ENERGINET

OUTLOOK FOR ANCILLARY SERVICES 2024-2040

CONTENT

READING GUIDE

This report targets both new and existing market participants. The section "Introduction and how to get started" particularly addresses new participants who may have limited or no prior knowledge of ancillary services and the balancing market.

"Status and projections" outlines Energinet's current procurement of ancillary services, along with projections for various ancillary service products in DK1 and DK2. The methodology is described under “Projection methodology”.

Finally, the section "Market development" offers an overview of market changes introduced in 2024, as well as anticipated short- and long-term developments in the market.

EXECUTIVE SUMMARY

Energinet is tasked with procuring ancillary services to balance Denmark's electricity grid when electricity consumption and production do not match. As Denmark increases its reliance on renewable energy sources such as wind and solar power, the need for ancillary services evolves accordingly.

This report outlines Energinet's current procurement of ancillary services and projections towards 2040. These projections represent Energinet's best estimates of Energinet's future need for ancillary services, drawing on updated methodologies, regulatory changes, and Denmark's political climate goals. The report also provides an overview of short- and long-term market developments for greater transparency

As the power system of the future takes shape, Energinet encourages more companies to offer their flexibility in the ancillary services markets. This not only strengthens security of supply but also presents new income opportunities for the companies.

For new market participants, the report provides a comprehensive introduction to ancillary services, detailing different types of ancillary services product and outlining the steps for market entry.

I hope both new and existing market participants will find valuable insights in this report, and that you find it an informative and enjoyable read.

Kia Marie Jerichau

INTRODUCTION
AND HOW TO GET STARTED

This section introduces ancillary services and the onboarding process for new market participants.

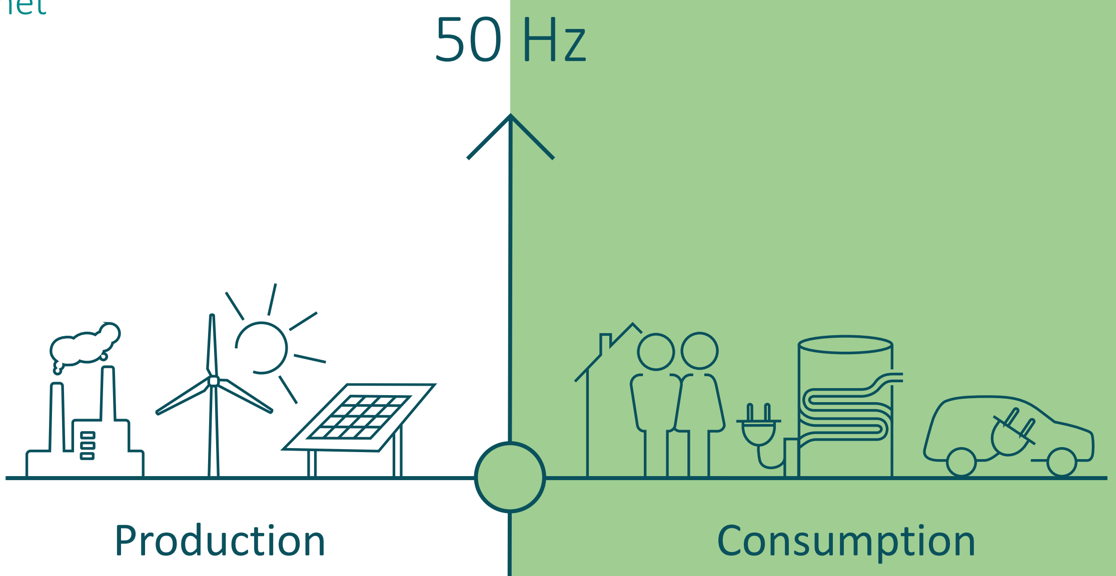
WHAT ARE ANCILLARY SERVICES?

Ancillary services comprise flexible production and consumption of electricity that Energinet procures to balance the power system.

At all times of the day, electricity consumption must equal production. This balance stabilizes the frequency in the power system around 50 Hz and ensures security of supply. Energinet pays market participants that deliver ancillary services for their flexibility.

These are some examples of market participants: Consumption units, such as electric boilers and batteries, can adjust consumption up and down according to grid needs, thereby underpinning the system balance. Likewise, production units, such as power plants, can adjust production up and down. On the other hand, wind turbines and solar power panels, for example, are only flexible when it comes to decreasing production, since these depend on weather conditions to increase production.

Energinet expects to see fewer traditional thermal power plants in future. For many years, these have been important to ensuring grid balance. In addition, renewable energy sources introduce more volatility to the power system. Consequently, a large and diverse portfolio of technologies is needed to balance the power system in the future.



UP-REGULATION AND DOWN- REGULATION

Ancillary services work in two directions: Up-regulation when the system is in power deficit, and down-regulation when the system is in power surplus.

Up-regulation: Ancillary service providers increase production or decrease consumption.

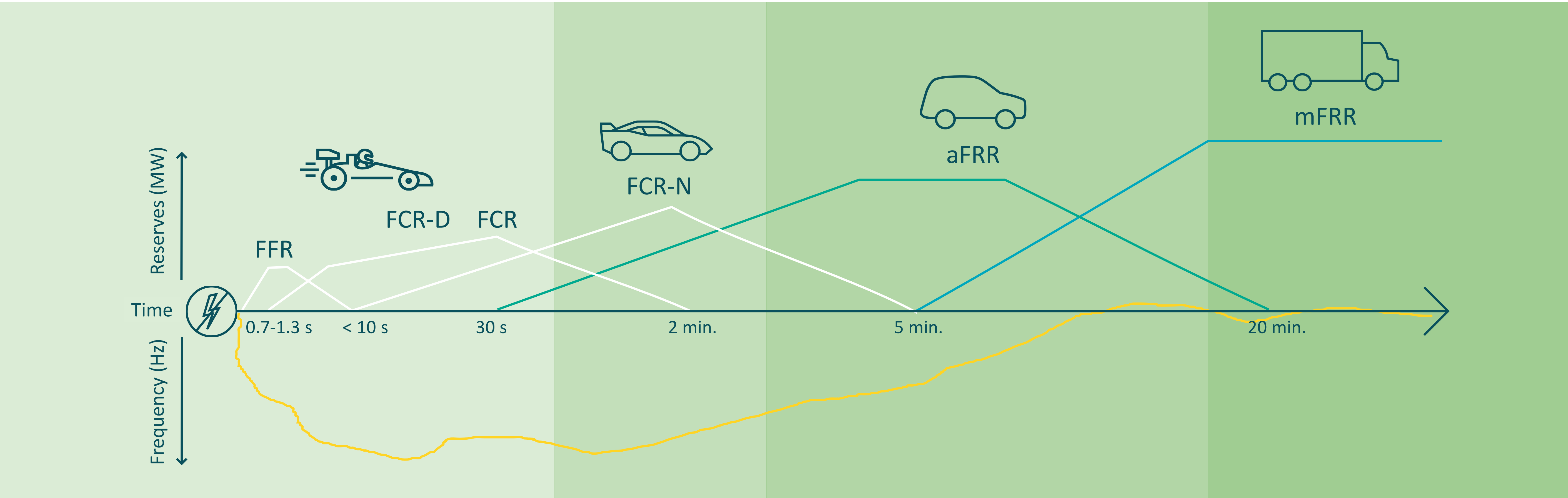
Down-regulation: Ancillary service providers decrease production or increase consumption.

Symmetric vs. asymmetric: Symmetric ancillary service products must be deliverable as both up-regulation and down-regulation. Asymmetric products must be deliverable as *either* up-regulation *or* down-regulation.

ANCILLARY SERVICES IN ACTION

The illustration below shows how, for example, an unexpected cloud cover over a large solar farm leads to a drop in frequency, illustrated by the yellow line. Various ancillary service products are activated to restore the frequency to 50 Hz.The ancillary service products vary in terms of e.g. volume, activation time and duration. The race cars illustrates the fastest products, which carry the smallest volumes of power and energy (FFR, FCR-D, FCR-N and FCR) . At the other end of the spectrum, the truck illustrates that the product with the longest activation time carries greater volumes of power (mFRR). The "Status and projections" section gives an overview of Energinet's current and projected procurement for each ancillary service product and describes each product in more detail.

Take this test to find out which ancillary service products your unit can deliver and get an indication of possible revenue based on historical prices. Please note that historical prices do not represent Energinet's expectations for future prices nor guarantee future earnings.



MARKET OVERVIEW

The tables below show how the different ancillary services are distributed on capacity and energy markets for DK1 (Western Denmark) and DK2 (Eastern Denmark).

In the capacity market, participants are compensated for offering long-term flexibility, ensuring that sufficient capacity is available to meet peak demand or respond to unexpected situations.

For the fast products such as FFR and FCR, there are only capacity markets. When selected in the capacity market, FFR- and FCR-bids is activated automatically according to grid needs.

For mFRR and aFRR, there are both capacity and energy activation markets. If, for example, an mFRR-bid is selected in the capacity market, the market participant is obliged to also submit a bid in the energy activation market.

DK1

PRODUCT	CAPACITY MARKET	ENERGY ACTIVATION MARKET
FCR	X	
aFRR	X	X
mFRR	X	X

DK2

PRODUCT	CAPACITY MARKET	ENERGY ACTIVATION MARKET
FFR	X	
FCR-D	X	
FCR-N	X	
aFRR	X	X
mFRR	X	X

PREQUALIFICATION OF FACILITIES

Facilities must be prequalified by Energinet to ensure that they meet the technical requirements for delivering ancillary services. This is called prequalification.

The illustration below gives an overview of the prequalification process. Read more about prequalification on Energinet's website.

Energinet has a technical support team, which supports market participants during the prequalification process. Energinet's prequalification support team can be contacted at PQ.audits@energinet.dk.

STEP 1: PREPARATION

Ensure correct market access:
To submit bids in the ancillary service markets, asset owners must either collaborate with a balance-responsible party (BRP) or balance service provider (BSP) or, alternatively, become a BRP or BSP. A non-exhaustive list of Danish BSPs and BRPs can be found on Energinet's website

Find technical market requirements:
Units must comply with the technical requirements for the relevant markets. Read more about the technical requirements in the Tender conditions

Decide on a date for the test:
Find a date for the prequalification test. Energinet must observe the test and be informed of the test date at least 7 days in advance.

STEP 2: PREQUALIFICATION TEST

Run tests and send data:
Run tests required for the specific markets and send data and test manual to Energinet in the correct format and resolution. Read more about the test Energinet's website

Make changes or adjustments:
Energinet may require some adjustments before a unit can be prequalified. When the adjustments have been made, a new test must be conducted.

STEP 3: APPROVAL

Energinet issues a prequalification:
If the test results satisfy all requirements, Energinet issues an official approval. The approval allows the BRP or BSP to submit bids from the prequalified units in the specific markets.

HOW TO GET MARKET ACCESS

To get access to the ancillary service markets, the asset owner must collaborate with a BSP or a BRP, which are companies approved to deliver ancillary services on behalf of one or more flexible assets.

BRP and BSP access to markets is granted upon meeting both the technical and financial requirements. Below is an overview of the onboarding process and requirements for new BSPs and BRPs. Electricity suppliers that want to become a BSP or BRP must go through the same process. Read more about how to register as a BSP or BRP on Energinet's website or contact electricitymarket@energinet.dk. Below is an overview of the process and requirements for new BSPs and BRPs.

AGREEMENT WITH ENERGINET

The company must provide relevant business information and financial guarantees to Energinet and sign relevant contracts with Energinet, which guarantee that the company meet the requirements for market participation.

SETTLEMENT AGREEMENT WITH ESETT

The company must sign a contract with eSett, which is the company responsible for the imbalance settlement. Additionally, the company must provide financial security to eSett and comply with relevant requirements. Read more on eSett's website.

REGISTRATION & PREQUALIFICATION

Assets that deliver ancillary services must be registered with Datahub, where Energinet gathers data about Danish electricity consumption and production. All assets in the BRP's or BSP's portfolio that deliver ancillary services must be prequalified. Read more about prequalification on Energinet's website.

PROJECTION METHODOLOGY

This section presents the methodology and assumptions behind the projections in this report.

ASSUMPTIONS AND METHODOLOGY

This outlook is based on historical data and model-generated results from Energinet's advanced energy modelling tool (BID3). The underlying assumptions follow the National Trends (AF23) from the Danish Energy Agency as input for Denmark. Assumptions for other European countries are based on data from the European Ressource Adequacy Assessment 2023 Edition (ERAA23) and data from the Ten-Year Network Development Plan 2024 (TYNDP22) for 2025-2034 and 2040, respectively. AF23, ERAA23, and TYNDP22 contain data about production capacity, demand, interconnector capacity, power plant- and interconnector outages, etc. and describe expected power system developments in all European countries. These are all new datasets compared to last year's edition of this report and might result in changed assumptions and, therefore, changed procurement needs compared to last year. An overview of data used is presented in Figure 1 and Figure 2.

ERAA23 contains two scenarios for the development in Europe: Scenario A – Central and scenario B – Sensitivity. One major difference between the two scenarios is that there is 16 GW less dispatchable capacity in Europe in scenario B, which results in a more stressed system with regards to resource adequacy. This is due to ENTSO-e's Economic Viability Assessment (EVA), where scenario A gives more weight to rare, bad climate years as an incentive for investment in new capacity. Energinet has chosen scenario B, as scenario B is considered a best-guess representation of the current investment climate in the European power markets, while scenario A is considered a more optimistic outlook. However, it is important to consider that these future scenarios involve high degrees of uncertainty.

The Danish Energy Agency's analysis assumptions also state that a significant portion of the dispatchable power plants will be decommissioned in the coming years. Energinet assesses that most of these plants have been available in the ancillary service markets, and thus, this could affect liquidity in the markets in the future.

FIGURE 1 DANISH CAPACITY

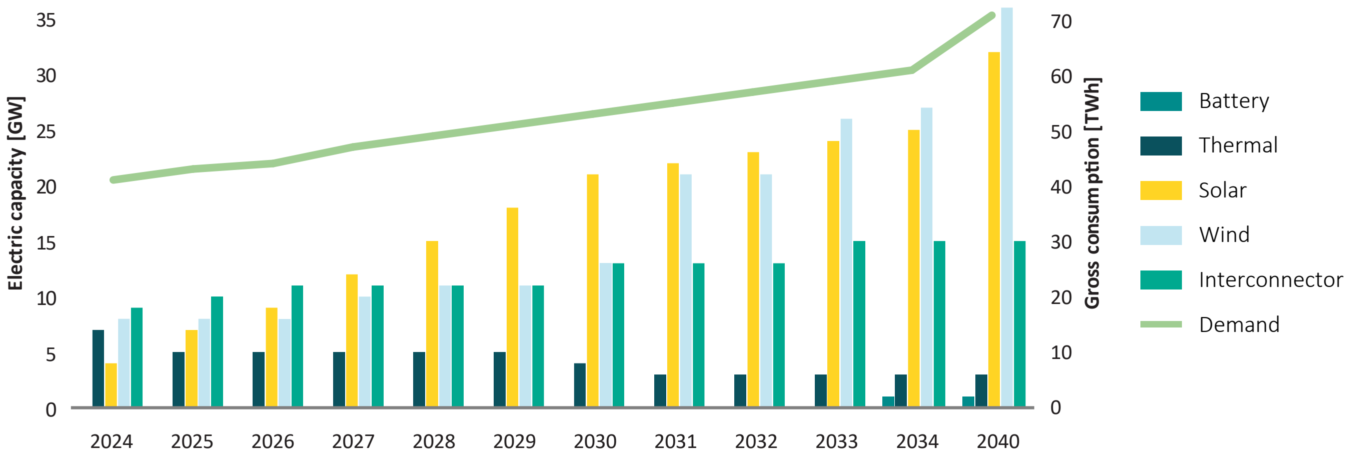


Figure 1 illustrates assumptions used for development of Danish production and interconnector capacity and yearly demand. Assumptions are based on AF23.

FIGURE 2 NORDIC CAPACITY

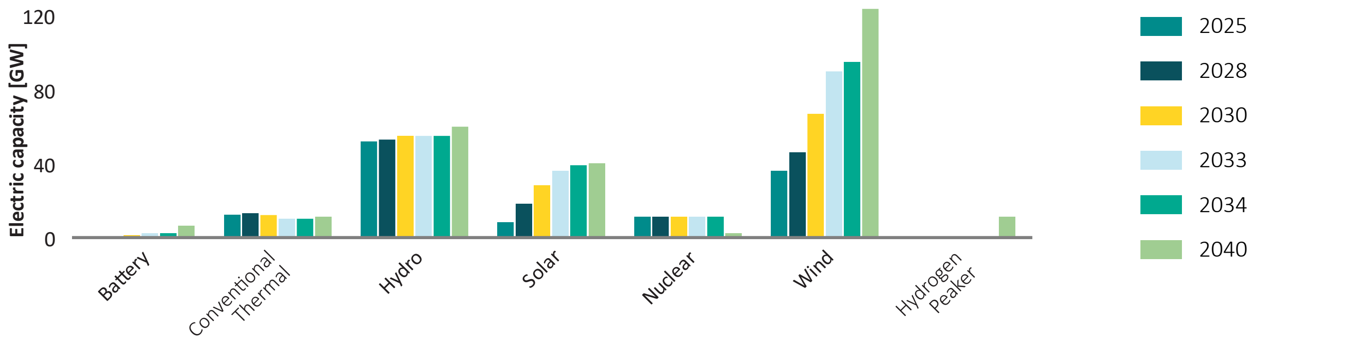


Figure 2 illustrates assumptions used for development of production capacity in the Nordic electricity system. Assumptions are based on AF23 for DK2 and ERAA23 and TYNDP22 for the remaining part of the Nordic system.

ASSUMPTIONS AND METHODOLOGY

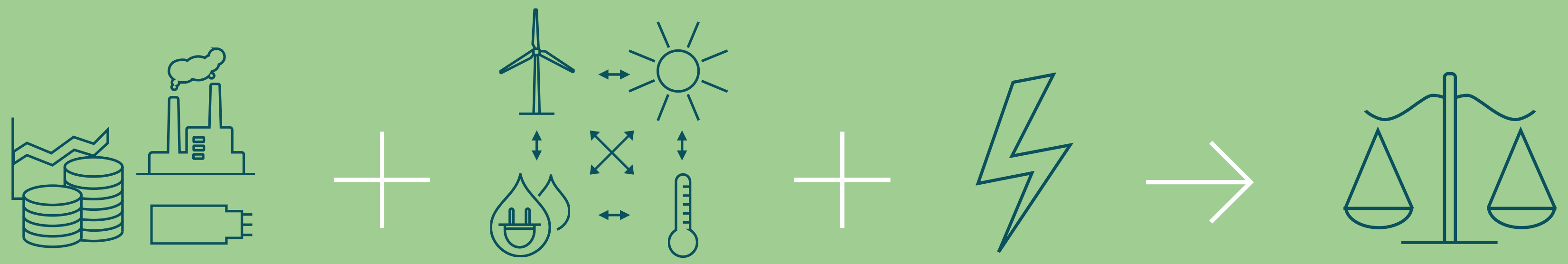
Based on data assumptions, BID3 is used to make an hourly dispatches for all of Europe for the simulation years 2025, 2028, 2030, 2033, 2034, and 2040 based on six climate years (historical years with measured insolation, wind, precipitation, etc.), giving a sample space for each simulation year for dispatched production, demand, and interconnector flows. These are used in the following methodologies of procurement needs of the individual ancillary services in DK1 and DK2, e.g. to determine reference incident, system inertia, sharing keys, and expected imbalances based on different dispatch scenarios.

Compared to last year's report, this is an increase in simulation years and climate years, aiming to achieve a more elaborate sample space. The six representative climate years are selected from ENTSO-e's Pan-European Climate Database (PECD). The database contains production profiles for wind, solar power and hydro as well as weather data for 35 different, historical years in the period 1982-2016. The six climate years selected represent a sample space of good, neutral, and bad weather years. A good weather year is typically described by high solar power and wind production, high precipitation and high winter temperatures. The selection also strives to represent a variation of good, neutral and bad weather years on the continent in different combinations with good, neutral, and bad weather years in the Nordic and Danish system. Energinet has chosen not to use the most extreme weather scenarios to obtain a more genuine sample space of expected procurement needs. On the next page, the difference in dispatched yearly production is illustrated for the Nordic region, based on the six different climate years for the simulation year 2030.

With the massive upward trend in renewables, climate years have a significant impact on the need for ancillary services – especially considering imbalances and system inertia. This mainly owes to renewable energy being dispatched instead of conventional thermal power plants, resulting in a lower contribution to system inertia and a higher probability of imbalances due to forecasting errors. Further, the Danish FCR sharing keys are calculated based on production and consumption, meaning that the more Denmark produces and consumes, the larger our FCR sharing key and procurement responsibility will be.

