The Challenges of Measuring GHG and Other Impacts of Transport Policies: Overcoming Data Limitations

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Presentation to

Global conference on Assessing Inland Transport CO2 Emissions and the Impact of Mitigation Policies

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Measuring Transport GHG Emissions

SIMPLE:
- evaluation framework and metrics

COMPLEX:
- measuring
- monitoring
- boundary setting
- causality determinations
Transport CO2 Analysis Needed at Multiple Analysis Scales

- **Project & Portfolio**: Need to take care to evaluate system-wide impacts, induced demand
- **Plan & Region**: Optimal scale to consider system impacts for metropolitan plans/programs
- **Nation**: Often best for evaluating large networks and system policies
GHG Estimates Affected by Boundary Definitions

CDM BRT Analysis:
Impact area boundary defined spatially

TEEMP: Impact area defined by travel shed

ORIGIN

Business as Usual

Intervention 1

Intervention 2

Intervention 3

DESTINATION
Sound GHG/Pollution Baselines Need Data

Motor vehicle fleet:
- Type
- Age
- Turnover rates
- Maintenance
- Fuel type
- Fuel quality
- Related emission factors

But this data is often not reliable or readily available.
Motor vehicle operating conditions:
- temperature, altitude
- speed & smoothness of traffic flow

But data on VKT by vehicle type by speed is often not readily available or reliably estimated

Barth & Boriboonsomsin 2008
Regional Transport Land Use Models Are Poorly Developed in Much of the World

Well calibrated models can help forecast vehicle activity changes. But poorly calibrated models can mislead policy makers.

Getting models in place in most cities by 2020 is achievable and desirable goal, but sketch tools are valuable to fill gaps in the interim.

Source: Wegener, 1995
Need to Invest in Transport Data & Analysis

Vehicle fleet activity analysis requires:
- Mode share and vehicle activity
- Travel surveys
- Bus company ridership
- Freight activity
- Traffic counts
- Vehicle sales data
- Motor fuels sales data
- Vehicle operating speeds
- GPS data loggers and vehicle monitors

Getting data for most cities by 2015-2020 is achievable and desirable goal, but sketch tools are valuable to fill gaps in the interim.
Different emission factor models show high variance in emission rates for same vehicle fleet with variation due to:

- Model type: binning vs. modal emission models
- Variations in speed correction factors
Transport Greenhouse Gas Analysis: Matching Assessment With Purpose

- Increasing rigor
- Increasing data needs
- Increasing costs

ADB Portfolio Carbon Footprint Analysis

GEF Project Appraisal

Supported NAMAS & City-Wide Inventories

CDM Credit Evaluation
If one lacks good data, it’s good to get started to support sound decisions using default data and appropriate policy-sensitive tools.

As sustainable mobility plans are implemented, agencies should invest in getting better data, inventories and analysis.
Far better an approximate answer to the right question... than an exact answer to the wrong question.

John W. Tukey (1962)

All models are wrong, but some are useful.

George E.P. Box (1979)

Credit: Yang JIANG, Daizong LIU, Suping CHEN, Assessment Tools for China Low-Carbon-City Projects From the CSTC’s Perspective, 2011
Introduction to TEEMP: what and why

- TEEMP – *Transport Emissions Evaluation Model for Projects*
- Free-of-charge, open source Excel-based models
- Help consider options & impacts
- Most appropriate for ex-ante evaluation in places with poor data
TEEMP Toolkit: Simple, fast, inexpensive

- Default data if local data is lacking: emissions by vehicle type by speed, travel activity parameters, elasticities
- Confidence in model outputs higher when local data replaces defaults
- Sensitivity to induced demand/rebound effects

Guides users to focus project design on factors contributing to more effective GHG reducing projects

Project emissions for 20-year life based on average emissions per unit of project length by project type for prototypical sample of projects

Source: ADB. 2010. Reducing Carbon Emissions from Transport Projects
• Indicators by project type can be applied rapidly
• Most useful when applied to large bundle of projects
• Low level of precision
• **Gross CO₂ emissions**: tons
• **CO₂ intensity per unit of mobility**: g/pass-km and g/ ton-km
• **CO₂ intensity per dollar of investment**: tons/USD$
• **Net no-build CO₂ effect**: tons relative to dynamic baseline
Cumulative Carbon Emissions from ADB Transport Projects

Cumulative CO2 Construction and Operations Emissions (Million Tons) of ADB-Funded Transport Projects during 2000–2009
Gross carbon emissions from construction & operations of ADB-funded transport projects estimated at 792 million tons*:
- Average 39.6 million tons/year
- About equal to transport sector emissions of Thailand or Philippines

CO₂ impact would have been cut by ¼ if half of funding that went to motorway projects had instead funded road rehabilitation, BRT, NMT projects*

* Source: ADB. 2010. Reducing Carbon Emissions from Transport Projects
Transport CO2 footprinting

