Photon Energy

BESS Quarterly Financial Analysis

October–December 2024

7 May 2025

Introduction

The Photon Energy BESS Quarterly Financial Analysis evaluates the financial performance of 1MW/1MWh and 1MW/2MWh battery energy storage systems (BESS) across the Czech Republic, Poland, Romania, and Hungary.

We've considered two main sources of income for this report: aFRR ancillary services (reservation, activation, recharging and discharging after activation) and day-ahead market (DAM) arbitrage.

The reported data are calculated using an optimisation tool that assumes optimal battery performance each hour.

Assumptions

- We take into account 5% noise in the forecasted data
- The availability of the battery is 96% of total time
- The battery system has a roundtrip efficiency of 94% (97% for charging and discharging)
- We assume a maximum of two operational cycles per day

This report covers the period from October to December 2024.

Monthly Average Revenues per 1 MWh

This table compares the monthly revenues per 1 MWh standalone battery (in EUR/MWh) for the months of October, November, and December 2024, highlighting the difference between revenues when the battery **participates exclusively in the day-ahead market (DAM)** and when it is **optimised for both the day-ahead and automatic frequency restoration reserves (aFRR)** markets.

Monthly Average Revenue per 1MW/1MWh Standalone Battery (EUR/MWh)

	DAM	DAM + aFRR					
	Total	aFRR				DAM	Total
		aFRR Up		aFRR Down			
		Reservation	Activation*	Reservation	Activation*		
CZ	**2,777**	12,608	823	37	2,206	1,070	**16,745**
PL	**3,048**	21,004	63	15,579	559	1,231	**38,436**
RO	**5,489**	3,662	277	3,654	4,554	2,021	**14,169**
HU	**4,724**	1,988	43	2,396	2,353	1,819	**8,599**

Monthly Average Revenue per 1MW/2MWh Standalone Battery (EUR/MWh)

	DAM	DAM + aFRR					
	Total	aFRR				DAM	Total
		aFRR Up		aFRR Down			
		Reservation	Activation*	Reservation	Activation*		
CZ	**2,328**	8,116	183	22	1,377	1,026	**10,723**
PL	**2,788**	15,360	17	9,212	336	1,246	**26,170**
RO	**5,069**	2,281	387	2,281	2,484	2,080	**9,513**
HU	**4,147**	1,230	22	1,511	1,476	1,735	**5,975**

** The activation portion of income includes expenses related to charging after activation Up and income related to discharging after activation Down.*

In Poland, there is additional income from the capacity market, which can be added to the total revenue. The monthly amount is EUR 1,368 for a 1MW/1MWh battery and EUR 2,766 for a 1MW/2MWh battery.

Monthly Average Revenues

Revenue from DAM Only

Across all countries, the monthly revenue from optimising a battery solely for the DAM remains lower compared to the combined strategy of optimising for both DAM and aFRR services.

- **Romania** shows the highest revenue from DAM alone per 1 MWh: EUR 5,489 for 1MWh, EUR 5,069 for 2MWh
- **Hungary** shows EUR 4,724 for 1MWh, EUR 4,147 for 2MWh
- **Poland** shows EUR 3,048 for 1MWh, EUR 2,788 for 2MWh
- **Czech Republic** has the lowest DAM-only revenue: EUR 2,777 for 1MWh, EUR 2,328 for 2MWh.

This indicates that DAM alone provides moderate returns but is not as lucrative as aFRR optimisation.

Impact of aFRR Optimisation

Optimising for both DAM and aFRR services significantly boosts revenue, particularly in Poland, where aFRR Up reservation contributes the most to total earnings.

- In **Poland**, **aFRR Up** reservation adds EUR 21,004/1MWh for a 1MW/1MWh battery and EUR 15,360/1MWh for a 1MW/2MWh battery, making it the largest source of potential revenue
- **Czech Republic** also benefits from **aFRR Up** reservation as the main source of profit: EUR 12,608/1MWh for 1MWh, EUR 8,116/1MWh for 2MWh
- **Romania** sees the highest revenue from **aFRR Down** activation: EUR 4,554/1MWh for 1MWh, EUR 2,484/1MWh for 2MWh
- **Hungary** sees smaller revenue boosts from aFRR optimisation: **aFFR Up** reservation provides EUR 1,988/1MWh – EUR 1,230/1MWh, while **aFRR Down** reservation provides EUR 2,396/1MWh – EUR 1,511/1MWh, showing a more limited benefit compared to Poland and Romania

1MW/1MWh vs. 1MW/2MWh Batteries

A 1MW/1MWh battery generates more revenue per 1MWh than a 1MW/2MWh battery, especially in Poland and Romania.

