

Learning from the Experts Webinar Series

Hydrogen & Offshore Wind



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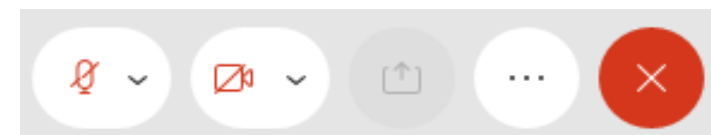
Meeting Procedures

Webinar recordings and presentations will be available at:

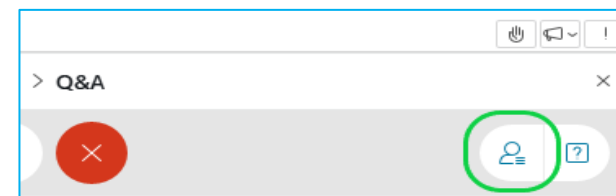
www.nyserda.ny.gov/osw-webinar-series

Participation for Members of the Public:

- > Members of the public will be muted upon entry.
- > Questions and comments may be submitted in writing through the Q&A feature at any time during the event.
- > If technical problems arise, please contact John.Necroto@nyserda.ny.gov



You'll see  when your microphone is muted



Learning from the Experts

This webinar series is hosted by NYSERDA's offshore wind team and features experts in offshore wind technologies, development practices, and related research.

DISCLAIMER:

The views and opinions expressed in this presentation are those of the presenter and do not represent the views or opinions of NYSERDA or New York State.



Power-to-X in Denmark

Henrik Nybo Lomholt
Special Advisor, M.Sc.

The Danish Energy Agency



WHO WE ARE

A government agency under the Ministry of Climate, Energy and Utilities



Danish Energy Agency

GLOBAL
COOPERATION

SUBSOIL
RESOURCES
AND RISK
PREPAREDNESS

ENERGY
EFFICIENCY

ENERGY
ADMINISTRATION

ORGANIZATION

UTILITIES
AND SUPPLY

SYSTEM
ANALYSIS

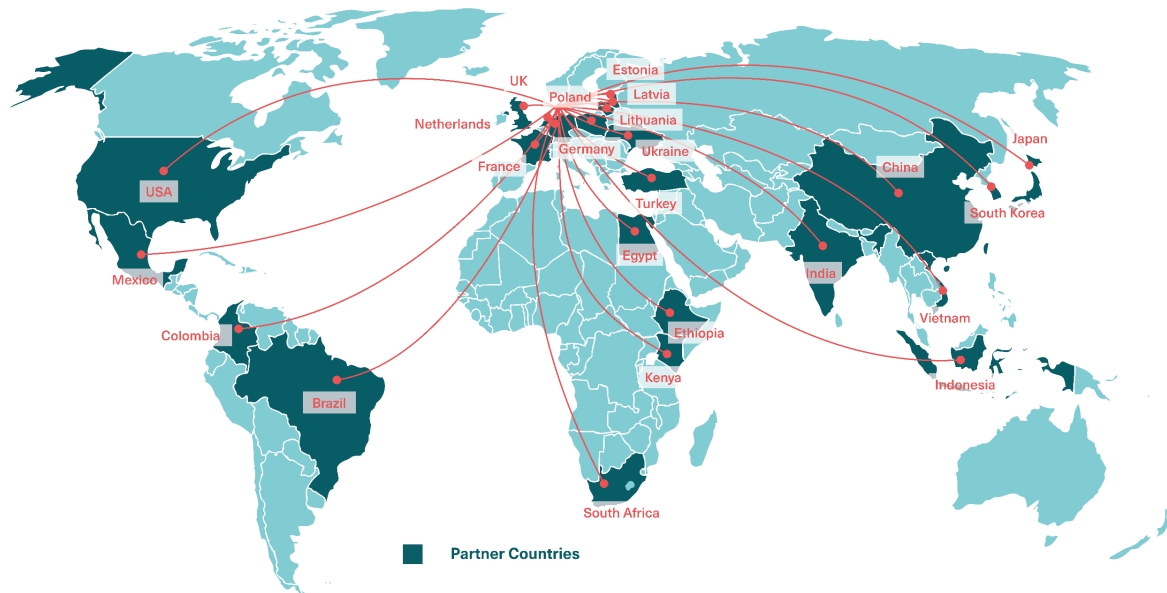
RENEWABLE
ENERGY

ENERGY
ISLANDS





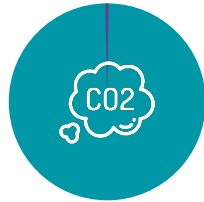
WHO WE COOPERATE WITH



IN DENMARK...



... we represent **0,07 %**
of the world's population

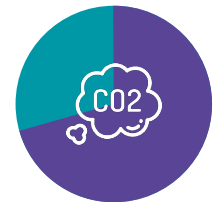


... we emit **0,1 %** of the
global CO₂ emissions

OUR PARTNERS...



