

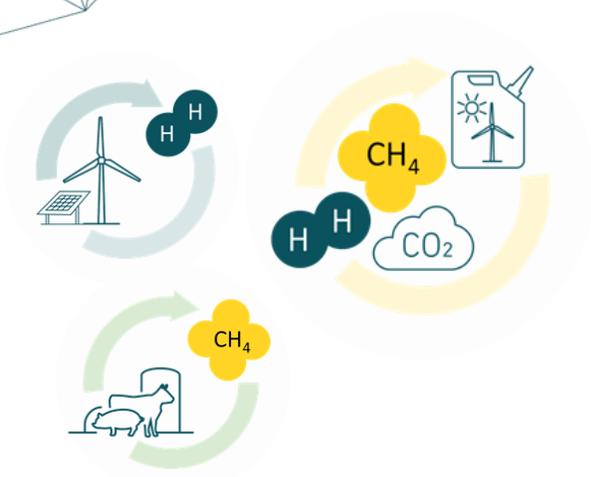
THE FUTURE INTEGRATED ENERGY SYSTEM

The role of hydrogen infrastructure

Energinet, System Development and Perspectives

Martin Hartvig, Ph.D. M.Sc.

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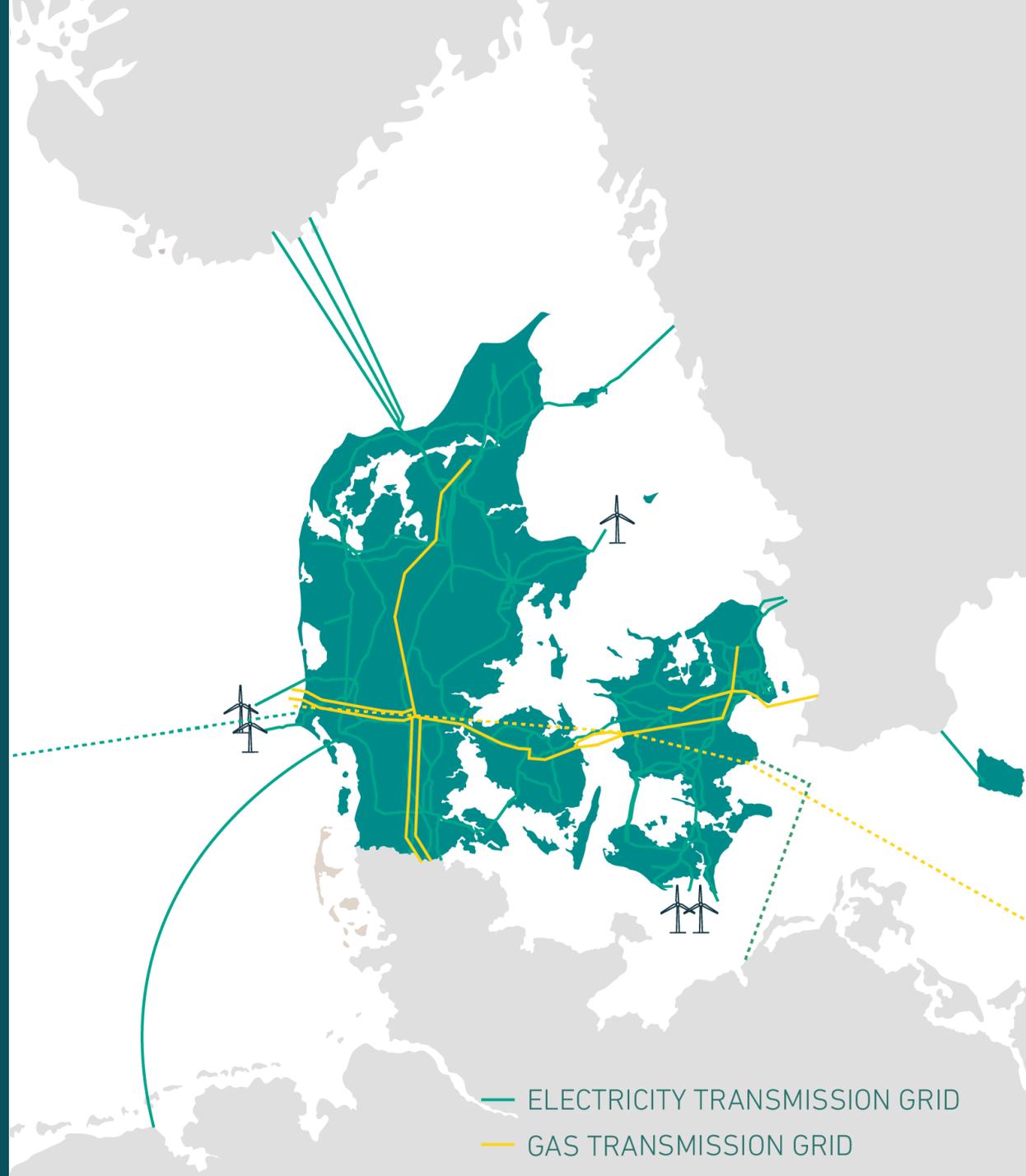


WE ARE WORKING FOR THE DANES

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

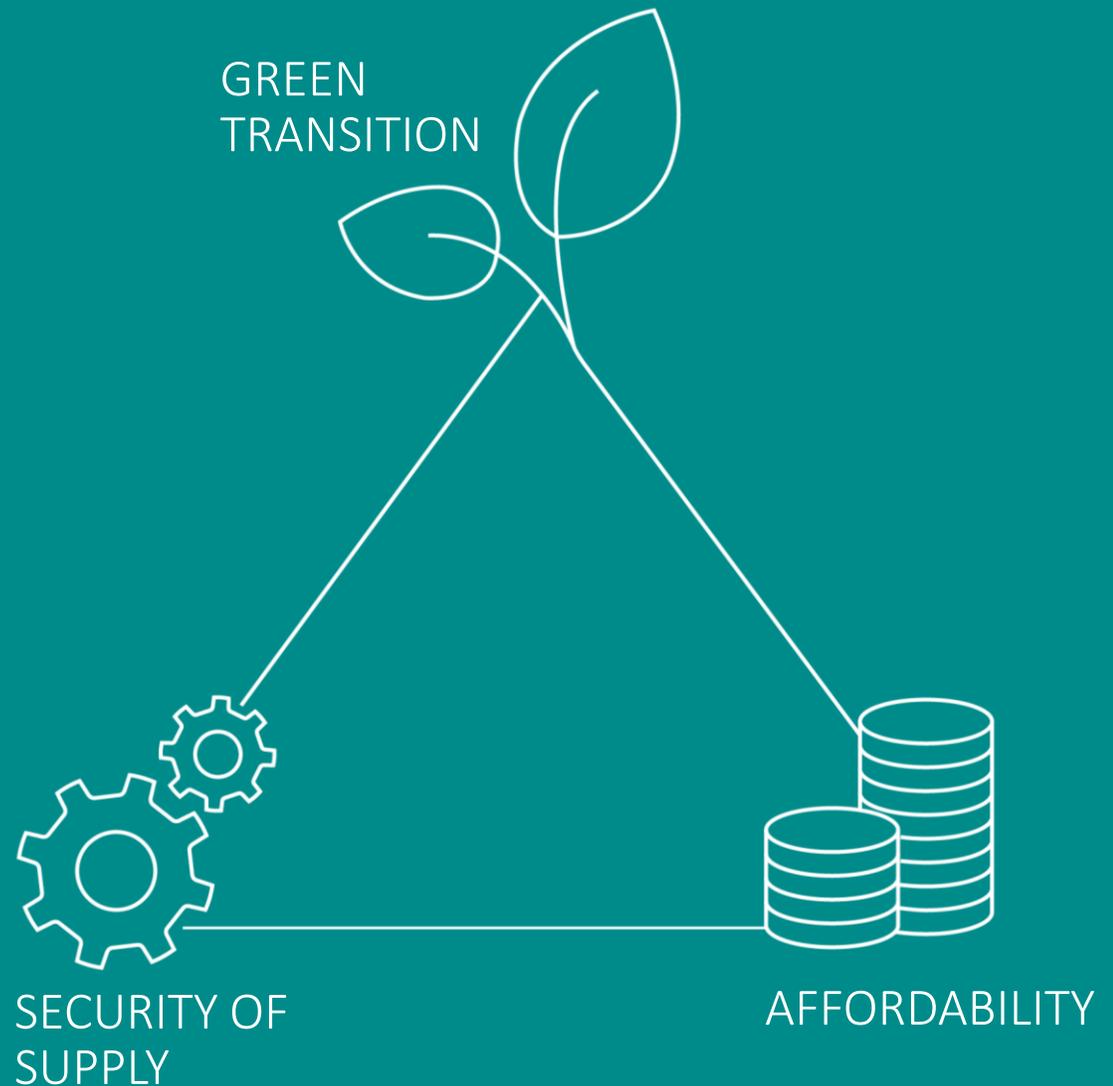
We safeguard society's interests as we move to a 100% green energy system.

