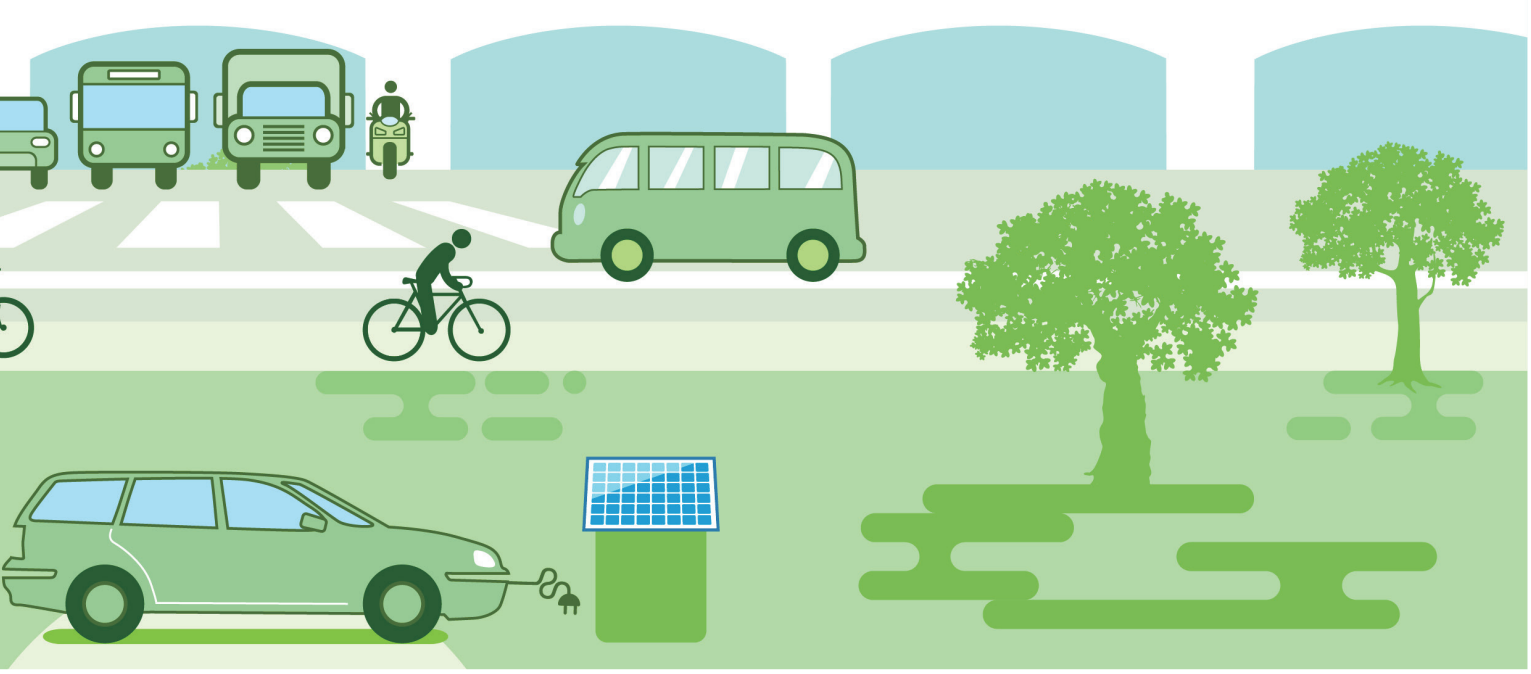
The Beijing Dialogue
Future of Urban Transport & Mobility in Beijing



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Foreword

Mr Guo Jifu,
Director of Beijing Transport Institute

In recent years, countries around the world have significantly accelerated the process of tackling climate change. A green and low-carbon transformation of the transportation sector is of great significance to the realization of China's dual carbon targets (CO2 peaking before 2030 and carbon neutrality before 2060). The rapid development of science and technology brings many opportunities and challenges to the transformation of the urban transport sector.

Multiple stakeholders in urban transport are collectively faced with the challenges of shaping urban mobility for a sustainable future. How should the future of urban mobility be envisioned? How can development strategies for urban transport be reshaped to create a sustainable future? How will scientific and technological innovations help to achieve high-quality development in the field of urban transport? These are key demands that can guide the way that urban transport planners, builders, policy makers, transport service providers and other relevant stakeholders work on together to determine their future actions.

In order to effectively cope with difficult issues such as climate change, the energy crisis, environmental pollution, traffic congestion, and demographic shifts, and to discuss developmental trends of urban transport in Beijing and relevant policies and regulations, we held the Beijing Dialogue workshop series together with GIZ and Agora Verkehrswende. Experts from the fields of transport, energy, urban planning, and other related industries were brought together to jointly discuss the vision of future urban transport and mobility in Beijing, identify required infrastructure and key technologies, and discuss an implementation roadmap, so as to accelerate the establishment of a sustainable urban transport system. The outcomes of the workshop series will be provided to local government actors as an important reference for their policy formulation processes.

Mr Sebastian Ibold,
Director of Sino-German cooperation on low carbon transport, GIZ

Decarbonising the transport sector is a major challenge that must be met if we are to achieve the goals of the Paris Climate Agreement. Our cities are of central importance in this aim. In particular, digitalisation and new technologies can make decisive contributions to increasing transport efficiency and driving the integration of traditional public transport modes and new mobility services, however, technology alone is not a solution in itself. Rather, a holistic societal rethink of transport services is required - based on the understanding that mobility transitions are ultimately urban transitions.

Today, urban mobility is generally considered only in a reduced or narrow way, for example as a commute between A and B, focusing solely on the goal of reaching a destination rather than looking at how to improve the mobility landscape as a whole. This perspective is mainly due to a lack of quality urban spaces affiliated with transport systems, but also due to the current orientation of the public towards transport infrastructures, which to many often represent barriers in public spaces that are difficult to overcome. We therefore need to rethink cities as a whole, design areas that can be used more effectively and sustainably, and adapt spaces more to the needs of urban residents, thereby creating socially accepted and appreciated locations where culture can be fostered and social interaction can take place. Urban transitions require strategic foresight to maximise positive effects and minimise risks. To be welcomed and effective however, they also require the involvement of society in their planning and processes, to ensure the highest possible acceptance for these transitions. The Beijing Dialogue is a format we have launched together with the Beijing Transport Institute and Agora Verkehrswende to share, discuss, and build upon different perspectives on what is needed to make mobility systems and cities as whole more sustainable, liveable, and accessible for us all.

Content

1 Background

Against the background of global climate change, cities around the world are under immense pressure to make their transport and mobility systems more sustainable and climate-friendly. Thanks to great advancements in technology including electro-mobility, shared mobility, autonomous driving and Big Data-based smart traffic management systems, opportunities are now available to make transport and mobility systems more efficient and sustainable. Along with these opportunities come the questions of understanding where the fields of transport and mobility are heading, and determining what is the most effective way to act against climate change in urban transport systems.

China's capital city of Beijing, with over 21 million inhabitants, is striving to develop a future-oriented sustainable urban transport and mobility system to ease traffic congestion and alleviate air pollution, as well as achieve its dual carbon targets of 2030 carbon dioxide emission peaking and 2060 carbon neutrality, which were set by the Chinese government in 2020.

To foster a debate between international experts on the future of sustainable transport and mobility, formulate a vision, and explore a roadmap for developing a sustainable urban transport and mobility system in Beijing, the Beijing Transport Institute (BTI), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and Agora Verkehrswende (Agora) jointly initiated the "Beijing Dialogue".

Under the umbrella of the "Beijing Dialogue", two workshops on future urban transport and mobility were held in November 2020 and June 2021 in Beijing, respectively. During the workshops, experts from industries, public sectors and academia debated on three themes: 1. "Vision of future urban transport & mobility: green, intelligent & shared"; 2. "Key infrastructures and technologies for future sustainable urban transport & mobility", and; 3. "Implementation roadmap for future sustainable urban transport & mobility: policies, regulations, construction and governance". Apart from the workshop series, the "Beijing Dialogue" also produced this report on Future Urban Transport and Mobility.

The result of the "Beijing Dialogue" is a vision for the future of urban transport and mobility in Beijing, which states that: "The future of urban transport and mobility in Beijing will be green, intelligent and shared". Based on the vision, ten recommendations as key results of the "Beijing Dialogue" were put forward (see details of them in chapter 5) to support the policy-making institutions of Beijing in further developing the city's transport and mobility systems in line with China's 2030 and 2060 climate goals.

Key results of the "Beijing Dialogue"

1. The future of urban transport and mobility in Beijing must be green, intelligent and shared.
2. To strengthen the Beijing-Tianjin-Hebei (Jing-Jin-Ji) city cluster, it is important to build integrated, resilient and multimodal transport networks.
3. Building functional mixed-use areas and realising the "15-minute city" is an effective way to improve the quality of urban life and reduce the total number of trips.
4. Against the background of changing demographic structures, urban transport needs to become more safe, accessible, convenient and comfortable.
5. Public transport must be the backbone of Beijing's urban transport system and needs to be well integrated with other transit modes and mobility services.
6. Electrification is key to the decarbonisation of Beijing's transport system and should be based on the integration of transport, energy and information sectors.
7. Digitalisation is key to the future development of sustainable and effective urban transport.
8. Multi-stakeholder cooperation is essential as there is no silver bullet to sustainable transport and mobility.
9. Guiding roadmaps are needed for achieving the vision of green, intelligent and shared urban transport in Beijing.
10. International exchange and cooperation are of great significance.

2 Research Methodology

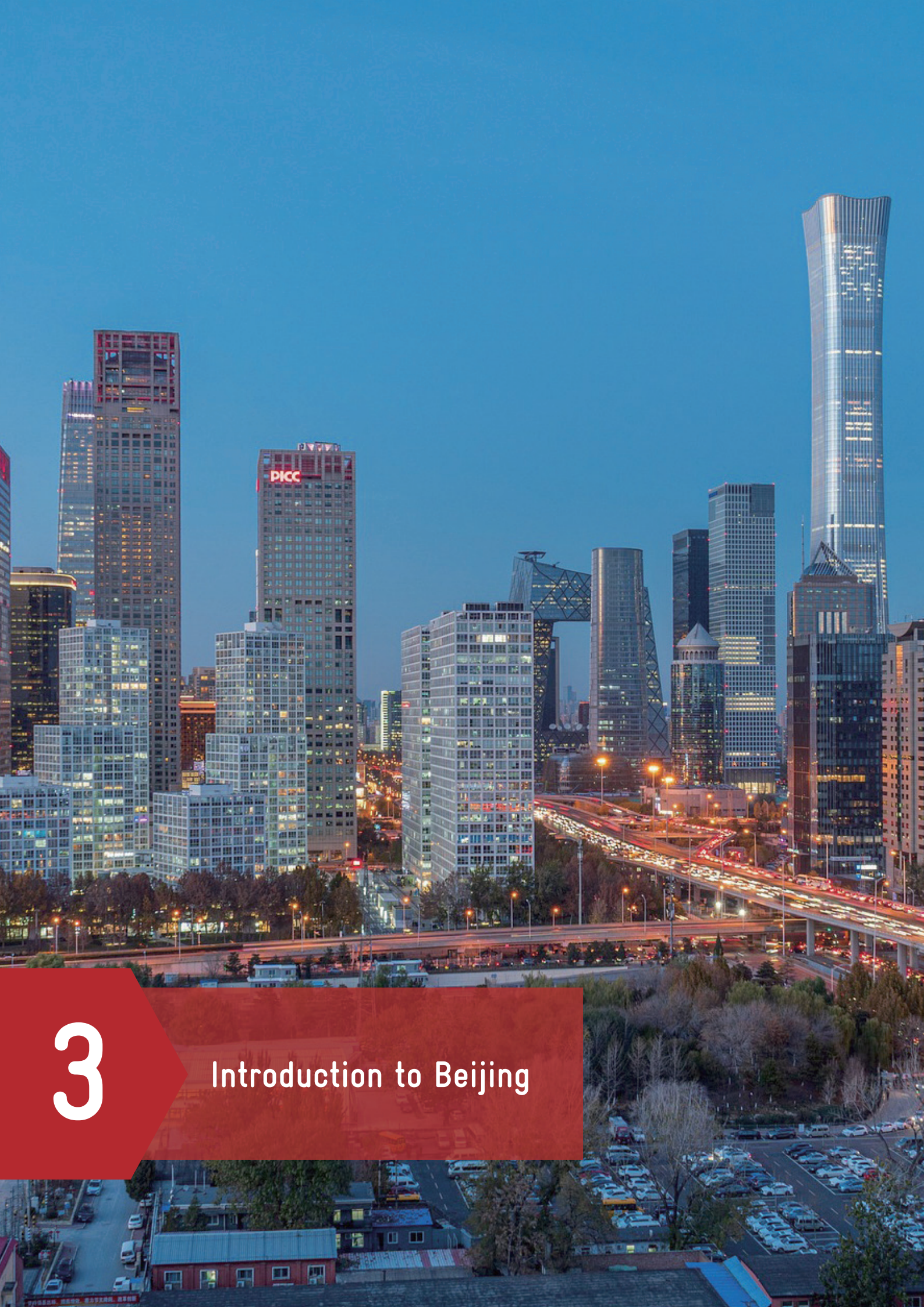
Based on research conducted by the BTI as well as results of the "Beijing Dialogue" workshop series, this report was composed to provide references to findings for the Beijing local government and to formulate a vision and explore a roadmap for developing a sustainable urban transport and mobility system in Beijing.

Research:

Various urban and transport planning reports released by national and city-level departments and institutions were reviewed. The primary research aims were to understand and analyse the dynamics and trends of Beijing's urban transport systems, predict the trend of electrification of the urban transport system, and make suggestions on the future role of new mobility services and autonomous driving vehicles.

Online survey:

In order to collect experts' opinions on the vision of Beijing's future sustainable urban transport and mobility system and key measures required to realise it, an online survey was conducted in November 2020. The questionnaire-based survey covered topics related to the vision of future urban transport and mobility in Beijing, impacts of changes in urban spatial patterns and demography on future transport trends, key infrastructures, technologies and future trends in green mobility, intelligent transport, and shared mobility. A total of 38 experts from transport, city planning, energy and other related sectors participated in the online survey. Detailed information on those surveyed can be found in the Annex.



3 Introduction to Beijing

Transport is a process to move people and goods from one place to another. The development of transport systems is closely connected with the development of urban spatial structures and land use, demographics, and the adoption of new infrastructures and technologies. Urban spatial structure changes and demographic changes affect the temporal and spatial distribution of travel demands as well as the requirements for the quality and options of transport and mobility services. Advanced and new technologies such as battery electric vehicles, smart transport systems or autonomous driving vehicles provide possibilities for developing a more effective and sustainable urban transport system.

The goals to tackle climate change, mitigate air pollution, build resilient infrastructure and make transport systems barrier-free and inclusive require ambitious measures and actions. Beijing is a forerunner in China when it comes to urban and transport innovation and achievements towards the goal of zero emission. This chapter highlights the main drivers of transition in Beijing's urban transport and mobility systems. Subsequently, the roles of spatial distribution, demographic structures, and some disruptive technologies will also be discussed.

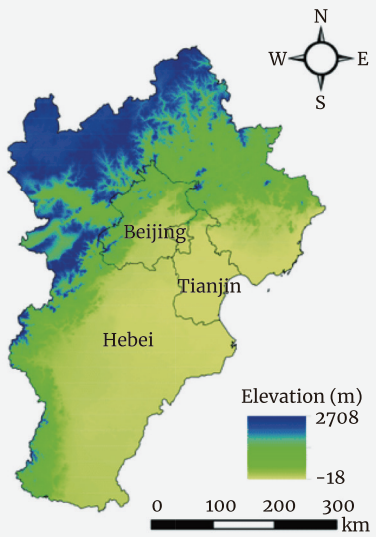
3.1 Urban development

The city of Beijing is in a process of relocating some of its non-capital functions to its suburbs, as well as to surrounding cities and provinces (for example, some manufacturing, logistics, wholesale markets, municipal government facilities and related institutions have been, or are to be moved). As a result, transport connections between the central areas and suburbs of Beijing will undergo major transformations. Against this background, this subchapter will first introduce the plans of the spatial integration of Beijing into the wider city cluster, within the Beijing-Tianjin-Hebei region (Jing-Jin-Ji region). Subsequently, corresponding solutions and opportunities will be introduced that arise from this spatial redistribution, such as mixed land use planning, transit-oriented development (TOD) and the concept of the 15-minute city.

3.1.1 A world-class city cluster

According to the *Beijing Urban Master Plan (2016-2035)*[1], the coordinated and integrated development of the Jing-Jin-Ji region is crucial for achieving overall sustainable development of Beijing. Beijing, as the core of the Jing-Jin-Ji region, will actively project its strengths to the city of Tianjin and the province of Hebei – which altogether house a population of about 110 million people – to enhance coordination within the region and to eventually establish a world-class city cluster (see Figure 3-1).

Figure 3-1 Jing-Jin-Ji region



(Source: Bing images)

With the process of further relocating Beijing's non-capital functions and integrating the Jing-Jin-Ji city cluster, the Beijing's subcentre in Tongzhou district of Beijing and the Xiong'an New Area of Hebei province (located to the south of Beijing), will take over some of Beijing's related functions and industries. Beijing, Tianjin and Hebei provinces will form a multi-layered, networked and multi-node urban spatial system in which the large, medium and small cities in the Jing-Jin-Ji region will create synergies and be developed based on their resources allocation. The subcentre will accommodate various administrative departments, commercial service centres, culture and tourism industries, and other non-capital functions which will be transferred from the centre of Beijing, while the Xiong'an New Area in the province of Hebei will host

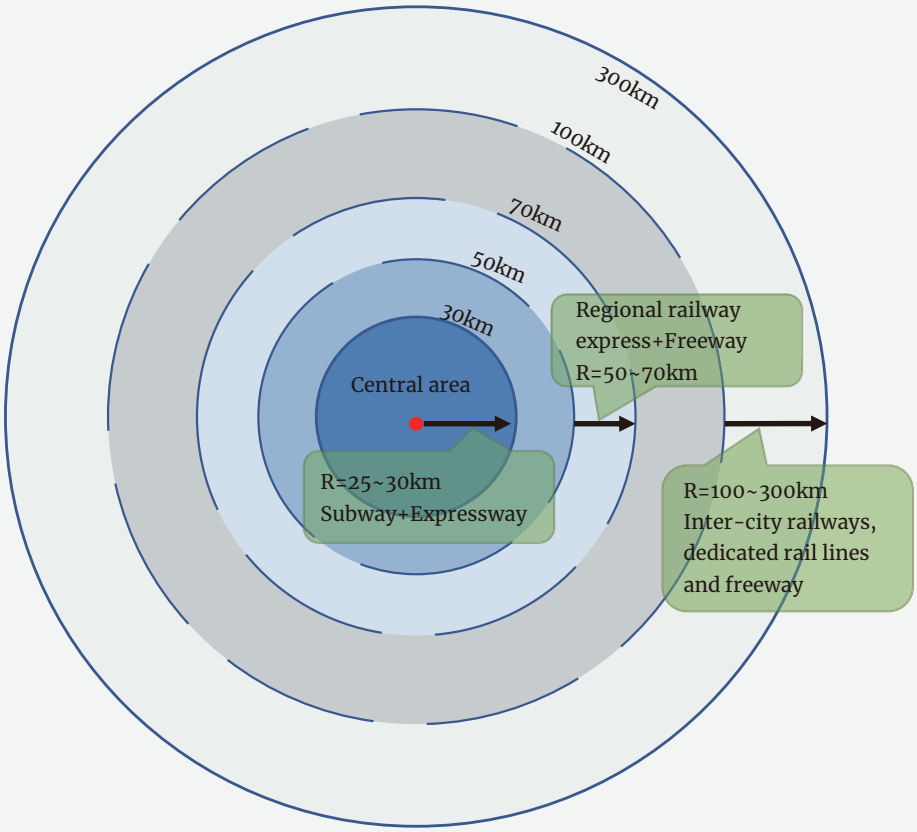
[1] Beijing Municipal Commission of Planning and Natural Resources. Beijing Urban Master Plan (2016-2035). September 29, 2017: http://www.beijing.gov.cn/gongkai/guihua/wngh/cqgh/201907/t20190701_100008.html

key administrative institutions, enterprise headquarters, financial institutions, and research and education institutions. The subcentre and the Xiong'an New Area will form Beijing's two new 'wings'.

Several national and municipal development plans have put forward clear requirements for the construction of the city cluster's transport system. The *Beijing Urban Master Plan (2016-2035)* outlines measures for the integrated development and the optimisation of the city cluster transport system, aiming to build rail-dominated and multi-node transport networks. A one-hour traffic circle will be created through multi-circle transport networks. The first circle of the multi-circle transport network (with a radius of 25–30 km) is reachable mainly by subways and city expressways; the second circle (with a radius of 50–70 km) is accessed by regional railway express (including suburban railways) and freeways; the third circle (with a radius of 100–300 km) is connected by comprehensive transport corridors including inter-city railways and dedicated rail lines for passenger transport and freeways[2] (see Figure 3-2). The *Outline for Building China's Strength in Transport*[3] released by the CPC Central Committee and the State Council in September 2019 put forward the goal to establish a "National 1-2-3 Travel Circle" system by 2035, the transport system will enable the commuting time within a city to be one hour or less, between two cities in the same city cluster to be up to two hours, and between two major cities across China to take, at the most, three hours.

With the accelerated construction of the city cluster of Jing-Jin-Ji, the supporting intercity transport system should be improved. Various transport infrastructures, such as intercity railways, suburban railways, subways and highways, need to be well integrated to meet rising demands for different purposes of travel and transport.

Figure 3-2 Multi-circle transport networks in Beijing



[2] Beijing Municipal Commission of Planning and Natural Resources. Beijing Urban Master Plan (2016-2035). September 29, 2017: http://www.beijing.gov.cn/gongkai/guihua/wngh/cqgh/201907/t20190701_100008.html

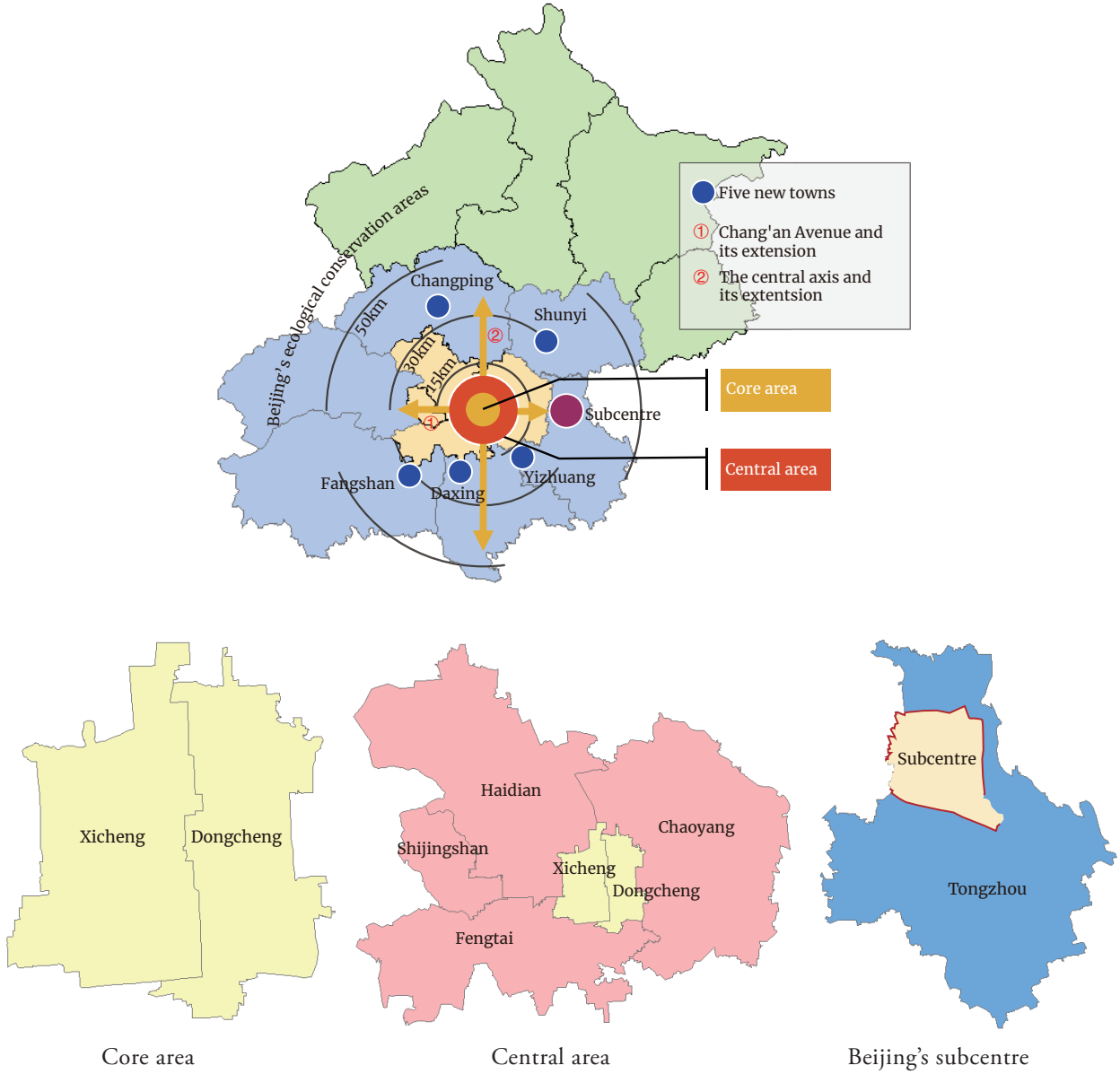
[3] CPC Central Committee and the State Council. Guidelines for Developing China's Transportation Strength. September 2019: http://www.gov.cn/zhengce/2019-09/19/content_5431432.htm

3.1.2 Urban spatial patterns

The *Beijing Urban Master Plan (2016-2035)* indicates that Beijing will form a new urban spatial structure with one core area (Dongcheng and Xicheng districts), one central area (Dongcheng, Xicheng, Chaoyang, Haidian, Fengtai and Shijiangshan districts) and one subcentre (in Tongzhou district), two development axes, multiple new towns (in Shunyi, Daxing, Yizhuang of Daxing, Changping, and Fangshan districts) and one ecological conservation zone (see Figure 3-3). The current monocentric development model will be changed into a new integrated urban development pattern.

