AURORA ENERGY RESEARCH

Hybrid PPAs in Europe: Unlocking New Value Streams

20 March 2025

Agenda

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I. Introduction to Hybrid PPAs

II. Case Study: Solar Peak Shaving PPA

III. Summary

While PPAs were in high demand during the energy crisis, the market has cooled down in 2024

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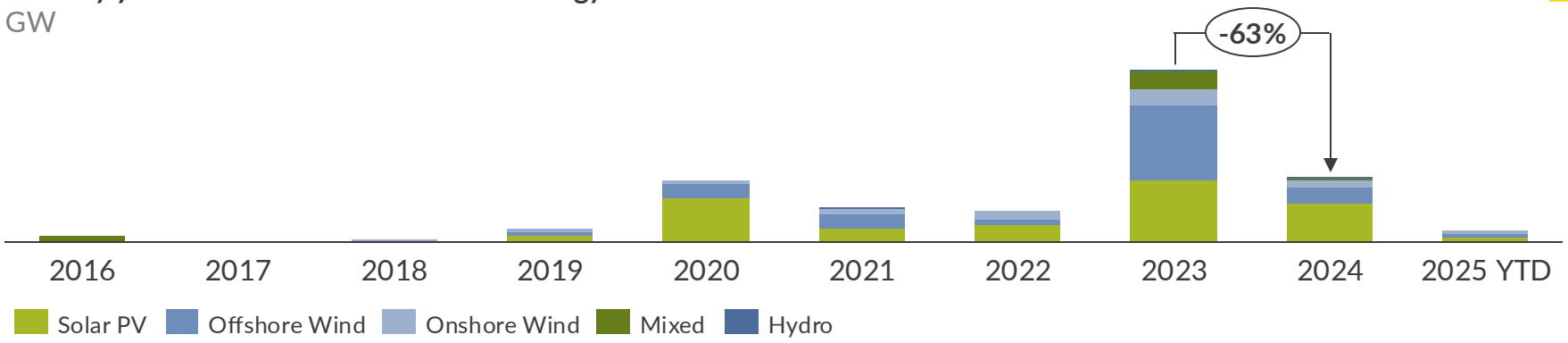
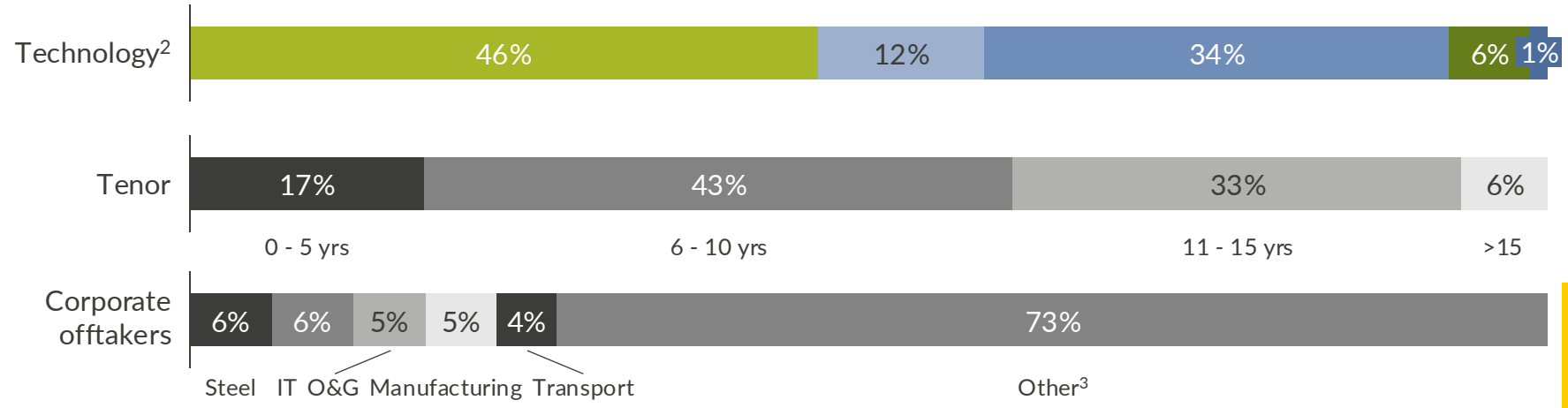
Total by year of announcement and technology[1]
GW



Contracted PPA capacity in Germany[1]
% of contracted capacity



- The volume of announced PPA deals fell by 63% from 2023 to 2024,
- Solar PV is the main technology for PPA deals in Germany in terms of contracted capacity, accounting for 46%.
- Tenors between 6 and 10 years are most common for PPAs in Germany.
- 74% of PPA capacity with disclosed offtakers are signed by corporates including major steel producers, and large IT and mobility companies.

