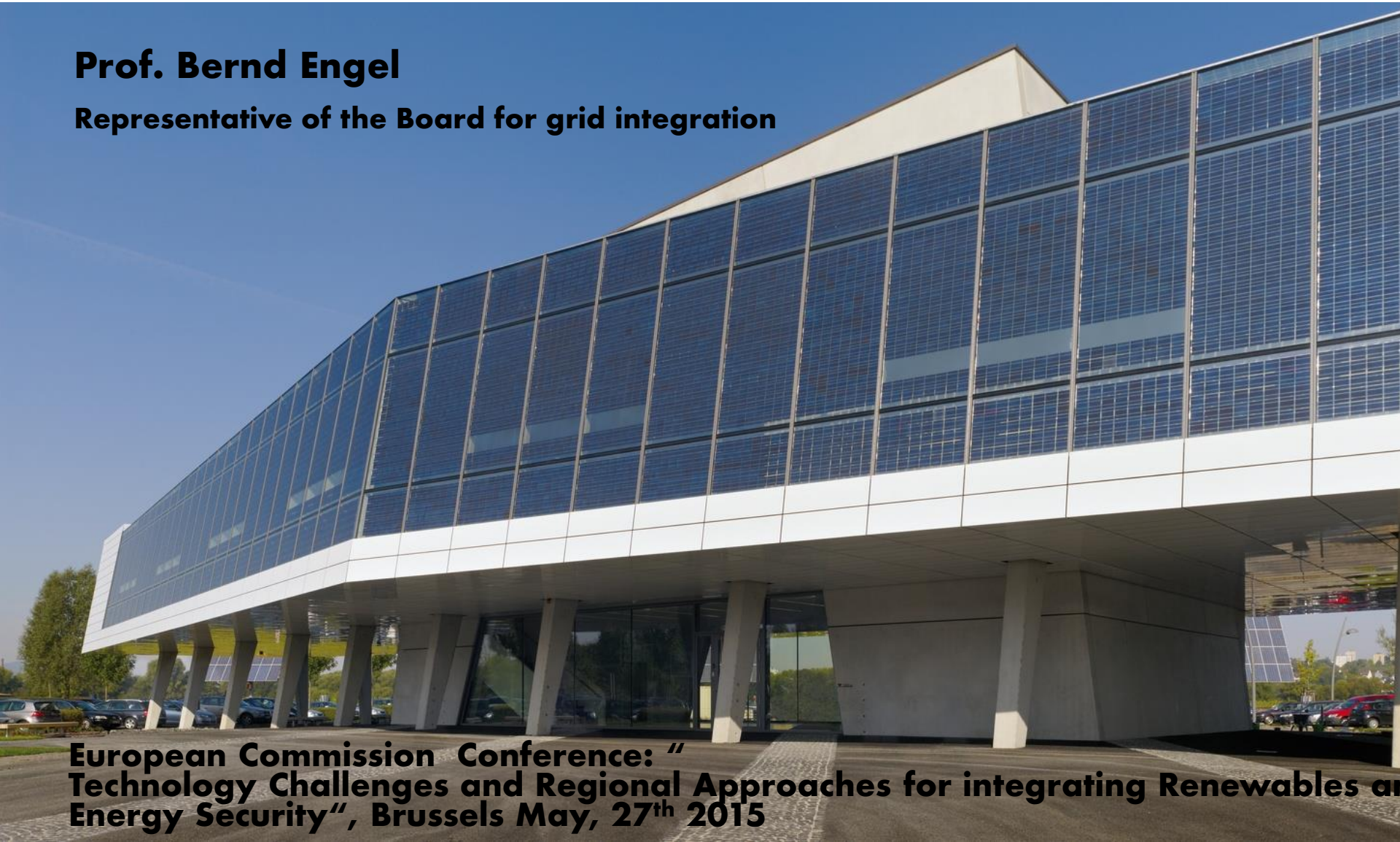
How to regulate self-consumption of electricity produced from PV panels so that it is beneficial to the energy system



Prof. Bernd Engel

Representative of the Board for grid integration

European Commission Conference: "Technology Challenges and Regional Approaches for integrating Renewables an Energy Security", Brussels May, 27th 2015

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Agenda

1 **Introduction**

2 Energy management on building level

3 SMA solutions

4 Conclusion

SMA Facts & Figures

Facts & Figures

- Founded: **1981**
- Sales 2014: **EUR 800 million**
- Installed global capacity : **> 40 GW**
- Employees: **+ 5.000 worldwide**
- R&D Professionals: **>1.000**
- Invest R&D 2014: **> € 100 Mio.**

Comprehensive Product Range

All PV applications

On-grid

Off-grid

Backup

All performance ranges

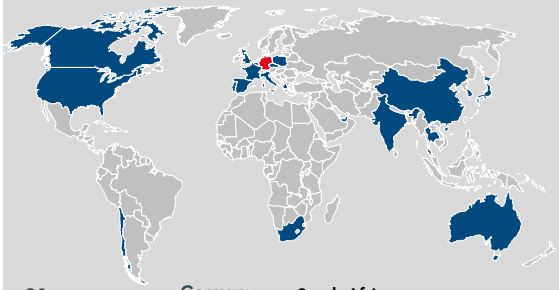
Industrial
> 1 MW

Commercial
30 – 500 kW

Residential
2 – 30 kW

Residential
< 2 kW

Global Presence



21 Subsidiaries Worldwide

Canada
Chile
USA

Germany
Belgium
Czech Republic
France
Greece
Italy
Poland
Portugal
Spain
United Kingdom

South Africa

Australia
China
India
Japan
South Korea
Thailand
United Arab Emirates

» SMA is the **global market and technology leader** for solar inverters

elenia
Institut für Hochspannungstechnik
und Elektrische Energieanlagen

renewables
Made in Germany

CV Bernd Engel

- Since 2011 Professor at Technical University Braunschweig for components for sustainable energy systems at the elenia institute
- Representative of the Board for grid integration at SMA Solar Technology AG
- Member of the working group “system stability” at the Federal Ministery for Economics and Energy (BMWi)
- Vice President of the Forum Network technology/Network operation (FNN) in VDE
- 2003 – 2011 Senior Vice President SMA Technology AG (solar inverter)
- 1996 – 2003 Site Engineering Director, Alstom Transport (trains)

