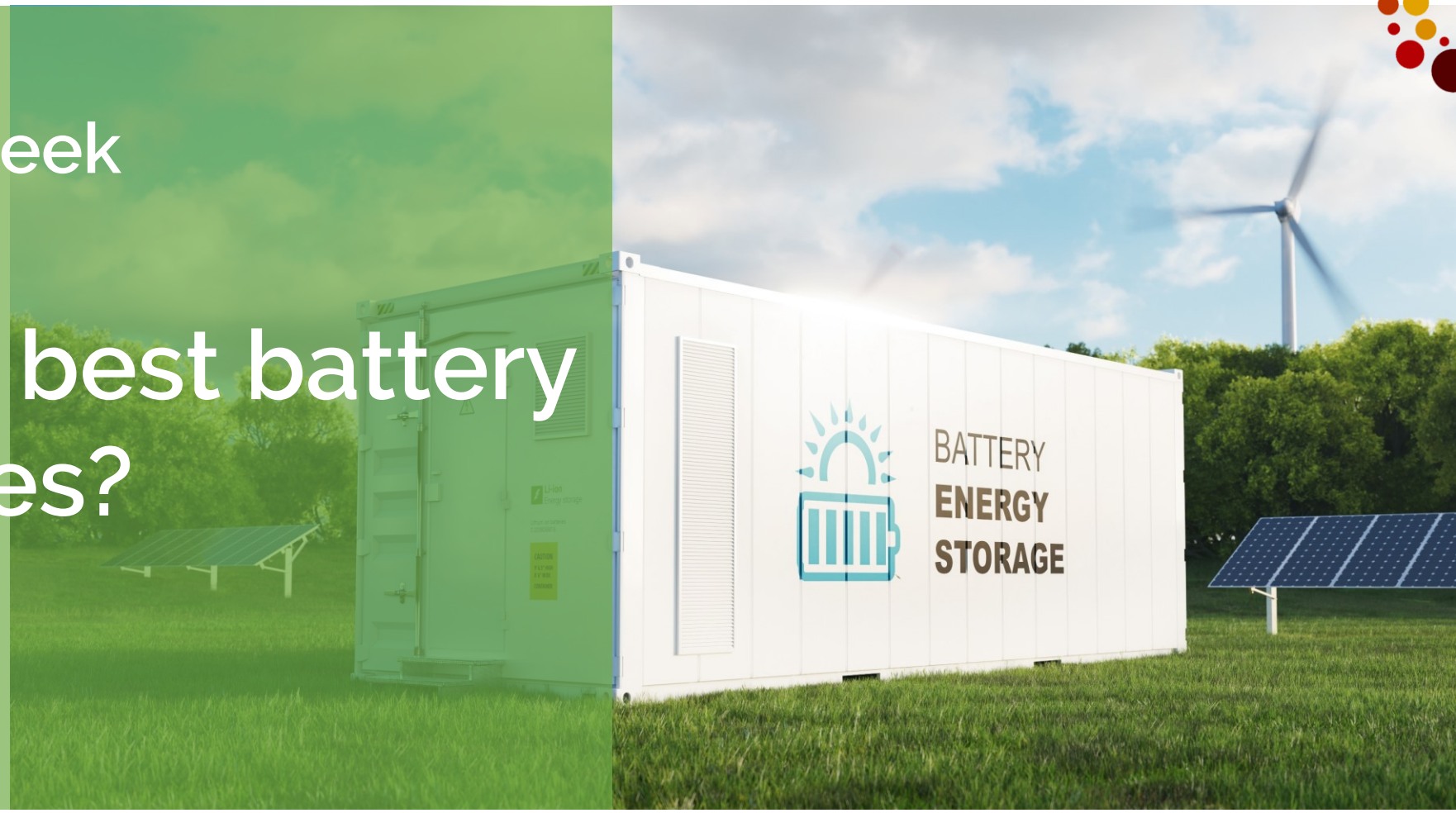
ENERGY TRADING WEEK

Energy Trading Week

What are the best battery business cases?



