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NEED FOR EXTREME EVENT CONSIDERATIONS IN ENERGY SYSTEM OPERATION

From a TSO perspective

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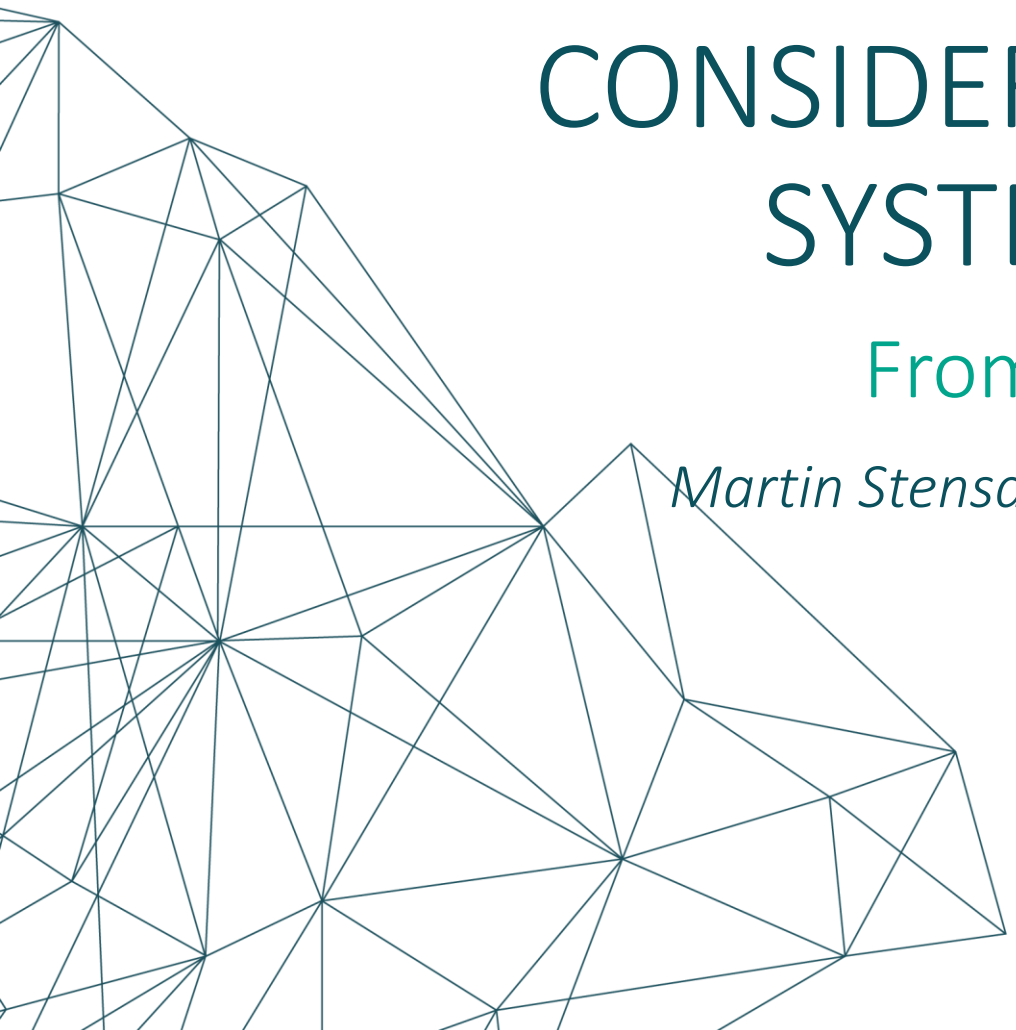

