Lanzhou Bus Rapid Transit (BRT) Project

Wayne Zhou
Technical Support Facility
Carbon Market Program
Asian Development Bank
Overview of BRT-based CDM

- Bus Rapid Transit (BRT) is a bus-based mass transit system that delivers fast, comfortable, and cost-effective urban mobility.
- Through the provisions of segregated right-of-way lanes, a BRT system can provide a higher quality of public transport service than can ordinary buses in mixed traffic in terms of passengers per hour, passenger comfort, station quality, operational speed and other parameters.
Overview of BRT-based CDM

- As of 15 July 2012, there are 11 registered BRT-based and MRT-based CDM projects worldwide.

<table>
<thead>
<tr>
<th>Country</th>
<th>Project</th>
<th>Methodology</th>
<th>Registered</th>
<th>Issuance</th>
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<tbody>
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<td>Columbia</td>
<td>BRT Metroplus Medellin, Columbia</td>
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Project Background

- The “Lanzhou Sustainable Urban Transport Project” is ADB’s first project to support bus rapid transit (BRT) in the PRC.
- It consists of 4 components under ADB financing:
  - (i) constructing and reconstructing 33.8 kilometers (km) urban roads, including BRT facilities and non-motorized transport (NMT) lanes;
  - (ii) introducing advanced traffic management;
  - (iii) implementing an advanced environmental monitoring system;
  - (iv) building capacity to support project implementation and BRT operation and management.
- Loan Agreement and Project Agreement signed on 30 March 2010.
Lanzhou BRT Project is aimed at meeting growing demand for urban public transport in Lanzhou by establishing a BRT system in Anning District of the city, which is scheduled to be operational from end of 2012.
Project Background

• Lanzhou BRT features:
  – 12.3 kilometres of physically segregated BRT corridor
  – 19 pairs of staggered stations
  – 12m-18m CNG-fuelled new and existing buses
  – flexible operation
  – At-grade boarding and alighting
  – Real-time bus operation information displays
  – Pre-boarding fare collection and fare verification
  – Free transfers between routes
  – Automatic vehicle location technology
  – Centralized control providing monitoring and communications to scheduling services and real-time response to contingencies

• Lanzhou BRT will use “flexible operation” system in which BRT routes can operate both inside and outside the BRT corridor. Advantages are:
  ➢ Removing the need for interchanges, transfer terminals and feeder buses
  ➢ Greatly reducing the number of passenger transfers in the system
  ➢ Enabling the use of both existing buses and specialized BRT buses
  ➢ Lowering construction and operating costs
Project Background

- GHG emissions are expected to be reduced by the project through:
  - Fuel-use efficiency improvement (per passenger transported) attributable to new and larger buses to be used by the BRT system as compared with vehicles used in the absence of the project.
  - Mode switching of passengers from taxis, private cars and motorcycles characterized by higher emission rates to BRT system due to the availability and attractiveness of the system in terms of reduced transport time and increased safety, convenience and comfort.
  - The flexible operation system integrating existing conventional bus fleets improving overall efficiency of public transport by providing a larger coverage of the BRT system in the district and allowing passengers to board and alight from a BRT route anywhere in the district where BRT routes are operating, not necessarily only along the BRT corridor.
  - Load increase through centrally managed organization dispatching vehicles of BRT fleets. The occupancy rate of vehicles can thus be increased due to organizational measures.

Methodology

- AM0031 “Baseline Methodology for Bus Rapid Transit Projects” (Version 03.1.0, EB58)

- The following methodological tools are referred to by the methodology:
  - “Tool for the demonstration and assessment of additionality” (Version 05.2.1, EB39)
  - “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” (Version 01, EB39)
Baseline Identification

• The baseline scenario of the proposed project activity is the continuation of the current public transport system in Lanzhou where passenger demands are met by various modes of transport including conventional buses, taxis, passenger cars, motorcycles and non-motorized transports (NMTs).

• The GHG emissions from trips that would have been made by BRT passengers using various modes of transport in the absence of the BRT system would form the baseline emissions.

Baseline Identification

• Prior to the project activity, the urban transport system of Lanzhou is composed of CNG buses, CNG taxis, gasoline passenger cars, gasoline motorcycles and non-motorized transport (NMT). No rail-based urban mass transit system exists in the city.
Additionality Demonstration

• According to AM0031,
  – “Where the BRT project is fully privately financed (including roads, infrastructure etc) or where the publicly financed component is fully repaid on commercial terms through tariffs charged to system users, the project proponent should use both investment analysis and barrier analysis.”
  – “If the infrastructure is fully publicly financed or not being repaid on commercial terms, project proponents may use a barrier analysis only.”

• Lanzhou BRT is part of Lanzhou Sustainable Urban Transport Project financed by ADB, Lanzhou Municipal Government and Bank of China.
• The public investment will not be repaid on commercial terms through tariffs charged to the BRT passengers.
• Investment analysis is not necessary. Only barrier analysis is undertaken to demonstrate additionality.

