



# Power-to-X in Denmark

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16. april 2024



Energistyrelsen

# 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

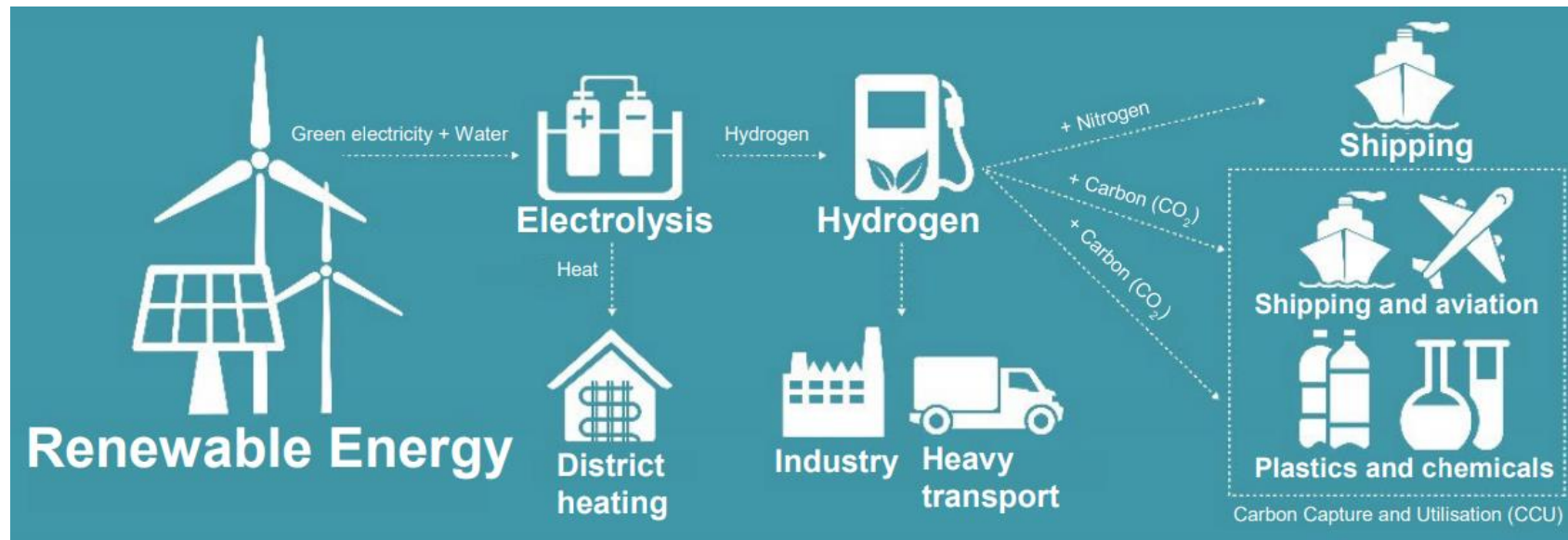


# Introduction



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

*"Green electrons as input and green molecules as output"*



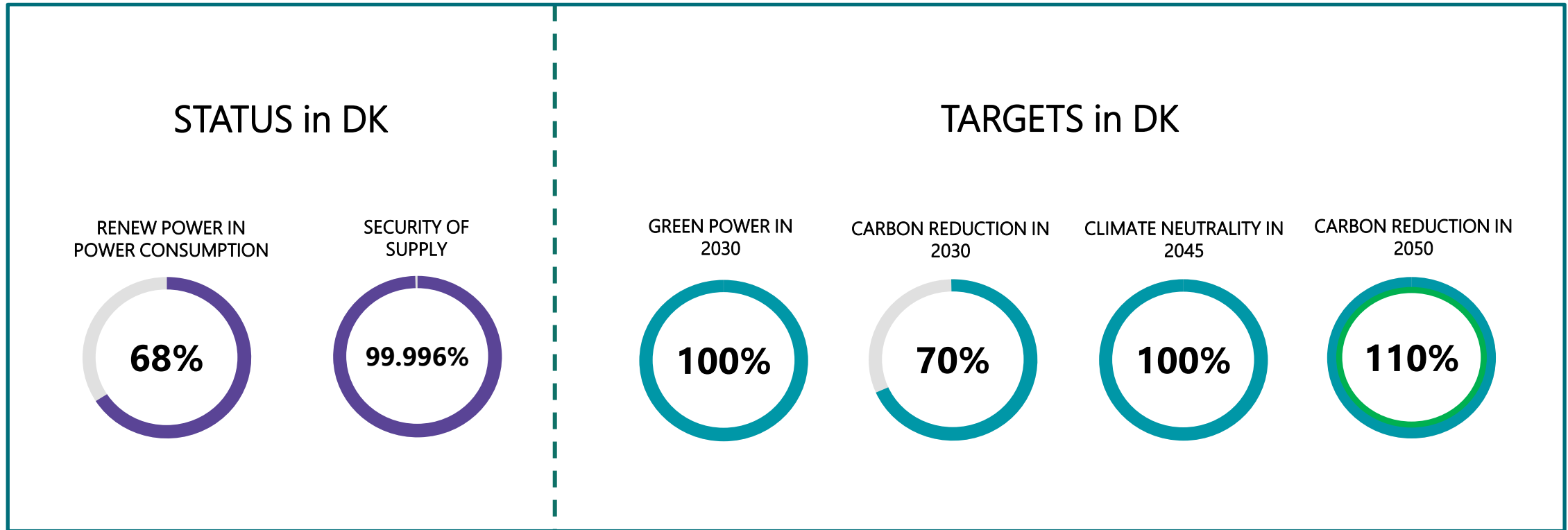
Product examples: Hydrogen (H<sub>2</sub>), Ammonia (NH<sub>3</sub>), Methanol (CH<sub>3</sub>OH), Methane (CH<sub>4</sub>) and Kerosene (C<sub>12</sub>H<sub>26</sub>-C<sub>15</sub>H<sub>32</sub>)



