3rd Power Price Forecasting Summit

Forecasting battery revenues

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KYOS

Agenda

1) KYOS and our relationship with energy prices
2) Battery revenue streams
3) KyBattery: Our inhouse model for battery valuations
4) Dynamic optimization with stochastic pricing
5) Passive imbalance trading
6) Forecasting long-term revenues for investment decisions and examples
7) Benchmarking real-life trading performance

About us

- Provide analytical support to energy companies
- Robust stochastic processes for price uncertainties
- Software to value and optimize complex energy assets with flexibility
  - Energy storage
  - Renewable PPAs
  - Natural gas storages
  - Gas swing contracts
  - LNG contracts
  - Power plants
- Delivered in **easy to use, on-line system**: the KYOS Analytical Platform

More than 100 corporate clients using KYOS software and services

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Energy storage revenue streams

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

Battery business case typically are a combination of revenue streams

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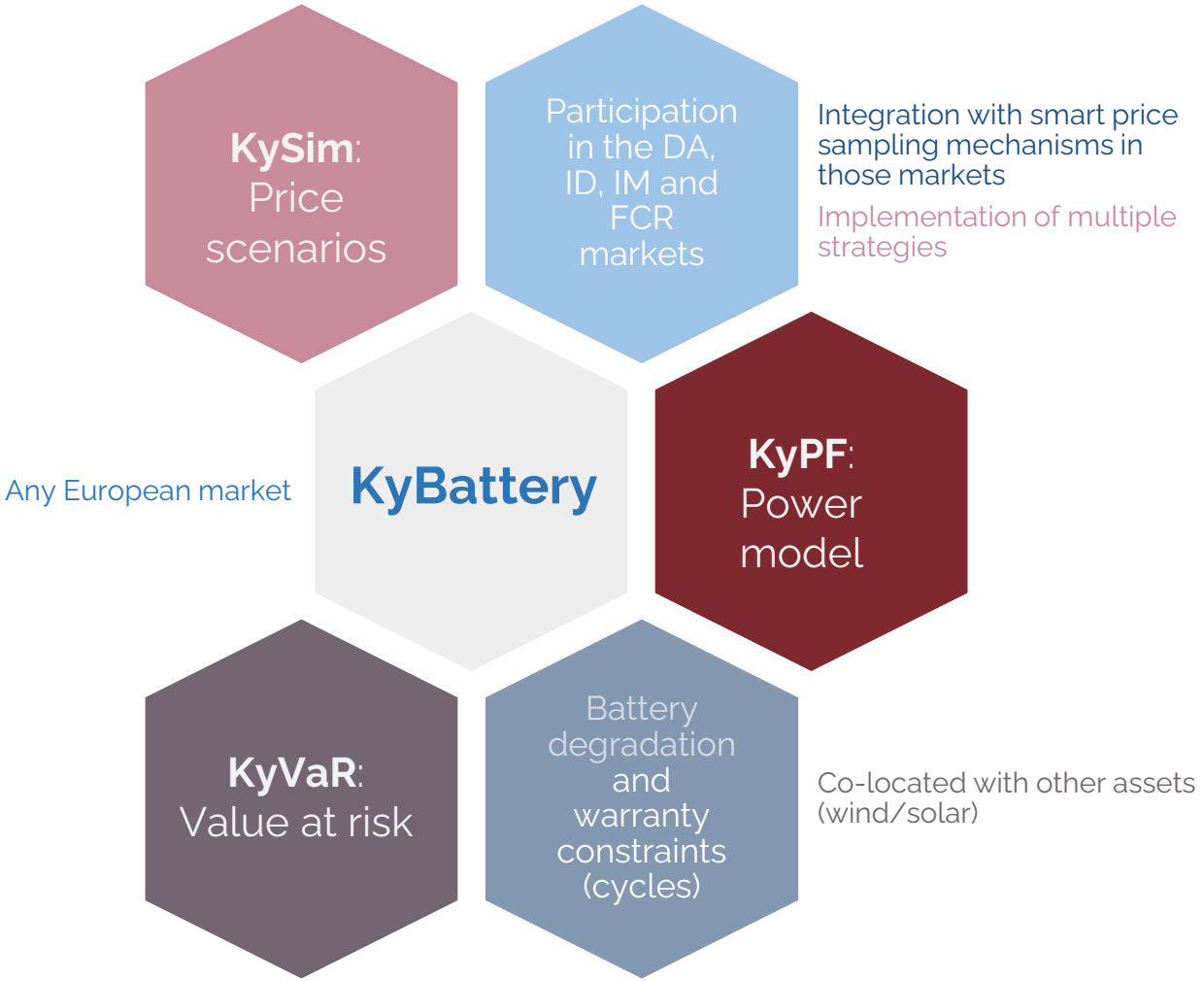
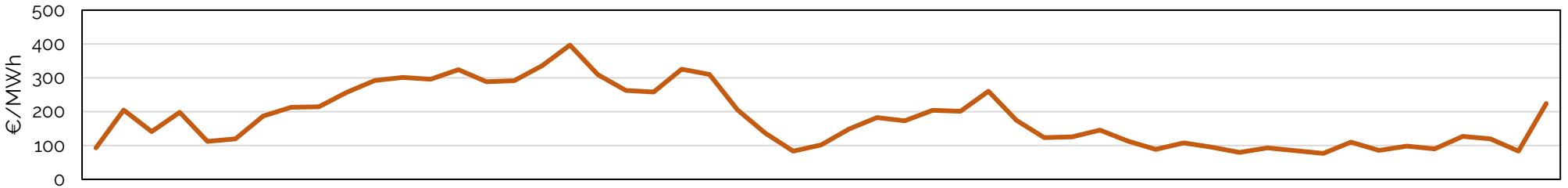
KyBattery as a valuation model



