



Power-to-X in Denmark

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Agenda

- Introduction
- Power-to-X drivers
- The Danish strategy for Power-to-X
- Key messages from the Danish Power-to-X analyses
- Status on Power-to-X in Denmark



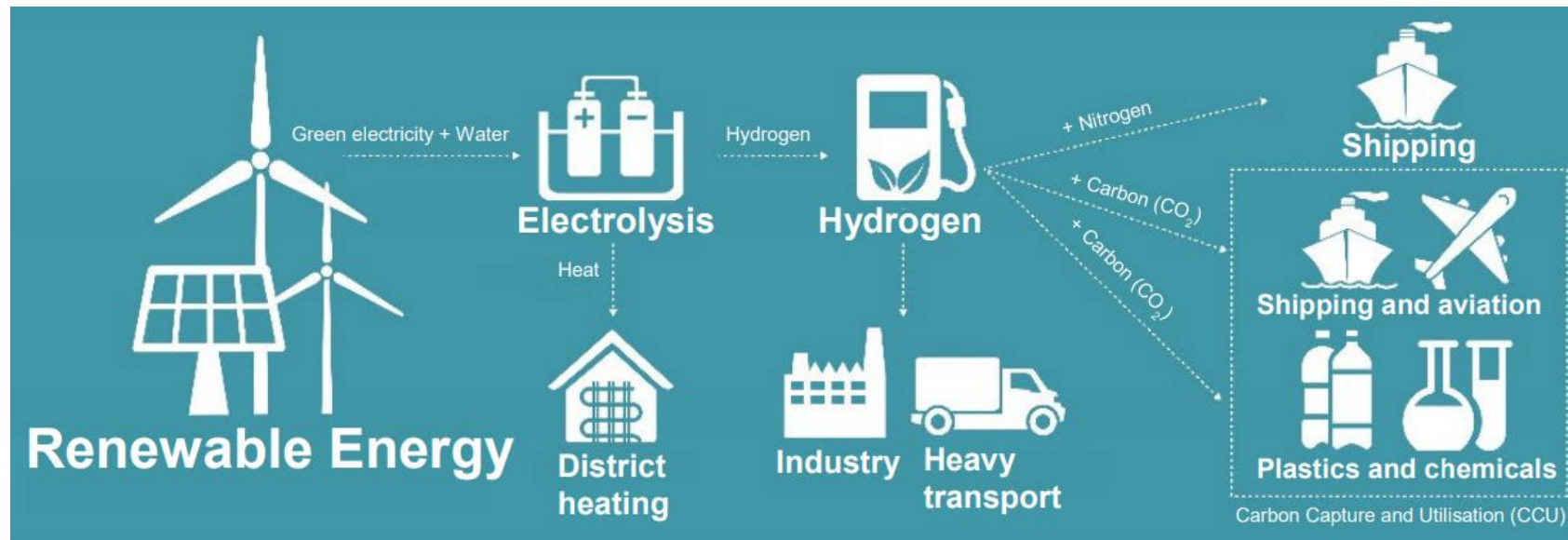
Introduction



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What do we mean by Power-to-X (PtX)?

"Green electrons as input and green molecules as output"

