Figure 2.2.12 shows the pollution control investments by the petroleum refining industry in this period. It is clear that much of the investment was centered on heavy oil desulfurization equipment for (falls under the category of product pollution control equipment). Therefore, investment in pollution control equipment for petroleum refining facilities per se was not as large as it seemed. Although the operation rate for desulfurization equipment for heavy oils was already extremely low in 1975, large investments continued to be made until around  $1976^{25}$ .



Source: TAKANO Akinobu, "Sekiyu Seiseigyo ni okeru Kankyo Taisaku", *Sangyo Kogai*, Vol.25 No.10, 1989, p.30. (Original source: material from Petroleum Association of Japan)



# 2.2.3 Analysis of Measures for Sulfur Oxide Control at the Local/Industry Sector Levels

This section reviews the cases that analyzed the SOx control measures taken in Japan with the focus on effects and impacts on a particular local area or a particular industry sector. It will describe how the policy measures for SOx control functioned and are evaluated, citing representative cases.

# a. Comparison between Air Pollution Damage Costs and SOx Control Costs in Yokkaichi City

# a.1 Occurrence of Air Pollution and Its Countermeasures

In Yokkaichi City, because of its extensive land suited for factory location and its superior port facilities, the Cabinet approved selling of approximately 660ha of government-owned land to private companies in 1955, for the purpose of building petrochemical complexes there. In 1959, the first complex was completed and put into operation, and by the time of the completion of the third complex in 1972, the complexes had the capacity of refining 505,000 barrels of oil and to producing 701,000 tons of ethylene, which was the largest in Japan<sup>26</sup>.

<sup>&</sup>lt;sup>25</sup> Ibid. pp.321-322

<sup>&</sup>lt;sup>26</sup> Chikyu Kankyo Keizai Kenkyukai (ed.), *Nihon no Kogai Keiken*, Godo Shuppan, 1991, p.28

The development process of the complexes and pollution and its countermeasures is as follows.

Development of Oil Complex	Pollution Condition, Patient Identification and Relief	Regulations etc.	Corporate Response
Cabinet decision on development of petrochemical complexes (1955) First complex operation started (1959)	Occurrence of noise, vibration and odor problems (1960) Identification of asthmatic patients (1961)	Yokkaichi Pollution Control Committee was established. (1960)	
Second complex operation started (1963)	The period of the highest SO <sub>2</sub> concentration (1962-1964) Medical benefit independently provided by the city started (1965) Damage lawsuit by residents (1967)	Yokkaichi was designated by Soot & Smoke Control Law as concerning area (1964) Air Pollution Control Law introduced K-value (1968) Pollution Control Plan was prepared (1970)	Stack height increased. (Since 1965)> Expansion of polluted area Heavy oil desulfurization equipment started operation. (1967)
Third complex operation started (1972)	Residents won the damage lawsuit. (1972) Pollution-Related Health Damage Compensation Law was enacted. (1974) SO <sub>2</sub> concentration met the environmental standard (1976)	Total amount control by Mie Prefecture Pollution Control Ordinance (1972) Introduction of inspection for flaming condition of factories (1973) Total amount control by Air pollution Control Law (1976)	Flue gas desulfurization facilities started operation. (1974)

# Table 2.2.3 Development Processes of Petrochemical Complexes in Yokkaichi and Pollution and Its Countermeasures

Source: Added and altered to Kito et al., Kankyo ni Hairyosita Kaihatu Seisaku no Yukosei, 199827

# a.2 Causality Analysis of Pollution Control Activities

Kito et al.<sup>28</sup> analyzed the causal structure of production activities of companies located in the petrochemical complexes and pollution related variables by creating a path diagram on the relationship among the variables.

The period of data used was 20 years from 1972 to 1992. The results of the path analysis is shown in Figure 2.2.13, and the path coefficients in the figure show the relationship between the explaining variable (the variable at the beginning of the arrow) and the explained variable (the variable at the point-end of the arrow). If the path coefficient is over 0, the larger the number, the higher possibility of an increase of the explaining variable value bringing the increase of the explained variable value. If the path coefficient is under 0, the larger the number, the higher possibility of an increase of the explaining variable value bringing the decrease of the explained variable value.

For example, when the fuel consumption (X1) increases, Y1 (S content ratio in the fuel used) decreases, but Y3 (SOx content of fuel used), Y2 (pollution control investments), and Y4

<sup>&</sup>lt;sup>27</sup> KITO Hirohumi, OKA Yoshihiro, ASAHI Sachiyo, TAKEMOTO Yukimasa, NISHIGAKI Yasuyuki , IIJIMA Masaki, *Kankyo ni Hairyosita Kaihatsu Sisaku no Yukosei – Yokkaichi Kogai no Keiryo Keizai Model Bunseki*, Godo Shuppan, 1998, p.10

<sup>&</sup>lt;sup>28</sup> Ibid. pp.18-20

(private capital stock for pollution control) increase. This is because companies in the petrochemical complex tried to choose low-sulfur fuel in the year when fuel consumption was large, but Y3 (SOx content of fuel used) increased all the same; and as a countermeasure, companies tried to reduce the amount of SOx emitted into the air by increasing Y2 (pollution control investments) and Y4 (private capital stock for pollution control).



X1: fuel consumptionX2: regulated env. valueY1: S content ratioY2: pollution control investmentY3: SOx content

Y4: private capital stockY5: SOx removedY6: unit cost of SOx removalY7: SOx emissions into the atmosphere

Note: Values between variables are path coefficients, and values under variables are contribution ratios. Source: KITO Hirohumi et al., *Kankyo ni Hairyosita Kaihatsu Sisaku no Yukosei – Yokkaichi Kogai no Keiryo Keizai Model Bunseki*, Godo Shuppan, 1998, p.10

Figure 2.2.13 Causal Structure of Industrial Pollution Caused by Production Activities of Companies at Petrochemical Complex

#### a.3 Comparison of Damage Costs and Pollution Control Costs

In *Japan's Experience in the Battle against Air Pollution* by the Committee for Japan's Experience in the Battle against Air Pollution, the SOx pollution damage costs and control costs in Yokkaichi City are compared as follows.

#### 1) Compensation Costs (Damage Costs)

Regarding the average compensation costs after 1974 (when the Pollution-Related Health Damage Compensation Law was enacted, and medical benefit and compensation for forgone earnings were started) as "costs for health damages," the yearly amount is 1,331 million JPY (at 1989 price).

# 2) Pollution Control Costs

When the average pollution control investment in private companies after 1971 (when the pollution control plan was implemented) is regarded as the equivalent of average depreciation costs. The sum of the average depreciation cost, operation costs (calculated as a certain percentage of the average depreciation cost), interests, and costs for the improvement of monitoring systems in the public sector (running costs included) and the development of green belt are considered to be "annual cost for air pollution control measures," the yearly cost is 14,795 million JPY (at 1989 price).

#### 3) Evaluation

In the Yokkaichi region, air pollution control costs are estimated at 14,795 million JPY, while damage costs (compensation costs) are 1,331 million JPY a year (at 1989 price) which is due to the fact that proper measures were not taken early enough.

In reality, although implementation of pollution control was follow-up of the pollution, the worst-case scenario was avoided. When damage costs that would have occurred are calculated if no pollution control measures were taken and if the severely polluted and thus damaged area -- Isogo area or the most polluted area in 1975, was to spread to the entire Yokkaichi City, as feared at the time, annual damage costs would have been 2,107 million JPY (at 1989 price), and would thus easily be larger than the cost for implementing air pollution control measures.

From the results, it is concluded in this report that in this case, investment in preventing health damage was rational even from the financial point of view.

#### b. Sulfur Oxide Control and Corporate Behavior in Kitakyushu City<sup>29</sup>

Kitakyushu City, one of the major industrial cities with large companies in material industries, such as steel, cement and chemicals, experienced serious pollution during the late 1960s and early 1970s, as many other industrial cities did. However, the city government overcame its pollution problems with unique strategies that differed from other cities, and is now recognized as one of the few "environmental cities" in Japan.

# b.1 Persuading Industry to Implement Pollution Control through the Results of Simulation Study

In 1969, the Ministry of International Trade and Industry carried out a general preliminary survey of industrial pollution in the Kitakyushu Area (hereinafter referred to as "general preliminary survey"). The general preliminary survey was a large study, studying weather conditions by using helicopters, then carrying out wind tunnel experiments based on the data collected. This survey was a full-scale survey that can be considered one of the first, leading surveys in the Japanese environmental assessment arena. Following the results of this survey, the city government gave administrative guidance to companies for the achievement of environmental standards by 1973. The city made each business establishment submit a plan for the implementation of pollution control measures, estimated future pollution conditions based on these plans, and then gave guidance for improvements.

This survey was meaningful in terms of making it possible to discuss the degree of pollution and the effects of measures with scientifically demonstrated numbers. The survey made clear the types of measures needed in this period of high economic growth, as well as the extent of the measures, in order to achieve environmental standards. The study gave the city government a solid base to effectively persuade companies to implement pollution control measures. The companies had no choice but to try to rebut arguments using numbers, as the persuasion was based on numbers.

<sup>&</sup>lt;sup>29</sup> FUJIKURA Ryo, "Kogai Taisaku no Shakai Keizaiteki Yoin Bunseki", *Kitakyushu Kogai Taisakushi - Kaisekihen*, Kitakyushu City, 1998, pp.206-208

In carrying out the general preliminary survey, the Kitakyushu Air Pollution Control Communication Committee was established, consisting of Kitakyushu City, Fukuoka Prefecture, the Kitakyushu Regional Bureau of the Ministry of International Trade and Industry, 30 major companies and 32 major factories in the city. This committee played an important role as the place where the city and private companies had realistic discussions, for subsequent air pollution control measures such as the concluding of pollution control agreements and implementation of SOx emission reductions.

#### b.2 Complicated Process for Fuel Change

In Kitakyushu City, as in other industrial cities, the SOx control measures began with expanding imported low-sulfur crude oil at first. Until the early 1970s, when the installation of heavy oil desulfurization equipment was progressing, the supply of low-sulfur heavy oil was not enough as demands increased due to air pollution control. The relative price of low-sulfur heavy oil to high-sulfur heavy oil increased. Prior to the full implementation of SO<sub>2</sub> control in the 1960s, the price difference between low- and high-sulfur heavy oils was only a few percent. Comparing the prices of the Indonesian Minas heavy oil (low sulfur content of only 0.3%) and high-sulfur heavy oil as of 1969, the former was 6,100 JPY/kl while the latter was 5,900 JPY/kl, which represents only a 3% difference. This price difference widened to 61 % in 1973 (see Figure 2.2.14).



Source: FUJIKURA Ryo, "Kogai Taisaku no Shakai Keizaiteki Yoin Bunseki", *Kitakyushu Kogai Taisakushi - Kaisekihen*, Kitakyushu City, 1998, p.208

# Figure 2.2.14 Trend in Prices of Heavy Oil by SOx Content (1958-1990)

Amidst such conditions that low-sulfur heavy oil was difficult to obtain, Kitakyushu City prioritized integrating and increasing height of stacks to lower sulfur concentration on the ground. Raising stack height is an effective quick-fix in certain highly polluted areas. In 1969, the Tohata joint thermal power plant built a high stack of 120 meter.

Kitakyushu City formulated the Implementation Guideline for Air Pollution Emergency Plan in Kitakyushu City in 1970, as an emergency measure for episodes of high SOx concentration in ambient air. This strengthened administrative guidance to companies for the shift to low-sulfur fuel.

The city government took a strict stance when companies consulted them about the installation of flue gas desulfurization equipment, considering safety and the possibility of secondary pollution from wastes from the desulfurization equipment. Flue gas desulfurization equipment became available around 1974, but at that time, the city government still assessed the conditions of technology development for the equipment

negatively. The city government regarded measurement values of emission gas from the desulfurization equipment as unreliable, and did not accept installing the equipment as guarantees for meeting emission gas standards. For the companies that were considering the establishment of flue gas desulfurization equipment, the city government required the installation of back-up facilities, in case the equipment malfunctioned. The city government also required the companies to stop operations altogether if the equipment and the facilities stopped functioning properly.

For companies located in Kitakyushu City, they had no choice but to convert their fuel to low-sulfur one, as the city government was skeptic about the flue gas desulfurization equipment. However, except large companies such as Nippon Steel Corporation who imported crude oil directly from the oil producing country, ordinary companies had difficulty in procuring low-sulfur fuel, especially after the first oil crisis of 1973, when oil supply was low. One company was required by the city government to reduce its  $SO_2$  emission to one-sixth of the past emission during the period from 1970 to 1975. The company estimated the fuel costs if it changed the fuel to the low-sulfur C-heavy oil, A-heavy oil and illuminating kerosene; the result showed that the increase in cost burden amounted to half the existing profits. However, in the end, the company accepted the huge increase in costs and changed the type of fuel. In the report mentioned above, Fujikura assumed that this decision was presumed to have been an on-the-edge decision for this company.

When sulfur contents are compared among liquid fuel used in Kitakyushu City, heavy oil supplied to all areas in Japan and low-sulfur heavy oil imported for non-refining use, it is clear that Kitakyushu City used liquid fuel that contained much less sulfur than the heavy oil supplied to all areas in Japan. Since the technological limit of indirect desulfurization at that time was 1.7%, it can be said that many manufacturers in the city were using the expensive, low-in-supply low-sulfur fuel.



Source: FUJIKURA Ryo, "Kogai Taisaku no Shakai Keizaiteki Yoin Bunseki", Kitakyushu Kogai Taisakushi - Kaisekihen, Kitakyushu City, 1998, p.209

# Figure 2.2.15 SOx Content in Fuel (1967-1990)

The city government's guidance for lowering the sulfur content in fuel was effective, and during the 1970s the sulfur content in the fuel used in the city lessened dramatically, along with the amount of sulfur dioxide emissions. The liquid fuel consumption in the city was the largest in 1973, but the  $SO_2$  concentration in the ambient air had started to decrease a few years before this. Although manufacturers in the city have been producing about the same production values in real term for the past 20 years, they achieved dramatic decreased of sulfur dioxide concentration by lowering the sulfur content in fuel.



Source: FUJIKURA Ryo, "Kogai Taisaku no Shakai Keizaiteki Yoin Bunseki", Kitakyushu Kogai Taisakushi - Kaisekihen, Kita Kyushu City, 1998, p.209



#### b.3 Characteristics of Sulfur Dioxide Control at Yahata Ironworks

There was little enthusiasm for energy saving amongst businesses in Kitakyushu City until 1973 when the first oil crisis struck. Nippon Steel Corporation announced a "5-year plan for the 10% reduction of energy" in 1974, where it aimed to reduce 10% of energy consumption compared to that in 1973 by 1980. The whole company struggled for this goal, undertaking such measures as changes in operation, investments for saving energy and the development of new technologies. As a result of these efforts, by 1978 (2 years before the target year), the company had managed to reduce energy consumption by 10.4%. At Yahata Ironworks, the reduction of energy consumption in the first half of 1980 was over 15%. Through the following years, during which there were the 2nd oil crisis and the sustenance of high prices for crude oil, Yahata Ironworks continued to work towards saving energy in many resourceful ways and recorded the maximum 27.5% reduction in the latter half of 1987.

Such intensive efforts to reduce energy consumption also contributed to the reduction of sulfur dioxide emissions. According to estimates made by Nippon Steel Corporation, for the reduction of sulfur dioxide emissions at Yahata Ironworks during the 20 years from 1970 to 1990, energy saving/material saving technology contributed 33%, the change to low-sulfide fuel 42%, and flue gas desulfurization 25%. In the iron and steel industry, flue gas desulfurization equipment is necessary, as it uses coal for raw material. However, even in such industries, the contribution of flue gas desulfurization is only a quarter of the whole SOx reduction. Energy saving contributes to one third of the reduction.

In the case of the levy under the Pollution-Related Health Damage Compensation Law, Nippon Steel Corporation estimated that if the flue gas desulfurization equipment had not been installed in a sintering plant at Yahata Ironworks, the levy imposed on the sintering plant alone during the latter half of the 1980s (when the levy rate became higher) would have been 2 billion JPY. In realty, because they reduced sulfur oxide emissions by flue gas desulfurization equipment, the levy was 300 - 400 million JPY. Since the running cost of

the desulfurization equipment was approximately 1.8 billion JPY, the installation of the equipment provided comparable economic benefit<sup>30</sup>.



Source: FUJIKURA Ryo, "Kogai Taisaku no Shakai Keizaiteki Yoin Bunseki", Kitakyushu Kogai Taisakushi - Kaisekihen, Kitakyushu City, 1998, p.273



# 2.2.4 Implications for Developing Countries

#### a. Identification of Emission Sources and Amounts

The sulfur contained in raw materials and fuel is emitted as sulfur oxide. To control the amount of SOx emissions, it is important to know the amount of sulfur content of the fuel as well as the type and the amount of fuel consumed by the businesses. Therefore, it is necessary to set up a system that makes it possible for administrative authorities to collect such information from businesses. In Japan, the levy system under the Pollution-Related Health Damage Compensation Law enabled authorities to collect data on SOx emissions.

# b. Importance of Pollution Prevention

As is clear from the Japanese experience, when factories are located in the vicinity of residential areas and emit large quantities of SOx without proper control mechanisms, there occur health problems such as asthma of the people living in the surrounding area, and the costs of compensating for such damages exceeds by far the costs of taking measures to control these emissions. In addition, it is necessary to take pollution prevention measures aggressively because it brings large benefits of reducing the health hazards to local populations.

# c. Effects of Direct Regulations (Command-and-Control Mechanism)

In the case of integrated steel factories, the most effective policy for lowering SOx emissions from large emission sources was direct regulations, as seen in Table 2.2.4. Hence there is no doubt that the development of direct regulations is important, but it is also clear that the marginal costs of desulfurization equipment are very high. It is pointed out that direct

<sup>&</sup>lt;sup>30</sup> Ibid. pp.212-213

regulations calling for flue gas desulfurization have limited the opportunity for more flexible measures.

During the 1970s and 1980s, technologies for flue gas desulfurization and lowering the sulfur content in fuel were under development; control measures such as pollutant dispersion by high stacks were gradually strengthened. As a result, expansion of damages due to air pollution could not be prevented. However, at present it is possible to implement regulations assuming that these technologies are available.

In Japan, no policy to reduce SOx emissions through economic instruments was introduced until 1973 because the health damages were so severe and because strict regulations were called for the swift resolution of these problems. Civil support for pursuing economic efficiency of the countermeasures could not be obtained. However, the introduction of economic instruments should also be considered to supplement the direct regulations of SOx emissions.

# d. Effects of Energy Saving and Fuel Shift

As is shown in Figure 2.2.17, it is analyzed that fuel shift and energy saving is the largest contributor to lower SOx emissions. Fuel prices are largely influenced by the structure of energy tax systems including custom duty. In the case of developing countries, it is often difficult to change the types of fuel used, as acquiring inexpensive fuel is the priority, but in such cases, energy savings and conserving raw materials are also an effective measure (see Section 2.5).

Policy Reduction Measure	Direct Control (Mainly Pollution Control Agreement)	Levy based on Health-Related Damage Compensation Law	Support for Pollution Control Investment
Reduction of production	<ul> <li>Decline of sintered ore production in the early 1970s.</li> <li>Overseas production of sintered ore</li> <li>In-house adjustment of basic steel</li> </ul>	<ul> <li>In-house adjustment of crude steel production</li> </ul>	Х
Lowering sulfur content in iron ore	<ul> <li>Decrease of the average sulfur content in iron ore in the 1970s.</li> <li>In-house adjustment of high-sulfur iron ore</li> <li>Reduction of pyrite cinder consumption</li> </ul>	<ul> <li>Decrease of the average sulfur content in iron ore</li> <li>In-house adjustment of high-sulfur coal</li> </ul>	Х
Lowering sulfur content in fuel	<ul> <li>In-house adjustment of high-sulfur coking coal</li> </ul>	<ul> <li>In-house adjustment of high-sulfur coking coal</li> </ul>	Х
Lowering sulfur content in coking coal	<ul> <li>Lowering the sulfur content in fuel</li> </ul>	<ul> <li>Lowering the sulfur content in petroleum fuel</li> </ul>	Х

# Table 2.2.4 Contribution of Sulfur Oxide Control Policies in Integrated Steel Factories

Policy Reduction Measure	Direct Control (Mainly Pollution Control Agreement)	Levy based on Health-Related Damage Compensation Law	Support for Pollution Control Investment
Installation of desulfurization equipment	<ul> <li>Installation of sintering furnace flue-gas desulfurization in the 1970s</li> </ul>	<ul> <li>Installation of sintering furnace flue-gas desulfurization in the 1980s</li> </ul>	<ul> <li>One year earlier installation of sintering furnace flue-gas desulfurization in the 1980s</li> </ul>
Energy saving	?	- (Small investment) ? (Large investment)	?

Note: ■: Contributed, □: Possibility of contribution, -: No contribution, X: essentially no relationship, ?: Unknown Source: MATSUNO Yu, "Tekkogyo ni okeru Iousankabutsu Haishutsu Sakugen heno Kakushu Kankyo Seisaku Shudan no Kiyo (2)", *Keizai Ronso (Kyoto University)*, Vol.160 No.3, 1997, p36

# 2.3 Industrial Water and Wastewater Management

# 2.3.1 Factors Influencing Industrial Water and Wastewater Management

Policy factors influencing corporate response concerning water and wastewater management consist of conditions for obtaining industrial water and discharging wastewater. Conditions for acquiring water include availability of water resources and costs, while those for discharging wastewater include effluent standards and the type of effluent receiver, i.e. public water or sewage system.

Conditions for water intake vary from cases where pumping up of groundwater, the most inexpensive water, is available, to cases where the development of industrial water supply systems is required, or to cases where ground subsidence due to over pumping of groundwater requires the use of industrial water and/or potable water supplies. These are all cost factors for industries. Costs of water usage are very low in areas where there is no constraint to the use of groundwater; motivation for rational use of water does not emerge in such cases. On the other hand, when use of groundwater is strictly regulated and when available water source is only potable water, the cost of water usage is very high, which creates an incentive for rational water use. Users of industrial water (industries) usually bear all the costs including the cost of water resource development. When they have a contract scheme for a certain amount of industrial water regardless of volume they actually need, that incurs considerable costs to industries. Those are basically given factors affecting industry's decisions on water usage, but setting a water rate structure, such as increasing water rate structure for potable water in order to promote water conservation practices, can be considered as policy variables.

Effluent standards are the basis of determining water discharge conditions. Factories established in an urban planning area become obliged to discharge their effluents to a public sewage system by the Sewage Law. While factories can discharge organic wastewater to the sewage system without extensive treatment, they should treat wastewater containing inorganic matter by a certain level prior to the discharge; therefore, connecting to the sewage system holds no advantage for inorganic effluent.

An administrative policy directing factories to discharge their effluents to sewage systems may be regarded as public management of effluent discharge to the environment. Although sewage charge is not classified as 'an environmental user fee,' it has the characteristics of one. This point can be illustrated by mandated installation of wastewater treatment facilities when a factory discharges inorganic effluent regardless of types of accepting water body (establishment of a pollutant removal facility is required if it is discharged to a sewage system). Before connecting to the sewage system, a factory paid no fees for discharging effluent to public water bodies, but the compulsory connection to the sewage system adds costs for industries. As for organic effluent, the sewage charge has the nature of an environmental user fee if it is higher than treatment costs required for discharging the effluent to a public water body.

Forcing factories to discharge their wastewater to a public sewage system and its pricing scheme meant policy variables.

The following sections consider how these policies on industrial water and wastewater management affected corporate behavior towards wastewater control and the reduction of environmental loads.

# 2.3.2 Cooperate Behavior concerning Industrial Water and Wastewater Management

Factories discharging effluents have been making decisions according to changes in external conditions such as policies on acquiring industrial water and discharging wastewater, regulating pumping-up of groundwater, and setting fee structures for potable/industrial water supply and sewage.

The following section summarizes how these decisions have been made in major industries.

### a. Industrial Water and Wastewater Management by Companies

Companies use industrial water for a variety of purposes, such as being used as an ingredient of actual products and for production processes, product processing, washing, direct or indirect cooling and others (air-conditioning, boiler, and domestic uses). The water may be reused/recycled within the company's premises, but it would eventually be discharged offsite.

