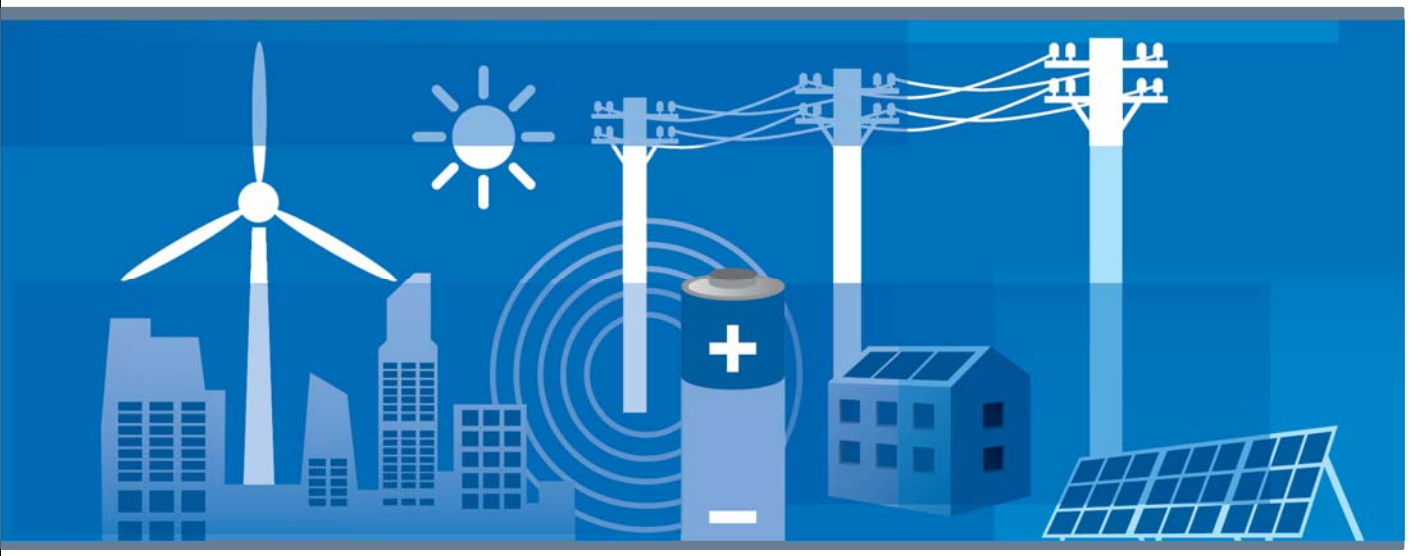
Berner Fachhochschule
Haute école spécialisée bernoise
Bern University of Applied Sciences

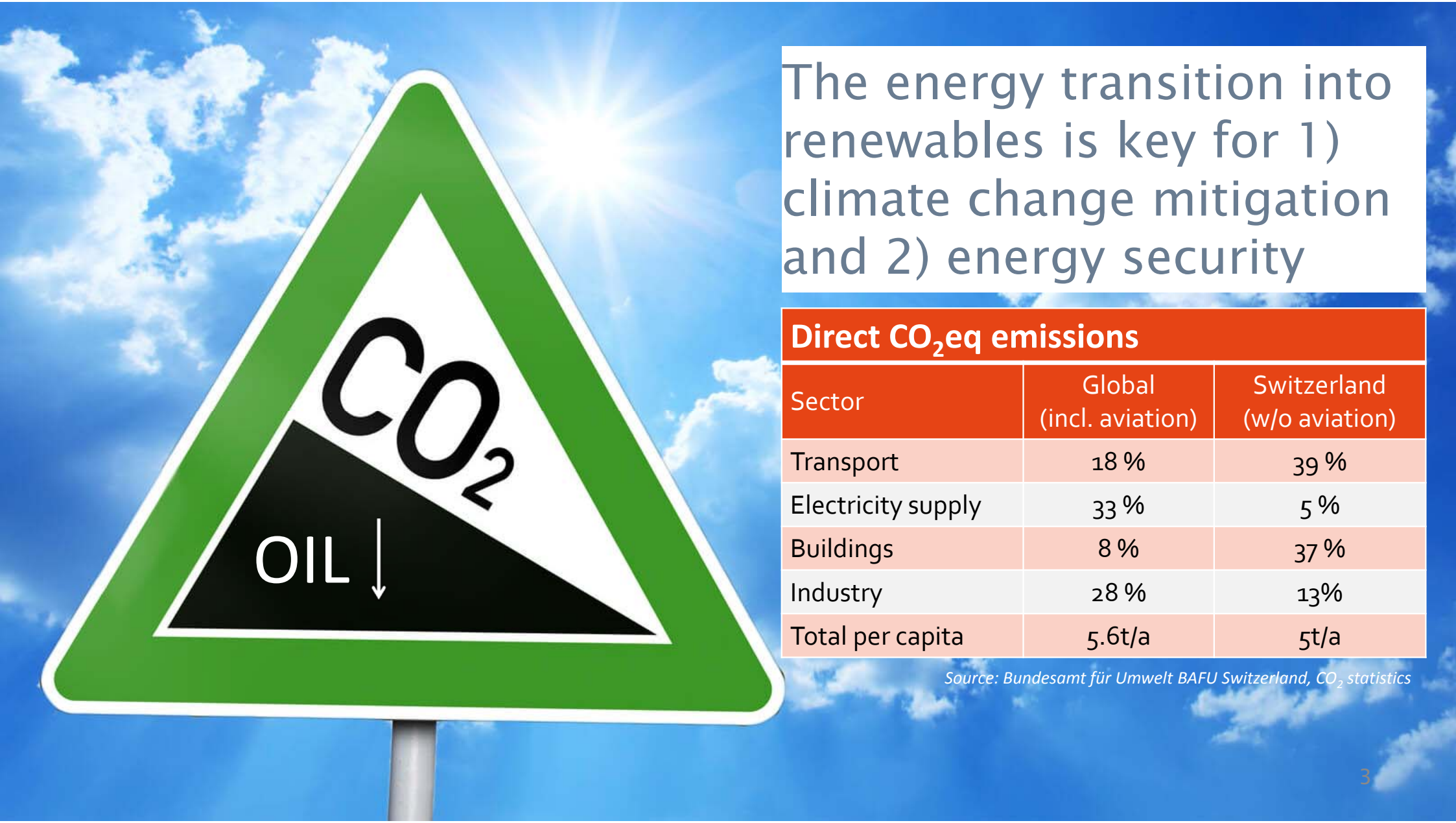


# Integration of Renewable Energy through Prosuming

Dr. Alejandro Santis: alejandro.santis@bfh.ch
BFH-CSEM Energy Storage Research Centre: www.bfh.ch/energy

- Institute of Energy and Mobility Research / Bern University of Applied Sciences


- Electrochemical energy storage systems
- Manufacturing technologies
- Mobility
- Business administration, innovation management and society
- Photovoltaics
- Power grids
- Hydrogen systems
- Optimization of solar energy use

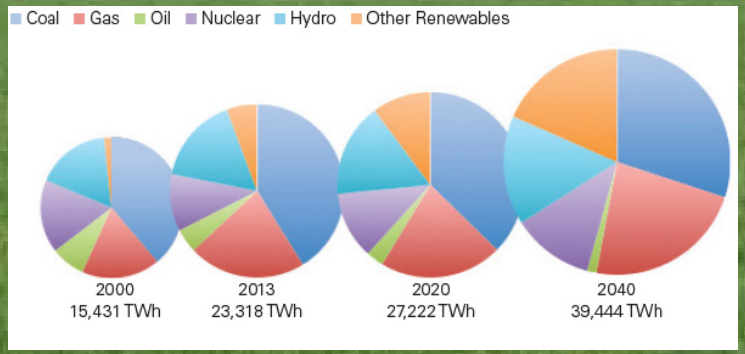



# The energy transition into renewables is key for 1) climate change mitigation and 2) energy security

| Direct $CO_2$eq emissions | | |
|---|---|---|
| Sector | Global (incl. aviation) | Switzerland (w/o aviation) |
| Transport | 18 % | 39 % |
| Electricity supply | 33 % | 5 % |
| Buildings | 8 % | 37 % |
| Industry | 28 % | 13% |
| Total per capita | 5.6t/a | 5t/a |

