



Draft MRV Blueprint for Urban Passenger Transport NAMAs

Illustrated by the Chinese Transit Metropolis Programme

8 November 2015

Draft for Comments

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#add reviewers in final version

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Illustrated by the Chinese Transit Metropolis Programme

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This draft for comments represents the conceptual part only. Emissions calculations have not yet been done.

We particularly invite methodological feedback to the baseline chapter.

The Project Context

The TRANSfer project is run by GIZ and funded by the International Climate Initiative of the German Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). Its objective is to support developing countries to develop and implement climate change mitigation strategies in the transport sector as „Nationally Appropriate Mitigation Actions“ (NAMAs). The project follows a multi-level approach:

- At country level, TRANSfer supports selected partner countries in developing and implementing NAMAs in the transport sector. The NAMAs supported by the project cover a broad variety of approaches in the partner countries Indonesia, the Philippines, South Africa, Peru and Colombia.

At international level and closely linked to the UNFCCC process, the project helps accelerate the learning process on transport.

NAMAs with a comprehensive set of measures (events, trainings, facilitation of expert groups, documents with guidance and lessons learned).

To encourage NAMA development worldwide, TRANSfer has set out to develop a first set of so-called MRV blueprints for transport NAMAs – a description of the MRV methodology and calculation of emission reductions for different NAMA types in the transport sector.

Activities at country and international level are closely linked and designed in a mutually beneficial way. While specific country experience is brought to the international stage (bottom-up) to facilitate appropriate consideration of transport sector specifics in the climate change regime, recent developments in the climate change discussions are fed into the work in the partner countries (top-down).

For more information see: www.transport-namas.org.

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Rationale for this blueprint

A number of developing countries such as Chile, Colombia, Indonesia, Ethiopia, Peru, Thailand, Uganda, Vietnam or South Africa (Fenhann, 2015 and GIZ, 2015) are proposing urban transport NAMAs. Reasons are that many cities suffer from the negative impacts of growing transport activities, such as air pollution, congestion, noise and safety issues and that low-carbon urban transport actions can simultaneously achieve emission reductions and considerable sustainable development benefits. Urban transport mitigation actions are often ‘nationally appropriate’.

Even though scenarios of the International Energy Agency (IEA, 2012) find that the highest GHG mitigation potential in the transport sector lies in introducing more fuel efficient vehicle technologies, these savings can be easily outbalanced through motorisation and increased kilometres travelled. As a consequence, complementary transport policies that reduce or restrain demand for the most inefficient modes (cars and trucks) are needed. City authorities are in the position to develop such policies and measures. Urban transport NAMAs can therefore play a strong role in mitigating greenhouse gas emissions, especially from passenger transport and daily commuting¹.

At the urban level, achieving significant GHG emissions savings from transport is, however, only possible through an integrated, comprehensive approach. Single measures (such as public transport projects, road (de-)construction and infrastructures for non-motorised transport, parking management etc.) have limited effects and need to be coordinated to exploit their full potential. It is therefore useful to look at packages of measures, whose joint impact is coherent and significant within the city boundaries. From a transport planning point of view, this is often done in so-called ‘sustainable’ or ‘integrated urban mobility plans’ (see for example Böhler-Baedeker et al., 2014; Rupprecht Consult, 2012). Such plans could therefore serve as a basis for urban transport NAMAs in the future.

To upscale the effects of sustainable urban transport interventions, several governments worldwide have introduced national urban transport policies or programmes that encourage and support cities to identify and realise sustainable urban transport measures; see Diaz and Bongardt (2013) for an international review. Some of these national policies and programmes make support to cities conditional on the development of integrated urban mobility plans. In developing countries and emerging economies, however, many cities lack the technical and financial capacities to develop integrated urban mobility plans and to implement related measures (Diaz and Bongardt, 2013; see also Rupprecht Consult, 2012).

Urban transport NAMAs can contribute to a faster and broader realisation of the mitigation potential in sustainable urban transport development. NAMAs can provide both technical and financial support:

- directly to cities, which is especially relevant for large megacities, or
- through developing effective national sustainable urban transport policies and programmes on national level. Such programmes then can initiate mitigation actions in several cities.

Nevertheless, the requirement to measure, report and verify (MRV) the mitigation impact of the NAMA remains a challenge to proponents of NAMAs on sustainable urban transport policies and packages of measures. Many think of CDM-type monitoring requirements and the high costs involved with assessing and annually monitoring single measures at such a detailed level of accuracy

¹ The largest share of emissions from freight transport is caused by long distance transport between cities. A single city usually can only influence the production patterns and freight transport activities to a very limited extent.

as is required by the CDM². This concern may even lead to actions not being developed as NAMAs, because MRV is perceived a too big burden.

However, NAMAs do not require the same level of accuracy as the CDM (as long as no offsetting takes place). Gladly, there are positive examples, too, such as the Colombian NAMA on Transit Oriented Development (TOD) or the Indonesian Sustainable Urban Transport Programme (SUTRI). So far, however, none of these urban transport NAMAs have yet finalised their MRV concept.

This blueprint aims to provide methodological suggestions on how to deal with the MRV of urban transport policies and programmes. It suggests a methodological approach to NAMA MRV for urban passenger transport NAMAs that measures development of GHG emissions at city level – and not for every single measure – and complements the citywide GHG emission accounting by selected progress and implementation indicators to assess success of measures. This way, transport data (e.g. mode split, fleet composition, etc.) and emission inventories at the city level can be used to measure and report impacts, instead of trying to assess single measures, whose GHG impacts cannot be easily isolated. Investments in reliable transport inventory data can then also be used to compare the emission inventory against a business as usual scenario, enabling cities to assess their sectorial emissions savings that are often needed as basis for climate action strategies.

This methodology or blueprint is based on work conducted by GIZ China in cooperation with local cooperation partners, such as the Beijing Transport Research Centre under the framework of two projects funded by the International Climate Initiative of the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) – Transport Demand Management in Beijing and TRANSfer. Please note that the project activities were not aimed at developing a registered NAMA, but to develop domestic mitigation actions and assess their potential mitigation impact. In the context of TRANSfer these experiences are now translated into a MRV approach for NAMAs. To illustrate the approach based on a real-world case, the Chinese Transit Metropolis Programme at the national level and the implementation efforts of the city of Beijing are used as examples.

² The Clean Development Mechanism is an offsetting mechanism, which allows industrialised countries to buy emission credits from developing countries instead of reducing emissions within their own boundaries. This means that for each tonne of CO₂ credited to a CDM project an additional tonne of CO₂ could be released to the atmosphere in an industrialised country. To ensure that the credited tonne of CO₂ is real, the monitoring requirements are very stringent.

1. Description of the mitigation action

The scope of the presented MRV approach is the national level Transit Metropolis Programme in China, which covers different bundles of measures addressing urban passenger transport emissions, including avoid, shift and improve measures in 37 pilot cities (see Figure 1).

The Transit Metropolis Programme (*gongjiao dushi* 公交都市) was initiated by the Chinese Ministry of Transport (MoT) in November 2011 to foster public transport expansion and improvement and more transit-oriented development in Chinese cities. 37 pilot cities have been officially approved by MoT as ‘transit metropolises’. Pilot cities must have a resident population of at least 1.5 million, be a national highway transport hub and have a comparatively better public transport system that has demonstration character (Chu, 2014) – in reality most pilot cities are provincial capitals. In addition, MoT set out a list of public transport indicators encompassing availability of public transport services, service quality, safety and user-friendliness that pilot cities should eventually attain. Indicators include inter alia a public transport mode share of 60% (only accounting motorised modes), that 90% of built-up areas be within 500 meters of a bus stop, bus travel speeds of more than 18kmh during peak times, but also that average energy intensity decreases by 10% or more compared to 2010 (Zhou, 2014). In addition, the Transit Metropolis Programme requires cities to present an integrated public transport plan to become a pilot city. This is significant, because common practice in Chinese cities is that separate plans are developed for different modes due to split responsibilities at city level, where the Construction or Urban Planning Bureau is usually responsible for non-motorised transport, as well as for land use plans and so called comprehensive transport plans, whereas the Transport Bureau is responsible for specialised public transport planning (Zhou, 2014).

The Transit Metropolis Programme can be seen as the demonstration arm of the Public Transit Priority Policy, first published in 2005 (Guofa [2005] No. 46) and updated in 2012 through the Guiding Opinions of the State Council on Giving Priority to Public Transportation in Urban Development (Guofa [2012] No. 64). The latter foresees that public transport be integrated into the local public budget, that buses should be exempted from the vehicle purchase tax and receive a fuel subsidy, that metro operators receive an electricity price discount, that land value around transit stations should be captured and that salaries of employees of public transport operators should increase regularly and not be less than average worker salaries (Jiang, 2013). It also stresses the importance to better integrate public transport services with other transport modes and to integrate public transport developments with urban development and urban reconstruction plans (Guofa [2012] No. 64).

Pilot cities of the Transit Metropolis Programme receive some seed funding from the National Government, which is financed by a fraction of the vehicle purchase tax (see Jiang, 2013). At the same time, cities can apply for additional funding under the programmes financed through the Energy Saving and Emission Control Fund. Numbers on the specific size of funding provided to Transit Metropolis cities from the national level are not publicly available, but research has shown that the bulk of the investment in transit metropolis developments is shouldered by local governments. For instance, the city of Kunming reserved a five-year budget of CNY 134 billion for its Transit Metropolis efforts. In comparison the three-year budget of the Energy Saving and Emission Control Fund (2011-2013) only amounted to CNY 1.5 billion (Zhou, 2014).

Since 2010, MoT also organises an annual Transit Metropolis Forum as a platform for capacity development and peer learning among representatives from the pilot cities, as well as other stakeholders.

Beijing was nominated a Transit Metropolis pilot city in 2012 (China Watch, 2014). Even though the Transit Metropolis Programme itself focuses on public transport development and quality improvement, it also stresses the importance of integration with urban development patterns and non-motorised modes. In line with that, pilot cities are increasingly putting policy packages on the table that go beyond the improvement of public transport infrastructure and services and also include travel demand management measures, such as vehicle registration limits, congestion charging, or parking management, as well as measures to promote walking and cycling and multimodality. Already in 2010, Guo Jifu, Director of the Beijing Transport Research Centre pointed out that “travel demand management is extremely important” for Chinese cities (Guo, 2010: 21).

In the specific case of Beijing, the measures considered in this blueprint include extensions and improvements of the bus and metro system, introduction of new energy buses, vehicle registration restrictions, and congestion charging (new energy vehicles is the Chinese terminology for alternatively fuelled vehicles, including electric propulsion systems).