KyBattery

At KYOS we assembled a powerful tool which combines the insights from other elements of our analytical platform with the complex nature of the market pool for batteries.

Dynamic storage optimization



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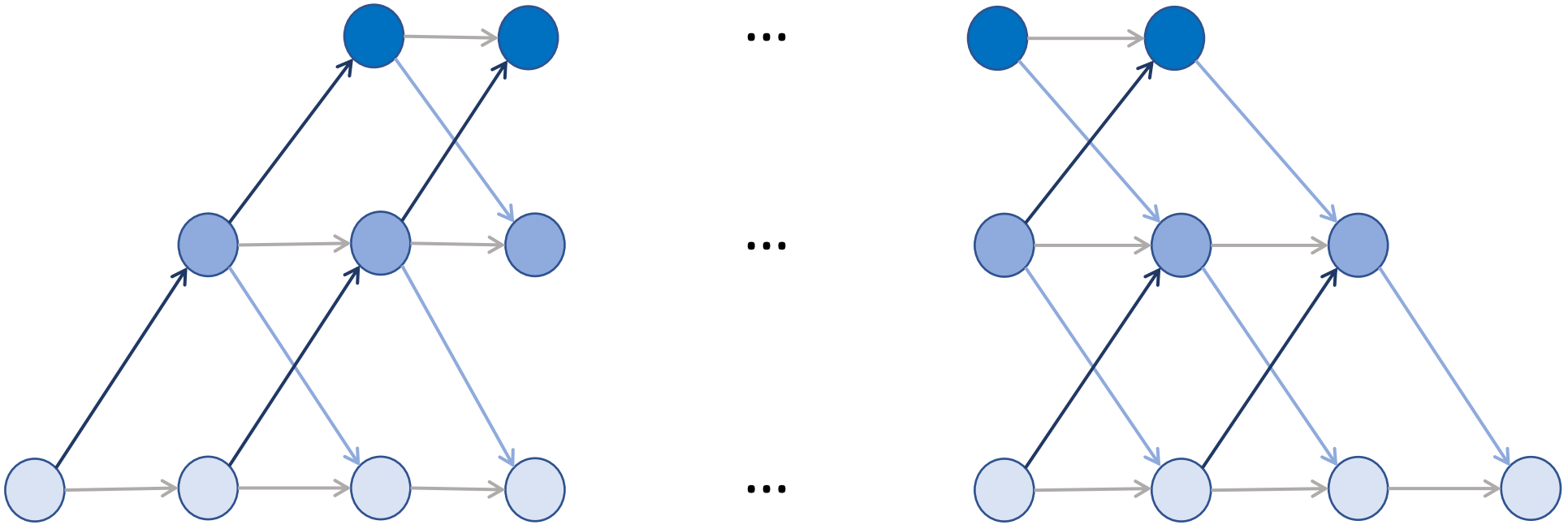

Stochastic prices → Least-squares Monte Carlo (LSMC) valuation

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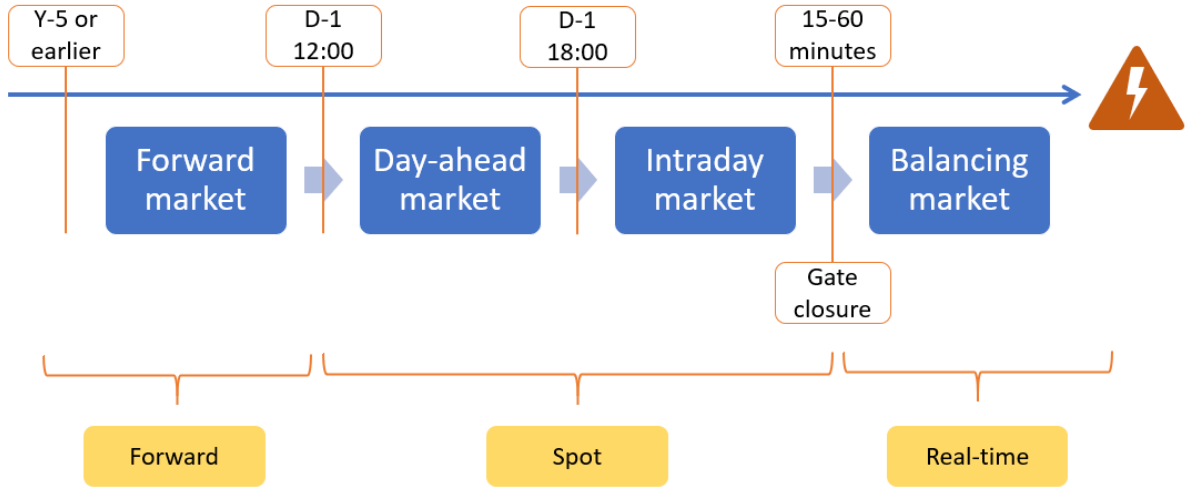
Real-time power markets

