CASE STUDY: APPLICATION OF EXPERIENCE CURVES IN THE ASTRA TRANSPORT MODEL

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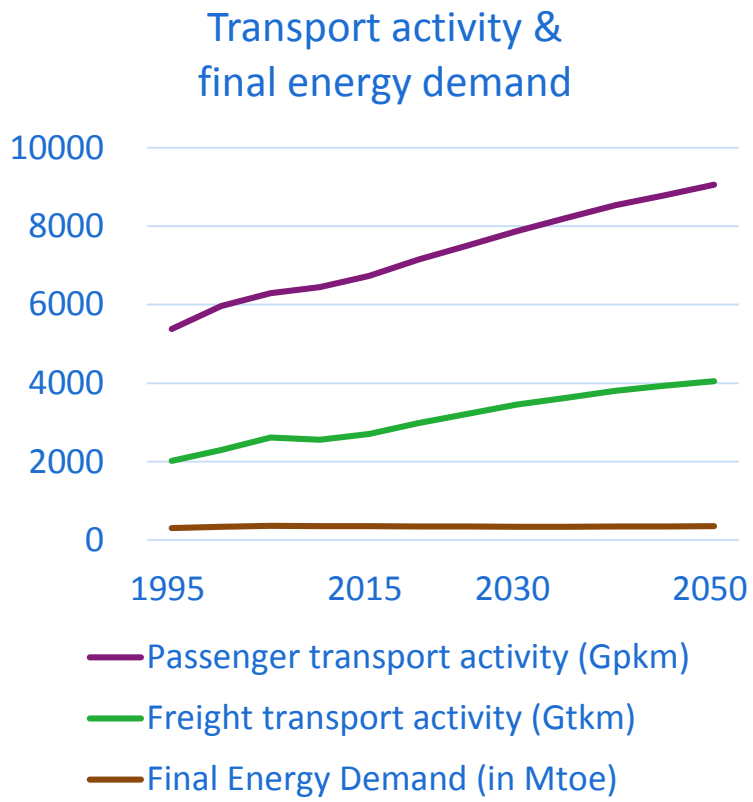
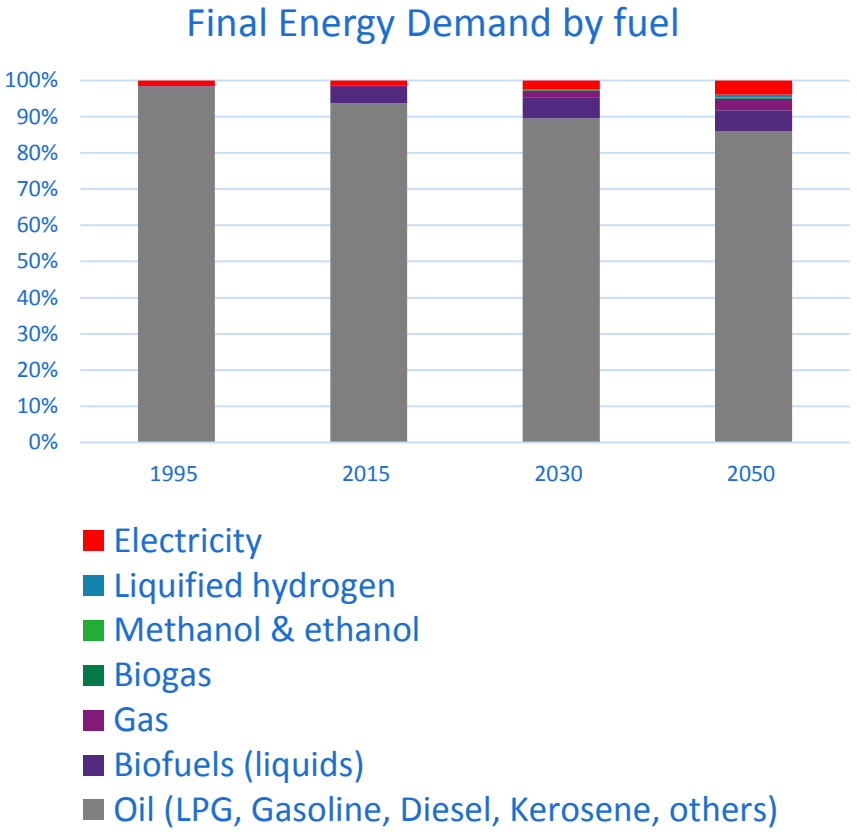
PRIMES REFERENCE SCENARIO EU28 FOR TRANSPORT