PV in Germany

> New PV installation in 2010-12: 7.5 GW each year

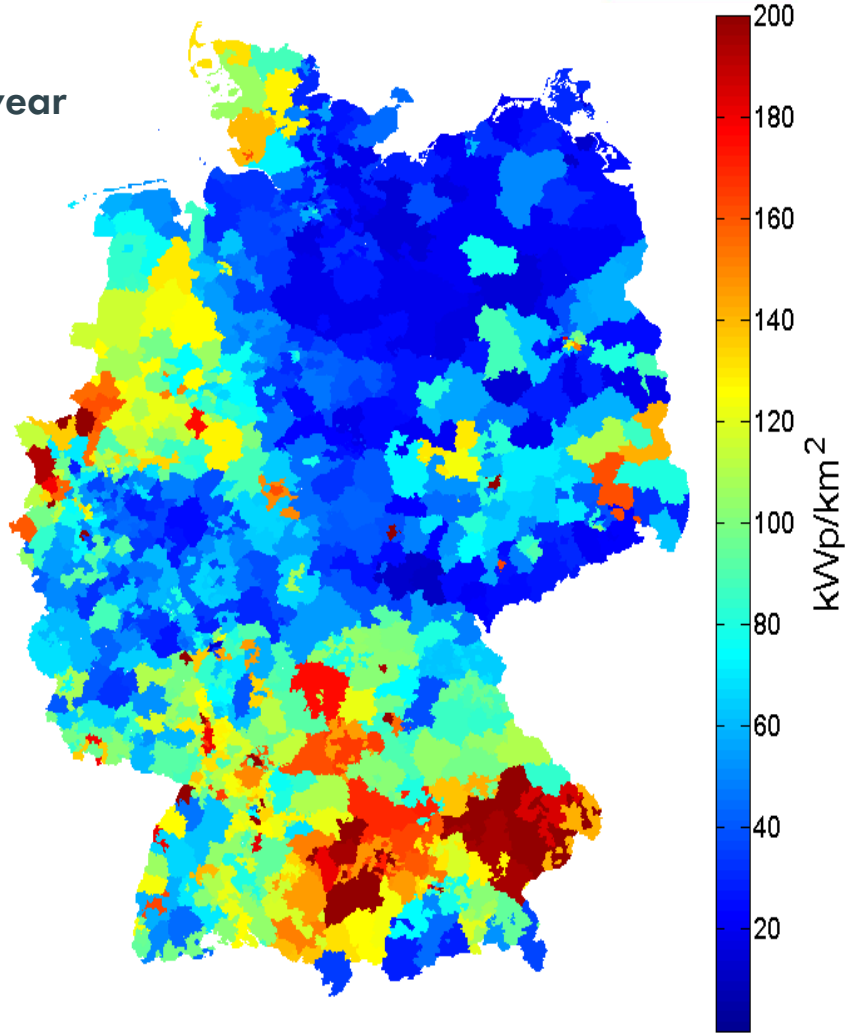
> New PV installation in 2014: 3.3 GW

> Total PV installation by 02/2015: 38 GW

> About 1.4 million PV plants in Germany

> PV Forecast for 2020: Est. 50 GW

> Total Wind Power installation: 38 GW



German system

> Total Generation Capacity: approx. 170 GW

> Minimum load: 35 GW

> Maximum load 85 GW

> Cross border transmission capacity: 8-14 GW

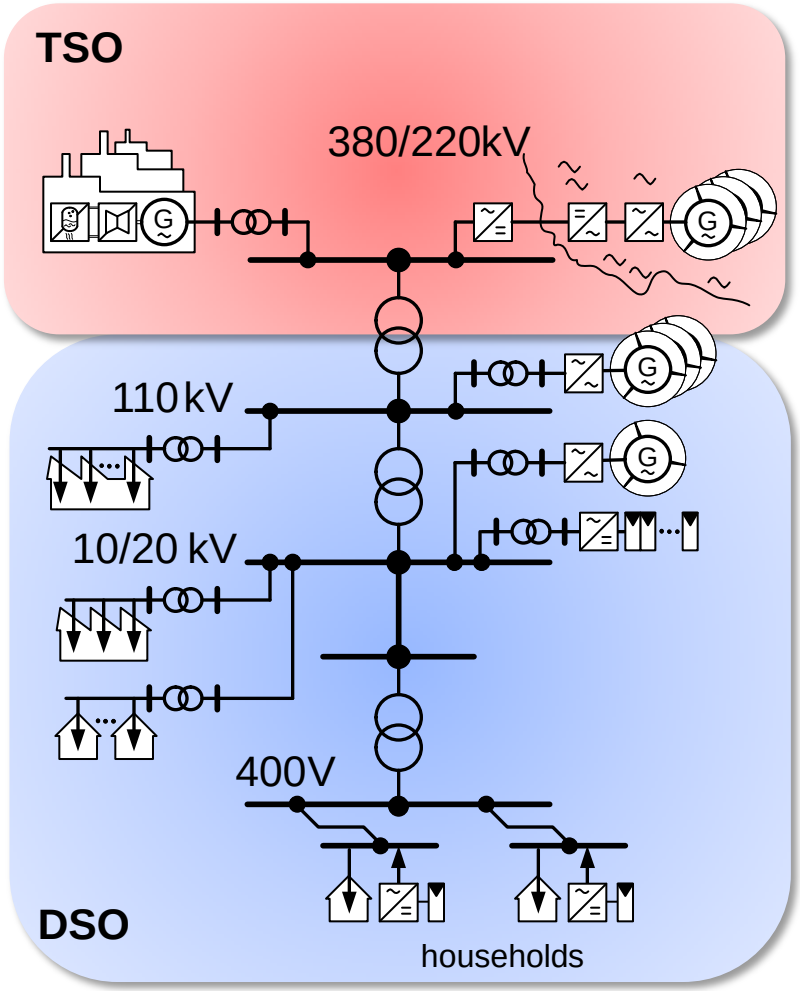
German grid structure and integration of renewables

> In the past all major power plants were connected to the transport network operated by the TSO

> Now wind parks and solar plants are connected to the distribution grid of the DSO

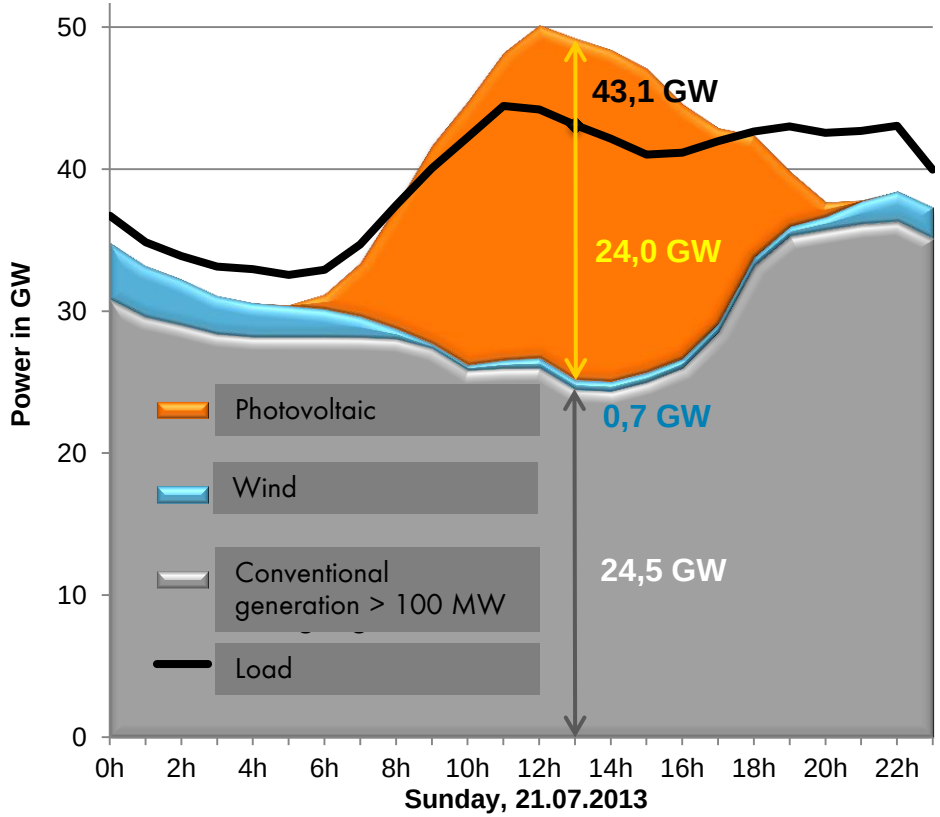
- Solar mainly in the LV grid (70 % out of 38 GW)
- Wind mainly in MV and HV grid (approx. 38 GW)

> Paradigm shift: From unidirectional to fluctuating bidirectional power flows



PV is becoming a fundamental column in the energy mix

- PV is being replaced peak power basically

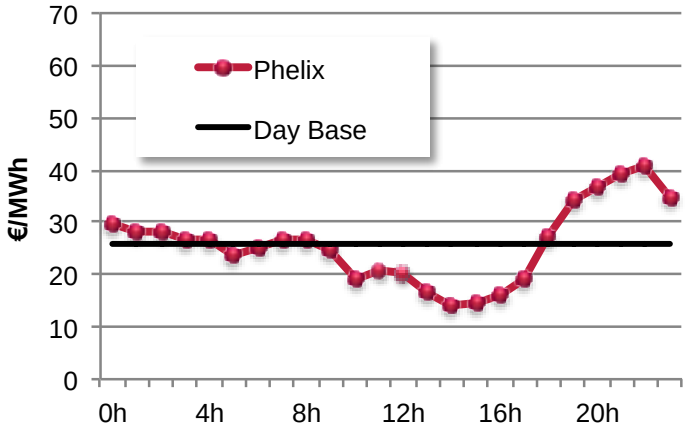


Source: EEX-Transparenzplattform, ENTSO-E, Grafik: F.Soyck – elenia

> Maximum high on a sunny Sunday noon in Germany (55% PV)

