How To Adapt Prosumer Systems With PV Batteries To The Need Of The Distribution Grids

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Energy Storage World Forum

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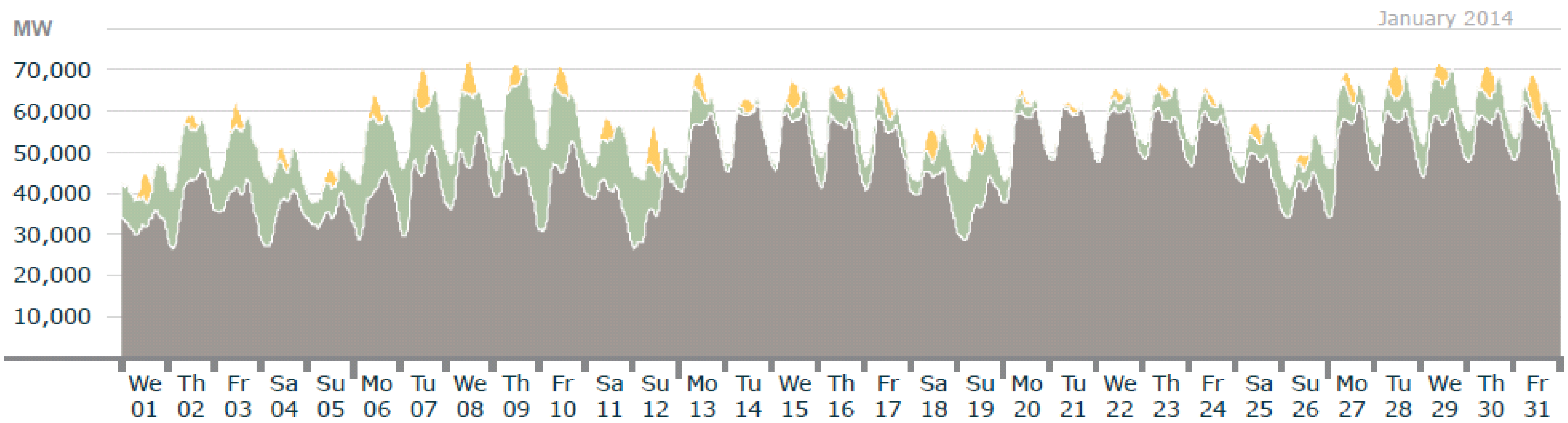
Agenda

- Motivation
- Chances and obstacles of self consumption of PV battery systems
  - Energy management
  - Energy flux analysis
  - Cost analysis
- Additional business cases
- Approaches for optimized operation of residential PV battery systems in distribution grids
  - Case 1: Allocation of capacity for grid services
  - Case 2: Bidding of primary control power
  - Case 3: Grid integration via "FlexController"
- Conclusions

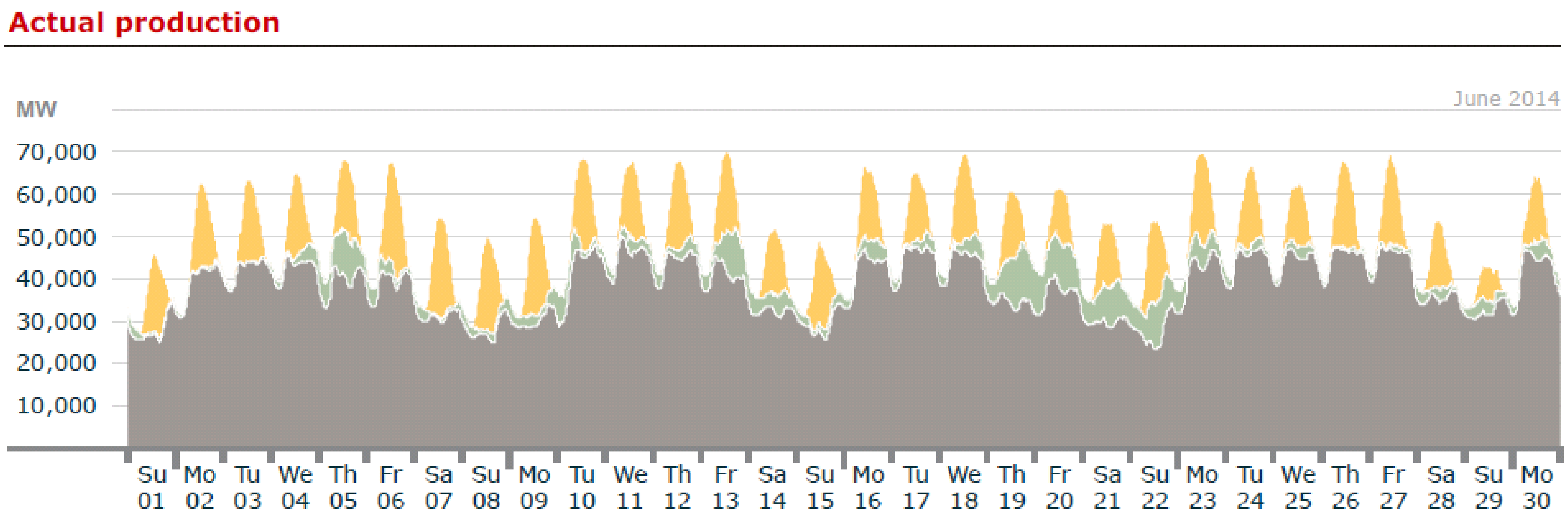
Motivation
Power production: January 2014



	max. power	date max. power	monthly energy
Solar	10.1 GW	07.01., 12:30 (+1:00)	0.75 TWh
Wind	25.0 GW	09.01., 18:30 (+1:00)	6.2 TWh
Conventional > 100 MW	62.2 GW	31.01., 08:00 (+1:00)	34.7 TWh

Graph: Bruno Burger, Fraunhofer ISE; Data: EEX Transparency Platform /

Motivation
Power production: June 2014

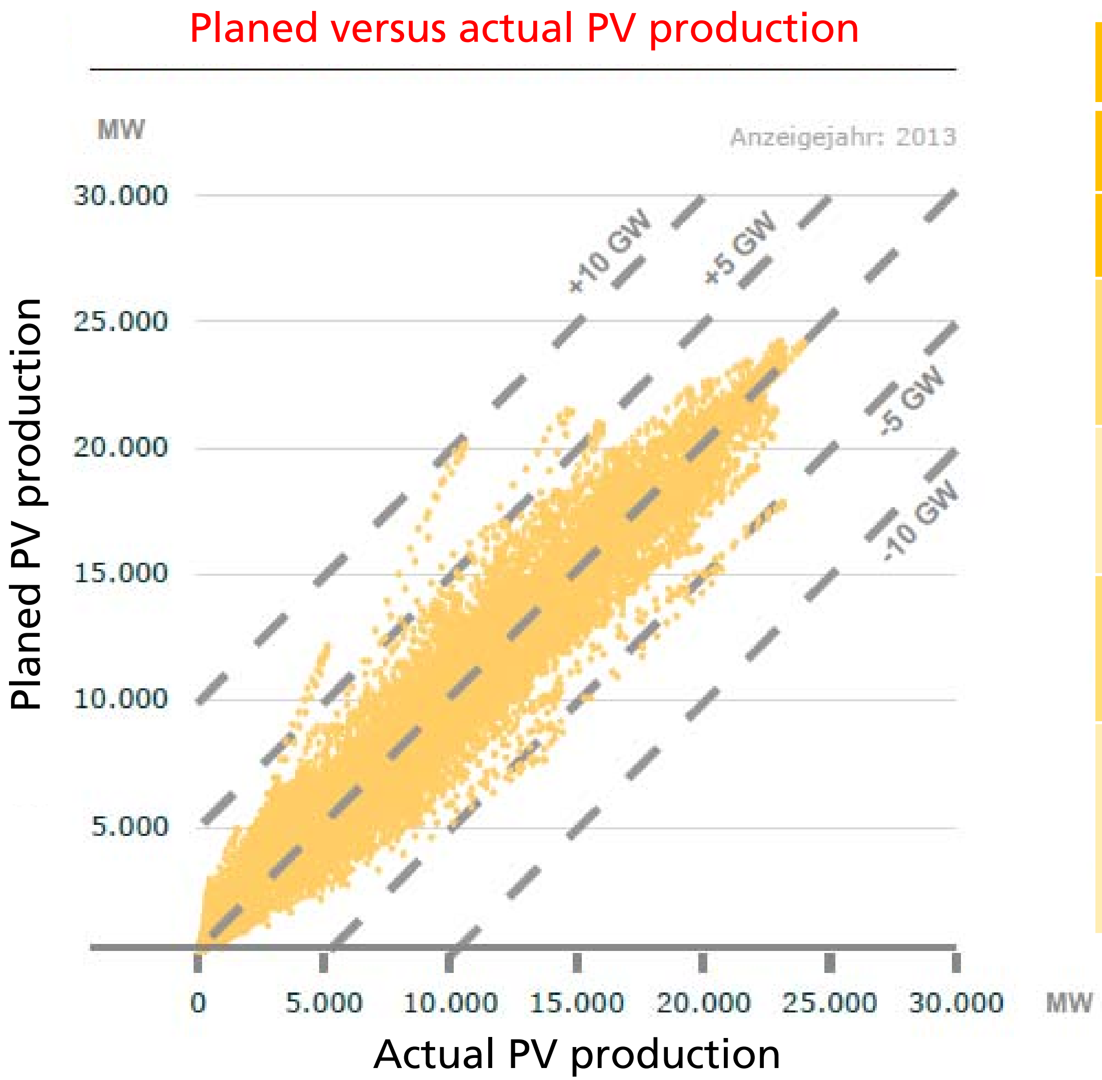


	max. power	date max. power	monthly energy
Solar	24.24 GW	06.06., 13:00 (+2:00)	4.84 TWh
Wind	13.7 GW	19.06., 18:45 (+2:00)	2.47 TWh
Conventional > 100 MW	50.3 GW	11.06., 08:00 (+2:00)	27.4 TWh