In summation, the values and ranges represented in this outlook are projected values of the need for ancillary services and not procurement-binding values. The projected values are Energinet’s best estimates – in a world of great uncertainty.

ILLUSTRATION OF THE BID- MODEL METHODOLOGY



CAPACITIES
E.g. power plants, interconnectors and electrolysis with associated costs

PROFILES
E.g. Renewable energy-production and electricity consumption

OUTAGES
Randomized outages of e.g. power plants and interconnectors

DISPATCH
Dispatch of production, consumption and interconnector flows based on socioeconomic optimisation

ASSUMPTIONS AND METHODOLOGY – CONSEQUENCE OF CLIMATE YEARS

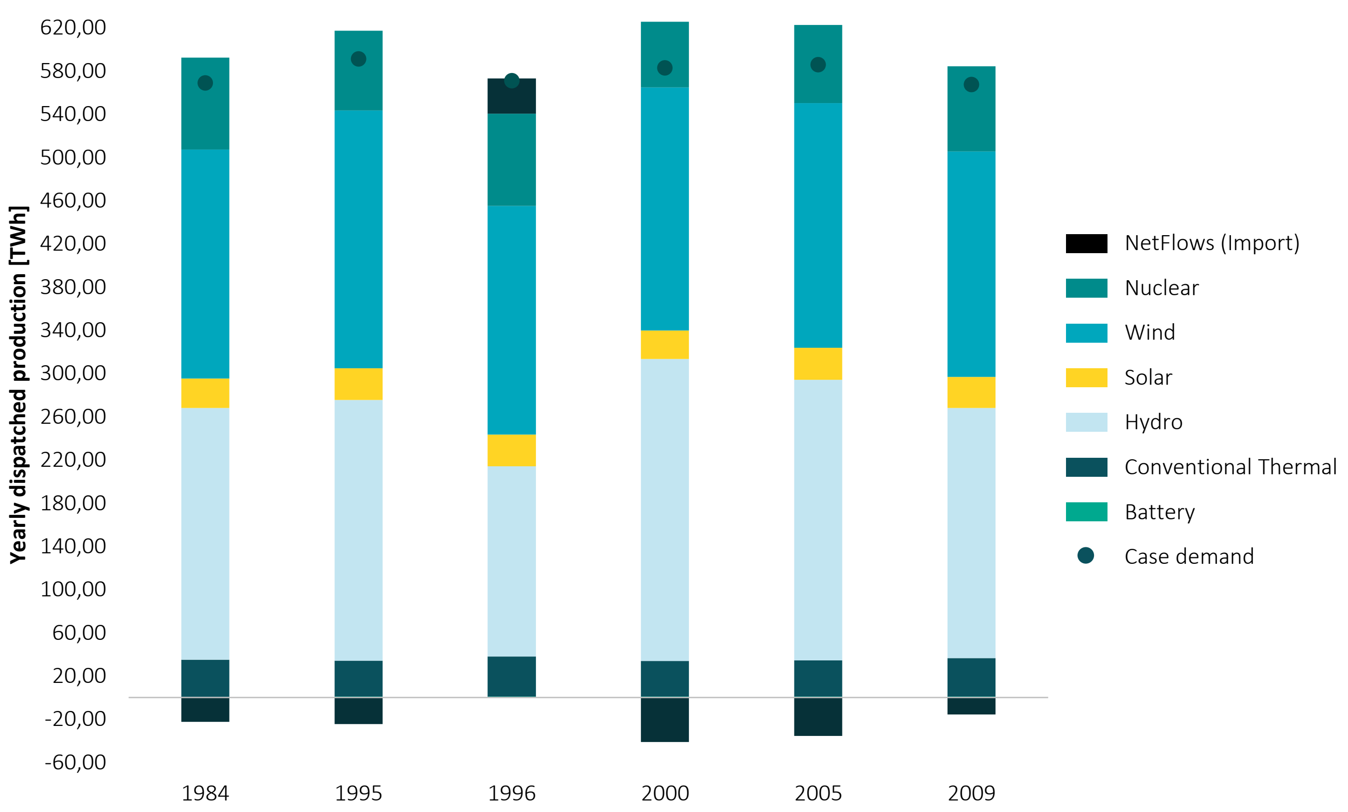
Climate year cases depict different combinations of hydro, wind, conventional thermal, nuclear dispatches, etc., giving a sample space of future system scenarios.

Figure 3 illustrates the difference in dispatched production for the Nordic region based on the six different climate years for the simulation year 2030. Climate years 1996 and 2009 represent bad climate years with low precipitation, wind, and solar power. 1984 and 2005 are neutral climate years, and 1995 and 2000 depict good climate years.

In general, good climate years mean increased hydro, solar, and wind production and less conventional thermal and nuclear production. Good climate years typically also mean higher temperatures in the winter, which leads to lower electricity demands. High levels of solar power and wind production generally mean that conventional thermal and nuclear production are not dispatched to the same extend, due to higher marginal costs. This means lower system inertia and higher probability of system imbalances, which in turn leads to higher procurement needs for ancillary services.

High levels of hydro production could also prevent conventional thermal and nuclear production from being dispatched. However, hydro power contributes to system inertia and does not lead to an increased probability of system imbalances.

FIGURE 3 YEARLY DISPATCHED PRODUCTION IN THE NORDICS FOR SIMULATION YEAR 2030



METHODOLOGY OF FORECASTING FCR

The dimensioning of the Frequency Containment Reserve (FCR) for all synchronous areas is governed by EU's the System Operation Guideline (SOGL), article 153.

According to SOGL, TSOs must annually assess the capacity need. For Continental Europe, the requirement is set at 3,000 MW in both the upwards and downwards directions, while in the Nordic region, it is based on the actual reference incident, typically 1,450 MW.

All FCR products for both DK1 and DK2 rely on sharing keys based on electricity consumption and production. This sharing key is used to distribute the required FCR capacities to each bidding area.

The projections rely on the electricity consumption and production obtained from BID3 simulations for all areas, which enables the estimation of the sharing key based on future production and consumption.

In the beginning of 2024, all TSOs in continental Europe unanimously submitted the new methodology of probabilistic dimensioning of FCR in continental Europe to their respective national regulatory authorities. In short, this new methodology uses the most recent characteristics of the system to probabilistically estimate how much FCR is needed to maintain a certain level of stability. This calculation is performed once per year. If the methodology is approved as expected, it will be implemented by the beginning of 2026 and most likely increase the total procurement of FCR slightly.

METHODOLOGY OF PROJECTING FRR-NEEDS

FRR comprises the manual Frequency Restoration Reserve (mFRR) and the automatic Frequency Restoration Reserve (aFRR). aFRR addresses variations in imbalances due to its faster activation time and reactive nature, while mFRR is activated as a proactive measure targeting large imbalances.The combined resources of frequency restoration reserves (FRR) must address three critical aspects: Special regulation (local needs), reference incident, and area imbalances.

To accommodate FRR needs, TSOs procure reserves but with a deduction due to sharing and netting of reserves with other areas and voluntary bids. See figure 4.

Each element involves high volatility, explaining why the required FRR need for a TSO is dynamic and changes for every market time unit (MTU). As a result, Energinet will introduce dynamic dimensioning by the end of 2024. Dynamic dimensioning means that Energinet will assess the need for FRR in each direction for the next day of operation, allowing more intelligent procurement based on anticipated needs. This approach enables TSOs to procure more resources during windy periods, when imbalances are more likely, and fewer resources during periods with low levels of renewable production.

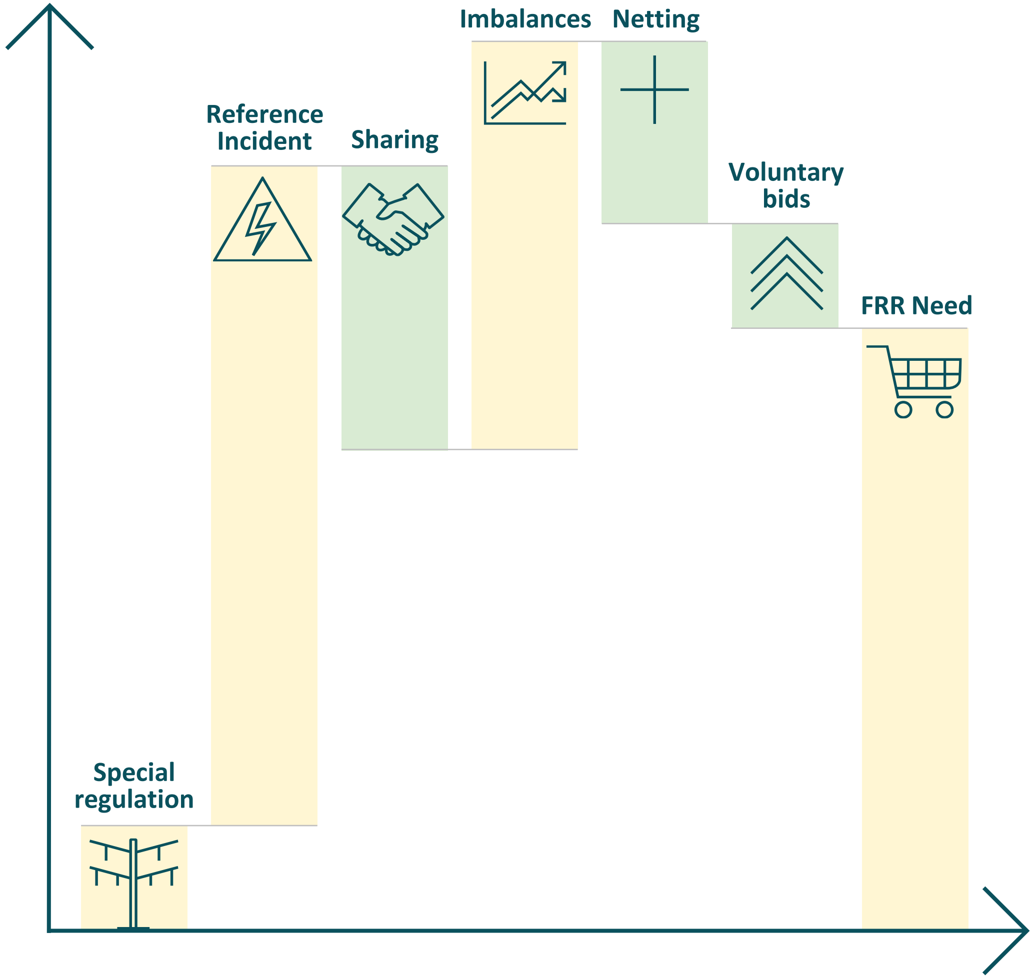
By 2025, the split between aFRR and mFRR will be based on a forecasted need for aFRR (to handle imbalances within the quarter of an hour) and the remainder will be procured as mFRR reserves.

Projections of the FRR need up to 2040 use the following approach:

- **Project future imbalances:** Scale current imbalance behaviour from forecast errors of wind and solar to match the future capacities of wind and solar plants.
- **Calculate of FRR need:** Apply the Nordic Dimensioning Methodology and the associated optimization model. This model uses simulated data such as flow and reference incidents from BID simulations and projected imbalances.

- **Special regulation** adds to FRR needs so the TSO can resolve local congestion within a bidding zone.
- **Reference incident** is the largest disconnection from a technical unit that an area can experience.
- **Imbalances** are the difference between planned and actual flows.

FIGURE 4 ILLUSTRATION OF THE METHODOLOGY FOR PROJECTING THE NEED FOR FREQUENCY RESTORATION RESERVES (FRR)



PROJECTION OF FUTURE IMBALANCES

Renewable energy sources and other fluctuating production or consumption units participate in the energy markets based on forecasts of production and consumption. However, forecasted and real-time values differ, creating imbalances. From a TSO perspective, these forecast errors, particularly from wind and solar power resources, are increasingly evident in the system balance. With the continued integration of intermittent production, these imbalances are expected to negatively affect the system balance further.

The methodology of generating future imbalances is based on current forecast error behavior when forecasting at least one hour ahead. By using forecast errors within this near, one-hour time horizon, this report assumes that market participants will make intraday trades to counter forecast errors generated in the day-ahead market and up to one hour prior to the operating hour. Thus, the resulting errors are only those generated within the hour. The behavior of the forecast errors is then interpreted statistically on a per-unit basis, allowing for scaling and aggregation. This behavior is illustrated in figure 5.

The projections in this report apply the hourly solar power and wind production values for each simulation year and climate year generated by BID3. These values are then applied in a stochastic process with the statistical input.

All solar power and wind parks are input in a Monte Carlo simulation, which generates an imbalance at plant level relative to the production level, as shown in figure 6 and 7. Small solar power parks and onshore wind turbines are aggregated into geographical clusters, treated as single entities within the simulation. Errors are summed for all plants, resulting in total system imbalances for each hour. By modelling individual imbalances simultaneously, errors can offset each other, offering a more realistic output. This imitates real system operation where each individual plant will be at various levels of imbalance, and to some extend cancel out each other's errors.

Parts of the puzzle are still missing when it comes to modelling an accurate development in imbalances from the expected development of fluctuating renewables. In this iteration, one imbalance distribution is used, which entirely depends on the forecast used and the production pattern of the year examined. This is scaled to the entire portfolio of parks, while real-world operation offers much more differentiated circumstances, such as differing park setups, the use of different forecast methodologies, different forecast input data, etc. These are all things that would increase the variability of imbalances and most likely increase the effects of cancelling out opposite imbalances.

Another missing factor is market dynamics which affect the imbalances from renewable production. This is not due to poor operations or difficulties in forecasting, but due to deliberate actions of asset operators. These dynamics are often fleeting and difficult to include or nearly impossible to predict.

FIGURE 5 IMBALANCE STATISTICS AT DIFFERENT LOAD FACTORS

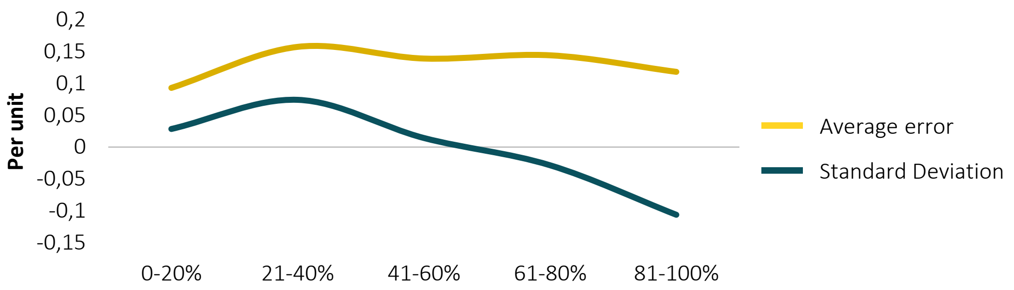


Figure 5: Methodology of imbalance estimates (representation of solar) using a representative solar park and the best available forecast of production, the following average forecast-error can be deducted. This behavior is used individually on each park to calculate total solar imbalance.

FIGURE 6 SIMULATED AND ACTUAL LOAD POINT DISTRIBUTION AT TOTAL LOAD POINT 0.6-0.7 FOR MEASURED DATA

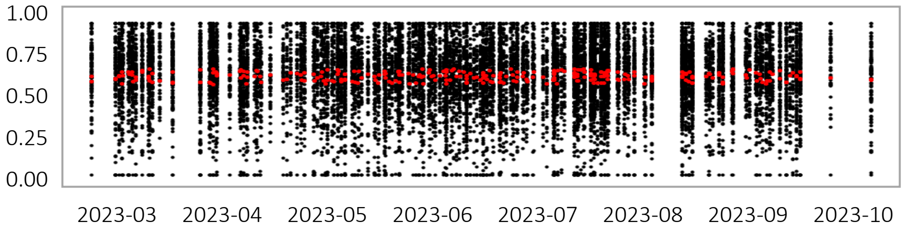


FIGURE 7 SIMULATED AND ACTUAL LOAD POINT DISTRIBUTION AT TOTAL LOAD POINT 0.6-0.7 FOR SIMULATED DATA

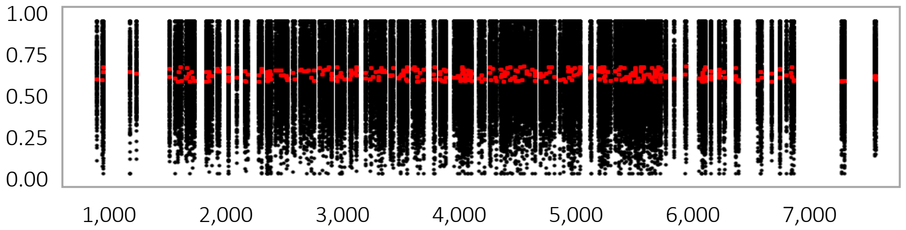


Figure 6 and 7: Scaling and aggregation, using the average spread of hourly load factors across the total Danish portfolio of PV parks ensures a realistic spread in imbalances and the effects of a population of PV parks to some extend cancels out each other's imbalances. Red dots are the aggregated capacity factor, while the black dots are individual PV park load factor.

METHODOLOGY OF CALCULATING THE FRR NEED

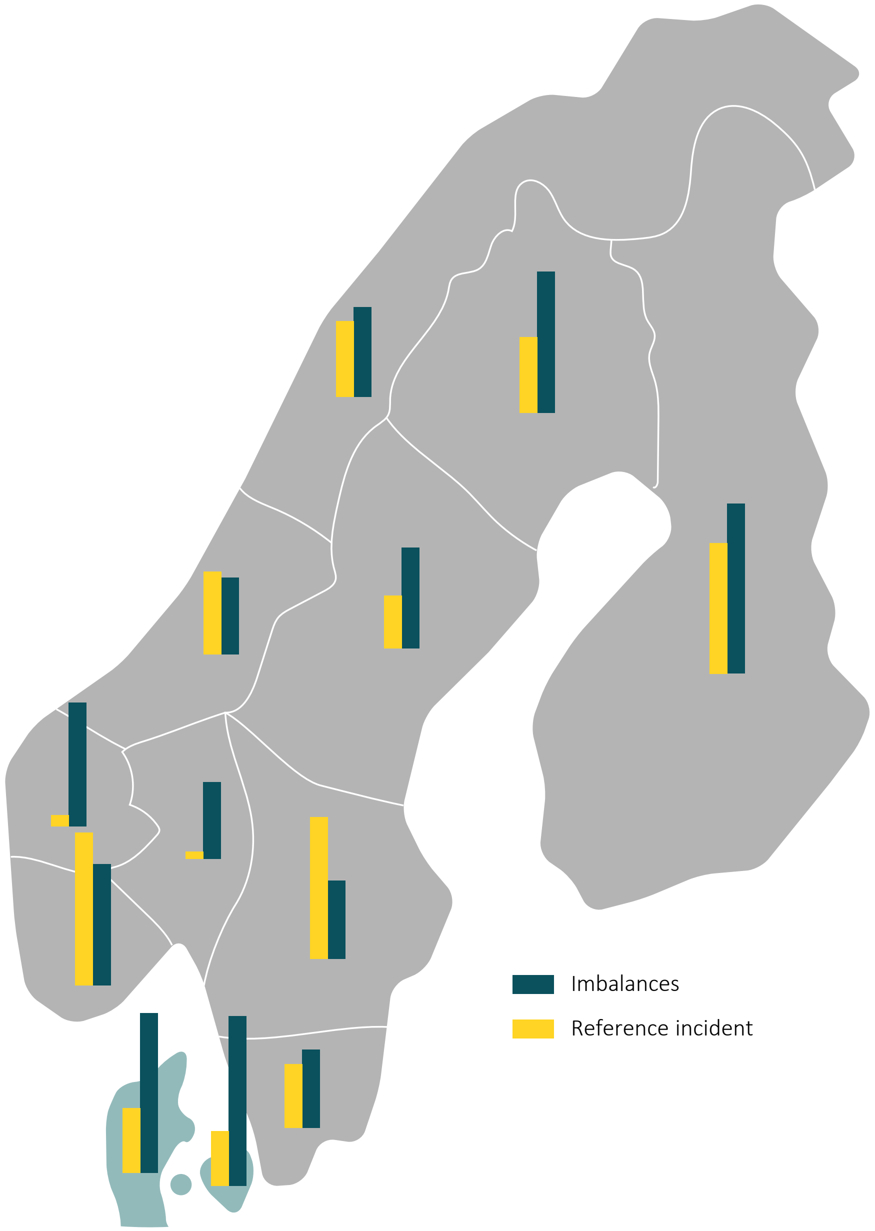
To make a more precise projection of the FRR need, this year's edition of the Outlook for ancillary services report includes optimized netting and sharing, and voluntary bids. This increases the complexity of the calculations, as future values from Nordic areas are needed and the Nordic TSOs' optimization script is used to calculate the FRR need for each TSO. The robustness of results are thereby improved compared to the 2023-edition of this report lacked optimized values for sharing and netting and ignored voluntary bids.