Additionality Demonstration

• **Investment barrier**: Registration of the proposed BRT as CDM project activity was one of the decisive factors considered by ADB and Lanzhou Municipal Government in decision-making process of project preparation and loan agreement.
  – According to the “Guidelines for Objective Demonstration and Assessment of Barriers” (Version 01, EB50 Annex 13), a loan agreement by a lender taking explicitly CDM registration into account is an objective means to demonstrate investment barrier.
  – CDM registration and CERs generation were explicitly taken into account in ADB’s RRP, Loan Agreement and Project Agreement.
  – Realization of CDM registration was articulated in the approval on Feasibility Study Report of Lanzhou Sustainable Urban Transport Project issued by Gansu Provincial Government.
Additionality Demonstration

- **Risk of operational deficit**: The BRT system is subject to operational deficit as the ticket income will not cover the total operational cost.
  - According to “Lanzhou BRT Project Feasibility Study Report”, over the operational period, the project is exposed to significant risk of running deficit due to high probability of ticket income being lower than total operational costs. The operation of the BRT would not be able to cover all operational costs with the ticket income, let alone the capital investment purchasing buses.
  - Great risk of having significantly less passenger ridership than originally projected which is the optimal scenario, in particular in the first few years of operation. Probability of such scenario is high as widely observed across China.
  - Typical examples are Chongqing BRT and Zhengzhou BRT as registered CDM projects.

Additionality Demonstration

- **Barrier due to prevailing practice ("first-of-its-kind")**: As of its starting date (30 Mar 2010), Lanzhou BRT was:
  - The first-of-its-kind in Gansu Province with total population of 26 million
  - The first-of-its-kind in Northwest China consisting of 5 provinces and autonomous regions with total population of 96.6 million
  - The second-of-its-kind in Western China consisting of 12 provinces and autonomous regions with total territory accounting for 70% of China and total population accounting for 25% of China (the first one is Chongqing BRT as a registered CDM project)
Calculations of BE, PE and LE

- The **Baseline Emissions (BE)** are estimated through two major steps:
  - Determination of emissions per passenger transported per vehicle category. This is calculated ex ante, including the usage of a fixed technology improvement factor.
  - Baseline emissions are estimated ex post based on the passengers transported by the project and their modal split. Core baseline parameters used for calculating the baseline emission factors are reviewed through an annual survey, with changes only being applied if the baseline emission factors would be lower than the original ones determined ex ante.

**Calculations of BE, PE and LE**

- **Baseline Emissions (BE)**
  - **Step 1: Determine Vehicle Categories**
    - Buses
    - Passenger cars
    - Taxis
    - Motorcycles
    - Non-motorized transport and induced traffic.
Calculations of BE, PE and LE

• **Baseline Emissions (BE)**
  
  **- Step 2: Calculate Emissions per Passenger**
  
  ➢ Determine Emissions per Kilometre for Vehicle Categories

  Emissions per km for vehicles of different vehicle categories are calculated using following formula:

  \[
  EF_{KM,i} = \sum_{x} SEC_{x,i} \times \left( EF_{CO2,i,x} + EF_{CH4,i,x} + EF_{N2O,i,x} \right) \times \left( \frac{N_{i,x}}{N_{i}} \right) \tag{1}
  \]

  Where:
  
  - \( EF_{KM,i} \) = Transport emissions factor per distance of category \( i \) (gCO\(_2\)e per kilometer driven)
  - \( SEC_{x,i} \) = Specific energy consumption of fuel type \( x \) in vehicle category \( i \) (litre per kilometer)
  - \( EF_{CO2,i,x} \) = \( CO_2 \) emission factor for fuel type \( x \) (gCO\(_2\) per litre)
  - \( EF_{CH4,i,x} \) = \( CH_4 \) emission factor for fuel type \( x \) (gCO\(_2\) e per litre, based on GWP)
  - \( EF_{N2O,i,x} \) = \( N_2O \) emission factor for fuel type \( x \) (gCO\(_2\) e per litre, based on GWP)
  - \( N_{i} \) = Total number of vehicles in category \( i \)
  - \( N_{i,x} \) = Number of vehicles in vehicle category \( i \) using fuel type \( x \)

  **Calculations of BE, PE and LE**

  • **Baseline Emissions (BE)**
    
    **- Step 2: Calculate Emissions per Passenger**
    
    ➢ Calculate Emissions per Passenger per Vehicle Category (for taxis, passenger cars, motorcycles)

    \[
    EF_{P,i} = \frac{EF_{KM,i} \times TD_{i}}{OC_{i}}
    \]

    Where:
    
