Data Availability for Measuring and Reporting Transport related Greenhouse Gas Emissions in Chinese Cities

by Institute of Comprehensive Transportation of National Development and Reform Commission of China (ICT)

giz
On behalf of BMZ Federal Ministry for Economic Cooperation and Development
ICT 国家发展和改革委员会综合运输研究所 Institute of Comprehensive Transportation of National Development and Reform Commission

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giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

of the Federal Republic of Germany

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1 Introduction

1.1 Background

Transport accounts for around 27% of world energy related GHG-emissions and its share in the overall energy consumption is continuously growing, which makes the transport sector to one of the most important contributors to global carbon emissions[1]. The combustion of fossil fuels is by far the largest source of GHG-emissions. This sector is contributing to a rising number of environmental and human-health problems. There is general scientific consensus that the earth is experiencing a long-term warming trend and that human-induced increases in atmospheric greenhouse gases (GHGs) are the predominant cause.

China, one of the most rapidly growing countries in the world, is experiencing rapid and substantial growth in economic and motorized mobility. Transport related energy consumption and pollution problems are poised to soar further. In 2008, consumption of fossil fuels in the transport sector accounted for 36% of national total fossil fuel consumption. Opportunities to reduce GHG-emissions from transportation include switching to alternative fuels, using more fuel efficient vehicles, and reducing the total number of miles driven.

By addressing energy security and climate change, Chinese central government has committed to reduce its carbon dioxide emissions per unit of GDP by 40 to 45 percent from 2005 levels and use non-fossil fuels for about 15 percent of its energy by 2020. Therefore, the Ministry of Transport sets specific targets in the 12th five year plan of highway and waterway energy saving and emission reduction plan.

A fundamental requirement in the effort to control GHG-emissions and pollutants in any form is to quantify the emissions being released. A robust approach to measure energy savings and emission reductions in the end of the designed schedule is an essential element in reviewing the performance. A reliable and transparent model should be applied to track the emission reductions, but so far this kind of model is not publicly available in China.

One of the aims of the Sino-German Climate Change Programme is to develop a system for monitoring and measuring the effects of both national and urban low carbon transport development paths. An emission model will be established to support this effort. GIZ requires an investigation of the data availability, data characteristics and data sources to measure GHG-emissions in the urban transport sector in order to develop a state of the art emission model in China.

This report shall support the activities of GIZ and the project partner, the Chinese Urban Sustainable Transport Research Center (CUSTReC), by assessing the availability and characteristics of data required for establishing a GHG emission quantification model in Chinese cities.

1.2 Approach

The aim of this study is to provide an overview of data quality and availability with regards to modelling carbon emissions in the urban transport sector. Specific data items and database were not accessed and acquired.

Considering the complex and diverse urban transport situation in China, it will be difficult to access information across the entire country. Hence, this study focuses on:

1) Identifying representing cities from Tier 1, Tier 2 and Tier 3 city groups;
2) Conducting an in-depth investigation of each of the identified cities;
3) Expanding the knowledge gathered in these exampling cities and produce a general understanding of data quantify and availability on different levels.

City scale information was collected through internet research and literature reviews, site meetings with local authorities, and commissioning local experts to access first hand information.

A blank information sheet was initially prepared by GIZ and will be filled in for each of the cities. This sheet was structured into three tables: 1) urban transport network characteristics and models; 2) transport activity data; 3) fleet, energy and emission data. Annex 1 presents the details of these tables.

The report is organized in the following sections:

- Introduction of the project background, objectives and approach.
- Basic information on selected cities.
- Transport emission monitoring and reporting practice in China.
- Summary regarding data availability, characteristics and ownership of selected cities.
- Brief discussion on challenges in collecting and processing information.
- Conclusion and recommendations.

2 Basic Information of Cities Reviewed

2.1 Identification of representative cites

According to the administrative division in China, there are three levels of cities, namely provincial-level cities (municipalities and special administrative region (SAR)), prefectural-level cities, and county-level cities. As of February 2012 the PRC has a total of 658 cities: 4 municipalities, 2 SARs, 284 prefecture-level cities (including the 15 sub-provincial cities) and 367 county-level cities (including the 15 sub-prefectural cities) [2].

The primary focus of this study is on the prefectural-level cities and above, considering a selection of "Low Carbon Transport Cities" or "Transit Metropolis Cities" identified by the Ministry of Transport. The analysis aims to include cities from different tiers.

After several rounds of discussions and evaluations, ten cities were identified as the cities to be assessed. These cities are:

- Tier 1 cities: ***Beijing, Shanghai, Guangzhou, Shenzhen;***
- Tier 2 cities: ***Harbin, Wuhan, Nanjing, Kunming, Guiyang;***
- Tier 3 cities: ***Jining.***

The geographical location of these cities is presented in **Figure 1**.

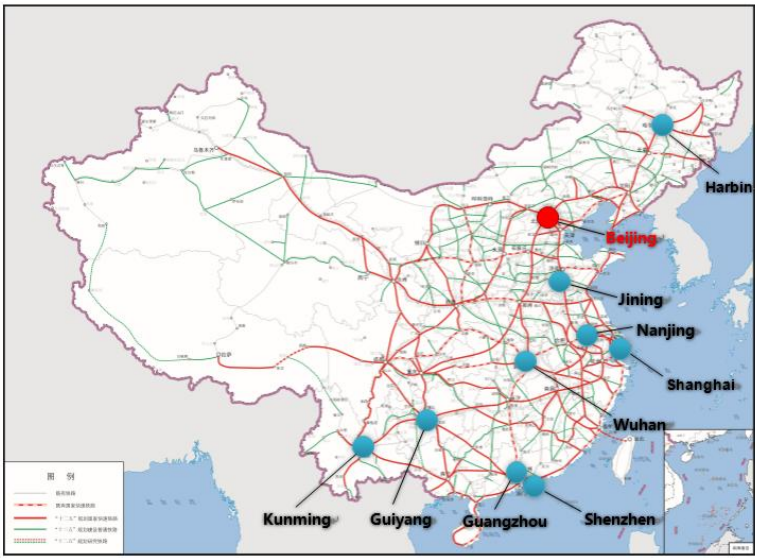


Figure 1: *Geographical location of the selected cities*

From a geographical perspective, the shortlisted cities distribute across the entire country, from north to south and from east to west. In the meantime, these cities represent the diversity of administrative and social-economic development levels.

Beijing and Shanghai are municipalities directly under the central government. Harbin, Wuhan, Nanjing, Guangzhou, Kunming and Guiyang are provincial capitals. Shenzhen is the first special economic zone and Chinas' fourth biggest city (in the view of GDP, 2012). Jining is an ordinary city in the Shandong province, and can be seen as a typical representation of middle and small cities in China.

Among the selected cities, Shanghai, Beijing, Guangzhou and Shenzhen are the four biggest cities (in the view of GDP, 2012). Beijing has the largest number of population and vehicles. Shanghai has the biggest GDP and built-up area. Information related to population, GDP, city built-up area and vehicle populations across the ten cities are shown in **Table 1.**

Table 1: *Basic information on selected cities*

Cities	GDP (Billion RMB)	Population (Thousand)	Built-up area[3] (Square km)	Area (Square km)	Vehicles (Thousand)
Beijing	1780[4]	20693[4]	1268	16808[5]	5200[4]
Guangzhou	1355[6]	8154[6]	700	7263[7]	2043[6]
Guiyang	170[8]	4452[8]	105	8034[9]	674[8]
Harbin	455[10]	10002[10]	234	53068[11]	917[12]
Jining	319[13]	8473[13]	100	62[14]	161[13]
Kunming	301[15]	6534[15]	269	21473[16]	1693[15]
Nanjing	720[17]	8162[17]	502	6597[18]	1178[17]
Shanghai	2010[19]	14192[19]	1563	6341[20]	2133[19]
Shenzhen	1295[21]	10543[21]	661	1953[22]	2211[21]
Wuhan	800[23]	8271[24]	507	8494[23]	1114[23]

2.2 City-level institutional arrangements and agencies

Due to the "central government" institutional structure of China's administrative system, most of the cities have a similar institutional arrangement and structure. With regards to the transport sector, and especially emission quantification in the urban transport system, five government agencies are linked closely to each other, and affiliated research institutes provide strong technical support to these actors. Figure 1 presents the related agencies linked to urban transport emission quantification.

