

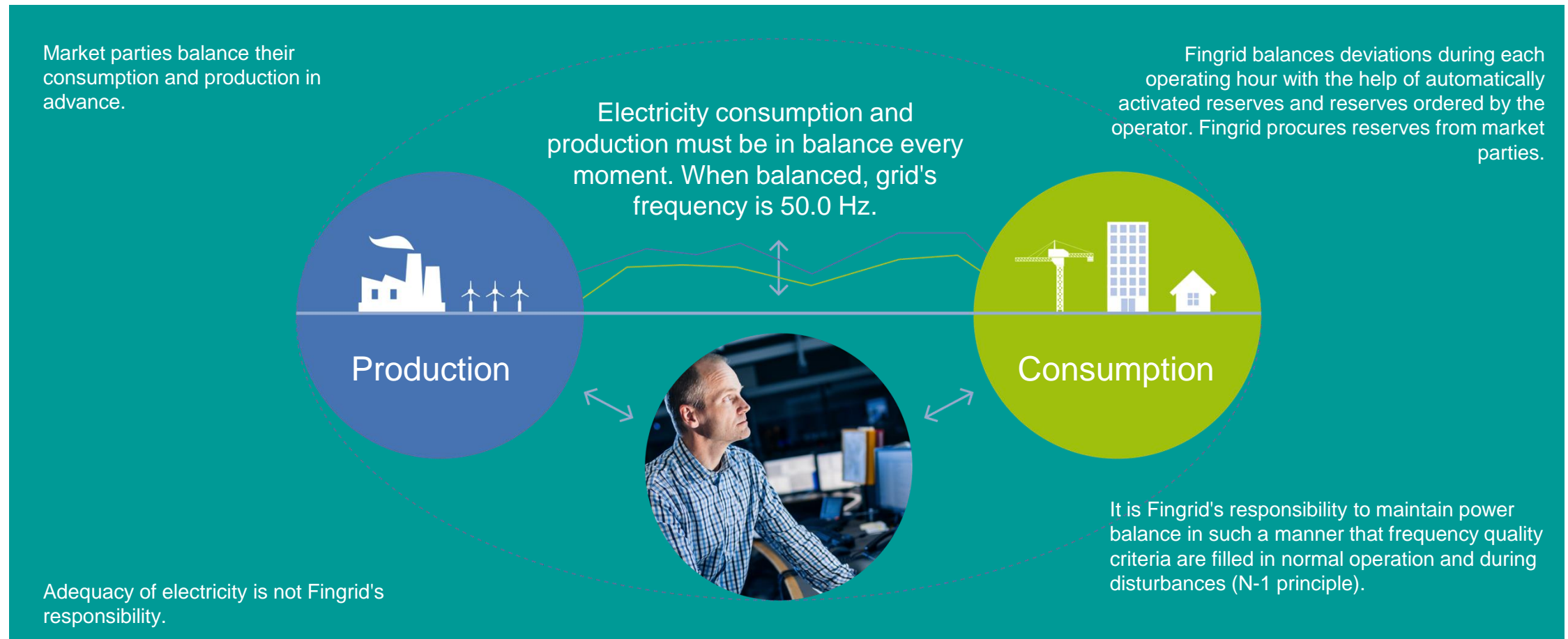


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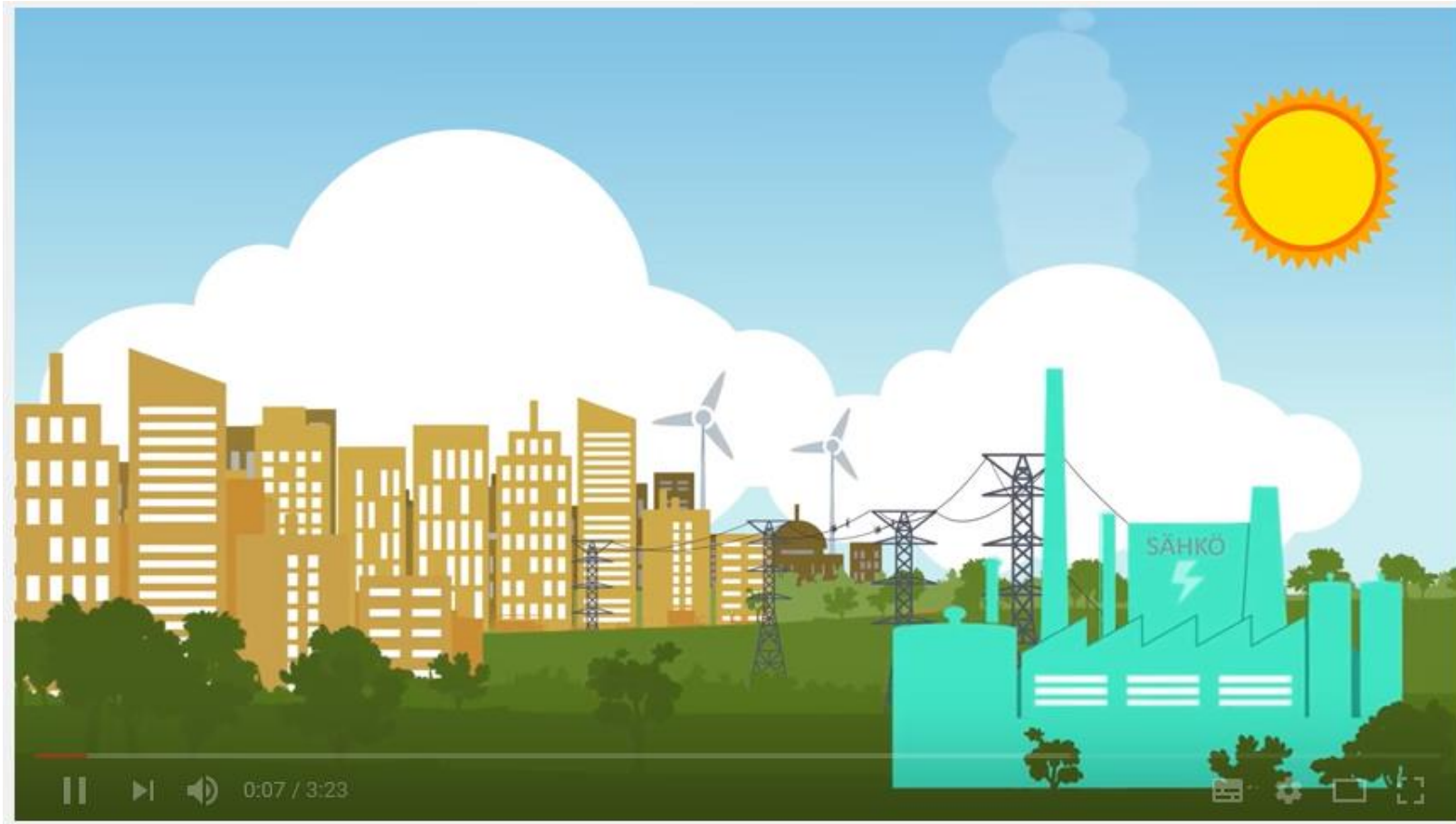
Reserve products and reserve market places