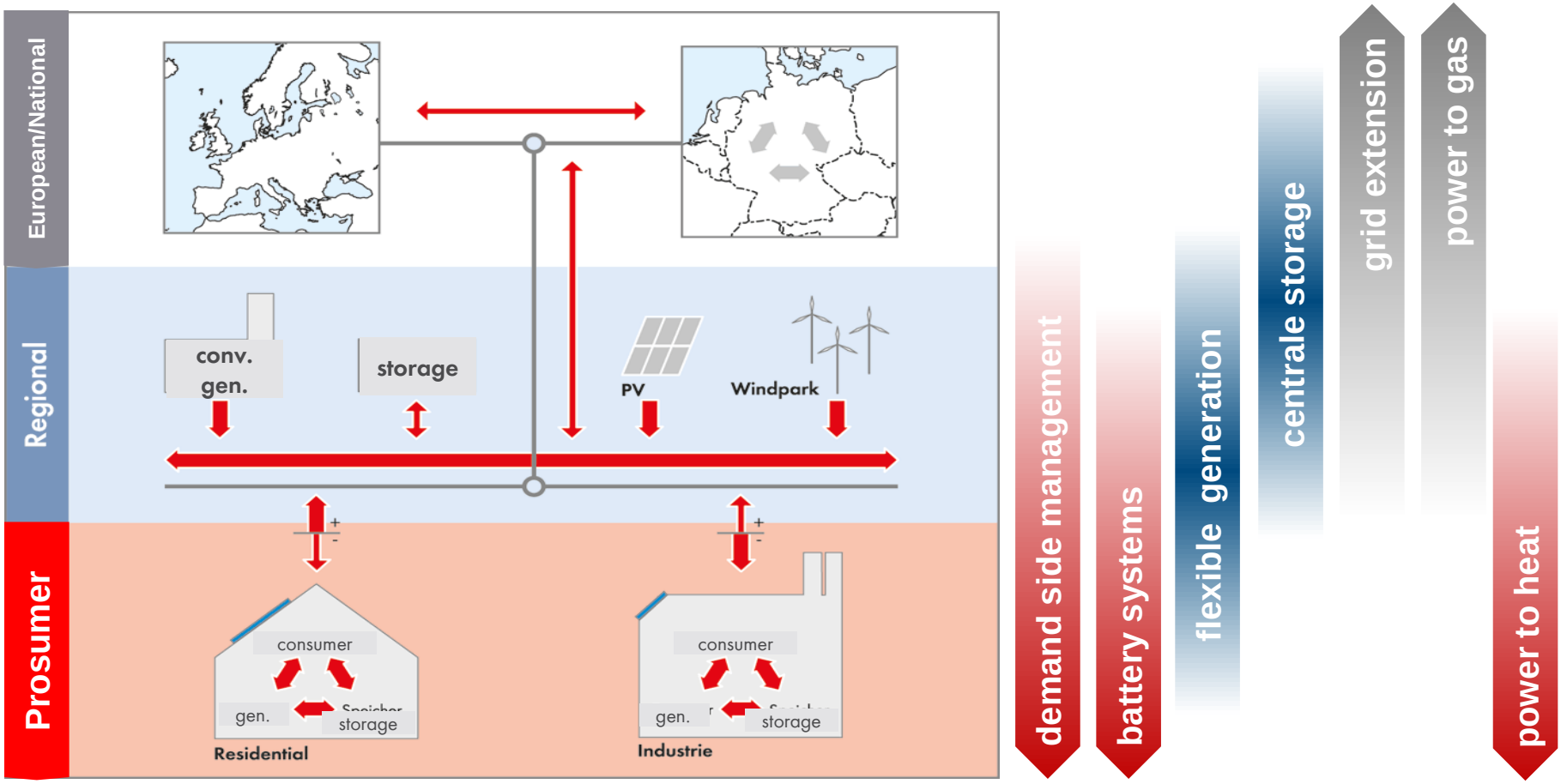
> 21,7% daily generated energy (PV); 204 GWh

> Reliable, regional next-day forecasts available



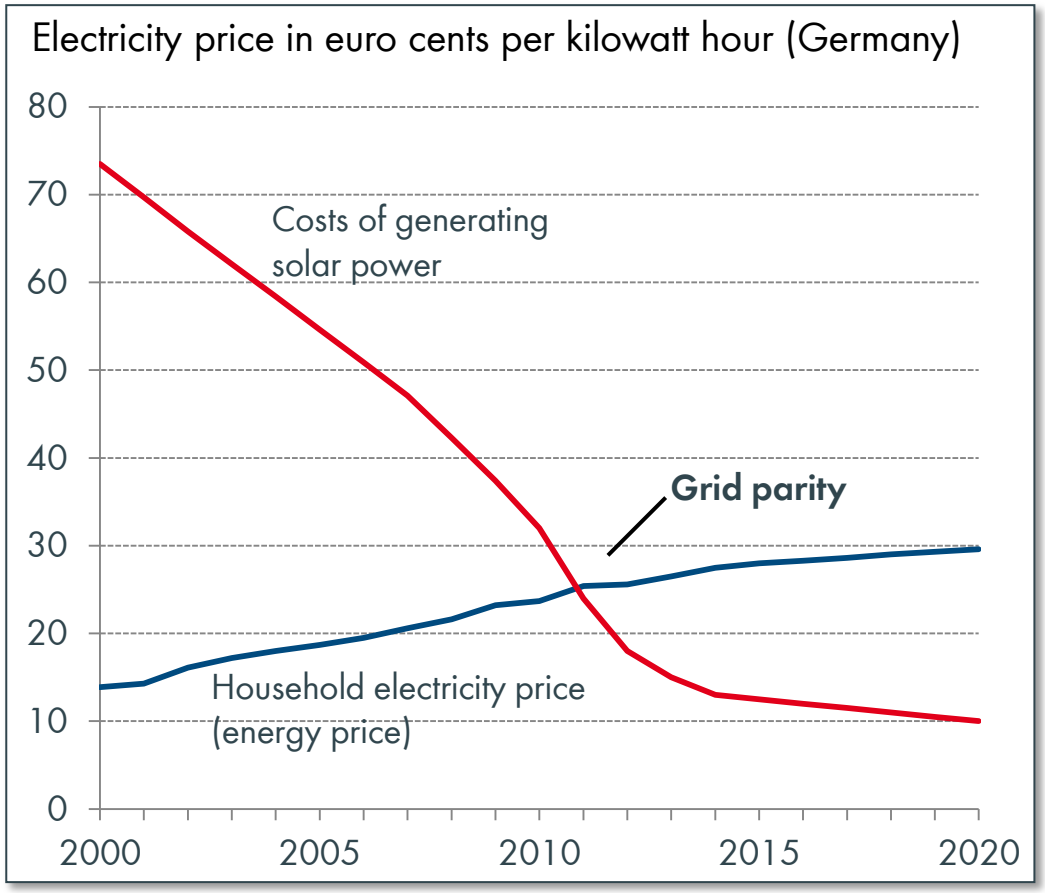
Source: EEX, Grafik: Soyck

Flexibility options on different levels



Flexibility options on <u>all</u> levels are reasonable and necessary

Solar power continues to become more cost-effective



> In Germany, in the past 10 years alone, the costs of generating solar power have dropped by over 60%.

