Smart Grids Europe
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Integration of DER into Distribution Grid Operation and Decentralized Energy Management

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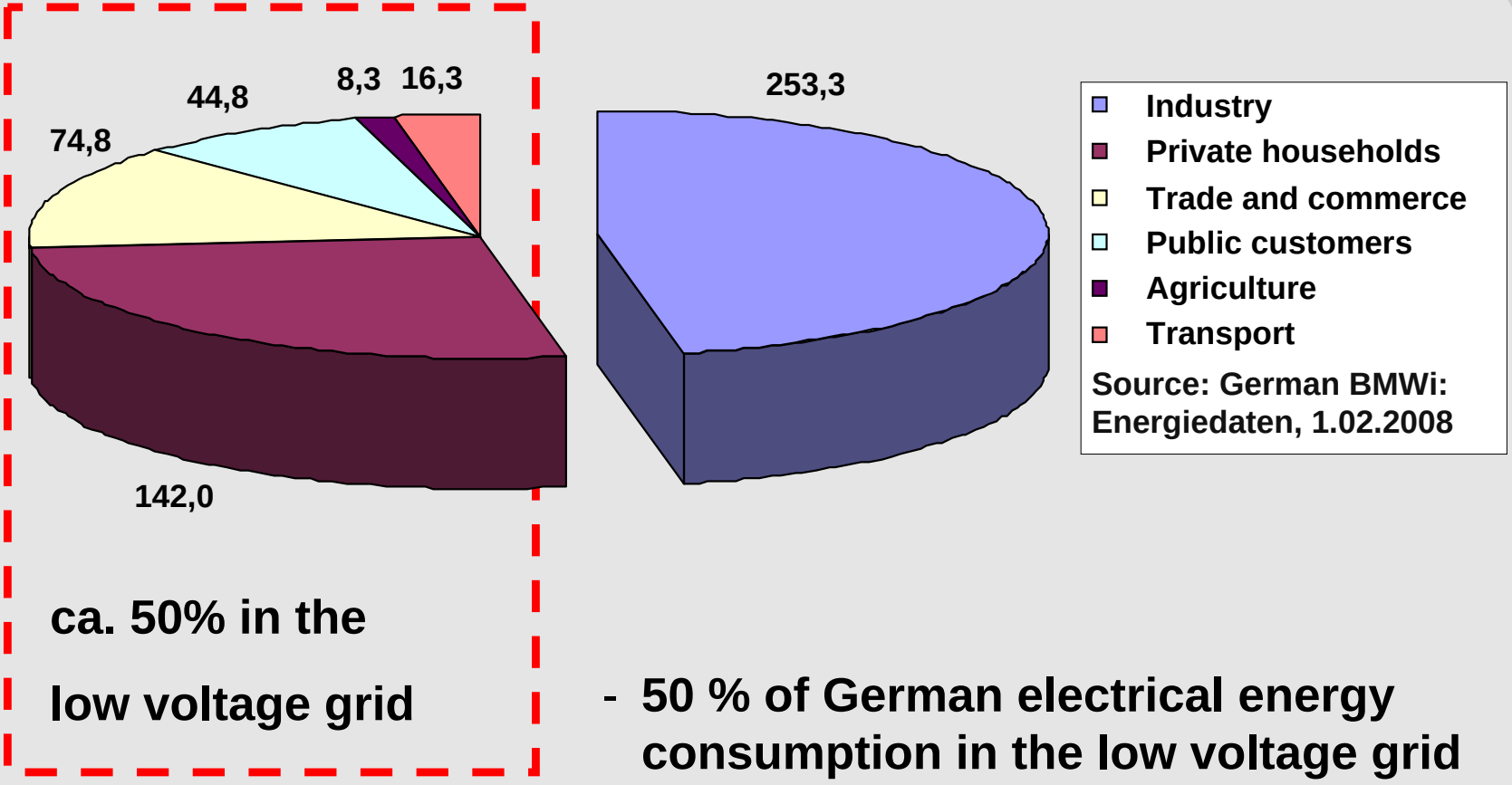
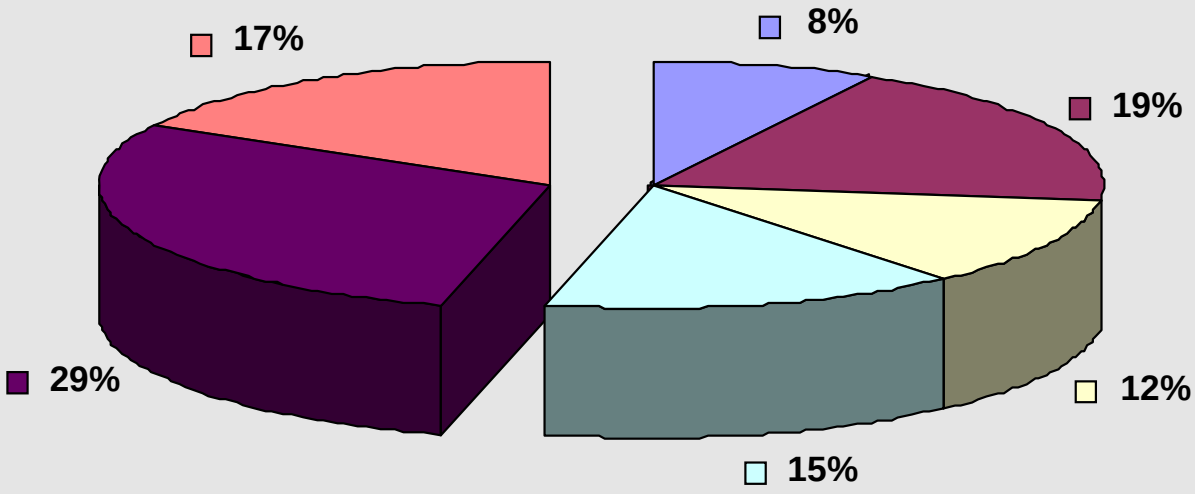
Domestic Energy Consumption in Germany 2006 in TWh (Total: 539,5 TWh)



