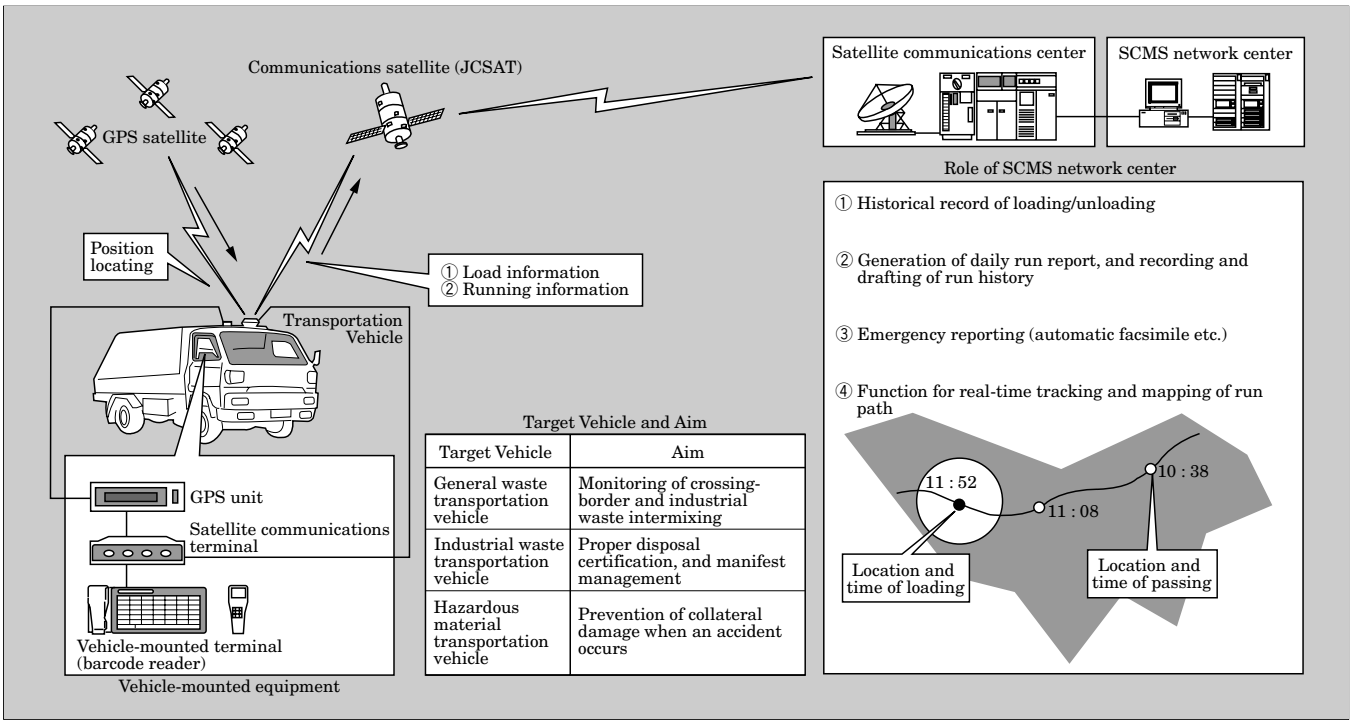
2. Overview of SCM Information Service

Figure 1 shows an overview of the SCM information service system.

(1) Overview of the service

Using the GPS (global positioning system) and a

Fig.1 Overview of SCM information service system



Target Vehicle and Aim

Target Vehicle	Aim
General waste transportation vehicle	Monitoring of crossing-border and industrial waste intermixing
Industrial waste transportation vehicle	Proper disposal certification, and manifest management
Hazardous material transportation vehicle	Prevention of collateral damage when an accident occurs

communications satellite and acting on behalf of the user, this service tracks and monitors the movement of transportation vehicles and the waste loaded on them to verify that the waste is properly treated. Further, this service provides users with various types of information.

(2) Telecommunications infrastructure

The telecommunications infrastructure used in the service is based on the "OmniTRACS" truck operation management system developed by Qualcomm Inc., a major U.S. telecommunications corporation. The infrastructure has been applied to waste management systems. Moreover, the service uses the "JCSAT" communications satellite, which is stationed southeast of Japan at an altitude of 36,000 km.

(3) Vehicle-mounted equipment

Each transporting vehicle is equipped with a satellite communications controller, an antenna, a GPS locating unit, a barcode reader, and a dedicated terminal.

(4) Features of the service

(a) The service area covers the entire country

Because satellite communications is utilized, the service can be used anywhere in Japan, including illegal waste dumpsites in mountainous regions or local areas.

(b) The service provides a system scaled to the user's needs

To obtain the service, collection/transportation enterprises just need to rent the necessary number of vehicle-mounted devices, corresponding to their own scale.

(c) The service promotes modernization of business operations systems

Office cost and time can be extensively reduced by modernizing business operations for waste disposal.

The waste transportation vehicle tracking and monitoring service is one practical example of the SCM information service. Waste is broadly divided into industrial waste and general waste. The service for each type of waste will be introduced below.

3. Application to Industrial Waste

3.1 Problems of industrial waste disposal

(1) Manifest management system

The waste disposal and clean-up law obligates industrial waste to be operated with the "Manifest System" (industrial waste-disposal voucher system) that controls the waste disposal flow with vouchers. The system regulates the following: the entry of required items in the so-called manifest vouchers, such as the waste classification, name, and handling precautions; the conveyance of necessary information from waste-emitting companies to transportation and disposal companies; and verification and recording that the waste has been properly transported and disposed, based on reference to the manifests retrieved from the final disposal companies.

However, forged manifests are appearing in some areas and the system is being somewhat enforced in name only.

(2) Greater responsibility for waste-emitting companies

The recently revised waste disposal and clean-up law obligates waste-emitting companies to take responsibility for their waste, until the final disposal stage. This requires the waste-emitting companies themselves to verify that the waste is indeed brought to a disposal plant and disposed.

3.2 Industrial waste transportation tracking and monitoring service

To solve the above-mentioned problems, the service, acting on behalf of a waste-emitting company, manages the manifest vouchers and monitors whether the waste itself is properly transported and disposed.

(1) Operation method (Fig. 2)

(a) Task of waste-emitting company (Fig. 2 ①)

The waste-emitting company buys special stickers (hazard labels) each with a barcode that contains data of the emitted waste classification, name of company division that is emitting waste, etc. Then, the company affixes the hazard labels for each waste-emitting company division on conventional dedicated waste containers or collection/transportation vehicles.

(b) Task of collection/transportation enterprise (Fig. 2 ②)

When collecting waste, the collection/transportation enterprise uses a vehicle-mounted barcode reader to read the hazard labels affixed by the waste-emitting company and the barcodes printed on received manifest vouchers. Then, the collection/transportation enterprise transmits that information via a communications satellite.

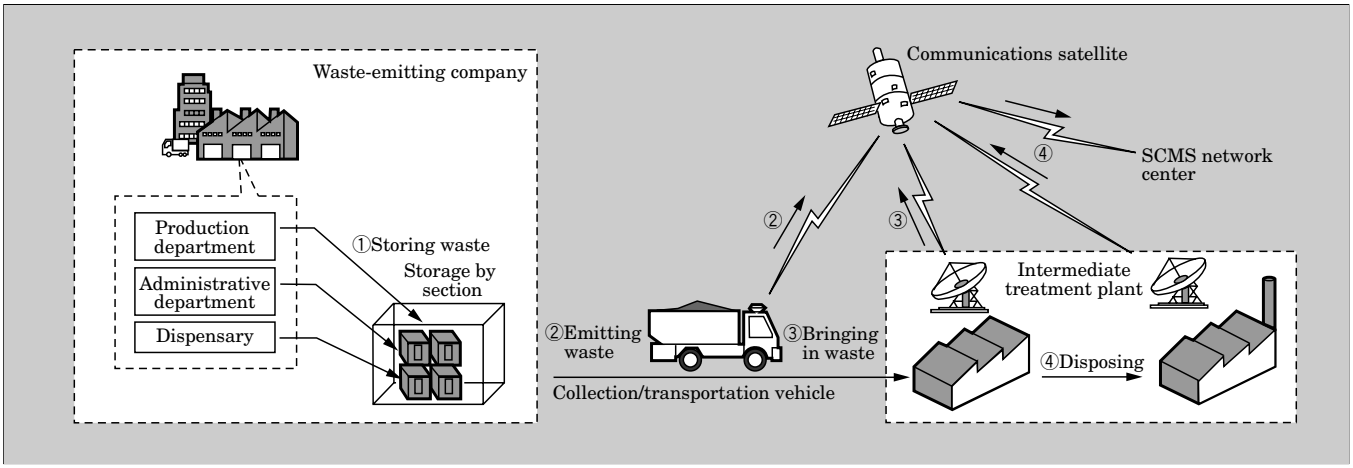
(c) Task of disposal plant (Fig. 2 ③, ④)

The disposal plant reads the barcodes printed on the hazard labels using a ground terminal installed at the plant, and transmits that information via the communications satellite.

(2) Service description

Through the above operations, various information is aggregated at the system network center via the communications satellite. The information includes the classification and mass of waste emitted from businesses, the historical records of a collection vehicle's run track, and the classes and masses of waste brought into waste treatment plants. The data obtained for waste collection is instantaneously compared with that obtained for the waste received at waste treatment plants. Any discrepancies are reported to the waste-emitting companies and the collection/transportation enterprises. In some cases, reporting to the supervising administrative agencies enables acci-

Fig.2 Operation of industrial waste transportation tracking and monitoring service



dents to be prevented and facilitates a rapid tracking down of the cause of the discrepancy (accidents including missing or illegal dumping of waste).

Waste-emitting companies, collection/transportation enterprises, and disposal plants are each obligated to submit disposal reports to the administrative agencies. The information service also includes means to prepare these reports by proxy.

(3) Effects of introducing the service

By tracking and monitoring the manifest vouchers, waste, and transportation vehicles, the waste-emitting companies can more efficiently implement manifest management and can reliably certify that proper waste-treatment is being performed.

The collection/transportation enterprises can achieve improved vehicle operating efficiency and can more efficiently implement manifest management with the service acting on behalf of the enterprise to manage operation of each vehicle's operation and automatically generate daily run reports.

3.3 Linkage with sectional aggregate management system

The SCM information service is used to verify and certify that waste from emitting companies has been properly disposed. Meanwhile, waste-emitting companies are struggling to initiate recycling activities and reduce trash through sectional metering management of the waste (including valuable substances) generated from their own places of business. The sectional metering management system described in this section proposes a solution for the above-mentioned needs.

(1) Sectional waste-emissions management system

In this system, a bar-coded label on which is printed the waste item and the emitting section name is affixed to each sorted small waste bag emitted from the various sections, as shown in Fig. 3. At a block collection site, each barcode is read and, at the same time, the mass of each bag is automatically measured. One general server controls the collected data in a uniform way, aggregating the data monthly by section and item, and supports information disclosure to each section's client.

(2) Manifest management linkage system

This system supports printing of the manifest vouchers and the hazard labels required when collected and sorted waste is commissioned to a collection/transportation enterprise. This allows a seamless link with the SCM information service. Moreover, the system can manage and distinguish collected waste commissioned this time from that postponed until next time. Furthermore, it prepares reports to submit to the administrative agencies based on the information from the manifest vouchers issued or retrieved.

4. Application to General Waste

4.1 Problems of general waste

Unlike industrial waste, each municipality is responsible for disposing of general waste. General waste is disposed in the trash incineration plant operated by each municipality. The inflow of waste into the plant is managed by allowing plant access only to authorized waste transportation vehicles.

However, many problems have been reported in the mass media, including the so-called "crossing-border waste problem" in which some general waste collection/transportation enterprises authorized by more than one municipality bring other municipalities' waste into low-cost municipal treatment plants, and the "industrial waste intermixing problem" in which industrial waste collected in transit storage yards or intermediate treatment facilities is mixed with general waste and brought into a municipal incineration plant.

