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ENERGY RESEARCH

Is the time for innovation in Germany already over?

Public Report: review of latest innovation auction results and business alternatives for large-scale solar and batteries

Aurora provides market leading forecasts & data-driven intelligence for the global energy transition

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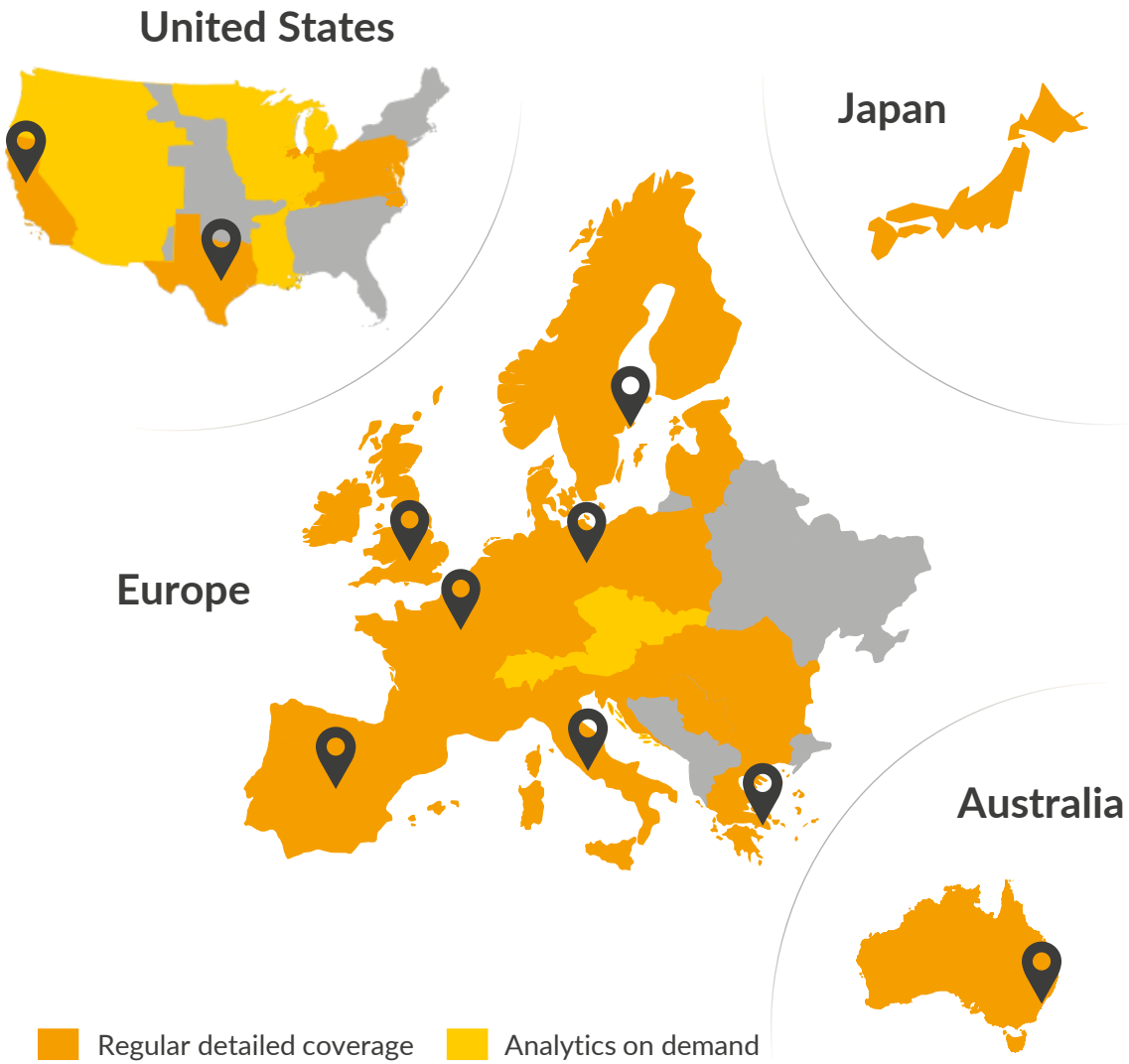
- Power markets
- Renewables
- Storage
- Electric vehicles
- Hydrogen H_2
- Carbon CO_2
- Natural gas



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Source: Aurora Energy Research

Our market leading models underpin a comprehensive range of seamlessly integrated services to best suit your needs

