THE ENVIRONMENT AND THE AUTOMOBILE INDUSTRY

1 Introduction

In FY 2014 automobile sales in Japan fell by 6.9% to 5.3 million vehicles compared to the previous year (FY 2013) due to the impact of the increase in the consumption tax, the first decline in sales in 4 years. Furthermore, in FY 2015 sales once again fell by an additional 6.8% compared to the previous year (FY 2014), to 4.94 million vehicles, marking the first time in four years that automobile sales in Japan fell to below the 5 million vehicle mark since FY 2011, immediately after the Great East Japan Earthquake and tsunami[1]. In FY 2014 the sales of mini-vehicles exceeded 40% of all vehicle sales in Japan for the first time in history, but the April 2015 increase of the mini-vehicle tax became a major reason for the drop in sales of mini-vehicles in FY 2015, which decreased by 16.6% compared to 2014 down to 1.81 million vehicles.

A large proportion of the Japanese vehicle market consists of fuel-efficient, low-emission vehicles such as hybrids and clean diesels. As a result, the CO_2 emissions of the transportation sector are declining every year. However, despite this trend, road vehicles account for virtually all CO_2 emissions in the transportation sector and continued efforts will be required to establish laws and develop technologies to further reduce fuel consumption and exhaust emissions.

2 Environmental Trends

2. 1. Japan

2. 1. 1. Reduction of greenhouse gas (GHG) emissions

At the 19th United Nations Climate Change Conference (COP 19) in 2013 it was decided that the participating nations would be asked to submit their Intended Nationally Determined Contributions (INDCs), which include their targets for reducing GHG emissions from the year 2020 onward, well in advance of the 21st United Nations Climate Change Conference (COP 21) in 2015. Japan submitted its INDC to the United Nations Framework Convention on Climate Change (UNFCCC) secretariat in July of 2015, setting its target to a 26% reduction in GHG emissions by the year 2020 compared to FY 2013 levels in (equivalent to a 25.4% reduction in emissions compared to the level in FY 2005)[2]. At the COP 21 meetings held in November of 2015 the Paris Agreement was adopted as a new international framework for reducing GHG emissions in place of the Kyoto Protocol[3]. Based on these new targets and agreements, the Global Warming Prevention Headquarters within the Japanese government compiled its "(Draft) Global Warming Prevention Plan" in March of 2016 to replace the previous "Kyoto Protocol Target Achievement Plan"[4]. This new plan cites the following as examples of the initiatives that will be pursuing in the transportation sector: the spread and popularization of next-generation automobiles, measures to improve the vehicles themselves, such as improving the fuel economy, measures to improve the flow of on-road traffic, the promotion of more environmentally-friendly driving techniques, and the promotion of logistics with a small carbon footprint.

Japan's total CO_2 emissions in FY 2014 were 1.265 billion tons. The amount of CO_2 emissions from electric power generation during that year decreased by 2.5% compared to the previous year (FY 2013) thanks to both a decrease in the amount of electric power consumed and improvements in the amount of emissions per unit of electric power generated. The amount of CO_2 emissions from the transportation sector decreased by 3.4% compared to the previous year (FY 2013), accounting for 17.2% or 217 million tons of all such emissions in Japan. Road vehicles accounted for 86.0% of these emissions, with passenger vehicles accounting for 50.8% and trucks accounting for 35.1% of this amount (Fig. 1).

2. 1. 2. Japan's preferential tax scheme for environmentally friendly vehicles

In 2009, Japan enacted a preferential tax scheme (affecting the motor vehicle weight tax and vehicle acquisi-

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tion tax) to encourage the popularization and adoption of environmentally-friendly vehicles. In 2015, the simple replacement of current standards with the 2020 fuel economy standards was supplemented by measures such as allowing some of the vehicles currently eligible for the preferential tax to remain eligible under the new standards (Fig. 2).

The special provisions for environmental measures in the vehicle tax system started in 2001 reduced the size of the taxation in accordance with the vehicle's emissions and fuel economy. These provisions were combined with higher taxation on other vehicles for a set number of years after new vehicle registration, and also remained in effect in 2015.

