# Understanding ultra-low and negative power prices: causes, impacts and improvements

Eurelectric position paper

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Eurelectric represents the interests of the electricity industry in Europe. Our work covers all major issues affecting our sector. Our members represent the electricity industry in over 30 European countries.

We cover the entire industry from electricity generation and markets to distribution networks and customer issues. We also have affiliates active on several other continents and business associates from a wide variety of sectors with a direct interest in the electricity industry.

## We stand for

The vision of the European power sector is to enable and sustain:
- A vibrant competitive European economy, reliably powered by clean, carbon-neutral energy
- A smart, energy efficient and truly sustainable society for all citizens of Europe

We are committed to lead a cost-effective energy transition by:

**investing** in clean power generation and transition-enabling solutions, to reduce emissions and actively pursue efforts to become carbon-neutral well before mid-century, taking into account different starting points and commercial availability of key transition technologies;

**transforming** the energy system to make it more responsive, resilient and efficient. This includes increased use of renewable energy, digitalisation, demand side response and reinforcement of grids so they can function as platforms and enablers for customers, cities and communities;

**accelerating** the energy transition in other economic sectors by offering competitive electricity as a transformation tool for transport, heating and industry;

**embedding** sustainability in all parts of our value chain and take measures to support the transformation of existing assets towards a zero carbon society;

**innovating** to discover the cutting-edge business models and develop the breakthrough technologies that are indispensable to allow our industry to lead this transition.

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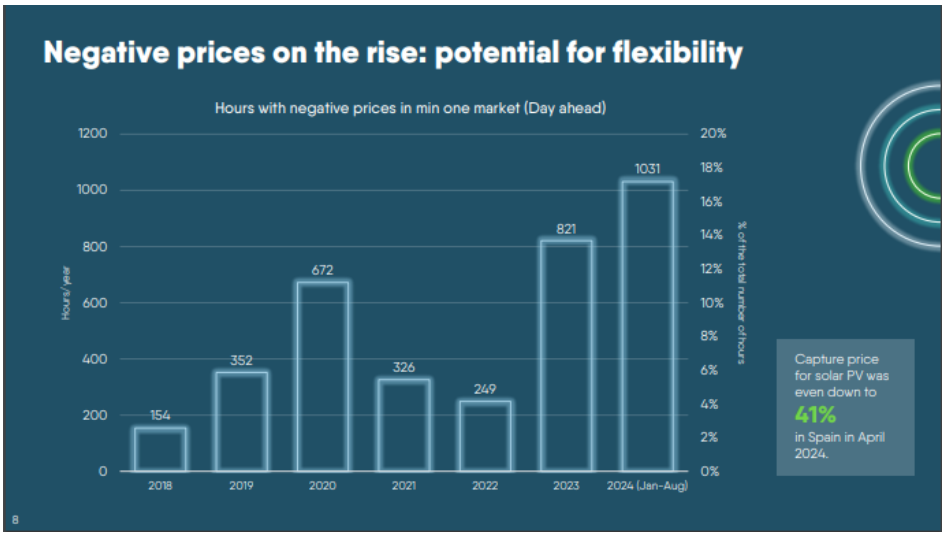
# Understanding ultra-low and negative power prices

## Introduction

Europe has successfully delivered on the first stage of the energy transition, achieving the decarbonisation of 74% of its electricity mix[1]. Moving forward, the second stage of the transition will require not only the continued expansion of clean and renewable capacity, but also significant investments in flexibility solutions, storage assets and to further boost electrification. Against this backdrop, the recent rise of negative power prices highlights the challenge posed by a stagnating rate of electrification (stuck at around 23% for the past decade [2]), decreasing electricity demand (down by 7.5% in 2023 compared to 2021 [3]) and limited flexibility resources within the power system. However, what the data alone does not capture is the multifaceted drivers behind ultra-low and negative prices across Member States. Recognising that there is no one-size-fits-all solution, Eurelectric has conducted a comprehensive analysis to outline the impacts, drivers, and potential solutions across the Union.