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

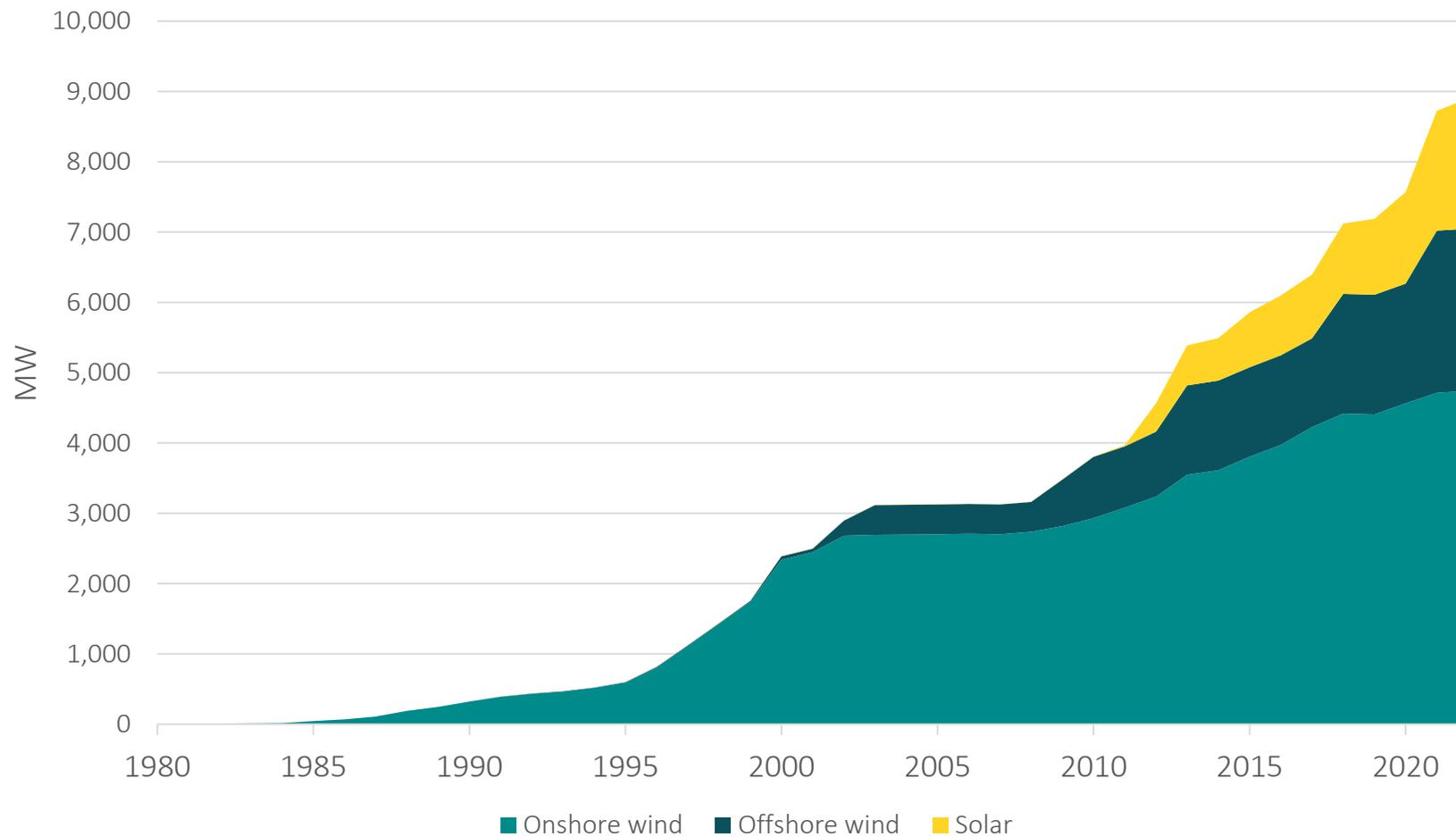


HOW TO BALANCE

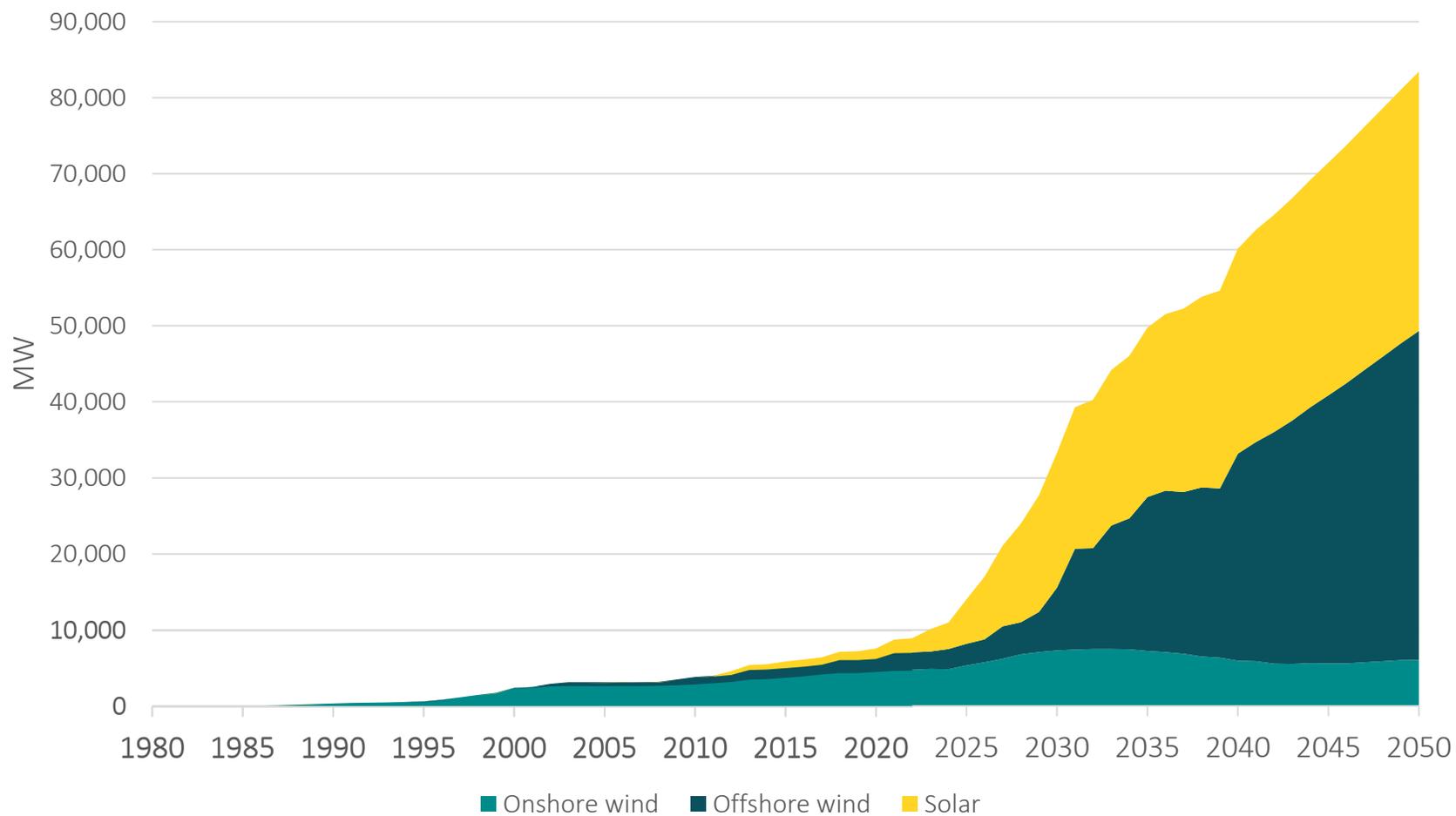
We work hard to make the green transition socioeconomic optimal while ensuring security of supply



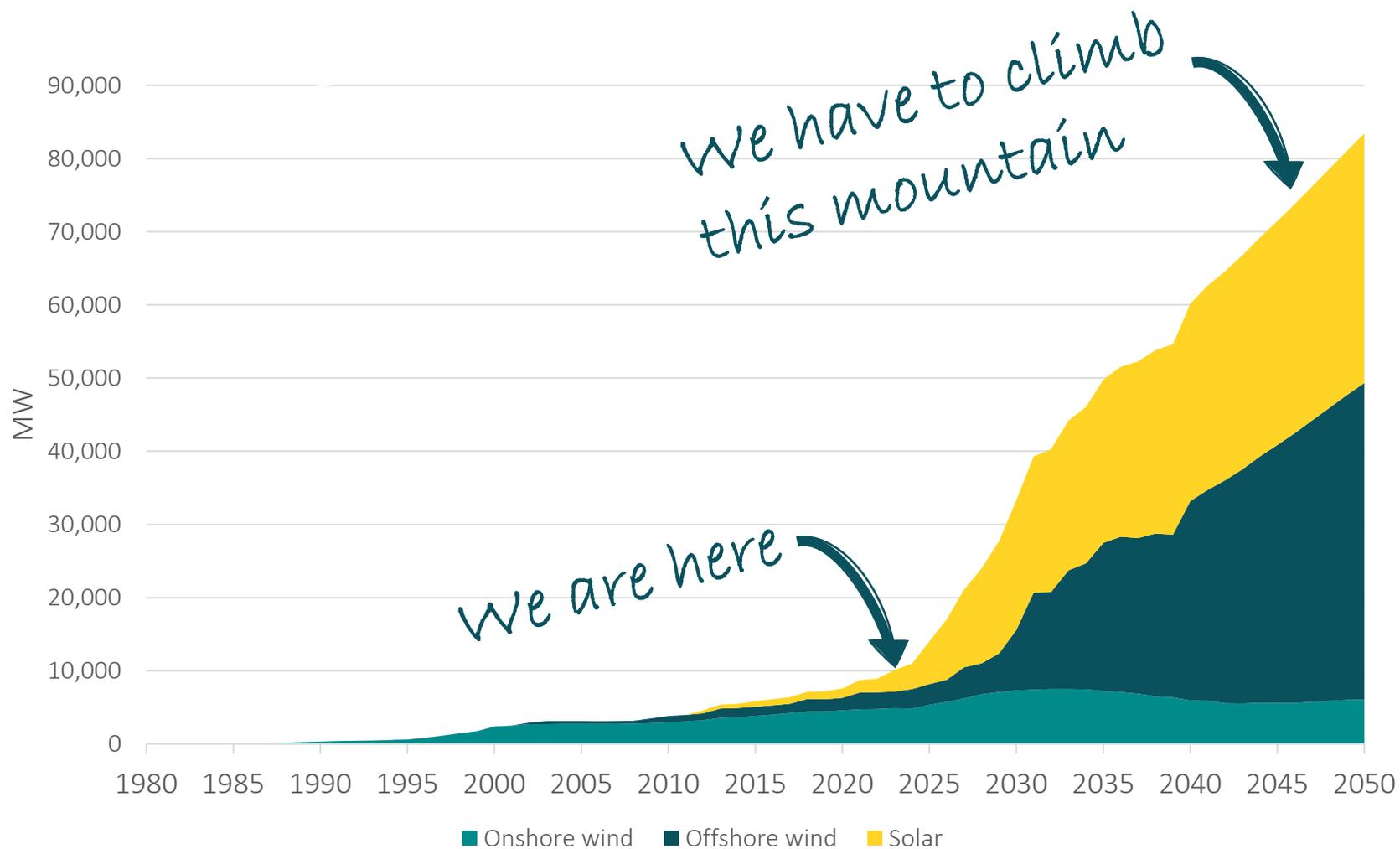
OVER 40 YEARS WITH WIND POWER IN DENMARK



OVER 40 YEARS WITH WIND POWER IN DENMARK



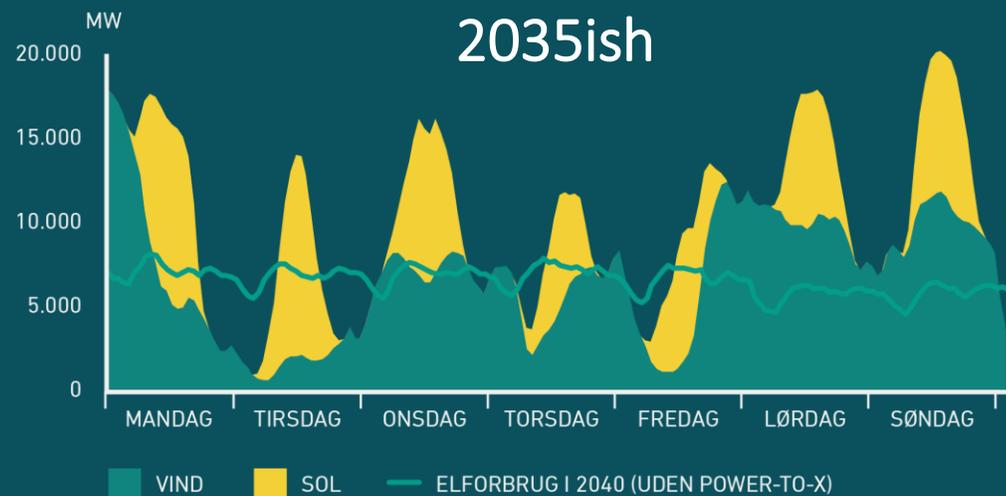
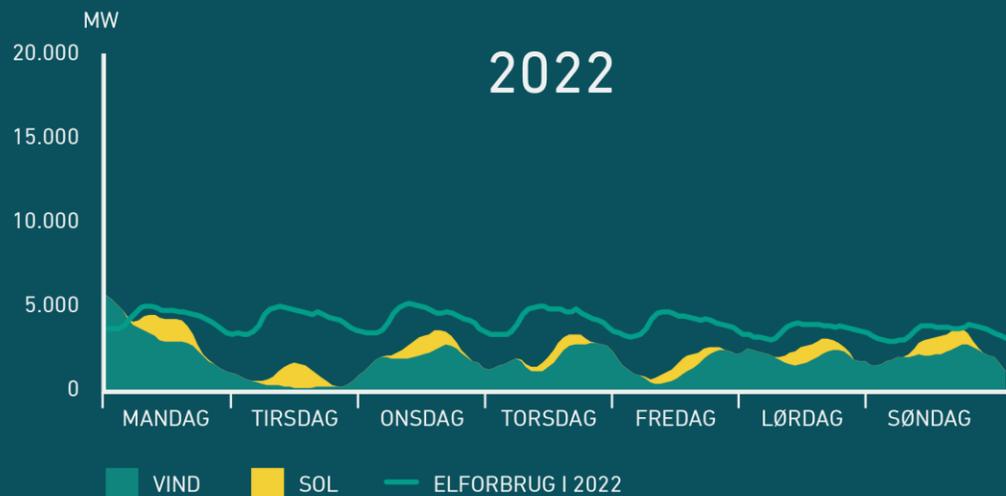
NEAR 40 YEARS OF INTERVALL POWER IN DENMARK



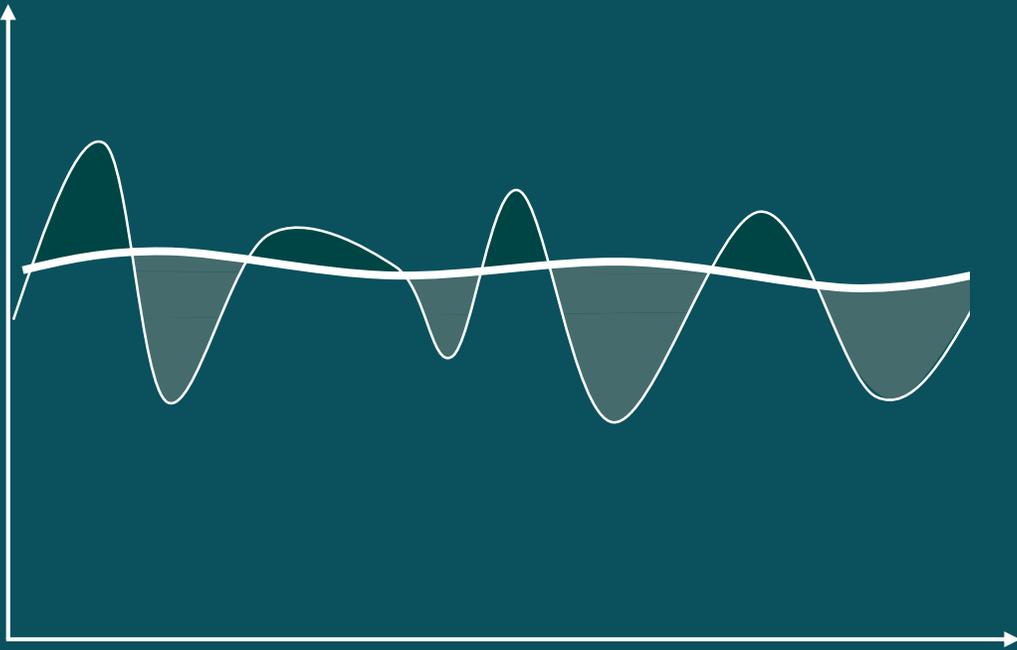
IN PROJECTIONS DEMAND AND SUPPLY DO NOT ALWAYS MATCH... BUT PHYSICS ENFORCES THIS BALANCE...



