K4K Food4Thought:

Start to demystify BESS (Battery Energy Storage Systems)

In the electricity industry there is a lot of talk about grid-connected battery solutions. Arguably, so much that unless you're an expert you can get lost easily. The intention of this article is to go back to basics and explain how to start making a business case for batteries by focusing on arbitrage opportunities; namely charging the battery when wholesale power market prices are low and discharging it when prices are high. Let's start by using historical data to assess how much money a battery might have earned and how this would have varied over time.

Before we dive into numbers, let's clarify what we mean when discussing batteries. There is plenty of technical jargon but at its heart a battery can be defined by two key characteristics: connection capacity and energy storage capability. So a one-hour battery with connection capacity of 1MW (power) will have storage capability of 1MWh (energy), an equivalent two-hour battery will be able to store 2MWh, etc. Batteries are not perfect so will be losses when you charge and discharge. A full charge and discharge is referred to as a "cycle" and cycling degrades the battery. Have you noticed that over time your rechargeable electric toothbrush needs to be recharged more often/for longer? This also happens with grid-connected batteries. By reducing the useful lifetime of your battery, cycling implies a cost. And this is separate from cycling losses. For example, if you charge with 1MWh but can only discharge say 0.85MWh later this means you have a 15% cycling loss. (Hydroelectric pumped storage power plants may not suffer much from degradation but have about 20-30% cycling loss.)

With this in mind, let's now define four 1MW batteries with 1, 2, 4 and 12-hours of storage, namely 1MWh, 2MWh, 4MWh, and 12MWh respectively. Let's assume a cycling loss of 15% and apply a variable cost to reflect degradation of 1€/MWh whenever you charge or discharge the battery. We won't limit the number of cycles. Then we set up an optimisation model that defines hourly charge and discharge cycles that maximise net income across the year using only the hourly day-ahead prices in the Spanish electricity wholesale market operated by OMIE (Operador del Mercado Ibérico de Energía - Polo Español) for the period between 1 January 2018 to 31 October 2023.

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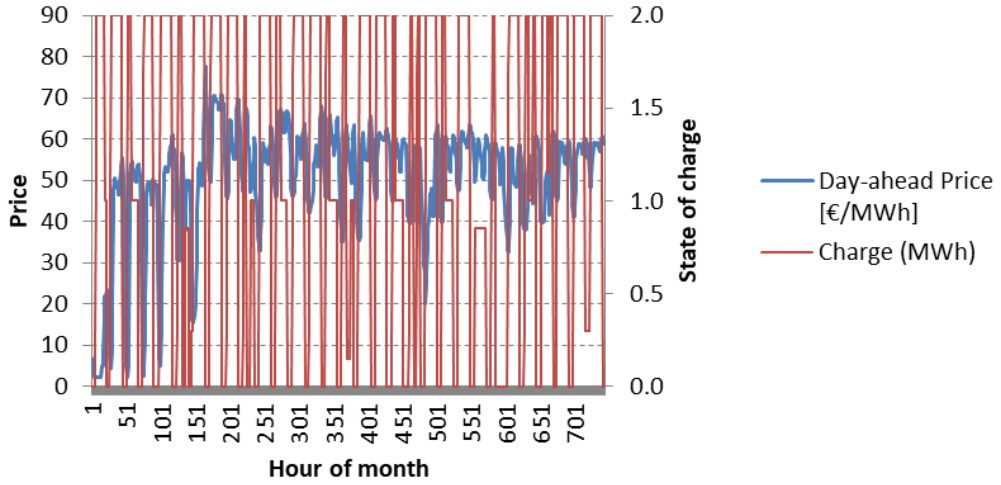
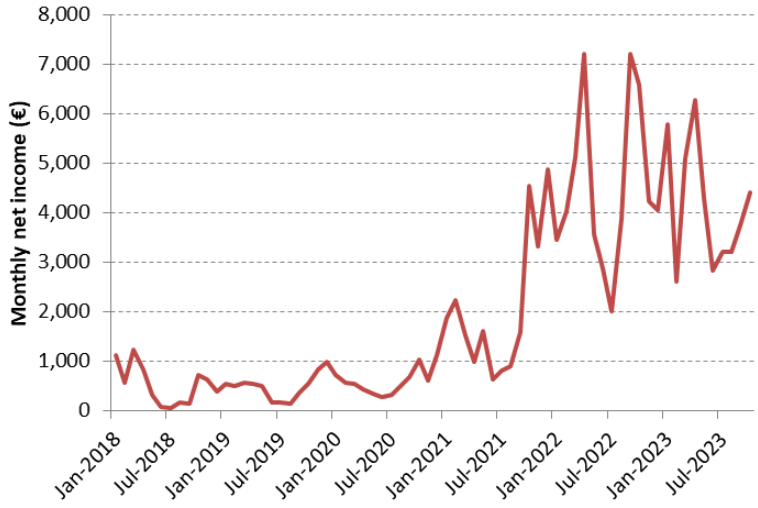
Figure 1: Hypothetical optimised operation of a 2-hour battery in January 2018



