Realistic Benchmarking of BESS trading performance

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# Energy storage -> strong growth expected

- Battery Energy Storage Systems (BESS) are becoming critical players in energy markets, especially for renewable integration and grid stability.

- As BESS assets increase in number, accurately benchmarking trading strategies is essential to ensure optimal performance and revenue generation.

- This presentation explores different types of BESS benchmarks and explains what you need to have for a successful BESS trading strategy
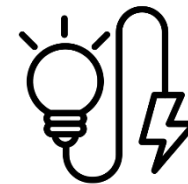
Flexibility sources

Need for accurate BESS valuations!

Conventional capacity

With co-firing of biomass or H_2
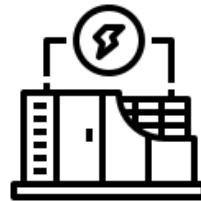
Storage

BESS

Demand/supply response

Flexible demand

Interconnectors

Transporting electricity between two market zones

* SolarPower Europe (2024): European Market Outlook for Battery Storage 2024-2028

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KYOS, our analytics, your advantage

Analytical models

Wide range of models for valuation, optimization and risk management.

Realistic simulations and advanced optimization of assets and contracts.

Provide you with the best basis to take decisions.

E/CTRM software.

A complete system for Energy/Commodity Trade & Risk Management

Combines physical commodity management with financial reporting.

Includes price analytics, valuation and advanced risk management tools.

Advisory services

We are specialists in valuation, optimization and risk management.

From a one-off deal valuation to assessing the risks of diverse portfolios.

An experienced expert team working together with you.

Subscriptions

Live or End-of-day market price forward curves (PFC)

Fundamental long-term (>30 year) power price scenarios and Monte Carlo simulations across Europe.

Market reports for BESS, PPA and interconnectors

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KYOS Energy Analytics

- Activities started in 2002, founded in 2008.

- 45+ people, head office in Haarlem, the Netherlands.

- Specialists in energy & commodity markets: trading, valuation, risk management.

- Combine quantitative background with practical solutions.

- More than 100 corporate clients across the world using our software services.
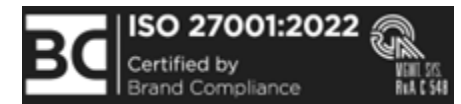
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How to benchmark BESS trading strategies?

Index
- Based on a transparent calculation
- Using accessible and liquid price data

Examples:
- DA-Index = 2 * (DAHighest – DALowest), using highest/lowest DA prices per day
- ID-Index = 1.5 * (IDHighest – IDLowest): same as above, but with e.g. ID3 prices
- Max { DA-Index, ID-Index }
- 'Multi-index': similar to the above, but with multiple sub-indices ('strategies'), including aFRR, FCR, etc. Selection based on the best in the days before

Pros/Cons if used in optimizer contracts:
- No need for open book / profit sharing
- Optimizer can trade as it likes, use portfolio benefits
- But: BESS revenue potential will diverge from index: contract might become a pain

How to benchmark BESS trading strategies?
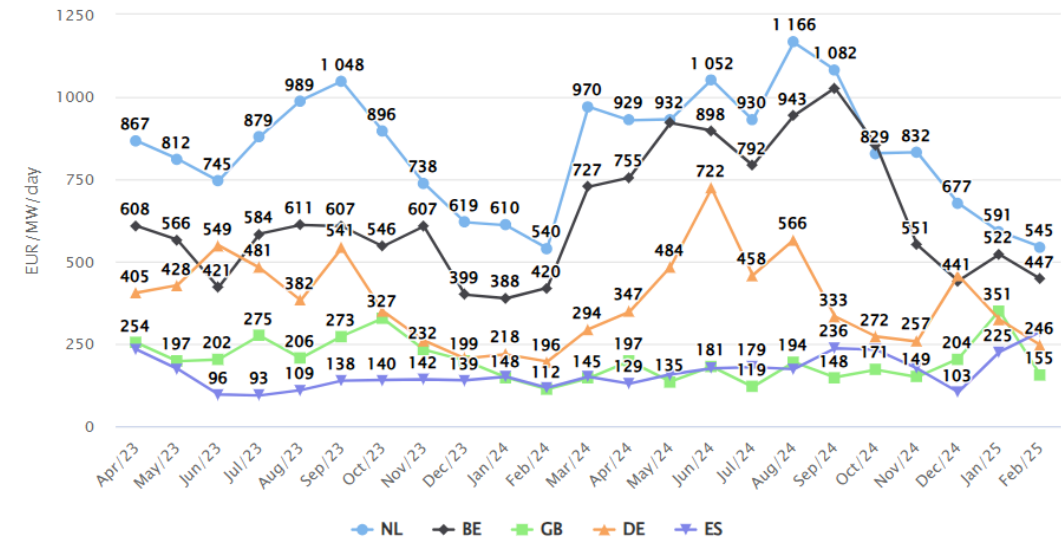
Stylized Trading Index

