Proposed Work Plan for the Scenario Process on Environmental Impact Assessment of Electro-Mobility in China

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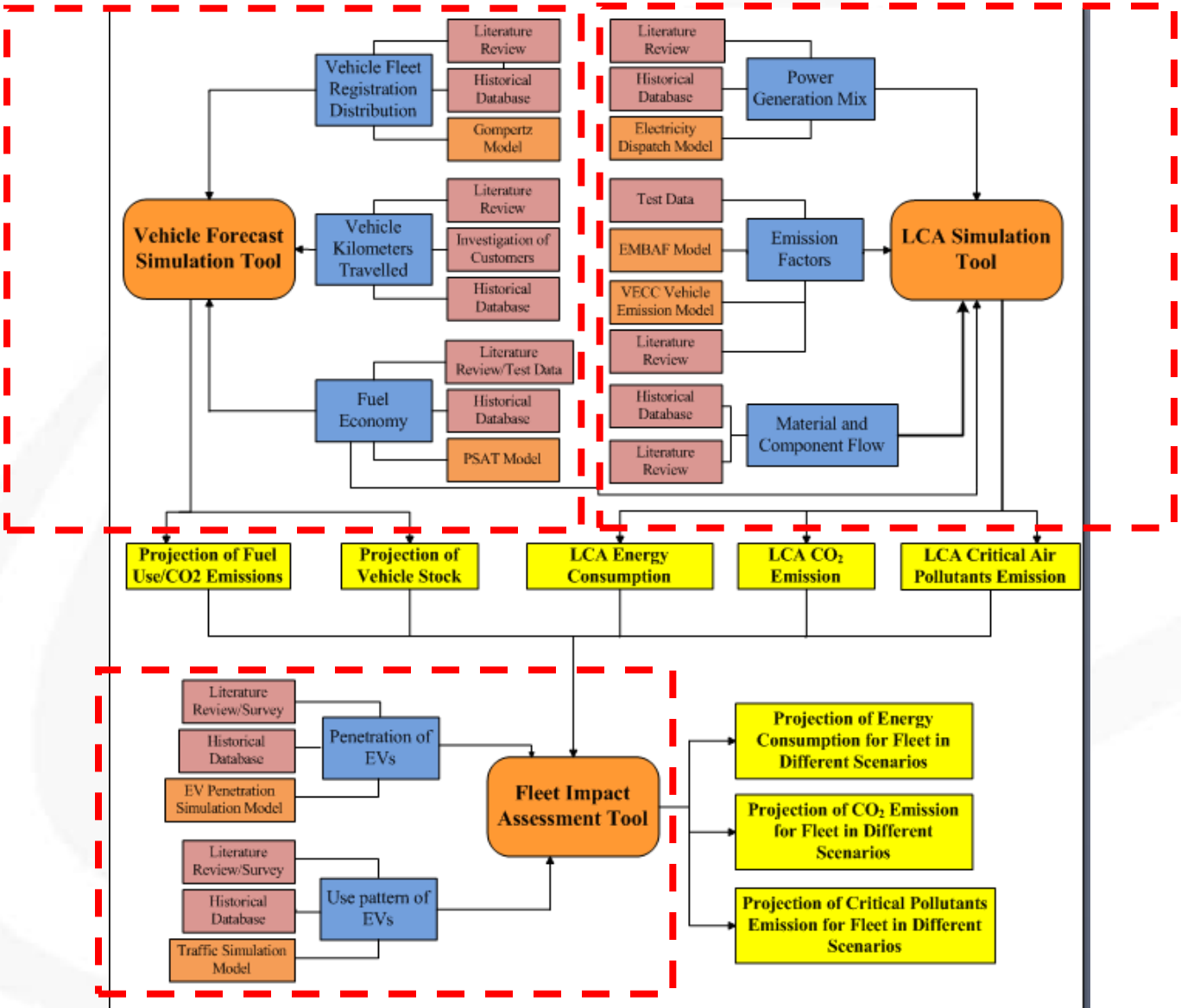
The goal of this project

- Identify and analyze the environmental impacts of Electro-Mobility in China. To this end, participatory scenario analyses will be performed, which quantitatively describe the market penetration of electric vehicles and take into account the share of renewable energies in the grid mix.
- Based on these scenario analyses, policy recommendations will be forwarded to the Chinese government to assist in the design of the regulatory framework.

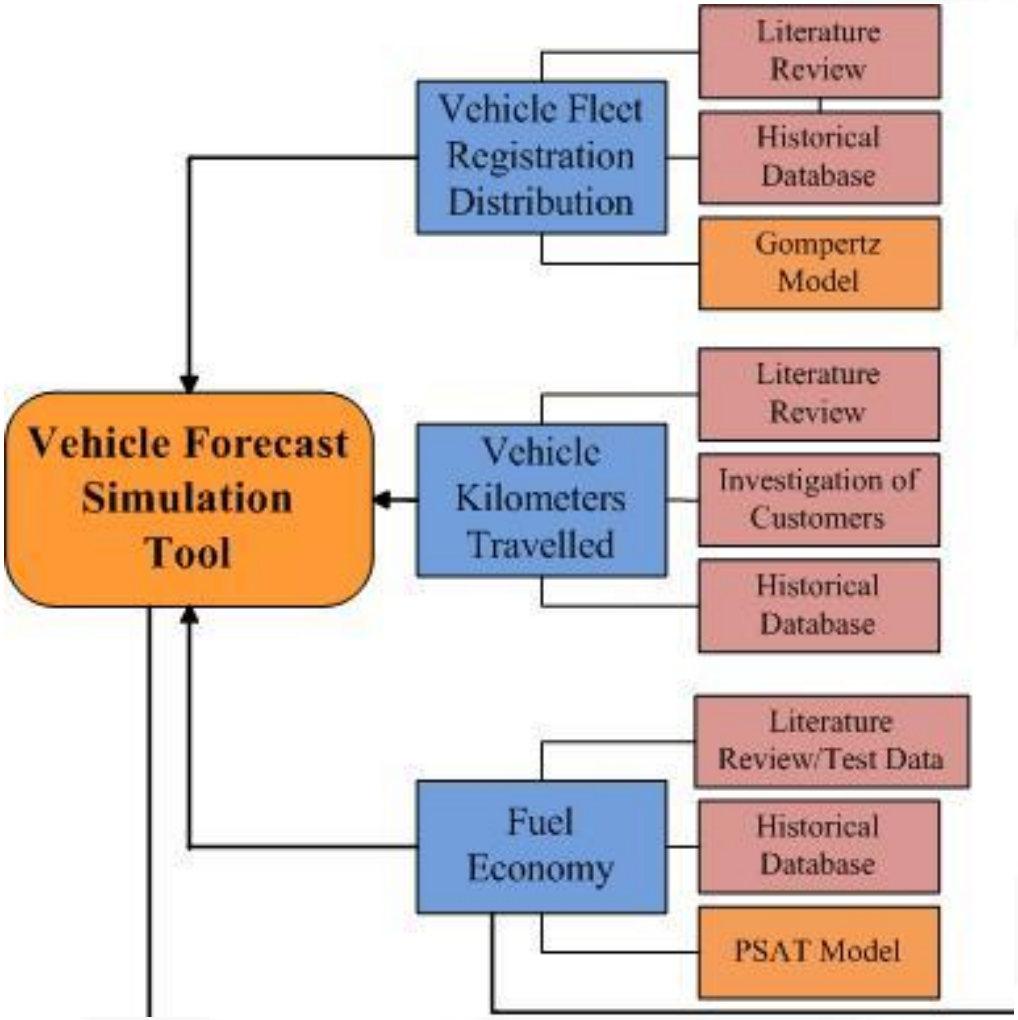
The content of the work

- Set up an appropriate Material Flow Model in order to calculate energy use, greenhouse gas (GHG) emissions and criteria air pollutants emissions of the vehicle fleet in China in a given year.
- Design a Baseline to describe the reference scenario for the vehicle fleet in China (including ICEVs and EVs).
- Design at least two alternative scenarios for EVs.
- Compare the environmental impacts for the different scenarios on national and on the level of selected provinces as well as for the applications of electric vehicles (EVs) in selected transport modes.
- Propose recommendations on how electro-mobility in China can be introduced to contribute most to climate and environmental protection and forward these recommendations to the Chinese government to assist in the design of the regulatory framework.