FINGRID

Balancing electricity consumption and production

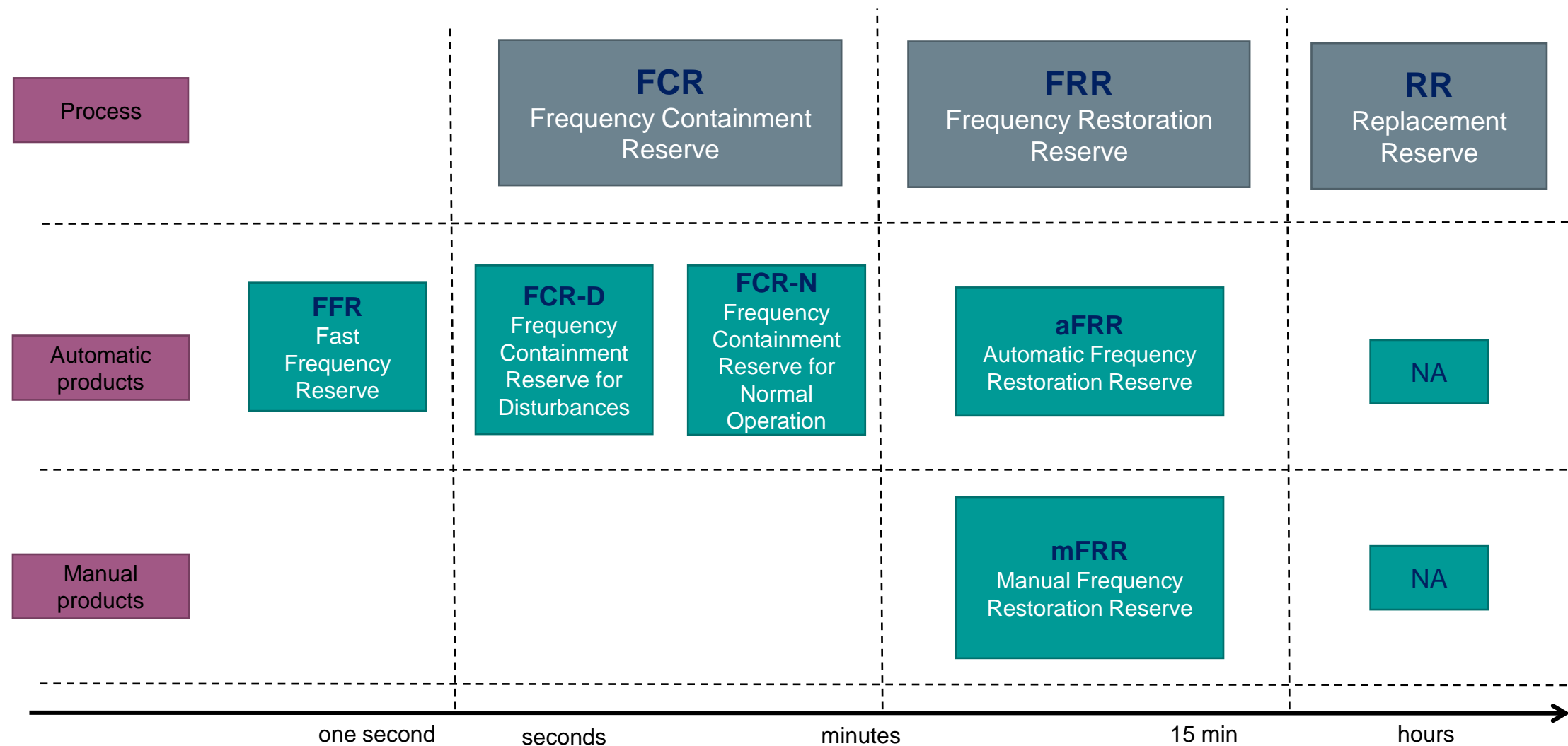


What are reserves?



<https://www.youtube.com/watch?v=D51AVy5wByM>

Reserves used in the Nordic countries



Reserve market places in Finland

FFR

FCR-D

FCR-N

aFRR

mFRR

Fast Frequency reserve,
Finland 18 %, Nordics total 0-300 MW (estimate)

Frequency Containment Reserve for Disturbances,
Finland ~300 MW, Nordics total 1450 MW upwards and 1400 MW downwards

Frequency Containment Reserve for Normal Operation,
Finland ~120 MW, Nordics total 600 MW

Automatic Frequency Restoration Reserve,
Finland 60-80 MW, Nordics total 300-400 MW

Manual Frequency Restoration Reserve
Reference incident + imbalances of balance responsible parties

