Balancing the Dutch electricity grid

Analysing the opportunities and challenges of (battery) energy storage

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Introduction

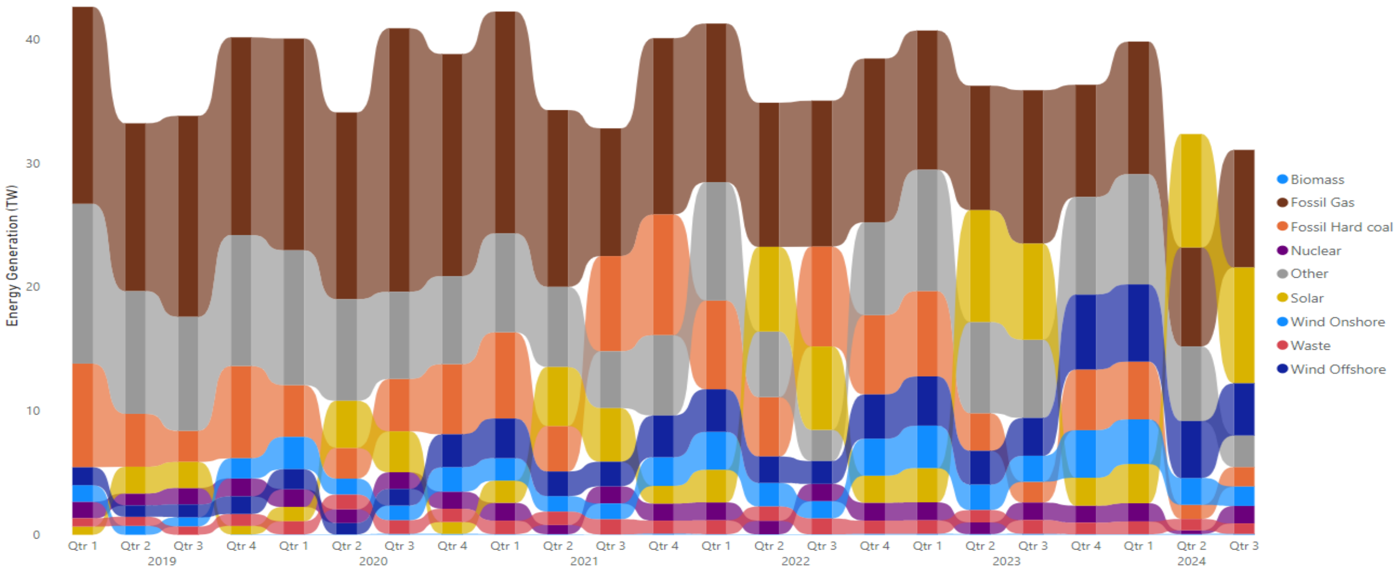
The Dutch electricity market is undergoing a profound transformation, driven by a national push towards sustainability and renewable energy integration. As the Netherlands sets ambitious climate goals, the share of solar and wind power in the energy mix is rapidly increasing, surpassing traditional fossil fuel sources. This shift brings both opportunities and challenges, especially with the expected rise of negative day-ahead prices and increased volatility in the imbalance market. Battery Energy Storage Systems (BESS) are emerging as pivotal tools for capitalizing on these fluctuations, offering potentially lucrative arbitrage prospects while maintaining grid stability. However, navigating this dynamic landscape demands sophisticated strategies, regulatory support, and significant infrastructure investments, which we elaborate on this article.

The changing energy generation profile of the Netherlands

The energy generation landscape in the Netherlands has undergone significant changes in recent years, driven by the nation's commitment to reducing carbon emissions and increasing the share of renewable energy sources. The Netherlands has set ambitious climate goals: by 2030, the country aims to generate 70% of all electricity sustainably, and by 2050, almost all energy supplies must be sustainable and CO2 neutral. This transition is supported by significant policy and investment efforts.