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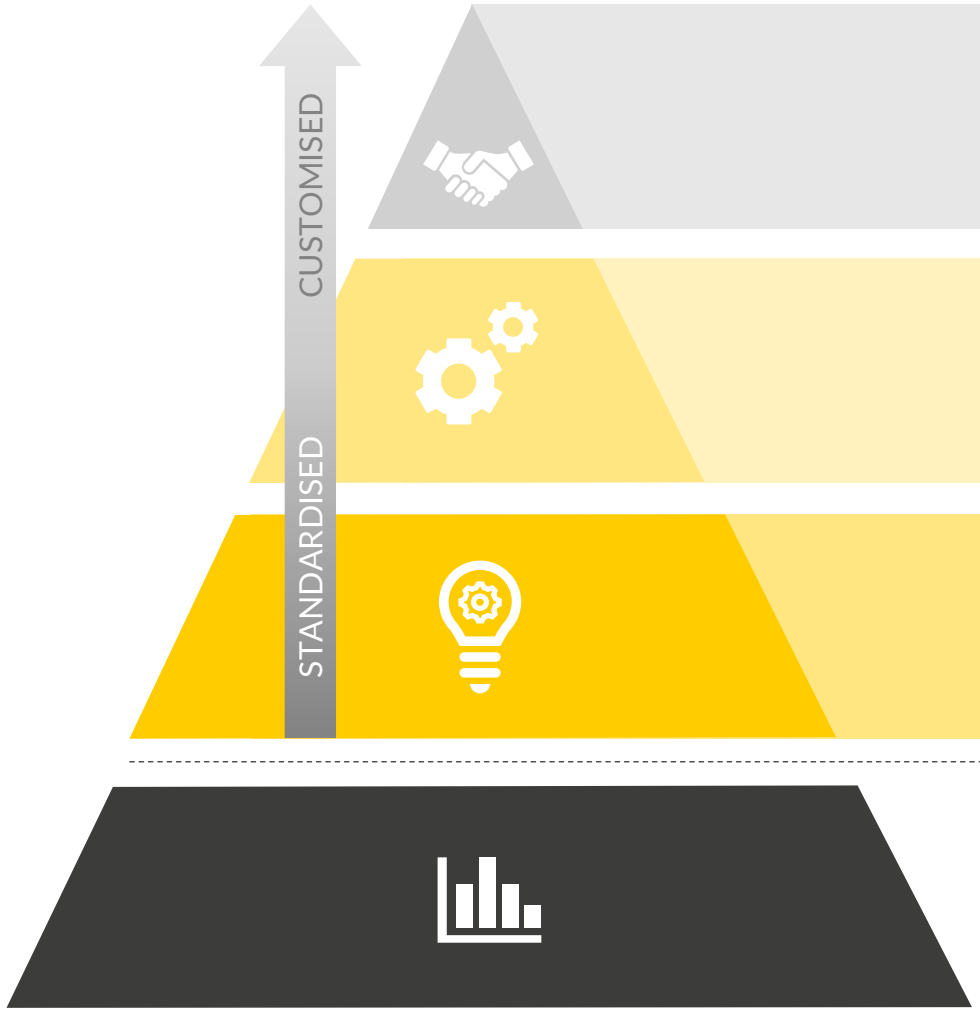

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Developed over 10 years, 40+ dedicated modellers

Source: Aurora Energy Research

Agenda

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I. What is the innovation auction scheme?

II. Why was the December 2022 auction undersubscribed? — Modelling co-located assets

III. What is the outlook on profitability for merchant co-location and stand-alone batteries?

Co-located battery + solar projects were historically driven by EEG innovation support, but last auction was heavily undersubscribed