Cyriel de Jong

29 September 2023

KYOS

KYOS Energy Analytics

- International client base across Europe, plus Americas and Japan
- 35+ people, headquartered in Haarlem (NL)
- More than 100 corporate clients for its software services

GOLD 2022 ecovadis Sustainability Rating

ISO 27001:2017 Certified by Brand Compliance

KYOS

Our analytics – your advantage

Software for energy valuation & optimization

Solutions for valuation, optimization and risk management, coupled with advanced forecasting and price simulations.

Power plants
Renewable generation
Gas storage
Gas swing contracts
Batteries
Options
.....

Software for multi-commodity exposures

The Commodity Portfolio & Risk Management software combines physical commodity management with financial risk reporting and price analytics.

It swiftly reveals the company-wide financial risks in clear reports.

Consultancy

We offer a wide range of top analytical services to companies in the energy and commodity markets. We are specialists in valuation, optimization and risk management.

Our expert services range e.g. from a one-off deal valuation to a complete solution for the risk management of a portfolio of assets and contracts.

Price data

Live or End-of-day market price forward curves are essential for trading, structuring and risk management.

In addition, we have a fundamental model for long-term (>30 year) power prices..

KYOS

KYOS approach to renewable energy assets

- Apply advanced financial models combined with experience of the energy markets to value and optimize assets and contracts.
  - Models developed by experienced quant team, over past 20 years.
  - KYOS is at the forefront of new developments, understanding the market's needs.
  - Continuous feedback from our clients helps us to stay ahead.

- Calculate the market value of an asset by optimizing it in the market with a range of trading strategies
  - Use realistic scenarios and trading strategies to assess the market value.
  - Use transparent methodologies and scenarios

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Energy storages

Energy storage -> strong growth

- Strong increase in renewable generation
- Phase out of conventional generation

- European Market Monitor on Energy Storage*
  - > 5-8GW/year growth
  - 57GW installed by 2030

- For reference: TenneT expects 10.3GW installed by 2030 in NL only
- Recent study** shows that 34GW of battery projects have requested grid connection in NL!

* European Association for Storage of Energy
** https://www.stratergy.nl/post/34-gw-aan-batterijprojecten-in-beeld-bij-netbeheerders-per-eind-februari-2023

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Energy storage – project valuation

Challenging!

- Different revenue streams
- Structurally changing markets
  - What works now, might not work tomorrow
- Regulatory changes
  - What will markets look like?
- Explain methodology to banks and investors

Energy storage – revenue streams

Value stacking

Battery business case is typically a combination of revenue streams

Balancing market (TSO)	FCR	+ stable payments - obligations reduce potential further revenue stacking
	FRR	
Wholesale markets	Voluntary balancing	+ price peaks + growing market - advanced trading system
	Intraday	
	Day ahead	
Local grid services	Congestion management	+ stable payments - location important
Portfolio optimization	Combine with other assets	+ increase overall revenue - more complex projects

