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参加者行動・期待の公的コーディネーション：東京における低公害自動車導入の試み

PUBLIC COORDINATION OF PARTICIPANTS' BEHAVIOR AND EXPECTATIONS: AN ATTEMPT TO INTRODUCE LOW-EMISSION VEHICLES IN TOKYO

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In developing a methodology of implementing sociotechnology, it would be a promising idea that the public sector promotes the introduction of new technologies by supporting the proper functioning of the market mechanism, rather than by replacing the market through direct regulation. In this paper, I examine the case of a recent attempt by Tokyo Metropolitan Government to make a shift in automobile uses in Tokyo from diesel vehicles to low-emission vehicles such as compressed natural gas vehicles. The new initiative encouraged car users, car makers, and fuel infrastructure providers to participate in open dialogues, with an intention to coordinate the behavior and expectation of the relevant actors crucial for the introduction of clean vehicles. The results of the public coordination and their implications are discussed.

Key Words: *public coordination, low-emission vehicles, technological lock-in*

1. Introduction

In our attempt to solve various issues occurring in the modern society, innovation increasingly plays a role of critical importance. Innovation is a dynamic process, in which complex interactions are involved between technological development, actors' behavior, and institutional environment, and a careful understanding of its nature is required in implementing public policies. Uncertainty, diversity, and interdependence are among the characteristics inherent in the process of technological change (Rosenberg, 1982, 1994). With the working of positive feedbacks, they could contribute to the emergence of "technological lock-in," a phenomenon which has been observed in many technological fields (Arthur, 1989; Cowan, 1990; Cowan and Gunby, 1996; David, 1985; Islas, 1997; Yarime, 2003).

Several mechanisms are considered to generate positive feedbacks. The first is economies of scale, or increasing returns to scale. One of the reasons to expect a company's average production cost to decline, at least initially, as its output expands is that fixed setup costs do not vary with the level of output (Carlton and Perloff, 1994). Thus, as a company produces more outputs than other companies, it gains more advantage over its competitors. A similar source of positive feedbacks is economies of scope, which mean that it is efficient to produce two or more products together (Panzar and Willig, 1977). Among the possible factors contributing to economies of scope is the use of common inputs, including raw materials and knowledge.

While these two mechanisms are considered to work in a static framework, a dynamic mechanism causing positive feedbacks is the so-called learning effect. Learning by doing, a form of learning which takes place at the manufacturing stage, consists of developing increasing skill in production (Arrow, 1962). This has the effect of reducing labor costs per unit of output, and the significance of this effect has been widely observed in many industries. Learning by using, on the other hand, generates gains as a result of subsequent use of products (Rosenberg, 1982). Particularly for complex new technologies, there are essential aspects of learning which are a function not of the experience involved in producing the product but of its utilization by the final user. As there types of learning accumulate, it becomes more efficient to produce and use new technologies.

The fourth mechanism considered to produce positive feedbacks is coordination failures. Coordination failures could be induced when there are strong complementarities among parts of a system (Milgrom and Roberts, 1992). In a large-scale, complex system, the existence of strong complementarities among different individual's decisions could give rise to a variety of stable outcomes. This is particularly the case for the energy and transportation sectors, in which a large number of users and extensive establishment of infrastructure are involved. The systemic character of technologies reinforces interdependence among different parts and poses a significant degree of rigidity, making a transition from one state to another extremely difficult. In this way, coordination failures in the behavior and expectations of relevant actors with diverse interests and characteristics could result in a state of technological lock-in.

There could be possibilities of escaping lock-in after a technology has achieved dominance in the market and has been able to enhance its comparative advantages over many decades. Cowan and Hulten consider the possible impact of six factors whose existence or strength could help the automobile market escape the lock-in of the gasoline car technology; namely, they are crisis in the existing technology, regulation, technological breakthrough producing a real or imagined cost breakthrough, changes in taste, niche markets, and scientific results (Cowan and Hulten, 1996). They argue that if regulation could create enough niche markets so that some self-reinforcing processes would become possible, the electric vehicle might emerge as a visible part of the automobile market.

In this paper, I conduct a case study of a recent attempt by the Tokyo Metropolitan Government to replace diesel vehicles by low-emission vehicles such as compressed natural gas vehicles. The experience in Tokyo illustrates the possibility and limits of escaping a state of technological lock-in by coordinating the behavior and expectations of relevant actors. In the following sections, I examine this case in detail and analyze the results and revealed problems. Some policy and institutional implications are discussed at the end of this paper.

2. An Attempt to Replace Diesel Vehicles with Low-Emission Vehicles in Tokyo

Despite previous efforts to curb automobile emissions, the concentrations of nitrogen oxides (NO_x) and suspended particulate matters (PMs) have remained high in Tokyo. It is estimated that diesel vehicles are responsible for about 70% of the NO_x and almost all of the PMs emitted by automobiles. Following a strong political initiative of the Governor of Tokyo, the Tokyo Metropolitan Government (TMG) started a “Campaign for No Diesel Vehicles” in August 1999. The ultimate goal of this campaign was to promote the conversion of diesel vehicles to low-emission vehicles such as compressed natural gas (CNG) and liquid propane gas (LPG) vehicles.