Obviously, companies want to secure and use water necessary for assuring the quality of their products. At the same time, the companies make various decisions in the direction of reducing total expenditures while meeting effluent standards through rationalizing the use of water as well as taking steps to control effluent (including discharging to the sewage system).

Water and wastewater management costs are composed of the following:

- i Water intake cost: the cost necessary for industry to acquire water for industrial activities. This includes the cost at the source of water (potable water charge, industrial water charge, electricity charges for pumping groundwater or river water, and/or pretreatment cost where necessary). The source of the water may be river water, groundwater, potable water, industrial water, and seawater (for indirect cooling).
- ii Cost of wastewater treatment or circulation: the cost necessary for treating wastewater for discharge to a public water body or sewage system, or the cost of treatment prior to reuse or re-circulating the water within the company.
- iii Discharge fee: the cost associated with discharging the effluent offsite, such as sewage charge.

Minimizing these costs, the companies make decisions on water and wastewater management measures.

Companies' decisions largely depend upon conditions specific to the area where they are located. Such conditions included the following:

- i Availability of free water resources: In general river water, groundwater, seawater can be taken as free if it is taken directly; some companies have their own dams, though pumping and/or pretreatment cost may involved.
- ii Potable/industrial water charge: When water is not available in the way mentioned above, companies have to obtain their water from potable water supply or industrial water which pose charges. When a company is located in an area without a relatively inexpensive industrial water system, it is obliged to pay for potable water.
- iii Sewage charges: Sewage charges are posed for companies discharging their effluents to the sewage system. However, effluent standards for sewage systems are less strict compared to discharging to public water bodies; thus it may be economically preferable to discharge it to the sewers. In Japan, factories are required to discharge their effluents to the sewage system if they are located within an area where sewage is provided. If they are located within a large industrial park near the coast where a sewage system is not available, then they can discharge their effluents to a public water body.

iv Effluent regulations: Two types of regulations are in place, water quality control and total pollution load control. The former can be avoided by dilution if a cheap water source is available. The latter, however, requires effluent sources to reduce concentrations of pollutants and volumes at the same time. Thus, the effluent discharge cost differs depending upon the types of regulations that are imposed.

Since the factory location determines external factors, such as conditions mentioned above, measures that companies can take become fairly limited to a combination of improvement and changes in production processes and input materials and treatment or recirculation of water.

# b. Factors Contributing to the Promotion of Water and Wastewater Management by Industries in Japan

In light of the external factors mentioned above, the factors contributing to the water/effluent measures carried out by industries in Japan can be summarized as below.

#### b.1 Regulations on Groundwater Pumping

The first factor that motivated the industry to rationalize water use was the regulation on groundwater pumping. Since Japan is abundant in groundwater, before the period of high economic growth, utilization of groundwater was the most economical way to meet industrial demands for water, but this resulted in annual ground subsidence of more than 1 meter and saltwater intrusion. The expansion of damages due to flood and high tide water and subsidence of houses and roads reached the level that could not be left as they were.

Accordingly in 1956, the Industrial Water Law was established to regulate the pumping of groundwater and to utilize alternative water supply sources to satisfy the industrial demands. The law, in principle, prohibited constructing a new well, while existing wells could be used for a period of one year after an alternative source of water had secured by the industrial water system. The law was effective since it did not just regulate the intake of water from existing wells, but developed in parallel with alternative water sources. In addition, in areas such as Osaka and Tokyo where ground subsidence was severe, rational use of water such as recirculation of cooling water was advised since the development of the industrial water supply system took a long time.

The regulation on groundwater pumping triggered rational use of water resources. Review and improvement of production processes or recirculation of the water per unit of production was promoted by companies who had used inexpensive groundwater for their water source as they now had to use either industrial water or more expensive potable water. This, in turn, resulted in a decrease in water consumption and subsequently effluent volume.

Water costs in the 1970s were 2 JPY/m<sup>3</sup> for groundwater, 4 JPY/m<sup>3</sup> for river water, 7 JPY/m<sup>3</sup> for industrial water in the southern Kanto region<sup>31</sup>, and 80 JPY/m<sup>3</sup> for potable water<sup>32</sup>. For a factory that switched to industrial water from groundwater with the water consumption of 1,000m<sup>3</sup>/day, the water costs increased by 210,000 JPY/month and 2,500,000 JPY/year. The cost of water supply increased further after that, and in 1980, 10 - 35 JPY/m<sup>3</sup> was charged for industrial water and 250 JPY/m<sup>3</sup> for potable water.

 $<sup>^{31}</sup>$  Based on "Study on Structure of Industrial Water Demand in Kanto Region," conducted in 1983 by the Kanto Regional Construction Bureau, Ministry of Construction. National average industrial water price was 5 JPY/m<sup>3</sup> in 1970 and 13JPY/m<sup>3</sup> in 1983 which indicated that the average price was higher in the southern Kanto region than the national average.

<sup>&</sup>lt;sup>32</sup> Ibid. The value is the average of water prices for large consumption facilities in Chiba, Kanagawa, and Tokyo.

### b.2 Compulsory Discharge to Sewage System

The regulation on groundwater pumping was implemented along with the development of the industrial water supply system, especially for areas with severe ground subsidence; thus, not all factories were subject to the regulation and/or the change in their water supply sources. In that sense, obligatory discharge of effluent to the sewage system depended on the degree of sewage system development. The factories located in areas which already had sewage systems were obliged to discharge their effluents and pay appropriate charges.

This motivated companies that consumed large amount of water and were located in the areas with sewage service to reduce the amount of effluent discharged to the wastewater system to reduce their production costs.

Incidentally, current (2001) sewage charges in Tokyo<sup>33</sup> are 289 JPY/m<sup>3</sup> for use of over 1,000m<sup>3</sup>/month, and 100-300 JPY/m<sup>3</sup> in general. In cities in the southern Kanto region in 1973, sewage cost 10-20 JPY/m<sup>3</sup> (10 JPY/m<sup>3</sup> in Tokyo) in 1977, and it jumped to 20-70 JPY/m<sup>3</sup> (75 JPY/m<sup>3</sup> in Tokyo), illustrating the seriousness of cost pressure.

#### b.3 Effluent Quality Regulation

The Industrial Wastewater Control Law was enacted in 1958. At first it did not have much impact at the factory level due to a weak monitoring and guidance structure. After the enactment of the Water Pollution Control Law in 1970, law enforcement became effective with strengthened monitoring, guidance and penalties. As a result, industries started to treat effluents before discharging them into the public water body.

Industries reduced effluent volume by reducing water consumption and increased recirculation of used water in order to reduce wastewater treatment costs. In addition, separate collection and treatment of wastewater by water quality (organic or inorganic, pollutants concentrations) became prevalent.

#### b.4 Effluent Pollution Load Regulation

Because effluent regulations alone would not rapidly improve water quality, especially in closed water systems like lakes and inner bays, regulations of total pollution loads began with the "Law Concerning Special Measures for Conservation of the Environment of the Seto Inland Sea" in 1973. This measure, aiming at industries located in specific areas, regulate pollution loads along with quality of the effluents, which provided further inducement for industries to rationalize water use.

In particular, those industries which had been diluting wastewater with cooling water or extra industrial water before discharge could not continue such activities and had to make a drastic improvement in water use and discharge flow.

<sup>&</sup>lt;sup>33</sup> Japan Sewage Works Association, "Sewage Statistics -- Financial Edition 2001", 2000 and Kanto Regional Construction Bureau, Ministry of Construction, "Study on Structure of Industrial Water Demand in Kanto Region", 1983

### **BOX: Fixed Price Contracts for Industrial Water Supply**

Upon the development of an industrial water supply system, the developer (mainly prefectural governments) asked water users (factories) to declare their water contract limit as water receiving rights based on their future water demand.

Many factories set a large contract water limit with the outlook of increased water demand. However, actual water consumption was much smaller than the limit because they reduced unit water consumption in response to the effluent regulations and increasing energy costs.

Evidently, excessive industrial water development resulted in an increased cost burden for the industries. The water rate based on the contract water limit reduced the motivation for industries to rationalize their water consumption, and they used the water to dilute effluent.

Since then, the water contract shifted to a system in which water was paid for according to metered consumption levels. This incident created important lessons for both supply side (public sector) and demand side (factories), and influenced future industrial water use policy and practice.

#### b.5 Sharp Increases in Energy Costs

Other than the four factors mentioned above, sharp increases in energy costs largely influenced water and wastewater management by companies. After the oil crises, both energy and water consumption were substantially reduced, particularly in the materials industry sector where advanced production technologies were developed. Examples include:

- Continuous Casting (Steel Industry) -- Molten steel can be cast continuously without being cooled and solidified.
- Direct Baking (Cement Industry) -- Cement can be directly baked in the kiln without making particles with added water.

# 2.3.3 Water and Wastewater Management in Major Industries

Figure 2.3.1 shows a forecast for 1977 of industrial water flow in the factories with more than 30 workers in the southern Kanto region based on the "Study on Future Changes in Industrial Water Demand" carried out by the Ministry of Construction. It shows the structure of water use, recirculation, treatment, and discharge in Japanese industry as a whole.

Following is a summary of the cost analysis in the study.

#### a. Situation in All Industry Types

#### a.1 Water Source

Water sources of the factories were industrial water supply (2.0 million  $m^3/day$ ), groundwater (1.2 million  $m^3/day$ ), river water (0.6 million  $m^3/day$ ), and potable water supply (0.6 million  $m^3/day$ ), totaling around 4.4 million  $m^3/day$  or 1.6 billion  $m^3/year$ . Annual costs of water intake were estimated at 65 million JPY/day, 3 million JPY/day, 2 million JPY/day, and 64 million JPY/day, respectively, totaling 48.5 billion JPY/year.

#### a.2 Recirculation and Treatment

Out of the 4.4 million  $m^3/day$  of water drawn by industries, approximately 0.2 million  $m^3/day$  was used as ingredient water and lost during cooling, and the rest was recycled and reused. In the end, approximately 4.2 million  $m^3/day$  of water was discharged as effluent.

Costs of recirculation and treatment were 118 million JPY/day and 204 million JPY/day, respectively. On annual basis this corresponds to 43 billion JPY and 74.5 billion JPY, indicating the huge burden imposed by water treatment costs on the industries.

#### a.3 Discharge

Out of the discharged water of 4.2 million  $m^3/day$ , less than 10% or 0.4 million  $m^3/day$  was discharged to the sewage system. The remaining 3.8 million  $m^3/day$  did not pose a cost burden for industries as it was discharged to public water bodies (effluent was treated to the level much stricter than that discharged to the sewage system).

On the other hand, less than 10 % of effluent going to the sewage system cost 19 million JPY/day for industries. On an annual basis this corresponds to 6.9 billion JPY.

Cost burden by industries may be assumed as follows:

- Cost of water intake was 32 JPY/m<sup>3</sup> for industrial water, 2 JPY/m<sup>3</sup> for groundwater, 4 JPY/m<sup>3</sup> for river water, and 107 JPY/m<sup>3</sup> for potable water. Average cost of all water sources was 30 JPY/m<sup>3</sup>.
- Cost of re-circulating water was 7 JPY/m<sup>3</sup>. Though the low cost of direct/indirect cooling water had some influence, cost effectiveness was large when compared to unit water intake cost. In addition, wastewater treatment cost was 49 JPY/m<sup>3</sup> while sewage charge was 50 JPY/m<sup>3</sup>.
- From the above, the total cost for water intake and discharge was 454 million JPY/day, or 124.3 billion JPY/year. In these figures, costs associated with effluent account for 45%. The proportion of water intake and discharge costs in total shipment values was only 0.5%, but it was significant when considered that the normal profit of a manufacturing firm amounts to a few percent of shipment values.

Items		ц	l	Fresh wate	er intake th	nsnd m <sup>3</sup> /	day	[						0
Industry	Fresh water consumption	Seawater consumptio	Potable water	Industrial water	Groundwater	River and other water sources	Total	Water conservation	Process/change	Circulating process/ fly loss	Cascade-out	Cascade-in	Discharged to outside (inc. discharged to sewage)	Discharged to sewage
Foods	924.6	50.1	101.7	155.0	214.7	204.8	685.2	0	39.3	2.5	15.5	15.5	643.6	64.8
Pulp & Paper	665.1	-	10.8	141.9	36.3	121.8	310.8	0	0	0.2	0.9	0.9	310.6	77.9
Chemical	7,667.6	4,845.9	56.2	750.6	233.8	48.5	1,089.1	0	1.1	65.8	55.0	55.0	1,022.2	72.2
Petroleum/coal	1,812.4	2,908.3	28.6	293.5	32	16.4	341.7	0	0	14.7	5.4	5.4	327.0	0
Ceramics/mfr stone clay	396.3	14.0	17.8	36.8	58.6	20.0	133.2	0	7.7	2.2	6.8	6.8	123.4	7.6
Steel	5,830.8	3,079.8	28.8	329.5	45.3	157.0	560.2	0	5.8	49.9	56.7	56.7	504.6	19.1
Non-ferrous metal	1,097.0	65.1	13.9	87.0	87.8	1.9	190.6	0	1.6	4.4	0	0	184.7	16.3
Transportation machines	1,121.4	5.3	38.5	61.7	111.5	0.2	211.9	0	0	5.9	16.7	16.7	206.0	23.6
Other machinery	1,340.7	29.1	134.2	109.3	175.4	7.3	426.2	0	0	8.7	48.4	48.4	417.6	55.0
Other manufacturing	628.7	-	162.4	64.5	249.5	4.3	480.7	0	7.2	19.9	26.5	26.5	453.3	43.4
Total	21 484 6	11 457 6	601.0	2 0 2 0 8	1 216 1	582.2	1 1 20 6	0.0	62.7	174.2	232.0	232.0	4 103 6	370.0

Table 2.3.1 Flow of Industrial Water in Tokyo and Three Neighboring Prefectures (1977)

Source: Kanto Regional Construction Bureau, Ministry of Construction, "Study on Projection of Changes in Industrial Water Supply Demand", 1980, p.166 2. Impacts of Utility Prices and Environmental Regulations on Industrial Pollution Control in Japan EX CORPORATION



Source: Kanto Regional Construction Bureau, Ministry of Construction, "Study on Projection of Changes in Industrial Water Demand", 1980, p.171



#### b. Measures Taken by Companies

Companies' responses to the effluent regulations and the water pricing policy can be largely classified into the following four categories:

- A. Improvement of production processes: Changes in raw materials and production processes, transformation of production technologies (change to non-water use or reduced water use processes)
- B. Improvement of water and wastewater management systems: Strict implementation of water management; separation of wastewater in different processes; recirculation or cascading use of used waster

- C. Optimization of wastewater treatment: Treatment for recycling; systematization of wastewater treatment incorporating separation of wastewater and reduction of water consumption measures
- D. Improvement of effluent discharge: Treatment before discharge to the sewage system; systematization of discharge corresponding to water quality regulations and total amount regulations

The relationship between the regulations and the actions taken by companies, or the priority actions adopted by the companies can be summarized as below:

#### i. Regulations on Groundwater Pumping

The regulations on groundwater pumping forced the companies to shift their water source from the least expensive groundwater to more expensive water sources.

--> The companies' responses to this regulation were inevitably to use less water, and they chose A or B type actions mentioned above.

--> As a result, the effluent volume decreased, and rationalization of water use by improvement of production processes in industry as a whole advanced. Many companies succeeded in reducing their mid- to long-term cost for water intake, treatment and discharge. With the introduction of B type actions, wastewater treatment for recirculation/reuse, which was close to C type actions, was also observed.

#### ii. Industrial Water Rate Structure

Mainly A and B type actions to reduce costs were seen in the course of converting water sources from groundwater to river water. As in the case of the groundwater regulation, C type actions were also seen.

On the other hand, the industrial water supply system was developed in Japan according to a scheme in which industries estimated their expected water consumption in their operational plans, and pay in accordance with the proposed volume regardless of actual consumption.

This fixed pricing approach was an obstacle to achieving a rational use of water before the compulsory sewage connection and the total pollution load regulation came into force.

#### iii. Development of Sewage System and its Charges

In addition to type A and B actions to reduce the volume of water consumption, type C actions, which were aimed at separating wastewater streams to reduce the amount of pre-treatment required to meet the discharge standards for the sewage and encouraging water reuse, were taken. Furthermore, highly cost effective pre-treatment systems for inorganic wastewater were installed, which would be categorized as type D actions, among industries discharging inorganic effluents.

# iv. Effluent Quality Regulation/Total Pollution Load Regulation

As for measures to respond to the effluent quality regulation, industries invested in rational (cost effective) treatment systems (type D), after taking type B and C actions to improve water/wastewater management to decrease treatment costs and/or optimize wastewater treatment.

#### v. Energy Conservation

For the purpose of energy conservation, improvement of production processes with less water consumption aiming to reduce energy costs (type A), energy conservation at the water intake/discharge (type B), and installation of new wastewater treatment technologies of energy saving type (type D) were seen.

As shown in Table 2.3.2, factories were apt to take upstream measures mainly focusing on reducing costs while meeting regulatory standards and/or guidance from authorities.

	A.	B.	C.	D.
	Improvement of	Improvement of	Optimization of	Improvement
	Production	Water/Wastewater	Wastewater	of Discharge
	Process	Management	Treatment	
		System		
Regulation on groundwater pumping	XX	XX	Х	-
Industrial water rate structure	XX	XX	Х	-
Enforced Discharge to	v	VV	vv	v
Sewage System	Λ	ΛΛ	ΛΛ	Λ
Effluent regulation and				
total pollution load	Х	XX	XX	XX
regulation				
Increase in energy costs	XX	Х	-	Х

Table 2.3.2 Factory Responses to Changes in External Factors

Legend

XX : highly relevant

X : relevant

- : irrelevant

Regulatory measures through monitoring and guidance mainly pushed for iii) and iv) actions. However, i) and ii) actions became most important as they were more cost effective for reducing the amount of wastewater, thus reducing the cost burden for industries.

As policy tools to promote such actions, economic incentives like tax breaks and financial aids for installing new equipment, or technical assistance were expanded. In addition, systems were developed including the Pollution Control Officer system and the submission of control plans to authorities in order to help factories take proper actions by themselves.



Figure 2.3.2 Measures for Industrial Water and Wastewater Management

# 2.3.4 Water and Wastewater Management by Major Industries

This section examines water and wastewater management practices in the 1970s by looking at the food processing and pulp/paper industries using data from the "Study on Forecast of Changes in Demand for Industrial Water."

# a. Water and Wastewater Management in the Food Processing Industry and its Cost Structure

In the southern Kanto Region, the food processing industry was the second largest water intensive industry next to the chemical industry. In 1975, the food processing industry accounted for 16% of all fresh water intake in the manufacturing industry. River water and groundwater consisted of about half of its water sources, and potable water comprised one

third. The ratio of industrial water use by the food processing industry was the least among manufacturing industries; furthermore, recirculation rates were also low.

It is characteristic of the food processing industry that much of the water was used for either washing processes or used as one of the ingredients of their products; cooling and temperature control use were relatively small.



Source: Kanto Regional Construction Bureau, Ministry of Construction, "Study on Projection of Changes in Industrial Water Demand", 1980, p118

# Figure 2.3.3 Schematic Water Flow of the Food Processing Industry (Southern Kanto Region/year 1977 base)

As an example of factories using groundwater as their main water source, water and wastewater management by a factory producing dairy products is described below.

The factory used groundwater as the only water source. While its water intake was 5,600  $m^3$ /day in 1974, it was drastically reduced to 2,500  $m^3$ /day in 1977. This reduction was achieved by strict regulation of groundwater pumping and water saving guidance by the Tokyo Metropolitan Government.

Rational use of water was mainly implemented in the cooling and washing processes. The reduction of water consumption in those two processes accounted for 95% of the total reduction, or  $3,000 \text{ m}^3/\text{day}$ .

Figure 2.3.4 shows the water flow in this factory in 1975.

2





Figure 2.3.4 Schematic Flow of Industrial Effluent in Daily Products Factories (1975)

Breakdown of cooling water was the supply to the cooling tower and the recirculation tank, and transient cooling water. The water was extensively recycled; the amount of water recirculated in the cooling tower was  $23,000 \text{ m}^3/\text{day}$ , and on average it was recirculated 84 times. The temperature difference at the entrance and the exit was 4 degrees Celsius, and total water hardness concentration was 3.8. Use for transient cooling water was scattered around in the factory, so as far as cost-effectiveness was concerned, recirculating this water had a relatively limited role.

A considerable reduction of water consumption was also accomplished in washing processes, namely from 3,800 m<sup>3</sup>/day in 1974 to 1,400 m<sup>3</sup>/day, though it still made up about 60 % of water use in the factory. Since the other water uses, such as domestic use, temperature control, boilers, and product ingredient, had very limited room for reduction, and washing water contained a high pollution load, it became a priority target for water and wastewater management.

Rationalization of water management was mainly achieved by changing to counter-current multistage cleansing for bottle, container box, and machine washing. In addition, the rationalization was made by a cascading use of the water; water used for bottle washing was reused for container box pre-washing, and alkaline wastewater for flue gas desulfurization process.

Costs for water rationalization were installing recovery tanks and pumps, piping, use of chemicals and electricity for cooling water, changing piping of bottle washing machines, and purchase of hand operated valves for cleansing water. In-house staff changed piping in accordance with the periodical repair, and the effective use of the existing cooling tower enabled the recirculation of cooling water. The cost required for the rationalization was smaller than the cost of groundwater (approximately 8 JPY/m<sup>3</sup>). Due to reducing the amount of effluent as well as effluent quality that the factory achieved, this rationalization actually resulted in profits. In real terms, this rationalization generated 38 million JPY/year (or 0.1% of annual shipment value); most of this was from reducing the wastewater treatment cost resulted from reducing water consumption.

This factory was located in an area where sewage service had not been provided. Should this factory be required to discharge their effluent to sewage and charged the fee of 110 JPY/m<sup>3</sup>, similar to that in urban areas, the cost of water and wastewater management in 1977 would have jumped from 300,000 JPY/day to 510,000 JPY/day, which in terms of the proportion of shipment value, would have increased from 0.28% to 0.47 %. Since the effluent quality was satisfactory, the value remaining at 5 ppm in terms of BOD, they continued to discharge it to a public water body. However, production costs would have increased as there was not much room for rationalization, had they been forced to discharge to the sewage system.

In this example, the factory faced the regulation on groundwater pumping at first. Rationalization was performed to respond to the regulation, and one can see there was not much more opportunity for further rationalization when sewage connection subsequently became mandated. Likewise, how policies affect water and wastewater management of a given factory depended not only upon the policy itself but also such factors as timing. Thus for this particular factory, much effort would have been taken to rationalize water use if the  $100 \text{ JPY/m}^3$  or greater sewage charge had been imposed before the regulation on groundwater pumping appeared. In reality, however, the regulation affected the behavior of this factory the most.

As mentioned above, company's behavior regarding water and wastewater management depends greatly on characteristics of the industry as well as factory location, and external factors such as timing of pricing or regulatory policies. In the southern Kanto region, the following sections address these issues as they have related to the food processing industry.

# a.1 Potable Water and Industrial Water Rates

In the food processing industry, requirements for water quality were inevitably high, and many of the factories were located inland where water sources were limited. Consequently, they were heavily dependent on potable water supplies. The price of potable water was sufficiently high to concern company managements. In view of the probability that prices would increase even more in the future, rationalization efforts were further stimulated. On the other hand, rationalization of industrial water use would have been of minimal significance because of the low dependence on industrial water supply in this sector, and in any case industrial water was much cheaper than potable water supply (see Table 2.3.3).

