Benefit of a Prediction System for Integrating Electrical Vehicles into Electrical Grids

Renewable Energy and Electrical Vehicles

Renewable Energy World Europe Conference

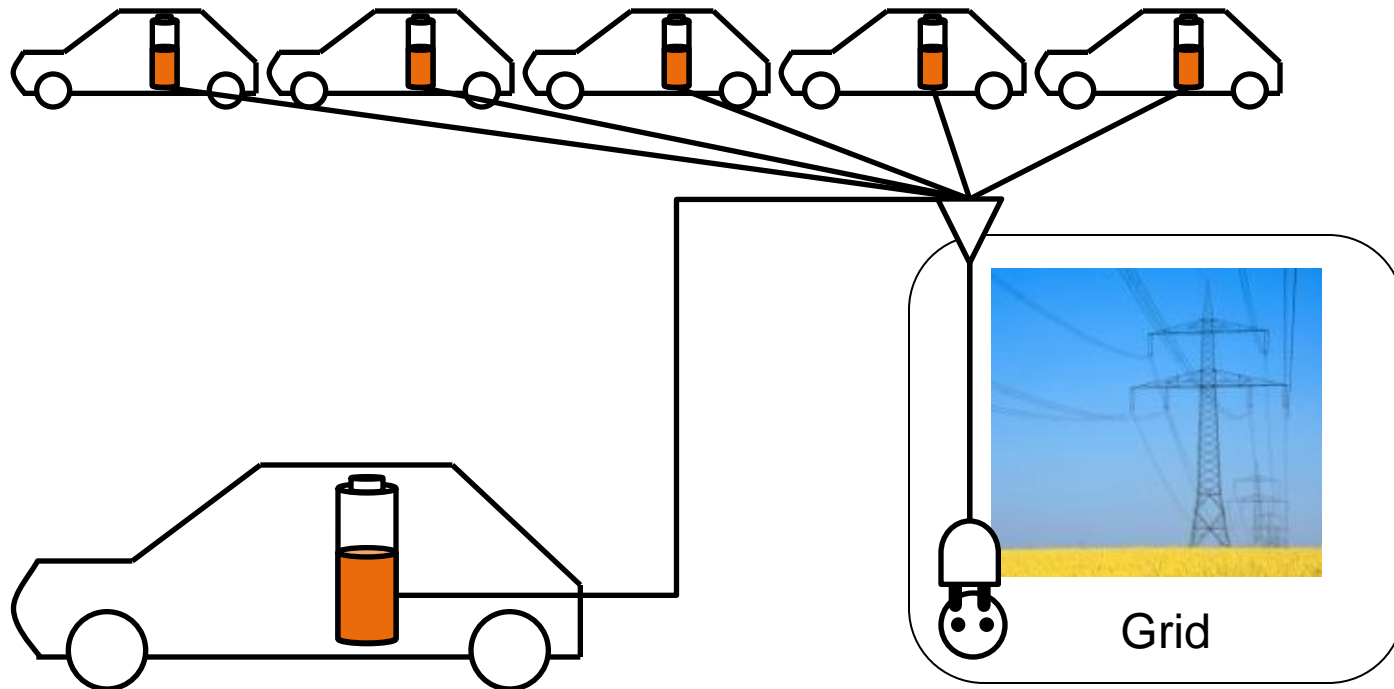08.-10. June 2010, Amsterdam, Netherlands