Logistics of methodology fundamental, tools and major data inputs/outputs



(1): Vehicle forecast simulation tool



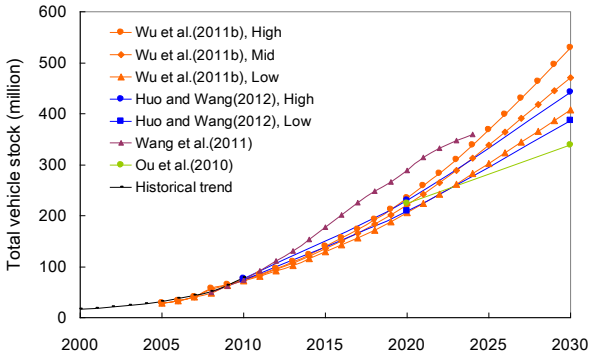
- **Vehicle growth pattern and vehicle fleet registration distribution**
- **Vehicle kilometer travelled and vehicle use pattern**
- **Fuel economy**

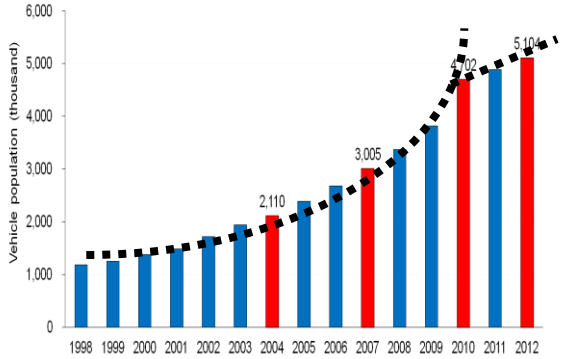
Light-duty vehicle growth pattern

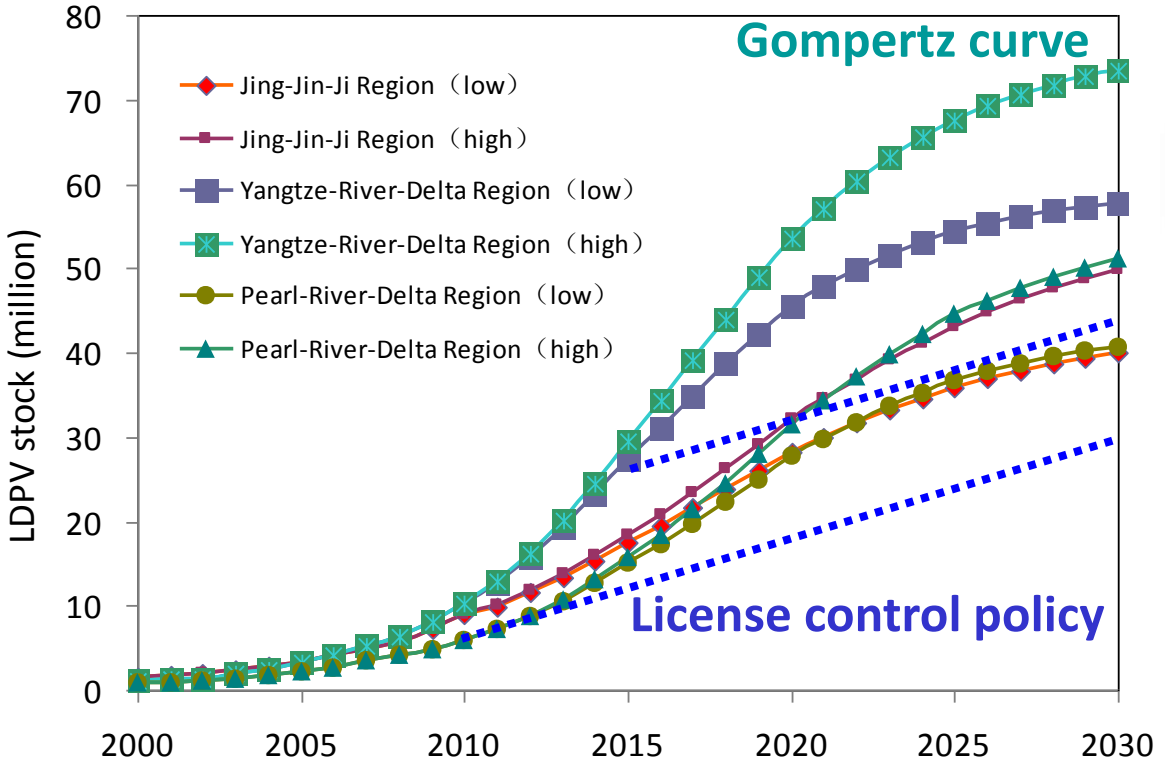
- Literature review
- Historical database
- Model simulation
  - ✓ Gompertz function