Efficiency increase included, but low shift to low-carbon technologies





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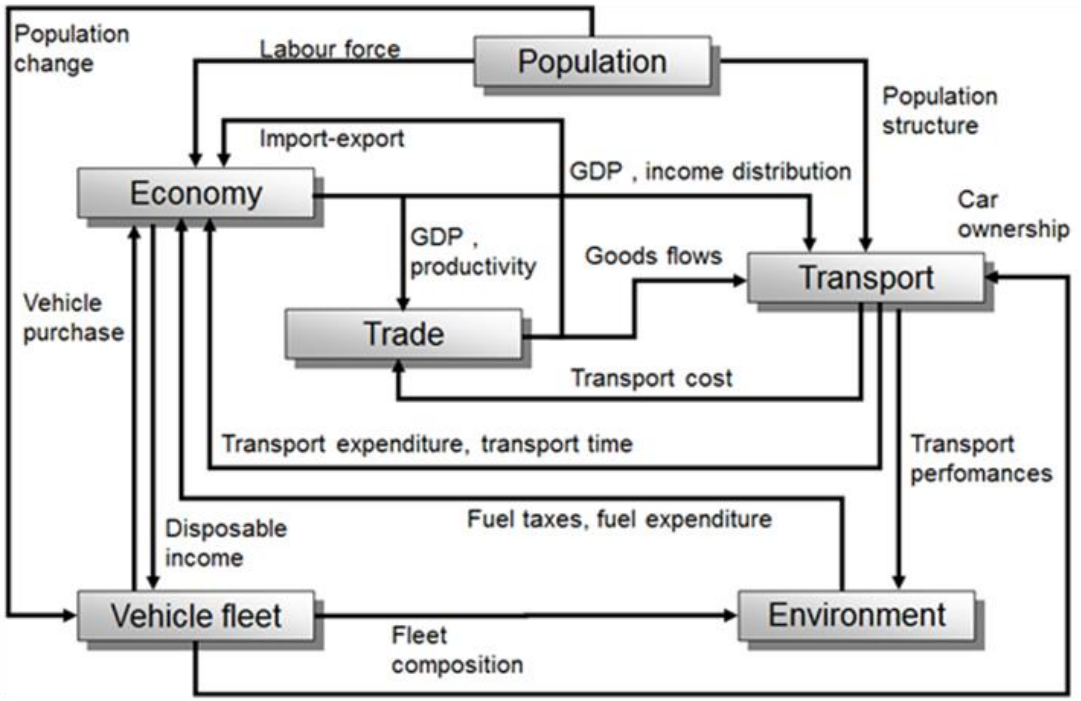
ASTRA - ASSESSMENT OF TRANSPORT STRATEGIES

ASTRA model: www.astra-model.eu

Main characteristics:

- System Dynamics
- Vensim® software
- 1995 to 2050 (dt = ¼ a)
- ~ 9,000 variables
- Modular structure
- EU28 + CH/NO
- Calibration of modules in sequence
- 3 Companies: TRT Trasporti e Territorio, M-FIVE, Fraunhofer ISI



