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Evaluation of the Aging of Energy Storage Systems in Low-Voltage Distribution Grids with Decentralized and Fluctuating Generation

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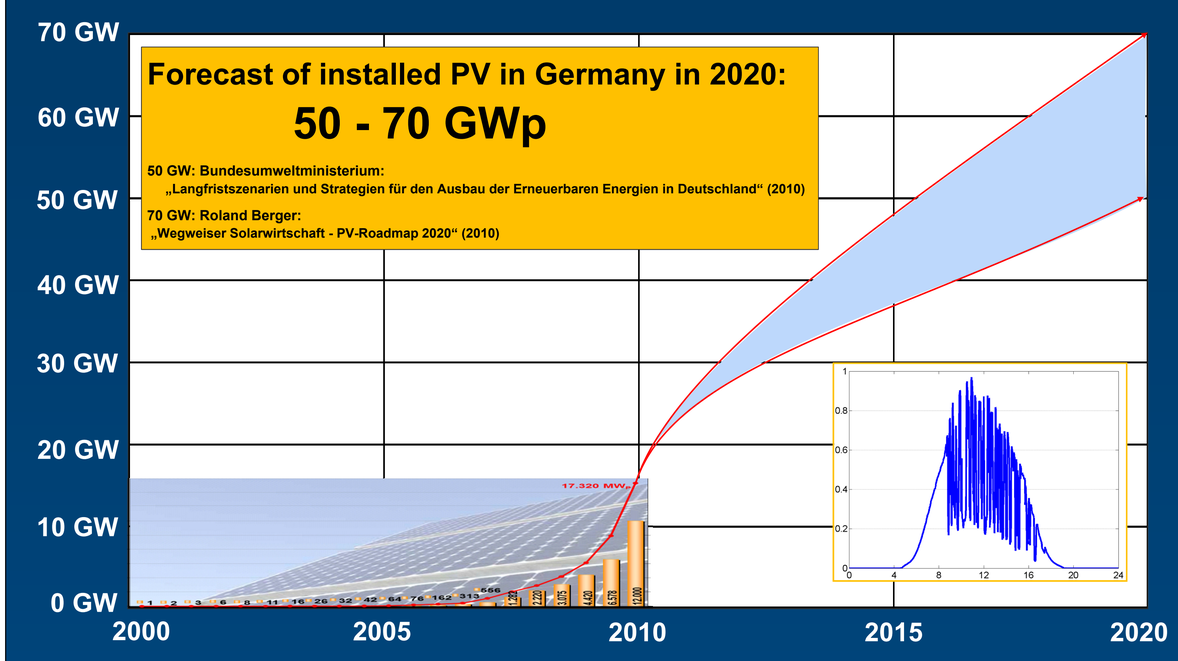
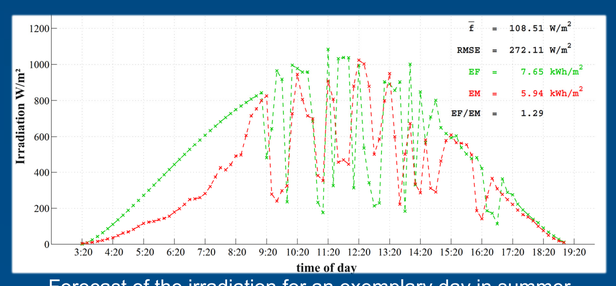
Installed power from photovoltaics in Germany



Irradiation and weather forecasts

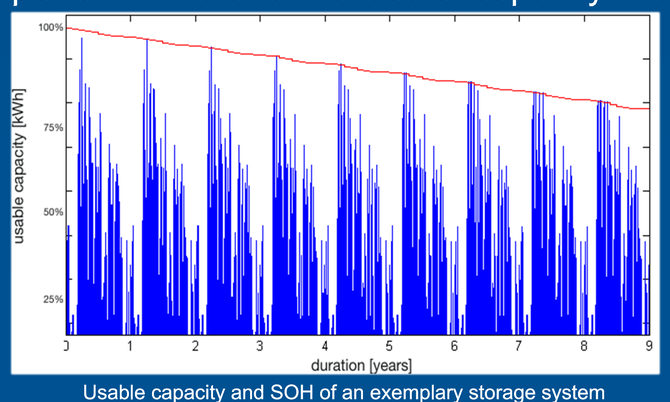
The concept uses **optimization** and **forecast methods** to reduce the required storage capacity and to enhance the **self-consumption** of the local energy generation at the same time.
Therefore local **weather forecasts** will be interpreted as well as the feed-in of the decentralized photovoltaic plants of the past few days.