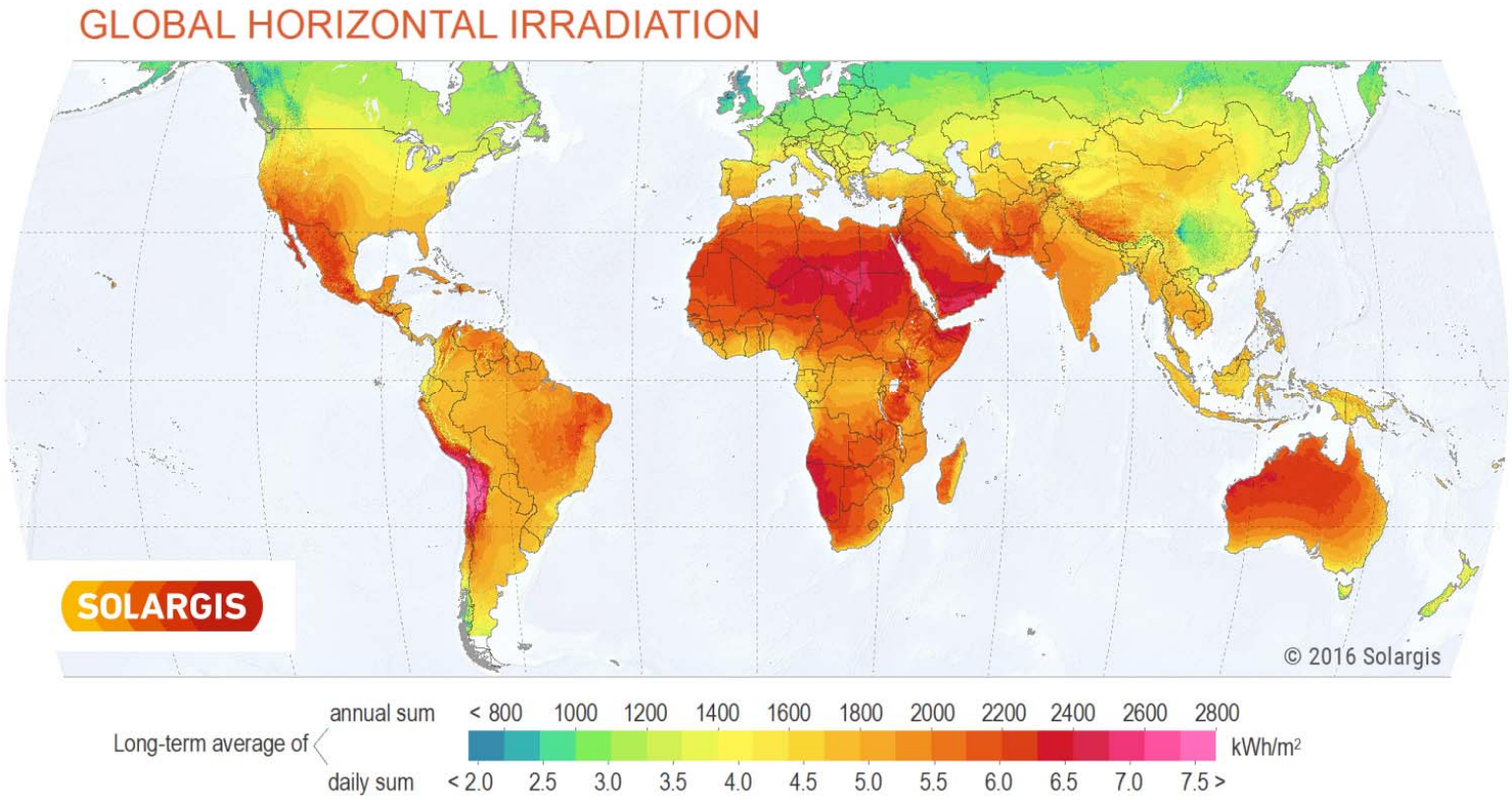
*Source: Bundesamt für Umwelt BAFU Switzerland, $CO_2$ statistics*

# Renewable electricity



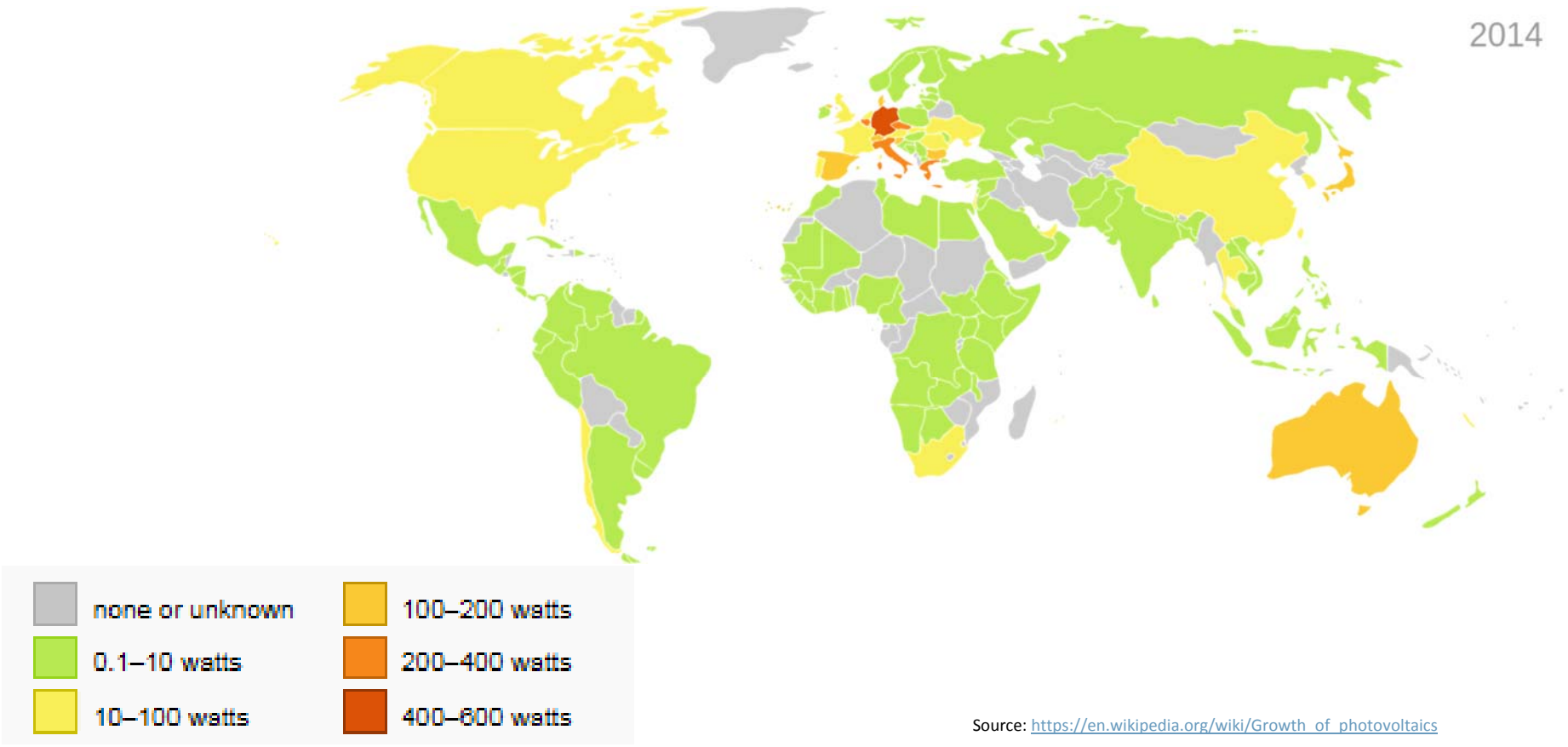

*Source: IEA, World Energy Outlook* (WEO-2015)

# Solar Energy Harvesting Potential




*Source: www.solargis.com; http://solargis.com/products/maps-and-gis-data/free/download/world*

