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NATIONAL OPEN ACCESS SCIENTIFIC CENTRE FOR FUTURE ENERGY TECHNOLOGIES

OPEN R & D LITHUANIA

Challenges of modelling transport sector in cross-sectoral energy planning models

Research is funded by the Scientific Council of Lithuania
Project No S-MIP-19-36

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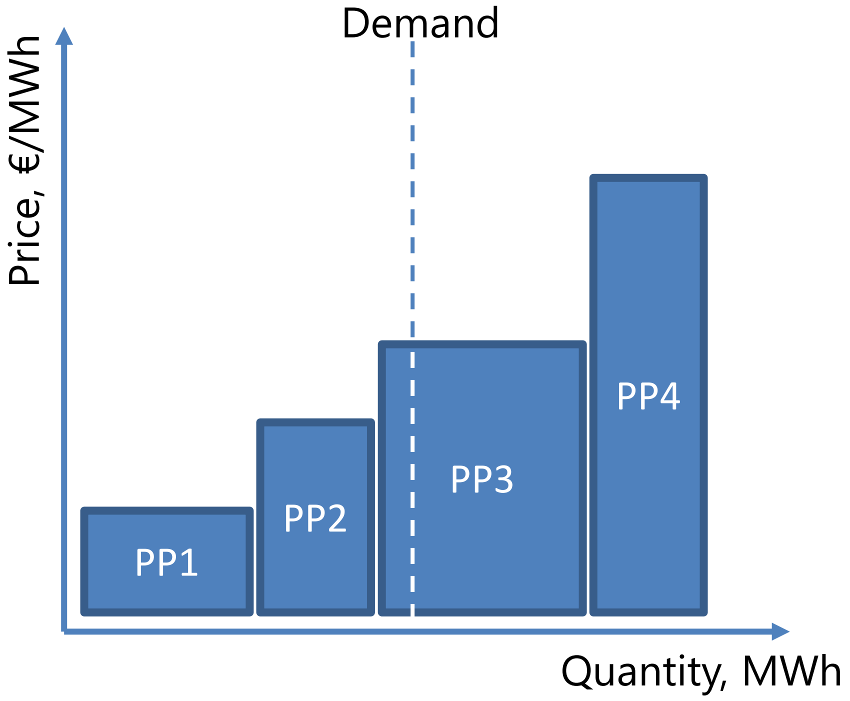
Lithuanian Energy Institute, laboratory of energy systems research

Energy planning model

Bottom-up LP/MIP partial equilibrium optimization model for energy planning



$$minimizes\ total\ discounted\ cost$$

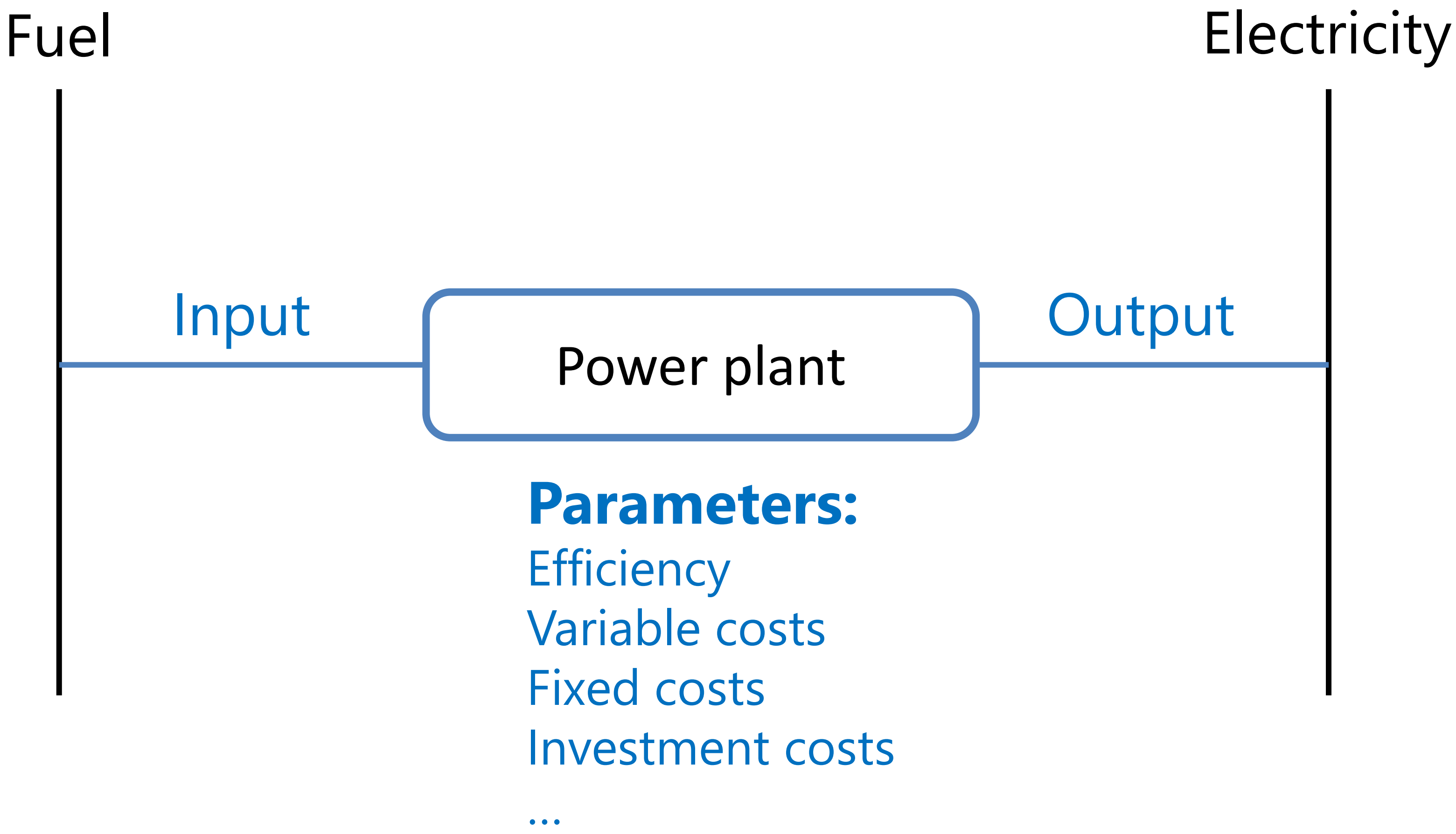
Energy planning modelling software:

- TIMES/MARKAL
- MESSAGE
- Balmorel

Why should you incorporate the transport sector?

- The most GHG emitting sector in US[1] and 2nd in EU[2]
- EU objective to reduce emissions by 90% till 2050[3]
- Zero carbon emission transport fuels: electricity, hydrogen, biofuels
- EV fleet expansion increases electricity demand and affects the shape of the demand curve
- The effectiveness of transport sector decarbonization depends on the electricity generation energy mix.
- Flexible electric vehicle charging to balance RES
- Hydrogen production through electrolysis

Challenge 1. How to model vehicles in a system designed to model an energy system



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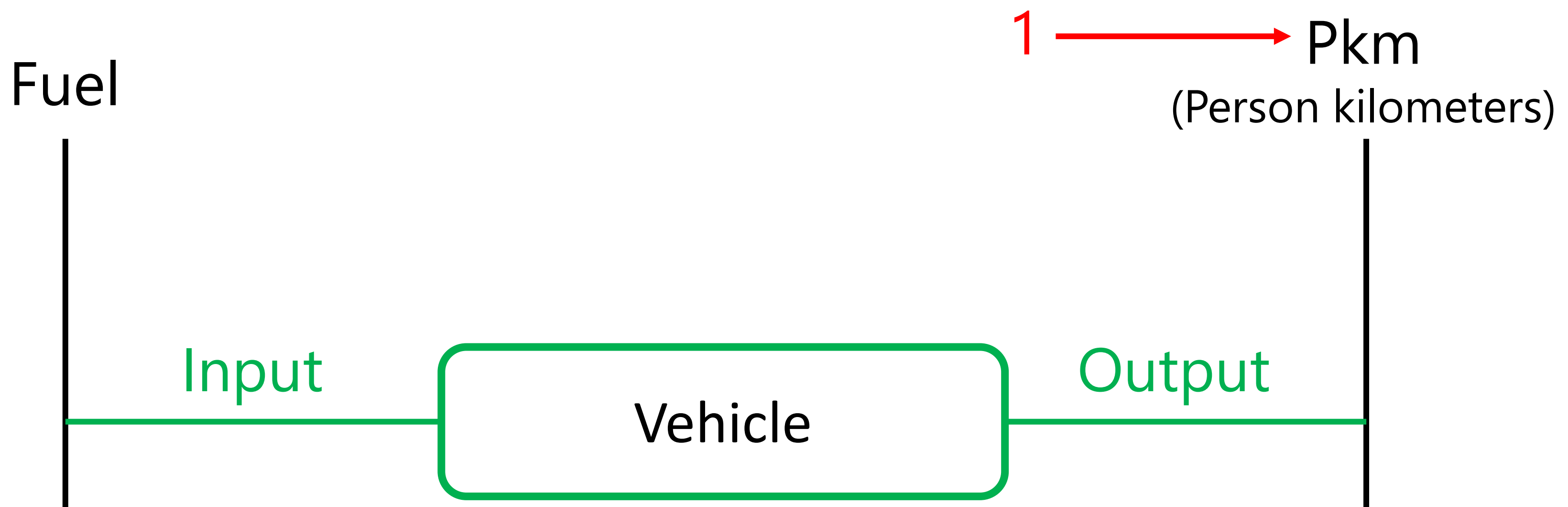


