HOW TO ADDRESS THE CHICKEN-EGG-PROBLEM OF ELECTRIC VEHICLES?

Introducing an interaction market diffusion model for EVs and charging infrastructure

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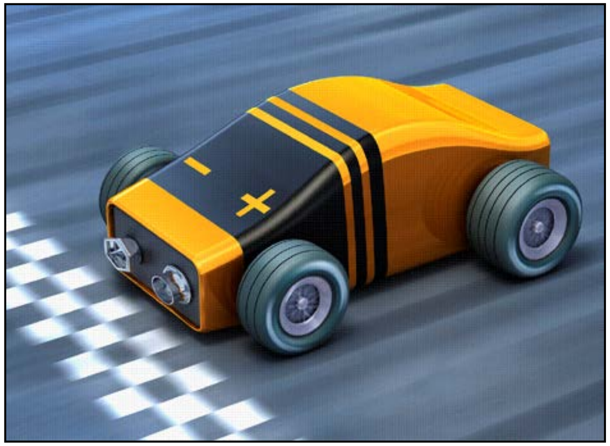

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Motivation: Is there a chicken-egg problem for plug-in electric vehicles?

- Potential PEV-users wish for charging infrastructure before purchase (Dütschke et al. 2012)
- Charging infrastructure may help to reduce range anxiety (Tate et al. 2008, Kurani et al. 1996, Kalhammer et al. 2007)

- Low usage of public charging points in PEV research projects (EV Project 2012, Bruce et al. 2012)
- Large deficit of current public charging points (Kley 2011)

- Users drive differently and have different purchase intentions (Plötz et al. 2013, Gnann et al. 2015a)

- Home charging possible for many users (Plötz et al. 2013) and sufficient for many potential PEV buyers (Kley 2011)

Models for co-diffusion of other alternative fuels available (Diesel, Gas, Hydrogen (Greene 1996, Sperling, Kurani 1987, Yeh 2007,…)), but transferability difficult due to PEV specialties

- Higher charging duration and lower ranges of PEVs (currently ca. 100-150 km)

Motivation: A model is built based on requests

→Request 1: Model the demand/desire for charging infrastructure

→Request 2: Consider the usage of public charging points

→Request 3: regard the varying driving

→Request 4: incorporate different charging facilities

→Request 5: charging time and frequency should be taken into account

Development of an agent-based model grounded on driving profiles that covers the interaction at public charging points and copes with PEV and charging infrastructure specialties.

