



# Forecasting Battery Revenues: An Analytical Approach

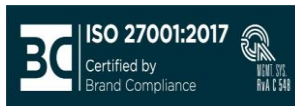
Ewout Eijkelenboom

Warsaw - 26 September 2023



# KYOS Energy Analytics

- International client base across Europe, plus Americas and Japan
- 35+ people, headquarter Haarlem, The Netherlands
- More than 100 corporate clients for its software services



# KYOS approach to renewable energy assets



- Apply advanced financial models combined with experience of the energy market to value and optimize renewable assets and PPAs.
  - Models developed by own quant team. All with background in econometrics or similar studies. Combined experience >40 years
  - Many KYOS employees have experience at energy companies and bring real life market knowledge.
- Calculate the market value that an asset can obtain by optimizing it in the market
  - Use realistic scenarios and trading strategies for the valuation of the market value.
  - Use transparent methodologies and scenarios



# KYOS renewable energy services



KYOS supports all players in the renewable energy sector

Project  
developer

Bank or investor

Utility or  
Aggregator

Corporate off-  
taker

Software

- KYOS Analytical Platform - complete software system to price and manage renewable assets, PPAs and energy storages
- Make long-term power price projections and perform what-if analysis
- Monitor and manage a complete portfolio of assets, PPAs and hedges
- Analyse different hedging strategies before entering in new deals
- Obtain detailed risk reports for managers, investors and analysts

Advisory

- Valuation and risk management support during PPA negotiations and M&A activities
- Regular PPA valuations for accounting and trading purposes
- Support with evaluating business cases of energy storage projects
- Benchmark projects for energy storage projects
- Support with arbitration cases, re-financing and re-powering



# KYOS Energy Analytics

- Some useful (free) publications



See: <https://www.kyos.com/knowledge-center/>



# 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.strategy.nl/post/34-gw-aan-batterijprojecten-in-beeld-bij-netbeheerders-per-eind-februari-2023>



# Energy storage – project valuation



## Challenging!

- Different revenue streams
- Structurally changing markets
  - What works now, will maybe not work tomorrow
- Regulatory changes
  - How will markets look like?
- Explain methodology to bank/investors!

