

# Practical Experiences from Project Development of Utility-Scale Solar and Storage Projects for Weak Grid Applications

Peter Hussinger, BayWa r.e.

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BayWa r.e.





# Agenda



1

**introduction**

2

**case studies**

A: battery peaker plant  
B: solar + storage park

3

**challenges and  
conclusion**

# BayWa r.e. in figures – dynamic growth and sustainable profitability



## Turnover 2018

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**€1,530.2**

Mio. Euro

## EBIT 2018

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**€72.5**

Mio. Euro

## Employees

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**1,800**

## Founded

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**2009**

Gathering our combined  
market experience under the  
BayWa r.e. umbrella

## Experience

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**2,500 MW**

Development and realisation of  
projects in the area of solar, wind  
power and bioenergy.

## Company

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100% Wholly owned subsidiary  
**of BayWa AG**



## Success based on more than 6,100 MW through our sound energy mix



We provide experience in the development and realisation of wind farms with an installed capacity of more than **1,400 MW**.



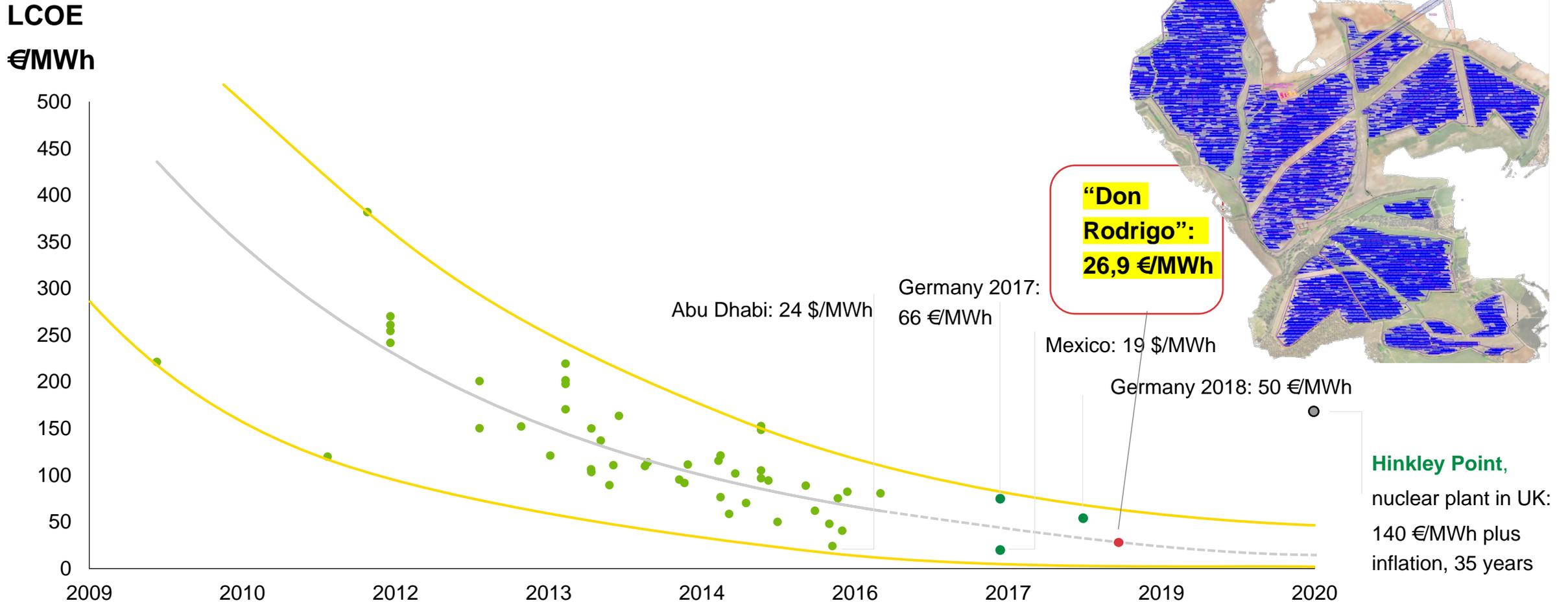
We have brought solar farms with an output of more than **1 GWp** to the grid. We have supplied our installers with solar modules with a total output of **2,400 MWp**.



We have developed and set up **34** biogas plants with a total biogas output of **113 MW**.