2. 1. 3. Incentive system to purchase environmentally friendly vehicles

In May 2013, "subsidies for promoting the adoption of clean energy vehicles (CEV subsidies)" were established to support the introduction of electric vehicles, plug-in hybrid vehicles, and clean diesels. In FY 2015 the applications for these subsidies started being accepted on September 24, 2015 and were accepted until March 14, 2016[7].

2. 2. Outside Japan

2. 2. 1. Reduction of GHG emissions in the transportation sector

In April 2014 the third working group report (mitigation of climate change) of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) was published[8]. In 2010, passenger transportation and freight transportation accounted for approximately 27% of the final energy consumption within the transportation sector and was responsible for 6.7 billion tons of direct CO_2 emissions. In addition, worldwide CO_2 emissions from passenger transportation and freight transportation are increasing, leading to reports predicting that baseline emissions will approximately double by the year 2050 if additional mitigation measures are not implemented. As part of these mitigation measures, automobile energy efficiency and vehicle performance are predicted to improve by 30% to 50% compared to 2010 levels by 2030. These predicted improvements in conjunction with other efforts, such as urban redevelopment, have shown that it is possible to reduce the final energy consumption of 2050 by approximately 40% compared to the baselines.

2. 2. 2. Trends in environmental regulations related to vehicles[9]

The U.S. government issued an advance notice of the new Tier 3 emissions standards in March 2013 and then in April of 2014 the final rules for Tier 3 were issued based on the results from additional examinations carried out in regard to these proposed rules. The state of California has also introduced separate zero-emission vehicle (ZEV) standards mandating the sale or lease of electric or fuel cell vehicles. In 2010, the National Highway Traffic Safety Administration (NHTSA) and Environmental Protection Agency (EPA) formulated Corporate Average Fuel Efficiency (CAFE) and GHG emissions standards covering passenger vehicles and light commercial vehicles between the years 2017 and 2025. The final regulations were issued in August 2012. In addition, final fuel economy and GHG emissions standards covering heavy duty vehicles were also issued in August of 2011. In June of 2015 the NHTSA and EPA also proposed new fuel efficiency standards for medium- and heavy-duty vehicles.

Europe plans to adopt the EURO 6 regulations for emissions covering passenger vehicles and light commercial vehicles starting in 2014, and they are also examining the possibility of introducing a NO_2 standard, the Real Driving Emissions (RDE) standards, and the Worldwide Harmonized Light Vehicles Test Procedure (WLTP) at the same time. In addition, they are considering CO_2 emissions standards for passenger vehicles and light commercial vehicles for the year 2020 and beyond. Targets of 95 g/km for passenger vehicles and 147 g/km for light commercial vehicles have already been decided upon. The specific details of these standards were proposed by the European Commission (EC) in July of 2012 and the final regulations were issued in 2014. In addition, the EC also issued a policy for reducing the amount of CO_2 emissions from heavy-duty vehicles in May of 2015.

In China, emissions standards are based on those determined by the Economic Commission for Europe (ECE) and EU directives. Although current Chinese standards for passenger vehicles are equivalent to EURO 4, other standards equivalent to EURO 5 have already been introduced in Beijing in February of 2013 ahead of the rest of the country. The targeted average fuel economy for passenger vehicles is 6.9 L/100 km by 2015 and 5.0 L/100 km by 2020. In an effort to achieve these targets, Stage 3 fuel economy standards were announced in December of

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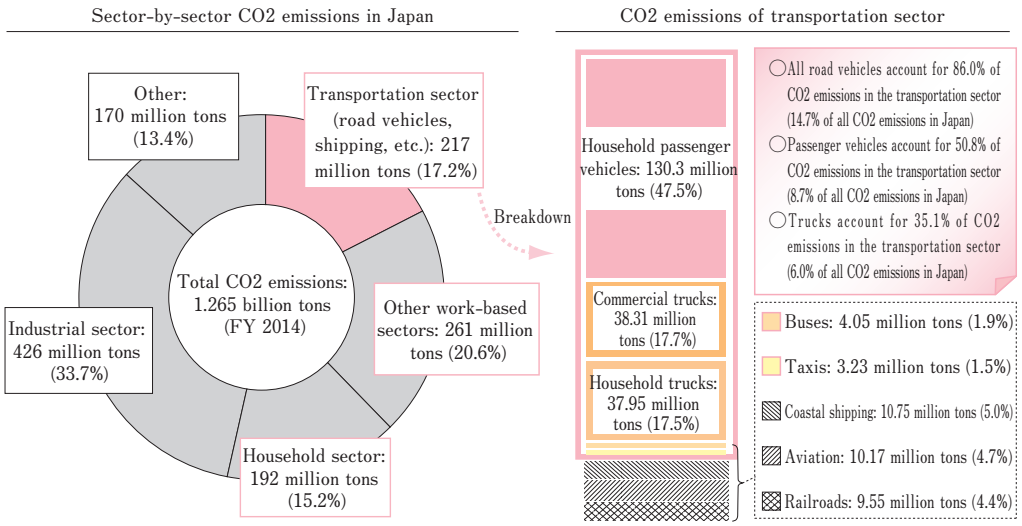

