



Energising Transport and Mobility in China

Status Analysis of a Mobility and Fuels Strategy



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Supported by the Transport Planning and Research Institute (TPRI) under the Ministry of Transport of the PR China:



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Glossary

A

APU	Auxiliary Power Unit
AQSIQ	Administration of Quality Supervision, Inspection and Quarantine

B

BAT	Best and Readily Available Technologies
BEV	Battery Electric Vehicle
BMVI	German Federal Ministry of Transport and Digital Infrastructure
BSTC	Beijing Science and Technology Commission
BTL	Biomass-to-Liquid

C

CAAC	Civil Aviation Administration of China
CAAM	China Association of Automobile Manufacturers
CATARC	China Automotive Technology & Research Center
CATS	China Academy of Transport Science
CBDR	Common But Differentiated Responsibilities
CCICED	China Council for International Cooperation on Environment and Development
CNG	Compressed Natural Gas
CNPC	China National Petroleum Corporation
CNREC	China National Renewable Energy Center
COFCO Group	China National Cereals, Oils and Food Corporation
CR	China Railway
CRRC	China Railway Rolling Stock Corporation

D

DOT	Department for Comprehensive Transport Planning
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E

EF	Energy Foundation
ERI	Environmental Research Institute
ETS	Emissions Trading System
EVs	Electrical Vehicles

F

FYP	Five-Year Plan
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G

GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
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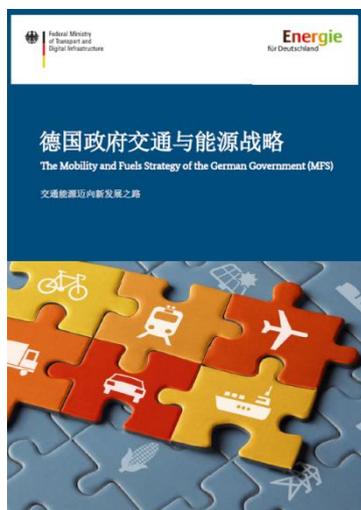
I

ICAO	International Civil Aviation Organisation
IPPC	Intergovernmental Panel on Climate Change
ITDP	Institute for Transportation & Development Policy

ITS	Intelligent Transportation System
L	
LCA	Life-cycle Assessment
LPG	Liquid Petroleum Gas
M	
MEP	Ministry of Environmental Protection
MFS	Mobility and Fuels Strategy
MIIT	Ministry of Industry and Information Technology
MoHURD	Ministry of Housing, Urban and Rural Development
MoST	Ministry of Science and Technology
MoT	Ministry of Transport
MoU	Memorandum of Understanding
N	
NDRC	National Development and Reform Commission
NEA	National Energy Administration
NEVs	New Energy Vehicles
NPE	National Platform for Electro-mobility
O	
ODM	Original Design Manufacturer
P	
PG	Petrol Gas
PHEV	Plug-in Hybrid Electric Vehicle
PKM	Person-Kilometre
PtG (H2)	Power-to-Gas (Hydrogen)
PtL	Power-to-Liquid
R	
RIOH	Research Institute of Highways
RNP	Required Navigation Performance
RMB	Renminbi (¥, exchange rate August 2016 1 EUR = 7,431 CNY)
RTK	Revenue Tonne Kilometre
RVSM	Reduced Vertical Separation Minimum
S	
Sinopec	China Petrochemical Limited
SNG	Synthetic Natural Gas
SOEs	State-Owned Enterprises
T	
TKM	Tonne-Kilometre
TPRI	Transport Planning and Research Institute
V	
VECC	Vehicle Emission Control Centre
VKT	Vehicle Kilometre Travelled
W	
WRI	World Resource Institute



1. Energising Transport and Mobility in China – An Initial Study on Mobility, Drives and Fuels in China



As a major global economic driving force, the transport sector –and in particular the automotive sector– has provided employment and shaped technological progress over the course of a century. This is true for Germany as much as it is for China. Daunting **climate and environmental concerns** have cast a large shadow on this development. The tangible negative impacts of transport such as air pollution, accidents, noise and congestion are more than a nuisance to residents living, working or visiting in China's megacities, along China's coastlines and waterways. A less perceptible, yet significant impact is the resulting carbon dioxide (CO₂) emissions from internal combustion engines burning fossil fuels. The associated negative social, environmental and climatic impacts pose a dilemma for policy makers worldwide. **Energy security, climate protection and air quality** have to be taken into account as much as economic efficiency, growth and acceptance. Accordingly, the purpose of practical transport policy is to facilitate mobility and to ensure that it is environmentally, economically and socially sustainable.

A **Mobility and Fuels Strategy (MFS)** attempts to address this and attempts to shed light on the following key issues: How can policy makers drive the process towards a future-proof mobility? How can the transport sector follow the lead of the energy sector, which has already embarked on a "Energiewende" (energy transition)? Which drive technologies, fuels, measures and regulations are available and suitable? These are among the main questions that the MFS of the German government answers. Questions that are equally pressing in the Chinese context.

This report summarises the research conducted by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the **German Federal Ministry of Transport and Digital Infrastructure (BMVI)**. The project called "Energising Transport and Mobility in China" has been implemented in cooperation with the Ministry of Transport (MoT) of the People's Republic of China and its think-tank the Transport Planning and Research Institute (TPRI). The purpose of the project was to identify the current development trends, barriers and prospects of key segments of a MFS in China with a focus on transport demand, fuels and drive system alternatives.

The project context: Sino-German Cooperation

During the Climate Negotiations in Paris end of 2015, China and Germany have shown dedication to protecting the climate and both identified transport as one of the key sectors to achieve this. This has been re-confirmed during the Sino-German government consultations that took place in Beijing in June 2016. It has been agreed by German Chancellor Angela Merkel and Chinese Premier Li Keqiang to cooperate in the area of alternative propulsion technologies, such as electric vehicles, but also to strengthen the cooperation in the railway and aviation sector. Parliamentary State Secretary at BMVI, Dorothee Bär, and Minister Yang Chuantang of the MoT of the Peoples Republic of China jointly signed a Memorandum of Understanding (MoU) to cooperate in the field of Mobility and Fuels Strategies and strengthen the cooperation between the transport industries in both countries.

Entry Points for a Mobility and Fuels Strategy in China

Policy makers have a wide range of policies and measures at their disposal to reduce emissions and energy demand and to encourage innovations in the transport sector. Reducing **transport demand** is the most direct way to save energy and emissions. Policies and measures that **avoid** the need to travel include flexible working-hours, home-office arrangements and smart land-use planning, which increases density in cities, and access to mass transit. In China, especially in an environment of rapid urbanisation, this can effectively reduce travelling distances and the amount of trips made. The **energy intensity** (energy consumed per person-kilometre or tonne-kilometre) can be reduced by encouraging a **shift** to sustainable transport modes such as public transport or by shifting goods transport by trucks to rail.

- ▷ Under the topic of **“Mobility”** in **Chapter 3**, avoid and shift policies of relevance in China will be discussed for each mode of transport. To do so, demand statistics, key drivers for demand, current regulations in China, barriers and opportunities will be presented.

Energy intensity can be further reduced by **improving** vehicle efficiency for example through low-resistance tires or the promotion of electric drive trains. Regulations such as fuel economy standards and investments in electric vehicle charging infrastructure are potential measures.

A **fuel switch** intends to reduce **carbon intensity** per unit of energy consumed. The actual CO₂ intensity for conventional fuels depends on the carbon content and on the efficiency of combustion. The climate protection potential of drive trains fuelled with electricity depends foremost on upstream emissions of power generation.

- ▷ Under the topic of **“Fuels and Drives”** in **Chapter 4** efficient engine technologies and alternative fuels will be discussed for all modes of transport and different energy sources.

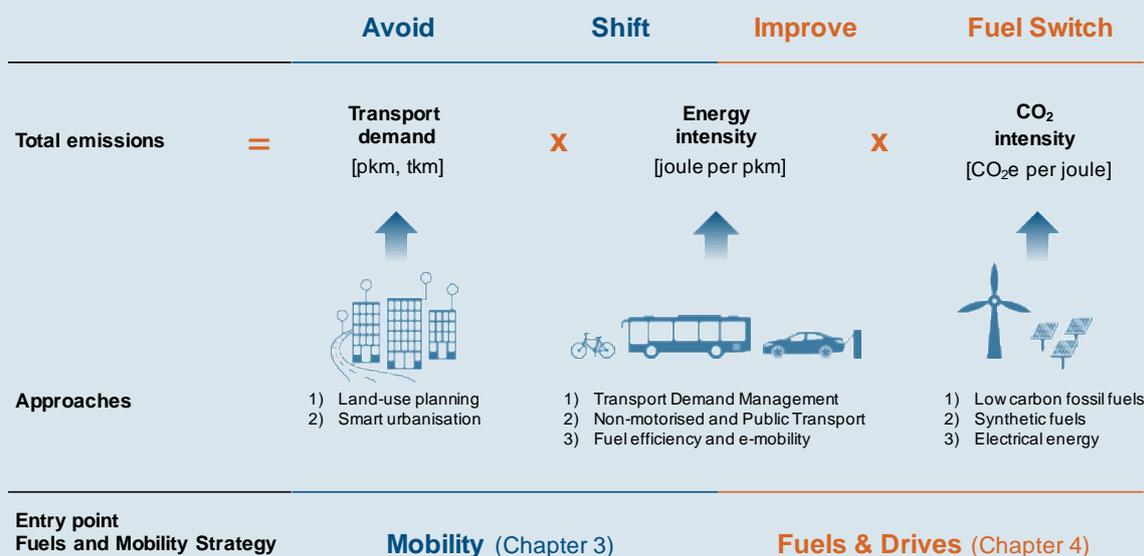


Figure 1: Avoid, shift, improve and fuel switches (A-S-I-F) are the conceptual entry points for this project (Source: Own based on Bongardt et al. 2013)

Methodological Approach

A key objective of the project was to promote the development of a participatory and integrated **MFS for China**. The German approach to a MFS was presented to relevant ministries and agencies and discussed in technical workshops and a larger policy forum in Beijing. After this first familiarisation with the concept, an interview matrix was developed by GIZ, TPRI and the Energy Research Institute (ERI) of the National Development and Reform Commission (NDRC). The complete matrix can be found in Annex A.

Interview requests were sent out to 25 key experts, of which 15 were subsequently interviewed. Each structured interview took between two to three hours. Experts represented mostly *think tanks* like the Research Institute of Highway (RIOH) and the China Academy of Railway Science, and universities such as the Civil Aviation University of China and Tsinghua University. From the public sector, the MoT and several municipalities were interviewed. The China Road Transport Association represented the private sector. Non-governmental organisations such as the Energy Foundation were participating in technical workshops.

The subsequent chapters summarise core messages derived from interviews and desk research. Results were presented and discussed during the *Policy Forum: Energising Transport and Mobility in China* in Beijing in July 2016.



2. Stakeholders for a Mobility and Fuels Strategy

Traditionally, transport infrastructure planning has been institutionally decentralised within major players such as the MoT, the Ministry of Railways, Ministry of Housing, Urban and Rural Development (MoHURD), and the General Postal Service Administration. With the increasing attention towards sustainability topics, with the development of new vehicle technologies and the appearance of new mobility services, interlinkages between multiple sectors and stakeholders are gaining significance. Concurrently, there is a tendency towards subsidiarity of policy making in China, which again integrates responsibilities and increases the need for interaction between different levels of government.

National energy savings, climate protection strategies, international climate negotiations and reporting are steered by the **National Development and Reform Commission (NDRC)**. Although positioned on the same administrative level as other Chinese ministries, NDRC has a coordination and decision-making role in many climate-change related aspects. This includes international climate negotiations and reporting. NDRC initiates own research and emission inventories development to its subordinate think tank – the **Energy Research Institute (ERI)** and the **National Center for Climate Change Strategy and International Cooperation (NCSC)**. ERI subsequently collects and verifies data from the respective competent sectorial ministries such as the MoT, while NCSC focus on strategic research and international cooperation. An influential centre under ERI is the **China National Renewable Energy Center (CNREC)**. CNREC is mainly tasked with developing strategies, policies and standards for the expansion of renewable energy in China. Both, ERI and CNREC, are key **intermediaries** between the mobility and energy sector.

The **MoT** is in charge of developing energy savings and climate change protection strategies and measures for all four modes of transport. Historically, the MoT was exclusively concerned with waterways and road transport. However, the **Civil Aviation Administration of China (CAAC)** was subordinated under the MoT in 2008. In 2013 the Ministry of Railways was dissolved and was split into a commercially operating **China Railway Corporation** for rail infrastructure construction and operations. The **National Railway Administration (NRA)** took over responsibilities for infrastructure planning, safety and regulation. These reforms made it possible to break up the monopoly, introduce competition and enhance the efficiency of the whole railway industry.

Sectorial priorities and programmes are being developed in the competent departments of the MoT. For energy savings and climate protection the **Department for Comprehensive Transport Planning (DOCT)** is in charge. The subordinate **Division for Environmental Protection** in practice develops policies for environmental protection in the maritime and road transport sector. Traditionally highly influential in terms of industry development and policy making are the **CAAC**, headed by a Deputy Minister, and the **NRA**, also headed by a Deputy Minister. Both, despite being integrated in the MoT, remain to enjoy some freedom and veto-power also in terms of energy savings measures in their respective modes. However, the DOCT coordinates energy savings strategies for all modes including urban transport, which the MoT took over from the **Ministry of Housing, Urban and Rural Development (MoHURD)** in 2008.

Especially as far as fuels and vehicle efficiency is concerned, the MoT has limited responsibilities. Interestingly the MoT only plays a minor role in the promotion of electro-mobility (see case study on Stakeholders for electro-mobility in Chapter 4.3).

The fundamental research, policy evaluation and scenario development is mainly delegated to four subordinate think tanks. In its research **TPRI** covers all modes of transport with a focus on developing climate protection policies, developing emission inventories and ex-post policy evaluation. The **Research Institute of Highway (RIOH)** is tasked with research on road transport specifically with a focus on commercial vehicles. RIOH monitors all pilot programmes on electric buses in China and supported the development of carhailing regulations technically. The **China Academy of Transport Science (CATS)** focuses on urban transport policy development and is in charge of supporting local authorities in developing urban transport emission inventories. The **China Waterborne Transport Research Institute** is tasked to monitor and conduct research on energy savings of inland waterways and maritime transport. The current major concern and focal area are air pollutants and alternative fuels.

There are several institutions not directly associated to the transport sector yet highly influential for its development.

A central veto-player and enabler for environmental programmes in the transport sector is the **Ministry of Finance (MoF)**. The MoF is responsible for budgeting and providing finances for transport infrastructure, pilot programmes and subsidies.

Second to NDRC, the **National Energy Administration (NEA)** is the most influential ministry and leading institution for the development of renewable energies including biofuels. NEA furthermore sets the standards for fuel quality. In addition, it coordinates highly influential state-owned enterprises such as Sinopec and State Grid (responsible for the electricity network and charging stations for electro-mobility).

The biofuel market is dominated by state-owned enterprises (SoEs) namely **China National Cereals, Oils and Food Corporation (COFCO Group)**, **China National Petroleum**

Corporation (CNPC) and China Petrochemical Limited (Sinopec). Due to the sensitivity in terms of biofuel and cropland competition, only SoEs have access to government incentives and subsidies.

The Chinese **Ministry of Environmental Protection (MEP)** is not responsible for climate change in the transport sector. Instead, the MEP is mainly concerned with air quality and is in charge of air pollution monitoring, mitigation strategies and emission inventories. Given the high government attention to this topic, MEP has gained influence in the transport sector as well. This is mainly exercised through the **Vehicle Emission Control Centre (VECC)** that is responsible for vehicle type approval from an environmental perspective (equivalent to the German Federal Motor Vehicle Transport Authority KBA). Since 2015 the MEP is in charge of defining the acceptable limits for exhaust emissions of new vehicles sold and will release the China VI standard by the end of the year. Previously, this task was undertaken by the **Ministry of Industry and Information Technology (MIIT)**. MIIT, however, stays responsible for corporate fuel economy standards and is also the most crucial ministry in regard to defining standards and technical regulations for electro-mobility.

The **Ministry of Land and Resources** is responsible for the development of plans and policies for the exploration and exploitation of oil, natural gas and coal. The **Ministry of Commerce** is responsible for energy circulation.

An important government advisory board on climate change related issues is the **China Council for International Cooperation on Environment and Development (CCICED)**, which was established in 1992 with approval of the Chinese government to support cooperation between China and the international community in the fields of environment and development. The Council composed of both Chinese and international members and advises the State Council (equivalent to a cabinet chaired by the premier and includes the heads of all departments and agencies) on climate change strategies including the transport sector.

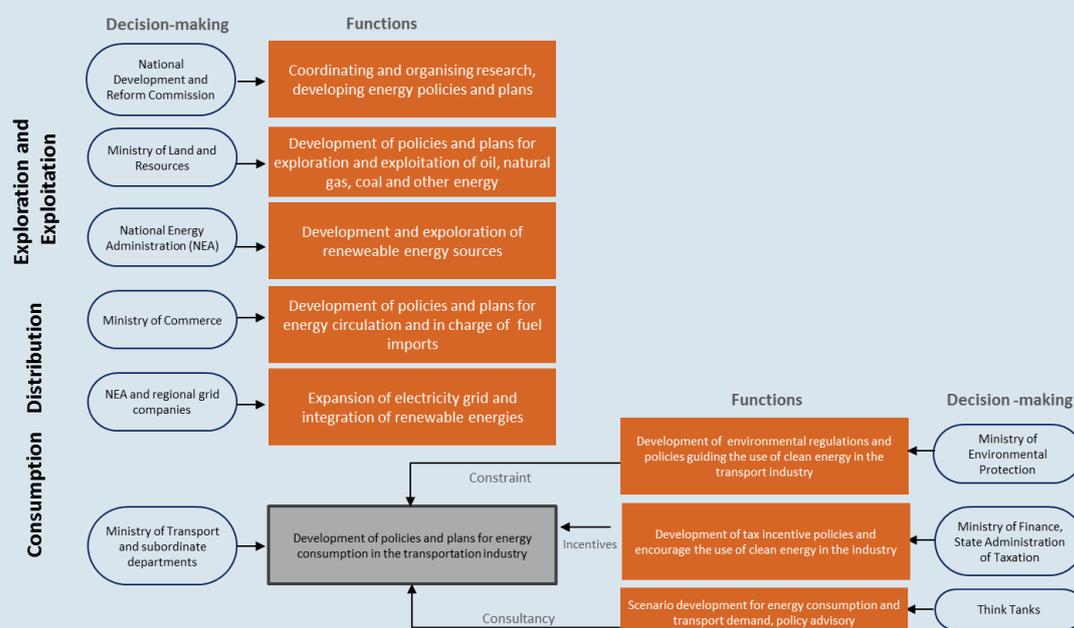


Figure 2: Chinese government institutions involved in fuel circulation and transport sector consumption (Source: Own)

Beyond the public governing bodies there are several pressure groups, industry associations and think tanks that provide methods and policy advisory, and finance pilots to a certain extent. An important

non-governmental organisation in China is the **Energy Foundation (EF)**. EF advises several Chinese governmental agencies and ministries, provides knowledge and seeds capital to pilot clean energy programmes throughout the country.

Institutional Barriers for a MFS Development

Competencies for fuels, drive systems and energy supply are highly dispersed. This raises some crucial barriers for the development of a MFS:

- 1) Availability of alternative fuels and energy sources are barely matched with the prospective development of the drivetrains and overall transport demand. Institutions such as NEA need to work closely with CAAC to estimate the potential supply and demand of biofuels for planes.
- 2) Emission and energy consumption scenarios developed by universities and institutes are insufficiently integrated in the political strategy development and decision-making process.
- 3) Private sector dialogues are ad-hoc and not systematically pursued. An institutionalized dialogue is required to ensure that innovations in different segments of the MFS (e.g. new mobility services, intelligent transport systems, etc.) are encouraged and a supportive regulatory environment is created.



3. Mobility

The Chinese economy looks back at decades of **strong and robust growth**. However, since 2012 China's economy has shown a slowdown, with growth rates declining from double digit levels (before the 2007-2009 financial crisis) to around 7% in 2015. Despite the slowdown (in China called „new normal“), the transport sector is expected to experience continuous growth in terms of passenger and freight volumes.

The focus of transport sector policy has long been on infrastructure development. However, it has now become a key industry and driver for China's industrialisation and market economy. Four out of ten strategic sectors identified in China's industrial agenda "**Made in China 2025**" are directly transport related namely the aviation and aerospace, new energy vehicles (NEVs), maritime transport, and railway industries.

The infrastructural foundations have been established in previous years: The Chinese **railway network** extends to 121.000

kilometres (km) of which 19.000 km are dedicated high-speed rail tracks, 60% of the worldwide high-speed rail network ⁽¹⁾. Today, seven out of the ten **largest ports** in the world are located in China ⁽²⁾. Overall domestic **freight volume** increased from 13.6 to 45 billion tonnes from 2000 to 2013.

The development of **individual mobility** has not been less notable: Every day 35,000 vehicles are added to already more than **144 million vehicles** driving on Chinese roads. The expressway network extends to 120.000 km. Public transport and non-motorised transport remain to be important modes of transport. In Beijing for example, 20% of trips are made by subway, 28% by bus and 12.6% by bike (down from 62% in 1986) ⁽³⁾. Private vehicle trips represent 30% of all trips and are roughly accounting for 30% of ambient **air pollution** in Beijing. The modal split statistic in Beijing does not include walking as a transport mode.

The **aviation sector** does not fall behind in any way. It is the fastest growing transport sector and is expected to continue to grow at an average of 4.5% over the next two decades. In the first six months of 2016 passenger trips even rose by 11% in comparison to the previous year, while cargo grew by 4%. Today China is the second largest single market in regards to passenger and cargo volumes by plane ⁽⁴⁾. The infrastructure investment focus continues to be on road network expansion and maintenance. According to the National Bureau of Statistics, 62% of fixed asset investments were earmarked for road infrastructure in 2014. 32% were invested in the railway and only 6% in the inland waterway sectors. The following table shows the investment priorities as stipulated in the 13th Five-Year-Plan (FYP) valid from 2016-2020.



High speed railway: Increasing total length of high-speed railways in service to 30,000km; linking more than 80% of big cities in China



Corridors: Linking highway and high-speed railway in border and coastal regions as well as along the rivers; constructing cross border corridors to neighbouring countries and main corridors along *One Belt, One Road*



Highway: Construction and upgrading of 30,000 km of highways



Civil airport: Construction of 50 new airports



Port and shipping facility: Improving the inland waterway channel *Bobai-Region* and further specialising berth for container, crude oil, LNG



City-cluster transportation: Constructing intercity traffic connections in city-clusters (*Beijing-Tianjin-Hebei, Yangtze River Delta, Pearl River Delta, upper reaches of Yangtze River, Chengdu-Chongqing*); implementing suburban rail demonstration projects



Urban transportation: Improving and optimising urban railway networks in megacities; accelerating the construction of urban railways in cities with a population of more than 3 million; building more than 3,000km urban railway connections



Rural transportation: Continuing development of rural road construction, in particular to solve the last mile problem and improve the connectivity of rural roads; improving infrastructure for post and express services



Transportation hubs: Constructing integrated passenger transportation and intermodal freight transportation hubs



Intelligent transportation: Promoting “Internet of Vehicles”, “Internet of Ship”, intelligent dispatching systems and autonomous driving; establishing a comprehensive public information platform and big data transportation centre



Electro-mobility: Expanding public and semi-public charging infrastructure for electric vehicles, develop market economy for electro-mobility

Table 1: Policy priorities in the 13th Five Year Plan (Source: 13th FYP, 2016)

Environmental Concerns Prevail

To date, transport demand and its related emissions have proven to be resistant to mitigation efforts. **Climate protection policies**, such as fuel economy standards, taxation or electro-mobility promotion have failed to effectively stop the growth of **CO₂ emissions** in most countries, including China. On the contrary, increases in fuel efficiency have been overcompensated by increasing demand not least on account of dropping fuel prices. Energy consumption of passenger vehicles increased from 52 million tonnes of standard coal to 170 million tonnes in 2010 and 252 million tonnes in 2013, which amounts to an almost six-fold increase in **energy consumption** with a clear trend towards further growth.

In 2011 the Chinese transport sector was responsible for 628 million tonnes of **CO₂ emissions**, a figure almost four times higher than in Germany ⁽⁵⁾. Current research by the study partner TPRI suggests that the road transport and mobile machinery sector could be responsible for a total 989 million tonnes of **CO₂ emissions** in 2014. However, while the transport sector accounts for 18% of total CO₂ emissions in Germany, China's transport related emissions only account for 8% ⁽⁷⁾. This provides a first indication about the global consequences, should the Chinese transport sector follow the unsustainable development trajectory experienced in Europe and the U.S: Two countries with significantly higher motorisation rates.

Transport Data

In terms of the **passenger transport demand**, railway and road transport continue to be the main modes of transport. Contrary to most other industrial countries, a growth similar to individual motorisation can be seen in the passenger volume of urban and high-speed rail. The most rapidly increasing mode of transport, however, is civil aviation, which is showing an exponential increase since 2000.