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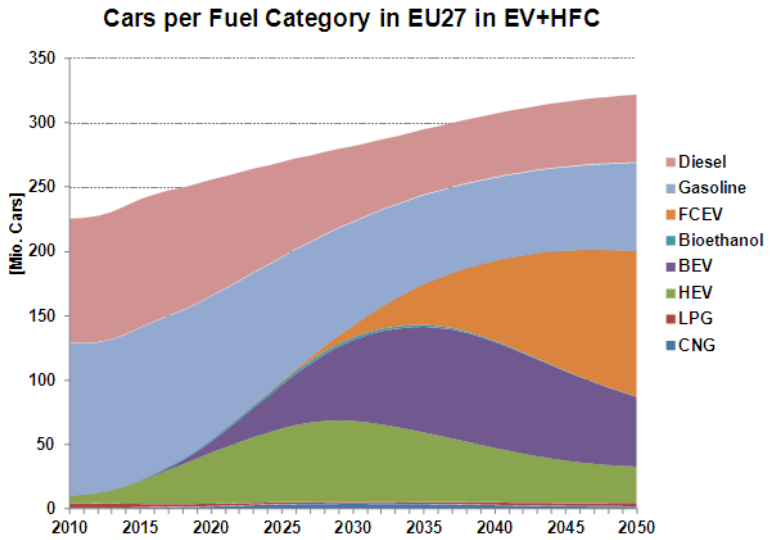
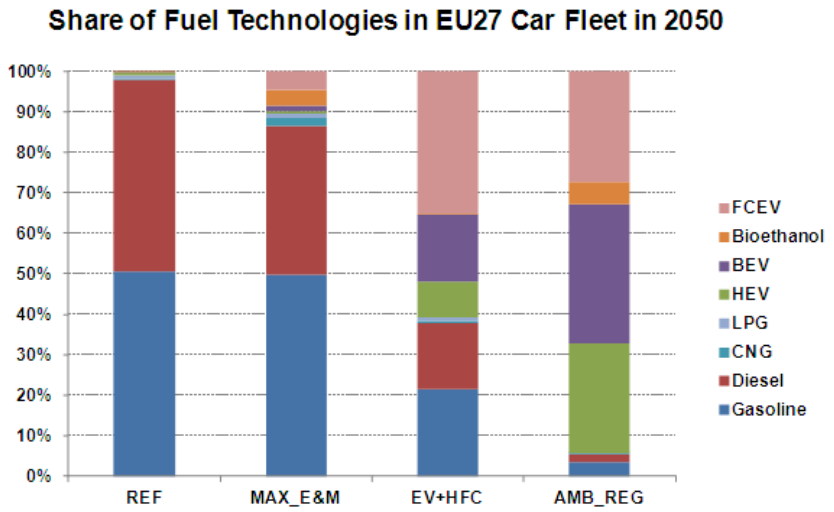
DIFFUSION OF TECHNOLOGIES

FLEET COMPOSITION BY SCENARIO

Development of vehicle fleet by technology for a specific scenario



Comparison of different scenarios



Source: Michael Krail (2012), Project GHG-TransPoRD, ASTRA model

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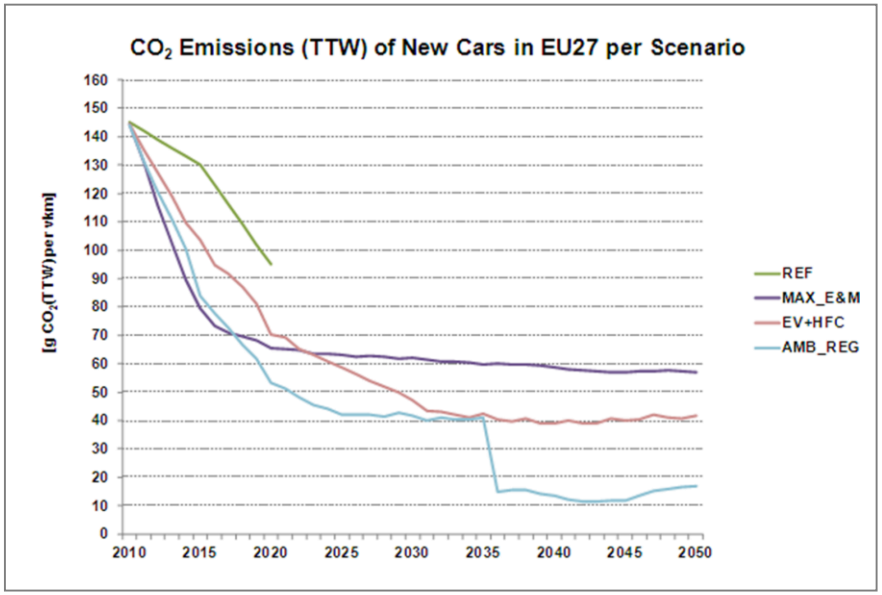
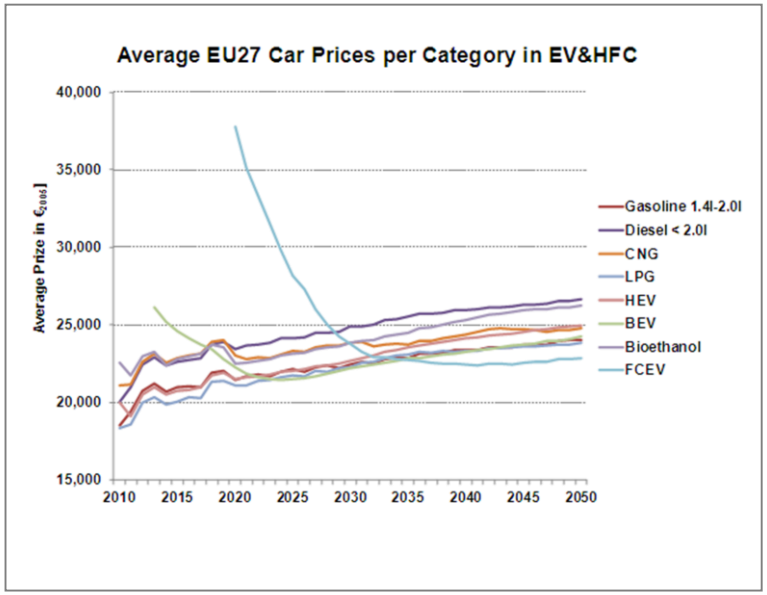
DIFFUSION OF TECHNOLOGIES

