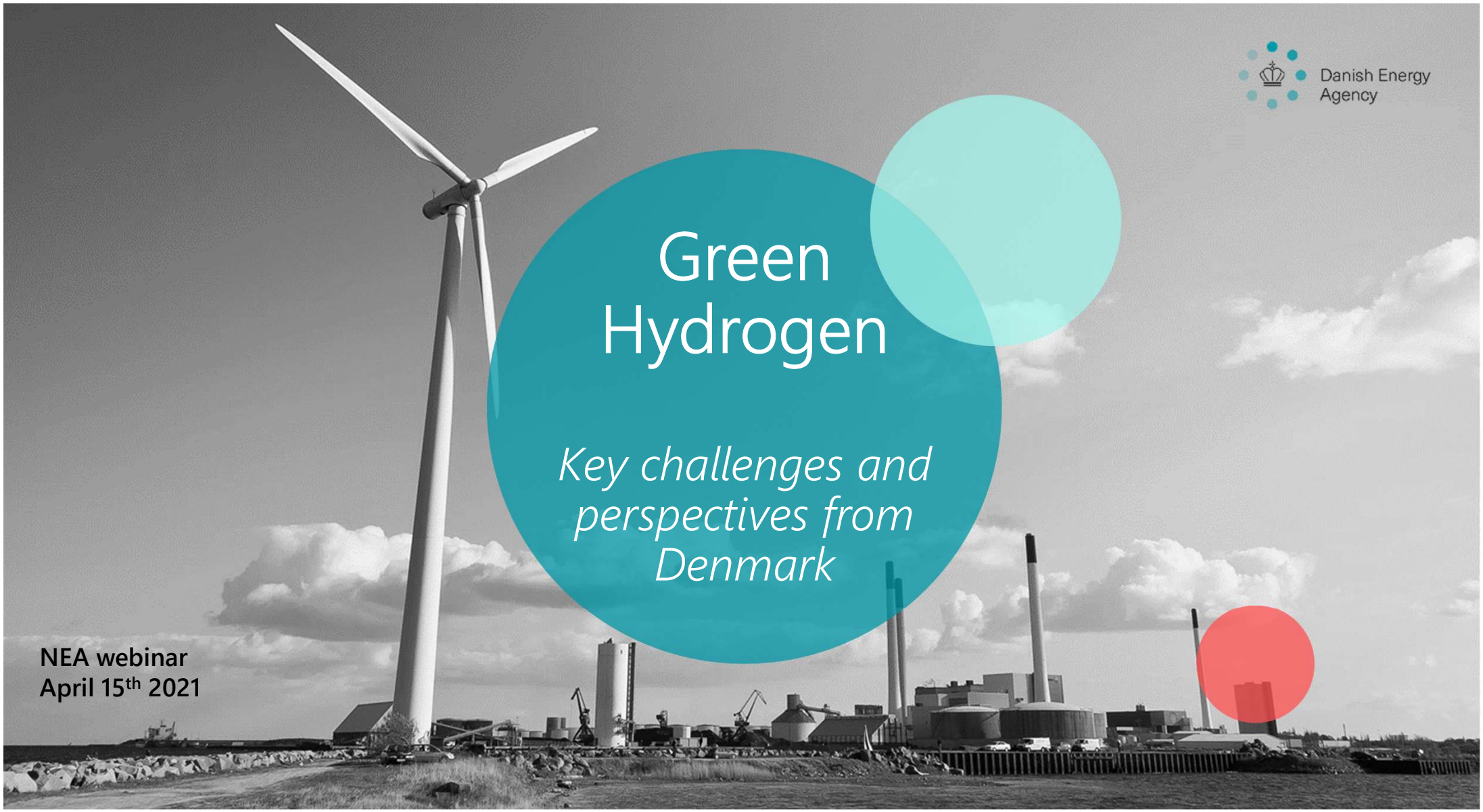
Danish Energy Agency
Green Hydrogen
Key challenges and perspectives from Denmark
NEA webinar
April 15th 2021