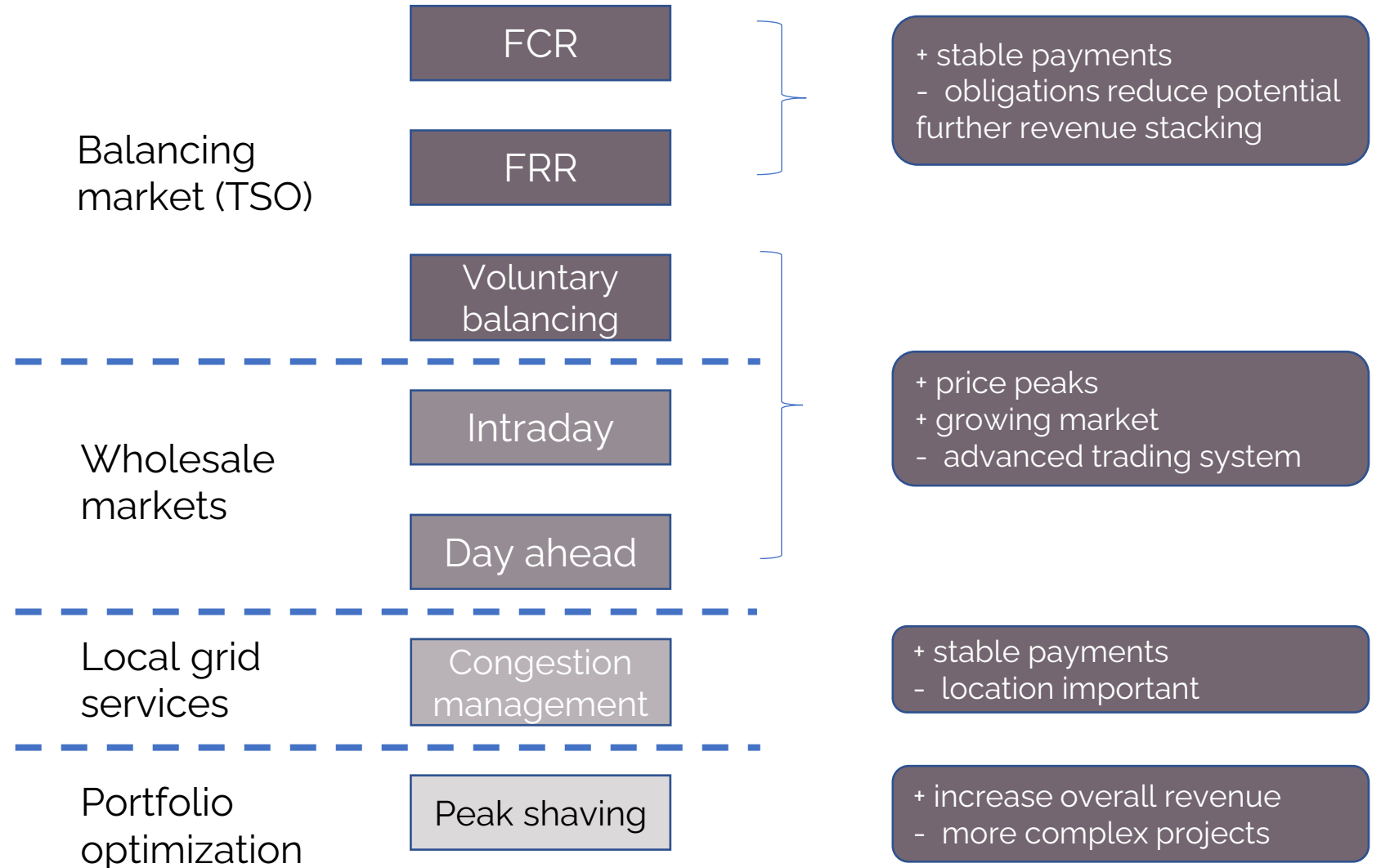




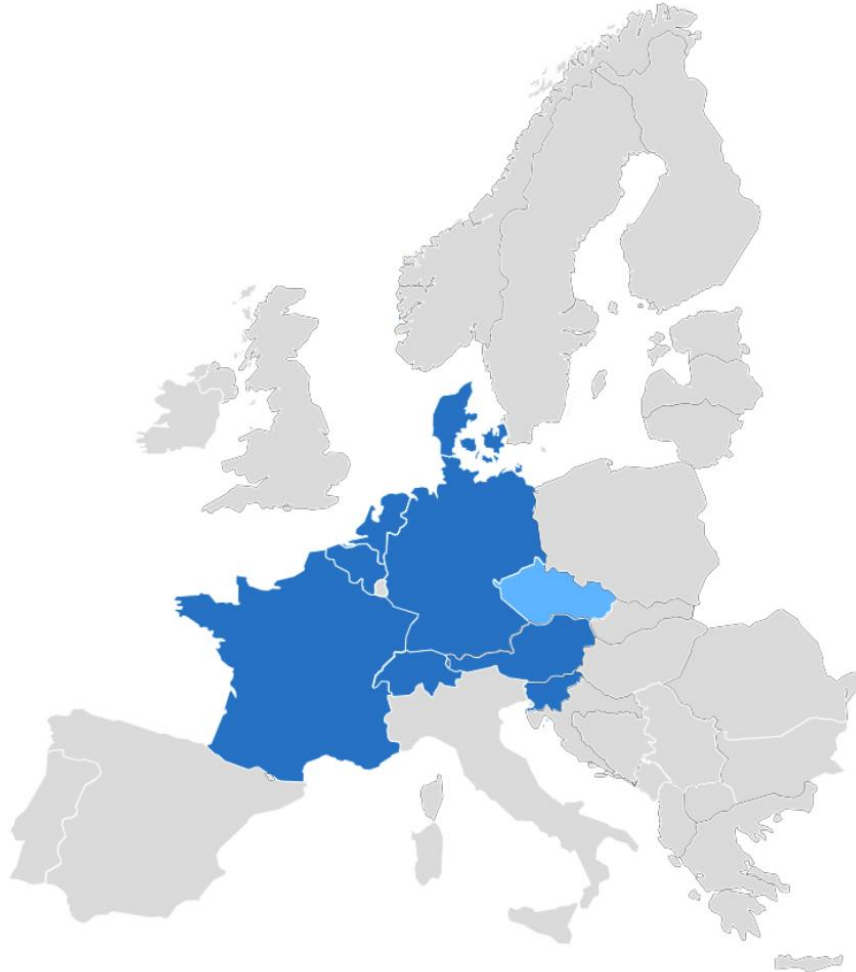
# Energy storage – revenue streams



Battery business case typically combination of revenue streams



# FCR market – traditional revenue stream



- 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.