# PV power has become the cheapest source of power in many regions worldwide





# Battery storage price development reminds at PV learning curve

One can see a similar price development for the storage learning curve as for solar PV

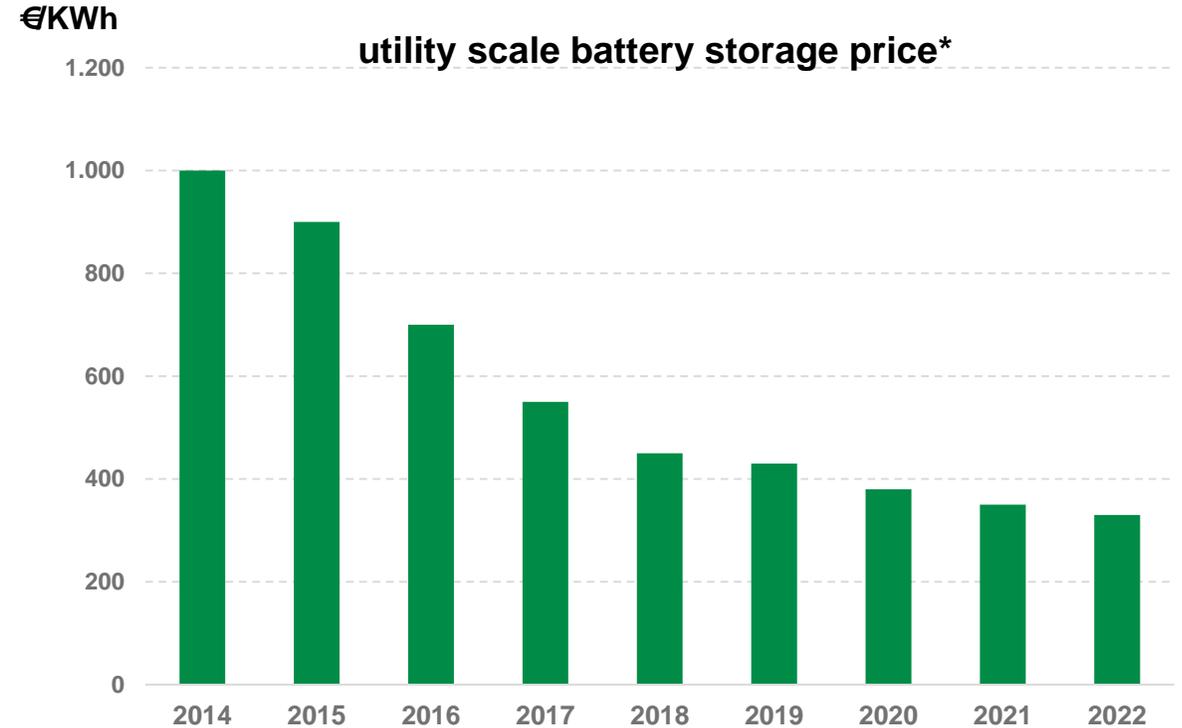
Between 2014 and 2018 battery prices fell about 50%, mainly driven by cell cost

But also system integrators are driving cost reductions in BoS and installation cost

Lower cost allow also long duration applications

Stationary storage sector benefits from growing e-mobility market so far

**risk of short in production due to future high demand of e-mobility sector**



\*5 MW / 20 MWh installed incl. Medium voltage equipment

Source: Supplier quotations & BayWa r.e. analysis



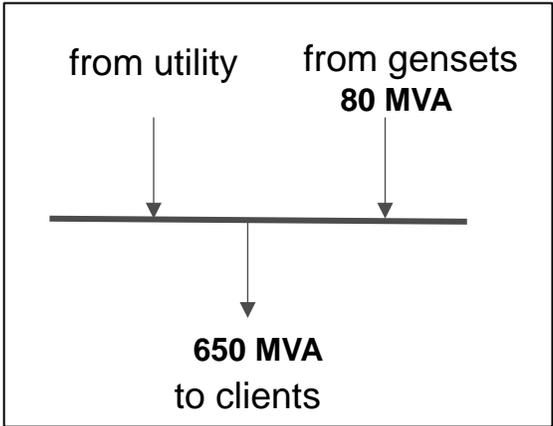
## **case studies**

**A: battery peaker plant in Sub-Saharan Africa**



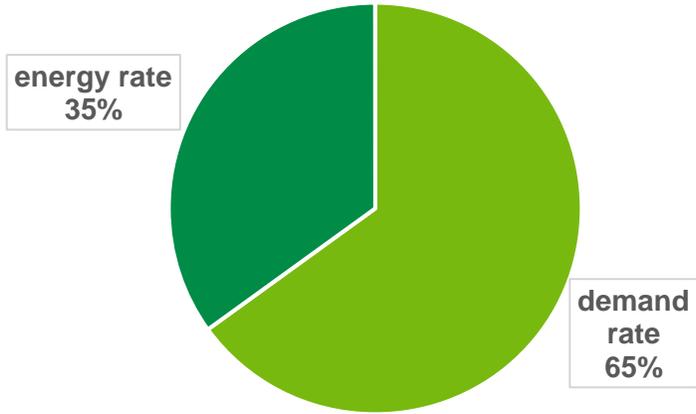
# Case study A: battery peaker plant to reduce diesel fuel consumption

