

如何利用模型计算交通排放

中国道路交通排放模型及其应用 China Road Transport Emission Model(HBFEA Expert Version)

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可持续交通项目，德国国际合作机构（GIZ）

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可持续交通在中国
SUSTAINABLE TRANSPORT IN CHINA



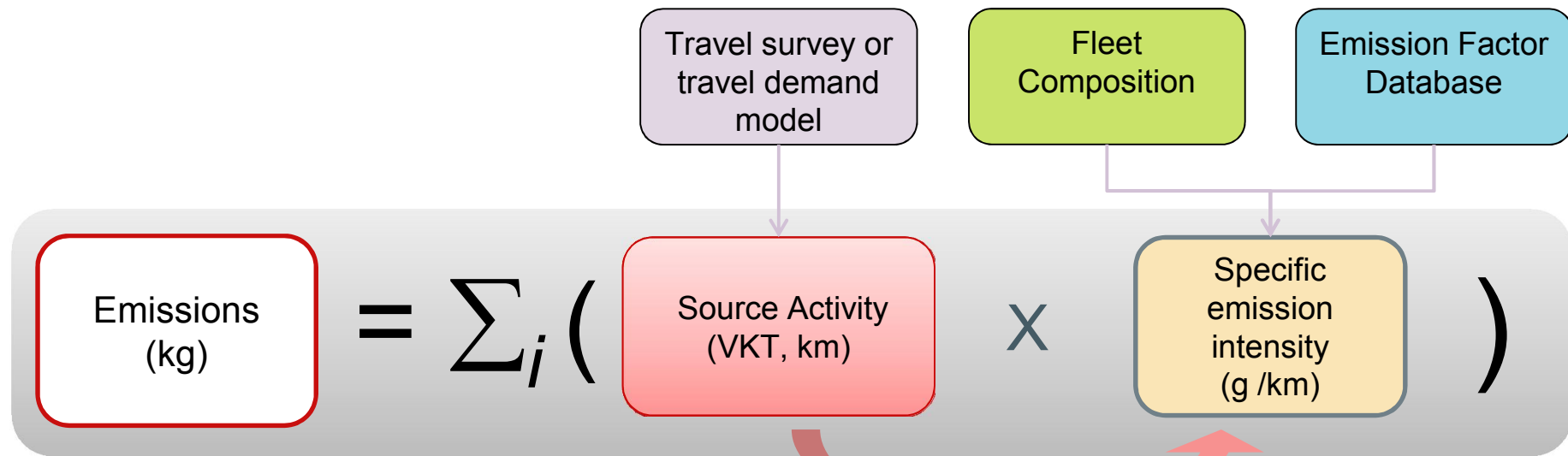


大纲Outline

- 欧洲道路交通排放因子手册 Handbook of Emission Factors in Road Transport(HBEFA)
- **HBEFA本地化技术思路** Approach to adapt HBEFA to China
- 交通排放计算工具 Emission quantification tool - software package



交通排放计算的基本公式

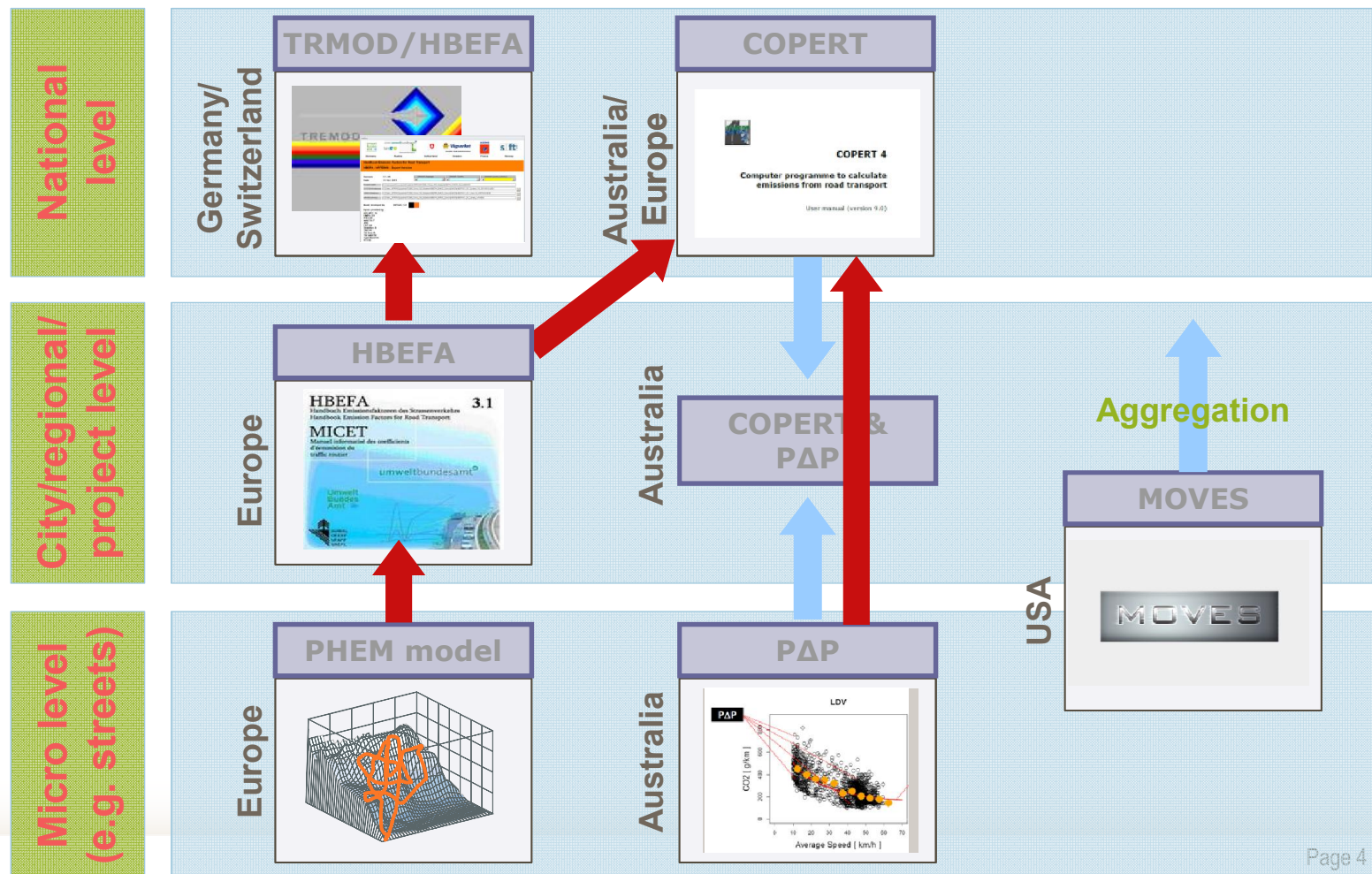


Where:

i : the type of activity, could be of multiple dimension



交通排放计算工具 Classification of different emission models used in Europe, Australia and USA



欧洲道路交通排放因子手册(HBEFA)



- HBEFA是由欧洲的数个国家联合开发的，包括德国、瑞士、奥地利、瑞典、挪威、法国等
- 1995年发布了第一版，此后在持续更新和完善，目前3.2版本
- HBEFA提供车辆热运行、冷启动和蒸发排放过程的排放因子。包括污染物排放因子、燃油消耗和二氧化碳排放因子等



HBEFA: Emission factors for different vehicle subsegments

Vehicle categories	Vehicle size	Fuel types	Emission Standards	Reduction technologies
Passenger Car	PC < 1.4 L	Gasoline	Pre Euro 1	Particle filter
Motorcycle	PC 1.4-2.0 L	Diesel	Euro 1	SCR
Urban bus	PC > 2.0 L	LPG	Euro 2	EGR
Coaches	Truck ≤ 7.5 t	CNG	Euro 3	...
Light duty veh.	Truck 7.5-12 t	FFV	Euro 4	
Single truck	Truck 12-14 t		Euro 5	
Truck trailer ¹⁾	...		Euro 6	

Abbreviations: PC = Passenger car; LPG = Liquefied Petroleum Gas; CNG = Compressed Natural Gas; FFV = Flexible Fuel Vehicles; SCR = Selective Catalytic Reduction; EGR = Exhaust Gas Recirculation

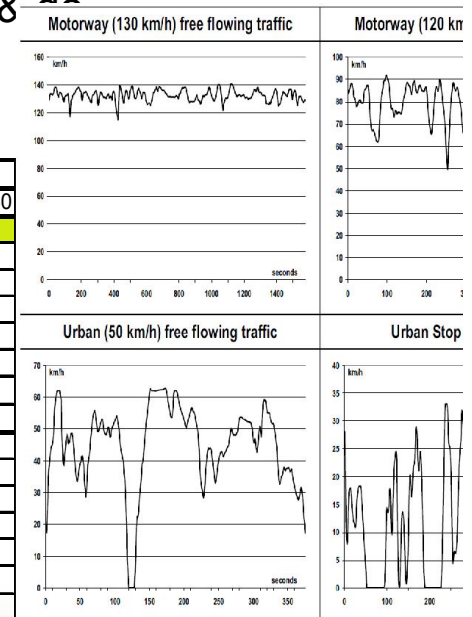
¹⁾ Including articulated vehicles.



