#### **PV (and batteries?) integration into electricity grids** Peter Toggweiler, Basler & Hofmann AG

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# Content

- Introduction
- Current market situation
- \_ IEA PVPS Task 14
- \_ IEC standards for PV grid connection
- Some selected simulation results
- \_ PV an batteries?

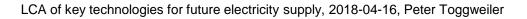


## Introduction

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The presentation was prepared in collaboration with Dr. Christof Bucher, Basler & Hofmann AG

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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**

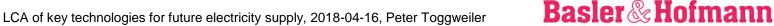
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## **Current status, observed by Solar Power Europe**

- \_ 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



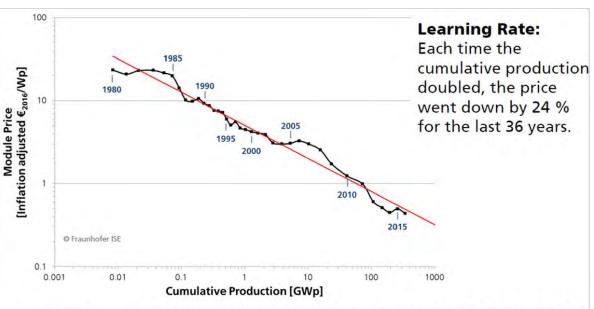
#### **Evolution of annual installed capacity**

EVOLUTION OF GLOBAL ANNUAL SOLAR PV INSTALLED CAPACITY 2000 - 2017 98,9 GW >98 GW in 2017 EUROPE AMERICA CHINA APAC MENA Row © SolarPower Europe 2018

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#### PV development shows a typical learning rate



Data: from 1980 to 2010 estimation from different sources : Strategies Unlimited, Navigant Consulting, EUPD, pvXchange; from 2011 to 2016: IHS. Graph: PSE AG 2017

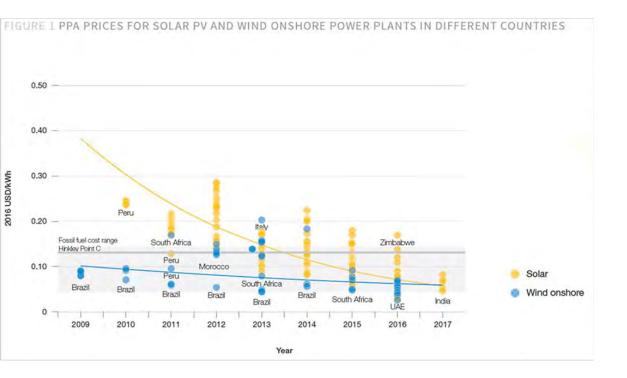
Module prices for orders > 1 MW are now in the range of 0.4 Euro/Wp

 Further price reductions are still possible, although from now on in small steps

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## 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

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#### IEA - PVPS Task 14

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# 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

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### 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

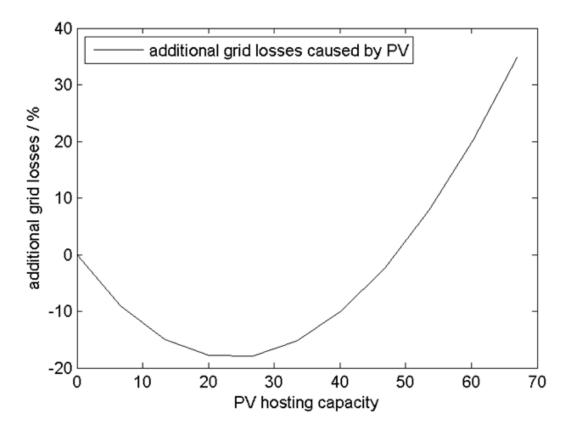
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# Some measures in high penetration scenarios

- \_ 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



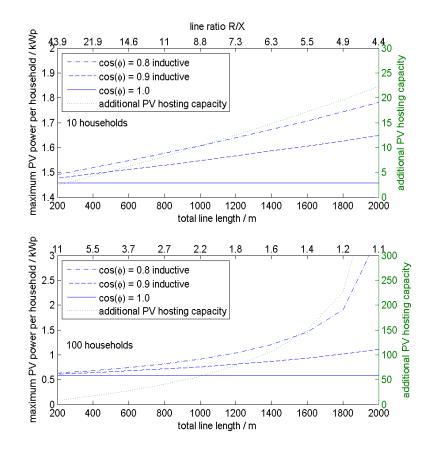
Loss minimisation at 25% PV penetration

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

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## **Reactive Power Control (RPC)**



