BeeBryte
Energy Intelligence

10 min

Electricity Storage

The price of the revolution

Johanna DREANO, Anne MERGY, Marine LECLERC

July 25th, 2018

Which Energy Management Strategy should be used to optimize the technical and economic performance of a stationary battery installed in a building?

Energy storage is part of today's energy transition hot topics, and includes many technologies with varying characteristics and performance.

Energy Storage Systems (ESS), and more particularly battery storage, are in vogue and have experienced unprecedented growth over the past decade. Batteries are everywhere. In your laptop, your tablet, your smartphone, your car... More and more often, the opportunity to install an ESS in a building or a Micro-Grid, connected or not to the grid, is being considered, either included in a renewable energy project or not. Is it technically relevant? Economically? Which technology is best adapted? And which management strategy shall be used to optimize its performance and meet technical-economic criteria?

Even if batteries' costs plummeted by 80 % since 2012[1], and should continue to do so in the coming years, the cost of hardware remains a key factor for investors and its impact on the project's Internal Rate of Return (IRR) shall be thoroughly studied.

In this article we will introduce you to the different strategies for operating a Lithium-Ion battery, and the influence of those strategies on the economic relevance of the investment.

BASIC ASSUMPTIONS

A behind-the-meter ESS can be functionally assimilated to an "energy buffer" allowing desynchronization of: (i) electricity consumption, (ii) grid usage and/or (iii) self-generation (e.g solar PV). Depending on the characteristics of the "energy time-shifting" (duration, power, etc.), the chemistry and ESS architecture shall be adapted to reach the highest efficiency and profitability.

In this article, we will focus more specifically on the relevancy of stationary ESS for grid-connected commercial and industrial buildings which are expected to grow their energy consumption by 1.6% per year until 2040[2]. We also choose a Lithium-Ion battery, which represents today the "Swiss-army Knife" of small and medium capacity storage systems. This type of battery is set to dominate the market in the coming years, benefiting among other things from traction linked to the growth in the electric mobility sector.

To illustrate the different management strategies of an ESS, we will analyze the French electricity market and take the example of a food & beverage industrial site with an annual consumption of 2.4 GWh, a contracted capacity of 480 kW and a Lithium-ion battery (50kW / 100kWh) installed behind the meter.

In order to determine the best control strategy, two sources of battery ageing must be taken into account. On the one hand, a "shelf" or "calendar" life, which we have set at 15 years, linked to the degradation of internal chemical components. And on the other hand, the degradation of its performance (decrease in capacity, increase in internal resistance, etc.) as a function of the number of cycles performed, which can be assimilated to "wear & tear". It is common practice (especially in the electric mobility field) to consider that a battery is "fully used" when its residual capacity falls below 80 % of its initial capacity. However, experience shows that recent Li-Ion batteries remain usable for stationary applications beyond this limit, with a capacity that continues to decrease almost linearly to less than 70 or even 60 % of its initial capacity before it collapses.

These two limits (shelf lifetime and maximum number of cycles) lead to different management strategies: one setting the limit of battery use at the conventional 80% value that we will correlate here to a total of 4,000 complete cycles, and the other one exploring usage up to 60 % of initial capacity (8,000 cycles), in accordance with the linear hypothesis mentioned above. In order to prevent a battery from being replaced at the end of its shelf lifetime without having been completely "worn out", a minimum cycling frequency must take place. With a shelf lifetime of 15 years, this corresponds to 270 cycles per year for the "80%" cycling strategy (i.e. 4000 cycles), and 530 cycles per year for the "60%" cycling strategy (i.e. 8000 cycles). In the following study, we will refer to this minimum number of cycles as "lost cycles" and to these two strategies as "**moderate cycling**" for 4,000 cycles, and "**intense cycling**" for 8,000 cycles.

STUDY OF THE BATTERY PROFITABILITY

An electricity bill is roughly divided into three items: (i) energy consumption, (ii) contracted capacity (or maximum power consumption, including any penalties in the event of exceeding the contracted value) and (iii) taxes. As the latter are indexed to energy and to contracted capacity, the utility bill therefore depends essentially on the energy consumed on the one hand and the power "consumed" on the other hand.