1.1. Context: Transport GHG Emissions in China

Beijing, as well as most other Chinese cities, has been facing an incredible growth in the last decades, both economically and in the number of inhabitants. Since early 1990 and today, the population of Beijing has doubled (Beijing Municipal Public Security Bureau, n.d., NBS, 2014) and now stands at 21 million inhabitants (NBS, 2014). Urban expansion, population growth and increased income levels have led to increased travel demand in Chinese cities. Both trip distances and numbers of trips have increased. Besides a growth in travel demand, the dominant modes of transport have changed from walking and cycling to car and public transport as travel distances and disposable incomes increased (Darido et al., 2009). The number of cars in Beijing has grown from about 1 million in 1997 to 5 million in 2013.

The World Bank estimates that already in 2006 GHG emissions from urban transport in China were 26 per cent of the total GHG emissions from all transport activity in the country and about 15 per cent of the CO₂ emissions per capita in China in the same year (Mehndiratta, 2012).

Chinese transport related CO₂ emissions account for 623 Mt in 2011 or roughly 7.5% of total CO₂ emissions³ (World Bank, 2015a, World Bank, 2015b). Compared to 1990, energy demand from the transport sector increased by nearly 700% (until 2012) due to rapid economic growth and a boom in personal car ownership (US EIA, 2014), which has reached 105 million in 2014 (Ministry of Public Security, 2015)⁴.

The sharp increase in motorised traffic has led to fast growth in transport energy demand and GHG emissions in many Chinese cities. What’s more, under the new policies scenario of the IEA (2014), the energy demand of the whole Chinese transport sector is estimated to nearly triple again by 2040 (Höhne et al., 2015).

Greenhouse gas emissions and increasing energy use are not the only sources of concern of rising transport demand. Motorised transport in Chinese cities also causes severe congestion and high levels of local air pollution. Both congestion and air quality have reached levels that are harmful to citizens’ health and can impact the economic attractiveness of cities: „Air pollution has become one of the major environmental and social concerns in China, and many Chinese cities report some of the world’s highest concentrations of PM.“ (Höhne et al., 2015: 22). For Beijing, the Beijing

³ Only energy-related emissions and emissions from cement production.

⁴ Total vehicle ownership has reached 154 million (including non-private and non-passenger vehicles).

Municipal Environmental Protection Bureau (2014) estimated that transport is responsible for roughly one third of locally caused PM 2.5 pollution.

1.2. Objective

The objective of the mitigation action is to reduce the CO_{2e} emissions from passenger transport in Chinese cities by providing high quality and efficient public transit services, integrated with urban development patterns⁵ and flanked by complementary measures to improve non-motorised transport facilities and manage travel demand. Through these measures the programme aims to both reduce kilometre travelled (avoid) and shift passengers from private cars to more sustainable transport modes, as well as to improve the energy efficiency of the public transport fleet.

The measures are also aimed to enhance overall quality of life in cities through the availability of improved and more convenient mobility services, compact urban development with less need to travel long distances, reduced congestion and better air quality.

1.3. Mitigation measure activities

The mitigation measure includes a nationally managed programme that spans different packages of measures on urban passenger transport that are implemented at the city level in each of the 37 pilot cities (see Figure 1).

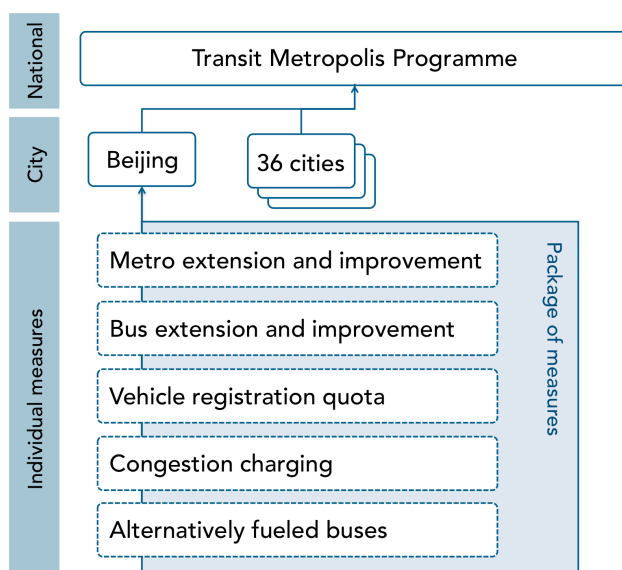


Figure 1: Three levels of activities of the Transit Metropolis Programme

⁵ The integration with urban development planning is a stated objective of the Public Transit Priority and related policy documents of the Chinese MoT, but has so far largely remained on paper. The authors are not aware of any genuine Transit Oriented Development initiative as part of the Transit Metropolis Programme.

1.3.1. National level

At the national level the Transit Metropolis Programme framed by the Transit Priority Policy encourages and supports cities in improving their public transport systems and inter-modal integration; it further attempts to nurture transit-oriented developments. The programme spans activities in 37 pilot cities.

The Ministry of Transport manages the Transit Metropolis Programme. The national level defines Transit Metropolis indicators, nominates pilot cities, approves of city-level activities and takes decisions on funding provided. The Ministry of Transport also organises capacity development and peer-learning events on an annual basis. Implementation of the measures themselves, however, is the sole responsibility of cities. The MoT is supported in all technical questions by its (state-owned) research institutes such as the China Academy of Transport Science (CATS), the Research Institute of Highway (RIOH) and the Transport Planning and Research Institute (TPRI).

1.3.2. City level (example Beijing)

At the city level, each city came forth with its own Transit Metropolis Action Plan (not publicly available). For illustration we use the city of Beijing as example. For the purpose of the analysis the following measures are included in the mitigation package for the case of Beijing:

- Expansion of the metro network
- Expansion of the bus network
- Introduction of alternatively-fuelled buses
- Vehicle registration restrictions
- Congestion charging

The timeframe is from 2013 (the year after Beijing became transit metropolis city) to 2020.

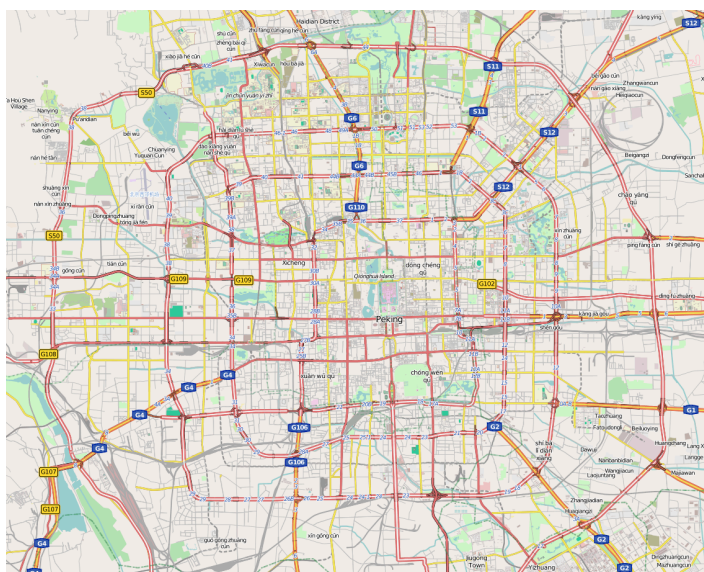


Figure 2: City of Beijing (Source: Open Street Map)

Expansion of the metro network

As of May 2013, the Beijing metro counted 456 km over 17 lines (Lines 1, 2, 4, 5, 6, 8, 9, 10, 13, 14, 15, Batong, Changping, Daxing, Fangshan, Yizhuang and Airport Express) and 227 stations (railway-technology, n.d.). As of December 2014, total length had already reached 527 km over 18 lines and Beijing officials plan to further expand the metro system at rapid pace, with four new lines due to start construction in 2015, in addition to extensions of two existing lines. The aim is to almost double the metro length and achieve 1,000 km until 2020. The current system carries around 10 million passengers per day (Smith, 2015).

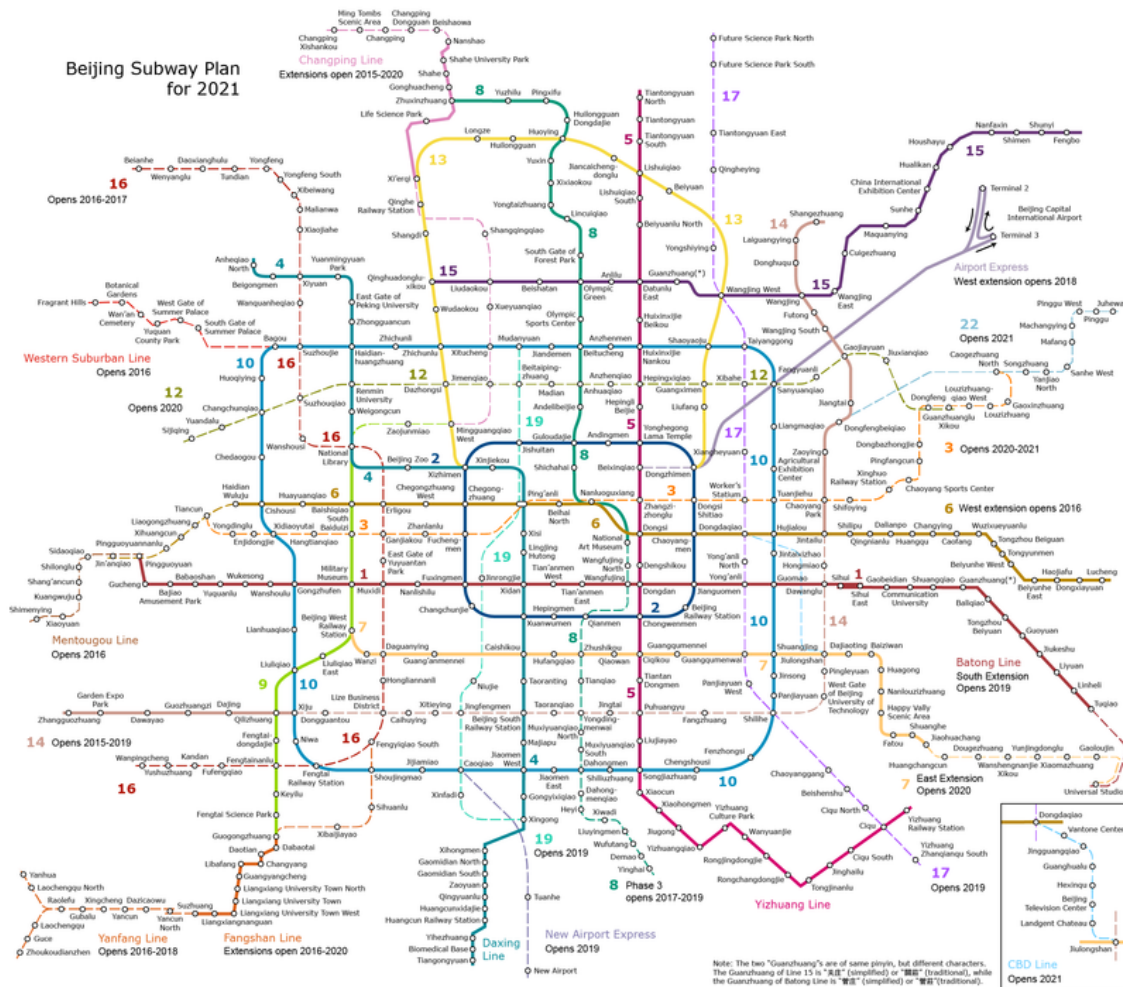


Figure 3: Beijing metro plan 2021 (solid lines: existing by end of 2014; dotted lines: planned) (Source: Ran and Hat600)

Expansion of the bus network

As of 2013, the Beijing bus system covered 785 routes and a total of 18,978 km.