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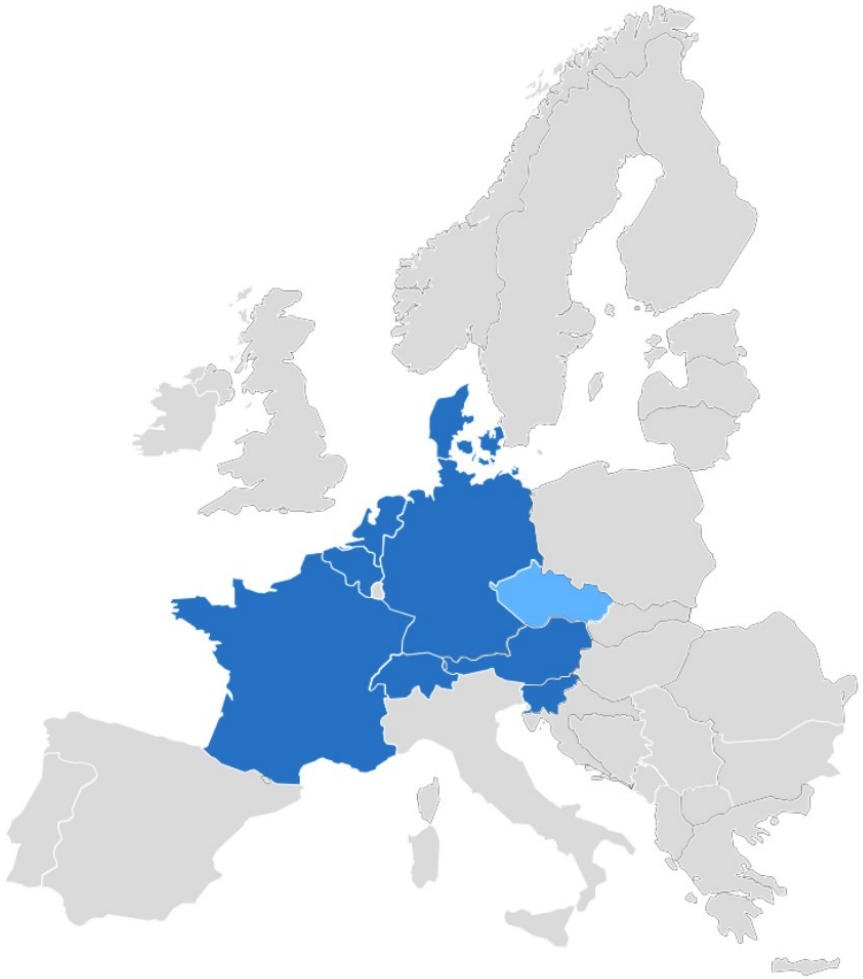
FCR Market



- Activation within max 30 sec
- TSOs from 8 countries
  - With internal limits (111 MW NL in 2023)
  - With export limits
- Common prices unless the above limits are violated in a country
- Delivery duration of 4 hours
- 1 MW resolution (& min bid)
  - Maximum indivisible bid of 25 MW
- Netherlands FCR offers
  - 38 MW, 2021 (March)
  - 68 MW, 2022 (March)
  - 76 MW, 2023 (March)

Frequency Containment Reserve (FCR) has been a primary source of revenue for batteries. It requires extremely fast response times, and is therefore quite ideal for flexible storage players.

