PV (and batteries?) integration into electricity grids

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Introduction

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PV and the public grid:
A dream team or a source of trouble?

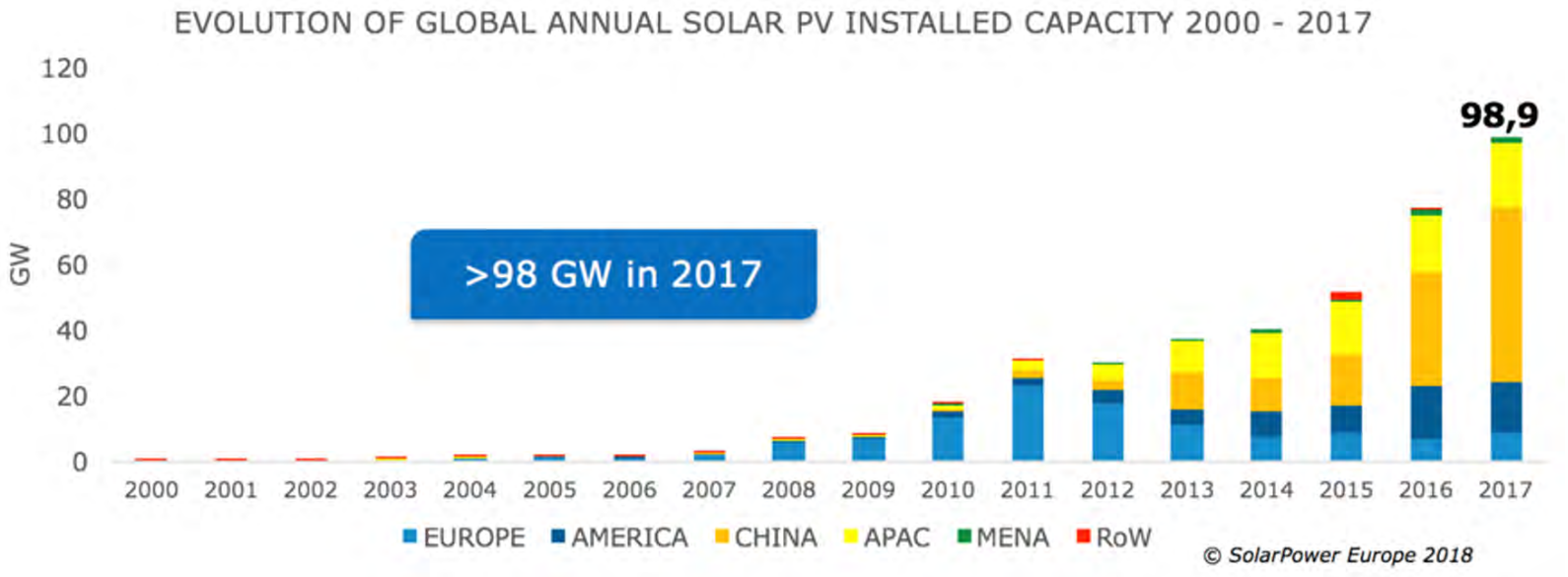
- More than 30 years experience show clearly: It works!
- For low shares of PV in the grid (low penetration), it is just simple. For high penetration rates there are some challenges.
- Meanwhile it is clear: PV is the main new power source and it offers great opportunities.
- A main game changer: Solar is available all over the world and the technology is ready.
- It is time to deal with.

Current market situation

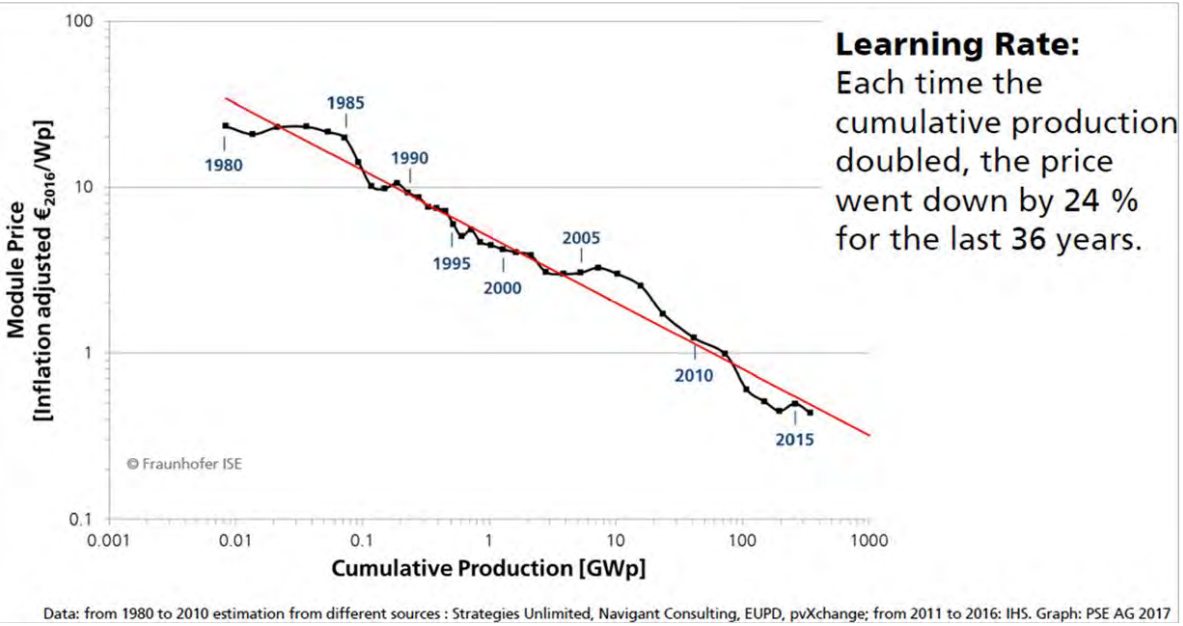
Current status, observed by Solar Power Europe