Source: OMIE and K4K calcs.

Figure 1 above shows the state of charge and hourly prices for the first month of 2018 for the 2-hour battery option. For January 2018, the net income achieved from arbitrage would have been €1,130. The evolution of monthly net income since then is shown in Figure 2 below.

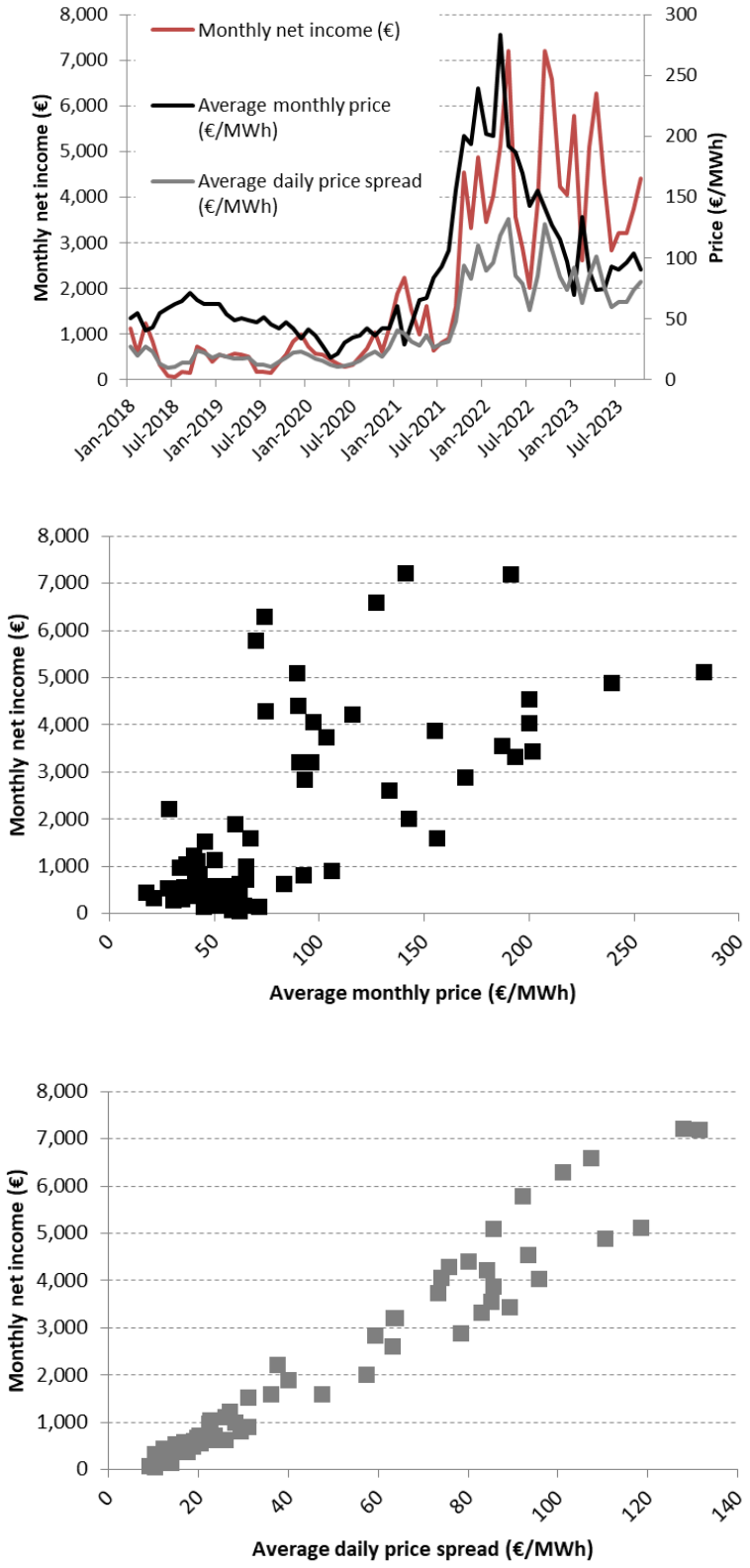
Figure 2: Monthly net income for hypothetical 2-hour battery