The trends in the number of CNG and LPG vehicles are shown in Figure 1. At the end of March 2000, the number of CNG vehicles used in Tokyo was 601, which was just a tiny fraction of all the vehicles, compared with 447,000 diesel vehicles running in the same period (Yajima, 2000). Although these efforts have contributed to raising the public awareness of the serious issue of air pollution in Tokyo, they were not sufficiently effective in encouraging automobile users to switch from diesel vehicles to less-polluting vehicles such as CNG vehicles to a large extent.

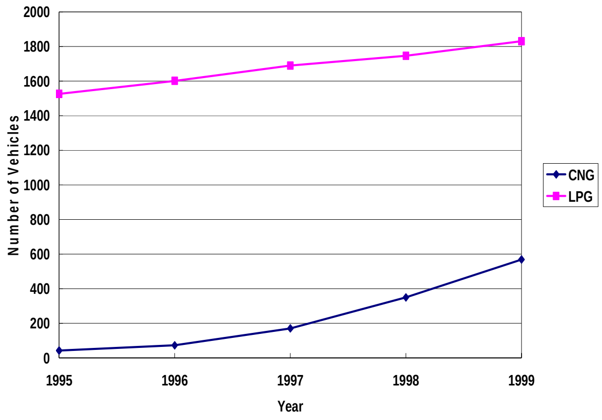

Figure 1 CNG and LPG Vehicles Used in Tokyo

Source: Tokyo Metropolitan Government (2000).

One of the reasons for this limited impact considered by TMG as crucial was coordination failures between car users, car makers, and fuel infrastructure providers. Car users do not buy CNG vehicles because they are expensive and it is not convenient to use these vehicles when there are not a sufficient number of natural gas fueling stations. Car makers, on the other hand, do not produce many CNG vehicles because users do not buy them, leaving the car prices high without economies of scale in production. And fuel infrastructure providers do not establish many natural gas fueling stations either, because there are not enough demands for natural gas used by CNG vehicles. These behaviors of the car users, car makers, and fuel infrastructure providers have created a vicious circle of lower demands and supplies, discouraging the introduction of CNG vehicles at a large scale.

Aiming at breaking the vicious circle, TMG started a new initiative which involved the relevant actors, that is, car users, car makers, and fuel infrastructure providers, to create a new market for CNG vehicles. In June 2000 the Bureau of the Environment of TMG invited major companies, including 13 car users, four car manufacturers, and four fuel infrastructure providers, to establish the Strategic Council for the Creation of New Markets to promote the introduction of CNG and LPG vehicles to Tokyo. The number of the participating companies was increased to 33 at the third meeting, with the addition of seven manufacturers of vehicles, including parts manufacturers, and five providers of fuel services. The Council was concluded with the fourth meeting held in November 2000 with the final participation of more than 200 companies.

One of the traditional roles which the public sector can play has been to provide public goods, which, at least theoretically, the market cannot supply or maintain. In this case, the intention of TMG was to support the proper functioning of the market mechanism, rather than replacing it (Figure 2).

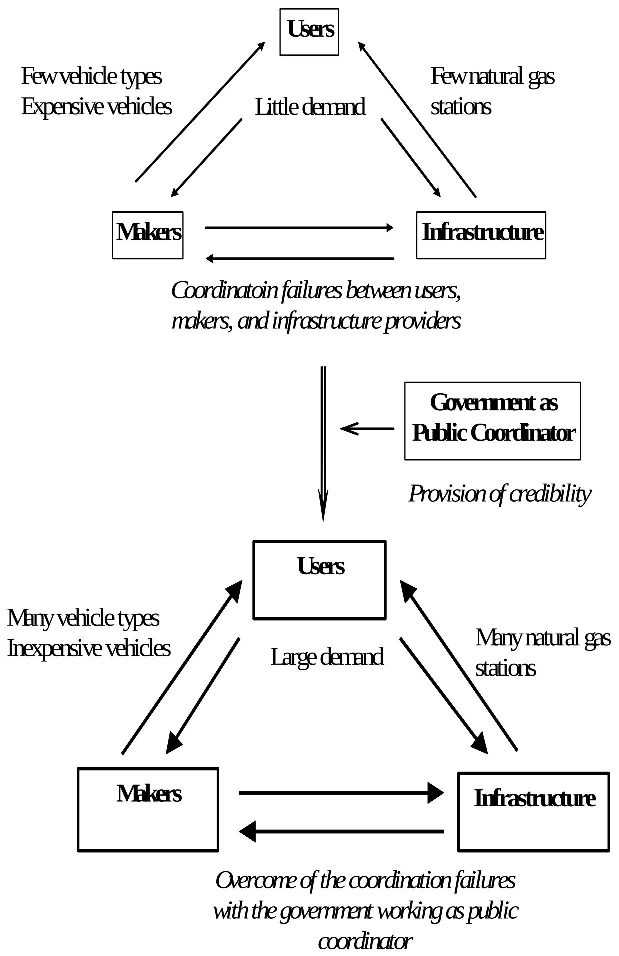

Figure 2 Public Coordination between Car Users, Car Makers, and Fuel Infrastructure Providers