Graph: Bruno Burger, Fraunhofer ISE; Data: EEX Transparency Platform /

Motivation

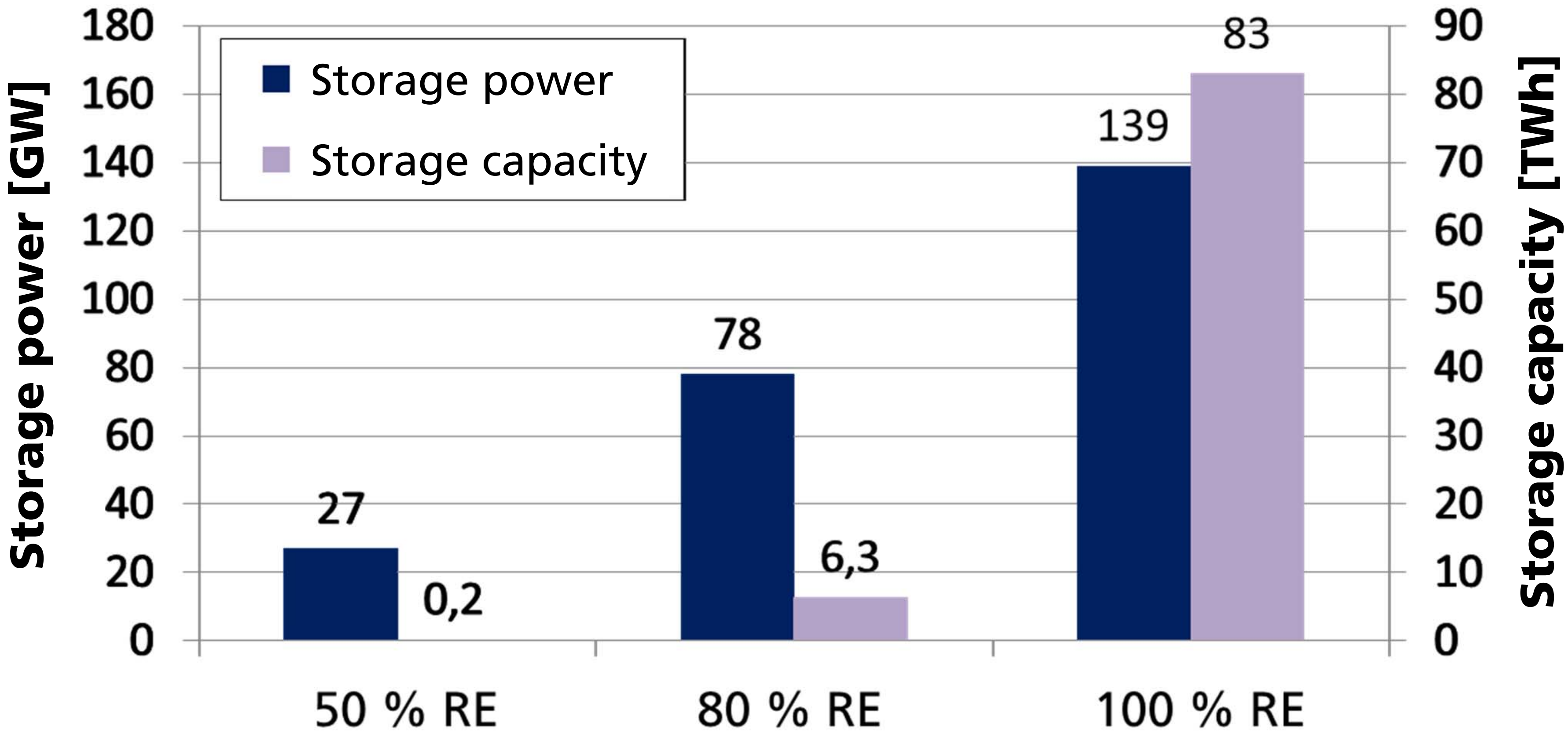
PV power production: Planed versus actual



Date	03.03.	03.04.
Time	13:15	12:30
GMT	+1:00	+1:00
Planed production	7.5 GW	19.7 GW
Actual production	13.7 GW	10.1 GW
Forecast error	-6.1 GW	+9.6 GW
Relative forecast error	-44.7 %	+94.8 %

Source: B. Burger, Fraunhofer ISE; Data: EEX Transparency Platform

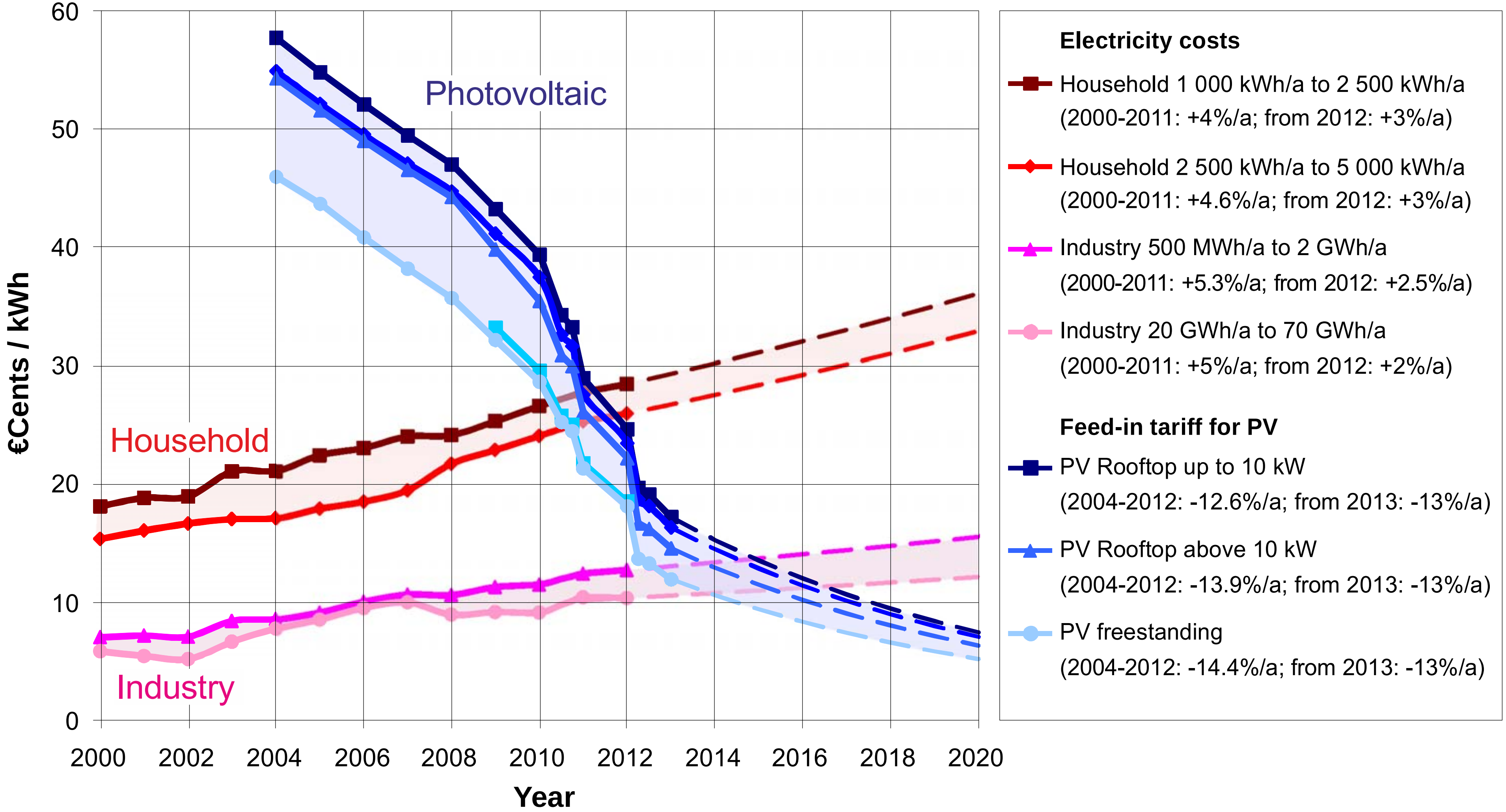
Motivation
Storage demand in Germany



Source: N. Hartmann, University of Stuttgart, Dissertation, 2013

Motivation

Electricity cost and feed-in tariffs in Germany

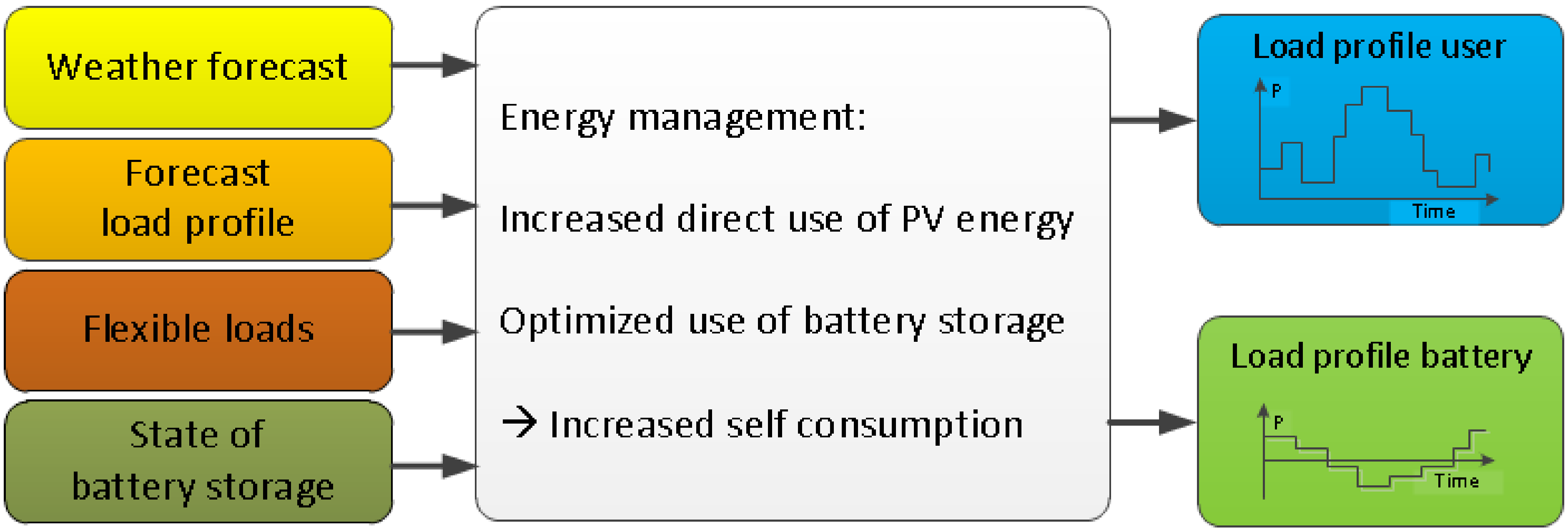


Source: B. Burger, “Energiekonzept 2050”, June 2010, FVEE, www.fvee.de, Update of 14.11.2012