Since 2000, Beijing has continued to experience rapid urbanisation, and the scale of the city's built-up area has greatly expanded. Large residential communities are now distributed across different districts of the city. However, Beijing's central area is still the commercial heart of the city. The average commuting distance has increased from 9.5 km in 2010 to 11.1 km in 2020 with the average commuting radius going up to 40 km[4]. According to this

■ **Figure 3-3 The urban structure plan of Beijing**



[4] Ministry of Housing and Urban-Rural Development, China Academy of Urban Planning & Design, and Baidu Map. Monitoring Report on Commuting Distance of Major Cities in China 2020. May 2020: http://huiyan.baidu.com/reports/landing?id=76

study's online survey, participants shared the common view that with Beijing's non-capital functions further shifting outwards, the average commuting radius and commuting distances would also be further extended. With this trend, plans for an appropriated urban spatial structure and more efficient travel systems need to be urgently developed. Based on this conclusion, three concepts can be introduced:

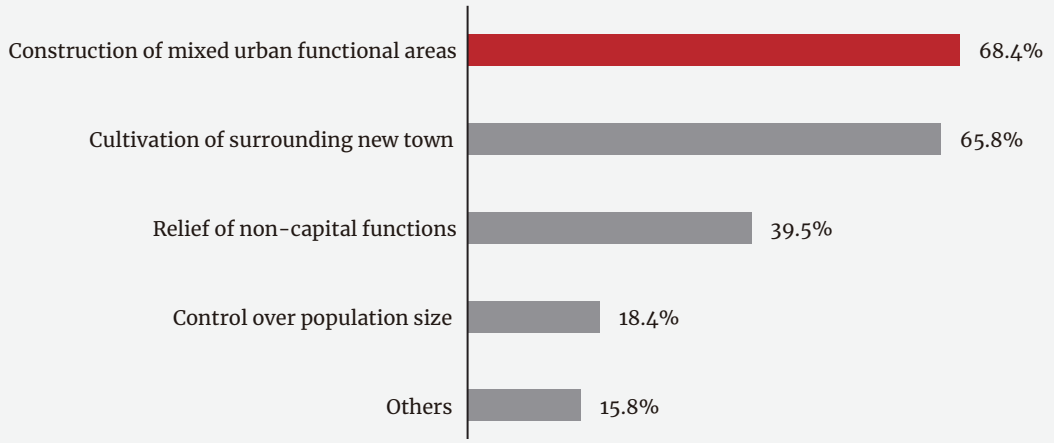
a) Mixed land use

The travel intensity of citizens is closely related to the level of mixed land use. The development of urban land use patterns has a profound impact on the travel distances and travel modes of people. The *Beijing Urban Master Plan (2016-2035)* requires the optimisation of commercial and residential area distribution for achieving a better jobs-to-housing balance. The plan also outlines the necessary improvement of employment policies to make Beijing's subcentre and new towns sustainable carriers of Beijing's non-capital functions. This study's online survey results showed that about 68 percent of respondents believed that the construction of mixed function areas could effectively reduce daily trips of people, and therefore alleviate traffic congestion in Beijing (see Figure 3-4).

b) Transit-oriented development (TOD)

TOD aims to concentrate jobs, housing and services near or along public transit lines by creating a high-density of mixed land use in conjunction with a pedestrian-oriented urban environment. The successful practice of this model in Singapore demonstrates that the TOD model can effectively alleviate the contradiction between living and transport services in densely populated urban areas[5]. The *Beijing Urban Master Plan (2016-2035)* mentions explicitly that Beijing will promote TOD, and that the local government will prioritise the allocation of residential and commercial functions along traffic corridors and around public transit stations. The *2021 Report on the Work of the Government of Beijing* for the first time proposed to construct a series of rail transit micro-hubs to form a unified development structure of rail transit stations and city spaces[6]. A total of 71 rail transit micro-hubs will be built in 14 of Beijing's 16 districts. This practice will not only strengthen the traffic function of rail transit stations, but also create entertainment, shopping and commercial opportunities. A "rail transit-based jobs-housing balance" will be gradually created. In downtown Beijing, TOD can be adopted in line with urban renewal projects to vitalise and optimise existing land resources. TOD will also be considered in the design of Beijing's subcentre and new towns so that they can be constructed in a rational spatial pattern for a balanced development between the city's downtown and suburban areas.

■ Figure 3-4 Measures to optimize Beijing's urban spatial pattern



[5] Beijing Municipal Commission of Planning and Natural Resources. TOD Planning Practice in Singapore [EB/OL]. http://ghzrzyw.beijing.gov.cn/zhengwuxinxi/zxzt/zhjtxsy/202001/P020200109516111389296.pdf

[6] People's Government of Beijing Municipality. 2021 Report on the Work of the Government. January 31, 2021 [EB/OL]. http://www.beijing.gov.cn/gongkai/jihua/zfgzbg/202102/t20210201_2249908.html

c) The 15-minute city

During the outbreak of COVID-19, a great number of people suffered from community or city lockdowns, which restricted their access to urban infrastructure and public services. Major cities around the world reiterated the importance of so-called 15-minute community-life circles and have sped up the necessary improvements of transport systems required to create these local areas[7]. The 15-minute city[8] is a concept which aims to optimise urban neighbourhoods, enabling citizens to meet most of their daily needs within a 15-minute walking distance (see Figure 3-5). Beijing is increasingly focusing on the construction of 15-minute walkable neighborhoods as a key to mitigate cross-district travel and alleviate traffic congestion. The concept has been already adopted in 2019, in the city's Lishuiqiao area and the Huilongguan-Tiantongyuan area in the city's Changping district. In the future, more districts should be encouraged to embrace this concept to satisfy residents' needs for public services, shopping, education, medical care and leisure within a 15-minute walking distance or a bike ride. However, with the popularity of the concept, short-distance travel demands may increase. Therefore, community-centred public and on-demand transport systems and active mobility networks (cycling, walking and other forms of micro mobility) should be significantly improved to meet these new travel demands.

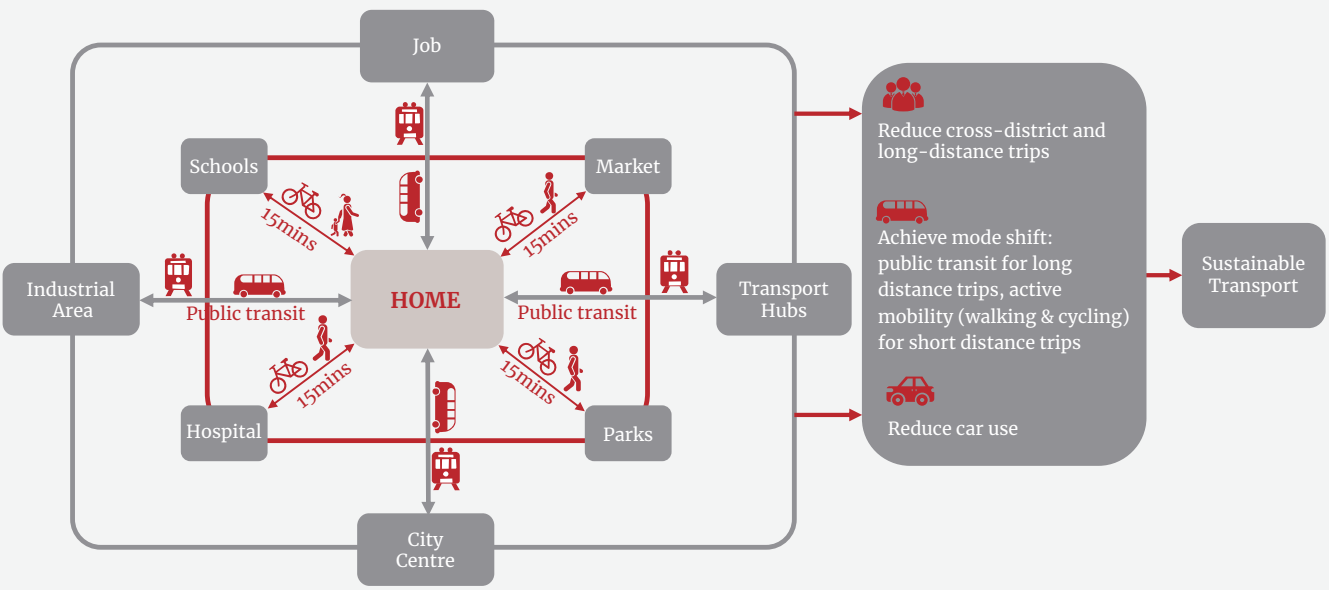
3.2 Demographics

With the reallocation of Beijing's non-capital functions, since 2017, the city's population has been slightly declining for five consecutive years. In 2021, Beijing's total permanent population was 21.886 million. Over the same time period, Beijing's population age and family structure demographics have undergone significant changes, which need to be taken into consideration when responsible authorities plan future transport and mobility services in Beijing. This subchapter will first introduce the main aspects of demographic change in Beijing, discuss how these demographic changes have posed challenges to mobility and transport services and then subsequently present related solutions.

3.2.1 Changing demographic structures

a) Aging population Beijing is facing the challenge of an increasingly aging population[9] (see Figure 3-6). At the end of 2021, 4.4 million people in Beijing were aged over 60, accounting for 20.2 percent of the permanent population. Compared with younger citizens, the elderly

■ **Figure 3-5 The concept of 15-minute city**



[7] LI Chunyan, GUO Jifu, KONG Hao, LIU Changping, LIANG Xiaohong, ZHAO Zhexi. Traffic Circulation in Beijing during COVID-19: Features and Revelations [C]. Beijing: 2020 Conference for Urban Transport Planning in China, 2020

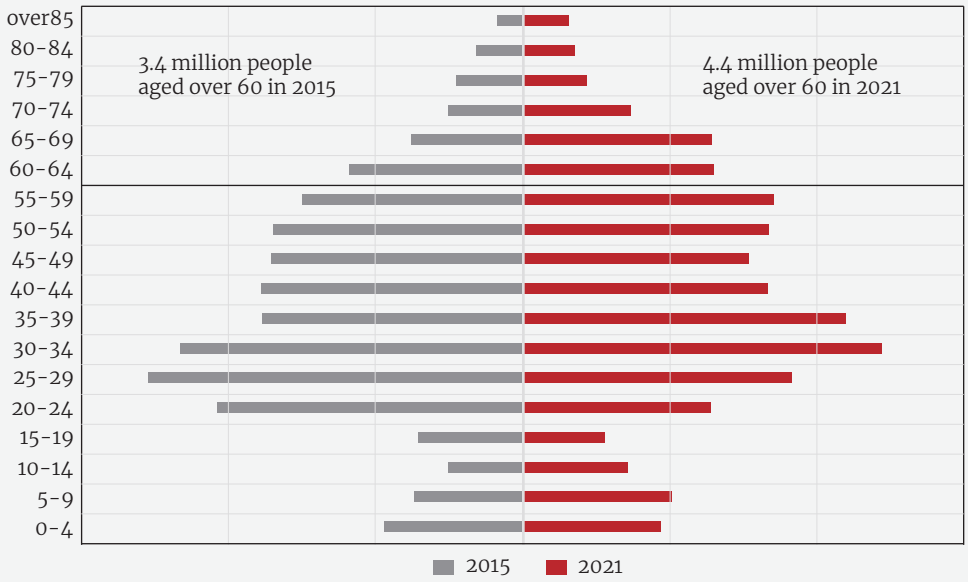
[8] Ministry of Housing and Urban-Rural Development. National Standard for Planning and Design of Urban Residential Areas. July 10, 2018: http://www.mohurd.gov.cn/wjfb/201811/t20181130_238590.html

[9] Data released by Beijing Municipal Bureau of Statistics. https://data.beijing.gov.cn/cms/web/bjdata/api/historyDownload.jsp?articleID=9008

have different travel demands with regards to travel routes, service frequency, service quality, safety, accessibility, travel modes, and travel times. This entails new requirements being demanded from urban transport systems, especially expectations for the building of barrier-free environments. In general, the elderly are in favor of public transit and walking. According to this study's online survey, by 2035 public transit and walking will continue to be the most popular travel modes among Beijing's senior residents. It is therefore necessary to establish an inclusive and accessible public transit system, develop infrastructures for active mobility, integrate all travel modes, and foster an environment for barrier-free transport and mobility services. For senior citizens, on-demand travel solutions including (autonomous) taxis and ride-hailing are convenient options to meet their specific travel needs (see Figure 3-7).

b) Changing family structures According to China's seventh national census in 2021, a family household in Beijing contained 2.31 persons on average, which is 0.14 person less than that a decade ago[10]. The family structure in Beijing has become more diversified since the implementation of the "two-child policy" on January 1, 2016[11] and the "three-child policy" on 31 May 2021[12]. In 2019, the proportions of two-person and three-person households declined slightly, while the shares of four-person households and five-person families increased to 0.11 percent and 0.07 percent from 0.09 percent and 0.05 percent in 2009 respectively[13] (see Figure 3-8). With the initiated "three-child policy", Beijing is expected to see more larger families in the future. Along with the diversification of family structures, family-based travel demands will also become more diverse. Larger families will be mindful of the safety, convenience and comfort of transport systems and their passenger carrying capacity[14]. Their travel demands[15] will focus on trips for education, leisure and entertainment. According to this study's survey results, respondents believed that by 2035, families will choose private cars, followed by public transit, taxis and ride-hailing as their preferred travel modes, over autonomous public buses, autonomous taxis, walking and cycling (see Figure 3-9).

■ **Figure 3-6 Age structures of Beijing permanent residents in 2015 and 2021**



[10] Beijing Municipal Bureau of Statistics. Main data of the seventh National census in Beijing [EB/OL]. http://tjj.beijing.gov.cn/tjsj_31433/sjjd_31444/202105/t20210519_2392526.html

[11] CPC Central Committee and State Council. Decision on Implementing the Universal Two-Child Policy and Reforming/Improving the Family-Planning Services Management. 2016: https://www.chinacourt.org/article/detail/2016/01/id/1782985.shtml (The Universal Two-Child Policy allows all couples, regardless of their household registration nature, residential region and nationality, to have two children without official approval.)

[12] On May 31, 2021, the Political Bureau of the CPC Central Committee held a meeting and unveiled an optimised policy that would allow all couples to have up to three children, with the support of relevant measures.

[13] National Bureau of Statistics. National Data [EB/OL]. https://data.stats.gov.cn/easyquery.htm?cn=E0103&zb=A030802&reg=110000&sj=2020

[14] People.cn. "Two-Child" Vehicle – a New Highlight in Automobile Consumption [EB/OL]. http://auto.people.com.cn/n1/2019/0607/c1005-31124983.html#:~:text=%E6%B1%BD%E8%BD%A6%E4%B8%9A%E5%86%85%E4%B8%93%E5%AE%B6%E8%A1%A8%E7%A4%BA,%E8%BA%AB%E9%9C%80%E6%B1%82%E4%BB%94%E7%BB%86%E8%A1%A1%E9%87%8F%E3%80%82

[15] China Centre for Urban Development. Changing Population Structure and Its Impacts on Transport in China [EB/OL]. https://www.163.com/dy/article/FQCITT4F05149666.html

Figure 3-7 Travel modes chosen by the elderly in Beijing by 2035

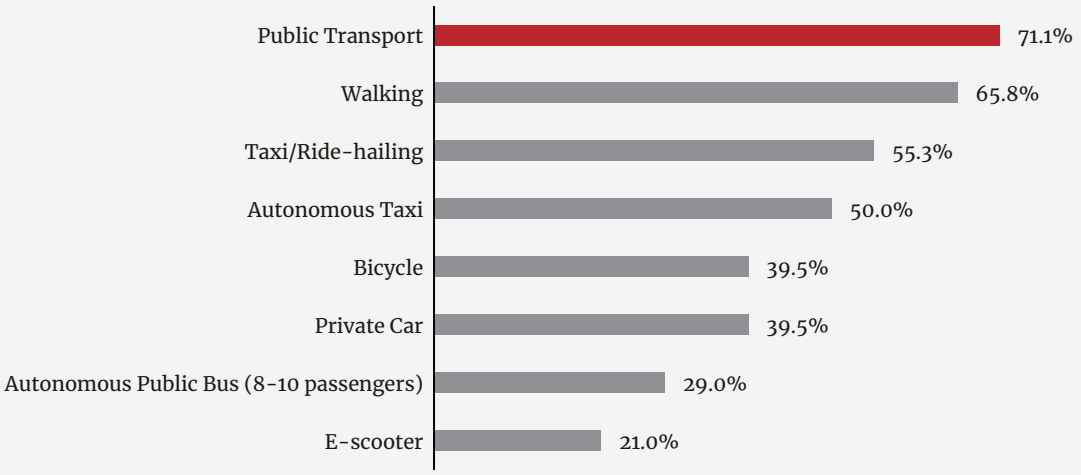


Figure 3-8 Proportion of family households in Beijing in 2009 and 2019

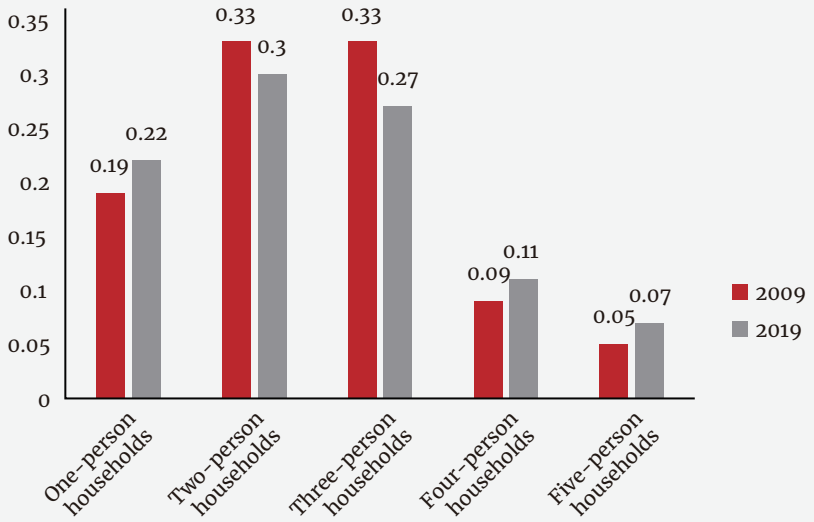
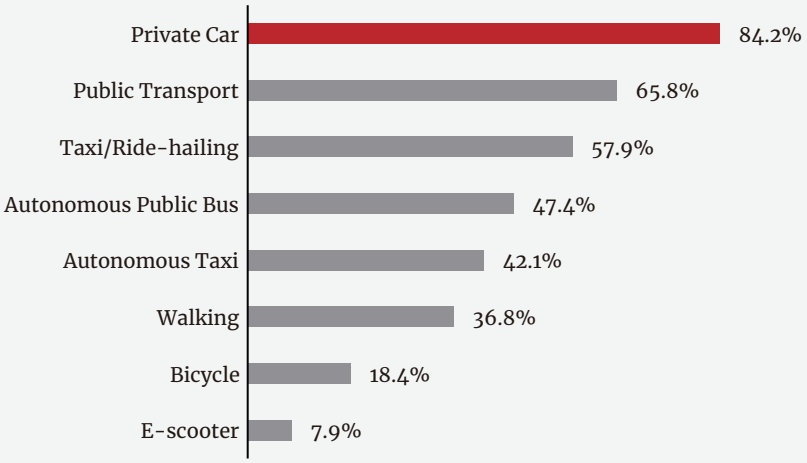


Figure 3-9 Preferred family-based travel modes by 2035



3.2.2 Open and inclusive urban transport

With changes in demographics and family structures, it is expected that Beijing will have more convenient, diversified, accessible, inclusive, comfortable and safe transport systems in the future. Beijing should therefore further expand barrier-free facilities and significantly improve the environment for active mobility (mainly cycling, walking and other forms of micro mobility), foster the integration of travel modes as well as transport services, and eventually build an open and inclusive urban transport system.

a) Barrier-free transport and mobility Existing barrier-free facilities in Chinese cities need to be optimised. Facility problems, such as inadequate coverage, inconvenient layouts, facilities occupied for other uses, and insufficient maintenance[16], need to be solved. In the *Outline for Building China's Strength in Transport in 2019*, the Chinese government set the goal of "building a sound barrier-free transport system by 2035", which implies a barrier-free mobility environment as a foundation. In the same year, the Beijing municipal government launched the *Beijing Action Plan for Further Building the Barrier-Free Environment (2019-2021)*[17], which explicitly requested the provision of barrier-free public transport facilities (for example blind tracks, underpasses and public parking facilities) and encouraged the use of different travel modes (including bus, taxi and subway services). This should be realised by designing barrier-free bus ramps and wheelchair fixtures in public buses, installing audio-visual features on public buses, and providing bus stop announcements for the visually impaired, and building curb ramps and barrier-free parking areas at bus stations. The experts participating in this study's survey suggested that Beijing should make consistent efforts in the provision of barrier-free facilities, especially for the elderly, children, the handicapped, and other disabled persons. The city should continuously improve its existing travel facilities to create an inclusive urban transport system for people of all age groups.

b) Safe and convenient active mobility The *Beijing Urban Master Plan* (*2016-2035*) outlines the overall goal of "building a walking- and cycling-friendly city" in order to create a green transport environment where residents can enjoy trips without the use of motorised transport. Such an environment is also a prerequisite for building a 15-minute city. The *Action Plan for Improving the Quality of Urban Active Mobility System in Beijing 2021*[18] highlights the design of road spaces for active mobility (such as cycling and walking), and promotes separated pedestrian and cycling lanes to improve road safety and create more space for them. The plan also proposes to establish active mobility zones, where users can enjoy appropriate facilities and green spaces. This study's survey results indicated that the elderly prefer short-distance trips and green transport modes, like public transit and walking. For them, active mobility will become their major transport mode. The urban planning and transport departments should give full consideration to the travel demands of the elderly in transport infrastructure planning and reconstruction, so as to create a safer, more comfortable and higher quality transport system for them.

c) Parallel innovation of traditional transport modes and intelligent applications In recent years, Beijing has been promoting intelligent and internet-based transport services. Ride-hailing, reservation-based and on-demand-based mobility services with contactless payments have become more popular. Additionally, autonomous taxis have also come into service in Beijing's Haidian district and Daxing's Yizhuang district. These new transport services provide alternative and efficient travel modes to residents, complementing public transport and active mobility services. However, these new services are not usable for all people. In particular, the elderly or the visually impaired have difficulties to use smart phone-based services. Such "digital divide" issues are common in China. At the end of 2020, there were approximately 4.29 million people aged 60 and above in Beijing. This number is predicted to reach 5.75 million by 2035[19]. Most of these individuals have had struggles with using a smartphone and many of them do not even own one. To solve the problem of this "digital divide", the State Council issued the *Action Plan for Addressing the Pressing Problems of the Elderly in*

[16] China Daily. To Facilitate the Construction of Accessibility Facilities [EB/OL]. http://finance.sina.com.cn/china/gncj/2021-04-12/doc-ikmyaawa9117660.shtml

[17] People's Government of Beijing Municipality. Beijing Action Plan for Further Building the Barrier-Free Environment (2019-2021). November 22, 2019: http://www.beijing.gov.cn/zhengce/zhengcefagui/201911/t20191122_518306.html

[18] People's Government of Beijing Municipality. Action Plan for Improving the Quality of Urban Active Mobility System in Beijing 2021. May 2021: https://baijiahao.baidu.com/s?id=1700089723417624891&wfr=spider&for=pc

[19] Beijing Municipal Civil Affairs Bureau and Beijing Municipal Commission of Planning and Natural Resources. Special Plan of Beijing for Elderly Services (2021-2035). September 29, 2021: http://www.beijing.gov.cn/zhengce/zhengcefagui/202109/t20210930_2505867.html

Using Smart Technologies in November 2020. This action plan encourages a balanced development between traditional transport services and intelligent transport applications to fit the needs of the elderly with more reliable, comfortable and convenient transport facilities and services[20]. Accordingly, Beijing's future urban transport system should be both "modernised" and "traditional". In the "modernised" respect, advanced technologies should be adopted to improve the capacity and efficiency of transport services. In the "traditional" respect, traditional services, such as booking a taxi by phone and paper tickets for travel, should be retained and optimised to satisfy the needs of the elderly and other disadvantaged and vulnerable groups. In addition, further awareness-raising and training programs for seniors to use digital applications and intelligent transport systems should be fostered to make intelligent mobility services available for all.

3.3 Technology and urban mobility

The rapid development of advanced technologies, such as the internet, Big Data, artificial intelligence (AI) and autonomous driving systems, has had a profound impact on urban transport in recent years. Thereby, the urban transport field is further undergoing tremendous changes, and so is the transport governance sector. In this context, this subchapter will first introduce the main drivers of technology-driven transitions in urban transport. This will be followed by a short introduction to the challenges of integrating multiple intelligent subsystems.

3.3.1 Technology-driven transitions

a) Digital economies and remote work setups Along with the rapid application of internet- and smartphone-based services, the emergence of digital and platform economies as well as mobile payment solutions have led to more consumers preferring e-commerce over buying products at physical stores.

From 2014 to 2020, online retail sales in China surged from EUR 335 billion to 1.4 trillion[21]. This trend led to a growing demand for urban freight transport. In 2012, the total number of delivered parcels was 5.69 billion. By the end of 2019, the number rose to 63.52 billion, showing an eleven-fold increase[22]. In 2021, the total business volume of courier services in Beijing hit 2.21 billion packages, rising 56.3 percent compared with 1.41 billion packages in 2015[23]. This number is expected to further grow in the future. In this study's survey, it was commonly believed that a significant increase in demand in urban freight transport services would pose new challenges to Beijing's transport system (see Figure 3-10).

