

EUROPE'S POWER MARKET DISLOCATION PRESENTS OPPORTUNITY FOR VALUE-ADD RENEWABLES INVESTORS

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Executive Summary

The European power market is experiencing a structural dislocation driven by growing renewables penetration. Supply frequently outstrips demand during midday hours in many markets, leading to negative wholesale prices, increased curtailment and falling capture rates. For infrastructure investors, this presents both a risk to the stable cashflows traditionally associated with renewable energy projects but also an opportunity.

The path forward is clear: value creation and downside protection will increasingly depend on hybridization and co-location of renewables with battery energy storage systems ("BESS") to better match generation with demand and allow for higher value offtake structures.

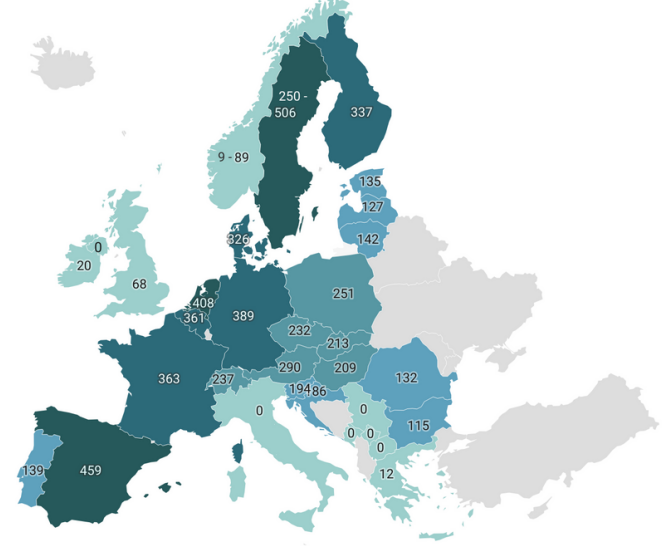
While these strategies require technical, energy market and development expertise, they present an opportunity for investors to generate attractive returns and protect their assets from the risks in a market undergoing transition.

1. Market Dislocation: Supply–Demand Imbalance & Lack of Flexibility

Negative Pricing Episodes

Negative prices are becoming more frequent in markets where renewables capacity growth has outpaced demand-side adaptation especially during peak renewable generation hours (usually at midday)¹. These include countries such as Spain, Germany and the Netherlands where in the first six months of 2025 the number of hours experiencing negative prices have already broken records (see Figure 1)².

Figure 1. Cumulative negative day-ahead prices across Europe for 2025

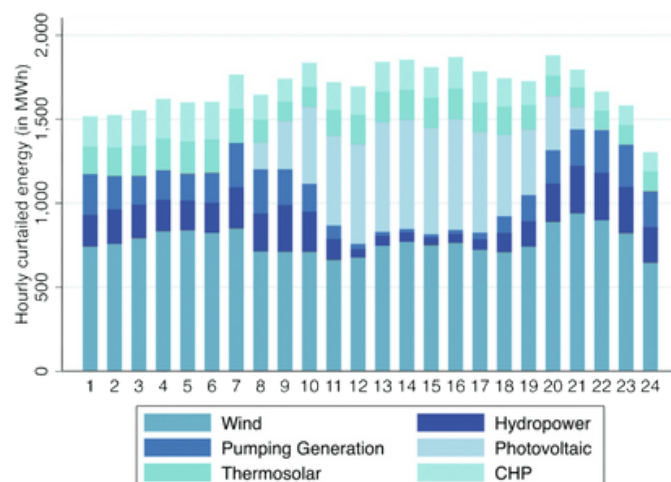


Source: Adapted from Montel Analytics map published by PV Magazine • Created with Datawrapper

Increasing Curtailment

Curtailment of renewables is rising as rapid wind and solar deployment outpaces grid expansion and flexibility. In 2024, Spain curtailed around 5% of scheduled PV output and 10% of wind, while across Europe more than 58 TWh of clean energy were curtailed in 2023—about 1% of total renewable energy generation³. This reflects mounting grid congestion, limited interconnection and inadequate storage capacity, all of which constrain the system's ability to absorb rising volumes of variable renewable power.