- Surpassing the 100 GW/year level in 2018
- A cost leader - and still improving
- The premier new power generation technology
- Market:
  - China makes the difference
  - The rise of India
  - The return of Europe
  - Emerging stars on the horizon
- .....

Evolution of annual installed capacity

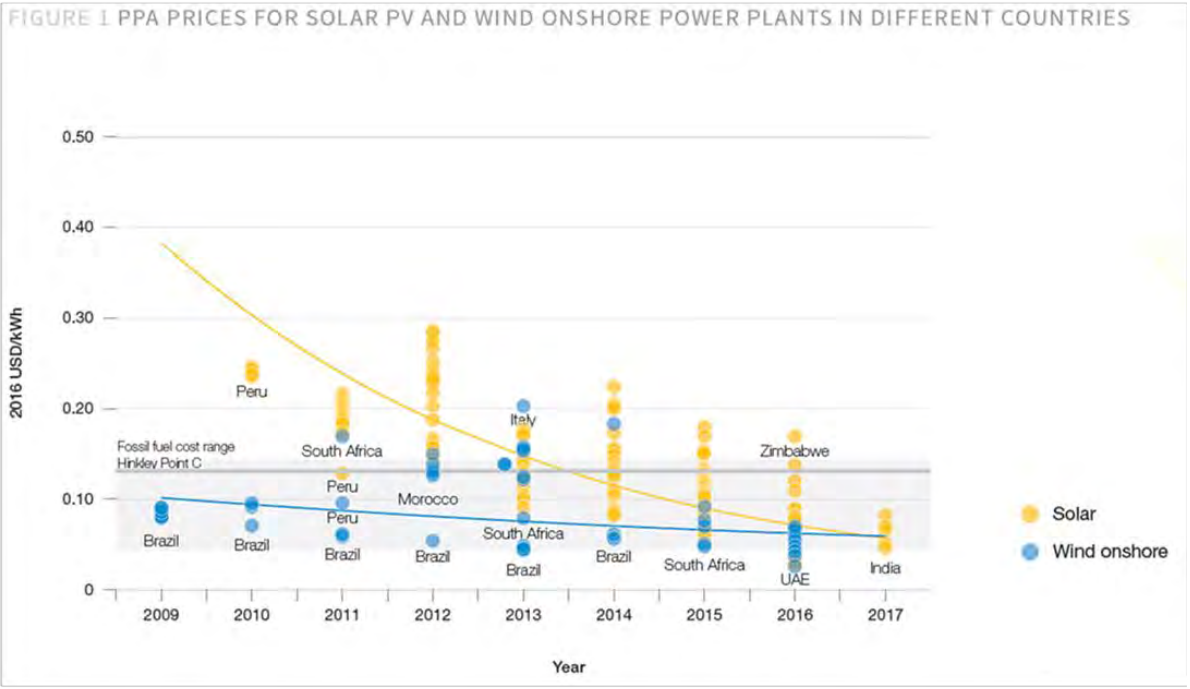


PV development shows a typical learning rate



- Module prices for orders > 1 MW are now in the range of 0.4 Euro/W_p
- Further price reductions are still possible, although from now on in small steps

PV reached the competitive generation cost level



- In many places of the world PV is meanwhile the most competitive power source

Solar Power Europe, 2017

IEA - PVPS Task 14

IEA-PVPS-Task 14: High Penetration of PV Systems in Electricity Grids

The activities are organized in subtasks as follows:

- Cross-cutting Subtask: Information Gathering, Analysis and Outreach
- Subtask 1: PV generation in correlation to energy demand
- Subtask 2: High PV penetration in local distribution grids
- Subtask 3: High penetration solutions for central PV generation scenarios
- Subtask 4: Smart inverter technology for high penetration of PV

IEC standards for PV grid connection

IEC - standards stand for high quality & performance

- TC 8: Systems aspects of electrical energy supply
  - JWG 10: Distributed Energy Resources Interconnection with the Grid
- SC 8A: Grid Integration of Renewable Energy Generation
  - WG 1: Terms and definitions of grid integration of r. e. generation
  - WG 2: Renewable energy power prediction
  - JWG 4: Grid code compliance assessment for grid connection of wind and PV power plants
  - AHG 3: Roadmap of grid integration of renewable energy generation
- SC 8B: Decentralized Electrical Energy Systems
- TC 82: Solar photovoltaic energy systems