Broadband internet and mobile office software make remote work possible. Working remotely can reduce daily commutes, especially during the COVID-19 pandemic. More than 70 percent of the surveyed participants believed that remote work could help to reduce passenger trips during rush hours. As new technologies and the digital economy take a crucial role in urban mobility systems, the development of the urban transport sector will be mainly driven by innovative productive elements (such as data, technology, and information) rather than traditional productive elements (including workers, equipment, capital, and energy). Traditional transport patterns with the focus on fixed bus stops, bus routes and bus schedules can no longer satisfy the demands of residents who nowadays expect convenient, rapid and diverse transport services. A demand-oriented, flexible and customized transport system is thus emerging.

b) Platform economy In the digital economy era, data is the most direct and critical productive element. Digital platforms with unrivalled access to data are creating a new type of supply-demand relationship and play a crucial role in transport arrangements, resource allocation and traffic management[24]. Such platforms are usually open and shared systems. Independent stakeholders, such as governments, transport service suppliers, passengers, and other partners (for example, insurance and legal businesses), can interact

[20] General Office of the State Council. Action Plan for Addressing the Pressing Problems of the Elderly in Using Smart Technologies. November 24, 2020: http://www.gov.cn/xinwen/2020-11/24/content_5563861.htm

[21] State Statistics Bureau. Statistical Bulletin of the People's Republic of China on National Economic and Social Development 2020 [EB/OL]. http://www.stats.gov.cn/ztjc/zthd/lhfw/2021/lh_hgjj/202103/t20210301_1814216.html

[22] White Paper on the Sustainable Development of Transport in China

[23] Beijing Municipal Postal Administration. Statistical Bulletin of Beijing Postal Industry development in 2021 http://bj.spb.gov.cn/bjsyzglj/c100057/c100058/202206/406c0951d3414d00ae84b340c719daa4.shtml

[24] Intelligent Transportation Technology. Impacts of Digital Economy on Transportation: Outlook and Key Issues [EB/OL]. https://www.sohu.com/a/418185316_468661

simply via the platforms. Travelers can use the platforms to obtain service information from transport providers (such as departure and arrival times) or real-time data (like road traffic information). Users can forward their demands to a transport service supplier and their demands and supplies can be immediately matched, and additionally, transport operators who provide bus, subway, taxi and railway services can offer real-time and accurate positioning information through the platforms. In this way, transport service systems will be restructured to be more efficient and convenient (see Figure 3-11).

Figure 3-10 Variation of urban freight transport demands by 2035, driven by the popularity of e-commerce

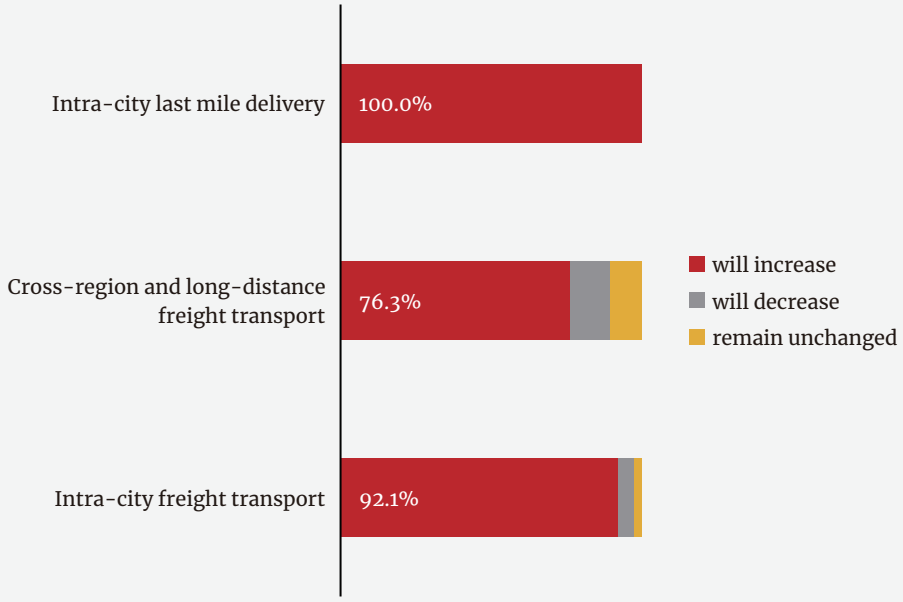
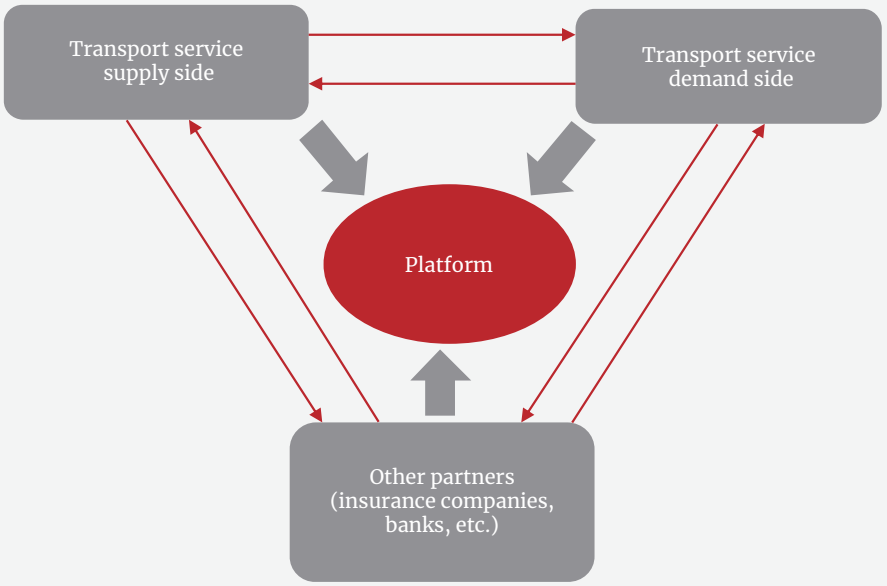


Figure 3-11 Logic of platform economy-empowered urban traffic management



3.3.2 Collaboration and adaptation of intelligent subsystems

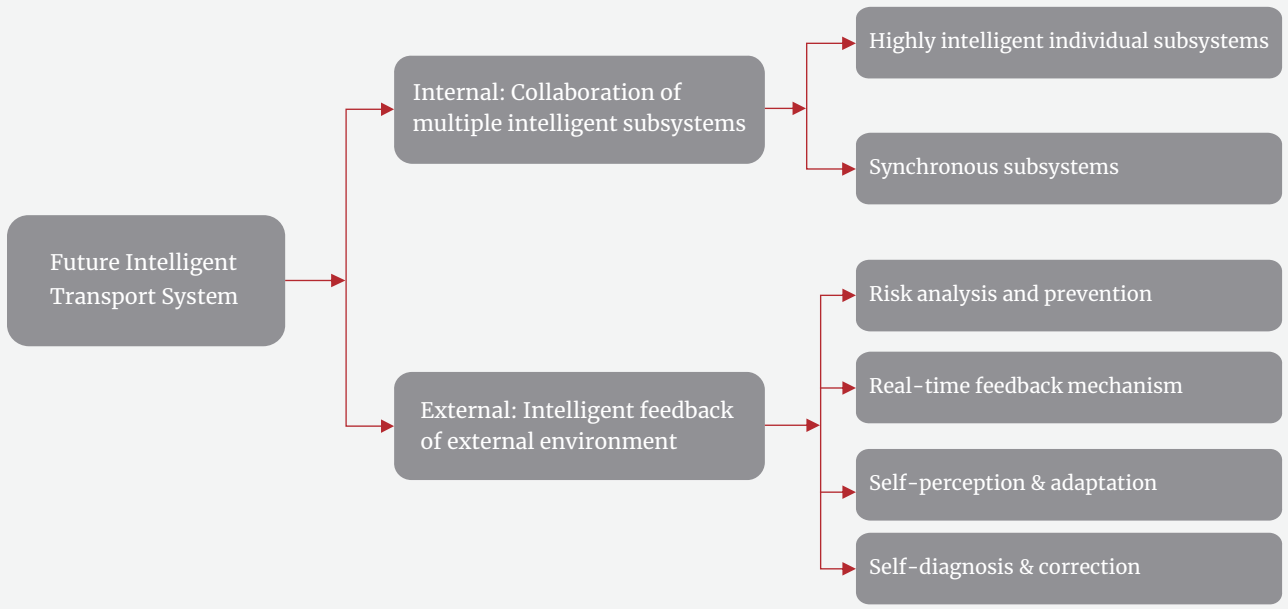
With the improvement of intelligent technology, future urban transport systems will integrate multiple intelligent subsystems, which run synchronously and adapt automatically to the external environment. On one hand, subsystems are required to be sufficiently intelligent, with intelligent coordination mechanisms operating between them. On the other hand, there is a need to support these systems with real-time, self-diagnostic and repairing intelligent feedback systems that can respond to external factors, such as human behaviour, weather conditions and other emergencies.

Intelligent integrated transport systems can be transport mode-based systems, including intelligent subway systems, intelligent bus systems, intelligent road network systems and other subsystems. Each subsystem itself is an independent and intelligent operation system, which can make real-time optimisation adjustments based on changes of traffic demands or external environmental factors. For example, an intelligent subway system can monitor and predict passenger flows among stations at peak hours in real time, send data to the supply end, flexibly adjust the service schedule, and let passengers obtain the schedule simultaneously. The collaboration and adaption of these subsystems means in general that when one subsystem changes its supply based on a changed condition, the other subsystems can obtain updated information immediately and adjust their own supplies according to these external environment changes, so as to realize collaborative adjustment among subsystems. For example, information about a delayed train at night could be transmitted to bus companies and other transport service providers in real-time. They could then respond by flexibly adjusting their service schedules based on passenger flows, such as extending the day's bus service hours, optimising the supplies of taxis, and providing on-demand bus rides, so as to effectively cope with the changes in demand due to the delayed train.

Intelligent transport systems can be divided into many functional subsystems, such as traffic volume monitoring systems, command and dispatch systems, traffic signal control systems, travel time monitoring systems, video monitoring systems, GPS monitoring systems, traffic violation monitoring systems, traffic guidance systems and related services. Once traffic volume monitoring systems identify traffic congestion, real-time information will be updated to traffic guidance systems or traffic signal control systems. Traffic jams could be eased quickly by guiding vehicles to change routes to alleviate traffic flows or by optimising traffic light controls at congested crossroads.

The biggest challenge to intelligent transport systems will be the development of multi-intelligent collaborative technology shared between traffic systems as well as intelligent sensing and feedback technology that can take into consideration external factors (see Figure 3-12).

■ **Figure 3-12 Structure of future intelligent transport systems**



4 Vision of Future Transport and Mobility in Beijing

In recent years, mobile Internet, artificial intelligence (AI), the Internet of Things (IoT), Big Data and new energy technologies have been widely applied in the transport and mobility sector, inducing a new transport and mobility era and revolution. New mobility and vehicle technologies, such as new energy vehicles (NEV), on-demand and shared mobility services, passenger and cargo drones, and autonomous driving units, have emerged. These innovations are offering opportunities to make transport more efficient and sustainable, but along with these opportunities comes the unpredictability of the future of transport and mobility and the impact it may have on climate change and the environment. What does the vision for the future of urban transport and mobility in Beijing look like and how can it contribute to achieving China's 2030 CO_2 emission peaking and 2060 carbon neutrality goals?

Based on national and municipal development plans, experts' opinions from the "Beijing Dialogue" workshop series as well as this study's online survey results, a vision for the future of Beijing's transport and mobility system has been formulated, which is that "The future of urban transport and mobility in Beijing will be green, intelligent and shared" (see Figure 4-1).

This vision is grounded on the "Avoid-Shift-Improve" approach, which promotes policies and measures aiming to reduce motorised trips through efficient urban planning and people-centred urban design, to shift to more sustainable travel modes such as public transport, walking and cycling, and to improve technological innovations in order to make transport systems clean and climate-friendly. The key implications of this developed vision are as follows:

a) Green The development of green and low carbon transport and mobility is the key to achieve China's 2030 and 2060 climate goals. Public transit will be increasingly prominent and become the primary choice in the urban transport system. As infrastructure and services for active mobility are improved, more people will choose green transport modes instead of driving private cars. The energy structure will be further optimized, and in parallel to cleaning the energy grid, fuels for motorised vehicles will shift from traditional fossil fuels to clean energy. The 15-minute city and people-centred urban design will be the core of Beijing's planning for communities and neighborhoods. These improvements are expected to save energy, reduce carbon emissions, and mitigate air pollution for passenger and freight transport.

b) Intelligent With the accelerating integration of the transport sector with the energy and information sectors and advanced technologies like Big Data, AI, and cloud computing, intelligence is a crucial element for the future development of Beijing's urban transport systems. This includes the development of smart infrastructure, transport modes, intelligent transport operations and management, and transport services. All transport subsystems and elements will be interconnected, allowing supply and demand information to be shared in real time, and enabling traffic management and operation to be much more efficient. In the future, intelligent transport platforms will include route planning, reservation services, seamless and barrier-free mobility services, contactless payment, and other applications. Intelligent transport systems can help improve mobility equity, reduce traffic congestion and ensure overall traffic safety levels.

c) Shared With the growing acceptance of shared mobility, this concept will become a critical component of the urban mobility system, especially when being effectively integrated with public transport to provide residents with diversified demand-based travel options. Among these diversified options, shared electric self-driving cars will be particularly popular. Moreover, shared mobility options will serve as an important supplement to public transport to provide safe, convenient, efficient, and seamless travel experiences.

This chapter will subsequently analyse in further detail these three main pillars: green, intelligent, and shared actions. The three pillars are regarded as integral and interconnected elements of future transport and mobility systems as well as of the overall vision of future transport and mobility in Beijing. It is significantly important to integrate each of the three pillars into each individual transport system (see Figure 4-1).

■ **Figure 4-1 Vision of Future Transport and Mobility in Beijing**

4.1 Green Transport and Mobility

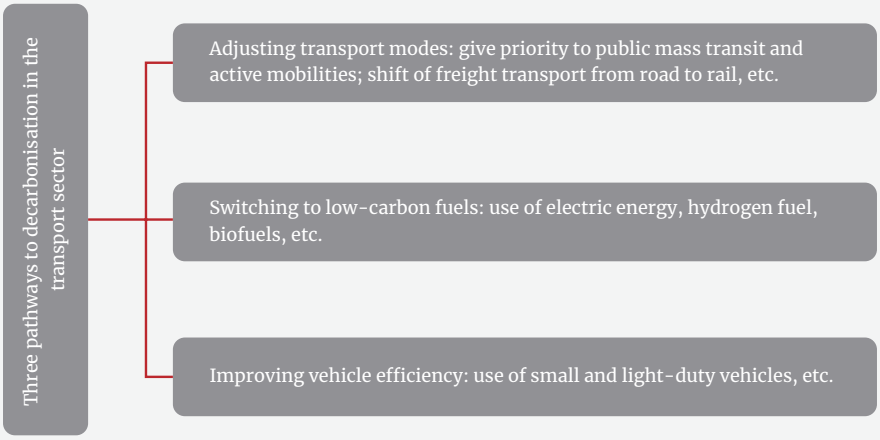
Considering the varying levels of carbon emissions from all sectors, the decarbonisation of the transport sector will be one of the key areas to achieving the goals of the Paris Agreement. In 2015, transport made up about two-thirds of global oil consumption levels. Road transport alone was responsible for half of global oil consumption. According to the United Nations, the transport sector accounted for over 24 percent of the total carbon dioxide emissions worldwide[25]. With the acceleration of China's urbanisation and the continuous growth of vehicle ownership numbers, energy consumption in transport will continue to increase. Strong policies and measures are needed to achieve the country's 2030 peaking and 2060 neutrality targets.

There are three main pathways to achieving the transport decarbonization (see Figure 4-2). First, promote energy transformation and increase the market share of NEVs; second, improve the efficiency of transport tools, for example, use small and light vehicles to reduce energy consumption; third, optimise transport structures (in passenger transport, promote green travel modes with low energy consumption, low emissions and high efficiency, such as public transport and cycling; in freight transport, promote transport modes with low-cost and low energy consumption, such as railways)[26]. Results from this study's online survey showed that a high dependence on cars, insufficient facilities for active mobility and limited resources for public transport were the main obstacles to developing a green and low-carbon transport sector in Beijing (see Figure 4-3). The survey results highlighted the importance of prioritising public transport and improving infrastructure for active mobility. In this context, the following subchapters will discuss the roles of public transport, active mobility, and NEVs in the green transport system in Beijing.

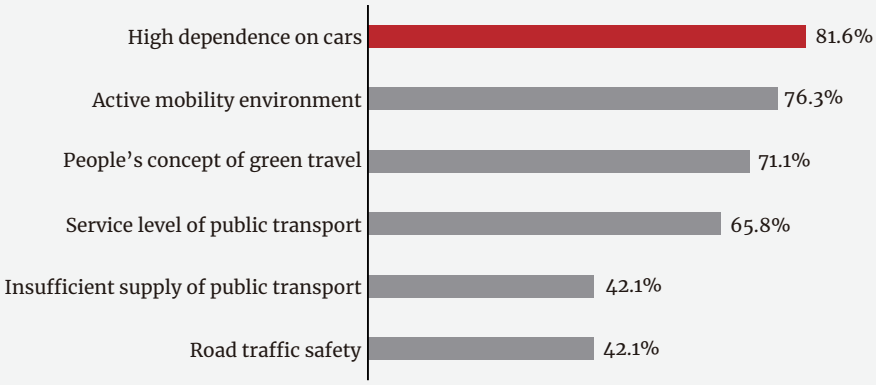
[25] Guangming Daily. Transport contributes to sustainable development [EB/OL]. October, 2021: https://epaper.gmw.cn/gmrb/html/2021-10/17/nw.D110000gmrb_20211017_1-03.htm

[26] Axsen J, Pltz P, Wolinetz M. Formulating a Strong Comprehensive Policy Mix for Deepening Carbon Dioxide Emissions Reduction in Road Transport [J]. Change of Natural Climate, 2020, 10(9):1-10

■ **Figure 4-2 Three main pathways of achieving transport decarbonisation**



■ **Figure 4-3 Main obstacles to green transport development in Beijing**



4.1.1 Public transport

In consensus that the improvement of public transport plays an important role in achieving a sustainable transport system, Beijing always adheres to giving priority to public transport and low carbon transport modes. This chapter highlights the role of public transport and its challenges in the process of constructing a green transport system in Beijing.

a) Public transport will remain the backbone of urban transport

Before the outbreak of COVID-19, public transport had been the main travel mode of Beijing residents

Since 2012, the passenger volume of public buses has constantly declined. In 2019, the travel mode share of public transport remained 31.8% in Beijing, followed by walking and driving cars[27]. In 2020, during the COVID-19 pandemic, the number of passengers who rode public buses declined by 42.2% compared with the volume in 2019 (see Figure 4-4). At the same time that rider numbers decreased, the total line length and network density of public buses was increasing.

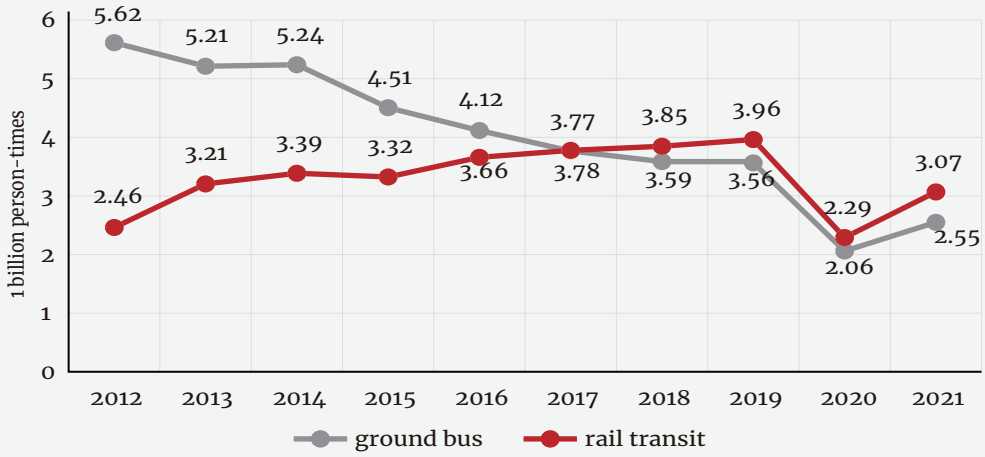
This study's online survey results showed that public transport would rank first – followed by cycling and private cars – among the future commuting travel modes of Beijing citizens. As for the travel modes chosen for leisure purposes, public transport would also remain the first choice for citizens (see Figure 4-5).

Low reliability and a competitive market are the main reasons for the decline of the passenger volume of public bus transit

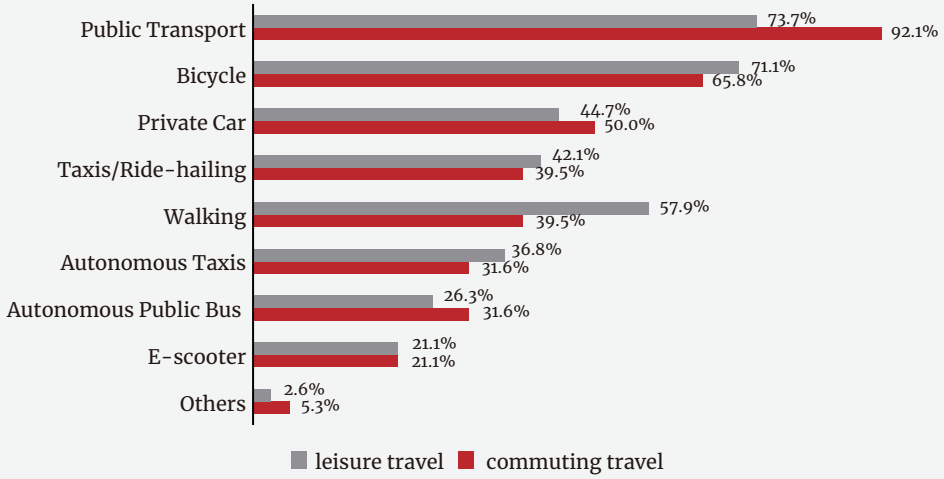
In recent years, various causes have led to the continuous decline of the passenger volume of public bus transit. These main causes include a low efficiency of bus operation and a highly competitive market. Regarding their operational

[27] Beijing Transport Institute. 2020 Beijing Transport Development Annual Report. Beijing: July, 2020

■ **Figure 4-4 Annual passenger volume of ground bus and rail transit from 2012 to 2021**



■ **Figure 4-5 Future mode choices of trips for living and commuting in Beijing**

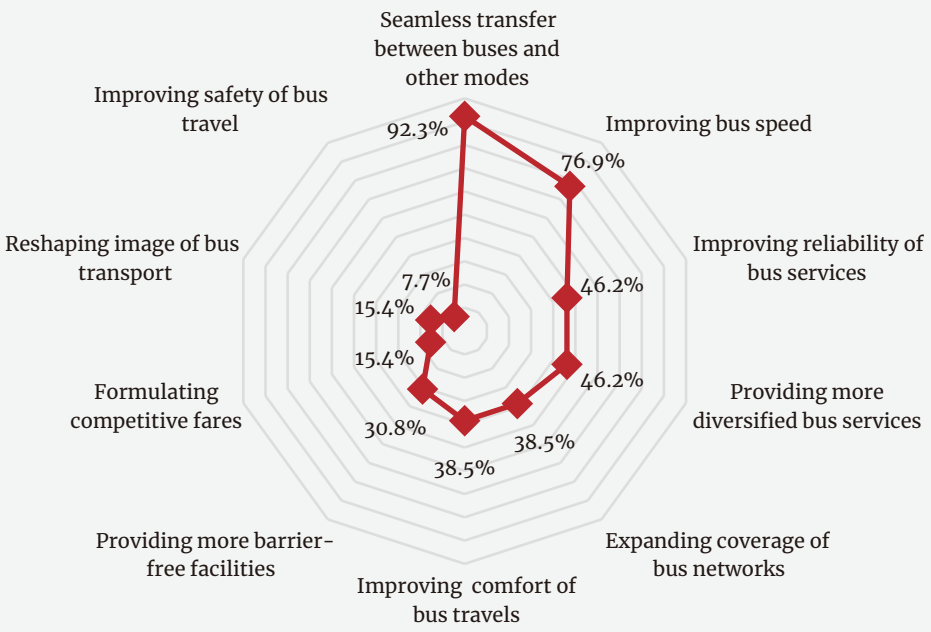


efficiency, public buses are less reliable than other transport services. This is due to the fact that bus routes had not been well planned or other transport options (subway and shared bicycles) are more convenient for travelers in some areas. Additionally, the public bus service operates in a fixed-point, fixed-line mode and on a time-scheduled basis. It is therefore incapable of responding to the flexible demands of passengers and thereby fails to provide convenient services to them. Regarding market competition, passengers are increasingly shifting to other transport modes, including the subway, private cars and new mobility modes, such as ride-hailing services and shared bicycles. Against the background of severe urban traffic congestion and the increasing pressure for energy conservation and emissions reductions, it is urgent to formulate strategies and policies to revitalise public transport, especially those that enhance the attractiveness of public buses.

b) The attractiveness and competitiveness of public transport

In order to improve the competitiveness of public transport, it is necessary to continuously improve its operational efficiency and services. As this study's online survey shows, the main factors influencing people's travel behaviour are travel time, comfort, reliability, and safety, as well as convenience and intellectualisation. When asked what needed to be improved in terms of making public transport more attractive, more than 90% of the respondents in the survey answered "to develop a seamless transfer between public transport and other transport modes, such as shared bicycles" (see Figure 4-6). It is also important to increase the efficiency and reliability of public transport services and to expand investments, and it would be helpful to open more subway lines, improve coverage of the subway and public bus networks, build comprehensive transport hubs, and construct bus-exclusive lanes. In terms of space reallocation, more than half of survey respondents believed that constructing more bus lanes would be one of the most effective measures to promote a green and low-carbon transport system in Beijing.

■ **Figure 4-6 Effective measures to improve public transport competitiveness**



> "We should indeed focus on improving public transport services; people will choose public transport, only when it is truly convenient and can meet their expectations. Otherwise, the public appeal to take public transport and travel green will just be an empty talk." – an expert in transport planning at the first workshop of the Beijing Dialogue Workshop Series

Enhance the construction of rail transport

The passenger volume of rail transit in Beijing is increasing year by year. In 2017, its passenger volume exceeded that of public buses for the first time. Rail transit has become the backbone of Beijing's urban public transport system, especially in rush hours. In the future, the city of Beijing should continue to expand rail transit networks and optimise the short- and long-term construction plans of rail lines, in keeping with the guiding idea of a dense network of subways in the central area, with good connections between central and peripheral districts, as well as the optimisation of transport hubs. The planning of rail transit should focus on making up for bottlenecks and shortcomings of the network structure (such as a lack of rail express lines between central and peripheral districts). The mileage of intercity railways and regional express lines (including suburban railways) should be significantly improved. It is estimated that by 2025 the mileage of rail transit in Beijing (including suburban railways) will reach 1600 km[28]. The extended suburban railway will effectively facilitate connections between the suburban areas of Beijing and cities within the Jing-Jin-Ji region. This is also of great significance to the relief of Beijing's non-capital functions and to the coordinated development of the Jing-Jin-Ji region.