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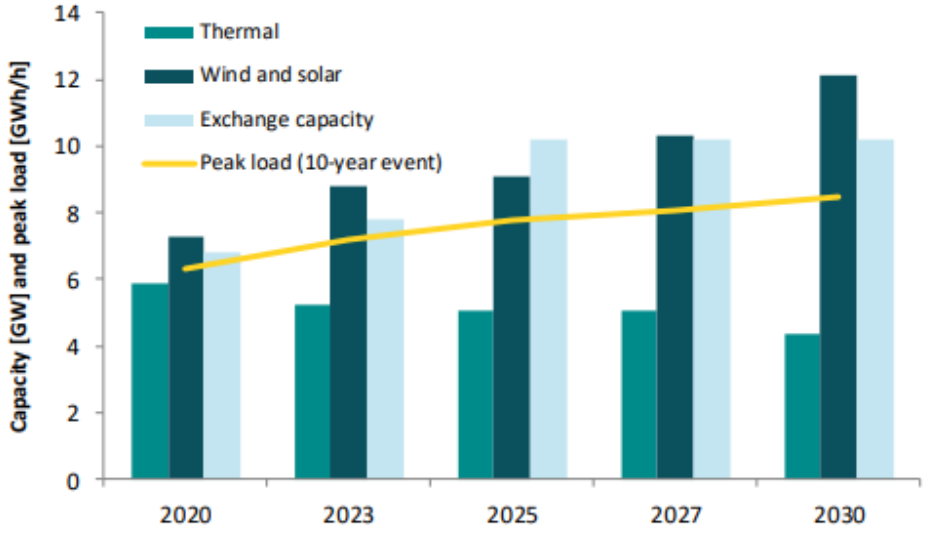
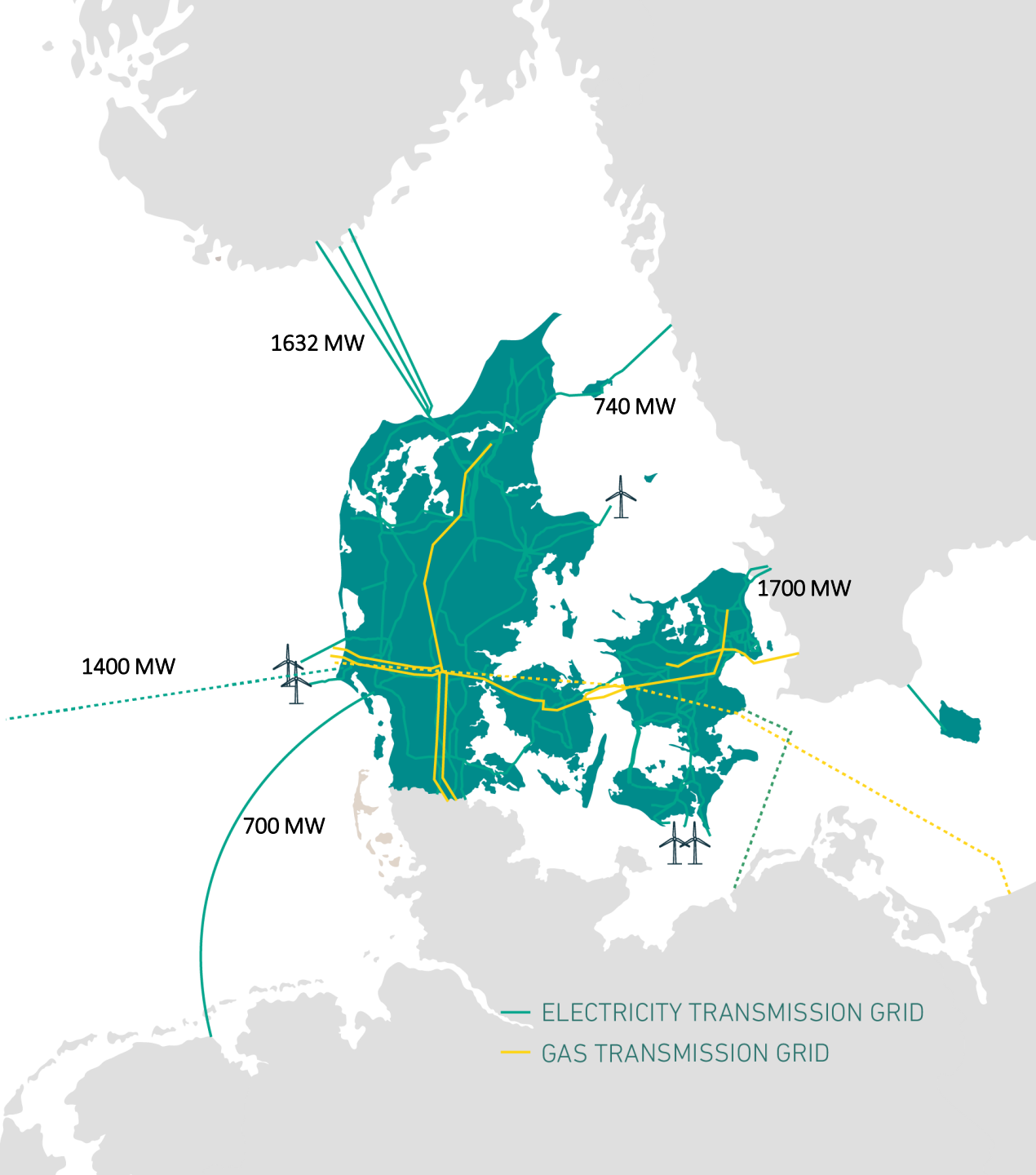
Social Mission: *A renewable energy system with a high level of security of supply and at an affordable price.*