# Installed PV in watts per capita




Source: https://en.wikipedia.org/wiki/Growth_of_photovoltaics

11

# SOLAR

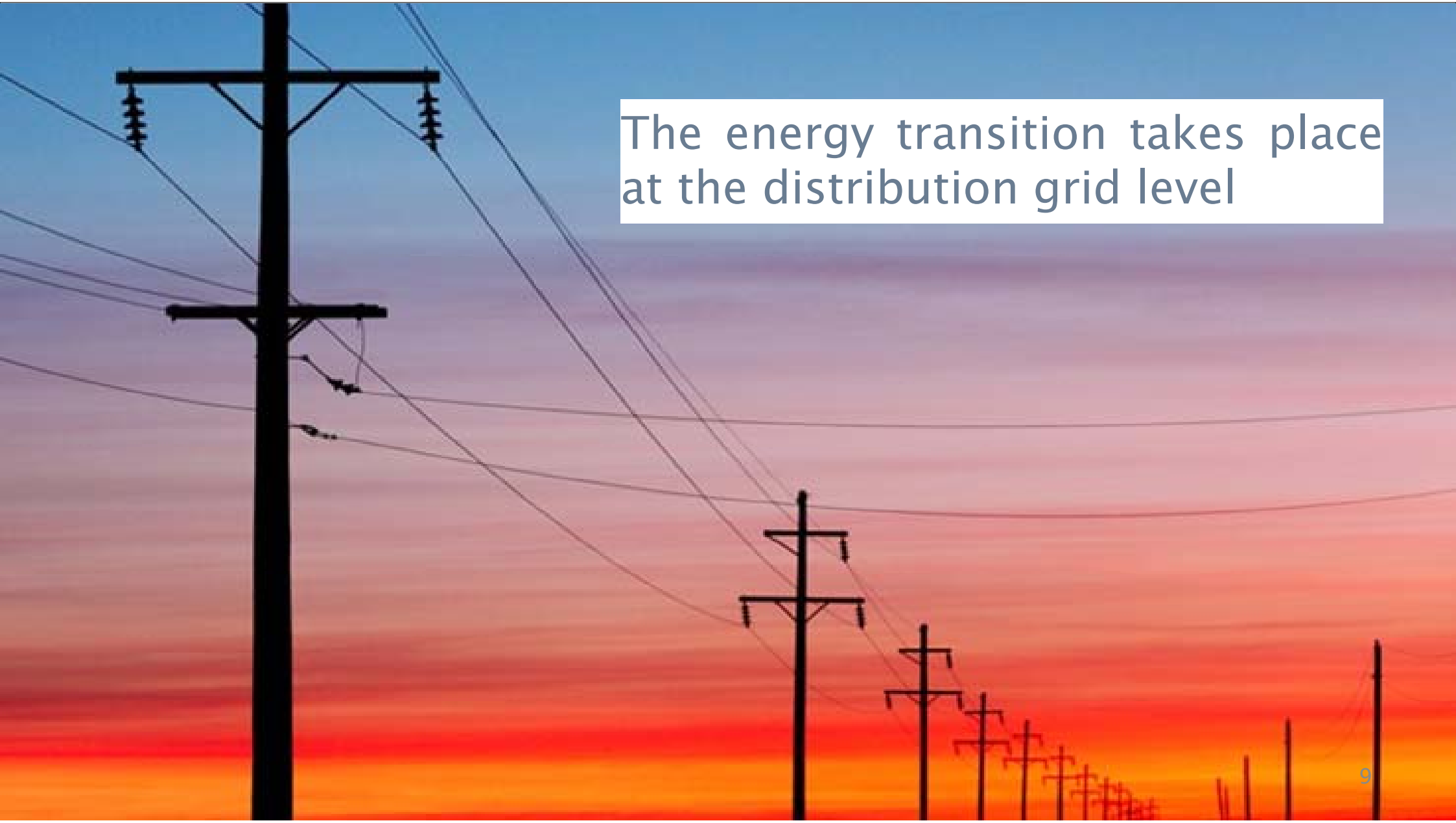
Solar panels, deployed on individual homes and businesses, shared among communities or as large-scale solar facilities, have become less expensive and more efficient in recent years. That's making it competitive with other technologies and driving a rapid growth in solar adoption.

Drop in the price of solar modules (per watt) since 2008

↓85%

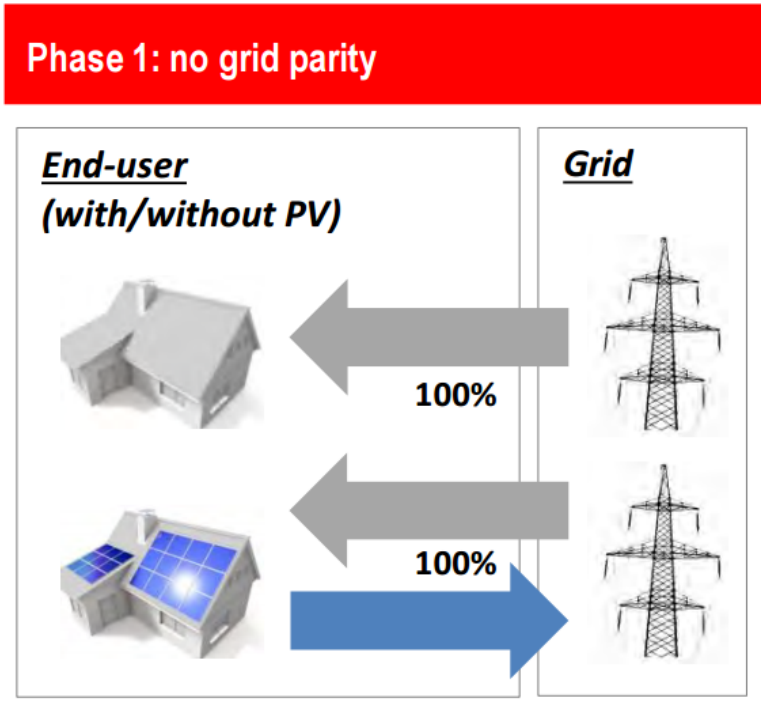
Source: Goldman Sachs Global Investment Research, PV Insights

# We are heading towards a decentralization of energy production


The energy transition takes place at the distribution grid level

# Two different worlds: producers and consumers

Grid parity for PV+Storage will change the business models of utilities



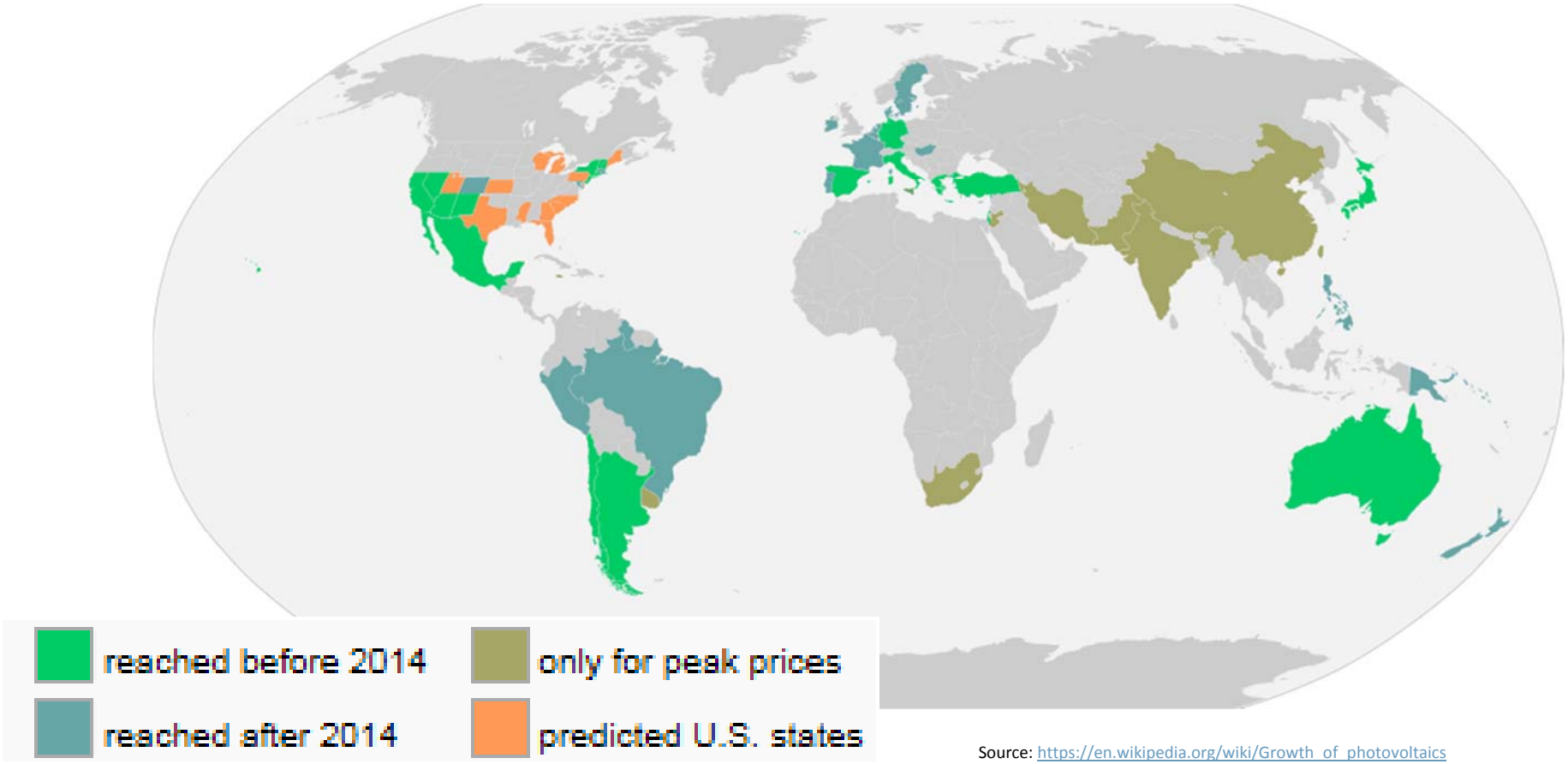

- 100% energy procurement from utility

- Funding model
- Growth controlled by funding

- No reduction of sales
- High peak loads
- High investments in grid infrastructure

