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

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

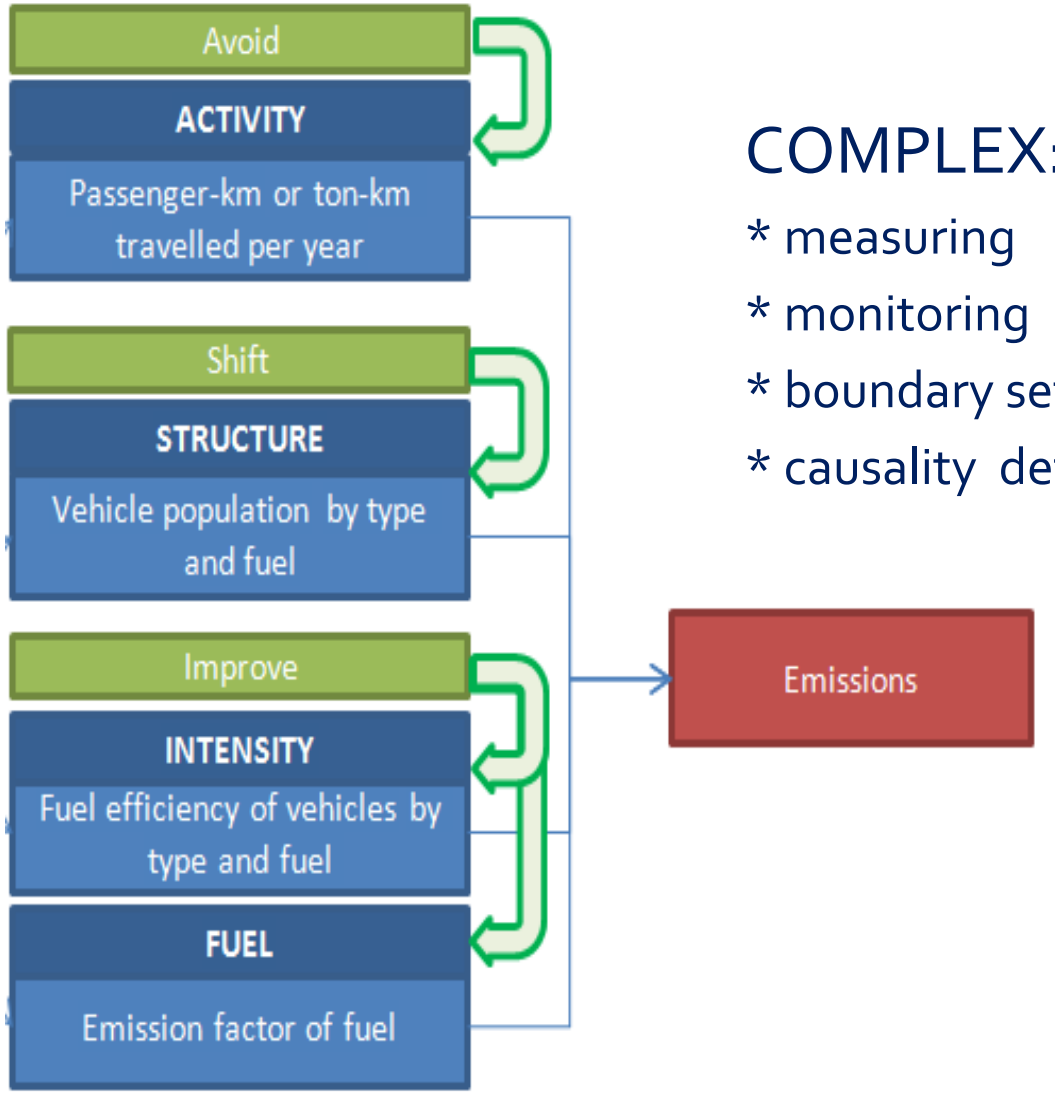
Palais de Nation, Geneva, Switzerland

24 April 2012

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

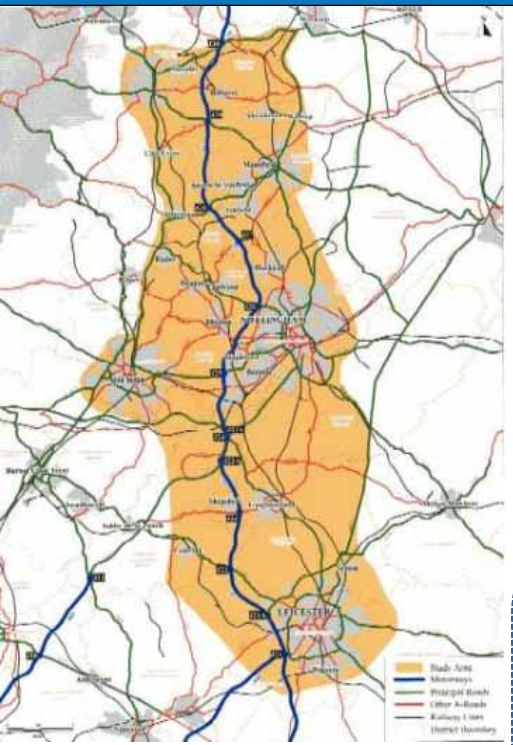
Plan & Region

Optimal scale to consider system impacts for metropolitan plans/programs

Nation

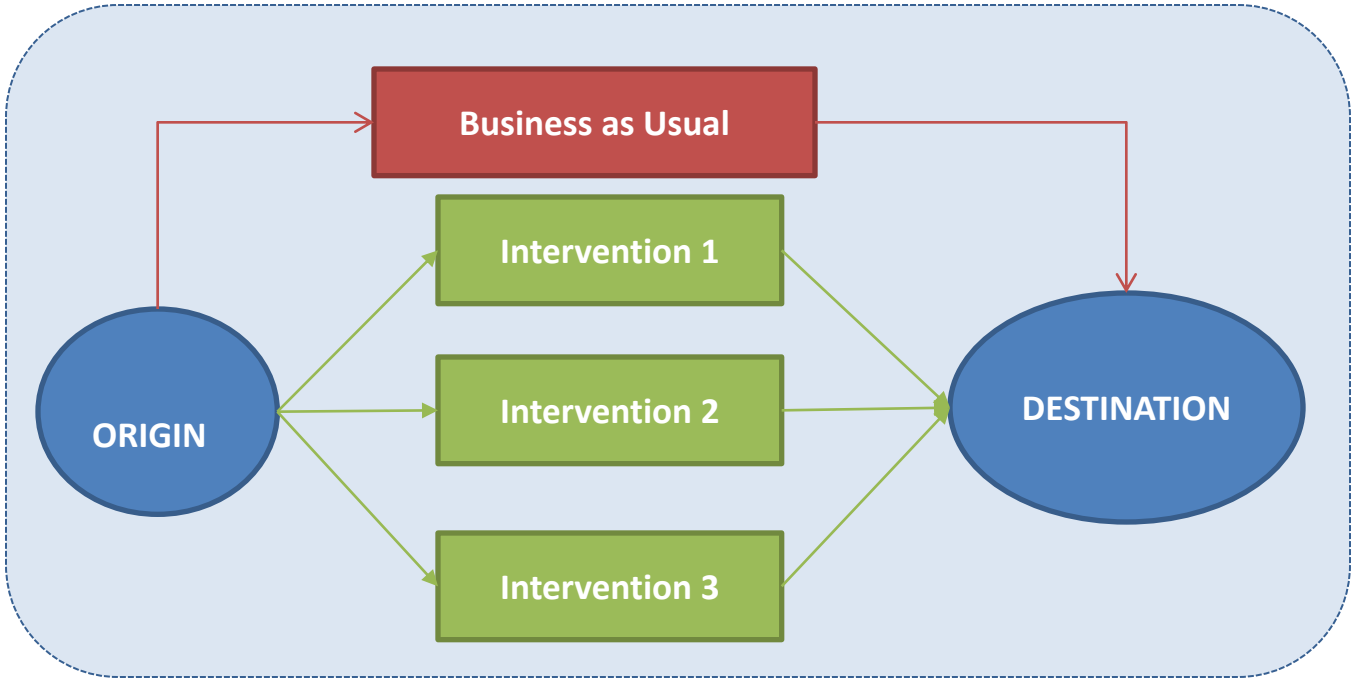
Often best for evaluating large networks and system policies