The market could sustain two states, one in which there are few CNG vehicles and one in which there are many, because of the positive feedbacks between car users, car makers, and fuel infrastructure providers. They could be regarded as two equilibria, and the transition from one to the other would be difficult to happen spontaneously, hence reaching the state of technological lock-in. By working as a public coordinator of the expectations and behavior of car users, car makers, and fuel infrastructure providers, TMG intended to replace the socially inferior equilibrium involving few CNG vehicles with the socially superior one which can maintain a large number of CNG vehicles. TMG expected that the public sector would be able to provide sufficient credibility for the coordination mechanisms between the private actors, which is considered to be crucial in escaping lock-in.

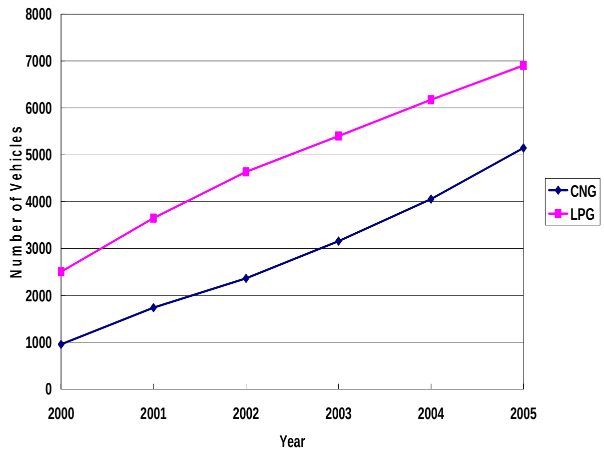

Figure 3 Plan of the Use of CNG and LPG Vehicles in Tokyo

Source: Tokyo Metropolitan Government (2000).

During the four meetings of the Council, the coordination failures between the car makers, car users, and fuel infrastructure providers were addressed. Effective measures were sought to overcome the coordination failures were actively thought by making the expectations and incentives of the relevant actors open to each other and encouraging honest and candid dialogues between the participants. At the end of the fourth meeting, the Council finally adopted the Tokyo Declaration for the Creation of New Markets, which basically said that car users will adopt more CNG vehicles, that fuel service providers will increase natural gas fueling stations, and that car makers will reduce the price and increase the variety of CNG vehicles at the same time. Effectively, the declaration made these commitments open to the public. Figure 3 gives the numbers of CNG and LPG vehicles planned to be used in Tokyo, based on the commitment which the participating companies have made to be implemented by 2005. If their commitments are to be implemented fully, more than 5,000 CNG vehicles will be running in Tokyo in 2005, an increase to almost ten times of those used in 1999.

3. Actors Involved in Introducing Low Emission Vehicles

In facilitating the introduction of CNG vehicles in Tokyo, three types of relevant actors were identified at the Strategic Council for the Creation of New Markets, namely, vehicle users, fuel infrastructure providers, and vehicle manufacturers. To investigate their behavior and expectations, as well as incentives behind them in detail, I focus my analysis on major actors in each of the three categories.

3.1 Vehicle Users

The council asked vehicle users to increase their adoption of CNG vehicles. I first look at the Tokyo Municipal Bus, which is owned and operated by TMG, as an important user of CNG vehicles in the public sector. Then I examine Sagawa Express, one of the largest private users of CNG vehicles in Tokyo.

3.1.1 Tokyo Municipal Bus

Tokyo Municipal Bus has adopted various types of measures for environmental protection since the early 1990s. Figure 4 gives the trends in the use of clean vehicles by the Tokyo Municipal Bus, including CNG, LPG, and hybrid vehicles, as well as diesel particulate filters (DPFs) designed to be installed for emissions from diesel vehicles.

While diesel hybrid buses were mainly introduced at the initial stage, the middle of the 1990s saw a shift in the emphasis to CNG buses, which can reduce the NO_x emissions by 60 - 70 %, compared with diesel buses, without producing any PMs. In January 1995 the Tokyo Municipal Bus started to operate the first CNG bus. One month later, a natural gas fueling station of its own was established at the Fukagawa bus terminal, and two more buses were introduced subsequently to evaluate the feasibility of CNG buses. The second natural gas station was built at the Rinkai bus terminal in March 1996, followed by the third established at the Kita bus terminal in March 1997. The introduction of CNG buses increased steadily, reaching as many as 28 in 1998. Recently, however, although the fourth natural gas station was built just next to the building of TMG, the adoption of CNG buses has declined to a low level, with only three vehicles purchased in 2000. Currently there are a little more than 100 CNG buses, which account for less than one tenth of the total of 1,591 buses operated by the Tokyo Municipal Bus.

