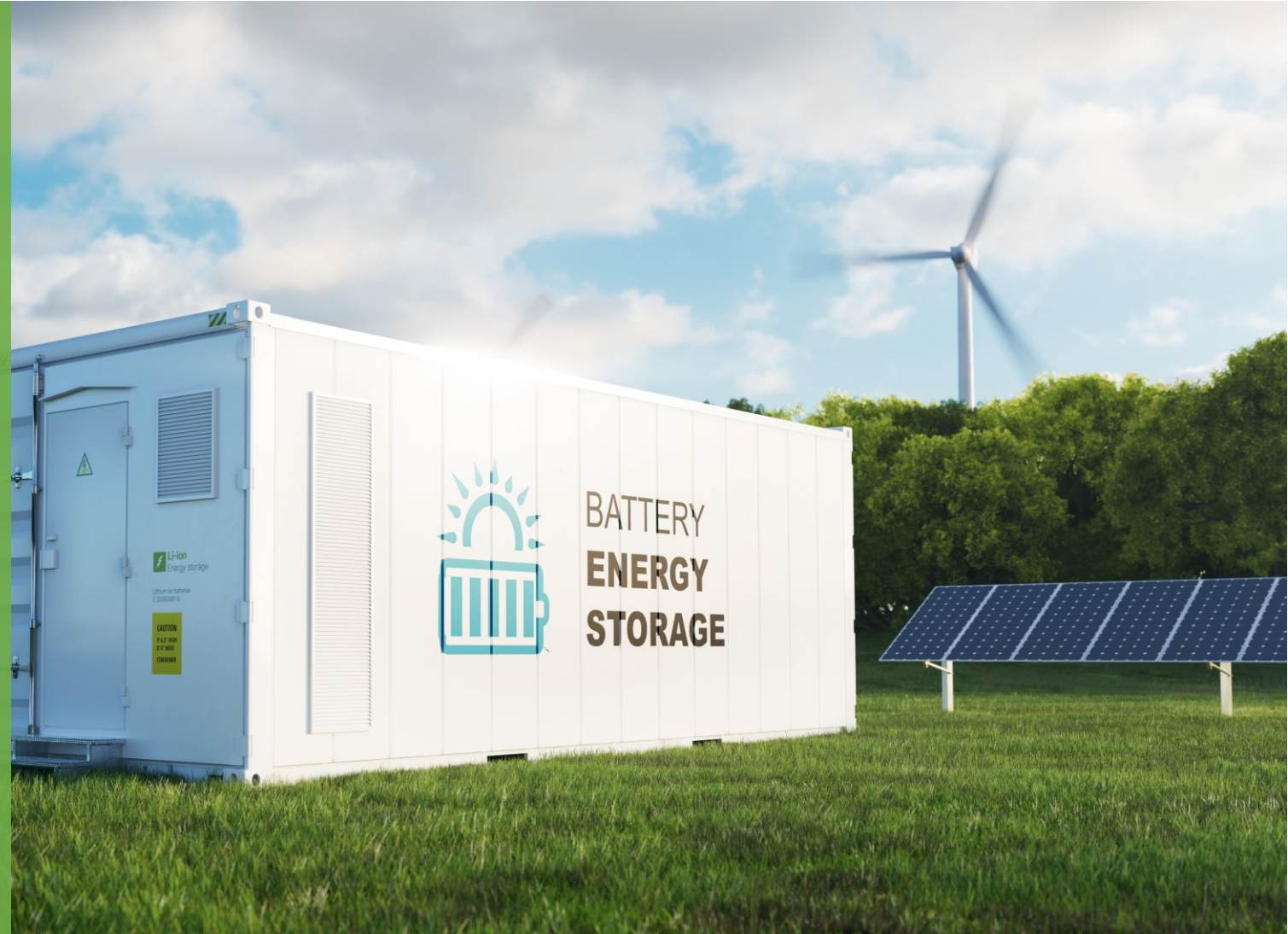


Energy storage report

KYOS benchmark -
assessments of battery
energy storage value

No 2 - September 2023



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	52.4	48.3	65.4	62.7	124.7	117.5	202.7	190.6
BE	48.2	42.3	80.1	79.9	96.0	91.8	192.6	179.7	
DE	51.3	46.0	68.2	65.7	91.5	87.2	n/a	n/a	
ES	41.2	34.5	n/a	n/a	49.6	44.5	n/a	n/a	

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. For more details, see next page of this report.