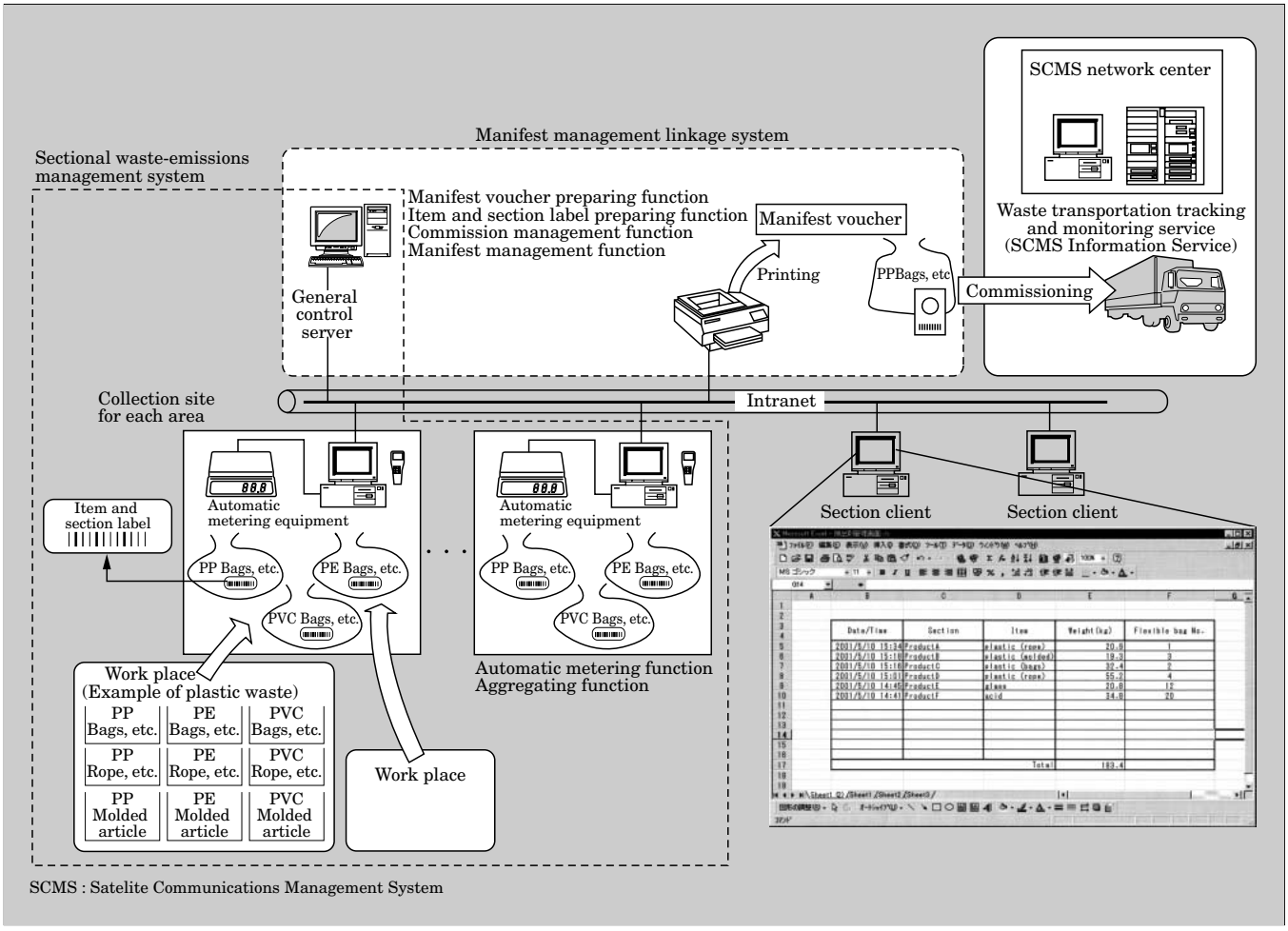
4.2 General waste transportation tracking and monitoring service

Figure 4 shows an overview of the general waste transportation tracking and monitoring service.

(1) Operation method

In addition to the GPS and the satellite communications equipment, each waste-collecting vehicle is equipped with a sensor that detects the start of

Fig.3 Overview of sectional aggregate management system



operation of waste loading equipment (packer) and a sensor that detects the dumping operation to emit waste. When either sensor detects operation, that information, together with GPS position data (latitude and longitude information), is transmitted to the system network center via the communications satellite.

Based on the received information, the system network center grasps where and in which municipality the waste was collected and to which plant it was transported. The center manages all of the data, and checks whether any violation exists. If a violation occurs, the center provides the trash incineration plants with the information described below in advance and prevents illegal waste from being brought in.

(2) Service description

(a) Crossing-border waste notification service

From GPS position data (latitude and longitude) at the time when the packer first began operation, the service determines the municipality in which the concerned vehicle works.

Next, the service investigates the location in detail every time the packer starts, and constantly checks whether the vehicle loads waste at any location other than in the municipality where the work is authorized. If a violation is detected, the service faxes the car number, together with notice of the loading in other municipalities, to the trash incineration plant.

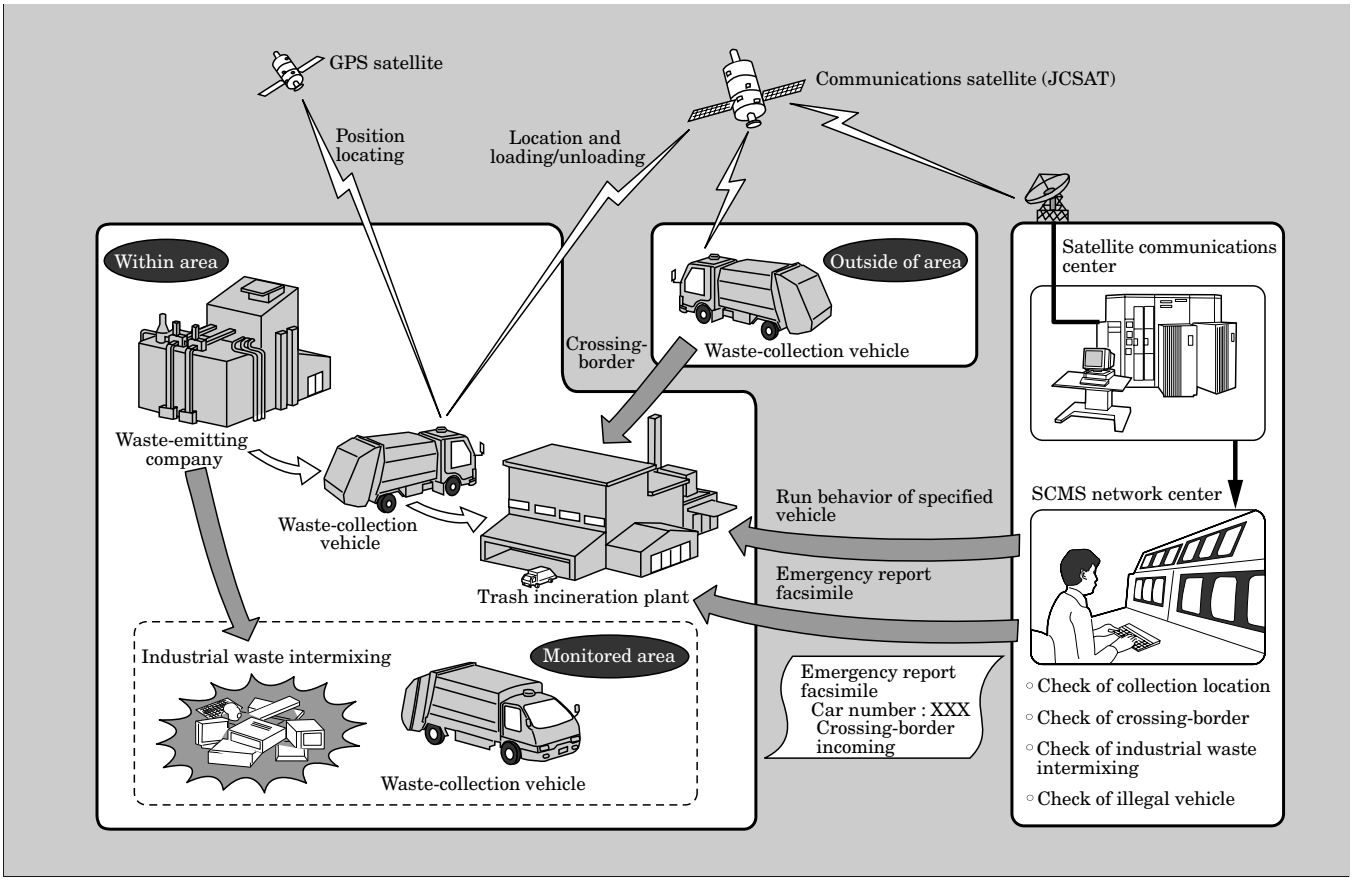
(b) Industrial waste intermixing notification service

The service registers the transit storage yards for industrial waste as areas to be monitored. Then, once the service detects that industrial waste has been loaded at these areas, it faxes the car number, together with notice of the illegal loading, to the trash incineration plant.

5. Conclusion

This paper has introduced an application of the SCM information service to waste transportation vehicles. In addition, another information service is now under development for crisis management use; if vehicles transporting dangerous or deadly toxins are involved in an accident, the system will rapidly report the load information, its treatment method, and medical countermeasures if an individual is exposed to the toxin. The system aims to save lives and prevent

Fig.4 Operation of general waste (business-owned) transportation tracking and monitoring service



disposal accidents without delay, and also to prevent collateral damage and to keep neighboring residents safe.

Fuji Electric continues striving to solve users' problems through extending applicability of the SCM information service toward a comprehensive environmental information service.

The Preservation of Environmental Health via Water Treatment Processes and Clean Energy Practices

Norimasa Nonaka
Kazumi Hirano

1. Introduction

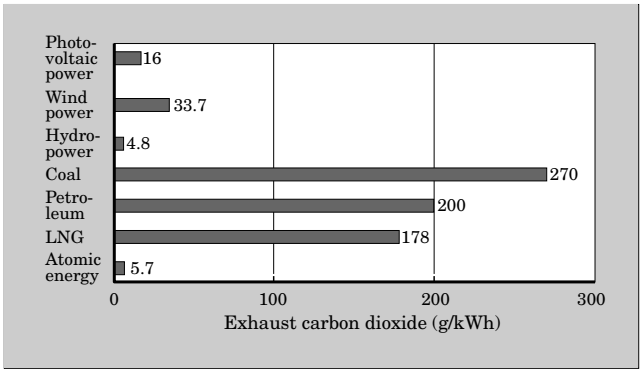
At present, various types of chemical products are being produced and many of which are disseminated as into the environment. This phenomenon may be particularly problematic in instances where pollutants accumulate in waterbodies and therefore, have potential to contaminate public water supplies. Ironically, some pollutants known to deleteriously affect water quality are produced as by-products during water treatment processes. Also of concern is the fact that hydrosphere, such as lakes, marshes and rivers, may be contaminated by human wastes, thereby promoting the growth and propagation of many disease-causing microorganisms.

In addition to water quality issues, the Greenhouse effect, have also become a pressing environmental issue for the global community. For this reason, conservationalists have advocated for the more stringent regulation of greenhouse gases (mainly carbon dioxide) and have ardently encouraged the utilization of alternative energy sources, thus lessening our dependence on fossil fuels. The amount of carbon dioxide emitted from various power generation systems is contrasted in Fig. 1. As depicted in the figure, the dramatic reduction of greenhouse gases by employing new, alternative energy sources is significant.

Environmental preservation has begun to be considered from a global perspective. This trend is beginning to influence the technological advances in the field of environmental preservation.

In this paper, Fuji Electric will present their recent technological advances in water quality analyzers and sensors for the improvement of our water resources. In addition, Fuji Electric will present their micro hydroturbine generation systems and photovoltaic-wind power hybrid generation systems as countermeasures to the global problem of environmental preservation.

Fig.1 Exhaust of carbon dioxide at each generation system



2. Water Pollution

2.1 Heavy metals and organic micro-pollutants

Typically, large quantities of heavy metals are not found in waterbodies because emission into the environment is strictly regulated. However, trace quantities of certain heavy metals may be common in the environment and may originate from such mundane items as electronic parts, batteries, etc. Heavy metals from industrial activities may also contaminate aquatic environs. For example, some heavy metals, such as lead, may be released into the environment as they "solve" out from metallic piping. In addition, the plating industry uses cyanide and large quantities of heavy metals, which may be inadvertently released into the aquatic systems.

Agricultural chemicals may result in the discharge of organic micro-pollutants into the environment. In such instances, contamination typically occurs as agricultural chemicals utilized in rice fields, farms, golf links, etc. are mobilized and transported into waterbodies by the surface runoff associated with precipitation events. Pollutants associated with surface runoff will undoubtedly pose a hazard to aquatic environments in the future and therefore, the monitoring of these systems has become an important issue in aquatic preservation. "Water security monitors" developed by Fuji Electric, utilize the nitrifying bacteria Nitrosomonas. These "water security monitors" can accurately detect very small concentrations of the above mentioned hazardous pollutants and thereby, allow the continuous monitoring of the quality of water flowing into a source of city water (Fig. 2).