Several factors could be identified to explain the relatively limited extent of the introduction of CNG buses by the Tokyo Municipal Bus. The first factor is the high price of CNG buses. Following the enactment of the Barrier-Free Law in November 2000, it has been required that municipal buses should have low floors for passengers with wheelchairs, effectively demanding the adoption of buses which contain no steps. No-step CNG buses are expensive, however, with their price of about 30 million yen, a price which is much higher than 22 million yen for ordinary CNG buses or 20 million yen for no-step buses with diesel engines. As no-step CNG buses, whose floor needs to be close to the ground, can not have a fuel tank under the floor, it has to be positioned on the top of the roof. That requires a special type of fuel tank which has sufficient strength with a light weight, in effect increasing the production cost, and hence the price, of CNG buses.

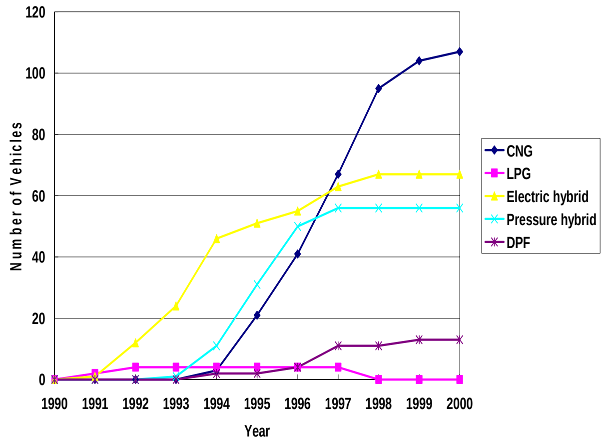

Figure 4 Use of Clean Vehicles by Tokyo Municipal Bus

Source: Tokyo Metropolitan Government (2001).

The second factor concerns the costly operation and maintenance of CNG buses. The reliability of various parts used in CNG buses was not sufficiently high initially, and there were many cases of malfunction, which required frequent repair. This problem has been improved to some extent since then through close cooperation and information exchange with car makers. And, as regulations concerning the safety of dealing with high-pressure gases were modified, the procedures for the inspection of fuel tanks have become simplified, reducing the maintenance cost of CNG buses. On the other hand, the natural gas fueling stations have been used intensively, and with various parts of the equipment worn out, the cost of maintaining the natural gas fueling stations has been rising.

As TMG is in a process of reviewing the subsidies to the Municipal Bus, it is now difficult to purchase as many CNG buses as before and to continue to establish and maintain natural gas fueling stations. This can be observed clearly in 1999 and 2000, when the introduction of CNG buses was particularly low, compared with the rapid increase in the previous years. The adoption of CNG buses is not expected to increase significantly in the future. While TMG is encouraging car users in the private sector to increase the adoption of CNG vehicles through the commitment at the Strategic Council for the Creation of New Markets, the extent of its own adoption is not particularly high. That would make TMG’s own political commitment to increase low-emission vehicles less credible to the participants in the Council.

3.1.2 Sagawa Express

Sagawa Express is a company which specialized in delivering goods to customers. The company started to operate clean vehicles in March 1991, with five electric vehicles introduced in Osaka and five methanol vehicles in Tokyo (Figure 5).

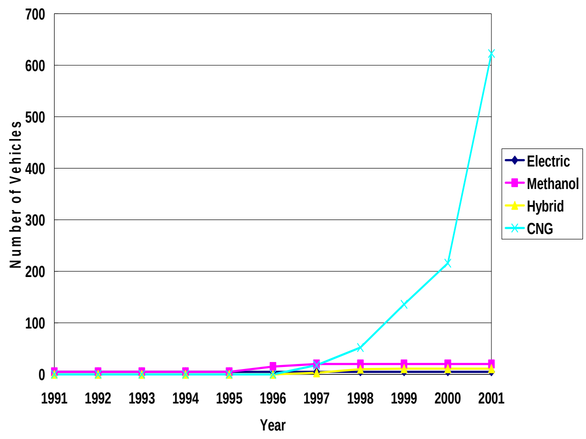

Figure 5 Use of Clean Vehicles by Sagawa Express

Sources: Sagawa Express (2001; 2001).

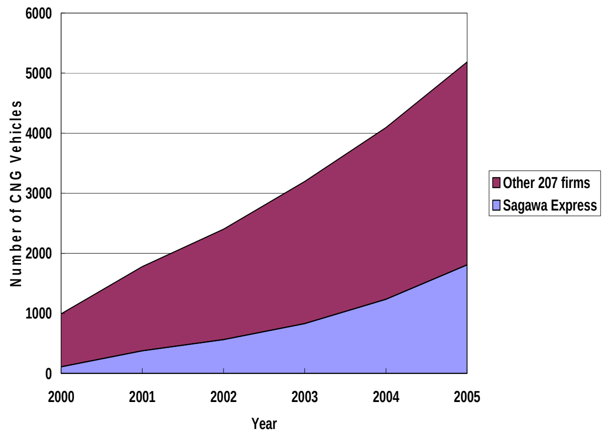

Figure 6 Plan of Using CNG Vehicles by Firms in Tokyo

Source: Tokyo Metropolitan Government (2000).

