

A landscape of rolling hills and fields under a cloudy sky. The foreground is dominated by tall, green grasses. The middle ground shows a series of fields, some of which are planted with crops, and a few scattered trees. The background features more rolling hills and a line of trees on the horizon. The sky is filled with soft, grey clouds, suggesting an overcast day.

A BALANCING PHILOSOPHY FIT FOR 100 % RENEWABLES?

THOMAS DALGAS FECHTENBURG, ENERGINET, SENIOR MANAGER/BALANCING PHILOSOPHER, ANCILLARY SERVICES

CENTRAL VS. DECENTRAL BALANCING

✓ Increased control with a central model

Provides the system operator with greater operational confidence. Centralized systems, where flexibility is managed directly by the operator, offer better control and visibility for system operations.

✗ Limit flexibility

Although centralized systems may feel more comfortable for the operator, they risk overlooking flexibility that is **not explicitly** available to the system operator. This means that valuable reactive flexibility may potentially be lost.

✓ Increased liquidity with a decentralized model

The market can respond dynamically to price variations almost in real time, and participation in explicit markets does not require compliance with specific technical requirements. As a result, flexibility resources can theoretically be utilized more effectively, which is expected to increase overall welfare.

📊 Increased complexity and mitigating measures?

It cannot be concluded whether the difference in liquidity can be addressed within a central model, for example by adapting technical requirements and introducing roles such as an independent aggregator, etc.

Similarly, it remains unclear whether the difference in control can be addressed within a decentralized model, for example by modeling and anticipating passive responses to different price signals and achieving the necessary geographic differentiation.

PROACTIVE VS. REACTIVE BALANCING

✓ Proactive balancing

Flexibility is activated in a planned manner and can be optimized based on price and need, particularly in relation to predictable variability and deviations, which can help manage increasing volumes of wind and solar in the system. It can also reduce reaction-time requirements because activation takes place ahead of the imbalance.

✗ Forecast precision dependency, and complex communication

This creates a dependence on forecast accuracy, since incorrect predictions leave residual imbalances. In addition, it introduces significant complexity in planning and coordination, as multiple actors must plan together and share data through advanced IT support.

✓ Reactive balancing

A direct response to actual imbalances provides high precision—you only react when the need arises. It also reduces the need for complex forecasting and coordinated planning. This enables rapid decision-making.

✗ Reduced activation precision

This may lead to the activation of more expensive resources and lower efficiency, since resources must be activated quickly and without optimal economic timing. It may also limit access to flexibility, as fewer actors and assets are realistically able to participate. And if the need is significant and activation is not fast or precise enough, it can lead to critical situations.

A key parameter in assessing a balancing philosophy is complexity. This applies both to the complexity faced by the TSO and by market participants. Does a theoretical advantage outweigh the introduction of additional complexity?

Risk vs incentive

Polluter pays (cost reflective) vs. risk premium

Stick or carrot?

Control vs innovation

Gate closure time vs. Planning/predictability

Complexity vs simplicity

For the TSO and the market,

I.e. standard products or tailored

International markets and harmonization,
or local and adaptive

Transparency vs speculation

Quality vs quantity

PQ vs audits

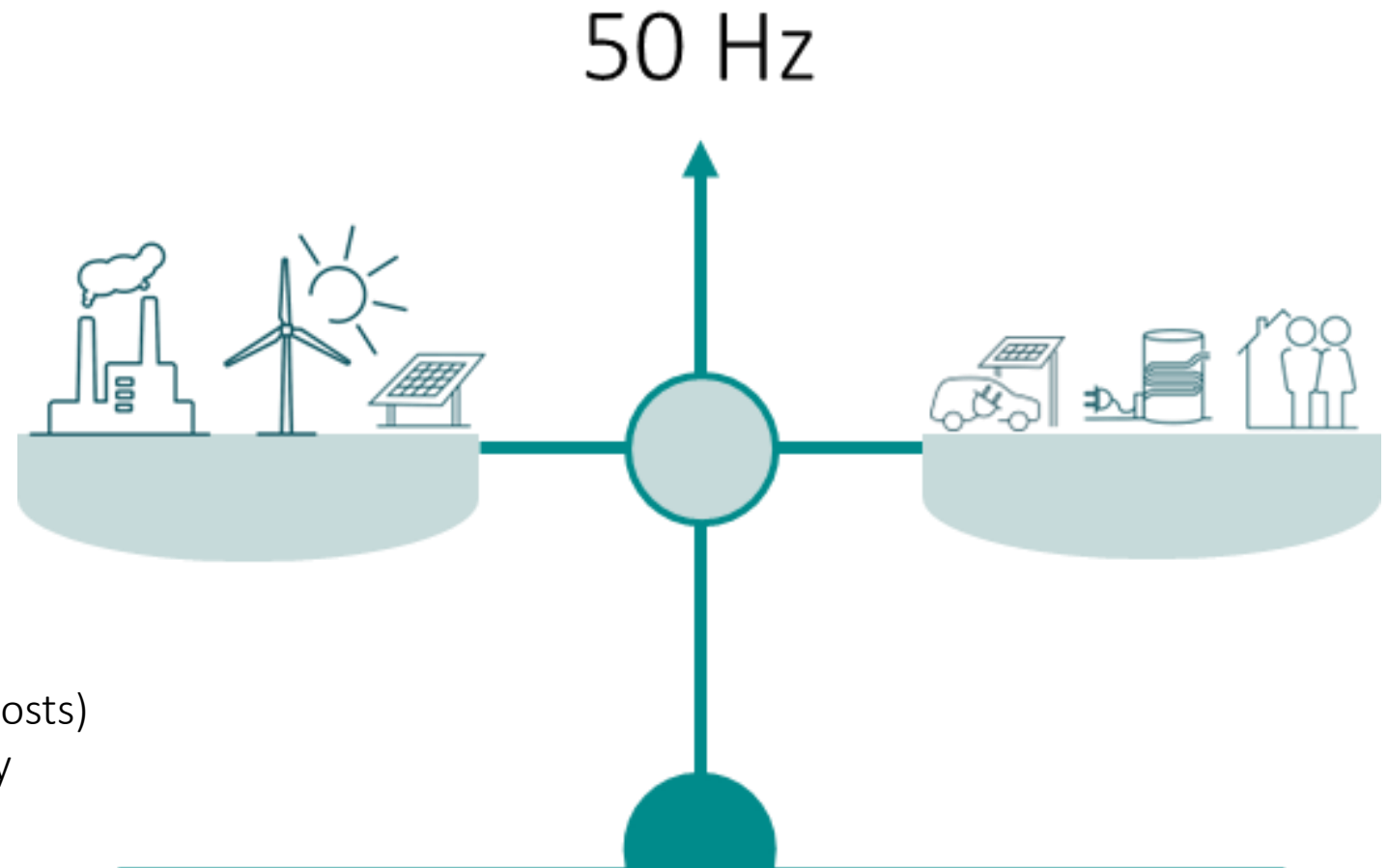
Tariffs (distribution) vs socio welfare (hidden costs)

Elastic demand (willingness to pay) vs. security

Bankability vs optimal dispatch

Non-asset backed trading or not? Imbalances

Local constraints vs. portfolio based bidding

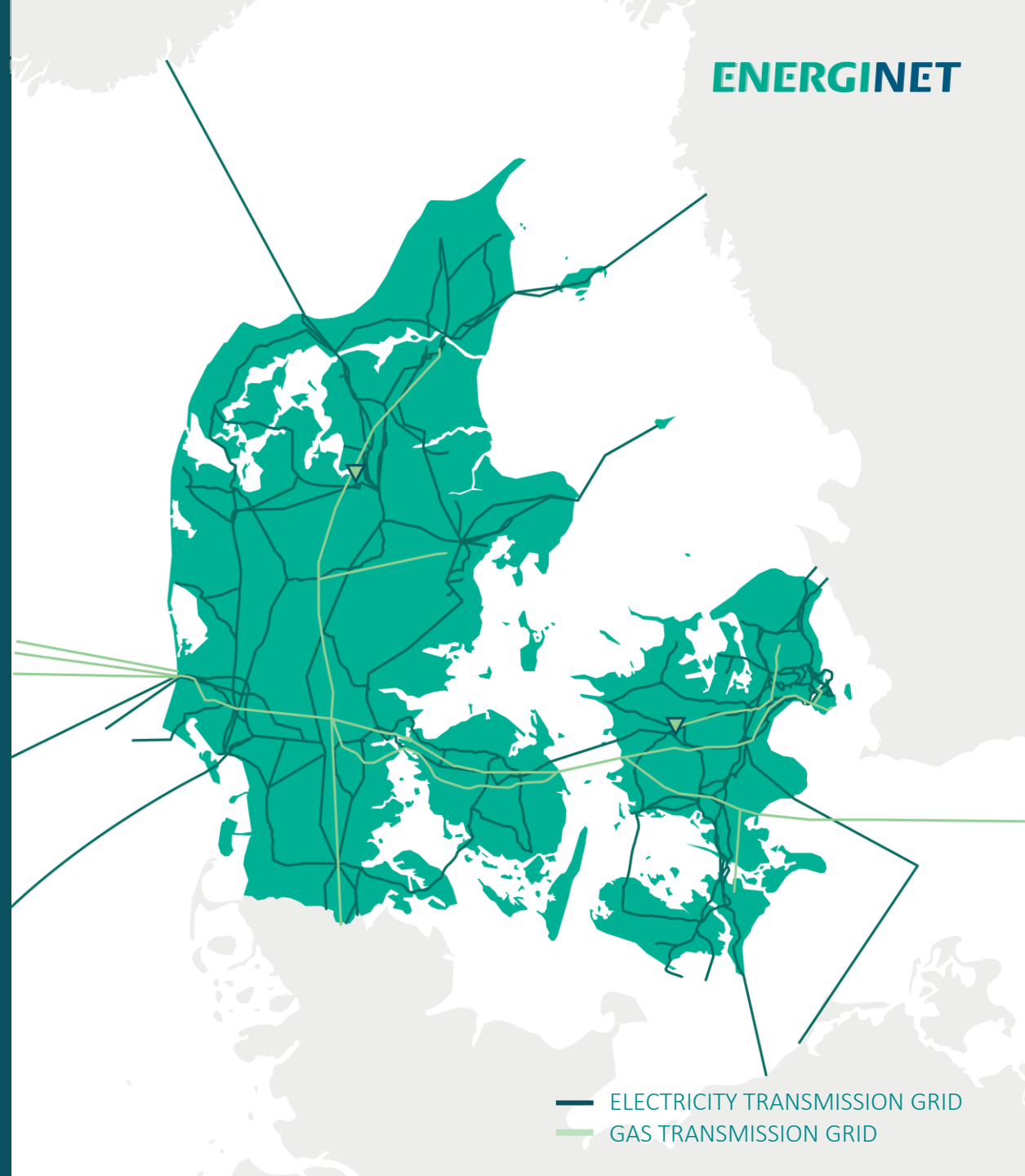


WE ARE WORKING FOR DENMARK

Energinet is responsible for the supply of gas and electricity in Denmark. **+hydrogen**

We safeguard society's interests as we move to a 100% green energy system.

We are a regulated TSO owned by the Danish Ministry of Climate, Energy and Utilities.



— ELECTRICITY TRANSMISSION GRID
— GAS TRANSMISSION GRID

UNITING MARKET LOGIC AND PHYSICAL REALITIES AFFECTS ALL ELEMENTS OF SECURITY OF SUPPLY



GRID
ADEQUACY



GENERATION
ADEQUACY



ROBUSTNESS



IT-SECURITY

THE DEMAND FOR GRID IS
RAPIDLY INCREASING

Accurate forecasts for consumption and production and local flexibility plays a crucial role in supplement to grid expansion.

ALL TYPES OF FLEXIBILITY HOLDS
VALUE WHEN MADE AVAILABLE

Early report of available flexibility is key across all markets. Aggregation of flexibility can unleash new potentials.

MARKET DYNAMICS MANIFESTS
IN VERY PHYSICAL WAYS

Digital solutions must build on fundamental physical principles to support security of supply.

IT IS THE FOUNDATION FOR
SECURITY OF SUPPLY

That calls for exceptionally high IT-security and redundancy. Control mechanisms must be designed to address 'fat fingers'.

HOW TO BALANCE

We aim to make the green transition socioeconomic optimal while ensuring security of supply

Which considerations would you focus on when shaping a balancing philosophy?