GHG Estimates Affected by Boundary Definitions



CDM BRT Analysis:
Impact area boundary defined spatially

TEEMP: Impact area defined by travel shed

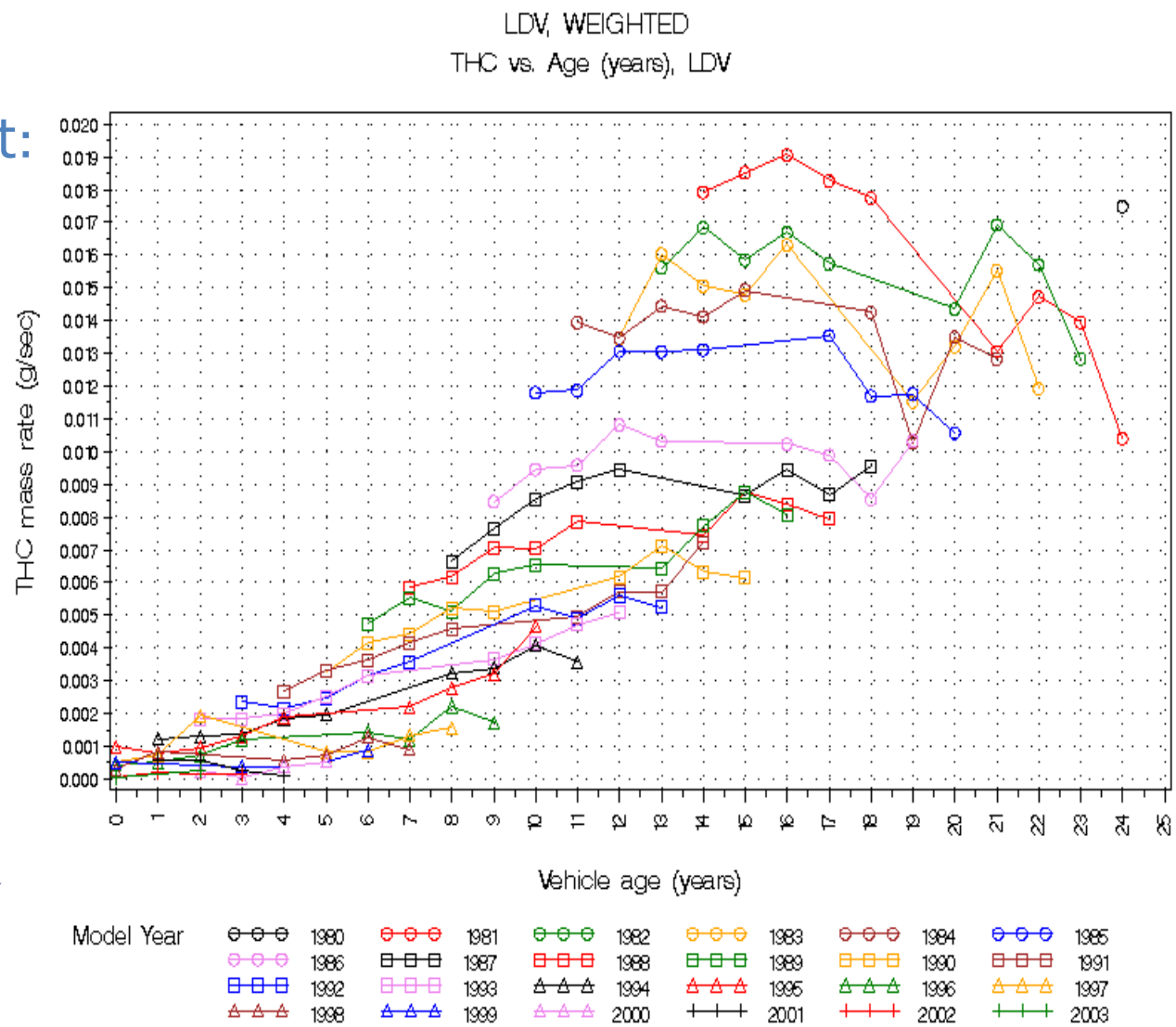


Sound GHG/Pollution Baselines Need Data

Motor vehicle fleet:

- Type
- Age
- Turnover rates
- Maintenance
- Fuel type
- Fuel quality
- Related emission factors

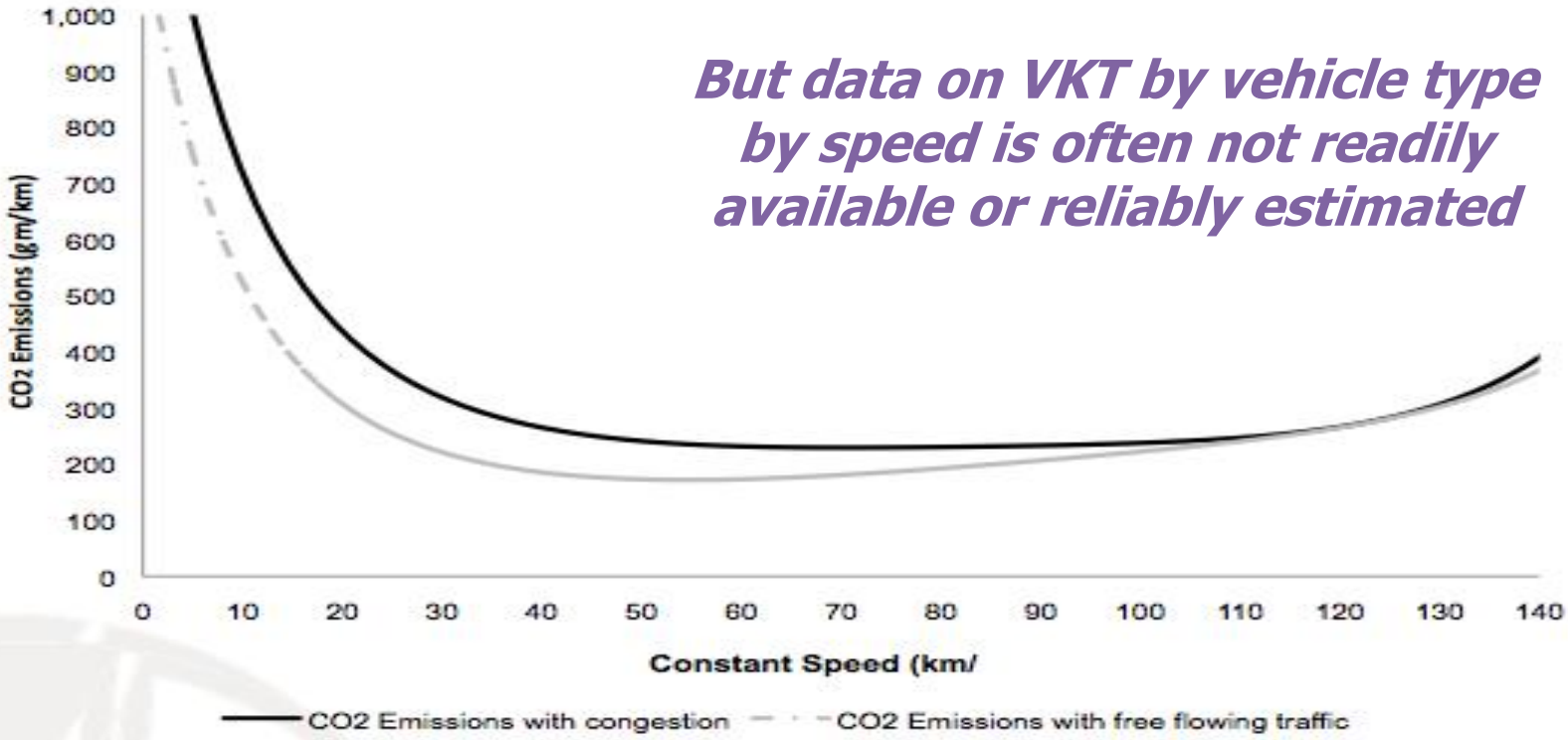
But this data is often not reliable or readily available