Case Sharing: Expansion of the Beijing Suburban Railway Network

In recent years, Beijing's suburban railway has developed rapidly with a continuous increase in its network and service coverage. By the end of 2020, Beijing had four suburban railway lines, namely the Beijing sub-centre Line, Line S2, the Huairou-Miyun-Beijing North Railway Station Line, and the Tongzhou-Miyun Line, covering a mileage of 400 km and a total of 24 stations[29] (see Figure 4-7). These lines effectively strengthen the rail transit links among Beijing's central urban area, subsidiary centre and outer suburban districts. Some milestones of the Beijing suburban railway lines are:

[28] Ministry of Transport. This is How Beijing Transportation Looks Like in the Future [EB/OL]. https://mp.weixin.qq.com/s/dHdFUHLKUa6ICkfw40jURQ2020

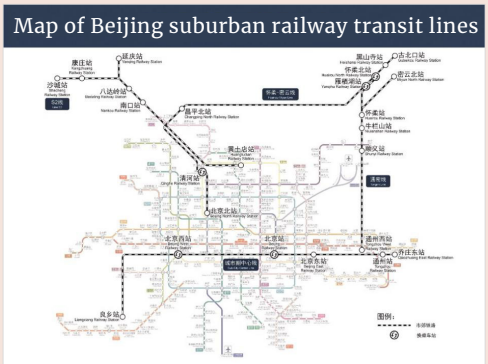
- On June 20, 2019, the Beijing sub-centre line started operation, allowing users to commute between the sub-centre in the east of Beijing to the Beijing West Railway Station within 43 minutes. Before the suburban railway line was opened, the same commute took two hours by subway.

- In January 2020, the Beijing West Railway Station allowed the mutual recognition of railway and suburban railway security inspections. This meant that passengers would only need one security check in their transit from subway to suburban railway systems, which greatly improves their transfer efficiency.

- In June 2020, the Tongzhou-Miyun Line was opened, connecting to Beijing's sub-centre and three suburban areas (Shunyi, Huairou and Miyun districts) in the northeast of Beijing's sub-centre.

- In September 2020, the Huairou-Miyun-Beijing North Railway Station Line was opened. The line greatly saved time for people traveling from the suburban districts of Huairou and Miyun to the central urban area. By extending the line from Miyun to the city centre, the annual passenger volume reached by 225,000 passengers in 2020 (an increase of 164.7% over 2019 levels)[29].

■ Figure 4-7 Map of Beijing suburban railway transit lines



(Source: 2022 Beijing Transport Development Annual Report)

Improve public bus services

Against the background of declining bus passenger volumes, the city of Beijing must make the public bus system more competitive and attractive. The Beijing Urban Master Plan (2016-2035) clearly proposes to improve the efficiency of bus operation and punctuality by optimising the planning, construction and management of bus lanes. In 2021, the total mileage of bus lanes in Beijing was 1,005 km, which will exceed 1500 km by 2035 according to the city's master plan. At present, an important measure to prioritise public buses in urban transport is the construction of dedicated bus lanes. Such bus-exclusive lanes can significantly improve the speed and reliability of public buses. Moreover, bus services should be diversified to meet personalised travel needs of citizens. This may include customised bus services for commuters to schools and workplaces. Bus operators should adhere to developing an intelligent bus system by adopting advanced technologies, such as Big Data and AI, so as to enable intelligent bus fleet management, including responsive dispatching services, and to provide accurate service information to passengers. In this way, public buses will be more convenient, efficient, and reliable.

Build comprehensive transport hubs

The New Master Plan of Beijing clearly proposes to strengthen the construction of passenger transport hubs and transport nodes, in order to improve the transfer efficiency of urban passenger transport systems. During the 14th Five Year Plan period, Beijing will further extend its integrated network of rail transit, public buses and active mobility services. For example, at the Qinghe railway station, passengers can take high-speed trains, suburban railways, subways, buses, taxis, or shared bicycles or also have the option to drive and park their private cars. Qinghe railway station, as a transport hub, greatly facilitates passengers' transfers between different transport modes. In this study's online survey, most respondents said that improving the transfer efficiency and convenience of switching between public transport and other transport modes would greatly enhance the competitiveness of public transport. In the future, comprehensive transport hubs and nodes should facilitate seamless transfers between public transport (like buses and subways) and other transport modes (such as taxis, ride-hailing services, and bicycle sharing programs). This will increase the attractiveness of public transport and further reduce citizens' dependence on private cars.

[29] Beijing Transport Institute. 2021 Beijing Transport Development Annual Report. Beijing: July, 2021

4.1.2 Active mobility

Active mobility plays a significant role in short distance travel in Beijing. Especially during the COVID-19 period, many citizens chose walking and cycling as their daily transport modes. In 2020, walking accounted for the highest mode share in Beijing, reaching 31.2%. The proportion of cycling also increased significantly compared with that of 2019, reaching 15.5% (see Figure 4-8)[30]. In 2020, walking and cycling trips composed 46.7% of total passenger transport volumes, reaching their highest shares in the past five years[30]. As zero-emission modes, walking and cycling should play a greater role in future urban transport systems. This subchapter first highlights the role of active mobility in Beijing's urban transport system, and then analyses the main challenges caused by the expansion of active mobility in Beijing.

a) Active mobility as an important element in Beijing's urban transport system

Urban transport does not only rely on public transport as the backbone of the transport system, but also looks to active mobility as an important alternative. These two forms of transit complement each other. Active mobility is a popular choice for citizens travelling in short distance ranges within 3 km. Such a travel choice is energy conserving and environmentally friendly. Walking and cycling play an important role during the "last mile", for connecting people to public transport facilities, such as subway stations and public bus stops. With the continuous improvement of active mobility infrastructure in recent years, such as the construction of designated lanes and bike-only roadways, Beijing is actively promoting its revival as a bicycle-friendly city.

Active mobility will occupy an important position in the future urban transport system of Beijing. According to the results of this study's online survey, apart from public transport, cycling will become the most common transport mode for commuters, followed by walking. However, the shortcomings of Beijing's active mobility environment (according to the same survey results) are mainly the poorly connected network of bicycle lanes and narrow sidewalks.

b) A walking and cycling friendly city

The New Master Plan of Beijing proposes the vision of building a walking and cycling friendly city. In the future, the city will make efforts in facility construction, operation and management to build a continuous, safe, well designed and human-centred pedestrian and bicycle network system, ensuring the right-of-way of walking and cycling individuals, to truly promote the city's potential to shift from relying on car-oriented transport to human-oriented transport, and create a convenient urban environment where people can live without cars.

<u>Comprehensively rearrange road spacing in favor of active mobility</u>

The key in improving the active mobility environment is to optimise the spatial utilisation of road resources and to reallocate road spaces occupied by motor vehicles to use them instead for walking and cycling. The *Beijing Active Mobility System Plan (2020-2035)* proposes that the future Beijing active mobility system should be continuous, safe, convenient, accessible, comfortable, healthy and all-age-friendly, which supports the development vision of a walking and cycling friendly city as suggested in the *Beijing Urban Master Plan (2016-2035)*. In this study's online survey, nearly 90 percent of respondents indicated that expanding footpaths and bicycle lanes would be the most effective way to promote the development of green transport in Beijing (see Figure 4-9). Building bicycle lanes and ensuring the right-of-way of cyclists is a common practice in Denmark and Germany to encourage green travel modes. In 2019, Beijing built the first exclusive bicycle lane, which greatly reduced travel time for cyclists, making cycling an important commuting mode to reach functional urban areas. In the future, Beijing should continuously improve its active mobility system through the rearranging of space and optimization of facilities at all levels to support related activities, accelerate the implementation of active mobility resources on roads, and improve the density of the bicycle lane network to constantly improve the level of attraction of active mobility options.

[30] Beijing Transport Institute. 2021 Beijing Transport Development Annual Report. Beijing: July, 2021

Figure 4-8 Transport & mobility structure in central urban areas of Beijing from 2018 to 2021

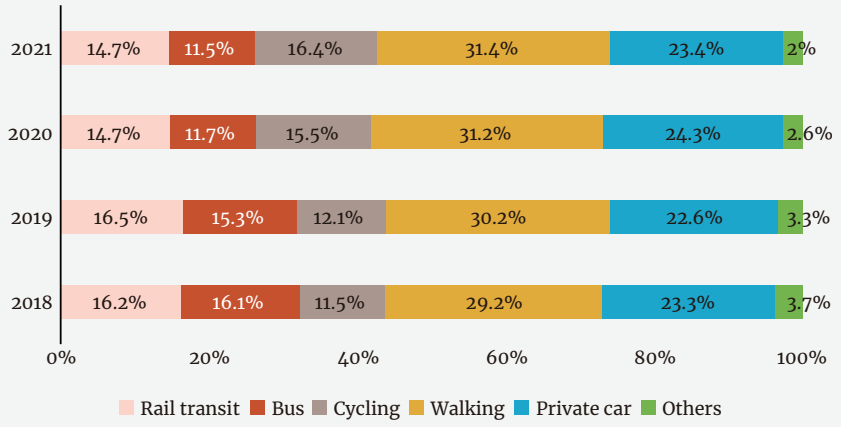
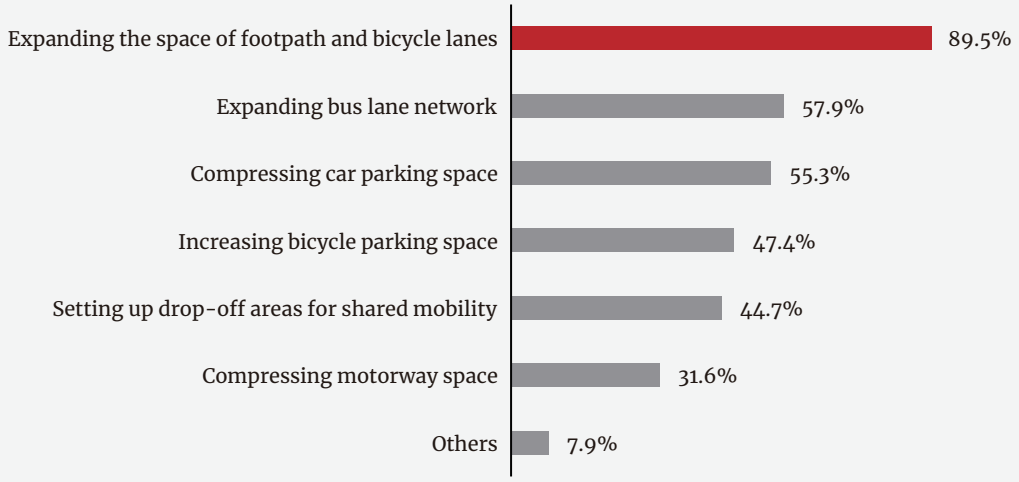


Figure 4-9 Effective measures to promote green transport development in Beijing



[31] Beijing Transport Institute. Effect Analysis and Suggestions on Beijing's Bicycle-Exclusive Road at its First Anniversary of Opening [EB/OL]. https://mp.weixin.qq.com/s/qfGro53KRXOGhsluy1dRWA

[32] Beijing Transport Institute. Consideration and Suggestion on Beijing's First Bicycle-Exclusive Road at its Second Anniversary of Opening [EB/OL]. https://mp.weixin.qq.com/s/EypnuDJ1QuQid8mrSGZYgg

[33] Beijing Transport Institute. 2022 Beijing Transport Development Annual Report. Beijing: July, 2022

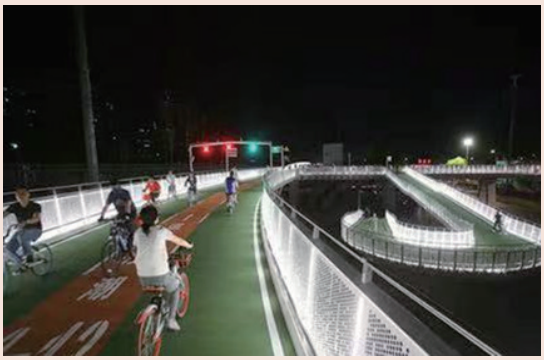
Case study: The First Dedicated and Elevated Bicycle Lane in Beijing[31,32]

On May 31, 2019, the first dedicated bicycle lane in Beijing was opened, connecting the Huilongguan Wenhua Road in the Changping district in the east with the Houchangcun Road in the Haidian district in the west. With a total length of 6.5km, the lane links the residential communities of Changping with the high-tech industry zone in Haidian. Along the bicycle highway, facilities including public toilets, parking areas, rest areas, bicycle boosting systems and reversible lanes can be found (see Figure 4-10 to Figure 4-13). Bicycle conveyor belts are even provided, to save the effort of riders pushing bicycles when they go upward on slopes, while resistance devices are installed to improve safety for cyclists on downward slopes. After the opening of the bicycle lane, cycling has become the most efficient mode of travel for commuters from Huilongguan to Shangdi. Compared with travel by cars and buses, cycling can save 32% and 50% of travel times respectively, effectively meeting people's "point-to-point" commuting demands. In 2021, the bicycle highway served 1.85 million cycling trips in total[33].

■ Figure 4-10 The First Dedicated and Elevated Bicycle Lane in Beijing

(Source: Bing.com)

■ Figure 4-11 Night lighting facilities



(Source: Beijing Transport Institute)

■ Figure 4-12 The cycling highway with a reversible lane in the middle

(Source: Beijing Transport Institute)

■ Figure 4-13 Bicycle boosting systems

(Source: Beijing Transport Institute)

<u>Strengthen the management of the operation and parking of shared bicycles</u>

Bike sharing is an effective option to meet citizens' demands for short-distance travel options and offers a seamless connection with the public transport system. However, shared bicycles have caused a range of problems to the city, such as disorderly parking, which seriously affects the city's image and hinders traffic flows. In order to regulate the use of shared bicycles, it is necessary to accelerate the formulation of technical specifications for shared bicycle systems as well as guidelines for bicycle parking. This will effectively help solve illegal parking issues and optimise the parking of shared bicycles, especially at rail transit stations and distribution centres with large passenger flows.

4.1.3 New energy vehicles (NEVs)

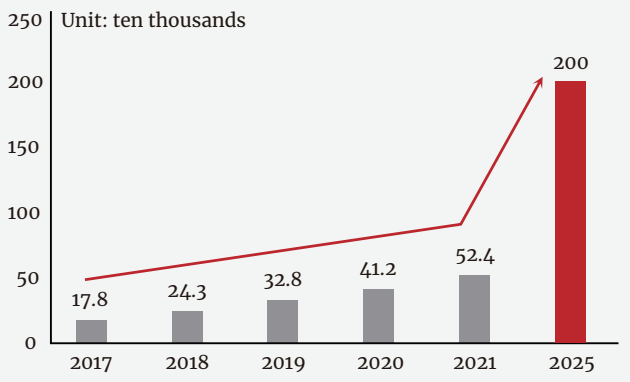
The New Master Plan of Beijing clearly demands that Beijing should strengthen energy conservation and emission reduction in its urban transport system, optimise the city's transport energy structure, and promote the large-scale application of new energy and clean energy vehicles. Promoting clean transport vehicles not only saves energy and reduces emissions, but also improves air quality in Beijing. Three tasks need to be considered for this goal: first, promoting the large-scale application of new and clean energy vehicles, especially to be used as taxis, buses, private cars, and vehicles for urban logistics and deliveries, while gradually scrapping old and high-emission vehicles; second, building more charging facilities, including charging piles, gas stations and other service facilities; third, optimising the energy supply structure, increasing renewable power generation, and reducing energy consumption and life-cycle emissions of new energy vehicles. The following subchapter will subsequently provide detailed solutions to the challenges faced when responding to these three tasks.

a) Large-scale application of new energy vehicles

The *New Energy Automobile Industry Development Plan (2021-2035)* issued by the General Office of the State Council in 2020 proposed that new energy vehicle sales – including battery electric vehicles, plug-in hybrid electric vehicles (including extended-range vehicles), and fuel cell vehicles – will reach about 20% of total new vehicle sales in China by 2025. Battery electric vehicles are expected to become mainstream in the car market by the same year. All vehicles in the public transport sector will be fully electrified and fuel cell vehicles will become commercially available.

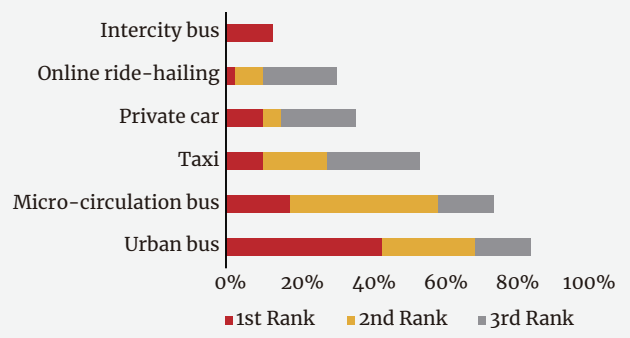
Promoting electrified vehicles is not only an effective way to save energy and reduce emissions, but also key to achieving China's climate goals of carbon peaking and neutrality. According to *Guidelines on the 14th Five Year Plan of Beijing's National Economic and Social Development and the Long-Term Goals for the Year 2035*[34], the accumulated numbers of new energy vehicles in Beijing will reach 2,000,000 and the vehicle electrification rate will increase from the current 6% to 30% by 2025. However, by the end of 2021, the total number of new energy vehicles (NEVs) in Beijing was only about 520,000[35] (see Figure 4-14). To achieve the targeted figure within the 14th Five-Year-Plan period (2021-2025), Beijing needs to add about 1,500,000 NEVs to its existing fleet, with an average annual increase of more than 350,000 NEVs. This means that the 14th Five-Year Plan will usher in a period of rapid development for electric vehicles in Beijing.

Figure 4-14 Ownership of new energy vehicles in Beijing



Small and light-duty vehicles are mainly driven in Beijing, and these will be the target vehicle groups to be replaced by electrified ones in the future. In this study's online survey, it was generally believed that – apart from private cars – vehicles from public sector fleets (including city buses and taxis) would be the second largest group to be electrified (see Figure 4-15). Delivery vehicles used for "last mile delivery" were also expected be electrified (see Figure 4-16). Therefore, to promote the application of new energy vehicles on a large scale, Beijing should not only give incentives to private car owners and public transport operators to buy new energy vehicles, but should also formulate a timeline for electrification in line with the development of the city.

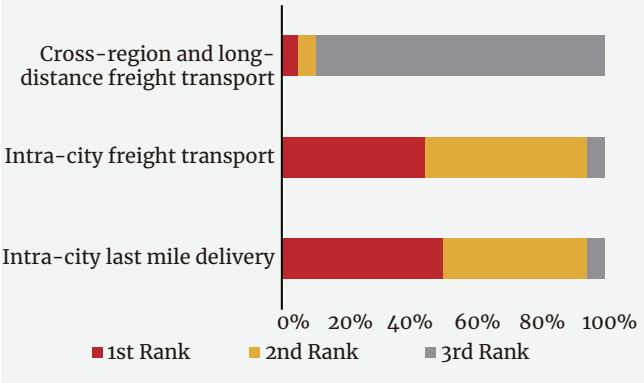
Figure 4-15 Main application scenario of electric vehicles in urban passenger transport by 2025



[34] CPC Beijing Municipal Committee. Guidelines on the 14th Five Year Plan of Beijing's National Economic and Social Development and the Long-Term Development Goals for the Year 2035. December 7, 2020. http://www.beijing.gov.cn/zhengce/zhengcefagui/202012/t20201207_2157969.html

[35] Beijing Transport Institute. 2021 Beijing Transport Development Annual Report. Beijing: July, 2021

Figure 4-16 Main application scenarios of electric vehicles in urban freight transport by 2035



Electrification of public buses and taxis

Public buses and taxis have always been the vanguard in promoting the electrification of transport in China. In recent years, Beijing has continuously promoted the electrification of public buses and taxis by issuing various action plans and providing financial incentives. The *Beijing's 2022 Action Plan on Pollution Prevention and Control*[36] demands that new vehicles for public transport, taxi fleets, city sanitation, postal service, and urban freight distribution units should be electric or hydrogen fuel cell vehicles. In 2020, new energy buses accounted for over 90% of public buses in Beijing, and the light-duty trucks driven within the Fifth Ring Road during the day were all new energy vehicles[37]. In 2021, the amount of battery electric taxis continued to increase, accounting for over 30% of all taxis in Beijing[38].

Electrification of private cars

The electrification of private cars is the main domain for action of the overall electrification of the transport sector. Currently, people must enter a lottery to obtain a new license plate in Beijing, as local authorities control the number of plates issued every year to reduce the severe congestion and air pollution in the city. In 2020, the authorities issued 60,000 new license plates for new energy cars. This puts a limit on achieving the 2025 target of 2,000,000 new energy vehicles in Beijing. However, for promoting new energy vehicles, Beijing has introduced a variety of related incentive policies. For example, the subsidy policy of "replacing fuel with electricity" was introduced to reduce the cost of replacing conventional cars with new energy vehicles. Beijing is also now updating its car parking policy to improve the attractiveness of choosing to drive new energy vehicles by providing them with parking incentives that are not offered to conventional vehicles.

This study's online survey results revealed that more than 60% of respondents believed that the phasing out of traditional fuel vehicles should be sped up. More than half of the respondents suggested an introduction of carbon taxes. Also, more than half of the respondents supported enhancing the right-of-way for electric vehicles (EVs). At the same time, attention should also be paid to the potential of rural vehicle electrification. Survey results showed that the government should thus formulate policies and establish facilities in advance to improve the adoption of EVs in rural areas, since private cars might still be the key transport mode for people in the countryside.

b) Supporting facilities

Further strengthen the construction of supporting facilities

With growing demand for new energy vehicles, the further construction of charging and refueling infrastructure is required. This study's online survey showed that the main reasons behind why Chinese consumers are hesitating to buy EVs are their limited battery life spans and short travel distances, long charging times, and high purchasing prices[39]. With new battery technology and growing productivity in the automotive industry, issues related to battery reliability will be eventually solved, while the cost of EVs is likely to decline. Also, the availability of charging facilities will become the main concern for consumers when purchasing EVs. Survey results showed that 54.8% of survey participants believed that sufficient coverage of charging piles is also of importance to accelerate the green and low-carbon transformation of urban transport systems (see Figure 4-17). Therefore, Beijing should boost the construction of charging facilities to provide more charging piles and reduce long waiting times to access them. Also, the city should develop an intelligent infrastructure service platform, which enables the intelligent management

[36] The People's Government of Beijing Municipality. The Beijing's 2022 Action Plan on Pollution Prevention and Control. March, 2022: http://www.beijing.gov.cn/zhengce/zhengcefagui/202203/t20220302_2620215.html

[37] Beijing Shows its "Green" Assets in the Transport Convention. Beijing Daily [EB/OL]. http://www.bj.xinhuanet.com/2021-10/15/c_1127959621.htm

[38] Beijing Transport Institute. 2022 Beijing Transport Development Annual Report. Beijing: July, 2022

[39] Thomas Gersdorf, Russell Hensley, Patrick Hertzke, Patrick Schaufuss and Andreas Tschiesner. Future of Electric Vehicles [EB/OL]. https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-road-ahead-for-e-mobility#

of charging facilities, allowing users to have easy access to available charging piles. A convenient charging process is crucial in shifting the preferences of consumers towards EVs.

Build a diversified charging facility network

At present, the charging pile network in Beijing consists of private and public charging piles, of which the public charging piles are mainly installed in the region within the Fifth Ring Road. In order to effectively meet the charging demands of EV drivers, Beijing should distribute charging facilities among residential areas, commercial areas, public places, and highways. In urban areas, Beijing should focus on improving the coverage of charging piles with consideration to placing them in areas accessible to high population densities as well as making sure they consider limited space resources. Also, emphasis should be laid on the construction of shared charging poles, allowing multiple cars to be simultaneously charged on one pole. In rural areas, residents are mostly living in detached houses, which are suitable for installing private charging piles. Greater coverage of charging facilities for private houses will also win more NEV users in rural areas.

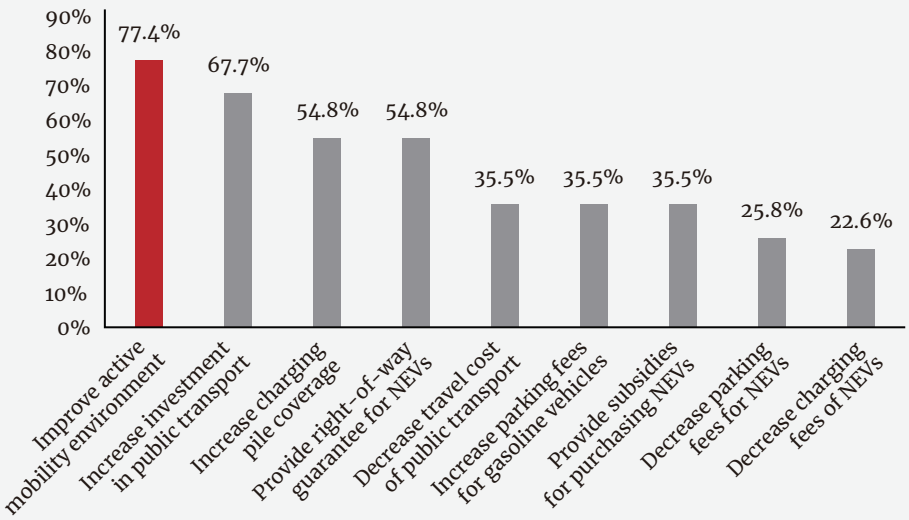
Accelerate research on solutions for power grid capacity expansion

With the continuous increase of EV ownership, charging demands also increase accordingly. The report on *Charging Facility Construction and Charging Behaviour in Beijing* shows that the charging peak hours of NEV users in Beijing are between 8:00-9:00 a.m., 15:00-16:00 p.m., and especially between 23:00-24:00 p.m.[40], as the charging price is lower at night. During peaks, the power grid is exposed to particularly high utilisation. In the future, the city of Beijing should invest more in research on finding solutions for expanding power grid capacity, especially in residential areas and commercial areas with high densities of people and high demands for power.

c) Energy structure

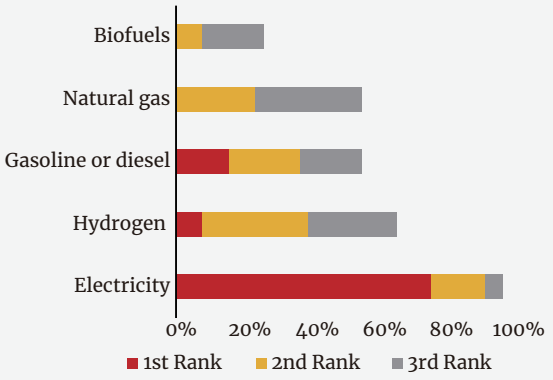
Vehicle electrification plays a leading role in the process of promoting the large-scale application of new energy vehicles. Electric energy will become an important energy supply in urban transport. This study's survey results showed that the main types of energy used in passenger transport vehicles in Beijing are expected to be electricity and hydrogen (see Figure 4-18). In future freight transport systems, the energy sources for vehicles are expected to be mainly electricity, gasoline or diesel, and hydrogen. However, differing from the field of passenger transport, gasoline and diesel will also still be essential in future freight transport (Figure 4-19).