André Baier, Manuel Wickert, Patrick Lichtner, Reinhard Mackensen

Fraunhofer IWES, Kassel, Germany

Outline

- Introduction

- Information Model

- Model Framework

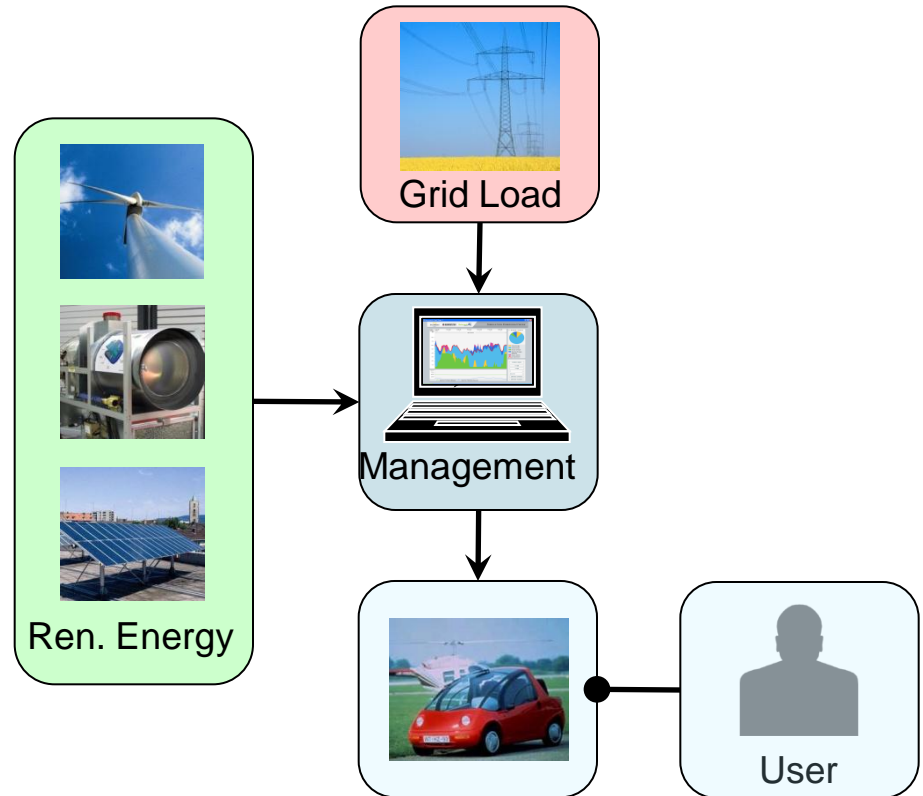- Results

Introduction

Grid

Introduction
Motivation and Goals

1. Guarantee availability of EV

2. Charge local generated renewable energy

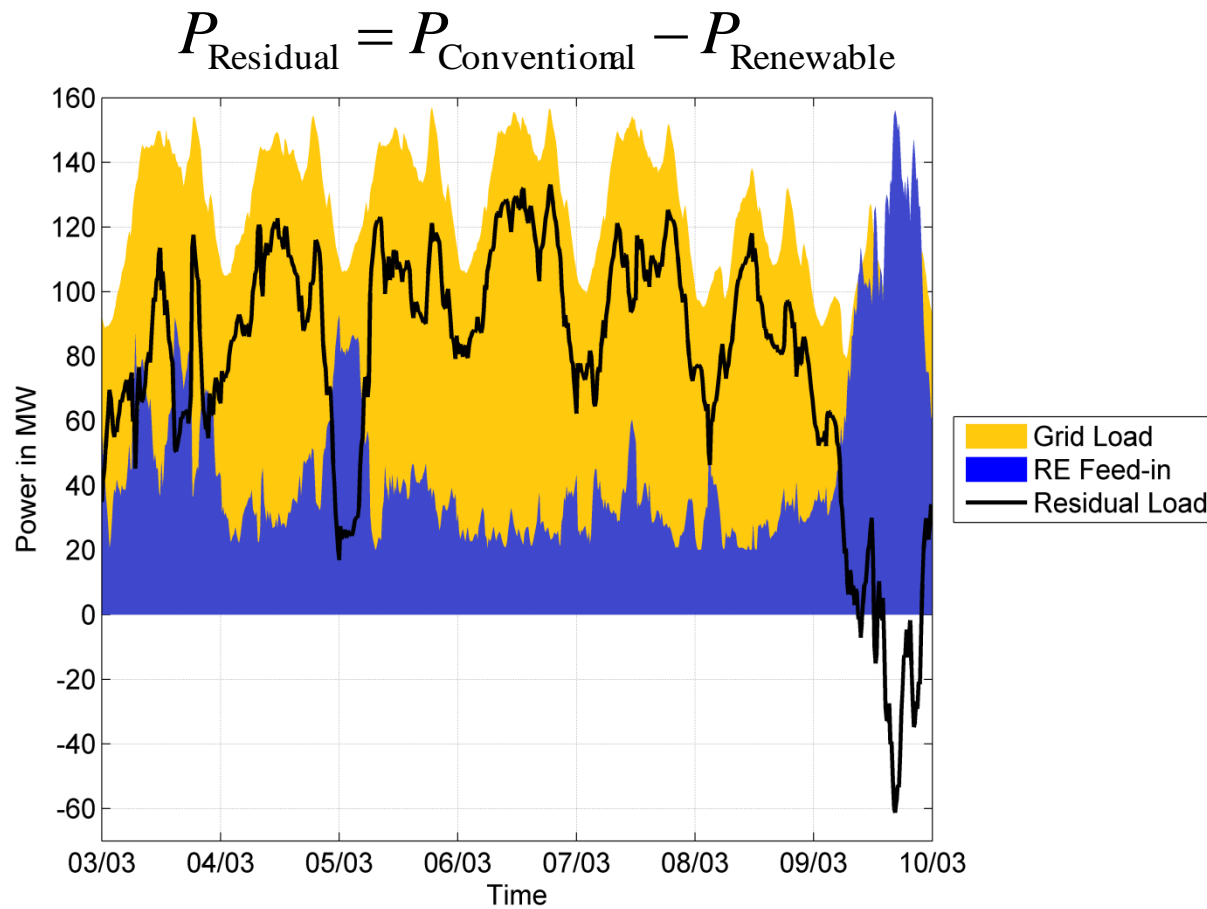3. Support the grid to handle the fluctuating renewable energy

➡ EV Management system

   1. Grid Load Prediction ⎤
                        ⎥ Residual Load
   2. RE Predictions ⎦

   3. EV Predictions

Grid Load

Management

Ren. Energy

User

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Introduction

Residual Load

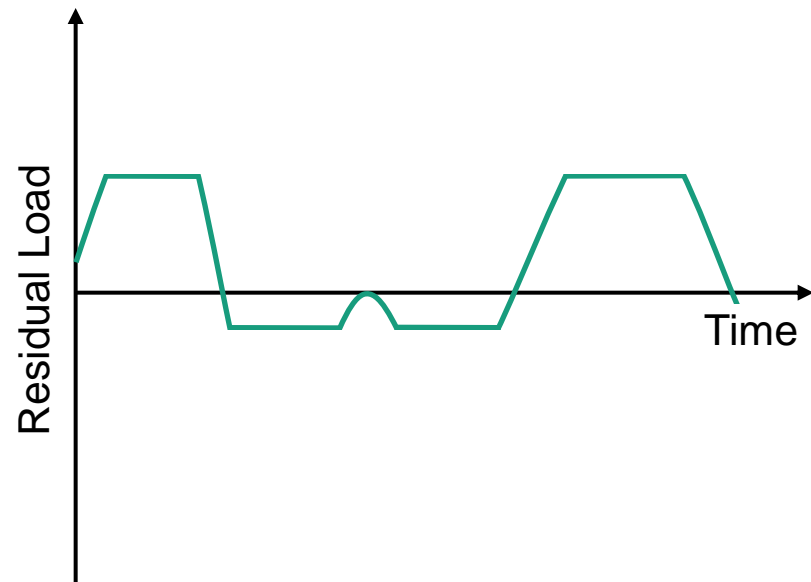$$P_{\text{Residual}} = P_{\text{Conventional}} - P_{\text{Renewable}}$$

