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Toward the Establishment of a Recycling-Oriented Society

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Abstract

Recent environmental problems cover an extremely wide spectrum of subjects from addressing the preservation of global warming, establishing a recycling-oriented society, to complying with the regulation of chemical substances. With the background of the alarmingly low capacities of landfill sites and the need for recycling brought on by the scarcity of resources, the Basic Law for Promoting the Creation of a Recycling-Oriented Society and other related laws have been enacted. In addition to withdrawing from mass production, mass consumption, mass waste economic system and utilizing the resources effectively by minimizing the waste disposals, the establishment of a recycling-oriented society are urgent. Through the attempting to recycle not only the by-products from its own production processes, but also the by-products from other industries and wastes materials from surrounding communities, Nippon Steel will achieve higher corporate activities by contributing to the establishment of a recycling-oriented society.

1. Introduction

The worldwide trends that have accelerated the structural changes in the domestic social economy during the last decade of the 20th century have been directed toward "Expantion of Information Technology" and "Globalization". Those trends have resulted not only in bringing about the changes in industrial structure and personal lifestyles, but also in implanting a common recognition among the all populations in the world to the new problems including the global environment and waste management.

Since the environment is essential to sustain life it should be maintained so that it can be equally shared by both present and future generations. With this background, the establishment of a full-fledged recycling-oriented society is urgently required so that the socioeconomic structure, as characterized by mass production, mass consumption, and mass disposal, can be basically reviewed, waste substances minimized for their effective utilization, and our society changed into "a sustainable one" (**Fig. 1**).

The steel industry has so far made strenuous efforts to eliminate hazardous emissions by investing continuously in the improvement

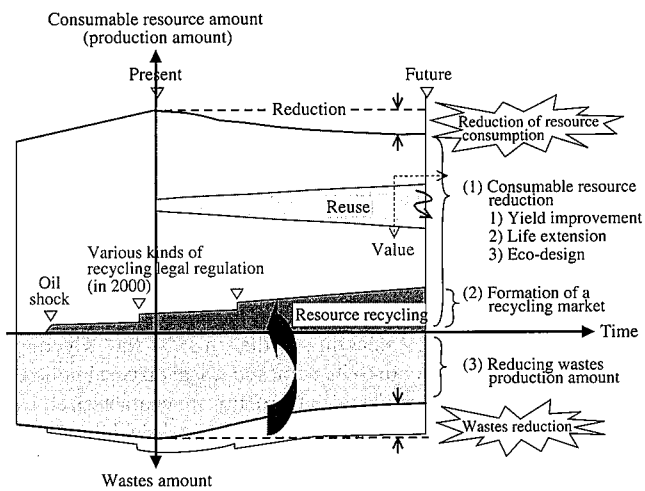

Fig. 1 Future image of the formation of a recycling-oriented society

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Table 1 Typical environmental measures at Nippon Steel

Energy problem
Global environmental problem
Wastes managemet problem

	A.D.	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Measures against chemical substances and water pollution / Measures against air	Reinforcing material yard water spraying	○								○	○	○
	Measures against rain at material yard	○	○	○		○	○				○	
	Measures for improving working environment at coke oven	○		○				○	○	○		○
	Renewal of coke oven cover								○	○		
	Measures against sintering dust raising		○	○	○			○	○	○		○
	Renewal of sintering dust collector	○	○	○	○	○		○		○		○
	Environmental measures at steel works	○	○	○	○		○				○	○
Recycling measures	Dust recycling equipment											○
	Waste plastics treatment equipment										○	
	Installation and renewal of incinerator					○				○		○
Amount invested in environmental measures (billion yen)		6.9	22.7	28.6	20.0	9.2	6.7	4.3	8.3	11.9	14.0	11.8

Total invested amount until 1990: 289.4 billion yen

of operations and equipment and in the development of new technologies so that environmental pollution can be prevented and industrial wastes can be reduced (**Table 1**).