Optimization of PV self consumption
Local energy management

- Increased direct use of PV energy
- Optimized use of battery storage

Reduction of volume of purchased grid electricity

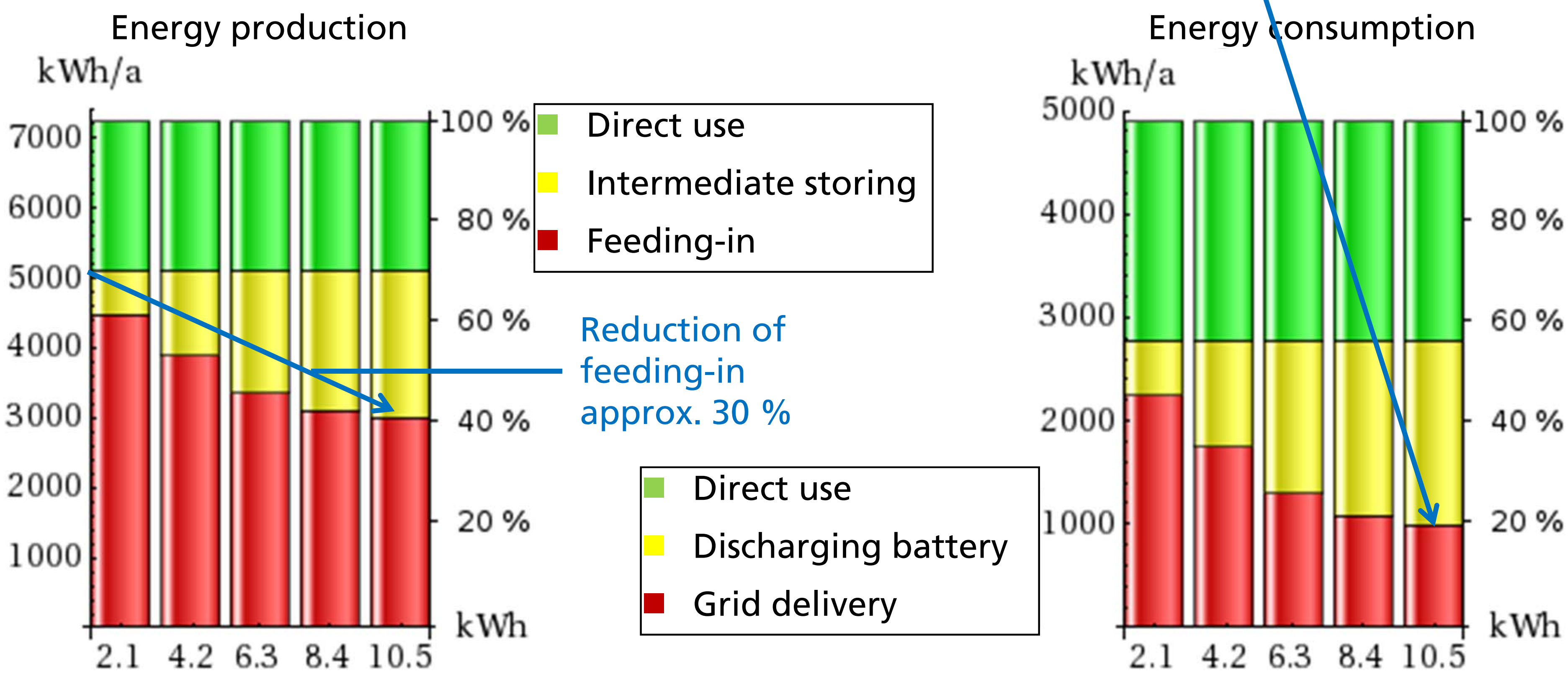


Optimization of PV self consumption

Analysis of energy fluxes (results of system simulation)

- Load (residential application): 4900 kWh/year
- PV generator size: 6 kWp
- Lithium-ion battery system: Variation of usable capacity

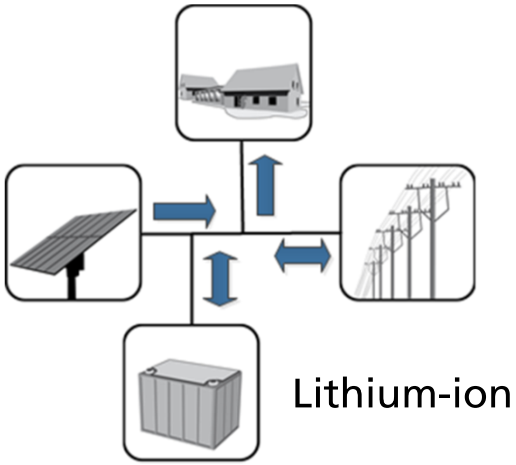
Only ~ 20 % have to be purchased from the grid