Figure 2. Volume of curtailed energy in Spain by technology and hour (horizontal axis) in 2024



Source: elaborated by IAEE Forum 2025, based on REE (2025) data

Lower Capture Rates

Capture rates, or the average electricity price that a project achieves compared to baseload prices, have declined across Europe. PV capture prices in the first half of 2025 fell by 8% across Europe, with significant regional variation (26% Southern Europe, 6% Central Europe, 10% Northern Europe)⁴.

Lagging Flexibility

Flexibility in Europe's power system - the ability of the system to adjust to variable generation and demand in real time - is urgently needed for the region's continued energy transition. While demand for flexibility is set to grow sharply over the coming decades, deployment of solutions (i.e. storage, demand response, increased interconnection between power grids) is still lagging renewables build-out⁵.

2. Implications for Infrastructure Investors

2.1 Increased Risk

Revenue Volatility

Single-technology merchant renewables projects are increasingly risky as they deliver volatile revenues that are exposed to negative pricing and curtailment⁶. Moreover, classic pay-as-produced power purchase agreements ("PPAs") are becoming scarce.

Volatile Revenues



Low PaP Offtake Demand



Tight Financing Conditions



Recalibrated Valuations



Financing Headwinds

Many banks have responded to this volatility by stepping away from financing merchant projects and, for those that still do, the conditions have tightened (higher debt service coverage ratios, etc.) Lenders are also integrating curtailment risk into their underwriting⁷.

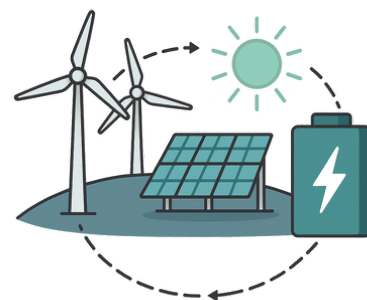
2.2 The Silver Lining

Valuation Reset

In the current environment, sellers have been forced to reduce their price expectations, especially in PV. This has resulted in a return to more rational valuations from the highs of 24 months ago. For example, mature PV assets in Spain are being sold for €30,000-€90,000/MWp in 2025, a considerable drop from the €150,000+/MWp where they were trading two years ago⁸. This recalibration offers investors the ability to acquire mature projects at entry points that are better aligned with long-term risk/return fundamentals.

Energy Transition Remains Intact

Heightened energy security concerns following the conflict in Ukraine combined with the EU's commitment to net zero by 2050 continue to drive ambitious energy transition and electrification policies. Electricity demand is projected to expand as much as 7% annually through 2030, with data centers alone expected to account for around 5% of total consumption⁹. Additionally, energy-intensive industries are increasingly relocating to renewable-rich geographies to secure low-cost clean power.



3. The Solution - Renewables 2.0

3.1 Hybridization & Co-location

Investing in “Renewables 2.0”— integrating multiple generation technologies and/or pairing with storage or flexible demand — is emerging as a critical strategy to enhance capture rates, diversify revenue streams, hedge against price cannibalization and mitigate against curtailment. Successfully executing on this strategy requires accounting for context-specific factors (such as system constraints and market dynamics) and a robust technical and economic feasibility analysis.

Renewables + BESS

Pairing renewables with BESS enhances both returns and resilience. Beyond the more efficient use of grid connections, renewables + BESS hybrids allow operators to shift output from oversupplied midday hours into higher-priced evening peaks, directly improving capture rates¹⁰. In markets with high renewables penetration combined with relatively high cost of electricity from gas turbines (i.e. Germany), large price spreads (especially in summer months) are driving the business case for solar + BESS configurations¹⁰. This also holds true for wind + BESS configurations¹¹.