Historically, fossil gas dominated electricity generation in the Netherlands. However, in the second quarter of 2024, solar energy surpassed gas, marking a milestone as the largest energy source. The renewable energy share increased from 19% in 2019 to 47% in 2023[1]. This shift highlights the impact of renewable sources, particularly solar and wind, becoming integral to the Dutch energy system despite their seasonality—solar energy peaks in summer, while wind energy peaks in winter.

Figure 1. Energy Generation in the Netherlands—2019-2024-Q3



Source: ENTSO-e, Nationale Energie Dashboard, Deloitte analysis

Source: 1) Centraal Bureau voor de Statistiek

The Dutch electricity market

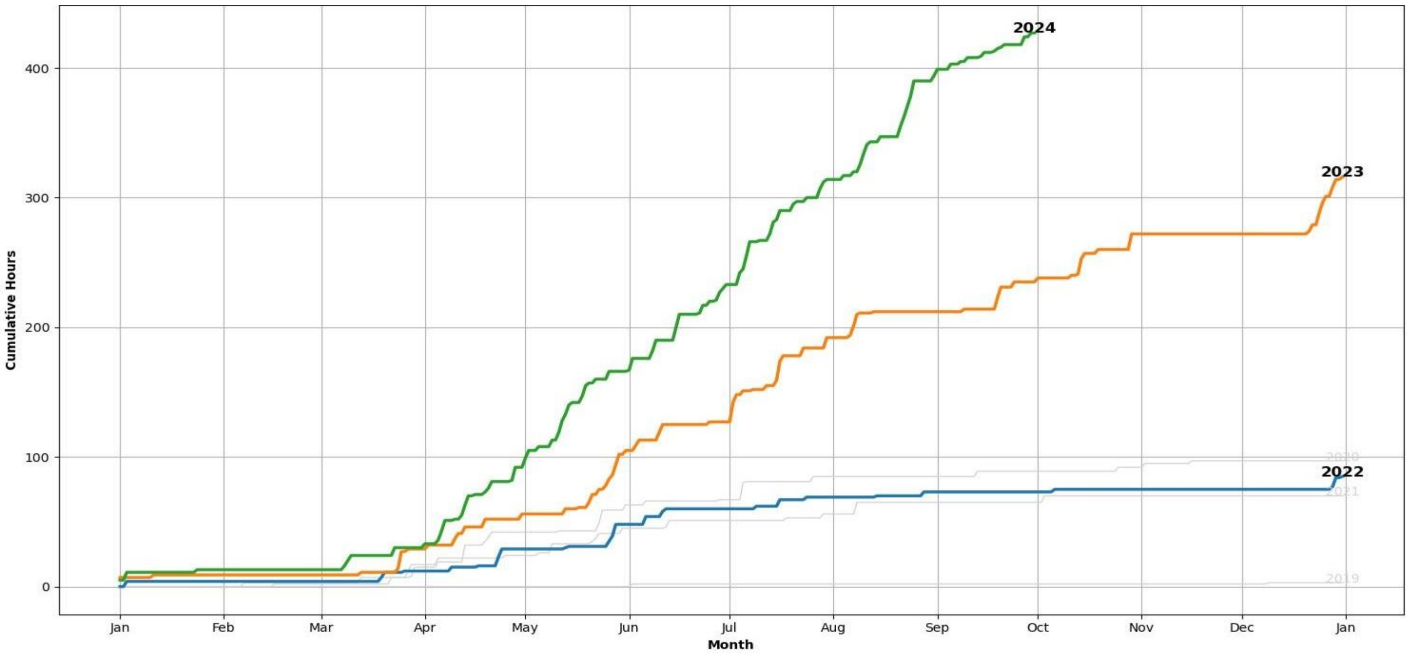
The energy market in the Netherlands has seen significant changes driven by the ongoing energy transition, new policy and technological advancements. Our previous articles have thoroughly explored various aspects of the energy storage market in the Netherlands, including an overview, market development, economics, and the total supply chain. In this article, we will discuss the Dutch electricity market, which can be divided into three main categories.