$$VSper_i = VSper_S \times e^{\alpha e^{\beta EconomyFactor_i}}$$

  - ✓ Logistic function
  - ✓ Richards function
  - ✓ Linear extrapolation
  - ✓ …

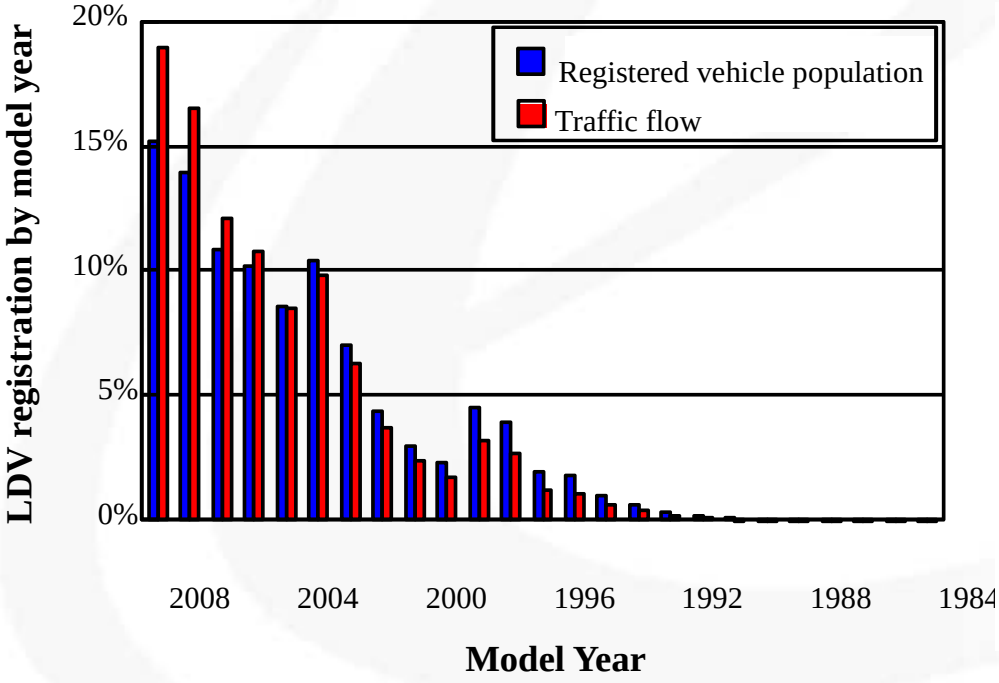




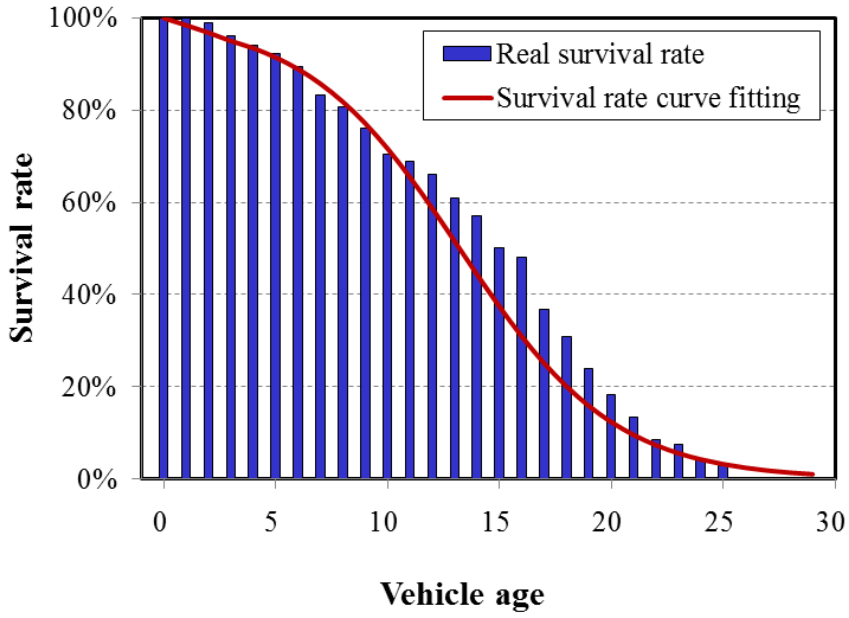


Vehicle fleet registration distribution

- Survival rate curve will be used to estimate old vehicles elimination proportion in the fleet
- Logistic function is applied to simulate vehicle survival rate curve



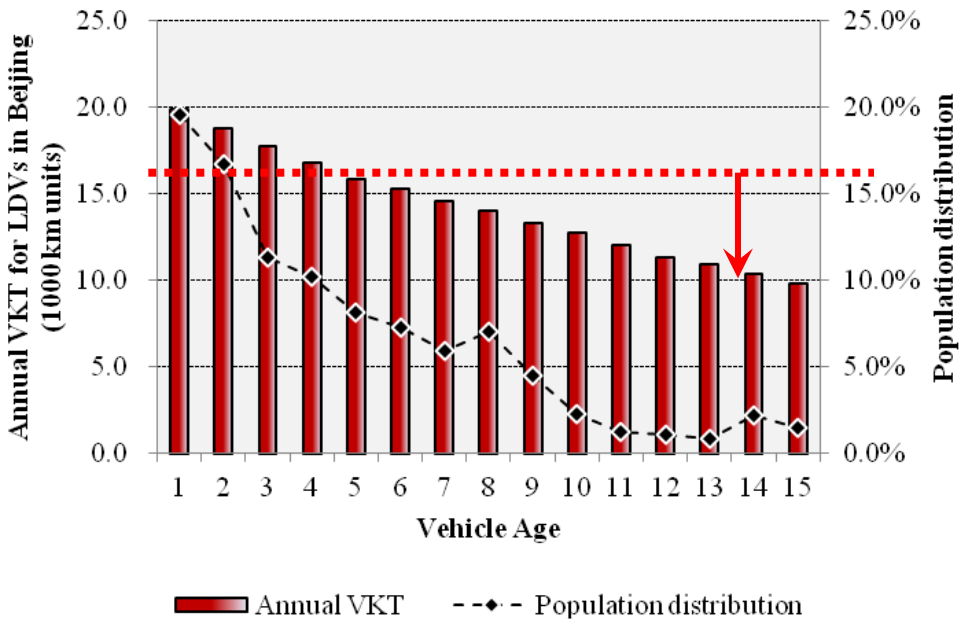
Registration distribution for LDPV in Beijing, 2009



Survival rate for LDPVs in China

LDV kilometer travelled (VKT)

- The VKT for Light-duty vehicle for a calendar year shows a clear decreasing trend by model year in China, especially in large cities (e.g., Beijing) with restriction rule for old vehicles