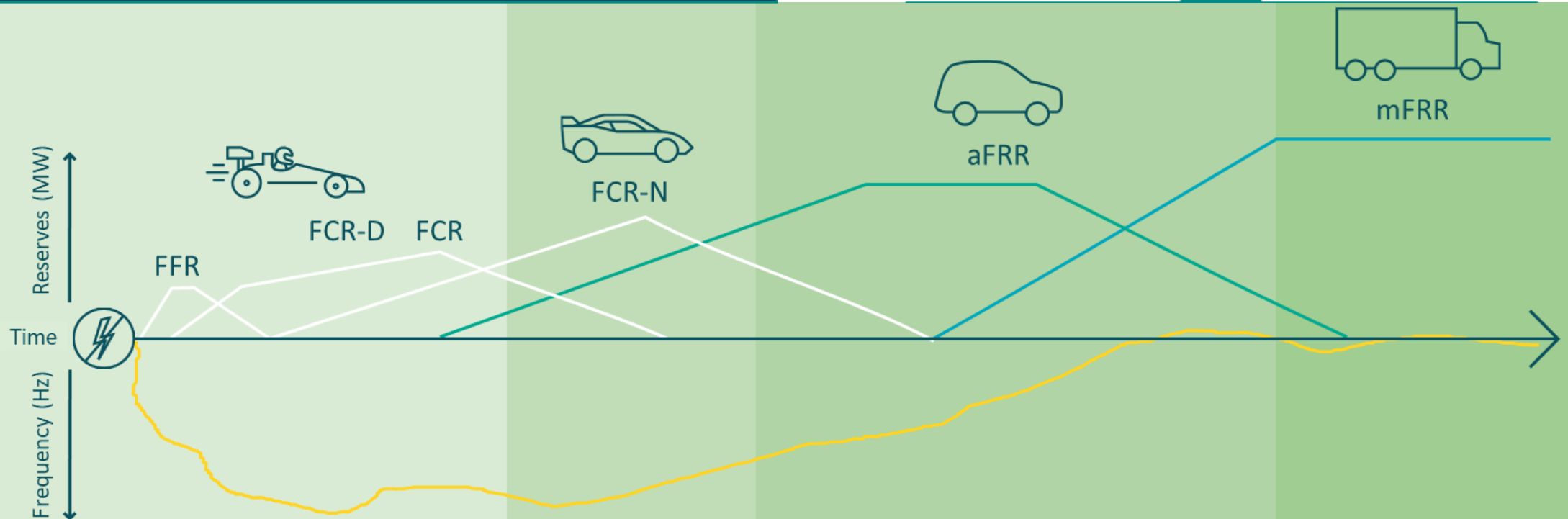
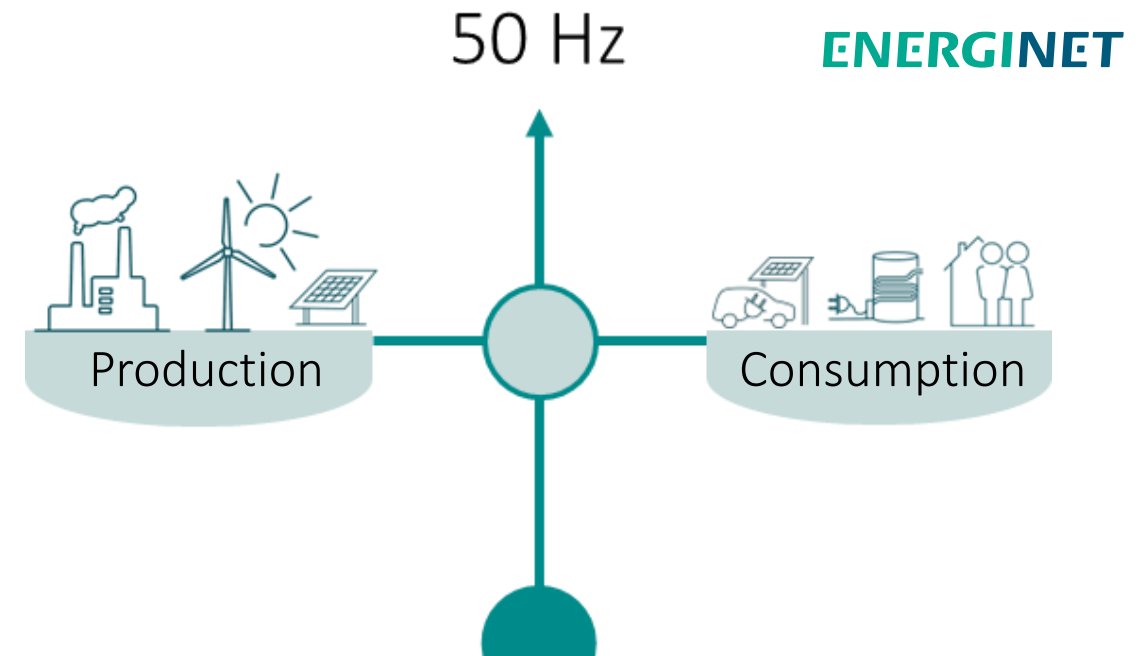


BALANCING THE ELECTRICITY SYSTEM

One of Energinet's main tasks is to balance the high voltage electricity system. We mainly do this through our ancillary service markets by paying stakeholders to:

- Produce more or less electricity, than planned
- Consume more or less electricity, than planned

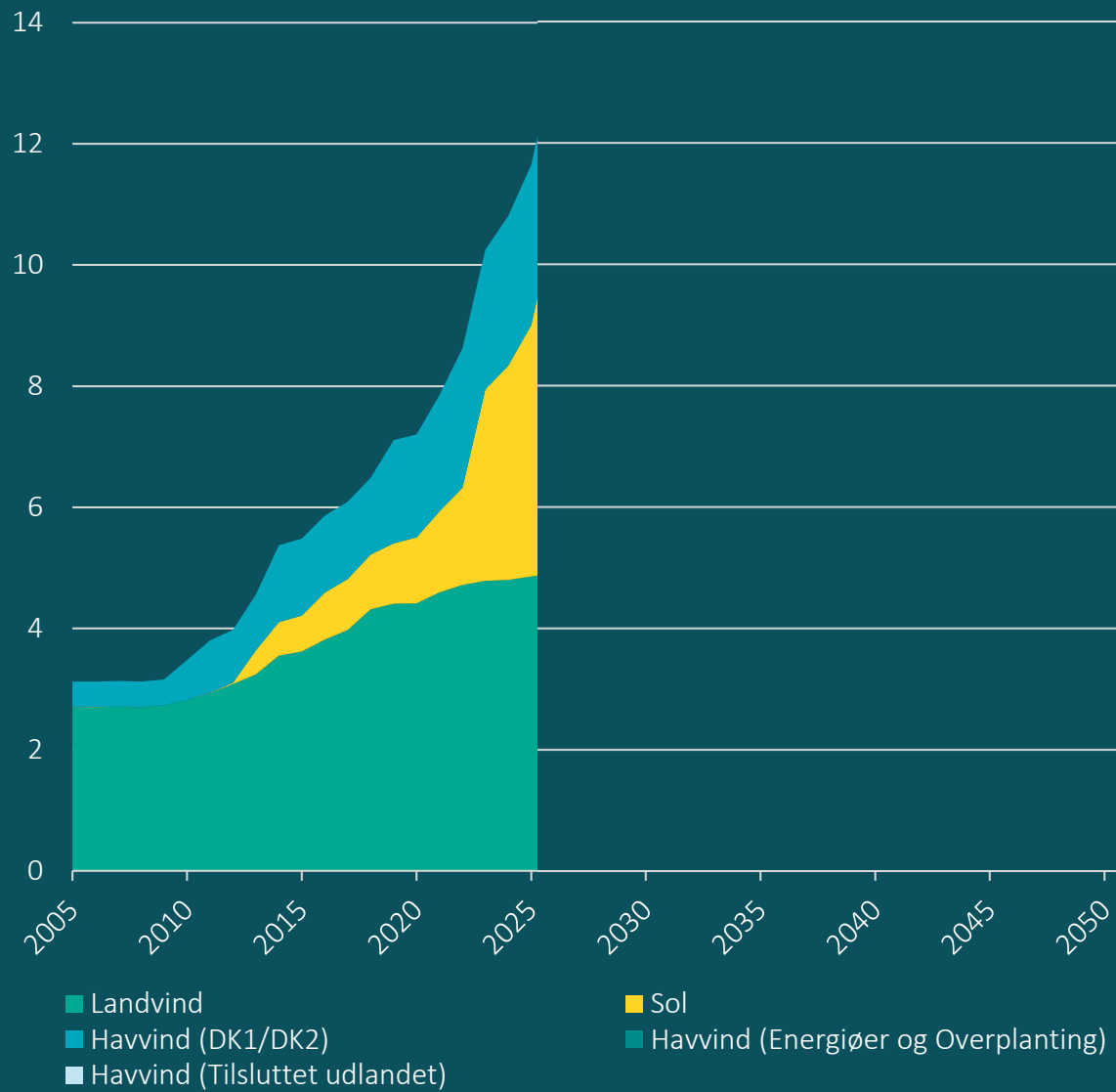
Energinet designs and buys the insurance for the electricity consumers and distribute costs via the electricity bill.



What happens next?

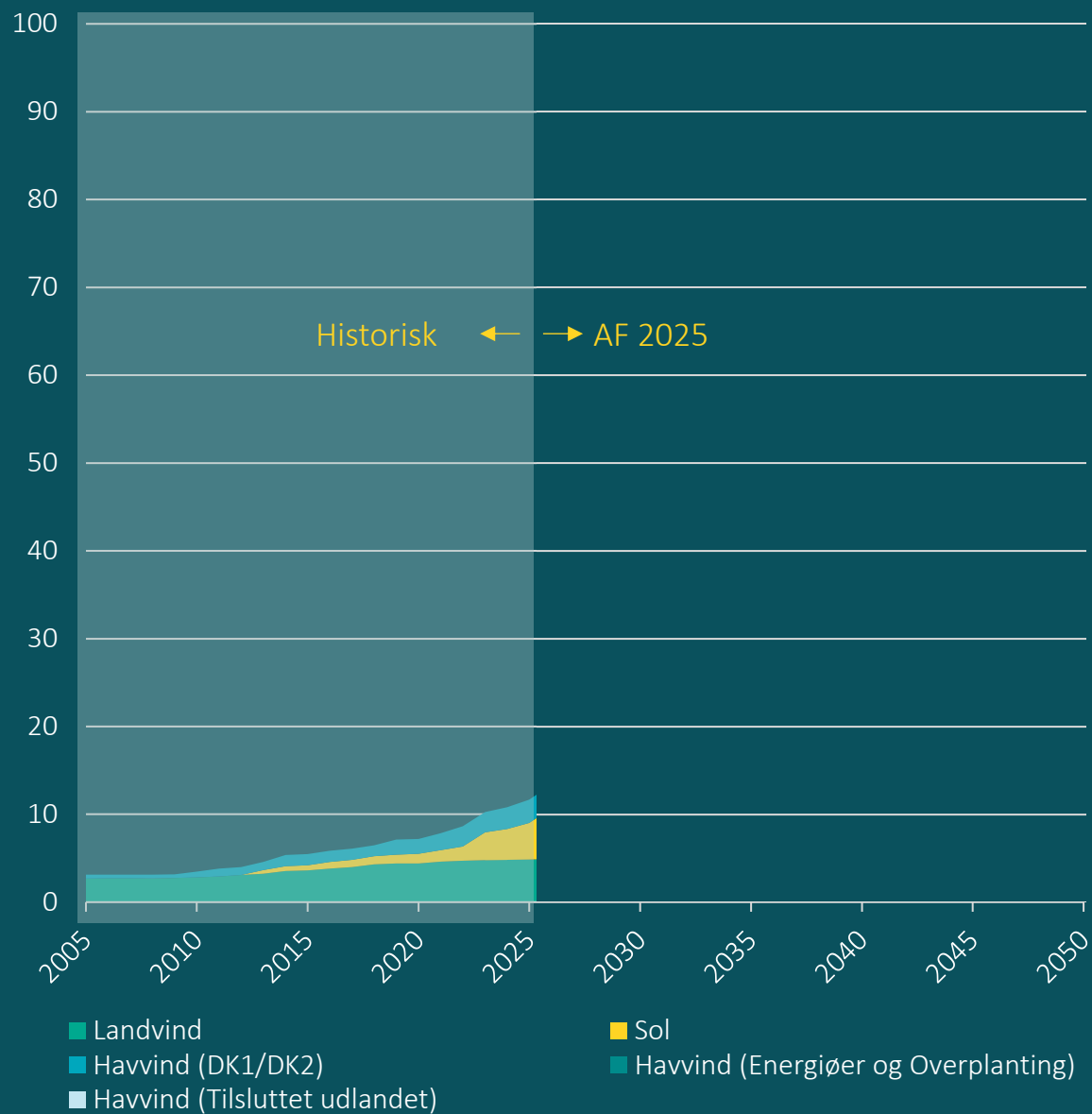
WIND- & PV CAPACITIES (GW)

Analyseforudsætninger 2025 (*høringsversion*)