Another aquatic environmental hazard are the endocrine-disrupting chemicals or hormone disrupters,

Fig.2 Measuring principle of water security monitor

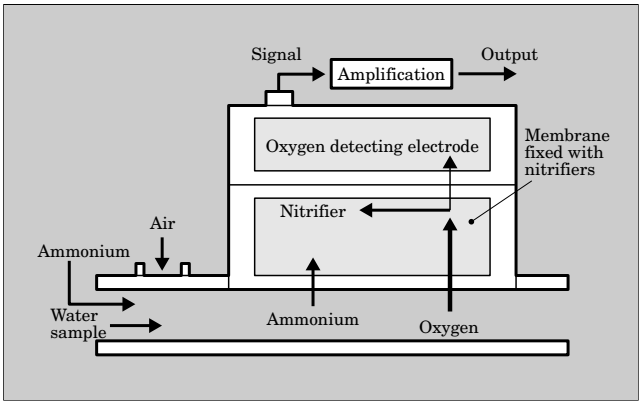
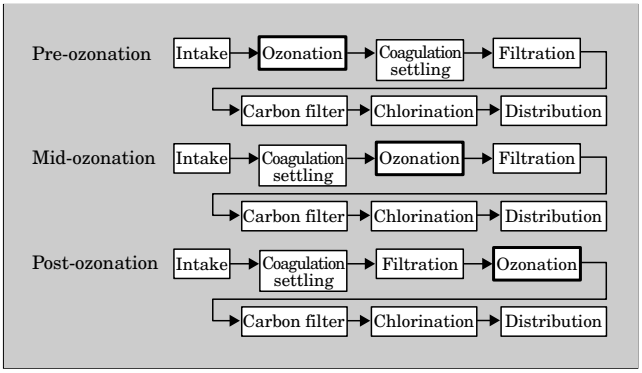


Fig.3 Advanced water treatment process



such as dioxins. In January 2000, legislation entitled "Specific Legislation for Dioxins and Analogous" was enacted thus regulating the concentration of dioxin permissible in discharged waters. In addition to this recent legislation, the interim guideline for drinking water quality standards has determined the allowable dioxin concentration to be ≤ 1 pg-TEQ/L. To treat organic micropollutants, an advanced oxidation process, which consists of a combination treatment of ozone, hydrogen peroxide, and ultraviolet radiation is being developed. Experiments on river water demonstrate that concentrations of trihalomethane formation potential (THMFP) and dissolved organic carbon (DOC) linearly decrease in proportion to the duration of simultaneous exposure to ultraviolet radiation and ozone [(1)].

2.2 Disinfection byproducts (DBP)

Disinfection byproducts differ from other pollutants in the respect that they are generated during the water treatment process. This unfavorable reaction occurs as chlorine, used in the disinfection process, reacts with organic substances to produce trihalomethane, a suspected carcinogen. The toxicity of these pollutants has justifiably resulted in the heightened concern over disinfection byproducts. Unfortunately, trihalomethane is just one of several hazardous chlorinated organic materials that are generated by chlorination treatment of city water. The identification of trihalomethane production from water treatment plants attracted the concern of the general public. However, the presence of trihalomethane and odor and tastes producing micropollutants in urban drinking waters has pushed forward the introduction of an advanced water treatment process (Fig. 3).

Unfortunately, new water treatment processes have resulted in the production and dissemination of new disinfection byproducts. For example, elevated levels of bromine ions in untreated water may react with ozone to produce a hazardous chemical which may deleteriously affect human tissues. Bromate ions are generated as below:

$$O_3 + Br^- \rightarrow O_2 + OBr^-$$

$$O_3 + OBr^- \rightarrow \frac{1}{2} O_2 + BrO_3^-$$

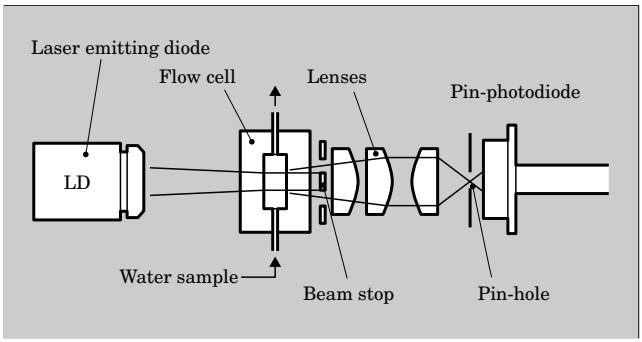
In the above reaction, following oxidation and decomposition of ozone and the trihalomethane precursor, bromic acid ions are formed by a reaction between excessive dissolved ozone and bromine ions. Fuji Electric is currently elucidating the mechanism of bromate formation as well as developing new technologies, which would regulate its formation.

2.3 Microbial pathogens

Chlorine disinfection has been introduced and adopted for public and wastewater treatment in Japan. This highly successful method is both economical and efficient. As a consequence, water contamination problems have been of only minimal significance for many years. However, recent concerns regarding the production of trihalomethane has relegated the problems associated with disinfection to be considered once more. For example, recent events such as the infection of Cryptosporidium in the Town of Ogose, in Saitama Prefecture, Japan in June 1996 has re-ignited research into the problem of pathogen infestation of waterbodies and demonstrated the importance of disinfection processes in water treatment systems. The fact that Cryptosporidium infestation in city water cannot be adequately controlled by chlorine disinfectant alone has illustrated the importance of treatment process monitoring and operational control. The "Interim guideline for Cryptospordium inactivation in drinking water" was adopted in August 1996 and revised in 1998. These guidelines specified that the turbidity of filtered water should be maintained below 0.1 degree. Accordingly, the importance of the filter backwash operation (the procedure necessary to meet this low-turbidity standard for treated water) has been re-emphasized. As such, highly sensitive turbidimeters developed by Fuji Electric have been deployed in many water purification plants and are being utilized for the monitoring and control of filtered water (Fig. 4).

Another issue of concern regarding the use of chlorine and/or chlorine compounds which are emitted

Fig.4 Measuring principle of high sensitive turbidimeter (Forward scattered light detection as particle number)



into the aquatic environment, is their deleterious affect on aquatic organisms. This concern has sparked interest in the introduction of UV disinfection systems (Fig. 5).

2.4 Water treatment technologies in the future

In Japan, from the 1980s to 2000, the growth and development of water treatment facilities has mirrored that of the economy. That is, with the changing circumstances of a growing economy, to the collapse of a "bubble economy" and subsequent shift to a slow-growth economy, the construction of water treatment facilities has changed from increasing the number and enlargement of facilities, to the construction of advanced treatment facilities and subsequently to small-scale facilities.

Indeed, the development of water treatment technologies has changed in response to the well documented environmental problems which threaten human health. For example, in the field of potable water treatment, first a physico-chemical treatment was introduced; this was followed by the introduction of a biological treatment which utilizes ozone and biological activated carbon (BAC), which was followed by membrane filtration. The effectiveness of treatment with ozone and BAC as a technology to remove micropollutants and to suppress trihalomethane has been proven in many water purification plants. Membrane technology, which differs from conventional technologies that remove pollutants on the order of mg/L, may virtually remove all pollutants over a definite particle size. As such, this technique has significantly changed the concept of water treatment. In the future, it is likely that the combined treatment of ozone, BAC and membrane filtration will continue to ensure that waters discharged from treatment systems pose no health risk. Fuji Electric is working to address these issues in a project entitled ACT 21. Experimental results up to the present suggest that when ozone-resisting membranes are employed and dissolved ozone concentration in the filtered water after pre-ozone treatment is maintained at levels greater than 0.2 mg/L, a flux (filtered water quantity per unit time and unit membrane area) four times larger than that without

Fig.5 Fuji's UV disinfection unit

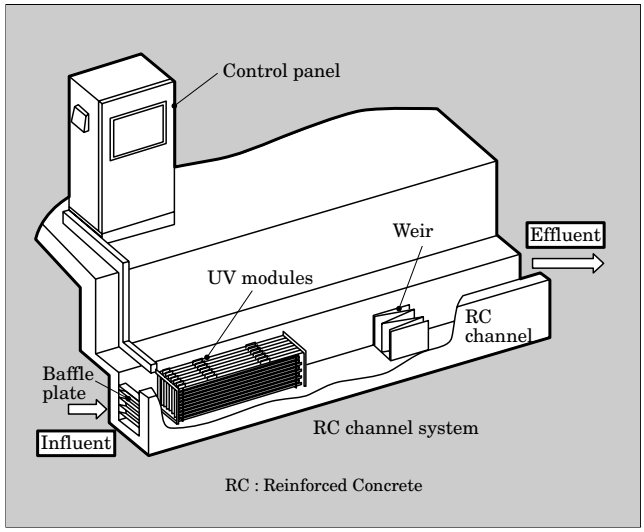
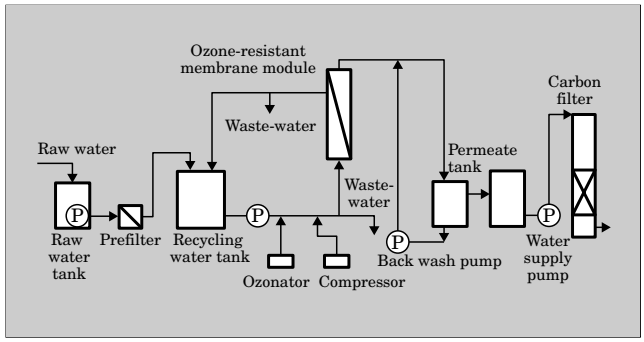


Fig.6 Advanced water treatment process with ozone-resistant membrane filtration



pre-ozone treatment can be obtained steadily (Fig. 6).

3. Recyclable Clean Energy and Environmental Protection

3.1 Micro hydroturbine generation system

Hydroturbine generation is the power generation system having the lowest carbon dioxide emissions. However, this technique has not been widely adopted by conservationalists because these large-scale hydraulic power plants usually require the construction of large-scale dams. Alternatively, micro hydroturbine generation systems, which provide an output of less than 500 kW, have been viewed favorably by conservationalists. This is due to the fact that the operation of micro hydroturbine generation systems is not dependent upon the construction of large-scale dams. Rather, they operate sufficiently in sites with water head less than 100 m and influent water flow of less than 3.5 m^3/s.

Several types of turbines are available for these systems, including Francis, Pelton, propeller and cross-flow. These turbines may be applied to various idle heads and influent water flows. Demand is increasing for micro hydroturbine generation system which utilize

idle head in city water supply systems or in sewage water systems as well as head caused by discharge of agricultural waters to rivers. For example, in public water supply systems, it is possible to utilize water flowing from a raw water basin into a water treatment plant for power generation. Harnessing this previously untapped energy resource may result in the reduction of electrical costs. Furthermore, the Francis hydroturbine generation plant, such as the plant delivered to the Mid-Prefectural First Water Service in Gunma Prefecture, has been furnished with special devices which allow drinking waters after chlorination to be utilized while ensuring that waters are at an acceptable hygienic standard.

3.2 Photovoltaic-wind power hybrid generation system

Interest in photovoltaic-wind power hybrid generation systems is spreading due to manufactures' efforts toward cost reduction. These systems are well suited for secluded sites, such as in mountainous regions or on solitary islands where utility distribution is not available. In these scenarios, the construction of a stand-alone type power generation system equipped with back-up power source must take into account the capacity of the generation facility and the power consumption of the load equipment. A particularly successful example worth mentioning is the photovoltaic-wind power hybrid generation system that was delivered to Senjogatake Refuge in the Southern Japan Alps in Hase Village, Kami-Ina District, Nagano Prefecture in November 1999. Installed on this system was an on-site wastewater treatment system designed to treat wastewater from the refuge in order to preserve the natural environment in this mountainous region.

3.3 Wastewater treatment system and power supply system

The refuge mentioned above is located halfway up the mountain at 2,900 m above sea level, thereby making it difficult to supply both power and water (Fig. 7). Moreover, due to the uniqueness of this alpine ecosystem, environmentally sensitive techniques were required. Figure 8 depicts the wastewater treatment system of the refuge.

In this system, a two-stage treatment of anaerobic and aerobic treatments is adopted, enabling the decomposition of organic substances and the reduction of biochemical oxygen demand (BOD) (Fig. 9).

Water treated by this system is re-circulated by a returning pump and then used as flush water for lavatories. Thus, the discharge of water into the environment is minimized.

Figure 10 depicts the construction of the hybrid generation system.

Power generating equipment used in this system consists of a 10.78 kW photovoltaic array, a 6.4 kW wind power generator and a back-up power supply consisting of a 25 kW diesel generator and 800 Ah/10h storage batteries.

In the daytime, the load equipment is powered by photovoltaic and wind power generation systems and simultaneously, excess power is charged into the storage batteries. At night, the load is powered by the wind power generation system and by the discharge of energy from storage batteries. If photovoltaic and wind power generation systems malfunction, the diesel generator may be activated by either an automatic or manual switch.