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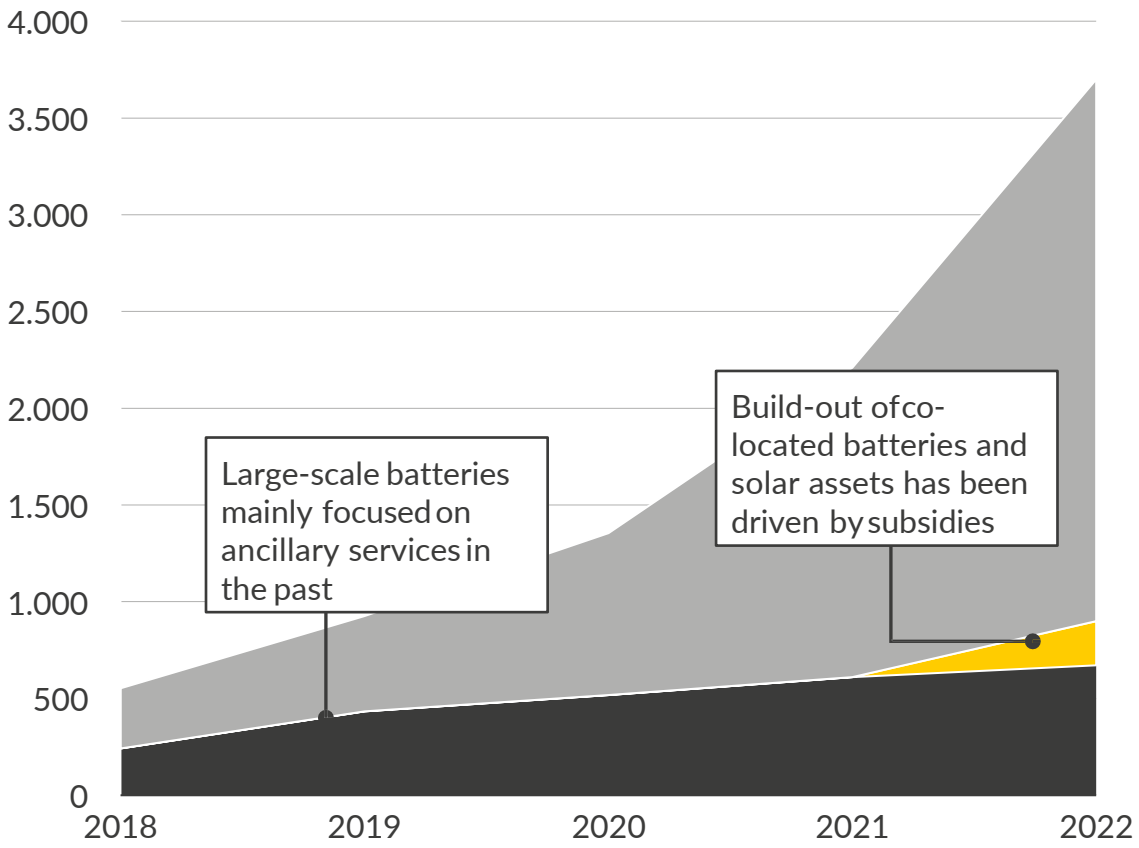
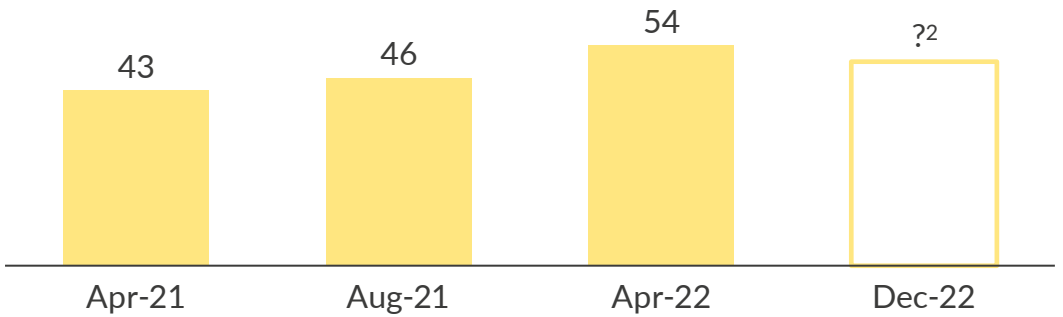
Historical battery capacity in Germany

MWh



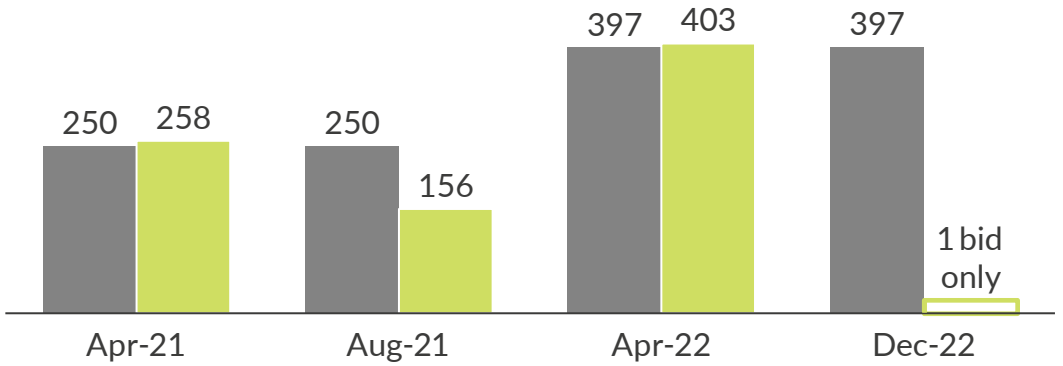
Average bid-levels in innovation auctions[1]

EUR/MWh (nominal)



Tendered and awarded capacity in innovation auctions

MW



Home storage | Co-located large scale | Stand-alone large scale

Tendered capacity | Awarded capacity

1) The first innovation auction took place in September 2020. It still allowed for single assets to participate and is therefore excluded in this overview. 2) No average bid level was published for the December 2022 auction as there was only one awarded bid.

