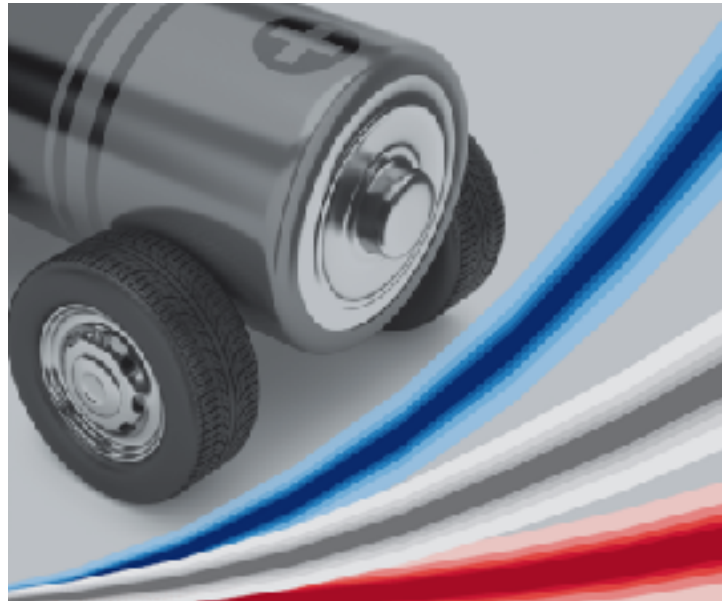


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# HOW MUCH CHARGING INFRASTRUCTURE IS NEEDED AND HOW DOES IT AFFECT THE LOAD SHIFT POTENTIAL OF ELECTRIC VEHICLES?

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EVS30, Stuttgart, 9th of October 2017

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# Agenda

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1. Motivation
2. Methodology
3. Case study
  1. Scenario set-up
  2. Results
4. Conclusion and outlook

# We pursue two research goals

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- Plug in electric vehicles (**PEVs**) as relevant option for decarbonization of transport sector
  - What does the **market penetration** look like?
  - Which types of PEVs and **user groups** are most likely to diffuse?
  - How does **additional charging infrastructure** influence the market uptake?



