Ministry of the Environment Commissioned Study

FY2014 Feasibility Study for Forming Large-scale JCM Project to Realize Low Carbon Society in Asia

Kingdom of Thailand
Project to Promote the Introduction of Japanese Secondhand Engines to Reduce Vehicle CO_2 Emissions

Report

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Kaiho Sangyo Co., Ltd.

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RECS International Inc.

Sustainability Science Consortium

Introduction

Kaiho Sangyo Co., Ltd. has proposed this project to verify the improvement in fuel consumption and reduction in CO_2 emissions by replacement with secondhand engines maintained in and exported from Japan, as a first step towards the aim of contributing to strengthening the competitiveness of the Thai automobile industry by establishing a secondhand automobile and parts recycling system and nurturing the automobile recycling industry. It was implemented as a JCM project feasibility study with the aim that preferential treatment can be applied and the project can be enabled by accounting the CO_2 reduction effect due to replacement of engines as JCM credits.

Initially it was envisaged that because fuel consumption deteriorates the greater the total mileage of a vehicle, fuel consumption would be improved and CO_2 emissions reduced by replacement with a well-maintained secondhand engine. In the tests carried out in Thailand it was not possible to obtain numerical evidence to verify this proposition, but the following useful suggestions for future project studies were obtained.

The overall fuel consumption of an automobile is determined by both the engine fuel consumption and the chassis fuel consumption, but it has been suggested that the effect of chassis fuel consumption is large due to corrosion and wear of the rotating system parts. Conversely if the maintenance of a vehicle is good, there is no great difference in engine fuel consumption with mileage.

Actually the amount of fuel consumption is determined by the quantity of fuel injected with one revolution of the crankshaft, and this is controlled by the ECU, so even if an engine has degraded, in high speed steady state driving the quantity of fuel injected for a given driving distance is the same as the theoretical quantity. On the other hand when the engine has degraded and the torque is reduced, if the same acceleration or cruising performance is required, it is necessary to use a higher engine rotational speed and lower gear with an engine with lower output, so the fuel consumption is increased.

In the study carried out in Thailand, it is considered that the difference in fuel consumption due to engine replacement was within the range of measurement error because the driving conditions were different before and after replacement of the engine. It is necessary to eliminate the effect of driving conditions on the fuel consumption in the comparison in order to measure the effect of improvement in fuel consumption due to engine replacement. However it is difficult to ensure that the driving conditions are always the same before and after replacement, so it is considered necessary to take more samples and compare the fuel consumption before and after replacement under various driving conditions. Also, it is possible to analyze in more detail the relationship between driving conditions and fuel consumption by also using OBD.

In this JCM project feasibility study, it was not possible to numerically confirm the fuel

consumption improvement and CO_2 emission reduction effect due to engine replacement. Therefore it was not possible to investigate the project income and expenditure plans, etc., based on the study results. It is considered important to utilize these lessons in any future JCM feasibility project aimed at large taxi companies or transport companies, etc., that use a large number of vehicles with low levels of maintenance.

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Acronyms & Abbreviations

ASEAN	Association of South‐East Asian Nations
ASR	Automobile Shredder Residue
BOI	The Board of Investment of Thailand
BSI	British Standards Institution
BTS	Bangkok Sky Train
CDM	Clean Development Mechanism
COP	Conference of the Parties
Co2	Carbon dioxide
ECU	Engine Control Unit
ELV	End of Life Vehicle
EU	European Union
FC	Franchise
GIS	Geographic information system
GHG	Greenhouse gas
HIDA	The Overseas Human Resources and Industry Development Association
IP	Implementation Plan
JCM	Joint Crediting Mechanism
JETRO	Japan External Trade Organization;
JICA	Japan International Cooperation Agency
JRS	Japan Reuse Standard
LPG	liquefied petroleum gas
LTA	Land Transport Authority
LLNL	Lawrence Livermore National Laboratory
MAP	Manifold Absolute Pressure
MRT	Mass Rapid Transit
MRV	Measuring Reporting and Verification

MVA	Motor Vehicle Act
NEDO	New Energy and Industrial Technology Development Organization
NESDB	Office of the National Economic and Social Development Board
NGV	Natural Gas Vehicle
NOX	nitrogen oxides
OBD	On-board diagnostics
PAS777	Publicly Available Specification
PDM	Project design Matrix
PM	Particulate matter、particulates
SOX	Sulfur oxide
TGO	Thailand Greenhouse Gas Management Organization
WTP	Willingness to pay

Chapter 1 Background and Objectives of the Study

1-1 Background to the Study

In 2013 sales of automobiles increased by 4.3% compared with the previous year to 84.64 million vehicles, the fourth consecutive annual increase. The number of automobiles owned in the world was 1.07108 billion in the year 2011, and 1.11456 billion in the year 2012, an annual increase of 43.48 million vehicles. It is estimated that the number of vehicles disposed[1] of annually is about 41 million vehicles, of which developed countries and developing countries account for about 50% each. Comparing the population per vehicle, in the year 2012 the world average was 6.3 persons per vehicle, and the value for Japan was 1.7 persons, for the Kingdom of Thailand (hereafter referred to as "Thailand") the value was 5.1 persons, for China was 11.8 persons, and for Indonesia was 13.2 persons.

As the population in developing countries continues to increase and the standard of living is raised, it is certain that the ownership of automobiles will continue to increase in the future in developing countries, particularly in Asia. Concerns regarding fuel consumption and recycling of automobiles is increasing in developed countries, but in most developing countries these concerns are still weak. As a result, although the spread of automobiles in developing countries has contributed to an improvement in convenience for people, it has also imposed a load on the global environment from the emission of CO_2 and harmful substances such as NOx, SOx, PM, etc.

Looking at the "Energy Consumption according to Industry" for Japan, it can be seen that the transport sector accounted for 23.5% in 2005, and 22.5% in 2013, and also from the "CO_2 Emissions according to Industry" the percentages of CO_2 emissions were 19.6% and 17.0% respectively, indicating a reduction in both cases. In the United States the transport sector accounted for 27.7% of energy consumption in 2013, and 33.9% of the CO_2 emissions (Lawrence Livermore National Laboratory). This indicates that the unit CO_2 emission of Japanese vehicles is smaller, the vehicles are compact compared with American vehicles, and the fuel consumption performance of the engines is excellent. This suggests that the establishment of a system for use of engines from secondhand Japanese automobiles with excellent fuel consumption performance can increase the potential for reduction in CO_2 emissions in developing countries, and is also appropriate as a resource efficiency and environmental measure. Japan is a country that manufactures the world's highest performance automobiles, and in particular in terms of engine performance greatly surpasses other countries.

In Japan the number of deletion registrations in 2012 and 2013 was 4.9 million vehicles, and exports of secondhand cars in these 2 years were also 1.2 million vehicles. Based on the

[1]Number of vehicles disposed＝Number of vehicles owned at the end of previous year＋Number of new vehicles registered in present year－Number of vehicles owned at the end of present year

Automobile Recycling Act the number of end of life vehicles are 3.56 million in 2012 and 3.58 million in 2013. (Japan Automobile Manufacturers Association "Automobile Statistics Monthly Report, Ministry of Finance "Trade Statistics of Japan", Japan Automobile Recycling Promotion Center homepage). These data are the statistical documents regarding Japan's exports of secondhand engines, and it will be necessary to study them closely later. Note that sales in 2013 were 5.37 million, an increase of 0.1% over the previous year.

1-2 Potential for Reduction in CO_2 Emissions by Export of Japanese Secondhand Engines

Since the Automobile Recycling Act put into force in Japan in 2005, more than 3.5 million end of life vehicles (ELV) have been properly processed annually. At present the domestic secondhand parts market has grown to a scale of ¥100 billion, but the overseas demand for functional parts such as engines, transmissions, etc., is larger than that of the domestic market. This is considered to be because the performance of Japanese engines is good, maintenance is carried out with the automobile inspection system, and road conditions are good, driving distances are also comparatively short, so engine degradation is small.

High quality secondhand Japanese engines have better fuel consumption compared with engines manufactured by other countries, the life is also much longer, so it is "waste" to recycle secondhand engines, which can still be used, for their material such as iron and aluminum. Automobiles are used by Japanese people for an average of 13 years with an average mileage of 130,000 km, which in developing countries is much longer. Also, driving automobiles with poor fuel consumption increases CO_2 emissions and causes atmospheric pollution due to harmful substances such as NOx, SOx, PM, etc. Therefore it is expected that fuel consumption can be improved by replacement with secondhand engines from Japan that are comparatively younger and that have been maintained with the automobile inspection system.

The Asian automobile repair industry already receives a supply of secondhand engines from Japan, which are vastly superior in terms of quality compared with engines from Korea, etc. Kaiho Sangyo Co., Ltd., who is the leading company of this JCM feasibility study, was certified in guidance by BSI of the United Kingdom with PAS 777 (Publicly Available Specification) for the functional evaluation of secondhand engines in 2013. The objective of this standard is to provide a specification for the evaluation and labeling of secondhand engines using a method that can be applied anywhere in the world.

The objective of this JCM feasibility study is to measure the CO_2 reduction effect of replacement with engines that have obtained PAS 777 evaluation, and construct a mechanism to enable preferential measures such as grant aid, etc., to be applied by obtaining credits under JCM. Although currently the numbers are small, Kaiho Sangyo has established a business foundation for the export of secondhand engines, and if the amount of reduction in CO_2 achieved in Thailand can be applied as bilateral credits with Japan, this can be a new solution for the global warming problem.

1-3 Evaluation of the Potential for Improvement in Fuel Consumption by Engine Replacement

In developing countries buying replacement vehicles every 13 years on average does not occur as in Japan, but repairs are repeatedly carried out, parts such as engines are replaced, and vehicles are used until they can no longer move. The objective of this JCM feasibility study is to study how much the fuel consumption can change and how much CO_2 emissions can be reduced by replacing an engine that has been driven several hundreds of thousands of kilometers with a secondhand engine from Japan that has been driven an average of 130,000 kilometers.

Regarding the relationship between secondhand engines and fuel consumption, the opinion of researchers in the field of internal combustion engines is “in the case of secondhand engines that are assumed to have driven 100,000 km, there would be differences in fuel consumption due to oil changes and maintenance, driving methods, etc., but there is no statistical data regarding these differences”.

When evaluating the fuel consumption, it is estimated that differences are produced depending on the vehicle category, the engine displacement, the driving method (at 60 km/h or 100 km/h), the road conditions (idling time), driving at a constant speed on a level road, driving on mountain roads, etc.

In order to obtain correct numbers ideally measurements of fuel consumption should be taken under all conditions, but this was not possible in this JCM feasibility study because of the time period and effort required. Therefore, the study was completed by selecting a very limited number of vehicles and vehicle types (categories, displacements).

In this project feasibility study, the fuel consumption performance before and after replacement was investigated by driving 140 km outward for a round-trip distance of 280 km using the comparatively flat region in Bangkok, partially within congested urban areas, but mostly on expressways. It was initially considered that there would be an overall difference in fuel consumption, but the study result obtained was that there was not much difference in fuel consumption performance under high-speed normal conditions. It is inferred that the difference in fuel consumption arises from conditions such as sudden acceleration or deceleration, and applying loads such as climbing slopes, etc.

If a difference in fuel consumption is found due to engine replacement in this JCM project feasibility study, the following three points can be considered.

(1) Reduction in torque.

(2) Exhaust gas due to incomplete combustion

(3) Engine problems

First, to drive with the same acceleration in the case of an engine with poor combustion efficiency, the engine rotation speed must be increased in order to maintain the output, due to the reduction in torque. In this case the rotational speed of the crankshaft is increased, the injection quantity is also increased, and as a result the fuel consumption is affected.

Also, a greater difference in fuel consumption is produced by repeated acceleration and

deceleration than by driving at high speed. In particular for driving on mountain roads where it is necessary to fully depress the accelerator pedal, a difference in fuel consumption is produced due to the reduction in torque.

Next, when there is incomplete combustion in the engine, CO_2 and HC are generated in the cylinder, and O_2 that has not been consumed can be detected in the exhaust gas. This is detected by an O_2 sensor which sends a signal to the computer to reduce the fuel.

Degradation of the engine occurs due to a combination of factors such as frequency of oil change, maintenance, mileage, etc., and is not limited to a single cause. Symptoms include wear of the piston rings, producing gas leakage (CO_2, HC), increase of the exhaust pressure, and reduction of engine power.

The fuel consumption (km/l) is determined by the fuel consumption rate (g/kwh) of the engine on its own, the speed change ratio of the transmission, the driving resistance, etc. When an automobile is new in general the catalog fuel consumption can be used for reference. However, with secondhand cars the fuel consumption varies with how they were used, and there is very little numerical data on this effect. Based on these results it was found that a difference in fuel consumption would be produced by evaluating under conditions of acceleration and climbing slopes, etc. Therefore, it is considered that companies that use vehicles under such driving conditions a lot can expect effect of engine replacement with an aim for improvement in profit by improving fuel consumption, and this would enable the JCM business.

1-4 Background and significance of PAS 777（Publicly Available Specification）

“PAS 777 originated from the concept of breathing life as products into secondhand parts.” As products they are exchanged at an appropriate price in a market created by buyers and sellers. Secondhand engines arising from Japan have an average driving distance of 130,000 km, and can still be driven for 500,000 km or more. Secondhand engines have sufficient value as products. However to achieve this value it is necessary that secondhand engines have visibility through traceability, quality standards, labeling, etc.

It was overseas buyers that first focused on Japanese secondhand engines. They bought up engines that had previously been scrapped for iron/steel or aluminum materials at a higher price. This was not a market, as the transaction was carried out at the price that they asked. In order to change this situation Kaiho Sangyo developed a specification for labeling with a radar chart that quantified 6 items; compression, mileage, starting, overheating, internal status, external status. This became the Japan Reuse Standard (JRS), upon which PAS 777 was based. However at the JRS stage this was just the specification of one private company, and it was insufficient for a fair market open to the world.

Under the guidance of BSI of the UK this became PAS 777, an open specification that anybody could use. Secondhand engines that can display the PAS 777 quality standard only arise from Japan. This is because only Japan satisfies the conditions of high performance at the production stage, low driving distance due to the narrow national land, maintenance in

accordance with the vehicle inspection system, and the national characteristic of carefully using things. PAS 777 is progressively spreading, and last year the world's first secondhand parts auction and market was held in Sharjah in the Middle East. Here the transactions were carried out based on an agreed market view of both buyers and sellers for secondhand engine products with their standard displayed.

In this project feasibility study, the effect of replacement with secondhand engines from end of life vehicles (ELV) was verified. Every year about 3.5 million ELVs arise within Japan, and about 40 million throughout the world. The vehicles weighing an average of 1.1 tons contain base metals such as iron, copper, aluminum, and rare metals such as gold, platinum, palladium, etc. ELVs are not waste or trash but they are urban mines that arise in cities where consumers and resources are in close contact.

It is said that Japan is a major nation in terms of urban mines, but the spirit of "waste avoidance" and "clean up" is spreading in developing countries, with the development of technologies, systems, and laws. Underground resources are stock, and the earth's capital, but urban mines are resources from the flow, or interest. In order to construct social systems for sustainable coexistence between mankind and the earth, the world must change to flow based on circulation.

Japan's contribution to the world as a major automobile nation that is advanced in automobile recycling is to construct the series of the flow "JCM → PAS 777 → auctions and markets → recycling business in developing countries → global development of venous industries → society based on recycling". Through this JCM project feasibility study, the potential for a new business model that Japan can bring to the world has been found. It is considered that this is in accordance with the intention for founding JCM.

1-5 Requests for Cooperation from Relevant Organizations after Commencement of the JCM Project Feasibility Study

This JCM project feasibility study investigates the effect of reduction in CO_2 emissions by replacement with Japanese secondhand engines that have been evaluated in accordance with PAS 777. This study is one important step towards establishing the secondhand cars and parts recycling system aimed by Kaiho Sangyo, cultivating the automobile recycling business, and contributing towards strengthening the competitiveness of the Thai automobile industry in the future.

This is also understood by the Office of the National Economic and Social Development Board (NESDB), which strongly wants to promote automobile recycling in Thailand. In Thailand, where they are trying to achieve sustainable development of the automobile industry as a key industry, the establishment and development of an automobile recycling business has been given high priority by the government of Thailand, and we have received a letter strongly supporting the project from Mr. Arkhom, the Secretary General of the NESDB which is leading this movement involving all the various government ministries and bodies.

Also, in order to be able to efficiently implement the forthcoming study, we contacted the following institutions in Bangkok immediately after starting the feasibility study to inform them that the JCM feasibility study had started and to request their cooperation when needed during the study.

< Organizations visited >

-Government of Thailand organizations

・ Office of the National Economic and Social Development Board (NESDB)
・Thailand Greenhouse Gas Management Organization (TGO)
・ Thai Subcontracting Promotion Association

-Japanese Government organizations in Thailand

・ Japan External Trade Organization (JETRO)
・The Overseas Human Resources and Industry Development Association (HIDA)
・ New Energy and Industrial Technology Development Organization (NEDO)

In the meetings with the above relevant organizations, the objectives and an outline of the project were described. Namely, it is a feasibility study commissioned by the Ministry of the Environment to establish private sector projects that can contribute as bilateral credits between the two countries, the scope of the feasibility study was described, and the scheme embraced in the feasibility study was explained.

In this feasibility study, based on the hypothesis that secondhand engines from Japan would be installed in comparatively old automobiles within Bangkok thereby reducing CO_2 in the exhaust gas, as MRV methodology it will be necessary to monitor the amount of reduction, report to a joint committee, establish methods of evaluation on reduction amount, and form a business scheme capable of enabling the JCM project formed from counterpart private companies or an international consortium.

An explanation and request for cooperation were given in order to gain the understanding of the relevant organizations of these conditions and qualifications required for a JCM project, and thereafter to ensure smooth information collection and various types of support.

1-6 Environmental Policies in Thailand

1-6-1 The11th National Economic and Social Development Plan (2012-2016)

The Government of Thailand formulates 5 year plans that outline the basic policies for development of the country every 5 years, and currently the 11th plan is being implemented. In the 11th plan, the following basic policies on environmental aspects have already being established.

a) Restoration, conservation, and creation of natural resources and environmental infrastructure

- Restoration and conservation of forestry

- Maintenance of GIS and data
- Promotion of a fairer land ownership and distribution
- Restoration of soil to ensure the agricultural productivity and food stability
- Creation of a system of management of marine and coastal resources
- Promotion of comprehensive water resource management for sustainable food supply and energy supply and to prevent flooding and drought
- Increase in water source and recharge areas
- Efficient and environmentally sound water use with good cost performance
- Preparation of a water resource master plan for supply of water for domestic use
- Fairer distribution and conservation of the blessings of biodiversity

b) Promotion of Thai society to an environmentally sustainable and low CO_2 emission society

- Transition of the industrial sector to low CO_2 emission
- Improvement in the energy efficiency of the traffic sector to reduce GHG
- Creation of environmentally friendly cities by promotion of comprehensive urban planning that integrates cultural, social, and ecological aspects
- Recommendation of consumption activities that promote transition to low CO_2 emissions and transition to an environmentally stable society

c) Strengthening the capabilities to respond to climate change

- Propagation and accumulation of knowledge regarding the effect of climate change and adaptation
- Development of management tools to response to climate change
- Strengthening the capacity for community response to climate change

d) Response to natural disasters

- Preparation of maps of regions at risk at the national, regional, and provincial level
- Improvement in effectiveness of disaster management
- Maintenance of database and remote communication network
- Preparation of disaster relief plan for all people in the country
- Strengthening of readiness and preparations among the private sectors, public

sectors, schools, local governments, etc.

e) Protection of industry within the environmental protection and climate change policies

- Monitoring of environmental conservation index that do not impact on international trade and investment
- Preparation of policies to respond to international agreements regarding environmental protection and climate change policies
- Strengthening research into the effect of international agreements on international trade, and preparation of a strategic plan to not harm products and businesses
- Recommendation of the introduction of carbon footprint for exporters
- Creation of priority measures for innovative companies that implement sustainable development

f) Strengthening the role of Thailand in international forums dealing with environmental problems

- Detailed examination of international agreements and monitoring of the status of the negotiations with other countries
- Strengthening the negotiation capability of government personnel
- Strengthening of cooperation within ASEAN and the main trading partners
- Support for the implementation of international agreements relating to natural resources and the environment

g) Reduction and management of pollution

- Reduction of atmospheric pollution, in particular PM10
- Increase in efficiency of solid waste management and community sewage processing
- Creation of system of management of toxic, electronic, and infectious waste
- Reduction in leakage and accidents relating to chemical substances
- Construction of warning systems and management systems for pollution accidents at national and regional levels

h) Strengthening of the system of management of natural resources and the environment with high efficiency, transparency and impartiality

- Strengthening of capabilities and strengthening of rights to enable communities

to sustainably utilize local natural resources in a balanced manner

- Strengthening the capabilities of and participation in communities
- Amendment and impartial application of laws in response to economic and social changes
- Changing government investment policies to promote conservation of natural resources and the environment
- Promotion of an environmental tax and budgetary measures to introduce preferential measures to promote efficient utilization of natural resources and reduction of pollution
- Creation of revenue for environmental conservation and biodiversity conservation
- Maintenance of databases, evaluation of system and support of research

Within the above policy which is "To promote the conversion of Thai society to an environmentally sustainable and low CO_2 emission society", the point regarding improvement of the energy efficiency of the traffic sector is relevant to this project. Specific measures include the maintenance of public transport and promotion of its use, and support of the use of natural gas and renewable energy such as energy from biological sources, improvement in driving practices, etc. Although replacement with high energy efficiency engines which is the target of this project is not mentioned, it is however sufficiently consistent with the main intention.

1-7 Automobile Industry and Environmental Problems in Thailand

Like other ASEAN countries, the automobile industry has been cultivated in Thailand as a pillar of import substitution industrialization, but in 1997 it was dealt a major blow in the Asian currency crisis. As a result of this the Government of Thailand embarked on cultivation of the export market for automobiles, aiming to develop the automobile industry under the slogan "The Detroit of Asia". As a result, in 2003 the number of vehicles sold exceeded that of Malaysia to become number one in ASEAN, and in 2005 the number of automobiles produced exceeded 1 million.

In 2010 the number of automobiles produced in Thailand was 1.65 million, of which about 900,000 were for export. In addition the Government of Thailand aims for production of automobiles in 2015 of 2.5 million, of which 1.5 million are for export.

In other words the automobile industry in Thailand is now a key industry, but in EU and Japan an extended producer responsibility that has been imposed on manufacturers, which has been expanded to include the used products stage. In Japan, based on this, Automobile Recycling Act of 2005 has imposed on manufacturers the responsibility for processing three items: chlorofluorocarbons, airbags, and ASR. The extended producer responsibility in Japan applies

to these three items, but in the EU such as Germany, etc., it applies to the whole vehicle. In Japan about 180 kg of ASR (shredder dust) used to be buried before this Act was adopted, but now about 95% of it is processed. The process of constructing a proper processing system in Thailand is not just a matter of improving the Japanese method, but entails the complete picture of Automobile Recycling Act, involvement of manufacturers, startup of recycling companies, etc.

Also environmental problems associated with the rapid expansion of automobile ownership have become serious, in particular in the Bangkok region, and measures against these problems have become urgent. In other words, Thailand is the front-runner among developing countries for environmental problems associated with automobiles.

1-8 Trends of Exhaust Gas Regulations and Reduction of CO2 Emissions in Thailand

Thailand has adopted strict regulations concerning exhaust gas before other Asian countries, and for small vehicles using natural gas or LPG as fuel, the same regulations as EURO 4 are applied from July 2014.

EURO 4 is the fourth level of regulations for exhaust gas in the European Union (EU), and is also referred to as Step 4. In Europe regulations for exhaust gas have been implemented since 1970 for passenger vehicles and light trucks, and, since 1988 for heavy trucks with a gross vehicle weight of 3.5 tons or more. These were subsequently strengthened in stages; in 2000 the third stage of regulation was implemented (EURO 3), and in 2005 the fourth stage of regulation was implemented (EURO 4). EURO 4 has a particularly strict standard for particulate matter (PM) for large diesel trucks of 0.02 g/kWh.

In Thailand currently the sixth stage of regulation which corresponds to EURO 3 is applied to new gasoline automobiles. The introduction of regulations equivalent to EURO 4 from 2012 was investigated, but at present their introduction has been postponed.

Table 1-1: Values of Exhaust Gas Regulations Applicable to Automobiles Used in Thailand

Car Type	Pollutant	Regulatory Limits	Measurement Equipment	Measurement
Gasolin Vehicle			Non- diffusion infrared detection	When the ca r idling in stop
1993/11/01 Before	CO	4.5%		
	HC	600ppm		
1993/11/01 Before	CO	1,5%		
	HC	200ppm		
1993/11/01 Before	CO	0.50%		
	HC	100ppm		

1-9 Eco-cars

The “eco-car policy” in Thailand is a policy of approval of “eco-cars” by the Board of Investment that initially started as a preferential tax treatment policy for assembly manufacturers.

The first stage of the "eco-car policy" commenced in 2007 and was applicable to gasoline vehicles of displacements 1,300 cc or less. There were various requirements such as a fuel consumption of 20 km or more per liter, compliance with the European exhaust gas regulations "EURO 4", and annual production from the fifth year onwards of 100,000 vehicles are more, etc. Preferential treatment of 8 years exemption from corporation tax was applied to approved assembly manufacturers of "eco-cars". Also, for purchasers (consumers), a goods tax rate of 17% was established as a preferential tax treatment for Thai "eco cars" (Cabinet decision June 2009). (Came into force from October 2009)

Second stage eco-car system (plan)

Applications for the second stage of "eco-car policy" were announced in April 2014.

The second stage "eco-car policy" corresponds to the European exhaust gas regulations "EURO 5", and apply to gasoline vehicles of displacement 1,300 cc or less and diesel vehicles of 1,500 cc or less having fuel consumption of 4.3 L of fuel for a driving distance of 100 km or more (23.3 km per liter or more). Applications were accepted up until the end of March 2014, and the conditions were that production must commence before year end 2019, and the production from the fourth year and beyond must be 100,000 vehicles or more per annum. Approved companies are exempt from corporation tax for six years, and are exempt from import tax for equipment and machinery. Approval of manufacturers that have applied for the second stage "eco-car policy" is scheduled to be made within 2014. The goods tax rate for passenger cars applicable to consumers is scheduled to be 14% (in the first stage "eco-car policy" it was 17%).

1-10 Climate Change Policies of the Bangkok Metropolitan Administration

It has been reported that 24% of the greenhouse gases of Thailand are emitted in Bangkok. In 2007 the Bangkok Metropolitan Administration jointly with 35 other organizations adopted a declaration of cooperation to resolve global warming problems. Bangkok Metropolitan Administration Action Plan on Global Warming Mitigation has been prepared and initiatives were undertaken with the aim of reducing GHG by 15% over the five-year period from 2007 to 2012. In this action plan policies are stated as five objectives as follows, (1) expansion of mass transit network system, (2) promotion of energy efficiency and the use of renewable energy, (3) energy efficiency and improve efficiency of buildings, (4) improvement in waste management and sewage treatment efficiency, and (5) promotion of greenery in urban areas. The Japan International Cooperation Agency (JICA) has provided technical support for the implementation of this action plan.

Of these targets, (2), (4), and (5) have generally been achieved, but for (1) it is said that it was not possible to achieve the plan because of difficulties in coordination between relevant organizations. The Bangkok Metropolitan Administration is evaluating the results of this action plan, and is proceeding with the work of formulating the Bangkok Master Plan on Climate Change 2013 to 2023 as a more comprehensive climate change policy. To support this work

JICA is implementing the “Project to improve the capability of preparation and implementation of the Bangkok climate change master plan (2013-2023)” between March 2013 and September 2015.
Although there is no mention of the engine replacement project, to the extent that it contributes to the GHG policy, it can be said that this project is on the same track as the GHG reduction policy of the Bangkok Metropolitan Administration.

1-11 Discussion of JCM with Thailand

In March 2012, the Government of Japan and the Government of Thailand announced a “Japan - Thailand Joint Declaration”, which agreed to initiatives with Thailand including the bilateral credit system (JCM) to realize low carbon growth. Although the Government of Thailand has approved the signature in the cabinet, as of March 2015 the bilateral documentation regarding JCM between Japan and Thailand has not yet been signed. It is considered that signing will be done not just within the government, but also with wide understanding and agreement of affected parties such as companies, the public, NPOs, etc.

Chapter 2 Study Methodology

2-1. Study Implementation System

The following shows the study implementation team organization and allocation of roles for the implementation of this study.

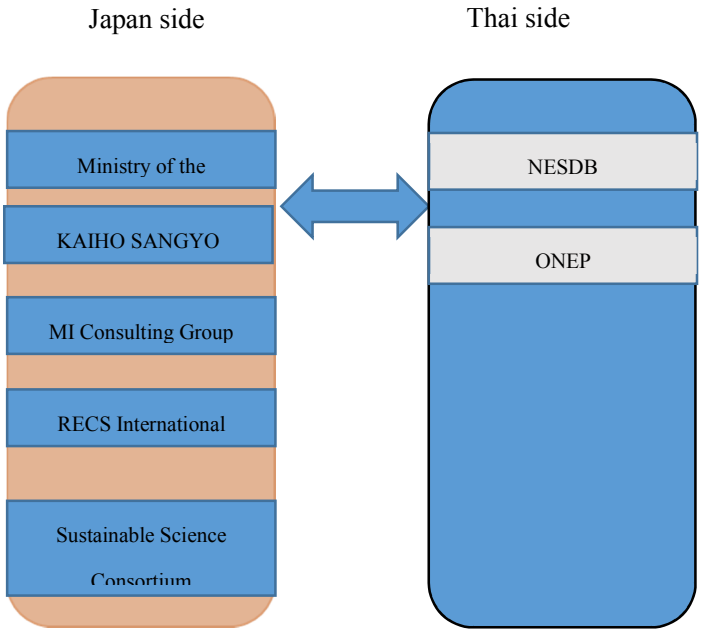


Figure. 2-1 Study Implementation System

Table 2-1 Allocation of Roles for Implementation of the Study

Organization name	Role	Main study results
Kaiho Sangyo Co., Ltd.	Overall responsibility for the study	Preliminary tests and implementation of JCM project feasibility study
M.I. Consulting Group	Negotiations with the host country	Selection of parent population and local partners
RECS International Inc.	Summarization of study results	Local survey of the automobile industry and secondhand vehicle market in Thailand
Sustainability Science Consortium	Development of MRV methodology Study of co-benefits	Investigation of experimental methods, development of MRV methodology

The investigation of the experimental methods is carried out by the whole team based on the knowledge of SSC and the local information collected by RECS/MI. Also, staff from RECS/MI participates in the various investigation work carried out by Kaiho Sangyo.

