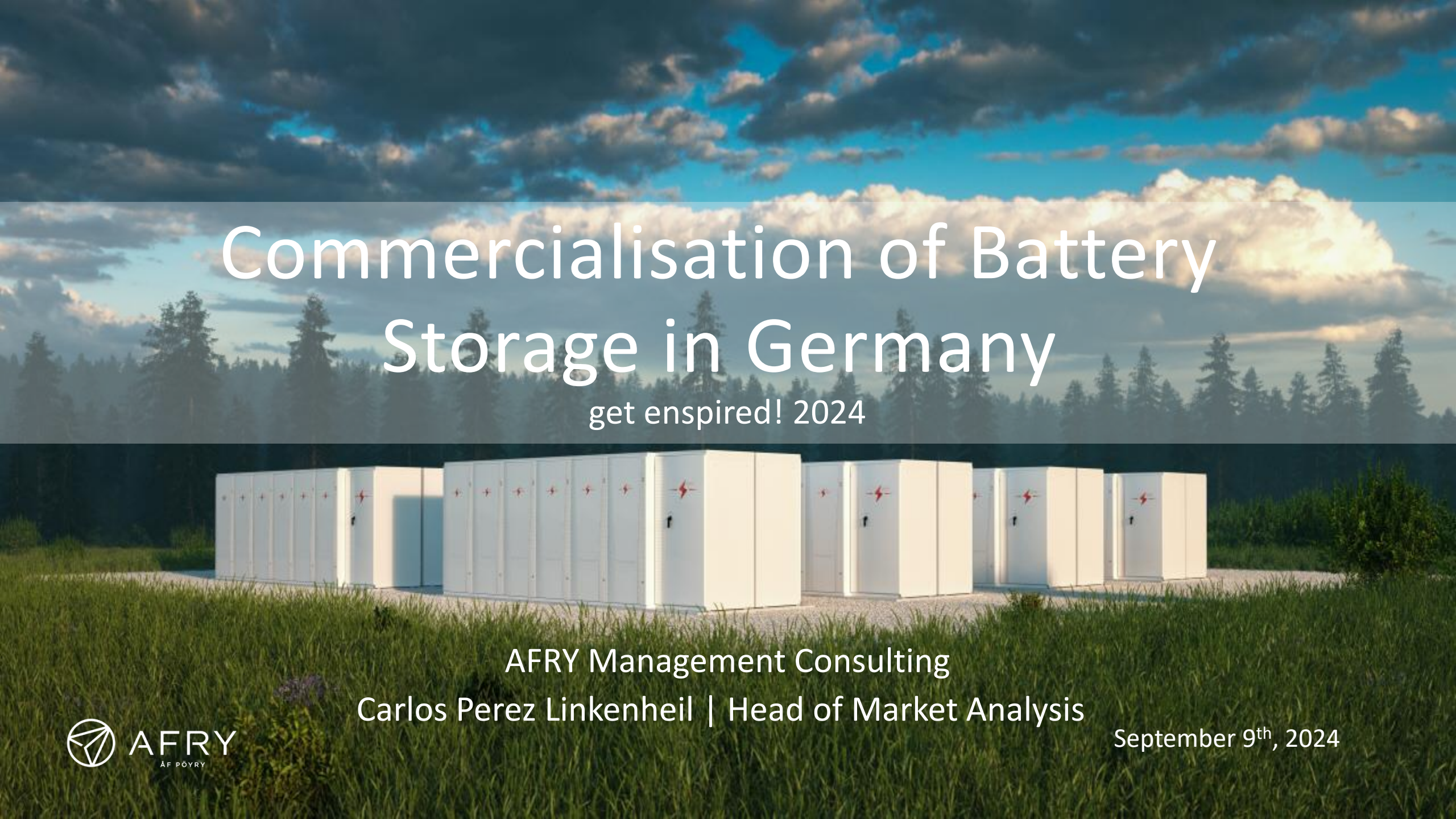


Commercialisation of Battery Storage in Germany

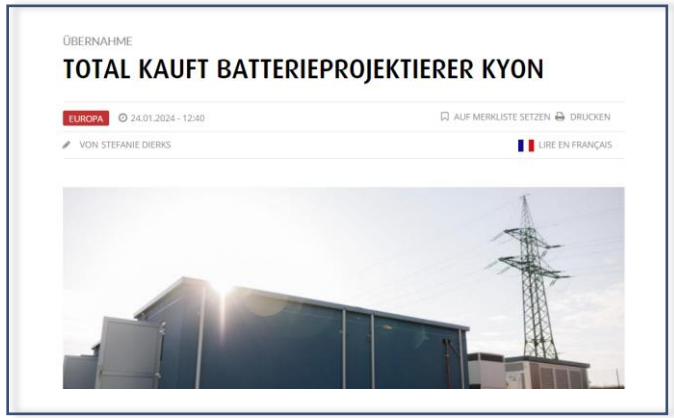
get enspired! 2024

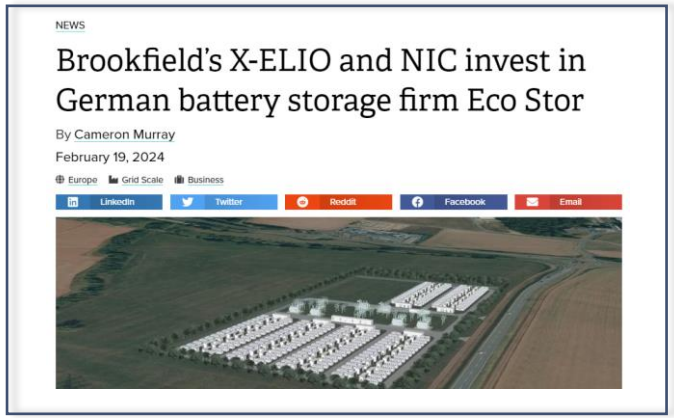
AFRY Management Consulting