2 →

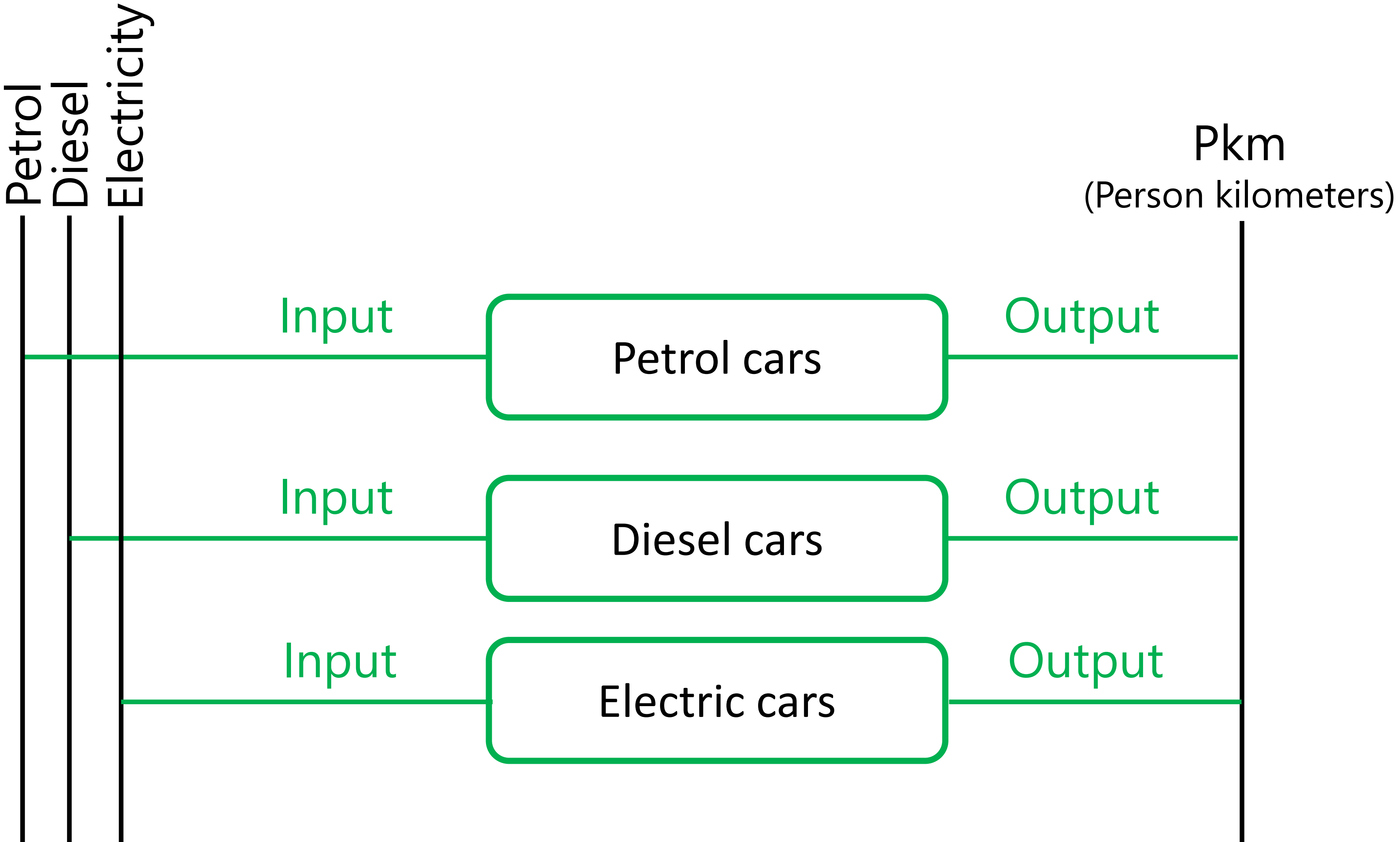
Parameters:
Efficiency
Variable costs
Fixed costs
Investment costs
...