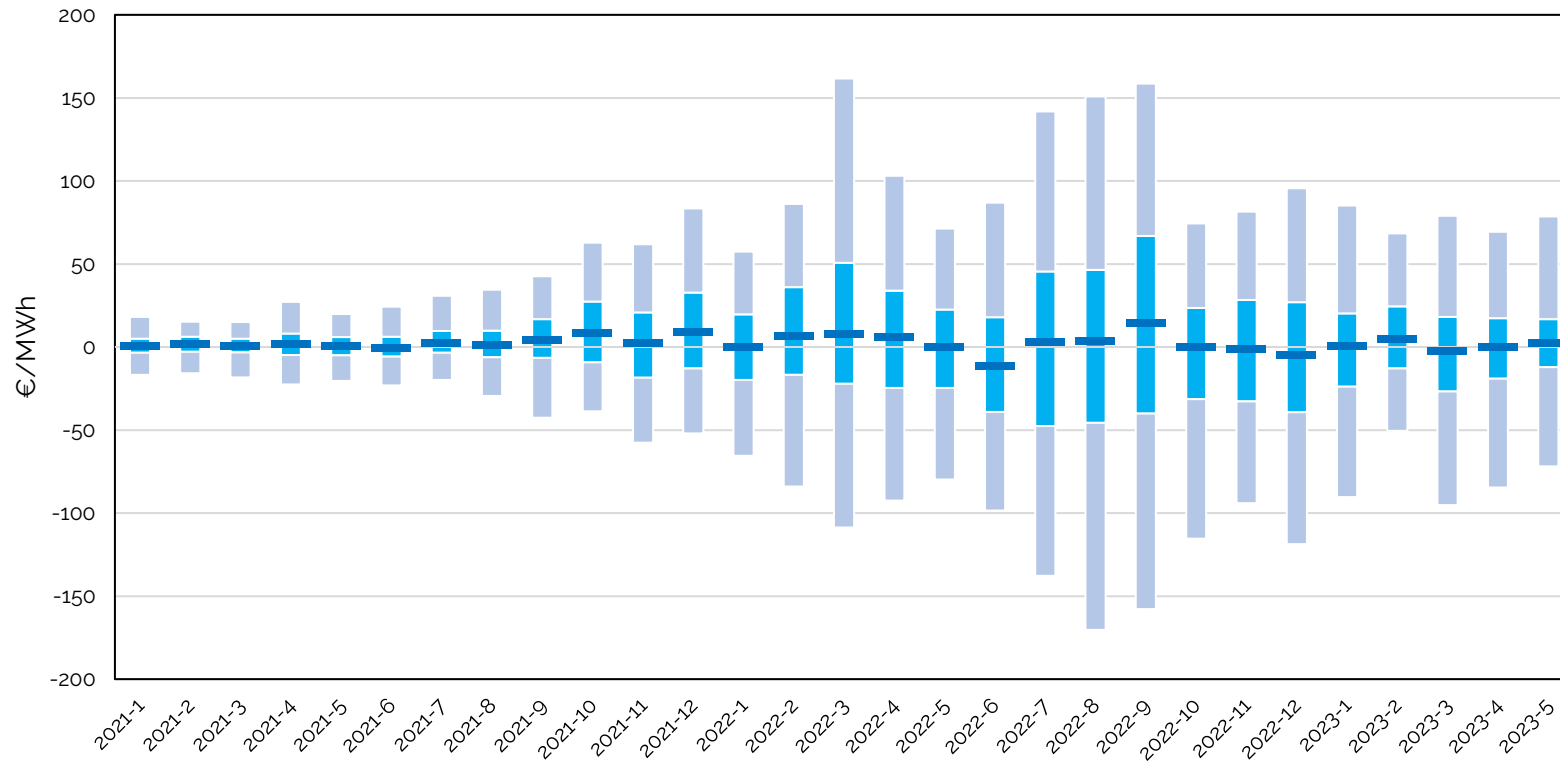


# Wholesale trading – new market



- Trading day-ahead and intraday (ID) gets more attractive
- Spreads show large increase
- ID volumes growing (e.g. EPEX ID showed in Aug2023 41% yoy growth!\*)

Difference between Day-Ahead and Intraday prices on the Dutch market



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



# Imbalance – selected markets



- Some markets (e.g. GB, NL) 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