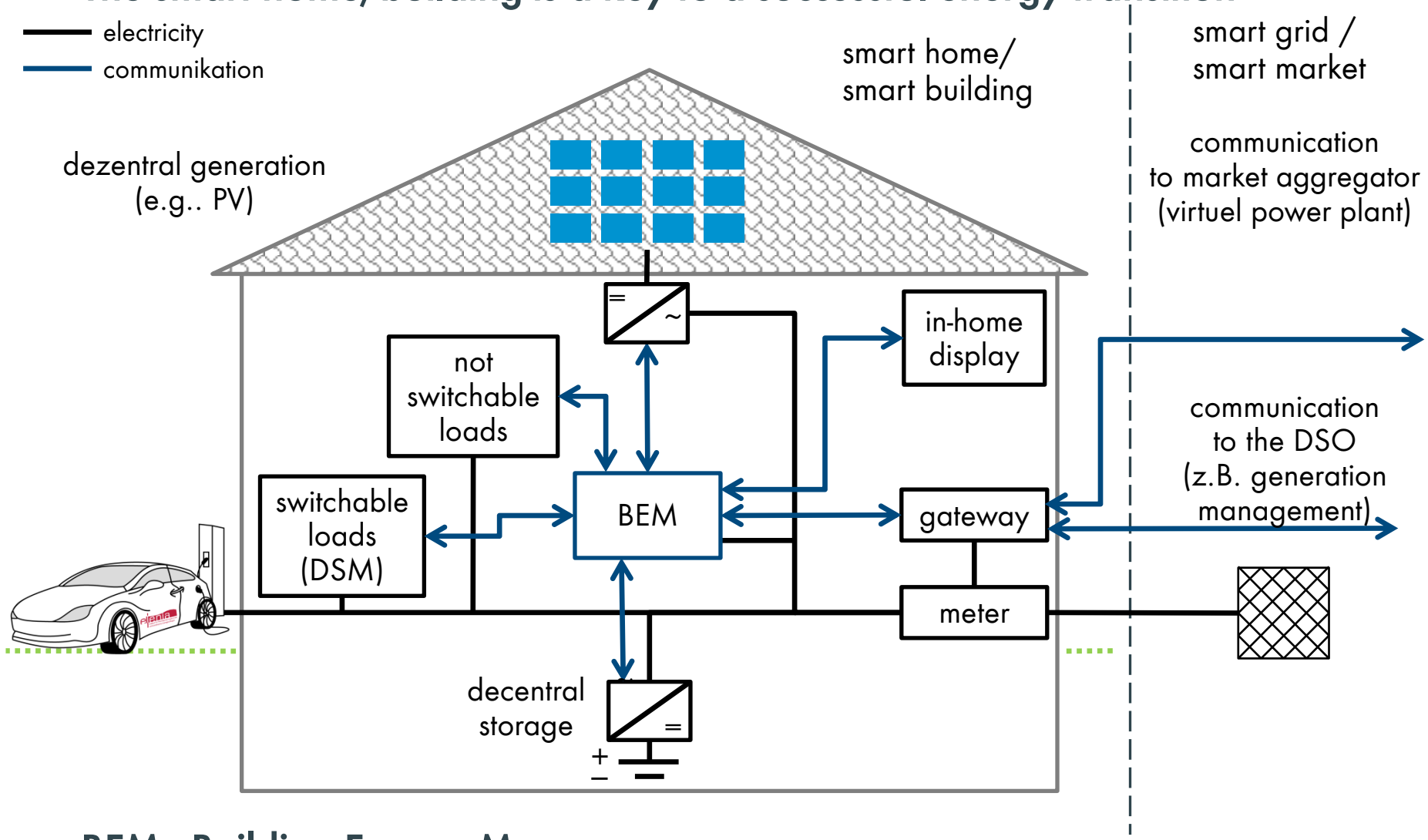
> Solar power is already more cost-efficient than conventional household electricity.

> A long-term, affordable energy supply requires further subsidies over the short-term in order to provide incentives for additional investments in system and storage technology.

The costs of generating solar power in Germany are already below the household electricity price.

Sources: SMA estimate, based on German Solar Industry Association PV roadmap

The smart home/building is a key to a successful energy transition

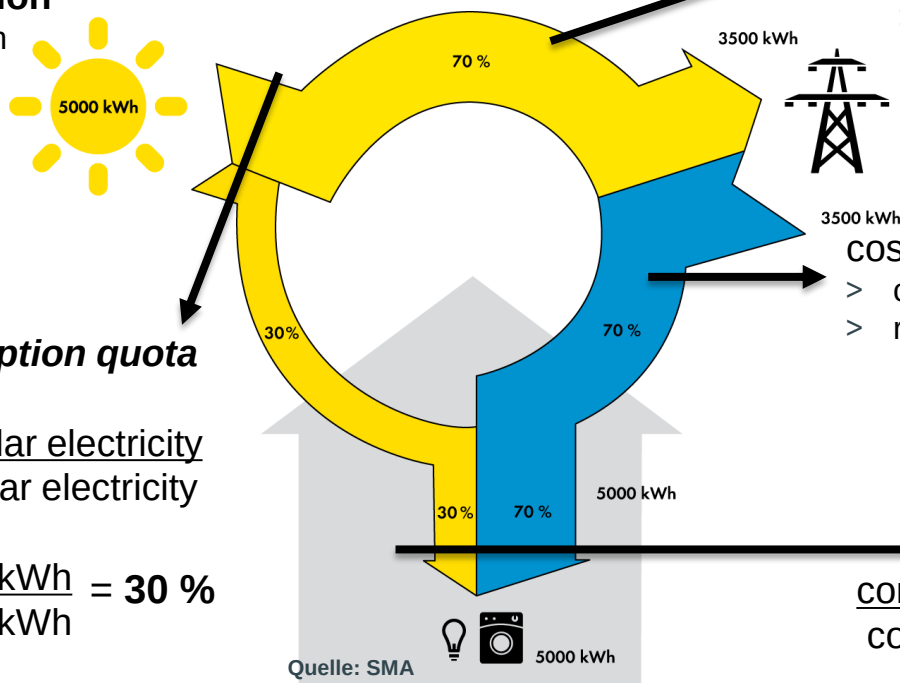


BEM : Building Energy Manager

Optimization criterias for PV solutions for self supply (grid connected)

cost of **PV generation**
> less than 12 ct/kWh
> falling

feed-in tariff
> ca. 12,5 ct/kWh in 03/15
> falling



cost of **purchased electricity**
> ca. 28 ct/kWh in 11/13*
> rising

*Quelle: BDEW Strompreisanalyse

Quelle:SMA

self consumption quota

$$= \frac{\text{consumed solar electricity}}{\text{complete solar electricity}} = \frac{1500\ \text{kWh}}{5000\ \text{kWh}} = \mathbf{30\ \%}$$

autarky quote

$$= \frac{\text{consumed solar electricity}}{\text{complete solar electricity}} = \frac{1500\ \text{kWh}}{5000\ \text{kWh}} = \mathbf{30\ \%}$$

- **self consumption quota = independance from feed-in tariff**
- **autarky quota = indepandance from consumption tariff**

Optimization criterias for PV solutions for self supply (grid connected)

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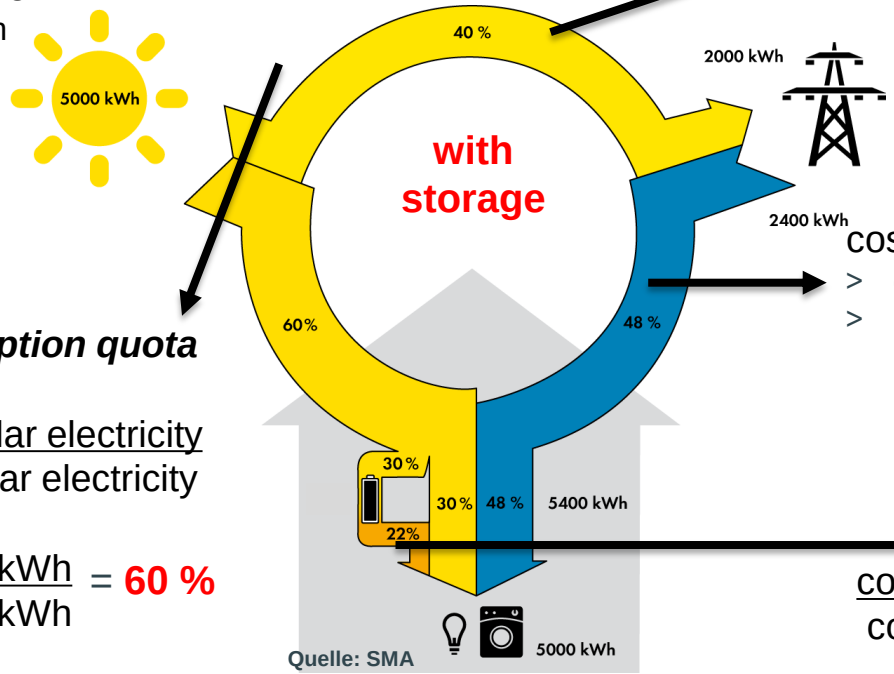