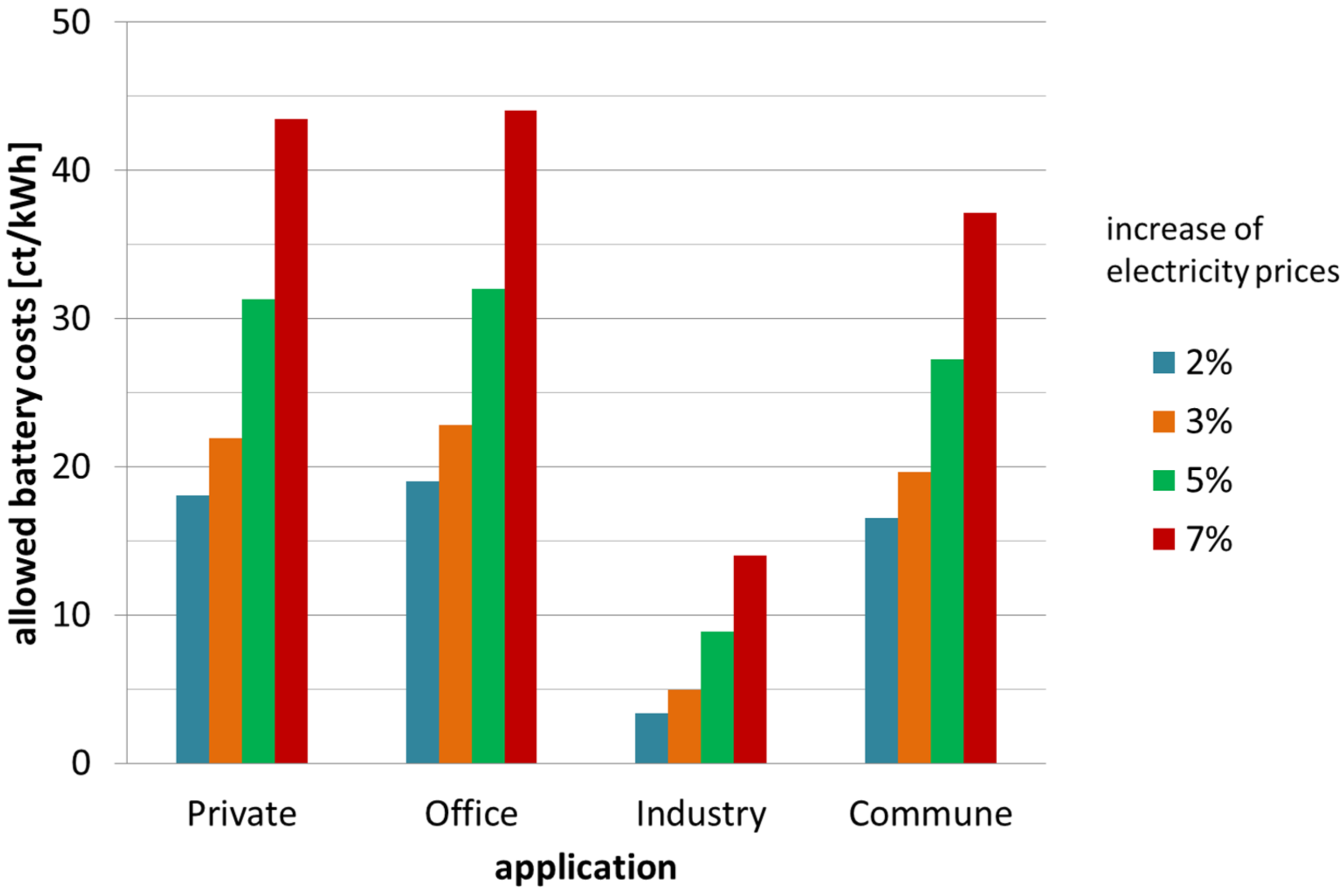


Optimization of PV self consumption
Cost analysis

Allowed cost for 4 self consumption applications

- Private / residential
- Office
- Industry
- Municipality





Optimization of PV self consumption

Cost analysis

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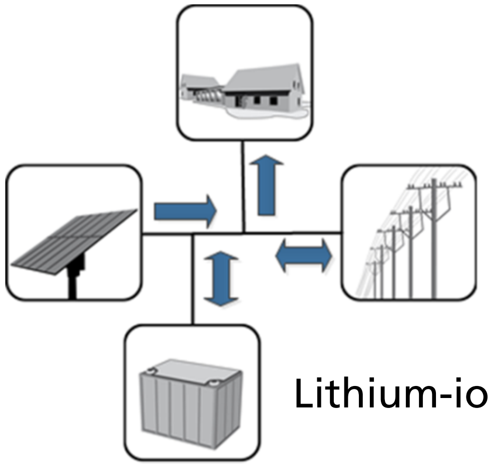
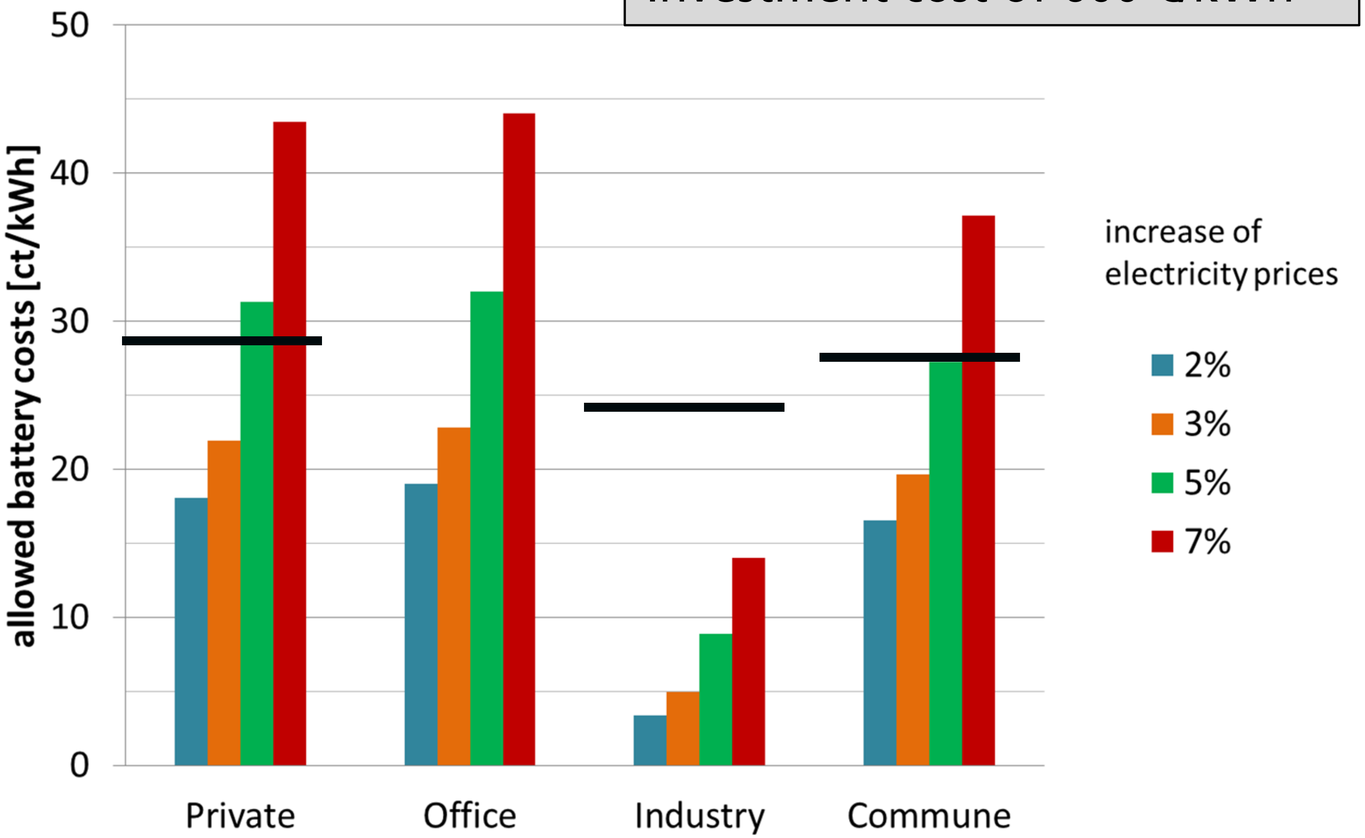


Lithium-ion

Current cost calculated with Investment cost of 600 €/kWh

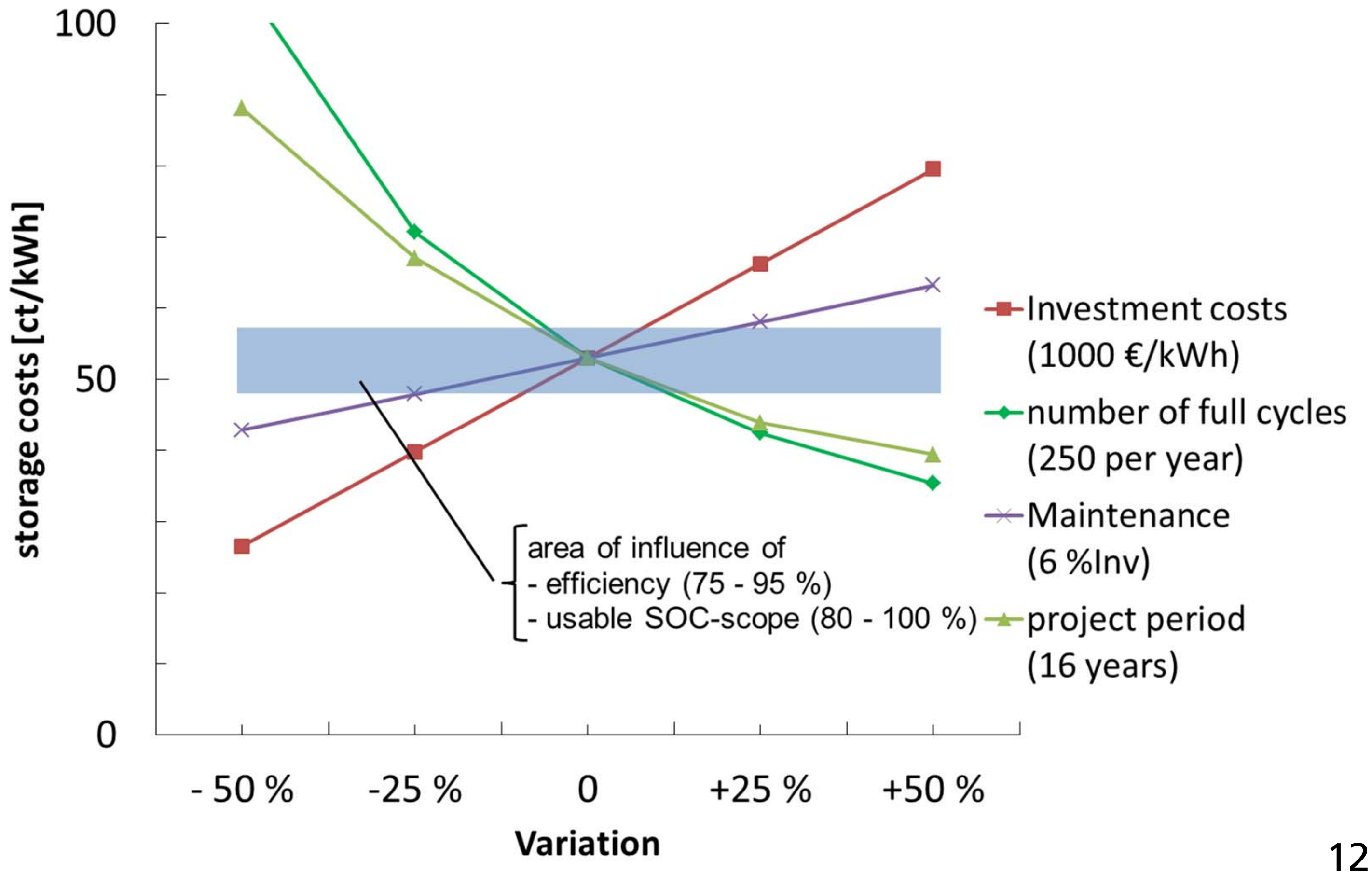


Cycles per year	221	75	256	227
Storage cost ct / kWh	28	81	24	27

Cost analysis and influencing factors
Example: Lithium-ion battery system

Cost drivers

- Investment cost
- Cycle number
- Operation and maintenance
- Project period



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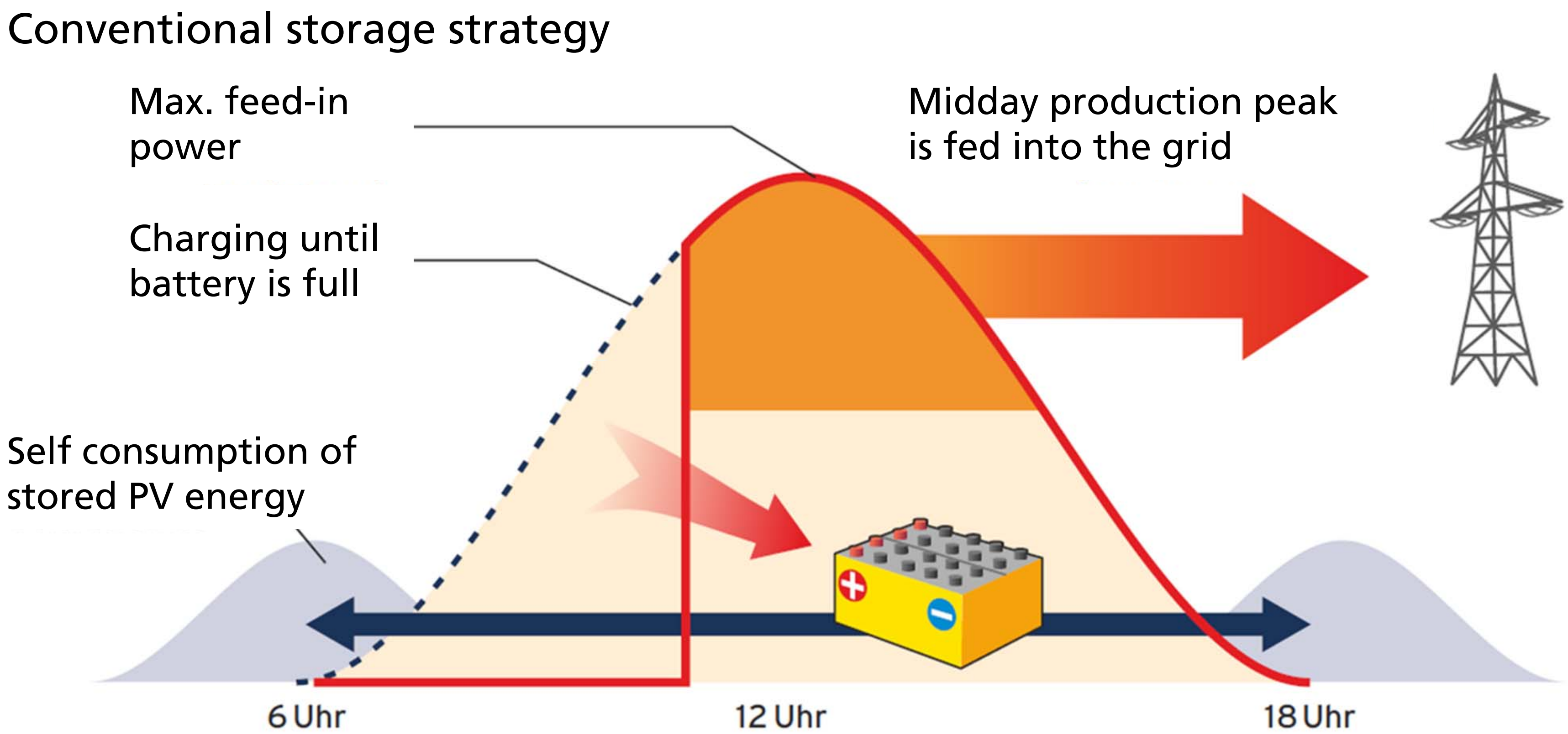
Operating control strategies
Conventional storage strategy

