Intelligent Charging Strategies for Electrical-Vehicles and the 7 German E-Energy ICT for E-Mobility Projects

TECHNISCHE UNIVERSITÄT DARMSTADT

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Agenda

1. Electric Mobility, What does this mean for the grid?

2. Electric Vehicles vs. Hybrid Vehicles in Germany

3. The requirement for ICT for E-Mobility

4. The German „ICT for E-Mobility“ Projects

Potential and benefit of E-Mobility

Reduction of Carbon Emission

- 14% of Germany's Carbon Emission is emitted by the transport sector

Secure of the Energy supply

- 97% of the petrol consumed in Germany is imported

Recuction of local emmission

- Reduction of noise, particulate matter, and exhaust gases

Integration of EVs into the electrical grid

- High load shifting potential (G2V)
- Optional possibility of feeding energy back into the grid (V2G)

Roadmap to an electrification of the transportation sector

Germany‘s „National Development Plan E-Mobility

2020	2030	2050
1.000.000 EVs	5.000.000 EVs	40.000.000 EVs

<u>All grid connected Electric Vehicles including:</u>

- Battery Electric Vehicles (BEV)
- Range Extended Electric Vehicles (REEV)
- Plug-In Hybrid Electric Vehicles (PHEV)

Demand for electrical energy

Average consumptions of small EV

Mitsubishi i MiEV:
12.3 kWh/100km

BMW MINI-E:
15.0 kWh/100km

Think City:
13.75 kWh/100km

Chevrolet Volt:
18.0 kWh/100km

Demand for electrical energy
Average consumptions of small EV

Mitsubishi i MiEV:
12.3 kWh/100km

Average consumption in real driving conditions estimated to be 20 kWh/100km

Average day trip of a small car in Germany is 30 km

➔ 6 kWh per day and car

BMW MINI-E:
15.0 kWh/100km

Think City:
13.75 kWh/100km

Chevrolet Volt:
18.0 kWh/100km

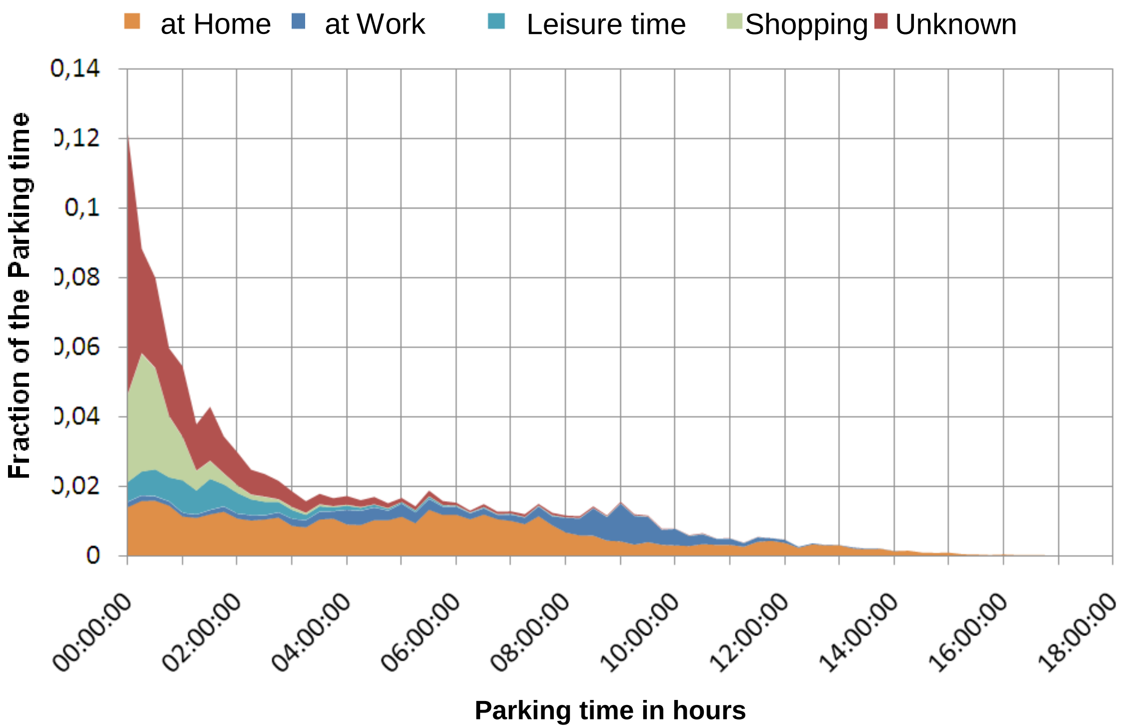
Demand for electrical energy

Based on:
•an average energy consumption of 6 kWh per day
•Germany‘s energy demand of 614.8 TWh per year (2008)

	2020	2030	2050
Energy demand of the EVs	2.19 TWh per year	10.95 TWh per year	87.6 TWh per year
Increasement of Germany‘s electrical energy demand	0.4 %	1.8 %	14.2 %

Demand for Power

Where do the cars need to charge?