		Orde	r of fac	tors in	fluence	d the		Orde	er of fac	tors in	fluence	ed the t	reatme	nt of	
		ratio	nalizat	ion of v	water u	Isage				wa	astewat	ter			
Factory	Introduction of pollution load regulation	Strengthened effluent standard	Strengthened regulation on groundwater pumping	Increasing cost of potable water	Increasing cost of industrial water	Increasing cost of swage use	Development of swage system	Introduction of pollution load regulation	Strengthened effluent standard	Strengthened regulation on groundwater pumping	Increasing cost of potable water	Increasing cost of industrial water	Increasing cost of swage use	Development of swage system	Note
Α	4	3	1	-	-	-	2	3	1	2	-	-	-	4	Rely only on groundwater
В	-	4	-	1	3	2	-	-	1	-	2	4	-	-	Neglected connection to the swage system
С	-	3	4	1	-	2	-	-	1	4	2	-	-	-	
D	3	4	1	5	-	-	2	1	2	3	5	-	-	4	Small amount of potable water is used for domestic use
Е	3	4	2	1	-	-	-	2	1	3	4	-	-	-	
F	4	3	1	2	-	-	-	2	1	3	4	-	-	-	
G	3	4	1	-	-	-	2	1	2	3	-	-	-	4	Rely only on groundwater
Н	-	4	-	1	3	2	-	-	1	-	2	4	3	-	Discharged to the swage system
Ι	4	3	2	1	-	-	-	2	1	4	3	-	-	-	
J	4	3	1	-	-	-	2	3	2	4	-	-	-	1	Rely only on groundwater

# Table 2.3.3 External Factors Influencing Priorities for Water and Wastewater Management among Ten Major Firms in Food Processing Industry

Source: Kanto Regional Construction Bureau, Ministry of Construction, "Study on Projection of Changes in Industrial Water Demand Induced by Implementation of Total Pollution Load Control", 1978, p.55

# a.2 Regulation on Groundwater Pumping

Compared with other industrial groups, the food processing industry in general was highly dependent upon groundwater supply. Consequently, the regulation on groundwater pumping had a major impact on their water management. Some factories located in areas with existing industrial water supply with a strict regulation on groundwater pumping were forced to change their water source to more expensive potable water because industrial water did not meet their water quality requirements. Some factories faced with a water price increase of about 100 JPY/m<sup>3</sup> required great efforts to rationalize their water uses. Nonetheless, not many factories in the food processing industry were obliged to convert their water sources to potable water supply because they were often sited inland and because the regulation on groundwater pumping was not fully imposed due to their small scale.

Many factories rationalized their water use in reducing within the range of several to tens of  $JPY/m^3$  following guidance from local authorities. As a result, synergistic effects of reducing effluent discharge and implementing the effluent regulation were observed in the reduction of pollution load.

# a.3 Development of Sewage System and its Charges

Since the food processing industry has been prone to generate organic effluents, their effluent had been discharged after treatment, such as that by activated sludge, even before sewage systems were developed. After the development of a sewage system, the effluent was discharged to the sewers in principle, and in-house treatment was no longer required, thus lessening the burden for the industry although they pay for the sewage charge (effluent quality of sewage was 300 ppm in BOD value).

In the Tokyo area where a sewage system had been provided, the sewage charge of 75  $JPY/m^3$  in 1968 was doubled several years later. Food processing factories in Tokyo asked the Metropolitan Government to allow them to discharge their effluent to public water bodies after decreasing BOD values to 5 - 10 ppm rather than to the sewage system. This is because of the following reasons. Although the food processing industry had made a

significant effort to rationalize water use, companies were reluctant to move forward to save water in bottle washing processes and recirculation because of a fear of creating a negative public image from a hygienic point of view, which limited the reduction of wastewater discharge. In addition, when the sewage charge became well over the in-house wastewater treatment costs, the charge greatly affected the business.

#### a.4 Regulations of Effluent Quality and Total Pollution Loads

Preceding the implementation of the regulation of total pollution loads, effluent standards were strictly enforced in the late 1970s. In the food processing industry in particular, in-house wastewater treatment had been carried out to meet the standards. Since rationalization efforts were undertaken when installing wastewater treatment facilities, many of the factories with washing processes for their processed products (foods) could easily meet the regulatory value for total pollution loads (discharged amount x effluent water quality). Since they had implemented rationalization and wastewater treatment when effluent standards were strictly imposed, many companies did not have to put much extra effort after the introduction of the total pollution load regulation.

The following measures were undertaken.

- i Since batch processes were mainly employed in washing processes in the food processing industry, the amount of wastewater fluctuated greatly, and thus difficulties persisted in stabilizing wastewater treatment. Adjustment tanks were installed to lessen such fluctuation.
- ii Advance water savings in washing process for reducing water and wastewater costs.
- iii By combining (i) and (ii), improve discharge effluent quality by advanced wastewater treatment such as the tertiary treatment.

tory	Effluent	Concentratio	on (ppm)	Effluent Facility (	Standards for Daily Averag	Existing (ppm)	Proposed Pollution Load Regulation	Reduction of Pollution					
$F_{2}$	BOD	COD	SS	BOD	COD SS f		for COD (ppm)	Load (%)					
Α	5.0	11.5	16	114	-	142.5	60	0					
В	10 or less	-	20 or less	(300)	-	(300)	20 (discharged to swage system)	0					
С	-	Unknown	-	(300)	-	(300)	20 (discharged to swage system)	0					
D	-	31.5	-	25	-	90	20	49.5					
Е	-	25	-	25	25	50	200	0					
F	-	22-24	-	25	25	50	200	0					
G	-	38*	-	25	25	50	60	0					
Н	-	273	-	(300)	-	(300)	110 (discharged to swage system)	0					
Ι	_	60	-	10**	10**	-	500	0					
J	-	58***	-	120	-	150	60	42					

Table 2.3.4 Response to Total Pollution Load Regulation by 10 Factories in Southern Kanto Region

Note 1. Factory D planed to discharge its effluent to the sewage system. At that point, the pollution load regulation would not affect the factory.

2. Effluent COD concentration of 38ppm (marked\*) at Factory G was that after treatment. This effluent was diluted with used cooling water and discharged with COD concentration of below 25ppm.

3. For Factory I, the prefectural government had imposed the guidance value (less than 10 ppm on BOD and COD (marked\*\*)). If the factory conducts wastewater treatment in order to meet this value, the pollution load regulation would also be cleared.

- 4. Effluent COD concentration of 58 ppm (marked\*\*\*) at Factory J was that after dilution by cooling water.
- 5. Values in ( ) indicate standards for effluent to be discharged to the sewage system.

Source: Kanto Regional Construction Bureau, Ministry of Construction, "Study on Projection of Changes in Industrial Water Demand Induced by Implementation of Total Pollution Load Control", 1978, p.93 Table 2.3.5 Effluent Quality from 10 Factories Responded to Survey in Southern Kanto Region and Proposed Total Pollution Load Regulation

									r
Factory	Industry Type (Products)	Location	Fresh water intake (m <sup>3</sup> /day)	Water for cleansing products in 1977 (m <sup>3</sup> /day)	Wastewater requiring treatment in 1977 (m <sup>3</sup> /day)	Reduction in COD load required by the proposed total pollution load regulation in 1977 (%)	Measures to comply with the proposed total pollution load regulation	Whether demands for industrial water decrease by the measures (fresh water base)	Existing total pollution load regulation by the local government
A	Daily products	Higashi- yamato, Tokyo	2,472 (groundwater only)	1,430	1,915	0	No further treatment necessary as current treatment level already satisfy the proposed pollution load value (22% of the proposed one)	No	None
В	Beer	Kita, Tokyo	7,048 (industrial water 4,514)	4,988	5,953	0	The proposed regulation will not be posed as effluent is discharged to the sewage system	No	None
С	Beer	Meguro, Tokyo	5,138 (industrial water 4 981)	4,857	3,900	0	Same as above	No	None
D	Beer	Fucyu, Tokyo	4,633	3,279	4,725	49.5	It is likely the proposed regulation will not be posed as effluent will be discharged to the sewage system in near future.	No	None
E	Soy source, seasonings	Choshi, Chiba	6,202 (potable water 4,336)	3,824	3,500	Unknow n	Advancing wastewater treatment technology	No	None
F	Soy source, seasonings	Noda, Chiba	13,693 (groundwater 10,457)	5,956	5,956	0	No further treatment necessary as current treatment levels already satisfy the proposed pollution load value (11% of the proposed one)	No	None
G	Distilled liquor	Matsudo, Chiba	4,631 (groundwater only)	1,890	1,980	0	No further treatment necessary as current treatment levels already satisfy the proposed pollution load value, but prefectural standards require 27 % reductions.	No	None
Н	Sugar	Koto, Tokyo	45,300 (river water 44,000)	710	545	0	The proposed regulation will not be posed: 44,000 m³/day of river water is used for indirect transient cooling water and discharged without pollution load.	No	None
Ι	Bean jam	Chiba	245 (groundwater 170)	70	200	0	COD effluent standard was strengthened from 60ppm to 10ppm, thus required advance treatment facility. This satisfies the proposed regulation.	No	None
J	Daily products	Hoya, Tokyo	5,482 (groundwater only)	3,303	1,440	42	Advanced wastewater treatment technology and rational use of water. Plans to discharge it to sewage in 5 years.	Slightly	None

Source: Kanto Regional Construction Bureau, Ministry of Construction, "Study on Projection of Changes in Industrial Water Demand Induced by Implementation of Total Pollution Load Control", 1978, p.93

# b. Water and Wastewater Management in the Pulp and Paper Industry and its Cost Structure

Having used 9.7 million  $m^3$  per day of fresh water in 1975, the pulp/paper industry was one of heaviest water consuming industries, second only to the steel industry, and accounted for 24 % of the water used by the whole industrial sector. However, in the southern Kanto region alone, there had not been many pulp/paper mills, and water consumption was fairly minor, being 0.4 million  $m^3/day$ , or 8.7 % of the whole industry in the region.

Since the pulp/paper industry has prospered for many years in Japan, the companies have historically held many water rights for river and groundwater. Although 87% of their water source was natural water nationwide, in the southern Kanto region, use of industrial water supply accounted for 56% while groundwater and river water was limited to 41% because of the regulation on groundwater pumping and the development of industrial water system.

On the other hand, intended use of water was similar to the national average; boiler, cooling and temperature control accounted for 3.2% and 6.8%, respectively, the remaining water being almost exclusively used for product processes and cleansing.

Figure 2.3.5 summarizes water flows in 12 major pulp/paper factories located in the southern Kanto region in 1977. As the figure illustrates, product processing and cleansing processes accounted for most of the water used in this industry.

Among the pulp/paper industry, manufacturers of paperboard and other paper products mainly made from used pulp/paper are in social concern from an environmental point of view in developing countries. Therefore, the following section will examine water and wastewater management by this type of paper mills.





Figure 2.3.5 Water Flow in Pulp/Paper Industry in Southern Kanto Region (1977)

# b.1 Paperboard Mills

Factory O will be examined in this section, as it was a typical paperboard mill using recycled paper. Its primary products were linerboards, color paperboards, and folding boxes, which were valued at 940 million JPY in 1977. The water flow in this factory is shown in Figure 2.3.6. The factory used to utilize a large quantity of groundwater, besides river water. With the Tokyo Metropolitan Government guidance, water sources were changed to the industrial water supply, and groundwater was supplied to boilers where it was repeatedly recycled. Potable water, on the other hand, was only used for boiler and domestic use.

Factory O took most of the required water from a river, but it used industrial water when it could not obtain enough water from the river.



Source: Kanto Regional Construction Bureau, Ministry of Construction, "Study on Projection of Changes in Industrial Water Demand induced by Implementation of Total Pollution Load Control", 1978, p.71

#### Figure 2.3.6 Schematic Water Flow in Paperboard Mill (1977)

Factory O used 1,700 m<sup>3</sup>/day of water for boilers, of which 500 m<sup>3</sup>/day was from groundwater and/or tap water used for the supplement to the recirculated water to compensate evaporation, fly loss, and leaks. The rest of the water was from the industrial water supply used for flue-gas desulfurization and ash cooling, which was discharged without treatment.

Factory O used 2,300  $\text{m}^3$ /day of transient cooling water for power generators, which flowed into a storage tank where it was then used for product treatment/cleansing purposes. In addition, it used 3,900  $\text{m}^3$ /day of river water for direct and indirect cooling of bearing housings, which scattered around the factory; the used cooling water was thus discharged without being recycled.

At Factory O, raw materials were composed of recycled paper (80%) and pulp (20%). Figure 2.3.7 illustrates the flow of the materials.



Source: Kanto Regional Construction Bureau, Ministry of Construction, "Study on Projection of Changes in Industrial Water Demand induced by Implementation of Total Pollution Load Control", 1978, p.70

Figure 2.3.7 Process of Cardboard Manufacturing

Water used for processing and cleansing of products in this paperboard manufacturing process was approximately 90,000 m<sup>3</sup>/day, of which, 39,000 m<sup>3</sup>/day was recirculated from other processes and 15,000 m<sup>3</sup>/day from white water pit after coagulation sedimentation treatment. The remaining 35,000 m<sup>3</sup>/day was supplied by river water as well as industrial water.

Factory O used  $135m^3/day$  of fresh water per ton of product (paper). Although this figure is somewhat larger than the unit water consumption by paperboard manufactures shown in Table 2.3.6, it was still similar to the average use considering this factory used a large quantity of recycled paper as raw materials that required a large quantity of water for pre-treatment.

Table 2.3.6 Unit Water	Consumption per	Ton of Product at Paperboard	Manufactures

			Unit: m <sup>°</sup> /t
	Average	Minimum	Maximum
Cardboards, linerboards	84.0	19.0	405.0
Cardboards, corrugated layers	53.1	20.0	188.0
White lined board	125.6	27.0	320.0
Strawboard/chipboard	90.8	26.0	160.0
Color lined board	129.1	51.0	240.0
Building materials / paper tube,	114.2	22.2	208.0
base paper	114.5	22.5	508.0

Source: Japan Industrial Water Association, "Concept of Rationalization of Water Use in Pulp and Paper Industry", 1974

Although the quality of river water in general had been improved, it only reached a SS content level of 80 ppm or so, which required coagulated sedimentation to bring the SS below a value of 20ppm in order to use for manufacturing purposes. Table 2.3.7 shows quality of wastewater before and after the treatment. The effluent standards at the time were 5.8 - 8.6 for pH, 120 ppm daily average for BOD, 120 ppm for COD, and 150 ppm for SS. This factory mainly removed SS while BOD was removed along with SS.

		Discharged	conce	Wastewate entration (	er (ppm)	Effluent concentration (ppm)			
		$(m^3/day)$	BOD	COD	SS	BOD	COD	SS	
Wastewater #1	system	15,000	144	180	311	83	104	70	
Wastewater #2	system	25,000	200	250	326	90	113	70	

Table 2.3.7 Quality of Wastewater and Effluent at Factory O

Source: Kanto Regional Construction Bureau, Ministry of Construction, "Study on Projection of Changes in Industrial Water Demand induced by Implementation of Total Pollution Load Control", 1978, p.71

To sense the burden of wastewater treatment costs imposed on this factory, a summary of wastewater treatment facilities and associated costs such as construction, operation and maintenance costs are shown in Table 2.3.8 and Table 2.3.9.

Facility #	Treatment method	Capacity	Year built	Building cost	Depre- ciation	Electric- ity re-	Chemical cost	# of staffs
		m <sup>3</sup> /day		Mil. JPY	Year	quired kWh/day	JPY/day	Person
a	Coagulation sedimentation	30,000	1958	61	12	2,425	406	1.5
b	Coagulation sedimentation	30,000	1965	105	12	2,425	812	1.5
с	Floatation	15,000	1972	115	12	2,497	10	1.5
d	Hi-speed coagulation sedimentation	30,000	1965	155	12	2,590	9	2

 Table 2.3.8 Summary of Water Treatment Facilities at Factory O

Source: Kanto Regional Construction Bureau, Ministry of Construction, "Study on Projection of Changes in Industrial Water Demand induced by Implementation of Total Pollution Load Control", 1978, p.71

Table 2390	neration Cost of	f Water Treat	ment Facilities	at Factory O
Table 2.3.3 0	peration Cost o			at raciory O

					Unit: JPY/day		
	Cost of	Cost of	Cost of Repair	Depreciation	Coadjuvant	Total	
	Electricity	Labor			(chemicals)		
Water	20,486	28,892	2,106	12,982	2,245	66,711	
Wastewater	11,031	15,558	1,134	6,991	1,208	35,922	
Total	31,517	44,450	3,240	19,973	3,453	102,633	

Source: Kanto Regional Construction Bureau, Ministry of Construction, "Study on Projection of Changes in Industrial Water Demand induced by Implementation of Total Pollution Load Control", 1978, p.71

According to these operating costs, the unit cost of wastewater treatment by floatation and coagulation sedimentation was  $2.5 \text{ JPY/m}^3$ , and surface water and recovered water cost  $2.0 \text{ JPY/m}^3$ . Thus water and wastewater management cost was very inexpensive, as was depreciation of the facility was small. However, when added to industrial water and potable water charges, total water costs jumped to 182 million JPY/year, or 1.9 % of total shipment value, showing the large burden the company faced.

Following is a summary of Factory O's responses to each external factor.

# i Potable Water and Industrial Water Rates

Industrial water that Factory O used cost 8.5 JPY/m<sup>3</sup> until 1975 but increased to 30 JPY/m<sup>3</sup> after 1976, while the cost of potable water that had been 75 JPY/m<sup>3</sup> was increased to 180 JPY/m<sup>3</sup> in 1975. For these reasons, this factory changed the contract on industrial water supply of  $15,000m^3/day$  to  $5,000m^3/day$  -- only one-third of the original contract. On the other hand, water sources for domestic use and boilers were changed from groundwater to potable water because of the regulation on groundwater pumping, potable waster volume increased from 20 m<sup>3</sup>/day to 360 m<sup>3</sup>/day.

Industrial water was used for indirect cooling for machinery and for adjusting chemicals, since river water had quality problems even after being purified.

# ii Effluent Regulations

Effluent standards were strengthened in 1979 when the daily average BOD value was set at 60 ppm, and the SS value at 120 ppm. In response to the strengthened regulation, Factory O was considering the introduction of activated sludge treatment before floatation and coagulation sedimentation. The factory was also planning to rationalize its water use in order to reduce construction and operating costs of the treatment facility at the same time. At that time, further strengthening of effluent standards and the introduction of total pollution load control were anticipated; the factory set a wastewater treatment target of 40

ppm BOD so that it could comply with the total pollution load regulation only by rationalizing water use. As water conservation measures, Factory O was planning to increase boiler drain recovery from 75% to 90% and decrease water use by increasing washing efficiency with amplifying water pressure. Furthermore, it was planning to convert production processes to those of water conservation type upon renewal of production facilities as they were aging.

### iii Charges for Discharge to Sewage

In the area where Factory O was located, sewage service was planning to be provided in the 1980s. At that time, the factory would be required to connect its effluent discharge to the sewage system, which would pose a huge cost burden that the factory's very existence might be threatened. Therefore, in order to avoid discharging effluent to the sewage system, Factory O was planning to make increased efforts to recycle used water and byproducts and to rationalize wastewater from production processes.

# b.2 Paper Mill

Factory P was specialized in high quality paper, and its major products were printing paper and miscellaneous paper (mainly photographic paper). The shipment value in 1977 was 16.1 billion JPY, while the production volume was 78,000 tons. The unit price of products is 20,500 JPY/ton, which is higher than 7,400 JPY/ton of the paperboard mill mentioned in the former sub-section.

Water flow at Paper Mill P is shown in Figure 2.3.8.

Factory P had water rights for an adjacent river that could provide 0.45 m<sup>3</sup>/sec (approximately 39,000 m<sup>3</sup>/day) of water with a COD value of 6 ppm; it required industrial water only 100 m<sup>3</sup>/day. The unit water consumption was 149 m<sup>3</sup>/ton-products, which was a bit higher than that at Factory O. Considering the quality of the product, Factory P's rationalization of water use was at a similar level of Factory O.

Water taken from the river and the industrial water supply was first stored in a tank and used after being filtered. As shown in Figure 2.3.8, most of the water was used in the paper making process (straining process). In this process, water from a multistage countercurrent washing process was separated in a separation tank; the upper layer of the water was sent to wastewater, and the lower layer of the water to a recirculation system in which the water was reused after raw materials in it were recovered.

Factory P's effluent was discharged into the same water system as Factory O. Though the same effluent standards were imposed, Factory P established a coagulation deposition facility with a cost of approximately 200 million JPY in 1973. With this investment, the quality of effluent improved to 30 ppm for BOD and COD and 45 ppm for SS, respectively, and Factory O would be able to meet the strengthened effluent standards to be imposed in 1978. Unit prices for water intake at Factory P as of 1977 were 30 JPY/m<sup>3</sup> for industrial water supply, 92 JPY/m<sup>3</sup> for potable water, 5 JPY/m<sup>3</sup> for river water, and several JPY/m<sup>3</sup> for filtering as pre-treatment. Annual water costs were 70 million JPY for water intake and 119 million JPY for discharge (electricity 10.4 million JPY, chemicals 15.3 million JPY, manpower 5.6 persons), half of which was those for contracting out the sludge treatment. Factory P's water costs were 1.2 % of the shipment value, which is much lower than those at other factories. This was explained by the fact that Factory P could use the good quality river water and needed not discharge its effluent into the sewage system.

Study on Japanese Experience in Industrial Pollution Control



Source: Kanto Regional Construction Bureau, Ministry of Construction, "Study on Projection of Changes in Industrial Water Demand Induced by Implementation of Total Pollution Load Control", 1978, p.67

Figure 2.3.8 Water Flow in Factory P

Following is Factory P's responses to each external factor.

# i Potable Water and Industrial Water Rates

Factory P received fairly limited volume of potable water and industrial water, costing 5.4 million JPY per year, and thus there was not much response to this factor.

### ii Effluent Regulation

Factory P had complied with the strengthened effluent standards. Even after the total pollution load regulation was imposed, the current treatment was enough to meet the standards if COD value, for instance, was set to be about 40 ppm under the regulation, leaving rationalization of water use the only necessary action.

However, if effluent standards were further toughened, measures had to be taken along with other actions like improvement of the yield rate, because treatment cost of sludge was quite large.

As far as water management was concerned, the mill intended to avoid rationalization of water for product treatment and cleansing as it had sufficient water rights and also needed to retain the quality of its products.

#### iii Charges for and Discharges to the Sewage System

The area in which Factory P was located was to have sewage service by the 1980s, though it anticipated it would discharge its effluent into the river if effluent treatment succeeded in decreasing the pollutant level to less than 20 ppm of BOD. In case discharge to the sewage system was unavoidable, rationalization of water use might be an option.

#### b.3 Summary of Water and Wastewater Management in Pulp and Paper Industry

The following section summarizes the structure of water use and discharge and associated costs, and responses to external factors by the pulp/paper industry.

#### 1) Structure of Water Use and Discharge

The pulp/paper industry which use recycled paper and/or pulp for its raw material is a water-intensive industry and requires a larger quantity of water than most other industries. Historically the industry has been located in areas where river or groundwater was readily available and could treat wastewater to a BOD level of 100 ppm. Therefore, this factor was not considered as an especially heavy burden for the industry.

For this reason, the industry was reluctant to take measures to rationalize its use of water. It tended to limit its actions to water recirculation in product treatment and washing processes for the sake of increasing the yield rate and the introduction of multistage countercurrent washing which requires low costs.

Nonetheless, increasing pre-treatment costs due to degrading river water quality, the regulation on groundwater pumping, and increasing charges for alternative water sources (i.e. industrial water supply) often caused sharp increases in water costs for the industry. In addition, effluent standards were strengthened, which increased wastewater treatment costs. The industry has been tackling rationalization of water use to deal with the water cost increase as well as the cost of sludge treatment.

The unit water consumption for a ton of paper produced in Japan around 1977 was 100 -  $150 \text{ m}^3$ /ton and is now reduced further.

#### 2) Costs of Water Intake and Wastewater Discharge

Costs of water intake and wastewater discharge differ according to the condition of the water sources and whether discharge to the sewage system is required. The source of water is of special importance. Whether a factory could use relatively cheap river or groundwater or had no choice but to rely on industrial water supply, made an enormous cost difference. (In fact costs of water intake and wastewater discharge varied between 1 and 7 % of shipment values.)

When mills faced the cost burden of using industrial water and/or connection to the sewage system, they responded the situation by rationalizing water use and improving effluent quality in order to avoid the connection to the sewage system (discharge to a public water body).

#### 3) Response to External Factors

#### i Potable Water and Industrial Water Rates

Use of potable water was limited to domestic purposes, and it was difficult to take actions against increasing water rates. For industrial water, however, ever-increasing charges, to 30 JPY/m<sup>3</sup> or more, made it necessary for the industry to rationalize water use, mainly in processing and washing.

#### ii Effluent Regulation

Effluent from the pulp/paper industry contained organic materials, and consequently the industry quickly responded to the tightened effluent standards and the total pollution load regulations. To respond to strengthening regulations, biological treatment facilities utilizing activated sludge had been installed, in addition to flotation and coagulation sedimentation facilities that improve yield rates.

