Beijing, 17th of March 2014

Meeting with the World Bank

# Handbook on Emission Factors of Road Transport for China

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# Contents

# Basis: HandBook on Emission FActors for Road Transport in Europe (= HBEFA)


- **HBEFA** is **emission model für road transport** which is developed on behalf of several European countries (e.g. Germany, Switzerland, Austria, Sweden, Norway, France)
- in **1995** the **first version** was published, in the meantime **20 years development time** with a budget **more than 20 million Euros**
- HBEFA provides **emission factors** for **air pollutants** as well as for **fuel consumption** and **$CO_2$ emission**
- **emission factors** are **available** on **disaggregated** and **aggregated level**

# Dependency of traffic activities and emission factors

**Emission = Traffic Activity (vkm) x Emission Factor (g/vkm)**

**Dependency**

- emission factors have to fit to the traffic activity data and vice versa
- traffic data should ideally be given for:
  - vehicle category
  - vehicle size
  - fuel type
  - technology (emission legislation classes)/age
  - load factor (trucks)
  - road gradient
  - traffic situation/driving cycles

**Covered by HBEFA**



Source: INFRAS.

# HBEFA provides emission factors for different sub-segments

| Vehicle categories | Fuel types | Vehicle size | Emission Standards |
|---|---|---|---|
| Passenger Car | Gasoline | PC < 1.4 L | Pre China 1 |
| Motorcycle | Diesel | PC 1.4-2.0 L | China 1 |
| Urban bus | LPG | PC > 2.0 L | China 2 |
| Coaches | CNG | Truck ≤ 7.5 t | China 3 |
| Light duty veh. | Electricity | Truck 7.5-12 t | China 4 |
| Trucks | | Truck 12-14 t | China 5 |
| | | ... | |

Abbreviations: PC = Passenger car; LPG = Liquefied Petroleum Gas; CNG = Compressed Natural Gas



Source: INFRAS.

# Emission factors of HBEFA depends additionally on traffic situations

- **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)

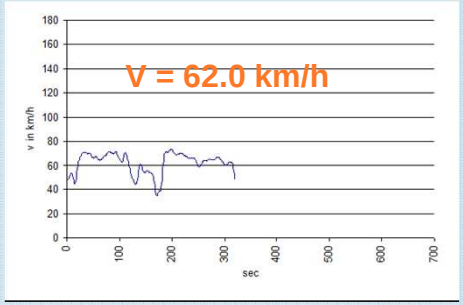
| | | | Speed Limit [km/h] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area | Road type | Levels of service | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | >130 |
| Rural | Motorway-Nat. | 4 levels of service | | | | | | | | | | | | |
| | Semi-Motorway | 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 | | | | | | | | | | | | |



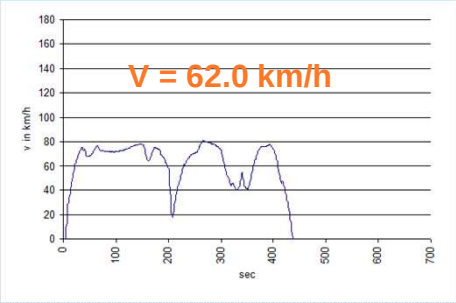
Source: INFRAS / Mario Keller.

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

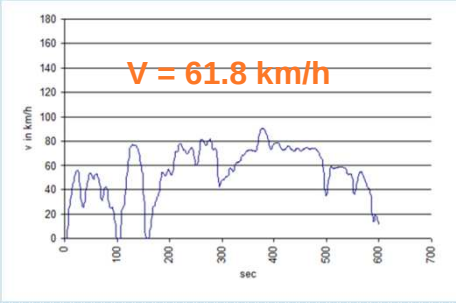
**Rural: Trunk road: 60 km/h, free flow**



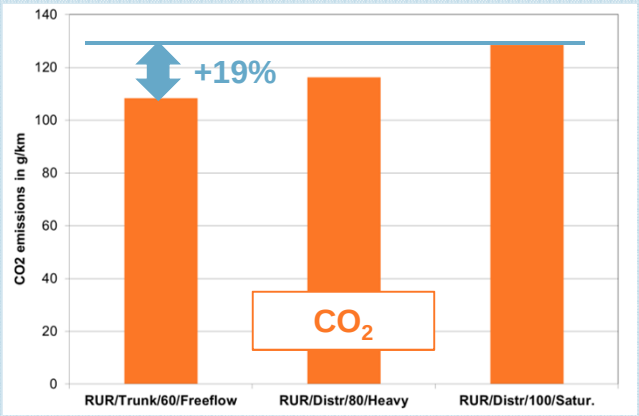

**Rural: Distributor: 80 km/h, heavy**

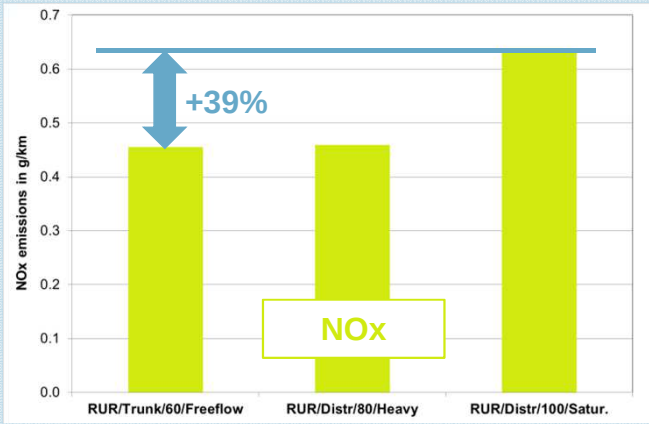



**Rural: Distributor: 100 km/h, saturated**




**Passenger car: diesel, 1.4-2.0 l, Euro 3**

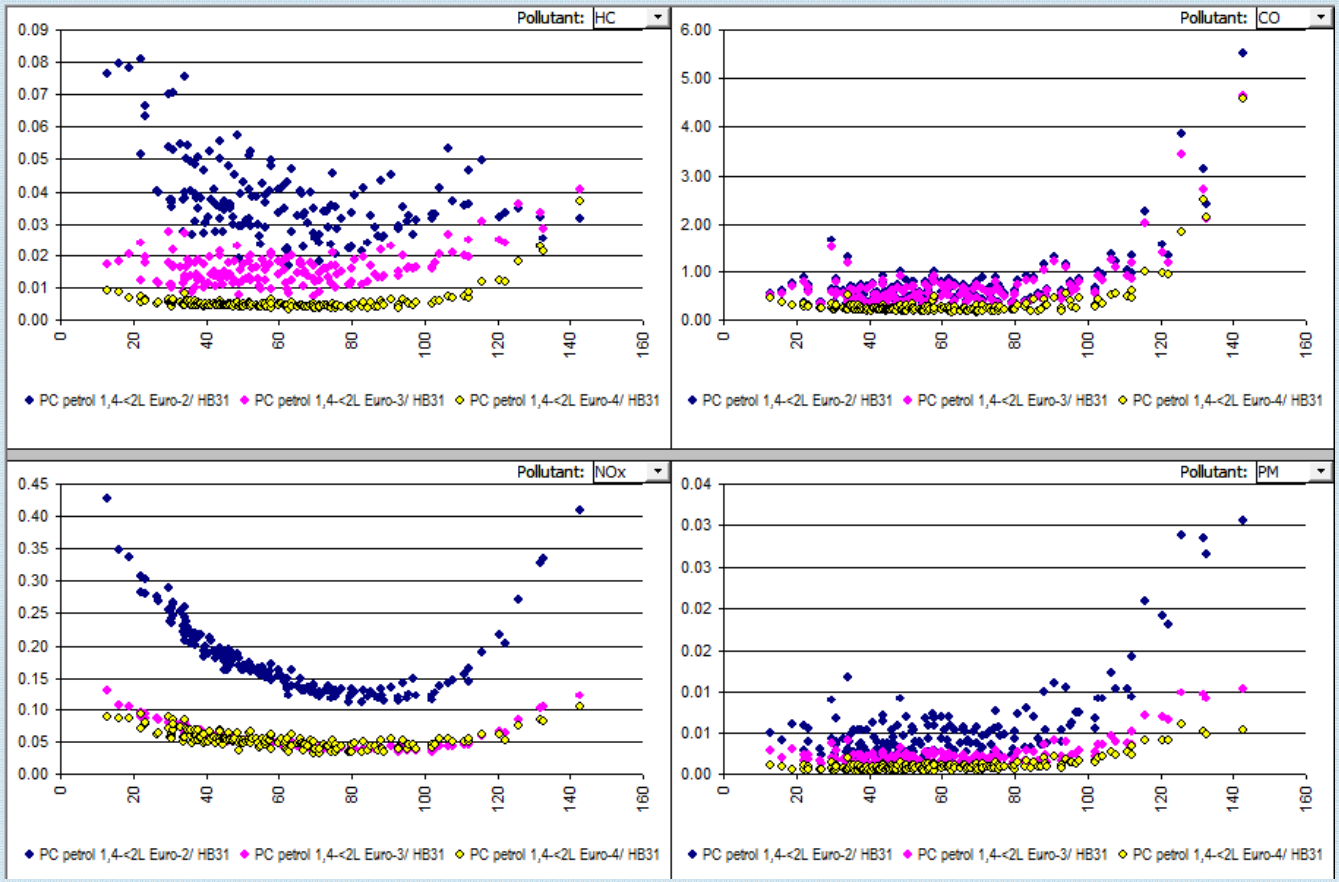



Source: INFRAS.