The ***Imbalance Market*** addresses discrepancies between the expected and actual electricity consumption and generation and is growing in importance with the rise of more volatile renewable energy production. The imbalance price is usually determined by the highest activated bid for upward capacity and the lowest activated bid for downward capacity on the aFRR market.

Electricity market categories

- **Wholesale markets:** Includes the forward and futures market, the day-ahead market, and the intraday market, allowing participants to trade electricity for various future periods and adjust their portfolios based on updated forecasts.
- **Balancing markets:** Ensures grid stability by compensating for real-time deviations between electricity production and consumption, utilizing mechanisms such as:
  - Frequency Containment Reserve (FCR),
  - Automatic Frequency Restoration Reserve (aFRR); and
  - Manual Frequency Restoration Reserve (mFRR).
- **Congestion markets:** Addresses local transmission capacity issues to prevent grid overload by using capacity limiting contracts (CBC) and redispatch mechanisms.

Figure 2. Cumulative number of hours with negative day-ahead prices in the Netherlands



Source: ENTSO-e, Deloitte analysis

Negative day-ahead prices

In October 2024, there has been a record high cumulative number of hours with negative day-ahead prices in the Netherlands. The day-ahead market best reflects the value of electricity during different hours, making the day-ahead price a critical indicator for the overall electricity market. Figure 2 shows that the cumulative number of hours with negative day-ahead prices is increasing year by year. In the first six months of 2024, the cumulative number of hours with negative day-ahead prices already reached 424 hours, thereby surpassing the total number for all of 2023.

The increasing number of negative day-ahead prices in the Netherlands can be explained by several factors:

1. **Increased solar and wind power supply:** It is more difficult to reduce generation or switch off renewable sources such as rooftop solar systems and offshore wind farms.
2. **Revenues from subsidies and support schemes:** Mechanisms like the SDE++ scheme provide financial incentives to continue generating power even at negative prices, as the subsidy is still paid out during periods of less than six consecutive hours of negative prices.
3. **Contracts with fixed remuneration:** Some generation sources operate under contracts that guarantee fixed payments regardless of market prices.
4. **Expensive to switch off:** For some power plants (e.g., gas-fired plants), it is costly to shut down and restart, making it more economical to continue operating even at negative prices.

The negative day-ahead prices, because of the increasing share of renewable energy production, underscore the critical need for energy storage solutions to manage supply and demand effectively. Effective energy storage can help balance the grid, store excess energy produced during peak renewable generation periods, and release it during times of high demand or low renewable output.

In 2023, the energy storage capacity in the Netherlands was 0.3 GW, compared to 36 GW[2] of renewable capacity, resulting in a storage-to-renewable capacity ratio of 1:100. By 2030, the renewable capacity of solar and wind is expected to increase to 77 GW, while storage capacity is projected to grow to 7.9 GW[3], improving the storage-to-renewable capacity ratio to 1:10. Despite this improvement, the storage capacity remains limited relative to the rapid expansion of renewable energy sources.

Possibilities for energy storage

Hydrogen Storage	Battery Storage	Thermal Energy Storage
Excess electricity can be used to produce hydrogen through electrolysis, which can then be stored and reconverted to electricity or used as a fuel in various applications.	Batteries can store excess electricity and provide rapid response power during peak demand periods, helping to stabilize the grid and integrate more renewables.	Excess electricity can be used to heat sand or stone, which can later be converted back to electricity or used directly for heating

Arbitrage opportunities for Battery Energy Storage System (BESS) on the Dutch imbalance market

The imbalance market is crucial for maintaining the balance between electricity supply and demand in real-time. It ensures that any discrepancies between forecasted and actual electricity consumption/production are corrected promptly. Imbalance prices are highly dynamic, reflecting real-time market conditions and can fluctuate significantly.

Balance Responsible Parties (BRPs) can access these imbalance prices through platforms like TenneT, which provides real-time pricing data and market information. While it is commonly referred to as the imbalance market, it is not a traditional market but rather a settlement mechanism for differences in electricity supply and demand, mainly acting upon the automatic Frequency Restoration Reserve (aFRR) market where TenneT sends activation signals every four seconds.

