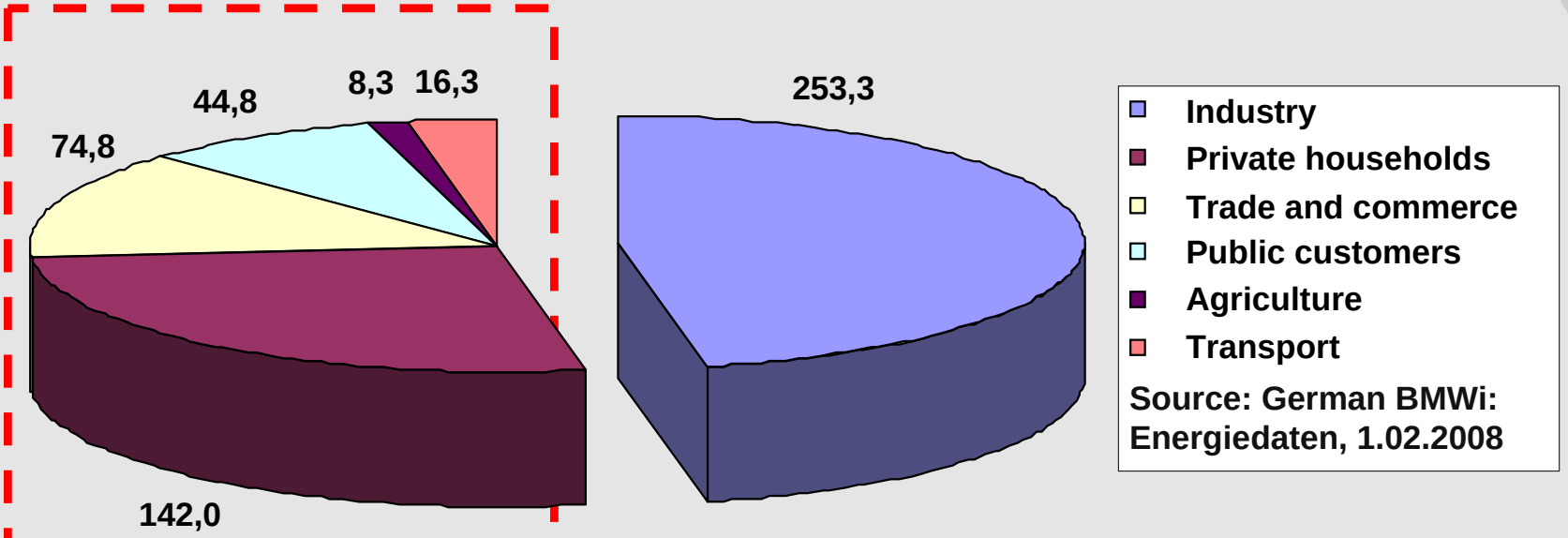
Bidirectional Energy Management Interface BEMI : Technical and Economical Integration of DER by Decentralized Decision

Dr. C. Bendel, D. Nestle, J. Ringelstein

ISET e.V., Königstor 59, D-34119 Kassel, Tel.: 0561 / 7294 234,
dnestle@iset.uni-kassel.de