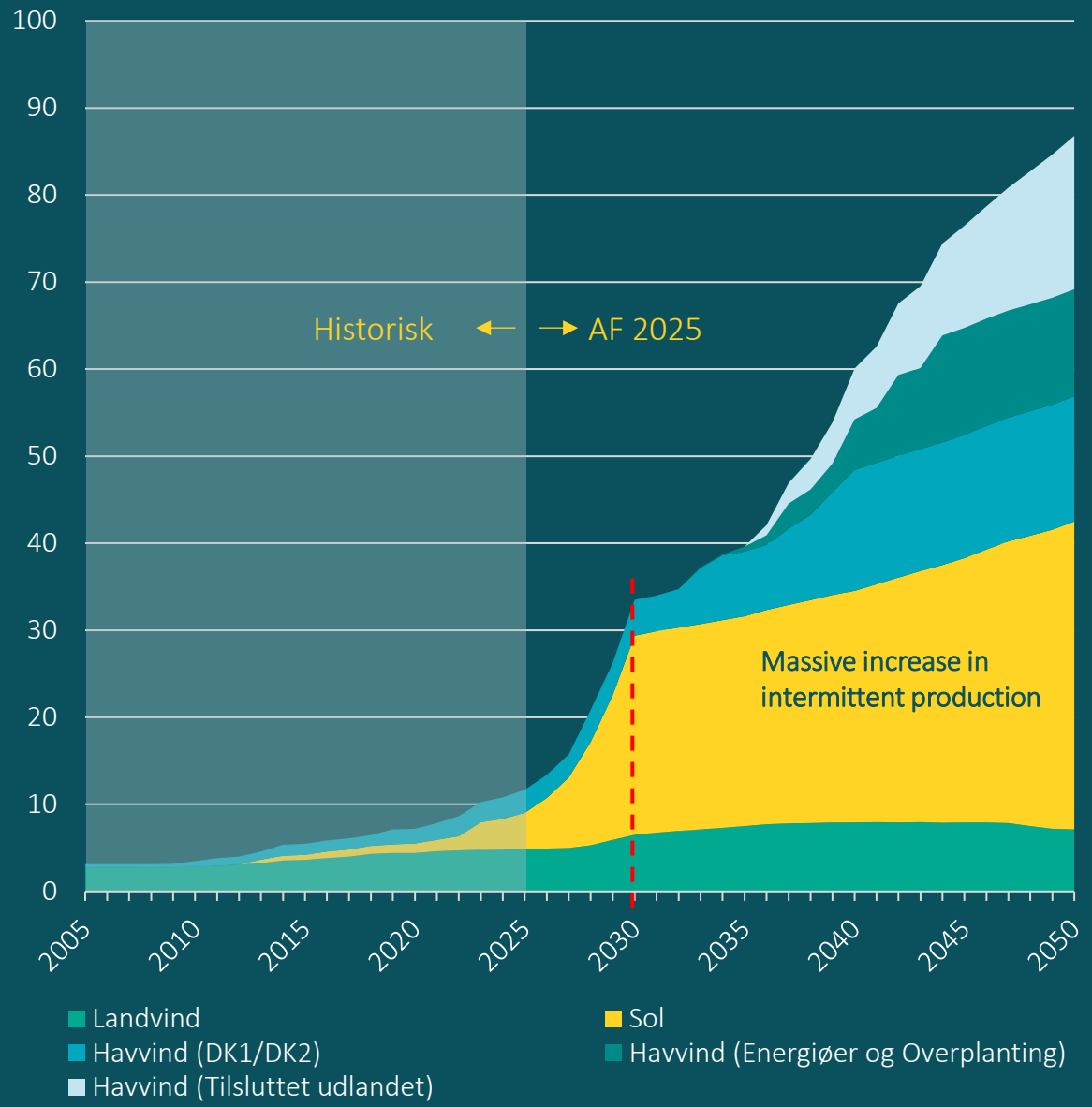
WIND- & PV CAPACITIES (GW)

Analyseforudsætninger 2025 (høringsversion)



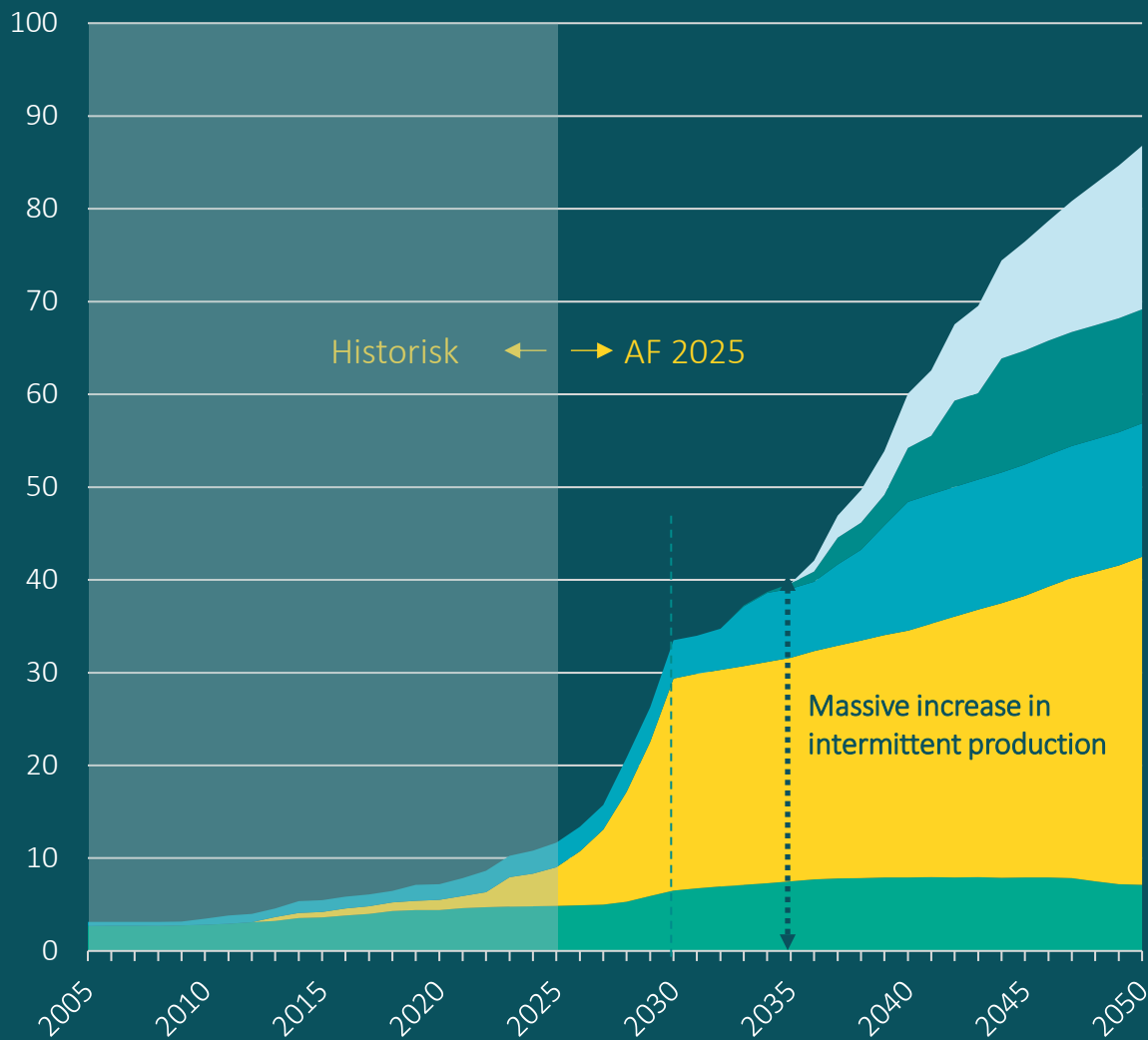
WIND- & PV CAPACITIES (GW)

Analyseforudsætninger 2025 (høringsversion)



WIND- & PV CAPACITIES (GW)

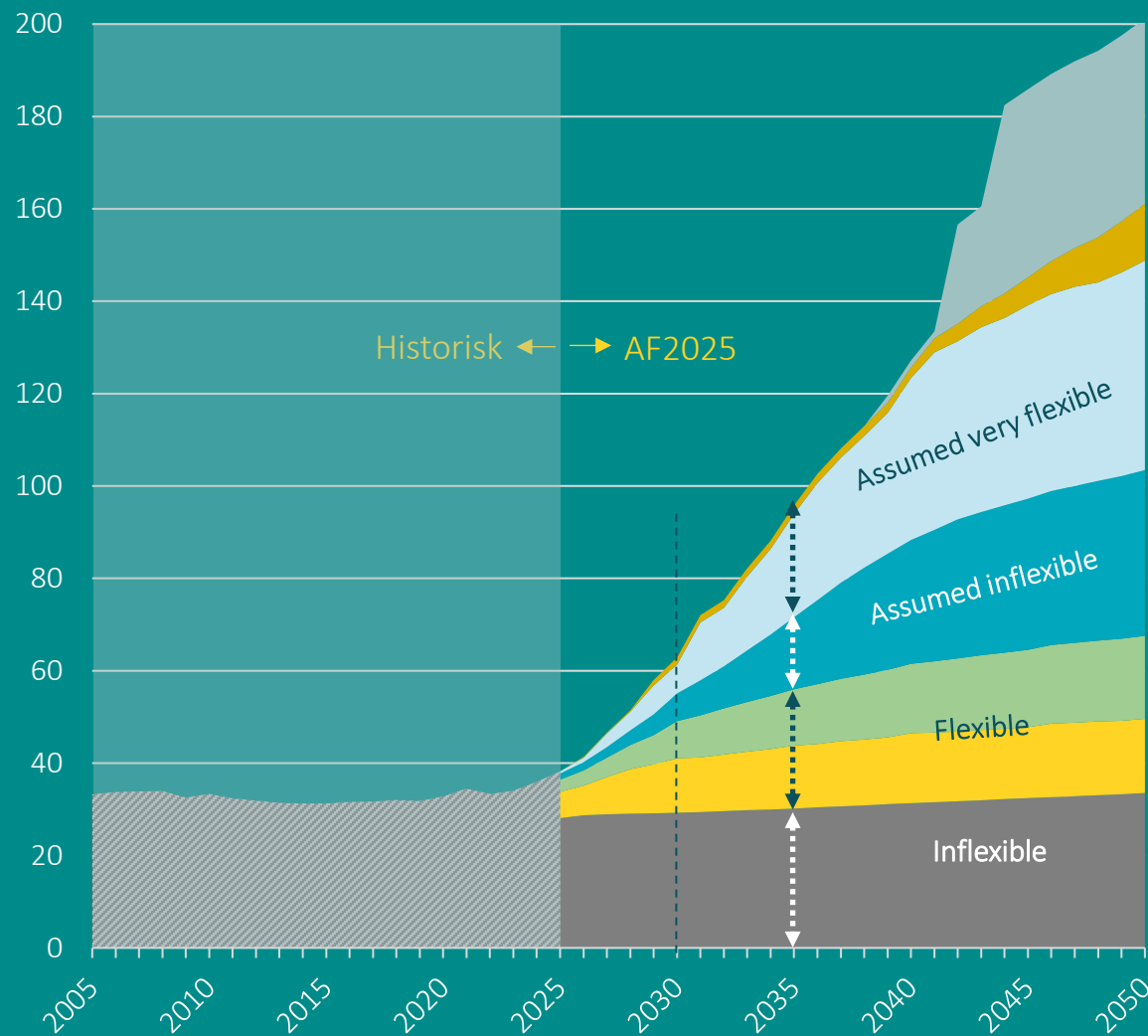
Analyseforudsætninger 2025 (høringsversion)



- Landvind
- Havvind (DK1/DK2)
- Havvind (Tilsluttet udlandet)
- Sol
- Havvind (Energigør og Overplanting)

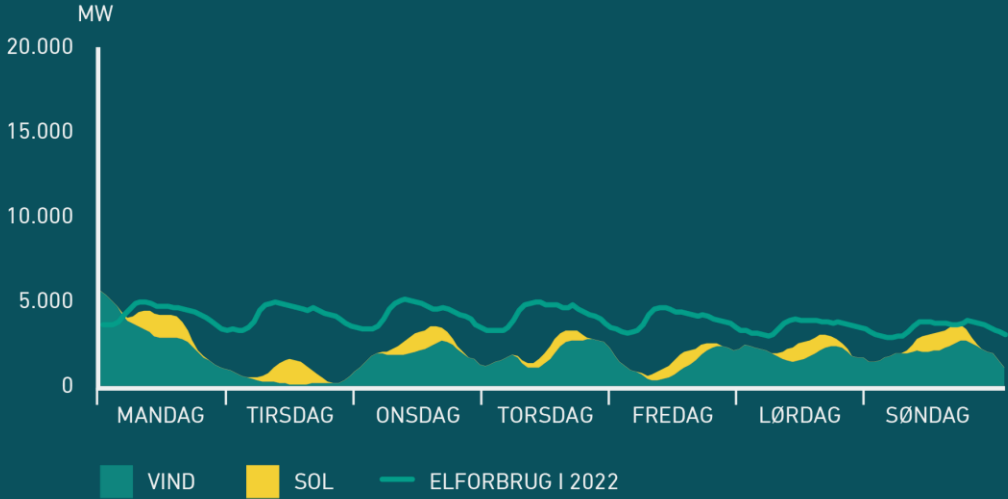
TOTAL CONSUMPTION (TWH)