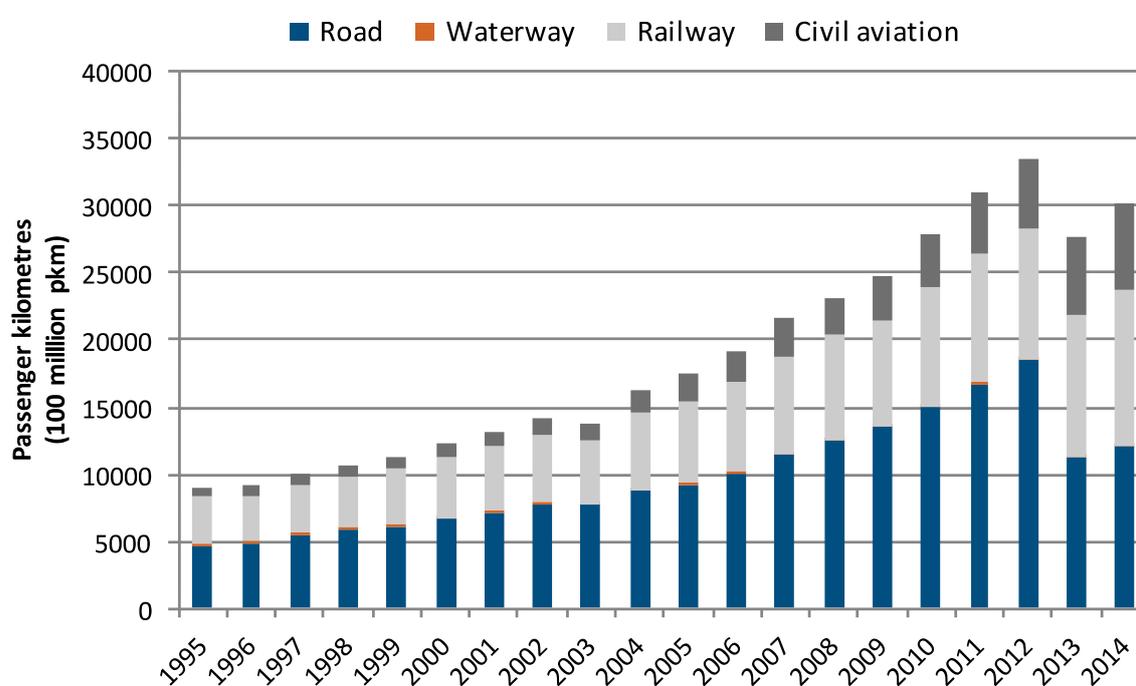


Figure 3: Passenger transport performance in China 1995-2014 (Source: China Statistical Yearbook, 2015)

While the **railway sector successfully competes** with the road transport sector in terms of passenger transport volumes, the freight transport sector depicts a significantly different picture. Within 10 years (from 2004 to 2014) the share of goods transported on rail dropped from 28% to 15% on account of a considerably higher share of goods being transported on roads. At the same time, the share of goods transported on China's vast road network increased from 11% to 33%.

Notably, inland **shipping** continues to be the main mode of freight transport. Its share increased from 51% to 60% from 2004 to 2014. Considering that the overall freight volume grew by almost three times, the maritime sector plays a crucial role in alleviating the risk of shifting a larger share of goods to trucks.

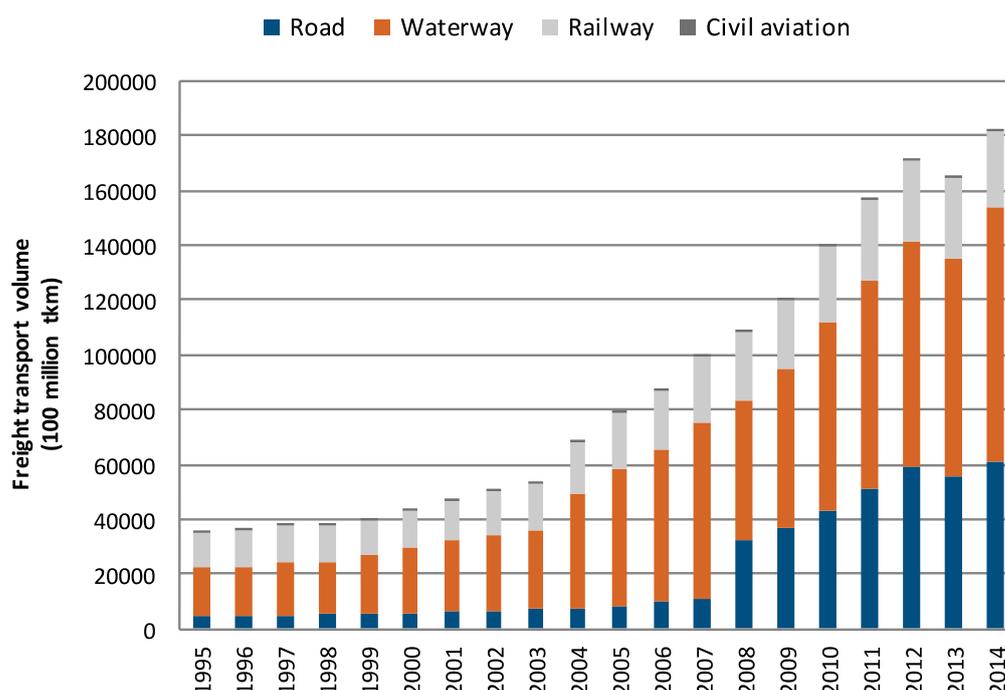


Figure 4: Freight Transport Volume in China 1995-2014 (Source: China Statistical Yearbook, 2015)

Sustainability Targets

The United Nations Climate Change Conference (COP21) in Paris end of 2015, preparations for the 13th Five-Year Plan (FYP) and *Made in China 2025*, and the decelerated economic growth have shaped the discussion on **transport policies in China** for the past year. In this context, China’s president Xi Jinping announced plans for comprehensive measures to develop a low carbon transport sector within the timeframe of the 13th FYP from 2016-2020. Xi Jinping stated that “*China will, on the basis of technological and institutional innovation, adopt new policy measures to improve the industrial mix, build low-carbon energy systems, develop green building and **low-carbon transport**, and build a nation-wide carbon emission trading market so as to foster a new pattern of modernization featuring harmony between man and nature*”.

The *Enhanced Actions on Climate Change: China's Intended Nationally Determined Contributions* submitted by China in June 2015 specified targets by 2030: Carbon dioxide emissions should peak by 2030, although they should **strive for an earlier peak**; carbon dioxide emissions per GDP should be reduced by 60% - 65% compared with 2005 values, and the proportion of non-fossil fuels in primary energy consumption should be increased to 20%. With regards to transport sector, the INDCs set the target to promote the share of public transport in motorized travel in big-and medium-sized cities reaching 30% by 2020, promote the development of dedicated transport system for pedestrians and bicycles in cities and to advocate green travel, accelerate the development of smart transport and green freight transport.

To accelerate the transition of the transport sector, the MoT has initiated the “*Four Transport Strategy*”. The strategy strives for an integrated, intelligent, green and safe transport system, whereas *green transport* serves as the guidance for all specific targets as in the table below.

	Indicator by 2020
Energy	1. 16% decline of energy consumption and 18% carbon dioxide emission of operating vehicles per unit

consumption and carbon emission intensity	transport volume compared to 2005
	2. 20% decline of energy consumption and 22% carbon dioxide emission of operating vessels per unit freight volume compared to 2005
	3. 16% decline of energy consumption and 30% carbon dioxide emission of urban passenger vehicle per unit person-time compared to 2005
	4. 10% decline of energy consumption and 12% carbon dioxide emission of port production unit per unit throughput compared to 2005
Supporting indicators	5. Population of new energy buses of 200,000 and 100,000 new energy taxis and urban distribution vehicles
	6. 90% of shore power use of main port ships and public berthing ships
	7. 50% of shore power supply capacity of special wharfs for containers, ro-ro passenger ships and passenger liners

Table 2: Targets of energy-saving and emission reduction for the transport sector in China

The Data Challenge

Data in the transport sector, in particular transport demand and energy consumption data, is one of the main challenges. This becomes evident in Figures 3 and 4 above. The drop in passenger kilometres in 2013 is by no means a factual result of fewer or shorter trips. In 2013 the MoT increased the number of **counting stations** for on-road vehicles which led to an increase in statistical accuracy and showed that road transport had been overestimated in the previous years

Data for **energy consumption** in the transport sector is equally problematic. There is no official data for energy consumption attributable for respective modes of transport collected by an official agency. Given that fuel consumption is taken into account in taxation, the only official data existing is for commercial vehicles. Thus, private and business vehicles, motorcycles, low-speed vehicles (agricultural transport vehicles, low-speed engineering machinery, etc.) and other vehicles (military vehicles, etc.) are not part of any official energy consumption statistics.

The quality of data collected in the field of **electro-mobility** has been discussed during the MFS workshops. A key concern is the definition of electric vehicles (all-electric range, size etc.). Given that subsidies for automotive companies and new mobility service companies (e.g. e-carsharing) and public transport operators depend on the amount of electric vehicles in operation, an improvement of data quality and monitoring was recommended.



3.1. Road Transport

Current Demand

Road transport has received most attention, both in terms of infrastructure expansion and in terms of environmental policies addressing increasing energy consumption and tailpipe emissions. In 2014, the road **passenger transport volume** and **road freight transport volume** reached 1.2 trillion person-kilometres and 6.1 trillion tonnes-kilometres, respectively. Road transport is accounting for 40% of total passenger and 35% of total freight transport performance. The passenger and freight transport volume of road transport have shown a trend of rapid growth: From 2000 to 2014, the passenger transport volume grew by 81.5% and freight transport by 895.4% respectively.

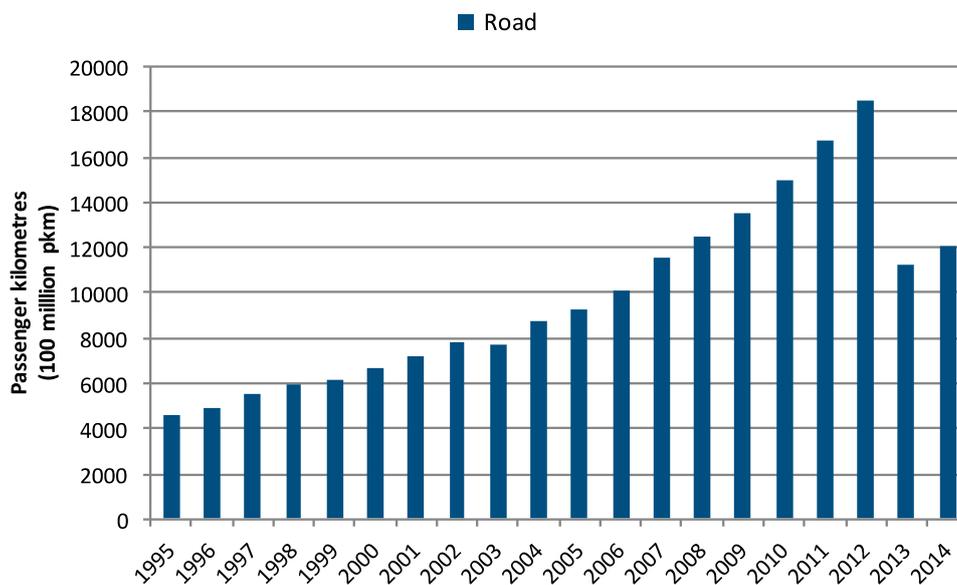


Figure 5: Passenger transport performance in China from 1995-2014 (Source: China Statistical Yearbook, 2015)

China's on-road vehicle fleet shows a rapid increase since 2000, which puts tremendous pressure on the environment, total energy consumption and the liveability of Chinese cities.

By the end of 2014, the total population of vehicles in China reached 245.8 million, of which 144.5 million were motor vehicles, 9.72 million were low-speed vehicles, and 91.53 million were motorcycles. 124 million motor vehicles are privately owned. Even though the absolute number of China's vehicle fleet is already unprecedented, the vehicle population per capita is still at a low level in comparison to developed countries. 80 out of 1,000 persons in 2015 own a car. A number that seems insignificant compared to Germany (561/1000) and the USA (828/1000) (7). Considering these numbers, it was eagerly discussed during the workshops and interviews, whether a similar growth pattern (as suggested by most fleet growth models) of the vehicle populations is indeed factually possible given the high urbanisation rate and **low bearing capacity** of cities.

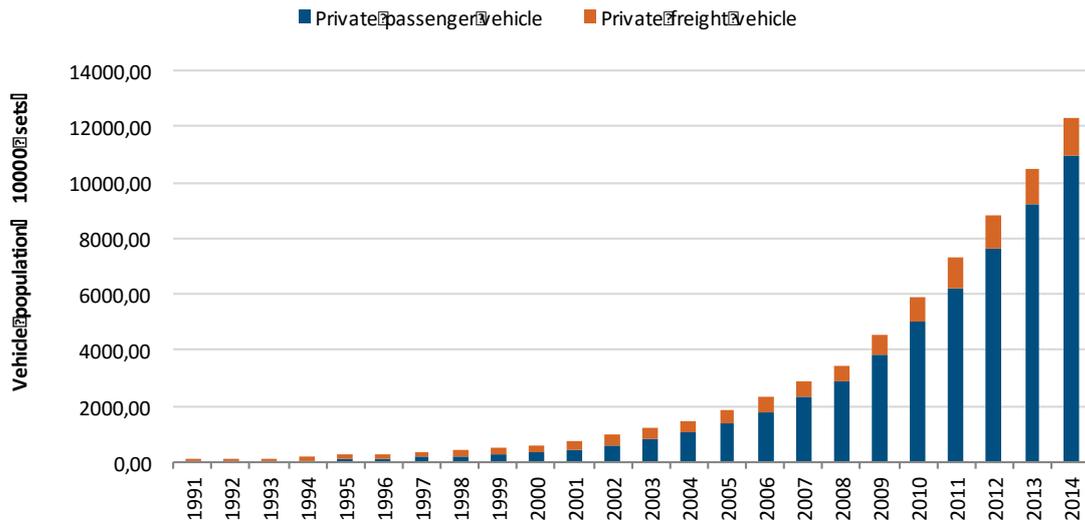


Figure 6: Private vehicle fleet in China 1991-2014 (Source: China Statistical Yearbook, 2015)

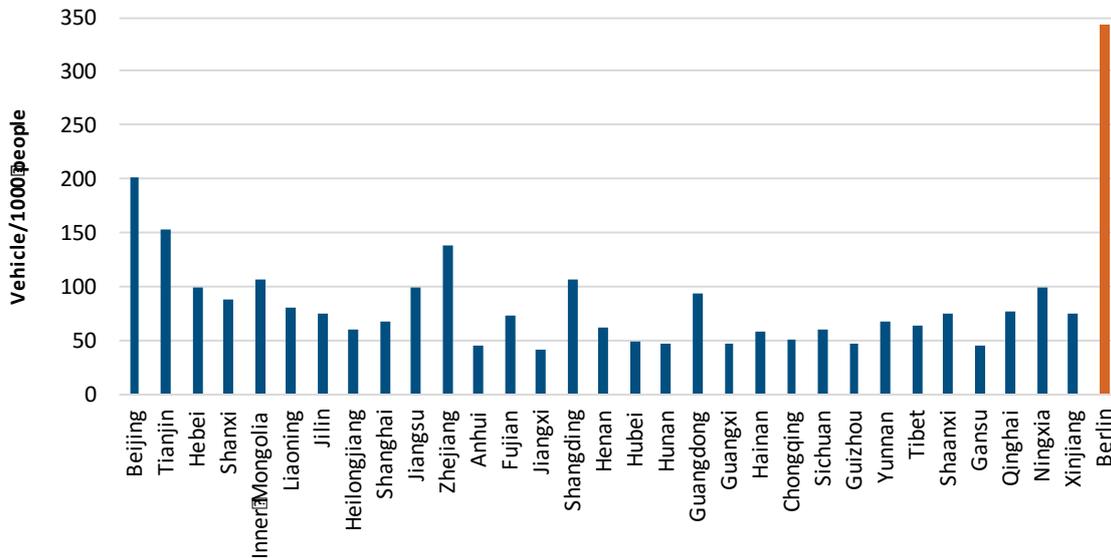


Figure 7: Vehicle Population per 1000 residents in selected cities in China compared to Berlin 2013 (Source: China Statistical Yearbook, 2015; Senatsverwaltung für Stadtentwicklung und Umwelt Berlin, 2013)

According to the outcomes of research (see Figure 8) conducted by the MoT, carbon dioxide emissions of China's road transport vehicles stood 989 million tonnes (mt), showing a continuous **upward trend** with decreasing growth rate⁽⁸⁾. The share of freight transport in energy consumption stands at 45% and is about to become the main source of road transport energy consumption and emissions.

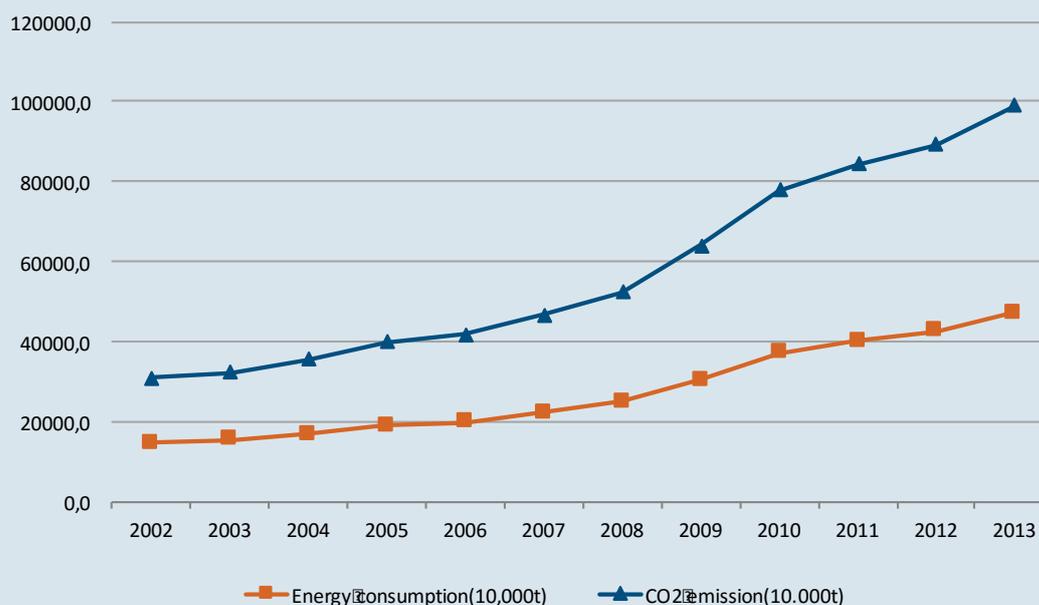


Figure 8: Energy consumption in standard coal and carbon dioxide emission of road transport in China 2002-2013
(Source: TPRI, 2014)

Policies and Trends

Since the road transport accounts for the **largest proportion of energy consumption** in the transport sector, energy conservation and emission reduction policies for cars and trucks are a clear focus of attention. Specifically measures to optimise freight transport, public transport development, transport demand management, and the promotion of intelligent transport systems (ITS) were implemented. Particularly in urban transport many policies were driven by the urgency to improve air quality. During the expert interviews the following key policies for intermodal freight transport, public transport and ITS were identified:

SN	Description	Policies	Description
1	Transit Policy First	Public Transit Priority Policy (2005) , Guiding Opinions of the State Council on giving Priority to Public Transportation in Urban Development (2012)	Public transport integration into the local public budget, exemption from vehicle purchase taxes for buses, fuel subsidies for buses, metro operators receive electricity price discount, land value capture around transit station should be pursued.
2	Pilot Public Transport Programme	Transit Metropolis Pilot Programme	Transit Metropolis Programme is the pilot programme – administered by the MoT – on a national level, aiming to promote transit-oriented development (TOD) and high quality transit services.
3	Local Transport Demand Management (IDM)	Vehicle Restriction Measures	Measures implemented on a local level include vehicle purchasing restrictions, driving bans, parking management, high-occupancy lanes. Especially larger municipalities are independent in their policy formulation.
3	Drop-and-Hook Logistics Pilot Programmes	Subsidy and investment programme for Drop-and-Hook market development	148 national pilot programmes for Drop-and-Hook transport were initiated and supported by the central fiscal funds; pilot programmes at provincial level were



			launched in Shandong Province, Jiangsu Province, Fujian Province, Guangdong Province.
4	Intelligent Transport	Scheme for Information Construction of Transport in Jilin Province, Several Opinions on Strengthening the Construction of Intelligent Transport System in Shanghai and Strategy for Intelligent Transport Development in 2012-2020	<p>Projects in the implementation of ITS focused on</p> <ul style="list-style-type: none"> - urban intelligent transport including parking information, cell-phone data analysis, traffic management, public transport information - digital expressway traffic flow management - electronic toll charging - intelligent logistic information and data sharing

Table 3: Selected road transport energy saving policies

The following policy trends were highlighted throughout the interviews because of their relevance for road transport demand and future emission trajectories:

Urban Transport Demand Management

The effects of continuing mass motorisation are daunting and exacerbated the pressure on Chinese city planners and political decision makers to provide liveable urban environments. This has led to an unprecedented implementation of transport demand management measures. In the last decade, the focus was on “push” measures that restrict **vehicle ownership and usage**. Following the early-adopter of these measures, Shanghai, Beijing has continuously reduced the number of allowed annual vehicle registrations. At present, 150,000 licences are in a licence plate lottery system each year. From 2018 to 2020, the Beijing Commission of Transport will cap the total number of newly added cars at 300,000 by issuing an average of 100,000 new license plates each year ⁹⁾. The current 5-year plan aims to limit the number of cars on the road to 6 million by the end of 2017 and 6.3 million in 2020. Chances of “winning” the lottery stand at 639:1. All registered vehicles are only allowed to be driven on 4 out of 5 weekdays.

Nonetheless, experts identified two divergent trends in terms of transport demand management measures. While many (mostly small and medium sized cities) follow the example of Beijing and **restrict vehicle registration** numbers, there is a trend towards **economic incentives** in larger cities. Beijing is currently discussing the implementation of a congestion charge, as known from London or Stockholm, which charges drivers based on the distance driven within the city centre.

Two main reasons for these deviating trends have been identified: Firstly, restrictive measures do not require much regulatory capacity, yet achieve the target of easing congestion with a high degree of certainty. Secondly, especially in larger cities with a higher degree of autonomy (tier 1 cities) local governments are aiming at a lower administrative interference and lower economic distortion.

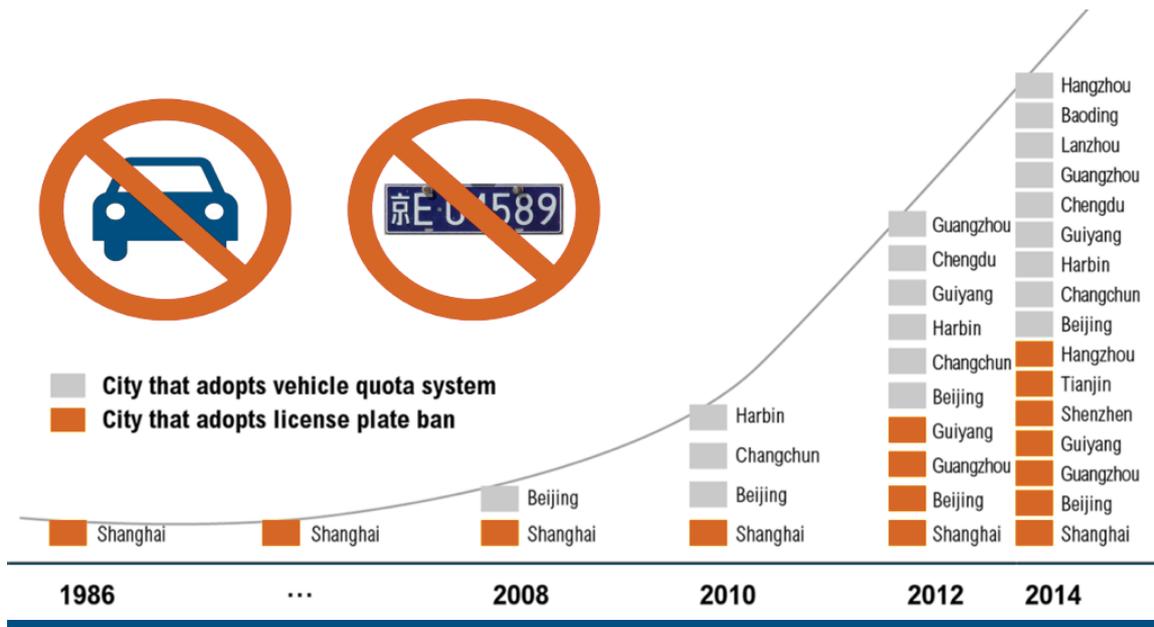


Figure 9: Several cities implement restrictive demand management policies in China (Source: World Resource Institute 2015)

Public Transit Priority

China has implemented an ambitious set of policies and programmes aimed at strengthening urban public transport and non-motorised transport over the last decade. In 2005, the country started its Public Transit Priority policy, which since then has been updated and expanded.

However, despite substantial investments in subways and bus systems, the share of public transport decreased in all major cities. This is why the MoT developed the large-scale *Transit Metropolis Programme* in 2012. Its goal is to drive **public transport expansion** and **transit-oriented development** in Chinese cities. Since then 37 pilot cities have been officially approved as transit metropolises. A series of indicators had to be met to be eligible for funding. For example, pilot cities must have a resident population of at least 1.5 million, be a national highway transport hub and have an existing public transport system that has exemplary character ⁽¹⁰⁾. Several indicators to be achieved by the pilot cities were set by MoT including accessibility to public transport, quality levels and energy consumption. Cities were furthermore required to present an integrated public transport plan to become a pilot city.

The 37 pilot cities receive seed funding from MoT which is financed through the vehicle purchase tax ⁽¹²⁾ and can receive additional funding through the *Energy Saving and Emission Control Fund*. The programme had a remarkable impact on urban **public transport in China**. The number of buses added in the context of the programme stood at 350,000 in 2015. 55% of buses added in Chinese cities since the programme initiation in 2012 were financed through the *Transit Metropolis Programme* ⁽¹³⁾. 92 additional subway lines have been opened. Bus Rapid Transit systems with a total length of 1500 km were supported. For the phase where an additional 50 pilot cities will be supported, the focus will be on service quality and alternative fuelled buses. An evaluation system for the quality of public transport services will be developed.

An important decision for the financing of urban transport projects is the **price deregulation** for public transport operators and the permission for urban authorities to issue special municipal bonds for transport projects. Additionally the MoT and the MoF have released new guidelines for the procurement of public transport services that encourage market based procurement ⁽¹³⁾.