#### iii Discharge to the Sewage System and Its Costs

Since the pulp/paper industry was a water-intensive industry, sewage charges were of crucial importance. If such charges could amount to as much as 10% of total production cost, paper mills may be forced to relocate or close down. Therefore, many mills improved effluent treatment facilities equivalent to the sewage standard and tried to reduce the amount of effluent discharged to the sewage system by rationalization of water use and introduction of advanced treatment facilities.

The regulation on groundwater pumping was strengthened in the late 1970s in Japan. Many mills had historically held water rights in their adjacent rivers or groundwater sources, and therefore did not have to use industrial water. For mills that had to change their water sources to industrial water, the 30 JPY/m<sup>3</sup> charge has further increased and has now become very large burden. From these points of view, if groundwater pumping is reduced by the regulation in developing countries, massive relocation or closure of paper mills may occur unless inexpensive water source, i.e. inexpensive industrial water supply is introduced and its rate is gradually increased.

# 2.3.5 Effectiveness of Industrial Wastewater Management for Improvement in Water Quality and Its Costs

#### a. Effect on Water Quality Improvement

Figure 2.3.9 shows the trend in river and coastal water quality in Yokohama, Osaka, and Kitakyushu, which are major industrial areas in Japan.

As this figure illustrates, each city showed much improvement in water quality in the early 1970s. Advancement of industrial wastewater management was primarily responsible although development of sewage systems also contributed this improvement.



Water Quality in Public Waters and Access to Sewerage by Residences, 1955-90



Water Quality in Public Waters and Percentage of Sewered Area by Residences, 1935-90





Water Quality in Public Waters and Access to Sewerage by Residences, 1955-90

#### Kitakyushu

Source: EX Corporation, "Japan's Experience in Urban Environmental Management", Metropolitan Environment Improvement Program, World Bank, 1996, p.27

Figure 2.3.9 Trends in Rivers and Coastal Water Quality in Three Major Industrial Cities (1955-90) Similar findings are identified in Figure 2.3.10 which shows changes in the rate of noncompliance with the environmental quality standards in rivers and coastal waters.



Source: EX Corporation, "Japan's Experience in Urban Environmental Management", Metropolitan Environment Improvement Program, World Bank, 1996, p.28

Figure 2.3.10 Changes in Ratio of Noncompliance with Environmental Quality Standards in Rivers and Coastal Waters (1971-88)

Wastewater management, which resulted in improvement of river and coastal waters taken by the industry had begun in the late 1960, with major measures being achieved around 1980.

#### b. Analysis of Wastewater Management Costs

Table 2.3.10 outlines the wastewater management costs of major industry in the southern Kanto region based on 1977 value.

The amount of wastewater discharged to sewage systems remained a little less than 10 percent of total wastewater at the time. That was probably because most of major facilities had located in coastal regions. It can be said, however, that the industry as a whole was still at a stage where only 10 to 20 percent of effluent was discharged into sewers.
Item		Cost o (mi	f Water illion JF	Intake Y)			tion	use	ter		er	ter costs	d to
Industry sector	Potable water	Industrial water	Groundwater	River water, others	Total	Cost for water conservation	Cost for recircula	Cost for cascade 1	Cost for wastewa treatment	Cost of sewage	Total cost for wat and wastewater	Ratio of wastewa costs to the total of	Ratio of water an wastewater costs shinment value
Food	12.3	3.6	0.4	0.4	16.8	0	0.8	0.1	40.9	3.2	58.6	0.64	0.65
processing													
Pulp/paper	1.2	5.6	0.1	0.2	7.1	0	6.1	0.0	16.2	3.9	29.3	0.55	1.69
Chemical	5.4	17.4	0.5	0.1	23.4	0	24.4	0.3	48.1	3.6	96.1	0.50	1.04
Petroleum/ coal	2.0	22.1	0.2	0.8	25.1	0	7.3	0.0	18.7	0	51.0	0.37	0.61
Ceramics/mfr stone clay	1.8	0.9	0.1	0.0	2.9	0	2.2	0.0	5.3	0.4	10.4	0.51	0.53
Steel	2.8	7.1	0.1	0.3	10.4	0	59.4	0.6	26.2	1.0	96.5	0.27	1.39
Non-ferrous metal	1.3	1.9	0.2	0.0	3.3	0	7.7	0	5.0	0.8	16.0	0.31	0.53
Transportation machinery	4.0	1.3	0.2	0.4	5.4	0	4.0	0.1	11.4	1.2	20.9	0.55	0.16
Other machinery	15.9	2.2	0.4	0.0	18.4	0	3.8	0.2	11.7	2.7	34.2	0.34	0.15
Other manufacturing	17.6	2.4	0.6	0.0	20.6	0	1.0	0.3	20.0	2.2	40.6	0.49	0.34
Total	64.3	64.5	2.8	2.2	133.4	0	116.7	1.6	203.5	19.0	453.6	0.45	0.50

Table 2.3.10 Wastewater Management Costs in Southern Kanto Region by Type of Industry (1977)

Source: Kanto Regional Construction Bureau, Ministry of Construction, "Study on Projection of Changes in Industrial Water Demand", 1980, p.167

Table 2.3.11 shows the volume ratio of wastewater requiring treatment to consumed water (newly supplied water = total waster use - reused water) and main treatment methods.

Industry	Ratio of Wastewater	Main Treatment Methods Employed
Food processing	75.7%	Biological treatment (activated sludge)
		Coagulated floated treatment for oily effluent
Pulp/paper	84.5%	Coagulated sedimentation, floatation, filtering
		Activated sludge treatment when effluent standards required a
		BOD value of less than 25 ppm
Chemical,	28.4%	Commonly, activated sludge treatment.
petroleum, and		Neutralization, coagulation sedimentation, coagulation
coal		floatation, oily water separation, and activated carbon
		treatment, depending on characteristics of effluent.
Ceramics/ mfr	20.3%	Coagulation sedimentation/filtering, septic tank for domestic
stone clay		wastewater
Steel	19.5%	Neutralization, reduction, and coagulation sedimentation for
		inorganic effluent.
		Activated sludge treatment for ammonia liquor from coke oven.
		Biological treatment for domestic wastewater.
Machinery	52.8%	Neutralization/coagulation sedimentation for inorganic effluent.
		Floatation treatment for oil-bearing effluent, bio-treatment for
		domestic wastewater as well.

Note: Ratio of wastewater to supplied water is derived from dividing total water used for product cleansing and other uses by supplied water. Treatment methods employed are standard practices of the factories surveyed.

Source: Kanto Regional Construction Bureau, Ministry of Construction, "Study on Projection of Changes in Industrial Water Demand induced by Implementation of Total Pollution Load Control", 1978

Based on above, the following points may be identified regarding the wastewater cost burden for factories.

- i Cost of industrial wastewater management was approximately 0.5 % of shipment value for all industry.
- ii Ratio of wastewater management costs to total water management costs was about 60 percent in water-intensive industries such as food processing and pulp/paper, 30 percent for industry using less water, and about a half on the average.
- iii Costs of raw water intake and circulation accounted for roughly half of water management costs.
- iv Wastewater treatment costs, including sewage charges, accounted for more than half of total wastewater management costs.

Under these circumstances, industrial wastewater management measures became an integral part of energy conservation and rationalization of production facilities.

A significant portion of the expense was for rationalization of production facilities, so the costs indicated here are not exclusively for actual wastewater management measures.

Water costs amounted to about 0.5% of shipment values in the 1970s. By contrast, as Figure 2.3.11 illustrates, labor costs accounted for about 10 to 20 percent of shipment value in the 1960s and 1970s, with an average of 13.5%. On the other hand, the average increase in labor cost was 14.1%, as shown in Figure 2.3.12, which accounted for 1.9% of shipment value at the time.

By comparison with other costs, the burden of wastewater treatment/discharge was manageable for Japanese firms at the time.



Source: Ministry of International Trade and Industry, Industrial Statistics Table - Industry, 1975

Figure 2.3.11 Ratio of Labor Cost to Shipment Value (1975)



Source: Ministry of Health, Labor and Welfare, Monthly Labor Statistics

Figure 2.3.12 Changes in Year-on-Year Ratio of Labor Cost in Manufacturing Industry (1953-2003)

# 2.3.6 Health Damages Caused by Water Pollution

A study group in the Environmental Agency analyzed the costs of health damages caused by organic mercury contamination in the Minamata Bay and cadmium pollution in the Jintsu River in Niigata Prefecture as well as the cost of their countermeasures<sup>34</sup>. Results of the study are shown below:

## a. Damage Caused in Minamata and Industrial Pollution Control

## a.1 Actual Conditions of the Pollution

In 1932 the Chisso Corporation, located in Minamata on Kyushu-island, started to discharge its effluent containing methyl mercury generated during acetaldehyde production into the Shiranui Sea. Until a closed wastewater circulation system was installed in 1966, methyl mercury had been released, and about 100 tons of mercury accumulated at the bottom of the bay. The mercury released into the environment accumulated in fish and shellfish, and for example, the concentration in the *asari* clam reached about 80 ppm in 1966 (by 1971 it had decreased to 4 ppm).

## a.2 Damages and Countermeasures

Damages caused by the discharge of effluent containing mercury and its countermeasures are summarized below.

<sup>&</sup>lt;sup>34</sup> Chikyu Kankyo Keizai Kenkyukai (ed.), Nihon no Kogai Keiken, Godo Shuppan, 1991

	Damages and Countermeasures	Costs	Remark
Health Damages	Number of patients officially recognized as	90.8 billion	3 billion JPY
C C	having Minamata Disease were 2,248 by the	JPY	annually
	end of March 1991 (of which 1004 were		afterward
	deceased) Monetary figure here represents		
	cumulative compensation until the end of		
	March 1991.		
Damages due to	Cost of dredging and land filling of 1.51	48.5 billion	
Contamination of	million m <sup>3</sup> of sediment contaminated with	JPY	
Sediment	concentration of more than 25 ppm by total		
	mercury		
Fishery Losses	Fishery compensation expense for 1959,	3.9 billion JPY	
	1973, and 1974		
Pollution Control	Mercury recovery by sedimentation tank	Approx. 0.4	
Measures	and effluent treatment in 1950s	billion JPY	
	Cost of developing complete recirculation		
	system in 1966		

Table 2.3.12 Damages and Countermeasures	Table	2.3.12	2 Damages	and	Countermeasures
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Source: Chikyu Kankyo Keizai Kenkyukai (ed.), Nihon no Kogai Keiken, Godo Shuppan, 1991

# a.3 Comparison of Damage Costs and Costs of Countermeasures

When the damage costs and the costs of countermeasures are compared, the former is approximately 100 times more than the latter. Implementing the countermeasures at an early stage to prevent damages would be rational even from a purely financial standpoint.

# Table 2.3.13 Costs of Damages and Countermeasures regarding Minamata Disease (at 1989 price)

Type of Damage	Annual Damage (million JPY)	Annual Cost for Countermeasures (million JPY)
Health hazard	7,671	
Contamination of the bay	4,271	
Fishery loss	689	
Total	12,631	123

Note: Damage costs are calculated by converting total cost of past compensations at 1989 price with interest rate of 7%, and repayment made in 30 years with principal-and-interest equal refund. Cost of the countermeasures are calculated from first the total investment made by Chisso Corp. for installing the complete closed cycle equipment was divided by 12, and then 4 times of that value was estimated as capital stock, and 30% of that value was assumed to be used as operation cost, and add 7 % of the interest. Source: Chikyu Kankyo Keizai Kenkyukai (ed.), *Nihon no Kogai Keiken*, Godo Shuppan, 1991

## b. Damage and Countermeasures in the Jintsu River Cadmium Pollution Case

## b.1 Actual Condition of the Pollution

Effluent and slag leachate from the Kamioka mine, said to be one of the best mines in the world at the time, were released over many years to the upper stream of the Jintsu River. The effluent and slag leachate included heavy metals including cadmium. Heavy metals were deposited in rice paddies and riverbeds, adversely affecting agriculture since about 1910. According to surveys carried out from 1971 to 1976, cadmium concentration in the soil of the contaminated farmland, reached a maximum of 4.85 ppm, the average being 1.12 ppm<sup>35</sup>. Cadmium concentration found in brown rice was 4.23 ppm at a maximum, and 0.99 ppm on average.

<sup>&</sup>lt;sup>35</sup> Cadmium concentration in normal soil of Jintsu-river alluvial fan was said to be 0.34 ppm.

# b.2 Damages and Countermeasures

The "Itai-Itai" (ouch-ouch) Disease was initially regarded as peculiar to the Jintsu River valley, and it was not until the mid 1950s that full-scale study of this illness started. In 1968 the Ministry of Health and Welfare officially announced that the Itai-Itai Disease was caused by cadmium which originated from the Kamioka copper mine.

The Toyama Prefectural Government began a medical relief effort for Itai-Itai Disease patients in 1968. From 1970, victims began to receive compensation, based on the Law on Special Relief of Pollution-Related Patients. Itai-Itai Disease was designated as one of the target diseases in the Pollution-Related Health Damage Compensation Law enacted in 1974. Besides damage to human health, the pollution also reduced agricultural yields. A summary of those losses is shown in Table 2.3.14.

	Damages and Countermeasures							
Health	Patients officially recognized as Itai-Itai Disease patients grew to 129 by the							
Damages	end of March 1991 (of which 116 had deceased). Compensation paid for the							
	accumulated damage till the end of March 1991.							
Agricultural	Drop in yield. Losses due to contaminated rice and costs of countermeasures.							
losses	Compensation paid to farmers for restriction of their cultivation.							
Restoration of	Soil dressing on the farmland of 1,500 ha where cadmium concentration							
Agricultural	exceeded 1 ppm. (began in 1979, completed 36% of the contaminated							
Land	farmland by 1992)							
Pollution	Improvement of wastewater and flue gas treatment in the factory (cadmium							
Control	concentration greatly fell below 0.01 ppm in the effluent). Covering of earth							
Measures	at mine collection site. Grass planting.							

Table 2.3. 14 Damages and Countermeasures	Table 2.3.14	Damages	and Co	ountermeasures
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Source: Chikyu Kankyo Keizai Kenkyukai (ed.), Nihon no Kogai Keiken, Godo Shuppan, 1991

## b.3 Comparison between Damage Costs and Costs of Countermeasures

Table 2.3.15 shows the annual cost of damages/losses and costs of countermeasures. Costs of countermeasures were lower than the actual damages caused by this pollution, indicating the justification for early prevention efforts.

Table 2.3.15 Cost of Damages and Countermeasures for Itai-Itai Disease Ca	ises
(at 1989 price)	

Type of damage/loss	Annual damages (million JPY)	Annual cost of countermeasures (million JPY)
Damage to human health	743	
Agricultural loss	1,775	
of which,		
compensation for leaving idle	882	
soil restoration	893	
Total	2.518	603

Note: Damage costs are calculated by converting total cost of past compensations at 1989 price with interest rate of 7%, and repayment made in 30 years with principal-and-interest equal refund. Costs of countermeasures were based on average cost of countermeasures implemented by Mitsui Mining & Smelting Corp.'s annual investment after 1973.

Source: Chikyu Kankyo Keizai Kenkyukai (ed.), Nihon no Kogai Keiken, Godo Shuppan, 1991

# 2.3.7 Implications for Developing Countries

## a. Cost of Water Intake and Discharge

When the cost of water is low, or when the water charge is fixed no matter how much water is used, incentives for conserving water are also low, and it is thus difficult to reduce water consumption.

Effluent discharge costs vary depending upon discharge conditions such as types of effluent receiving body and effluent regulations. In both cases, however, increasing costs affect the rationalization of water use. Even for water-intensive industries, the cost of water and wastewater is typically less than one percent of shipment value, which makes it difficult for improvement of water use efficiency to be target of cost rationalization. However, when looked at from a profit point of view, water costs should not be neglected as the ordinary profit is usually only a few percent of the cost price.

Water rationalization can easily be performed by industries since it is directly connected to reduction of production cost. In addition, understanding the flow and amount of water is fairly straightforward; it is easy for companies to plan on how to rationalize water use. In the areas where water use is constrained, incentives to rationalize the use of water are likely to work. In addition, there are also water treatment needs for the improvement of product quality.

Companies recognize costs as water and/or sewage charges more sensitively in the following cases:

- When charge collection rates are low, unfailing collection makes companies to recognize costs. As for swage charges, their collection rates may increase if they are collected with water charges.
- Water charges are often subsidized in developing countries. If water supply companies/entities start to make their business economically viable, water charges may be increased.

## b. Capacity of Various Actors to Implement Water and Wastewater Management and Development of Organizational Arrangement

Industries are key player to implement measures, and local governments have a role in monitoring pollution and offering guidance and advice. Manufacturers of treatment facilities and treaters of waste oil and wastewater also participate.

Policies related to capacity building and systems for these bodies are as follows:

- i Pollution Control Officers: The number of qualified officers in water pollution control increased among local authorities, polluting business establishments, and waste management and treatment companies.
- ii Managers in Charge of Pollution Control: These headed units which enabled companies to address pollution control in an integral fashion and to establish in-house systems to track down the pollution.
- iii Training, education and research to enhance capacity of company staff.
- iv Development of an equipment manufacturing and treatment industry for pollution control.

## c. Strong Leadership of Local Governments in Monitoring/Guidance

Based on the Water Pollution Control Law, local governments improved the practicability of monitoring and guidance by identifying those facilities that required special attention, and developing an inspection and notification system for such facilities. Furthermore, local

authorities were empowered to conduct on-site inspections, to require specific remedial actions, and where necessary to order the closure of facilities.

# d. Linking of Economic Incentives for Pollution Control Investments and Regulatory Measures

This point is dealt with in detail in Chapter 1. Financial assistance including subsidies, low-interest loans, and tax breaks for pollution control investments supported private industries' efforts to respond in a short period to regulatory and legislative measures.

# e. Regulations on Groundwater Pumping for Ground Subsidence and Development of Industrial Water Supply to Provide Alternative Sources of Water

Since large urban areas like Tokyo and Osaka suffered ground subsidence due to over-pumping of groundwater, the Industrial Water Law was established in 1956 to regulate the pumping of groundwater. The development of an industrial water supply system permitted a gradual reduction in the use of existing groundwater sources. Beside cost issues, it was unrealistic to convert the industrial water supply system to a potable water system; therefore, development of a dedicated industrial water supply was rational decision.

# f. Gradual Implementation of Water Pollution Control

Water pollution control in Japan was implemented in the following order: (a) rationalize water use, (b) regulate groundwater pumping, (c) develop industrial water supply, (d) regulate wastewater quality/concentration, (e) gradually increase industrial water price (f) develop and gradually increase prices for use of sewage system, and (g) implement total environmental load regulation.

As a result of the above, industry was encouraged to undertake low cost Cleaner Production (CP) type actions, such as rationalization of water use and segregation of effluent. Through this experience, industry realized that by carrying out CP type actions it would eventually lead to upstream cost reduction as well as reducing the cost of end-of-pipe measures.

# g. Cost-Effectiveness of Preventive Measures

Pollution had caused severe damages to human health, agriculture, and fishery. The costs associated with those damages/losses were much more than those of appropriate preventive measures. It therefore often makes much sense to implement pollution prevention measures in advance.

# 2.4 Market and Cost of Industrial Waste Management

This section describes problems that Japan experienced right after the introduction of an industrial waste management system based on the Waste Management Law, impacts of the change in the management system due to the law amendment, and costs accrued from illegal dumping of wastes.

# 2.4.1 Problems upon the Introduction of Industrial Waste Management System<sup>36</sup>

# a. Characteristics of Industrial Waste Management

Industrial waste management has the following characteristics not only applying to Japan.

- i It is essential to identify the flow of industrial waste in order to manage it properly. This is difficult for following three reasons. A manifest system can be utilized to track the flow of industrial waste, but it requires extensive monitoring capacity.
  - Many businesses discharging industrial waste do not know with any accuracy the quantity and quality of their waste by waste-type.
  - Many actors are involved in managing the flow of waste, involving collection and transportation, treatment, and final disposal.
  - The transportation route is also an important factor since the locations of discharge and treatment/disposal are usually different.
- ii In many cases, illegal dumping is the most cost effective way of discarding the waste if only treatment/disposal costs are concerned. Thus illegal dumping or other unlawful treatment activities will be a consequence if businesses simply try to cut the cost.
- iii Compared to air and water pollution, improper treatment and disposal is not easily identified.

# b. Difficulty in Enforcement of Legal System

The Waste Management Law of 1970 stipulates that the principal responsibility for waste treatment/disposal rests with the generator/discharger. When generators/dischargers cannot treat the waste by themselves, the law allows them to contract out to outside industrial waste treaters. Most of dischargers of industrial waste did contract out to outside treaters for final disposal. Although prefectural governments had the obligation to monitor and provide necessary guidance, it was actually impossible to track down the enormous number of the business entities that treated and/or disposed of industrial waste.

Even though many of the waste dischargers tried to properly treat/dispose their wastes, it was difficult to identify those dischargers who did not mind breaking the law. Enforcement of the Waste Management Law of 1970 encountered the following difficulties:

i Ambiguity in definition of waste and difficulty of determining waste types:

Waste acid, waste alkaline, waste oil, and sludge were not clearly defined and hard to distinguish. Additionally, for industrial waste containing toxic substances, facilities that were to generate hazardous waste were specified in the law – limiting the targeted facilities the law applied. For sludge, a dissolution test can be performed to

 $<sup>^{36}</sup>$  In this section of 2.4, 'Waste Management Law of 1970' indicates the law which enacted in 1970 and it includes the revision in 1976.

determine whether the waste should be categorized as hazardous waste, but the procedures, including sampling and analysis, were too complicated.

ii Difficulties in securing appropriate treatment/disposal:

With an amendment to the law in 1976, structures of landfill sites for industrial waste were defined in three categories depending upon types of industrial waste. However, it was difficult to monitor the type of waste stream entering the landfills, so it became hard to prevent all types of industrial waste from going into cheaply made landfill sites.

iii Limitation of dischargers' liability:

Dischargers were released from their liability if treatment was contracted out. A manifest system had not been developed, so it was difficult to trace where the responsibility rested, even if the discharger was identified.

### c. Legal Formation of an Industrial Waste Management Market

Following are characteristics of the industrial waste management market in view of the regulation on treatment in the Waste Management Law of 1970 (amended 1976).

i Entry into Business

There was no strict restriction for entering into the waste management market. In other words, it was easy to obtain the title (certification) to become a treater/disposer. Even if some legal problem arose, they could simply obtain a new title (certification) and continue their usual business. For the construction of industrial waste treatment/disposal facilities, a notification was only necessary if those who construct the facilities held the treater/disposer permit.

ii Revocation

There were no rules for revoking the permit so that revocation did not occur.

iii Supervision

Liability was transferred when the discharger contracted to treatment/disposal companies, which made it difficult for local governments to supervise the liability of the discharger. The treatment/disposal companies were required to report the amount of waste they treated/disposed of to prefectural governments, but it was practically impossible to check and supervise the amounts reported on paper and the amount actually landfilled. Therefore, in the cases of improper treatment/disposal of waste, it was very difficult to supervise the discharger of the waste since the manifest system had not been introduced.

iv Penalties

Fines for illegal dumping/disposal were very light, so had little preventive impact.

### d. Delayed Introduction of New Scheme and Administrative Improvement

Control over industrial waste management was initiated based on the Waste Management Law of 1970 (implemented in 1971), but administrative capacity of prefectural and major municipal governments for industrial waste management was not sufficient for enforcement of the law.

From an administrative point of view, industrial waste management is very hard to monitor because, unlike air or water pollution sources that tend to be fixed to one location, industrial waste can not easily distinguished at source, generation spreads in/around a factory, and entities responsible for storage and treatment often change. Therefore, it took some time to

establish a system to properly monitor the waste stream. Every local government had a limited number of staff for addressing industrial waste issues. This happened because the Waste Management Law was established in accordance with the principle that waste dischargers themselves would be responsible for treatment and disposal of their waste, and form a market without strict regulations. Unfortunately, there were many waste dischargers and treaters who deviated from the sprit of the law. As Kitamura<sup>37</sup> mentioned about administrative attitude, at that time, involved parties to the policy making recognized that to promote to establish waste treatment/disposal system was the most urgent task rather than strengthen the regulation under the situation of an immature waste treatment/disposal system. They probably aimed to put a public- label as a permission for treaters who could at least collect and transit wastes regardless of qualities and let dischargers know that treaters were available, instead of selecting good quality treaters. The situation of regulation system is described below.