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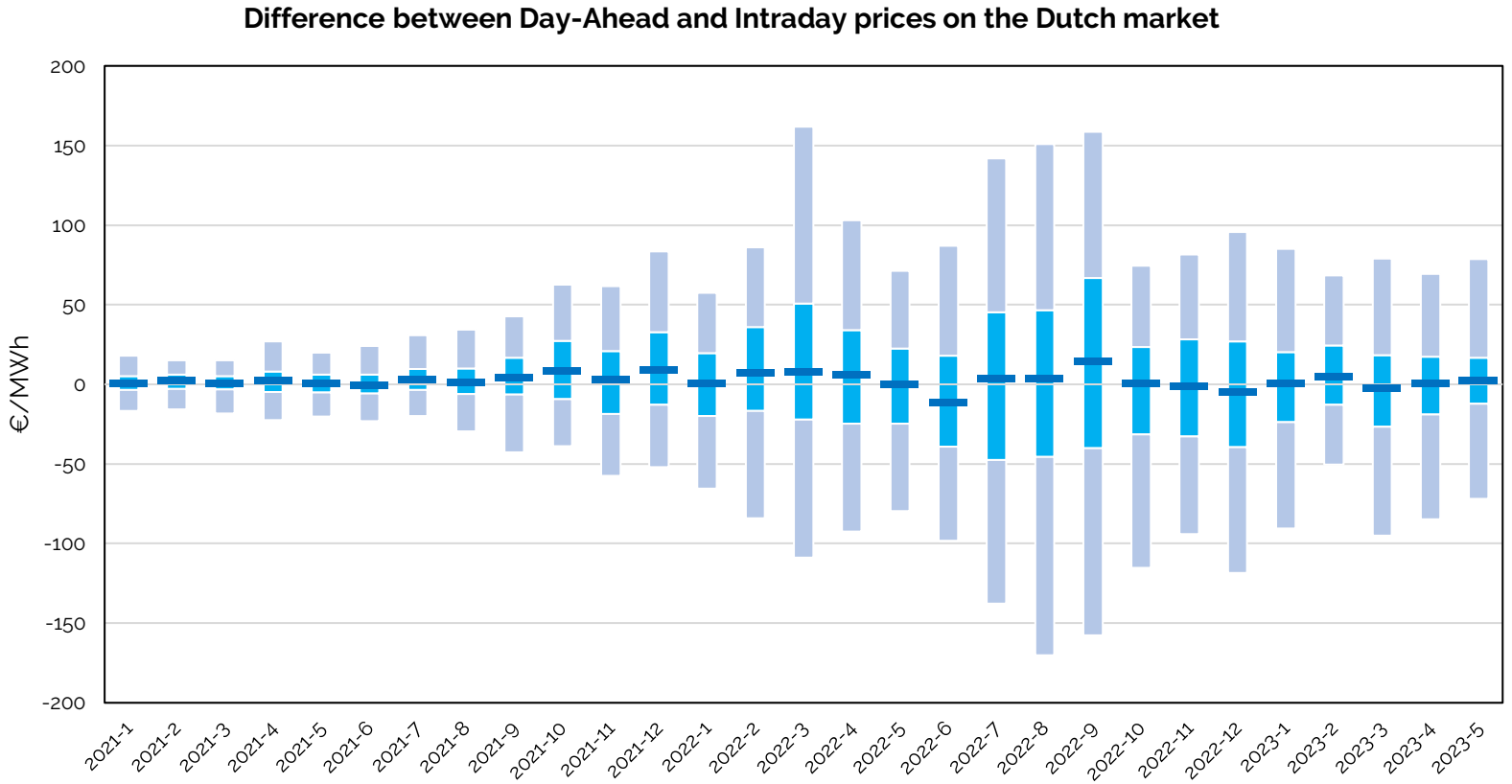
Wholesale trading – new market

- Trading day-ahead and intraday (ID) gets more attractive
- Spreads show large increase
- ID volumes growing (e.g. EPEX ID1 showed in 41% yoy growth in Aug '23*



* https://www.epexspot.com/en/news/monthly-power-trading-results-august-2023

Imbalance trading – attractive in some markets

- Some markets (e.g. GB, NL, BE, AT) allow for passive imbalance trading
  - Market player takes deliberate short/long imbalance position
  - Based on expectation of imbalance price

Forecast of imbalance price for next PTU is high: likely that system will be short
Decision: optimizer will discharge battery for next PTU
In case forecast was right: system is short and TSO will need to purchase energy. Long position of optimizer will be rewarded

- Requires advanced forecasting skills and quick operational handling

Approaches to energy storage valuations

	Backtest	**Forward looking**
Requirement	Realistic trading strategy	
Pros	• Actual historical data	• Can take future changes into account • Probabilities
Cons	• How to account for future changes? • Only one reality	• More complex modelling approach

