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BACKGROUND STUDY

Climate protection and energy efficiency in the transport sector – The case of Japan

Jana Narita, adelphi

With support from: Thorsten Koska, Wuppertal Institute; Nicole Plewnia, German Chamber of Commerce and Industry in Japan; Feres Mezghani, adelphi

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Publisher: adelphi
Alt-Moabit 91
10559 Berlin
T: +49 (030) 8900068-0
E: office@adelphi.de
W: www.adelphi.de

Author: Jana Narita

Support from: Thorsten Koska, Wuppertal Institute
Nicole Plewnia, German Chamber of Commerce and Industry in Japan
Feres Mezghani, adelphi

Contact: narita@adelphi.de

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Abstract

Japan is considered as a pioneer in the development and dissemination of new drive systems such as hybrid and battery electric vehicles and fuel cell vehicles. Furthermore, the Japanese fuel economy is one of the best worldwide and the share of railways for passenger transport is much higher than in many other developed countries.

The objective of this background study is to provide an in-depth overview and critical analysis of Japanese concepts and activities for climate protection and energy efficiency in the transport sector and derive recommendations for the Japanese-German energy dialogue.

Therefore, in a first step, some background data on the structure, GHG emissions and energy consumption of the transport sector in Japan is presented and the relevant stakeholders from policy, industry and research in the field of transport and sustainable mobility are introduced.

The study then gives a comprehensive overview of Japanese policy objectives, strategies and measures with respect to climate protection and energy efficiency in the transport sector including the promotion of fuel efficiency, the dissemination of environmental friendly vehicles, measures in freight transport as well as policies for increasing public transportation and cycling.

The next chapter sets the Japanese developments into international context and in particular carries out a comparison to the German transport sector and activities of the German government. In the last part, potential topics for Japanese-German energy dialogue are derived.

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List of Abbreviations

AI	Artificial intelligence
ANRE	Agency for Natural Resources and Energy
ASPIRE	Asia and Pacific Initiative to Reduce Emissions
BEV	Battery electric vehicle
BRT	Bus Rapid Transit
CDO	Continuous Descent Operation
CEM	Clean Energy Ministerial
CO_2	Carbon dioxide
ECCJ	Energy Conservation Center Japan
EDMS	Eco-Driving Management System
ETC	Electronic Toll Collection
EU	European Union
EV	Electric vehicle
EVI	Electric Vehicles Initiative
FCV	Fuel cell vehicles
FY	Fiscal Year
GHG	Greenhouse gas
HEV	Hybrid electric vehicle
ICT	Information and Communication Technology
INDC	Intended Nationally Determined Contribution
ITPS	Institute for Transport Policy Studies
ITS	Intelligent Transport Systems
JAF	Japan Automobile Federation
JAMA	Japan Automobile Manufacturers Association
JARI	Japan Automobile Research Institute
JITI	Japan International Transport Institute
JPY	Japanese yen
JR	Japan Railways
JRTT	Japan Railway Construction, Transport and Technology Agency
JTRI	Japan Transport Research Institute
LNG	Liquid national gas

LRT	Light Rail Transit
METI	Ministry of Economy, Trade and Industry
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
MoE	Ministry of the Environment
Mtoe	Mega tonne oil equivalent
NALETEC	National Agency for Automobile and Land Transport Technology
NEDO	New Energy and Industrial Technology Development Organization
PHEV	Plug-in hybrid electric vehicle
PNLTES	Post New Long-Term Emission Standards
PRILIT	Policy Research Institute for Land, Infrastructure, Transport and Tourism
R&D	Research and development
RNAV	Area navigation
toe	Tonne oil equivalent
TTG	Transport Task Group
USD	United States Dollar
VICS	Vehicle Information and Communication System
WHTC	World Harmonized Transient Cycle
WLTP	Worldwide Harmonized Light Vehicles Test Procedure

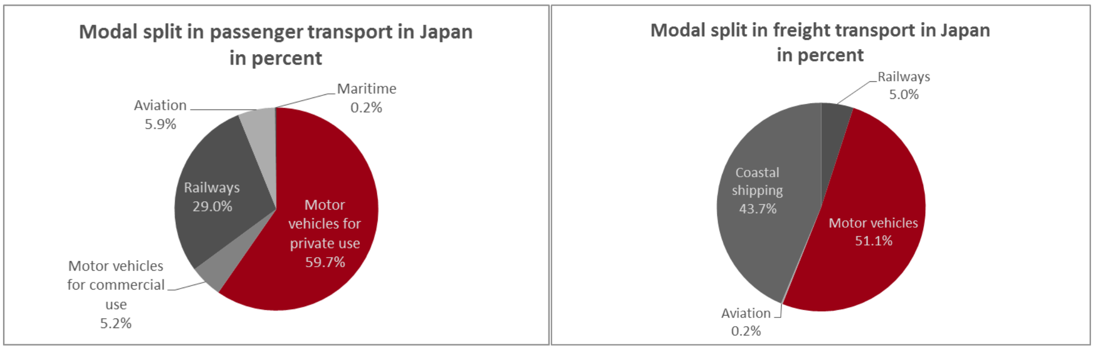
1 Background data on the transport sector in Japan

This chapter gives an overview of the structure of the Japanese transport sector including figures for modal split in passenger and freight transport, the development of CO_2 emissions and energy consumption in the transport sector as well as the main stakeholders of the sector.

1.1 Structure of the transport sector

Figure 1 shows the modal split in 2014 in passenger and freight transport in Japan. Motor vehicles for private use account for around 60% of passenger transport volume, railways for 29% and aviation for around 6%. In freight transport motor vehicles also have the greatest share with 51%, while coastal shipping accounts for 44% and railways for only 5% of the transport volume. In total, 1,428,500 million passenger km and 422,900 million ton km have been travelled in 2014 (Ohta et al. 2015). With a population of about 127 million inhabitants (The World Bank 2017), passenger transport volume is around 11,248 km per capita.

Figure 1: Modal split (transport volume) in passenger and freight transport in Japan in 2014



Source: Own depiction based on data from Ohta et al. (2015)

Japan has a well-developed road and rail network, which has to face special challenges due to the topographical features of the country with its high shares of mountains. The transport infrastructure is concentrated mainly in and between the urban areas of the Pacific Coast such as Tokyo, Nagoya and Osaka (Fraunhofer IAO 2018). According to the Global Competitiveness Report of the World Economic Forum, Japan occupies top positions regarding the transport infrastructure. Out of 137 countries, Japan ranks at place 2 for the quality of railway infrastructure, place 6 for the road quality, place 21 for the quality of port infrastructure and 26 for the quality of air transport infrastructure (Schwab 2017).

1.1.1 Road transport and automotive industry

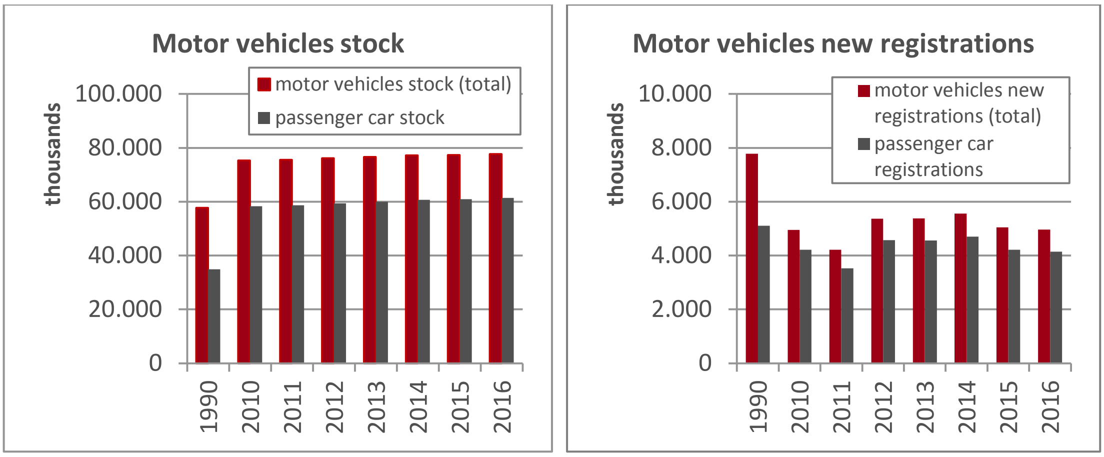
With a total length of roadways of approximately 1.22 million km, Japan ranks 6th worldwide regarding the total length of roadways. In comparison, the roadways in Germany add up to around 0.83 million km. However, Japan expressways have a total length of 8,428 km, while expressways in Germany in total are 12,993 km long (CIA 2018; BMVI 2017a). The topographic situation of Japan with a great share of mountains that necessitate narrower streets could be a reason for the smaller amount of expressways.

With about 9 million vehicles produced in 2016, Japan is the third largest automobile manufacturer worldwide after China and the United States (OECD and iea 2017). The automotive industry is one of the most important industries of Japan. 17.8% of all shipments income comes from this industry and 8.7% of the total work force works in businesses related to motor vehicles. There are 14 motor vehicle manufacturers; the largest ones are Toyota, Honda and Nissan (Ohta et al. 2015). For passenger vehicles these three manufacturers together have a market share of 75% in the Japanese market (Fraunhofer IAO 2018).

The number of registered motor vehicles has been over 75 million since 2005 and is still increasing each year, mainly due to growth of the passenger car stock. The stock of trucks has been decreasing since 1993. The development of the motor vehicle stock and newly registered motor vehicles for the last seven years is shown in Figure 2.

The passenger car market in Japan is dominated by gasoline cars, while diesel cars only have a small share (Yang and Bandivadekar 2017). Hybrid electric vehicles currently make up a share of around 31% in new car sales and electric and plug-in electric vehicles about 1.2% (Tanaka 2018).

Figure 2: Motor vehicles stock and new registrations



Source: Own depiction based on data from JAMA (2017)

1.1.2 Rail transport and public transport

The preferred mean of passenger transport in Japan beside motor vehicles is the train - for short as well as for long distances. All large cities are connected to the 2,630 km high-speed rail (Shinkansen) network (AHK Japan and VDI/VDE-IT 2014; MLIT 2015a).

The railway share in passenger transport volume in Japan is much higher in comparison with many western countries. It declined over several decades due to a shift from rail to motor vehicle transportation, before rebounding in the 2000s. Recently, it is getting close to its peak of the early 1990s again, probably because of the boost of the Shinkansen which connects distant cities in very short times (Lipscy and Schipper 2013). Rail transport in

Japan is very punctual in comparison with other countries, such as Germany. One reason is the consistent separation of the high-speed network from regional and freight rail transport.

The total length of the railway network is 27,311 km and thus shorter than the German network with 43,468 km (CIA 2018). The expansion of the network in Japan is very time consuming and expensive due to the topographical conditions, i.e. land restrictions.

In 1987, the Japanese Government started to divide and privatize the Japanese National Railway. Today, most trains are operated by the Japan Railways (JR) Group that consists of six passenger operating companies (JR Hokkaido, East, Central, West, Shikoku, Kyushu), a nationwide freight operating company (JR Freight) and one company for research and IT-services, respectively (Railway Technical Research Institute and Railway Information System/ JR System) (Ohta et al. 2015). JR East, Central and West have been in full private ownership since 2005 and JR Kyushu since 2016, while JR Hokkaido, JR Shikoku and JR Freight are still owned by the Japan Railway Construction, Transport and Technology Agency (JRTT), an independent administrative institution of the government (JRTT 2016).

Regarding short distance travel, public transport systems are of great importance in Japan's urban areas. For instance, the metropolitan area of Tokyo has the largest public transport network in the world. It is connected by 158 suburban railway and subway lines with over 4700 route kilometres and a total of 2200 stations. 40 million passengers are carried every day not including the long-distance trains (Neidhart 2017).