With this extension of the calculation, additional assumptions are required:

- **Imbalance Data:** For the other Nordic areas, 2023 values are assumed throughout all scenarios. This static approach is used due to the extensive resources needed to examine and create imbalance datasets for all the other Nordic areas as done for DK1 and DK2.
- **Voluntary Bids:** Voluntary bids are included at a constant 30 % of the 2023 level. This value is somewhat arbitrary but reflects the loss in capacity of combined flexible heat and power plants while considering a change to 15-minute market time units (MTU). After switching to 15-minute MTU’s it will be easier to assess the volume of voluntary bids.

These assumptions and data are applied with the BID output in an optimization model. The model nets imbalances and distributes FRR, representing the 'true' need, which is what a TSO should have procured in hindsight.

Each TSO will forecast the next day's needs, incorporating a security level and forecasting with a confidence interval. Therefore, a margin is added to the model's output by evaluating the statistical behavior of Energinet's forecast and integrating that into the dataset.



NORDIC DIMENSIONING METHODOLOGY

The Nordic TSOs collaborate to ensure a very high level of security of supply with the lowest possible costs. To achieve that goal, the Nordic TSOs have developed an optimization model that seeks to minimize the FRR procurement, while respecting the following set of principles:

- **Imbalance principle:** Each area must be able to cover its own residual imbalance after netting the imbalances between all zones.
- **Special regulation principle:** Each area is responsible for managing local regulation needs.
- **Voluntary bid restrictions:** Maximum 80 % of the historic voluntary bids can be used to reduce the local procurement.
- **Flow restrictions:** Sharing via HVDC is restricted to 600 MW per interconnector.
- **Fairness principles for sharing:** Sharing benefits should be equally divided among TSOs.
- **Sharing of reference incident:** Sharing of reserves to handle the reference incident is allowed but governed by following rules.
  - Areas can only share what is available within the Control Area (E.g. Denmark, Sweden, Norway) respecting internal available transmission capacity (ATC).
  - Sharing always respect ATC

STATUS AND PROJECTIONS

This chapter gives a status on Energinet's current procurement of ancillary services in DK1 and DK2 and Energinet's projected need for ancillary services towards 2040.

HIGHLIGHTS FROM PROJECTIONS

OVERALL OUTLOOK

Projections towards 2040 indicate a significant increase of approximately 150 % in Energinet's overall need for ancillary services as shown in figure 8. Energinet’s need for ancillary services to balance the power system is expected to rise particularly sharply leading up to 2033, followed by a more moderate increase from 2033 to 2040.

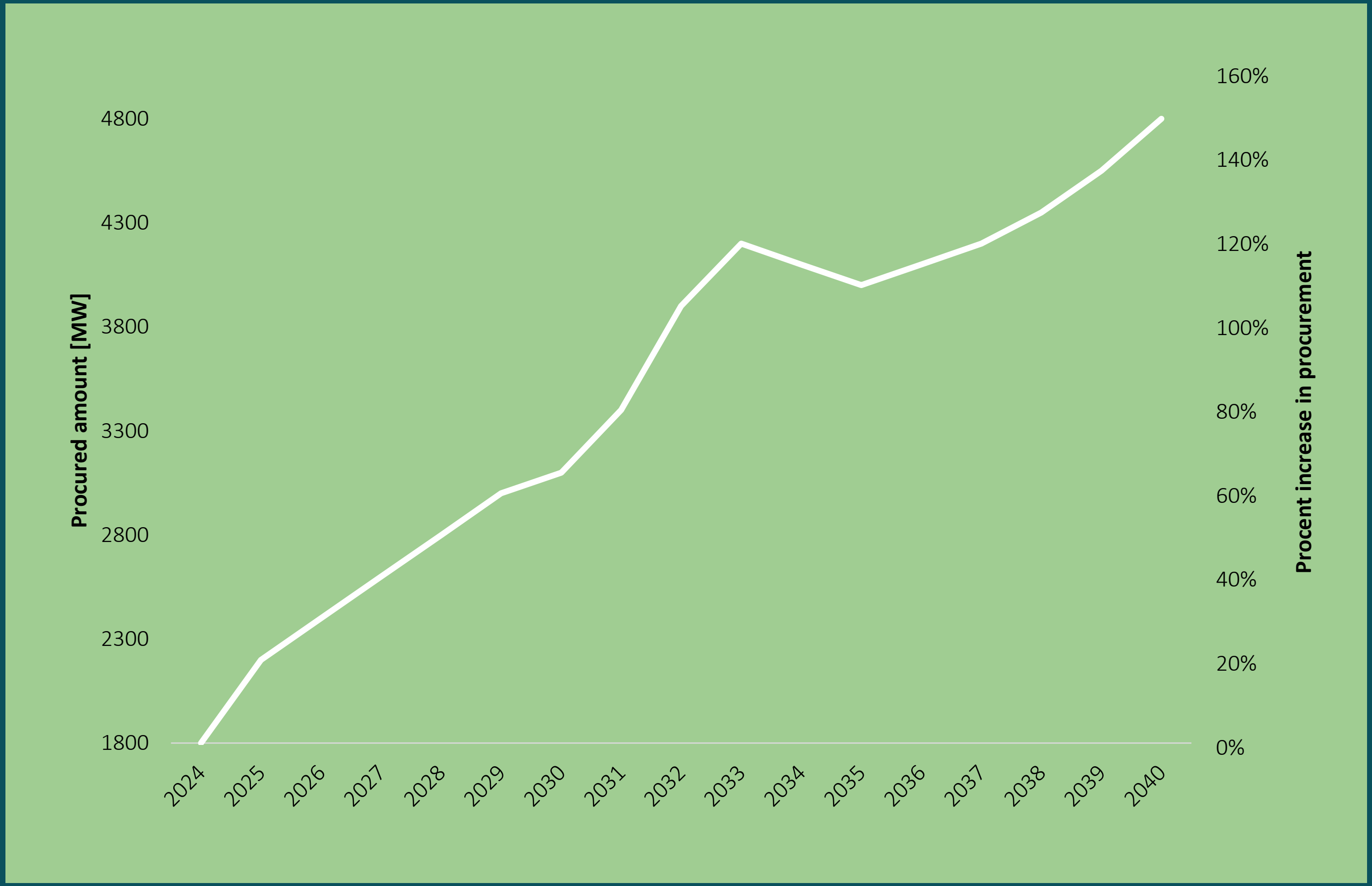
It is important to note that this overall projection account for substantial differences in the projected need for various ancillary service products.

Adjusted projections of aFRR and mFRR Needs

Compared to last year's edition of the report, the projected need for aFRR has been revised upward for both DK1 and DK2. This adjustment is primarily due to higher expectations for solar and wind production, leading to increased imbalances.

In contrast, expectations for the mFRR need have been revised downward for both up- and down-regulation in DK1 and DK2. The main reason is changes in the methodology behind the projections, where voluntary bids and the actual TSO procedure, with an optimized approach to netting and sharing, have been incorporated. Additionally, the downward adjustment in the projected mFRR need can be attributed to the increased expectations for the aFRR need.

FIGURE 8 SUMMED AVERAGE PROCUREMENT ACROSS ALL ANCILLARY SERVICES



HIGHLIGHTS FROM PROJECTIONS

HIGHLIGHTS IN WORDS

- The most significant changes in reserve needs are the increase for aFRR and mFRR for up-regulation in DK1 and for down-regulation in DK2. This is illustrated for mFRR in figure 9 and 10 .
- The overall trend for FCR in DK1 indicates a nearly linear increase with projections indicating a need of 2-4 times current level. In addition, the 100 MW export cap can be adjusted if Danish market participants starts to reach the export limit.
- Denmark's share of FCR-N and FCR-D for both up-regulation and down-regulation is increasing. When factoring in exports to Svenska kraftnät, the market appears to remain at its current level.
- The projection shows that the need for FFR will experience exponential growth towards 2030. The projection indicates a level 6-9 times higher in 2030 compared to the current need.

FIGURE 9 PROJECTED NEED FOR mFRR FOR UP-REGULATION IN DK1

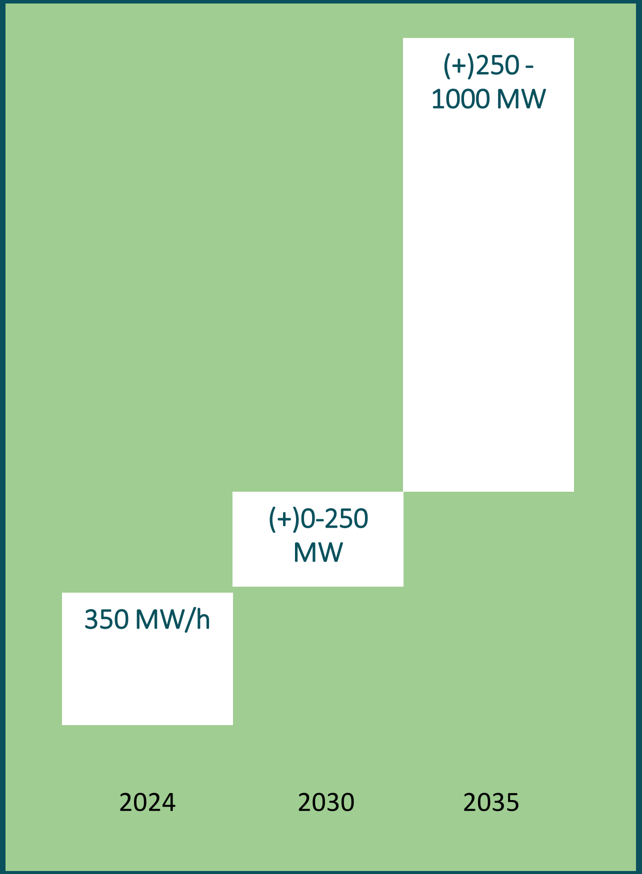
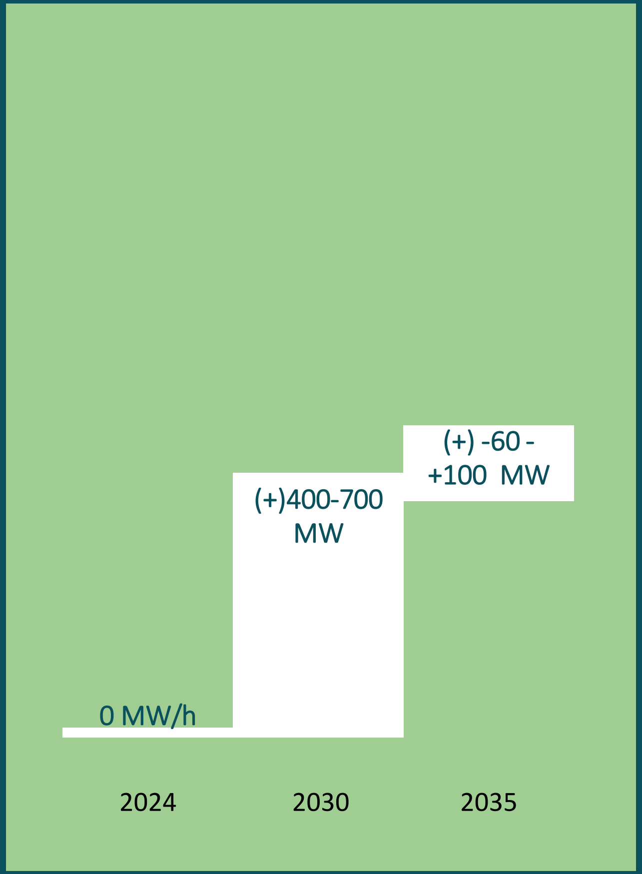


FIGURE 10 PROJECTED NEED FOR mFRR FOR DOWN-REGULATION IN DK2



STATUS AND PROJECTIONS FOR mFRR – INTRODUCTION

mFRR is an abbreviation of Manual Frequency Restoration Reserve. mFRR helps to alleviate major imbalances and ensures balance in the power system during extended periods of unplanned fluctuations.

mFRR is used both for up-regulation and down-regulation. mFRR is an asymmetric product, meaning that market participants are only required to provide either up-regulation or down-regulation.

Energinet procures mFRR in advance in the capacity market to ensure that enough energy is reserved. If a bid is choosen in the capacity market, the market participants is obligated to submit a matching bid in the energy activation market.

mFRR must be fully activated within 15 minutes. When the automated Nordic mFRR market is implemented in the beginning of 2025 the full activation time is reduced to 12.5 minutes.

mFFR is procured in both DK1 and DK2. There is a monthly mFRR auction in DK2 and an hourly mFRR capacity auction which is shared between DK1 and DK2.

In Energinet's Balance Universe you can get an overview of current and historical procurement volumes and prices for mFRR. Here, you will also find Energinet's Revenue Calculator, which offers an indication of which ancillary services a facility can deliver, as well as potential revenue based on historical prices. Please note that historical prices do not reflect Energinet's expectations for future prices nor do they guarantee future earnings.

CURRENT PROCUREMENT OF mFRR AT THE DAILY AUCTION IN DK1 AND DK2

Figure 11 shows the mFRR procurement volumes and prices in the daily auction in DK1 and DK2 from October 2023 to September 2024.

The need for mFRR is based on the loss of the largest local unit (reference incident). The resulting mFRR need in DK1 is 300 MW, because a sharing agreement between DK1 and DK2 reduces the need in DK1 by 300 MW. aFRR procurement of 100 MW in DK1 reduces the need for mFRR as well. The need in DK2 is 623 MW.

mFRR capacity is procured on an hourly basis at daily auctions in a common market between DK1 and DK2. With this common market, it is possible to exchange up to 10 % of the capacity between DK1 and DK2 via the Great Belt Connection. This means that demand in one area can be covered by supply in another area.

Reservations of transmission capacity ensure that energy can be transferred at any time. On 19 November 2024, a trilateral mFRR capacity market between Denmark, Sweden and Finland will replace the current DK1-DK2 market.

Figure 12 and 13 show the prequalified mFRR capacity in DK1 and DK2 in 2024. It is important to note that the quantities show a combination of both new and existing assets.

FIGURE 11 PROCURED mFRR CAPACITY AND PRICES IN THE DAILY AUCTION 2023-2024

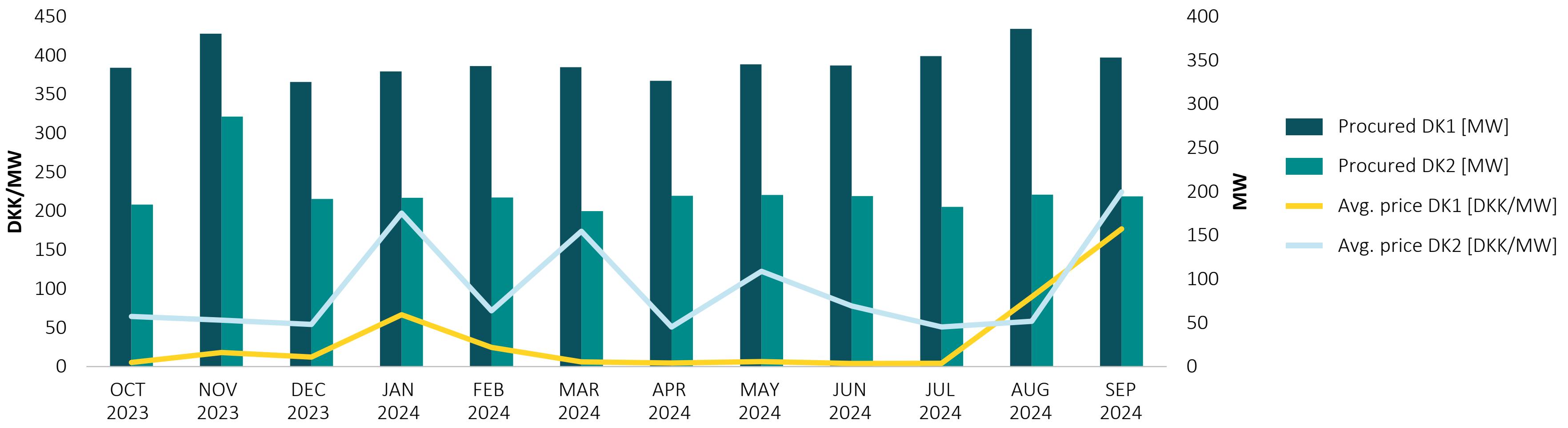


FIGURE 12 NEW PREQUALIFIED mFRR CAPACITY in DK1 2024

TECHNOLOGY	mFRR Up CM (12,5 min FAT) (MW)	mFRR Down CM (12,5 min FAT) (MW)
Steam turbine	164	242
Diesel engine	29,5	29,5
Electric boiler	473,3	472,3
Gas engine	46	42,5
Heat pump	0,1	0,1
Wind turbines	245	235

Figure 12: The indicated prequalified capacity covers both new and existing facilities. Numbers have been updated November 15, 2024.

FIGURE 13 NEW PREQUALIFIED mFRR CAPACITY in DK2 2024

TECHNOLOGY	mFRR Up CM (12,5 min FAT) (MW)	mFRR Down CM (12,5 min FAT) (MW)
Steam turbine	41	45
Diesel engine	1,7	1,7
Electric boiler	36	36
Gas engine	6,7	6,7
Gas turbine	6,2	3,5
Thermal Storage	5	5

Figure 13: The indicated prequalified capacity covers both new and existing facilities. Numbers have been updated November 15, 2024.

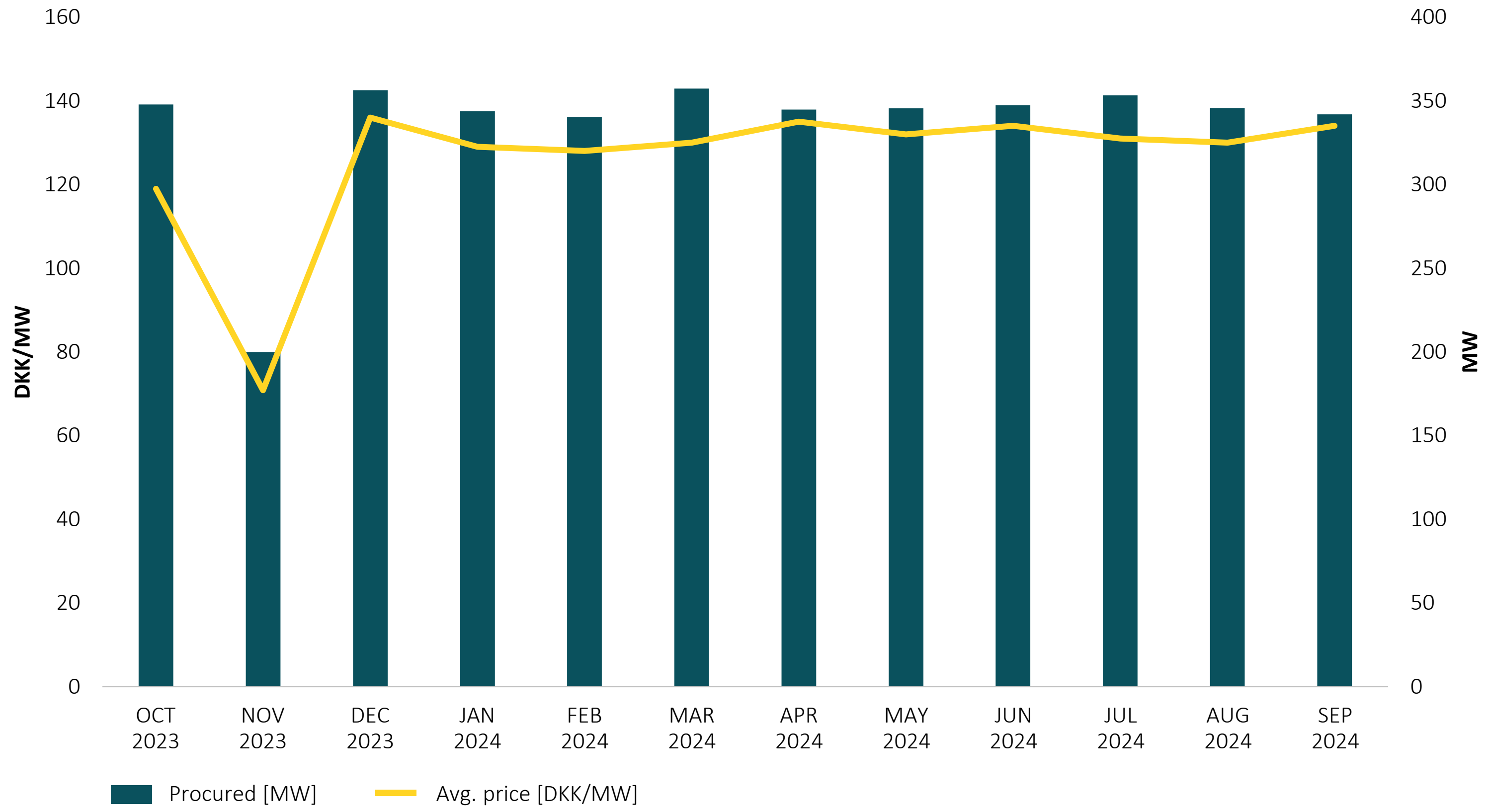
CURRENT PROCUREMENT OF mFRR AT THE MONTHLY AUCTION IN DK2

Figure 14 shows Energinet's procurement of mFRR capacity and prices in the monthly auction in DK2 from October 2023 to September 2024. The monthly mFRR up-regulation auction only exists in DK2. Historically the monthly market could cover up to maximum 60 % of the mFRR need in DK2.