→ No significant positive effect for the distribution grid

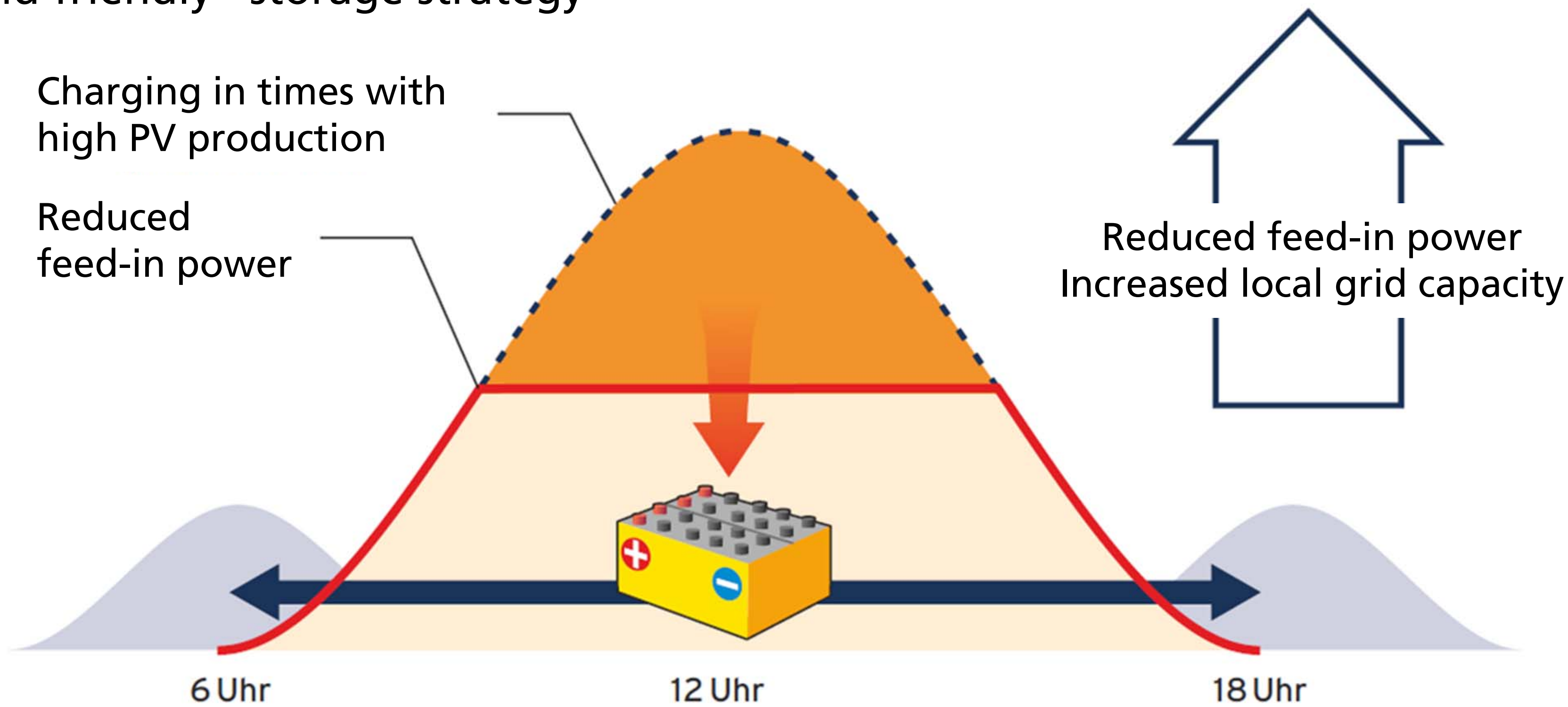


Source: J. Mayer (BSW), C. Wittwer (ISE), Batteriespeicher: Ein sinnvolles Element der Energiewende. Berlin, Pressefrühstück 25.1.2013

Operating control strategies
"Grid friendly" storage strategy

- → Reduced feed-in peak power decreases problems in the distribution grids
- → Reduced feed-in peak power up to 40 % without yield losses
- → 66 % increase of PV power in local distribution grids possible

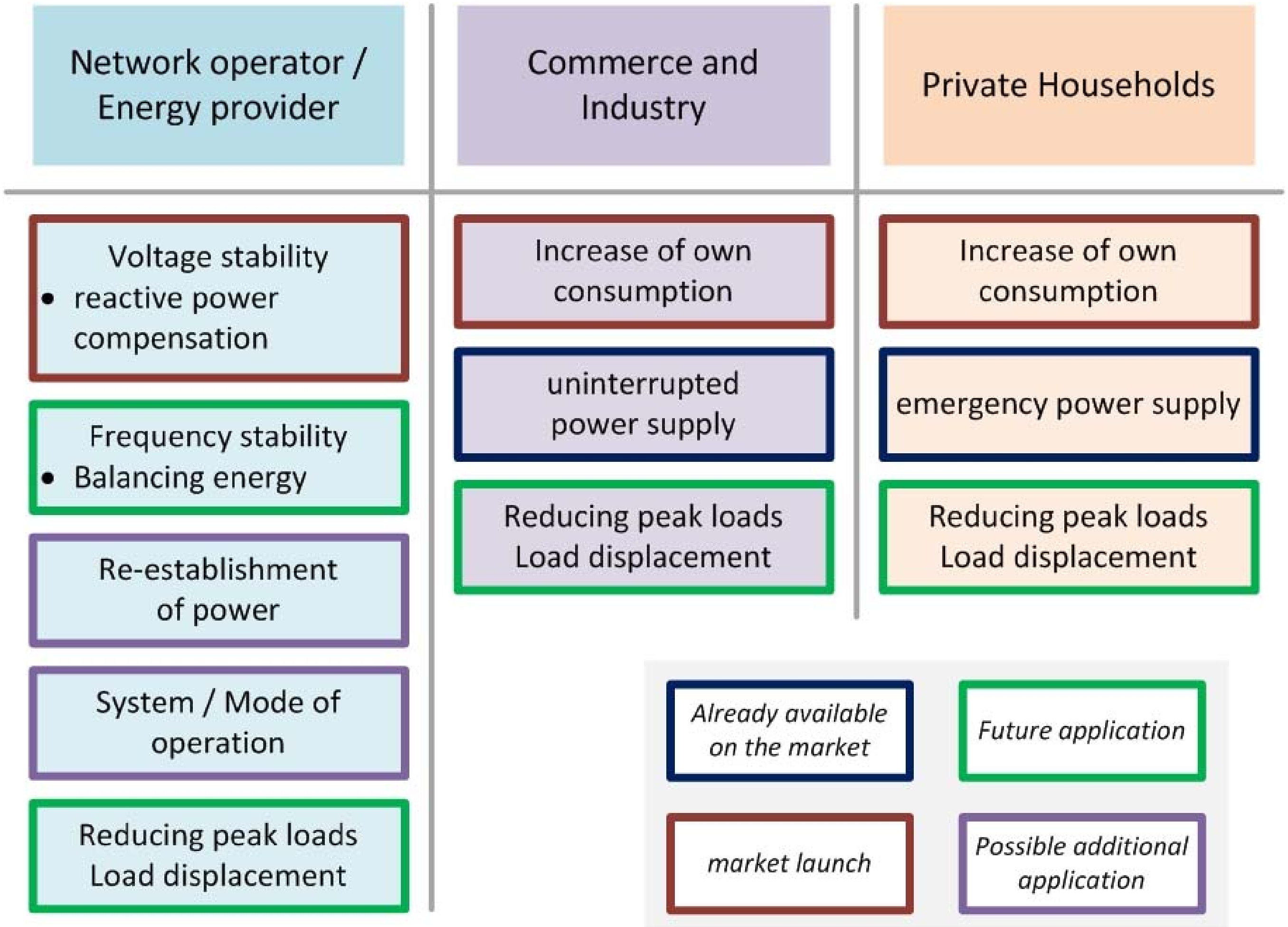
"Grid friendly" storage strategy



Source: J. Mayer (BSW), C. Wittwer (ISE), Batteriespeicher: Ein sinnvolles Element der Energiewende. Berlin, Pressefrühstück 25.1.2013

Stationary battery systems
Additional business cases beyond PV self consumption

- Multiple use of storage device
  → Additional services, e.g. grid support
  → Additional revenues



