ECONOMICS OF PV STORAGE

A brief analysis of technology, costs
and payback of battery storage

White Paper

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INTRODUCTION

Storage solutions for PV systems play a major role in the future of energy supply based on 100% renewable energy generation for households, a key component of our vision of 24 hours of sun.

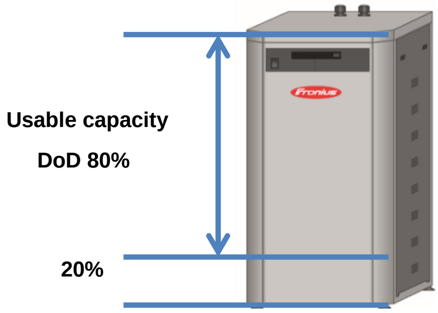
As the technology is relatively new and the prices are still high there is currently some uncertainty about how to select the most suitable technology is and what the real costs of storage are. A common approach is to compare the upfront costs of different batteries, but, as shown in this paper the real cost of energy storage is not determined from upfront cost alone.

Key characteristics & criteria for batteries

Not every battery is equal. They can differ in many ways, which leads to a significant impact on battery characteristics such as lifetime, usable energy and performance capability. This paper summarises the key characteristics and calculations to consider when choosing a storage solution. Also, an example is given at the conclusion of this paper showing how to calculate the real cost of storage taking into consideration these key characteristics.

Depth of discharge (DoD)

This characteristic gives the difference between nominal and usable storage capacity of the battery. It defines the actual energy which can be stored in and used from the battery. For example, a battery with 5kWH nominal storage capacity and 80% DoD can actually provide just 4kWH of usable energy. The given 80% is the maximum DoD of the battery, which can't be set to a higher value for example 90%. The rating of the lifetime or charging cycles is given based on this value. However, it usually can be set to a lower value, for example 70%, which will increase the lifetime of the battery, as explained below.



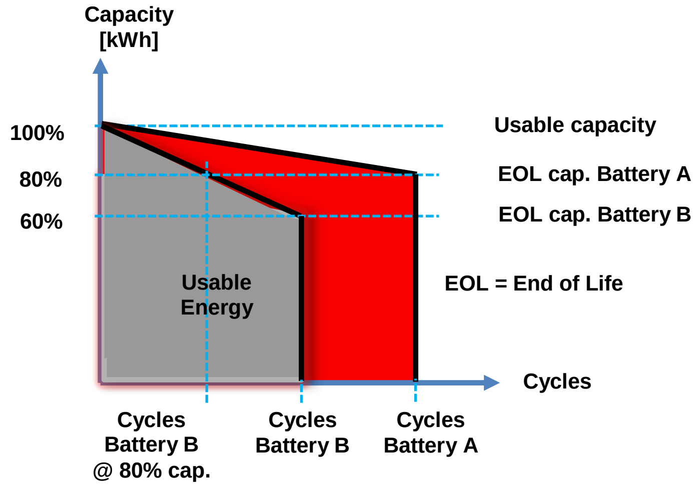
Charging cycles

Charging cycles define the actual lifetime of the battery. One cycle is equal to a **full** discharging and charging of the usable storage capacity of the battery based on the maximum DoD value. So, discharging the battery to 50% of the usable capacity and recharging it back to 100% counts as half a cycle, not a full cycle. Reaching the given cycles number doesn't mean the battery isn't usable anymore. There is often a rest capacity left which is defined as the end of life capacity (EoL) characteristic.

End of life capacity (EoL)

This defines the rest value of the battery after the given cycle life. Batteries don't have a storage capacity of 100% over their whole lifetime. Their storage capacity decrease in a linear course depending on the number of charging and discharging cycles. The total amount of usable energy over the lifetime of battery is therefore less than the usable capacity multiplied by the given charging cycles.

The picture on the right shows and compares this for two batteries, which have the same usable capacity but different EoL values (80% & 60%). As the linear course is steeper if you have just 60% EoL capacity, the field under the curve and therefore the total usable energy over the lifetime is less compared to the curve of the battery with 80%. This highlights that the EoL capacity value has a significant impact on the total usable energy of the battery over its lifetime.