From February 2025, the design of the monthly auction will change. Moving forward the monthly auction will only be for the specific product, slower resources, which is a mFRR product with a full activation time between 12,5 and 90 minutes. The standard mFRR product will be procured entirely on the daily mFRR auction. As is the case with standard mFRR reserves, slower mFRR reserves must also place energy bids in all contracted hours.

The procurement volumes will be based on price elasticity-based demand. In practice, this means that Energinet will only procure slower resources on the monthly auction if it is assessed that this will be cheaper than procuring the same amount in the daily auction. Price elasticity thus means that the produced amount on the monthly auction can vary. Energinet has the option to procure maximum the amount determined in the sharing agreement with Svenska kraftnät. Read more about price elasticity on page 50.

FIGURE 14 PROCURED mFRR CAPACITY AND PRICES IN THE MONTHLY AUCTION 2023-2024



PROJECTED NEED FOR mFRR FOR UP-REGULATION IN DK1

Energinet's projected need for mFRR for up-regulation in DK1 is shown in figure 15.

Trend 2025-2030: The projections indicates a 2025 need of 600 MW/h, which decreases towards 2030 to 400 MW/h. The overall FRR need is not decreasing, but the procured aFRR volumes are increasing, which impacts the remainder to be procured in the mFRR up market. There is a significant spread of 200 MW/h, indicating that some climate years would entail increased procurement.

Trend 2030-2035: There is an increase in the mFRR reserve need from 400 MW/h to 1.100 MW/h. The need derives from the implementation of the North Sea Energy Island and expected imbalances associated to a wind farm with high capacity on a relative limited geographical area. The spread is close to 700 MW/h.

Trend 2035-2040: During this period, the median value suggests a slight decrease in the reserve demand, reaching roughly 900 MW/h in 2040. The spread in FRR upward in 2040 ranges from 1.000-2.200 MW/h. With an aFRR of reserve of roughly 600 MW/h in 2040, the remaining need for mFRR is 400- 1600 MW/h, which is a quite significant spread.

The projection from the 2023-version of this report suggested 600-800 MW/h in 2030, 1.500-2.200 MW/h in 2035, and 2.500-3.200 MW/h in 2040. Compared to those values, the projected mFRR need for up-regulation is decreased. Some reserves are procured as aFRR. However, the main cause for the decrease is the changes to the projection methodology; inclusion of voluntary bids and the use of the actual TSO procedure with optimized approach for netting and sharing.

FIGURE 15 PROJECTED NEED FOR mFRR FOR UP-REGULATION IN DK1

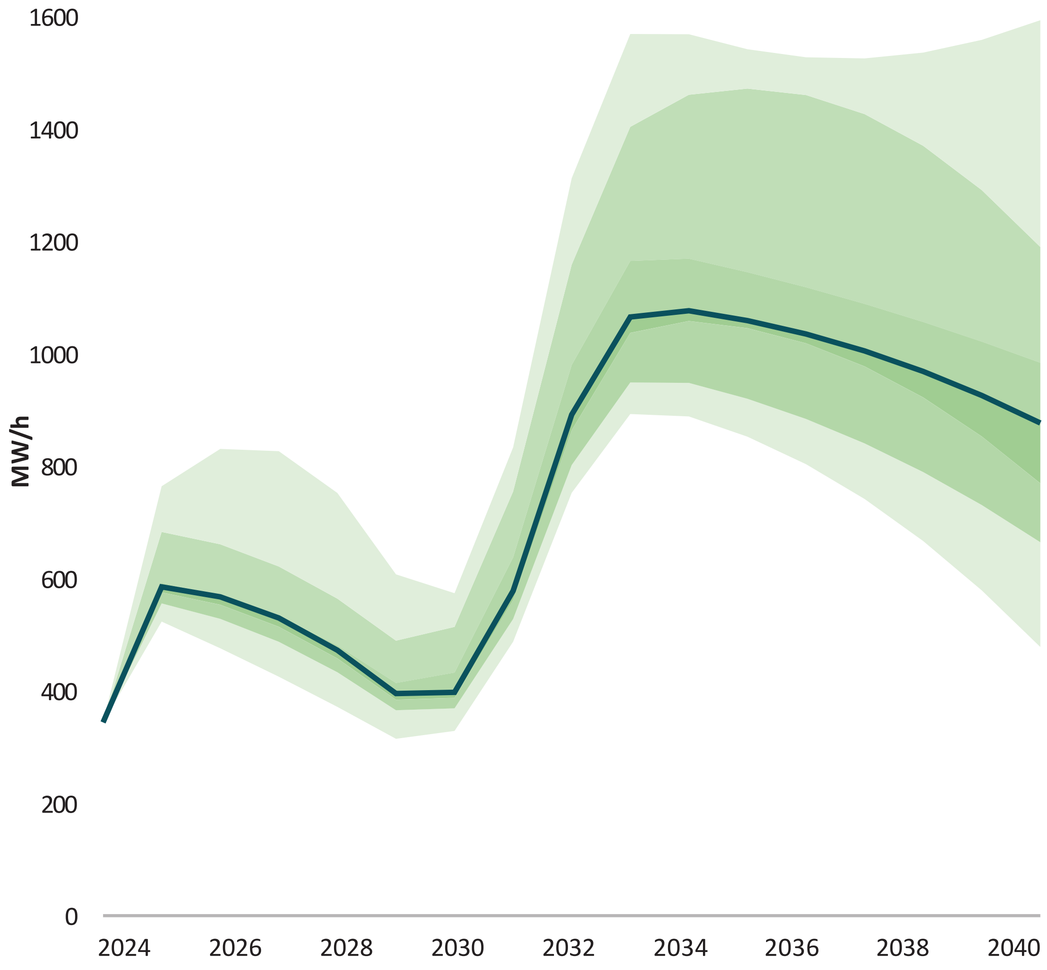


Figure 15 Median of projected need with 90 %,75 % and 10 % confidence intervals.

PROJECTED NEED FOR mFRR FOR DOWN-REGULATION IN DK1

Energinet's projected need for mFRR for down-regulation in DK1 is shown in figure 16.

Trend 2025-2030: From almost no procurement in 2025 to 50-200 MW/h in 2026, the short-term trend shows an increase. A local peak occurs in 2028, followed by a decline towards 2030, due to increased aFRR procurement to handle imbalance changes.

Trend 2030-2035: While the overall FRR need increases, aFRR procurement also increases towards 2035, decreasing the volume to be procured as mFRR downward reserve. However, there is a large spread in the results, indicating variations in different climate years.

Trend 2035-2040: During this period, the median value suggests an increase in reserve demand, reaching roughly 325 MW/h. The spread in FRR down-regulation needs in 2040 ranges from 600-1,400 MW/h. With aFRR needs of roughly 600 MW/h in 2040, the remaining spread for mFRR is 20-800 MW/h, which is quite a significant spread.

Projections from 2023 suggested 600-800 MW/h in 2030, 1,300-2,000 MW/h in 2035, and 2,300-3,000 MW/h in 2040. Compared to those values, the mFRR need has decreased significantly. Some reserves are procured as aFRR, but the main cause for the decrease is the inclusion of voluntary bids, which is significant for DK1 due to its history of using special regulation.

FIGURE 16 PROJECTED NEED FOR mFRR FOR DOWN-REGULATION IN DK1

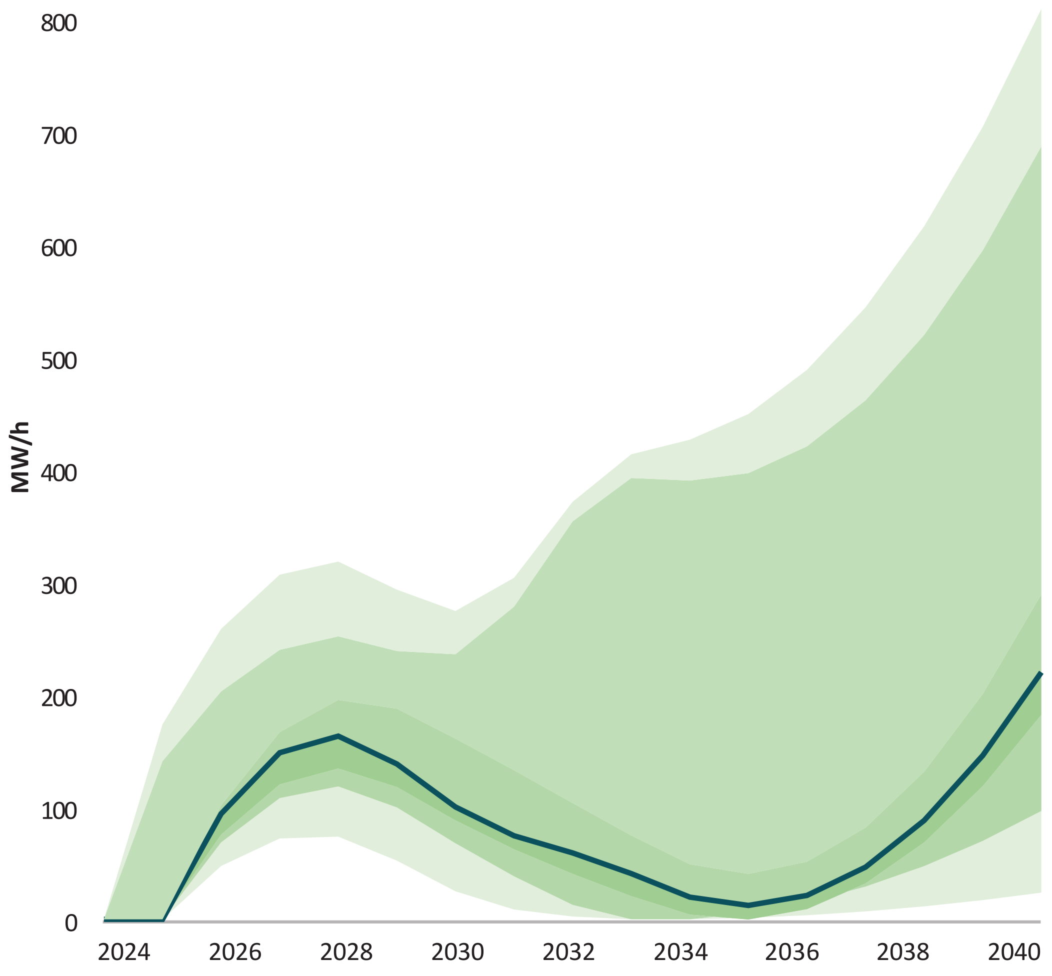


Figure 16 Median of projected need with 90 %,75 % and 10 % confidence intervals.

PROJECTED NEED FOR mFRR FOR UP-REGULATION IN DK2

Energinet's projected need for mFRR for up-regulation in DK2 is shown in figure 17.

Trend 2025-2030: The projections indicates a 2025 need of 600 MW/h, which decreases towards 2030 to 530 MW/h. The FRR need is not decreasing, but the procured aFRR volumes are increasing, which impacts the remainder to be procured in the mFRR up market negatively. There spread is in range of 200 MW/h between high and low projections, indicating that some climate years would entail increased mFRR reserves.

Trend 2030-2035: The trend of decreasing need for mFRR for up-regulation in DK2 is continuing towards 2035, going from 530 MW/h to 480 MW/h. However, the spread increases significantly with an upper value of 770 MW/h and a lower on 420 MW/h. The spread derives from the implementation of Bornholm Energy Island, Hesselø and Kriegers Flak 2 and the associated imbalances.

Trend 2035-2040: During this period, the median value suggests a slight increase towards 500 MW/h, but the projections mainly indicate a somewhat steady level in the reserve need.

The projections from the 2023-version of this report suggested 800-1,100 MW/h in 2030, 900-1,400 MW/h in 2035, and 1,000-1,600 MW/h in 2040. Compared to those values, the mFRR need for up-regulation is decreased substantially. Some reserves are procured as aFRR, but the main cause for the decrease is the inclusion of voluntary bids and using the actual TSO procedure with optimized approach for netting and sharing.

FIGURE 17 PROJECTED NEED FOR mFRR FOR UP-REGULATION IN DK2

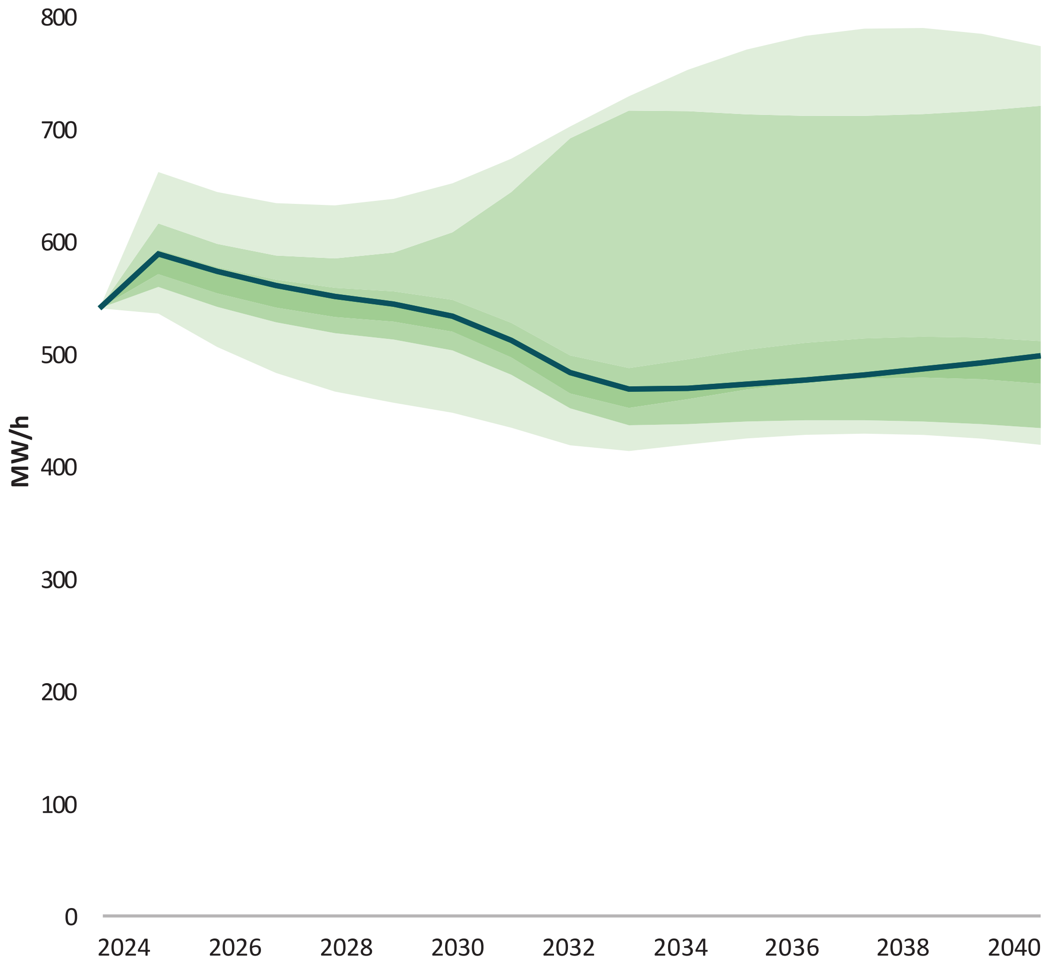


Figure 17 Median of projected need with 90 %,75 % and 10 % confidence intervals.

PROJECTED NEED FOR mFRR FOR DOWN-REGULATION IN DK2

Energinet's projected need for mFRR for down-regulation in DK2 is shown in figure 18.

Trend 2025-2030: In 2025 the expected procurement of mFRR reserves for down-regulation is around 80 MW/h. The projection indicate that the need for mFRR reserves for down-regulation in DK2 will increase from a range of 0-200 MW/h in 2025 to 400-600 MW/h in 2030. The spread is 200 MW/h over the period, indicating that reserve need can differ a lot depending on climate year.

Trend 2030-2035: While the overall FRR need is steady, the aFRR procurement increases towards 2035, which decreases the residual to be procured as mFRR downward reserve. The spread in the results seems to increase, but with a somewhat fixed upper level on 700 MW/h.

Trend 2035-2040: During this period, the results suggests an increase in the reserve demand, reaching roughly 550 MW/h. The spread in FRR downward in 2040 ranges from 620-1,100 MW/h. With an aFRR reserve of roughly 220 MW/h in 2040, the remaining spread for mFRR is 400-900 MW/h, which is a quite significant spread.

2023-projections suggested 750-1,000 MW/h in 2030, 900-1,300 MW/h in 2035, and 1,000-1,300 MW/h in 2040. Compared to those values, the mFRR need is significantly decreased. Some reserves are procured as aFRR, but the main cause for the decrease is the inclusion of voluntary bids and the optimized approach for netting and sharing.

FIGURE 18 PROJECTED NEED FOR mFRR FOR DOWN-REGULATION IN DK2

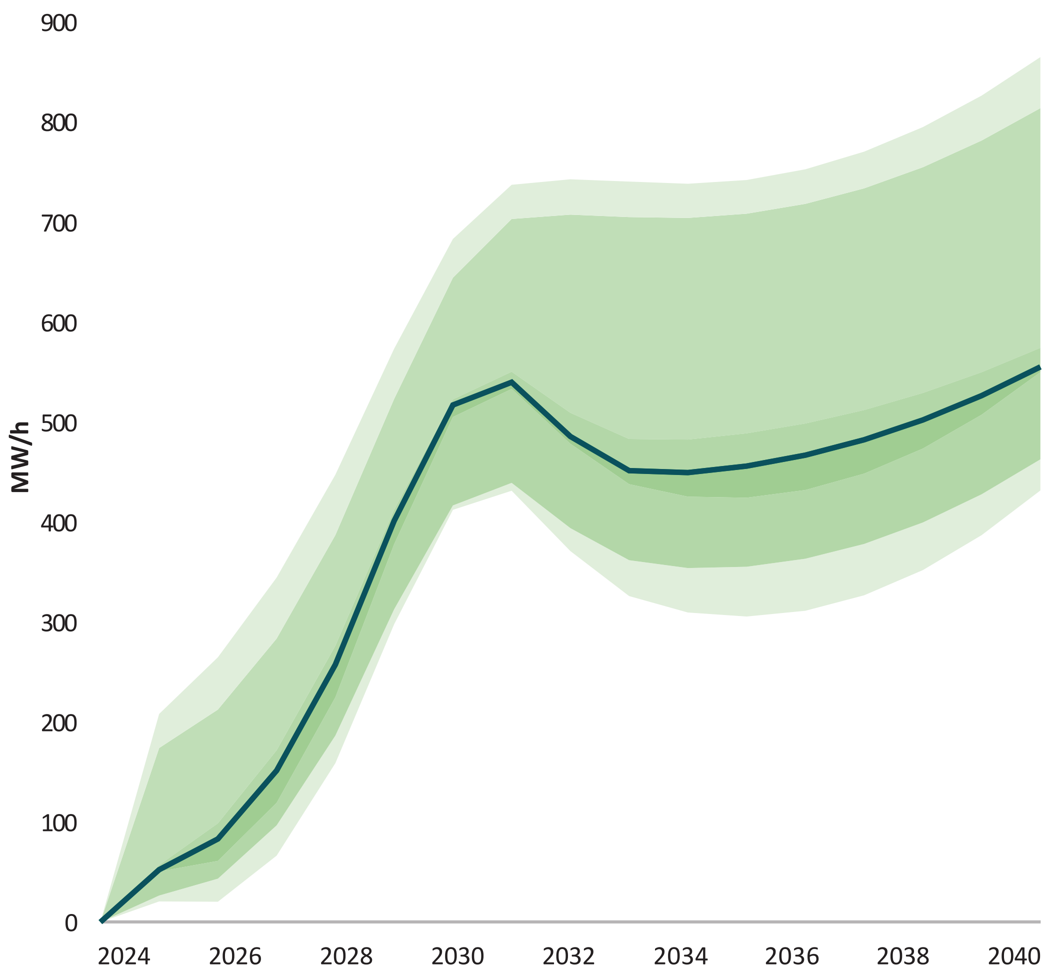


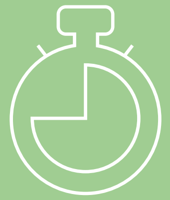
Figure 18 Median of projected need with 90 %,75 % and 10 % confidence intervals.

