B-55.6 A study on renovation of urban transport systems for complying with the emission reduction target (Final report)

Contact Person Yuichi Moriguchi
Section Head, Social and Environmental Systems Division,
National Institute for Environmental Studies, Environment Agency
16-2 Onogawa, Tsukuba, Ibaraki 305-0053 Japan
Phone +81-298-50-2540 Fax +81-298-50-2572
E-mail moriguti@nies.go.jp

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Abstract: This research aims to develop a methodology to introduce policies to lower the environmental load of urban transport systems and to estimate the target value of reduction resulting from each countermeasure in a city scale. In addition, the study seeks to formulate necessary policy options for Japan, which are feasible in achieving the calculated target value in reducing future CO_2 emission. A financing scheme for the implementation of the policy instrument packages is also established.

Analysis of recent trend in Japanese CO_2 emission reveals that the large increase of the transport-related emission since late 1980s was mainly due to worse fuel efficiency of larger-sized private passenger cars.

In examining the policy packages for environment load reduction, the study collects contemporary policy cases in OECD countries, particularly that of the EU countries and summarizes the effects as well as problems associated with these policy cases. Transport policies in EU countries are characterized by the recognition of international joint implementation in the improvement of inter-city network, especially railway, in coordination with each country's original domestic countermeasures. Such a case is among the main focus of this study.

In order to secure information on the policy trends and discussions on transport policy directions, the research group participated in the "Environmentally Sustainable Transport (EST)" project, wherein experts in the OECD countries present various transport-environment countermeasures together with their results and evaluation. Survey and interviews involving persons in charge of the transport-environment policy in each country was also conducted.

Finally, the study forecasts the environmental load reduction attributed to the introduction of Transit Oriented Development (TOD) in a Japanese city, and implicates the required policies on transport, land-use planning, financing, and taxation.

1. Introduction

All over the world, environmental load, such as CO_2 emission, from the transport sector is drastically increasing. This trend is expected to continue without the implementation of any appropriate countermeasures. In Japan, effective measures against the rapid growth of CO_2 emissions from transport sector are urgently needed. However, definite emission reduction targets from the transportation sector for each city type are currently not established. This results to difficulties in decision making on coming up with suitable transport policies for each city.

On the other hand, EU countries set their target reduction values by "back casting approach"; a method wherein the required reduction value and the contribution of each policy implementation are determined based on the forecasted future trend of emissions. This target value is used in establishing reduction policies.

2. Research Objectives

Recognizing such situation, this study aims to present the target values for the case

of Japan, together with the corresponding transport policy options required in achieving a reduction of CO_2 emissions that will set it in its acceptable level by the year 2010.

3. Methods, results and discussions

(1) Analysis of the recent trend of CO_2 emissions in Japan

In order to grasp the overall trend of CO_2 emissions in Japan, sectoral emission inventory during past 30 years were compiled using energy balance statistics by types of major energy-related activities; energy conversion, industry, residential and commercial (R&C), and transport. Since the first oil crisis in 1973, each sector shows considerably different trend. Among them, the emission from the transport sector shows almost constant upward trend. As a consequence, the transport-related CO_2 emission in late 1990s is more than twice compared to the emission in 1973. In particular, there found constant and large increase of the emission from transport sector in 1990s, in spite of the smaller or even negative growth in GDP.

In order to investigate the reason of such specific trend in the transport sector, several indicators representing the structure of energy consumption for both passenger and freight transport were selected and their trends were analyzed. During the period from 1990 to 1996, the growth in the energy consumption for passenger transport was as much as 25%, whereas the growth for freight transport was 12%. More specifically, the energy consumption by private passenger cars has shown 35% growth (40 % if light passenger cars is included), and this contributes largely to the overall increase in CO_2 emission of the sector.

Then the energy consumption was further broken down to indicators of traffic volume and fuel efficiency. The increase in passenger-kilometers traveled by private passenger cars is about 20% during this period, which is slowed down compared to the 44% increase in the latter half of 1980s. Nevertheless, the energy consumption in absolute term shows higher increase because of the worse fuel efficiency. The fuel efficiency per passenger-kilometer basis in 1996 was 17% worse than in 1990, whereas there was 14% improvements from 1985 to 1990. Although the almost constant growth in energy consumption (4-6% per annum) has been observed during late 1980s and early 1990s, the main factor contributing to the growth has shifted from the longer travel distance to the worse fuel efficiency.

