

FLEXIBILITY THROUGHOUT THE CLEAN ENERGY TRANSITIONS

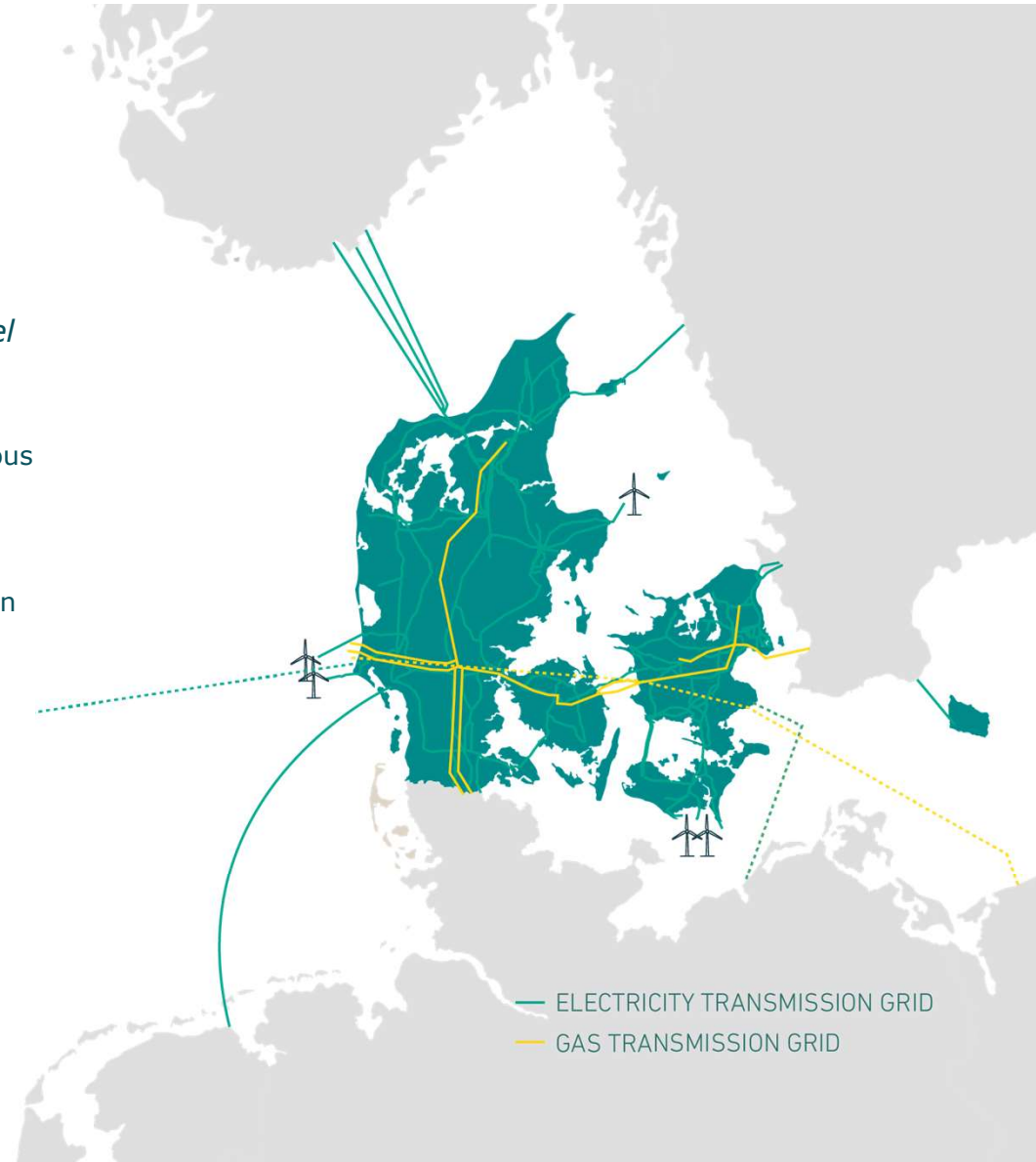
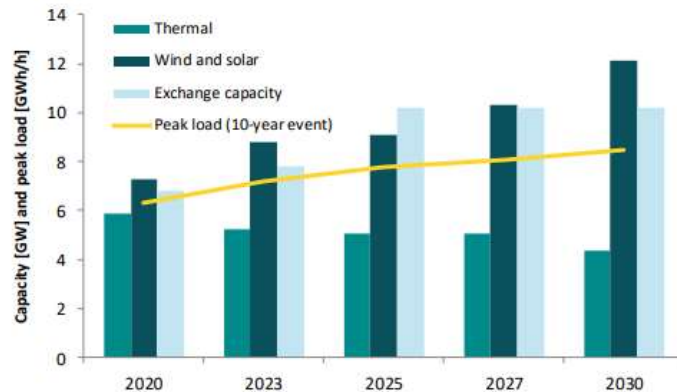
An overview of how flexibility is provided today and tomorrow in systems with high shares of VRE to ensure electricity security

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ENERGINET

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 and soon UK.



An astronaut in a white spacesuit stands on the dark, cratered surface of the moon. In the background, the blue and white horizon of the Earth is visible against the blackness of space. The scene is lit from the left, casting a long shadow of the astronaut onto the lunar surface.