STATUS AND PROJECTIONS FOR aFRR – INTRODUCTION

aFRR is an abbreviation of Automatic Frequency Restoration Reserve. aFRR helps to address large and rapid imbalances and regulates the imbalance of the bidding zone towards zero.

aFRR is used both for up-regulation and down-regulation. aFRR is an asymmetric product, meaning that market participants are only required to provide either up-regulation or down-regulation.

Energinet procures aFRR in advance in the capacity market to ensure that enough energy is reserved. If a bid is choosen in the capacity market, the market participants is obligated to submit a matching bid in the energy activation market.



aFRR must be fully activated within 5 minutes.

aFFR is procured in both DK1 and DK2. DK2 is part of the Nordic aFRR capacity market, while DK1 has a separate aFRR capacity market.

In Energinet's Balance Universe you can get an overview of current and historical procurement volumes and prices for aFRR. Here, you will also find Energinet's Revenue Calculator, which offers an indication of which ancillary services a facility can deliver, as well as potential revenue based on historical prices. Please note that historical prices do not reflect Energinet's expectations for future prices nor do they guarantee future earnings.

CURRENT PROCUREMENT OF aFRR IN DK1

Figure 19 shows Energinet's procurement of aFRR capacity and prices in DK1 from October 2023 to August 2024.

On 2 October, Energinet went from procuring aFRR capacity with energy commitment in weekly auctions to a new aFRR market identical to the one in DK2, but exclusively for market participants in DK1. The transition took place in connection with DK1 being connected to the European platform for energy activation, PICASSO.

The change means that aFRR capacity is now procured in daily auctions for each hour of the following day. The market is asymmetrical, and the capacity commitment is to submit bids to the energy activation market. The aFRR need in DK1 has been stable at 100 MW for many years. Energinet has seen a lack of competition in the aFRR market in DK1, but the new market design could attract more market participants.

In case of a single bidder, settlement is made at the regulated price, and bidders have the right to ask for settlement at Cost Plus. Periods without competitive bids are indicated in the figure as periods with no market price indicated.

When DK1 got connected to PICASSO, Energinet consequently stopped procuring capacity in the weekly auctions. With the connection to PICASSO, the combined market for capacity and energy activation was also discontinued; from that point on, there has been a capacity market and an energy activation market, respectively. At the time of preparing this report, it was not possible to include data from the time following the transition to PICASSO, and it should therefore be noted that any prices included in this report stem from the former market set-up.

It is important to note that the prequalified capacity listed in figure 20 and figure 21 is a combination of both new and existing assets. The largest share comes from existing assets which have had to be re-approved in respect of the new requirements in connection with the transition to PICASSO.

FIGURE 19 PROCURED aFRR CAPACITY AND PRICES IN DK1 2023-2024

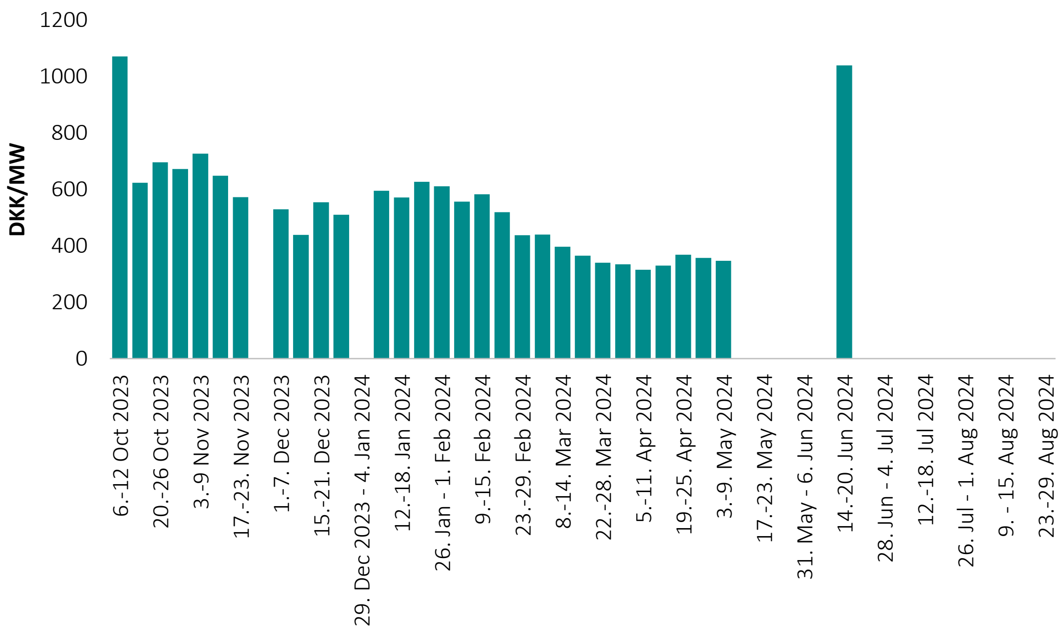


FIGURE 20 NEW PREQUALIFIED aFRR CAPACITY IN DK1 2024

TECHNOLOGY	Capacity (MW) up-regulation	Capacity (MW) down-regulation
Steam turbine	51,9	51,9
Diesel engine	28,9	18,8
Electric boiler	343,7	298
Wind turbines	245	235

Figure 20: The indicated prequalified capacity covers both new and existing facilities. Numbers have been updated November 15, 2024.

PROJECTED NEED FOR aFRR IN DK1

Energinet's projected need for aFRR towards 2040 in DK1 is shown in figure 21. The calculations show that the need for aFRR for up-regulation and down-regulation nearly coincide, and the projections are therefore shown in a single figure.

Part of the FRR need is covered by aFRR to quickly counter imbalance changes. Starting in 2024, the procurement is 100 MW/h for both up-regulation and down-regulation, but several analyses indicate that the need for aFRR is greater, as shown in the projections.

Trend 2025-2030: The need increases linearly towards 2030 with only minor variation in the results. Projections suggest an aFRR need in 2030 ranging from 250-320 MW/h for both up-regulation and down-regulation. The median value indicates a total aFRR need of close to 600 MW/h in 2030 (up-regulation and down-regulation).

Trend 2030-2035: The aFRR need escalates from 300 MW/h to 500 MW/h, closely related to the development in imbalances that mostly stems from the commissioning of the North Sea Energy Island due to its large capacity. The spread increases, indicating increased uncertainty, but remains within a 75 MW/h interval.

Trend 2035-2040: During this period, there is a slow rise towards a maximum of 600 MW/h and a lower interval of 500 MW/h. Note that there are no simulation years between 2035 and 2040.

Compared with the projections from last year's report, the need for aFRR capacity has increased significantly. Rather than a slow progression to roughly 300 MW/h by 2040, the need now seem to double. This increase is partly due to higher expectations for solar power and wind production in AF23 which causes more imbalances.

FIGURE 21 PROJECTED NEED FOR aFRR IN DK1

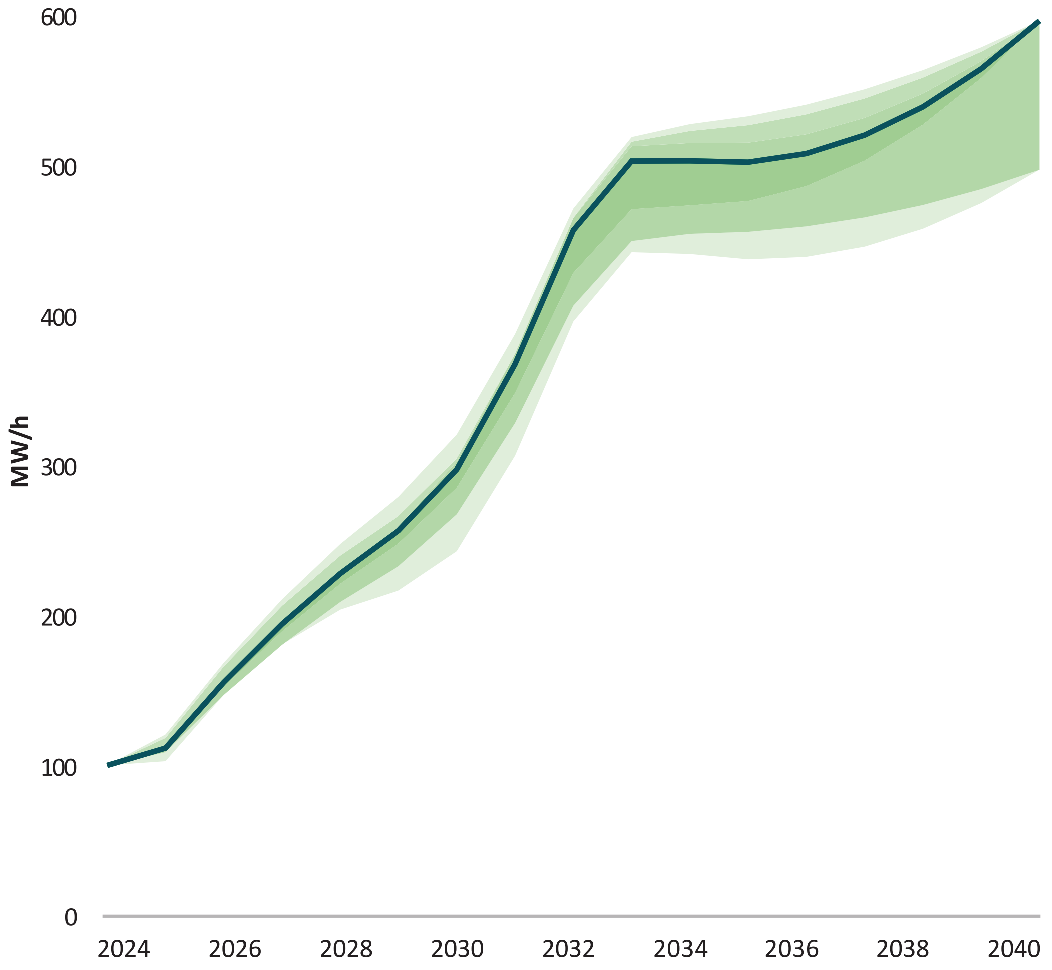


Figure 21 Median of projected need with 90 %,75 % and 10 % confidence intervals.

CURRENT PROCUREMENT OF aFRR IN DK2

Figure 22 shows Energinet's procurement of aFRR capacity and prices in DK2 from October 2023 to July 2024.

Energinet procures aFRR capacity in DK2 based on current need, which is assessed continuously by all Nordic TSOs. Since 1 July 2024, The Nordic TSO's has procured aFRR volumes of 300 MW in most hours and 400 MW in the morning hours on weekdays. In the late evening hours, 400 MW down-regulation is also procured.

The current Danish need is 0/38/52 MW for both up-regulation and down-regulation at different hours at the day. aFRR is procured hourly in a common Nordic market with separate auctions for up-regulation and down-regulation.

In October 2024, Energinet became connected to PICASSO, the common European platform for aFRR energy activation. This means that aFRR is procured in an energy activation market separate from the capacity market. With that, procured capacity bids must be submitted as energy bids in PICASSO. The price of aFRR is determined on marginal pricing on PICASSO.

Figure 22 shows procured capacity per hour and the average hourly price per MW. The figure indicates, that Danish market participants have supplied a relatively small share of the Nordic demand. At the same time, it is evident that the price has remained somewhat stable during the period.

It is important to note that the prequalified capacity listed in figure 23 and 24 show a combination of both new and existing assets.

FIGURE 22 PROCURED AFRR CAPACITY AND PRICES IN DK2 2023-2024

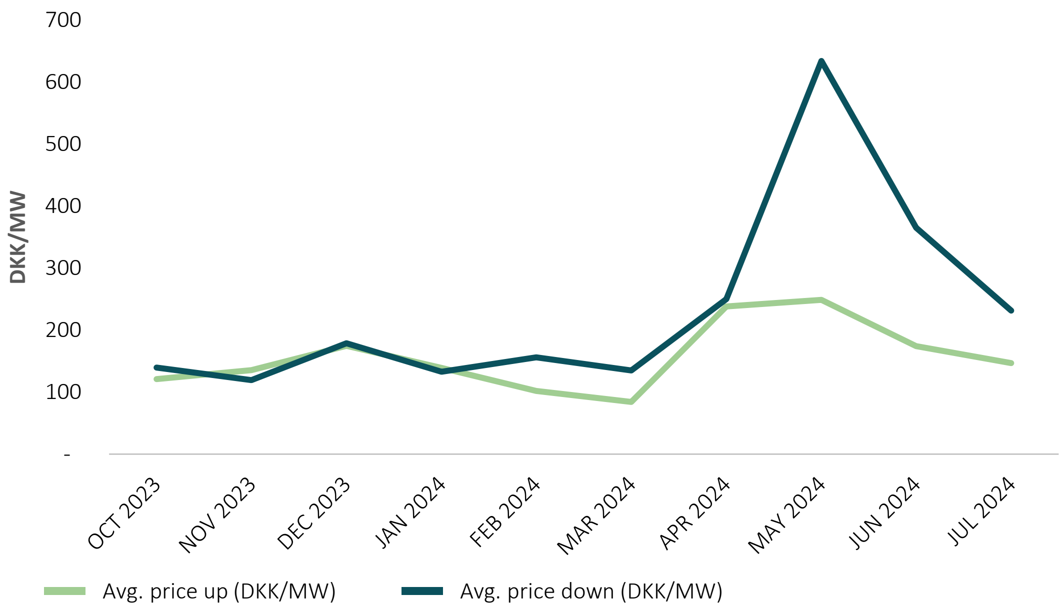


FIGURE 23 NEW PREQUALIFIED aFRR CAPACITY IN DK2 2024

TECHNOLOGY	Capacity (MW) up-regulation	Capacity (MW) down-regulation
Steam turbine	41	45
Electric boiler	32,2	34,2
Gas engine	0,3	-
Thermal storage	5	5

Figure 23: The indicated prequalified capacity covers both new and existing facilities. Numbers have been updated November 15, 2024.

PROJECTED NEED FOR aFRR IN DK2

Energinet's projected need for aFRR towards 2040 in DK2 is shown in figure 24. The calculations show that the aFRR up-regulation and down-regulation needs nearly coincide, and the projections are therefore shown in a single figure.

Part of the FRR need is covered by aFRR to quickly counter changes in imbalances. Starting in 2024, the procurement ranges between 40-50 MW/h for both up-regulation and down-regulation, based on the quality of the Nordic frequency. When aFRR switches to being activated by the Area Control Error (ACE), Energinet's analyses indicate a slight increase in the aFRR need.

Trend 2025-2030: The aFRR need in DK2 increases moderately towards 2030 with a narrow spread in the results. The projections suggest a need for aFRR in 2030 ranging between 80-100 MW/h for both up-regulation and down-regulation. The median value indicates a total need for aFRR close to 180 MW/h in 2030, comprising both up-regulation and down-regulation.

Trend 2030-2035: The aFRR need escalates further from a median on 90 MW/h to 200 MW/h in 2035. The increase is closely related to the development of imbalances, which is impacted by Bornholm Energy Island, Hesselø, and Kriegers Flak 2. The spread also increases, indicating higher uncertainty of the results, but remains within a 25 MW/h interval.

Trend 2035-2040: During this period, there is a slow rise towards a maximum of 220 MW/h and a low value of 180 MW/h. Note that there are no simulation years between 2035 and 2040.

Compared with projections from 2023, the need for aFRR capacity has significantly increased. Rather than a slow progression to roughly 100 MW/h in up-regulation needs and 150 MW/h in down-regulation needs by 2040, needs are now greater and seen earlier. This increase is partly due to higher expectations for solar power and wind production in AF23, which cause further imbalances.

FIGURE 24 PROJECTED NEED FOR aFRR FOR UP-REGULATION AND DOWN-REGULATION IN DK2

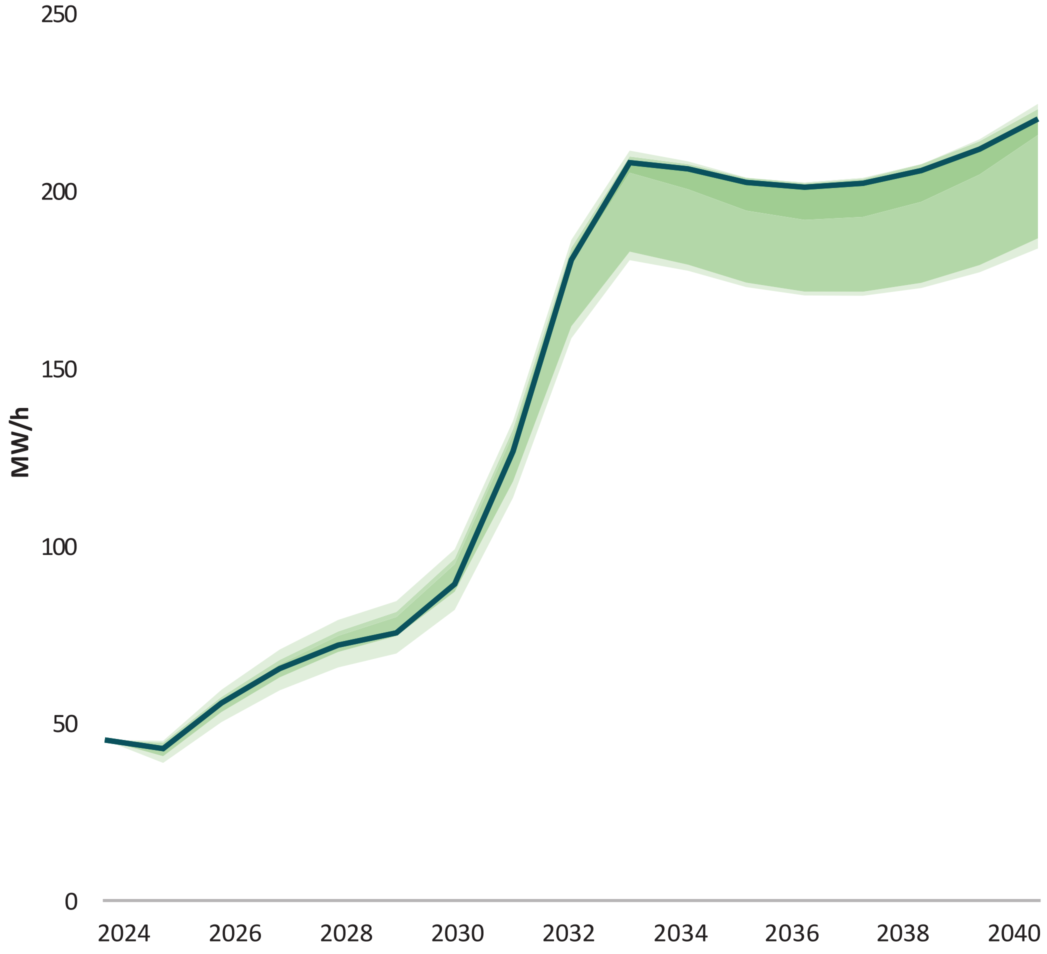


Figure 24 Median of projected need with 90 %,75 % and 10 % confidence intervals.

STATUS AND PROJECTIONS FOR FCR – INTRODUCTION

FCR is an abbreviation of Frequency Containment Reserve. FCR responds quickly and automatically to frequency deviations in the power system.

FCR is used for both up-regulation and down-regulation. FCR is a symmetrical product, meaning that market participants must be capable of providing both up-regulation and down-regulation.

Energinet procures FCR in advance in the capacity market to ensure that enough energy is available for automatic activation.

FCR must be fully activated within 30 seconds.

Energinet only procures FCR in DK1 at a common central European market.