    - \( EF_{P,i} \) = Transport emissions factor per passenger before project start, where \( i = C \) (passenger cars), \( M \) (motorcycles) or \( T \) (taxis) (grams per passenger)
    - \( EF_{KM,i} \) = Transport emissions factor per distance of category \( i \) (gCO\(_2\)e per kilometer driven)
    - \( OC_{i} \) = Average vehicle occupancy rate of vehicle category \( i \) (passengers)
    - \( TD_{i} \) = Average trip distance for vehicle category \( i \) (kilometers)

    **Note:** A change in the occupancy rate of taxis is considered as leakage.
Calculations of BE, PE and LE

• **Baseline Emissions (BE)**

  – **Step 2: Calculate Emissions per Passenger**
  
  ➢ Calculate Emissions per Passenger per Vehicle Category (for buses)

  \[
  EF_{p,z} = \frac{EF_{KM,2,s} \times DD_{z,s} + EF_{KM,2,M} \times DD_{z,M} + EF_{KM,2,L} \times DD_{z,L}}{P_z}
  \]

  Where:
  
  \( EF_{p,z} \) = Transport emissions factor in buses before project start (grams per passenger)
  
  \( EF_{KM,z,s} \) = Emissions from small buses (gCO₂e per kilometer)
  
  \( DD_{z,s} \) = Total distance driven by small buses (kilometer)
  
  \( EF_{KM,z,M} \) = Emissions from medium buses (gCO₂e per kilometer)
  
  \( DD_{z,M} \) = Total distance driven by medium buses (kilometer)
  
  \( EF_{KM,z,L} \) = Emissions from large buses (gCO₂e per kilometer)
  
  \( DD_{z,L} \) = Total distance driven by large buses (kilometer)
  
  \( P_z \) = Passengers transported by buses in the baseline¹

  **Note:** A change in the occupancy rate of buses is considered as leakage.

Calculations of BE, PE and LE

• **Baseline Emissions (BE)**

  – **Step 3: Technological Change**

  ➢ A constant average improvement rate per annum is established per vehicle category and applied to each year. (0.99 for B/T/C, 0.997 for M)

  – **Step 4: Change of Baseline Parameters during Project Crediting Period**

  ➢ Load factor (i.e. occupancy rate) or the number of passengers per vehicle. Considered as leakage.
  
  ➢ The distance driven by passengers using the BRT might change or not be equivalent to the average distance driven used to calculate BE. To be surveyed. Only downward adjustment will be made.
  
  ➢ Type of fuel used by passenger cars. Only relevant for passengers who have switched from cars to public transport. To be surveyed. Only downward adjustment will be made.

  – **Step 5: Policy Effects**

  ➢ Regular monitoring and assessment of policies to identify impacts on modal split, fuel usage, maximum vehicle ages, etc.
Calculations of BE, PE and LE

• **Baseline Emissions (BE)**
  
  **Step 6: Determination of BE**
  
  The BE are ex ante estimated based on the ex ante determined BE factors per passenger of various vehicle categories, total amount of BRT passengers and modal split of BRT passengers in the absence of the BRT system.

  \[ BE_y = \sum_i \left( EF_{P,i,y} \times P_{i,y} \right) \]

  Where:
  
  \( BE_y \) = Baseline emissions in year \( y \) (tCO₂e)  
  \( EF_{P,i,y} \) = Emissions factor per passenger in vehicle category \( i \) in year \( y \) (grams per passenger)  
  \( P_{i,y} \) = Passengers transported by the project (BRT) in year \( y \) who without the project activity would have used category \( i \), where \( i = Z \) (buses, public transport), \( T \) (taxis), \( C \) (passenger cars), rail-based urban mass transit (\( R \)) or \( M \) (motorcycles) (passengers)

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**Calculations of BE, PE and LE**

• **Baseline Emissions (BE)**

  **Step 6: Determination of BE**

  \[ EF_{P,i,y} = EF_{P,i} \times IR_{i,y} \times CD_{i,y} \]

  Where:
  
  \( EF_{P,i,y} \) = Transport emissions factor per passenger in vehicle category \( i \) in year \( y \) (grams per passenger)  
  \( EF_{P,i} \) = Transport emissions factor per passenger before start of project (grams per passenger)  
  \( CD_{i,y} \) = Correction factor for changing trip distance in category \( i \) for the year \( y \), where \( i = T \) (taxis), \( C \) (passenger cars) or \( M \) (motorcycles)  
  \( IR_{i,t} \) = Technology improvement factor at year \( t \) for vehicle category \( i \)  
  \( t \) = Age in years of fuel consumption data used for calculating the emission factor in year \( y \)

  For \( CD_{i,y} \), it shall only be applied if \( TD_{i,y} < TD_i \). For passenger cars, \( EF_{KM,C,y} \) shall only be adjusted if \( EF_{KM,C,y} < EF_{KM,C} \).
Calculations of BE, PE and LE

• **Baseline Emissions (BE)**
  
  **Step 6: Determination of BE**

\[ P_{i,y} = P_y \times S_{i,y} \]

Where:

- \( P_{i,y} \) = Passengers transported by the project who in absence of latter would have used transport type \( i \), where \( i = Z \) (buses, public transport), \( T \) (taxis), \( C \) (passenger cars), \( M \) (motorcycles), \( NMT \) (non-motorized transport), \( R \) (rail-based urban mass transit) and \( IT \) (induced transport, i.e., would not have traveled in absence of project) (millions)

- \( P_y \) = Total passengers transported by the project monitored in year \( y \) (millions)

- \( S_{i,y} \) = Share of passengers transported by the project which in absence of latter would have used transport type \( i \), where \( i = Z \) (buses, public transport), \( T \) (taxis), \( C \) (passenger cars), \( M \) (motorcycles), \( NMT \) (non-motorized transport), \( R \) (rail-based urban mass transit) and \( IT \) (induced transport, i.e., would not have traveled in absence of project) (%)

The Project Emissions (BE) are from all buses of the BRT system. Considering the data availability, Alternative (A) “Use of Fuel Consumption Data” is used to calculate total project emissions.

\[ PE_y = \sum_x \left[ TC_{PI,x,y} \times (EF_{CO2,x} + EF_{CH4,x} + EF_{N2O,x}) \right] \]

Where:

- \( PE_y \) = Project emissions in year \( y \) (tCO2e)

- \( TC_{PI,x,y} \) = Total consumption of fuel type \( x \) in year \( y \) by the project (million litres/m³)

- \( EF_{CO2,x} \) = CO₂ emission factor for fuel type \( x \) (gCO₂ per litre/m³)

- \( EF_{CH4,x} \) = CH₄ emission factor for fuel type \( x \) (gCO₂e per litre/m³, based on GWP)

- \( EF_{N2O,x} \) = N₂O emission factor for fuel type \( x \) (gCO₂e per litre/m³, based on GWP)

The specific fuel consumption of the BRT system (i.e. fuel consumption per distance driven) needs to be cross-checked for the purpose of quality assurance and quality control.
Calculations of BE, PE and LE

- The following Leakage Emissions (LE) shall be addressed:
  
  **a) Change of Load Factor**
  
  - The project could have a negative impact on the load factor of taxis or the remaining conventional bus fleet. Load factor changes in the baseline public transport system are thus monitored.
  - Leakage is only included if the load factor changes by more than 10%, as certain variations in the load factor caused by external circumstances are normal.
    - If \( \text{ROC}_{Z_0} - \text{ROC}_{Z_y} \leq 0.1 \) then \( \text{LE}_{LZ_0} = 0 \), i.e. if the occupancy rate of buses is not reduced by more than 0.1, then the project has had no negative effect.
    - If \( \text{OC}_{T_0} - \text{OC}_{T_y} \leq 0.1 \) then \( \text{LE}_{LT_0} = 0 \), i.e. if the occupancy rate of taxis is not reduced by more than 0.1, then the project has had no negative effect.

- The following Leakage Emissions (LE) shall be addressed:
  
  **b) Impact of Reduced Congestion on Remaining Roads:** A BRT project reduces buses on the road and thus potentially reduces congestion. Reduced congestion has the following impacts relevant for GHG emissions:
  - “Rebound effect” leading to additional trips and thus higher emissions;
  - Higher average speeds and less stop-and-go traffic leading to lower emissions.

- **c) Upstream Emissions of Gaseous Fuels:** In case of more gaseous fuel are used in the project than in the baseline case the upstream emissions of gaseous fuels should be included. No leakage emissions should be included.
  
  Leakage is only considered if the total annual effect is to reduce estimated emission reductions.
Calculations of BE, PE and LE

• Baseline Traffic Survey
  ➢ On-site CDM baseline traffic survey was carried out in the period of 19 to 23 April 2010. Supplementary survey of additional samples was completed in May 2010.
  ➢ The survey covered all urban areas of Lanzhou City including Anning, Chengguan, Qilihe and Xigu Districts.
  ➢ The survey was designed by the Technical Support Facility under ADB Carbon Market Program and conducted by ADB Loan Lanzhou Project Management Office, Lanzhou Jiaotong University and Gansu Provincial Vocational Police College.
  ➢ Support and cooperation from Lanzhou Public Transportation Group and the local traffic police made possible the survey implementation.