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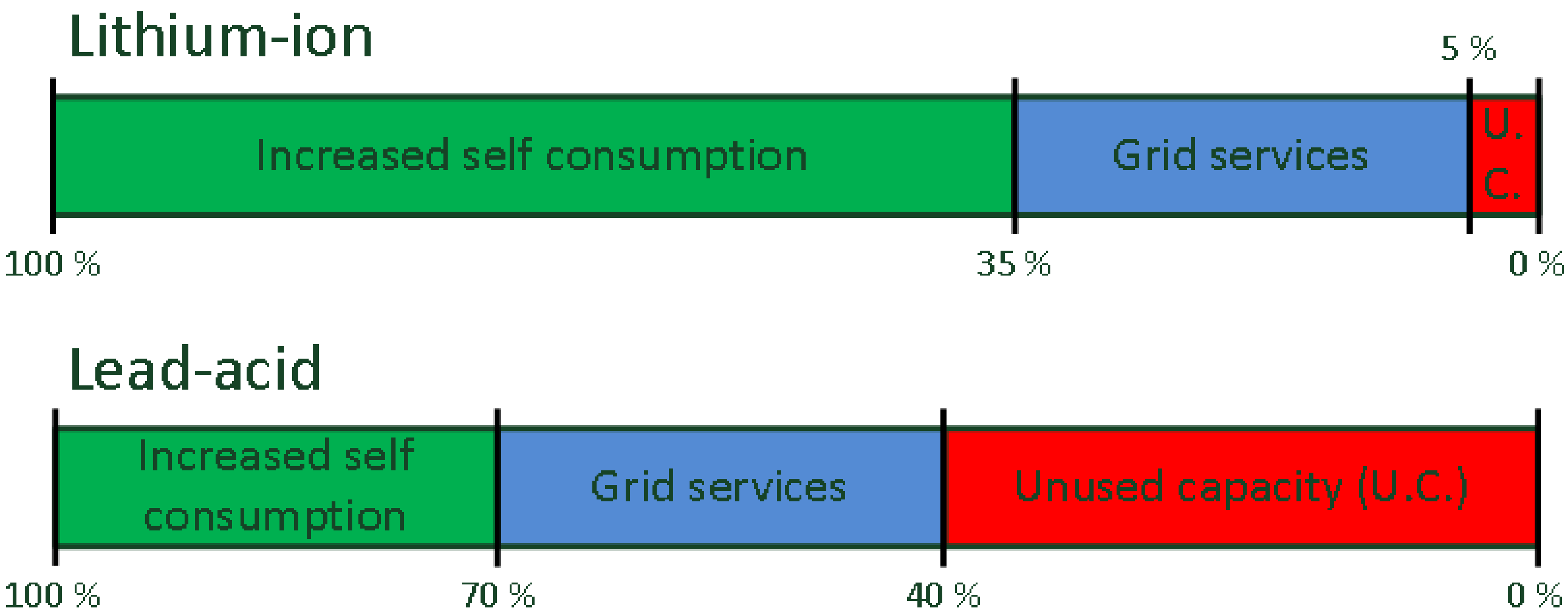
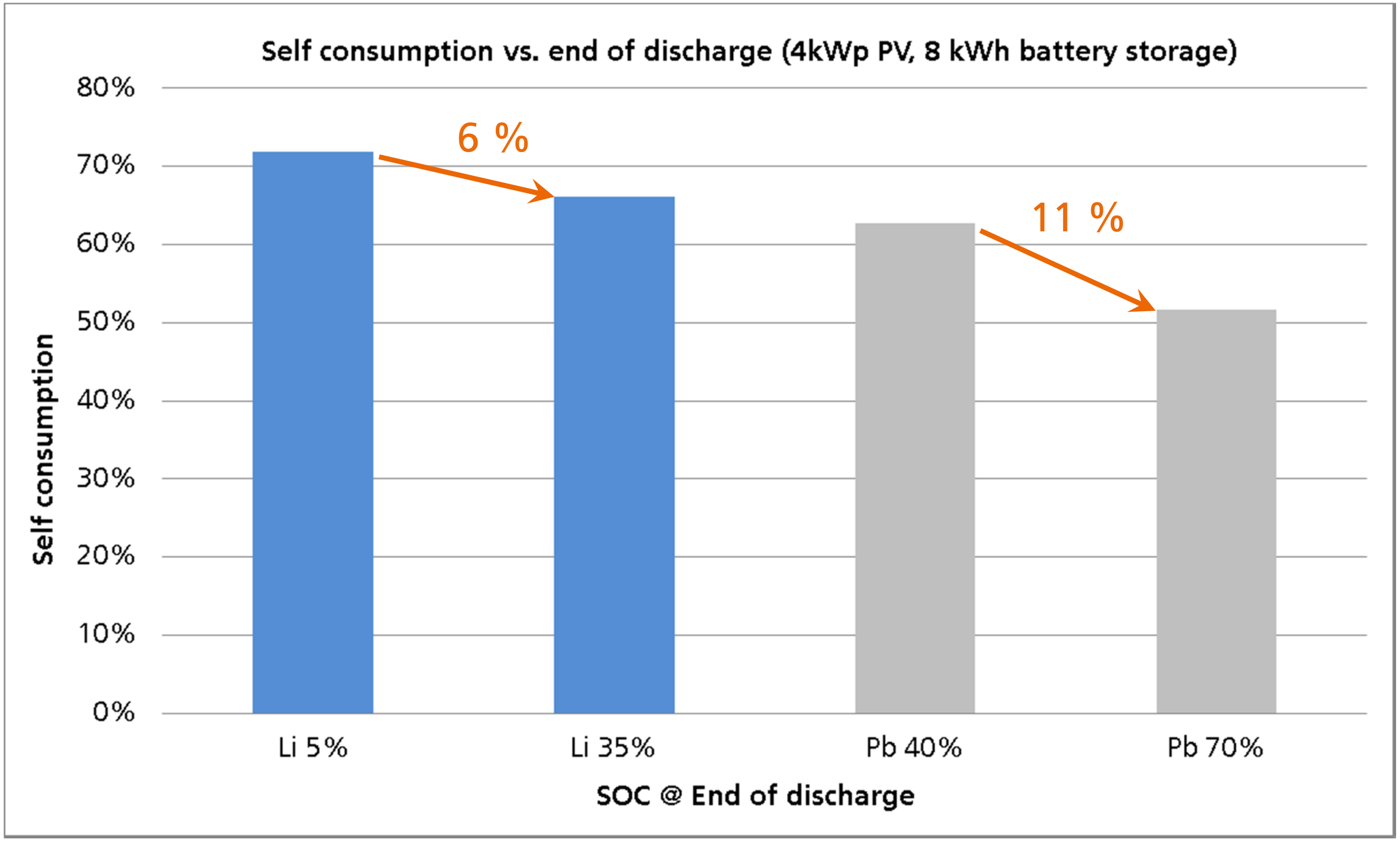
Optimized operation of residential PV battery systems
Case 1: Allocation of capacity for additional grid services



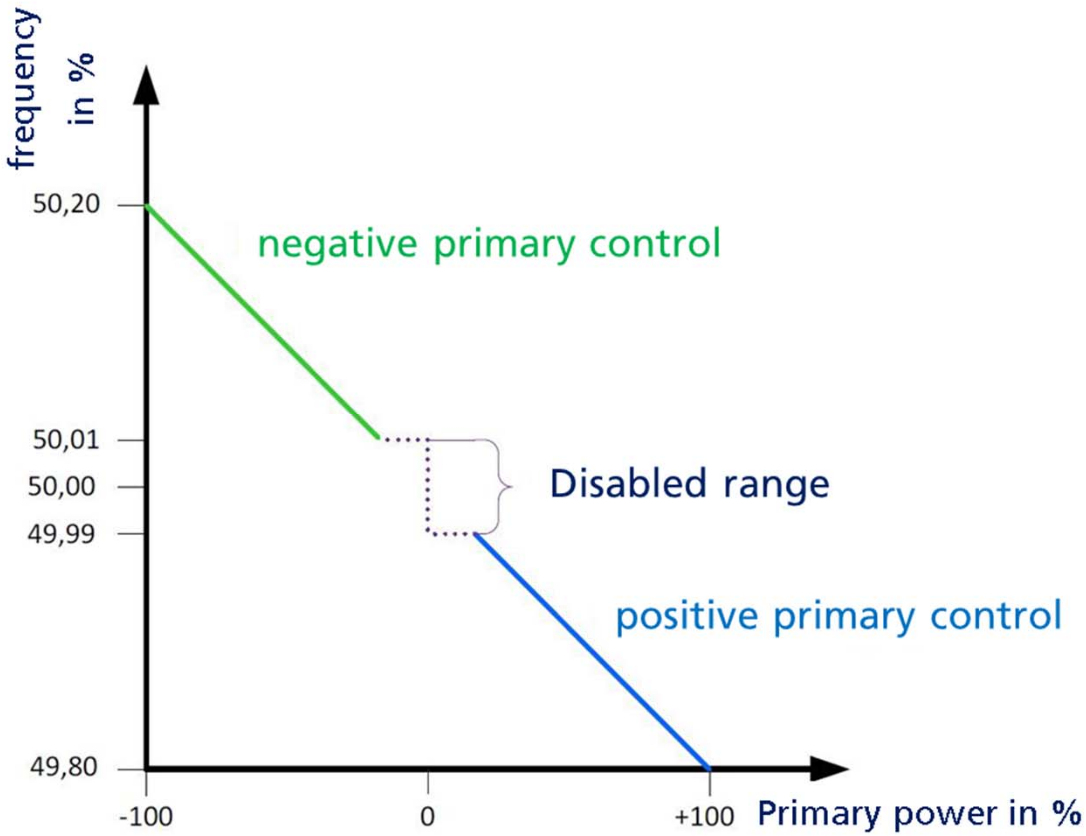
Optimized operation of residential PV battery systems
Case 1: Allocation of capacity for additional grid services

→ Reduction of PV self consumption



Optimized operation of residential PV battery systems
Case 2: Bidding of primary control power

- Positive und negative primary control power for frequency stabilization
- Price per power and pay-as-bid, minimum power for bidding: 1 MW !!!
- Market volume < 600 MW



Source: G. Bopp et. al., Intersolar conference, Munich 2.6.2014

Optimized operation of residential PV battery systems
Case 2: Bidding of primary control power