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Quelle:SMA

self consumption quota

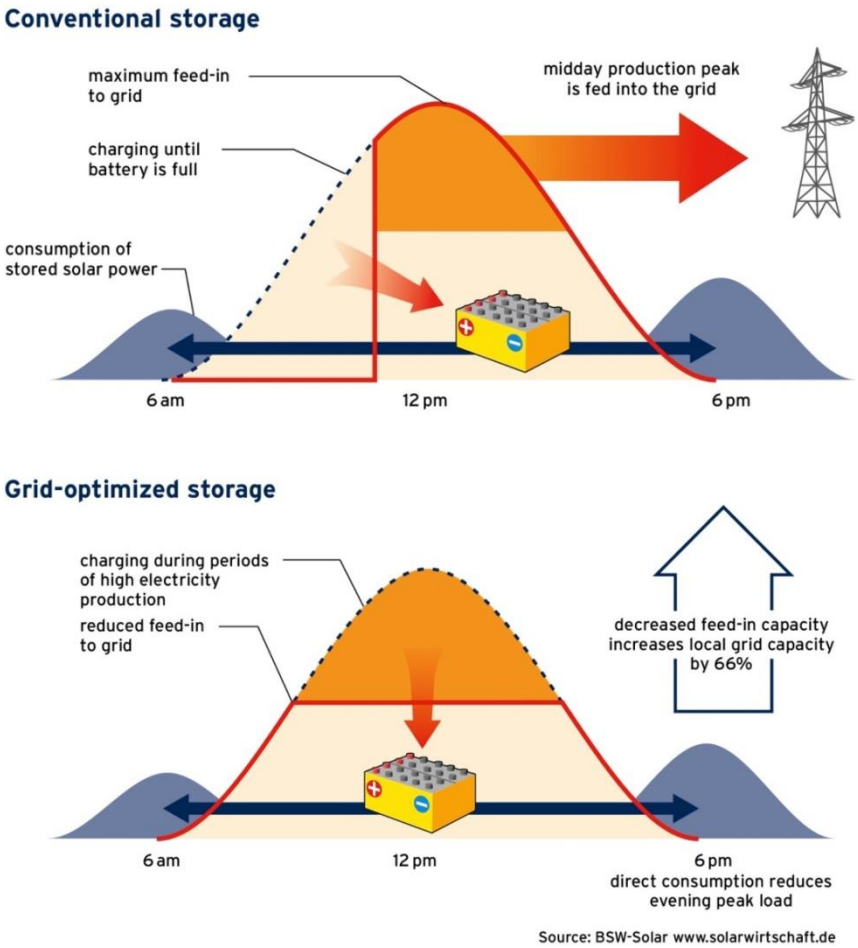
$$= \frac{\text{consumed solar electricity}}{\text{complete solar electricity}} = \frac{1500\ \text{kWh}}{5000\ \text{kWh}} = \mathbf{60\ \%}$$

autarky quote

$$= \frac{\text{consumed solar electricity}}{\text{complete solar electricity}} = \frac{1500\ \text{kWh}}{5000\ \text{kWh}} = \mathbf{52\ \%}$$

- **self consumption quota = independance from feed-in tariff**
- **autarky quota = indepandance from consumption tariff**

Grid Optimized PV Storage Systems



The German market incentive program for PV battery systems is a success story

- **More than 6000 battery systems in 2014 funded** – target of market creation fulfilled (ca. 15,000 battery systems since 2013 in the LV grid)
- **Prices are falling due to quantities, techn. progress und competition** – price decrease by 25 % in 2014
- **grid-optimized operation established** – new standards in Germany published by FNN (Forum Network Technology/ Network Operation)
- **characteristics of the grid-optimized operation:**
  - 60 % limitation of the installed PV power
  - same characteristics as decentral generators:
    - first approaches for frequency and voltage control
    - 50.2 Hz frequency dependent power reduction
  - remote control possible in future (RJ45)
  - software update possible for future requirements
- **grid-optimized operation increases the grid capacity by 66 %**

© BSW-Solar

The success story should be continued in a version 2.0

- **The grid and system optimization should be further developed in a version 2.0**
- **BSW proposals for a version 2.0:**
  - **A new power limitation of 50 % - good for DSOs (less grid enhancement) und system bilance in Germany (TSO)**
  - **local voltage control Q(V) – storage system are helping the DSO**
  - **power absorption at 50.2 Hz and power delivery at 49.8 Hz for an improved frequency control**
- **The price learning curve must be followed for a short period of time to allow the usage of battery systems without public funding in the future**

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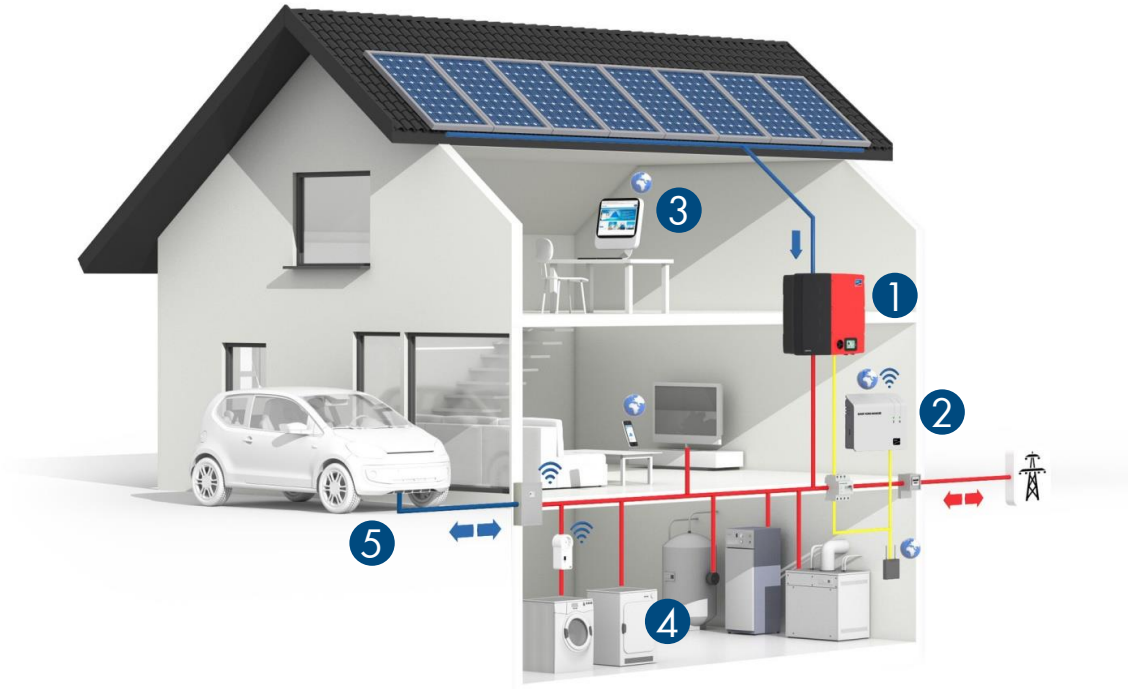
The SMA solution for a successful energy transition



1. **Sunny Boy 5000 Smart Energy** converts direct current into alternating current and can store 2 kWh of solar electricity
2. **Sunny Home Manager** harmonizes power generation and consumption times
3. **SMA Sunny Portal** for energy forecast, remote monitoring and home energy management
4. **Controllable electrical appliances** that do not have specific turn-on times can be activated by the Sunny Home Manager and hence included in the intelligent load management system
5. **Electric car**, when combined with the right inverter, can also be used for additional power storage

The SMA Smart Home is tailored to the requirements of the future energy supply.