Calculations of BE, PE and LE

• Baseline Traffic Survey
  ➢ The primary purpose of the survey was to collect necessary data and information through on-site objective measurements and subjective interviews. The results of the survey, in conjunction with other data and information from other sources, were used to determine the baseline emission factors per passenger transported by various modes of transport under the business-as-usual scenario.
Calculations of BE, PE and LE

• **Baseline Traffic Survey**

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<th>Parameter</th>
<th>Description</th>
<th>Unit</th>
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<tr>
<td>OCC</td>
<td>Average occupancy rate baseline of passenger cars</td>
<td>passengers</td>
</tr>
<tr>
<td>OCT</td>
<td>Average occupancy rate baseline of taxis</td>
<td>passengers</td>
</tr>
<tr>
<td>OCM</td>
<td>Average occupancy rate baseline of motorcycles</td>
<td>passengers</td>
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<tr>
<td>TDT</td>
<td>Average trip distance baseline for taxis</td>
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<td>TDC</td>
<td>Average trip distance baseline for passenger cars</td>
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</tr>
<tr>
<td>TDM</td>
<td>Average trip distance baseline for motorcycles</td>
<td>km</td>
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<tr>
<td>SEC</td>
<td>Specific fuel consumption of passenger cars</td>
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<tr>
<td>SEC_M</td>
<td>Specific fuel consumption of motorcycles</td>
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<td>TRC</td>
<td>Number of daily trips realized by passenger cars baseline</td>
<td>number</td>
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<td>S_i</td>
<td>Share of passengers transported by BRT who in the absence of the BRT would have used transport mode i, where i= Z (buses, public transport), T (taxis), C (passenger cars), M (motorcycles), NMT (non-motorized transport) and IT (induced transport)</td>
<td>%</td>
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<tr>
<td>ROCZ_0</td>
<td>Average occupancy rate relative to capacity of buses in baseline</td>
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<tr>
<td>SRS</td>
<td>Share of road space used by public transport in baseline</td>
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<tr>
<td>VBL</td>
<td>Average speed of passenger cars in baseline</td>
<td>Km/h</td>
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**Calculation of Emission Factor of Taxi in Lanzhou**

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<th>Parameter</th>
<th>Description</th>
<th>Source</th>
<th>Unit</th>
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<tbody>
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<td>Standard deviation</td>
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(Calculation: as the error of margin is less than 5% of mean, the requirements of AM0031 are met.)

Average trip distance of taxi: 6.79 km

Specific CNG consumption of taxi: 8 (m³/100km)

NCV of CNG: 35.13 MJ/m³

CO₂ emission factor of CNG: 56.1 gCO₂/MJ

CH₄ emission factor of CNG for taxi: 123.38 gCO₂/m³

N₂O emission factor of CNG for taxi: 187.94 gCO₂/m³

Emission factor per distance of taxi: 182.6 gCO₂/km

Technology improvement factor: 0.99

Emission factor of taxi (gCO₂/passenger):
- Year 2013: 1114 gCO₂/passenger-trip
- Year 2014: 1103 gCO₂/passenger-trip
Calculations of BE, PE and LE

Some baseline parameters derived from results of baseline traffic survey

Calculation of Emission Factor of Passenger Car in Lanzhou

<table>
<thead>
<tr>
<th>Occupancy rate</th>
<th></th>
<th>Source</th>
<th>On-site survey</th>
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<tbody>
<tr>
<td>Mean</td>
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<tr>
<td>Standard deviation</td>
<td>0.83 passengers</td>
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<td>Sample size</td>
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<td>Upper bound of 95% confidence interval</td>
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<td>Error of Margin</td>
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(Calculation: as the error of margin is less than 5% of mean, the requirements of AM0031 are met.)

Average trip distance of passenger cars | 10.3 km | Source | On-site survey |
Specific gasoline consumption of passenger cars | 7.84 (litre/100km) | Source | On-site survey |

CO2 emission factor of gasoline, passenger car | 2313.00 gCO2e/litre | Source | AM0031 (v3) |
CH4 emission factor of gasoline, passenger car | 11.00 gCO2e/litre | Source | AM0031 (v3) |
N2O emission factor of gasoline, passenger car | 14.00 gCO2e/litre | Source | AM0031 (v3) |
Technology improvement factor | 0.99 | Source | AM0031 (v3) |

Emission factor of passenger cars (gCO2/per passenger) | | | | |
| Year 2013 | 1073 gCO2/passenger-trip | | |
| Year 2014 | 1063 gCO2/passenger-trip | | |

Calculation of Emission Factor of Motorcycle in Lanzhou

<table>
<thead>
<tr>
<th>Occupancy rate</th>
<th></th>
<th>Source</th>
<th>On-site survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1.47 passengers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.58 passengers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample size</td>
<td>752 unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper bound of 95% confidence interval</td>
<td>1.5115</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower bound of 95% confidence interval</td>
<td>1.4285</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error of Margin</td>
<td>0.0415</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Calculation: as the error of margin is less than 5% of mean, the requirements of AM0031 are met.)