Short time parking: at shopping or somewhere on the streets

long time parking: at home and at work

Demand for Power

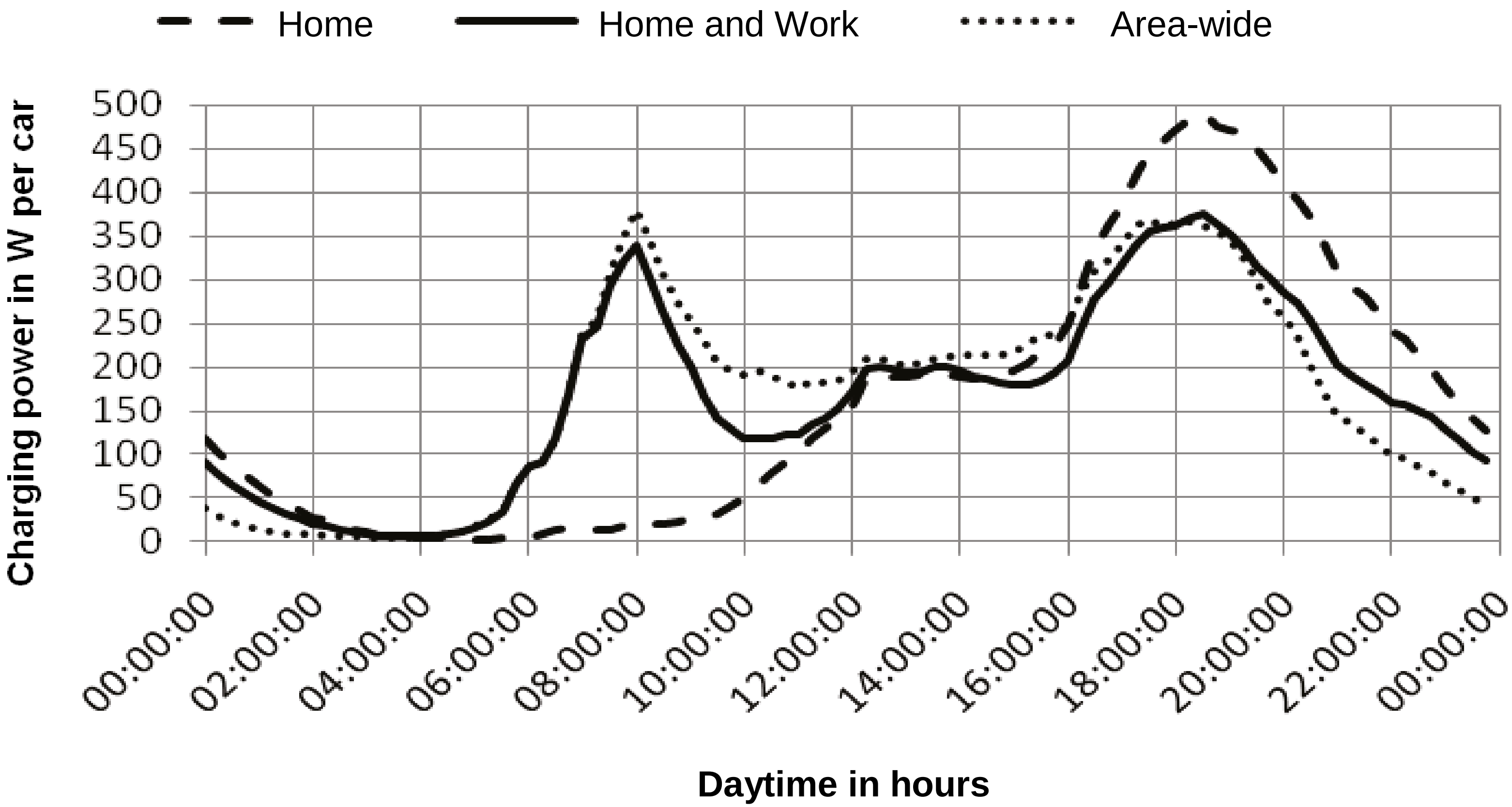
Three charging scenarios

Stage 1
- **Scenario „Home“**
- Low expansion of charging infrastructure

Stage 2
- **Scenario „Home and Work“**
- Medium expansion of charging infrastructure

Stage 3
- **Scenario „Area-wide“**
- High expansion of charging infrastructure

Demand for Power:
Average charging load profile



<u>Assumptions:</u>

- •3.7kW max. charging power
- •Average daytrip 30km (18.5 miles)

Demand for Power

Overview of the power peaks of different scenarios

Stage of infrastructure expansion	2020	2030	2050
„Home“	Evening: 480 MW	Evening: 2.4 GW	Evening: 19.2 GW
„Home and Work“	Evening: 380 MW Morning: 340 MW	Evening: 1.9 GW Morning: 1.7 GW	Evening: 15.2 GW Morning: 13.6 GW

Demand for Power

Overview of the power peaks of different scenarios

Stage of infrastructure expansion	2020	2030	2050
„Home“	Evening: 480 MW	Evening: 2.4 GW	Evening: 19.2 GW
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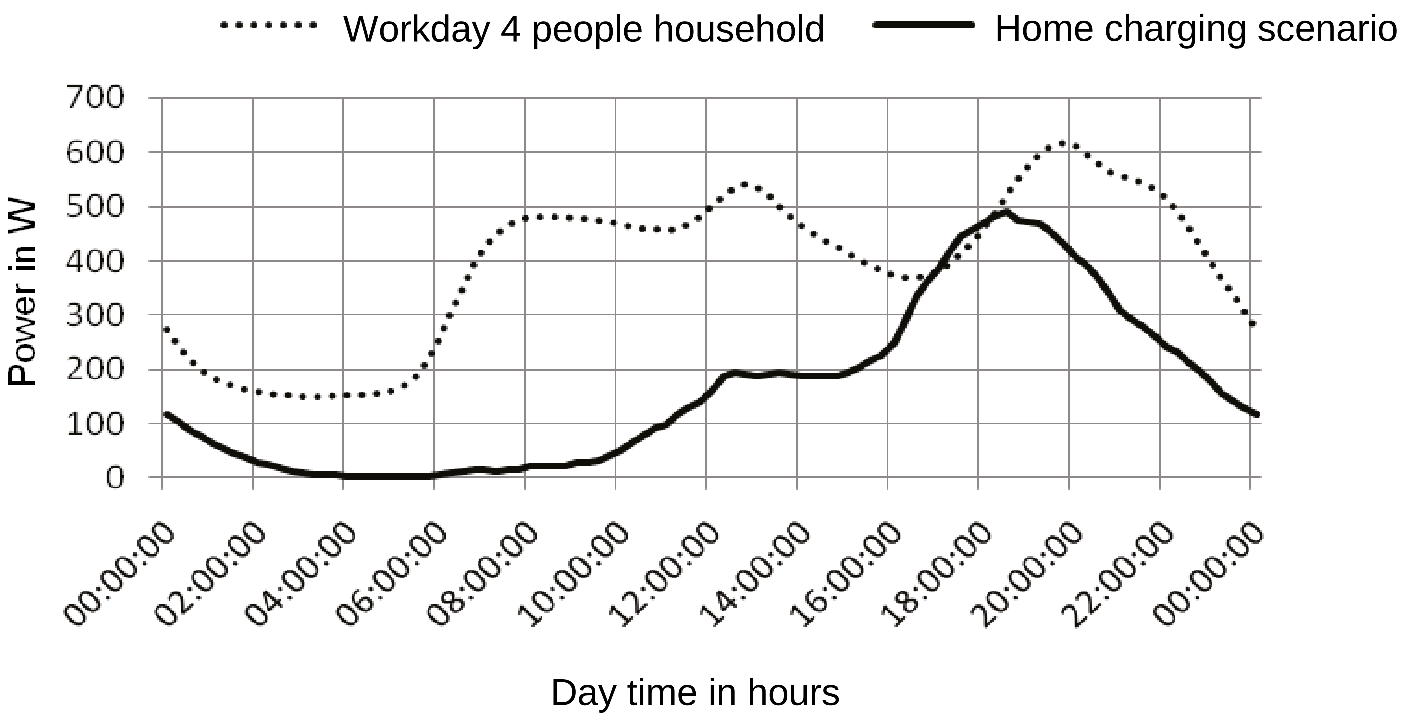
The power peaks will increase further more,
if fast-charging with high power consumption is implemented