* Emissions caused by electric power generation by power companies and heat generation by heat service utilities are included in the sector responsible for the final demand in accordance with the volume of emissions.
* There are cases where the numerical values of the totals do not tally up due to rounding.
* Created by the Environmental Policy Division of the Ministry of Land Infrastructure and Transport (MLIT)) based on the "Final Reported Values of Japanese National Greenhouse Gas Emissions Data (FY 1990 to FY 2014)" published by the Greenhouse Gas Inventory Office of Japan.

Fig. 1 Breakdown of transportation sector CO2 emissions[5]

Applicable vehicles & conditions		Name of tax	Content of special provisions					
· Electric vehicles · Fuel cell vehicles · Natural gas vehicles (Reduction of NOx by 10% or more from 2009 emissions regulations)		Acquisition tax	Nontaxable					
· Plug-in hybrid vehicles · Clean diesel passenger vehicles (Passenger vehicles that conform to 2009 emissions regulations)		Vehicle weight tax	Tax exempt *1					
	Fuel economy performance / Emissions performance		2015 fuel economy standard			2020 fuel economy standard		
			Achieved	+5% over	+10% over	Achieved	+10% over	+20% over
Gasoline engine vehicles (Including hybrid vehicles)	Reduction of emissions by 75% from 2005 emissions regulations	Acquisition tax		20% reduction	40% reduction	60% reduction	80% reduction	Nontaxable
		Vehicle weight tax	Original tax rate *2	25% reduction		50% reduction	75% reduction	Tax exempt *1

Fig. 2 Summary of Tax Reductions for Environmentally-friendly Passenger Vehicles (Numbers in red: 2015 tax amendments).[6]

2011 and Stage 4 standards were issued in December of 2014. The Chinese Ministry of Industry and Information Technology also introduced stricter fuel economy standards for heavy-duty commercial vehicles in 2012, and the Ministry of Transport is now considering stricter fuel economy standards for large buses and heavy-duty trucks.

Emissions and fuel economy standards are being strengthened in other countries around the world as well. In consideration of this trend, the United Nations (UN) is accelerating the harmonization of international standards and has drawn up Global Technical Regulations (GTR) concerning the formulation of test methods for exhaust emissions and unified vehicle testing modes based on the 1998 Agreement on GTRs. The Worldwide Harmonized Motorcycle Emissions Certification (WMTC) procedure, Worldwide Harmonized Heavy-Duty Certification (WHDC) procedure, Off-Cycle Emissions (OCE) procedure, and Non-Road Mobile Machinery (NRMM) procedure have already been drawn up, and in March of 2014 the Worldwide harmonized Light-duty driving Test Cycle (WLTC) was also established.