Activated

In large frequency deviations
In low inertia situations

In large frequency deviations
Up-regulation and down-regulation separately

Used all the time

Used in certain hours

Activated if necessary

Activation speed

In a second



In seconds



In three minutes



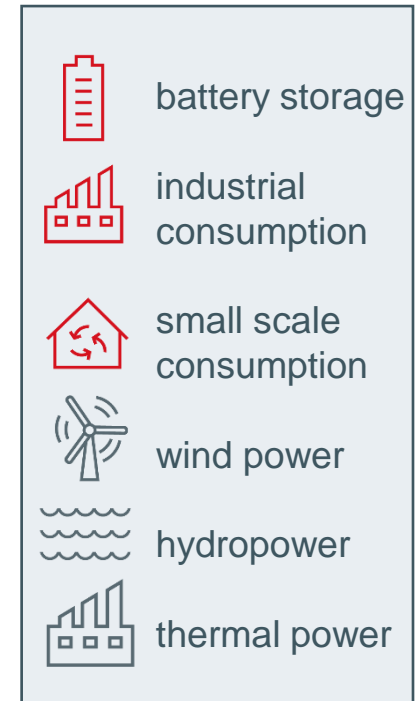
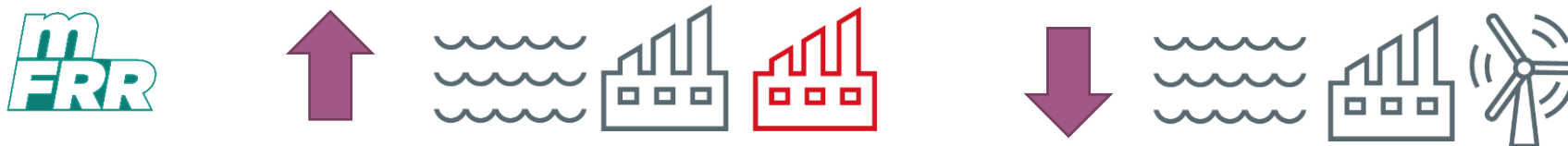
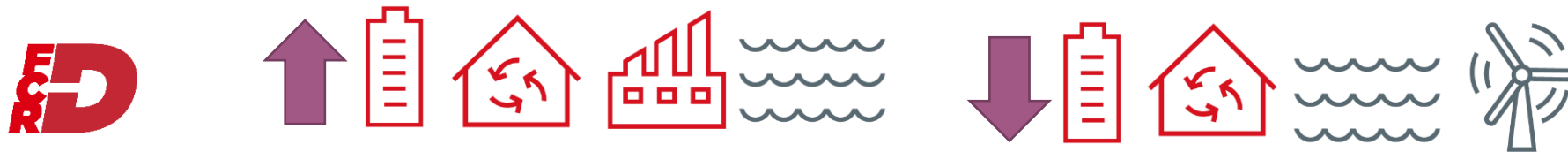
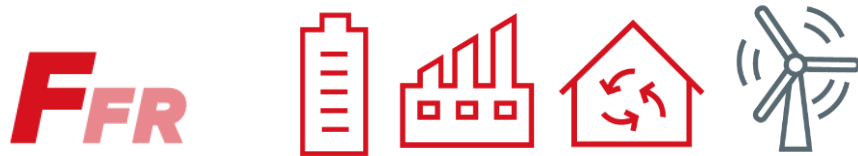
In five minutes



In fifteen minutes



Suitable technologies for the reserve products



Fast Frequency Reserve

- Needed to handle disturbances in low inertia situations
 - Typically needed: spring, summer and autumn (especially weekends and night-time)
 - FFR need is strongly dependent on the hydrological situation in the Nordics
- Very fast response in case of a large underfrequency
 - 1.3 s / 49.7 Hz, 1.0 s / 49.6 Hz or 0.7 s / 49.5 Hz
 - Minimum duration 5 s if deactivation speed is max. 20% of FFR capacity per second, otherwise 30 s
- Daily procurement (based on inertia forecast) through national hourly market with capacity payment based on availability
 - Price level dozens of euros/MW,h
 - Minimum bid size 1 MW



Frequency Containment Reserve for Disturbances



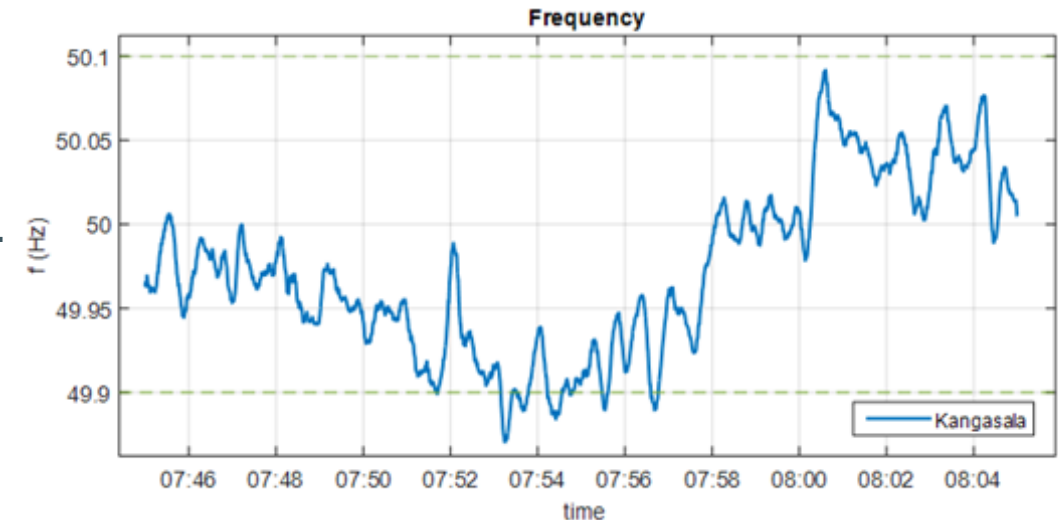
- Activates quickly and linearly in larger frequency deviations
- Divided into two products:
 - FCR-D up: upregulation product (power plants increase production, loads reduce consumption)
 - FCR-D down: downregulation product (power plants decrease production, loads increase consumption)
- Automatic control based on local frequency measurement
- Hourly market with capacity payment based on availability
 - Price level of FCR-D up around 2 €/MW,h in yearly market and from a couple of euros to dozens of euros/MW/h in the hourly market
 - Price level of FCR-D down 10 €/MW,h in yearly market and dozens of euros/MW,h in the hourly market
 - Minimum bid size is 1 MW



Frequency Containment Reserve for Normal Operation



- Continuously activates within the standard frequency range
- Symmetrical product, must be able to increase power and decrease power.
- Automatic control based on local frequency measurement.
- Hourly market with capacity payment based on availability and activation payment based on activated net energy.
 - Price is around 13 €/MW,h in the yearly market and dozens of €/MW,h in the hourly market
 - Minimum bid size is 0.1 MW