In addition, local preparations for the preliminary tests and the JCM project feasibility study

are mainly implemented by MI, and the actual implementation of the tests is carried out through cooperation between Kaiho Sangyo, RECS, and MI.

2-2. Local Support System

A support system is formed with Kaiho Thailand as the core, in order to enable the study activities such as local surveys, surveys for selection of local partners, etc., to be smoothly implemented. The main support items are as follows.

- Introduction of companies related to the automobile industry and secondhand market, and participation in meetings
- Ensuring vehicles and drivers for preliminary studies and other studies
- Acquisition of locally procured equipment necessary for the study
- Selection of driving routes
- Participation in study preparations within Japan
- Participation in studies

2-3. Work Content

2-3-1 Study of the Current Automobile Industry and Secondhand Car Market in Thailand

A local study is carried out of the automobile industry, the automobile recycling industry, and the secondhand car market in Thailand, to grasp the characteristics of Thailand by comparing Japan and Thailand.

(1) Preparations in advance (work within Japan)

Based on study reports concerning automobile recycling carried out in Thailand in the past as basic data, and referring to information obtained in Japan on the trends of the secondhand car market in Thailand, etc., data relating to the automobile industry is updated, and the laws and regulations related to recycling and the roles and functions of the relevant government organizations are grasped.

(2) Local studies

A local study is carried out into the automobile and parts recycling system, documents are collected, and the following information is summarized and the current situation and issues are analyzed. The study is implemented in Thailand based on the relevant data obtained in the study of the current situation in Japan, the study policy, and the interviewees. The study content and items are envisaged to be as follows.

1) Overview study of the secondhand car market
2) Study of status of automobile registrations, deletions, vehicle inspection system, and taxation system
3) Study of the status of vehicles used for passenger transport/freight transport in the Bangkok area
4) Study of the secondhand car market in the Bangkok area
5) Study of the status of the relevant government organizations and industry

organizations

(3) Organization period within Japan

The information obtained in the activities (1) and (2) will be summarized.

2-3-2 Selection of Local Partners

In the Bangkok area, the parent population that is the target of this study and the future engine replacement business (population having large quantity of vehicles using engines that have driven at least 200,000 km) will be identified, and local companies/organizations that own vehicles and that could become partners in the engine replacement business will be selected.

(1) Advance survey (work within Japan)

1) Collection, analysis, and investigation of existing relevant documents, information, and data.
2) Preparation of a list of documents, information, and data that needs to be collected in Thailand.
3) Preparation of a list of companies with a high degree of interest in automobile and parts recycling business and engine replacement business in Thailand, and summarization of the information.

(2) Local studies (envisaged be carried out three times lasting from 1 week to 10 days)

Hold meetings with companies identified during the work within Japan, and study the following items.

1) Collection of information from the relevant authorities, study of the actual status, investigation of potential alliances
2) Collection of information on local manufacturers, study of the current status
3) Identification of candidate local partners
4) Advance coordination for the study of status of automobile usage
5) Investigation of the potential for forming an international consortium to implement the project

(3) Period of organization within Japan

The information obtained in the activities (1) and (2) will be summarized.

2-3-3 Study of the Status of Automobile Usage in Thailand

Data will be collected on automobile fuel consumption, fuel efficiency, etc., for driving within Bangkok city and on expressways in the outskirts, as basic information for quantification of the amount of reduction of automobile CO_2 emissions and for investigation of the MRV methodology.

2-3-4 Establishment of MRV Methodology and Methods of Calculating Co-benefits

(1) Local survey

A local survey will be carried out in this study to construct the MRV and to quantitatively calculate the co-benefits. Specifically the traffic situation in Thailand will be observed, and in addition opportunities will be taken for discussions with local relevant persons (for example, university staff specializing in traffic matters, environmental organizations), and an investigation of the co-benefits items and study method will be carried out.

(2) MRV methodology

1) Construct MRV methodology

From the results of the preliminary studies implemented and this study, a method (model) for calculating the CO_2 reduction effect due to engine replacement will be constructed.

2) Investigation of MRV validity

The validity of the proposed MRV methodology will be investigated from the point of view of cost of implementing the MRV, acceptability in the host country, and construction of the business model.

3) Confirmation of MRV methodology

The MRV methodology will be confirmed with a view not only to the Bangkok area, the subject of this study, but also to future overseas recycling businesses.

(3) Method of calculating co-benefits

A method of calculating the envisaged co-benefits, such as reduction in atmospheric pollution due to NOx, SOx, PM, and reduction in noise and vibration, will be constructed.

(4) Technical verification (holding evaluation meetings)

Evaluation meetings will be held with influential persons to evaluate from the technical viewpoint the proposed MRV methodology and method of calculating the co-benefits, to verify the effectiveness and validity of these methods.

2-3-5 Formulation of Business Plan

A study will be carried out into the details of a more specific business plan to solve the issues based on the results of the above studies and overall general information.

The item studied for formulating the business plan will be as follows, and if is necessary additional items will be added.

- Disposition on the content and scale of the initial business
- Calculation of MRV and co-benefits in the initial business
- Investigation of the business system
- Confirmation of the necessity of establishing a local company
- Estimation of initial business costs
- Economic and financial analysis of the business
- Confirmation of the conditions for implementing the business

2-3-6 Preparation of Report on Results

A report that summarizes the results of the above work will be prepared (draft, final draft, and final report).

2-4. Schedule of the Study

The work schedule is as follows.

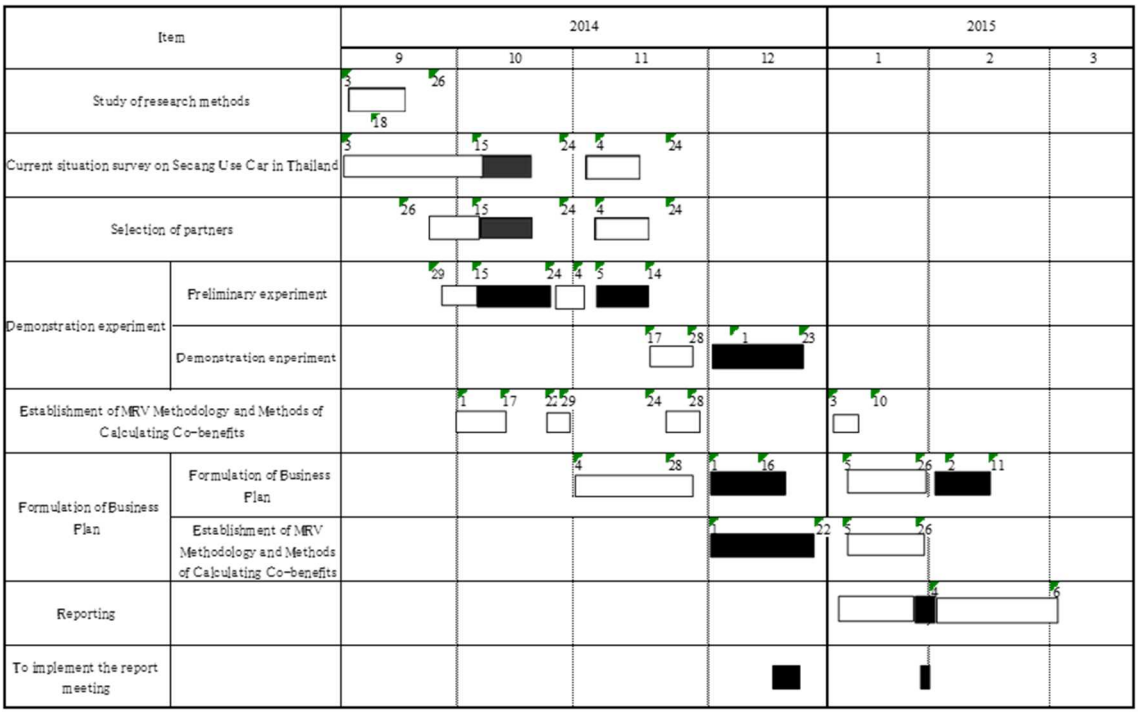


Figure. 2-2 Work Schedule

Chapter 3 Study of the Automobile Industry and Status of Secondhand Car Utilization in Thailand

3-1 Summary of the Automobile Industry and the Secondhand Car Market in Thailand

3-1-1 The Number of Registered Automobiles

Statistics on automobiles registered as of the end of 2013 are shown in Table 3-1. In the following section, the current status of the Thai automobile industry as indicated in this table is discussed.

Table 3-1 Numbers of Registered Automobiles

Item			Registration numbe			%		
			Thailand	Bangkok	Other Area	Thailand	Bangkok	Other Area
1.	**Vehicle**		**33,520,175**	**8,047,392**	**25,472,783**	100.0	24.0	76.0
1.1	6 seater car		6,736,562	3,356,099	3,380,463	100.0	49.8	50.2
1.2	More than 7 seater of microbus		430,188	216,080	214,108	100.0	50.2	49.8
1.3	A van Pickup		5,734,302	1,154,712	4,579,590	100.0	20.1	79.9
1.4	Three-wheeler		1,598	818	780	100.0	51.2	48.8
1.5	Taxi (between prefecture)		3	0	3	100.0	0.0	100.0
1.6	Taxi (City)		114,616	111,860	2,756	100.0	97.6	2.4
1.7	Taxi (The fixed line)		3,180	2,669	511	100.0	83.9	16.1
1.8	Motorcycle taxi		20,602	9,000	11,602	100.0	43.7	56.3
1.9	Hotel Taxi		2,913	680	2,233	100.0	23.3	76.7
1.10	Travel taxi		1,706	1,040	666	100.0	61.0	39.0
1.11	Rental car		77	68	9	100.0	88.3	11.7
1.12	Motorcycle		19,853,157	3,066,088	16,787,069	100.0	15.4	84.6
1.13	Tractor		398,071	71,891	326,180	100.0	18.1	81.9
1.10	Load roller		11,256	3,270	7,986	100.0	29.1	70.9
1.10	Vehicle(Agriculture)		97,111	4	97,107	100.0	0.0	100.0
1.10	Trailer		3,000	1,737	1,263	100.0	57.9	42.1
1.10	Motorcycle(Public)		111,833	51,376	60,457	100.0	45.9	54.1
2.	**Vehicle (Bisinesws)**		**1,104,231**	**169,467**	**934,764**	100.0	15.3	84.7
2.1	Bus		139,847	39,534	100,313	100.0	28.3	71.7
	2.2.1	Shuttle bus	*87,514*	*23,986*	*63,528*	100.0	27.4	72.6
	2.2.2	Bus (No fix line)	*40,843*	*12,421*	*28,422*	100.0	30.4	69.6
	2.2.3	Private bus	*11,490*	*3,127*	*8,363*	100.0	27.2	72.8
2.2	Truck		963,173	129,933	833,240	100.0	13.5	86.5
	2.2.1	Truck (No fix line)	*226,934*	*66,576*	*160,358*	100.0	29.3	70.7
	2.2.2	Private truck	*736,239*	*63,357*	*672,882*	100.0	8.6	91.4
2.3	Local Bus		1,211	0	1,211	100.0	0.0	100.0
Grand total			**34,624,406**	**8,216,859**	**26,407,547**	100.0	23.7	76.3

(1) Types of vehicles

In Thailand, vehicles are grouped into two, one group to which the Motor Vehicle Act applies and another to which the Land Transport Act applies. Vehicles subject to the Motor Vehicle Act include passenger cars, vans, three-wheel cars, taxicabs, motorcycles and tractors, while vehicles subject to the Land Transport Act include buses and trucks. As of the end of 2013, under the Motor Vehicle Act, Thailand had a total of 33.52 million units of vehicles of all kinds registered and a total of 13.04 million four-wheeled automobiles registered in around the nation, while the city of Bangkok had 4.85 million units of registered four-wheeled automobiles. The number of vehicles of all kinds registered under the Motor Vehicle Act in Bangkok was 8.05 million, which represents 24% of the national total, while the number of vehicles registered

under the Land Transport Act in the city was 169,500 units, representing 15% of the national total.

(2) Composition by vehicle type

Looking at the composition of registered vehicles by vehicle type, it is found that the top ranking vehicle type registered in Thailand is motorcycles (57% of the national total of registered vehicles), followed by passenger cars with seating for up to six people (20%) and vans and pickup trucks (17%). Meanwhile, in Bangkok, the top ranking vehicle type registered is passenger cars with seating for up to six people (41%), followed by motorcycles (37%) and vans and pickup trucks (14%). It is found that passenger cars are widely used in Bangkok.

3-1-2 Penetration Rate of Automobiles

The penetration rates of automobiles in Thailand and the world are shown in Table 3-2. The penetration rate of automobiles in the entire Thailand is at around the same level of the world average or somewhat higher than that. In its capital, Bangkok, the penetration rate is on a par with that of developed countries or at a slightly higher level.

Table 3-2 Penetration Rates of Automobiles in Thailand and the World (Unit per 1,000 people)

	Passenger car	Vehicle
Thailand	102	197
Bangkok	407	587
America	385	801
Australia	560	704
Italia	613	694
Canada	595	623
Swiss	553	607
France	497	600
Japan	466	597
Word	110	158

3-1-3 Number of Registered Vehicles by Vehicle Type

Table 3-3 shows changes in the number of vehicles registered in Thailand by vehicle type over a period from 2008 to 2013. Several trends can be found from the figures in this table.

From 2008 to 2013, vehicles registered in Thailand increased 31% from 26.42 million to 34.62 million units. This represents an annual increase of 5.6% on average. Of automobiles registered, passenger cars with seating for up to six people recorded the largest increase of 77% (an annual increase of 12.1%). Particularly from 2011 to 2012, the number of vehicles of all types registered increased 7.6%, while the growth rate for passenger cars with seating for up to six people was significantly high at 17.1%. This major growth can be considered a result of the

government's program to promote purchase of new vehicles.

Table 3-3 Changes in the Number of Vehicles Registered in Thailand by Vehicle Type

Item			Initial registration number						Growth rate (%/Year)					
			2008	2009	2010	2011	2012	2013	2008-09	2009-10	2010-11	2011-12	2012-13	2008-13
1.	**Vehicle**		**25,511,574**	**26,257,935**	**27,530,042**	**29,204,511**	**31,439,643**	**33,520,175**	**2.9**	**4.8**	**6.1**	**7.7**	**6.6**	**5.6**
1.1	6 seated car		3,809,082	4,078,547	4,496,828	5,001,442	5,856,454	6,736,562	7.1	10.3	11.2	17.1	15.0	12.1
1.2	More than 7 seated of microbus		379,210	383,684	392,354	403,321	417,529	430,188	1.2	2.3	2.8	3.5	3.0	2.6
1.3	A van Pickup		4,552,284	4,696,897	4,894,655	5,137,564	5,437,988	5,734,302	3.2	4.2	5.0	5.8	5.4	4.7
1.4	Three-wheeler		1,326	1,381	1,414	1,435	1,477	1,598	4.1	2.4	1.5	2.9	8.2	3.8
1.5	Taxi (between prefecture)		13	11	4	4	3	3	-15.4	-63.6	0.0	-25.0	0.0	-25.4
1.6	Taxi (City)		84,785	90,999	97,477	103,391	109,281	114,616	7.3	7.1	6.1	5.7	4.9	6.2
1.7	Taxi (The fixed line)		5,045	4,534	3,679	3,368	3,293	3,180	-10.1	-18.9	-8.5	-2.2	-3.4	-8.8
1.8	Motorcycle taxi		21,939	21,615	21,310	21,018	20,716	20,602	-1.5	-1.4	-1.4	-1.4	-0.6	-1.2
1.9	Hotel Taxi		1,873	1,841	1,848	1,792	1,975	2,913	-1.7	0.4	-3.0	10.2	47.5	9.2
1.10	Travel taxi		778	795	787	859	1,099	1,706	2.2	-1.0	9.1	27.9	55.2	17.0
1.11	Rental car		100	85	74	76	88	77	-15.0	-12.9	2.7	15.8	-12.5	-5.1
1.12	Motorcycle		16,264,404	16,549,307	17,156,712	18,018,066	19,023,751	19,853,157	1.8	3.7	5.0	5.6	4.4	4.1
1.13	Tractor		134,181	171,721	219,755	273,640	334,292	398,071	28.0	28.0	24.5	22.2	19.1	24.3
1.10	Load roller		9,438	9,759	10,057	10,487	10,872	11,256	3.4	3.1	4.3	3.7	3.5	3.6
1.10	Vehicle(Agriculture)		84,534	87,628	87,857	91,135	94,551	97,111	3.7	0.3	3.7	3.7	2.7	2.8
1.10	Trailer		1,724	1,987	2,129	2,510	2,800	3,000	15.3	7.1	17.9	11.6	7.1	11.7
1.10	Motorcycle(Public)		160,858	157,144	143,102	134,403	123,474	111,833	-2.3	-8.9	-6.1	-8.1	-9.4	-7.0
2.	2.1	Bus	**905,779**	**925,802**	**954,787**	**990,426**	**1,037,334**	**1,104,231**	**2.2**	**3.1**	**3.7**	**4.7**	**6.4**	**4.0**
	2.2.1	Shuttle bus	125,397	127,013	131,735	134,973	137,609	139,847	1.3	3.7	2.5	2.0	1.6	2.2
	2.2.2	Bus (No fix line)	*83,782*	*84,174*	*87,547*	*89,085*	*88,902*	*87,514*	0.5	4.0	1.8	-0.2	-1.6	0.9
	2.2.3	Private bus	*31,375*	*32,270*	*33,346*	*34,824*	*37,467*	*40,843*	2.9	3.3	4.4	7.6	9.0	5.4
2.2	Truck		*10,240*	*10,569*	*10,842*	*11,064*	*11,240*	*11,490*	3.2	2.6	2.0	1.6	2.2	2.3
	2.2.1	Truck (No fix line)	771,554	791,414	816,844	852,923	898,214	963,173	2.6	3.2	4.4	5.3	7.2	4.5
	2.2.2	Private truck	*147,770*	*156,237*	*168,906*	*181,832*	*201,389*	*226,934*	5.7	8.1	7.7	10.8	12.7	9.0
2.3	Local Bus		*623,784*	*635,177*	*647,938*	*671,091*	*696,825*	*736,239*	1.8	2.0	3.6	3.8	5.7	3.4
2.3	Microbus		8,828	7,375	6,208	2,530	1,511	1,211	-16.5	-15.8	-59.2	-40.3	-19.9	-32.8
Grand-total			**26,417,353**	**27,183,737**	**28,484,829**	**30,194,937**	**32,476,977**	**34,624,406**	**2.9**	**4.8**	**6.0**	**7.6**	**6.6**	**5.6**

3-1-4 Numbers of Vehicles Newly Registered and Deregistered

The number of newly registered vehicles by vehicle type in Thailand is shown in Table 3-4 and the estimated number of deregistered automobiles is shown in Table 3-5. From these tables, several trends can be found.

Table 3-4 Changes in the Number of Newly Registered Vehicles by Vehicle Type

Item			Initial registration number						Growth rate (%/Year)					
			2008	2009	2010	2011	2012	2013	2008-09	2009-10	2010-11	2011-12	2012-13	2008-13
1.	**Vehicle**		**25,511,574**	**26,257,935**	**27,530,042**	**29,204,511**	**31,439,643**	**33,520,175**	**2.9**	**4.8**	**6.1**	**7.7**	**6.6**	**5.6**
1.1	6 seated car		3,809,082	4,078,547	4,496,828	5,001,442	5,856,454	6,736,562	7.1	10.3	11.2	17.1	15.0	12.1
1.2	More than 7 seated of microbus		379,210	383,684	392,354	403,321	417,529	430,188	1.2	2.3	2.8	3.5	3.0	2.6
1.3	A van Pickup		4,552,284	4,696,897	4,894,655	5,137,564	5,437,988	5,734,302	3.2	4.2	5.0	5.8	5.4	4.7
1.4	Three-wheeler		1,326	1,381	1,414	1,435	1,477	1,598	4.1	2.4	1.5	2.9	8.2	3.8
1.5	Taxi (between prefecture)		13	11	4	4	3	3	-15.4	-63.6	0.0	-25.0	0.0	-25.4
1.6	Taxi (City)		84,785	90,999	97,477	103,391	109,281	114,616	7.3	7.1	6.1	5.7	4.9	6.2
1.7	Taxi (The fixed line)		5,045	4,534	3,679	3,368	3,293	3,180	-10.1	-18.9	-8.5	-2.2	-3.4	-8.8
1.8	Motorcycle taxi		21,939	21,615	21,310	21,018	20,716	20,602	-1.5	-1.4	-1.4	-1.4	-0.6	-1.2
1.9	Hotel Taxi		1,873	1,841	1,848	1,792	1,975	2,913	-1.7	0.4	-3.0	10.2	47.5	9.2
1.10	Travel taxi		778	795	787	859	1,099	1,706	2.2	-1.0	9.1	27.9	55.2	17.0
1.11	Rental car		100	85	74	76	88	77	-15.0	-12.9	2.7	15.8	-12.5	-5.1
1.12	Motorcycle		16,264,404	16,549,307	17,156,712	18,018,066	19,023,751	19,853,157	1.8	3.7	5.0	5.6	4.4	4.1
1.13	Tractor		134,181	171,721	219,755	273,640	334,292	398,071	28.0	28.0	24.5	22.2	19.1	24.3
1.10	Load roller		9,438	9,759	10,057	10,487	10,872	11,256	3.4	3.1	4.3	3.7	3.5	3.6
1.10	Vehicle(Agriculture)		84,534	87,628	87,857	91,135	94,551	97,111	3.7	0.3	3.7	3.7	2.7	2.8
1.10	Trailer		1,724	1,987	2,129	2,510	2,800	3,000	15.3	7.1	17.9	11.6	7.1	11.7
1.10	Motorcycle(Public)		160,858	157,144	143,102	134,403	123,474	111,833	-2.3	-8.9	-6.1	-8.1	-9.4	-7.0
2.	2.1	Bus	**905,779**	**925,802**	**954,787**	**990,426**	**1,037,334**	**1,104,231**	**2.2**	**3.1**	**3.7**	**4.7**	**6.4**	**4.0**
	2.2.1	Shuttle bus	125,397	127,013	131,735	134,973	137,609	139,847	1.3	3.7	2.5	2.0	1.6	2.2
	2.2.2	Bus (No fix line)	*83,782*	*84,174*	*87,547*	*89,085*	*88,902*	*87,514*	0.5	4.0	1.8	-0.2	-1.6	0.9
	2.2.3	Private bus	*31,375*	*32,270*	*33,346*	*34,824*	*37,467*	*40,843*	2.9	3.3	4.4	7.6	9.0	5.4
2.2	Truck		*10,240*	*10,569*	*10,842*	*11,064*	*11,240*	*11,490*	3.2	2.6	2.0	1.6	2.2	2.3
	2.2.1	Truck (No fix line)	771,554	791,414	816,844	852,923	898,214	963,173	2.6	3.2	4.4	5.3	7.2	4.5
	2.2.2	Private truck	*147,770*	*156,237*	*168,906*	*181,832*	*201,389*	*226,934*	5.7	8.1	7.7	10.8	12.7	9.0
2.3	Local Bus		*623,784*	*635,177*	*647,938*	*671,091*	*696,825*	*736,239*	1.8	2.0	3.6	3.8	5.7	3.4
2.3	Microbus		8,828	7,375	6,208	2,530	1,511	1,211	-16.5	-15.8	-59.2	-40.3	-19.9	-32.8
Grand-total			**26,417,353**	**27,183,737**	**28,484,829**	**30,194,937**	**32,476,977**	**34,624,406**	**2.9**	**4.8**	**6.0**	**7.6**	**6.6**	**5.6**

Table 3-5 Changes in the Number of Deregistered Vehicles by Vehicle Type

Item				The estimated value of De installation Vehicle				
				2009	2010	2011	2012	2013
1.	Vehicle			1,481,467	1,529,819	1,396,780	1,382,698	1,432,959
	1.1	6 seated car		39,685	47,457	37,067	39,171	43,791
	1.2	More than 7 seated of microb		12,368	14,898	13,995	13,914	12,590
	1.3	A van Pickup		61,455	65,742	50,726	51,297	54,046
	1.4	Three-wheeler		33	43	65	91	76
	1.5	Taxi (between prefecture)		2	7	0	1	0
	1.6	Taxi (City)		4,712	2,323	3,457	5,110	6,499
	1.7	Taxi (The fixed line)		630	945	413	173	197
	1.8	Motorcycle taxi		505	491	485	515	349
	1.9	Hotel Taxi		179	100	273	-89	-674
	1.10	Travel taxi		16	35	-16	-137	-352
	1.11	Rental car		15	14	2	21	17
	1.12	Motorcycle		1,350,904	1,371,502	1,273,023	1,251,691	1,292,571
	1.13	Tractor		4,714	6,361	5,527	7,238	9,845
	1.10	Load roller		317	435	231	175	298
	1.10	Vehicle(Agriculture)		-167	2,934	-99	-6	23
	1.10	Trailer		37	77	100	65	115
	1.10	Motorcycle(Public)		6,062	16,455	11,531	13,468	13,568
	Vehicle (Business)							
2.	2.1	Bus		44,190	49,802	52,964	58,601	53,434
		2.2.1	Shuttle bus	8,314	9,503	7,961	8,906	9,547
		2.2.2	Bus (No fix line)	5,726	6,749	5,170	5,707	5,991
		2.2.3	Private bus	2,210	2,379	2,369	2,740	3,031
	2.2	Truck		378	375	422	459	525
		2.2.1	Truck (No fix line)	34,153	38,869	41,140	48,644	43,570
		2.2.2	Private truck	3,422	3,492	5,424	8,172	7,284
	2.3	Local Bus		30,731	35,377	35,716	40,472	36,286
	2.3	Microbus		1,723	1,430	3,863	1,051	317
	Grand Total			1,525,657	1,579,621	1,449,744	1,441,299	1,486,393

The annual total number of newly registered vehicles for all vehicle types was between 2.3 million to 3.7 million units and the number increased or decreased from the previous year varies depending on the year. The annual number of newly registered vehicles in 2012, 3.72 million units, was the largest, which corresponds to an increase of 17.8% on a year-on-year basis.

From 2008 to 2013, newly registered passenger cars with seating for up to six people increased 2.8 times from 330,000 to 920,000 units (an annual average increase of 22.9%).

From the numbers of already registered and newly registered automobiles recorded annually during the period, the number of deregistered vehicles was estimated. Of vehicles of all kinds that have been registered, it is estimated that from around 1.45 million to 1.58 million units are deregistered annually. The number of passenger cars with seating for up to six people deregistered annually is between 37,000 to 47,000 units.

3-2 Status of the Taxi Industry in Thailand

The current status of the Thai taxi industry which has been studied as a candidate parent population for this project is discussed below.

3-2-1 Numbers of Registered Taxicabs

Motor Vehicle Act applies to taxicabs. There are six kinds of taxi services in Thailand including inter-province taxi, city taxi, fixed-route taxi, tuku-tuku, hotel taxi and tourist taxi. As of the end of 2013, the numbers of taxicabs registered in Thailand are as follows.

Table 3-6 Numbers of Registered Taxicabs

Item	Thailand		Bangkok		% (in Bangkok)
	Registration	%	登録台数	%	
Taxi (between prefecture)	3	0%	0	0%	-
Taxi (City)	114,616	80%	111,860	89%	97.6
Taxi (The fixed line)	3,180	2%	2,669	2%	83.9
Motorcycle taxi	20,602	14%	9,000	7%	43.7
Hotel Taxi	2,913	2%	680	1%	23.3
Travel taxi	1,706	1%	1,040	1%	61
Grand-total	**143,020**	**100%**	**125,249**	**100%**	**87.6**

By looking at the numbers of registered taxicabs, it is found that city taxicabs are dominant both in the entire nation and in the city of Bangkok, representing 80% of all registered taxicabs in the entire country and 89% in Bangkok. Of all city taxicabs, 98% are registered in Bangkok. According to Table 3-3 (The Number of Registered Vehicles by Vehicle Type), the number of city taxicabs registered in the entire country increased from 84,000 units in 2008 to 115,000 units in 2013, an increase of 35% over the period (an annual increase of 6.2%). The numbers of taxicabs registered and deregistered in Bangkok are shown in Table 3-7. The number of taxicabs newly registered every year is around 10,000 units.

Table 3-7 Numbers of Registered Taxicabs (Bangkok)

Year	General registration numbe	Initial registration number	DE installation
2008	n.a	11,897	-
2009	103,356	10,948	-
2010	108,434	8,575	3,497
2011	113,763	9,075	3,746
2012	118,980	10,443	5,226
2013	123,529	11,249	6,700

3-2-2 Taxi Service System

Newly purchased taxicabs can be used for taxi service for 9 years after purchase. If a taxi service is offered with secondhand cars, those cars which have been used for less than 2 years can be in service as taxicabs. If the service is offered with secondhand cars which have been used for 2 years, the service can be offered for the remaining 7 years.