At constant kWh consumption, it is possible to reduce these two items by price arbitraging and by performing power peak-shaving. These savings opportunities will be studied independently and then cumulatively. In each case, we will compare the two strategies: moderate or intense cycling.

Note: In addition to the potential savings on the electricity bill, a storage asset can generate additional revenue by providing various services to the grid (demand-response, frequency regulation, etc.) that can be accumulated in terms of cashflows, and contribute significantly to the profitability of the investment. These grid services are deliberately not taken into account here.

TRADING-RELATED SAVINGS

Trading is the exploitation of market volatility & spreads between low & high prices. Here, we consider a purchase price indexed to the wholesale electricity spot market price. Although it is currently not very common in France for end-consumers to buy electricity directly from the spot market, it is quite frequent in other countries and we believe that such an opportunity is likely to develop across Europe in the coming years. The spot market presents more trading opportunities and is a better case to illustrate our study.

The basic idea of trading is to "over consume" by charging the battery when electricity is the cheapest (and incidentally the cleanest), and to "under consume" by discharging the battery when electricity is most expensive (and incidentally the most carbon-intensive), to reduce its electricity bill. Thus, from the grid point of view, the load profile of the site is modified to take advantage of the electricity price volatility.

We studied the evolution of the IRR of an ESS investment used for trading purposes only, based on its wear and tear and the expected evolution of economic assumptions in the coming years. The results confirm the intuition that in France, it is more interesting to use the battery intensively, since a larger number of cycles offers more trading opportunities (which explains the higher IRR values in intense cycling).

Taking into account the reduction in storage system costs[3] combined with the increase in energy costs in the coming years, IRRs remain negative with -4.7% for moderate cycling and -4.0% for intense cycling, even in 3 years with a pure trading strategy, as illustrated below.

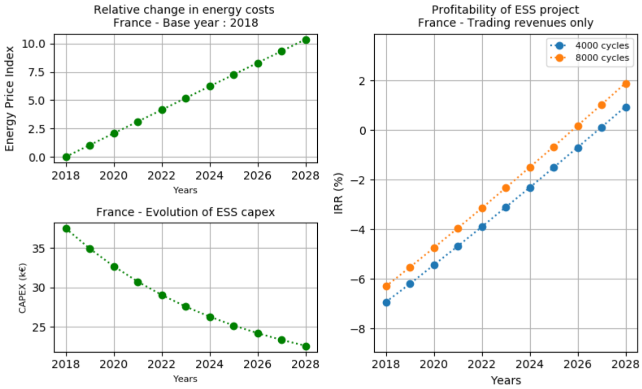


Figure 1: ESS profitability in trading - France

The increase in battery performance (number of cycles, efficiency, etc.) in the future will also positively influence profitability, but this parameter is not simulated here.

IRRs depend on the characteristics of the SPOT price, which shows little volatility in France. Consequently, trading opportunities with current French prices generate a profit lower than the cost of ESS wear and tear, so it is not worth cycling the ESS beyond its number of lost cycles.

However, if trends are confirmed, the economic opportunities related to trading should be multiplied tenfold thanks to a French wholesale market (SPOT) much more accessible to individuals.

PEAK-SHAVING RELATED SAVINGS

Peak-shaving of the power load is another source of savings, by reducing the contracted capacity. The battery is charged preferentially during periods of low consumption, and rather than drawing all the energy from the grid during peak periods part of the energy is supplied by the battery, which makes it possible to control and limit the grid power demand, and thus reduce contracted capacity and avoid certain penalties.

We studied the evolution of the IRR of an ESS investment in France for peak-shaving only, based on its wear & tear assumptions and the expected evolution of economic assumptions in the coming years.

As illustrated below, the IRR increases over the years and, unlike trading opportunity, the 8,000-cycle strategy generates fewer savings than the 4,000-cycle one.

