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Political Economy of Low Sulfurization and Air Pollution Control Policy in Japan: SOx Emission Reduction by Fuel Conversion

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In the early stages of the development of Japan's environmental policy, sulfur oxide (SOx) emissions, which seriously damage health, was the most important air pollution problem. In the second half of the 1960s and the first half of the 1970s, the measures against SOx emissions progressed quickly, and these emissions were reduced drastically. The most important factor of the reduction was the conversion to a low-sulfur fuel for large-scale fuel users, such as the electric power industry. However, industries started conversion to low-sulfur fuel not due to environmental concerns, but simply to reduce costs. Furthermore, the interaction among the various interests of the electric power industry, oil refineries, the central government, local governments, and citizens over the energy and environmental policies led to the measures against SOx emissions by fuel conversion.

Keywords: environmental policy, air pollution, low sulfurization, crude oil combustion
JEL classification: Q28, O13, N55

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Introduction

In the history of the development of Japan's environmental policy, many socio-economic arguments involving development and the environment in a developing country have been mounted. In this paper, we will focus on the measures against sulfur oxide (SOx) emissions, as this was the most important subject concerning the abatement of air pollution in Japan in the 1960s and 1970s, and it was the field in which the measures progressed most quickly. Furthermore, we will show that (1) the resource and energy policy and the industrial pollution control policy reflected the close relation between the two fields from the early stages of environmental policy development in Japan, and (2) for the electric power industry, which is the most influential energy industry, the resource and energy policy and the industrial policy served as the background in which the measures against SOx progressed quickly.

The conversion of high-sulfur fuel to reduced-sulfur fuel was the most effective means of handling SOx emissions, which represented the major part of the early stage of air pollution control. We will investigate the background of SOx reduction by fuel conversion by focusing on the electric power industry, as it was the largest fuel consumer and one of the main SOx emitters in Japan at that time.

Through combustion, the sulfur in fuel combines with oxygen and generates SOx. First, the measures for reducing the discharge of SOx to the ambient air is divided into two categories: (1) the measures for decreasing the sulfur content in the fuel in advance, and (2) the ex post measures for removing SOx from flue gas after it has been generated in the process of fuel combustion. The former measures can be further classified into two categories: (1-1) the measures for introducing reduced-sulfur fuel (crude oil combustion, import of low sulfur crude oil, and naphtha combustion), and (1-2) the desulfurization of heavy fuel oil with high sulfur content (sulfur content accumulated into heavy fuel oil in the oil refining process). The latter measures can be classified as (2) flue gas desulfurization measures.

In the first half of the 1960s, the SOx pollution in the air in Japan expanded rapidly and became a serious social problem. Since flue gas desulfurization was technically imperfect at the time, the low sulfurization of fuel was the main measure against SOx emissions. Although

combating SOx by the low sulfurization of fuel was not technically difficult, the supply of low-sulfur fuel was limited, and since the price was also high as compared to high-sulfur fuel, conversion was not necessarily an easy choice.

It was the late 1960s when the battle against air pollution by low-sulfur fuel gained strong momentum. The rise of public opinion against environmental pollution and the stricter environmental regulations enacted by the local governments as compared to those of the central government were the most important factors that enabled the rapid movement toward reducing the discharge of SOx. However, it can be said that the background that enabled such rapid development of environmental regulations in Japan has yet to be fully explained.

We will also consider the socio-economic background in Japan that made it possible to quickly react against air pollution by means of low sulfurization in the late 1960s and early 1970s, by shedding light on the connection between resource and energy policy and environmental policy.

1. Measure against SOx Emissions by the "Low Sulfurization Program" of the Ministry for International Trade and Industry

Since the mid-1960s, a significant part of the SOx emissions control measure was the quantitative reduction of the discharge from fixed sources, such as large-scale factories and power plants. The components of the series of regulations belonging to the "low sulfurization program" were (1) import of low-sulfur crude oil, (2) installation of heavy oil desulfurization equipment, (3) technological development and installation of flue gas desulfurization facilities and (4) increase of effective stack height. The legal basis of the measure against SOx in 1968 was the Air Pollution Control Law, the successor of the 1962 Smoke and Soot Regulation Law. However, administrative guidance without legal authority was offered to the industries handling the supply and demand of fuel, in the background of such formal, law based regulation.