#short para on development plans to be added

Introduction of alternatively-fuelled buses

As of 2013, the majority of buses were diesel fueled (15,986) followed by LPG and CNG buses (6,111); Beijing also already ran 910 electric and 862 hybrid buses.

#short para on planned developments to be added

Vehicle registration restrictions

Beijing started to limit the maximum monthly number of new car registrations in early 2011. Beijing uses a public license plate lottery to do so (instead of an auctioning system, such as in Shanghai or Singapore), which randomly allocates registration rights to lottery participants. Participants must be registered in Beijing or be residents who have paid taxes in Beijing for 5 years. In addition, individuals who already have registered a vehicle on their name may not enter the lottery. The lottery is managed by the Beijing Transport Commission and is held on the 26th of each month. It was originally restricted to 20,000 new registrations in each round, of which individuals competed for 17,600 plates; commercial cars such as rental cars and taxis were allocated 400 license plates, businesses 2,000 plates. Lottery winners have six months to purchase a car with the won “quota”, if they exceed the six month the quota is returned to the next lottery round (Jun et al., 2014). With the release of the Beijing Clean Air Action Plan, Beijing further halved the allowed number of newly registered vehicles from 20,000 to 10,000 per month with the aim to limit the total number of vehicles to not more than 6 million by 2017 (Beijing Municipal Government, 2013).

Congestion charging

This activity covers introducing congestion charging in Beijing. Currently, different scenarios are discussed. For illustration purpose, we assume a distance-based charge within the fifth ring road for all private vehicles. All private cars (and trucks) will be charged per kilometre driven with a flat kilometre charge equal for all vehicles (motorcycles are not included in the assumed design).

At the same time, the revenue from the congestion charge can generate additional resources (both funds and urban space), which then become available for sustainable modes of transport. A reinvestment of earned funds in public transport services is assumed for the congestion charge as part of this mitigation activity.

(Please note that the congestion charging scheme presented here is just one of several options that have been analysed and discussed in Beijing. At the time of writing, there has been no official decision on introducing any type of congestion charging system in Beijing and the distance-based is – though most effective – the least likely one.)

1.4. Other relevant policies

In the 12th five-year plan (2011 -2015), the Chinese government set itself the target to reduce carbon intensity by 17% compared to 2010, which was echoed for carbon intensity of public transport in the work programme on the 12th five-year plan for controlling transport emissions in the transport sector, released by the Ministry of Transport in 2012. Taxis should even achieve a reduction of 26% of carbon intensity per trip (Jiaozhengfafa [2012] No. 419).

The State Council in its Energy-Saving and New Energy Vehicle Industrialization Plan from 2012 targets a fuel consumption standard of 5.0 L/100km (fleet-average) in 2020 (Guofa [2012] No. 22), which was proposed as Phase 4 fuel consumption standard by MIIT in 2014 and would regulate all new cars sold in China from 2016-2020. The new standard would lower the fuel consumption by almost 2 litres from a fleet average of 6.9 L/100km in 2015 (ICCT, 2014).

As described under 1.1 the Chinese Ministry of Transport has been promoting a Transit Priority policy since 2005 to counter the trend of losing public transport shares to private mobility.

In addition, in September 2013, the State Council released the National Clean Air Action Plan that targets transport as one of the core pillars besides the industry and energy sectors. Objectives include the improvement of fuel quality and an improved environmental management of motor vehicles, as well as the elimination of pre EURO IV vehicles and a tightening of fuel consumption standards.

Also in September 2013, Beijing released its own Clean Air Action Plan to limit industrial and transport-related pollution as a reaction to extreme air pollution events in January of the same year. Although targeted at air pollution, the Beijing Clean Air Action Plan (2013-2017) encompasses a range of measures that address the reduction of fuel consumption and overall kilometres travelled in Beijing (within the 6th ring road) – most of these measures tighten existing travel demand measures and include a stricter vehicle registration control (reduced from 20,000 to 10,000 new registrations per month), potential introduction of congestion charging, road charges etc., but other measures also target efficiency improvements (phase-out of old vehicles, promotion of clean energy vehicles). Through all these measures, the Beijing government expects to reduce the total vehicle fuel consumption by at least 5% compared to 2012. The Beijing Clean Air Action Plan reinforces some of the measures already included in the Transit Metropolis package, in particular the vehicle registration limitation.

2. Scope and boundaries of the monitoring approach

The Transit Metropolis Programme and related Transit Metropolis Action Plans at city level aim at increasing the modal split of public transport and to lower the share of private motorised travel, as well as to improve the public transport fleet in the city territory. Shifting the modal split from private cars to public transit has implications for fuel consumption and related GHG emissions of passenger travel activity in a city; procurement of alternatively fuelled buses can further improve the emission intensity of bus transit. But these measures can also have unintended effects, such as shifting people from using non-motorised modes to public transport or other indirect effects (see chapter 2.2).

In addition, the Transit Metropolis Programme promotes multimodality and thereby indirectly also the improvement of non-motorised transport infrastructures. At the city level, as exemplified by Beijing, the Transport Commission further combines the expansion and improvement of public transport (pull policies) with policies to limit private car use (push policies), such as the vehicle registration quota and congestion pricing. These policies interact with and affect each other, making it difficult to quantitatively isolate the GHG impacts of each single measure. On top, other transport policies, such as the new fuel consumption standard for passenger cars (see chapter 1.4 above) also affect overall fuel consumption of private travel in the cities, by gradually improving the vehicle fleet – a development that needs to be considered in the baseline, when assessing the programmes' impacts.

Apart from GHG emission impacts, the mitigation package can cause several sustainability benefits or adverse effects (see chapter 2.5). The following chapter analyses the direct and indirect GHG and sustainability impacts of the Transit Metropolis Programme and its implementation in the city of Beijing. The impact analysis informs the boundary setting for the MRV approach in chapter 2.5.

2.1. Cause-impact relation from transport interventions to GHG emissions impacts

The impacts of the Transit Metropolis Programme occur at different levels of aggregation: (1) at the national level for the combined impacts of the whole programme with its 37 pilot cities, (2) at the level of each individual city and (3) at the level of individual measures (compare figure 1 above). However, the effects of each individual measure are always impacted by the effects of all other measures and are therefore difficult to attribute to a single measure only. The overall effects of a package of measures can be different from the sum of the effects of single measures that are implemented in isolation due to mutually reinforcing or diminishing effects.

Consequently, to understand the impacts of the package as a whole (city level), the aggregated effects of all measures within the package (measure level) need to be assessed. The sum of the impacts of the packages in all 37 cities, constitute the impacts of the whole programme (national level).

To be able to decide on the most relevant indicators for impacts of the policy package, however, first the effects of individual measures and their respective interactions need to be identified. Impacts can be directly linked to the measure(s) or be indirectly caused by them. Impacts can result from the use phase (transport activity/operations), before (upstream) or after (downstream) (see Figure 5).

According to the ASIF framework (see figure 2) the total GHG emissions caused by motorised travel (transport activity/operation phase) are a function of travel activity by different modes, the specific energy consumption of each of those modes (litre of fuel/km) and the specific GHG emission intensity of the fuel (or energy) used.

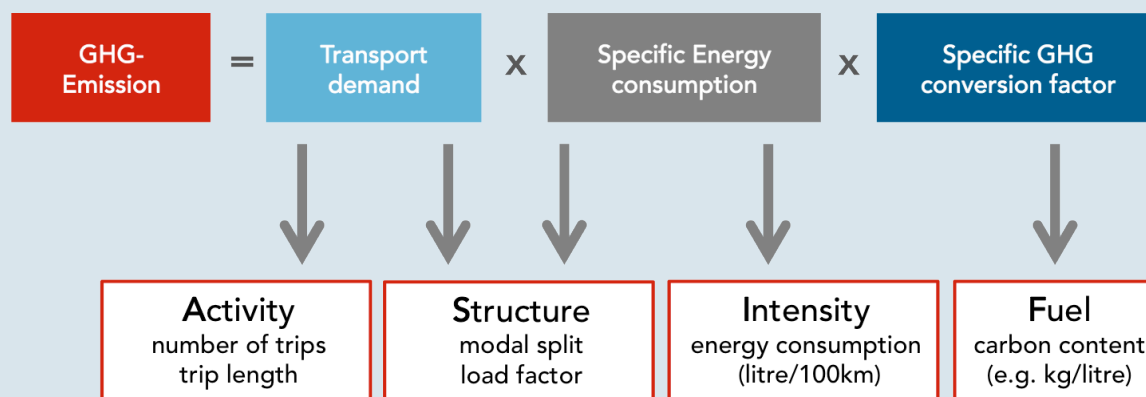


Figure 4: ASIF Framework to calculate transport emissions

Figure 5 maps the ASIF parameters, as well as indirect GHG emission sources along the different life-cycle phases of transport interventions. Visualising the effects of policies and measures in such a matrix can help to identify the data needs of policy packages (as illustrated in Figure 7 and in Table 4 (chapter 3)).