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

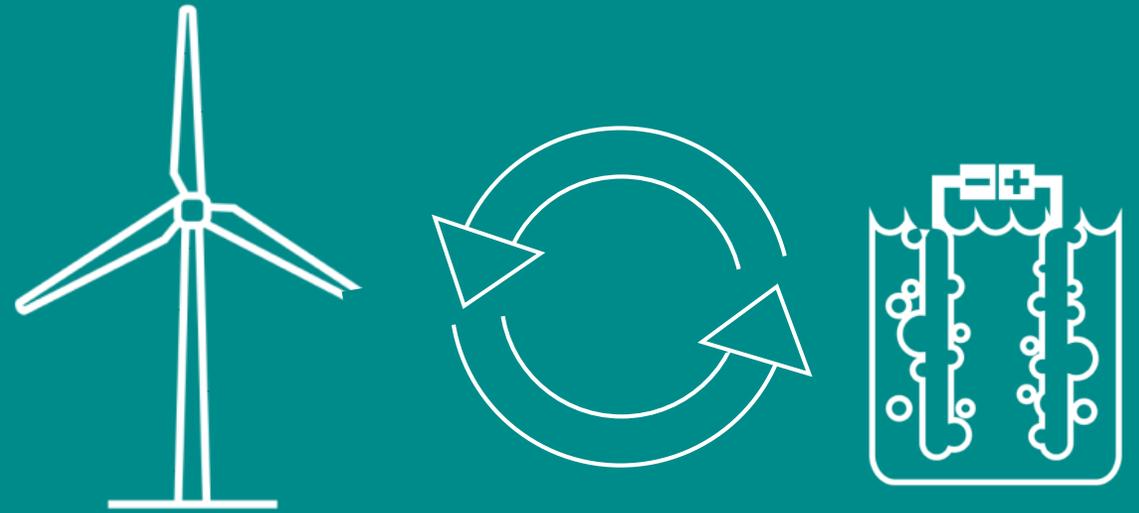


WIND CURTAILMENT



A ONE WAY STREET

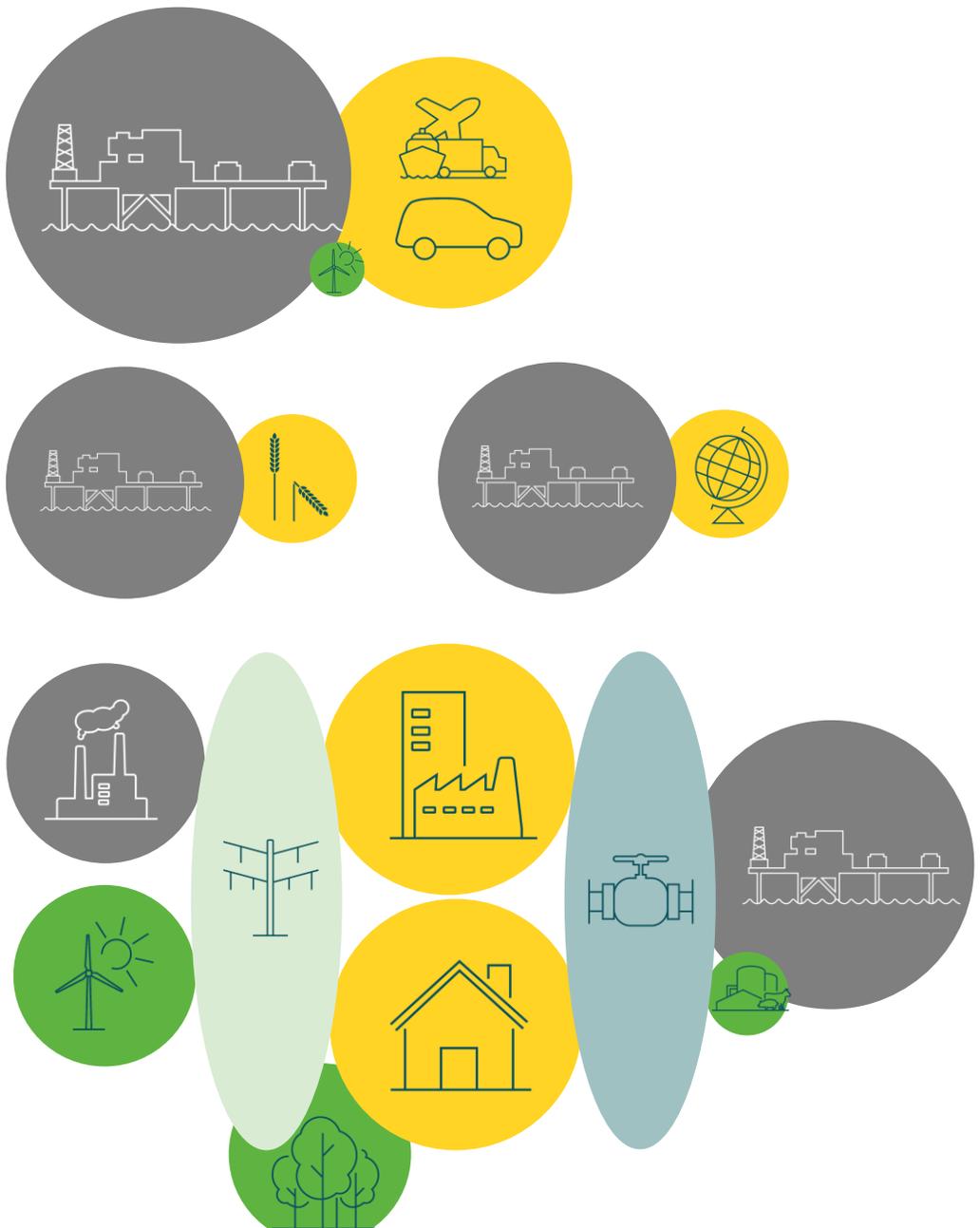
WIND & ELECTROLYSIS



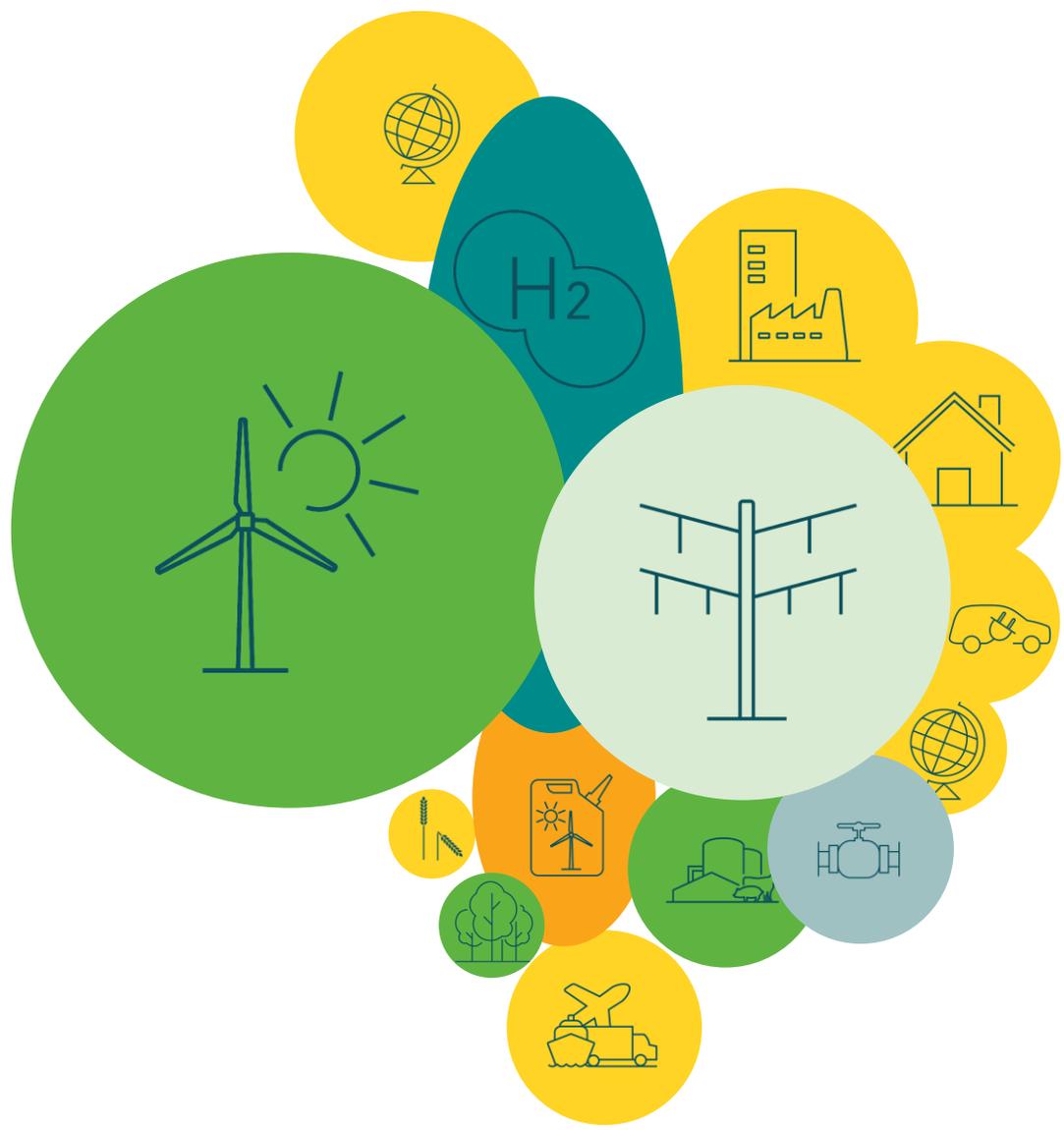
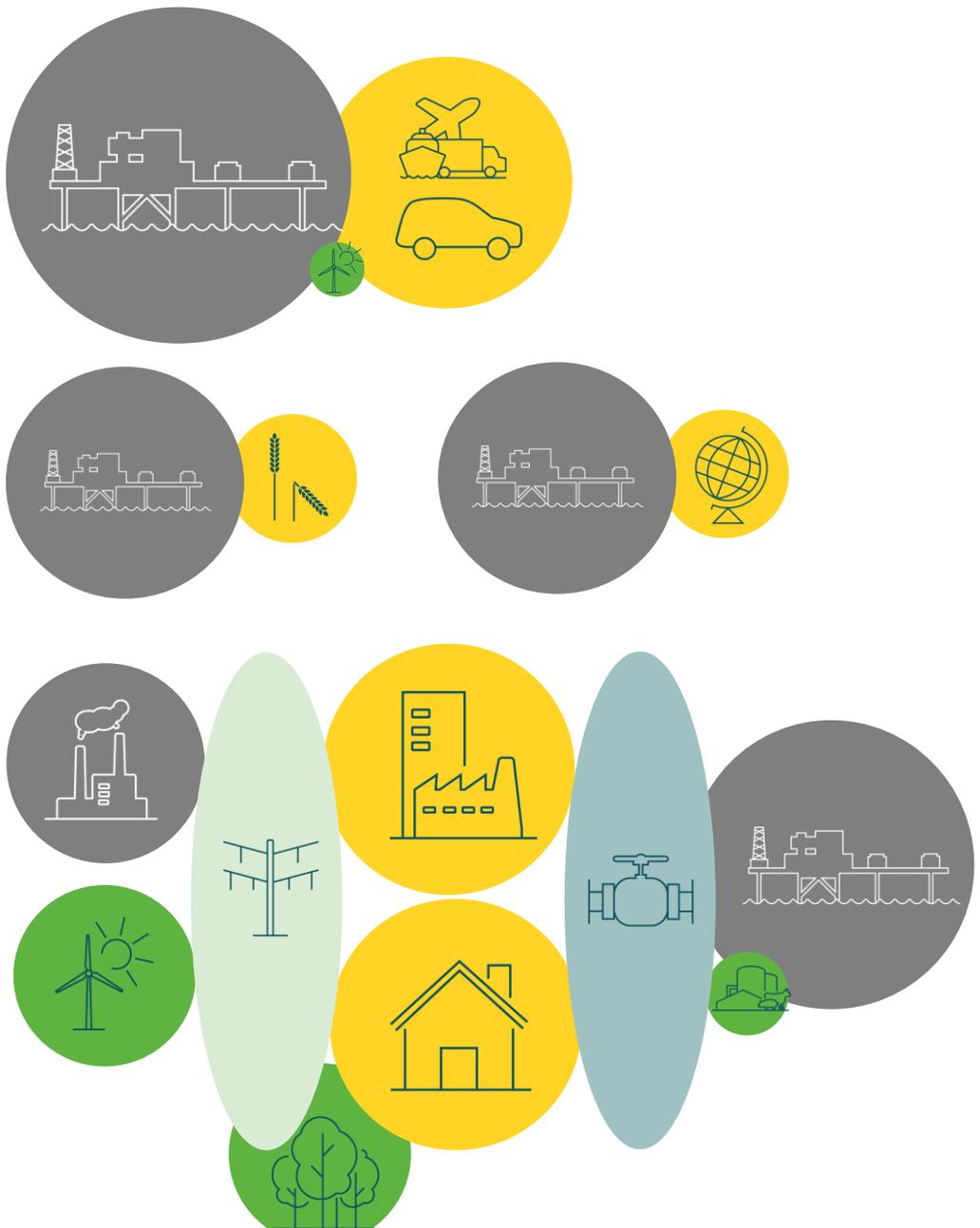
SYNERGY & BUILDOUT

What do we need to do?