EXEMPLARY RESULTS: EMISSIONS, CAR PRICES

Development of emissions for different scenarios



Development of car prices by technology



Source: Michael Krail (2012), Project GHG-TransPoRD, ASTRA model

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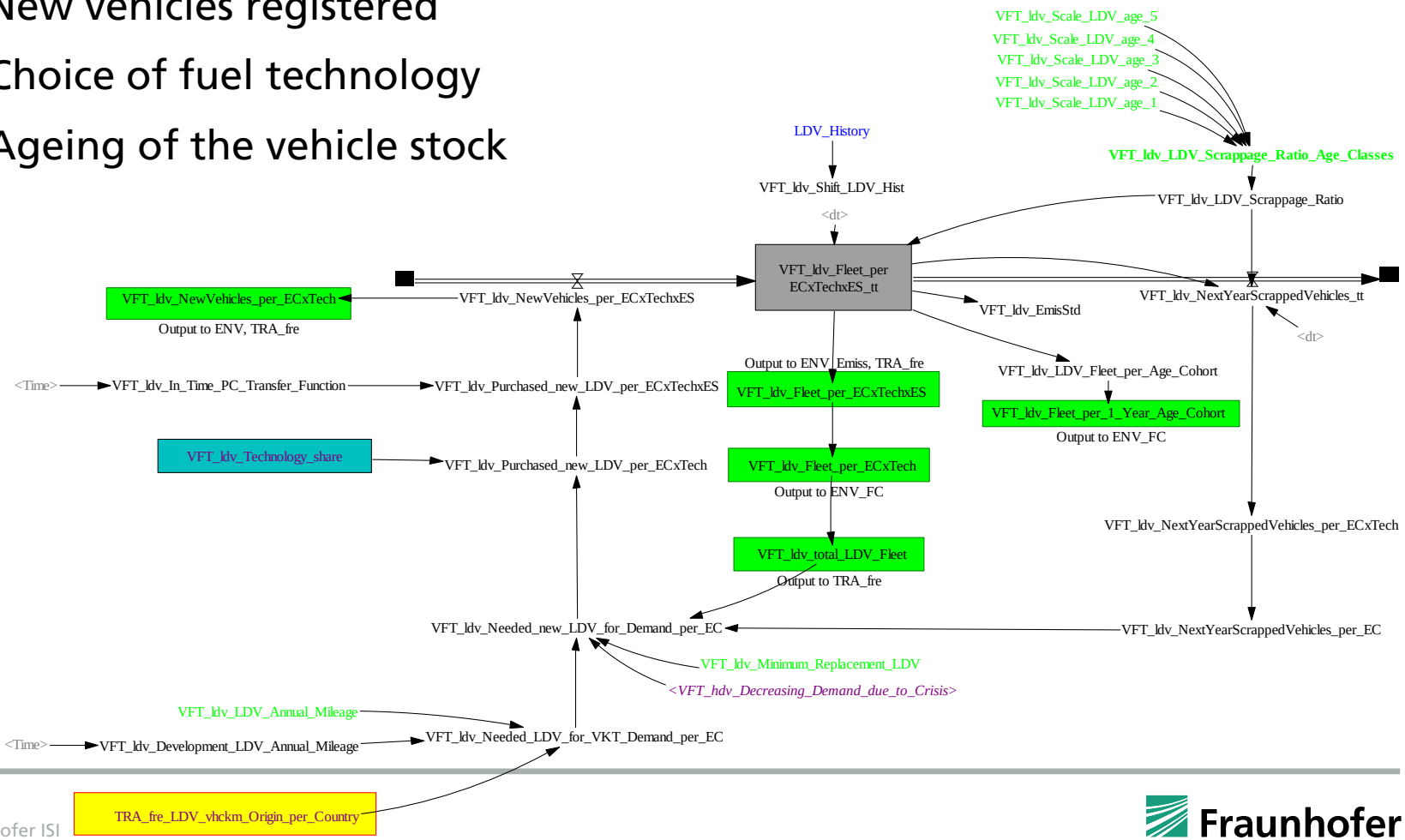
VEHICLE FLEET MODULE

