

# Introduction to Norwegian reserve markets



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*Read more about the requirements and prequalification process [here](#) (in Norwegian):*

[Om systemansvaret](#)

[Om reservemarkedene](#)

[Introduksjon til reservemarkedene](#)

# Introduction to the power system and balancing needs



Picture: Work on power line.

# The energy market and the reserve markets ensure balance in the power system

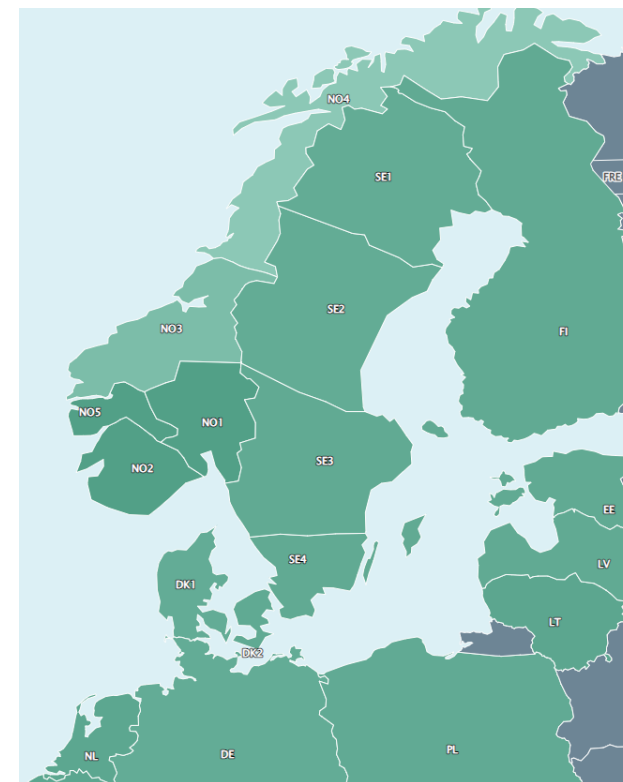
- **The power system** must always be in balance. That means that the sum of production, consumption and net import/export must be zero at any time to maintain system stability
- **The energy market** has several purposes. The market produces a common price based on the balance between planned production and demand each hour. This incentivises every participant to plan themselves into balance
- Statnett is responsible for keeping the system in balance during the operation by procuring reserves in the **reserve markets**.
- The energy market ensures that the total production resources are utilized in a cost efficient way since the cheapest production is traded first. In longer term the energy prices contribute to cost effective investments in production and consumption



Picture: Production, power grid and consumption are connected.

# The energy price is determined in each bidding zone

- There are five bidding zones in Norway with an individual price
- Consumption and production are matched on a common market platform
  - Nord Pool and Epex Spot are operating market platforms in the Nordic
- The energy price is determined the day before delivery
  - The market result is published before 13:00.
  - The price is determined based on the balance between production, consumption and import/export in each bidding area
  - The result is a price for each hour for each bidding zone the next day
  - The price from the day-ahead clearing is referred to as *spot price*
- Before the market clearing
  - Available transmission capacity between bidding zones is specified by the TSOs (which is Statnett in Norway)
  - The market participants must send in bids for how much they want to buy and sell to which price by 12:00.



Picture: Overview of Scandinavian bidding zones.  
The picture is from [Day-ahead overview | Nord Pool](https://www.nordpoolgroup.com/en/day-ahead-overview)  
([nordpoolgroup.com](https://www.nordpoolgroup.com))



# The energy market – agreed balance

- The energy market ensures the market clearing by executing a centralized algorithm that finds the optimal combination of traded volume and price for the energy hour by hour
  - The market equilibrium determines how much energy should be produced and consumed (volume) to what price
- In the period between clearing of the spot market and the delivery hour, the market participants can adjust their market position in the *intra day market*