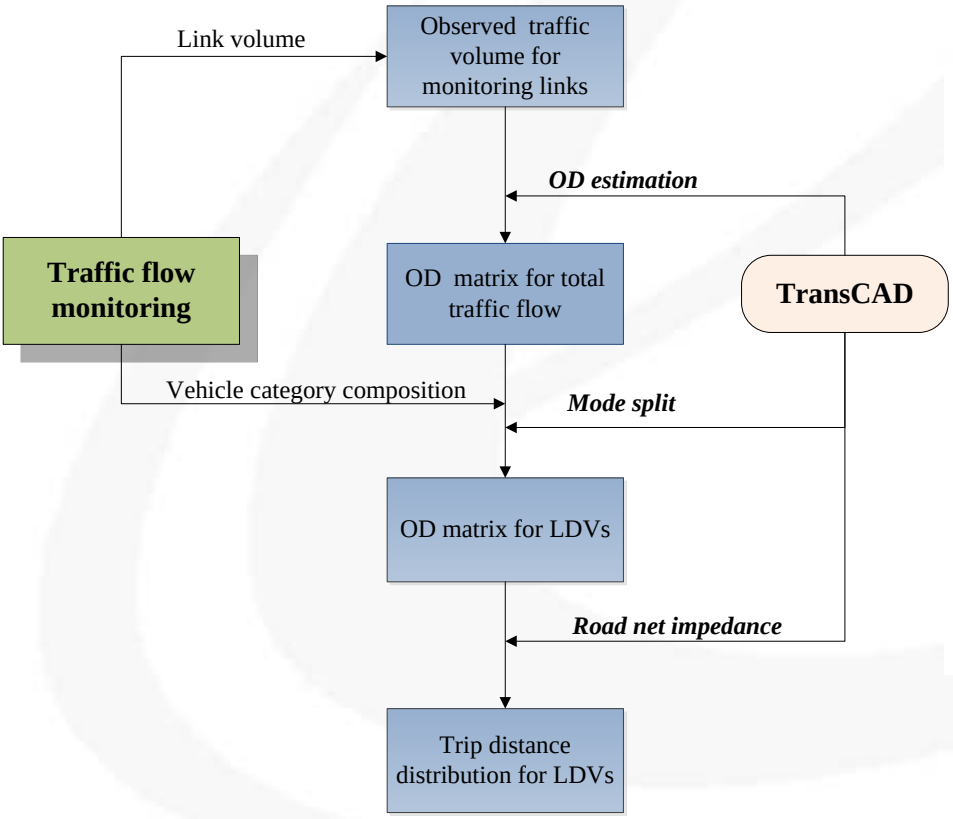


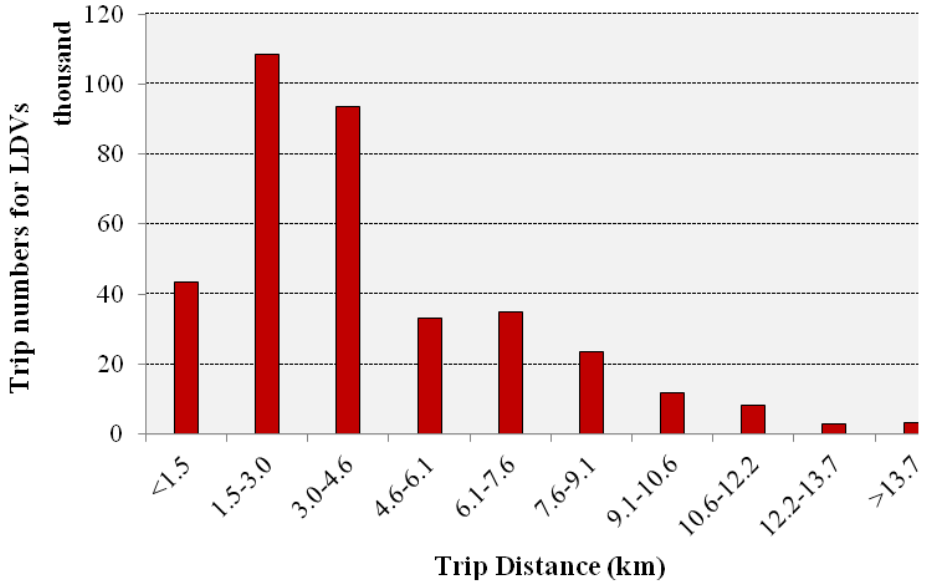
Annual VKT for Beijing's LDV fleet by age, 2010

- Forecast of LDV fleet-averaged VKT in the future is a complicated issue
  - ✓ Continue to decrease and then maintain stable?
  - ✓ First decrease and then increase slowly?

LDV use pattern

- The use pattern for LDV fleet needs a large number of survey data
- At present, such local data are scarce in cities of China

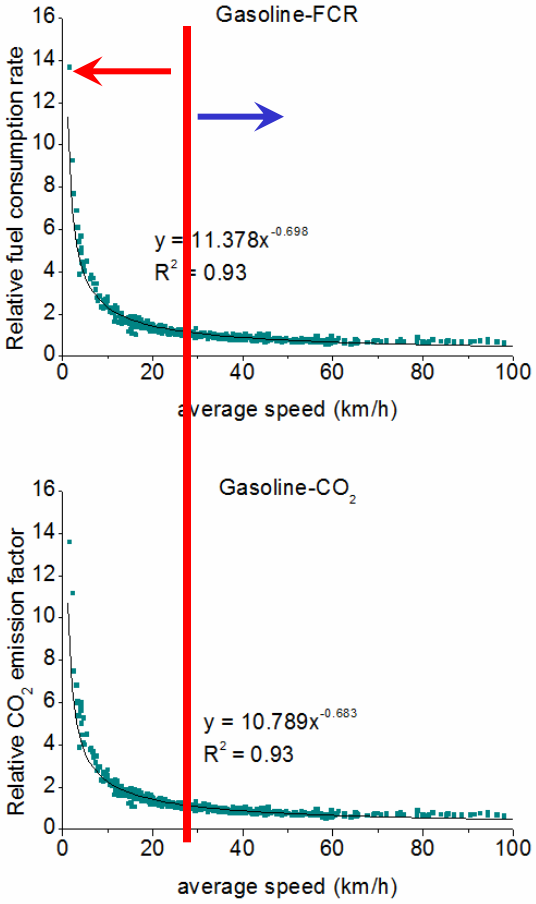




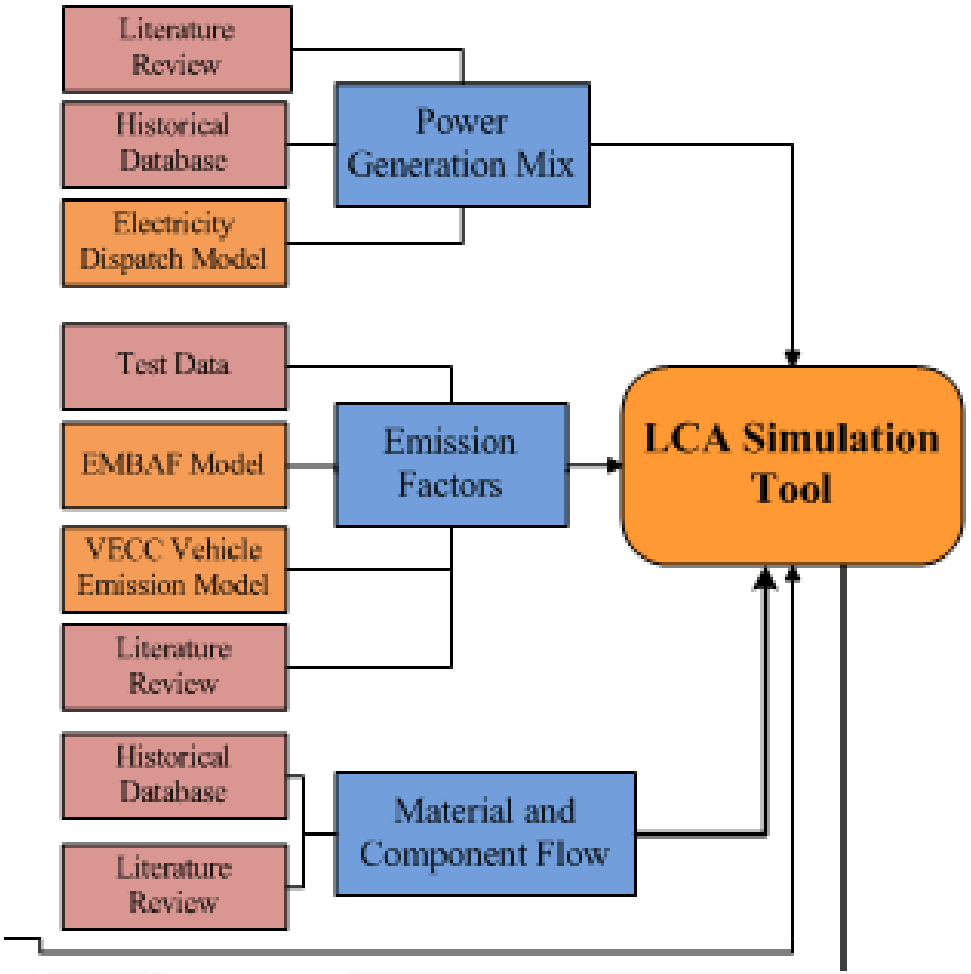
A case study of trip distance distribution in Macao, 2010

LDV fuel economy

- The implementation of stage I-III fuel economy standards
- The goal of fuel economy for future
  - ✓ 1) 2015: 6.9 L/100 km; 2) 2020: 5.0 L/100 km
- U.S. NAS scenarios and other data sources are taken into account for future fuel economy
  - ✓ Literature review and inputs from stakeholders
  - ✓ The most recent test data for new cars in China
  - ✓ Model simulations (e.g., AUTONOMIE)
- Adjustment of on-road fuel economy vs. lab-tested fuel economy needs to be carefully examined, especially for EV technologies