TenneT determines the imbalance price mainly on the highest activated aFRR bid from a merit order list of all aFRR energy bids. This price is what Balancing Service Providers (BSPs) receive, and BRPs must pay this price for any imbalances they cause. Conversely, if BRPs help resolve system imbalances, they receive the imbalance price from TenneT. This incentivizes BRPs to adjust their portfolios to reduce overall system imbalances.

If no balancing energy is activated during an Imbalance Settlement Period (ISP), the imbalance price is set using the neutral price, which is the average of the first upward and downward bids. This approach ensures the imbalance market maintains real-time grid stability and can provide financial incentives for market participants to contribute to system balance.

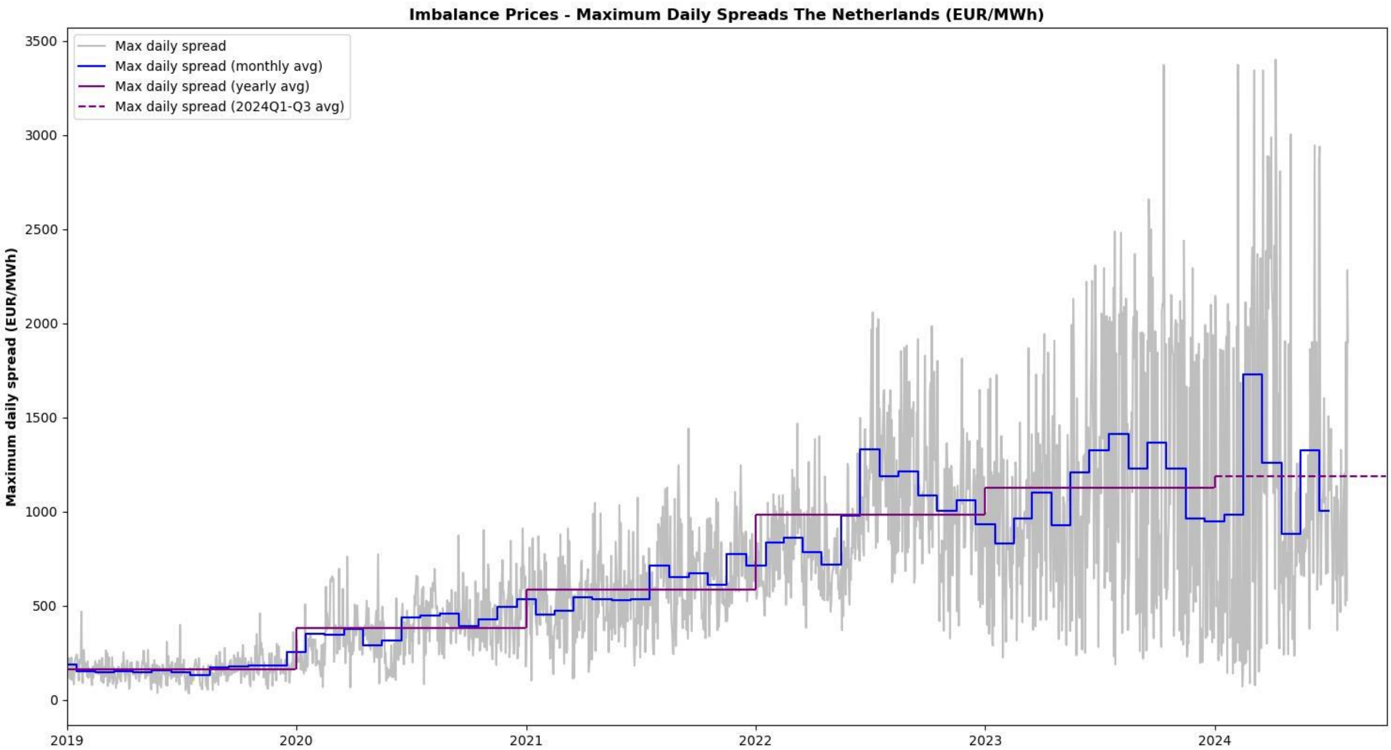
Source: 2) Rijksoverheid, DNE research; 3) Energy Storage NL