Although there is no upper age limit on a taxi driver's qualification, there is a lower age limit which is 25 years old. If a driver fails to have their competence confirmed in the eyesight test and health checkup, he or she will not be qualified as a taxi driver.

3-2-3 Status of Taxi Operation

The total travel distance of a taxicab is around 300 km daily. In cumulative total, a taxicab will have traveled 9,000 km in a month and 810,000 km in 9 years. According to hearing investigations conducted with several taxi drivers in Bangkok, such long-distance travel usually does not pose a problem to the taxi engine.

Taxicabs operating in Bangkok are painted with different colors to identify each of the different service categories. Taxicabs painted with both yellow and green are individually-owned taxies and those painted with other colors (pink, blue, yellow, red, etc.) are owned by taxi service companies.

It is said that taxi drivers have a relatively larger income than others such as salespeople and construction and civil engineering workers. Some of those who migrate from home to Bangkok work as taxi drivers in the city.

Most taxicabs use LPG as fuel. Although the government has a policy to promote the use of natural gas vehicles (NGVs), NGVs are not as widely used as the government expects, because of a shortage of fuel supplying stations and a longer time to refuel.

3-3 Summary of the Secondhand Car Market in Thailand

3-3-1 Status of Registration of Secondhand Cars

In Thailand, no statistics including sales by secondhand car dealers have been kept. Therefore, we have estimated the size of the Thai secondhand car market by defining that vehicles that are newly registered in the year are new vehicles and others in the registry are secondhand (used) cars. We subtracted the number of newly registered vehicles by vehicle type of 2013 from the national total number of registered vehicles by vehicle type and determined the number of registered secondhand vehicles of all kinds in 2013 as being 30.99 million units, which represents 89% of the total number of vehicles in the registry, while the number of used passenger cars with seating for up to six people was 5.81 million units, representing 86%.

As a result of the continued strong annual growth since 2008, the number of secondhand passenger cars with seating for up to six people increased 67% from 3.48 million to 5.81 million units (an annual increase of about 10.8% on average).

Table 3-8 Sizes of Secondhand Car Market

	Item	2008	2009	2010	2011	2012	2013	Growth rate
1.	**Vehicle**							
2	General registration number	9.7	8.4	10.1	10.5	11.5	10.5	
3	Used car	23,855	24,892	25,604	27,035	28,754	30,991	5.4
4	Initial registration number	8.6	7.6	10.4	10.8	15.3	13.7	
5	Used car	3,480	3,769	4,031	4,460	4,962	5813	10.8

3-3-2 Status of Secondhand Car Dealers

We conducted a hearing investigation on secondhand car dealer and obtained the following information.

- In the entire country of Thailand, there are about 3,000 secondhand car dealers. In Thailand, car dealers are grouped by the size of their vehicle stock and dealers having more than 150 units/month in stock are defined as large-sized companies. Middle-sized companies are those having 50 to 100 units/month in stock and small-sized companies are those having less than 50 units/month in stock.
- In 2013, the Association of Used Cars was established in Thailand. There are about 200 large-sized secondhand car dealers who are members of this association in the country. The Association of Used Cars does not keep data and statistics on its members' sales.
- The Association of Used Cars introduced us to Siam Car Garden Co., Ltd. (SCG) and we conducted an interview with the company.
- SCG sells about 80 to 110 secondhand cars monthly. The company has about 650 secondhand cars in its stock, which include about 400 cars from Toyota. SCG has a total of 3 sales bases in the suburbs of Bangkok.
- Secondhand cars being sold by SCG are those with 3 to up to 5 years having passed after the registration. The company only sells secondhand cars whose total travel distance is less than 100,000 km. About 80% of the product lines handled by the company are Japanese cars. The number of cars sold most is Toyota, which is followed by Honda, Isuzu, Nissan and Mazda. SCG also sells some secondhand cars from BMW and VW but it handles only a few American cars.
- About 70% of the company's customers are individual customers, 20% are business customers and 10% are car rental companies. In recent years, many customers who are car importers are coming from Myanmar, Sri Lanka, Singapore and the Philippines to buy Toyota's Hilux Vigo in Thailand, where the Toyota model is produced in the largest quantity in the world. The demand for other models is low.
- SCG sells secondhand cars after carrying out maintenance on the purchased cars. The major work conducted in the maintenance process is replacement of parts such as bumpers and

wheels and the engine is rarely replaced.

- One of recent trends found is a decrease in the number of secondhand cars sold. This is happening as the result of a cash rebate program the government introduced for new car purchases in 2012. Other factors inhibiting sales of secondhand cars include consumers' holding off spending in the aftermath of the recent political turbulence and tighter bank financing.

First-time Car Buyer Program (Single article tax rebate for first-time car buyers)
Under this program, if a consumer buys a car produced in Thailand for the first time and the car is: (1) a passenger car with an engine displacement smaller than 1,500cc, (2) a pickup truck or (3) a 4-door pickup truck, the consumer can claim back up to THB100,000 (approx. JPY260,000) tax rebate. Consumers could make a claim if they purchased or reserved a car by the end of 2012. Buyers of about 800,000 cars made the claim.
However, because buyers who had been unable to buy a car borrowed money and bought a car on a loan payment plan by using this incentive program, an increased number of cars were returned because many of such buyers became unable to continue payments. Hence, the returned cars flooded into the secondhand car market leading to an excessive supply and hence to a drop of secondhand car prices. (Source: JETRO's Bangkok Report)

It is projected that secondhand cars that need engine replacement under this project are probably longer than those currently sold by SCG in terms of both years used and travel distance.

3-3-3 Status of Distribution of Secondhand Cars

The status of how automobiles are distributed in Thailand is shown in the following figure.

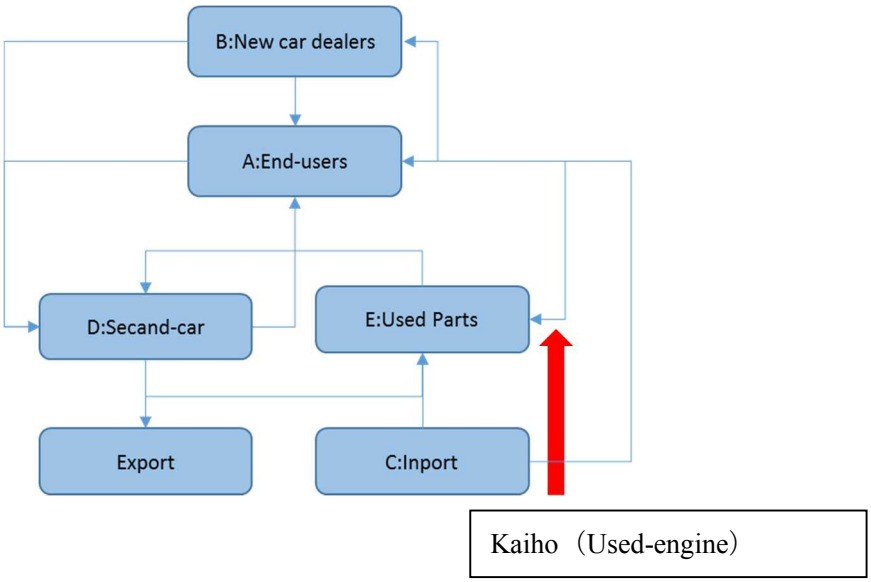


Figure. 3-1 Distribution of Secondhand Cars

A: End-users: Consumers to purchase automobiles. Secondhand cars are also traded between end-users in the form of private sale.

B: New car dealers: Approved regular dealers who sell and maintain brand cars manufactured by auto manufacturers.

C: Import market (importers): Those who import automobiles on a parallel import basis. Kaiho Thailand also imports engines and parts to sell in the secondhand parts market.

D: Secondhand car market (secondhand car dealers): There are no secondhand car centers, also known as tent dealers, specialized in the purchase of secondhand cars but there are dealers whose main business is to sell secondhand cars. Recently, secondhand cars are sold through auction. There are 4 secondhand car auctioneers in Thailand including Manheim, Apple, Union Auction, and Siam Inter Auction.

Trade-in price evaluation: Salespersons working at new car or secondhand car dealers evaluate trade-in prices of secondhand cars. If a secondhand car is in good condition, the dealer who buys the vehicle will resell it, while cars that have a total travel distance exceeding 150,000 km, gas fueled vehicles that are altered to natural gas vehicles, vehicles whose odometer is maliciously altered, or accident cars are resold to secondhand car centers (aka tents).

3-4 Status of the Transport Industry in Thailand

It is considered that the transport industry also has strong needs to replace engines of trucks as trucks are heavily used in the industry.

3-4-1 **Numbers of Registered Trucks**

The number of newly registered trucks increased 96%, almost doubled, over a period from 2008 to 2013 (an annual increase of 14.5% on average), and as a result the share of new trucks in all registered trucks increased from 7% to 11%. In 2013, a total of 855,000 secondhand trucks were registered.

Table 3-9: Numbers of Registered Secondhand Trucks

Year	2008	2009	2010	2011	2012	2013
Item						
Truck						
Registration number	7.1	6.8	7.9	9.1	10.5	11.3
Used car (One thousand cars)	717	737	753	776	804	855

3-4-2 Status of Truck Usage in Transport Industry

Interview was conducted with transport companies and obtained the following information.
The interview was conducted with Mr. Sirichai of Blue and White (BW) who was introduced by Mr. Kan (Secretary, 02-671-3620) and Mr. Nipat (085-074-2208) of the Thai Transportation and Logistics Association (TTLA).
BW has a total of 500 vehicles including pickup trucks. Pickup trucks owned by BW are about 200 units in total and BW also has 300 units of 15 to 50-ton heavy-duty trucks.
Trucks owned by the company are all newly purchased vehicles, obtained from dealers of Isuzu or Hino trucks.
Usually these trucks are used for about 5 to 10 years until they become unable to run. The trucks vary by individual difference in terms of durability and some can be used for more than 10 years.
Currently, about 20% of all trucks BW owns have their engine already replaced.
At BW, heavy-duty trucks travel a distance of 10,000 km monthly (which means they will have traveled 120,000 km in one year and 1,200,000 km in 10 years).

BW repairs its trucks using secondhand parts imported from Japan, including engines. In Thailand, many parts shops offering secondhand parts can be found in Rangsit, Bang Na and etc. although secondhand parts purchased in those shops are sometimes poor in quality. If possible, the company wants to procure parts directly from Japan.

The repair department of BW only repairs engines in which a problem is found. It is

considered that replacing the engine is the best way.

When a truck becomes unable to travel, BW tries to sell it but the deal cannot be made sometimes because no agreement on price is reached with the buyer. In such cases, the truck will be scrapped and its parts will be used for the repair of other trucks.

BW is the largest transport company in the eastern part of Thailand. It is fully owned domestically. Although the company covers the entire area of Thailand in its sales activity, it is particularly strong in the northeastern area including Korat. The company's largest customer is supermarkets (large-sized ones), followed by local convenience stores. Cargos are delivered directly to major supermarkets, while deliveries to local convenience stores are made at its delivery centers

3-5 Automobile Inspection and Registration Systems in Thailand

3-5-1 Automobile Inspection System

The systems for automobile inspection and registration in Thailand are the responsibility of the Department of Land Transport, and the Motor Vehicle Act and the Land Transport Act govern these two systems. Specifically, the Motor Vehicle Act applies to passenger cars and commercial cars and the Land Transport Act applies to large-sized diesel cars such as buses and trucks. Automobiles are required to pass a periodic inspection if they are to travel on public roadways in Thailand.

Passenger cars are required to receive an annual automobile inspection when 7 years have passed since their new car registration. For passenger cars for which 7 years have not passed, automobile dealers affiliated to car manufacturers recommend receiving regular maintenance, while automobile inspection is not mandatory.

Commercial cars are required to receive an annual automobile inspection from the first year after they are registered as new cars. In case of taxicabs, the automobile inspection needs to be taken at a higher frequency, every 6 months and those with 10 years passed since manufactured are not allowed to operate as taxicabs. It is considered that such a strict requirement is in place because of the fact there are more than 100,000 taxicabs even only in Bangkok and taxicabs have an environmental impact such as air pollution and a quasi-public role in the society.

Bus, trucks and other large-size diesel vehicles are required to receive an annual automobile inspection from the first year after their new car registration just as in the case of commercial cars.

Passenger/commercial cars are to receive the inspection at private automobile inspection stations licensed by the Department of Land Transport, while buses and trucks are to receive it at the inspection stations of the department. Inspection is made on car exterior, brakes, sideslip, speedometer, underside, noise, exhaust gas (CO, HC), etc. The inspection fee varies depending on vehicle type, for example, it costs TBH200 for a passenger car. The automobile inspection certificate has to be presented when a car owner renews his or her automobile registration every year. As seen from this fact, the automobile inspection system is closely linked to the automobile registration system.

Although these two systems have already been established, how they are operated is not clear. The private inspection station visited for this study had only simple exhaust gas inspection equipment and a sideslip inspection area and there were no other inspection equipment that can be found in Japanese inspection stations. It is considered that one of major causes of air pollution in Bangkok is diesel fumes emitted by buses belching black exhaust. It is expected that with fume gas inspection strictly conducted on buses that have a strong public nature, these older buses will be replaced with new buses. The laws' anti-air pollution and traffic safety purposes can be realized only when the laws are enforced in a just manner, not just by establishing systems.

3-5-2 Automobile Registration System

Same as the automobile inspection system, the automobile registration system is under control of the Department of Land Transport. When basic information on a new car is registered completely, a license plate and a registration certificate sticker will be issued to the owner of the car. Later, the registration has to be renewed every year, and for which, the car owner has to (1) pay vehicle tax, (2) present the automobile inspection certificate and (3) have compulsory insurance. When the renewal is completed, a new registration certificate sticker will be issued and by displaying the sticker, the car owner is allowed to drive the car on public roadways.

In Thailand, there is also a deregistration system. The system is used when a car is exported, lost because of theft, etc., or stopped to be used. If the car owner fails to pay the vehicle tax for 3 years, deregistration is automatically done. For vehicle tax, reduced tax rate is applied for old vehicles.

Figure. 3-2: Automobile inspection system

Chapter 4 Survey on RV Methodology Preparation

This chapter describes the survey on MRV methodology preparation as JCM project. First section describes in detail the estimate of project implementation effect on local survey. Second section, in accordance to MRV methodology, builds the survey method, and also considers the issues and potentialities.

For more information the study team described in Chapter 5. Subject of this JCM business, vehicle number, mileage was also assumed a long taxi industry. The study team examined the MRV methodology and JCM commercialization. Results of this survey, taxi industry, owns a lot of long vehicle of the total mileage. Further, a taxi vehicle has grasped that it tends to increase. If a taxi be satisfied JCM business was population, it was considered that it would expected benefits associated with the CO2 reduction effect and it

4-1 Basic Survey for MRV Directional Study

4-1-1 Purpose

Kaiho Sangyo arranged used-engine, and MI conducted a model proving test at local site. The model proving test was intended to examine the actual business potential in Bangkok metropolitan. Besides Bangkok, the possibility to expand the study nationally and in neighboring countries of Thailand was in view.

4-1-2 Local Overview

(1) Railway

In Bangkok there are elevated railroad (BTS, Bangkok Skytrain) and subway (MRT); BTS operates 4 - 8 minute intervals and MRT 3 to 5 minute intervals. At some of BTS major stations, ticket gate and shopping center are connected by pedestrian bridge, even during daytime there are many passengers. Morning and evening commuting rush hour is congested that people are hardly able to move.

(2) Road Conditions

The main means of transportation of local people is vehicle, thus causing traffic jam every day at returning home hours. Walking distance of just 40-minute took double the time when travelled by taxi. One taxi obviously looked old with noise vibration coming from within the cab body all the time. The taxi drivers' driving technique was very much rough and far from eco-driving. There are many vehicles believed to be running at poor condition as represented by vehicles mentioned.

The road is characterized by wide major intersection and wide dimension, but there was no signs for traffic regulation and not kept orderly. Motorcycles ran threading through the cars, and even rampantly running in opposite direction, the traffic jam was serious.

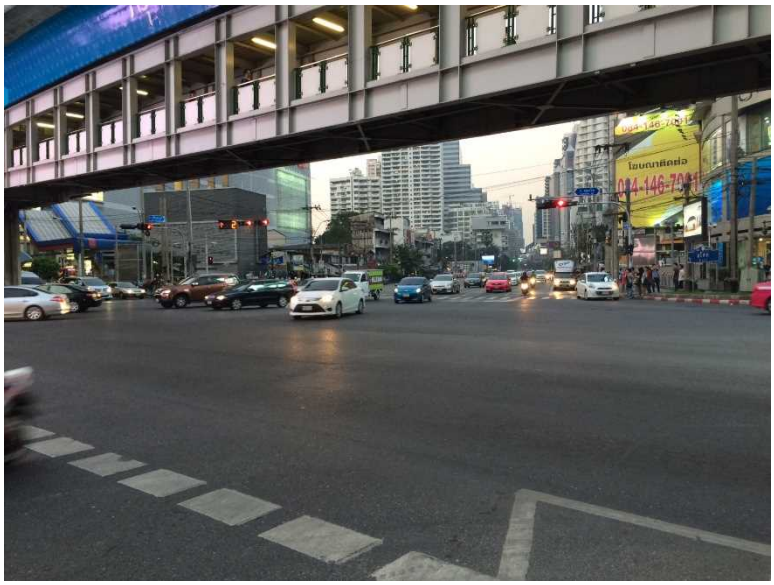


Figure 4-1 Bangkok City Major Intersection at No Traffic Jam

Figure 4 Bangkok City At Traffic Jam

4-1-3 Preliminary Test

Date: 2014/11/21(Fri)～22(Sat)

Time: 8:00 ~ 20:00

Frequency: 3 Round Trip (6 x)/day (1. 8:00-10:30, 2. 12:00-14:30, 3. 16:00-19:30)

No. of units: 4 vehicles

(1) Running Rout

The running rout is shown in the following figure4-3

Running Route: Bangkok city <-> Amata Nakorn (approx. 70km)

- Bangkok city: ESSO (Intersection of Rama IV Road & Sukhumvit Soi 24 Road)
- Amata Nakorn: ESSO (Intersection of Thanon Sukprayun & Rat Samoson)

Explanation to Participating Drivers

- Travel record: Memo the start, arrival, mileage and fuel amount
  * Before travel: Reset trip meter
  * Make sure to get receipt from highway
- Fuel: Gasohol 91
- Fuel amount: Fill-up in each travel
  * Automatic stop until clicking sound. Do not top up.
  * When filling, make sure to get receipt.
- Following time is only as a guide. Drive at normal speed and observe safety.

Preliminary Test Route

From : Bangkok : ESSO (Intersection of Rama IV Road. & Soi Attha Kawi (Sukhumvit soi 24)

To : Amata Nakorn : ESSO (Intersection of Thanon Sukprayun & Rat Samoson)

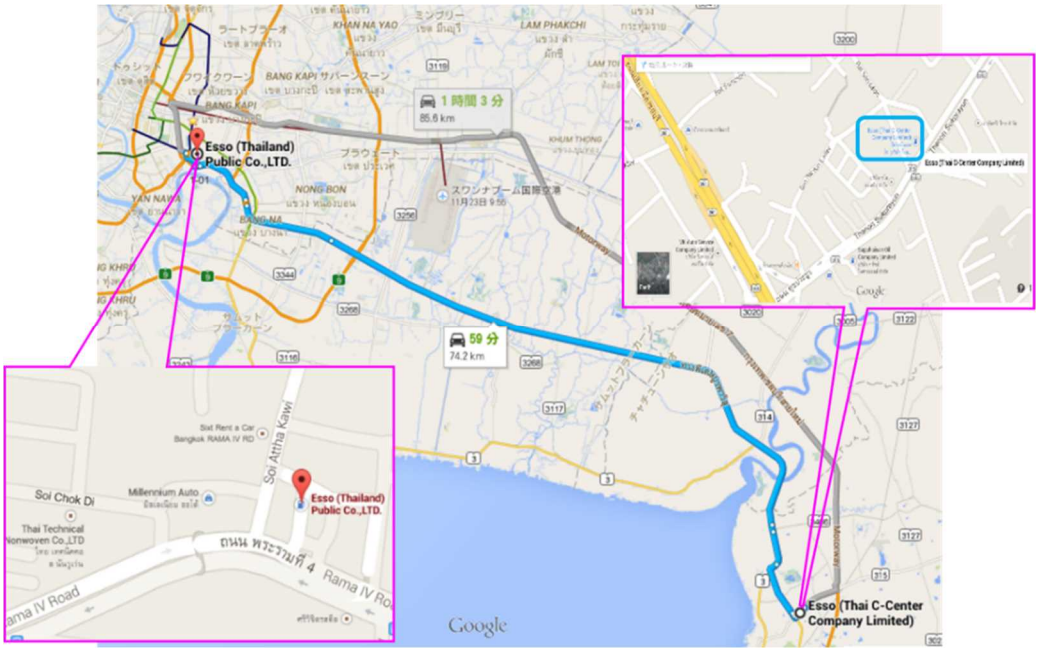


Figure 4-3 Preliminary Test Route

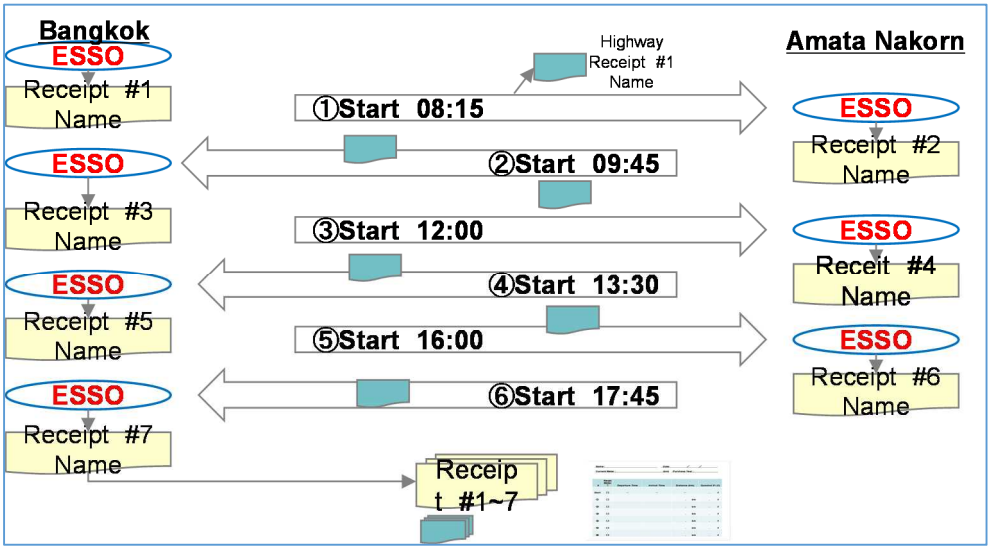


Figure 4-4 Preliminary Test Flow

Name: Date: 2014 ／ 11 ／ 21 (Fri.)

Current Meter : (km) Car Purchase Year :

C	Reset Meter ?	Departure Time	Arrival Time	Distance (km)	Gasohol 91 (ℓ)
	—	—	—	—	. ℓ
①	□			. km	. ℓ
②	□			. km	. ℓ
③	□			. km	. ℓ
④	□			. km	. ℓ
⑤	□			. km	. ℓ
⑥	□			. km	. ℓ

Figure 4-5 Preliminary Test Survey Slip

(2) Target Vehicle and Driver

4 units of taxis that are the target under study, included relatively still new with more mileage and less mileage. One more passenger boarded besides the taxi driver, or a weight was loaded.

Table 4-1: Target Vehicle Information

Driver	Number	Purchase year	Mileage	Engine Type	Tire Type	Fellow passenger	
						Day1	Day2
KAN	5323	2006	768,047KM	MT、3 ZZ	185/70 R14	SOGA	SOGA
SARAWUT	5576	2012	264,722KM	AT、1 ZR	195/65 R15	Pot	Pot
LAE	6613	2014	89,000KM	MT、1 ZR	195/65 R15	Weight (60kg)	OTAKE
ANUKOOL	9783	2014	33,357KM	MT、1 ZR	195/65 R15	Weigh t	Weigh

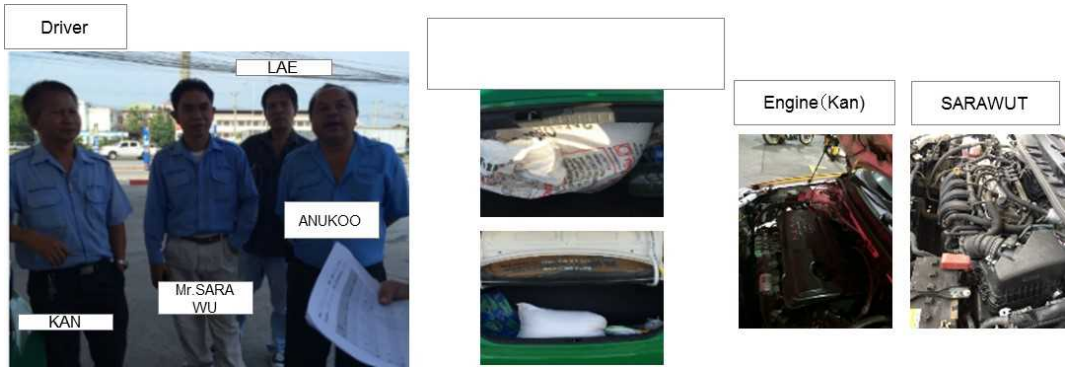
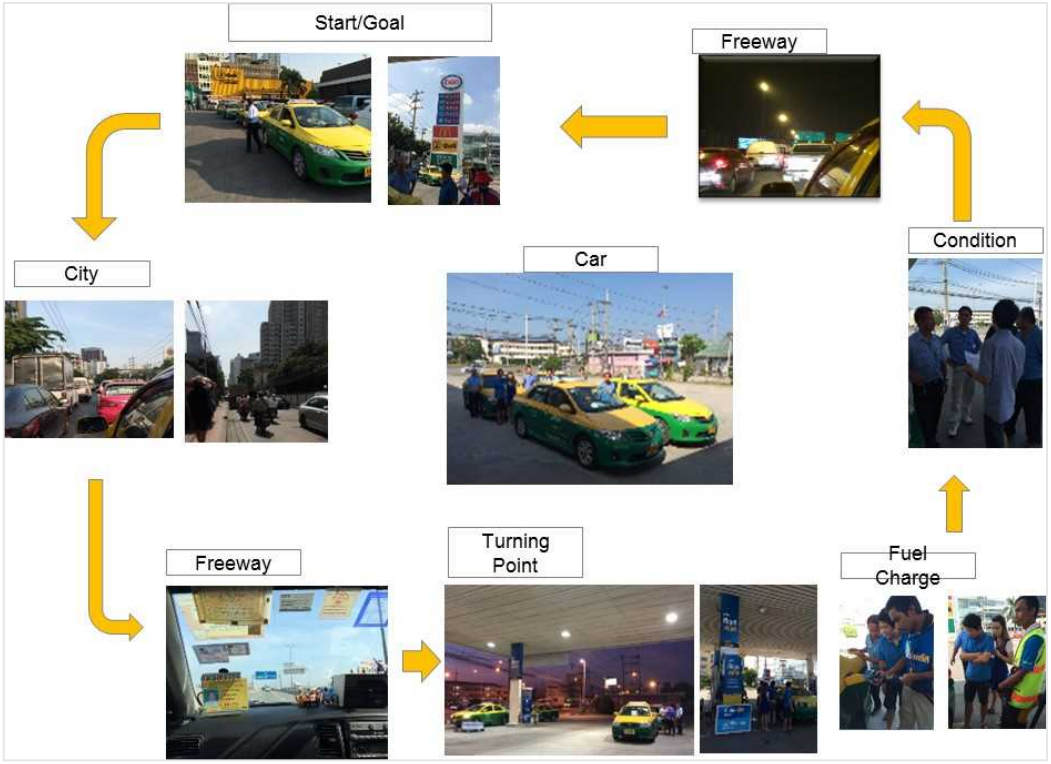


Figure 4-6 :Appearance of various places during preliminary test



4-1-4 Result of Preliminary Test

Preliminary test is shown in the following Table4-2. Vehicles of Mr. Kan and Mr. Sarawut are relatively high mileage vehicles as shown on the top. Looking at this result, in comparison to particularly high mileage vehicle of Mr. Kan, the 2 vehicles shown in lower row have good fuel efficiency by about 19%. Therefore it is possible to measure the fuel efficiency difference by the performance of engine.