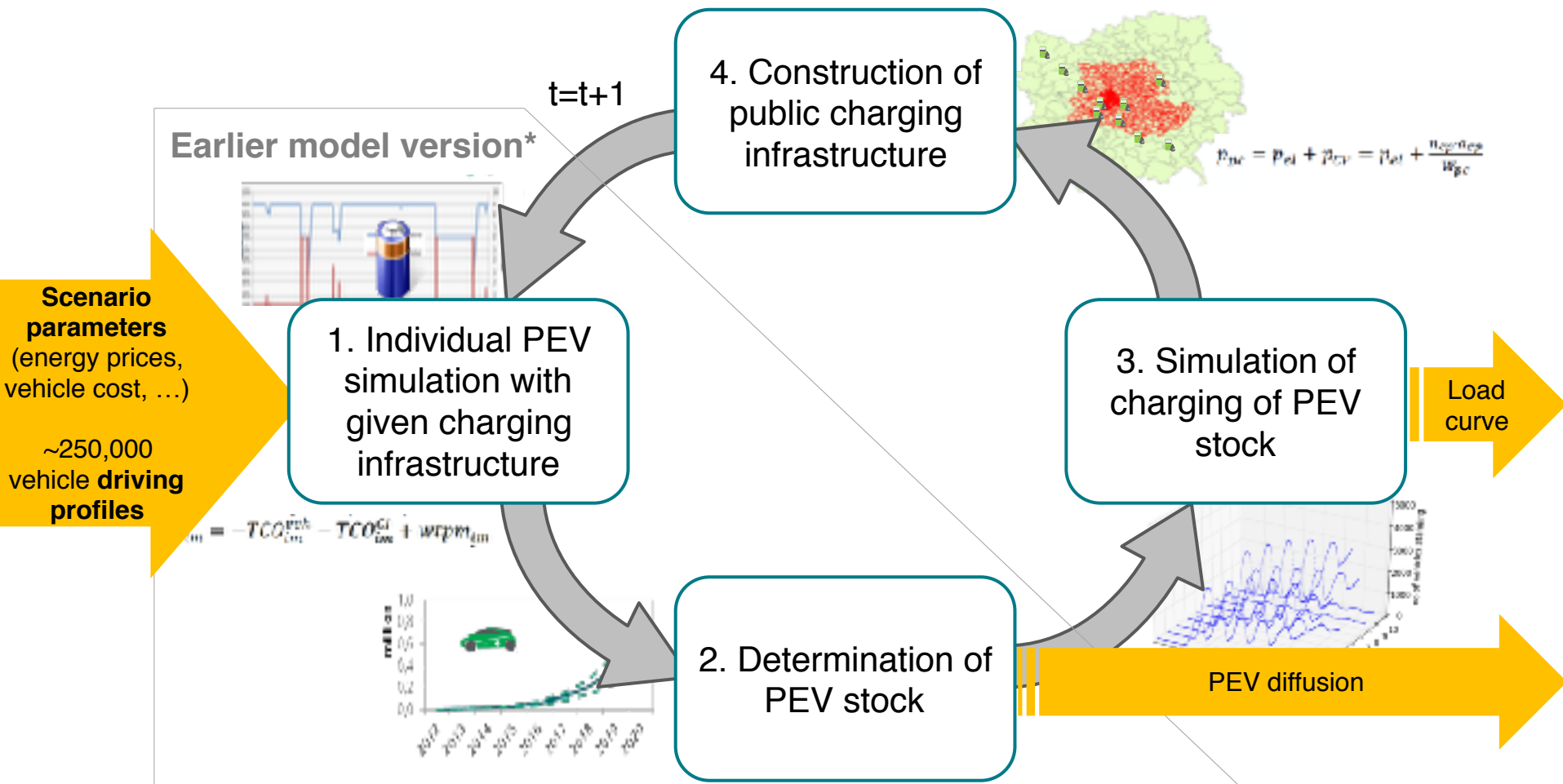
**ALADIN**

- Increasing share of RES-E generation => rising need for **flexibility** in the electricity system
  - What is the **demand response** (DR) contribution of PEVs?
  - What happens without DR?
  - How does additional **charging infrastructure** influence the DR potential?