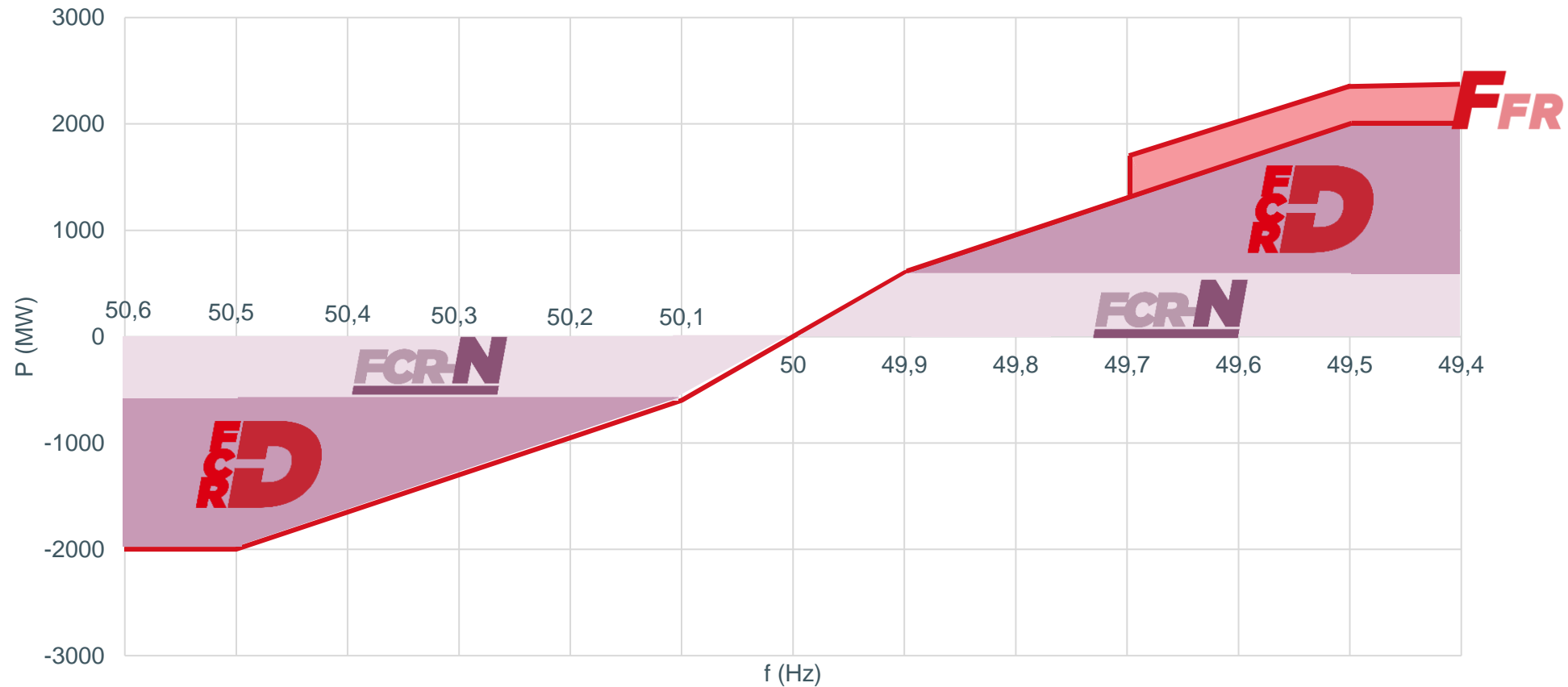
Summary of technical requirements of FCR products

	Minimum bid size	Activation performance	Stability requirement
Frequency containment reserve for normal operation	0.1 MW	<p>Tested with sine wave tests in frequency domain</p> <p>In time domain approximately: ~ 63 % / 1 min ~ 95 % / 3 min With ± 0.1 Hz step frequency change</p>	<p>Valid</p> <p>Tested with sine wave tests in frequency domain</p>
Frequency containment reserve for disturbances up	1 MW	<p>Power: 86 % / 7.5 s Energy: 3.2 x capacity* / 7.5 s</p> <p>With fast frequency change from 49.9 Hz to 49.5 Hz</p>	<p>Dynamic FCR-D up: Valid</p> <p>Tested with sine wave tests in frequency domain</p> <p>Static FCR-D up: Not valid</p>
Frequency containment reserve for disturbances down	1 MW	<p>Power: 86 % / 7.5 s Energy: 3.2 x capacity* / 7.5 s</p> <p>With fast frequency change from 49.9 Hz to 49.5 Hz</p>	<p>Dynamic FCR-D down: Valid</p> <p>Tested with sine wave tests in frequency domain</p> <p>Static FCR-D down: Not valid</p>

*Reserve capacity maintained in FCR market

Reserve activation based on frequency

- Activation linearly based on frequency deviation guarantees equal activation from all providers.



Market places for Frequency Containment Reserves



Yearly market

- Bidding competition for the next year is organized every autumn.
- The bidding competition determines the volumes for each provider and a fixed yearly market price, which is the same for every provider and corresponds to the most expensive accepted bid.
- Reserve provider submits hourly FCR volumes by 18:00 (EET) the previous day.

Hourly market

- Possible to enter at any time of the year.
- Hourly reserve bids (€/MW and MW) shall be submitted by 18:30 (EET) the previous day.
- Fingrid purchases the required amount of reserve from hourly market. Purchases are not necessarily made for every hour.
- Each hour has its own price, corresponding to the most expensive accepted bid.
- Capacity that is constrained for the yearly market cannot be bid to the hourly market.