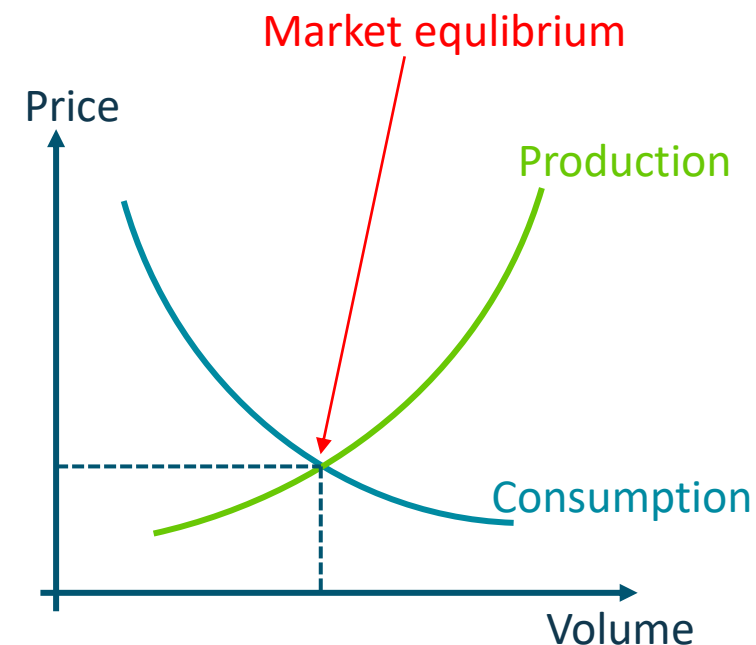
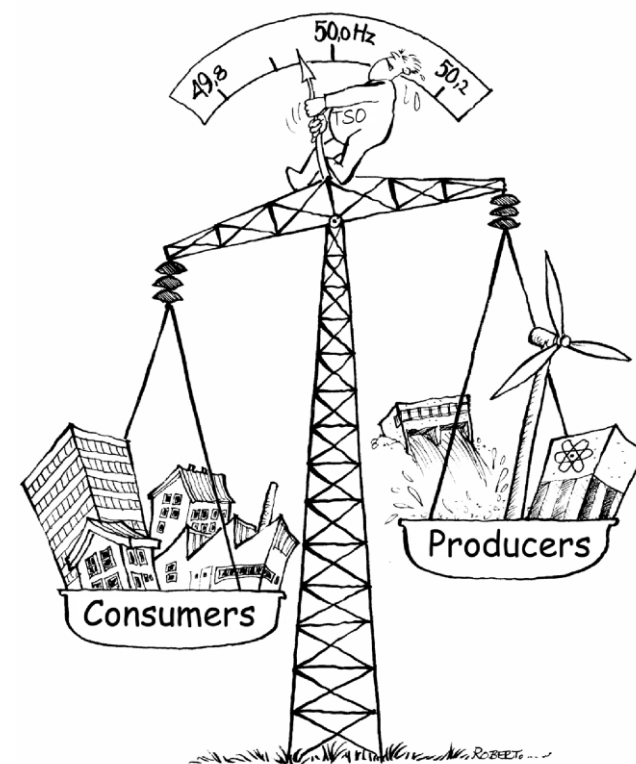


Figure: The market equilibrium where consumption matches production gives the market balance. The market equilibrium establishes the price that all the market participants are exposed to. The volume in the equilibrium is the total traded volume that hour (production is equal to consumption).

# Purpose of reserve markets

- The energy market ensures that the power system is balanced *before* delivery. However, there will always be some deviations in actual production or consumption, and outages can occur. This leads to *imbalances*.
- This imbalance must be handled by Statnett, which buys different products in the reserve markets. The participants in the reserve markets get paid to adjust their consumption or production if needed. Some reserve markets require automatic solutions, fast responses and short duration, while others require more energy for a longer period of time.
  - Statnett ensures sufficient reserves through *capacity markets*
  - The reserves are activated automatically during the delivery hour or through specific *activation markets*



Imbalance between consumption and production leads to frequency deviations.

# Why is the frequency important?

- Statnett uses reserves to keep the frequency at nominal value – 50 Hertz (Hz)
- Frequency is a measure of the balance of the system
- In case of imbalance, the frequency changes
  - More consumption than production leads to a decline in the frequency
  - More production than consumption leads to an increase in frequency
- If the frequency drops too much, generators can switch off automatically. This leads to a further decline in frequency and further disconnections. This spiral creates a risk of system collapse.
- To avoid this, Statnett must maintain system balance and ensure that enough reserves react fast if major imbalances occur.