Introduction to speaker

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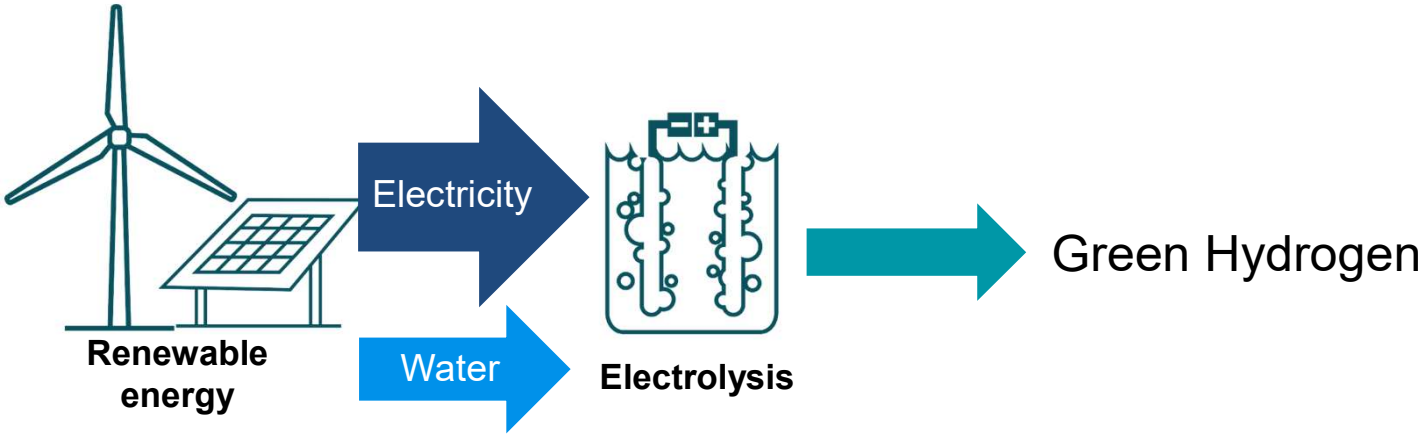
/gregersnslarsen/

Topics and messages

PTX in Denmark, lessons being learned and the role of PTX in the future

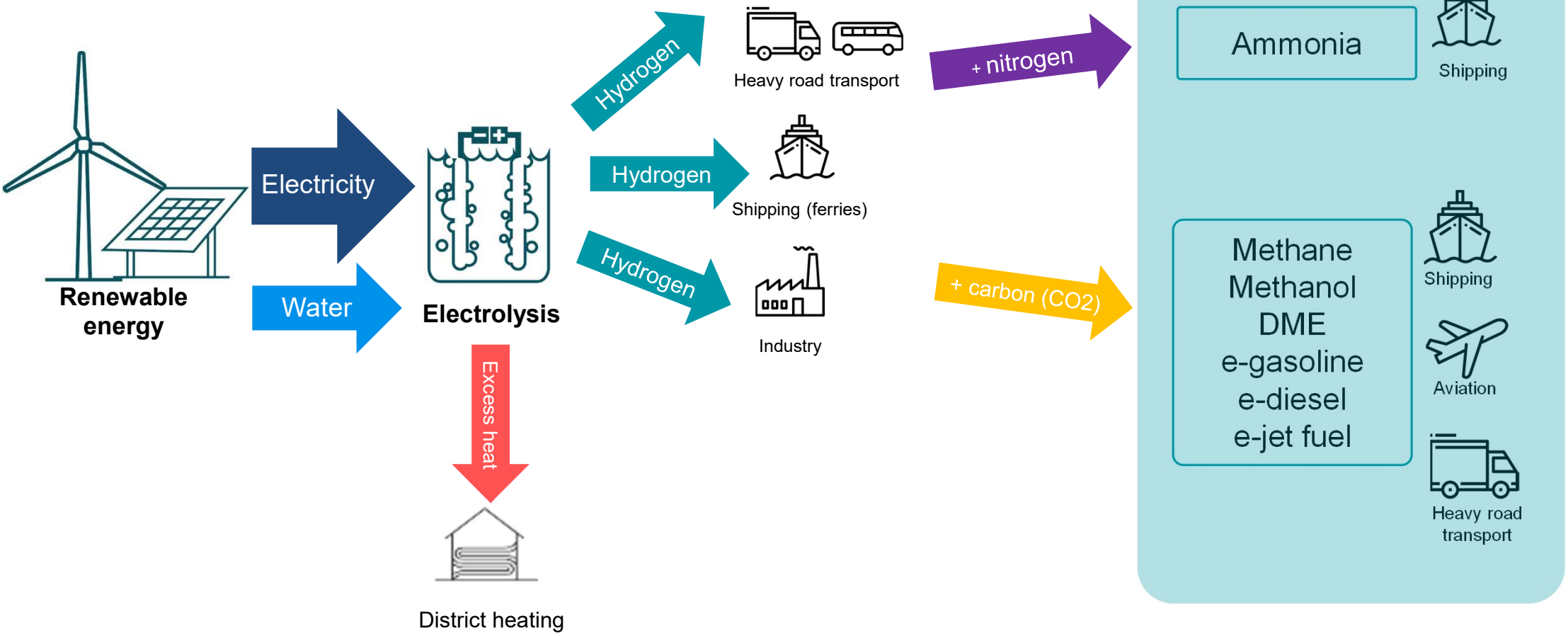
- PTX is not the primary technology, but necessary in the long run
- Useful for the "high-hanging-fruit" sectors
- DK has just started its process
- DK will use mix of PTX technologies
- There may be technical limitations in future for PTX utilization