- **Balances the Danish electricity system** consisting of two synchronous areas (DK1 in Continental Europe and DK2 in the Nordic area) connected through HVDC (600 MW).
- Owns and operates ~7.000 km transmission lines in Denmark.
- Connected to Sweden, Norway, Germany, the Netherlands UK.
- More than 2000 employees





HOW DOES ENERGINET USE FORECASTING

ARE EXTREME SITUATIONS MISSING?

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Calculation time before operational hour

Approx -36H | *-72H to -1H* | *-1H to realtime*

DYNAMIC RESERVE DIMENSIONING

Reserve procurement depending on expected imbalances

Forecast includes many aspects of power system dynamics

Forecast of extreme weather can ensure higher procurement

SECURITY CALCULATIONS

Grid calculations based on expected production/consumption

Partially market input and forecasted values

Transmission lines operation and bottleneck estimation

PROACTIVE BALANCING

Close to real-time imbalance forecast enables proactivity

Economically efficient balancing from central TSO dispatch

Mitigate e.g. storm shutdown extreme event

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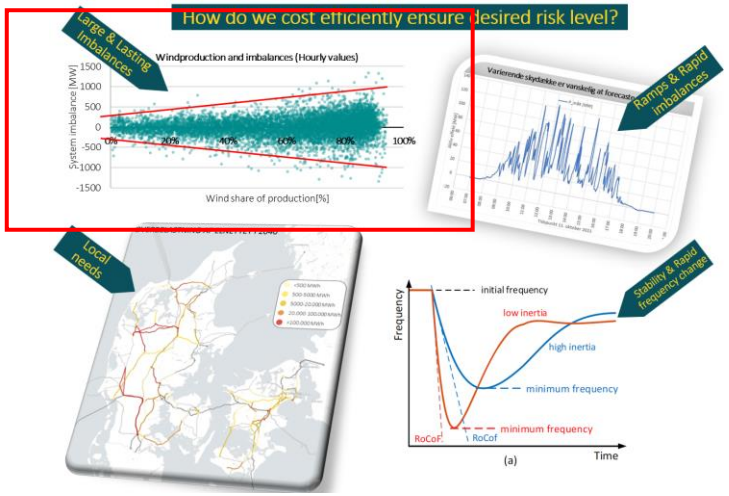
DYNAMIC DIMENSIONING