Demand for Power

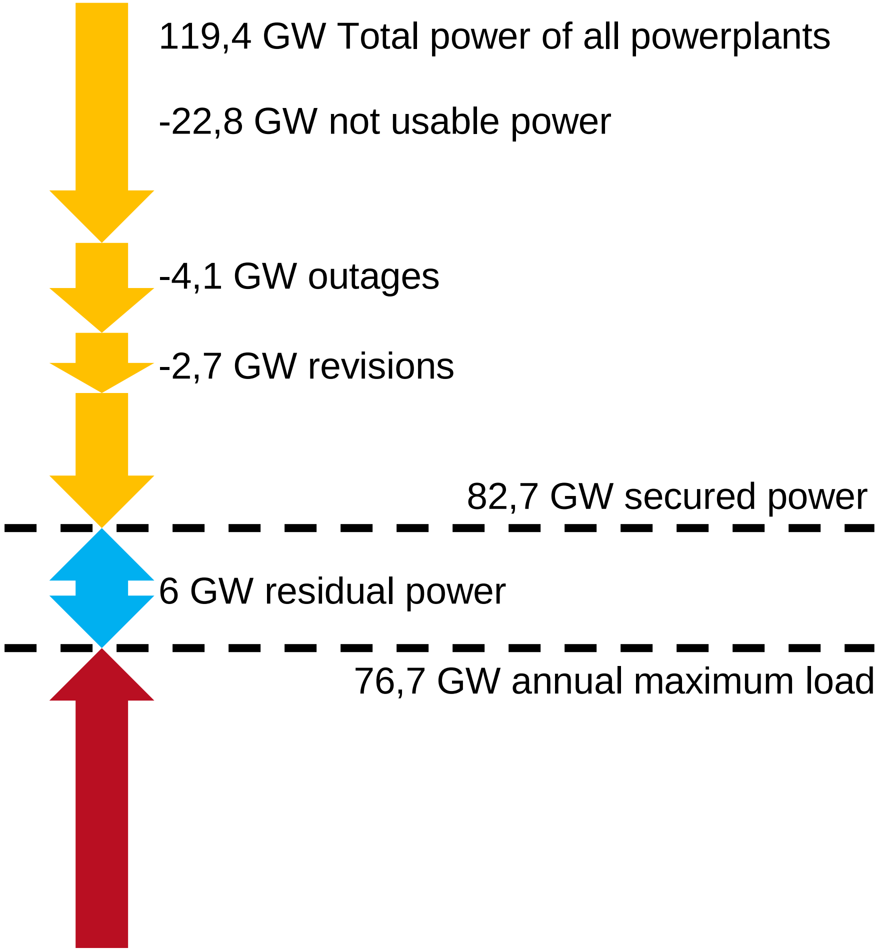
Average consumption of a four people household



- The peak of the charging load profile is close to the peak of the standard household load profile
- Critical for substations and transmission lines might occure even at a relatively low number of EVs due to local concentrations

Demand for Power

Secured Power from all powerplants in Germany



Source: dena
2005

• annual maximum load occured in the evening

Worst Case (Scenario home + work):
76,7GW max. annual load +
15,2GW Charging load

91,9GW annual load

➔No security of supply

➔Research for integration of E-mobility into the grid is necessary

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Risks and Drawbacks of E-Mobility

High investment needs

Future cost degression of traction batteries is unclear

- Availability of raw materials
- Battery research is still expandable
- Lack of standardization could lead to point solutions

User Acceptance

- High expectations could lead to disappointment
- Fear of high costs, safety issues, battery life span and battery range

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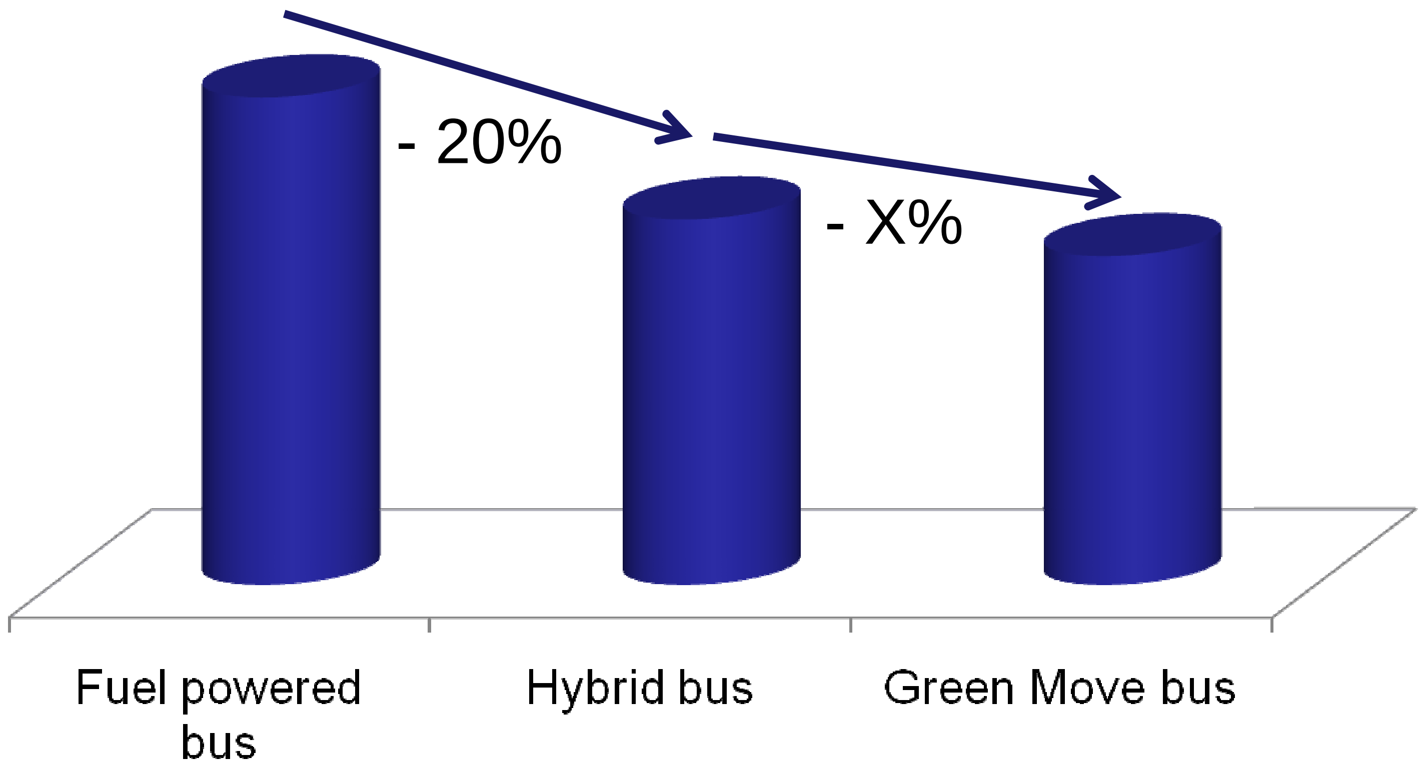
Most of the risks and drawbacks are related with the battery