Introduction
Management Strategy

- Charging to low residual load

- Feed-in to high residual load

- Smoothing of the residual load

- EV storage for RE with additional influence of the grid load
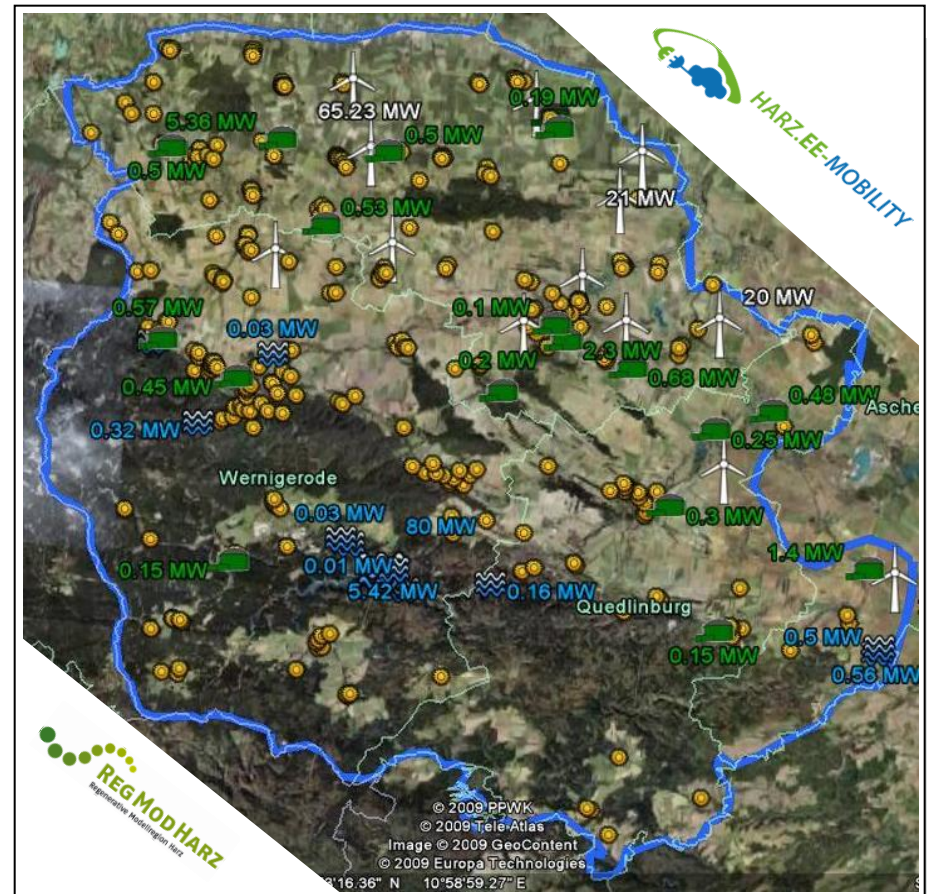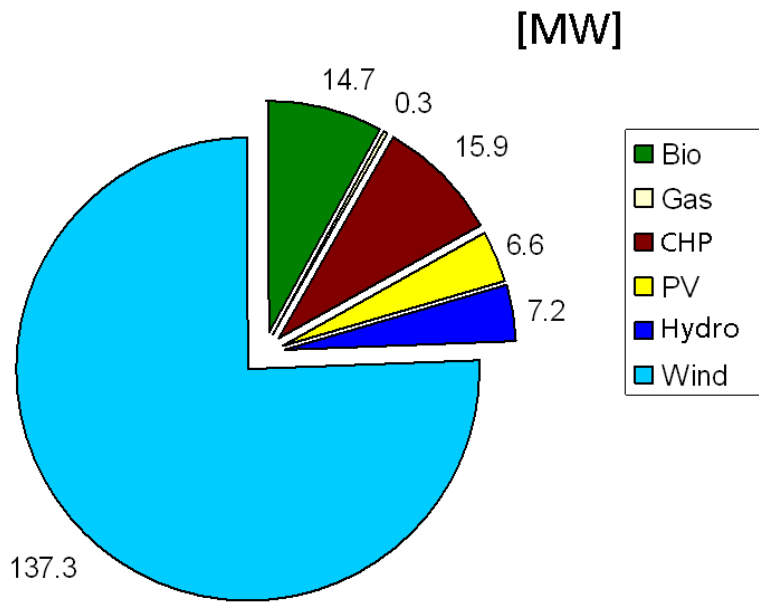
Information Model

- Model to process the predictions

- EV charge load management

  → Control of the charging

- EV feed-in power management (V2G)

  → Control of feed-in and recharging

G. Load pred.

Ren. Energy prediction

Residual Load Prediction

Management

EV pred.

EV Load Control

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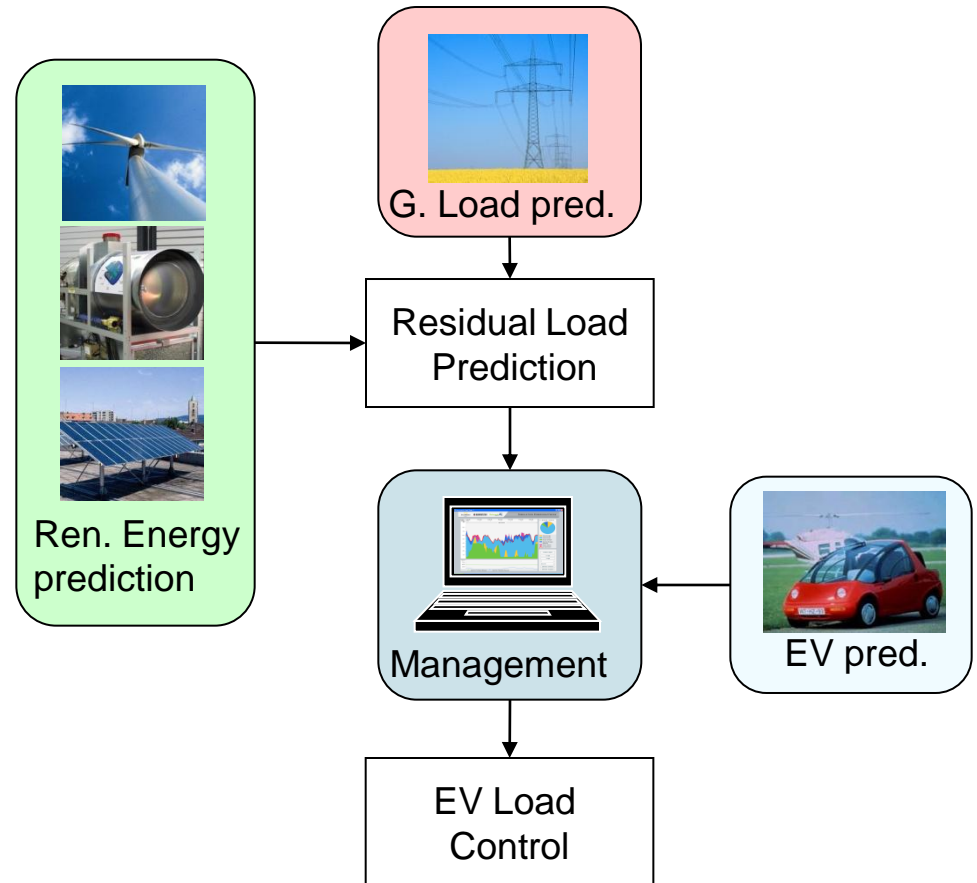
Model Framework