ENERGINET

GREEN ENERGY FOR A BETTER WORLD
Energinet creates the foundation in Denmark for
a safe and efficient green transition

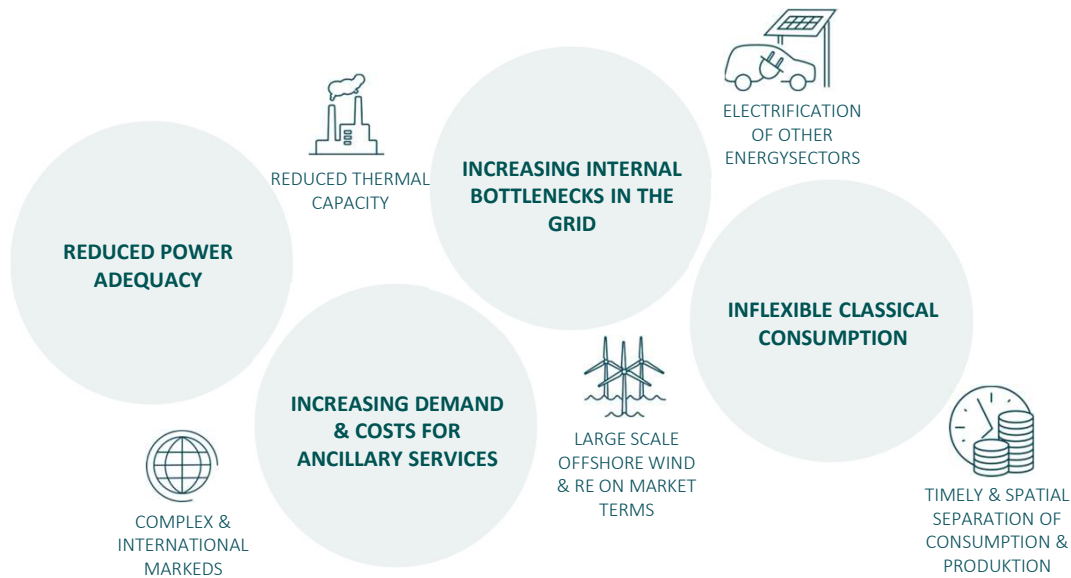
2030

100 % green electricity
70 % CO₂ reduction (compared to 1990)

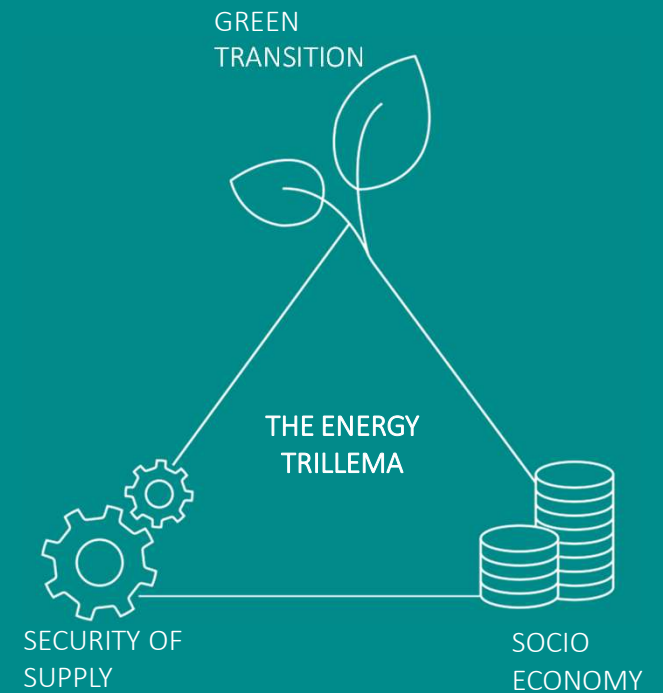
Energinet creates the foundation, the providers create the solutions

What is the challenge in a 100% RE based electricity system?

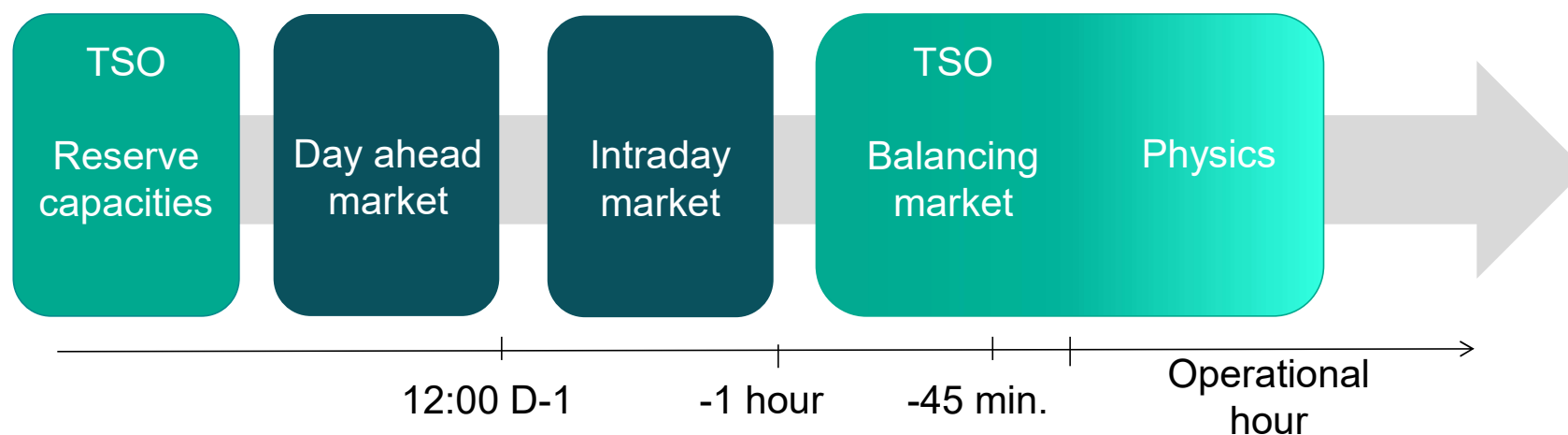
- How is the electricity markets part of the solution?