The Advisory Committee for Energy, which is the consultative body of the Ministry for International Trade and Industry (MITI), installed a committee to oversee the low sulfurization measure, and this committee approved the low sulfurization program in 1969. This program defined the targets for the supply amount and average sulfur content of fuel according

to each grade of crude oil of the oil refinery companies supplying heavy fuel oil. On the other hand, for the demand side of fuel, the targets for the amount used and sulfur content were set according to each combustion area, categorized by population density. Accordingly, the program provided a road map for low sulfurization in the long term. Based on this plan, the administrative guidance to both the supply and demand sides was carried out by MITI, to align the interests of the industries.[1]

Although the import of low sulfur crude oil was the most effective and efficient measure of low sulfurization before the first oil shock, the measure reached its limit due to the short supply of low-sulfur crude oil after the oil shock. Thereafter, oil refineries began installing the heavy oil desulfurization equipment, and the large fuel users, such as the electric power industry and iron and steel industry, later began installing flue gas desulfurization facilities. On the other hand, in order to carry out this program, the government assisted in the research and development of flue gas desulfurization and heavy oil desulfurization equipment by allocating funds to private enterprises and semi-governmental research institutions. Furthermore, low interest loans were offered by government financial agencies, including the Japan Development Bank, for the installation of this equipment, in addition to a corporate tax break according to the accelerated depreciation of special taxation measures, tax exemptions, a fixed property tax, and import duties, in order to ease the financial burden shouldered by private companies. In the implementation process of the low sulfurization program, MITI provided administrative guidance in connection with the interest adjustment between related industrial associations, and asked for participation in the program.

Naphtha is generated at a fixed rate in the crude oil refining process, and is almost the sole raw material of the petrochemical industry. Therefore, the supply and demand trends of heavy fuel oil were also an important concern for the petrochemical industry. It is known that the oil industry was influenced heavily by MITI in this period. In particular, the oil refinery industry was subject to the powerful intervention of MITI with regard to the quantity of production, prices, capital investment, etc., after the enactment of the Petroleum Industry Law in 1962.

2. Expansion of Crude Oil Combustion by the Electric Power Industry

Although thermal power generation in Japan was only 7,200 million kW of the total generation of 40,800 million kW of electricity in FY 1951, when electric power reorganization was realized, thermal power generation amounted to 54,400 million kW of the total electricity production of 116,800 million kW in FY 1961. Thermal power generation surpassed hydraulic power generation in the production of electricity in FY 1962. The percentage of heavy fuel oil thermal power within the total thermal power generation was only 4% at the end of FY 1959. When the Heavy Oil Boilers Control Law was revised in 1960, the regulations on the construction of the heavy oil thermal power plants were eased, and construction progressed. Heavy fuel oil thermal power generation reached 51% at the end of FY 1967, and exceeded coal burning power generation. The sum total of heavy fuel oil and crude oil had already exceeded coal in FY 1964. In this way, the dependence on heavy fuel oil in the electric power industry increased rapidly.[2]

The electric power industry had introduced crude oil combustion as a substitute for heavy fuel oil for thermal power plants before MITI launched the low sulfurization program. The Tokyo Electric Power Company (TEPCO), which was the largest fuel oil user in Japan, had already started carrying out crude oil combustion in 1962. Prior to this, in 1959, the electric power industry had requested a series of preliminary crude oil combustion experiments to the Central Research Institute of Electric Power Industry, and conducted the comparative experiments on the combustion of crude and heavy fuel oils using TEPCO's large boiler in 1960. As a result, TEPCO began using crude oil as fuel for thermal power generation.[3] Even if they used crude oil with relatively high sulfur content, the generation of SOx should have been lower in the case of crude oil combustion, compared to the combustion of heavy oil refined from the same crude oil without heavy oil desulfurization. This is because heavy fuel oil contains the highest sulfur content, which remains at the end of the oil refinery process. Thus, crude oil combustion proved to be an effective measure for SOx discharge reduction.