Creators of imbalances

- Balancing Responsible Parties (BRP)
- Control generation / consumption
- To match their forecast (e-program)
- If not: create imbalances

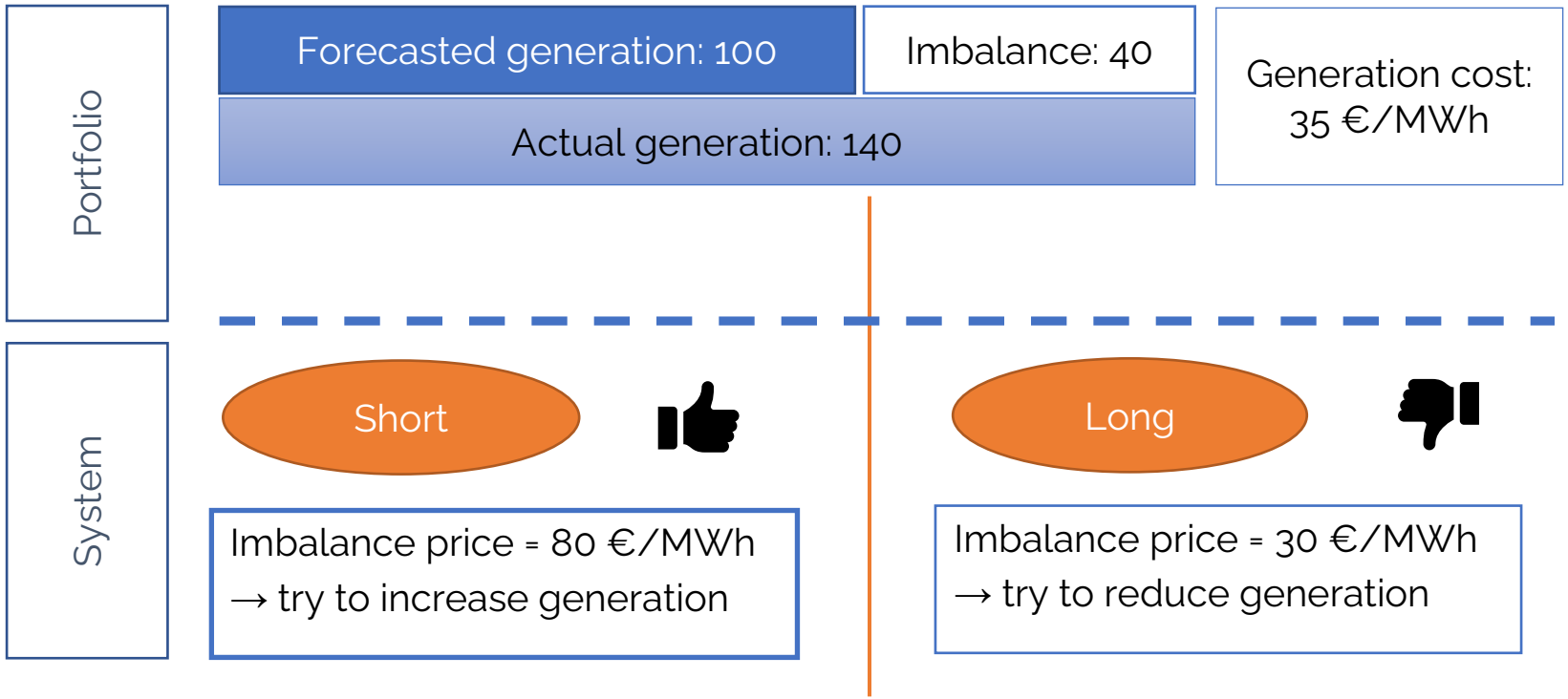
Providers of ancillary services

- Balancing Service Providers (BSP)
- Provide capacity to the TSO
- Are paid for their services
- Are activated when needed
- Resolve system imbalances



What is passive imbalance trading?