Challenges

The experts interviewed were asked about the most pressing challenges in terms of providing sustainable mobility on the road network.

Urban Design

At first glance the picture we have of Chinese cities and the statistics don't match: How is it possible that Beijing is facing severe congestion while having a considerably lower motorisation rate than cities in Germany? The answers are long distances and high density. The population density in urban areas in China is significantly higher compared to Germany or the United States. From the perspective of integrated land-use and transport planning this is an ideal situation to achieve high accessibility to public transport. However, the focus of transport planning in China's cities is on accessibility to road infrastructure which has resulted in the development of urban canyon and urban sprawl. This does not only encourage the usage of a private car but also substantially decreases the convenience of non-motorised transport and accessibility to public transport.



Integrated Public Transport Planning

A major challenge in the context of the *Transit Metropolis Programme* is the integration of public transport services in urban and transport infrastructure planning. Rail systems and public transport infrastructure are often considered an exterior component rather than an integral component of land-use planning and transport demand management. First attempts to tackle the problem are taking shape in form of integrated public transport plans. To receive funding from national governments for the transit metropolis programme, cities need to develop integrated plans for all modes and



integrate land-use planning. In this context, the City of Beijing has effectively integrated several transport demand management measures with the objective to shift passengers from private cars to public transport (see Figure 10).

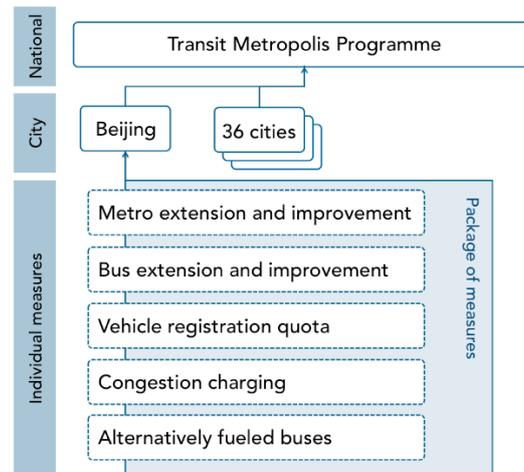


Figure 10: MRV Blueprint for Urban Passenger (Draft) (Source: Transport National Appropriate Mitigation Actions Illustrated by the Chinese Transit Metropolis Programme, 2015)

Consistent Financing for Public Transit

Another important element of public transport funding in China is the manner in which cities can issue and manage debt. Currently there is no dedicated national fund to support urban public transport and non-motorised transport development in Chinese cities beyond the Transit Metropolis Programme. At present, fuel consumption and vehicle purchase tax revenues, which are currently the main revenue source in transport, are generally earmarked for highway construction in preference to public transport. Usually national funding is only provided for capital investments, rather than in operations. Cities rely to a large extent on land concessions to generate revenue for public transport. This has created an unsustainable income stream which makes it difficult to fund regular occurring operational costs. Also, there is a detrimental effect of these land concessions in terms of urban transport. The more land is being sold, the larger the chances of urban sprawl, lower densities and dependence on car based transport systems. Currently cities make no or very limited use of the benefits generated through public transport such as increased land values along transit corridors. It is of key importance to de-link urban revenue from land concessions. ⁽¹⁴⁾

Yet, some cities are the exception to the rule. Shanghai, for example, dedicates its number plate auction revenues to public transport investments and has successfully implemented transit-oriented corridors. The *Transit Metropolis Programme* further foresees that public transport should be integrated into the local public budget and that the municipal authorities make full use of land value capture around transit stations. While the national government provides seed funding, the bulk of investments are borne by local authorities.

Vehicle fleet growth rate and uncertainty

The high rate, at which vehicle fleet growth will continue, was considered to be the single most important impeding factor on the liveability of cities, on air pollution and greenhouse gas emissions.

Experts stated that both the rate of growth as well as the growth pattern towards a saturation rate are unprecedented and to a certain extent unexpected. The growth rate so far mainly has been determined by economic development, urbanisation and population growth. An important China specific factor has not been captured adequately by transport demand models: The saturation level of



China's road network. Experts consider this to be considerably lower in comparison to countries with a lower population density in urban agglomerations. It was suggested that the current trend towards lower mileage per vehicle might already indicate a trend towards saturation. An analysis of academic studies (see Figure 11) stresses the high uncertainty in terms of the fleet development. Even in a relatively short prediction period the vehicle size varies between 300 and more than 500 on-road vehicles in 2030.

To an extent only known in China, it is further expected that demand management policies will have a major effect on the vehicle stock in the future. For instance, the City of Beijing will further reduce annual vehicle registrations to 100,000 vehicles per year.

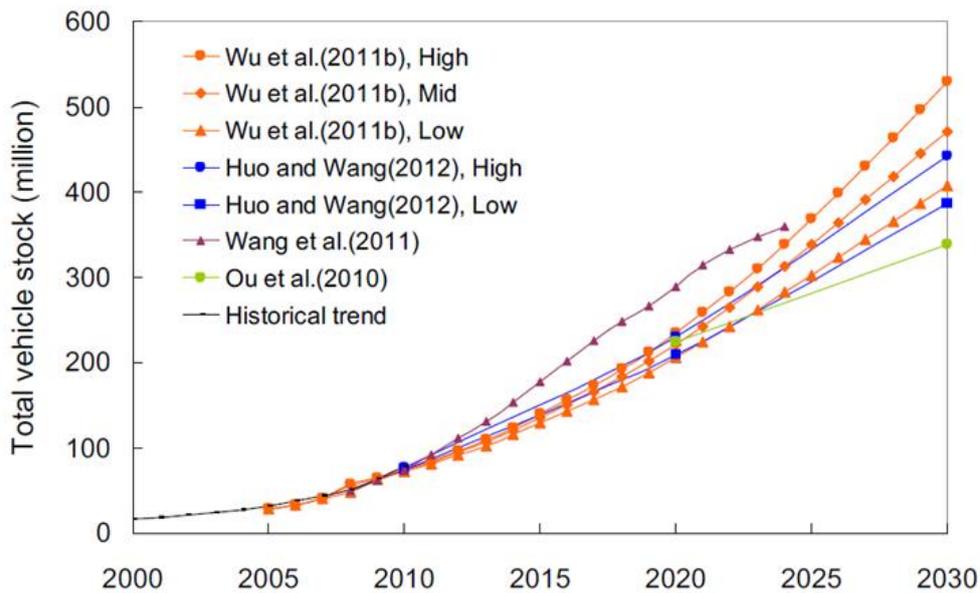


Figure 11: Uncertain growth trends for the Chinese total vehicle stock (own compilation based on Wu et al. (Source: 2011, Huo and Wang 2012, Wang et al 2011, Ou et al. 2010)

Any sensible transport policy and strategy requires adequate data and a degree of predictability – this is no less true for the development of a comprehensive strategy like the MFS. An assessment to evaluate which policy measures, drive systems and fuels are most promising in reducing energy consumption and emissions can only be done if a relatively clear picture on key drivers for demand, fleet composition and future policies exists. The accuracy of models and availability of demand data on a national level is a key challenge for strategy development in China.

Fragmented Freight Industry

By the end of 2014, 7.45 million hauliers and freight forwarders with a total number of 14 million trucks were operating on the market. 99% of these hauliers are so called “individual operators” with one or two trucks. The current market structure barely allows for optimisation of the logistic chain. According to data released by the NDRC, 37% of all trips were made with no cargo in 2014. In addition to the high share of empty trips, the **load factor** of trucks is very low in general. Consolidation of shipments, high utilisation of transport capacities and optimisation of transport routes is difficult to coordinate in a fragmented industry. Data sharing on route and cargo sharing rarely occurs.



Operators in the road freight market are unable to invest in **energy efficient vehicles**. The lack of funding closely relates to the size of the company, unfair competition caused by overloading and uncertainty of business as most operators are providing only basic transport services without value added logistics services, leading to product homogenisation and short-term contracting of customers.

Case Study: Private Sector Initiatives for Green Freight	
The China Green Freight Initiative (CGFI) is China's national voluntary private sector programme, which aims to improve energy efficiency and reduce emissions from road freight, improve and upgrade road trucks in China, and promote broader sustainable development of China's road freight sector. The programme consists of three components: Green management, green technology and green driving.	
Governance and Funding	
Programme Type	CGFI was launched in 2012 as public-private partnership by the China Road Transport Association (CRTA), backed by the MoT (MOT) and other ministries, and supported by the Research Institute of Highways (RIOH) and Clean Air Asia (CAA). Funding is provided by the Energy Foundation but additional partners contribute actively.
Programme Scope	
Members	As per May 2015, 20 carriers joined the programme and participated in the pilot of the CGFI draft standards. Lenovo and Procter & Gamble joined the programme in 2014.
Emissions	CO ₂ , PM, NO _x , SO _x , because CGFI aims to address government policy objectives in relation to climate and clean air.
Solutions	Vehicles/fuels and fleet management. Modal shift will be considered in the future.
Programme Components	
Targets	Instead of setting targets for individual companies, member carriers are encouraged to meet the requirements under the CGFI standards for green trucks and green carriers.
Actions	<ul style="list-style-type: none"> – Green management: Aims to improve fleet management, for example, through better loading practices, logistic alliances and drop-and-hook practices using articulated vehicles and long-trucks. – Green technologies: Aims to promote the adoption of green technologies for trucks e.g. through lightweight trucks, low-resistance tires. Through the development of green truck standards and issuance of a catalogue of green technologies and energy-saving products the process will be supported. – Green driving: Driver-training programmes to promote eco-driving through the development of eco-driving training programmes and guidebooks. <p>Future priorities for CGFI include: policy support and service for freight enterprises; promote and implement standards; accelerate industry-government alliance; establish a data collection and assessment method; start pilot projects such as technology verification.</p>
Measurement Reporting & Verification	CGFI plans to develop a methodology for calculating road freight emissions, which will build on existing international methodologies, frameworks and standards, and could be developed in parallel to methodologies for other modes (air, sea, rail, inland waterways, and transshipment centers).
Labels & Recognition	CGFI is developing two standards: The Green Freight Enterprise Standard and Green Freight Vehicle Standard. The standards can be the basis of a potential carrier label under CGFI.

Table 4: Case Study China Green Freight Initiative



Entry Points for a Mobility and Fuels Strategy - Expert Recommendations

Mobility scenarios

Comprehensive mobility strategies for cities and regions should be a priority considering the environmental degradation in many Chinese cities and the plans to strengthen regional integration. A comprehensive regional mobility strategy should be based on a robust mobility assessment (assessment of current transport demand and energy consumption of all modes of transport in a region) and an analysis of changing preferences of urban citizens. Some recommendations for the development of mobility plans were given:

- quantified review of the current development status of mobility and transport patterns (e.g. planning procedures and strategies, review of past strategies, transport demand situation, availability of public transport services, mobility behaviour) both for passengers and freight.
- development of an online platform that allows for sharing of standardised data from e.g. mobility surveys and traffic counts.
- Integration of mobility assessments and scenario development in regular policy making process (e.g. the five-year city development plans, regional cluster development plan).

Digitalisation

The speed of digitalisation in road transport and the application of intelligent transport systems are considered key challenges but also an important opportunity to improve customer experience in mass transit systems, improve operational efficiency, increase safety of road transport and improve the utilisation of assets and infrastructure.

The following recommendations were made:

- Accelerate the application of intelligent transport systems in public transport operations both in terms of passenger information systems and improved scheduling and maintenance management. Create best-practice sharing hub between cities (e.g. on standard data formats, service level agreements for operators, procurement sharing).
- Facilitate the exchange between industry and regulator (local, national and international) on the legal and regulatory framework on automotive and connected driving (data safety, standardization) for private and public transport vehicles.
- Apply big data analysis in urban mobility planning: The processing of large data volumes available from GPS tracking, mobility and transport mobile phone apps, online-user generated content is inconsistently used and still widely untapped. The data should be used



to establish the potential of intelligent transport systems and digitalization to avoid and shift traffic (inherent part of mobility scenarios).

- Initiate a discussion on the possible impact of automotive driving and digital transport management on transport demand.

Improve freight industry dialogue and cooperation

The consolidation of shipments, increased utilisation of transport capacities, route optimization and empty trip reductions can be achieved by a systematic cooperation between freight forwarders. For example, logistics cooperation between medium size companies can connect shippers, parcel service providers, and truck drivers.

Improve freight market administration

Fleet renewal should be a key priority of policy making. The existing regulatory framework is sufficient but requires improved enforcement of vehicle standards, overloading and industry administration. Additionally, public funding for a scrapping-scheme of polluting vehicles should be considered.

Research on road trains

The potential application of road trains in China should be explored in regards to their environmental impact and road safety. The interviewed experts suggested that larger trucks are considerably more efficient as they do not only increase the load factor but could also replace old engine technologies and consolidate the market.

Develop City Logistic Concepts

City logistic concepts should be an integral part of an urban mobility strategy. Carriers that are implementing innovative city logistics concepts should be supported, standards for delivery vehicles in urban area established and transit and parking policies for freight vehicles developed.



3.2. Rail Transport

Current Demand

In the past railway transport has always been an important mode of transport in China. In 2014, China's passenger railway transport volume reached 1.2 trillion pkm resulting in a modal share of 39%. Freight transport volume reached 2.8 trillion t-km, a modal share of 15%. Compared to 2000 this represents an increase in passenger volume of 156% and 100% in terms of freight. An unprecedented, 2.5 billion passenger trips were made on trains in 2015. Today, the Chinese railway network extends to 121,000 kilometres (km) of which 19,000 km are dedicated high-speed rail tracks. 60% of the worldwide high-speed rail track can be found in China. 24 cities are currently operating different urban rail transit systems with a total length of 3,300km.

The rapid increase in passenger volume is mainly attributed to the rapid increase in the high-speed railway network coverage. Regional trains have not been given the same attention. Despite the fact that freight and passenger railway networks are separated, the overall amount of goods being transported on trains is declining. The main reason is that the rail network is utilised to a large extent to transport mass goods such as steel and coal. Both industries are declining while the demand for on-time delivery for higher value goods increases.

Remarkable success has been achieved in the energy conservation and emission reduction owing to a number of policies and measures taken in the railway transport sector. The national railway energy consumption in 2015 stood at 15,700,000 tonnes of standard coal, reduced by 833,700t (5.0%) compared to the previous year. This is despite the fact that overall transport volume increased. The energy consumption of unit transport volume was 4.68t of standard coal/million tkm. A reduction of 6.6% compared with that of 2010.



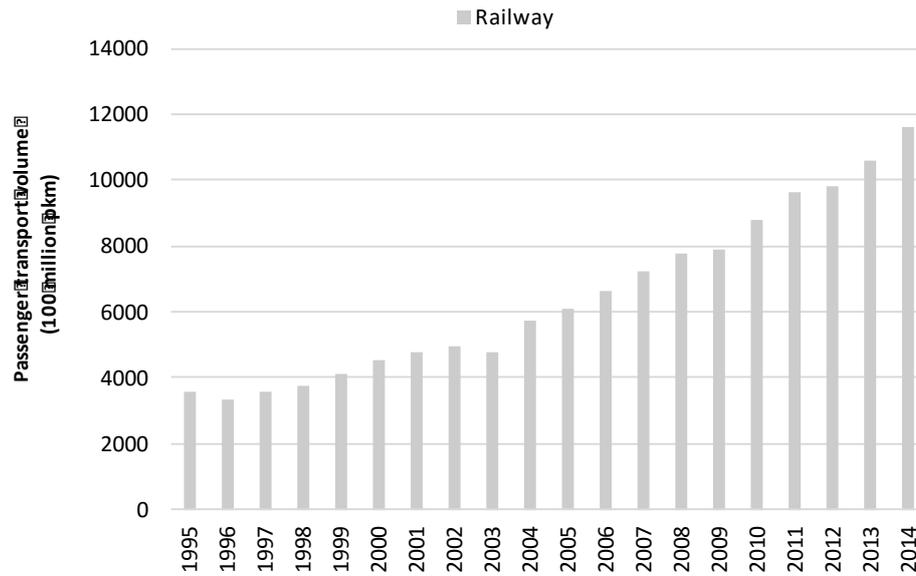


Figure 12: Passenger Transport Volume of Transport Industry in China during 1995-2014 (Source: China Statistical Yearbook, 2015)

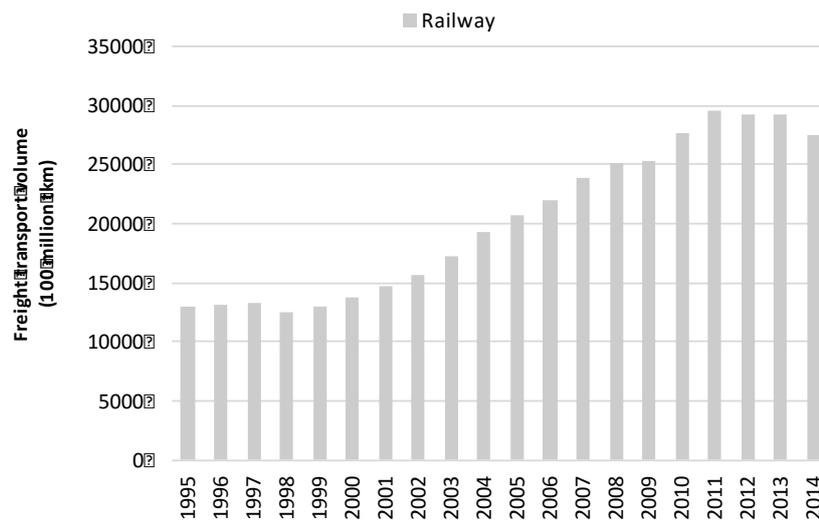


Figure 13: Freight Transport Volume of Transport Industry in China during 1995-2014 (Source: China Statistical Yearbook, 2015)

Policies and Trends

Transport policy in China clearly prioritises railway infrastructure development. It is largely acknowledged that railway exclusively provides the required transport capacity. With the rapid expansion of renewable energies in China, the advantages of railway in energy conservation and environmental protection will be further tapped into. Therefore, railway policy mainly focuses on infrastructure development and further electrification. In 2016 alone, 800 million RMB are planned to kick off investments for the *Transport Programme 100-200-300*. The aim of the programme is to expand high-speed rail network to 30,000 km by 2020. By then, 80% of Chinese large and medium sized cities should be connected to high-speed rail.



Regional Integration and international rail connections

To improve connectivity of structurally weaker regions, the expansion of rail infrastructure focuses mainly on central and west China. Beyond that, the national government sees regional train connections as a backbone of the recently launched City-Cluster-Initiative (A more detailed overview on the City-Cluster-Initiative can be found in Chapter 2.1.5.2. Integrated urban and regional transport planning). The focus of development will be to increase capacity and connectivity of regional intercity and suburban trains. New institutions are currently being discussed and to some extent already initiated –see example of the Jing-Jing-Ji Railway Company below.

Regional Rail In Jing-Jin Ji – Following the German Example?

The two cities (with a province status like Berlin or Hamburg) **Beijing** and **Tianjin** and the Hebei province- traditional called Jing-Jin-Ji complete the largest agglomeration area in China and the largest regionalisation project worldwide. With a size of 200.000 square metres the city-cluster¹ is double the size of Bavaria and has –with around 130 Mio. people- more residents than any European country.

Suburban and intercity trains –comparable to the German S-Bahn and Regionalbahn- are missing to a large extent. Both train categories have the potential to replace private car commuting if adequately integrated into the public and non-motorised transport system. This is why the China Railway Rolling Stock Corporation Limited (CRRC) founded the Jing-Jin-Ji Intercity Railway Investment Company in mid-2015, together with the Beijing and Tianjin municipalities and Hebei province. While the focus will be on developing the infrastructural requirements during the initial stage, the long-term goal is to promote regional connectivity, operate regional and suburban trains and ensure adequate integration into the overall public transport system. With an investment of 193 billion RMB by 2020 the company is expected to build 1000 km of railway infrastructure in the cluster.



The strategic management of the Jing-Jin-Ji Railway Company is set up similar to German Transit Companies (Verkehrsverbünde), where provinces and municipalities are represented in the boards, an approach that has been proven successful in terms of ensuring seamless local and regional multi modal public transport. According to one of the railway experts interviewed, the competitiveness of railway in the Jing-Jin-Ji region will be decided by the ability of the Jing-Jin-Ji Railway Company to “*move from asset to mobility management*”.

Another major policy development influencing the railway sector is the “One Belt- One Road Initiative” to revitalise and expand the historic Silk Road. Railway experts highlighted that the high political attention to the initiative will have a largely positive impact on national intermodal transport. Contrary to mass-goods oriented domestic railway network infrastructure, the Eurasia railroad is exclusively planned for time-sensitive, high value goods that are being transported in containers. To

¹ The City-Cluster-Initiative is explained in more detail in Chapter 3.6 „Urbanisation“



support the *One Belt, One Road* initiative China will develop transfer hubs to distribute containers between modes which benefit domestic logistics as much as they supports international rail transport.

Private Investment in Rail Infrastructure and Operations

To sustain investments in railway infrastructure local and national governments increasingly seek for private investments. In 2015, NDRC released *the guiding suggestions to encourage private investment in railway construction*. Since then, private investments in construction and operation of rail services are legitimate. Various financial schemes are supported, such as public-private partnerships in form of franchises or equity cooperation. Due to concerns regarding lengthy break-even periods and guarantee mechanisms, the market remains hesitant, however.

Challenges

Intermodal Freight Transport

Continuously declining demands for bulk cargo (e.g. coal, ore, etc.) and increasing demand for time-sensitive goods require structural adjustments of the rail freight sector. Just in time delivery, door to door logistics, tracking and tracing are logistical developments rather easily met by road freight transport. As a consequence, the railway is continuously losing market share in China during past years. The share of rail freight transport performance fell from 31% in 2000 to 15% in 2014.

The main identified challenges to offer a competitive logistic service on rail are:

1. Infrastructure

- Last mile connectivity for sea port hinterland traffic is insufficient. The railway network is hardly integrated with the port infrastructure. The lack of direct railway connections to ports leads to additional road transshipment between sea and rail which increases the cost and complexity of handling for operators and customer.
- Transshipment terminals for continental intermodal transport are lacking. Most of logistics parks have no railway connection or intermodal transport infrastructure. There are currently only nine central container terminals in China.

2. Standards and Harmonisation

- Standardised inland containers, swap bodies and semitrailers for land transport are not widely used in China. This restricts the promotion of intermodal transport systems which is a key barrier for the promotion of a shift of freight to rail.

Standards for rail transport units such as railway flatcar and road trailers are not harmonised countrywide. This further restricts the multi modal handling of goods.

3. Operations

- The structural change towards an intermodal logistic chain is further hindered by a lack of capacity in the competent institutions. The railway operational management is still based on block train services instead of waggon load traffic.

Low utilisation of return cargo

Economically unequal regions hinder a profitable domestic operation of two-way traffic. The same holds true for rail traffic between Germany and China. The low volume of return cargo from Germany is a key challenge. First examples for return traffic include automotive industry component supplies or chemical industry products.



Entry Points for a Mobility and Fuels Strategy - Expert Recommendations



Expand an integrated passenger rail transport in city-clusters

Each city-cluster is composed of individual and widely differentiated urban transport systems in each of the cities. In the context of a regional mobility strategy focussing on rail two priorities should be set:

- 1) Integration of different transport modes to increase transfer efficiency. The integration should not entirely focus on infrastructure but also on convenience of intermodal passenger trips (e.g. integrated payment, ticketing, route planning)
- 2) Develop and integrate all four layers of railway from an operational management and infrastructure perspective including national high-speed trunk rail lines, intercity rail lines, suburb rail lines and urban subway networks.

Developing a rail track based Beijing-Tianjin-Hebei Megapolis has been a shared target among the involved municipalities.

Improve intermodal freight and improve modal integration

Beyond the evident need for improved intermodal infrastructure, the operational management of intermodal logistic chains needs to be improved. Freight rail operations in China are largely dominated by the CRRC and China Railways (CR). Historically both companies focused on the transport of long-distance heavy goods such as coal and ore. Transport of containers and high value goods requires a new set of operational management skills, tracking infrastructure and supply chain management. Especially in high density agglomeration areas with a high density road network, as seen at China's east coast, a highly efficient rail operations management is required to challenge trucks as the fierce competitor. It is recommended to improve knowledge exchange with European railway operations, where equally efficient operations are required in order to compete with road freight transport.

Digitalise energy consumption data collection and processing

Energy consumption data collection and information systems of railway stations and operators need to be established and improved in order to be able to collect and process real-time statistics. Stations are to adopt intelligent energy management systems to most efficiently steer rail traffic.



3.3. Shipping

Current Demand

Waterway transport is a low-cost, low-pollution, and low-carbon mass transport mode. China has a coastline of 18,000 km and the world's longest and most extensive inland waterway system with a total of 126,300 km of navigable waterways. Maritime transport is the cornerstone of international trade and global economy. China's undoubted role as a **global player** in international trade is confirmed by data: In 2014, freight throughput of China's coastal main ports size reached 7.7 billion tonnes, a six-fold increase compared to 2000. Today, 7 out of the 10 largest ports –in terms of transport volume- in the world are located in China (3). Shanghai being the largest and Tianjin (located 100 km east of Beijing) is completing the top 10. For passenger transport shipping does not play a crucial role.

With a modal split of 50%, **shipping is currently the main mode of freight transport** in China. The waterway freight turnover—including river, coastal, and ocean shipment—accounts for about half of the overall freight transport in China. In 2014, China's shipped freight volume reached 9.3 trillion tonne-km of which maritime transport accounted for 5.6 trillion tonne-km (60%). China's shipping continues to show a rapid growth trend. In 2014, the inland waterway and maritime transport volume increased by 291% and 228% compared to 2000, respectively.