Sound GHG/Pollution Baselines Need Data

Motor vehicle operating conditions:

- temperature, altitude
- speed & smoothness of traffic flow

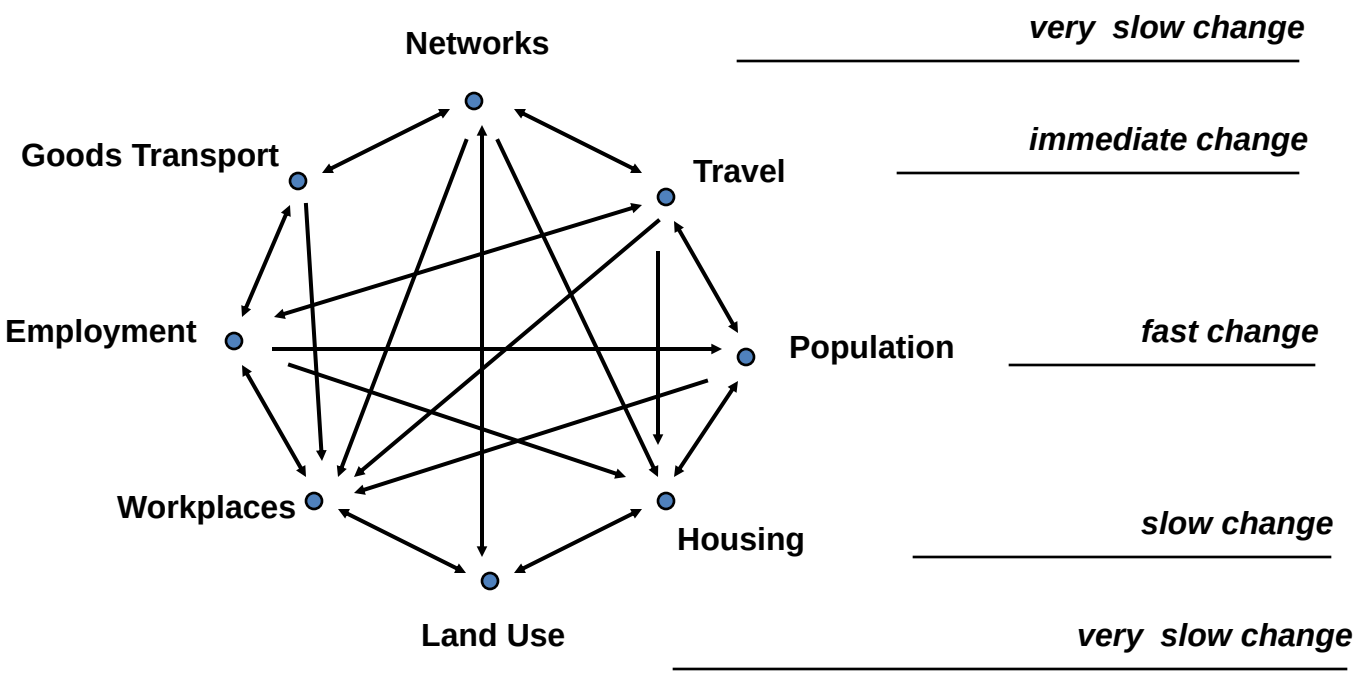


But data on VKT by vehicle type by speed is often not readily available or reliably estimated

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



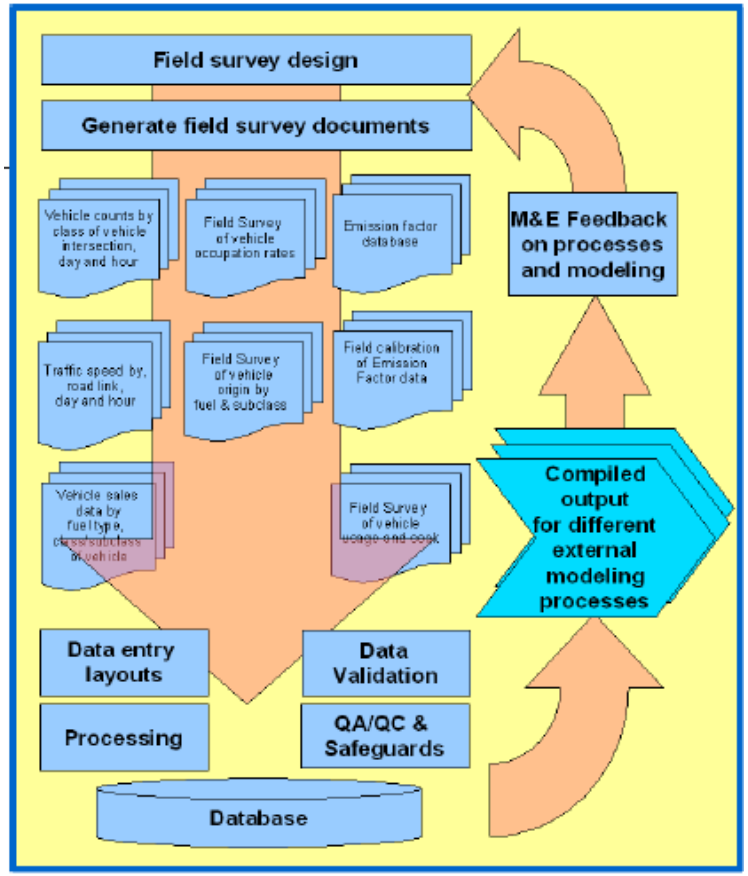
Getting models in place in most cities by 2020 is achievable and desirable goal, but sketch tools are valuable to fill gaps in the interim

Source: Wegener, 1995

Need to Invest in Transport Data & Analysis

Vehicle fleet activity analysis requires:

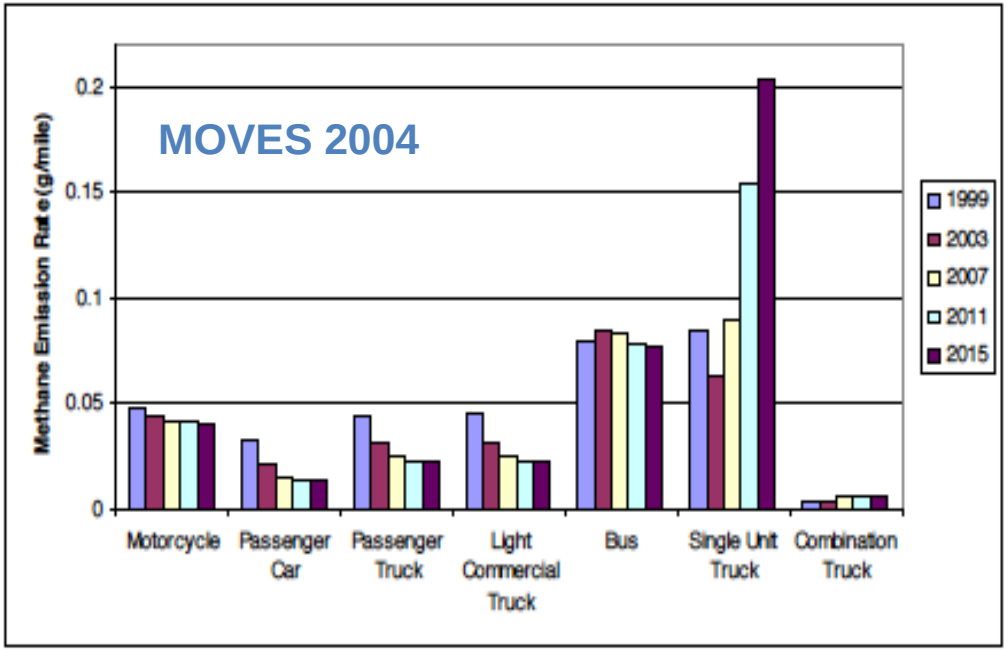
- Mode share and vehicle activity
- Travel surveys
- Bus company ridership
- Freight activity
- Traffic counts
- Vehicle sales data
- Motor fuels sales data
- Vehicle operating speeds
- GPS data loggers and vehicle monitors