Analyseforudsætninger 2025 (høringsversion)



- Klassisk elforbrug
- Datacentre
- Power-to-X (Energigør)
- Varme
- Power-to-X (DK1/DK2)
- Transport
- Carbon Capture
- Historisk forbrug (totalt)

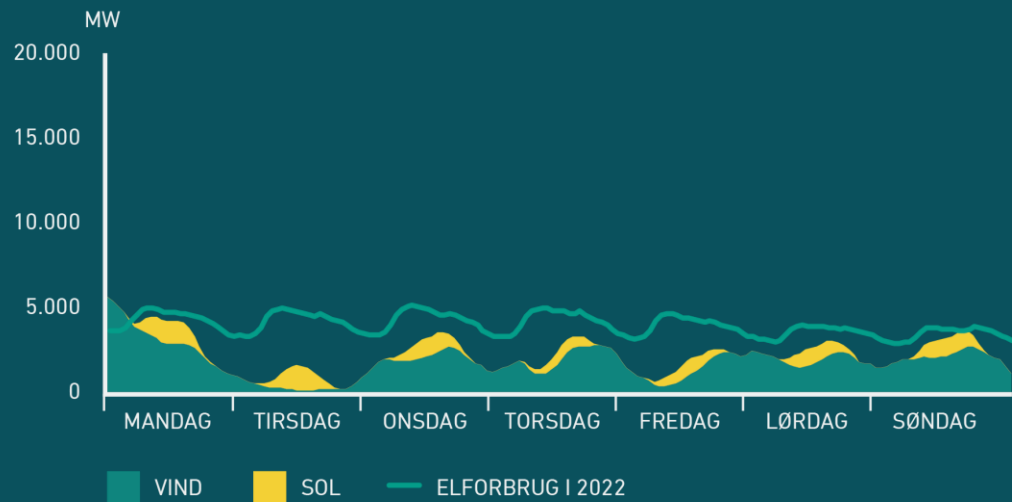
IN PROJECTIONS DEMAND AND SUPPLY DO NOT ALWAYS MATCH... BUT PHYSICS ENFORCES THIS BALANCE...



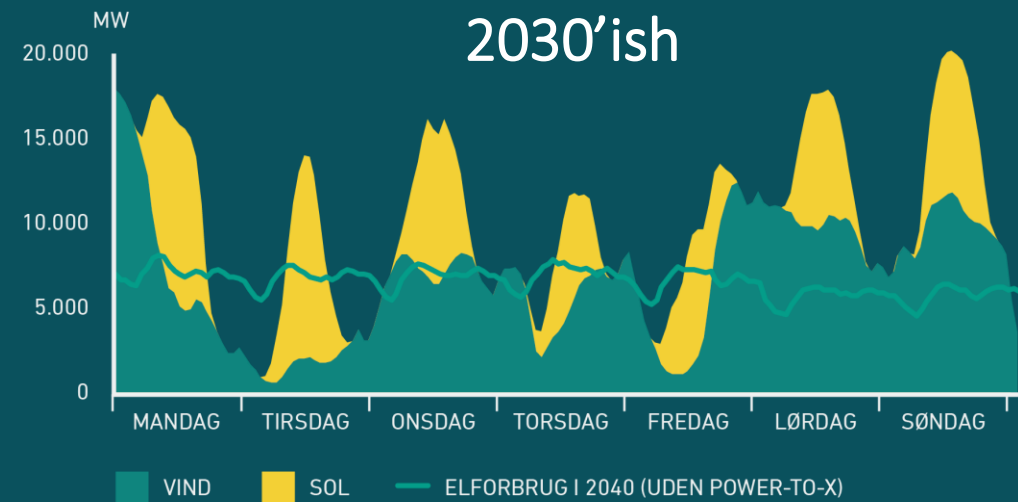
PREDICTABLE!

IN PROJECTIONS DEMAND AND SUPPLY DO NOT ALWAYS MATCH... BUT PHYSICS ENFORCES THIS BALANCE...

STOP
A NEED FOR REAL FLEXIBILITY IN THE TRANSITION



PREDICTABLE?



FLEXIBILITY IS KEY!

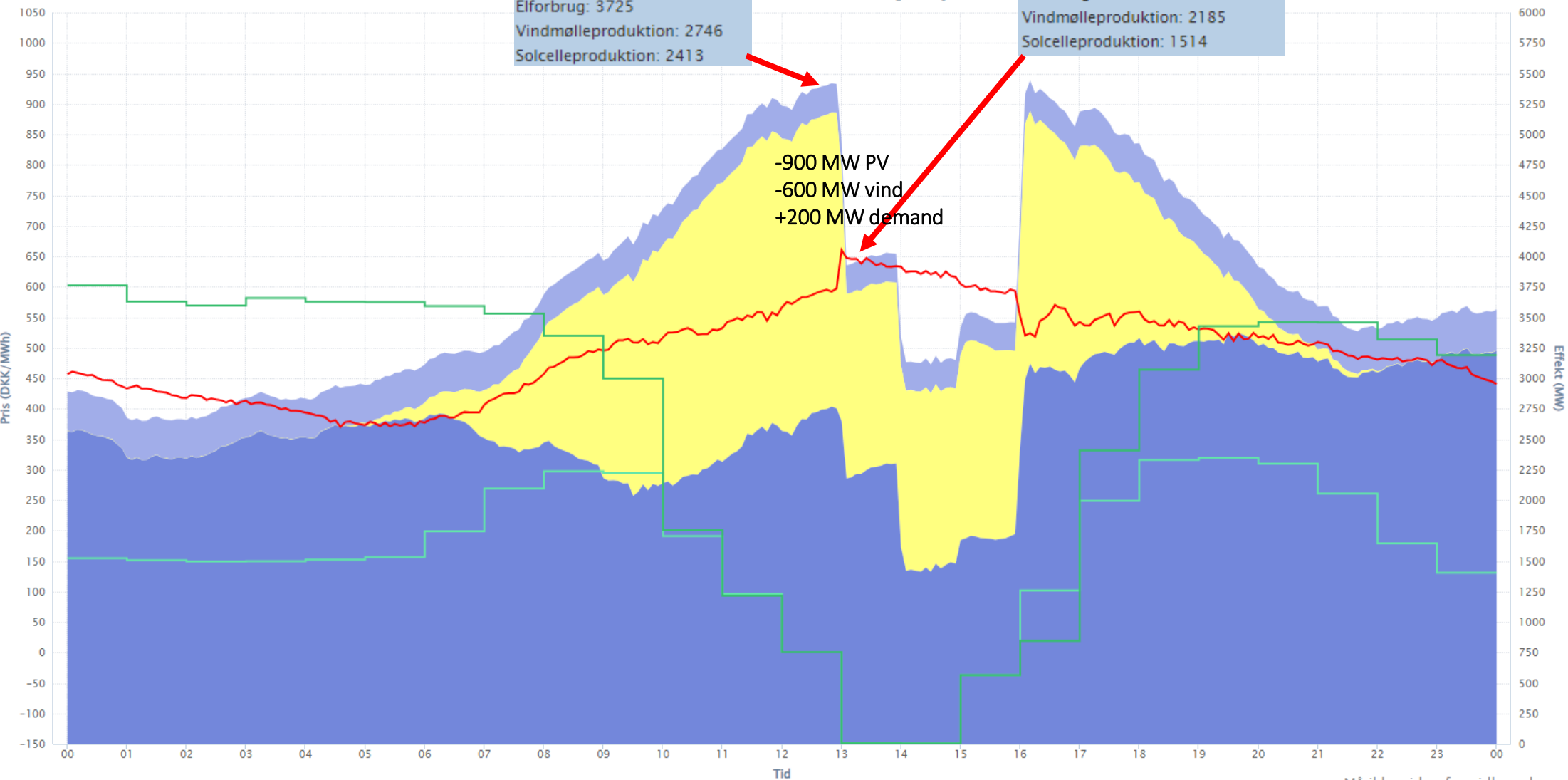
Lørdag, 10. jun 2023 12:45
 Pris (DKK/MWh)
 Elspotpris, Vestdanmark: 0.60
 Effekt (MW)
 Elforbrug: 3725
 Vindmølleproduktion: 2746
 Solcelleproduktion: 2413

Lørdag, 10. jun 2023 13:10
 Pris (DKK/MWh)
 Elspotpris, Vestdanmark: -148.70
 Effekt (MW)
 Elforbrug: 3978
 Vindmølleproduktion: 2185
 Solcelleproduktion: 1514

Danmark, lørdag, 10. jun 2023

-900 MW PV
 -600 MW vind
 +200 MW demand

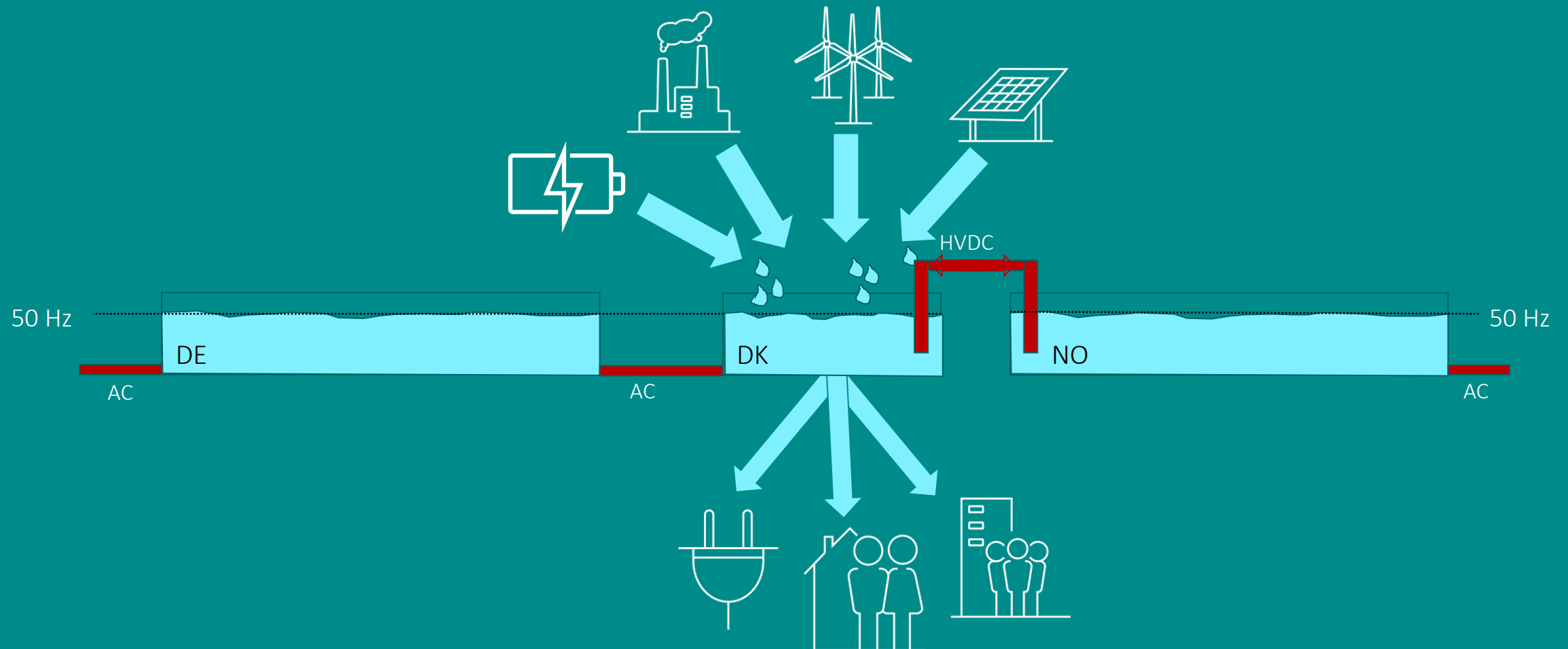
- Elspotpris, Vestdanmark
- Elspotpris, Østdanmark
- Elforbrug
- Vindmølleproduktion
- Solcelleproduktion
- Decentral kraftvarmeproduktion
- Central kraftvarmeproduktion