## The numbers - negative price hours have surged in 2024

The 2024 edition of the Power Barometer reveals a significant uptick in the incidence of negative prices across Europe. In 2023, the number of hours with negative prices quadrupled in at least one price zone in day-ahead, reaching 821 hours, and by September 2024, this total had already surpassed the previous year, climbing to 1031 hours[4].

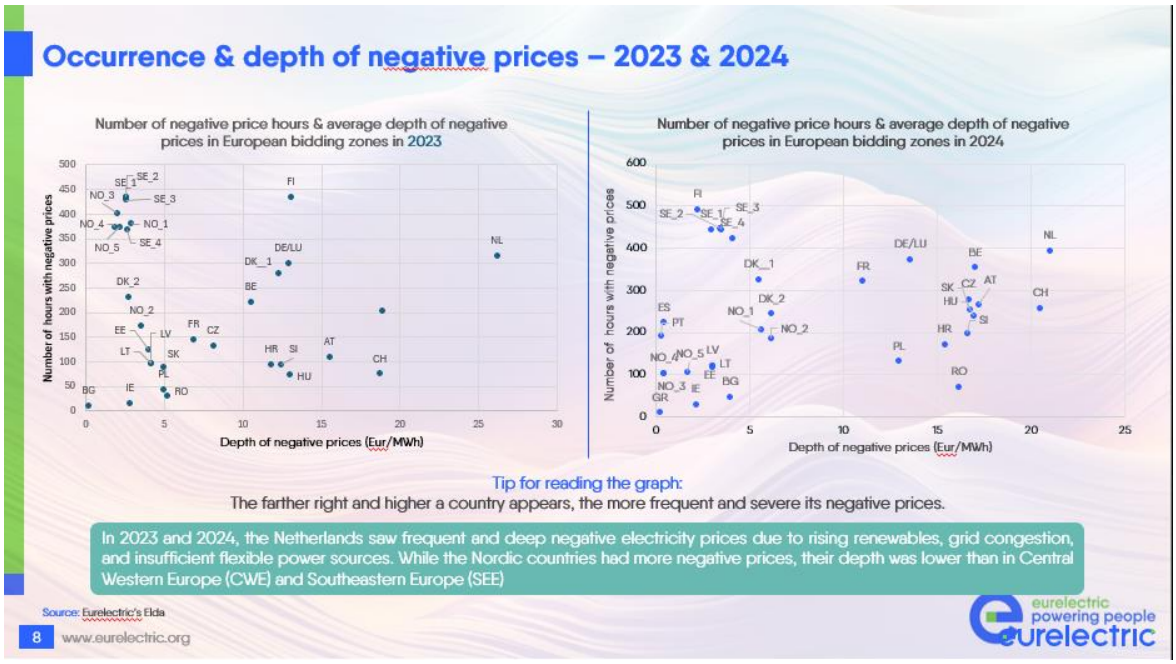



Historically, negative prices were primarily observed in the intraday market. However, 2024 marked the first appearance of negative prices in the Day-Ahead-Market (DAM) across several

1 Eurelectric (2024) - Power Barometer 2024 (slide 3)
2 Eurelectric (2024) - Power Barometer 2024 (slide 5)
3 Eurelectric (2024) - Power Barometer 2024 (slide 6)
4 Eurelectric (2024) - Power Barometer 2024 (slide 8)

European countries, including Greece, Spain, Portugal, and Poland. In addition, markets like Romania and Switzerland experienced more pronounced negative prices, while other markets like Italy experienced rising instances of ultra-low prices but have not yet faced negative prices in the DAM during this period.

Meanwhile, in the Nordics, an increased frequency of negative prices is observed, though to a lesser extent than mainland Europe, due to the presence of more diverse clean power generation portfolios and higher levels of flexibility.




Following this trend, it is expected that negative prices will become more common in the short term, particularly during periods of low demand and favourable renewable energy generation conditions.

## The causes - why do negative and ultra-low power prices occur?

Since electricity is difficult to store at scale, the power system must constantly balance supply and demand in real time, thus, during times of low demand and high supply ultra-low[5] and even negative power prices may occur. This means that generators are faced with a situation where they must pay to feed their electricity into the system.