Figure 4-17 The most effective incentive measures to promote green and low-carbon transformation of urban transport

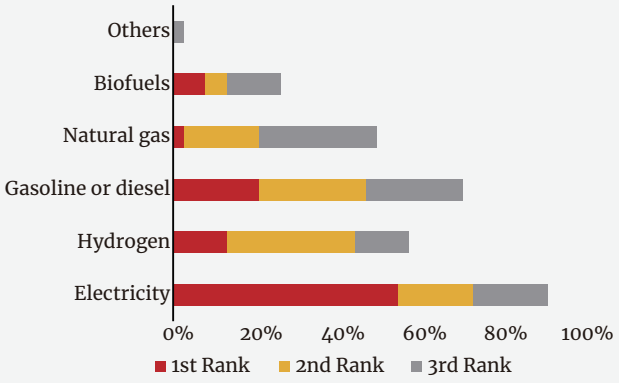


[40] Echong Network. Report on Charging Facility Construction and Charging Behaviour in Beijing in 2019 [EB/OL]. https://mp.weixin.qq.com/s/Bh0fWghyBbFvlanuvaC3kw

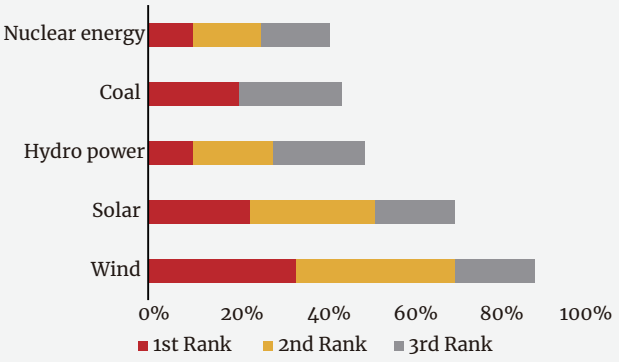
■ **Figure 4-18 Main energy used by vehicles in Beijing's urban passenger transport by 2035**



■ **Figure 4-19 Main energy used by vehicles in Beijing's urban freight transport by 2035**



■ **Figure 4-20 Main sources of electric energy used by vehicles in Beijing's urban transport by 2035**



> "When it comes to the electrification of transport and mobility, we should first pay attention to the energy structure, only electrification based on green energy generated from renewable resources, will be truly meaningful" – an expert in transport energy, at the first workshop of the Beijing Dialogue Workshop Series

During the process of promoting vehicle electrification, special attention needs to be paid to the overall field of energy supply structures. In the future, the construction of a green electricity supply system should be accelerated, therefore supporting energy supply structures should also be optimised, the proportion of electricity generated from new and renewable energy sources should be increased, and the energy consumption and emissions of new energy vehicles throughout their life cycle should be reduced. At present, China relies heavily on coal for power. To decarbonise the transport sector, joint efforts and collaborative innovations between the transport sector and the energy sector are needed to ensure that the electric energy used in urban passenger and freight transport is generated from renewable energy. In recent years, renewable energy technologies – such as wind power and photovoltaic power – have significantly improved, while their costs continue to fall. Renewable energy sources, as forms of alternative energy, are gradually becoming an important force in the transformation of the energy mix[41]. In this study's online survey, respondents predicted that in the future, China's power generation for transport systems will mainly be derived from wind energy, solar energy, and hydropower, which will largely replace coal power (Figure 4-20). It is therefore necessary to accelerate the construction of renewable power generation facilities, including wind turbines and solar panels, to effectively be able to meet the growing demand for green power in the future. Residents in rural areas may also supply themselves with green electric energy by installing solar panels on the roofs of their houses.

[41] National Energy Administration. Appropriate National Support in Renewable Energy Power Generation Projects [EB/OL]. http://www.nea.gov.cn/2020-11/30/c_139555798.htm

4.2 Intelligent Transport and Mobility

With the accelerated integration of the transport sector with advanced technologies such as Big Data, AI and cloud computing, the concept of an intelligent transport system has gained popularity in the development of urban transport systems. In recent years, several plans and outlines have been released at the national level, suggesting that the development of intelligent transport must be accelerated, including clear requirements for promoting the digitisation of transport infrastructure, building comprehensive transport data centre systems and improving the level of intelligent transport management and services. The future intelligent transport system will integrate intelligent infrastructures, vehicles, transport operations, and maintenance and management services. All transport subsystems and elements involved will be interconnected, and data on demand, data supplies as well as management options, will be shared in real-time. On-demand mobility services will be widely applied and can help solve problems such as traffic congestion, inconvenient transport services, and a lack of safety measures. Against the background of this outlook, this subchapter will first provide a detailed overview on the major technological trends and challenges of intelligent urban transport systems. This will be followed by an in-depth assessment of the opportunities and challenges related to the implementation of transport reservation systems, mobility-as-a-service, and autonomous driving in future intelligent transport systems of Beijing.

4.2.1 Major trends and challenges

a) The future intelligent transport system goes beyond intelligent transport

This study's survey showed that future intelligent transport systems will be more than only the promotion of intelligent means of transport. These systems will require intelligent infrastructure, allowing autonomous vehicles to operate safely in all scenarios. In the future, smart vehicles will run on smart roads, which will enable vehicle-road communication by using devices from the Internet of Things (IoT), providing safer and more efficient mobility services at a lower cost. Moreover, smart operation and management operations will also be essential elements in intelligent urban transport systems. Urban traffic management authorities will rely on Big Data, supercomputing, and simulations for accurate policymaking, so as to continuously improve the efficiency of urban transport operations and services.

> "In the future, Beijing will promote the development of smart vehicles, intelligent road infrastructure and intelligent management simultaneously to achieve an intelligent transport system – an expert in intelligent transport, at the second workshop of the Beijing Dialogue Workshop Series

b) The urban traffic brain will help build an intelligent traffic management system

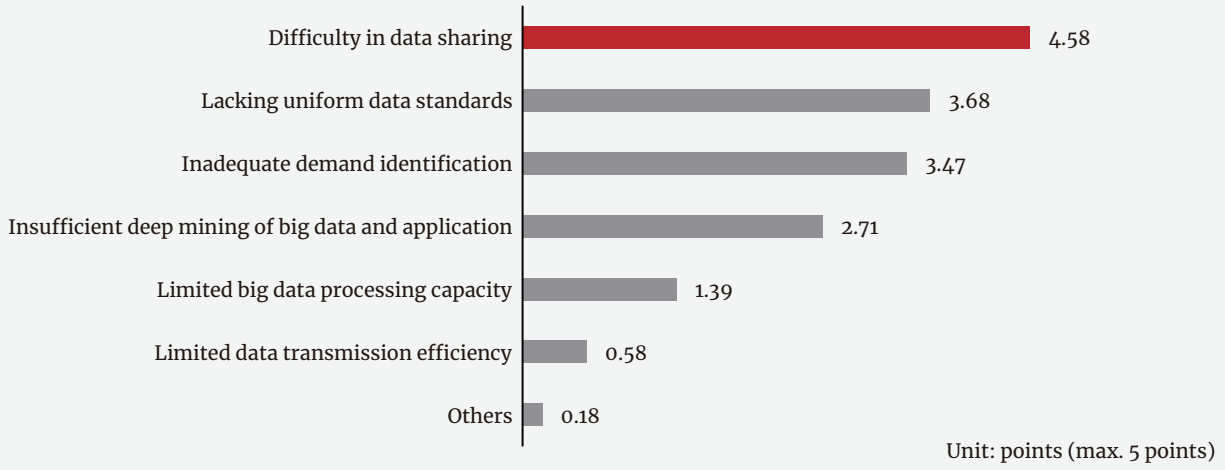
Originating from the dynamic development of internet technology, an urban traffic brain can help build an intelligent traffic management system. At present, the concept of an urban traffic brain has been adopted in multiple Chinese cities such as Shenzhen, Hangzhou, Jinan, Guangzhou and Chongqing[42]. In 2019, Beijing started preparing the *Beijing Intelligent Transport Action Plan*. According to the plan, Beijing was to strengthen the role of Big Data and also build an urban traffic brain. Beijing is now continuously optimizing and upgrading the traffic brain, and gradually promoting the construction of a "five-in-one" traffic brain, which means it will merge the five functions of intelligent monitoring, intelligent prediction, intelligent scheduling, intelligent management and intelligent evaluation into one traffic system. Beijing is expected to complete a comprehensive system to help make traffic decisions through monitoring and warning systems by the end of 2023. With the empowerment of the traffic brain based on Big Data, the capabilities of traffic monitoring, comprehensive coordination and scheduling tasks among transport service providers will be significantly improved. The modernization of the city's traffic governance system and capacity will then also be vigorously developed[43,44].

[42] Equal Ocean. The future has already come? In depth research on "Urban Brain" Transport System [EB/OL]. https://mp.ofweek.com/smartcity/a945683928196

[43] The People's Government of Beijing Municipality. Beijing's 14th Five-Year Plan for Transport Development and Construction. May 2022: http://www.beijing.gov.cn/zhengce/zhengcefagui/202205/t20220507_2704320.html

[44] Beijing Municipal Commission of Transport. Beijing's 2022 Action Plan on Comprehensive Transport Management. April 2022: http://jtw.beijing.gov.cn/xxgk/tzgg/202205/t20220509_2705677.html

■ **Figure 4-21 The largest obstacles in developing future urban intelligent transport in Beijing**



c) The development of intelligent transport is still confronted with many challenges

Due to inconsistent data standards, challenges of data sharing across departments, and immature technology for deep data mining, the development of intelligent urban transport systems in China still faces many obstacles and problems. China currently has not established a comprehensive standard system for traffic data. Data fragmentation, technology barriers for developing intelligent transport platforms, and hurdles between enterprises and governments have led to isolated data islands. As a result, most data cannot be interconnected and shared[45]. According to most participants in this study's online survey, difficulties in cross-regional and large-scale data sharing are the largest obstacles to developing an intelligent transport system in Beijing. In order to make use of the advantages of data that is available, and facilitate the government's related decision-making processes, Beijing's authorities should first seek breakthroughs in promoting data sharing and establish a unified data standard for creating an intelligent urban transport system (see Figure 4-21).

4.2.2 Reservation systems

With the adoption of information and communication technologies, reservation systems can balance the supply and demand of transport systems through precise demand adjustments and the optimal allocation of transport resources. On the supply side, reservation systems can improve the efficiency and accuracy of their transport services. On the demand side, users can greatly reduce their waiting time when traveling based on updated schedules provided by reservation systems. With the development of technologies such as autonomous driving and the internet of vehicles, on-reservation transport will further become a new type of transport service and contribute to alleviating traffic congestion in cities. In Beijing, reservation systems are already applied in urban passenger transport settings.

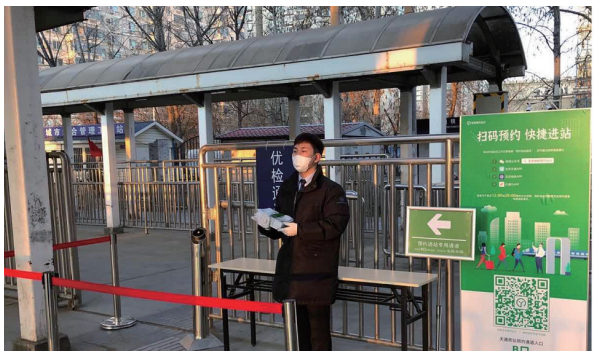
a) Subway reservations

On March 6, 2020, the Beijing Municipal Commission of Transport launched a pilot subway reservation project at two subway stations, allowing passengers to reserve a time slot through their smartphones for when they enter the subway station during the rush time between 9 and 9:30 a.m. After they make their reservation, passengers may arrive at the reserved time and quickly enter the subway system through a dedicated path, to avoid a long queue. On April 29, 2020, subway reservations were introduced at the Caofang Station of Subway Line 6. From April 2020 to April 2021, 1,170,000 reservations were made on this system, saving an estimated 40,000 hours of riders' travel time, or 3.5 waiting minutes per passenger per day. Today, many passengers have gotten used to making a reservation before taking the subway[46]. Subway reservations can effectively reduce waiting times during peak hours and accurately control the passenger flows, also leading to safer travel during the COVID-19 pandemic. After the pandemic, the measure can still help control travel demands at stations with high passenger flows (see Figures 4-22 and 4-23).

[45] National Geomatic Centre of China. It is urgent to break "isolated data islands" to maximize urban efficiency by using intelligent transport [EB/OL]. http://sgic.geodata.gov.cn/web/sgic/zhcs18/info/2018/3408.html

[46] Jiemian News. Beijing Subway piloted "reservation-based travel" for one year, saving 3.5 minutes per person per day [EB/OL]. https://www.jiemian.com/article/5972094.html

■ **Figure 4-22 a dedicated path at Tiantongyuan station on Line 5 of the Beijing Subway**



(Source: Beijing Transport Institute)

■ **Figure 4-23 passengers are entering the subway station through dedicated paths**

(Source: Beijing Transport Institute)

b) Car route reservations

From October 15 to 19, 2018, peak time reservations to enter the ramp section of the Beijing-Tibet Expressway at Huilongguan West Street in Beijing were trialed. Since the intersection is extremely jammed during rush hours on weekdays, entering it by reservation could save each driver 17 minutes to 39 minutes[47]. Adjusting traffic flows based on reservations is an effective way to reduce traffic congestion during peak hours, even if applied only on a small scale. The reservation model can be used for bottleneck sections of urban roads and bus-only sections with a low utilisation rate. By using simulation technology, a balanced supply and demand travel schedule can be compiled, which will result in an overall optimisation of the transport system.

c) Bus reservations

In early 2020, with the resumption of work and school after the initial COVID-19 breakout, the "Beijing Bus Reservation" app was launched in Beijing. The service enabled passengers to make reservations or buy bus tickets for public buses through a mini-app on WeChat. By March 2020, based on travel demand, a total of 172 routes allowing bus reservations were designed for work commuters. With 155 daily rides, 102 buses were put into operation, which have served 1,261 passengers on a day. The average vehicle occupancy rate was held below 50% due to the requirements of COVID prevention guidelines. This on-demand bus service covered large residential areas, such as Huilongguan, Tiantongyuan, and Liyuan, and commercial areas, such as Guomao Mansion, Jinrong Street, Xierqi, and Zhongguancun[48]. The reserved bus travel system ensured people's travel safety during the pandemic and met the passengers' "point-to-point" travel demands. In addition, the reservation service increased capacities of the public bus fleets. With the increasing demand for personalised and high-quality service, reservation systems should be widely applied in the future of public bus transit.

4.2.3 MaaS platforms

Mobility-as-a-Service (MaaS) is a novel but quickly developing concept in the transport sector. The goal of MaaS is to integrate multiple travel modes into one service platform, thereby improving people's travel experience and guiding people to shift from individual motorised transport towards green transport modes. According to the *Outline for Building China's Strength in Transport*, China should vigorously develop shared transport systems, build mobility service systems based on the application of mobile intelligent terminal technology, and perceive mobility as a service-oriented industry, which should make transport services convenient, comfortable, economical, efficient and available for all citizens.

Following this guidance, the Beijing Municipal Commission of Transport collaborated with Alibaba's Amap (China's leading map service provider) to launch a Beijing MaaS Platform in November 2019, which was the first pilot of an integrated mobility platform in China. The MaaS platform integrated not only various forms of transport services (including public buses, subways, and taxis), but also various functions, such as providing real-time information on bus arrivals, end-to-end trip planning support, public transport route planners, travel guidance tips at peak times, bus and subway congestion information and crowd density status at popular destinations. By the

[47] Guo Jifu, Diao Jingjing. Application of Reservation in Urban Transport at System-Practice in Huilongguan District of Beijing [EB/OL]. https://mp.weixin.qq.com/s/uj2TAnezuYrGOHG9inK4FQ

[48] Beijing Municipal Commission of Transport Office. Work Dynamics [J]. Beijing Daily Traffic Information, 2020

end of 2020, the Beijing MaaS platform reached more than 24,000,000 users. It provides real-time information for more than 95 percent of bus lines, with an accuracy rate of over 97 percent[49]. In September 2020, the platform launched a green travel incentive action. The App can calculate carbon savings achieved by people's green travel behaviour and reward them with transport coupons and store or movie vouchers accordingly. This action will help promote the shift from car travel to green travel modes amongst consumers. Since the launch of this action, about five percent of app users have changed from self-driving to public transport travel[50]. In the future, Beijing will continue to promote the development of the MaaS platform and continuously enrich its service scenarios and functions to improve the quality of integrated mobility services, guide people to travel green, and help Beijing achieve its dual carbon goals.

According to this study's online survey, more than 80% of respondents believed that MaaS will become widely applied in urban transport systems by 2035. They also thought that it would play an active role in promoting green and sustainable transport. However, nearly 90% of the respondents still believed that platform operators should optimise their platform's services and improve their operating efficiency. For example, it is necessary to further integrate services such as bike-sharing, ride-hailing and parking management options into the platforms, which will allow people to access all transport services in one program to improve their travel experience. In addition, more than 60% of respondents stressed that relevant government departments, platform operators and service providers should work together to promote the effective development of the platform and make positive contributions to the promotion of green, low-carbon and sustainable urban transport.

4.2.4 Autonomous driving

a) The adoption of autonomous driving

In 2020, eleven Chinese ministries and commissions jointly issued the *Strategy of Innovation-Driven Development of Intelligent Vehicles* to accelerate the innovation and development of the industry for the use of intelligent vehicles[51]. The strategy declares that the development of intelligent vehicles is of great strategic significance to China and has also become the strategic direction of the global automotive industry. The overall strategic vision of the industry is to manufacture vehicles with conditional automatic driving functions on a large scale and develop vehicles with highly automatic driving functions in specific environments by 2025.

Autonomous driving has already been piloted in different scenarios, such as in passenger transport (bus, taxi), logistics distribution, sanitation operations, ports and docks, mining, and retail services. After the outbreak of the COVID-19 epidemic in 2020 – in order to minimise the potential risk of infection – Baidu, JD.COM, Meituan, IDRIVERPLUS, Neolix, UNITY DRIVE, Xingshentech and other companies provided some services by deploying low-speed self-driving vehicles in different areas and neighborhoods in Beijing. These autonomous vehicles carried out indoor-and-outdoor disinfection, body temperature detection and distributed goods and food. In October 2020, Baidu launched a self-driving taxi pilot project in Beijing, allowing passengers to place orders at self-driving taxi stations in the Haidian district and the Yizhuang area in the Daxing district[52]. In the future, with continuous innovation in the field of intelligent vehicles, China will have safer, more efficient and greener intelligent vehicles.

b) Autonomous vehicle adoption in the freight transport sector

In this study's online survey, over 60% of respondents believed that autonomous driving would be first commercially used in freight transport. Logistics in industrial parks and ports, last-mile urban distribution and short-distance freight transport in cities will thus become the top three application scenarios of autonomous vehicles in freight transport. In the field of urban passenger transport, the main application scenarios of autonomous vehicles by 2035 were predicted to be as short-distance buses, urban buses, ride-hailing vehicles and taxis (see Figure 4-24). People maintained a rather conservative attitude towards purchasing autonomous driving cars, mainly due to their safety concerns.

[49] Beijing Transport Institute. 2021 Beijing Transport Development Annual Report. Beijing: July, 2021

[50] Zhou Yufang, Chen Jiaqi. "MaaS makes the whole city green" Green mobility Low-carbon Inclusive Action [EB/OL]. https://mp.weixin.qq.com/s?https://mp.weixin.qq.com/s?__biz=MzA5NTE4OTUzMg==&mid=2456481127&idx=2&sn=0f1a32dc113030a9e3c8a684ce8f1d43&chksm=87dd6214b0aaeb02d0e0f3688dbb01a9d70ae9c37796eb0013928e9fcae3765923ebdb1b4c08&mpshare=1&scene=1&srcid=0720ueVbs61fb3Vruem8d6iH&sharer_sharetime=1626772583192&sharer_shareid=67db57db5484e577d32d377cb746763d#rd

[51] NDRC, Cyberspace Administration of China, MOST, et al. Innovation and Development Strategy of Intelligent Vehicles [EB/OL]. February 10, 2020: https://www.ndrc.gov.cn/xxgk/zcfb/tz/202002/t20200224_1221077_ext.html

[52] 36kr. Beijing fully embrace driverless taxis, and free trial is available from today on [EB/OL]. https://www.36kr.com/p/921022159194499

c) Vehicle-road coordination systems

There are two main pathways towards developing autonomous driving systems: the first is to develop single intelligent vehicles and the second is to develop vehicle-road cooperation systems (see Figure 4-25). In this study's online survey, two-thirds of respondents believed that vehicle-road cooperation systems would be the main development path for autonomous driving. Regarding the development of single intelligent vehicles over the past decade, there have been great advances in solving many challenges of autonomous driving, but there are still issues relating to the perception and prediction abilities of vehicles, such as how to tackle the black box effect of AI technology and how to simulate and verify millions of extreme driving conditions based on software, to ensure safety during actual driving scenarios. All of these factors render existing intelligent vehicles as not yet suitable for large-scale commercial use. For vehicle-road cooperation systems, information interactions based on roadside intelligent facilities and vehicle-side intelligent terminals can make up for the lack of perception ability of vehicles and effectively improve the safety of automatic driving. However, the main obstacle in the development of vehicle-road collaboration systems is the feasibility and affordability of covering all roads with sufficient intelligent facilities. It is necessary to accelerate the layout of intelligent road infrastructure and promote the interconnection between road facilities, intelligent vehicles, operation services, safety management and traffic command systems. However, it is also necessary to define road grades according to the level of intelligent infrastructure they would require, as well as clarify access areas and driving routes for autonomous vehicles.

No matter what path is taken, the systematic creation of laws and standards is required for the development of autonomous vehicles. This should include defining the responsibilities of autonomous vehicles, improving data management norms, and promoting the revision of the *Road Traffic Safety Law*. On the whole, the field of autonomous driving still has a long way ahead due to various obstacles.

Figure 4-24 Application scenarios of autonomous driving in urban passenger transport by 2035

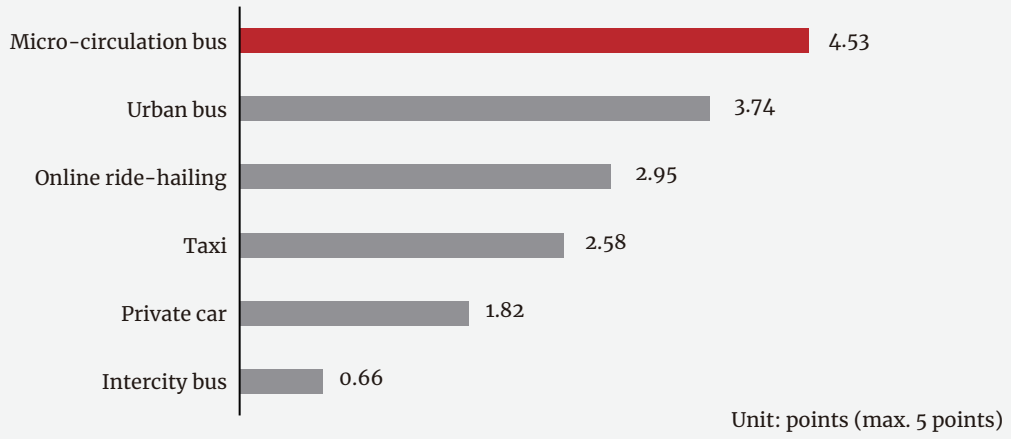
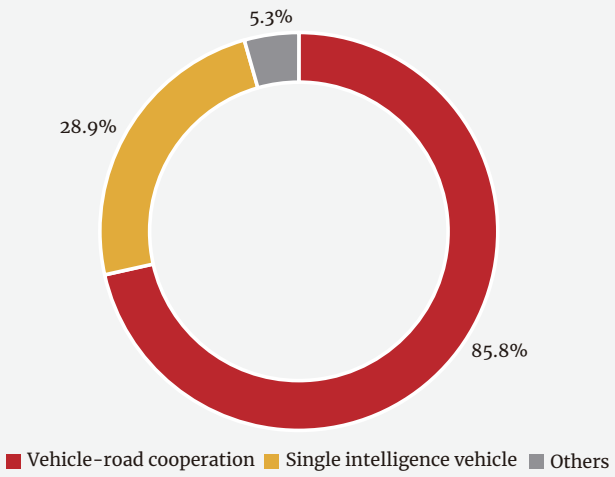


Figure 4-25 Main implementation paths of autonomous driving



4.3 Shared Mobility

Shared mobility is a merging traffic mode where travelers share a vehicle either simultaneously as a group or over time through a personal rental. There are various forms of shared mobility, including but not limited to ride-hailing, bicycle-sharing, car-sharing and other on-demand mobility services. The following subchapter will first introduce the main drivers for shared mobility development in Beijing. This will be followed by an analysis of how shared mobility is altering the travel habits of Beijing residents.

4.3.1 Development trends

With the accelerating integration of emerging technologies and the transport industry, the concept of shared mobility and its related services has emerged (see Figure 4-26). Throughout the past decade, various new mobility services have started changing the mobility landscape of Chinese cities, including bicycle-sharing, carpooling, car-sharing, and ride-hailing services. Bicycle-sharing services, for example, have disrupted urban short-distance travel norms within only few years. Dockless shared bicycles rented via mobile internet have gradually replaced shared bicycles bound to parking docks. Throughout this development, bicycle-sharing has gradually shifted from having a disorderly and excessive deployment style to orderly deployment and refined management systems. By the end of 2021, there were 956,000 shared bicycles in Beijing, a decrease of over 1.2 million vehicles compared with 2017. Ridership in 2021, however, had reached 950 million, an increase of 38% compared with the previous year[53]. Nowadays, shared bicycles are an important transport mode for urban short-distance travel and the "last-mile" connection to urban public transport. In the future, it will be necessary for local authorities to continue refining their operating strategy, strengthening parking management plans, and promoting shared bicycles to better integrate them with public transport systems.