$$\eta_{fuel} = \frac{100 \cdot OR}{FC} \left[\frac{Pkm}{kg}\right]$$

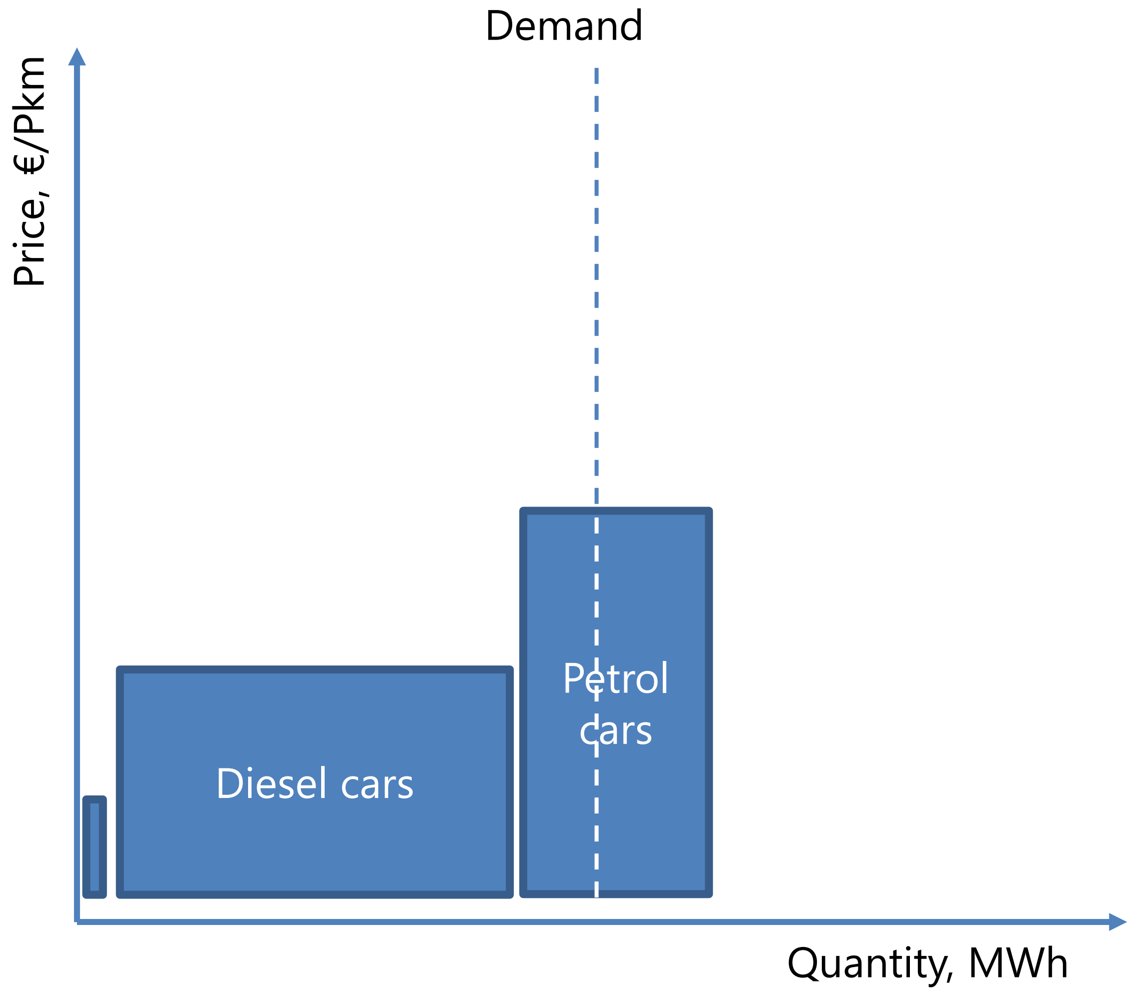
OR – occupancy rate

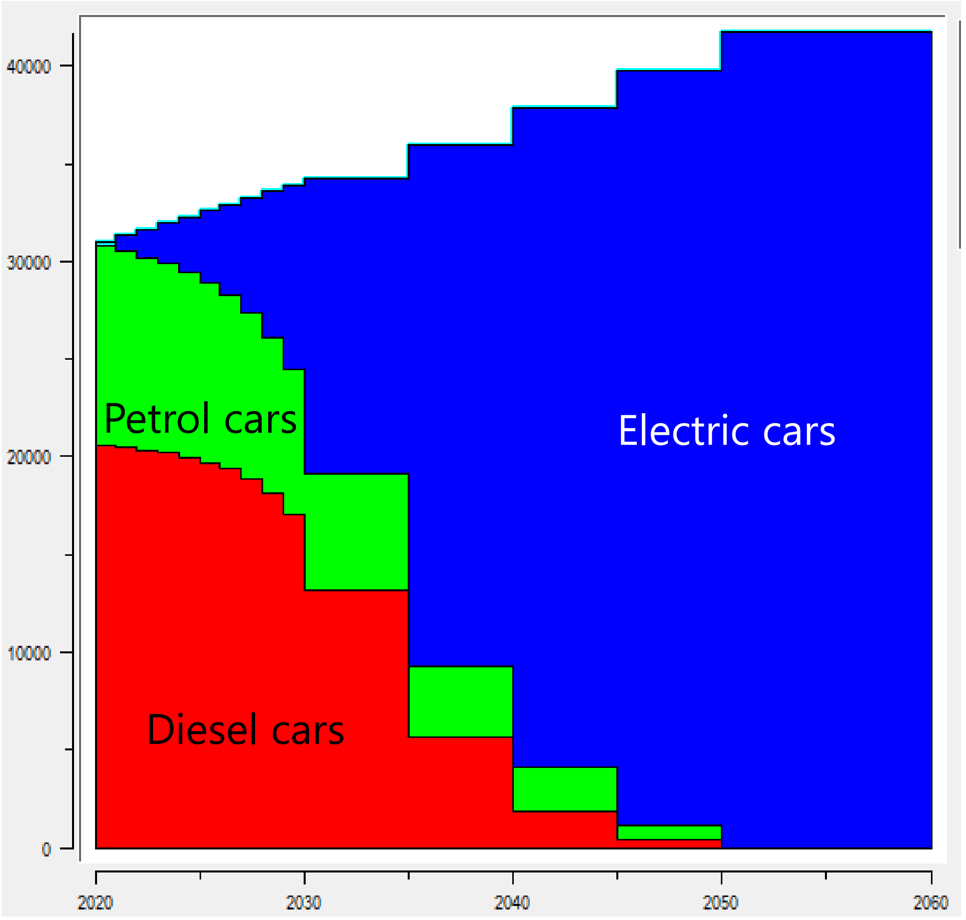
FC – fuel consumption kg/100km

Challenge 1. How to model vehicles in a system designed to model an energy system



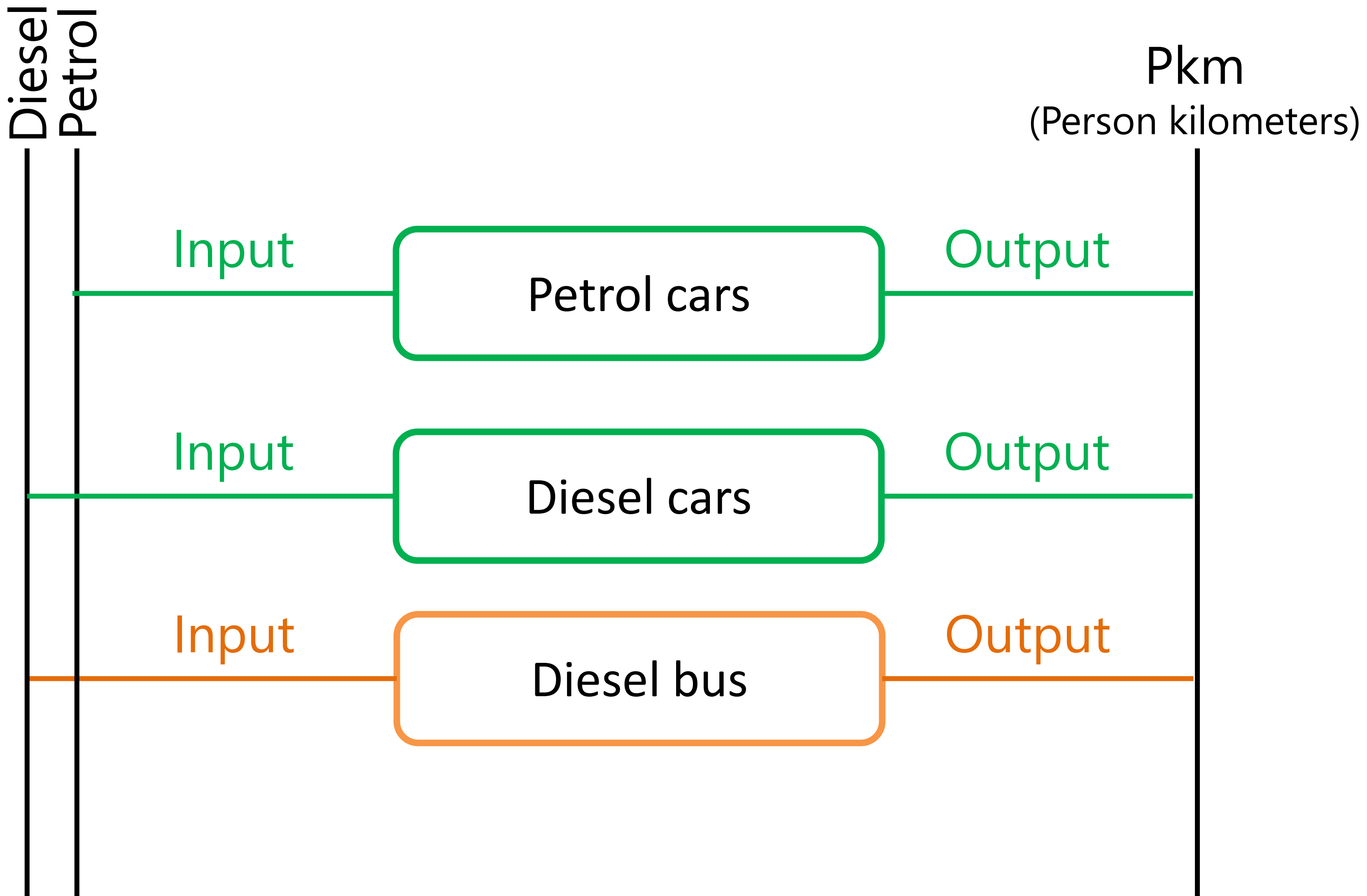
Challenge 1. How to model vehicles in system designed to model energy system