# Example of HBEFA “hot” emission factors calculated for different traffic situations

## Example: Gasoline passenger car in Europe (Euro 2 - Euro 4)




Source: Mario Keller (INFRAS) 2011.

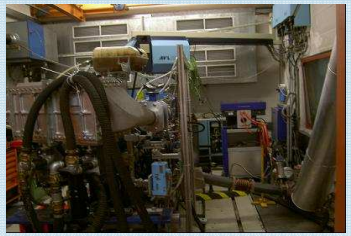
# Emission factors of HBEFA are calculated with PHEM (Passenger car and Heavy duty Emission) Model


(Real world) driving cycles

Passenger car

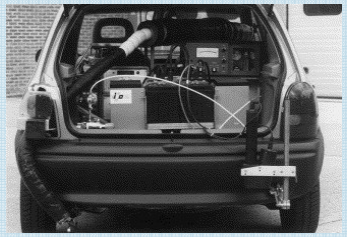
Roller test bench

Trucks



Engine test bed

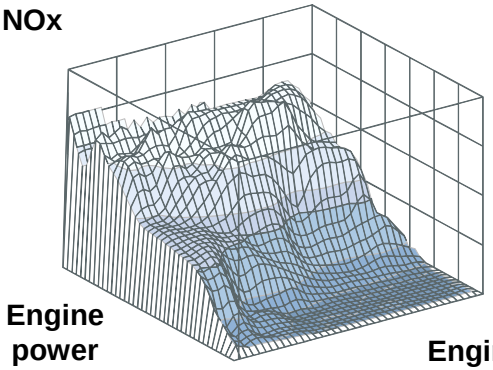
(Additional)



On-Board measurements

Engine maps

- Engine maps are based on real world measurements data
- Type approval cycles can't be used




PHEM model

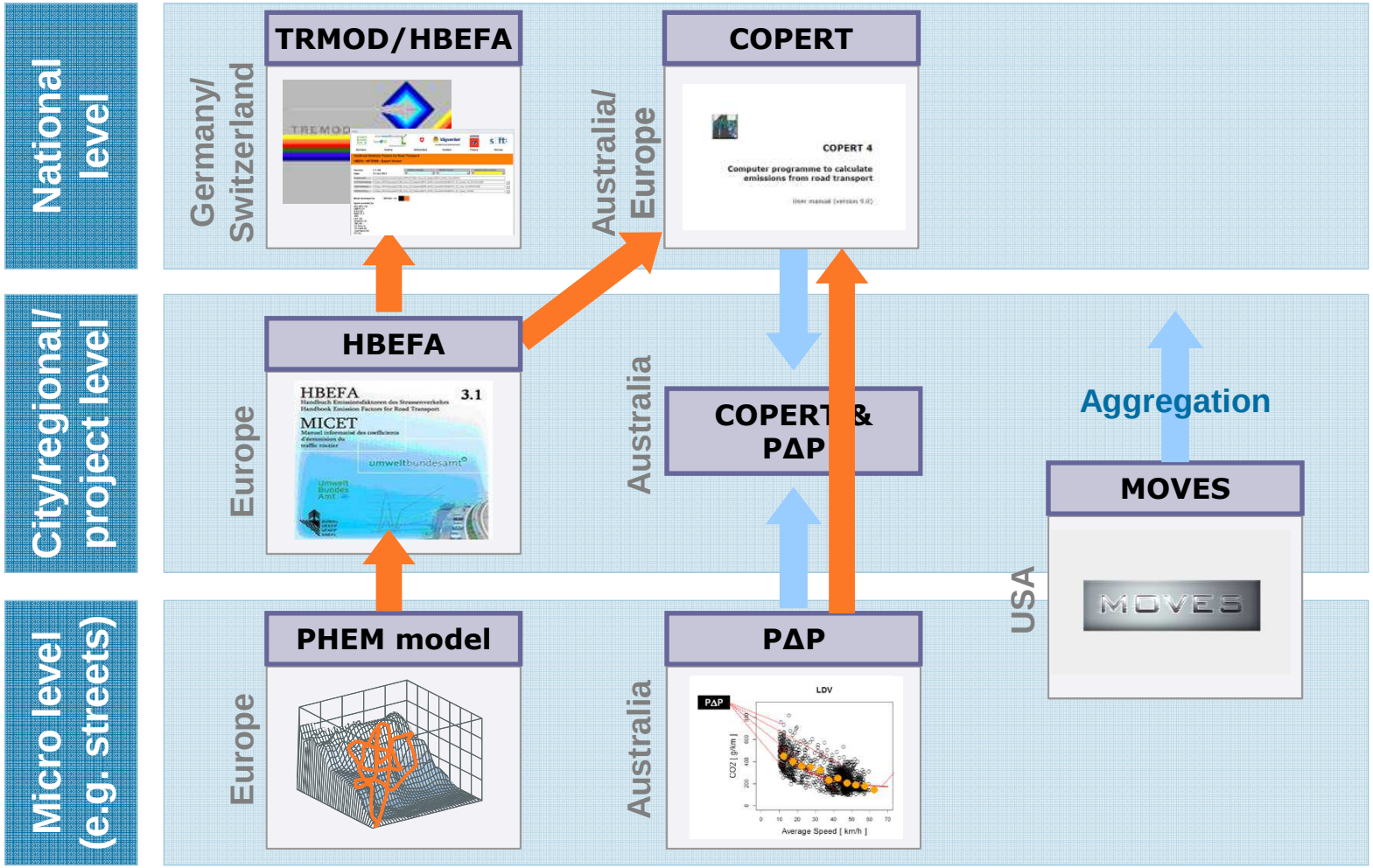
# HBEFA is often data source of GHG emission inventories of Germany cities

| | Bremen | Region Hannover | Braun-schweig | Leipzig | Cologne | Frankfurt /Main | Tübingen | Munich |
|---|---|---|---|---|---|---|---|---|
| **Fuel consumption and direct GHG emission factors** | | | | | | | | |
| **Road** | MOBILEV (HBEFA) | HBEFA | HBEFA | HBEFA | [WWF 2009] | TREMOD | HBEFA at VISUM | HBEFA |
| **Public transport** | PT operator | PT operator | PT operator | PT operator | PT operator | TREMOD | PT operator | PT operator |
| **Rail** | - | German railways | German railways | UBA[1] | TREMOD | TREMOD | - | German railways |
| **Inland navigation** | - | UBA[1] | UBA[1] | - | LANUV[2] | - | - | - |
| **Air transport** | - | conclusions by analogy | - | LfULG[2] | Airport Köln-Bonn | - | - | - |

› **HBEFA is central database for emission calculation on city level in Germany**

Source: IFEU 2012.

# Classification of different emission models used in Europe, Australia and USA




Source: INFRAS.

# Examples of emission calculation of freight transport in Europe


**TREMOD**

**EcoTransIT World (www.ecotransit.org)**


**Map&Guide**


**NTM**


**LogEC**




Source: INFRAS.