- Based on a more realistic trading strategy, multi-cycle, etc.
- Using accessible and liquid price data
- More difficult to replicate without the right calculation tools

Examples: KYOS, Suena, RWTH Aachen

https://power.kyos.com/battery-index

- Two hour BESS
- Trade on intraday
- Trade on imbalance markets
- Historical profitability in 5 countries

How to benchmark BESS trading strategies?

Almost Real

- Based on a very realistic trading strategy
- Using actual order book data of continuous intra-day, plus other revenue sources
- Can only be replicated with the same trading robot

BESS Report - single asset				
General Data				BESS send-out, own consumption, PV cons
BESS name	BESS Frankfurt 8			
Start date/time	1-Mar-25 00:00	1.70		
End date/time	2-Mar-25 00:00	Number of cycles		
Energy capacity (MWh)	12.00			
Charge capacity (MW)	6.00			
Discharge capacity (MW)	6.00	94		
		Uptime (%)		
Technical Data				
Start SoC	MWh	3.74		consumption — delta_SoC — generation
End SoC	MWh	5.99		**Cumulative cashflows**
Uptime	%	94.00		

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BESS optimization software by KYOS

- **KYOS Analytical Platform including KySim and KyBattery:**

  Software or traders, analysts, portfolio & risk managers for:
    - **Optimization and valuation**: power plants, renewables, energy storage, options
    - **Price modeling**: forecasting, forward curve management, price simulation
    - **Risk management**: deal capture, portfolio & risk reporting, hedge optimization

- **KYOS REFLEX = BESS real-time optimizer:**

  Algorithmic trading software for battery energy storage (BESS) optimizers

Backtest & Future

KYOS Analytical Platform:

KySim: simulation engine
KyBattery: BESS
optimization & valuation

Backtest & Real-time

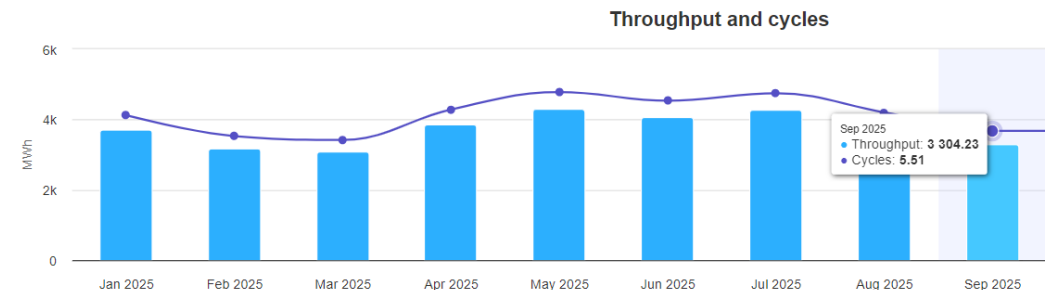KYOS REFLEX:
real-time battery optimizer

KyBattery: future revenue assessment

- Calculates future market value, **stacking revenue streams**:
  - Day-ahead, intraday, passive imbalance or a combination
  - Combine with optimizing in FCR or aFRR market
  - Stand-alone or co-located asset