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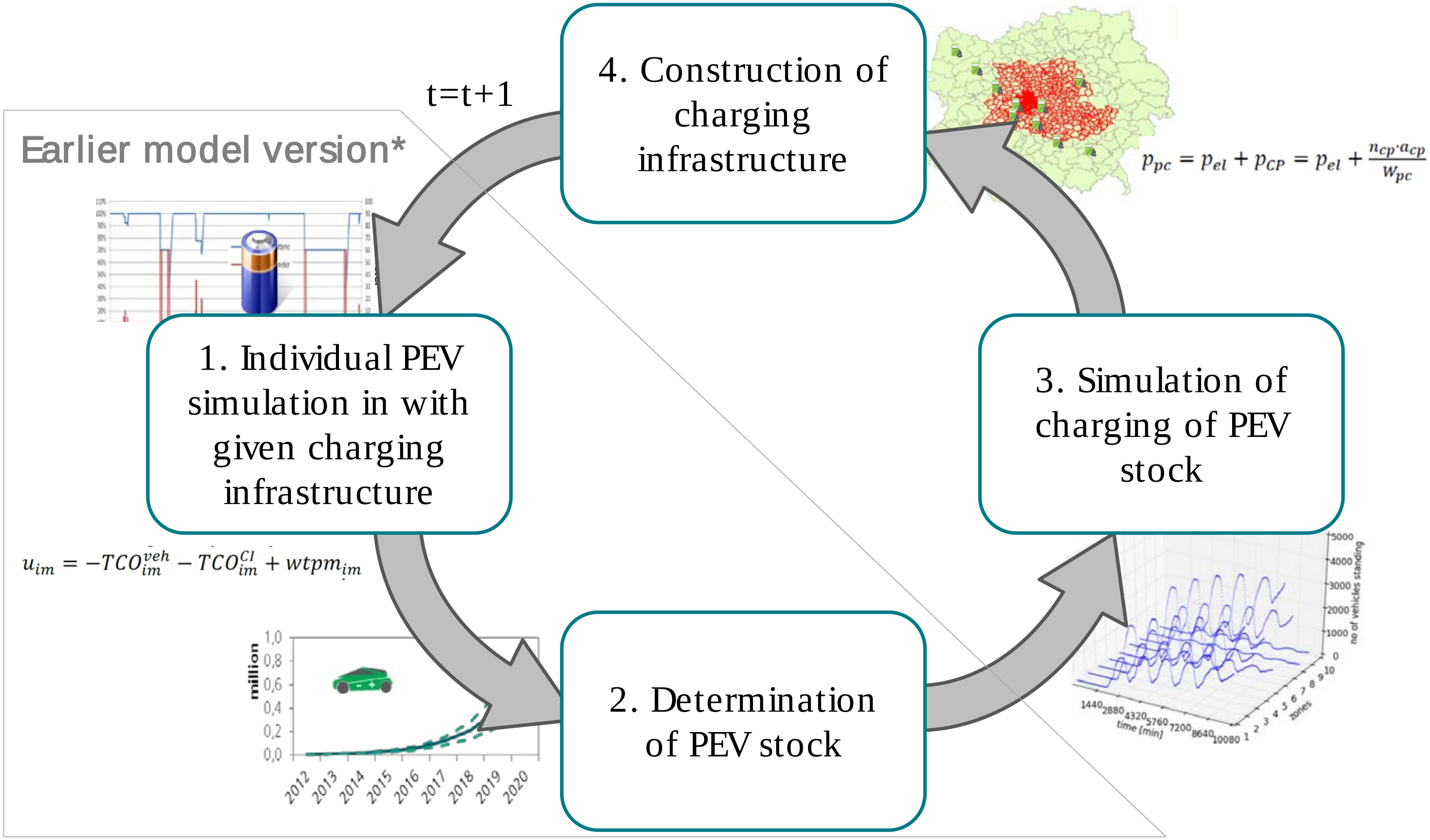
Method: The model uses a feedback loop for the PEV and public charging point stock.



*As presented in Plötz, Gnann, Wietschel, Ulrich: „How to foster EV market penetration?“ and published in (Plötz et al. 2014, Gnann et al. 2015b)

Data: 1.3 million vehicle driving profiles of the region of Stuttgart are simulated as EV

- Mobility panel of 5,000 households for one week in the region of Stuttgart (see map)
- Transfer to all people in the region of Stuttgart based on socio-demographic data and trip matrices
- 2.7 Mio. inhabitants and 1.3 million vehicles (Hautzinger et al. 2013)

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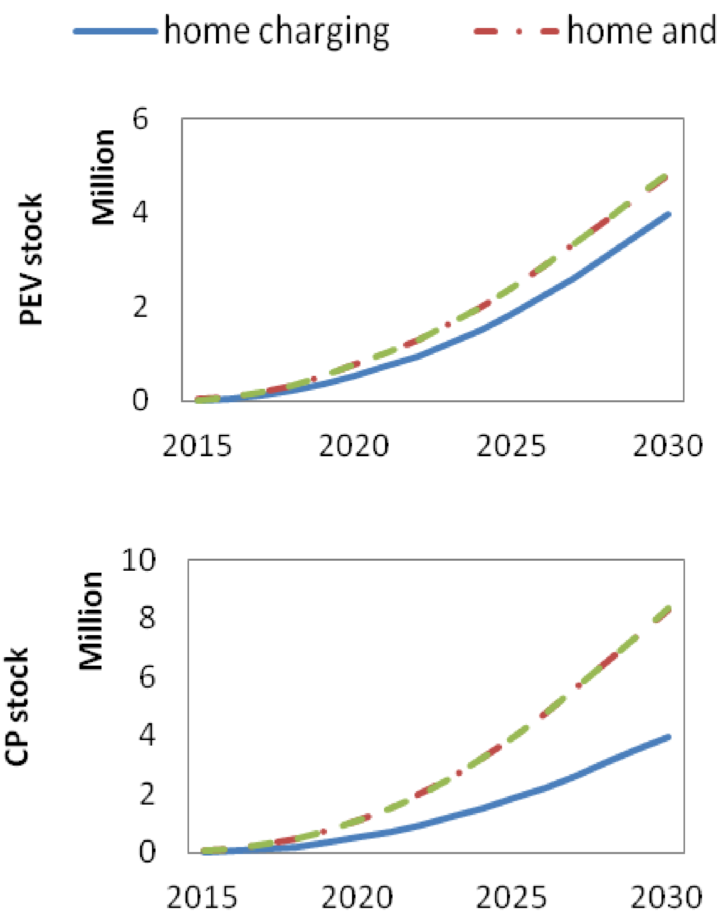
Results: The PEV diffusion with home charging can be increased with charging at work.