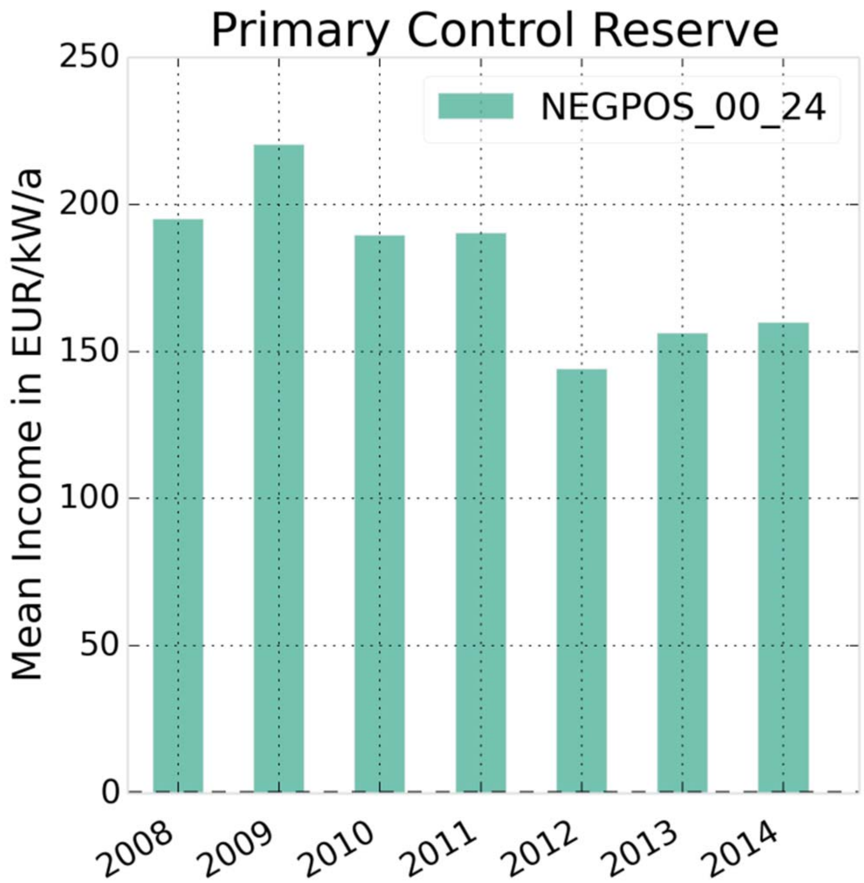
Classical self consumption

Example:

- Battery system: 10 kWh / 10 kW
- PV system: 10 kWp
- Load: 4 650 kWh
- Annual revenue in case of self consumption: approx. 280 €/a
- Battery system cost: approx. 10 000 €

Source: G. Bopp et. al., Intersolar conference, Munich 2.6.2014

Primary control power



Optimized operation of residential PV battery systems

Case 2: Bidding of primary control power

Classical self consumption

Example:

- Battery system: 10 kWh / 10 kW
- PV system: 10 kWp
- Load: 4 65…
- Annu… consu…
- Batte… system cost: approx. 10 000 €

Primary control power

Example:

- Reduction of self c… sumption
- … imary control
- … !!!

Simplified consideration !!!
Reality will be somewhere in between and depends on a number of parameters !!!

Annual revenues = primary control power + self consumption

Annual revenues = 7.5 kW * 150 €/kW*a + 75 €/a
= 1125 €/a + 75 €/a
= 1200 €/a

Source: G. Bopp et. al., Intersolar conference, Munich 2.6.2014

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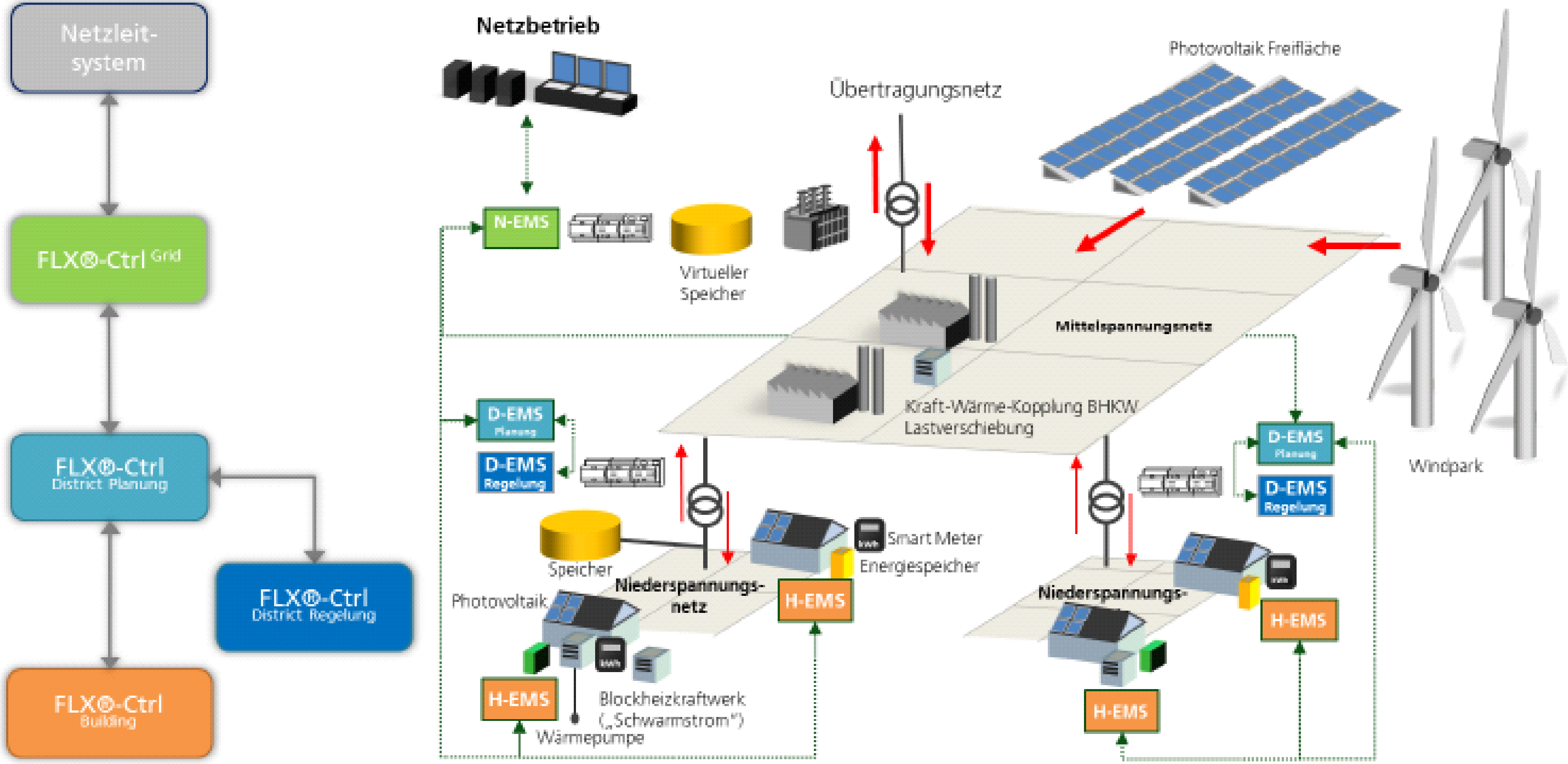
Optimized operation of residential PV battery systems
Case 3: Grid integration via “FlexController”



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Optimized operation of residential PV battery systems

Case 3: Grid integration via "FlexController"

→ Various flexibility options

Additive generation

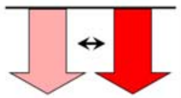
- Application: rare short-term peak loads
- Technology: e.g. emergency power units (hospitals)

Dispatchable generation

- Application: frequent and high short-term peak loads
- Technology: CHP units

Electric power storage

- Application: daily balancing of power demand and generation
- Technology: e.g. battery systems, decentralized and "centralized"



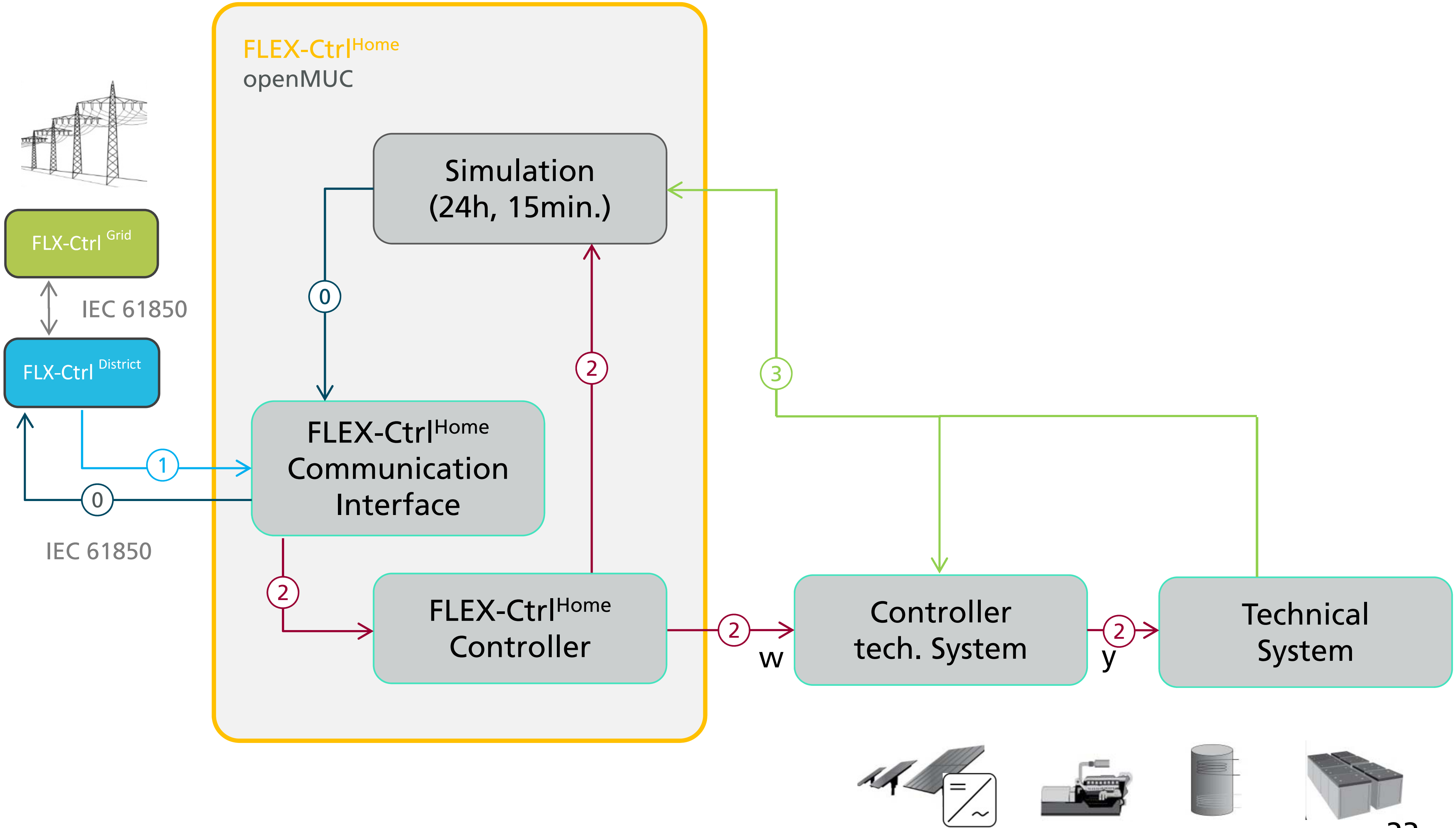
Dispatchable load

- Application: frequent and high short-term generation peaks
- Technology: e.g. heat pumps with thermal storages, electric cars (!)