Steel manufacturers can contribute to the establishment of a recycling-oriented society by recycling iron materials, utilizing recycled resources by taking advantage of the existing infrastructures, and using technologies to eliminate hazardous emissions. It is particularly worthy to note that the present steel manufacturing process has the potential to form a social infrastructure characterized by safety, reliabilitation and high efficiency in the effective utilization of waste substances when deregulation is enforced. More concretely, with the techniques related to high-temperature fusion treatment using blast furnaces, converters, and electric furnaces serving as platforms along with designs for iron manufacturing equipment and operation techniques cultivated thus far, fusion of the application of those techniques into an appropriate interface technology that best utilizes of them can be considered.

It is firmly believed that the high-efficiency production system of which Japanese steel industry can boast will contribute to the effective utilization of recycled resources and the elimination of hazardous emissions in the future to win high praise and interest from among the general public.

This report deals with the total aspect of how Nippon Steel Corporation is taking steps toward establishing a recycling-oriented society.

2. Recent trends of policy on the environment relative to the formation of a recycling-oriented society

2.1 Trends in foreign countries

In Europe, environmental policies have become important political problems since the 1980's. In Germany, the government enacted an ordinance in 1991 to make self-governing bodies responsible for recycling packaging wastes out of the waste substances treated by the self-governing bodies, enacting further in 1994 the "Cycling Economy/Waste Act" as core to its domestic waste disposal policy.

The environment-related laws in Germany are characterized by three principles: "Principle of hazard prevention", "Principle of polluters' responsibility", and "Principle of cooperation". In accordance with those basic principles, environment-conscious production processes have been developed with an aim at the symbiosis of ecology and economy so that the additional cost for recycling and the cost for repairing after the occurrence of pollution can be reduced.

The environmental policy in Europe is characterized by a long-term environmental plan formulated by each country for the promotion of comprehensive prevention programs. Those plans are not only requesting the cooperation of those concerned based on the mid- and long-term targets, but also encouraging the adoption of an auditing system for grasping comprehensively how the plans are being undertaken and the utilization of economic expertise as an incentive for tackling them. Economic incentives include an environmental levy on products, a deposit system, a preferential taxation system, and an environmental tax. In some countries are taken not only compulsory measures stipulated by laws and regulations but also other measures utilizing an independent agreement with the industry concerned and financial incentives.

2.2 Trends in our country

(1) Basic Plan for the Environment

As a new framework of the environmental policy stemming from the conventional basic law for environmental pollution control, the environmental protection law and the basic plan for environmental pollution control were enacted in 1993 and 1994, respectively. The basic plan for environmental pollution control has declared the four targets. Namely, they are: "circulation", "symbiosis", "participation," and "international activity". The fundamental principles are stipulated for the environmental policy, for the roles of respective governing bodies, and for the measures for policy making.

(2) Basic Law for Promoting the Creation of a Recycling-oriented Society

The basic law for the promotion of the establishment of a recycling-oriented society was enacted, and fully enforced in January, 2001 to arrange in order the existing method of implementation so that the problems can be quickly dealt with, including a high-level transition of the amount of discharged wastes, the congestion of reuse and recycling, scarcity of final disposal sites, increased illegal waste dumping, and increased use of un-recyclable resources, such as fossil fuel and mineral resources. Central Council for Environmental Pollution Control is now studying a guideline to formulate a basic plan.

This law indicates a basic concept of how basic principles, the responsibility of each self-governing body, and a national policy should be with a view to securing the recycling of social substances, controlling the consumption of natural resources, and reducing environmental load. In addition, the following laws were materialized as the ones by which the ideologies of the laws can be concretely imple-