Although more methanol vehicles were adopted in subsequent years, the introduction of these two types of clean vehicles was basically stopped, as the company thought that the technical reliability of them was not improved to a satisfactory level. The company adopted 18 CNG vehicles for the first time in 1997. That decision was made by the company's top management when the Third Conference of the Parties to the United Nations Framework Convention on Climate Change (COP3/UNFCCC) was held in Kyoto, the city where its headquarters is located. Since then, CNG vehicles have been introduced at an increasing pace, and the total number of CNG vehicles operated by the company reached 623 in the fiscal year of 2001.

With other vehicle-operating companies which participated in the Strategic Council for the Creation of New Markets, Sagawa Express published its plan of introducing CNG vehicles by 2005, as you can see in Figure 6. CNG vehicles will be increasingly used by the company in the future. The total number of its CNG vehicles running in Tokyo is expected to reach 1,800 in 2005, which represents more than 30 % of approximately 5,200 CNG vehicles to be introduced by all the participating companies. Since the company operates approximately 3,400 vehicles in Tokyo, a little over half of them will be CNG vehicles, a ratio which is much higher than that for the Tokyo Municipal Bus.

While Yamato Express, a rival company in the same business, has basically decided to adopt LPG vehicles, Sagawa Express has chosen CNG vehicles. That is because the company considers that CNG vehicles emit much less carbon dioxide than LPG vehicles, which is an important factor for the company to be regarded as a user of clean vehicles. An additional factor would be the fact that the number of the company's distribution bases is relatively small, concentrated in several areas within Tokyo. That makes it easier and less costly for the company to utilize natural gas fueling stations in an efficient way, compared with its rivals.

The running cost of CNG vehicles per kilometer is approximately 14 to 18 Japanese yen. This is not significantly different from that of diesel vehicles, except for an increase in the cost of inspecting the fuel tank, which needs to withstand a pressure as high as 200 atm. A major obstacle to the introduction of CNG vehicles, however, is their high price, as is also mentioned in the case of Tokyo Municipal Bus. As you can see in Table 1, currently the cost necessary to convert a diesel vehicle to a CNG vehicle is estimated to be 1,460,000 yen for a two-tonne truck. Financial support from various sources, including public organizations such as TMG and New Energy and Industrial Technology Development Organization (NEDO) as well as those in the private sector like Tokyo Gas Company, accounts for 1,280,000 yen, almost 90 % of the necessary cost. That allows the company to pay only 180,000 yen, which is a little more than 10 % of the original cost. In this way, the purchase of CNG vehicles is heavily dependent on the availability of subsidies.

Another obstacle is the lack of natural gas fueling stations. Sagawa Express established its own natural gas station for the first time in April 1994. This construction, however, which cost 120 million yen, was only possible by relying on subsidies provided by TMG and NEDO. As this fueling station can supply natural gas to only 80 trucks a day, a tiny fraction of the CNG vehicles operated by the company daily, the company needs more fueling stations. That will require a significant amount of investment, which would be a difficult task to implement by a single private company. Although the total number of natural gas fueling stations in Tokyo is rising, they will not be sufficient to deal with more than 1,700 CNG vehicles to be introduced by 2005. While the company has established two natural gas stations by itself, the company emphasizes it is important that much more natural gas stations should be established by fuel infrastructure providers in order to increase the number of CNG vehicles.

Table 1 Composition of Payment for the Purchase of CNG Vehicles

Conversion Cost from a Diesel to CNG vehicle[a]		1,460,000 yen[c]
Subsidies	NEDO[b]	730,000 yen
	Japan Trucking Association	200,000 yen
	TMG	300,000 yen
Purchase Promotion	Tokyo Gas Company	50,000 yen
Actual Payment	Sagawa Express	180,000 yen

a: The calculation is based on a 2-tonne truck produced by Isuzu Motors.
b: New Energy and Industrial Technology Development Organization. NEDO provides subsidies for just a half of the cost necessary for the purchase of CNG vehicles. The target set by NEDO is to support the purchase of 5,000 CNG vehicles.
c: One US dollar is equal to approximately 120 Japanese yen in summer 2001.
Source: Sawaga Express (2001).

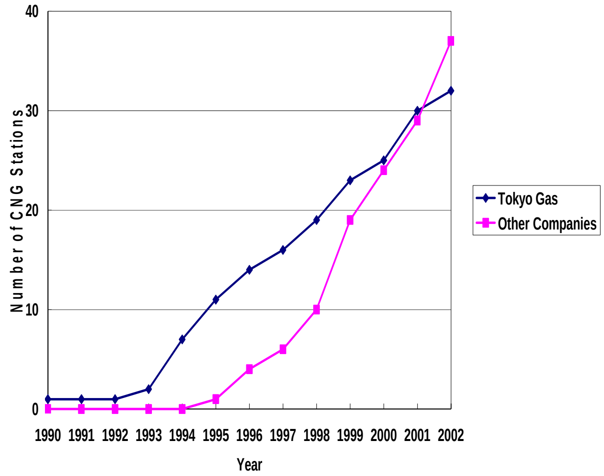

Figure 7 Installation of CNG Stations in the Kanto Region

Data as of June 14, 2002.
Calculation based on Japan Gas Association (2000) and Tokyo Gas (2001; 2002).