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**

Potential for load management in german households



- Lighting Appliances
- Cooking, Cloth drying
- Entertainment & Telecommunication
- Room heating
- Coolers & Freezers
- Washing mach., dish cleaners, Warm water

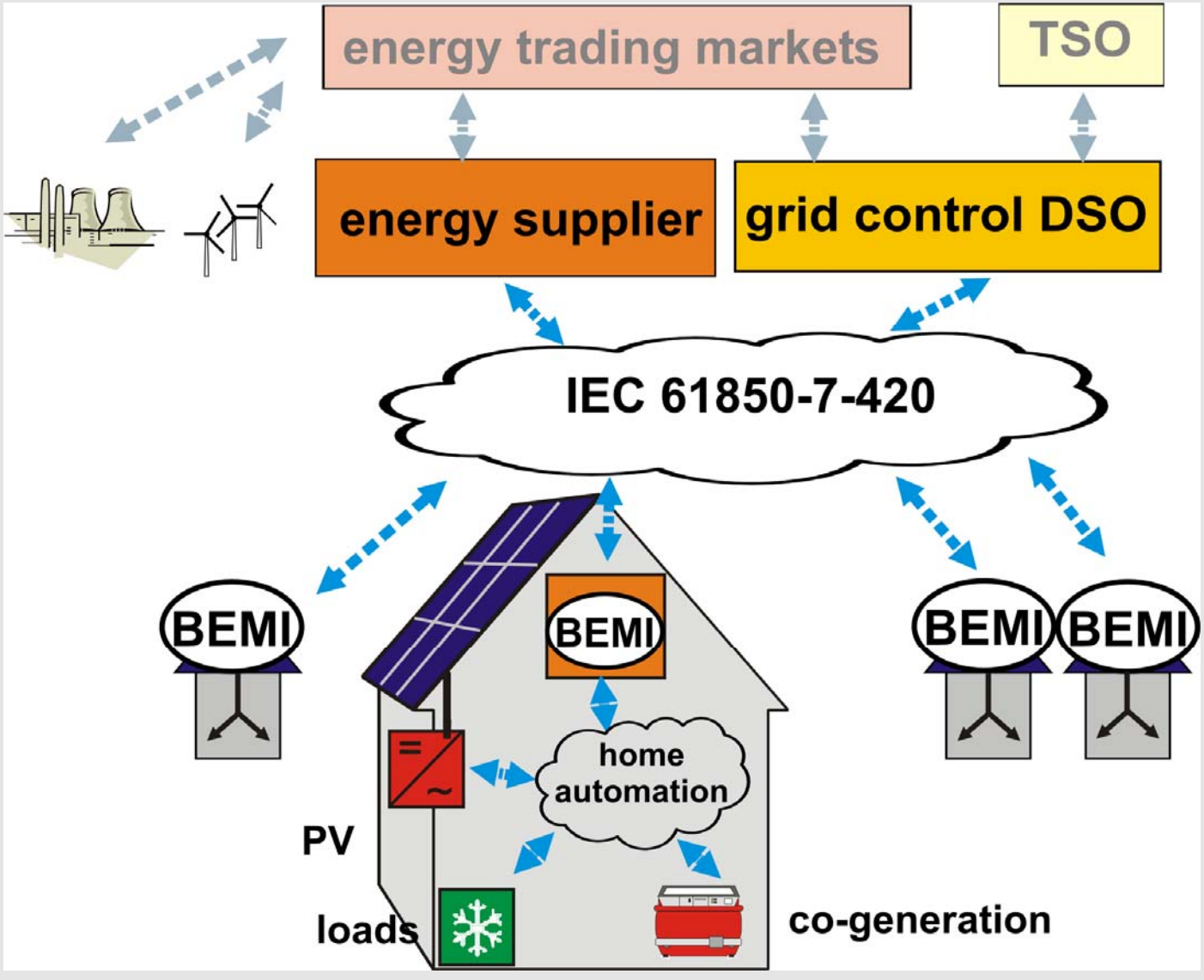
Source: diagram according to BDEW press release on household electricity consumption, 17.01.08

- 40-50% of electricity consumption caused by shiftable loads
- Future: heat pumps, plug in hybrids, electric vehicles, …
- Restrictions for load management:
  - Washing machine: User constraint for deadline, …

Management of micro-generators and demand side is key element in future smart low-voltage grids !