Following the integration of platform economy and shared mobility systems, various ride-hailing services emerged in China, establishing a low-cost matching mechanism between supply and demand for transit options. Platform-based ride-hailing services are more convenient than traditional taxis, since passengers book pick-ups through a smartphone and they don't need to wait at the curb to wave to an empty taxi. Rather than waiting while empty taxis didn't stop, or drivers refused ride requirements, ride-hailing services made traveling by taxis more reliable and convenient. App-based ride-hailing reduces idle taxis, saves energy and reduces emissions and has become an important part of the urban transport system. However, the prevalence of affordable shared mobility modes, in particular ride-hailing, also has disadvantages. In 2015, Gao et al. (2016) conducted two questionnaire surveys on Beijing ride-hailing users to quantitatively analyze the changes in residents' mode choice after the ride-hailing services were rolled out. According to Gao's study, the scale of the ride-hailing market in Beijing was huge. With 3.5 million trips per day, ride-hailing accounted for 11 percent of the city's total passenger trips and about 58% of ride-hailing passengers were used to take public transport and riding bikes[54], which implied the necessity for government management departments to deepen their research on the development strategies and policies of the ride-hailing industry and guide its orderly development on the premise of not exacerbating urban traffic congestion.

According to this study's online survey, most respondents agreed that shared mobility would remain a prevalent travel mode of urban mobility, contributing to decarbonising the transport sector. Considering the relationship between shared mobility and the public transport system, more than half of respondents were of the opinion that shared mobility would not replace public transport, but rather it would become an important supplement to urban public transport, especially when integrated into a green, shared and intelligent urban transport system (see Figure 4-27).

> "Before talking about shared mobility, we must first define what shared mobility is. With limited space resources, shared mobility should effectively share the existing and limited resources to improve the efficiency of the transport system." – an expert from Transport Planning, at the second workshop of the Beijing Dialogue Workshop Series

[53] Beijing Transport Institute. 2022 Beijing Transport Development Annual Report. Beijing: July, 2022
[54] Gao Yong, An Jian, Quan Yuxiang. The influence of online ride-hailing on the choice of mobility mode and traffic operation [J]. Urban Transport, 2016 (5): 1-8

In terms of market performance, shared mobility can meet individualised travel needs with its convenient and efficient services. Shared mobility is expected to change consumers' concept of owning and using vehicles. Instead of relying solely on privately owned vehicles, consumers may choose to share vehicles with others or buy corresponding mobility services according to their needs. Thereby, the utilisation efficiency of vehicles and road resources in cities will be improved and traffic congestion will be alleviated[55]. At the same time, shared mobility is also expected to change the basic attributes and service modes of traditional public transport. It will transform public transport from meeting high-density passenger demand and providing services with fixed route operations towards meeting both high- as well as low-density passenger demands and providing customized services, such as on-demand bus services. Thus, the concept of shared mobility will contribute to the innovation of public transport service modes and continuously improve attraction levels of public transport.

Figure 4-26 Development milestones of shared bicycles in China

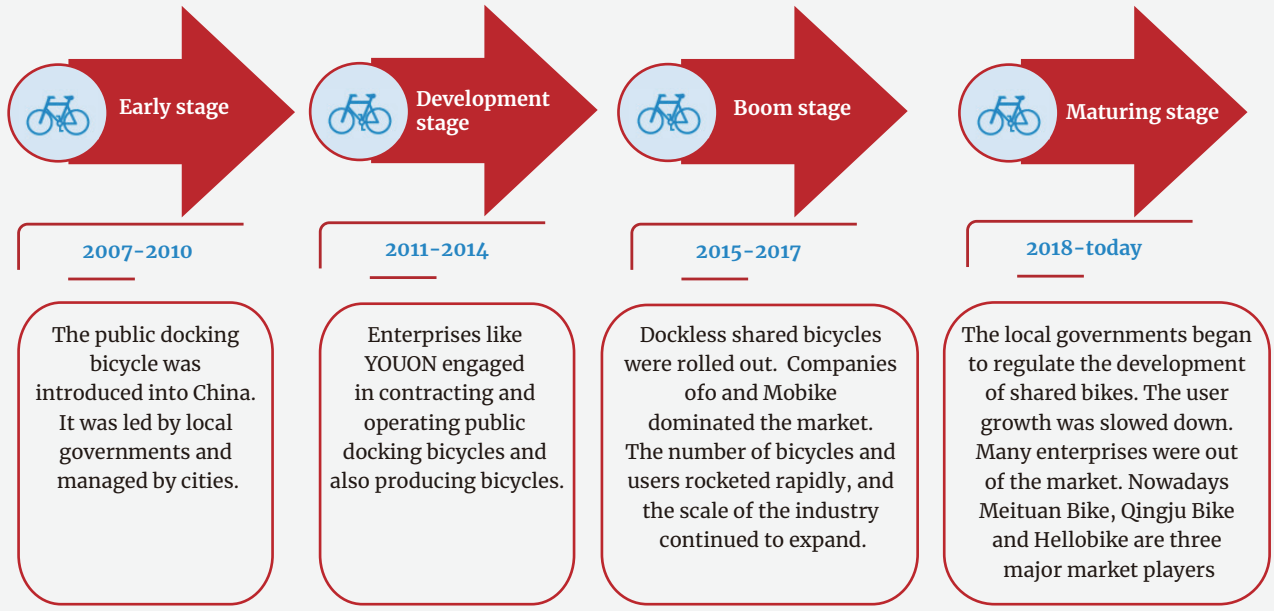
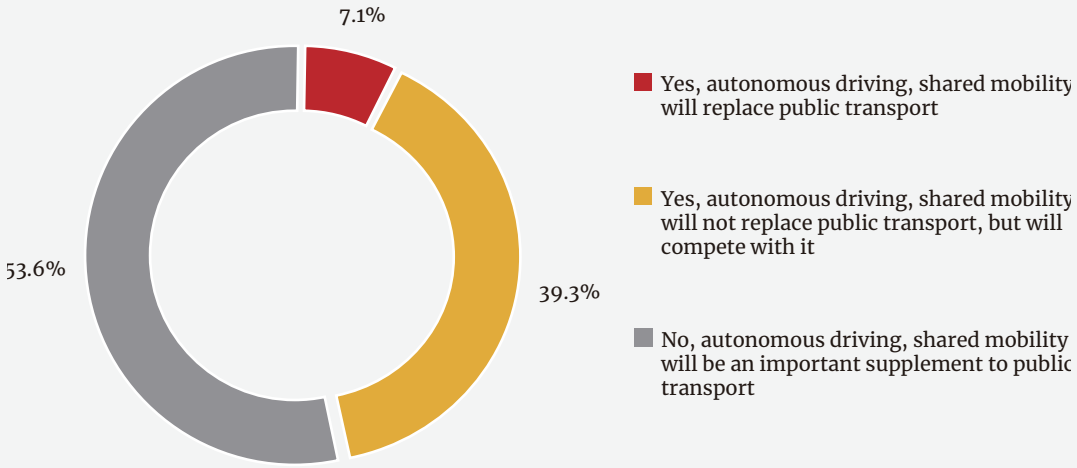


Figure 4-27 Influence of new mobility services such as autonomous driving and shared mobility on public transport



[55] China Environmental Protection Foundation - Green Mobility Special Fund, North China University of Technology and China Automotive Technology Research Centre-Strategy and Policy Research Centre. Report on China's Shared Mobility Development (2020-2021) [R]. Beijing: Social Sciences Academic Press, 2021

4.3.2 Mobility behaviour

Shared mobility, especially e-hailing, is more efficient than private car ownership, and can be a green transport mode with the aim to save energy and reduce emissions. Although China has proposed to develop an intelligent, safe, green and shared transport system by 2035, private car ownership is still continuously growing. Therefore, a shared mobility culture needs to be cultivated. According to this study's online survey, few participants had experienced car rides shared with strangers, and about half of the respondents owned cars. Only 38% of them had ever offered rides to strangers and a quarter of them said they would not do it again. As for survey participants who were not car owners, 88% of them had booked a carpooling service, and also committed to a carpool ride in the future. Half of the respondents who never booked a carpooling service, had no intention to use the service in the future (see Figures 4-28 and 4-29).

The main factors affecting people's decision to provide or use car-pooling or car-sharing services included safety, time and privacy. According to this study's online survey, the main reasons why car owners are unwilling to provide rides to strangers were listed as safety concerns, prolonged travel times and a lack of privacy. The main reason why people were unwilling to use a car-pooling or car-sharing service was long travel times. It is obvious that there is still a long way ahead in shifting a mindset from car ownership to a shared mobility culture. In order to further stimulate the potential of shared mobility to alleviate urban traffic congestion and improve the utilisation of space and idle cars, local authorities need to release relevant incentive policies, laws and regulations. For example, the responsible authorities can provide economic incentives for shared mobility, allocate exclusive drop-off areas for shared mobility, or offer more conveniences for shared mobility (see 4-30).

Figure 4-28 Whether respondents owning cars provided carpooling for others or not

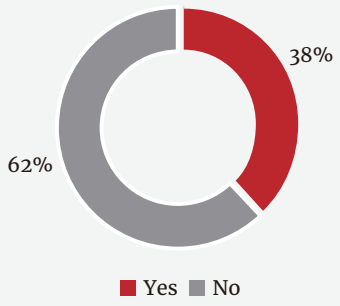


Figure 4-29 Whether car-free respondents ever used ride sharing or not

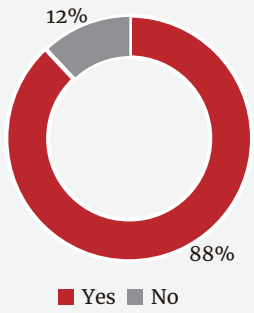
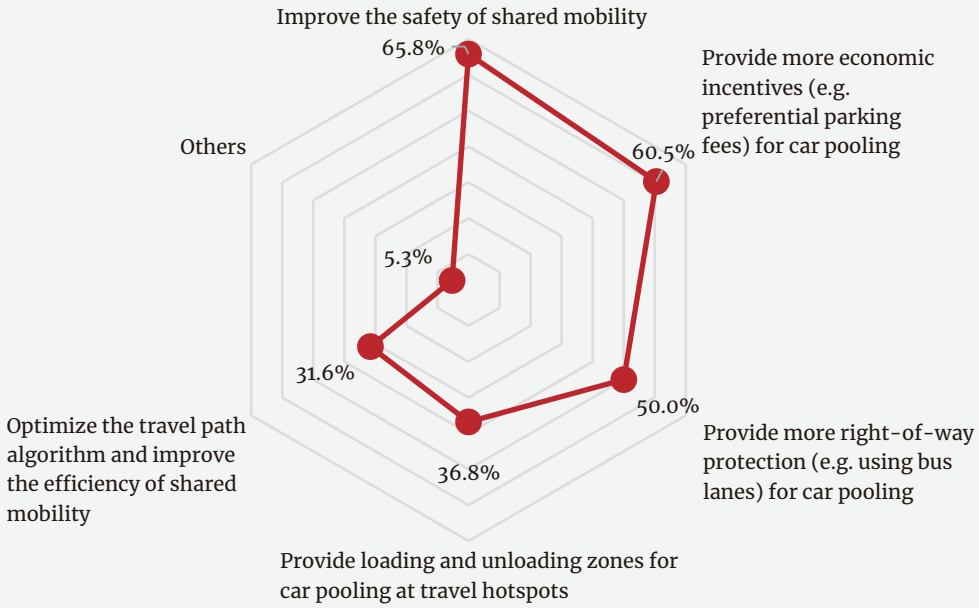


Figure 4-30 Measures conducive to fostering shared mobility culture



5 Conclusion and suggestions

At present, the level of urban intelligence is increasing, technology and policy for autonomous driving is moving towards reaching the stage of application, support for shared mobility is booming, and the electrification of vehicles is now considered to be a central element to achieving carbon peaking and carbon neutrality. The future of urban transport will be an integrated green, intelligent and shared system. The cross-border integration of EVs, shared mobility and autonomous driving will breed new mobility modes and service systems, minimise the consumption of resources, create development opportunities and help eliminate the negative impacts of urban transport on the environment. The electrification of transport will be a basic requirement for energy transformation in the future. The development of shared mobility will effectively improve vehicle occupancy rates, reduce the waste of road resources, and alleviate the traffic pressure caused by the high proportion of cars carrying only one person. It will also provide an important application scenario for autonomous vehicles. The continuous maturity of autonomous driving technology will rely on Internet of Vehicles (IoV) and Vehicle to Everything (V2X) technology[56] to effectively improve road efficiency and safety. Without organic integration of these technologies, it will be difficult to achieve a safe, green and efficient transport system (see Figure 5-1).

Based on the "Beijing Dialogue" workshop series, the research conducted for this study and its subsequent described vision, ten recommendations are put forward here, which aim to support Beijing's transport and mobility policy-making institutions in their efforts to further develop the city's transport and mobility systems in line with China's 2030 and 2060 climate goals.

Figure 5-1 The future of urban transport and mobility

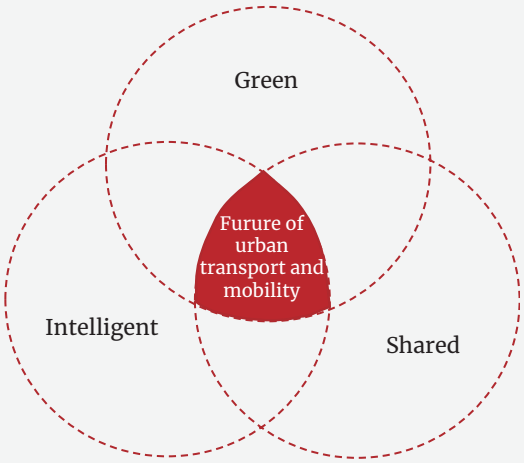


Figure 5-2 Key results of the "Beijing Dialogue"

- The future of urban transport and mobility in Beijing must be **green**, **intelligent** and **shared**.
- To strengthen the Beijing-Tianjin-Hebei (Jing-Jin-Ji) city cluster, it is important to build **integrated**, resilient and **multimodal transport networks**.
- Building functional mixed-use areas and realizing the "**15-minute city**" is an effective way to improve the quality of urban life and reduce the total number of trips.
- Against the background of changing demographic structures, urban transport needs to become more **safe**, **accessible**, **convenient** and **comfortable**.
- **Public transport** must be the backbone of Beijing's urban transport system and needs to be well integrated with other transit modes and mobility services.
- **Electrification** is key to the decarbonisation of Beijing's transport system and should be based on the integration of transport, energy and information sectors.
- **Digitalisation** is key to the future development of sustainable and effective urban transport.
- **Multi-stakeholder cooperation** is essential as there is no silver bullet to sustainable transport and mobility.
- **Guiding roadmaps** are needed for achieving the vision of green, intelligent and shared urban transport in Beijing.
- **International exchange** and **cooperation** are of great significance.

[56] Internet of Vehicles (IoV) is a distributed network that supports the use of data created by connected cars. Vehicle to Everything (V2X) is a communication system that allows vehicles to communicate with other vehicles or elements of the traffic system that may affect the vehicle.

(1) The future of urban transport and mobility in Beijing must be green, intelligent and shared.

In order to fight global climate change in line with the goals of the Paris Agreement and China's Nationally Determined Contributions (NDCs), and to reach more sustainable all-round development in the framework of the Sustainable Development Goals (SDGs), the urban transport and mobility systems of Beijing, driven by the rapid development and adoption of new technologies such as Big Data, artificial intelligence (AI) and the Internet of Things (IoT), shall be green, intelligent, and shared in the future. Beijing's transport system must as soon as possible become carbon neutral, fully integrated, accessible, barrier-free, inclusive, and intelligent and provide optimized mobility solutions in order to solve traffic problems such as congestion, noise, road safety issues, air pollution, and greenhouse gas emissions and to make the city as a whole more livable and attractive.

(2) To strengthen the Beijing-Tianjin-Hebei (Jing-Jin-Ji) city cluster, it is important to build integrated, resilient and multimodal transport networks.

With the development of the Jing-Jin-Ji city cluster region, Beijing's urban functions will be increasingly rearranged into a larger urban-rural agglomeration context. Its functional integration with cities such as Tianjin, Baoding or Xiong'an will be further strengthened. Along with this development comes extended urban commuting distances and growing inter-city transport demands. More integrated and diverse mobility modes must therefore be provided, multimodality must be promoted and comprehensive transport networks and corridors must be planned and constructed to increase transport efficiency.

(3) Building functional mixed-use areas and realising the "15-minute city" is an effective way to improve the quality of urban life and reduce the total number of trips.

Currently, one of Beijing's largest challenges regarding urban planning is making efficient use of spatial resources. In order to effectively optimise Beijing's urban spatial pattern and reduce cross-regional and long-distance commuting, residential areas need to be located closer to workplaces and mixed-use urban areas need to be developed with diversified functions. In addition, enabling people to conveniently reach essential urban services within 15-minute walking distances by building "15-minute neighborhoods" will effectively improve people's quality of life.

(4) Against the background of changing demographic structures, urban transport needs to become more safe, accessible, convenient and comfortable.

With a growing proportion of people aged 60 or above, there is a large demand for accessible and barrier-free transport, facilities and services. Furthermore, based on the three-child policy, it is hoped that in the future the fertility rate will increase in China. The change of family structures brought along by two- or three-child families will inevitably lead to more diverse mobility behaviours. In the future, Beijing's urban transport system, especially public transport systems, must become more safe, accessible, convenient and comfortable in order to effectively cope with new demands arising from demographic changes. The city must become family and child-friendly with a strong focus on improving spatial quality including the construction of public playgrounds and benches.

(5) Public transport must be the backbone of Beijing's urban transport system and needs to be well integrated with other transit modes and mobility services.

Public transport will remain the backbone of Beijing's transport system. The vigorous development and promotion of public transport is fundamental to solving the city's transport problems. It is necessary to further expand the public transport system, improve its service levels, reliability and overall quality, and thereby encourage citizens to use public transport more often. Shared mobility services such as ride-hailing and active mobility modes should be well integrated and mainly function as a complement to public transport.

(6) Electrification is key to the decarbonisation of Beijing's transport system and should be based on the integration of transport, energy and information sectors.

Vehicle electrification is key to achieving the decarbonisation of transport. Nevertheless, attention should be first paid to electric energy supply structures. At present, China's electricity supply mainly depends on coal power. In terms of the power generation type of Beijing, thermal power generation accounted for the largest proportion, accounting for about 97% of the city's energy

supply in 2021. To decarbonise the transport industry, it is urgently necessary to increase the share of renewable energy in the overall energy mix and to make concerted efforts for the integrated development of the transport, information and energy sectors. Meanwhile, it is necessary to continuously align and optimise urban and land use planning with the needs for EVs, in order to increase charging infrastructure coverage.

(7) Digitalisation is key to the future development of sustainable and effective urban transport.

Digitalisation and the emergence of the platform economy are radically changing people's consumption patterns and society as a whole. The use of E-Commerce, internet-based food delivery, or online ride-hailing services has led to increasing demand for urban freight and passenger transport systems, and thus more traffic and emissions, which poses new challenges to the sustainable development of urban transport. To open the potential of digitalisation for Beijing's future sustainable transport system, it is important to develop related frameworks and mechanisms for uniform data standards, data sharing and privacy protection, so as to effectively meet the needs of users and management departments and improve abilities relating to risk prevention and the capabilities of traffic controls. Furthermore, with a large-scale application of autonomous driving on public roads in Beijing, it is also necessary to improve and develop relevant standards, laws and regulations.

(8) Multi-stakeholder cooperation is essential as there is no silver bullet to sustainable transport and mobility.

In order to realise the future vision of green, intelligent and shared urban transport in Beijing, cooperation between various stakeholders is crucial. Those stakeholders include, among others, local governments, researchers, internet companies, the automotive industry, energy companies and utilities, urban planners, investment and financing institutions and of course, citizens. In order to reach this goal, existing mechanisms for multi-stakeholder coordination and participation in Beijing should be strengthened and further developed, and new dialogues and exchange formats should be established.

(9) Guiding roadmaps are needed for achieving the vision of green, intelligent and shared urban transport in Beijing.

The green, low-carbon and sustainable transformation of Beijing's transport systems needs to be based on a long-term development strategy, as well as systematic and scientific guiding roadmaps. This includes the development of a transport sector early peaking action plan and carbon neutrality roadmap, which need to be fully aligned with China's 2030 carbon emission peaking and 2060 carbon neutrality goals, as well as the goals of the 14th Five-Year Plan and the long-term objectives of 2035. These should include aspects of socio-economic transformation, the integration of energy, transport and information sectors, as well as technology, governance, management, finance and construction partners. Plans should also contain public transport and shared mobility development considerations, and an integration plan, an active mobility strategy, a timetable for the phasing-out of internal combustion engine vehicles, as well as clear guidance for the role of electrification in transport. In addition, the roadmaps should focus on awareness measures and incentives for green travel habits.

(10) International exchange and cooperation are of great significance.

The realisation of the Paris Agreement is a global challenge. Only with close cooperation between countries and cities, can global warming be tackled effectively. The EU aims at achieving carbon neutrality by 2050 and China wants to reach its carbon emission peak before 2030 and carbon neutrality by 2060. These are good cooperation frameworks under which joint efforts to fight climate change can be made and aligned. Under these frameworks, cities can also better align their visions for early carbon peaking and carbon neutrality and foster cooperation in form of climate partnerships, knowledge and experience exchanges, joint research initiatives and pilot projects. This is particularly true for the transport sector, as cities around the world, in the EU and China, are seeking visions for their future transport and mobility systems and innovative solutions and approaches to make transport systems and cities as a whole more climate-friendly, sustainable and livable. Beijing, as a global megacity, can offer many best practices and experiences in testing such innovative approaches.

To meet these suggested goals, it is therefore urgent to build a platform dedicated to the international exchange of advanced experience and cooperation in these areas. In the future, the Beijing Dialogue shall be continued as a platform for international exchange and cooperation among policy makers, researchers and other stakeholders. It will take place annually in Beijing. In the Beijing Dialogue, the focus shall lay on the future of transport and mobility in cities around the world and their implications to today's decision-making processes. Topics could cover transport policy, technical standards, circular economies, renewable energy, low-carbon technologies, smart cities, the transition towards green transport and the implications of this field to societies as a whole. The Beijing Dialogue is expected to provide intellectual support for Beijing and other cities at home and abroad to accelerate the transition to green and low-carbon transport systems.

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Annex

Questionnaire and survey results

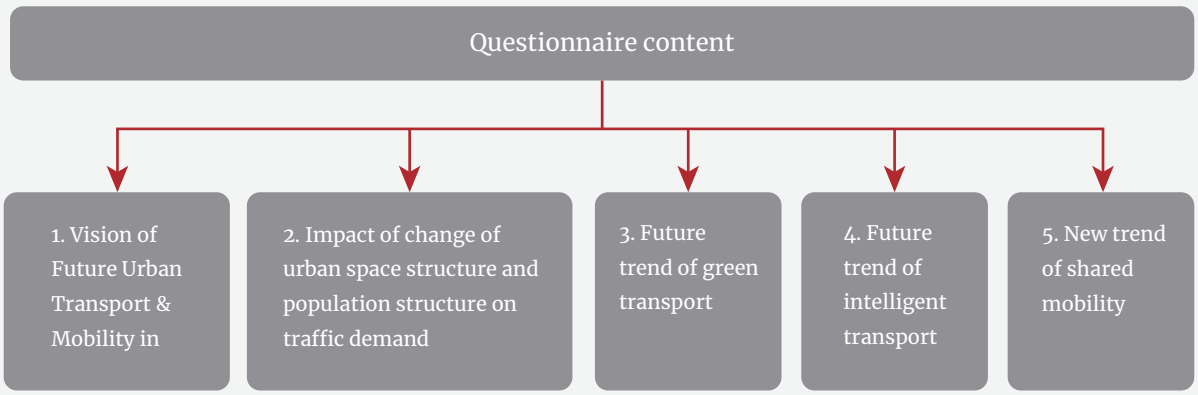
Questionnaire and survey sample

In order to collect the opinions of experts from related areas on the vision of future urban transport & mobility in Beijing, we designed and conducted an online questionnaire in November 2020. Experts from transport, planning, energy and other areas participated and relevant data were collected. The questionnaire included five parts, which were "Vision of Future Urban Transport & Mobility in Beijing", "Impact of Beijing urban spatial structure and population structure change on transport", "Future trend of green transport", "Future trend of intelligent transport" and "New trend of shared mobility" respectively (see Figure 1).

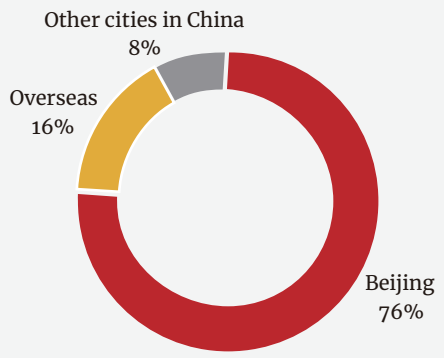
The "Vision of Future Urban Transport & Mobility in Beijing" part includes eight questions, covering the outlook of future mobility, structure of transport modes, and attitudes towards new mobility services such as shared mobility and autonomous driving. The "Impact of Beijing urban spatial structure and population structure change on transport" part includes 11 questions, covering the urban spatial structure change and the future traffic demands and mode choices of the elderly and families. The "Development Trend of Green Transport" part includes 13 questions, covering the main challenges in the future of green transport development, the most effective policy tools to promote green transport and the application scenarios of NEVs. The "Future trend of intelligent transport" part includes 15 questions, covering the main obstacles to intelligent transport, future trends of MaaS and autonomous driving and the implementation path of autonomous driving. The "New trend of shared mobility" part includes five questions, covering the attitudes towards shared and hourly based electric vehicles, the main factors influencing people's shared mobility behaviour, and parking measures for shared bicycles.

38 experts participated in the online survey. Most of them (76%) were from Beijing and 16% were from overseas. Around 32% of the surveyed experts were female, while the majority (68%) were male. 76% of the participants were aged 31-60, and 3% were aged over 60. Most participants had a professional background in transport (71%), or energy (8%). 53% of the participants had over 15 years of working experience. Some opinions of this research report were supported by the survey results. Due to the limited sample, some opinions may be controversial. See Figures 2 to 6 for further information on the surveyed respondents.