# Drivers for Power-To-X in Denmark



# Large share of RE and An Ambitious Climate policy

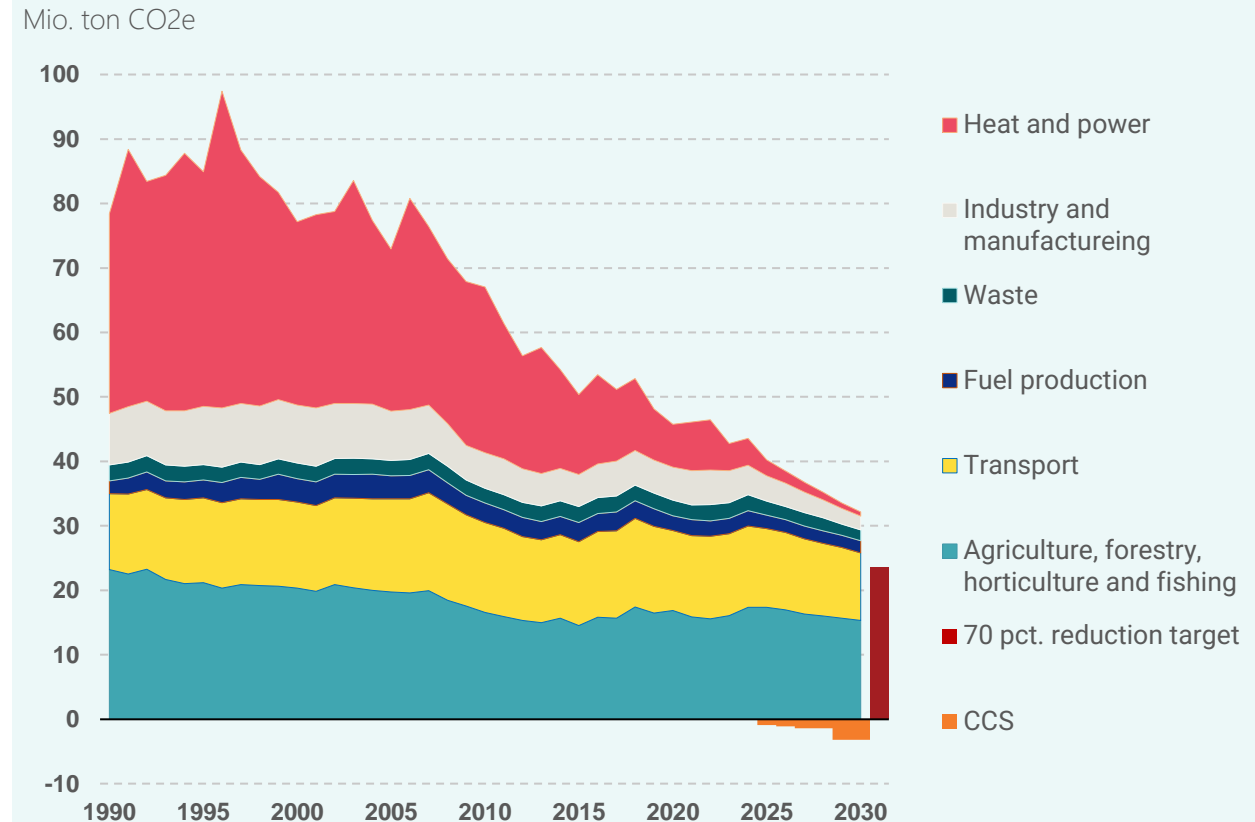


# Emissions are declining

- *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



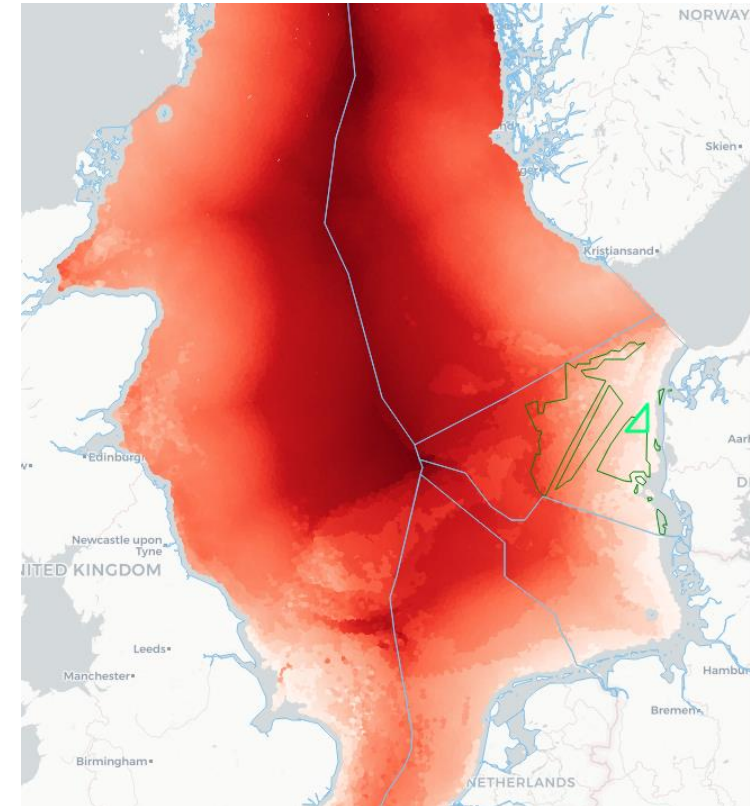
# Power-to-X production potential in Denmark

## Energy system in Denmark and Power-to-X

- Increasing share of the electricity consumption is based on renewable energy. In 2020 the share was 68%.
- 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*

- The Climate Agreement for Energy and Industry 2020:
  - Agreement of the Danish Parliament to prepare a Danish strategy for Power-to-X (PtX) and Carbon Capture and Utilization (CCU).
- The Government's strategy for Power-to-X – December 2021.
- Based on more than 20 analyses totalling more than 500 pages.
- Simultaneously the PtX agenda has accelerated.
- More than 35 Power-to-X projects has been announced in Denmark totalling more than 9 GW combined



# Objectives in the strategy for PtX

*The strategy presents four objectives for the development and utilization of Power-to-X in Denmark*

The objectives sets out the guiding principles for the use of PtX-technology, hydrogen and fuels in Denmark:

1. PtX is to be used in the green transition, where it is the cheapest and most sustainable option.
2. Framework and infrastructure must enable the development of PtX to a point where it is competitive with biofuels and PtX suppliers from abroad on market terms.
3. PtX-production has to happen in a way where it creates value for the Danish energy system.
4. The reason for promoting production of hydrogen and PtX-fuels in Denmark is to support industry and export markets.



# Agreement on hydrogen and PtX

*Adoption of the strategy by Parliament*

## 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

## Green reform (June 2022):

- Renewable energy package (done)
  - Ensuring sufficient green electricity and zoning for RE and PtX
- CO<sub>2</sub> tax on industry and domestic transportation
  - Support schemes for transition in industry and transportation