Green Hydrogen - Basics



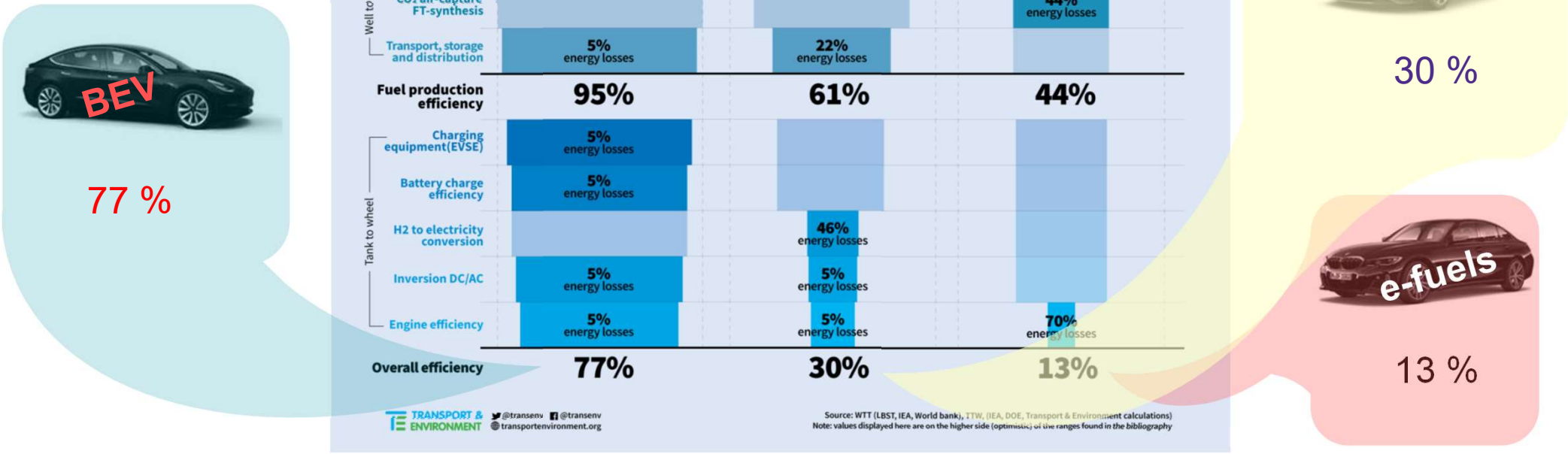
Upgraded Green Hydrogen

where electrification is not possible



Direct electrification is most efficient

Electron-to-wheel efficiencies for zero emission cars



Source: "Roadmap to decarbonising European cars", Transport & Environment, 2018

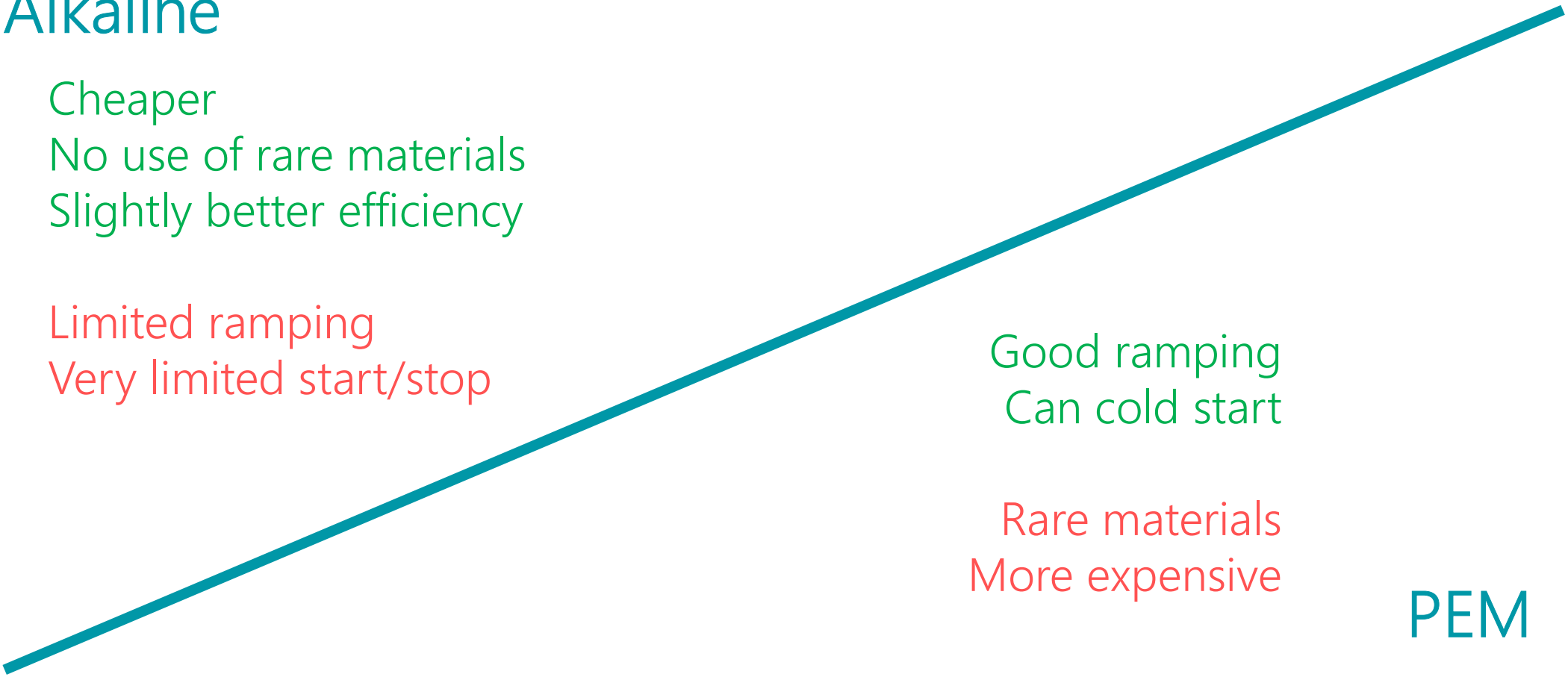

GREEN
HYDROGEN
TECHNOLOGIES
IN PLAY

Electrolysers - Alkaline vs. PEM

Alkaline

Cheaper
No use of rare materials
Slightly better efficiency

Limited ramping
Very limited start/stop



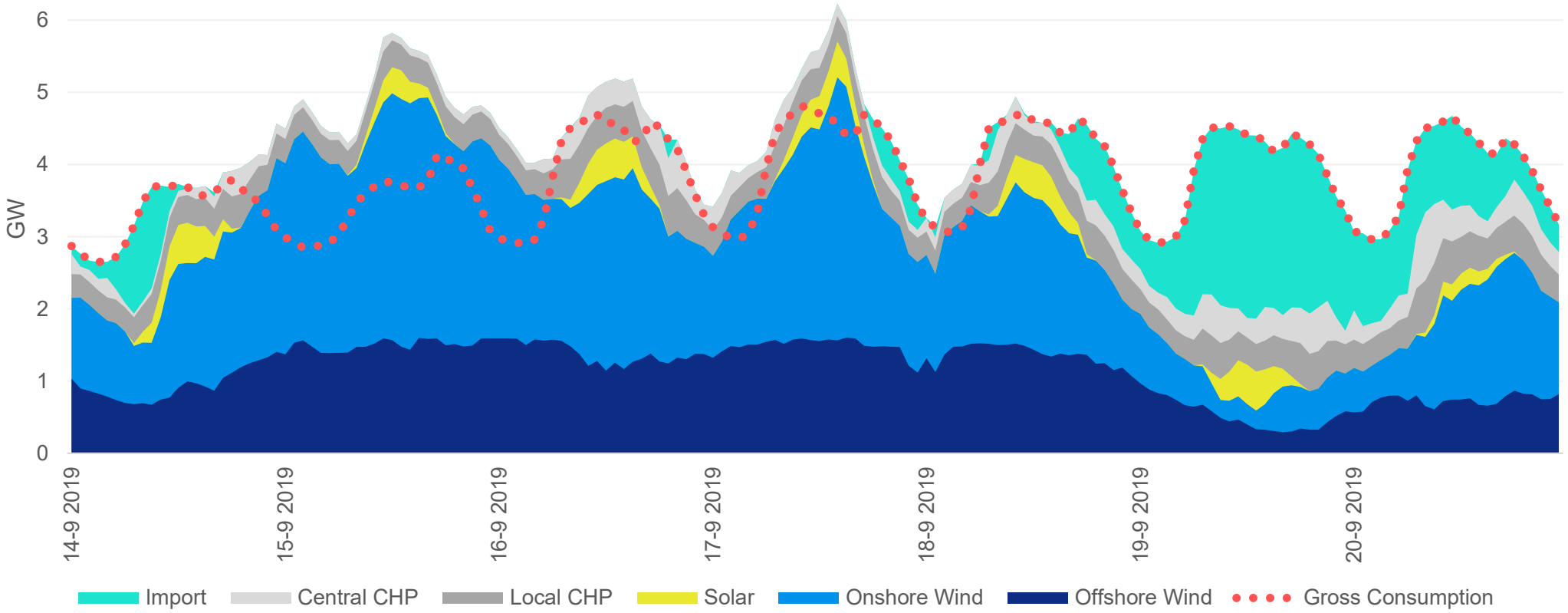
Good ramping
Can cold start

Rare materials
More expensive

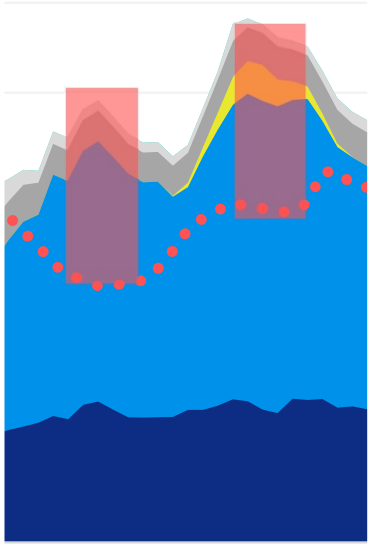
PEM

Electrolyser - Alkaline vs. PEM

VRE both baseload and flex



VRE both baseload and flex



More VRE is to make this the default, not a rare occurrence

Stable overproduction compared to general demand

Higher VRE production peaks


PLANS AND
PROJECTS IN
DENMARK

Substantial industrial interest in hydrogen and power-to-x

CIP and partners

- Vision of 1 GW electrolysis
- 900,000 tons of ammonia

Industrial consortium announced May 25th 2020

- Ørsted, A.P. Møller - Mærsk, DSV Panalpina, DFDS, SAS, Copenhagen Airport
    - vision of 1.3 GW electrolysis plants for production of green fuels

Maersk Mc-Kinney Møller Center for Zero Carbon Shipping

- Linked to Maersk's ambition on the first CO2-free ocean-going vessel no later than 2030
- 133 mill. € over the next 10 years


ENERGYWATCH

Oil & Gas Renewables Cleantech Policy & Trading

CIP to build Europe's largest PtX plant in Denmark

Heavyweights within shipping and agriculture are prepared to handle the producti up to 900,000 tonnes of green ammonia per year at facility potentially ready in five years. The approximately EUR 1bn investment will be made through a new fund.


rsted consortium unveils 1.3GW offshore wind to green hydrogen project

lanned facility will use the clean H2 to produce more than 250,000 onnes of sustainable fuel for buses, trucks, ships and airplanes annually