Experts from the Waterborne Transport Research Institute identified the following key reasons for the continuing expansion of the shipping industry:

1. Rapid acceleration and modernisation of China's economy and expansion of international trade relations, expansion of trade institutions and increasing number of free trade agreements
2. The size and interconnectivity of China's inland waterways
3. China's "rail and waterway first" policy that encouraged shipping as a dominant mode of freight transport.
4. Continuing importance of coal and steel, goods which are most suitably transported on ships

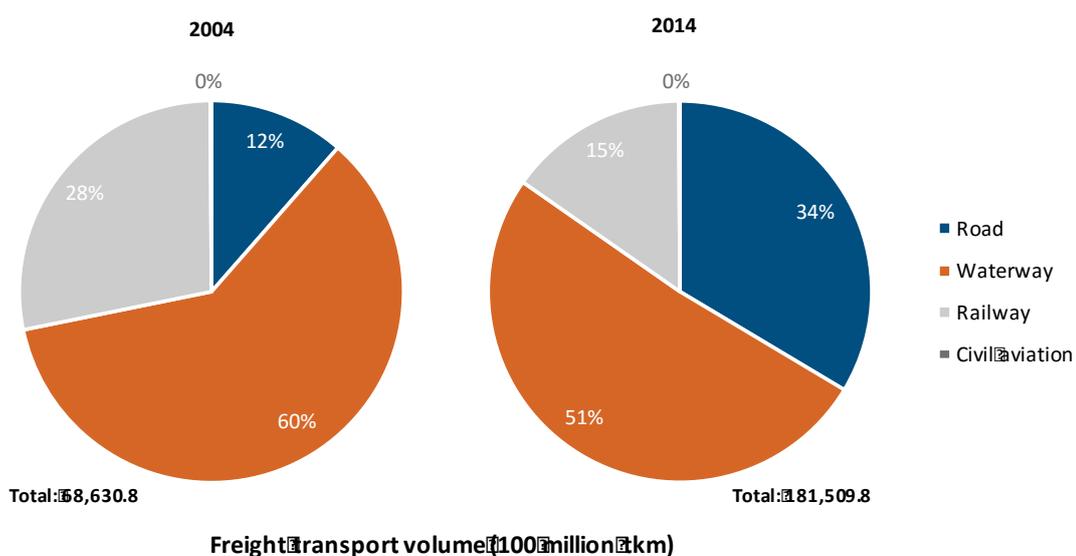


Figure 14: Modal Share Freight Transport (Source: China Statistical Yearbook, 2015)



China's current statistical standard for energy consumption measurements in the transport sector does not include the shipping industry. Consequently, there is neither an official emission inventory nor are there official industry development scenarios or forecasts.

According to TPRI research, in 2013 the energy consumption and carbon emission of China's shipping sector was 57.75 million tonnes of standard coal and 125.42 million tonnes of CO₂ emissions respectively. Both numbers are far below those of the road transport despite a considerably higher transport volume. Energy consumption and greenhouse gas of shipping experienced a slow growth during the nineties, and embraced significant upsurge since 2000. At the same time, the shipping transport industry witnessed a gradual reduction of passenger transport volume.

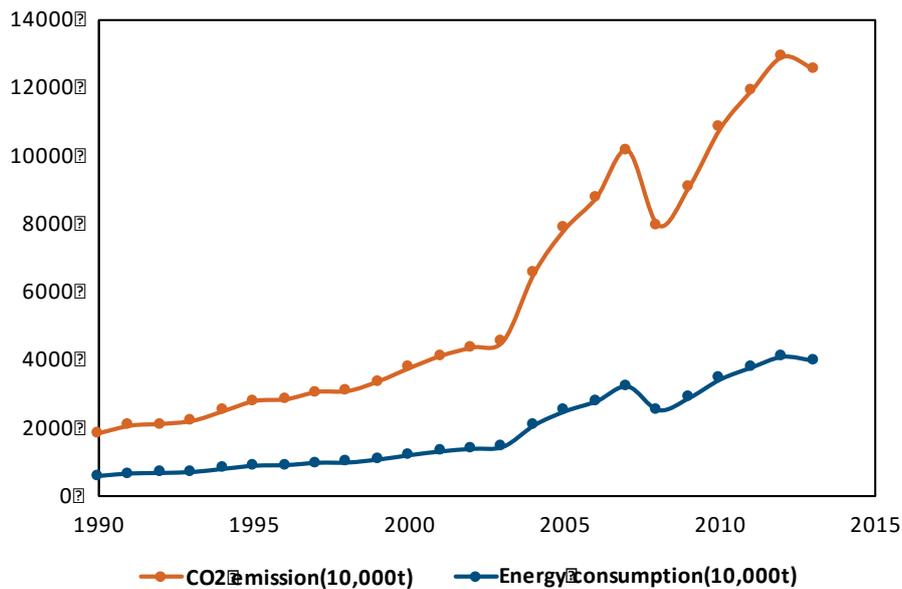


Figure 15: Energy Consumption (standard coal equivalents) and Carbon Emission of Shipping Transport in China of Inland Waterways and Coastal Shipping during 1990-2013 (Source: TPRI, 2014)

Beyond CO₂ emissions and energy consumption, the MoT is concerned with air pollution from the shipping industry. Research has shown that **around 70% of pollutant emissions** from international shipping occur within 400km of coastlands and are carried hundreds of kilometres inland on the account of land-sea winds⁽¹⁵⁾. In China, policies addressing air pollution are especially critical considering that the largest ports in China are also located in the regions with the highest population density such as the Pearl-River-Delta with the cities of Shenzhen, Guangzhou, Hong Kong, Macau and Foshan. Almost 60 million people are living in this economic centre and are affected by air pollutants from nearby ports.

Policies and Trends

In recent years, MoT has expanded the construction of inland waterways to accelerate the development of the shipping industry and to fully tap into the energy conservation and emission reduction potential. A shift from road freight transport to shipping remains a policy priority. Beyond infrastructure development, policy makers are concerned with fuel quality and low carbon fuels, ship design standards, emission standards and emissions produced at ports (by port operations and landed ships).



To implement the national strategy set out in the 12th and 13th Five Year Plan, the MoT (MOT) has developed a set of technical standards and specifications for low-carbon ports, including vessel engine specifications, vessel design standards, and operational management certifications. In the 12th Five Year Plan policies and regulations mainly focused on CO₂ emission reduction. In the 13th five year plan further combined measures are planned to be put in place to mitigate both air pollutants and CO₂ emissions.

To do so, the MoT has issued comprehensive research on the preparation of standards for fuel consumption and CO₂ emissions. Financial incentives to shift towards low carbon fuels (especially LNG), standards and specifications for efficiency evaluation of ships in operation as well as the early termination of high-energy-consumption ships in operation are currently being implemented. Technical and financial assistance is given to shipping enterprises in establishing an energy efficiency management system to promote energy efficiency evaluation.

Another policy focus is port emission reduction. Current environmental policy in the shipping industry foresees upgrading port infrastructure with green technologies such as off-shore power supply, electricity powered gantry cranes, upgrading of heavy duty port vehicles and cargo-handling machinery, vapour recovery as well as emission accounting measures.



The International Maritime Organization (IMO) has outlined standards for greater efficiency throughout all stages of a ship's lifecycle. The Energy Efficiency Design Index (EEDI) is used to calculate a vessel's energy efficiency. This is based on a complex formula, taking the ship's emissions, capacity and speed into account. The EEDI requires newest ships to become gradually more efficient. The MoT is currently in the process of establishing a database for EEDI compliance and industry monitoring in China.

Market-based measures such as emissions trading are foreseeable in the future and will create further incentives to invest in efficient ships and efficient port operations. Shanghai is in a pilot-phase to report, measure and verify emissions from its local port. Being the largest port in the world, this has quite a few implications for the national emission trading system (ETS) that will be launched in 2017. Key problems for the consideration of the entire shipping sector in an ETS are the boundaries for sea transport (essentially an international reporting system would be required) and accounting procedures for inland waterways.

As far as shipping pollution standards are concerned, the Effluent Standard for Pollutants from Ships (GB 3552-83), enacted in 1983, is currently the only standard that targets pollution from vessels, and it covers effluent and garbage discharge only.



SN	Title	Issued by	Main contents
1	National Plan for Inland Waterways and Ports 2007 to 2020	MoT	The plan foresees channel dredging, upgraded and new locks, ship lifts, and new and upgraded terminals for both bulk and container traffic. The plan foresees to expand inland waterways to 19,000 km compared to less than 9,000 km in 2006.
2	“12th Five-Year Plan” for Energy Conservation and Emission Reduction for Road/Shipping Transport (2011-2015)	MoT	The energy consumption for unit transport volume of ships in operation reduces by 15%. The energy consumption for unit throughput of port operations reduces by 8%.
3	Overall Implementation Scheme for Energy Conservation and Emission Reduction for Shipping Transport in the “12th Five-Year Plan” Period	MoT	Application of LNG-driven and electrically driven horizontal transport vehicle technology on a pilot basis” and “application of inland water diesel-LNG hybrid-driven ship technology on a pilot basis”
4	Opinions on Accelerating the Development of Inland Water Transport (e.g. the Yangtze River), 2011	MoT	It is proposed to complete the construction of a high-efficiency, reliable and green modern inland water transport system. The focus is on improved intermodality with a focus on pipelines and road infrastructure. The plan foresees a strong role for provincial governments. They are responsible for providing funding, guide medium sized operators in scaling up operations, develop support services such as warehousing and land distribution and develop a monitoring system for pollution and emissions.
5	Implementation Scheme for the National Promotion of Inland Ship Type Standardization in the “12th Five-Year Plan” Period (2011-2015)	Bureau of Shipping Transport, MoT	No access to the shipping market will be given to new non-standard ships for inland water transport. The existing non-standard ships will be withdrawn from the market in stages which leads to a fleet renewal. The standards aim at a unified ship design in terms of size, weight etc.
6	Management Measures for Subsidy on Ship-Class Standardization on Inland Waters 2014	MoF, MoT	The policy focuses on fleet replacement by providing subsidies for efficient ships: CNY30,000 for vessels with a tonnage under 1,000 tons, CNY40,000 for vessels above 1,000 tons but under 2,000 tons, and CNY50,000 for vessels over 2,000 tons.

Table 5: Energy Conservation & Emission Reduction Polices in the Shipping Transport Sector

Challenges

Unbalanced cargo flow and lack of intermodality

The inland waterway shipping industry relies on a high utilisation rate to run a competitive logistic service. The high economic disparity between provinces leads to an unbalanced flow of goods which makes it difficult for operators to run profitable businesses. The problem is further exacerbated by a lack of intermodal handling facilities. Interfaces with other modes are required in order to be competitive with a highly flexible road transport.

Lack of emission inventories for ports and shipping industry

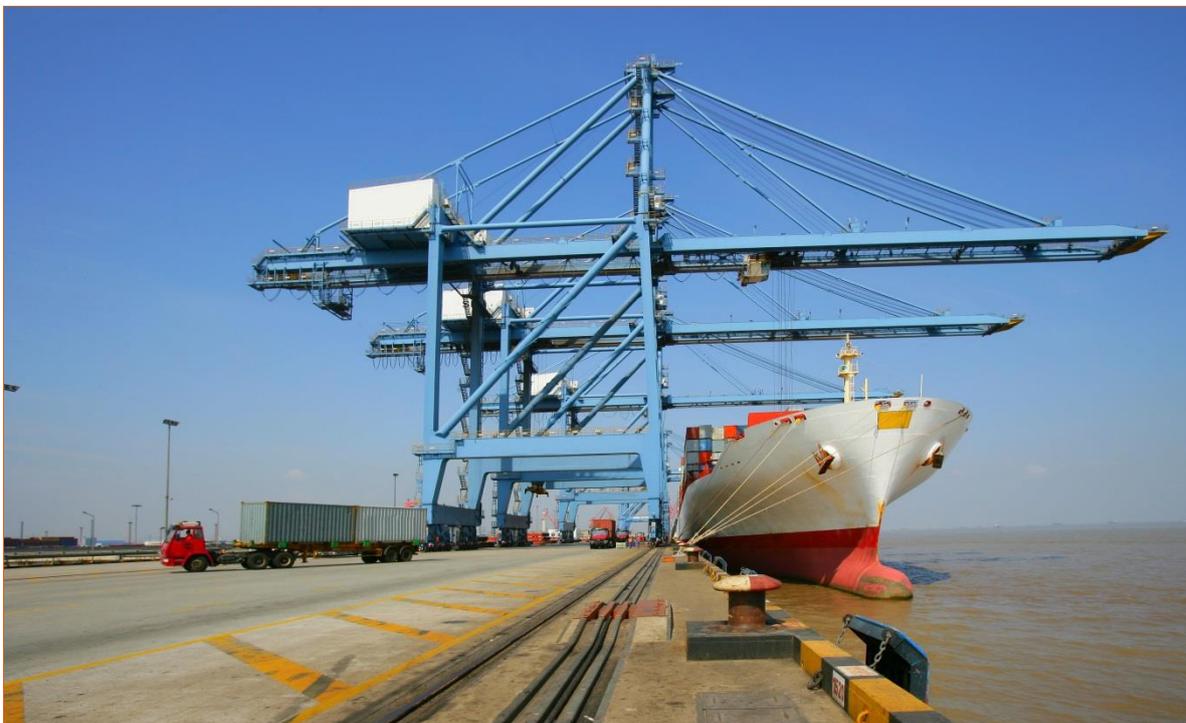
Since the adoption of China’s 12th FYP (2011-2015) for Environmental Protection, the MEP and the MoT have issued a series of regulations, fiscal incentives and measures to implement and encourage emission reduction projects. However, to monitor the implementation and to prioritise measures adequate data and baseline studies are still missing or currently being developed. So far, only the cities of Shanghai, Shenzhen and Hong Kong have produced emission inventories ⁽¹⁶⁾. Inventories are a



prerequisite to effectively introduce mitigation measures both at ports and for ships. More information on energy and emission saving potentials of proposed measures could further reduce opposition from ports and the shipping industry.

High competitiveness among ports in Asia

As stated, 7 of the largest 10 ports are located at China's east coast. 15 out of the 20 largest ports are located in Asia. In this highly competitive environment, environmental policy making is extremely difficult as most measures such as off-shore power infrastructure, fuel switches and engine upgrades come at substantial costs for the industry. Being a major source of income for the region, a major provider of employment and the backbone of supporting economic activities, ports are considered a key asset for the region and therefore fear a reduction in demand if high-cost measures are implemented. However, there has been a largely consistent national policy making by MoT to ensure that the regulations are implemented by all ports. The IMO has put efforts into the alignment of engine efficiency standards, for example, to further support fair competition despite more stringent environmental standards.



Entry Points for a Mobility and Fuels Strategy - Expert Recommendations

Develop clean port plans

Clean Ports Plans take account of strategies to reduce pollution from every source including ships, trucks, trains and cargo-handling equipment. Strategies could include mobility measures such as financial incentives for speed reduction but also investments in shore power and LNG infrastructure as well as incentives for pollutants reducing technologies and efficient engines. Ports can also implement technology advancement programmes in the framework of Clean Port Plans to test new technologies and share their results. Two key underlying success factors for Clean Port Plans were identified:

- Before drafting Clean Port Plans ports should develop an emission baseline. By developing



an emission inventory sources and relevance of different pollutants can be identified. This allows to more accurately evaluate costs and benefits of various pollution control measures specific to a port or region. Given the high competitiveness of the industry, the most cost effective measures should be implemented first.

- The incentive and penalty structure, in particular, highly depends on an adequate monitoring and evaluation programme that can be agreed upon by a multi-stakeholder landscape.

Given the different situation at each port in terms of the goods handled, the types of ships landing and also in terms of geographic and weather conditions, port specific emission inventories are required but national accounting and monitoring standards should be the basis.

Expand incentives for fleet renewal

During the 12th Five Year Plan period ambitious regulations and incentive programmes have driven the development and deployment of alternative fuels and advanced emissions control technologies on ships on a pilot scale. A well balanced policy approach to environmental standards is considered a key success factor to allow the shipping industry to keep its share in overall freight transport. It is therefore recommended to upscale the incentive programmes for the deployment of environmental technologies for engines and alternative fuels and to continue the scrapping programme on a larger scale. At the same time ambitious emission standards should be adopted.

Optimize shipping industry organisation and management

A number of measures were further suggested to improve the shipping industry efficiency:

- No other mode suffers as badly from a lack of integration into the overall transport system as the inland waterway. The government's regional cluster development initiatives such as the Beijing–Tianjin–Hebei (Jing-Jin-Ji) and Yangtze river economic corridor could be a good entry point to address the current disintegration. It is desirable to set up alliances of different government levels, freight forwarders and shipping companies to ensure an integrated transport planning that plans for intermodal, combined transport and efficient inland ports.
- The application of cloud computing technology can improve port efficiency by realising data integration between different businesses and administrations along the supply chain. Information sharing, resource matching, intermodal freight matching, routing etc. The experts recommended to initiate industry task forces that are potentially involved in developing joint e-commerce platforms such as financial institutions, customs, logistic enterprises (across modes) and cargo owners.
- Intermodal and combined transport of container shipping should be further supported through infrastructure development and operational improvements. This includes truck roll-on-roll-off [ro-ro] vessels.
- Lock management and capacity needs to be improved. Lock waiting times are a key challenge for inland waterways.



3.4. Aviation

Current Demand

Air transport is the transport mode embracing the most robust growth in recent years. In 2014, China's air passenger transport volume reached 633 billion pkm, freight transport volume reached 19 billion tkm, accounting for 21% and 0.1% of the total passenger and freight transport volume. China has the most rapidly growing passenger aviation market in the world (by total passenger numbers). Between 2009 and 2014, the number of annual passengers increased by over 47% to a total of 391,000,000⁽¹⁷⁾. According to the CAAC, in the first 6 months of 2016 the amount of passenger trips rose by 11% to 230 million and 60 new international and 151 new domestic routes opened, a clear indication for continued growth expectations.

Despite having established an energy consumption monitoring platform in 2011, the data has not been released publically by the CAAC. According to own research by TPRI on behalf of the MoT, the energy consumption of China's air transport industry reached 32 million tonnes of standard coal in 2014. 97% of energy consumption can be directly attributed to flight operations. The remaining 3% is attributable to energy consumption of airport ground handling.

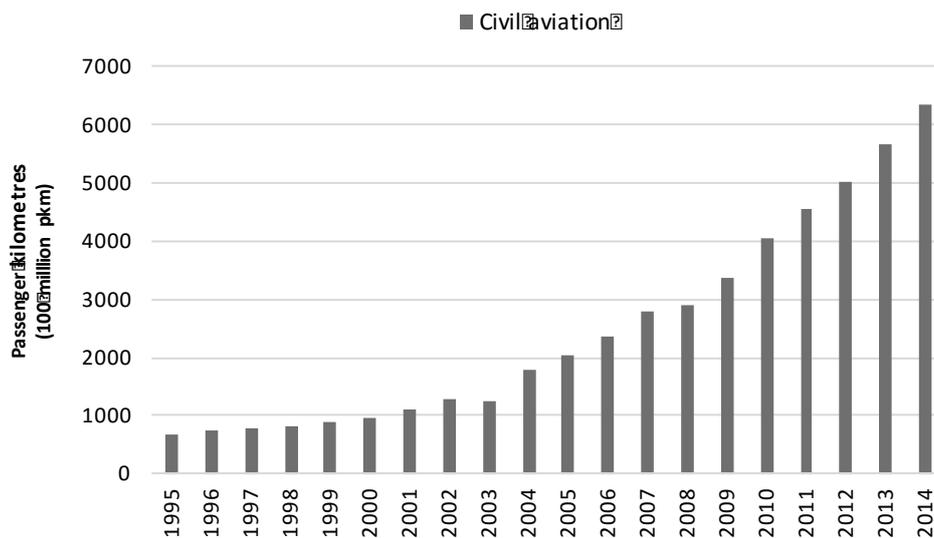


Figure 16: Passenger transport performance of the civil aviation industry in China including domestic and international flights (Source: China Statistical Yearbook, 2015)

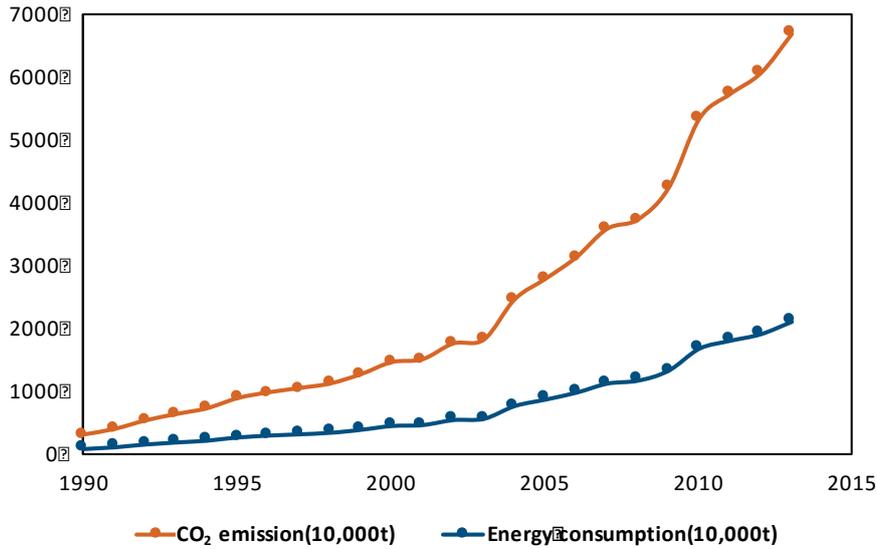


Figure 17: Energy consumption and carbon emissions of China's air transport industry during 1990-2013 including domestic and international flights (Source: TPRI, 2014)

Policies and Trends

Global environmental policy making in the aviation sector is mainly driven by the International Civil Aviation Organisation (ICAO), a United Nations Institution. Its medium term goal is “keeping the global net carbon emissions from international aviation from 2020 at the same level” (18). Given current best available technology, this would require an emission reduction of 1 million tons CO₂ annually after 2020 until 2050. This represents a target that is higher than current overall emissions. This objective could only be achieved through the industry-wide application of power-based fuels and biofuels (See Figure 18 below) (20).

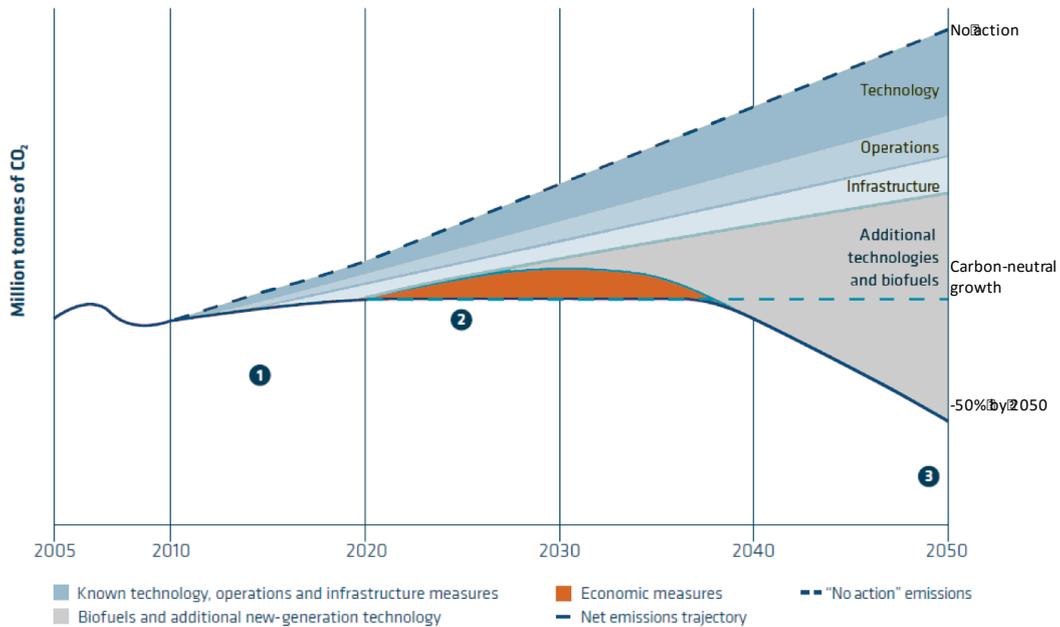


Figure 18: Emission Reduction Scenarios in the Aviation Sector (Source: Air Transport Action Group, 2015)



As a council member of the ICAO, the CAAC has taken the responsibility to implement climate protection measures and promote environmental policy in the civil aviation sector. CAAC has issued a State Action Plan aiming for specific energy consumption reductions of 22% per Revenue Tonne Kilometre (RTK) by 2020 compared to 2005. The aviation experts also highlighted that principles of "Common But Differentiated Responsibilities (CBDR)" and respective capabilities should be considered when setting mitigation objectives and measures.

SN	Title	Issued by	Main contents
1	Civil Aviation Industry Energy Conservation and Emission Reduction Plan 2005-20015	CAAC, NDRC	Energy consumption and CO ₂ emissions per tkm should be reduced by 15% compared to 2005 and the decontamination rate of refuse and sewage treatment rate of new airport would reach 75% in 2015.
2	Opinions of CAAC on Accelerating the Promotion of Energy Conservation and Emission Reduction within the Industry	CAAC	Fuel consumption per Revenue Tonne Kilometre in civil aviation will be reduced by 22% by 2020 in comparison to 2005.
3	Management of Special Funds for Energy Conservation and Emission Reduction of Civil Aviation 2012	CAAC, MoF	The fund is used in areas such as technical innovation of civil aviation energy conservation, energy-saving civil aviation management, application of new energy supply purchasing and renovation of new energy or energy-saving ground vehicles and construction of route optimization projects. It further includes renovation of facilities for airport waste, sewage treatment and water reuse; construction of civil aviation energy conservation and emission reduction standards, statistics, monitoring and evaluation.
4	Civil Aviation Energy Conservation Special Fund Project	CAAC	528 million RMB are earmarked to support the implementation of 238 energy-conservation and emission-reduction pilot projects.
5	Civil Aviation Industry Energy Conservation and Emissions Reduction Plan (2005-2015)	CAAC	Analysis of the status of energy conservation and action plan for emission reduction measures.