Further IEC TCs with Related Scope

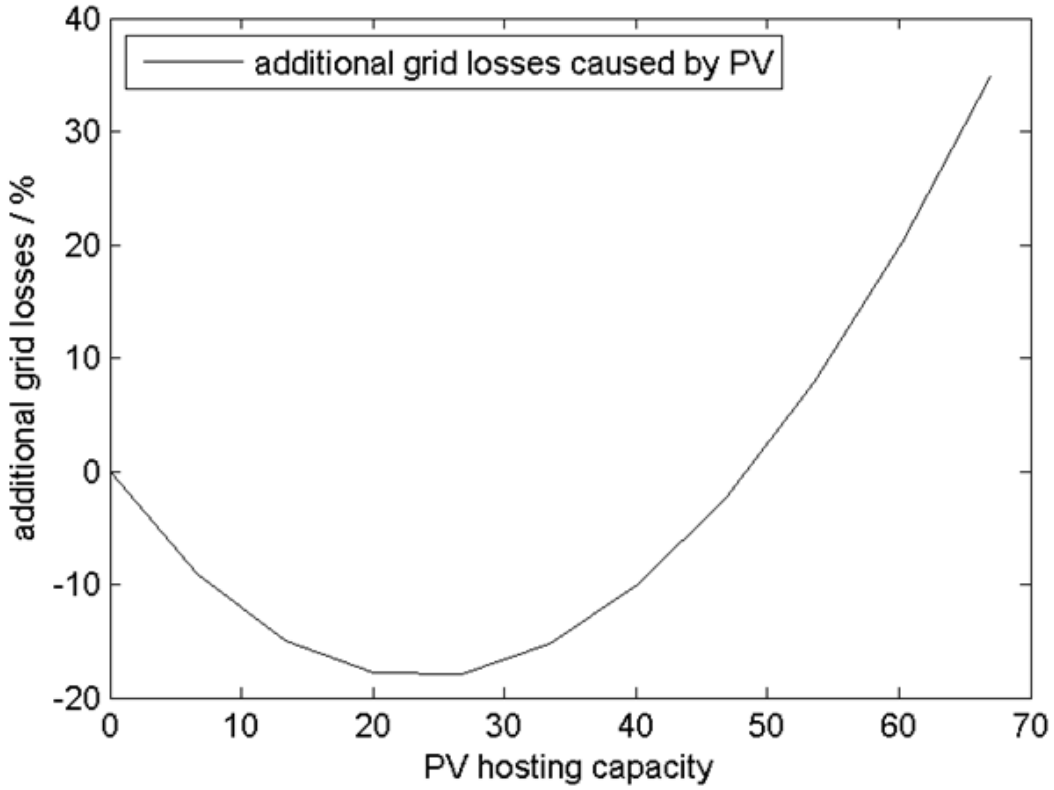
- TC 57: Power systems management and associated information exchange
- TC 64: Electrical installations and protection against electric shock
- PC 118: Smart grid user interface
- TC 120: Electrical Energy Storage (EES) Systems

Some selected simulation results

Some measures in high penetration scenarios

- RPC: Reactive power control
- APC: Active power curtailment
- Orientation of PV-modules
- Storage
- DSM: Demand side management, load control
- OLTC: On Load Tap Changer transformer

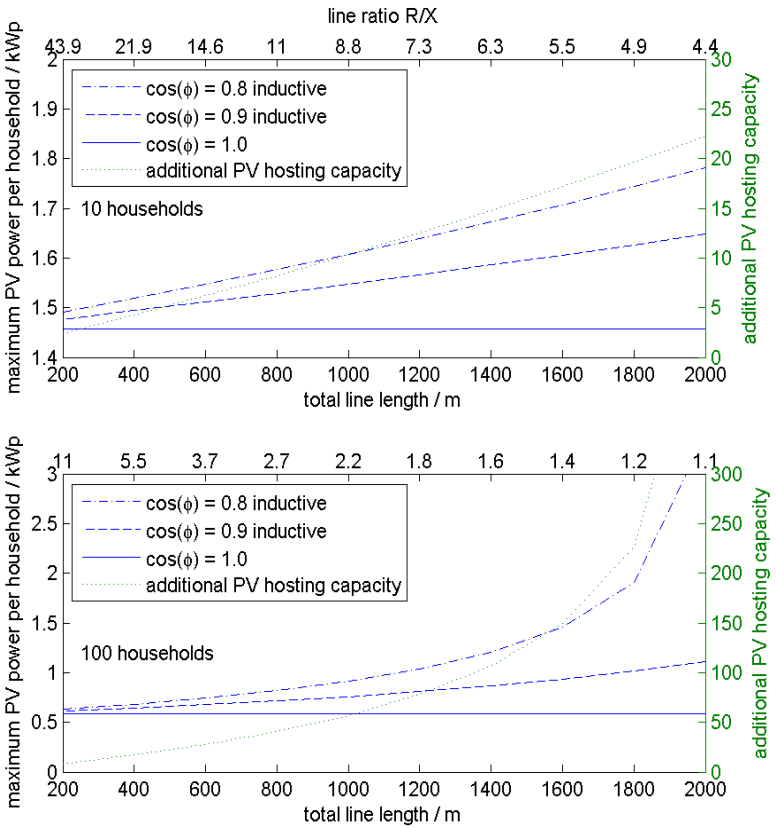
Reduced grid losses due to distributed generation