## Situation on site



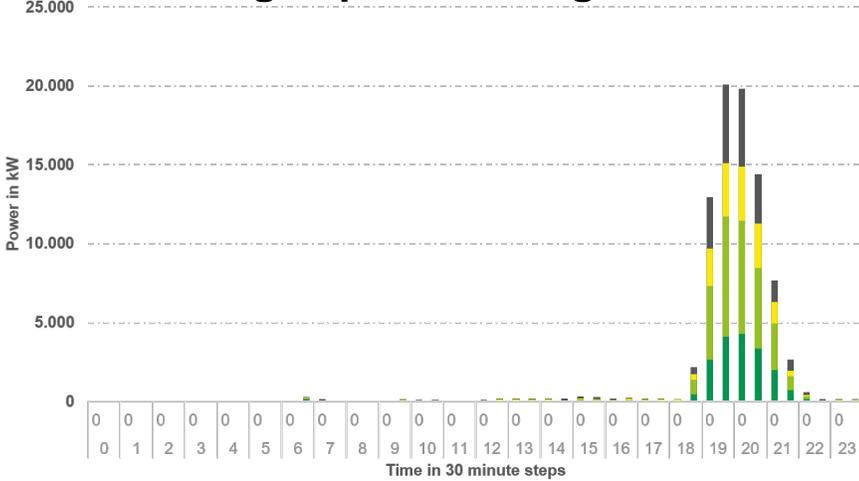
A TSO is coordinating ~650 MVA of client capacity

## Power purchase pricing from utility



Purchase power is mainly driven by demand rate

## average operation of genset fleet

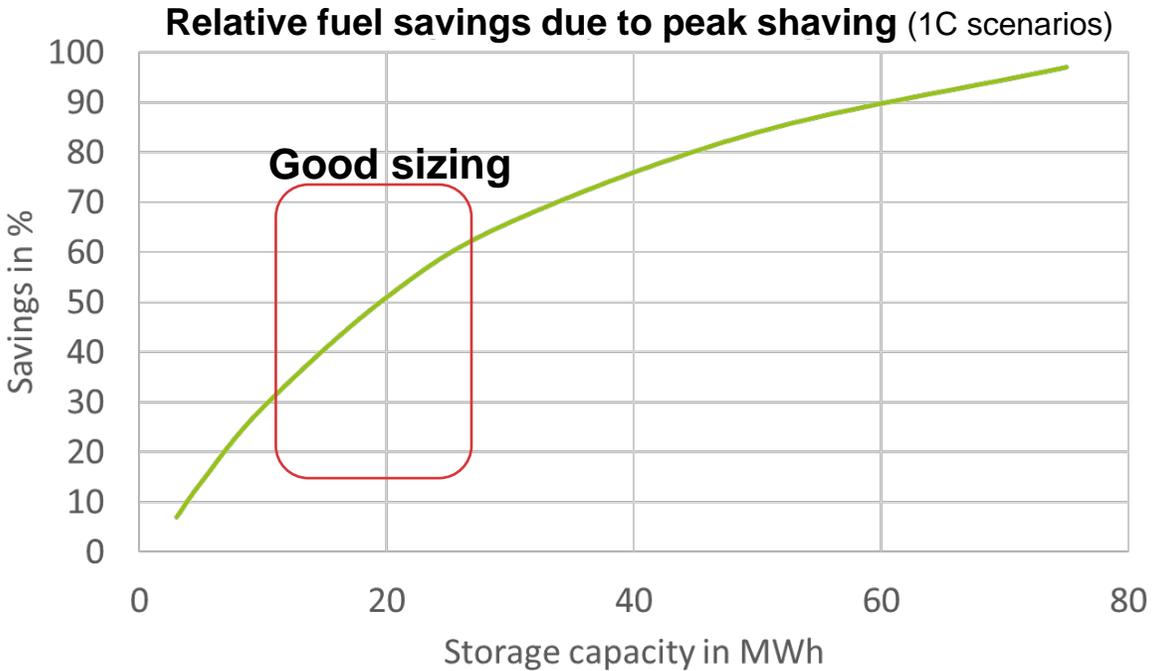


Diesel operation in the evening, Fuel cost ~1\$/l  
Ageing diesel genset parks  
Future PV expansion plan will not reduce peak demand hours in the evening

In order to reduce third-party power purchases the TSO wants to increase his power generation assets. PV doesn't reduce the demand peak. Ageing genset units ask for reinvest of dispatchable assets



# Case study A: Battery peaker plant



## Advantage

On technical perspective more efficient use of existing genset can reduce fuel consumption up to 20% per day (idle time, start-up time, efficiency curve)

## Sizing

For small sizing project fix cost dominate for big sizing a saturation is notable  
Good sizing for 10 to 25 MWh

→ **Economic use case: Battery storage can reduce fuel consumption considerable and generate payback periods of 4-5 years**

“Where can I sign the contract?”