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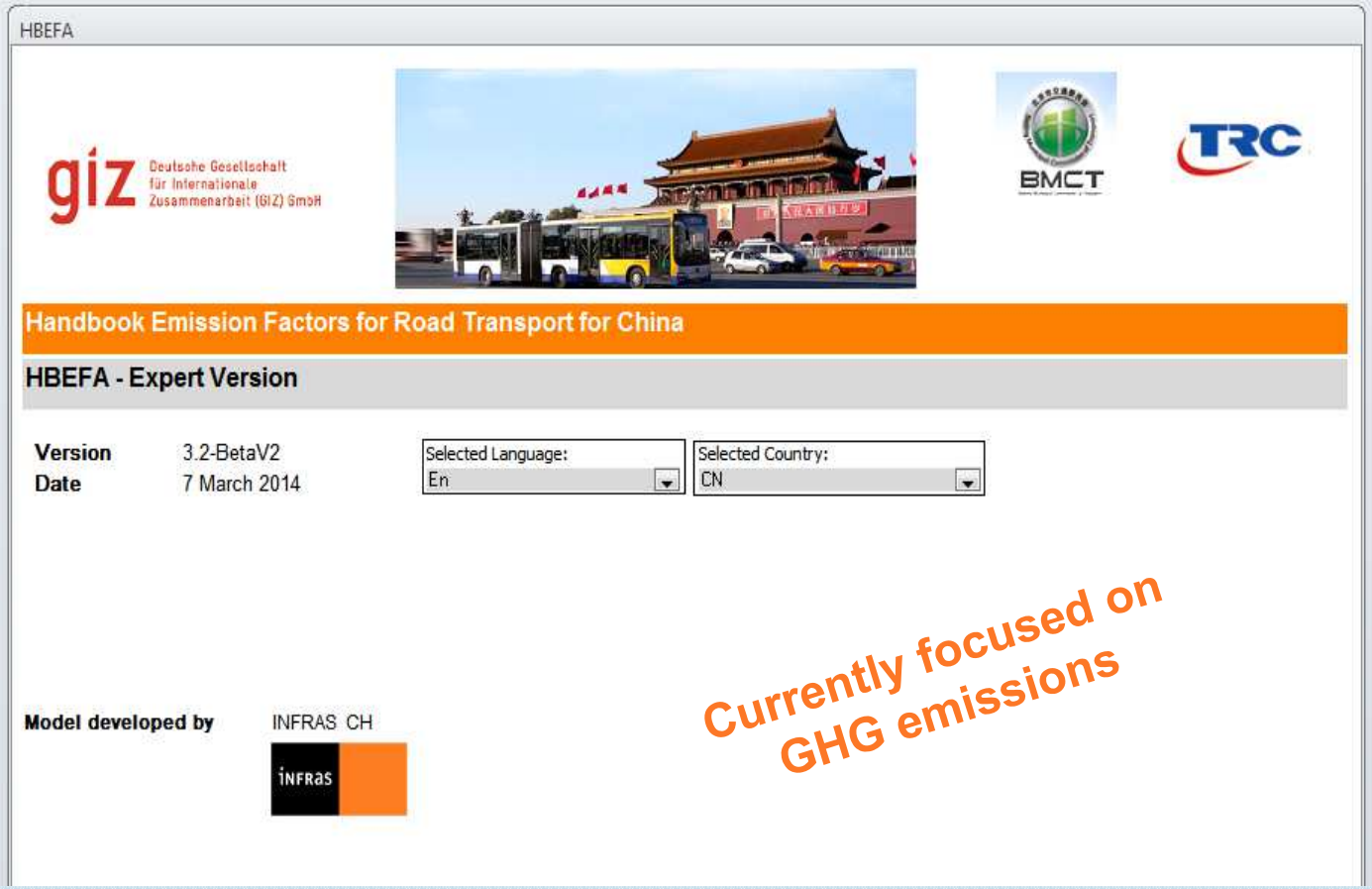
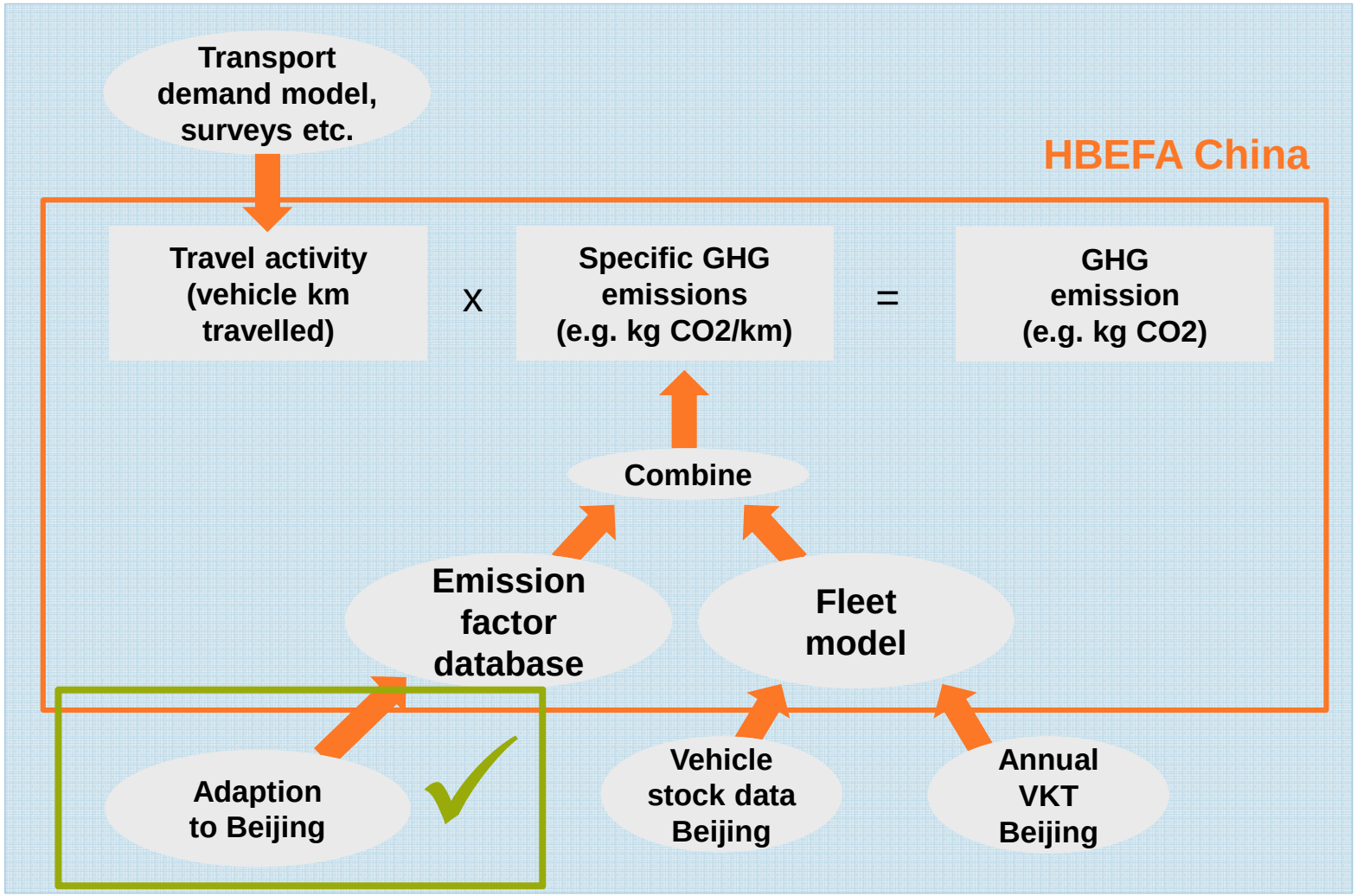
Adoption of HBEFA to China

# Handbook on Emission Factors for Road Transport for China developed by GIZ



# HBEFA Expert Version and interfaces to other external data sources

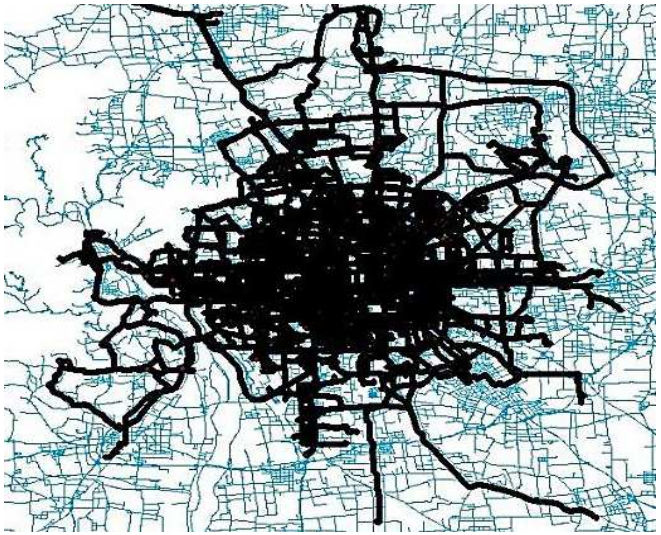





Source: INFRAS.

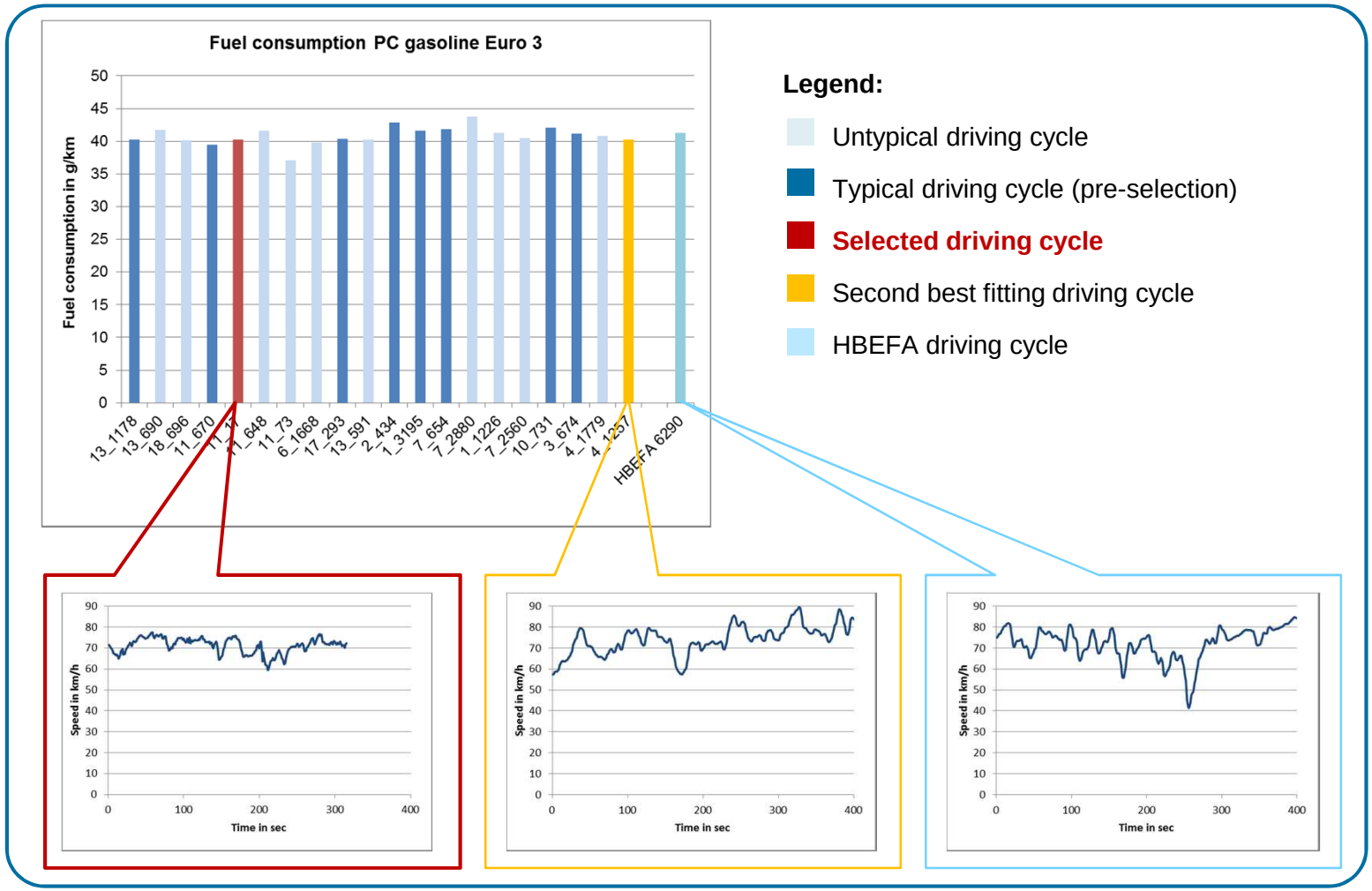
# Collection of GPS data in Beijing and Shenzhen by taxis to identify representative traffic situations