• No standard methodology yet
  – ADB, some other MDBs evaluating emissions of many transport projects
  – IDB has commissioned handbook for transport project CO2 estimation
  – World Bank moving towards quantifying & publishing its transport CO2 emissions

• Nov. 2010: GEF adopted TEEMP methodology for transport GHG project evaluation
TEEMP features

- Sketch and detailed analysis options*
- Scorecards to see the impact of design – good vs bad*
- Considers emissions from construction, operations, and affected motorized vehicles against dynamic baseline
- Automatic definition of impact boundaries
- Quantification of CO₂, PM and NOₓ emissions
- Estimation of traffic fatalities, other co-benefits
- Can reflect “GEF-indirect” replication impacts

* Some models only
1. Bike sharing
2. Bikeways
3. Pedestrian Facility Improvement
4. BRT
5. LRT/MRT
6. Roads Projects – Expressways, Rural Roads and Urban Roads
7. Railway
8. City Sketch Analysis and Other Strategies - Commuter Strategies, Pricing Strategies, Eco-Driving, PAYD Insurance
Run through of TEEMP: project scenario

<table>
<thead>
<tr>
<th>Activity</th>
<th>Number of trips</th>
<th>Average Trip Lengths</th>
<th>Average Speeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure</td>
<td>Mode shares (%)</td>
<td>Average occupancies</td>
<td>Vehicle fuel split</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vehicle emission standards split</td>
</tr>
<tr>
<td>Intensity</td>
<td></td>
<td></td>
<td>Fuel Efficiencies of vehicles</td>
</tr>
<tr>
<td>Fuel</td>
<td></td>
<td></td>
<td>Emission Factors</td>
</tr>
</tbody>
</table>

Emissions from the motorized vehicles within the scope of the analysis are also quantified under the BAU & project scenario, accounting for changes in ASIF parameters.
Emissions from the construction of certain types of transport projects are significant and need to be considered in the emissions analysis.
### Run through of TEEMP: project scenario

Emissions from the operation of some project types (e.g. electricity consumption from MRT operations) are considered as well.

<table>
<thead>
<tr>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of electricity used</td>
</tr>
<tr>
<td>Emission Factor of the Grid</td>
</tr>
<tr>
<td>Fuel used for Project Vehicles</td>
</tr>
</tbody>
</table>
### Basic Information

<table>
<thead>
<tr>
<th>Project name</th>
<th>Location</th>
<th>Details</th>
<th>Base year</th>
<th>Days in a year</th>
</tr>
</thead>
</table>

### Information on the BRT System Features and Ridership

<table>
<thead>
<tr>
<th>Length of BRT</th>
<th>BRT Ridership</th>
<th>BRT Scorecard</th>
<th>Land Use Impact Factor</th>
</tr>
</thead>
</table>

### Vehicle Fuel Intensity and Emission Factors

<table>
<thead>
<tr>
<th>Fuel Type Split</th>
<th>Technology Split</th>
<th>Fuel Efficiency (km/unit of consumption @ 50 kmph)</th>
</tr>
</thead>
</table>

- Easier to use menu and shortcuts
- Integration of peer-reviewed BRT Scorecard
- Inclusion of more co-benefits in Results page
### Sketch Analysis

- Considers the ridership or the length of BRTS constructed using the current literature available in estimating the emissions
- A ridership calculator is provided in TEEMP model to project the ridership of the BRT project

### Detailed Analysis

- Construction, operation (of BRT buses) and traffic emissions
- Land-use factor has been proposed to account for land-use modifications and its subsequent impacts on travel pattern
TEEMP Example: Bus rapid transit

**Sketch A**
- Basic project information
  - Input the ridership values or use the ridership estimator
  - Emission Factors
  - Outputs

**Sketch B**
- Basic project information
  - Length of BRT route
  - Emission Factors
  - Outputs

**Full Model**
- Basic project information
  - Input the ridership values or use the ridership estimator
  - Characteristics of the vehicles within the area of analysis
  - Define the BRTS project components – scoring factors
  - Characteristics of the BRT buses
  - Construction parameters
  - Outputs
## TEEMP BRT Model Uses BRT Standard Scorecard

Scoring factors point to elements that contribute to most effective BRT corridor and system performance