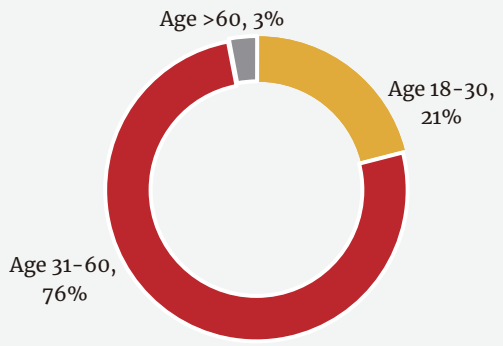
Figure 1 Questionnaire content



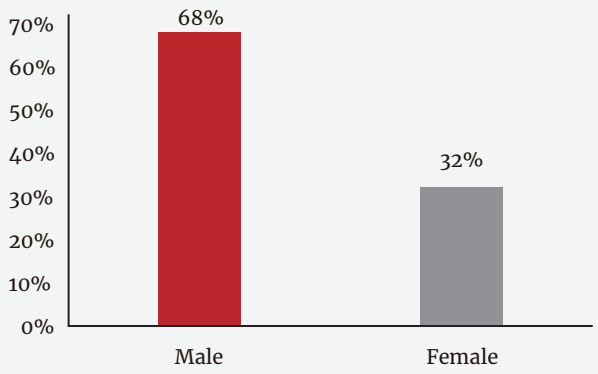
■ Figure 2 Geographical distribution of the participants



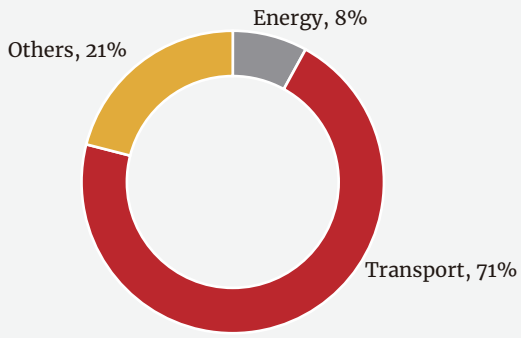
■ Figure 3 Age distribution of the participants



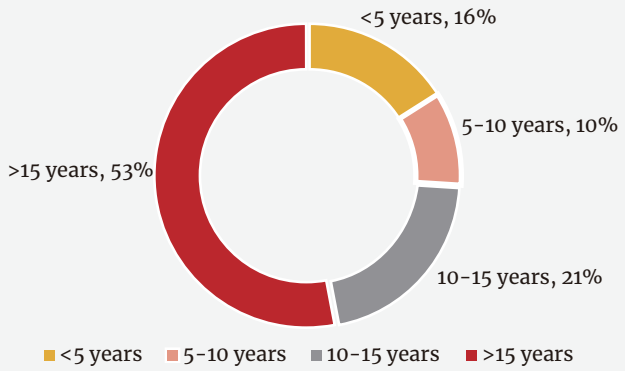
■ Figure 4 Gender distribution of the participants



■ Figure 5 Professional background of the participants



■ Figure 6 Years of working of the participants



Main survey results

(1) Vision of Future Urban Transport & Mobility in Beijing

By 2035, the major modes for urban mobility in Beijing will be public transport (73.68%), bicycle (71.05%) and walking (57.89%). (see figure 7)

In the future, major factors that influence residents' mode choice will be time consumption, travel comfort, service reliability, safety and intelligence levels. (see figure 8)

Effective measures that public transport suppliers should take to enhance their competitiveness in future transport include building seamless connections between public transport and other modes and increasing the speed of buses. (see figure 9)

By 2035, the rapid development of new technologies and digital business models will lead to an increase of last-mile delivery systems. (see figure 10)

Figure 7 Major modes for urban mobility in Beijing by 2035

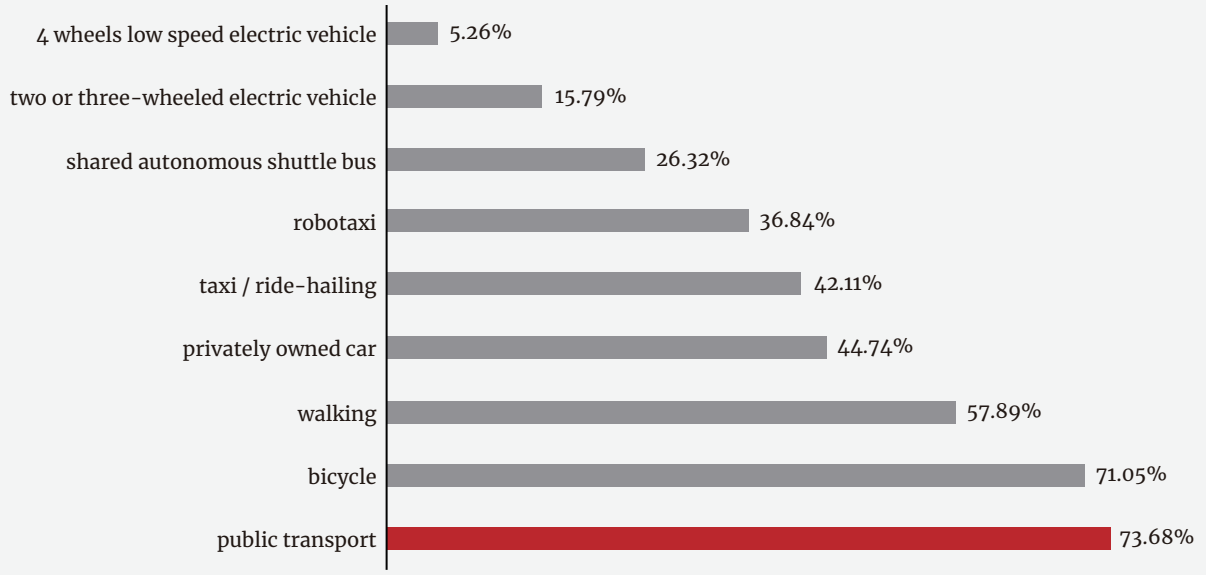
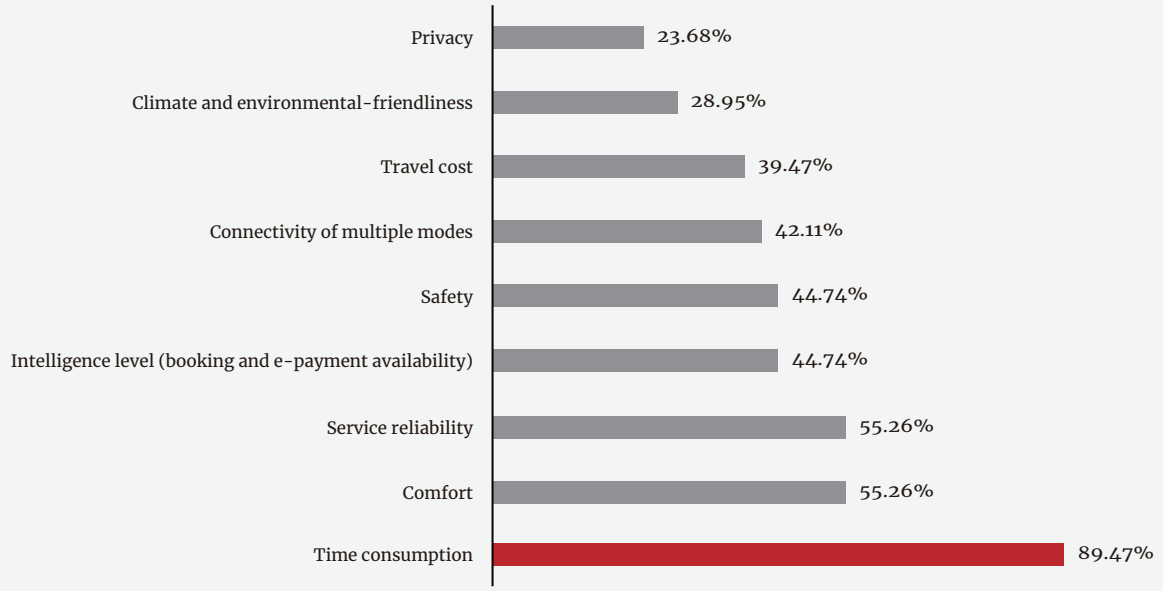
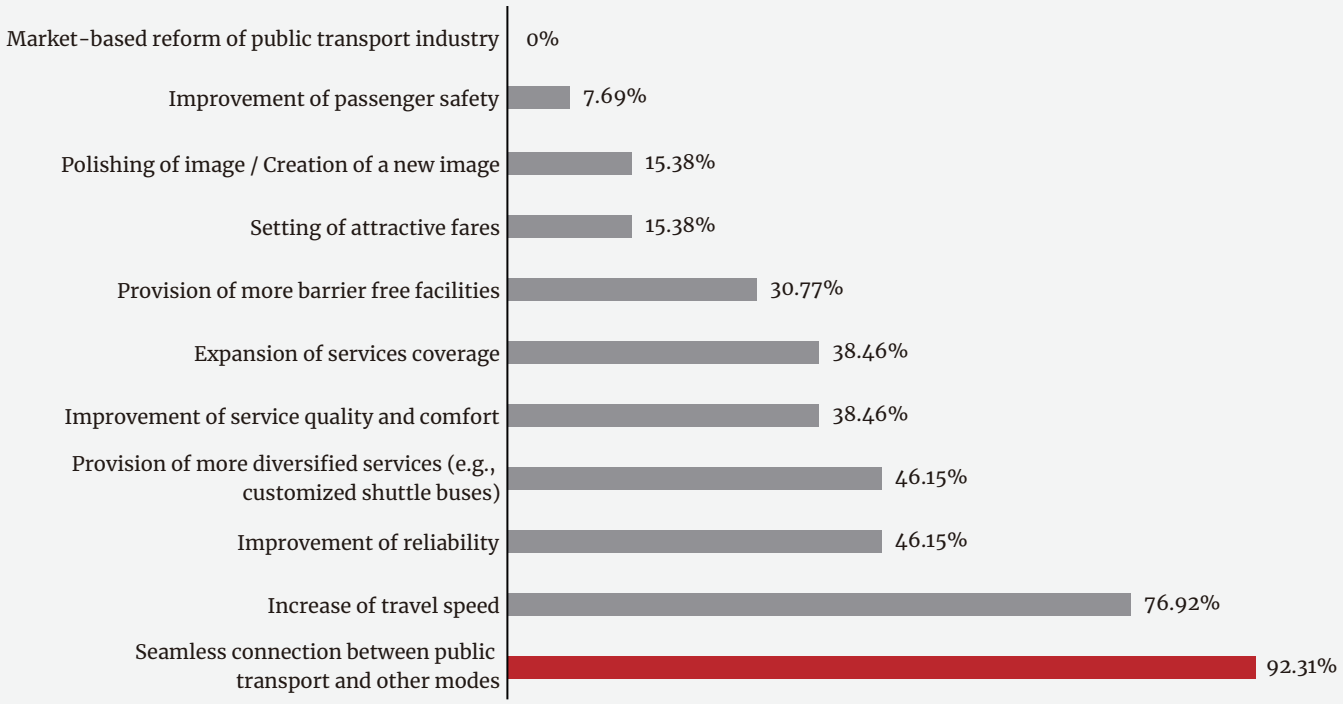


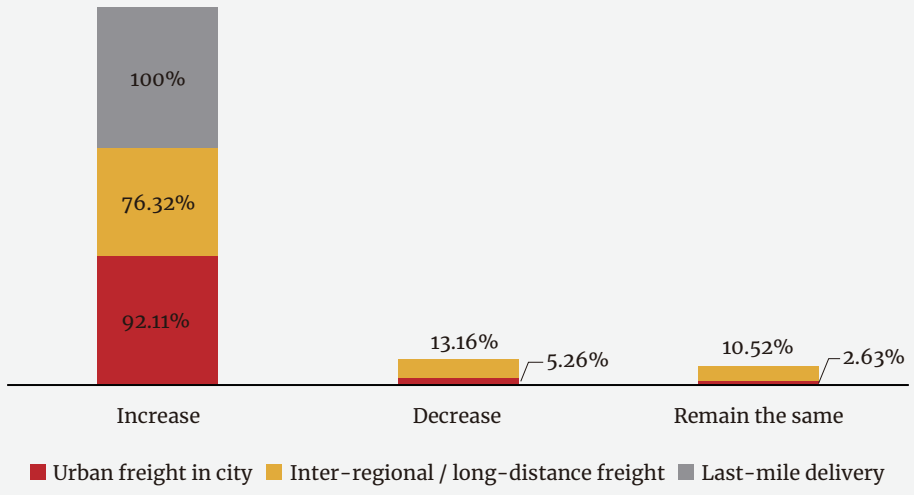
Figure 8 The main factors to be considered in the choice of travel modes for urban residents in the future



■ **Figure 9 Effective measures to enhance the competitiveness of public transport**



■ **Figure 10 Impact of rapid development of Internet on urban freight transport in the future**



(2) Changes in Urban Spatial Patterns and Demographic Structure

By 2035, important changes will take place in Beijing's urban spatial structure. The number of surrounding new towns will continue to increase, forming a multi-centre pattern and finally developing an urban agglomeration with surrounding cities. (see figure 11)

As for the choice of travel modes, the elderly will pay more attention to safety, convenience, comfort and facilities (such as barrier-free facilities and voice broadcasting). (see figure 12)

In the future, family-based travelers will prefer private cars (84.2%), public transport (65.8%) and taxi or online car-hailing services (57.9%). (see figure 13)

Figure 11 Changes of the cities and urban spaces by 2035

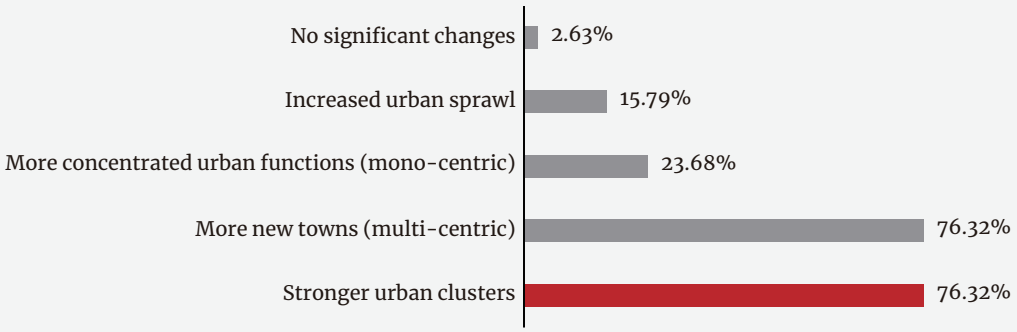


Figure 12 The importance the elderly attach on aspects of transport services

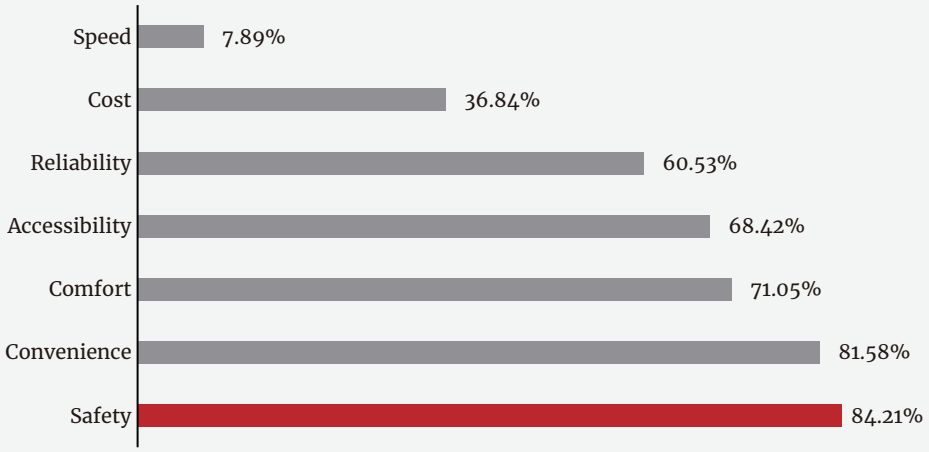
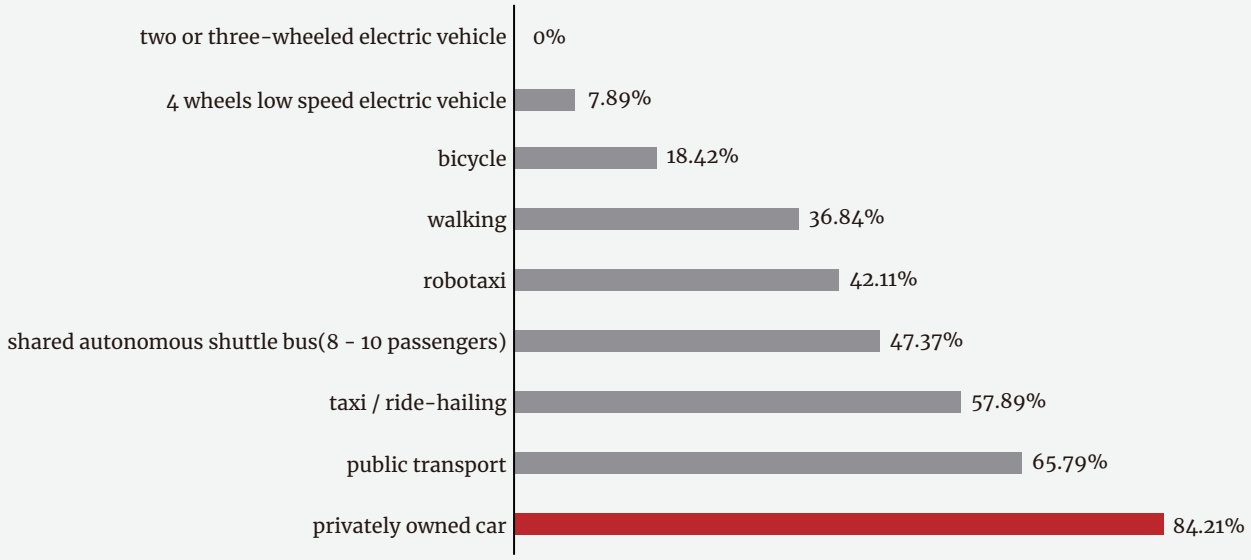


Figure 13 modes preferred for family trips in the future



(3) Future Trends in Sustainable Mobility

Obstacles and challenges that Beijing's green transportation development will face in the future are a strong dependence on private cars (81.6%), a lack of walking and cycling infrastructure and services (76.3%), and a lack of public green transport lifestyle and behaviour choices (71.1%). (see figure 14)

With regard to regulatory policies, the most effective tools to promote Beijing's transport shifting towards green and low-carbon options are the phasing-out of internal combustion engine vehicles (65.6%), parking management (62.5%), levy taxes for CO2 emission (56.3%) and zero-emission vehicle zones (50%). (see figure 15)

Regarding incentive policies, the most effective tools to promote urban transport electrification are improving the environment for cycling and walking (77.4%), increasing investment in public transport (67.7%) and providing more mobility benefits for electric vehicles (54.8%). (see figure 16)

By 2035, the main energy sources in Beijing's urban passenger transport will be the direct use of electricity and hydrogen. (see figure 17)

By 2035, the main energy sources in Beijing's urban freight transport will be electricity, gasoline and diesel. (see figure 18)

By 2035, electric vehicles in passenger transport will be mostly used as urban buses, mini-bus services and taxis. (see figure 19)

By 2035, electric vehicles in freight transport will be mostly used in last mile delivery and urban freight (short-medium distances). (see figure 20)

Figure 14 Obstacles and challenges that Beijing's green transportation development will face in the future

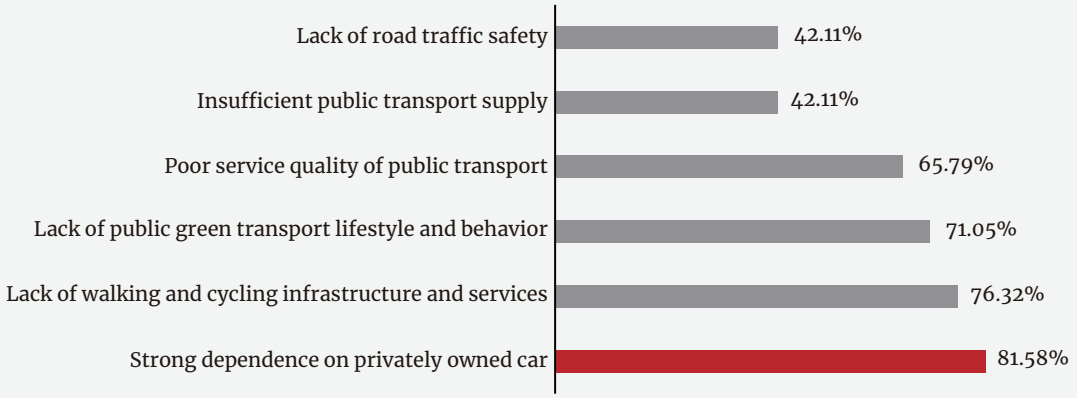


Figure 15 Regulatory policies to promote green transport development in Beijing

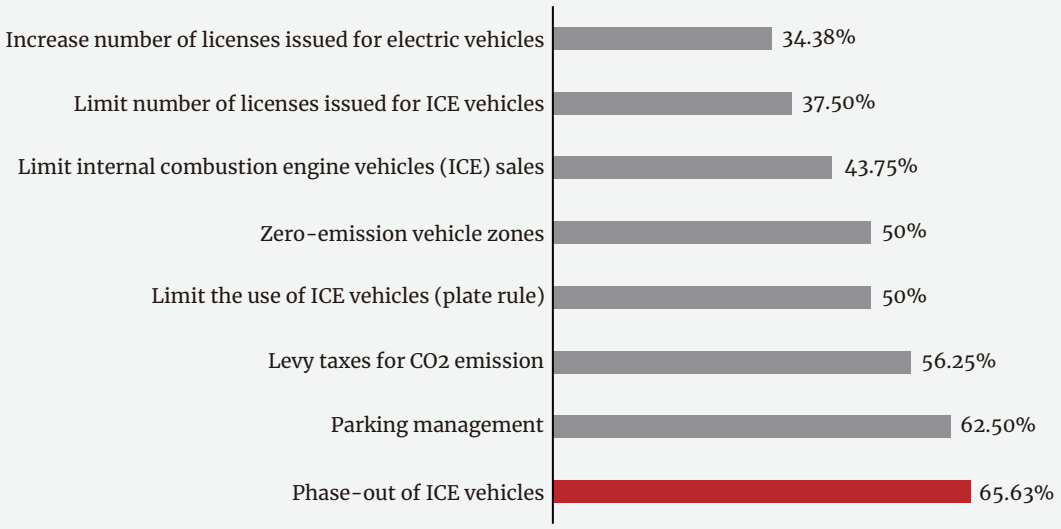


Figure 16 Incentive policies to promote the development of green transportation in Beijing

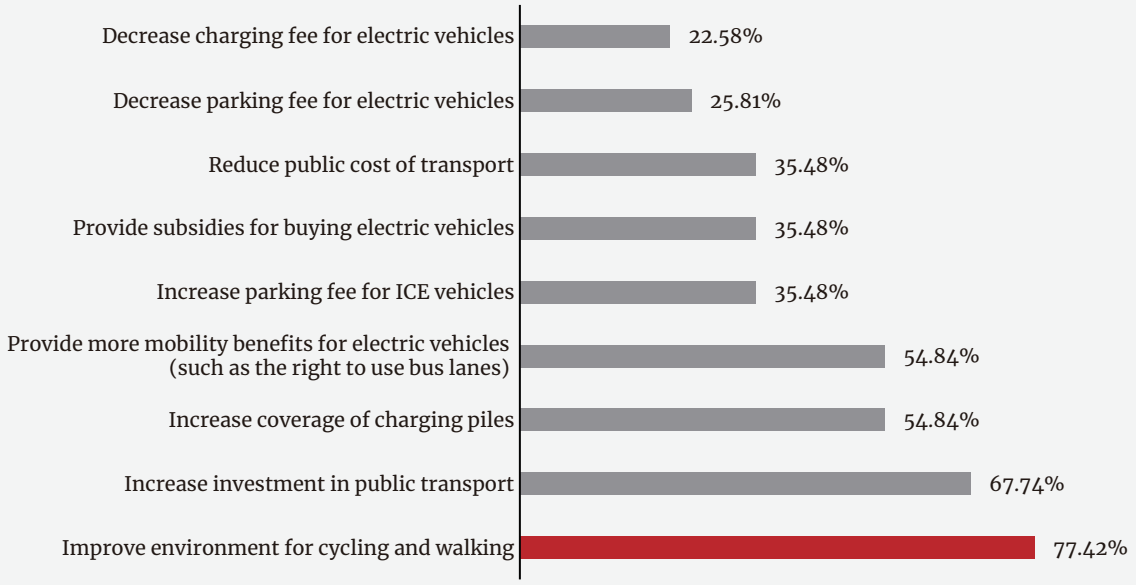


Figure 17 The main energy sources in Beijing's urban passenger transport by 2035

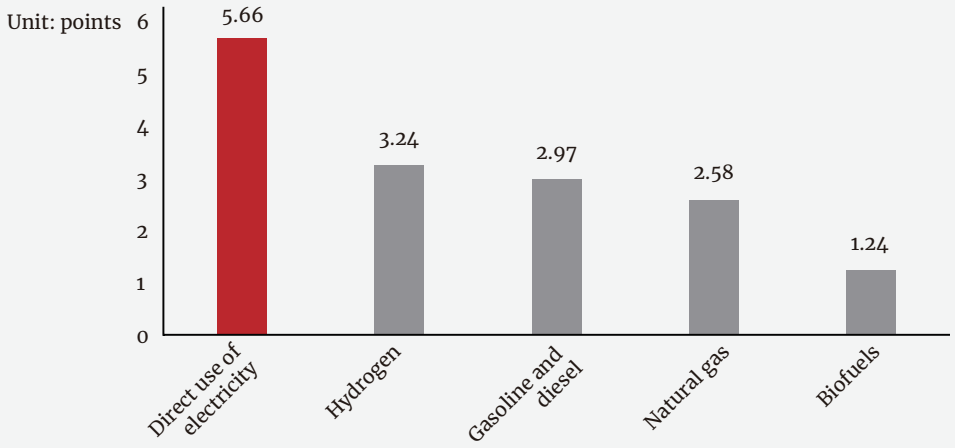
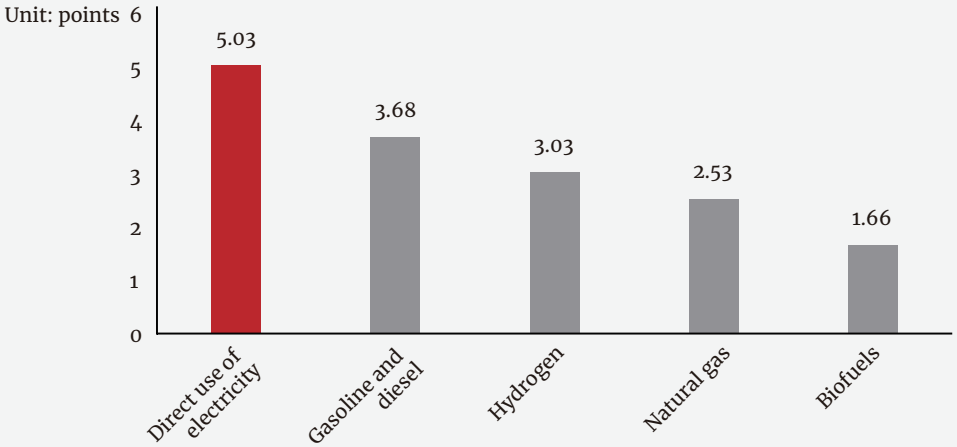
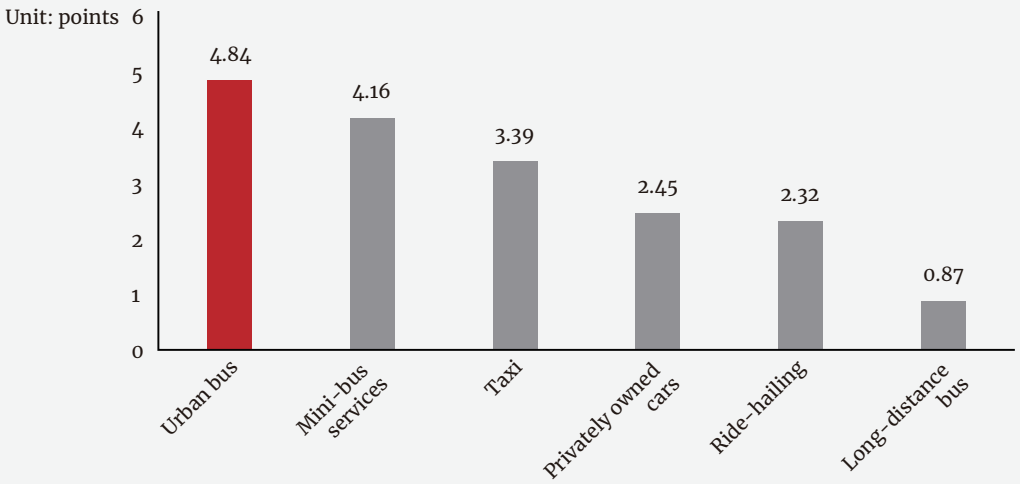