Model Region Harz

- Study for model region Harz

- Rural region in central Germany

- High penetration of renewable energies:

[MW]

Pie chart values: 14.7, 0.3, 15.9, 6.6, 7.2, 137.3

Legend:
- Bio
- Gas
- CHP
- PV
- Hydro
- Wind

Source: Google Earth / IWES

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Model Framework
Simulation Model

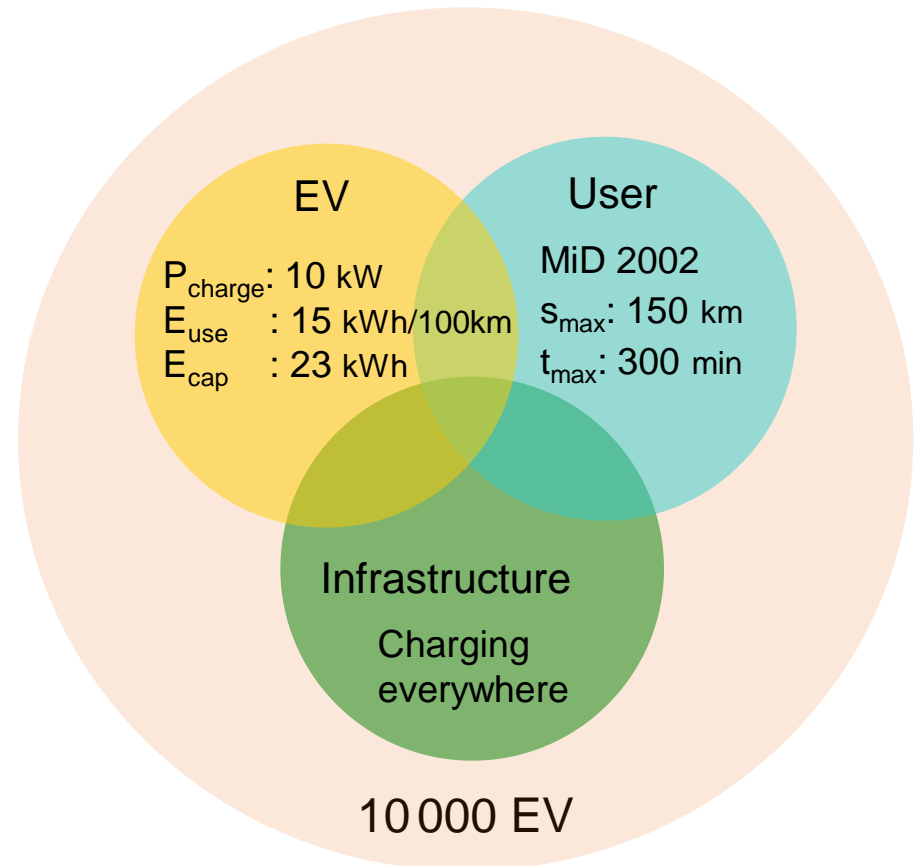- Agent Bases Monte Carlo Simulation

- User model

  - Driving behavior →MiD 2002

  - Charging behavior estimated

- EV model

  - Const. charge capacity

  - Const. consumption

  - Equal battery capacity

- Infrastructure model
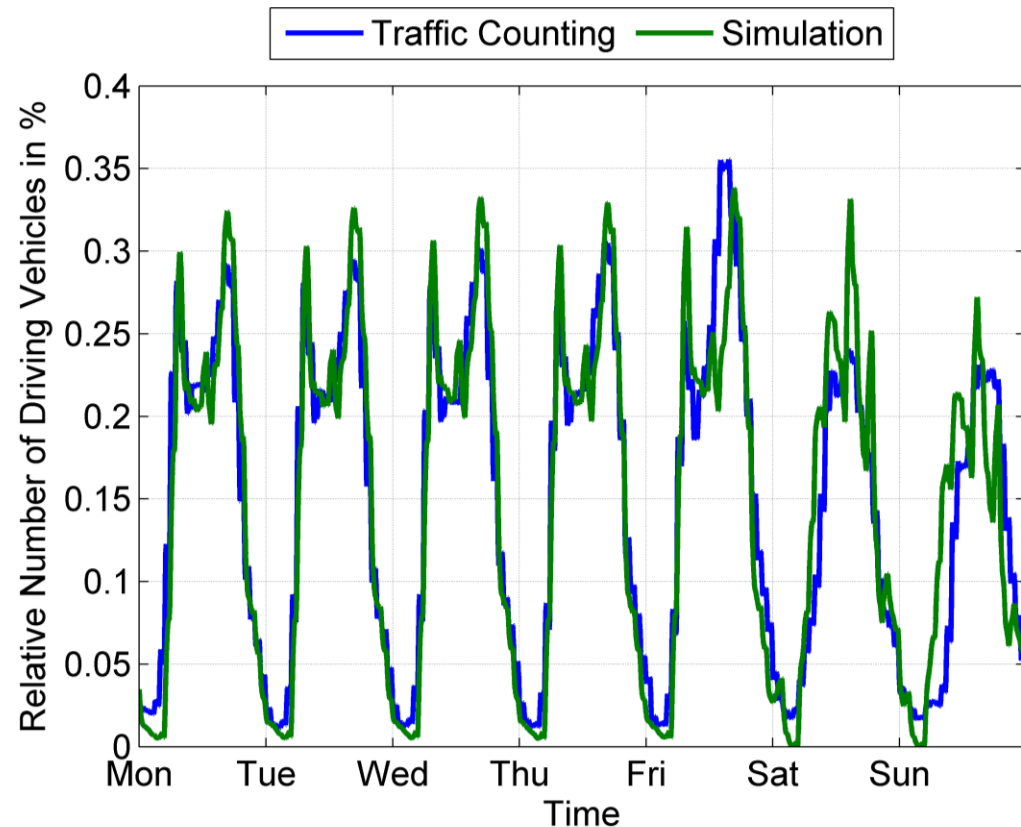
  - Charging everywhere