Table4-2 Result of Preliminary Test

	Mr.KAN						5323	Mr.SARAWUT						5576
	#	出発時刻	到着時刻	所要時間	走行距離 (km)	給油 (ℓ)	燃費	#	出発時刻	到着時刻	所要時間	走行距離 (km)	給油 (ℓ)	燃費
DAY1	D1-①	8:10	9:39	1:29	68.4km	7.005ℓ	9.8km/ℓ	D1-①	8:05	9:39	1:34	67.7km	7.829ℓ	8.6km/ℓ
	D1-②	10:07	11:22	1:15	75.3km	6.601ℓ	11.4km/ℓ	D1-②	10:08	11:28	1:20	74.5km	6.650ℓ	11.2km/ℓ
	D1-③	12:15	13:29	1:14	68.2km	6.363ℓ	10.7km/ℓ	D1-③	12:15	13:32	1:17	67.6km	5.123ℓ	13.2km/ℓ
	D1-④	13:52	15:12	1:20	75.2km	6.139ℓ	12.2km/ℓ	D1-④	13:50	15:10	1:20	74.6km	7.676ℓ	9.7km/ℓ
	D1-⑤	15:59	17:34	1:35	68.2km	5.828ℓ	11.7km/ℓ	D1-⑤	16:00	17:32	1:32	67.6km	4.610ℓ	14.7km/ℓ
	D1-⑥	18:19	20:06	1:47	75.2km	8.600ℓ	8.7km/ℓ	D1-⑥	18:20	20:00	1:40	74.6km	7.672ℓ	9.7km/ℓ
	Day1			8:40	430.5km	40.536ℓ	10.6km/ℓ	Day1			8:43	426.6km	39.560ℓ	10.8km/ℓ
DAY2	D2-①	8:09	9:07	0:58	68.2km	10.134ℓ	6.7km/ℓ	D2-①	8:09	9:20	1:11	67.6km	7.173ℓ	9.4km/ℓ
	D2-②	10:14	11:36	1:22	68.2km	6.389ℓ	10.7km/ℓ	D2-②	10:09	11:35	1:26	74.4km	4.148ℓ	17.9km/ℓ
	D2-③	13:37	14:39	1:02	69.2km	8.458ℓ	8.2km/ℓ	D2-③	13:27	14:40	1:13	65.1km	7.824ℓ	8.3km/ℓ
	D2-④	15:46	17:03	1:17	75.2km	6.419ℓ	11.7km/ℓ	D2-④	15:45	17:01	1:16	74.5km	7.850ℓ	9.5km/ℓ
	Day2			4:39	280.8km	31.400ℓ	8.9km/ℓ	Day2			5:06	281.6km	26.995ℓ	10.4km/ℓ
	Total			13:19	711.3km	71.936ℓ	9.7km/ℓ	Total			13:49	708.2km	66.555ℓ	10.6km/ℓ

	Mr.LAE						6613	Mr. ANUKOOL						9783
	#	出発時刻	到着時刻	所要時間	走行距離 (km)	給油 (ℓ)	燃費	#	出発時刻	到着時刻	所要時間	走行距離 (km)	給油 (ℓ)	燃費
DAY1	D1-①	8:10	9:39	1:29	66.2km	7.053ℓ	9.4km/ℓ	D1-①	8:05	9:39	1:34	66.1km	7.412ℓ	8.9km/ℓ
	D1-②	10:08	11:27	1:19	72.8km	6.143ℓ	11.9km/ℓ	D1-②	10:08	11:27	1:19	72.7km	5.984ℓ	12.1km/ℓ
	D1-③	12:15	13:30	1:15	66.2km	4.635ℓ	14.3km/ℓ	D1-③	12:15	13:33	1:18	66.1km	4.929ℓ	13.4km/ℓ
	D1-④	13:50	15:10	1:20	72.7km	6.291ℓ	11.6km/ℓ	D1-④	13:50	15:23	1:33	72.2km	6.446ℓ	11.2km/ℓ
	D1-⑤	15:53	17:31	1:38	66.1km	4.298ℓ	15.4km/ℓ	D1-⑤	15:53	17:30	1:37	66.0km	3.530ℓ	18.7km/ℓ
	D1-⑥	18:15	20:05	1:50	72.9km	6.752ℓ	10.8km/ℓ	D1-⑥	18:15	20:06	1:51	72.8km	6.847ℓ	10.6km/ℓ
	Day1			8:51	416.9km	35.172ℓ	11.9km/ℓ	Day1			9:12	415.9km	35.148ℓ	11.8km/ℓ
DAY2	D2-①	8:09	9:07	0:58	66.1km	6.036ℓ	11.0km/ℓ	D2-①	8:09	9:10	1:01	66.0km	6.228ℓ	10.6km/ℓ
	D2-②	10:14	11:34	1:20	72.8km	5.038ℓ	14.5km/ℓ	D2-②	10:09	11:35	1:26	76.8km	5.083ℓ	15.1km/ℓ
	D2-③	13:27	14:41	1:14	67.2km	6.221ℓ	10.8km/ℓ	D2-③	13:27	14:43	1:16	67.1km	5.891ℓ	11.4km/ℓ
	D2-④	15:46	16:57	1:11	72.8km	7.434ℓ	9.8km/ℓ	D2-④	15:45	17:03	1:18	72.9km	7.687ℓ	9.5km/ℓ
	Day2			4:43	278.9km	24.729ℓ	11.3km/ℓ	Day2			5:01	282.8km	24.889ℓ	11.4km/ℓ
	Total			13:34	695.8km	59.901ℓ	11.5km/ℓ	Total			14:13	698.7km	60.037ℓ	11.6km/ℓ

Table 4-3 Preliminary Test Log Record

Day1

Point	Time	LAP	状況	Time	LAP	状況	Time	LAP	状況
	①			③		冷房入れていても日差しが暑い	⑤		
Bangkok ESSO	8:10			12:15			15:59		
↓	↓	0:14	市内を抜けるのにやや渋滞	↓	0:24	交差点手前で渋滞。	↓	0:34	渋滞。バイク多。交差点手前までほぼ動かない状態
Intercection Rama IV Rd. & Sukhumvit	8:24			12:39			16:33		
↓	↓	0:12	Soi 101 あたりで渋滞	↓	0:11		↓	0:13	
Intercection Sukhumvit & Bang Na Trat Rd.	8:36			12:50			16:46		
↓	↓	0:07		↓	0:05	快調	↓	0:06	快調
Highway IC	8:43			12:55			16:52		
↓	↓	0:38	平均100-120km/h、空港付近で渋滞	↓	0:28	平均100-120km・h、渋滞なし	↓	0:32	快調。平均120km/h。出口渋滞で3分程度ロス
Highway IC	9:21			13:23			17:24		
↓	↓	0:18	平均80-100km/h	↓	0:06	快調	↓	0:10	ほぼ順調
Amata Nakorn ESSO	9:39			13:29			17:34		
	68.4km	**1:29**		**68.2km**	**1:14**		**68.2km**	**1:35**	

Point	Time	LAP	状況	Time	LAP	状況	Time	LAP	状況
	②			④		さらに暑い…	⑥		すっかり暗くなりました。
Amata Nakorn ESSO	10:07			13:52			18:19		
↓	↓	0:10		↓	0:13	高速入口手前で渋滞	↓	0:15	2か所渋滞ポイントあり。工業地帯から金曜夜の帰宅
Highway IC	10:17			14:05			18:34		
↓	↓	0:26	順調。平均100-12km/h。出口付近でタイヤがバーストしたばかりの軽トラックあり。事故にも巻き込まれず、渋滞も免れた。	↓	0:27	快調。平均100-12km/h。出口手前でやや渋滞	↓	0:37	快調。出口で10分渋滞
Highway IC	10:43			14:32			19:11		
↓	↓	0:07	快調	↓	0:06		↓	0:27	大渋滞
Intercection Sukhumvit & Bang Na Trat Rd.	10:50			14:38			19:38		
↓	↓	0:21	Sukhumvit通りに入ってから渋滞プンナウィティ駅まで。橋を越える手前からやや渋滞	↓	0:17	プンナウィティ駅近辺でやや渋滞Sukhumvit交差点手前でやや渋滞	↓	0:13	ほぼ渋滞せず
Intercection Rama IV Rd. & Sukhumvit	11:11			14:55			19:51		
↓	↓	0:11	やや渋滞	↓	0:17	やや渋滞、Goal近辺は混雑	↓	0:16	快調
Bangkok ESSO	11:22			15:12			20:07		
	75.3km	**1:15**		**75.2km**	**1:20**		**75.2km**	**1:48**	

Day2

Point	Time	LAP	状況	Time	LAP	状況	Time	LAP	状況	Time	LAP	状況
	①			③			①			③		
Bangkok ESSO	8:09			13:27		ESSO⇒Lunch⇒スタート	8:09			13:27		ESSO⇒Lunch⇒スタート
↓	↓	0:07	順調	↓	0:20	交差点手前で渋滞。	↓	0:08	快調	↓	0:20	交差点手前で渋滞。
Intercection Rama IV Rd. & Sukhumvit	8:16			13:47			8:17			13:47		
↓	↓	0:14	Bang Chak駅近辺でやや渋滞。	↓	0:13		↓	0:13	Bang Chak駅/Udom Suk付近ですこし渋滞	↓	0:12	プンナウィティ駅あたりから渋滞
Intercection Sukhumvit & Bang Na Trat Rd.	8:30			14:00			8:30			13:59		
↓	↓	0:05	快調。	↓	0:06	快調		0:04	快調	↓	0:05	快調
Highway IC	8:35			14:06			8:34			14:04		
↓	↓	0:26	快調。120km/h平均	↓	0:27	快調。100-120km/h平均	↓	0:28	平均100-120km・h、渋滞なし	↓	0:32	平均100-120km・h、渋滞なし
Highway IC	9:01			14:33			9:02			14:36		
↓	↓	0:06		↓	0:06		↓	0:05	平均80-100km/h	↓	0:05	快調
Amata Nakorn ESSO	9:07			14:39			9:07			14:41		
	68.2km	**0:58**		**69.2km**	**1:12**		**66.1km**	**0:58**		**67.2km**	**1:14**	

Point	Time	LAP	状況	Time	LAP	状況	Time	LAP	状況	Time	LAP	状況
	②			④			②			④		
Amata Nakorn ESSO	10:14			15:46			10:14			15:46		
↓	↓	0:22	Uターンポイントまで渋滞12分。高速の入口で渋滞	↓	0:13		↓	0:20	高速下信号折り返し地点まで少し渋滞。高速料金所前で少し渋滞	↓	0:11	快調
Highway IC	10:36			15:59			10:34			15:57		
↓	↓	0:26		↓	0:30	平均100-110km/h（やや抑えめ）	↓	0:28	平均100-120km・h、渋滞なし	↓	0:26	平均100-120km・h、渋滞なし
Highway IC	11:02			16:29			11:02			16:23		
↓	↓	0:05		↓	0:08	やや渋滞。Sukhumvit通り入口で、バス後部炎上車（消火後）による渋滞あり。	↓	0:13	快調	↓	0:07	快調
Intercection Sukhumvit & Bang Na Trat Rd.	11:07			16:37			11:15			16:30		
↓	↓	0:19	やや渋滞	↓	0:15	快調。途中、バイク事故による渋滞あり。	↓	0:09	Sukhumvit通りに入ってから渋滞プンナウィティ駅手前まで。	↓	0:12	Skhumvit70付近で少し渋滞
Intercection Rama IV Rd. & Sukhumvit	11:26			16:52			11:24			16:42		
↓	↓	0:10		↓	0:11		↓	0:10	ゴール付近ノロノロ運転	↓	0:15	ゴール付近ノロノロ運転
Bangkok ESSO	11:36			17:03			11:34			16:57		
	75.2km	**1:22**		**75.2km**	**1:17**		**72.8km**	**1:20**		**72.8km**	**1:11**	

4-1-5 Survey Test

(1) Test Method（JRS/PAS777）

JRS (Japanese Reuse Standard) is the quality standard of used-car parts developed by Kaiho Sangyo when distributing used-car parts. In addition, JRS/OAS777 is the public specification of measurement and measuring method for used-engine by JRS. What is described in JRS is as follows. A study was made whether JRS/PAS777 index is applicable to measure the degree of deterioration of used-engine, and JRS index of the target engine was also described and studied.

- Unique identifying number allocated to vehicle and parts
- Details of vehicle and engine model
- Information of oil level, damage and missing parts
- Compression gauge, mileage, radar chart displaying engine condition
- Inspection company, inspection in-charge and inspection date
- Bar code built-in with above data

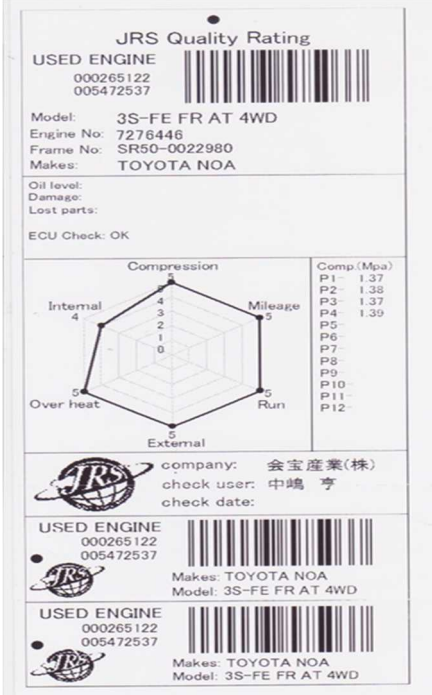


Figure 4-7 JRS tag

(2) Implementation Date

Travel was carried out before remounting on 2014/12/9 & 10, while travel was carried out after remounting on 2014/12/16 & 17. Travel 2 round trips per day considered as 1 test. Before and after the remounting, both consisted 2 days, totally 2 times measurement. Outward departure time was set at 10 am and 4 pm.

Target Vehicle Under Study and Engine

Table 4-6 shows 5 units of vehicles used in proving test. In this report, common name A vehicle ~ E vehicle is used. A ~ D vehicles are taxis and E vehicle is private car. A, B and D vehicles are stick-shift (manual), C vehicle is stick-shift remodeled to automatic car, and E vehicle is

automatic car. A, D and E vehicles had 1600cc, B and C vehicles had 1800cc engines mounted originally. B, C and D vehicles had already remounted engine once in past, total mileage is known but mileage after remounting is unknown.

Table 4-7 shows the specification of engine after remounting and measurement result of JRS/PAS777. Only A vehicle that had 1600cc engine, 1800cc engine was remounted, otherwise other vehicles are remounted with same engine model. In addition, only A and B vehicles are equipped with OBD (On-board diagnostics).

(3) Running route

Table 4-8 shows the running route. Bangkok was designated as starting point and Pattaya as half-way point. Running route was between two points 2 round trips. On the way was running 66km highway.

* Starting point ---gas station within Bangkok city

Address: Soi Attha Kawi, Khwaeng Khlong Tan, Khet Khlong Toei, Krung Thep MahaNakhon 10110 Thailand

* Half-way point --- Pattaya

Address: Motorway 7, Muang Patthaya, Amphoe Bang Lamung, Chang Wat Chon Buri 20150 Thailand

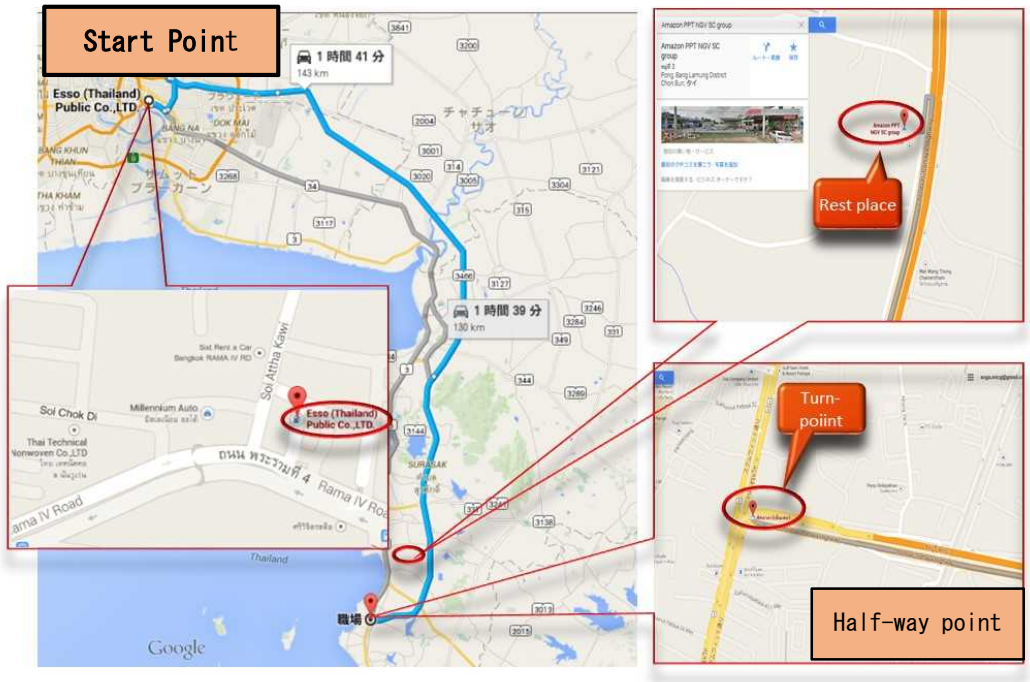


Figure 4-8 Running Route

(4) Measurement Method

5 units of vehicles traveled in a caravan from Bangkok to Pattaya for 2 round trips a day. Adequate amount of refueling at outward voyage, and then at return trip refueling until tank was full. At every round trip, required time, mileage, fuel consumption were measured and in

case of vehicle equipped with OBD terminal, fuel consumption, mileage and carbon dioxide emission were measured.

This process was carried out before remounting and after remounting, for 2 days each, thus totally 4 days.

- Refueling meter at gas station: measure fuel consumption
- OBD terminal: measure fuel efficiency, fuel consumption and carbon dioxide emission
- Taximeter: measure mileage and required time

Figure 4-9 OBD Terminal Working at Testing

(5) Test Precaution

- At highway maintain and travel 110km/h as much as possible
- At general road drive as usual safe driving
- Refueling at gas station is inaccurate, so visually confirm that tank is full
- For before and after remounting, have common test day and time

4-1-6 Test Result and Devise

(1) Correlation of mileage and fuel economy

Being able to determine the correlation between mileage and fuel economy, about deterioration of fuel consumption can be estimated from the traveling distance. Was considered to be available to determine the target vehicle reloading. In addition, mileage is easily the available data. Estimates of reloading the target vehicle speed and the GHG reductions in Bangkok city is also available. This assumption was evaluated and Discussion of the original survey data

(2) Travel Data

Travel data for before and after remounting is shown in Table 4-8 and Table 4-9. Some points of issue are as follows.

1) Mileage

In this test, 5 units of vehicles traveled the same route in caravan. Before remounting and

after remounting respectively, same route a day of 2 round trips, total 4 round trips. Therefore, mileage of each vehicle is expected to be approximately the same. However, as shown in Figure 4-11, B vehicle's meter clearly shows a high reading, and contrary to that, C vehicle's reading is low. The average of other vehicles A, D and E readings was taken, and assumed 554 km mileage a day. Since the purpose of this study is comparison of fuel cost, so when same route is travelled it is same as comparing only with fuel consumption, and there is no significant meaning in 554km itself.

2) Regarding Gasohol 95 Refill

In Table 4-7, before remounting, on second day vehicle B ran out of gasoline, so hurriedly refueled with Gasohol 95 (gasoline 95%, alcohol 5%). As far as table 3 shows, there is no big difference in fuel consumption, therefore this difference is ignored.

3) Fuel Consumption

Similarly, since same route is travelled, each vehicle is supposed to have same fuel consumption each day. However, fuel consumption changes depending on running speed and traffic congestion. This time fill-up method is adopted, so accuracy depends whether refueling is properly done or not. Therefore, before and after remounting for 2 days respectively, the changes of fuel consumption for each vehicle is shown in figure 2. Following formula is used to calculate fuel consumption.

Fuel consumption change (%) = 1st day fuel consumption – 2nd day fuel consumption/average of 2-day fuel consumption

As shown in Figure 4-12, most values are below 5%, but E vehicle before remounting (17.7%), after remounting (9.3%), B vehicle after remounting (34.2%) is high. B vehicle after remounting is obviously abnormal value; a difference of 34.4% (approx. 20 liters) after traveling a same route is unlikely. Therefore fuel consumption data that is almost the same as 1st day was adopted, 2nd day was assumed to failed in refueling, thus it was rejected.

The data of E vehicle is also doubtful, but it was adopted and treated to have 15% error in analysis from then on.

4) Travel Time

The total mileage also differs between before and after remounting. The reason is because before-remounting test run was carried out on holiday. The average time of before-remounting for 2 days is 8 hours 3 minutes, and after-remounting is 8 hours 44 minutes. Idling may have consumed the fuel of this time difference. Even if idling estimated at most, it is believed 1 liter which was then added in analysis.

(3) Comparison Before and After Remounting

Based on section (1), Table 4-4 shows the comparison of fuel cost before and after remounting. This was re-calculated with uniform mileage 554km. As said in section (1), "corrected fuel cost" of after-remounting is calculated after fuel consumption 1 liter caused by idling is subtracted and it is shown in this table.

Figure 4-10 shows the comparison of fuel efficiency before and after remounting. Plot

at upper to pale blue triangle shows that fuel efficiency is improved (fuel cost of plot included in triangle is decreased). Black plot shows fuel efficiency not corrected by idling, red plot is fuel efficiency corrected. From this Figure4-10, correction is considered appropriate, so further discussion shall be on corrected fuel efficiency. From this Figure, fuel efficiency is almost not changed or is within measurement error. Therefore it can be concluded in this test that fuel efficiency by remounting-engine was not measured.

When looking at the difference of engine size, 1600cc (D, E vehicles) obviously has better fuel efficiency than 1800 cc (B, C vehicles). Vehicle A had engine-remounted from 1600cc to 1800cc, but fuel cost did not worsen particularly, even after remounted it belonged to 1600cc group. This may be collateral evidence that fuel cost is not determined by engine alone. Assuming fuel efficiency is divided into that of engine (engine fuel cost) and that of other than engine (body fuel cost), this shows that fuel efficiency of vehicle as a whole is determined by combining both of them.

Table 4-4: Comparison of Fuel Efficiency after Correction

1day Millage	554 km

Car	Total Milage (km)	Day	Before		After		
			Consumption fue (l)	Millage (km/l)	Consumption fue (l)	Millage (km/l)	Eficiency (km/l)
A	720,000	D-1	41.2	13.5	40.15	13.8	14.2
		D-2	38.9	14.3	41.63	13.3	13.6
B	350,000	D-1	63.1	8.8	62.30	8.9	9.0
		D-2	64.1	8.6	–	–	–
C	250,000	D-1	45.7	12.1	46.72	11.9	12.1
		D-2	44.0	12.6	49.03	11.3	11.5
D	400,000	D-1	42.4	13.1	44.39	12.5	12.8
		D-2	41.4	13.4	43.07	12.9	13.2
E	270,000	D-1	43.3	12.8	43.63	12.7	13.0
		D-2	36.3	15.3	39.75	13.9	14.3

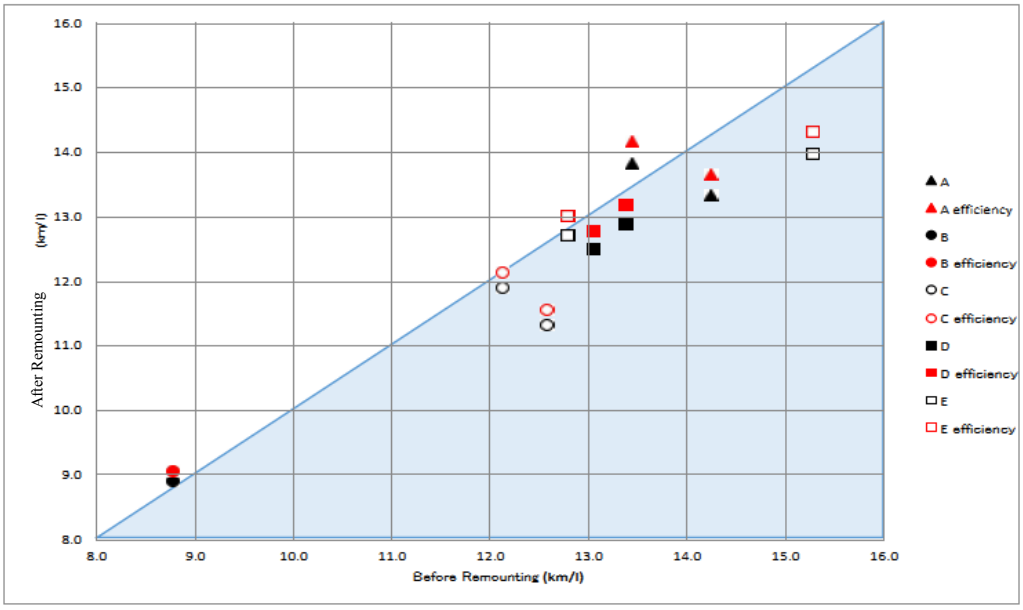


Figure 4-10: Comparison of Fuel Efficiency Before and After Remounting

Figure 4-13 shows the relationship of mileage and fuel efficiency. Qualitatively, as

mileage increases fuel efficiency is expected to worsen but it is not shown in this Figure. For 1600cc vehicles D and E, fuel efficiency tends to worsen as mileage is increased, but E vehicle has range variation of fuel efficiency and lack in accuracy. If B vehicle value is normal level, the fuel efficiency of 1800cc (B, C vehicles) show worsening trend, but if B vehicle is abnormal level, then as mileage increases in 1800cc (A, C vehicles) fuel efficiency is expected to improve which is not seen. From Figure 4-13, it is hard to describe the relationship between vehicle mileage and fuel efficiency.

(4) Comparison of JRS/PAS777 and Fuel Efficiency in Engine After-Remounting

Then, the relationship between JRS/PAS777 and fuel efficiency before and after remounting (after correction of idling) was analyzed. First, Figure 5 shows the JRS/PAS777 evaluation result of before and after remounting engine for each vehicle. As this Figure shows, the Mileage of JSR/PAS777 value of before and after remounting has a big difference, but other items showed only 5 or 4. There is no big difference. Maybe a little poorer quality engine for before-remounting should have been selected.

A relationship of this radar chart dimension and fuel efficiency was analyzed in Figure 6. From this Figure, there was no particular correlation found.

Finally, Figure4-14 shows the relation of each axis and fuel efficiency of JRS/PAS777. From this Figure, no particular observation was noted between each axis and fuel efficiency of JRS/PAS777. Only in the Figure of “Mileage”, it can be said that index 1 ~ 5 of Mileage has no correlation with fuel efficiency. Axis 1 ~ 5 of JRS/PAS777 has discontinuous ordering, it was not possible to get correlation with quantitative fuel efficiency. Rather JRS/PAS777 is a tool to measure basic engine performance e.g. engine starts or overheats. The test carried out on before-remounting, all the vehicles except one had good maintenance, since taxi was the study target. Performance was good except Mileage; no difference was noted in JRS/PAS777 before and after remounting. Regarding engine intended for remounting, no difference (i.e. car body fuel efficiency was apparent) was noted since engines used for testing were collected from those passing JRS/PAS777 with excellent results.

(4) Conclusion

In “Promotion project to introduce Japanese used-engine supporting reduction of vehicle emission CO2 in Thailand”, analysis result of proving test was conducted from 2014/12/8~22 at Bangkok Thailand. Vehicles used in the test are 4 taxis that are actually used in normal service and a private car. Individual differences were big on maintenance level, modification, and the test result reflected these differences. In section 2, after showing the data of study vehicles, section (1) described the comparison of mileage and fuel consumption data and reviewed their correction method. Based on this correction method, section (2) described the comparison of fuel efficiency of before and after remounting. If vehicle fuel efficiency is divided into the part determined by engine performance (engine fuel cost) and the part determined by other than engine (car body fuel cost), then the effect of car body fuel cost is big; and improvement of

engine fuel efficiency after remounting was not apparent tin entire vehicle. Furthermore, section (3) analyzed the relation between fuel efficiency after remounting and JRS/PAS777 evaluation. As a result, JRS/PAS777 is a method to measure basic engine performance, i.e. engine not starting or overheat. Engines collected for testing this time are those that passed JRS/PAS777 evaluation with excellent performance, and no difference was noted. Therefore, the result exhibited was the difference in car body fuel efficiency.

From above, vehicle fuel efficiency is determined by overall mechanism of both engine and car body fuel efficiency. Along with remounting engine, improvement of car body fuel efficiency is considered to be valuable method to reach the purpose of this project.

(5) Devise

1) Aging and Fuel Efficiency of Engine

Any vehicle cannot maintain the initial fuel efficiency. Worsening of fuel efficiency is considered due to rust and wear of rotational system leading to loss of smoothness, and dirt adherence to engine exhale and exhaust parts causing clogging. Rotational parts are specifically tires, brake rotor, hub bearing, drive shaft; and exhaling and exhaust parts are such s air cleaner, throttle valve and exhaust pipe. Parts included are those not possible to do service maintenance by individual, it is considered that as soon as vehicle mileage is increased the engine deteriorates. Oil change and maintenance are also the cause of engine deterioration. It results to wear of piston ring and gas (CO2,HC) leakage. Phenomenon is high exhaust pressure and low engine power. If regular maintenance of other parts is not done, further worsening of fuel efficiency is expected. Deteriorated engine will have decreased compression (cylinder internal pressure), internal combustion efficiency also decreases. If combustion efficiency decreases, engine output also decreases. Present vehicles have ECU controlled fuel injection device, even if engine deteriorates, theoretically fuel injection volume is same for the mileage. Therefore, it means fuel combustion rate is the same even if good engine is mounted. If engine deteriorates, following 3 points may show the difference. 1. Breakdown risk, 2. Incomplete combustion with difference in emissions, 3. Decreased torque. With decreased torque and if running at same speed, and if with poor engine it will have to raise the rotation in order to keep the output in order to run. In other words, to keep the same accelerating and cruising performance, engine with low output will have to raise the rotation at low gear, which increases fuel consumption. Then, the crank rotation increases, fuel injection increases and influencing the fuel efficiency.

Engine efficiency is fuel consumption per 1 horsepower (engine power). For gasoline engine with lowest fuel consumption, crank rotation becomes 200/psh~260/psh, the lower the value is considered fuel-efficient. Fuel cost (km/L) is determined by fuel consumption rate (g/kwh), transmission gear rate and running resistance of engine alone.

From these things, in regards to fuel efficiency for JRS/PAS777, there is correlation between 3 points, namely, compression, overheat and mileage. Therefore, in evaluating PAS777 of before

remounting-engine, it is necessary to assume the condition from these 3 points. Furthermore, engine deterioration in PAS777 evaluation is likely applicable to assumption of breakdown risk and usage-expectance instead of annual fuel cost. For this reason, through 10-year project, time-oriented analysis, especially remounting timing is considered when conducting life-cycle analysis, wherein established coefficient of breakdown risk and engine lifetime can be utilized.