Sources: BNetzA, Aurora Energy Research

The innovation tender format does not allow for grid charging of the storage, hence limiting ancillary market and arbitrage revenues

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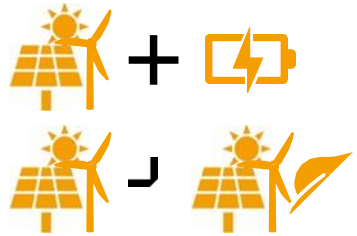
1 Technical requirements in innovation auctions

I Plant combinations

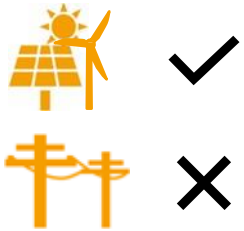


II Storage capacity

min. 25 % of whole asset

min. 2h storage duration

III Storage charging



2 Flex market participation of co-located battery and solar PV

	Contract period	Innovation asset[1]	Merchant asset[2]
Day-Ahead	1 h	◕	●
Intraday	15 min	◕	●
aFRR energy	15 min	◑	◕
aFRR capacity	4 h	◔	◕
FCR capacity	4 h	○	◕

Indication of market participation: ○ Not possible; ◑ Partially possible; ● Fully possible

1) Innovation assets are limited in their flex market participation due to the prohibition of charging the battery from the grid. Additionally, the shared grid connection with the RES asset restricts the possibilities of providing upward flexibility.
2) Limitations for merchant co-located batteries are only due to the shared grid connection with the RES asset.

Sources:, BNetzA, Aurora Energy Research

As the time of high subsidies from the innovation tenders is over, the future of co-location will become more reliant on flexibility markets

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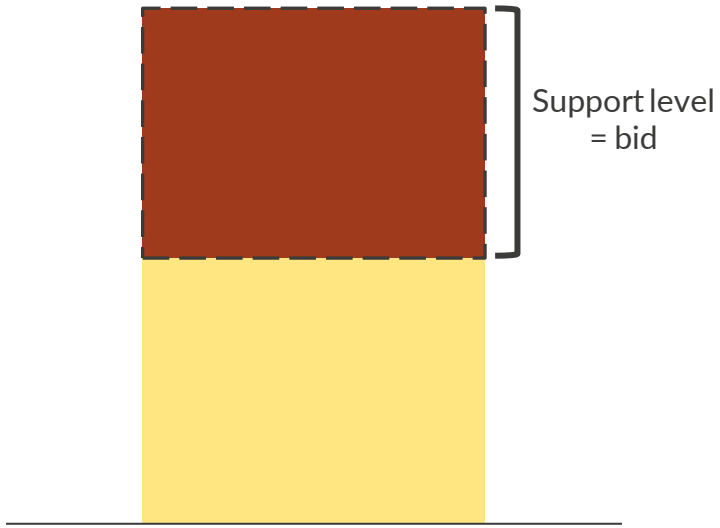
1 1.2 GW of co-located solar PV and batteries have been awarded with the **attractive fixed market premium**, payable on top of market revenues.

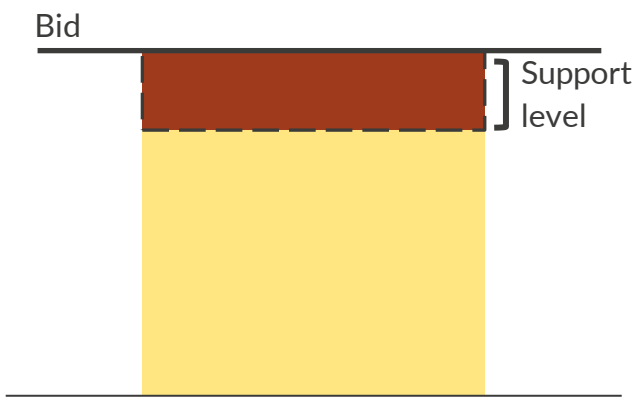
2 From December 2022, co-located solar PV and batteries can compete for a **floating market premium** in the altered innovation tenders.