Micro co-generation with heat storage

Structure of liberalized energy market with decentralized control



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

Barriers and Opportunities

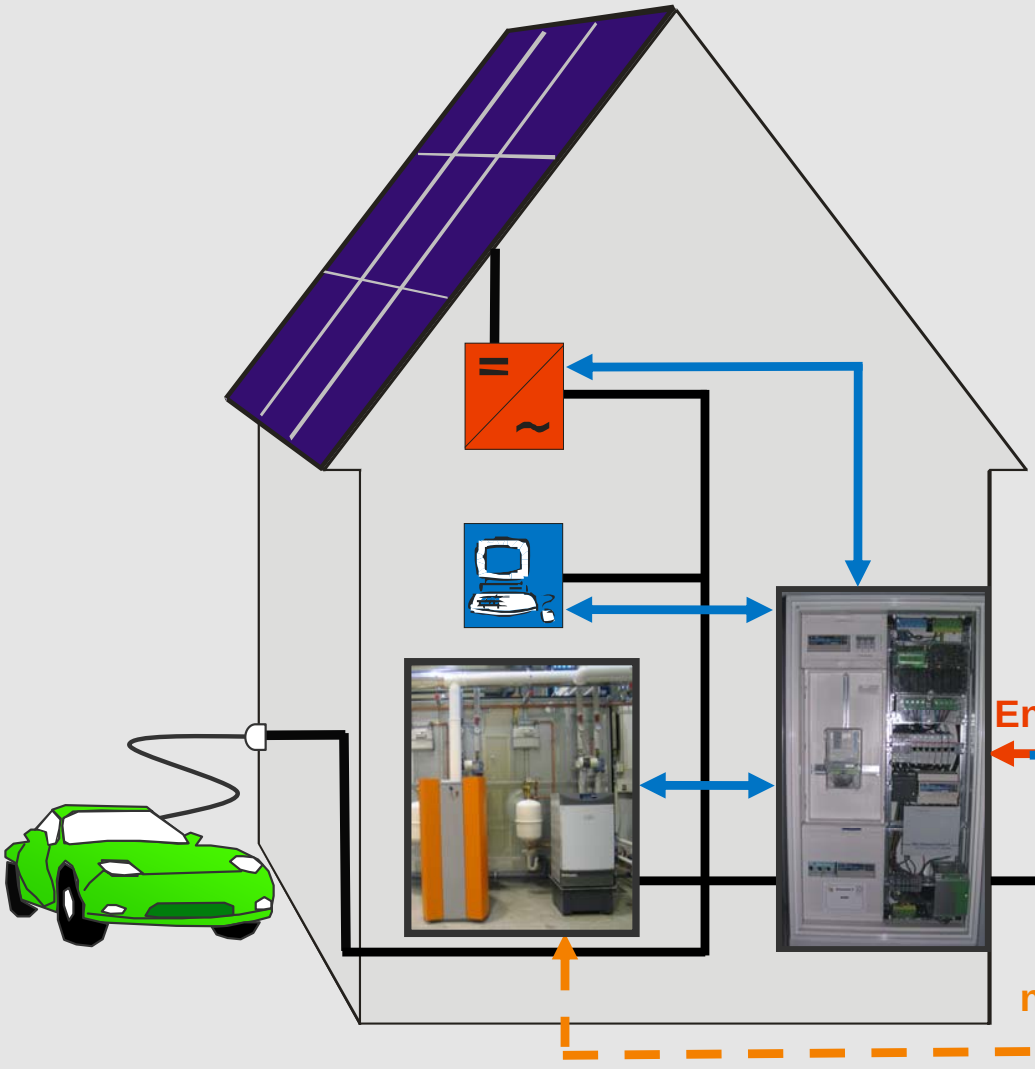
Cost

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

„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

Grid connection point today

Cloth Dryer

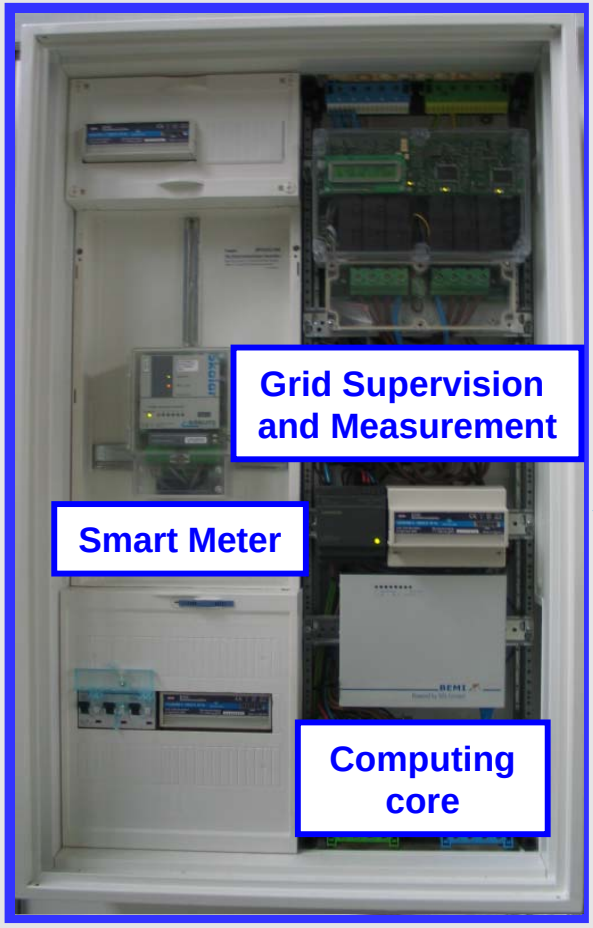
Freezer

CHP

Inverter

Energy flow

Grid connection point equipped with BEMI



Pool-BEMI

Tariffs

Metering data
Measurement data

Cloth Dryer

Freezer
Temperature supervision

PDA

WLAN-Router

Switching box

CHP
Temperature supervision

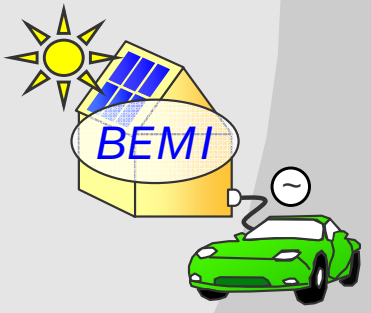
Inverter, controllable

Energy flow

Standardized communication

BEMI is more than Smart Metering:

- **load- and generation profiles for billing**
- **Applications:**
  - **Feedback for forecast of customer reaction**
  - **Short-term customer information on consumption**



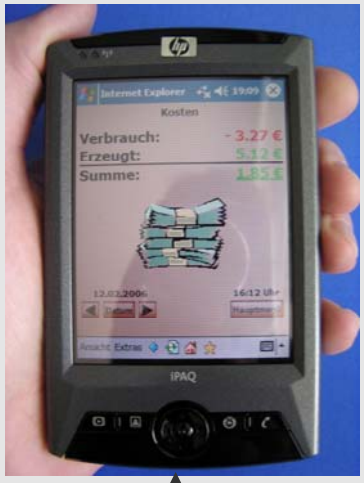
Integration of „Plug-in Hybrids“

- **Large number of battery storage devices**
- **Management by BEMI is ideal strategy**
- **Applications**
  - **Charging of plug-in cars using renewable sources**
  - **Potential for peak load reduction /balancing power**

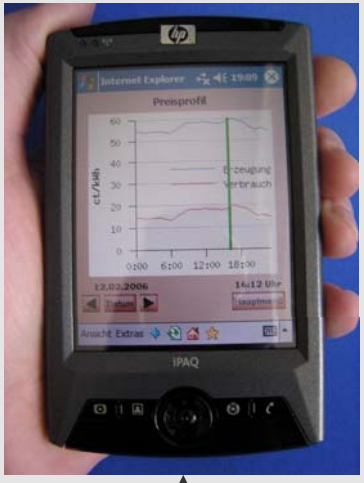
Test Site at ISET in DeMoTec with two households (hardware simulation)