Source: swiss utility solutions, Präsentation an der 13. Nationalen PV-Tagung, 2015

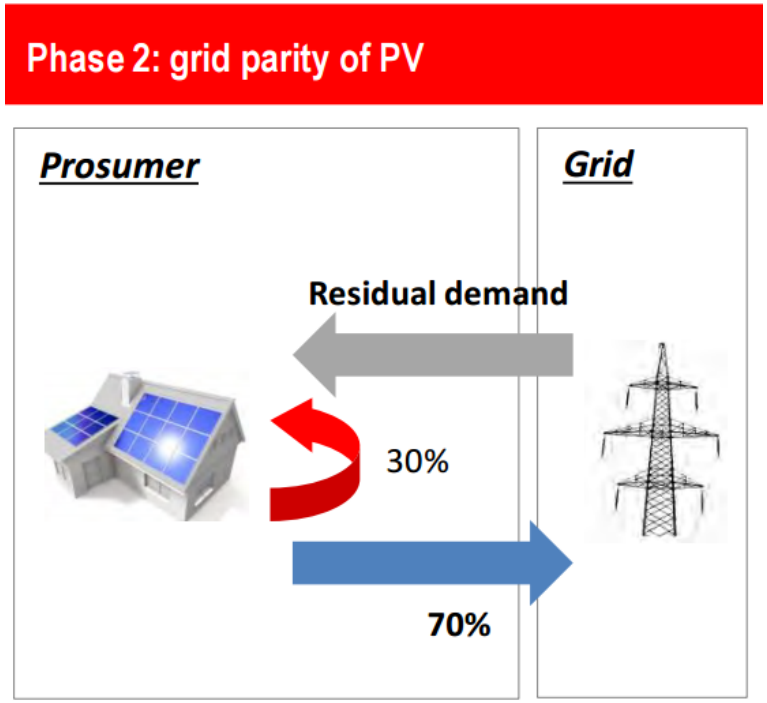
# Grid parity for solar PV around the world




Source: https://en.wikipedia.org/wiki/Growth_of_photovoltaics

# Prosumers – PV production becomes more profitable

Grid parity for PV+Storage will change the business models of utilities




- Own consumption regulation
- Is the PV-production at the same time as the need of electricity: own consumption
- Otherwise the residual demand or a surplus of production is balanced by the grid

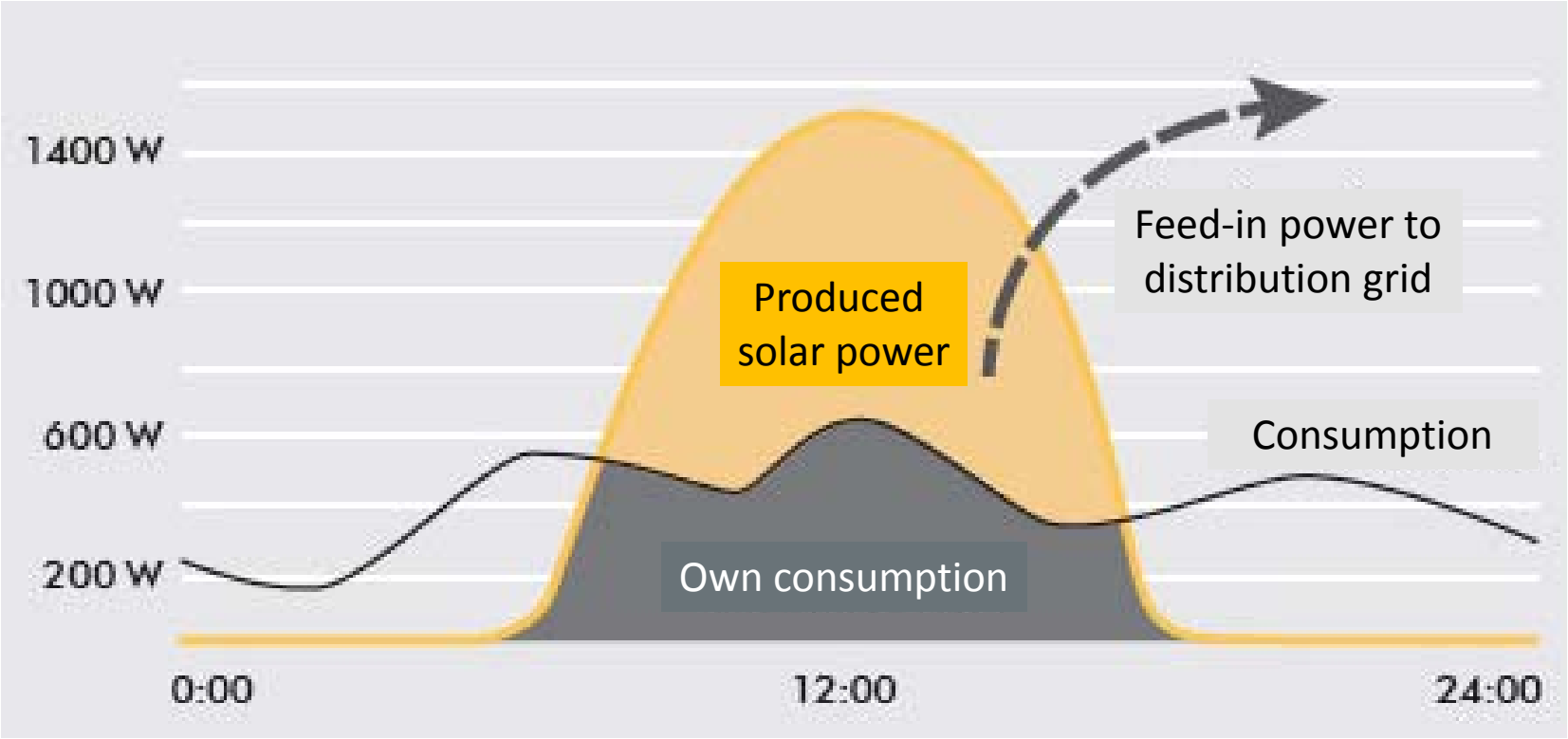
- PV-production profitable
- Growth can be partly controlled by tarifs

- Reduction of sales (grid and energy)
- High peak loads
- High investments in grid infrastructure

Source: swiss utility solutions, Präsentation an der 13. Nationalen PV-Tagung, 2015

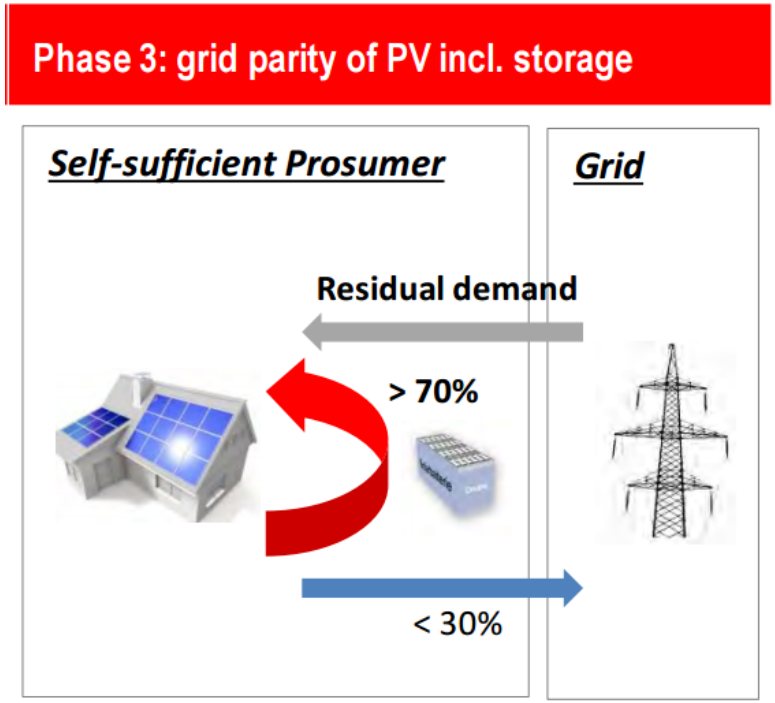
# Wihout Energy Storage

## Unused solar power is fed into the distribution grid



# Prosumers with solar energy storage

Grid parity for PV+Storage will change the business models of utilities




Source: swiss utility solutions, Präsentation an der 13. Nationalen PV-Tagung, 2015