Picture: The frequency is 50,00 Hz.



# Time line

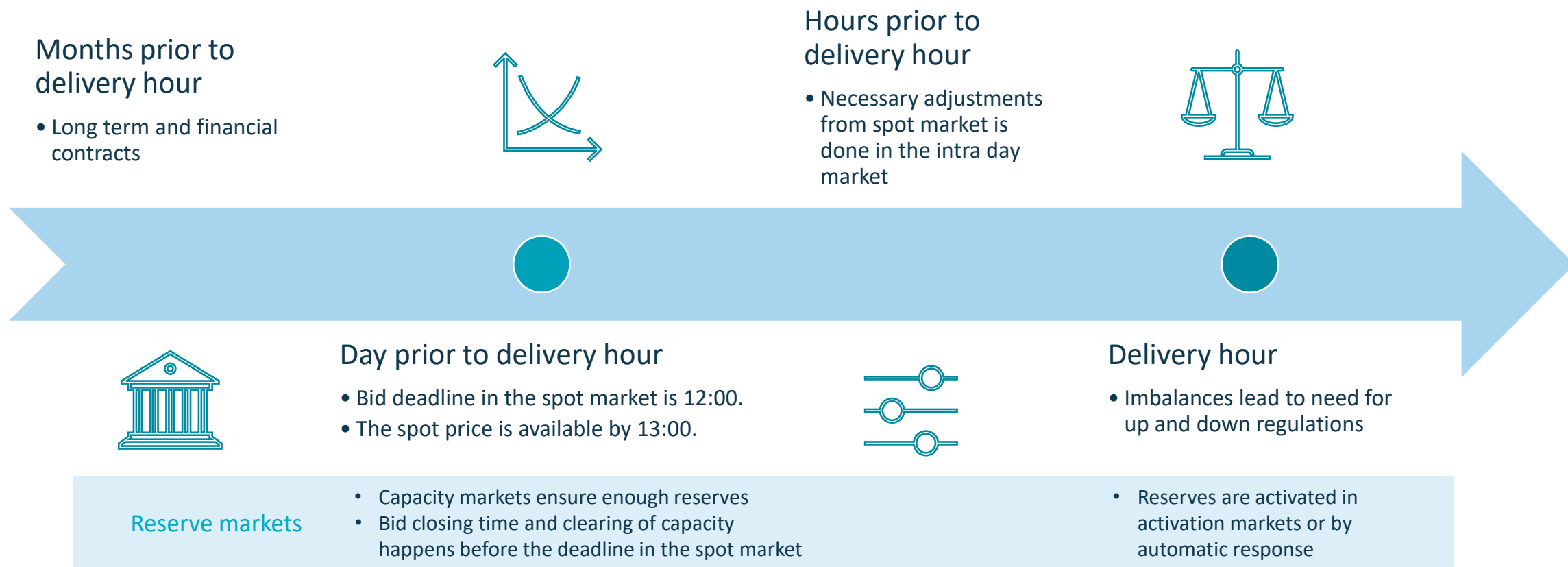


Figure: The timeline describes when different activities and trades are carried out. Financial and long-term contracts take place several months or years before the hour of operation. Clearance in the spot market and reserve markets generally takes place the day before. You can trade in the intraday market almost right up to the hour of operation. At the hour of operation, the power traded is consumed and produced. If imbalances occur, the reserves are activated to manage these.

# Overview of reserve markets



Illustration of power line to industry area.

# Statnett's reserve markets

Statnett currently procures four categories of reserve products with different response times and durations.

- **Fast Frequency Reserves (FFR)**
  - 0,7-1,3 seconds response; 5-30 seconds duration
  - Capacity market and compensation for activation
- **Frequency Containment Reserves (FCR-N\* og FCR-D\*\*)**
  - 30 seconds response; minimum 15 minutes duration
  - Capacity market and compensation for activated volume (FCR-N)
- **Automatic Frequency Restoration Reserves (aFRR)**
  - Full response in 2 minutes; duration as long as the bid period lasts
  - Capacity market and compensation for activated volume (soon activation market)
- **Manual Frequency Restoration Reserves (mFRR)**
  - Full response in 12,5 minutes\*\*\*; duration as long as the bid period lasts
  - Capacity market and subsequent activation market