Hybrid Vehicles as a bridging technology

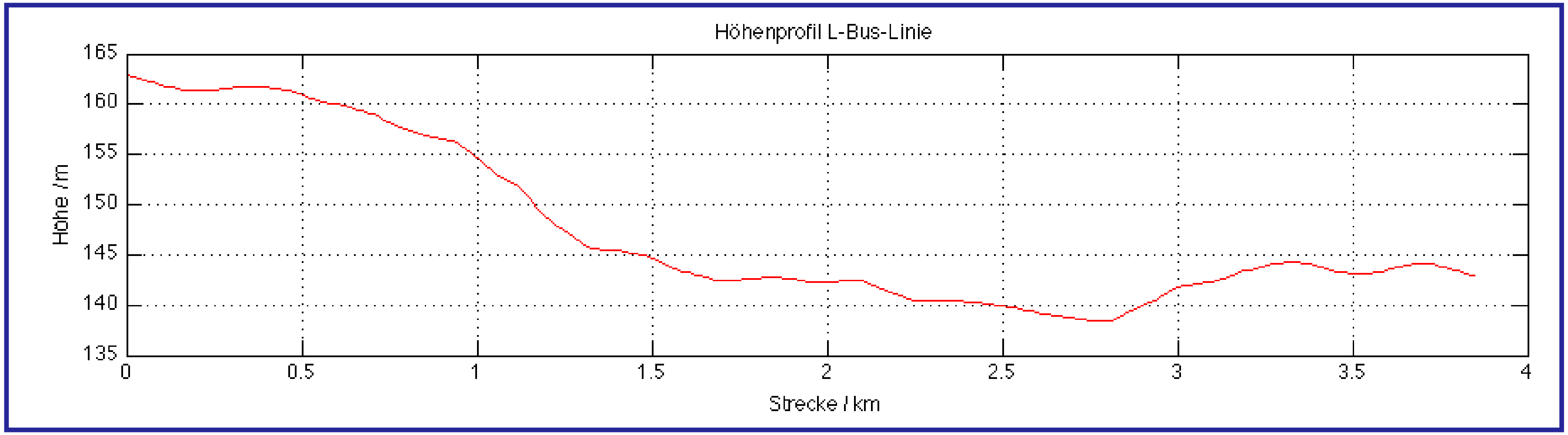
Hybrid Vehicles allow the introduction of electric driving while reducing the disadvantages of BEVs

- The fuel powered engine allows day trips of any distance
- A small battery capacity with low electric range can be used
- Series production of Hybrid Vehicles will ramp up the production of electric drive components and lead to lower prices

Predictive Hybrid System at the example of a public transportation bus



Predictive Hybrid System at the example of a public transportation bus



Optimization strategy

Speed-profile

Hight-profile

Mass-profile

MATLAB & Simulink Modell of the Hybrid-bus

Optimization strategy

Speed-profile

Hight-profile

Mass-profile

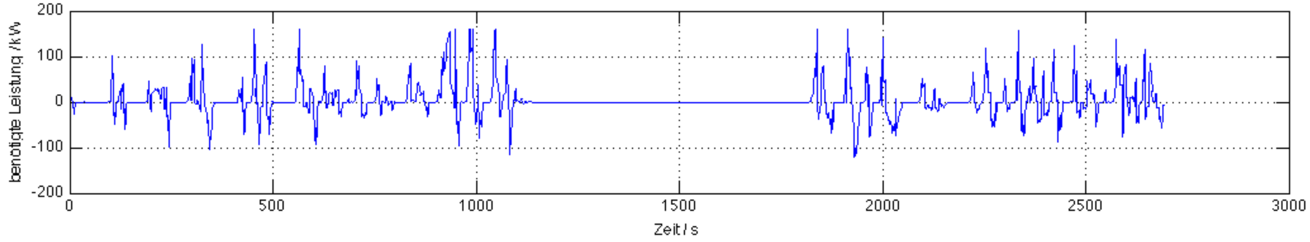
MATLAB & Simulink Modell of the Hybrid-bus

Load-profile

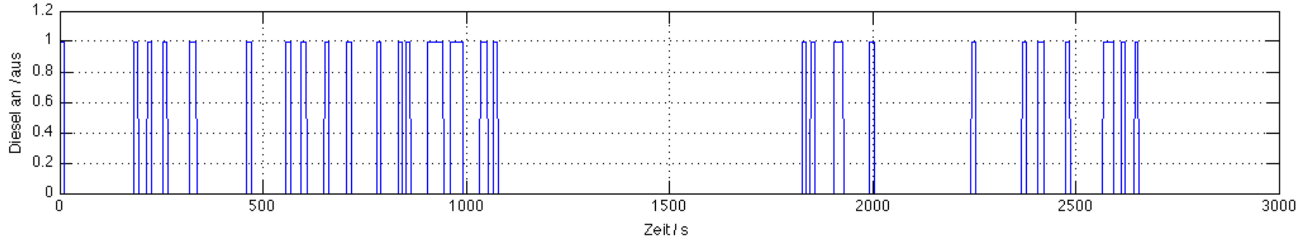
Optimization of the energy-management of the Hybrid-bus according to the route