Fig.7 Landscape of the Southern Japan Alps Senjougatake refuge

Fig.8 Construction of Senjougatake refuge

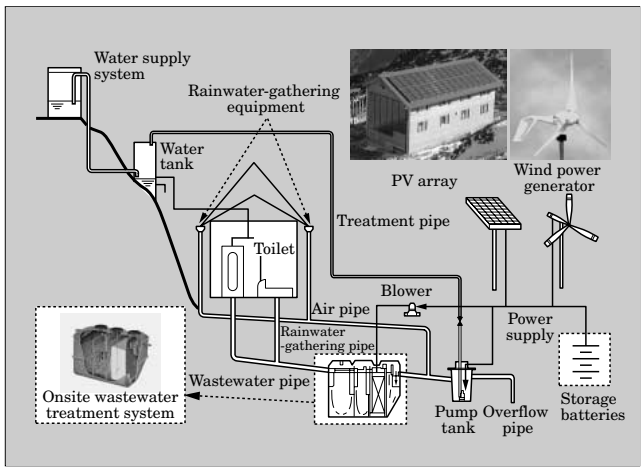


Fig.9 Structure of onsite wastewater treatment system

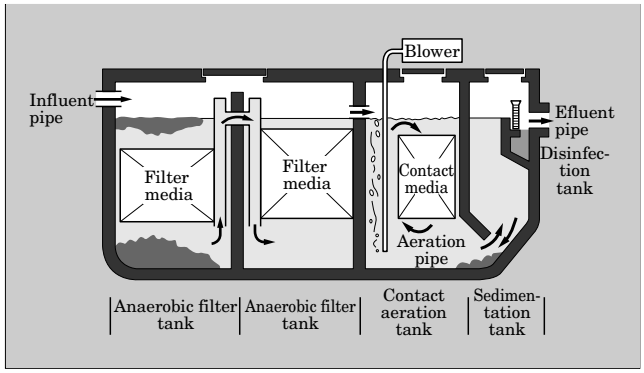
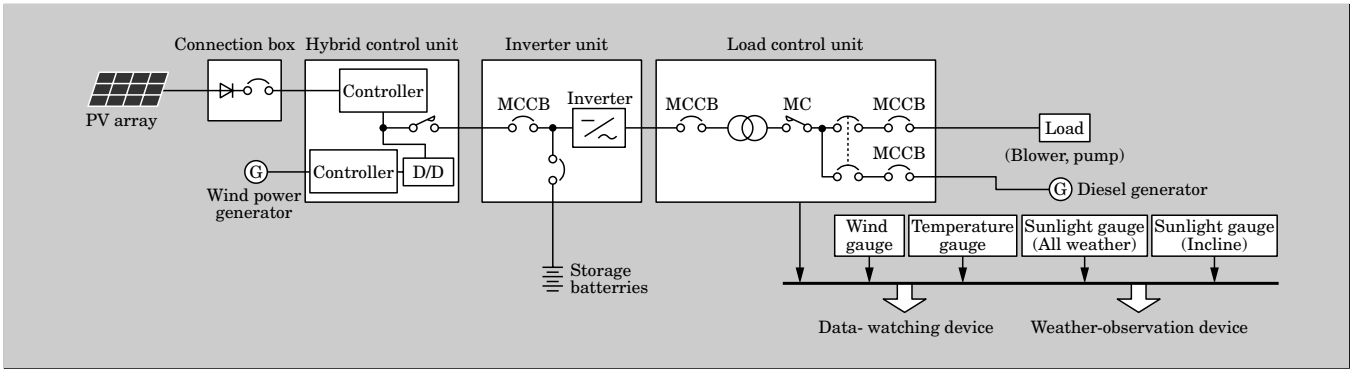


Fig.10 Construction of hybrid generation system



As depicted in Fig. 7, photovoltaic panels are mounted on the roof and walls of the refuge and 16 sets of windmill generators (400 W each) are installed around the refuge. During the summer mountain climbing season, generated power will be used to drive the mechanical equipment of the wastewater treatment system and to run the electrical equipment of the facility. While the refuge is closed for winter, the photovoltaic panels on the roof, windmill generators around the facility and indoor diesel generator will be dismounted and stored on account of the heavy snowfall. During the winter season, power supply to the heaters of the wastewater treatment tank is maintained by photovoltaic panels on the wall and by four sets of wind power generators.

As the technology of hybrid generation systems (photovoltaic and wind power) progresses there will undoubtedly be advances in the ability of these systems to generate high quantity and quality electricity, which is independent of the prevailing weather conditions.

By examining the data collected throughout the year on weather conditions and operating conditions of each generating facility, Fuji Electric researchers are committed to constructing the most suitable hybrid generation systems.

4. Conclusion

Unfortunately at present, our global environment may pose several threats to human and ecosystem health, such as endocrine-disrupting chemicals, the ozone hole, the greenhouse effect, etc. In fact, in the USA, quite often-electoral candidates must have strong environmental policies in order to be seriously considered for election. Likewise, the business community must take a firm stance on environmental issues and introduce measures such as environmental accounts. As such, Fuji Electric is dedicated to encouraging those research activities, which attempt to remedy our most pressing environmental problems, such clean water and energy facilities. Fuji Electric is pleased to have had the opportunity to present some of our recent developments in environmental research. Moreover, we pledge continued support to the further development of technologies designed to protect and enhance our environmental resources.

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Fuji Electric's Energy Conservation Activities and Techniques

Eiji Fukuda
Shinichi Kubota
Takeshi Uemura

1. Introduction

The setting of specific numerical targets for the reduction of CO_2 emission by the Kyoto Protocol (COP3), which was held in 1997 to prevent global warming, was a logical step toward protecting the environment. Subsequently in Japan, with the increasing number of enterprises that acquire self-imposed restraining ISO14001 certification, energy conservation has been promoted with the enactment of the Amended Energy Conservation Law.

Fuji Electric has been promoting the sale of products and systems for environment and energy conservation even prior to the first oil shock. Since 1998, we have expanded our energy conservation diagnostic activities, always keeping in mind "usefulness and economic feasibility for users" which is an especially "basic concept of energy conservation." Through these activities, we were fortunate to have had the opportunity to hold discussions with many users. From the discussions, we have uncovered many techniques of energy conservation and system concepts for energy conservation solutions.

Because energy conservation is a long-term ongoing activity, it is important to determine a practical plan each year, and to continue advancing the concepts one step at a time. As a result, the progress in each field will be clear.

This paper describes Fuji Electric's energy conservation measures and techniques, which have been planned and applied according to three important main themes of energy saving as shown in Fig. 1.

2. History of Energy Conservation

Table 1 lists the history of energy conservation. It is said that the concept of energy conservation was established after the 1st and 2nd oil shocks. Before that time, the only example of energy conservation was the regulation of heat management.

Most of Fuji Electric's energy saving products were developed, produced and introduced to the market after 1970. Especially in the 1970's, new and alternative energy caused a flurry of development. Energy saving equipment was introduced to the market in the 1980's and heat storage systems and power electronics products were sold in the 1990's. Following COP3, Fuji Electric also has developed a product line of eco-monitoring system products, and is compiling a database to reduce the increasing energy consumption.

3. Business Factors Relating to Energy Conservation

Figure 2 shows the business factors relating to energy conservation. User confidence has been cultivated by providing an energy saving diagnostic service free of charge to users during the early stages of energy saving activity. Unfortunately Fuji Electric was unable to offer sufficient benefits to the users. The reason for the above failure was because use of highly efficient equipment such as electric inverters or lighting was proposed without an underlying plan to compile a database to understand the present state.

Recently we have been working on applications of new alternative energy sources, energy saving solutions, etc. and have proposed a "comprehensive energy solution."

When this systemization becomes established, we believe that the Energy Service Company (ESCO) will grow even more.

Fig.1 Important themes in the promotion of the Amended Energy Conservation Law

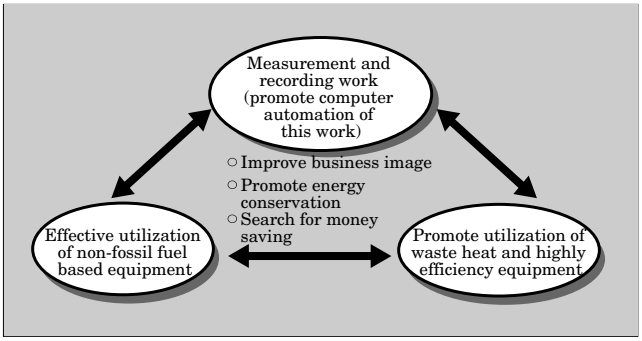
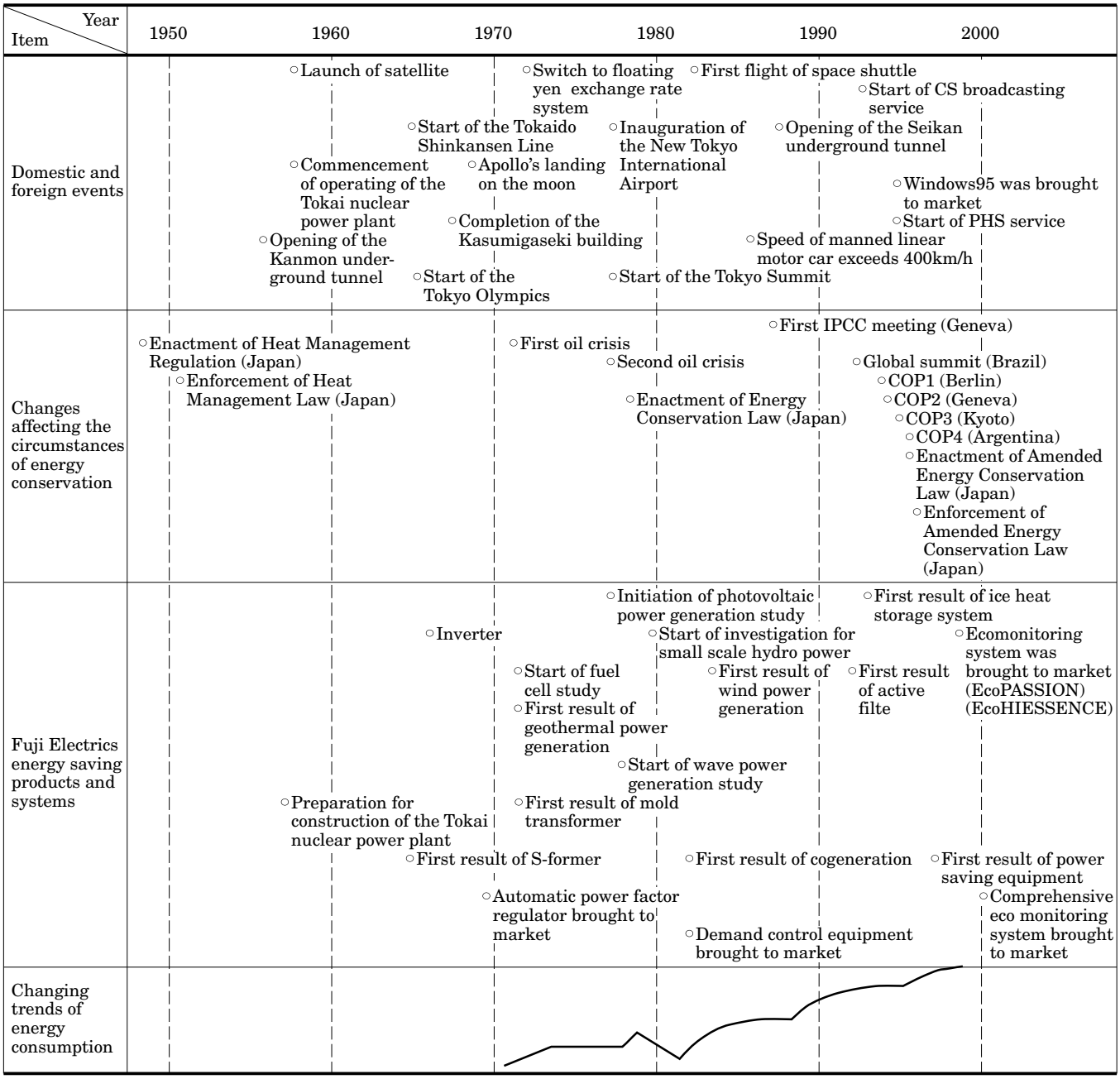


Table 1 History of energy conservation



4. Measures for Energy Conservation

Since enterprises typically have a tendency to move slowly when considering cost reduction strategies for energy, a "DSM (Demand Side Management)" system has been introduced so that the enterprise can by itself manage and control the energy demands. The description "within the enterprise" usually means that DSM is energy management on user side, in contrast to that of an electric power company. DSM is a type of energy management technique for the user.

Fuji Electric is already producing a highly regarded, flexible wireless network type, energy saving monitoring system, and has further plans to apply the system to create a network of energy saving data.

5. Engineering Activities at Fuji Electric

Engineering for energy saving is aligned with the interests of users, and through cooperation with the user, Fuji Electric resolves problems and satisfies user needs. Thus, it is important to recognize and understand the "actual conditions and problems of users." It is relatively easy to determine the targeted field of energy conservation by understanding when, where and how much energy is being consumed in each field segment as shown in Fig.3.