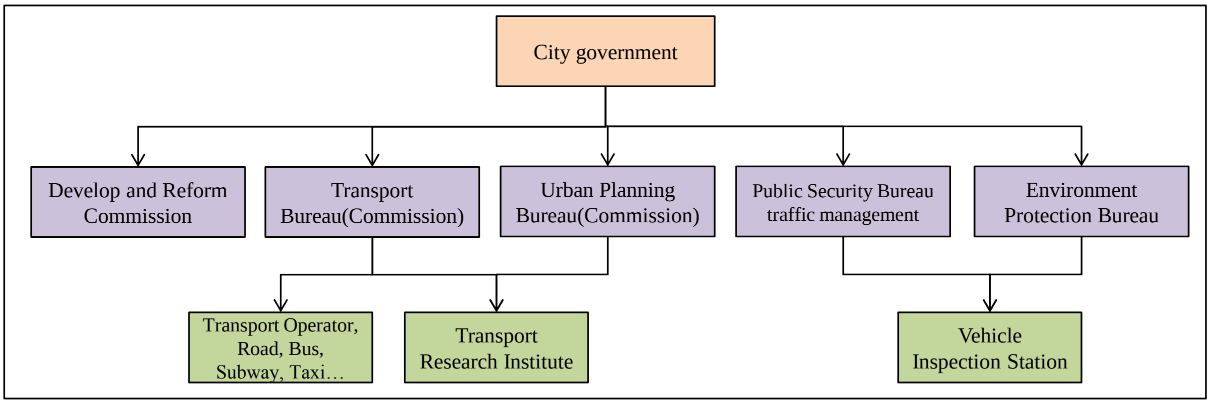


Figure 1: *Related agencies in urban transport emission quantification*

The five government agencies are linked to transport emission modelling and quantification:

- **Development and Reform Commission (DRC)** is a macroeconomic management agency under city government, which has broad administrative and planning control over social and economic development. The corresponding agency on national level is the National Development and Reform Commission (NDRC). The local level DRC takes primary leadership to promote strategies on sustainable development and to undertake comprehensive coordination of energy saving and emission reduction. DRC reviews and evaluates the annual performance of energy saving and carbon emission reduction in the transport sector.
- **Transport Bureau**, in some cities also called Transport Commission, is the main management agency in charge of the transport system. The responsibility of this department is to draw up a development plan of city transportation infrastructure and transport industry, manage and maintain transportation infrastructure, and supervise the operation of the transportation market. The corresponding agency on national level is the Ministry of Transport (MOT). Transport operating companies, such as highway, bus, subway, taxi etc. accept administrative guidance of the Transport Bureau. Hence, Transport Bureau has a strong influence on these operating companies since most of them are state owned. The Transport Bureau could access the detailed operational data in a bottom-up approach.
- **Urban and Rural Planning Department** formulates and revises the city master plan and coordinates the city development and land use. Regarding the transport system, the

planning department is responsible for the transport infrastructure planning, such as comprehensive transport planning, subway planning and public transit planning. Consequently, it provides information about planned and existing transport infrastructure. The corresponding agency on national level is the Ministry of Urban and Rural Development (MOHURD). In some cities, the planning department also maintains a citywide travel demand model which could predict transport activities across cities for a base year and future scenarios.

- **Traffic Management Bureau in Public Security Bureau,** manages road traffic operations in a city. It maintains citywide vehicle registration database which could provide detailed fleet composition in a city.
- **Environment Protection Bureau (EPB),** is in charge of the environmental protection of a city. Its primary function is focusing on pollutants and improvement of air quality. National and local EPBs are responsible for Vehicle Emissions Management. EPBs need to draw up vehicle emission standards for difficult management areas. The Ministry of Environmental Protection will publish vehicle emission standards which are suitable for the whole country and local EPBs will publish vehicle emission standards which are suitable for specific cities. Of course, the emission standards of local cities are stricter than national emission standards. However, EPBs are mainly focusing on pollutant emissions, and not on carbon emissions.

Besides the government related agencies, other stakeholders also play a key role in transport emission quantification:

- **Transport Research Institute**, affiliated with government agencies provides strong technical support to the government. These institutes are the main affiliates of the Transport Bureau or the Urban and Rural Planning Department. Most of the data collection and emission modeling work are taken by these institutes. Generally, the research institutions related to transport are all or at least once attached to government departments. Such as Kunming Urban Transit Institute is attached to the Kunming Urban Planning Bureau and Shenzhen Urban Transport Planning Center Co., Ltd is attached to the Transport Commission of Shenzhen Municipality. The major responsibility of these institutions is to provide technology support for government departments and assist government managers for decision-making. So, in theory, except the transport infrastructure planning and transportation operation information, these research institutes also hold some technical information, such as trip survey data, travel demand model and FCD system.
- **State-owned operation enterprises.** In most situations, public transit systems, especially for subway and bus, are operated by state-owned enterprises which belong to city governments. There are also some such enterprises provide other transport service, such as freight and taxi. These enterprises hold the first-hand operation information about transport service. And, these enterprises are mainly guided and supervised by transport management departments. Actually, almost all the state-owned operation enterprises need to report the operation information to transport management departments.

- **Private operation enterprises.** Private operation enterprises are the principal parts of the transport service market, especially for freight and taxi service. Taking Beijing as an example, there are 51761 self-employed households or logistics enterprises and 101 passenger transport enterprises in 2010. However, the operation information of these enterprises needs to be estimated based on a sampling survey. Hence, the accuracy of such data is not high.

Take Beijing as an example, Figure 2 shows the related agencies in urban transport emission quantification in Beijing.

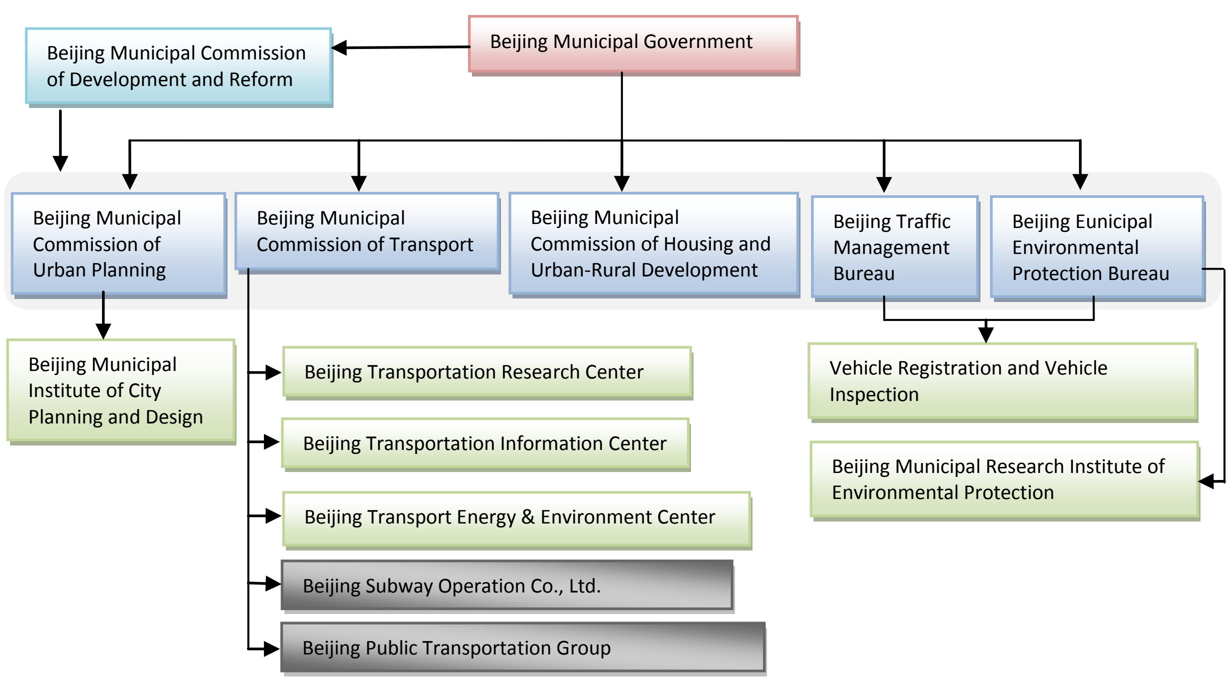


Figure 2: *Related agencies in urban transport emission quantification in Beijing*

3 Transport emissions monitoring and reporting practice in China

3.1 Approach to quantify GHG emissions

Generally, emissions in the transport sector can be accessed through a bottom-up or a top-down methodology.