Consideration of extreme events to achieve a proper risk level

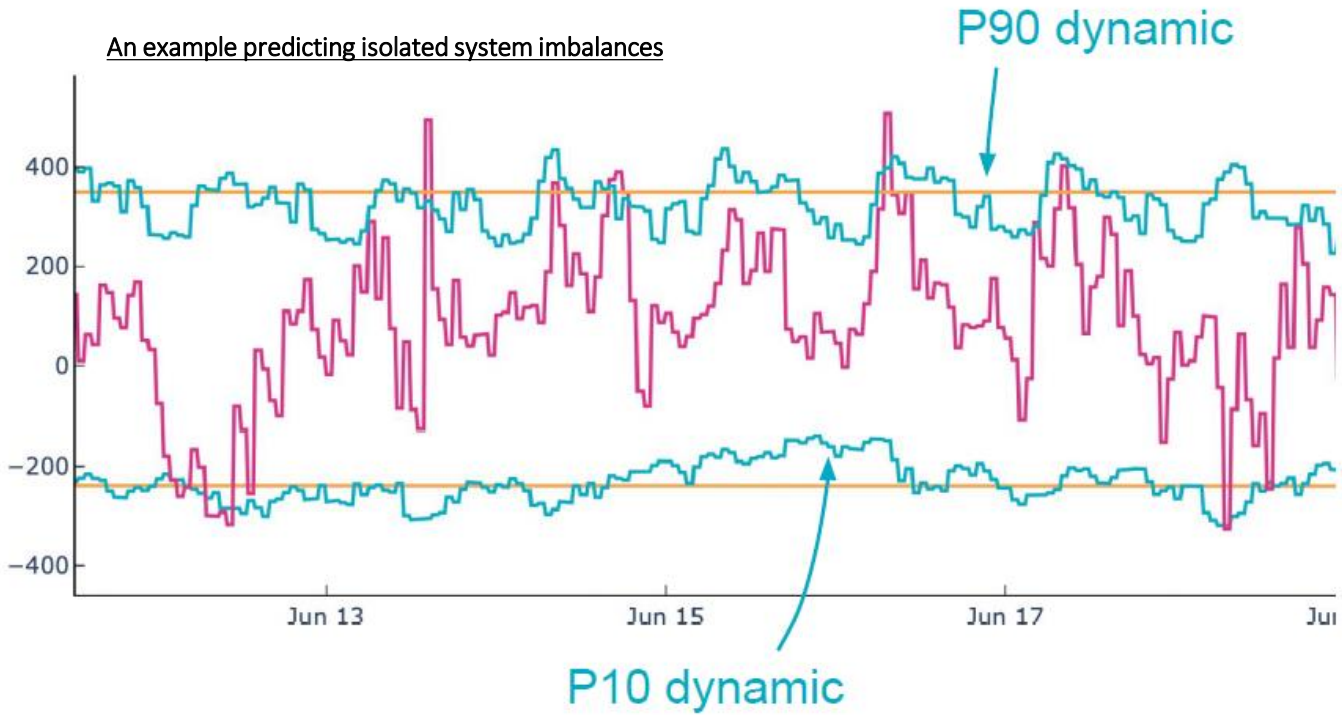
DYNAMIC DIMENSIONING

Dynamic Dimensioning to ensure what is needed, when it's needed ➔ Estimated early D-1.

- Daily predicting FRR demand per hour for the coming day of operation.
- Increased imbalances from renewables, hence the need for hourly resolution of dimensioning.
- Using historical values and <u>forecasts</u> to predict tomorrows needs is a ***dynamic approach***.