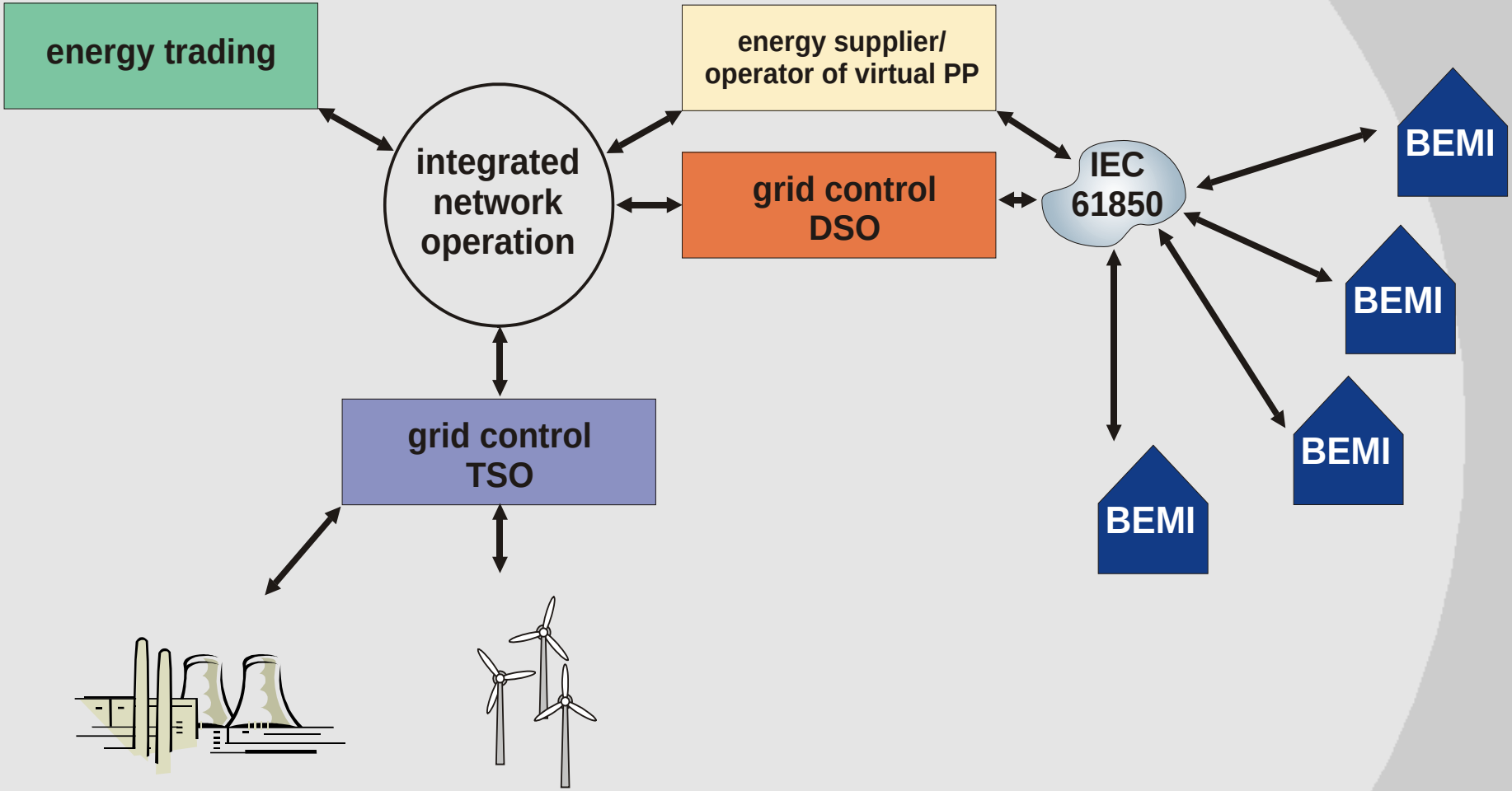
Domestic Energy Consumption in Germany 2006 in TWh (Total: 539,5 TWh)



ca. 50% in the low voltage grid

- 50 % of German electrical energy consumption in the low voltage grid
- Management only by fixed load profiles and ripple control
- Also more and more micro-generators

Structure of liberalized energy market with decentralized control



- Flexibility for each individual customer
- Reliability by statistical averaging on aggregation level