ENERGINET

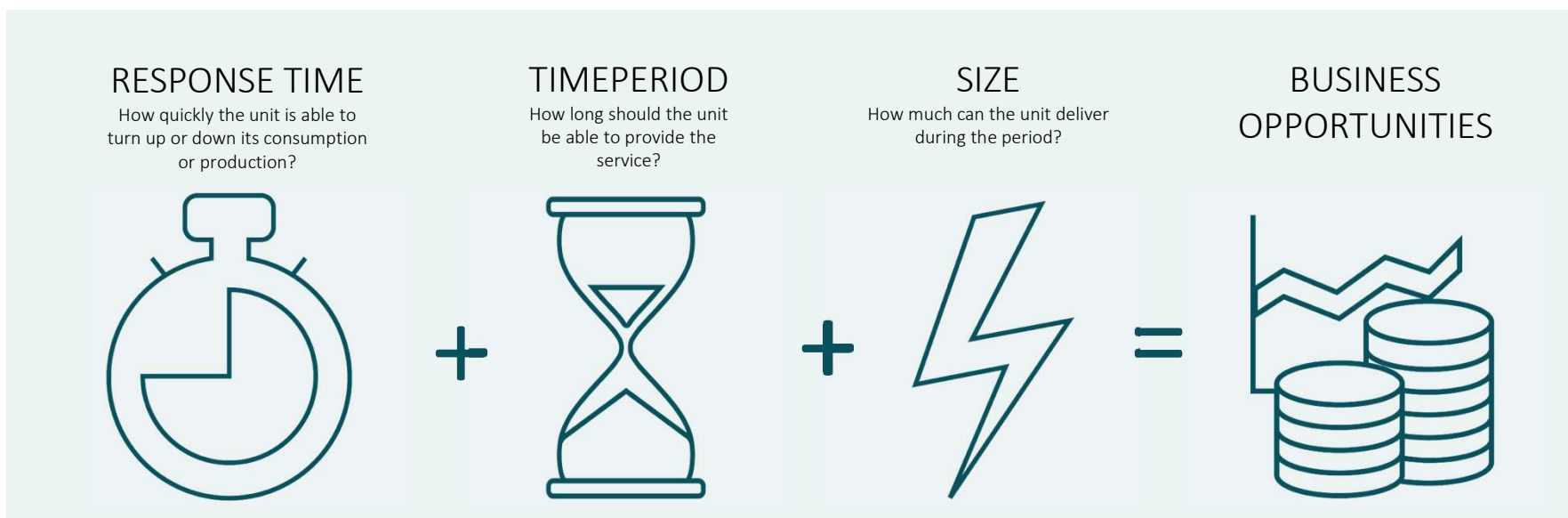


THE ENERGY AND RESERVE MARKETS



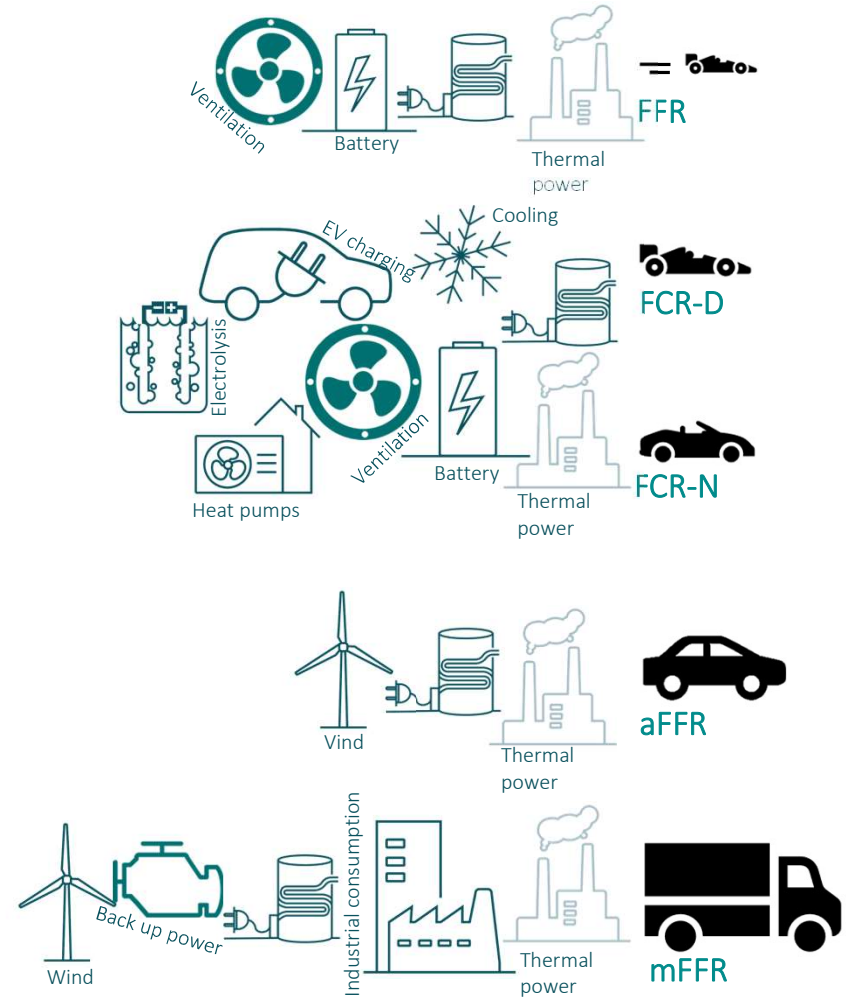
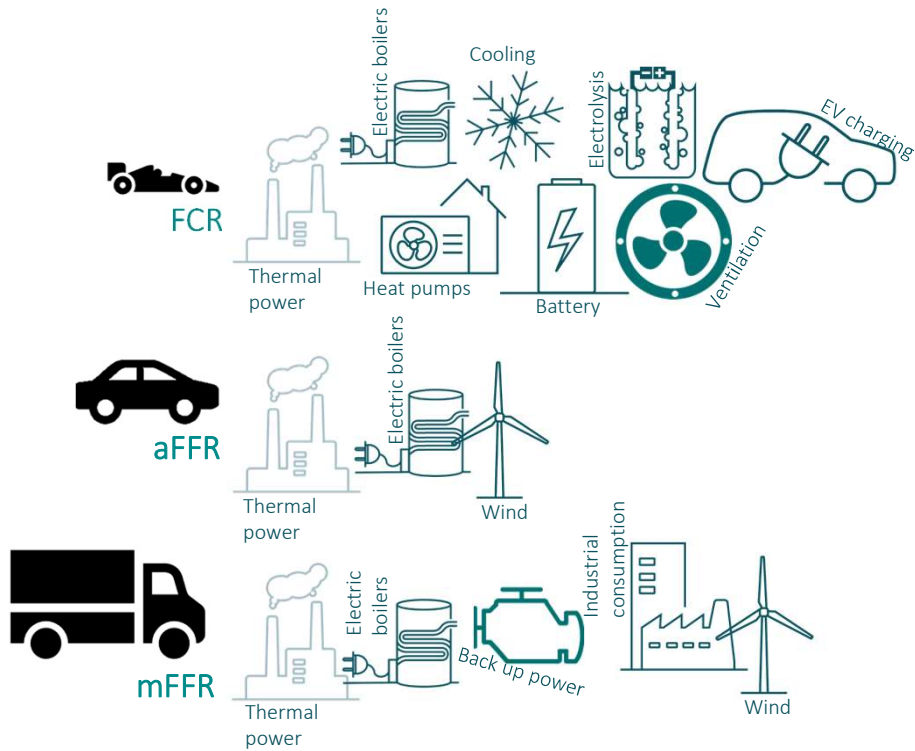
The decreased predictability of the consumption and production in the operational hour creates larger imbalances and hence an increased demand for balancing reserves. So do internal bottlenecks if they are to be handled with flexibility.

BALANCING REQUIREMENTS → BUSINESS OPPORTUNITIES



ANCILLARY SERVICE : TECHNOLOGY

The technologies that provides the different services today. Wind power is expected to provide FCR soon.



CHALLENGES IN A 100 % RENEWABLE ELECTRICITY SYSTEM

Wind and PV in DK in 2020 (ca.)