Ultra-low and negative prices typically occur in the middle of the day during the spring and summer months, when solar generation is at its peak, and occasionally at night during winter due to high wind output. They also tend to be more frequent on weekends and holidays, when overall demand is lower. In recent years, the occurrences of ultra-low and negative prices have increased, with these periods becoming more prolonged.

[5] 'Ultra-low' power prices can be defined as price levels below the LCOE of a technology for a sustained period, even if above zero. While LCOE reflects the full cost of generation, market prices are inherently driven by system marginal prices, which are based on variable production or opportunity costs. Additionally, the definition is dependent on different factors, including generation costs, CAPEX, and national specificities. For the purpose of this paper, special attention is given to levels between €10 and €30/MWh, recognising that this threshold provides a more concrete benchmark.

Multiple factors are driving downward price pressure in European electricity markets. Importantly, ultra-low power prices occur when multiple conditions converge: high-RES (renewable energy source) generation combined with low and inflexible electricity demand. These situations are often exacerbated by regulatory challenges and limitations in grid infrastructure, including cross-border congestion.

*Conditions leading to downward price pressure in European electricity markets*

| | High RES generation during favourable weather conditions | Low electricity demand, even after making use of flexibility | Regulatory issues | Grid congestions at the border | Other |
|---|---|---|---|---|---|
| Austria | x | x | x | x | |
| Belgium | x | x | x | x | x |
| Bulgaria | x | x | x | x | |
| Denmark | x | x | | | |
| Estonia | x | x | | | |
| Finland | x | x | | | |
| France | X | x | x | x | |
| Greece | x | x | x | x | |
| Germany | x | x | x | x | |
| Ireland | x | x | x | x | |
| Italy | x | x | x | | |
| Netherlands | x | x | x | x | x |
| Romania | x | x | | | x |
| Slovakia | x | x | x | | |
| Spain | x | x | | | |
| Poland | x | x | x | x | |
| Portugal | x | x | | | |
| Switzerland | x | x | x | x | x |

*Source: Eurelectric*

1. **High RES generation during favourable weather conditions**: regions with a high share of weather-dependent renewables, in particular solar power generation, are more likely to experience ultra-low and negative prices.

2. **Low electricity demand even after accounting for flexibility**: limited or inflexible demand during certain hours or seasons (e.g., weekends, holidays) contributes to the occurrence of negative prices. While flexibility could increase demand during periods of high supply, current market and regulatory frameworks often fail to provide the necessary incentives. Factors such as electricity contract structures, lack of dynamic network tariffs, and insufficient mechanisms to encourage demand-side responsiveness may hinder the effective utilisation of flexibility.

    - **Impact of certain RES support schemes:** Certain support schemes can incentivise RES generators to produce even when prices are negative. For instance: Feed-in tariffs (FiT) decouple generation from market prices and provide the producer with a fixed payment for every kWh produced, regardless of market price. For example, in France, around 24 GW of the total 44 GW of installed RES capacity operates under such support schemes, insulated from market fluctuations until 2030.

- Green certificates (or equivalent mechanisms as GdOs) provide a fixed payment in addition to the market price, encouraging generators to produce until the price falls below the combined value of the premium and the market price. For instance, in Bulgaria, certain RES producers are motivated to sell electricity even at negative prices to ensure they retain their green certificates and avoid disconnection.
- Some contracts for differences (CfDs) were designed to provide financial support irrespective of the market price to ensure that generators and consumers maintain a level of economic viability despite market fluctuations

It is important to note that while some of these conditions are still taking place, these legacy support schemes that incentivise production irrespective of the market price are being phased out for large generation facilities due to revised European legislation. For instance, in both the EU Climate, Energy and Environmental Aid Guidelines (CEEAG) State Aid rules, as well as the more recent revision of the Electricity Market Design.