- **Advanced trading strategies**

- **Realistic price simulations**

- **Expected value** and **risk distribution**

Battery: VPS - constrained [60]	Capacity: 17.5 MW / 25 MW / 600 MWh	RTE: 70%
Swiss Power [49]	Valuation method: LSMC (100 sim)	Start date: 2025-01-01
Day-ahead (primary)		KySim ID: 145
Job ID: 81567	Created at: 2024-08-29 12:24:19	By: KYOS	Valerio Avenoso

Value   Transactions   Cycles   State of charge   Distributions

Model run
○ Intrinsic ● Simulations

Aggregation
● Monthly ○ Yearly

Throughput and cycles

Sep 2025
- Throughput: **3 304.23**
- Cycles: **5.51**

KyBattery: Backtest & Future

Backtest

Pros
- Actual historical data
- 'Easy' to check

Cons
- Only one reality, no scenarios
- Requires index or detailed data (order book)

Use forecast to improve backtest

Use backtest to validate forecast

Forward view

- Takes future market changes into account
- Probabilities and simulations, risk
- More complex modelling approach
- Requires market view on future volatility

See power.kyos.com for historical index

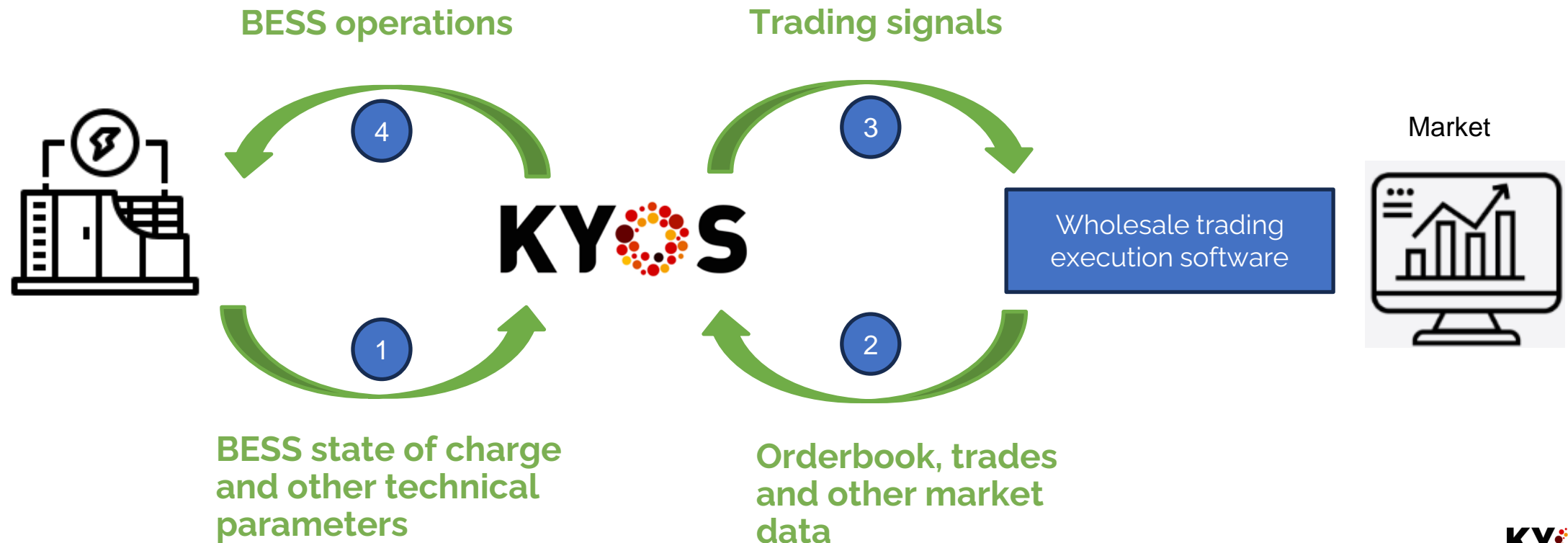*See power.kyos.com for 2026 forecast*

Realistic price data
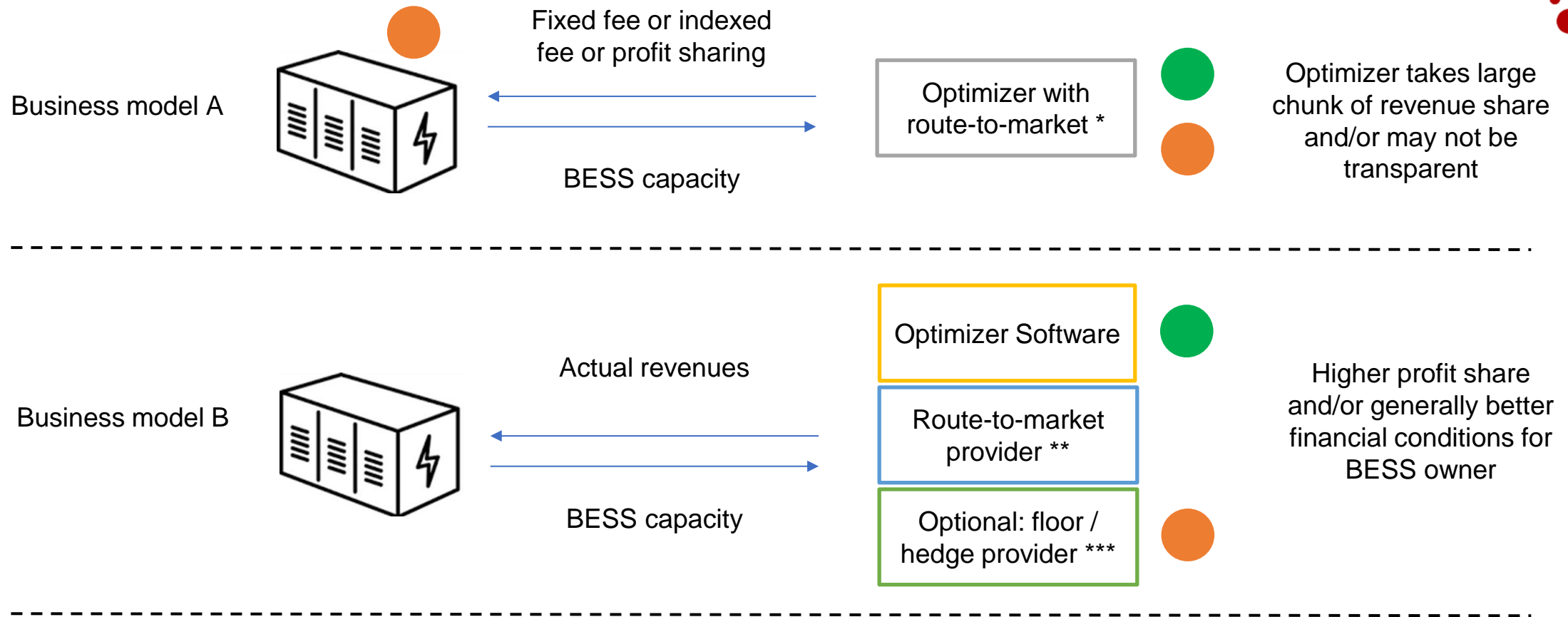
Realistic trading strategies

KYOS REFLEX = real-time battery optimizer

- KYOS offers **real-time multi-market battery optimization software**
- Collaborate with wholesale market execution software
- Very real trading performance: orderbook instead of ID1 index
- Can be run **real-time,** in **shadow-trading** or in **backtest** mode

BESS operations

Trading signals

Market

4

3

1

2

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Wholesale trading execution software

BESS state of charge and other technical parameters

Orderbook, trades and other market data

Where does KYOS REFLEX optimizer software fit in?