1.1.3 Shipping

The Japanese coastline is 29,751 km long and is intensively used for freight transport (CIA 2018). 44% of freight transport volume is processed by coastal shipping. Traditionally coastal shipping was the most important mean for freight transport with a share of nearly 50% until the fiscal year 1985 when it was overtaken by motor vehicles. Coastal shipping, thus, could play an important role for modal shift activities to reduce greenhouse gas (GHG) emissions (Ohta et al. 2015). The merchant marine, i.e. ships engaged in the carriage of goods, consisted of 5,289 ships in 2017. Thereby, Japan is on rank 3 worldwide. Germany for instance, only has 614 ships in the merchant marine (CIA 2018). Three major ocean shipping companies account for around 70% of the total Japanese income in ocean shipping: Nippon Yusen Kaisha, Kawasaki Lines and MO Lines (Ohta et al. 2015). In the period from 2005 to 2014, the Japanese merchant fleet carried constantly around 10% of the global marine cargo volume. Furthermore, the Japanese shipbuilding industry has with 20% and 27 billion USD of sales the third largest share on the world market. The number of shipbuilding orders to Japanese companies has been increasing since 2013. Reasons are amongst others the development of energy efficient technologies and the global standardization of these technologies (Mori 2016).

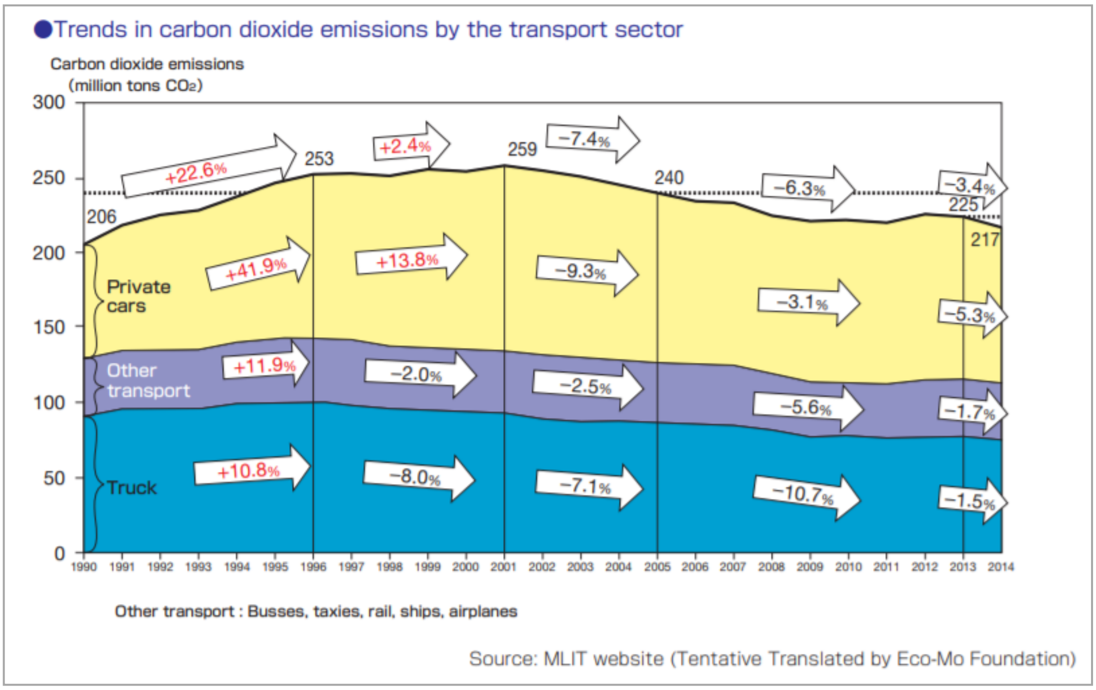
1.1.4 Aviation

Passenger activity by airplane increased rapidly from 19.1 billion passenger km in 1975 to 84.1 billion passenger km in 2014 (Lipscy and Schipper 2013; Ohta et al. 2015). This is around 6% of the passenger transport volume whereby travel activity to foreign countries is not included. There are 82 airports that together process about 2.2 million take-offs and landings each year. In 2014, the air transport sector contributed to Japanese GDP by a gross value added of around $55 billion (Oxford Economics 2016). The two major domestic airline companies are All Nippon Airways and Japan Airlines.

1.2 GHG emissions and energy consumption in the transport sector

In 2016, 18.8% of total CO_2 emissions in Japan originated from the transport sector, i.e. 215 million tons of CO_2 (preliminary figure). Compared to 2005, CO_2 emissions in the transport sector have declined by 11.9% while total CO_2 emissions went down only by 5.2% (MoE 2018). However, recent emission values are still higher than values in 1990 as can be seen in Figure 3. The figure shows the development of total CO_2 emissions in transport in Japan between 1990 and 2014. Important reasons for the emission reduction that started in the early 2000s are the increase in vehicle fuel efficiency and a higher efficiency in freight transport, i.e. truck transport. CO_2 emissions from trucks have been decreasing due to a reduction in total distances travelled, a shift from privately-owned trucks to freight services, the adoption of eco-driving by fleet operators and higher fuel efficiency (JAMA 2016a).

Figure 3: CO_2 emissions in transport in Japan



Source: Eco-Mo Foundation (2017)

Table 1 shows the CO_2 emissions by transportation mode. Motor vehicles for freight and passenger transport comprise together 86% of total CO_2 emissions in the transport sector. Therefore, further improvements in fuel efficiency and changes in the usages of freight and passenger vehicles are crucial to achieve significant CO_2 emission reductions.

Table 1: CO_2 emissions in transport by transportation mode in 2015 (in kt)

Private motor vehicles	**100.120**	**46.9%**
Cargo vehicles	**39.940**	**18.7%**
Cargo vehicles (privately owned)	**36.330**	**17.0%**
Busses	**4310**	**2%**
Taxis	**3070**	**1.4%**
Aviation	**9.900**	**4.6%**
Coastal shipping	**10.510**	**4.9%**
Railways	**9.160**	**4.3%**

Source: Own depiction based on data from MLIT (2017c)

The total final energy consumption in Japan in 2015 was 291.3 Mtoe. Final energy consumption in transport accounted for 71.3 Mtoe (24.5%) whereby 98% came from oil products and the rest from electricity and natural gas (iea 2017b). Between 2004 and 2014, final energy consumption in transport declined by 12.1% (iea 2016a).

1.3 Main stakeholders in the transport sector in general and with respect to sustainable concepts and technologies

In Japan, three ministries share the responsibility for the transport sector: The **Ministry of Land, Infrastructure, Transport and Tourism (MLIT)**, which has the main responsibility for developing transport related policies, the **Ministry of Economy, Trade and Industry (METI)**, and the **Ministry of the Environment (MoE)**. The distribution of regulatory authority with respect to energy efficiency and emission reduction policies focused on road transport is summarized in Table 2.

Table 2: Distribution of regulatory authority

Agencies/Organizations	Tailpipe emissions[a]	Fuel sulfur	Fuel economy	Green freight	Alt. fuel[b]	Regulatory compliance	Legal enforcement
Ministry of Economy, Trade and Industry		√	√	√	√	√	
Ministry of Land, Infrastructure, Transport and Tourism	√		√	√	√	√	√
Ministry of the Environment	√					√	

a. The Ministry of the Environment is responsible for the development of the specific permissible limits included in the emission standards, and the Ministry of Land, Infrastructure, Transport and Tourism is responsible for the development and implementation of the standards.

b. The Ministry of Economy, Trade and Industry took on jurisdiction over biofuels and other fuels through the Act on the Quality Control of Gasoline.

Source: Du and Miller (2017)

Other governmental institutions related to the transport sector are the **Japan Transport Safety Board**, an agency under the auspices of the MLIT, and the **Agency for Natural Resources and Energy (ANRE)** under the METI. The **National Agency for Automobile and Land Transport Technology (NALTEC)** is a technical agency that carries out compliance procedures for emissions standards and works on emission tests for vehicle type approval (Yang et al. 2017). Furthermore, the **Japan Railway Construction, Transport and Technology Agency (JRTT)** is an independent administrative institution of the state that undertakes construction and technical support projects for railway and other transportation. The **New Energy and Industrial Technology Development Organization (NEDO)** as one of the largest public research and development management organizations in Japan is an incorporated administrative agency since 2003. NEDO concentrates on addressing energy and environmental problems and enhancing industrial technology development and is also a relevant stakeholder with respect to (sustainable) transportation, i.e. electric vehicles, batteries and fuel cell technology (NEDO 2017).

Several research institutes focus on transport issues. The **Japan Transport Research Institute (JTRI)** is an independent, non-profit foundation which was established under the auspices of the MLIT. It undertakes research and survey programs on transport related topics, evaluates transport policy and gives recommendations to the Japanese government. It comprises the Institute for Transport Policy Studies (ITPS), the Japan International Transport Institute (JITI) and the Research and Consulting Office (JTRI 2012).

The **Policy Research Institute for Land, Infrastructure, Transport and Tourism (PRILIT)** was established in 2001 under the MLIT and is committed to promote the policies of MLIT from mid- to long-term perspective, carrying out research on the usage, development and maintenance of the resources in the areas land, infrastructure, transport and tourism. Thereby it takes into account socio-economic changes (PRILIT 2016).

Other relevant research institutes are the **Japan Automobile Research Institute (JARI)** which has the research areas environment & energy, safety and IT & electronics (JARI 2018) and the **Japan Research Center for Transport Policy** which performs surveys and research on transportation policies and holds forums, workshop, lectures and other events (The Japan Research Center for Transport Policy 2016).

Regarding relevant stakeholders in industry, the **Japan Automobile Manufacturers Association (JAMA)** established in 1967 is a non-profit industry association which includes Japan's fourteen manufacturers of passenger cars, motorcycles, buses and trucks (Toyota, Nissan, Honda, Mitsubishi, Suzuki, Mazda, Subaru, Isuzu, Kawasaki Heavy Industries, Yamaha Motor Company etc.). The JAMA supports the development of Japan’s automotive industry amongst others with respect to the development of sustainable mobility (JAMA 2016b). For sustainable transport JAMA suggests an integrated approach that involves the development and diffusion of next-generation vehicles including fuel-cell, electric, plug-in hybrid and clean diesel vehicles, the further performance improvement of conventional international combustion engines as well as the support of fuel-conserving eco-driving and measures to improve traffic flow (JAMA 2016a).

The **Japan Automobile Industries Association (JAIA)** is a public corporation which aims at the development of the automobile importing trade by compiling statistics, providing information on import of foreign vehicles, improving trade conditions and cooperating with government agencies (JAIA 2018).

2 The role of the transport sector in political strategies for climate protection and energy supply

As shown in Table 3, Japan pledges in its **Intended Nationally Determined Contribution** (INDC) to reduce total CO_2 emissions by 25% in fiscal year 2030 compared to the fiscal year 2013 (the pledge for total GHG emissions is 26% respectively). The target for CO_2 emissions in the transport sector is a reduction of around 28%. For reaching this target, the government plans to reach further improvements in fuel efficiency and promote next-generation vehicles. Other measures comprise traffic flow improvement, promotion of public transport, modal shift, energy efficiency improvement of railways, aviation and ships, and the promotion of eco-driving, automatic driving, car-sharing and Intelligent Transport Systems (ITS) (UNFCCC 2015).

Table 3: Estimated emissions of energy-originated CO_2 in million t CO_2

	Estimated emissions of each sector in FY 2030	Actual emissions in FY 2013	Actual emissions in FY 2005
Energy originated CO_2	927	1,235	1,219
Industry	401	429	457
Commercial and other	168	279	239
Residential	122	201	180
Transport	163	225	240
Energy conversion	73	101	104

Source: Own depiction based on UNFCCC (2015)

The Plan for Global Warming Countermeasures was decided in May 2016. It describes the emissions reduction targets of the Japanese government, provides basic information on measures to be taken by the public and private sector as well as the policies to be implemented by the national and local governments (MoE 2016b). Regarding the transportation sector the plan emphasizes, amongst others, the ongoing promotion of the diffusion of next-generation vehicles, financial support for research on increasing the durability of batteries for electric vehicles and financial support for increasing the infrastructure of hydrogen stations. Furthermore, measures to improve traffic flow, the promotion of public transport and of low carbon logistics as well as measures for modal shift and the improvement of the infrastructure for bicycles are part of the plan (MoE 2016c).