Carlos Perez Linkenheil | Head of Market Analysis

September 9th, 2024

RECENT NEWS OF BESS TRANSACTIONS AND MARKET ENTRANTS

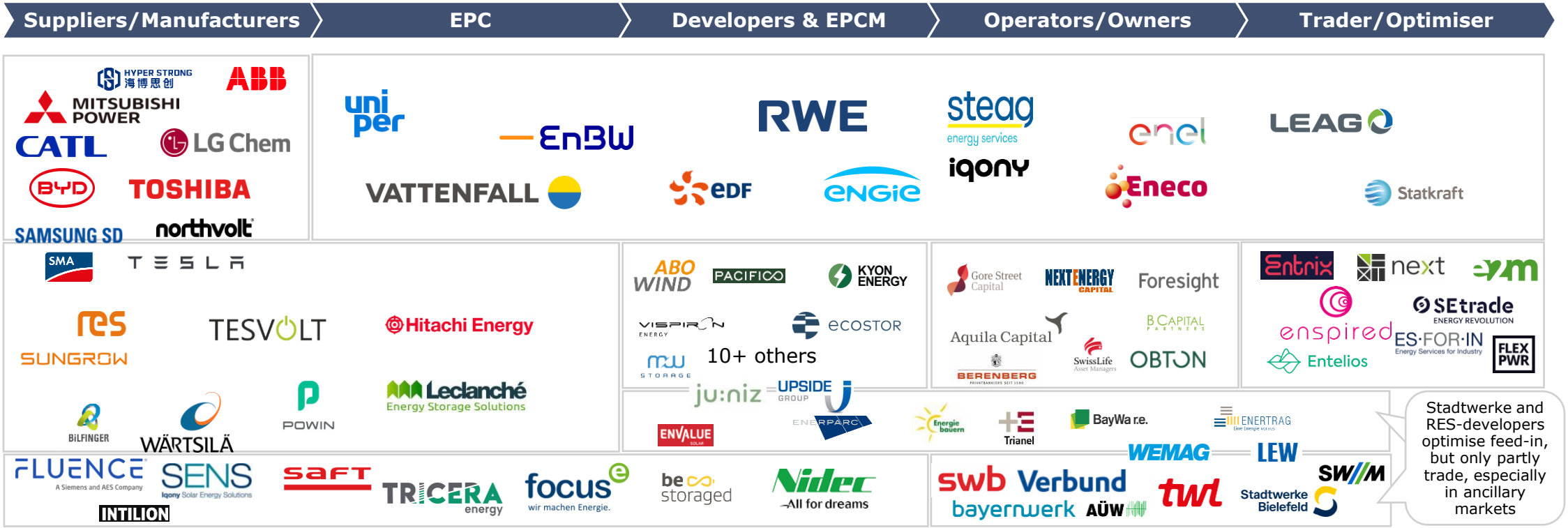
Development and investment in the German BESS market are on the rise