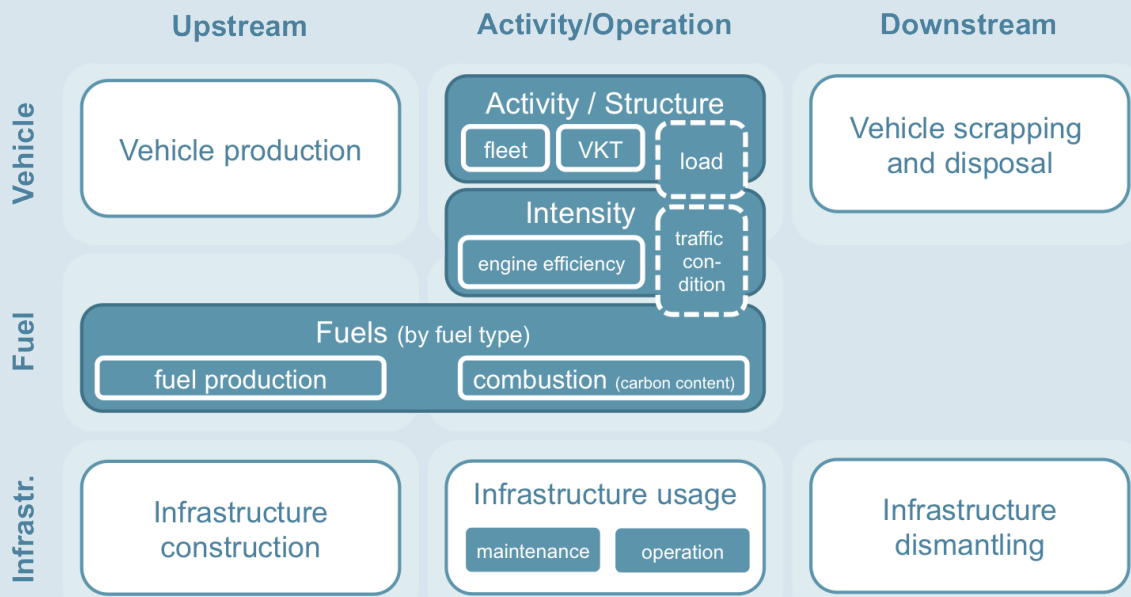


Figure 5: Different GHG emission sources and parameters for emission calculation along the life cycle of transport interventions (Source: Bongardt et. al., 2015)

Following this approach, each mitigation measure or package of measures needs to be analysed regarding their impacts on the following guiding questions (Dünnebeil and Keller, 2015):

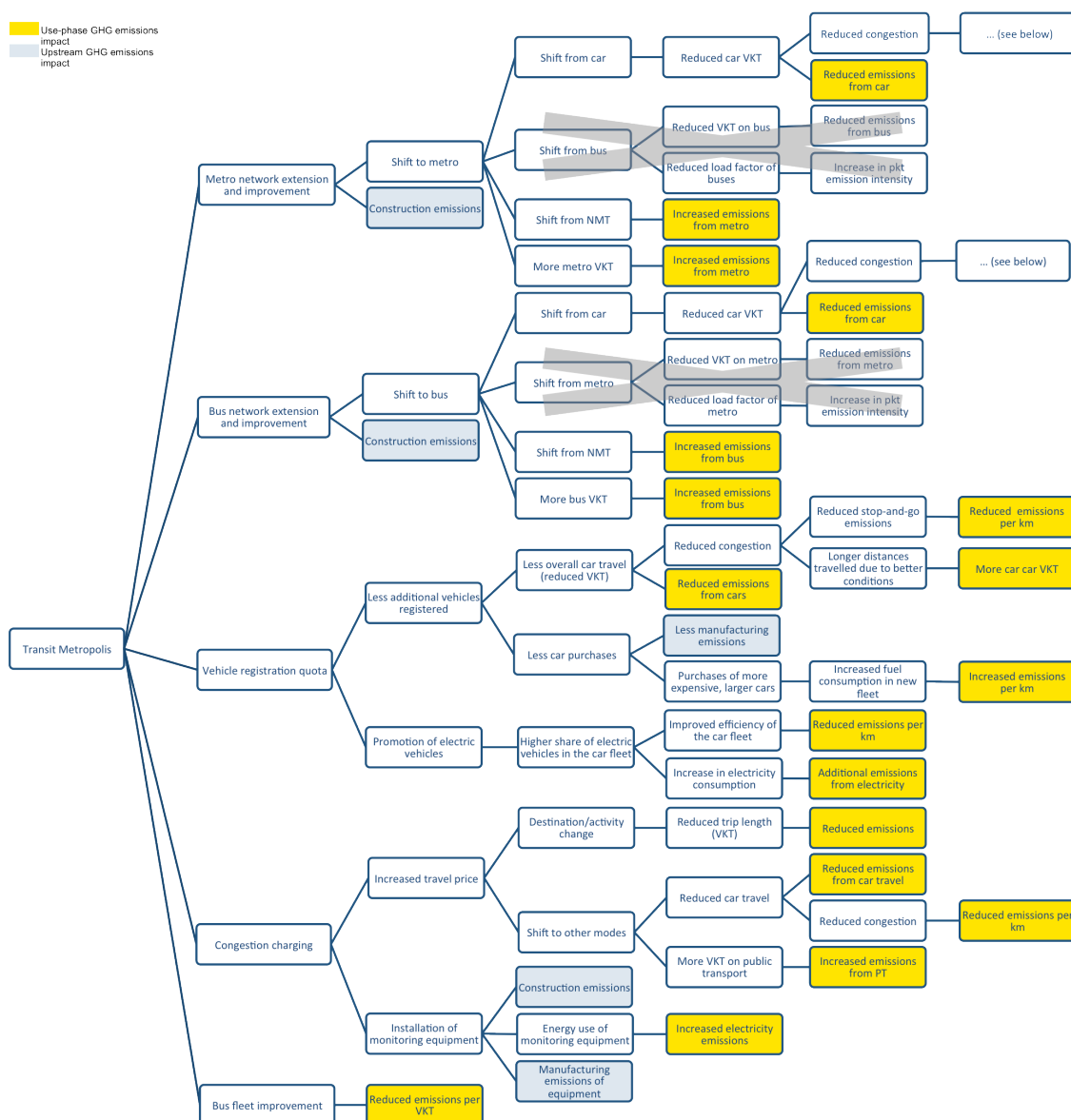
- **Activity:** Does the measure reduce or increase transport activities (VKT), influencing number or distance of trips or vehicle load factors?
- **Structure:** Does the measure induce a shift of transport activities between transport modes with different specific GHG emissions?
- **Intensity:** Does the measure lead to changes of energy efficiency of the vehicle fleet?
- **Fuels:** Does the measure induce a change in energy carriers with different GHG emissions intensity per energy consumption?

2.1.1. GHG impacts of the Transit Metropolis Programme

The impacts of the Transit Metropolis Programme result from:

- The definition of transit system requirements and the provision of co-finance for the improvement and expansion of public transport (and non-motorised transport) infrastructure;
- The requirement of an integrated transport plan, which should enhance integrated transport planning and thereby increase the attractiveness of multimodal public transport, leading to higher mode shares of public transport and reduced car use; as well as spurring travel demand measures to limit private car use;
- Provision of co-finance for the improvement of bus technologies, leading to improved fleet efficiencies.

The impacts of the Transit Metropolis Programme occur at the level of each pilot city. The policy interventions of the pilot cities are not single measures, but policy packages, in which the policies mutually influence each other. The most important GHG impacts of the exemplary policy package in Beijing are illustrated in Figure 6 below using a causal chain map⁶ as suggested by WRI (2014) in its standard for accounting of mitigation actions. Some effects of single policies may cancel each other out in the policy package. For instance, the expansion of the metro network could lead to a shift from bus to metro, but since demand is expected to surpass supply and since the bus network is expanded and improved at the same time, any shifts from bus to rail or vice versa will be marginal and not lead to an absolute reduction. Some of the effects also overlap, such as potential congestion reduction effects of public transport expansion, as well as of the congestion charge (see also next chapters).



⁶ Causal chains or cause-impact chains can be a useful tool to map and identify all possible direct and indirect impacts of an intervention (both GHG impacts and other sustainable development impacts). After impact identification the most important impacts can be chosen based on their likeliness and relevance (cf. WRI, 2014). Impact chains can thereby also help to draw the GHG assessment boundaries.

Figure 6: Cause impact chain for GHG emissions of Transit Metropolis Beijing⁷

The policy packages of the Transit Metropolises differ from city to city, but core indicators to reflect the main GHG effects of a package of measures including public transit expansion, travel demand measures and bus fleet improvement can be generalised (see Table 4, chapter 3); the main GHG effects are summarised in Table 1 (not all cities include bus improvements, in this case, these effects may be ignored). The impact of the whole Transit Metropolis Programme is the sum of emission reductions and sustainable development impacts of all 37 pilot cities.

Table 1: Main direct and indirect GHG effects of the Transit Metropolis Programme (Beijing)

Effects		Impact on emissions
Direct effects	Increased metro vkt (and pkm)	Increasing metro emissions
	Increased bus vkt (and pkm)	Increasing bus emissions
	Mode shift from car to bus and metro	Reducing passenger car emissions
	Mode shift from e-bike to bus and metro	Reducing passenger e-bike emissions
	Avoided kilometres travelled by car	Reducing passenger car emissions
	Improved efficiency of the bus fleet	Reducing emission intensity of bus passenger transport
	Increased electricity consumption in rail stations and for congestion charging equipment	Increased emissions
	Congestion impact	Reduced stop-and-go emissions of passenger cars
Indirect effects	Vehicle manufacturing emissions without registration restrictions and mode shift (baseline)	Avoided emissions from car manufacturing
	Rail and bus lane construction	Increased emissions
	Road construction without Transit Metropolis (baseline)	Avoided emissions
	Upstream well-to-tank (WTT) diesel and gasoline emissions of fuel without vehicle registration restrictions and mode shift (baseline)	Avoided emissions
	Change in the efficiency of the car fleet as result of the license plate lottery	Unsure (likely more electric vehicles, but also a tendency towards bigger cars)

The following sections provide a summary of the GHG impacts of each of the measures in the Beijing package of measures and how they interact.

⁷ Shift from or to motorised two-wheelers is another potential effect that could be included in the impact chain, but was left out for reasons of clarity.

2.1.2. GHG Impacts of the expansion of the metro network

Metro expansion is mainly infrastructure investment increasing the supply of rail-based public transport capacity for passenger transport. The increased availability of metro services leads to passengers using the metro instead of other modes. Metro fees in Beijing are distance-based, starting at 3 CNY for trips below 6km and go up to 10 CNY (92-112km). These prices are competitive and metro services are reliable (and much more reliable than car use) so that the additional metro services are expected to be matched with an additional demand of metro services, resulting in a shift to metro from other modes. Thereby affecting the structure of travel. This shift can have a positive impact if done from car and bus use, due to lower emission factors per passenger km of metro services, but could potentially also have a negative impact if users shift from non-motorised modes.

Additional emissions are generated by the operation of new metro stations and – prior to the use-phase – through metro construction.

2.1.3. Impacts of expansion of the bus network

Cause-impact relations of the expansion of the bus network and services are practically the same as for metro, with emission reductions being caused as a consequence of shift from car to bus travel. Switches from metro to bus are also possible due to lower fares of bus services. Fares start at 2 CNY for the first 10 km and rise by 1 CNY for each additional 5 km.

The combination of expansion and improvement of both rail and bus services also interact with each other. A switch from car to metro and bus might for some users only be attractive in combination, e.g. if new bus services are used to reach metro stations or to complete trips from a metro station. It is the combination of rail and bus services that will allow Transit Metropolis cities to achieve the targeted density in services and will make public transit more attractive to current car users.

2.1.4. Impacts of introduction of alternatively fuelled buses

The introduction of „new energy buses“ (alternatively fuelled buses or e-buses) results in an efficiency improvement of the bus fleet and thereby in lower emissions per passenger km of bus travel and thereby also in emission reductions (for performance of electric and hybrid buses see Grütter, 2014).

2.1.5. Impacts of vehicle registration restrictions

The most prominent direct effect of vehicle registration restrictions (vehicle quota) is the limitation of car growth and thereby also a reduction of vkt by car compared to the business-as-usual development – in other words it reduces travel activity by car. At the same time it indirectly pushes residents who might already have purchased a car under unconstrained circumstances to (continue to) use public transport services instead.