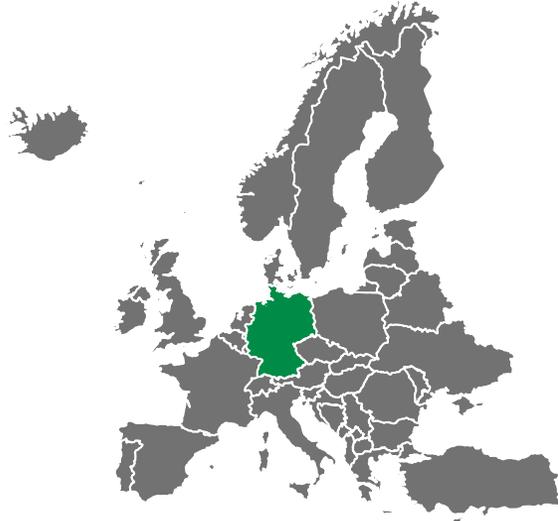
## case study B: PV park grid integration

### In Europe

- For larger PV parks, 1-2 curtailment actions per month
  - In rural regions potentially excess voltage problems
  - Interconnected and strong grid
  - Strict requirements from grid operators
- **No mayor problems yet**
- Decreasing feed-in tariffs
  - Rising RE shares → more fluctuations
  - Rising intraday price differences at the power exchange market

→ **Future potential for battery merchant applications with PV parks**

**e.g. Germany**



### In Sub-Saharan Africa

- Often ageing generation units (hydro power, gensets)
- Not enough generation capacity installed
- Developing countries with high irradiation but weak electric grids, often no feed-in tariffs yet
- Strict grid code requirements for PV parks concerning fluctuation rate

→ **Potential for storage already today**



**Sub-Saharan Africa**



# grid code examples from Kenya, Zambia, East African Power Pool

The Declared Data capability test shall demonstrate that the *Generating Plant* can be scheduled and dispatched in accordance with the Declared Data. To pass the test, the *Generating Plant*

The Dispatch according to the Generation Schedule

- In the case of a registered generating plant
- In the case of a dispatch equivalent generating plant
- In the case of a registered generating plant
- In the case of a dispatch equivalent generating plant
- In the case of a registered generating plant

The Ancillary Services System Operator shall conduct the test where applicable

7.1.2.5 Ramp Rates

The Wind Turbine / Solar Power Generating Plant control system shall be capable of controlling the ramp rate of its Active Power output. There shall be two maximum ramp rates per minute ramp rate averaged over 10 minutes.

7.2.5 Ramp Rates

Ramp Rate requirements shall be consistent with the EAPP IC requirements for the Kenya National Transmission Grid.

CHAPTER 7

MW per minute ramp rate average applicable for all ranges of operation.

The power output of Solar Power Generating Plant from the network.

It is recognised that falling wind speed ramp rate settings to be exceeded.

It shall be possible to vary each of these two maximum ramp rate range between one (1) and thirty (30) MW per minute. The RPP system shall have the capability to vary the ramp rate in MW per minute and ten (10) minutes.

The Wind Turbine / Solar Power Generating Plant setting and changing the ramp rate

Active power control functions

7.3.8.1.1. RPPs shall be capable of controlling the ramp rate of its active power output with a maximum MW per minute ramp rate set by SO, TNSP or DNSP as the case may be.

7.3.8.1.2. In case of variations in energy resources, the RPP shall design and ensure that the ramp rate of its generating units does not exceed the ramp rate capability of the regulating power unit(s).

7.3.8.1.3. These ramp rate settings shall be applicable for all ranges of operation including positive ramp rate during start up, positive ramp rate only during normal operation and negative ramp rate during controlled shut down. They shall not apply to frequency regulation.

For solar PV RPPs, in terms of power rate limit, the inverter should have the capability to limit the increase in power export to 10% of nominal rated capacity per minute. If the inverter has storage capabilities, it should also be able to limit the decrease in power export by 10% per minute.

7.3.8.1.4. The RPP shall not perform any frequency response or voltage control functions without having entered into a specific agreement to this effect with the DNSP.