Barriers and Opportunities

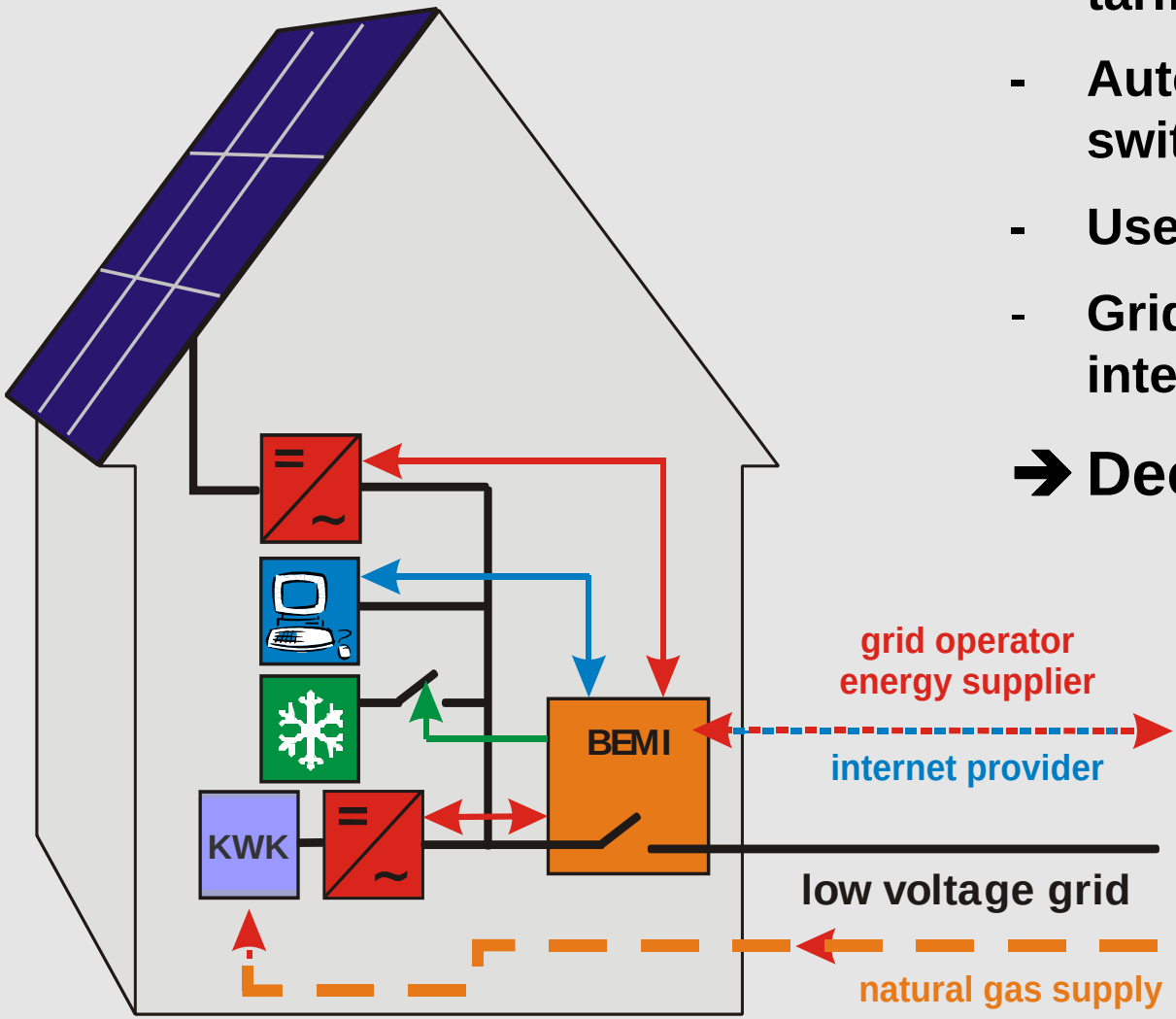
Cost

- ➔ Use of existing communication infrastructure
- ➔ Minimise individual design effort (Plug&Play)
- ➔ Standardisation

„I don’t want anybody to fumble with my household“

- ➔ management that is hardly recognized by customer
- ➔ economical incentives
- ➔ variable tariffs: customer decides, effect on the grid by statistical balancing
- ➔ principle of „decentralised decision“

Bidirectional Energy Management Interface - BEMI



- Central information: variable tariffs
- Automated optimisation and switching of device schedules
- User interaction
- Grid connection point as intelligent interface

➔ **Decentralized decision**

- Observation of grid connection point
- Open standards for communication

Test Site at ISET in DeMoTec with two households (hardware simulation)