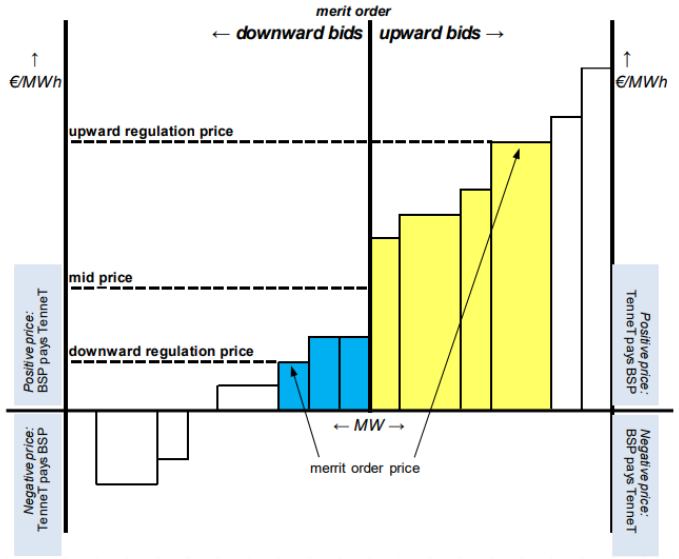
- Traditionally, BRPs have had to minimize the imbalances in their own portfolio
- TSOs increasingly accept, even encourage, BRPs to help correct the system imbalance