For more information on the Hybrid PPAs MCS Please contact

Mar Escobedo, Commercial Associate

1) based on public announcements and Aurora insights as of March 2025. 2) Weighted by capacity for all categories. 3) Other includes RWE, Vodafone, Covestro, Statkraft, Evonik, Volkswagen, DHL, Bosch, Google, and others. 4) Undisclosed includes PPAs where the offtaker cannot be assigned to a category based on publicly announced information.
Source: Aurora Energy Research

Decreasing power prices and increasing cannibalization reduce the value of traditional Pay-as-Produced structures

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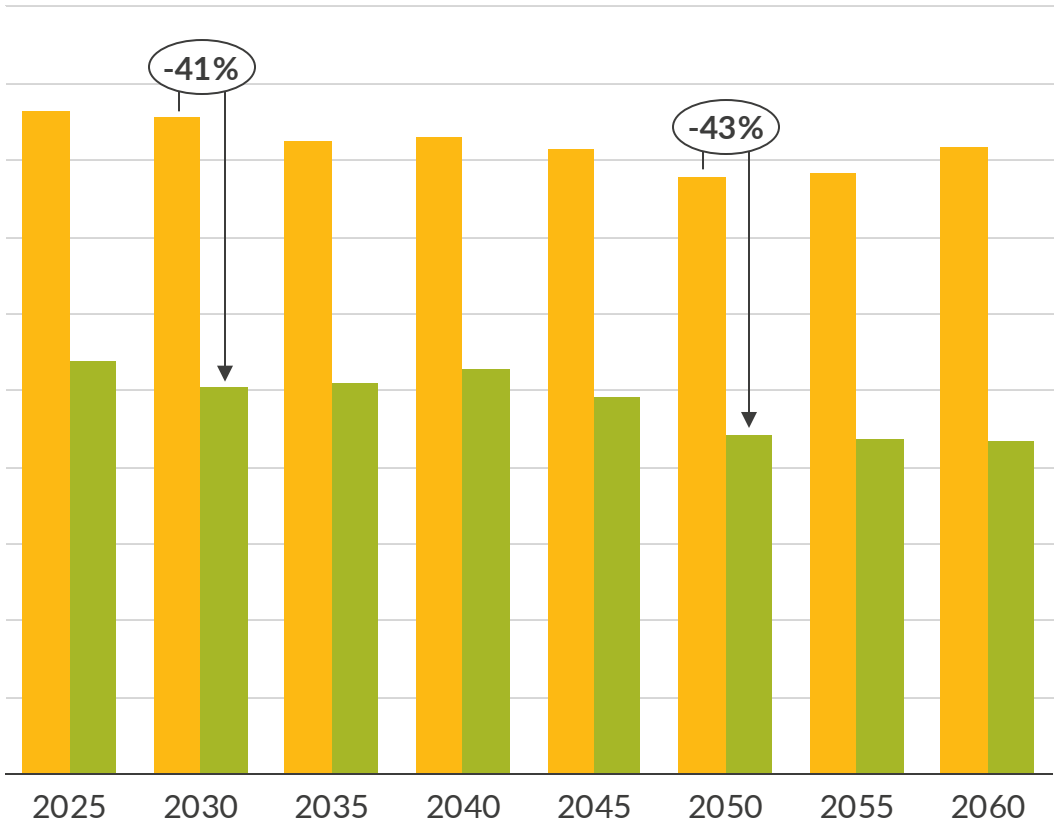
Solar capture prices vs. baseload prices (Germany)
EUR/MWh



Solar capture prices vs. baseload prices (Spain)
EUR/MWh

As-produced PPAs are limited to cover between 20-70% of typical offtaker demand, setting an upper boundary to ambition levels