  - Driving everywhere

EV

P_{charge}: 10 kW
E_{use} : 15 kWh/100km
E_{cap} : 23 kWh

User

MiD 2002
s_{max}: 150 km
t_{max}: 300 min

Infrastructure

Charging everywhere

10 000 EV

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Model Framework
Simulation Results
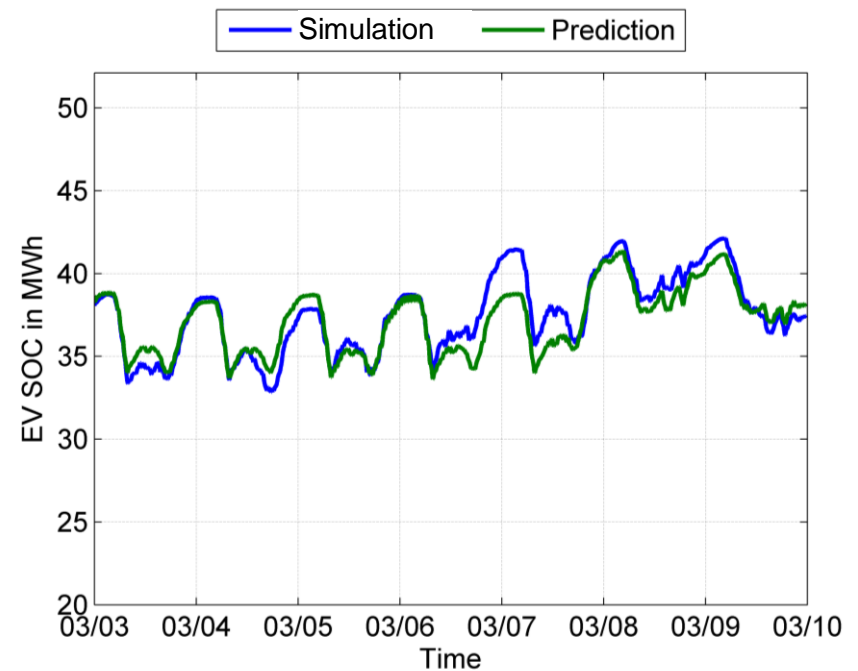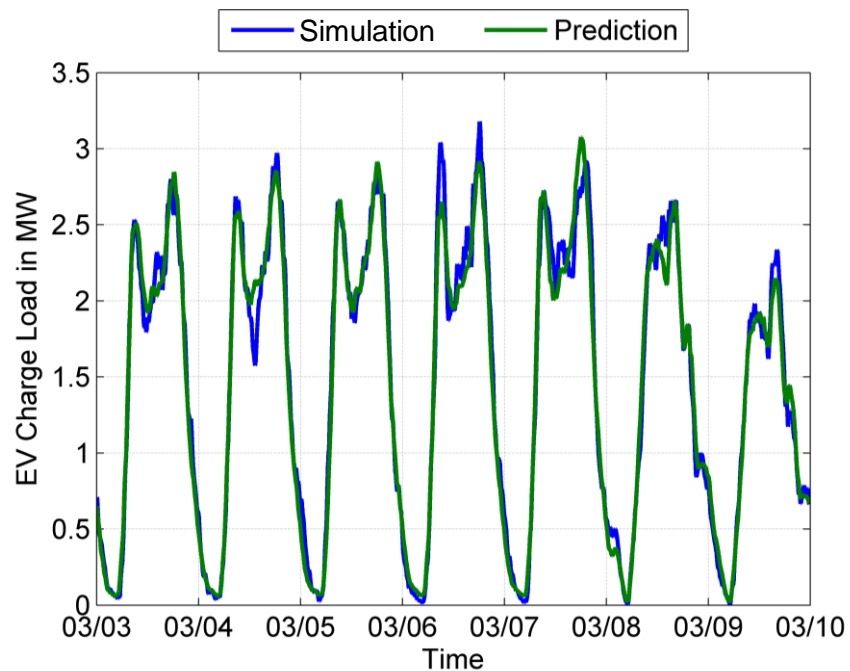
- Results shows the same characteristics as MiD 2002

- Good correlation with traffic counting 0.95
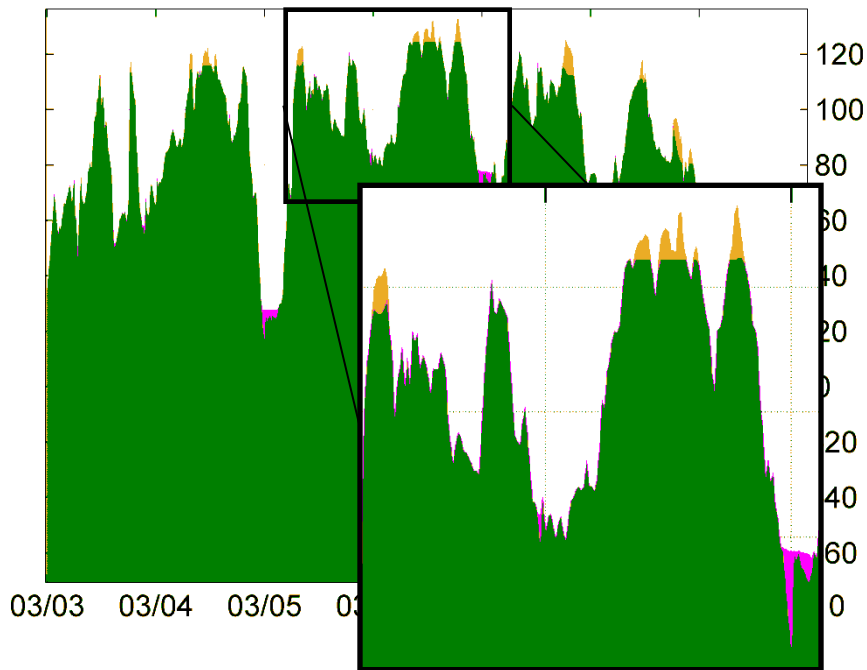
Model Framework