The Global Environment Committee of the Central Environment Council furthermore published the **Long-term Low Carbon Vision 2050** in March 2017 which is used by the MoE as a basic principle for the reduction of GHG emissions in the long term. This vision formulates ways for reducing GHG emissions by 80% in 2050 and includes amongst others a future vision of the Japanese society for the transport sector. According to this vision, in 2050 fuel efficiency is greatly increased and most passenger cars have an electric motor with low-carbon electric power and hydrogen generated by renewables. Autonomous driving is in practice and reduces emissions by eco-friendly driving and automatic selections of routes without congestion. Also ride- and car-sharing are largely used. Energy efficiency in railroads, aircraft and ships is increased and in freight transport travel distances are shortened and loading rates are improved. Urban structures are compacter increasing the convenience of public transport (Global Environment Committee 2017).

The first **Basic Plan on Transport Policy** was approved by the Cabinet in February 2015 and comprises the period until FY2020. The Basic Plan follows the Basic Act on Transport Policy (enacted in 2013) which defines the basic policy direction of the national government in the transport sector comprising international, national and regional transport and specifies the responsibilities of the parties involved (Eco-Mo Foundation 2017). The Basic Plan describes targets and measures for the three basic directions of transport policies: 1. Realize user-friendly transport, 2. Build up interregional and international passenger transport and logistic networks that build a foundation for growth and prosperity, 3. Create a foundation of sustainable, secure and safe transport. Targets that concern sustainability aspects are the vitalization of public transport services, the encouragement of sustainable transport services and usage of bicycles and the reduction of CO2 emissions from transport and energy conservation for instance by a further increase of next-generation vehicles and green logistics (MLIT 2016).

Within the **Next-Generation Vehicle Strategy** (2010) the Japanese government sets targets concerning the share of next-generation vehicles in total car sales by 2030. “Next-generation vehicles” comprise hybrid electric vehicles (HEV), battery electric vehicles (BEV), plug-in hybrid electric vehicles (PHEV), fuel cell vehicles (FCV) and clean diesel vehicles. As shown in Table 4, the government aims to increase the share of these vehicles to 50-70% by implementing measures for creating initial demand, developing the infrastructure and supporting research and development (R&D) to improve performance (Maruyama 2014). Reaching the targeted share of 20-30% for BEV and PHEV is expected to be especially challenging; their share in 2017 was still below 2% (Oba 2016; Tanaka 2018). Nevertheless, their number has been steadily increasing since 2009 reaching an amount of 151 thousand vehicles in 2016 (iea 2017a).

Table 4: Share of next-generation vehicles in total car sales

	2017 (Status)	2020 (Target)	2030 (Target)
Conventional Vehicles (gasoline-powered)	63.97%	50-80%	30-50%
Next Generation Vehicles	36.02%	20-50%	50-70%
Hybrid vehicles	31.2%	20-30%	30-40%
Electric vehicles **Plug-in hybrid vehicles**	0.41% 0.82%	15-20%	20-30%
Fuel-cell vehicles	0.02%	～1%	～3%
Clean diesel vehicles	3.52%	～ 5%	5-10%

Source: Own depiction based on data from Tanaka (2018); Maruyama (2014)

The **Strategic Roadmap for Hydrogen and Fuel Cells** was formulated in 2014 by the "Council for a Strategy for Hydrogen and Fuel Cells" and describes a comprehensive strategy towards a "hydrogen-based society". The strategy comprises R&D support for stationary fuel cells and FCVs and the development and installation of the necessary infrastructure such as hydrogen stations. Targets for FCVs are set as follows: 40,000 by 2020, 200,000 by 2025 and 800,000 by 2030. About 160 hydrogen stations are planned to be constructed by 2020, about 320 by 2025 and 900 by 2030 (METI 2016; ICCT 2017). In particular until mid-2020, the government will be proactively involved in the implementation of the Strategic Roadmap and will provide comprehensive financial support. Afterwards, development is planned to continue by proactive efforts of the private sector (Shinka 2014).

The **Basic Hydrogen Strategy** was formulated in 2017 after the second meeting of the Ministerial Council on Renewable Energy, Hydrogen and Related Issues took place in December 2017. The first meeting was held in April 2016 after Prime Minister Abe requested relevant ministers to formulate a basic strategy for hydrogen-related policies by the end of 2017 to encourage the government to unite its efforts for the accomplishment of a world-leading hydrogen-based society. The strategy is an addition to the 4th Strategy Energy Plan (2014) and the Strategic Roadmap for Hydrogen and Fuel Cells. The focus lies on the individual introduction and dissemination of relevant hydrogen technologies as introduced in the roadmap, the role of hydrogen as a new carbon free energy option and further on the development of policies agreed on by the whole government apparatus (all related ministries ranging from hydrogen production to utilization are involved). Further, the government decided on specific measures and milestones that shall be achieved until 2030.[1]

In addition, the Tokyo Metropolitan Government formulated a regional roadmap for hydrogen and fuel cells which sets the following targets for the Tokyo Olympics in 2020: 35 hydrogen stations, 6,000 fuel cell passenger vehicles, 100 fuel cell buses and 150,000 residential fuel cell systems (ICCT 2017).

The General Outline Plan on Logistics is published every 5 years. The newest one describes measures in logistics for the period FY 2017- FY2020. To address environmental concerns and achieve CO_2 emission reductions the plan comprises the following measures (MLIT 2017b):

- Improvements of energy efficiency in the supply chains
- the support of partnerships between consignor and transportation companies to induce modal shift (pointing out the importance of shipping)
- CO_2 reduction in ports, airports and warehouses for instance, by energy efficient cooling
- the avoidance of traffic jams by traffic demand management using Information and Communication Technology (ICT) and Artificial Intelligence (AI) and by using different fees on expressways and
- the promotion of liquid national gas (LNG)- ships.

[1] A summary of the keypoints of the basic hydrogen strategy can be found here : http://www.meti.go.jp/english/press/2017/pdf/1226_003a.pdf

3 Policies and measures

This chapter summarizes the most important policy measures of the Japanese government for the reduction of emissions and energy use in the passenger and freight transport sector.

3.1 Emission standards, fuel efficiency standards and the Top Runner Program

With respect to **tailpipe emission standards** Japan is one of the leading countries among the G20 economies together with Canada, the EU and the US (Du and Miller 2017). Limit values for tailpipe emissions for new vehicles are determined by the MoE under the Air Pollution Control Law. First emission limits for light-duty vehicles were introduced in the 1970's and tailpipe emission standards have been strengthened three times since 2000 with the last amendment in 2009-2010 leading to the "Post New Long-Term Emission Standards" (PNLTES) for light duty (passenger vehicles and light trucks < 3.5 t) and heavy duty vehicles (trucks and buses > 3.5 t). The PNLTES comply in stringency with Euro VI standards and apply for all new vehicles since 2010[2]. For certification testing, Japan-specific drive cycles have been used in the past. However, since 2016, the World Harmonized Transient Cycle (WHTC) is applied for heavy duty vehicles and emissions of light duty vehicles will be tested with the Worldwide Harmonized Light Vehicles Test Procedure (WLTP) from 2018 (TransportPolicy 2018c).

To improve the fuel efficiency of vehicle fleets and thereby contribute to emission reductions the introduction of minimum energy performance standards is an important measure. Japan introduced **fuel efficiency standards** for passenger vehicles in the 1980s as the second country worldwide after the United States (GFEI 2014), Furthermore, Japan defined efficiency standards for heavy-duty vehicles in 2006 as the first country worldwide (iea 2016b).

The fuel efficiency standards are under the scope of the **Top Runner Program** which was introduced in 1999 in the frame of the Energy Conservation Act to improve the energy efficiency of products, inter alia of passenger and freight vehicles. Based on the product with the highest energy efficiency currently on the market in the respective product group, the program sets target standard values for energy efficiency (in case of motor vehicles "fuel efficiency") for multiple years in the future that must be adhered to on a weighted average by product manufacturers. Thereby, target values for vehicles exist for different categories which are based on fuel type and weight classes (iea 2016b; METI 2015c). In case the standards are not met in the target year, penalties for manufacturers such as public announcements and fines exist, however, the penalty procedure is relatively loose (Maeda 2007).

[2] The NOX emission limit for diesel heavy duty vehicles was tightened in 2016.

The Top Runner Program furthermore supports consumers to select vehicles with high fuel efficiency by attaching stickers to the vehicles with respective information (MLIT 2015c).

(Lipscy and Schipper 2013) summarizes the following advantages of the Top Runner Program:

- Standards are feasible as they are based on existing products.
- Standards are likely to be strict enough because they are continuously updated based on the most efficient products.
- Long negotiations with the industry are not necessary and the opportunity for industry lobbying is reduced. The implementation of the program happens generally automatically without large political interference.

On the other hand, the program does not encourage efficiency improvements by weight reduction because different target values exist depending on the weight class. Furthermore, the detailed division in a large number of weight classes could also be motivated by the idea to build a barrier against competitors from other countries (Lipscy and Schipper 2013).

The procedure of determining new fuel efficiency standards (Top Runner Standards), based on the vehicles with the highest performances on the market, includes several closed meetings of METI, MLIT and the car industry. The achieved agreement is then discussed in the "Council" that comprises a subcommittee of the Transport Policies Council and a working group on classification standards for automobiles under the Advisory Committee for Natural Resources and Energy. The Council agreement is published and opened for public consultation before it becomes the new fuel efficiency standard (Iguchi and Hillman 2012; METI 2017b).

Table 5 summarizes the Japanese fuel efficiency standards since 2015 for light-duty and heavy-duty vehicles. Values show the estimated average fuel efficiency that is reached when the targets in the different weight classes are met.

Table 5: Japanese fuel efficiency standards

			Fuel efficiency standard	Corresponding GHG emission standard in gCO_2/km
Light-duty vehicles	2015	passenger cars	16.8 km/l	142 g/km (Yang and Bandivadekar 2017)
		light trucks ≤ 3.5 t	15.2 km/l	
		Small busses	8.9 km/l	
	2020	passenger cars	20.3 km/l	122 g/km (Yang and Bandivadekar 2017)
	2022	light trucks ≤ 3.5 t	17.9 km/l	133 g/km (Yang and Bandivadekar 2017)

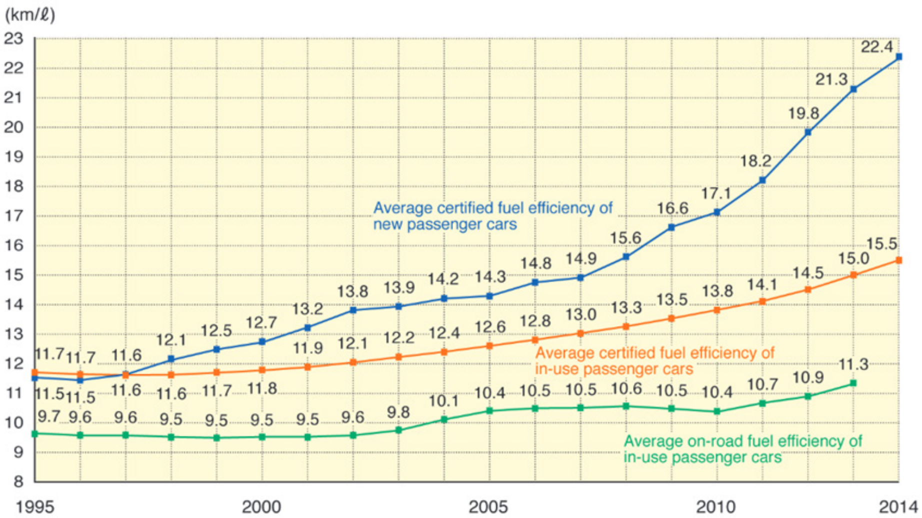
			Fuel efficiency standard	Corresponding GHG emission standard in gCO_2/km
Heavy-duty vehicles (>3.5 tons)	2015	Trucks	7.09 km/l	370 g/km (TransportPolicy 2018a)
		Buses	6.30 km/l	416 g/km (TransportPolicy 2018a)
	2025 (as proposed in Dec 2017; new standard is expected in April 2018 after public consultation)	Trucks	7.63 km/l	
		Buses	6.52 km/l	

Source: Own compilation based on TransportPolicy (2018b, 2018a); Yang and Bandivadekar (2017); METI (2017c)

Figure 4 shows the development of the average fuel efficiency of passenger cars from 1995 to 2014. Fuel efficiency for passenger car improved by 48.8% between the fiscal years 1995 and 2010. This increase was higher than the initially expected 22.8% (METI 2015c) and can be mainly attributed to the rapidly growing HEV market. The fuel efficiency target for 2015 for passenger vehicles was already achieved in 2011 and the 2020 target in 2013 (Yang and Bandivadekar 2017). Post 2020 fuel efficiency standards for passenger vehicles are under discussion since March 2018 (METI 2018).