## Upcoming national proposals

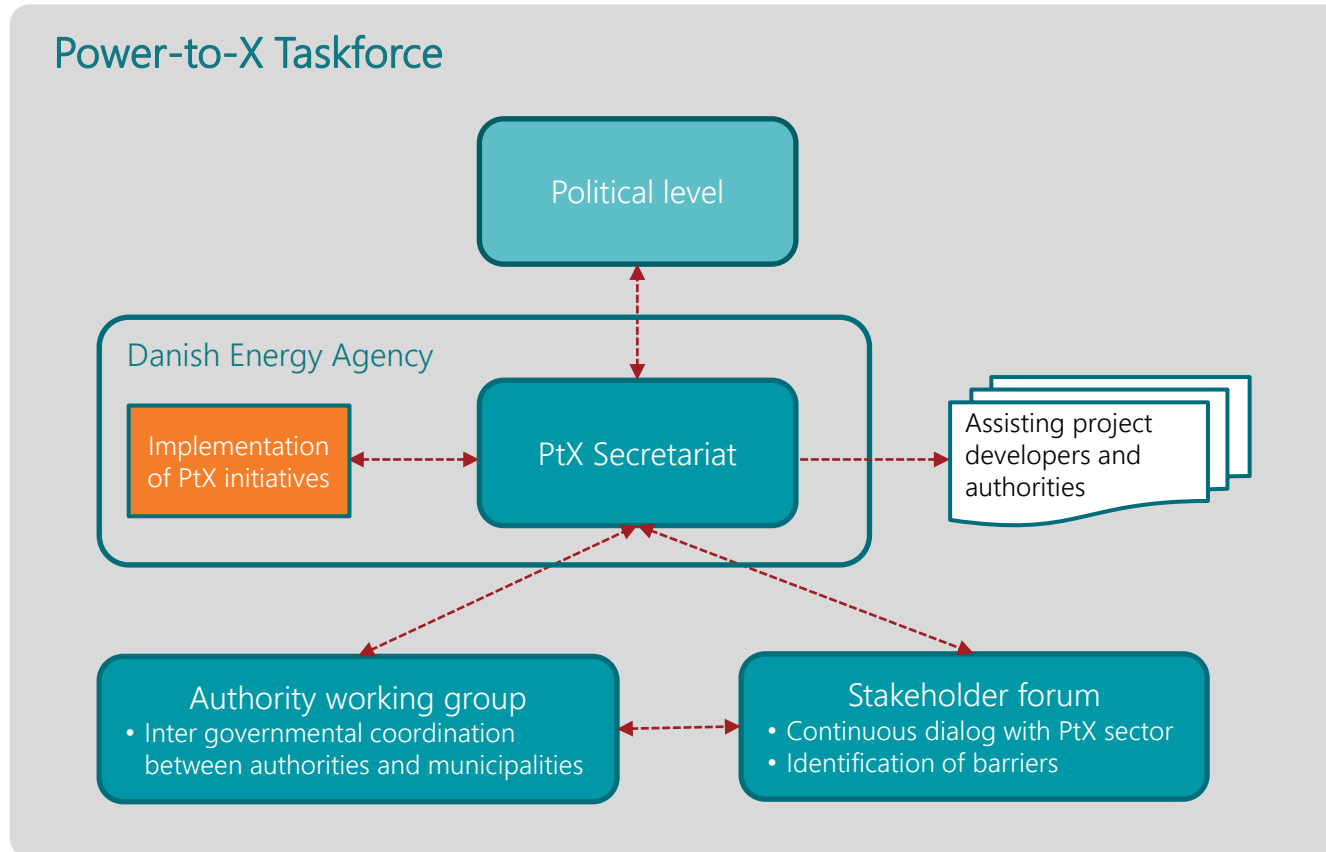
- Policy proposal for green road transport (passengers and heavy transportation)
- Proposal on CO<sub>2</sub> tax on flights

## New EU-legislation (*Fit-fo-55*):

- ReFuelEU Aviation – *blending mandates*
- ReFuelEU Maritime – *blending mandates*