Må ikke videreformidles uden reference til EMD International A/S



BALANCING THE SYSTEM



DAY-AHEAD AND INTRA-DAY DO
THE BULK WORK OF BALANCING,
WITHIN EACH QUARTER-HOUR

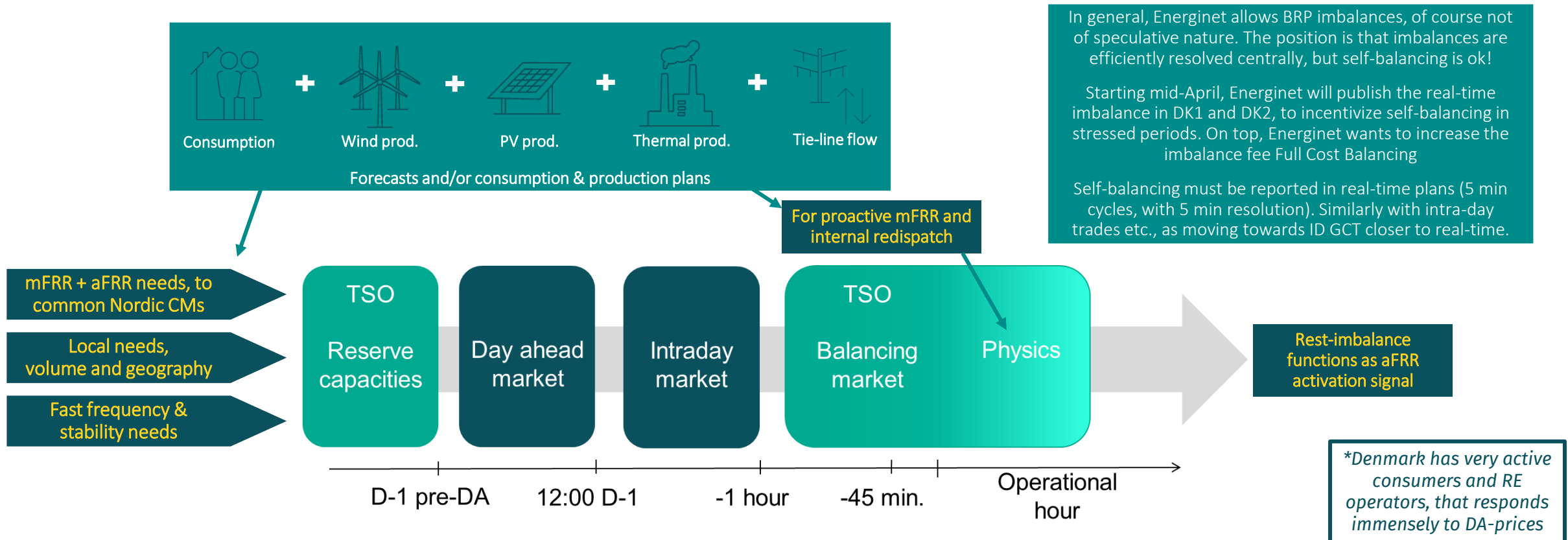
BUT FLEXIBILITY IS MORE THAN
RESPONDING TO THE DAY-AHEAD
PRICE!

ENERGINET, PROACTIVE BALANCING

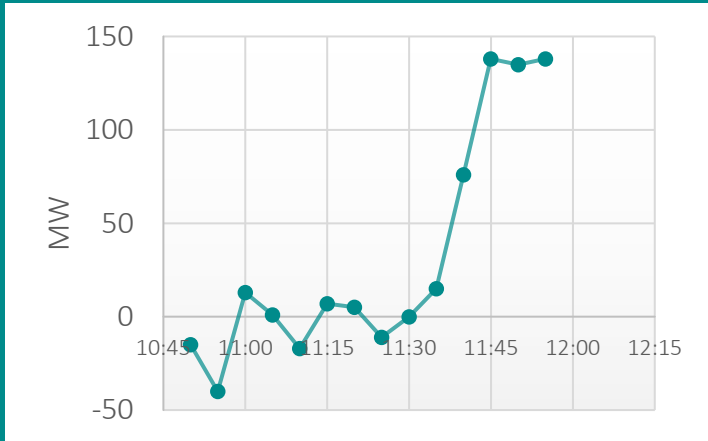
HOWEVER, STILL INCENTIVIZING SELF-BALANCING → TO ENSURE TARGETED RISK LEVEL, AT MINIMUM SYSTEM COSTS.

Energinet forecasts the short-term imbalance, to proactively use mFRR energy bids. The residual imbalance is left for aFRR, as a result of “fast” imbalances or unprecise mFRR activation. aFRR will be dimensioned accordingly.

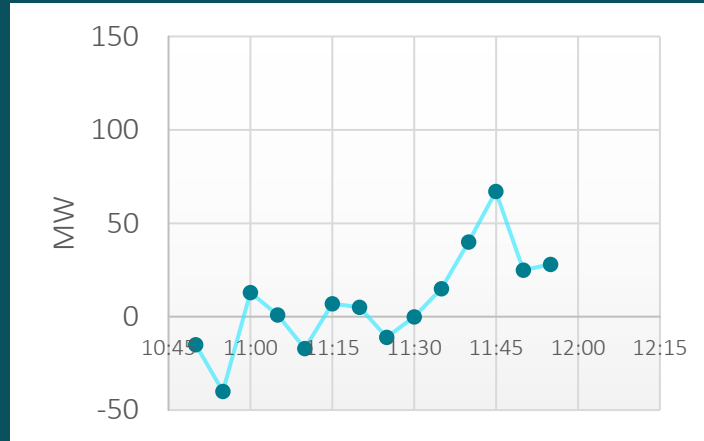
To forecast the short-term ACE OL for the coming MTU, Energinet has own forecasts, which is supplemented by “real-time” production + consumption plans → If renewables are not producing as much as possible, and to provide information on centrally controlled consumption and production*. Internal redispatch is done with local mFRR bids coordinated with the balancing process. Forecasts and plans are geographically distributed too.



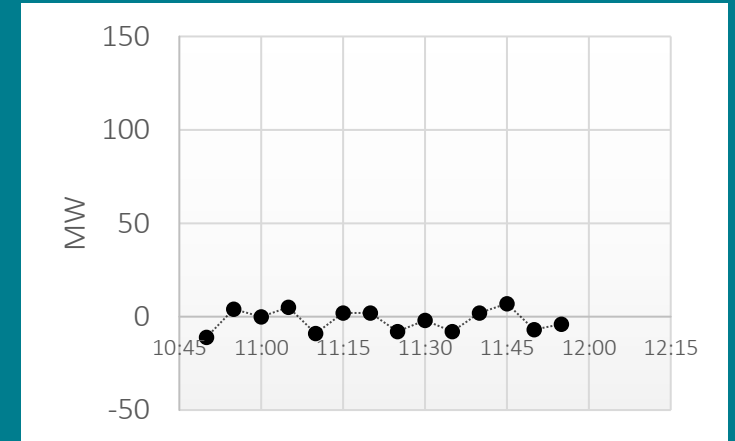
IMBALANCE BEFORE REGULATION



IMBALANCE AFTER MFRR



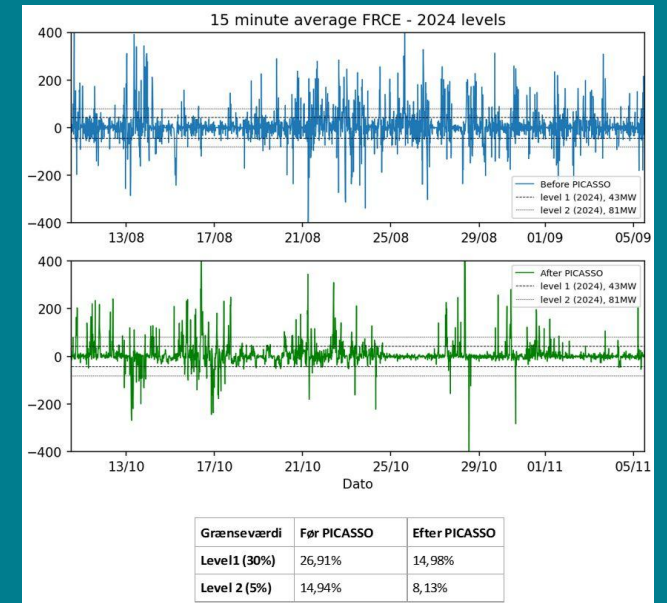
IMBALANCE AFTER AFRR



mFRR EAM

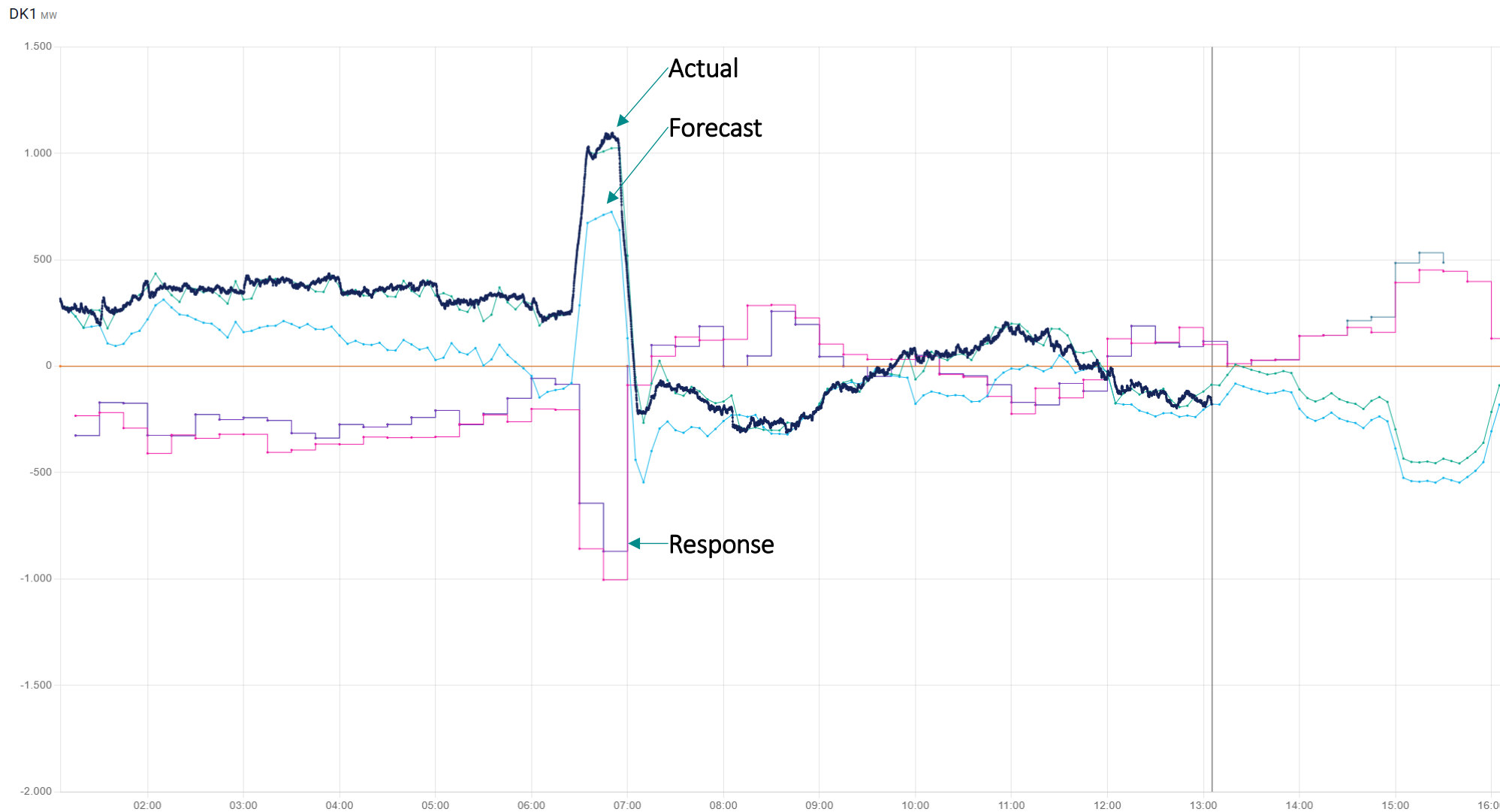
+

New LFC and PICASSO to cover the residual



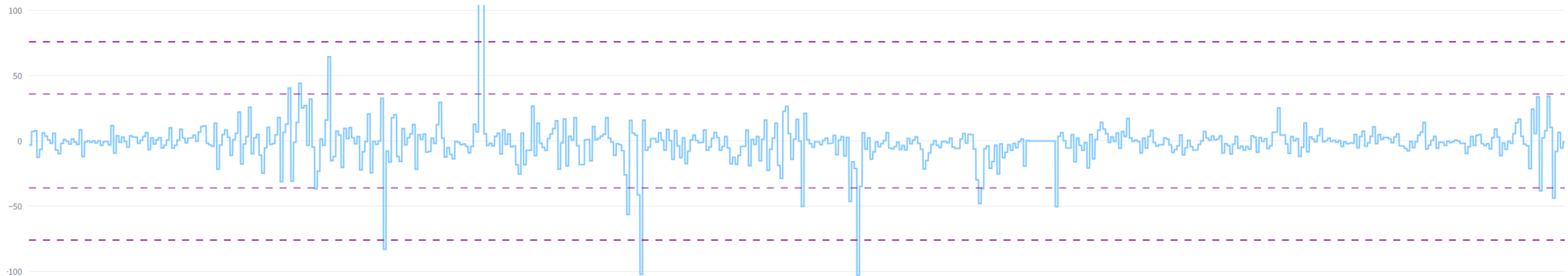
We publish the proactive request for mFRR prior to real-time imbalance: <https://www.energidataservice.dk/tso-electricity/ImbalancePrice>

ENERGINET'S FORECASTED IMBALANCE AND RESPONSE TO IT, DK1



THE RESIDUAL IMBALANCE IN DK1, THE LAST WEEK

IT HAS "NEVER" BEEN BETTER!