Table 6: Energy Conservation & Emission Reduction Polices in the Aviation Transport Sector

Under the state action plan the CAAC implements comprehensive energy efficiency programmes and actions with a focus on upgrading of airports and low energy consuming ground handling infrastructure.

Remarkable success has been achieved in energy conservation and emission reduction owing to a series of policies and measures taken. According to the statistics available from CAAC, fuel consumption in the aviation sector per tkm in 2015 was 0.3 kg. A reduction of 13.5% compared to 2005. However, the emission reduction of higher engine efficiencies has been overcompensated by an increase in transport volume.



In 2015, support was provided for 220 projects in eight categories (among them: electrification of ground vehicles, new engine technologies) meeting the *Guidelines for Special Funds for Energy Conservation and Emission Reduction of Civil Aviation* ⁽²⁰⁾. By conducting the programme of replacing the Auxiliary Power Unit (APU) operations by gate powers in Beijing Capital International Airport, Shanghai Pudong International Airport, and Guangzhou Baiyun International Airport, 38,000 tonnes of fuel were saved and 121,000 tonnes of carbon dioxide emissions mitigated. According to preliminary estimates, the reduction in average annual CO₂ emissions would reach over 900,000 tonnes when all projects are put into operation ⁽²⁰⁾.

A crucial environmental policy in the aviation sector will be the national emissions trading system (ETS). In the “13th Five-Year Plan” period, a unified carbon market will be built in China that will include the aviation sector (passenger and freight transport as well as airports) as one of eight key emitting sectors. So far Shanghai has implemented an ETS pilot and developed guidelines for monitoring, evaluation, verification and boundaries. The *Shanghai Development and Reform Commission guidance for quantification and reporting in the aviation sector* gives a first hint on how the reporting system could look like on a national level. All air carriers are required to report on the emissions of all aircrafts operating on domestic flights. International flights including Hong Kong, Macau and Taiwan as well as training and non-commercial flights are excluded from the trading scheme. The nationwide trading system will be established from 2017 onwards.

Moving towards a low-carbon economy is not a domestic but international challenge. This is especially accurate for the civil aviation sector. There is no end to the current growth trend in sight. According to the civil aviation experts growth will be further encouraged by the following developments:

- ▷ Increasing connectivity of medium sized cities: It is government policy to increase the economic integration of medium-sized cities (mainly tier 3 and 4 cities). The number of China's airports with scheduled flight will increase to 270 by 2020 from around 175 in 2010. The demand is fuelled by an increasingly wealthy middle class across China.
- ▷ The Silk Road initiative is also certain to boost air traffic further. Easing visa requirements and increasing trade agreements with neighboring countries and regional partners will further drive demand upwards.
- ▷ The deregulation of the civil aviation sector in the region will further increase competition and reduce ticket price and fuel demand.

Challenges

Technological lock-in

Environmental regulations addressing engine efficiency are only gradually reaching their objectives. This is due to the technological lock-in (fossil fuel dependency) the industry finds itself in. Long research and production timespans, 20-30 year operational lifespans and a lack of readily available technological alternatives hinder the turnaround of the industry. It is therefore expected that the China ETS will lead to an influx of emission permits to the aviation sector and force other sectors to mitigate first and at lower costs. The long-term price signals for the aviation industry and the consumer depend on the emission price and are not predictable at this stage. It is to be seen whether emission trading will deliver enough incentives for a further fleet renewal and effectively cap emissions.



Entry Points for a Mobility and Fuels Strategy - Expert Recommendations



According to the expert interviews further industry optimisation is achievable to effectively reduce emissions.

Optimise flight operations

Route and fleet management are considered key strategies to improve operational efficiency. The experts stated that in many cases technologies and procedures are already readily available but application lags behind, thus recommending the following:

- Optimise route planning and apply advanced technological solutions to establish the most efficient trajectory in terms of distance, flight altitude, wind direction and speed. This includes the application of satellite navigation, automatic dependent surveillance-broadcast, regional navigation, required navigation performance (RNP), reduced vertical separation minimum (RVSM) and the continuous descent approach to shorten flight routes, maintain optimal flight height, and improve airspace management level and operation efficiency.
- Reduce auxiliary power unit usage e.g. through replacement of ground energy supply with electrically powered ground equipment.
- Implement and further strengthen research on weight reduction measures including operating standards.
- Apply latest air traffic management system and scheduling software to avoid flight delays (to avoid holding and queuing aircrafts with engines running in the air and on the ground), re-routing and route deviation.
- Increase the load factor by incentivising carrier alliances and further conduct research on light-weight materials.

Scale-up energy-saving transformation of airport facilities

Ground-handling equipment should to a large extent be electrified through incentive programmes. A “*transformation from oil to power*” should be the guiding principle for airport facilities. For this reason, technical standards and airport design specifications should be established to allow the administration



to monitor energy consumption and emission reduction efforts. Key entry points for electrification are:

1. Airport connections: Encourage commuting by train through combined ticketing, adequate rail infrastructure, frequent schedules, parking management.
2. Electrification of ground-handling airfield vehicles (including passenger buses, cargo vehicles, pushback tugs etc.).

Develop long-term industry scenarios

The current action plans and energy reduction measures in the aviation sector are primarily based on best and readily available technologies and tested measures. There is a strong industry incentive to implement these measures regardless of environmental policy as roughly 25% of carrier costs are resulting from kerosene consumption. Carriers' decisions on long-term technological and fuel switches are less straightforward, though. They depend on the regulatory framework conditions and fuel or technology readiness.

For example: an investment in bio kerosene-ready turbines will only be made if long-term government policy is to support the production of biokerosene which in turn depends on many factors such as the actual quantity available, land-use change considerations and relative fuel costs. The same argument holds true for power-based fuels and drive train alternatives. Given that the (highly concentrated but competitive) aviation industry is characterised by long development cycles, decisions for alternative fuels and engines have to be made under a predictable long-term regulatory environment. However, long-term scenarios that forecast the industry development, that assess fuel and technology readiness, that analyse the impact of different regulatory pathways are not available.

Not only for the aviation industry, but also for the regulator knowledge and scientific evidence on the reciprocal impact of regulations and technology options are essential to develop the most suitable policies.

It is therefore recommended to develop participatory developed aviation sector scenarios that take into account demand growth, turbine technology pathways, alternative fuel and energy availability and regulatory interventions.



3.5. New Mobility Services

Solutions to satisfy increasing demand for personal mobility can be found beyond public transport services and private car ownership. New mobility services have led to a significant disruption of the traditional road transport industry in China.

With 1.4 billion single trips booked through the Didi Smartphone App in 2015, **Didi Chuxing** is the world's largest new mobility service company. In comparison, Uber reached its 1 billion trip in 2015 but after 5 years of global operation ⁽²²⁾. With the take-over of Uber China by Didi Chuxing in August 2016, Didi has now over 95% market share and is basically the monopolistic supplier of **carhailing** services in China. By now Didi Chuxing claims to handle 14 million rides per day, including licensed taxis, carpooling, private car hailing and chauffeur services that are all integrated in one smartphone application ⁽²³⁾.

New Mobility Service: A definition

Carsharing: Carsharing can be characterised as a member-based mobility service, which provides on demand, self-service, pay-per-use and short-term access to a fleet of vehicles maintained by a professional carsharing company. Usually members pay a single registration fee, a monthly membership fee and a usage fee according to time and/or distance of the rental period.

Station-based Carsharing: Station-based carsharing companies operate by offering vehicles at designated carsharing stations within a defined service area. Depending on their availability, the cars can be reserved spontaneously or in advance via phone call, website or smartphone app. Most station-based carsharing companies offer round-trip usage, requiring the customers to pick up and return the vehicles at the same location. In China station-based carsharing is the most common service as it does not require publically available parking spaces. However, it provides less flexibility than free-floating carsharing. Stations are often located in off-street parking locations and not easily visible to new customers.

Free-floating Carsharing: Free floating carsharing services stand out by providing vehicles without designated carsharing-stations. The cars, which can be localised via service hotline, website or smartphone app, are parked on legal public parking spaces, parking garages or underground car parks within a geographically defined services area. Members of free floating carsharing services can pick up and return the vehicles at any legal parking space without being dependent on a specific carsharing station. In China free-floating carsharing faces the challenge of providing adequate parking for its users ⁽²⁴⁾.

Carhailing/Ridehailing: Carhailing or ridehailing is an immediate on-demand service for a predetermined trip. The customer submits a trip request through a smartphone application -such as Didi Chuxing or Uber- which is then routed through the online platform to registered drivers who use their own cars to provide the service. Carhailing pricing is similar to that of metered taxis, although all hiring and payment is handled exclusively through the carhailing company and not with the driver personally. Some operators calculate the price on a distance basis; otherwise, the price is calculated on a time basis. The world largest smart mobility service provider Didi Chuxing integrates ridehailing, taxi hailing, bus hailing and premium chauffeur services in one smartphone app.





The carsharing industry is much more dispersed and competitive than the carhailing sector but by no means less innovative. Numerous (e-) carsharing services have emerged in China since 2010. Carsharing operators appear and disappear on a monthly basis. The most important carsharing services are listed in Table 7.

While carsharing operators are prominent in most European cities, the availability in China is still limited. Yi Dian Zuche is currently the largest Chinese carsharing company. In 2009, the company pioneered carsharing in China with ten shared cars and five stations in Beijing. Since then, Yi Dian Zuche has expanded its service to nine other Chinese cities, offering a total of 1,000 vehicles to almost 280,000 registered members. Certainly, with about 5000 vehicles registered for carsharing in 2015 the absolute number is impressive but in relation to China's populous cities, the services are still operating on a small scale. Nevertheless, with the start of Car2go (Daimler) in Chongqing in May 2016 the first international operator started its services in China ⁽²⁵⁾. After only two months 78.000 users registered and 40.000 trips were made in the first weeks.



Service	Operator	Business Modell	No. of Vehicles	No. of Stations	Members	Cities	Website
Yi Dian Zuche 	EduoAuto (Beijing) Technology Co., Ltd	Station-Based Carsharing	1000	769	278,419	Various incl. Shenzhen and Beijing	http://www.yidianzc.com/
China Car Clubs 	Hangzhou Cherry Intelligence Co. Ltd.	Station-Based Carsharing	200 (incl. 50 EV)	78	38,000	Hangzhou	http://www.ccclubs.com/
Car2go 	car2go China Co., Ltd.	Free floating carsharing	25	5	78,000	Chongqing	https://www.car2go.cn/CN/en/chongqing/
Wei Gong Jiao 	Zhejiang Kandi Electric Vehicles Co., Ltd.	Station-Based E-Carsharing	~2500 (estimated, EV only)	34	n.d.	Hangzhou	No website available. Booking only via WeChat.
EVCARD 	New Energy Vehicles Operating Services Co., Ltd.	Station-Based E-Carsharing	50 (EV only)	53	n.d.	Shanghai	http://www.evcardchina.com
Green Go 	Beijing Heng Yu New Energy Car Rental	Station-Based E-Carsharing	700 (EV only)	26	15,000	Beijing	http://www.green-go.cn/
GX Zuche 	Car-sharing Rental Co.,Ltd.	Station-Based Carsharing	100 (incl. 10 EV)	50	2000	Yantai	http://www.gx-zuche.com

Table 7: Industry overview (Source: Own research, July 2016)



Policies and Trends

Similar to many other countries worldwide, the rapid development of new mobility services in China has proven to be a tremendous challenge for regulators on a national and local level. **Regulatory grey areas** such as business licensing, driver qualification and driver licensing, insurance coverage, liabilities for traffic accidents and taxation have to be addressed by different levels of government. Tangible economic and social issues such as the competition with the taxi industry and market monopolisation have dominated national media coverage in China throughout 2016.

To a large extent carsharing and carhailing regulations are drafted, implemented and enforced on a local level. However, the MoT is responsible for the development of policy guidelines. **Carsharing services** are currently regulated mainly through the same laws and regulations as rental services. A new legislation that includes the concerns of the carsharing industry and sets fair competition standards is currently being drafted.

After a lengthy industry and public consultation process, in July 2016 the State Council released “*Guidelines on the development of the taxi industry*” which defines **carhailing** as a taxi services. On the same day the MoT released the first national regulations for app-based ridehailing services worldwide. Previously private drivers were not legally allowed to charge passengers for their services, a grey area on which both Didi and Uber operated on a large scale. With the new regulations published the following industry standards are set:

- All drivers have to register as commercial drivers and apply for a commercial vehicle license from the local taxi administration. After 600.000 kilometres or 8 years operation time carhailing vehicles have to be scrapped.
- Drivers need to be in possession of a driver’s license and need to proof driving experience of more than 3 years, have no criminal record or charged with driving under the influence of drugs. Further driver training needs to be carried out by the carhailing company including related law and regulation training, professional ethics training, service specification training, etc. Drivers are not allowed to solicit customers in public areas and streets. All drivers should have a carhailing transportation license and ODM car driving license. Carhailing operators are liable for drivers and passengers in terms of traffic accidents just like other transport services.
- Carsharing operators can set their own prices “with certain exceptions”.
- Insurances and taxation falls under the responsibility of the carhailing company and not the driver.

Most importantly, beyond these regulations local authorities are eligible to set more stringent rules and laws. Therefore, legal certainty is only achieved to some degree. In practice, the total number of commercial licences is regulated by local authorities. Thus, compulsory registrations as commercial vehicles have far-reaching consequences. The hitherto entirely open market can now effectively be capped by limiting the number of commercial licenses being issued to carhailing operators. Beyond that, local authorities are eligible to set prices for carhailing above taxi industry prices. Carhailing operators are not allowed to offer prices below costs.

The discussions during the project workshop have shown that municipalities will use this freedom in regulating the carhailing industry in regard to their own strategic planning direction and individual circumstances. Representatives from Shenzhen and Wuhan considered new mobility services as an “effective last-mile solution that will strengthen the role of public transport”. Transport planners



from Handan, on the other hand, considered that new mobility services may shift more traffic from public and non-motorised transport to cars.

In Germany the changing set of values from “owning to sharing” has been a driver behind new mobility services. This does not seem to be a trend in China yet. The interviewed experts and the panellists during the policy forum identified some key drivers behind the development of carsharing in the future:

- Local Science and Technology Commissions are faced with ambitious electric vehicle industry development targets imposed by central government. Promoting **e-carsharing** is considered a crucial strategy in increasing user acceptability of electric vehicles and encourages the development of a charging infrastructure. It further reduces two main barriers for the market development of electric vehicles: High vehicle prices and range anxiety.
- An increasing number of cities introduced private car **ownership restrictions**. Carsharing can provide individual mobility without requiring ownership. Offering carsharing services can effectively increase the acceptability of restrictive transport demand management measures.

Challenge

Lack of research on the environmental impact of New Mobility Services

It is assumed and shown by different studies internationally that an adequate integration of carsharing and carhailing in urban transport may delay or reduce private car ownership. Moreover, carsharing users tend to shift their mobility behaviour towards public and non-motorized transport modes, which contributes to a reduction of the overall vehicle kilometres travelled. It was also argued that carsharing improves fuel efficiency. The argument is that carsharing vehicles are more fuel efficient than the average private vehicle.

Whether this behavioural and fleet change actually occurs depends on many factors among them the personal tendency to value ownership and individual mobility, the availability of high-quality public transport, density of carsharing vehicles, parking opportunities etc. Systematic research analysing the environmental impact of new mobility services in China is missing.

Speed of technological innovation in carhailing services

The high pace in innovation in terms of smartphone applications, digital payment systems and mapping services are increasing the convenience and competitiveness of new mobility services. Technological advancements are often steps ahead of regulatory framework developments. The lengthy industry consultation process for the development of the first carhailing policy has been surpassed by a rapid market development leading to a grey market in many aspects.

It is the administration’s difficult task to ensure that new mobility service policies facilitate innovation and address user mobility needs while at the same time ensure fair competition, compliance with safety standards and an adequate integration into the overall transport system.

Parking Management

Unregulated parking and inconsistent enforcement of parking regulations are key barriers for carsharing operators. Parking management that ensures -e.g. through adequate pricing- some availability of on-street parking is a basic requirement for carsharing services to function. The introduction of comprehensive pricing schemes could shift demand towards off-street parking and open up highly valuable public on-street parking spaces for carsharing. In many cities parking



regulations are designed and enforced by several institutions on a district level. Free-floating carsharing in particular could tremendously benefit from the consolidation of parking authorities, as the operators depend on finding an agreement with cities on how to pay for the usage of public parking spaces.

Inconsistent policies on a local level

The variety of local laws and regulations makes it difficult for the carsharing and car rental operators to scale-up operations throughout the country. This however is a key requirement to achieve the required economies of scale for a profitable operation and secondly increases user convenience when being able to use the same operators in different cities.

Entry Points for a Mobility and Fuels Strategy - Expert Recommendations



Ensure adequate integration into the urban transport system

To tap into the actual energy saving potential of new mobility services its role in the overall urban transport system needs to be well planned. Carsharing in particular should not be considered a monomodal transport mode. Carsharing users should be encouraged to organise their mobility needs around carsharing, public and non-motorised transport. The following key recommendations were given for the development of new mobility services in China:

- Consider new mobility services in existing, traditional infrastructure and mobility planning procedures. This includes demand modelling, scenario development and appraisal.
- Assess energy saving potentials of new mobility services based on cooperative research with carhailing and carsharing companies as a foundation for scenario development.
- Implement a city wide parking management system that integrates carsharing. A pricing is key that ensures availability for carsharing vehicles.
- Ensure inter- and multimodal linkages. Carsharing stations should be in close proximity to bus, subway and train stations to facilitate an easy modal switch. Public transport companies can support this by providing parking spaces or agree on integrated ticketing and one trip pricing solutions.
- Offer continuous capacity building, knowledge exchange between cities nationally and internationally to ensure that administrations can keep up with innovations without having to “reinvent the wheel”.



3.6. Urbanisation

China's urbanisation rate currently stands at 56% and is expected to reach 60% in 2020. Evidently China's urbanisation process is far from slowing down but some of its fundamental features are changing. So far, one of the key characteristics has been the rise of large cities along the east coast. In the future this will turn into a more decentralised process emphasising the growth of smaller and medium-sized cities with up to 5 million residents. It is suggested that by 2030 more than 200 cities have more than one million residents.

The Chinese State Council has initiated the development of regional city-clusters in 2014 in the context of the "National New Type Urbanisation Plan". The aim is to steer urbanisation more effectively, to create economic hubs and enable resource sharing between cities in the region that ultimately increase labour productivity. Eleven of them will be developed in the near future. Among them is the Jing-Jin-Ji region.

Challenges

Structured urbanisation (called "new type urbanisation" in China) and the development of city-clusters are named as key challenges to be addressed in regional and urban transport policy due to the following reasons:

1. While a decentralised urbanisation might alleviate existing pressure on China's megacities, it creates a new challenge for smaller public authorities. The planning requirements are becoming more sophisticated with increasing demand for public services. However, smaller cities typically have lower planning capacities for example in terms of urban transport planning and financing.
2. Given that the city-clusters cross local as well as provincial administrative borders, institutional cooperation is considered a key challenge to ensure policy and regulatory coherence.
3. The increased exchange of goods, services and people between cities is the core objective of the cluster development. This will increase pressure on existing transport infrastructure and, for instance, requires new infrastructure developments for rail and intermodal freight transport. Nevertheless, this challenge has also been seen as an opportunity to leap-frog to new solutions such as suburban trains, electrified freight transport etc.
4. Car-oriented infrastructure planning: The existing standards for road infrastructure and land-use planning require high capacity road space and extensive parking to accompany housing and other infrastructural developments. This effectively prevents a modal shift towards public and non-motorised transport.



Entry Points for a Mobility and Fuels Strategy – Expert Recommendations

No planning procedures are established between the administrations in the city-clusters. Therefore, new and integrated mobility strategies could be piloted on a regional level. During the panel discussions it was a common understanding that regional mobility planning in the context of a rapid urbanisation has a high potential to reduce transport demand. This holds especially true in comparison to developed countries where urban design and infrastructure is pre-existing to a large extent. For that reason, it was suggested to:

- Support municipal transport commissions and provincial MoT's to draft a regional mobility strategy,
- Review existing road infrastructure standards and integrate standards for transit-oriented-development and non-motorised friendly road space in a pilot city-cluster,
- Increase the knowledge base on integrated land-use and transit planning,
- Share best-practices regarding regional cooperation in supplying transport services e.g. regional transit alliances, planning hierarchy, financing of regional transport, integrated planning.



4. Fuels and Drives

In Chapter 3 challenges and approaches to facilitate mobility of goods and people in China were discussed. Chapter 4 focuses on fuels and drive systems (engine technologies) to move vehicles, planes and ships. It provides a first overview on the application of fossil fuels, biofuels, power based fuels and electrical energy in the Chinese transport sector.

After a brief introduction to the fuels and drive systems options available in China, the current energy and fuel policy is briefly presented. Subsequently the three pillars of fuels will be discussed in terms of current application, challenges and entry points for a MFS:

- Fossil Fuels (Chapter 4.1)
- Electrical energy (Chapter 4.2)
- Biofuel (Chapter 4.3)

Alternative Fuel Options

Fuels that can be used in **conventional internal combustion engines** with no –or in the case of plane turbines- slight adjustments of the drive system include **biofuels** and **power-based fuels**. **Biofuels** are divided into three generations. “1.0 generation” conventional biofuels are made from sugar, starch, oil crops and also called food-based fuels. 1.5 generation biofuels are non-grain, but sugar or starch based ethanol or Jatropha-based non-edible biodiesel. 2.0 generation biofuels are called non-food biofuels. 2.0 generation –also known as advanced biofuels-, are fuels that can be manufactured from various types of biomass including waste, corn cob or corn stalk.

Drive System	Fossil Fuels (Chapter 4.1)	Low-Carbon Fuel Options		
		Electrical Energy (Chapter 4.2)	Power-based fuels (Chapter 4.2)	Biofuels (Chapter 4.3)
Diesel and Petrol Engine (incl. Hybrid)	Petrol, Diesel, Liquid Natural Gas (LNG), Liquefied Petroleum Gas (LPG)		Power-to-Liquid (PtL)	Biodiesel, Biokerosene Biomasse-to-Liquid (BTL)
Gas Engine (incl. Hybrid)	Petroleum Gas (PG), Compressed Natural Gas (CNG)		Power-to-Gas (PtG)	Biogas, Synthetic Natural Gas (SNG)
Electric Motor		Battery Electric Vehicles, Trolley Buses and Trucks		
Fuel Cell + Electric Motor	Hydrogen from PG		Power-to-Gas-Hydrogen (PtG-H2)	Hydrogen from Biomass

Figure 19: Fuels and drive systems addressed in Chapter 2 (Overview based on INFRAS)

Power-based fuels are produced with electricity through different processes. They can be divided into **synthetic fuels** such as “power-to-gas (PtG)” and “Power-to-Liquid (PtL)” and the direct use of electrical energy in **electric motors**.

A well-known synthetic fuel is hydrogen which is produced through water electrolysis. Through subsequent methanisation PtG is produced. Through a process called Fischer-Tropsch Synthesis liquid hydrocarbon (PtL) can be produced. The major advantage of PtL and PtG is that it can be burned in conventional internal combustion engines. It allows for a full electrification of the transport sector without changing engines or turbines. The low energy efficiency of the production process currently prevents synthetic fuels to be applied in a larger scale.

New drive systems are required for **hydrogen** (fuel cell) and direct application of electrical power. **Electric motors** are the most direct way to use electrical energy and have consequently also the highest energy efficiency. That is, to drive a car, any power-based fuel option consumes substantially more primary energy than direct use of electricity in a battery electric vehicle.

Power-based fuels are a highly controversial topic (a discussion on the climate protection potential on electro-mobility can be found in Chapter 4.2). This is especially true for the indirect use of electrical energy through PtG and PtL processes. China has increasingly invested into thermal coal power plants that produce PtG and PtL – also called coal-to-oil or coal-to-gas. The main motivation behind this is to ensure security of energy supply. Given the high endowment of coal in China this is a sensible policy. However, the environmental consequences could be severe as the energy efficiency is low and the life-cycle emissions of coal-to-oil considerably higher than conventional fuels. Besides hydrogen, PtG and PtL on the basis of renewable energies only play a role in academic discussions in China and have not found their way into practical transport policy.

In contrast, **Liquid natural gas (LNG)**, **compressed natural gas (CNG)** and **liquefied petroleum gas (LPG)** receive substantial attention in current policy making in China and are presented in Chapter 4.1.

Motivation and Challenges for Alternative Fuels and Drives in China

A low-carbon or decarbonised transport sector based on alternative power-based fuels is only attainable with a high share of renewable energies in the primary energy production. However, a focus on complete decarbonisation does not entirely do justice to the current discussion in China. Greenhouse gas mitigation is currently considered a co-benefit rather than the primary goal. Alternative fossil fuels such as LPG and CNG and fuel efficient combustion engines continue to play a crucial role.

What drives Chinese decision makers to promote alternative fuels and drive systems? Three main reasons were identified:

1. Low-carbon fuels are promoted with the **primary goal to reduce air pollutants**. This is especially true for the currently pursued mass application of LPG (a by-product of natural gas and crude oil production) for heavy duty vehicles and inland shipping as well as CNG mainly for light duty vehicles and buses. LPG and CNG have considerable advantages over petrol and diesel in terms of tailpipe emission but also reduce carbon-dioxide emissions under certain conditions. The ability of CNG and LPG to reduce greenhouse gas emissions over the entire fuel lifecycle depends on the source of the gas and the fuel it is replacing. Air quality is also a key motivation behind the electrification of public bus fleets. Contrary to the private vehicle fleet that is considered comparatively modern, the current bus fleet is mainly equipped with China 3 diesel engines.
2. **Fuel dependency** is a major consideration in the current policy mix for alternative fuels. It is an important motivation behind the development of electro mobility, gaseous fossil fuels and coal-to-oil. Currently China imports 59.5% of its liquid fossil fuels.
3. **NEVs** (including battery electric vehicles, (plug-in) hybrids and fuel cell vehicles) are mainly promoted for **industrial policy** considerations. Wide-ranging policy support is given to the local automotive industry.