Source: Energy Storage News, Energate Messenger, PV Magazine

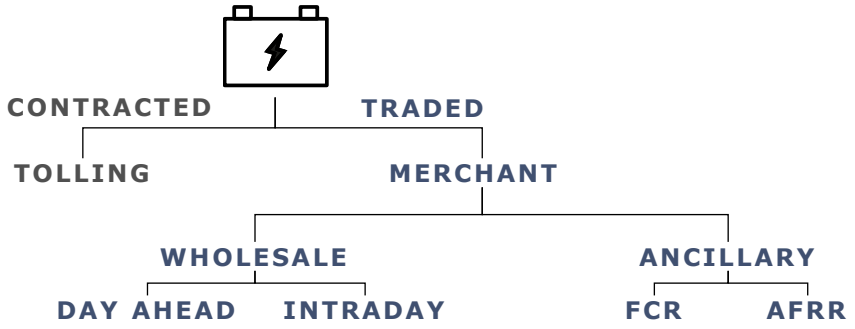
We have ourselves a German BESS market

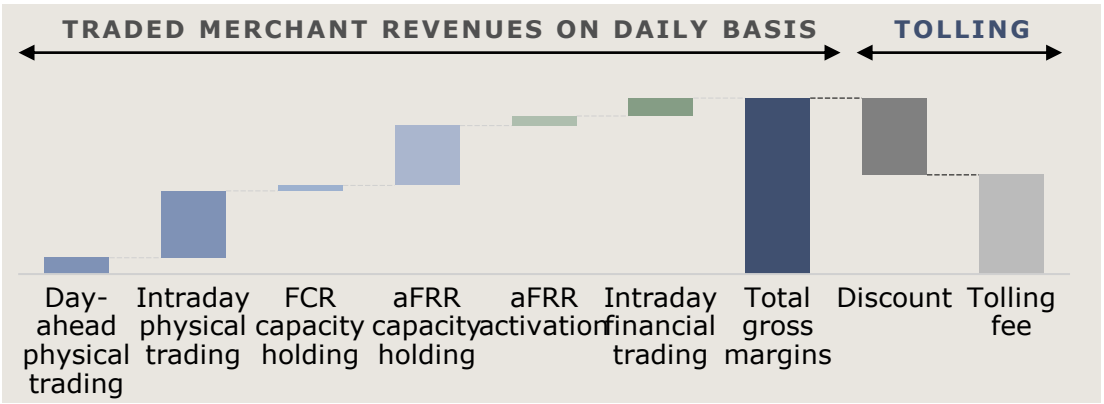


Source: AFRY analysis

Maximising BESS value through cross-market-optimisation of revenues

STRUCTURING





Source: AFRY

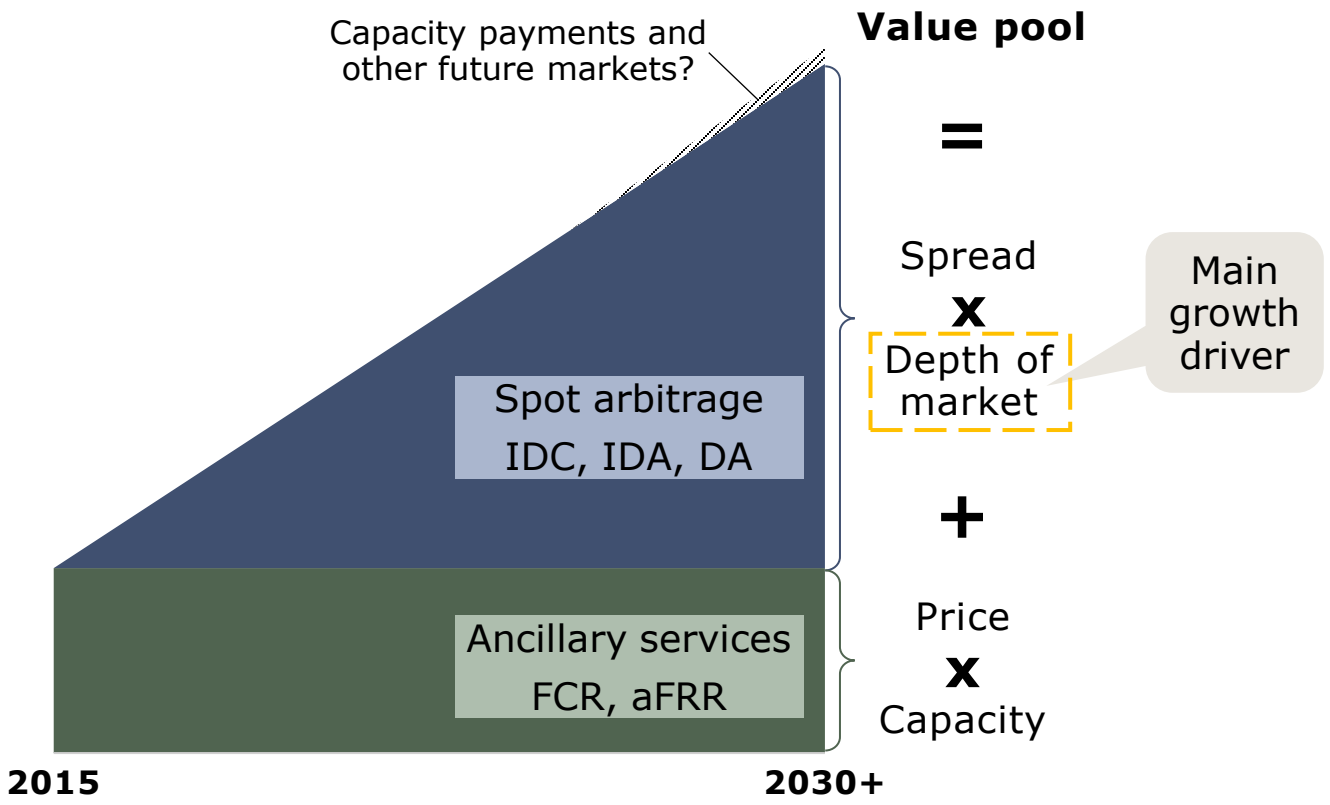
HOW A BESS MAKES MONEY

1. Capture increase volatility in wholesale market - buy low and sell high strategy
2. Offer its capacity for ancillary markets for system stability
3. Quickly able to re-optimise on continuous basis its position with AI algos and very high flexibility
4. Ability to cross optimise over these markets to maximize its bottom line

ARE BESS GOING TO CANNIBALISE THEMSELVES OVER TIME?