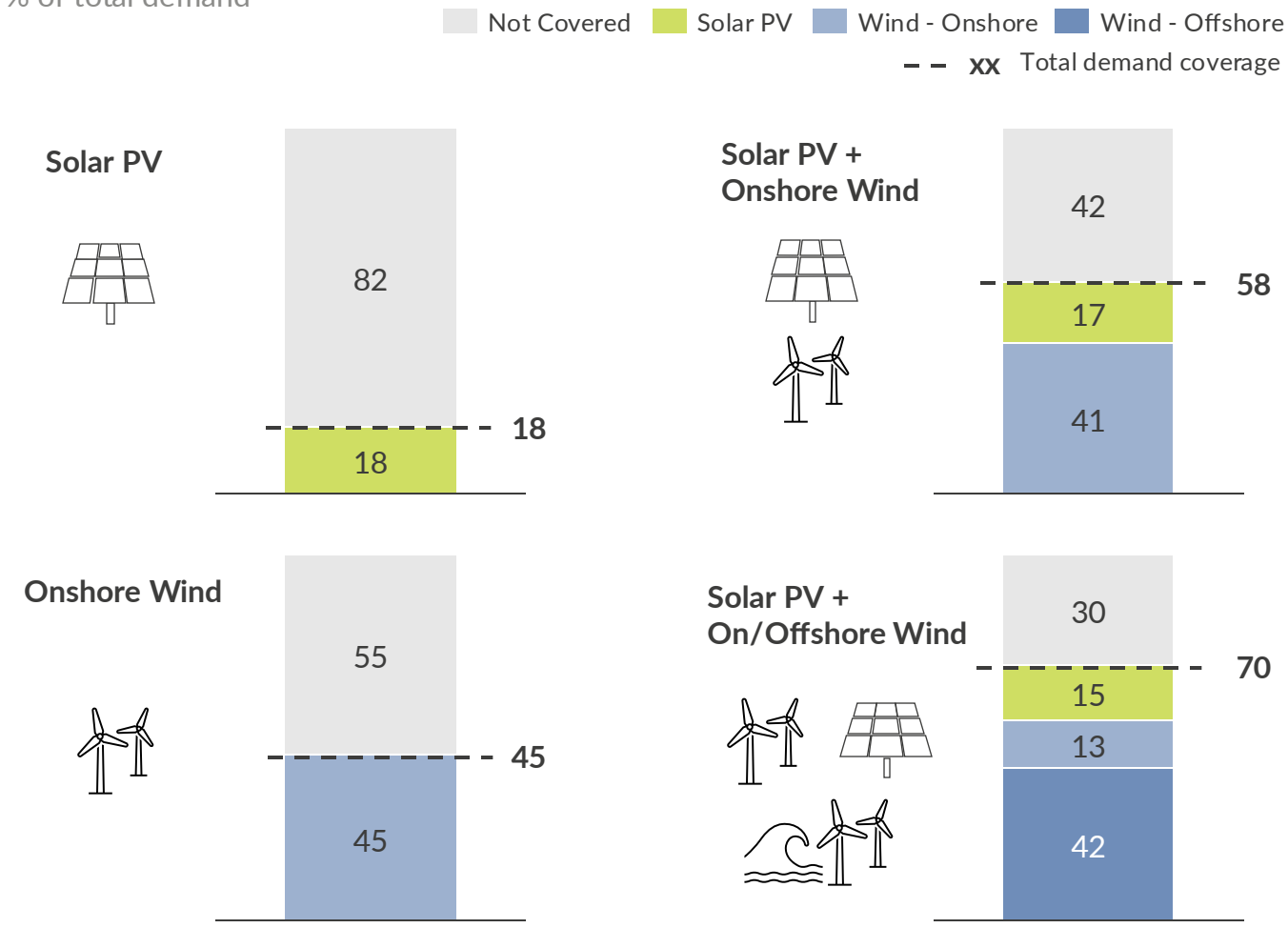
Typical **offtaker demand** profiles often resemble **baseload** shape

Ambition to cover substantial amount of load via PPA limited by the match of generation and consumption profile

Excess generation limited due to market risk implications and own-use requirements

Natural **upper limit** of demand coverage via **as-produced PPA** profiles

Annual demand covered by as-produced PPA profiles[1]
% of total demand



1) Assuming flat baseload demand throughout the year; assuming typical generation profiles for different technologies and optimal combination to maximize load coverage. Limiting excess generation to a total of 5% of total generation. For typical generation profiles in Germany.