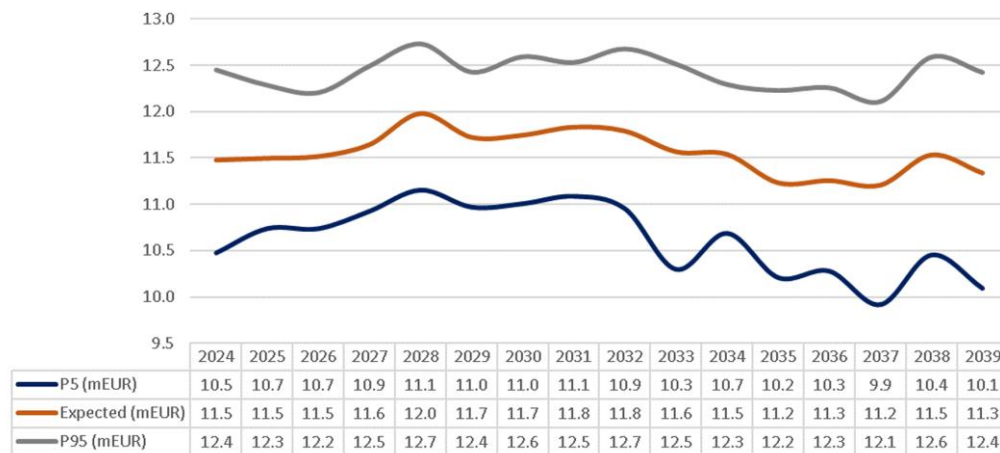
# Energy storage valuation



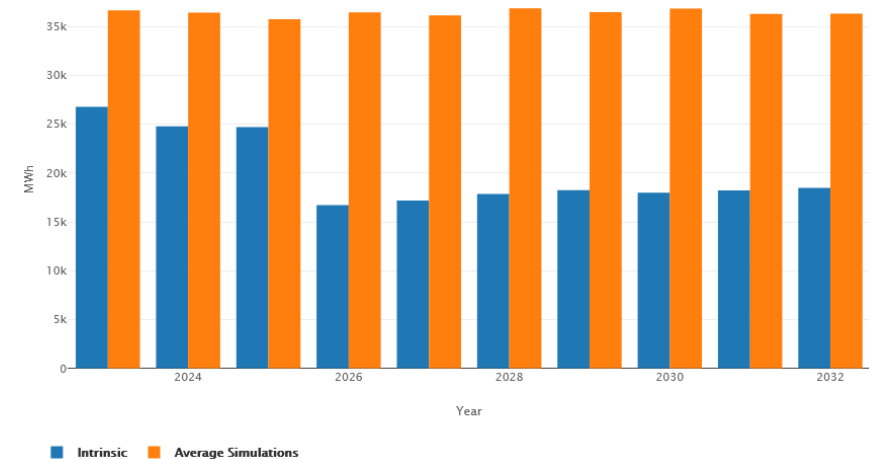
- Valuation of energy storage assets based on price simulations
- Calculates market value of the asset in different energy market:
  - Day-ahead, intraday, imbalance or a combination of these markets
  - Combine with optimizing in FCR market
- Uses advanced trading strategies to calculate value of the asset, avoiding perfect foresight
- Expected value and probability distribution



Cashflow Distribution (millions EUR)



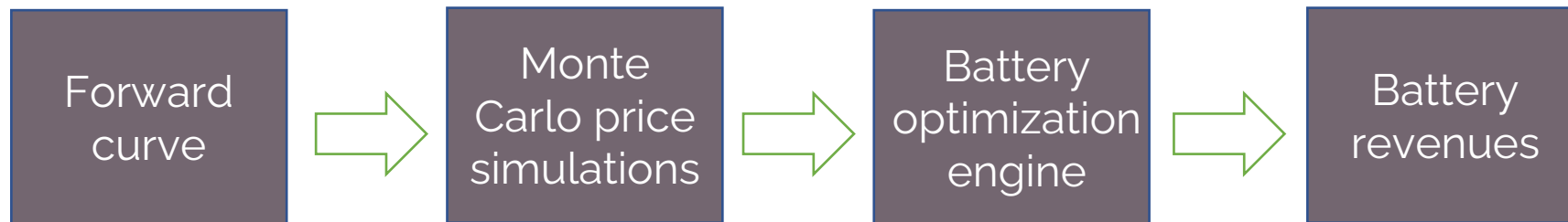
Throughput @ discharge



# KYOS KyBattery – methodology



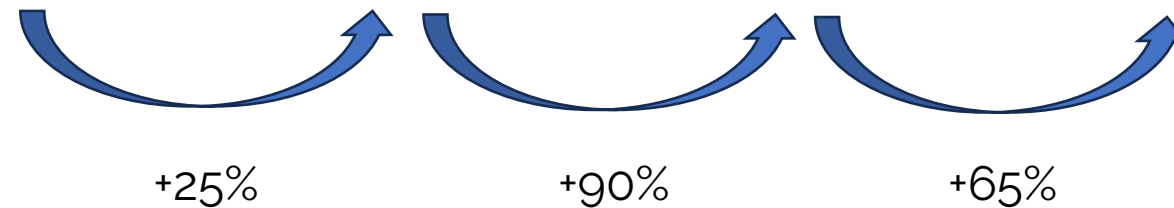
- The trading strategy should take into account the stochastic (uncertain) nature of the short-term market prices
- Central input is a price forward curve (e.g. hourly/half-hourly)
- Generate accurate Monte Carlo price simulations (e.g. for day-ahead, intraday)
- Use Least-squares Monte Carlo to perform 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



# Example

- 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



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

- KYOS performed various bankable valuations to support client with their battery business case
- Including in-depth discussions with banks about underlying methodology



# Contact Details



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



[info@kyos.com](mailto:info@kyos.com)

<https://www.kyos.com/contact/>

KYOS  
Nieuwe Gracht 49  
2011 ND Haarlem  
The Netherlands