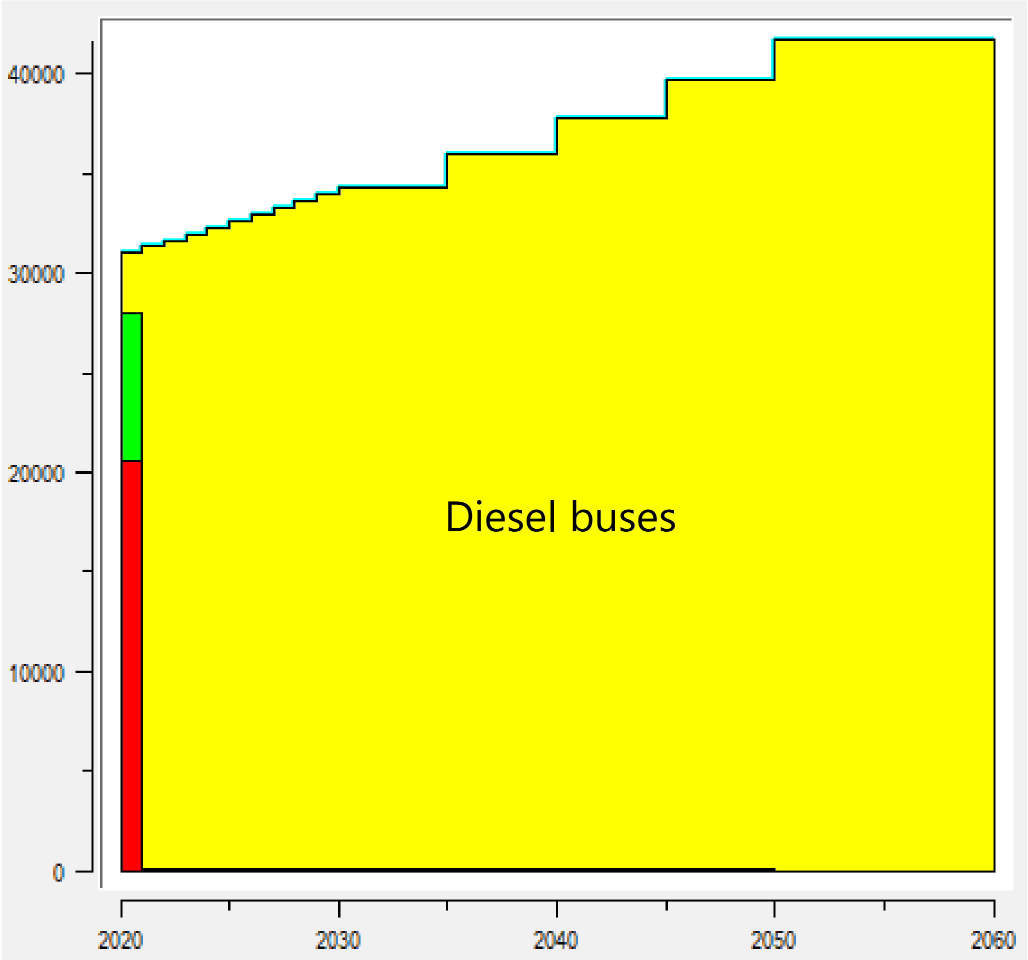
* Investments costs and fuel prices were assumed to be constant

Challenge 2. Public transport



Challenge 2. Public transport

Public transport is much more cost-efficient compared to private transport!



Challenge 2. Public transport

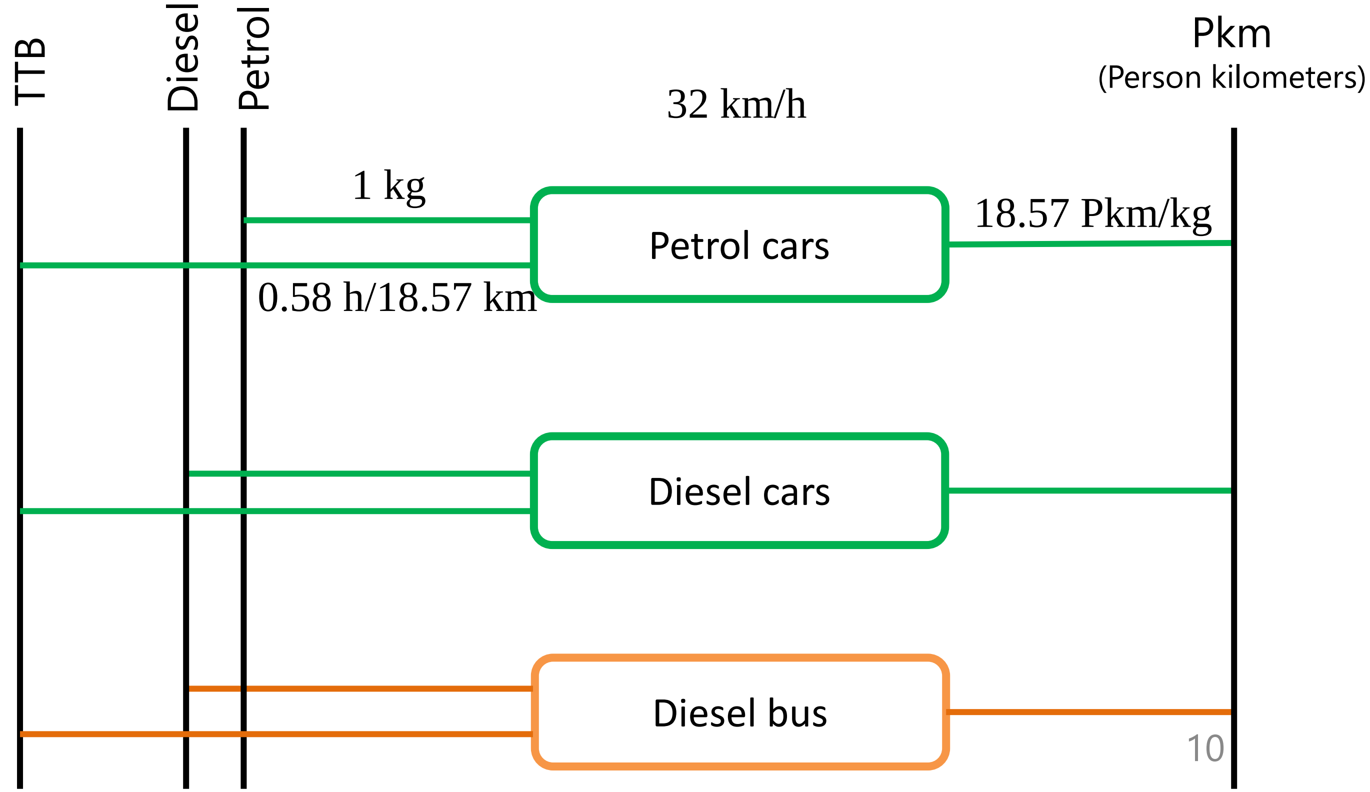
ELSEVIER
Applied Energy
Volume 135, 15 December 2014, Pages 429-439

Incorporating travel behaviour and travel time into TIMES energy system models

Hannah E. Daly [a,b,*], Kalai Ramea [c], Alessandro Chiodi [a], Sonia Yeh [c], Maurizio Gargiulo [a,d], Brian Ó Gallachóir [a]

$$\text{TCR} = \frac{\eta_{fuel}}{\bar{v}} \quad \left[\frac{h}{x\ km}\right]$$

$$\bar{v} - \text{average speed} \left[\frac{km}{h}\right]$$

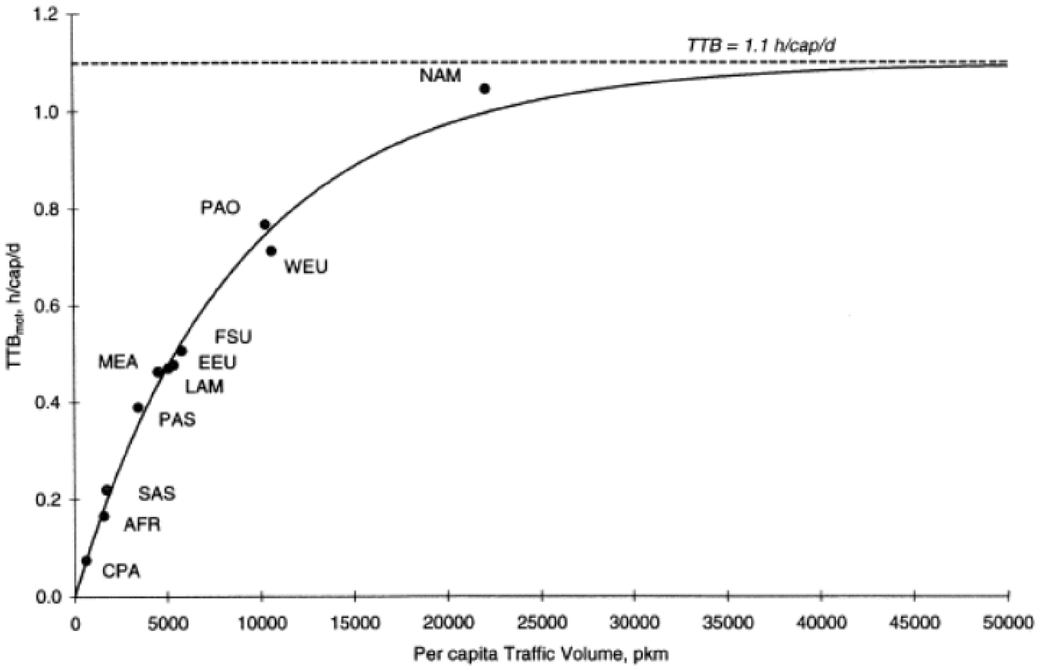


Challenge 2. Public transport

Transportation Research Part A: Policy and Practice
Volume 34, Issue 3, April 2000, Pages 171-205