However, the electric power industry, including TEPCO, started carrying out crude oil combustion in thermal power plants, not because of the reduction of SOx emissions, but because the price of the heavy fuel oil refined in Japan was comparatively high. Thus, crude oil combustion was introduced as a fuel cost-cutting measure. Further, the price of petroleum products was controlled by the policy intervention, and naphtha was fixed to budget prices for

the promotion of the petrochemical industry. Heavy fuel oil was set at a comparatively high price, the import of heavy oil was strictly controlled, and the amount was limited. Although heavy fuel oil was cheaper than crude oil in the international price per combustion calorie, heavy fuel oil was priced higher than crude oil in the domestic market. The restricted import of heavy fuel oil to protect the oil refinery industry drove up the price of this oil and it ran short in the domestic market.

Although the price of the heavy fuel oil that the electric power industry purchased was an average of 7,480 yen/kL in 1960, the including-tax average import price of the crude oil that oil refinery industry imported was 5,600 yen/kL, and its spread was large.[4] This price difference compelled the electric power industry to conceive of crude oil combustion. Since MITI's petroleum policy was premised on the maintenance of "consumption place refining principles," the fixed rate of heavy oil from crude oil was produced and supplied to the domestic market through the oil refinery process. However, crude oil combustion had the potential of promoting a disruption to the demand-and-supply balance of petroleum products, by decreasing the demand for heavy fuel oil. In order to maintain the quantity of production of light oil, such as naphtha and gasoline, in which the supply and demand were even, the oil refinery companies had to secure the heavy fuel oil market.

Moreover, since the oil refinery industry could receive no profit when crude oil was combusted directly without refining, they opposed to the expansion of crude oil combustion in the electric power industry. The crude oil combustion of low-sulfur crude pressed the supply of low sulfur crude for refining, and the oil refinery industry insisted that this process was not useful for low sulfurization as a whole in Japan.

Due to the oil refinery industry's strong opposition to the electric power industry's application to MITI for permission to combust crude oil, permission was denied in FY 1960 (in order to import crude oil at the time, the government needed to meet a quota of foreign currency). This posturing of the oil refinery industry in response to the electric power industry carrying out crude oil combustion led to the substantial reduction of the heavy fuel oil price in the second half of FY 1960. In February 1961, the electric power industry requested that MITI assign the foreign currency for the import of crude oil and C heavy oil directly to the electric power companies. On the other hand, MITI proposed new plans in October 1961 as follows: (1)

establish a study group to carry out crude oil combustion experiments on boilers for the generation of electric power, and (2) purchase Kafji crude oil from the Arabian Oil Company for the combustion tests. Then, the crude oil combustion test study group was established from the Federation of Electric Power Companies. It conducted the combustion experiments and declared in March 1963 that no significant problems had been found. Hence, it became national policy that only the Arabian Oil Company's Kafji crude oil could be used in the crude oil combustion process.

Since there was an oversupply of crude oil, the oil refinery industry needed to cooperate with the electric power industry, from the perspective of the reservation of the market for high-priced Kafji crude oil. Moreover, each electric power company had invested in the Arabian Oil Company. However, the sulfur content of Kafji crude oil was dramatically high. From FY 1964, on the condition that the supply of the Kafji crude oil used for crude oil combustion was received from the oil refinery companies, the full-scale enforcement of crude oil combustion took effect.

The electric power industry, which aimed reducing fuel costs with the expansion of crude oil combustion, focused on making the Kafji crude oil as a breakthrough, by using the oversupply issue of Kafji crude oil. On the other hand, the oil refinery industry, which had conflicting interests with the electric power industry, understood the concerns of the electric power industry.[5] Although a clear standard for the quantitative restriction of crude oil combustion did not exist at the beginning of the 1960s, the quantity of the electric power industry's crude oil combustion was determined to be within the limits of the amount of the "Bunker C" heavy fuel oil import schedules, which depended on a petroleum supply plan, "in case crude oil combustion [was] not introduced," according to the report of the Advisory Committee for Energy of February 1967 (consultative body of the Minister of International Trade and Industry). However, the import restrictions on crude oil for combustion were disregarded gradually by the electric power industry, and crude oil combustion of imported crude oil was expanded.[6] Although the crude oil for combustion was initially limited to Kafji crude oil, the rules were extended to crude oil with super-low sulfur content, such as Minas crude oil, due to the need to reduce air pollution.