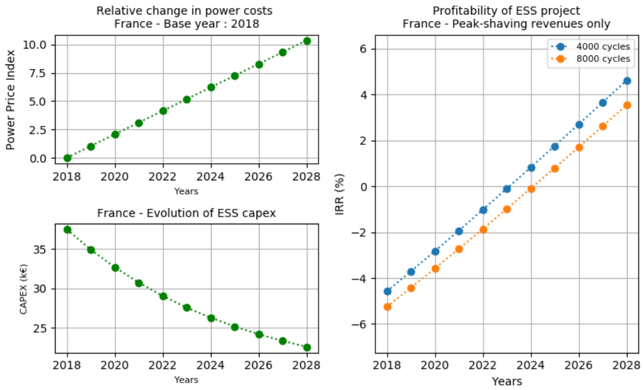


Figure 2: ESS profitability in peak-shaving - France

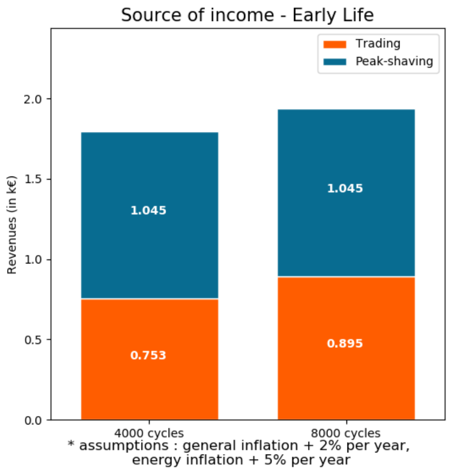
Indeed, the performance of the battery in peak-shaving mode depends on its usable capacity which decreases with aging. Intense cycling that accelerates ageing therefore also accelerates loss of peak-shaving performance.

Taking into account the evolution of storage system costs[3], which are expected to decrease by 18% in France in 3 years, combined with the increase in the cost of contracted capacity in the coming years, IRRs remain negative with -1.9% for moderate cycling and -2.7% for intense cycling, even in 3 years in peak-shaving alone.

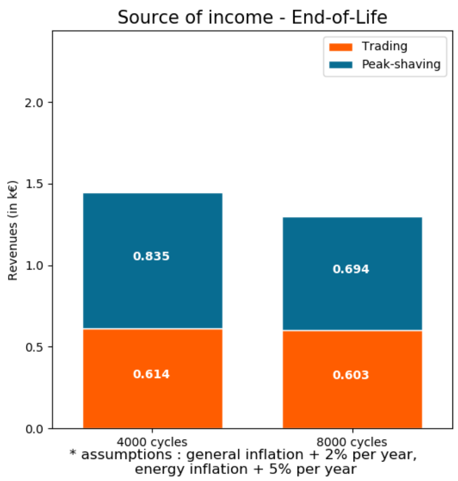
COMBINATION OF THE TWO OPPORTUNITIES

These simulations showed that the choice of a larger cycling number had antagonistic effects on the various savings opportunities. A large number of cycles generates more trading opportunities but accelerates cell ageing which impacts peak-shaving performance. In practice, it is much more cost-effective to combine the two services to increase savings, as illustrated in the two simulation results below.

In early life, usable battery capacities are similar in both cycling strategies, and peak-shaving savings are nearly the same. However, a more frequent cycling increases the share of savings related to trading.



At the end of its life, the intensively cycled battery has a more degraded capacity. The savings generated through peak-shaving opportunities are lower than those generated by moderate cycling, while the impact on trading is more limited.



In the French market, peak-shaving provides a slightly higher share of savings, so a moderate cycling strategy is needed, as confirmed by the currently slightly higher internal rate of return. Even if moderate cycling generates less savings at the beginning of life, the difference in savings over the lifespan is compensated with a positive IRR of 0.6%, compared to 0.5% for intense cycling.

If we observe the evolution of an ESS economic performance in a combined trading & peak-shaving strategy (see figure below), we see that the two profitability curves cross-over, due to energy inflation which favours trading opportunities.