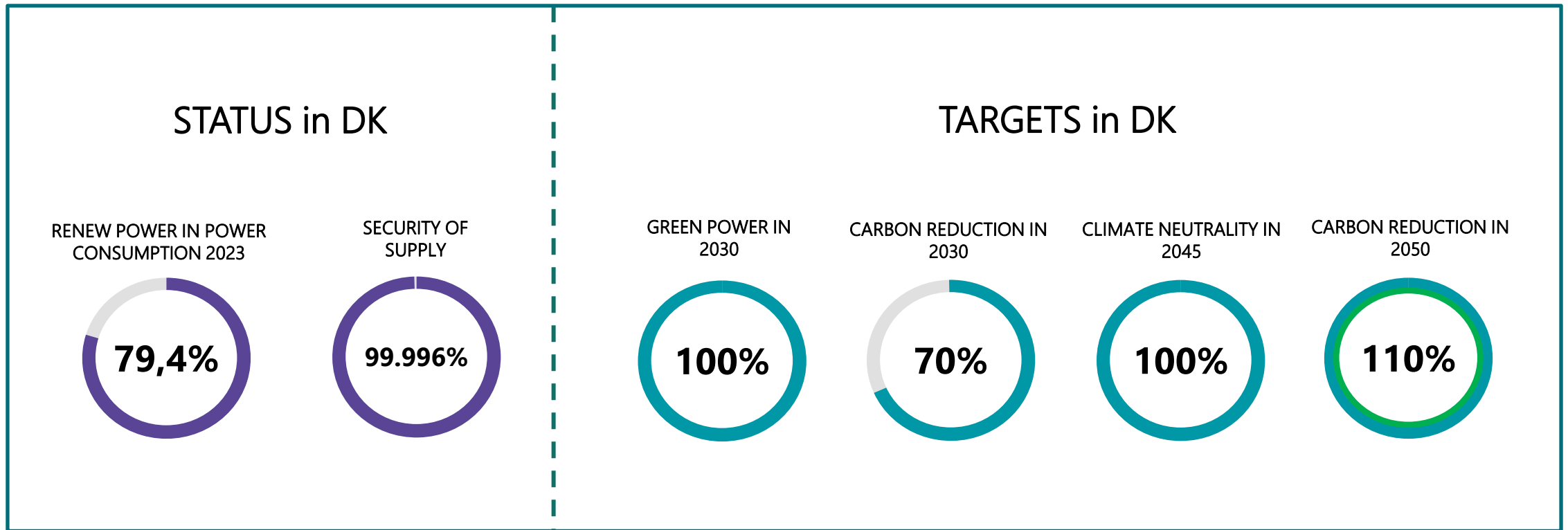


Product examples: Hydrogen (H₂), Ammonia (NH₃), Methanol (CH₃OH), Methane (CH₄) and Kerosene (C₁₂H₂₆–C₁₅H₃₂)