3. Crude Oil Combustion as a Low Sulfurization Measure by Fuel Conversion

As stated above, the electric power industry started carrying out the combustion of the high-sulfur Kafji crude oil in thermal power plants. Furthermore, the constraints restricting crude oil combustion to Kafji crude oil imposed by MITI and the oil refinery industry were removed, as the electric power industry cited low sulfurization as a social need and air pollution control to justify its actions.

Although the progress of industrial pollution regulation was a factor that brought about a general cost increase for the electric power industry, the social need for low sulfurization presented an opportunity for the electric power industry to escape the restrictions of fuel use that the government and the domestic primary energy supply industry had imposed. The diversification of fuel use for thermal power generation, the reduction of the use of the expensive domestically refined heavy fuel oil, and the reduction of fuel costs could occur simultaneously. It was more advantageous to the electric power industry to limit the measures against SOx to fuel conversion and to postpone for as long as possible the introduction of the flue gas desulfurization facilities in thermal power plants. In the late 1960s, no flue gas desulfurization facility had been established for commercial technology.

While there were conflicting interests among the industries, the low sulfurization program was promoted by MITI. Then, the electric power industry further advanced the measure of low sulfurization by fuel conversion, and crude oil combustion came to be regarded as part of the low air pollution control measure, as the local governments tightened up air pollution regulations through pollution control agreements in response to increasing public opposition to air pollution.

The incident that had the greatest impact was the pollution control agreement concluded in September 1968 by TEPCO and the Tokyo Metropolitan Government with regard to the construction of the Oi Thermal Power Plant on reclaimed wharf ground. In the agreement, TEPCO promised to use only super-low sulfur Minas crude oil, with only 0.1% sulfur content, as fuel from FY 1973 at the Oi Thermal Power Plant. This unheard of provision incorporated in the pollution control agreement was, in fact, proposed by TEPCO to the Tokyo Metropolitan Government.[7]

The conclusion of this agreement was a big shock to the oil refinery and petrochemical industries, both of which were vehemently opposed to using the fine quality, super-low sulfur crude oil, of which absolute quantities were limited, for crude oil combustion without refining. The electric power industry was able to conduct advantageous negotiations concerning the crude oil combustion with the oil refinery industry, the petrochemical industry, and MITI, using the pressure of the local governments and local residents. After TEPCO concluded the pollution control agreement on the air pollution prevention of the Oi Thermal Power Plant with the Tokyo Metropolitan Government in 1968, Japan's nine major electric power companies concluded pollution control agreements one after another with the local governments where their electric power plants were located. Most of the agreements included an article concerning the concrete regulation of the low sulfurization of fuel. In order to avoid the electric power industry's excuses for crude oil combustion expansion, the oil refinery industry had to hurry to produce low-sulfur heavy fuel oil. The installation of heavy oil desulfurization equipment in oil refineries and technological research and development for such equipment were advanced quickly.

Mr. Kazutaka Kikawada, then president of TEPCO, determined the exclusive use of Minas crude oil with super-low sulfur content at the Oi Thermal Power Plant. President Kikawada was also the first in the world to decide to use liquefied natural gas (LNG) as the fuel for an electric power plant, and he decided to implement the exclusive combustion of naphtha in some thermal power plants in 1972. This decision was probably due to the fact that the location of the power plant was making it impossible to proceed without taking radical counter-measures against air pollution, and the importance of the battle against air pollution was recognized when the local government, especially the Tokyo Metropolitan Government, pressed for the conclusion of the pollution control agreement. However, simultaneously, the use of Minas crude oil and LNG led to the diversification of the sources of primary energy, and this became a foothold for freedom from the restrictions of MITI's fuel supply regulation. It is thought that President Kikawada himself recognized the aspect of the fuel diversification brought about by low sulfurization, and he should have taken into consideration air pollution management when he decided to introduce Minas crude oil and LNG.[8]