- GPS transmitters were applied to record real road vehicle movements
  - measurements are made once every second (1 Hz)
  - data collected in Beijing and Shenzhen
  - around 2,000 hours of GPS data

Source: GIZ.

# Identification and selection of typical traffic situations for Chinese cities

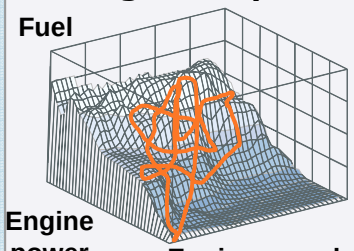


# Calculation of China specific emission factors for all traffic situations using the PHEM model

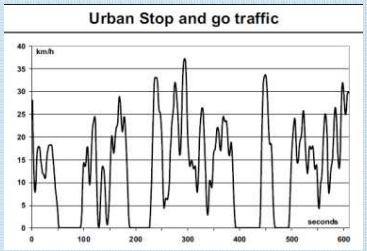
**Real world emission measurements**

**PHEM model**

**Engine map**

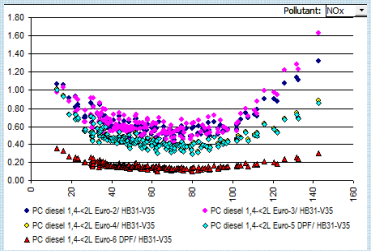



**Traffic situations**

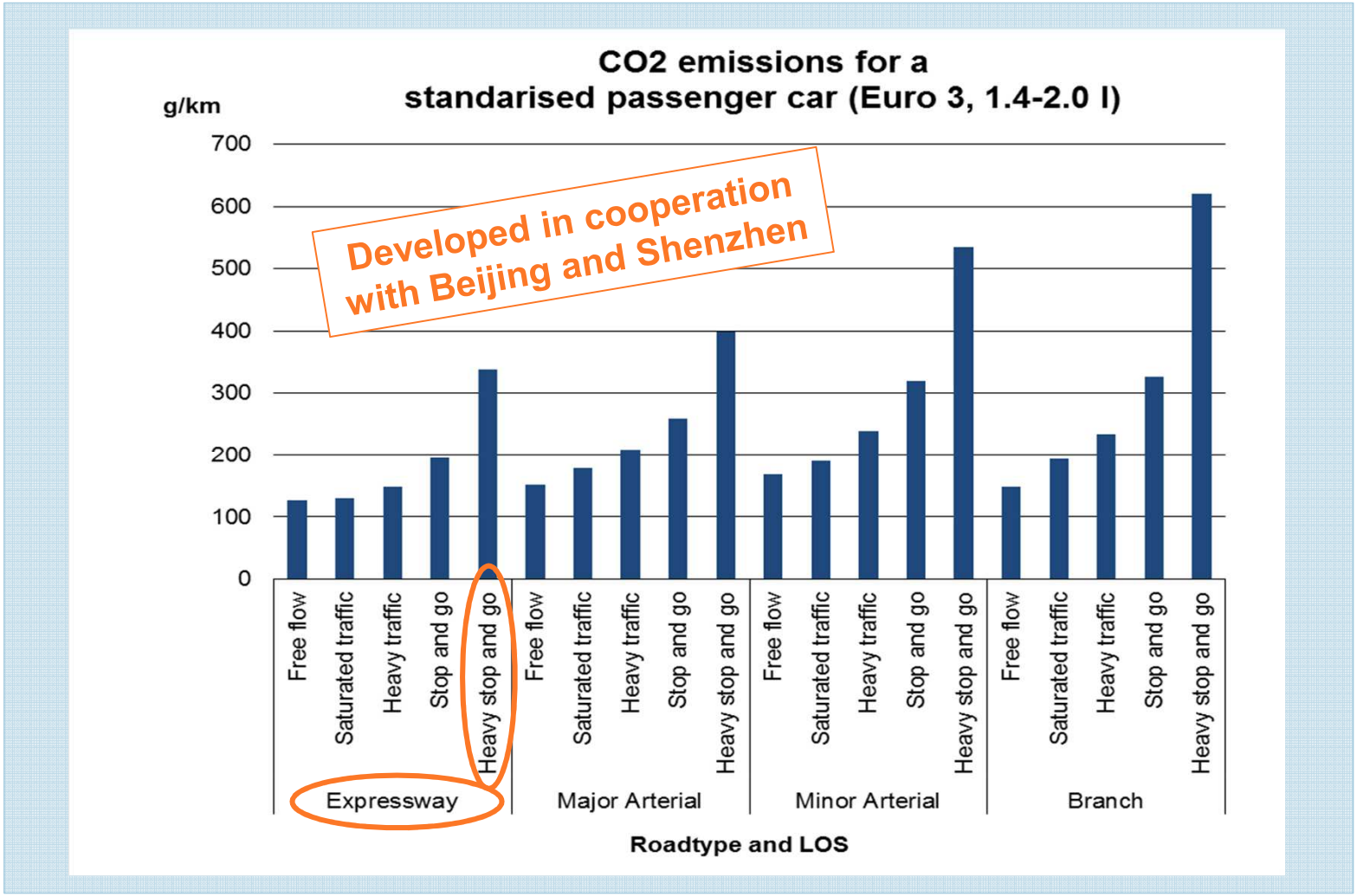



- approach was used for Beijing and Shenzhen
- existing engine maps (particularly for $CO_2$) can be used for the calculation of emission factors based on Chinese traffic situations

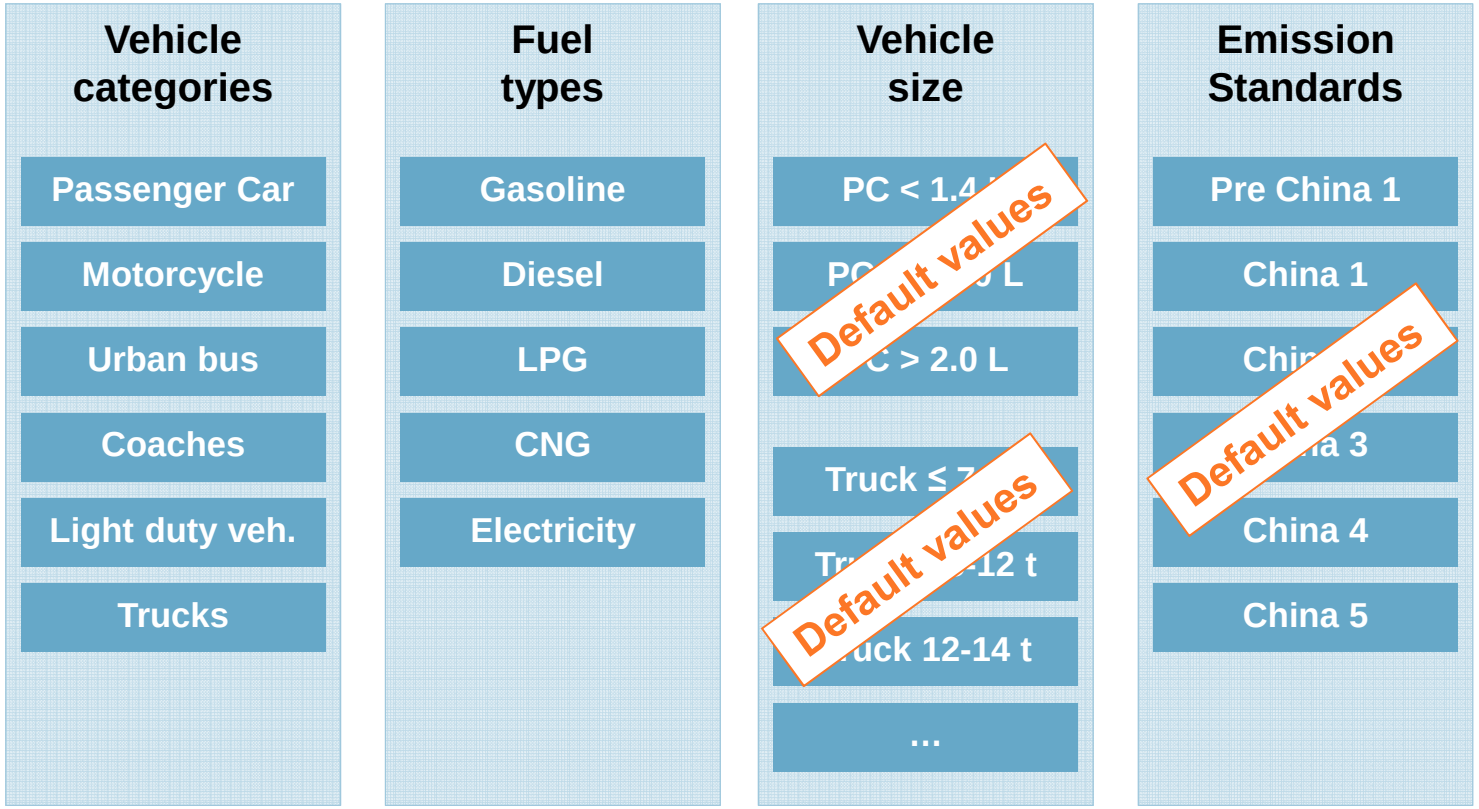
**Emission factors**



# HBEFA China includes specific emissions factors for Chinese cities



# HBEFA China provides emission factors in different level of aggregations




Abbreviations: PC = Passenger car; LPG = Liquefied Petroleum Gas; CNG = Compressed Natural Gas