<u>An example predicting isolated system imbalances</u>



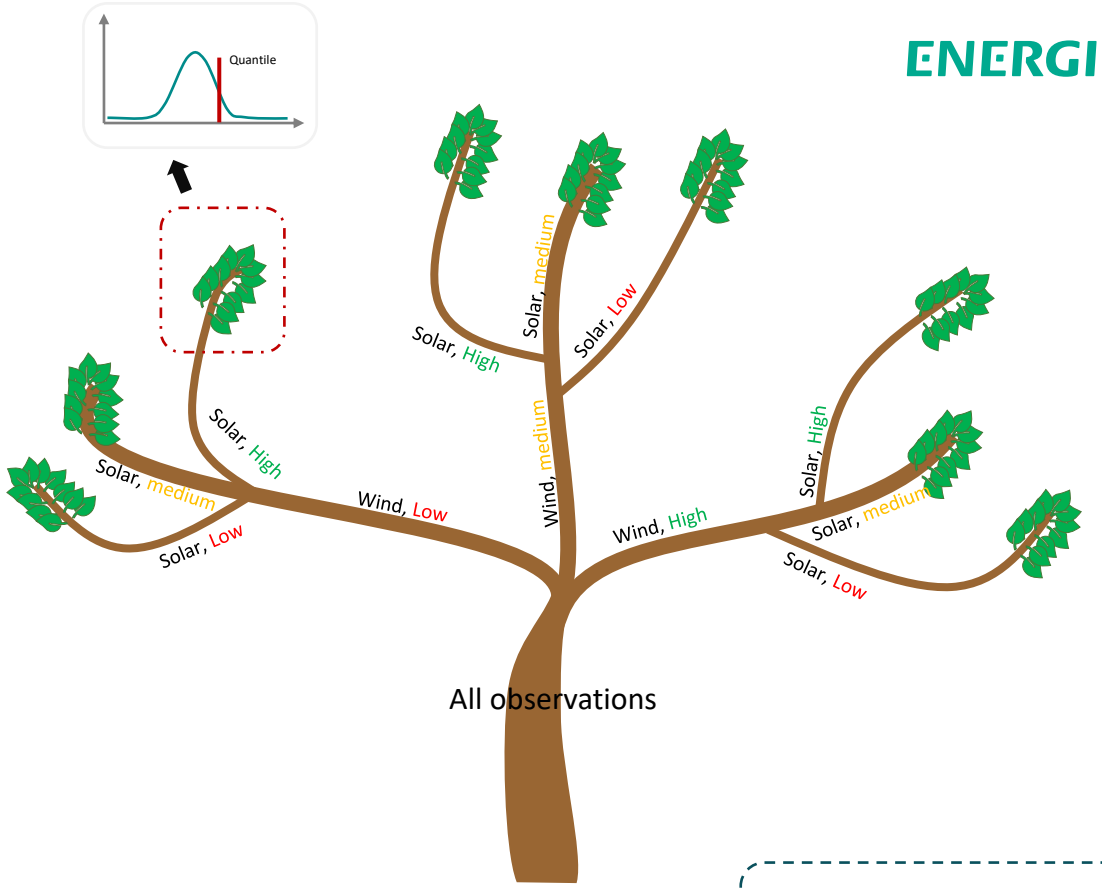
DYNAMIC DIMENSIONING

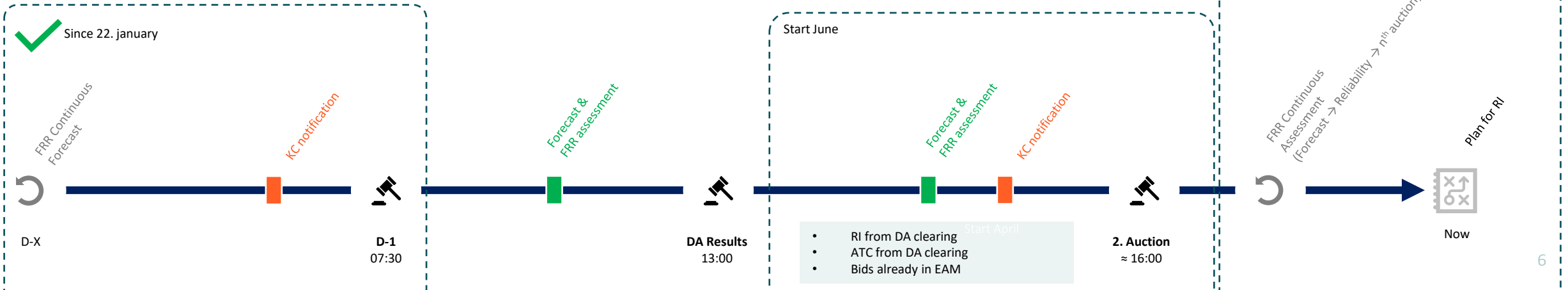
HOW IT WORKS

Bayesian Model for forecasting.
All observations (leaves) are bundled into several branches. The model finds a representable branch and calculates statistical distribution and takes the chosen quantile.

Two forecasts:
- FRR need (RI+NI-sharing-netting)
- Voluntary bids

Following forecasts are used as input
- Time, temperature, wind, solar, consumption and max IC capacities, (soon forecast of ATC).





ARE EXTREME EVENTS CORRECTLY REPRESENTED?

Lack of historical data on extreme events obscurs our risk level

Is the approach suitable for extreme situations or is the timespan too long?

Should extreme events be covered by this methodology?