It is often said that the fuel efficiency of cars has been improved. This may be true for the same displacement category. However, the considerable increase of larger sized private passenger cars since the end of 1980s has made the societal average fuel efficiency much worse than ever. Large sized cars are typically RVs (recreational vehicles) to satisfy the increasing demand of recreational use of passenger cars. Lighter taxation on the larger-sized cars by tax reform in 1988 seems to move toward opposite direction to "green tax reform".

(2) Classification of transport-environment policies

A field research and interview survey aimed to compile various transport-environment policies particularly on the reduction of environmental load was conducted for EU countries. These policies are then categorized based on: a) the degree of environmental influence, and b) the methodology. The policies were then analyzed in order to understand the relationship mechanism between the countermeasures and the corresponding environmental load reduction.

a) The transport- environment influence mechanism

The mechanism wherein transport influences the environment can be understood by illustrating the phases of the implementation of transportation projects as shown in Figure 1. This involves six phases namely: 1) background, 2) policies/countermeasures, 3) causes, 4) transport phenomena, 5) environmental impacts and 6) social problems.

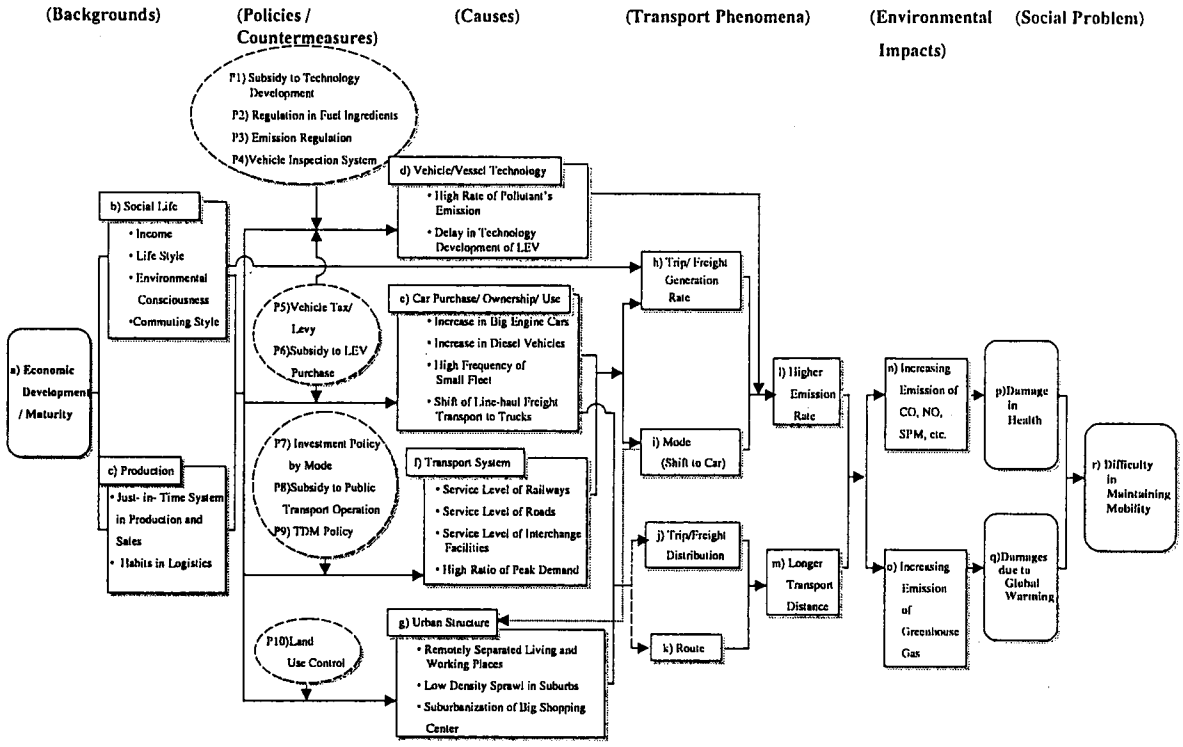

Figure 1. The mechanism that transport influences the environment

Transportation changes the background of the environment as it results to (a) economic development/maturity. This in turn, influences (b) the people's social life in the form of changes in income, environmental consciousness, and commuting style; and likewise influences the (c) firms' production in the form of changes in the system of operation in production and sales, as well as, some practices in logistics.