Since the license plate lottery in Beijing includes a certain share of license plates reserved for electric vehicles, it also promotes a change in the vehicle fleet to include more electric vehicles. While in 2014 the reserved license plates were never fully used and the lottery for electric vehicles was temporarily suspended, the demand for electric vehicles appears to be increasing as the chances to win a “traditional” license plate are constantly diminishing. In June 2015, Beijing therefore started auctioning 5,697 licenses. In total, 30,000 licenses are reserved for electric vehicles in 2015, which

come on top of the 120,000 licenses for “traditional” vehicles. Compared to the roughly 5 million vehicles at the end of 2014, this effect will remain marginal for the next years, but may gain significance over time⁸.

An unintended effect is that indirectly, the license plate lottery may actually lead to a less efficient vehicle fleet. Analysis of the effects of the lottery have shown, that the average fuel consumption of newly purchased cars has gone up since its introduction as buyers moved towards more upmarket brands and car sales of middle and small cars have dropped disproportionately compared to SUVs (Jun et al., 2014). Other indirect effects may be longer distances travelled per car as the positive effect on congestion relieve makes car travel more attractive.

On the other hand, the vehicle restriction may in the mid- to long-term lead to less vehicle manufacturing due to a smaller car market, especially when more and more cities begin to introduce similar policies. Less car manufacturing would reduce production emissions. However, these effects are subject to a lot of uncertainty and so far few studies exist so that no robust estimation of the size of this effect can be made. Reduced emissions through less car manufacturing are therefore not considered.

When the license plate lottery was first announced, many people advanced their purchasing decision to buy a car before the policy would be enforced. Apart from that, a black market on car licences temporarily emerged, offering “license plate renting” services for those who did not win the lottery, counteracting the effect of the policy to some extent in the beginning. However, the Beijing Municipal Government quickly took countermeasures and declared the quota trading as illegal and held those caught breaking the law legally liable. So this effect is regarded insignificant today.

2.1.6. Impacts of congestion charging

Congestion charging increases the cost of car travel and thereby pushes people to either travel less/shorter distances (avoid) or to shift their travel activity to other modes. Both activities reduce emissions by either avoiding trips altogether or by shifting to more efficient modes. At the same time, the avoided car travel also leads to congestion relieve, which reduces stop-and-go emissions and improves the overall efficiency of the system. These effects can be significant, as CO₂ emissions in heavy stop-and-go traffic were found to be more than three times higher than in free flow conditions (Sun et al., 2014).

Another direct emission impact of congestion charging is the energy use to operate the charging and surveillance systems, as well as the construction emissions of installing that same equipment.

By pushing additional users towards public transport through price policy the congestion charge influences the effects of metro and bus expansion. What’s more, it generates additional revenue that can be used to further enhance mass transit. On the other hand the investments in high-quality public transport also make the public transport option more attractive and thereby strengthens the shift effect of car drivers, who might otherwise decide to pay more rather than use inconvenient public transport services. So the policies mutually reinforce each other in terms of shift to public transport (push and pull).

The congestion charge also affects trucks in a similar way than private car travel by increasing the price and may lead to less travel. However, operators of freight transport may not have a choice to change or avoid routes in the short-term and cannot easily switch to other modes. A congestion

⁸ Assuming a constant increase of 120,000 „traditional vehicles“ and 30,000 electric vehicles for the next ten years, the vehicle share of electric cars would be roughly 5%.

price may nevertheless incentivise optimisation of freight transport and avoidance of empty hauls. In the presented MRV approach, however, the focus is on passenger transport so that effects on truck traffic are not considered. This is also due to the fact that almost no data on urban freight in Beijing is available.

2.2. Impacts of the policy package and potential interaction with other transport activities

As described above, the measures of the policy package all mutually reinforce each other. The registration quota, reduces the number of cars and therefore affects the demand for public transport services. Similarly, the congestion charge makes driving more expensive and thereby not only tries to reduce the km travelled but also provides an incentive to switch to public transport. On the other hand the provision of better and more comprehensive metro and bus services incentivises the switch to public transit and provides the necessary supply to take up the shifted demand from car travel.

The improvement of the public bus fleet is the only measure that could be isolated more easily.

The sum of policies and measures included in the policy package in Beijing affects all ASIF parameters, as illustrated in Figure 7 (in dark blue). This means that these factors need to be considered in emissions calculations (see Table 4).

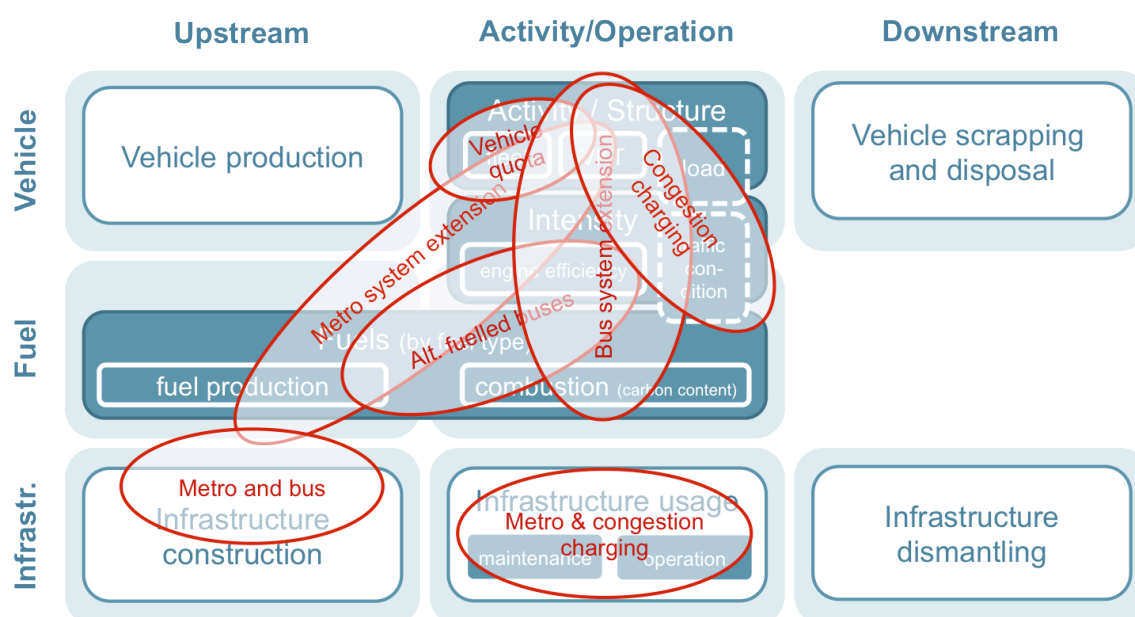


Figure 7: ASIF parameters affected by Beijing Transit Metropolis policy package

The measures of the Transit Metropolis package also interact with additional national policies. The above mentioned fuel economy standard (see section 1.4) lowers the emissions of the car fleet, thereby decreasing the emission reductions through a shift from car to public transport. This development would be accounted for in the baseline. The Beijing Clean Air Action plan further reduced the monthly available license plate quota, greatly enhancing the effects of the license plate lottery.

2.3. Sustainable development impacts

Complementing the GHG reduction effects, the implementation of integrated urban passenger transport packages of measures have several additional sustainable development effects (see Table 2 below). Sustainable development benefits can also be derived from the causal chain used for GHG impacts.

Table 2: Main sustainable development effects of the Transit Metropolis Programme (Beijing)

Criteria	Impact description
Environmental	
Energy use	<p>A shift from car to public transport and congestion reductions both lead to reduced energy consumption per passenger km.</p> <p>The increase of metro services will, however, increase electricity consumption and electricity generation-related emissions.</p> <p>An unintended shift from non-motorised to public transport can also cause additional energy consumption per pkm.</p> <p>As public transport is usually more efficient in terms of energy consumption per pkm, a net decrease in energy use can be expected.</p>
Air quality	<p>A shift from car to public transport, especially metro reduces the tailpipe emissions of CO, NO_x and soot (PM) per pkm. The alleviation of congestion can have additional positive impacts by reducing stop-and-go traffic, which has higher pollutant (as well as GHG) emissions than free flow traffic.</p> <p>The size of the air quality effect depends on the exhaust emissions of the car fleet, as well as the (new and expanded) bus fleet and the emission factors of electricity production.</p>
Land use	<p>Integrated urban transport planning can have a positive effect on land consumption by transport infrastructure. Cars use much more space to transport the same number of passengers as do buses, metro systems, bikes and feet. Shifting people from cars to public transport and non-motorised modes therefore reduces the required space for transport infrastructure.</p>
Economic	
Reduced congestion / societal costs	<p>The alleviation of congestion reduces the societal costs caused by (unexpected) delays and improves the reliability of travel times.</p> <p>Costs to society are further reduced through safer and cleaner traffic, limiting health expenditures.</p>
Travel time	<p>The alleviation of congestion leads to travel time savings for private car and bus users (if buses do not travel on dedicated bus lanes).</p> <p>Designing denser and better integrated public transit systems with intermodal hubs may also reduce the travel times of public transit customers.</p>

Travel costs	Public transport fares are usually lower than a comparable trip by private cars, if the full costs of operation (and ownership) are taken into account. Improvement of public transit networks increases accessibility for low-income groups and a shift from private car to public transport can lead to individual cost savings.
Job creation	<p>The extension of public transit systems, as well as the introduction of congestion charging creates temporary jobs for metro and (to a lesser extent) bus network and monitoring equipment construction and permanent jobs for additional service staff.</p> <p>In addition, better access to mobility and improved network connectivity of public transport may improve access to job opportunities.</p>
Energy security	The reduction of vkm travelled by private car can reduce the oil demand and thus oil import costs and import dependency at the national level.
Social	
Human health	<p>Improved air quality through a shift to public transit, as well as the improvement of the bus fleet, reduces the air pollution concentration levels and thereby the impacts on human health.</p> <p>In addition, public transport users usually have a higher level of physical activity, leading to positive health effects.</p> <p>The reduction in traffic accidents through reduced car travel is another positive impact on human health.</p>
Traffic safety	Studies have shown positive effects of congestion charging on the number of car accidents.
Passenger comfort	Improved public transit services and inter-modal opportunities can increase public transit user satisfaction.

2.4. Data availability

The data availability varies from city to city. In the case of Beijing and other developed cities in China, such as Shenzhen, Shanghai or Tianjin data availability is generally rather good and cities maintain their own travel demand model and decent transport inventories, which can be used for detailed calculations if combined with an emission model. Data on motorised two-wheelers (in Beijing mostly e-bikes) is however comparatively patchy and e-bikes and motorcycles are not yet included in Beijing's travel demand model. Also for road freight traffic data is hardly available.

In medium-sized cities or cities in less-developed areas, travel demand models are usually not maintained and more aggregated data must be used (see Table 4 for data sources of required data).