INTELLIGENT DEMAND CONTROL - PLANNING

Energy consumption of three devices (without interuption- e.g. washing machine)

1.

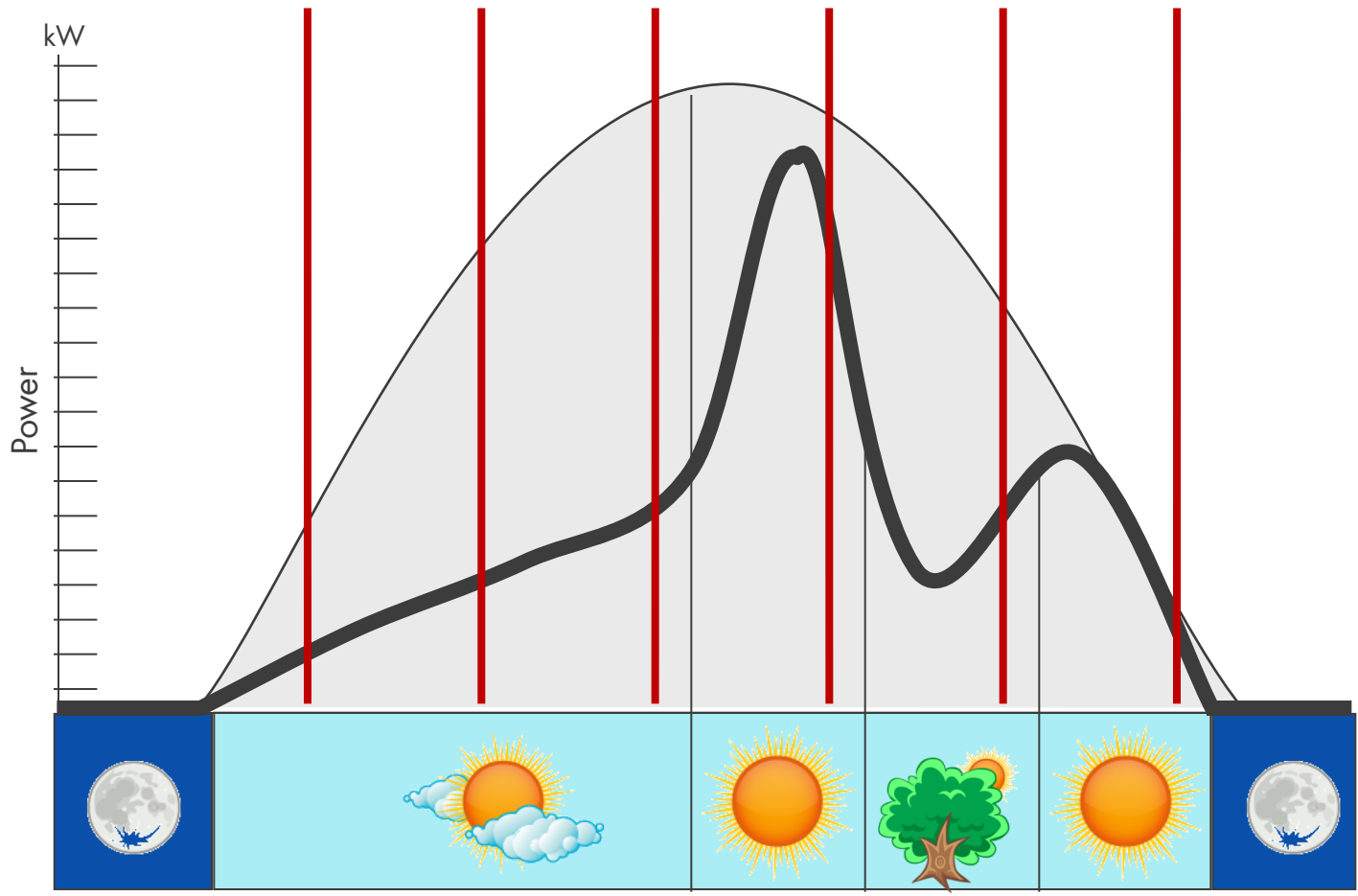
2.

3

energy consumption of a not programmable devices (e.g. heat pumps)

... can be distributed

weather prognosis at 09:00 a.m.



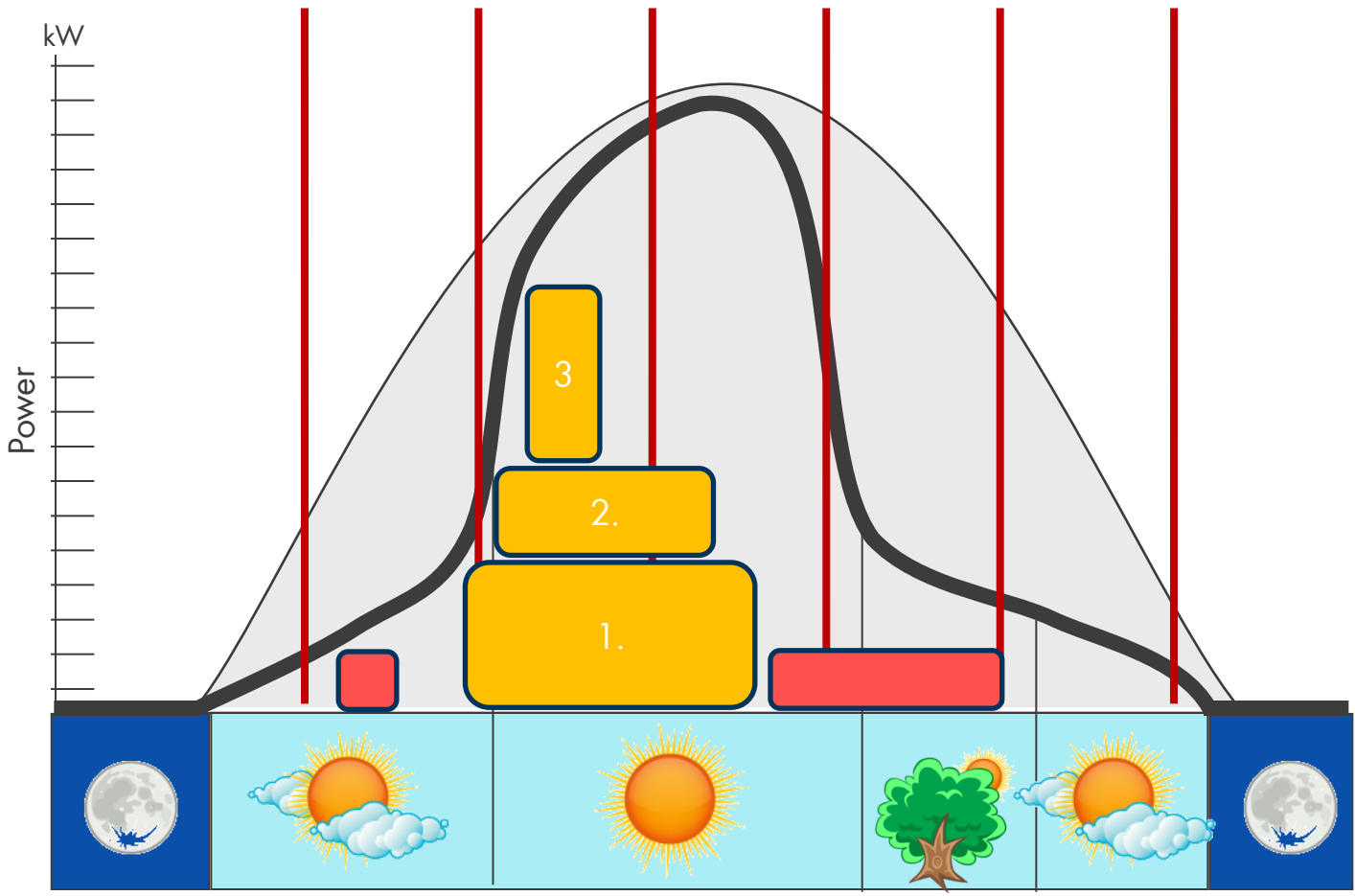
INTELLIGENT DEMAND CONTROL - PLANNING

Energy consumption of three devices (without interuption- e.g. washing machine)

energy consumption of a not programmable devices (e.g. heat pumps)