The Electricity Regulation establishes that two-way CfDs or equivalent schemes are the only type of public support scheme eligible for new low-carbon and renewable capacity but only when electricity prices are positive; the latter condition is due to the CEEAG. Thus, ensuring that renewable generators curtail their output when market conditions indicate oversupply, helping to prevent exacerbation of negative prices and promoting better market integration and reducing the amount of additional subsidy. At the same time, we must note that small plants (under 400 kW for generators commissioned before 1 January 2026, 200 kW for those commissioned after) are generally exempt from this requirement, as the CEEAG does not impose the same requirements on them to shield smaller renewable producers from market volatility and reduce administrative burdens; this may maintain a significant market distortion in the long run, since the exempted small plants can represent an important aggregated volume.

Additionally, at Member State level, there are several examples illustrating willingness to correct such distortions. For instance:

- Greece has strict rules that cut support for RES under Feed-in Premium (FiP) if prices are zero or negative for two consecutive hours.
- Italy cuts support for CfDs following six consecutive hours of negative prices.
- Estonia is phasing out older support schemes that provide lump-sum payments regardless of price.
- In Denmark, both premiums and CfDs are designed to eliminate economic support during negative price periods (although some older wind projects still benefit from support at all times, regardless of market signals; however, this is decreasing as their support periods are coming to an end).
- Ireland has reformed its REFIT wind scheme, which previously allowed negative bidding, and now mandates new capacity to be contracted under a two-way CfD with a zero-price cap, thus, ensuring that generators are not eligible to receive support payments for electricity sold at negative prices.
- Germany plans to phase out its support for new assets during times of negative prices by 2027.

3. **Conventional inflexible assets - with technical or financial limitations**: Regarding technical limitations, some market actors cannot adjust output because they are not designed or equipped to halt production (‘must-run’). Also, some plants are required to run to maintain grid stability, or their output cannot be modulated because of environmental regulations. For other generation units dispatch decisions may be triggered by other demand like heat (and linked support schemes) instead of electricity prices. For example:

- In Bulgaria, around 500 MW of must-run district heating and industrial co-generation power plants contribute to negative prices in the bidding-zone.
- In Greece, lignite-fired plants, which operate between October and April for district heating, can trigger low or negative prices in the DAM during periods of low demand or high-RES output.
- In Austria, district heating needs, particularly during cold winters with strong wind generation, increase the chances of negative prices. Furthermore, restrictions under the Water Framework Directive affect run-of-river plants.
- In Denmark, district heating has a must-run commitment to produce regardless of the electricity prices.

As per the financial and technical constraints, plants with high start-up costs or low ramp-up rates, such as nuclear or lignite-fired power plants, it is more economically rational to offer electricity at negative prices to avoid the costs linked with shutting down and/or the potential loss of profits from higher future prices.

4. **High penetration of non-market-reactive prosumers**: Households with PV may inject energy into the grid regardless of market prices due to net metering, the absence of wholesale price pass-through or control by the system operator, or lack of price awareness. When a significant share of generation assets fails to respond to market price signals, this may lead to significant negative prices.

   For instance, this issue is particularly prevalent in Romania, and in Germany, where approximately two-thirds of new solar capacity installed in 2024 consists of systems up to 100 kW with a guaranteed a fixed FiT for 20 years. Without adequate incentives to curtail energy injection or to increase local consumption, excess generation can exacerbate local surpluses, leading to negative prices. This situation is compounded by the fact that prosumers are often not charged for the grid issues their surplus energy creates, which reduces their motivation to adjust their output or demand in response to market conditions.

5. **Merchant bidders and power purchase agreements (PPAs):** Contracts like PPAs may mandate a minimum level of production, prompting bidders to submit slightly negative bids to guarantee their generation is accepted, as seen in the Danish market. Additionally, merchant bidders or RES plants operating under PPAs might bid slightly below zero to ensure they qualify for the issuance of Guarantees of Origin. More broadly, when a PPA is structured on an 'pay-as-produced' basis, it can create distortive effects similar to those of a FiT.