First of all, the Waste Management Law mandated prefectural governors to develop an industrial waste management plan. However by the end of December 1973, only three prefectures had established such plans out of 22 prefectures surveyed. Reasons for delay, according to the prefectures that had not done so, were as follows:<sup>38</sup>

- a. Difficulty in investigating the status of the condition of discharge, treatment, and disposal.
- b. Difficulty in determining the contents of the management plan, especially necessity of publicly run treatment facility or its scope.
- c. Difficulty in securing sites for treatment facilities and final disposal site.
- d. There was no deadline for developing the plan.

At the end of December 1975, 4 years after the law was put into force, 14 prefectures out of 47 still had not developed the waste management plan. Even in the plans the local governments prepared, there was not a single plan that identified and predicted the discharge, treatment, and disposal of industrial waste, and how the government would undertake the countermeasures<sup>39</sup>. It was, indeed, still in a learning phase.

Secondly, the local governments had not successfully listed the target companies to be monitored, particularly those discharging industrial waste containing toxic substances (see Table 2.4.1). As for on-site inspections, the status of implementation varied nationally, and about one-third of the authorities conducted on-site inspection only 10 times or less in a given year (see Figure 2.4.1). When looked at how the on-site inspections were carried out, as seen in Table 2.4.2, about one-third of the governments notified the businesses prior to the inspections. This was because of lack of experience of on-site inspectors, at the early stage of administration of industrial waste management, they needed learn from related parties in plants. In addition, administrative guidance was given to violators, but manual and guideline were not started to develop until the late of 1980s.

The third matter is ability of examination. The ability of administration to examine and judge application is fundamental of license system, but the author heard from some related parties to industrial wastes management businesses that there were many cases in which licenses were given for technically insufficient facilities. Lawyers, who handled suits against the waste management administration, also express their doubt of administrative ability<sup>40</sup>.

Fourthly, there was a communication problem within a local government, between the relevant sections, such as air, water, and sewage. To give an example, one prefecture had

<sup>&</sup>lt;sup>37</sup> KITAMURA Yoshinobu, Yureugoku Sangyo Haikibutsuho, Dai-ichi Hoki Shuppan, 2003, p27

<sup>&</sup>lt;sup>38</sup> Administrative Management Agency, "Advise Based on Results of Administrative Inspection on Industrial Waste Management, August 1974", *Kogai to Taisaku*, Vol. 10 No.9, 1974, p.83

<sup>&</sup>lt;sup>39</sup> SAKURAI Kunitoshi, "Sangyo Haikibutsu Gyosei no Mondaiten", *Kokumin Keizai*, No.135, 1976, p.61

<sup>&</sup>lt;sup>40</sup> KITAMURA Yoshinobu, Yureugoku Sangyo Haikibutsuho, Dai-ichi Hoki Shuppan, 2003, p27

given a city government the authority for on-site inspection in accordance with the Water Pollution Control Law, while inspections targeted for industrial waste were authorized to a public health center (which was under the prefectural government). In order to accurately inspect the industrial waste, especially for sludge, information on production processes and wastewater treatment processes was vital. However, there was no effort to fill the information gaps that resulted from dividing inspection authorizations. In another instance, staff from a public health center did conduct the whole inspection, including air, water, and industrial waste. In this case, while the information gaps mentioned above were avoided, coordination with other departments in the prefectural government was left alone with the public health center -- placing excessive burden on them<sup>41</sup>.

In Tokyo, there was no consistency on its guidance since comprehensive consideration was not paid to the integration of air pollution, water quality, and waste management in inspecting the factories. It is now clear that the administrative system was not properly set up based on the Waste Management  $Law^{42}$ .

Table 2.4.1 Listing of Industrial Hazardous Waste Discharger (Surveyed in Nov. 1974)

	Listed all	Listed partially	None	Unknown	Total
Prefectures	15(32%)	23(49%)	8(17%)	1(2%)	47(100%)
Major cities	7(23%)	13(43%)	6(20%)	4(13%)	30(100%)
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Source: SAKURAI Kunitoshi, "Sangyo Haikibutsu Gyosei no Mondaiten", Kokumin Keizai, No.135, 1976, p.61

Table 2.4.2 Method of On-site Inspection

	Notified to business prior to inspection	No notification	Depends on conditions	Unknown	Total
Prefectures	16(34%)	22(47%)	6(13%)	3(6%)	47(100%)
Major cities	9(30%)	13(43%)	5(17%)	3(10%)	30(100%)

Source: SAKURAI Kunitoshi, "Sangyo Haikibutsu Gyosei no Mondaiten", Kokumin Keizai, No.135, 1976, p.61



Source: SAKURAI Kunitoshi, "Sangyo Haikibutsu Gyosei no Mondaiten", Kokumin Keizai, No.135, 1976, p.61

Figure 2.4.1 Distribution of Number of On-site Inspection (FY1973)

<sup>&</sup>lt;sup>41</sup> Ibid, pp.61-63

<sup>&</sup>lt;sup>42</sup> HISHIDA Kazuo, "Sangyo Haikibutsu Shoriho no Mondaiten to Kogo no Kagai", *Kagaku to Kogyo*, No. 29, Vol. 9, 1976, pp.87-90

Compliance of administrative regulation system by waste dischargers and treaters are described as below. According to the on-site inspection for waste dischargers by the Tokyo Metropolitan Government in 1977, lack of understanding about the Waste Management Law and unknown or noncompliant of consignment standards occupied one-quarter, even seven years after the enactment of the Waste Management Law.

	-							- 1-					,
Identified Business Establishmer	Problem	Facility		Laws and regulation		Treatment technology & recycle		Othe	ers	Total			
Scale by number of employees	Number of inspections	Lack of storage facility	Lack of notification for treatment facility	Defective management of treatment facility	Unknown or noncompliant of consignment standard	Defects of records & entries	Lack of understanding of laws and regulations	Volume reduction	Recycling	Treatment method and technology	No analysis on composition/characte ristics of the waste	Provision of information	
300 -	254	60	36	3	216	109	214	11	61	62	53	1	826
100 - 299	309	59	36	7	275	148	268	8	57	87	63	9	1017
1 - 99	775	151	94	15	659	429	642	9	75	120	347	9	2551
Total	1338	270	166	26	1150	686	1124	28	193	269	463	19	4394
Ratio (%)		62	3.8	0.4	26.2	15.6	25.6	0.6	4.4	6.1	10.5	0.4	100

Table 2.4.3 Identified Problems upon On-site Inspection (Tokyo: result of 1977)

Note 1: This table was developed based on actual matters identified at the on-site inspections of 1338 business establishment for 22 types of business in manufacturing and non-manufacturing industries.

2: In a case of more than two matters were identified in one establishment, cases are added up in appropriate section repeatedly.

Source: FUJINO Shuzo, "Sangyo Haikibutsu wo meguru Shomondai", Kogai Kenkyu, Vol.8 No2, 1978, pp.2-12

The survey conducted by the Administrative Management Agency, (thought to be conducted in 1973) showed that improper treatment or illegal dumping cases were founded in 102 business establishments out of targeted 320. Also 107 business establishments out of 320 commissioned treatment of their waste to unauthorized treaters<sup>43</sup>.

The Pollution Control Bureau of the Tokyo Metropolitan Government conducted a survey from April 1974 to March 1975 on 4,500 plants about transporters/treaters of their wastes (67% of surveyed responded). That survey revealed that 1,338 waste transporters/treaters (77%) out of 1,774 were unauthorized. In addition, on-site inspection by the Cleansing Department of the Tokyo Metropolitan Government at the same time founded that 64% of transporters/treaters of sludge, 90% of those of waste oil and 68% of those of waste plastics were unauthorized, which overwhelmed the number of authorized ones. However, the relationship between authorized transporters/treaters and unauthorized ones were not so much like competitive, because unauthorized transporters/treaters with two or three dump trucks took on as second tier subcontractor from authorized ones in many cases<sup>44</sup>.

# 2.4.2 Waste Treatment/Disposal Fees and Waste Reduction

## a. Industrial Waste Treatment/Disposal Fees

From the establishment of the law in 1970 until 1997 when a major revision was made, the fees for industrial waste treatment/disposal stayed relatively low since the enforcement of

<sup>&</sup>lt;sup>43</sup> Administrative Management Agency, "Advise Based on Results of Administrative Inspection on Industrial Waste Management, August 1974", Kogai to Taisaku, Vol. 10 No.9, 1974, p.86

<sup>&</sup>lt;sup>44</sup> YORIMOTO Katsumi, "Sangyo Haikibutsu", *Gyoseigaku Koza 5 Gyosei to Kankyo*, University of Tokyo Press, 1976, pp.156-157

relevant regulations supporting the development of a market system for proper treatment was very hard. This, in turn, formed a vicious cycle of improper treatment. Table 2.4.4 exemplifies the common waste disposal fees in the Kanto region at the time.

	Year	Leachate-controlled type landfill (cinder/sludge)	Non-leachate-controlled landfill
Metropolitan area	1982	7,000 - 8,000 JPY /t	1,000 - 2,000 JPY /t
Kanto region	1992	11,000 - 22,000 JPY /t	1,000 - 4,000 JPY /t

Table 2.4.4 Levels of Waste Disposal Fees among Private Waste Treaters

Source: Data for the Metropolitan area (1982) is from Saitama-ken Kankyo Hozen Kosha (Saitama Pref. Environmental Protection Corporation), "Study for Consideration of Waste Management Practice in Broader Area", 1983, p.11. Data for the Kanto region (1992) is from Japan Business Federation Special Committee for Environmental Protection, "Report on Recycling Industrial Waste", 1993.

In the 1980s, disposal fees in the Tokyo Metropolitan area for leachate-controlled type landfill run by private entities were between 7,000 to 8,000 JPY, and those for the non-leachate-controlled type landfill were 1,000 to 2,000 JPY. Although these fees varied among areas, the level of the fees in the Metropolitan area was not particularly high. When the 1990s came, the disposal fees increased due to the shortage of landfill sites, but fees for the non-leachate-controlled landfill sites remained low in real terms.

The fees stated above were those announced publicly. In practice, however, the market was in tough competition, and thus the many treaters accepted waste at below the published  $price^{45}$ .

By amendments of the law in 1997 and 2000;

- Liability of waste dischargers has been strictly established,
- Requirement for certification of waste treaters has been strengthened, and
- Heavy penalties for illegal actions were set.

The amendment made it easy to revel improper waste treatment/disposal and strictly enforce the law. Since then, industrial waste treatment/disposal fees have continued to increase<sup>46</sup>, especially after the revision of 2000. The main factor for the increase was that waste dischargers now face rigid liability for their waste, so that they started to look for a contractor who they could trust.

	Non-leachate-controlled landfill (JPY)	Controlled landfill (JPY)
October 1991	6,000	13,000
October 1995	5,970	19,750
October 1999	6,600 - 8,000	18,000 - 28,000
	(on average) 7,300	(on average) 23,000
January 2004	8,000 - 13,000	20,000 - 35,000
	(on average) 10,500	(on average) 23,000

Table 2.4.5 Construction Waste Disposal Fees (in Chiba Prefecture)

Note: Year and month indicate the time of publication of "Kensetsu Bukka (Construction Prices)" and actual prices are few months older. Prices are based on data from National Federation of Industrial Waste Management Associations Kanto Regional conference.

Source: Construction Research Institute, Gekkan Kensetsu Bukka (Monthly Construction Prices)

<sup>&</sup>lt;sup>45</sup> National Federation of Industrial Waste Management Associations, "Treatment/Disposal Fees for Construction Waste in Kanto Region", *INDUST*, Vol.9, No. 11, 1994, pp.50-57

<sup>&</sup>lt;sup>46</sup> Documents for the industrial waste tax in the Mie prefecture reported that treatment prices in the Kinki region in 1998 was 10,000 - 11,000 JPY per ton, but by 2001 it increased to 20,000 - 22,000 JPY.

Commissioned fees for the disposal in a controlled type landfill in Chiba Prefecture jumped 1.8 times from 13,000 JPY in 1991 to 23,000 JPY<sup>47</sup> in 2004. It is about 4 times higher than the disposal fees in 1982. Fees for the disposal in a non-leachate-controlled type landfill also increased to 10,000 JPY in 2004, 5 times of the 1982 level<sup>48</sup>.

Table 2.4.6 shows fees for the treatment of construction waste. The fees increased over the past decade, but the rate of increase has been, compared to the disposal in a landfill, small.

	January, 1990	January, 1995	October, 1999	January, 2004
Concrete mass, less	600	1,100	1,200	1,600
than 30cm (plain				
concrete) (JPY/t)				
Concrete mass, greater	1,000	1,500	1,700	2,000
than 30cm (plain				
concrete) (JPY/t)				
Asphalt mass, less	600	1,000	1,200	1,300
than 40cm (JPY/t)				
Asphalt mass, greater	800	1,300	1,500	1,400
than 40cm (JPY/t)				
Construction sludge	-	-	9,000	9,000
$(JPY/m^3)$				
Construction muddy	4,500	6,000	9,500	9,500
water $(JPY/m^3)$				
Wood waste	15,000	16,000	7,200	9,500
	(JPY/4t-truck)	(crushing)	(crushing)	(crushing)
		21,000	(JPY/m <sup>3</sup> )	(JPY/m <sup>3</sup> )
		(incineration)		
		(JPY/4t-truck)		

Table 2.4.6 Construction Waste Treatment Fees (in Chiba Prefecture)

Note: Year and month indicate the time of publication of "Kensetsu Bukka (Construction Prices)" and actual prices are few months older. Prices are based on data from National Federation of Industrial Waste Management Associations Kanto Regional conference.

Source: Construction Research Institute, Gekkan Kensetsu Bukka (Monthly Construction Prices)

The level of incineration fees changed from 35,000 JPY per ton of waste in 1999 to 46,000 JPY within 2 years, an increase of 1.3 times in two years.

## Table 2.4.7 Incineration Fees

	October, 1999	October, 2001
JPY per m <sup>3</sup>	8,800	11,500
JPY per ton	35,200	46,000

Note: Prices are for combustibles. Bulk specific gravity of 0.25t/m<sup>3</sup> was used for conversion of per ton of waste. Source: Construction Research Institute, *Gekkan Kensetsu Bukka (Monthly Construction Prices)* 

Treatment/disposal costs for industrial waste vary a great deal. Examples of treatment costs are shown in Table 2.4.8.

<sup>&</sup>lt;sup>47</sup> Construction Research Institute, Gekkan Kensetsu Bukka, May 2003, Price level in the Kanto region

<sup>&</sup>lt;sup>48</sup> Saitama-ken Kankyo Hozen Kosha, "Study for Consideration of Waste Management Practice in Broader Area", 1983, p.11. Survey results on consignment charge for industrial waste management around 1982.

	Commissions for Industrial Waste
	Treaters in 2000
	(Median)
Sludge	17,500 JPY/t
-	$10,500 \text{ JPY/m}^3$
Waste paper	25,500 JPY/t
	$7,000 \text{ JPY/m}^3$
Glasses/ceramics	5,000 JPY/t
	$10,000 \text{ JPY/m}^3$
Debris	1,700 JPY/t
	$3,500 \text{ JPY/m}^3$
Waste woods	15,000 JPY/t
	6,000 JPY/m <sup>3</sup>
Waste metals	6,750 JPY/t
	$5,500 \text{ JPY/m}^3$
Slag	9,000 JPY/t
Animal & plants	12,000 JPY/t
wastes	
Waste acid, waste	21,000 JPY/t
alkali	
Waste plastics	40,000 JPY/t
	8,500 JPY/m <sup>3</sup>
Waste oil	20,000 JPY/t
Ash	19,000 JPY/t

Table 2.4.8 Example of Industrial Waste Treatment/Disposal Cost by Waste Type

Source: Office of Prime Minister, "FY2001 Report on Study on the Establishment of a Sound Material-cycle Society (Study on Recycling Industry)",

http://www.kantei.go.jp/jp/mille/zyunkangata/dai5/pdfs/siryou7.pdf

## b. Discharge, Recycling, and Treatment of Industrial Waste

The following Figure 2.4.2 indicates the estimated quantity of industrial wastes that have been discharged, recycled, and disposed of from 1975 to 2000. The quantity discharged increased from 1975 to 1990 but become steady in the 1990s. The quantity disposed of also increased from 1975 to the early 1990s, but in the 1990s it actually started to decrease. Recycling had increased in the same period as well, but stabilized in the early 1990s. The period from the 1970s through 1990 did not show much decrease in disposed quantity, indicating there had not been much incentive for waste reduction. The years from 1982 to 1992 show an increase in fees, but these were small in real terms.



Note: Data for 1975 is for discharged amount only. Combined amount is whole discharged amount for all other years.

Source: Data from Ministry of Health and Welfare, *White Paper on Health and Welfare*, and Ministry of the Environment, *White Paper on Sound Material-Cycle Society*.

Figure 2.4.2 Changes in Amount of Industrial Waste Discharged/Disposed (1975-2000)

As seen in Figure 2.4.3, the quantity of waste disposed of decreased after 1993, and by 2000 the rate of landfilling became 12 %. On the other hand, the recycling rate jumped from 17 % in 1996 to 45% in 2000.



Source: Data from Ministry of Health and Welfare, *White Paper on Health and Welfare*, and Ministry of the Environment, *White Paper on Sound Material-Cycle Society*.

Figure 2.4.3 Transition of Amount of Waste Generation, Recycling, Reduction and Disposal (1980-2000, 1980 = 100)

### c. Effect of Increased Fees on Disposed Amount of Waste

Due to strong community opposition and the fact that amendments of the law in 1997 and 2000 made it difficult for new businesses to enter the waste management market, construction of new landfill sites has seen a sharp decrease.



Source: Ministry of the Environment, 2003 White Paper on Sound Material-Cycle Society, p.72

# Figure 2.4.4 Trend in Permits Issued for New Landfills (1996-2000)

The amended Waste Management Law of 2000 established a strict liability for waste dischargers. Even if improper treatment was done by a certified treater, liability still remained with the waste discharger. The waste dischargers, therefore, became greatly concerned about the risks, and tried to avoid treaters who lacked credibility. The dischargers are no longer excused for not knowing how their wastes are being treated/ disposed of.

Since the market conditions were established, the waste that had to go to leachate-controlled type landfill started to flow into the limited number of such type landfill sites. This reflected the increasing disposal fees. In addition, the industrial waste management business itself is a high-risk business, which also has led an increase in fees. The same tendency can be seen for the non-leachate-controlled type landfills.

As a result, the amount of waste landfilled greatly decreased, as shown in Figure 2.4.2, and the rate of landfilled waste dropped to around 37%. Approximately 4 billion tons, or 5 billion m<sup>3</sup> of waste have been treated since 1970. Because of cheap treatment fees, the scarce space of landfills had been used without much effort on waste reduction.

Considering that half of 400 million tons of industrial waste generated annually, or 200 million tons of industrial waste, was going to outside contractors for treatment<sup>49</sup>, and assuming the average fee per ton of industrial waste was 15,000 JPY before the amendments and 30,000 JPY after, the cost to dischargers soared from 3 trillions JPY before the revisions to 6 trillions JPY afterwards. This was a huge burden for industry, and presumably helped to form awareness about the need for a major industrial waste reduction effort. As industry pursued waste reduction methods, the amount disposed fell from 70 million tons in 1997 to 45 million tons in 2000. Assuming average treatment costs of 15,000 JPY per ton in 1997, total cost in that year was approximately 1 trillion JPY. Without waste reduction efforts, the cost would have been 2 trillion JPY, but the effort made by industries brought the cost to 1.35 trillion JPY, only a 350 billion JPY increase comparing to the amount prior the amendments. It can be said that increasing fees accelerated the recycling and reduction effort on the dischargers' side, which, in turn, resulted in a decreased amount of final disposal.

Waste recycling was the main contributor to this waste reduction effort. The amount of recycling increased by 34 million tons from 1996 to 2000. Advanced treatment, such as melting or incineration treatment, cost 30,000 to 40,000 JPY for a ton of waste, which was

<sup>&</sup>lt;sup>49</sup> ISHIWATA Masayoshi, Sanpai Connection, WAVE Publishers, 2002

more expensive than recycling. For waste discharging businesses, treatment does not reduce cost burden. Therefore, it can be presumed that the industry chose a more inexpensive way of waste reduction, i.e. recycling.

In recent years, the scarcity of industrial waste landfill sites has become adequately assessed, and the market has reacted accordingly, which increased construction of waste recycling and treatment facilities. Figure 2.4.5 shows levels of treatment fees -- for a model case -- for construction wastes after the amendment of 2000. Landfilling used to be the cheapest means of disposal, but recycling has become increasingly cost-effective as landfilling fees have moved to new phase.

The marginal cost of incineration is higher than that by other methods of treatment so that incentives for incineration treatment often do not work even if treatment charges are raised. Nonetheless, in the Tokyo Metropolitan area, when costs of waste collection and transportation are taken into account, incineration is becoming more attractive, leading to construction of new incinerators.

In summary, when the scarcity of landfill sites is adequately reflected in waste treatment/disposal fees, dischargers make an effort to reduce their waste stream.



Note: Disposal costs for the year 2000 and 2003 are set from construction prices. Incineration costs are estimated based on the following assumption; cost of facility construction is 30 million JPY per ton of waste, 10 years redemption, maintenance and repair cost is 1.0 of the facility redemption cost, 70% operating rate, and average cost considering manpower, ash disposal, management costs, and profits. No change is assumed for year 2000 and 2003. Recycling costs are derived from interviews with waste treater: 7,000 JPY per m<sup>3</sup>, and 27,000 JPY per ton for specific gravity of 0.26. No changes are assumed for both year 2000 and 2003.

Figure 2.4.5 Model of Fees for Construction Waste by Treatment Methods

## d. Involvement of Public Bodies in Waste Management and its Influence on Market

In the 1970s, some local governments established public corporations for waste management in order to tackle the issue of industrial waste management. In 1984, such public corporations numbered 23, of which 11 operated only landfill sites, while 9 corporations operated both treatment facilities and landfills, and 3 corporations operated intermediate treatment facilities only<sup>50</sup>. These public corporations were established because urgent

<sup>&</sup>lt;sup>50</sup> Ministry of Health and Welfare, "Study on Examination of Efficient Implementation of Industrial Waste Management with Public Involvement", 1985

development of such facilities was needed - faster than could-be-achieved by private industry alone - and pollution prevention objectives also required additional treatment/disposal facilities. In 2000, there were 77 public corporations, including those in a planning phase<sup>51</sup>.

With the help of these public corporations, the waste management system was established, but it has always been a matter of debate as to whether or not governmental involvement was necessary. Financial departments of the local governments were inclined to believe that the private sector should be entrusted with the responsibility of industrial waste management.

In 1984, treatment fees set by public corporations were in the case of the Osaka Industrial Waste Management Corporation, 4,800 JPY/m<sup>3</sup> for leachate-controlled type landfill and 1,000 JPY/t for non-leachate-controlled type landfill. As another example, the Okayama Prefecture Environmental Conservation Corporation, charged 2,000 JPY/t for both leachate-controlled type and non-leachate-controlled type landfills, both of which were sea area land reclamation landfills. Both landfills were developed for small and medium size companies, but they became the leading price for privately run industrial waste management facilities in neighboring areas. Since the early 1990s, the Osaka Bay Regional Offshore Environmental Improvement Center has been accepting industrial waste from the Kinki region at their large-scale sea area land reclamation site. Treatment fees as of October 2003<sup>52</sup> were, for leachate-controlled type landfill, 9,870 JPY/t for incineration ash and 7,700 JPY/t for sludge, and for non-leachate-controlled type landfill, 3,360 JPY/t for debris and 3,360 JPY/t for glasses/ceramics. They are relatively low charges but have become rough indicators of such prices in the Kinki region.

It is true that developing private facilities in Osaka was a complex task, but developing private facilities within Kinki area was achievable. When the private sector built industrial waste management facilities in the area, conditions such as location and financial efficiency were more disadvantageous than those for the public facilities, so the fees at the private facilities should have been higher than those at the public ones. However, in reality, the former was set as the similar level of the latter due to the influence of the latter. Such a phenomenon was commonly seen in other areas with public waste management facilities.

Private waste management operators had to match their prices to those set by public corporations because the public corporations led the market price. This might have had some negative impact on private companies; in order to provide the same kind of services as for public facilities, the private operators might lower the quality of their facilities or performed poor maintenance.