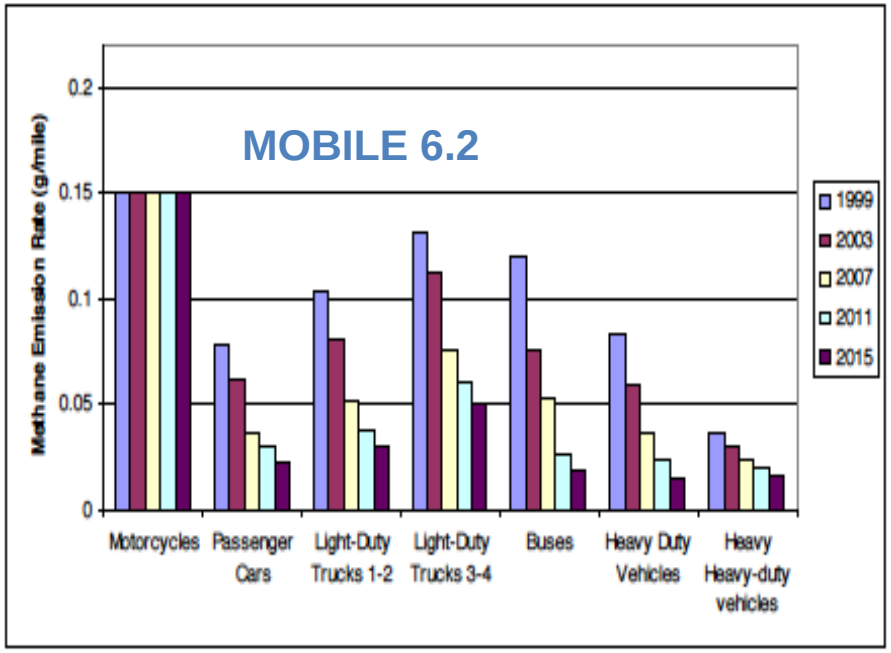


Transport Activity Measurement Toolkit - TAMT

Getting data for most cities by 2015-2020 is achievable and desirable goal, but sketch tools are valuable to fill gaps in the interim

High Variability Between Emission Factor Models



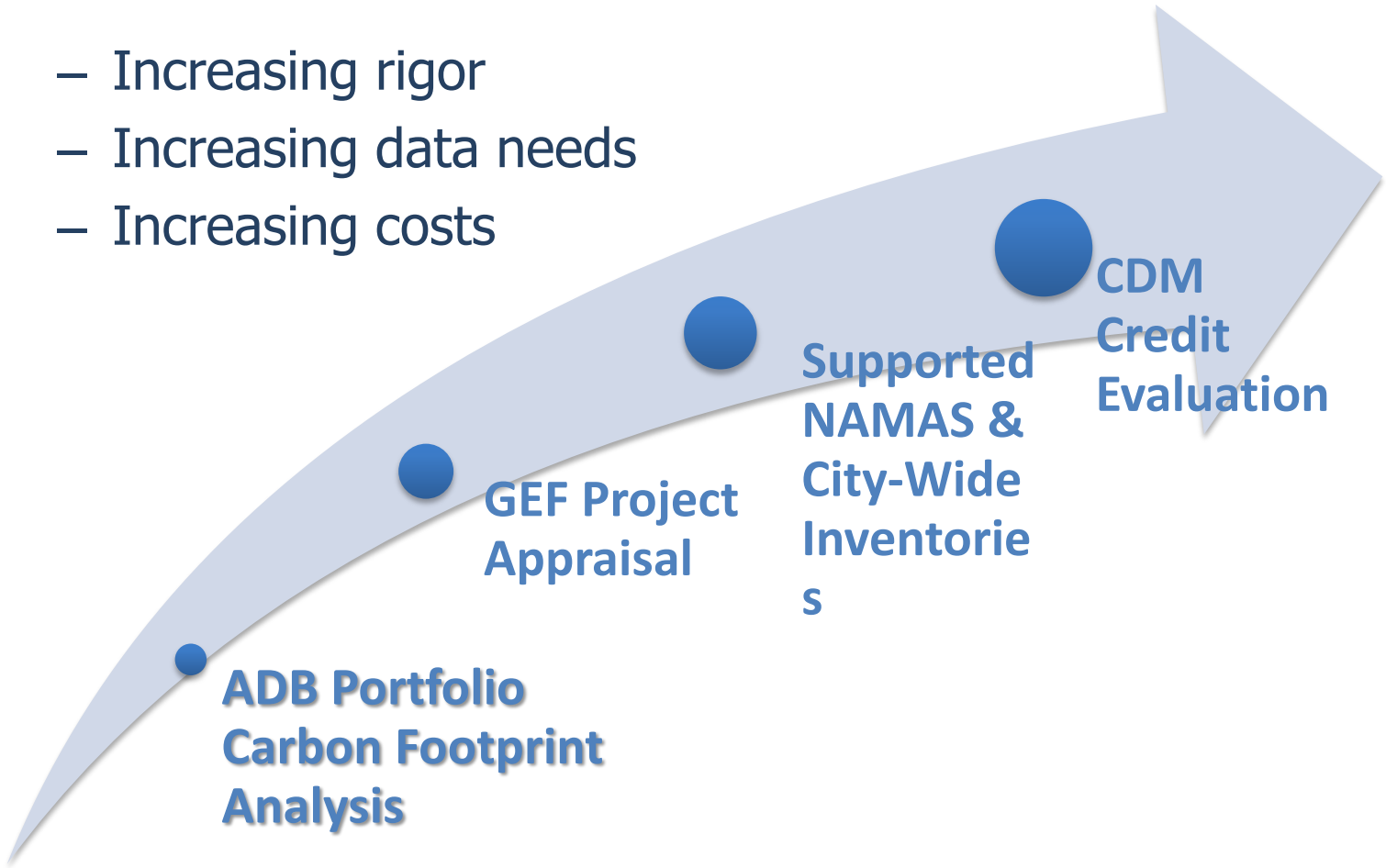


Different emission factor models show high variance in emission rates for same vehicle fleet with variation due to:

- 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



Good tools with defaults data go a long way

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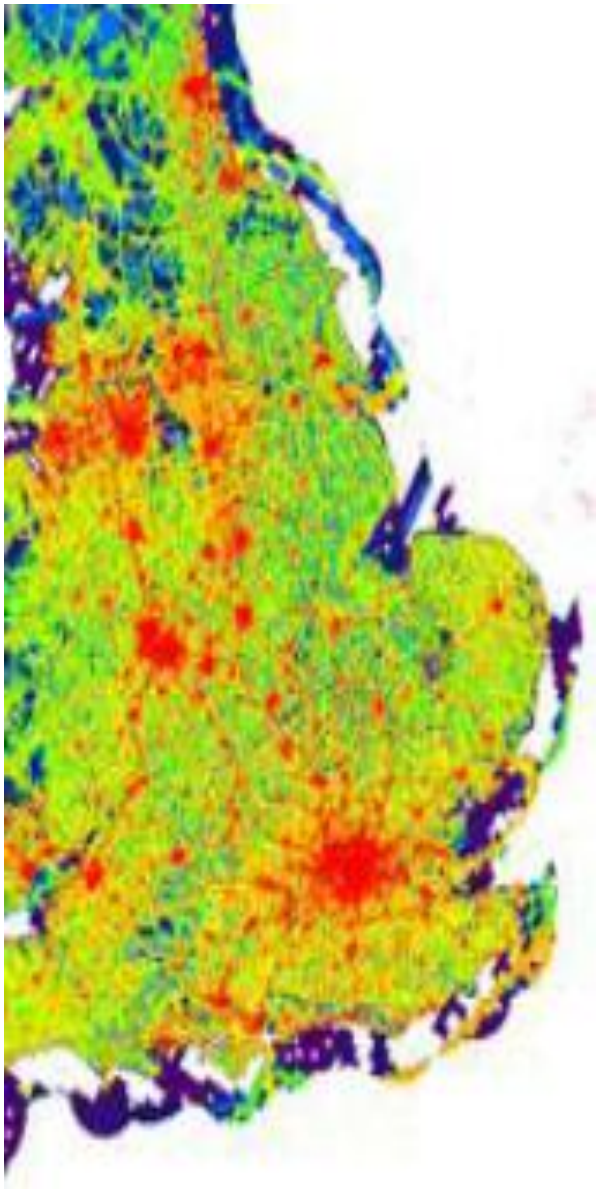
If one lacks good data, it's good to get started to support sound decisions using default data and appropriate policy-sensitive tools

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)

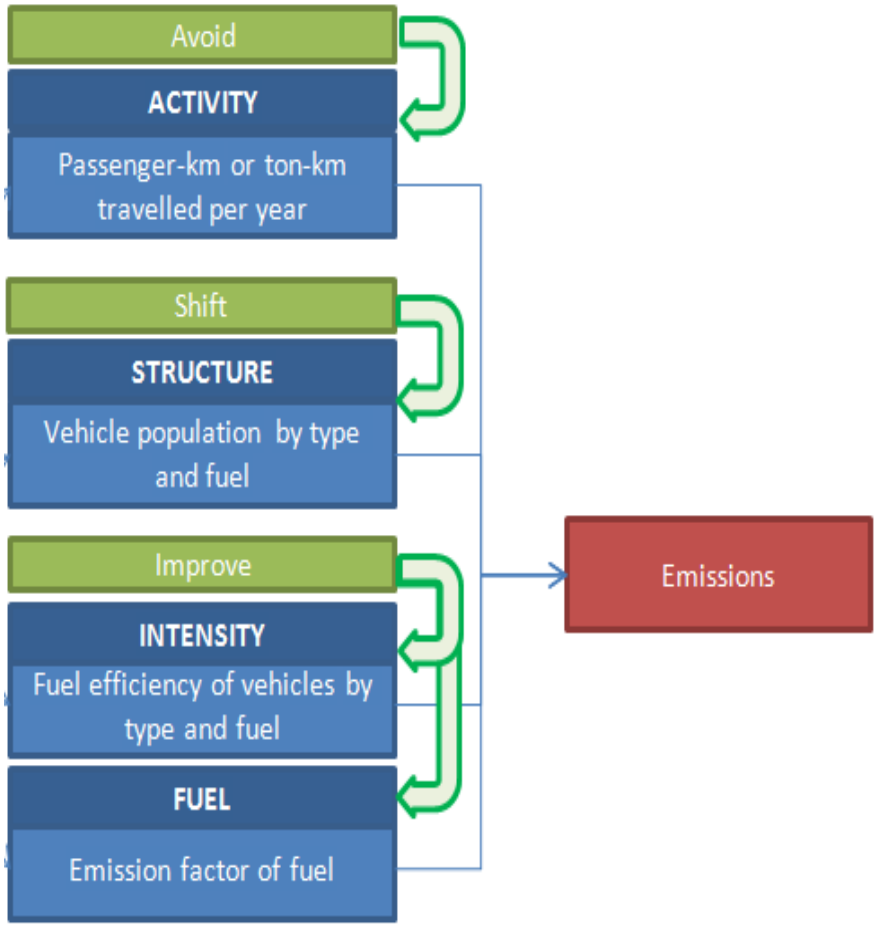
All models are wrong, but some are useful.