Implications

Pure-play pay-as produced PPA of solar PV or Onshore Wind can **cover 25-45%** of annual baseload **demand** without excessive overproduction

Pooling both technologies can raise this coverage to ~60%

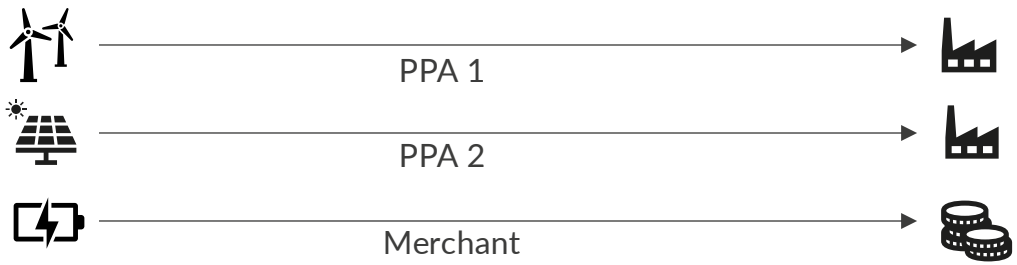
Pooling all available technologies and combining them in an optimal way can **at most cover 70%** of an annual baseload **demand**

Higher ambition levels require shaping of profiles to better match supply and demand – this can be achieved via **wholesale markets** or **storage technologies**

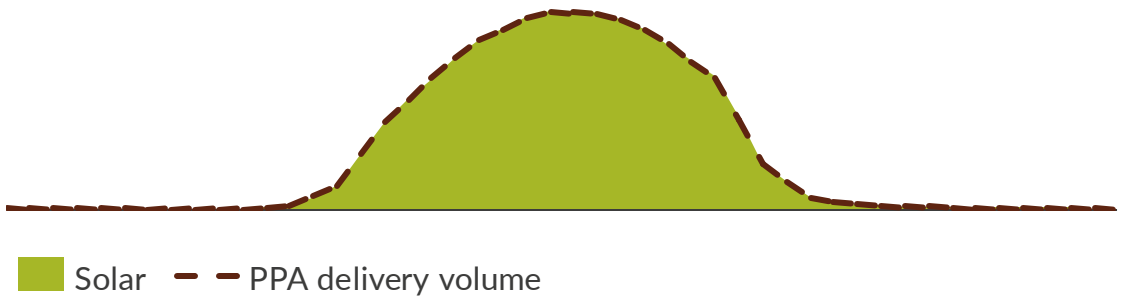
To meet the challenges of traditional, as-produced structures the industry is considering the move to hybrid and shaped PPA setups

Traditional as-produced PPA structures

So far, PPAs have primarily been used to sell energy from a single asset. Batteries, however, are rarely secured under long-term offtake agreements and are typically traded in wholesale and balancing markets.

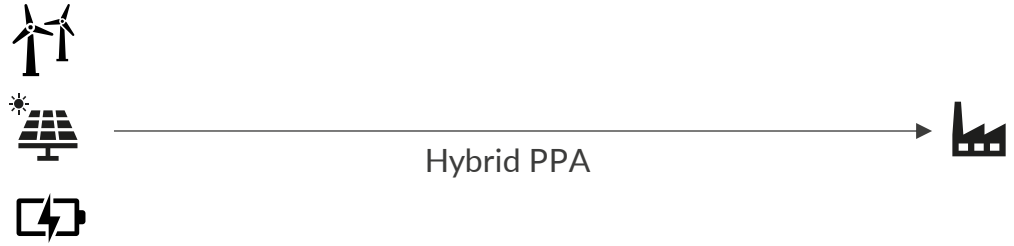


The most common volume structure for wind and solar PPAs is pay-as-produced, exposing the offtaker to volume and cannibalisation risk.