Results of a static optimization

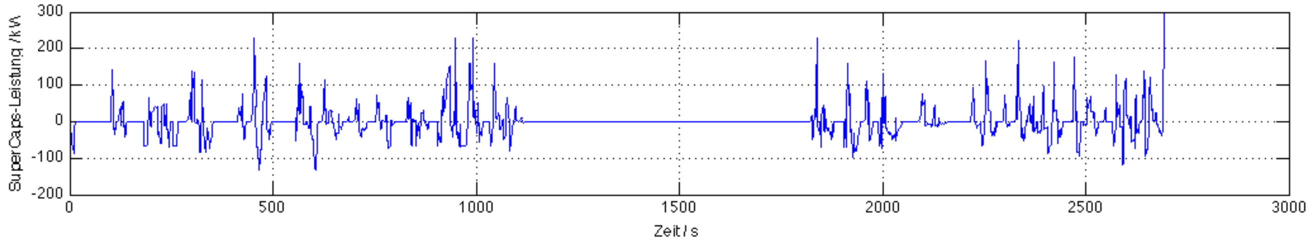
Load demand



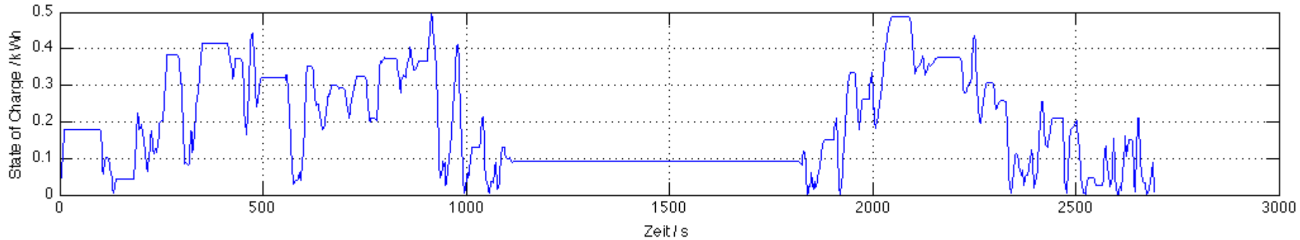
Generator on/off



Power output of the supercaps



State of charge



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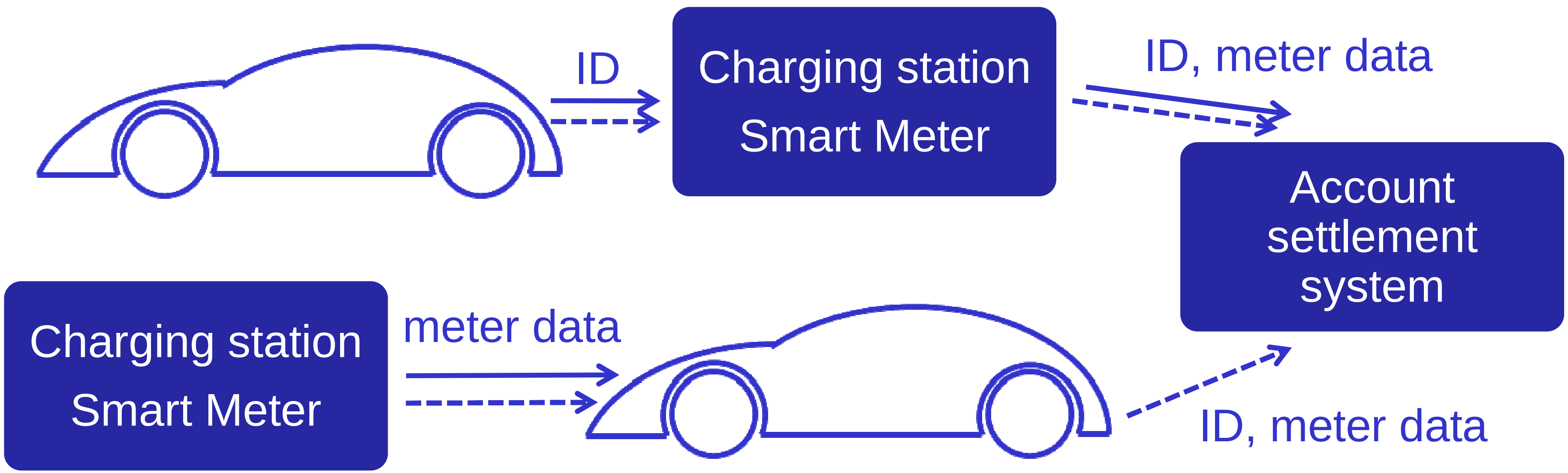
Requirement for ICT
ICT for the charging-points

Charging at home requires a suitable outlet

Charging at public charging stations requires communication
- Vehicle or user identification
- Metering of the charged energy
- Transmission of the ID and the meter data to an account settlement system