The top-down approach considers fuel consumption, i.e. fuel sales, and employs emission factors, which represent the carbon content of a specific fuel type, to calculate transport-related emissions. The bottom-up approach, on the other hand, estimates GHG emissions based on transport activity data such as the distance travelled vehicle type and road type. Both approaches can be used simultaneously to allow a cross checking of the results. Both approaches are highly dependent on the availability of accurate statistics, such as fuel statistics, travel demand models and travel activity data.

At the moment, most of city and provincial level GHG emissions were quantified through a top-down approach framework.

In the context of this project, a bottom-up approach will be applied to establish the emission model to quantify emissions. The amount of GHG emissions caused by motorized transport depends on the one hand on the extent of transport activities. On the other hand it depends on the specific energy consumptions of the used means of transportation and on the specific GHG emissions of the final energy carriers. This relation is illustrated in **Figure 4** [25].

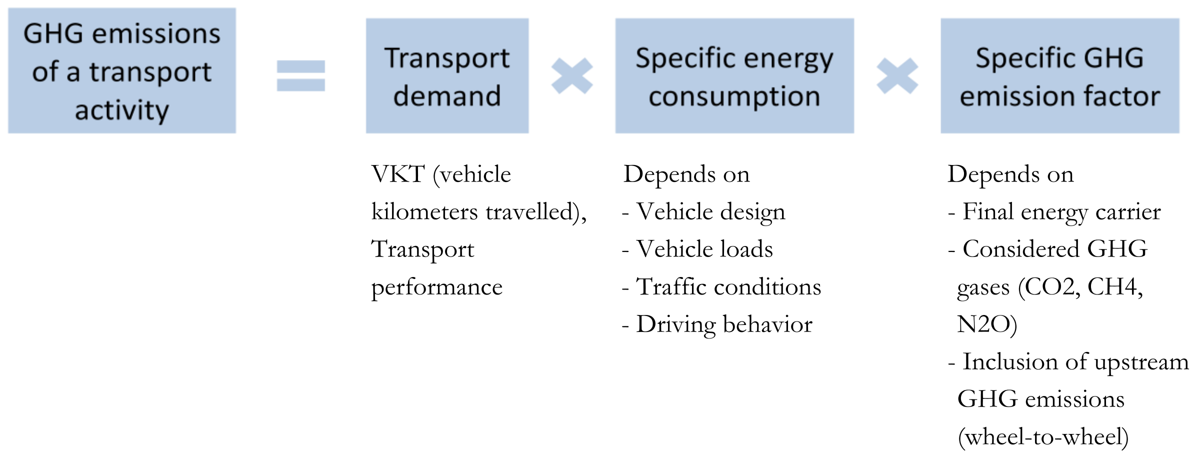


Figure 3: *GHG emissions calculation scheme for motorized transport activities*

3.2 National and local emissions monitoring and reporting

China's initial National Communication, submitted to The United Nations Framework Convention on Climate Change (UNFCCC) in 2004, included its first GHG inventory, covering 1994 emissions from the energy sector, industrial processes, agriculture, land-use change and forestry, and waste. China released its second National Communication in 2012, which includes a more developed inventory covering 2005 emissions of all six primary GHGs.

The 1994 inventory has been prepared by the methods provided by the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and using IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories as a reference. Transport was included in the energy sector and its emissions were calculated with a top-down approach. The National Development and Reform Commission (NDRC) leaded this process and primary data source was collected by the National Bureau of Statistics and other state-owned research institutes.

Effective monitoring, reporting and verification (MRV) of greenhouse gas (GHG) emissions is critical for tracking progress towards the achievement of emission reduction targets on local levels. Over the years China has developed strong institutional arrangements, appropriate policies and capacities on national level to deal with different aspects of energy saving and emission reduction management. However, such efforts have not necessarily led to an appropriate reduction on the local level due to the lack of institutional mechanism, capacities and public awareness.

At the moment, most of the local research is focusing on energy-intensity instead of greenhouse gas emissions. Due to the fact, that this is the most important indicator of local performance with regards to energy conservation and emission reduction that the central government evaluates.

4 Data availability, characteristics, ownership and accessibility

Based on information collected from meetings with local agencies, online searches and consultation with local experts, the following section summarizes a detailed evaluation of data on availability, characteristics and ownership of GHG emission quantification. Therefore, the following part is an overall description and analysis about data availability. Detailed information can be found from the annex tables.

4.1 General street network data

At the moment, most cities in China established Geographic Information System (GIS) database which contains detailed information on road network in the administrative boundary of the city, such as length, number of lanes and road type etc. The database was updated regularly once a year. Transport authorities or its affiliated research institutes can access this database to acquire information.

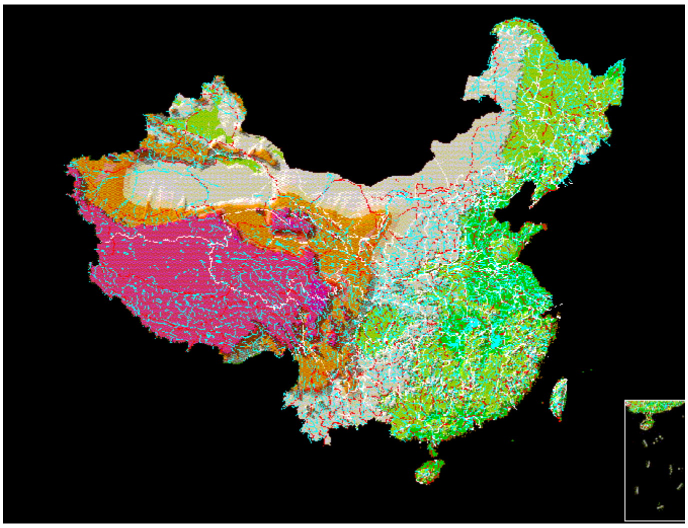
The city transit operators maintain first hand information regarding the transit network. For example, bus operating companies have all information about bus lines in the city, while the subway operating companies have all information about the subway network. Since public transport operating enterprises are under administrative management of the Transport Bureau (commission), the Transport Bureau (commission) can access all these network information by request.

According to national regulations, the use of GIS spatial data means that confidentiality and privacy issues relevant to these data must be carefully addressed. Currently these databases are not open to the public. In general there are two approaches to obtain this data:

- Cooperate with local institutes or commissions to provide a statistical summary of desired information. But it needs to be stressed that local institutes cannot give out raw/original data of the GIS database.
- Obtain information from city publications, such as annual transport reports or statistical yearbooks.

4.1.1 Detailed street maps with GIS coordinates

All selected cities have the latest (2012) and detailed street maps with GIS coordinates. The data items which are contained in GIS networks are substantially similar. Detailed information of each street segment, such as name, length, width and number of lanes, can be found from the GIS network database. Generally, GIS networks are held and maintained by Urban and Rural Planning Department and their affiliated research institutions. However, in some cities, some other research institutions with strong technical capacity also hold the detailed GIS network to support their research work, such as Beijing Transport Research Center.



The 1:4M-scale Topographic Database of the National Fundamental Geographic Information System of China (1:4M DB) can be downloaded from the official website: http://nfgis.nsdi.gov.cn/nfgis/english/default.htm. The contents of the 1:4M DB are: main rivers (level 5 and above), main roads, railways, cities (county and above), boundaries (county boundary and above) and so on.

Due to what have been mentioned before, because of involving intellectual property, the GIS road network is not open to the public.

4.1.2 Length of street network and each street segment

The length of each segment needs to be abstracted from the GIS network database. Consequently, the availability, characteristics and ownership of this data is the same as GIS network database. However, the total length of street network is a summarized data. So this data can also be reached from other public or not public materials, such as transport annual reports and statistical yearbooks.

The total length of street work can be reached through public materials, such as statistical yearbooks, annual reports or websites. Even if there is no published material, such data can still be accessed through discussions or surveys with local government or research departments. However, similar with GIS road network, the data about the length of each street segment is not open accessible.