For freight vehicles, fuel efficiency improved by 13.2% between FY 1995 and 2010 (METI 2015c).

Figure 4: Development of average fuel efficiency of passenger cars



Source: JAMA (2016a)

3.2 Promoting the dissemination of next-generation vehicles

The government promotes the purchase of next-generation vehicles by offering tax breaks since 2009. Tax breaks are available for the motor vehicle taxes tonnage, acquisition and ownership and the level of tax reduction depends on the type and the fuel efficiency of the vehicle (iea 2016b; Kuramochi 2014) “The more eco-friendly the vehicle, the higher is the tax” break. The tax breaks were originally thought to end by March 2012 but were extended several times. One reason for the extension was the support of domestic sales of the Japanese automotive industry to make up for the losses in the global market that occurred due to the appreciation of the yen (Alhulail and Takeuchi 2014; iea 2016b).

Fuel efficiency requirements for the tax exemption have been tightened over time (Nikkei Asian Review 2016).The current tax break scheme is valid until March 2019. While BEV, PHEV and HEV, for instance, are fully exempted from the acquisition tax, there are also tax reductions (to a smaller degree) for gasoline vehicles with high fuel efficiency values. As example the tax exemptions for passenger cars for the FY 2018 are shown in Table 6.

The Japanese government additionally supports the purchase of next-generation vehicles by providing purchase subsidies. Starting with the phase from 4/2009 to 9/2019 there have been several periods of purchase subsidy provision with different underlying conditions and subsidy amounts depending on the environmental performance of the vehicle. For instance, in 2011 the maximum subsidy amount for BEV and PHEV was 1 million JPY[3] per vehicle. In 2012, the grant covered up to 50% of the price difference between a BEV or PHEV and a corresponding conventional vehicle (Frieske et al. 2015).

Statistical evaluations of the tax break and subsidy programs for the period 2006 to 2013 show an increase in sales figures for next-generation vehicles by around 16% because of the tax break policy, and an increase by 21.5% for the first subsidy wave and by 10.7% for the second subsidy wave (Alhulail and Takeuchi 2014). The Japan Center for Economic Research found for FY2009 that the tax breaks and subsidy programs only contributed to CO_2 reductions of 0.1% of total national CO_2 emissions with specific mitigation costs of 56,000 JPY[4] per t CO_2 (Kuramochi 2014).

The most recent purchase subsidy scheme was introduced in 2016 in order to especially foster the dissemination of BEV. It provides gradually higher subsidies with an increase in the electric range of the vehicle. Thereby, the maximum subsidy amount is set at 850,000 JPY[5]. The BEV Nissan Leaf with a 30-kWh battery, for instance, gets a subsidy amount of 330,000 JPY[6]. After introducing the subsidy scheme the sales of BEVs increased by nearly 50% while the sales of PHEVs, which typically have smaller electric ranges, decreased by 34%. However, there might have been other factors that influenced this market development such as the introduction of the new Nissan Leaf and the falsification of fuel economy standards by Mitsubishi in 2016 (iea 2017a).

[3] Around 8333 EUR, assuming an exchange rate of 1 EUR = 120 JPY

[4] Around 467 EUR, assuming an exchange rate of 1 EUR = 120 JPY

[5] Around 7083 EUR, assuming an exchange rate of 1 EUR = 120 JPY

[6] Around 2750 EUR, assuming an exchance rate of 1 EUR = 120 JPY

Table 6: Tax breaks for eco-friendly passenger cars for the FY 2018

applicable period: motor vehicle acquisition tax (acquisition tax): 01.04.2018 – 31.03.2019; motor vehicle weight tax (weight tax): 01.05.2018 – 30.04.2019
applicable content: Limited to new vehicle registration within the applicable period

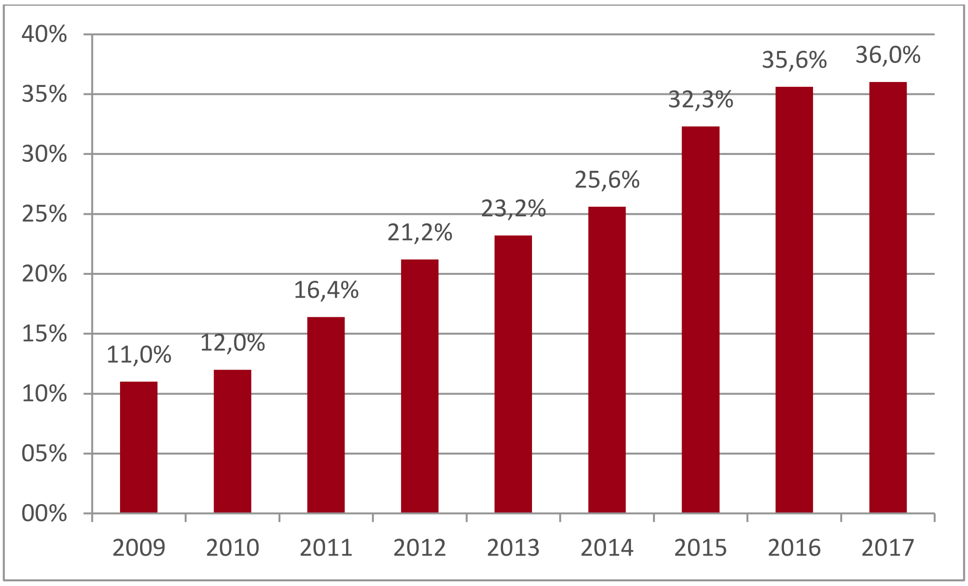
subject & requirements		**tax items**		**special measures**								
- electric vehicle - fuel-cell vehicle - natural gas vehicle - Plug-in-Hybrid - Green diesel car		acquisition tax		tax free								
		weight tax	initial inspection	tax free								
			1st follow-up examination	tax free								
	Fuel efficiency / Emission performance			fuel economy standard (FY 2015)			fuel economy standard (FY 2020)					
				compliant	+5 %	+10%	compliant	+10%	+20%	+30%	+40%	50%
- Gasoline powered car - LPG vehicle (Hybrid included)	75% reduction from 2005 Emission Standard or 50 % reduction from 2018 Emission Standard are eligible	acquisition tax					-20%	-40%	-60%	-80%	tax free	
		weight tax	initial inspection				-25%	-50%	-75%		tax free	
			1st follow-up examination									Tax free

Source: Translated from MLIT (2017a)

To promote the dissemination of electric vehicles the METI furthermore developed the "EV / PHEV Towns" demonstration project. Starting in 2009, in total 18 prefectures were selected as EV / PHEV demonstration areas which were supported in the four priority areas: 1. creation of demand; 2. development of infrastructure; 3. education and public awareness; 4. Evaluation and improvements. Various initiatives were implemented and supported by special subsidies, such as the usage of electric vehicles as rental cars, taxis buses or company cars. In addition, local governments are actively raising public awareness through exhibitions, test drive events and the dissemination of information through websites (Frieske et al. 2015).[7]

The development of next-generation vehicles in total car sales between 2009 (when the first tax break and subsidy schemes were introduced) and 2017 is illustrated in **Fehler! Ungültiger Eigenverweis auf Textmarke.**. The share of these vehicles has increased steadily and has reached 36% in 2017. Thereby, the majority of sold next-generation cars are HEVs (METI 2018).

Figure 5: Development of next-generation vehicles in total car sales between 2009 and 2017 (in % of total new car sales)



Source: Own depiction based on METI (2018)

[7] Detailed descriptions of the activities in the 18 demonstration prefectures can be found here http://www.cev-pc.or.jp/event/pdf/evphvtown_report2013_en.pdf

Infobox: Development of BEV and FCV and charging infrastructure

In Japan, the main initiation and development of HEVs, BEVs and FCVs has been made by the automakers. The Japanese government did never promote HEVs directly apart from offering purchase subsidies starting in 1999 after the market introduction of the first models. BEVs and FCVs have been supported more intensely however, for instance, by the promotion of the electric charging and hydrogen infrastructure. Furthermore, in 2004, the automakers asked the government for basic research work support for FCVs. Indirect factors also supported the technology development such as the high competition on the domestic market as well as the long national support for battery research and development (not only for vehicles but also other technologies) (Pohl 2012). In the following, the development and status quo of BEV and FCV is explained in more detail also pointing out the respective support policies of the government.

For BEV and PHEV, in addition to purchase subsidies and tax incentives (see Chapter 3.2) the Japanese government also supports the development and expansion of the **charging infrastructure**. 50-66% of the investment costs for a fast-charging stations and its installation are subsidized. In Japan, a manufacturer-independent standard plug for fast charging stations, the CHAde-MO plug, was introduced relatively early which led to a rapid spread of these charging stations. Additionally, *Nippon Charge Service LLC,* a company jointly established in 2014 by the car manufacturers Toyota, Nissan, Honda and Mitsubishi, is driving forward the development and expansion of the charging network (Fraunhofer IAO 2018).

By 2016, the **electric car stock** (BEV and PHEV) in Japan was around 151,000 vehicles and 17,260 slow charging units and 5,990 fast charging units had been installed across the country (iea 2017a).

As written in Chapter 2, the Japanese government aims to increase the share of **FCVs** in total vehicle sales to 1% in 2020 and 3% in 2030. The target is to have 40,000 FVC on the streets until 2020 and 800,000 until 2030. About 160 hydrogen stations are planned to be constructed by 2020, about 320 by 2025 and 900 by 2030. The transition to hydrogen for the vehicle fleet is part of a comprehensive strategy for a “hydrogen-based society” which aims to transform all energy sectors to hydrogen.

The Japanese government provides around 350 million USD per year for the development and implementation of hydrogen and fuel-cells and therewith more subsidies than every other state. (For comparison: the United States invest around 125 million USD, Germany around 85 million USD and France around 40 million USD) (Heid et al. 2017). Regarding hydrogen mobility, the financial support specifically is used for (ICCT 2017):

- The construction of hydrogen stations. They are subsidized up to two thirds of “initial capital expense”.
- Reducing the price of hydrogen. The hydrogen fuel is subsidized such that the price is reduced to 10 USD per kilogram because station fuel revenues are not expected to offset the costs for the next years.
- The purchase of FCV. Purchase tax breaks and subsidies are offered for next-generation vehicles (also see Chapter 3.2).

Additionally, the city of Tokyo has set up a fund of 40 billion JPY (around 333 million EUR) for the period 2016-2020 to promote FCV, fuel cell busses and the implementation of the hydrogen infrastructure (Tokyo Metropolitan Government 2017)

Infobox: Development of BEV and FCV and infrastructure (continued)

As of April 2018, **100 hydrogen stations** had been constructed in Japan (Ohira 2018) and by April 2017 about **1,700 FCVs** had been sold (LeSage 2017). The installation of hydrogen stations has been focused on the four metropolitan areas Tokyo Aichi, Osaka and Fukuoka and over a third of the stations are mobile, i.e. tube trailers (ICCT 2017). Especially regarding the number of FCV the gap between the actual figure (1,700 vehicles) and the targeted values (40,000 FCV by 2020) is still large.

Toyota first started FCV development in 1992 with Honda following in 1994 and Nissan in 2000. Demonstration vehicles were developed by all three automakers and in 2009 the first deliveries of the FCX Clarity of Honda took place (Pohl 2012).

In 2015, Toyota introduced the production model Mirai into the market that has a range of about 400 km under real conditions. Until mid of 2017, only 3,600 Toyota Mirai had been sold on the global market showing that FCV are still a niche market. In addition to passenger cars, Toyota is currently also researching and testing the suitability of fuel cell drives for trucks and buses. Honda manufactured the FCX Clarity, a FCV in small series, since 2008 to test the technology in everyday life. Finally, in 2016, the Honda Clarity Fuel Cell followed as a mass-production model, which can be leased in Japan and the USA (Fraunhofer IAO 2018).

Takeshi Uchiyamada, Chairman of Toyota Motor Corporation is also Co-Chair of the Hydrogen Council which was set up during the World Economic Forum in 2017 and is committed to driving forward the global energy transition through hydrogen and hydrogen-based vehicles (Fraunhofer IAO 2018). The council is made up of 18 leading energy, transport and industry companies, amongst others, Honda, BMW, Audi, Kawasaki and Daimler (Hydrogen Council 2018).