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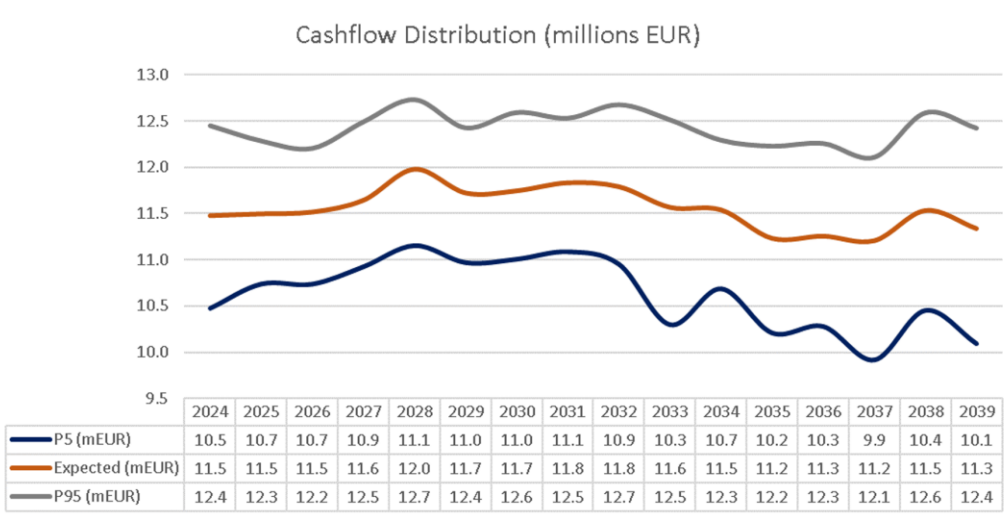
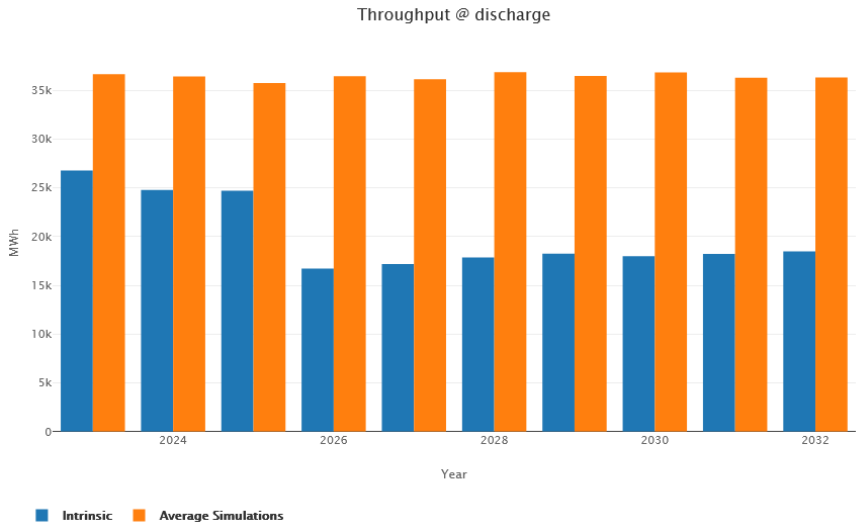
KyBattery – Energy storage valuation

- Valuation of energy storage assets based on price simulations
- Calculates market value of the asset in different energy markets:
  - Day-ahead, intraday, imbalance or a combination of these markets
  - Combine with optimizing in FCR market (FRR coming soon)
- Uses advanced trading strategies to calculate value of the asset, avoiding perfect foresight
- Expected value and probability distribution
- Model can also value energy storage that shares grid connection with renewable asset.
- Wide range of technical/contractual battery constraints allowed, incl. cycle constraint

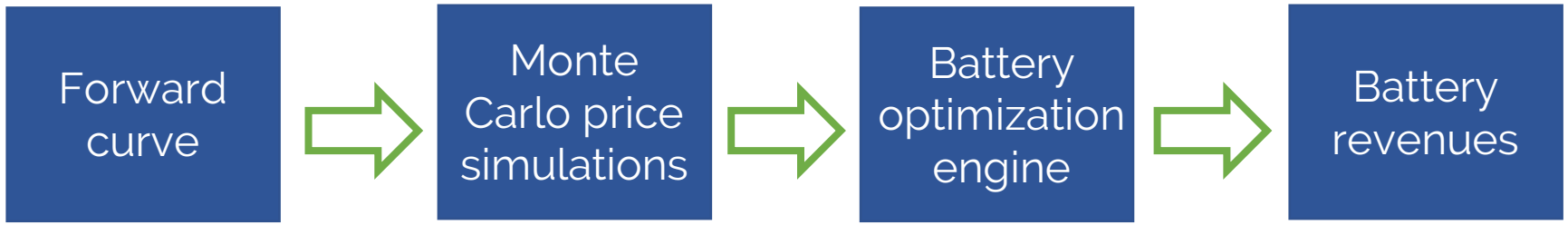


	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
P5 (mEUR)	10.5	10.7	10.7	10.9	11.1	11.0	11.0	11.1	10.9	10.3	10.7	10.2	10.3	9.9	10.4	10.1
Expected (mEUR)	11.5	11.5	11.5	11.6	12.0	11.7	11.7	11.8	11.8	11.6	11.5	11.2	11.3	11.2	11.5	11.3
P95 (mEUR)	12.4	12.3	12.2	12.5	12.7	12.4	12.6	12.5	12.7	12.5	12.3	12.2	12.3	12.1	12.6	12.4