FROM FOSSIL CHAINS TO A RES-E ECOSYSTEM



FROM FOSSIL CHAINS TO A RES-E ECOSYSTEM



While making sure we min[sum(CO2emissions(yr)]

HOW TO REDUCE EMISSIONS MOST EFFICIENT?

How to get most CO2 reduction the same amount of money?

It is at least 2,7-5,2 (1,3-2,6) times more CO2 efficient to do direct instead of indirect elektrification

Direct electrification
350-680gCO2/kWhe

Indirect elektrificering
130-260gCO2/kWhe



1kWh



~0g/kWhe



2,5kWh

1kWh

46-51%



~680g/kWhe



1,67kWh

1kWh

59%



~350g/kWhe



2kWh



1kWh

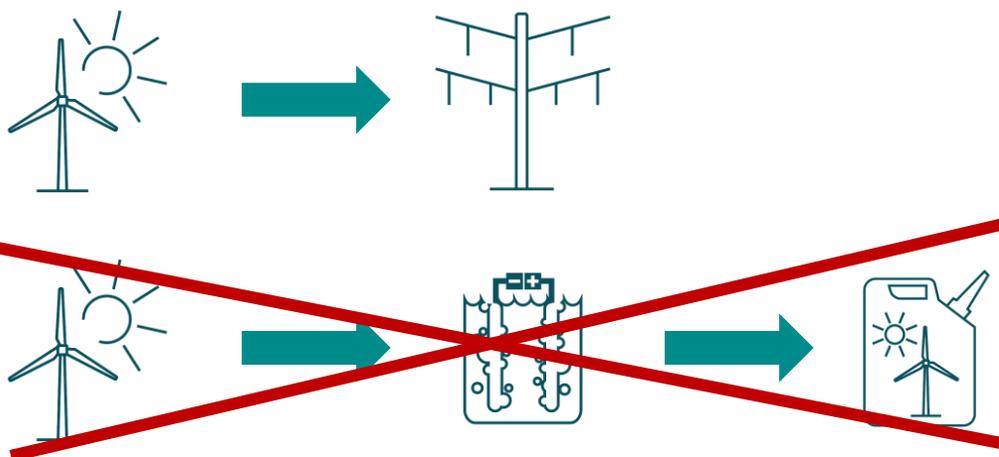


~260gCO2/kWh (520)

RE FUELS WITHOUT SLOWING THE TRANSITION?

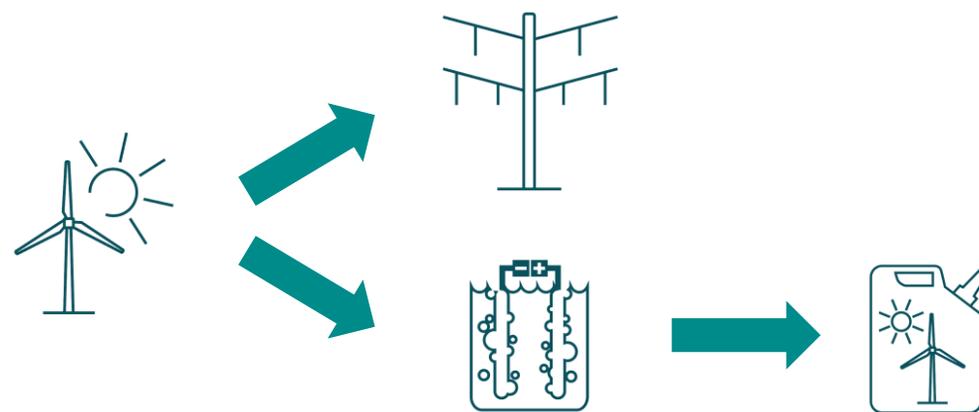
If there's a wish for maximal CO₂-reduction when producing H₂/PtX the production must take place using system integration

Direct + indirect electrification



Also looks expensive compared to hotspots

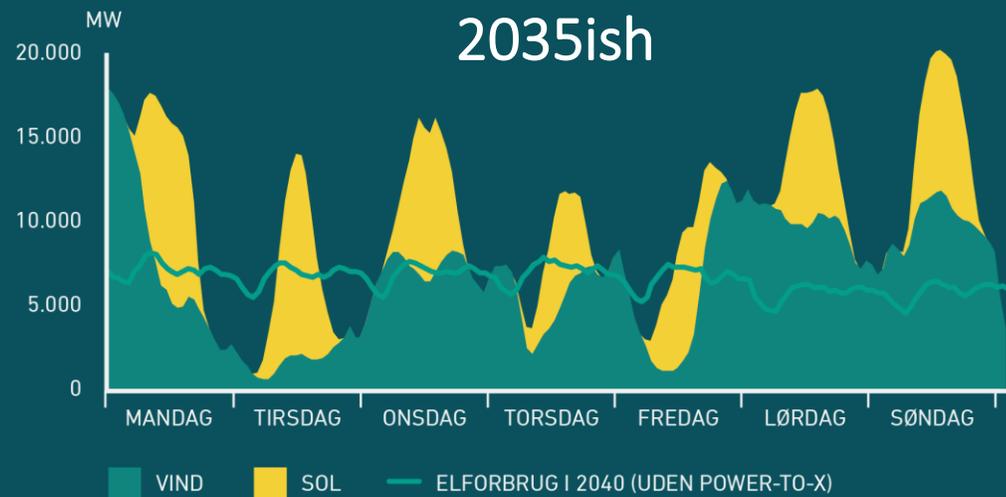
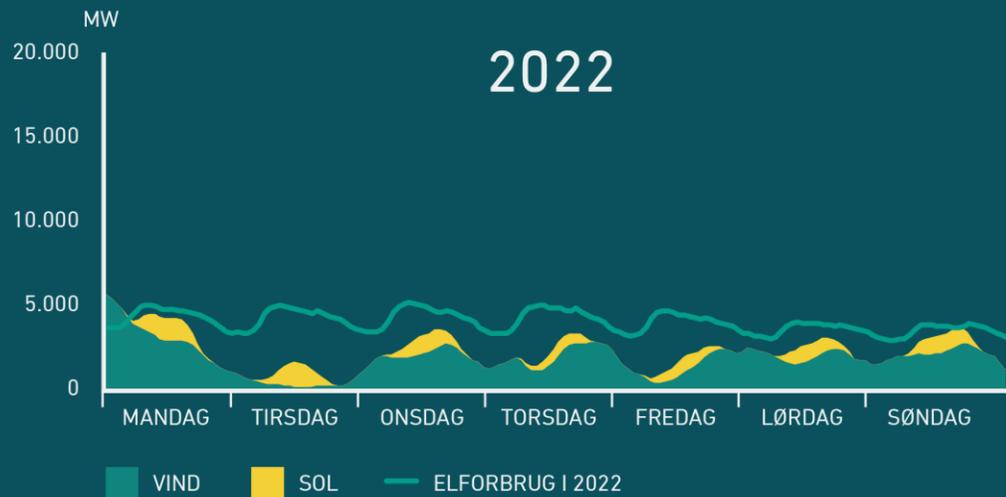
System integration



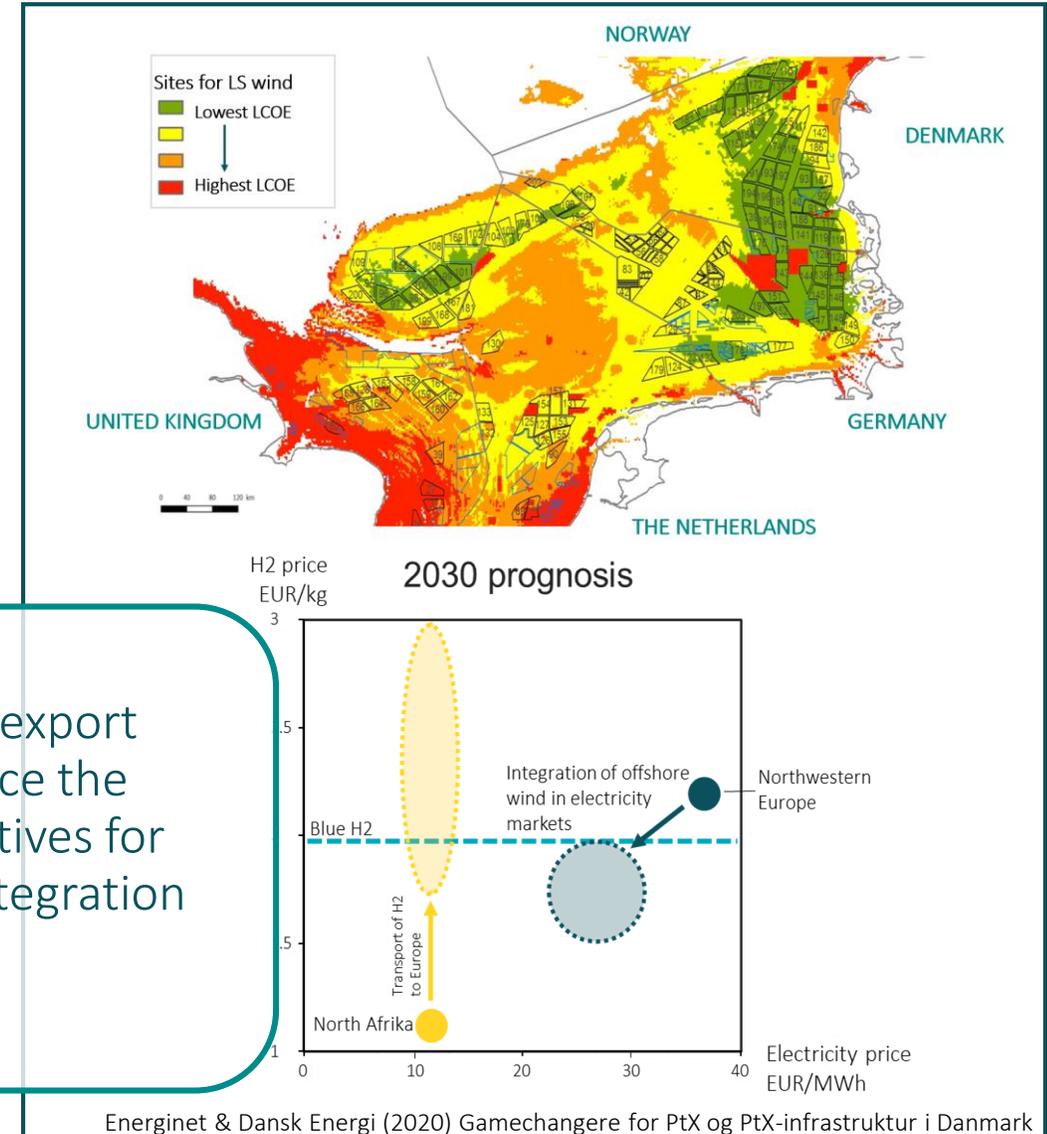
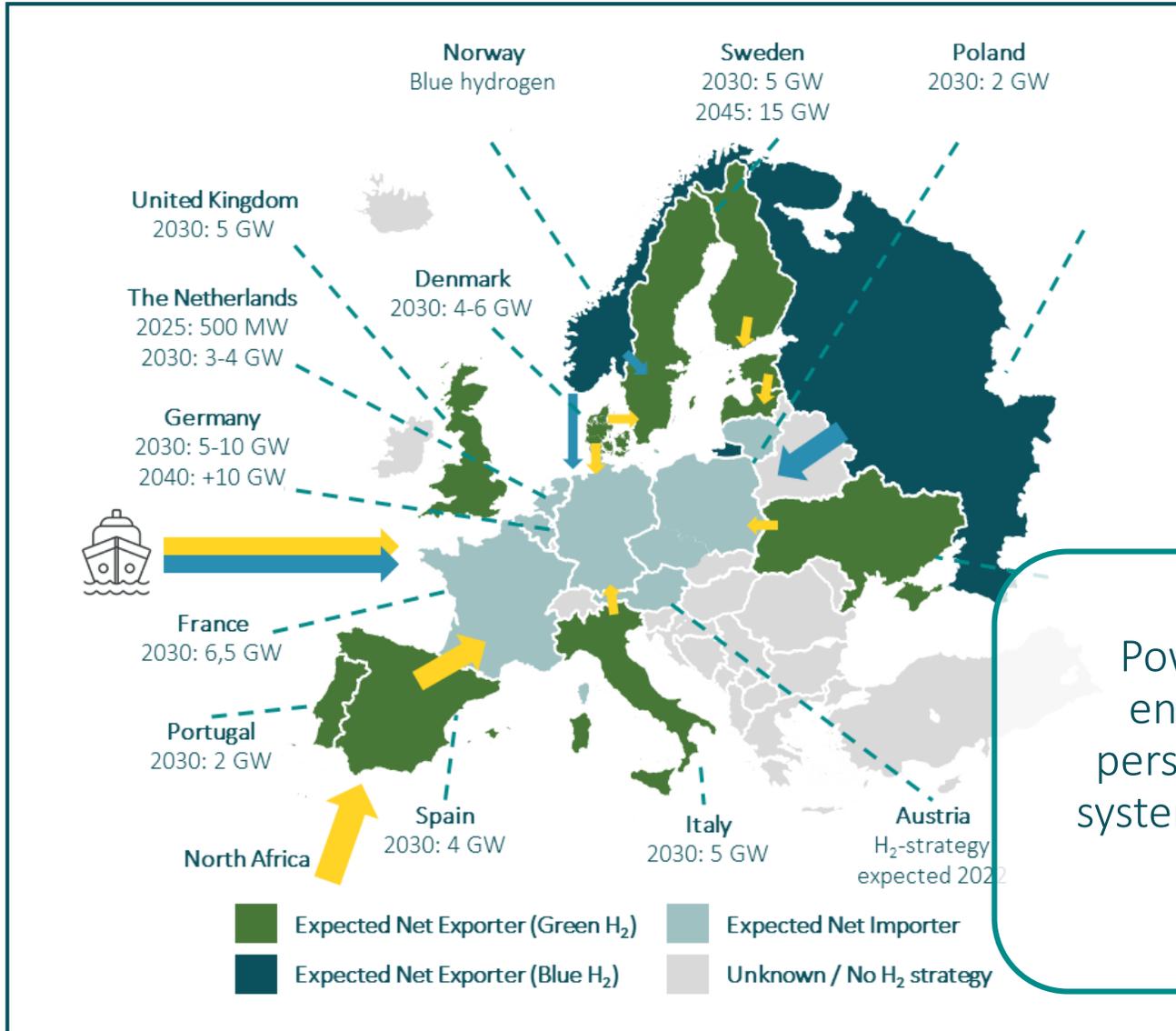
Hydrogen infrastructure can be important support that electrolyzers indeed "play together! With the green transition in the power grid