Source: rechargenews.com/

Examples of ongoing RD&D projects

Substantial industrial interest in hydrogen and power-to-x

Greenlab Skive

- Hydrogen, methanol and storage
- 12 MW electrolysis +1.6 MWh battery

Everfuel and Shell

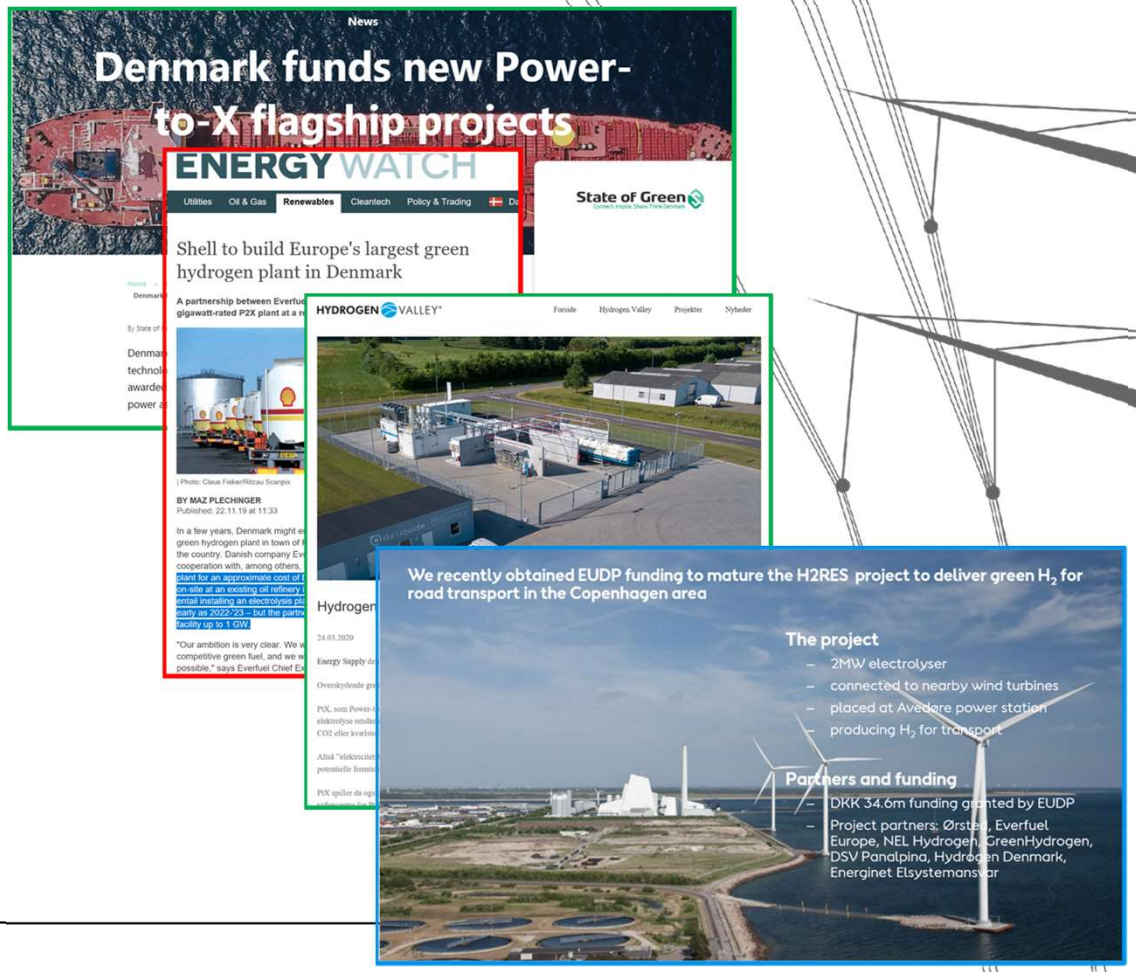
- Hydrogen
- 20 MW -> 1 GW PEM for use in refining

Hydrogen Valley and Air Liquide

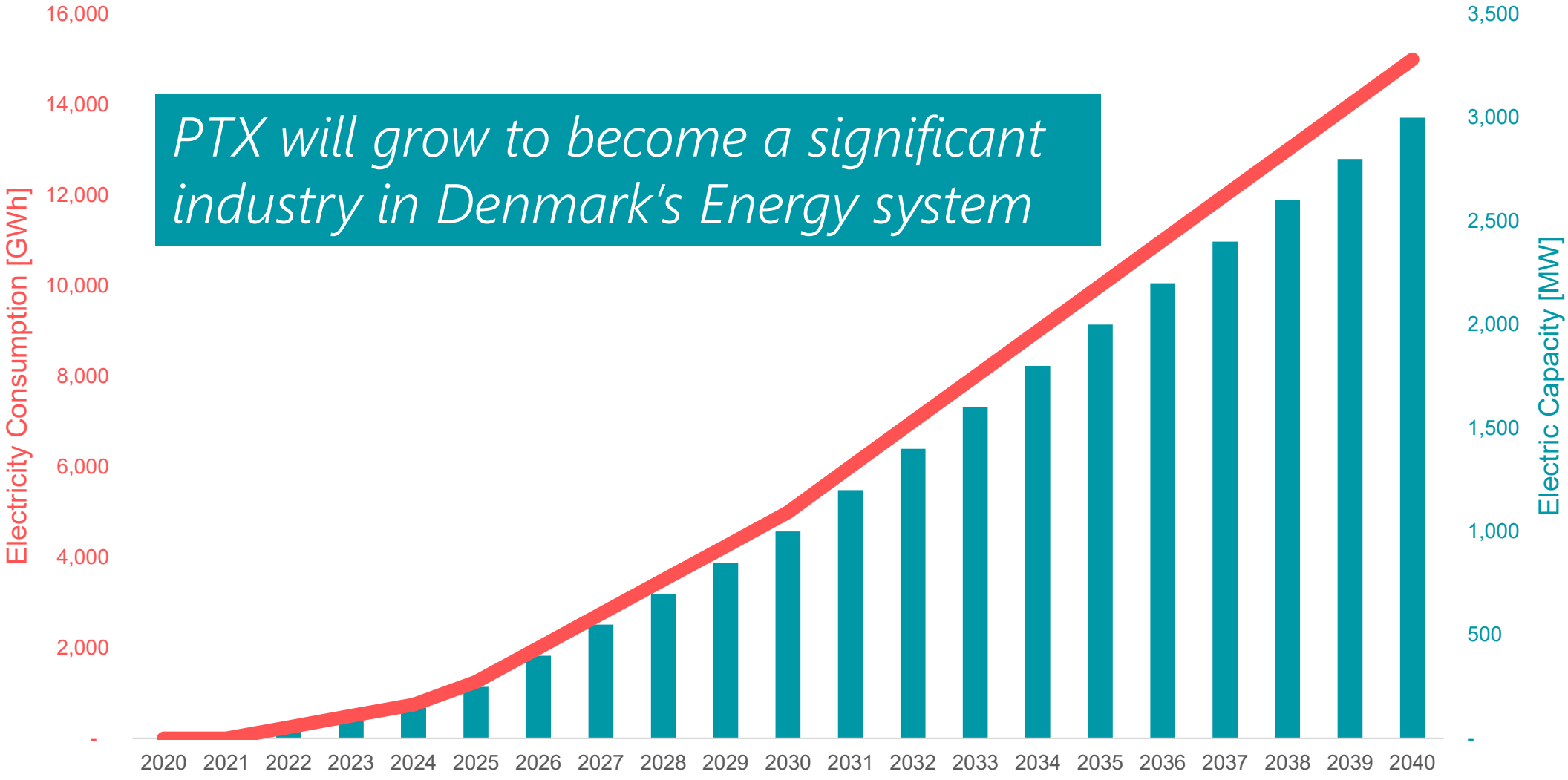
- Hydrogen
- 1 MW PEM for transportation