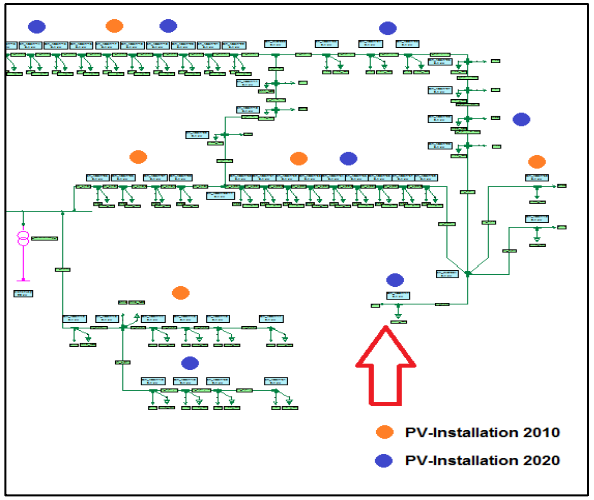
Requirement for ICT

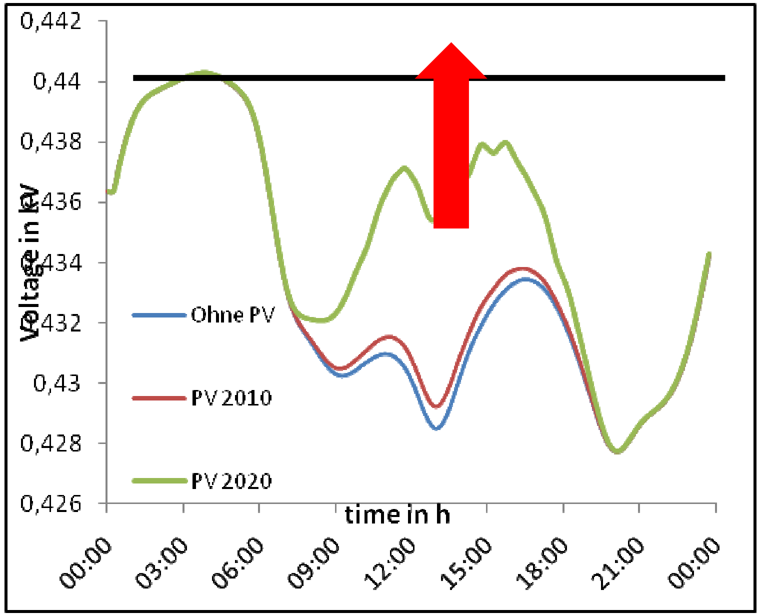
Volatile structures of renewable energies

• Simulation of a real existing 400V voltage grid with an Installed photovoltaic peak power of 26kWp.

•Scenario 2020: 130 kWp photovoltaic

➔The voltage stability is at risk. Today we already have problems in rural areas, where farmers have big photovoltaic arays on their barns





Source: Modellbildung und Simulation von Energiespeichern im Niederspannungsnetz,
Dipl.-Ing. Steffen Schinz TU Darmstadt

Requirement for ICT

Volatile structures

➔ Volatile generation structure

➔ Volatile consumption structure

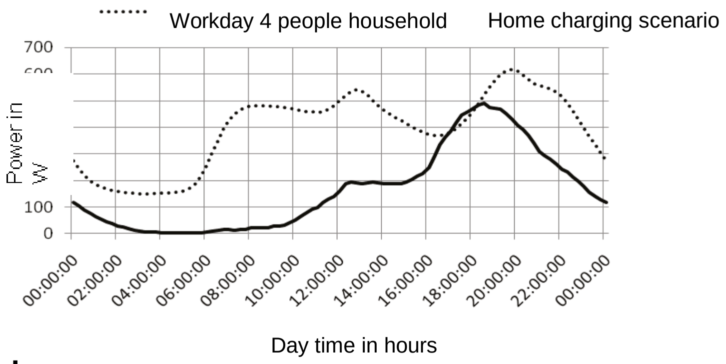
➔A volatile generation structure leaded to the today‘s energy supply problem of the shift between renwable energy generation and consumption. What happens if we get a volitile comsumption structure too?

➔ E-Mobility must be integrated into a Smart Grid, intelligent charging strategies are necessary.

Requirement for ICT
Intelligent Charging strategies

- Integration of charging points into a Smart Grid
  - Time shifted loading ➔ peak reduction

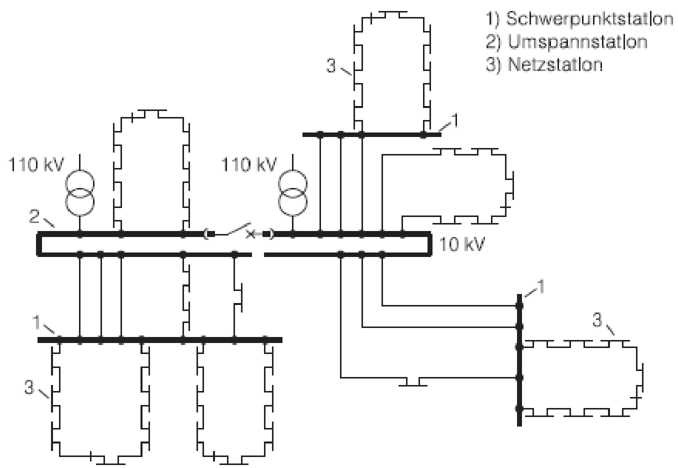
- Intelligent charging strategies for load adaption of renewable energies



- Destinations:
  - Providing the voltage stability in low voltage grids (only 10% difference is allowed)

  - Avoiding overloading of the local transformator

  - Increasing the simultaneus consumption of renewable energies when they generate energy



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500 Million Euro R&D Project Fundings

Federal Ministry of Building, Transport and Housing
8 Model-Regions with fieldtests
115 Million Euro

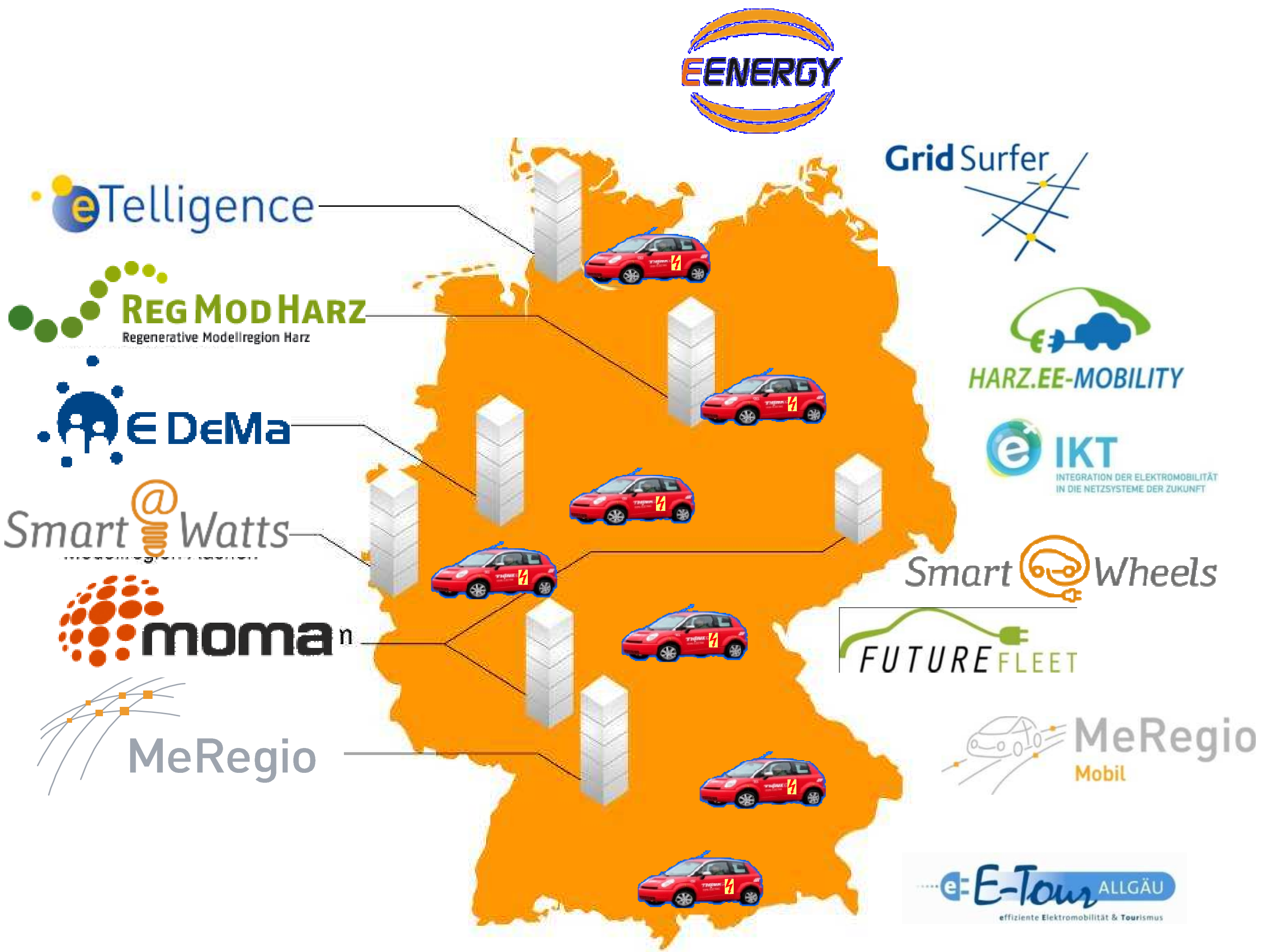
Federal Ministry of Education and Research
electrochemistry, system research, production technology, 125 Million Euro
Battery technology, battery recycling,