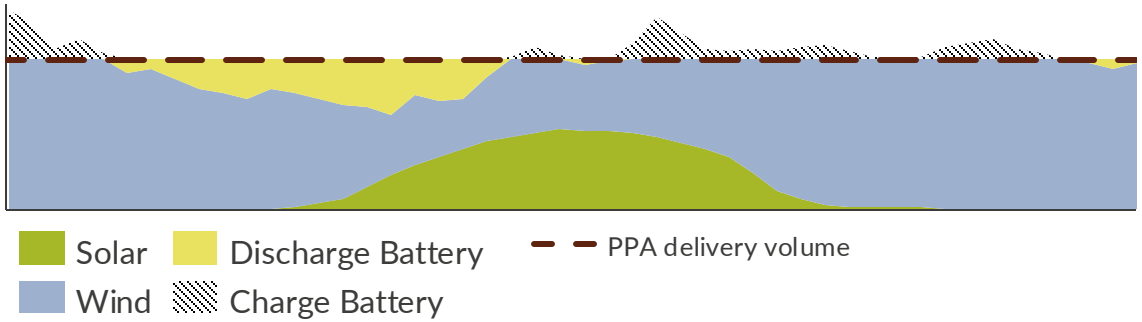


Hybrid and shaped PPA structures

Under a **hybrid PPA**, co-located assets are bundled under a single offtake agreement, enabling the business case optimisation and long-term revenue security of the entire portfolio.



Under a **shaped PPA**, volume structures deviate from the standard pay-as-produced model by following a predefined pattern, such as annual or monthly baseload or a fixed profile. To ensure shaped PPAs remain 100% green, a hybrid setup incorporating multiple assets is required



Sources: Aurora Energy Research

Each PPA profile offers unique value propositions and comes with specific challenges

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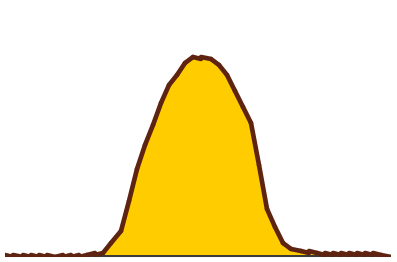
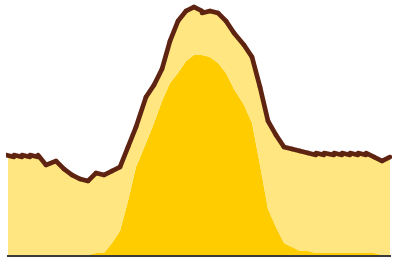
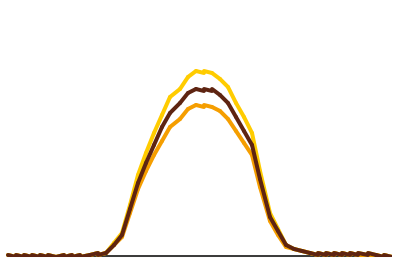
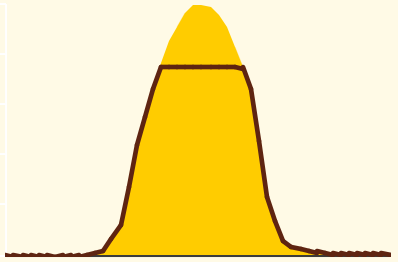
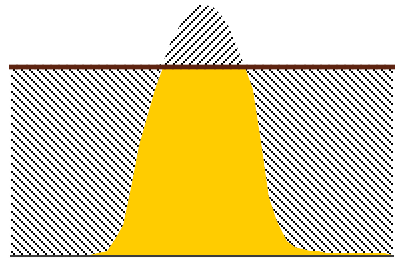
Case study following

PPA

Generation

	As-Produced/Forecasted	Pooled	Fixed Shape	Peak-Shaving	Baseload
Profile					
Advantages	No additional shaping required Full generation volume covered	No additional shaping required Full generation volume covered Better demand coverage via profile combination	Fixed, reliable shape for offtaker Shape resembling actual production makes firming easier	Easier to integrate into demand profile due to reliable peak generation	Most preferable shape for most (industrial) offtaker due to reliable shape
Challenges	Fully exposed to capture prices Difficult to integrate into demand profile in large volumes	Fully exposed to capture prices Difficult to integrate into demand profile in large volumes	Integration into demand profile still limited Shaping risk with supplier of PPA	Introduces merchant risk for excess volumes or requires battery for shaping	Difficult to shape, either substantial merchant exposure or complex asset combination to firm physically