Then again, development of waste management facilities with governmental involvement had the effect of restraining illegal dumping<sup>53</sup>. Considering the social cost of restoring the status quo from illegal dumping that occurred before adequate legal and enforcement mechanisms were put into place, the public corporations and their inexpensive price settings had a certain benefit in restraining further occurrence of the illegal dumping.

# 2.4.3 Social Costs of Illegal Industrial Waste Treatment/Disposal

# a. Occurrence of Illegal Industrial Waste Treatment/Disposal under the Waste Management Law of 1970

The basic policy of industrial waste management in the Waste Management Law established in 1970 was to require the waste discharger to properly treat/dispose its own waste. When the waste generating/discharging businesses could not treat or dispose the waste in

<sup>&</sup>lt;sup>51</sup> Kankyo Eisei Shisetsu Seibi Kenkyukai, *Nihon no Haikibutsu 2000*, p.84

<sup>&</sup>lt;sup>52</sup> Osaka Bay Regional Offshore Environmental Improvement Center: http://www.osakawan-center.or.jp/

<sup>&</sup>lt;sup>53</sup> Before the governmental involvement in industrial waste treatment/disposal in Osaka, illegal dumping was a major problem within the prefecture. Reference: KURODA Takayuki, *Sangyo Kogai no Shuchaku-eki/Sangyo Haikibutu*, Doyukan, 1996

accordance with treatment/disposal standards set by the national government, then they could contract out the treatment/disposal to qualified outside treaters in the market. The role of the national and prefectural governments was limited to monitoring of the market.

Because there were so many waste dischargers that did not comply with the law and because it was difficult for the governments to monitor the conditions of industrial waste management, prevention of improper treatment practices, including illegal dumping, were big issues. The occurrence of such improper treatment/dumping led to a sense of mistrust among local communities. This consequently caused difficulties for attempts to develop new facilities, which in turn resulted in further illegal dumping.

Corporate responses to regulations on industrial waste depend on their recognition of the risks associated with non-compliance. At least until the amendment of 1997, these risks were considered to be low among waste discharging industries.

Even though most of the waste generating industry performed proper treatment, as the large volume -- or 400 million tons -- of industrial waste generated annually, a small percentage of illegally acting became a serious problem. The volume of illegally dumped industrial waste uncovered in the past decade has been of the order of 400,000 tons per year. This is for only the known amount; if unidentified waste is included, this figure would be several times higher.

Typical improper disposal of industrial waste includes disposal of the waste that should go to a leachate-controlled type landfill in non-leachate-controlled type landfill and illegal dumping.

It was commonly known among experts in the field that since the capacity of leachate-controlled type landfills was smaller than the market required, much waste was poured into the non-leachate-controlled type landfills. In that regard, past non-leachate-controlled type landfills and surplus soil landfills received waste with high polluting potential.



Source: Kankyo Eisei Shisetsu Seibi Kenkyukai, Nihon no Haikibutsu 2000, and Ministry of the Environment, "Status of Illegal Dumping of Industrial Waste."

# Figure 2.4.6 Trend in Amount of Illegal Dumping and Number of the Incidents (1993-2002)

According to a survey carried out to identify illegally dumped industrial waste remaining as of 1st of April 2003, there were 2,505 such cases with an accumulated amount of 10.96 million tons (see Figure 2.4.7).



Source: Ministry of the Environment, "Result of the Study on Remaining Illegally Dumped Industrial Waste FY 2003"



Taking into account the above conditions, the cost of restoring the status quo may possibly be gigantic if environmental pollution from illegally dumped industrial waste is found. Since the late 1990s, restoration efforts and measures to prevent improper dumping have been undertaken. In many cases when a problem surfaced, the parties have not had the financial capability to handle it, so governmental intervention has been required. In other words, the general public has had to assume the social cost burden.

## b. Social Cost for Restoring the Status Quo

There have been no estimates of the cost of damage to human health, or losses to agriculture or fishery directly caused by the improper treatment/disposal of waste including illegal dumping. However, such potential has been pointed out. Investigations at such sites have begun, and toxic substances have been found in some cases. In some cases, toxic substances themselves were left behind, and wastes were illegally dumped in someone else's property.

Usually, a person (or business) who caused the problem is the one who is supposed to restore the status quo. Nonetheless, it is often the case that finding the party responsible is difficult, and even if he/she is found, that person often does not have the financial ability to take the necessary measures. Employing public money to clean up such sites was in such cases unavoidable, and the 1997 amendment of Waste Management Law established a fund to do so. When prefectural governments executed the clean-up as administrative subrogation for the sites illegally dumped prior to June 1998, the national government bore one-third of the cost while the local government covered the remainder. The burden on local governments was severe, so that cleaning-up of large-scale illegal dumping sites was slow. In response to this situation, the Law concerning Special Measures for the Removal of Obstacles caused by Specified Industrial Waste -- effective for 10 years -- was enacted in June 2003, and carrying out restoration efforts became possible for illegally dumped sites that existed before 1997 through assistance from the central government (subsidies and tax revenues allocated to local

governments). The Teshima Island illegal dumping site in Kagawa Prefecture and other illegal dumping sites in Iwate and Aomori Prefectures were cases dealt with under this law.

Both these cases required highly expensive measures, as toxic substances were found in leachate from the dumped waste<sup>54</sup>. In the case of Teshima Island, the clean-up cost is estimated to be 50 billion JPY<sup>55</sup>. Estimated amount of the waste to be treated is 675,000 tons which makes the cost of clean-up 74,000 JPY per ton <sup>56</sup>. In the case of the illegal waste dumping at the border of Iwate and Aomori, the waste amount is estimated to 800,000 tons and total clean-up cost 65.5 billion JPY. Cost per ton is 80,000 JPY. Both cases show the enormous cost of restoring the status quo<sup>57</sup>.

In the Teshima case, the waste treater was said to be accepting the waste for about 2,000 JPY per ton. The market price of waste disposal in a non-leachate-controlled type landfill was, in the 1980s, 5,000 JPY/ton, and that in a leachate-controlled type landfill was 10,000 JPY/ton. In other words, because the waste discharger saved 3,000 to 8,000 JPY/ton, a gigantic additional cost became necessary. A similar point can be made about the lwate-Aomori case. Here the waste discharger saved about 5,000 JPY/ton of waste which should have gone to a leachate-controlled type landfill but was actually disposed of in non-leachate-controlled type landfill. This cost taxpayers a huge amount.

It is probable that there remain similar illegal dumping sites or landfill sites with poor management. It is highly possible that toxic substances may be detected if past or closed landfills are surveyed. In such cases, permanent containment may be required. If the consequences are limited, impermanent containment may be applied.

Though it is difficult to estimate the cost of restoration precisely, a rough calculation can be tried as follows:

The accumulated quantity of known illegally disposed waste (see Figure 2.4.7) by 2002 was approximately 10 million tons. For the sake of calculation, the quantity of improperly treated waste (latent disposal, for example, waste stream which should go to a leachate-controlled type landfill flowing to a non-leachate-controlled landfill) is estimated as 10 times more than the amount found annually (experts in the field sense that the difference between actual amount of waste illegally dumped and the amount found is in the order of several tens of times not 100 times). The quantity of illegal dumping found every year is approximately 400,000 tons<sup>58</sup>, thus actual number can be calculated as in the order of 4 million tons. This is about 1 % of the total industrial waste generated in a year. This figure also represents 2.7% of all industrial waste treated in the past (150 million tons). Assuming illegal dumping occurred in 1970 to 1997, however, 100 million tons of illegally dumped waste might have been accumulated.

<sup>&</sup>lt;sup>54</sup> TSUGARUISHI Akihiko, "Aomori Iwate Kenzakai Sangyo Haikibutsu Fuhoutoki Jiken", *Tyosei*, Environmental Dispute Coordination Committee, No. 26

The Ministry of the Environment disclosed information on wastes that had become subject of special measures to bring to the status quo. Both indicate majorities of the illegally treated waste were hazardous waste.

<sup>&</sup>lt;sup>55</sup> Shikoku Shinbun, September 19, 2003.

<sup>&</sup>lt;sup>56</sup> Although cost of remaining facilities may be less than mentioned here because of amortizing cost since they could be utilized after the 10 years project period, such aspect is not considered here.

<sup>&</sup>lt;sup>57</sup> Information disclosed upon application of the Law concerning Special Measures for the Removal of Obstacles caused by Specified Industrial Waste by the Ministry of the Environment.

<sup>&</sup>lt;sup>8</sup> Kankyo Eisei Shisetsu Seibi Kenkyukai, Nihon no Haikibutsu 2000

Ministry of the Environment, "Status of Illegal Dumping of Industrial Waste"





Figure 2.4.8 Estimated Cost for Restoring to Status Quo

If the future cost of restoration is assumed to be similar to the two cases mentioned above, it would be 70,000 JPY per ton while the total cost would be 7 trillion JPY<sup>59</sup>, as shown Figure 2.4.8. If the proper treatment/disposal cost was 10,000 JPY per ton of waste, then the whole cost would have been 1 trillion JPY. In other words, the small saving the improperly treating/disposing business entities have made eventually turned to 7 times more, or 7 trillion JPY, as social cost in later years. It can be estimated that the illegally dumped waste dischargers had paid 500 billion JPY for improper treatment/disposal of their waste, assuming they paid only half of what would have been required. If that was the case, then the total cost for proper treatment/disposal becomes 7.5 trillion JPY. This indicates that under ordinary circumstances, the cost would have been only 1 trillion JPY but restoring later cost an additional massive 6.5 trillion JPY.

The known quantity of illegally dumped waste is about 10 million tons already. That waste stream alone would cost 700 millions to 1 trillion JPY for restoring the status quo.

The above calculations are only a rough order estimate of the accumulated amount of improperly treated/disposed waste. Even so, the cost is likely to be in the order of 7 trillion JPY, that is 1.3 % of current Japan's GDP of 530 trillion JPY.

Although the cost is a rough estimate based on vague assumptions, it has become obvious that avoiding proper treatment and disposal measures will result in extremely large social costs in later years.

# 2.4.4 Waste Disposal Tax

The Mie Prefecture introduced a waste disposal tax in 2001. The rate was 1,000 JPY/ton, and other prefectures introduced similar tax schemes. As of 2004, the introduction of a waste disposal tax scheme was accepted by 8 prefectures and 1 major city with a typical rate of 1,000 JPY/ton.

Apparently the waste disposal tax was added on top of the treatment/disposal fee, but this did not increase the tipping fee paid by waste dischargers. It seems that disposal contractors

<sup>&</sup>lt;sup>59</sup> Value is the estimated volume of 100 billion tons of improperly treated/disposed waste stream from 1970 to 1997 multiplied by 70,000.

instead absorbed the additional amount through improved business efficiency because the additional amount of 1,000 JPY/T was only 5% of the appropriate disposal price<sup>60</sup>.

As the waste disposal tax was borne by disposal contractors, no effect on waste reduction can be expected on the part of waste dischargers. In fact, there is no report so far that suggests the waste disposal amount was reduced due to introduction of the waste disposal tax.

# 2.4.5 Implications for Developing Countries

# a. Establishment of Regulation System

Establishing a regulation system is important since regulatory measures are playing a primary role, especially for hazardous waste management. Japanese cases were already described in the former sections, and a hazardous waste working group of ISWA (International Solid Waste Association)<sup>61</sup> stated the following as system components of regulation.

Table 2.4.9 Components of a Regulatory System for Hazardous Waste Management

	Definition of "Waste" and "Hazardous Waste." The classification system that accepts ambiguity.				
	Waste dischargers' responsibilities include;				
	i) Register as a discharger, and provide periodic information on source, class, amoun and management method of wastes.				
	ii) Provide steps to minimize waste generation.				
	iii) Management obligation to be legally responsible for wastes until they reach a proper destination.				
	Permission or registration of persons who conduct collection, transfer, storage treatment, and disposal of wastes.				
	Transportation management consists of;				
	i) Manifest or transport ticket system to ensure wastes arrive at a designated destination.				
	ii) Standards for design and configuration of vehicles. Specification of vehicles.				
	iii) Container specification. Container to hold wastes during transportation.				
	iv) Labeling for the waste containers and vehicles				
	v) Contingency plan for emergency, leakage and accidents.				
	Export and import management for the implementation of the Basel Convention Recycling is to be promoted in such ways not to provide loopholes for ones who try to export and discard their waste in other countries.				
	Permission for waste storage, recycling, treatment or disposal facilities in order to make sure they are designed and managed in an environmentally safe manner.				
	Requirement for local governments or the central government to establish a hazardous waste management plan. They are particularly required to ensure the current and future availability of appropriate treatment facilities.				
	Management program for past or dismantled hazardous wastes sites.				
Som	e: ISWA International Perspectives in Hazardous Waste Management: 1999 Edition, 1999				

<sup>&</sup>lt;sup>60</sup> Ministry of the Environment, "Material for the 9<sup>th</sup> Meeting to Discuss Industrial Waste Disposal Policy and Taxation", 2004

<sup>&</sup>lt;sup>61</sup> ISWA, International Perspectives in Hazardous Waste Management: 1999 Edition, 1999

# b. Difficulties in Achieving Appropriate Treatment/Disposal of Industrial Waste in a Free Market

Easy entry to the industrial waste management market increases the size of the industry and makes it hard to monitor the flow of industrial waste that is discharged.

It is necessary to clarify conditions for exiting the market. Without this, waste treaters who improperly treat/dispose accepted waste will appear and stay in the market. Monitoring and exiting conditions must be spelled out.

In developing countries, a disorganized waste treatment/disposal industry will emerge if entry into the market is too easy. The result will likely be numerous cases of improper treatment/disposal. It is suggested that the number of businesses entering into the waste management market should be restricted, and a system of monitoring their activities be established. This policy is followed by European nations, especially for hazardous waste management industry.

# c. Need for Strict Application of Responsibility of Waste Discharging Companies

The amendments of Waste Management Law in 1997 and 2000 strengthened the responsibility of waste discharging firms, controls of waste treatment/disposal companies, and penalties, which made waste dischargers to recognize the cost of non-compliance. As a result, the dischargers started to seek reliable/creditable waste treatment/disposal companies. This resulted in forming a healthy market in the waste management area. It has become clear that when proper market conditions are established, treatment fees achieve a correct balance between demand and supply. It is particularly true that increasing prices reflect the scarcity of landfill sites. This creates incentives to recycle and reduce the flow of industrial waste.

In order to for the market mechanism to function properly in this area, an efficient legal system must be in place to ensure the liability of waste dischargers.

# d. Indispensability of a Monitoring System

In order to secure the proper treatment/disposal of industrial waste in local areas, it is indispensable to monitor the waste dischargers and treaters by a local/regional office of the appropriate authority. However, it is almost impossible to completely monitor and control the flow of industrial waste since the waste moves every day. The flow is hard to track even if the manifest system is established. Therefore, it must depend to some extent on motivation to compliance by waste dischargers, but equally necessary to make clear to waste dischargers that their activities are being monitored.

In view of the difficulty of monitoring, it is essential to reduce the burden of responsible authorities as much as possible by simplifying the flow of the industrial waste stream as much as possible.

# e. High Social Costs due to Improper Treatment/Disposal of Waste

In incomplete industrial waste management systems, i.e. those without clear definition of dischargers' liability and without strict enforcement of the law, illegal dumping will be inevitable. This will leave a huge negative heritage for later generations. It can be clearly seen in the cases of the Teshima Island and the Iwate-Aomori illegal waste dumping incidents in Japan. The restoration effort in those cases has cost more than 10 times the cost of illegally disposing of the waste at the time. It means that if one tries to save on costs by improper treatment/disposal methods, then a much greater cost will be incurred in the future.

In addition, it is practically impossible to seek out the illegally discharging parties and demand payment for clean-up costs. In the end, local and/or national governments, and therefore taxpayers, have to assume the burden.

# 2.5 Energy Saving Measures

This section analyzes how industries introduced energy shift and energy saving measures to absorb the impact of increased energy costs. Trends in investment in energy saving facilities will be discussed with reference to the expanded financial support program. Further, reduction of environmental loads resulting from energy saving will be discussed based on the estimated effect of energy saving measures. Energy related taxes in Japan do not aim at pollution control, but the impact of increased energy taxes on industries will also be discussed.

# 2.5.1 Impact of Energy Cost and Energy Related Taxation Scheme in Japan

# a. Comparison of Energy Prices between Japan and Other Countries

Prices of heavy oil for industry have always, except in 1994, been higher in Japan in comparison with those in other G7 countries (the seven developed countries excluding Japan). For example, the Japanese heavy oil price is about 1.0~1.5 times higher than the G7 average (see Figure 2.5.1 and Figure 2.5.2).



Source: IEA, Energy Taxes and Prices







Figure 2.5.2 Scale Factor of Heavy Oil Prices for Industry in Japan to the Average of Other G7 Countries (1981-1996)

Prices of electric power for industry have also been higher in Japan in comparison with the other G7 countries. Although the ratio of electric power prices in Japan to the average of the other G7 countries is becoming smaller, it has been more than 1.5 (see Figure 2.5.3 and Figure 2.5.4)



Source: IEA, Energy Taxes and Prices

Figure 2.5.3 Comparison of Power Prices for Industry in Japan to the Other G7 Countries (in PPP, 1981-1996)



Source: IEA, Energy Taxes and Prices



# b. Energy Tax System in Japan

Energy prices are defined by prices of energy sources, energy production costs, energy taxes, and the like. Energy taxes in Japan are summarized as in Figure 2.5.5.



(\*) Sales tax is imposed on sales price of light oil and jet fuel oil, not include aviation fuel tax nor light oil delivery tax. On the other hand, sales tax is imposed on sum total of sales price, petroleum tax or gasoline tax and local road tax of LP gas and gasoline.

Source: Petroleum Association of Japan, Sekiyu Zeisei Binran 2003, and others.

Figure 2.5.5 Energy Tax System In Japan (as of January 2003)

The following section discusses changes in the Petroleum Tax and the Power Resources Development Promotion Tax, which have a large impact on the industry.

The Petroleum Tax introduced in June of 1978 aimed at the development of oil related industries, securing oil reserves for government and private sectors, strengthening the industrial system, promotion of alternative energy development and energy saving. A tax was added to the petroleum price from 6/1978 to 8/1988. The taxation base was 3.5% of the duty and the value in terms of CIF, and it increased to 4.7% in 9/1984. From 8/1988 the taxation base was changed to petroleum volume (2,040 JPY/kl). The petroleum tax as of 1978 was estimated based on the CIF value and the duty (for refining) of crude oil as follows:

Year	Petroleum Tax (JPY/kl)	Tax Rate	CIF Price(JPY/kl)	Tariff (JPY/kl)
1978	639	3.5%	17,627	640
1979	1,196	3.5%	33,522	640
1980	1,689	3.5%	47,629	640
1981	1,859	3.5%	52,466	640
1982	1,896	3.5%	53,533	640
1983	1,567	3.5%	44,141	640
1984	2,125	4.7%	44,575	640
1985	1,832	4.7%	38,340	640
1986	687	4.7%	13,970	640
1987	774	4.7%	15,838	640
	(1988.8-) 2,040			(1988.8-) 530
				(1989.4-) 350
				(1992.4-) 315
				(1997.4-) 215
				(2002.4-) 170

Table 2.5.1 Transition of Petroleum Tax on Crude Oil (Estimate)

Note: Petroleum duty without exploited crude oil, during April-May 1978 was 750 JPY/kl and exploited crude oil duty during June 1978 - March 1979 was 530 JPY/kl.

Source: Institute of Energy Economics, Japan, 2001 Summary of Energy and Economic Statistics and Petroleum Association of Japan, Sekiyu Zeisei Binran 2003

Since the petroleum tax was an ad valorem tax, the amount of petroleum tax was strictly proportional to the crude oil price. Thus, it increased dramatically during the oil crises. In 1988, the petroleum tax became a per unit tax (2,040 JPY/kl), which was equal to 16.4% of the sum of crude oil CIF value (11,910 JPY/kl) and import duty (530 JPY/kl).

The petroleum tax was also imposed on imported LPG, domestic natural gas, and imported LNG from 9/1984. It was an ad valorem tax (tax rate was 1.2% of the price) upon its introduction but changed to a per unit tax in 8/1988. The tax rate was 670JPY/t for imported LPG and 720JPY/t for domestic natural gas and imported LNG.

Aiming at promotion of power plant construction, which was not easily accepted by local residents living near construction sites, the Power Resources Development Promotion Tax was established in 1974 when demand for power was increasing. The collected tax was partly used for constructing welfare facilities as compensation for local residents, as well as for public relations activities. The tax rate has been changed from the introduction in 1974 as in Table 2.5.2.

Year of Establishment	Tax Rate	Purpose of the Ordinance/Reason for Tax Rate Change
1974	85JPY/1,000kWh	Promotion of nuclear, thermal and hydro power plant
1980	300JPY/1,000kWh	Expand purpose of taxation and utilize the revenue to promote oil alternative energy power generation
1983	445JPY/1,000kWh	Decrease of surplus by creation of new subsidy system, anticipated increase in subsidy with establishment of nuclear plant, revenue shortage by sluggish growth of electricity demand

Table 2.5.2 Transition of Power Resource Development Promotion Tax Charge

Source: Fukushima Prefecture Energy Policy Review Committee, "Dengen Sanpo Kofukin Seido ni tsuite" 19th meeting doc.2

The petroleum tax had been collected for the purpose of ensuring a stable supply of petroleum, promotion of petroleum substitution, and energy saving measures, and the Power Resource Development Promotion Tax for the purpose of promotion of locating power plants. The energy tax system in Japan was reviewed from the viewpoint of reducing  $CO_2$  generated from energy consumption in 2002. As a result, the petroleum tax has come to be a financial resource for energy-related measures contributing to  $CO_2$  reduction. In addition, coal has become a new object of taxation, and the existing taxation rate has been changed for the sake of equitable burden sharing of energy consumers (see Table 2.5.3)<sup>62</sup>. Moreover, the name has been changed from the Petroleum Tax to the Petroleum and Coal Tax in accordance with the taxation on coal. The Power Development Promotion Tax has been lowered because measures on power generation from new energy sources have come to be funded by the Petroleum and Coal Tax.

	Existing	2003.10	2005.4	2007.4
Imported LPG (JPY/t)	670	800	940	1,080
Domestic Natural Gas & Imported	720	840	960	1,080
LNG (JPY/t)				
Coal (JPY/t)	-	230	460	700
Promotion of Power Resources	445	425	400	375
Development Tax (JPY/1,000kWh)				

Table 2.5.3 Review of Energy-related Taxes

Source: Ministry of Economy, Trade and Industry, "Review of Energy Measures", 200363

## c. Ratio of Energy Tax to Energy Price

While oil refining and power generation are subject to the business tax, the property tax, and the like, other than the energy taxes, this section reviews the ratio of the energy tax to the energy price for A heavy oil<sup>64</sup>, C heavy oil<sup>65</sup>, and electricity which are main energy sources for the industry.

The petroleum tax had been an ad valorem tax from April 1978 when it was introduced in August 1988; the ratio of the tax to the heavy fuel price was constant. After the petroleum tax has become a per unit tax, the ratio of the petroleum tax to the price of C heavy oil has been higher than that of A heavy oil (see Figure 2.5.6 and Figure 2.5.7).

http://www.env.go.jp/policy/info/energy/04.pdf

<sup>&</sup>lt;sup>62</sup> Ministry of Economy, Trade and Industry / Ministry of the Environment, "Review of Energy Policy and Fundamental Enhancement of Environmental Considerations in the Energy Policy",

<sup>&</sup>lt;sup>63</sup> http://www.meti.go.jp/report/downloadfiles/g30313b085j.pdf

<sup>&</sup>lt;sup>64</sup> "A" Heavy Oil is refined mineral oil with low kinetic viscosity (equal to or slower than 20mm<sup>2</sup>/s) and sulfur content (equal to or lower than 2.0 mass %).

 $<sup>^{65}</sup>$  "C" Heavy Oil is refined mineral oil with high kinetic viscosity (equal to or faster than 50mm<sup>2</sup>/s) and sulfur content (equal to or lower than 3.5 mass %).



Note: To make the calculation easier, it was set that petroleum tax imposed on 1kl of crude oil made the transition to 1kl of heavy oil was applied.

Source: Institute of Energy Economics, Japan, 2001 Summary of Energy and Economic Statistics and Figure 2.5.1.