Prediction Model for the Simulation

	EV Charge Load	EV State of Charge
RMSE	0.12 MW	0.83 MWh
Correlation	0.99	0.92

Results
V2G Shifting Management

Feed-in and charge schedule on predicted residual load
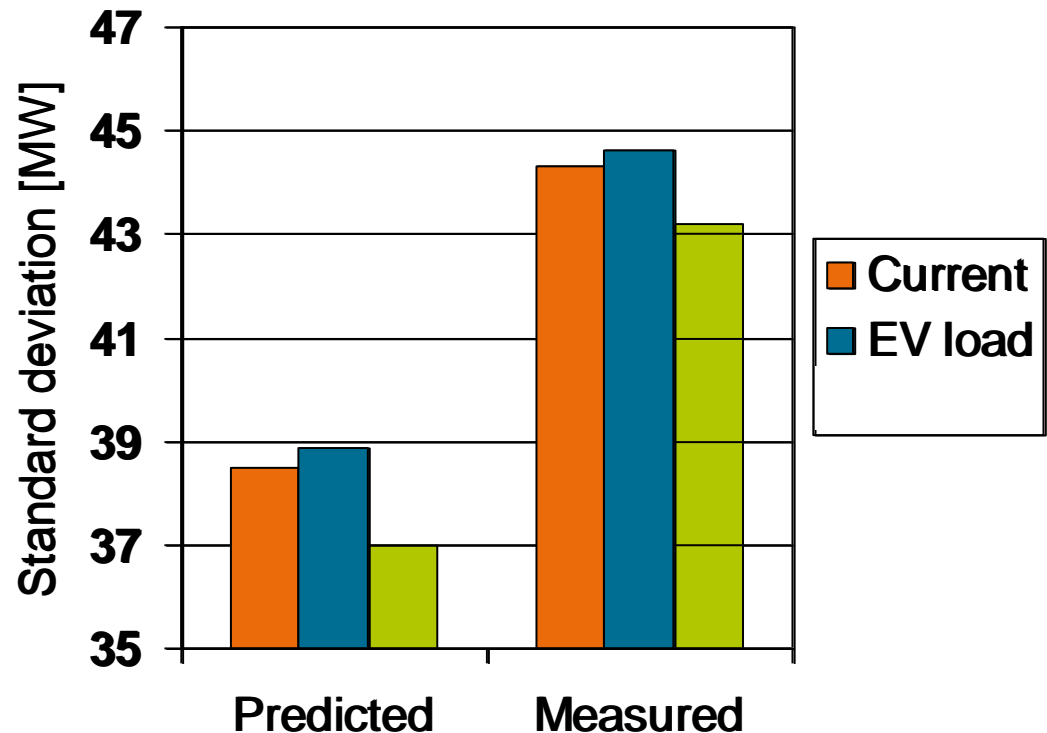
Feed-in and charge schedule on measured residual load

Results

- STD for the smoothness of the residual load

- Smoother residual load

  → RE generation and grid load are more balanced

Summary

- EV predictions and simulation were developed and successful applied

- An information model was introduced
    - Management of the EV charge load and V2G
    - Charging only locally generated RE
    - Integration of a mass of EV into the grid

- Results for model region Harz with 10 000 EV
    - Positive impact of V2G shifting despite the prediction errors

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Thank you for your attention

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Energy Meteorology & Wind Power Management
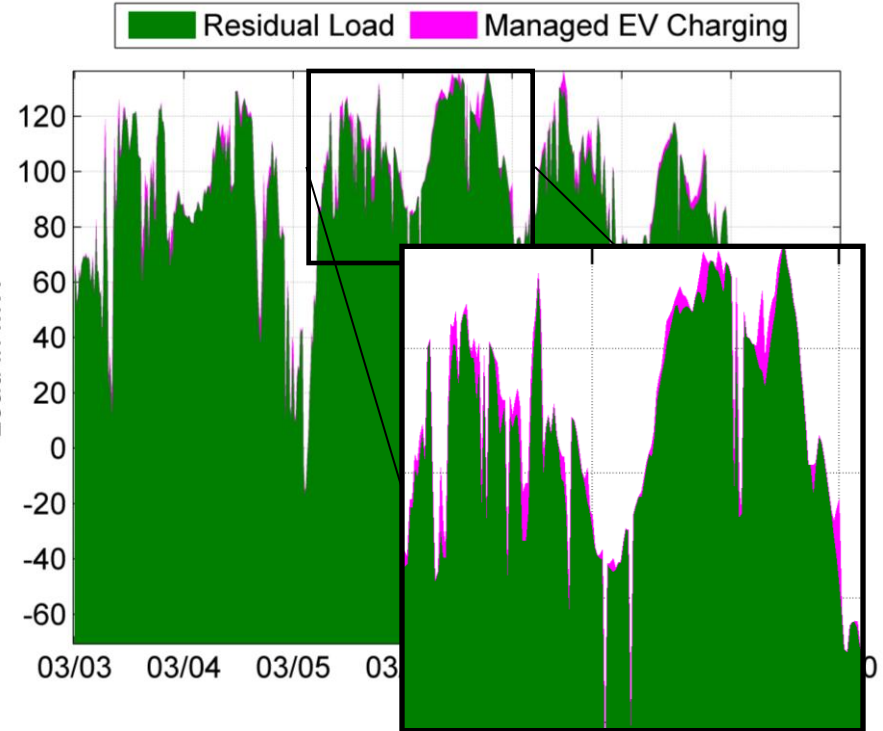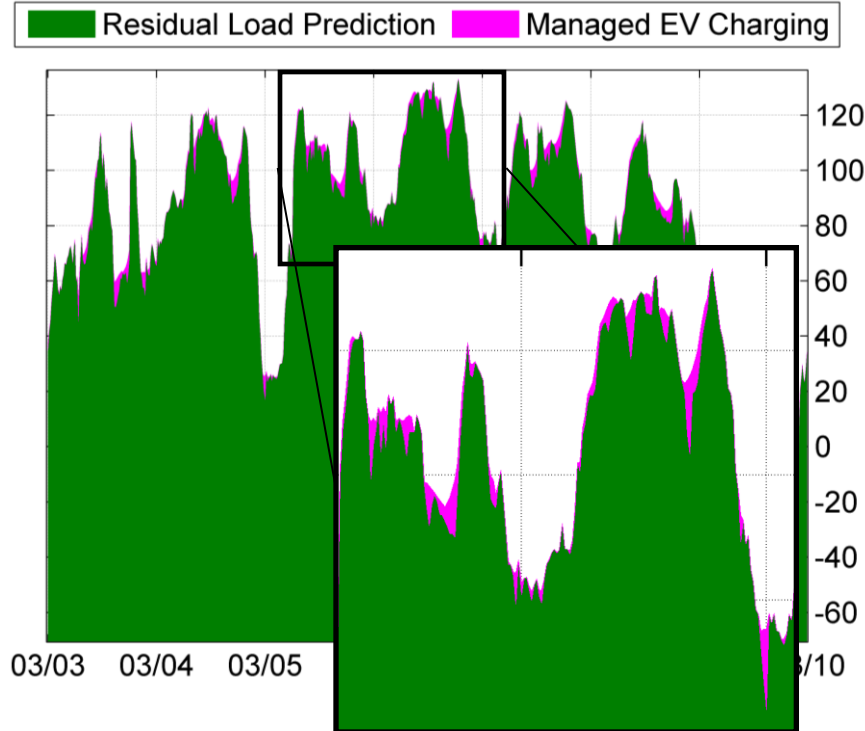**R&D Division Energy Economy and Grid**
Operation