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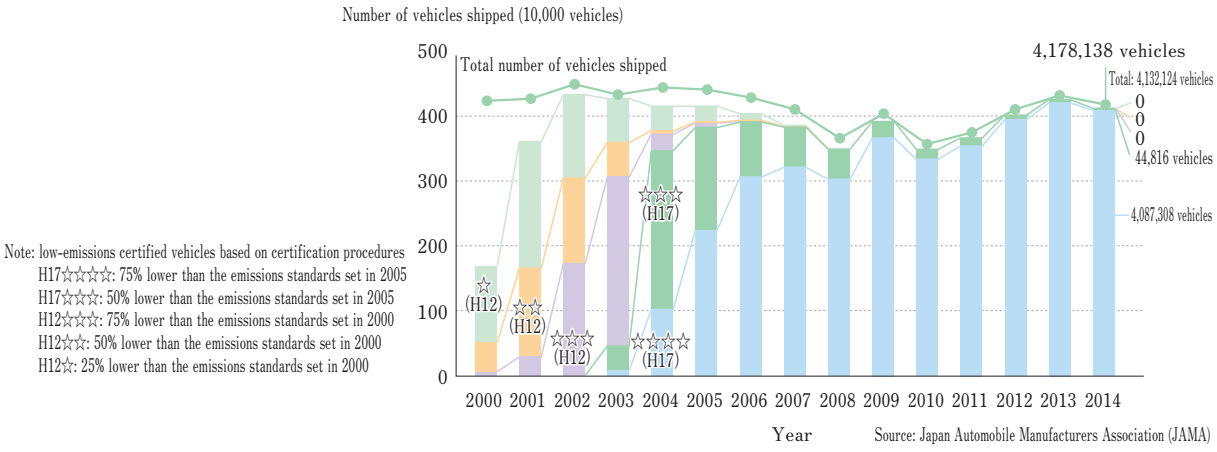

Fig. 3 Shipments of Low-emission Vehicles as a Percentage of all New Vehicles[10]

3 Automotive Environmentally Friendly Measures

3. 1. Urban environmental issues

3. 1. 1. Gasoline vehicles

Recent gasoline engine vehicles achieve extremely high environmental performance by combining direct fuel injection and the burning of the fuel at the theoretical air-fuel ratio, namely stoichiometric combustion, with a 3-way catalyst. Gasoline engines designed specifically for use in hybrid vehicles also employ technologies such as cooled exhaust gas recirculation (EGR) and the Atkinson cycle to achieve both low emissions and low fuel consumption. The number of certified low-emission gasoline passenger vehicles exceeded 99% of new vehicle sales in 2014. Of these vehicles, over 98% achieved emissions 75% lower than the standards set in 2005 (i.e., vehicles awarded four stars (☆☆☆☆)) (Fig. 3).

On the other hand, these same direct injection gasoline engine vehicles emit at least 10 times more particulates (soot) as conventional gasoline vehicles (port injection gasoline engine vehicles) and countermeasures are required to identify and help address the current situation as soon as possible[11]. Due to this situation, the mass production of a PM (particulate matter) removing filter or "Gasoline Particulate Filter (GPF)" specifically for direct injection gasoline engine vehicles has begun and there are also efforts underway to apply the PM regulations in EURO 6 to direct injection gasoline engine vehicles.[12]

3. 1. 2. Diesel vehicles

To comply with the post new long-term regulations, most diesel fuel vehicles have adopted high-pressure multi-stage fuel injection, variable geometry turbochargers, and exhaust gas recirculation (EGR) to control combustion in combination with aftertreatment systems such as diesel particulate filters (DPF) or selective catalyst reduction of NOx using urea as a reduction catalyst (urea SCR).

However, in 2013 a NPO (nonprofit organization) concerned with environmental issues called the International Council on Clean Transportation (ICCT) requested scientists at a small lab at West Virginia University to measure the exhaust emissions coming from diesel engine passenger vehicles manufactured by Volkswagen (VW) during actual on-road driving. The results of these measurements revealed that in actual driving (not laboratory testing) the vehicles emitting amounts of nitrogen oxides (NOx) anywhere from 5 to 35 times larger than the legally allowed limit under U.S. emissions standards. The EPA then asked VW for an explanation and the company admitted that it had been using special software (a defeat device) to apply emissions controls only during laboratory emissions testing and thereby illegally avoid compliance with U.S. emissions regulations. The EPA publicly released these results and admissions in September of 2015.

In response to these findings, the Japanese Ministry of Land, Infrastructure and Transport (MLIT) and the Ministry of the Environment (MOE) established the "Investigative commission to review inspection methods for diesel passenger cars and other vehicles in light of the exhaust emissions cheating incidents" in October of 2015. The commission thoroughly considered whether or not appropriate inspections could be carried out using only