In Thailand car inspection system is once in 7 years, the system of car recycling and scrapping is not ready, and it has been a prevailing thought to use the car until it does not run anymore. Therefore, before test was conducted, the average fuel cost of vehicle is estimated to be about 8km/L. Drivers who cooperated in monitoring this time had their vehicles maintained well, but there are many vehicles running in the city not well maintained. When that scale of vehicle in Thai market is specified, estimation of GHG reduction effect with engine remounting business can be considered.

2) Factors Influencing Fuel Efficiency

Regarding the factors affecting fuel efficiency, besides the result of car-body fuel efficiency result, such as vehicle weight, mounted parts and driving manner may be a big factor. However, Thai road condition is poor and daily driving manner cannot be said as safe. In this project, engine-remounting and information link with the drivers through maintenance and monitoring can be utilized; these factors to improve fuel cost, eco-drive method can be instructed, these can add incentive plus monitoring result gives understanding quantitatively, thereby if more effective reduction of GHG emission can be achieved, at the same time not only technically, but can create opportunity to introduce Japanese eco-friendly ways to Asian nations.

3) Issue on Fuel Efficiency Measuring Method

Even if improvement effect by engine remounting is small but by making error range smaller, by arranging the environment to measure such effect, by deploying as business to many targets, and then it can be reported as valid GHG reduction method. A devise on fuel efficiency measuring method is shown.

<In case of Gasoline/Gashole>

When compatibility in the shape of refueling nozzle and vehicle filler cap is poor, there were cases of auto-stop sensor not working properly. When preliminary test was carried out locally, especially in case of old car, refueling pipe was thin (or bending), thus causing significantly slow refueling speed. Furthermore, when the speed of refueling to pass the pipe to the car tank is slower than that from the filling machine, even if the tank is not fully filled there was a case sensor temporarily detected full and then stopped refilling. In addition, depending on gas station, the ground sloping is different (strictly speaking, even at same gas station, ground sloping is different at several spots). For this reason, refilling needs to be done at same place by same person. Additionally, since gasoline expands and shrinks depending on the temperature, the difference due to season and temperature can be considered.

<In case of OBD>

Signal from OBD II is sum of 1 x fuel injection from injector (fuel injection device). Injector is controlled by accelerator position, air flow and rotation. There is a MAP within computer;

where and how much appropriate fuel blowout is determined, and the signal displayed on monitor shows quite accurate fuel efficiency. Currently, it is genuinely employed in many cars and displayed in the meter, it has higher future applicability. Particular information “able to run under same condition or not” is given from OBD II, and GPS can be used to set up speed to measure the interval; “running at same speed, different accelerator position, different rotation range” if measured, then it is able to analyze the relation with fuel efficiency in detail.

4) Verification of Engine-Remounting Effect and Carbon Price

By assuming that engine-remounting can bring about improvement of fuel efficiency, study how much effective. First, in model proving test the fuel efficiency from 12.4km/L to 12.6km/L can be measured giving 1.6% improvement, so observe this improvement. Carbon price is assumed at about 10,000yen per CO2, emission coefficient used is 2.32kgCOs/L which is standard value in reported measurement. In local survey, with annual mileage is 20k kg, engine supposed to use 300k kg, so Japan in engine running 130k kg would be running additional 200k kg in Bangkok, thus 10-year improvement effect is assumed as achieved. Also, implementation of remounting if done in later year, the more fuel efficiency is thought to improve. However, before and after remounting is to be improved, 10-year fuel improvement of fuel efficiency shall have no change.

Under this assumption, calculated effect per one unit is as shown below. For target study of one unit in 10 years, the carbon dioxide reduction is 587kg CO2, when changed to carbon cost 5874 yen.

However, from data that taxi travels 500km a day, depending on targeted vehicle the annual mileage is thought to be 100k kg. In such case, when calculated same way, the carbon cost is 29,000 yen.

CO2 discharge coefficient(Gas)
2.32 kgCO2/L
10000 yen/tCO2
10 yen/kgCO2
The amount of emission(1km) Before Remounting
0.187 kgCO2/km 12.4 km/l
Replace (year)
10 年
After Remounting
0.184 kgCO2/km 12.6 km/l

Improve effect		Mileage/year	The emission/year	Co2 price/year
0.003 kgCO2/km	1.60%	20,000 km	58.7432 kgCO2	587 円

The amount of emissio/10year	Co2 Price/10year
587.432 kgCO2	5,874 yen

However, this alone looks difficult to bear the cost of remounting engine of each unit. Here, the effect of reducing the gasoline consumption is incorporated by fuel efficiency. Gasoline price in Thailand in 2014 was 1 L about 40 bahts. When 130 (yen/L) is considered as reduction effect, for 10-years gasoline reduction is 2155 liters, so the reduction of gasoline consumption is 165,000 yen. Gasoline price fluctuation is great, but together with carbon price the amount is considered enough to handle the cost for remounting. Economic value of this project even if fuel improvements effect is 1.6% it may be feasible.

Supposing fuel improvement efficiency of carbon dioxide reduction for remounting engine efficiency is conducted only with carbon cost, say engine remounting cost is 75,000 yen, and then same assumption is estimated. Supposing taxi mileage is 100k km, fuel efficiency improvement is 4.2%, and then required improvement is 0.5jm/L. When general annual average mileage of vehicle is assumed as 20k km, the fuel efficiency improvement is 25% with 3.1km/L of fuel efficiency improvement is desirable. As stated beforehand, engine exchange plus maintenance and driving method (eco-drive) all together promoted, the values are sufficiently feasible.

From the data of Bangkok city, there are 110k units of taxis. In 10 years, supposing 5% of engine is remounted, and the effect was calculated if 100 units of vehicles are increased yearly. Table shows that accumulation of 10 years brings reduction of 40,000k ton of CO2; even if in carbon cost, estimated as 40,000k yen. From this fact, one unit of vehicle which is the target of this project, is small and measurement is difficult, but GHG reduction potential and its economic potential is feasible.

Table 4-5：10-Year Project Implementation Estimate (Fuel Efficiency Improvement 4.2%)

Project Year	Number of Reduce Vehicle	Co2 Emission	The price of Carbon
1	100	75	750
2	200	150	1,500
3	300	225	2,250
4	400	300	3,000
5	500	375	3,750
6	600	450	4,500
7	700	525	5,250
8	800	600	6,000
9	900	675	6,750
10	1,000	750	7,500
Total	5,500	4,125	41,250

Table 4-6：Information of vehicles used in proving test

Vehicle	Symbol	Type ID Driver's AT/MT	Model	Reg year Number of Remounting Reg	Total Mirage [km] (as of	Emission[cc] Type of Engine	Size of Fuel Tank [L]	Type of tire	Type of Remounted Engine	Total Mirage or mounted engine
A	▲	TOYOTA 5323 Kan MT	2004	2004 None MR053ZEC10 7113266	720,000	1600cc 3ZZ-4547153	54	14/185/70 615	1800cc 1ZZ-1291996	139,000
B	●	TOYOTA 8093 Kin MT	2003	2003 2 MR053ZEC10 7026936	350,000	1800cc 1ZZ-0842911	54	15/185/55 584	1800cc 1ZZ-Z015519	139,000
C	○	TOYOTA 3361 Lex MT→AT	2005	2005 2 MR053107137 048	250,000	1800cc 1ZZ-0900527	54	17/205/45 616	1800cc 1ZZ-1078350	97,000
D	■	TOYOTA 436 Phat MT	2005	2005 2 MR053ZEC10 7118560	400,000	1600cc 4A-L833128	54	17/205/45	1600cc 4A-M476932	180,000
E	□	TOYOTA 2659 Nong AT	1996	1996 None AE111-9502110	270,000	1600cc 4A-L104738	40	14/175/65	1600cc 4A-M319904	156,000

Table 4-7：Information of the specification of engine after remounting

Vehicle A						
Type of Vehicle	Frame Number	Marque	Manufacture	Year	Total Mileage	
ZNE10	2509	WISH	TOYOTA	2003	139,000 km	
Model of Engine	details of engine	Wheel Drive	TM	Wheel Drive	condition of Engine	Detail of Engine Condition
1ZZ-FE	CVTPLASTIC-INTAKEecuharnessfuse	FF	AT	2WD		
Number of Air-Bag	Category of Production	Reg Number of eEngine	DG	Contracted		
E2 M P2		1291996	G			
Original Registrated Number						
318955						
Information of Engine						
Model of Engine	Engine Detail	Condition of Engine	Lank	Total Mileage		
1ZZ-FE	CVTPLASTIC-INTAKEecuharnessfuse		C	139,000 km		
Value of Standard Compression	1.30 MPa					
P1	1.42 MPa	P2	1.39 MPa			
P3	1.41 MPa	P4	1.38 MPa			
P5		P6				
P7		P8				
P9		P10				
P11		P12				
Condition of Engine Start	5 Good Starting					
Corrosion	4 10% of Corrosion					
Overheated	5 Good					
Sludge	5 Good					
Level of Oil	OK					
Part of Damage						
Part of Defective						
Overall Evaluationof JRS						
Complession	Mileage	Run	External	Over heat	Internal	
5	4	5	4	5	5	

Vehicle B						
Type of Vehicle	Frame Number	Marque	Manufacture	Year	Total Mileage	
ZCT10	53564	オーパ	トヨタ	2005	139,000 km	
Model of Engine	details of engine	Wheel Drive	TM	Wheel Drive	condition of Engine	Detail of Engine Condition
1ZZ-FE	PLASTIC-INTAKE fullharness	FF	AT	2WD		
Number of Air-Bag	Category of Production	Reg Number of eEngine	DG	Contracted		
E2 M P2		Z015519	G			
Original Registrated Number						
321105						
Information of Engine						
Model of Engine	Engine Detail	Condition of Engine	Lank	Total Mileage		
1ZZ-FE	PLASTIC-INTAKE fullharness		A	139,000 km		
Value of Standard Compression	1.30 MPa					
P1	1.39 MPa	P2	1.46 MPa			
P3	1.46 MPa	P4	1.46 MPa			
P5		P6				
P7		P8				
P9		P10				
P11		P12				
Condition of Engine Start	5 Good Starting					
Corrosion	5 10% of Corrosion					
Overheated	5 Good					
Sludge	5 Good					
Level of Oil	OK					
Part of Damage						
Part of Defective						
Overall Evaluationof JRS						
Complession	Mileage	Run	External	Over heat	Internal	
5	4	5	5	5	5	

Vehicle C						
Type of Vehicle	Frame Number	Marque	Manufacture	Year	Total Mileage	
ZCT10	37371	OPA	TOYOTA	2002	97,000 km	
Model of Engine	details of engine	Wheel Drive	TM	Wheel Drive	condition of Engine	Detail of Engine Condition
1ZZ-FE	PLA-INTAKE ecu	FF	AT	2WD		
Number of Air-Bag	Category of Production	Reg Number of eEngine	DG	Contracted		
E2 M P2		1078350	G			
Original Registrated Number						
314291						
Information of Engine						
Model of Engine	Engine Detail	Condition of Engine	Lank	Total Mileage		
1ZZ-FE	PLA-INTAKE ecu		A	97,000 km		
Value of Standard Compression	1.30 MPa					
P1	1.36 MPa	P2	1.35 MPa			
P3	1.39 MPa	P4	1.33 MPa			
P5		P6				
P7		P8				
P9		P10				
P11		P12				
Condition of Engine Start	5 Good Starting					
Corrosion	5 10% of Corrosion					
Overheated	5 Good					
Sludge	5 Good					
Level of Oil	OK					
Part of Damage						
Part of Defective						
Overall Evaluationof JRS						
Complession	Mileage	Run	External	Over heat	Internal	
5	5	5	5	5	5	

Vehicle D						
Type of Vehicle	Frame Number	Marque	Manufactur	Year	Total Mileage	
AE111	6108418	SPACIO	TOYOTA	1999	180,000 km	
Model of Engine	details of engine	Wheel Drive	TM	Wheel Drive	condition of Engine	Detail of Engine Condition
4A-FE	DIST ecu harness	FF	AT	2WD		
Number of Air-Bag	Category of Production	Reg Number of eEngine	DG	Contracted		
E2 M P2		M476932	G			
Original Registrated Number						
321348						
Information of Engine						
Model of Engine	Engine Detail	Condition of Engine	Lank	Total Mileage		
4A-FE	DIST ecu harness		B	180,000 km		
Value of Standard Compression	1.30 MPa					
P1	1.37 MPa	P2	1.32 MPa			
P3	1.38 MPa	P4	1.42 MPa			
P5		P6				
P7		P8				
P9		P10				
P11		P12				
Condition of Engine Start	5 Good Starting					
Corrosion	5 10% of Corrosion					
Overheated	5 Good					
Sludge	5 Good					
Level of Oil	OK					
Part of Damage						
Part of Defective						
Overall Evaluationof JRS						
Complession	Mileage	Run	External	Over heat	Internal	
4	3	5	5	5	5	

Vehicle E						
Type of Vehicle	Frame Number	Marque	Manufactur	Year	Total Mileage	
AE111	6070775	SPACIO	TOYOTA	1998	156,000 km	
Model of Engine	details of engine	Wheel Drive	TM	Wheel Drive	condition of Engine	Detail of Engine Condition
4A-FE	DIST ecu harness fuse	FF	AT	2WD		
Number of Air-Bag	Category of Production	Reg Number of eEngine	DG	Contracted		
E2 M P2		M319904	G			
Original Registrated Number						
319254						
Information of Engine						
Model of Engine	Engine Detail	Condition of Engine	Lank	Total Mileage		
4A-FE	DIST ecu harness fuse		CD	156,000 km		
Value of Standard Compression	1.30 MPa					
P1	1.34 MPa	P2	1.37 MPa			
P3	1.37 MPa	P4	1.33 MPa			
P5		P6				
P7		P8				
P9		P10				
P11		P12				
Condition of Engine Start	5 Good Starting					
Corrosion	4 10% of Corrosion					
Overheated	5 Good to Start					
Sludge	4 Confirmed Few Sluge, Observed Clearly Bottom of Cap					
Level of Oil	OK					
Part of Damage						
Part of Defective						
Overall Evaluationof JRS						
Compression	Mileage	Run	External	Over heat	Internal	
5	3	5	4	5	4	

Table 4-8 : Travel data for before remounting

Vehicle A Experiment Period (Before remounting) 2014/12/09-12/10													5323
#	Departure Time	Arrival Time	Time Required	Total Mileage (km)	OBD (On-board diagnostics)				Taximeter			Refueling (ℓ) Started with full tank	Fuel Efficiency
					Fuel Efficiency (KPL AVG)	CO2 Emission (G/L AVG)	Fuel Used (Litter)	SP	Driving Distance (Km)	Cost(Baht)	Time Required		
D1-①	9:55	11:54	1:59	153.8km	-	-	-	-	-	-	-		-
D1-②	12:45	14:43	1:58	124.8km	-	-	-	-	-	-	-	16.479ℓ	-
D1-③	15:23	17:35	2:12	153.7km	-	-	-	-	-	-	-		-
D1-④	18:16	20:19	2:03	124.9km	-	-	-	-	-	-	-	24.691ℓ	-
Day1			8:12	557.2km								41.170ℓ	13.5km/ℓ
D2-①	11:08	13:21	2:13	153.7km		-	-	-	154.2km	1,209	2:15		-
D2-②	14:04	15:54	1:50	124.9km	14.6	-	-	-	125.1km	931	1:40	10.000ℓ	-
D2-③	16:20	18:38	2:18	153.7km	13.5	-	-	-	154.2km	1,203	2:18		-
D2-④	19:15	20:52	1:37	124.9km	14.3	-	-	-	125.3km	933	1:36	28.865ℓ	-
Day2			7:58	557.2km								38.865ℓ	14.3km/ℓ
Total			16:10	1114.4km								80.035ℓ	13.9km/ℓ

Vehicle B Experiment Period (Before remounting) 2014/12/09-12/10													8093
#	Departure Time	Arrival Time	Time Required	Total Mileage (km)	OBD (On-board diagnostics)				Taximeter			Refueling (ℓ) Started with full tank	Fuel Efficiency
					Fuel Efficiency (KPL AVG)	CO2 Emission (G/L AVG)	Fuel Used (Litter)	SP	Driving Distance (Km)	Cost(Baht)	Time Required		
D1-①	9:55	11:55	2:00	162.0km	8.5	-	-	-	-	-	-		-
D1-②	12:47	14:46	1:59	133.0km	9.3	-	-	-	-	1,013	-	20.000ℓ	-
D1-③	15:23	17:35	2:12	163.0km	9.6	-	-	-	-	1,277	-		-
D1-④	18:17	20:21	2:04	132.0km	8.7	-	-	-	-	1,013	-	43.118ℓ	-
Day1			8:15	590.0km								63.118ℓ	9.3km/ℓ
D2-①	11:06	13:26	2:20	162.8km	9.2	-	-	-	163.1km	1,283	-		-
D2-②	14:11	15:54	1:43	132.0km	9.4	-	-	-	132.5km	997	-	11.000ℓ	-
D2-③	16:19	18:40	2:21	162.6km	9.3	-	-	-	163.1km	1,277	-	10.000ℓ	-
D2-④	19:14	21:04	1:50	132.3km		-	-	-			-	43.140ℓ	-
Day2			8:14	589.7km								64.140ℓ	9.2km/ℓ
Total			16:29	1179.7km								127.258ℓ	9.3km/ℓ

Vehicle C Experiment Period (Before remounting) 2014/12/09-12/10													3361
#	Departure Time	Arrival Time	Time Required	Total Mileage (km)	OBD (On-board diagnostics)				Taximeter			Refueling (ℓ) Started with full tank	Fuel Efficiency
					Fuel Efficiency (KPL AVG)	CO2 Emission (G/L AVG)	Fuel Used (Litter)	SP	Driving Distance (Km)	Cost(Baht)	Time Required		
D1-①	9:55	11:53	1:58	143.9km	-	-	-	-			-		-
D1-②	12:51	14:40	1:49	116.9km	-	-	-	-	117.0km	891	-	20.000 ℓ	-
D1-③	15:20	17:29	2:09	144.0km	-	-	-	-	144.0km	1,113	-		-
D1-④	18:15	20:17	2:02	116.9km	-	-	-	-	117.0km	879	-	25.678 ℓ	-
Day1			7:58	521.7km					378.0km	2,883		45.678 ℓ	11.4km/ ℓ
D2-①	11:03	13:22	2:19	143.8km	-	-	-	-	144.0km	1,123	-		-
D2-②	14:13	15:51	1:38	116.8km	-	-	-	-	117.0km	865	-	10.000 ℓ	-
D2-③	16:19	18:39	2:20	144.0km	-	-	-	-	145.0km	1,121	-		-
D2-④	19:12	20:47	1:35	116.9km	-	-	-	-	117.0km	859	-	34.001 ℓ	-
Day2			7:52	521.5km					523.0km	3,968		44.001 ℓ	11.9km/ ℓ
Total			15:50	1043.2km					902.0km	6,813		89.679 ℓ	11.6km/ ℓ

Vehicle D Experiment Period (Before remounting) 2014/12/09-12/10													436
#	Departure Time	Arrival Time	Time Required	Total Mileage (km)	OBD (On-board diagnostics)				Taximeter			Refueling (ℓ) Started with full tank	Fuel Efficiency
					Fuel Efficiency (KPL AVG)	CO2 Emission (G/L AVG)	Fuel Used (Litter)	SP	Driving Distance (Km)	Cost(Baht)	Time Required		
D1-①	9:55	11:59	2:04	153.0km	-	-	-	-	-		-		-
D1-②	12:51	14:42	1:51	125.0km	-	-	-	-	-	949	-	20.000 ℓ	-
D1-③	15:21	17:29	2:08	153.0km	-	-	-	-	-	1,177	-		-
D1-④	18:17	20:20	2:03	124.0km	-	-	-	-	-	945	-	22.447 ℓ	-
Day1			8:06	555.0km								42.447 ℓ	13.1km/ ℓ
D2-①	11:06	13:24	2:18	153.0km	-	-	-	-	-	1,177	-		-
D2-②	14:14	15:54	1:40	126.0km	-	-	-	-	-	927	-	10.000 ℓ	-
D2-③	16:20	18:39	2:19	153.0km	-	-	-	-	-	1,197	-		-
D2-④	19:15	20:47	1:32	126.0km	-	-	-	-	-	921	-	31.394 ℓ	-
Day2			7:49	558.0km								41.394 ℓ	13.5km/ ℓ
Total			15:55	1113.0km								83.841 ℓ	13.3km/ ℓ

Vehicle E Experiment Period (Before remounting) 2014/12/09-12/10													2659
#	Departure Time	Arrival Time	Time Required	Total Mileage (km)	OBD (On-board diagnostics)				Taximeter			Refueling (ℓ) Started with full tank	Fuel Efficiency
					Fuel Efficiency (KPL AVG)	CO2 Emission (G/L AVG)	Fuel Used (Litter)	SP	Driving Distance (Km)	Cost(Baht)	Time Required		
D1-①	9:55	11:59	2:04	152.0km	-	-	-	-	-	-	-		-
D1-②	12:51	14:46	1:55	124.0km	-	-	-	-	-	-	-	20.000 ℓ	-
D1-③	15:21	17:29	2:08	152.0km	-	-	-	-	-	-	-		-
D1-④	18:16	20:18	2:02	124.0km	-	-	-	-	-	-	-	23.307 ℓ	-
Day1			8:09	552.0km								43.307 ℓ	12.7km/ ℓ
D2-①	11:03	13:21	2:18	151.0km	-	-	-	-	-	-	-		-
D2-②	14:11	15:56	1:45	123.0km	-	-	-	-	-	-	-	10.000 ℓ	-
D2-③	16:19	18:39	2:20	152.0km	-	-	-	-	-	-	-		-
D2-④	19:12	20:50	1:38	123.0km	-	-	-	-	-	-	-	26.258 ℓ	-
Day2			8:01	549.0km								36.258 ℓ	15.1km/ ℓ
Total			16:10	1101.0km								79.565 ℓ	14.0km/ ℓ

Table4-9 : Travel data for after remounting

Vehicle A	Experiment Period	(After remounting)	2014/12/16-12/17								5323
#	Departure Time	Arrival Time	Time Required	Total Mileage (km)	OBD Fuel Efficiency (KPL AVG)	OBD CO2Emission (G/L AVG)	OBD Fuel Used (Litter)	Taximeter Cost(Baht)	Taximeter Distance	Refueling (ℓ) Started with full tank	Fuel Efficiency
D1-①	9:43	11:58	2:15	153.7km	13.2	180.4	11.6	1,205.0	154.2km		-
D1-②	12:41	14:57	2:16	124.3km	12.5	226.6	10.0	943.0	125.2km	16.000 ℓ	-
D1-③	15:31	17:43	2:12	153.3km	13.7	173.2	11.2	1,199.0	154.1km		-
D1-④	18:15	20:18	2:03	124.9km	13.0	200.4	9.6	957.0	125.3km	24.147 ℓ	-
Day1			8:46	556.2km						40.147 ℓ	13.9km/ ℓ
D2-①	10:34	12:49	2:15	153.7km	13.2	189.8	11.5	1,207.0	154.2km		-
D2-②	13:25	15:31	2:06	124.5km	12.3	222.1	10.1	961.0	125.2km	10.000 ℓ	-
D2-③	15:48	18:22	2:34	153.7km	13.6	184.1	10.8	1,225.0	154.2km		-
D2-④	18:53	20:41	1:48	124.9km	12.7	204.2	9.8	949.0	125.3km	31.632 ℓ	-
Day2			8:43	556.8km						41.632 ℓ	13.4km/ ℓ
Total			17:29	1113.0km						81.779 ℓ	13.6km/ ℓ

Vehicle B	Experiment Period	(After remounting)	2014/12/16-12/17								8093
#	Departure Time	Arrival Time	Time Required	Total Mileage (km)	OBD Fuel Efficiency (KPL AVG)	OBD CO2Emission (G/L AVG)	OBD Fuel Used (Litter)	Taximeter Cost(Baht)	Taximeter Distance	Refueling (ℓ) Started with full tank	Fuel Efficiency
D1-①	9:43	11:58	2:15	162.8km	12.2	201.6	9.6	1,279.0	163.3km		-
D1-②	12:40	14:58	2:18	132.2km	10.4	312.8	11.7	1,009.0	132.6km	20.000 ℓ	-
D1-③	15:30	17:44	2:14	162.8km	11.3	189.7	13.4	1,277.0	163.3km		-
D1-④	18:14	20:19	2:05	132.0km	11.4	289.1	11.3	1,021.0	132.7km	42.304 ℓ	-
Day1			8:52	589.8km						62.304 ℓ	9.5km/ ℓ
D2-①	10:34	12:50	2:16	162.8km	12.0	193.0	?	1,285.0	163.3km		-
D2-②	13:25	15:23	1:58	132.2km	11.3	264.2	11.0	1,001.0	131.3km	10.000 ℓ	-
D2-③	15:49	18:23	2:34	162.8km	11.2	201.4	13.5	1,303.0	163.3km		-
D2-④	18:53	20:42	1:49	132.2km	11.6	258.3	?	1,013.0	132.7km	34.119 ℓ	-
Day2			8:37	590.0km						44.119 ℓ	13.4km/ ℓ
Total			17:29	1179.8km						106.423	11.8km/ ℓ

Vehicle C	Experiment Period	(After remounting)	2014/12/16-12/17										3361
#	Departure Time	Arrival Time	Time Required	Total Mileage (km)	OBD (On-board diagnostics)				Taximeter			Refueling (ℓ) Started with full tank	Fuel Efficiency
					Fuel Efficiency (KPL AVG)	CO2 Emission (G/L AVG)	Fuel Used (Litter)	SP	Driving Distance (Km)	Cost(Baht)	Time Required		
D1-①	9:42	11:58	2:16	144.0km	-	-	-	-	144.4km	1,127	2:15		-
D1-②	12:38	14:57	2:19	116.9km	-	-	-	-	117.2km	871	1:58	20.000ℓ	-
D1-③	15:29	17:43	2:14	144.0km	-	-	-	-	144.4km	1,117	2:13		-
D1-④	18:15	20:12	1:57	117.0km	-	-	-	-	117.4km	887	1:55	26.715ℓ	-
Day1			8:46	521.9km								46.715ℓ	11.2km/ℓ
D2-①	10:34	12:49	2:15	144.0km	-	-	-	-	144.5km	1,121	2:15		-
D2-②	13:24	15:26	2:02	116.9km	-	-	-	-	117.3km	889	1:40	10.000ℓ	-
D2-③	15:49	18:22	2:33	144.0km	-	-	-	-	144.5km	1,137	2:18		-
D2-④	18:50	20:37	1:47	117.0km	-	-	-	-	117.4km	877	1:36	39.025ℓ	-
Day2			8:37	521.9km								49.025ℓ	10.6km/ℓ
Total			17:23	1043.8km								95.740ℓ	10.9km/ℓ

Vehicle D	Experiment Period	(After remounting)	2014/12/16-12/17										436
#	Departure Time	Arrival Time	Time Required	Total Mileage (km)	OBD (On-board diagnostics)				Taximeter			Refueling (ℓ) Started with full tank	Fuel Efficiency
					Fuel Efficiency (KPL AVG)	CO2 Emission (G/L AVG)	Fuel Used (Litter)	SP	Driving Distance (Km)	Cost(Baht)	Time Required		
D1-①	9:43	11:59	2:16	153.0km	-	-	-	-	-	1,191	-		-
D1-②	12:41	14:59	2:18	124.0km	-	-	-	-	-	939	-	20.000ℓ	-
D1-③	15:31	17:44	2:13	153.0km	-	-	-	-	-	1,193	-		-
D1-④	18:14	20:20	2:06	124.0km	-	-	-	-	-	955	-	24.391ℓ	-
Day1			8:53	554.0km								44.391ℓ	12.5km/ℓ
D2-①	10:34	12:50	2:16	152.5km	-	-	-	-	-	1,191	-		-
D2-②	13:25	15:29	2:04	124.0km	-	-	-	-	-	949	-	10.000ℓ	-
D2-③	15:50	18:22	2:32	152.9km	-	-	-	-	-	1,211	-		-
D2-④	18:54	20:41	1:47	124.2km	-	-	-	-	-	941	-	33.066ℓ	-
Day2			8:39	553.6km								43.066ℓ	12.9km/ℓ
Total			17:32	1107.6km								87.457ℓ	12.7km/ℓ

Vehicle E	Experiment Period (After remounting) 2014/12/16-12/17												2659
#	Departure Time	Arrival Time	Time Required	Total Mileage (km)	OBD (On-board diagnostics)				Taximeter			Refueling (ℓ) Started with full tank	Fuel Efficiency
					Fuel Efficiency (KPL AVG)	CO2 Emission (G/L AVG)	Fuel Used (Litter)	SP	Driving Distance (Km)	Cost(Baht)	Time Required		
D1-①	9:43	11:58	2:15	152.2km	-	-	-	-	-	-	-		-
D1-②	12:40	14:58	2:18	123.0km	-	-	-	-	-	-	-	20.000 ℓ	-
D1-③	15:31	17:43	2:12	152.3km	-	-	-	-	-	-	-		-
D1-④	18:15	20:18	2:03	123.0km	-	-	-	-	-	-	-	23.633 ℓ	-
Day1			8:48	550.5km								43.633 ℓ	12.6km/ ℓ
D2-①	10:34	12:49	2:15	151.5km	-	-	-	-	-	-	-		-
D2-②	13:23	15:30	2:07	122.1km	-	-	-	-	-	-	-	10.000 ℓ	-
D2-③	15:49	18:22	2:33	151.4km	-	-	-	-	-	-	-		-
D2-④	18:50	20:40	1:50	122.1km	-	-	-	-	-	-	-	29.750 ℓ	-
Day2			8:45	547.1km								39.750 ℓ	13.8km/ ℓ
Total			17:33	1097.6km								83.383 ℓ	13.2km/ ℓ