\* FCR-N is a normal reserve (hence N) and applies to frequency deviations within the normal band, i.e. up to 0.1 Hz in each direction of 50 Hz

\*\* FCR-D is operational disturbance reserve (hence D) and applies to deviations outside the normal band

\*\*\* The requirements is 15 minutes today, while it will become 12,5 minutes when transitioning to mFRR EAM

*Read more about conditions for participation, implementation guide and prequalification documents:*

[Fast frequency reserves – FFR](#)

[Primærreserver – FCR](#)

[Sekundærreserve – aFRR](#)

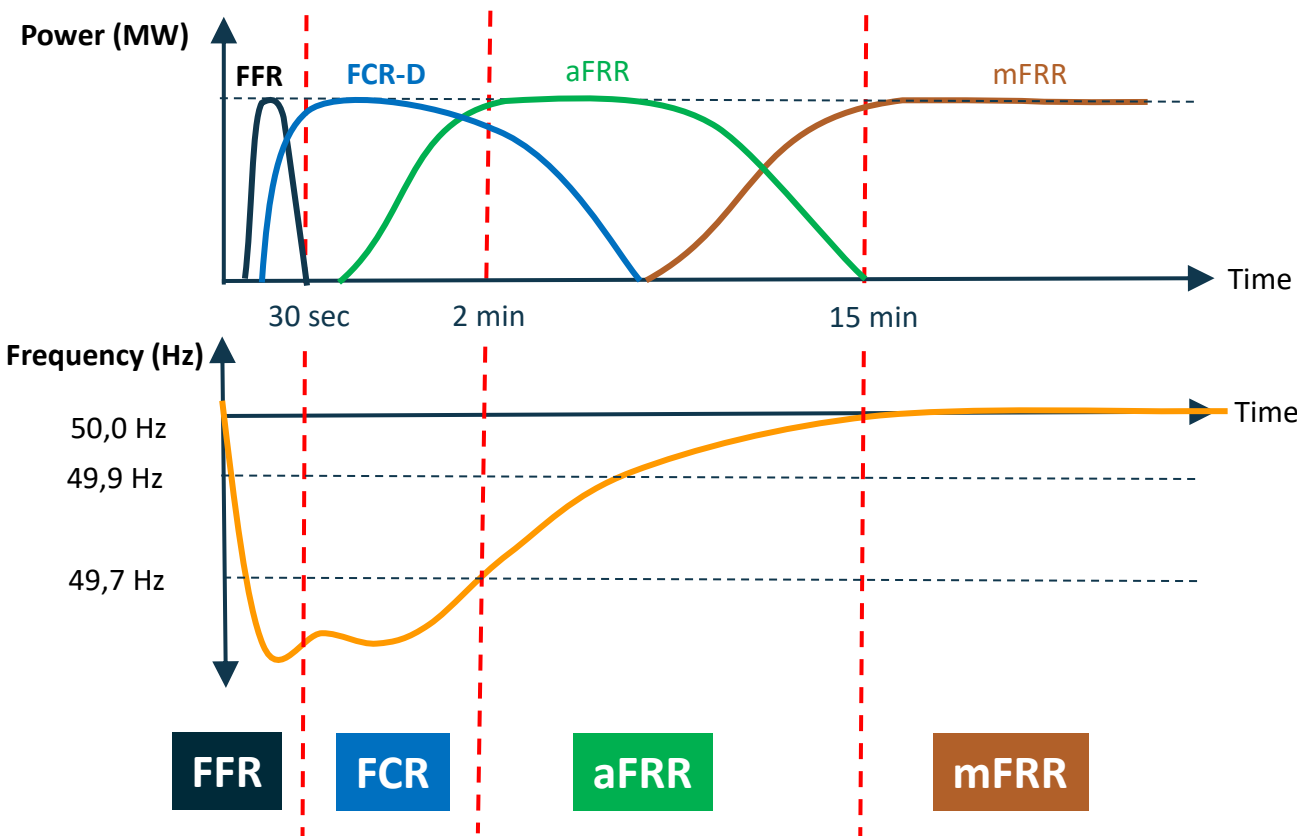
[Tertiærreserver – mFRR](#)