Note: To make the calculation easier, it was set that petroleum tax imposed on 1kl of crude oil made the transition to 1kl of heavy oil was applied.

Source: Institute of Energy Economics, Japan, 2001 Summary of Energy and Economic Statistics and Figure 2.5.1.

# Figure 2.5.7 Transition of Ratios of Petroleum Tax to Wholesale Price of C Heavy Oil (1965-1997)

In 1978, because the crude oil price was cut by about 20 % comparing to the previous year due to strong Japanese JPY value, heavy fuel prices stayed lower than those in the previous year even though the petroleum tax was introduced. The crude oil price cut seems to have completely absorbed impacts of the introduction of the petroleum tax on the heavy fuel prices. From 1979 to 1980 when the crude oil price rose dramatically due to the second oil crisis, the petroleum tax charge increased because of the rise in heavy fuel prices accompanied the weak Japanese JPY value.

As for electricity, the Power Resources Development Promotion Tax charge has been increased in 1980 and 1983 since it was introduced in 1974, and the ratio of the tax to the electricity price has been increased from 0.7 to 3.3 %, which is lower than that of heavy fuels (see Figure 2.5.8).

In addition, increases in electricity prices in 1974 when the tax was introduced and 1980 when the tax charge was increased were mainly attributed more to factors other than the tax (see Table 2.5.4). The impacts of the introduction and the increase of the tax seem relatively small. On the other hand, in 1983 when the tax charge was increased, the increment of the tax charge was directly reflected in the electricity price since changes of the other factors were small.



Source: Institute of Energy Economics, Japan, 2001 Summary of Energy and Economic Statistics

## Figure 2.5.8 Transition of Ratio of Power Resources Development Promotion Tax to Electricity Price for Large Users (1965-1997)

Table 2.5.4 Breakdown of Electricity Price Change Compared to the Previous Year

	Tax Added	Price Increase Excluding Tax
1974	+85 JPY	+4,045 JPY
1980	+215 JPY	+7,405 JPY
1983	+145 JPY	-35 JPY

Source: Based on Table 2.5.2 and Institute of Energy Economics, Japan, 2001 Summary of Energy and Economic Statistics

The petroleum tax and Power Resources Development Promotion Tax were not aimed at reduction of energy consumption on the part of industries, but the resulting increases in energy price inevitably increased the benefit of energy saving programs; it shortened the payout time of investments in energy saving facilities.

# 2.5.2 Changes in Energy Price

The steep rise in crude oil prices during the first and the second oil crisis led that of heavy fuel oil, electricity, and gas prices. The average nominal price<sup>66</sup> of energy used in the industry sector was 1.9 JPY/1,000kcal in 1973; it increased by 5.6 times to 10.5 JPY/1,000kl in 1982. The average real price of energy (at 1973 price) increased by 3.4 times to 6.5 JPY/1,000kl in 1982. The increase in energy costs was very large compared to those in labor costs (nominal unit cost per hour) (2.2 times), raw material costs (excluding energy) (2.3 times), and capital costs (1.3 times) during the same time period (1973 to 1982)<sup>67</sup>.

As for the transition of energy prices per calorie, with the first oil crisis as a turning point, heavy fuel oils (A and C) became cheaper than coal. After the second oil crisis, the price

<sup>&</sup>lt;sup>66</sup> The average of energy prices per calorie weighted by corresponding energy consumption.

<sup>&</sup>lt;sup>67</sup> KIHUNE Hisao, "Dokawaru Sangyo Energy Shohi", Energy Keizai, Vol.11 No.10, 1985, p.77

difference between heavy fuel oils and coal expanded. After the Plaza Accord of 1995, all energy prices went down, but the order of the energy prices per calorie have been the same; electricity as the highest, followed by utility gas, A heavy fuel oil, C heavy fuel oil, and coal as the lowest (see Figure 2.5.9).



Note: General coal was imported price and heavy oil was sales price. Calculated as 1kWh=860kcal. Source: Institute of Energy Economics, Japan, 2001 Summary of Energy and Economic Statistics

# Figure 2.5.9 Transition of Energy Prices (per Calorie, 1965-1999)

Changes in nominal energy price per calorie during 1973 and 1982 are 1.7 times<sup>68</sup> for general coal, 5.4 times for A heavy fuel, 6.7 times for C heavy fuel, 4.1 times for electricity and 2.9 times for utility gas, which shows that the increase in C heavy fuel oil price was the largest.

# 2.5.3 Changes in Energy Costs and Energy Consumption

# a. Transition of Energy Consumption Patterns

The main energy source for the manufacturing sector had been shifted from coal to oil by 1965. Oil consumption was curbed by the oil crises in 1973 and 1979, implementation of the administrative guidance on reduction of oil consumption (1973 to 74), and enactment of the Law on Rationalization of Energy Consumption (1979 and thereafter). However, oil consumption by the manufacturing sector has been increasing due to the sharp fall of oil price in 1986.

Data on energy consumption by industry shows that coal consumption has been increasing in the ceramic and cement, pulp and paper, steel industries. Especially coal consumption by the ceramic and cement industry has been increasing since 1980, which is after the second oil crisis, accounting for about 50% of the total energy consumption after 1981 (see Figure 2.5.11). Coal consumption by the pulp and paper industry had shifted to increase since 1979, accounting for about 10% of the total energy consumption after 1988 (see Figure 2.5.12).

<sup>&</sup>lt;sup>68</sup> Since no data for general coal price in 1973 is available, the price in 1970 is used for the calculation.



Source: Agency for Natural Resources and Energy, *Comprehensive Energy Statistics* Figure 2.5.10 Transition of Energy Consumption by the Manufacturing Sector by Fuel Type (1960-2000)



Source: Agency for Natural Resources and Energy, *Comprehensive Energy Statistics* Figure 2.5.11 Transition of Energy Consumption by Ceramic and Cement Industry by Fuel Type (1960-2000)



Source: Agency for Natural Resources and Energy, *Comprehensive Energy Statistics* Figure 2.5.12 Transition of Energy Consumption by Pulp and Paper Industry by Fuel Type (1960-2000)

# b. Impacts of Changes in Energy Costs on Energy Consumption Patterns

The ceramic and cement, pulp and paper, and steel industries that have increased coal consumption have a higher ratio of fuel costs in production costs compared to other industries (see Figure 2.5.13). They shifted their energy source from heavy fuel oil to coal as a tool to cut energy costs because the energy price per calorie of heavy fuel oils (A and C) exceeded that of coal after the first oil crisis, and because the difference in price per calorie between heavy fuel oils and coal expanded after the second oil crisis (see Figure 2.5.9).



Note: Production cost = total amount of cash earnings + raw material amount used + fuel amount used + purchased electricity amount used + consignment production cost. Source: Ministry of International Trade and industry, *Industrial Statistics Table - Industry* 

## Figure 2.5.13 Ratio of Energy Costs to Production Costs (1960-2000)

The cement industry had shifted fuel for kilns from domestic coal to heavy fuel oils by the late 1960's; it shifted back from heavy fuel oils to coal in order to adjust to the continued increases in heavy oil prices by around 1981. Energy costs (fuel and electricity costs) comprise about 1/3 of overall cement costs. Since the price per calorie of coal is close to half that of heavy oil the cement industry rapidly shifted kiln fuel from heavy oil to coal to achieve cost reduction<sup>69</sup>.

The pulp and paper industry increased new construction and expansion of coal boilers during the late 1980s because coal attained price advantages compared to heavy fuel and because stable supply of energy in the future was necessary. Breakdown of the boilers newly constructed and expanded during the five years from 1985 are about 40% for coal, 30% for black liquor, 25% for heavy oil and 5% for other<sup>70</sup>.

The steel industry shifted blast furnace injection fuel from heavy fuel to coke after the second oil crisis. Heavy fuel used for blast furnace accounted for 34% of the total oil consumption by the industry in 1973, but it became zero (all coke operation) in 1982<sup>71</sup>. At that time, it was estimated that shifting blast furnace injection fuel from heavy fuel to coke was advantageous if generation of by-products such as coke gas was considered when heavy fuel price per calorie was equal to or higher than 1.1 times of coal price per calorie and that so

<sup>&</sup>lt;sup>69</sup> YAMAGUCHI Takao, "Kaku Gyokai no Sho Energy Tenbo – Cement Kogyo", *Sho Energy*, Vol.35 No.1, 1983, pp.12-19

<sup>&</sup>lt;sup>70</sup> Tsusan Shiro Chosakai, *Pandect of Energy Saving 1994*, p92

<sup>&</sup>lt;sup>71</sup> INOUE Kiyohiko, "Kaku Gyokai no Sho Energy Tenbo – Tekkogyo", *Sho Energy*, Vol.35 No.1, 1983, pp.6-11

was even if generation of by-products was not considered when the former was equal to or higher than 1.9 times of the latter<sup>72</sup>. The ratio of C heavy fuel price to imported coal price on a per calorie basis was between 1.1 and 1.3 before the second oil crisis, but it became 2.0 in 1979 and increased to nearly 3.0 in 1980<sup>65</sup>; the expansion of the price difference between heavy fuel oil and coal is considered to accelerate the shift to the all coke operation. The shift deteriorated the fuel ratio (fuel consumption per steel production) and stability of the operation because it was difficult to control heat of a large size blast furnace by coke combustion. In addition to these factors, reduction of the coke ratio (coke consumption per unit of steel production) became necessary to extend life span of the coke furnace, which resulted in adoption of powdered coal injection operation (coal is powdered and injected to a blast furnace without coke process). These changes made the steel industry increase coal consumption from the late 1980s.

# 2.5.4 Changes in Energy Costs and Energy Consumption Rate

### a. Transition of the Energy Consumption Rate in the Manufacturing Sector

Energy consumption rate per added value (weighted index of industrial production (IIP)<sup>73</sup> in industries) started decreasing in all industrial sectors after the first oil crisis in 1973. However, it should be noted that the decreasing trend became milder after 1986 when the imported crude oil price dropped substantially, and also that the energy consumption rate increased as much as 10% after 1990 for such industries as textiles, cement, food/tobacco, and steel (see Figure 2.5.14).



Source: Institute of Energy Economics, Japan, 2001 Summary of Energy and Economic Statistics

Figure 2.5.14 Changes in Energy Consumption Rate per IIP (1965-1998)

### b. Impact of Increased Energy Costs on Energy Consumption Rate

Energy consumption is greatly affected by increased energy cost. The pulp and paper industry, in which energy is a large proportion of total production cost, mainly uses C-heavy oil. The energy consumption rate per unit of production kept decreasing from the years prior to the oil crisis until the Plaza Accord, during which the C-heavy oil price increased. This means that energy saving measures were generally applied in this industry (see Figure 2.5.15, Figure 2.5.16). After the Plaza Accord in 1985, prices of imported oil and petroleum associated products decreased due to the stronger JPY. However, the energy consumption

<sup>&</sup>lt;sup>72</sup> UEZONO Masatake, "Sekiyu Kiki wo Keikitoshita Nihon Tekkogyo no Sho Energy Taisaku", *Keiei Kenkyu*, Vol. 48 No. 1, 1997, pp.135-152

<sup>&</sup>lt;sup>73</sup> IPP is an average of production volume of items representing each industry that is weighted according to size of value added. The sum of the weights is set as 10,000 for the whole industry.
rate did not go back to the previous high level, which prevailed prior to the oil crisis. This is because the application of energy saving measures was already generalized in Japan.



Source: Institute of Energy Economics, Japan, 2001 Summary of Energy and Economic Statistics





Source: Institute of Energy Economics, Japan, 2001 Summary of Energy and Economic Statistics

Figure 2.5.16 Relationship between Wholesale Heavy Fuel Oil Price and Energy Consumption Rate per IIP in Pulp and Paper Industry

According to a study to estimate the impact of energy cost on energy demand, the price elasticity of imported crude oil is higher in the manufacturing sector than in households; the price elasticity in non-ferrous metal and chemical industries is higher than that in other industries though the period for which the estimate was made varies by industry sector (see Table 2.5.5). As shown in Figure 2.5.14, energy consumption rates in non-ferrous metal and chemical industries have sharply decreased since 1973; these industries improved their energy efficiency by sensitively responding to the change in energy prices. Heavy fuel oil price elasticity is higher in steel, ceramic and cement industries that have shifted their main energy source to coal.

	Price Elasticity of Imported Oil		Price Elasticity of	
	Real Elasticity of Real Imported Oil	Estimated Terms	Heavy Oil (Estimated Terms 1965-81)	
Whole Manufacturing Industry	-0.21	1975-92	-0.546	
Foods	-0.15	1973-92	-0.117	
Pulp/Paper	-0.20	1975-92	-0.443	
Chemicals	-0.33	1975-92	-0.396	
Ceramics/Stones	-0.18	1975-92	-0.752	
Metals	-0.15	1975-92	-0.936	
Non-ferrous Metals	-0.38	1975-92	-0.422	
Metals, Machineries	-0.06	1971-92	-0.347	
Other Industries	-0.11	1976-92	-	
Private Division (House Hold)	-0.04	1973-92	-0.538	

### Table 2.5.5 Energy Price Elasticity

Source: Regarding the Price Elasticity of Imported Oil, based on AMANO Akihiro, "Enegy Kakaku no Henka to Enery Shuyakudo nitsuite" *Nihon Keizai Kenkyu*, No. 32, 1996, p.186. Regarding the Price Elasticity of Heavy Oil, based on OKAYA Yukio, "Sekiyu Seihin Kakaku Henka no Juyokozo ni ataeru Kando Bunseki", *Energy Keizai*, Vol.9 No12, 1983, p.7.

### 2.5.5 Energy Saving Measures for Manufacturing Industries

Energy saving efforts were made even before oil crises in Japan in the interest of business efficiency. After the oil crises, energy saving measures were vigorously taken up by industries. This section summarizes transition of energy saving measures by the steel and pulp and paper industries whose investments in energy saving were quite large (see Figure 2.5.17).

### a. Transition of Energy Saving Measures in Pulp and Paper Industry

In the early 1970s, every pulp and paper mill was struggling to improve heat management because right or wrong heat management severely affected business profits; the ratio of steam generation cost to product cost ranged from 5 to 15 %, which was largest next to the raw wood cost and labor  $\cos^{74}$ . Since the two oil crises, the pulp and paper industry has been tackling energy saving such as introduction of energy saving facilities, improvement of operation, and utilization of used paper<sup>75</sup>.

Characteristic energy saving measures in the pulp and paper industry are utilization of black liquor (pulping waste liquor) as an energy source, utilization of waste paper, and introduction of a cogeneration system. In the kraft paper production process, concentration of black liquor by an evaporator and combustion of organics such as lignin in the black liquor in the recovery boiler can generate about 1/3 of necessary energy at an integrated pulp and paper mill. In Japan, limited availability of coniferous trees as raw materials for pulp in 1950s promoted development of kraft pulp mills that could utilize broadleaf trees<sup>76</sup>. At the beginning, the main purpose of a recovery boiler is to recover chemicals used and purify wastewater by combusting organics; therefore, heat efficiency of the boiler was improved<sup>77</sup>.

<sup>&</sup>lt;sup>74</sup> ISHIGURO Kyusaburo, "Kami Pulp Kogyo niokeru Netsukanri no Suii to Vision", *Netsukanri to Kogai*, 1971.11, pp.42-46

<sup>&</sup>lt;sup>75</sup> HORI Sadao, "Kaku Sangyoukai no Sho Energy Tenbo", *Sho Energy*, Vol.50 No.1, 1998, pp.35-39

<sup>&</sup>lt;sup>76</sup> Japan Environment Corporation, "Kogai Boshi Gijutsu Manual – Kami Pulp Sangyo", 1998

<sup>&</sup>lt;sup>77</sup> EGUSA Shigeo, "Kaku Gyokai no Energy Tenbo – Kami Pulp Kogyo", Sho Energy, Vol. 35 No.1, 1983, pp.20-27



Note 1: Energy saving equipment means an equipment whose energy efficiency is highly improved compare to existing equipment, a waste energy salvage equipment, an equipment that aims to efficiency improvement of main body, and an equipment that improve production process in order to save energy.

Note 2: Facility investment amount was actual result of companies that replied to the survey which had energy saving investment plan and numbers were different every year but 1983's was estimated amount.

Source: Ministry of International Trade and Industry, Capital Investment Plan of Major Industries, each year





Source: Ministry of International Trade and Industry, Annual Statistics on Pulp and Paper Industry, each year

# Figure 2.5.18 Used Volume of Raw Materials for Paper and Ratio of Waste Paper to the Raw Materials (1960-2000)

Waste paper had been utilized as raw material for paper production before the oil crisis; it has already gone through the pulping process, which means it requires less energy for processing. Since the oil crisis, utilization of waste paper has been recognized as one of the important energy saving measures<sup>78</sup>. The ratio of waste paper as pulp to raw materials was 28% in 1960, 33% in 1970, and 41% in 1980, and has been on the rise ever since.

<sup>&</sup>lt;sup>78</sup> Since energy consumption rate for waste paper pulp is considerably law (paper board: electricity consumption rate 230kWh, steam consumption rate 27litter, foreign paper: 350kWh, 49litter) compared to that for craft pulp

In the early 1980s, there were many opportunities for energy saving; pulp and paper mills could achieve remarkable energy saving with small-scale capital improvements such as prevention of heat loss, recovery of waste heat, improvement of fans and pumps, review of operation methods/processes, and expansion of waste paper utilization, which did not cost too much. On the other hand, in the late 1980s, almost all the energy saving measures with low cost had already been implemented, which means that energy saving measures by themselves were not sufficient; pulp and paper mills could only achieve additional energy saving with large capital investment at the timing of facility renewal with expansion of production capacity, labor saving, and/or energy saving<sup>79</sup> (see Table 2.5.6).

Period	Energy Saving Technologies	Organizations	Change of Energy Unit
1970s	-Change Batch type of Pulping to continuous system (Mainly in proliferation) -Improvement of dehydration efficiency on papermaking process	Establish Energy Saving Promotion Committee in each factory, mobilized operators and engineers, and examine concrete plans and manage them elaborately	After the 1 <sup>st</sup> oil crises, unit consumption energy increased by introduction of pollution control facilities and increase of pulp production by newspaper weight saving
Early 1980s	Review and check details of operation methods, excess capacity of facility make small facility changes lead to energy saving effect	Establish small group to identify seeds for energy saving on the production process and promote improvement	Stellar effect of energy savings
Late 1980s	Achieve energy conservation when modernizing the factory for facility renewal and addition	(Heavy oil price became sluggish and importance of energy savings faded	Unit came to progress slightly without any big effect (Most of practicable energy saving measures had been done and no other measures can be practiced without deficit)

Table 2.5.6 Transition of Energy Saving Measures in Pulp and Paper Industry

Source: Japan Paper Association "Gyokai ni okeru Sho Energy no Genjo to Mitoshi", *Netsukanri to Kogai*, Vol.29
No.1, 1977, pp.46-50 HORI Sadao, "Kaku Sangyokai no Sho Energy Tenbo", *Sho Enery*, Vol.50 No.1, 1998, pp.35-39

Capital investment in energy saving in the pulp and paper industry was 6 billion JPY in 1979 and increased to 48.5 billion JPY in 1985 (see Figure 2.5.19). After 1985, capital investment in energy saving shrank in accordance with the decline in energy prices but marked the largest-ever amount of 58.9 billion JPY in 1990.

Although the data source for Figure 2.5.20 is different from that in Figure 2.5.19, it shows that, capital investment with energy saving as secondary objective was mainstream in 1979 in the pulp and paper industry, but gradually shifted to a primary objective into early 1980s<sup>80</sup>. Examples of capital investment with energy saving as primary objective include enhancement of black liquor recovery evaporators, conversion of cooking pots from batch type to continuous type, and recovery of waste heat. Examples of that as secondary objective are

processed in a continuous pot (800kWh, 283 litter), enhancement of waste paper utilization is a cornerstone of energy saving (Tsusan Shiro Chosakai, *Pandect of Energy Saving 1982*, pp.369-370)

<sup>&</sup>lt;sup>79</sup> HORI Sadao, "Kaku Sangyokai no Sho Energy Tenbo", *Sho Energy*, Vol.50 No.1, 1998, pp.38

<sup>&</sup>lt;sup>80</sup> Decision-making about capital investment in energy saving as primary or secondary objective depends on each company's recognition; therefore, capital investment in the same facility may be categorized as primary or secondary depending on the company (e.g. a continuous cooking pot in the pulp and paper industry).

construction and expansion of pulping facilities, renovation of boilers, and establishment of electricity controllers.



Note: The number for 1983 is estimate. Source: Ministry of International Trade and Industry, *Capital Investment Plan of Major Industries*, each year





Source: Japan Development Bank, Chosa, No.40 in 1980, No.47 in 1981, No.64 in 1983, and No.75 in 1984.



Cumulative capital investment in energy saving during the three years before 1980 (1976 to 1979) was 5.3 billion JPY, which resulted in saving 420,000 kl of petroleum according to one report<sup>81</sup>. The cost saving from the fuel saving would be 9.9 billion JPY if calculated with the average retail price of C heavy fuel oil during the three years (23,666 JPY/kl), which means that the capital investment could be paid back in a short time. On the other hand, cumulative capital investment in energy saving during the three years after 1996 (1997 to 1999) is 97 billion JPY, which resulted in 570,000 kl/year<sup>82</sup>. The cost saving from the fuel saving would be 11.2 billion JPY if calculated with the average retail price of C heavy fuel

<sup>&</sup>lt;sup>81</sup> EGUSA Shigeo, "Kaku Sangyokai no Sho Energy Tenbo", Sho Energy, Vol.35 No.1, 1983, pp.20-26

<sup>&</sup>lt;sup>82</sup> Japan Paper Association, "Sixth (2003) Kankyou ni kansuru Jishu Kodo Keikaku (Ondanka) follow-up Tyousa Kekka", http://www.jpa.gr.jp/rengokai/shiryo/data/follow\_06.pdf

oil during the three years (19,686 JPY/kl). The Japan Paper Association, the industry association for the pulp and paper industry, developed a voluntary action plan regarding environment in January 1997 with a target of a 10% reduction in the fossil fuel energy consumption rate (baseline year 1990) by 2010. Although effectiveness of capital investment in energy saving decreases as energy saving is promoted, which means the payback period of such investment becomes longer, the industry has continued to make efforts to prevent global warming.

#### b. Transition of Energy Saving Measures in Iron and Steel Industry

In the iron and steel industry, fuel and electricity consumption rates by individual production processes were used as indicators of the evaluation standard for operation performance and cost reduction before the first oil crisis; coke oven gas and blast furnace gas were utilized as fuel. The iron and steel industry has been promoting energy saving by improvement of plant operation after the first oil crisis and innovation of production facilities and introduction of energy saving facilities after the second oil crisis.

Characteristics of energy saving measures in the iron and steel industry can are the reduction of energy consumption by drastic shortening of production processes and improvement of yield ratios such as continuous casting and continuous annealing, and utilization of heat, electricity, and fuel by recovery of waste energy, including coke dry quenching facilities and blast furnace top pressure recovery turbine. Continuous casting is a method to manufacture slabs directly from molten steel; its installation began in the late 1960s in order to increase capacity and speed of iron and steel production systems and enjoy benefits, for instance cut-down of manufacturing lead-time and improvement of product quality. With the two oil crises in the 1970s as a turning point, continuous casting was introduced in each steel plant one after another in order to enjoy benefits of yield ratio improvement and energy saving. In 1985, the ratio of steel plants having continuous casting exceeded 90%<sup>83</sup> (See Figure 2.5.21).



Source: IE Committee of Japan Iron and Steel Federation, "IE ni yoru Jissenteki Mondai Kaiketsu no Susumekata" and Tsusan Shiryo Chosakai, *Pandect of Energy Saving 1994* 

### Figure 2.5.21 Changes of Ratio of Steel Plants with Continuous Casting (1970-2000)

Coke dry quenching (CDQ) is a method to cool down coke by inactive gas and recover waste heat as steam. It was developed because water quenching resulted in degradation of coke quality, and causing air and water pollution. CDQ was first introduced to Japan in 1976 and then to each steel plant after the second oil crisis. The ratio of steel plants with CDQ was 70% in 1987 and increased to 85% in 1996, which is the highest in the world. Compared to

<sup>&</sup>lt;sup>83</sup> UEZONO Masatake, "Sekiyu Kiki wo Keikitoshita NihonTekkogyo no Sho Energy Taisaku – Koro Maker wo Chushin ni", Keiei Kenkyu, Volume.48 No.1, 1997, pp.135-152

other energy saving facilities, CDQ requires a huge capital investment (10 to 20 billion JPY per unit) and a long pay back period (three to five years). The reason why CDQ was adopted so quickly is that CDQ provides benefits of not only energy saving but also improvement of coke quality and reduction of air/water pollutants<sup>83</sup>.