Drivers for Power-To-X in Denmark



Large share of RE and An Ambitious Climate policy

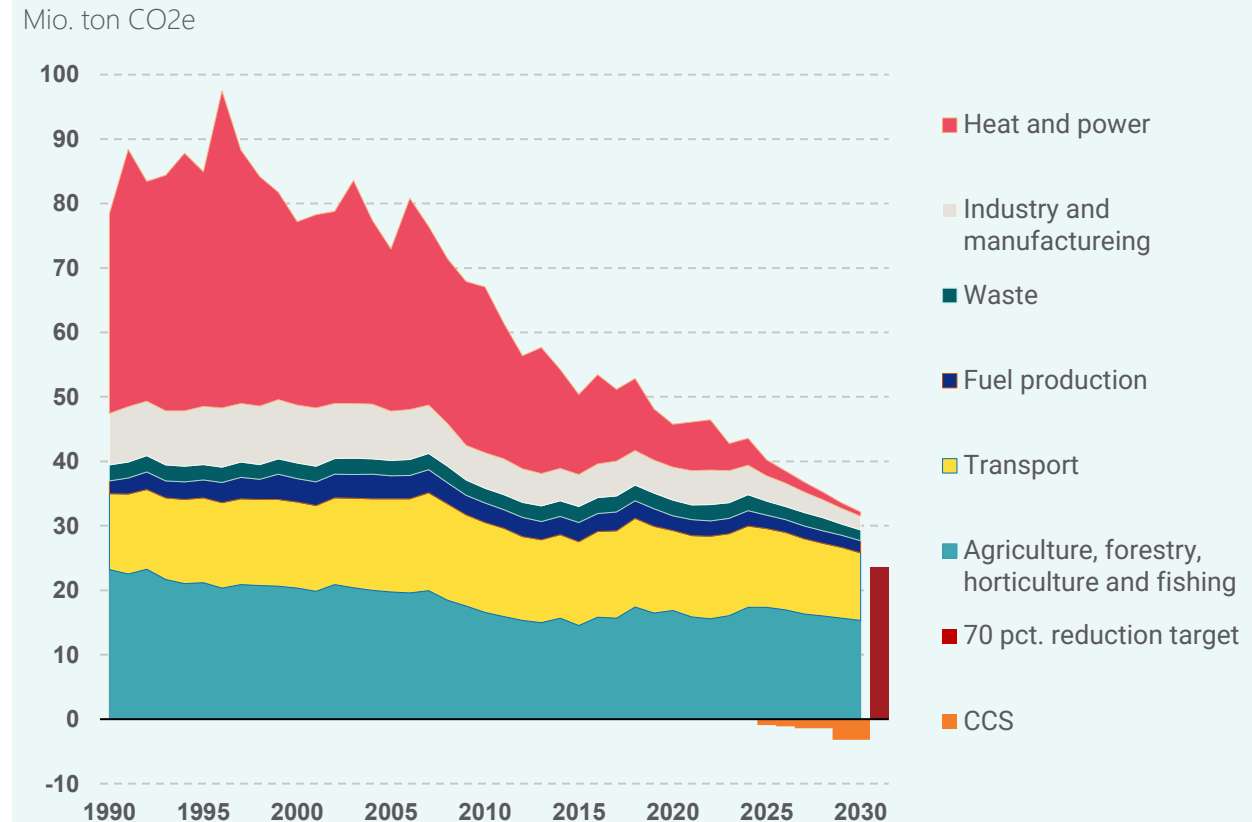


Emissions are declining

- But not in every sector

- The green transition is on its way in **energy and utility sector** and the **industry**
 - Further reductions in these sector are limited and costly.
- Fulfilling targets in 2030, 2045 & 2050 requires reductions or compensation in hard-to-abate-sectors e.g. **transport** and **agriculture**
- Direct electrification solve part of the challenge in **transport sector** and **industry**
 - However there are a need for renewable fuels in specific segments
- **Power-to-X** is expected to play a large role within Shipping, aviation, heavy transportation and some industries

Total national emissions, KF23



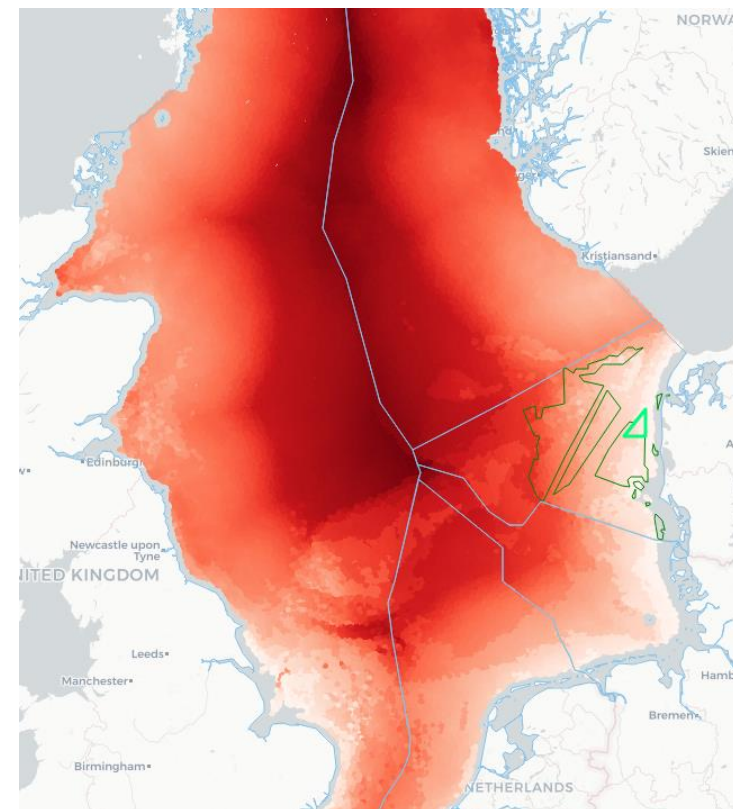
Power-to-X production potential in Denmark

Energy system in Denmark and Power-to-X

- Increasing share of the electricity consumption is based on renewable energy. In 2023 the share was 79%.
- The North Sea offers a substantial offshore wind resources with competitive electricity costs and a well developed and functioning electricity grid.
- Flexible PtX plants located near RE resources enables lower demand for grid expansions.
- Extensively developed district heating grid enables utilization of excess heat from PtX.

Know-how and partnerships:

- Know-how in all parts of the value chain
- Partnerships for PtX, aviation, shipping etc.