- Loss minimisation at 25% PV penetration

Source: Simulation of Distribution Grids with Photovoltaics by means of Stochastic Load Profiles and Irradiation Data

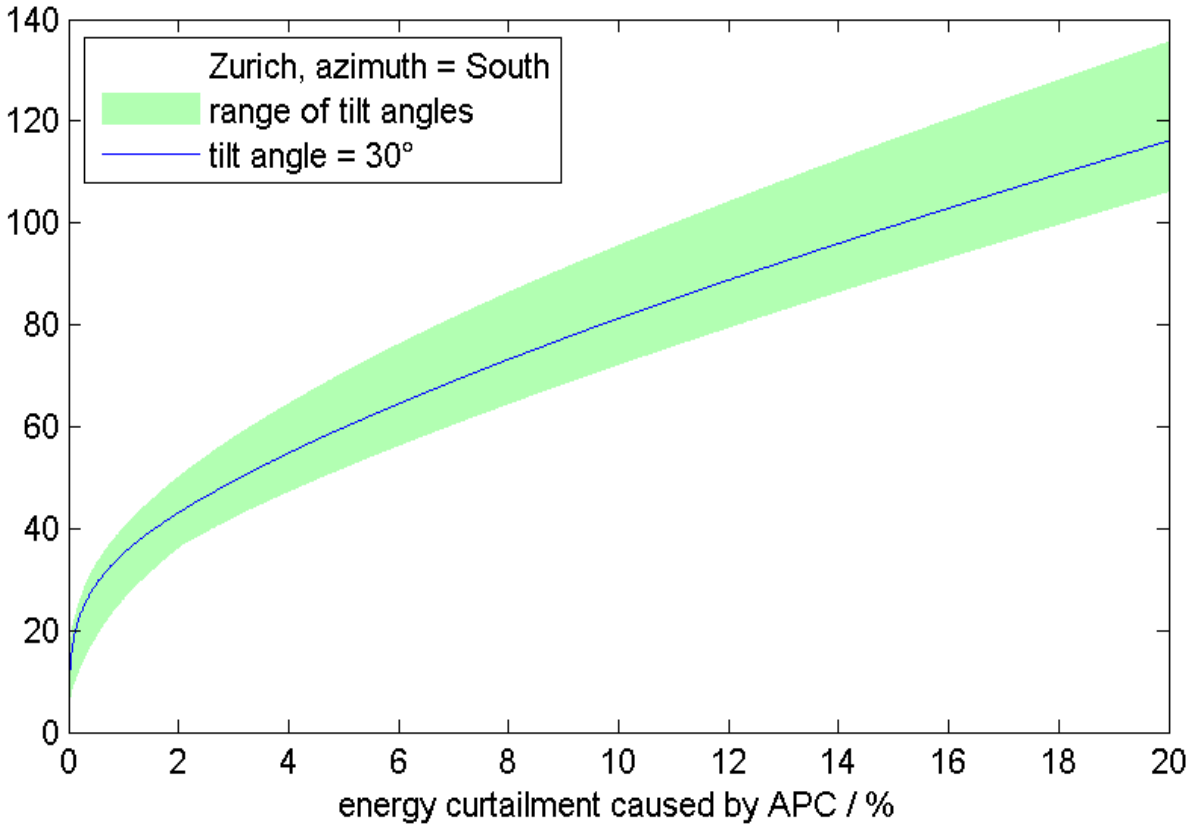
Reactive Power Control (RPC)



- Highly dependent on grid properties (R/X-ratio).
- No general statement possible.
- From almost no effect to doubling HC.

Source: Simulation of Distribution Grids with Photovoltaics by means of Stochastic Load Profiles and Irradiation Data

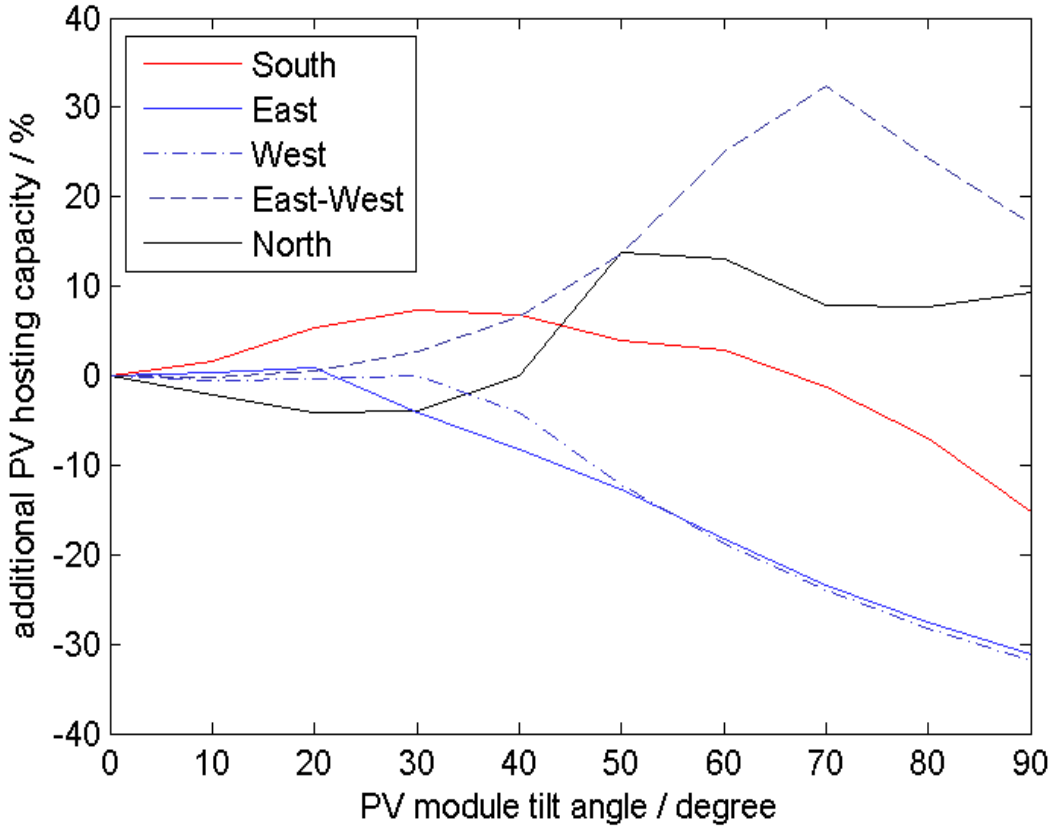
Active Power Curtailment (APC)