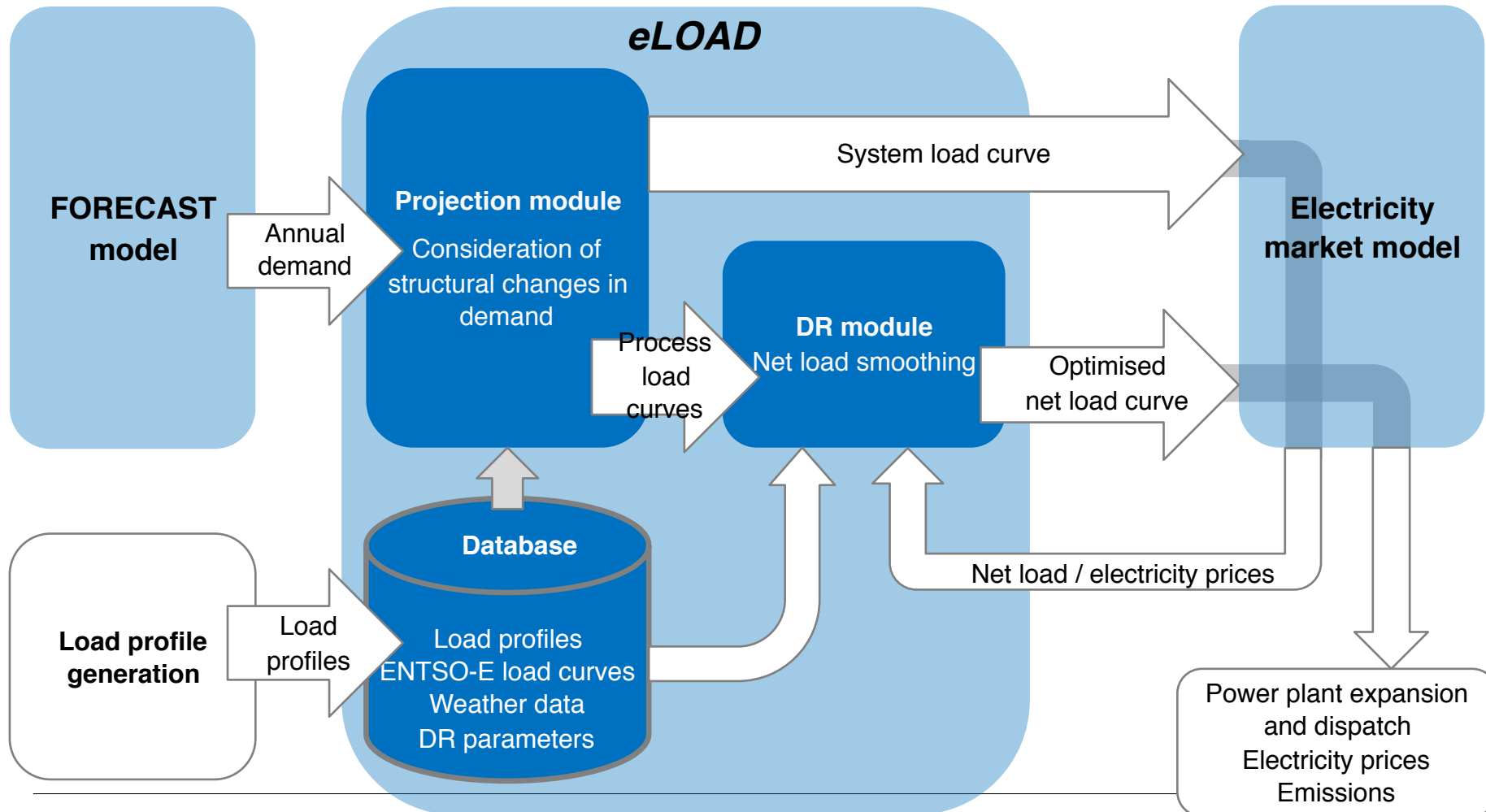
**eLOAD**

# We model the stock evolution of PEVs and charging points in ALADIN



\*As published in (Plötz et al. 2014, Gnann et al. 2015)

# We assess changes in the system load curve and the impact of DR in eLOAD



# We use three charging scenarios for Germany until 2030

## ALADIN

### PEV market penetration modeling

- Driving profiles for the region of Stuttgart for private and commercial vehicles [1]
- Differentiation of charging infrastructure availability:

| Scenario | @home =<br>Domestic/<br>commercial | @Work  | @Public |
|----------|------------------------------------|--------|---------|
| S1       | 3.7 kW                             | -      | -       |
| S2       | 3.7 kW                             | 3.7 kW | -       |
| S3       | 3.7 kW                             | 3.7 kW | 3.7 kW  |

## eLOAD

### DR modeling

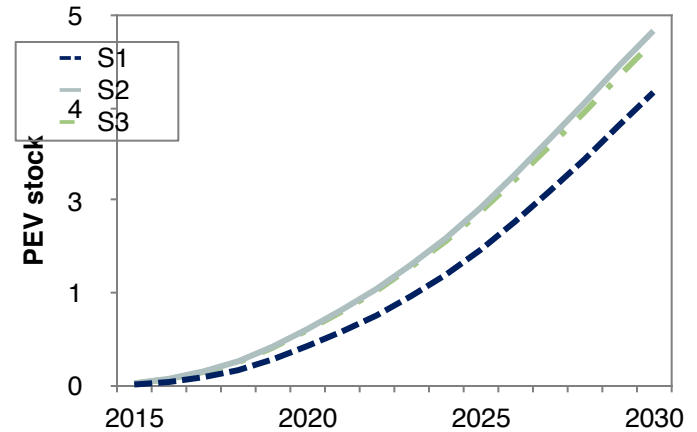
- **Scenario framework:** Leitstudie [2]
  - RES share: 35%/50% (2020/2030)
  - Total electricity demand: -9% /-15% vs. 2010 (523 TWh)
- **DR setting**
  - Modeling of private and fleet PEVs
  - Net load as basis for optimization
  - No monetary parameters considered
  - No other DR option considered