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

STOP
A NEED FOR REAL FLEXIBILITY IN THE TRANSITION

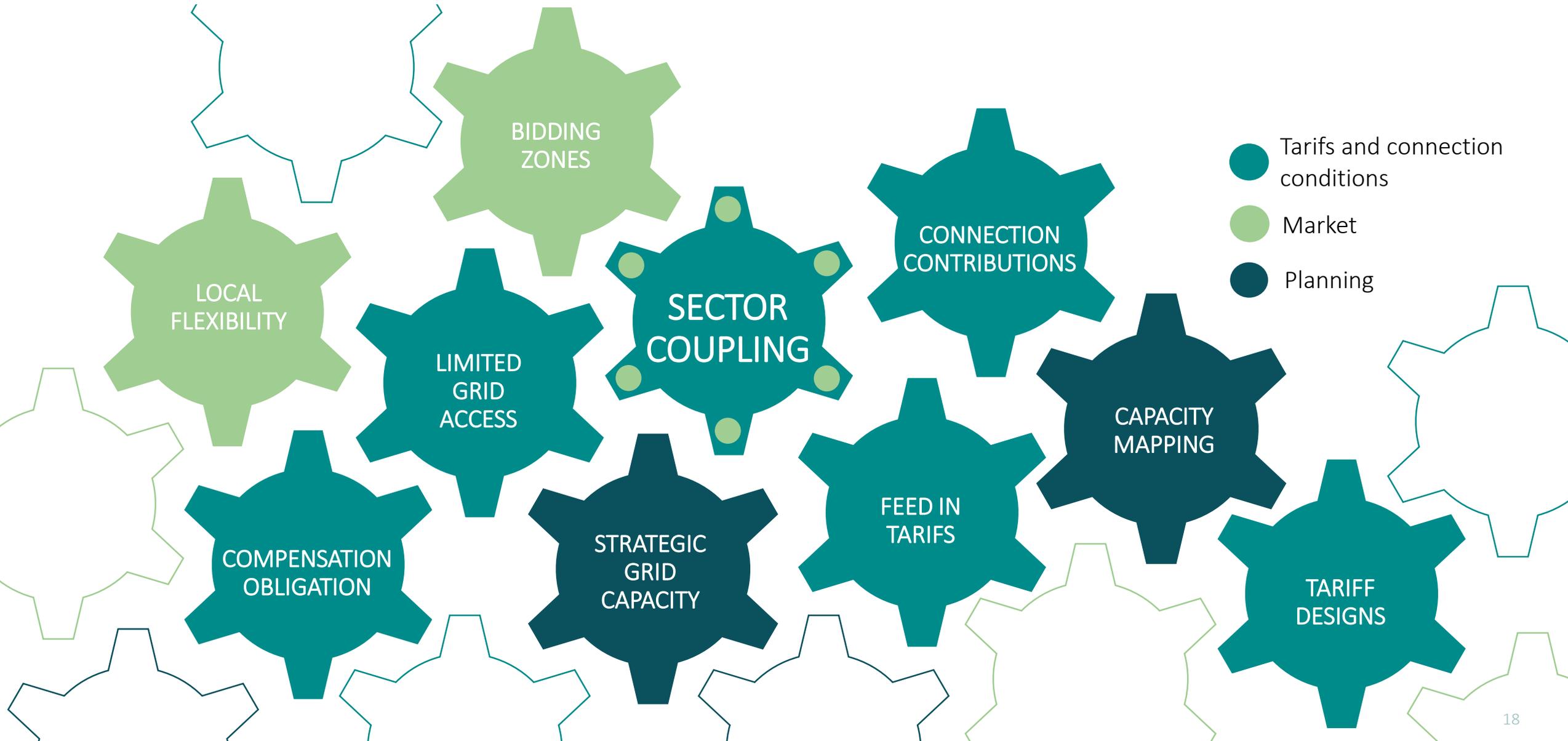


INTEGRATION OF HYDROGEN – NOT ONE SIZE FITS ALL



Power export enhance the perspectives for system integration

GRID PLANNING IS MORE THAN HARDWARE



DANISH ENERGY ISLANDS

North Sea: capacity of 3 GW wind in 2030 rising to 10GW in 2030ies

Baltic Sea: capacity of 2 GW in 2030



ENERGINET

<http://en.energinet.dk/Green-Transition/Energy-Islands>

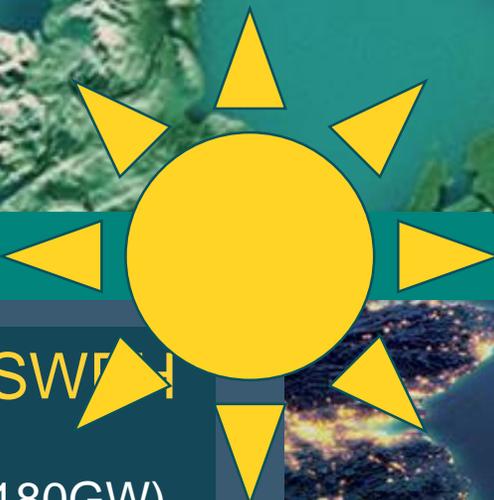
NORTH SEA WIND POWER HUB - NSWFH

International massive build-out of North Sea wind (180GW)

Essential to meet European contribution to Paris agreement

Combined wind landing and ICs (hub & spoke concept)

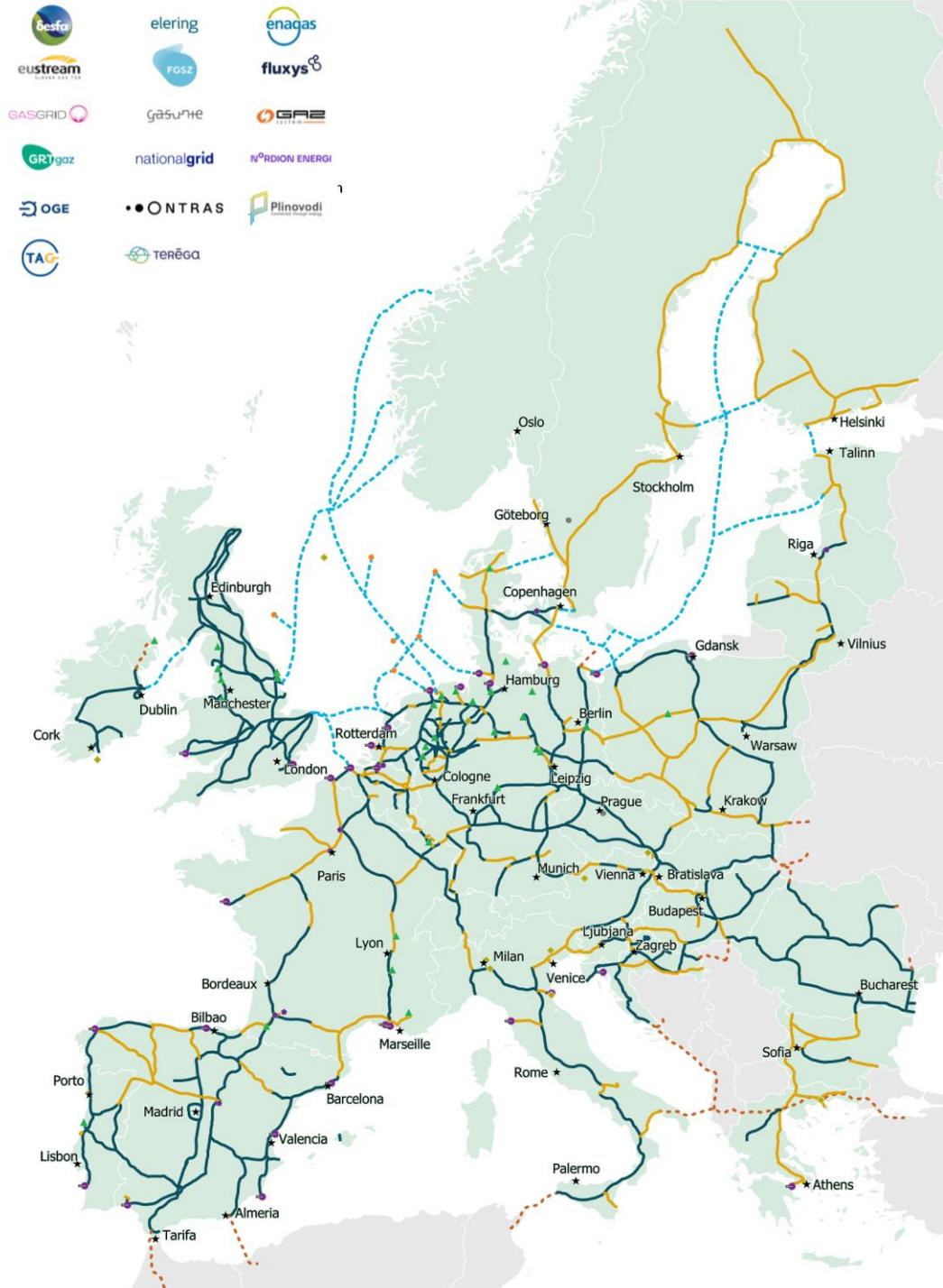
Effective integration in Europe



THE TSO'S VISION OF A

“EUROPEAN HYDROGEN BACKBONE”