- Renewable Energy Directive II – *CI-demands*



# 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



# Competitiveness with biofuels (medium-long term)

*"Costs of electricity consumption dominate hydrogen production costs"*

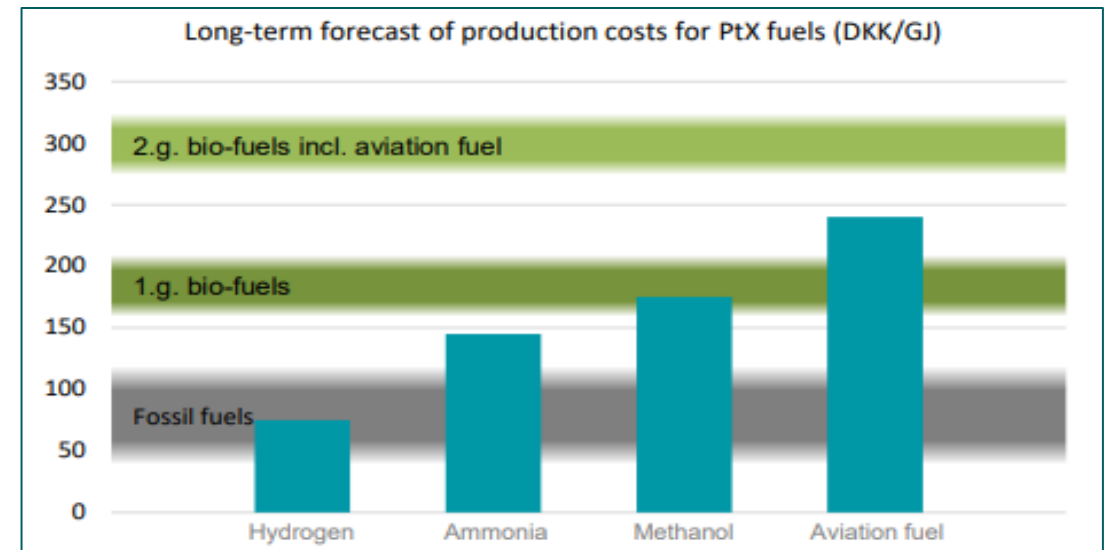
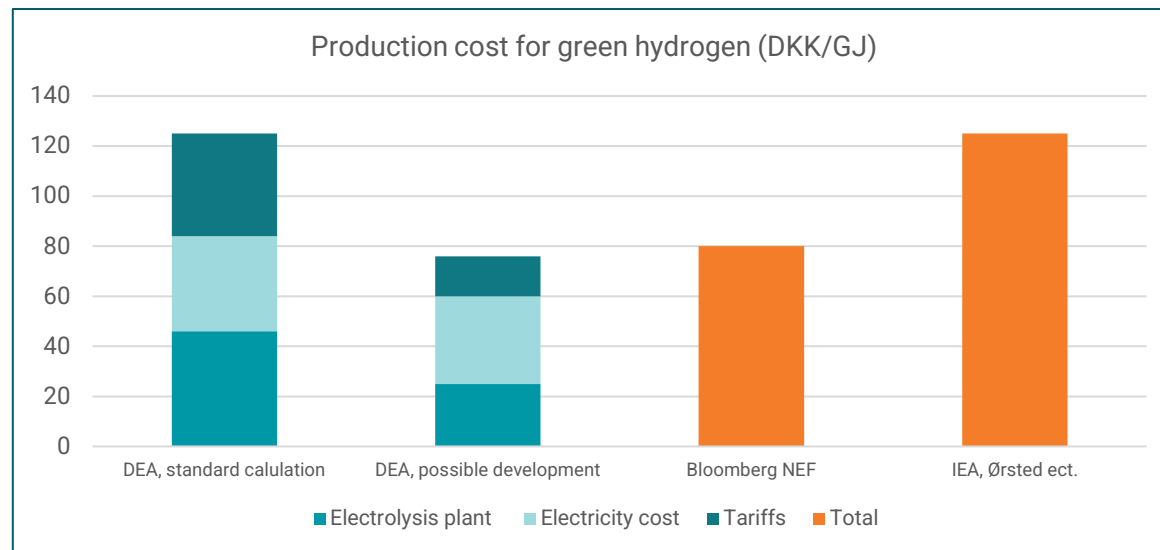
## Estimated costs of green hydrogen production