Such background factors, together with the influence of the countermeasures, influence the development of transport phenomena. Meanwhile, the cause factors are classified into four, namely: (d) vehicle technology, (e) car purchase, ownership and use, (f) transport system, and (g) the urban structure. The state of vehicle technology includes items such as type of vehicle/vessel and quality of engine/motor. The state of car purchase, ownership and use, includes the shift in engine / motor type (e.g. gasoline, diesel, hybrid, electric, natural gas, etc.) and car class, which are strongly influenced by the tax/levy structure and subsidy. The state of transport system includes the service levels of railways, roads, ports, airports and interchange systems with respect to other modes. This is a factor of infrastructure improvement and operation management, which are influenced by the policies of investment, the operation subsidy and TDM. Finally, the urban structure includes the distance between work places and houses, the density of sprawl in suburbs and the sub-urbanization of big shopping centers, which are influenced by the land use control systems.

The actual flow of influence is different between developed and developing countries. In developed countries, urban structure is almost fixed and, therefore, is not a dominant factor of change in the environment while in developing counties, controlling sub-urbanization is an essential factor under a rapid urban population growth as it determines the future long- term effects.

b) Policy approaches in dealing with environmental indicators

Transportation policies for the improvement of the environment are classified into: 1) technological; 2) institutional; and 3) enlightening policies.

Technological policies are classified into three types. The first type is the vehicle/vessel technology which improvement of engine technology; like improvement of gasoline engine; and development of low emission vehicle such as electric and hybrid cars. The second is the infrastructure structure and construction technology which includes tunnels / bridge or earth embankment/cut works. The third type is the infrastructure management which includes traffic demand management, ITS and other management technologies.

Meanwhile, institutional policies are classified in two: the non-economic policies and the economic policies. Non-economic policies includes fuel ingredient regulation, emission regulation, traffic management and land use control; while the economic policies includes the greening of car related taxes, road pricing, subsidies to construction and operation of low emission mode and interchange facilities between modes.

Enlightening policies include education in schools, promotion of ecological driving, and penetration of environmental consciousness through pricing and taxation.

(3) Participation and data collection at the Environmentally Sustainable Transport (EST) project

In 1995 the OECD initiated the Environmentally Sustainable Transport (EST) Project. The objective of the EST Project is to facilitate the development of environmentally sound transport policies, taking into account the environmental impacts at the global, regional, and local levels. The project is also an attempt to establish a venue upon which a wide range of stakeholders including policy makers and economists can communicate. The project operates within a framework that goals, objectives, targets, or standards can be set by the government and be implemented effectively.

The EST Project is consists four phases. Phase 1, includes the review of the relevant activities of member countries; as well as the development of the working definitions and criteria for EST. Phase 2 is primarily scenario development wherein several scenarios are constructed with the participation of member countries. The scenarios include the business-as-usual scenario (BAU) and three emission reduction scenarios referred to as EST1, EST2 and EST3. EST1 pertains to emission reduction attributed to the innovation of emission technologies, while EST2 pertains to emission reduction attributed to the control of transportation demand. EST3 represents the combination of EST1 and EST2. Phase 3 mainly concerns with the identification of policy instrument packages for the implementation of the constructed scenarios. This phase also involves the refinement of EST3 scenario together with the assessment of the social and economic implications of the BAU and the EST3. Phase4 comprises the refinement of the definition and criteria of achieving EST and the establishment of policy guidelines on development in relation to EST.

The Project instilled a fundamental consciousness that guided as to what research the Japanese participants should undertake in relation to the OECD/EST scheme. As a result, the EST Japan committee headed by its chairman, Professor Yoshitsugu Hayashi, conducted a study that analyzes the effects of taxation to the car cohort and the total Life Cycle CO_2 emissions. The results of the study are reported to EST committee.

(4) Estimation of nationwide CO_2 emission reduction targets

To estimate for the necessary nationwide reduction in environmental load, this study utilized the backcasting approach that was formulated in the EST project. The target value of CO_2 emissions from the Japanese urban transport in 2010 is assumed to be the same level as that in the 1990. The needed amount of reduction for different policy options in order to achieve the target value is calculated.

Particularly for the urban passenger transport, the target value in relation to the population size of the city is estimated, according to the characteristics of urban transportation activities. Several suitable transport policy alternatives for each city size

Table 1. Estimated results of the CO_2 emission and increase rate for each city size