Source: Simulation of Distribution Grids with Photovoltaics by means of Stochastic Load Profiles and Irradiation Data

- Sacrifice 3% energy to increase the PV-hosting capacity by 50%.

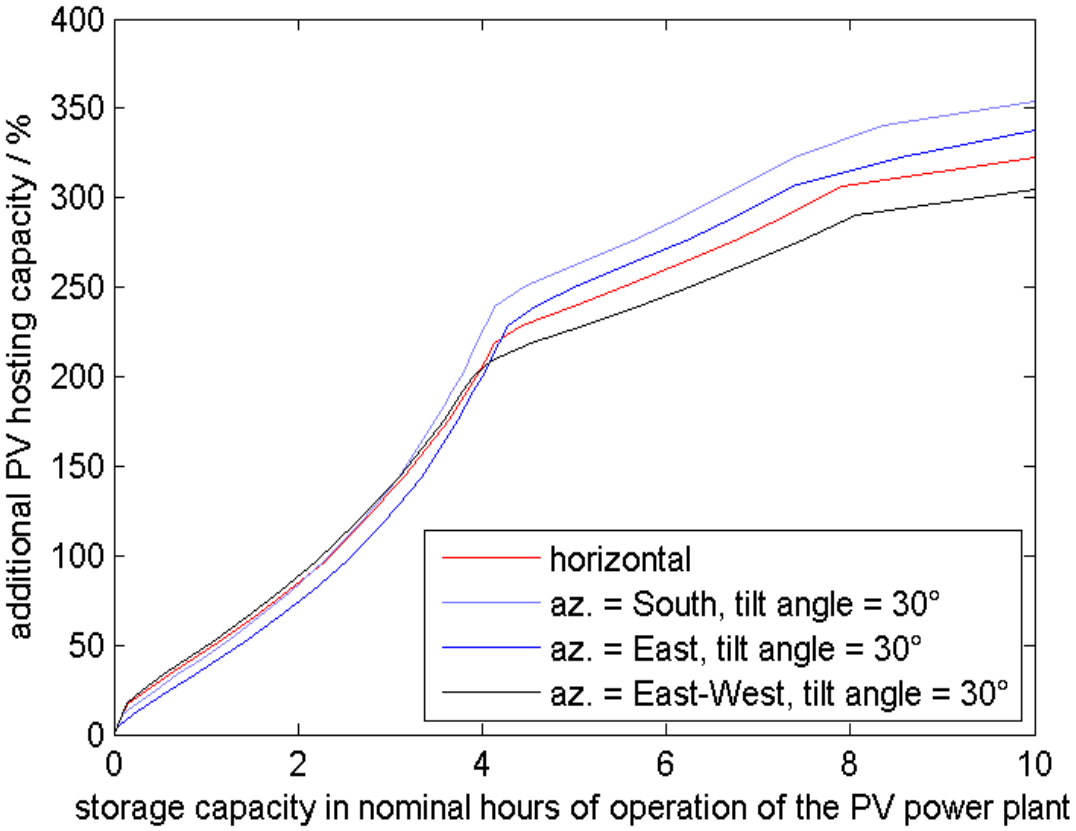
Different Orientation of PV Generator



Source: Simulation of Distribution Grids with Photovoltaics by means of Stochastic Load Profiles and Irradiation Data

- Benefit of different orientation is only small.
- No benefit for tilt angles smaller than 30°.