Considerable potentials for lowering production costs through:

- Scaling and industrialization of electrolysis technology and plants
- Appropriate regulation

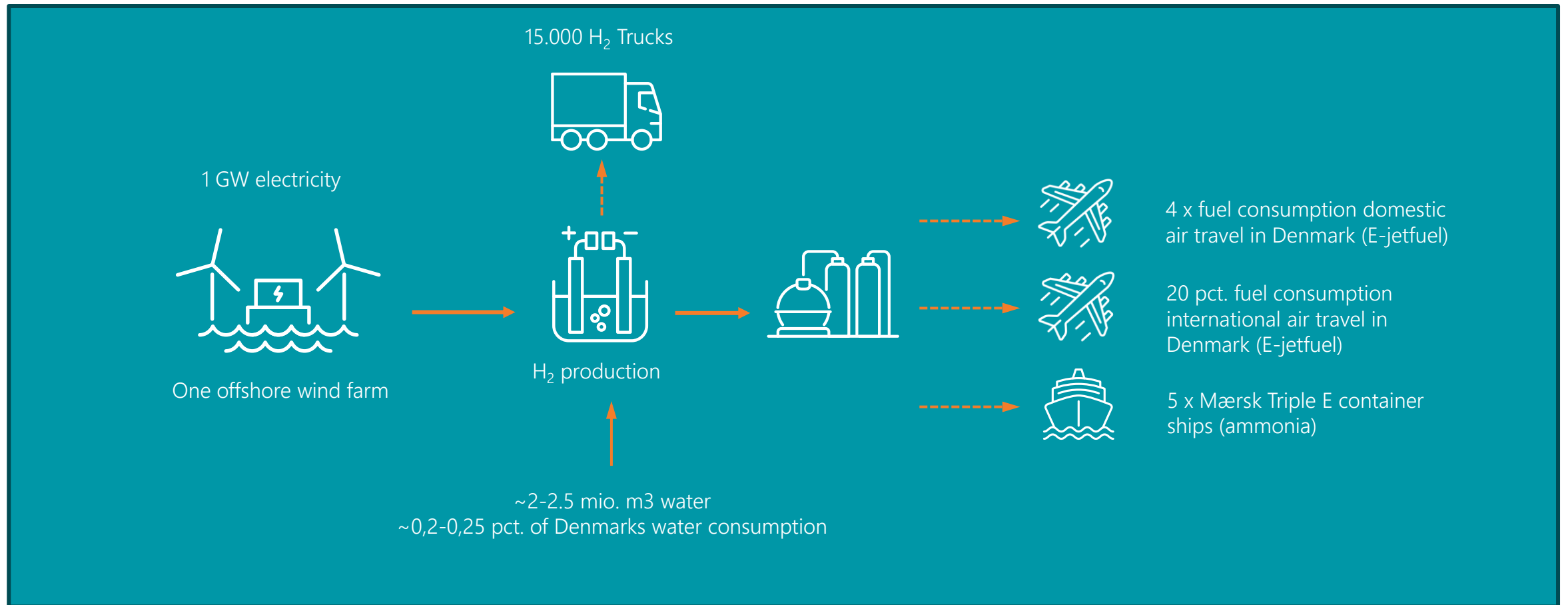
## Competition with other fuels

- E-fuels (E-Ammonia, E-methanol and E-kerosene) cannot compete with fossil fuels on the medium term if ever
- E-fuels are expected to be competitive compared to 2. generation biofuels on the medium-long term.