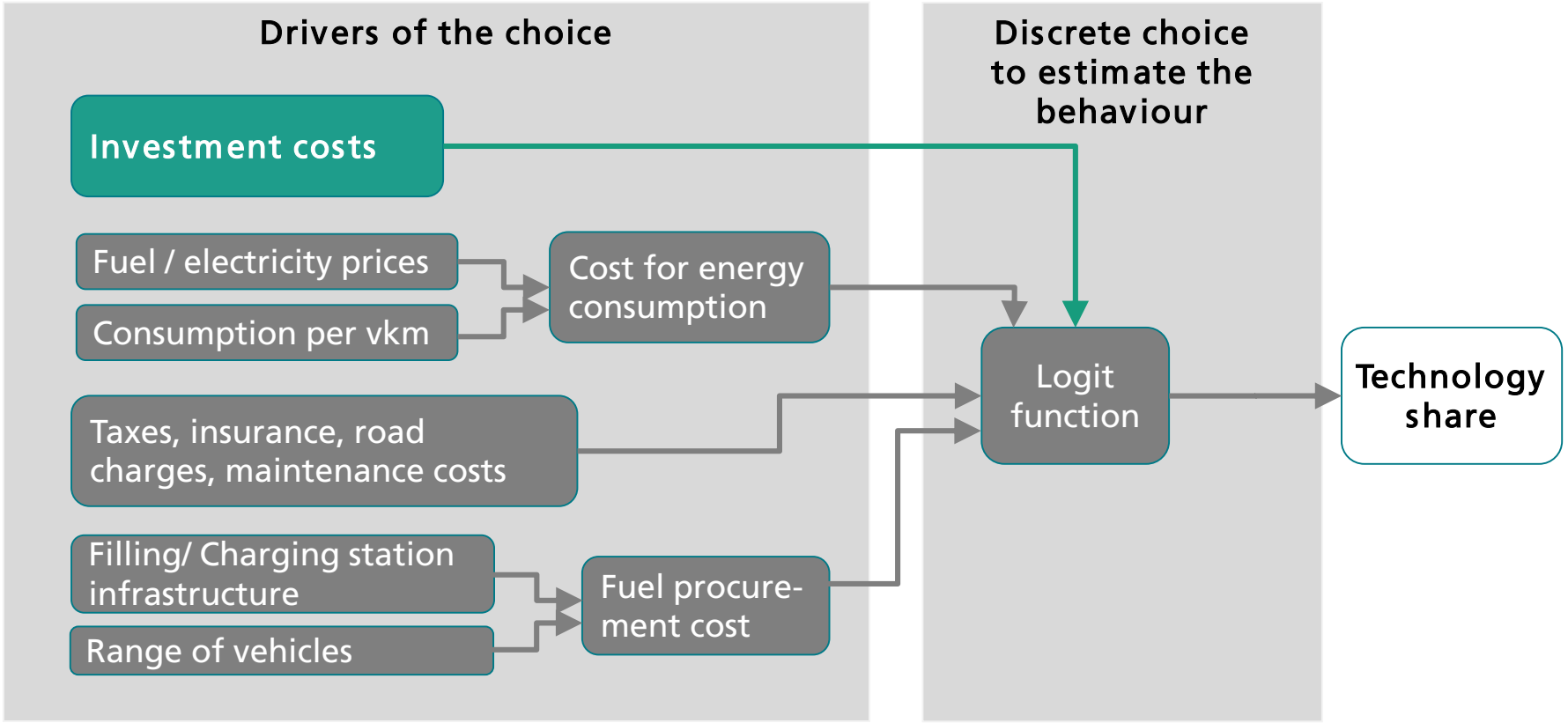
SIMULATING FLEET DEVELOPMENT IN 4 SUB-MODULES

- New vehicles registered
- Choice of fuel technology
- Ageing of the vehicle stock