3 Outside the EEG support, **merchant battery business models** offer additional revenues from flexibility markets.

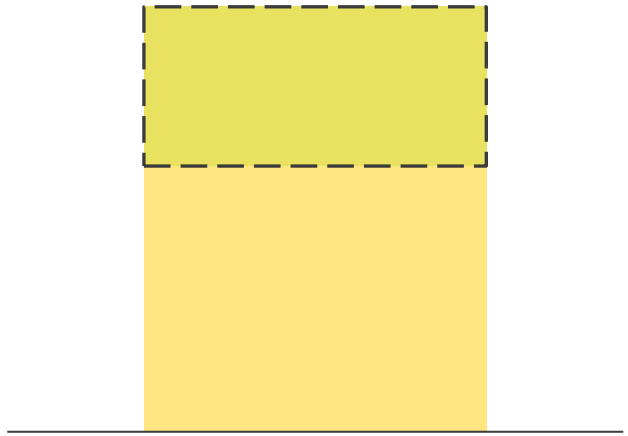
Revenues under fixed market premium
EUR/MWh



Revenues under floating market premium
EUR/MWh



Revenues in a merchant set-up
EUR/MWh



Average capture price | Subsidy payment | Additional revenues from flexibility markets

Sources: BNetzA, Aurora Energy Research

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Our Aurora battery dispatch model uses our flexibility market price forecasts, while assuming imperfect foresight for within-day markets

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Flexibility markets, battery and solar parameters[1]

- Day-Ahead prices
- Intraday prices
- FCR prices
- aFRR prices for capacity and energy
- Degradation, cycling rates, duration, efficiency
- Solar production and grid connection size

Imperfect foresight battery dispatch model

1 Optimisation process for day-ahead markets

- Optimisation of markets that take place day-ahead (Day-Ahead and FCR markets)
- We assume perfect foresight of one day
- The model solves for actions in these markets simultaneously

2 Dispatch based on real-time knowledge

- Batteries have limited foresight into Intraday prices (until next committed Day-Ahead trade)[2]
- Battery gains insight into aFRR energy markets in real time
- Based on results of stage 1, battery charges or discharges if within-day market prices are more attractive than planned actions
- Model accounts for upcoming commitments and applies penalties for missed actions

Results

- Battery and solar dispatch
- Revenues per market
- NPV and IRR

For more information on our flexibility market offerings, please contact **Benjamin La Trobe, Germany Commercial Associate**