# Which reserves are used when?

- The frequency changes within the *normal band* (49,9-50,1 Hz) all the time due to slow imbalances
  - FCR-N, aFRR and mFRR are used
  - FCR-N limits frequency deviations and stabilizes, but the underlying imbalance must be covered by mFRR
- *The next slide* shows what happens if there is a large imbalance, typically in the event of an error/outage that causes the frequency to fall below 49,9 Hz
  - FFR, FCR-D, aFRR and mFRR are then activated in sequence as shown in the figure
- *Explanation of the example on the next slide:* An outage causes a major loss of production, and the frequency decreases rapidly. Then the reserves will behave like this:
  - 1) FFR will activate about 1 second after the frequency has passed 49,7 Hz and slows down the frequency fall
  - 2) By the time FFR is deactivated (after 30 seconds), FCR-D will be fully activated to stabilize the frequency
  - 3) After 2 minutes, the aFRR should be fully activated to return the frequency towards the normal band between 49,9 and 50,1 Hz
  - 4) mFRR replaces the activated aFRR resources and maintains the necessary balance until new balance is achieved in the energy market

# Which reserves are used when?

The figure shows how the frequency can fall if a large component in the power system is disconnected due to an outage, and how the reserves are activated to handle this incident.



**FFR** Slows down the frequency drop

**FCR** Stops the frequency drop and stabilizes the frequency at a new level

**aFRR** Brings the frequency back towards the nominal frequency (50,0 Hz)

**mFRR** Releases aFRR and maintains balance until new balance is reached in the energy market



# What does it mean to participate in the reserve markets?

- **The capacity markets\*** (FFR, FCR, aFRR, mFRR) ensure that there are sufficient available resources to respond when needed during the purchasing period. Entities with an accepted capacity market bid must react automatically or commit to participate in the subsequent activation market
  - In the event of an accepted capacity market bid, the resource(s) shall be available for activation
- **Activation markets\*** (aFRR\*\*, mFRR) are used to buy bids that involve an up or down adjustment of consumption or production
  - Upon activation, the resource shall deliver according to the market requirements
- Prices in capacity markets are quoted in EUR/MW/h
  - Total payment must be multiplied by the MW volume and the number of hours the bid applies to
  - Payment regardless of whether resources are activated or not
- Price in activation market is given EUR/MWh/h
  - Total payment must be multiplied by the number of MWh delivered during the hour (different prices per hour)
- Resources participating in reserve markets must be prequalified
  - This process is not the same for all markets



Figure: Participation in the capacity market entails an obligation to participate in the subsequent activation market, but not the other way around.

\* The Nordic mFRR markets will replace the current markets for tertiary reserves, RK and RKOM, in 2023/2024

\*\* Activation market for aFRR (aFRR EAM) will be introduced in 2024

# Upcoming changes in the reserve markets

- In the coming years there will be a fundamental shift in the aFRR and mFRR markets through the introduction of a new *Nordic balancing model (NBM)*.
- 15-minute resolution for activation bids, imbalance price and settlement are introduced
- NBM involves
  - Common Nordic capacity market for aFRR and mFRR
  - Norwegian and Nordic activation markets will become part of the European platforms for aFRR (PICASSO) and mFRR (MARI)
  - Common bid lists lead to Norwegian bids competing with European and Nordic bids
- Names of the new markets
  - RKOM was replaced by **mFRR CM** (CM = capacity market) February 11<sup>th</sup>, 2024
  - RK is replaced by **mFRR EAM** December 3<sup>rd</sup>, 2024 (EAM = energy activation market), then MARI (common European clearing)
  - Today's aFRR becomes a pure capacity market, called **aFRR CM**
  - Activation of **aFRR** will be market-based in PICASSO (common European clearing)
- Participants who are currently considering participation in the reserve markets must look at the requirements of the new aFRR and mFRR markets coming through NBM

Read more:

[NBM](#)

Years used later in this presentation for implementing NBM are based on [Nordisk balanseringsmodell lanserer oppdatert veikart | Statnett](#)