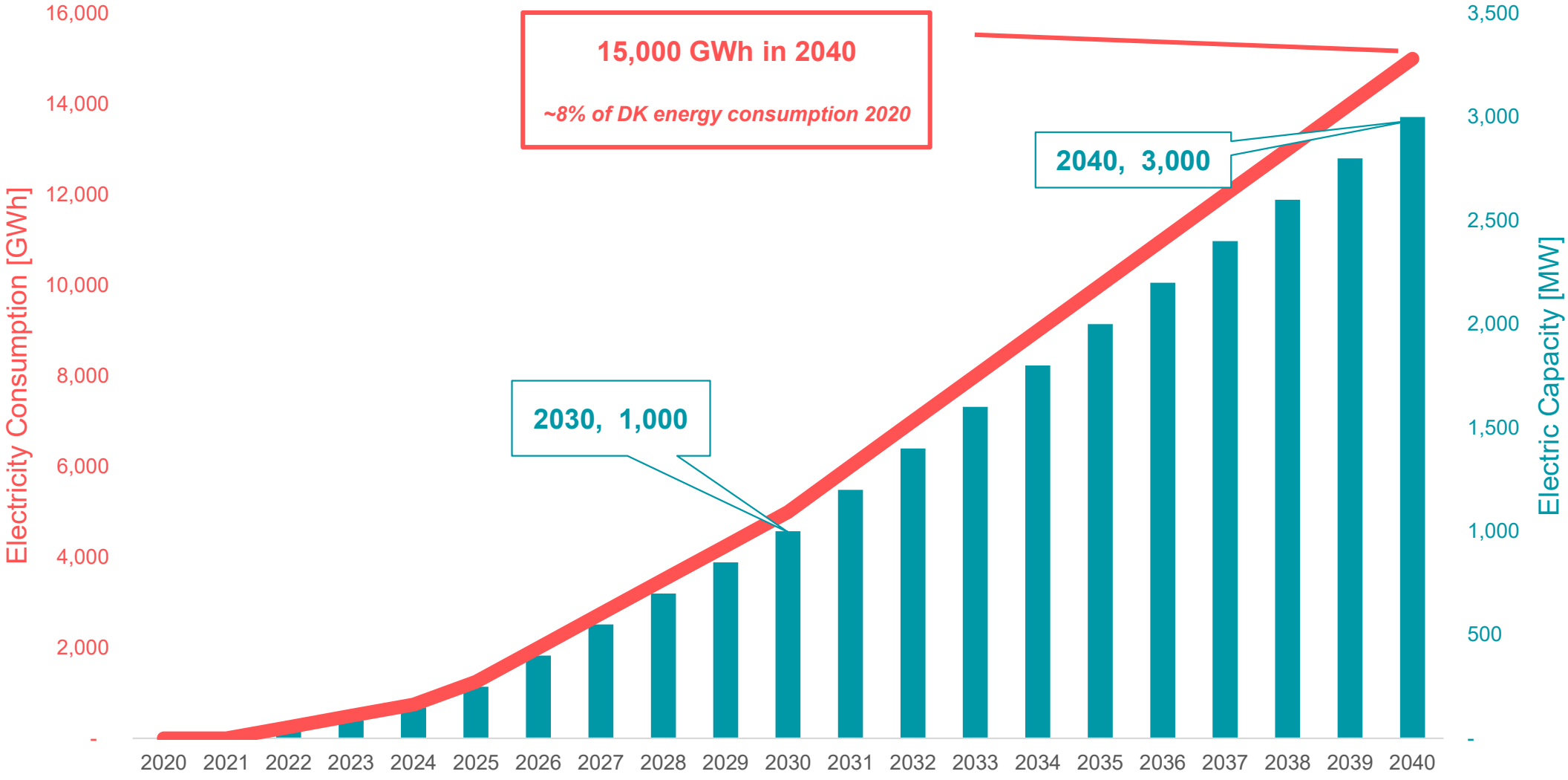
Ørsted and partners (H2RES)