Automatic Frequency Restoration Reserve **aFRR**

- Activates continually according to an activation signal sent by Fingrid within five minutes.
- Bids for up-regulation and down-regulation capacity are submitted separately.
- Pro-rata activation in relation to bid size.
- Hourly market with capacity payment based on availability and activation payment for energy
 - Capacity payment price level around dozens of euros/MW,h.
 - Activation payment according to balancing energy market price.
 - Minimum bid size 1 MW



Balancing energy markets

- Fingrid's balancing energy markets are a part of Nordic balancing energy markets, where bids are activated in price order, technical conditions considered.
- Bids can be delivered and updated 45 minutes before each operating hour.
- Separate up- and down-regulation bids.
- Minimum bid size 5 MW or 1 MW (restricted amount).
 - It is allowed to submit five up-regulation and five down-regulation bids below 5 MW but above 1 MW, if electrical order is used.
- Manual activation in fifteen minutes.
- Bids are ordered electrically by message or by phone.
- Marginal pricing i.e. payment is calculated based on the ordered energy and the most expensive bid used in each hour (as exception special regulation is priced by pay-as-bid principle).
 - Up-regulation price is always at least the spot price. Down-regulation price is at most the spot price.



Reserve power plants



- Fingrid has reserve power plants at its disposal. The power plants are owned by Fingrid or leased with long-term contracts. In total the capacity amounts to 1250 MW.
- The reserve power plants ensure that Fingrid has access to a sufficient amount of manual frequency restoration reserve.
- The reserve power plants are started only after other bids on the balancing energy market have been activated.
- The reserve power plants are not used for commercial electricity production.

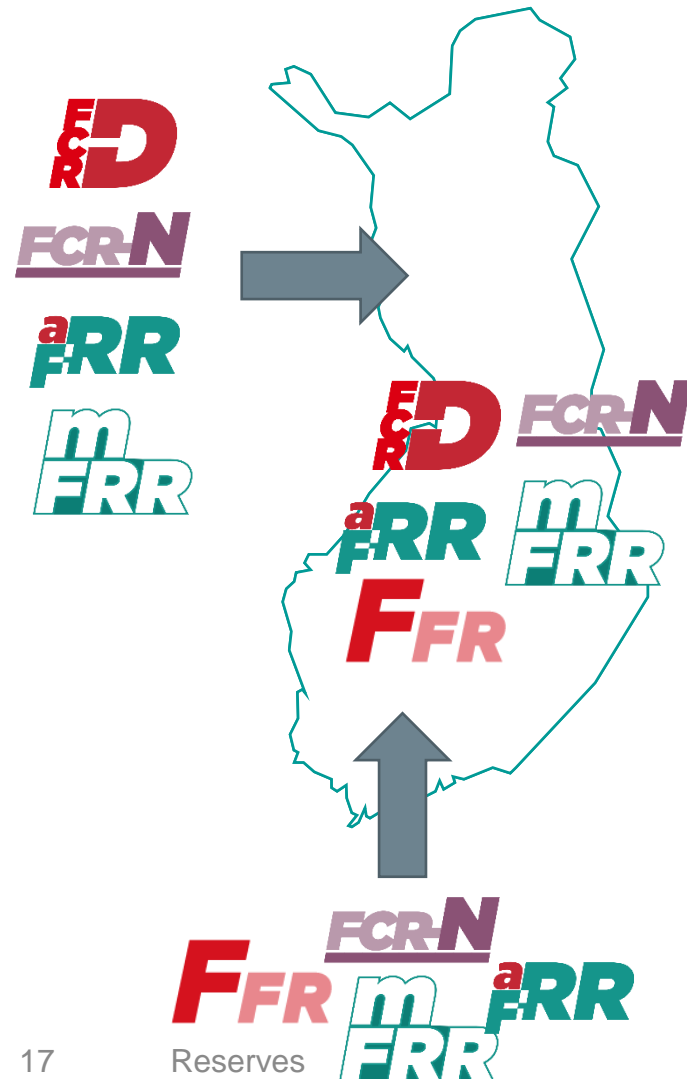


Balancing capacity markets



- With balancing capacity markets, Fingrid secures that it has enough available up-regulation bids on the balancing energy market for the next day.
- Procurements from the balancing capacity markets are made hourly, the bidding competition is organized the previous day (D-1 at 09:30 EET)
- Balancing Service Provider (BSP) whose bid is accepted in the bidding competition is obliged to deliver up-regulation bids to the balancing energy market (= balancing capacity bid).
- In the balancing energy market, the balancing capacity bids are equal to voluntary energy bids.
- The BSP receives capacity payment for submitted bids to the balancing energy market, and energy payment if the bids are activated.

Procurement of reserves



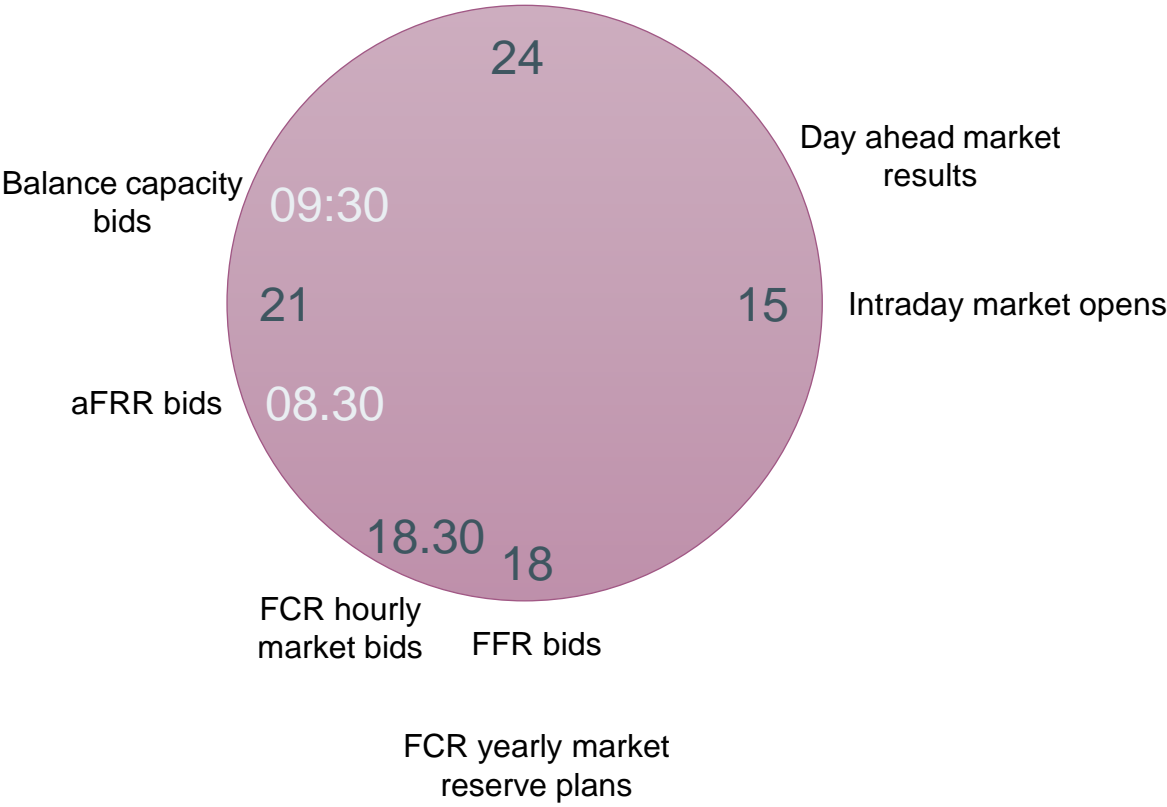
Power production, consumption and energy storage participates in the Finnish reserve markets.