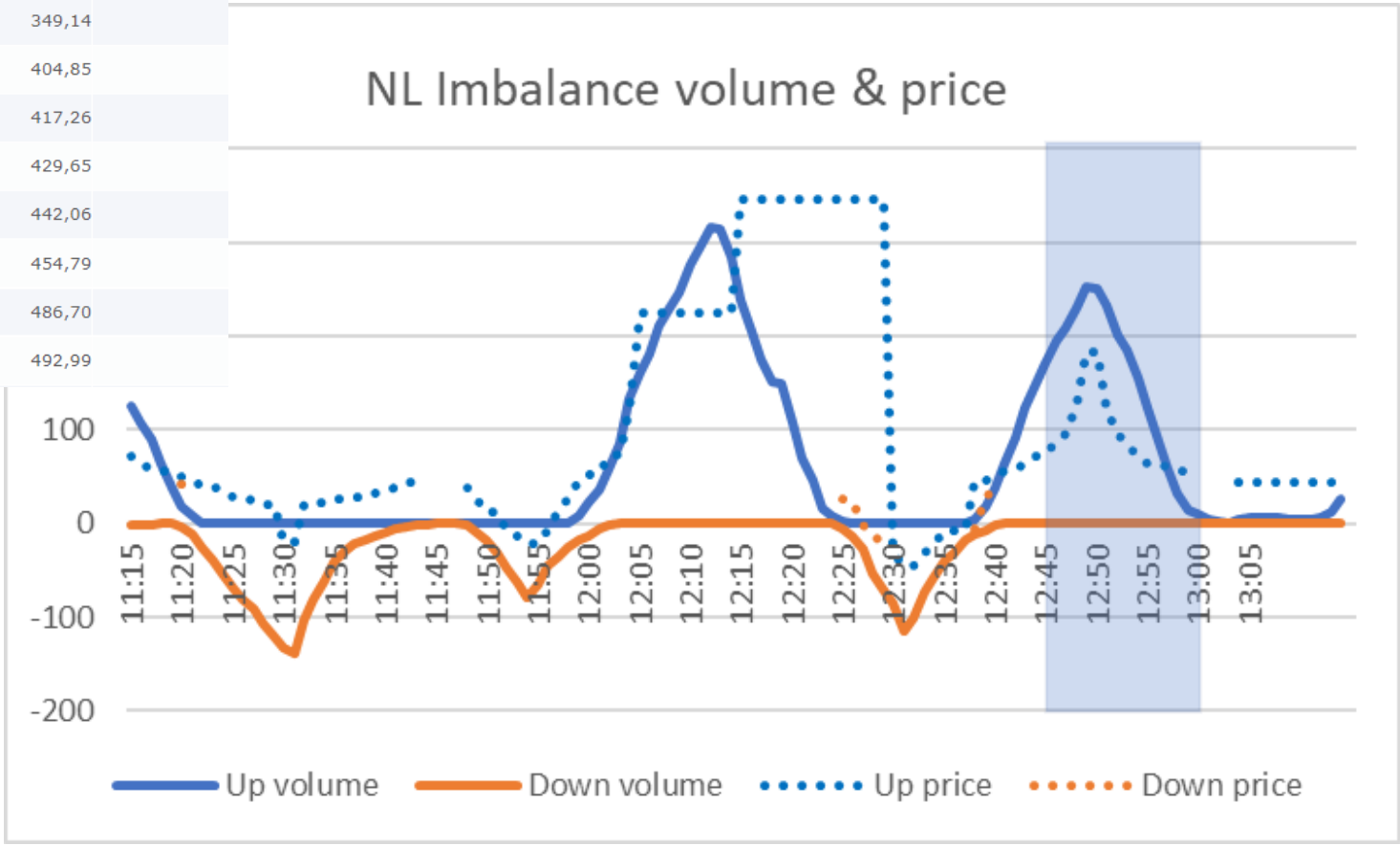


A price forecasting game with the TSO

Table | Table 2-hours | XML | Explanation | Export data

Time indication			Activated power					Price development	
			Regulating		Reserve		Emerg. (0/1)	Highest price	Lowest price
Number	Seq. nr.	Time	Up	Down	Up	Down	Up	Up	Down
1	526	08:45	135	0	0	0	0	349,14	
2	525	08:44	149	0	0	0	0	404,85	
3	524	08:43	160	0	0	0	0	417,26	
4	523	08:42	170	0	0	0	0	429,65	
5	522	08:41	152	0	0	0	0	442,06	
6	521	08:40	194	0	0	0	0	454,79	
7	520	08:39	203	0	0	0	0	486,70	
8	519	08:38	209	0	0	0	0	492,99	





Source: TenneT

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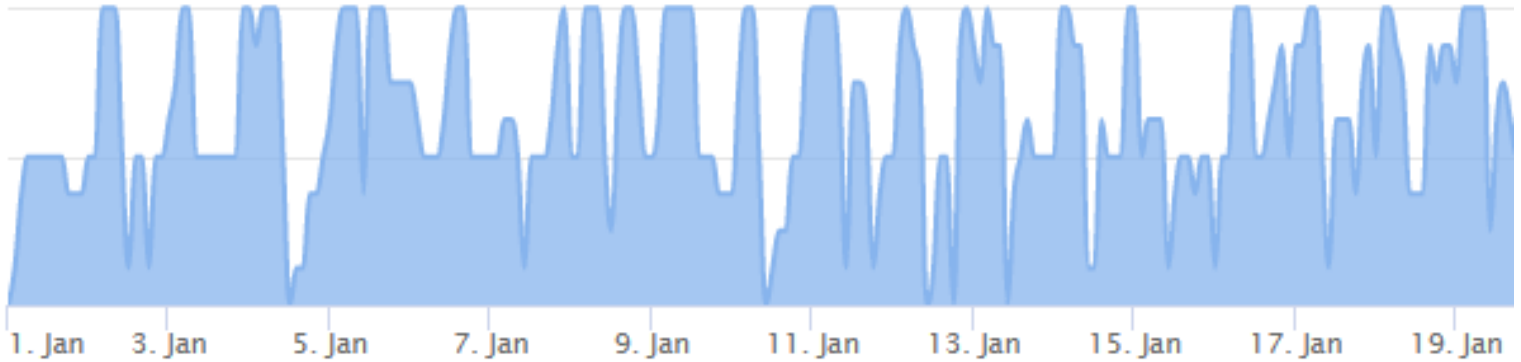
Pick the pattern with imbalance trading

A



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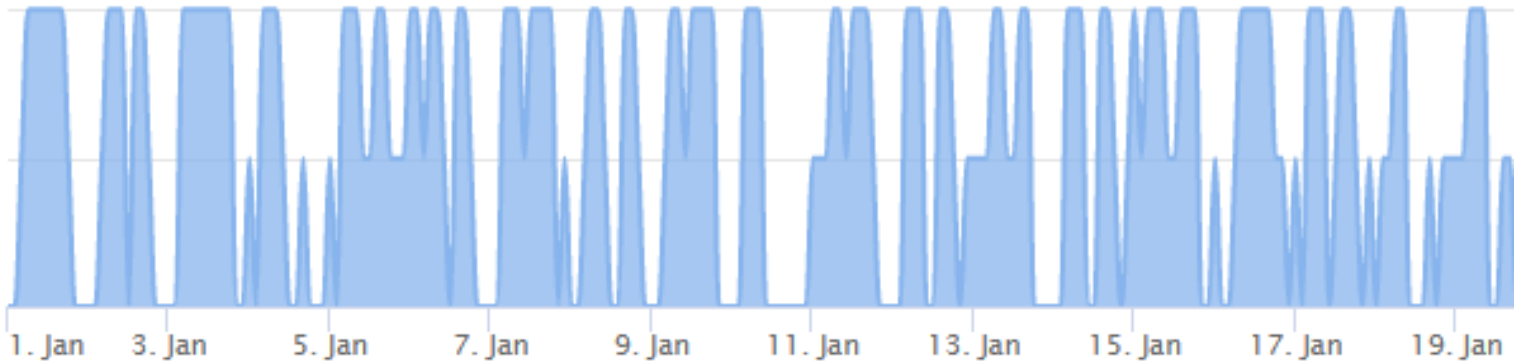

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Long term investment decisions

Historical energy commodities markets data

Fundamental hourly price forward curve

KyPF

Integrated hourly price forward curve

KyCurve

Historical intraday, imbalance and FCR prices

Monte Carlo simulations of forward and day-ahead prices

KySim

Simulations of intraday and imbalance prices

KySim

Optimization of the battery trading decisions in energy and capacity markets

KyBattery

In orange: the KYOS modules used for the analysis

Future prices estimations

Spreads, volatilities, and uncertainties estimations

Battery cashflows projections

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Battery valuations

KyBattery helps to determine battery valuations under different scenarios and market circumstances.