Forecast of the irradiation for an exemplary day in summer

Effects / Results

Different scenarios for the optimal usage of energy storage systems in low-voltage distribution networks with a high degree of decentralized generation are being evaluated. For each cycle the efficiency, the performance and the loss of capacity is being calculated.

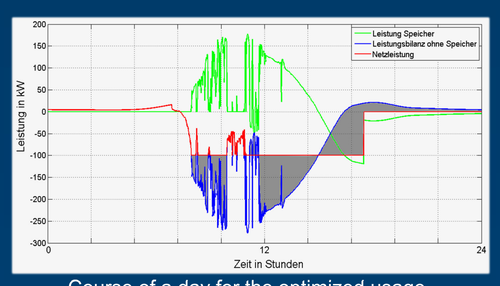


Usable capacity and SOH of an exemplary storage system

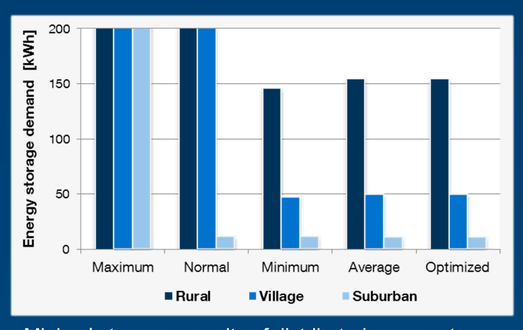
Based on these simulations it is possible to estimate the state of health of the system (see exemplary results in the figure) and to determine the battery's lifetime.
This information is necessary for the optimization of the storage system.

Decentralized energy storages

Local energy storages, which save the surplus generation, can be an alternative to grid enforcement and can be essential for a stable and efficient energy network in the future. The minimal storage capacity necessary to fully integrate the possible photovoltaic plants is being calculated for several reference network.



Course of a day for the optimized usage of decentralized energy storages

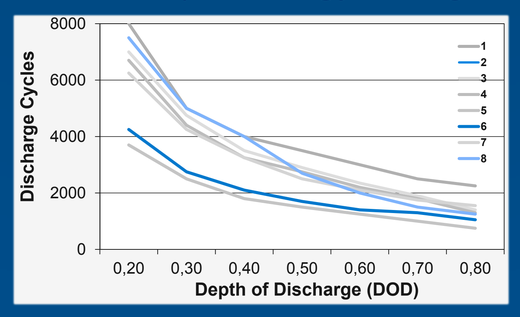


Minimal storage capacity of distributed energy storages necessary to fully integrate the photovoltaic plants

The power units of the storages are best chosen in the range from 60 % to 85 % of the respective plant size. Storage capacities for about 2.5 to 4 full load hours are sufficient for the best exploitation. The local demand can mostly be covered with the help of the existing storage reserves.

Aging of electrical energy storage systems

Each cycle of a battery system causes irreversible losses in the usable storage capacity. Therefore a simulation model of the relevant aging phenomena (i.e. cycle lifetime and calendar lifetime) of energy storage systems was developed.
The **cycle lifetime** is mainly influenced by the charge and discharge cycles during operation. The **calendar lifetime** of a battery system is given by the processes, that occur without any operation of the system.



Optimization

Intelligent management systems can help to reduce the aging of the battery and increase the system lifetime. Recommendations for the optimal operation method and dimensioning of the storage systems can be derived.

relative storage size	relative lifetime	relative costs
50%	81%	67,8%
100%	100%	100%
200%	143%	138%

Identification of the estimated lifetime and the changes in the battery performance during the operation period lead to more reliability and economic system operation.

References:
[1] Bodach, M.: *Energiespeicher im Niederspannungsnetz zur Integration dezentraler, fluktuierender Energiequellen*, Technische Universität Chemnitz, 2006
[2] Sauer, D.U.: *Optimierung des Einsatzes von Blei-Säure Akkumulatoren in Photovoltaik-Hybrid-Systemen unter spezieller Berücksichtigung der Batteriealterung*, Ulm, 2003

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