HBEFA排放因子与交通运行工况关系密切

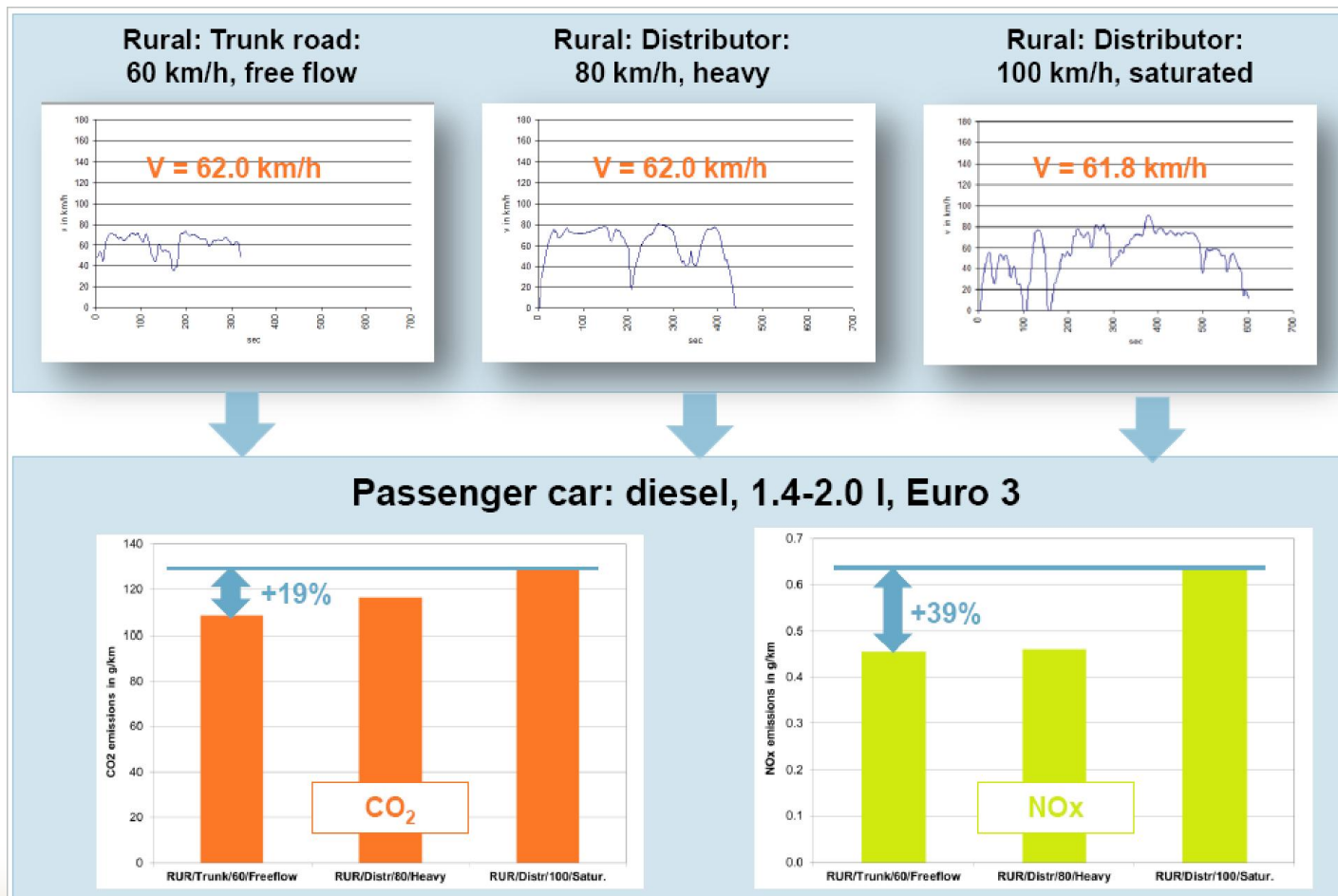
- **traffic situations** of HBEFA are categorised by:
 - › **areas:** urban/rural
 - › **road types:** e.g. motorway, trunk road
 - › **speed limits:** e.g. 50 km/h
 - › **levels of services:** free flow, heavy traffic, saturated, stop & go
- 276 different traffic situations (more than 120 for urban areas)

Area	Road type	Levels of service	Speed Limit [km/h]											
			30	40	50	60	70	80	90	100	110	120	130	>130
Rural	Motorway-Nat.	4 levels of service												
	Semi-Motorway	4 levels of service												
	TrunkRoad/Primary-Nat.	4 levels of service												
	Distributor/Secondary	4 levels of service												
	Distributor/Secondary(sinuous)	4 levels of service												
	Local/Collector	4 levels of service												
	Local/Collector(sinuous)	4 levels of service												
	Access-residential	4 levels of service												
Urban	Motorway-Nat.	4 levels of service												
	Motorway-City	4 levels of service												
	TrunkRoad/Primary-Nat.	4 levels of service												
	TrunkRoad/Primary-City	4 levels of service												
	Distributor/Secondary	4 levels of service												
	Local/Collector	4 levels of service												
	Access-residential	4 levels of service												
	Access-residential	4 levels of service												

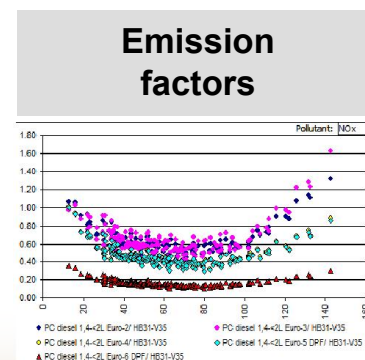
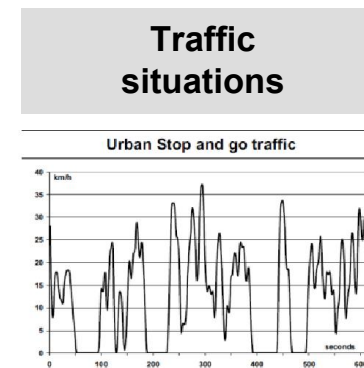
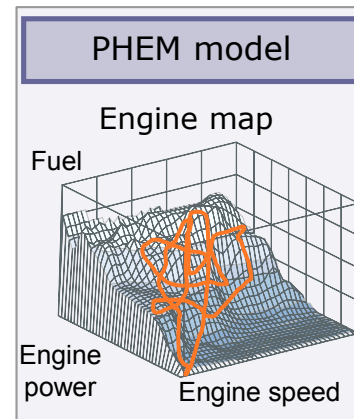




Emission factors only based on average speed are not sufficient for detailed analyses

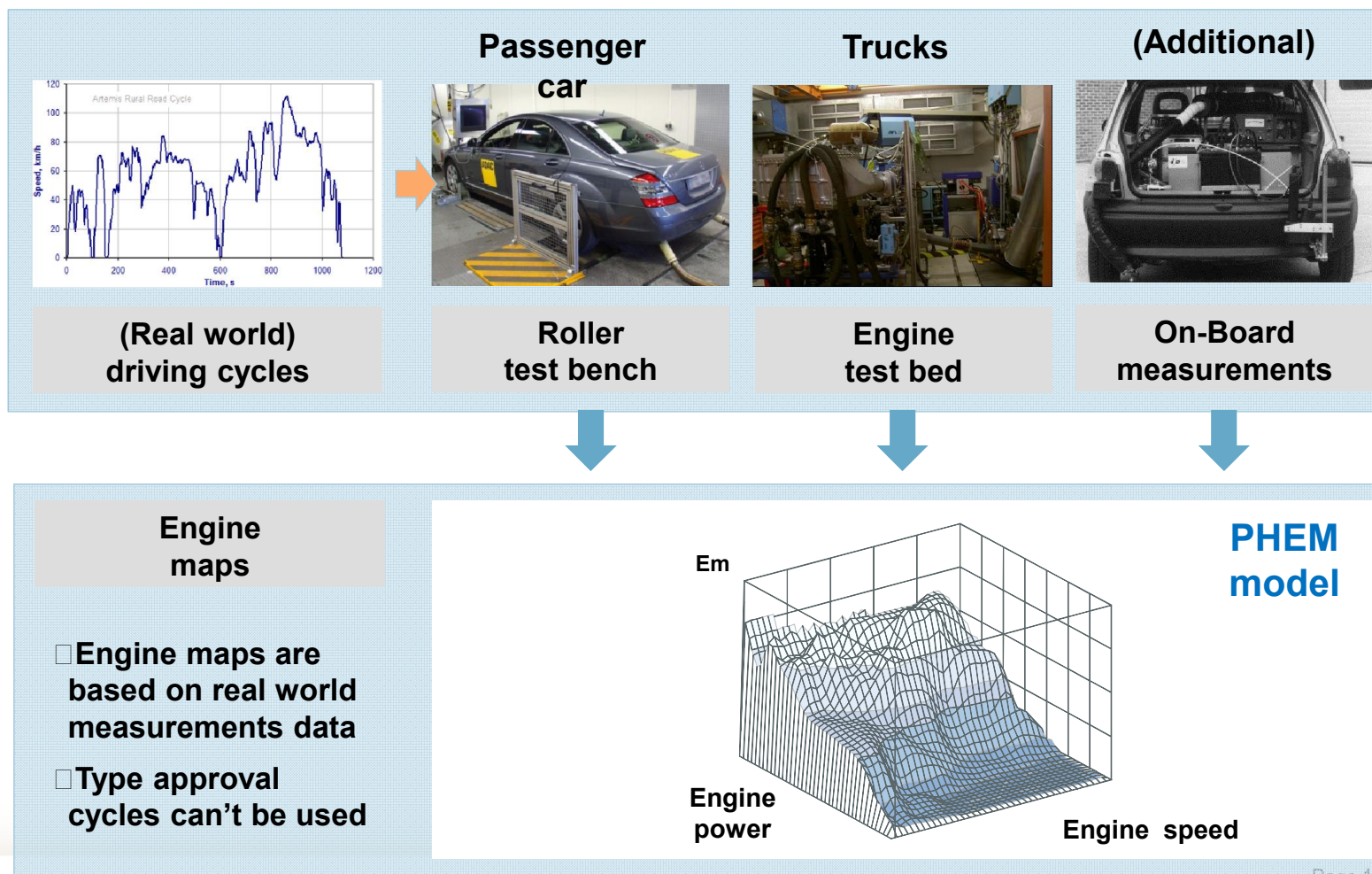


HBEFA approach: Calculation of emission factors for all traffic situations using the PHEM model