Source: OMIE and K4K calcs.

There is a noticeable change in results from mid-2021 which coincides with the rise in gas and electricity prices introduced by the growing tension with Russia. However, as shown in Figure 3 below, whilst higher prices certainly help, the evolution in net incomes is best explained by the increase in the daily difference between maximum and minimum hourly prices.

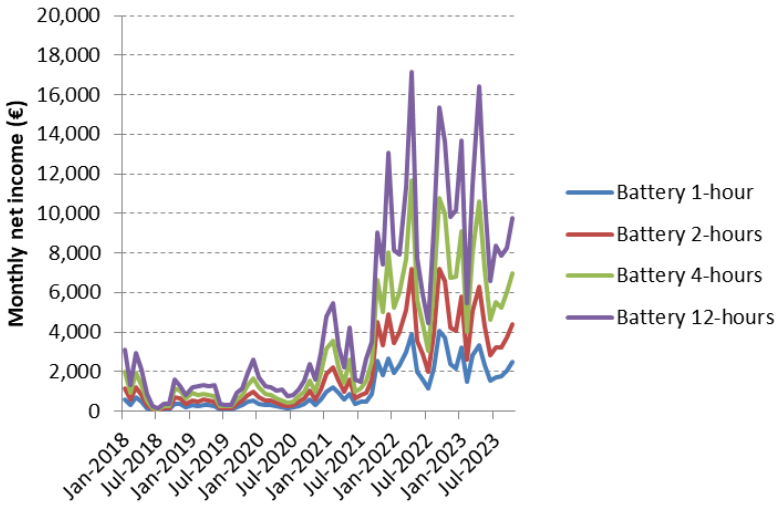
Figure 3: Main drivers of monthly net income for hypothetical 2-hour battery



Source: OMIE and K4K calcs.

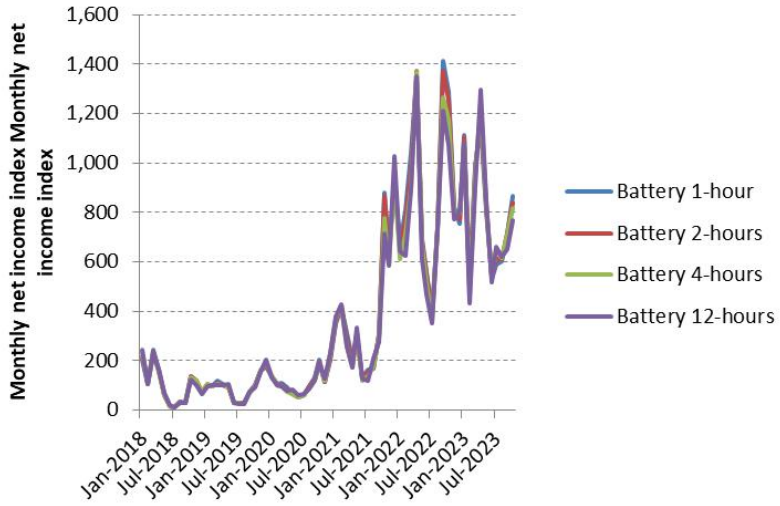
The same calculations can be done for the other battery configurations as shown in Figure 4. This shows that having more storage capability results in higher net incomes. However, when we normalise using 2018 as the base year, the four indices are remarkably similar as shown in Figure 5 below. Currently the arbitrage opportunity is worth eight times what it was in 2018.