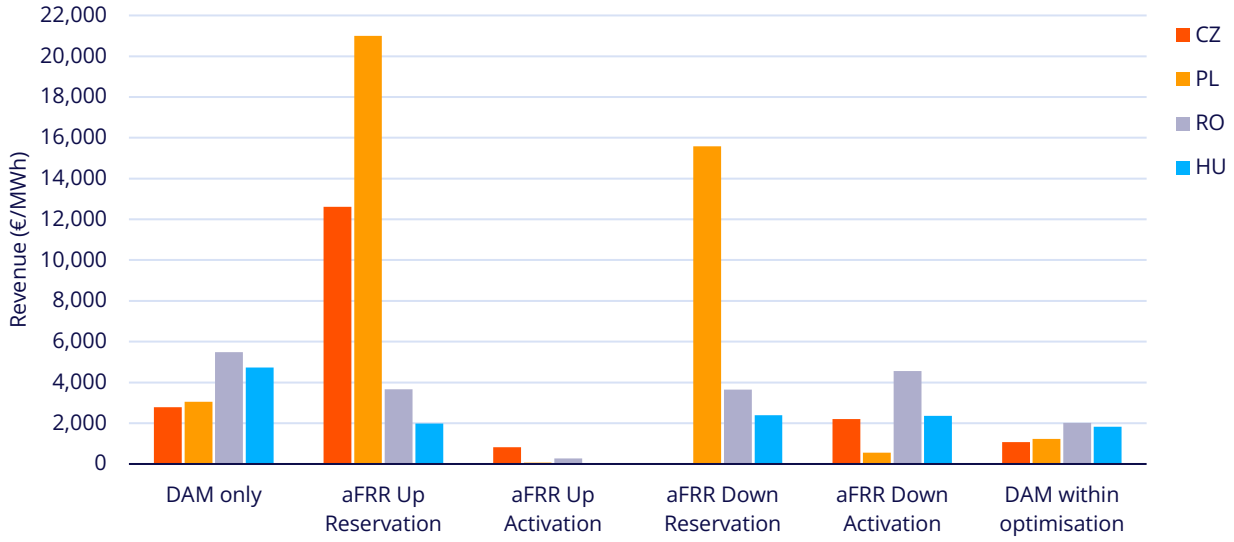
- In **Poland**, a 1MW1MWh battery earns EUR 38,436/MWh, significantly more than a 1MW/2MWh battery at EUR 26,170/MWh. The difference is particularly large for aFRR Up reservation, where a 1MWh/1MW battery earns EUR 21,004/MWh, compared to EUR 15,360/MWh for a 1MWh/1MW battery
- **Romania** follows a similar trend, with revenue from DAM + aFRR decreasing from EUR 14,169/MWh (1MW/1MWh) to EUR 9,513/MWh (1MW/2MWh), emphasising the importance of battery capacity optimisation
- **Czech Republic** also sees a revenue decline in 1MW/2MWh batteries, with total revenue decreasing from EUR 16,745/MWh (1MW/1MWh) to EUR 10,723/MWh (2MWh)
- **Hungary** shows a less pronounced difference between the two battery sizes, with total revenues of EUR 8,599/MWh (1MW/1MWh) and EUR 5,975/MWh (1MW/2MWh), indicating a smaller-scale benefit from optimisation

Country Variations:

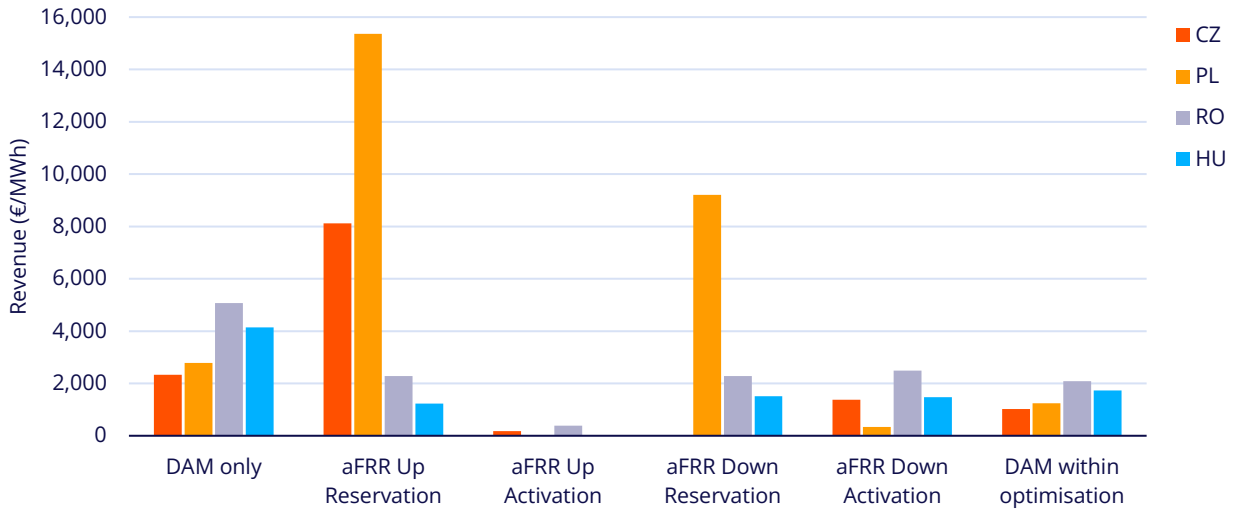
Poland and Romania emerge as the most lucrative markets for optimising battery services between DAM and aFRR, with strong revenue increases driven by aFRR Up reservation and aFRR Down activation, respectively.

- **Poland** sees the most dramatic increase in revenue when optimising for both DAM and aFRR, particularly from aFRR Up reservation
- **Romania** benefits strongly from aFRR Down activation revenue, making it a key market for flexibility-based optimisation.
- **Czech Republic** also shows notable revenue gains from aFRR Up reservation, though at a smaller scale than Poland
- **Hungary** shows smaller increases in revenue from aFRR, with DAM-only revenue already relatively high, suggesting that additional optimisation into aFRR is less impactful.

Monthly Average Revenue for Oct–Dec 2024 1MW/1MWh Standalone Battery



Monthly Average Revenue for Oct–Dec 2024 1MW/2MWh Standalone Battery



Prices Report: Assumptions

Pricing for aFRR Ancillary Services [1]

	Reservation	Activation
CZ	Pay as bid	Marginal price
PL	Marginal price	Marginal price
RO[2]	Marginal price	Marginal price
HU	Pay as bid	Pay as bid

Pricing for the Capacity Market in Poland

Parameter	Value[3]
Correction factor for batteries	95%
Capacity market service	Max 4 hours in row
Capacity market testing	4x per year
Capacity market hours	7–22
Latest available price	303.87 PLN/MW/year

Network Tariffs [4]

	EUR/MWh
CZ	38
PL	47
RO	21
HU	28

[1] *80% successful auctions for reservation and 50% for activations.*

[2] *In Romania, ancillary service offers must be symmetrical. Participants must participate in both directions, Up and Down.*

[3] *These values are valid for 2024. The price reflects the average price from additional auction. System stress events (SSE) not counted, in 2024: 3 hours of SSE in Poland.*

[4] *This fee is applied whenever a battery is charged from the grid, for the purpose of DAM arbitrage and when recovering from activation Up.*

Price Report

This table provides detailed pricing information (in EUR) for different countries and different energy market mechanisms. The table captures a range of statistics for each country, including the **mean**, **minimum**, **maximum**, and **standard deviation.**