Revenues (€/kWh/y)	Market	Period	Day-Ahead		Intraday		Intraday + imbalance	
			Average	10%	Average	10%	Average	10%
	NL	Cal2024	45.0	35.0	71.0	65.8	117.4	108.5
	BE	Cal2024	49.2	34.8	70.1	61.5	113.7	104.2
	DE	Cal2024	49.7	25.5	70.2	55.6	n/a	n/a
	ES	Cal2024	29.9	20.8	36.2	28.5	n/a	n/a

- Battery revenues in €/kWh/y for a stand-alone located, 0.5C battery with a roundtrip efficiency of 86% and a warranty constraint of 730 cycles per year.

*We publish a free quarterly report with updates on these figures.

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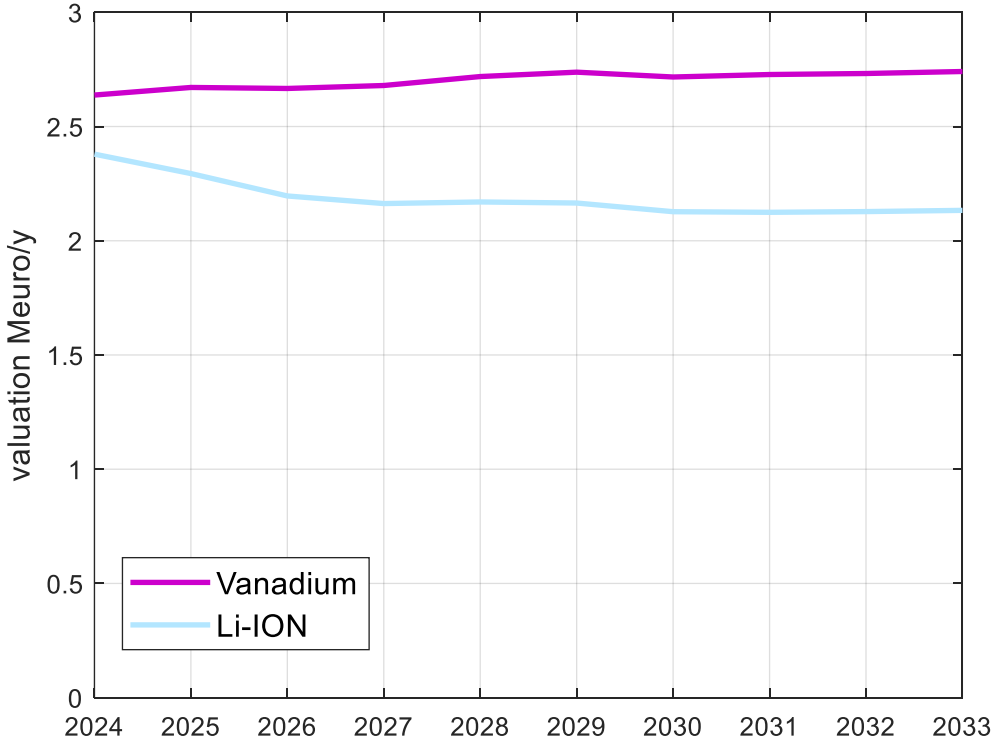
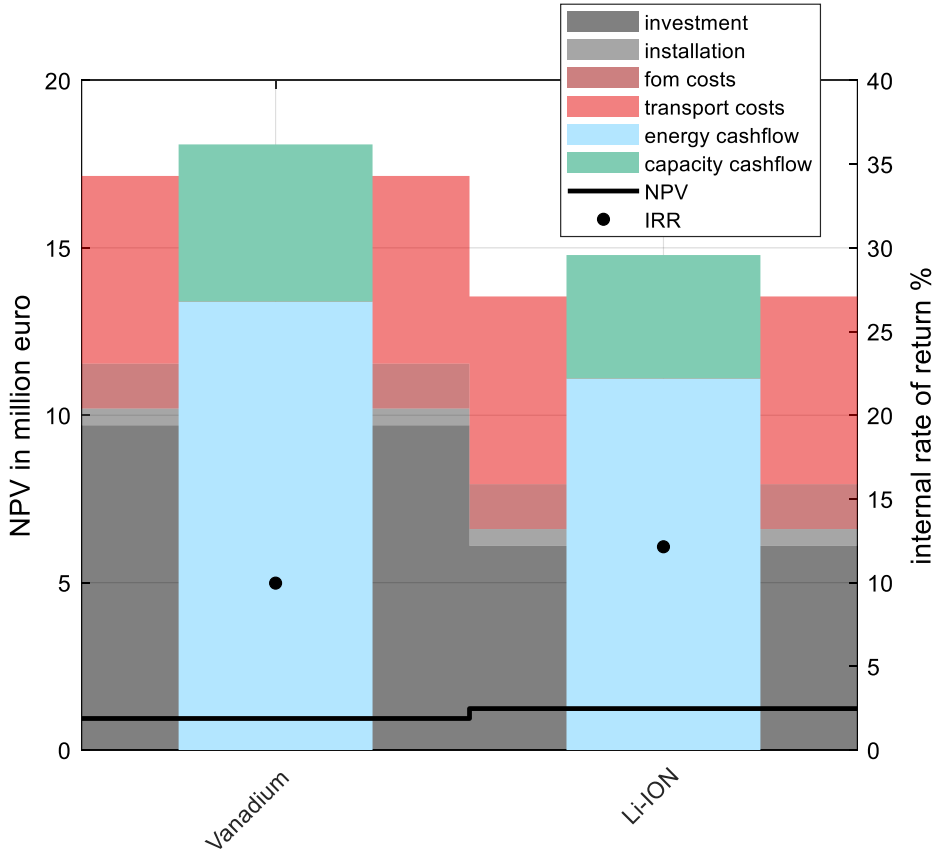
A few valuation examples