**Grid code requirements on solar PV asks for ramp rate restriction for both increase and reduction of power nowadays**



## Case study B: solar park with/without storage

Simulation of a pure 20 MWp fixed tilt solar park without/with battery storage



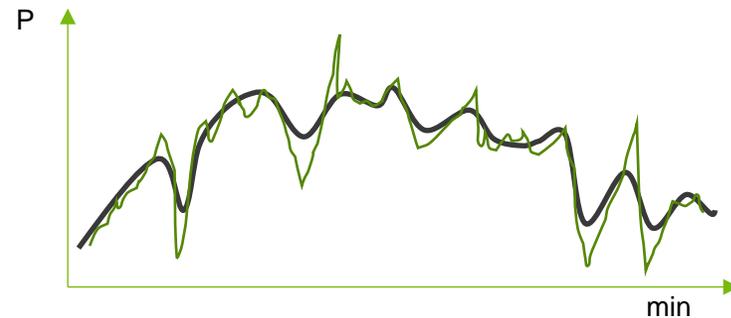
### Data base

1 min weather data from meteorological station for the year 2016

### Battery use case

Smoothing / ramp rate control

→ reduce PV power fluctuation rate



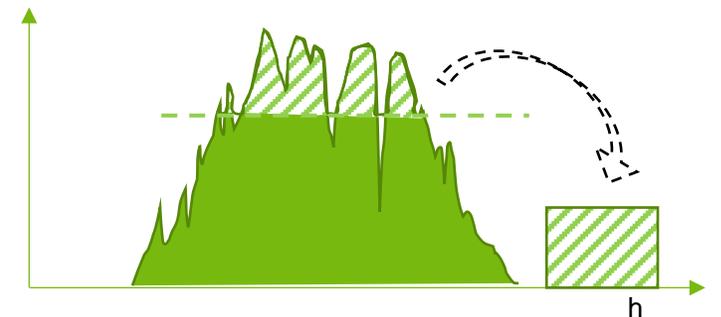
### Benefit

Battery storage integration to **comply with the grid code requirements** regarding allowed ramp rates

### Battery use case

Supply shifting

→ shift solar power to evening hours



### Benefit

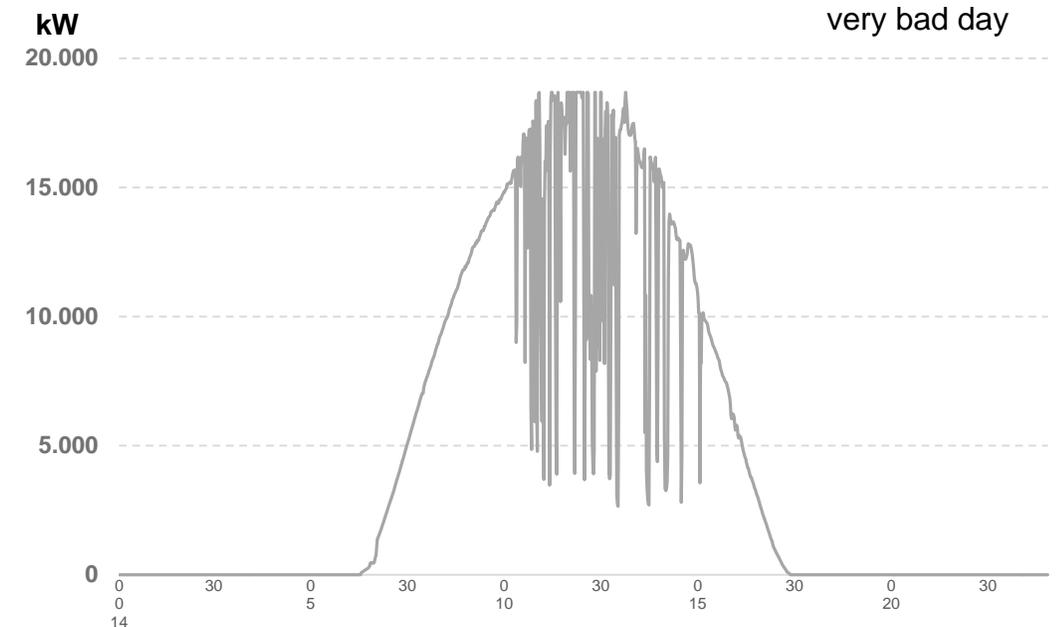
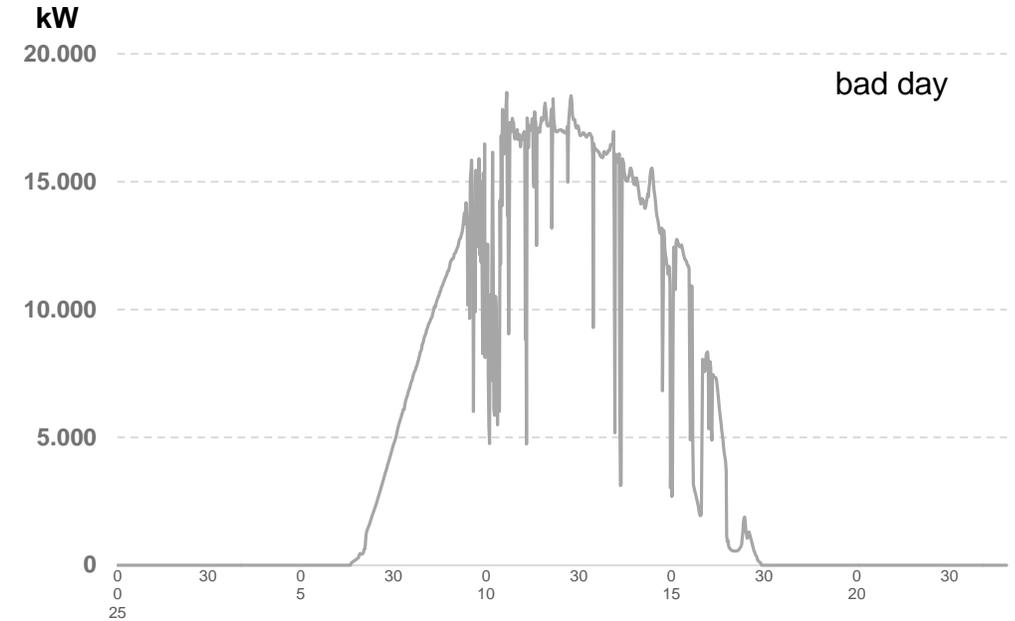
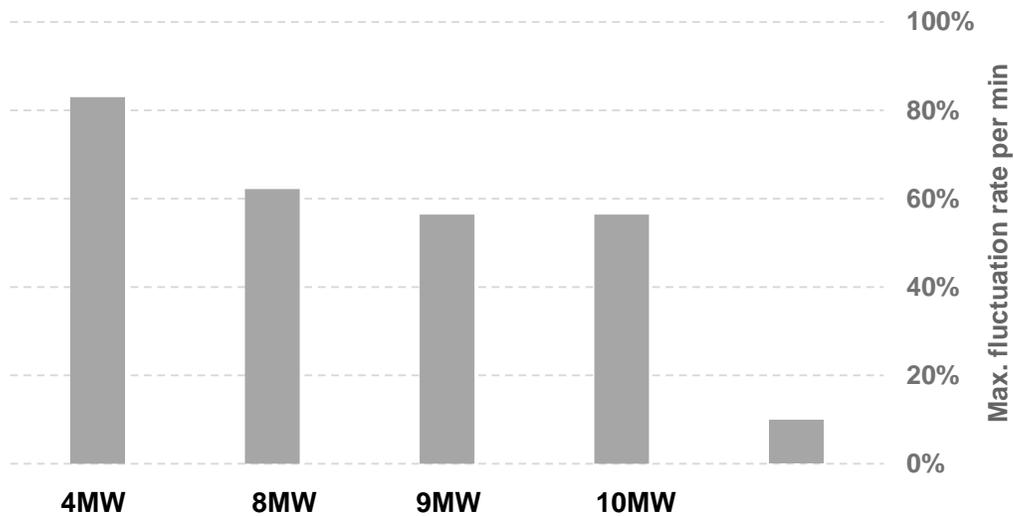
Battery storage integration to **generate added value for the utility** by supplying energy during peak demand