In 1965, TEPCO decided to construct a thermal power plant where the exclusive

combustion of LNG would be carried out, and the plan was carried out conjointly with the Tokyo Gas Company.[9] Although public opposition to air pollution was mounting, it was not yet recognized as a decisive constraining factor on the location of an electric power plant. Moreover, Governor Minobe's Tokyo Metropolitan Administration, which promoted the anti-pollution measure as part of its reformist strategy, was not yet organized. The recognition of importance of the anti-pollution measure at this time was based on President Kikawada's foresight and intelligence. However, his personality alone cannot sufficiently explain the decision making of TEPCO on air pollution management. It was before the formation of the Minobe Metropolitan Administration when TEPCO proposed the Minas crude oil combustion at Oi in September 1965, and the diversification of the fuel for electric power generation could be considered to have laid the foundation for the decision making of the Minas crude oil combustion.

The measure against the SOx discharge of electric power companies progressed quickly, triggered by the Yokkaichi air pollution judgment in 1972. In the Yokkaichi air pollution litigation, it fought for the joint tort about the health damage caused by SOx emission of defendants, Chubu Electric Power Company and the petrochemical companies in the Yokkaichi industrial complex, and the plaintiff victim won the case. TEPCO, Chubu Electric Power Company, and Kansai Electric Power Company could only locate thermal power plants in the surrounding areas of large populated cities; therefore, they were pressured by the local governments of these areas for drastic SOx discharge reduction. Despite the positive response to the development of flue gas desulfurization technology—TEPCO having developed dry type desulfurization equipment—they were not accepting of the introduction of flue gas desulfurization facility, and the low sulfurization of fuel was at the core of their measure. President Kikawada thought that the direction of fuel low sulfurization was a more radical measure compared to end-of-pipe type pollution prevention equipment, and that the low sulfurization of fuel should have been pursued before flue gas desulfurization. The view of the president is considered to have been the main factor behind TEPCO's stance.[10]

4. Political Economy of Low Sulfurization in Japan

We would like to show clearly that low sulfurization before the introduction of LNG progressed

quickly, as a result of the interaction of interests among the actors, such as the electric power industry, the oil refinery industry, the central government, local governments, and local residents. We will refer to the interaction among these actors with such different interests as “the political economy hypothesis of low sulfurization” in the early stage of air pollution control policy in Japan.[11]

Although the local governments did not have the authority to regulate industrial pollution any tighter than the central government did in those days, since the central government’s industrial pollution regulation was extremely loose as compared to the actual environmental pollution situation, there was a need for certain regulation measures to be adapted to the actual condition. The pollution control agreement was invented under these circumstances, and was thereafter utilized by the local governments in various areas. For private companies, the pollution control agreement was a promise to local residents to prevent pollution, in which the local government acted as an intermediary. It was also desirable for the companies located in densely populated areas to enter into pollution control agreements with the local government, to prevent disputes with the local residents. As stated earlier, the electric power industry was able to negotiate advantageously with the oil refinery industry, the petrochemical industry, and MITI concerning the combustion of crude oil and naphtha in thermal power plants, using the strong pressure exerted by the local governments and local residents for the prevention of pollution. Moreover, the concrete regulation of the low sulfurization of fuel was included in most of the pollution control agreements between Japan’s nine major electric power companies and the local governments in the areas where their thermal power plants were located.[12]

Furthermore, in 1971, the electric power industry, together with the iron and steel industry, claimed naphtha as a low-sulfur fuel. As the expanding demand for petroleum chemicals reached the ceiling, naphtha supply and demand were eased, and the surplus of naphtha was also seen abroad. Therefore, it was expected that naphtha could be obtained at low prices. Naphtha combustion by the electric power and iron and steel industries strongly stimulated the petrochemical industry, where naphtha represents almost the only raw material, rather than the oil refinery industry.[13] However, naphtha combustion by the electric power and iron and steel industries was ultimately accepted.