Onshore wind	4.325 MW
Offshore wind	1.700 MW
PV	1.025 MW
Total	7.050 MW

Wind and PV in DK in 2030

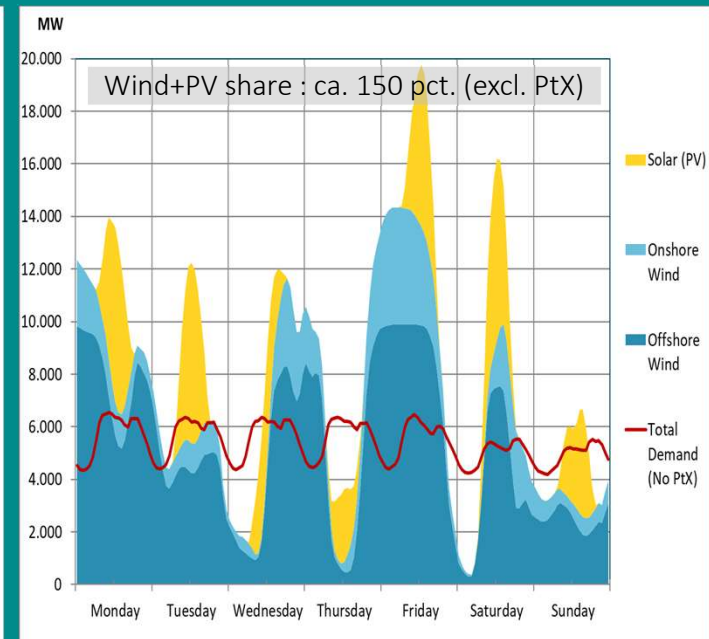
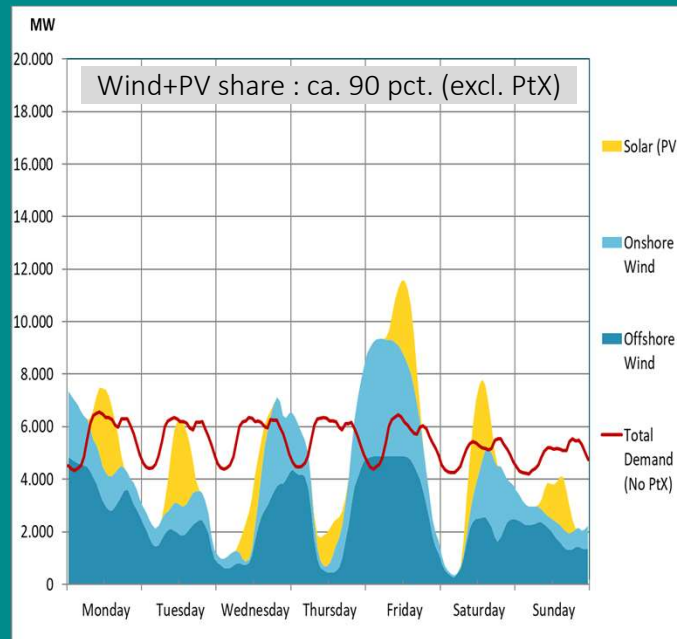
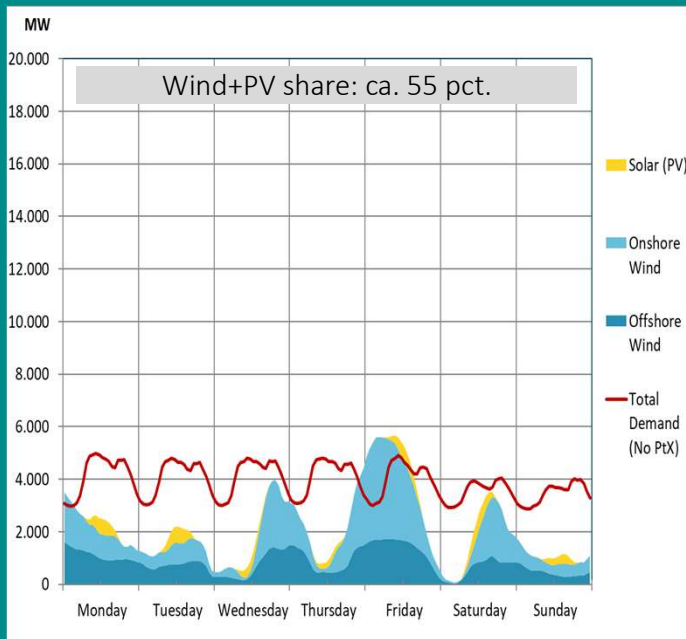
Cf. AF2019

Onshore wind	4.600 MW
Offshore wind	4.900 MW
PV	4.900 MW
Total	14.400 MW

Wind and PV in DK in 2030 (+10 GW)