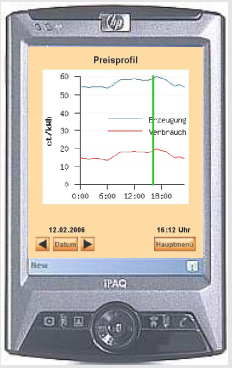
Test Site at ISET in DeMoTec

Micro co-generation with heat storage

Communication BEMI

Device Switch Box

WLAN



PDA (User Display)

WLAN

Price Profile

Web-Services

Metering data

Measurement data

WLAN-Router

Ethernet

Profile meter

Ethernet

BEMI Core (embedded Linux System)

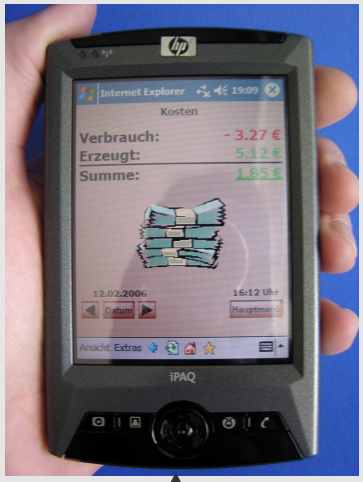
Server providing Web-Interface

RS-232

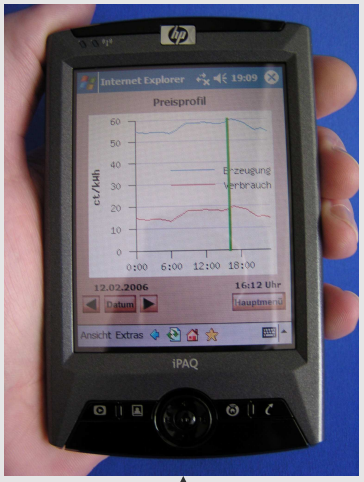
Grid measurement / surveillance

Human Machine Interface
PDA – Personal Digital Assistant)