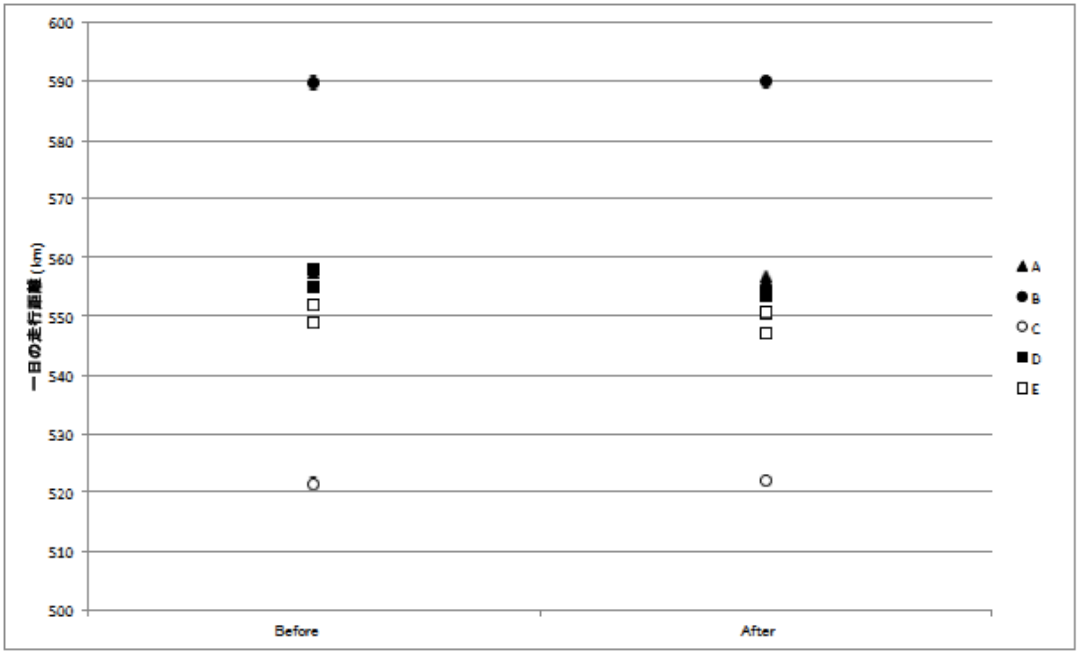


Fig:4-11：The mileage a day

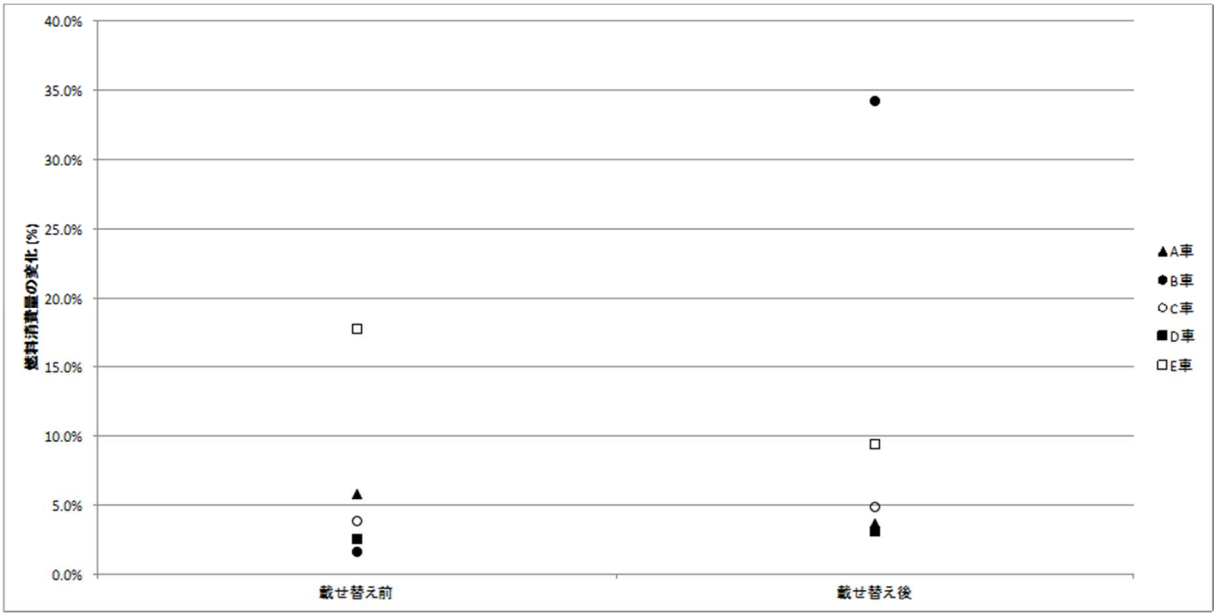


Fig4-12：Fuel consumption

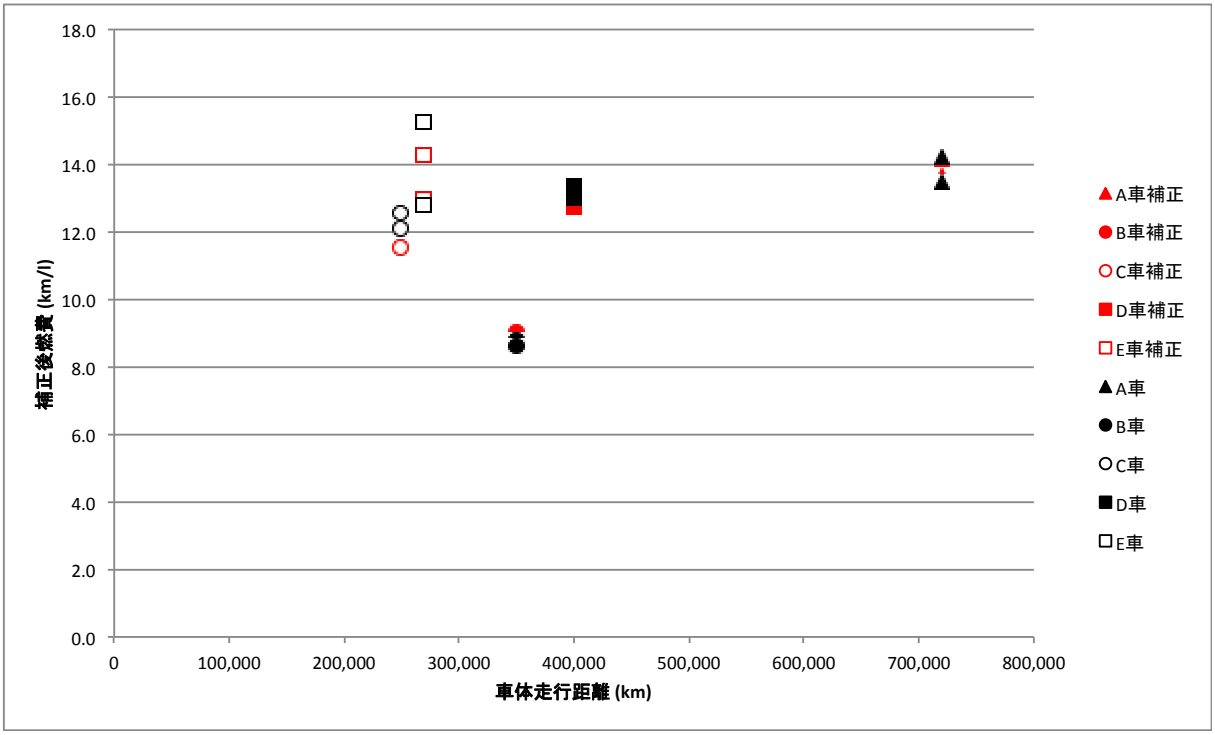


Fig4-13：Millage and Fuel consumption

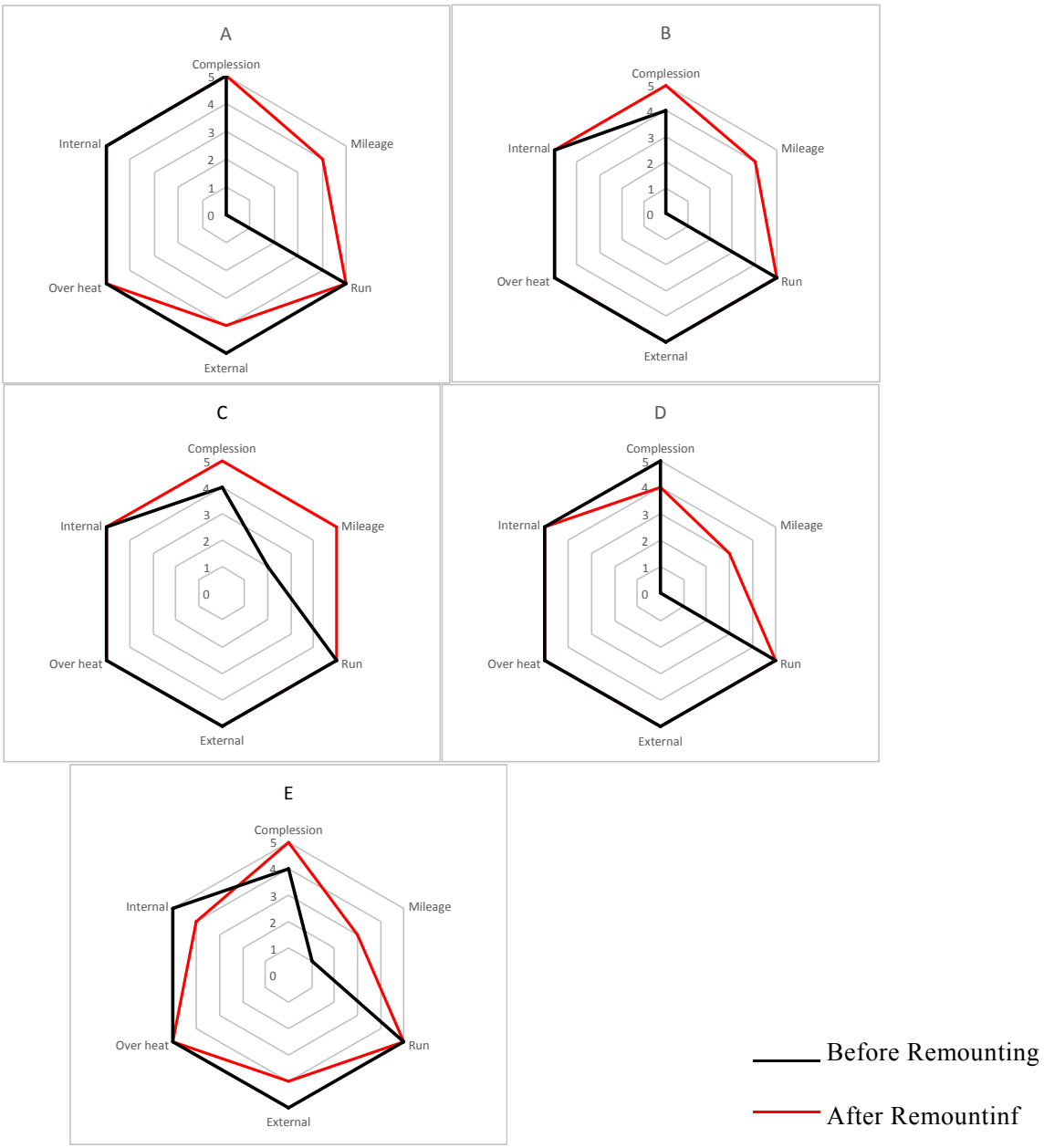


Fig 4-14：Car information of JRS/PAS777

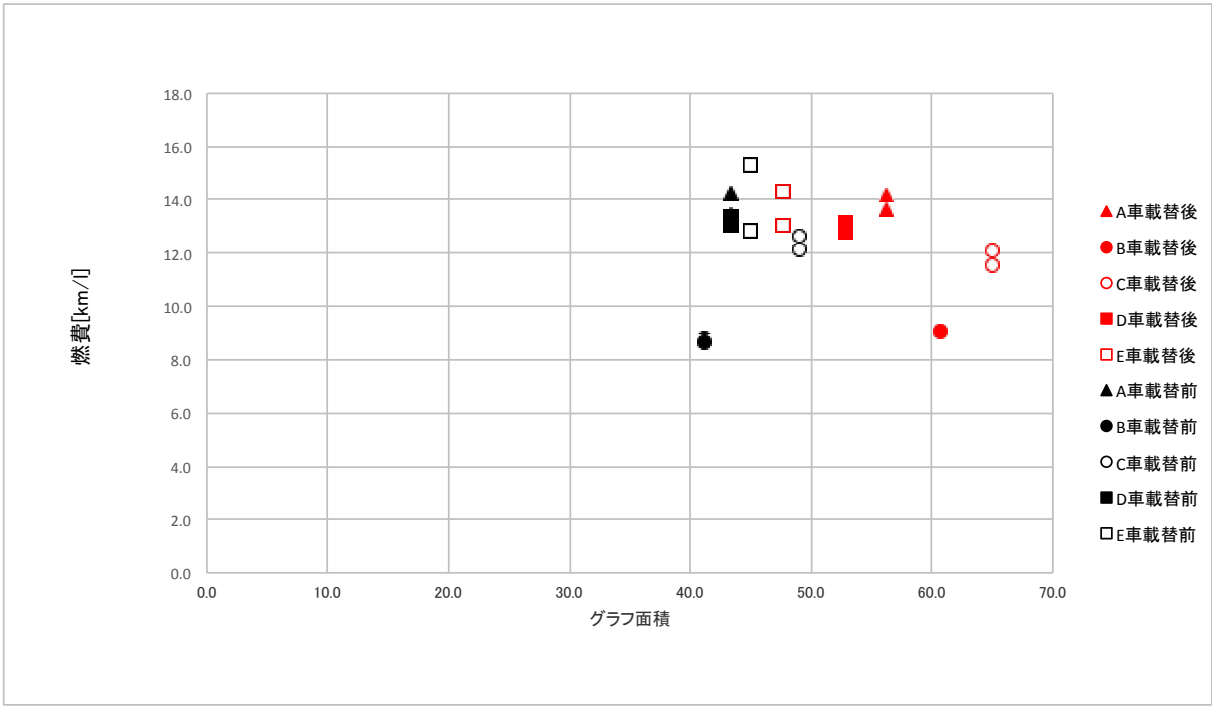
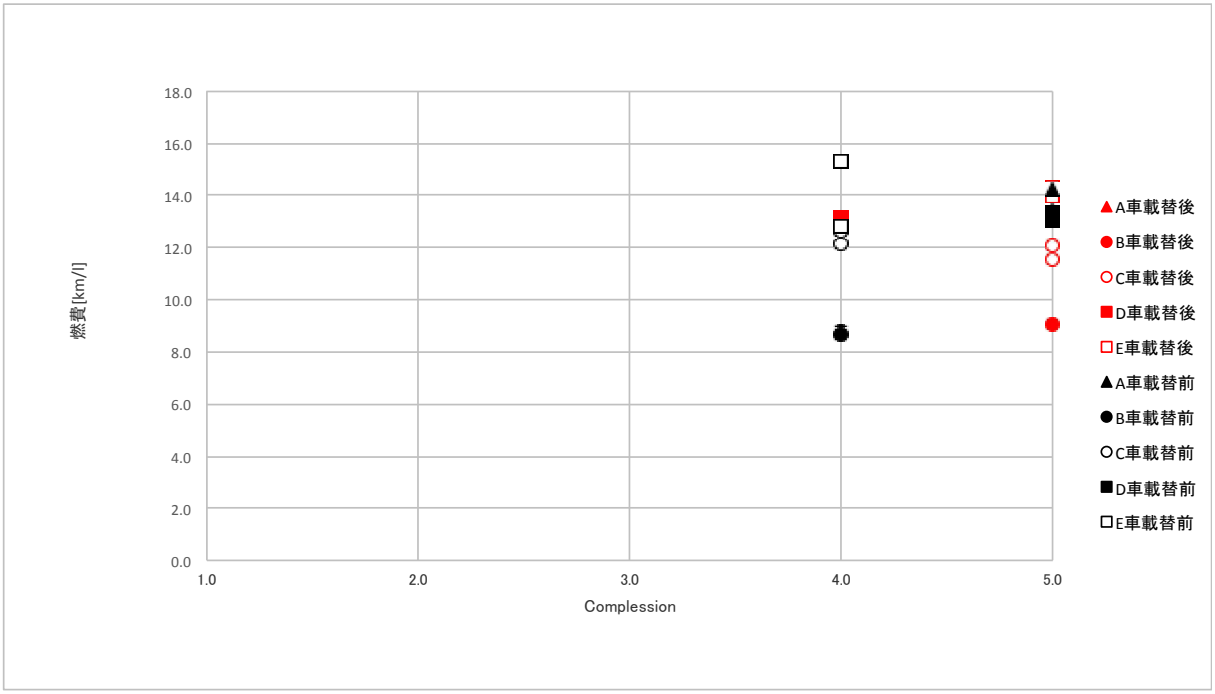
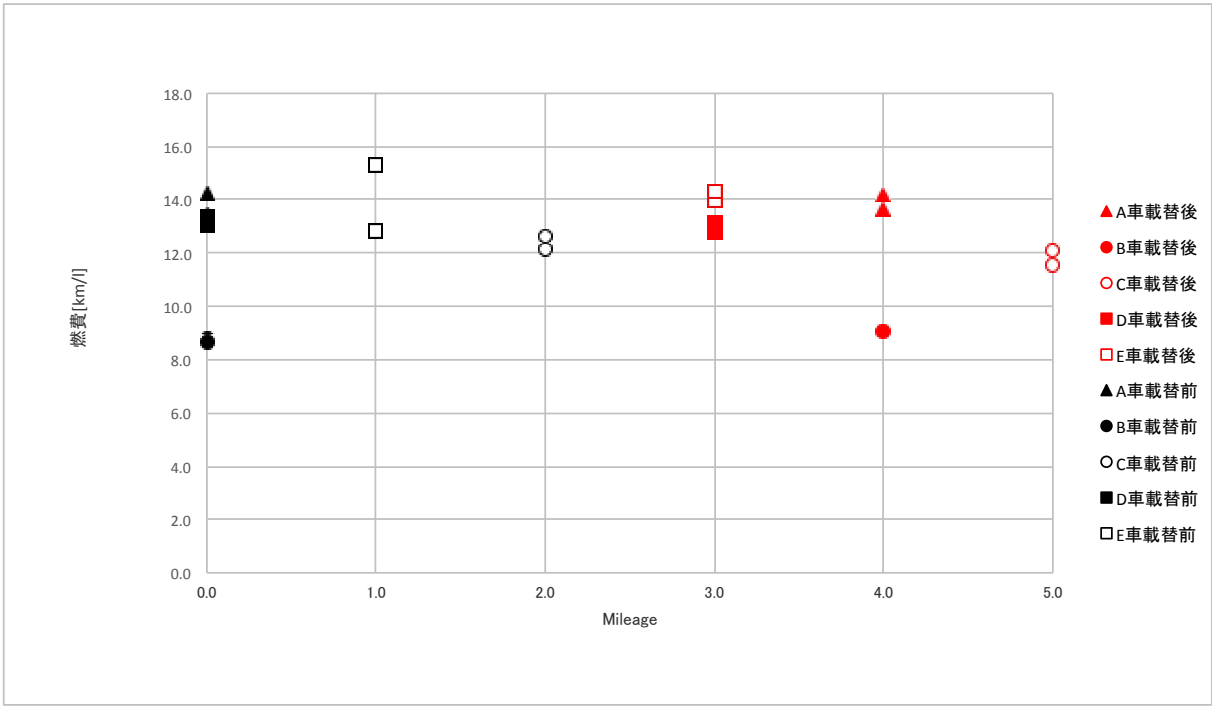
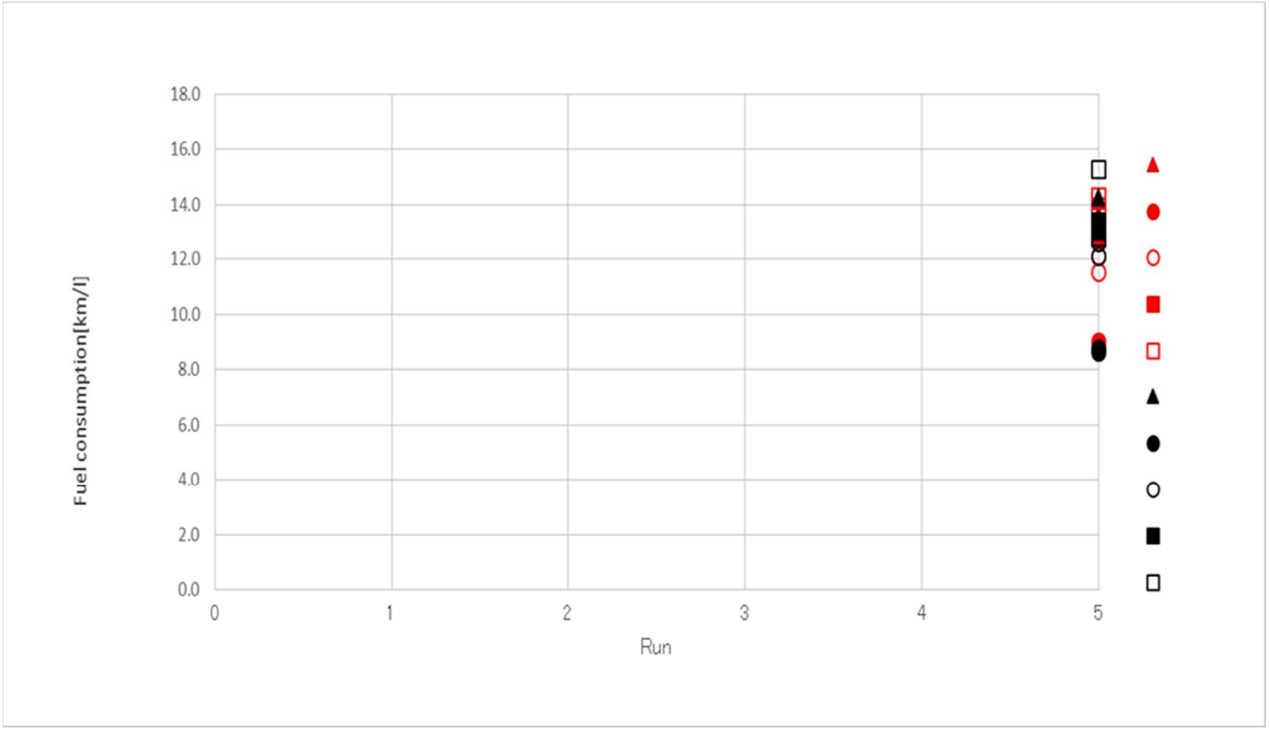
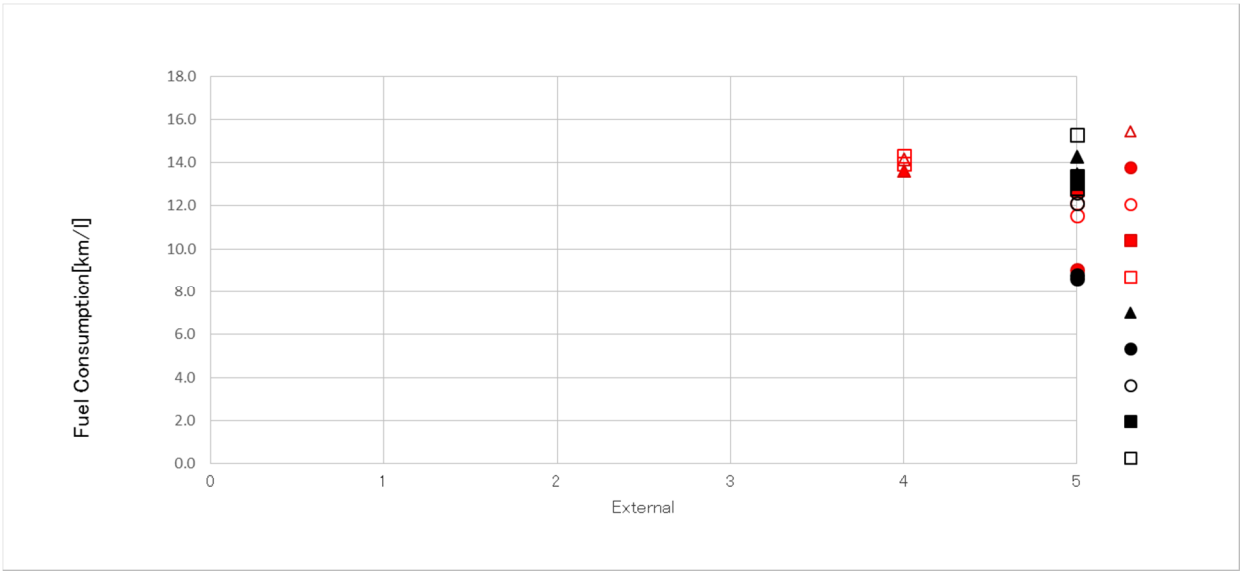


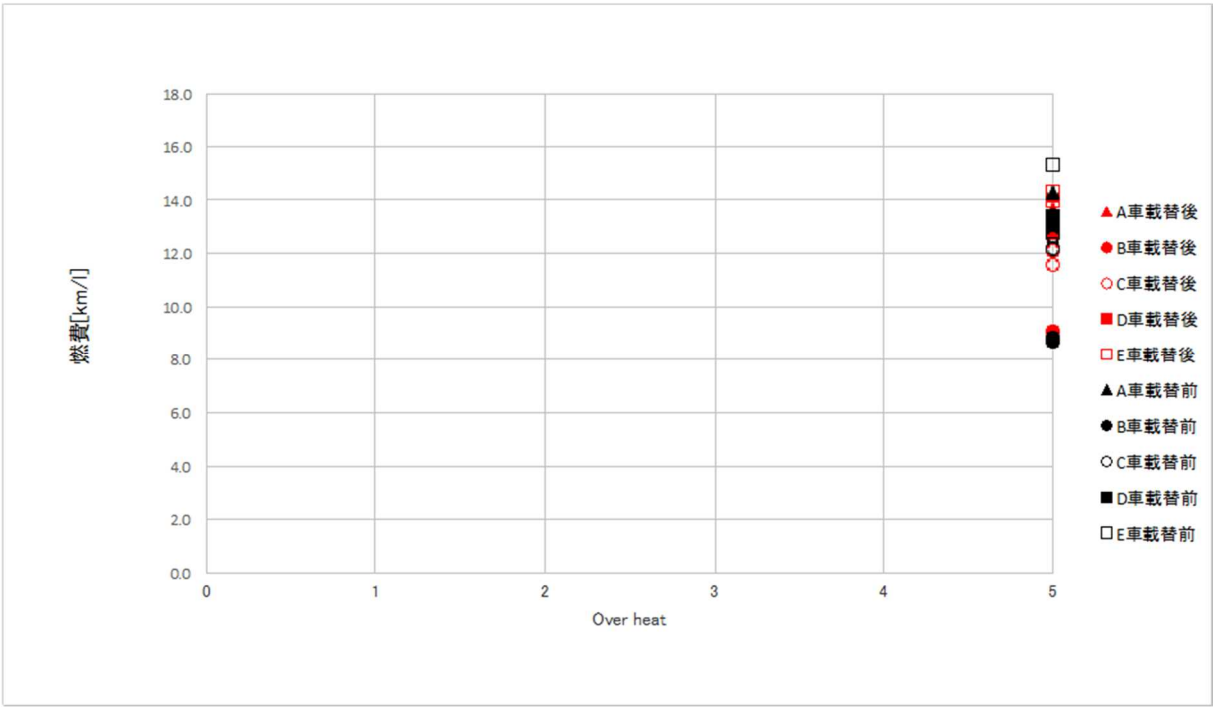
Fig 4-15：Fuel consumption of JRS/PAS777




燃費[km/l]
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0.0
1.0
2.0
3.0
4.0
5.0
Mileage
A車載替後
B車載替後
C車載替後
D車載替後
E車載替後
A車載替前
B車載替前
C車載替前
D車載替前
E車載替前


Fuel consumption[km/l]
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
1
2
3
4
5
Run


Fuel Consumption[km/l]
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
1
2
3
4
5
External


燃費[km/l]
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
1
2
3
4
5
Over heat
A車載替後
B車載替後
C車載替後
D車載替後
E車載替後
A車載替前
B車載替前
C車載替前
D車載替前
E車載替前

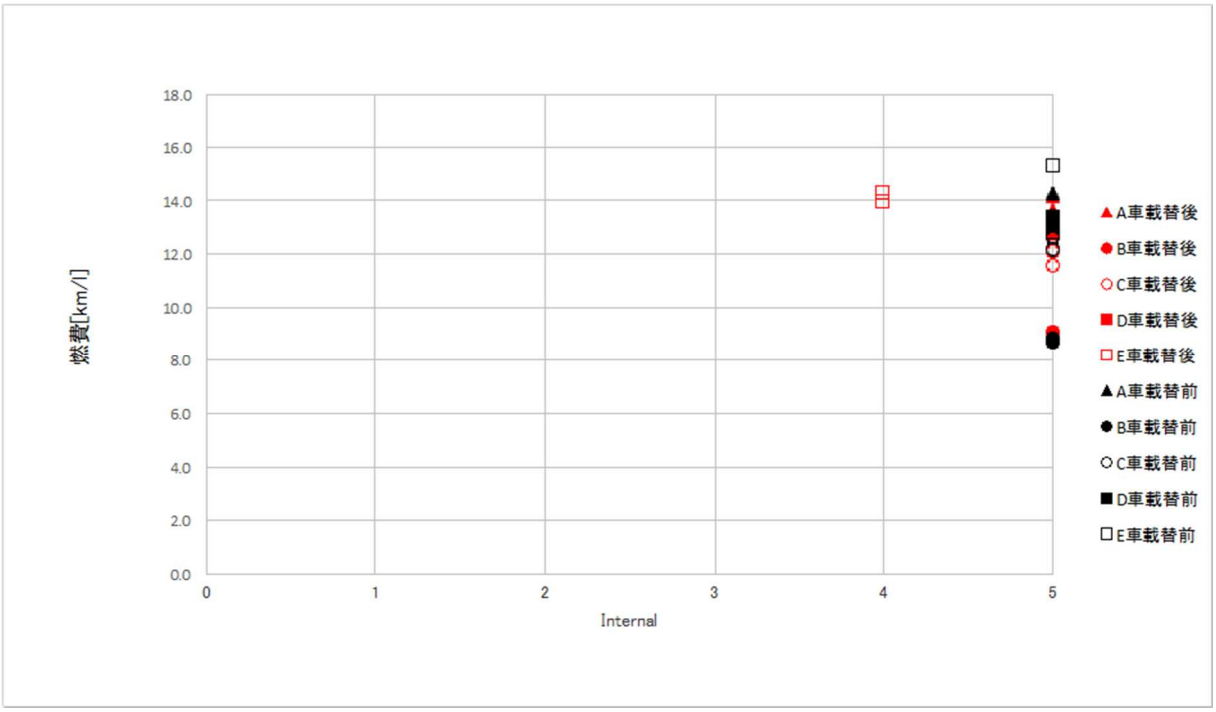


Fig. 4-16: JRS/PAS777 data and Fuel consumption

4-2 Establishment of a Methodology for MRV

A methodology for MRV will be established based on the study result of 4-1.