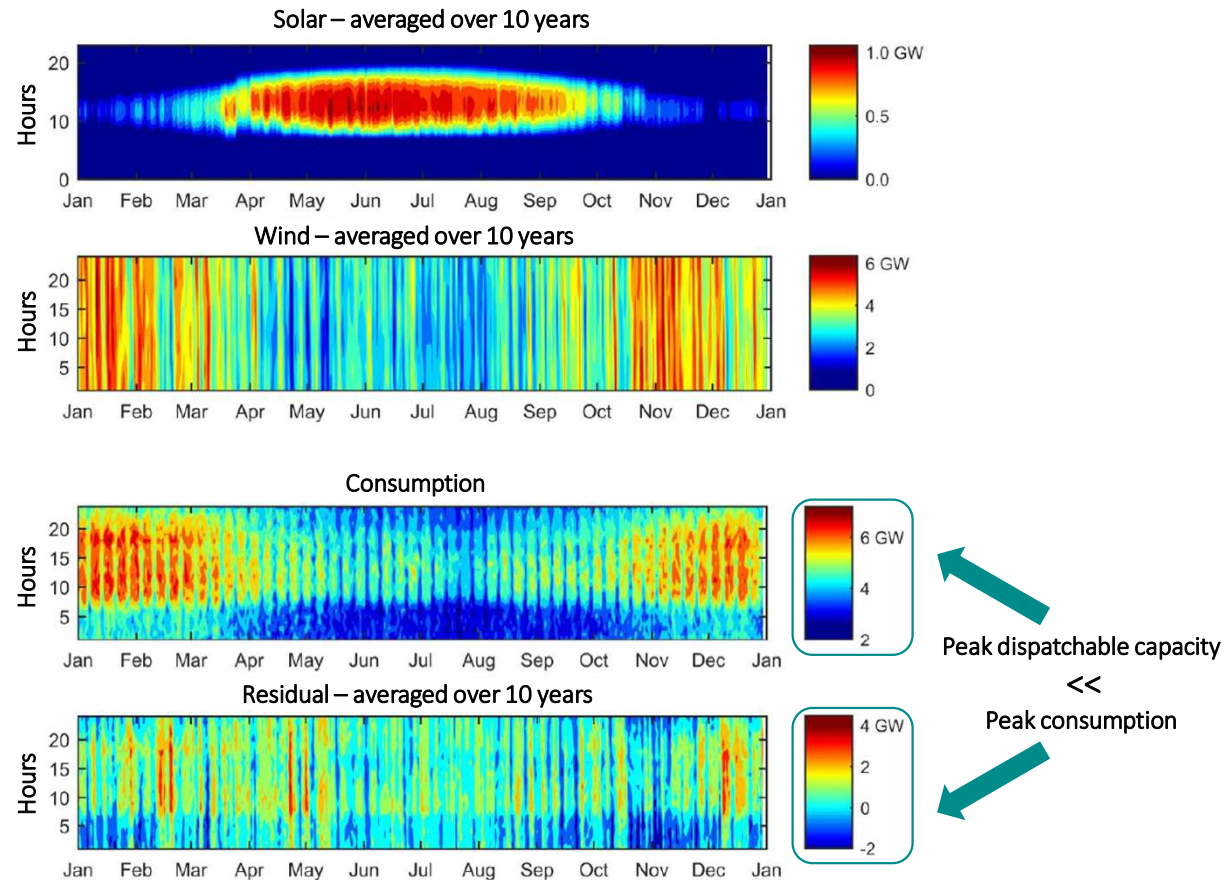
Cf. AF2019 + 5 GW offshore wind og 5 GW PV

Onshore wind	4.600 MW
Offshore wind	9.900 MW
PV	9.900 MW
Total:	24.400 MW

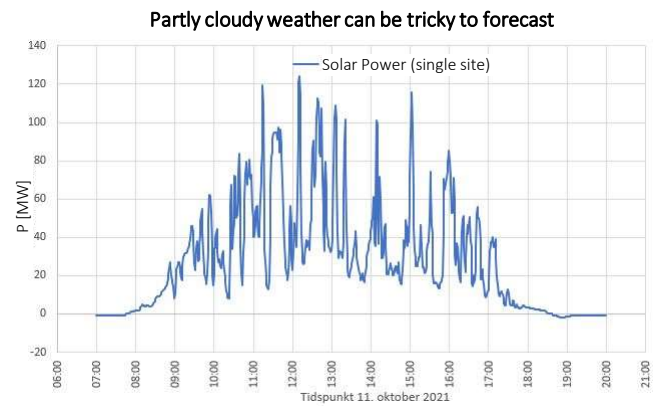
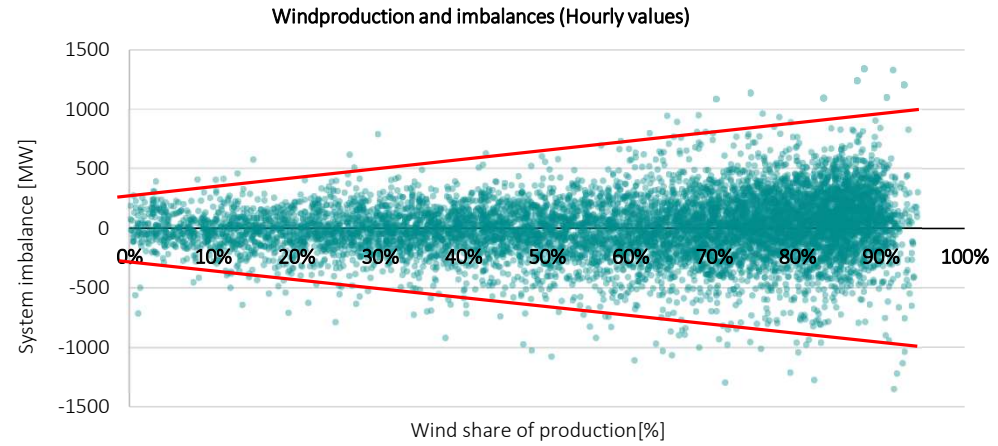


BALANCE BETWEEN RENEWABLES AND CONSUMPTION

- Balancing of the electricity grid becomes increasingly difficult as the renewables capacity is increasing
- Short term storage and infrastructure optimization is needed with batteries and EVs
- Additional flexible demand, i.e. electrolysis, heat pumps, industrial heating / cooling, data centers, etc. is needed
- Electrolysis is the key to enable more renewables!



The need for balancing is rising with the share of renewable energy



CAPACITY RESERVES FROM RENEWABLES AND FLEXIBLE DEMAND

Assumptions: Forecasting precision and tools have high enough quality to meet firmness requirements.