- Procuring is market-based and providers' participation is optional.
- Market prices are determined by the marginal pricing principle.

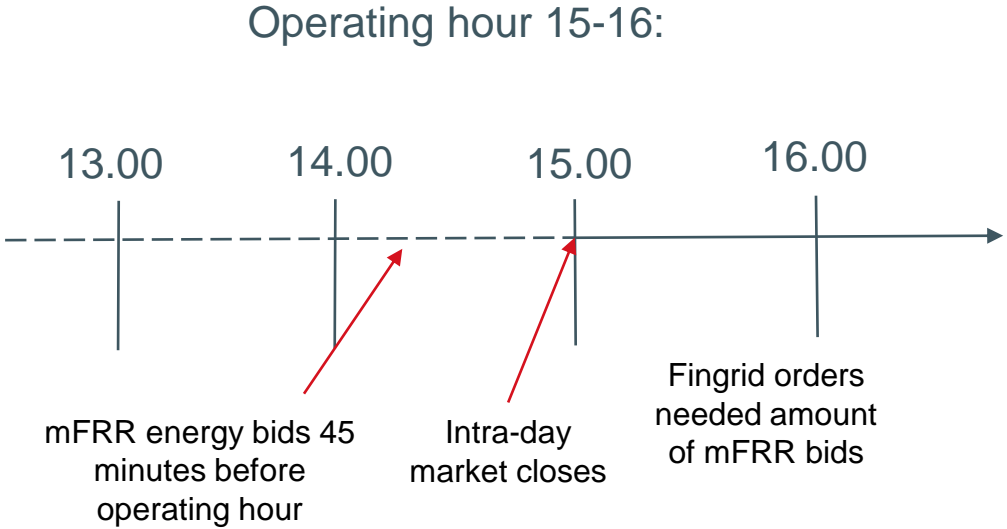
Fingrid trades reserves and balancing energy with neighbouring TSOs

Reserve markets' timetable (in EET/EEST)

Day before D-1



Delivery day D



Examples of annual income from reserve capacity markets

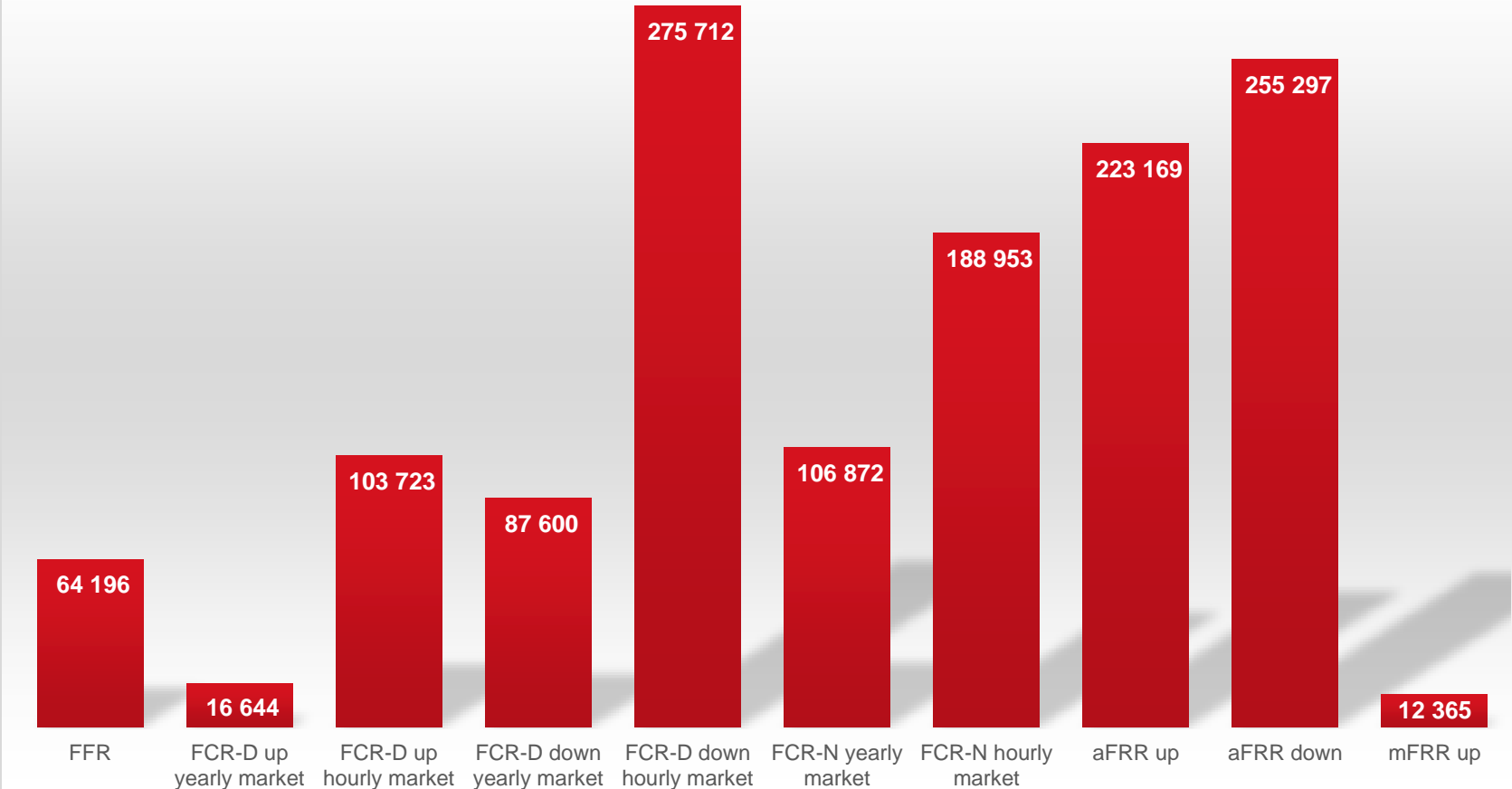
Market	Price (€/MW,h)	Annual number of hours (2021)
FFR	45,4	1414
FCR-D up yearly market	1,9*	8760
FCR-D up hourly market	12,6	8232
FCR-D down yearly market	10*	8760
FCR-D down hourly market	32***	8616***
FCR-N yearly market	12,2*	8760
FCR-N hourly market	21,9	8628
aFRR up	38,9	5737
aFRR down	44,5	5737
mFRR up	2,3	5376