MRV methodology (planned): “A project to promote replacement of engines with secondhand engines that were Japanese-manufactured and acquired a high score based on the PAS777 standard.”

(1) Title of the methodology

“A promotion on replacement of engines with secondhand engines that were Japanese-manufactured and acquired a high score based on the PAS777 standard”

(2) Summary of the project to which the methodology applies

This methodology will promote replacement of deteriorated vehicle engines in Thailand with secondhand Japanese-manufactured engines that acquired a high score based on the PAS777 standard and hence will improve fuel consumption. The methodology, for this purpose, will apply to a project to achieve a larger reduction of GHG emissions in comparison with the reference scenario.

(3) Eligibility criteria

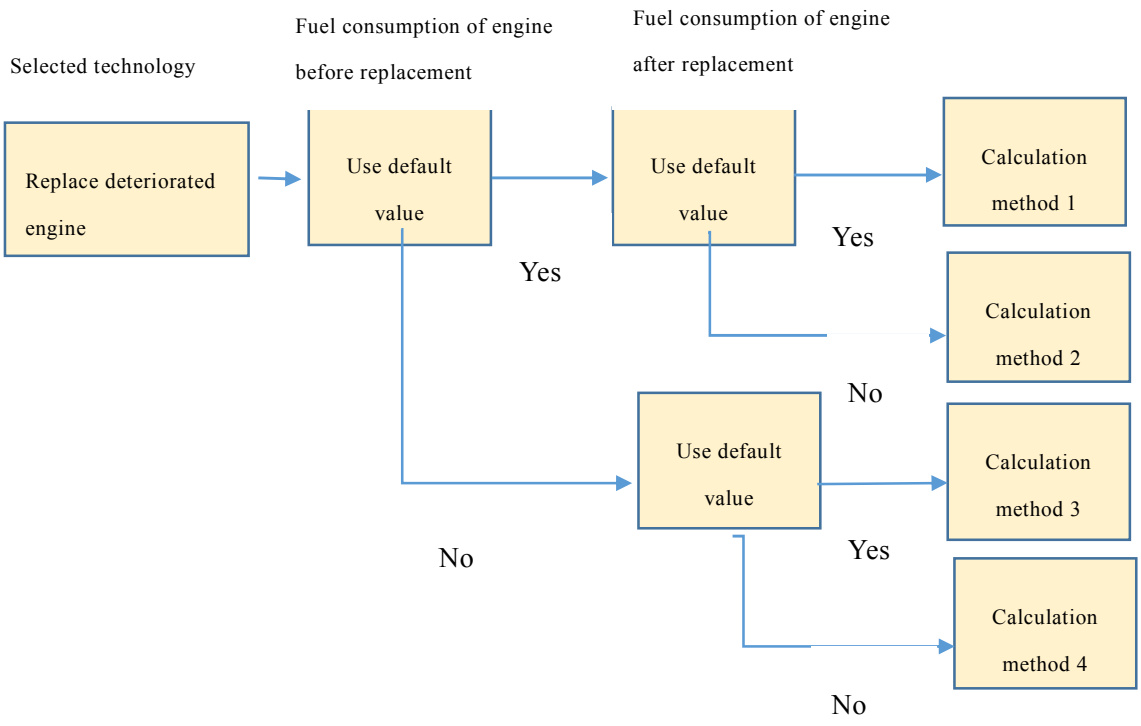
This methodology can apply to a project that satisfies <u>all</u> of the following requirements:

		Check
Requirement 1	The deteriorated vehicle engine has to be replaced with a secondhand Japanese-manufactured engine that acquired a high score based on the PAS777 standard.	☐
Requirement 2	Replacement of engine has to be made on the same vehicle model (with the same vehicle body) existing and registered in the Kingdom of Thailand.	☐
Requirement 3	Either the travel distance of the vehicle for which replacement of the deteriorated engine is planned has to be identifiable and exceed 200,000 km or the engine is in poor condition with a possibility of causing further deterioration in fuel consumption.	☐

Requirement 4	[Only when the calculation method 3 or 4 is selected] The fuel consumption of the deteriorated engine before replacement has to be measurable.	☐
Requirement 5	[Only when the calculation method 2 or 4 is selected] The fuel consumption of the deteriorated engine after replacement has to be measurable.	☐

(4) Selection of a calculation method

The entity that implements the project can select the calculation method most suited to their project using the following flowchart.



(5) Data necessary for calculation

For each of the calculation methods to be selected using the flowchart in (4) above, data to be collected in advance during the project registration process or to be calculated after the project implementation are set forth as follows:

1) Calculation method 1: Default value

FCi Fuel consumption [km/l] of Automobile i

Regarding fuel consumption, if the deteriorated engine of a target automobile is not replaced, the engine is considered to continue to further deteriorate but, as a conservative value, a measurement obtained at the time the engine is replaced will be used until the project is completed.

1. Conservative default value based on an actual measurement

Passenger car (1,600-1,800 cc class): 12.4 [km/l]

2. Conservative default value based on existing data

It will be obtained from an average of actual automobile fuel consumption in Thailand.

3. Default value obtained by making correction on the catalog fuel consumption data

It will be obtained by multiplying the manufacturer's catalog fuel consumption indicated for the engine model by a coefficient to understand the actual fuel consumption.

FCPi Fuel consumption [km/l] of Automobile i after engine replacement

1. Conservative default value based on actual measurement

Passenger car (1,600-1,800 cc class): 12.6 [km/l]

2. Conservative default value based on existing data

It will be obtained by multiplying the average fuel consumption in Japan by a correction coefficient for the traffic condition in Thailand (correction coefficient to take the poorer traffic infrastructure of Thailand than that of Japan into account).

3. Default value obtained by correcting the catalog fuel consumption

It will be obtained by multiplying the manufacturer's catalog fuel consumption shown for the engine model by a coefficient to obtain the actual fuel consumption and a correction coefficient to take the traffic condition in Thailand into account.

DDi,y Total travel distance [km/y] of Automobile i

The meter installed on the automobile will be read. It is desirable that the installation or leasing of devices for more accurate understanding of travel distance will be studied, including the installation of an odometer and a GPS device.

2) Calculation methods 2 to 4: Monitoring of fuel consumption

FCi Fuel consumption [km/l] of Automobile i

FCPi Fuel consumption [km/l] of Automobile i after engine replacement

Whichever of the above methods is selected, it is desirable that the sample automobile will be monitored and measured continuously for one year to take the seasonal changes into account.

a. Measurement of fuel consumption using the full-tank method

In order to level off sampling errors that can be caused depending on the selected measurement method, samples will be selected on which the travel distance and fuel supply will be measured monthly for one year each before and after engine replacement. Particularly since such errors can be large when the full-tank method is selected, it is desirable that errors will be leveled off by measuring the effect annually.

Taxi companies have a system for “driver’s daily reporting,” under which taxi drivers are required to report to the company on a daily basis. It is considered that, by collecting data of certain level of accuracy through this reporting system, a larger amount of measurement and data will be obtained than at present.

b. Measurement of fuel consumption using the OBD method

Similarly to as with the above method, samples will be selected on which the travel distance and fuel consumption will be measured monthly for one year each before and after engine replacement. This method, however, will provide more accurate data than the full-tank method and since an OBD device is often installed on a new automobile, the OBD method should be selected when possible.

(6) Definition of terms

Term	Definition
Replacement of engine	Replacement of the deteriorated engine installed in a passenger car with another engine for the purpose of improving the automobile's fuel consumption.
Full-tank method	A method to calculate the fuel consumption of an automobile by measuring the travel distance and the difference of fuel amount between when the tank was filled up first and when the tank is filled up again.
OBD method	A method to calculate the fuel consumption of an automobile based on data displayed on On-Board Diagnostics device (ECU) installed on the automobile to provide computer-aided self-diagnosis of automobile failure. Some of such devices can display measurement of fuel actually consumed or direct fuel consumption.

Vehicles with a later model year (newer vehicles) have an OBD II terminal on the body and by using it, data on travel distance and fuel consumption can be extracted electronically. Indicators typically extractable from the OBD II terminal are as follows:

(i) Engine speed, (ii) fuel ejection amount, (iii) travel distance, (iv) accelerator positons and speed and (v) fuel consumption.

(7) Project boundary

The project boundary shall include facilities for determining the following:

- GHG emissions created in connection with the operation of the vehicle
- GHG emissions created in connection with replacement and disposal of the engine
- GHG emissions created in connection with export of secondhand engines from Japan to Thailand

(8) Reference scenario

The deteriorated engine will not be replaced and the passenger car continues to travel with such engine installed on it.

The reference scenario will be updated if any new standards are set up concerning fuel consumption or if there is any change in the average fuel consumption as a result of some technical innovation during the project.

(9) Reference emission amount and calculation of the amount

$$RE_y = \sum_{i=0}^{N_y} \frac{DD_{i,y}}{FC_i} * EF$$

REy Reference CO2 emission amount for the year [kgCO2/y]

FCi Fuel consumption [km/l] of Automobile i

DDi,y Annual travel distance [km/y] of Automobile i

EF GHG emission coefficient of gasoline [kgCO2/L]

Ny The number of targeted automobiles

$$PE_y = \sum_{i=0}^{N_y} \frac{DD_{i,y}}{FCP_i} * EF$$

PEy CO2 emission amount under the project [kgCO2/y]

FCPi Fuel consumption after replacing the engine [km/l] of Automobile i

DDi,y Annual travel distance [km/y] of Automobile i

EF GHG emission factor of gasoline [kgCO2/L]

Ny The number of targeted automobiles

(10) Leakage emission amount and calculation of the amount

When this project is implemented, a new process will take place in which secondhand engines are imported from Japan and replaced engines are disposed.

Disposal of replaced engines will be necessary even if this project is not implemented and it can be viewed that disposal is inevitable and only different engines will be disposed of. In this relation, since secondhand ELV engines having been in service in Japan for 13 years on average will be used in Thailand without being recycled, in a cascade-like manner, which prolongs the product life, and this means that the amount of engines disposed in total in Japan and Thailand will decrease. Presently in Thailand, however, there is no established reuse system for engines and as replaced engines will be disposed not in Japan but in Thailand, it is expected to create a larger environmental burden. As shown in the figure below, the disposal process in Japan will just be moved to Thailand. In this project, however, it is aimed that the project will be expanded to also include the establishment of a system for recycling and disposing of automobile parts appropriately. Therefore, in the project implementation stage, it is expected that there will be co-benefits in the reduction of environmental burden throughout Thailand as a system to realize "3R/Reduce, Reuse and Recycle" of automobiles will be established that benefits not only the project's target vehicles but also a wide range of other vehicles.

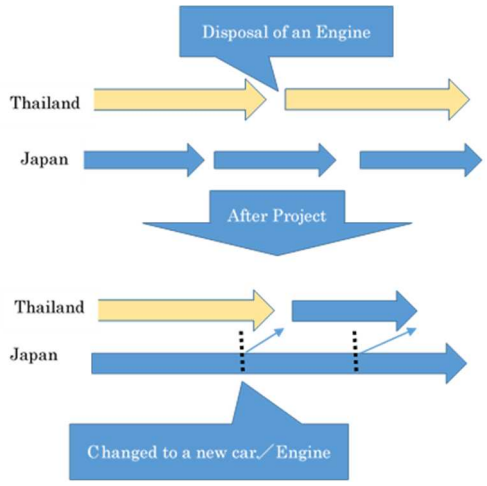


Figure 4-17 Flow of Engine Replacement and Disposal under this Engine Replacement Project

(11) Calculation of an emission reduction amount

The amount of emission reduction will be calculated based on obtained reference CO2 emission amount and the project emission amount.

$ER_y = RE_y - PE_y (- L_y)$

ER_y CO2 emission reduction amount [tCO2/y]

RE_y Reference CO2 emission amount [tCO2/y]

PE_y Project CO2 emission amount［tCO2/y］

L_y Leakage emission amount [tCO2/y］

(12) Monitoring method

The entity that implements this project has to monitor the parameters listed below based on the selected method to calculate reference emission amount.

Measurement method and procedures

Fuel consumption and travel distance will be measured basically by reading the meter and other instruments installed on the target vehicles. The meter and other instruments will be read as part of taxi companies' daily administration work and additionally when engine maintenance is carried out.

FCi Fuel consumption [km/l] of Automobile i

FCPi Fuel consumption [km/l] of Automobile i after engine replacement

DDi,y Annual travel distance [km/y] of Automobile i

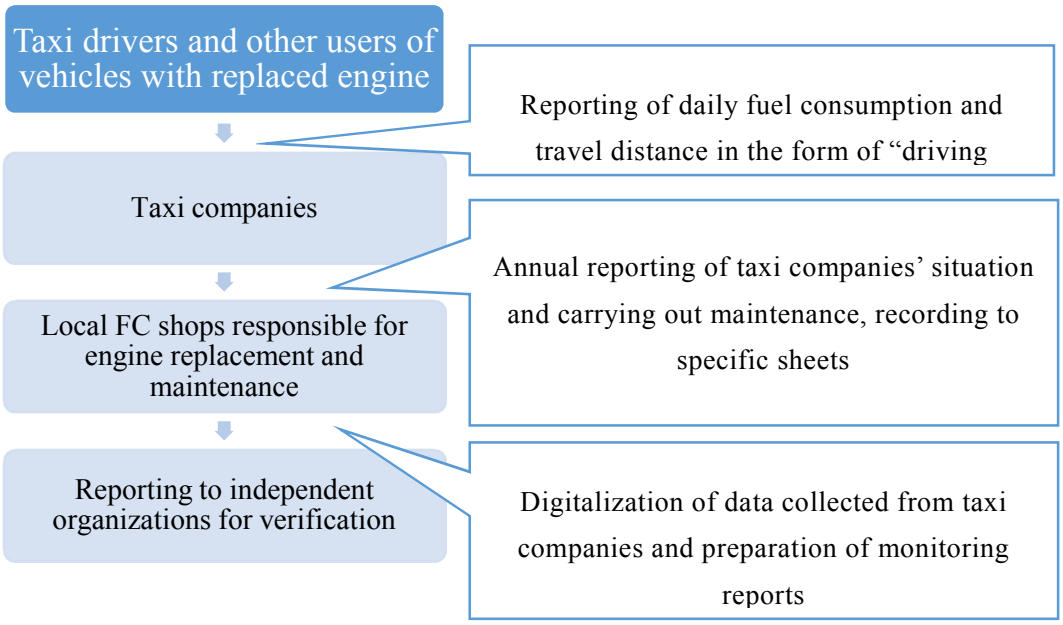


Figure 4-18 Flow of Monitoring Works

Applied standards and accuracy of measurement

Measurements obtained from a certain number of sample vehicles through both the full-tank and OBD methods will be reported monthly. These vehicles each will have a meter installed and provide reference values. As careful attention will be requested for record-keeping and

maintenance and refueling in order for the meter and other instruments to operate appropriately, the measurement accuracy will improve.

Personnel and entities responsible for measurement

Responsibility for collecting measurement data from participants of this study is with local FC shops, which will also be responsible for monitoring. Those FC shops will communicate with users and confirm how to carry out the monitoring work at the same time as when the replaced engine is maintained. This way, users will have an incentive to participate in the monitoring process since it is incorporated in the regular process of engine maintenance and they do not need to go to a special place to have their vehicles checked by a special instrument.

The monitoring cost will be paid by the International Consortium. In connection with this, it is expected that local FC personnel will need to be trained and qualified so that they will be able to prepare monitoring reports appropriately. Training on how to read items required by the PAS777 standard, however, has already been given at the Education Center and therefore, training on monitoring items for JCM such as reading meters can be incorporated in the existing training process. As the result, necessary human resources will be supplied easily.

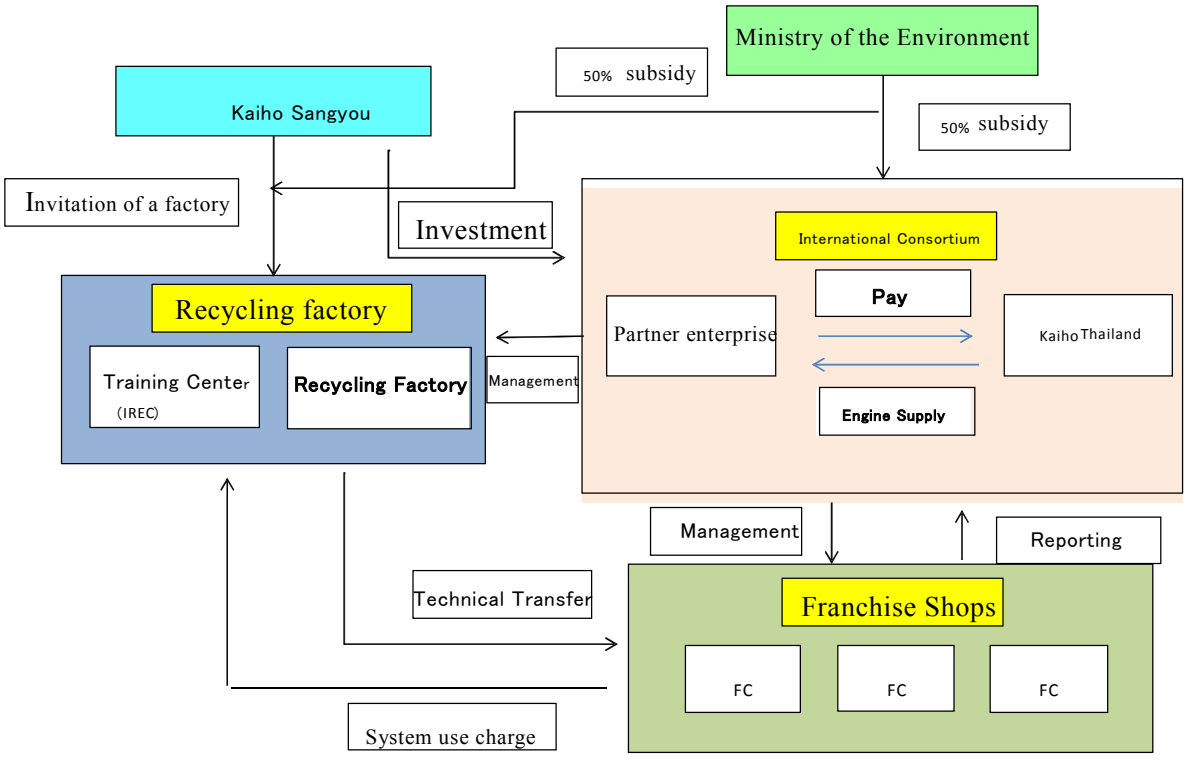


Figure 4-19 Flow of Project Schemes starting from Local FC Shops

In addition, the entities participating in this project have to take the responsibility to work on a system for recycling parts of scrapped vehicles so that engines imported from Japan will not be

discarded illegally in Thailand.

(13) Measures for realizing and verifying the project

For the verification project, of which scope is determined as mentioned above, an implementation plan (IP) will be established through a feasibility study. The IP will define contents of the project as well as the following:

1) Capital, member companies and investment ratios of the local corporation to be established in Bangkok

2) The support system on the Japanese side led by the Ministry of Environment and the support system on the Thai side including NESDB

3) Technology and human resources development plans

4) Raw material procurement plan

5) Market development strategy and export plan

6) Systems and methods for measuring and monitoring the effect such as CO2 reduction

With the above details incorporated, a project design document (PDD) for the verification project will be prepared. The document will clarify the project design matrix (PDM) and its details.

PDD will specify the following:

Project objective (objective of the verification project)

1) Higher rank objective (targeted under the overall project concept)

2) Output (related to the production and effect realized by the verification project)

3) Activities under the project (activities to be carried out in the verification project)

4) Measurement method (particularly for measuring the effect)

5) Preconditions (government policies, legal system, etc.)

The outcome of the verification project can be verified by following such PDD. In this way, particularly, the effectiveness of the project can be measured based on the MRV method.

Chapter 5 Review Business Possibility

5-1 Selection of Local Partner

5-1-1 Selection Policy

As a result of reviewing MRV methodology, it was decided to select local partner based on following recognition.

- Fuel efficiency of vehicle depends on maintenance condition of engine, but as the travel distance is longer, fuel efficiency deteriorates
- As energy efficiency deteriorates, the amount of CO2 emission is increased.
- The total mileage of used-engine introduced this time from Japan is basically 100k to 150k km.
- In order to expect effect of engine remounting, at least engine with total mileage more than 300k km is desirable.
- Therefore, local partner to be selected in this business should basically possess/use vehicle with total mileage more than 300k km.

5-1-2 Selection Background

As mentioned in Chapter 3, currently not much old model vehicles are found in Bangkok metropolitan, due to following main factors

- Thailand is ahead of Asian countries, it has made a regulation of emissions and CO2 regulation, alongside vehicle inspection system is established.
- With regard to private car, the application of vehicle inspection starts in the 6th year from new car purchase, so generally owners purchase a new car before vehicle inspection.
- Total mileage of most of the used vehicles displayed at secondhand car market is mostly about 100k km.
- By new car incentive policy that was taken in 2012 to 2013, the replacement cycle of new cars has become shorter.

Therefore, targeting the private cars for Japanese used-engine remounting business, the total mileage of engine is short and difficult to conclude.

Next, the results are as follows carrying out interviews for commercial vehicles, e.g. taxis and trucks.

5-1-3 About the Taxi

- As described in (4) hereafter, number of taxis that are registered in Bangkok metropolitan is about 110k units.
- There is a market rule that taxis can be used for 9 years from the day of new purchase. For this reason, vehicles operating more than 10 years theoretically do not exist as taxis. Vehicles over 10 years and road-going can be sold at used-car market, otherwise the

components parts are turned into recycling. In this study, it was not able to have clear-cut finding where the vehicles that have passed more than 10 years are sold.

- According to information some taxi drivers, they normally run 500km/day (12 hours shift, running 24 hours), annual mileage 200k km. Therefore, if operating continuously for 9 years, the total mileage would be 1,800k km.
- Therefore, there are many taxis operating even comparatively new vehicle targeting total mileage more than 300k km.

5-1-4 About the Truck

- In this study, we interviewed the following companies located in Bangkok city.
- In this company, the vehicles used for 10 years are replaced with new cars.
- Vehicles used for 10 years are distributed to used-car market.
- Maintenance of engine and auto body as well as maintenance check is same level as Japanese domestic standard, even after using for 10 years the total mileage is about 200k km, and fuel efficiency at maintenance check is kept similar to new car.

5-1-5 Various Vehicles Used by Thailand Metropolitan Government

- In interviews made with Thailand Metropolitan officials, it was said that buses, state cars and garbage trucks are quite old caused by lack of budget and there was an advice they may have poor fuel efficiency.
- Gathering of information was attempted in order to understand the situation, although the respondents showed interest but were told unless “effect from Japanese engine replacement” is verified with clear-cut advantage, they cannot set a negotiation and no information was provided.
- If proving test can confirm the replacement effect, we consider requesting for information. Regrettably, replacement effect was not verified, so we had to give up acquiring further information.
- Furthermore, according to Thailand Greenhouse Gas Management Organization (TGO), the Bangkok metropolitan has decided to introduce low-emission bus in near future.

  Below, I referred to the hearing notes and taxi companies and track officials.

  - Taxi company (which is a small, company name unknown)

  Taxi and thing applies to the industry in general, but the vehicle was used without new to 9 years related to mileage and must be scrapped as a taxi.

  ・ 9 years vehicle that was used as a taxi, to change the body color, sell used car trader replace the license plate. Some people buy a very rare individual.

  ・ Annual mileage is about 300,000km from 250,000km. Because it is often failure at 500,000km, at that time, we have been sorting put overhaul or engine.

Oil exchange frequency is every 7000kmg. About once every 10 days is doing the oil change.

Depending on the method of operation and driver, overhaul at 300,000km, engine replacement at 700,000km, it is often the mission exchanged more than 700,000km.

The company which was the company doing the following 2 businesses, and made only transportation sector become independent of the company of 2002 year establishment which was packing, was keeping and was transporting it as consistency in February, 2013, and was established.

* Part collection of cargo related to Toyota (transportation to the automobile factory which is Toyota from the component facility in each site place)
* Delivery of supplement parts (the supply which are supplement parts to a dealer of red snapper whole (equality part neighboring country) from an automobile factory of Toyota)
* About 900 transportation vehicles are possessed together with in-house possession and sub-contractor property.
* Upkeeping maintains the level which doesn't change at all with Japan. Maintenance facilities are also possessed in the company site.
* It's being changed to a new car in about 7 years basically.
* When passing for 7 years, a case beyond 200,000 kilometers can happen to see the mileage much.
* But, upkeeping is being done tightly, so the mileage is hardly also inferior beyond 200,000 kilometers.
* I have a dealer of Toyota take whether the destination in the track where an average of 7 years have been passed applies a tender to a secondhand professional in more than one red snapper localness and sells it to a knocking down enterprise back by valuableness in exchange for a new car or one of them is chosen (When being huge, I bid and when they're 1 car and 2 cars, it's taken back.)
* When more than 200,000 kilometers of liability issues when an accident has occurred, will run and are in the driving experiment to take back as a used car and offer an immediately before car as an investigation vehicle clearly, they aren't hesitant.
* But, maintenance is managing the above-mentioned street tightly, so I have confidence that the mileage isn't inferior, so a possibility which becomes a partner enterprise is low.

MITSIAM MOTORS AUTOMOTIVE(THAILAND) Co., Ltd.

* MITSIAM MOTORS, MITSUI BUSSANN AUTOMOTIVE (THAILAND) Co., Ltd. But, the dealer's firm established in Thailand as well as HINO MOTORS.

* The car type which is being treated is a truck made by HINO MOTORS.
* MITSIAM MOTORS also receives business of the regular inspection from a sale destination and maintains one as in Japan.
* A used car is taken back at the time of new car sale and the used car is often sold to a broker.
* A broker seems to be selling to an auction whether it's taken out by a personal network because the used car MITSIAM MOTOR takes back is the used car which isn't old relatively.
* It seems that a secondhand truck is used at companies of transportation of resources and construction firms, etc. in a rural area more than Bangkok.
* Quite old truck is used by a transportation company of resources and a building constructor, and may demand of a secondhand engine be expected fairly by the industry?
* It seems circulated by broker's network because an auction market of a used car isn't established sufficiently in Thailand.

TRI RETCH ISUZU LEASING(THAILAND) Co., Ltd.

* TRI PETCH ISUZU LEASING Co., Ltd. is the dealer's company Thai Mitsubishi established with Isuzu Motors.
* The car type which is being treated is all cars made by Isuzu Motors, a pickup truck, mostly, everything.
* Much, one for for individuals and small and medium enterprises don't grasp the situation of the maintenance because the one which is being treated is a pickup truck.
* It's little, but business of the regular inspection is also received from an orderly sale destination and one as in Japan is maintained.
* To tend to use the agricultural person concerned thoroughly, when it's compared with Japan, there is a car of the considerable mileage.
* It has to be based, be the car which became quite old and come to hinder use, may not transshipment use of an engine be done?
* Most is a diesel engine for a local pickup truck.
* The rear is remodeled and there is something being used like a car, and it isn't possible to come across this in Japan.

5-1-6 Selection of Local Partner

From the above results, we focused on taxi business since they have many vehicles with long total mileage, and it was decided to select a local partner from among them. In aforementioned, since the taxi company interviewed possess only 20 units and is small-size company, so we tried contacting taxi company that hold bigger units. Although contacted the Bangkok metropolitan

that have jurisdiction over the taxi industry, they said unless the advantage of remounting effect is clearly mentioned it is difficult to introduce cooperating taxi company, hence contact with large-scale taxi company was not realized.

5-1-7 The situation of the Thai taxi industry.

The Study Team referred to the situation of the Thai taxi industry about registration number in particular in Chapter 2, but when even if general registration number in Bangkok and a change in initial registration number are seen, the JCM business which made the taxi the population from now on tends to be increased, and is concluded, I think you'd be able to expect CO2 reduction effect and the merit with that certain degree of.