City group (Number)	1990		2010							
			Do Nothing				20% improvement of fuel efficiency			
	Total [kt-C/ year]	Per capita [t-C/ year]	Total		Per capita		Total		Per capita	
			[kt-C/ year]	Increase rate[%]	[t-C/ year]	Increase rate[%]	[kt-C/ year]	Increase rate[%]	[t-C/ year]	Increase rate[%]
Tokyo ward area (1)	1,072 (4.8%)	0.133	1,246 (3.8%)	16.2	0.172	29.5	1,052 (4.0%)	-1.9	0.146	9.3
Over 1 million (19)	3,922 (17.4%)	0.175	5,850 (17.9%)	49.2	0.240	37.2	4,799 (18.1%)	22.4	0.197	12.5
0.5 -1 million (193)	7,632 (33.9%)	0.188	11,555 (35.3%)	51.4	0.255	36.0	9,381 (35.4%)	22.9	0.207	10.4
0.1-0.5 million (3,018)	9,897 (43.9%)	0.192	14,041 (42.9%)	41.9	0.262	36.8	11,248 (42.5%)	13.7	0.210	9.6
Total	22,523 (100%)	0.183	32,692 (100%)	45.1	0.251	36.6	26,480 (100%)	17.6	0.203	10.7

were assessed and considered.

The CO_2 emissions from passenger transport in 2010 are estimated for different reduction scenarios and city types as presented in the Table 1.

As a result, it is found that there is no single policy option is effective, even if vehicle fuel consumption efficiency would be drastically improved. This suggests the necessity of combining various policy options. The result further shows that effective measures are essential in small cities, whose transport activities are strongly dependent on automobiles, comprising about 80% of the total CO_2 emission from urban passenger transport.

(5) An examination of the feasibility of CO_2 reduction due to Transit Oriented Development (TOD)

Based on the results of the policy surveys conducted in the EU countries, it is found that the following concepts are necessary in order to realize a low-emission city. These concepts include: a) the integrated and seamless transport systems; b) land use planning in consideration of reduction of transport-related environmental load; and c) the utilization of the polluter pays principle (PPP) in securing financial resources. One of the countermeasures that encompass all these concepts is the Transit Oriented Development (TOD). The TOD promotes a compact and concentrated development in areas near stations public transport facilities as these developments result to areas of low emission type. TOD was first initiated in the US, and is presently spreading in the EU countries.

The establishment of TOD project requires land use planning system such as the ABC policy in Holland, wherein the developments are based on the condition of public transport infrastructure provision. This policy makes the land value in TOD area increase. The capital gain can then be eased to public transport provision and maintenance. Naturally, vehicle transport itself and suburbanized location, which induces vehicle transport, should share in the payment of environmental cost in form of tax.

This study calculates the environmental effects and other influences of a public transport facility in a case study area involving a typical car-dependent city in Japan. Two cases were considered, namely: a) new LRT (Light Rail Transit) provision only; and b) new LRT provision and TOD-type redevelopment. Accordingly, it is forecasted that the first case produces little shift from car to tram, and the effect of emission reduction is very low. In this case, it will be necessary to subsidize the tram operation because of the low ridership, even if all construction cost is paid by public budget. However, in the case

in which TOD is implemented with the public transport improvement, tram operation yields no loss and in addition, it even results to sufficient environmental load reduction. The realization of such scenario requires support through institutional and economic incentive, promoting full subsidization of the construction of LRT and the promotion of high-density development along the LRT line.

(6) Effects of car-related tax weights between purchasing, owning and using stages

This study also provides a tool to examine the changes in car market configuration, the life cycle CO_2 emission from automobile transport and the tax revenues due to taxation policies. In order to estimate the effects of tax policy on CO_2 emission quantitatively, a model system that forecasts car cohort by engine class and age is developed. It contains models, which represent economic behavior when the tax rates are changed in the stages of 1) purchasing, 2) owning, and 3) using of cars. As this model system can forecast the number of existing cars by engine class and age, it makes it possible to examine the balance in taxation rates among the three stages of car ownership for reducing life cycle CO_2 emissions. An example of output of the model is the estimation of the impact of the 1989 Tax Reform.

In Japan, car-related tax rates were considerably changed due to the tax reform in 1989 when consumption tax was introduced. Before 1989, passenger cars were classified into big passenger cars (whose displacement is roughly over 2,000cc <class A>) and small passenger cars. Tax rates for purchasing and owning of big passenger cars were about twice as high as those of small passenger cars were. But, after the tax reform, the tax rates for purchasing and owning for both classes became almost equal. As a result, the number of purchase of big passenger cars increased drastically.