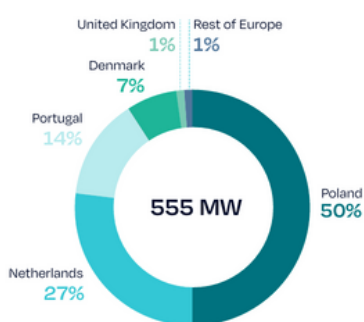
Renewables-BESS hybrids also mitigate curtailment by storing energy during congested periods instead of wasting it, while providing access to ancillary services markets and diversifying revenue streams¹².

Solar + Wind Hybrids

In many European markets, solar output peaks midday and during the summer months, while wind generation is stronger in the evening and during winter months. The uncorrelated generation profile or “complementarity” of combining these two resources has the potential to flatten generation profiles, improve grid matching capability, diversify revenue streams and improve capture rates. By the end of 2024 these hybrids accounted for less than 1% of Europe’s utility-scale solar installed capacity with countries such as Poland, the Netherlands and Portugal leading in its adoption due to their favorable regulatory landscape¹³.

Figure 3. Leading markets for wind + solar hybrids

Geographical breakdown of Hybrid Solar + Wind installations at the end of 2024



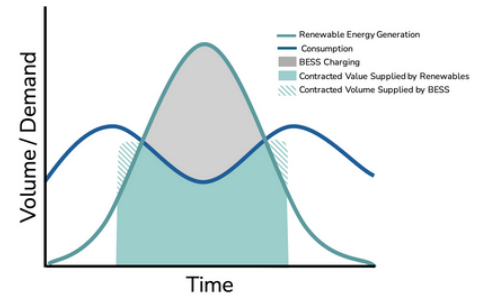
Source: Rystad Energy Powercube
Image Source: Solar Power Europe, 2025

Demand Anchors

Emerging asset strategies are increasingly locating renewable generation near industrial loads—such as data centers and electrified industrial plants. These demand anchors provide compelling alignment between supply and consumption, enabling structured long-term contracts and commanding premium pricing. For example, driven by the favorable conditions in the Nordics (colder climate, cheap renewable energy and investor-friendly regulations), data center electricity use in Sweden is projected to grow to 4.0–4.4 TWh in 2025, up from 2.8–3.2 TWh in 2022¹⁴.

3.2 Smarter PPAs: From Pay-as-Produced to Hybrid

Given these challenging market conditions there has been a shift toward more structured offtake agreements where contracts are no longer just about volume, but about flexibility and firmness of supply. Hybrid PPAs, combining two or more resources (solar/wind + storage, or wind + solar, etc.) to provide a firmer supply profile that more closely matches customer load are gaining popularity. PPA structures can vary greatly depending on counterparty needs, risk-sharing requirements and the local energy market dynamics.



Renewables + BESS (co-located) Hybrid PPA

In this structure, a single contract covers a renewables plant + BESS at the same site. Energy from PV/wind plant can be stored and discharged to meet an agreed delivery profile, often with rules on state-of-charge, cycling and degradation. While the market is nascent, hybrid PPAs are being executed (i.e. Zelestra and EDP signed a hybrid PPA for 170MW PV + 400MWh BESS in 2025 designed to supply firm evening blocks¹⁶).

Multi-technology Hybrid PPA

In a multi-technology hybrid, a single PPA wraps output from wind and solar (co-located or portfolio), using the natural complementarity of profiles to deliver a firmer shape (see figure 4). Having two alternating technologies significantly reduces dependence on changing environmental conditions (i.e. lack of wind or sunshine at any given time), facilitating more stable renewable production, according to Iberdrola, whose hybrid project in Burgos, Spain co-locates 69 MW of wind and 74 MW of PV¹⁷.