Box 1: Transport Development Annual Reports

In China, about more than a dozen cities (there is no exact number) are going to publish reports to summarize and analyze the transport development and operation annually. Among the selected cities, Beijing, Shanghai, Nanjing, Wuhan, Guangzhou, Shenzhen and Kunming publish such reports every year. The content of the annual reports is substantially similar. It covers city development (economy, society, population and so on), transport infrastructure, vehicle, travel characteristics, road traffic operation, passenger transport, freight, traffic safety and environment. Most of the reports are not public. However, some of them still can be reached through the internet (mostly not the latest or not the full version). The following is a list about public annual report from the internet.

- **Beijing transport annual report (full version,2011), Urban and rural planning departments,** http://translate.google.cn/?hl=zh-CN&tab=wT#zh-CN/en/%E5%AE%8C%E6%95%B4%E7%89%88
- **Shanghai comprehensive transportation annual report (full version, 2009),** http://wenku.baidu.com/view/702eb2d076a20029bd642db4.html
- **Wuhan transport development annual report** (brief version, 2012), http://www.whtpi.com/page/web/7/31/201210231608190017.html
- **Guangzhou Transportation Development Annual Report** (full version, 2010), http://www.gztpri.com/sitecn/Perper/3891.html
- **Kunming Transportation Development Annual Report** (full version, 2011), http://www.kmuti.com/Html/?10227.html

4.1.3 Length of network of trolley busses, BRT and subway

Trolley bus, BRT, and subway system are public transit. So, if the selected cities do have such a system, the operation enterprises have first-hand and latest information. As mentioned before, these enterprises are basically state-owned and need to report operation data to Transport Management Departments. Hence, the Transport Management Departments of selected cities also have such datasets. And, because the BRT and subway are essential for the transport infrastructure, the main information can also be found from public resources, such as encyclopedia website. **Table 2** shows the data availability of trolley busses, BRT and subway systems in selected cities.

Table 1: *Data availability for length of network of trolley busses, BRT and subway*

	Trolley busses	BRT	Subway
Beijing	Available (2000[1]-2012)	Available (2006-2012)	Available (2000-2012)
Guangzhou	Available (2000-2012)	Available (2010-2012)	Available (2007-2012)
Guiyang	N/A	N/A	N/A
Harbin	N/A	N/A	N/A
Jining	N/A	N/A	N/A
Kunming	N/A	Available (2000-2012)	Available (2012)
Nanjing	N/A	N/A	Available (2005-2012)
Shanghai	Available (2005-2012)	N/A	Available(2000-2012)
Shenzhen	N/A	N/A	Available (2004-2012)
Wuhan	Available (2000-2012)	N/A	Available (2007-2012)

Generally, such data is much easier to reach through public material. Even if there is no published material, such data still can be accessed from discussion or survey with local government or research departments.

For example, the Beijing Bus Group provides detailed information about the number of operating bus lines, length of operating bus lines, total vehicles, annual VKT and amount of passengers starting from 1949. This information can be found via the official website: http://www.bjbus.com/home/popup_statistic_detail.php.

4.1.4 Length of bicycle network

There is no special statistical dataset on the length of bicycle network in all selected cities. So, seemingly, there is no direct approach to get such data.

But to some extent, such data can be estimated from GIS road network. So, in theory, the Urban and Rural Departments have such data. However, this conclusion is not suitable for Guiyang. The situation of Guiyang is quite different from other cities. Due to the special topography, Guiyang is not suitable for bicycles. There are no bicycle lanes in Guiyang.

4.1.5 Length of streets with exclusive bus lanes

The setting of exclusive bus lanes needs to consider the influence of road conditions and other vehicles. Generally, the Transport and Traffic Management Departments conduct the exclusive bus lanes setting together. So, both of these two departments have such data. **Table 3** shows the data availability of exclusive lanes in selected cities.

[1] The earliest starting year of data availability is 2000. Because, we thought that it was unlikely to use the data for a very history. So we set 2000 as the earliest starting time. Such as the length data of Beijing subway system can be got since 1967. However, we only took 2000 as the starting year.

Table 2: Data availability exclusive lanes in selected cities

	Exclusive bus lanes
Beijing	available(2000-2012)
Guangzhou	N/A
Guiyang	Available (2012)
Harbin	Available (2009-2012)
Jining	Available (2010-2012)
Kunming	Available (2000-2012)
Nanjing	Available (2007-2012)
Shanghai	Available (2005-2012)
Shenzhen	Available (2000-2012)
Wuhan	Available (2002-2012)

Generally, such data is much easier to reach through public material. Even if there is no published material, such data still can be accessed from discussion or survey with local government or research departments.

4.1.6 Differentiation by street types

As mentioned above on GIS road network, the information contained in the GIS network database is very detailed. So the differentiation of different street types can be resulted from network GIS analysis. The availability, characteristics and ownership of this data is the same with GIS network database.

Similar with GIS road network, the data on differentiation by street types is not under open access.

4.2 Travel demand model

Travel demand models are the very basic and important technical support for decision-making in transport system planning and construction. So, if Chinese cities have had conducted and finished comprehensive transport planning or special planning, travel demand models would exist. But establishing a travel demand model is quite expensive and time consuming. The capacity of travel demand models may vary significantly across cities considering the technical and financial resources. Some cities established a model with advanced methodology and update those regularly, while some cities have a very simplified model to meet the minimum requirements of scenario evaluation when developing the city master transport plan.

Generally, because the travel demand model is a core technology of research institutions, there is no public access to the travel models. The most feasible way would be to cooperate with local research institutions who own the models. Even though, only the analysis can be reached not the whole dataset model.

4.2.1 Availability of travel model

All the selected cities have travel demand models. These models were built by local or nonlocal research institutions based on travel surveys and other data sources. Usually, cities in China conduct large-scale travel surveys every five years. But, due to technological and financial limitations, most cities cannot conduct trip surveys for a regular time or small sampling surveys. Hence, for some cities, travel models only get updated when there are projects requiring them. In other words, the travel models of such cities are not necessarily up to date.

Among the selected cities, Beijing, Shanghai, Guangzhou, Shenzhen, Kunming, Nanjing, Wuhan and Harbin travel demand models are built by local research institutions. Hence, local government departments, urban and rural planning departments or transport management departments share travel models with local research institutions. Guiyang and Jining invited external consultants to assist them to conduct comprehensive transport planning. **Table 4** shows the builders of travel demand models of different selected cities.

Table 3: *Travel demand models builders*

	Model builder
Beijing	Beijing Transportation Research Center (BTRC)
Guangzhou	Guangzhou Transport Planning Research Institute (GTPRI)
Guiyang	Guiyang Urban Planning and Design Institute
Harbin	Harbin Urban and Rural Planning and Design Research Institute (HURPDRI)
Jining	China Academy of Urban Planning & Design (CAUPD)
Kunming	Kunming Urban Transport Institute (KUTI)
Nanjing	Nanjing Institute of City & Transport Planning Co., Ltd (NICTP)
Shanghai	Shanghai Urban and Rural Construction and Transportation Development Research Institute (SURCTDRI)
Shenzhen	Shenzhen Urban Transport Planning Center Co., Ltd (SUTPC)
Wuhan	Wuhan Transport Development Strategy Institute (WTDSI)

During the research process, local research institutions were also invited to participate in the research work. And at last, the travel demand models were also transferred to them. But, as previously mentioned, the local research institutions of these two cities do not have enough technology ability to update the models regularly.

Box 2: Trip surveys in select cities

Please find below brief information about trip surveys of the selected cities.

- **Beijing**

Beijing conducted four trip surveys since 1986.

Table 5: *Basic information about four trip surveys in Beijing*

Year	Area	Families	Sample Rate
1986	central city and part of suburb	75,000	5%
2000	central city and two satellite cities	62,000	2.1%
2005	whole city proper	82,000	1.5%
2010	whole city proper	46,900	0.59%

The surveys in Beijing are more advanced than average Chinese surveys. Advanced information technologies were also used in a survey in 2010, like floating car data, IC card data, detector data and video data. The survey was conducted for multi purposes, including resident travels, public transportation, vehicle amount and resident employment.

It is worth noticing that although the latest survey in 2010 covered fewer samples, they were more significant to describe the transportation situation in Beijing. Therefore, the resident survey in Beijing is more scientific and effective.

- **Shanghai**

Shanghai conducted five trip surveys since 1981.