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>MAX SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SERVICE PLANNING</strong></td>
<td></td>
</tr>
<tr>
<td>Off-board fare collection</td>
<td>7</td>
</tr>
<tr>
<td>Multiple routes</td>
<td>4</td>
</tr>
<tr>
<td>Peak frequency</td>
<td>4</td>
</tr>
<tr>
<td>Off-peak frequency</td>
<td>3</td>
</tr>
<tr>
<td>Express, limited, and local services</td>
<td>3</td>
</tr>
<tr>
<td>Control center</td>
<td>3</td>
</tr>
<tr>
<td>Located In top ten corridors</td>
<td>2</td>
</tr>
<tr>
<td>Hours of operations</td>
<td>2</td>
</tr>
<tr>
<td>Multi-corridor network</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>MAX SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INFRASTRUCTURE</strong></td>
<td></td>
</tr>
<tr>
<td>Busway alignment</td>
<td>7</td>
</tr>
<tr>
<td>Segregated right-of-way</td>
<td>7</td>
</tr>
<tr>
<td>Intersection treatments</td>
<td>6</td>
</tr>
<tr>
<td>Passing lanes at stations</td>
<td>4</td>
</tr>
<tr>
<td>Minimizing bus emissions</td>
<td>4</td>
</tr>
<tr>
<td>Stations set back from intersections</td>
<td>3</td>
</tr>
<tr>
<td>Center stations</td>
<td>3</td>
</tr>
<tr>
<td>Pavement quality</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>MAX SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STATION DESIGN AND STATION-BUS INTERFACE</strong></td>
<td></td>
</tr>
<tr>
<td>Platform-level boarding</td>
<td>6</td>
</tr>
<tr>
<td>Safe and comfortable stations</td>
<td>3</td>
</tr>
<tr>
<td>Number of doors on bus</td>
<td>3</td>
</tr>
<tr>
<td>Docking bays and sub-stops</td>
<td>2</td>
</tr>
<tr>
<td>Sliding doors in BRT stations</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>MAX SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>QUALITY OF SERVICE AND PASSENGER INFORMATION SYSTEMS</strong></td>
<td></td>
</tr>
<tr>
<td>Branding</td>
<td>3</td>
</tr>
<tr>
<td>Passenger information</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>MAX SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INTEGRATION AND ACCESS</strong></td>
<td></td>
</tr>
<tr>
<td>Universal access</td>
<td>3</td>
</tr>
<tr>
<td>Integration with other public transport</td>
<td>3</td>
</tr>
<tr>
<td>Pedestrian access</td>
<td>3</td>
</tr>
<tr>
<td>Secure bicycle parking</td>
<td>2</td>
</tr>
<tr>
<td>Bicycle lanes</td>
<td>2</td>
</tr>
<tr>
<td>Bicycle-sharing integration</td>
<td>1</td>
</tr>
</tbody>
</table>

**TOTAL**                                                                 | **100**   |
**TEEMP BRT Model Uses BRT Standard Scorecard**

With deductions for elements contributing to poor performance

<table>
<thead>
<tr>
<th>POINT DEDUCTIONS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Low commercial speeds: minimum average commercial speed below 13 kph (8 mph)</td>
<td>-10</td>
</tr>
<tr>
<td>Peak passengers per hour per direction (pphpd) below 1,000</td>
<td>-5</td>
</tr>
<tr>
<td>Lack of enforcement of right-of-way</td>
<td>-5</td>
</tr>
<tr>
<td>Significant gap between bus floor and station platform</td>
<td>-5</td>
</tr>
<tr>
<td>Station encroaches on sidewalk or busway</td>
<td>-3</td>
</tr>
<tr>
<td>Overcrowding</td>
<td>-3</td>
</tr>
<tr>
<td>Poorly-maintained buses and stations</td>
<td>-3</td>
</tr>
<tr>
<td>Distances between stations too long or too short</td>
<td>-2</td>
</tr>
</tbody>
</table>

**BRT Standard**

- **Gold**: 85 points or above
- **Silver**: 70–84 points
- **Bronze**: 50–69 points
**Input Data**

- Construction Materials – Steel, Cement and Bitumen
- Ridership (Base, Intermediate and future year) – Ridership Calculator
- Trip length of BRT users
- Length of BRT line
- Average speed of modes
- Fuel Economy Annual Yearly Improvement (%)
- Fuel Economy (KMPH measured @ 50kmph speed) at Base Year
- Upstream effect of emissions due to fuel production
- Gasoline and Diesel emission factors
- Mode share of BRT users in BAU case
- Emission factors for PM and NOx.
- Average Trip Length of modes in BAU
- Average Occupancy of Modes in BAU
- City Trip characteristics
- Fuel Split % of Vehicles
- Technology split %
- Motorized modeshift factor
- Public Transport and Intermediate Public Transport Mode Shift Factor
- Landuse factor
- BRTS – Component information - Running ways, stations, vehicles, service patterns, ITS application, BRT branding
Evaluates the impact of a multi-modal City Plan via:

- Scoring matrix for City Plan
- Current and projected city development and transport trends
- Proposed projects and investments
- Impacts in emissions, traffic deaths, time, and fuel saved
Also allows user to easily “revise” the project types, intensity, and timeline of for implementation of city plan to create “alternative scenarios” and evaluate marginal changes in costs and impact.
Final screen shows the range of possible impacts of the Transportation Plan in terms of emissions avoided, fatalities avoided, time saved, and fuel saved for the Transportation Plan scenario and the revised scenario compared to BAU.
Contextualizing projects in urban development patterns and linking to building energy efficiency

Source: Yang JIANG, Daizong LIU, Suping CHEN, Assessment Tools for China Low-Carbon-City Projects: From the CSTC’s Perspective, 2011