Energy Consumption in China

Over the past 30 years, the total energy consumption of China showed a continued but volatile growth trend. In 2014, China's total annual energy consumption stood at 4.26 billion tonnes of standard coal, ranking first in the world, accounting for more than 20% of the world's total energy consumption. Currently, China's coal consumption accounts for about 66% of primary energy use, 35 percentage points higher than the world average ⁽²⁶⁾. China aims to increase the share of non-fossil energy to 15% by 2020 and 20% by 2030.

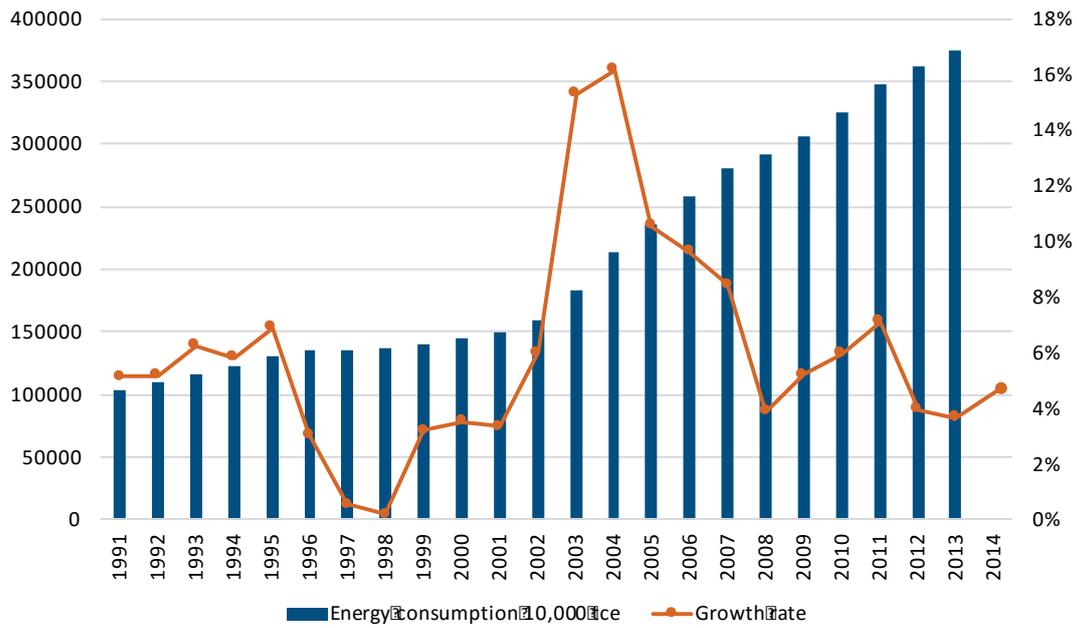


Figure 20: China's Total Energy Consumption during 1991-2013 (Source: China Statistical Yearbook, 2014)

Energy Demand of the Transport Sector

Given the current drive technology and fuels trajectory, it is inevitable that the transport and power sector are increasingly interacting. Electricity is required for fuelling electric vehicles as much as it is to produce power-based fuels such as hydrogen.

According to China's official statistics, the energy consumption of the transport industry in 2012 amounted to 315 million tonnes of standard coal, accounting for 9% of the total national energy consumption (see Figure 21). However, the official statistics exclude private road transport. According to TPRI research, the energy consumption of the road transport sector is estimated at 472 million tonnes (mt) of standard coal in 2013. The energy consumption shows a clear tendency towards growth in absolute and relative numbers. However, due to the increased energy efficiency of practically all modes of transport the growth rate in demand is faster than the growth rate in energy demand.

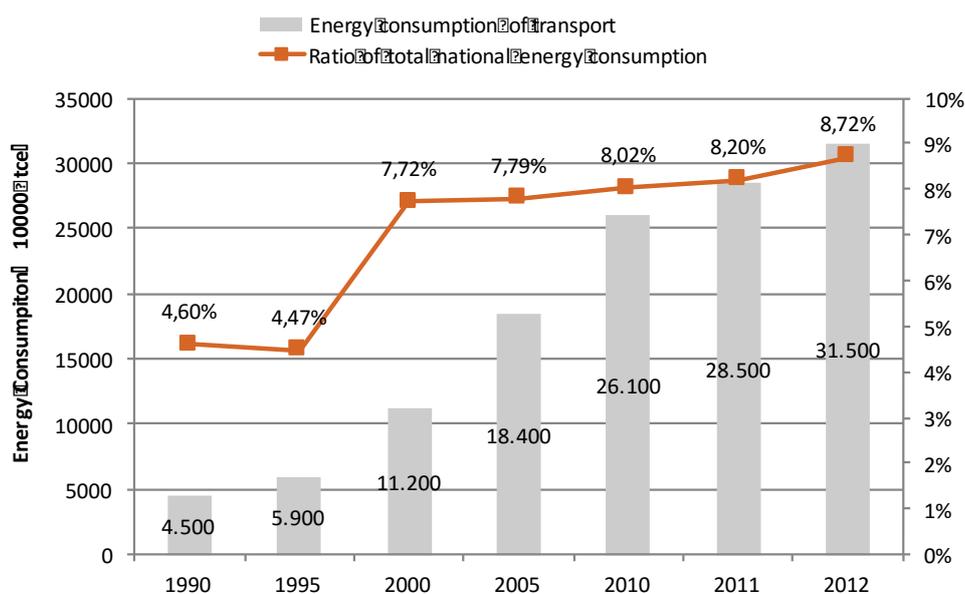


Figure 21: Energy Consumption of the Transport Industry 1990-2012 excluding private vehicles (Source: China Statistical Yearbook, 2015)

Energy sources in the transport sector have changed rapidly since 2000. While the proportion of coal as a primary energy source decreased by almost half, the kerosene consumption increased threefold and diesel consumption fourfold. Alternative fuel sources, such as natural gas and direct consumption of electricity, show a clear trend towards growth.

	Coal 10,000t	Coke 10,000t	Crude oil 10,000t	Gasoline 10,000t	Kerosene 10,000t	Diesel 10,000t	Fuel oil 10,000t	Natural Gas 10om3	Electricity 100 mio kWh
2000	1140.0	11.2	175	1387.8	536.4	2543.8	850	5.81	281.2
2012	614.2	0.09	119.4	3753	1787	10727	1383.9	154.5	915.4
%	-46%	-99%	-32%	170%	233%	322%	63%	2559%	226%

Table 8 Transport sector energy consumption (Source: China Statistical Yearbook, 2015)

China's railway transport sector drastically reduced the share of steam locomotives fuelled with coal in 2000. Since then, a rapid electrification has progressed. The increase of electricity consumption in the transport sector can therefore be attributed to the railway sector. No data is available on the electrical energy consumption of the road transport sector. The increase in natural gas is mainly attributable to shipping.



4.1. Fossil Fuels

Despite the fact that growth rates of fossil fuel consumption have slowed down, it was a common understanding that, at least to some extent, all modes of transport will rely on fossil fuels for the coming decade. Currently the automotive sector accounts for 55% of the total gasoline and diesel consumption with a clear tendency towards growth. 70% of marginal demand on fuel stems from the automotive sector ⁽²⁷⁾.

Fossil fuel consumption in the transport sector has been at the centre of policy making due to high pressure to improve air quality in the short-term. Given that complete drive system switches (e.g. to fuel cells) require a considerably long time of market preparations, low-carbon fossil fuels and low-sulphur fuels were seen as a short-term solution, especially for heavy duty vehicles and the shipping industry.

Policies and Trends

Fuel Economy Standards in Road Transport: Reducing fuel consumption of internal combustion engine vehicles is a key pre-requisite to reduce overall emissions from road transport. The most crucial policy in this respect is the *Chinese Corporate Fuel Economy Standard*. Technical improvements of conventional vehicles, such as lightweight design or reduction in engine friction will be required to effectively reduce emissions from road transport in the short-term. The MIIT published the first vehicle fuel consumption related policy in 2004 including the national standard on "*Limitation of Fuel Consumption of Passenger Vehicles*" (GB 19578)". In phases MIIT drives an increased energy efficiency of newly sold vehicles until 2020. The current fourth phase requires automotive producers to comply with an average 5.0 litre/100km fuel consumption of newly sold vehicles by 2020. NEVs are taken into account with so called "super credits". Currently one NEV (with a minimum all-electric driving range of 50 km) is considered in the average fleet fuel consumption with 0.0 litre/100km fuel consumption with the factor 5. That is, each NEV sold by an automotive company counts as five zero fuel consuming vehicles in the average fleet consumption calculation. The factor will gradually be reduced to encourage increasing energy efficiency of electric vehicles.

Fuel economy standards in China are not only implemented for environmental reasons but also encourage a modernisation of Chinas automotive industry. Chinas current industrialisation policy *Made in China 2025* foresees considerable improvements in vehicle efficiencies. The technological road map for *Made in China 2025* stipulates among others the following goals:

1. **Low Resistance Tires:**

The wet-skid, wear and noise performance of domestically produced low-resistance is improved by 2025. Rolling resistance will be reduced by 30%, realising a fuel saving of over 6%. The market share of domestic brand products will exceed 50%.

2. **Lightweight components:**

Representative domestically produced lightweight components such as steel/aluminium mix, aluminium/fibre and carbon fibre body will account for 20% of the market share.

3. **Efficient internal combustion engines:** The thermal efficiency of gasoline engine of passenger vehicles will be not less than 40%, with an equipment rate of domestic brand products of 40%; the diesel thermal efficiency of heavy-duty commercial vehicles will be no less than 52%, with an equipment rate of domestic brand products of 60%.



Fuel Economy Standards in Aviation: It is widely acknowledged that efficiency standards in aviation require an international effort. Since 2010 the ICAO Committee for Environmental Protection has been working on an industry wide CO₂ standard. In February 2016, ICAO has released a proposal for CO₂ limits for all planes put into operation after 2028 – thus, taking into account the long research and development phase for turbines and plane design. On average the standard requires a 4% reduction in fuel consumption as of 2028 compared to aircrafts delivered in 2015. The required reduction per aircraft depends on the maximum take-off mass and ranges from 0-11%. The standard has not yet been ratified by the ICAO council and its 36 members ⁽²⁰⁾.

Gaseous fossil fuels: Beyond engine efficiency, the Chinese government continuously promotes a fuel switch to gaseous fossil fuels due to air quality considerations. At present, CNG and LNG are the most frequently used gaseous fuels in internal combustion engines of heavy duty vehicles and (mainly inland waterway) vessels.

So far China's shipping industry relies on marine diesel and heavy oil with currently rare practical application of LNG. Increasing environmental concerns in terms of air pollution along ports and waterways resulted in a policy priority from traditional fossil fuels to LNG. Since 2011, MoT has developed the “*Pilot Programme of Natural Gas Vehicles Applied in Intercity Road Transport*”, and initiated projects in regard to the “*application of natural gas vehicles in road transport, and application of natural gas ships in inland water transport*”. The MoT plans to reach a minimum share of 10% of domestic ships being fuelled with LNG by 2020. LNG ships are exempted from vessel taxation. Several subsidies, scrapping and tax-cut policies support this initiative.

SN	Name	Issued by	Main content
1	Natural Gas Utilization Policy 2012	NDRC	Next to buildings, utilities and factories, the government for the first time targeted the transport sector with the Natural Gas Utilisation Policy of 2012. The policy encourages retrofitting of buses, taxis, trucks, and vessels. Subsidies are provided for retrofitting and infrastructure development.
2	Energy Development Strategic Action Plan (2014-2020)	The General Office of the State Council	The plan envisages the share of natural gas in the primary energy consumption mix is to rise to above 10%. It is planned to steadily develop natural gas transport with a focus on urban buses and taxis as well as heavy-duty commercial vehicles.
3	Guiding Opinions of MOT on the promotion and application of LNG in the Shipping Industry 2013	MOT	The application of LNG in water transportation will be accelerated and pilot projects of LNG fuelled vessels in inland waterways will be carried out. Energy saving and emission reduction plans of water transportation will be implemented and vessel efficiency standards will be formulated. Subsidies will be replaced with incentives, which will be given to qualified projects of energy saving and emission reduction.
4	Implementation Plan on LNG Application Pilot Programme in the Water Transport Industry 2014	MOT	Selection of 16 LNG pilot programmes in the water transport industry, including construction of movable and shore-based fuelling stations
5	Regulations for Emission Control Areas 2016	MOT	Regulations, designating three areas as sulphur control areas will take effect from 1st January 2019. Eleven key ports have been allowed to impose requirements for fuel burned at berth on 1st January 2016. Mandatory port requirements will go into force on 1st January 2017 for all ports in designated areas.

Table 9: Formulation of Policies in the Sector of Natural Gas Vehicles and Ships



The policies on natural gas deployment were considered largely successful. Beginning of 2015, approximately 4 million natural gas vehicles were in operation on China's roads. 118 inland waterway and seagoing vessels were retrofitted with LNG drive systems in the context of the MoT pilot application programme.

Fuel quality standards in maritime and road transport: The shipping sector accounted for around 8.4% of China's sulphur dioxide emissions and 11.3% of nitrogen oxide emissions in 2013. Ships, including ocean-going vessels, which operate in areas near the Pearl River Delta, Yangtze River Delta and the Bohai Sea, are therefore obliged to use fuels containing less than 0.5% sulphur from 1st January 2019 onwards ⁽²⁷⁾.

China's gasoline and diesel quality standards for road transport have tightened rapidly as well. As of December 2017 the China V standard applies and allows a maximum sulphur content of 10 parts-per-million (ppm) for diesel and gasoline.

Despite the clear focus on air quality, fuel quality standards were considered essential in terms of climate protection as they reduce the emissions of short-lived climate pollutant emissions such as black carbon.

Challenges

Imported fuel dependency

By 2013, the share of imported petroleum in total domestic oil consumption in China rose to an all-time high of 58% compared to 33% in 2000. A high dependence on fuel import makes the economy vulnerable to external shocks and price fluctuations. China imports roughly 30% of its natural gas and is the fourth largest gas importer in the world. However, China has made significant strides in diversifying its natural gas and oil supplies. Domestic gas production has risen by 164% from 2004 to 2014 ⁽²⁸⁾.

Low quality fuels

Most cargo ships are fuelled by residual fuel with a high sulphur content which forms sulphur dioxide when combusted. Residual shipping fuels and the high share of non-regulated diesel vehicles in off-shore operations are the main source of ambient air pollution in adjacent cities. To meet the fuel sulphur mandates most shipping companies have opted for low sulphur fuels. However, it was argued that the infrastructure for low-sulphur fuels such as LNG and CNG is still limited. Adding to the problem are the relative prices between residual fuel and LNG. Since the second half of 2014, domestic and overseas fuel oil prices have suffered from a continuous sharp decline. As a result, natural gas vehicles and ships lose their previous economic advantages.

Regulatory framework for Natural Gas Deployment

Shipping experts were mainly concerned with the current regulatory framework in terms of safety specifications for ships and fuelling infrastructure. The approval process for gas stations along waterways is still considered cumbersome due to the involvement of multiple competent departments.



Entry Points for a Mobility and Fuels Strategy – Expert Recommendations

All Modes

Develop short and long-term fuel strategy scenarios for non-electrifiable drivetrains

The short- and mid-term dependency on fossil fuels has been highlighted by a range of experts concerned. A short-term fuel switch towards natural gas and an expansion of the required fuelling infrastructure should continue to be a government priority. However, it was also suggested to develop alternative pathways for “non-electrifiable” modes that continue to be fossil fuel dependent:

- **Heavy duty vehicles:** For heavy duty vehicles there was no common understanding whether an electrification of the drivetrain is technically and environmentally feasible. Differentiated studies to establish whether an electrification of heavy duty vehicles is possible for urban, regional or national intercity transport should be conducted.
- **Aviation and maritime:** The application of power-based and biofuels in the aviation and maritime sector should be further investigated in terms of its economic and technical feasibility and overall fuel availability.

Shipping

Promote the use of clean shore power technology of anchored ships

Off-shore power supply allows ships to turn off engines on board and instead use cleaner shore side electricity to power refrigeration, lights, pumps, and other equipment being used while at berth. According to the *Implementation Plan for the Special Action of Ship Port Pollution Control (2015-2020)* issued by the MoT, 90% of main port ships and public berthing ships will use shore power, and 50% of containers, ro-ro passenger ships and passenger liners have the capacity to be supplied by shore power by 2020. Given the vast international experience with off-shore power supply and local electricity grid connection, port authorities should seek an active exchange internationally.

Improve emission standards for vessels

Strengthen emission standards for new vessels is considered the most crucial policy to encourage an upgrading of ship engines and ship design standards. The limits of and measurement methods for ship engine exhaust emissions (the First and Second Stages in China), which are currently under development in China, should be more stringent than the IMO Tier II standards, considering the high number of people living adjacent to ports, waterways and shores in China.

Actively promote the application of LNG

The full implementation of the instructions of the MoT on promoting the application of LNG in the shipping transport industry should be pursued in the current five-year planning period. However, a further improvement of standards and specifications for LNG filling facilities should be initiated. Training for shipping crews and wharf operators should be standardised.

Road Transport

Integrate NEVs into fuel economy standards

The current “super-credit” regulation will be gradually phased out until the end of the Fuel Economy Standard phase IV in 2020. It was recommended to integrate electric vehicles according to their actual energy consumption into the FES phase V. This requires a standard on measuring energy



consumption standards for electric vehicles to encourage energy efficient electric vehicles.

Focus on important intercity road connections for CNG and LNG infrastructure

To advance market development for natural gas fuelled vehicles the gas station and pipeline infrastructure needs to be strengthened. The cluster development could be an opportunity to develop infrastructure and reach the required economies of scale, agree on harmonised standards and improve cooperation between institutions in the approval process.

Aviation

Accelerate technological upgrading of aircraft engines

The fleet renewal should be further encouraged through incentive programmes especially for research on hybrid engine technologies. To improve the knowledge base in the industry and for policy makers an energy-saving and emission reduction database for aircrafts and engines should be developed.



4.2. Electrical Energy

The electrification of the entire **railway sector** and rapid market development of **electric vehicles** were considered key elements for resource-saving and climate-friendly transport. The electrification in the aviation and maritime transport concentrate to a large extent on the electrification of ground-handling vehicles and machinery, off-grid solar energy systems at airports and off-shore power supply. An electrification of the drivetrain in both sectors is currently technically not feasible.

Renewable Energy in China

Upstream emissions occurring during energy production are essentially determining the climate protection potential of electro-mobility, an electrified railway sector and power based fuels. Despite the continuous dominance of coal-based power production presented in Chapter 4, a rapid

expansion of renewable energy sources is currently ongoing.



According to current governmental plans, the share of coal in the electricity production shall decline to less than 62% by 2030 ⁽²⁹⁾. By 2020 the coal consumption is to be reduced by 160 million tonnes⁽³⁰⁾. These ambitious plans have already found their way into policy implementation: China is leading worldwide investments in renewable energies, having spent an equivalent of 75 billion Euros into this expansion of renewables in 2014 – twice as much as the USA as the runner-up ⁽³¹⁾.

The share of hydropower in primary energy production reached 1.1 trillion kwh in 2015, up 20% compared to the previous year. The thermal power output reached 4.2 trillion kwh, down 0.7% year on year, accounting for 72% in energy mix. Figure 22 below shows that the share of renewables in the overall electricity generating capacity reached 33% and the share in the energy mix reached 25%. The availability of renewable energy is regionally highly different. While hydropower is mainly available in China's South-West, wind power is mainly generated in Inner Mongolia and off-shore.

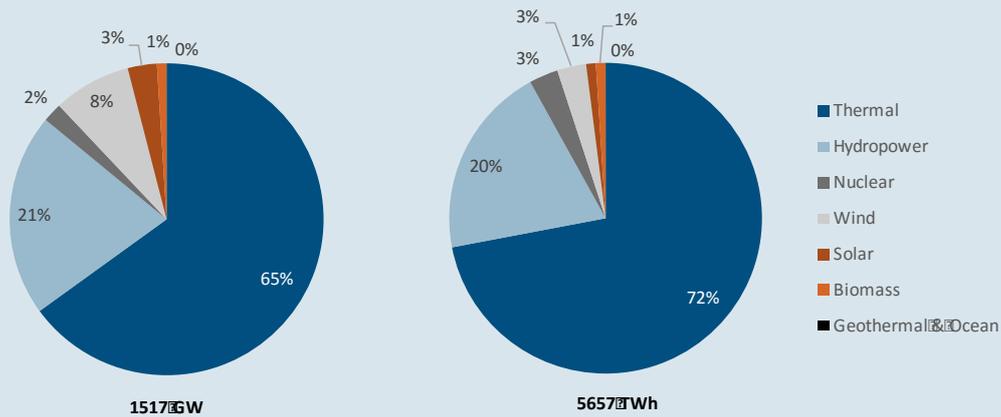


Figure 22: Installed capacity (left) and electricity generation mix (right) in China in 2015 (Source: China National Renewable Energy Centre, 2016)

Policies and Trends

Monetary purchasing subsidies for electric vehicles, super credits in fuel economy standards, tax exemptions, and enormous investments in rail network electrification: China is sparing no efforts in its drive towards electrifying its road and rail transport. And at least for the railway sector this is reflected in numbers.

In 2014, the energy consumption of national railway transport enterprises converted to 16 million tonnes of standard coal, up 7.0% compared to 2003. 65,000 km of the 121,000 km overall network are electrified.

The electrification of road transport does not keep up with the railway sector but has achieved remarkable results in the last year. In 2015 alone, Chinese customers purchased three times more electric vehicles than in the previous year. With unit sales of 188,000 purely electric vehicles, China has surpassed the United States of America as a leading market for electric cars. A total of 375,000 NEVs (plug-in hybrids, battery electric vehicles and fuel cell vehicles) were sold in 2015 (33).

Given that NEVs produced outside of China are exempted from incentives and subject to import taxes, the growth was mainly driven by domestic production. The foundation for the market uptake are battery electric and plug-in hybrid vehicles. Despite a technologically neutral policy approach, fuel cell vehicles have not yet entered a market growth stage.

New Energy Vehicle Promotional Policies

China's ambitious NEV programme dates back more than seven years. Since the "Demonstration Project for the Promotion and Application of 1,000 Energy-Efficient and New-Energy Vehicles in Ten Cities on an Annual Basis" launched jointly by MOST, MOF, NDRC and MIIT in January 2009, a series of policies and documents have been introduced. About 66 national policies and specifications in terms of promotion, industry standards and charging infrastructure were introduced from 2014 to the first half of 2016. By July 2015, about 175 local promotional policies were issued. The policies, regulations and measures that were considered most influential in driving market uptake are listed in the table below:



	Policy, Regulation, Measure	Issued by	Main content
1	Energy Conservation and New Energy Automobile Industrial Development Planning (2012-2020)	The State Council	Electro-mobility considered the primary strategic direction for the automotive sector industrial transformation.
2	Guiding Opinions about Accelerating New Energy Automobile Promotion and Application 2014	The General Office of the State Council	Eliminate regional protectionism, and implement unified national standards and industrial standards for new energy automobiles and charging facilities across the country.
3	Notice about Exempting New Energy Automobiles from Vehicle Purchase Taxes 2014	MOF and MIIT	New energy vehicles are exempted from vehicle purchase taxes from Sep. 1, 2014 to Dec. 31, 2017.
4	Implementation Plan on New Energy Automobiles Purchased by Government Agencies and Public Institutions 2014	MIIT, MoST, MoF, NDRC	From 2014 to 2016, 30% of all government vehicles for central stage agencies and all cities listed in the promotion plan are NEVs.
5	Working Plan on New Energy Vehicle Promotion in the Public Service Sector 2014	MIIT, NDRC, MOST, MOF	It is proposed to totally operate 20,222 new energy automobiles, and build 94 charging stations and 16,200 charging piles in the public transport service sector in Jing-Jing-Ji Region from 2014 to 2015.
6	Application Opinions about Accelerating the Promotion and Application of New Energy Automobiles in the Transport Sector 2015	MOT	City bus, taxi and urban logistics shall be taken as the key sector for promotion and application of new energy automobiles. By the end of 2020, the number of new energy automobiles shall reach 200,000, and 100,000 for new energy taxis and urban logistic vehicles respectively.
7	Fiscal Support Policy for New Energy Automobile Promotion and Application in 2016-2020	MOF, MOST, MIIT, and NDRC	Continue to implement the subsidy policies for new energy automobile promotion and application in 2016-2020; properly lower the subsidies for other models (excluding fuel cell vehicles). See Table 16.
8	Notice about adding Urban Electric Subsidy Policies 2015	MOF, MIIT, and MOT	Before the notice only conventionally fuelled buses were receiving purchasing subsidies. With the notice special subsidies are available for electric buses. Subsidy levels correlate with the number and operational mileage of new energy buses operating
9	Guiding Opinions about Accelerating Electric Vehicle Charging Infrastructure Construction 2015	The General Office of the State Council	By the end of 2020, a charging infrastructure system shall be built to satisfy the charging demands of more than 5 million electric vehicles.
10	Electric Vehicle Charging Infrastructure Development Guidelines (2015-2020)	NDRC	Construction of 12,000 centralized charging stations and 4.8 million distributed charging piles across the country by the end of 2020.

Table 10: Formulation of Policies in the Electric Automobile Sector

It was widely agreed that these policies were highly successful in initiating market development both from a supply as much as from a demand side. A comprehensive **policy switch** has been initiated in 2015 to increase the economic sustainability of electro-mobility, to

- reduce the burden on national and local government budget,
- circumvent overcapacity
- avoid economic subsidy fraud of non-competitive producers
- increase international competitiveness.

Municipal NEV incentives

Especially local financial subsidies and exemptions from restrictive transport demand management measures have proven to be a highly enabling factor for the NEV market uptake. In Beijing the overall **number of registration plates** issued on an annual basis stands at 150.000 and will be



reduced to 100,000 from 2018 on. Currently, 40% of all number plates issued are reserved for New Energy Vehicles. Additionally, NEVs are exempted from driving restrictions in the city.