... can be distributed

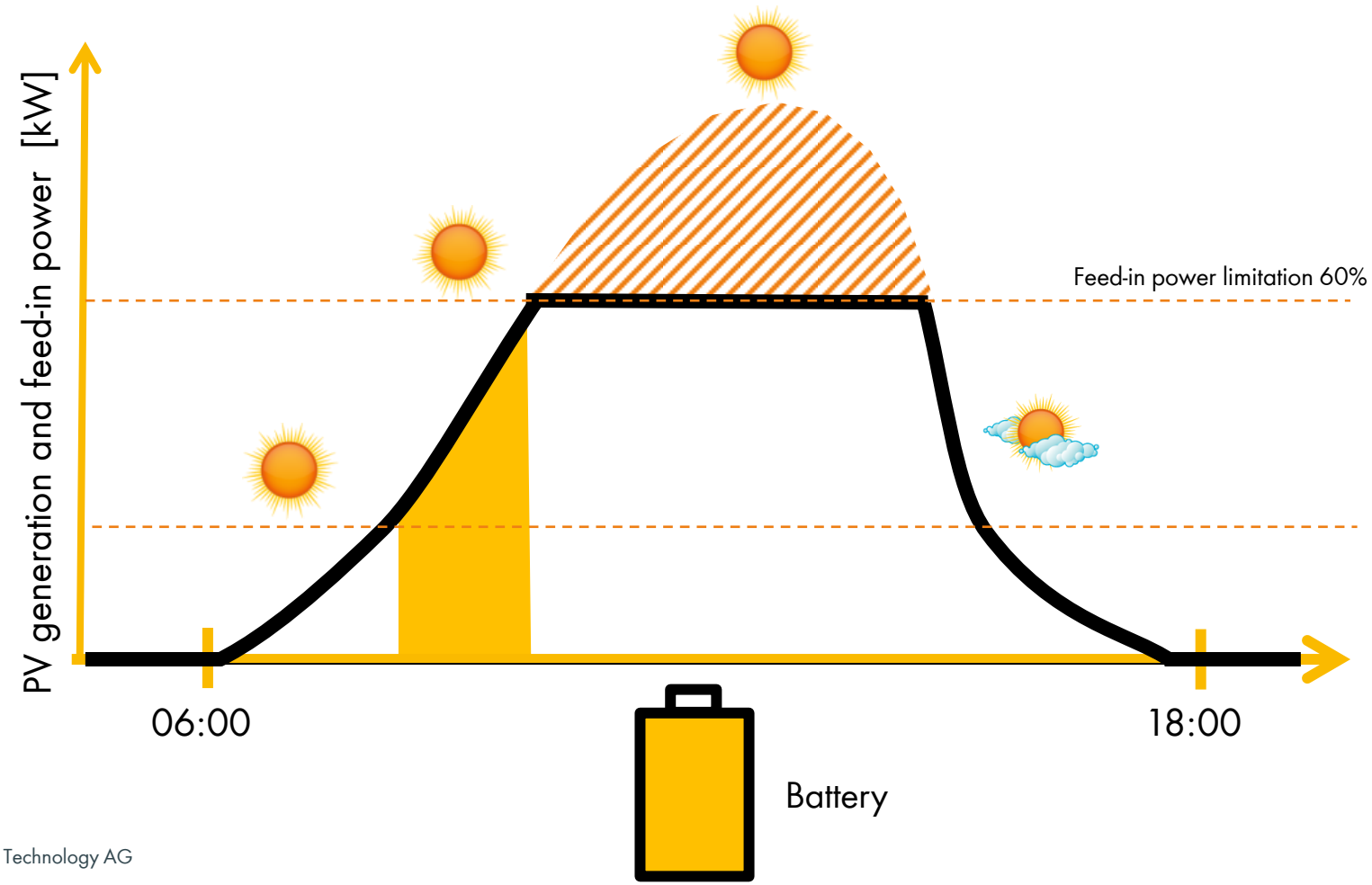
updated weather prognosis at 09:30 a.m.



Intelligent storage of PV energy

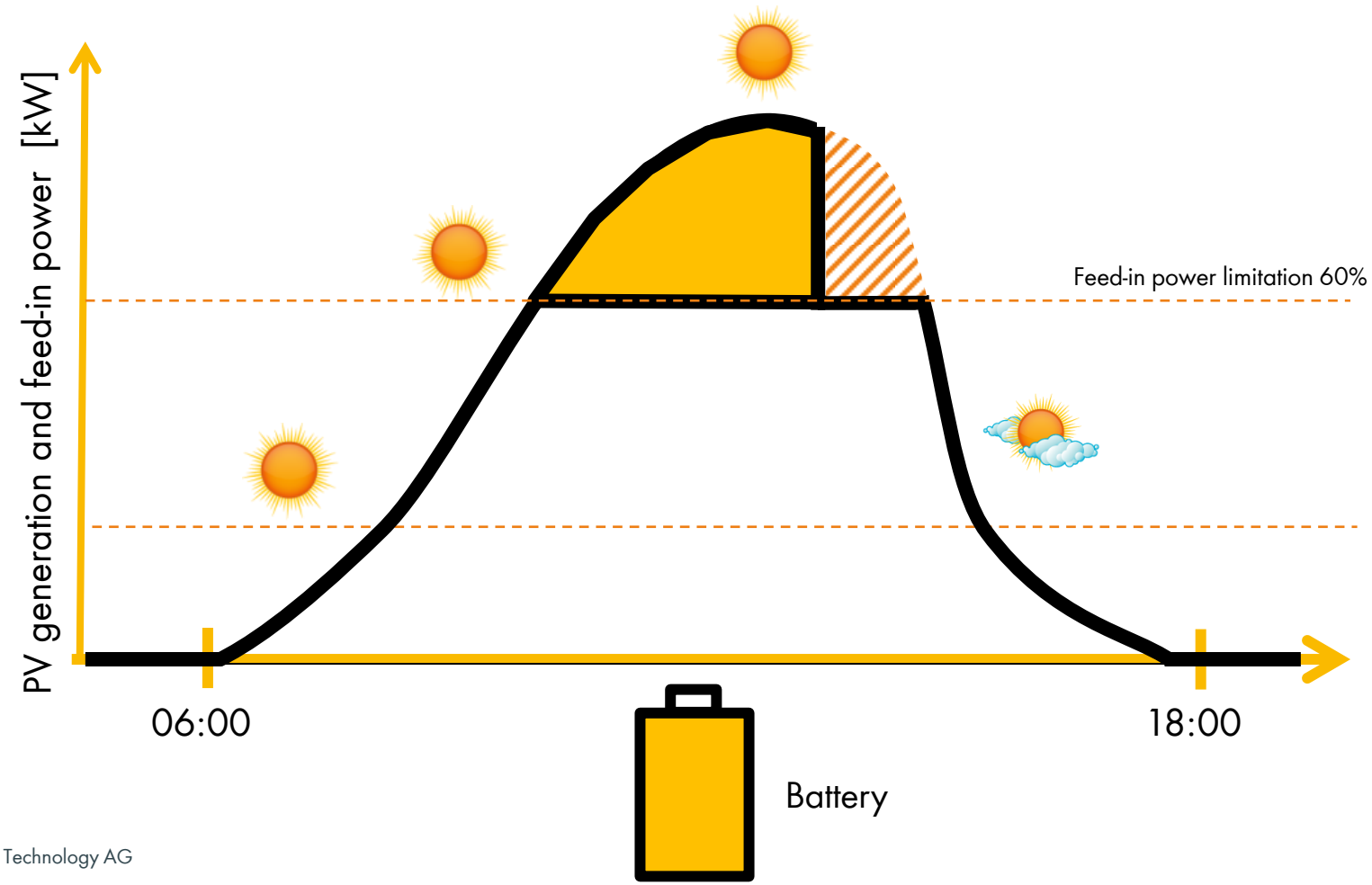
- **Conventional control of battery systems**

  → losses during feed-in power limitation



Intelligent storage of PV energy

- **intelligent control of battery systems**
  - based on weather prognosis
    → avoiding of losses during feed-in power limitation



SUCCESS FACTORS
ENERGY MANAGEMENT

Energy

a good energy management adapts to the behaviour of the customer
.... and not vice versa!