Levelized Cost of Electricity, DKK/MWh

210 217 224 231 237 244 251 258 265 272 278 285 292 299 306 313 319 326 333 340

The strategy for Power-to-X in Denmark



STRATEGY FOR POWER-TO-X

A new and rapidly developing agenda

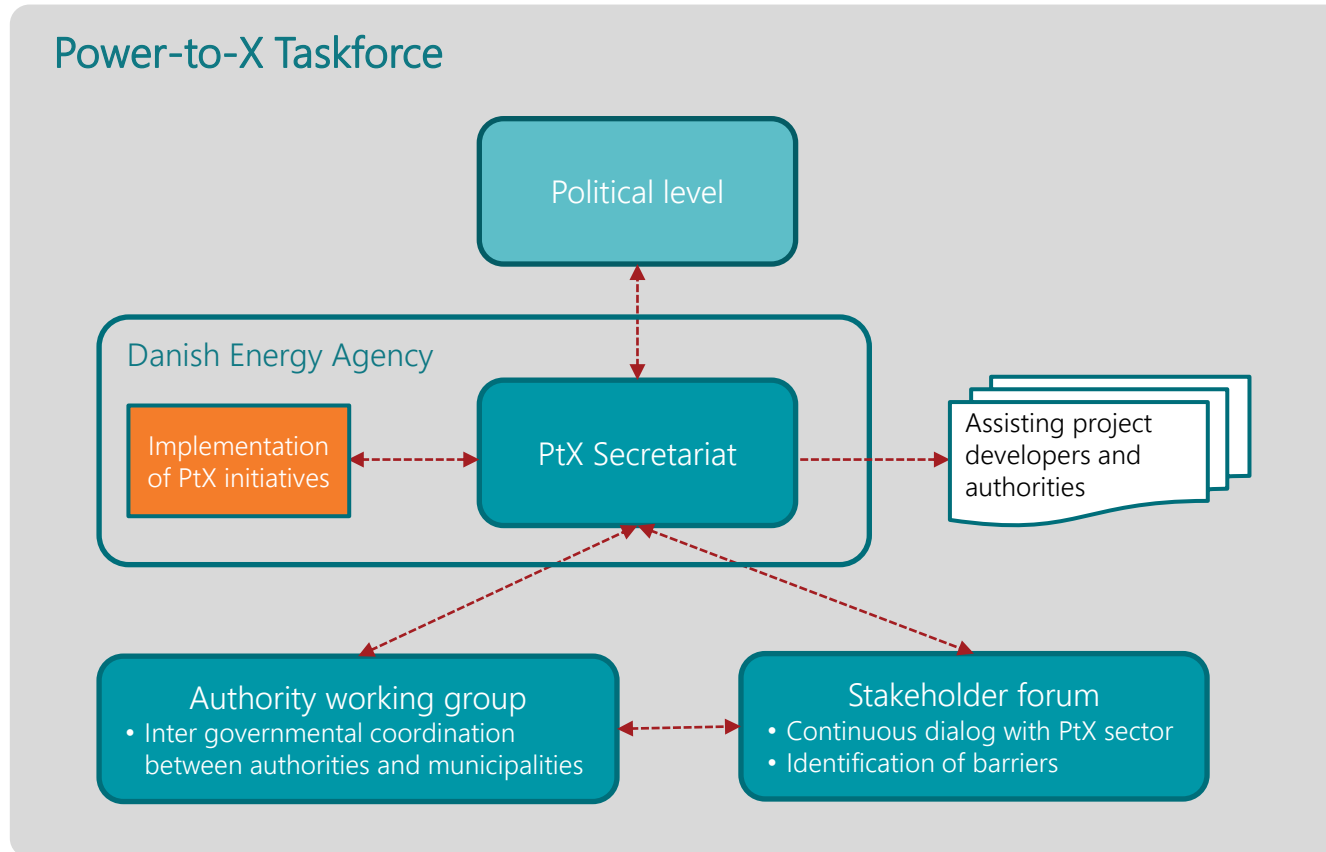
- Agreement of the Danish Parliament to prepare a Danish strategy for Power-to-X (2020).
- The Government's strategy for Power-to-X (December 2021).
- Political 'agreement to develop and promote hydrogen and green fuels' (Marts 2022).

Content of the agreement:

- Target of 4-6 GW electrolysis capacity by 2030
- One tender of 1.4 billion DKK, as a production subsidy for 10 years – to be launched in 2023
- Direct connections of RE-production and consumption
- Geographically differentiated electricity tariffs
- 57 mill. DKK in 2022-2026 for a PtX-taskforce
- First steps towards establishing a hydrogen infrastructure enabling export to Germany



ORGANIZATION OF POWER-TO-X TASKFORCE



Purpose

The PtX-Taskforce contributes to coordination between public authorities and ensures dialog between municipalities and the PtX sector.