CHOICE OF FUEL TECHNOLOGY

SCHEME ON SIMULATING THE CHOICE IN ASTRA



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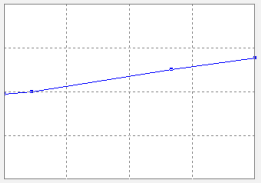
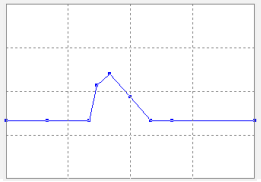
PURCHASE PRICES BY TECHNOLOGY

SEVERAL FACTORS USED FOR CALCULATION

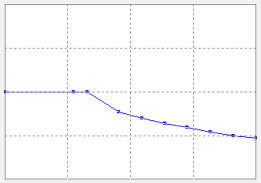
- Basic vehicle price * Price level adjustment by country
- Additional costs for alternative fuel cars by technology



Development of car prices reflecting the **trend** of **more expensive safety, efficiency and convenience**



Price increase to achieve the **CO_2 emission limits** affecting only fossil-based cars



Price decline for BEV and FCEV representing higher economies of scale induced by R&D derived from GHG-TransPoRD with an assumed learning rate in a one-factor learning curve of 10%. Underlying diffusion scenario with a share of 65% on total fleet until 2050.

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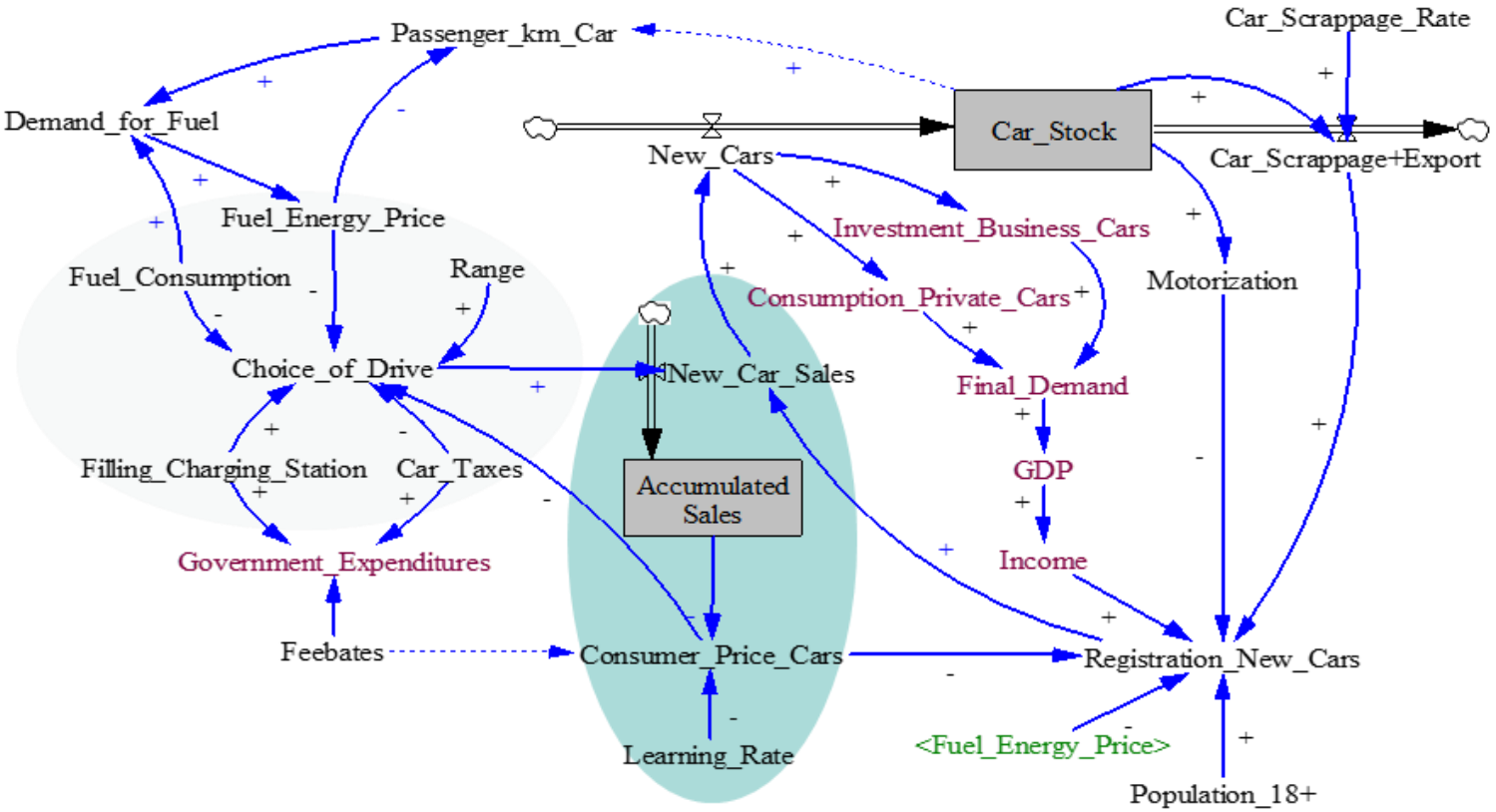
EXPERIENCE CURVES FOR CAR PRICES