KyBattery – methodology

- The trading strategy should take into account the stochastic (uncertain) nature of the short-term market prices
- Central input is a price forward curve (e.g. hourly/half-hourly)
- KySim generates the Monte Carlo price simulations (e.g. for day-ahead, intraday)
- KyBattery uses Least-squares Monte Carlo to perform a realistically optimal trading strategy:
  - Uncertainty in prices (Monte Carlo)
  - Least-squares regressions to decide about optimal trading
- The result is a complete distribution of revenues streams



Long-term bankable assessments

Fundamental hourly price forward curve — KyPF

Monte Carlo simulations of forward and day-ahead prices — KySim

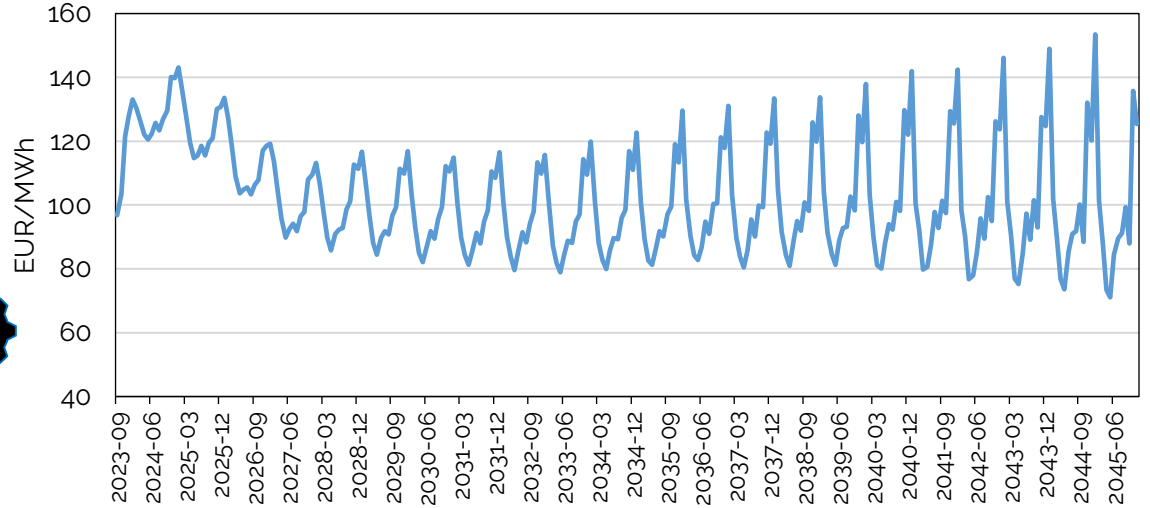
Simulations of intraday and imbalance prices — KySim

Optimization of the battery wholesale trading decisions — KyBattery

Input data assumptions

- Power demand projections
- Power plants, efficiency, start-up costs, …
- Interconnection capacity
- Renewable capacity & shapes
- Fuel & co2 prices, FX rates, …

Power price forecasts



At KYOS, fundamental curves are based on a Weather Year, where the historical wind, solar and consumption profiles are replicated to the future years but scaled to the projected levels of renewable capacity and power demand.