Data availability assessment in Chinese cities

As a first step in order to identify suitable emission calculation approaches and possibilities for transport related emission calculations in Chinese cities a screening of the available data bases was conducted. Data availability was investigated in representative cities of different size and stages of development based on document analysis and interviews for a standard set of data (including data on the general street network, availability and characteristics of travel demand models, passenger and freight transport data, including breakdown of vehicle registration data into sub-categories, etc., and energy-consumption related data). Findings are summarised in the report Data Availability for Measuring and Reporting Transport Related Greenhouse Gas Emissions in Chinese Cities (ICT, 2013). The report also includes a description of the definition of vehicle classes in Chinese statistics.

Data on sustainable development benefits is generally good. Data on fuel consumption and travel times can be generated using the travel demand model, where available. In cities without travel demand models, travel time may not be feasible to assess. In Beijing, transport-related air pollution can also be calculated based on outputs of the travel demand model using the China Road Transport Emission Model. In other cities air pollution can be estimated using average emission factors.

Data on traffic accidents and fatalities as well as land use of transport infrastructure is available from official statistics at different degrees of detail and quality.

2.5. System boundaries

Table 3: System boundaries of the Transit Metropolis Programme

Boundary elements	Description
Temporal boundary	2013-2020
Sectoral boundary	The MRV approach covers urban passenger transport by by metro, bus (including BRT) and cars. E-bikes are not yet included due to missing data on travel activity.
Territorial boundary	Due to the nature of the mitigation activity, the territorial boundary distinguishes between two layers of analysis: <ol style="list-style-type: none">1. At the national level the territorial boundary includes all 37 pilot cities and their respective territorial assessment boundary.

-
2. At the city level, each city must determine a suitable territorial boundary for itself. For citywide activities it is recommended to set the territorial boundary according to the boundaries that are already being used by local administrations for transport planning, cover most of the transport volume and which correspond with the available data as much as possible.

In the case of Beijing the entire urban area within the 5th ring road is chosen as territorial boundary, because this corresponds to the travel demand model used by the city's Transport Commission and therefore also to the available transport statistics. It also corresponds to the area that would be affected by the assumed congestion charge and most of the activities on transit expansion.

GHG included

The focus is on direct, activity-based GHG emissions. The monitoring covers tank to wheel CO₂, CH₄ and N₂O emissions, as well as emissions related to electricity generation, which are also included as direct emission source.

Indirect emissions of infrastructure operations are based on the electricity consumption of these services in the use phase (e.g. electricity used for congestion charging equipment or in metro stations).

Other indirect upstream and construction emissions are not included in the monitoring.

In order to nevertheless account for upstream GHG emissions from fuel consumption, which lie outside of the assessment boundary (no refineries within Beijing's 5th ring road), a default correction factor is applied for well-to-tank emissions based on literature and emissions are presented as indirect emissions. If available, local / national default factors should be used for calculations. If no local data is available from previous studies, international defaults can be used, such as provided in the CDM methodological tool on "Upstream leakage emissions associated with fossil fuel use"⁹ (cf. Table 3).

A rough one-off estimation of construction emissions for metro expansion is provided based on existing literature to take these emissions into account as leakage.

Reduced emissions through less manufacturing of cars due to restricted demand are not included in the assessment of indirect emissions due to a lack of data and high uncertainties on the size of the effects of the license plate lotteries on manufacturing. Not including these additional emissions savings is conservative.

Sustainability effects included

The analysis covers NO_x and PM emissions from passenger transport, the land use of transport infrastructure within the territorial boundary, road accidents, jobs created, congestion developments based on the

⁹ <http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-15-v2.0.pdf>

traffic performance index in the cities (if assessed by the cities anyhow), which is also an important aspects of the aims of the Transit Metropolis Programme.

Cities with travel demand models can also calculate and report travel time developments every few years. Passenger comfort is assessed based on passenger satisfaction surveys of public transport companies.

Energy security is assessed based on the net fuel savings of the mitigation activities, which are calculated anyhow for GHG emissions assessment.

3. Monitoring and reporting approach

The monitoring and reporting approach for the Transit Metropolis Programme includes information on the urban passenger transport-related GHG emissions reductions in the 37 pilot cities (GHG impact), additional sustainable development effects of the Transit Metropolis actions (SD impact), indicators that reflect the progress towards goal achievement of the Programme (transport system impact), as well as indicators that reflect implementation of the mitigation action (implementation progress and quality). Whereas GHG emissions and the transport system impact are assessed on city level for the whole package of measures, the success of single measures can be assessed on the basis of a mix of qualitative and quantitative implementation indicators (see Table 7).

Figure 8 illustrates the monitoring approach.

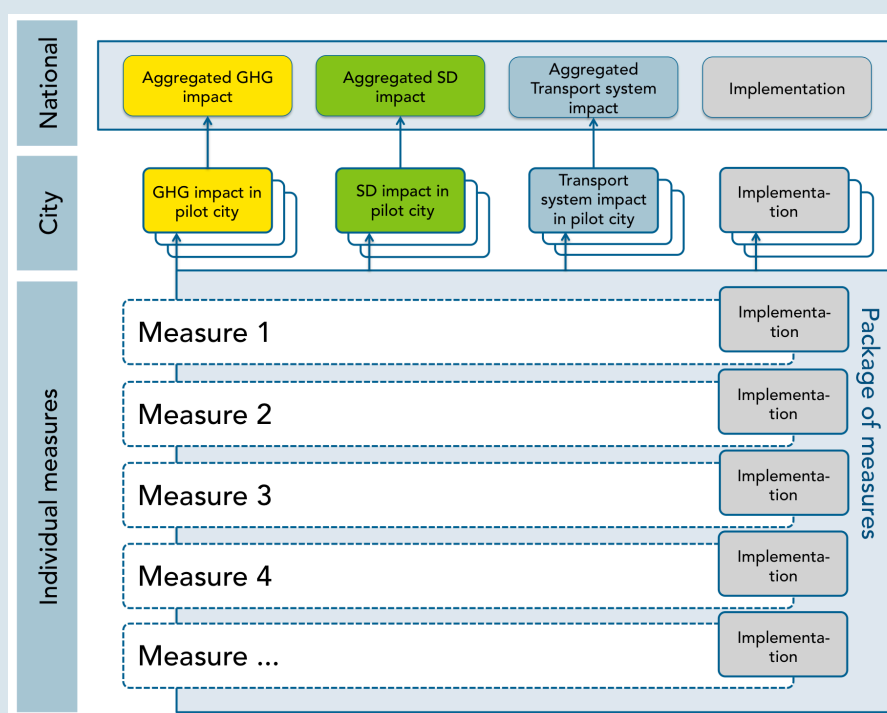


Figure 8: Monitoring approach of Transit Metropolis Programme

3.1. Methodology and indicators

GHG emission impact

The GHG emissions effect (reported in CO₂eq) is monitored at the city level, using bottom-up urban transport inventories to calculate the total emissions of urban passenger transport (differentiated by mode). The monitored values are compared to a baseline scenario (see chapter 4) for urban passenger transport emissions (differentiated by mode) to estimate the emission reductions (see Figure 9 for illustration).

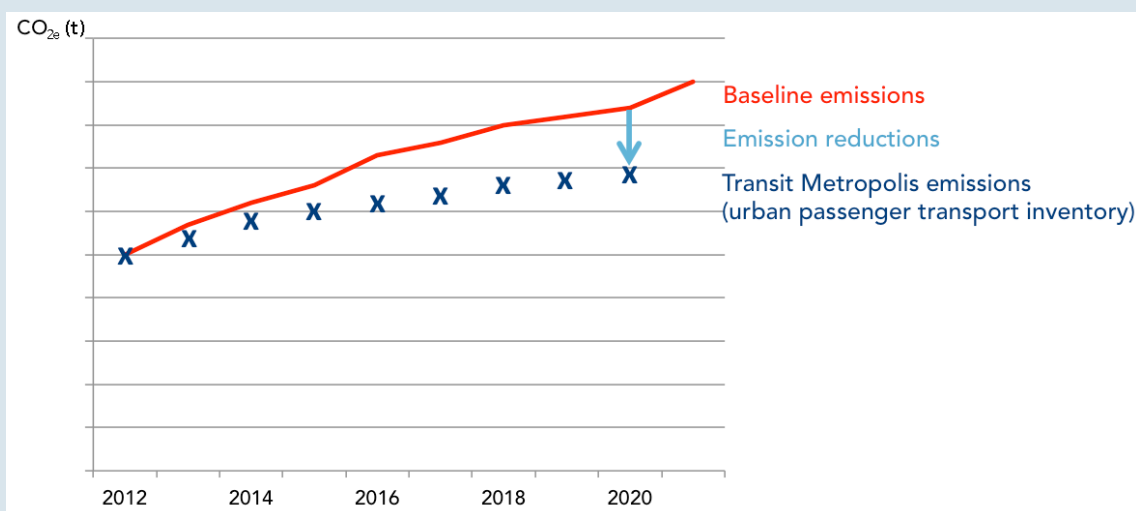


Figure 9: Emission reduction assessment for urban passenger transport

This approach requires activity data (VKT) for each transport mode and an emission factor per transport mode. The emission factor is a result of the respective vehicle fleet of each mode and the local driving conditions. This data can be disaggregated to different levels of detail, depending on local data availability in each city (see box below for more information on emission factors).

For metro and bus services total electricity and fuel consumption reported by public transport operators can be used to calculate emissions of bus and metro services (within the fifth ring road) top-down. But activity based calculations can be used to triangulate the top-down calculation in case top-down data encompasses activities outside of the territorial boundary or data is considered not reliable. Table 4 provides an overview of the required data parameters and their respective information sources.

