Electric vehicle user behavior and policy implications
What can we learn from field studies?

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- **Focus**: the **user perspective** on EVs
  - User experience & user behavior
  - Implications for EV design & policy

- **Conducted BEV field trials** since 2008
  - MINI E Berlin 1.0 & 2.0, BMW ActiveE Berlin, ...
  - Methodology for international MINI E field trials (US, UK, France,...)

- **Topics** under investigation: the BEV user & ....
  - Range, eco-driving, HMI design, apps for multimodal mobility, safety, acoustics, regenerative braking, acceptance, charging, V2G, W2V, ....

- **Methods** (Cocron et al., 2011; Franke et al., 2014a)
  - Field trials & field experiments, data logging, diaries...
  - Focus groups, interviews, questionnaires, ....
  - Usability tests, expert evaluation, ...
Barriers to widespread EV adoption

- **Attitude–behavior gap**
  - Attitudes towards EVs: generally very positive
  - Purchase intentions: generally relatively low

- **Barriers?** (e.g., Bühler et al., 2014a)
  - “I cannot charge at home.” ➔ charging infrastructure development
  - “EVs are too expensive.” ➔ policy & mass market
  - “Can I really cope with the limited range?”

- **Limited range as a challenge for widespread acceptance of EVs**
  - Larger batteries are not the ultimate solution
    - Ecological footprint of battery production

- **Better understand user-range interaction**
  - Can users adapt to limited range?

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EV field trials – data basis

MINI E Berlin 1.0 & 2.0 field trials (2008-2011)
- $N = 110$ private users, 6 months BEV use
  - (>100 fleet users, >40 carsharing users)
- Urban mobility ($\varnothing$ 38 km/day)
- BEV: MINI E, around 160 km range

BMW ActiveE Leipzig – long-distance commuter field trial (2012-2015)
- $N = 75$ private users, 3 months BEV use
- Commuter mobility ($\varnothing$ 94 km/day)
- BEV: BMW ActiveE, around 130-160 km range
- Preliminary data (max. $N = 60$)

Longitudinal research designs:
- T0: before EV experience, T1: with EV experience
Can user adapt to limited range?

Drivers adapt to EV range...
- Increase in comfortable range & perceived fit of mobility resources vs. needs
  (Franke et al., 2012b; Franke et al., 2014b)

How long does it take?
- Urban mobility profile (⌀ 38 km/day): ≈ 2400 km (62 car usage days)
  (Pichelmann et al., 2013)
- Commuter mobility (⌀ 94 km/day): comfortable range stable after >6 weeks usage
  (Franke et al., 2014b)

However: Adaptation does not come automatically (without effort)
- Users who + actively explore and exhaust range = + improvement in comfortable range
  (Franke et al., 2012b)
- Users who + actively try to understand range dynamics = + increase in range prediction skills
  (Franke et al., 2014a)

Implications:
- Practical experience is crucial for EV acceptance & resolving perceived range barrier
- Potential to increase speed & effectiveness of adaptation ➔ gamification
Do users experience range anxiety?

After adaptation phase (T1):

- Relatively high **range satisfaction**: most users experience range as sufficient
  - Urban mobility (\(\bar{\varnothing} 38 \text{ km/day}\)): \(\approx 90\%\) (Franke et al., 2012a; Franke & Krems, 2013a)
  - Long distance commuters (\(\bar{\varnothing} 94 \text{ km/day}\)): \(\approx 79\%\)

- Stressful range situations (**range anxiety**) occur **seldom**
  - Urban: \(\approx 1\) stressful range situation per month (Franke et al., 2012a; Franke & Krems, 2013a)
  - Commuters: \(\approx 2.4\) stressful range situations per month (Franke et al., 2014a)

- Users avoid range stress \(\Rightarrow\) **range comfort zone**

- **Implications:**
  - Range anxiety not adequate to characterize everyday range experience
  - Comfortable range better accounts for user experience and behavior

  - Relevant **benchmark variable** to optimize electric mobility systems
Which factors lead to a higher comfortable range?

- Technical | competent | performant | comfortable range

+ Comfortable Range  = + range satisfaction (Franke & Krems, 2013a)

Higher usable range if... (Franke et al. 2012a; Franke & Krems, 2013a)
- Users can subjectively control & predict range resources
- Prior knowledge & daily range practice
- Certain personality characteristics

Implications:
- Increase controllability of range resources – range elasticity & safety options
- Reliability of range estimation & recharging opportunities – trust is important

What is the optimal range? (Franke & Krems, 2013c)

- Range preferences (RP) decrease with experience
- RP > average daily distance
- RP ≈ maximum daily distance in typical week
- Objective range needs predict RP at T1 (not T0)

Fig. 1. Cumulative distributions of $M_{7D}$ and $Max_{7D}$ and T1 minimum acceptable range ($N=64$).

Implications:

- Potential customers with EV experience do not request exaggerated range setups
- “Simulate” experience? Mobility logging & informative feedback
  - Yet: quality of simulation & feedback very important (trust)

Does it also work without charging at home?

- **Matched samples** from MINI E Berlin studies, N = 36 (Bühler et al., 2014b)
  - Matched according to charging needs (daily distance), age, gender, ...
  - **Home chargers** (HC): home-based charging station
  - **Public chargers** (PC): no charging opportunity at home, > 85% public charging, public charging station in walking distance of home/work

- **Results:**
  - Charging frequency: **HC** = 3.4 events/week *versus PC* = 2.0 events/week
  - After adaptation no significant differences in...
    - ... perception of EVs (both positive), perceived usefulness & satisfaction
    - ... willingness to recommend & purchase intentions

- **Implication:**
  - Electric mobility also feasible with only public charging

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Can we easily get green energy into batteries?

**Renewable** (green) energy as **prerequisite** for sustainable electric mobility

- When is energy “green”? – Excess energy from renewable sources (e.g., wind-to-vehicle, W2V)

**Does this come automatically?** (Franke & Krems, 2013b)

- MINI E Berlin 1.0: W2V system shifted energy input to “green windows”
- Users develop different charging routines ("charging styles")
  - Charging when necessary vs. charging when opportunity
  - Charging style is related to W2V efficiency
- **Incentive mechanism necessary** for +W2V efficiency
  - Gamification (money is not the only way)
- Project: Managed Charging V3.0
  - Field test of incentive mechanisms for intelligent charging

Summing up

- **E-Mobility** already **works** in its current stage of development
- However: **psychological barriers** have to be addressed

Perceived range barrier can be overcome by **practice** in dealing with range
- However: support of adaptation process $\Rightarrow$ gamification
- Maybe helpful: simulation of EV mobility

Available **safety options** can increase controllability of range $\Rightarrow$ + comfortable range
- Reliability is crucial – e.g. public charging with reservation

**Battery development**: reduce vehicle price or increase battery range?
- Users can adapt to limited range $\Rightarrow$ rather reduce vehicles costs
- High variance in preferences & mobility needs $\Rightarrow$ different battery sizes

**Environmental benefit** of EVs is strongly dependent on the **user factor**
(Franke et al., 2012c)
Thanks a lot for your attention!

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References