[1] (Hautzinger et al. 2013, Fraunhofer ISI 2014); [2] (Fraunhofer ISI et al. 2017)

# The main charging options are at home and at work

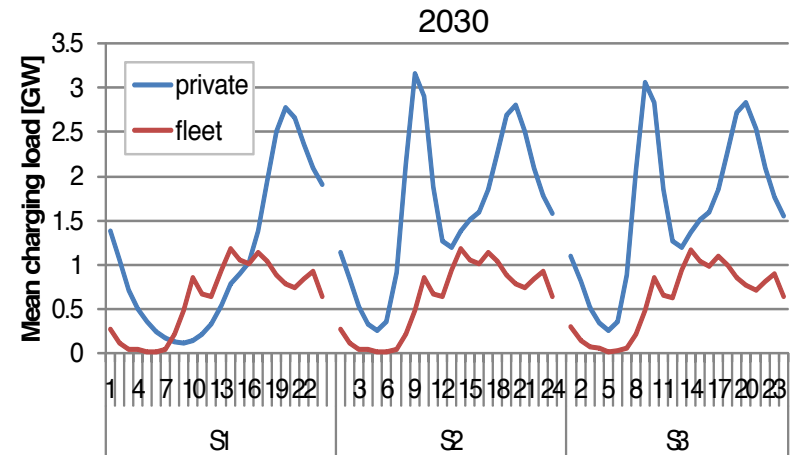
## PEV market diffusion

- Substantial PEV market penetration possible with only **@home** charging infrastructure
- Charging **@work** (S2) increases market shares and PEV stock
- **@public** has no impact



## Uncontrolled charging

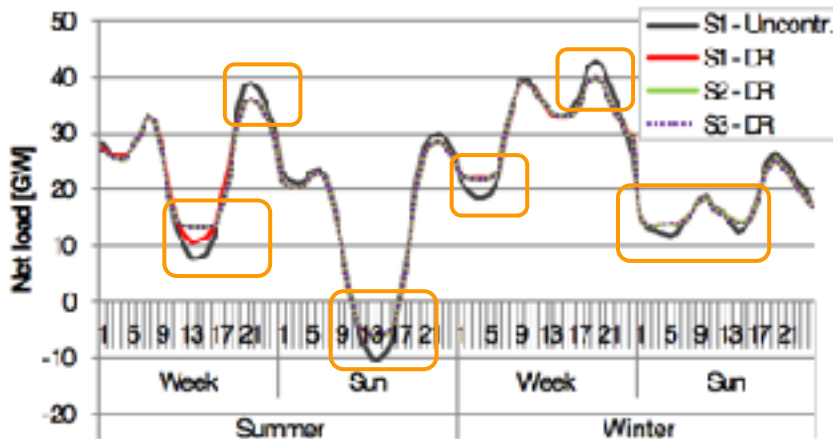
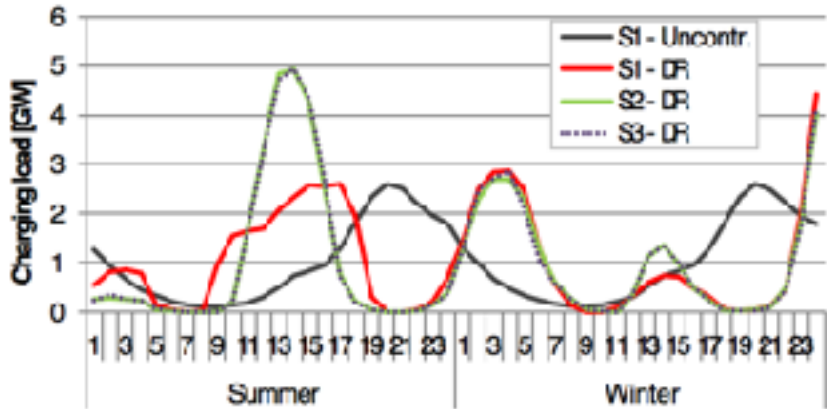
- Charging **@home**:
  - Fleet PEVs charge during the day => less impact on system load peaks
  - Private PEVs in evening hours: +3 GW
- **+@work**: additional morning peak
- **+@public** without impact