- approach is also feasible for other countries
- existing engine maps (particularly for CO₂) can be used for the calculation of emission factors based on local traffic situations

PHEM模型 (Passenger car and Heavy duty Emission Model) in detail



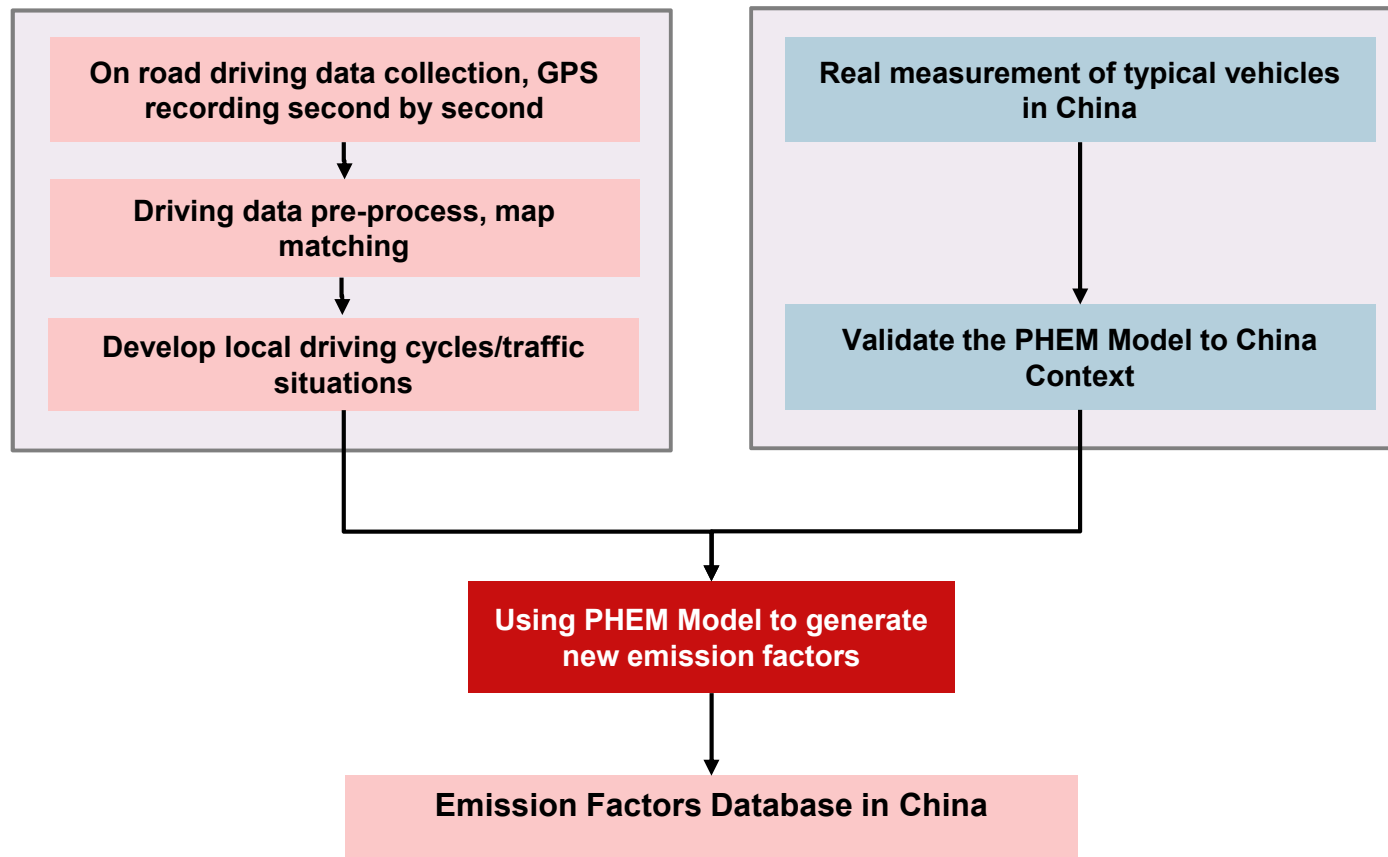


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HBEFA本地化的技术思路 Approach to Localize HBEFA





Specification of Traffic Situations in China

Considering the on road traffic conditions and network performance in Beijing, traffic situations was specified as:

- 5 road type: Highway, Expressway, Major Arterial, Minor Arterial, and Branch Road
- Speed limit for each road type
- 5 Level of Service (comparing to 4 LOS in HBEFA)

Level of service	LOS 1: Free flow	LOS 2: Saturated traffic	LOS 3: Heavy traffic	LOS 4: Stop and go	LOS 5: Heavy stop and go
Congestion level	Unimpeded	Basically Unimpeded	Mild congestion	Moderate congestion	Severe congestion
Unit	km/h	km/h	km/h	km/h	km/h
Highway/Expressway	>55	40-55	30-40	20-30	≤20
Major arterial	>44	30-40	20-30	15-20	≤15
Minor arterial	>35	25-35	15-25	10-15	≤10
Branch	>35	25-35	15-25	10-15	≤10





机动车行驶数据采集 On Road Driving Data Collection

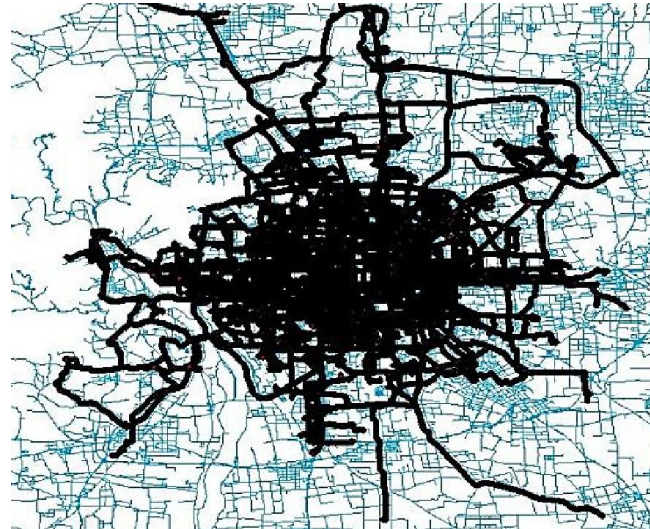
- GPS transmitters were applied to record real road vehicle movements.
- Measurements are made second by second (1 Hz)
- GPS data was collected in both Beijing and Shenzhen with a total of more than 2000 hours of driving data

GPS receiver





地图匹配 Map Matching to identify road type



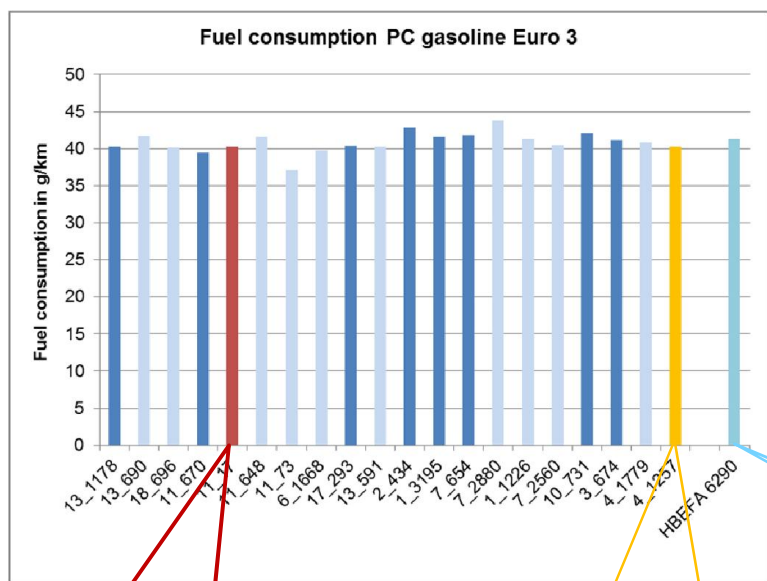
Beijing TRC floating car system was applied as a tool to conduct map matching