Growing value pool hedges against cannibalisation of BESS

VALUE POOL DEVELOPMENT IN M€

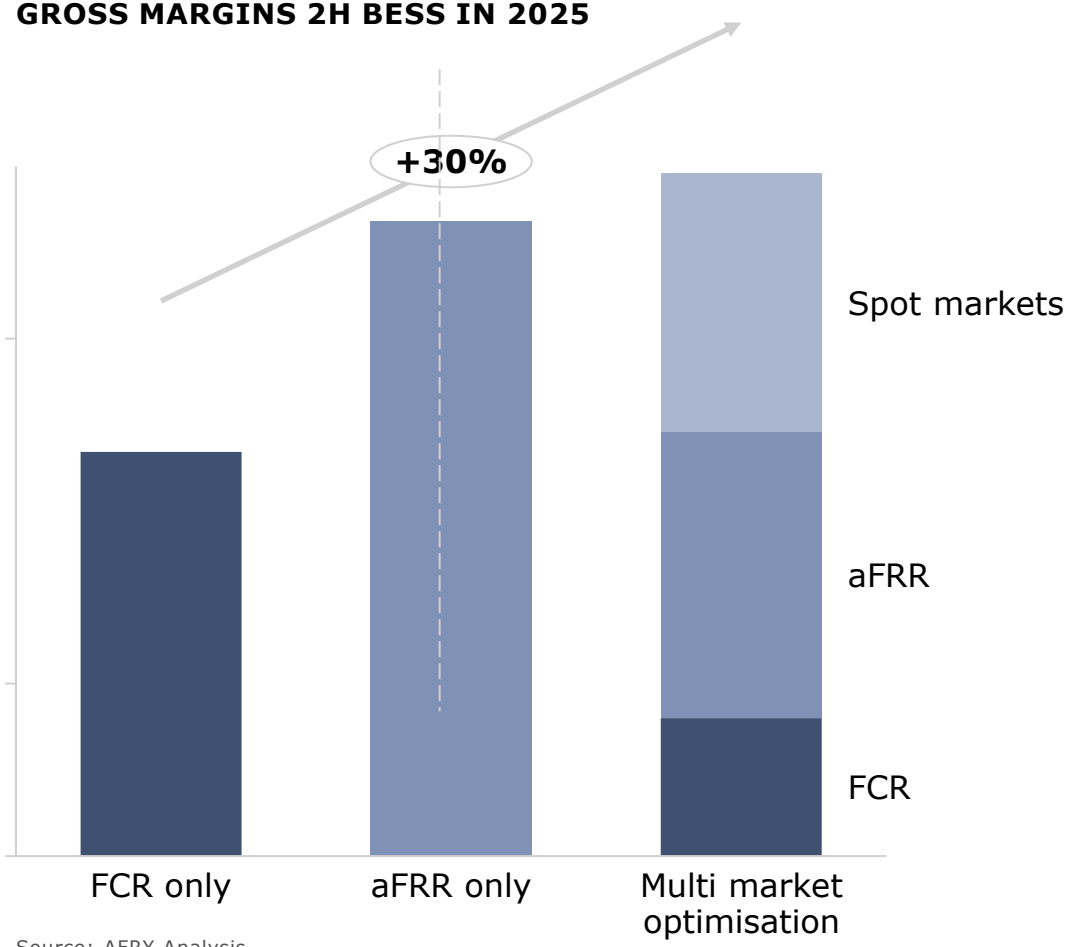


MAIN DRIVERS

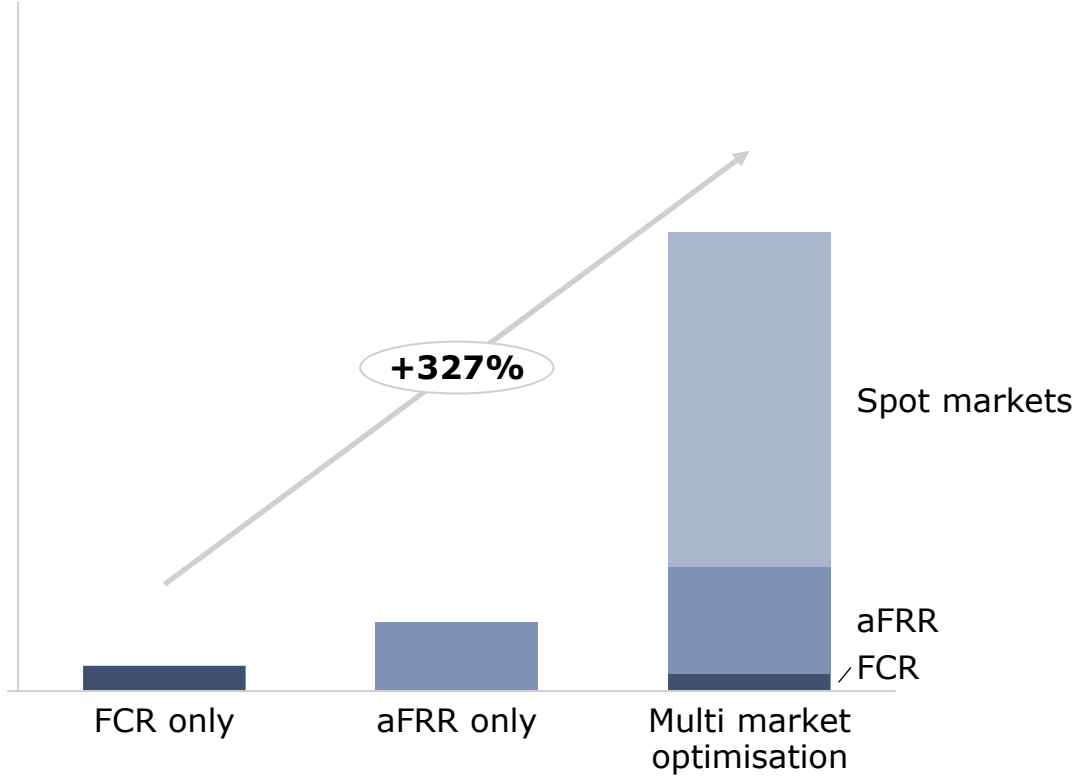
- Coal exit and RES deployment will drive need for system flexibility
- ID volumes will continue to be driven by increasing RES forecast errors
- Demand for ancillary services is expected to remain stable