Japan H_2 Mobility was established in February 2018, as a collaboration of automotive companies, hydrogen stations owners and operators as well as financial investors. The company aims at accelerating the development of the hydrogen station network in Japan. Therefore, next to the strategic deployment of hydrogen stations, it also addresses topics as standardization of equipment to reduce the costs for hydrogen construction (JHyM 2018).

3.3 Promotion of traffic demand management and ITS

Several traffic flow measures are being implemented to improve the traffic flow and therewith reduce CO_2 emissions. Measures promoted by the government include the development of ring roads and other arterial road networks to reduce through traffic in city centres, the improvement of the infrastructure for cyclists (cycle paths) and the implementation of ITS.

ITS integrate people, roads, and vehicles using the latest ICT, thereby enabling an intelligent use of roads, the reduction of congestion and thus emissions as well as an increase of the safety of drivers and pedestrians by the avoidance of accidence (MLIT 2015c). Targets of the government are to reduce traffic congestion on major roads by 50% in 2020 compared to 2010 and to reduce fatalities to less than 2,500 compared to 4,863 in 2010. The promotion activities for ITS involve four ministries and agencies: the MLIT, the METI, the National Police Agency (NPA) and the Ministry of Internal Affairs and Communications (MIC) (MLIT 2012c).

To this end, 1,600 ITS spots in the streets were established with appropriate transmission interfaces, which can establish communication links with more than 100,000 vehicles equipped with appropriate interfaces. By today, ITS offer the following services (Fraunhofer IAO 2018):

- Dynamic route guidance: Large-area traffic congestion data is collected enabling intelligent route guidance via navigation systems.
- Safety support: The driver can be warned of "near-misses" in advance.
- Electronic toll collection: Thereby the traffic congestion in front of toll stations at the expressways is reduced.

Vehicle Information and Communication System (VICS) provide road traffic information such as travel time, congestion conditions, and traffic restrictions on a real-time basis to the on-board car navigation screens. If drivers use this information, the mileage can be improved and CO_2 emissions reduced (MLIT 2015c). VICS caused an annual reduction of CO_2 emissions of 2.4 million tonnes in 2009. In June 2012, around 35 million vehicles were equipped with VICS (MLIT 2012a).

Electronic Toll Collection (ETC) Systems are meanwhile available on all national expressways and most toll roads in Japan. With a usage rate of around 90% on national expressways and roughly 51 million vehicles equipped with ETC systems, nearly all toll-gate congestion on expressways have been eliminated (MLIT 2015c). This resulted in an annual CO_2 reduction of 0.21 million tonnes (MLIT 2012c). Since 2015, ETC 2.0 on-board units are available, which collect additional data such as vehicle speed, travel route and travel time data. Using this data, they enable other services apart from the toll payment such as flexible toll rates to reduce congestion and accidents (MLIT 2015c).

ETC enhancement policies include the subsidization of toll operators and financial incentives for private on-board unit owners such as special discounts on the toll fare up to 50% and a flat toll on holidays (Mitsubishi 2014).

3.4 Promotion of eco-driving

To reduce fuel efficiency of motor vehicles by positively impacting driver’s behaviours the government supports the dissemination of eco-driving. The “Eco-Drive Promotion Liaison Committee” was formed in 2003 and includes 4 ministries and agencies: the National Police Agency, METI, MLIT and MoE (ECCJ 2017). The Committee formulated the “10 Recommendations for Eco-driving” in 2003 and partly revised the list in 2006 and 2012. The recommendations are as follows (METI 2015b):

1. Press the accelerator gently when accelerating
2. Reduce acceleration and deceleration while keeping enough distance between cars
3. Release the accelerator earlier when decelerating
4. Use air conditioners appropriately
5. Avoid unnecessary idling
6. Avoid traffic jams; leave home with time to spare
7. Check the pressure of the tires as the first step toward better maintenance
8. Take out unnecessary loads
9. Do not block traffic when parking
10. Be aware of your fuel consumption

The Committee declared the “National Action Plan to Promote Eco-Driving” in 2006 and the period 2006-2008 was set as a focus period for promoting and disseminating eco-driving. The action plan comprises the following measures: review of the eco-driving definition and establishment of performance indicators, dissemination and educational activities for eco-driving, dissemination and promotion of supportive equipment for eco-driving, establishment of an evaluation system of eco-driving, enabling activities that involve local governments and other organizations and conducting surveys (MoE 2006; ECCJ 2017).

The implementation of the action plan involved several stakeholders: the Energy Conservation Center Japan (ECCJ) for developing training tools for drivers, conducting workshops and supporting local governments, the Japan Automobile Federation (JAF) for offering workshops for drivers, as well as automotive and instrument manufacturers for the development of idling stop systems, eco driving support systems etc. (Funazaki 2012).

The eco-driving program aims to raise the awareness of drivers for energy-efficient behaviour. Next to a reduction in fuel efficiency and therewith a decrease in CO_2 emissions, which is estimated to be about 5-10% (Funazaki 2012), eco driving also has a positive impact on the reduction of traffic accidents. The implementation of Truck Eco-Driving Management Systems (EDMS), with the on-board equipment being subsidized by the government, led to a decrease in fuel consumption by 26.3% (Oba 2016). The promotion activities for eco-driving by the government and the support of the usage of EDMS for trucks, busses and taxis are ongoing (MoE 2016c).

3.5 Expansion of the high-speed rail network (Shinkansen)

Development and expansion of the railway network for high-speed trains (Shinkansen) is regulated in the Nationwide Shinkansen Railway Development Act (from 1970, last amended in 2002) (MLIT 2006). The JRTT has the responsibility to oversee the construction of all Shinkansen lines; it owns the infrastructure and leases it to the operators. 2/3 of direct construction costs for new lines are paid by the national government, 1/3 by the local governments. The operator pays (leasing) route usage fees based on the operating income of the new Shinkansen but does not have to bear any direct construction costs. Approval for the construction of a new line is given by the government if certain criteria are met, such as profitability and consent from local municipalities and concerned JR operators (Takatsu 2007).

The development of Shinkansen increased the convenience of railways due to high frequency of high-speed trains and the substantial travel time reductions. For instance, the travel time for the route from Tokyo to Nagano was reduced from 2h 56 min to 1 h 23 min and the travel time from Nagano to Kanazawa was reduced from 3 hours and 51 minutes to 2 hours and 28 minutes (IHRA 2016). Thus, the Shinkansen development contributed to a higher usage of railways in passenger transport and led to modal shift from road and air transport to railways (Lipscy and Schipper 2013; MLIT 2015a). For instance, before the Shinkansen route from Osaka to Kumamoto was opened, only 30% of passengers for this route used the train, compared to a share of 70% after the route was opened (IHRA 2016).

The main reasons for promoting the expansion of the Shinkansen are however the support of interests of the rail and construction industries and the overall goal to develop the transportation network. CO_2 emission reductions are mostly seen as an important externality of the policy (Lipscy and Schipper 2013).

3.6 Promotion of light-weight vehicles (Kei-cars)

Already since 1949, there is a Japanese standard for small light-weight vehicles, so called Kei-cars. A vehicle class comparable to Japanese Kei-cars is not available in Germany. Since 1988, the maximum values valid for Kei-cars are 3,390 mm length and 1,475 mm width as well as 47 kW output and 660 cm^3 displacement (Fraunhofer IAO 2018).

Measures to promote the dissemination of Kei-cars also contribute to higher total fuel efficiency of vehicles because Kei-cars are lighter and smaller than normal passenger cars and thus have a tendency to be more efficient (Lipscy and Schipper 2013).

Policy measures to promote Kei-cars in Japan comprise lower insurance costs, lower taxes (only around a third of the next larger vehicle class), highway discounts and loose registration requirements. Thereby, several incentives are only available in rural areas to particularly support areas with limited public transportation services. In recent years however, the qualifications for the Kei-cars status have been gradually relaxed reducing the gap to regular passenger cars (Lipscy and Schipper 2013; Fraunhofer IAO 2018).

Kei-Cars make up about one third of new passenger car sales in Japan (JAMA 2018). Generally, among the major global light-duty vehicle markets, Japan is one of the countries (next to India, Indonesia and Brazil) with the largest shares of small vehicles, or in other words, with a vehicle footprint smaller than 4 m^2 which is a proxy for the vehicle size. A smaller vehicle footprint often positively affects the fuel efficiency of the vehicle (OECD and iea 2017).

3.7 Optimizing logistics

To reduce CO_2 emissions in logistics the government undertakes several measures for the optimization of truck transportation and modal shift of freight transport to railways and shipping. For the optimization of truck transportation joint transportation and the usage of containers on a round-trip basis to avoid empty runs are promoted. To increase **modal shifting**, the government supports the development of freight cars for railways that can carry larger containers and provides subsidies for the acquisition of containers for railways that correspond to the size of ten-ton trucks. The overland transportation of internationally shipped container cargo is planned to be reduced by supporting the development of international container and logistic terminals (MLIT 2015c).

The government also financially supports the **conversion of passenger train lines for the usage of freight transport** since 2000 providing 30% of the costs (iea 2016b; MLIT 2013b). Moving freight from trucks to railways is challenging because a high capacity of rail track utilization has been already achieved. Especially in urban areas there is little space for commercial use. As passengers rail transport is prioritized over freight transport in Japan, freight traffic needs to stop in hours of high track utilization which can lead to delays. Furthermore, due to land limits and high population densities a further expansion of the rail network is associated with high costs and time (Lipscy and Schipper 2013).

Nevertheless, the initiatives of the government seem to be fruitful as logistics companies in Japan are increasingly shifting their movements from trucks to rail, in some cases even cooperating with competing companies. For example, Asahi Breweries Ltd. and Kirin Brewery Co. joined to bring their products made in the Kansai region to the joint logistics centre in the Ishikawa Prefecture via the JR freight company. This alone saves around 10,000 truck trips a year (Fraunhofer IAO 2018).

In the following, three measures of the government aiming at emission reduction in logistics are described in more detail.

3.7.1 Regulation for consigners and transportation companies

The regulation for consigners and transportation companies is part of the Energy Conservation Act since 2006. It obliges freight transport and passenger service companies to take energy-saving and reporting measures (iea 2016b).

The regulation covers (Eco-Mo Foundation 2017):

a) Freight and passenger carriers with a transport capacity of at least 200 trucks or buses, 350 taxis, 300 railway carriages, 20,000 tons of passenger ship or/and coastal shipping total tonnage or 9,000 tons of maximum take-off weight for aircraft (555 carriers under this regulation in March 2016).

b) Freight consigners (businesses that transport their goods by carriers) with an annual freight transport order of at least 30 million ton-kms (842 companies under this regulation in June 2015).

Affected companies are required to submit medium and long-term plans and regularly report their energy consumption status related to transportation. Thereby, the numerical target is to reduce energy consumption by an annual average of 1%. To achieve this target, companies can implement the following measures: Usage of vehicles with low fuel consumption, promotion of eco-driving, reduction of air freight traffic, modal shifting, improvement of cargo loading efficiency, internal trainings, etc. (ANRE 2011). In case the energy saving activities of a company are insufficient, the government gives recommendations for actions. If these are not implemented the name of the company is disclosed and fines can be imposed (ECCJ 2007).

After the introduction of the regulation energy consumption for freight carriers and consigners affected by the regulation has dropped. GHG emissions in the freight transport sector as a whole declined from 34.5 million tonnes of petroleum equivalent in 2006 to 30.4 million tonnes in 2009. However, there is no data on the specific contribution of the regulation (ANRE 2011).

3.7.2 The Eco Rail Mark and Eco Ship Mark

The MLIT furthermore introduced the Eco Rail Mark and Eco Ship Mark in 2005 and 2008, respectively, to promote modal shift, to recognize businesses that contribute to the reduction of environmental burdens and to encourage customers to support such businesses (MLIT 2008).

Companies can use the **Eco Rail Mark** if at least 15% of their transports on distances larger than 500 km are realized by rail. A product can get the Eco Rail Mark when 30% or more of its transportation is processed by rail (MLIT 2008). 161 products and 86 cooperating companies have been certified with the eco rail mark until August 2015 (MLIT 2015c). A committee determines whether a product or producer meets these criteria. The aim is to increase rail transport performance to 25,640 Mtkm by 2030, a rise of around 33% compared to 2013 (Ecos Consult 2017a).