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Case Study: on peak-shaving, the battery charges during peak hours and discharges when solar generation falls below the PPA threshold

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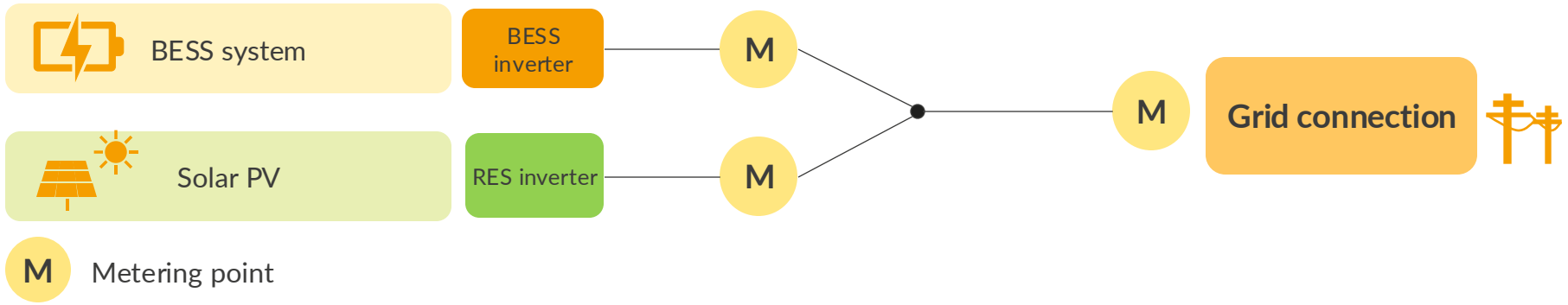
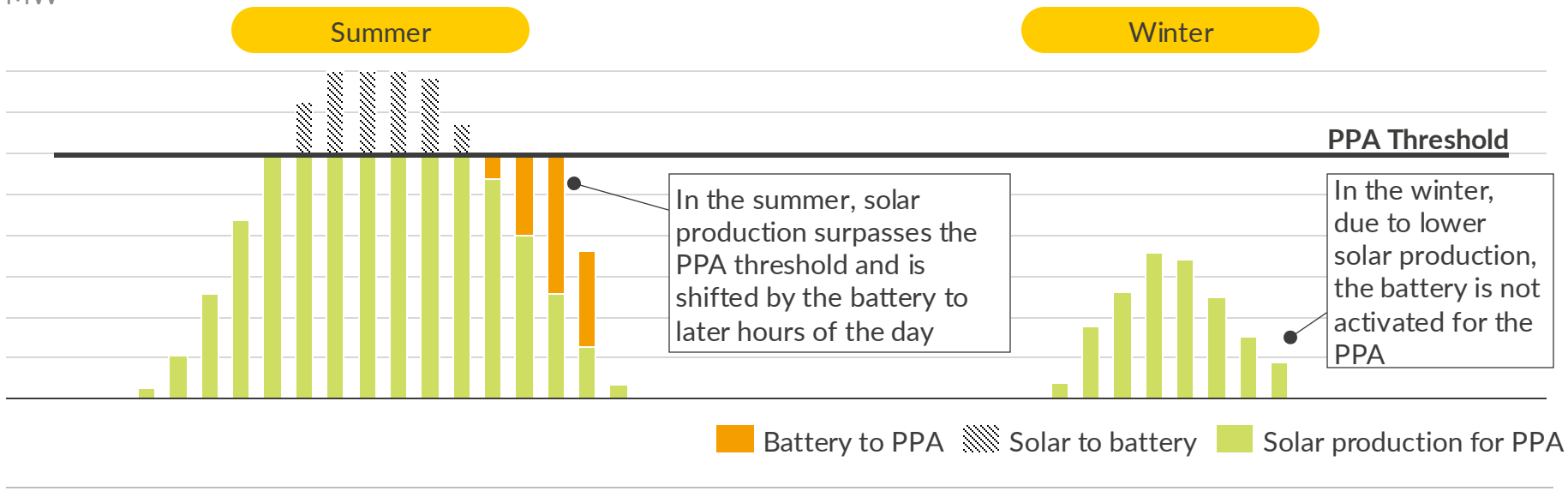
Schematic representation of the co-located assets in a hybrid PPA configuration