Table 6: *Basic information about four trip surveys in Shanghai*

Year	Area(km2)	Sample Amount	Sample Rate
1981	230(built up area)	210,000	3%
1986	6180(city proper)	240,000	2%
1995	6340(city proper)	130,000	1%
2004	6340(city proper)	90,000	0.5%
2009	6340(city proper)	150,000	0.8%

- **Guangzhou**

There were two large-scale trip surveys in Guangzhou. The first survey was in 1984, which covered nearly 56000 residents as samples. The result of the first survey was very important for urban transportation planning in Guangzhou. As the first survey was quite early, in 2005, Guangzhou municipal government provided a second "Resident Trip survey" which involved the departments of urban planning, statistics, police, transportation, tourism, civil administration and education. The second survey covered the city properly (nearly 78,000 families and 251,000 residents).

- **Shenzhen**

There are more than four large-scale resident trip surveys in Shenzhen. The third survey was in 2001, covered the Shenzhen Special Zone and outside zones, sample rate was 5% in the special zone, and 2.5% outside of the special zone. The latest survey was in 2010, conducted by Urban Planning Land and Resources Commission of Shenzhen Municipality.

- **Wuhan**

There are three large-scale resident trip surveys in Wuhan. The first survey was in 1988, the second in 1998, but the details are not clear. The third survey was in 2008, this survey covered the city properly with 13 administrative areas, 126 streets, 712 travel zones, 37,500 families and 120,000 residents and the sample rate was 1.5%.

- **Nanjing**

Nanjing conducts a small sample (3,000-5,000) trip survey every year.

- **Kunming**

Kunming did three large-scale resident trip surveys in 1994, 2005 and 2011. The survey in 2005 covered the city properly with 18,000 families and more than 50,000 residents. The survey in 2011 was a larger scale survey, and the sample rate was 2%. The survey in 2011 provided important data for metro planning in Kunming. In addition, a small sample (1,000) survey will be conducted in Kunming for updating the travel model owned by Kunming Urban Transport Institute.

- **Harbin**

Harbin did two resident trip surveys in 2000 and 2009. The survey in 2009 was hosted by Harbin municipal government, covered Harbin city properly with 30,000 families and 80,000 residents. It is worth noticing that the original intention of the survey in 2009 was providing base data for the metro planning in Harbin.

- **Guiyang**

Guiyang did two large-scale resident trip surveys in 2001 and 2008 (the exact sample scale are both not clear), and one small trip survey (approximately 5000 residents) in 2012.

4.2.2 Modelling area

The modelling areas of most of the reviewed travel demand models cover the reviewed city properly, while Beijing's and Shanghai's travel demand models cover also administrative boundaries.

In order to forecast the transport demand of future scenarios, these models also provide future versions, which cover larger areas.

4.2.3 Base year

Modelling base years for travel demand models is strongly linked to the travel survey year since the travel survey data provides a basis for the establishment or calibration/validation of these models. Considering the rapid evolvement of urbanization and traffic congestion, most of the cities spend quite an amount of resources to investigate the transport systems. Citywide travel surveys were conducted regularly in recent decades. For example, Beijing is currently updating its model based on the 2010 travel survey data. **Table 7** shows the base year of travel demand models in the selected cities.

Table 7: *Base year of travel demand models*

	Base year
Beijing	2010
Guangzhou	2006
Guiyang	2012
Harbin	2009
Jining	2011
Kunming	2011
Nanjing	2011
Shanghai	2009
Shenzhen	2010
Wuhan	2008

4.2.4 Traffic data on street level

The situation of data availability for traffic data on street level is much more complicated. Parts of datasets, e.g. the number of vehicles or mileages on each street, can be reached through on-road collection equipment. Complete datasets should be estimated based on travel demand models. So, generally, such data is not disposable.

Additional information, such as stop and go information and FCD are also quite diverse in the different cities. Some cities have such data, and some cities do not have such data. Similarly, such data is not disposable.

4.2.5 Number of vehicles for each street segment

The number of vehicles for each street segment can be estimated based on the travel demand models. However, most travel demand models only simulate the related transport system for part times (often peak hours) of a day, the weekly or annual traffic flows need to be expanded based on statistical trends. The travel demand models only simulate limited vehicle types, such as passenger cars or busses. The volume of other vehicle types cannot be estimated.

Transport and Traffic Management Departments also have some on-road testing equipment, such as sensor or video systems, which analyze traffic volume of streets and highways. However, this on-road equipment only covers main roads. The overall traffic volume can only be distinguished through vehicle sizes.

This data is not discretionary. Cooperating with local research institutions or government departments is needed to get such data.

4.2.6 Alternative: mileages differentiated by vehicle types/sizes and time for each street

This data can be estimated based on travel demand models. But, as mentioned above, there are limitations about these datasets, such as only data of part time of a day and only certain vehicle types can be distinguished.

Cities with FCD systems can calculate this data based on the track of taxis. Of course, this data can only describe the trip situation of taxis.

This data is not disposable. Cooperation with local research institutions or government departments is needed to get such data.

4.2.7 Additional information

Road capacity

Box 3: Standards for Road Capacities in China[2]

The authority industry standard containing road capacity values is the Code for Design of Urban Road Engineering[3] (CJJ37-2012) [26]. This standard provides the capacity of urban freeway and other types of roads. The following tables show the road capacity of different kinds of roads.

Table 7: *Capacity of a lane of freeway*

Design speed(km/h)	100	80	60
Basic capacity(pcu[4]/h)	2200	2100	1800
Design capacity(pcu/h)	2000	1750	1400

Table 8: *Capacity of a lane of other types of roads*

Design speed(km/h)	60	50	40	30	20
Basic capacity(pcu/h)	1800	1700	1650	1600	1400
Design capacity(pcu/h)	1400	1350	1300	1300	1100

Of course, "real" capacity needs to be calculated through many factors, such as width of lanes, slope and isolation barrier. Taking Beijing as an example, Beijing municipal commission of transport provides road capacity values for Traffic Impact Assessment (TIA). The following table shows the road capacity of different kinds of roads in Beijing

[2] Basic road capacity stands for number of vehicles passed through a lane in a certain time period under the condition of free flow traffic, which means no interactions between vehicles.
[3] Design capacity stands for number of vehicles passed through a lane in a realistic road traffic situation.
[4] PCU stands for Passenger Car Unit.

Table 9: *Capacity of roads in Beijing*

Road grade	Location of lane	Saturation capacity	Reduction factor	Remark
Freeway	---	1800pcu/lane/h	1	---
Ramp of freeway	---	1600pcu/lane/h	1	---
First class highway	---	2500pcu/lane/h	1	---
Second class road	---	1100pcu/lane/h	1	---
Third class highway	---	700pcu/lane/h	1	---
Fourth class highway	---	500pcu/lane/h	1	---
Urban freeway	Left	1800pcu/lane/h	1	---
	Middle	1800pcu/lane/h	0.9	---
	Right	1800pcu/lane/h	0.85	---
Side road of urban freeway	Left	750pcu/lane/h	1	---
	Right	750pcu/lane/h	0.9	Separation
		750pcu/lane/h	0.8	Non-separation
Arterial road	Left	960pcu/lane/h	1	---
	Middle	960pcu/lane/h	0.9	---
	Right	960pcu/lane/h	0.8	Separation
		960pcu/lane/h	0.7	Non-separation
sub-arterial road	Left	730pcu/lane/h	1	---
	Right	730pcu/lane/h	0.9	Separation
		730pcu/lane/h	0.7	Non-separation
Branch road	Width<12 m	300pcu/lane/h	1	---
	12 m <Width< 16 m	600pcu/lane/h	1	---
	Width>16 m	900pcu/lane/h	1	---

Average speed

There are several methods to estimate, calculate or collect this data. Cities with floating vehicle systems can provide real time network performance. The average speed on an hourly basis can be calculating based on FCD data. On-road sensor or video system can also provide real time speed information. But, this equipment only covers main roads. At last, part of this data can be estimated based on travel demand models. However, as mentioned above, the travel demand models can only provide data of part of time and certain kinds of vehicle types.

This data is not under open access. Cooperation with local research institutions or government departments is needed to get such data.