European Hydrogen Backbone vision for 2040



H₂ Network Germany & Denmark

Hyperlink 3 (PCI) + Danish backbone West (PCI)

2022-23 Feasibility

2022-23 Maturation

2025-2028/30 Construction

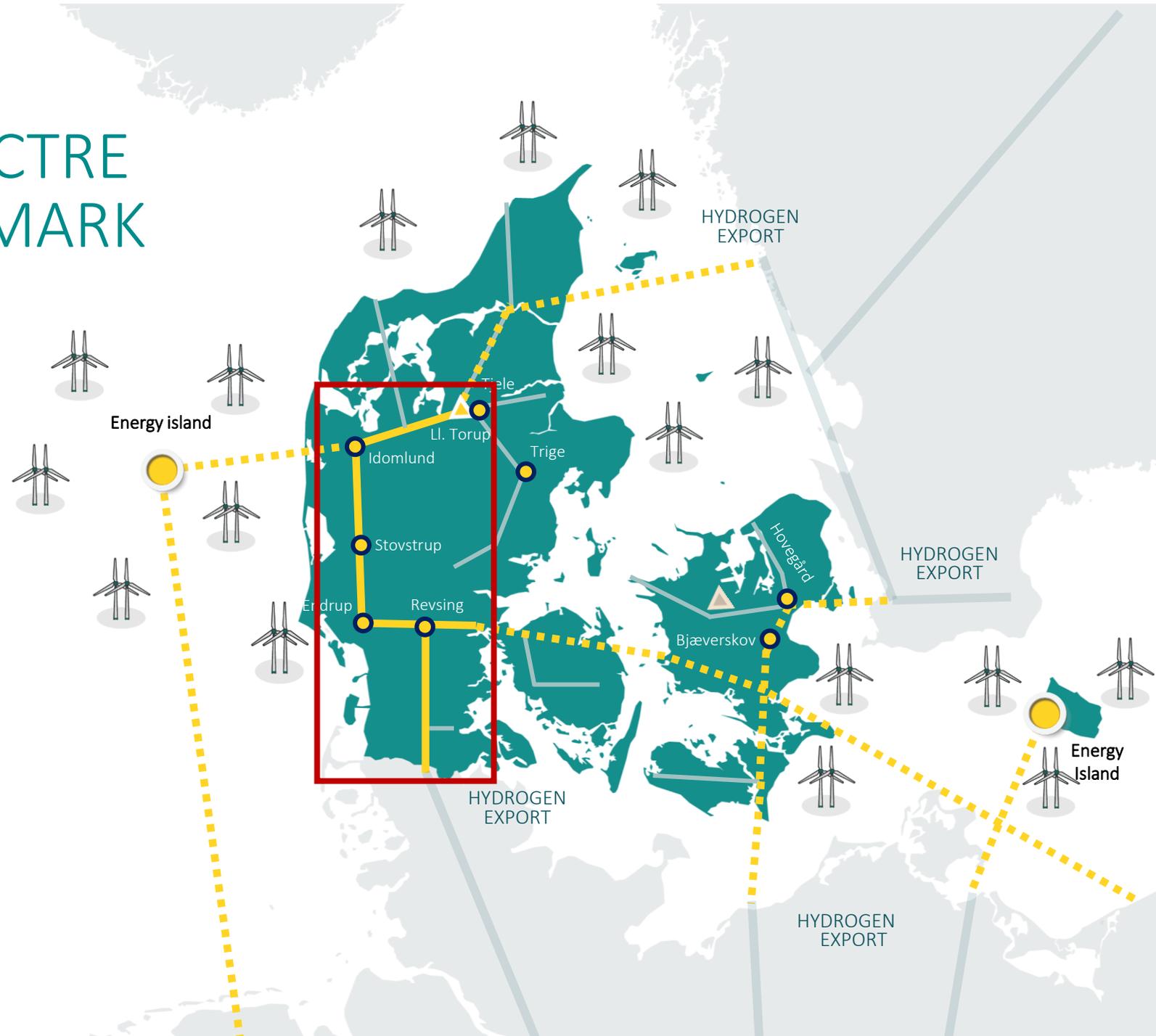
-  Electrolysis
-  Hydrogen storage
-  Energy Hub
-  Hyperlink 3 (PCI)
-  Danish backbone West (PCI)
-  Other pipelines



POTENTIALS FOR HYDROGEN INFRASTRUCTRE DEVELOPMENT IN DENMARK

Hydrogen Infrastructure

- High capacity
- Low capacity
- Cavern storage
- Potential highcapacity connections
- European Hydrogen Backbone
- Central point in electricity grid



INTEGRATED ENERGY SYSTEM & HYDROGEN INFRASTRUCTURE



Socioeconomic integration of large-scale renewables require sector coupling of power and hydrogen



Cross-planning maximizes utilization of existing grid, reduces grid new and offers competitive tariffs



Hydrogen infrastructure should serve large & small, producers and consumers



New fleksible demand can balance the power grid and provide ancillary services



A Danish Hydrogen Backbone is closely linked to the European system



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The end

Additional slides

EJERSKAB OG DRIFT AF FREMTIDENS DANSKE BRINTINFRASTRUKTUR

Afklaring af Energinets og Evidas rolle i brintsystemet

Ny politisk aftale om ejerskab og drift af brintinfrastruktur giver Energinet og Evida en rolle i udviklingen af rørledningsinfrastruktur

Energinets rolle er:

At forbinde grænseoverskridende rørbaseret brintinfrastruktur til et dansk modtagepunkt,

At forbinde brintinfrastruktur i offshorerørledninger og grænseoverskridende brintrørledninger på tværs af landet med et brintlager, en såkaldt ryggrad,

At udføre opgaven som systemansvarlig virksomhed

Evidas rolle er

At forbinde indenlandske brintproducenter og forbrugere,

For at forbinde ovenstående til et sammenkoblet brintsystem.

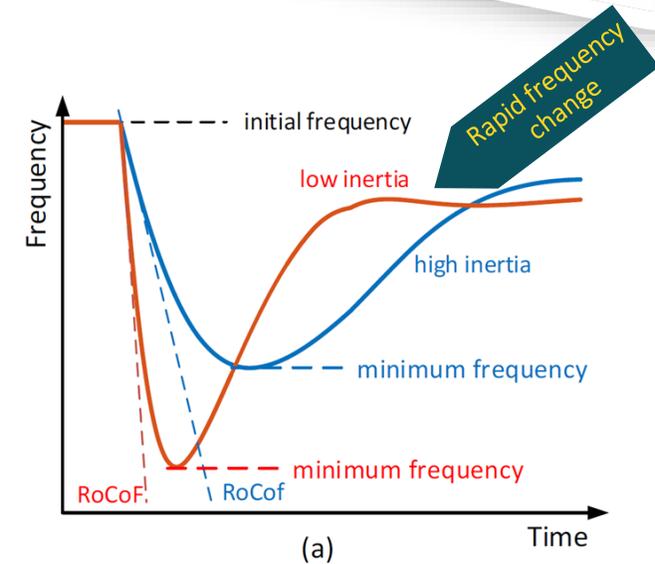
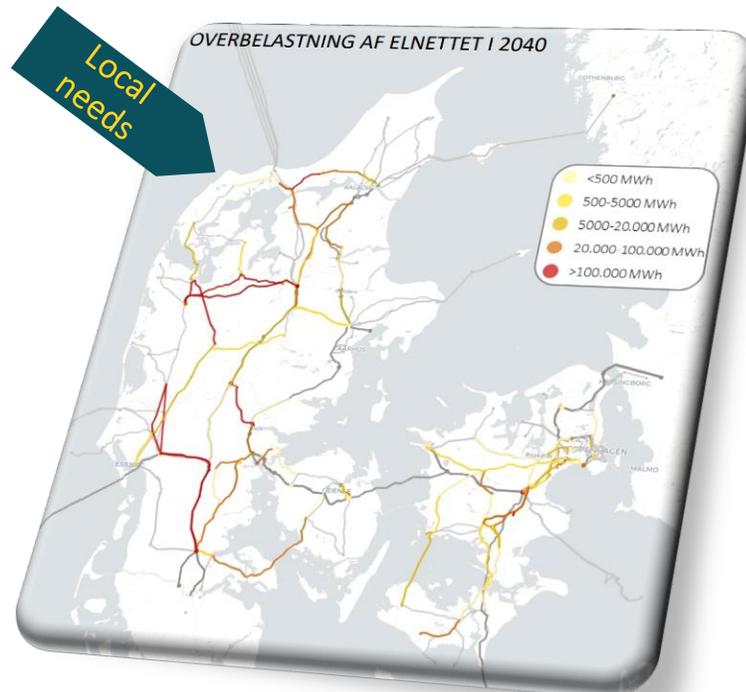
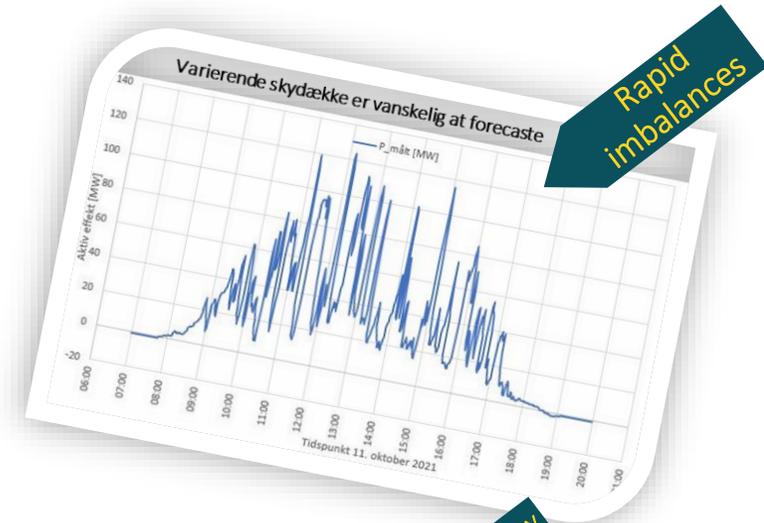
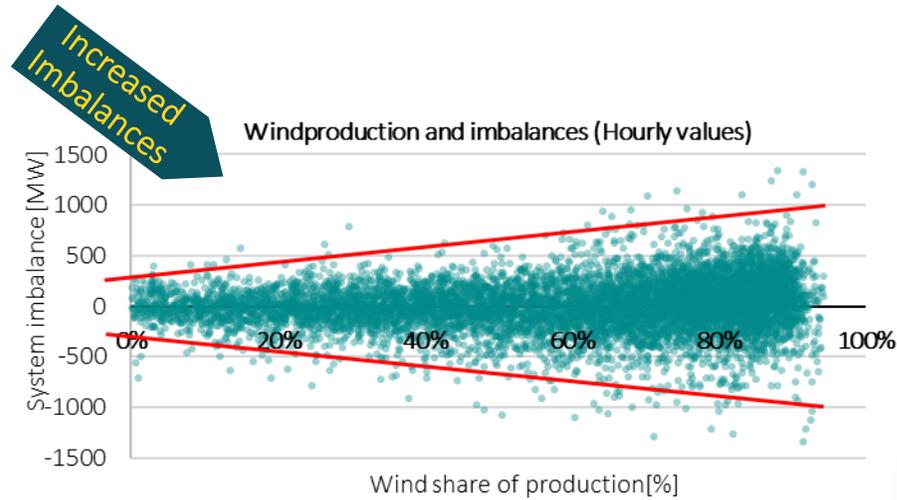


Setting the scene: The need for ancillary services increase



Green transition increases the need for balancing

- Low inertia (rotational energy) results in less time to react*
- More and greater imbalances due to forecast errors*



Scenario report: Expectations on future AS provision needs

Frequency-dependent



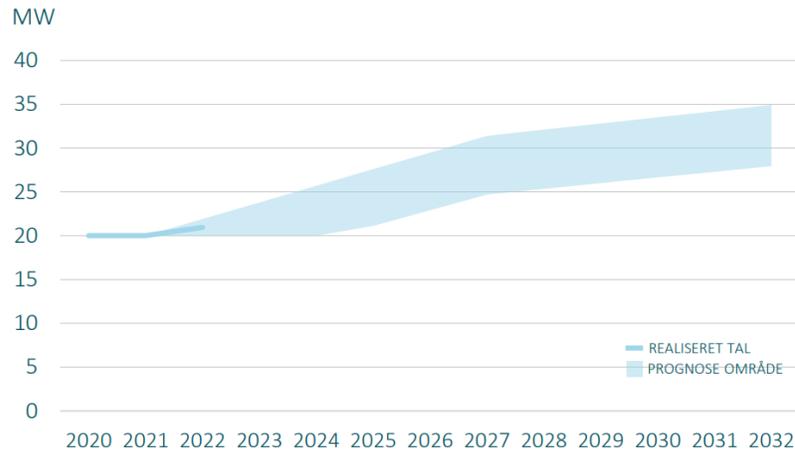
Reason for increase?