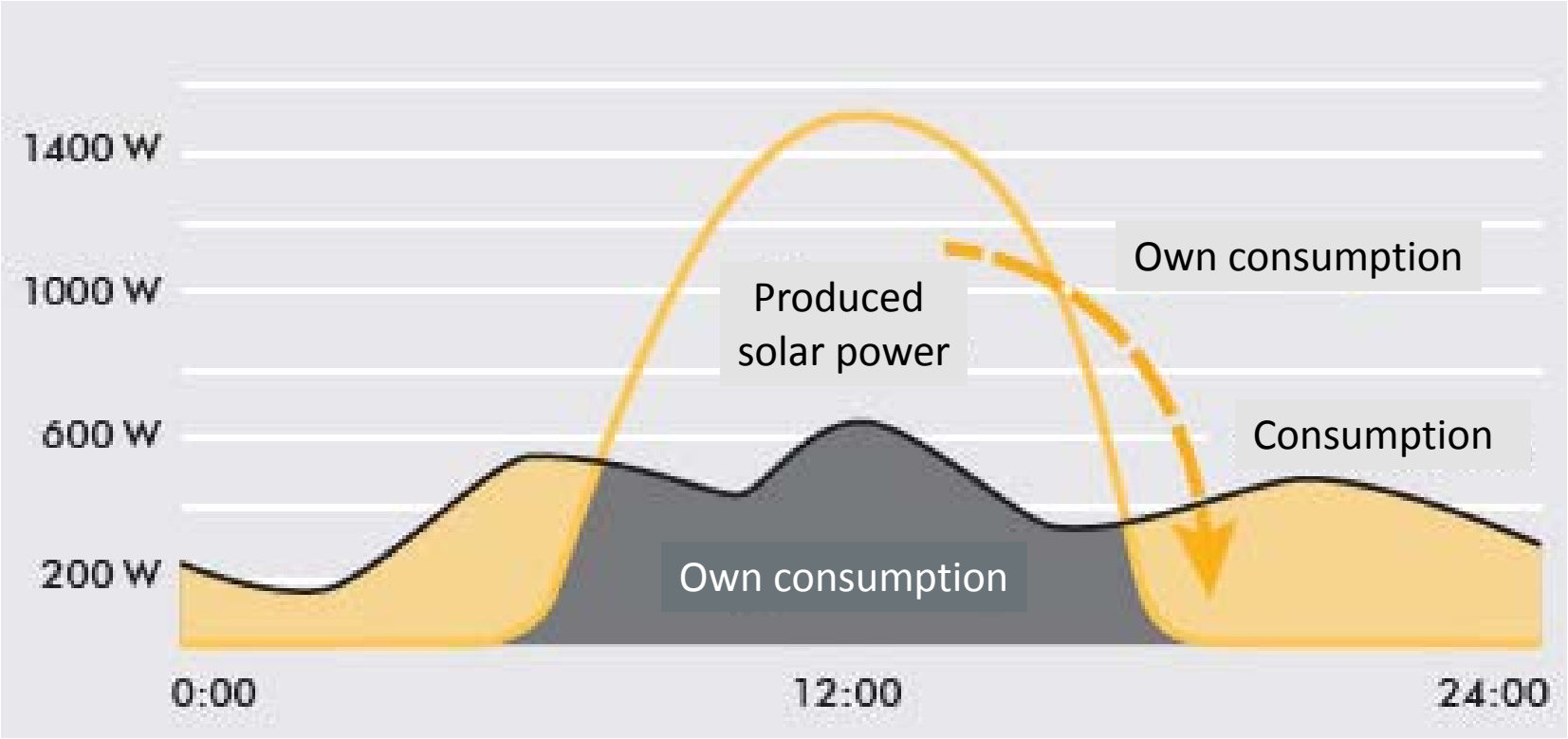
- Prosumer covers the electricity needs by PV-production and storage
- the residual demand or a surplus of production is balanced by the grid

- PV-production and storage profitable
- Growth can't be controlled

- Massive reduction of sales (grid and energy)
- Depending on utility (and regulation):
  - Maximum peak load
  - Investments in grid infrastructure

# With Energy Storage

## Produced solar power is stored and self-consumed

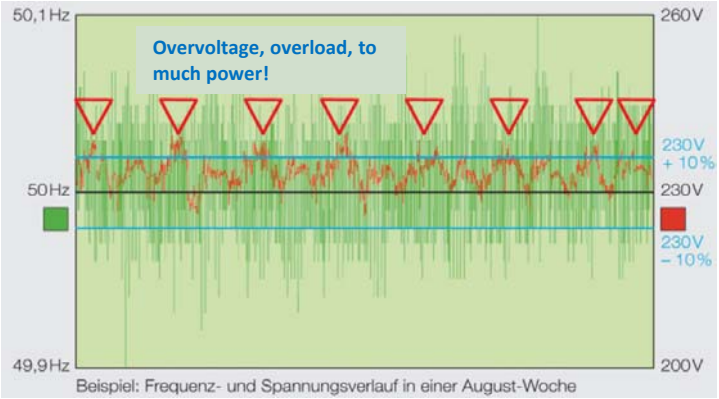


# Challenges for the distribution grid operator

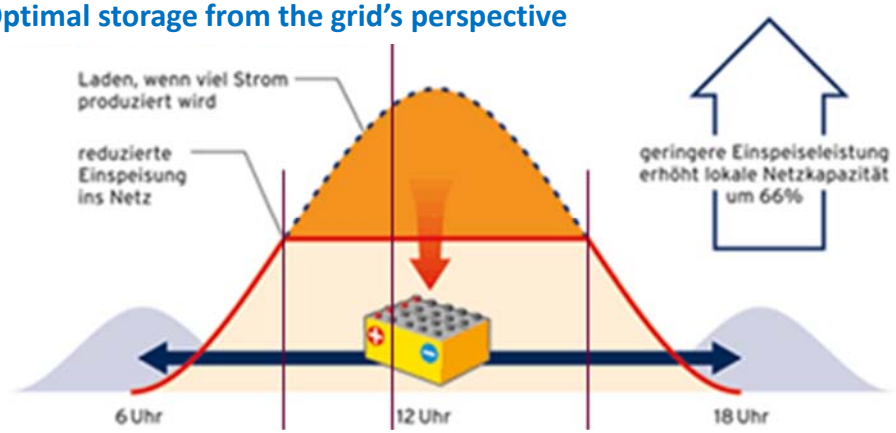
- Benefits for prosumers
  - Shifting of solar generated power usage to the night
  - Increase of self-consumption and profitability of the installed system
  - Reduction of electricity purchase from the grid
  - Cost advantage when PV-power is consumed

- Benefits for grid operators
  - Smoothing of feed-in peaks (peak-shaving)
  - Avoidance of overvoltages in the distribution grid (buffering of excess energy)
  - Voltage control in the local grid
  - Increase of the local grid capacity without additional infrastructure