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SECURITY CALCULATIONS

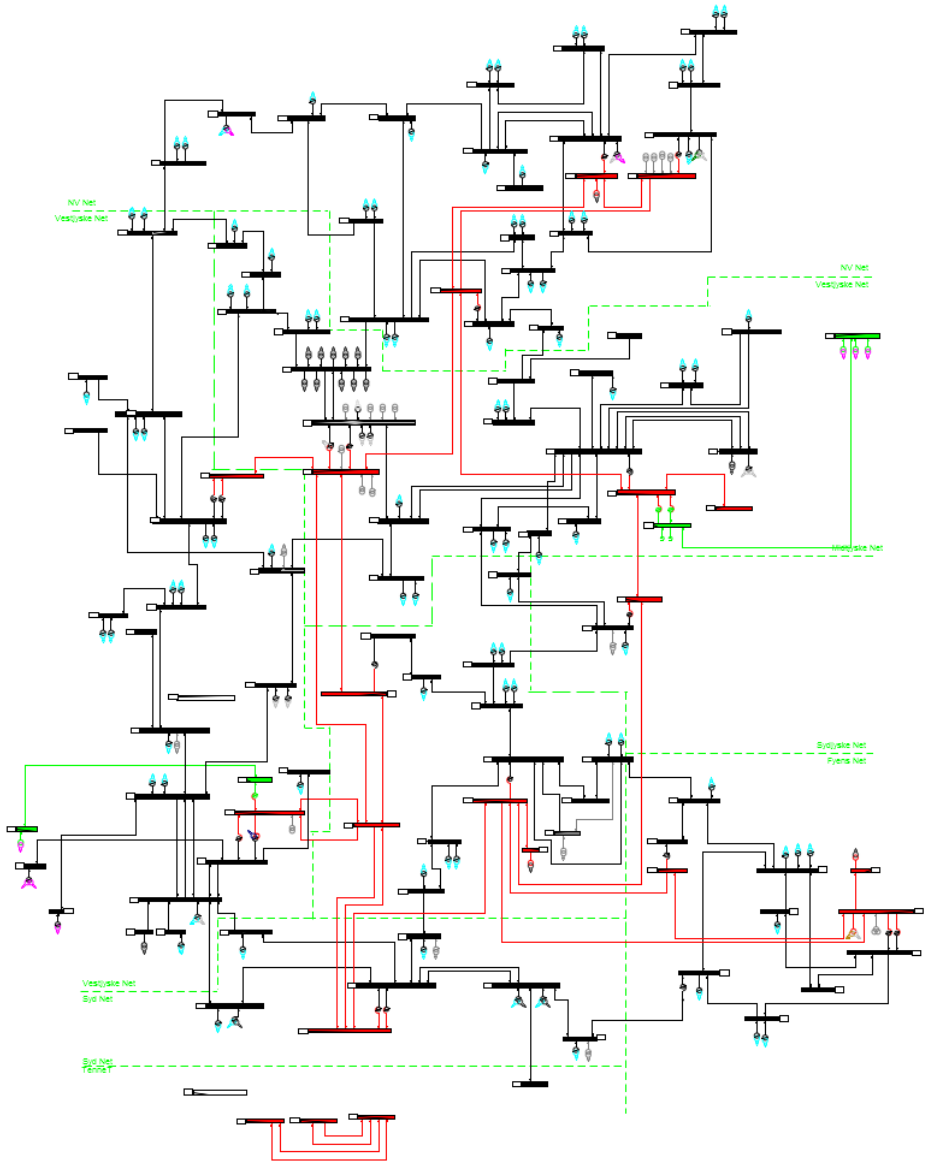
SECURITY CALCULATIONS

Continuously updated calculations about load flows and grid strenght

Tool used by kontrol center to evaluate if grid is able to handle coming situations.

Runs some basic standard grid operational scenarios.

Uses updated inputs from markets, UMMs and grid knowledge to estimate if operation is safe – and where something should be done.



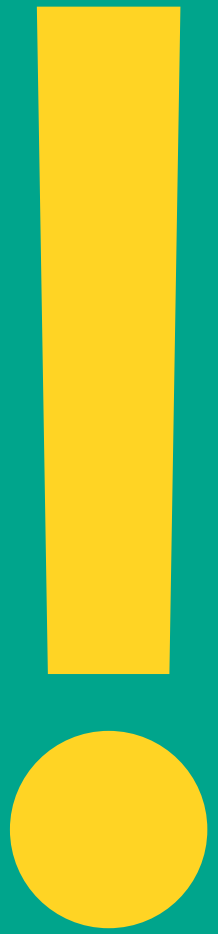
DK1 grid diagram

EXTREME EVENT FORECASTS CAN SAVE RESSOURCES

By knowing more accurately which scenarios are most likely, simulations can be run more efficiently.

Knowledge about timing and location is crucial and will enable control center operators to act precisely and with high impact.

Allows for preemptive downregulation of production hubs.