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**

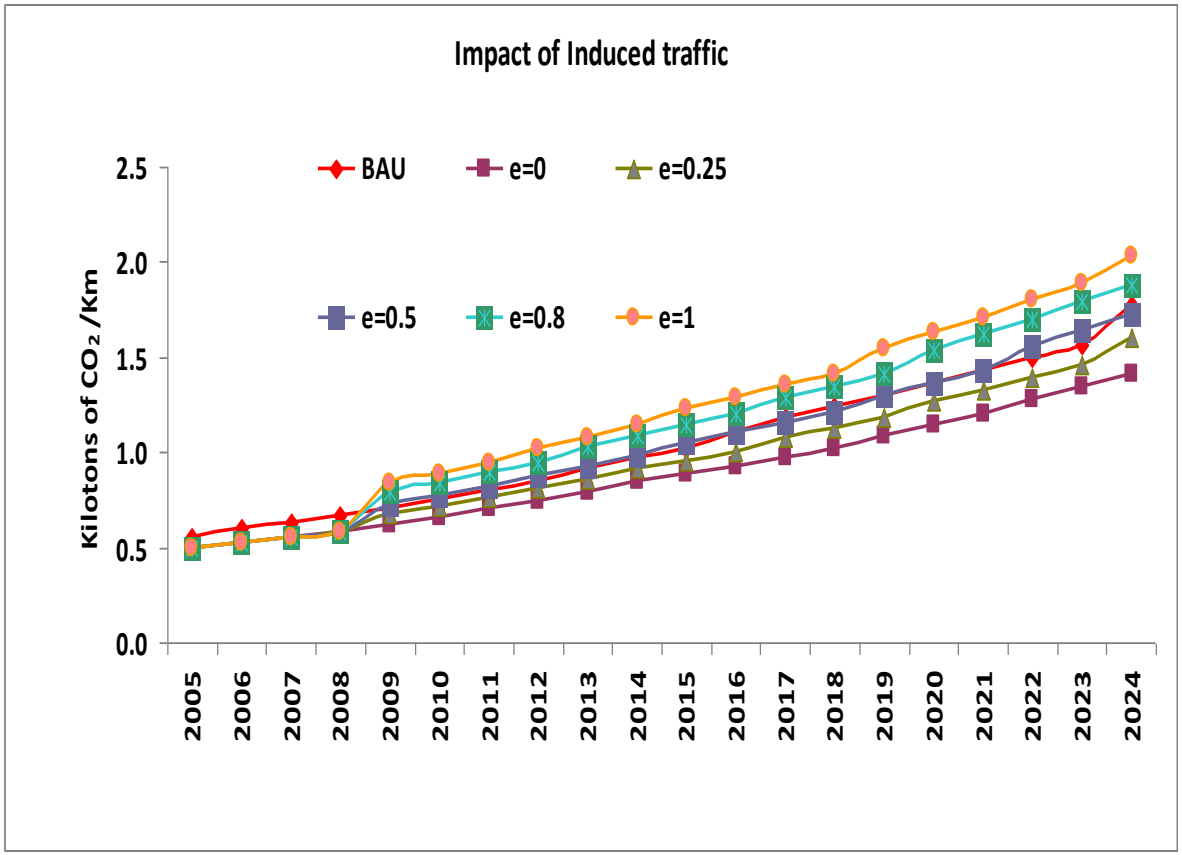
Introduction to TEEMP: what and why

- 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



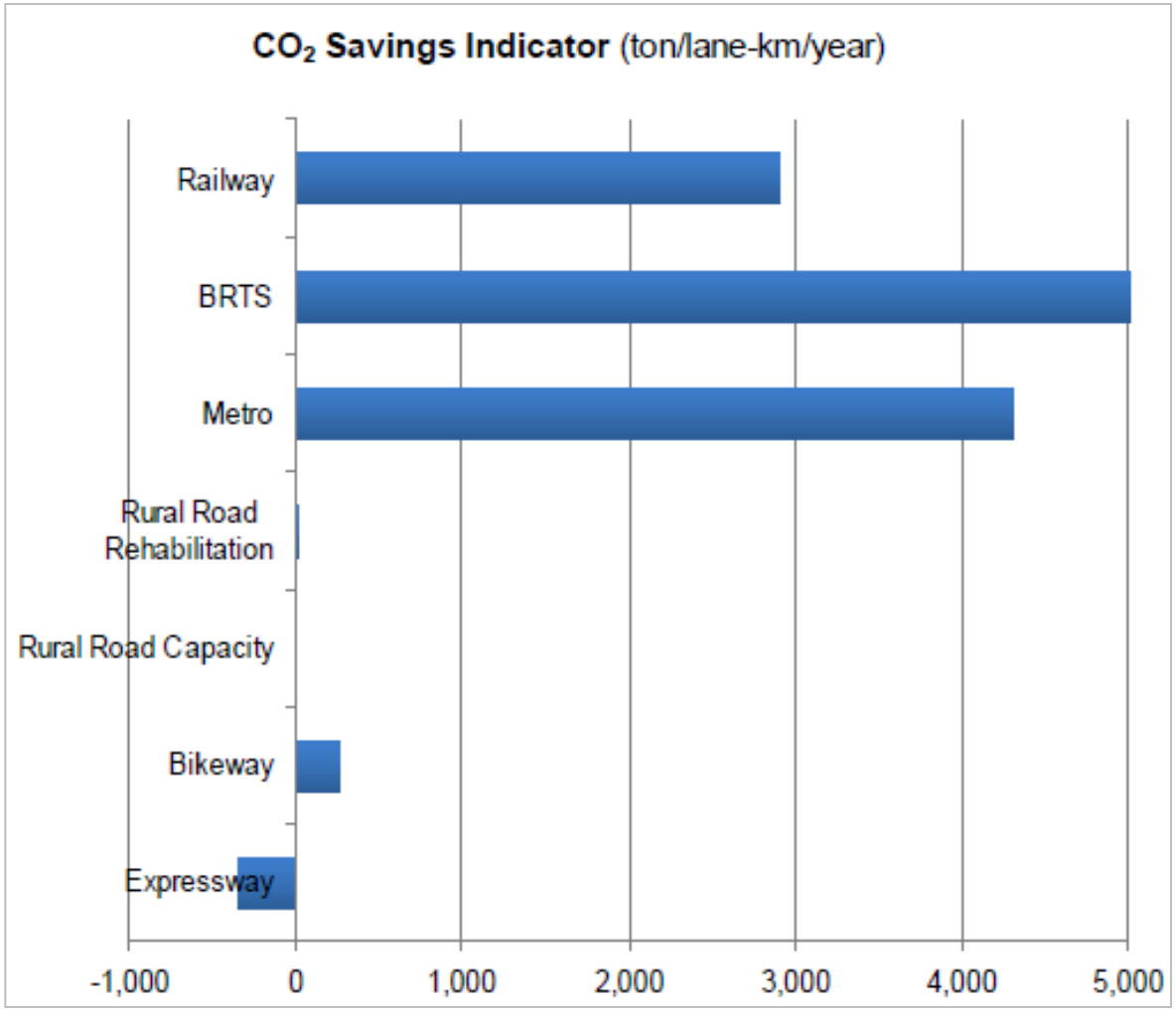
ADB: *Reducing Carbon Emissions from Transport Projects*

- 1st analysis with TEEMP: Asian Development Bank's transport portfolio of loans and grants approved during 2000–2009
- 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*

CO2 Tons Saved Per Kilometer per Lane Per Year

- Indicators by project type can be applied rapidly
- Most useful when applied to large bundle of projects
- Low level of precision

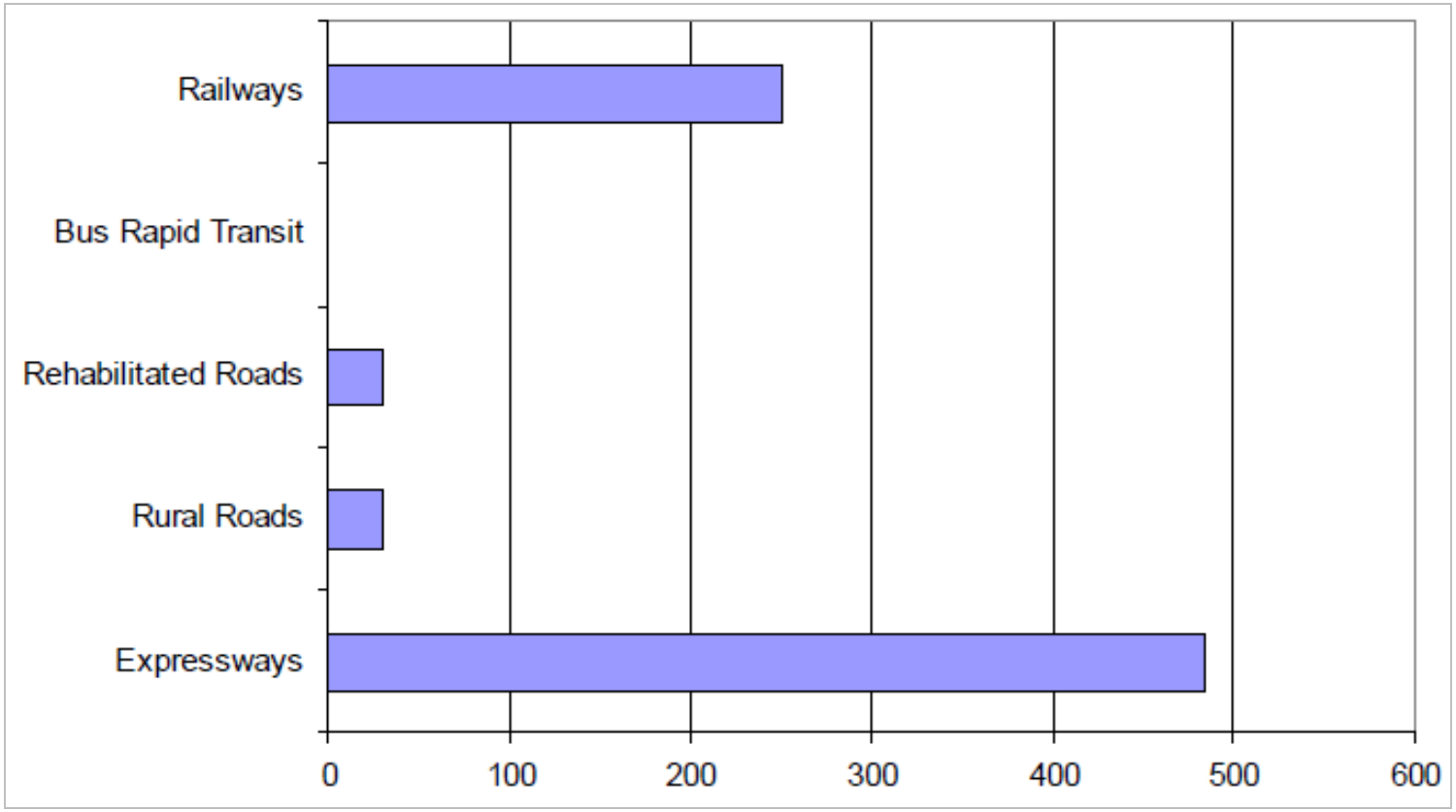


CO2 Tons Saved per Kilometer per Lane per Year

ADB Study Carbon Metrics: Project and Portfolio

- ***Gross CO_2 emissions:*** tons
- ***CO_2 intensity per unit of mobility:*** g/pass-km and g/ ton-km
- ***CO_2 intensity per dollar of investment***: tons/USD$
- ***Net no-build CO_2 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