Business model A

Fixed fee or indexed fee or profit sharing

BESS capacity

Optimizer with route-to-market *

Optimizer takes large chunk of revenue share and/or may not be transparent

Business model B

Actual revenues

BESS capacity

Optimizer Software

Route-to-market provider **

Optional: floor / hedge provider ***

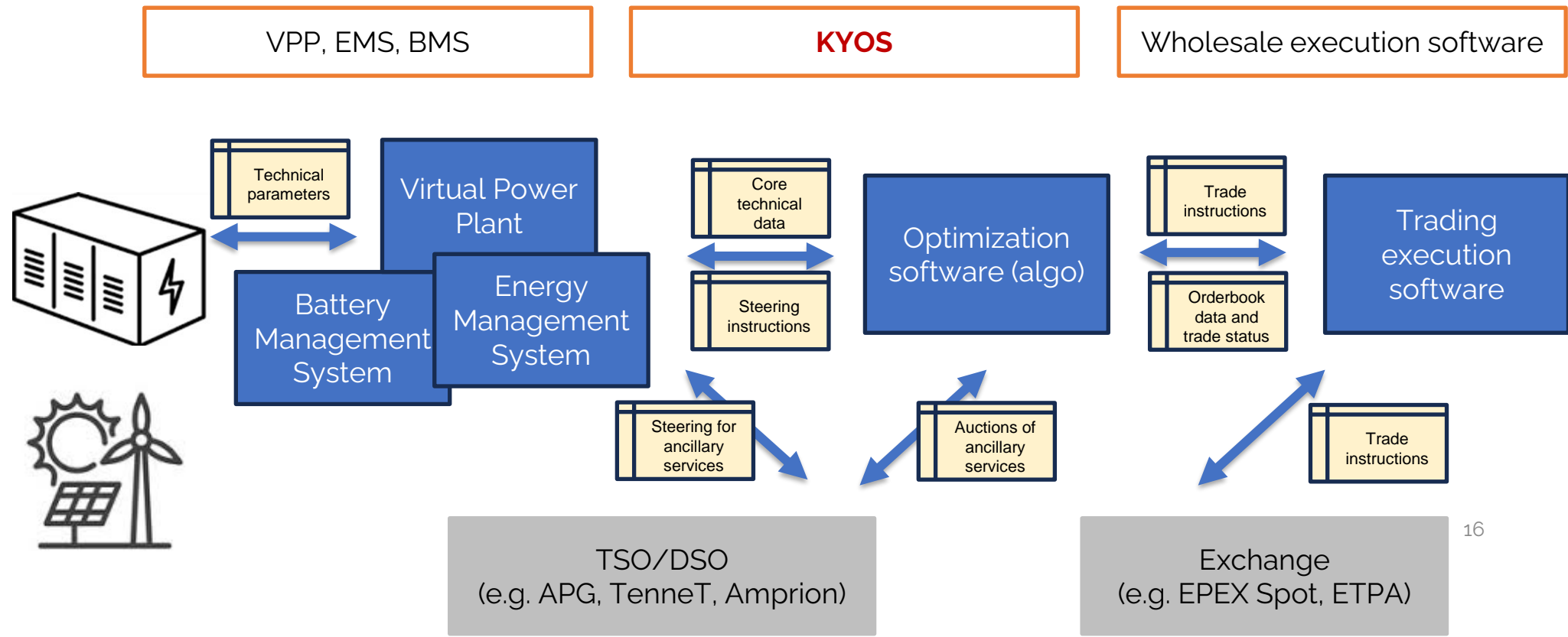Higher profit share and/or generally better financial conditions for BESS owner

*: Optimizer with route-to-market: can be a traditional utility with trade floor, an energy trading house or an aggregator

**: Route-to-market provider: cost-effective service provided by specialist firm or any of the above

***: Floor / hedge provider: energy trading house or financial player which guarantees minimum income in return for a fee