		DAM	aFRR Reservation		aFRR Activation	
			Down	Up	Down	Up
CZ	mean	118	0.07	28	50	121
	min	-14	0.01	10	-2,607	-144
	max	845	0.56	42	2,065	2,302
	std	65	0.14	6.3	129	117
PL	mean	114	34	50	111	114
	min	-15	5.1	4.2	-167	-167
	max	660	152	363	403	491
	std	60	30	46	64	65
RO	mean	133	17	17	-38	208
	min	-13	14	13	-1,272	0.00
	max	843	28	29	265	1,490
	std	94	2.53	2.92	140	209
HU	mean	133	5.2	4.7	7.4	147
	min	-13	0.00	0.00	-116	0.00
	max	895	47	49	86	4,203
	std	92	7.3	7.5	21	283

Insights

Day-Ahead Market (DAM) Prices

- The mean DAM price is highest in Romania and Hungary at EUR 133/MWh, followed by the Czech Republic at EUR 118/MWh and Poland at EUR 114/MWh
- The standard deviation (volatility) is highest in Romania (94) and Hungary (92), indicating greater price fluctuations compared to the Czech Republic (65) and Poland (60)

aFRR Reservation Prices

- Downward reservation prices are minimal in the Czech Republic (EUR 0.07/MWh) but much higher in Poland (EUR 34/MWh), Romania (EUR 17/MWh), and Hungary (EUR 5.2/MWh).
- Upward reservation prices are highest in Poland (EUR 152/MWh max), with Romania (EUR 28/MWh) and Hungary (EUR 47/MWh) having much lower peaks

aFRR Activation Prices

- Downward activation shows extreme volatility, especially in the Czech Republic (EUR -2,607/MWh minimum) and Romania (EUR -1,272/MWh minimum), with Hungary (EUR -116/MWh) and Poland (EUR -167/MWh) being relatively stable
- Upward activation prices peak at EUR 4,203/MWh in Hungary, far exceeding the other countries: Czech Republic (EUR 2,302/MWh); Romania (EUR 1,490/MWh); Poland (EUR 491/MWh). This indicates major price surges in Hungary

Key Takeaways

- Hungary and Romania show the most extreme price variations, especially in upward activation prices
- Czech Republic has the lowest aFRR reservation prices, particularly for downward reserves
- Poland has high aFRR reservation prices, but relatively stable activation prices
- Extreme negative activation prices in the Czech Republic and Romania indicate periods of significant market imbalance.

Overall Summary

Revenue Comparison (DAM vs. DAM + aFRR)

- Optimising battery operation for both DAM and aFRR significantly increases revenue, with Poland and Romania benefiting the most
- DAM-only revenues are highest in Romania (EUR 5,489/MWh) and lowest in the Czech Republic (EUR 2,328/MWh)
- In Poland, aFRR Up reservation contributes significantly to total earnings

Battery Size Impact (1MW/1MWh vs. 1MW/2MWh)

- Smaller 1h batteries (1MW/1MWh) generate more revenue per MWh than larger 2h ones, particularly in Poland and Romania
- In Poland, a 1MWh battery earned EUR 38,436/MWh, while a 2MWh battery earned EUR 26,170/MWh – highlighting the importance of size optimisation
- To meet full potential, batteries should be aggregated

Country-specific Observations

- **Poland:** the most lucrative market, with strong gains from aFRR Up reservation.
- **Romania:** benefits the most from aFRR Down activation.
- **Czech Republic:** moderate benefits from aFRR Up reservation, but lower activation revenue
- **Hungary:** shows limited benefits from aFRR, with relatively high DAM revenue.

Price Insights

- **DAM prices:** Highest in Romania and Hungary (EUR 133/MWh) and lowest in Poland (EUR 114/MWh)
- **aFRR reservation prices:** Poland has the highest Up reservation price (EUR 152/MWh), while the Czech Republic has the lowest Down reservation price (EUR 0.07/MWh).
- **aFRR activation prices**: Hungary experiences extreme peaks (EUR 4,203/MWh for Up activation), whereas the Czech Republic and Romania have negative activation prices, indicating market imbalances

Ready for further insights?

Connect with our team today to learn more about the data presented in this report, or to explore how we can help you develop a profitable and sustainable BESS solution.

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