ADB: *Reducing Carbon Emissions from Transport Projects*

- 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
- CO_2 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 CO_2, PM and NOx emissions
- Estimation of traffic fatalities, other co-benefits
- Can reflect "GEF-indirect" replication impacts

* Some models only

TEEMP: Separate Tools for Different Project Types

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

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

Activity	Number of trips Average Trip Lengths Average Speeds
Structure	Mode shares (%) Average occupancies Vehicle fuel split Vehicle emission standards split
Intensity	Fuel Efficiencies of vehicles
Fuel	Emission Factors

Run through of TEEMP: project scenario

Emissions from the construction of certain types of transport projects are significant and need to be considered in the emissions analysis

Amount of Materials Used

Emission Factors for Materials (embodied emissions)

Run through of TEEMP: project scenario

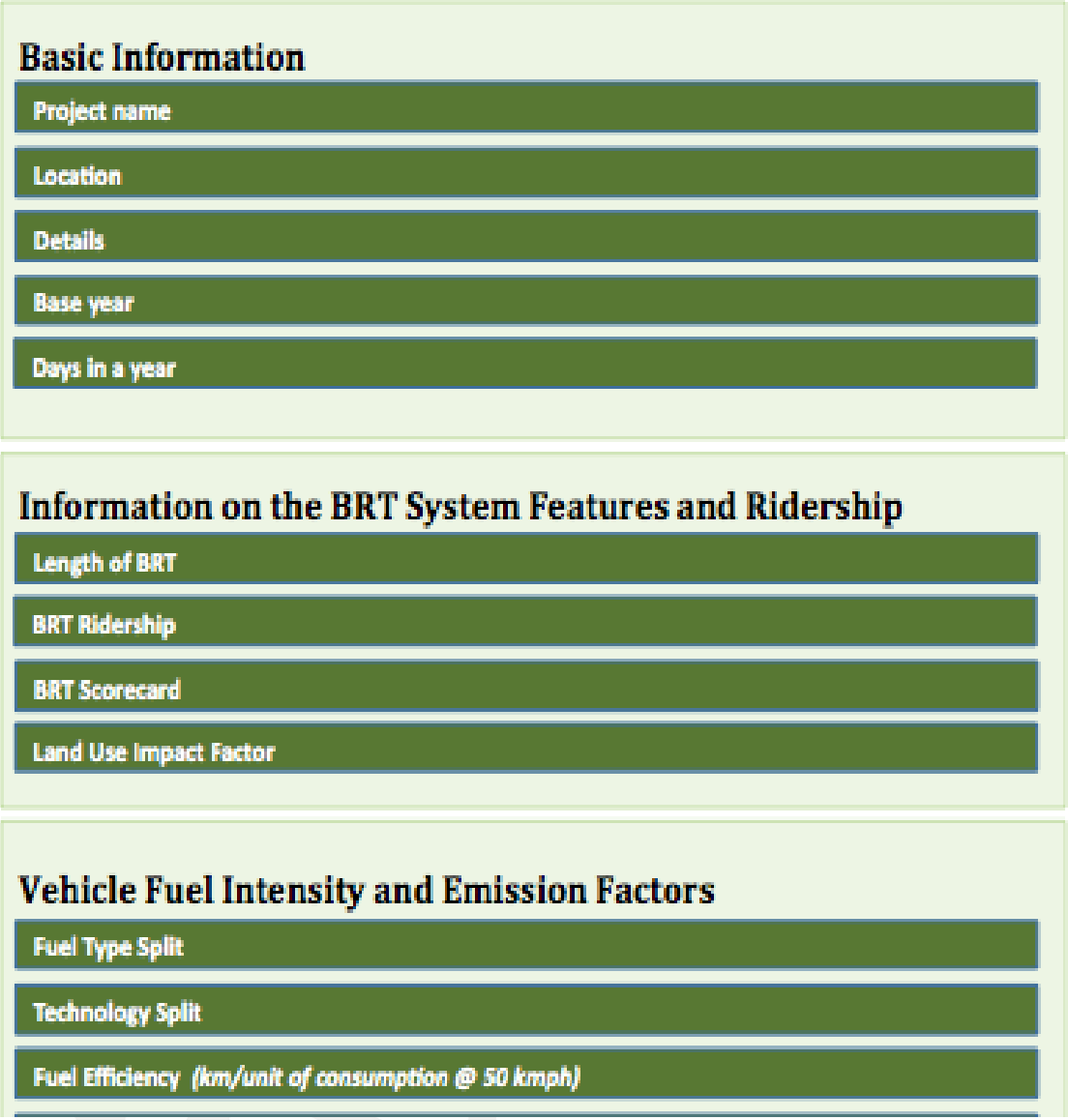
Emissions from the operation of some project types (e.g. electricity consumption from MRT operations) are considered as well

Amount of electricity used

Emission Factor of the Grid

Fuel used for Project Vehicles

TEEMP BRT Model (2012 version)



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

TEEMP Example: Bus rapid transit

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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

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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

CATEGORY	MAX SCORE
SERVICE PLANNING	
Off-board fare collection	7
Multiple routes	4
Peak frequency	4
Off-peak frequency	3
Express, limited, and local services	3
Control center	3
Located In top ten corridors	2
Hours of operations	2
Multi-corridor network	2
INFRASTRUCTURE	
Busway alignment	7
Segregated right-of-way	7
Intersection treatments	6
Passing lanes at stations	4
Minimizing bus emissions	4
Stations set back from intersections	3
Center stations	3
Pavement quality	2

	MAX SCORE
STATION DESIGN AND STATION-BUS INTERFACE	
Platform-level boarding	6
Safe and comfortable stations	3
Number of doors on bus	3
Docking bays and sub-stops	2
Sliding doors in BRT stations	1
QUALITY OF SERVICE AND PASSENGER INFORMATION SYSTEMS	
Branding	3
Passenger information	2
INTEGRATION AND ACCESS	
Universal access	3
Integration with other public transport	3
Pedestrian access	3
Secure bicycle parking	2
Bicycle lanes	2
Bicycle-sharing integration	1
TOTAL	**100**