| Scenario | @home  | @Work  | @Public |
|----------|--------|--------|---------|
| S1       | 3.7 kW | -      | -       |
| S2       | 3.7 kW | 3.7 kW | -       |
| S3       | 3.7 kW | 3.7 kW | 3.7 kW  |

# Charging at home offers large load shifting potentials

Private PEVs, weekday, compared to S1, 2030



## Impact on charging profile

- Shiftable load of smart charging **@home**:  
→ ~3 GW for private PEVs in midday hours
- **+ @work/public**: +5 GW for private PEVs; no impact on comm. PEVs

## Impact on peak load and curtailment

- Smart charging **@home**:
  - Max. net load: -2.4GW / -3.6%
  - RES curtailment: -1.6 TWh / -26%
- **+ @work**: Curtailment: -1.8 TWh / -30%; but no further peak load reduction
- **+ @public**: No additional impact

| Scenario | @home  | @Work  | @Public |
|----------|--------|--------|---------|
| S1       | 3.7 kW | -      | -       |
| S2       | 3.7 kW | 3.7 kW | -       |
| S3       | 3.7 kW | 3.7 kW | 3.7 kW  |

# This model combination improves earlier approaches

Trade-off between accuracy of consideration of individual restrictions vs. computation time

**Consideration of individual restrictions  
(Loss of representativeness)**

**Lower computation time  
(Loss of detail)**

## Dallinger, Wietschel 2012

- load shifting calculation for 12,000 individual vehicles and aggregation
- shifting to all stops allowed
- neglects other options for load shifting

à renewable integration:  
0.21-0.30 TWh/mn. PEV in 2030

## This study:

- simulation of 250,000 individual vehicles (in ALADIN)
- aggregated of load and availability curve for two different user groups (in eLOAD)
- shifting to stops with charging infrastructure

à renewable integration:

0.39-0.40 TWh/mn. PEV in 2030

## Bossmann 2015

- calculation with one load profile for all vehicles
- shifting to all stops allowed
- considers other load shifting options

à renewable integration:  
1.64 TWh/mn. PEV in 2050

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# Charging at home permits load shifting and can be increased with work charging

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## Findings

- **PEV market uptake** already takes place with **charging at home**
- PEV stock in 2030 is dominated by **PHEV** → **reduced DR potential** due to smaller batteries and lower electricity demand
- **Commercial fleet vehicles** have significant shares but low impact on system peak load
- **Smart charging at home** facilitates the **integration** of **private** PEVs in the system
  
- **Charging at work** and increases PEV market penetration and flexibility potential
- **Smart charging** smoothens the net load but may imply **new** system load **peaks locally**.
- **Public slow charging** has **no effect** on PEV diffusion & load shifting potential.

## Outlook

- Consider impact of smart PEV charging on **power market and prices**
- Compare **flexibility potential** of PEVs with other flexibility options

# Thank you for your kind attention!

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[www.sef-bw.de](http://www.sef-bw.de)

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[www.profilregion-ka.de](http://www.profilregion-ka.de) or

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