The future mobility of the world population

Andreas Schafer [a], David G Victor [b, 1]



Travel time budget for motorized travel [h/cap/d]:

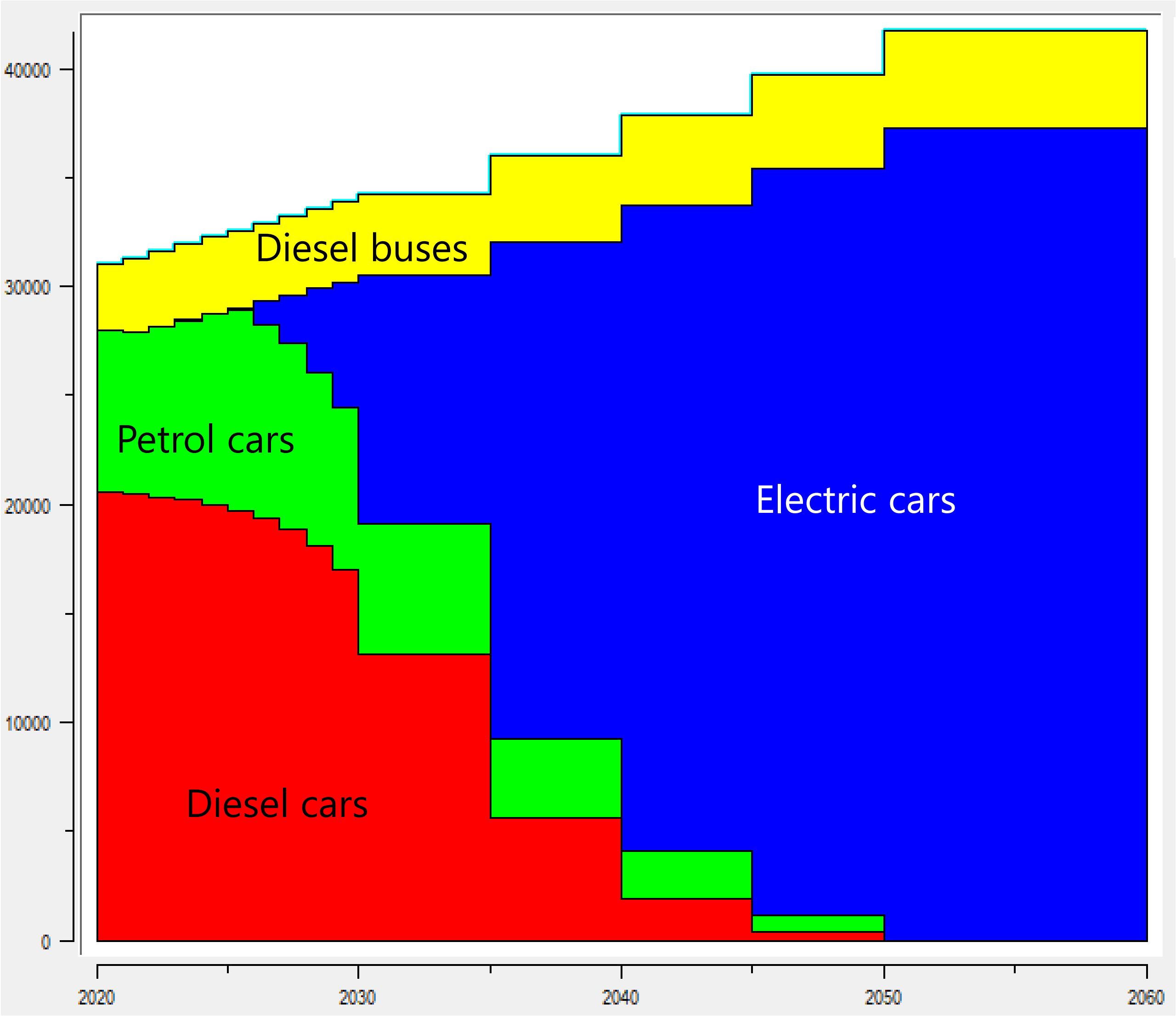
$$ttb_{mot} = a + \frac{b}{(TV - c)^d}$$

$$a = -\frac{b}{(-c)^d}$$

$$b = \frac{1.1}{\left(\frac{1}{(240000 - c)^d}\right) - \left(\frac{1}{(-c)^d}\right)}$$

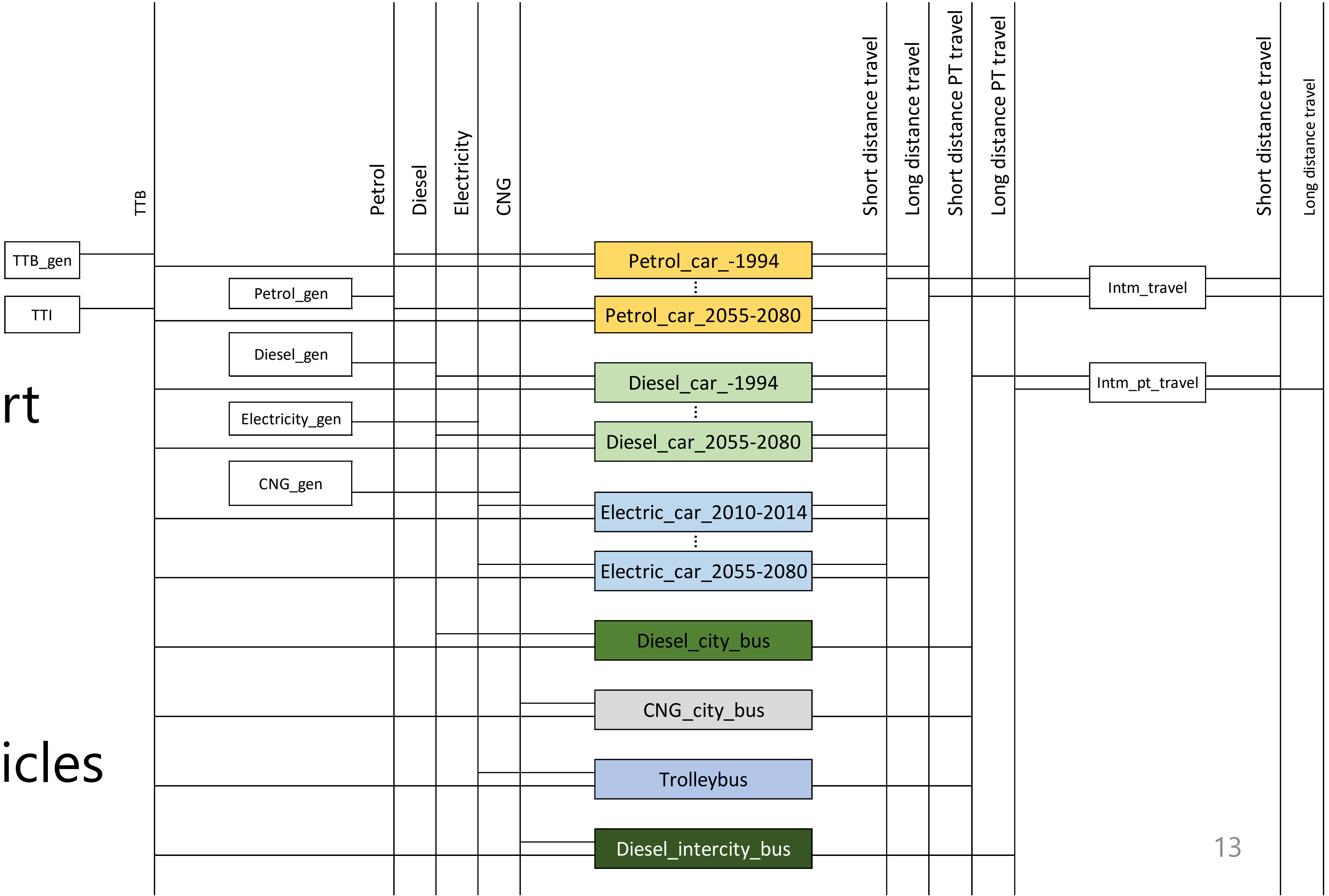
$c = -176083 \qquad d = 20$

Challenge 2. Public transport



Challenge 3. Increasing the detail

- Distinguishing short and long distance travel
- Additional vehicle types
- Distinguishing vehicles by build year