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PROACTIVE BALANCING

Near real-time warning of extraordinary situations

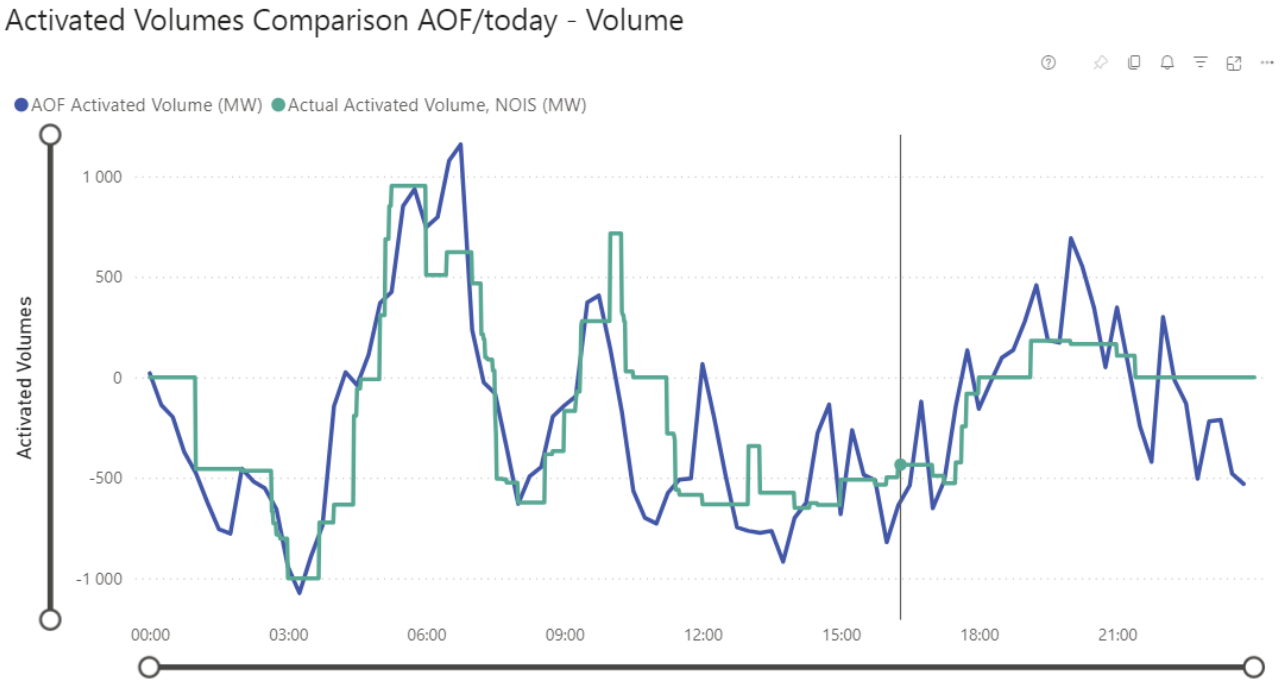
TRANSITION TO AUTOMATED MFRR EAM

Before 4th of March:

- Bid selection and activation are done manually by an operator.
- Bid lists and bid activation are valid (primarily) for one hour.

From mFRR EAM, after 4th of March:

- Activations are based on forecasted imbalances and a simple activation optimization
- Bid selection is based on data from four TSOs: mFRR needs, bid list, and available capacity change every quarter.
- Bid activation



SHORT TERM IMBALANCE FORECAST

Inputs:

- Production mix, and interconnector usage
- Demand levels
- Balance plan from balance responsible parties
- Changes in weather
- And more..

All combined to create an accurate estimate of the coming imbalance, which ensures cost-effective balancing and utilization of ressources.

But what if homogenous the forecasting can lead to significant errors?

BRP plans are a significant input to forecast imbalances.

We see a harmonization of weather dependent production forecasts in the private sector.

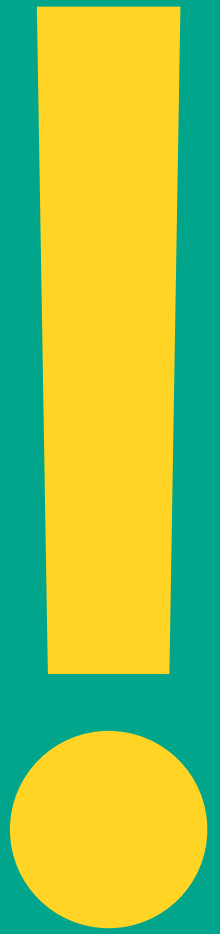
Tendency to have significant forecast errors at the same time and in the same direction magnifying the problem.

FORECAST HARMONIZATION MAY LEAD TO EXTREME EVENTS

If all market actors wrongly estimates power production og consumption homogenously a non extreme event may become one.

Energinet uses 3 different forecasts to mitigate problem.

But market participants do not have the same incentive.



FORECASTING IN THE ENERGY SECTOR IS CRUCIAL AND DEVELOPMENTS IN EXTREME EVENTS AS WELL

By closing some of the gaps established a more reliable, efficient and cheaper operation of the grid will be possible

Knowledge of extreme events in due time can enable a more accurate risk assesment and proper reserve procurement

Knowledge about time and place of potential extreme events can let operators handle the incident in a timely manner

Harmonization of forecasting providers and methodology is becoming a weak link

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Thank you for your attention