To avoid continuing to justify crude oil combustion expansion to the electric power

industry, the oil refinery industry could rapidly pursued the low sulfurization of heavy fuel oil and advanced the introduction of heavy oil desulfurization equipment in oil refinery plants in addition to the development and improvement of heavy oil desulfurization technology. Heavy oil desulfurization equipment was affected by a low operating ratio caused by overinvestment during the first half of the 1970s. Although it was a common problem among oil refinery plants, if an operating ratio fell, as in the case of the heavy oil desulfurization equipment, the cost per unit of production would increase remarkably. The cause of overinvestment was that the desulfurization of heavy fuel oil was emphasized more than needed in the low sulfurization measures. Moreover, heavy oil desulfurization became an insufficient measure by itself, as the SOx effluent control was tightened up. Furthermore, the electric power industry, the largest consumer of fuel, coped with this by combusting low-sulfur crude oil and naphtha. The expansion of the crude oil and naphtha combustion by the electric power industry accelerated the oil refinery industry's expansion of heavy oil desulfurization facilities, and this could be considered to have become a cause of overinvestment and excess capacity as a result.

Although the large-scale investment in the heavy oil desulfurization equipment of the oil refinery industry from the start to the middle of the 1970s translated to an overinvestment and caused a low operating ratio of equipment, the expansion of heavy oil desulfurization is considered to have significantly affected the improvement of the air pollution in Japan as a whole. Large-scale enterprises, such as those in the electric power industry and the iron and steel industry, introduced the combustion of low-sulfur crude oil as a measure against SOx emissions, and when this was insufficient, they were able to install flue gas desulfurization facilities, but it was difficult for small and medium-sized enterprises (SMEs) to introduce such measures. However, since the supply of low-sulfur heavy fuel oil increased due to the expansion of the heavy oil desulfurization equipment, it became possible for SMEs to decrease the discharge of SOx by burning low-sulfur heavy fuel oil in boilers as usual, without the introduction of flue gas desulfurization equipment in these boilers.

Various kinds of oil, such as heavy fuel oil and light oil, were generated at a fixed rate by refining crude oil needed to be consumed in a certain form. Since there was a limitation to the supply of low-sulfur crude oil, the promotion of the desulfurization of heavy fuel oil was also important for the promotion of the low sulfurization measure. Furthermore, the fuel supply

target for supplying low-sulfur fuel to overpopulated areas was at the core of MITI's low sulfurization program.

5. Conclusion: SOx Discharge Reduction by Fuel Conversion as an Unintentional Result of the Interaction among Interests

When industry interests were in opposition, such as oil refinery and electric power, in the low sulfurization program, MITI tried to adjust these interests among the *genkyoku* in the Ministry, which had jurisdiction over each industry. MITI could not set forth an energy policy on the basis of compatibility with the measures against industrial pollution, beyond the interest adjustment between the related industries. Moreover, the administrative guidance concerning petroleum policy seldom took into consideration the substitutive relationship between two aspects of crude oil, namely, as fuel and as a raw material, which made the conflict of interest serious, as shown in the relation between the combustion of crude oil and naphtha and the provision of low-sulfur heavy fuel oil by heavy oil desulfurization.

However, the combustion of crude oil and naphtha by the electric power and iron and steel industries was confirmed after all and expanded gradually, and the air pollution prevention in those industries progressed quickly as a result. Conversely, it can be said that the social need for the prevention of air pollution brought about the de facto decline of the intervention authority of MITI where the fuel use of the electric power and iron and steel industries was concerned.

The social need to combat air pollution and the strong demand for low sulfurization by the local governments also became an excuse for large fuel consuming industries to expand the "freedom" of fuel choice, thereby escaping the central government's regulation. Moreover, the promotion of the measure against SOx by the low sulfurization of fuel enabled the large users of fuel to defer the capital investment to flue gas desulfurization.