Stop and go information

Usually the network traffic performance is classified into four or five situations, and stop and go is the most congested situation. From the view of public, residents in Beijing, Shanghai, Nanjing, Shenzhen, Guangzhou and Wuhan can get real time traffic status from internet websites. This information is based on on-road sensor and video equipment or FCD system. However, public traveler can only get the status pictures with different colors or comprehensive indexes, not for real speed values. The other four cities also have some stop and go information. But is it not under public access. The transport and traffic management departments hold it. And this information is also resulted from on-road sensor and video equipment or FCD systems.

This data is not under open access. Cooperation with local research institutions or government departments (less possibility) is need to get such data.

FCD

Among the selected cities, Beijing, Shanghai, Nanjing, Shenzhen, Guangzhou and Wuhan, Kunming and Harbin have floating car systems. Figure 4 shows the number of floating cars in different cities.

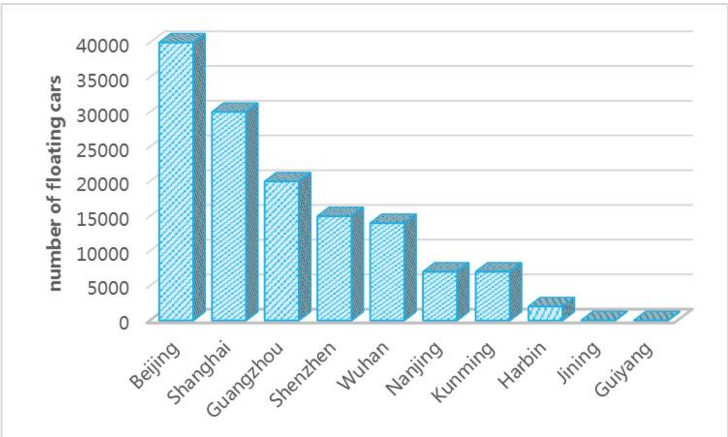


Figure 4: *The number of floating cars in different cities*

The above data is not under open access. Cooperation with or at least investigation of local research institutions or government departments is needed to get such data.

However, the public can still browse real-time traffic information through the following websites:

- Beijing:

  1) http://sslk.bjjtgl.gov.cn/roadpublish/Map/trafficOutNew1.jsp

  2) http://www.bjtrc.org.cn/PageLayout/IndexReleased/Realtime.aspx

  3) http://eye.bjjtw.gov.cn/Web-T_bjjt_new/Main.html

- Shanghai: http://www.jtcx.sh.cn/index.html
- Nanjing: http://map.baidu.com/fwmap/zt/traffic/index.html?city=nanjing
- Shenzhen:

  1) http://szmap.sutpc.com/

  2) http://www.e511.com/roadStateIndex.do

4.3 Passenger transport data

In general, passenger transport data of passenger cars needs to be estimated through travel demand models. And, regarding that busses, subways and taxis are currently operated by state-owned enterprises or managed by transport management departments, passenger transport data of these is much easier to get compared to other travel modes. Therefore, due to lose management, the passenger transport data for other travel modes are hard to get.

Generally, the data about passenger transport data is not under open access. Cooperation with local research institutions or government departments is needed to get such data.

4.3.1 Passenger kilometres

For passenger cars, there is no direct statistical data of total passenger kilometers. This data needs to be estimated based on trip survey data and travel demand. The total travel volume and average trip distance of passenger cars is needed. These two datasets can be resulted from travel demand model and travel survey. So, basically, the availability, characteristics and ownership of this data is the same as with travel demand models. This conclusion is also suitable for motorcycles, but only if the trip survey covers it (only the trip surveys of Nanjing, Guiyang and Kunming cover the trip characteristic of motorcycle.)

For the subway system, passengers need to use their IC card when enter or leave the subway stations. So it is uncomplicated to calculate the passenger kilometers with data of IC card.

The situation for busses and taxis is a little different. Bus operation companies calculate the relatively accurate value of passenger volume with data of IC cards. However, for bus lines under NO 600, passengers only need to swipe when they get on the bus. In other words, passenger do not need to swipe when they get off the bus. So, there is no integral trip for most passengers and the trip length of each passenger cannot be analyzed. On the contrary, with the taximeters of taxis, the travel distance of each passenger can be calculated. But, there is no exact data about the passenger volume. So the passenger kilometers still need to be estimated based on travel demand models and trip surveys.

The passenger kilometers of passenger cars are not available. The passenger kilometers of public transit, such as subway and bus, is available. The owners of this data are the Urban and Rural Planning and Transport Management Departments. Of course, related research institutions and operation companies also hold this data.

4.3.2 Average number of trips per day and average trip length per person by modes of transport/vehicle types

Except of the average trip length per person on subway, which can be calculated based on IC card database, the other data needs to be estimated through trip surveys.

So the owners of this data are the Urban and Rural Planning and Transport Management Departments. Of course, related research institutions also hold this data.

4.3.3 Mileages travelled within an investigation area by vehicle types

The travel mileages of passenger cars needs to be estimated based on travel demand models. However, the same data of busses can be got from bus operation companies. The bus operation companies have detailed operation information for each bus.

So, similarly, urban and rural planning and transport management departments hold this data.

4.3.4 Average occupancy rates/load factors for different modes of transport/vehicle types

This data is the basic parameter for travel demand models. So it can be got both from survey data and/or travel models.

So, similarly, urban and rural planning or transport management departments hold this data.

4.3.5 Number of commuters across city boundary (originating and terminating traffic)

The number of commuters across city boundaries needs to be estimated based on trip survey data and travel demand models. So, basically, the availability, characteristics and ownership of this data is the same with travel demand models. And, similarly, Urban and Rural Planning or Transport Management Departments hold this data.

By the way, the on-road senor or video equipment can count the traffic volume on the main roads which connect the main city with suburban districts. However, this data can only reflect the total volume on the main roads. It cannot figure out the exact volume of commuters.

4.3.6 Additional: average capacity of subway trains

This data is the basic information of subway operation status. The subway operation companies will report this data to Transport Management Departments for a regular time. So both the Transport Management Departments and subway operation companies hold this data.

4.3.7 Freight transport data

Every year, Transport Management Departments of selected cities will conduct small sampling survey for freight transport. And, the tone kilometers, traffic volume and load factors can be estimated based on the survey. However, there is only the total amount. So this data, based on different types of trucks, cannot be distinguished. And, because of the limited sample size, the accuracy of this data is on a quite low credibility.

The total amount of freight transport data is under open access. This data can be found from statistical yearbooks or annual reports. Unfortunately, there is no more detailed information.

Box 4: Vehicles Classification in China

For different purposes, there are many classification methods in China. Considering that the Traffic Management Departments are responsible for vehicle registration. This report took the classification method of Public Security Departments as standard.

"Power-driven vehicles types--Terms and definitions (GA802—2008)" [27] is a public safety standard which was published by the Ministry of Public Security of the People's Republic of China (MPS). The purpose of this standard is to provide standard definitions for different kinds of vehicles. The standard stipulates that, generally, a type of a vehicle is named by the combination of terms of vehicle size and structure. Taking passenger car as an example, it could be divided into three types, large cars, small cars and mini-cars. More information can be found from supplementary materials.

The following **Tables 10** and **11** show the vehicle classification based on size and structure.

Table 10: *Glossary Classification based on Vehicle Size*

Vehicle Classification based on Vehicle Size		
Classification		**Description**
Passenger car	Big size	The length is greater than or equal 6000mm or has more than 20 or 20 seats.
	Medium size	The length is less than 6000mm and has more than 10-19 seats.
	Small size	The length is less than 6000mm and has not more than 9 or 9 seats, but not including mini passenger car.
	Mini size	The length is less than 3500mm and the total displacement of engine cylinders is not more than or equal 1000 ml.
Truck	Heavy size	The total mass is greater than or equal 12000kg.
	Medium size	The length is greater than or equal 6000mm or the total mass is greater than or equal 4500kg and less than 12000kg, but not including low-speed truck.
	Light size	The length is less than 6000mm and the total mass is less 4500kg, but not including mini truck, three-wheeled vehicle and low-speed truck.
	Mini size	The length is less than or equal 3500mm and the total mass is less than or equal 1800kg, but not including three-wheeled vehicle and low-speed truck.
	Three-wheeled vehicle	Powered by diesel engines, the maximum design speed is less than equal to 50km/h, the total mass is less than or equal 2000kg, the length is less than or equal 4600mm, the width is less than or equal 1600mm, the height is less than equal to 2000mm, having three wheels.
	Low-speed vehicle	Powered by diesel engines, the maximum design speed is less than 70km/h, the total mass is less than or equal 4500kg, the length is less than or equal 6000mm, the width is less than or equal 2000mm, the height is less than equal to 2500 mm, having four wheels.
Special operations vehicles	Based on the classification rules of truck, special operations vehicles can be classified into heavy, medium, light and mini size.	
Tramcar	Refer to the specifications related provisions of passenger car.	
Motorcycle	Ordinary	The maximum design speed is greater than 50km/h or the total displacement of engine cylinder is greater than 50ml.
	Light	The maximum design speed is less than or equal 50km/h or the total displacement of engine cylinder is less than 50ml, if using engine-driven.
Trailer	Heavy size	The total mass is greater than or equal 12000kg.
	Medium size	The total mass is greater than or equal 4500kg and less than 12000kg.
	Light size	The total mass is less than 4500kg.