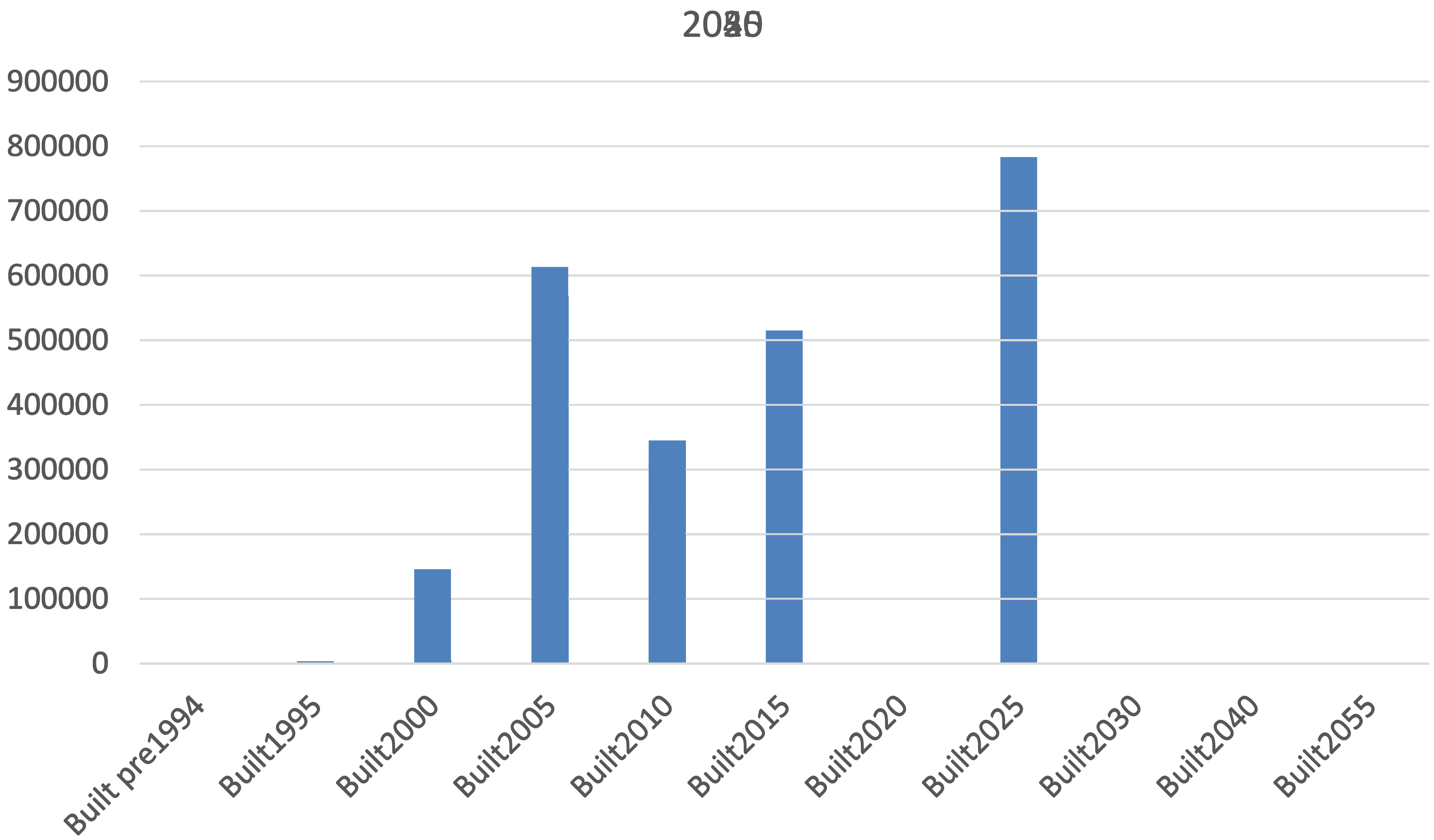


Challenge 3. Increasing the detail

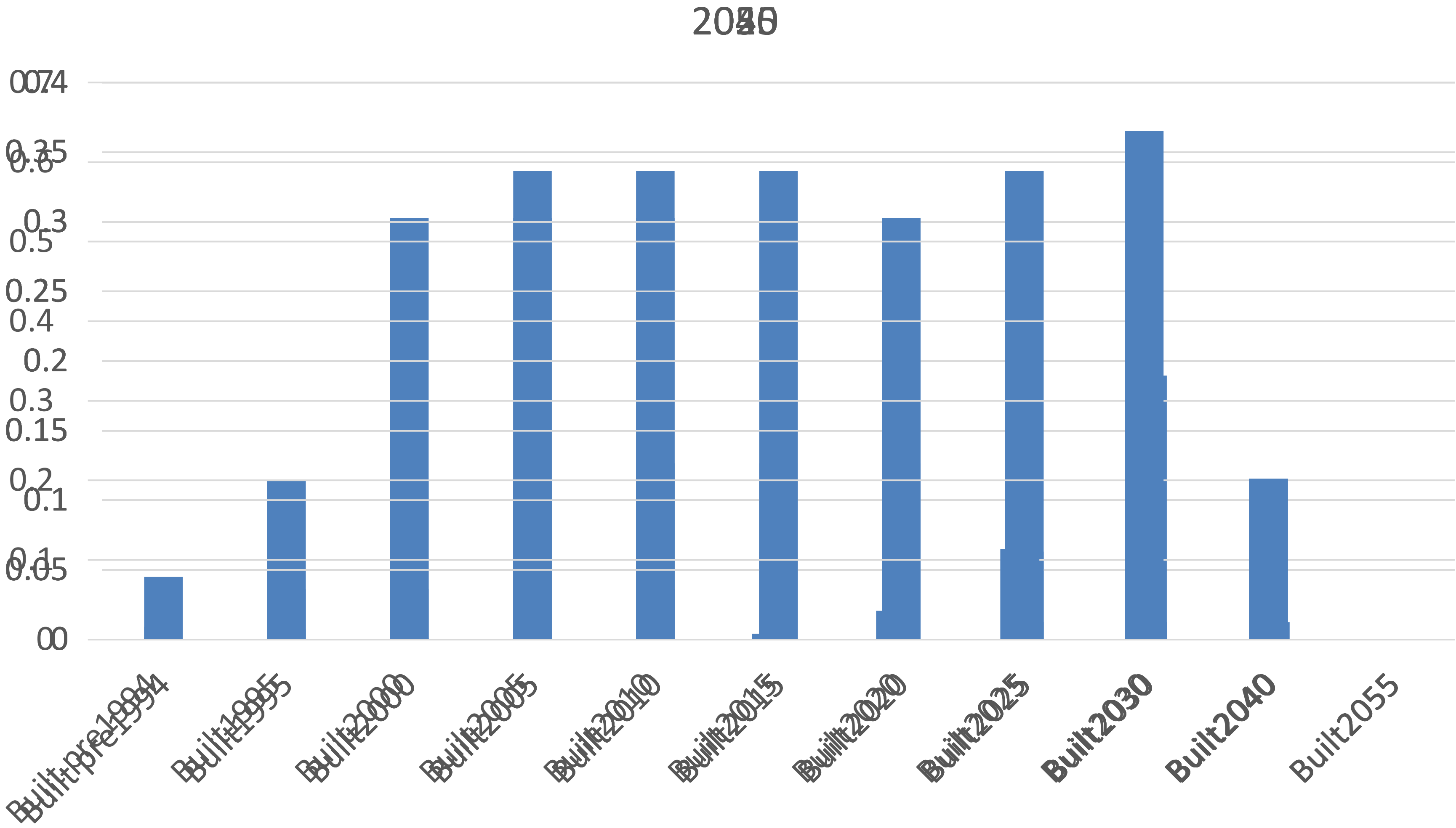
Vehicle parameters that depend on its build year/age:

- Purchase cost
- O&M cost
- Fuel economy
- Cost of EV inconvenience

Problem: unrealistic car age distribution



Vehicle age constraints



Vehicle age constraints

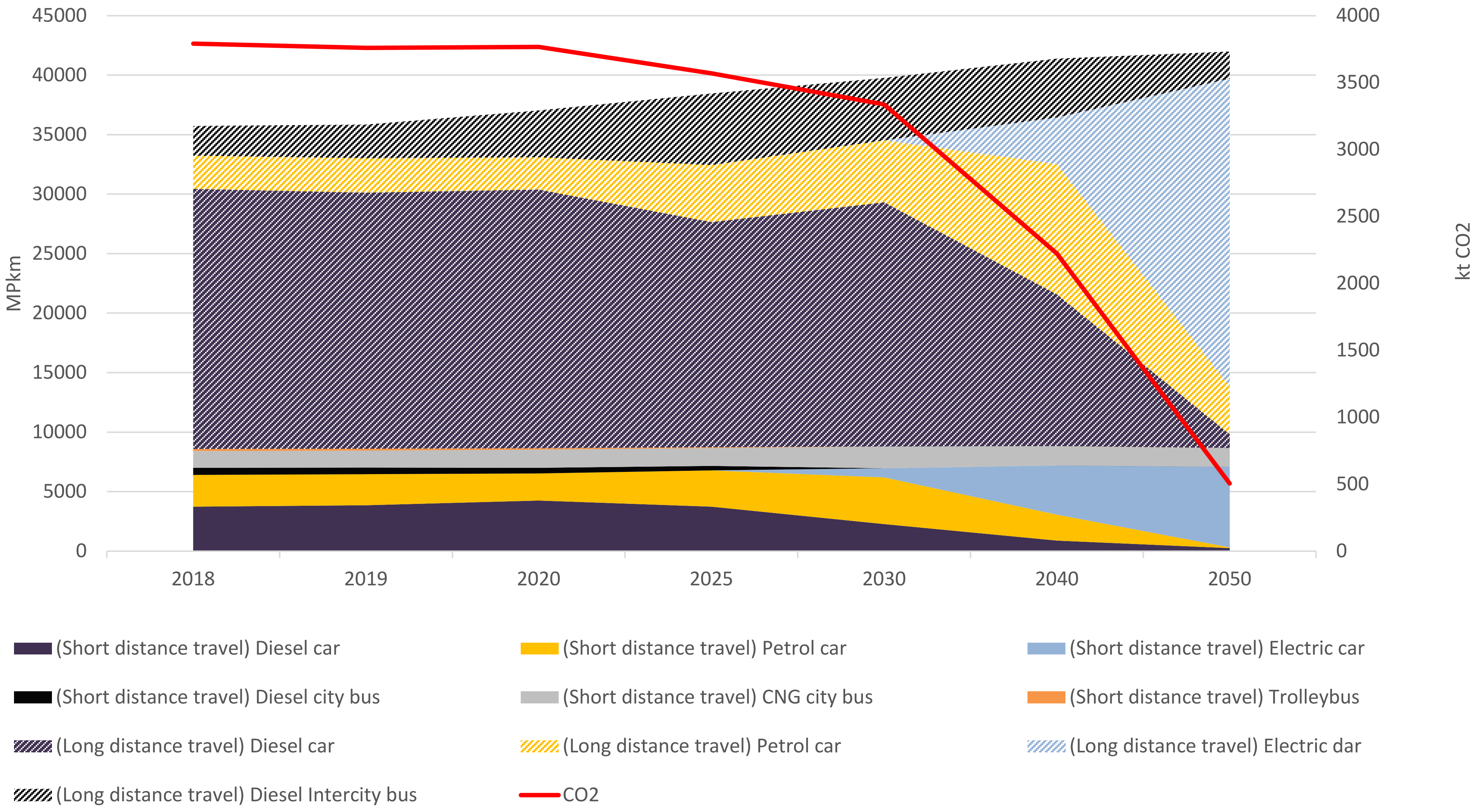
$$\sum_{f} PKT_{y,f,a,d} = \alpha_{y,a,d} \cdot \sum_{f,a} PKT_{y,f,a,d}$$

$$\sum_{a} \alpha_{y,a,d} = 1$$

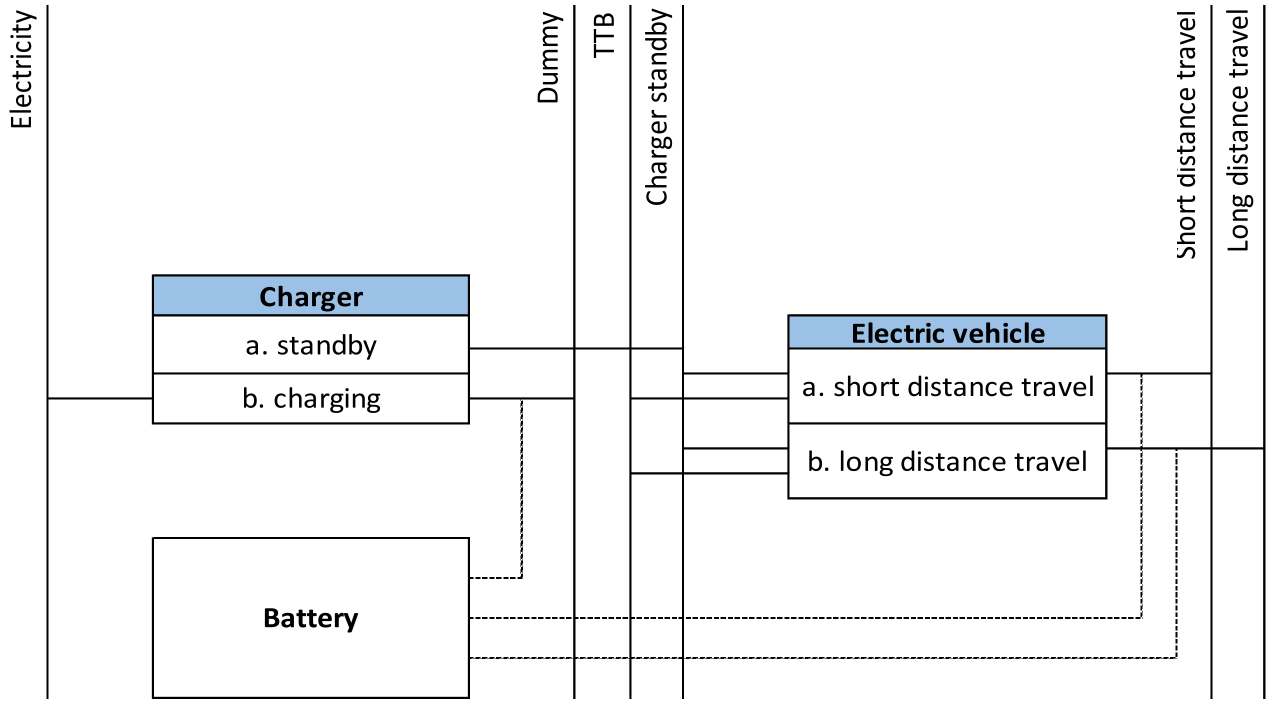
y – vehicle type
f – fuel type
a – vehicle age group
d – travel mode (short or long distance travel)

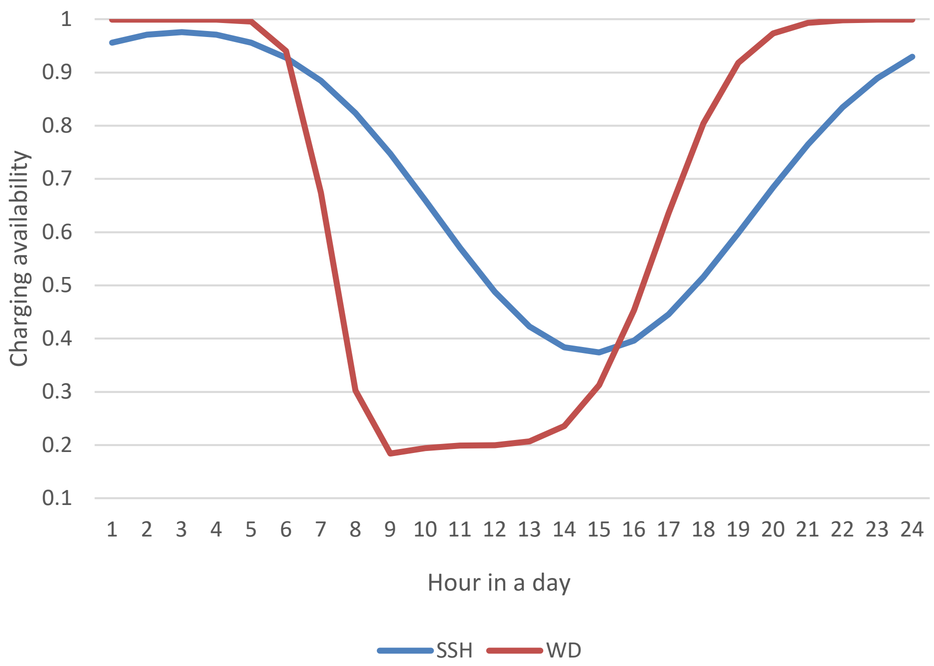
$\alpha_{y,a,d}$ - the share of age group *a* in age distribution of the vehicle type *y*.