Blast furnace top pressure recovery turbine (TRT) recovers pressure energy as electricity; it requires less capital investment and electricity generation costs compared to thermal and hydroelectric power generation because it does not need auxiliary fuel. Since the two oil crises sharply increased the electricity price, plants with a blast furnace have begun to be equipped with TRT. About 80% (32 out of 39) of the medium to large size blast furnaces (equal to or large than 2,000m<sup>3</sup>) have TRT as of the end of December 1980 (see Figure 2.5.22). Although the main purpose of TRT is power generation, TRT also functions as a pollution prevention device because wet and dry types of TRT collect dust by venturi scrubber and electric precipitation or bag filter respectively<sup>83</sup>.

In the 1970s and 1980s, the iron and steel industry promoted energy saving through productivity improvement by continuous casting and continuous annealing and through introduction of large-scale energy recovery facilities. In the 1990s and thereafter, while energy consumption has increased due to high value added to products and environmental protection measures, the industry enhances energy recovery facilities, improve power generation efficiency, and utilize waste plastics<sup>84</sup>. Energy saving was realized through operation improvement at the floor level voluntary management activities in the beginning. After energy saving without capital investments reached the limit, the industry made large investments in facilities with large energy saving benefits<sup>85</sup>.



Source: Tsusan Shiryo Chosakai, Pandect of Energy Saving 1994



The iron and steel industry made large capital investments in energy saving facilities from 1979 to 1982 (see Figure 2.5.23). This is due to introduction of continuous casting facilities that can achieve high energy saving through omitting production process and improving yield rate, and blast furnace top pressure recovery turbines that can utilize exhaust gas.

<sup>&</sup>lt;sup>84</sup> Japan Iron and Steel Federation, "Tekkogyokai no Chikyu Ondanka Taisaku heno Torikumi Jokyo nitsuite" http://www.jisf.or.jp/kankyo/index.htm, 2004.1.9

<sup>&</sup>lt;sup>85</sup> INOUE Kiyohiko, "Kaku Gyokai no Energy Tenbo – Tekkogyo", Sho Energy, Vol.35 No.1, 1983, pp.6-11



Note: The number for 1983 is estimate. Source: Ministry of International Trade and Industry, *Capital Investment Plan of Major Industries*, each year



Although the data source of Figure 2.5.24 is different from that in Figure 2.5.23, one can see that capital investment with energy saving as its primary objective was almost at the same level as that of the secondary objective from 1979 to 1984 in the iron and steel industry. Examples of capital investment with energy saving as the primary objective include blast furnace top pressure recovery turbines, dehumidifying air blasting (humidity reduction of air to be blown to a blast furnace), preheating of air gas in an air-heating furnace, and CDQ. Those with secondary objectives include continuous casting, continuous annealing, hot charge, and direct metal rolling.



Source: Japan Development Bank, Chosa, No.40 in 1980, No.47 in 1981, No.64 in 1983, and No.75 in 1984.



A document on a certain steel plant states that the investment in energy saving was not approved if its pay back period was more than 1.5 years while it was approved if 1.2 years. A pay-back period of investment by energy type at the steel plant is calculated based on the benefits against investment in energy saving and energy price per calorie (see Figure 2.5.25), which shows that electricity and heavy fuel oils, having a short pay-back period, were targeted for energy saving investments. Annual energy saving benefits against investment

were 65, 35, 19, and 17 trillion calories per 100 million JPY in 1974, 77, 80, and 83 respectively. The benefits are diminishing as energy saving measures progress. This fact tells us that energy saving measures were selected and implemented in order of their investment efficiency<sup>86</sup>.



Note: A pay-back period of investment was calculated taking a inverse of energy price per calorie multiplied by energy saving investment efficiency which was proposed in Nippon Steel Corporation Yawata Works Yawata Works Sho Energy - 560 man heno Chosen

Source: MATSUNO Yu, "Tekkogyo ni okeru Iousankabutsu Haishutsu Sakugen heno Kakushu Kankyo Seisaku Shudan no Kiyo (2)", Keizai Ronso (Kyoto University), Vol.160 No.3, 1997, p.230



Although investment efficiency diminishes as energy saving measures are promoted, the Japan Iron and Steel Federation, the industry association of the iron and steel industry, developed a voluntary action plan for protecting the environment. Companies belonging to the Federation have been making efforts to reduce by 2010 energy consumption by  $10\%^{87}$ compared to that of in 1990.

#### **Energy Saving Measures in Small and Medium Enterprises** c.

This section analyses factors that supported energy saving measures in small and medium enterprises based on the results of the interview survey conducted under this study and information in the literature, "Cases of Pollution Prevention and Energy Utilization Improvement" by Japan Small Business Corporation (1984).

#### c.1 **Background and Results of Implementing Energy Saving Measures**

Small and medium size companies had already started trying to reduce energy consumption rates before the oil crises. According to Shosigen Sho Energy-ka Taisaku Chosa (Study on Material and Energy Saving Measures) (1974), the ratio of the small and medium size companies that implemented full-fledged management of heat and energy to those surveyed under the study was 15% before the first oil crisis and increased to 35% after the first oil crisis. This is because 1) impacts of energy price increases were big, and 2) it was possible that energy efficiency be improved in a much shorter time than improvements in material

<sup>&</sup>lt;sup>86</sup> MATUNO Yu, "Tekkogyo ni okeru Iousankabutsu Haishutu Sakugen heno Kakushu Kankyo Seisaku Shudan no Kiyo (2)" Keizai Ronso (Kyoto University), Vol.160 No.3, 1997, pp.215-234 <sup>87</sup> Japan Iron and Steel Federation, "Tekkogyokai no Chikyu Ondanka Taisaku heno Torikumi Jokyo nitsuite",

http://www.jisf.or.jp/kankyo/index.htm

shifts or utilization efficiency<sup>88</sup>. After the second oil crisis, it became difficult to shift the increase in energy price to product prices; small and medium size companies implemented measures to cut production costs such as energy and material saving<sup>89</sup>.

When energy consumption rates of small and medium companies are compared between the periods before and after the first oil crisis (in 1973 and in 1978), that of the whole manufacturing sector increased by about 13 % while that of the heavy industry consuming a lot of energy increased by about 25%, which is about twice as much as the former as can be seen in Table 2.5.7.

Industry	1973	1978	Rate of Improvement (%)
Light Industry for Material Production	4.16	3.84	7.7
Light Industry for Processing	1.71	1.47	14.0
Heavy Industry for Material Production	8.75	6.59	24.7
Heavy Industry for	1.40	1.24	11.4
Processing			
Total Manufacturing	3.08	2.69	12.7

Table 2.5.7 Improvement of Unit Energy Consumption of Small and Medium Size
Companies

Source: Small and Medium Enterprise Agency, 1981 White Paper on Small and Medium Enterprises

The energy consumption rate per production index of the manufacturing sector has been broadly flat or slightly increased since 1985. However, according to the interview survey and the information about energy saving cases in "Cases of Pollution Prevention and Energy Utilization Improvement," small and medium size companies have been making efforts to save energy for the sake of continuous cost reduction through introduction of energy saving facilities upon renewal of the production facilities.

#### c.2 Energy Saving Measures in Small and Medium Size Companies

Energy saving measures adopted in small and medium size companies as of 1980 (after the second oil crisis) were mainly saving of electricity and fuel through proper operation of equipment, which was relatively easy to implement; they were intended to implement in the future measures requiring capital investments such as introduction of energy saving facilities and rationalization of production processes consuming a lot of energy<sup>90</sup>. Energy saving measures at small and medium size companies evolved from those requiring no or low costs such as electricity/fuel saving through proper operation of equipment to those requiring capital investments such as changes in production processes and facilities.

#### c.3 Schemes for Implementation of Energy Saving Measures

At the time of the first oil crisis, then Ministry of International Trade and Industry designated January to March 1975 as a period of intensive energy management and promoted a campaign to increase efficiency of energy consumption and energy saving. During that period, the factories which fell in the category of large energy consumer specified by Heat Management Law were required to prepare an energy saving plan and report the results of the implementation of the plan. According to the reports, various energy saving committees were formed in most of the large factories; the typical name of such committees was energy saving committee or heat management committee. Such a committee was headed by a

<sup>&</sup>lt;sup>88</sup> Small and Medium Enterprise Agency, 1976 White Paper on Small and Medium Enterprises

<sup>&</sup>lt;sup>89</sup> Small and Medium Enterprise Agency, 1981 White Paper on Small and Medium Enterprises

<sup>90</sup> Ibid.

factory manager or assistant to the factory manager. The meeting was held monthly in most factories to promote energy saving measures. Factories encouraged employees to propose new ideas, held seminars and study meetings, prepared posters and campaign mottos, and used internal broadcasting to raise awareness of the importance of energy saving<sup>91</sup>. The factories which fell in the category of large energy consumer specified by Heat Management Law are mainly large companies, and they took systematic actions as mentioned.

In small and medium size companies, the existing sections managing design, operation, and maintenance of production facilities, such as production departments, seemed to develop and implement energy saving measures including introduction of energy saving facilities. In companies having QC circles, energy saving measures proposed by employees were implemented. Since the QC circle process requires employees to realize results of their proposals, energy saving measures requiring large capital investments were likely to be implemented through preparation by a technical section such as a production department and decision by a board of directors.

Small and medium size companies were frequently assisted by local government agencies and local industrial technology centers in collecting heat management data or formulating energy saving plans.

### c.4 Information for Energy Saving Measures

Since the establishment of the Heat Management Association in the 1950s, information about energy saving measures and technologies has been provided through magazines such as *Heat Management* and books such as *Lectures on Heat Management Technologies*. The title of the magazine was changed from *Heat Management* to *Heat Management and Industrial Pollution*, and since the 1970s to *Energy Saving*, a monthly magazine published by the Energy Saving Center. In addition to such information, in small and medium scale industries, energy saving technology information was obtained through seminars held within industry associations, and technical gatherings hosted by local industrial technology centers as well as from magazines or circulars. One enterprise that was interviewed stated that they visited other enterprises that introduced some energy saving technologies shown in a magazine, and installed it themselves after hearing and confirming the advantages of such technologies.

There was a case where a boiler manufacturer proposed an energy saving facility, which then was installed and checked by boiler users.

The Energy Saving Center and Small and Medium Scale Enterprise Corporation also assisted industries by diagnosing energy consumption, holding seminars and giving suggestions for energy saving measures.

#### c.5 Funding for Implementation of Energy Saving Measures

The Development Bank of Japan and the Japan Finance Corporation for Small Business provided small and medium scale industries with low interest rate loans for energy saving measures. Municipal government offices also provided their independent funding programs for small and medium scale industries. Such financing programs were studied in detail by equipment manufacturers such as boiler manufacturers, and they advised their clients to use such loans to promote sales of their products. Often, information from such manufacturers turned out to be most reliable and practical for the clients.

<sup>&</sup>lt;sup>91</sup> Ministry of International Trade and Industry, "Energy Saving Plan Jan.-Mar. 1975", *Netsukanri to Kogai*, Vol.27, No.4, 1975, page 23~27.

#### d. Impacts of Financial and Fiscal Measures for Promoting Capital Investment in Energy Saving Facilities

#### d.1 Outline of Financial and Fiscal Measures for Promoting Capital Investments in Energy Saving Facilities

Tax reduction and low interest rate loans for capital investment in energy saving facilities were both started in 1975. As for the national tax, special depreciation of efficient energy and resource utilizing facilities was introduced in 1975, and as for the local tax, reduction of the taxation base of property tax for energy saving facilities was introduced in 1979. Since large capital investments became necessary as energy saving measures were promoted, the Tax System to Promote Energy Measures was established in order to promote such investments by the private sector in 1981. The tax system allows business entities to choose either exemption of corporate tax (7% of the acquisition value of the energy saving facility) or special depreciation (30% of the acquisition value); they cannot enjoy the other special depreciation system. Upon the introduction of the Tax System to Promote Energy Measures, about 1 trillion JPY worth capital investments in energy saving facilities was expected, and tax abatement was estimated as 80 billion JPY<sup>92</sup>.

As for the low interest rate loans for efficient energy utilization, the Japan Development Bank started in 1975, the Japan Finance Corporation for Small Business in 1978, and the National Life Finance Corporation in 1980. These loans with interest rates lower than market interest rate were provided for installation of energy-saving production facilities and waste heat recovery facilities<sup>93</sup>. The total amount loaned by these public financial institutions was 3.2 billion JPY only by the Japan Development Bank in 1975, 18.4 billion JPY by the three financial institutions in 1980, and increased to 128.8 billion JPY in 1990 (see Figure 2.5.26).



Source: Tsusan Shiryo Chosakai, *Pandect of Energy Saving 1994*, and documents from Japan Finance Corporation for Small Business, and National Life Finance Corporation.



#### d.2 Effects of Low Interest Rate Loans and Preferential Tax Treatment for Promoting Capital Investments in Energy Saving Facilities

For decision making on capital investments, business owners are likely to prefer a shorter pay-back period because of the following reasons<sup>94</sup>:

<sup>&</sup>lt;sup>92</sup> "Zadankai: Kigyo Keiei ni okeru Sho Energy Setsubitoshi no Arikata", *Sho Energy*, Vol.33, No.7, 1981, p1-10

 $<sup>^{93}</sup>$  The long-term prime rate was 8.5% in 1981. The Japan Development Bank provided the loans with annual interest rate of 8.0% for higher energy efficiency (20% of energy saving or higher) and 8.4% for other (lower than 20% of energy saving).

<sup>&</sup>lt;sup>94</sup> Energy Saving Center, "Sho Energy Toshi no Keizaisei", *Energy Keizai*, Vol. 6 No.1, 1980, pp.2-12

- 1. Business owners are likely to be highly evaluated if they seek sales increase by production capacity expansion rather than cost reduction by energy saving if both achieve the same profit.
- 2. Outlook of energy prices is unclear in a long term.
- 3. Since companies largely depend business financing on turnover of short-term fund whose interest rate is lower than that of long-term one, they tend to recover the capital invested as soon as possible.

The rate of return on capital investments in energy saving in the iron and steel industry was estimated for the cases 1) 10% of investment tax reduction and 2) 1/5 of special depreciation for the first year; 10% investment tax reduction and 2.3 % annual increase in energy price have the same effect, and so do 1/5 of special depreciation and 1.3% annual increase in energy price<sup>95</sup>. A payback period of energy saving investments could be shortened by increases in energy prices as well as tax reduction and special depreciation. In addition, low interest rate loans have the same effect since they reduce investment costs.

Because the increase rate of crude oil price was 154% at the first oil crisis and 90% at the second oil crisis, one could estimate how much the increases in energy prices increased economic efficiency of energy-saving investments. Although effects of tax reduction, special depreciation, and low interest rate loans were smaller than those of energy price increases, they contributed to shortening a payback period of energy-saving investments, which could influence the decision on the investments by business owners.

# 2.5.6 Reduction of Energy Consumption and Environmental Loads by Energy Saving Measures

#### a. Industrial Pollution Caused by Energy Consumption

Levels at which energy consumption leads to industrial pollution are selection and combustion of fuels, emission of pollutant, and regional accumulation of the pollutants. Factors that pose environmental loads and issues that should be tackled against the pollution at these levels are summarized in Table 2.5.8.

Process	Factors Influencing Environmental Load	Issues on Pollution Control
Selection of	-Industrial structure for mass	-Conversion of industrial structure for
Energy and	energy consumption type	low energy consumption
Energy	-Types of fuel	-Switch to clean fuel
Consumption	-Amount of fuel consumption	-Reduction of fuel consumption
	-Combustion technology	-Development and dissemination of low
		pollution combustion technology
Discharge of	Standards and applicability of	Expanding applicability, increasing
Waste Products	pollutants removing technologies	efficiency and lowering costs of pollution
		removing technology
Regional	-Concentration of pollution	-Dispersion of energy consumers
Accumulation	sources (land use)	-Identification of cause-and-effect
	-Combined pollution	relationship of combined pollution

Table 2 5 0 Dalatian	ohin hatwaan E	Enoraly Concumpt	tion and Indua	trial Dallutian
radie z b o Relation	ISHID DEIWEEH F	-nerov Consumo	non and mous	

Source: YOSHIDA Fusao, Bunken nimiru Sho Energy Gijutsu-Kenkyu Sekiyu Kiki Iko no Genba Gijutsu Ashiato to Kadai, 1988

<sup>&</sup>lt;sup>95</sup> I: initial investment of 3 billion JPY, C<sub>1</sub>: annual cost reduction by energy saving investment of 5.5x 10<sup>8</sup> JPY/year, C<sub>2</sub>: annual depreciation value of 2 x 10<sup>8</sup> yen/year, n: lifetime of 15 years, y: corporate tax rate of 40%, I: rate of return, I = {(1+i)<sup>n</sup>-1/i(1+i)<sup>n</sup>} {C<sub>1</sub>\*(1-y)+C<sub>2</sub>\*y} when there is no financial or fiscal measures.

Primary environmental loads from energy consumption are thermal pollution,  $CO_2$  emission, air pollution (sulfur oxides, nitrogen oxides, particulates, carbon hydride, carbon oxide, dioxins, and the like), bad odor, noise, vibration, and waste (residual ash). Secondary environmental loads from treatment of air pollutants are water pollution and waste (treatment sludge). Among these environmental loads, generation mechanisms of sulfur oxides, nitrogen oxides, and particulates are summarized in Table 2.5.9.

Air Pollutant Process of Formulation Remarks Sulfur Oxides Sulfur compounds of the fuel are Amount of SOx generation depends not on (SOx) oxidized by combustion. type of fuel or combustion facilities but on amount of sulfur in the fuel. Nitrogen Oxides The higher the temperature and the longer the -Nitrogen compounds in the fuel are (NOx) oxidized by combustion. retention time, the more NOx is formed. -Nitrogen in the combusting air is The more excess air, the more formation of oxidized by high temperature. NOx in normal combustion. As for the types of fuel, more NOx is produced in the order of coal, heavy oil, light oil, gasoline and natural gas. However, structure of combustion facilities and combustion condition may change this order oppositely. Ash Dust -Unburned substances of the fuel. The less excess air, the more dust is produced in normal combustion. -Air shortage causes formulation. -Sulfuric acid made by sulfur in the About kinds of fuel, the more ash and sulfur fuel bands to ash and soot. are included, the more dust is produced.

Table 2.5.9 Generation Mechanisms of Air Pollutants from Energy Consumption

Source: EX Corporation, "Technical Manual on Air Pollution Prevention in Developing Countries – Petroleum Refining Industry", 2003

#### b. Changes in Energy Consumption and Generation of Air Pollutants

With regard to the reduction of sulfur oxide emissions, it can be concluded that changes in emission factors (regulations, enforcement) were more effective than reduced energy consumption in reducing sulfur oxide emissions (see Figure 2.5.27). However, with regard to reduction of nitrogen oxide, it can be concluded that reduction of energy consumption and enforcement of regulations had almost same degree of effect (see Figure 2.5.28).



Source: Environment Agency, *1976 White Paper on the Environment* Figure 2.5.27 Factors Inducing Sulfur Oxides Emissions (1971-1974)



Source: Environment Agency, *1976 White Paper on the Environment* Figure 2.5.28 Factors Inducing Nitrogen Oxides Emissions (1971-1974)

### 2.5.7 Implications of Japanese Experience for Developing Countries

#### a. Reduction of Energy-related Subsidies and Introduction of Measures to Promote Investment in Energy Saving

In Japan, the two oil crises sharply increased energy prices, and taxes introduced for stable energy supply and development of energy alternate to oil boosted energy prices by 10 %. Such increases in energy prices acted as a pressure to reduce production costs in business entities and encouraged their efforts to improve energy efficiency. In addition, the introduction of policy measures to shorten the payback period of an investment in energy saving facilities, such as tax reduction, accelerated depreciation, and low interest loans, increased the investments. Energy saving measures resulted in reduction of air pollutants and carbon dioxides, which means that they functioned as environmental measures.

On the other hand, after the two oil crises, coal prices per calorie became lower than for other energy; the industries with high ratio of energy to production costs, such as cement/glass and iron and steel industries, shifted their energy sources from heavy fuel oil to coal. Preferential tax treatment was applied to coal combustion facilities including pollution abatement facilities as "oil alternate energy utilization facilities<sup>96</sup>," which is considered to have promoted coal utilization by companies. The shift from heavy fuel oil to coal was not a desirable option from the viewpoint of reduction of carbon dioxides per combustion calorie.

There exist energy-related subsidies that suppress energy prices both in developed and developing countries; most of them are targeted to fossil fuels. Many developing countries reduced the energy-related subsidies in 1990s, but there is still room left for the countries to gain economic benefits by improvement of energy efficiency and environmental benefits such as reduction of carbon dioxides from reduction of the energy-related subsidies (see Table 2.5.10)<sup>97</sup>. As in the case of Japan in which increases in energy prices promoted companies' efforts to improve energy efficiency, which resulted in reduction of air pollutants and carbon dioxides, elimination or reduction of existing energy-related subsides is expected to have the same effects in other countries. It would be desirable that energy-related subsides are reduced so that energy prices per calorie can be linked to the magnitude of the environmental load.

<sup>&</sup>lt;sup>96</sup> ITO Yasushi, "Nihon ni okeru Sho Energy Toshi Sokushin Shudan no Bunseki", *Chibashodai Ronso*, Vol.35 No.3, 1997, pp.108

<sup>&</sup>lt;sup>97</sup> World Bank, World Development Report 2003

			Impact of subsidy elimination		
Country	Subsidy Rate (against Standard Price%)	Total amount of Subsidy (\$ billion)	Improvement of Economic Efficiency (against GDP %)	Reduction Rate of Energy Consumption (%)	Reduction Rate of Carbon Dioxide (%)
Iran	80.4	3.6	2.2	48	49
Venezuela	57.6	1.1	1.2	25	26
Russia	32.5	6.7	1.5	18	17
Indonesia	27.5	0.5	0.2	7	11
Kazakhstan	18.2	0.3	1.0	19	23
India	14.2	1.5	0.3	7	14
China	10.9	3.6	0.4	9	13
South Africa	6.4	0.08	0.1	6	8
The World	21.2	17.2	0.7	13	16

Table 2.5.10 Existing Energy-related Subsidies and Impacts of Their Elimination

Source: World Bank, World Development Report 2003, Table 2.3

### b. Promotion of Energy Saving Measures Not Requiring Large Capital Investments

Japanese companies started their energy saving measures with no/low cost such as combustion management and moved to those with large capital investments after these no/low cost options were all implemented. In developing countries there would be room to implement no/low cost energy saving measures. It would be effective for them to implement no/low cost energy saving measures such as reduction of  $O_2$  % in exhaust gas, proper operation and management of equipment, and inspection and maintenance of thermal insulation of utility pipes and equipment. Especially for promoting energy saving measures in small and medium size companies, it would be desirable to provide sections designing, operating, and maintaining production facilities (e.g. manufacturing units) with information about energy saving technologies, dispatch experts to the factories to analyze energy utilization and find energy saving options, and establish government organizations to develop and follow-up policy measures to promote energy saving. In addition, it would be effective for the government to encourage industry associations to hold study sessions on energy saving so that companies can exchange relevant information with others in the same industry.

# c. Introduction of Policy Measures Contributing to Shortening of a Payback Period of an Investment

After implementing almost all the no/low cost energy saving measures, companies would tackle energy saving measures with capital investments such as change/modification of production process and facilities. Since most of the companies would like to make the payback period short such as one or two years, they would not invest in the facilities that can certainly reduce energy but have a long payback period. Therefore, it would be effective for the government to implement policy measures, such as preferential tax treatment and low interest loans, to make the payback period shorter for the facilities with a long payback period. Upon implementing such measures, preferential treatment of investments that could achieve production expansion, efficiency improvement of raw material use, and energy saving at the same time would be desirable for enhancing companies' business management.

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## 2 IMPACTS OF UTILITY PRICES AND ENVIRONMENTAL REGULATIONS ON INDUSTRIAL POLLUTION CONTROL IN JAPAN ....2-1

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