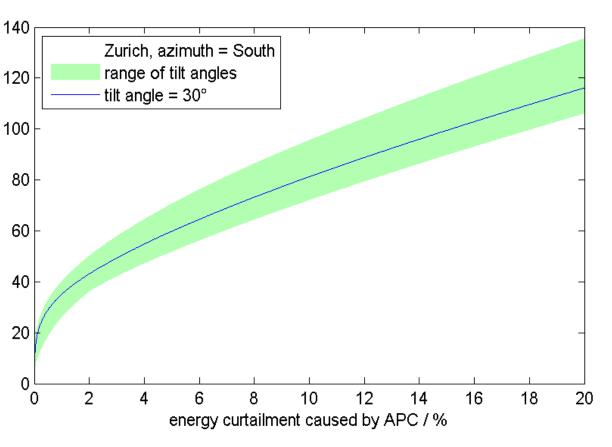
Highly
 dependent on
 grid properties
 (R/X-ratio).

- 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

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# **Active Power Curtailment (APC)**



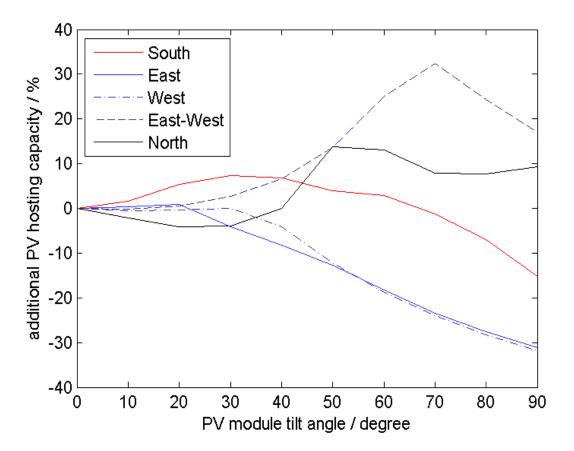
Sacrifice 3% energy to increase the PV-hosting capacity by 50%.

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

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#### **Different Orientation of PV Generator**



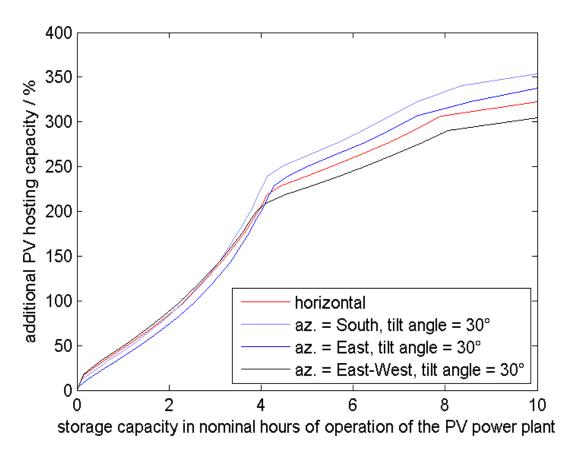
 Benefit of different orientation is only small.

 No benefit for tilt angles smaller than 30°.

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

## Storage



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

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

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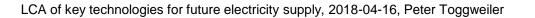
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### **PV and batteries?**

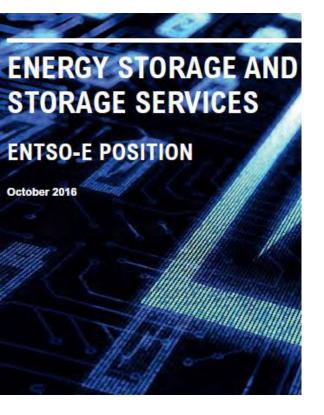
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## **Current market drivers**

- \_ 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

Advanced Storage Technologies	are multi-purpose	and require a healthy investment environment
	Integration of RES in the energy market	<b>Competitive investment target</b> Regulated investment may be relevant as a starter/transition policy, with auctioning of the regulated capacity to competitive players.
	Existing and future system services	Competitive else regulated investment
		TSOs invest only if competition is not relevant or efficient, especially for locally bound services or areas with insufficient competition.
	Enabling efficient grid development	Regulated investment