# Smoothing

- Reduction of fluctuation rate from max. 78%/min down to less than 10%/min of nominal power
- The sun doesn't always shine and there are clouds influencing the daily amount of generated energy
- Ramp rates per minute are controlled by charging and discharging the batteries

## Simulation models help to find optimal battery sizing

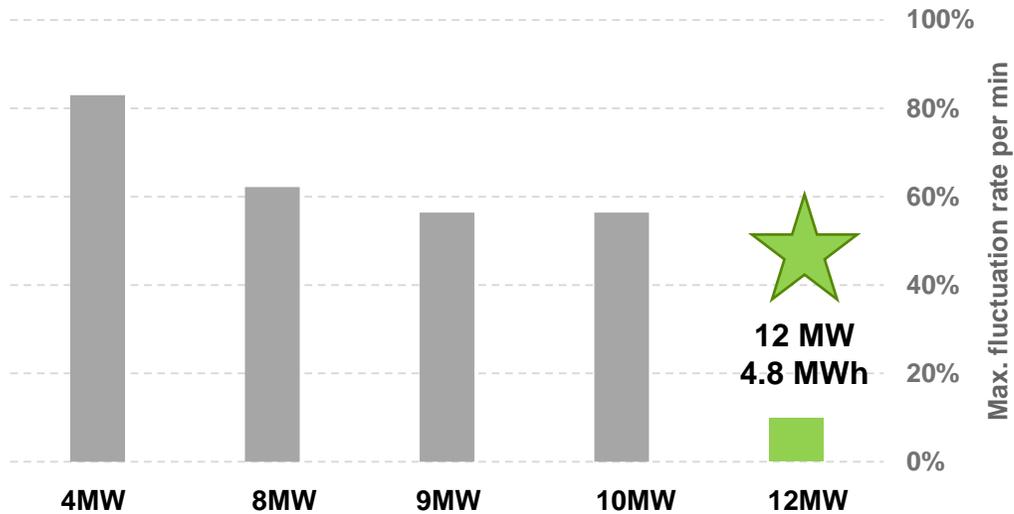




# Smoothing

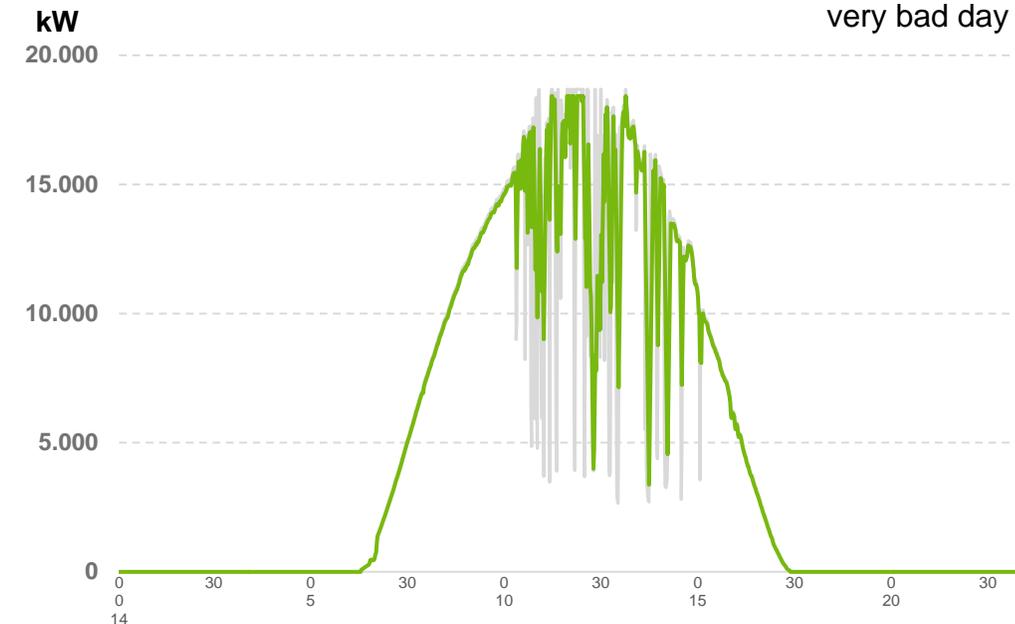