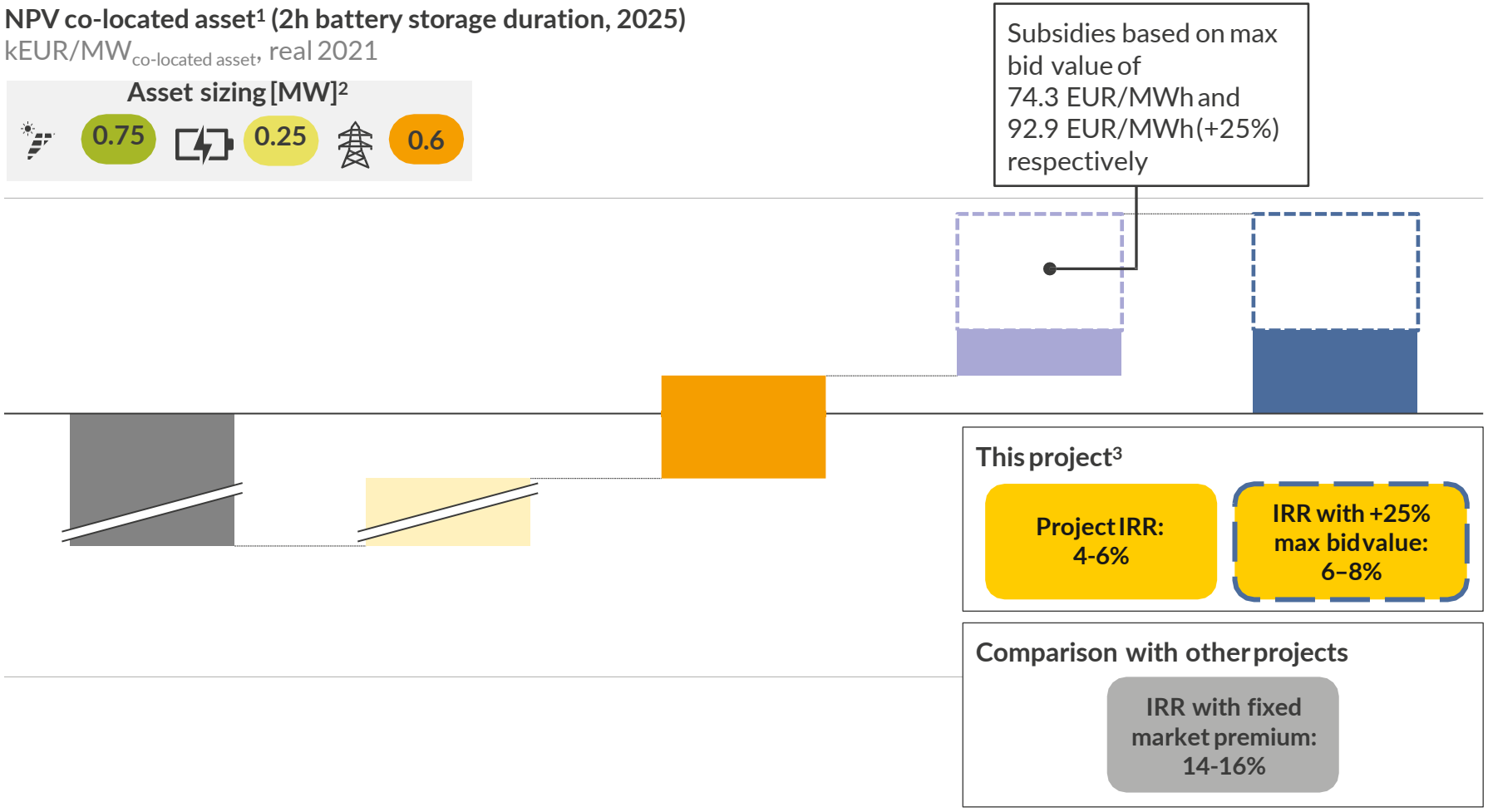
✉ **benjamin.latrobe@auroraer.com**

1) All prices have hourly time granularity. 2) Limited Intraday forecast based on the assumption that battery needs to optimise state of charge with regard to upcoming committed trades, i.e. in the Day-Ahead market.

Source: Aurora Energy Research

Innovation assets generate most of their revenues by wholesale arbitrage, apart from selling solar power on the day-ahead market

NPV co-located asset[1] (2h battery storage duration, 2025)
kEUR/MW$_{co\text{-}located\ asset}$, real 2021



1) Assuming a 30-year lifetime of the solar asset and a 15-year lifetime of the battery with replacement of the first battery after 15 years. The second battery CAPEX is discounted. 2) Results presented are for 1 MW co-located asset, consisting of 0.75 MW solar and 0.25 MW battery. Grid connection is 0.8 times solar peak capacity = 0.6. 3) IRRs are stated as real, pre-tax values.
Source: Aurora Energy Research

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- The project IRR of an innovation asset with COD in 2025 is 10 percentage points below that of an asset in the old subsidy scheme with a fixed market premium
  - A potential increase of the maximum bid value by 25% could increase IRRs back up again by about 2 percentage points
- Nevertheless, the innovation scheme offers a secured subsidy floor which enables improved debt financing conditions as it protects against downside risk
- Participation in ancillary services is rather insignificant during the time of subsidy, due to the regulatory limitations.