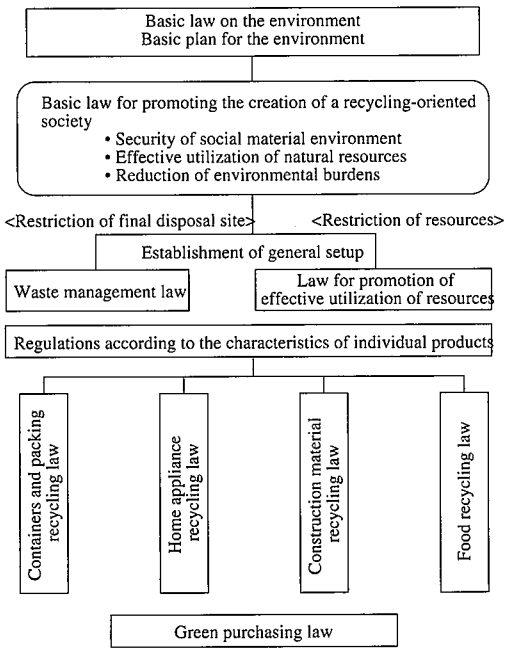


Fig. 2 Legal system for promoting the creation of a recycling-oriented society

mented, revised waste disposal law, law of promoting the effective use of resources, and law of recycling packaging wastes, law of recycling used electric home appliances, and green purchase law. Thus a recycling-related law system was established with the level highest in the world (**Fig. 2**).

(3) Waste Management Law

After its enactment in 1970, the waste management law went through several revisions and was established and fully enforced after April, 2001 with the regulations and standards for waste management provided for an appropriate disposal of waste substances, the installation of waste disposal facilities, and waste service companies. The waste management law was revised to place greater emphasis on reinforcing the measures against illegal disposal.

(4) Law for Promotion of Effective Utilization of Resources

The Industrial Structure Council of the Ministry of Economy, Trade and Industry envisioned a recycling economy with the establishment of a recycling economy system in July, 1999, recognizing that it is an urgent task to change from an economic society, characterised by mass production, mass consumption, and mass disposal, to tackling the formation of a recycling society in the face of the stringent problem of final disposal sites and the future exhaustion of resources. To materialize the expansion of 3 R's proposed in this report, namely Reduction (measures against the production of wastes) and Reuse (measures to reuse wastes for parts) and Recycling measures (measures to reuse wastes for raw materials), the "Law for Promotion of Utilization of Recyclable Resources" enacted in 1991 was drastically revised and "Law for Promotion of Effective Utilization of Resources" was enforced in April, 2001.

As described above, one system after another was established under the new ideology to take a great step toward the establishment of a recycling-oriented society (a new system of securing environmental safety) with the activities in each unit of a country, a nation, and a company integrated. In this context, the steel industry is requested to contribute concretely to a recycling-oriented society by taking advantage of its technology and infrastructure, with the obvious steps of recycling its own by-products.

3. Movement toward the formation of a recycling-oriented society in the industrial sector

(1) National guideline on the reduction of wastes

The Government decided at the Cabinet conference "A target of waste reduction" in September, 1999 to reduce final disposal amounts by half in fiscal 2010 in comparison with that in fiscal 1996 as a target of promoting recycling.

(2) Voluntary action program of environmental protection by the Federation of Economic Organizations (Keidanren)

The steel industry formulated "Voluntary action program relative to the environmental protection by the steel industry" at the meeting of Keidanren in 1996 and is acting in various ways with a target of reducing 75% of the final disposal amount of slag, dust, and sludge in 1990 by 2010.

Keidanren formulated its independent action program of environmental protection with a target set of reducing industrial wastes in 1997 and is following up its action based on its annual data report (**Fig. 3**).

(3) Compliance with the waste management law

Pursuant to the enforcement of the basic law for promoting the creation of a recycling-oriented society, the actual results and the plan of collecting wastes - a subject of the law - are reported to each self-governing body. Each self-governing body is expected to decide the details upon consultation. In the steel industry, slag and scale are typical target items.

(4) Compliance with the law for promotion the effective utilization of resources

Appointed as "Specified resource conservation business" on which is imposed concrete responsibility in accordance with the law for promoting the effective use of resources, the steel industry is requested to deal with the prevention of the production of by-products and the promotion of the utilization of the by-products as recycled resources. The steel industry is therefore trying, for example, to prevent the production of slag by elaborating the production process as well as to use it effectively as the raw materials of cement and roadbeds.