The purpose of the PtX-Taskforce is to identify and solve regulatory barriers for developing a new utility sector in Denmark.

Moreover it is the purpose to ensure common rules for documentation of green hydrogen and develop tools that supports optimal socioeconomic location of PtX-plants.

Part of the PtX-Taskforce is a PtX Secretariat, which will be point of contact and support project developers and authorities with guidelines regarding permit procedures etc.

Key messages from the Danish Power-to-X analyses



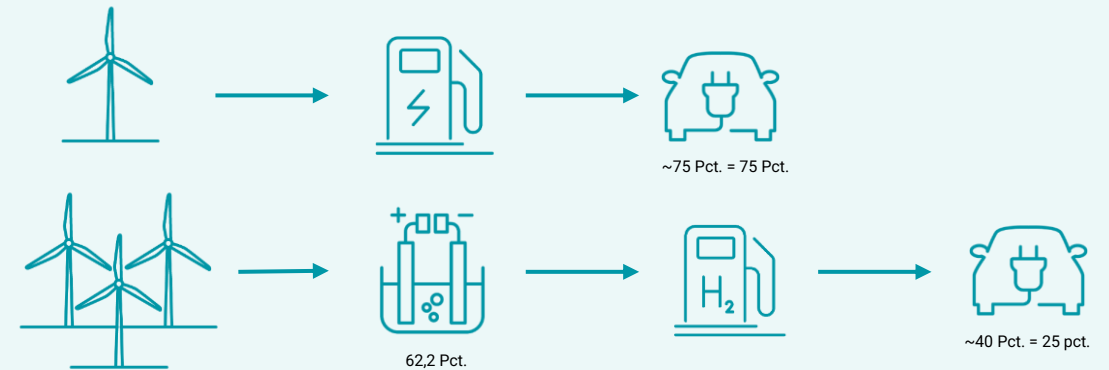
POWER-TO-X VS. DIRECT ELECTRIFICATION?

Examples of energy efficiency through electrification

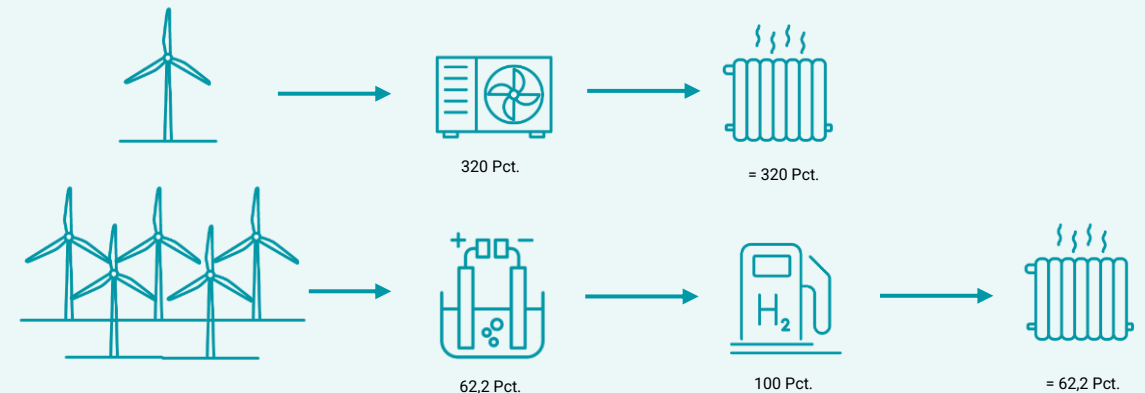
- Energy demand for electrification and Power-to-X
 - A hydrogen powered vehicle requires three times the energy compared to an electrical vehicle
 - A hydrogen boiler for space heating requires approx. five times the energy compared to a heat pump
- More efficient Power-to-X technologies are being developed, but direct electrification is often the best option and should be prioritized wherever it is possible
- Too early utilization of Power-to-X can delay green transition and GHG-reductions