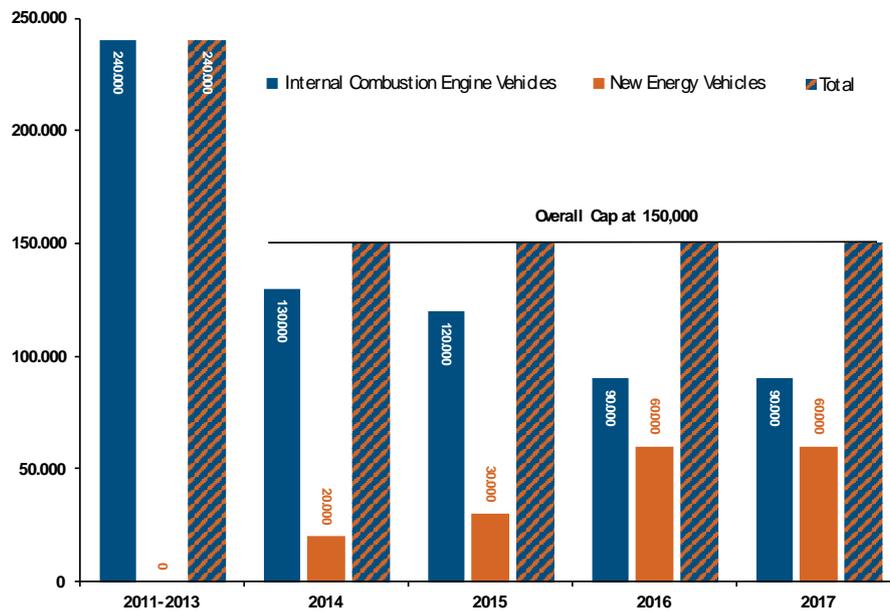


Figure 23: Vehicle registration cap in Beijing (Source: Own graph based on notices issued by the Beijing Municipal Commission of Transport, 2016)

Incremental reduction of direct financial subsidies for electric vehicles

In January 2014, the responsible Chinese authorities issued new evaluation criteria for the financial support to electric vehicles. Both the amount of subsidies and subsidy criteria changed (from battery size to all-electric-range). The MoF plans to completely end direct purchasing subsidies as of 2021. See table below:



Vehicle type	Subsidy criteria 2016 - 2020 Range [km] / Length [m]	Phase III: 2016-2020			Subsidy criteria 2013 - 2015 Range [km] / Length [m]	Phase II: 2013-2015		
		2019-2020 (-40%)	2017-2018 (-20%)	2016 (Baseline)		2015 (-10%)	2014 (-5%)	2013 (Baseline)
BEV (Passenger vehicles)	100 - 150 km	15,000 RMB (2,122 EUR)	20,000 RMB (2,829 EUR)	25,000 RMB (3,536 EUR)	80 - 150 km	31,500 RMB (4,455 EUR)	33,250 RMB (4,703 EUR)	35,000 RMB (4,950 EUR)
	150 - 250 km	27,000 RMB (3,819 EUR)	36,000 RMB (5,092 EUR)	45,000 RMB (6,365 EUR)	150 - 250 km	45,000 RMB (6,365 EUR)	47,500 RMB (6,719 EUR)	50,000 RMB (7,072 EUR)
	250 km and more	33,000 RMB (4,668 EUR)	44,000 RMB (6,223 EUR)	55,000 RMB (7,779 EUR)	250 km and more	54,000 RMB (7,638 EUR)	57,000 RMB (8,062 EUR)	60,000 RMB (8,487 EUR)
PHEV (Passenger vehicles)	50 km and more	18,000 RMB (2,546 EUR)	24,000 RMB (3,395 EUR)	30,000 RMB (4,243 EUR)	50 km and more	31,500 RMB (4,455 EUR)	33,250 RMB (4,703 EUR)	35,000 RMB (4,950 EUR)
BEV (Bus)	Subsidy based on: - Energy efficiency - weight - length	Up to: 360,000 RMB (50,919 EUR)	Up to: 480,000 RMB (67,893 EUR)	Up to: 600,000 RMB (84,866 EUR)	6 - 8 m	270,000 RMB (38,190 EUR)	285,000 RMB (40,311 EUR)	300,000 RMB (42,433 EUR)
					8 - 10 m	360,000 RMB (50,919 EUR)	380,000 RMB (53,748 EUR)	400,000 RMB (56,577 EUR)
					10 m and longer	450,000 RMB (63,649 EUR)	475,000 RMB (67,185 EUR)	500,000 RMB (70,721 EUR)
PHEV (Bus)	Subsidy based on: - Energy efficiency - weight - length	Up to: 180,000 RMB (25,460 EUR)	Up to: 240,000 RMB (33,946 EUR)	Up to: 300,000 RMB (42,433 EUR)	10 m and longer	225,000 RMB (31,825 EUR)	237,500 RMB (33,593 EUR)	250,000 RMB (35,361 EUR)

Table 11: National EV subsidies in China from 2013-2020 (Source: Ministry of Science and Technology)

Industrialisation Policy - Made in China 2025:

China published its industrial policy *Made in China 2025* in May 2015. A strong focus lies on the continuous development of electro-mobility. By 2020 the electro-mobility sector is supposed to be a “market-driven and enterprise-oriented industrial system”. Key driver behind the electro-mobility market development is the ambition to advance the domestic automotive industry. The domestically added value share of vehicles sold in China is supposed to reach 40% in 2025. For NEV the domestically added value should account for 70% by 2025. Through increased competition between protected “local champions”, current market imperfections (e.g. skewed investment decisions based on local subsidies) should be rectified. A market consolidation further aims at improving compliance with safety and quality standards. The consequences for international companies operating on the Chinese market are not yet foreseeable.

Charging Infrastructure:

From 2014 to 2015 the number of publically accessible slow-charging stations increased from 21.000 to 47.000. Fast charging opportunities grew from 9 000 to 12 100 units (34). The expansion of the charging infrastructure is financially supported by the MoF. In November 2014, the Chinese government issued new regulations to subsidise the development of charging facilities for electric vehicles. MoF will directly transfer subsidies to the respective city governments proportional to the number of electric vehicles registered in the municipality. Under the leadership of NEA, guidelines for an EV charging infrastructure (2015-2020) were published. A minimum of 4.8 million charging piles and 120.000 charging stations are to be constructed until 2020.

Electrification of public road transport:

In November 2015, the MoT, MoF and MIIT jointly released a new regulation, which obligates local governments and other public transport agencies and companies to promote the integration of electric buses in public transport fleets. In selected municipalities like Beijing, a share of 80% of



NEVs in the bus fleet until 2019 is foreseen. By 2020, 200,000 city buses and 100,000 taxis shall be pure EVs.

Local authorities have since then implemented large scale pilots with a variety of different charging methods and drivetrain technologies. A total of 529,000 public buses, from which 36,500 are electric buses, are operating in Chinese public transport fleets. Large scale pilots have been introduced over the last few years covering different operational modes and charging systems (See Table 12 below)

City	Chongqing	Chongqing	Beijing	Shanghai	Shenzhen	Qingdao
Number of vehicles	31	1304	640	70	2000	250
Bus type	Pure electric bus	Plug-in hybrid bus	Trolley bus	Pure electric bus	Pure electric bus	Pure electric bus
Battery type	Lithium-ion battery (Li4Ti5O12)	Lithium-ion battery (Li4Ti5O12)	Lithium iron phosphate battery (LiFePO4)	Super capacitor battery	Lithium iron phosphate battery (LiFePO4)	Lithium iron phosphate battery (LiFePO4)
Charging technology / time	Fast charging (10 min)	Fast charging (5 min)	In motion charging	Fast charging on station (30 seconds)	Slow charging (6-8 hours)	Battery-swapping (10 min)
Specifications	<ul style="list-style-type: none"> - Fewer charging processes - High charging facility utilisation - No attenuation under 4000 charging cycles - Each 10 minute charging cycle equals 50 kilometres 	<ul style="list-style-type: none"> - Less battery charging - Low degree of dependence in the charging facility - Max Mileage over 250,000 km (failure rate 0.58%) 	<ul style="list-style-type: none"> - Less battery charging - High operation efficiency - Full use of the existing trolley charging network - Off line mileage more than 50% 	<ul style="list-style-type: none"> - Full use of parking time on each station to charge - Less battery loading - Very short charging cycles 	<ul style="list-style-type: none"> - Large space required for battery - Low charging facility utilisation - Battery with severe attenuation less than 85% carrying capacity of the conventional vehicles with same length 	<ul style="list-style-type: none"> - Very low return rate of capital investment - Immense investment on land - Covering an area with 5,814.2 square metres

Table 13: Electrification of public road transport pilots overview (Source: Based on Research Institute of Highway, 2016)

Electrification of two- and three wheelers

In 2015, China produced some 198 million electric scooters making it by far the largest supplier in this field ⁽³⁴⁾. In many cities two-wheelers dominate the cityscape. Nonetheless, the future policy direction is not certain. As far as **electric-two wheelers** are concerned, policy makers argued that the highly deregulated market poses a considerable risk to road safety. Moreover, it has been claimed that electric two-wheelers mainly replace non-motorised and public transport trips. However, a counter argument was made that they provide efficient last-mile transport and might encourage multi-modal trip behaviour and replace vehicle trips.



A lively discussion also surrounds the growing numbers of electric **three-wheelers** for last mile deliveries (see picture to the left). Supported by the national MoT and the Logistic Association, cities like Beijing encourage the usage of electric three-wheelers as a way to reduce air pollution in cities. Other cities, like Shenzhen, completely ban three-wheelers from operating in the city, mainly on the account of road safety considerations.

Challenges

Local protectionism

Beijing, Shenzhen and Shanghai have shown that the development of citywide charging infrastructures, local promotional policies, and market access at a municipal level are drivers for a nationwide market uptake of electro-mobility. However, the wide-ranging scope of local competencies has also had adverse effects: Some regulations were designed in such a way that they gave preferential access to local producers of EVs. For example, plug-in hybrid vehicles were not listed for preferential registration in Beijing because the local automotive company only produces battery electric vehicles. On a national scale this has hindered competition and sustainable national market development. Especially smaller producers “survived” on the account of local subsidies.

As one of the most strategic new industries that China is currently promoting, electro-mobility requires comprehensive and long-term planning. The experience from the NEV demonstration programme shows that short-term policies with differentiation between a national and local level cause uncertainty and skews investment decisions. It is therefore vital to develop a long-term and sustainable policy framework that encourages the industry to focus on its own strategy and product planning.

Electrification of heavy duty vehicles

The electrification of heavy duty commercial vehicles is high on the agenda of the MoT. The number of electric buses in the public bus fleet has grown considerably in the last year. However operational complications with current pilot projects were controversially discussed during the interviews. Battery attenuation (battery life time below expectation), charging facilities (long distances of empty trips to charging stations), unclear responsibilities for battery recycling and currently low operational reliability have been considered crucial issues to be resolved. Up to now, fully electric buses are not cost competitive with their conventional alternative.



Despite these challenges it was stated that electric buses are technically close to market readiness. The operational environment buses operate in is conducive to electrification. The enabling factors are opportunities for frequent charging at bus stops or bus depots, opportunities for installing overhead charging infrastructure in a dense urban environment, and opportunities for making use of regenerative braking (energy lost due to braking is recovered and utilised to charge the battery which is particularly feasible in an urban environment with frequent stop and go). These opportunities do not exist for long-distance heavy duty vehicles operating outside cities. While a discussion on alternative fuels for heavy duty vehicles was initiated through a stakeholder dialogue process by the MoT, no systematic research on possible technological roadmaps or pilot projects have been initiated.



Interoperability of charging infrastructure

The national and global harmonisation of standards and technology for e-mobility, electricity network interface, as well as charging interoperability to ensure future electric vehicles and charging stations work together seamlessly, are imperative preconditions for the adoption of EVs. Industry standards for vehicle charging interfaces have been finalised by the MIIT. However, interoperability between different charging infrastructure operators and EVs remains a challenge. Payment procedures, vehicle grid communication and safety standards require further harmonisation.



Coal based energy production and Electro-mobility : How do the two go together?

Whether an electrification of transport in a country with a high share of coal in primary energy production is a climate-friendly solution or exacerbation of the problem is a common debate - especially outside China. The motives of China's industrial policy are straightforward, yet environmental protection as a driver is not equally unambiguous. Dominant coal-fired electricity production is sparking doubts whether an electrification of vehicle drivetrains, the electrification of the railway sector and the prospective production of power-based fuels have a positive climate impact.

Life-cycle assessments (LCA) that take into account emissions occurring during energy production as much as the emissions produced during vehicle operation and production attempt to address this concern.

The key conclusion of LCAs conducted for electro-mobility in China ⁽³⁵⁾ shows that the long-term mitigation potential of NEVs could come at significant abatement and environmental costs today. Given high share of emissions in coal production, EVs do not possess a climate protection advantage in 2016.



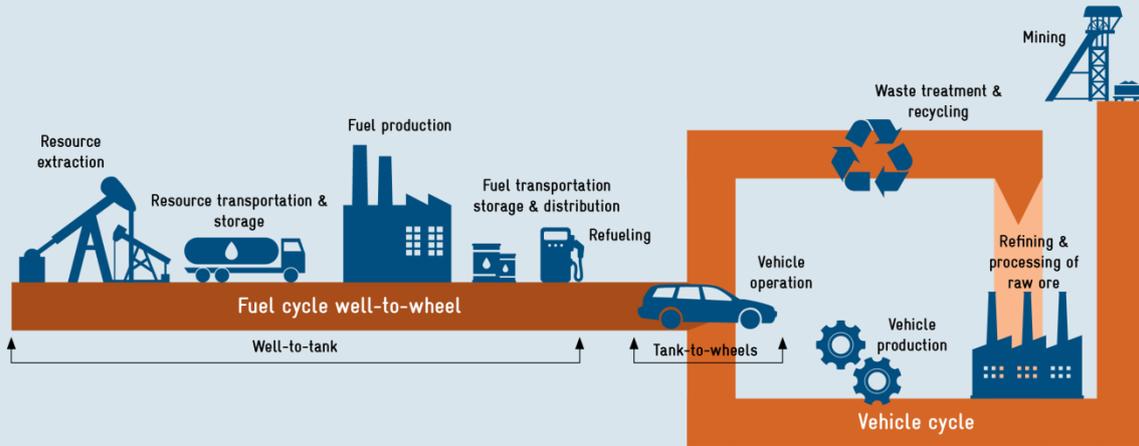


Figure 24: Climate Impact Life-Cycle Assessment Methodology

Nonetheless the LCA also shows that a low-carbon automotive sector is prospectively not attainable without electrification of individual mobility. The main reasons are that internal combustion engines reach their efficiency maximum without an electrification of the drivetrain. Simultaneously, energy production becomes gradually cleaner in China.

What are the implications of these results for policy making in China?

A comprehensive systemic climate and environmental approach is required beyond the mere promotion of electric vehicles. The following challenges are to be addressed:

1. Reduce energy consumption in battery production and battery recycling.
2. Drive the transformation of the energy sector. In the short term install dust removal and desulfurization technology, in the long-term strive for a carbon-free primary energy production.
3. Explore and implement flexibility options for thermal power plants to more effectively integrate renewable energies.
4. Implement policies that reduce demand for private individual mobility (see Chapter 2).

The question whether the substantial investments in electro-mobility are justified from an environmental point of view was not unambiguously answered. But there was a common agreement that alternatives are lacking. It is uncontested that demand for motorised individual mobility in China will not slow down significantly any time soon.

The effect of not investing in electro-mobility now - to enable it to develop at the same pace as renewable energies - could therefore be very costly in the long run. Long development cycles in the automotive industry, long innovation cycles for traction batteries and a costly charging infrastructure require early collaboration across industries and the state. International standardization processes equally require substantial time.

If government agencies, car manufacturers and utilities fail to drive the market expansion now, the road transport sector is likely not ready on time **to harvest the climate protection benefits of EVs that the power sector is providing in the future**. Consequently, there is a strong case to support electro-mobility despite a high share of coal-based energy production. Investment in electro-mobility can even support the transition of the energy sector as it drives innovation for battery storage systems, off grid solutions and vehicle-to-grid systems to stabilise renewable energy supply.



Entry Points for a Mobility and Fuels Strategy – Expert Recommendations



Scenarios for renewable energy availability

The quantitative availability of renewable energy sources should be compared to the future demand of the transport sector subject to different technology and demand scenarios. Given the difference of regions in terms of grid capacity and renewable energy availability it is advisable to analyse scenarios on a regional level.

Enhance research and knowledge base for alternative drive systems and fuels for heavy duty vehicles

In July 2016 the MoT initiated a status quo analysis for the electrification of heavy duty vehicles (public transport, taxi and carsharing, logistic). The focus of the current phase is to assess the current application and experience in terms of operational implications, infrastructure and status of drive technologies. A mobility and fuels strategy could help to broaden the knowledge base nationally and internationally and support the MoT in developing adequate supportive measures and a technological roadmap.

International exchange on demonstration programmes on fuel cell vehicles

Despite a mainly neutral subsidy structure, battery electric vehicles have surpassed hydrogen powered fuel cell vehicles in terms of market uptake by a long way. However, fuel cell vehicles remain a priority to the Chinese government as much as battery electric vehicles. Smaller pilot and demonstration programmes have shown that neither the required charging and distribution infrastructure nor the model availability suffices. Experts suggested an increasing international and inter-city exchange on current technologies, infrastructure standards, hydrogen permit procedures, pilot project results and capacity building programmes.

Improve knowledge base for cities on NEV promotion measures

The initial pilot cities for electro-mobility promotion –among them being Shenzhen, Shanghai and Beijing – have gathered many experiences in setting up institutions, evaluating pilot programmes, drafting policies and promoting local businesses. It was suggested to develop a platform where these lesson-learnt are collected and shared. A city network on electro-mobility promotion could further support this process.

Continue the expansion of an electrified railway sector

The further electrification of the railway sector is considered a high policy priority. The possible utilisation of electric traction systems that turn the train's kinetic energy back into electricity and returns it to the supply system to be used by other trains or the general utility grid should be assessed.



Stakeholder Analysis: Institutions for New Energy Vehicles

As one of the most strategically important industries in China, NEVs are high on the political agenda of China's central government. The lead task to develop the NEV industry is assigned to the NDRC, MoST, MoF, MIIT, and the Administration of Quality Supervision, Inspection and Quarantine (AQSIQ).

MoST has been focusing on technology development of NEVs from a very early stage on, starting from China's 10th FYP in 2001. MoST initiates research and development projects for core components of EVs and provides governmental funding for research projects. Funding does not discriminate against any technological pathway and covers all drive train and fuels options. In particular, fuel cell technology is one of the focal areas of MoST. International cooperation projects in this respect (e.g. with NOW GmbH) are supported and coordinated by MoST.

The rapid development of NEVs in China in recent years is strongly driven by purchase subsidies. MoST and **MoF** have taken the lead in developing and administrating these fiscal policies. The two ministries are responsible for evaluating the demonstration city's performance, manage fund declarations and supervise expenditure. MoF is also responsible for developing other related fiscal policies, such as tax exemption for EVs or fuel subsidy for new energy buses.

The **NDRC** in China is responsible for setting economic and social development strategies and plans at a macro level. As for the automobile industry as well as NEV industry, NDRC sets rules when it comes to construction production facilities. NDRC is responsible for setting criteria for new EV manufacturers (e.g. research capacity, technical know-how, capital endowment). If the manufacturers fail to meet the mandatory requirements they are not allowed to build a vehicle factory in China.

The **MIIT** develops policies and strategies for domestic industry development. In general, MIIT is involved in all policy making processes related to the NEV industry. MIIT sets market access regulations for the NEV industry, including the traction battery industry. Industrial standards in the field of NEVs (mainly vehicle-related standards) are to be approved by MIIT, and selected standards will be treated as technical regulations for product certification. The development of Corporate Fuel Economy Standards is also led by MIIT. As far as the market access for imported NEVs is concerned, the **AQSIQ** sets the regulations for product certification.

Beyond the five leading ministries several other institutions play a key role:

The overall planning of the development of charging infrastructure is the responsibility of **NEA**, which is supervised by NDRC. NEA drafts guidelines for charging infrastructure deployment and oversees its implementation. Another significant role of NEA is taking the lead for development of grid-related standards, e.g. charging standards of EVs.

The development of policies to support the development of commercial NEVs is supervised and promoted by the **MoT**. MoT sets industry targets and takes the lead in assessing the cities' performance.

Municipal governments in China play a central role in terms of implementing national policies as well as defining local promotional policies. So-called "NEV Promotion Offices" were established in several municipal governments. For example, the **Beijing Science and Technology Commission (BSTC)** has the leading role in NEV demonstration programmes. A NEV Development Promotion Center was established by BSTC. This centre is responsible for coordinating with other commissions,



such as the **Beijing Development and Reform Commission** (in charge of charging infrastructure), the **Beijing Commission of Economy and Information Technology** (in charge of market access regulation and the related certification procedure), the **Beijing Commission of Transportation** (in charge of transport policies, e.g. license plate exemptions) for development of local policies and regulations. Generally, important policies and regulations must be jointly developed by all related authorities and then submitted for approval by the political leadership.



Representatives of local authorities discussed challenges cities are facing in terms of supporting a transition towards low-carbon transport (Frederik Strompen, Beijing 2016)

Similar to the National Platform for E-Mobility (NPE) in Germany, China established the “**China EV100**” committee in May 2014. China EV100 gathered around 100 representatives, consisting of high-ranking government officials (e.g. Minister for Science and Technology, Minister for Industry and Information Technology and other representatives from almost all ministries in China), leading think tanks, research institutes (e.g. the Development Research Center under the State Council, CATARC) and business leaders. China EV100 is dedicated to promoting the exchange between all stakeholders in the field of EVs in China and developing policy recommendations for the central government. An International advisory board supports China EV100 in promoting an international dialogue and cooperation. Chief executive officers of German car manufacturers and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH are members of the advisory board.

There are a number of international organisations, NGOs and foundations in China, who support different development agendas of the Chinese government. In the field of EVs or transportation in a broader sense, the **Energy Foundation China (EF)** plays a vital role. EF China works closely with national and local governments on a wide range of related topics, such as LCA of EVs in terms of CO₂ emissions and energy consumption, EV user behaviour or promotional policies.

The **China Association of Automobile Manufacturers (CAAM)** has not been as vocal in the development of NEVs as the individual companies were. The Chinese car manufacturer **BYD** sold the largest amount of EVs in 2015 worldwide, well ahead of Tesla and Nissan. BYD produces battery



electric vehicles, plug-in hybrid electric vehicles, and electric buses and exports their products to several markets, mainly in South America and the United States. With its strong R&D capability in batteries and integrated strategy for both EV and new energy business, BYD has become the front runner of the Chinese EV industry.

The **State Grid Corporation of China** is the largest utility enterprise worldwide. In China, it has the main responsibility for construction and deployment of charging infrastructures. Until the end of 2015, State Grid has built 28,600 charging pillars and 1537 charging stations. Fast charging stations along several main highways in China are being built rapidly, covering 81 cities with a total length of 11,000km. Besides grid companies, private enterprise in China are actively engaged in this industry.

Potevio New Energy Co.Ltd is one of the largest private companies that builds charging networks and operates charging infrastructures. Over 10,000 fast charging poles have been built by Potevio. Potevio collaborates with BMW on its ChargingNow service in China.

4.3. Biofuels

Just after the United States and Brazil, China is currently the world's third largest producer of biofuels⁽³⁵⁾. Bioethanol is currently produced on an industrial scale in several provinces. Controversies surrounding indirect land use changes and the competition with areas under cultivation have led to a tight regulatory framework for planting crops especially for biodiesel. The application in China's transport sector is limited to less than 1%. In 2015 the production of bioethanol for mandatory blending in some provinces stood at 3.08 billion litres and biodiesel (mainly from residual cooking oil) stood at 1.14 billion litres⁽³⁶⁾.

Policies and Trends

The focus of the *13th FYP for Renewable Energies* -that is currently in an expert consultation process- foresees the production of 2 million tonnes of biodiesel and biokerosene by 2020. A key priority will be to avoid any competition with arable land. For this reason, the biofuel production will focus on energy crops of the 1.5 generation (non-grain) on marginal and semi- deserted land and 2nd generation fuels (cellulosic ethanol and agricultural residue).

MoST has initiated several pilot projects on biofuels in the transport sector and driven the regulatory framework for an application in the transport sector. In 2001 China released regulations *Denatured Fuel Ethanol and Bioethanol Gasoline for Automobiles*, establishing E10 production standards. In 2002, the government began to enforce the *Law Concerning Testing for the Use of Bioethanol Gasoline for Automobiles*, launching a model to introduce E10 into strategic areas of China. Today, six provinces have adopted an E10 blend mandate. A pilot biodiesel programme for transportation fuel started in Hainan in 2010. However, the trial was only applied to two counties due to inconsistent feedstock supplies (primarily waste cooking oil) and discontinued eventually.

Beyond the road transport sector, the aviation sector initiated a few pilot projects. Boeing, Hainan Airlines and China Petroleum & Chemical Corporation Beijing initiated a biokerosene trial in 2013. The pilot has not been transferred into a regular application. The source of biokerosene in the pilot project was mainly waste oil for which restrictions are considerably less stringent than for food-crop based biofuels. However, the main challenge is the low quantitative availability. The applied kerosene was a mixture of 50% aviation biofuels and 50% traditional petrochemical fuel. Boeing continues to work with a wide range of stakeholders to develop new sustainable aviation biofuels. For example, the use of tung seed for biofuels is being explored. Boeing cooperates with the Commercial Aircraft Corporation of China and the Civil Aviation University of China to carry out the required research on aviation biofuels.