MINUTTER

10.000

8.000

6.000

4.000

2.000

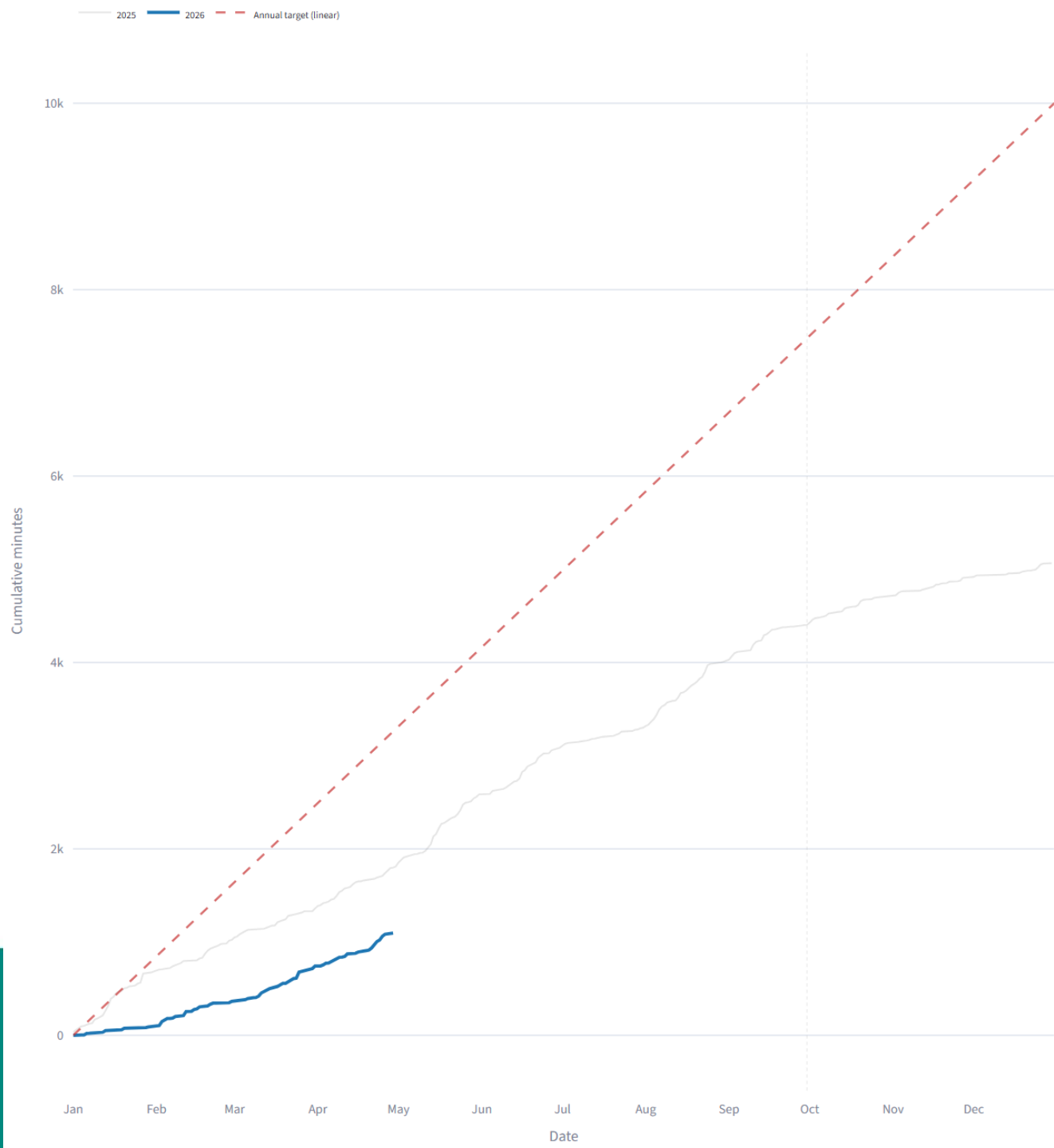
0

Januar

December

FREKVENSKVALITET

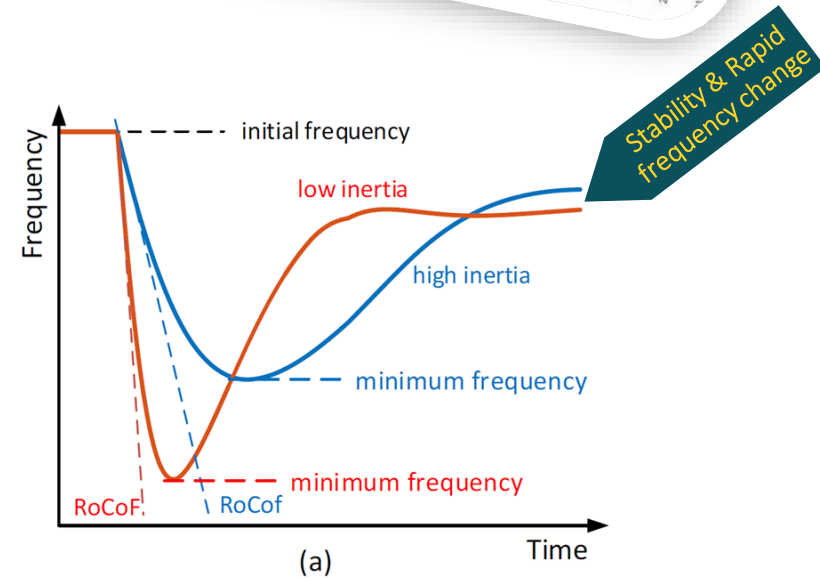
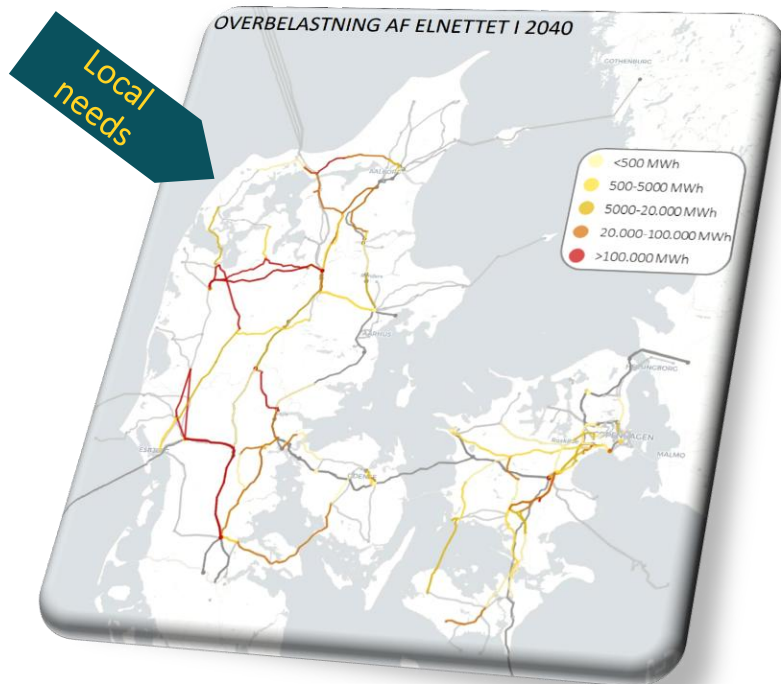
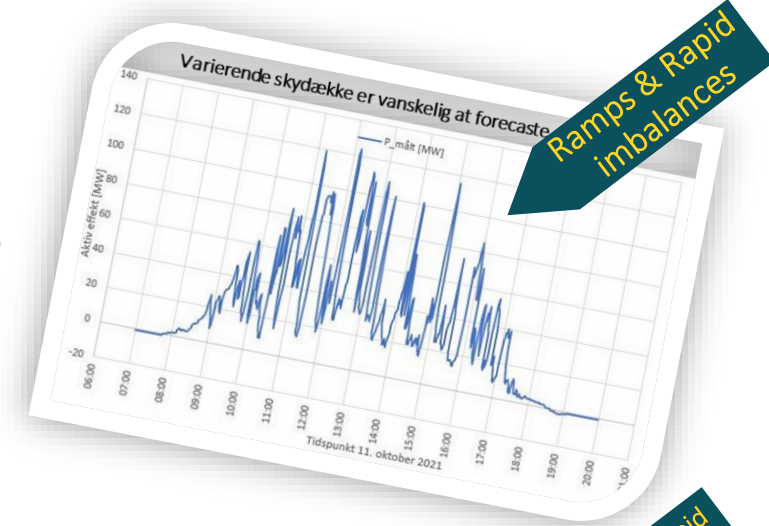
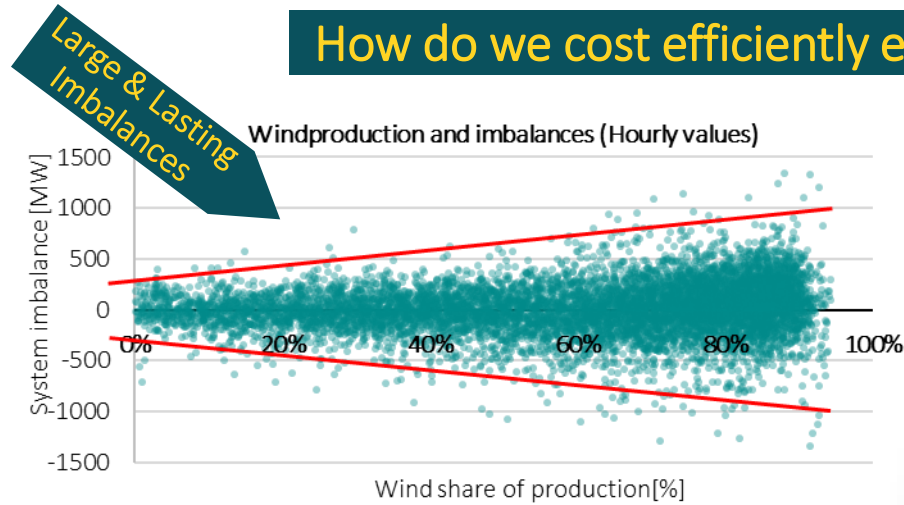
- 2021
- 2022
- 2023
- 2024
- 2025



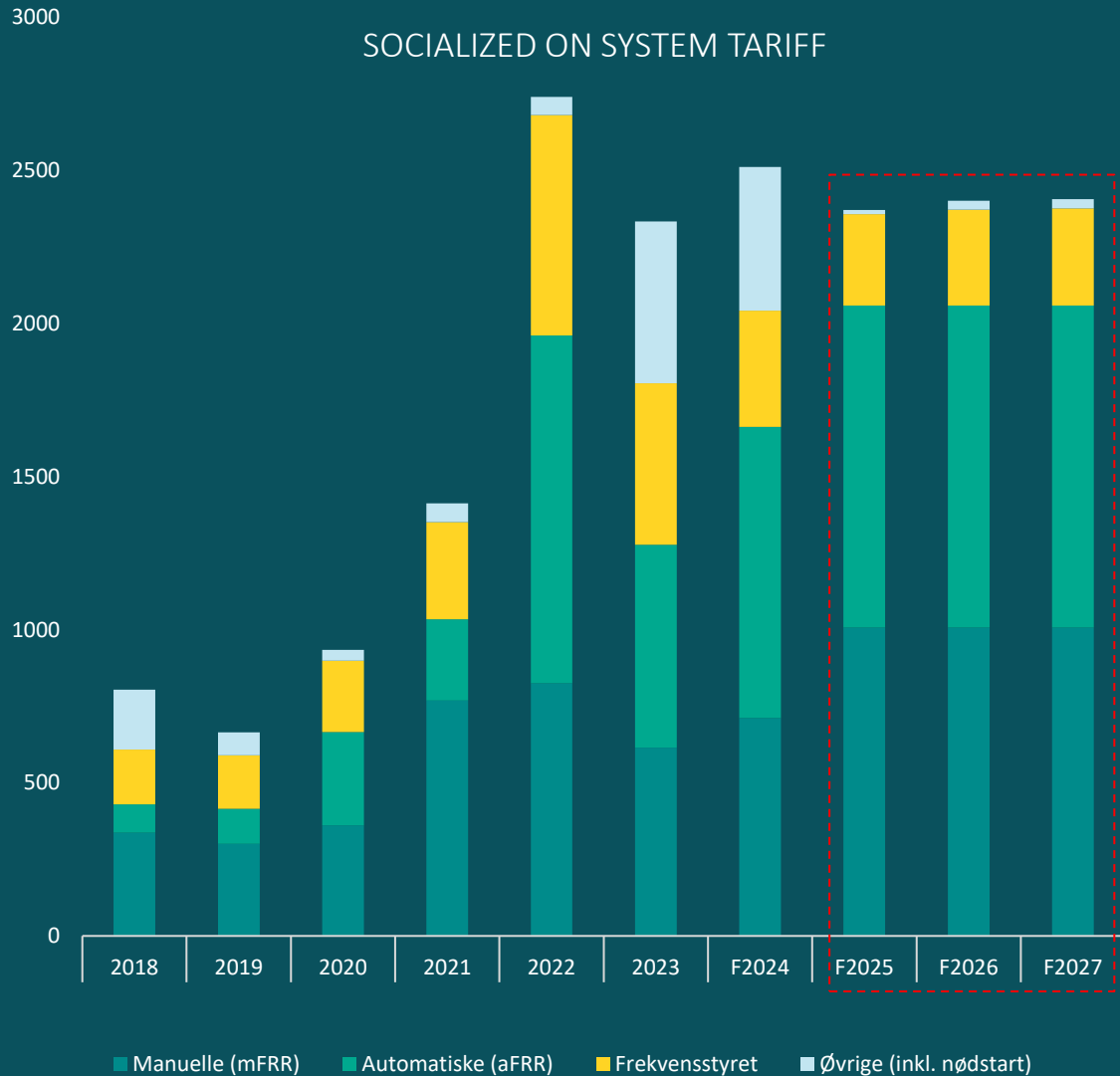
The need for ancillary services increases with the green transition