Fraunhofer Institute for Wind Energy and
Energy System Technology IWES
Königstor 59, 34119 Kassel

Results

Load Shifting Management

- 75 % of EV park longer than 7 h

- → Shifting in between 7 h assumed

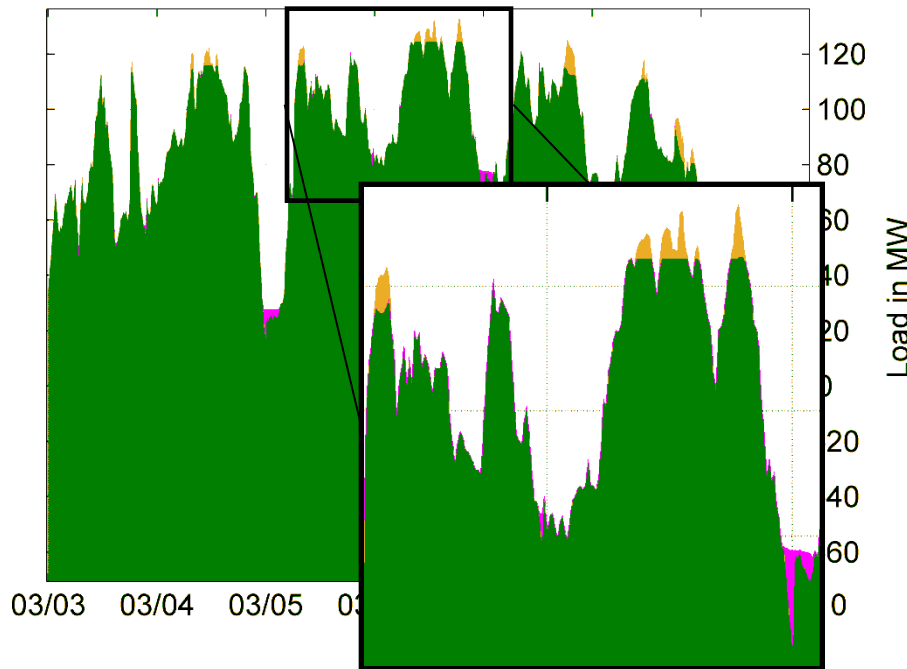- Prediction errors yield to a less effective management
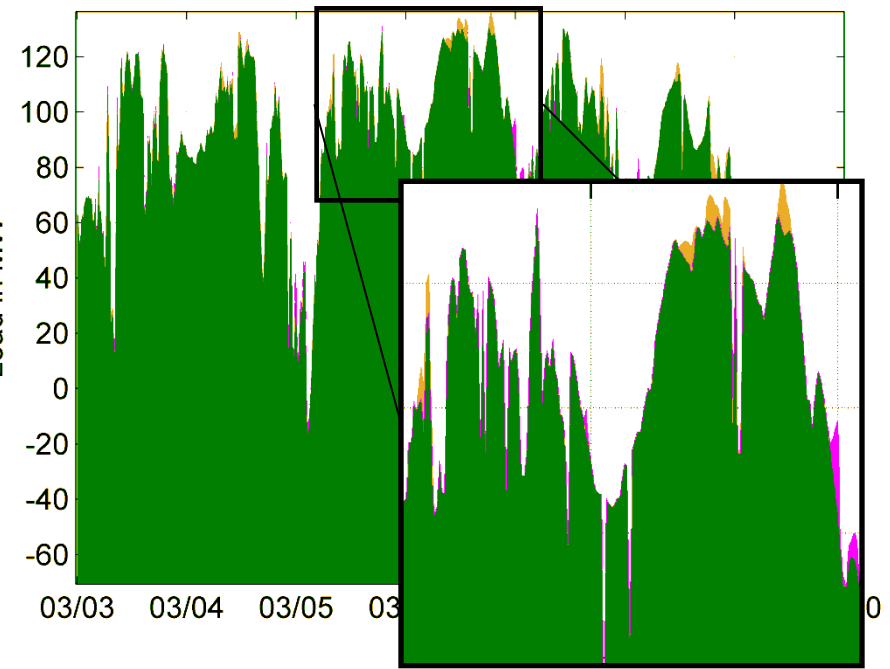
Results