Cost

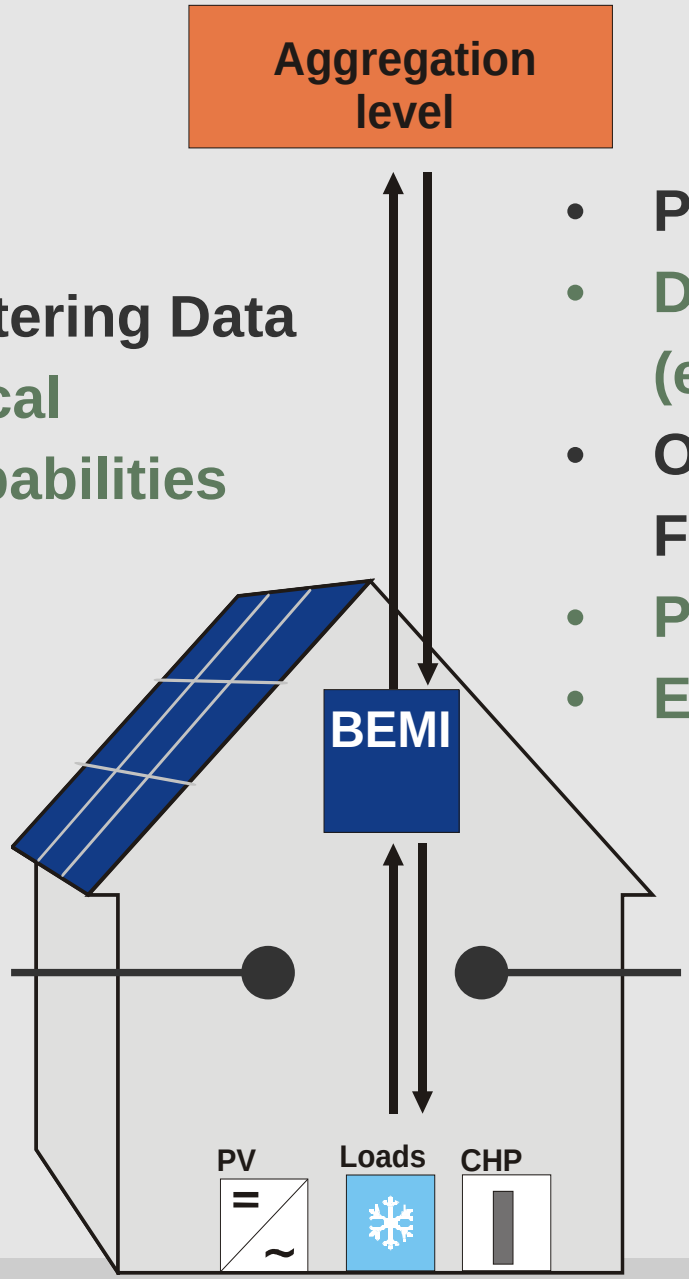


Price profile (variable tariff)