**Conventional storage**




**Optimal storage from the grid's perspective**

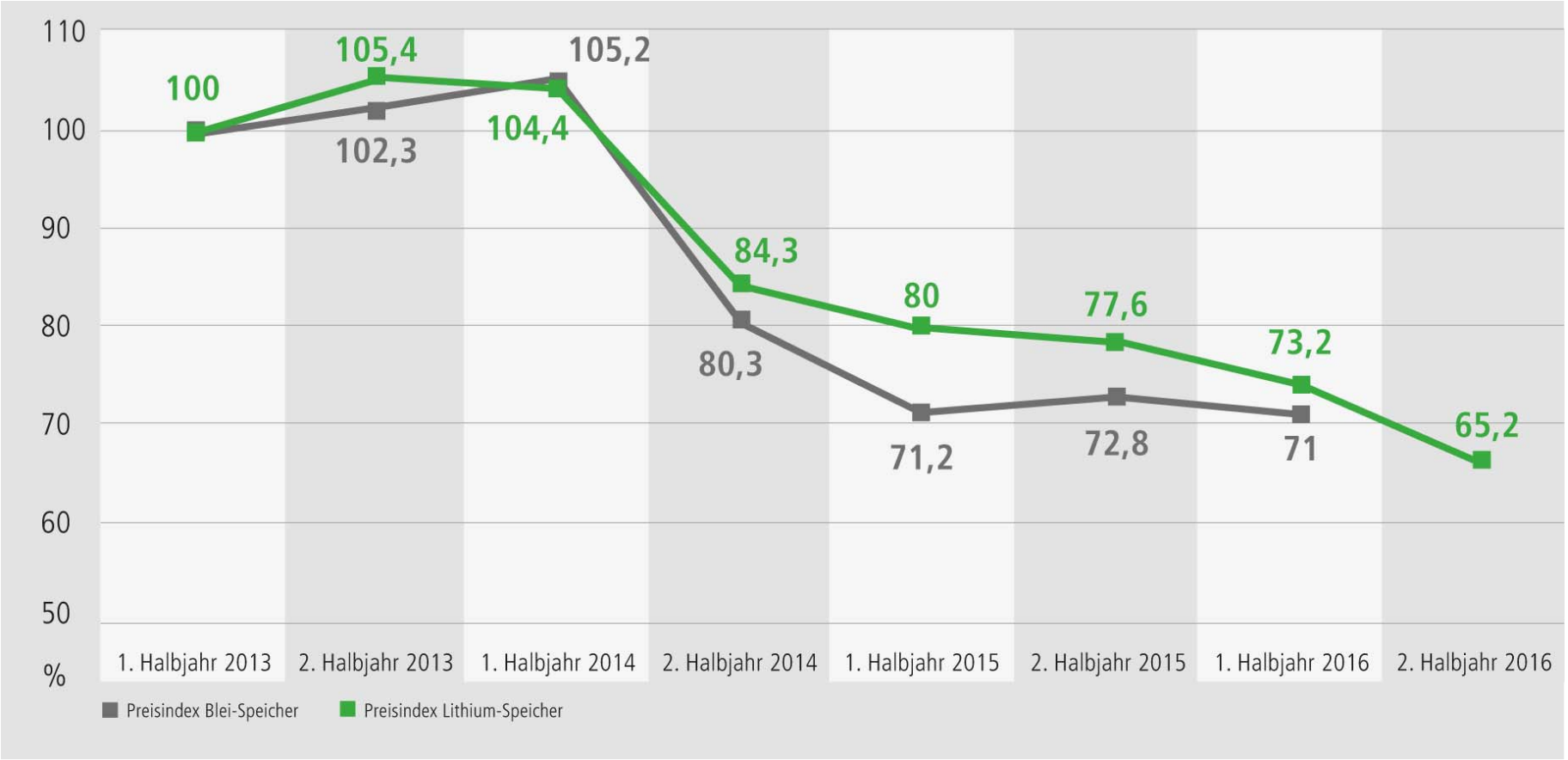





Quelle: Arbeitskreis Energieberatung - 49. Tagung |
Elektrische Energiespeicher in Gebäuden | Lukas Quurck |


# E-Mobility and PV increase the ROI and lower the $CO_2$-footprint

# Prices for solar energy storage continue falling



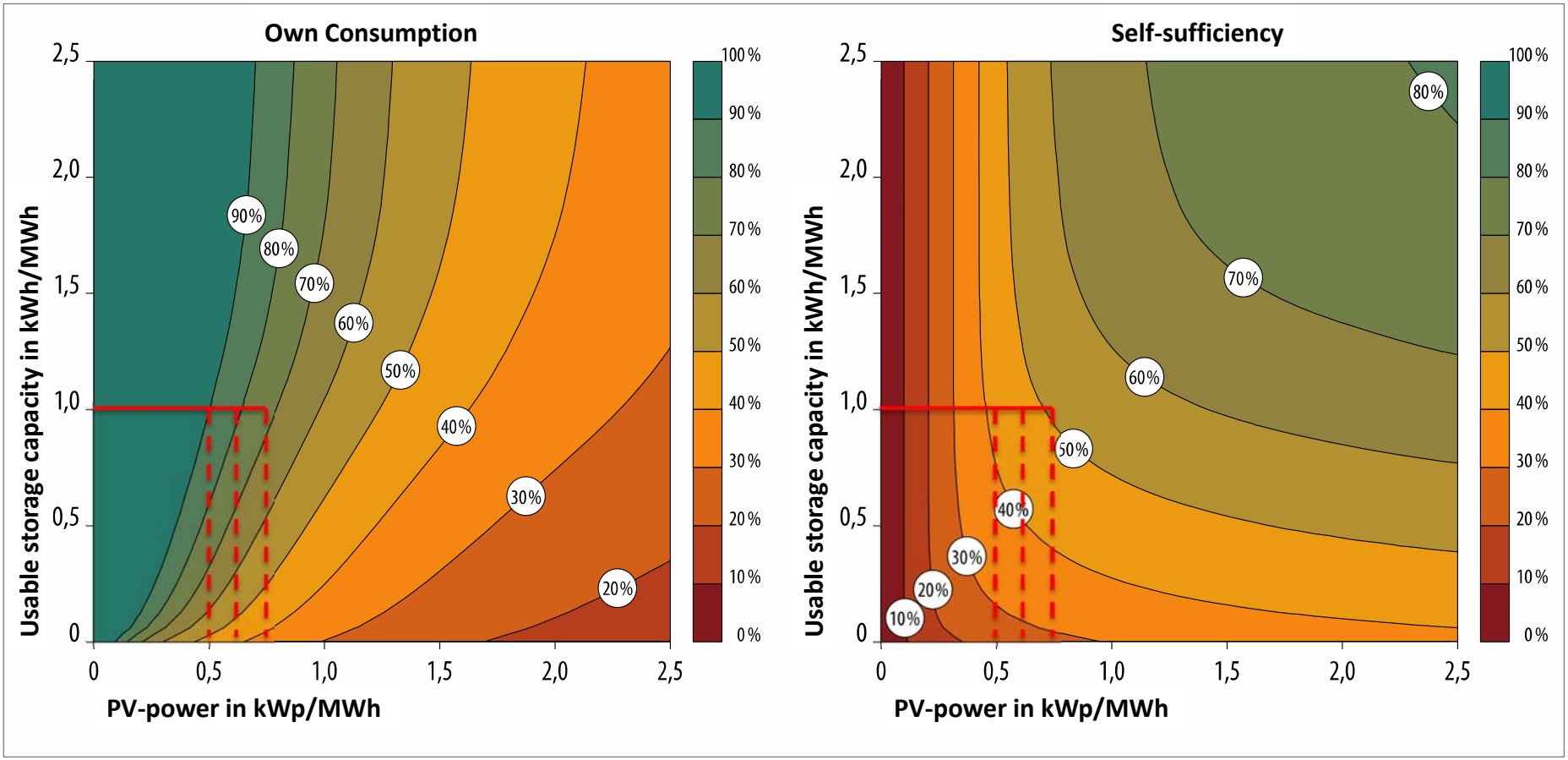

Start: 1. Halbjahr 2013 mit 100 %. Hinweis: Der Preisindex der jeweiligen Speicher-Technologie wird auf Basis des durchschnittlichen Speicherpreises (Größenklassen bis 10 kWh) vom BSW-Solar mit Unterstützung der ees Europe ermittelt.

| | Tesla Powerwall (7kWh) | Varta Engion Home 5.8 kW (2.8 kW System plus 6 Module) | RWE HomePower Storage Eco 9.0 | IBC Solar SolStore 6.5 Li | Sonnenbatterie eco 8.0 | Akasol neeoQube |
|---|---|---|---|---|---|---|
| Price | 4’216 € * | 7’703 € | 12’259 € | 7’500 € | 11’300 € | 7’150 € |
| kWh (usable) ** | 5.6 | 5.2 | 7 | 4.7 | 8 | 4.4 |
| Price/Energy | 753 €/kWh | 1’480 €/kWh | 1’750 €/kWh | 1’595 €/kWh | 1’412 €/kWh | 1’625 €/kWh |
| Weight | 100 kg *** | 126 kg | 200 kg | 95 kg | 230 kg | 62 kg |
| Weight/Energy | 18 kg/kWh | 27.5 kg/kWh | 28.5 kg/kWh | 20.2 kg/kWh | 28.75 kg/kWh | 14 kg/kWh |
| Charge cycles | 5’000 | 14’000 | 8’000 | 5’000 | 10’000 | 5’000 |
| Prices/Charge | 0.15 €/kWh | 0.11 €/kWh | 0.22 €/kWh | 0.32 €/kWh | 0.14 €/kWh | 0.33 €/kWh |
| Warranty | 10 y | 7 y for the System, 10 y for the cells | 10 y | 10 y | 10 y on the cells | 10 y or 5’000 cycles |
| Features | | $LiFePO_4$ cells (lifespan 20 y) | Integration in smart home systems | Approx. 15 y lifespan | 100 % DoD, long lifetime | compact, charges in 1 h, 20 y lifespan |

* Wholesale price incl. Inverter from SMA for 1.543 € (inverter only for illustration purposes)
** with regard to discharge capacity (the standard value for Tesla is 80 %)
*** without inverter