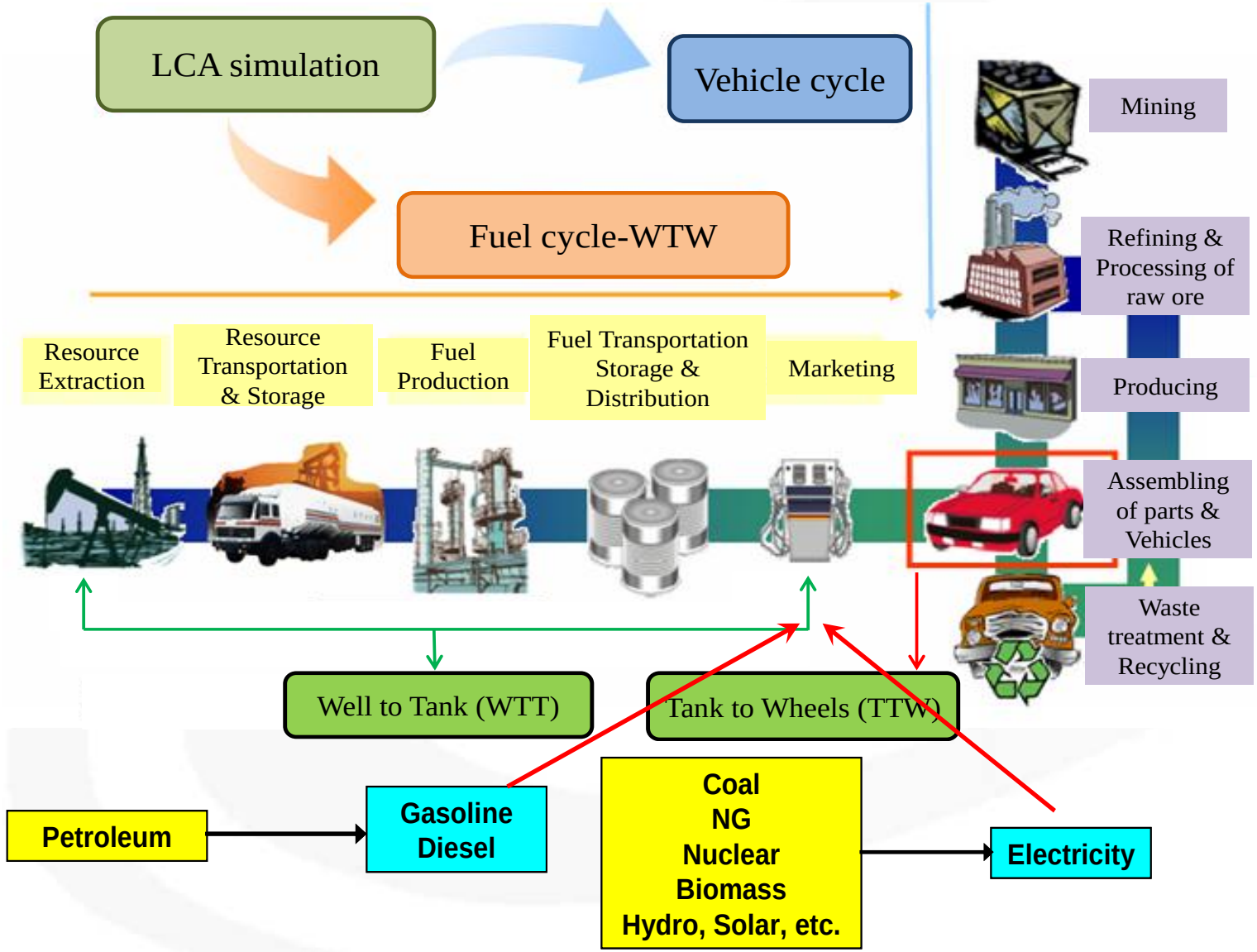


(2): LCA simulation tool



- **Upstream fuel cycle stage: power generation mix, energy efficiency and emissions, etc.**
- **Vehicle operation stage: fuel economy and emission factors**
- **Vehicle material cycle stage: material flow, vehicle component (e.g., battery), etc.**