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## Simulation models help to find optimal battery sizing



**12 MW – 4.8 MWh battery to stabilize the 20 MWp solar park**

Source: Master Thesis Zaid Al-Jallah at BayWa r.e.





# Supply shifting

limit solar generation and supply excess energy in the evening

## Battery storage for supply shifting

Direct solar grid feed-in is limited to 13 MW (65% of nom power)

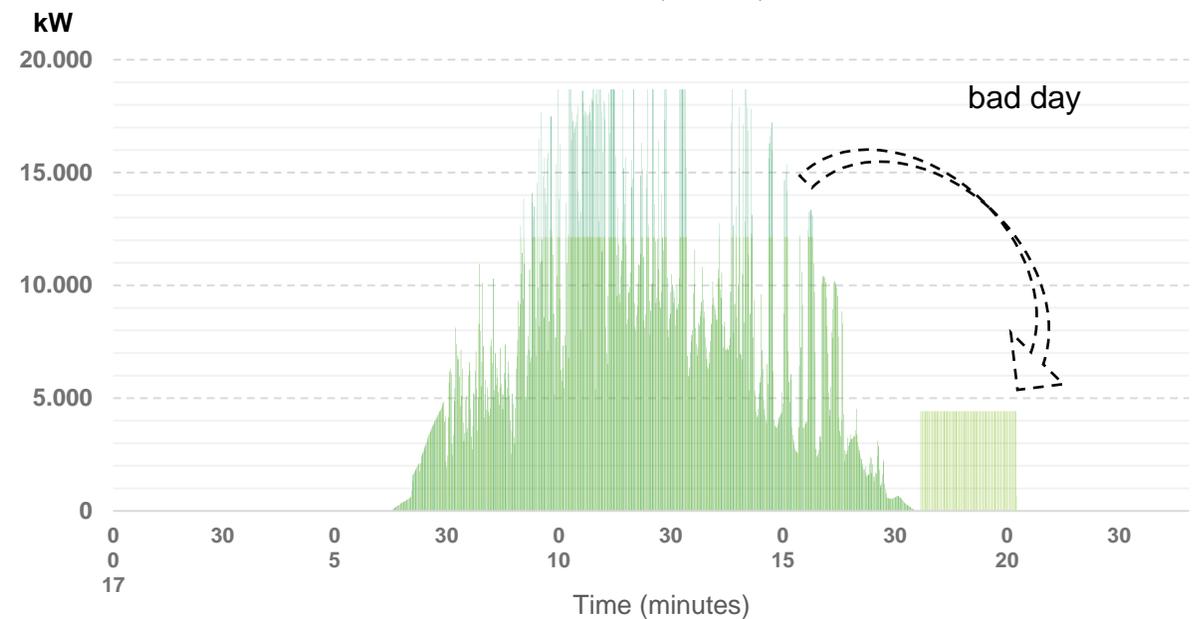
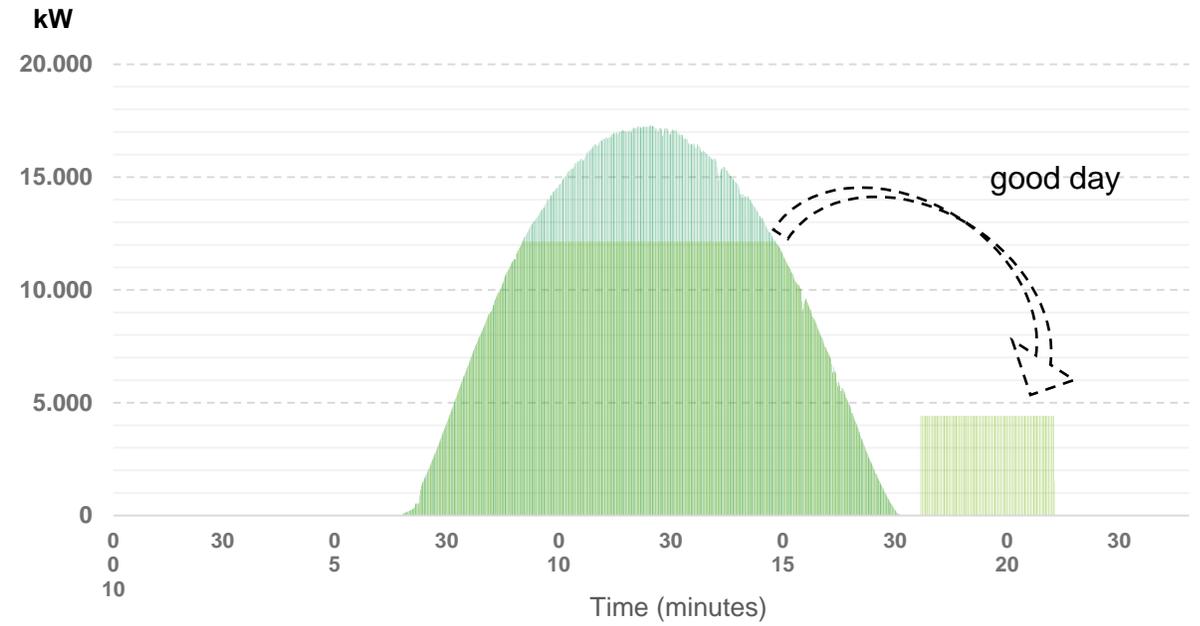
excess generation is stored in batteries