Human Machine Interface
PDA – Personal Digital Assistant)

Cost

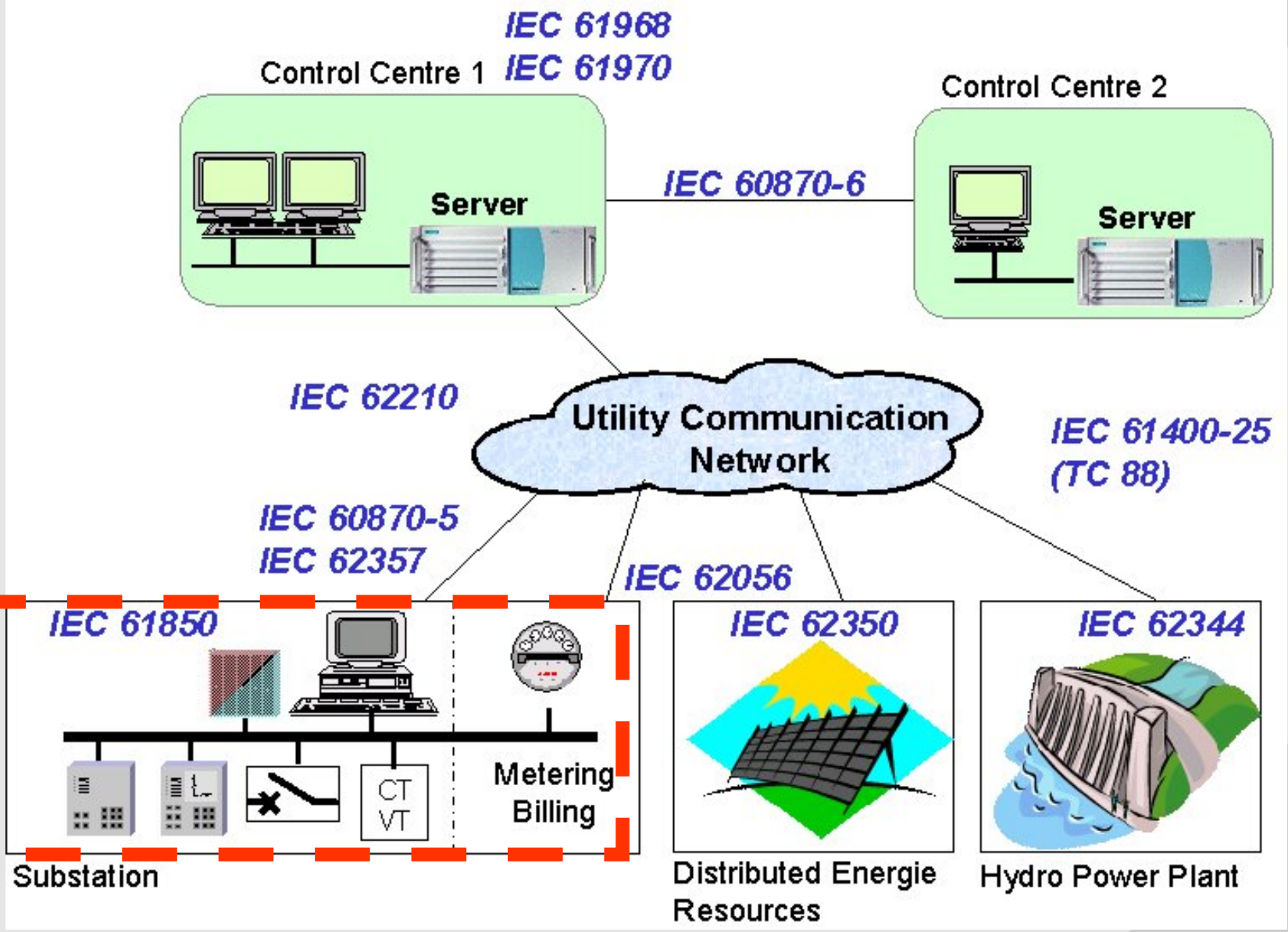


Price profile (variable tariff)