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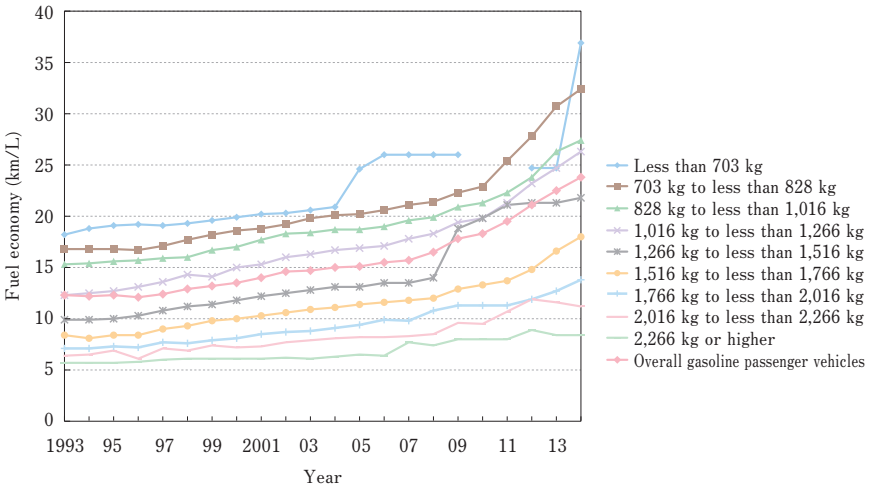

Fig. 4 Trends in the Average 10-15 Test Cycle Fuel Economy of Gasoline Engine Passenger Vehicles[14]

current bench testing evaluations, and is also conducting a review of current inspection methods from a technical perspective in consideration of possibly adding an actual on-road driving exhaust emissions test[13].

3. 2. Global environmental issues

3. 2. 1. Improving fuel economy

One recent trend seen in the efforts of automobile manufacturers to improve the fuel economy of gasoline engine passenger vehicles is to reduce the size of the engine along with adopting direct fuel injection and turbochargers. The competition to achieve better fuel economy is particularly fierce in the market for light vehicles, and some manufacturers have substantially improved the fuel economy of their vehicles by introducing regenerative braking systems to recover energy from braking. As a result, the average overall fuel economy for gasoline engine passenger vehicles reached 23.8 km/L in 2014, which is substantially better than the equivalent standard for 2015 (18.6 km/L) (Fig. 4). In addition, the passenger vehicle fuel economy standards for 2020 were set in March 2013, and their target is a 19.6% improvement compared to the 2015 standard. As a result, automobile manufacturers will need to continue focusing on fuel economy.

However, as fuel-efficient vehicles become more popular and widely used, the divergence between the real-world and the advertised fuel economy has become an issue, particularly because this divergence increases for vehicles with better environmental performance. Real-world fuel economy is affected by various factors, including use environment, driving style, and operational status

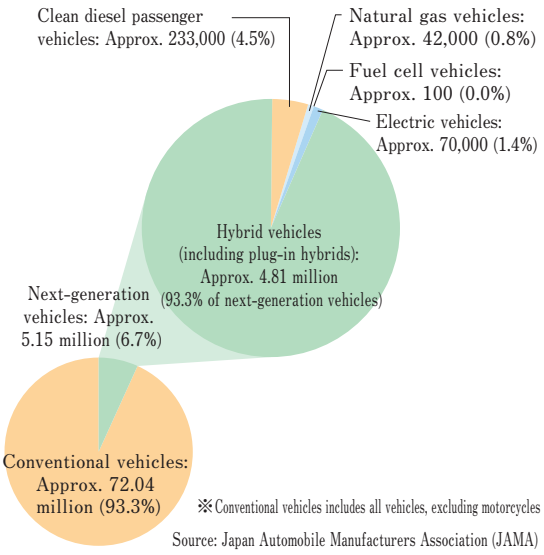

Fig. 5 Breakdown of Vehicle Ownership and Next-generation Vehicles (FY 2014)[10]

of electrical equipment. Various measures will be required to address this issue.