# Energy balance

Annual consumption





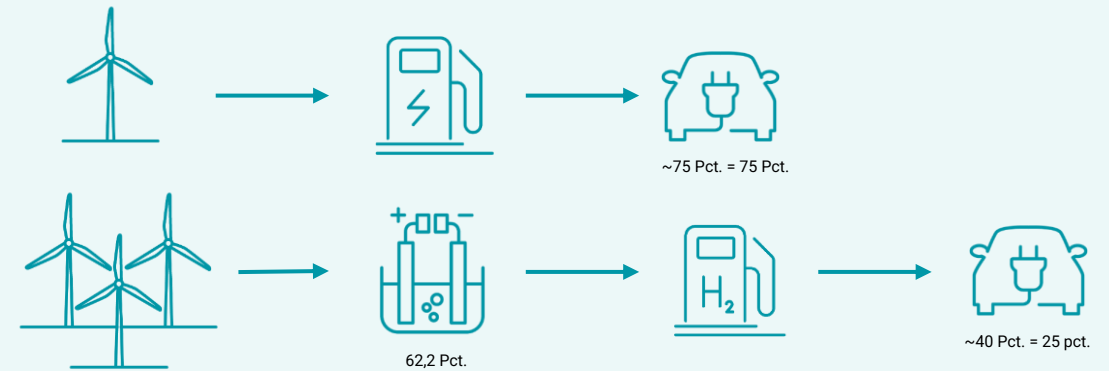
# POWER-TO-X VS. DIRECT ELECTRIFICATION?

## Examples of energy efficiency through electrification

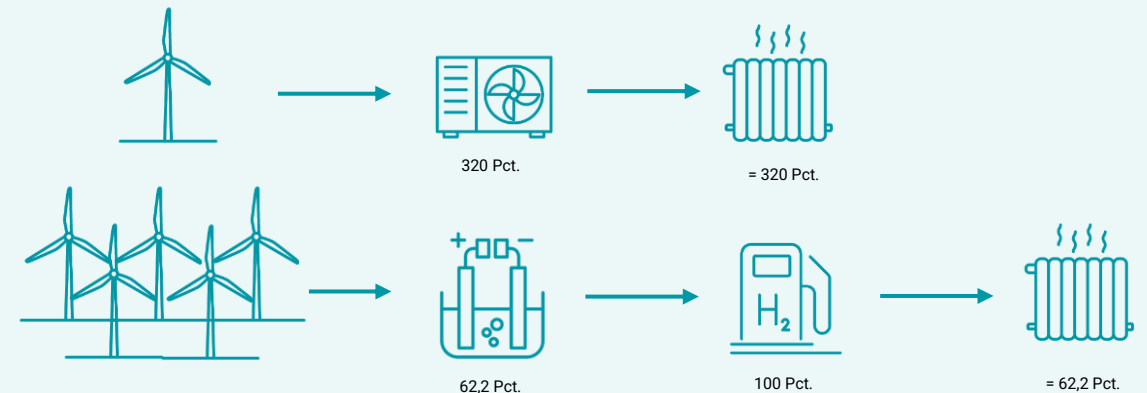
- Energy demand for electrification and Power-to-X
  - A hydrogen powered vehicle requires three times the energy compared to an electrical vehicle
  - A hydrogen boiler for space heating requires approx. five times the energy compared to a heat pump
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- 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
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- 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