Figure 4: Monthly net income for batteries with different storage capabilities



Source: OMIE and K4K calcs.

Figure 5: Index of monthly net income (2018-100)

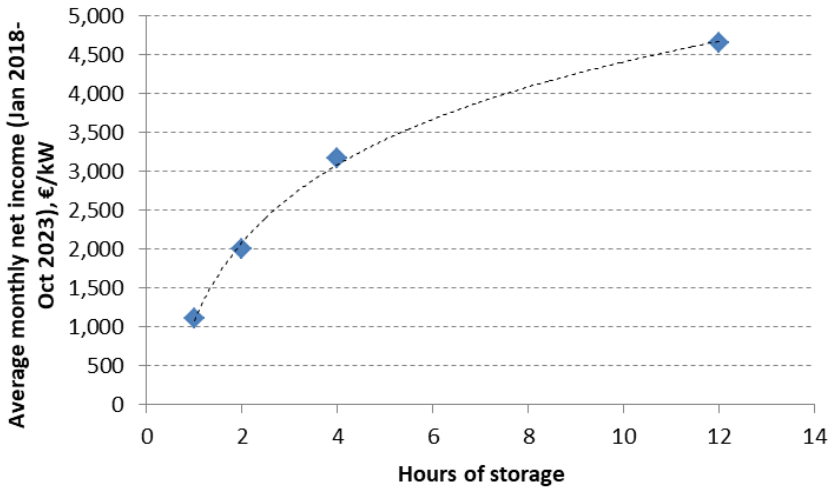


Source: OMIE and K4K calcs.

Finally, one can calculate the average monthly net income for each of the battery configurations over the entire period. This is shown in Figure 6 below. Whilst net income rises with storage capability, it suffers from diminishing returns. In other words, the increase in net income drops with every hour's worth of storage that is added. And economist would tell you that to maximise net income you should keep adding storage

capability until the incremental cost of storage capacity is equal to the incremental income.

Figure 6: Average monthly net income by battery configuration (Jan 2018-Oct 2023)



Source: OMIE and K4K calcs.

If we use historical results for reference of the possible range of annual income in the future, we can compare these to the levelised annual cost of a battery investment. 2,000 €/MW for a 1-hour battery would translate to 24,000 €/MW per year or 24€/kW/year if you prefer to think in terms of kW. But we have seen spikes twice that high. These figures can be directly compared to the cost of the annual battery investment: X €/kW for capex multiplied by Y as the LRCCR (Levelised Capital Charge Rate). If a 1-hour battery costs 500€/kW (and I'm not saying this is the case but to simplify things) and the LRCCR was 9%, we would be talking about 45€/kW/year compared to 24€/kW/year. This helps explain the view shared by many that income from arbitrage alone is not enough to justify an investment in batteries.

Of course the past is not a predictor of the future and more volatile prices resulting from, say, excess renewable generation can be expected to lead to wider intraday price spreads. And the "missing money" problem could also be overcome if batteries can layer additional income from ancillary services or capacity markets. In Spain, however, there is no market for Frequency Containment Reserve ("FCR"), "primaria" in Spain, since plants that can provide this service must to do at zero cost to the system operator, Red Eléctrica de España ("REE"). And the design of a capacity market has not yet been approved although the Spanish government's proposal is being reviewed by Brussels and is expected to be ready for launch in the second half of 2024. Nevertheless, there are already 2.5GW and 6.5GW of new pumped storage and new battery projects respectively with connection permits and authorisation from REE. So, while there is still some way to go, investors are taking steps to ensure that, once economic conditions improve, they will be ready to crack on.

Mr. Kim Keats

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