The oil refinery industry was thus forced to expand the capital investment to expensive heavy oil desulfurization equipment and begin supplying low-sulfur heavy fuel oil as quickly as possible. As a result, there was superfluous investment in heavy oil desulfurization equipment, and the oil refinery industry was afflicted by the low operating ratio of the heavy oil

desulfurization equipment. However, the supply expansion of low-sulfur heavy fuel oil by heavy oil desulfurization prevented a shortage of the limited low-sulfur crude oil and eased the measures against SOx discharge for SMEs, for which introducing flue gas desulfurization facilities was difficult.

First, the electric power industry introduced crude oil combustion to reduce power generation costs and to escape the central government's fuel regulations, under the guise of freedom to make fuel choices. In reality, the decision was completely unrelated to the SOx discharge reduction resulting from the low sulfurization of fuel. The Council for Industrial Planning, a private think tank established by Mr. Yasuzaemon Matsunaga, who continued to argue passionately for the relief of the fuel regulation and the liberalization of imports, conceived of crude oil combustion. Moreover, this was before measures against industrial pollution became a policy concern, providing more evidence that the conception of crude oil combustion had little to do with any desire to reduce SOx emissions. The interaction among actors, such as electric power as a user of fuel, oil refineries as suppliers, the petrochemical industry as users of raw material, local governments, local residents, and the central government, brought about the reduction in SOx emissions by fuel conversion, and the expansion of the freedom to make fuel choices for large fuel users as a result. It is also possible to conclude that confusion arose due to the central government's industrial policy, since the substitution of fuels, the complicated interaction among actors, the compatibility of the measures of the battle against air pollution, and industrial promotion were not necessarily taken into consideration. Moreover, the progress made on the SOx emissions reduction front can also be regarded as a revelation of the "dynamism" (by Kikkawa, 2004) of the electric power industry before the oil shock of the 1970s.

The policy intervention that brought about the distortion of energy prices reduced air pollution as a result. However, it failed to realize the original policy aim as an energy policy and industrial promotion policy for the energy industry. The distortion of the price produced by the policy intervention unexpectedly made a comparatively high-priced heavy fuel oil with high sulfur content, which led to tremendous SOx emissions, and made relatively cheap crude oil with low sulfur content.

The result from the political economy of low sulfurization suggests the possibility that

the policy intervention that brought about the distortion of prices was effectively able to serve as the measure against environmental pollution emissions. This means that it might have become an effective measure if the economic measures for pollutant discharge reduction, such as pollution tax and emission trading, had been introduced in the 1960s. Moreover, if we can consider crude oil combustion and naphtha combustion as kinds of technological innovation, the distortion of the relative price of fuel, brought about by intervention of the energy policy, will be considered to have become the pressure applied to urge technological innovation in the electric power industry, which is a large fuel user.

[1] On the “low sulfurization program” by MITI, see Ministry of International Trade and Industry [1969], etc.
[2] See Kikkawa [2004: 247-249], and Nippon Oil Company [1988].
[3] See Nippon Oil Company [1988].
[4] Although the average price of heavy fuel oil at the time would have been about 1.34 times (≒ 7,480 / 5,600) the crude oil at the price per simple volume, if calorific power is taken into consideration, the price ratio would be shortened a little to the average calorific-power of 9,900 kcal/L of heavy fuel oil, since crude oil has an average calorific-power of 9,400 kcal/L (this relies on “Energy Statistics” 1967 edition). At the price per calorific power, the average price of heavy fuel oil was about 1.27 times that of crude oil.
[5] See Nippon Oil Company [1988: 658-659].
[6] See MITI [1969].
[7] See Kobayashi [2002: 37-38].
[8] Based on the lecture of Mr. Osamu Kobayashi at the research group meeting of IDE, July 10, 2002. Mr. Kobayashi was the vice Director of Environmental Protection Department, Tokyo Electric Power Company.
[9] See Tokyo Gas Company [1990].
[10] According to Kobayashi [2002: 25-26], especially Tokyo Electric Power showed prejudice in the acquisition of better quality fuel.
[11] “The political economy hypothesis of low sulfurization” is based on Terao [1994: 314-325]. See also Terao [2007] and Ito [1992].
[12] We found that some of the pollution prevention agreements at that time already included the article on the installation of flue gas desulfurization facilities.
[13] See Petroleum Association of Japan [1971: 175-178].

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