Table 4: Indicators and data sources for emission calculation or urban passenger transport

Indicator	Information sources	Monitoring interval	Comments
Kilometres travelled by metro, bus and cars (vkt)	Metro and bus company statistics; household surveys for cars and extrapolations of household surveys. Most larger Chinese cities conduct a	Annual	For bottom-up calculation of GHG emissions, energy

Indicator	Information sources	Monitoring interval	Comments
	<p>comprehensive household survey every five years with smaller samples in the intermediate years that are used to extrapolate the comprehensive household survey.</p> <p>For Beijing, VKT data for passenger cars are available from the travel demand model based on a travel survey in 60,000 households.</p>		consumption and pollutant emissions
Total energy consumption of metro services (kWh/annum)	Metro company statistics	Annual	For top-down calculation of GHG emissions of metro services
Electricity emission factors (CO₂/kwh)	China distinguishes between five different electricity grids; the National Development and Reform Commission (NDRC) provides emission factors for all five grids.	Latest version of emission factors provided by NDRC	
Vehicle fleet data for buses, cars	<p>Vehicle registration data is used to determine the relative share of vehicle sub-categories for cars and buses (engine sizes and fuel type).</p> <p>Fleet data is available from traffic management bureaus (registration database).</p>	<p>Fleet data needs to be assessed once for the first year, afterwards, the fleet data only needs to be updated, adding additional vehicles and deleting those unregistered.</p>	<p>For bottom-up calculation of GHG emissions, energy consumption and pollutant emissions;</p> <p>For monitoring overall fleet efficiency improvements.</p> <p>Registration databases only cover vehicles registered in the respective city. They cannot provide fleet information on transit traffic, or incoming traffic from outside the city boundary.</p>

Indicator	Information sources	Monitoring interval	Comments
Emission factors by mode	<p>If localised emission factor databases exist, they can be used (see box below for more information on emission factor databases).</p> <p>In China the China Handbook for Emission Factors includes CO₂ emission factors for cars and soon also for buses¹⁰, distinguished by engine size, fuel used and driving situations.</p> <p>If emission factor databases do not yet exist, information needs to be collected on the specific fuel consumption of vehicles in the fleet¹¹ multiplied by the calorific value of each fuel and the CO_{2e} emission factor for each fuel.¹²</p>	Latest version of emission factors provided in the local emission factor database.	For buses and cars, the emission factors need to be known for different vehicle sub-categories which requires a break-down into fuel type and vehicle size (see fleet data above). Average emission factors can then be aggregated based on the relative shares in vkt.
Total energy consumption of bus services by fuel type	Bus company statistics	Annual	
Net Calorific Values of fuels	IPCC; Default values can be used as national values will only differ marginally from defaults	Latest version of IPCC data	
CO₂ emission factors of fuels	IPCC; Default values can be used as national values will only differ marginally from defaults	Latest version of IPCC data	
Biofuel share per fuel type	Government data sources or petroleum companies	Annual	

While an inventory approach does not allow attributing the effects to a single measure of the package, it takes important synergy effects into account and allows determining the GHG impact of

¹⁰ Until emission factors will have been adapted to Chinese circumstances, EU values are used for buses.

¹¹ Vehicle registration data can be used to determine the relative share of vehicle sub-categories (engine sizes) for cars and buses. But for buses, data is usually available from bus companies. If default values based on manufacturers and norms are used for fuel consumption, a correction factor of around 0.2 may have to be applied to balance the fact that manufacturer data is known to understate the real-world fuel consumption by (at least) 20%. If manufacturer data is separated in total/urban/highway the urban value needs to be used. If fuel consumption data is based on studies, they need to be representative for urban travel.

¹² For CO_{2e} conversion factors, IPCC default values can be used.

the Transit Metropolis packages in each pilot city at a reasonable level of confidence. If available, bottom-up calculations can be cross-checked with fuel sales data on the city territory.¹³

Emission factors for road transport

Emission factors are values for the specific emissions in g/km, differentiated by road vehicle categories (passenger cars, light duty vehicles, heavy duty vehicles, buses, and motorcycles). In the European Handbook Emission Factors for Road Transport (HBEFA) emission factors are provided for all regulated and the most important non-regulated air pollutants, as well as for fuel consumption and CO₂.

The European emission factors have been adapted to Chinese characteristics in a multi-year cooperation between the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and transport planners, scientists and transport experts from four Chinese cities, including Beijing and Shenzhen.¹⁴ More information on how to adapt the HBEFA emission factors to local conditions can be found in a technical paper by Sun et al. (2014).

The emission factors in the China Road Transport Emission Model (the China version of HBEFA) are disaggregated by vehicle type, engine capacity, fuel, road type and driving cycle, allowing very detailed calculations if linked with travel demand models. At the same time, the detailed emission factors can be aggregated to average emission factors based on average vehicle fleet composition and average driving situations. Ideally, average emission factors should also be localised, reflecting the local vehicle fleet, as well as local driving conditions (such as the percentage of stop-and-go traffic) in the city. This allows to take developments in the vehicle fleet, as well as in the level of congestion into account in the emission calculation. If national average values are used, impacts of the measure on the efficiency of the vehicle fleet or congestion are not reflected. International defaults for emission factors are not recommended to be used, due to very high uncertainty (high deviation from the actual local values due to different vehicle fleets, roads and driving characteristics).

¹³ Cross-checking with fuel sales will always show some discrepancies, because fuel sales data does not account for “grey imports” of fuel by cars that are filled outside of the city and cannot account for fuel being filled in the city but used outside of the assessment boundaries. Consequently there is also uncertainty attached with fuel sales data, but a cross-check can provide confirmation that the approximate size of emissions is correct.

¹⁴ The project was part of Sino-German government cooperation and funded by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety.

In the case of Beijing and other similar cities, travel demand models can be linked to emission models to calculate the emissions. In this case the local vehicle fleet characteristics and the emission factor database are included in the emission model, whereas the activity data is inserted via an interface with the travel demand model. In this case, congestion impacts can also be included in the emission assessment. Beijing uses PTV VISUM linked with the China Road Transport Emission Model (a Chinese version of the European Handbook for Emission Factors for Road Transport, which has been adapted to Chinese driving cycles and includes a Chinese emission factor database, see box above) to calculate its emissions.

Cities without travel demand models, calculate their passenger transport emissions based on the following formulas:

$$UPTE_y = \sum_{i=1..n} TA_{i,y} \times EF_{i,y}$$

Where:

UPTE Urban Passenger Transport Emissions in year y (tCO_{2e})

TA_{i,y} Travel activity of mode i in year y (vehicle-km)

EF_{i,y} Emission factor of mode i in year y (gCO_{2e}/km)

$$EF_{i,y} = SFC_{i,y} \times NCV \times EF_{CO_2}$$

Where:

EF_{i,y} Emission factor of mode i in year y (gCO_{2e}/km)

SFC_{i,y} Specific fuel consumption of mode i in year y (l or kWh/km)

NCV Net Calorific Value of fuel x (MJ/l or kWh)

EF_{CO2} CO₂ Emission factor of fuel x (gCO₂/MJ)

Sustainable development impacts

Regarding sustainable development impacts, the following indicators are monitored:

Table 5: Indicators and data sources for monitoring sustainable development impacts

Indicator	Information sources	Monitoring interval
Environmental		
NO_x and PM emissions from passenger transport	<p>The air quality improvement is determined based on avoided NO_x and PM emissions due to avoided vehicle-km of cars based on the mode-shift in the mitigation action minus the additional NO_x and PM emissions due to increased vehicle-km by buses.</p> <p>Data used are Chinese default emission factors per vehicle-km based on the average vehicle population age per mode.</p> <p>Cities with travel demand models, such as Beijing,</p>	Annually

Indicator	Information sources	Monitoring interval
	can combine travel demand models with emission models to calculate car and bus related NOx and PM pollution based on disaggregated emission factors and reflecting actual congestion levels.	
Land use by transport infrastructure	City statistical yearbooks	Annually
Economic		
Congestion	Based on developments of the congestion index that is monitored anyhow in Chinese cities by local transport authorities (mostly by traffic management departments).	Annually
Jobs created	Based on contracts for construction of new transit services (temporary jobs) and information on additional service staff by bus and metro companies (permanent jobs).	Every 5 years
Energy security	Energy security is assessed based on the aggregated net fuel savings across all 37 pilot cities compared to the baseline.	Every 5 years
Social		
Road accidents	City statistics (traffic police / public security bureaus)	Annually
Passenger satisfaction	Passenger satisfaction is monitored and reported as proxy indicator for the attractiveness of public transport services based on regular passenger satisfaction surveys of bus and metro companies.	Every 3 years (depending on schedules of transit companies)

Transport system impact (goal achievement)

Ultimately, the goal of the Transit Metropolis programme is to increase the public transit share in its pilot cities to 60% of all motorised travel with bus travel speeds of more than 18kmh during peak times, accessibility of bus stations within a radius 500 meters in 90% of built-up areas and decreased energy consumption by 10% or more compared to 2010, as well as to improve integrated transport planning. So these parameters need to be monitored to track progress towards goal achievement at city level.

Table 6: Indicators and data sources for monitoring the transport system impact

Indicator	Information Sources	Monitoring interval
Modal split of all motorised modes (bus, metro, car) (number of trips)	Household surveys	Every 5 years
Bus travel speeds at peak times (km/h)	Based on GPS measurements obtained from bus companies or traffic management departments.	Annually
Coverage of bus stations (percentage of built-up area with bus stations within 500m radius)	Bus companies	Annually
Energy consumption of bus transport (kJ / bus km)	Fuel consumption data by bus companies. In China, fuel consumption data is already reported to the national level due to a fuel subsidy policy that pays subsidies based on the reported amount of fuel consumed. This data can be used, even though there may be a slight bias due to overreporting of fuel consumption.	Annually
Integrated urban transport plan Assessment of the level of integration of urban and transport planning and of different transport modes in the integrated urban transport plan.¹⁵	Application material of pilot cities/local transport authority	Once upon pilot city approval

In our case, indicators on goal achievement also reflect the contribution to transformational change of the mitigation action. Some climate finance providers, namely the NAMA Facility and the Green Climate Fund, require the identification of indicators that reflect transformational change potential¹⁶. In the case of the Transit Metropolis Programme, the modal split development reflects the transformational change towards transit-oriented cities. Since the achievement of a 60% share of motorised travel is a long-term target, the relative increase of the public transport share in the mode split can be used to reflect the transition towards transit metropolises and monitor progress. If

¹⁵ The Transit Metropolis Programme requires cities to submit an integrated urban transport plan. Assessing the quality and level of integration of these plans should therefore be part of the Transit Metropolis Programme or similar National Urban Transport Programmes that make integrated planning a requirement for funding support. The assessment of the plans can then also be used for NAMA reporting.

¹⁶ The Green Climate Fund uses the term „paradigm shift“ instead of transformational change.

additional data on passenger kilometres was available, CO₂/pkm could be used to monitor overall efficiency improvements in the pilot cities across modes. However, this would require additional data on occupancy rates, which is not needed for the inventory approach to GHG emission calculations.

Implementation monitoring

Beyond GHG emissions and goal achievement on city-level, there is a need to also ensure individual measures are on track. This should provide the necessary level of confidence, that city-level developments actually are related to the implemented measures.

A mix of qualitative and quantitative implementation indicators are used to track progress in the implementation of the individual mitigation action, as well as the quality of implementation. Implementation progress can be monitored at the national level, such as financial reports on the budget provision to different pilot cities, trainings and conferences organised etc.; at the city level, such as approval of the Transit Metropolis Action Plan at city level, leveraged funding provided by the city to different measures; or at the level of measures, such as the opening of a license plate lottery, updates on the km of new metro and bus lines, the design of a congestion charging system etc.

The quality of implementation includes a qualitative assessment of parameters such as the level of integration in the integrated urban transport plan, the implementation of measures according to the plan, the achievement of certain quality standards of the implemented transit projects, such as BRT Gold Standard¹⁷. The quality of integrated urban transport plans could also be considered an indicator for the potential for transformational change.

The implementation indicators depend on the packages of measures in the pilot cities. For the policy package of the city of Beijing Table 7 summarises exemplary indicator sets to monitor implementation progress and quality of single measures.