Fig.2 Business factors of energy conservation

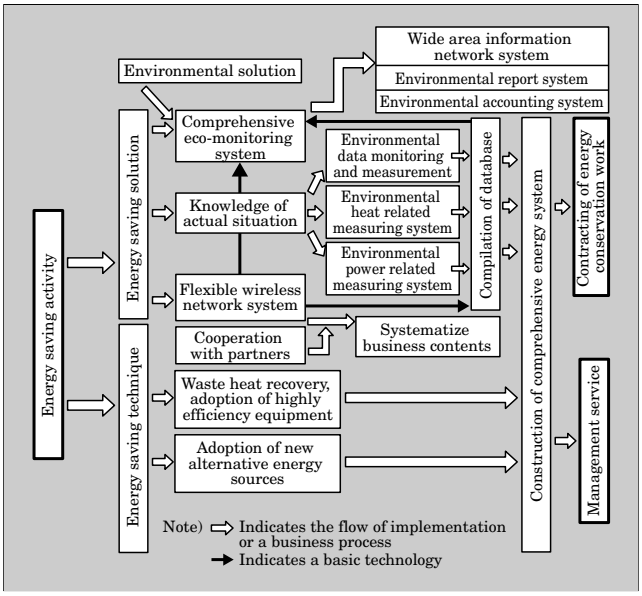
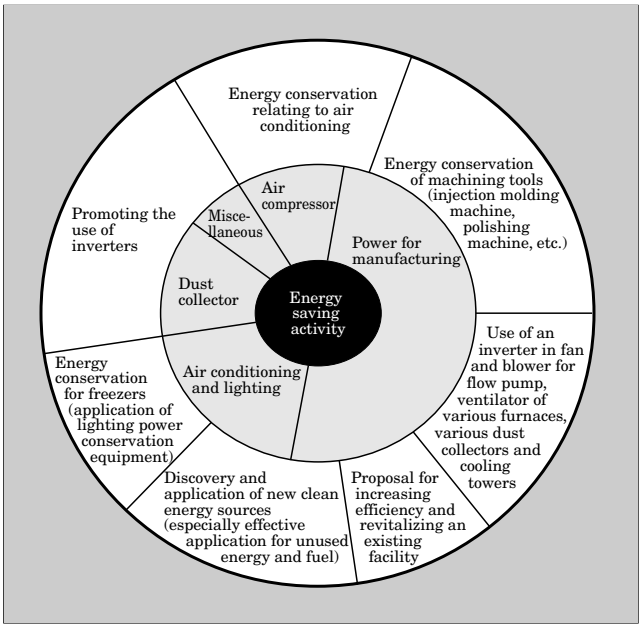


Fig.3 Energy consumption distribution and energy saving items in factory



Fuji Electric has performed assessments of manufacturing factories both internal and external to our company, as the central activities of the "diagnostic service for energy saving." As a part of these activities, we suggest measures to increase energy efficiency, and then implement those measures for the user. We will describe the energy saving items and measures implemented in the following sections.

6. Measures and Controls of Energy Saving Items

Energy conservation is based on the aggregation of data (compilation of a database) that is collected by using measuring and recording equipment as described in Fig. 1. It is important to tie specific measures to the extracted energy saving item through analysis and processing of the database.

Table 2 Flow of diagnostic service for energy saving

Class / Step	Description of activity	Main items to check or activities to implement
1st step	Completion of user requirement list and feasibility consultation	① User's address and name of person in charge ② Received voltage and contracted power ③ Power usage ④ Electric power rates ⑤ Status of ISO certification acquisition ⑥ Equipment description and capacity ⑦ Desired measures to implement for energy conservation ⑧ Existence of measurement and recording data ⑨ Energy consumption percentage, etc.
2nd step (1st diagnosis)	Check user's location (qualitative check by observation)	① Is the received power appropriate (load factor, power factor, etc.) for the equipment and substation? ② Are operating states of various machine tools appropriate? ③ Are the working states of air conditioning and lighting appropriate? ④ Is the utility's operating state appropriate? ⑤ Is the working state of the air compressor appropriate? ⑥ Is working state of the dust collector appropriate?
3rd step	Prepare and submit the 1st diagnostic report	① Are all user concerns covered? ② Is a more detailed check necessary? ③ Is there interest in new alternative energy sources?
4th step (2nd diagnosis)	Check based on measurement and recording at user's location (quantitative check)	① Visualization of each load characteristic by measuring ② Analysis and processing of data ③ Estimation of practicality and economics for extracted items ④ Verification of unchecked items, etc.
5th step	Prepare and submit the 2nd diagnostic report	① Verification of user and measure or time ② Check of environment where measures are to be implemented
6th step	Inquiry and submission of written estimate	① Determine cost of implementing the measures
7th step	Implementation and completion of measures	① Check user's satisfaction with the results of the measures

6.1 Diagnostic service for energy saving

As shown in Table 2, the "diagnostic service for energy saving" begins from the 1st step of surveying the user's conditions, and completes at the 7th step of implementation. It is important that steps 1 through 7 are processed repeatedly.

6.2 Extraction of energy saving items

After Fuji Electric has performed the diagnostic service and found and stored items for which energy conservation is to be implemented, in order to tie the items to actual measures, it is important to classify them as short-, middle-, or long-range measures as shown in Table 3.

As is clearly shown in Table 3, since most of the short-range measures are concerned with daily work and have a low cost of implementation, they can be easily employed; on the other hand, the cost of implementation is high for the middle- and long-range measures. However, it is important to consider middle- and long-range planning to continue the activities of energy conservation.

6.3 Examples of energy saving measures

(1) Promotion of inverters

Inverters can control adjustable speed motors with high efficiency. Energy saving has been enhanced by using inverters in the fans and pumps for air conditioners, feed and waste water ducts, dust collectors, exhaust fans, etc. with square-law reduced torque characteristics. Since the fan or pump capacity usually exceeds that of the facility by 20 to 30%, the flow is restricted by adjustable valves or dampers. By using an inverter and regulating the flow via adjustable speed operation to minimize the delivery head, the power consumption is drastically cut. Conventional inefficient adjustable speed machines such as the fluid coupler and eddy-current coupler can rapidly enhance their energy saving characteristics by incorporating inverters.

Figure 4 shows an example of the energy saving effect when an inverter is used in a fan motor. Since air volume of the fan is usually proportional to rotation speed, the rotation speed can be decreased to 70% when using a reduced air volume of 70%. Because shaft power is proportional to the cube of the number of rotations, the input power becomes 34%.

Although the use of inverter is problematic with regard to high frequency harmonics, power factor, switching surge over voltage, etc., improvement is seen in the characteristics of input/output circuit filters, reactance for power factor enhancement, PWM (pulse width modulation) converter, active filters, etc. When promoting the use of inverters, it is desirable to understand the precise energy saving effects and to implement middle- and long-range plans.

(2) Application of energy saving devices to lighting

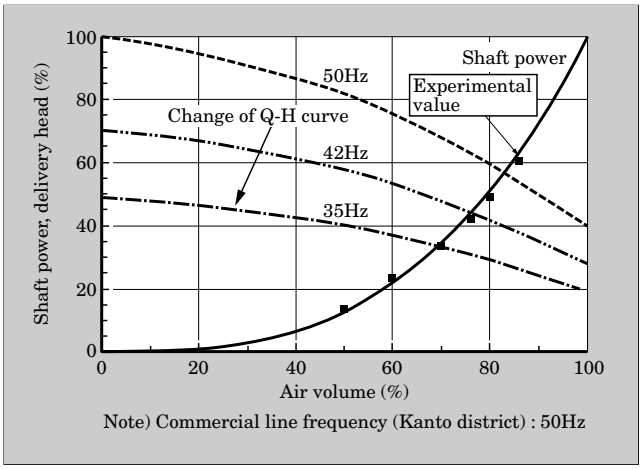
In a typical power source for lighting apparatus, the allowable fluctuation in voltage is 101±6V (95 to 107V) for 100V rated lighting. Illuminance and useful lifetime of general lighting are guaranteed in this range. Accounting for voltage fluctuations, the voltage supplied to 100V lighting is usually 105V. Generally, voltages 5 to 10V greater than the minimum requirement of 95V are applied to lighting apparatus.

The device which reduces the electric consumption of lighting apparatus by regulating the supplied voltage to a constant 95V is known as an "Energy Saving Master", the brand name of Fuji Electric. This energy saving device is connected near the panel board terminal and controls the fluctuating 95 to 107V supply voltage to be a constant 95V. As the device is a non-step voltage regulator constructed with IGBT

Table 3 List of energy saving items

Class	Energy saving items	Common items
Short -range measures (reduce daily waste)	○ ON · OFF management of lighting, office automation machines (turn completely OFF when not in use) ○ Management of air conditioner temperature (adhere to optimum temperature settings) ○ Dispose of unnecessary equipment	Construction of a measurement and recording system (EcoPASSION, Eco HIESSENCE, comprehensive eco supervision system)
Middle -range measures (introduction of light equipment)	○ Add an inverter to fan and pump motors(optimization of rotation) ○ Introduce power saving equipment to the lighting source (optimization of voltage) ○ Refurbish and streamline transformer (higher efficiency and optimum capacity) ○ Manage number of compressors and use an inverter to control air compressors (optimum control of capacity)	
Long -range measures (large -scale measures)	○ Refurbish obsolete equipment ○ Reduce energy consumption of production system (convert from air driven to electronic machinery) ○ Introduce cogeneration ○ Introduce ice heat storage ○ Introduce new alternative energy sources (wind power, hydropower, photovoltaic, fuel cell, wave power)	

Fig.4 Variable speed fan characteristics



Note) Commercial line frequency (Kanto district) : 50Hz

Fig.5 Principle of electricity conservation

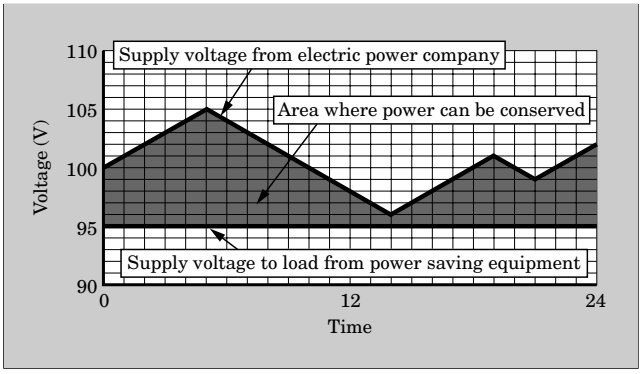
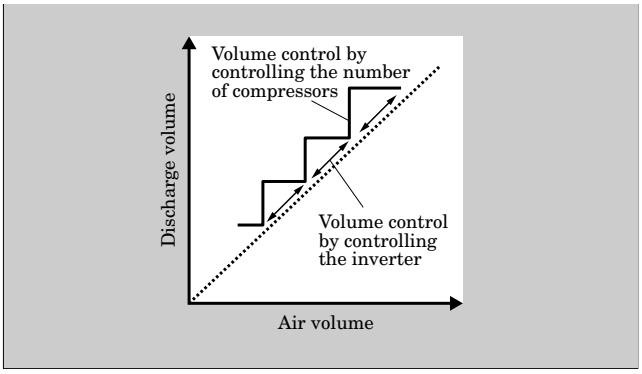


Fig.6 Air volume control of air compressor



technology, it controls the supply voltage more smoothly than a tap-changing controlled transformer. The electric saving principle of the "energy saving master" is shown in Fig. 5. When we reduce the supply voltage from 105V to 95V, power consumption is reduced by approximately 20% because the power consumption for lighting is proportional to the square of the applied voltage.

(3) Replacement of transformer

With a smaller load factor of the transformer, total transformer efficiency will decrease because the rate of non-load loss increases with lower load factor. Usually the maximum total efficiency is obtained by using an oil filled transformer with load factor of 40 to 60%, or a mold-type transformer with load factor of 50 to 70%. But surprisingly in actual operation there are many cases of light loads with 20 to 30% load factors. For example, if we replace an oil filled transformer having a load factor 20% with a high efficiency mold-type transformer of 1/3 the capacity, the load factor increases by a factor of 60% and an approximate 1.5% reduction in power can be obtained. Although the percentage of reduction is low, the annual amount of power reduction (kWh) is significant because the transformer operates throughout the year.

In the case of such a low load factor, it is important to increase the load factor through replacement with an optimum transformer or by streamlining the transformer group. Furthermore, we have considered the case of replacing an oil filled transformer with a high efficiency mold transformer. The mold transformer has additional merits of flame resistance, virtually maintenance-free operation and increased reliability with high efficiency.

(4) Energy conservation of the compressor

Many air compressors are used as power sources at machine factories or forging works. Sustaining high efficiency through optimum maintenance, adoption of looped piping, and the optimum design of piping have been considered as energy saving measures for compressors. Regulation of the number of compressors and control of the inverter are also considered as energy saving measures.

One of the mechanisms for compressor volume control is the "unload control" which reduces the fluctuation of a delivery head. However, the accompanying decrease in efficiency is a disadvantage of unload control. Regulation of the number of compressors is a means to achieve highly efficiency air volume control. When using multiple compressors, selection of the number of compressors to operate depends on the load air volume. This method is able to increase efficiency during partially loaded conditions. As shown in Fig. 6, by combining compressor number control with inverter utilization, we can use continuous air volume control.