Device schedules

Communication Requirements for Decentralised Decision



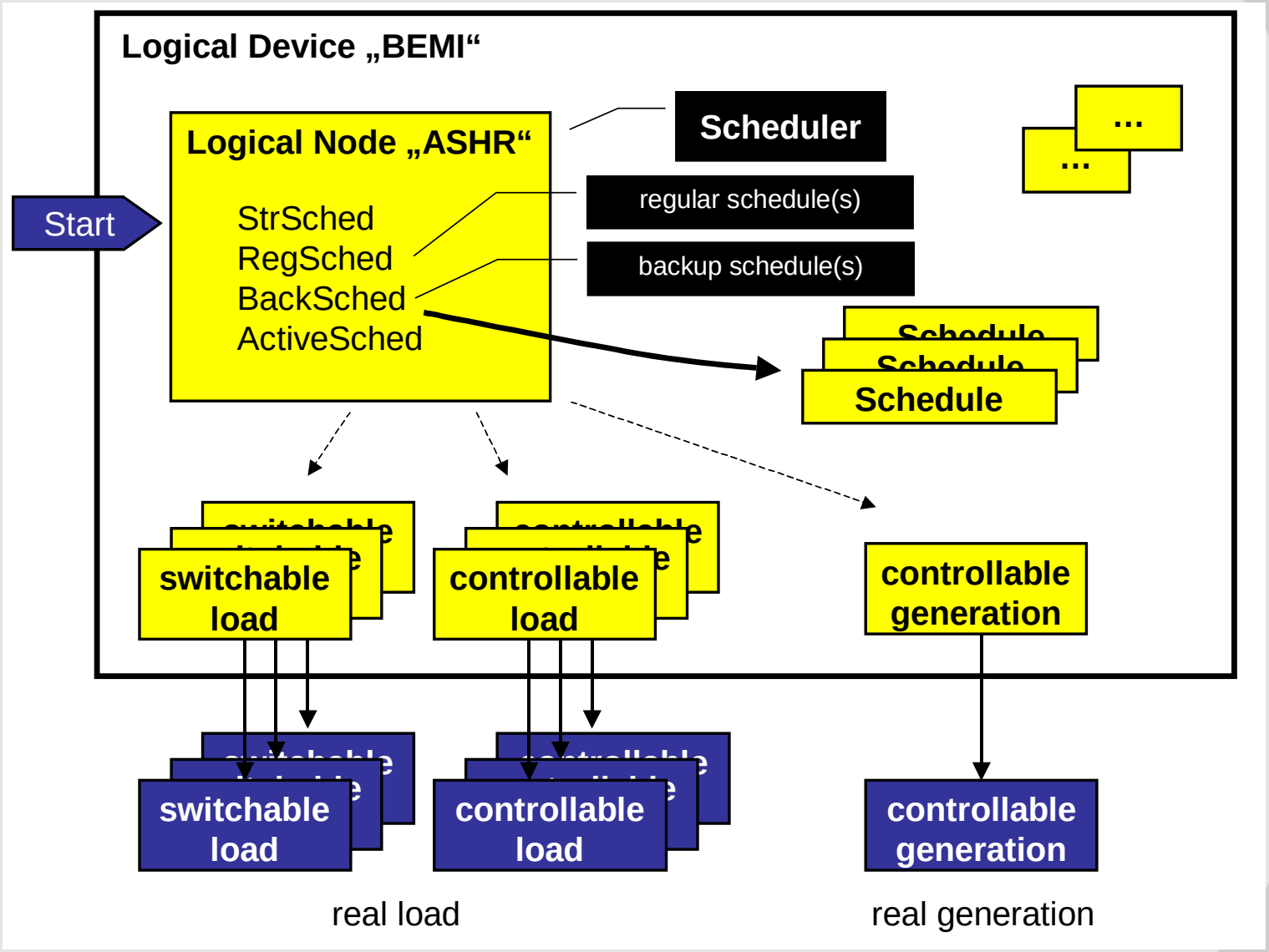
- Metering Data
- Local capabilities

- Price Profiles
- Demand profiles (e.g. reactive power)
- Outdoor Temperature Forecast
- Profile Updates
- Emergency Signals