The *NEA Action Plan for Energy Development (2014-2020)* aims to “actively develop transport fuel substitutes, reach technical maturity of advanced biomass energy (2nd generation biofuels), and prioritize new generation non-grain fuel ethanol and biodiesel and pilot micro-algae to oil technology development and demonstration.” 300 million tons of cellulosic and non- grain based ethanol will be produced by 2020. Consequently, grain based subsidies were abolished in 2015 and no new grain-based projects are allowed to be initiated. Non-grain ethanol and cellulosic ethanol is being supported financially through direct subsidies and through tax exemptions. Currently, 750 RMB per tonne subsidy for *generation 1.5* ethanol productions and 800 RMB per tonne subsidy for *generation 2.0* biofuels are granted by the Chinese government.

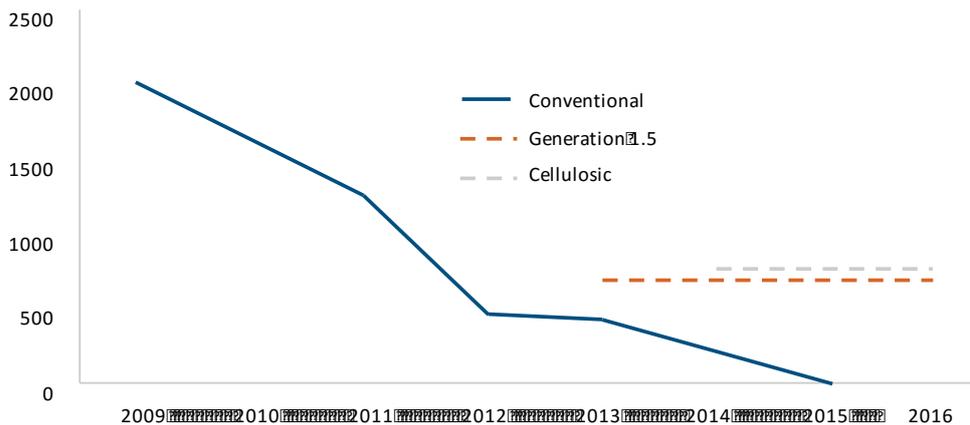


Figure 25: Biofuel subsidies (RMB/ton) (Source: Innovation Center for Energy and Transport Beijing)

Challenges

Feedstock availability

The availability of cropland to plant feedstock is the main challenge for further promotion of biofuels in China. Planting of corn and grain is not allowed for biofuel production while other feedstocks (such as Cassava and Jatropha) are mainly imported. The technical quantitative availability of feedstock and agricultural residual for cellulosic ethanol and biomass-to-liquid has not been systematically assessed for application in the transport sector. Experts suggested that the biodiesel production capacity from waste cooking oil could be around 5 billion litres. A lack of large scale collection channels hinders the actual utilisation. Equally challenging is the collection and transport of feedstock from China's small scale farmers for processing to cellulosic ethanol.

Entry Points for a Mobility and Fuels Strategy – Expert Recommendations

Enhance research and knowledge base for 2nd generation biofuels

One of the main reasons why there are hardly any private investments into 2nd generation biofuels in China is the uncertain outlook in terms of demand from the transport sector and the long-term policy priorities. To address both issues a MFS can contribute

- firstly by comparing the technical quantitative availability of corn cob/stalk for cellulosic ethanol and the availability of agricultural waste for biomass-to-liquid with the perspective consumption in the transport sector and
- secondly by facilitating an industry dialogue from a demand side (e.g. aviation industry) and a supply side (e.g. Sinopec).

These processes would facilitate the development of a long-term policy environment and a technological roadmap which might give investors the necessary confidence to invest in biofuels. However, the research should also focus on the actual climate impact of biofuels. It was suggested to link financial subsidies to actual life-cycle emissions of different biofuels.



5. Roadmap

Avoiding and shifting transport demand or even an energy transition in the transport sector are highly complex tasks. They require cooperation, coordination and long-term planning. One of the core tasks of the research project was therefore to develop recommendations for the development of a MFS in China. Early on in the consultation process with the MoT and subordinate think tanks the idea for a MFS on a regional level came up. A large nation like China with 1.4 billion residents, with diverse regions and unequal socio-economic conditions is difficult to accommodate in one nationwide strategy. This is especially true for alternative drive systems and renewable energies which depend to a large extent on the local circumstances. A regional approach to the MFS is therefore a promising concept. The City-Cluster-Initiative by the State Council is an adequate entry point for the following reasons:

1. Contrary to the national level, transport and **energy consumption data, technical capacity and methodological foundations** are more advanced on a regional level. This is especially true for pilot city-clusters. These have in common that they are already **established economic hubs** with substantial human capacities and higher quality transport demand data that can be utilised to develop a regional strategy.
2. **Energy consumption** in the city-clusters is substantially higher compared to the rest of the country. The same holds true for **motorisation**. Air quality in the agglomerations of, for example, Jing-Jing-Ji and the Pearl-River-Delta is substantially worse than in less developed parts of China. Consequently, the **pressure on local governments** to develop solutions is considerably higher. A MFS could be an important initial support process in this respect.

3. **Planning cycles** for the city-cluster development are less rigidly established under the five year planning frameworks known on a national and regional level. A MFS on a cluster level could feed into the current strategic development without running parallel to established planning processes.
4. Many investments and regulations directly affecting a MFS are to a large extent implemented on a **local and regional administration level** such as the development of infrastructure for alternative fuels, new mobility services and public transport.

Based on the stakeholder analysis and the results presented in the above chapter, an initial roadmap is suggested by the research team (see figure below). The Jing-Jin-Ji region is considered particularly suitable for a pilot project. The close proximity and administrative relationship with the national government allows for a scaling-up of the project results. At the same time the region receives considerable attention in terms of renewable energy and sustainable transport development. It is more than a regional concept. A region with 130 million residents has a signalling effect beyond provincial and national borders.

The **MFS** should be developed in a participatory manner and based on integrated transport and energy scenarios for the region. **Technical studies and a stakeholder dialogue** feed into the MFS development.

An **implementation team** under the auspices of the MoT will be responsible for the technical groundwork. Given that the key task is to establish a joint “scenario-process” integrated for the energy and the transport sector, it is suggested to work with a think tank under the MoT (such as TPRI or CATS) and a think tank under NDRC (such as ERI or CNREC). The implementation team will further consist of local authorities including the transport commissions and local development and reform commissions.

To **support** the development of the MFS, several **technical studies** and **workshops** will be initiated by the implementation team. The final topics will be agreed upon after consultation with MoT (and other respective bilateral and industry platforms). In course of the current project phase, several key topics that should feed into the scenario process were identified:

Mobility	Fuels	Cross Cutting
<ul style="list-style-type: none"> – Integrated regional rail in the Jing-Jin-Ji region – Mobility and consumption data acquisition methods, data standards, verification and sharing – Urban mobility modelling – Urban mobility concepts – Impact assessment of new mobility services – Intermodal freight solutions – Intelligent transport systems and digitalisation 	<ul style="list-style-type: none"> – Analysis of technical fuels availability and commercial viability – Infrastructure requirements for different fuels and drive systems in the region – Standardisation roadmap – Policy support for hydrogen – Electrification options for heavy duty vehicles 	<ul style="list-style-type: none"> – Comparative assessment of alternative fuels supply and transport demand scenarios in the region – Regional planning approaches and institutional support mechanisms

Table 14 Suggested topics for the technical studies

Stakeholder Participation

The role of participation and dialogue processes in China were discussed with several local stakeholders. The responses and opinions ranged from “not feasible” to “indispensable for acceptability of the results of any strategy”.

Especially the representatives from the municipalities had diverse opinions on the feasibility of comprehensive stakeholder participation. Representatives of Wuhan and Shenzhen highlighted the importance of stakeholder participation in the context of new mobility service regulations. The MoT itself has initiated several expert hearings for the electrification of commercial vehicles.

A lesson learnt from the current project phase is that small focal group discussions and interactive workshops are more suitable than larger forums as commonly known in China. A participation process will therefore be pursued for **specific technical topics** (see Table 17) rather than for the MFS in general. This ensures that the stakeholders participating are directly affected and needed in their expertise. To do so, an **industry platform** will be attached to the MFS pilot project. This ensures that policy recommendations and technological developments are mutually supportive. **Policy workshops** between the implementation team and MoT are required to scale up the results of the MFS.

A **dialogue between Germany and China** contributes to a bilateral flow of information, knowledge and innovations that can support the development of technical studies as much as the policy dialogue. The support through bilateral cooperation has been agreed between BMVI and MoT in the context of the government consultations in June 2016. Minister of Transport Yang Chuantang and State Secretary Dorothee Bär signed an MoU that foresee the establishment of working groups to jointly fast-track the development of several mobility and fuels related topics and pilot projects. Bilateral working groups can directly contribute to the FMS pilot project.

Roadmap towards a Mobility and Fuels Strategy in China

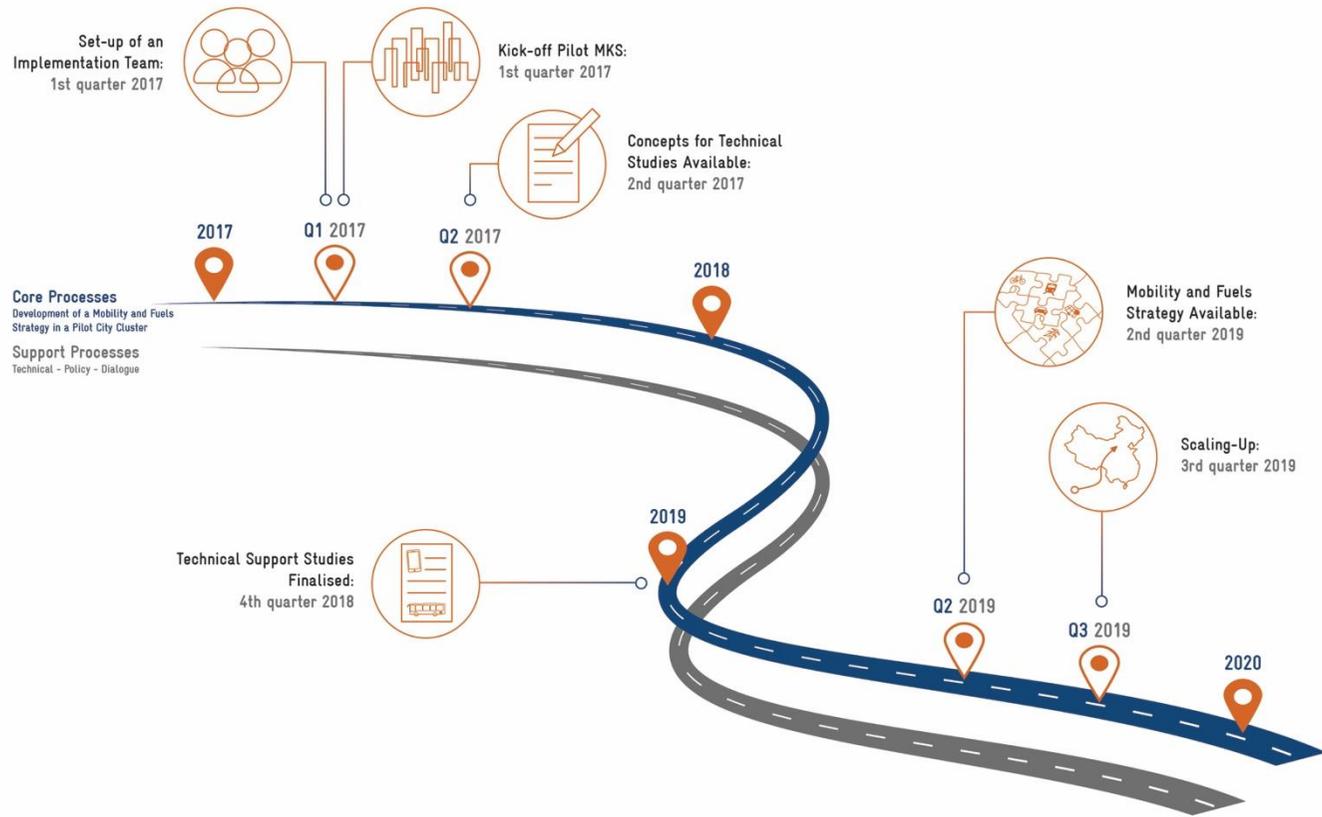


Figure 26: Roadmap towards a Mobility and Fuel Strategy in the Jing-Jin-Ji region



Set-up of an implementation team:
The implementation team is responsible for drafting the MFS, for conducting modelling processes, for the coordination of technical studies and the stakeholder participation process.



Kick-off pilot MFS:
MoT initiates a kick-off workshop and initiates cooperation with the competent local institutions.



Concepts for technical studies available:
The implementation team and the industry platform suggest topics for technical studies. The implementation team drafts terms of reference and issues the studies.



Modelling process:
The implementation team develops model-based mobility, drive technologies and fuels scenarios.



Technical support studies finalised:
Results of technical support studies in fuels, mobility and cross-cutting topics will be discussed in focal group workshops.



Mobility and Fuels Strategy available:
Based on the technical research studies, the scenario process and the supportive dialog a MFS for the region will be developed.



Scaling-up:
Learnt lessons and methods will be presented in workshops and published online.

Support Processes:

- Technical and policy dialogue
- Workshops for scenario development
- Innovation platform



Sino-German Cooperation on Fuels and Mobility Strategy: A win-win

The rapid market development of electro-mobility in China and the impact of China's renewable energy investments on solar panel prices have taught some valuable lessons: China's role in the energy and transport world cannot be underestimated. Whether drive systems and renewable energy technologies make it into large scale applications is to a large extent decided on Chinese markets. At the same time, more and more innovations –from electric buses to new mobility services – spill over from China to the rest of the world. China is the largest energy consumer in the world. Working together with China on a long-term strategy for sustainable mobility, alternative drive systems and low-carbon fuels is therefore a mutually beneficial and promising approach with global relevance.

A Chinese Mobility and Fuels Strategy –developed with German expertise and experience – creates solutions and answers questions that are urgently needed worldwide.

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List of Experts Interviewed

SN	Name	Employer	Specialty
1	Civil Aviation University of China	Chen Jingjie	Civil aviation
2	China Academy of Railway Sciences	Zhou Xinjun	Railway
3	China Waterborne Transport Research Institute	Peng Chuansheng	Waterborne transport
4	China Automotive Technology & Research Center	Huang Yonghe	New-energy vehicles
5	Institution of Energy, Environment and Economy, Tsinghua University	OuXunmin	Electric vehicles
6	China Road Transport Associations	Wang Limei	Environmentally-friendly freight transport
7	Research Institute of Highway MoT	Yu Yanchun	Environmentally-friendly freight transport
8	Energy Research Institute, National Development and Reform Commission	XuHuaqing	Sustainable energies
9	National Energy Conservation Center	XuZhiqiang	Sustainable transport development
10	Safety Supervision and Green Transport Division of Transport Commission of Shenzhen Municipality	Zhao Yanni	Low-carbon transport
11	Technology Division of Transport Commission of Chongqing Municipality	GuoLiangjiu	Low-carbon transport
12	China National Renewable Energy Centre	Liu Jian	Renewable energies
13	Urban and Rural Passenger Transport Management Office of the MoT	CaiTuanjie	Passenger transport
14	Freight Transport and Logistics Management Office of the MoT	Yu Xingyuan	Freight transport
15	Development Research Center of the State Council	Guo Jiaofeng	Transport development planning

A Research Questions

Modes of transport and drive systems				
	Road transport (passenger and freight)	Air transport	Shipping (inland/international)	Rail transport (passenger and freight)
Policies	<p>1. Existing objectives in the road transport sector <i>e.g. specific and sectorial emission reduction goals and standards, fleet composition, fuel types, etc.</i></p> <p>2. Measures and legal frameworks put in place to achieve objectives <i>e.g. regulatory, legal or fiscal policy i.e. NEV promotion, energy tax, mobility concepts, etc.</i></p> <p>3. Main barriers/challenges to - achieving the above objectives with current measures - implementing the above measures</p>	<p>1. Existing objectives in the air transport sector <i>e.g. specific consumption goals, fuel types, industry development, etc.</i></p> <p>2. Measures and legal frameworks <i>e.g. emissions trading, alternative fuels, mobility and logistics management, etc.</i></p> <p>3. Main barriers/challenges to - achieving the above objectives with current measures - implementing the above measures</p>	<p>1. Existing objectives in shipping sector <i>e.g. specific consumption goals, fuel types, industry development, etc.</i></p> <p>2. Measures and legal frameworks <i>e.g. emissions trading, alternative fuels, etc.</i></p> <p>3. Main barriers/challenges to - achieving the above objectives with current measures - implementing the above measures</p>	<p>1. Existing objectives in the rail transport sector <i>e.g. infrastructure development, urban and regional train development, high speed network, share of renewables in fuels, etc.</i></p> <p>2. Measures and legal frameworks <i>e.g. emissions trading, etc.</i></p> <p>3. Main barriers/challenges to - achieving the above objectives with current measures - implementing the above measures</p>

<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Status Quo</p>	<p>4. Demand in road transport sector (current demand in pkm, tkm, vkm) <i>divide per freight and passenger, if possible urban and regional transport</i></p> <p>5. Energy consumption in the road transport sector <i>compared to other modes, between modes</i></p> <p>6. Current trends in fuels for road transport</p> <ul style="list-style-type: none"> - Conventional fuel - Electricity-based fuel - Biomass-based fuel - Practical barriers for fuels <p>7. Market penetration of different alternative drive system <i>share and state of technology e.g. market readiness of fuel cell drives, market share of NEV.</i></p> <p>Following drive systems are relevant: internal combustion engines, battery electric vehicles, plug-in hybrids, fuel cell)</p>	<p>4. Demand in aviation sector (current domestic/international demand, freight and passenger)</p> <p>5. Energy consumption in aviation sector</p> <p>6. State of the art of plane fleet (fleet age, specific average consumption)</p> <p>7. Current trends in fuels for air crafts</p> <ul style="list-style-type: none"> - Kerosene - Biokerosene 	<p>4. Demand in shipping (inland) sector (sea transport, inland Shippings)</p> <p>5. Energy consumption in shipping sector</p> <p>6. State of the art of plane fleet (fleet age, specific average consumption)</p> <p>7. Current trends in fuels for ships <i>e.g. biofuels, LPG</i></p>	<p>4. Demand in rail sector (current demand in pkm, tkm, vkm) <i>- divide per freight and passenger, if possible urban, regional transport, high-speed</i></p> <p>5. Energy consumption in the rail transport sector (compared to other modes)</p> <p>6. State of the art of train fleet (fleet age, specific average consumption, propulsion technology)</p> <p>Following drive systems are relevant: diesel powered, electricity powered)</p>
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Scenarios</p>	<p>8. (Availability of) future road transport demand development scenarios (pkm, tkm, vkt, pj)</p>	<p>8. (Availability of) future air transport demand development scenarios - Demand and energy</p>	<p>8. (Availability of) future shipping transport sector development scenarios - Demand and energy</p>	<p>7. (Availability of) future rail transport demand development scenarios (pkm, tkm, vkt, pj)</p>

<ul style="list-style-type: none"> - Demand and energy demand forecast - Application in policy development (policies above) - Methodological/ statistical foundation (trend forecasting) - sensitivity/ impact of policies (existing and planned) <p>9. Future technology scenarios and forecasts (statistical predictions and opinions)</p> <ul style="list-style-type: none"> - drive systems market penetration <p>10. Scenarios and forecasts for energy/fuels used in road transport sector:</p> <ul style="list-style-type: none"> - Conventional fuel - Electricity-based fuel - Biomass-based fuel - Practical barriers for fuels <p>11. Other challenges and issues</p> <ul style="list-style-type: none"> - Safety - Resource availability - Technological readiness - Affordability - Fuels 	<p>consumption forecast</p> <ul style="list-style-type: none"> - Application in policy development (policies above) - Methodological/statistical foundation (trend forecasting) - sensitivity/impact of policies (existing and planned) <p>9. Future technology scenarios and forecasts (statistical predictions and opinions)</p> <ul style="list-style-type: none"> - Engine technology - Practical barriers <p>10. Scenarios and forecasts (and opinions on) sources of energy/fuels used in air transport sector:</p> <ul style="list-style-type: none"> - Kerosene - Biokerosene <p>11. Other challenges and issues</p>	<p>consumption forecast</p> <ul style="list-style-type: none"> - Methodological/ statistical foundation (trend forecasting) - sensitivity/impact of policies (existing and planned) <p>9. Future technology scenarios and forecasts (statistical predictions and opinions)</p> <ul style="list-style-type: none"> - Engine technology <p>10. Scenarios and forecasts (and opinions on) sources of energy/fuels</p> <p><i>e.g. biofuels, LPG</i></p>	<ul style="list-style-type: none"> - Demand and energy consumption forecast - Application in policy development (policies above) - Methodological/statistical foundation (trend forecasting) - sensitivity/impact of policies (existing and planned) <p>8. Future technology scenarios and forecasts (statistical predictions and opinions)</p> <ul style="list-style-type: none"> - practical barriers for alternative drive systems <p>9. Scenarios and forecasts for energy/fuels used in rail transport sector:</p> <ul style="list-style-type: none"> - Conventional fuel - Electricity-based fuel - Biomass-based fuel - Practical barriers for fuels <p>10. Other challenges and issues</p> <ul style="list-style-type: none"> - Safety - Resource availability - Technological readiness - Affordability - Fuels
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Potentials and Barriers	<p>12. Potential use of renewable energy for road transport - current plans for integration of renewable energy in the transport sector - competition for renewable energy with other sectors</p> <p>13. Barriers regarding the development of alternative drive systems in the road transport sector</p> <p>14. Potential and barriers to new mobility concepts (e.g. carsharing, carpooling, transport demand management, logistic concepts)</p>	<p>12. Potential use of renewable energy (for example biokerosene) for air transport</p> <p>13. Barriers regarding the development of alternative drive systems in the aviation sector</p> <p>14. Potential and barriers to mobility concepts (demand management)</p>	<p>11. Potential use of renewable energy (for example LNG) for shipping</p> <p>12. Barriers regarding the development of alternative drive systems in the shipping sector</p>	<p>11. Potential use of renewable energy for rail transport - current plans for integration of renewable energy in the transport sector - Competition for renewable energy with other sectors</p> <p>12. Barriers regarding the development of alternative drive systems in the rail transport sector</p>
Policy Planning	<p>15. Planning and decision making processes on road transport related issues - Role and responsibilities of involved entities - Specific activities of involved entities</p>	<p>15. Planning and decision making processes on air transport related issues - Role and responsibilities of involved entities - Specific activities of involved entities</p>	<p>13. Planning and decision making processes on shipping related issues - Role and responsibilities of involved entities - Specific activities of involved entities</p>	<p>13. Planning and decision making processes on rail transport related issues - Role and responsibilities of involved entities - Specific activities of involved entities</p>

Fuels and fuels infrastructure			
Policies	Conventional fuels	Alternative fuels: Electricity-based fuels	Biomass-based fuels
		<p>1. Existing objectives for conventional fuels <i>e.g. fuel quality, fuel independency, air quality, etc.</i></p> <p>2. Measures and legal frameworks <i>e.g. emissions trading, energy taxation, fuel quality directives, pollutant emission standards, etc.</i></p> <p>3. Main barriers/challenges to - achieving the above objectives with current measures - implementing the above measures</p>	<p>1. Existing objectives for renewable energy <i>e.g. grid mix, infrastructure expansion, technology development, net integration etc.</i></p> <p>2. Existing objectives for electricity based fuels in the transport sector <i>e.g. hydropower, power to gas, power to liquid, battery electric drives, etc.</i></p> <p>3. Measures and legal framework <i>e.g. energy tax, research projects, etc.</i></p> <p>4. Main barriers/challenges to - achieving the above objectives with current measures - implementing the above measures</p>

<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Status Quo</p>	<p>4. Conventional fuels and related infrastructure - demand in the transport sector per mode-availability of fossil fuel types - current fuelling infrastructure</p> <p>5. Current technological advancement and development of conventional fuel based vehicle technology e.g. engine efficiency, etc.</p>	<p>5. Current availability of renewable energy - Overall production per technology - Sectorial demand - Current application in the transport sector</p> <p>6. Current technological development and availability of electricity based fuels - Hydrogen - renewables for BEVs - Design fuels for ICEVS - Others</p> <p>7. Infrastructure for electricity based fuels</p>	<p>4. Current supply of biomass – based fuels - Overall production per biomass source - Sectorial demand - Current application in the transport sector</p> <p>5. Current technological development and availability of Biomass-based fuels and related infrastructure</p>
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Scenarios</p>	<p>6. Future fossil fuels demand scenarios (per mode)</p>	<p>8. Future demand of modes of transport using electricity-based fuels - Scenarios for the application of electricity based fuels for different transport modes</p> <p>9. Forecasts on electricity-based fuels regarding - Technical potential - Availability</p>	<p>6. Future demand and modes of transport using biomass-based fuels - Scenarios for the application of electricity based fuels for different transport modes</p> <p>7. Forecasts on biomass-based fuels regarding - Technical potential - Availability</p>
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Potentials and Barriers</p>		<p>10. Future technical potential and availability scenarios (Mengenpotenzial) - Technical supply potential for different renewable energy sources</p> <p>11. Barriers for the development and integration of renewable energies for the transport sector e.g. <i>electricity/energy demand from other sectors,</i></p>	<p>8. Future technical potential and availability scenarios (Mengenpotenzial) - Technical supply potential for different biomass-based fuels</p> <p>9. Barriers for the development and integration of renewable energies for the transport sector</p>

		<i>infrastructure for the integration of renewable energies, etc.</i>	<i>e.g. electricity/energy demand from other sectors, land-use change, etc.</i>
Policy Planning	7. Planning and decision making processes on conventional fuels related issues - Role and responsibilities of involved entities - Specific activities of involved entities	12. Planning and decision making processes on electricity-based fuels related issues - Role and responsibilities of involved entities - Specific activities of involved entities	10. Planning and decision making processes on biomass-based fuels related issues - Role and responsibilities of involved entities - Specific activities of involved entities

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