To choose between two possible batteries, for example:

1) A UK 10MW/2h Li-ION battery with degradation and warranty constraints (cycles/year)
2) A UK 10MW/2h vanadium battery without degradation or warranty constraints but with a higher capex



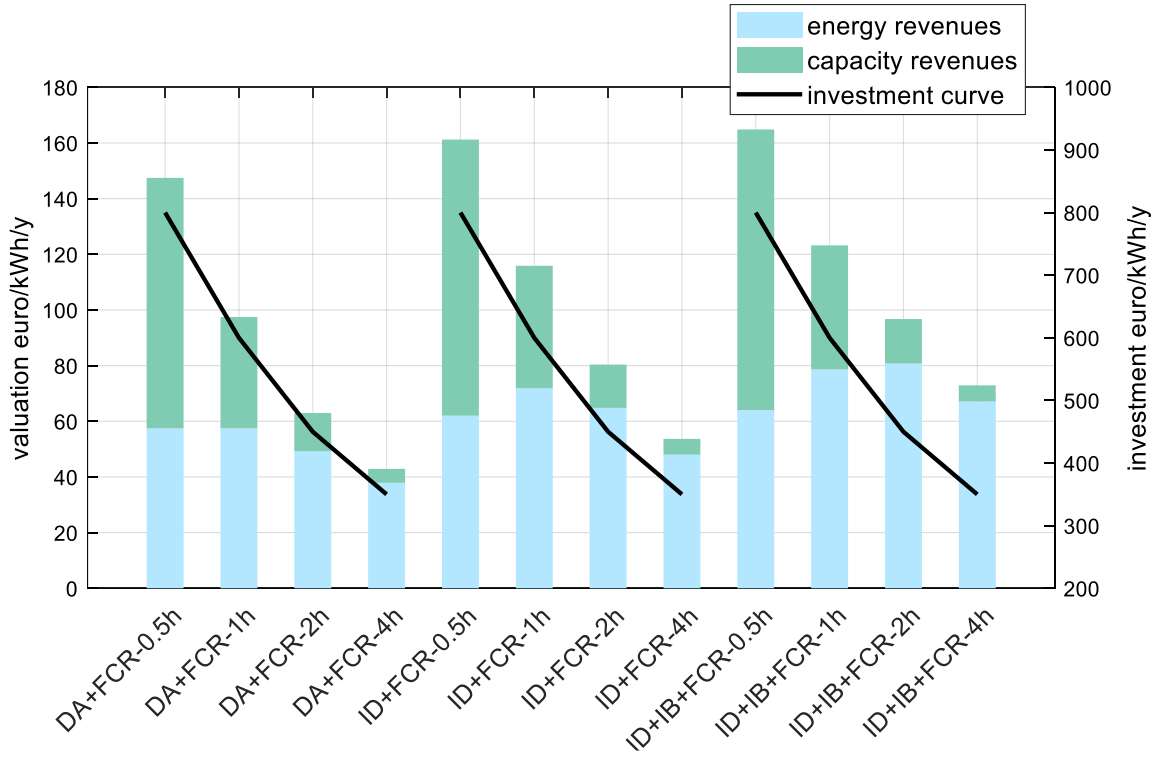


A few valuation examples

To optimize storage capacity for different markets:

Business case comparison in two axis:

1) Storage capacity: 30 min, 1h, 2h and 4h batteries
2) Market participation: day ahead, intraday, and imbalance



A few valuation examples

To value grid constraining for congestion management:

What happens with a TSO/DSO give temporary connection contracts to batteries?