- Management-related device parameters
- Measurement values
- Device Status

- Switch and control commands

Communication Data Models for Decentralised Decision

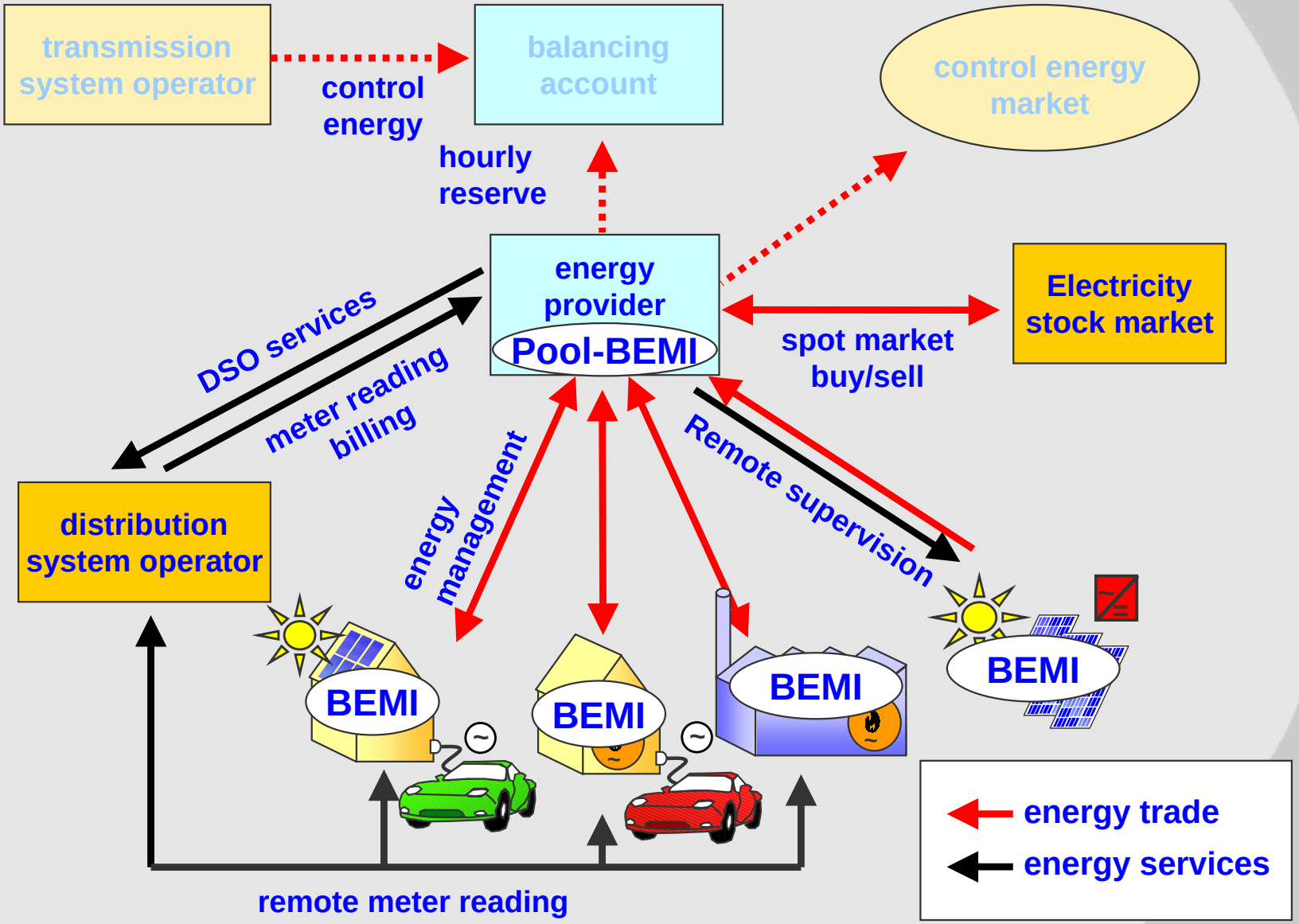


Devices for energy management in private households

- Cooling-/freezing devices
  Electrical heating systems
  Electrical water heating
  Air conditioning
  Cogeneration systems
  Washing machines
  Dish washers

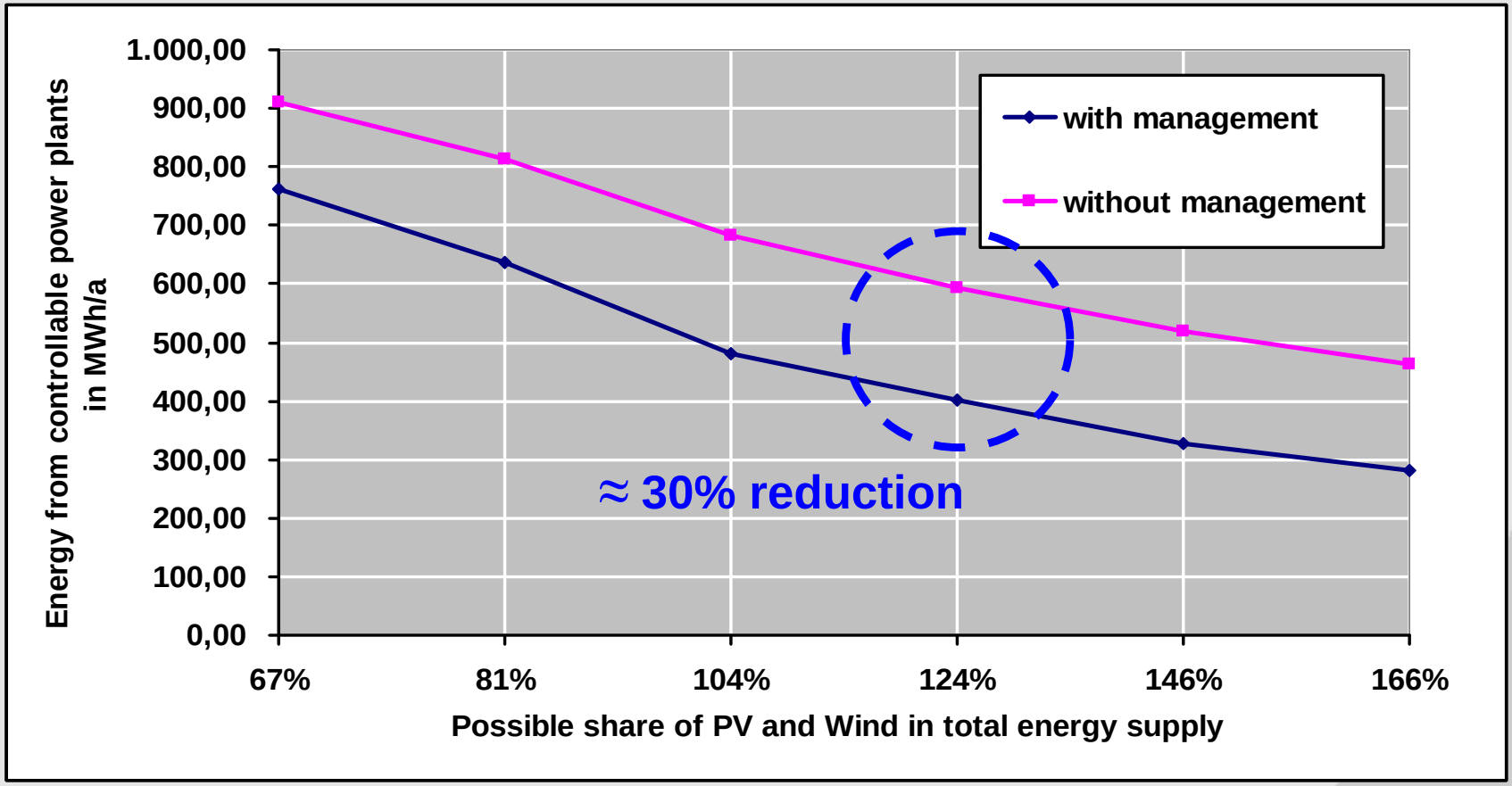
- in the future: UPS
  plug-in cars
  PV-systems with battery storage