DK1 share of CE's 3 GW increases.

FIGUR 13

FCR DK1

PROGNOTISERET KAPACITETSBEHOV



Quick imbalances



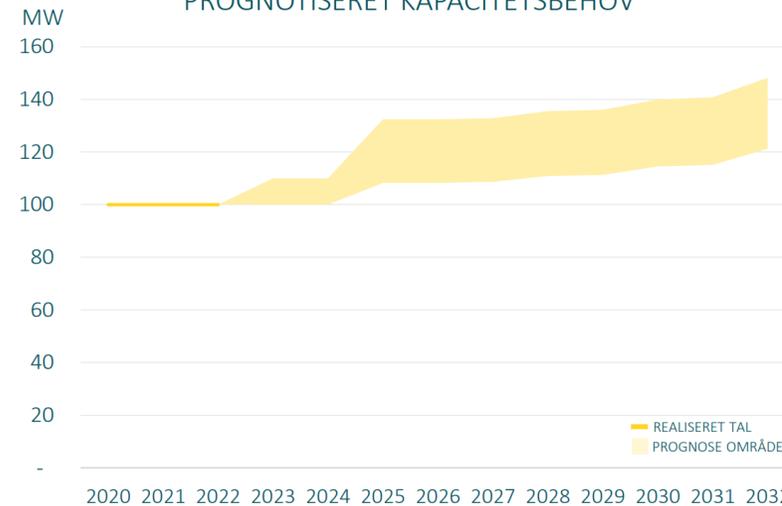
Reason for increase?

Nordic aFRR CM & CE PICASSO EAM → 5 min FAT

FIGUR 22

aFRR DK1

PROGNOTISERET KAPACITETSBEHOV



Long-term imbalances



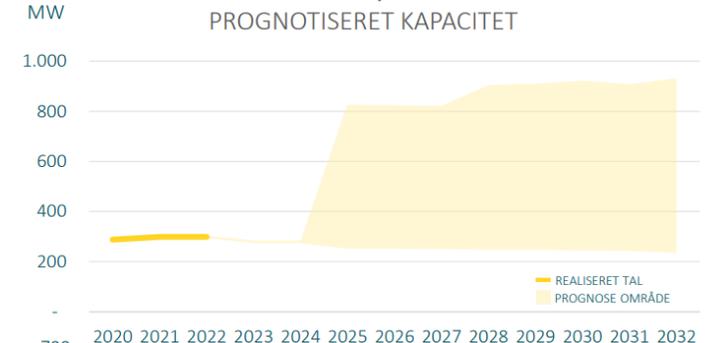
Reason for increase?

New Nordic dimensioning & 1 GW dimensioning incident in 2026 (PtX)

FIGUR 27

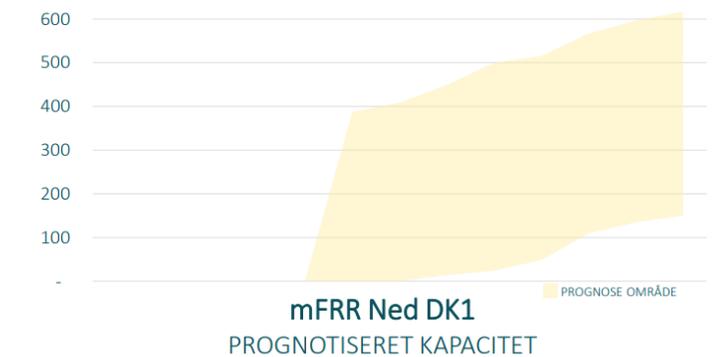
mFRR Op DK1

PROGNOTISERET KAPACITET

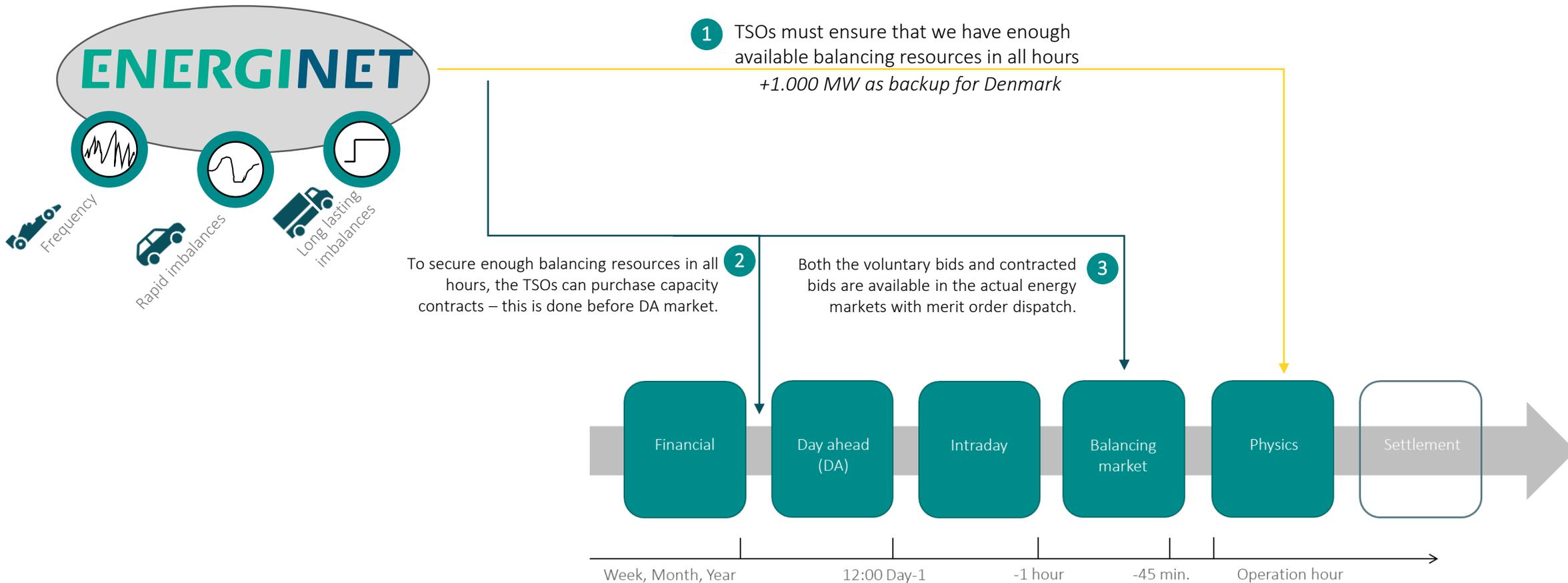


mFRR Ned DK1

PROGNOTISERET KAPACITET



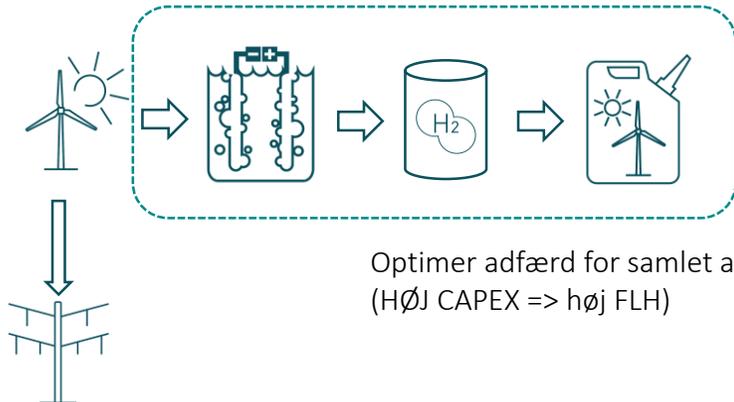
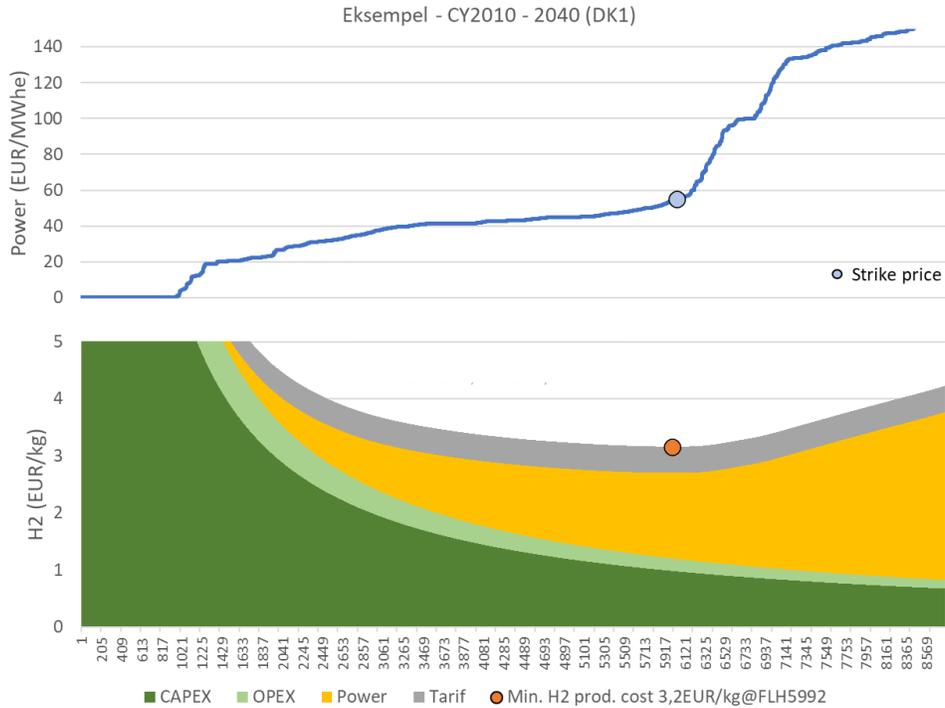
HOW DO WE PROCURE RESOURCES?



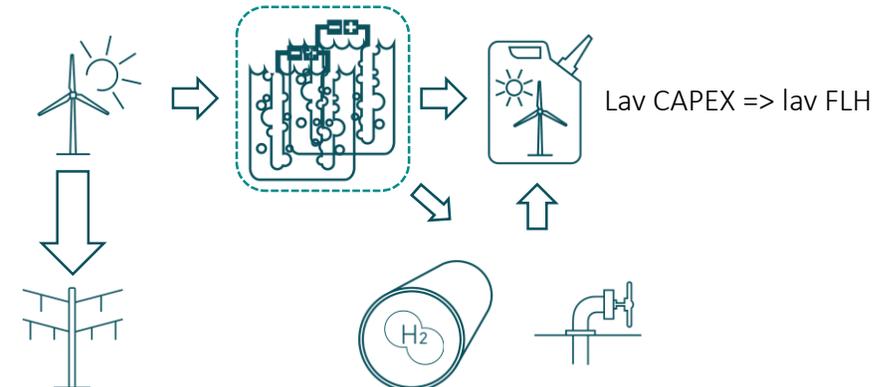
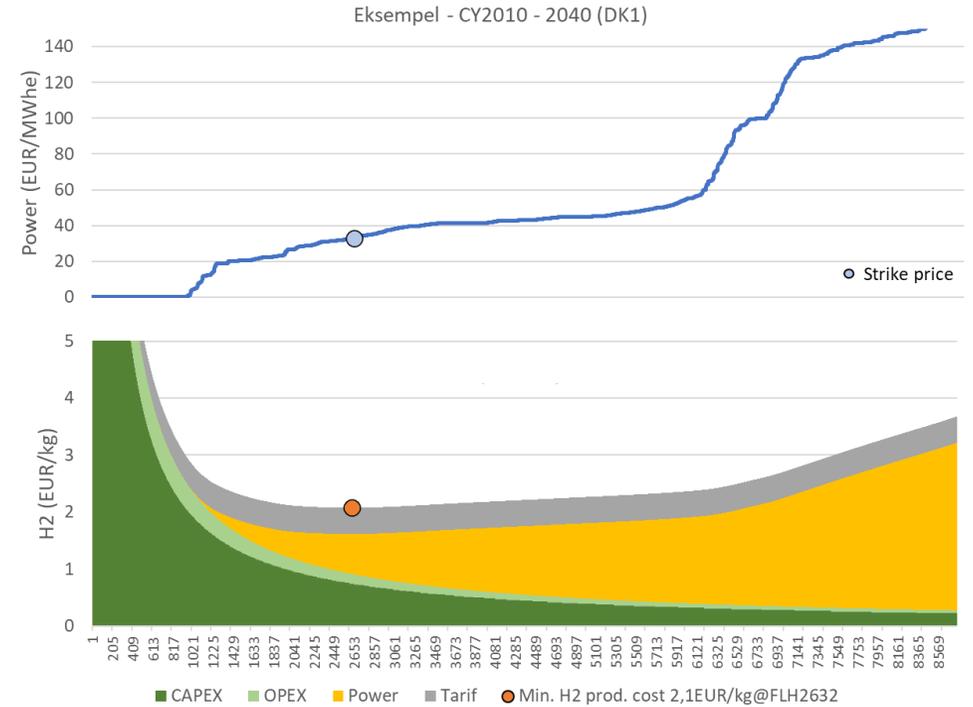
BRINTINFRASTRUKTUR ENABLER FLEKSIBILITET