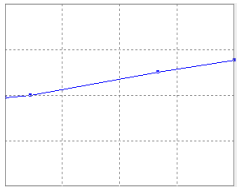
IMPLEMENTED IN SD BY INFLOWS IN STOCK



Source: Michael Krail (2012), Project GHG-TransPoRD, ASTRA model

COMPONENT-BASED APPROACH

SUMMATION TO CAR PRICE BY TECHNOLOGY

Technology-dependent	with learning	Price for major technology-dependent **components**
	without further learning	- for Electric Vehicles (Power electronics, Transmission,...) **Price for further parts related to a technology** - for Internal Combustion Engines (exhaust system,...)
Technology-independent		**Base price for all parts that are independent of the technology** (Chassis, seats, etc.)

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COMPONENT-BASED APPROACH

LEARNING CURVES FOR SINGLE COMPONENTS

Main technology-dependent components to be considered for learning curves:

- **Battery (kWh)**, Battery management system, Electric motor (kW)
- **Fuel Cell stack (kWh)** incl. BOP (balance of plant), Hydrogen tank (kWh)

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EXPERIENCE CURVES FOR CAR PRICES

COMBINING ENDOGENOUS & EXOGENOUS DATA

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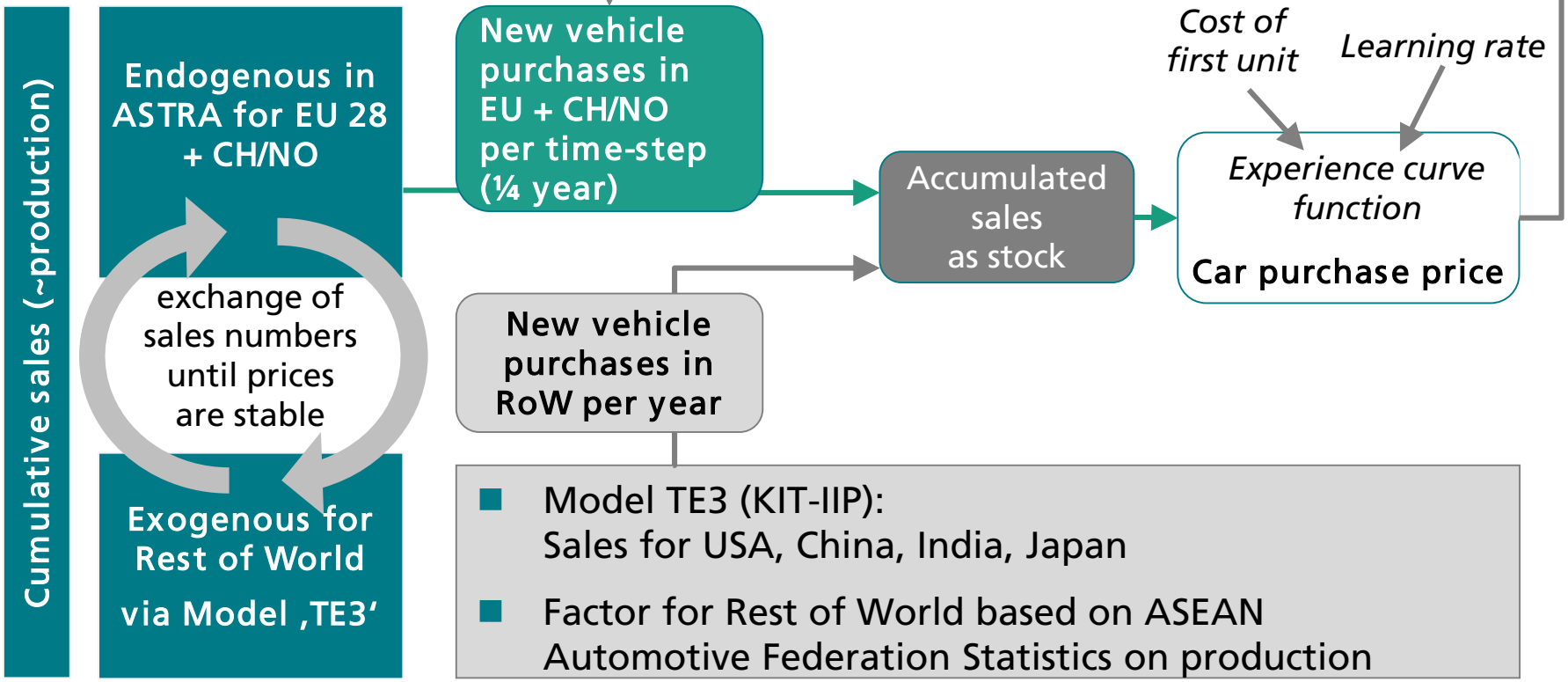