Descriptive statistical driving cycle data

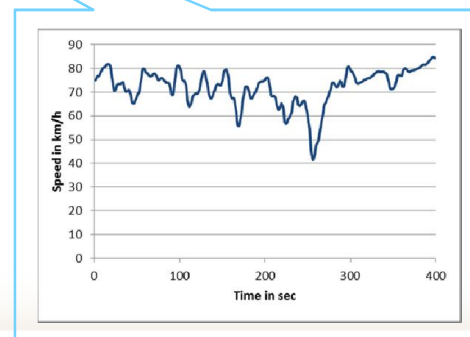
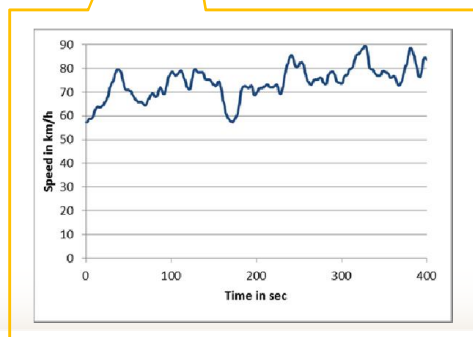
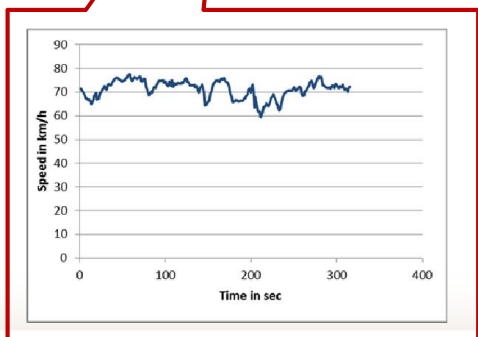
	Cell count	Dist(km)	Total time(h)	Average weighted by distance		
				Speed (km/h)	RPA (m/s ²)	Stop time (%)
Branch	1436	1804.30	138.52	21.41	0.17	25.7%
Expressway	1631	5916.15	170.78	45.43	0.14	4.9%
Expressway sideroad	1132	2083.92	92.18	31.68	0.17	16.8%
Highway	559	2683.08	75.59	54.18	0.13	9.4%
Major Arterial	1997	3919.51	202.59	28.14	0.19	33.3%
Minor Arterial	1836	2787.30	169.23	21.68	0.19	29.4%
National Highway	25	55.26	2.24	25.54	0.19	27.4%
Provincial Highway sideroad	26	73.60	2.54	35.16	0.17	19.6%
	180	201.20	14.01	20.26	0.20	37.4%
SUM	8822	19524.32	867.68			

Identification and Selection of Typical Cycles



Legend:

- Untypical driving cycle
- Typical driving cycle (pre-selection)
- Selected driving cycle**
- Second best fitting driving cycle
- HBEFA driving cycle



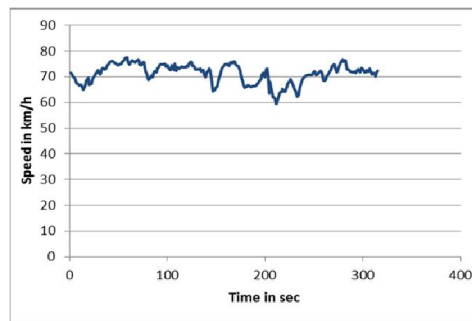
In principle HBEFA
cycle can be used

Selection of Chinese specific traffic situations -Expressway/Highway

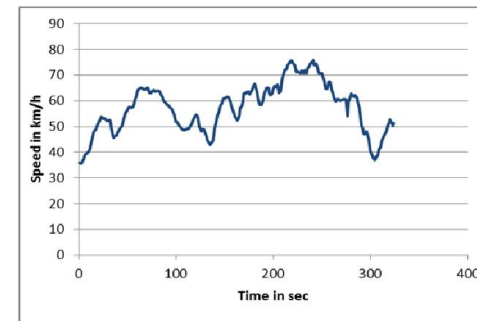
Key parameters:

	Average speed	RPA	% stop time
	km/h	m/s ³	%
LOS 1	71.2	0.09	0%
LOS 2	57.3	0.11	0%
LOS 3	42.3	0.13	1%
LOS 4	25.8	0.17	7%
LOS 5	12.0	0.17	26%

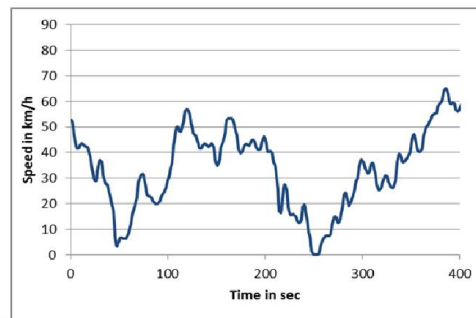
LOS 1: Free flow



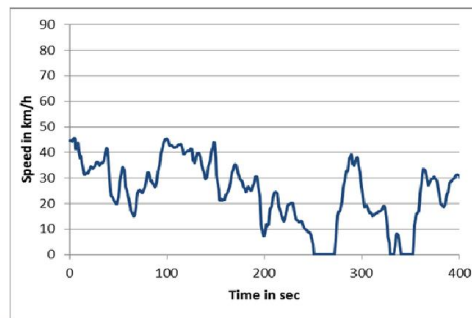
LOS 2: Heavy



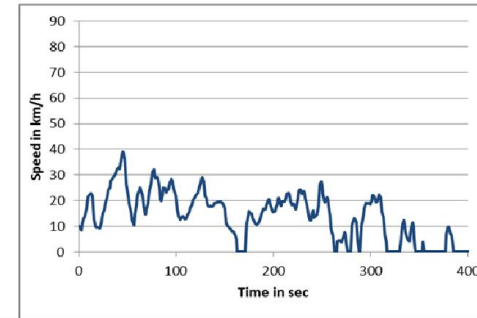
LOS 3: Saturated



LOS 4: Stop+go 1



LOS 5: Stop+go 2



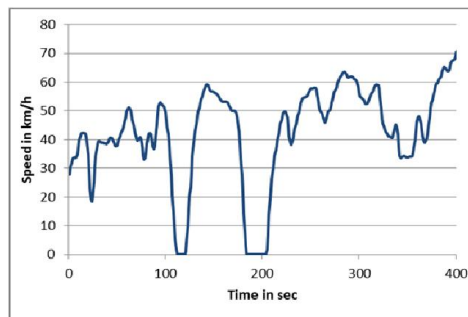
Selection of Chinese specific traffic situations

-Major Arterial

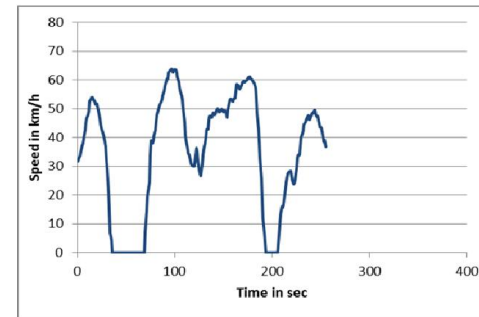
Key parameters:

	Average speed	RPA	% stop time
	km/h	m/s ³	%
LOS 1	49.8	0.17	5%
LOS 2	34.8	0.20	18%
LOS 3	24.2	0.20	28%
LOS 4	17.6	0.23	40%
LOS 5	8.4	0.21	62%

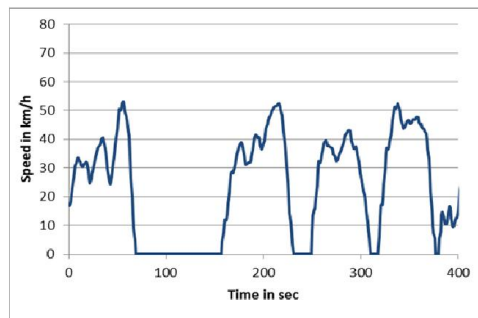
LOS 1: Free flow



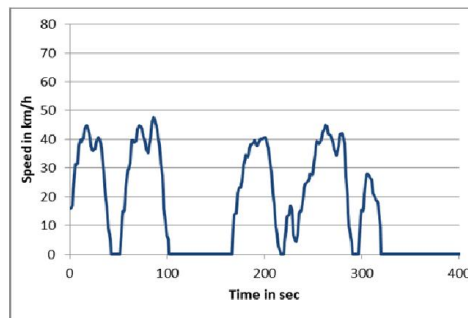
LOS 2: Heavy



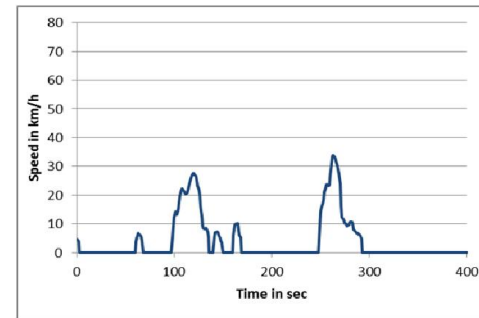
LOS 3: Saturated



LOS 4: Stop+go 1



LOS 5: Stop+go 2

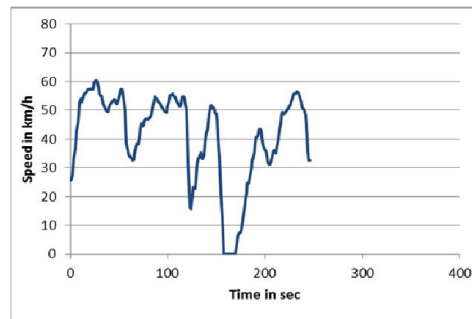


Selection of Chinese specific traffic situations -Minor Arterial

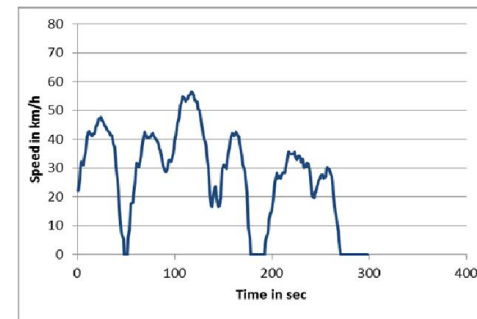
Key parameters:

	Average speed	RPA	% stop time
	km/h	m/s ³	%
LOS 1	41.0	0.19	5%
LOS 2	27.3	0.18	16%
LOS 3	18.8	0.19	27%
LOS 4	12.5	0.23	43%
LOS 5	5.3	0.20	65%

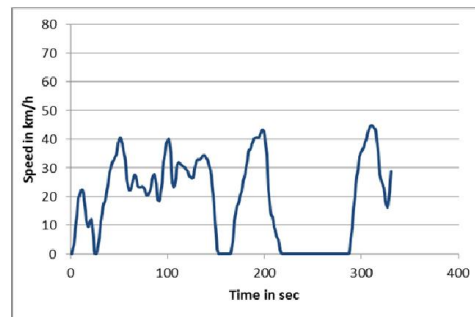
LOS 1: Free flow



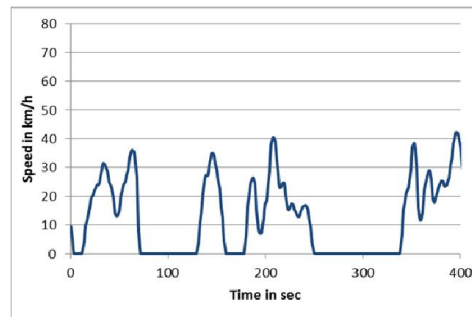
LOS 2: Heavy



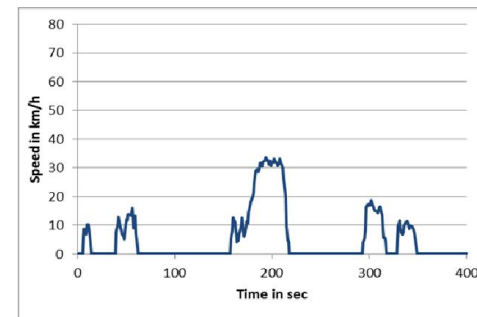
LOS 3: Saturated



LOS 4: Stop+go 1



LOS 5: Stop+go 2

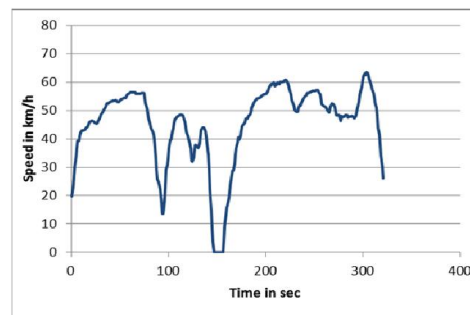


Selection of Chinese specific traffic situations -Branch

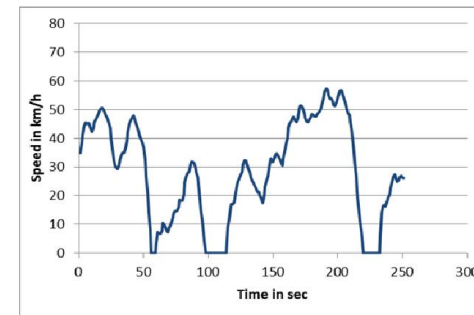
Key parameters:

	Average speed	RPA	% stop time
	km/h	m/s ³	%
LOS 1	45.7	0.12	3%
LOS 2	28.5	0.20	14%
LOS 3	19.6	0.19	21%
LOS 4	11.9	0.19	27%
LOS 5	4.5	0.18	60%

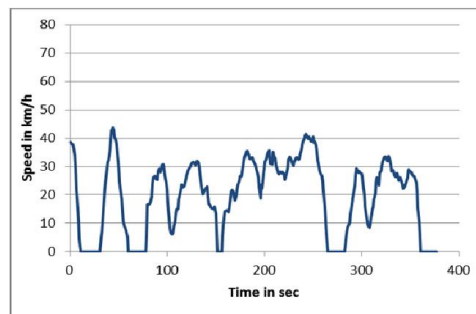
LOS 1: Free flow



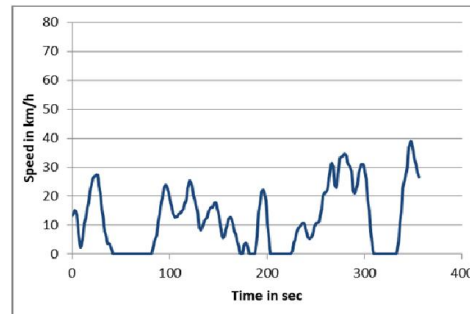
LOS 2: Heavy



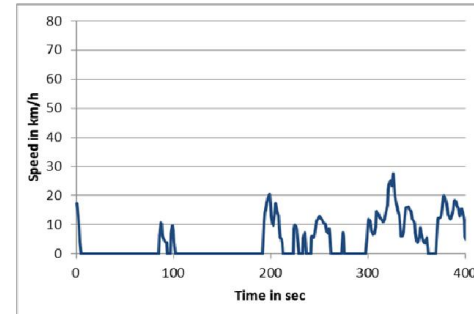
LOS 3: Saturated



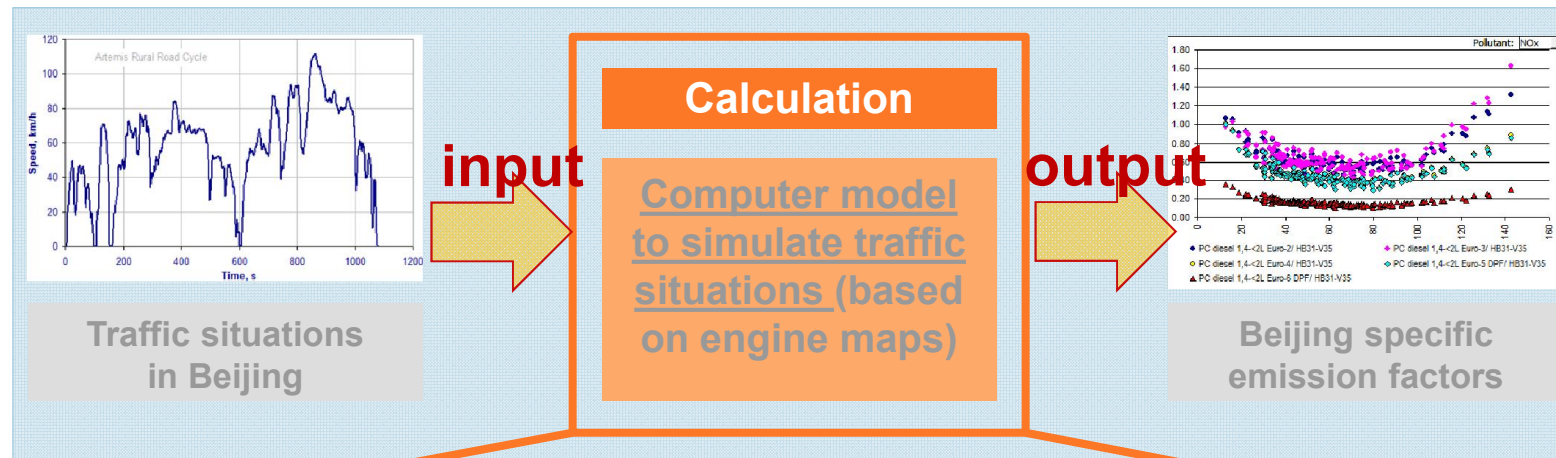
LOS 4: Stop+go 1



LOS 5: Stop+go 2



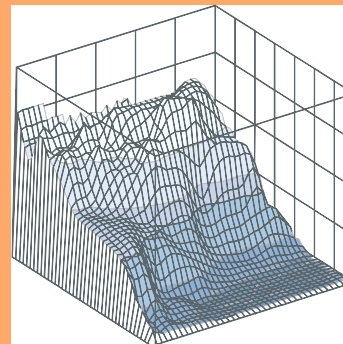
生成本地化的排放因子 Generate localized emission factors