Battery value assessments went up compared to the first report. A higher daily spot price volatility in Spain increased the expected value from day-ahead trading by almost 40%. The biggest increase in all countries is in the intraday trading, with and without imbalance trading, where the previous report conservatively used price spreads from 2021 only (see valuation

methodology on next page for details). We were not sure at the time if the high spread volatility of 2022 would persist, but it largely did, so we now included the complete history from 2021 to today in the simulation model. Consequently, intraday trading assessments went up by 30-76%, and intraday + imbalance by 69-73%.

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 valuation timeframe
- Batteries have a round trip efficiency of 86%, this is based on 92.7% charge and discharge efficiency
- 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 trading date for all values is September 4th, 2023
- Day-ahead (DA): value generated by trading exclusively in the day-ahead market, hourly granularity
- Day-ahead and FCR (DA+FCR): value generated by offering capacity in the FCR market or trading in the day-ahead market, hourly granularity. The assumed FCR price is the average of the past 12 months.
- Intraday (ID): value generated by trading exclusively in the intraday market, 15 min granularity for NL, DE, BE, and 1 h for ES
- Intraday + Imbalance (ID/IB). This shows the value of passive imbalance trading combined with intraday trading. The imbalance price forecasts are estimated with a multi-linear regression on historical imbalance and intraday prices. Note that passive imbalance trading only applies to NL and BE.
- Intraday and imbalance prices are simulated based on historical spreads with the day-ahead prices in the period January 2021 and September 2023.
- The table shows the average across the simulations and the 10th percentile, which is a more conservative value estimate.

Price history: day-ahead



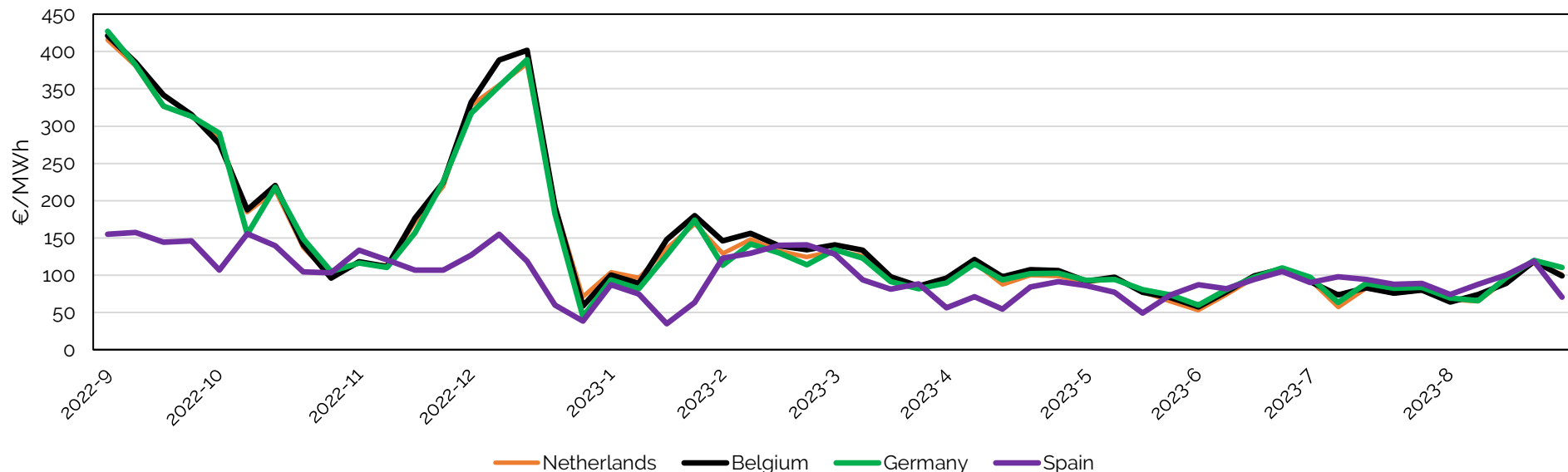
Day-ahead price history:

The chart represents the trend over the last 12 months of the weekly average day-ahead price across the four selected countries.

Day-ahead prices maintained a relatively stable level in 2023 compared to the high volatility of 2022.

While in 2022 day-ahead prices in Spain did not reach the same peak levels as the other countries thanks to its cap on gas price, the gap closed in 2023 thanks to the general decrease of the absolute price level.