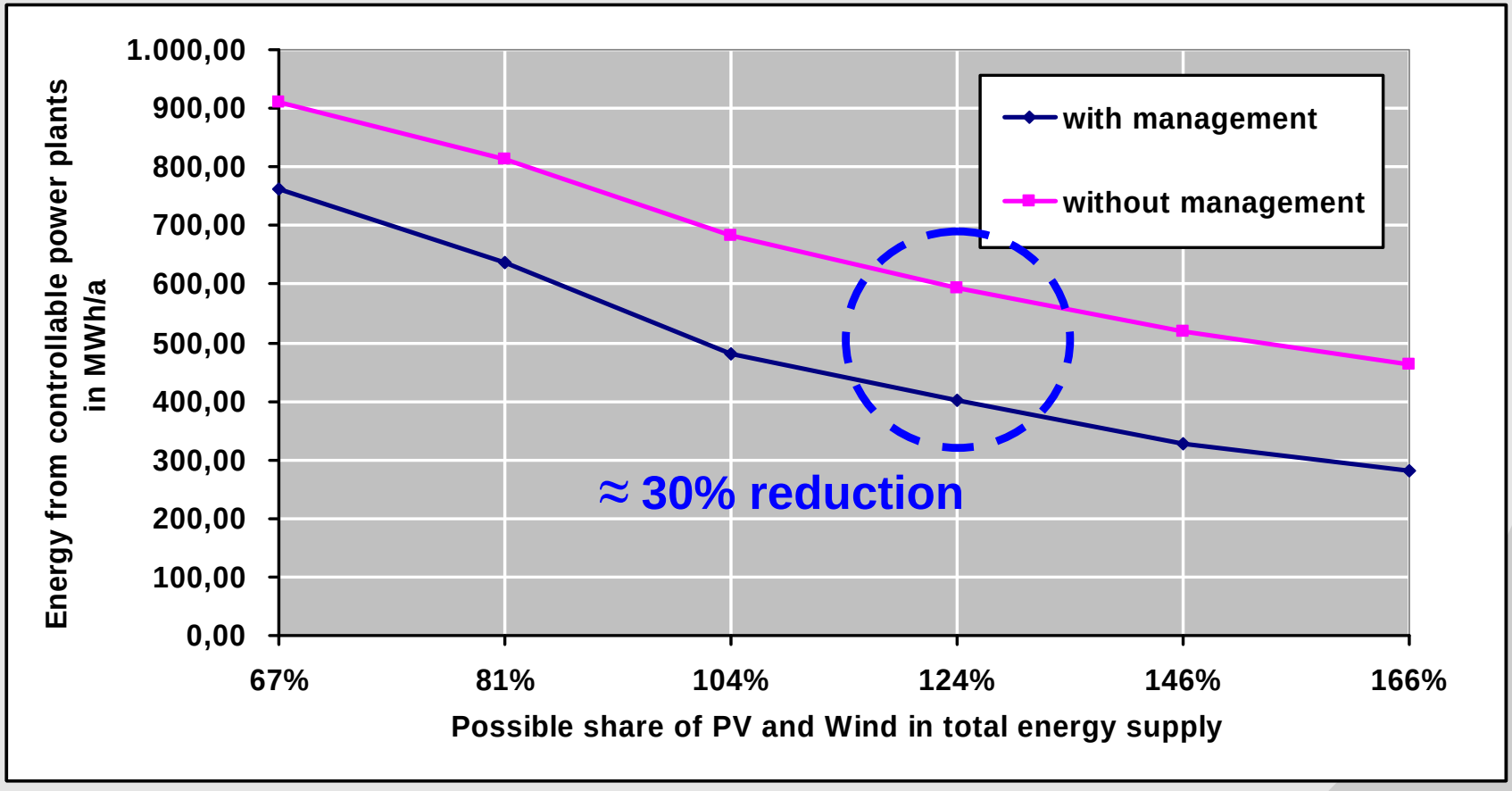
Device schedules

IEC 61850-7-420 im Utility Communication Network © SCC

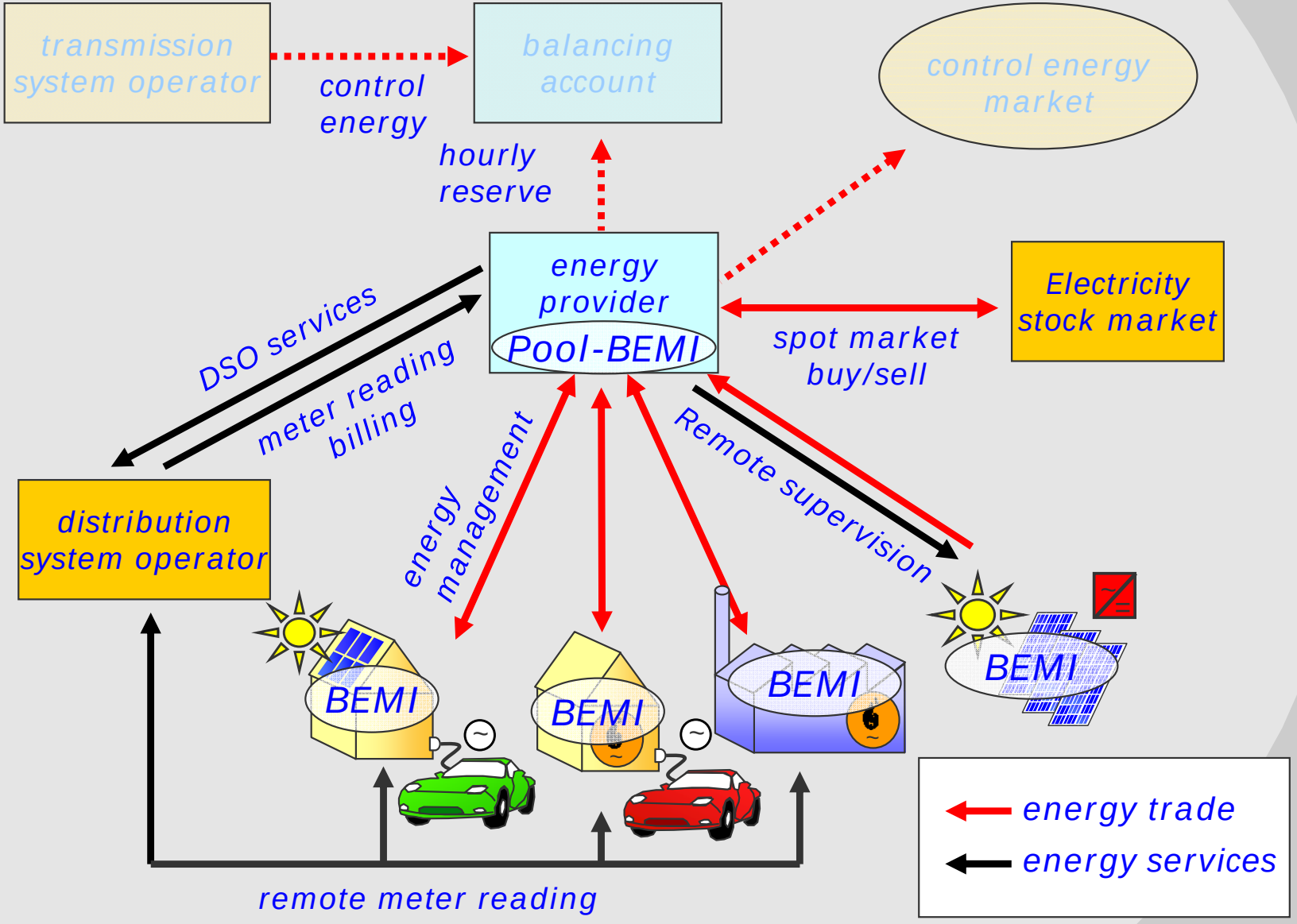


BEMI for integration of fluctuating generation from PV and wind power

- 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



BEMI in the liberalized energy market