Use KYOS REFLEX for trading

Use KYOS REFLEX for benchmarking
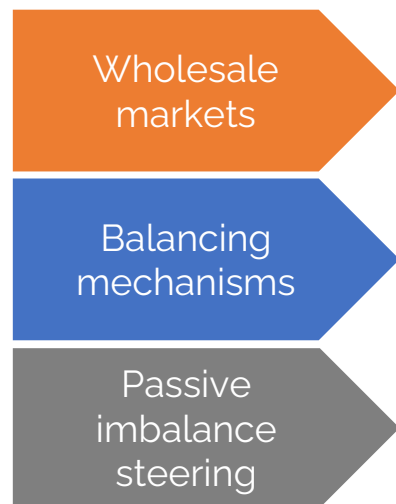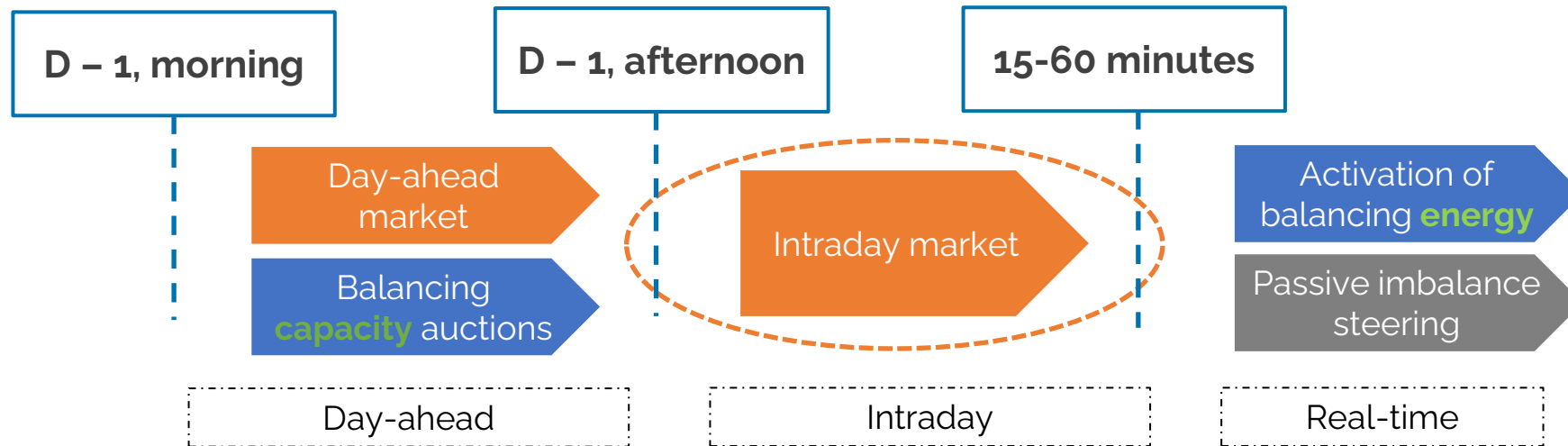
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KYOS REFLEX optimization software

VPP, EMS, BMS	KYOS	Wholesale execution software

Technical parameters

Virtual Power Plant

Battery Management System

Energy Management System

Core technical data

Steering instructions

Optimization software (algo)

Trade instructions

Orderbook data and trade status

Trading execution software

Steering for ancillary services

Auctions of ancillary services

Trade instructions

TSO/DSO
(e.g. APG, TenneT, Amprion)

Exchange
(e.g. EPEX Spot, ETPA)

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Different short-term power market mechanisms with intraday at the core

The intraday market is at the core of any optimization and generates around 2/3 of the earnings in smart BESS strategies.

| D – 1, morning | D – 1, afternoon | 15-60 minutes |

Day-ahead market		
Balancing **capacity** auctions	Intraday market	Activation of balancing **energy**
		Passive imbalance steering

| Day-ahead | Intraday | Real-time |

Wholesale markets

Most wholesale trading for short-term power happens on exchanges: EPEX, ETPA, Nordpool, EXAA, … They are either auctions (e.g. EPEX day-ahead, EPEX intraday auctions) or continuous trading platforms.

Balancing mechanisms

Balancing mechanisms (also called ancillary services) are instruments operated by Transmission System Operators (TSO) to maintain the balance on the grid. The TSO pays market participants for available **capacity**, often procured via daily auctions, and/or for the **energy** provided. Most attractive: aFRR, secondary reserve Similar instruments are operated by Distribution System Operators (DSOs) for local grid balances.