Mere VE i kontakten hos Fru Jensen og billigere brint og PtX brændsler

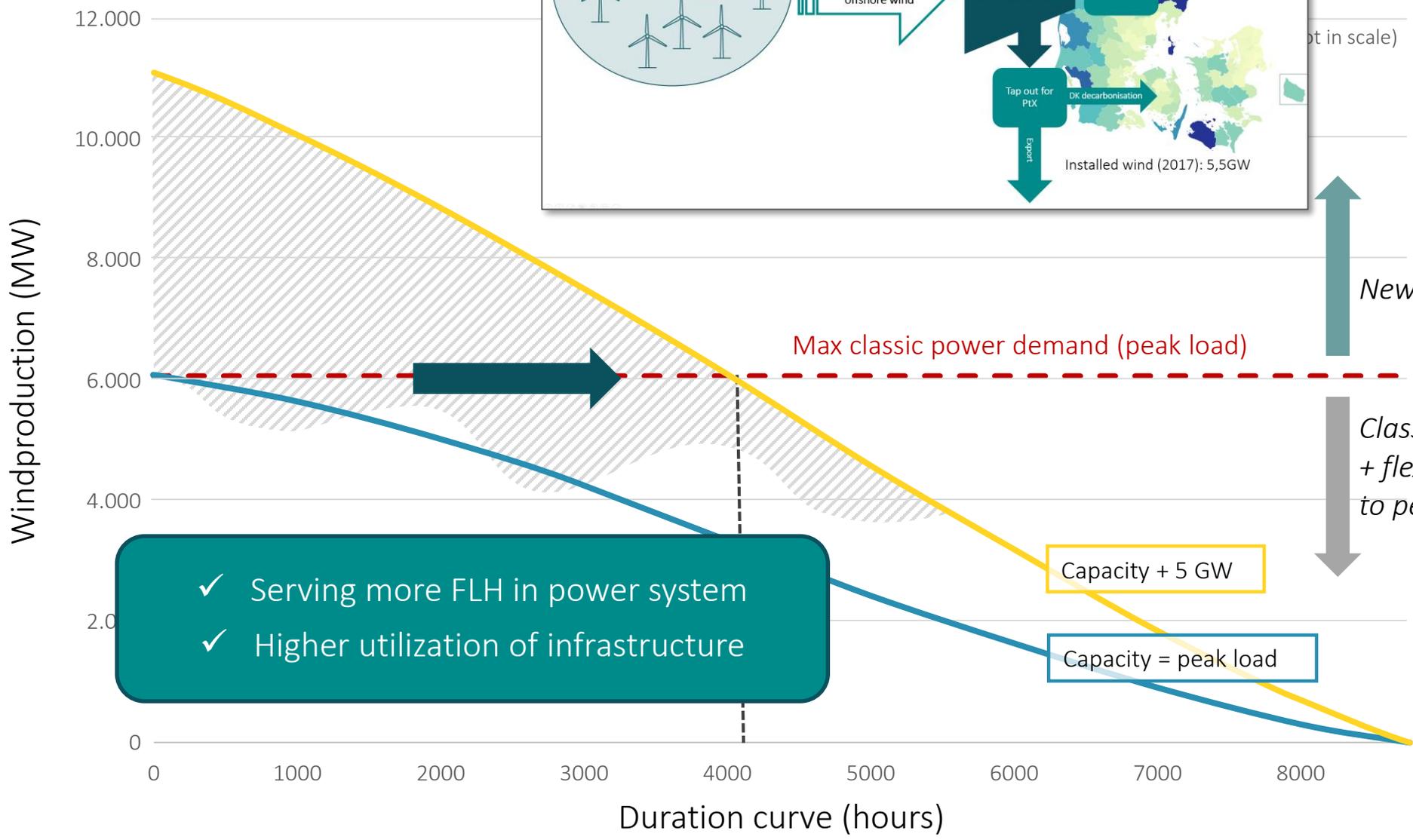
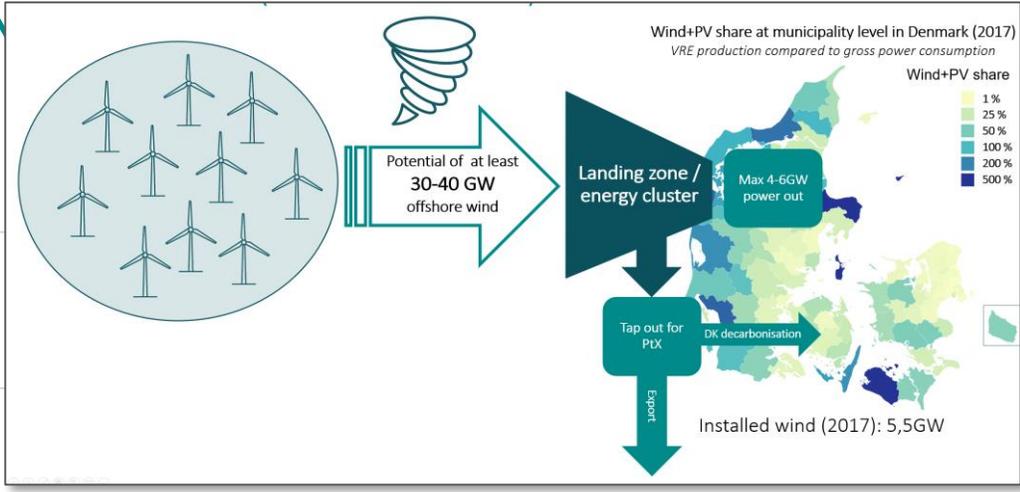
(Samt høj forsyningsikkerhed: effektilstrækkelighed og systemydelser)



Optimer adfærd for samlet anlæg i elmarked (HØJ CAPEX => høj FLH)

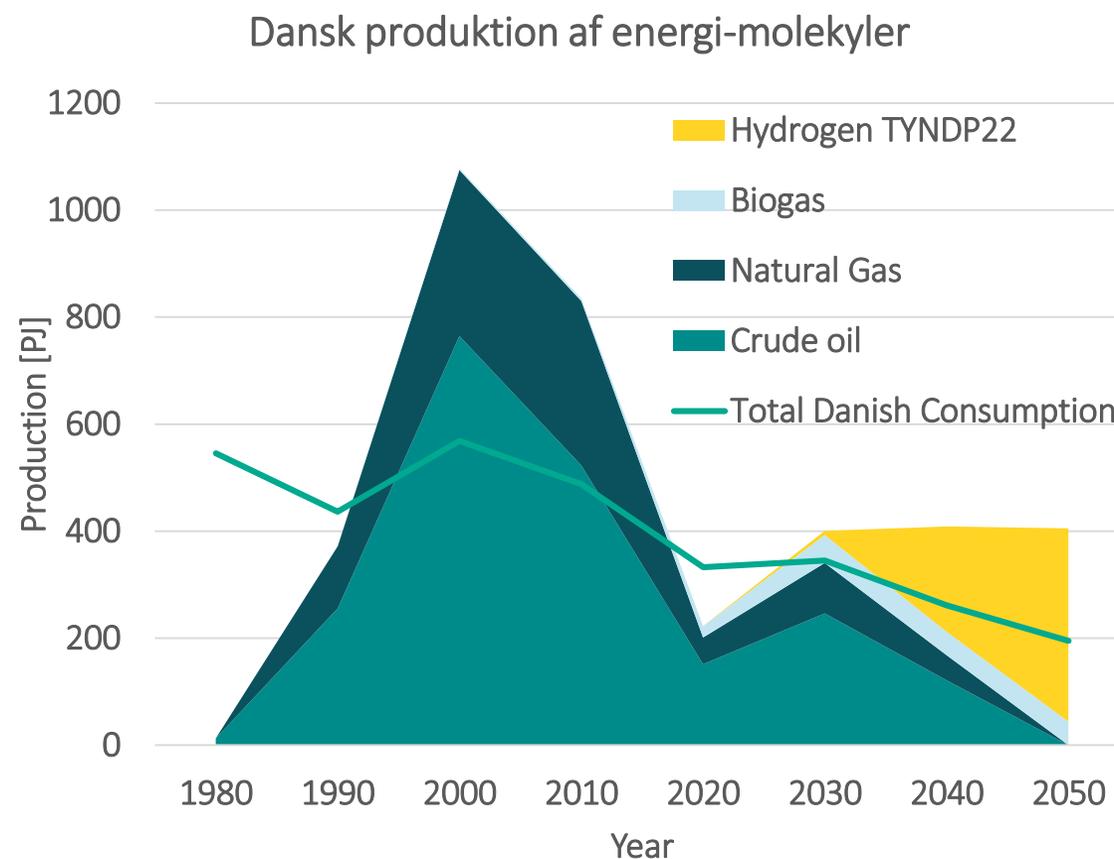
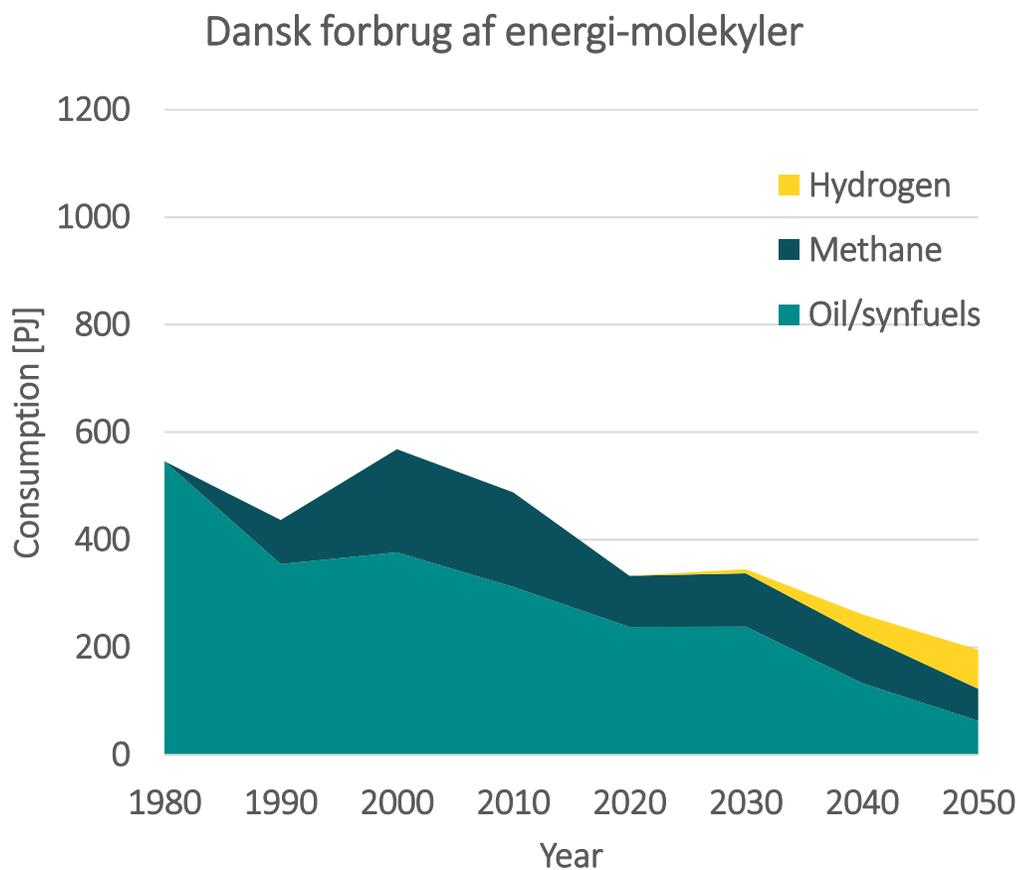


SYSTEM INTEGRATION



- ✓ Serving more FLH in power system
- ✓ Higher utilization of infrastructure

DK SOM EKSPORTØR AF ENERGI-MOLEKYLER*



SOCIO-ECONOMIC ANALYSIS

CBA following the ENTSO-e's methodology and Danish guidelines – General principles