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 colspan="5">Customer notification of system state</td></tr>
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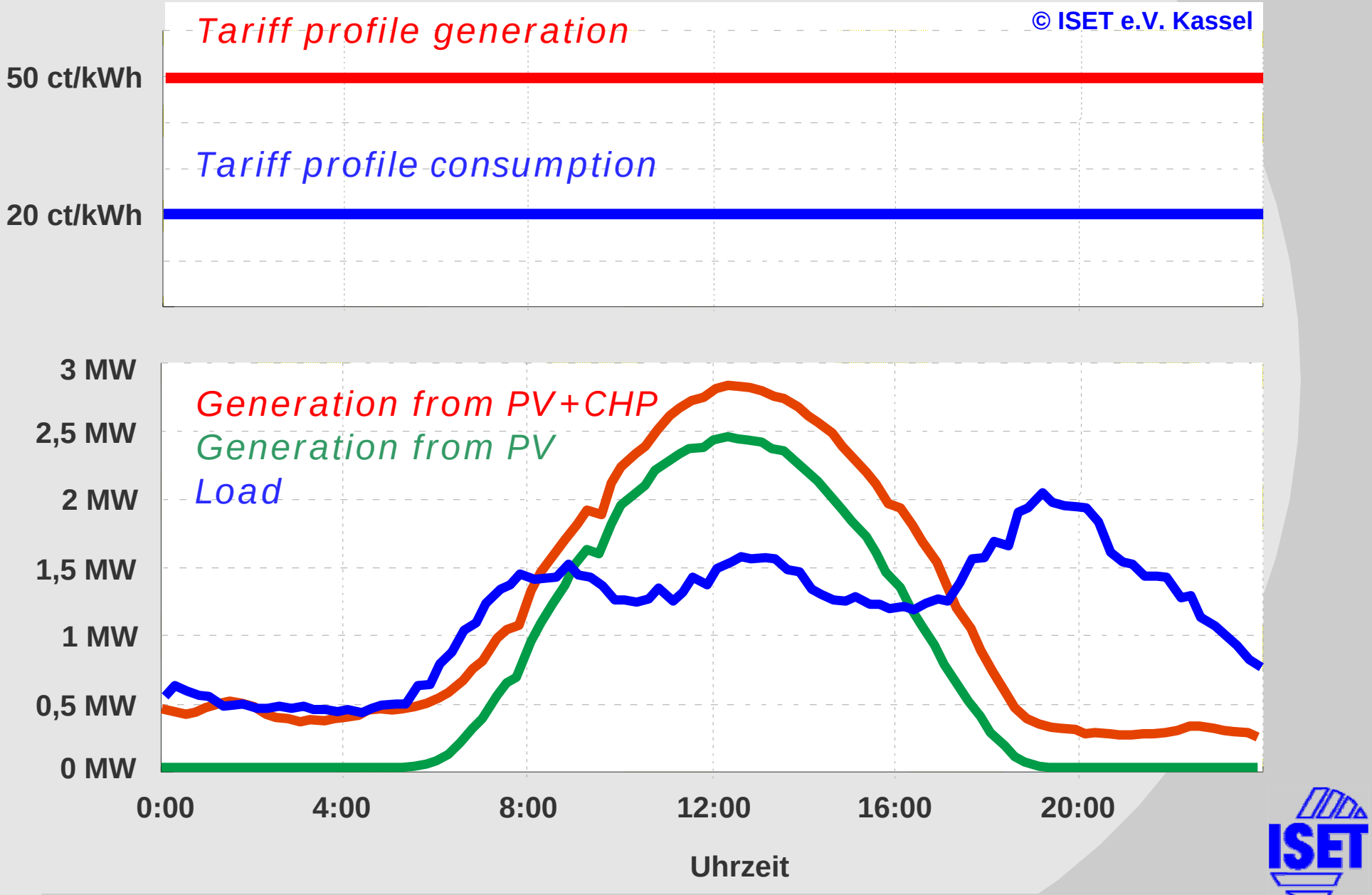
Simulation of 2500 households with BEMI, Photovoltaic (PV) and CHP generators