- 2 MW electrolyses
- For transportation



PTX will grow to become a significant industry in Denmark's Energy system



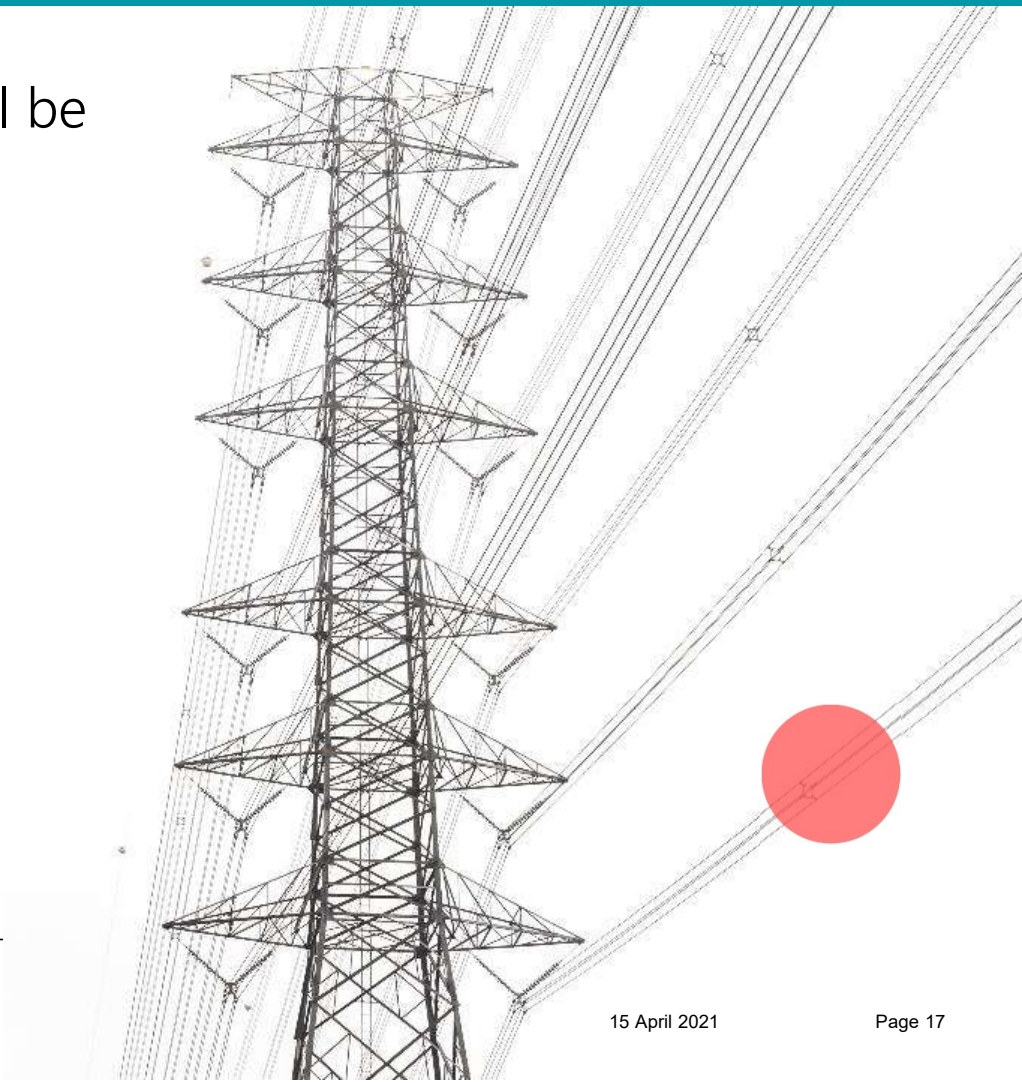


Danish Energy Agency

Topics and messages

PTX in Denmark, lessons being learned and the role of PTX in the future

- Heavy transport, shipping and aviation will be major consumers of PTX
- Projections to have PTX as major part of Denmark's energy system
- PTX less efficient and costlier than direct electrification – high hanging fruits
- The relevant industries, with support from government, are already working on PTX

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Thank You