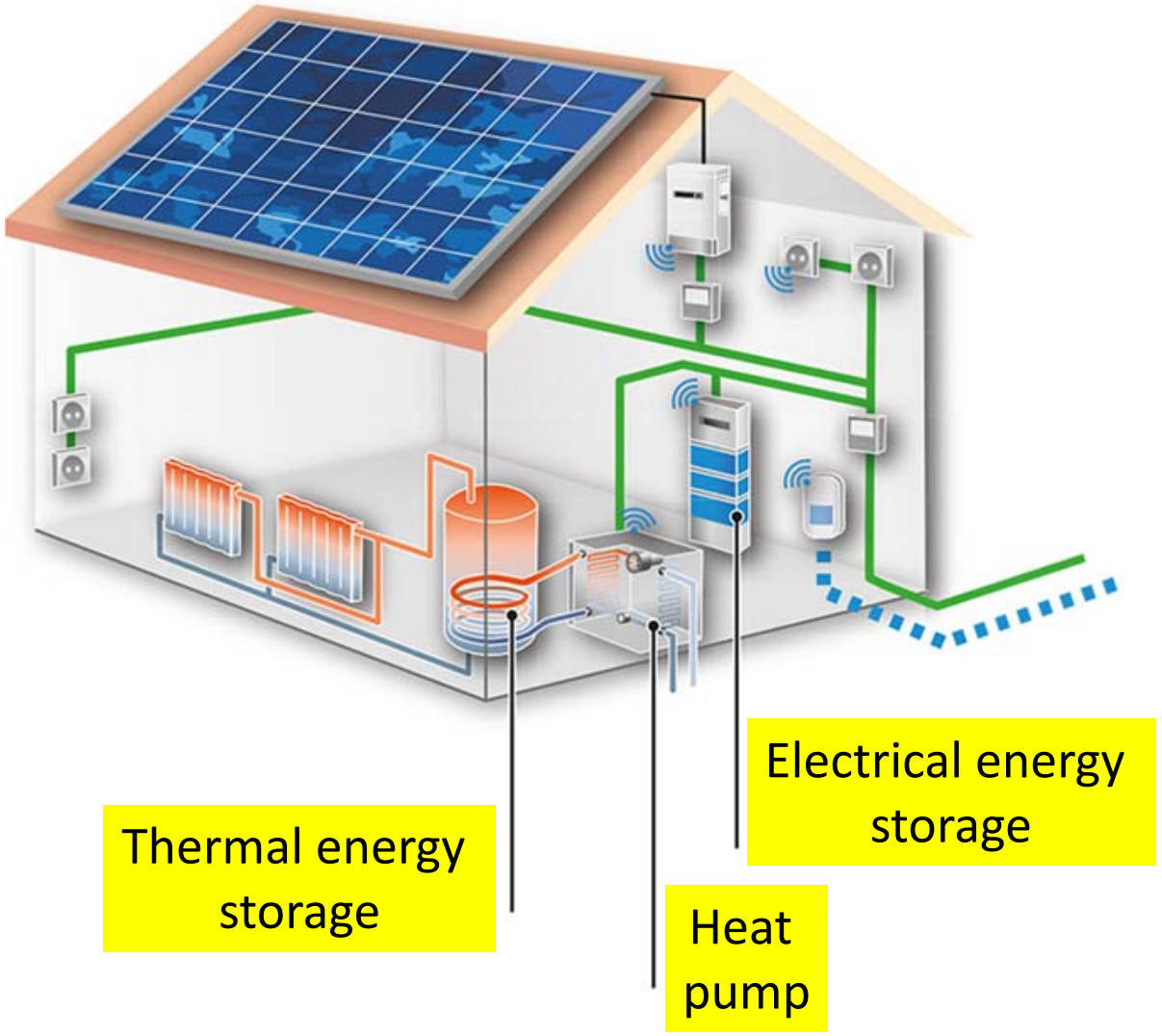
# Affordable solar energy + storage ≠ complete independence

Grafiken: Solarpraxis AG /Harald Schütt



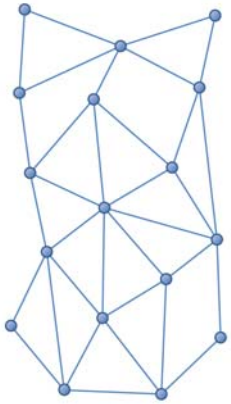
# Energy consumption in buildings

- Ca. 90 % of the energy in buildings is used for space and water heating. In a smart building, heat pumps can be operated with PV-power to store thermal energy, leading to an increase in own consumption.

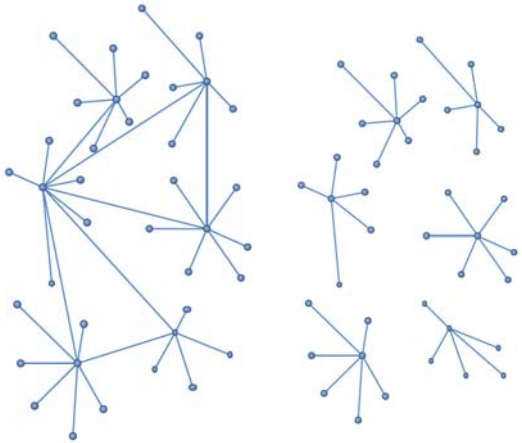


# Prosumer Market Models

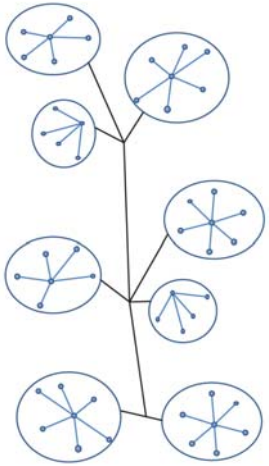
Peer-to-peer

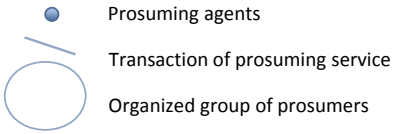


Prosumer-to-grid



Organized prosumer groups






*Source: Nature Energy, 16032, 2016*

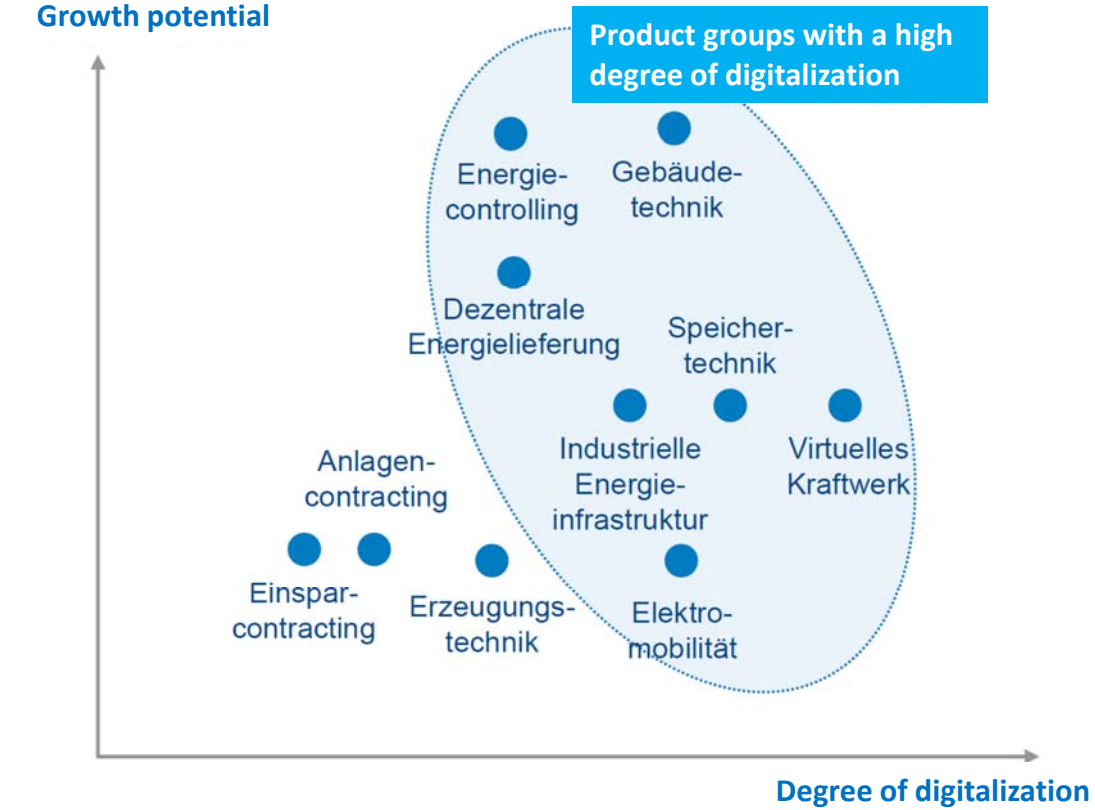
# Conventional consumers and new Prosumers in the grid

| Dimension | Conventional grid consumers | Smart prosumers |
|---|---|---|
| Resilience and self-healing | Operators respond to prevent further damage, focus is on reaction and protection of assets following system faults | Consumers or their devices can automatically detect and respond to actual and emerging transmission and distribution problems; focus is on prevention |
| Information and consumer involvement | Consumers are uninformed and non-participative in the power system | Consumers are informed, involved and active |
| Quality of energy services | Produced in bulk, typically through centralized supply | More modular and tailored to specific end uses, which can vary in quality |
| Diversification | Relies on large centralized generating units with little opportunities for energy storage | Encourages large numbers of distributed generation deployed to complement decentralized storage options, such as electric vehicles, with more focus on access and interconnection to renewables and V2G systems |
| Competitive markets | Limited wholesale markets still working to find the best operating models, not well suited to handling congestion or integrating with each other | More efficient wholesale market operations in place with integrated reliability coordinators and minimal transmission congestion and constraints |
| Optimization and efficiency | Limited integration of partial operational data and time-based maintenance | Greatly expanded sensing and measurement of grid conditions; technologies deeply integrated with asset management processes and condition-based maintenance |