Energy demand for direct electrification and Power-to-X

Electrical vehicle vs hydrogen powered vehicle

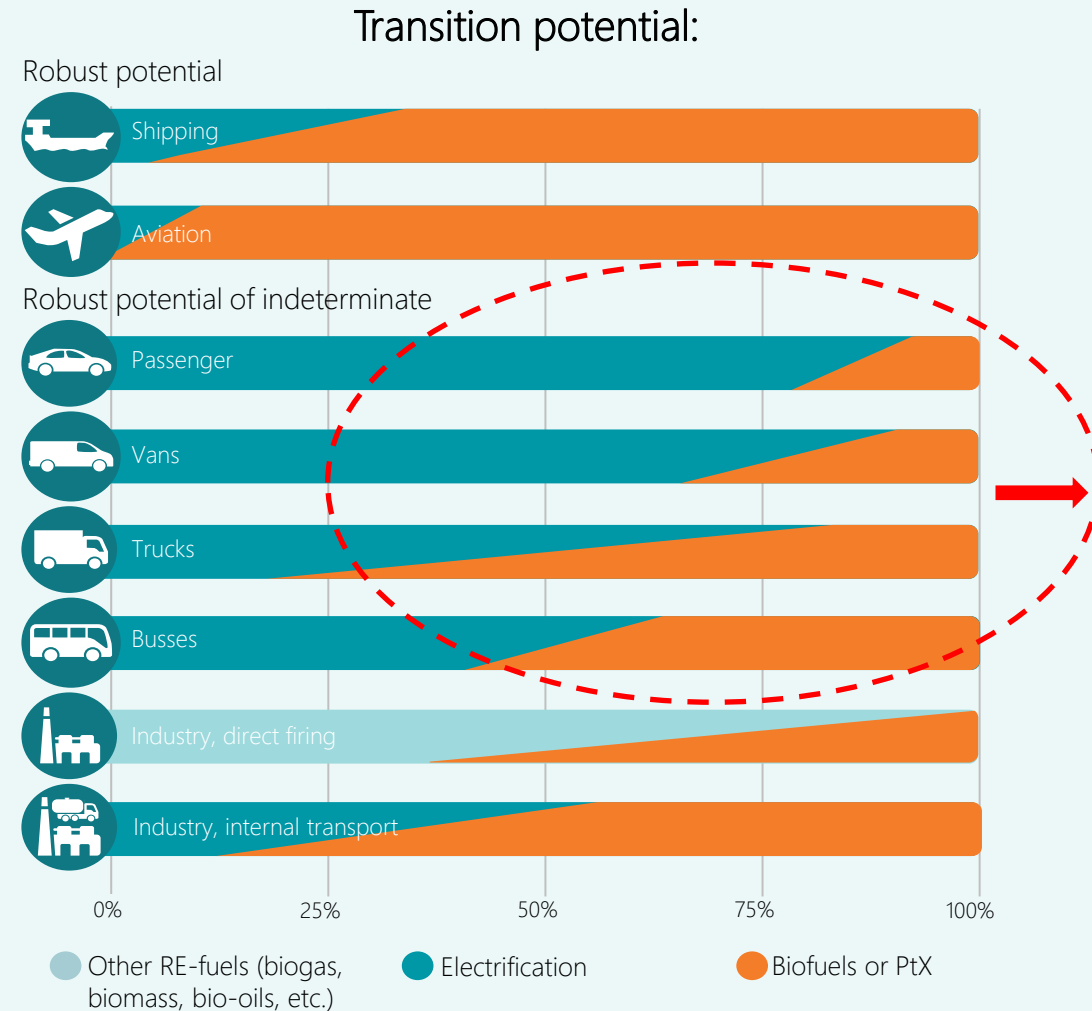


Space heating: Heat pumps vs hydrogen boilers



Utilization of PtX in Denmark

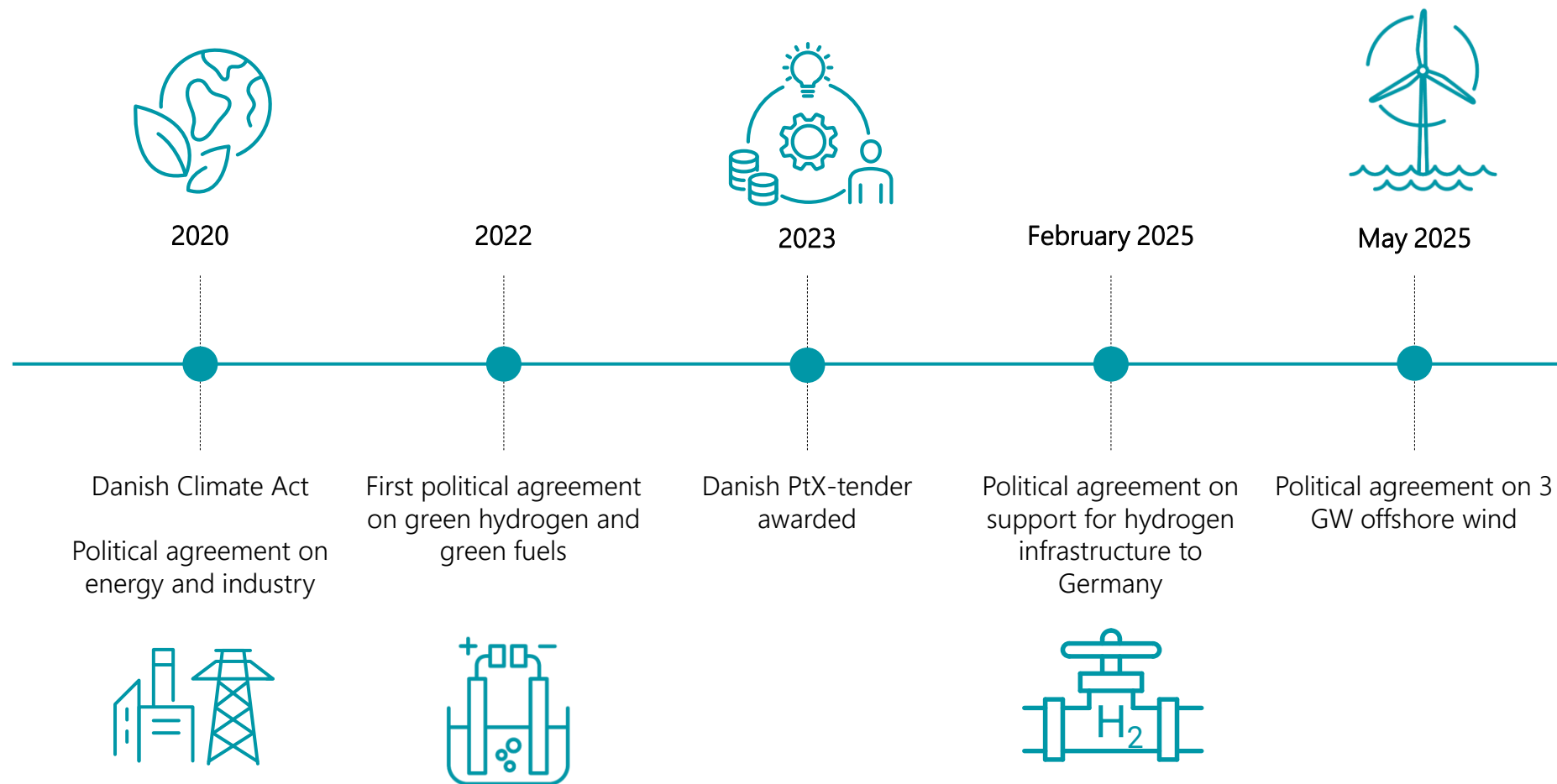
- Power-to-X will remain more expensive than direct electrification where that is applicable.
- Green hydrogen and e-fuels are expected to become cheaper than advanced biofuels (medium-long term).
- Fairly certain of dominant position within shipping and aviation.
- More uncertain in other parts of land based transportation, industry, agriculture and defense.
- No role in heating or electricity generation in Denmark as cheaper options exist:
 - Heat pumps and district heating for space heating
 - Biogas for peak electricity production



Status on Power-to-X in Denmark



The (political) PtX journey in Denmark



Hydrogen infrastructure to Germany

Focus on "The Seven"

- *State loan and operational support ~1.5 billion*
- *Booking requirement on 0,5 GW hydrogen*
- *First transport of hydrogen in the end of 2030*