Federal Ministry of Economics and Technology
recuperation, Optimization traction train,
75 Million Euro
vehicle development

Federal Ministry of Environment, Nature Conservation and Nuclear Safety
Hybrid-Buses, fieldtests, public-transport
115 Million Euro

ICT for Electric Mobility
45,5 Million Euro
Renewable Energies, Smart grids.

Interaction with E-Energy, the German program of Smart Grids



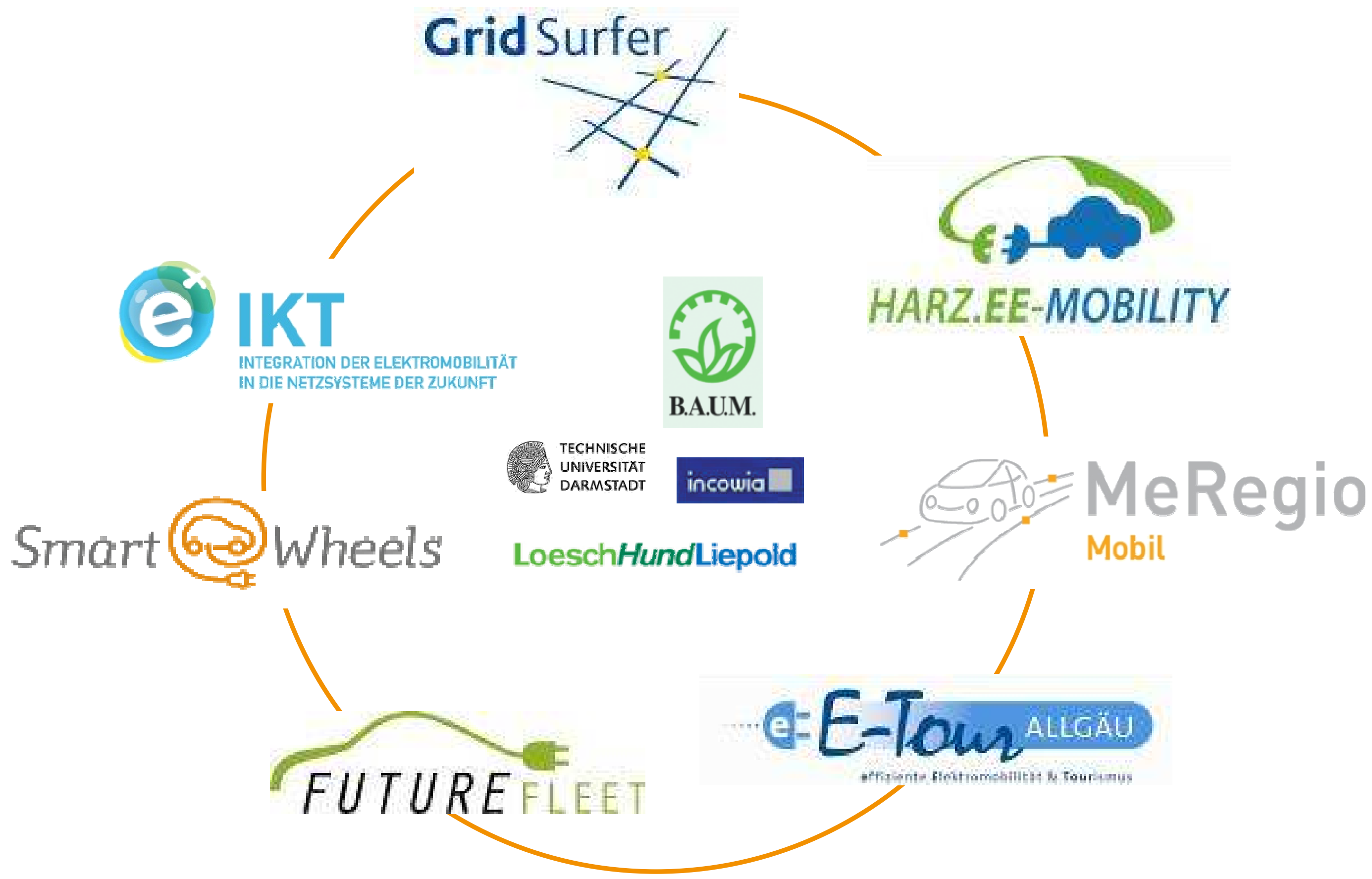
ICT for Electric Mobility

- Cooperation between the *Ministry of Economics and Technology* and the *Ministry of Environment, Nature Conservation and Nuclear security*
- More than 50 members of 7 project consortia
- Total volume more than 100 Million Euro including fundings of the mebers of the consortia
- Startet in autumn 2009, ends in autumn 2011
- The projects have an extra ancillary research, which is coordinating between the 7 Projects