Multi market stacking is a must to have a viable & robust business case

GROSS MARGINS 2H BESS IN 2025



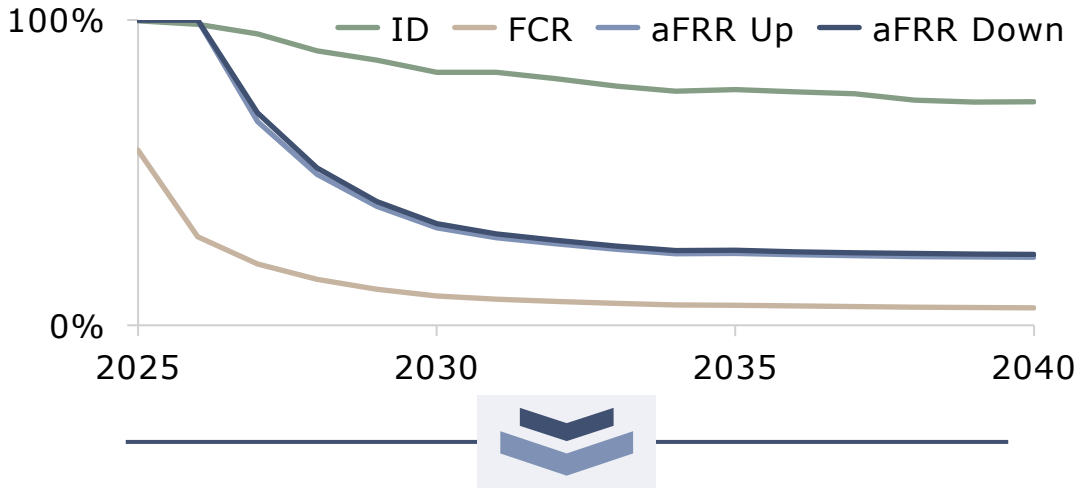
GROSS MARGINS 2H BESS IN 2035



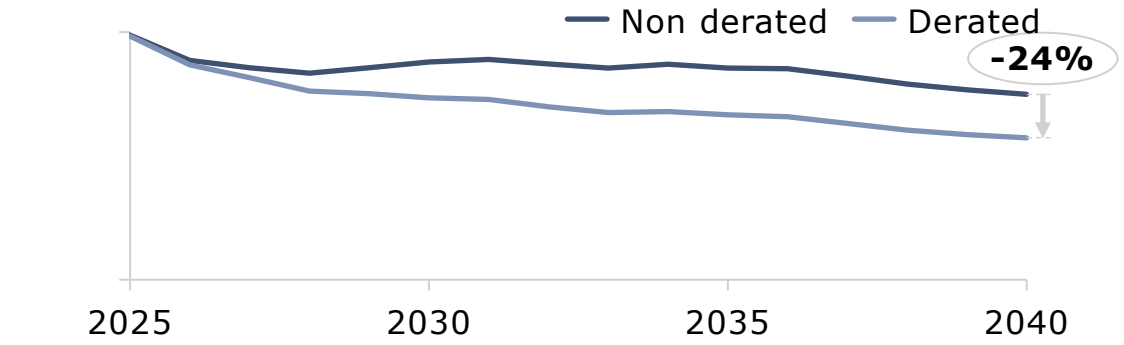
Source: AFRY Analysis

Strong cannibalisation mainly on ancillary markets, ID offering low derating

DERATING FACTORS



CANNIBALISATION OF GROSS MARGINS

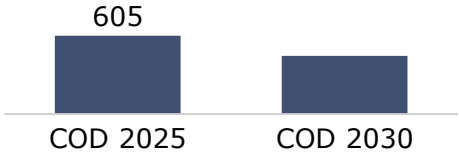
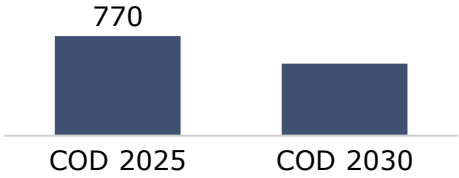
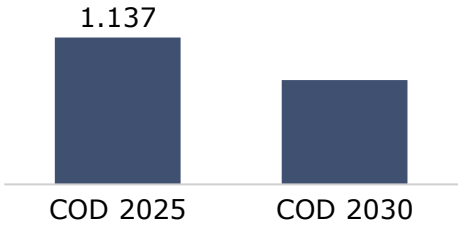


Source: AFRY analysis

1. FCR has been the most popular market, but oversupply means it will be cannibalized first
2. aFRR competition is growing, with more BESS entering by 2030, but derating will remain constant at 20-30% post-2030
3. Intraday market competition will rise as ancillary services revenue drops, with RES growth leading to a steady derating decline from 100% to 60% by 2050
4. On average, derating increases over time due to continuous BESS deployment, counteracted by increase in RES