3. 2. 2. Popularization of next-generation vehicles

The "Strategy for promoting environmentally friendly vehicles" drawn up by the Japanese Ministry of the Environment (MOE)[15] and the "Next Generation Vehicle Strategy 2010" from the Ministry of Economy, Trade and Industry (METI)[16] call for the development and full-scale introduction to the market of next-generation vehicle technologies (i.e., for hybrid, electric, clean diesel, fuel cell, and natural gas vehicles) to help counter global warming, as well as to help strengthen the international competitiveness of the Japanese automotive industry. Since the full-scale introduction of the preferential tax

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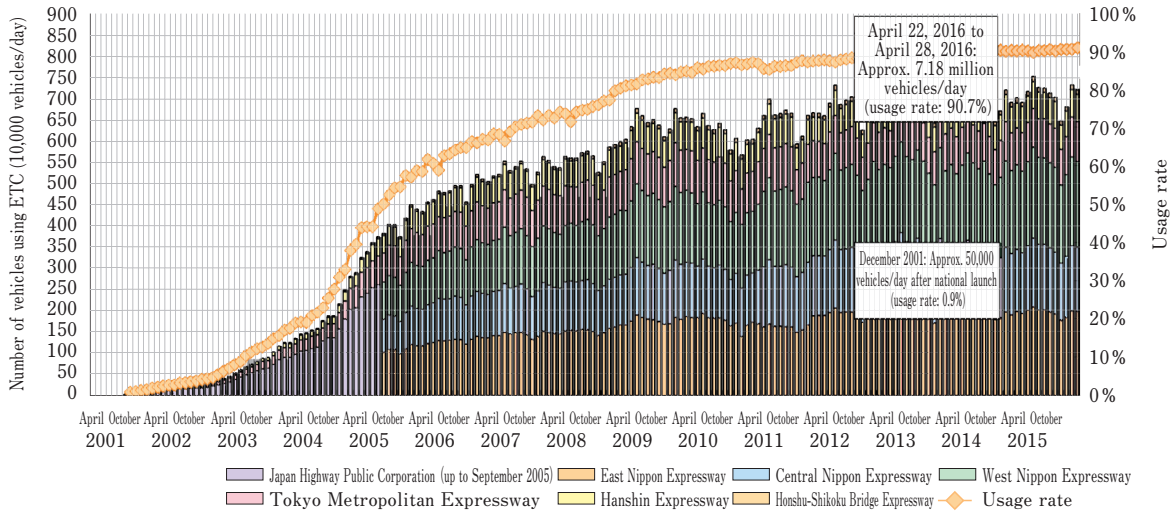

Fig. 6 ETC Usage Rate[17]

scheme and incentives for environmentally-friendly vehicles in 2009, sales of next-generation passenger vehicles have increased substantially, reaching roughly 5.15 million vehicles in 2014. Approximately 93.3% of these vehicles are hybrids. However, only about 6.7% of all vehicles on the roads in Japan are classified as next-generation vehicles and further efforts to promote their popularization will be needed (Fig. 5).

3. 3. Traffic environment measures

3. 3. 1. Promotion of ITS

Currently, various ITS-based services have become widespread across Japan, including the non-stop Electronic Toll Collection (ETC) system and Vehicle Information and Communication System (VICS). In January of 2016, the ETC usage rate reached 90.3% and the number of vehicles equipped with onboard VICS units had reached a total of approximately 49.38 million units as of December 2015. These systems help improve fuel economy and reduce exhaust emissions by facilitating the smooth flow of traffic (Fig. 6). In addition, ITS spot services began operating in roughly 1,600 locations around Japan in 2011 (Fig. 7). These use the same communication technology as ETC to provide various information-based services. One example of an ITS spot service is dynamic route guidance, which provides real-time road traffic information for urban expressways as well as highways offering several possible routes over a wide area that crosses prefectural boundaries. The vehicle navigation system can then search and select the fastest route based on the latest regularly updated information, allowing for more efficient travel.

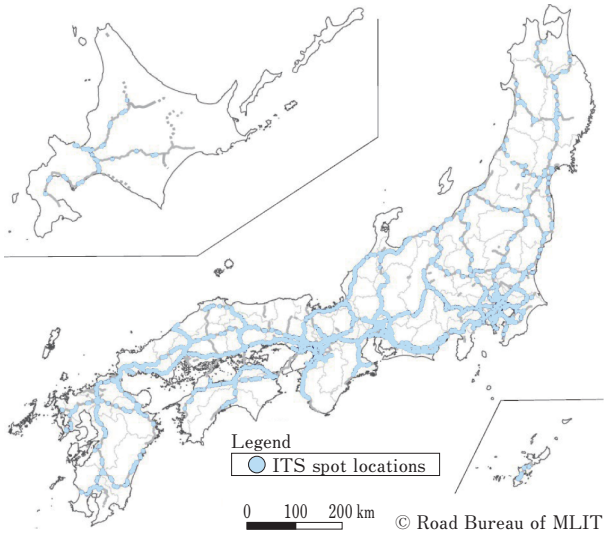

Fig. 7 Map of ITS spot locations in Japan (as of Apr. 1, 2016)[18]