TEEMP BRT Model Uses BRT Standard Scorecard

With deductions for elements contributing to poor performance

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

Gold: 85 points or above

Silver: 70–84 points

Bronze: 50–69 points

TEEMP Example: Bus rapid transit

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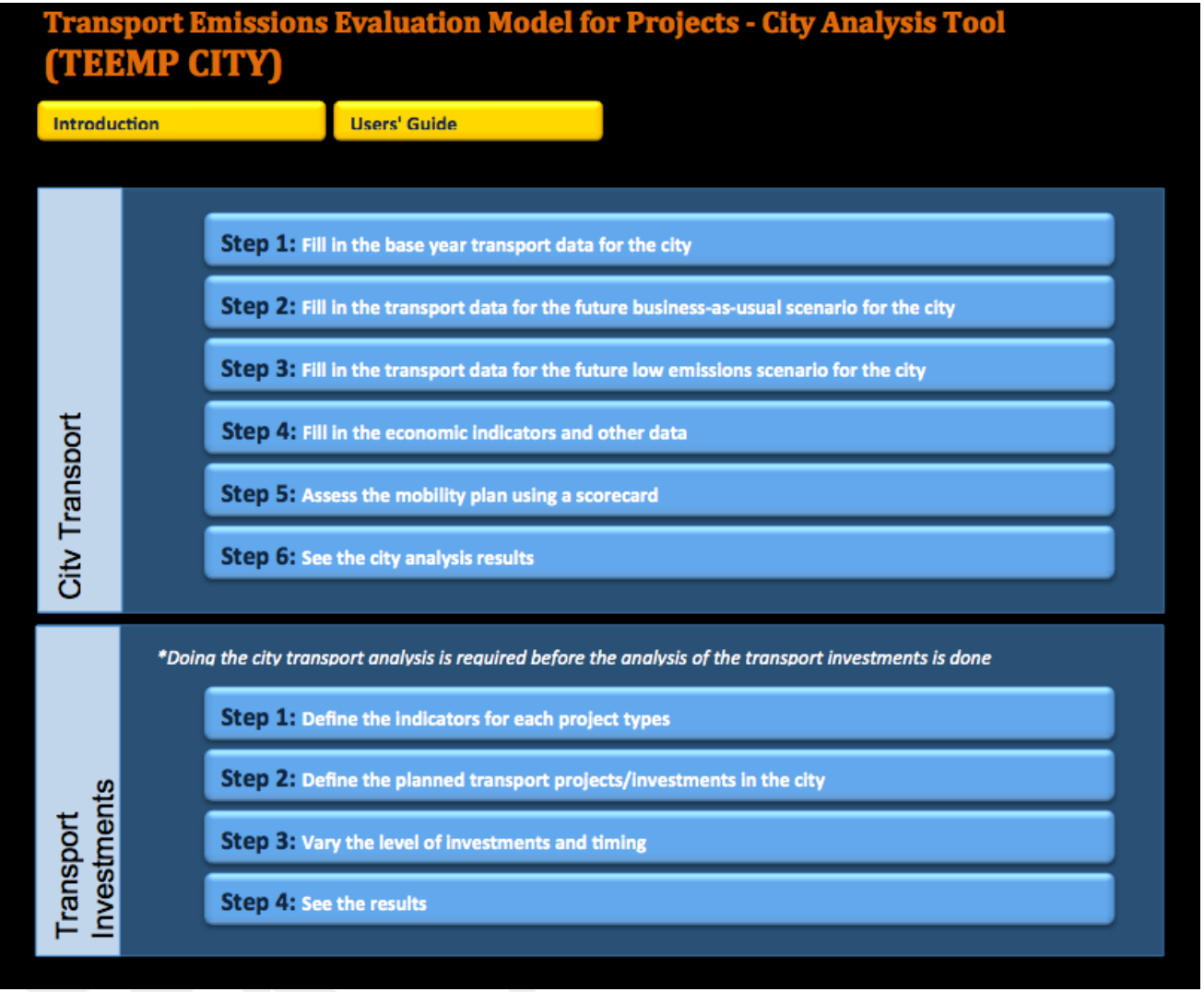
Input Data
• Construction Materials – Steel, Cement and Bitumen • Ridership (Base, Intermediate and future year) – Ridership Calculator • Trip length of BRT users • Length of BRT line • Average speed of modes • Fuel Economy Annual Yearly Improvement (%) • Fuel Economy (KMPL measured @ 50kmph speed) at 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

TEEMP City



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

Transport Project Investments Analysis: Emissions Impacts Calculator (2)

Vary the parameters for the original set of planned projects to see difference in the scale of impacts

TEEMP City

Name of Project	Project characteristics			Project Timeline		
	Original value	Revised Value	unit	Start of Operation- (Between 2009 to 2030)		
				Original Year	Revised Year	
Augmentation of Bus fleet	450	900	bus	2013	2013	
Augmentation of Bus fleet	100	200	bus	2019	2019	
Augmentation of Bus fleet	1,000	2,000	bus	2024	2024	
BRTS	93	186	km	2013	2013	
BRTS	65	130	km	2019	2019	
BRTS	7	14	km	2024	2024	
Metro/Monorail	48	49	km	2013	2013	
Metro/Monorail	26	22	km	2019	2019	
Metro/Monorail	36	30	km	2024	2024	
Bikeway	80	160	km	2019	2019	
Bikeway	80	160	km	2024	2024	
Pedestrian Walkway Improvement	2,000,000	4,000,000	$ investment	2013	2013	
Pedestrian Walkway Improvement	2,400,000	4,800,000	$ investment	2019	2019	
Urban Road 2 lane to 4 lane	100	38	km	2013	2013	
Urban Road 2 lane to 4 lane	100	36	km	2019	2019	
New Roads 4 lane	50	19	km	2013	2013	
New Roads 4 lane	80	34	km	2019	2019	
New Roads 4 lane	94	35	km	2024	2024	
Urban Road 4 lane to 6 lane	6	3	km	2013	2013	
Urban Road 4 lane to 6 lane	7	3	km	2019	2019	
Urban Road 4 lane to 6 lane	30	14	km	2024	2024	
Parking	5	7	parking terminal	2013	2013	
Parking	5	7	parking terminal	2019	2019	
Truck Terminals	400,000	548,000	$ investment	2013	2013	
Truck Terminals	800,000	1,104,000	$ investment	2019	2019	

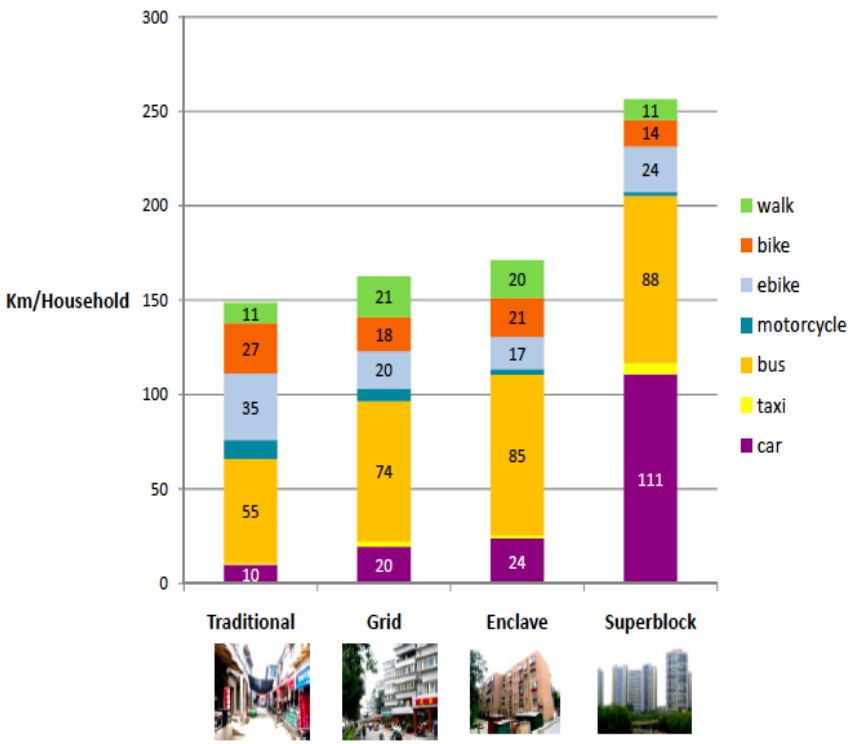
Also allows user to easily "revise" the project types, intensity, and timeline of for implementation of city plan to create "alternative scenarios" and evaluate marginal changes in costs and impact.

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.

Next Generation Tools

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



For more information

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