4. Activity at Nippon Steel Corporation

Immediately after its start in 1970, Nippon Steel Corporation has set up the Environmental Control section at its head office to be en-

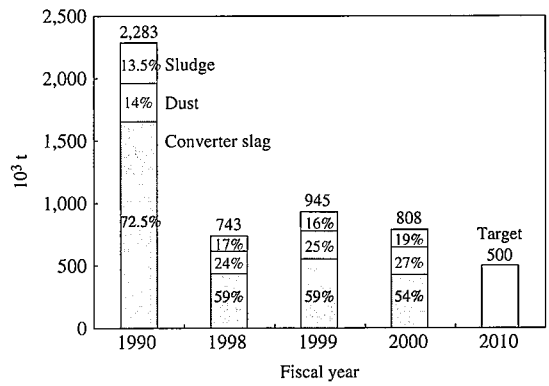


Fig. 3 Voluntary action plan by steel industry of reducing industrial wastes

gaged in environmental conservation activity. Its environmental basic policy, formulated in 1972, was reviewed several times and further reviewed in January, 2000 as well. The basic policy comprises Contributions to the establishment of a society committed to environmental preservation, Reducing environmental impact at every stage of operations, and International contribution through initiatives for environmental preservation on a global scale. As its mid-term environmental management plan based on the foregoing, it is developing a concrete activity by adopting the following platforms: Initiatives for preservation of the global environment, Initiatives for creation of recycling-oriented society, Initiatives for contribution, through products and engineering, to environmental preservation, energy saving and conservation of resources, and Initiatives for reducing environmental impact. It is actively engaged particularly in improving the rate of converting by-products, produced in the production process, to resources, minimizing wastes, and reusing by-products produced in other industries and societies as important tasks.

(1) Recycling of steel products

The yield of steel products amounts to about 0.8 billion tons every year with some 12 billion tons accumulated now in the society. Those out of service are collected as iron scrap. The iron scrap makes up an effective recycling system in which they are used either partly with iron ore as the main component or mainly for iron manufacture (**Fig. 4**).

(2) Recycling of by-products

<Slag recycling>

The slag yielded as a by-product in iron manufacture is mainly composed of lime (CaO) and silica (SiO_2). Since it contains no other organic substance, it is used for various applications, such as raw material for cement, soil conditioners and roadbeds.

It is produced in a blast furnace in the iron making process and in the steel making process. In the blast furnace, 300 kg of slag is produced per ton of pig iron, while 150 kg of slag is produced per ton of molten steel in the steel making process. Since blast furnace slag is very similar in component to cement, almost 100% of slag is used for mixing in cement material and as blast furnace cement.

Blast furnace slag in a molten state, when quenched with water, results in granulated slag that cures with water. Pulverized granulated slag, when mixed in Portland cement, is called "blast furnace cement". Since blast furnace cement replaces about 45% of Portland cement with blast furnace slag, it helps to save the resource of slime. It is also effective for preventing the temperature-induced cracking of large structures because of its excellent long-term strength and small hydration heat. In addition, it is remarkably effective for controlling salt damages and alkaline reactions of aggregates in coastal structures. It is therefore specified as "a special procurement item" for public works and also adopted in "Common Specifications for Construction Work" compiled under the supervision of the Ministry of Land, Infrastructure & Transport.

Since converter slag is higher in basicity (CaO/SiO_2) than blast furnace slag, it swells when used as it is. It then becomes necessary before delivery to stabilize lime (aging) either by storing it for a long time or by steaming.

<Dust and sludge recycling>

Dust, produced in a blast furnace and a converter in a steelworks, is already recycled and sold to the extent of 95%. With a view to increasing further the rate of recycling, however, rotary type reducing furnaces were installed in three steelworks, namely, Kimitsu, Hirohata, and Hikari Works, where metals contained in dust and sludge are reduced and pelletized for recycling in the steel-making process (**Photo 1**). With this technology, the dust, hitherto considered unrecyclable because of the presence of zinc in it, is now recyclable. In addition, the zinc, separated and recovered, can also be sold.

(3) Recycling of by-products generated by other industries

<Acceptance of waste acid, aluminum dross, and discarded tires>

By-products from other industries and societies are being positively used as a substitute for raw materials that are purchased in the steel-making process. Concretely, sludge from the paper industry and aluminum dross from the aluminum manufacturing industry are used as insulating material and steel auxiliary, a nickel catalyst used for petroleum refining and food purification is used as a raw material of stainless steel, and waste acid from the semiconductor manufacturer is used for acid pickling of stainless steel.