6. **Cross-border effects**: countries connected to bidding zones with low or negative prices can be affected by cross-border electricity flows. For instance, Denmark's connection with the Netherlands can lead to full imports at negative prices. However, it is important to note that market integration, including mechanisms like market coupling, has been overall beneficial for welfare by enabling consumers to access cheaper electricity. In most cases, low or negative prices occur simultaneously, primarily during periods of high renewable output and low demand coupled by a lack of flexibility across the system, rather than being exacerbated by interconnectors.

As outlined in this section, negative prices arise primarily from external factors to the electricity market design. Therefore, claims suggesting that the existing market design structure disincentivises the deployment of renewable and low-carbon capacity are not only unfounded but fundamentally misleading.

The market design is inherently structured to facilitate the integration of RES, promoting competition and encouraging investment in low-carbon technologies. However, to effectively address the challenges associated with negative prices, it is crucial to further enable different flexibility solutions by implementing the existing regulatory framework adequately. This may also necessitate additional supportive guidance and policies in certain contexts to better align market mechanisms with the objectives of increasing renewable and low-carbon capacity.

## The impacts - do ultra-low and negative power prices disincentivise the decarbonisation of the power sector?

First, it is important to note that negative prices in themselves are not inherently problematic; they are simply a reflection of a lack of flexibility in the system. However, the increased occurrence of ultra-low and negative prices poses a significant challenge to the decarbonisation of the power sector, disincentivising investment in new renewable and low-carbon assets needed for a net-zero future. Negative prices often occur in the middle of the day during spring and summer or at night in winter, correlating strongly with low flexible demand and high renewable generation. However, in recent years, their occurrence has become more frequent, with deeper price declines and longer durations, highlighting a widening gap between renewable generation and insufficient demand and flexibility resources (such as storage and demand-response solutions) in European markets.

Fortunately, price signals in a specific market offer only a partial view of the overall economic viability of a specific asset. Generation assets benefit from multiple revenue streams beyond wholesale markets, including ancillary services, capacity remuneration mechanisms (where they exist) and certain assets may benefit from support mechanism (e.g. in the form of FiTs, or CfDs partially /totally shielding from price and volume risks). In addition, effective hedging strategies can reduce price risks provided forward markets with longer maturities are sufficiently liquid, helping protect assets even when spot market prices are low or negative.

However, despite these diverse revenue stream possibilities, the business case for renewable and low-carbon generation assets becomes a lot more unpredictable. Recovering CapEx and securing PPA offtakers becomes more challenging due to lower average annual prices and heightened risk on generated volume, thus leading to potential revenue losses.

## Improvements - building a business case for further electrification and flexibility

Europe has entered the first stage of the energy transition with substantial success in deploying renewable and low-carbon capacity. However, limited storage, flexible generation and demand response restrict the system's ability to absorb or shift excess electricity. To ensure balanced growth in renewable and low-carbon capacity, the second stage of the transition requires, next to the necessary grid investments, scaling up investments in electrification, storage and flexible resources while designing support schemes aligned with market dynamics and the regulatory framework:

### Foster electrification and promote electricity demand

To address stagnating electrification rates within the EU, increasing the current rate from 23% to 35% by 2030 is critical. Achieving this ambitious target requires a coordinated approach to foster flexible electrification across multiple end-use sectors. Key initiatives include:

1. **Developing a comprehensive Electrification Action Plan and a European Electrification Bank.** An ambitious investment plan is essential to achieve Europe's decarbonisation and strategic autonomy goals. The forthcoming Electrification Action Plan by the European Commission will provide a roadmap for all market participants and investors, and should include a European Electrification Bank inspired by the concept of the Hydrogen Bank to enhance industry competitiveness and streamline investments.

2. **Reforming the Energy Taxation Directive.** Revising tax structures to support electrification of end uses, renewable and low-carbon solutions while penalising carbon-intensive options can encourage both businesses and households to switch to electric solutions. As outlined in our *Decarbonisation Speedways*, an electrification rate between 50% and 70% is essential to reach climate neutrality.