Exemplary PPA Solar and Battery dispatch



- The PPA profile sets a maximum delivery cap, typically 80% of the installed asset capacity
- The co-located battery is sized to accommodate the maximum volumes exceeding the PPA threshold
- Peak shaving structure achieves a revenue uplift via PPA value increase
- The residual battery is used to optimise freely against the market and generate additional revenues in day-ahead, intraday and ancillary markets

For more information on the Hybrid PPAs MCS

Please contact

Mar Escobedo, Commercial Associate

Case Study: The peak shaving PPA could increase the overall demand potential by 25% and increase PPA profile value by 2.6%

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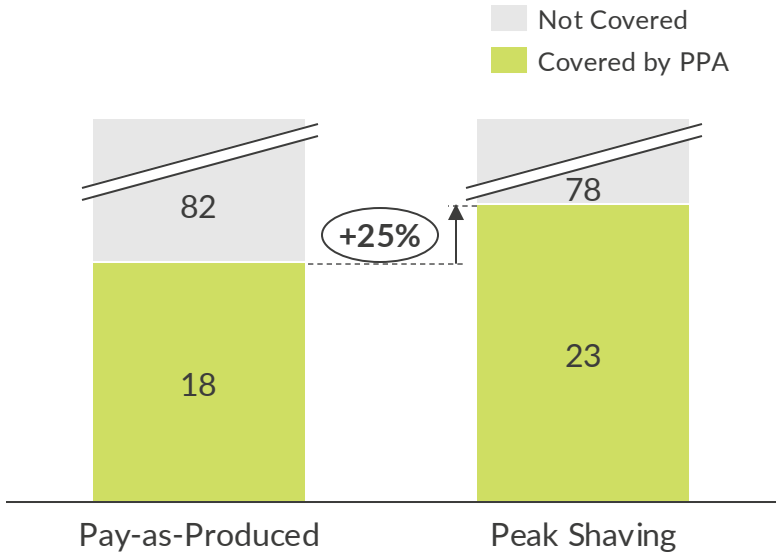
I Potential PPA demand coverage

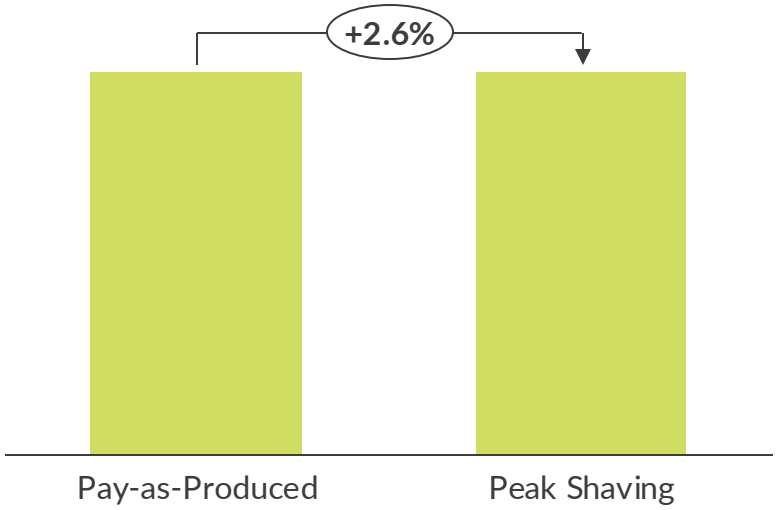
Max. baseload demand covered by PPA[1]
% of annual baseload total demand



Peak shaving at 20% of annual peak load observed **increases potential uptake of PPA profile** into baseload demand profile **by 25%.**