V2G Shifting Management

- 60 % of storage always available

- → 60 % of pred. SOC is used for V2G

- Only V2G, no normal charging
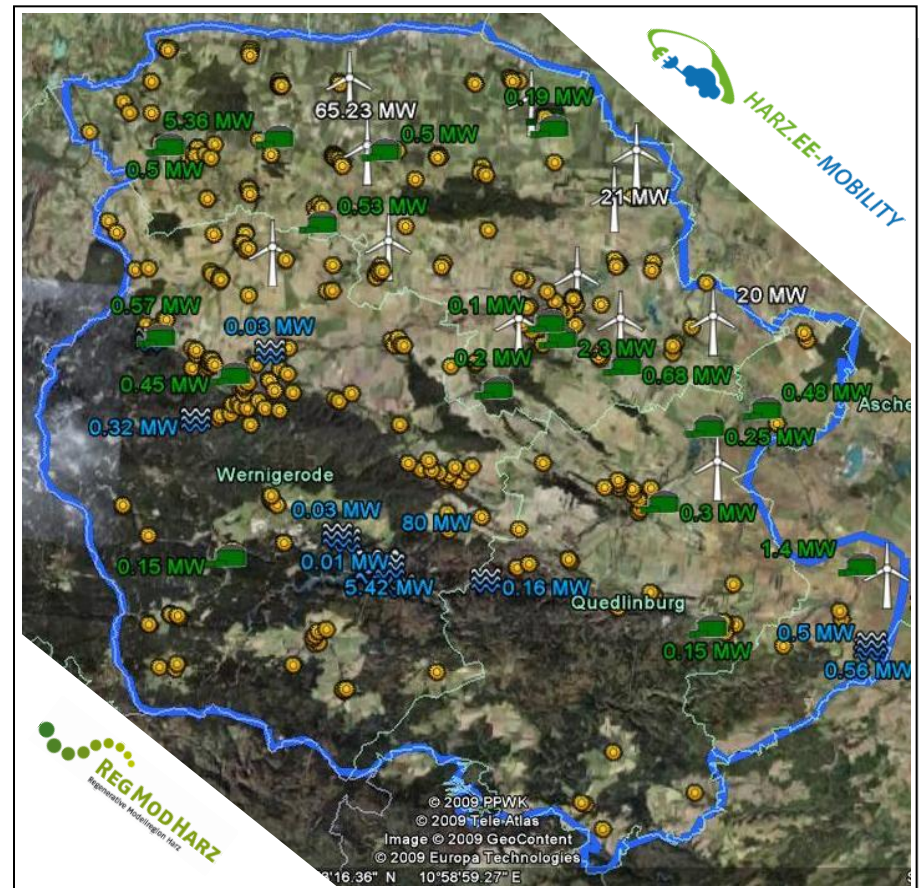
Results
## Application of the Information Model

- Model region Harz
  - RE predictions
  - Grid load prediction
- EV simulation
  - EV charge load prediction
  - EV SOC prediction
- All data from 2008
- Test week:

  From   03. March 2008

  To   09. March 2008

Source: Google Earth / IWES

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Results

- STD for the smooth-ness of the residual load

- Smoother residual load

  → RE generation and grid load are more balanced

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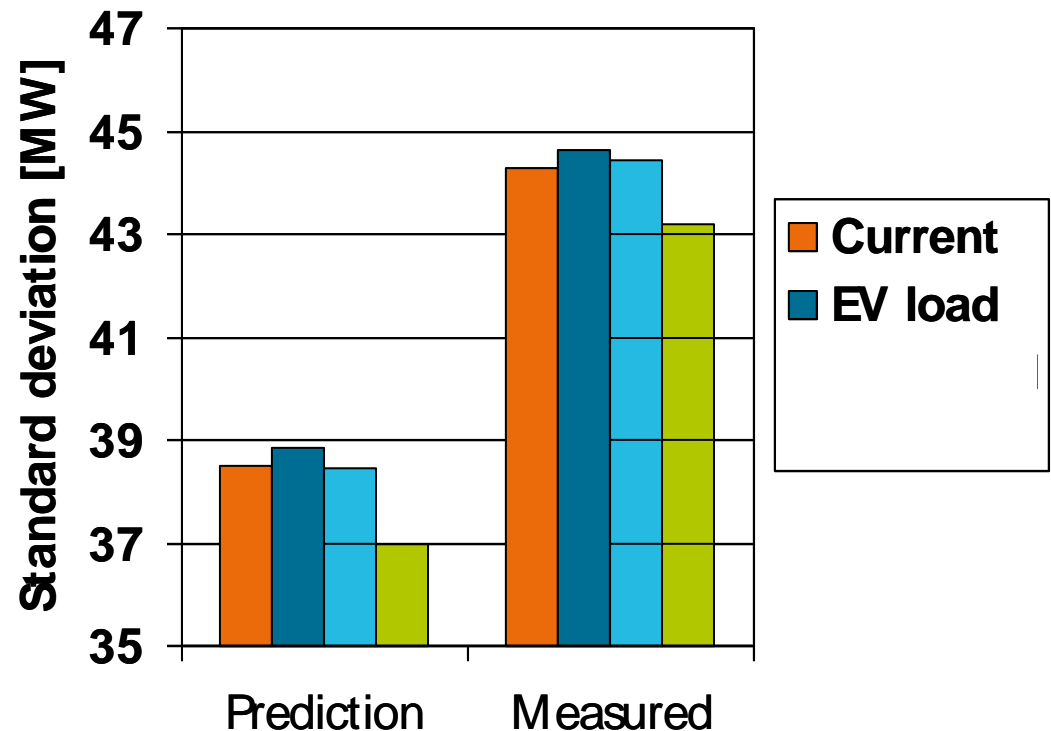
Model Framework
Prediction Models EV

- EV prediction models for the management system
  - Charge load of all EV
  - State of charge of all to the grid connected EV

- Steady characteristics over the year
  - EV Charge load
  - EV SOC

- Standard curves for each day of the week are used

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Prediction

Other Predictions

- **Wind power prediction**
  - On IWES developed WPMS

- **Photovoltaic prediction**
  - Currently under development

- **Bio gas**
  - Steady feed in is assumed (German EEG payment)

- **Grid Load**
  - Standard load curves are used

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Information Model

Load Shifting Management

- EV load prediction
- Residual load prediction