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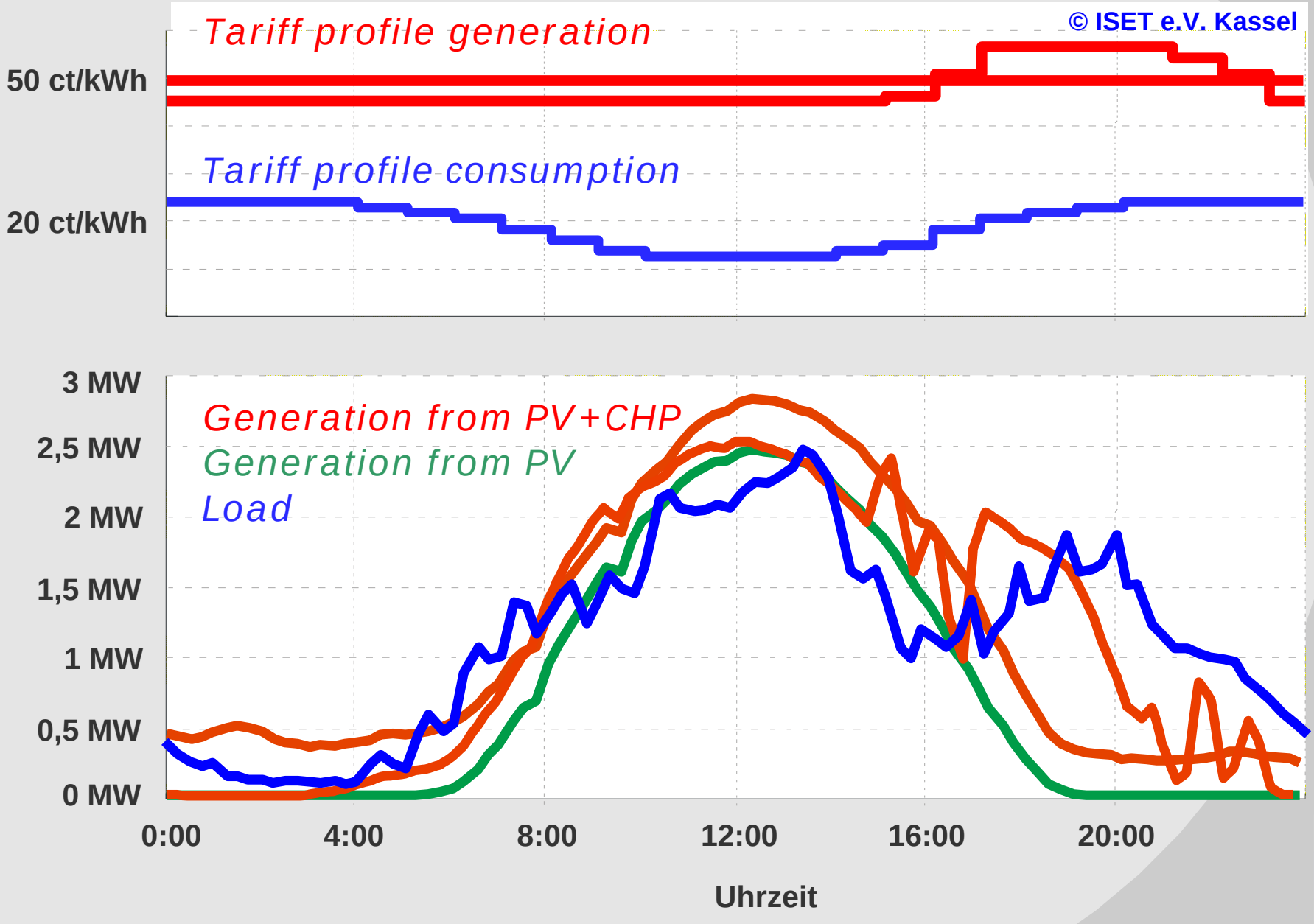


Outlook: Home automation

- So far home automation exists mostly in industial buildings with facility management using bus systems like EIB/KNX, LON, now also Ethernet
- IP-based solutions for computer-/telephone-networks with increasing dissemination
- New IT-technologies will create low-cost solutions in near future
  - ➔ costumer friendly configuration as comfortable as communication networks
  - ➔ not primary for critical applications like lighting with many nodes

Outlook: Home automation

- A lot of innovative radio-based products are in the pipe-line (e.g. Z-Wave, ZigBee, Bluetooth, MbusRF)

  Goal: Consumer area and Smart Metering
- Area private households / small industries
- Radio standards with auto-Routing
- Smart Metering : also PLC technologies in mind (e.g. Digitalstrom-Technology)

➔ **Goal: low-priced mass market**

Outlook: BEMI-Platform

The hardware and software components could also be used for many other applications in energy management and energy efficiency

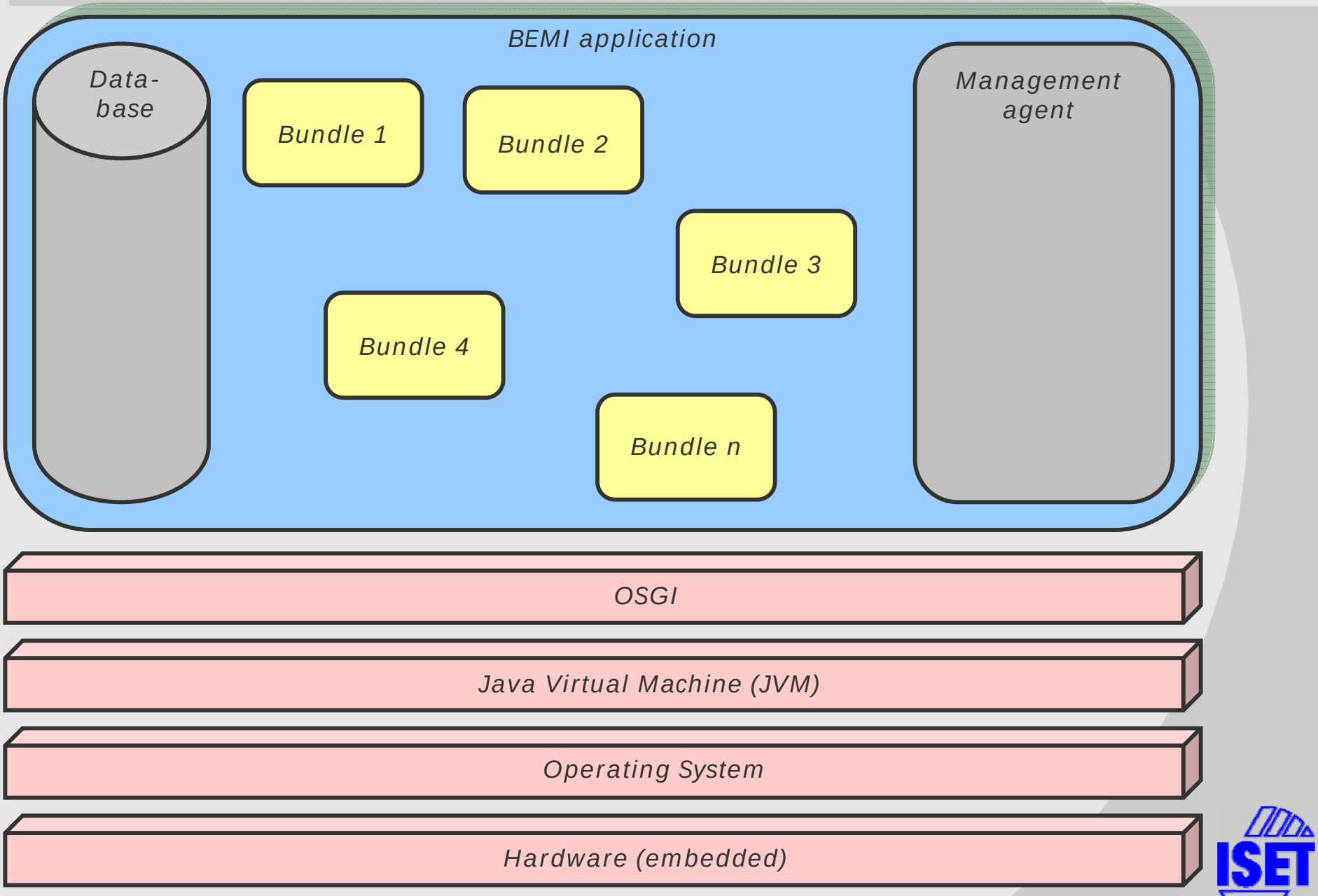
- ➔ **Sub-functionalities should be available as Services also to other applications**
- ➔ **Several applications from different manufacturers should be able to run on a single BEMI-computer**