- Many PEVs with home-only charging
- Increase of PEV stock by 10-20% through work charging
- **No increase with public charging**
- ~70% PHEV independent of charging scenario (but depending on costs assumptions)

- CP stock equal to number of PEVs in home only charging (precondition)
- CP stock doubles with work charging (precondition)
- Small increase of CP stock for public charging points

Charging with 3.7 kW in all scenarios and at all locations.
Annual cost for public charging point: 800€/a (2015), 450€/a (2030)
Annual subsidized price: 100€/a (2015), 450€/a (2030)
Initial public charging price: 0.40€/a (2015)

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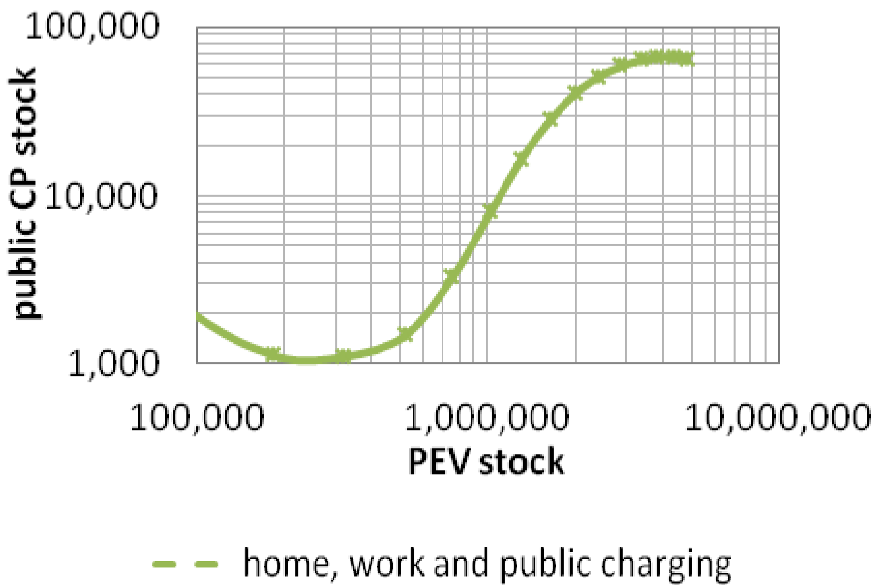
Results: Public charging points have no techno-economical influence on PEV diffusion



- PEV stock independent of public charging point stock
- Number of PEVs has large influence on number of public CPs
- **Public charging points only with subsidies**

- Tipping point (saturation) when decrease of subsidy is equivalent to increase of energy charged in public ($\Delta a_{cp} = \Delta W_{cp}$)

$$p_{pc} = p_{el} + p_{CP} = p_{el} + \frac{n_{cp} \cdot a_{cp}}{W_{pc}}$$

Charging with 3.7 kW at all locations.
Annual cost for public charging point: 800€/a (2015), 450€/a (2030)
Annual subsidized price: 100€/a (2015), 450€/a (2030)
Initial public charging price: 0.40€/a (2015)

Discussion & Conclusions: Home charging is most important for PEVs, then at work, then in public.

Discussion

- Techno-economical analysis of charging infrastructure, **psychological need** (value for the possibility) of public charging **not reflected**
- Data sets with **limited observation period**, yet additional calculations show no qualitative differences
- **Only slow charging** (AC) analyzed with this approach, yet approach not useful for fast charging

Conclusions

- **Charging at home** is **mandatory** for PEVs!
- Charging at work increases number of PEVs
- **Public slow charging without influence** from techno-economical point of view and **subsidies necessary**
- Differentiation of **different charging infrastructure** access **types** is **important**.
- Differering user behavior should be addressed.
- ABM is best solution for this complex system

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Thank you for your attention!

Further questions?

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