At Hirohata Works the method of melting cold iron resources, in which iron scraps are melt by blowing pulverized coal and oxygen into a converter, has been adopted since 1993 to secure iron resources due to the shutdown of the blast furnace. Discarded tires have replaced part of this pulverized coal for use as a fuel resource. Steel wires contained in the discarded tires by about 14% are used as an iron source, while the gas produced, rich in hydrogen content, is

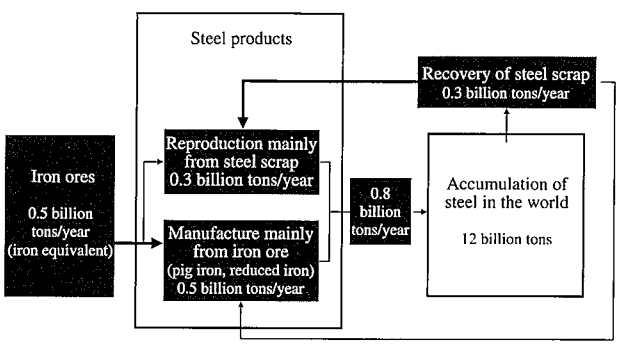


Fig. 4 Reproduction of iron/recycling system

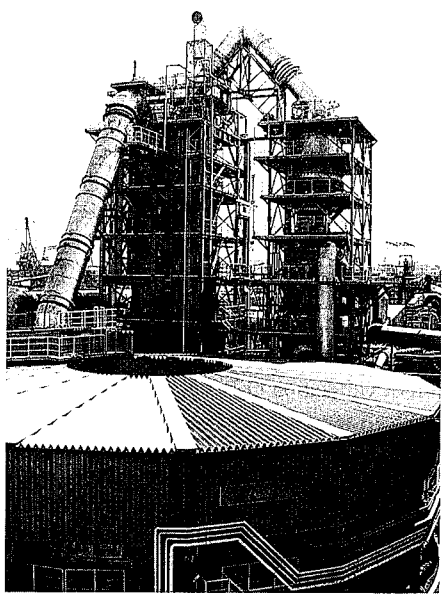
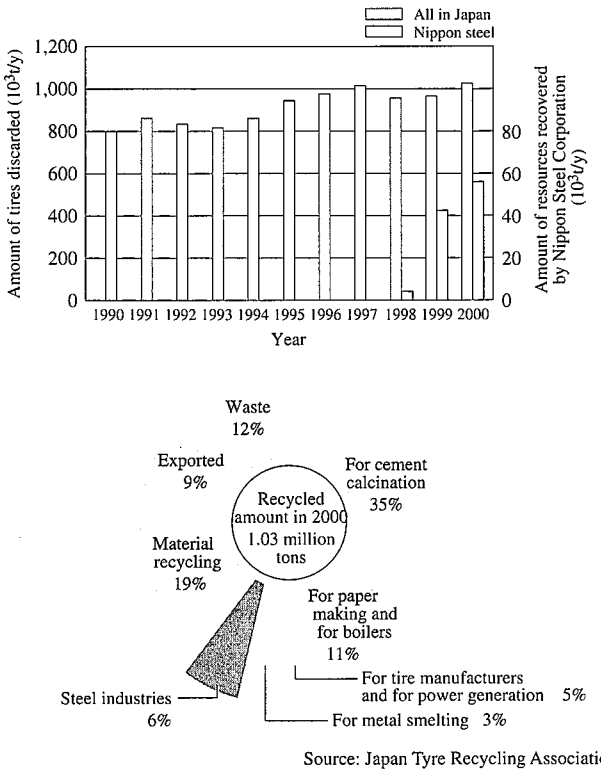


Photo 1 Dust recycling plant at Kimitsu Works



Source: Japan Tyre Recycling Association

Fig. 5 Results of resource recovery from discarded tires and recycling conditions

recycled for use as an energy source in the steelworks. In this manner, 57 thousand tons of discarded tires were recycled in 2000, accounting for about 6% of the total discarded tires recycled in Japan (**Fig. 5**).