In Energinet's Balance Universe you can get an overview of current and historical procurement volumes and prices for FCR. Here, you will also find Energinet's Revenue Calculator, which offers an indication of which ancillary services a facility can deliver, as well as potential revenue based on historical prices. Please note that historical prices do not reflect Energinet's expectations for future prices nor do they guarantee future earnings.

CURRENT PROCUREMENT OF FCR IN DK1

Energinet only procures FCR in DK1 at a common central European market. The Danish share of FCR-capacity is determined based on the sum of consumption and production relative to the total production and consumption of the European synchronous area. Currently, the share of DK1 is approximately 0.83 %, equivalent to 25 MW. In addition, Denmark is allowed to share up to 100 MW with the members of the FCR cooperation, making the FCR market total 125 MW/h in 2025 for a Danish market participant. The 100 MW export to Germany can be increased if Danish market participants start to saturate the market.

Figure 25 shows Energinet's procurement of FCR capacity and prices in DK2 from October 2023 to September 2024. In 2024, Energinet has procured 25 MW FCR per hour on an annual basis.

There have been no major changes to the FCR market in 2024. The market is characterized by its stability, but also by a lack of Danish market participants. Energinet does not expect any changes to the FCR market in the near future.

Prequalified capacity in 2024 is shown in figure 26. It is important to point out that the quantities comprise a combination of both new and existing facilities.

FIGURE 25 PROCURED FCR CAPACITY AND PRICES IN DK 1 2023-2024

FIGURE 26 NEW PREQUALIFIED FCR CAPACITY IN DK1 2024

TECHNOLOGY	Capacity (MW)
Battery	1
Electric boiler	75

Figure 26: The indicated prequalified capacity covers both new and existing facilities.

PROJECTED NEED FOR FCR IN DK1

Energinet's projected need for FCR in DK1 towards 2040 is shown in figure 27.

Trend 2025-2030: With an increasing degree of electrification and the continued development of renewable energy sources, the Danish FCR sharing key is expected to increase. As a result, further FCR capacity will be needed in DK1. The scenarios suggest a rise of additional 25 MW/h by 2030, bringing the total market capacity to 150 MW/h, where off 50 MW/h is the Danish share.

Trend 2030-2035: Further growth is anticipated, with an increase of approximately 20-30 MW/h, expanding the market to around 160-170 MW/h, where off 60-70 MW/h is the Danish share.

Trend 2035-2040: The same upward trend is projected for 2035-2040, where the FCR reserve capacity is expected to reach between 170-195 MW/h, with the Danish share being 70-95 MW/h.

Compared with the projections in last year's report, projections show little deviation, indicating stable expectations for energy production and consumption across Europe.

The FCR requirement for Continental Europe is set in the EU System Operation Guideline (SO GL) at 3 GW for both up-regulation and down-regulation. In the beginning of 2024, all TSOs in continental Europe unanimously submitted the new methodology of probabilistic dimensioning of FCR in continental Europe to their respective national regulatory authorities. If the methodology is approved, it is expected to slightly increase the FCR need. Read more about dimensioning of FCR and the new methodology on page 14. Looking further ahead, an increase in limited energy reservoirs (LER) penetration of the FCR markets will increase procurement more significantly.

FIGURE 27 PROJECTED NEED FOR FCR IN DK1

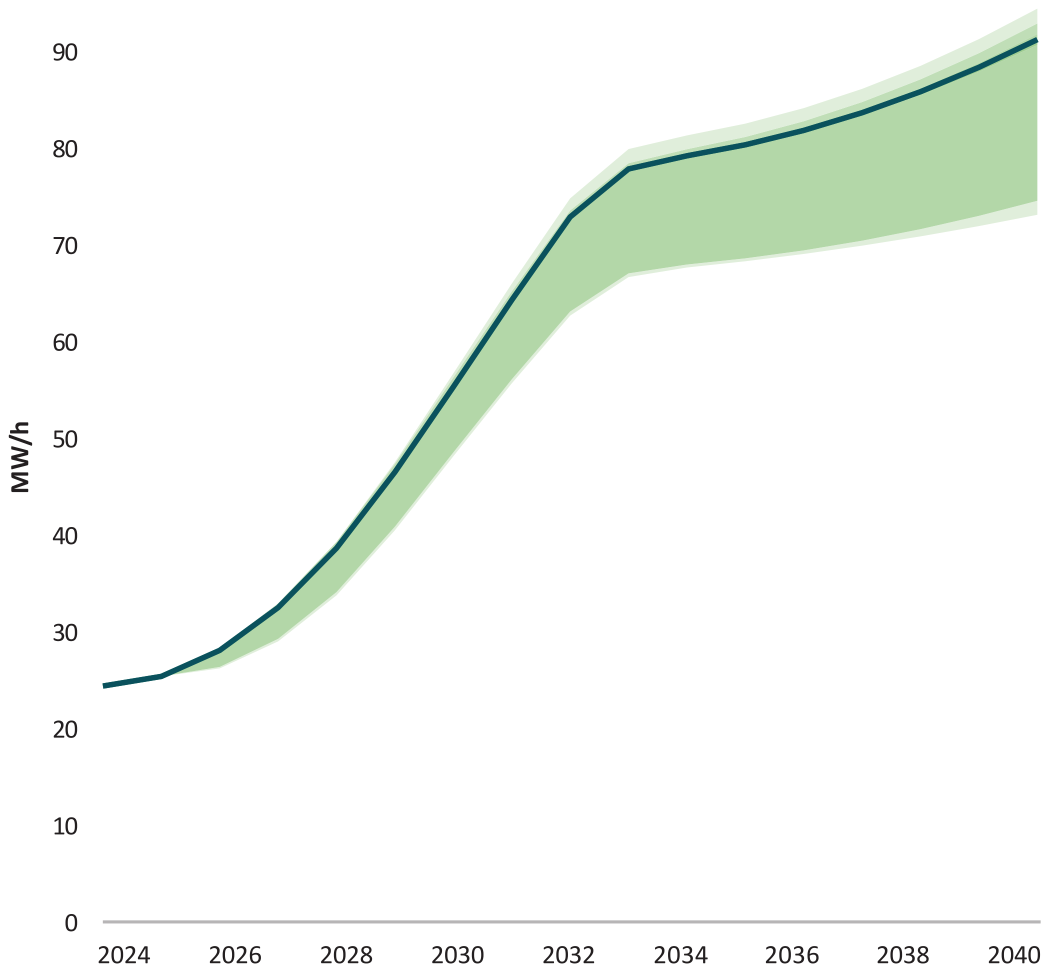


Figure 27 Median of projected need with 90 %,75 % and 10 % confidence intervals.

STATUS AND PROJECTIONS FOR FCR-D – INTRODUCTION

FCR-D is an abbreviation of Frequency Containment Reserve – Disturbance. FCR-D is designed to stabilize the frequency in the power grid in DK2 and the rest of the Nordic synchronous area in the event of frequency drops or deviations.

FCR-D is used for both up-regulation and down-regulation. FCR-D is an asymmetric product, meaning that market participants are only required to provide either up-regulation or down-regulation.

Energinet procures FCR-D in advance in the capacity market to ensure that enough energy is available for automatic activation.

86 % of the FCR-D capacity must be activated within 7.5 seconds.

Energinet only procures FCR-D in DK2 in a common Danish-Swedish market.

In Energinet's Balance Universe you can get an overview of current and historical procurement volumes and prices for FCR-D. Here, you will also find Energinet's Revenue Calculator, which offers an indication of which ancillary services a facility can deliver, as well as potential revenue based on historical prices. Please note that historical prices do not reflect Energinet's expectations for future prices nor do they guarantee future earnings.

CURRENT PROCUREMENT OF FCR-D IN DK2

Energinet procures both FCR-D up-regulation and FCR-D down-regulation in a Danish-Swedish market. FCR-D is procured on an hourly basis, and the combined Danish-Swedish need is approximately 610 MW for FCR-D up-regulation, with a Danish share of 43 MW, and approximately 512 MW for FCR-D down-regulation, with a Danish share of 42 MW in 2024.

The maximum Danish coverage of the Swedish share is 1/3, meaning that the potential market for Danish market participants amounts to 232 MW up-regulation and 199 MW down-regulation.

FCR-D is activated more frequently than FFR, and delivery is proportional to the frequency deviation. Since large frequency deviations are rare, full activation of FCR-D is only seen in extreme situations.

The FCR-D market runs efficiently, and Energinet finds it positive that Danish market participants deliver increasing volumes.

Figure 28 shows Energinet's procurement of FCR-D capacity and prices in DK2 from October 2023 to September 2024. The price drop in May for FCR-D down-regulation in Sweden-East and DK2 continued into September. Prices remain extremely low for the season.

FIGURE 28 PROCURED FCR-D CAPACITY AND PRICES IN DK2 2023-2024

A contributing factor to the low prices is a significant increase in the number of prequalified facilities in Sweden. The amount of batteries/energy storage systems in Sweden capable of delivering FCR-D has grown by more than 250 MW during the first half of 2024.

Figure 29 presents new prequalified static FCR-D capacity, and figure 30 presents new prequalified dynamic FCR-D capacity. It is important to point out that the volumes comprise a combination of both new and existing assets, which Energinet in 2024 has approved to deliver FCR-D.

FCR-D down-regulation is a product which is still in the implementation phase. In September, the Swedish need for FCR-D for down-regulation was set at 410 MW, and this value was raised by 60 MW as of 1 October 2024. The full Swedish need is 547 MW. In December 2024 Svenska kraftnät will announce how much the demand for FCR-D down-regulation will be increased effective from January 1st 2025.

FIGURE 29 NEW PREQUALIFIED STATIC FCR-D CAPACITY FOR UP-REGULATION AND DOWN CAPACITY IN DK2 2024

TECHNOLOGY	FCR-D Up Capacity (MW)	FCR-D Down Capacity (MW)
Electric Vehicles	25,5	
Flexible consumption	0,31	8,2
Electric boiler		1,4
Fanset		6,1
Load bank		5,8
Solar PV		29

Figure 29: The indicated prequalified capacity covers both new and existing facilities.

FIGURE 30 NEW PREQUALIFIED DYNAMIC FCR-D CAPACITY FOR UP-REGULATION AND DOWN-REGULATION IN DK2 2024

TECHNOLOGY	FCR-D Up Capacity (MW)	FCR-D Down Capacity (MW)
Battery	21,9	21,4
Electric boiler		2,5
Load bank	1,2	1,3
Fanset		7,1

Figure 30: The indicated prequalified capacity covers both new and existing facilities.

PROJECTED NEED FOR FCR-D IN DK2

Energinet's projected need for FCR-D in DK2 towards 2040 is shown in figure 31. Since the need for FCR-D for up-regulation and down-regulation will be very similar, the projections are shown together. FCR-D is procured on a common Danish-Swedish market. Read more about the FCR-D market and the Danish market share on page 37-38.

The FCR-D need is based on the largest incident (reference incident, RI) at the Nordic level for both up-regulation and down-regulation. The dimensioning of the largest unit is continuously updated, causing some variations in FCR-D needs throughout the year. In the long term, with larger units and more fluctuating production, the FCR-D requirement might change more frequently.

FCR-D for down-regulation is still a relatively new ancillary service product, which is why the Swedish TSO Svenska kraftnät has gradually increased the procurement need over the past few years. Svenska kraftnät has announced in *Behov av reserver idag och i framtiden* that they will procure the full amount of FCR reserves from 2025 onward.

Trend 2025-2030: Towards 2030 the trend for the Danish sharing key seems to increase steadily. By end 2030 the projections indicates a range of 38-51 MW. Sweden is experiencing a decrease, causing an overall decline in the Danish-Swedish FCR-D need in this period.

Trend 2030-2035: The Danish need increases quite significant towards 2033 due to Bornholm Energy Island gradually starting production. By 2035 the projections of the Danish need indicates a range between 55-72 MW/h. In a Danish-Swedish perspective, results indicate a continuous slight decrease.

Trend 2035-2040: From 2035 to 2040, projections indicate a slight increase in the need for FCR-D with need ranging between 58-81 MW/h. The same applies when looking at the Danish-Swedish market, where the procurement returns to the 2030 level.

The results are largely consistent with the values and trends from the 2023-version of this report. The main difference is in the upper projections from 2030. Last year's projections indicated close to 240 MW, whereas this year's calculations show 230 MW, which is the current procurement level.

FIGURE 31 PROJECTED NEED FOR FCR-D IN DK2

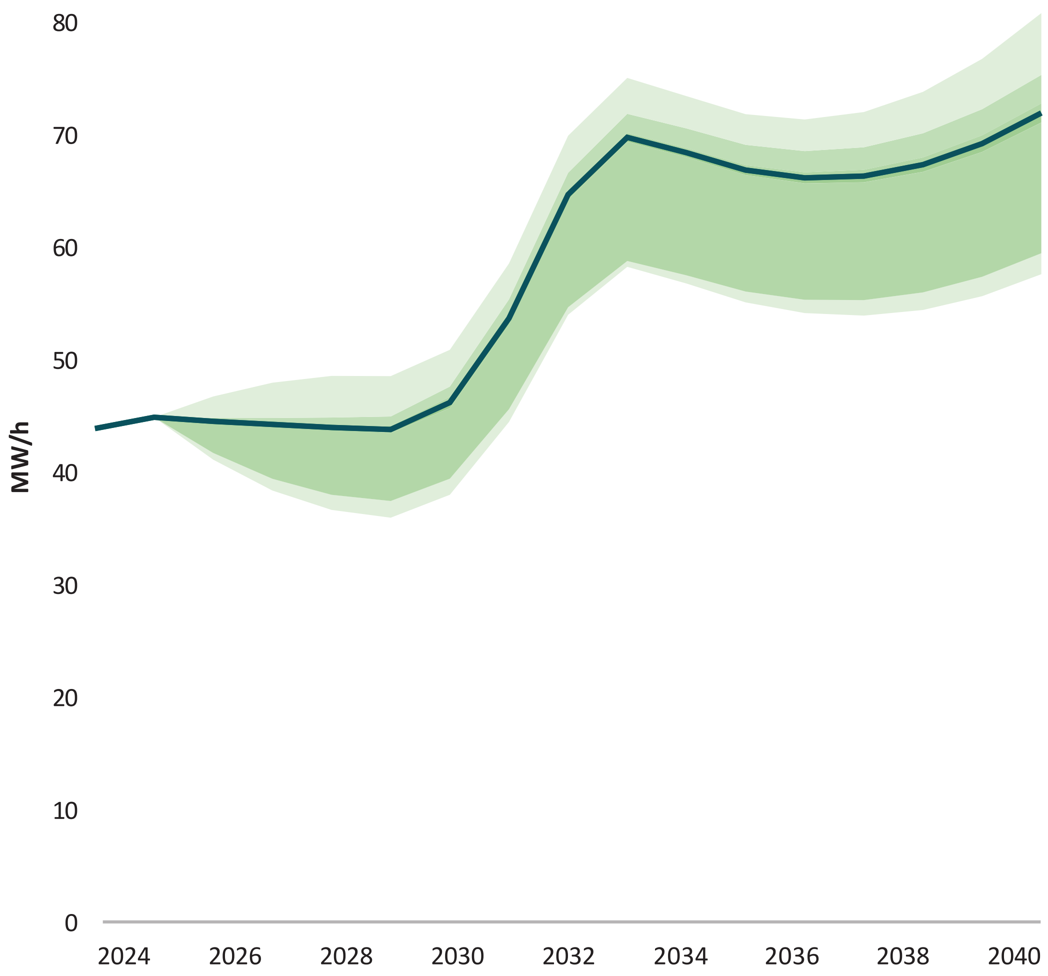
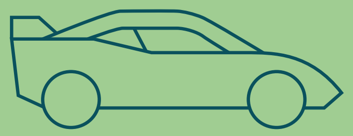


Figure 31 Median of projected need with 90 %,75 % and 10 % confidence intervals.

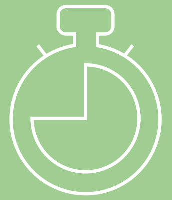
STATUS AND PROJECTIONS FOR FCR-N – INTRODUCTION



FCR-N is an abbreviation of Frequency Containment Reserve – Normal. FCR-N is designed to continuously stabilize the frequency in the power grid in DK2 and the rest of the Nordic synchronous area.

FCR-N is used for both up-regulation and down-regulation. FCR is a symmetric product, meaning that market participants are required to be capable of providing both up-regulation and down-regulation

Energinet procures FCR-N in advance in the capacity market to ensure that enough energy is available for automatic activation.



63 % of the FCR-N capacity must be activated within 60 seconds, and 95 % must be activated within 3 minutes.

Energinet only procures FCR-N in DK2 at a common Danish-Swedish market.

In Energinet's Balance Universe you can get an overview of current and historical procurement volumes and prices for FCR-N. Here, you will also find Energinet's Revenue Calculator, which offers an indication of which ancillary services a facility can deliver, as well as potential revenue based on historical prices. Please note that historical prices do not reflect Energinet's expectations for future prices nor do they guarantee future earnings.

CURRENT PROCUREMENT OF FCR-N IN DK2

Figure 32 shows Energinet's current procurement of FCR-N capacity and prices in DK2.

Energinet procures FCR-N in a joint Danish-Swedish market with the Swedish TSO Svenska kraftnät. The market trades on an hourly basis and has a combined Danish-Swedish need of approximately 252 MW.

The current allocation key for DK2 is approximately 3 %, resulting in an 18 MW need. The Swedish share and need are much higher at 231 MW. The maximum allowed Danish coverage is 1/3 of the Swedish need. Thus, for a Danish market participant, the FCR-N market totals 95 MW.

FCR-N has a high activation rate since it is activated within the frequency range 49.9 Hz to 50.1 Hz. This means that FCR-N deliveries involve significant energy activation, resulting in energy payments based on the best of the regulating power price and spot price. As FCR-N is a symmetric product, it typically reduces the overall energy from an FCR delivery since up-regulations and down-regulations tend to offset each other over time.

It is important to point out that the prequalified capacity listed in figure 33 shows a combination of both new and existing assets.

FIGURE 32 PROCURED FCR-N CAPACITY AND PRICES IN DK2 2023-2024

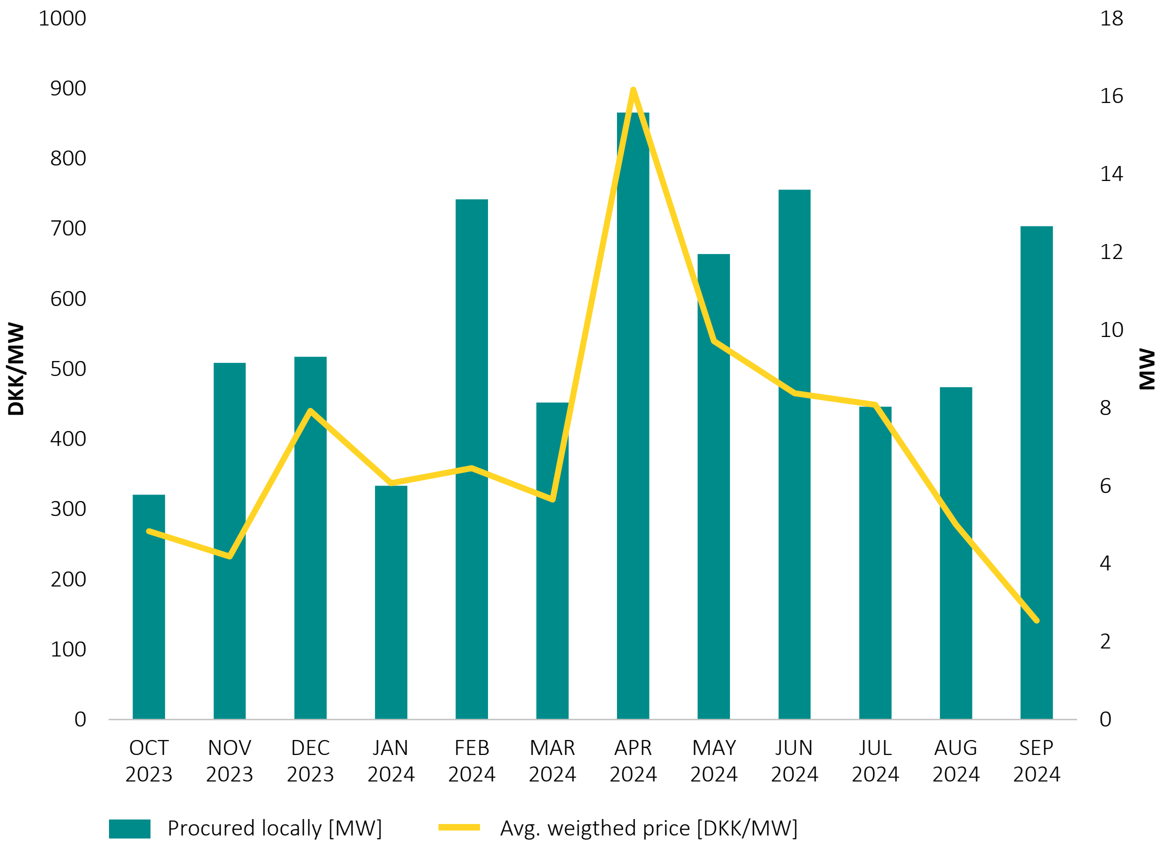


FIGURE 33 NEW PREQUALIFIED FCR-N CAPACITY IN DK2 2024

TECHNOLOGY	Capacity (MW)
Battery	6.2
Electric boiler	9.2
Electric vehicles	0.4

Figure 33: The indicated prequalified capacity covers both new and existing facilities.