Consumption is expanding from the former gas as fuel gentle with the environment that a diversion to liquefied petroleum gas (LPG) and compression natural gas for cars (CNG) was developed, cleaner and excellent in the combustion efficiency as use fuel of a taxi. Because a red snapper government suppresses the upper limit of the natural gas price for natural gas cars (Natural Gas Vehicle; NGV) substantially compared with the gasoline price, NGV is spreading. On the other hand there are a lot of gasoline cars even now for the private car with the short mileage because of being few gas stations corresponding to the thing the vehicle for which natural gas is used has to put the exclusive equipment switched from gas use to LPG and CNG use on which, LPG and CNG.

Further since putting it in this demonstration experiment, both vehicles were the bye fuel type which uses gasoline fuel and NGV fuel. The performance of the NGV filler (the pressure) is different every NGV station and equipment. When large truck filled next at the time of the same refueling more at the timing of filling, when I had the influence influential in measurement from the present state of can get up on the pressure of my filler, it was considered and other result and gasoline fuel were used.

5-2 Assumed Business Model

5-2-1 Business Concept

The project considered in this JCM project feasibility survey is “Thai government to introduce Japanese used engine in order to realize low carbon society and improve fuel efficiency leading to reduction of vehicle CO2 emission”. The project concept is comprised of 3 keywords. First, “business which is based on environment policy of government”, second, “excellence of Japanese used-engine”, third, “building the system to promote recycling system”.

5-2-2 Concept of Business Model

The business model in this project is supposed to be a joint venture between a major taxi company operating in Bangkok city and Kaiho Sanngyo Co., Ltd.

The sales of Japanese used-engine is assumed as business scope of Kaiho Sangyo, the tasks such as business operation and fee collection as task of local resource of co-management.

In reality it would be unlikely for individual to raise a fund and purchase Japanese used-engine; it is assumed that main customer are major taxi company, bus company, transport company, government and university research.

Also, CO2 reduction effect brought about by engine remounting shall be purchased by Japanese government, and the amount of difference from such reduces cost incurred by remounting used-engine by purchaser.

On the other hand, CO2 reduction is brought about mainly by improving fuel efficiency. From the perspective of taxi company, improvement of fuel efficiency = fuel price deceleration. If after Japanese government bought the CO2 emission reduction effect, the used-engine price is cheaper than fuel cost caused by improvement of fuel efficiency, then the taxi company may proactively remount the engine.

5-2-3 Scenario for Carrying Business Implementation

This project is implemented through the following steps.

(1) Survey Confirmation Stage

Detail survey on business profitability

Survey the motivation of engine remounting

Survey the sale destination of currently sold engine

(2) Business Preparation Stage

Establishment of local company

Training of the staffs

(3) Business Implementation Stage

Export used-engine from Japan

Local company is established to operate business of remounting the imported used engine on vehicle with high total mileage.

Bangkok city is aspiring to develop clean city, reduction of exhaust gas and CO2 emission from motor vehicles, to meet with the measures of Bangkok city. If any kind of support can be provided by Bangkok city, business potential of this project intensifies.

5-3 Study the Outline of Profitability

One single owner of the taxi (private taxi, owner taxi, only person driving this taxi) used in preliminary test and full-scale test in this study currently operates vehicle that is already over 9 years, the fuel and maintenance cost data were recorded considerably in detail, therefore these data were used. If remounted with better fuel efficient engine, profitability was considered as a “taxi owner”.

The result is as follows, if engine is remounted at end of 6th year, for a total cost of 10-years is reduced by 75,000 bahts. When engine remounting cost is lesser, then the taxi company recognizes the advantage of remounting.

Table5-1 : Outline of Profitability

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	
Present Situation										Unit : Baht	
	0	1	2	3	4	5	6	7	8	9	合計
1. The purchase price	789,000										
2. Maintenance		16,300	30,800	25,500	30,300	32,300	37,300	33,300	39,300	35,300	280,400
3.Overhaul								8,500			8,500
4.Consumption of Fuel		45,205	45,724	45,724	47,357	49,725	53,757	68,250	64,658	70,816	491,215
5.Cost (2～4)		**61,505**	**76,524**	**71,224**	**77,657**	**82,025**	**91,057**	**110,050**	**103,958**	**106,116**	780,115
Replacement of engine											合計
1. The purchase price	789,000						XXX				
2. Maintenance		16,300	30,800	25,500	30,300	32,300	37,300	33,300	39,300	35,300	280,400
3.Overhaul											0
		240	240	240	230	215	200	190	200	200	
4.Consumption of Fuel		45,205	45,724	45,724	47,357	49,725	53,757	45,724	45,724	45,724	424,664
5.Cost (2～4)		**61,505**	**76,524**	**71,224**	**77,657**	**82,025**	**91,057**	**79,024**	**85,024**	**81,024**	705,064

Incidentally, the cost of used-engine is 120,000 yen/unit (prime cost, transport cost, remounting fee included). For example if JCM project can provide half the price, it was possible assumption that remounting business can be established.

5-4 Result of JCM Project Feasibility Survey

However, as a result of JCM project feasibility survey, regrettably improvement of fuel efficiency and reduction of CO2 by engine remounting was not obtained in study. What can be assumed at current stage is to take Delivery Company, possessing vehicles fuel efficiency can be observe, as counter partner by next fiscal year.

Meanwhile, JCM project feasibility study this time, improved fuel efficiency and reduction of CO2 by remounting engine to Toyota vehicle taxis were not obtained. However, note that there is following possibility.

5-5 Feasibility of This Project in Other Country

This survey is merely targeted and conducted at Bangkok metropolitan. Not limited to taxis, the detail information regarding used-vehicles, where they are sold to Thai rural areas was not obtained, however Thai rural areas environment standard in entire Thailand and business plan at rural areas is recognized not that difficult.

In this regard, however there is business possibility targeting developing city with loose environment standard, insufficient engine maintenance, and high mileage vehicles more than Thailand.

Chapter 6 Co-benefits Survey

In this chapter, with respect to co-benefits brought to Thailand, the model project conducted a simulation by utilizing the result of model proving test. Social value of the model project was estimated.

6-1 Co-benefits Needs for Indicator Development

In conducting the GHG emissions reduction project, emphasis not only on the benefit of developed countries to achieve carbon credit, but there is a need to focus on co-benefits acquisition by the hosting countries. Currently co-benefits remains to be qualitatively described, selection method with emphasis on co-benefits in the selection of project still lack transparency and objectivity. If the interests of developing countries remain unclear it is ambiguous to contribute sustainable development, thus long-term sustainability of the CDM and JCM cannot be expected. For quality improvement of project and long-term sustainability of business, we aim to build a mechanism with an emphasis on sustainable development of developing countries, rather than for the purpose of achieving carbon credit only. To develop a quantitative evaluation index for co-benefits enables selection of project in an objective and fair way, consequently GHG emissions reduction with sustainable development and building low-carbon society in developing countries are possible.

6-2 Purpose

While number of cars owned is expanding due to the rise in population and living standards, the environmental policy to promote emissions such as carbon dioxide and sulfur oxides from car and contribute to the establishment of recycling system in developing countries is poor. The purpose is to achieve co-benefits such as improvement of air pollution and health hazards, and contribute to the establishment of sustainable development and low-carbon society in developing countries.

This model project is intended to improve fuel efficiency by mounting the Japanese used-engine to Thai automobile. Japanese used engine has the feature of good fuel efficiency and long-life in contrast with used-engine of other countries. In developing countries with large number of deteriorated fuel efficient cars overs years of running, a significant improvement of fuel efficiency and reduction of carbon dioxide and sulfur oxides associated therewith is expected by mounting the Japanese technology to their automobiles.

6-3 Air Pollution Improvement as Co-benefits

Co-benefits brought by model project to Thailand are described. Model project is for the purpose of reducing the fuel consumption by automobile, reduced fuel consumption leads to

reduction of carbon dioxide (benefit) and reduced automobile exhaust gas emissions (co-benefits) leads to air pollution improvement.

6-3-1 Air Pollution Caused by Vehicle Emissions

Effects of vehicle emissions is summarized in Table 6-1. They are obtained by considering the production of SOx, NOx, SPM and photochemical oxidants..

Table 6-1 Air Pollutants and Damage from Vehicle Emissions

Damage	Damage content
Health Damage	Fever, cough, sputum, feeling of foreign body in eyes & nose, cold symptoms, lacrimation, lung cancer, asthma
Environmental damage	Poor eyesight, acid rain (damage to trees, crops & river organisms and corrosion of building), long activity limitation
Economic damage	Increased medical expense, environment maintenance and recovery

6-4 Indicator Development Method

In this section a method of measuring the co-benefit effect is described. First, based on fuel efficient improvement 0.1km/L (12.4km/L – 12.5km/L) that is the result of model proving test, a simulation was conducted for 3 cases on carbon dioxide and sulfur oxides reduction. Simulation coverage is limited not to entire model project but to vehicle mileage. Therefore distribution of used-engine and processing of chlorofluorocarbon from disposed engine are not included. The value of co-benefits of model project for each case was estimated from the questionnaire result that was carried out locally.

6-4-1 Air Quality Standards

Documents were investigated on contribution of Bangkok air pollution and transportation department upon index development. First, out of air pollutants discharged in Bangkok 80% of NOx, 75% of CO, 54% of PM and 87% of HC are derived automobiles. Note that SOx contribution was small. (OTP, 2013) On the other hand, when air quality standards were investigated, all the indicators except PM have met the environment standards. In the following simulations on the assumption that those below air quality standards do not bring damage and shall not be taken into account in this report. Therefore here after, only PM is covered.

6-4-2 PM_{10} と $PM_{2.5}$

Among the points in Bangkok metropolitan having the highest annual average concentration

for PM_{10} and $PM_{2.5}$ is selected and shown in Table 5-2. (Pollution Report, 2012) The location of highest point of PM_{10} is Santipap Rd Pom Prap Sattru Phai Dist., and highest point of $PM_{2.5}$ is Din Daeng Rd. Din Daeng Dist.

Air quality standards generally are set into two, long-term and short-term standards, the purpose of which from human health perspective is to prevent long-term accumulation and short-term exposure to high concentration. In the simulation, the daily average standards for the purpose of reducing the health risk of short-term due to exposure to high concentration was set to be evaluated and adopted as air pollution resolution guide.

Table 6-2 Air Concentration of PM_{10} and $PM_{2.5}$ in each point

Point	Object substance	Standard value [μg/m³]		Annual average concentration ([μg/m³]	Average daily maximum concentration [μg/m³]	Days passed (day)
		Annual average	Daily average			
Santipap	PM_{10}	50	120	78	211	24
Din Daeng	$PM._{25}$	25	50	34	86	46

6-4-3 Contribution per Vehicle

Bangkok metropolitan has a population of 8,249,117 people; registered cars are 3,467,252 units (OTP, 2010). Also, since 54% of the PM emitted in Bangkok is derived from the vehicles, contribution levels (hereafter, referred to as PM contribute concentration) to average daily maximum concentration per vehicle is calculated by following formula.

$$\text{PM contribute concentration} = \frac{average\ daily\ maximum\ concentration}{units\ of\ registered\ cars\ in\ Bangkok} \times 0.54$$

Table 6-3 PM Contribute Concentration

Substance	PM Contribute Concentration [μg/m³/vehicle]
PM_{10}	3.29×10^{-5}
$PM_{2.5}$	1.34×10^{-5}

6-5 Simulation

Based on the assumption of previous section, it was decided to carry out the simulation of 3 cases below. In this section, reduction of carbon dioxide was estimated.

Case 1. Business assumed scale

Case 2. Introduction to all taxis in Bangkok

Case 3. Air quality standard achievement

First, the estimated result of carbon dioxide emission reductions of assumption and those derived from vehicles for each case was written down.

(1) Case 1: Business assumed scale

This model project, from 2015 to 2020 for 6 years, was expected to reach a total of 1350 units in increments of 50 units every year, starting with introduction of 100 units of used-engines. As an initial case, it was simulated in business scale that is assumed.

The average annual mileage of Thai automobile is assumed to 20,000km, GHG emissions per gasoline 1 liter was using coefficient of 2322kg CO_2/L.

First, following formula is used to calculate the reduction. Table 5-4 shows the calculated result. As shown in the Table, 128,000 tons CO2 can be reduced in continuation from 2015 to 2020.

Annual fuel reduction per unit $= \frac{20,000}{12.4} - \frac{20,000}{12.5} =$ 14.3[l/Year/unit]

Table 6-4 Carbon Dioxide Reduction of Business Assumed Scale

Year	2015	2016	2017	2018	2019	2020	Total reduction (t)
Number of units (unit)	100	150	200	250	300	350	-
Total number of units (unit)	100	250	450	700	1000	1350	-
GHG reduction (t)	3,328	8,320	14,977	23,297	33,282	44,930	128,135

(2) Case 2: Introduction to all taxis in Bangkok

The number of registered taxis in Bangkok metropolitan is about 110,000 units, which is the target of this model project to introduce used-engine. Therefore, Table 5-5 shows the result considering a case applying to all vehicles.

Table 6-5 Carbon Dioxide Reduction of All Taxis Introduced

Year	2015	2016	2017	2018	2019	2020	Total reduction (kt)
Number of units (unit)	15,000	15,000	20,000	20,000	20,000	20,000	-
Total number of units (unit)	15,000	30,000	50,000	70,000	90,000	110,000	-

GHG reduction (kt)	499	998	1,664	2,330	2,995	3,661	12,148

(3) Case 3: Air quality standard achievement

Finally, the assumption was made on scale necessary to achieve daily average standards for PM_{10} and $PM_{2.5}$. Reduction of daily average maximum concentration to the environment standards is considered as air pollution resolution, also PM is the contribution of 54% of emission from vehicle through human activity (OTP, 2013) and Table 5-6 shows how to calculate number of units required for standard achievement from concentration (hereafter, referred to as PM contribute concentration) contributing to air pollution per vehicle in Bangkok metropolitan.

Table 6-6 Required Units for the Standard Achievement

Substance	Ave daily ($\mu g/m^3$) (Max value) – (Standard value)	PM contribute concentration ($\mu g/m^3$)	Required improved number (unit)
PM_{10}	91	3.29×10^{-5}	2.77×10^{6}
$PM_{2.5}$	36	1.34×10^{-5}	2.69×10^{6}

Looking at this Table, since more vehicles require PM_{10}than $PM_{2.5}$, value of PM_{10} is adopted and assumed 2.8×10^{6}units scale. In order to achieve this value in 2020 in the project period, assuming that a gradual introduction similar to other cases, Results are obtained as shown in Table 5-7.

Table 6-7 Carbon Dioxide Reduction for Standard Achievement

Year	2015	2016	2017	2018	2019	2020	Total reduction (kt)
Number of units (unit)	133,333	133,333	133,333	133,333	133,333	133,333	-
Total units (unit)	133,333	266,667	400,000	533,333	666,667	800,000	-
GHG reduction (kt)	4,438	8,875	13,313	17,750	22,188	26,625	93,189

6-6 Questionnaire

This section has described the questionnaire contents to carry out the monetary evaluation from people's recognition. The purpose of questionnaire is from the willingness to pay for resolving air pollution, is to determine the effect of this model project and each simulation.

6-6-1 Questionnaire Survey Method

Questionnaire survey was carried out in Bangkok metropolitan. 100 people were randomly selected and they were explained about the effects on health, environment and economic damages caused by air pollution; they were questioned if this model project can resolve the current air pollution, how many bahts they are willing to pay monthly. Also, information from respondents reflected their awareness on air pollution. See appendix 1, 2 for survey form used in questionnaire.

In the questionnaire, for a hypothetical change, question method was used to ask people their willingness to pay. Here CVM survey, a double bound method of two-choice format was used, after asking about 40 bahts, prepared question with 80 bahts at most and 20 bahts at least for respondent's selection.

6-6-2 Questionnaire Result

List of questionnaire result is as per appendix 3. From the result, monthly willingness to pay to resolve air pollution by model project becomes a distribution as shown Figure 5-1, and it has been calculated to average 23.8 bahts per month.

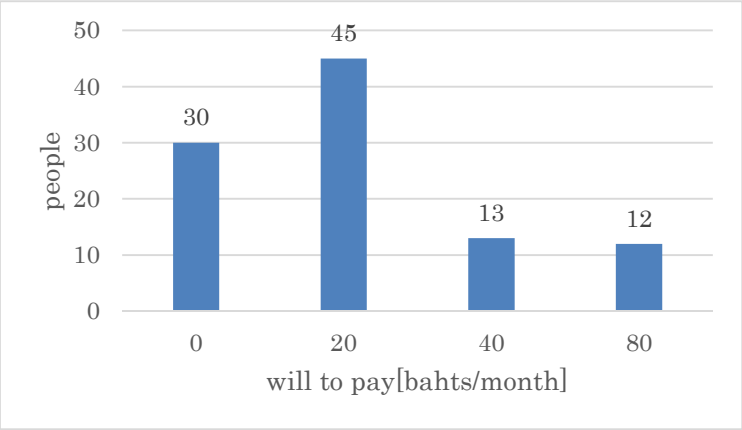


Figure 6-1 Will to Pay Distribution

6-7 Co-Benefit Indicator Development

On the assumption of simulation, air pollution was to resolve when it is below the environment standard. As described above, simulation was carried out specifically on $PM_{10}$and $PM_{2.5}$, NOx and SO_2 were excluded from discussion. The value effect was determined as shown in Table 5-8. In addition, baht is equivalent to current value.

$$\textit{Value of co-benefit effect} = \sum \frac{PM contribe\ concentration \times unit}{daily\ ave \max concentrtion - standard\ value} \times will\ to\ pay \times population$$

Table 6-8 Value List of Co-benefit Effect

Case	CO_2 Reduction [Mt-CO_2]	PM_{10}[μg/m³]	$PM_{2.5}$[μg/m³]	Value of co-benefit effect (bahts)
1	0.13	0.044	0.018	1,148,547
2	12	12.0	4.9	310,533,134
3	155	92	38	2,355,947,815

Willingness to pay (hereafter, referred to as WTP) in this report, is used for asking the value to resolve air pollution, and it was considered in order to explore the factors affecting the value of air pollution by information of other items.

(1) Age, Monthly Income

First, age-group of respondents is shown in Figure 2. There were many in 20's and 30's and no 70's. Average willingness to pay by age-group is shown in Figure 3, and that WTP of 30's was the highest, the value increased as age-group increased from 10, 20, 30, but gradually decreased after 40's. So when monthly income by age-group is calculated, those under 20's is 7,000 bahts, 20's is 17,000 bahts, 30's is 28,000 bahts and then 40's, 50's only 1,000 bahts increased from 30's reaching 29,000 bahts, and then decreasing in 60's with 22,000 bahts. (Fig 4) Although it is qualitative as shown in the Figure, tendency of WTP is higher can be said to be through 30's. However, it is believed that after no change in 30's monthly income with WTP is rather getting lower and there may be other contributing factors.

Furthermore Figure 5 shows the distribution of monthly income and WTP. The average monthly income in Thailand is said to be about 30 000 bahts and average WTP is stable about 30 bahts, but a large variation was observed in the monthly income of over 40000 bahts. Although the WTP in the vicinity of the average monthly income is reliable to some extent, WTP of wealthy needs future investigation.

Occupation was also investigated, but there was no correlation noted between income and WTP.

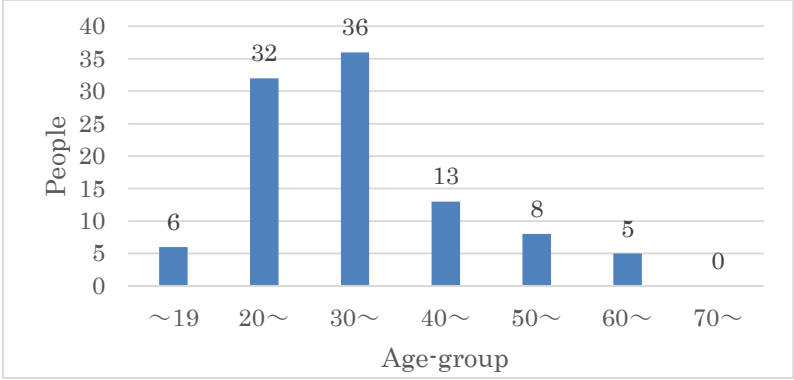


Figure6-2: Age-Group Number

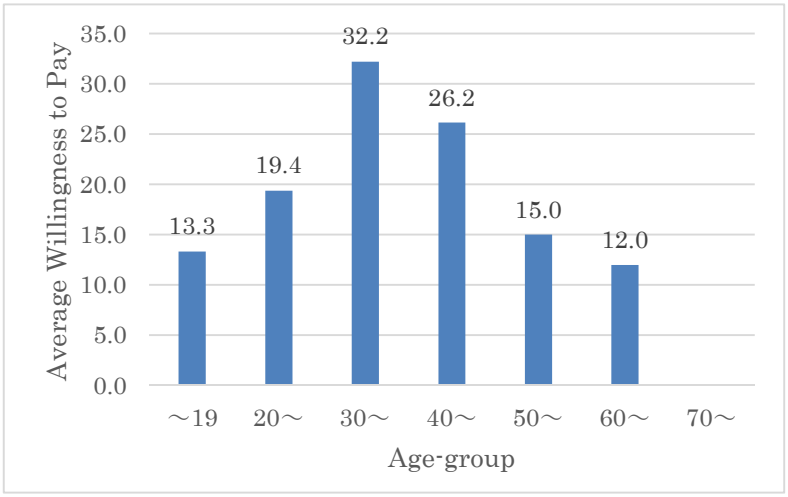


Figure 6-3:Age-group and Average Willingness to Pay

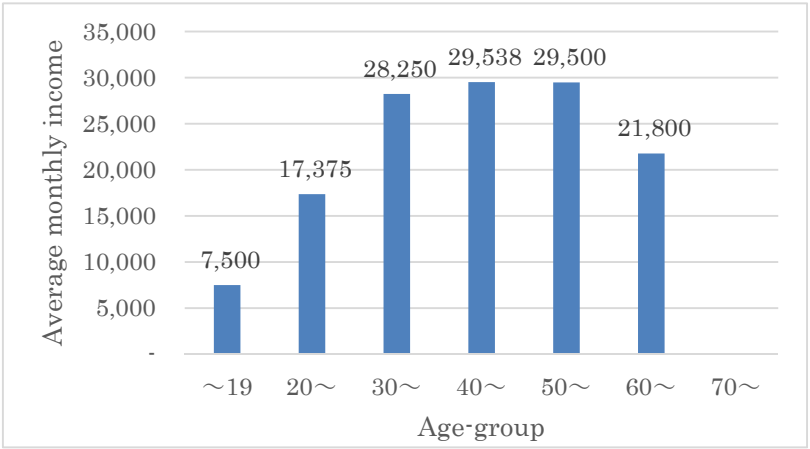


Figure 6-4:Comparison of Age and Average Monthly Income

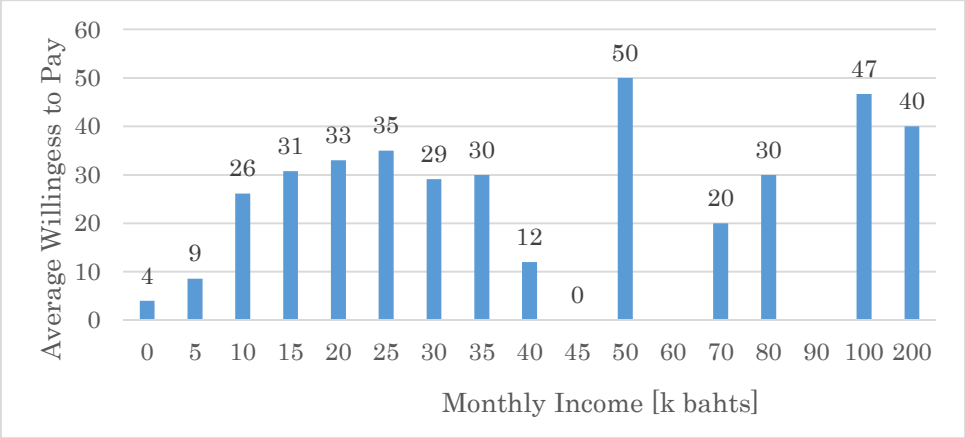


Figure6-5 :Monthly Income and Willingness to Pay

(2) Hometown, Resident Period

Next, hometown and resident period were devised to measure the value of the entire city of Bangkok. In Figure 6 WTP distribution is shown by hometown, in Figure 7 it is by resident period, these show that WTP tends to get cheaper as residing period is longer, except when one resides average of 41 to 50 years. Resident period less than 10 years and shorter are mostly people coming from outside Bangkok, and their WTP is the highest for they found the value in moving into Bangkok city. They compare air pollution of their former residence with Bangkok and recognize the seriousness of air pollution in Bangkok. Also, as the resident period becomes longer the WTP becomes cheaper; this may be due to people getting accustomed to the characteristics of the city.

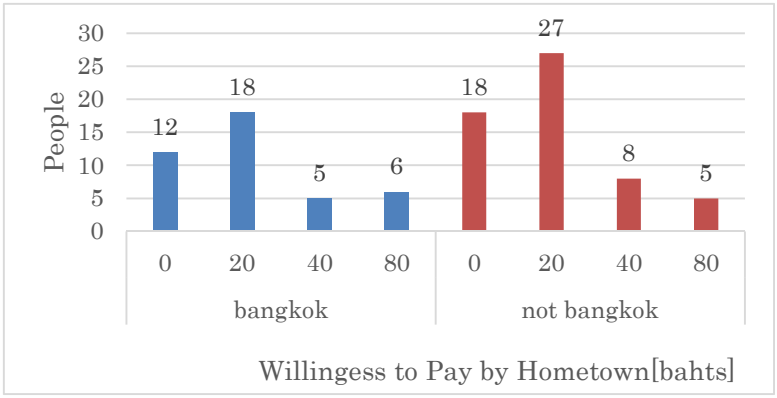


Figure6-6: Willingness to Pay by Hometown

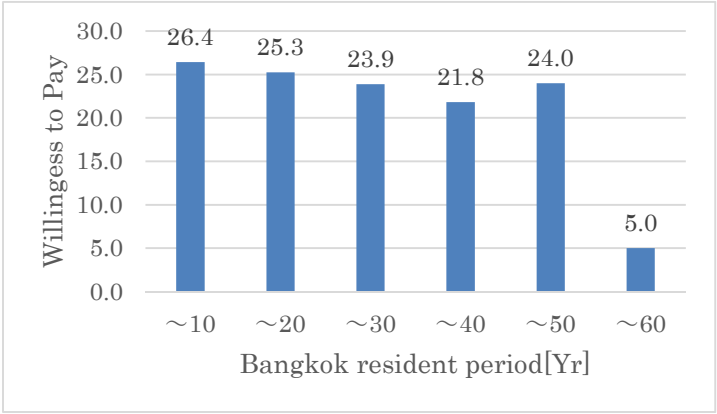


Figure 6-7: Resident Period and Willingness to Pay

(3) Gender

The average WTP by gender is shown in Figure 8 and the impact of gender is studied. Sample target were 43 men and 57 women, the average number of children 0.62 men and 0.47 women. The average WTP is higher for women but number of children is low. The assumption of the more children the higher the WTP did not apply here. The survey did not include the age of children and therefore cannot make assertion, however if respondent is not a parent or if the child is not in growing stage, presence of child does not affect environmental awareness.

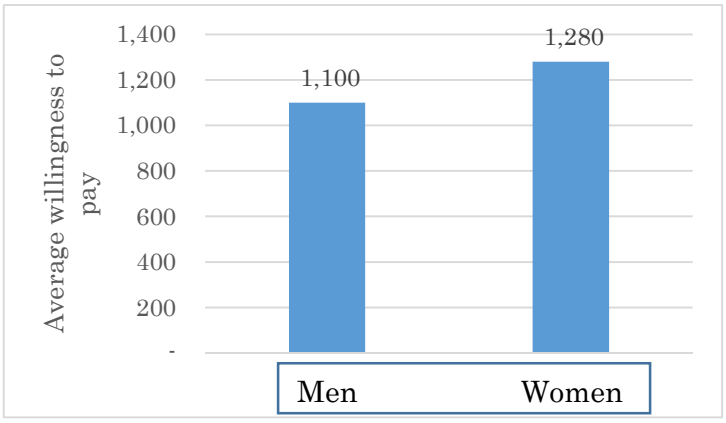


Figure6-8: Gender and Willingness to Pay

6-8 Conclusion

In this report, co-benefits rating index associated with the feasibility investigation of model project were developed. The result is summarized below.

- As a result of measuring the effect not covering co-benefit indicator development, the model project reduced 128kt carbon dioxide, 0.044μg/m³PM_{10},0.018μg/m³$PM_{2.5}$, with 1,150,000 bahts worth of co-benefit effect.
- When introduced to all the taxis, the reduction of carbon dioxide to 12Mt, PM_{10} to

12.0μg/m³, $PM_{2.5}$ to 49μg/m³, with 3,1050,000 bahts worth of co-benefit effect.

- The value of resolving the air pollution in Bangkok by PM is 2.3 billion bahts, it can be achieved by this project by introducing 2.8×10^6 units.

6-9 Future Theme

- Accuracy of Model Project Experiment

Thailand is facing serious traffic congestion at daily basis and any disturbance can happen at road experiments. In addition to differences in highway and general road, weekday and holiday, the presence of road construction greatly affects traveling by vehicle.

- Validity of Co-benefit Evaluation Index

In order to develop evaluation index, a small number of 100 respondents in Bangkok were surveyed, and such result cannot be generalized. Also as a target, not only people living in Bangkok city but also it is required to take into account the value of people living in areas outside of Bangkok.