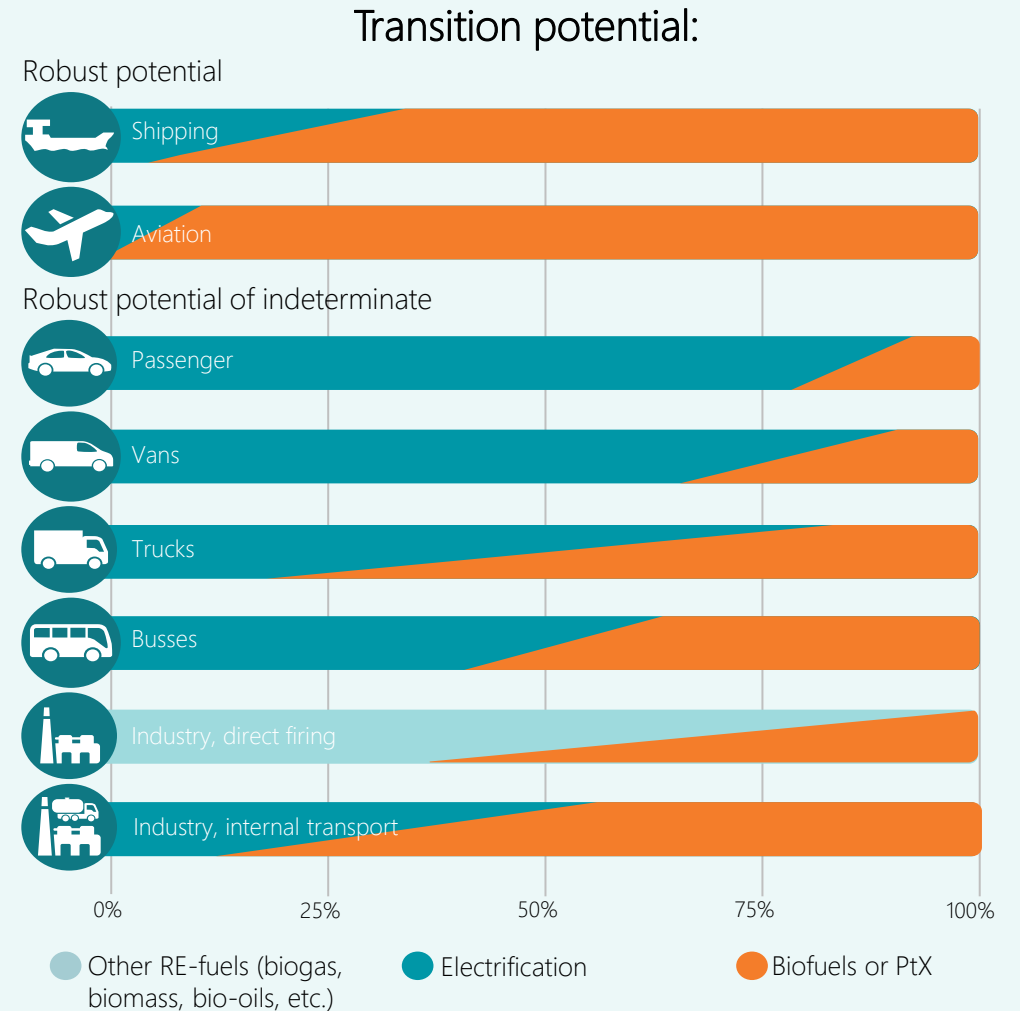


### Space heating: Heat pumps vs hydrogen boilers



# Utilization of PtX in Denmark

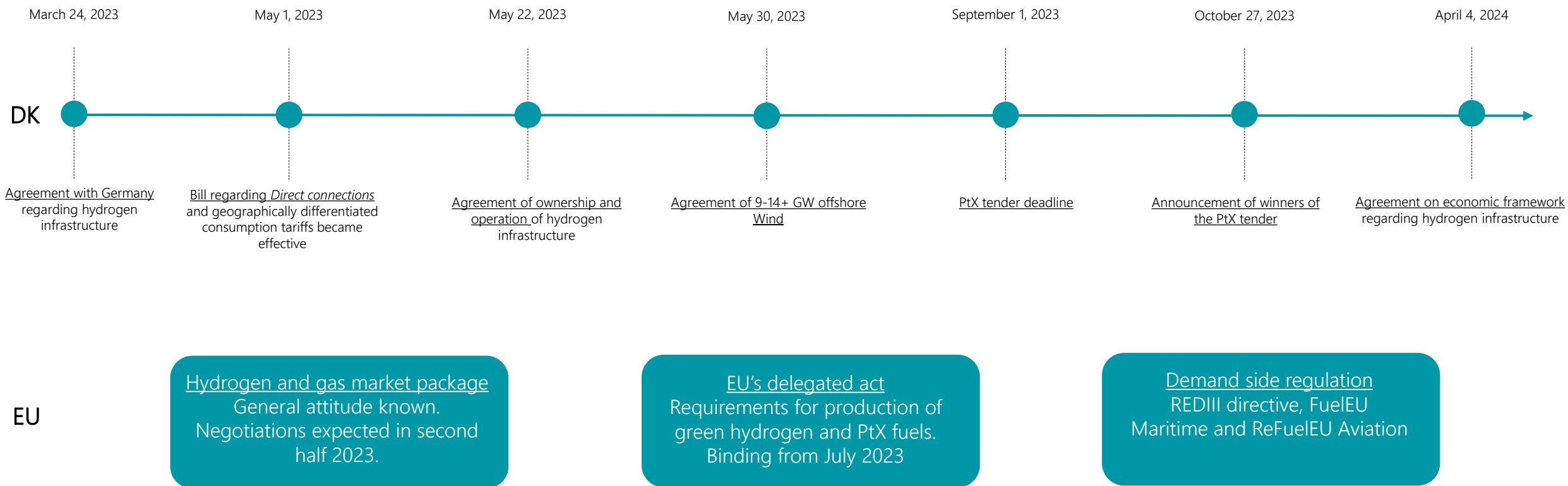
- Power-to-X will remain more expensive than direct electrification where that is applicable.
- Green hydrogen and e-fuels are expected to become cheaper than advanced biofuels (medium-long term).
- Fairly certain of dominant position within shipping and aviation.
- More uncertain in other parts of land 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