BEMI in the liberalized energy market



BEMI for integration of fluctuating generation from PV and wind power

- Goal: Reduction of energy production from controllable power plants
  ➔ Using power from PV and wind as efficiently as possible
- Simulation of 6400 BEMIs with refridgerators and washing machines



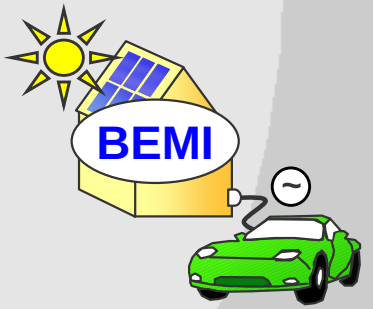
Possible applications and distribution grid services

More critical operation states →

<table>
<tr><th>Normal Operation</th><th colspan="2">Compromised Operation</th><th colspan="2">Disturbed Operation</th></tr>
<tr><td colspan="2">Load profile influencing</td><td colspan="2"></td><td></td></tr>
<tr><td colspan="2">Peak load reduction</td><td colspan="2"></td><td></td></tr>
<tr><td colspan="2">Balancing energy provision</td><td colspan="2"></td><td></td></tr>
<tr><td colspan="3">Automatic grid state supervision,
Supervision of customer power supply</td><td colspan="2">Fault detection</td></tr>
<tr><td colspan="3">Grid bottleneck supervision and avoidance</td><td colspan="2">Secure DER shutdown for grid maintainance</td></tr>
<tr><td rowspan="2"></td><td colspan="2" rowspan="2"></td><td>Blackout notification for DSO</td><td>Island operation mode</td></tr>
<tr><td>Grid recon-struction</td><td></td></tr>
<tr><td colspan="4">Local voltage control and power quality optimization</td><td></td></tr>
<tr><td></td><td colspan="4">Customer notification of system state</td></tr>
</table>

BEMI contains „Smart Metering“-Functions:

- Remote Meter Reading,
  ¼ h acquisition of load- and generation profiles
- Applications:
  - Feedback for forecast of customer reaction
  - Short-term customer information on consumption
  - Power limits for customers with outstanding payment possible



Integration of „Plug-in Hybrids“

- Large number of battery storage devices with low capacity
- Management by BEMI is ideal strategy
- Applications
  - Charging of plug-in cars using renewable sources
  - Additional potential of peak load reduction /balancing power

Summary

- Enormous potential for generation and load shifting in the low voltage grid
- Management based on variable tariffs and transmission of day-ahead price signal by web services demonstrated
- Optimal power generation with DER needs coordinated action
  - ➔ standards for interfaces, protocols and services
  - ➔ clearly defined contractual and technical interfaces

➔ Decentralized decision based on central and local information