The **Eco Ship Mark** can be used by companies if they use shipping for over 20% of their total freight transports, if they increased their shipping freight volume by at least 10% in comparison to the previous year or if they decreased their CO_2 emissions by modal shift by at least 10% compared to overland transportation (Kao Corporation 2018). In February 2015, 94 consignors and 110 logistic business companies have been certified with the eco ship mark (MLIT 2015c).

3.7.3 Green Logistic Partnership Program

The "Excellent Green Logistics Commendation Program" was initiated to promote voluntary measures and cooperation between companies in the field of green logistics. Awards and subsidies can be gained for remarkable achievements that are based on collaborations between logistic business operators and transport companies. Since 2005, METI and MLIT are organising the Green Logistic Partnership Conference together with the private sector to inform about green logistics on the basis of existing collaboration projects, to recognize excellent efforts and to raise public awareness. As of 2015, the program had 3,300 member companies and organizations (METI 2015a; MLIT 2015c, 2015b).

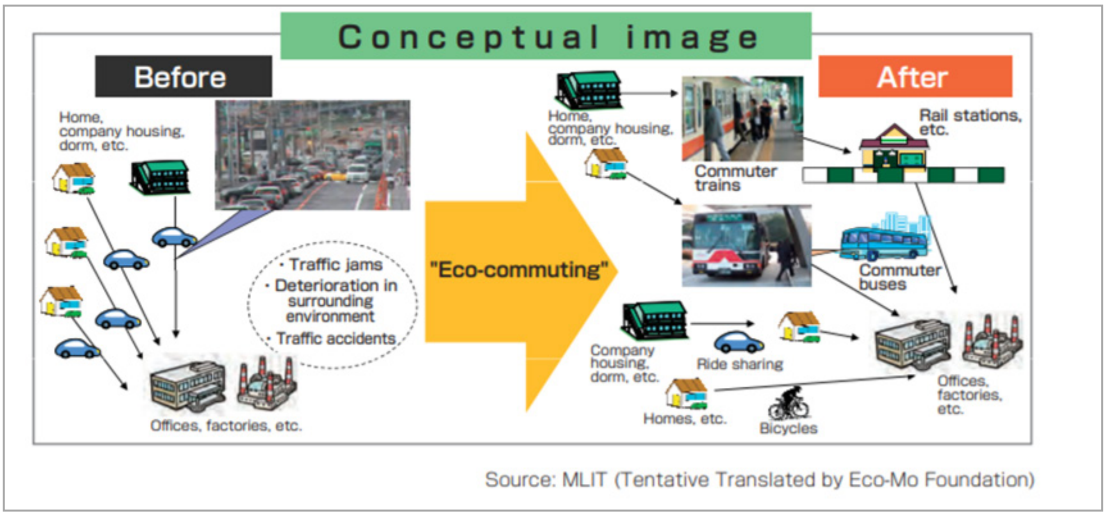
3.8 Public transportation and cycling policies

The Japanese government also promotes modal shift from private cars to public transportation and cycling. It supports the creation of new railroad lines, new public transportation systems (Eco-Mo Foundation 2017) and supports the promotion of public transit IC cards and other computerization initiatives in order to increase the convenience of public transportation (MLIT 2015c).

The government further supports rail operators for measures that increase the convenience of public transportation and railroads in Japan. Thereby the focus is on achieving greater speeds on existing arterial railroads and on freight rail lines, implementing smooth interconnections and on improving railway stations and implementing barrier-free measures in railway stations. Additionally, Light Rail Transit (LRT) is promoted as part of the MLIT's regional public transportation provision, maintenance and improvement project. These streetcar transportation systems use low-floor trams (LRVs), provide easy boarding and increase punctuality, travel speed and comfort (Eco-Mo Foundation 2017).

Another measure to support public transportation and cycling is the **Eco-commuting Promotion Action Program** that exists since 2007.

Figure 6: Concept of the Eco-commuting Promotion Action Program



Source: Eco-Mo Foundation (2017)

As shown in Figure 6, it promotes the modal shift from private cars to public transportation, bicycles and walking for commuting. By involving the transportation operators as well as the business sector and members of the government the efforts are based on mutual cooperation of all relevant stakeholders. The **Excellent Eco-Commuting Business Site Certification System** was introduced in 2009 in order to certify businesses which actively promote eco-commuting. In December 2016, 649 business sites were registered under the Certification System (Eco-Mo Foundation 2017). Certified companies have to report their efforts every year. Companies which reach significant improvements get a recommendation as nominees for the MLIT Minister's Award (JFS 2009).

Cycling accounts for 20% of the traffic within distances of less than 5km. For improving the cycling environment the government for instance support the development of the cycling route network and of parking facilities, the education on bicycle riding rules, and communication projects to encourage citizens to use bicycles (MLIT 2012b). Parking spots are especially created at railway stations and bus stops to increase the connection between modes of transportation. In FY 2007, 98 bicycle-friendly model areas have been selected and are supported with subsidies in order to improve the cycling environment by the development of bicycle roads lanes and sidewalk that can be shared by pedestrians and cyclists (MLIT 2013a). The **Guideline for Creating a Safe and Pleasant Environment for Bicycle Use** was last reformulated in 2016 and adapted plans for bicycle networks and the creation of bicycle travel spaces are being formulated and implemented by the related ministries and agencies (Eco-Mo Foundation 2017).

In 2015, over 70 cities across Japan have been introducing **public bicycle sharing projects**. However, number of bicycles and parking stations are small in the many of these projects. Due to limited budgets, most cities start with a small number and plan a gradual increase. This hampers the spread of usage, as the service level of bicycle sharing systems increases with density of bicycles and parking stations (Suzuki and Nakamura 2017).

3.9 Other policies and measures

The **Green Purchase Law** (enacted in 2000) encourages green procurement in public authorities and institutes, amongst others with respect to passenger and freight vehicles (MoE 2016a). The **Green Contract Law** (enacted in 2007) which aims to promote emission reduction by public authorities and institutions defines award criteria and procedures and covers, amongst others, the procurement of ships and motor vehicles (MoE 2014a).

Regarding the next-generation vehicle target of 50-70% until 2030, the Japanese government has set the intermediate goal to achieve a share of around 40% of next-generation vehicles in the governmental fleet by 2020. These are around 9 thousand out of 22.6 thousand vehicles in the governmental fleet (CEM and EVI 2016).

The **Low Carbon City Act** commits local governments since 2012 to set up "low carbon development plans" that also concern the transport sector. Targets are the improvement of travel speed through road development, traffic demand management and the development and promotion of public transport (MLIT 2014; MoE 2014b).

Additionally, the government supports the development of technologies to further **increase environmental performance and energy efficiency in the railway sector in shipping and in aviation**. For instance, further improvements of energy efficiency of railways, the construction of energy-saving vessels and energy conservation measures in the port area are supported (MLIT 2015c). The government also promotes the usage of LNG vessels for freight transport in order to decrease nitrogen oxide emissions (Ecos Consult 2017a). For increasing energy efficiency in aviation, the improvement of aerial traffic systems by implementing the Continuous Descent Operation (CDO) and the improvement of area navigation (RNAV) is supported. Additionally, Japan participates in the Asia and Pacific Initiative to Reduce Emissions (ASPIRE) where airline companies and air traffic control authorities work on achieving higher efficiency in aviation, and takes part in the discussion on a global scheme for reducing CO_2 emissions from international aviation (MLIT 2015c).

As demonstrated with the examples of the expansion of the Shinkansen network and the promotion of Keijidosha, also policies that are not primarily focussing on emission reduction or energy efficiency in transport had a large impact on the structure of the transport sector in Japan and contributed to lower emissions. Public transport also might be more attractive compared to other countries as **costs for motor vehicle ownership and usage are very high** in Japan. This comprises high taxes, the requirement to register for a(n expensive) parking space and the expressway tolls which are immense compared to other developed countries. The revenues from the fees and tolls are used for the construction and maintenance of infrastructure in rural areas (Lipscy and Schipper 2013).

On the other hand, gasoline and diesel prices are lower than in countries with high gasoline and diesel taxation such as Germany. In Japan, the average gasoline price was 138 USD cents per litre in 2014 compared to 180 in Germany. The average Japanese diesel price was 110 USD cents per litre while the average diesel price in Germany was at 158 USD cent per litre in 2014 (GIZ 2015).

4 Japans activities in the global context and comparison to Germany

4.1 Evaluation in the global context

The Japanese transport sector is one of the most energy efficient worldwide (Lipscy and Schipper 2013) and Japan is seen as a pioneer in new drive systems as HEVs and FCVs as well as different vehicle concepts such as the Kei-Cars (Fraunhofer IAO 2018). This chapter concentrates on fuel economy of motor vehicles and the development of electric vehicles and FCVs in the international context.

But also apart from the technological efforts to save emissions in motorised transportation, Japan appears to save emissions in international comparison because Japanese travel less and shorter distances than people from many other developed countries and the share of railways for passenger transport is much higher (Lipscy and Schipper 2013). It seems plausible to attribute this to the fact that the largest urban areas Tokyo, Osaka and Nagoya are relatively close to each other which leads to shorter travel distances as well as to the high population density that leads to more mass transit and higher time costs of travelling as traffic might be slower. However, in an international comparison (Lipscy and Schipper 2013) showed, that Japanese still travel less and use public transportation more when taking the high population density and the travel distances into account. They conclude, that non-policy factors cannot fully explain the modal split in passenger transport in Japan.

4.1.1 Energy efficiency and emission standards

Japanese average fuel economy is one of the best worldwide (OECD and iea 2017). Compared to China, the US and the EU the Japanese vehicle fleet has the lowest CO_2 emission values in terms of official as well as in terms of real-world CO_2 emission values (Tietge et al. 2017).

Japan is member of the **Transport Task Group (TTG)**[8] which was established by the G20 with the aim to increase energy efficiency and decrease environmental impacts of motor transport, particularly of heavy-duty vehicles and to exchange best practices on cost-effective energy efficiency and emission reduction measures in transport. Analyses are conducted to investigate chances, barriers, benefits and costs of energy efficiency measures for heavy-duty vehicles (IPEEC 2017).

With its PNLTES described in Chapter 3.1, Japan is one of the TTG members, next to the United States, the European Union and Canada, that has implemented “world-class” **tailpipe emission standards** for light-duty and heavy-duty vehicles. While **fuel efficiency standards** for light duty vehicles have been implemented by nearly all TTG members, Japan is one of the only four TTG economies that have adopted fuel efficiency standards for heavy-duty vehicles (next to Canada, China and the United States) (Miller et al. 2017).

[8] The leading members of the TTG are the European Commission and the United States. Participants are Argentina, Australia, Brazil, Canada, China, Germany, India, Italy, Japan, Mexico, Russia and the United Kingdom.

Comparing the **fuel efficiency development of light-duty vehicles** from 2005 to 2015 on a global level, Japan has made the third-largest improvements after Turkey and the United Kingdom. However, in total, fuel efficiency improvements in OECD economies slowed down between 2014 and 2015. The major reasons for this slowdown were an increase of the share of sales of OECD economies with lower fuel efficiency compared to the OECD average and a **trend reversal** which took place in Japan between 2014 and 2015. After years of fuel efficiency improvements, fuel efficiency in Japan got worse by 4.5% from 2014 to 2015. The fact that fuel efficiency standards for light-duty vehicles in Japan were "met well in advance of the target date" discouraged further improvements after the target was met. Apart from a decline in hybrid sales, the average fuel consumption increased mainly because of a "market shift towards larger vehicles". The fuel efficiency target values in Japan for 2015 were still met in spite of the trend reversal because the average fuel consumption in 2014 was already far below the fuel efficiency target values for 2015 (OECD and iea 2017).

If emission reduction for passenger vehicles in Japan would have continued at the same rate as in the period 2010 to 2014, 82 gCO_2/km would be achieved in 2020 which is below targets set in other countries (Yang and Bandivadekar 2017). However, while Japan currently has the most efficient passenger vehicle fleet in international comparison (in terms of official CO_2 values) and efficiency standards have led to large improvements in the past, the Japanese 2020 target value of 122 gCO_2/km is less ambitious than targets of other countries or regions such as South Korea (97 gCO_2/km in 2020), EU (95 gCO_2/km in 2021), China (117 gCO_2/km in 2020) and India (113 gCO_2/km in 2022) (Tietge et al. 2017; OECD and iea 2017). Thus, Japanese fuel efficiency standards fall behind other countries if they are not tightened.