Nearby assessment – valuation for 2024

- 2 Hour battery, revenues for 2024 in €/kWh

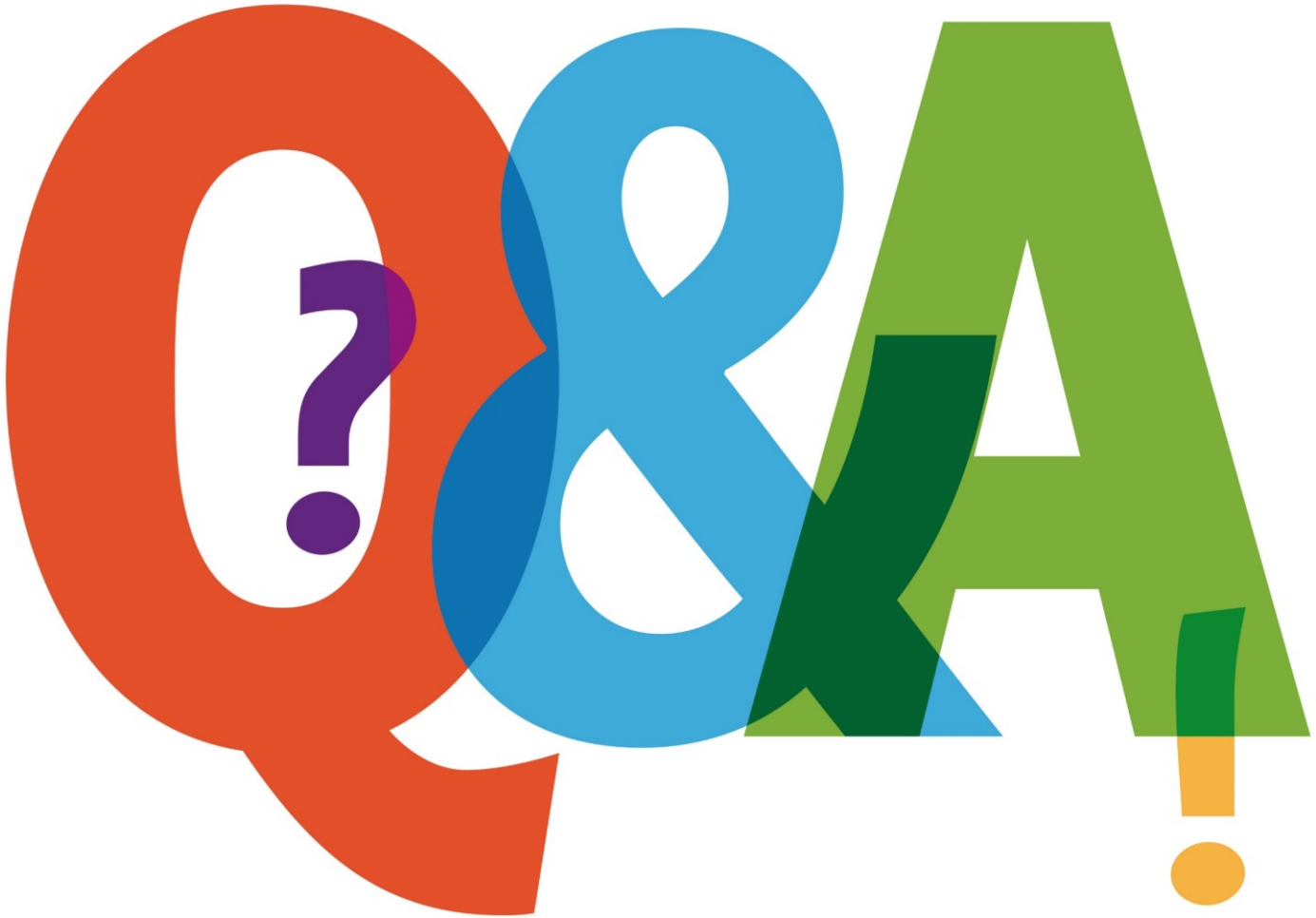
Market	Day-Ahead		Day-Ahead + FCR		Intraday		Intraday + imbalance	
	Average	10%	Average	10%	Average	10%	Average	10%
NL	52.4	48.3	65.4	62.7	124.7	117.5	202.7	190.6

+25% +90% +65%

For more information: https://www.kyos.com/energy-storage-report/

- KYOS performed various bankable valuations to support clients with their battery business case
- Including in-depth discussions with banks and investors about underlying methodology and approach to realize the value in practice

Questions and Answers



Contact Details

We look forward to supporting you with the right tools and advice in the rapidly changing energy sector!

KYOS

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