PROJECTED NEED FOR FCR-N IN DK2

Figure 34 shows Energinet's projected need for FCR-N in DK2 towards 2040.

FCR-N is currently dimensioned based on a historical assumption that consumption can vary relatively quickly by approximately 1 % of 60 GW, resulting in a minimum Nordic requirement of 600 MW. In the projections, this assumption has not been changed, i.e. only the sharing keys based on consumption and production have been changed.

Trend 2025-2030: Towards 2030, the trend for the Danish sharing key seems to be increasing and by 2030 the projected Danish share ranges from 16-21 MW. There is a peak in the Danish-Swedish market in 2027, but Sweden are experiencing a decrease which causes an overall decrease in the Danish-Swedish FCR-N market in 2030 compared to the current level.

Trend 2030-2035: With the gradual increasing production from Energy Island Bornholm and larger consumption, the Danish share increases significantly. The projections indicates a need ranging between 22-30 MW/h. In the Danish-Swedish market, the prognosis indicate a slight decrease due to a continuous diminishing Swedish sharing key.

Trend 2035-2040: From 2035 to 2040, there is a slight increase indicating the Danish share to range between 24-34 MW/h. In the Danish-Swedish market, the level returns to a 2030 level. This increase could be even higher if Sweden decides to build the proposed nuclear power plants, assuming they will be operational by 2040.

The results are largely consistent with the values and trends from the 2023 projections. The main difference is in the upper projections from 2030: last year, these indicated a value slightly above 100 MW, whereas this year's calculations show a value of 95 MW.

FIGURE 34 PROJECTED NEED FOR FCR-N IN DK2

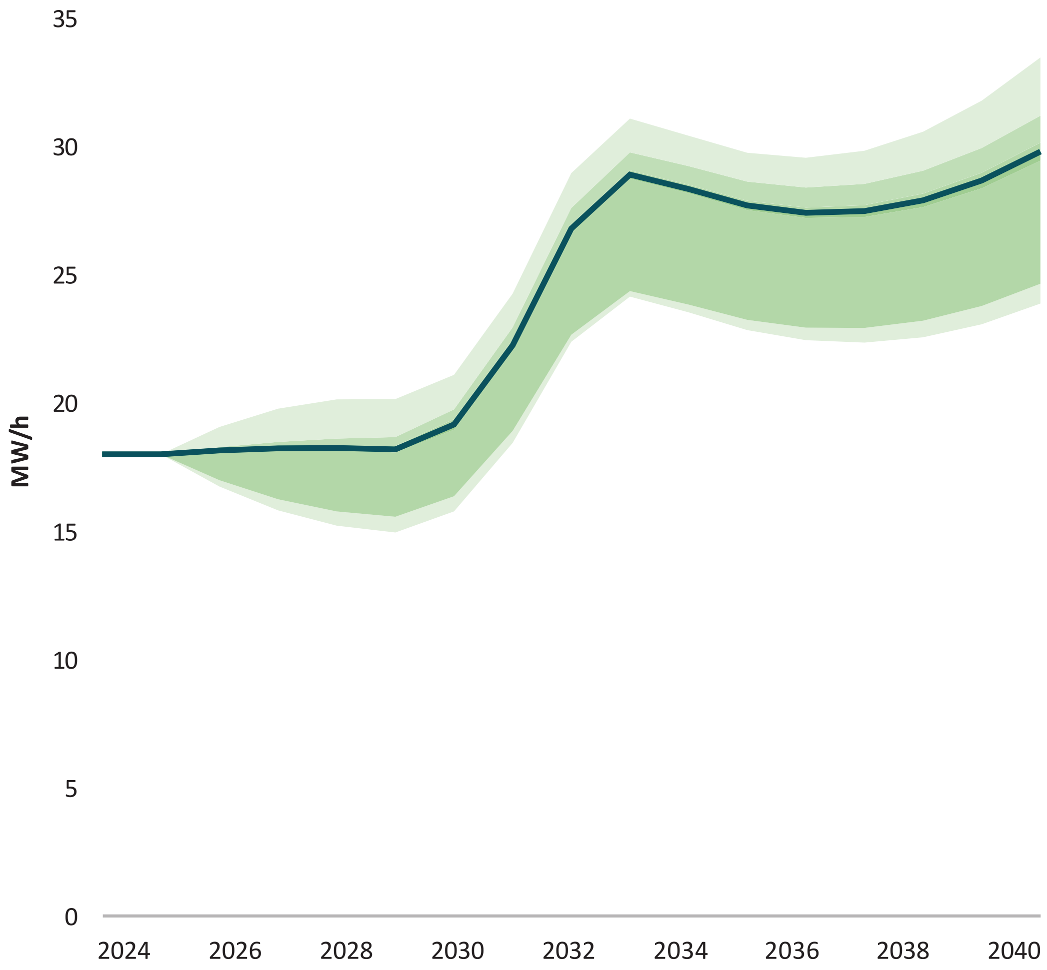


Figure 34 Median of projected need with 90 %,75 % and 10 % confidence intervals.

STATUS AND PROJECTIONS FOR FFR – INTRODUCTION

FFR is an abbreviation of Fast Frequency Reserve. FFR mitigates large frequency drops by rapidly providing more energy to the power system.

FFR is only used for upregulation.

Energinet procures FFR in advance in the capacity market to ensure that enough energy is available for automatic activation.

FFR must be fully activated within 0.7-1.3 seconds.

Energinet only procures FFR in DK2.

In Energinet's Balance Universe you can get an overview of current and historical procurement volumes and prices for FFR. Here, you will also find Energinet's Revenue Calculator, which offers an indication of which ancillary services a facility can deliver, as well as potential revenue based on historical prices. Please note that historical prices do not reflect Energinet's expectations for future prices nor do they guarantee future earnings.

CURRENT PROCUREMENT OF FFR IN DK2

Figure 35 shows Energinet's current procurement of FFR capacity and prices in DK2.

Energinet has procured FFR since 2020. It is procured hourly, and the need for FFR is continuously estimated by Energinet and the other Nordic TSOs.

In previous years, the FFR market in DK2 was characterized by few bidders and an increased need for FFR during wintertime. Consequently, Energinet encouraged market participants to report their available quantities so that the market could operate optimally. In 2023, more bidders joined the market and are actively participating. In 2024, Energinet has seen good market participation.

In 2024, approximately 17.4 MW of new capacity has been prequalified to provide FFR in DK2 as shown in figure 36. It is important to note that the this is a combination of both new and existing assets

FIGURE 35 PROCURED FFR CAPACITY AND PRICES IN DK2 2023-2024

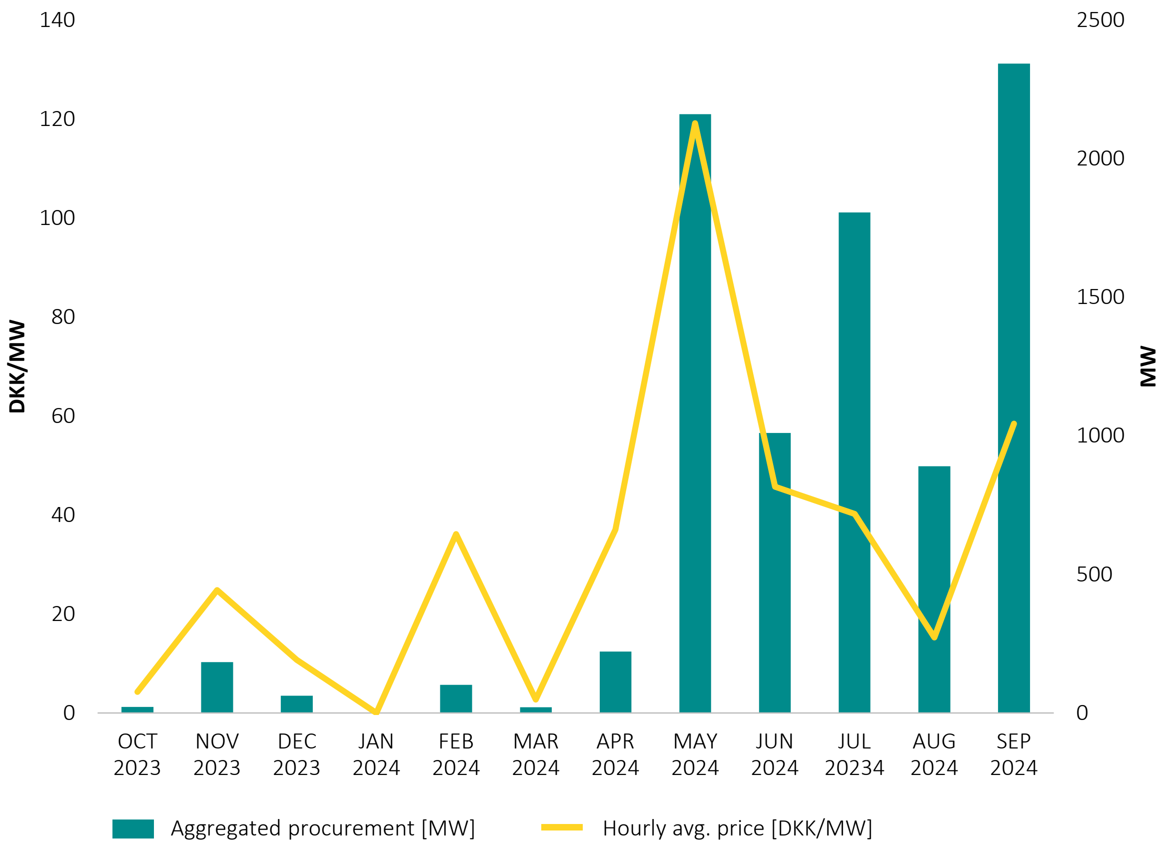


FIGURE 36 NEW PREQUALIFIED FFR CAPACITY IN DK2 2024

TECHNOLOGY	Capacity (MW)
Battery	17.4

PROJECTED PROCUREMENT OF FFR IN DK2

Figure 37 shows Energinet's projected need for FCR-N in DK2 towards 2040. Note that FFR is highly seasonable, and that projections are shown as average procurement over the year.

The procurement of FFR is directly linked to the inertia level in the Nordic electricity system, which in turn is dependent on the ratio of renewable energy sources in the system. Nuclear power plants, thermal power plants, and hydroelectric power increase inertia levels. On the other hand, solar power and wind power reduce inertia levels when they replace nuclear and thermal power plants.

The rise in renewable energy sources increases both the number of hours when FFR is required and the necessary FFR volumes. Therefore, the FFR forecast is highly dependent on assumptions about production from various technologies, which vary in the different climate years.

The projection does not include the possible introduction of dynamic FFR, which is a potential upcoming new and dynamically more stable product. Introduction of dynamic FFR may lead to a reduction in the procurement of traditional FFR. However, the introduction of dynamic FFR is uncertain, and the design is still under development.

Trend 2025-2030: The trend in this period is relatively stable, so the FFR market is expected to remain at a similar level to what we have seen in recent years. From 2025, projections show average procurements ranging from 4 MW to 10 MW a year. The highest hourly procurement seen across outcomes is 70 MW. By 2030, the range increases to 6-12 MW/h on average, with a maximum value of 80 MW/h.

Trend 2030-2035: Numerous wind farms significantly increases the FFR need. The average FFR need increases to 20-35 MW/h, with hourly maximum values at up to 120 MW.

Trend 2035-2040: Towards 2040, there is a large spread due to high ratio of capacity from renewable energy sources. In the different climate years, the ratio of renewable energy source has a significant impact on the results. The trend shows an increased FFR need. However, Swedish nuclear plants and new inverter technologies with inertia capabilities could influence the FFR procurement need.

The results are largely consistent with the projections from 2023. The main difference is the more stable period in 2025-2030, where last year's report indicated a linear increase.

FIGURE 37 PROJECTED NEED FOR FFR IN DK2

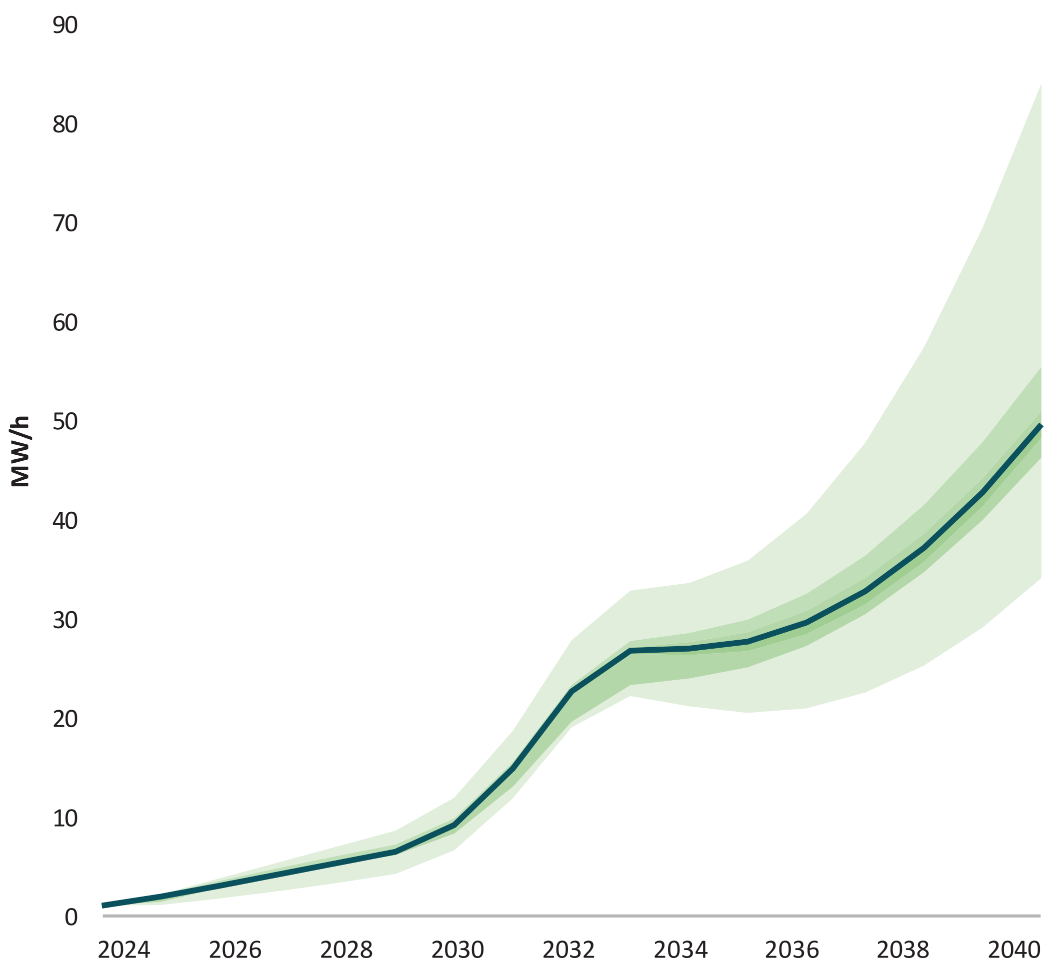
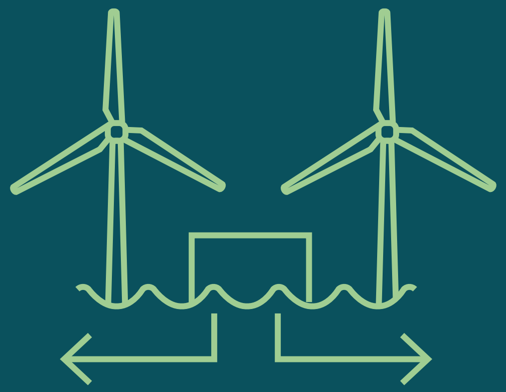


Figure 37 Median of projected need with 90 %,75 % and 10 % confidence intervals.



MARKET DEVELOPMENT

This section outlines market changes introduced in 2024 and coming market changes in the short and long term.

MILESTONES IN 2024

The way the power system is balanced is undergoing substantial changes leading to Nordic and European harmonisation and automatisation of the markets. In 2024, several major market changes are implemented.

OCTOBER 1: NEW LOCAL AFRR CAPACITY MARKET IN DK1

An aFRR capacity market in DK1 was introduced on similar terms as the Nordic aFRR capacity market in DK2. The changes in the aFRR capacity market enables the connection to the European energy activation platform, PICASSO, and gives market participants the opportunity to bid into two separate markets

OCTOBER 2: DANISH CONNECTION TO PICASSO

Connection to the European aFRR energy activation market, PICASSO, gives Danish market participants in DK1 and DK2 access to bid aFRR energy into an European market for aFRR. PICASSO makes it possible for TSOs to activate aFRR across Europe, thereby increasing flexibility in the European aFRR-market.

OCTOBER 29: FLOW-BASED: NEW NORDIC CAPACITY CALCULATION

Flow-based is a new Nordic capacity calculation methodology introduced in the Nordic day-ahead market. Flow-based provides market participants with more accurate information about the capacity in the grid. Flow-based impacts the power flows and allows for a better utilisation of the grid.

NOVEMBER 19: TRILATERAL mFRR CAPACITY MARKET

Implementation of a common mFRR capacity market for Denmark (DK1 and DK2), Sweden and Finland. The trilateral mFRR capacity market allows Danish participants in both DK1 and DK2 to sell mFRR capacity to Sweden, where both mFRR up- and down-regulation capacity are currently procured.

DECEMBER 1: NORDIC AND DYNAMIC DIMENSIONING

Nordic and dynamic dimensioning will be implemented for mFRR up-regulation as part of the transition to the automated Nordic mFRR energy activation market. Nordic and dynamic dimensioning allows the procured capacity volume to vary hourly based on expected imbalances.

MILESTONES TOWARDS 2030 AND BEYOND

This timeline provides an overview of the coming changes to the ancillary service markets on the short and long term.

2025

Q1 2025: AUTOMATED NORDIC mFRR ENERGI ACTIVATION MARKET

In the beginning of 2025, an automated Nordic market for mFRR energy activation will go live, introducing automatic balancing every 15 minute. The automated Nordic market for mFRR energy activation replaces the current Nordic hourly market and is a part of the phased integration into the European mFRR energy activation market, MARI.

FEBRUARY 1, 2025: PRICE ELASTICITY IN PROCUREMENT OF mFRR BALANCING CAPACITY – STEP 1

With the introduction of price elasticity, Energinet's procurement of mFRR balancing capacity in the monthly auction will be dependent on the expected cost of mFRR balancing capacity in the daily auction. Read more on page 50.

2025: NEW IMBALANCE SETTLEMENT

The new imbalance settlement is a change in the calculation of the imbalance price, so that it will be determined based on both mFRR and aFRR. This means that the future imbalance price will depend on the price developments for both mFRR and aFRR energy activation. Additionally, the method for settling mFRR activation as relative to the imbalance volume will change.

Q1 2025: 15 MIN mFRR ENERGY ACTIVATION MARKET

Implementation of a 15-minute time resolution for mFRR energy bids. This change is part of the stepwise implementation of the common European mFRR energy activation market, MARI, and coincides with the transition to the 15-minute MTU in the intraday market.

2026

2026: DANISH CONNECTION TO MARI

MARI, the common European mFRR energy activation market, will be implemented in both DK1 and DK2. The Nordic mFRR energy activation market is a step towards the connection to MARI, and MARI will thus replace the Nordic market. The major market changes to the mFRR energy activation market will occur with the go-live of the Nordic market.

2026: NEW IMBALANCE FEE

The principle of the new imbalance fee is that market participants that cause imbalances will also cover related costs, referred to as “full-cost balancing”. Energinet expects a gradual implementation of the new imbalance fee as of Q1 2026. Read more on page 51.