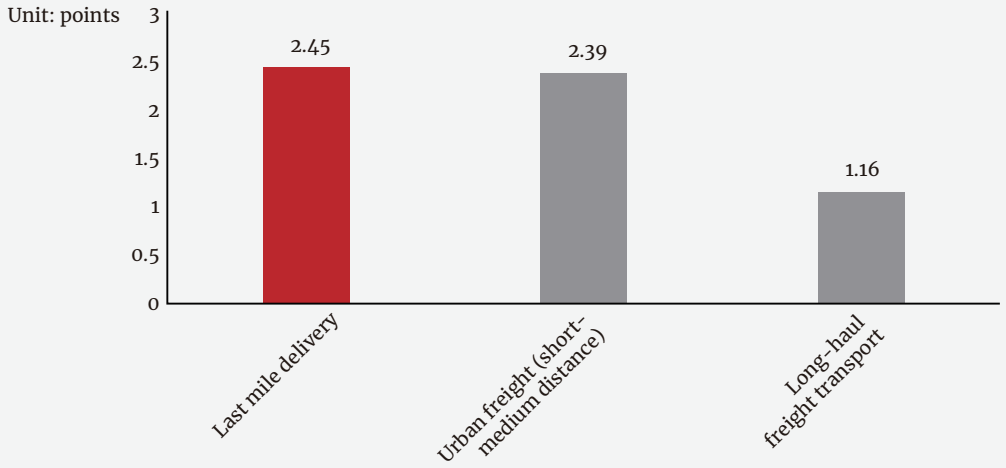
Figure 18 The main energy sources in Beijing's urban freight transport by 2035



■ **Figure 19 The main application scenarios of electric vehicles in the field of urban passenger transport by 2035**



■ **Figure 20 Electric vehicles in freight transport will be mostly used by 2035**



(4) Future Trends in intelligent Transport

The main obstacles to the future development of urban intelligent transport in Beijing are cross-regional and large-scale data sharing (4.58), inconsistent data standards (3.68) and insufficient demand identification (3.47). (see figure 21)

ITS will be mainly applied in Beijing in traffic management and transport planning and driving safety assistance and intelligent highways. (see figure 22)

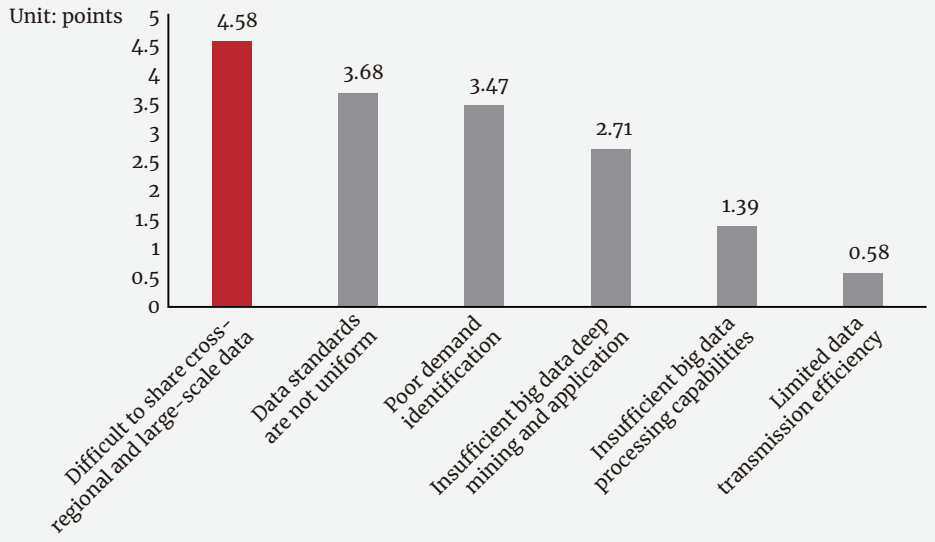
The main factors that will drive integrated mobility service platforms to play an important role in urban transport systems in the future are if: 1. Platform operators optimise services and improve operational efficiency and, 2. Mobility service providers improve service levels and collaboration among government authorities, platform operators and service providers. (see figure 23)

By 2035, autonomous driving in land-based passenger transport will be mainly applied in mini-bus services, urban buses, and ride-hailing. (see figure 24)

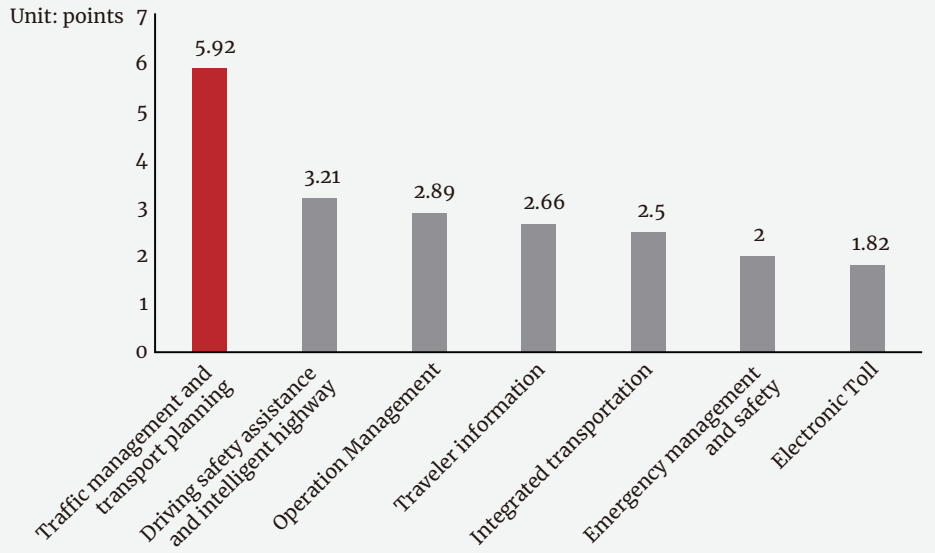
By 2035, electric vehicles in land-based freight transport will be mostly used in industrial park and port logistics and last mile delivery. (see figure 25)

The most important factors that people consider when purchasing or using autonomous vehicles are safety (92.1%), cost of purchase or use (71.1%) and privacy (50%). (see figure 26)

■ **Figure 21 The main obstacles that Intelligent Transport System (ITS) development will face in Beijing**



■ **Figure 22 Main application fields in Beijing for future urban intelligent transportation systems**



■ **Figure 23 The main factors that will drive integrated mobility service platforms to play an important role in urban transport systems in the future**

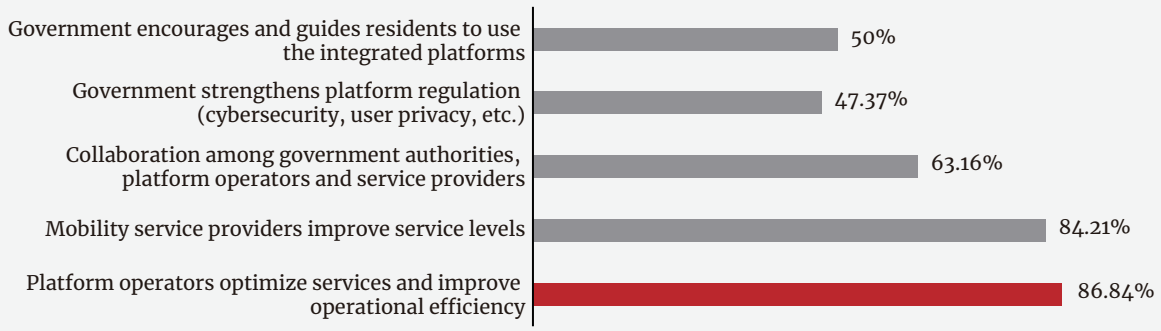


Figure 24 How autonomous driving in land-based passenger transport will be mainly applied by 2035

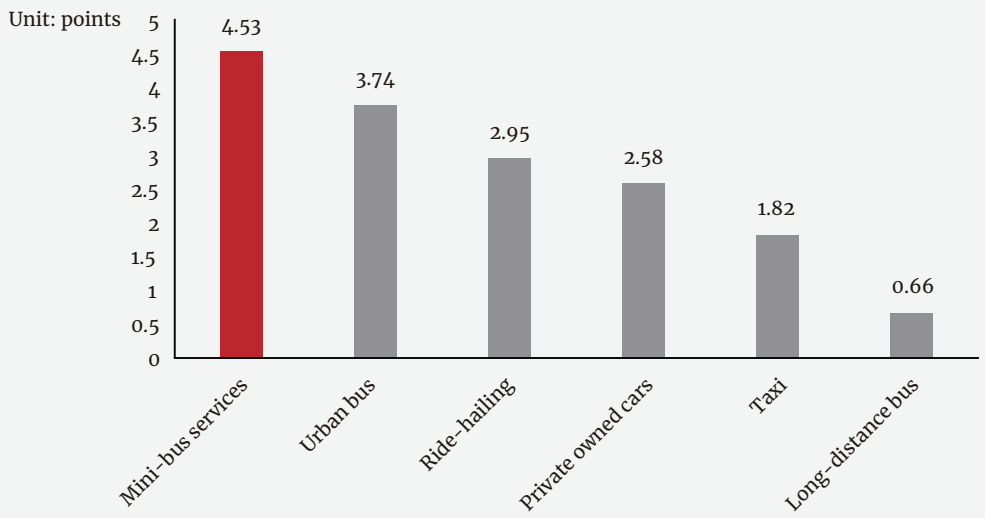


Figure 25 Which electric vehicles in land-based freight transport will be mostly used by 2035

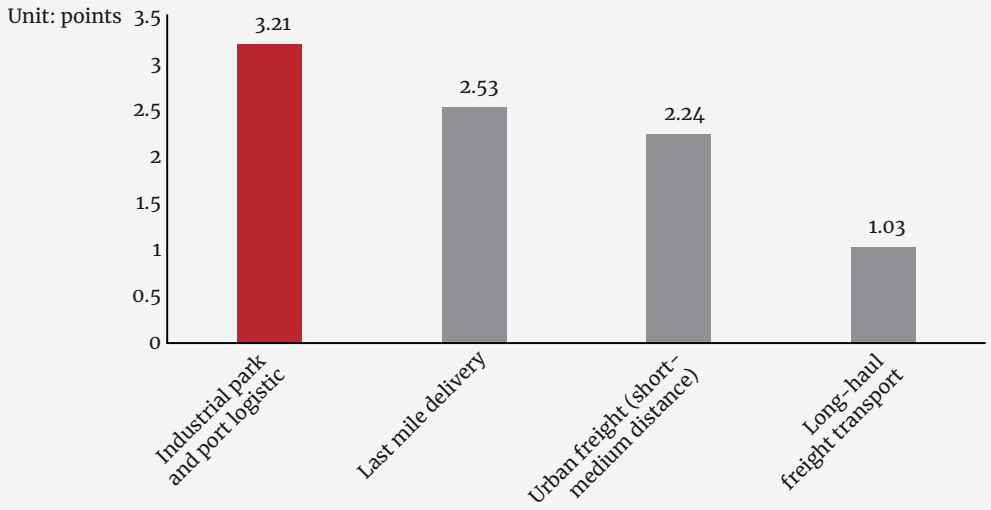
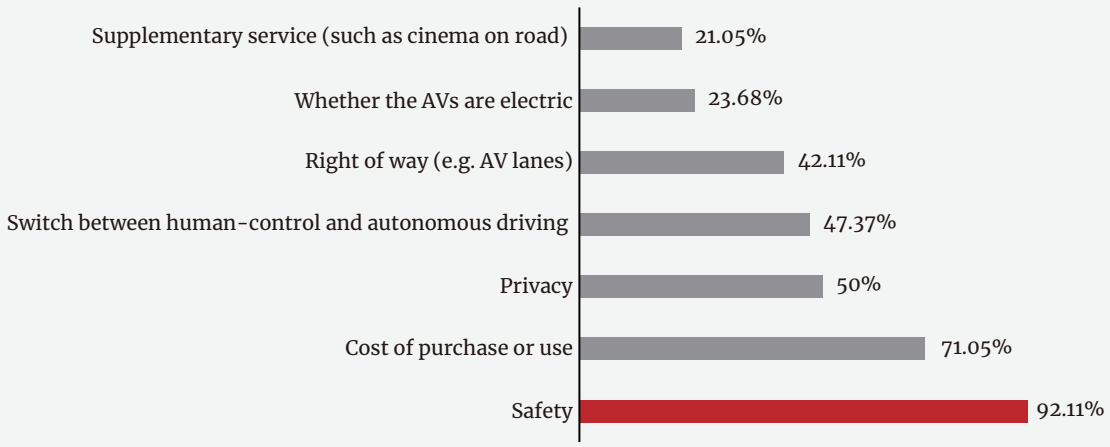


Figure 26 The most important factors that people consider when purchasing or using autonomous vehicles



(5) New Trends in Shared Mobility

By 2035, the sharing proportion of autonomous vehicles will be the highest, reaching 61.5%, followed by bicycles. The sharing proportion of cars will be 54.2%. (see figure 27)

The reasons why drivers are expected to not like providing ride-hailing or car-sharing service in the future are longer travel times (54.6%), a lack of safety (27.3%) and privacy (18.2%). (see figure 28)

Effective measures to promote the cultivation of shared travel culture are improving the safety of shared travel, providing more economic incentives for multiple users sharing one car (such as preferential parking fees) and providing more right of way guarantees for multiple persons in one car (such as the use of bus lanes). (see figure 29)

With the rapid development of shared bicycles, the issue of parking chaos has become increasingly prominent. The most effective measures in the management of shared bicycles are enhancing bicycles operation, maintenance and scheduling and increasing parking spaces for shared bicycles. (see figure 30)

To realize the vision of future urban transportation development, it is necessary to take actions at the city level, which are changing the urban planning concept (from car-oriented to people-oriented), upgrading the transportation infrastructure (such as adding new energy charging piles and smart signal lights) and providing more right of way guarantees for public transport and active mobility. (see figure 31)

Figure 27 The sharing proportion of travel modes by 2035

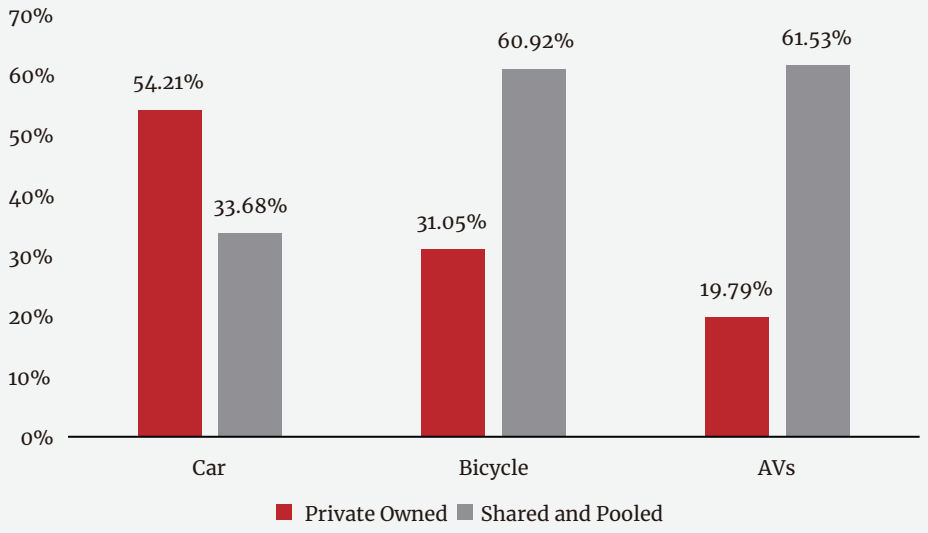


Figure 28 Reasons why drivers don't like providing ride-hailing or car-sharing services

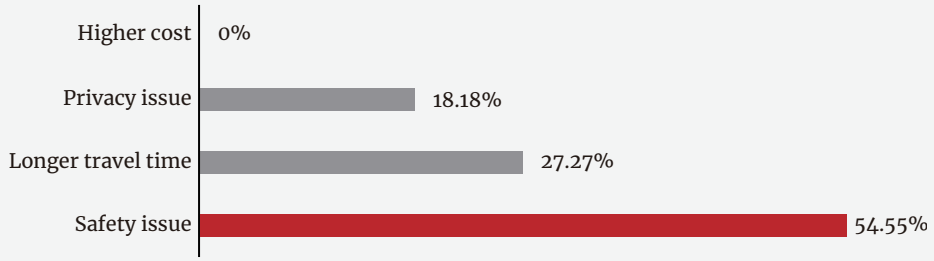


Figure 29 Measures which will effectively promote a culture of sharing in the city

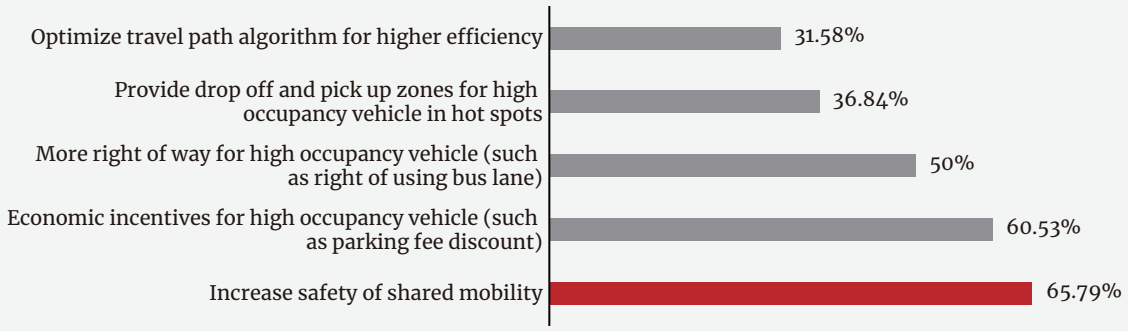


Figure 30 The most effective measures in the management of shared bicycles

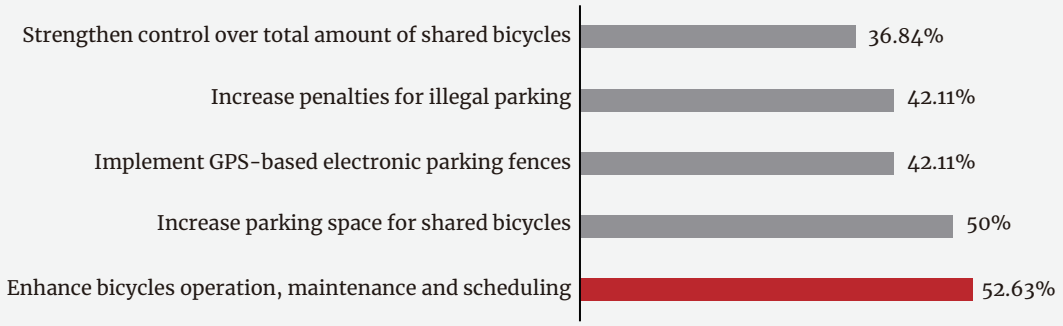
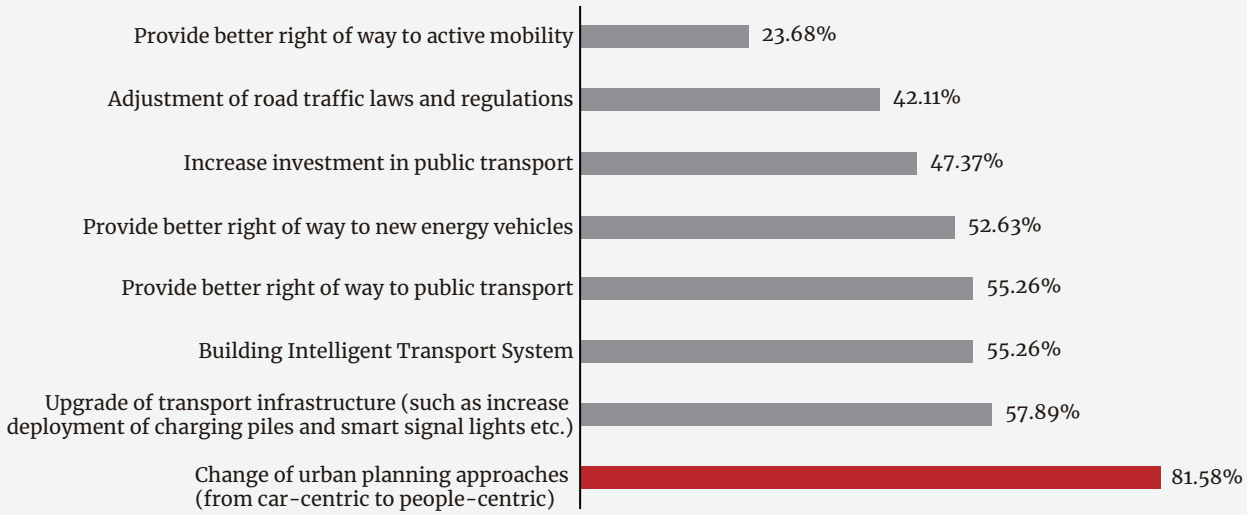
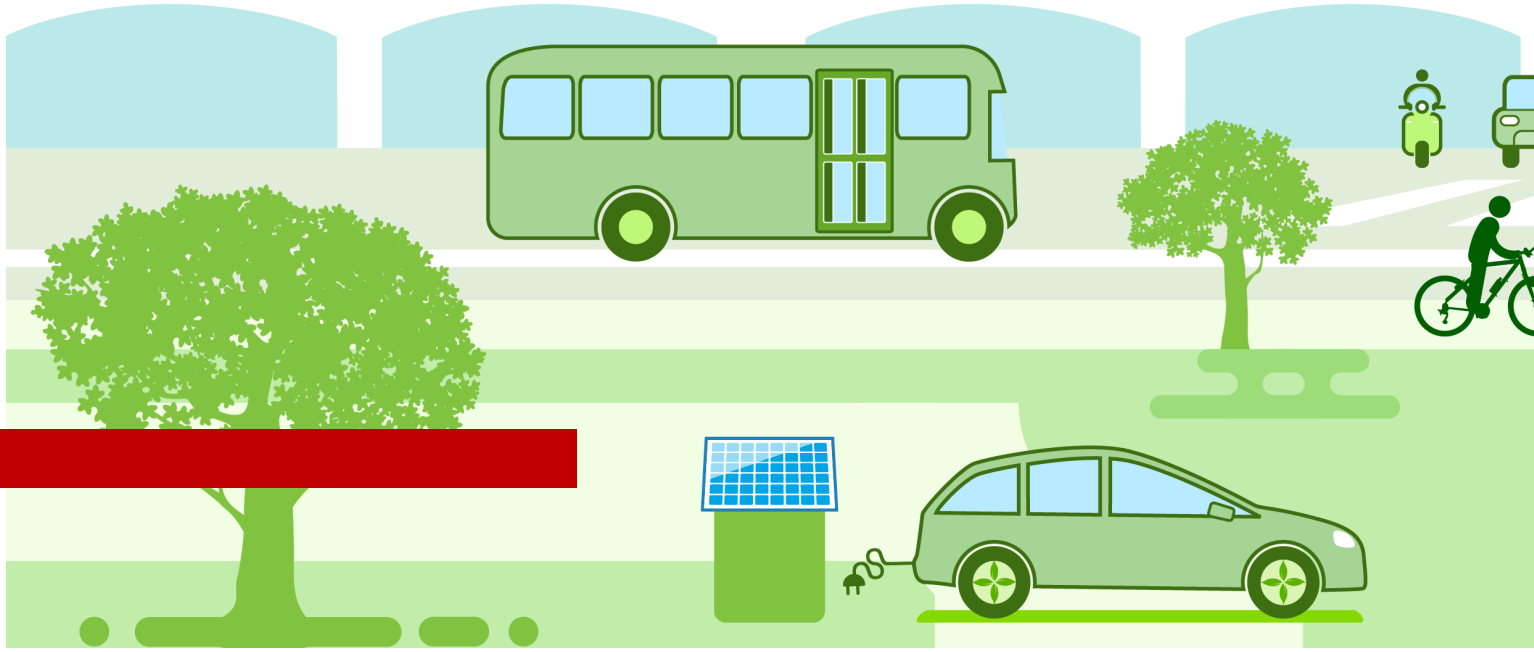


Figure 31 Major changes to be made at the urban level to realize the vision of future transport development





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