Computer simulation



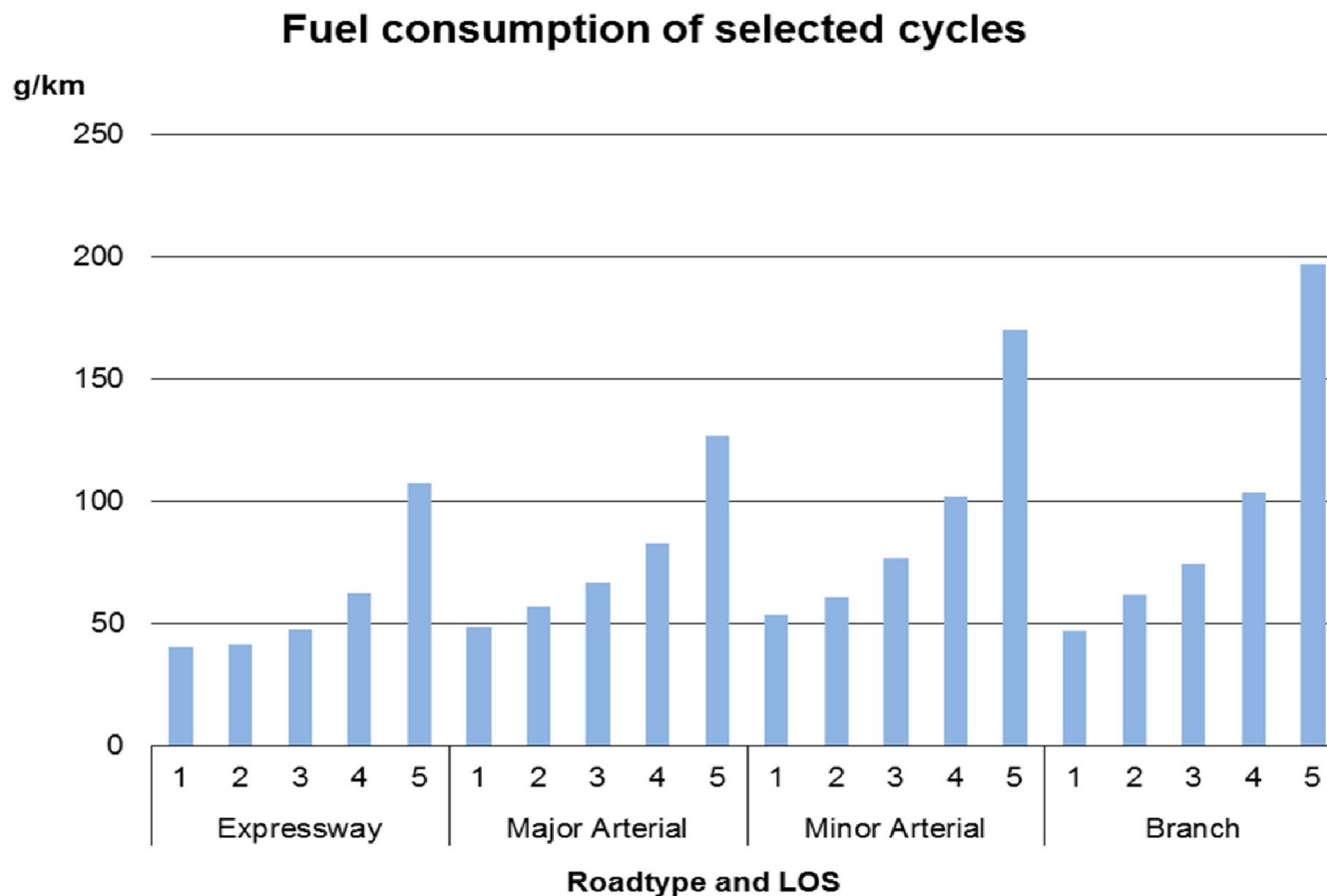
Engine map



- › PHEM model: calculation of engine maps for fuel consumption based on measurement data
- › simulation of emission factors based on new traffic situation by using the engine map
- › methodology of HBEFA 3.1

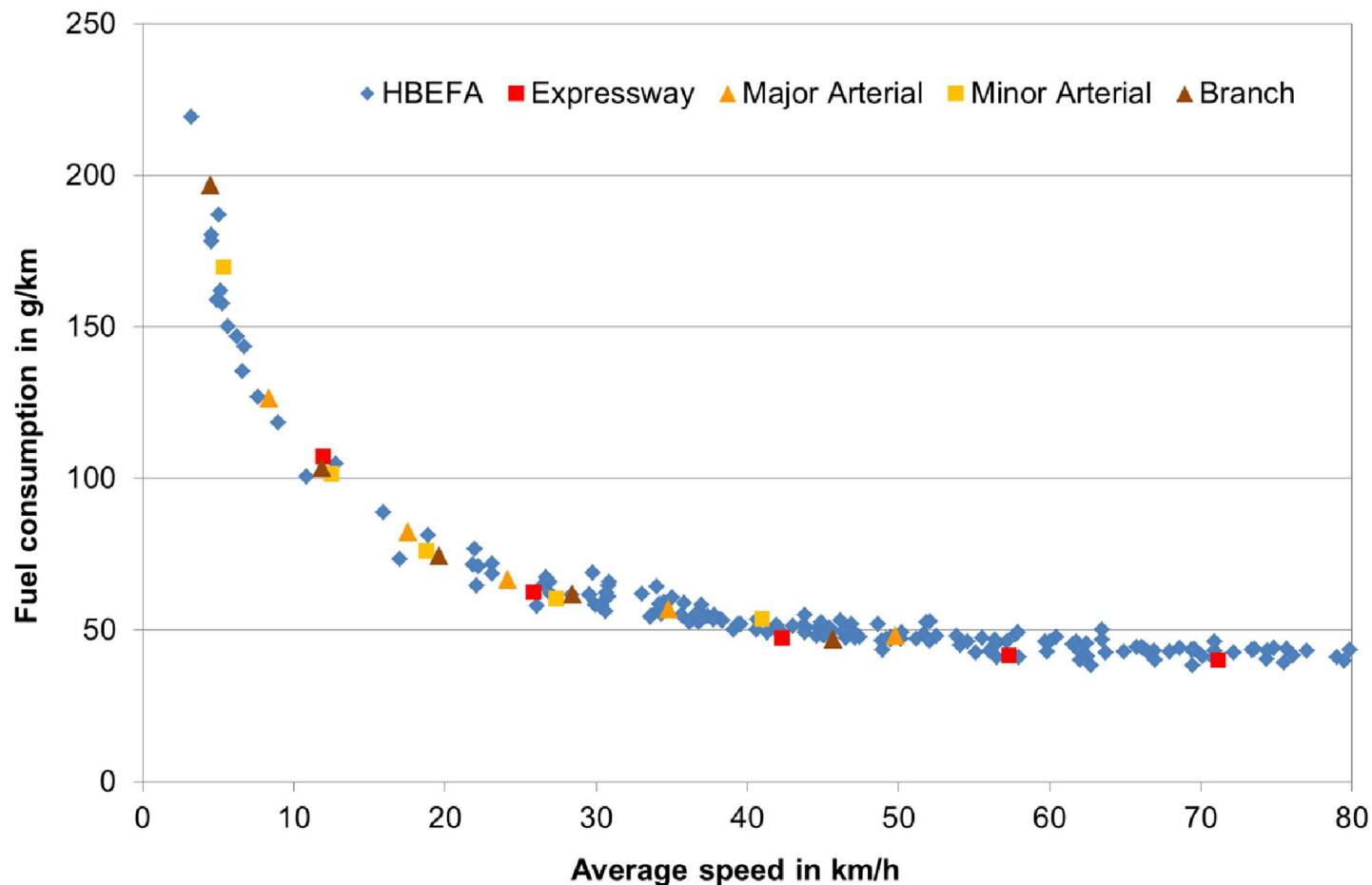


Fuel consumption of gasoline fueled passenger cars (Euro 3) for the Chinese traffic situations



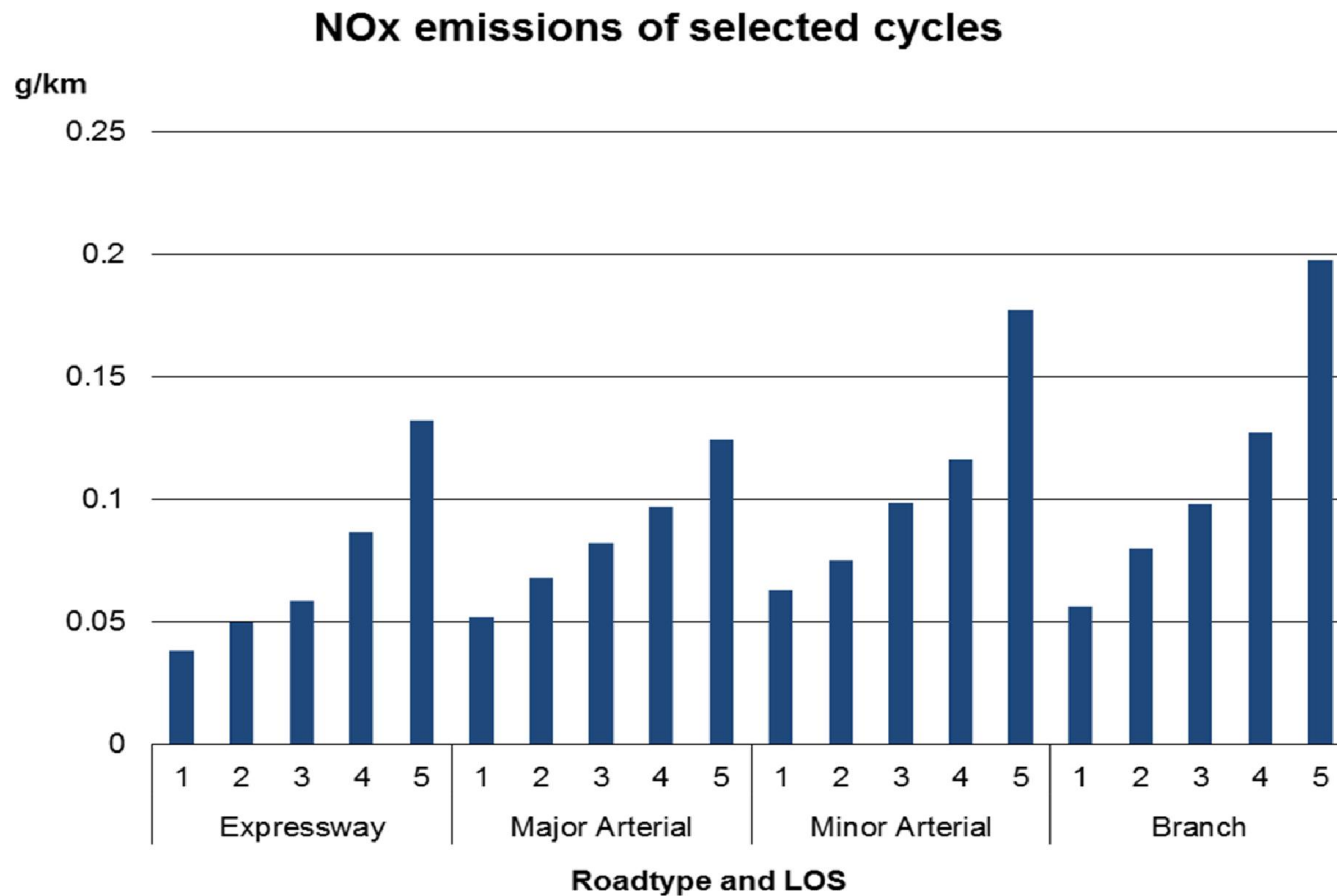


Fuel consumption of gasoline fueled passenger cars (2002): Chinese and HBEFA traffic situations