Average trip distance of motorcycle | 5.99 km | Source | On-site survey |
Specific gasoline consumption of motorcycle | 2.2 (litre/100km) | Source | On-site survey |

CO2 emission factor of gasoline, motorcycle | 2313.00 gCO2e/litre | Source | AM0031 (v3) |
CH4 emission factor of gasoline, motorcycle | 29.00 gCO2e/litre | Source | AM0031 (v3) |
N2O emission factor of gasoline, motorcycle | 7.00 gCO2e/litre | Source | AM0031 (v3) |
Technology improvement factor | 0.997 | Source | AM0031 (v3) |

Emission factor of motorcycle (gCO2/per passenger) | | | | |
| Year 2013 | 203 gCO2/passenger-trip | | |
| Year 2014 | 202 gCO2/passenger-trip | | |
Calculations of Emission Factor of Bus in Lanzhou

- Some baseline parameters derived from results of baseline traffic survey

**Calculation of Emission Factor of Bus in Lanzhou**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual total passengers with all buses in baseline</td>
<td>615,548,365 passenger</td>
<td>Bus Company</td>
</tr>
<tr>
<td>Annual total distance travelled by all buses in baseline</td>
<td>143,013,462 km</td>
<td>Bus Company</td>
</tr>
<tr>
<td>Average bus usage per trip of a passenger</td>
<td>1.53 bus per trip of a passenger</td>
<td>On-site survey</td>
</tr>
<tr>
<td>Specific CNG consumption of bus</td>
<td>31.41 (m3/100km)</td>
<td>Bus Company</td>
</tr>
<tr>
<td>NCV of CNG</td>
<td>35.1 MJ/m3</td>
<td>Gas Company</td>
</tr>
<tr>
<td>CO2 emission factor of CNG</td>
<td>56.1 gCO2/MJ</td>
<td>IPCC, V2, Chapter 1, Table 1.4</td>
</tr>
<tr>
<td>CH4 emission factor of CNG for bus</td>
<td>515.8 gCO2/m3</td>
<td>IPCC, V2, Chapter 3, Table 3.2.4</td>
</tr>
<tr>
<td>N2O emission factor of CNG for bus</td>
<td>99.7 gCO2/m3</td>
<td>IPCC, V2, Chapter 3, Table 3.2.4</td>
</tr>
<tr>
<td>Emission factor of bus (gCO2/per m3)</td>
<td>2586.3 gCO2/m3</td>
<td></td>
</tr>
<tr>
<td>Emission factor of bus (gCO2/per km)</td>
<td>812.4 gCO2/km</td>
<td></td>
</tr>
<tr>
<td>Technology improvement factor</td>
<td>0.99</td>
<td>AM0031 (v6)</td>
</tr>
</tbody>
</table>

**Emission Factor of bus (gCO2/per km)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Emission factor of bus (gCO2/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>788</td>
</tr>
<tr>
<td>2014</td>
<td>780</td>
</tr>
<tr>
<td>2015</td>
<td>773</td>
</tr>
<tr>
<td>2016</td>
<td>765</td>
</tr>
<tr>
<td>2017</td>
<td>757</td>
</tr>
<tr>
<td>2018</td>
<td>750</td>
</tr>
<tr>
<td>2019</td>
<td>742</td>
</tr>
</tbody>
</table>

**Emission Factor of bus (gCO2/per passenger)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Emission factor of bus (gCO2/passenger-trip)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>280</td>
</tr>
<tr>
<td>2014</td>
<td>277</td>
</tr>
</tbody>
</table>

**Calculations of BE, PE and LE**

- Emission Reductions (ER)

<table>
<thead>
<tr>
<th>Crediting period Year</th>
<th>Estimation of baseline emissions (tCO2e)</th>
<th>Estimation of project activity emissions (tCO2e)</th>
<th>Estimation of leakage emissions (tCO2e)</th>
<th>Estimation of overall emission reductions (tCO2e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>29,527</td>
<td>17,723</td>
<td>0</td>
<td>11,804</td>
</tr>
<tr>
<td>2014</td>
<td>30,096</td>
<td>18,609</td>
<td>0</td>
<td>11,487</td>
</tr>
<tr>
<td>2015</td>
<td>31,812</td>
<td>19,539</td>
<td>0</td>
<td>12,273</td>
</tr>
<tr>
<td>2016</td>
<td>33,474</td>
<td>20,516</td>
<td>35</td>
<td>12,923</td>
</tr>
<tr>
<td>2017</td>
<td>34,927</td>
<td>21,542</td>
<td>236</td>
<td>13,149</td>
</tr>
<tr>
<td>2018</td>
<td>36,347</td>
<td>22,619</td>
<td>416</td>
<td>13,312</td>
</tr>
<tr>
<td>2019</td>
<td>37,736</td>
<td>23,750</td>
<td>589</td>
<td>13,396</td>
</tr>
<tr>
<td>Total (tCO2e)</td>
<td>233,918</td>
<td>144,297</td>
<td>1,276</td>
<td>88,345</td>
</tr>
</tbody>
</table>
Calculations of BE, PE and LE

- Sensitivity analysis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
<th>Change required for 5% reduction of ERs</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC_{P,J,x,y}</td>
<td>Total consumption of CNG by project in year “y”</td>
<td>0.72%</td>
</tr>
</tbody>
</table>