II PPA capture value

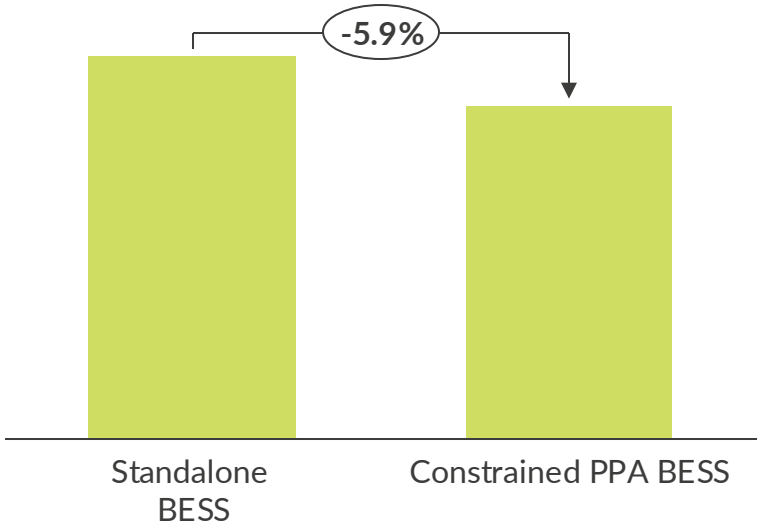
Average capture price of PPA profiles
EUR/MWh



PPA capture value increases by 2.6% due to peak shaving activities indicating potential PPA price increase of similar magnitude.

III Overall setup revenues

Battery Revenues
€/kW (real 2023)



Reduced battery revenues due to commitment compared to standalone battery case limited to 6% of annual revenue.

1) Assuming flat baseload demand throughout the year; assuming typical generation profiles for different technologies and optimal combination to maximize load coverage. Limiting excess generation to a total of 5% of total generation.

Shaping a PPA can increase capture value, increase offtaker compatibility and improve financing conditions

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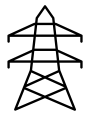
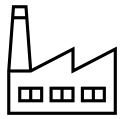
Increase PPA value

Shift generation from renewables from lower- to higher-price hours, **improving capture price profile** and therefore PPA value and revenues



Leverage existing infrastructure

Leverage scarce grid connection via **co-location** of storage with RES assets, while simultaneously improving attractiveness of co-located RES asset



Improve demand compatibility

Improve compatibility with offtaker load profile, **enable higher share of PPA** in procurement mix and unlock achieving PPA ambitions or requirements, thus **increasing overall PPA demand**

De-risk battery revenues

De-risk proportion of battery revenues by locking them in via PPA, improving overall risk profile and financing cost for battery assets

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Key takeaways

1. Due to increasing cannibalization of renewable capture prices, traditional “as-produced” PPAs struggle to achieve capture prices that ensure sufficient revenue.

2. Offtakers can only absorb a limited amount of as-produced PPAs into their portfolio. Alternative shapes such as peak-shaving can cover a higher share of baseload demand and therefore unlock additional PPA demand.

3. The fundamental market value of Hybrid PPA profiles is typically higher compared to the generation profile of standalone RES assets, leading to higher PPA prices.

4. Due to the PPA commitment, the BESS has less room to freely optimise across all available markets. However, securing a part of the BESS revenue stream long term, improves the project bankability and may lead to better financing conditions.

5. The overall benefit of a hybrid PPA depends on the underlying shape and setup – we will analyse different strategies in our upcoming Multi-Client-Study on hybrid PPAs in Europe.

Source: Aurora Energy Research

Join us on our Multi-Client Study focusing on Hybrid PPAs Analysis – registration open until the end of March!

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The study aims to provide in-depth insights into the market dynamics and optimisation of Hybrid PPAs , via a Multi-Client-Study (MCS). This allows us to create a comprehensive analysis at a competitive rate, while simultaneously bringing key players in the PPA market together.

HYBRID PPAs MULTI-CLIENT STUDY – Key topics to be covered

- Market assessment of different PPA shapes to maximise revenue.
- Optimal asset mix (renewables & storage) to minimise costs.
- Evaluation of extra income from secondary markets and GoO revenues.
- Financial and risk analysis to assess profitability and feasibility.
- Evaluation under different market conditions and regulatory frameworks.
- Focus on mature European PPA markets

Integrated deliverables…

Multi Client Study Report and databook
Compiling all work and feedback

3 Workshops
Dicuss in a collaborative format

LUMUS for PPAs

Free trial subscription **to Aurora's Lumus PPA pricing software**

… with additional benefits

1500 hours of resources from Aurora's teams

Priced at a competitive rate

Drawing on Aurora's extensive experience

For more information on the Hybrid PPAs MCS , please contact

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Source: Aurora Energy Research