Note: It must be noted that the arbitrage opportunities may be impacted by changes in the market, such as the recent entrance to PICASSO or the delay in balance delta communication by TenneT

Increasing volatility on the imbalance market creates arbitrage opportunities for BESS operators, whilst contributing to grid stability

In this article, we will focus on the increasing volatility in the Dutch imbalance market. BRPs can participate in the imbalance market without offering a specific balancing product. This practice is referred to as passive imbalancing whereby BRPs deviate from their E-program (forecast of supply and demand of the BRPs portfolio) to support with balancing the grid. To understand the trends and volatility in the Dutch imbalance market, we have analysed the maximum daily spreads[1] of imbalance prices (EUR/MWh) from 2019 until September 2024. The data reveals an increasing trend in the volatility of imbalance prices, with in 2023 an average maximum daily spread exceeding 1,200 EUR/MWh and the first 9 months in 2024 show a higher average maximum daily spread.

This increasing volatility on the passive imbalance market creates arbitrage opportunities for BESS operators. By leveraging these fluctuations, BESS operators can enhance profitability through strategic buying and selling. Specifically, charging the battery when the imbalance price is negative and discharging when the imbalance price is positive or high can yield positive revenue streams. This buy-low and sell-high strategy enables BESS operators to profit from price differences, contributing to grid stability while generating positive revenues.



Source: ENTSO-e, Deloitte analysis

Note: 1) The maximum daily spread is calculated as the difference between the highest and lowest imbalance prices recorded within a single day,

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Practical example: Charging a 2 MWh battery based on imbalance prices

The second week of September 2024 was characterised by high volatility in imbalance prices. Let's take that week as an example to demonstrate the potential of BESS in the imbalance market. Assume a 2 MWh battery with no ramp-up rate, capable of 10 cycles[2] in one week, and perfect foresight of imbalance prices to showcase the potential revenue stream. Using Python for Power System Analysis (PyPSA) to maximize revenues on the imbalance market, and incorporating the above assumptions, the strategy would involve:

- Charging when the imbalance price is negative
- Discharging when the imbalance price is positive

Our analysis highlights the potential financial benefits of leveraging energy storage in a volatile market. The imbalance prices fluctuating between nearly 1,900 €/MWh and minus 1,000 €/MWh this week in September present a significant arbitrage opportunity for charging a battery based on these prices. It's important to note that this analysis is solely focused on generating revenue in the imbalance market, without considering taxes, grid tariffs, or other associated costs.

However, it must be emphasized that the primary goal of batteries active in the balancing markets is to stabilize the grid. Energetically, this means maintaining the grid frequency at 50 Hz, and technically, it involves preventing grid congestion. Therefore, it is crucial for participants to adhere to the obligations set by TenneT. The objective should not be solely to generate profit but to balance the grid, which can concurrently yield positive returns.