Challenge 3. Improving detail



Challenge 4. Electric vehicles





$$\eta_{EV} = \frac{C_{vehicle}}{P_{charger}}$$

$C_{vehicle}$ – capacity of single vehicle

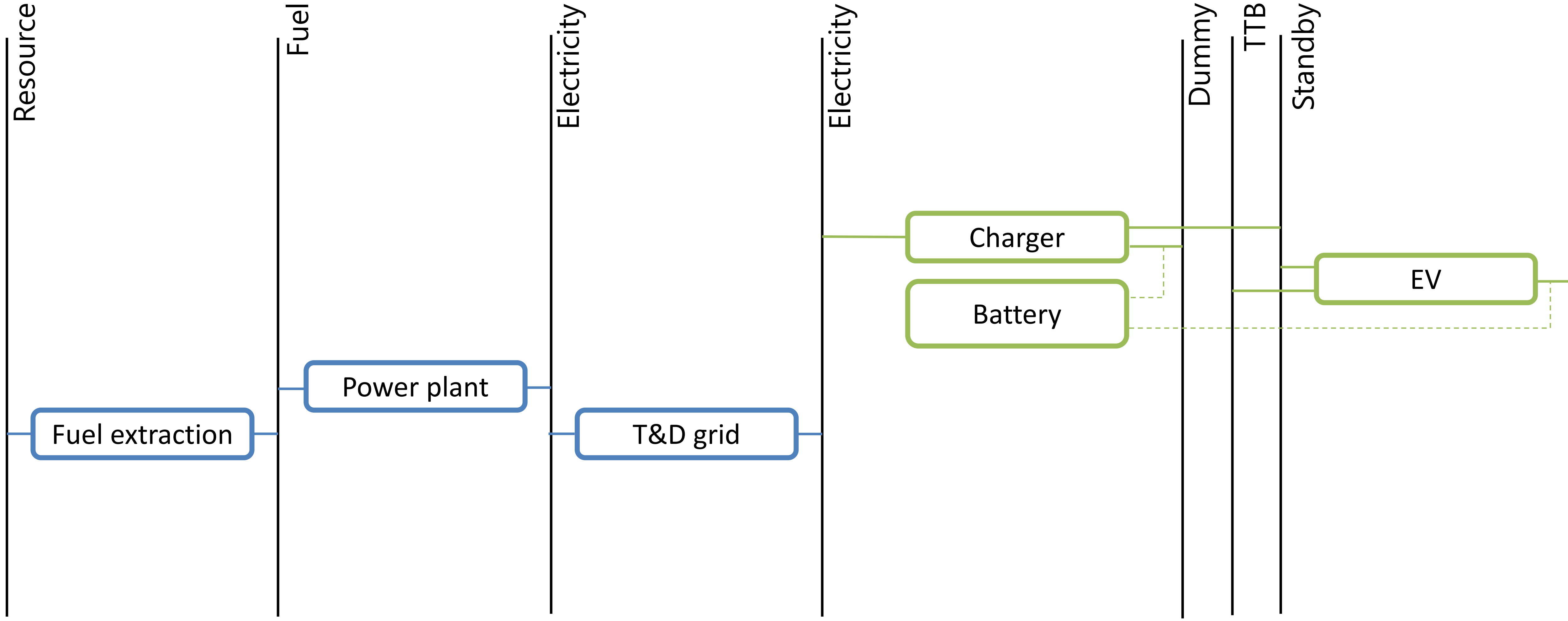
$$C_{vehicle} = \frac{365 \cdot 24 \cdot \mathrm{OR} \cdot \bar{v} \cdot OT}{10^6}$$

OT – operation time

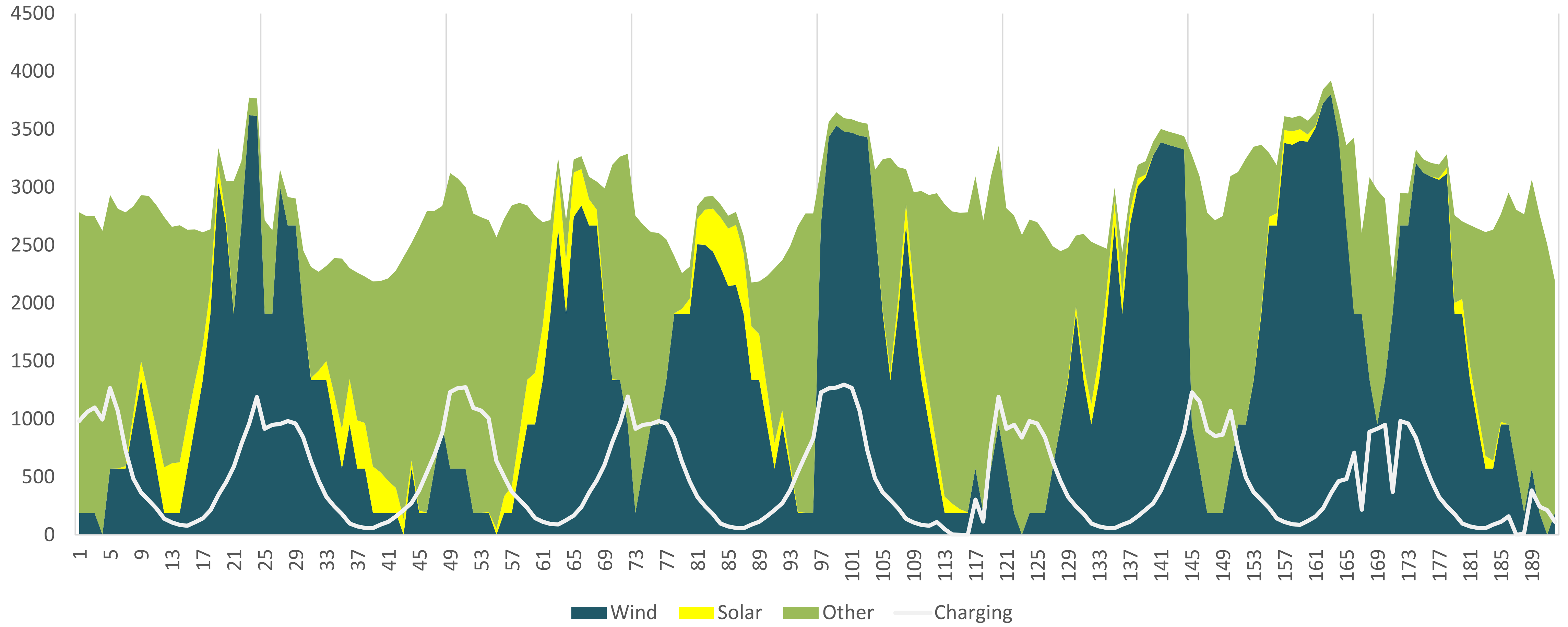
$$consa = -\frac{1000}{r \cdot 365 \cdot 24 \cdot OR}$$

r – EV efficiency km/kWh

Challenge 5. Incorporating transport model into power system model



Challenge 5. Incorporating transport model into power system model



Further improvements

- Vehicle classes (e.g. A-B, C-D, E-F, J)
- Constraints on market penetration
- Consumer groups by income (untested)

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