Full Danish Hydrogen Backbone is still the ambition

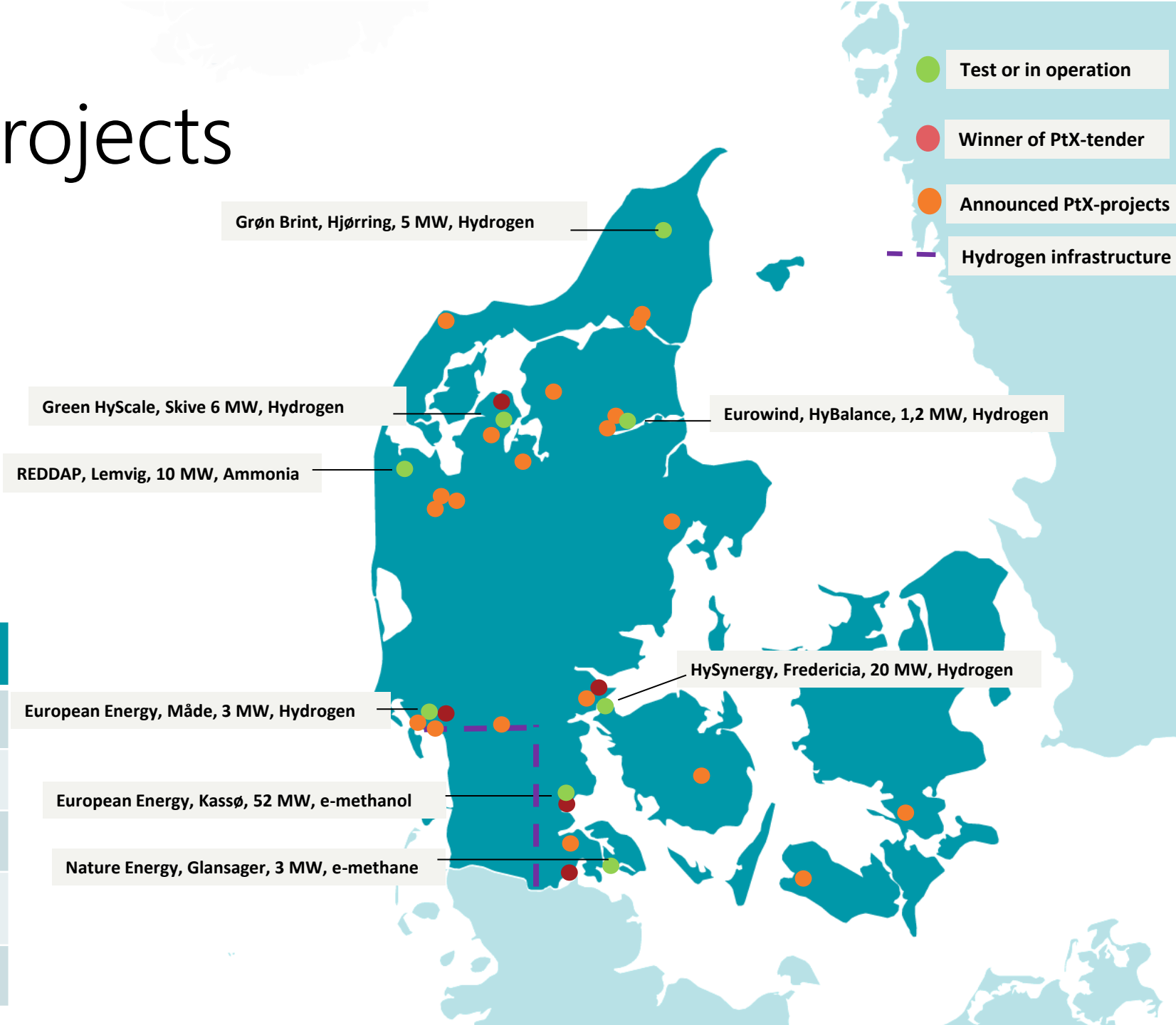
- *Requires new political agreements*



Status on PtX-projects

- Approx. 100 MW electrolysis established
- Further 209 MW from PtX-tender (table below)
- Announced projects corresponding to approximately 9.5 GW electrolysis capacity

Company / Project	Location	Capacity [MW]	Expected product
European Energy / Vindtestcenter Måde K/S	Esbjerg	9	Hydrogen
European Energy / Padborg PtX ApS	Padborg	150	Methanol/ e-SAF
Electrochaea / Biocat Roslev	Rybjerg	10	E-methane
European Energy / Kassø PtX Expansion ApS	Røddekro	10	E-Methanol
HyproDenmark / Everfuel	Fredericia	30	Hydrogen



Thank you for today



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