Figure 4. Electricity stored in battery and imbalance prices over time

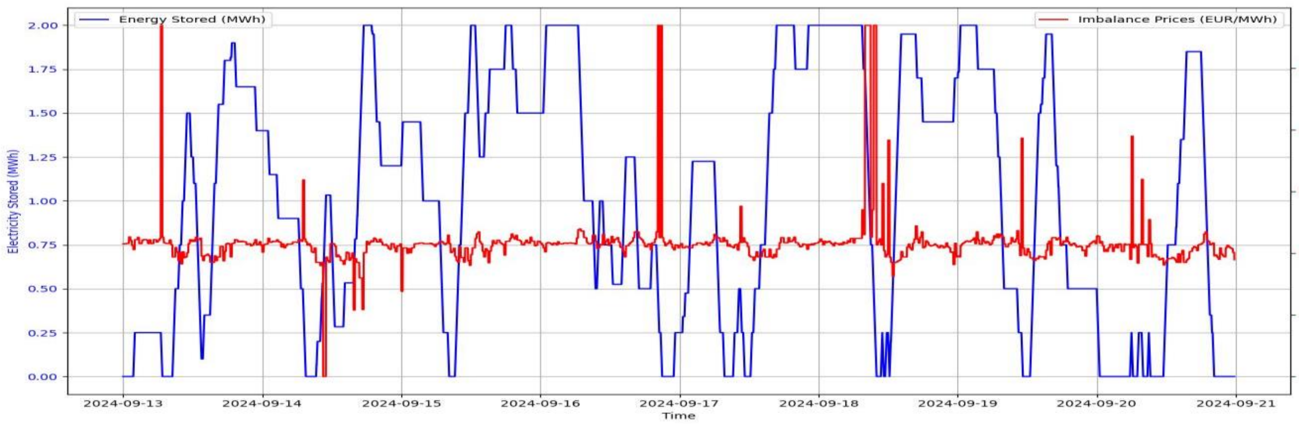

Figure 5. Cumulative income (EUR) from 13 to 21 September 2024

Source: ENTSO-e, Deloitte analysis

It must be noted that imbalance trading carries significant risks. Control State 2 ("Regeltoestand 2"), a control state managed by TennT, occurs when there is both an electricity surplus and shortage on the grid within a fifteen-minute period. This can happen when major players quickly adjust their production or consumption in response to fluctuating imbalance prices. This means that within the same quarter-hour, adjustments must be made to both reduce and increase production. Each imbalance delta (the amount of energy charged or discharged) must be paid for, potentially resulting in a negative trading outcome for the BESS operator.

Note: 2) A cycle refers to one complete charge and discharge process, where the battery is charged from empty to full and then discharged back to empty;

It must be noted that the arbitrage opportunities may be impacted by changes in the market, such as the recent entrance to PICASSO or the delay in balance delta communication by TenneT

Challenges to overcome

While opportunities exist, there are also significant challenges to address:

Market Complexity: The increasing complexity of the imbalance market requires sophisticated tools and expertise to navigate effectively. Market participants must invest in advanced analytics to make informed decisions.

Regulatory Framework: Ensuring a supportive regulatory framework is essential to manage volatility. Policymakers need to balance between promoting renewable energy integration and maintaining market stability. Given the increasing proportion of renewable energy generation, it is imperative to develop flexible frameworks that can adapt to the variability and unpredictability inherent in these energy sources. Lately, TenneT implemented a ramp rate[3] of 20% which affects how quickly assets can respond to imbalance prices. This measure is taken to prevent grid outages due to rapid overreactions, which could worsen balance quality by activating more power than necessary to resolve the imbalance.

Infrastructure Investment: Upgrading grid infrastructure to handle the variability and enhancing interconnection with neighbouring markets can mitigate some of the volatility, both in prices and in supply and demand. This requires substantial investment and coordinated efforts among stakeholders. Additionally, if a large number of households adopt home batteries, there is a risk that simultaneous charging and discharging could create extreme peaks and troughs in demand, potentially overloading the grid. Effective grid management and coordination mechanisms will be essential to prevent such scenarios.

Conclusion

The increasing volatility in the Dutch electricity market presents both opportunities and challenges for market participants. By leveraging advanced energy storage solutions, flexibility services, and innovative technologies, stakeholders can capitalize on the dynamic market conditions.

While financial benefits from BESS can be notable, the primary focus should be on balancing the grid and preventing grid congestion. This means ensuring grid stability and supporting renewable energy integration. Revenue generation can be a secondary objective, but grid stability should remain the priority.

As Deloitte, we are committed to helping our clients navigate this evolving landscape and harness the potential of the energy transition in the Netherlands.

For more insights on BESS projects, the revenue potential on different energy markets and financing options, please reach out to our Energy, Resources & Industrials team at Deloitte. Let us help you turn volatility into opportunity.

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Note: 3) A ramp rate of 20% for batteries limits the change in power output or input to 20% of the battery's total capacity per minute, ensuring gradual adjustments to prevent grid instability

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