Day-ahead prices



Price history: daily spreads



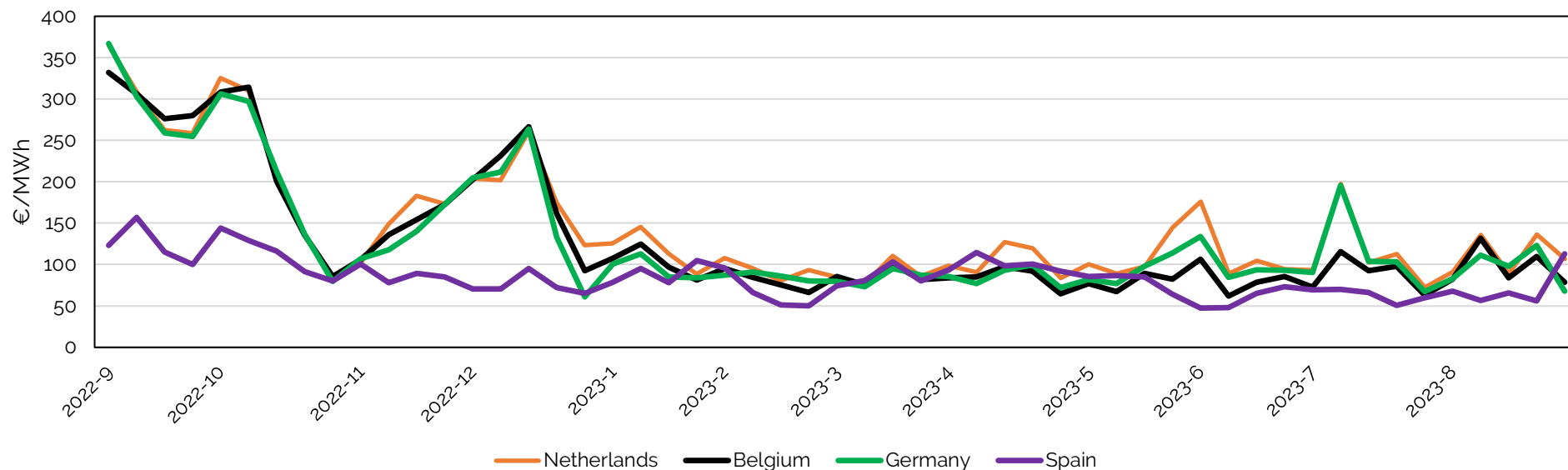
Day-Ahead daily spreads:

The chart represents the trend over the last 12 months of the weekly average daily spread (difference between max and min hourly price within the day) on the day-ahead market across the four selected countries.

The trend in daily spreads resembles that of absolute prices, with a relatively stable 2023

compared to a more volatile 2022. Daily spreads in Spain remain on average slightly lower than those of the other countries whereas in The Netherlands they are generally the highest. In summer 2023, many countries saw spikes in daily spreads due to prices dropping below zero during the central hours of the day.

Day-ahead average daily spreads



Price history: intraday daily spreads



Intraday daily spreads:

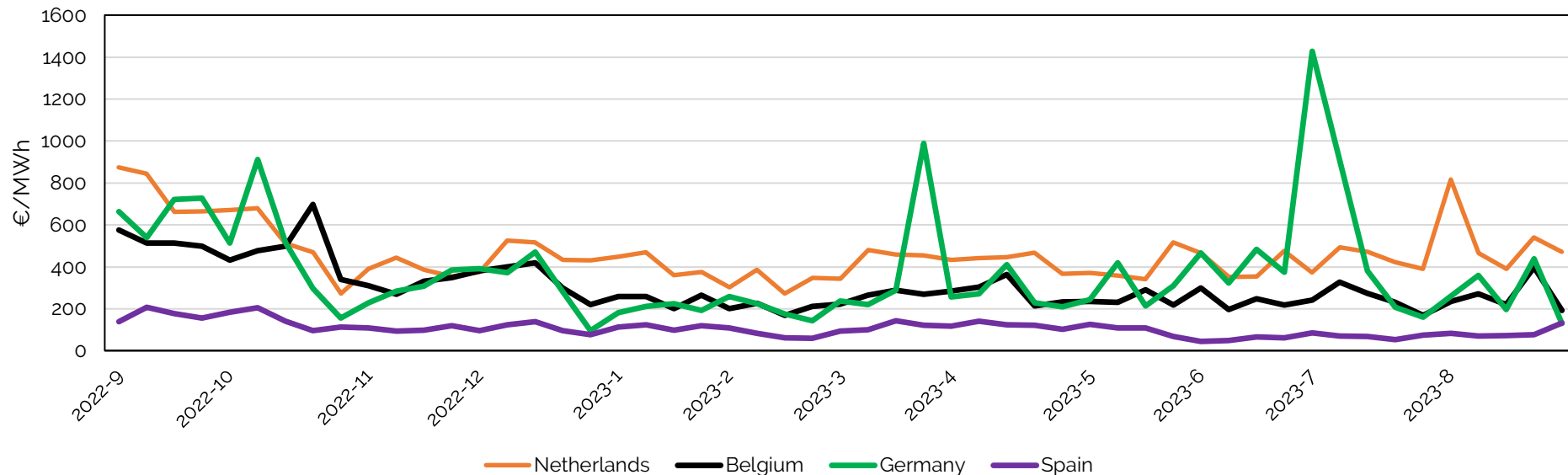
The chart represents the trend over the last 12 months of the weekly average daily spread (difference between max and min hourly price within the day) on the intraday market across the four selected countries.