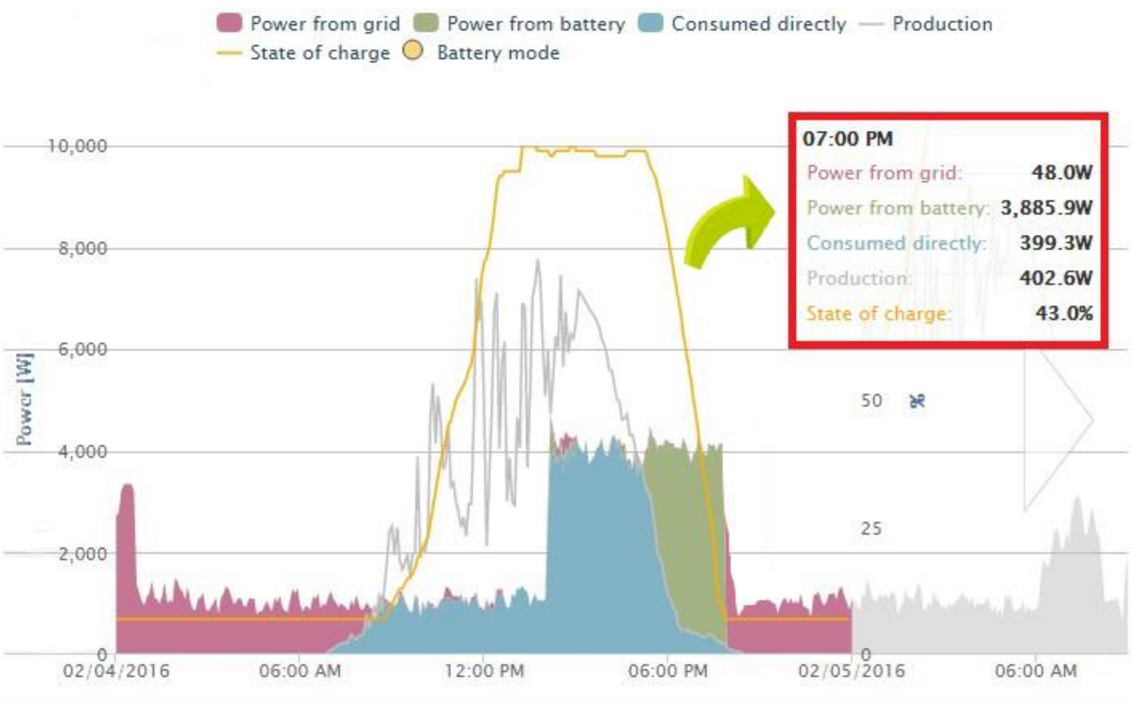


Charging and discharging capabilities

Maximum charging and discharging capabilities can have a big impact on the performance rating of the battery, as well as on payback and return on investment (ROI). Below is a screenshot showing the consumption and production values of one of the systems in our free monitoring portal Solar.web (www.solarweb.com). It shows the curves for the power production of the installed PV system, the state of charge values from the battery, as well as the consumption curve and how much energy for self-consumption was supplied by the battery.

As highlighted in the red boxes, consumption during the night was around 4kW power demand. In this example the installed Fronius Solar Battery was able to supply this power demand (green curve) and the customer didn't have to purchase any additional electricity from the grid.

With batteries that have lower discharging capabilities than 4kW the above wouldn't be possible. This means the customer would have to buy additional electricity from the grid, whether or not the battery had enough energy stored to supply the energy demand. This significantly effects payback and ROI figures, especially with recent or imminent changes to time-of-use-tariffs.



The same counts for charging capabilities. For example on a scattered cloudy day with intermittent bursts of high irradiance, batteries with higher charging capabilities can and store more energy than batteries that limit the input power. So there is more energy stored in the battery and available for consumption during the night, which is likely to reduce the need to purchase additional electricity from the grid.

How to calculate the real cost of energy storage

As shown, the above-mentioned characteristics can have a big impact on the real cost of storage. Below is a simple calculation, which takes the upfront cost, DoD (nominal v's usable energy) and cycle life into consideration. This calculation is based on the following equation:

$$Cost\ of\ energy\ storage = \frac{upfront\ cost\ of\ battery}{total\ battery\ capacity \times DoD \times Cycles}$$

In this example we compare a cheaper battery with lower performance values to a more expensive battery with higher performance values:

Nominal kWh Price	$ 500	$ 1500
Max. DoD	40%	80%
Life cycles	3000	8000
Usable kWh Price	500/0.4 = $1250	1500/0.8 = $1875
Price usable/cycle	1250/3000 = c$ 41.7	1875/8000 = c$ 23.4

Calculating the real cost of storage can be more complicated and time-consuming than just comparing the upfront cost. The basic and easy calculation above clearly shows that a lower upfront cost doesn't equal a lower total, or actual cost. Plus, there are still other factors to consider when calculating the real cost of storage, such as the previously-mentioned end of life capacity and charging and discharging capabilities. That being said, using the characteristics in the example above to calculate payback scenarios for you customers will provide accurate figures for the most cost-effective solution.

Buying a new PV Storage system or retrofitting a well-designed/well-sized storage device to an existing PV system can have a huge positive impact on self-consumption (self-sufficiency) ratio, minimise your electricity consumption from the grid and take us another step closer to the vision of 24h of sun. But, as the cost for PV storage is still very high, the choice of the right battery technology is as important as the capacity and upfront cost of the battery. Why? In order to maximise or even create a return of investment and make your system ready to meet the requirements of the future electricity market.

Our PV calculator for different payback & investment scenarios takes some of the above characteristics into consideration and may help you to calculate the real payback and ROI of a PV system with storage. It can be downloaded from our website via Fronius PV Calculator