➔ **standardized and extensible interfaces of the components**

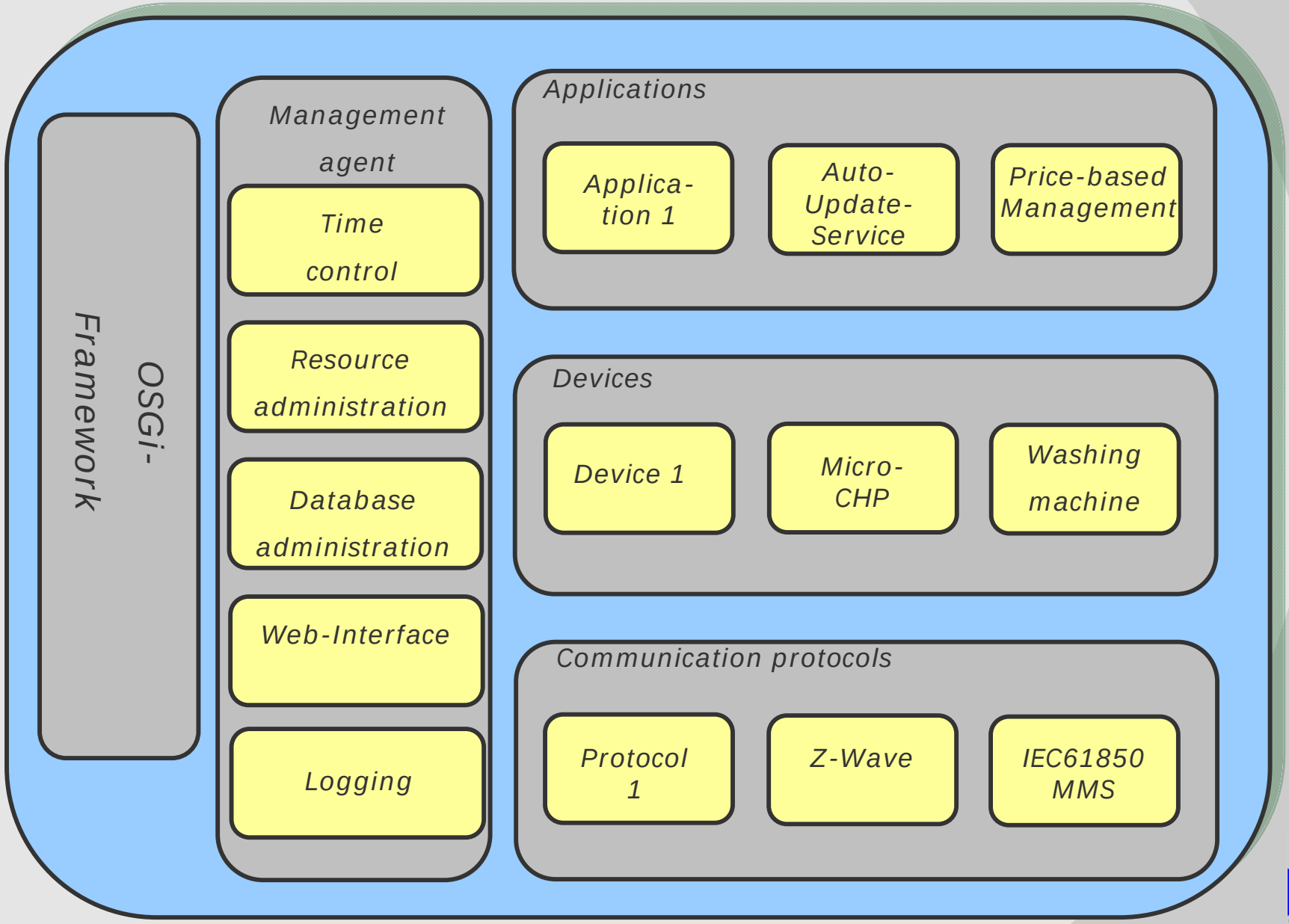
Outlook: BEMI-Platform

- Applications are installed on top of a framework offering the various sub-functionalities
- The framework offers hardware-independent access to Services.
  Applications should be hardware-independent when delivered to customer
- Within the framework all hardware resources as well as other data that is generated outside BEMI (e.g. price of electricity) are represented by standardized data objects

Framework OSGi

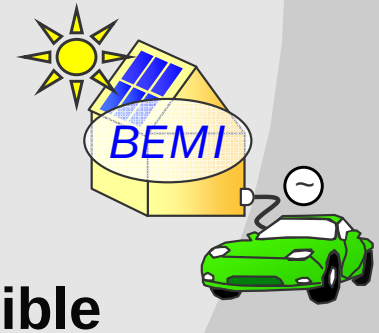


BEMI application



Conclusion and outlook

- Decentral decision for strategy of energy management
- Automatic Optimization of device schedules and device switching
- Open communication standards with true interoperability
- User display with user interaction
- Network/grid monitoring
- Management of loads and generation
- Involving Plug-in Hybrids and e-mobility
- Parallel operation with „virtual power plant“ possible
- Further development: Projects Modellstadt Mannheim, RegMod Harz, SmartHouse/SmartGrid



Thank you for your attention !

.. Any questions ?

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