also when looking at the intraday market, whereas in Spain they remain the lowest.

Even though on average Germany does not have the highest intraday spreads among the four countries, German intraday prices reached the highest peaks during spring and summer 2023

Daily spreads in The Netherlands confirmed to be the highest among the selected countries

Intraday average daily spreads



Price history: FCR



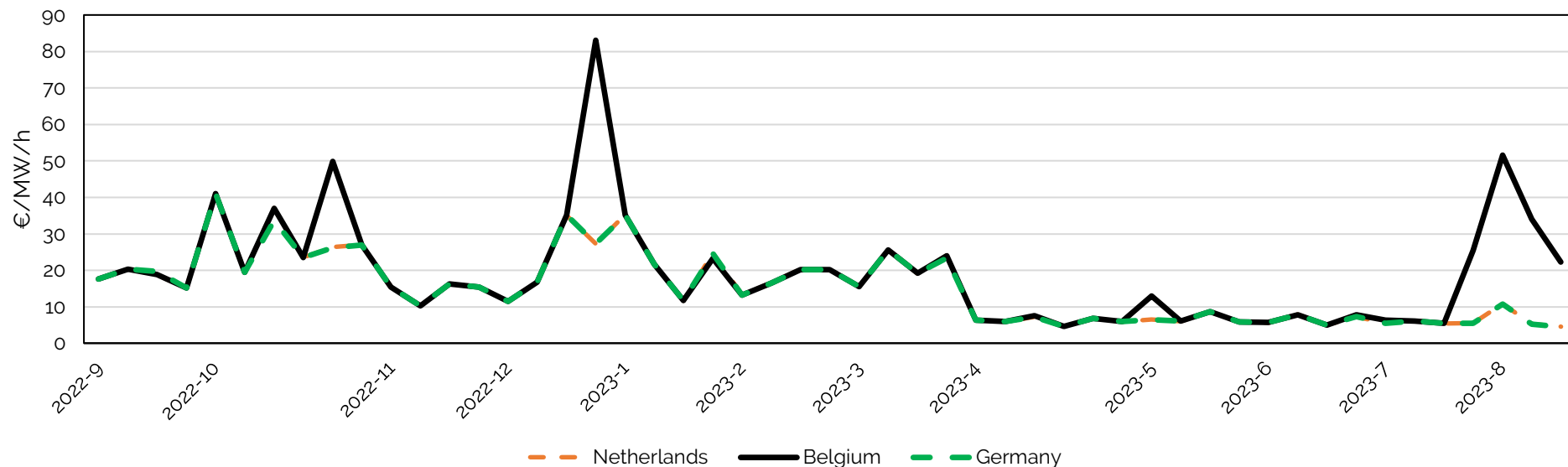
FCR price history:

The chart represents the trend over the last 12 months of the weekly average FCR price across the four selected countries.

FCR average prices have stabilized below the 10€/MW/hr threshold since it dropped in April this year. The converging trend in the FCR market continues for the three explored countries.

The Netherlands and Germany have been almost completely pegged in the last year, while Belgium has done the same for most of the year. In August, Belgian FCR prices have diverted again above the FCR homogenized price. Spain is not under the geographical coverage of the FCR market.

FCR prices





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

Do not hesitate to contact us for more information, or ask for a short demonstration: info@kyos.com



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