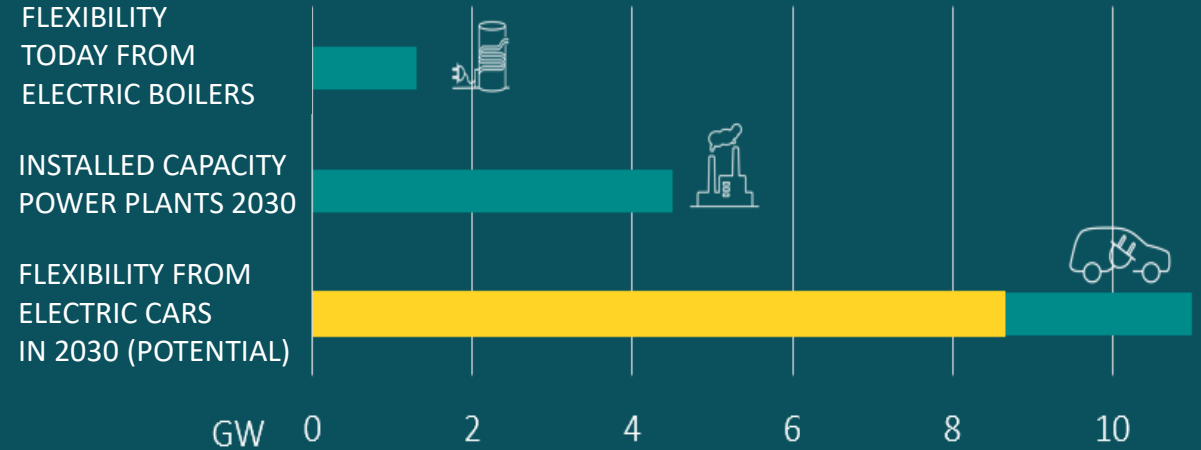
How do we cost efficiently ensure desired risk level?



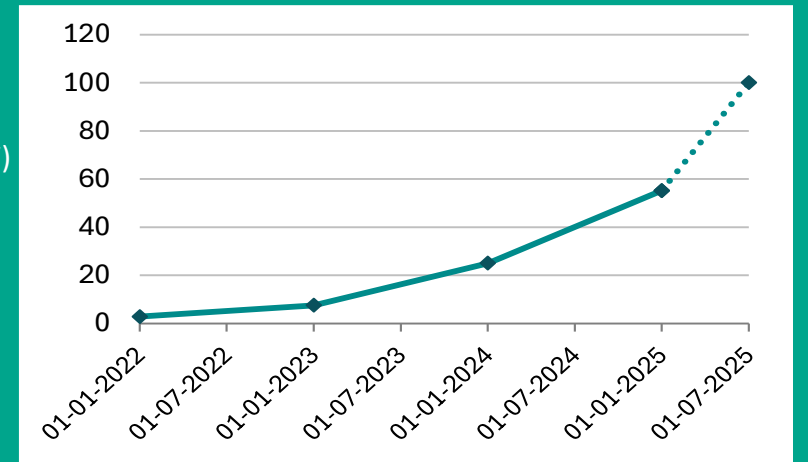
THE COST OF BALANCING THE POWER SYSTEM IS INCREASING SIGNIFICANTLY...



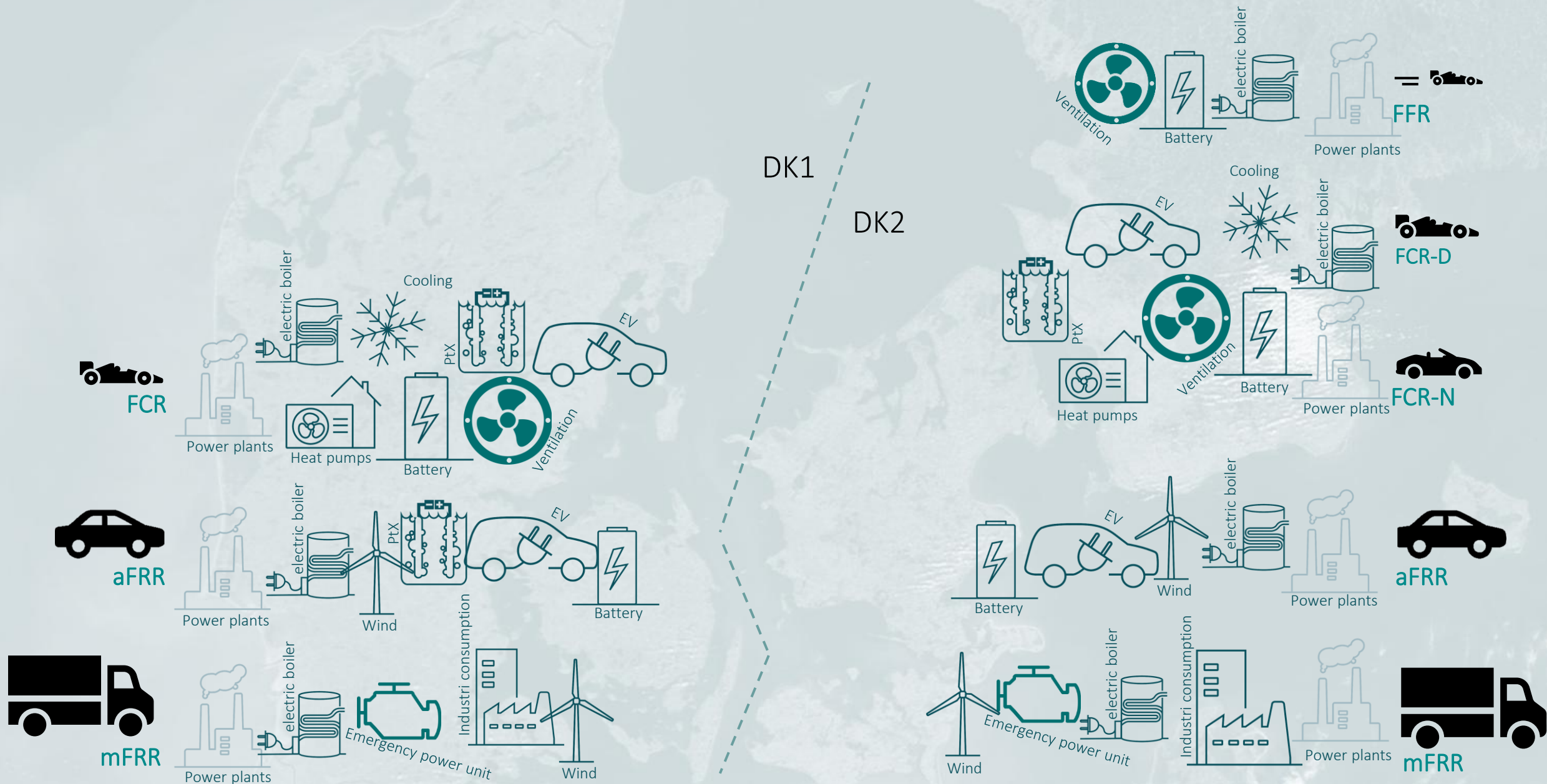
...AND WE NEED TO UNLOCK FLEXIBILITY POTENTIALS THROUGH NEW TECHNOLOGY AND GREEN BUSINESS MODELS

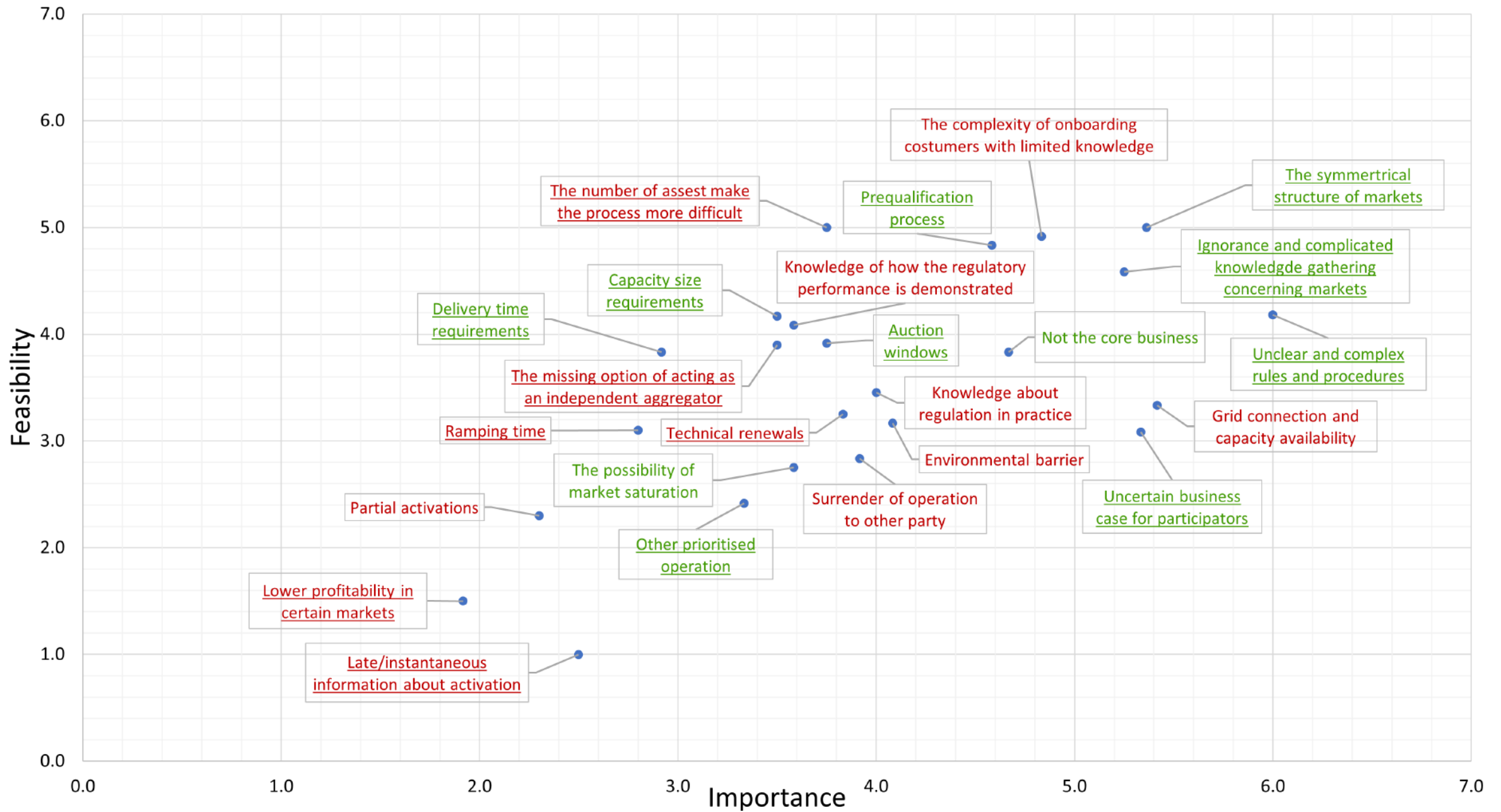


ACCUMULATED BATTERY CAPACITY (MW) APPROVED TO DELIVER ANCILLARY SERVICES IN DENMARK
PIPELINE OF 6 GW



ANCILLARY SERVICES: QUALIFIED TECHNOLOGIES





FLEXIBLE CONSUMPTION FOR THE DELIVERY OF SYSTEM SERVICES



Flexible consumption can deliver system services, and it is already doing so at a rapidly growing scale!