Table 11: *Glossary Classification based on Vehicle Structure*

Vehicle Classification based on Vehicle Structure	
Classification	Description
Passenger car	Ordinary
	double-deck bus
	sleeper coach
	articulated bus
	saloon car
	special bus
	trolleybus
	off-road bus
Truck	Ordinary
	Van
	Box truck
	Closed van
	Tank truck
	flatbed truck
	container truck
	dump truck
	Special structure of the truck
	semi-trailer
	Lorry trailer
Motorcycle	two wheeler
	positive motor tricycle for carrying passengers
	positive motor tricycle for carrying goods
	motorcycle with sidecar
full trailer	Ordinary
	Van
	Box
	tank
	flatbed
	container
	dump
	Special purpose
	Living
semitrailer	Ordinary
	Van
	Box
	tank
	flatbed
	container
	dump
	low bed
	Special structure
	purpose
	Living
wheeled machinery	Loading machinery
	Mining Machinery
	Grading Machinery

4.3.8 Fleet data

As mentioned before, the major responsibility of the Traffic Management Departments is to assure traffic safety. These departments manage the vehicle and drivers registration database. So, this department holds detailed information about diverse kinds and types of vehicles. Actually, in China mainland, every legal vehicle needs a Motor Vehicle Register Certificate, which records the basic information of the vehicle, including vehicle type, engine no and type, fuel type and registration date.

So, from the vehicle registration database, the number of vehicles per registration year, size and engine types can be got. The average year and growth rate of different kinds can also be calculated.

By end of 2011, among motor vehicles in China, the population of passenger vehicles reached 74.784 million, accounting for 75.9% of the total fleet. Among passenger vehicles, the population of mini passenger vehicles was 4.1%, the population of small passenger vehicles was 73.7%, the population of medium passenger vehicles was 1.6%, and the population of large passenger vehicles was 1.3%.

However, for E-bicycles and regular bicycles is no mandatory registration required, so the database can only provide the number of registered E-bicycles and bicycles. There is no known method to get average yearly mileages of these kinds of vehicles.

In general, the data on total numbers of different kinds of fleet can be through public material. But more detailed information on fleet data is not under open access. Cooperation with local traffic management departments is needed to get such data.

Box 5: Motor Vehicle Register Certificate

In China mainland, every legal vehicle needs a Motor Vehicle Register Certificate (MVRC). The format of MVRC is made by Ministry of Public Security of the People's Republic of China. There are total 32 information fields, mainly including Motor Vehicle Owner, Vehicle Type, Engine Model, Fuel Type, Displacement/Power Output, Outline Dimension, Ratified Seating Capacity, Manufacture Date and so on. More information can be found from supplementary materials.

Table 12 shows the main contents of MVRC.

Table 12: *Contents of MVRC*

<table>
<tr><th colspan="7">Registration Summary</th></tr>
<tr><td rowspan="2">I</td><td colspan="2">1. Motor Vehicle Owner / Type and Number of Identification Certificate</td><td colspan="4">XX / Resident ID Card / XXXXXXXXXXXXX</td></tr>
<tr><td>2. Registration Authority</td><td>Traffic Police Detachment, Public Security Bureau of XX City</td><td>3.Registration Date</td><td></td><td>4. Registration No. of Motor Vehicle</td><td></td></tr>
</table>

<table>
<tr><th colspan="5">Registered Motor Vehicle Information</th></tr>
<tr><td>**5. Vehicle Type**</td><td colspan="2"></td><td>6. Vehicle Brand</td><td></td></tr>
<tr><td>**7. Vehicle Models**</td><td colspan="2"></td><td>8. Colour</td><td></td></tr>
<tr><td>**9. VIN**</td><td colspan="2"></td><td>10. Made-in-China / Imported</td><td></td></tr>
<tr><td>**11. Engine No.**</td><td colspan="2"></td><td>12. Engine Model</td><td></td></tr>
<tr><td>**13. Fuel Type**</td><td colspan="2"></td><td>14. Displacement / Power Output</td><td>ml / kw</td></tr>
<tr><td>**15. Manufacturer**</td><td colspan="2"></td><td>16. Steering Mode</td><td></td></tr>
<tr><td>**17.Wheel Track**</td><td colspan="2"></td><td>18. Number of Tyres</td><td></td></tr>
<tr><td>**19. Tyre Specification**</td><td colspan="2"></td><td>20. Number of Leaf Spring</td><td></td></tr>
<tr><td>**21. Wheelbase**</td><td colspan="2">mm</td><td>22. Number of Axles</td><td></td></tr>
<tr><td>**23. Outline Dimension**</td><td colspan="3">Length Width Height mm</td><td rowspan="6">**33. Seal of Issuing Authority:**

Traffic Police Detachment, Public Security Bureau of XX City, XX Province

34. Date of Issue:</td></tr>
<tr><td>**24. Interior Dimension of Container**</td><td colspan="3">Length Width Height mm</td></tr>
<tr><td>**25. Total Mass**</td><td>kg</td><td>26. Ratified Load Capacity</td><td>kg</td></tr>
<tr><td>**27. Ratified Seating Capacity**</td><td>people</td><td>28.Traction Mass</td><td>kg</td></tr>
<tr><td>**29. Seating Capacity of Cab**</td><td>people</td><td>30. Usage</td><td></td></tr>
<tr><td>**31. Source of Vehicle**</td><td></td><td>32. Manufacture Date</td><td></td></tr>
</table>

There is no emission standard information required in vehicle registration database. However, based on some information such as vehicle model, engine model and manufacture date, the emission standard of each vehicle can be checked from the Vehicle Environmental Type Check Database of Vehicle Emission Control Centre of MEP (Ministry of Environment Protection).

The format of the vehicle registration database is uniform in China mainland. Therefore the approach is suitable for all the selected cities.

In general, vehicle registration database is not under open access. Cooperation with local traffic management departments is needed to get such data. This database was also maintained by local environmental protection bureau.

4.4 Energy data

4.4.1 Fuel sale data

There is no doubt that fuel sales enterprises have detailed information about fuel sale data in each of the selected cities.

But, statistics departments only publish highly aggregated data about energy consumption. Usually in the current annual statistical yearbook, fuel consumptions of commercial vehicles are included in a "transport, logistics and postage" section, while the fuel consumption of private passenger cars are classified as "social total" items. It is not possible to separate the specific amount of fuel consumption for each transport mode. So, there is no direct method to get this data. However, in some cities or province, the Petroleum Marketer Associations (PMA) is the semi-official petroleum institution which collects sale information if the enterprise is a member of PMA.

Therefore, the fuel sale data is not under open access. Cooperation with local PMA is needed to get such data.

4.4.2 Average specific fuel consumption of new registered passenger cars and light commercial vehicles

The Ministry of Industry and Information Technology releases fuel economy of the new passenger cars (Class M1 vehicle), light good vehicle (Class N1 vehicle) [28] and mini bus (Class M2 vehicle) [28] starting from 2010 via the website http://chinaafc.miit.gov.cn/. The average fuel consumption includes urban driving patterns, rural driving patterns, and composite driving patterns.

Box 6: Light Commercial Vehicle (LCV) in China

In China mainland, there is no authority definition for LCV. Based on the national standard [29] published by General Administration of Quality Supervision, Inspection and Quarantine, the LCVs are Class N1 vehicles (the design speed must be greater than or equal 50km/h) or Class M2 vehicles (the maximum mass is below 3500kg).