However, due to the compressing mechanism of the compressor, it is necessary to consider the suitability of variable speed compressors on a case-by-case basis. In an example where an oil feeding type compressor was remanufactured into an inverter driven type and variable speed control was used to control the speed within a range of 30 to 100%, power consumption was reduced by 15%.

(5) ESCO business

ESCO collects discounted electric power and fuel bills by insuring a reduced quantity of consumed energy, assembling project financing for profitability, and implementing measures to realizing the guaranteed characteristics. Fuji Electric has implemented the first ESCO effort at a health and environmental facility in Ishikawa Prefecture. The insured power reduction rate of 10% was determined by implementing the following three measures: use of inverters in the fans and pumps for air conditioners, use of electricity saving devices in lighting apparatuses, and lowering the capacity of transformers and using molded type transformers. An approximate power reduction of 12% has been achieved after implementing these measures for electric saving. The funds for investment are scheduled to be collected over a 6-year period.

7. Application of New Alternative Energy Sources

7.1 Necessity of new alternative energy sources

New aternative energy will become a potentially large market in the long run, and is a pillar of Japan's energy policy for the purpose of simultaneous achieve-

ment of the 3Es: Energy security, Economic growth and Environmental protection for energy.

To achieve the 3E goals, it is necessary to promote energy conservation to reduce energy consumption. It is also important to introduce new alternative energies such as "non-fossil fuel energies" to supply energy.

7.2 Amendment concerning the rational use of energy and new alternative energy

The Amendment Concerning the Rational Use of Energy stipulates that "electric power generated by photovoltaic, wind power, etc. is exempt from efforts to rationalize the consumption of energy."

In other words, non-fossil fuel energy sources (photovoltaic, wind power, hydropower, geothermal power, wave power, nuclear power, etc.) are very important as they are not subject to energy management.

Power from fuel cells is also exempt from energy management as it is classified as a non-fossil fuel energy source. However, the facilities that supply the fuel to the fuel cells are subject to energy management.

Table 4 shows the relations between the Amendment Concerning the Rational Use of Energy and new alternative energy sources.

7.3 Application of various assistance systems

In Japan, as the field of new alternative energy is a growing market that is receiving governmental guidance, it is important to reduce the investment cost to users by applying various systems of assistance.

Assistance, financing and tax related support are provided by governmental organizations such as the New Energy Development Organization (NEDO) and the New Energy Foundation (NEF).

Table 4 Relation to Amended Energy Conservation Law

New alternative energy source	Relation to Amended Energy Conservation Law		Remarks
○ Photovoltaic generation ○ Wind power generation ○ Geothermal power generation ○ Wave power generation ○ Nuclear power generation	Not applicable	Exempt from energy management due to classification as a non-fossil fuel energy source	The energy source may be subject to regulation depending on its system construction. As such, permits must be obtained from the relevant authorities for each new alternative energy source.
○ Fuel cell generation	Not applicable	Exempt from energy management due to classification as a chemical reaction based energy source	
	Applicable	Fuel supply is subject to energy management	
○ Cogeneration	Applicable	However, recommended from the standpoint of equipment introduction with high energy efficiency	

7.4 New alternative energy solution

New alternative energy, which is necessitated by the present socio-economic conditions, is widely used to "liberalize the market for electrical power" and "promote regional power distribution" in addition to its stated purpose to "prevent global warming through energy conservation."

Fuji Electric has proposed to its users optimum solutions which include some merits of "understanding the present state of energy usage", "adoption of new alternative energy sources" and "evaluation after the introduction of new alternative energy sources", and are based on the current socio-economic conditions.

Table 5 lists the new alternative energy sources promoted by Fuji Electric and the general trends of each field.

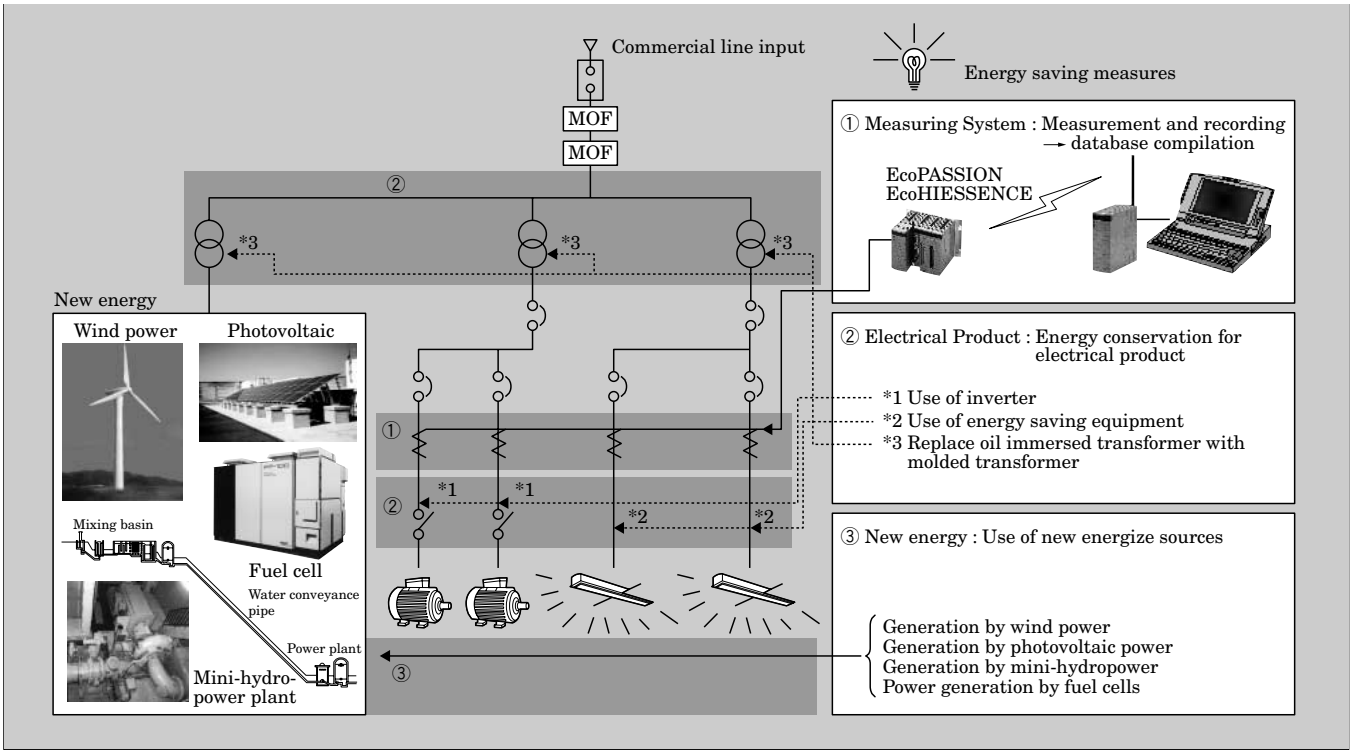
8. Systemization of Energy Conservation

Important points for energy conservation are the extraction of the energy conservation item and the

Table 5 Major new alternative energy sources and their general trends in Japan

New alternative energy field	Estimated supply	Market trend
Wind power generation	14 MW (in 1996) 300 MW (in 2010)	○ Recently rapidly growing field ○ Market scale will grow to approx. 12 billion yen/year ○ Approaching price level that is competitive with commercial power rates
	Current status (in 1999) : Aggregate output approx. 70 MW	
Photovoltaic generation	57 MW (in 1996) 5,000 MW (in 2010)	○ Practical application of crystal solar cell ○ Developing thin film solar cell ○ Trending toward lower cost but still expensive
	Current status (in 1998) : Aggregate output approx. 130 MW	
Fuel cell	16 MW (in 1996) 2,200 MW (in 2010)	○ Practical application of phosphoric acid type fuel cell ○ Trending toward lower cost but still expensive ○ Accelerated development of power for car and home (solid polymer fuel cell)
	Current status (in 1999) : Aggregate output approx. 120 MW	
Cogeneration	3,850 MW (in 1996) 10,020 MW (in 2010)	○ Convention energy is used in a new format (most economical) ○ Remarkable micro gas turbine for distributed power
	Current status (in 1998) : Aggregate output approx. 4,630 MW	
Mini-hydro-power generation Wave power generation	——	○ Can effectively use a small water fall ○ Can use rich natural energy

Fig.7 Systemization of energy conservation



implementation of countermeasures based on analysis of the database compiled from the data of measurement and recording equipment. Utilization of additional non-fossil fuel energy sources is also important. Due to its widespread use, long-term measures and promotion, this system of energy conservation appears at first glance to be merely a business that supplies equipment and facilities; however, if scrutinized closely, it is actually an excellent energy conservation system as shown in Fig. 7.

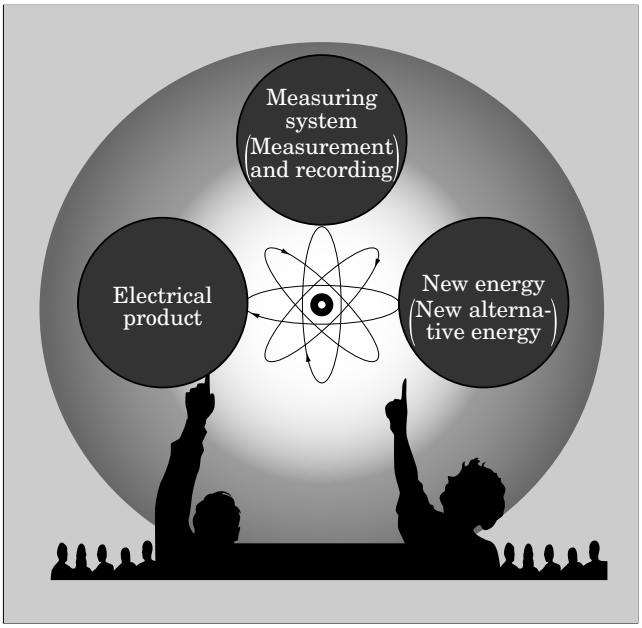
For this reason, it is important to plan and implement energy conservation comprised of the following three basic components: a Measuring system, Electrical products and New alternative energy sources. As shown in Fig. 8, Fuji Electric has been promoting this concept as “MEN”, an acronym based on the first letter of each component.

9. Conclusion

Although we are experienced in energy saving techniques and have learned much, our knowledge increases with each energy conservation problem we tackle.

In response to the need for energy savings, we can always find new themes and offer new solutions. Fuji Electric will continue to learn from its experiences and provide satisfying solutions to its customers.

Fig.8 Three basic components “MEN” of energy conservation



Fuji Electric's Environmental Preservation and Energy Conservation

Mitsuru Yamada

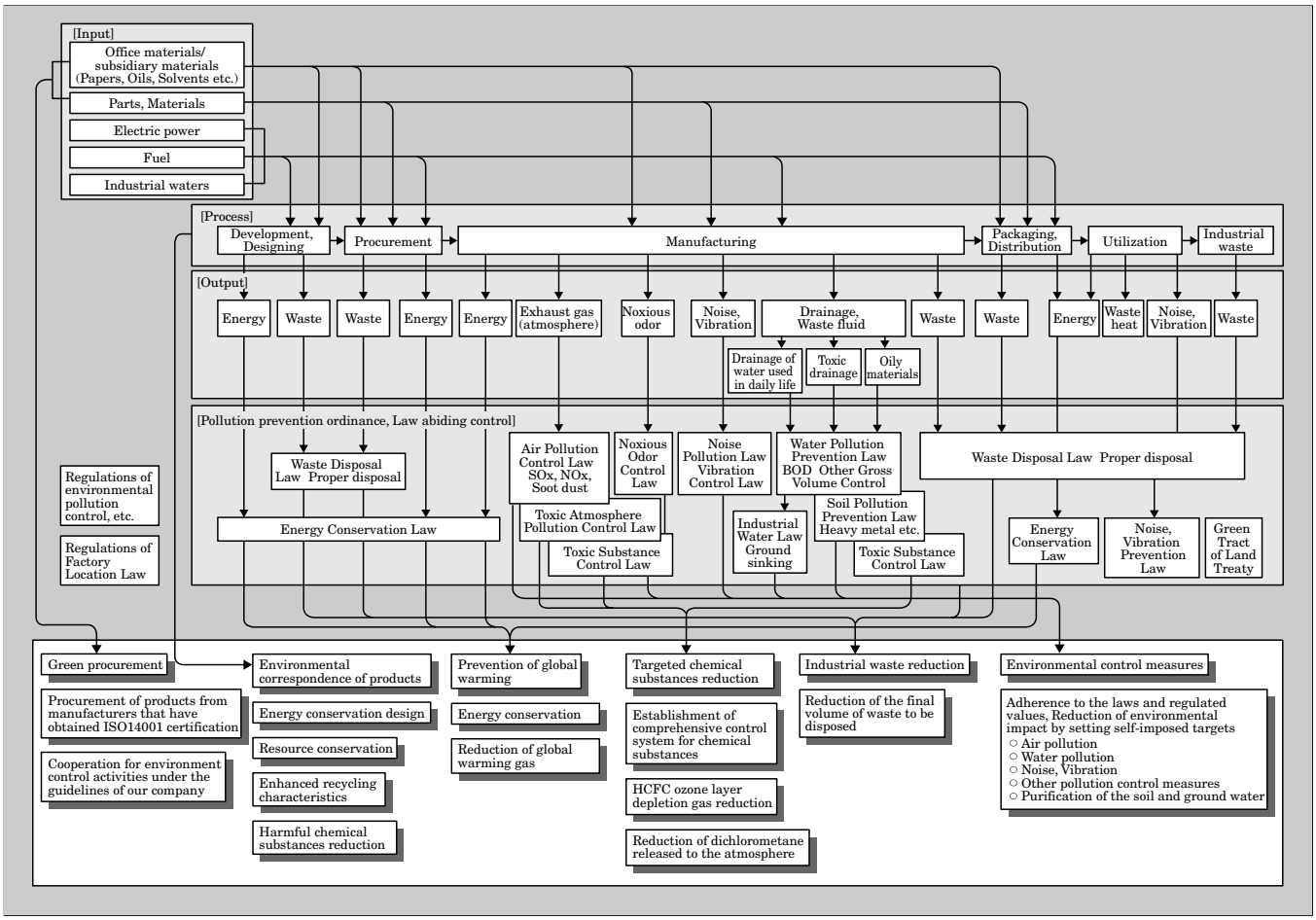
1. Introduction

By achieving our corporate mission of "contributing to prosperity", "encouraging creativity" and "seeking harmony with the environment," Fuji Electric desires to be recognized as a trusted enterprise among the community, suppliers, and business partners as a good industrial citizen of the global society.