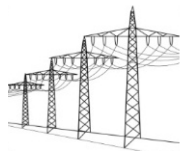
Additive load

- Application: rare generation peaks
- Technology: e.g. electrical heating (domestic hot water, district heating)

FLEX-Ctrl^{Home} Architecture



FLEX-Ctrl^{Home} Architecture



FLX-Ctrl ^{Grid}

FLX-Ctrl ^{District}

FLEX-Ctrl^{Home}
openMUC

Simulation
(24h, 15min.)

0

FLEX-Ctrl^{Home}
Communication
Interface

0

FLEX-Ctrl^{Home}
Controller

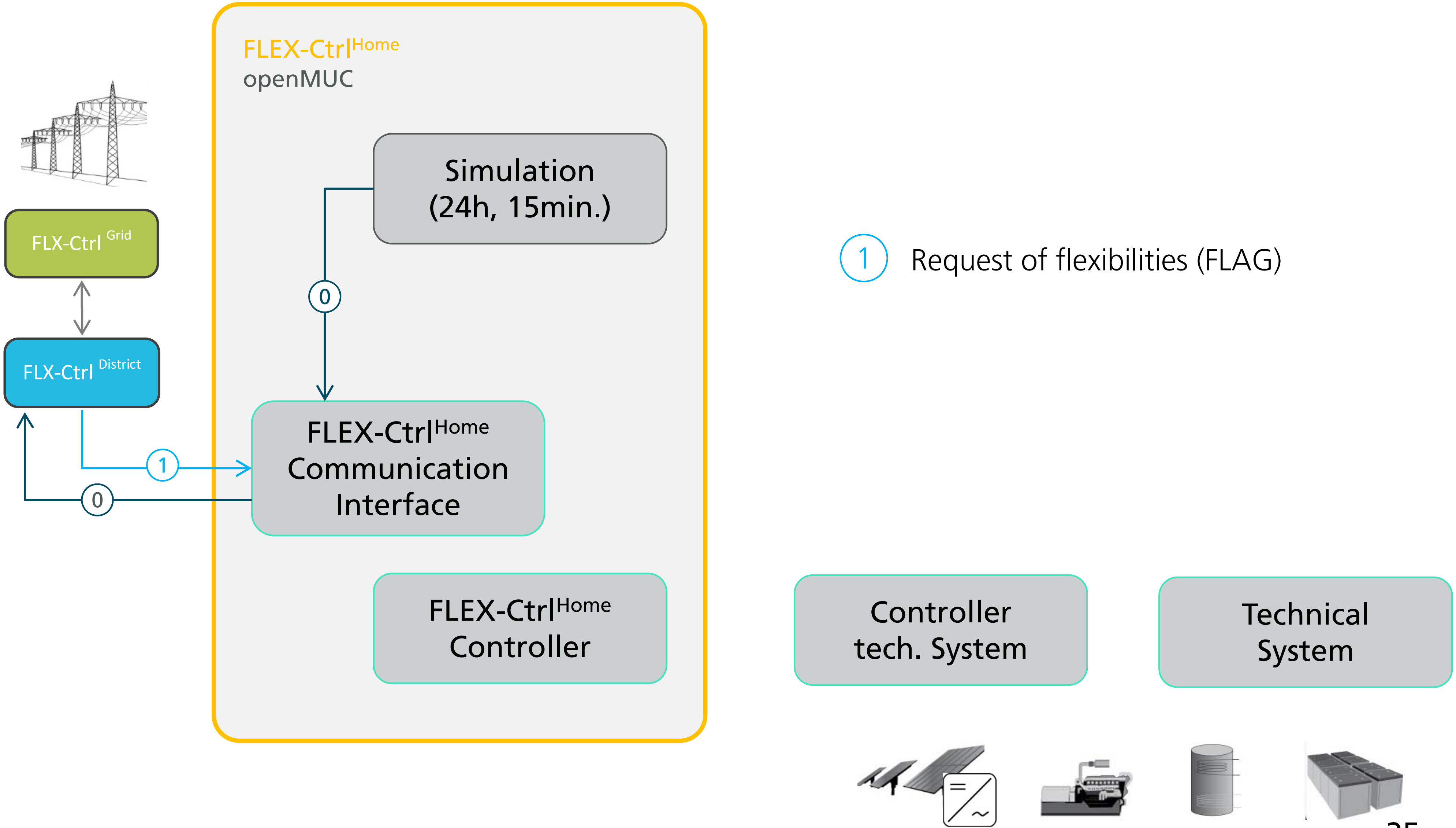
0

- 24h-forecast for power at default operation
- Flexibility of power for every 15 min / 24 h
- Qualitative parameters

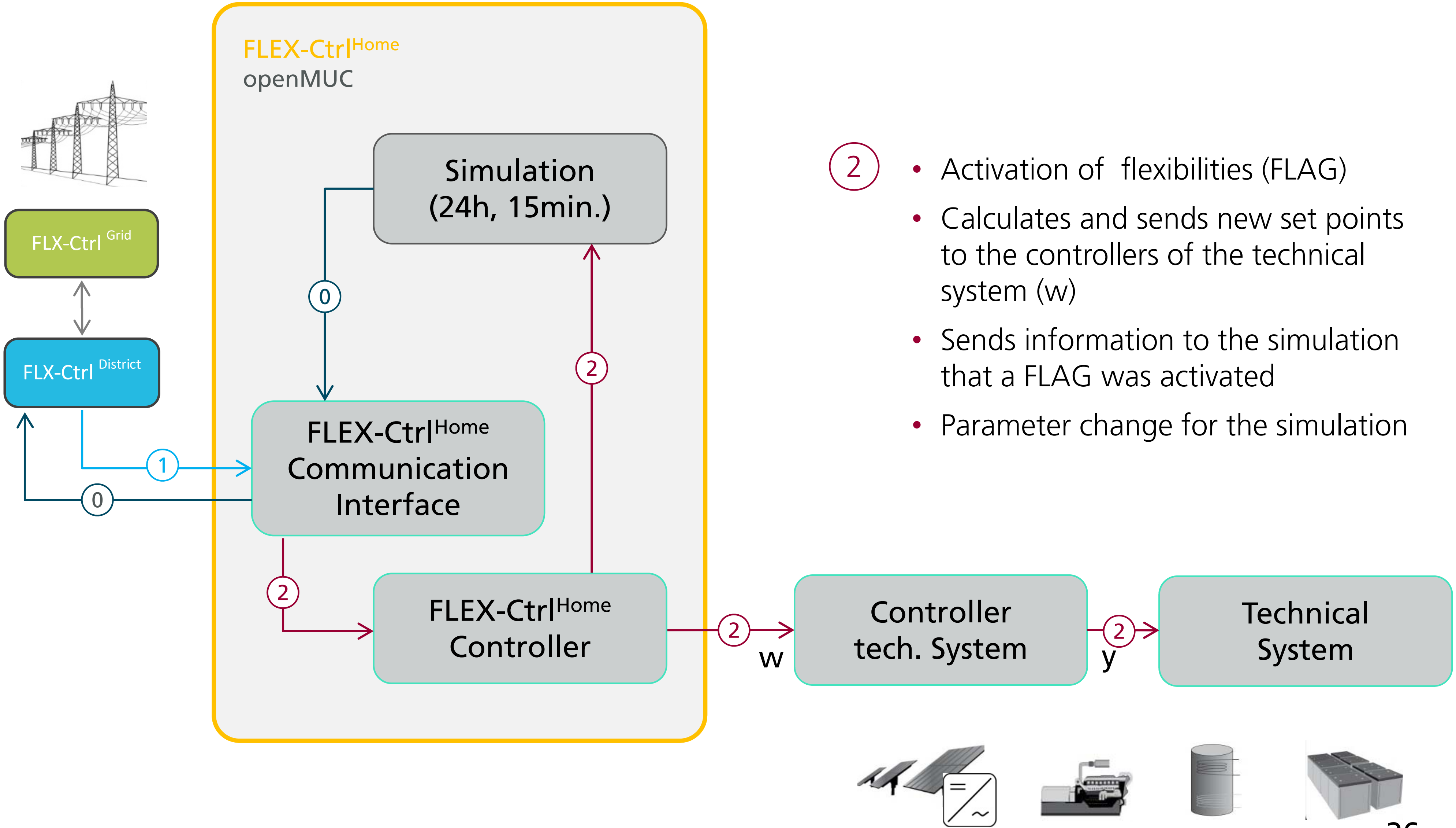
Controller
tech. System

Technical
System

FLEX-Ctrl^{Home} Architecture



FLEX-Ctrl^{Home} Architecture



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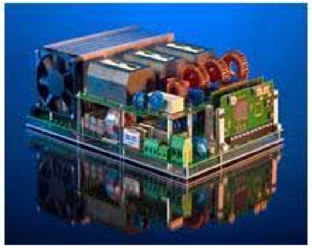
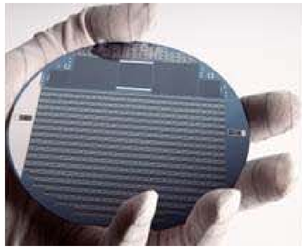
- Activation of flexibilities (FLAG)
- Calculates and sends new set points to the controllers of the technical system (w)
- Sends information to the simulation that a FLAG was activated
- Parameter change for the simulation

Conclusions

- Storages crucial for **large scale integration** of fluctuating renewables
- Especially **lithium-ion** battery systems very interesting for the use in grid-connected PV applications
- Lithium-ion batteries on the way to be **profitable**, dependent on the specific application and the corresponding boundary conditions
  - But: Cost still have to be decreased → Detailed **cost analyses** important
- **Multiple use** of storage systems may improve the economics and is crucial from a technical point of view
- **Advanced operating control strategies** combine self consumption with additional grid services
- But: There are more **flexibility options** in the (distribution) grid, which also have to be considered → Smart integrated system solutions

Thanks for your attention !!!

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