M/H	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	0	5	5	5	5	5	0	0	0	5	5	10	15	15	10	5	5	0	0	0	0	0	0	0
2	10	10	15	15	15	15	10	5	5	10	20	25	30	30	25	20	10	5	0	0	0	0	5	5
3	20	30	35	35	35	35	25	15	15	30	40	45	50	50	45	40	30	10	0	0	0	5	10	15
4	45	45	50	50	50	50	45	40	40	45	50	50	50	50	50	50	45	35	20	20	20	25	35	40
5	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	45	30	25	30	35	45	50
6	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	45	35	30	35	40	45	50
7	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	35	30	35	40	45	50
8	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	45	35	30	30	40	45	50
9	45	50	50	50	50	50	45	40	40	50	50	50	50	50	50	50	50	30	20	15	15	25	30	40
10	35	40	45	45	45	45	35	25	30	40	50	50	50	50	50	50	40	15	5	5	5	10	15	25
11	10	15	20	20	20	20	10	5	5	15	25	35	35	40	35	25	15	5	0	0	0	0	5	5
12	5	5	10	10	10	10	5	0	0	5	15	20	25	25	20	15	5	0	0	0	0	0	0	0

... relax the profile

M/H	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	15	20	20	20	20	20	15	15	15	20	20	25	30	30	25	20	20	15	15	15	15	15	15	15
2	25	25	30	30	30	30	25	20	20	25	35	40	45	45	40	35	25	20	15	15	15	15	20	20
3	35	45	50	50	50	50	40	30	30	45	50	50	50	50	50	50	45	25	15	15	15	20	25	30
4	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	35	35	35	40	50	50
5	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	45	40	45	50	50	50
6	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	45	50	50	50	50
7	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	45	50	50	50	50
8	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	45	45	50	50	50
9	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	45	35	30	30	40	45	50
10	50	50	50	50	50	50	50	40	45	50	50	50	50	50	50	50	50	30	20	20	20	25	30	40
11	25	30	35	35	35	35	25	20	20	30	40	50	50	50	50	40	30	20	15	15	15	15	20	20
12	20	20	25	25	25	25	20	15	15	20	30	35	40	40	35	30	20	15	15	15	15	15	15	15

... until it is fully unconstrained

M/H	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
3	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
4	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
5	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
6	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
7	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
8	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
9	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
10	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
11	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
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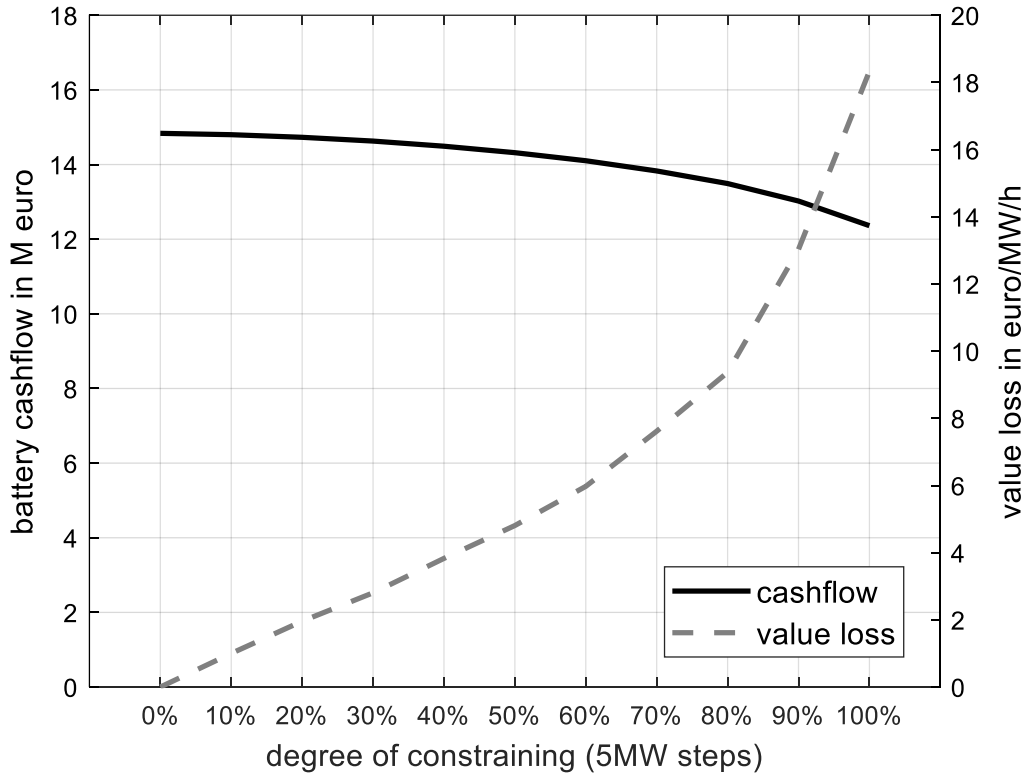

Benchmarking real-life performance

Owner

Trader

Benchmark provider KYOS

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Questions and Answers

- Time for questions!

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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