At present, various threats to the global environment such as global warming, depletion of the ozone layer, acid rain, deforestation and desertification are demanding our attention, and the role of corporate enterprises in environmental issues is increasing more and more.

In 1992, the "Basic Policies of the Fuji Electric Group on Environmental Protection" was established. Based on efforts to "provide ecological products and technologies that serve useful purposes in protecting the environment," and to "conduct environmentally conscious production activities," the Fuji Electric Group is pursuing corporate activities that encourage the development of a "recycling society" that can utilize limited resources efficiently. In addition, from a manufacturer's perspective, environmental technology

Fig.1 Relationship between enterprise activities and the environment



is considered as one type of production technology, and together with basic manufacturing technology, management technology and quality assurance technology, forms the basis for business activities.

As shown in Fig. 1, by clarifying the possible environmental affects which may arise from the business activities of Fuji Electric, the prevention of global warming, reduction of industrial waste, reduction of targeted chemical substances, application of products for the environment, and measures for environmental preservation have been vigorously promoted.

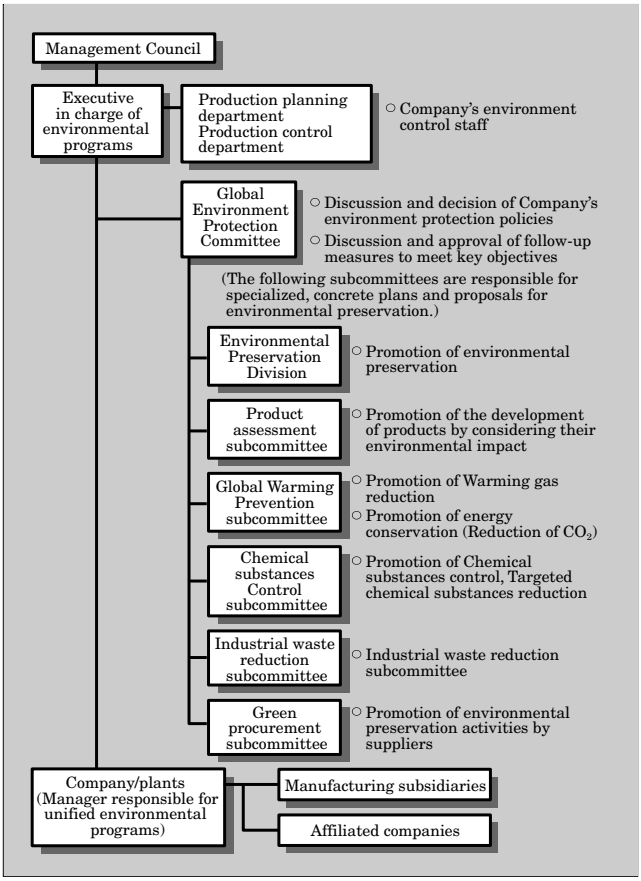
Table 1 Details of environmental preservation activities

Year	Fuji Electric Initiatives	Trends in Japan
After 1969		1967 Basic Law for Environmental Pollution Control enacted 1968 Air Pollution Control Law enacted Kanemi Oil incident (PCB-tainted oil)
1970	Established company's Pollution Prevention Committee	Established Water Pollution Prevention Law Established Soil Pollution Prevention Law etc.
1971	Commenced maintenance of factory drainage system and living water drainage treatment equipment Suspended the production of equipment that uses PCBs	
1973		NOx Regulations enacted
1977	Introduced low NOx boilers	
1978		Water quality gross volume regulation (COD) enacted
1979	Commenced 10% waste reduction activities	
1981		NOx gross volume regulation enacted
1984	Initiated pollution prevention management at subsidiaries	Provisional drainage standards for trichlene and other chemicals enacted
1988		Ozone Layer Protection Law enacted
1989	Established company's CFC control committee	
1990		Action Plan to Cope with Global Warming (Japanese Government)
1991	Established global environment protection committee	Law for Promotion of Effective Utilization of Resources enacted
1992	Established "Basic Policies of the Fuji Electric Group on Environmental Protection"	Notice of guidelines to indicate dangerous and harmful chemical substances, etc. (MSDS)
1995	Completely suspends use of specified CFCs and trichloroethane Acquired certification of conformance to BS7750 Environmental Management System for Suzuka plant	Container and Package Recycling Law enacted
1997	Total ban on use of Trichloroethylene	3rd Conference of the Parties (COP3) to the United Nations Framework Convention on Climate Change
1998	Acquired ISO14001 certification for all 10 plants in Japan	
1999	Initiated "Green Procurement" standards with suppliers	

2. Details of Environmental Preservation Activities

The details of environmental preservation activities by Fuji Electric are shown in the Table 1. In 1970, a "Pollution Prevention Committee" was organized and developed to take up pollution prevention measures which were considered the social theme of the time. Further, in 1991, the committee was reorganized to form the "Global Environment Protection Committee," and the company executive in charge of environmental programs was appointed as the committee chairman to deal with today's various environmental problems. In this manner, environmental awareness has been strengthened. The in-house system of promoting environmental preservation activities is shown in Fig. 2.

Fig.2 In-house promotion system of environmental preservation activities



3. Environmental Management System

As shown in Table 2, since Fuji Electric's Suzuka Plant acquired BS7750 certification of the Environmental Management System in 1995, 10 plants have established and acquired ISO14001 certification of the Environmental Management System. Thereafter, in conformance with this system, Fuji Electric has been working to reduce environmental impact and has enjoyed high evaluation during third party surveillance (continuous examination).

Hereafter, to improve the disclosure of information concerning our environmental preservation activities, ongoing environmental performance reviews shall performed in conformance with the new international standard ISO14031 "Environmental Performance Evaluation," and the evaluation results shall be announced both within the company and to the outside world. At the same time, we will create a system that rapidly reflects these reviews with improved efforts. Moreover, Fuji Electric manufacturing related companies (subsidiary plants) are in the process of acquiring ISO14001 certification.

4. Introduction of Environmental Impact Reduction for the Products

For the purpose of providing products, in consideration of the environmental impact throughout their entire cycle, namely, manufacturing, usage and disposal, Fuji Electric is working to reduce environmental impact, starting at the stages of design and development. By employing individual environmental impact evaluation standards for each type of equipment, measures are being developed to perform environmental evaluations and to reduce the environmental impact. To accelerate the future provision of environmentally conscious products, the development of design technologies, production technologies and evaluation systems will be vigorously promoted. Examples of Fuji Electric's efforts to reduce the environmental impact of products are described below.

Table 2 Status of acquired ISO14001 certification

Date of certification (Expiration date)	Plant name of site	Certifying body (Certification number)
December 1995 (December 2001)	Suzuka Plant	Japan Audit and Certification Organization (EC98J2011)
March 1997 (March 2001)	Fukiage Plant	Japan Electric Safety & Environment Technology Laboratories (E97-116)
April 1997 (April 2003)	Mie Plant	Japan Audit and Certification Organization (EC97J1001)
August 1997 (August 2003)	Tokyo Plant	Japan Audit and Certification Organization (EC97J1059)
August 1997 (August 2003)	Kobe Plant	Japan Audit and Certification Organization (EC97J1061)
January 1998 (January 2004)	Kawasaki Plant	Japan Audit and Certification Organization (EC97J1177)
March 1998 (March 2004)	Ootawara Plant	Japan Electric Safety & Environment Technology Laboratories (E97-036)
March 1998 (March 2004)	Chiba Plant	Japan Audit and Certification Organization (EC97J1229)
June 1998 (June 2004)	Matsumoto Plant, Yamanashi Plant	Japan Audit and Certification Organization (EC98J1023)

4.1 Vending machine, refrigerated showcase

(1) Energy conservation

An automatic tuning system was developed which is capable of controlling the operation of refrigerated showcases and refrigerators in supermarkets or conveniences store in accordance with seasonal or day and night varying conditions. Through applying this system, electric consumption has been reduced by approximately 49% per year (compared to our company's other products) and the emission of carbon dioxide (CO_2) was reduced by 47% on average per year.

(2) Resource conservation

By making canned beverage vending machines smaller and lighter weight, the number of parts has been reduced and the parts have been standardized. As shown in Fig. 3, by improving the storage efficiency, a reduction of 27% in volume, 40% in total number of parts and 30% in the mass of products was attained when comparing a 1999 model vending machine to a 1990 model.

4.2 Electromagnetic switch

Energy conservation was achieved through the utilization of a new type of super magnet that can reduce input power by 40% and coil consumption power by 20%.

Fig.3 Resource conservation of the canned beverage vending machine

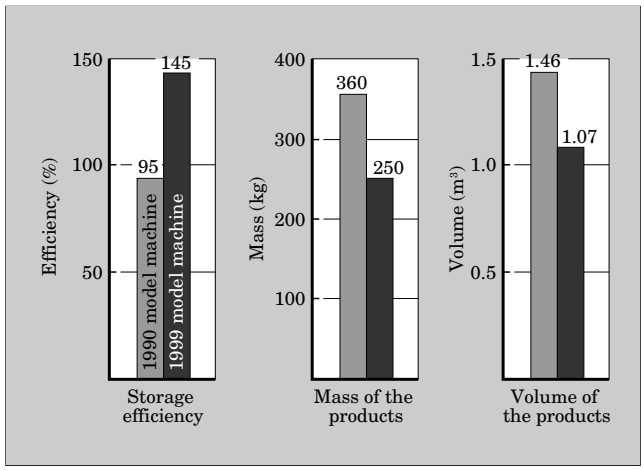
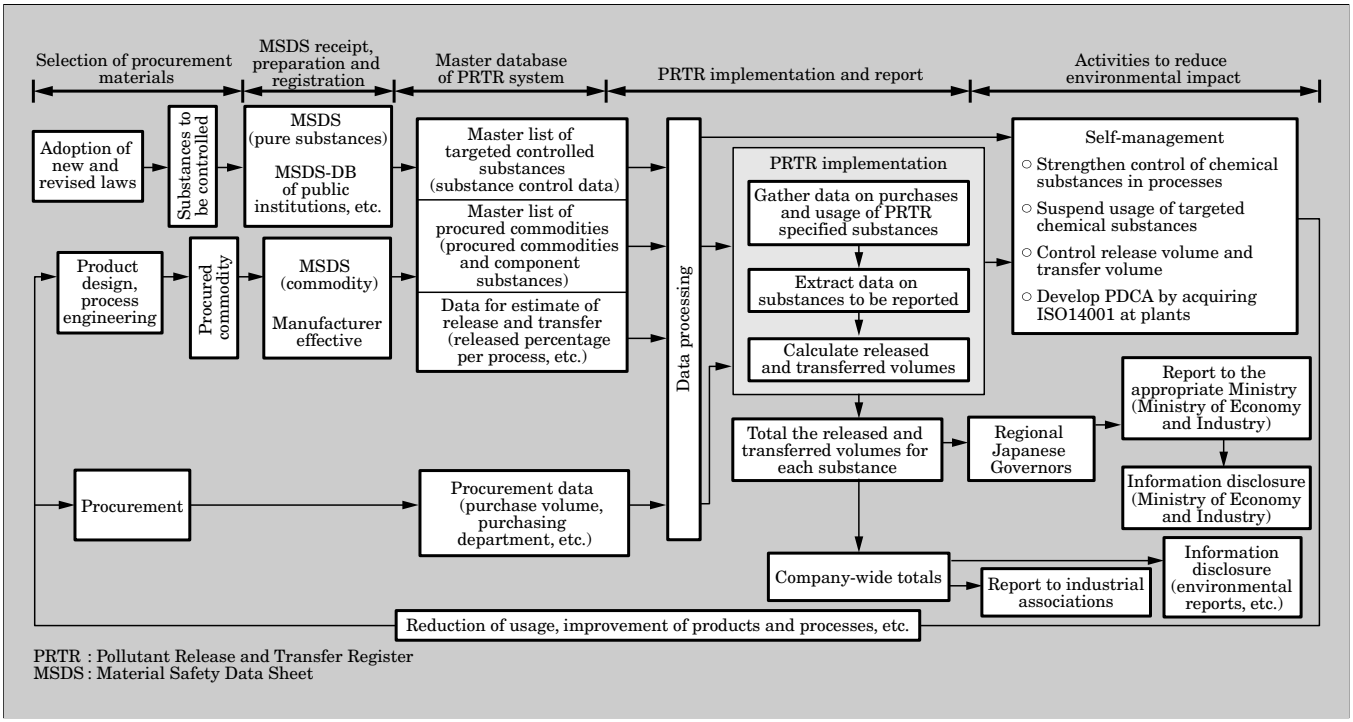