in the evening feed-in of stored energy at peak demand times

→ reducing the necessary grid connection of the solar park

→ added value for stored energy in the evening

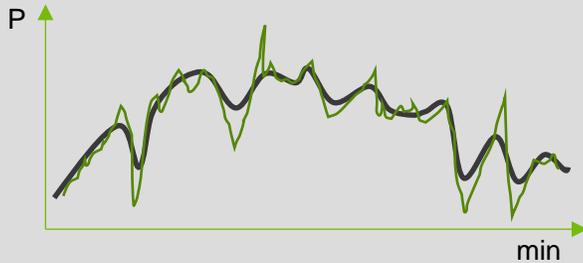
**Battery sizing: 6,4 MW – 13,8 MWh to shift 35% peak power to the evening hours**





# Technical and economic review of results

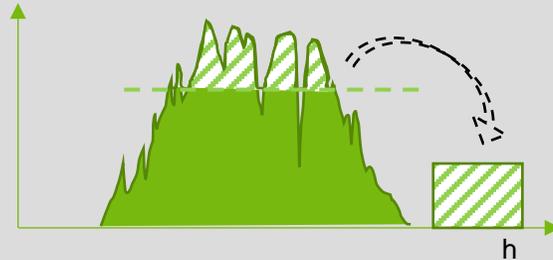
## Smoothing



storage sizing 12 MW – 4.8 MWh

- 2,5C battery
- 135 cycles/yr
- **power storage**

## Supply Shifting



storage sizing 6.4 MW – 13.8 MWh

- 0,46C battery
- 283 cycles/yr
- **energy storage**

- Different storage requirements for the use cases
- Battery application needs to be defined before

**Better PV power quality for smoothing scenario**  
**Planned power generation for supply shifting**  
there are more use cases than these two...  
but: the better energy needs to find its value for the customer

## Economic evaluation



### 25 yr LCOE extra cost vs. standard PV park

- PV-battery LCOE is always higher than PV only
- An **LCOE increase of 17% and 37%** can be expected
- in absolute numbers an add-on of 1.3-1.8 ct/kWh

**→ No doubling of LCOE due to storage integration**

“Where can I sign the contract?”



# challenges and conclusion



## Challenges in hybrid project development



- **investment hurdle**

due to unknown development of third-party power purchase contracts

- **lack of operational know how**

large scale battery systems in that size often unknown to customers

- **less investor experience**

regarding storage IRR and payback periods

- **added value**

the value of non energy related services like blackstart capability or voltage control hard to evaluate in simulations

- **PPA**

PV developers are used to structure single technology PPAs

- **Best time to invest**

customer uncertain about the best time to invest when battery prices keep falling



# Conclusion

## PV

- PV has become the **cheapest source of power** in many regions of the world
- grid integration of RE
  - Europe: **For rising RE shares growing challenges** with fluctuation of solar and wind
  - Developing countries: today already **strict requirements concerning fluctuation of RE and weak grid support**

## Storage

- **Learning curve for battery storage follows** development of early days **PV learning curve**
- PV - battery use cases:
  - **Storage turns PV into a controllable power plant**
    - higher value of the energy for the customer
    - better power quality needs to find its value for the customer

**PV and battery go hand in hand**



**for better energy!**



**Thank you for  
your  
attention!**

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