* yearly market price 2022

** volume weighted average price 2021

*** average of 1/2022

Income per 1 MW of reserve capacity (€)



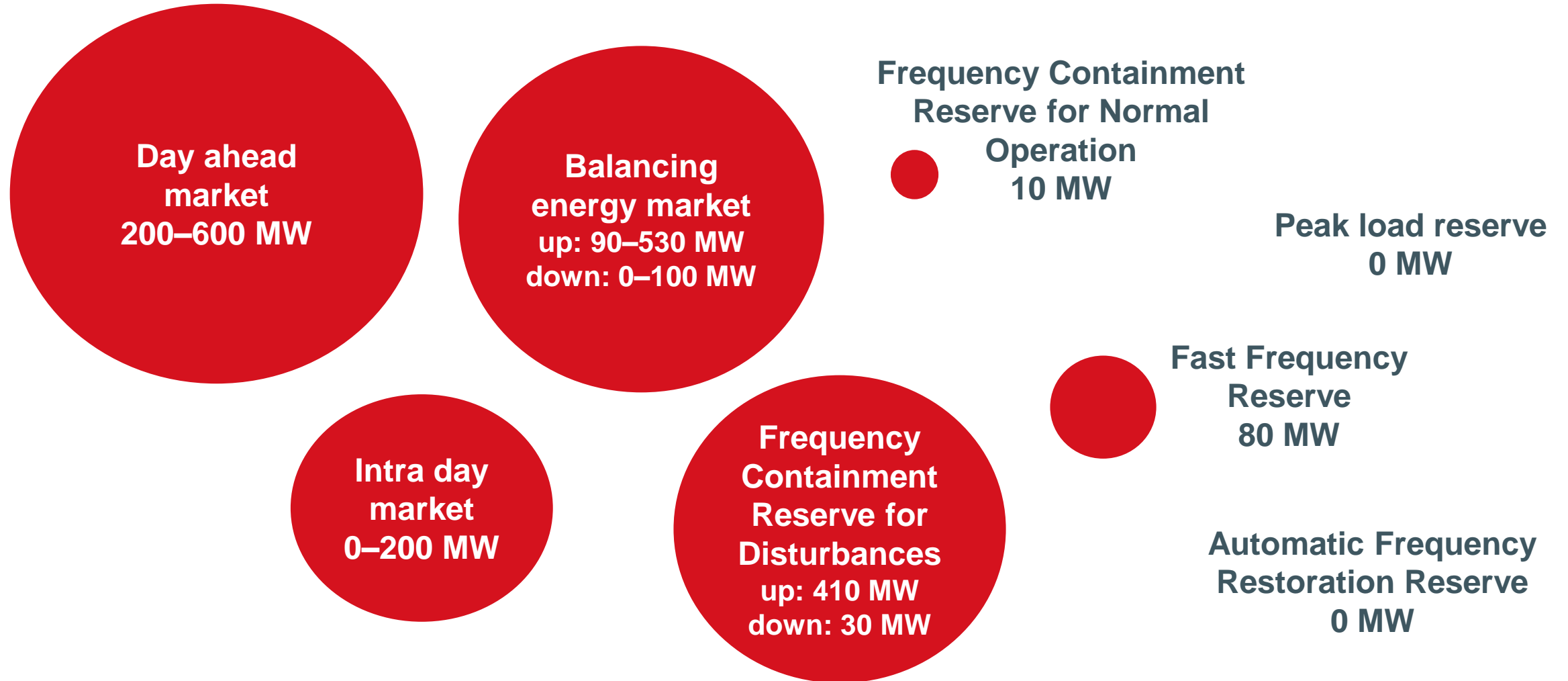
Prices are published on Fingrid's webpage:

<https://www.fingrid.fi/en/electricity-market/electricity-market-information/reserve-market-information/>

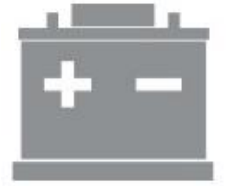
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Demand side response participation in Finnish markets