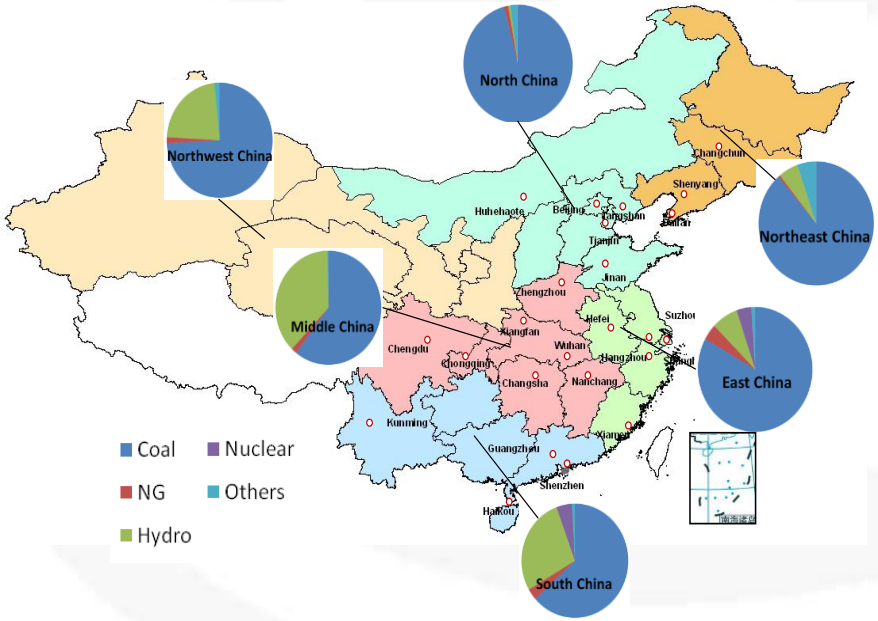
LCA system boundary

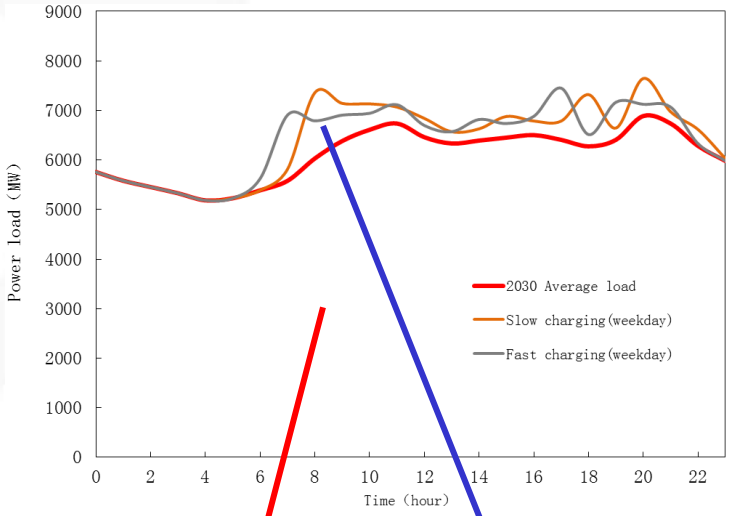


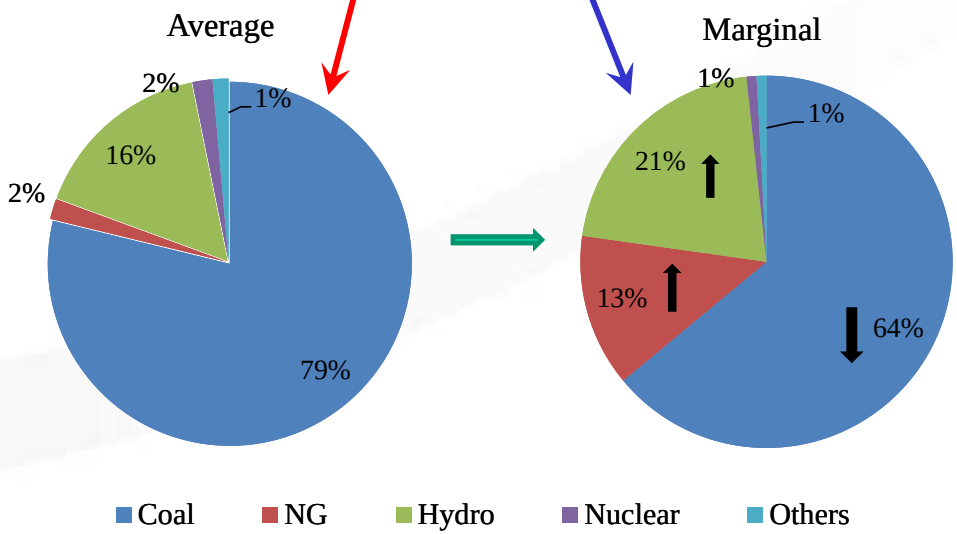
Electricity generation profiles

- **Regional variation needs to be carefully examined**
- **Average vs. Marginal**

Regional electricity generation in 2010







Electricity generation profiles

- **Promotion of new technologies and renewable power**
  - ✓ Coal power: supercritical, ultra-supercritical, IGCC, etc.
  - ✓ Renewable power: solar, wind, hydro, nuclear, etc.
- **More and more stringent emission control for coal power in China**
  - ✓ A new emission standard for coal power was just released, which is equivalent to the current control strength in the U.S.
  - ✓ A detailed emission database has been developed in Tsinghua

Air pollutant emission factor calculation:

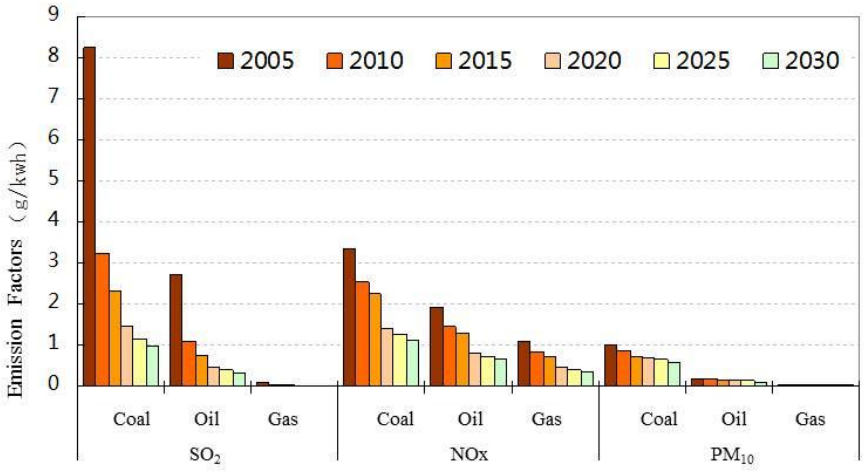
$$EF_i = EF_{noni}\left(1-\sum_j X_j\right)+\sum_j\left(EF_{noni}X_j\left(1-\eta_j\right)\right)$$

EF_i: Emission factor for pollutant *i*.

EF_{noni}: Emission factor without control for pollutant *i*.

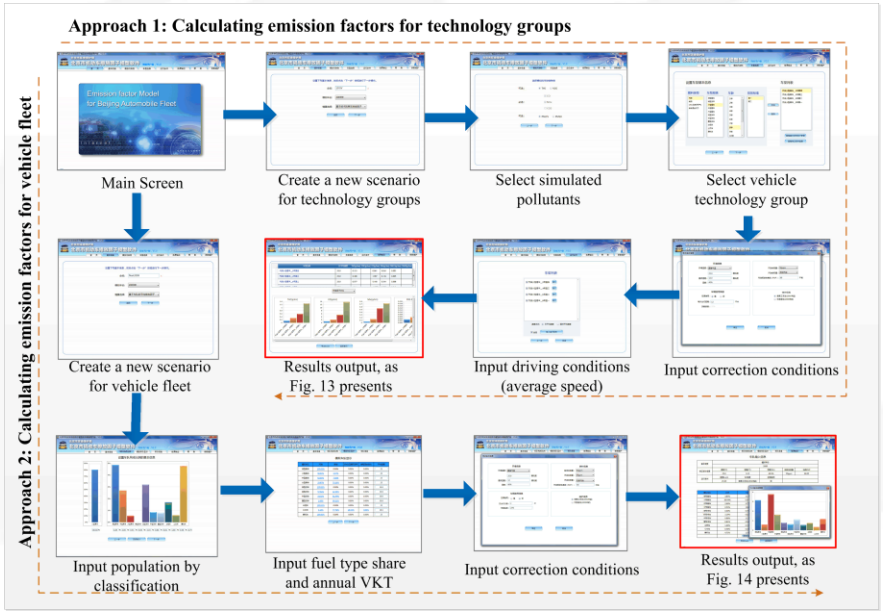
X_j: Proportion of pollutant control technology *j*.

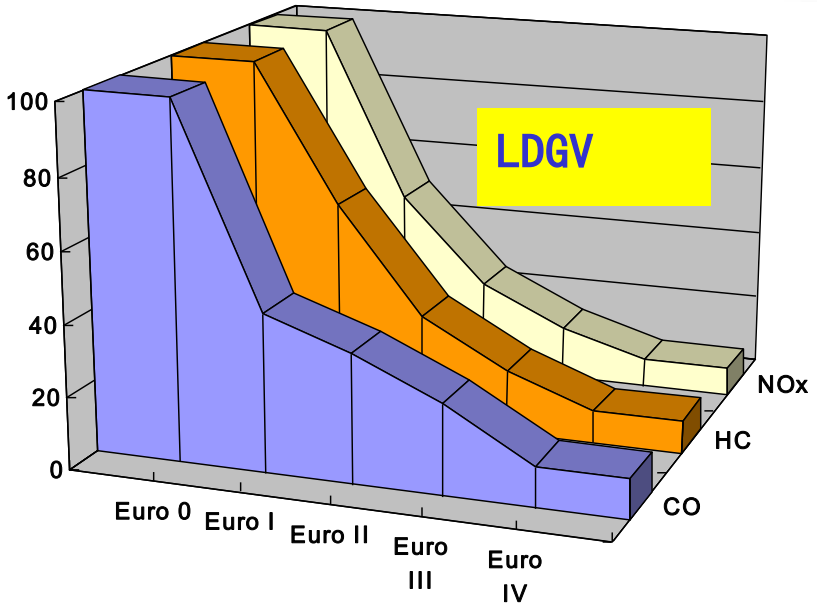
η_j: Removal efficiency of pollutant control technology *j*.