3. 3. 2. Popularization of environmentally friendly driving techniques

The Eco-Drive Promotion Liaison Committee, a joint organization of the Japanese National Police Agency (NPA), METI, MLIT, and MOE, designated November as the official national environmentally-friendly driving month (official name: Eco-Drive Promotion Month) since this is a popular month for leisure trips and people have more opportunities to drive. This committee also promotes coordination for the holding of symposiums and events around the country to popularize and promote environmentally-friendly driving. This committee also created ten recommendations for environmentally-friend-

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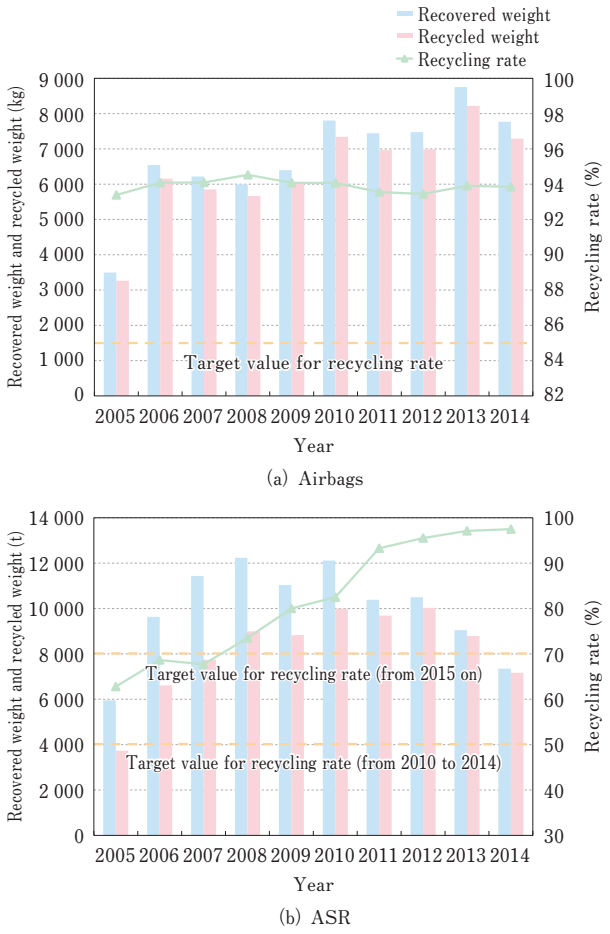

Fig. 8 Weights of Recycled Materials and Recycling Rates[21]

ly driving in 2003, which were then partially amended in 2006 and 2012[19].

3. 3. 3. More efficient logistics and encouraging use of public transportation

In April of 2012, after the approval of the Fourth Basic Environment Plan by the Cabinet, MLIT formulated its Environmental Action Plan for the seven year period from 2014 to 2020. One of the aims of this Action Plan is to counteract and alleviate global warming to achieve a low carbon society. It includes measures to encourage the use of public transportation by increasing the user friendliness of railways and buses and by promoting mobility management, as well as measures to increase the efficiency of logistics by promoting a modal shift from transportation by truck to transportation by trains or ships, as well as by boosting the efficiency of international freight transportation[20].

3. 4. Measures for used vehicles

The End-of-Life Vehicle (ELV) Recycling Law introduced in January 2005 obligated each automobile manufacturer to carry out recycling and treatment of chlorofluorocarbons, airbags, and automotive shredder residue (ASR). In FY 2014, the weight of recovered airbags was 7,800 kg and the recycling rate was 93.8%. This was a decrease of 0.1% from the 93.9% recycling rate achieved in FY 2013, but it maintained a recycling rate that greatly exceeded the target rate of 85%. In the same year, 7,400 tons of ASR was recovered and a recycling rate of 97.5% was achieved. This was up 0.4% from the 97.1% rate achieved in 2013. The ASR recycling rate has exceeded the target value for 2015 and on of 70% since 2008 (Fig. 8).

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