SUCCES FACTOR
NEW STANDARDS FOR COMMUNICATION

Common open communication standards for the building automation:

> **EEBus** enables control of diffent device in the building

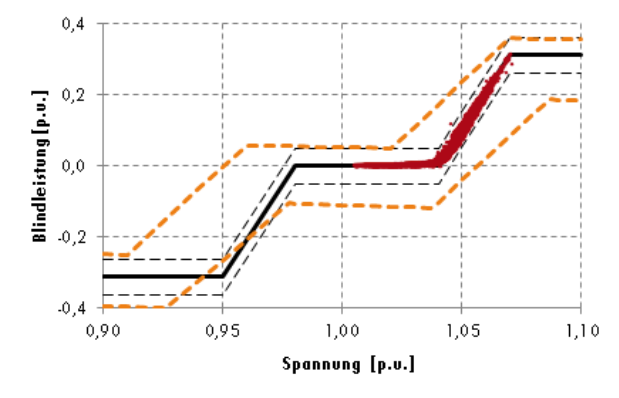
> **Modbus TCP/IP according Sunspec** for the inverter interface

Standards are an essential building block for energy management

Voltage Control

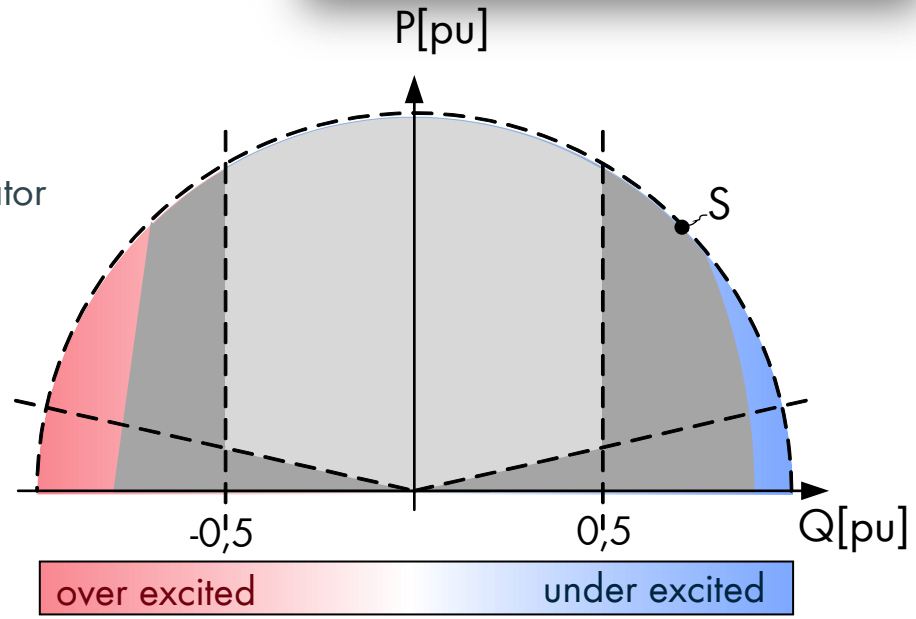
… by providing reactive power

- Range (VDE-AR-N 4105): $0{,}90_{\text{under excited}} \leq \cos\varphi \leq 0{,}90_{\text{over excited}}$
- Q fix / cos φ fix
- Q(V) / cos φ (P) characteristic



… during night (Q@Night)

- full 2-quadrant operation (until P=0)
  like phase shift operation of synchronous generator



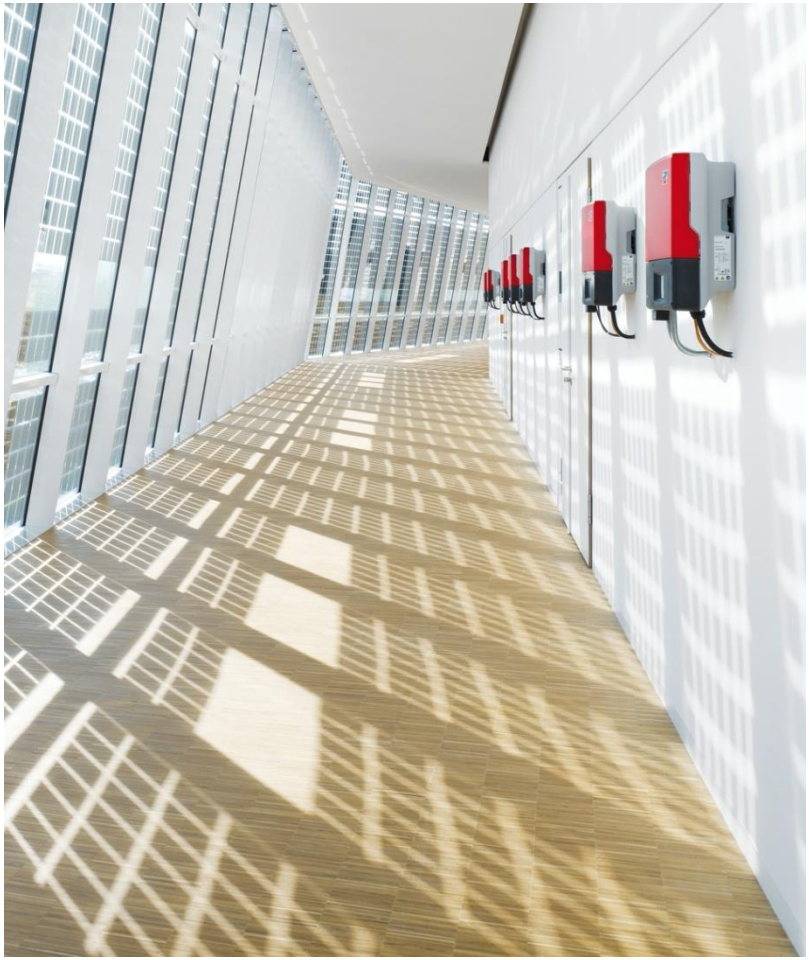
Synchronous generator (theory)
PV inverter generation 2010
New PV inverter generation

Conclusion

- PV is an important column of the „energy transition“ in GER/EU
- Battery systems improve the grid integration of solar systems
- PV battery systems according the German market incentive program set a new benchmark for grid optimized operation:
  - 60 % power limitation of installed PV power (in future 50%?)
  - contribution to frequency and voltage control
- Energy management on building level based on weather prognosis will be a key factor for the integration of renewables in the future
- Energy storage and management is a key industry in the future
- Public participation „at home“ is a condition for the acceptance of the „energy transition“ by the citizens

» PV self-consumption of electricity produced from PV panels is beneficial to the energy system

Thank you for your attention!



ENERGY THAT CHANGES

Prof. Bernd Engel

Representative of the Board

for grid integration

Bernd.Engel@SMA.de

SMA Solar Technology AG

Sonnenallee 1

D-34266 Niestetal

www.SMA.de