Energy storage report

KYOS benchmark - assessments of battery energy storage value

No 3 – Dec 2023

KYOS

Battery revenue assessments 2024

Revenues 2024 (€/kWh)

Market	Day-Ahead		Day-Ahead + FCR		Intraday		Intraday + imbalance	
	Average	10%	Average	10%	Average	10%	Average	10%
NL	45.3 ↓	40.9 ↓	56.3 ↓	55.2 ↓	120.6 ↓	113.0 ↓	190.8 ↓	182.2 ↓
BE	40.5 ↓	36.9 ↓	105.4 ↑	79.9 ⇔	67.5 ↓	64.1 ↓	169.0 ↓	157.9 ↓
DE	43.0 ↓	38.7 ↓	57.4 ↓	55.9 ↓	84.1 ↓	78.8 ↓	n/a	n/a
ES	40.4 ↓	35.8 ↑	n/a	n/a	47.2 ↓	42.6 ↓	n/a	n/a
GB	29.0	24.3	n/a	n/a	45.2	41.6	70.4	66.0

Battery revenues in €/kWh in 2024 for a stand-alone located, 0.5C battery with a roundtrip efficiency of 86% and a maximum of 730 cycles per year. For more details, see next page of this report.

In comparison with our last update, we observe a decrease in all battery valuations driven mostly by the lower level of the 2024 forward curves.

Also noticeable is the lower value from arbitrage in Great Britain (GB) and Spain (ES), where battery revenues have been historically fuelled by the procuring of ancillary services, which for consistency purposes are left out of the valuation methodology used in this report.

The high valuation for the intraday strategy in the Netherlands (NL) is well above the projections for the other markets, thanks to the consistently high daily intraday spreads in the Dutch power market. This seems to be a new normality in the Dutch intraday market due to fast deployment of residential photovoltaics.

Finaly, high FCR prices in Belgium (BE), fueled by scarce flexibility in their system, drive the DA+FCR strategy value well above the ones reported for the Netherlands and Germany (DE).

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Explanation and methodology

Battery definition

- The batteries are of type 0.5C; this means that the battery can be fully charged or discharged in 2 hours
- No degradation is assumed over the valuation period (2024)
- Batteries have a round trip efficiency of 86%, based on 92.7% charge and discharge efficiency
- The number of cycles per year is limited to 730
- All assets are stand-alone.
- Variable grid costs of 1€/MWh are taken into account

Valuation methodologies

- All valuations have been performed with KYOS software and models: KyBattery and KySim. The values are expressed in €/kWh.
- The trading date for all values is December 1st, 2023.
- The model uses Monte Carlo simulation and Least Square Monte Carlo optimization, combined with a smart trading rule for the imbalance market.
- Day-Ahead (DA): trading in the Day-Ahead market, hourly granularity.
- Day-Ahead and FCR (DA+FCR): offering capacity in the FCR market (4 hours) or trading in the Day-Ahead market, hourly granularity.
- Intraday (ID): trading in the intraday market, 15 min granularity for NL, DE, BE, 30 min for GB, and 60 min for ES.
- Intraday and imbalance (ID+IB): trading in intraday, combined with passively trading imbalance. Only where passive imbalance trading is allowed (NL/BE 15 min, GB 30 min).
- A multi-linear regression on historical imbalance and intraday prices is used to generate imbalance forecasts for the trading strategy.
- ID and imbalance prices are simulated according to the historical market volatility between 2021-01-01 and 2023-12-01.
- The FCR prices of the last 12 months are taken into account.

Day-Ahead daily spreads

The daily Day-Ahead (DA) power price spread is the highest DA price on the day minus the lowest price on the day per hour (grouped in hourly average blocks for sub-hourly prices).

The spreads declined over the last 12 months from the extreme spreads in 2022. However, in all countries except Spain there was a slight increase in the last three months. This corresponds to an expected autumn behaviour due to a typically higher wind generation (and intermittence from it) together with the slight uptrend in the gas prices associated with the lower temperatures.

In the last year and quarter, The Netherlands presents the highest daily DA spreads, while Spain (characterized by lower DA prices) presents the lowest ones, noticeably stable for the last 3 years.