status 1.2.2022









Providing reserves from energy storage

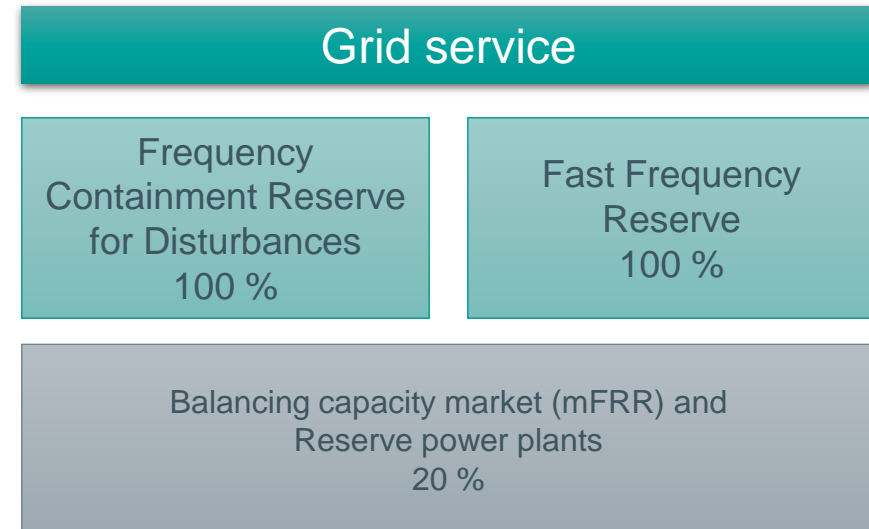
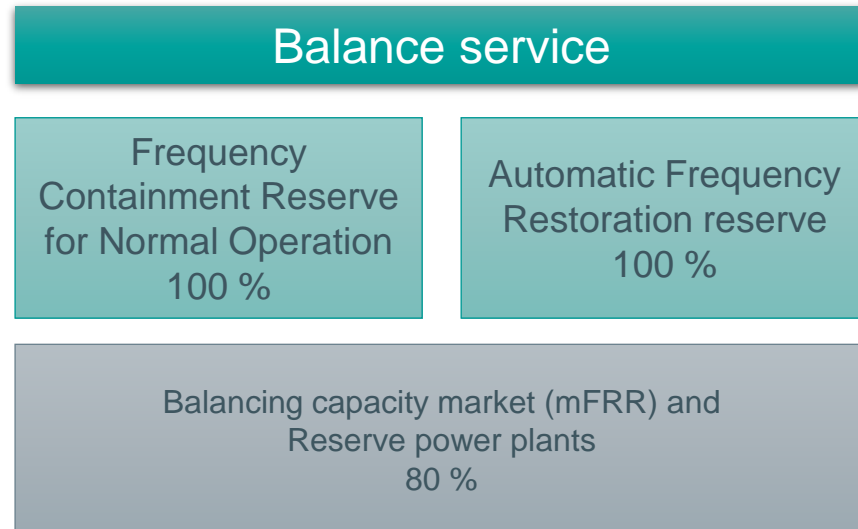


- Battery energy storage systems are suitable to provide especially reserves that require a fast response but a rather limited duration of activation.
 - FFR and FCR-D are very suitable products for batteries. FCR-N is also suitable but required energy capacity is larger.
 - In FCR products real-time telemetry is required to monitor the state of charge of the battery.
- Balancing Service Provider is responsible for sufficient energy capacity to always maintain and activate the contracted reserves.
- Additional power on top of maintained capacity is required for energy management in FCR products.
- In aFRR product, reserve provider should use intraday market or compensation from their own portfolio for energy management.

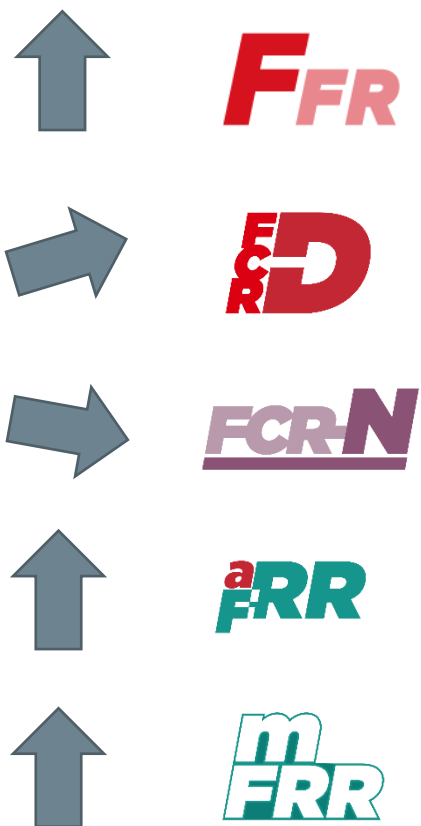
Minimum dimensioning for continuous activation at full reserve power

	Fast Frequency Reserve	5-30 s
	Frequency Containment Reserve for Disturbances	20 min
	Frequency Containment Reserve for Normal Operation	1 h (for both up and down regulation)
	Automatic Frequency Restoratin Reserve	1 h
	Balancing Energy Market	1 h
	Balancing Capacity Market	3 h

Reserves and balancing energy markets costs covering



- Fingrid covers balancing energy market fees with imbalance power trade. Imbalances are traded with balance responsible parties who had balance deviation in that hour. The price of imbalance power is based on balancing energy markets and day ahead market price in that hour.



Growing demand
for reserves



Connection to European energy
markets in aFRR and mFRR

Contact persons at Fingrid

Topic	Contact person(s)
Common inquiries about procurement, reserves and joining the reserve markets	Customer team: Jukka Kakkonen, Mikko Haapamäki, Taneli Leiskamo, Tuomas Mattila
Fast Frequency Reserve (FFR)	<i>Markets, contracts and Terms and conditions:</i> Mikko Haapamäki <i>Technical requirements and prequalification:</i> Pia Ruokolainen, Elisa Konttila
Frequency Containment Reserve (FCR)	<i>Markets, contracts and Terms and conditions:</i> Taneli Leiskamo <i>Technical requirements and prequalification:</i> Pia Ruokolainen, Elisa Konttila
Automatic Frequency Restoration Reserve (aFRR)	<i>Markets, contracts and Terms and conditions:</i> Tuomas Mattila, Joonas Muikku <i>Technical requirements and prequalification:</i> Pia Ruokolainen, Elisa Konttila
Balancing Energy- and -Capacity markets (mFRR)	Otso-Ville Rinne, Jukka Kakkonen
Data exchange	Antti Hyttinen, Jussi Karttunen
VAKSI	Jussi Karttunen, Antti Hyttinen
RESTORE	Jussi Karttunen
Realtime telemetry	Erno Paananen
MARI	Anders Lundberg
PICASSO	Vesa Vänskä, Tuomas Mattila

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Thank You!

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