This point of the insufficient establishment of infrastructure for natural gas would be a critical bottleneck in introducing CNG vehicles. That would increase the necessity of close coordination with regard to investments to be made by vehicle users and fuel infrastructure providers.

3.2 Fuel Infrastructure Providers

Fuel infrastructure providers were requested by the Strategic Council to increase the number of CNG stations established in Tokyo. At the end of March 2000 there were only 20 CNG stations in Tokyo, among which only 11 stations were open to the general public. I take a close look at the case of Tokyo Gas, one of the leading fuel infrastructure providers in the region.

3.2.1 Tokyo Gas

Tokyo Gas is the largest gas company, not only in Tokyo but also in Japan. The company has been actively promoting the use of CNG vehicles, which will increase the demand for natural gas, the company's main product. A project team for CNG vehicles was established within the company in 1991. The Japan Gas Association, which includes Tokyo Gas as a member, also established its CNG vehicle division one year later. Figure 7 indicates that the company has so far built 32 CNG stations in the Kanto Region, which is the most populous region containing Tokyo. While other companies, including several gasoline suppliers, have started to construct CNG stations recently, Tokyo Gas has remained the major CNG-providing company, accounting for just less than a half of the total of 69 CNG stations located in the Kanto Region.

Requested by the council, Tokyo Gas presented its plan of constructing natural gas stations in the future. According to the plan, the company will continue to be the main provider of CNG fueling stations, with its steady, long-term commitment to construct at least five natural gas stations every year until 2005. On the other hand, there are only a handful CNG fueling stations which were planned to be installed in 2000-2001 by other energy companies such as Cosmo Petroleum and Nichimen Energy. Tokyo Gas basically considers itself as a company which specializes in providing natural gas, lacking sufficient knowledge and expertise on know-how necessary to manage and operate fueling stations for automobiles. It hopes that other companies will increase their own constructions of CNG stations in the future.

A crucial problem in increasing the number of CNG stations is the high cost of their establishment. Although Tokyo Gas is willing to continue to make investments in the fueling infrastructure, the cost of constructing a CNG station is very large, ranging from 90 to 120 million yen. Currently, generous subsides are provided by NEDO to support the so-called eco stations, which include the supply of natural gas, together with electricity and methanol for clean vehicles. Table 2 gives the composition of the subsidies for establishing eco stations. Compared with approximately nine billion m^3 of natural gas which the company deals with annually, the amount of natural gas consumed for CNG vehicles is currently less than 1 million m^3, still far short of the scale necessary to have any impacts on the corporate strategy. As the sales of natural gas for CNG vehicles are still a tiny fraction of the whole business, it would be difficult for the company to maintain the construction of as man CNG stations as the current level.

Table 2 Subsidies for the Establishment of Eco Stations

Object	Amount	Remark
Establishment	90,000,000 yen	Target of 30 eco stations
Operation	2,000,000 yen	For the initial three years
Conversion of facilities	17,000,000 yen	

Source: Japan Gas Association (2000).

Potentially, oil companies could contribute to increasing facilities for providing natural gas by expanding the gasoline stations they have already established. That would be efficient in the sense that economies of scope could be utilized. Currently, however, although some companies, notably Cosmo Petroleum, are engaged in establishing infrastructure for natural gas, basically there is little inventive for other oil companies to make large investments in constructing CNG stations. That is hardly surprising, considering that natural gas competes directly with the conventional gasoline as the fuel for automobiles. It would be only after they are convinced that there will be a large shift from gasoline vehicles to CNG vehicles that they could be expected to start to actively establish infrastructures for providing natural gas. That, in turn, would depend on how many CNG vehicles would be demanded by car users.

3.3 Vehicle Manufacturers

The Strategic Council has asked vehicle manufacturers to reduce the prices of CNG vehicles, to increase the cruising range and the efficiency in fuel consumption, and to improve the maintenance and inspection systems for CNG vehicles. To examine the behavior of the manufacturers of CNG vehicles, we look at the case of Isuzu Motors.

3.3.1 Isuzu Motors

Isuzu Motors is currently the largest maker of diesel vehicles in Japan. Its corporate strategy is basically that diesel vehicles will remain the company's main type of vehicles, coupled with further improvement in pollution abatement technologies such as new catalysts, filters, and engines. As the air pollution issue is increasingly becoming serious in large cities, however, the company expects that CNG vehicles will play a role in ameliorating the air quality in urban areas, while rural areas will continue to depend on diesel vehicles, whose thermal efficiency is very high, which could contribute to reducing CO_2 emissions.

As the scale of the CNG vehicle market is small, with an annual production of 700 vehicles in Japan, it is difficult for car manufacturers to exploit the economies of scale fully. Thus the production cost of CNG vehicles remains high, compared with that of conventional diesel vehicles widely used for buses and trucks.