Storage



Source: Simulation of Distribution Grids with Photovoltaics by means of Stochastic Load Profiles and Irradiation Data

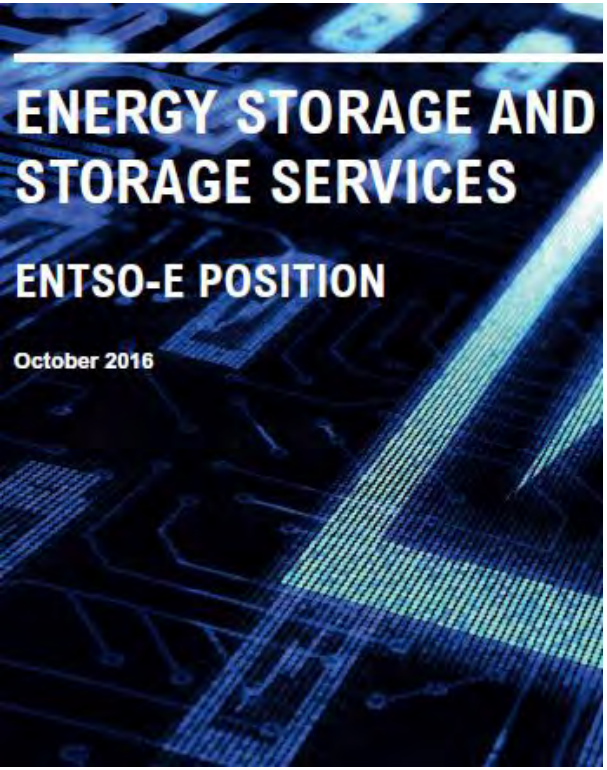
- 200 % more PV in the grid with a storage of 4 nominal operation hours.

PV and batteries?

Current market drivers

- New technologies are available
- Increase of own consumption of local solar production
- Peak load cutting
- Further services

ENTSO-E position paper: General principle for TSOs



- Storage should compete on a level playing field with other technologies, and the tariff structures should ensure neutrality of storage.
- Storage devices should not be restricted to a single service, as this would not be economically efficient;
- The TSOs should have access to data for central and distributed storage facilities for system security for all timeframes.