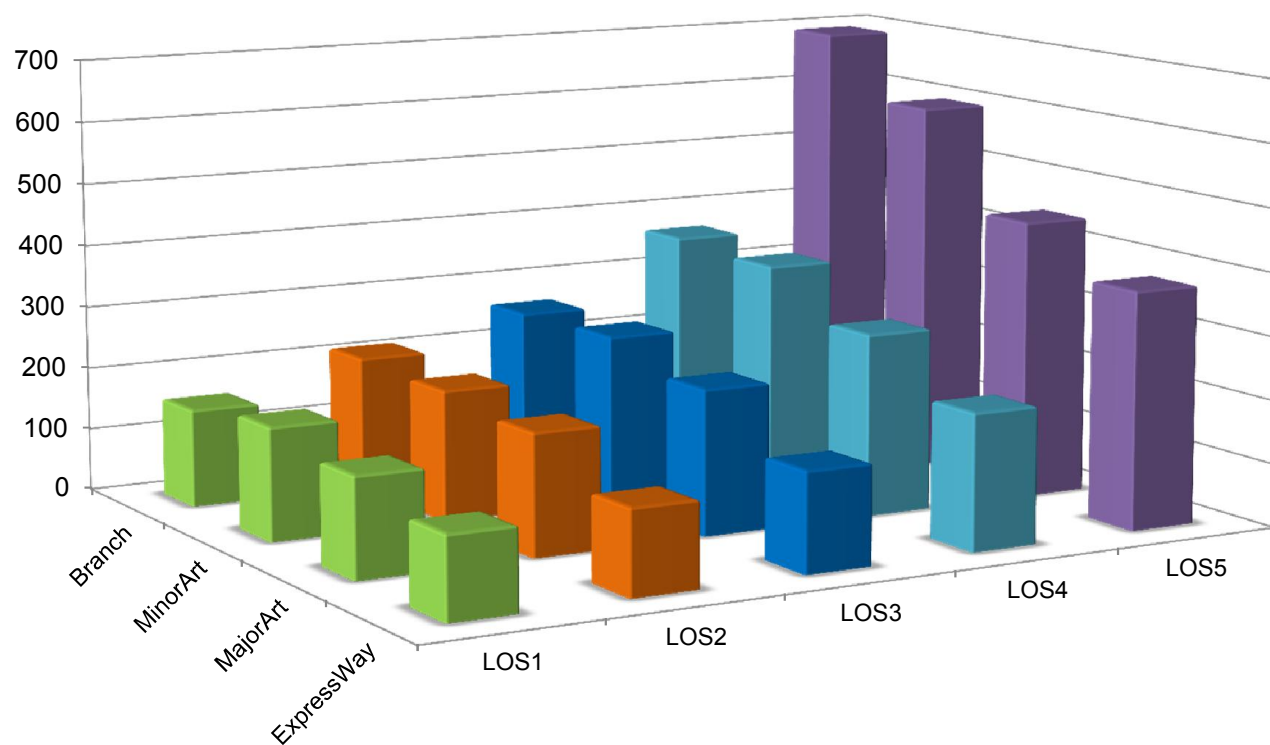


NOx emissions of gasoline fueled passenger cars (Euro 3) for the Chinese traffic situations



二氧化碳排放因子

欧四 1.6排量的车不同工况CO₂排放强度（克/公里）



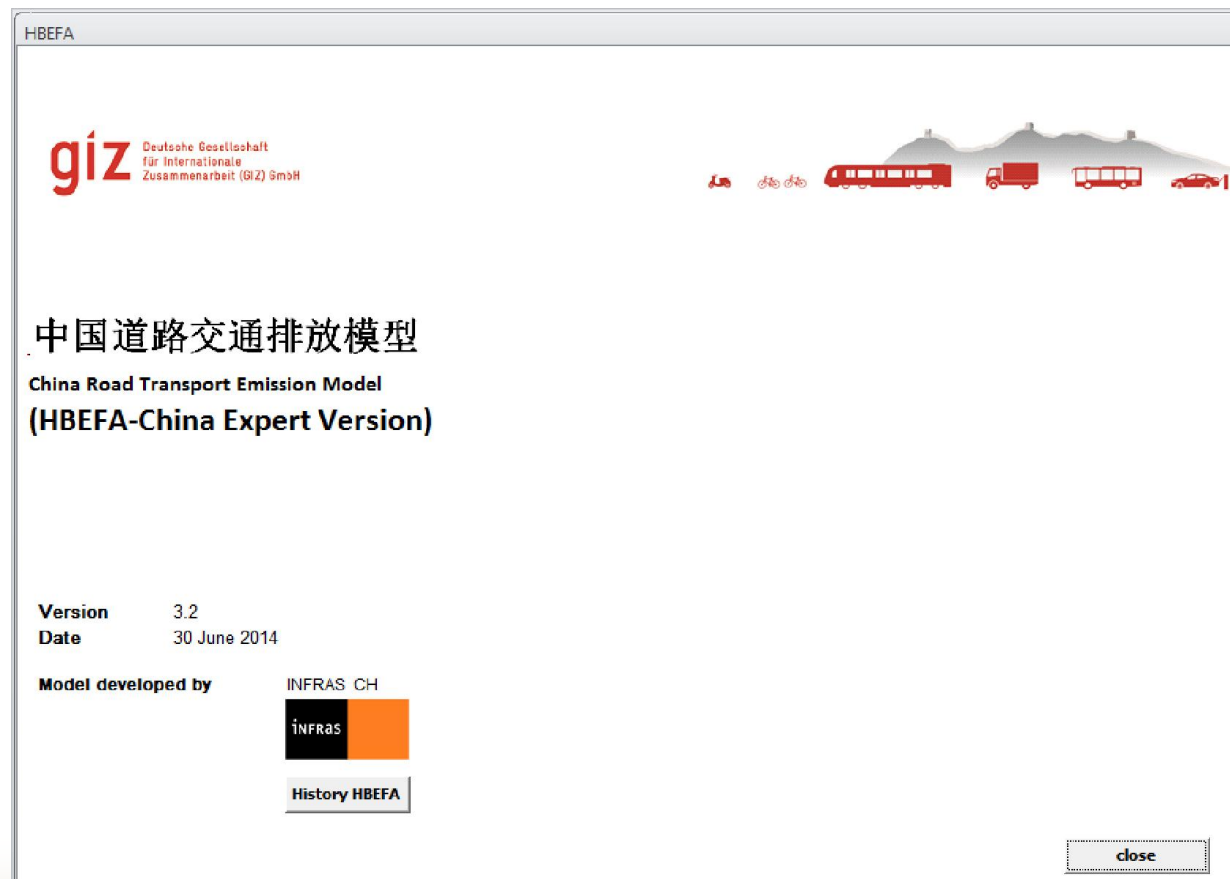
大纲Outline

- 背景 Background information for adaption of emission factors
- **HBEFA**本地化技术思路 Approach to adapt HBEFA to China
- 交通排放计算工具 Emission quantification tool - software package