Passive imbalance steering

In some markets (NL, BE, not DE) it is allowed to purposely create imbalance with your asset: consume electricity not purchased or produce electricity not sold. This is profitable when the system benefits from this imbalance and the optimizer correctly estimates the imbalance in the current 15-minute time interval.

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KYOS REFLEX- above market performance

- Different BESS bencharks emerged over last 6-12 months
- KYOS REFLEX optimizer outperforms benchmarks using similar strategies

Germany - comparison between ID benchmarks

Real-time Optimizer | suena - ID continous | RWTH ID1
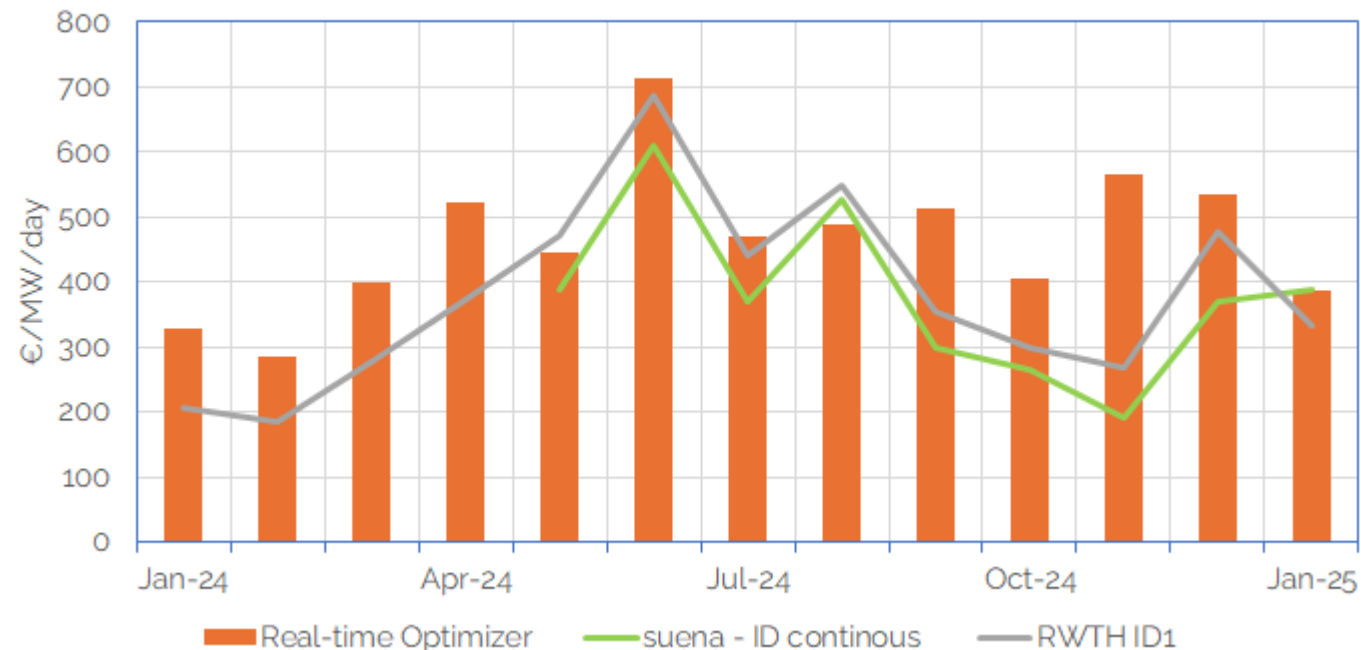
How to get there with KYOS?

1
- Bankable BESS assessments and reports
- Asset-specific calculations, incl. co-located assets
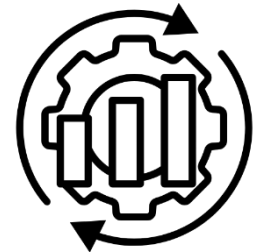
2
- KyBattery Valuation software
- Make your own assessments across Europe

3
- KYOS REFLEX real-time battery optimizer
- Multi-market optimizer software

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