Source: INFRAS.

# Average distribution of emission factors in in China as default values for HBEFA China

› **For example: Shares of emission standards**

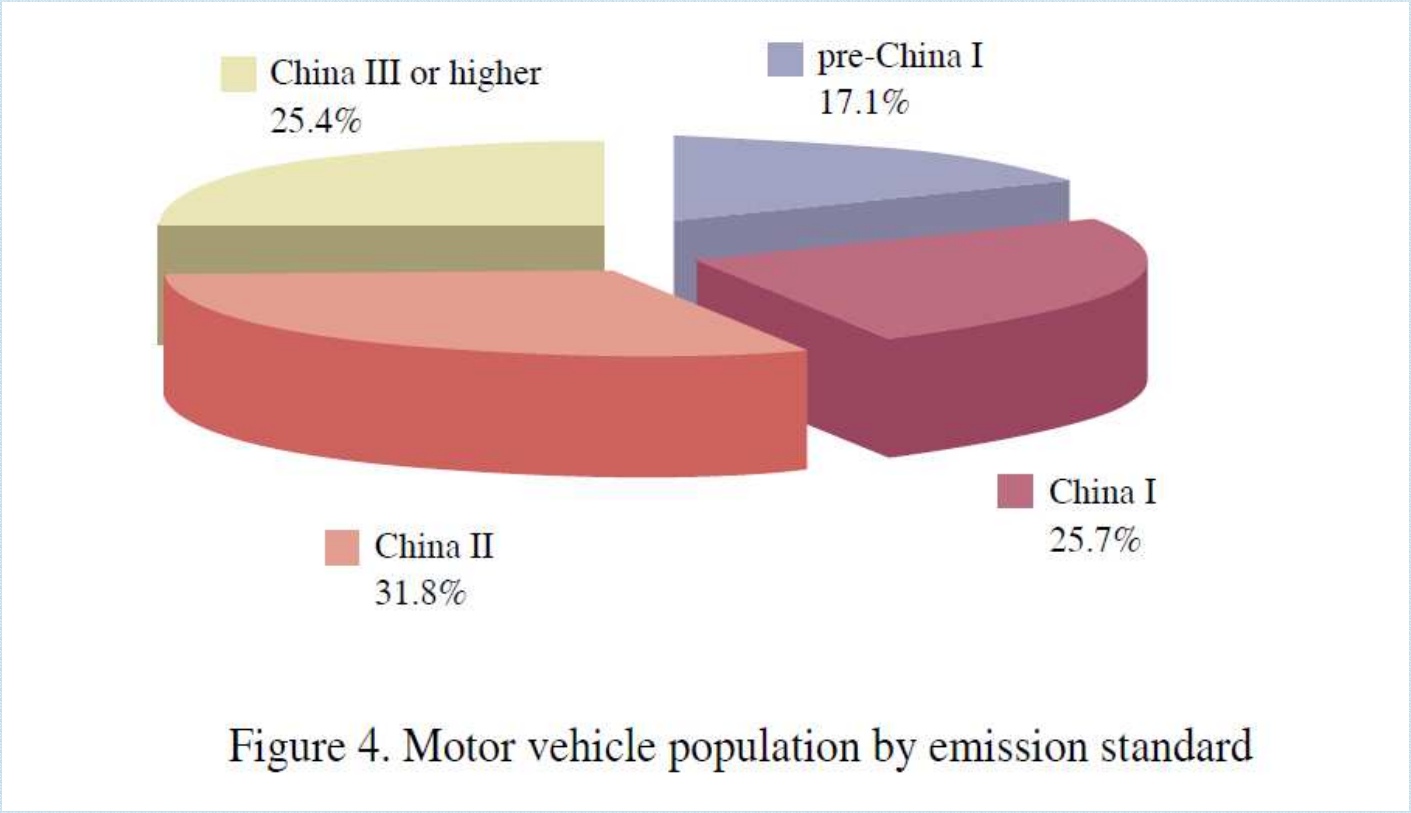
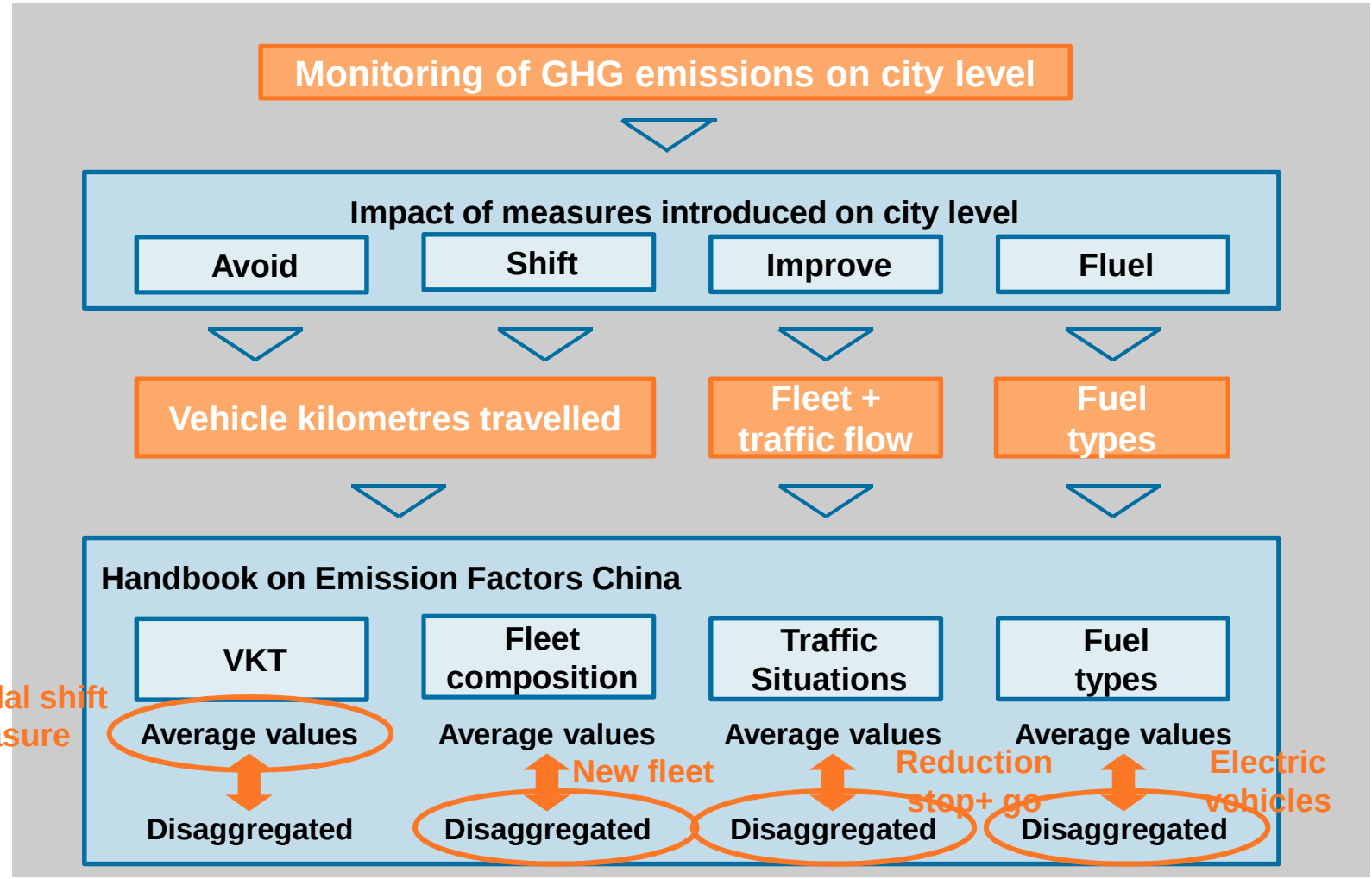



Figure 4. Motor vehicle population by emission standard

Source: VECC.