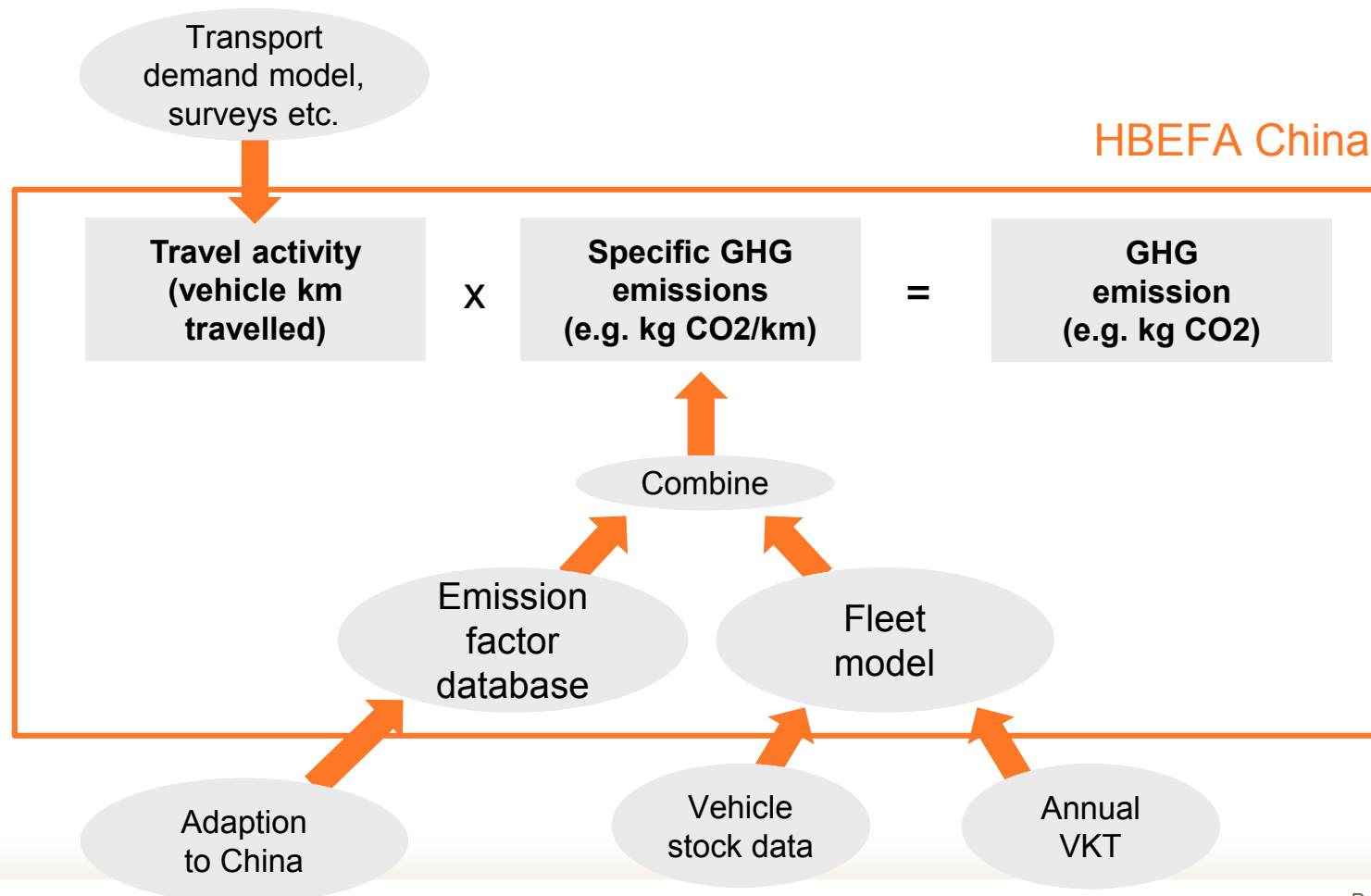
China Road Transport Emission Model

交通排放计算工具





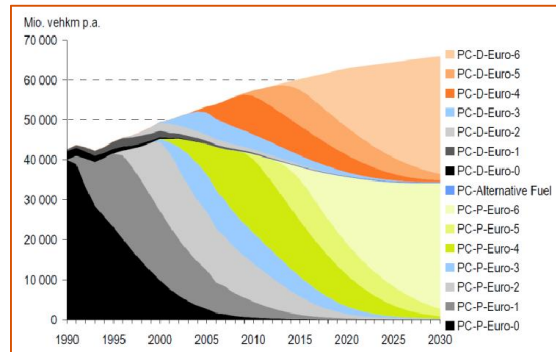
HBEFA Expert Version and interfaces to other external data sources





Overview of HBEFA – modules/sub-models

Fleet model



Emission factor database

Veh Sub-Segment	Size	Concept	KM Odometer	weight (%)	Speed per SubSegm.			EFA per SubSegm.		
					Avg. km/h	Load-0% km/h	100% km/h	Avg. g/km	Load-0% g/km	100% g/km
3PC petrol <1.4L <ECE	<1.4L	PC P China-0	50000	100.0%	71.2			11.490		
1PC petrol <1.4L ECE-1500	<1.4L	PC P China-0	50000	100.0%	71.2			11.490		
3PC petrol <1.4L ECE-1501/102	<1.4L	PC P China-0	50000	100.0%	71.2			11.490		
3PC petrol <1.4L ECE-1503	<1.4L	PC P China-0	50000	100.0%	71.2			11.490		
1PC petrol <1.4L ECE-1504	<1.4L	PC P China-0	50000	100.0%	71.2			8.252		
3PC petrol <1.4L AGV82 (CH)	<1.4L	PC P China-0	50000	100.0%	71.2			3.954		
3PC petrol <1.4L conv other con	<1.4L	PC P China-0	50000	100.0%	71.2			3.954		
7PC petrol <1.4L Ucat	<1.4L	PC P China-0	50000	100.0%	71.2			5.347		
3PC petrol <1.4L PreChina 3W/C	<1.4L	PC P China-0	50000	100.0%	71.2			0.646		
3PC petrol <1.4L PreChina 3W/C	<1.4L	PC P China-0	50000	100.0%	71.2			0.644		
3PC petrol <1.4L China-1	<1.4L	PC P China-1	50000	100.0%	71.2			0.644		
3PC petrol <1.4L China-2	<1.4L	PC P China-2	50000	100.0%	71.2			0.283		
3PC petrol <1.4L China-3	<1.4L	PC P China-3	50000	100.0%	71.2			0.282		
3PC petrol <1.4L China-4	<1.4L	PC P China-4	50000	100.0%	71.2			0.158		
3PC petrol <1.4L China-5	<1.4L	PC P China-5	50000	100.0%	71.2			0.201		
3PC petrol <1.4L China-6	<1.4L	PC P China-6	50000	100.0%	71.2			0.132		

Emission model

Select all parameters for your case. Then specify a name for this set and let the program calculate

Select VEHICLE CATEGORIES

☒ PC ☐ LDV ☐ HGV ☐ Urban Bus ☐ Coach ☐ MC

Select COMPONENTS (Pollutants)

☒ regulated ☐ Fuel consumption ☒ CO2 ☐ CH4 ☐ others Construct your own list

Select YEAR(s)

☐ 1990 ☐ 2005 ☐ 2020 ☐ 1995 ☐ 2010 ☐ 2025 ☐ 2000 ☐ 2015 ☐ 2030 Construct your own list

Select FLEET COMPOSITION (traffic scenario)

☒ h: weighted with fleet composition ☐ h: per subsegment (without weighting)

Being PC V1

Specify parameters to HOT EMISS ON FACTORS

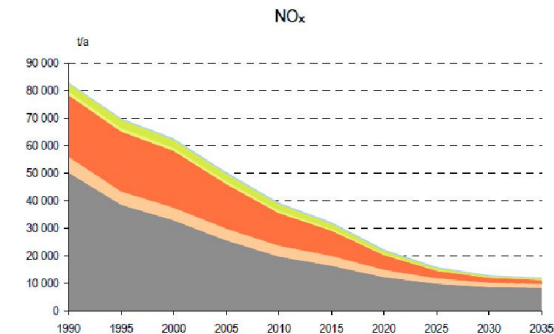
☐ Individual Traffic Situations: Construct your own list

☐ Aggregate Traffic Situations (incl. Gradient Distribution): Construct your own list

TDM-Input

idUM	LENGTH	TYPE	IDRoadType	Year	DTIn
11	0.28	35	65	2012	
11	0.28	35	65	2012	
11	0.28	35	65	2012	
11	0.28	35	65	2012	
11	0.28	35	65	2012	
11	0.28	35	65	2012	
5002	0.148	68	65	2012	
5002	0.148	68	65	2012	

Result: Emissions





Interface 排放模型软件界面

Microsoft Access

File Settings Definitions FleetModel TrafficDataSets EmissionFactors EmissionModel Wizards Library Extras

create TDS Fleet model Emission model DataTransfer ToGIS HBEFA wizards

Import data from EXCEL files

Utility to import user data from Excel to HBEFA

Stepwise procedure to import data from Excel:

Button 1. Select the directory where the data (XLS, XLSX, CSV) are stored which shall be imported.
Button 2. List all Files of the selected directory and then select (mark) the (XLS, XLSX or CSV) file with the data which you want to import. Double click on file name lists all sheets of the file (=button 3).
Button 3. List all sheets of the selected file (button 2).
 > for CSV-Files: Select (mark) the sheet with the data which you want to import. The name of the selected sheet appears in red.
 > for XLS or XLSX-Files: the program reads always the first sheet (if the file contains several sheets)

Selected Country: CN

1. Select directory -->

2. List all files of selected directory; then select (mark) the file (Excel or CSV) with the data to be imported. (Double click lists all sheets - as point 3.)

3. List all sheets
Then select (mark) the relevant sheet.

Selected Sheet: #Error

TC_TmpList_Sheets

#Deleted

*

TrafficVol (predefined)

> Select import specification

ImpSpec_TrafficData_VehCat

View details of selected Import specification

> Select Target TDS where the imported data shall be stored

#Records in selected TDS:

Update TDS List

> Import linkwise traffic vol data and store in linkwise format in target TDS

Start Import procedure

Explanations and utilities

Explanations about import of TrafficVolume data from CSV-or XLS-files

Option: define new TDS Option: rename TDS

Option: delete TDS Option: edit TDS

Option: View Input TrafficVolumes Option: view IMPORT LOG file

Num Lock

谢谢! Thank you very much for your attention!

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SUSTAINABLE TRANSPORT IN CHINA