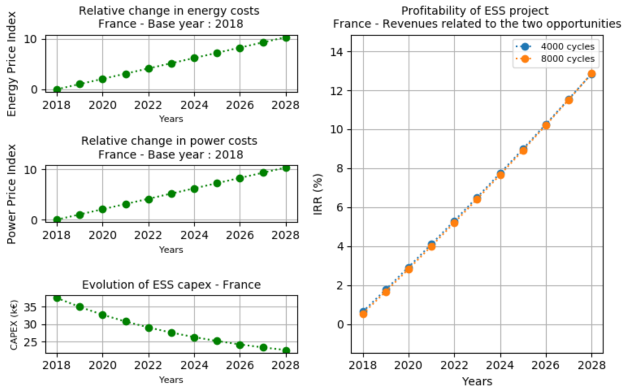


Figure 3: ESS Profitability [trading + peak-shaving] - France

Thus, by following either a moderate or intense cycling strategy, the savings generated by the combined use of an ESS in trading & peak-shaving would make it possible to reach an IRR of around 4.0 % within 3 years.

AND WHAT ABOUT OUTSIDE FRANCE?

We have seen that the French market remains inauspicious to an ESS project at this time. However, other markets are already profitable, such as Singapore or Australia.

Singapore is characterized by a full liberalization of the energy market, with greater spot price volatility than in France but not enough to compensate for the loss of peak-shaving revenues when the battery cycling is 'intense'. Thus, as in France, the moderate cycling strategy is the most profitable with an IRR currently at 9.3% (15.5x better than France) against 14.2% in three years (3.5x better than France).

Australia is characterized by a sparse network and high demand charges are making peak-shaving revenues higher than in France. But the difference is even more dramatic in terms of price volatility which is so high that it compensates for the loss of battery capacity with 'intense' cycling. As a consequence, in some Australian states, we now reach an IRR higher than 80% in intense cycling (170 times higher than France for the same strategy!), And around 120% within three years (nearly 30x better than France).

CONCLUSION

The more volatile the market, with a significant spread between extreme prices and a short trading time-step, the more interesting trading opportunities are. Peak-shaving is more cost-effective in jurisdictions with high demand charge. It is therefore important to adjust the operational strategy of an ESS depending on the user profile and the market in which it operates.

The development of stationary ESS, coupled with favorable price outlook (lower storage costs, higher energy costs), should lead to an increase in the economic profitability of energy projects with storage.

In addition, we have only dealt here with price arbitrage and peak shaving services, but it is possible to further improve the profitability of such projects as BeeBryte does by stacking grid services (demand response, reserve, frequency regulation, etc) and coupling the ESS with existing flexible loads (e.g. heating-cooling systems).

As we have seen, the relevance of such storage projects strongly depends on the local, current and future characteristics of markets and tariff structures. Australia is emerging today as particularly conducive to ESS investments. But today in Singapore, and within a few years in France, the profitable incorporation of stationary storage will contribute to an increased resilience of the grid, allowing for greater penetration of intermittent renewable energies like solar and wind.

If you are wondering about the technical and economic relevance of an ESS investment or would like to be advised in the optimal sizing of such a system, do not hesitate to contact us!

1. P Maloney, « not so fast : battery prices will continue to decrease but at a slower pace GTM says, 2018

2. WBCSD, “Energy efficiency in Buildings, Business Realities and Opportunities”, 2009

3. P.D’Aprile, J.Newman, D. Pinner « the new economics of energy storage », 2016

BeeBryte is using IoT, AI and BlockChain to get commercial buildings, factories, EV charging stations or entire eco-suburbs to consume electricity in a smarter, more efficient and cheaper way while reducing carbon footprint!

BeeBryte is based in France and Singapore, and is accelerated by Intel & Techfounders.

Since its creation in 2015, BeeBryte’s solutions have been awarded by prestigious organizations, such as EDF Pulse, DENA Start-up Energy Transition award & Hello Tomorrow Challenge.

contact@beebryte.com
www.twitter.com/BeeBryteGroup
www.beebryte.com