*Source: Nature Energy, 16032, 2016*

# New business models go hand-in-hand with digitalization

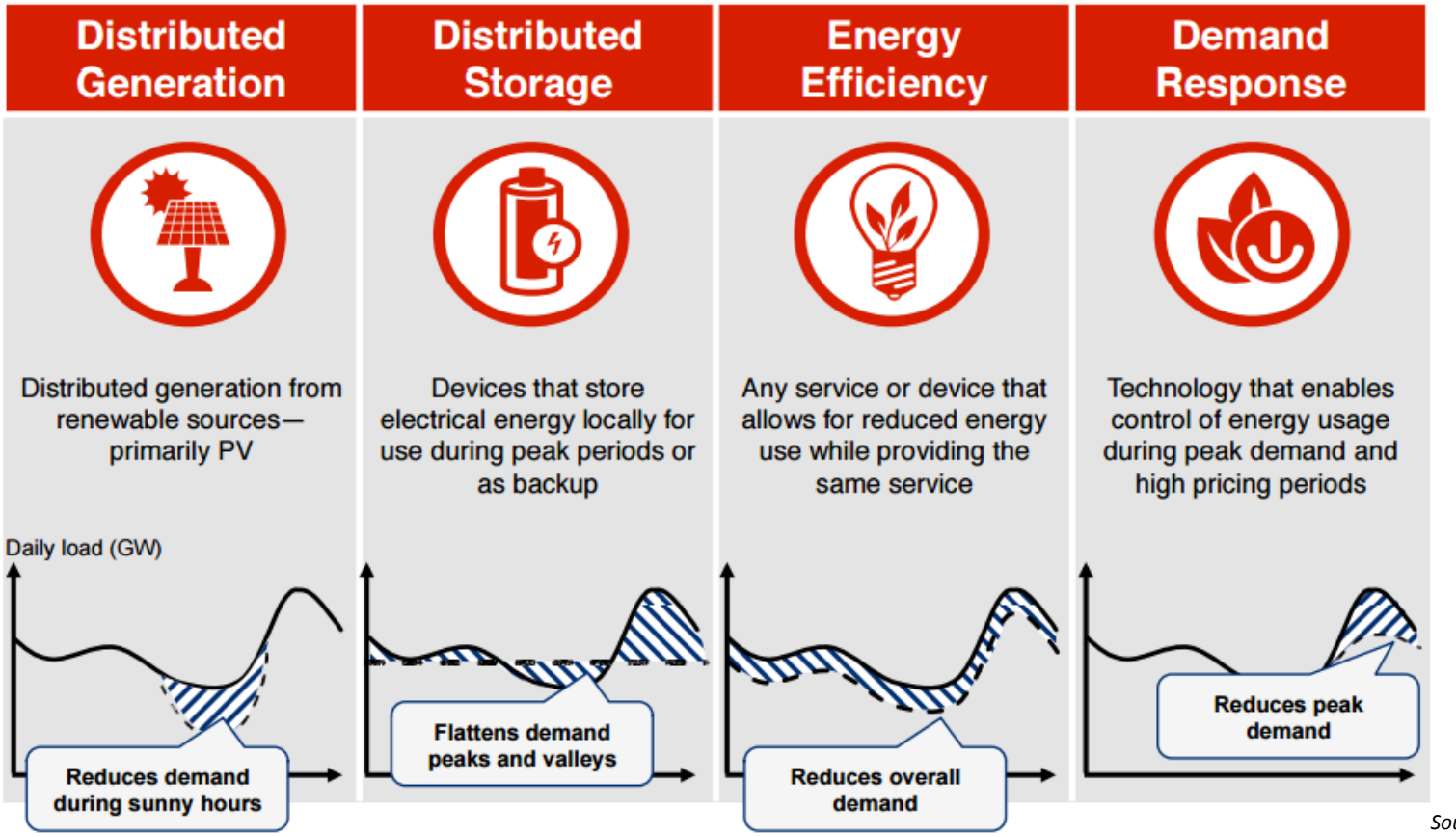
# Top 10 product groups for new business models




1) Hohes oder sehr hohes Wachstumspotenzial (Häufigkeit der Nennung)
Quelle: Arthur D. Little

- Three from 10 growing market products are either technology based or digital energy services
- High impact of cluster products from energy media and energy technology (e. g. storage, decentralized energy distribution, energy management, e-mobility)
- The conventional grid operator should adapt its business models to accomodate prosumers behavior with future grid operational challenges

# Different levels of E-Management




*Source: World Economic Forum, Future of Electricity 2017*

# Summary

- The energy transition towards more renewables is key to global warming mitigation.
- The energy transition is taking place through the interplay between decentralized energy production (prosumers) and the utilities at the distribution level.
- Grid parity for PV+Storage will change the business models of utilities.
- New business models through digitalization is needed on all levels.
- E-Mobility and PV will increase the ROI and lower the $CO_2$-footprint.

# Summary

- Increasing energy sources contribute to increasing complexity in grid management, while most utilities still operate along traditional lines. A change from centralized power distribution to decentralized smart grids, and investing in education at all levels to build capacity for handling the complexity, is required.

- Remote areas lack attention from central government, noting challenges to increasing access including high initial investment costs, fragmented policies, heavy subsidy dependence, low maintenance of infrastructure, and a dearth of innovative business models.

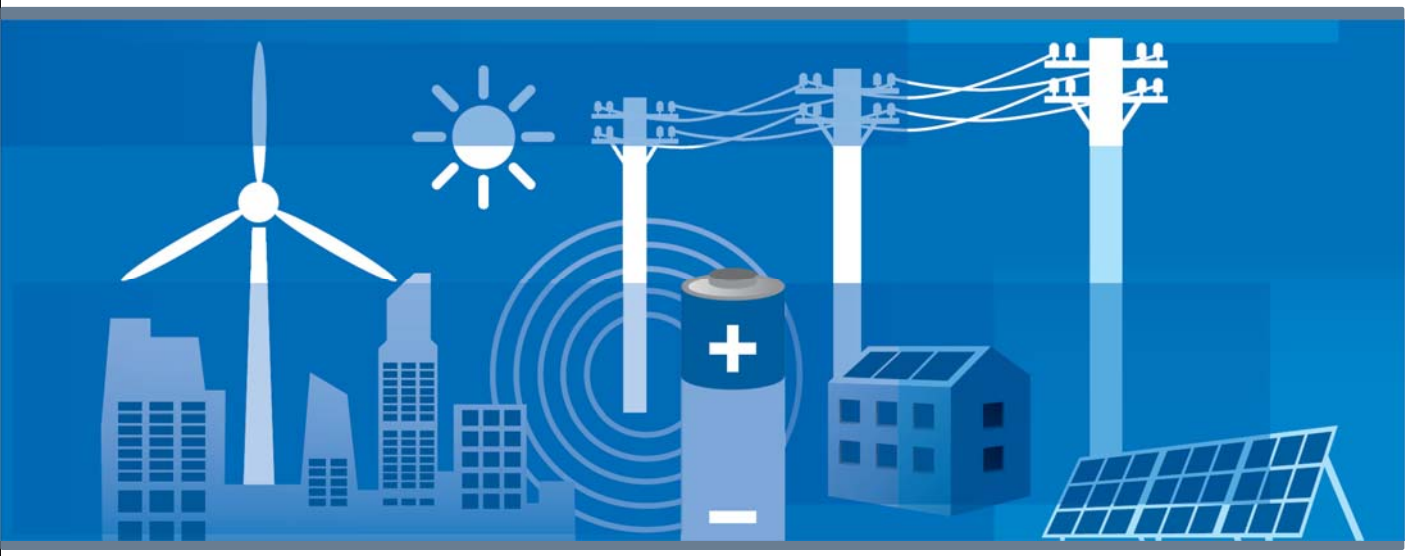
# Highly recommended literature

- Vaclav Smil, “Energy Myths and Realities” (2010)

- David MacKay, “Sustainable Energy, without the hot air” (regularly updated) downloadable https://www.withouthotair.com/download.html

- Vaclav Smil, “Energy Transitions” (2010)

Berner Fachhochschule
Haute école spécialisée bernoise
Bern University of Applied Sciences



# Questions?

Prof. Dr. Alejandro Santis: alejandro.santis@bfh.ch

BFH-CSEM Energy Storage Research Centre: www.bfh.ch/energy

- Institute of Energy and Mobility Research / Bern University of Applied Sciences