Regarding light commercial vehicles Japan has the strictest fleet target with 133 gCO_2/km by 2022, followed by Canada, the US, and the EU (Yang and Bandivadekar 2017).

Generally, to avoid that standards lag behind the actual technology developments (as for Japan where 2020 standards determined in 2011 were already achieved in 2013), careful and in-depth studies should be performed before standards are determined to assess the development of the vehicle fleet and the technology (Yang and Bandivadekar 2017).

Another important issue is that, even though vehicle emissions and fuel consumptions have been reduced over years, large **differences between on-road performance and official certified CO_2 emission values** have been found in several countries including Japan. The gap of these values for passenger cars in Japan grew from 23% in 2009 to 44% in 2014. Mitsubishi Motors Corporation increased the measured fuel efficiency by 4% to 11% "using inaccurate road-load parameters for measuring fuel efficiency" for a period longer than a decade. Other large gaps between on-road and certified CO_2 emission values have been found for the European Union, China, and the United States (Yang et al. 2017; Yang and Bandivadekar 2017).

Comprehensive compliance and enforcement (C&E) mechanisms are needed in order to ensure correct vehicle tests by the manufacturers and to enable regulators to identify noncompliance and to carry out measures against violation (Yang and Bandivadekar 2017). After the Mitsubishi scandal, the Japanese government started to carry out unannounced witnessing of the tests of manufacturers starting in September 2016. Generally, next to the United States and South Korea, Japan is the country with the most comprehensive C&E programs with a clear governmental obligation, strong legislative support, and corrective methods and serious financial or reputational penalties in case of noncompliance. Data and information transparency however is not good in Japan as well as in other countries (Yang et al. 2017).

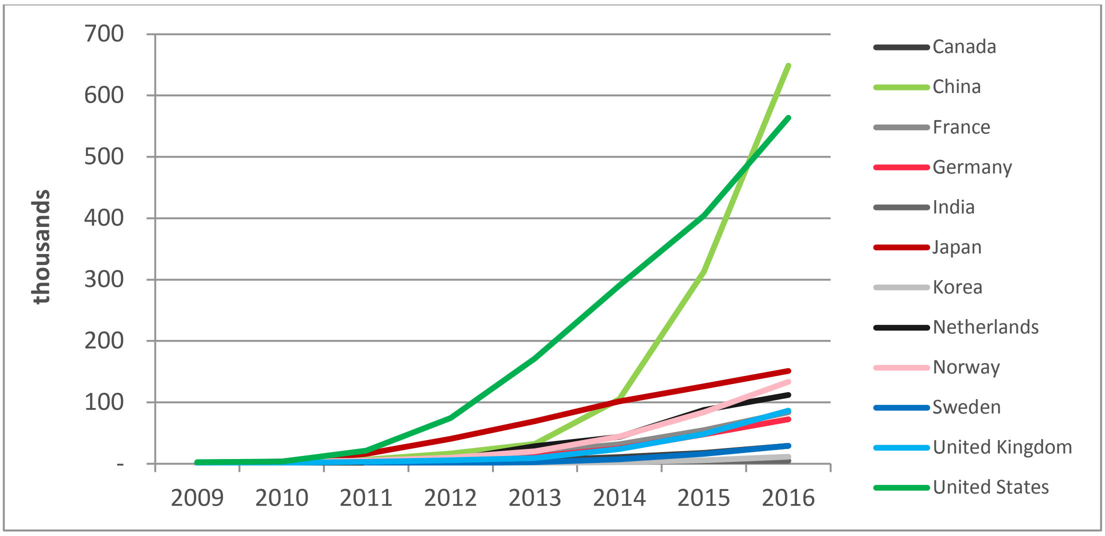
4.1.2 BEVs, HEV, and FCVs in the international context

Japan (as well as Germany) is one of **ten member governments of the Electric Vehicles Initiative (EVI)** which was established in 2009 as multi-government policy forum under the Clean Energy Ministerial (CEM) with the target to accelerate the usage of electric vehicles worldwide (iea 2017a).

95% of global electric car sales occur in ten countries only: China, the United States, Japan, Norway, France, Germany, the Netherlands, Sweden, the United Kingdom and Canada (iea 2017a).

As shown in Figure 7, the number of BEVs and PHEVs in Japan has been steadily increasing since 2009 reaching and amount of 151 thousand vehicles in 2016. Thereby, Japan is one of the largest electric vehicle markets worldwide, ranking on place 3 after China and the United States. Furthermore, Japan is also one of the countries with the most developed fast charging infrastructure having a comparably high share of fast charging units per EV (iea 2017a).

Figure 7: Battery electric cars and plug-in hybrid electric cars, stock by country



Source: own illustration based on data from iea (2017a)

In 2015, Japan was the country with the highest market share of **HEVs** worldwide and still the only market with a double-digit hybrid vehicle market share, even though the hybrid market share stagnated since 2012 and went down below 15% in 2015. On global average hybrids were nearly "twice as efficient as internal combustion engines" in 2015 (OECD and iea 2017).

By today, the Toyota Prius which was first introduced in 1997 is with almost 4 million sales the world's most successful HEV. Next to Toyota in particular Honda and Mitsubishi are seen as pioneers in hybrid technology (Fraunhofer IAO 2018).

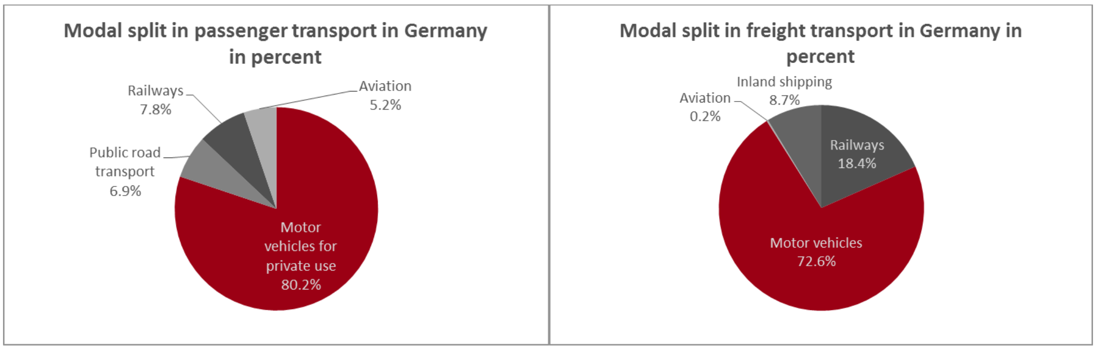
With respect to fuel cell technologies, Japan is a frontrunner in international comparison, already having significant fuel cell research outputs before 1995 (Haslam et al. 2012). Between 2010 and 2015, Japan remained innovation leader for FCV with 28% of FCV patens (25% from Germany), while Germany had more patents regarding BEV (34% compared to 23% in Japan). However, patent cultures in Japan and Germany are very different, limiting the comparability and conclusion regarding the innovations in the two countries (Fraunhofer IAO 2018; Haslam et al. 2012).

By 2017, the Toyota Mirai accounted for around 75% of FCVs sold globally, followed by Hyundai Tucson in ix35 (11%) and the Honda Clarity and earlier FCX model (10%). Around 48% of global FCVs sales have been carried out in California, around 35% in Japan and 14% in Europe (ICCT 2017).

4.2 Comparison to Germany

Germany, with a population of about 82 million inhabitants had a passenger transport volume of around 1,180,800 million passenger km in 2015 and a freight transport volume of 633,600 million ton km. Therefore, passenger transport volume per capita is higher than in Japan: 14,400 km in Germany compared to 11,248 km per capita in Japan. Figure 8 shows the modal split in Germany in passenger and freight transport. Motor vehicles have a greater share in private passenger transport than in Japan with around 80% (in Japan 60%) as well as in freight transport with around 73% (in Japan 51%). Railways only account for 8% of passenger transport volume (compared to 30% in Japan) and shipping only for around 9% of the freight transport volume (compared to 44% in Japan).

Figure 8: Modal split (transport volume) in passenger and freight transport in Germany 2015



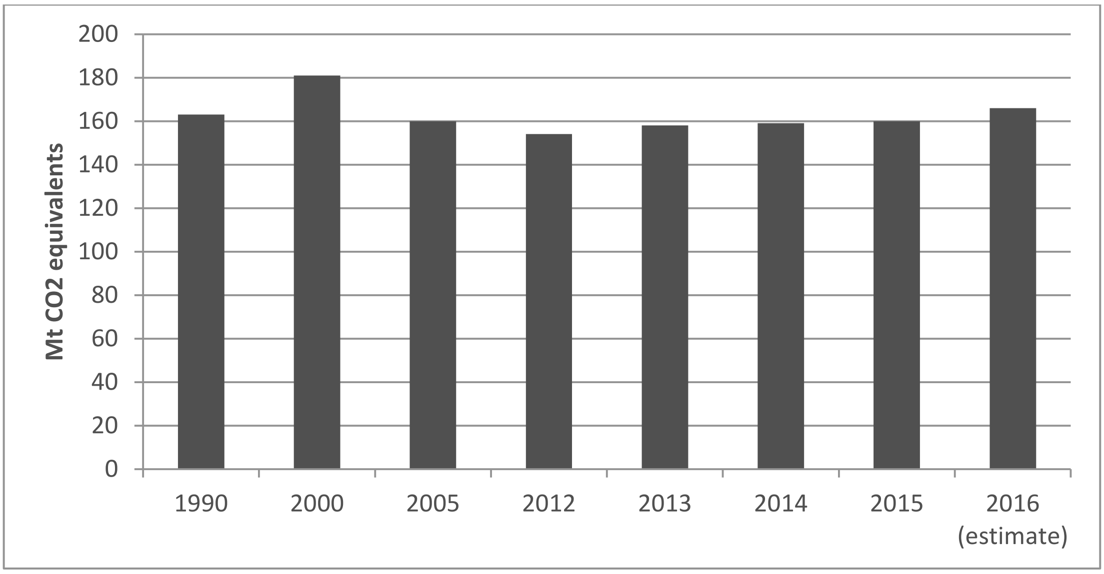
Source: BMVI (2017b)

Furthermore, in Germany around 12% of journeys were made by bicycle in 2014 compared to around 10% on average in Japan. In general, Germany is more advanced when it comes to the cycling path network and the safety of cycling paths, bicycle parking spaces, public bicycle sharing services and e-bikes (Ecos Consult 2017b).

In its *Energy Concept from 2010* the German Government sets the target to reduce final energy consumption in the transport sector by around 10% until 2020 and by around 40% until 2050, compared to 2005 levels. Furthermore, the number of electric vehicles is aimed to be increased to 1 million by 2020 and to 6 million by 2030 (BMWi and BMUB 2010).

However, the final energy consumption developed in the opposite direction of the targeted objective showing an increase of 1.3% in 2015 compared to 2005 levels (BMWi 2016). Accordingly, GHG emissions in transport sector also have been increasing in recent years as can be seen in Figure 9. In 2016, around 166 million tonnes of CO_2 equivalent (estimate) were emitted which is even higher than the value of 1990 (163 million tonnes of CO_2 equivalent). Energy efficiency gains due to improved vehicle fuel efficiency and CO_2 savings due to the increased usage of biofuels have been offset by the rise in transport volume. Since 1960, passenger and freight transport volume in Germany has increased fourfold (BMUB 2016).

Figure 9: Emissions in transport in Germany



Source: BMUB (2017)

Also in Japan, present emission values in the transport sector are higher than values in 1990. However, different to Germany, in recent years CO_2 emissions in Japan declined by 11.9% and final energy consumption decreased by 12.1 % between 2004 and 2014 (see Chapter 1.2). Total final energy consumption in transport in 2015 was higher in Japan with 71.3 Mtoe than in Germany where 55.7 Mtoe were consumed. However, in terms of per capita values energy consumption is larger in Germany with 0.68 toe compared to 0.56 toe in Japan (see Table 7).