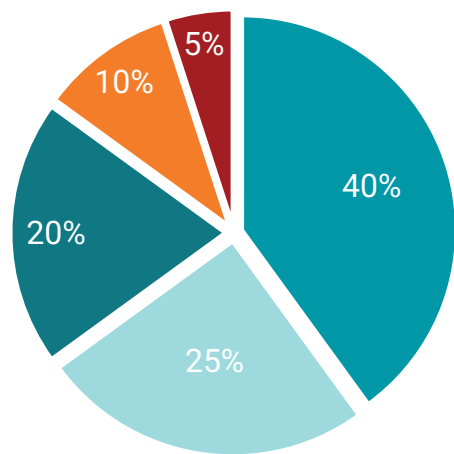
# Status and Development in Power-to-X



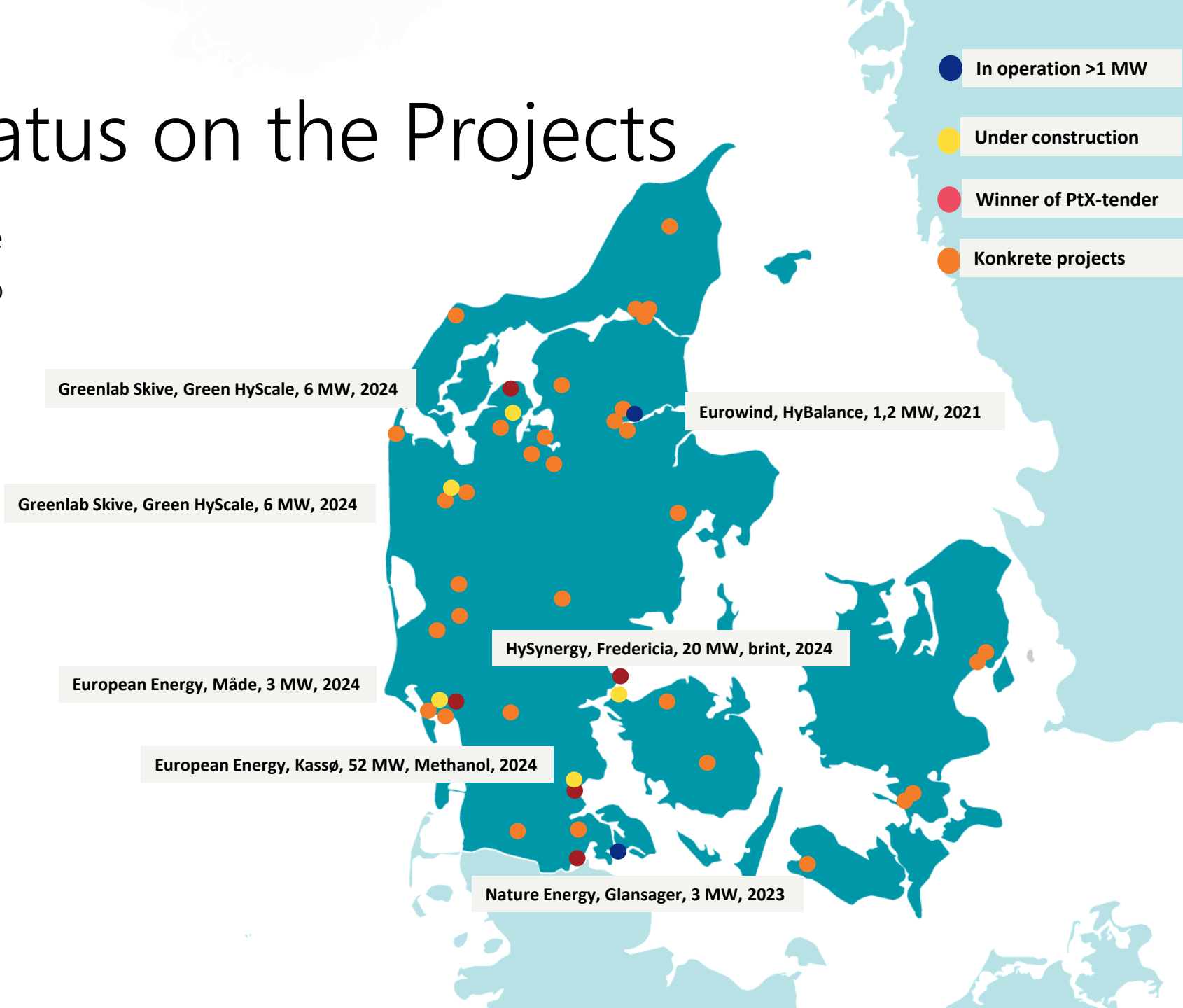


# PtX-pipeline: Status on the Projects

- The Pipeline-list is a momentary capture
- Total concrete projects corresponding to approximately 9.5 GW electrolysis capacity in 2030
- Confidential, non-concrete and unknown projects



■ Hydrogen   
 ■ E-jetfuel   
 ■ E-methanol  
■ E-ammonia   
 ■ E-methane



Thank you for today



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