Cross section work between the 7 projects

- Standardized calibration boundary conditions for Smart Grids and battery-charging stations
- Authentification- and identification management
- Challenges of existing standards and the Extending work of those
- ICT based solutions for load management in grids, feed in possibilities of electric vehicles into the grid
- Requests to the infrarstructure (hardware, networks, applications), data management and interfaces, reference architectures
- Chances and constraints of buisiness cases concerning user acceptance, stability of the law and economical efficiency and resulting market potentials

The 7 ICT for E-Mobility Projects



E-Tour Allgäu

ICT and Electric Mobility for tourismn in Allgäu

•Requirements for the desire to be mobile in rural touristic areas
•**Destination:** Solve the desire for mobility in Allgäu by complying with a maximum of environment protection.
•**Realization:** Development car-sharing programes, Integration of EV

- **Consortium leader**: Allgäuer Überlandwerk GmbH
- **Consortium members** : University Kempten, John Deere Werke GmbH, MoveAbout Deutschland, Soloplan GmbH, ENERGY4U GmbH, TU München, Universität Tübingen
- **www.ee-tour.de**

Electric vehicles as mobile storages in Smart Home Energy management Systems

•Developing and field test of the infrarstructer for a larger amount of EV including connection to intelligent household appliances in low voltage grids
•**Destination:** Developing and assembling of EV infrastructure in Baden-Württemberg and field tests
•**Realization:** Using the car battery as a virtual storage, coupling of household loads and appliances with EV, implementing management strategies

- **Consortium leader** EnBW AG
- **Consortium members :** Fraunhofer-Institut für System- und Innovationsforschung, Karlsruher Institut für Technologie (KIT), Adam Opel GmbH, Daimler AG, Robert Bosch GmbH, SAP AG, Stadtwerke Karlsruhe GmbH
- **http://meregiomobil.forschung.kit.edu**

Grid Surfer

Urban integration of Electric Vehicles into energy systems, including Battery Changes

• Development of a concept for connecting EV to electrical grids, solving the problem of the range of the EV in urban areas
•**Destination:** Solving the problem of EV ranges in urban areas
•**Realization:** Development of EV, Proving battery change concepts for charging, G2V, V2G, finding out the neccessary changings of the distribution grid for EV

▸**Consortium leader:** EWE AG

▸**Consortium members:** E3/DC GmbH, Next Energy - EWE-Forschungszentrum für Energietechnologie e.V., OFFIS

▸**www.ewe.de/ewe-macht-zukunft/grid_surfer.php**

Future Fleet

FUTURE FLEET

Integration of Electrical vehicles in commercial vehicle fleets

- Fleets of companies with EV, controled by a fleet management based on renewable energies
- **Destination:** Integration of 100 EV into the company vehicle fleet of SAP and MVV, charged by only renewable energies
- **Realization:** Management software, analysis of user acceptance, analysis of EV parameters and monitoring

- **Consortium leader:** SAP AG
- **Consortium members:** MVV Energie AG, Öko-Institut e.V., Institut für sozial-ökologische Forschung (ISOE), Hochschule Mannheim
- **www.futurefleet.de**

HARZ.EE-MOBILITY

Electrical vehicles as mobile storages

•Integration of the EV into a grid with high amounts of renewable energies by ICT
•**Destination:** Covering the security of the grid, renewable energies for the mobility of people
•**Realization:** Development and proving of ICT based key technologies for connecting EV to a grid by providing the stability

- **Consortium leader:** Otto-von-Guericke-Universität Magdeburg
- **Consortium members:** DB Rent GmbH , E.ON Avacon AG, Fraunhofer IFF und IWES, Halberstadtwerke GmbH, Hochschule Harz, in.power GmbH, Krebs & Aulich GmbH, Otto-von-Guericke-Universität Magdeburg, RegenerativKraftwerk Harz GmbH & Co. KG, Siemens AG, Stadtwerke Blankenburg GmbH
- **www.harzee-mobility.de**

e IKT

IKT
INTEGRATION DER ELEKTROMOBILITÄT
IN DIE NETZSYSTEME DER ZUKUNFT

ICT based integration of electrical vehicles in the grid of tomorrow

•Electric Mobility based on urban generation of renewable energies
•**Destination:** Development of an innovative charging, control and billing management
•**Realization:** Development of a central billing system, Development of Charging stations.

▸**Consortium leader:** RWE AG

▸**Consortium members:** Ewald & Günther Unternehmensberatung GmbH & Co KG, SAP AG, TU Dortmund, TU Berlin

▸**www.ikt-em.de/de/e-mobility.php**

Smart Wheels

Intelligent electric mobility in the area of Achen

•Development of buisiness cases and convergent ICT services for preparation of electric mobility by an intermodal traffic system and the integration into Smart Grids
•**Destination:** Development of an intermodal traffic concept (using electrical buses, electrical cars and electrical bikes) for conquering the limited range
•**Realization:** Development of new business cases, stabile integration of EV into the infrastructure of local utilities

- **Consortium leader:** FEV Motorentechnik GmbH
- **Consortium members:** Forschungsinstitut für Rationalisierung (FIR), STAWAG Stadtwerke Aachen AG,MENNEKES Elektrotechnik GmbH & Co KG, RWTH Aachen, regio iT aachen GmbH
- **www.smartwheels.de**

Working groups and crossection work

4 groups:

1) Buisiness cases

Infrastructure, Mobility provider, utility

2) Law

Boundary conditions from the german Measure Law for Smart grids and Charging points

3) Interoperability

Interoperability of EV between the 7 projects

4) Communication

ICT

Group Interoperability

- **Cooperation of the 7 projects concerning standardization, international standards**

- Working with standardization boards

- Taskforce 1: Battery fieldtest research
  - Establish comparability
  - Collecting datas
  - **Results until now:** - Agreement for using same test procedure for testing batteries
    - Common Data Collection point
- Taskforce2: Intermodale possibility of charging of EV in all 7 projects
  - EV shall be able to charge in every model project are
  - **Results until** now: - Agreement for same specification for RFIDcard based access to charging points
    - Agreement for same specification for the identification of EV by ID

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