Table 3 Expected Reductions in the Price of CNG Vehicles

Car maker	Vehicle type	Current price	Target price	Minimum production
Nissan Diesel	Medium-sized truck, 4 t	9.20 M yen (1.9)	7.50 M yen (1.5)	1,000 vehicles /year
Hino	Short flat-floor truck, 2 t	4.47 M yen (1.6)	4.19 M yen (1.5)	1,000 vehicles /year
Toyota	Standard truck, 2 t	4.67 M yen (1.7)	4.10 M yen (1.5)	1,000 vehicles /year
Mitsubishi	Small-sized truck, 2 t	4.78 M yen (1.65)	4.00 M yen (1.38)	1,000 vehicles /year
Isuzu	Long flat truck, 2 t	4.80 M yen (1.6)	4.00 M yen (1.35)	5,000 vehicles /year

The numbers in parenthesis refer to the ratio of the price of CNG vehicles to that of diesel vehicles of the same type.
Source: Tokyo Metropolitan Government (2000).

Table 3 shows some of the estimations made by the major producers of CNG vehicles, concerning the price reductions which could be expected when the production level is increased. The table includes the data provided by Nissan Diesel, Hino, Toyota, Mitsubishi as well as Isuzu. As you can see, the current level of production is far less than that required by these manufacturers to reduce the cost of production. One of the factors contributing to the high manufacturing cost is that CNG vehicles require special parts such as fuel tank which can withstand high pressure with a light weight. Since these parts are produced only for a limited number of specialized products, their demands are relatively small, which results in high prices. Potentially effective measures to solve this problem would be the standardization of the size and shape of various parts and joint purchases from parts makers. It might be difficult that these measures will be actually adopted by the car manufacturers, as they are competing with one another in the same market. Nevertheless, this point illustrates the possibility of ameliorating a state of technological lock-in through coordination of actors' behavior.

Another important issue concerning the introduction of clean vehicles is that there are currently several types of alternatives which could replace the currently dominant gasoline vehicles. In addition to CNG vehicles, they could be electric vehicles, methanol vehicles, hybrid vehicles, hydrogen vehicles, and, sometime in the future, fuel cell vehicles. Different companies would have different corporate strategies regarding the type of clean vehicles on which they focus. For example, Isuzu Motors is not particularly interested in developing fuel cell technologies at this moment, because the company expects with sufficient confidence that diesel vehicles, with their economic and environmental performance significantly improved, will be able to compete with fuel cell vehicles in the long run.

On the other hand, companies like Toyota and Honda have been actively involved in conducting research and development (R&D) activities on hybrid vehicles and fuel cell vehicles, the extent of which could be observed by examining corporate strategies (Mytelka, 2003). In particular, their hybrid vehicles have been marketed aggressively and sold well not only in Japan, but also in the United States and Europe (Shiroyama, 2001). Under the presence of diversity of alternative technologies, different types of clean vehicles could be pursued by different companies. That in effect will induce divergent demands for fuels among natural gas, methanol, hydrogen, and gasoline. Coupled with the establishment of different types of fuel stations, the car manufacturers cannot achieve the economies of scale in their productions, which would be crucial in reducing the price of alternative vehicles.

4. Regulatory Conditions

In addition to the behavior of the car users, car manufacturers, and infrastructure providers, it is important to take into account other factors which would influence the introduction CNG vehicles. Here I consider the regulatory conditions influencing the behavior of the relevant actors. It is interesting to note that while regulations on emissions from diesel vehicles have been tightened, other regulations concerning the use of CNG vehicles have been relaxed.

On the one hand, a new regulation has been enacted since October 2003, which specifies standards for PMs emitted by new diesel vehicles as well as those currently in use. That effectively requires the users of diesel vehicles to install the DPFs approved by the governor of Tokyo. Furthermore, another regulations has been introduced, by which large companies operating more than 200 vehicles are required to adopt clean vehicles for at least 5 % of the total number of vehicles they use by the end of March 2005 (Tokyo Metropolitan Government, 2002).

On the other hand, several regulations have been relaxed in order to remove obstacles for the introduction of CNG vehicles. Table 4 gives some of the revisions and modifications of the regulations concerning the handling of high pressure gases such as compressed natural gas, the operation of CNG vehicles, and the establishment of natural gas fueling stations. The High Pressure Gas Safety Law, Gas Utility Industry Law, Fire Service Law, and Road Transport Vehicles Law are among those regulations which have been revised or modified, making the construction of CNG stations and the use of CNG vehicles less costly and, consequently, easier.

Table 4 Revision of Regulations on the CNG Vehicles and Refueling Stations

Regulation	Revision
High Pressure Gas Safety Law	
• 1st revision (3/1994)	- Established new standards for CNG vehicles and their refueling stations
• 2nd revision (4/1997)	- Deregulated mobile standards which restrict parking space, etc. - Reduced the number of qualified safety officers - Deregulated re-inspection for vehicle cylinders - Reduced safety distance at refueling stations
• 3rd revision (4/1998)	- Established new standards for all-composite tanks
Gas Utility Industry Law	
• 1st revision (3/1995)	- Specified the vehicle refueling appliance (VRA) as a gas installation - Excluded VRA from the application of the High Pressure Gas Safety Law
• 2nd revision (2/1996)	- Abandoned the requirement for permission for the sale of CNG
Fire Service Law	
• 1st revision (4/1995)	- Enabled the construction of CNG refueling stations together with gasoline stations
• 2nd revision (3/1997)	- Established new standards for setting up compressors underground
Road Transport Vehicles Law	
• Revision (12/1995)	- Established new standards for CNG vehicles - Enabled ownership by anyone as for ordinary vehicles

Source: Japan Gas Association (1999).