(4) New activity

(a) Waste plastics recycling

For efficient use of the infrastructure of its equipment, the steel industry is effectively using waste plastics for a blast furnace and coke ovens as substitutes for coal. Undoubtedly, this serves to solve the problem related to the disposal of waste plastics, save resources by recycling, realize energy conservation, and prevent the global warming by reducing the discharge of CO_2, thus contributing to the creation of a recycling-oriented society.

After a series of tests for effective utilization of waste plastics for a coke oven, Nippon Steel Corporation started recycling waste plastics in 2000 when its technology relative to "the method of recovering chemical materials for a coke oven" was officially authorized in accordance with the law for recycling container packages.

According to containers and packaging recycling law, plastics for container packages, discharged from general households, are classified and collected by respective self-governing bodies, and delivered to a steelworks. Those collected waste plastics are reduced in volume and molded after removing foreign matter to render them suitable in quality and shape for charging into a coke oven, crushing, and removing chlorine compounds. Then, they are mixed with coal, charged into a coke oven, heated to 1,200°C in an enclosed carbonization room to be pyrolyzed. From the high-temperature gas produced then are recovered hydrocarbon oil (light oil and tar), coke oven gas, and a residue from which coke is recovered. The hydrocarbon oil is used as chemical raw material, while the coke oven gas is used at a steelworks as fuel gas and at a power plant. In this system,

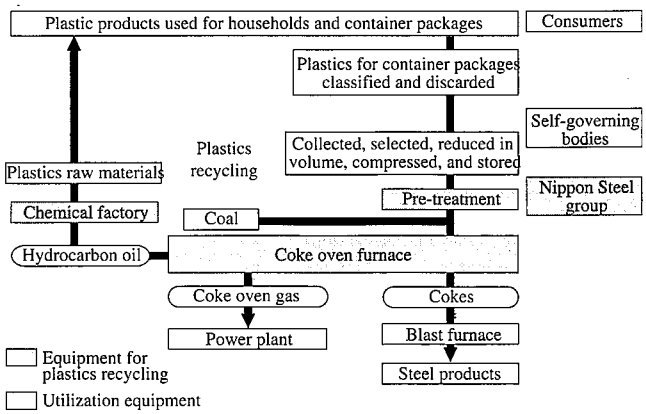


Fig. 6 Plastics recycling flowchart

40% of charged plastics is recycled as hydrocarbon oil, 20% as coke, and 40% as coke oven gas (**Fig. 6**).

The waste plastics recovery equipment is expected to run at Nagoya and Kimitsu Works from October, 2000, and at Yawata and Muroran Works after 2002.

This technology is expected to reduce 1.5% equivalent of CO_2 by accepting 1 million tons in 2010 in the independent action program of the steel industry relative to the global warming problem as well.

(b) Shredder dust treatment

With the recycling-related laws formulated, the movement toward the appropriate recycling of automobiles is actively discussed. The establishment of a recycling system is under discussion relative to the recycling of automobiles with emphasis placed on 1) the prevention of illegal dumping of discarded automobiles, 2) continual recycling and appropriate treatment, and 3) minimizing a final disposal amount.

ASR (Automobile Shredder Residue), a residue with metals, such as iron, removed from an automobile shredded after removing useful and harmful parts, is land filled at a final disposal site. It is requested in the new recycling system, however, to minimize the production of ASR, and take appropriate measures in terms of the reduction of environmental burdens and reduction of a final disposal amount. Nippon Steel Corporation is making headway to respond to the new social need with priority given to the technology of the gasification pyrolysis furnace, well-established already in general waste incinerators.

(c) Environmental solutions fields

Nippon Steel Corporation has developed technologies accumulated in the long history of iron making, offering at home and abroad the technologies related to the environment and energy-saving plant operation. It is also going to offer environmental solutions business that will contribute to the formation of a recycling-oriented society over a broad range from waste disposal to water treatment, energy utilization, and soil purification.