Average daily spread in the Day-Ahead prices (€/MWh)

Country	Last 36 months	Last 12 months	Last 3 months
NL	133.5	117.2	122.1
BE	124.9	100.7	107.9
DE	123.3	107.1	120.4
ES	72.8	74.6	72.0
GB	143.4	90.4	93.0

Intraday daily spreads

The daily Intraday (ID) power price spread is the highest intraday price on the day minus the lowest price per hour (grouped in hourly average blocks for sub-hourly prices).

After the rise starting towards the end of 2021, Germany, Belgium and The Netherlands have maintained high values through 2023. In the coming months and years, we will see if this is the new normality in these ID markets.

Great Britain has experienced a reverting of the high ID spreads, mainly driven by the flexibility in the GB electricity market with 5 GW of storage installed capacity (battery & pump-hydro).

The difference between countries is significant, where the Netherlands is at almost four times higher intraday spreads than Spain (276 vs 76 €/MWh).

Average daily spread in the Intraday prices (€/MWh)			
Country	**Last 36 months**	**Last 12 months**	**Last 3 months**
NL	238.8	262.6	275.6
BE	173.5	151.6	147.7
DE	202.9	202.1	189.0
ES	85.0	86.6	76.1
GB	163.1	117.5	109.7

Imbalance daily spreads

The daily Imbalance (IB) power price spread is the highest imbalance price on the day minus the lowest price per hour (grouped in hourly average blocks for sub-hourly prices).

There are contrasting trends in the daily spreads of imbalance power prices in Europe. GB spreads have been continuously dropping in this year (similarly to Intraday), opposite to BE and NL. The spreads differ largely across the countries, with GB below 200 €/MWh, while Belgium and the Netherlands have spreads 2 (BE) to 3 (NL) times higher.

These differences are not only explained by the relatively larger flexibility in Great Britain, but also from the high presence of renewables installed capacities, underscored by an aggressive adoption of roof-solar generation in Belgium and the Netherlands. This has progressively displaced flexible generation "out-of-merit", increasing the imbalance costs, reflected in the high imbalance prices and price volatility. Just as for intraday spreads, it is interesting to see if these high levels will be maintained in the future.

Average daily spread in the Imbalance prices (€/MWh)			
Country	**Last 36 months**	**Last 12 months**	**Last 3 months**
NL	536.8	610.4	642.4
BE	444.5	439.0	441.6
GB	249.5	193.4	173.6

FCR prices

Frequency Containment Reserve (FCR) prices have remained almost completely equal in the Netherlands and Germany for most of the last year. Despite a slight step-up in the last month, both markets are maintaining the downward trend in FCR prices that has accompanied the drop in gas prices.

Belgium, in contrast, has experienced soaring FCR prices since July of this year, due to the scarce flexibility in their system, with the lower share of flexible gas-fired power stations.

Both Spain and Great Britain are not under the geographical coverage of the FCR market, as they have their own capacity retribution mechanisms in place for frequency regulation.

Average FCR prices (€/MW/h)

Country	Last 36 months	Last 12 months	Last 3 months
NL	19.89	12.83	12.48
BE	31.21	25.02	47.29
DE	17.64	12.67	12.46

KYOS - Energy Storage Services

Software – KyBattery

1) State of the art tool to provide energy storage valuations

2) Based on Monte Carlo price simulations and Least-squares Monte Carlo to perform realistically optimal trading strategy

3) Supports wide range of battery configurations

4) Supports different technologies: Li-ion, pumped hydro, flow batteries, compressed air energy storage

5) Supports different set-ups: standalone assets, co-located assets

6) Participation in multiple markets: day-ahead, intraday, imbalance, and FCR (also combined strategies).

Consulting – examples

1) Valuation of battery cashflows with different market participation approaches to develop business cases

2) Independent assessment of expected revenue streams for third parties

3) Comparison between different storage assets and types to identify competitive advantages per market

4) Battery sizing for optimal network use in combination with co-located generation assets

5) Benchmarks to validate performance of energy storage optimizers

Across all European markets, for all energy storage techniques

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