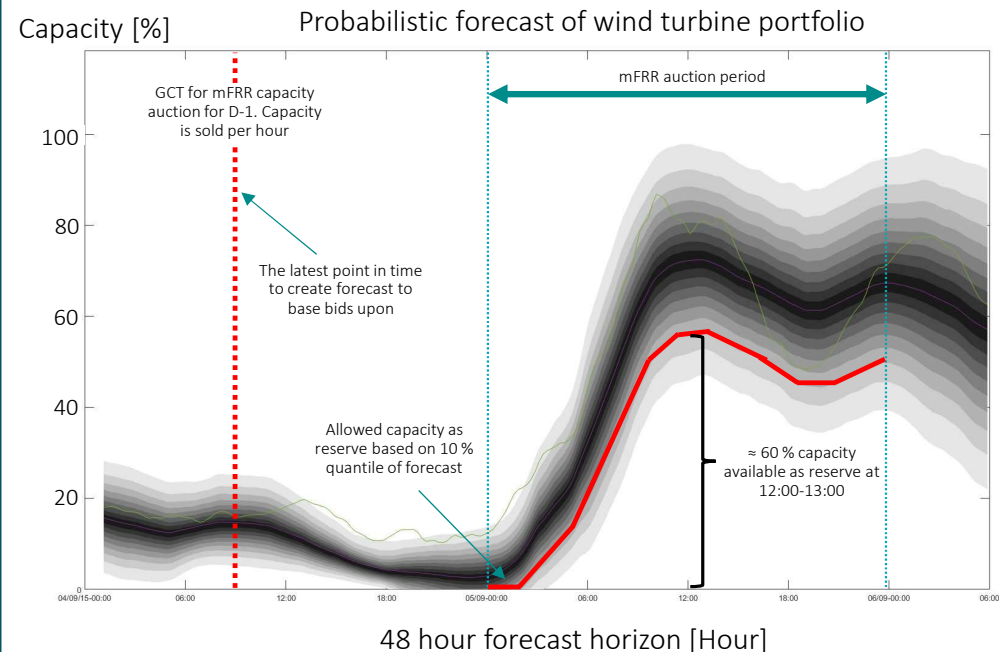
Result: Increased liquidity and better utilization of existing resources.

Method: Precision of forecasting must be proven based on at least 3 months of historical data.

Renewables & Flexible demand will be allowed to bid in capacity equal to the **10 % quantile of a probabilistic forecast**, to ensure that the capacity is available.

The rest can be bid into the energy markets, day-ahead and intra-day from the 10 % quantile and up.

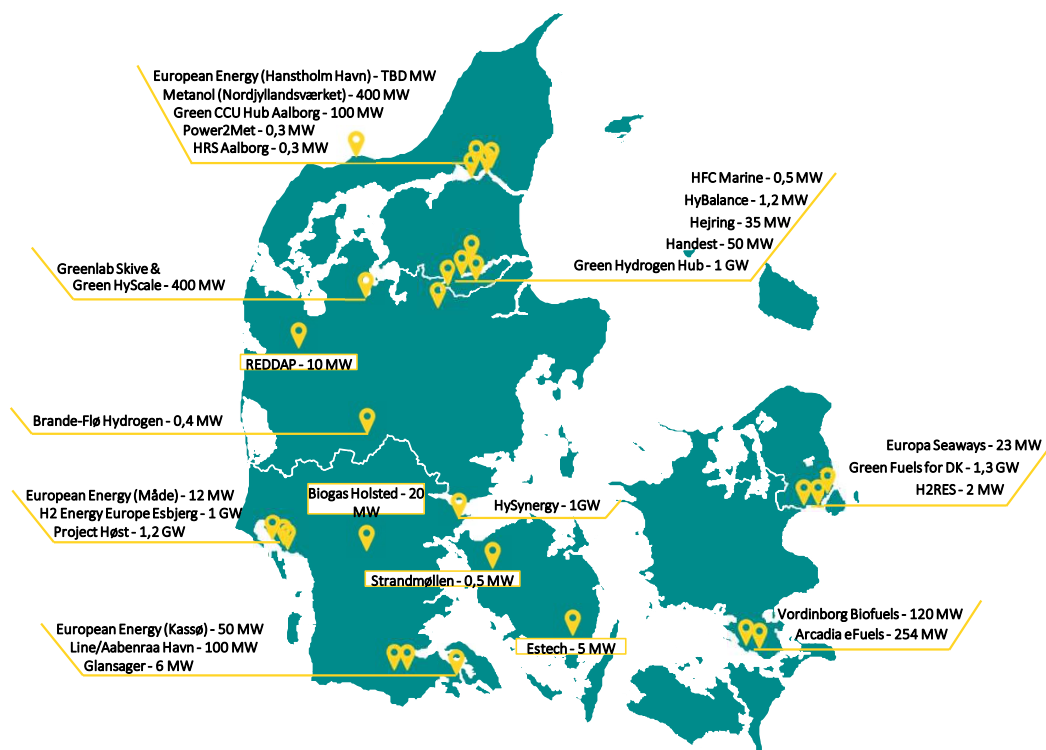
At times with the largest uncertainties the spread is larger, and hence the capacity that can be bid is reduced (to maintain firmness)



The Figure shows the spread of production from a wind turbine portfolio, where every shade represents 5% quantile.