# Capacity markets

Market	Minimum volume (MW)	Time periods of purchase	Bid/price for each	Requirements
FFR	1 / 5	Season (summer)		Automatic response when the frequency is below 49,7/49,6/49,5 Hz
FCR-D	1	1 and 2 days before delivery hour	Direction, BZ*, hour	Automatic response when the frequency is out of range 49,9 – 50,1 Hz
FCR-N	1	1 and 2 days before delivery hour	BZ*, hour	Automatic response when the frequency is within the range 49,9 – 50,1 Hz
aFRR	1	1 and 2 days before delivery hour	Direction, BZ*, hour	Automatic response when the frequency is out of range 49,9 – 50,1 Hz (will soon be a commitment to participate in aFRR EAM)
mFRR	1	1 and 2 days before delivery hour	Direction, BZ*, hour	Participation in mFRR EAM

\* BZ = Bidding Zone

\*\* Day, Night, Monday-Friday and Saturday-Sunday

# Activation market

Market	Minimum volume (MW)	Bid closing time	Bid/price for each	Requirements
mFRR EAM	1*	45 minutes before delivery hour	Direction, BZ**, quarter	Response when activation message is received

\* Today, the minimum volume is 5 MW in NO1 and NO3, and 10 MW in the other bidding areas.

\*\* Bidding Zone

# Reserve markets in detail



Illustration showing various graphs and curves.



# FFR – Fast Frequency Reserves

- FFR will slow down the *speed* of frequency changes in the same way that rotating mass does
- Statnett buys two products: **FFR Profile** and **FFR Flex**
  - **FFR Profile** is constantly armed *all nights and all weekend* (min. 1 MW)
  - **FFR Flex** is armed *on weekly orders* from Statnett (min. 5 MW)
  - Each product is currently purchased once a year for the summer season (in 2023 this period is from April 29<sup>th</sup> to October 30<sup>th</sup>)
- There are three possible activation combinations:
  - 1) Full response within 0,7 seconds at frequency below 49,5 Hz
  - 2) Full response within 1,0 seconds at frequency below 49,6 Hz
  - 3) Full response within 1,3 seconds at frequency below 49,7 Hz
- Delivery time can be 5 or 30 seconds
  - If 5 seconds are selected, delivery must be reduced by 20% of prequalified capacity per second after 5 seconds
- The frequency must be measured at least 10 times per second with an accuracy of at least 10 mHz
- Vendor must be prequalified prior to participation
- Compensation is paid upon activation for the cost of activation (not market-based)
  - The supplier states the activation cost in the bid – this is fixed throughout the contract period

# FCR – Frequency Containment Reserves

- FCR will stop the frequency change, i.e. stabilize the frequency at a new level
- There are two products: FCR-N and FCR-D
  - FCR-N, normal operating reserves to handle frequency changes within the normal band (49.9-50.1 Hz)
  - FCR-D, operational disturbance reserves to handle frequency changes outside the normal band, typically in the event of major failures or outages
- FCR-N is a symmetrical product, while FCR-D has separate purchases and prices per direction (up/down)
- FCR-N is bought continually, while FCR-D is bought if needed and considered year to year. The purchases in each market are done daily.
- FCR shall be delivered as a linear response to the frequency deviation
  - Automatic activation based on local frequency measurement
- FCR-D must have an 86 % response within 7.5 seconds, and 100 % in 30 seconds
- FCR-N must have an 63 % response within 60 seconds, and 95 % in 3 minutes
- Delivered energy related to FCR-N is priced at the mFRR price in the imbalance settlement
- Delivered energy related to FCR-D is priced at 0 in the imbalance settlement

# aFRR CM – automatic Frequency Restoration Reserves

- aFRR should bring the frequency back towards the nominal value (50 Hz)
  - **Today, this is only a capacity market** where activated volume is compensated by the regulating power price in the direction of the regulation (the imbalance price) in the relevant hour.
- aFRR is an asymmetrical product that has its own price for up and down regulation
- Bids are activated in price order and the market price is based on the marginal price concept
- The marginal price concept means that all bids that are activated will be paid the price for the most expensive activated bid
- The capacity market is cleared one day before the day of operation
  - Deadline for submitting bids is at 7:30 the day before
  - Bids are sent per hour for the operating day (upcoming days) and a price per hour is formed per bid area
- Automatic activation is based on signal from Statnett
  - The signal is a "delta setpoint", i.e. how much the supplier should deviate from planned production and other reserve deliveries
  - Secure communication channel (ICCP) between the SCADA systems of the TSO and the supplier is required
  - The offered volume must be fully activated within 5 minutes, preferably within 2 minutes
  - Delivered energy is priced at mFRR price in imbalance settlement
- When activating, the required volume is currently distributed equally between the different actors in percentage terms.