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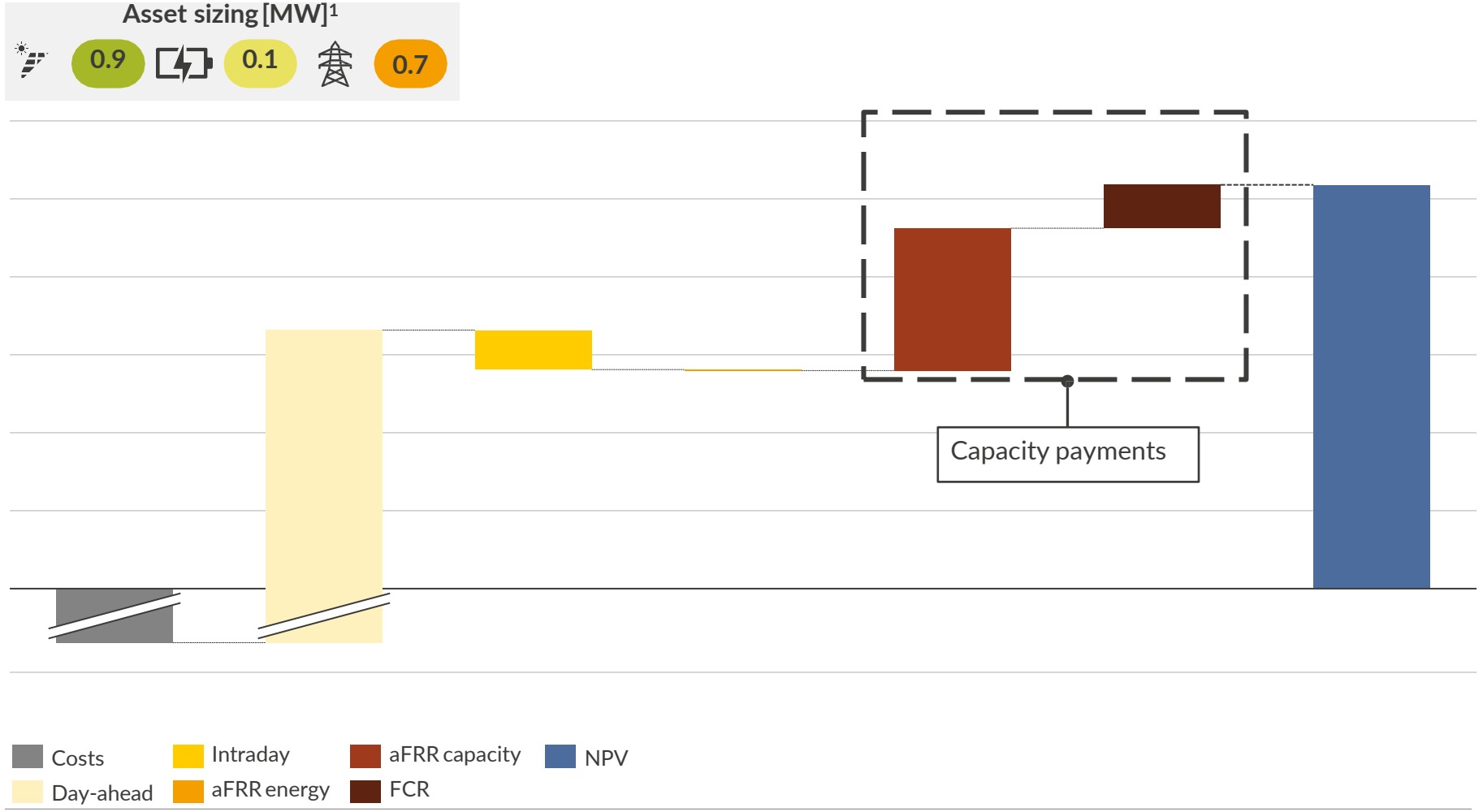
Capacity payments are the most attractive revenue stream for assets active in ancillary services as the respective energy is often not called

NPV co-located asset (2h battery storage duration, 2025)
kEUR/MW$_{\text{co-located asset}}$, real 2021



1) Results presented are for 1 MW co-located asset, consisting of 10/11 MW solar and 1/11 MW battery. Grid connection is 80 % of the solar peak capacity.

Source: Aurora EnergyResearch

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- Merchant co-located assets optimize their trading to participate on the capacity markets. The assets benefit from the low likelihood of being called in these markets, which means no (dis)charging and respective degradation, and the stored energy can likely be used in another trade
- To this end, the co-located asset often buys energy to charge the battery on Intraday and aFRR energy, leading to negative net revenues on these two markets
- A merchant set-up allows for an optimised sizing ratio of both components; the improved project IRR compared to the standalone business modelscan mostly be attributed to cost savings.

Aurora's market forecasts show that batteries are profitable in Germany and can add value to a solar asset when co-located