Forecasts (& baseline) are necessary as reserves are procured the day before the operating day, to ensure that the sold flexibility is also available when it needs to be delivered.

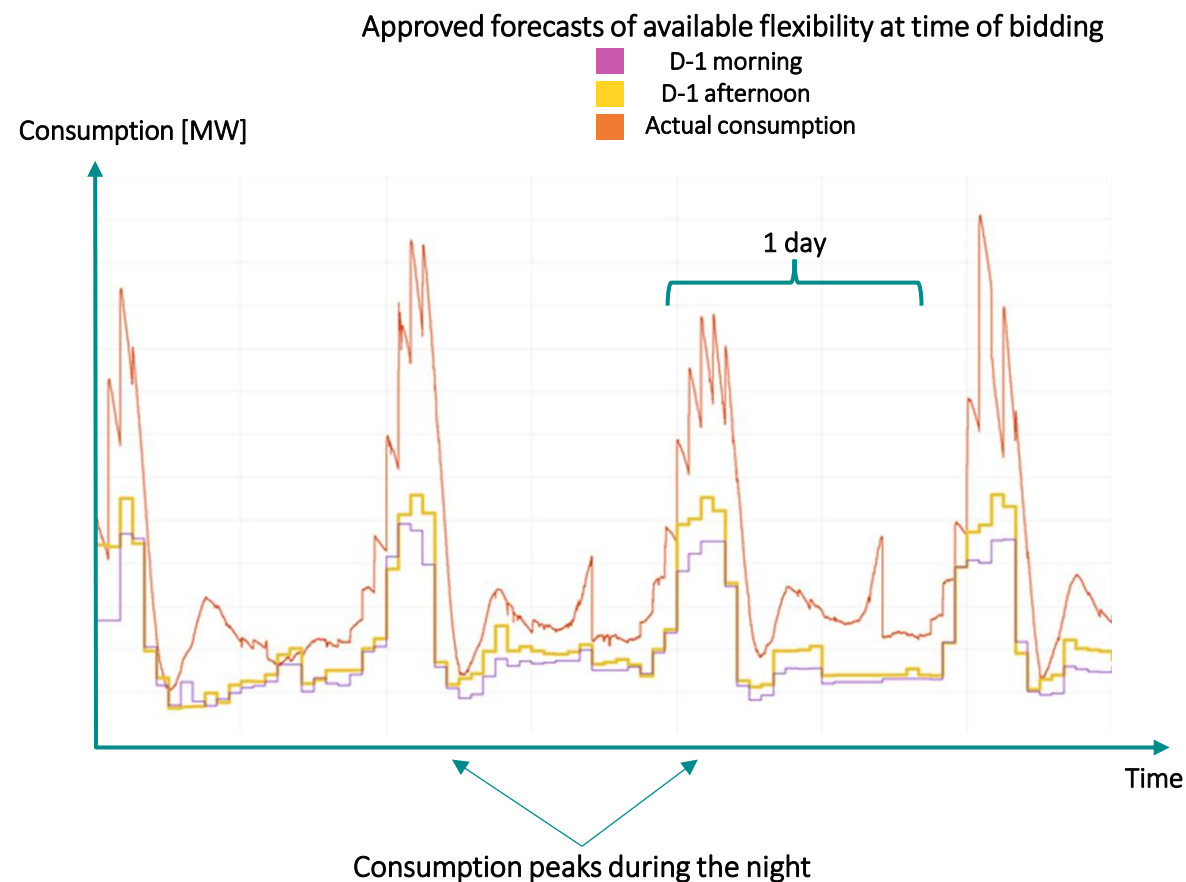


Offering flexibility to the market is difficult!
How do attract new flexibility, and help overcome barriers on the way

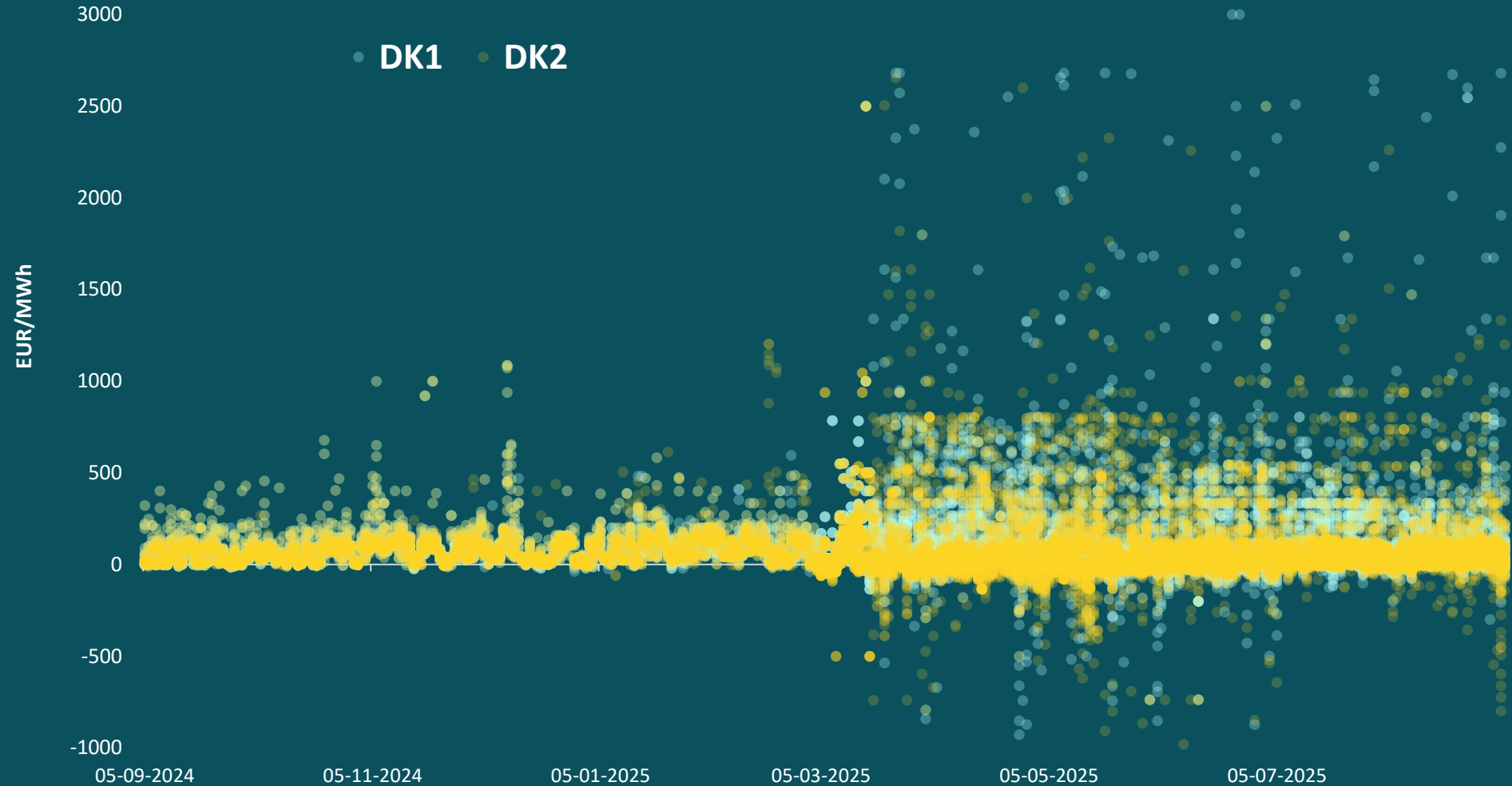
→ The lowest denominator will dictate the result

<https://energinet.dk/el/balancing-og-systemydelse/>

Actual consumption and forecast data from an EV portfolio



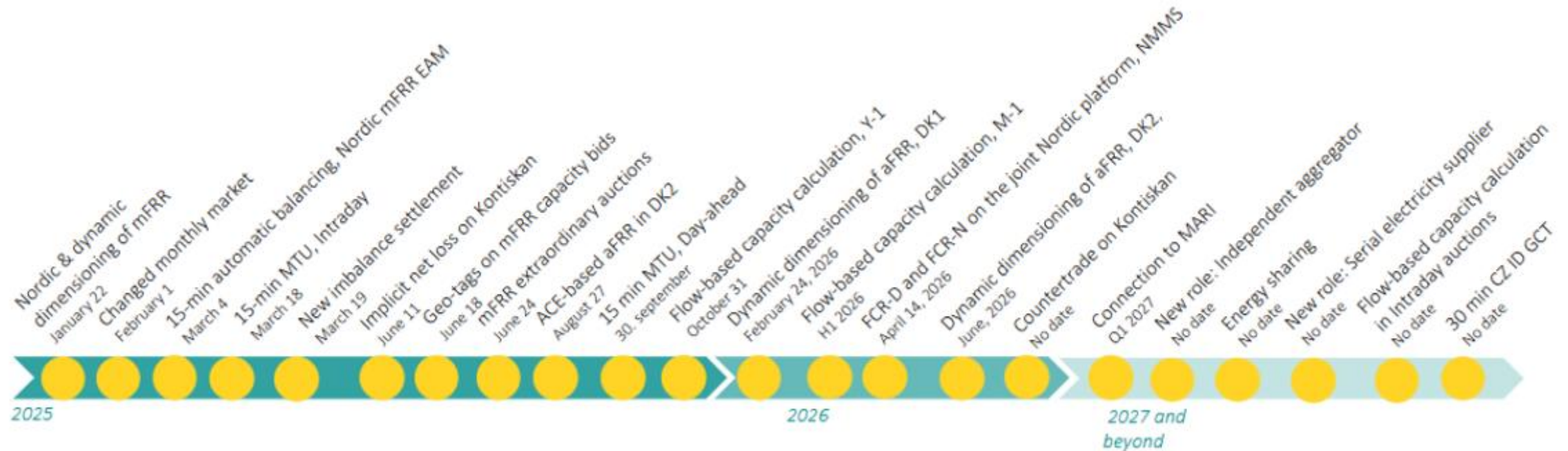
WHAT HAPPENED TO THE IMBALANCE PRICES IN DENMARK IN THE LAST YEAR?



TIMELINE FOR MARKET CHANGES

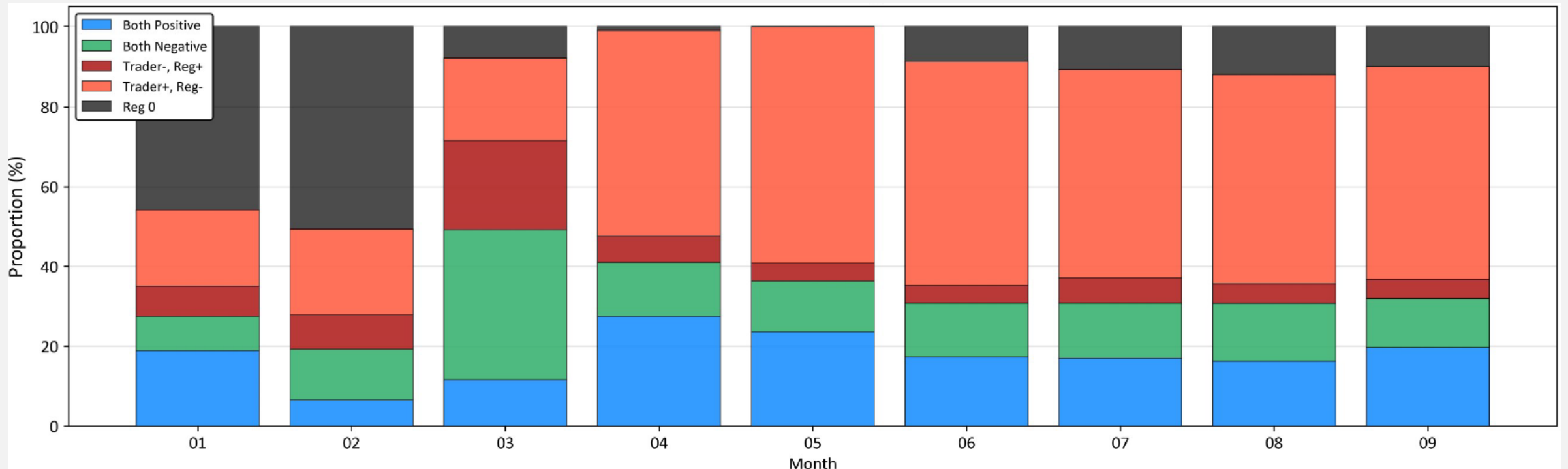
= WHAT WE DO TO MATCH MARKETS AND PHYSICS

Updated November, 2025



Trader imbalances suddenly predicts system imbalances way better?

2025 – DK1



SECURITY OF SUPPLY
IS A **JOINED EFFORT**

