

TenneT's position on Battery Energy Storage Systems (BESS)

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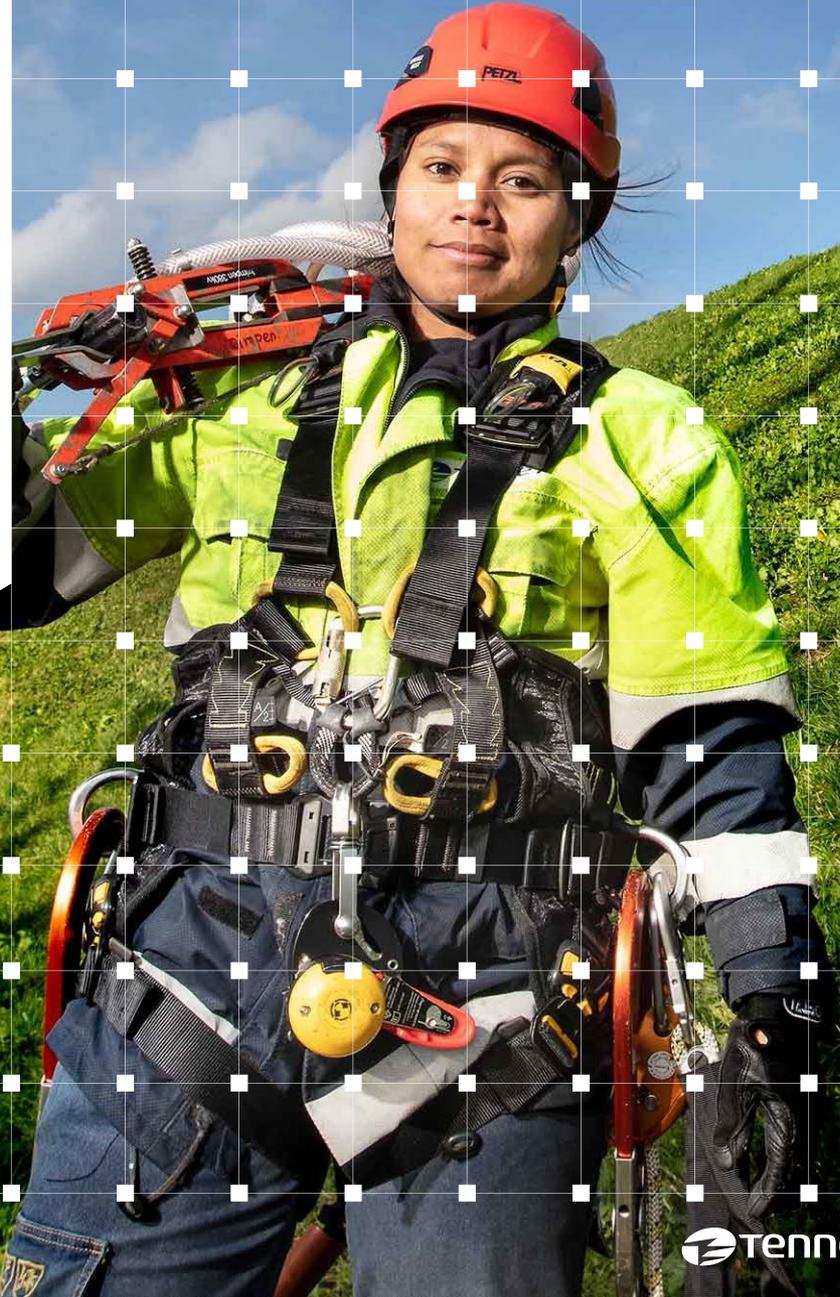
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Executive Summary



Executive Summary

TenneT's position regarding Battery Energy Storage Systems (BESS)



In order to be able to execute our TSO balancing task in the future, TenneT has a strategy to prepare for expected developments (2025-2030) in the Dutch electricity market. BESS connections can be of important added value to provide ancillary services to execute our balancing and transportation tasks. This document intends to provide an overview of TenneT's position on the application of large batteries (>70MW) by market parties to the grid, to be used as guidance to the market including authorities

We face several near term challenges that require us to rethink our view on large energy storage solutions:

- ▶ Near term grid volatility rises due to wind and solar dependence, which will progressively require more effort to balance the electricity grid
- ▶ Multiple large market parties reached out to TenneT to understand our position with regard to BESS in the size of 70MW – 500MW, as recent price volatility and height can potentially result in a viable business case for BESS
- ▶ **Within TenneT, BESS are very much wanted from a Transport perspective in the form of upward and downward dispatch. Also we expect an increasing need of balancing (FRR) products, for which BESS can be deployed**

In the following chapters, we give an overview of the current market developments, the current products for which BESS can be used and where you can find additional info on BESS

Executive Summary

BESS potential support to TenneT



Provision of fast frequency response services (FCR, FRR)

With ultra-fast response times, BESS have a clear ability in providing FCR services. A BESS can also be used for the other balancing (FRR) products



Congestion management services (bilateral contracts, GOPACS)

BESS can provide flexibility using bilateral contracts with network operators or via market-based congestion management, next to grid reinforcement



Voltage support and stabilization

BESS can be deployed to deliver or absorb Reactive Power and can potentially provide Black-start services

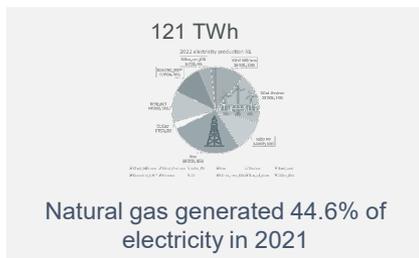
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Recent market developments and price volatility



Current electricity market

Natural gas and coal mitigates grid volatility* caused by wind and solar today



Electricity producers are conventional, large-scale and concentrated

Wind and solar generated 24.5% of electricity in 2021

Today's grid is a balanced mix of volatile wind and solar combined with stable conventional electricity sources

RES output fluctuates due to weather dependency and high ramp rates

Stable conventional generators and flex provided by natural gas and coal manages RES volatility

It is expected that the increasing penetration of renewables in the long-run, combined with high fossil fuel prices in the short term, will exacerbate the volatility across electricity markets even more. Also decommissioning of coal-fired powerplants does relate to higher volatility expectations

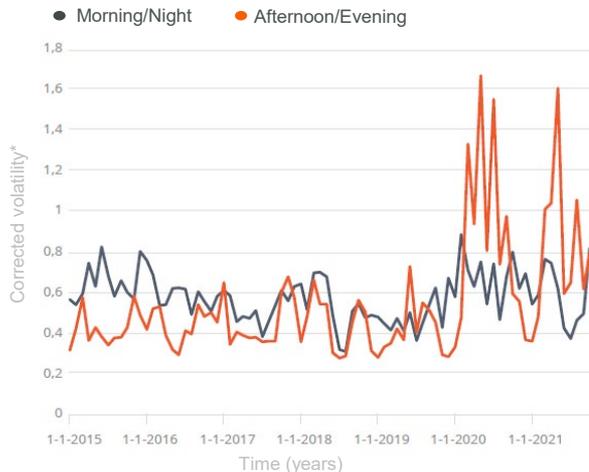
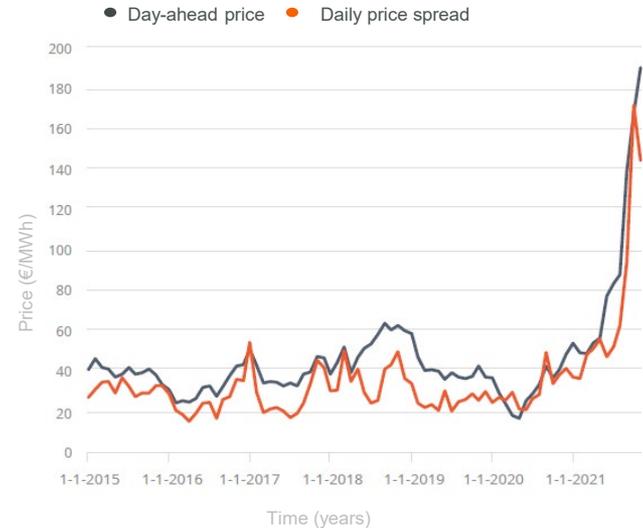
* Refers to the instability of the grid that can result from intermittent generation from renewable sources