The developed model was applied in analyzing the 1989 Tax Reform in order to test how the model estimates the (a) changes in car class share; (b) the amount of CO_2 emission; and (c) the amount of car-related tax revenue due to the tax reform. The result

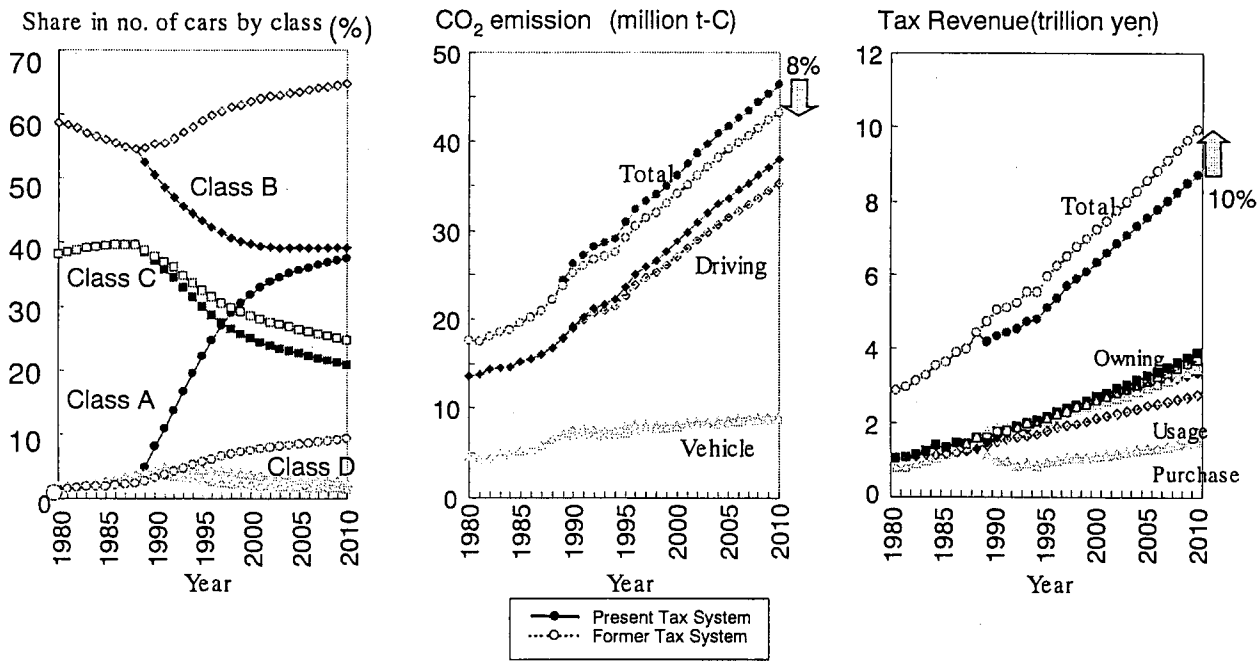

Figure 2. Forecast in cases of keeping current tax rate and resetting the rate at the rate before 1989 tax reform

* Class A: 2,001 cc or bigger, Class B: 1,501 cc - 2,000 cc, Class C: 1,001 cc - 1,500 cc, Class D: 1,000 cc or smaller

shows that, if the tax reform had not been executed, the shift from Class B to Class A (big passenger cars) cars had not occurred, and that the CO_2 emission from all passenger cars in 2010 could have been lower by 8 %. Accordingly, the tax revenue would have been higher by 10%. The calculated result is presented in Figure 2.

Using this model, it is found that the spiral rating of purchase and ownership taxes according to engine size, as shown above, is effective in reducing CO_2 and in securing financial resource.

4. Summary

The following items briefly summarizes the output of the study:

1) Analysis of the recent trend in Japanese CO_2 emission reveals that the large increase of the transport-related emission since late 1980s was mainly due to worse fuel efficiency of larger-sized private passenger cars.

2) Based from the forecasting results, the amount of transport-related CO_2 emission in 2010, will increase by 40% from that in 1990, if no reduction plan is implemented, particularly that the increase in passenger transport is remarkable. Restraining such emission increase requires not only countermeasures on the generation source but also complex countermeasures on transport system and urban structure.

3) Various transport-environment policies on environmental load reduction were compiled from the conducted survey involving EU countries. An analysis on these policies leads to the investigation of the mechanism of relationships between countermeasures and environmental load reduction.

4) Analysis of the countermeasures adopted in EU countries indicated that policy options on environmental load reduction requires the implementation of various planning concepts. These includes: a) integrated and seamless transport systems; b) land-use planning concerning reduction of transport-related environmental load; and c) collection of financial resources based on polluter pays principle.

5) Further, the study presented countermeasure packages involving the identified planning concepts that are necessary in achieving a low-emission city. This includes the transit-oriented development (TOD) and greening of car-related tax system. Both countermeasures were analyzed using numerical models to calculate for their environmental effects. A fund circulation system for financial resources requiring implementation of transport-environment policies is likewise introduced indicating the necessity of its connection with the spatial-transport planning system is.