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ISSUES FOR IMPLEMENTATION

DIVERSE ASPECTS AT SOME POINT IN QUESTION

Learning across fleet types and need for exogenous data for RoW for trucks, light duty vehicles and busses

Component-based instead of vehicle-based

Scaling effects on prices for larger batteries

Spillover effects from stationary storage on **battery prices**

Technology change, e.g. new battery types

Proceeding in case of lack of data for components: Option to deviate learning curve parameters, e.g. by grouping parts with similar learning types?

Time-step ¼ year – combination with 1 year for RoW

Transfer from learning to prices – adaptations required: e.g. OEMs sell alternative fuel cars for first 5 years without margin, after 5 years smoothly to margins above the Learning Curve line

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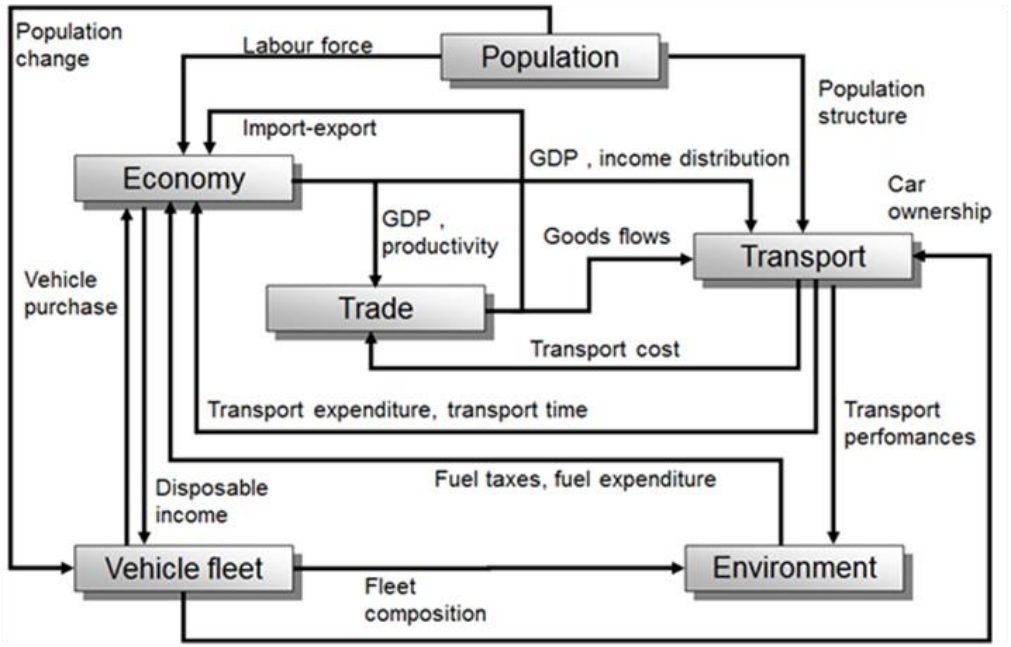
FURTHER TECHNOLOGICAL LEARNING

IMPACT IN ASTRA FOR FLEET & ENVIRONMENT



- Capacity / range of vehicles
- Weight of batteries
- Bio-fuels
- PtX-fuels
- Consumption / energy efficiency
- Emissions

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