Light-duty vehicle emission profiles

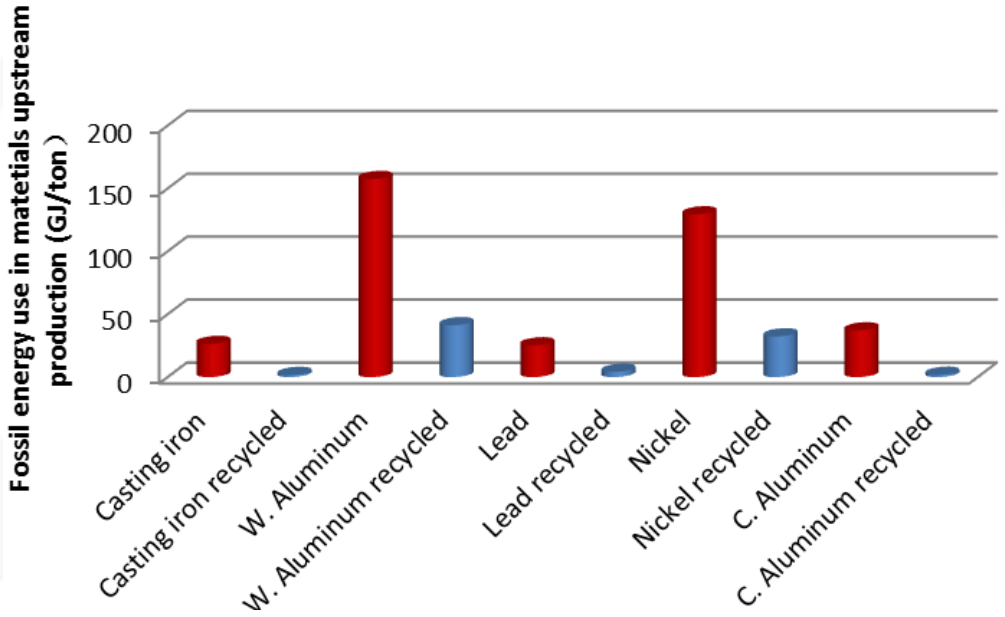
- **Conventional light-duty ICEVs**
  - ✓ Model simulation: e.g., the EMBEV model (V1.0)
  - ✓ New data from literature and stakeholders to take into account the impacts of newer emission standards: Euro VI, Tier 3, etc.
- **HEVs and PHEVs**
  - ✓ The most recent test data from literature and stakeholders



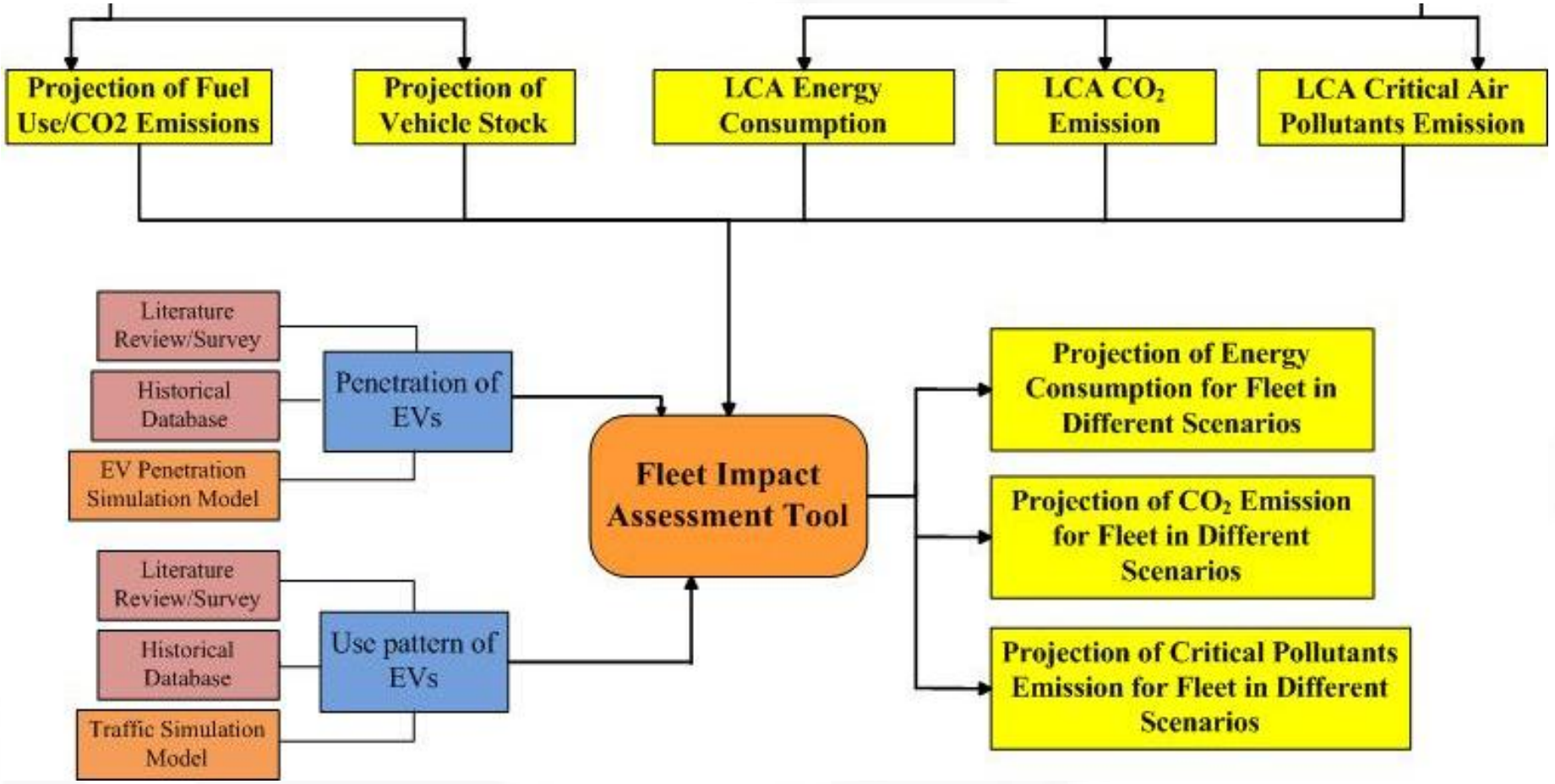


Vehicle material and component cycle

- **Energy balance for major vehicle materials and components**
  - ✓ A Chinese-specific database for major materials and components (especially for batteries) has been developed by Tsinghua and Ford
  - ✓ Only energy use and CO_2 emission will be examined for vehicle cycle
- **Recycling and reuse for major vehicle components**
  - ✓ Li-ion batteries: inputs from another project supported by GIZ and stakeholders