Figure 4. Comparing single vs multi-technology generation profiles

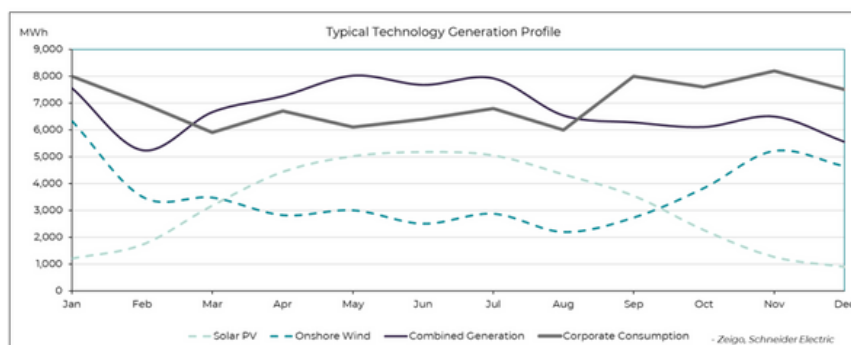


Image Source: Zeigo by Schneider Electric, 2024

Portfolio Hybrid PPA (virtual/financial)

In this structure, a contract referencing a portfolio of assets and storage (not necessarily co-located), designed to deliver a target hourly or block profile. The seller aggregates different sources across geographies to meet a buyer's demand profile virtually. For example, Google and Microsoft procured 24/7 carbon-free PPAs in Europe by sourcing from diverse assets across the region that deliver firm hourly-matched clean supply¹⁸.

Figure 5. Key dimensions of a 24/7 clean PPA

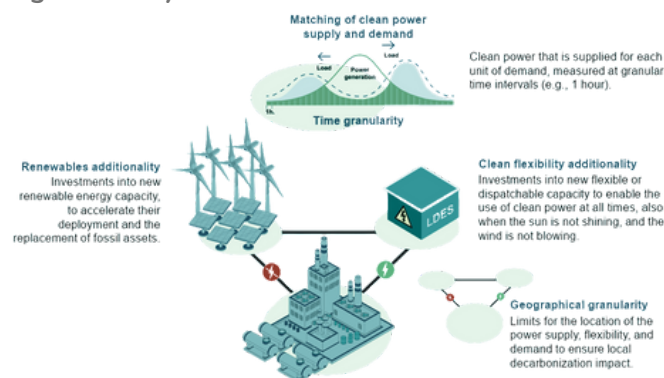


Image Source: McKinsey & Company, LEDS Council 2022 reportⁱⁱⁱ

Figure 6. Tolling agreement example

A tolling agreement **guarantees revenues** to the asset owner, with the **optimizer taking on all trading risk**

Revenue split (£k/MW/year)

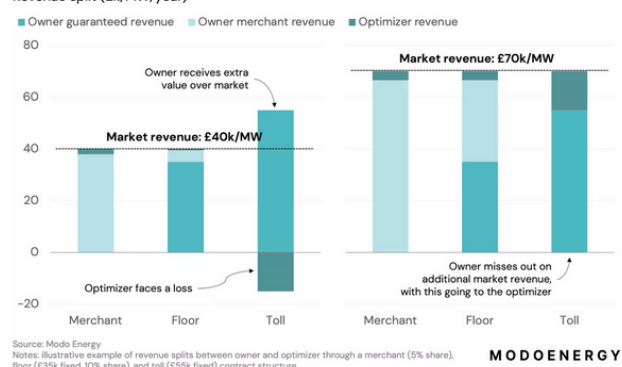


Image Source: Modo Energy, 2024

Hybrid PPA with BESS “tolling” / optimizer component

The PPA covers renewable energy while a companion storage tolling/optimizer agreement governs how the BESS is dispatched and how revenues are shared. The optimizer manages market bidding, ancillary services, and arbitrage while the asset owner receives a fixed fee, floor structure or revenue share¹⁹.