ENTSO-E

ENTSO-E position paper: Primary business cases

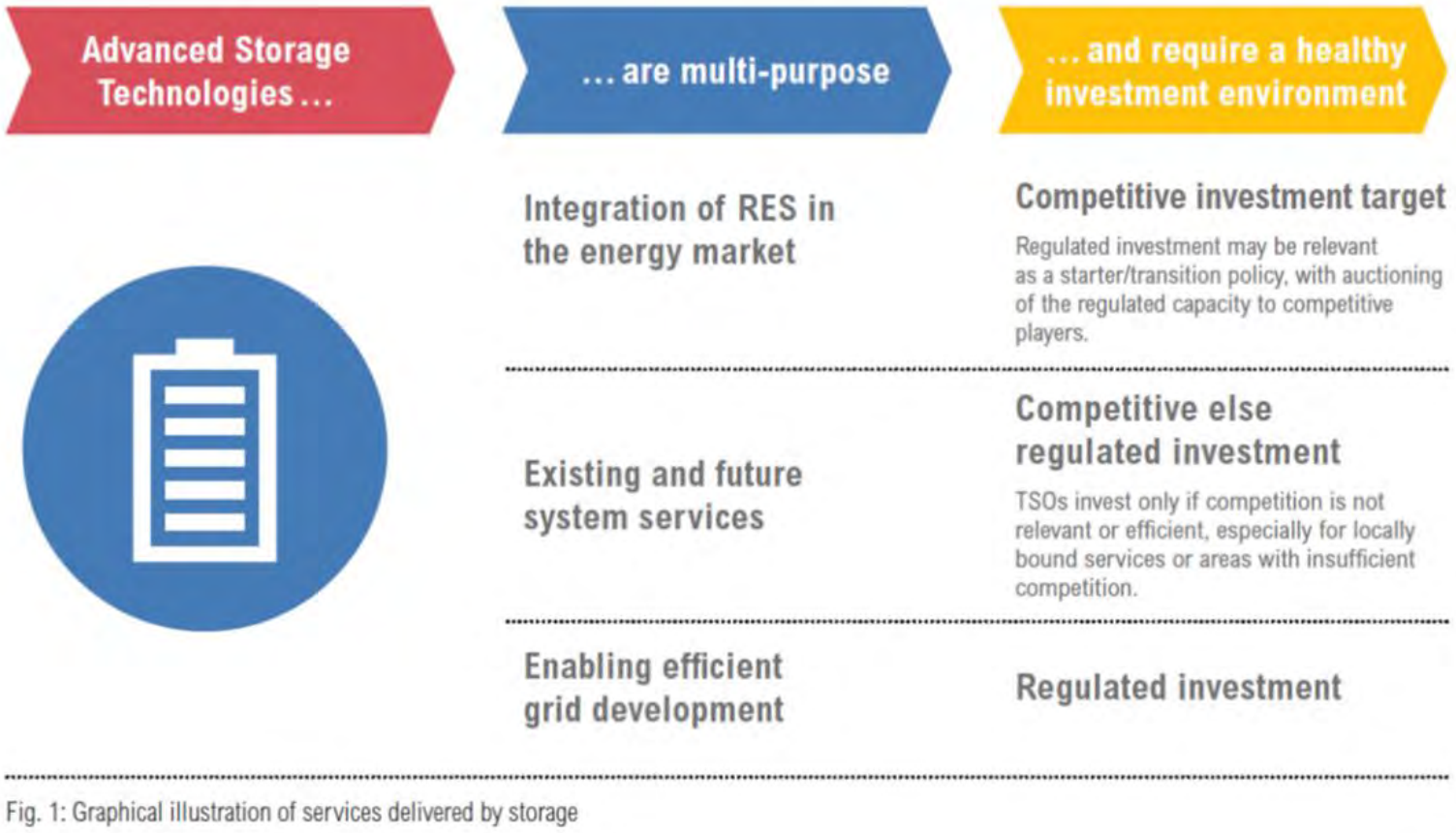


Fig. 1: Graphical illustration of services delivered by storage

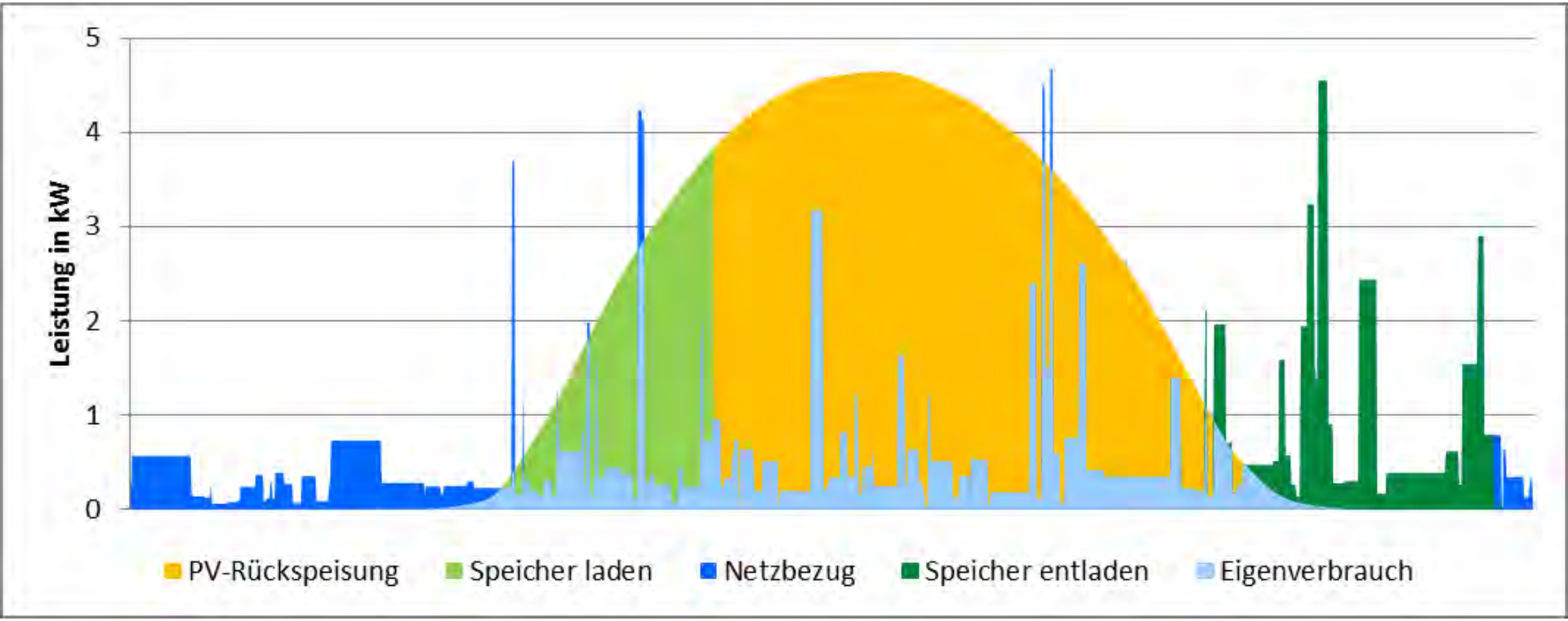
ENTSO-E POSITION Paper: ENERGY STORAGE AND STORAGE SERVICES

Decentralized storage connected with the public gird

Three main operation modes:

- Optimisation of own consumption
- System service for the grid
- Combined mode

Own consumtion



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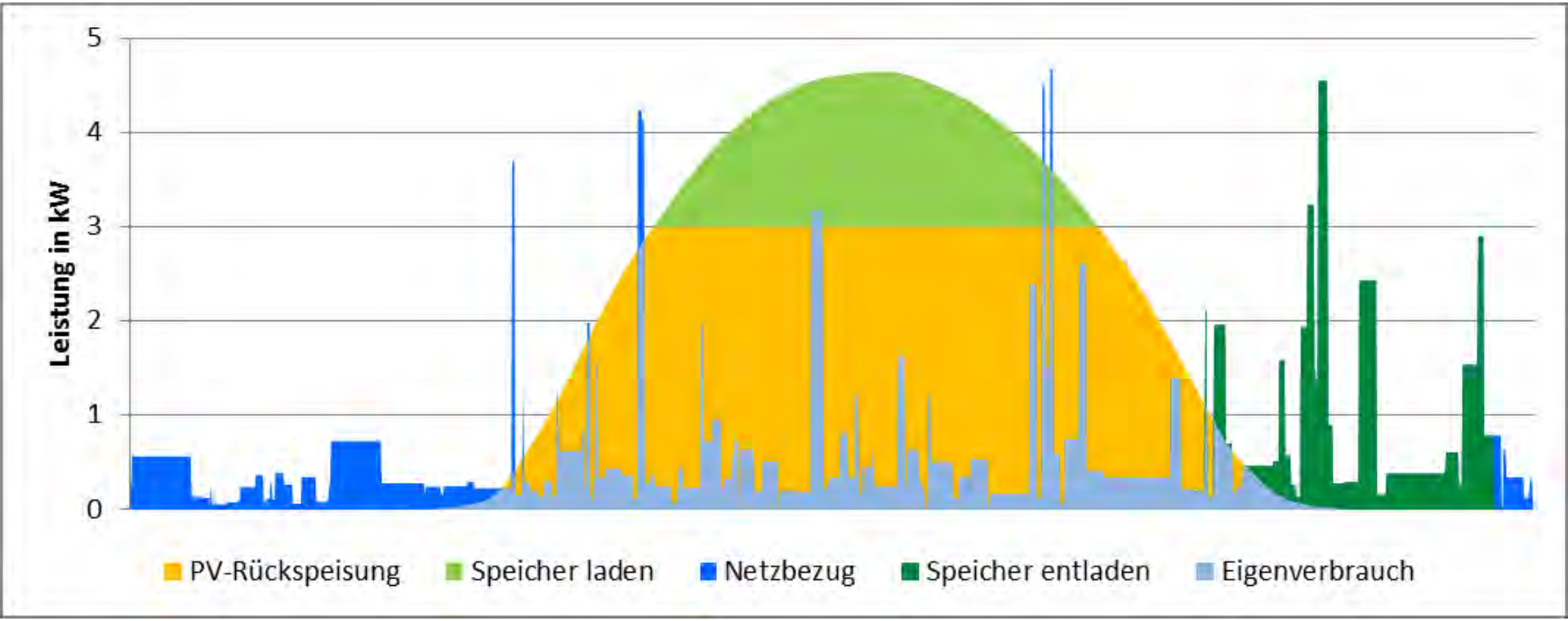
Grid support



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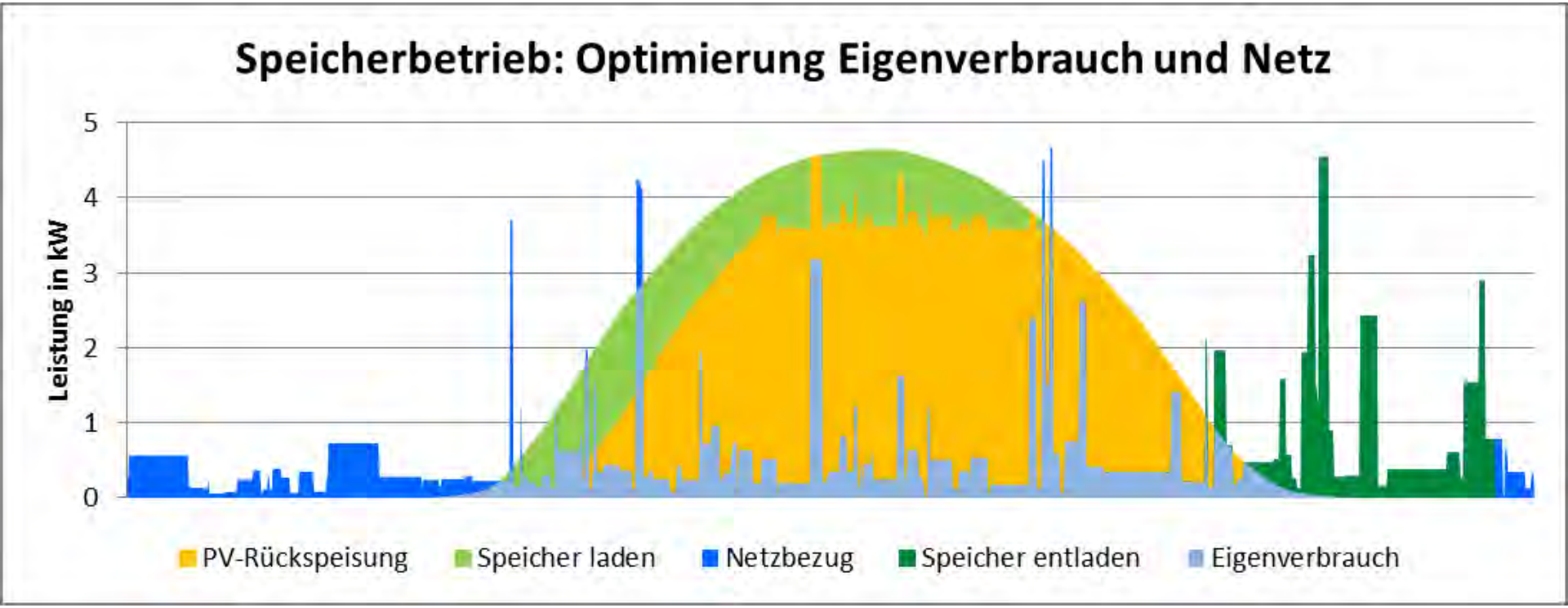
Combination: Grid support & own consumption



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Thank you for you attention!