OPTIMAL BATTERY DURATION

A 2h battery is currently the most profitable BESS option

BESS duration	IRR-Range[1] COD 2025	IRR-Range[1] COD 2030	Turnkey CAPEX kEUR/MW	Comments
1h	4 – 9 %	8 – 10 %		– 1h battery mainly active on the ancillary services markets esp. FCR-market resulting in the lowest gross margins with ~21% lower specific CAPEX than the battery with a duration of 2h
Currently the most favourable BESS duration				
2h	**9 – 12 %**	**10 – 12 %**		– 2h battery with most favourable IRRs, due to high gross margins and medium specific CAPEX – Gross margins of 2h battery increase strongly compared to 1h battery due to higher capacity availability on spot markets and aFRR
4h	6 – 10 %	10 – 11%		– Gross margins of 4h battery exceed 2h battery gross margins due to higher capacity availability – CAPEX (COD 2025) of 4h 48% higher than 2h battery – Overall resulting in lower IRRs compared to the 2h battery

1) Source: AFRY analysis

In addition to potential capacity payments, big BESS could generate proceeds through new grid services, which are currently being discussed

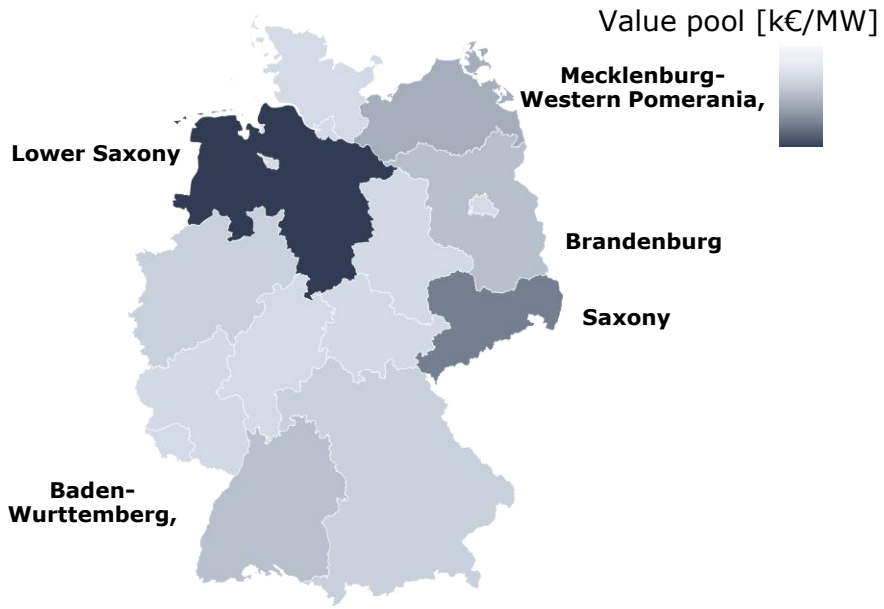
	INSTRUMENT	DESCRIPTION	STATUS & DEVELOPMENT	VALUATION	IMPACT
Congestion	**Market-based procurement of flexibility option ("Redispatch 2.0")**	Grid and flexibility operators agree on grid-relieving schedule adjustments for compensation through market-based flexibility procurement	Currently, TSOs don't redispatch batteries as generators due to IT integration complexity and payment cost evaluation	Upside potential for market-based redispatch with revenue stacking being partly possible, however "Grid Boosters" are expected to take Lion share	⊕ High
	Dynamic network tariffs	Dynamic grid charges are tariffs tied to indicators like grid utilisation or the spot market	Dynamic network tariffs are not in line with current regulation; however, they could offer high potential due to risen congestion management costs	Impact on BTM business cases and TAM	⊕ Low
Non frequency ancillary services	**Black start capability**	Black start capability is the recovery of a power generator from a total shutdown through an auxiliary power source without electrical energy supply external to the power generator	BNetzA has introduced market-based procurement for the TSOs, officially including BESS	Currently highly unattractive for 2h BESS (40-50 k€/MW/y). Contracts over 5-10 years and prohibit battery from monetising its flexibility in other markets	None
	Voltage control via reactive power	The voltage level is controlled to operate the grid within the voltage limits and stability. If the voltage is falling below the specified voltage band, the loss can be compensated by feeding in reactive power	As market-based procurement is necessary due to EU law, the BNetzA submitted a draft concept of the market design which is technology neutral	Bilateral negotiations between conventional generators and TSOs for VaR-prices, fluctuated in a range of 0.08-2.27 EUR/MVaR	⊕ Low

Note 1 Based on variable capacity expressed in NEP 2035 (Network development plan 2037/2045) | Impact is assessed regarding whether the reform is likely to come in the next years and how the impact on BESS would be with + = positive impact - = negative impact and ? = implementation unclear/not in the near future