# Objectives of GHG emission monitoring influences the level on details for input data



# Summery of the key issues of the Handbook on Emission factors for China

| Issue | Handbook of Emission Factors for China developed within the Sino-German project |
|---|---|
| Scope | • Following vehicle types:<br>– passenger cars<br>– taxis, urban busses and coaches<br>– motorcycles and trucks<br>• Next step: rail transit (underground) |
| Monitoring method | • using a bottom up approach (based on the activity level)<br>• combination with fuel statistics (top-down approach) |
| Key indicators | • concerns the total amount of GHG emissions of all models of road transport (currently without rail transit)<br>• enables to monitor all kind of measures: changes of passenger trips/modal shift measures, introduction of new fleets, efficiency of vehicles, changes in traffic flow, alternative fuels |
| Emission factor | • $CO_2$ and GHG emissions (sum of $CO_2$, $CH_4$, $N_2O$)<br>• Limited and unlimited air pollutants (e.g. NOx, PM, NMHC) |

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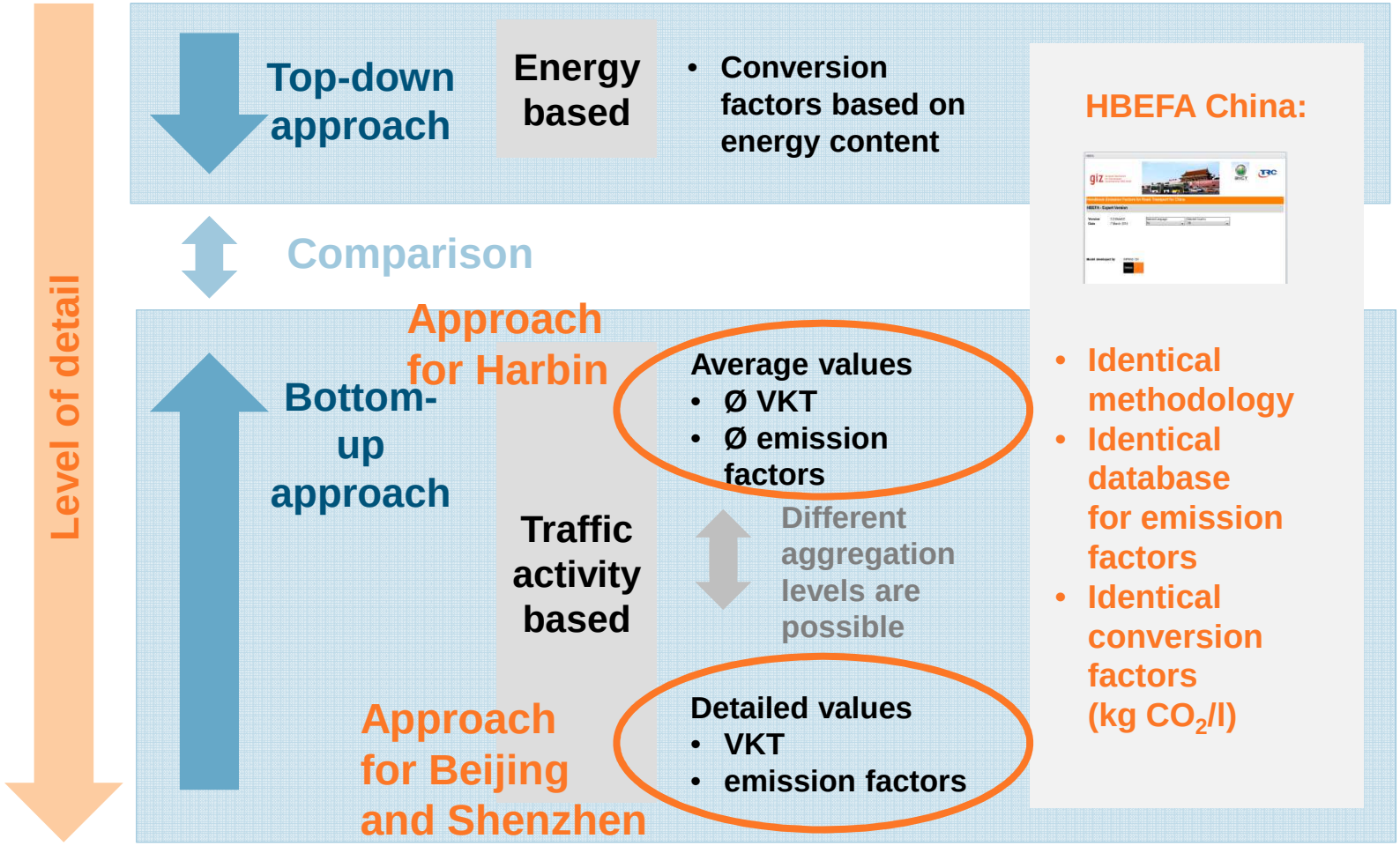
- Adoption of HBEFA to China
- Benefits for Chinese Cities

Benefits for Chinese Cities

# HBEFA China is a consistent method for GHG quantification on detailed and simplified level



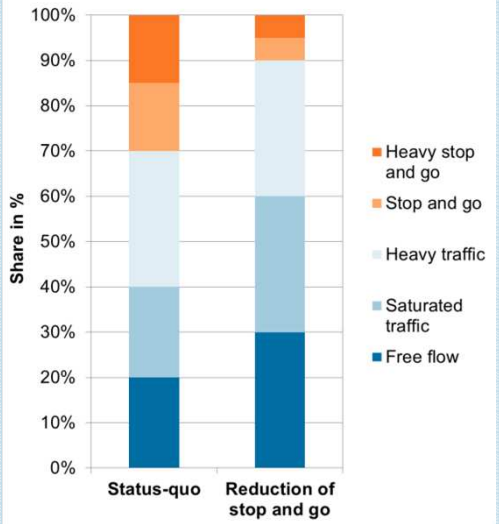



Source: INFRAS.

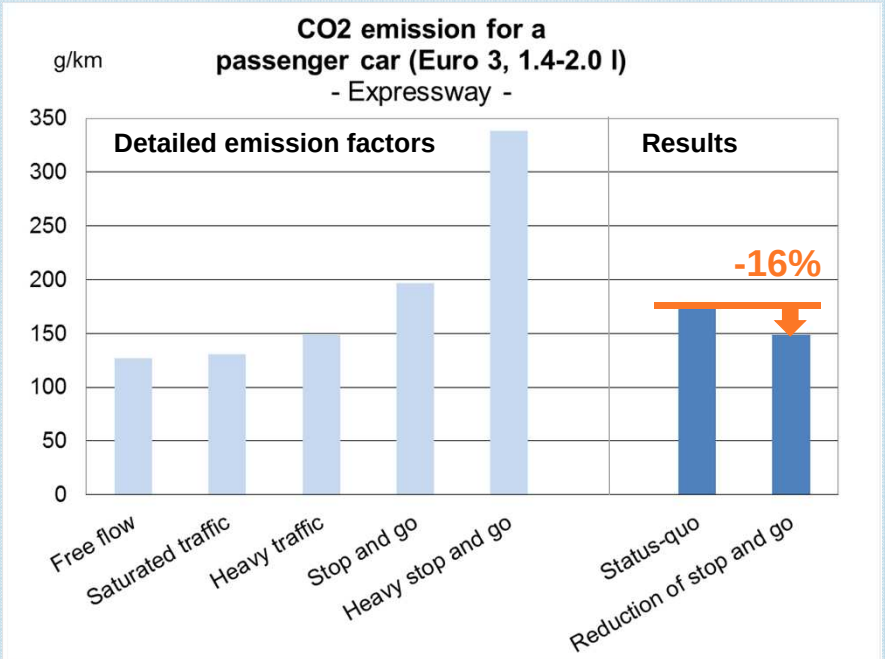
# HBEFA China delivers emission factors to monitor all kind of measures (1)