RAPID INCREASE IN PTX-PROJECTS

Publicly announced electrolysis capacity from PtX projects/visions for 2030 has increased since January 2020 from 40 MW to app. 7000 MW.



Kilde: <https://brintbranchen.dk/danske-brintprojekter/> og offentliggjorte PtX-projekter i danske medier.

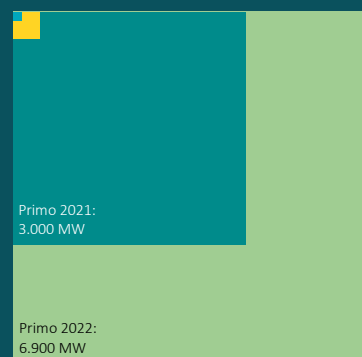
Increase in announced electrolysis capacity in 2025 og 2030 from PtX projects/visions

Announced capacity (MW)	In operation in 2025	In operation in 2030
Primo 2019	4	4
Primo 2020	40	40
Primo 2021	400	3.000
Primo 2022	2.500	6.900

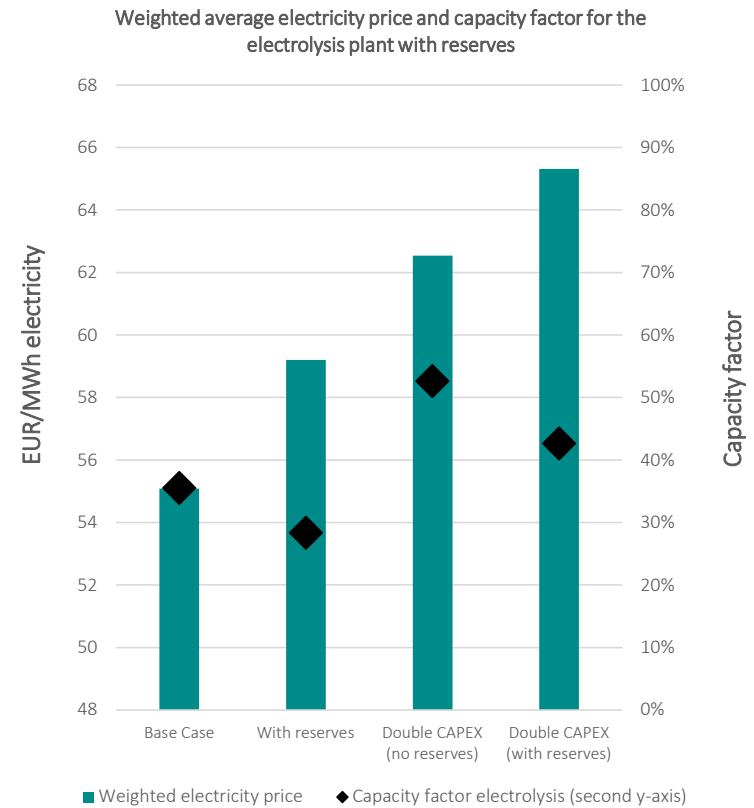
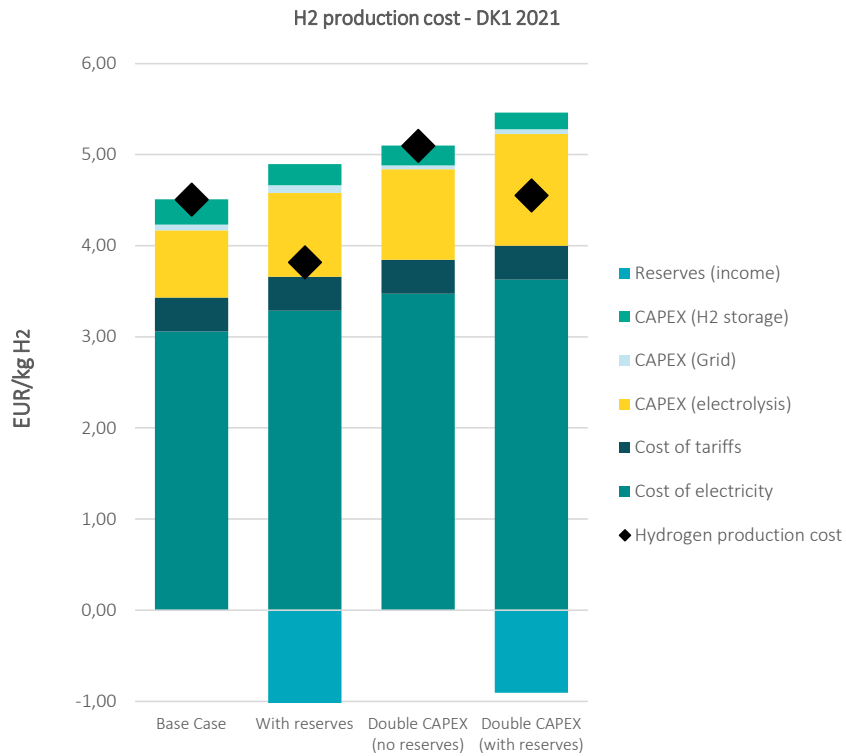
In operation in 2025



In operation in 2030



LCOH BASED ON MODEL FOR 2021 - BASE SCENARIO WITH/WITHOUT RESERVES



QUESTIONS?