Baseline Emissions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
<th>Change required for 5% reduction of ERs</th>
</tr>
</thead>
<tbody>
<tr>
<td>P_{y}</td>
<td>Passenger transported by the project (BRT)</td>
<td>-1.89%</td>
</tr>
<tr>
<td>SEC_{CNG,T}</td>
<td>Specific energy consumption of CNG by taxis</td>
<td>-10.80%</td>
</tr>
<tr>
<td>SEC_{CNG,Z}</td>
<td>Specific energy consumption of CNG by buses</td>
<td>-3.63%</td>
</tr>
<tr>
<td>OCC</td>
<td>Average occupancy rate of passenger cars</td>
<td>5.48%</td>
</tr>
<tr>
<td>OCT</td>
<td>Average occupancy rate of taxis</td>
<td>10.29%</td>
</tr>
<tr>
<td>TDC</td>
<td>Average trip distance of passenger cars in baseline</td>
<td>-5.98%</td>
</tr>
<tr>
<td>TDT</td>
<td>Average trip distance of taxis in baseline</td>
<td>-9.33%</td>
</tr>
<tr>
<td>TDM</td>
<td>Average trip distance of motorcycles in baseline</td>
<td>&gt;-100%</td>
</tr>
<tr>
<td>P_{z}</td>
<td>Passenger-trips realized with buses in the baseline</td>
<td>4.08%</td>
</tr>
<tr>
<td>DD_{z}</td>
<td>Total distance driven by all buses in the baseline</td>
<td>-3.92%</td>
</tr>
<tr>
<td>S_{2}</td>
<td>Share of BRT passengers using buses for baseline trip</td>
<td>-3.92%</td>
</tr>
<tr>
<td>S_{3}</td>
<td>Share of BRT passengers using taxis for baseline trip</td>
<td>-6.09%</td>
</tr>
<tr>
<td>S_{4}</td>
<td>Share of BRT passengers using motorcycles for baseline trip</td>
<td>-9.33%</td>
</tr>
<tr>
<td>S_{5}</td>
<td>Share of BRT passengers using motorcycles for baseline trip</td>
<td>&gt;-100%</td>
</tr>
</tbody>
</table>

Monitoring

- All parameters in relation to baseline, project and leakage emissions that are necessary for ex-post monitoring during crediting period are tabulated as follows, with project-specific circumstance and characteristics being duly taken account of.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>P_{y}</td>
<td>Total passengers transported by the project in year “y”</td>
</tr>
<tr>
<td>S_{iy}</td>
<td>Share of passengers who in the absence of the project would have taken transport mode “i” in year “y”</td>
</tr>
<tr>
<td>TC_{P,J,x,y}</td>
<td>Total fuel (CNG) consumption by the project in year “y”</td>
</tr>
<tr>
<td>N_{i,y}/N_{x,y}</td>
<td>Number of taxis and conventional buses still operating in year “y”</td>
</tr>
<tr>
<td>N_{ix}</td>
<td>Number of vehicles in vehicle category “i” using fuel type “x”</td>
</tr>
<tr>
<td>NCV_{BRT,y}</td>
<td>Net calorific value of the natural gas used by the project during the year “y”</td>
</tr>
<tr>
<td>OC_{T,y}</td>
<td>Average occupancy rate of taxis in year “y”</td>
</tr>
<tr>
<td>ROC_{C,y}</td>
<td>Average occupancy rate relative to capacity of buses in year “y”</td>
</tr>
<tr>
<td>XC_{iy}</td>
<td>Fuel type used from BRT passengers who in the absence of the BRT would have used passenger cars</td>
</tr>
<tr>
<td>TD_{U,TM,y}</td>
<td>Average trip distance of BRT passengers who in the absence of the BRT would have used passenger cars, taxis or motorcycles</td>
</tr>
</tbody>
</table>

- Policies that may affect baseline parameters
Implication of Version 4 of AM0031

• Version 4.0.0 of AM0031 has been valid from 25 Nov 2011 onwards

• The grace period of Version 3.1.0 of AM0031 will expire on 25 July 2012

• Simplification of applicability conditions
  – Removal of the condition requiring that the project has a clear plan to reduce existing public transport capacities either through scrapping, permit restrictions, economic instruments or other means and replacing them by a BRT system;
  – Removal of the condition that the local regulations do not constrain the establishment or expansion of a BRT system;
  – Removal of the condition requiring that the BRT system partially or fully replaces a traditional public transport system in a given city and stating that the methodology cannot be used for BRT systems in areas where currently no public transport is available;
Implication of Version 4 of AM0031

• Simplification of BEs and PEs
  – Removal of analysis on policy effects in determination of BEs
  – Removal of sensitivity analysis on parameters for calculating BEs and PEs
  – Reduces monitoring requirements set in the monitoring survey from annual monitoring to monitoring in the years 1 and 4 for parameters determining BEs, such as $S_{i,y}$, $OC_{i,y}$, $ROC_{i,y}$, $N_{Z,y}$, $N_{T,y}$, $N_{i,x}$, $V_{P,y}$, etc.