3. **Modernising the distribution grid**: investments in grid infrastructure must focus on enhancing resilience, reliability, and capacity to accommodate the growing share of renewable and low-carbon energy sources as well as electricity storage solutions, while also ensuring efficient electricity distribution. For this purpose, our recent study *Grids for Speed* identifies an annual investment need of €67 billion which can be reduced to €55 billion if we enable anticipatory investments, asset performance excellence and grid-friendly flexibility solutions.

### Further develop flexibility resources at scale and across timeframes

As variable renewable energy sources like wind and solar gain dominance in the energy mix, the need for a new investment architecture within the market design framework becomes increasingly pressing. This architecture should aim to enhance the flexibility of existing firm assets while facilitating the integration of new flexible resources. Key considerations include:

1. **Implementing an adequate investment framework**: the swift implementation of the recent Electricity Market Design reform is critical, particularly its focus on the pivotal role of long-term contracting and de-risking tools (such as PPAs and two-way CfDs). By ensuring these mechanisms remain system-friendly and adaptable to evolving market conditions—as envisaged by the recent reform—they can drive the deployment of flexible and dispatchable assets, which are essential for managing price volatility. Eurelectric's studies, *A Market Design Fit for Net Zero* and *Unlocking the Power of CfDs to Accelerate the Energy Transition*, offer key recommendations to align these mechanisms with market needs. Moreover, the forthcoming 2025 Eurelectric study on Security of Supply will outline the necessary investment and regulatory frameworks to enhance system flexibility while ensuring adequacy.

2. , in which market-based long-term contracts (including PPAs and two-way CfDs) will play a growing role. It will also ensure coordinated investments across various industry segments and sectors, including demand-side management, as they evolve.

3. **Scaling up energy storage solutions**: these will be essential for smoothing out fluctuations in renewable generation and demand while ensuring grid reliability. Establishing an enabling regulatory and investment framework is essential to scaling up storage capacity across various timeframes—from short-term battery storage to long-duration solutions like pumped hydro or decarbonised thermal assets. These storage systems will play a pivotal role in balancing supply and demand. A well-designed framework will incentivise investment, streamline permitting processes and ensure

storage technologies are fully integrated into market structures to support system flexibility and resilience.

4. **Enabling prosumers through smart infrastructure and tariffs**: the further deployment of advanced metering infrastructure is crucial for providing real-time data, enabling consumers to make informed decisions about their usage and production.

5. **Further integrating demand response at wholesale level**: It is essential to ensure that European wholesale and balancing markets facilitate downward bids (increased demand) from Demand Response mechanisms, including aggregation. This integration must align with existing market structures, such as balancing responsible parties (BRPs) and necessary supplier adjustments, as outlined in the draft Network Code on Demand Response.

### Ensure support schemes are system friendly and market-based

To effectively tackle the challenges posed by variable renewable generation and negative pricing, it is crucial to implement the recent review of the Electricity Market Design swiftly. This includes provisions ensuring that support schemes, such as FiTs and two-way CfDs, are designed to reflect market realities and incentivise responsive pricing signals, while still providing a favorable investment climate for investors and ensuring manageable risks. Key steps to achieve this include:

1. **Designing adaptive support mechanisms**: in accordance with the current provisions of the CEEAG and the recent revision of the Electricity Market Design, support schemes and de-risking mechanisms, such as PPAs and CfDs, must be sufficiently flexible to respond to market signals. Member States should implement these mechanisms effectively, ensuring that the scope for exemptions is minimised to avoid undermining the integrity and effectiveness of support schemes.

2. **Phase-out legacy support schemes**: as these can be misaligned with current market dynamics and distort pricing signals. Transitioning to market-based mechanisms like two-way CfDs and PPAs will better align incentives with market conditions.

3. **Promote system flexibility**: support schemes must incentivise not only renewable generation but also flexible resources like demand-side response and storage. A market framework that encourages investment in flexibility is crucial for balancing supply and demand, particularly in the face of increasing renewable penetration and cross-border congestion.

Eurelectric pursues in all its activities the application of the following sustainable development values:

Economic Development

- Growth, added-value, efficiency

Environmental Leadership

- Commitment, innovation, pro-activeness

Social Responsibility

- Transparency, ethics, accountability

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