Table 7: Indicators and data sources for monitoring implementation of single measures

Indicator		Data source
Expansion of the metro network		
Implementation	▪ Kilometres of new metro lines	Metro company
Quality of implementation	▪ Length of walkways at intersections	Metro company
	▪ Integration with the bus network	Planning Bureau
	▪ Assessment of public-private partnerships?	Metro company
Implementation results	▪ Number of passengers	Metro company
	▪ Used load capacity	Metro company
Expansion of the bus network		
Implementation	▪ Kilometres of new bus lines	Bus company

¹⁷ <https://www.itdp.org/library/standards-and-guides/the-bus-rapid-transit-standard/about-the-brt-standard/>

	Indicator	Data source
Quality of implementation	▪ Integration with the metro network	Planning Bureau
	▪ Assessment of alternatives / consideration of BRT?	Planning Bureau
	▪ For BRT: planning and implementation according to BRT Gold Standard or similar?	BRT company
Implementation results	▪ Number of passengers	Bus company
	▪ Used load capacity	Bus company
Introduction of alternatively fuelled buses		
Implementation	▪ Number of alternatively fuelled buses	Bus company
	▪ VKT of alternatively fuelled buses	Bus company
Quality of implementation	▪ Ex-ante assessment of alternative bus technologies?	Bus company
	▪ Number of additional buses needed due to (a) lower passenger carrying capacity compared to conventional buses, (b) time needed for charging, and (c) need for maintenance.	Bus company
Implementation results	▪ Share of alternatively fuelled buses of total fleet	Bus company
Vehicle registration restrictions		
Implementation	▪ Restrictions of vehicle registration officially introduced	Official regulation
Quality of implementation	▪ Types of vehicles affected (which vehicles are exempted?)	Official regulation
	▪ System design / Accessibility of remaining registrations (e.g. an egalitarian lottery or a price mechanism that disadvantages less wealthy populations)	Official regulation
	▪ Generation of revenues / overview of costs and revenues	
Implementation results	▪ Number of new vehicle registration per month compared to past trends by vehicle type	Vehicle registry, Statistical bureau
Congestion charging		

	Indicator	Data source
Implementation	<ul style="list-style-type: none"> ▪ Congestion charging officially introduced (including information on the zone and number of people affected) 	Official regulation
Quality of implementation	<ul style="list-style-type: none"> ▪ Scenario modelling used to compare effects of different congestion charging designs and identify most suitable option? ▪ Number of violations against congestion charge 	Project documentation, Beijing Municipal Transport Commission Camera surveillance, Traffic police
Implementation results	<ul style="list-style-type: none"> ▪ Change in congestion within (and outside of) the congestion charging zone ▪ Change in number of car trips to the city centre / congestion charging zone 	Traffic performance index, Beijing Transport Research Centre Travel survey, Beijing Municipal Transport Commission

Aggregated impacts at the programme level

Total GHG emission reductions compared to the baseline and the achieved sustainability effects in all 37 pilot cities can be aggregated to report the effects of the national Transit Metropolis Programme. The indicators for transport system objectives (goal achievement) can also be analysed for all 37 pilot cities to report the percentage share of achievement.

If CO₂/pkm was monitored in pilot cities, an average value could be calculated and monitored over time.

3.2. Institutional setting

At the national level, the Ministry of Transport is responsible to report the aggregated effects of the Transit Metropolis Programme. MoT affiliated research centres such as the Chinese Academy of Transportation Sciences (CATS) are commissioned to collect data and report on progress on a project basis. For some tasks, institutionalised data collected by general units for statistics is used directly e.g. the public transport database can provide additional data on public transport network characteristics in the pilot cities.

At city level, the respect transport authorities would be in charge. In the case of Beijing, Beijing Municipal Commission on Transport (BMCT) is the political organisation responsible for the development of Beijing's transport system, while the Beijing Transportation Research Centre (BTRC) delivers transportation planning and modelling support. BTRC maintains the Beijing travel

demand model and operates the emission model for Beijing. The Environmental Protection Bureau (BEPB) provides data on pollutants and the traffic police supplies fleet data based on the vehicle registry.

3.3. Calculation of mitigation action emissions

This is the result of the annual GHG emission inventory of urban passenger transport in each city.

In Beijing, this is done with PTV Visum in combination with the China Road Transport Emission Model, except for metro services, which are calculated separately.

→ *In an application of this blueprint, please add results of your bottom-up inventory of urban passenger transport here*

	Year 1 (in Mt/CO _{2e})		Year 2		Year 3	
	direct	indirect ¹⁸	direct	indirect	direct	indirect
Beijing						
City 2						
City 3						
Total of all pilot cities						

3.4. Calculation of potential leakage emissions

Leakage emissions include emissions related to metro and bus lane construction based on default values. The emissions are only calculated once ex-ante and averaged over the years. They are not based on monitoring the exact construction in each implementation year.

→ *In an application of this blueprint, please add results of leakage calculations here*

3.5. Recommendations for replication

If a national sustainable urban transport programme is developed as a NAMA from the beginning, guidelines for bottom-up urban transport inventories can be worked into the programme design from the start. This helps to establish clear and mandatory procedures for transport data collection, monitoring and management. At the same time the database for urban transport planning is improved.

In some cases data is in principle available, but not easily accessible, because other stakeholders than the project proponents own it. For instance, whereas the Beijing Transport Research Centre under the Transport Commission holds the travel demand model in Beijing, the Environmental Protection

¹⁸ Indirect emissions include upstream emissions of fuel consumption based on default values for each type of fuel.

Bureau owns data on vehicle emission concepts of the vehicle fleet. In these case negotiations may be needed to access the data, as was the case in Beijing.

Integrating a data sharing and management regulation in the programme from the national level can alleviate these difficulties and establish efficient data collection and processing procedures from the start.

The key for successful sustainable urban transport interventions lies in the integration of all modes and the integration of transport and urban planning to maximise mitigation benefits. Including a requirement for integrated transport plans or sustainable urban mobility plans (SUMP) into a national urban transport programme therefore has great potential to improve transport planning and sustainable transport system development long beyond the NAMA lifetime. To be effective, not only the existence, but also the quality of SUMP should be assessed and rated.

Both impact monitoring and integrated transport planning are likely to require capacity development at the local level. It is therefore recommended to also design a training component and provide clear guidance on the design and procedures of developing integrated urban transport plans / SUMP and urban transport inventories. This can be done by setting up a formalised “Technical Support Unit” within the national transport authority to coordinate capacity development and provide technical assistance.

An inventory based MRV approach as presented here, is in principle adaptable to any package of mitigation measures as GHG emissions are always assessed on the basis of travel activities and the related emission factors. Only the indicators to monitor transport system impacts and implementation need to be adapted according to the local policy mix. For instance, if parking policies or bike sharing are included in the policy mix, additional indicators will be necessary to reflect progress in the achievement of these specific policy goals.

4. The Baseline

→ *This chapter requires further clarifications, all comments are highly welcomed.*

In order to calculate emission reductions, a baseline needs to be established against which the transport-related emissions of the Transit Metropolis system can be compared. The baseline is a counterfactual that describes how the transport system and its emissions would have developed in the absence of the Transit Metropolis Action plan and related measures.

4.1. Identification of the baseline scenario

The baseline is based on assumptions about a possible alternative future in the absence of the Transit Metropolis Programme. Different assumptions are possible. The following list provides the main differences of the baseline scenario to the Transit Metropolis implementation that influence the travel activity by different modes, the modal split and the energy efficiency of modes:

- slower pace of metro and bus network developments,
- no alternatively fuelled buses – higher fuel intensity of bus fleet,
- fast increase in vehicle ownership (main effect),

- higher levels of congestion.

Cities with travel demand models can theoretically model the travel activity (and modal share) for the baseline scenario. However, this requires significant amounts of additional manpower to adjust the travel demand model to the hypothetical baseline scenario (different number of bus and metro lines, different vehicle fleet database etc.). In most cases a simpler calculation based on assumptions will be done using the ASIF formula. In this case, assumptions have to be made for all the parameters presented in Table 4 above (apart from the total fuel consumption of bus and metro services), namely vehicle fleet developments and travel activity developments by mode.

Baseline assumptions are a mix of extrapolation of historic trends and expert judgement.

The increase in vehicle ownership is derived from increases prior to the introduction of license plate lottery in relation to GDP growth and current applicants for license plates (only taking the applicants for license plates as the source for vehicle ownership is likely to overestimate the increase in motorisation, since often several family members apply in order to increase the chances of winning and because some may apply earlier than they necessarily need a car, because it is unclear when they will be successful).

Additional policy interventions outside of the scope of the national urban transport programme that are introduced during the implementation period must also be taken into account in the baseline calculation, such as in the case of an introduction of fuel economy standards, which would affect the energy consumption and emission factors of the baseline vehicle fleet.

4.2. Calculation of baseline emissions

The baseline is usually calculated already once ex-ante as part of the development of a mitigation action proposal or NAMA proposal, together with an ex-ante estimation of the expected emission reductions. As part of the monitoring process, the baseline needs to be recalculated with adjusted values for the basic socio-economic determinants mentioned above in order to reflect the real-world developments. E.g. assumptions of the population increase largely affect the assumed increase in vehicle ownership in the baseline scenario. All values that can be monitored therefore need to be adjusted annually and the baseline calculation rerun. Such a dynamic baseline reduces uncertainties in the emission reduction calculation.

Sustainable development effects are also estimated based on the travel activity and modal shares in the baseline scenario.

→ *In an application of this blueprint, please add results of baseline calculations here*

4.3. Recommendations for replication

→ *to be added as required after real-world application*

5. The mitigation action impact

The GHG reduction impact, as well as the impact on air quality is based on the baseline minus the mitigation action emissions. Other sustainable development effects, such as accidents are likewise compared to baseline estimates.

5.1. Calculation of emission reductions

→ *In an application of this blueprint, please add results of the calculated mitigation impact here*

5.2. Assessment of uncertainties involved and consistency of data

→ *To be expanded after application of this blueprint*

The MRV approach reflects transport activity in the city territory and therefore also reflects new national policies, not originally covered by the Transit Metropolis Programme, such as fuel efficiency standards. If such new policies are introduced, they can, however, be reflected by adapting the (dynamic) baseline to include a faster improvement in fuel efficiency in the baseline calculation as mentioned above.

The inventory approach to GHG emission calculations follows a territorial approach, covering all traffic on the territory within assessment boundaries, apart from motorised two-wheelers, which are not yet included.

Emission factors have been adapted to real-world driving situations in China and therefore present a good level of accuracy.

5.3. Assessment of sustainable development impacts

→ *In an application of this blueprint, please add results of the estimated sustainable development impacts here*

5.4. Assumptions and lessons learned for replication

→ *Please add all assumptions made in calculating the mitigation action impact, especially those for the baseline*

5.5. Verification

Verification of mitigation and sustainable development impact assessments, as well as implementation progress in each of the pilot cities requires transparent data management and reporting, making all assumptions and calculation steps explicit and providing necessary databases and materials for cross checks.

→ *to be completed after real-world application*

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