Volatility developments: day-ahead market prices

Volatility remains as high as ever

The day-ahead data displayed in the figure on the right-hand side is useful to show structural price trends in electricity markets. What is striking is not only the upward trend of recent months, but also the huge increase in volatility compared to the period before - as reflected in the growing daily price spread (i.e. the spread between daily peak and off-peak electricity prices)

- ▶ The increasing penetration of intermittent renewables and the consequent weather dependency boosts grid volatility and rapid price changes



* 0.8 means that the price fluctuation in that half of the day was 80% of the average daily price.

By correcting the absolute price fluctuations for the average price on that day, it is visible that price fluctuations have been steadily increasing

- ▶ While in 2019 the adjusted volatility in the afternoon was lower than that in the morning almost every month, since 2019 midday volatility has become increasingly prominent
- ▶ The reason for this is the rapid growth of renewables, which has led to relatively lower prices in the afternoon compared to the evening
- ▶ This trend offers growing opportunities to deploy BESS for peak shaving, as combined with arbitrage on wholesale markets

Volatility developments: balancing market prices

Volatility remains as high as ever

Just like the day ahead market, balancing markets are also undergoing significant and rapid changes

- ▶ Near term grid volatility rises due to wind and solar dependence, which progressively requires more effort to balance the national energy grid
- ▶ An important solution for any mismatch is the use of flexibility, of which BESS is a direct source, to retain reliable and cost-efficient operation of the power system
- ▶ The nature of BESS makes it interesting as flexibility source, as BESS can store and supply to the power grid almost instantaneously, facilitating near-real time system balancing



The day-ahead price, imbalance price, and the price difference between them, on an autumn day

Due to a growing share of renewable energy in the long term, and high fossil fuel prices in the short term, price volatility and thus demand for flexible power will further increase. It is expected that the demand for flexibility will grow faster than the supply, hence BESS will become an increasingly valuable asset

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Overview of current products and systems

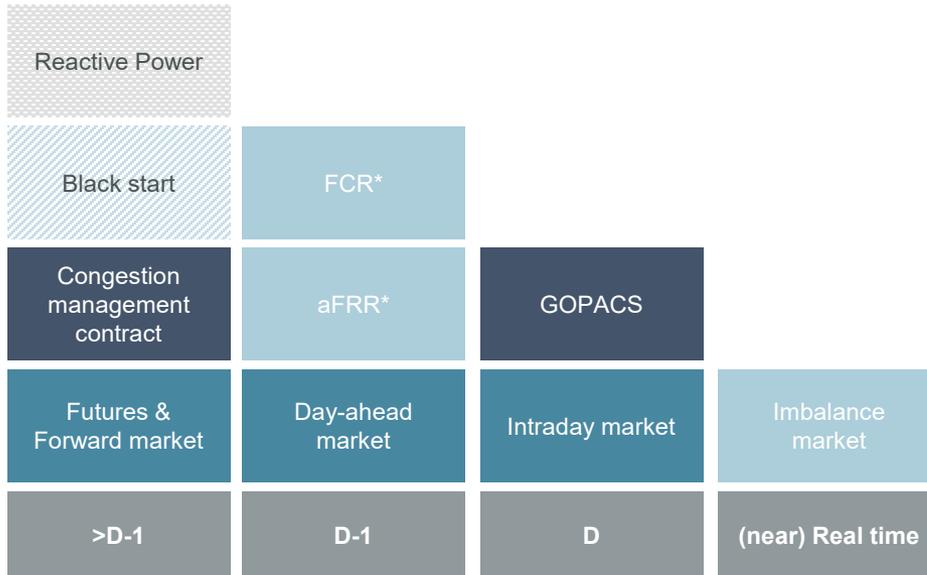


Current products and systems

Viable business case for BESS and TenneT in electricity markets

Current market developments create attractive opportunities for BESS owners. Hence, it is important to investigate how does BESS potential match with our main focus areas, as TenneT

Overview of decision moments and products where BESS create revenue



*Activation of reserved power is determined (near) real time

- Wholesale markets
- Congestion markets
- Balancing markets
- Reactive power supply
- Black-start supply