AFRY ÅF PÖYRY

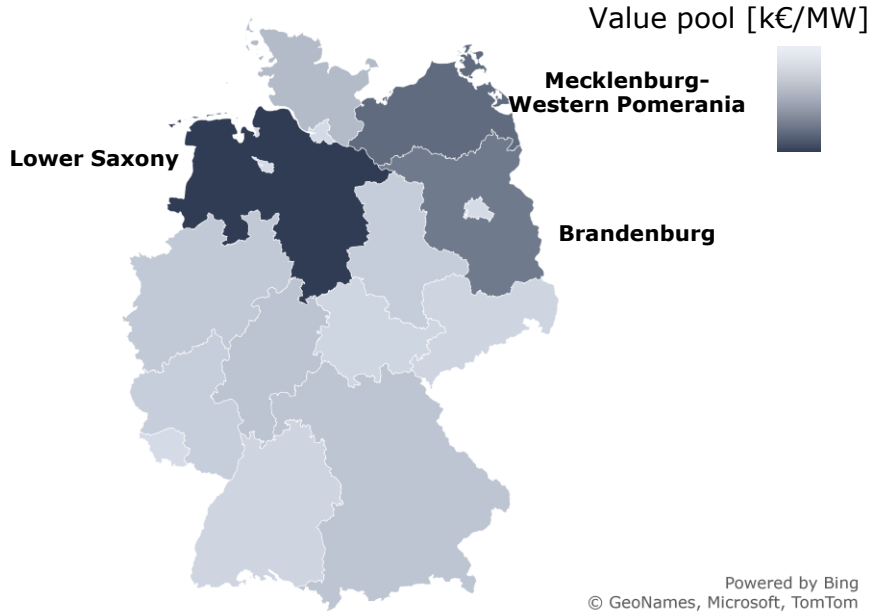
Growing RES curtailment and redispatch costs leads to local potential BESS upsides

BESS REACTIVE POWER UPSIDE PER REGION IN 2030



- Lower Saxony has the highest upside potential due to high redispatch demand and moderate reliance on coal
- In contrast, Saxony, Baden-Württemberg, and Brandenburg face medium redispatch demand but have high coal reliance, reducing reactive power availability in the future

BESS RES TECHNICAL CURTAILMENT UPSIDE IN 2030



- By 2030, AFRY forecasts total wind and solar technical curtailment to reach approximately 11.5 TWh
- Lower Saxony is projected to have the highest upside potential in 2030 followed by Brandenburg and MeckPom

AFRY MANAGEMENT CONSULTING

Leading advisor for the transition of the energy and bioindustry sectors

Presence	Revenue	Projects	Staff	Backed by
5	110 million	>100	800+	19,000
continents	EUR in 2022	countries	management consultants	experts at AFRY

Energy transition

- Global transition towards decarbonised energy system
- Sector integration due to decarbonisation and electrification (e.g. mobility, industries, cities)
- Need for smart infrastructure to enable transition and new decentralised business models

+

Transition to Bioeconomy

- Growing sustainability awareness and commitment
- Global shift in demand and products
- Need for green carbon to ensure full decarbonisation
- Resource scarcity

AFRY provides end-to-end services along the BESS value chain

1. MARKET ANALYSIS

AFRY's Flexibility Report provides **fundamental market insights**. It forecasts revenue potentials based on fundamental price projections up to 2040 for flexibility assets integrating key factors like grid capacity, generation capacity mix and policies & regulations.

2. BUSINESS CASE ASSESSMENT

AFRY's in-house battery optimisation modelling approach illustrates the business case of specific battery asset by **optimising and maximising the revenue stacking** specific to the assets design, markets and location.

3. DUE DILIGENCE SUPPORT

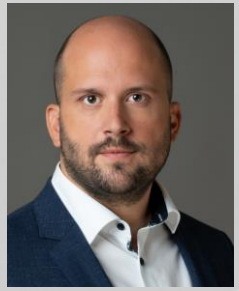
AFRY evaluates the project's financial feasibility and supports to obtain equity or debt financing by offering tailor-made **commercial and technical Due Diligences** on Battery Energy Storage Systems (BESS).

4. ADDITIONNAL OFFERINGS

AFRY's bespoke modelling and geo-data driven approach enables us to identify the attractive regions for BESS development on state or project specific level, forecasting local curtailments and congestion patterns and support in submitting the grid connection request

Thank you for your attention!

- The slides will be shared with all attendees
- Let’s take the opportunity to discuss your questions over a drink in the next two days



Carlos Perez Linkenheil
Senior Principal | Head of Market Analysis Germany
M: +49 152 229 680 40
carlos.perezlinkenheil@afry.com