\*

\* With the introduction of PICASSO in 2026, an accepted bid in the capacity market (aFRR CM) will entail an obligation to bid into the activation market

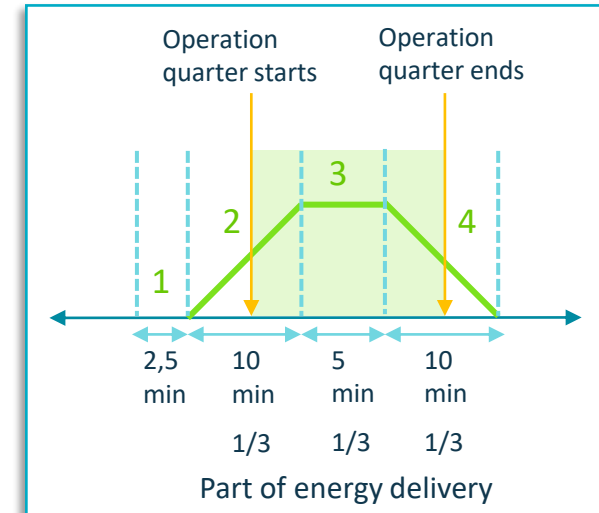
# mFRR CM – manual Frequency Restoration Reserves

- *A Nordic mFRR CM will replace the current the national mFRR CM*
- The mFRR capacity market (CM) is intended to ensure sufficient capacity for the mFRR energy activation market (EAM)
- mFRR is an asymmetric product which has a separate up and down regulation
- Accepted bids in the capacity market have an obligation to bid into the activation market
  - Payment in the capacity market is independent of whether bids in the activation market are activated or not
- The market price is based on the marginal price concept
- The capacity market is cleared one day before operating hour
  - Deadline for submitting bids is at 7:30 the day before
  - Bids are sent per hour for the operating day (next day) and a price per hour is formed per bidding zone

# mFRR EAM – manual Frequency Restoration Reserves

## ➤ Replacing the current RK market December 3<sup>rd</sup>, 2024

- Participation in the activation market does not require participation in the capacity market first (mFRR CM)
- Participation requires the ability to receive online orders through *eBestill*, i.e. the use of electronic messages to activate bids
- The market price is based on the marginal price concept
- The deadline for submitting bids is 45 minutes before the operating hour
  - When the bids have 15-minute resolution, the deadline for bid submission will be 25 minutes
- When activation is needed, TSO sends an order (through *eBestill*) to the BSP
  1. From notification of activation (order) until the response starts, the BSP has **2,5 minutes**
  2. Then the BSP has **10 minutes** to ramp up to the full response
  3. Full response should be maintained for **5 minutes**
  4. Finally, the BSP must ramp down for **10 minutes** (unless the activation is valid for several hours)



The figure shows how mFRR EAM should be delivered upon activation. The BSP receives a signal 7,5 minutes before the operating quarter. After 2,5 minutes, the asset(s) in the bid should be activated. Within ten minutes, the bid should be fully activated. After five minutes, the descent starts which should run smoothly for 10 minutes.



## For further information or interest

- To analyze potential revenues based on historical data, the different prices can be extracted here:
  - Spot prices: [Market data | Nord Pool](#) og [Market Data | EPEX SPOT](#)
  - Price for mFRR EAM (activation / regulation price): [Market data | Nord Pool](#)
  - Price for aFRR CM: [Data View \(nucs.net\)](#)
  - Price for mFRR CM: [Data View \(nucs.net\)](#)
  - Prices for the capacity markets: [Tall og data fra reservemarkeder | Statnett](#)
- For further questions related to participation in a reserve market
  - Contact Statnett on [bsp@statnett.no](mailto:bsp@statnett.no)