## Fictive example: Reduction of shares of stop + go traffic for Expressway

**Shares of traffic situation for Expressway**

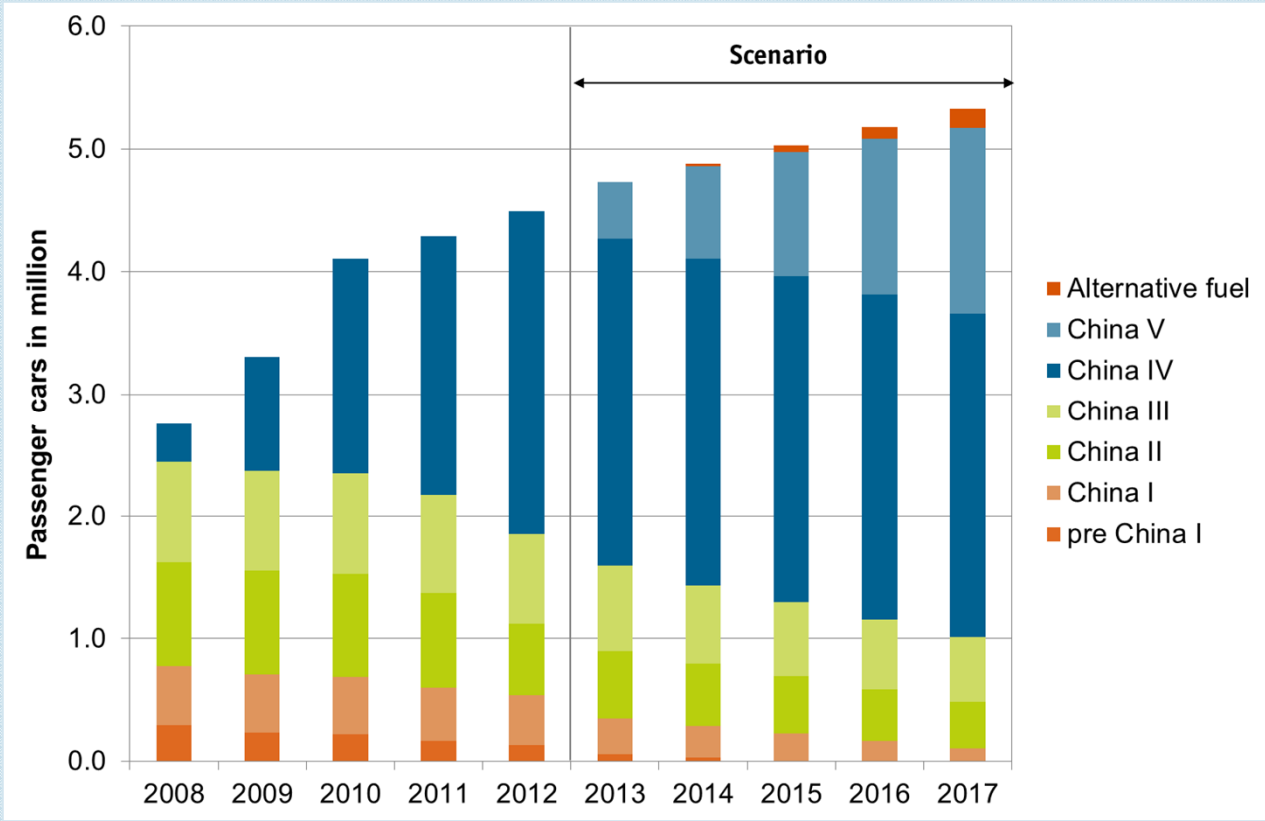



**$CO_2$ emission for passenger car for Expressway**



# HBEFA China delivers emission factors to monitor all kind of measures (2)

## Example Beijing: Impact of introduction shemes of new vehicles



Benefits for Chinese Cities

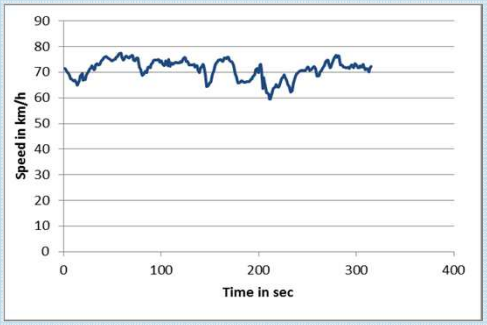
# HBEFA China based on comprehensive groundwork done by Beijing and Shenzhen

## Example: Selection of typical traffic siutation for Expressway/Highway

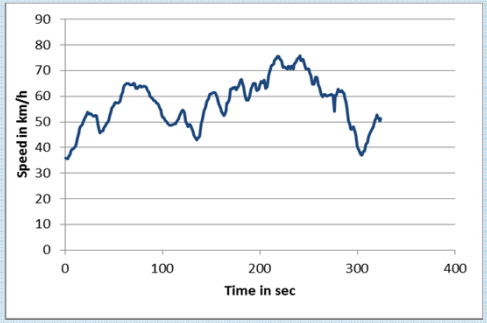
### Key parameters:

| | Average speed | RPA | % stop time |
|---|---|---|---|
| | km/h | m/s3 | % |
| **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% |