Around 18% of total GHG emissions in Germany originate from the transport sector. According to the **Climate Action Plan 2050** which was adopted in 2016, the German government targets a 40-42% decrease in GHG emissions in the transport sector by 2030 relative to 1990 levels with the final goal of making the transport sector “nearly independent of fossil fuels and hence greenhouse gas neutral” by 2050 (BMUB 2016). Like in Japan, in Germany most of GHG emissions in the transport sector are emitted in road transport, i.e. originate from motor vehicles (96%) (BMUB 2017).

To reduce emissions in the transport sector the German government focuses on an increase of energy efficiency of motor vehicles, alternative drive systems especially based on electricity, modal shift, i.e. an increase of public transport, railway transport and transport by cycling and on foot, increasing intermodal connections and settlement and transport planning that avoids traffic (BMUB 2017).

Tailpipe emission and fuel efficiency standards for motor vehicles are set on EU level (see Chapter 4.1.1). **Electric mobility** has been funded by the German government since 2007 and a new law, the Electric Mobility Act (Elektromobilitätsgesetz, EmoG), became effective in 2015 which allows, for instance, exemptions from parking fees for electric vehicles and the reservation of parking spaces at charging stations in public areas. The development of the charging infrastructure is being funded with 300 million EUR until 2020. In addition, the government provides a purchase premium of 3000 EUR for PHEV and of 4000 EUR for BEV (environmental bonus) since 2016. The total funding limit is 1.2 billion EUR whereby half is funded by the government and half by the automotive industry. Additionally, BEV are exempted from the motor vehicle tax for 10 years. The government furthermore supports research and development of electric mobility with 2.2 billion EUR (BMWi 2017; BMUB 2017).

By 2016, around 73,000 BEV and PHEV have been in use in Germany which is around half as much as in Japan. Furthermore, there were 16,550 publicly accessible electric slow charger units and 1,403 fast charging units installed in Germany compared to 17,260 and 5,990 in Japan respectively (see Table 7).

Nevertheless, also in Japan there is still a large gap to the targeted 15-20% share of BEV and PHEV in new car sales and actual values. While HEV already achieved a share of over 30% in 2016 in Japan, share for BEV and PHEV is still below 2% (see Table 4).

The usage of hybrid and battery electric busses and the procurement of electric vehicles by municipalities are also promoted by the German government. In addition, **research into** the production of gas or liquid fuels which are produced using renewable electricity such as **power-to-gas methane or power-to-liquid** is supported especially in regards to usage for shipping and aviation. The expansion of rail transport is supposed to enable further emission reductions. Investments are made in the rail network to **increase the railways share in freight transport** by 43% between 2010 and 2030. The government further supports municipalities in improving the **cycling infrastructure** and the development of cycle expressways. Thereby, electric bicycles are of increasing importance: More than 2.5 million pedelecs and e-bikes are already used in Germany today. Integrated urban and spatial planning further aims at achieving a shift to cycling and walking by reducing distances between homes and central service areas (BMUB 2017, 2016). Furthermore a **digitisation** strategy for the transport sector is thought to also reduce GHG and standards for smart roads are planned to be trialled (BMUB 2016).

Not only Japan but also Germany strongly pushes research and development of hydrogen and fuel cells within the *National Hydrogen and Fuel Cell Technology Innovation Programme* (NIP). In the first phase between 2007 and 2016 a total of 700 million EUR was funded for the market preparation of products from these technologies. The private industry provided an equal amount. In the second phase which ends in 2026 the government and the private industry both provide 250 million EUR. Government funds for instance are used to pay half of the construction costs for hydrogen stations and to reduce fuel production costs to less than 4 EUR per kilogram until 2021. The public-private partnership *Clean Energy Partnership* set up the H2Mobility, a consortium of companies that plan and construct the network of hydrogen stations. The plan of H2Mobility is to achieve 100 hydrogen stations until 2019 with around 60 stations in six metropolitan areas and 40 as connectors and destinations (ICCT 2017).

By now, Germany has the second largest publicly accessible hydrogen station network worldwide after Japan (100 stations) with 45 stations in operation by the end of 2017. The German network of public stations has doubled in 2017 and by 2019 the number is expected to grow to 100 stations (TÜV Süd 2018). Altogether, similar to Japan, Germany strongly supports the development of hydrogen mobility. However, the Japanese strategy has a stronger focus on an overall hydrogen-based society and sets precise targets for FCVs and hydrogen stations. Furthermore, the funds of the Japanese government concerning hydrogen and fuel cells are even higher than in Germany.

Generally, Japan and Germanys measures for sustainable mobility have some similarities. Both countries are pushing forward alternative transport systems and are investing strongly in the development of hydrogen and fuel cell technologies and infrastructure as well as in the infrastructure of BEV. While the Japanese government took an approach that supports the dissemination of next-generation vehicles in general and therefore for instance reached a high share of HEV, tax and purchase incentives of the German government only focus on BEV and PHEV. Both countries are implementing measures for modal shift from motor vehicles to public transportation and cycling and intend to increase intermodal connections to raise the attractiveness of public transportation. Shifting road freight transport to railways is also targeted by both countries; in Japan approaches also focus on shifting freight transport to shipping. Generally, Japan seems to have a longer history of measures that aim to optimize freight transport and logistics with respect to GHG emitted. For instance, a regulation for consigners and transportation companies is in force since 2006. In Japan furthermore measures that did not initially aim for GHG emission reductions nevertheless are likely to have contributed to lower shares in road transport and/or lower emissions: The expansion of the Shinkansen network and the promotion of Kei-cars as well as high costs associated with motor vehicle ownership and usage. Also, different from Germany, Japan has speed limits on all expressways that are in force since their construction and also contribute to a lower emission output.

Table 7: Transport statistics for Japan and Germany

	Japan	Germany
Population (The World Bank 2017)	127 million	82 million
CO_2 emissions million tons/ tons per capita CO_2 (UN 2017)	1 214.0 / 9.6	719.9 / 8.9
CO_2 emissions in Transport sector (MoE 2018; BMUB 2016)	215 million tons of CO_2 (preliminary figure FY 2016)	166 million tons of CO_2 equivalent (preliminary figure 2016)
Emission reduction target for transport sector (Table 3) (BMUB 2016)	32% in FY 2030 compared to FY 2005 (energy originated CO_2) Reduction by 77 million tonnes of CO_2 emissions	40-42% in 2030 compared to 1990 (GHG emissions) Reduction by 65 to 68 million tonnes of CO_2 equivalent
Total final energy consumption and final energy consumption in the transport sector (2015) (iea 2017b)	Total final energy consumption: 291.3 Mtoe. Final energy consumption in transport 71.3 Mtoe (24.5%)	Total final energy consumption: 220.2 Mtoe with 55.7Mtoe in the transport sector (25.3%)

	Japan	Germany
Energy consumption in transport per capita	0,56 toe	0,68 toe
Number of publicly accessible EV charging points 2016 (iea 2017a)	Slow Charging units:17,260 Fast Charging units: 5,990	Slow Charging units: 16,550 Fast Charging units: 1,403
Electric car stock (BEV and PHEV) 2016 (iea 2017a)	151.250	72.730

5 Summary and recommendations for Japanese-German dialogue

This study gave a comprehensive overview of the structure of the Japanese transport sector and political strategies and measures for reducing emissions and increasing energy efficiency in this sector. These comprise the top runner program which sets fuel efficiency standards based on the vehicles with the highest energy efficiency on the market, tax exemptions and subsidies for the acquisition of environmental friendly vehicles, the promotion of ITS and eco-driving, measures to increase public transportation and cycling such as the Eco-commuting Promotion Action Program and measures to optimize logistics and freight transportation for instance, the regulation for consigners and transportation companies. Furthermore, measures that did not initially aim for GHG emission reductions such as the expansion of the Shinkansen network, the promotion of Kei-cars and high costs associated with motor vehicle ownership and usage also are likely to contribute to a higher usage of railway and public transportation and/or lower emissions in the transport sector.

In international comparison, Japanese travel less and shorter distances than people from many other developed countries and the share of railways for passenger transport is much higher. Furthermore, the Japanese average fuel economy is one of the best worldwide and Japan is one of the only four TTG economies that have adopted fuel efficiency standards for heavy-duty vehicles. However, while fuel efficiency standards have led to large efficiency improvements in Japan in the past, current Japanese passenger vehicle efficiency standards are less ambitious and fuel efficiency dropped by 4.5% between 2014 and 2015.

Japan is a pioneer in the development and dissemination of new drive systems such as HEV, BEV and FCVs. Japan is the country with the highest market share of HEVs worldwide and also regarding the car stock of BEV and PHEV, Japan ranks on place 3 after China and the United States. Furthermore, Japan is among the countries with the most developed fast charging infrastructure for EV. However, while the target value for the share of BEV and PHEV in new car sales is 15-20% until 2020, the current share is still below 2%. Japan furthermore strongly supports the development and dissemination of FCV and hydrogen stations within its comprehensive strategy towards a “hydrogen-based society”.

While emissions in the transport sector in Japan have declined in recent years, current CO_2 emission values are still above 1990 emission levels. In Germany, emissions have increased in recent years and emission levels also are around the values from 1990. Therefore, in both countries further action is needed in order to reach sufficient emission reduction in the transport sector. As in both countries the road transport sector is the largest emitter, policies should focus on modal shift to railways, public transportation, cycling and walking. Additionally, a further increase of fuel efficiency of motor vehicles and alternative drive system and fuels such as BEV and FCV should be promoted. Furthermore, also international aviation and shipping needs to be addressed, which is not part of the national emissions in Japan and Germany that were shown in this study.

Based on this study, potential topics for the energy dialogue between Germany and Japan and for future cooperation projects in the context of climate protection and energy efficiency in the transport sector are derived:

1. **Development of alternative drive-systems and fuels and charging infrastructure:** The comparison showed that Germany and Japan are pushing forward technologies and charging infrastructure for alternative drive-systems such as BEV and FCV. Exchanging experiences on government support for technologies and infrastructure for passenger as well as for freight transport could accelerate this development.

2. **Purchase incentives for alternative drive-systems and fuels:** Both countries have tax and purchase incentives for the dissemination of BEV and PHEV. In Japan these incentives are available for other next-generation vehicles as well. As both countries struggle to reach target shares and number for BEV and PHEV, lessons learned could be exchanged and future measures could be jointly developed.

3. **Fuel efficiency and emission standards for motor vehicles:** The top-runner model applied in Japan could be discussed as an approach to further developing the EU's fleet CO2 emission limits for passenger cars and light commercial vehicles. Even though this process does not apply to Germany alone a bilateral discussion between Japan and Germany still could be important as Germany has a relevant impact at EU level.

4. **Modal shift in passenger transport:** Both countries are taking measures for modal shift from motor vehicles to public transportation and cycling and intend to increase intermodal connections to raise the attractiveness of public transportation. Exchanging strategies and lessons learned from implemented measures could be part of the Japanese-German dialogue. Thereby, also Japanese measures and figures responsible for a high attractiveness of railways in long- and short distance travel (e.g. the network expansion of the Shinkansen and the high punctuality of railways in general) could be an interesting insight.

5. **Optimizing logistics and freight transport:** An exchange of policies and measures for decreasing emissions in freight transport could accelerate achievements in this area. Modal shift in freight transport is targeted in both countries and lessons learned could be exchanged. Furthermore, Germany could learn from some measures that Japan has implemented such as the regulation for consigners and transportation companies.

6. **Traffic demand management and ITS:**
   The countries could further exchange on measures and experiences regarding traffic demand management in order to improve the traffic flow and thereby reduce emissions. Here, also Japanese experience on the implementation of ITS for intelligent route guidance, reduction of congestions, safety support and ETC are of interest. (The latter could be interesting in comparison with the toll collection of the LKW-Maut in Germany).

   The Hannover Declaration from 2017 which was agreed between the German Federal Ministry for Economic Affairs and Energy (BMWi) and the Ministry of Economy, Trade and Industry (METI) could be a link for cooperation in some of the mentioned fields. This declaration aims at cooperation between Japan and Germany in the field of the Fourth Industrial Revolution and collaborations regarding the automotive industry are included. For instance, cooperation in basic research on international combustion engine, autonomous driving technologies, connected vehicles and the development of charging infrastructures for next-generation vehicles are envisaged (METI 2017a).

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