The classification of power-driven vehicles is based on the standard which was published by General Administration of Quality Supervision, Inspection and Quarantine, "Classification of power-driven vehicles and trailers (GB/T 15089-2001)" [28]. This standard classified power-driven vehicles and trailers into five types: Class L (two or three motor vehicles), Class M (motor vehicles have at least four wheels and are used for carrying passenger), Class N (motor vehicles have at least four wheels and are used for carrying goods), Class O (trailers, including semi-trailers) and Class G (SUVs). According to the standard, Class M2 vehicles are passenger vehicles which have more than 9 seats (including the driver's seat) and the maximum mass are not exceeding 5000 kg. Class N1 vehicles are goods vehicles whose Maximum mass are not exceeding 3500kg.

4.4.3 Electricity used by trolley busses and subway trains

In a regular time, maybe a quarter or six months, bus or subway operation companies will report on energy consumption in daily operation to Transport Management Departments. So, the total amount and average consumption of electricity can be calculated. Obviously, both bus or subway operation companies and Transport Management Departments have such data.

In general, the electricity used data is not under open access. But, as mentioned before, the bus or subway operation companies need to report such data to local Transport Management Departments. So it is much easier, comparing to other energy consumption data, to get such data based on the cooperation with local transport management departments.

4.4.4 Average specific electricity consumption per mileages (kWh/km) for E-bicycles

There is a lack of research on the average electricity consumption per mileage under real traffic situations. But this indicator could be found from the user manual or specifications of E-bikes which is a laboratory testing value.

Under current battery and technology situation, this indicator is 1.0-1.2kwh/100 kms.

4.4.5 Emission data

Different enterprises use different enterprise standards for fuel. Hence, the energy content in the fuel is different in cities. However, there is no evidence to prove that any of the selected cities have used test data on the energy content in fuel, not to mention the indirect CO2 emissions for the production of fuels.

There is no direct relationship between electricity production and sales. So it is difficult to collect the average CO_2 emissions for electricity and share of power plant types in a total amount of electricity production for the different cities. However, the share of power plant types in total amount of electricity production can be discussed nationwide. From the website of China Electricity Council (CEC), the share of power plant types in total amount of electricity production for recent years can be found. **Table 13** shows the basic statistic data of electricity production in 2011 and 2010.

Table 13: *Basic statistic data of electricity production* [30]

	Unit	2010	2011	Growth rate (%)
The total generated energy	Twh	42278	47306	11.89
Hydroelectric power	Twh	6867	6681	-2.71
Including: pumped storage	Twh	108	109	0.61
Thermal Power	Twh	34166	39003	14.16
nuclear power	Twh	747	872	16.67
wind power	Twh	494	741	49.91
Solar Power	Twh	1	7	459.47
geothermal power, tide power, etc	Twh	1	1	1.01

5 Challenges in collecting and processing information

At the moment, in China, most of these transport data are maintained internally by governmental agencies or affiliated research institutes, and are not under open access. Sometimes, it is required to pay a substantial amount of money to get partial of these datasets. However, in some cases, it is not possible to access the data even if you are willing to pay.

China has not yet started to measure emissions in the transport sector in a systematic manner. So there is not an organization or research institute to assemble all these data. The transport surveys or statistical data are not tailored to meet the data demand for modelling emissions. The biggest challenge is that the statistical data are distributed among several departments. What is worse, seldom cities have the mechanism to share and exchange these data among different authorities. So, firstly, there is no common and authenticated data system. Secondly, local experts or even civil servants in government can only introduce the brief information about public kinds of data.

The other challenge is that most of the data is not under open access. It is difficult to access and get detailed information on these kinds of datasets. Actually, more effort was needed for data acquiring than on data analysis itself.

The last challenge or maybe problem is that the accuracy of some data is not reliable. Though the present existence of some data were confirmed, the accuracy is doubtful regarding the analysis of the statistical method, such as the number of motor-cycles and bicycles, as well as the freight transport data.

6 Conclusions and recommendations

6.1 Basic conclusions

- Authorities, such as statistic and transport departments, do not have a systematic planning and integration about transport statistical data.
- At the moment, the statistical data is separated in different departments. Due to the lack of exchange and communication mechanism, cities have rarely authenticated and/or reliable database of the whole transport system.
- Most detailed information is not under open access. The data from public resources are mostly macro data which are useless for emission quantification.
- Recently, most cities started to conduct more and more surveys and statistics to support decision-making within the field of development issues. However, surveys and statistics are financially supported by cities governments, the investigative and statistical results do become eventually private property of research institutions.
- There is no direct correlation between detailed levels of data and the location of the city. Development levels of the economy and transport sector have strong effect on the detail-level of the data. Because cities with high development level of economy need to face more complicated transport problems. So they need more detailed transport data to support decision-making. Of course, economical ability decides whether cities have enough financial budgets to conduct surveys.

6.2 Challenges and opportunities for emission quantification.

- Lacking open and authentically data sources: Most of the required data for emission quantification are not open for public access. And, there is no comprehensive and authority department which can provide valid data. It is a difficult and time-consuming work to collect and identify data from diverse/separate departments. Sometimes, due to different statistical periods and methods, the values of the same data may differ. So, it is also difficult to identify correct values unless with good communication with the local related departments.
- Lacking of statistical data: The second challenge is that there are still a lot of required statistical data which do not exist yet. More work needs to be done to complete the statistical data indexes.
- Lacking of enough accuracy for existing statistical data: The accuracy of some of the existing data is not reliable. The main reason is incorrect statistical method or not enough sampling sizes.
- However, in order to support the decision-making about transport development and solving transport problems, more and more cities pay attention to collect data. So, recently, it is a great opportunity to provide and complete the standard and mechanism of data collection and processing.

6.3 Recommendations

For short-term goals, such as calculating a specific value of CO2 emissions for a city, a project team with strong coordination abilities and in cooperation with local research institutions is recommended. Recently, there are a lot of datasets needed to be estimated based on local models or database, which is not under open access.

- As what has been analyzed in chapter 4, macro data can be found through public or semi-public sources, such as statistical yearbooks, transport annual reports and even encyclopedic knowledge from the internet.
- A project team with strong coordinating ability is needed to get detailed operation information and vehicle registration data. Almost all the operation data can be reached through government departments. Actually, these data are not completely unavailable. Flexible methods still can be used depending on the coordinating abilities of the project team.
- Cooperation with local research institutions is necessary to get travel data. But it is unlikely to get the complete travel demand model or trip surveys data. So, it is even more important to cooperate with local research institutions.

For long-term goals, in order to provide more accurate data to quantify CO2 emissions in China, standard methodologies and rules are needed to be establish and apply valuable datasets. Of course, not only research institutions, but also related governments need to pay great effort to achieve this goal.

- Data systems and calculation methods which are suitable for the specific situations for each city with a different development level need to be established. It will make the CO2 emission quantification work more standardized, efficient and accurate.
- Statistical data systems and methods also need to be revised to fit the new data systems and calculation methods.

Supplementary files

The following shows the list of electronic version of supplementary files which were used during the research. These files are mainly available in the internet and therefore public accessible.

1. Shenzhen statistical yearbook (Chinese version), 2011.
2. Wuhan Statistical yearbook (Chinese version), 2012.
3. Jining statistical yearbook (Chinese version), 2012.
4. Beijing transport annual report (Chinese version), 2011.
5. Shanghai comprehensive transportation annual report (Chinese version), 2009.
6. The four times the city's comprehensive transport survey in Shanghai (Chinese version).
7. Electric Power Industry statistics data (Chinese version), 2011.
8. Establishment and application of Harbin transportation models (Chinese version), 2005.
9. Motor Vehicle Register Certificate (Chinese and English version).
10. Power-driven vehicles – Types – Terms and definitions (GA 802-2008, Chinese version).

The following shows the list of supplementary files which were also used during the research. But these files are not electronic versions. Most of them were got through personal relationship.

1. Beijing transport annual report (Chinese version), 2012.
2. Wuhan transport development annual report (Chinese version), 2012.
3. Nanjing transport annual report (Chinese version), 2011.
4. Guangzhou transport development annual report (Chinese version), 2010.
5. Shenzhen transport development annual report (Chinese version), 2008.

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