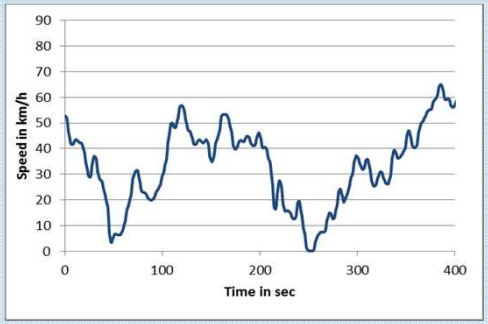
### LOS 1: Free flow



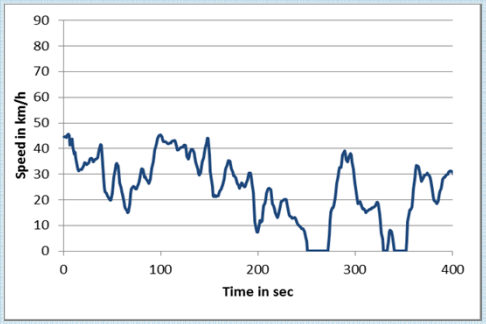

### LOS 2: Heavy



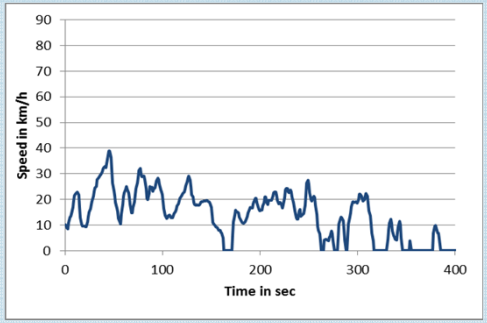

### LOS 3: Saturated




### LOS 4: Stop+go 1

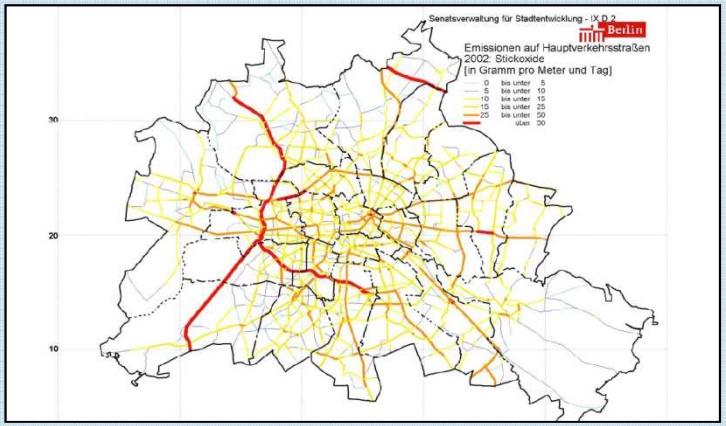



### LOS 5: Stop+go 2

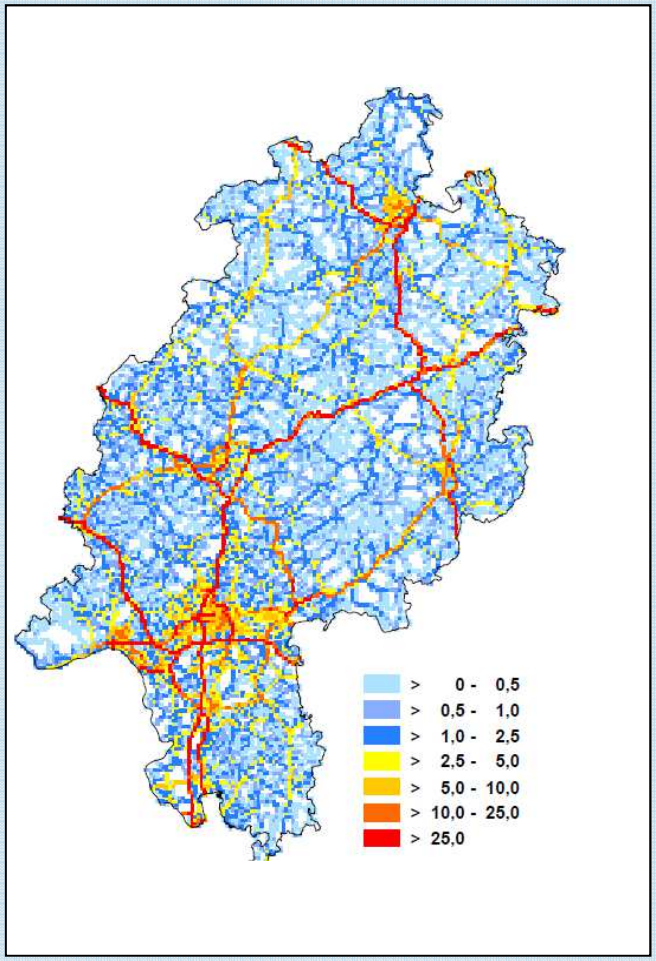


# HBEFA China can also be used for the calculation of air pollutants: Examples of NOx emissions

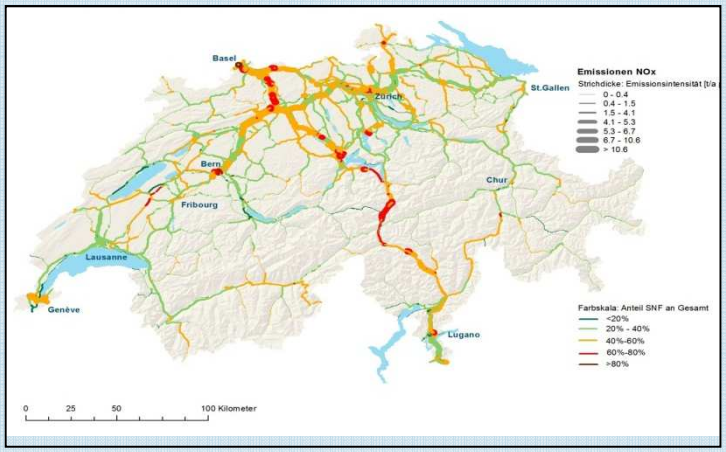
## Berlin




## Federal state Hessen




## Switzerland (only freight)

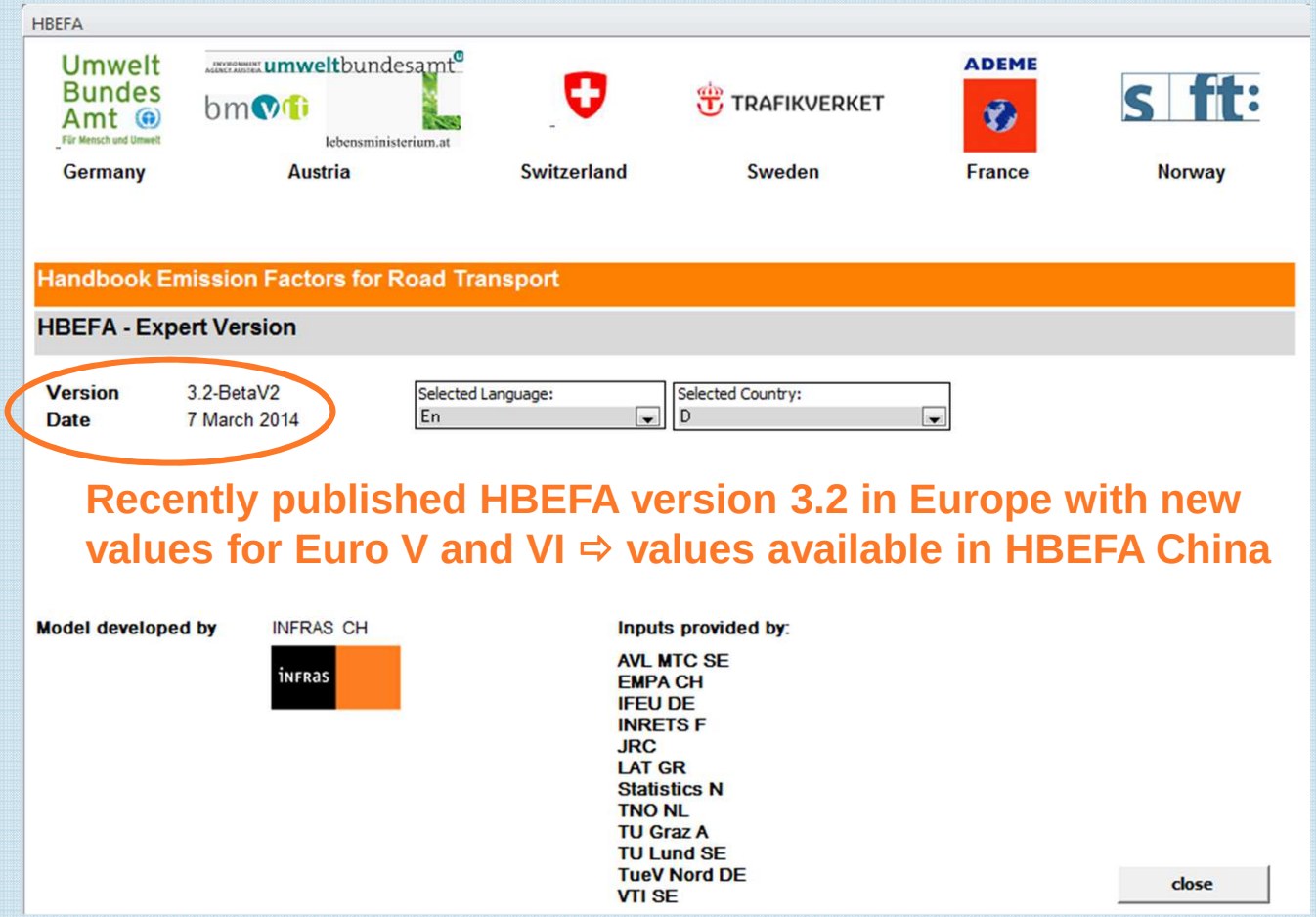





Sources: SenStadt Berlin, HLUG, Infras.

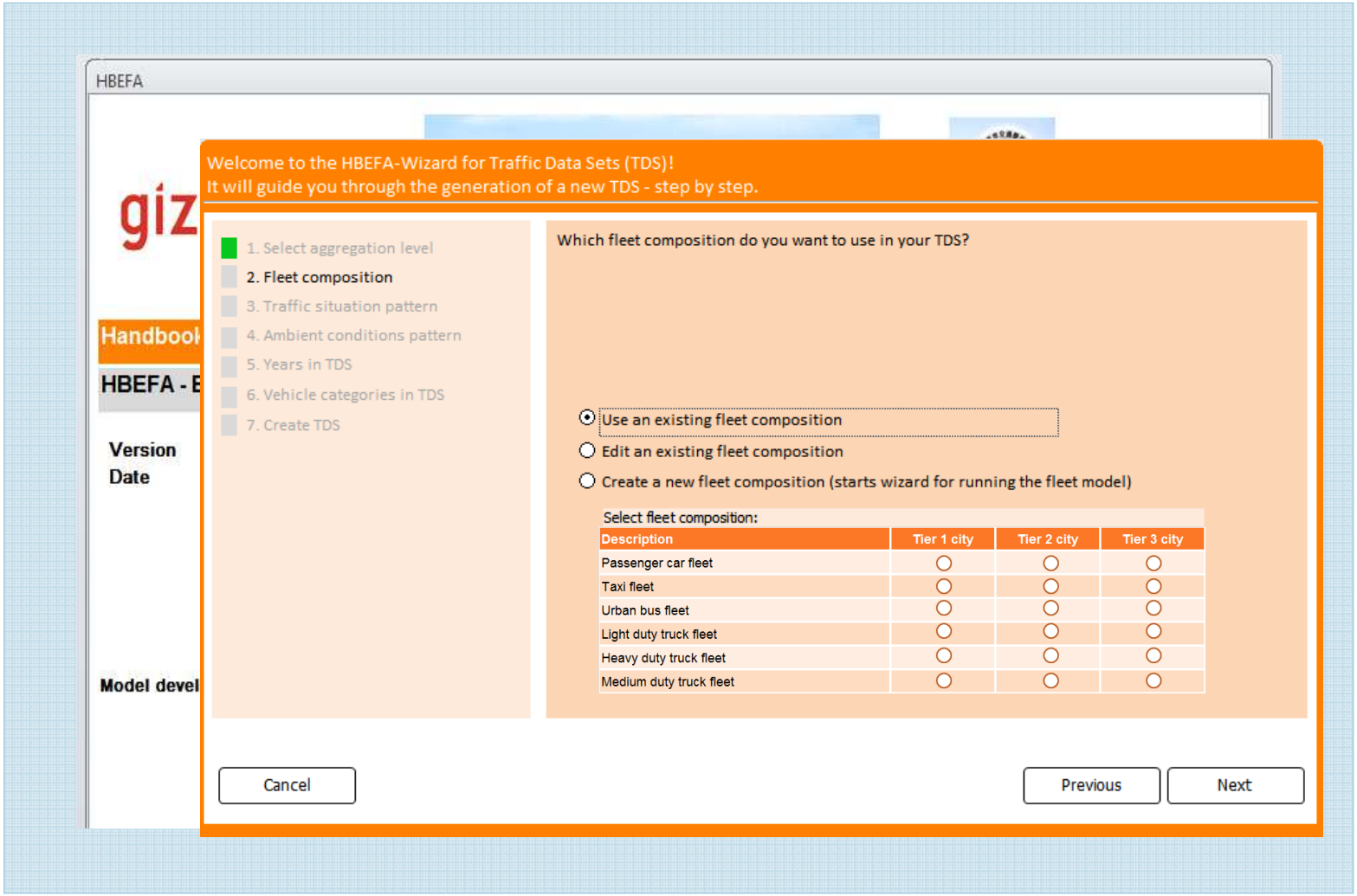
Benefits for Chinese Cities

# HBEFA China will continuously participate of developments in Europe



Benefits for Chinese Cities

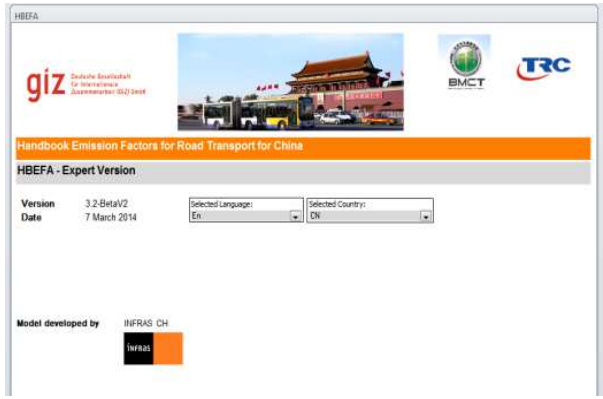
# Next version of the model will provide user-friendly access to the model



# Summary of benefits using HBEFA for Chinese Cities

1. HBEFA China is a consistent method for detailed and simplified level

2. HBEFA China delivers emission factors to monitor all kind of measures




3. HBEFA China based on comprehensive groundwork done by Beijing and Shenzhen

4. HBEFA China can also be used for the calculation of air pollutants

5. HBEFA China will continuously participate of developments in Europe

6. Next version of the model will provide user-friendly access to the model

# Thank you for your attention

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