- ▶ The potential of BESS can be harvested for each of the products depicted on the left, by deploying flexible capacity at various market segments and at different timeframes
- ▶ Many single markets are not profitable in themselves for BESS owners, but can contribute to a “stacked” business case*
- ▶ There is a wide variety of revenue streams to be realized by generating explicit value with storage. At the same time, BESS provide opportunities for TenneT by responding to TenneT’s needs in key focus areas. An overview of the opportunities of BESS integration for TenneT is provided in the next slide

* Battery owners or portfolio owners with battery assets can optimize their revenues by utilizing different market segments: the wording “stacked” refers to value creation from different markets and services. Note that, however, entering into (e.g.) a FCR or FRR contract implies that it is not possible to utilize BESS to deliver other products during the period of contract

BESS can respond to our needs in key focus areas

Opportunities for TenneT by integrating large BESS

BESS can be deployed in a multitude of ways to support our system and transmission services, with potential yet to be explored in several areas, as displayed below

System services		Transmission services	
<i>Balancing reserves</i>		<i>Congestion management / redispatch</i>	
aFRR	<ul style="list-style-type: none"> BESS penetration is already advancing Not high demand for FCR yet, but FRR demand size is expected to grow and its providers to change As less conventional power plants will be available to offer FCR/aFRR for balancing purposes, incorporating large-scale storage solutions is a promising way forward for TenneT 	GOPACS	<ul style="list-style-type: none"> There is a high demand for upward, but also downward dispatch At the moment, congestion is growing faster than the possibilities of timely grid reinforcements, while the storage costs are decreasing Batteries are an increasingly attractive (even when temporary) solution, to deliver congestion management, especially in the form of upward, downward and cross-border dispatch
<i>Black start facility</i>		Contracts	<i>Reactive Power</i>
<ul style="list-style-type: none"> BESS can offer reliable black start functionality in the event of grid collapse (experience with BESS application to be gained) Current specifications in the Netcode are drawn up focussing on fossil-based generation plants, while DERs (e.g. wind, solar and BESS) are currently not accounted for To harvest BESS potential to deliver black start functionality, the Netcode should be adjusted to accommodate for the technical possibilities offered by storage and RES 		<ul style="list-style-type: none"> In the future, BESS might provide flexibility by means of bilateral contracts with network operators Developments need to be monitored after the change of the Netcode (Netcode Elektriciteit) on Congestion Management expected in Q3-2022 	<ul style="list-style-type: none"> There is a high potential for BESS to absorb and generate reactive power to alleviate voltage level challenges, as renewable energy generation continues to grow it causes more and more voltage level challenges in our grid

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Market Information



Market Information

External Publications

In the (recent) past several documents have been published which include history, future, financial aspects and other relevant information on a BESS as well as grid opportunities. Please find below a list of suggested readings for the Dutch market specifically.

It must be said that parts of these reports are actually already outdated with the current situation of even higher price volatility and height. More international reporting can be found online.

- ▶ Smart Storage Trendrapport 2022, published by DNE Research
- ▶ Omslagpunt grootschalige batterijopslag 2021, published by CE Delft
- ▶ Annual Market Update 2021, published by TenneT (see: https://tennet-drupal.s3.eu-central-1.amazonaws.com/default/2022-07/Annual_Market_Update_2021_0.pdf)
- ▶ 2022 Battery Scorecard, published by DNV

TenneT is a leading European grid operator. We are committed to providing a secure and reliable supply of electricity 24 hours a day, 365 days a year, while helping to drive the energy transition in our pursuit of a brighter energy future – more sustainable, reliable and affordable than ever before. In our role as the first cross-border Transmission System Operator (TSO) we design, build, maintain and operate 24,500 kilometres of high-voltage electricity grid in the Netherlands and large parts of Germany, and facilitate the European energy market through our 16 interconnectors to neighbouring countries. We are one of the largest investors in national and international onshore and offshore electricity grids, with a turnover of EUR 6.4 billion and a total asset value of EUR 32 billion. Every day our 6,600 employees take ownership, show courage and make and maintain connections to ensure that the supply and demand of electricity is balanced for over 42 million people.

Lighting the way ahead together

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