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

Reduction of local emission
• 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

All grid connected Electric Vehicles including:

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

2020
1,000,000
EVs

2030
5,000,000
EVs

2050
40,000,000
EVs
Demand for electrical energy
Average consumptions of small EV

- Mitsubishi i MiEV: 12.3 kWh/100km
- Think City: 13.75 kWh/100km
- BMW MINI-E: 15.0 kWh/100km
- Chevrolet Volt: 18.0 kWh/100km
Demand for electrical energy
Average consumptions of small EV

Mitsubishi i MiEV: 12.3 kWh/100km

Think City: 13.75 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

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)

<table>
<thead>
<tr>
<th></th>
<th>2020</th>
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<td><strong>Energy demand of the EVs</strong></td>
<td>2.19 TWh per year</td>
<td>10.95 TWh per year</td>
<td>87.6 TWh per year</td>
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<td><strong>Increasement of Germany’s electrical energy demand</strong></td>
<td>0.4 %</td>
<td>1.8 %</td>
<td>14.2 %</td>
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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

Assumptions:
- 3.7kW max. charging power
- Average daytrip 30km (18.5 miles)
## Demand for Power

Overview of the power peaks of different scenarios

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<td>„Home“</td>
<td>Evening: 480 MW</td>
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<td>„Home and Work“</td>
<td>Evening: 380 MW</td>
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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 occur even at a relatively low number of EVs due to local concentrations
Demand for Power
Secured Power from all powerplants in Germany

- 119.4 GW Total power of all powerplants
  - 22.8 GW not usable power
  - 4.1 GW outages
  - 2.7 GW revisions

- 82.7 GW secured power

- 6 GW residual power

- 76.7 GW annual maximum load

- 76.7 GW annual maximum load

- Worst Case (Scenario home + work):
  - 76.7 GW max. annual load +
  - 15.2 GW Charging load

- 91.9 GW annual load

- No security of supply

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

Source: dena 2005
1. Electric Mobility, What does this mean for the grid?

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3. The requirement for ICT for E-Mobility

4. The German „ICT for E-Mobility“ Projects
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
Risks and Drawbacks of E-Mobility

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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

- 20%

Fuel powered bus  Hybrid bus  Green Move bus

- X%
Predictive Hybrid System at the example of a public transportation bus
Optimization strategy

- Speed-profile
- Height-profile
- Mass-profile

MATLAB & Simulink Model of the Hybrid-bus
Optimization strategy

- Speed-profile
- Height-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 arrays on their barns.

Source: Modellbildung und Simulation von Energiespeichern im Niederspannungsnetz, Dipl.-Ing. Steffen Schinz TU Darmstadt
Requirement for ICT
Volatile structures

A volatile generation structure leaded to the today’s energy supply problem of the shift between renewable energy generation and consumption. What happens if we get a volatile consumption 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 transformer

- Increasing the simultaneous 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
Renewable Energies, Smart grids 45.5 Million Euro
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 members of the consortia

- Started 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
- Authentication- 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 infrastructure (hardware, networks, applications), data management and interfaces, reference architectures
- Chances and constraints of business cases concerning user acceptance, stability of the law and economical efficiency and resulting market potentials
The 7 ICT for E-Mobility Projects
ICT and Electric Mobility for tourism 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 programs, 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 infrastructure 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](http://meregiomobil.forschung.kit.edu)
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 necessary 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
Integration of Electrical vehicles in commercial vehicle fleets

- Fleets of companies with EV, controlled 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](http://www.futurefleet.de)
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](http://www.harzee-mobility.de)
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](http://www.ikt-em.de/de/e-mobility.php)
Intelligent electric mobility in the area of Achen

• Development of business 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, stable 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](http://www.smartwheels.de)
Working groups and crossection work

4 groups:

1) Business 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
    • 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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