Fig.4 Concept of comprehensive chemical substance control system



PRTR : Pollutant Release and Transfer Register
MSDS : Material Safety Data Sheet

4.3 Earth leakage circuit breaker, wiring circuit breaker

Some of the plastic material used in covers for earth leakage circuit breakers and wiring circuit breakers was changed from thermosetting resin to thermoplastic resin, which can be recycled. By adopting the above measure, product waste at the time of scrapping was reduced through recycling by approximately 54 tons/year.

4.4 Development of environmentally conscious technology

Two types of solder, lead-free high melting point soft solder (tin, silver alloy base) and low melting point soft solder (tin, bismuth alloy base), were developed in-house and have started to be used in some products.

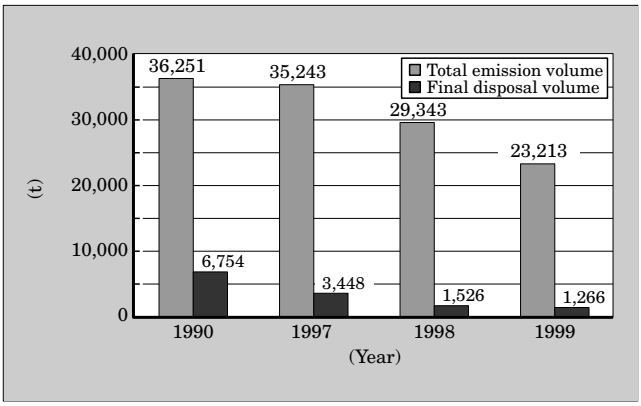
5. Efforts to Decrease Chemical Substances

Now that the problem of environmental pollution by chemical substances has intensified, Fuji Electric is working to develop its own chemical substance comprehensive control system to respond to needs for risk management and information disclosure, in addition to dealing with the prior issues of ozone layer preservation, global warming prevention, and the reduction of chemical substances such as harmful air pollutants.

With the above system, Fuji Electric promotes the precise reduction of chemical substances through the comprehensive management of purchasing volume, emission and transfer volume of all chemical substances it uses.

Figure 4 shows the concept of the Comprehensive Chemical Substance Control System which is under development at present.

Fig.5 Waste emission totals



6. Reduction of Industrial Waste

So far, Fuji Electric has worked to reduce the volume and promote recycling of industrial waste. On the other hand, demands for a "recycling society" have increasing with the enactment of laws such as the Container and Package Recycling Act in April 2000 and the Household Appliances Recycling Act in April 2001, etc.

In response to these trends, Fuji Electric is promoting new efforts aiming to "strengthen control against outbreaks, utilize recycled resources, and recycle to reduce the volume of final waste disposal." As shown in Fig. 5, Fuji Electric's total emission and final disposal of industrial waste were reduced drastically in 1999 compared to 1990. We plan to reduce the

emission of voluminous waste (such as plastic waste, wastepaper, etc.) to the final disposal site, by tracing the waste to its source and implementing remedial measures.

7. Environmental Preservation Measures

In response to the expansion of international regulations regarding the prevention of global environmental pollution since the Montreal Agreement of 1987, a basic policy for the total abolition of specific CFCs has been decided and efforts are progressing to reduce usage of benzene, trichloroethylene, and tetrachloroethylene. As a result, usage of specific CFCs and trichloroethane was banned in 1995, and trichloroethylene was banned in 1997. In addition, a wide array of environmental preservation activities are underway, geared toward prevention of environmental pollution, including the enacting of laws and regulations, and the implementation of measures to lessen the risk of pollution.

8. Promotion of Environmental Preservation Activities by Suppliers (Green Procurement)

Approximately half of Fuji Electric's total production yield depends on the procurement of supplies from third party vendors. For this reason, it is considered necessary that environmental preservation be expanded to third party vendors so that Fuji Electric's products shall be environmentally conscious products.

At Fuji Electric, Green Procurement is advanced on a broad scale ranging from the products themselves from the perspective of life cycle assessment, to manufacturing activities and regular work duties, including office supplies. As such, Fuji Electric is requesting suppliers to cooperate in efforts to preserve the global environmental and to control pollution.

9. Measures to Prevent Global Warming

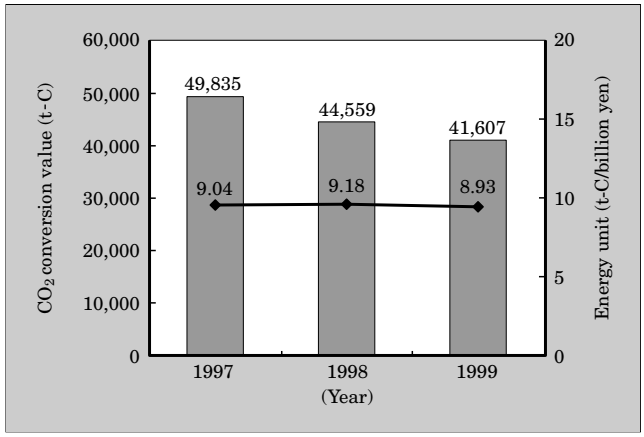
9.1 Efforts to conserve energy

Based on the Global Warming Control Kyoto Protocol (COP3), the target reduction rate for global warming gas emissions in Japan was set at 6%. To achieve this reduction, the Japanese "Comprehensive Global Warming Prevention Measures Act" was enacted in 1998, and domestic measures to address global warming were strengthened.

The history of energy conservation activities of Fuji Electric can be traced back to the time of the Oil Shock. Since then, the following steps and measures have been explored and promoted.

(1) "Energy Rationalization Law" (Energy conservation law)
(2) Setting of self-imposed targets (voluntary plan) introduced by the Japan Electrical Manufacturer's Association (JEMA)

Fig.6 Results of energy conservation



(3) System improvement to monitor and control energy consumption conditions
(4) Quantitative monitoring of energy consumption volume, and changing the setting of air conditioners
(5) Efforts dealing with both aspects of the heightened conservation awareness and enforcement activities that specifically relate to the wasted consumption of energy

From the viewpoint of capital investment in energy conservation, the introduction of such energy conservation equipment and facilities as inverter systems, high-efficiency motors, distributed installation of air conditioners, power saving equipment and permanent heat storage equipment, etc. have been encouraged. Thus it has been planned to reduce the number energy units per production yield.

In June 1998, on the occasion of an amendment to the Energy Conservation Law, Fuji Electric established a minimum energy conservation target of 1%/year reduction in energy units.

By introducing power saving equipment made by Fuji Electric and through measures to conserve lighting power, Fuji Electric has been using power monitoring devices to precisely control power. As shown in Fig. 6, it has been planned to reduce the total energy volume to 2.952 t-C (CO_2 conversion value) compared to the year 1998; thus the energy unit per production yield becomes 8.93 t-C/billion yen and a year-over-year reduction of 2.7% is achieved.

10. Conclusion

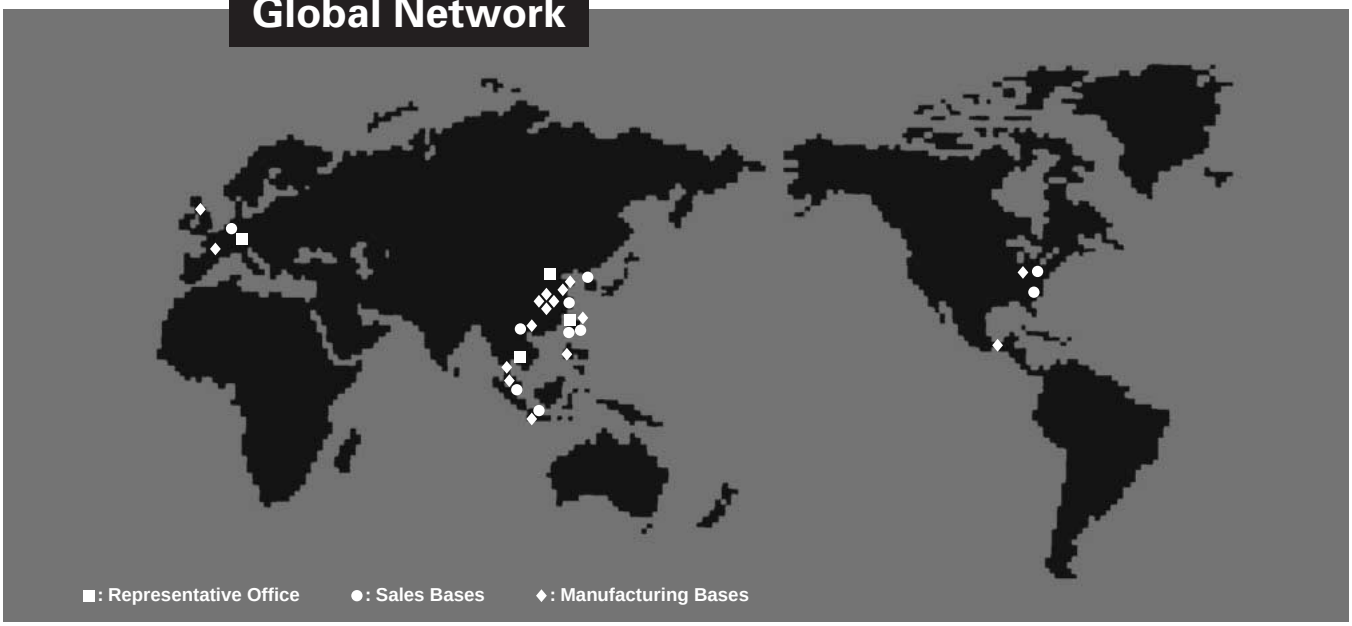
Some of Fuji Electric's environmental activities have been introduced above, but continuous improvement of environmental policy is one stipulation of the ISO14001 standards. Aiming at further improvement, this matter will be vigorously dealt with in the future.

In addition, the contents introduced in this paper have been reported in the "Environmental Report", 2000 edition, published by Fuji Electric.

Business Outline of the Each Internal Company

Company	Business Areas	Major Products
Energy & Electric Systems Company	Providing optimal solutions from information control systems to substations to meet the individual needs and demands of each customer	Water treatments systems; information, telecommunications and control systems; measuring and instrumentation systems; power systems; environmental equipment and systems; industrial power supplies; electrical equipment for rolling stock; substation systems; thermal, hydraulic and nuclear power plant equipment; and others
ED & C · Drive Systems Company	Delivering broad FA system components, individually or as integrated small-scale systems	Small-scale systems combined with PLCs, inverters and actuators; FA control equipment; low-voltage circuit breakers; molded transformers; drive control and power electronics; and others
Electronics Company	Providing distinctive electronic devices, based on our world-leading technologies	Power semiconductors; ICs; magnetic disks; photoconductive drums and peripherals; and others
Retail Support Equipment & Systems Company	Promoting consumer convenience and comfort, through machinery and systems focused on vending machines	Vending machines; beverage dispensers; food machines; freezing and refrigerated showcases; coin mechanisms and bill validators; leisure-related systems; and others

Global Network



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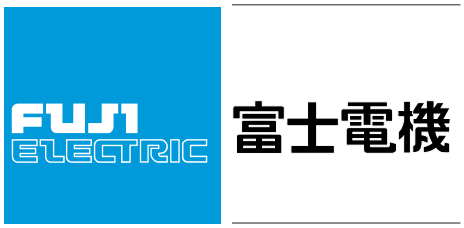

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