• Simplification of Leakage
  – Further elaboration on parameters and calculation of leakage
  – Reduced monitoring requirements for leakage.
    ➢ For leakage from changes in load factor of buses and taxes, the frequency of monitoring is reduced from every 3 years to the years 1 and 4.
    ➢ For leakage from reduced congestion, the requirement to estimate it ex ante is replaced with the requirement of:
      ▪ (1) not to conduct monitoring, in case the implementation of the project activity does not lead to a reduction of road space; and
      ▪ (2) to monitor in the year 1 and 4, in case the implementation of the project activity leads to a reduction on road space;
Implication of Version 4 of AM0031

• More guidance on survey
  – Revision of guideline for load factor studies for buses based on "visual occupation"
  – Provision of guideline for load factor studies for buses based on "boarding-alighting surveys"
  – Revision of guideline for load factor studies for taxi, with the provision for motorcycles and passenger cars.
  – Provision of detailed guideline on methodological design of surveying BRT passengers to determine the parameter of $S_{i,y}$, namely, the share of passengers transported by the BRT who in the absence of the BRT would have used other modes of transport (conventional buses, taxis, passenger cars, motorcycles, rail-based urban mass transit, NMT, induced transport), and the parameter of $T_{D,i,y}$

• “Innovative” approach to additionality demonstration:
  – **Scenario 1**: BRT projects in LDCs are automatically additional.
  – **Scenario 2**: For projects in non-LDCs and facing the first-if-its-kind barrier, the EB Guidelines on additionality of first-of-its-kind project activities shall be followed to demonstrate the additionality.

Transport is NOT one of the 4 types of measures covered by Guidelines on Additionality of First-Of-Its-Kind Project Activities (EB63, Version 01.0), hence some approach different from what are defined by the Guidelines (outputs, technologies, etc.) shall be proposed by the PP to demonstrate the project is a "first-of-its-kind".
Implication of Version 4 of AM0031

- **Scenario 3**: Projects that are in non-LDCs and not first-of-its-kind shall undergo the following procedure

![Figure 1: Additionality demonstration](image)

- **Step 1 Country Level Assessment**:
  - Big countries with a number of mega-scale cities with existing BRTs and/or to-be-established BRTs could be disadvantaged.

- **Step 2 City Level Assessment**:
  - Cities with existing BRTs could be disadvantaged.
  - Projects seeking extensions of existing BRTs are likely to encounter difficulty in meeting the requirement of not more than 20% of the total public transport ridership in the city.
  - Ambiguity regarding comparability of data on ridership of different public transport categories (vintage, time span, spatial scope, etc).
  - Risk of availability of and/or accessibility to operation data
Implication of Version 4 of AM0031

Scenario 3 sets forth stringent provisions in the 3 steps:

Step 3 Project Level Assessment:

- Projects with more than 50% of the total capital investment financed by banks and/or government are not allowed to make investment analysis as Procedure A.

- For Procedure B, medium and small scale BRTs would be in a disadvantaged position when assessing if the annual revenues from CERs would be more than 10% of total annual O&M costs.

- If the threshold of 10% is applied to registered BRT projects for cross-check, some of registered projects would not be additional in the context of Version 4 of AM0031.

- Considerable probability that the actual O&M costs would be greater than PE’s projection whereas the actual amount of CERs would be significantly less than PDD.

- Strong in-house/external expertise and experience of DOEs in transport sector are essential to validating the reliability and credibility of data, rationales, assumptions and justifications in respect of the assessment of the O&M costs of BRTs.

- New projects would be further disadvantaged if the generally downward trend of carbon price in the current marketplace will continue.
Conclusion

• BRT/MRT-based CDM is complicated, time-consuming and resource-consuming.

• “Conditions Precedent” to make CDM possible:
  – Well-prepared project feasibility study report (FSR) by qualified and experienced design institute (O-D survey, traffic modelling, forecasting of passengers and fuel consumption, etc)
  – Well-documented prior consideration of CDM (FSR, EIA, Approvals, RRP, Agreements, etc)
  – Funding for traffic survey, PDD, validation (significantly costly than normal projects!), monitoring (intensive monitoring activities required), verification, etc.
  – Strong partnership with local government agencies (approvals, statistics data accessibility, facilitation of traffic survey)
  – Support from local counterparties with experience (transport knowledge, experience and capabilities in conducting survey)
  – Sensible DOE’s, preferably those having hands-on experience in transport CDM
  – More user-friendly methodologies (simplification of leakage calculation, simplification of survey requirements, less stringent requirements on additionality for projects in non-LDCs)

Thank you!

Wayne Zhou
Technical Support Facility, Carbon Market Program
Asian Development Bank
Email: wzhou@adb-apcf.org