<Gasification pyrolysis furnace>

Since the direct waste melting and recycling system on the basis of blast furnace technology pyrolizes various kinds of solid wastes, including incombustibles, en bloc at a high temperature of over 1,700°C, it is an epoch-making technology for solid waste treatment that prevents the evolution of harmful gases, such as dioxins, reduces wastes for land filling drastically, recovers resources for construction materials from the resulting slag and metals, and utilizes recovered energy for local heat sources. As of November, 2001, the

Table 2 Record of orders received of gasification pyrolysis furnaces by Nippon Steel

Place of delivery	Location	Capacity	Startup
Kamaishi City	Kamaishi City, Iwate Prefecture	50 t/day × 2 furnaces	September, 1979
Ibaraki City (1st factory)	Ibaraki City, Osaka Prefecture	150 t/day × 3 furnaces	August, 1980
Ibaraki City (2nd factory)	Ibaraki City, Osaka Prefecture	150 t/day × 2 furnaces	April, 1996
Sonryu Hygiene Organization	Tatsuno City, Hyogo Prefecture	60 t/day × 2 furnaces	April, 1997
Kagawa Prefecture Eastern Sanitation Organization	Nagao Town, Kagawa Prefecture	65 t/day × 2 furnaces	April, 1997
Iizuka City	Iizuka City, Fukuoka Prefecture	90 t/day × 2 furnaces	April, 1998
Ibaraki City (1st factory modernization)	Ibaraki City, Osaka Prefecture	150 t/day × 1 furnace	March, 1999
Itojima Area Fire House Welfare Organization	Shima Town, Fukuoka Prefecture	100 t/day × 2 furnaces	April, 2000
Kameyama City	Kameyama City, Mie Prefecture	40 t/day × 2 furnaces	April, 2000
Akita City	Kawabe Town, Akita Prefecture	200 t/day × 2 furnaces	April, 2002 (scheduled)
Takizawa Village	Takizawa Village, Iwate Prefecture	50 t/day × 2 furnaces	December, 2002 (scheduled)
Makimachi and Other Three Villages Hygiene Organization	Nishikanbara Country, Niigata Prefecture	60 t/day × 2 furnaces	April, 2002 (scheduled)
Narashino City	Narasino City, Chiba Prefecture	67 t/day × 3 furnaces	April, 2003 (scheduled)
Kazusa Clean System Ltd.	Kisarazu City, Chiba Prefecture	100 t/day × 2 furnaces	April, 2002 (scheduled)
Kagawa Prefecture Eastern Sanitation Organization	Nagao Town, Kagawa Prefecture	65 t/day × 1 furnace	April, 2002 (scheduled)
Toyokawa Houhan Hygiene Organization	Toyokawa City, Aichi Prefecture	65 t/day × 2 furnaces	April, 2003 (scheduled)
Kouchi Eastern Environment Facilities Organization	Nakamura City, Kouchi Prefecture	70 t/day × 2 furnaces	April, 2003 (scheduled)
Tajimi City	Tajimi City, Gifu Prefecture	85 t/day × 2 furnaces	April, 2003 (scheduled)
Oita City	Oita City, Oita Prefecture	129 t/day × 3 furnaces	April, 2003 (scheduled)
Koga City and One City, Four Towns Waste Treatment Organization	Koga City, Fukuoka Prefecture	80 t/day × 2 furnaces	April, 2003 (scheduled)
Seino Environment Maintenance Organization	Ogaki City, Gifu Prefecture	90 t/day × 1 furnace	April, 2004 (scheduled)

company has accepted an order for 21 furnaces, accounting for about 1/3 of a total of 66 furnaces throughout the country. There are some 1,500 incinerators of general wastes domestically. It is expected to develop this system as a facility for harmonizing with the environment in the future (**Table 2**).

5. Future prospects

With various legal systems related in recent years to form a recycling-oriented society, resources are going to be recovered from those items hitherto discarded as wastes in the fields of containers and electric home appliances, and automobiles this year.

Although it is essential to develop the recycling industry as a venous industry for the formation of a recycling-oriented society, management of the venous industry by the collection and delivery of wastes alone will not lead to the promotion of recycling because of the obstacles awaiting in terms of technology development and cost. Since the venous industry has realized continual innovation in the manufacturing process, it may be safe to say that the organic combination of the arterial industry with the venous one can be realized if the latter plays a role as the heart.

The steel industry is capable of contributing greatly to the establishment of a recycling-oriented society by taking advantage of its existing infrastructure to the utmost. Nippon Steel Corporation will therefore try to offer various environmental solutions now and in the future as well.