3.3 Selective Investments - Technical Expertise Matters

It is important to note that not all renewable energy projects are created equally – differences in underlying project quality, resource availability, local grid constraints and the dynamics of regional electricity markets can have a major impact on returns. Investors will need the technical and industry expertise to select the right projects.

4. Spain: A Case Study on Dislocation and the Renewables 2.0 Opportunity

Spain today embodies both the challenges and opportunities of Europe's accelerated energy transition. In just a few years, the country has added record levels of renewable capacity—particularly solar PV—at a pace that has outstripped electricity demand growth, transmission upgrades and storage deployment. The result is an oversupplied midday market, insufficient system flexibility and rising exposure to cannibalization risk.

Earnings Impact: Capture Price Compression

The financial consequences are clearly visible with Spain's volume-weighted average PV capture price falling by ~40% year-on-year to €45.56/MWh in 2024, one of the sharpest declines across Europe²⁰. This erosion highlights the difficulty of maintaining predictable revenues when merchant risk dominates.

Volatility and Spread Opportunities

Yet, volatility is also creating new value pools. Daily spreads reached a record €94/MWh in 2025, reflecting widening differentials between midday hours and premium evening peaks²¹. Modeling across European markets shows that even a modest 2-hour BESS addition can unlock double-digit capture price uplift, while simultaneously reducing curtailment²².

Policy Tailwinds and Regulatory Support

Spain's policy landscape is also shifting decisively. The country's ambitious National Energy and Climate Plan "NECP" targets 22.5 GW of storage by 2030²³, and regulators are taking measures such as declaring BESS a public utility and relaxing certain permitting burdens - structural reforms designed to encourage faster build-out of BESS (both stand alone and co-located) to strengthen the Spanish electric system.

Demand Anchors and Industrial Pull

Spain is emerging as one of Europe's demand anchor hubs. Investments from AWS (€15.7bn)²⁴ and Microsoft (€6.7bn)²⁵ into Spanish data centers are creating stable, long-term electricity demand that can be co-located with renewable generation. These corporates increasingly prefer structured PPAs that deliver reliability and 24/7 carbon-free supply, supporting premium pricing for well-designed hybrid assets.

Investor Takeaway

Spain remains one of Europe's most dynamic PPA markets, with contracting steadily evolving beyond pay-as-produced into shaped and firm block structures that price in flexibility and downside protection. For disciplined investors, the dislocation is not a deterrent but an entry point into Renewables 2.0

5. Conclusion

Europe's electricity market dislocation driven by high renewables penetration undermines the traditional renewables investment case of single technology merchant and pay-as-produced offtake structures. Infrastructure investors seeking stable returns must evolve. By embracing Renewables 2.0 strategies (hybridizing multiple technologies, co-locating BESS etc.) and structuring more sophisticated offtakes, investors can not only protect their assets against the downside but also improve capture rates and lock in higher value PPAs — turning market volatility into long-term value.

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Fiona is a member of the investment team at Frontier Renewables, a specialist investment manager focused on Renewables 2.0, targeting mid-market projects in Europe via dedicated fund vehicles. The firm has a successful 17-year track record, with deep technical and development experience.



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Figures

Figure 1: Jul 2025, PV Magazine, *Record solar output in Europe drives rise in negative price hours*

Figure 2: Mar 2025, Davi-arderius et al, IAAE Energy Forum, *Technology Determinants of Renewables Curtailment: The case of Spain*

Figure 3: Mar 2025, Solar Power Europe, *Embracing the benefits of hybrid PV systems*

Figure 4: Apr 2024, Zeigo by Schnieder Electric, *Multi-Technology and "Portfolio" PPAs - An Emerging Trend*

Figure 5: May 2022, McKinsey & Company, LDES Council, *A path towards full grid decarbonization with 24/7 clean Power Purchase Agreements*

Figure 6: Jun 2024, Modo Energy, *Battery tolling agreements: How do they work?*