Beyond those rather practical revisions and modifications of specific regulations concerning CNG vehicles, however, there is no clear plan for the future use of natural gas in the transportation sector. That has resulted in inadequate confidence among the relevant actors to make large investments in CNG vehicles and fueling stations. This could be dealt with appropriately by energy policies at the national government level.

5. Concluding Remarks

In an attempt to escape the state of technological lock-in, TMG started a new initiative to create a large market for low-emission vehicles. The initiative was intended to overcome coordination failures between car users, car makers, and fuel infrastructure providers through commitments made by the actors with regard to the use of low-emission vehicles. To the extent that the number of CNG vehicles used in Tokyo is expected to increase from about 600 in 2000 to over 5,000 in 2005, it could be argued that this new type of public initiative has succeeded in encouraging the introduction of CNG vehicles in Tokyo.

Compared with 450,000 diesel vehicles currently running in Tokyo, however, this level of CNG vehicles is still low, which is equivalent to just one percent of the number of diesel vehicles. And the establishment of natural gas fueling infrastructure remains very small, compared with the existing conventional gasoline stations. Thus, TMG's new initiative was not successful in achieving a transition from the lower equilibrium with few CNG vehicles to the higher equilibrium with a large number of vehicles. More than five billion yen was spent as subsidies for CNG vehicles in 2000, a half of which was allocated to the purchase of vehicles and another half to the construction of fueling stations (Japan Gas Association, 2000).

While the traditional roles of the public sector were considered to be correcting market failures and providing goods which market cannot support, this case shows the possibility and limit of the role of public coordinator. TMG attempted to provide credibility to the commitment made by the participants, which was expected to function to coordinate the expectations and behavior of the relevant actors towards introducing CNG vehicles. In addition to the imposition of regulations on emissions and provision of subsidies to R&D activities, the public coordination of the behavior and expectations of private actors could be a new role which the public sector legitimately plays. By supporting the proper function of the market mechanism, this new function could open a potential of going beyond the traditional division of market failures and government failures.

TMG's efforts to rectify the coordination failures, however, could not succeed in escaping the state of technological lock-in. The planned use of clean vehicles in the future was limited to a low level. As a majority of the CNG vehicles would be introduced by a single company, the commitment by other car uses, including TMG itself, to introduce clean vehicles was simply not sufficient. Automobile manufacturers could gain only a very small market for CNG vehicles they produce. Hence the economies of scale could not be utilized to a full extent. Also the scale of the establishment of natural gas fueling stations remained negligible, as most of the gasoline suppliers are not interested in providing natural gas at their existing stations. That diminished the potential of the economies of scope in providing fuels.

In the end, the intended coordination of the behavior and expectation of the relevant actors was not sufficient to make it possible for the market to reach a scale on which its spontaneous evolution becomes feasible. That could occur in the presence of technological uncertainty, diversity, and interconnectedness. Car manufactures would choose different corporate strategies, between pursuing the existing technology of diesel vehicles with pollution abatement equipment and developing new clean technologies such as CNG vehicles, under large uncertainty with regard to which technology will be the best in the long term. Similarly, fuel suppliers would decide on the type of fuels they provide, between the conventional gasoline and new fuels such as natural gas, methanol, or hydrogen, without knowing which one will be demanded most. As expectations could be diverging, it is crucial that the relevant actors are strongly convinced that a specific type of clean vehicles will become dominant for a robust coordination.

The extent of available knowledge and information would be limited with regard to the characteristics and progress of diverse technologies, including CNG vehicles, electric vehicles, methanol vehicles, hybrid vehicles, hydrogen vehicles as well as technologies for the reduction of pollutants emitted from diesel vehicles such as DPFs. Thus it might not be appropriate for the public authority to pick up a particular type of clean vehicles from the beginning. Information on the experience and interest should be shared among the stakeholders, and they should be encouraged to be actively engaged in an evolving process of learning at the public arena for potential coordination. Although the recent attempt by TMG did not turn out to be a remarkable success, at least it could be regarded as a step in the right direction.

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参加者行動・期待の公的コーディネーション：東京における低公害自動車導入の試み

Public Coordination of Participants' Behavior and Expectations: An Attempt to Introduce Low-Emission Vehicles in Tokyo

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社会技術を実践する方法論として、公的セクターの介入が、規制によって市場を代替するのではなく、むしろ市場機能をサポートすることによって新技術の導入を促進することが有望と考えられる。本研究では、東京におけるディーゼル車から低公害自動車への転換に関して、ユーザー・自動車メーカー・燃料提供者の間のコーディネーションの失敗を解消することを目指し、公的な場における各関係者間での情報交換・意思疎通を通じた相互の行動・期待のすり合わせによって新しい技術の市場を創造しようとする試みを取り上げ、その成果と課題を分析した。

キーワード：公的コーディネーション、低公害自動車、技術的ロックイン