Fig. 1: Graphical illustration of services delivered by storage

ENTSO-E POSITION Paper: ENERGY STORAGE AND STORAGE SERVICES

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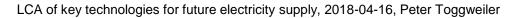
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### Decentralized storage connected with the public gird

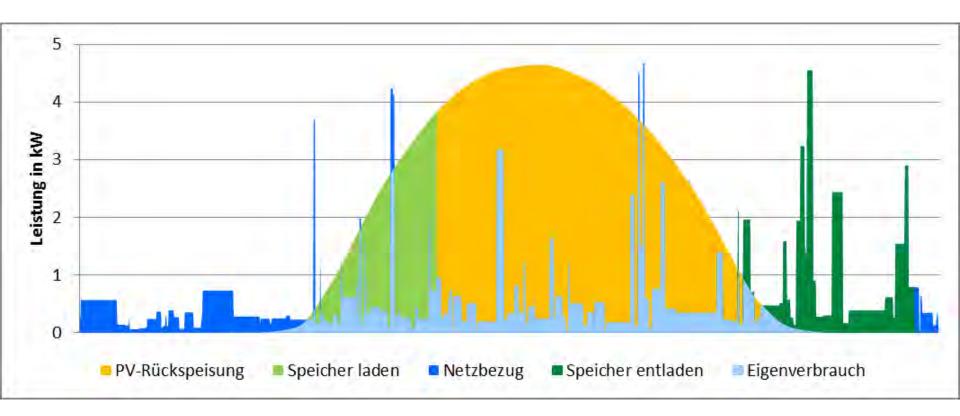


Three main operation modes:

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



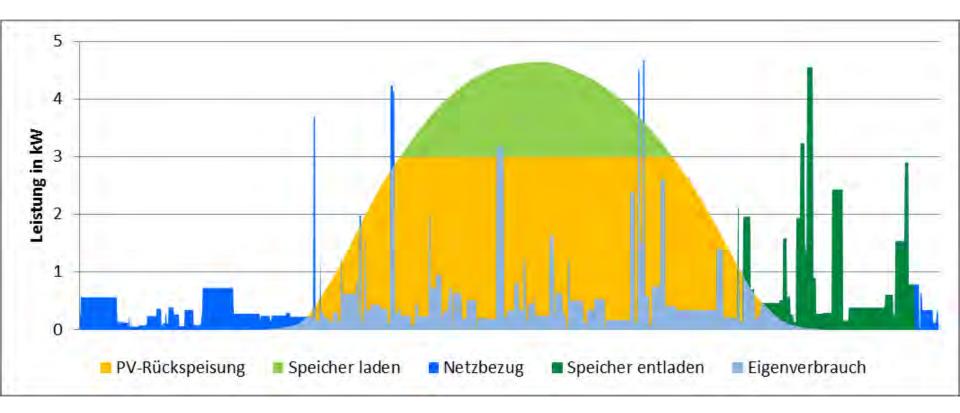
# **Own consumtion**



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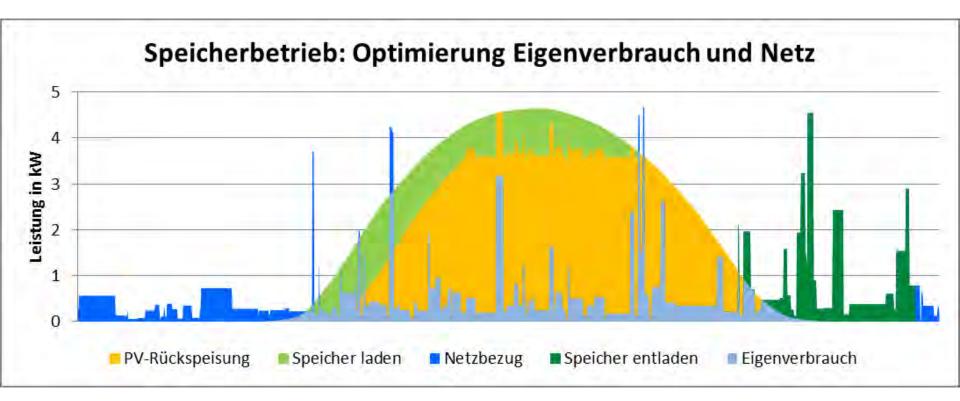
# **Grid support**



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# **Combination: Grid support & own consumption**



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#### Thank you for you attention!

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