MILESTONES TOWARDS 2030 AND BEYOND – CONTINUED

2026

2026: INTRODUCTION OF THE INDEPENDENT AGGREGATOR ROLE

Energinet expects to implement the independent aggregator role in 2026, with the purpose of releasing flexibility potential, among distributed energy sources in particular. Read more on page 52-53.

PRICE ELASTICITY IN PROCUREMENT OF mFRR BALANCING CAPACITY – STEP 2

The intention with step 2 of price elasticity in procurement is to ensure that Energinet does not procure mFRR balancing capacity if the costs exceed the value generated. However, the intention is not to reduce the procured amount of balancing capacity on average. The methodology is currently under development. Read more on page 50.

2030

BORNHOLM ENERGY ISLAND

Energinet expects that Energy Island Bornholm will have its own offshore bidding zone, DK3, as well as its own independent balancing area. DK3 will be balanced independently based on the same principles as DK1 and DK2. Read more on page 55.

NORTH SEA ENERGY ISLAND

The North Sea Energy Island is subject to ongoing political and technical discussions nationally and with international partners. Energinet expects that the North Sea Energy Island will have its own offshore bidding zone and independent balancing area

PRICE ELASTICITY OF PROCUREMENT OF mFRR CAPACITY

By February 1st, 2025, the procurement of mFRR capacity in the monthly auction depends on the expected cost of mFRR capacity in the daily auction.

Making procurement of mFRR capacity in monthly auctions dependent on the expected cost of mFRR balancing capacity in the daily auction is the first step towards introducing price elasticity in demand in the procurement of mFRR capacity.

With this methodology, Energinet can optimize the procurement of mFRR capacity, so that mFRR capacity is procured in the auction where it is expected to have the lowest cost.

The "mFRR insurance" can be too expensive
Energinet aims to advance the introduction of price elasticity in demand, ensuring that mFRR capacity is not procured if deemed too costly as an "insurance" measure.

Hence, in case the cost of mFRR capacity exeeds e.g. Value of Lost Load (VoLL) times the probability of needing the capacity, mFRR capacity should not be procured. The methodology of this step has yet to be finalized, and the implementation date is still to be decided.

It is important to mention that the intention is not to lower the procured amount of balancing capacity on average. The intention is only to ensure that mFRR capacity will not be procured if the costs exceed the value of the function it is intended to serve.

The initial ideas point to a methodology, where MW of mFRR capacity are held up against VoLL. The initial ideas also introduce a lower limit, so that the procured amount of mFRR capacity can never be lower than e.g. 90 % of the primary mFRR capacity demand.

> With this methodology, Energinet can optimise the procurement of mFRR capacity, so that mFRR capacity is procured in the auction where it is expected to have the lowest cost.

NEW IMBALANCE FEE

Energinet is currently working on an adjustment of the imbalance fee. The principle behind the new imbalance fee is to charge the true cost of resolving an imbalance to those causing it.

Energinet expects an increased need for purchasing mFRR and aFRR reserves during periods when expected consumption and production deviate from actual values, known as "normal imbalances."

This increased need is due to the introduction of a new Nordic and dynamic methodology for dimensioning mFRR and aFRR reserves, which accounts for imbalances — a factor not included in the previous method.

Additionally, normal imbalances are expected to rise further with the introduction of more renewable energy sources and due to decentralised, flexible consumption.

An adjusted imbalance fee shall ensure that the costs related to the increased reserve requirements are covered by the market participants causing the imbalances.

With input from stakeholders, Energinet is finalizing the methodology for adjusting the imbalance fee to ensure a fair distribution of costs, which would otherwise be borne by consumers through the system tariff.

A *polluters pay* principle

Energinet advocates for an imbalance fee that reflects the real costs of imbalances and provides stronger incentives for market participants to promote the system balance.

Energinet is working on a methodology based on the concept of full cost balancing. Full-cost balancing means that Energinet’s actual costs associated with mitigating imbalances are reflected in the overall level of the imbalance fee. A polluters pay principle implies that the individual imbalance fee will reflect participants' own imbalances.

Thus, the full cost balancing concept aims to reflect the actual costs of Energinet’s additional reserve procurement due to imbalances. The polluters pay principle introduces a stable mechanism intended to motivate market participants to improve their forecasting and balancing efforts.

Energinet expects that the new imbalance fee will lead to a more stable and efficient grid, contributing to a fairer distribution of balancing costs. The new imbalance fee must be approved by the Danish Utility Regulator before it can take effect. Energinet anticipates a gradual implementation of the new imbalance fee starting in the first quarter of 2026.

NEW ROLE: INDEPENDENT AGGREGATOR

The independent aggregator role was approved by The Danish Utility Regulator in October 2024. By introducing this new role, Energinet wants to give distributed energy resources in particular the opportunity to release their flexibility potential.

Today, a classic aggregator (BSP) is only allowed to deliver energy-lean ancillary services. This new role of independent aggregator can deliver all types of ancillary services, but without the balancing responsibility of the balance-responsible party (BRP). Energinet is working on developing the compensation and correction model for the independent aggregators so the financial impact on BRPs is minimised.

Aims to release more flexibility potential
The purpose of introducing the new role of independent aggregator is to release more flexibility potential and thereby lower the costs of ancillary services. The independent aggregator role is expected to release flexibility potential among distributed energy sources in particular.

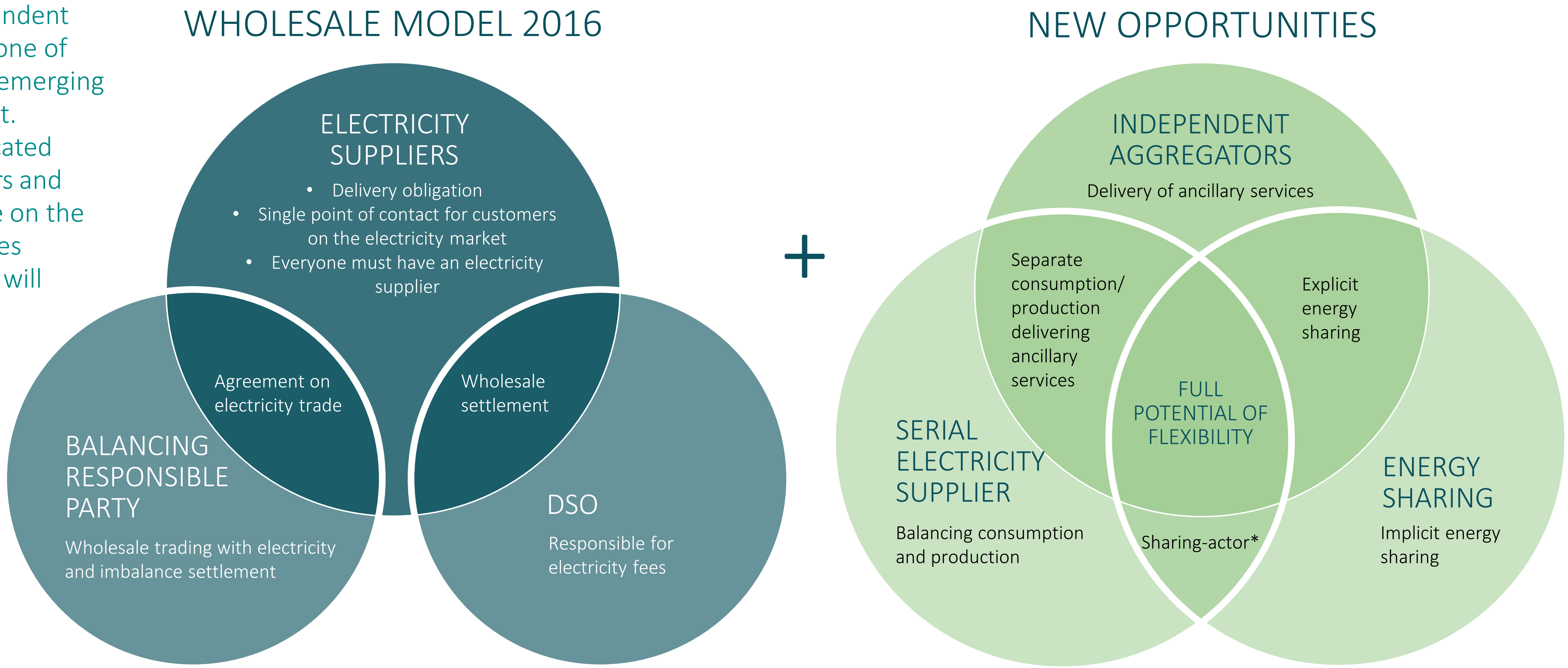
The potential for new business models and diversification of the energy market is large and will enable more flexibility to participate. Therefore, Energinet expects a large change in the providers of ancillary services with the implementation of the independent aggregator role.

One of several new roles
The independent aggregator is only one of the new roles that will be introduced in the retail market. Also, dedicated electricity suppliers and energy sharing are on the horizon. All these new roles and opportunities will support the flexibility agenda. Read more on page 53.

The roles are currently under development in collaboration with markets participants. Independent aggregator is the first new role to be implemented, expectedly in 2026. Energinet initiates the development of the dedicated electricity supplier and energy sharing roles in 2024. The implementation dates for those new roles are not yet scheduled.

NEW ROLE: INDEPENDENT AGGREGATOR

The role of independent aggregator is just one of several new roles emerging in the retail market. Additionally, dedicated electricity suppliers and energy sharing are on the horizon. These roles and opportunities will play a key part in advancing the flexibility agenda.



A normal electricity supplier can also be a sharing actor

INTERNAL BOTTLENECKS

The power system is undergoing rapid changes due to the green transition, increasing the demands on the grid to handle greater energy volumes and peaks. While planning sufficient grid expansion, alternative measures are also needed to address bottlenecks and local overloads.

The power system is evolving, requiring the grid to manage greater energy volumes and peaks. Also, energy must travel longer distances, as renewable production and increased consumption are unevenly distributed across regions.

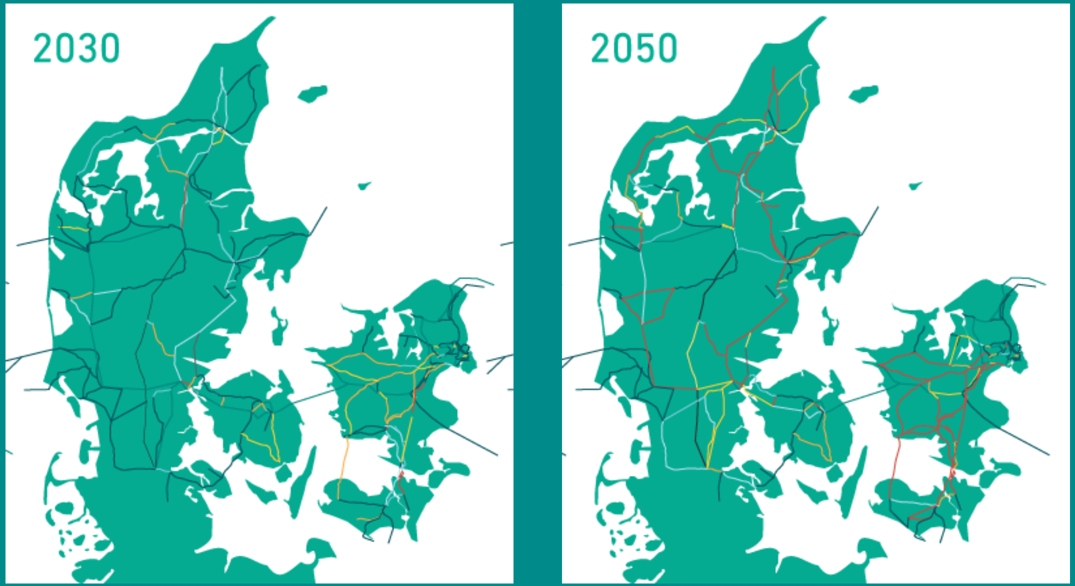
Measures to manage bottlenecks
Until sufficient grid expansion is in place, there is a need to handle bottlenecks and local overloads with different measures. These measures include, among other things, temporary limited grid access, geographical tariffs, and the use of geo-tagged balancing products (mFRR and aFRR).

As mFRR energy activation is for balancing purposes only, local bottlenecks are addressed with a national supplement to the mFRR energy activation market. Since December 2023, Energinet requires geographical tags (geo-tags) on all mFRR energy bids. When Energinet connected to the European balancing platform for aFRR, PICASSO, in October 2024, the same geo-tag requirement was introduced for the aFRR energy activation market. This is meant to ensure that aFRR activations do not worsen any potential bottleneck either.

Geo-tags ensure that available assets are utilised efficiently
Energinet anticipates an increase in bottlenecks in the grid, which means that more facilities will be unavailable to provide balancing services. Therefore, Energinet must ensure that available assets are utilised efficiently. Thus, Energinet expects that it will be necessary to introduce geo-tags in the mFRR and aFRR capacity markets in the coming years as well.

Energinet is continuously working to develop new measures to utilise flexibility and handle internal bottlenecks in collaboration with DSOs and other relevant parties.

INTERNAL BOTTLENECKS, ACCUMULATED



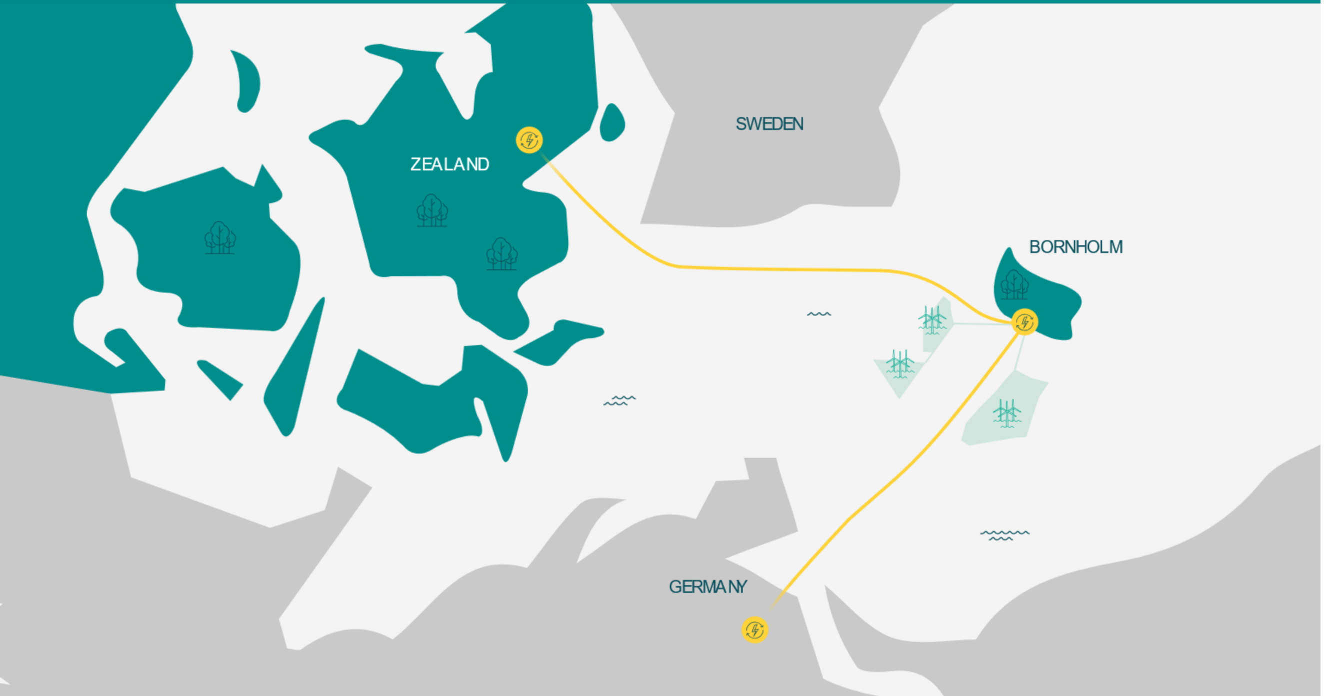
Signatur (MWh)

- 0 (400 kV)
- 0 (132/150/220 kV)
- < 500
- 500 - 5.000
- 5.000 - 20.000
- 20.000 - 100.000
- > 100.000

INTERNAL BOTTLENECKS

Energinet expects several existing lines in the current transmission grid to be overloaded on the short and long term. The illustration shows forecasted overloaded lines based on data from the Danish Utility Regulator (AF2022), considering the largest incident (reference incident, N-1) and the existing grid. The shown overloads are accumulated per year.

ENERGY ISLAND BORNHOLM WILL BE A SEPERAT BIDDING ZONE CONNECTED TO THE NORDIC REGION AND CONTINENTAL EUROPE



BALANCING ENERGY ISLANDS

Energinet expects the future Danish energy islands in the North Sea and Bornholm to be independent offshore bidding zones, that are also balanced independently. Energinet expects to balance offshore bidding zones in the same way as the existing bidding zones, DK1 and DK2, and that reserves for the offshore bidding zones will be procured through the common Nordic reserve capacity markets. However, it will not be possible to deliver FCR-products to or from energy islands.

ENERGY ISLAND BORNHOLM

When Energy Island Bornholm goes live, it will have its own bidding zone, DK3. Energinet anticipates balancing DK3 in the same manner as DK1 and DK2.

In 2023, Energinet got approval to establish a new bidding zone in connection with Energy Island Bornholm, DK3. Energinet expects DK3 to be balanced independently based on the same principles used today for the two existing bidding zones, DK1 and DK2.

Connected to European and Nordic balancing markets

When Energy Island Bornholm is commissioned, Energinet will be connected to the European markets for mFRR and aFRR energy activation, MARI and PICASSO. This means that imbalances from DK3 will be managed using balancing bids from MARI and PICASSO, as will be the case for DK1 and DK2.

Energinet is obligated to ensure availability of reserves for its balancing areas, including DK3. Energinet expects the reserves for DK3 to be procured in the common Nordic capacity markets, where reserves for both DK1 and DK2 will also be procured in the future.

No FCR markets at Energy Island Bornholm

Due to a relatively small electricity system on Energy Island Bornholm, the frequency must be maintained with the help of direct current converters. Ordinary frequency reserves (FCR) will be far too slow to maintain a stable frequency on the energy island. Instead, the response will be delivered within 1 second by the direct current converters and then handled by frequency reserves on the mainland before the normal balancing procedure handles the actual imbalance.

Therefore, there will be no markets for FCR on Energy Island Bornholm, and facilities on the energy island will not be able to participate in neither the Nordic FFR, FCR-D or FCR-N markets, nor the FCR markets in Continental Europe

APPENDIX

APPENDIX (MEDIAN FORECAST VALUES)

Year	DK2-FFR_MW	DK2-Down mFRR_MW	DK2-Down aFRR_MW	DK2-Up mFRR_MW	DK2-Up aFRR_MW	DK2-FCRN_MW	DK2-FCRD Down_MW	DK2-FCRD Up_MW	DK2-Down FRR_MW	DK2-Up FRR_MW	DK1-Down mFRR_MW	DK1-Up mFRR_MW	DK1-Down aFRR_MW	DK1-Up aFRR_MW	DK1-FCR_MW	DK1-Down FRR_MW	DK1-Up FRR_MW
2024	1	2	46	540	47	92	182	223	48	587	-	348	100	100	124	100	448
2025	2	54	45	589	45	95	226	231	100	635	-	592	112	112	125	95	710
2026	3	85	57	573	57	97	234	236	142	633	95	574	156	156	137	238	734
2027	4	153	67	560	67	98	237	238	219	631	151	536	195	195	146	335	735
2028	5	259	74	551	74	97	236	236	332	629	166	478	229	229	151	389	711
2029	6	402	77	544	77	95	230	230	480	626	141	400	258	258	153	397	663
2030	9	517	91	533	91	93	224	224	611	629	102	402	299	299	155	403	707
2031	15	540	128	511	128	92	222	222	672	643	76	585	369	369	162	449	961
2032	22	486	182	482	182	92	221	221	671	665	60	902	459	459	172	523	1,370
2033	27	452	209	467	209	91	220	220	664	677	41	1,078	506	506	178	553	1,597
2034	27	450	207	468	207	90	217	217	660	677	20	1,089	506	506	179	534	1,616
2035	27	456	203	471	203	89	215	215	662	677	13	1,071	505	505	180	525	1,600
2036	29	467	202	475	202	88	214	214	671	680	22	1,047	511	511	182	538	1,579
2037	33	482	203	480	203	89	214	214	687	686	47	1,017	523	523	183	571	1,552
2038	37	502	207	485	207	90	216	216	710	694	89	980	542	542	186	626	1,519
2039	42	526	213	491	213	91	220	220	741	704	148	937	568	568	188	700	1,481
2040	49	555	221	497	221	93	224	224	779	718	224	887	600	600	191	796	1,437