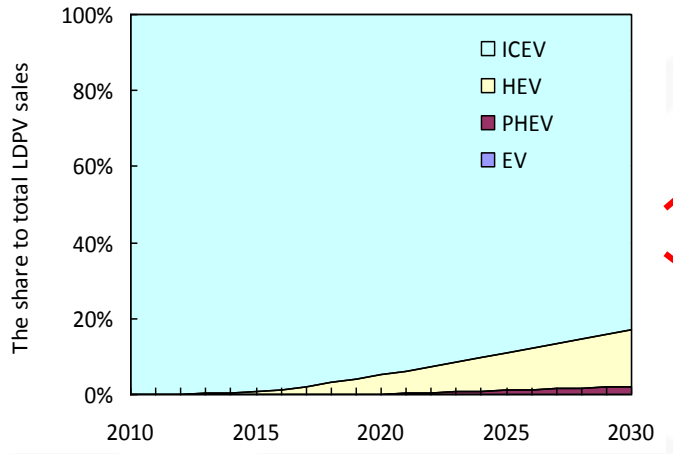
(3): Fleet impact assessment tool



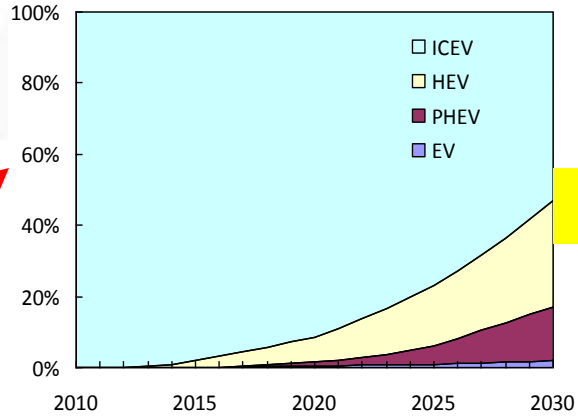
- The scenarios for penetration of different EV technologies
- Use pattern of EVs

EV penetration scenarios

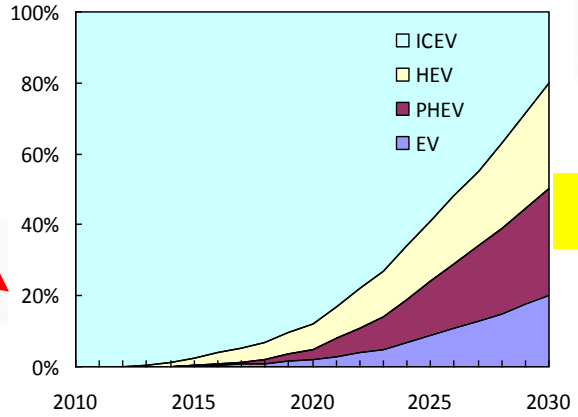
- **Definition of baseline and alternative scenarios**
  - ✓ National and local plans on EV demonstration and promotion
  - ✓ Inputs from stakeholders: e.g., IEA, CAE, ERI, CEPRI, universities, etc.



Baseline ??



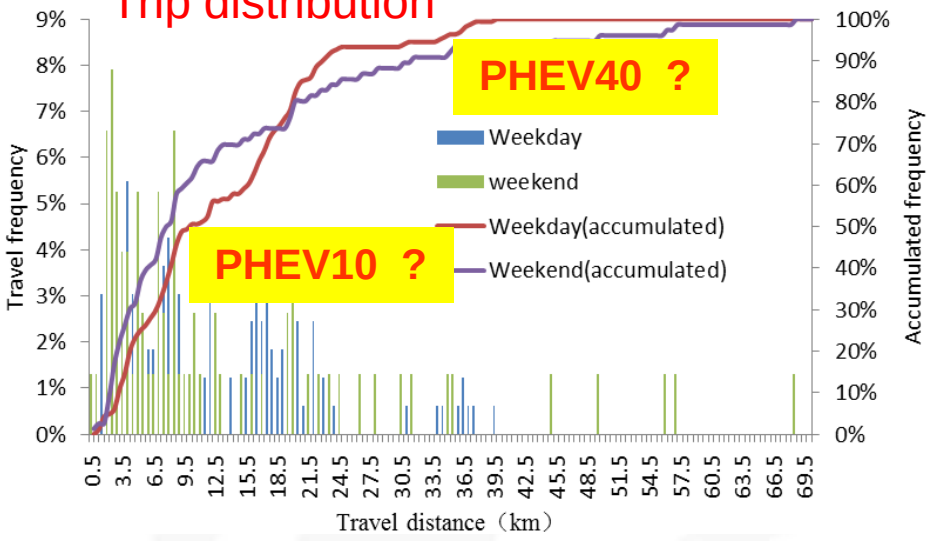
Alternative ??



Alternative ??

EV use patterns

Trip distribution



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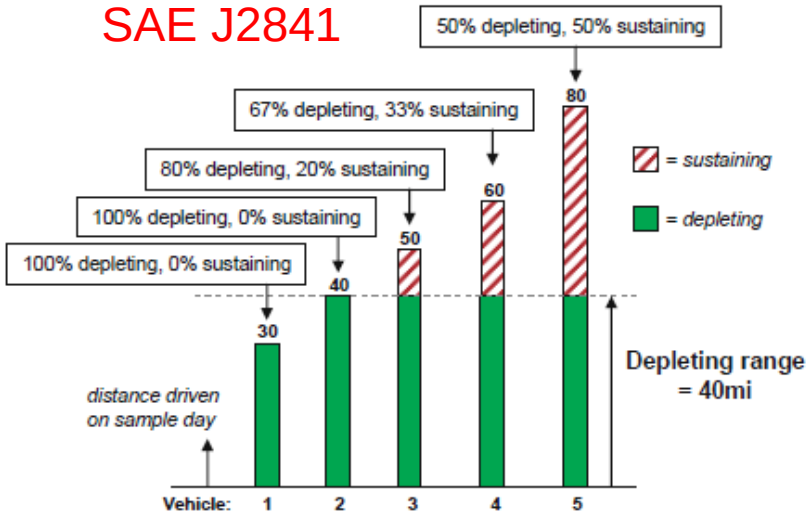

- Selection of AER for PHEV
  - ✓ PHEV10 ?
  - ✓ PHEV40 ?
- The VKT for PHEV/BEV vs. ICEV: shorter for PHEV/BEV?
- Consumer acceptance
  - ✓ Compact car ?
  - ✓ Big SUV ?

Scoping—System boundaries

- LCA simulation boundary
  - ✓ Vehicle operation stage
  - ✓ Fuel cycle
  - ✓ Vehicle material cycle
- Vehicle technology boundary
  - ✓ Propulsion options: ICEV, HEV, PHEV, BEV
  - ✓ All electric range for PHEV: 10 - 60 km
  - ✓ Fleet options: light-duty passenger car fleet and taxi fleet
- Regional boundary
  - ✓ National level
  - ✓ Six regional grid systems
  - ✓ Beijing and/or other demo cities

Scoping—System boundaries (cont'd)

- **Temporal boundary**
  - ✓ **2010-2030**
- **Impact categories**
  - ✓ **Energy: fossil energy use and petroleum energy use**
  - ✓ **GHG emissions: GHG is primarily CO_2, supplemented by N_2O and CH_4**
  - ✓ **Criteria air pollutant emissions: CO, NO_X, SO_2, VOC, and $PM_{2.5}$. This part is only for fuel cycle analysis. Due to a large amount of data not currently available, simulation of emissions of vehicle material cycle will not be covered at this stage.**

Contributions to the expert workshops

Five expert and stakeholder workshops with the following topics

- Kick-off, methodologies and scoping (May 2013)
- Development of the power sector and electricity grid (June 2013)
- Market penetration of EVs, mobility behavior and use pattern (June 2013)
- EV and ICEV technologies (efficiency, costs, emission factors) (TBD)
- Presentation of results and discussion of policy recommendations (TBD)

Thank you for your attention !

Questions ?