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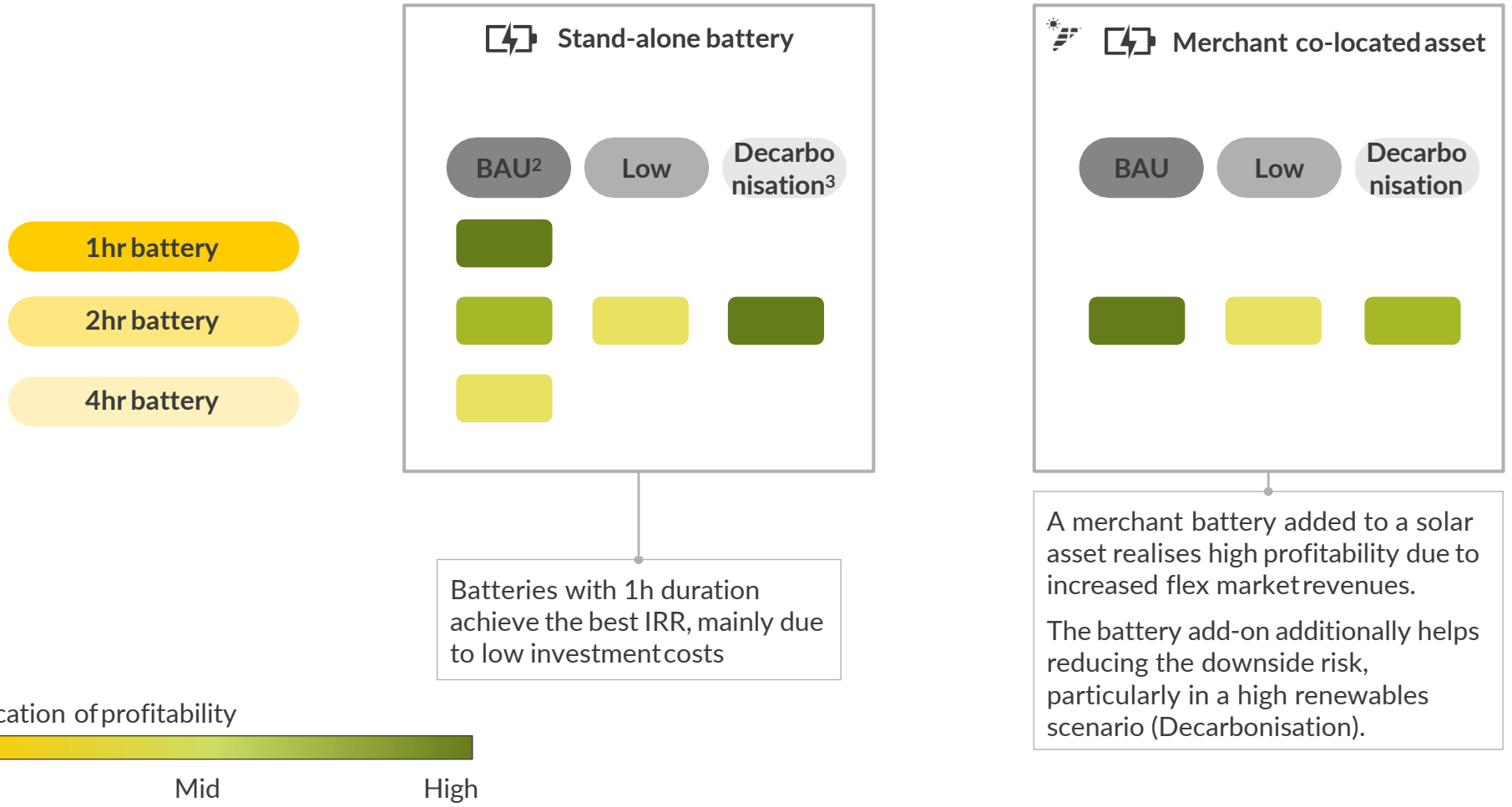
Economics for new-build battery entering the market 2025[1]
real IRR in %



1) Including grid fees. 2) Business as usual scenario – assuming relatively moderate speed of decarbonisation. 3) Scenario assuming fast decarbonisation in accordance with ambitious government targets.

Source: Aurora Energy Research

Key takeaways

1. The innovation auction scheme supports asset combinations with a market premium. In practice, only **combinations of solar and batteries** have been awarded so far.

2. **Innovation tenders have become considerably less attractive**. The change from a fixed to a floating market premium leads to a large drop in paid subsidies. Project IRRs decrease by around 10 percentage points to 4-6% (depending on solar generation). Consequently, the first tender under the new conditions in December 2022 was severely undersubscribed and only one bid was awarded. A potential increase of the maximum bid value by 25 % could increase IRRs back up again by about 2 percentage points.

3. As operation on flexibility markets is restricted and grid charging is prohibited for assets operating under the rules of the innovation auction scheme, **revenues are lost compared to a merchant co-located set-up**. In the merchant case, profitability increases through additional battery cycles as well as through revenues from the aFRR capacity and FCR markets. An advantage of the EEG framework remains that it can be used to secure higher debt financing.

4. **Stand-alone batteries are profitable in Germany**, when using an advanced trading strategy in a business as usual scenario. Independent of the strategy, the business model requires trading over the different flexibility and wholesale markets to realise sufficient margins.

Source: Aurora EnergyResearch

Access detailed power market analysis and investment case data for batteries with our German Flexible Energy Market Service

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Flexible Energy Market Service

Forecast Reports & Data

Technology and Market Development Reports

- Overview of regulatory framework for batteries
- Revenue stacking models for batteries
- Projections for battery CAPEX and OPEX by delivery year
- Reports and datasets follow the same format with content tailored to specific markets

Forecast Data

- Central case forecast prices provided at hourly granularity until 2050:
  - Wholesale power prices
  - Balancing market prices
  - Intraday, FCR and aFRR market prices

Investment Cases

Standalone battery

- Multiple investment cases per country or zone including:
  - Arbitrage of wholesale market and balancing market
  - Focused participation in frequency control market (if applicable)
- Annual project margins to 2050; IRR and NPV for multiple entry years

Discuss how our Flexible Energy Market Service can help your business with
Benjamin La Trobe, Germany Commercial Associate

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Details and disclaimer

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Is the time for innovation already over?
Public Webinar

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