... represent ~**61 %** of
the world's population



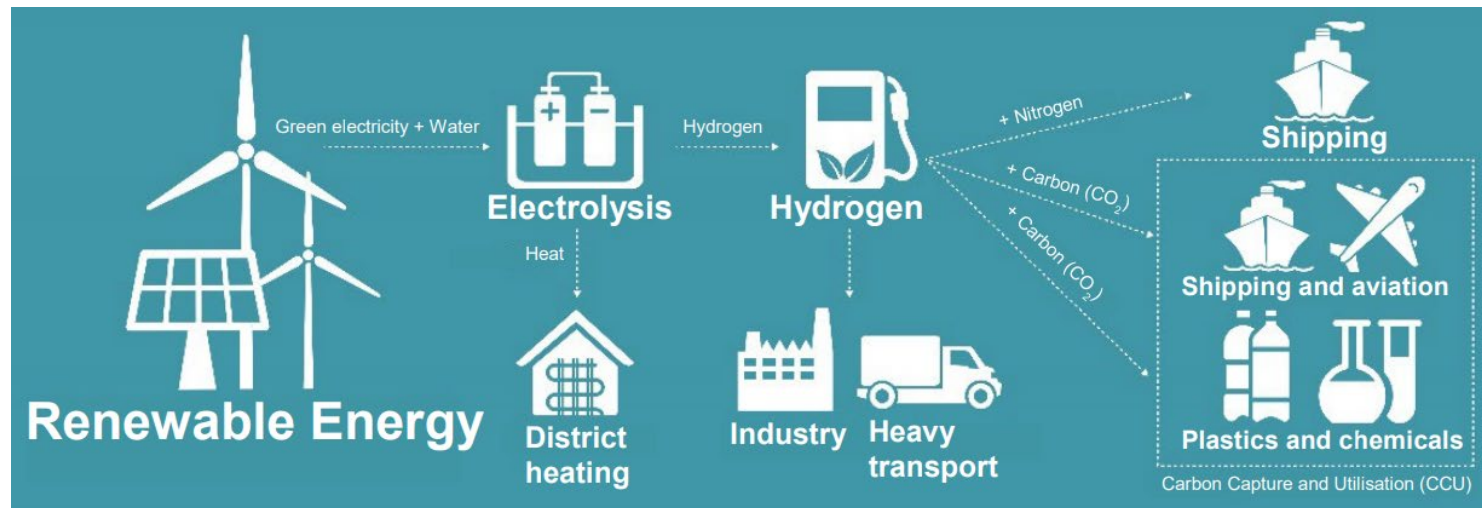
... emit **70 %** of the
global CO₂ emissions



INTRODUCTION

WHAT DO WE MEAN BY POWER-TO-X (PTX)?

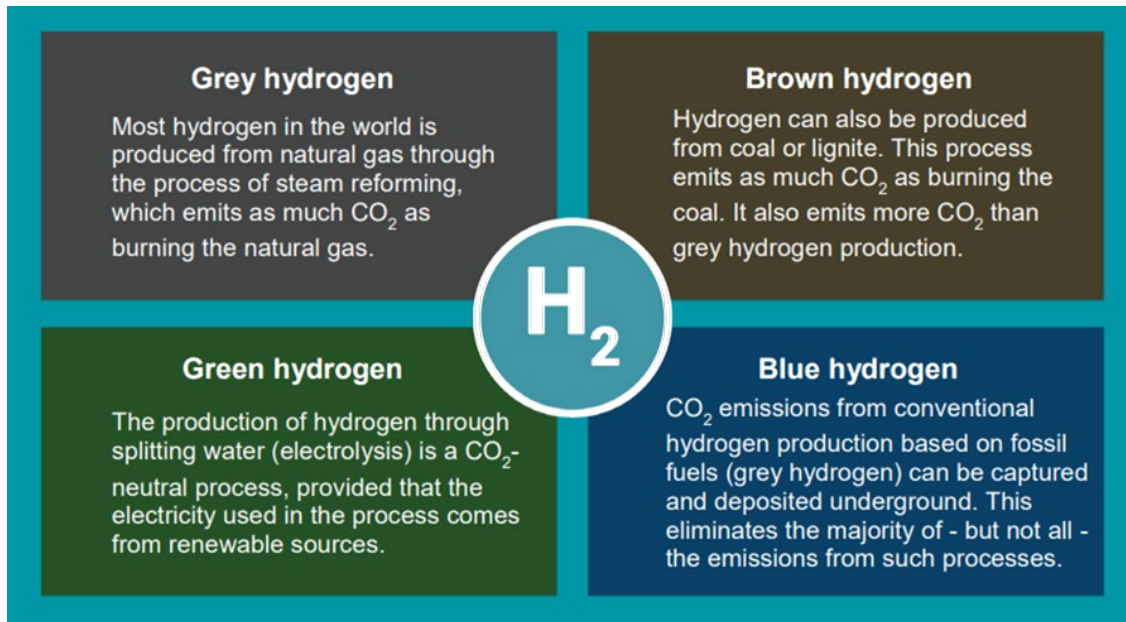
"Green electrons as input and green molecules as output"



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



HYDROGEN DEFINITIONS



Green hydrogen is the pathway in the Danish energy transition.



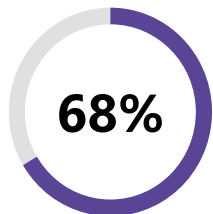
POWER-TO-X DRIVERS



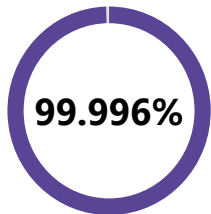
LARGE SHARE OF RE AND AN AMBITIOUS CLIMATE POLICY

STATUS

RENEW POWER IN
POWER CONSUMPTION



SECURITY OF
SUPPLY

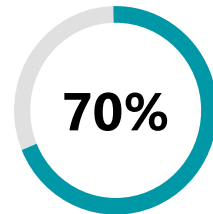


TARGETS

GREEN POWER
IN 2030



CARBON REDUCTION
IN 2030



CLIMATE NEUTRALITY
IN 2045

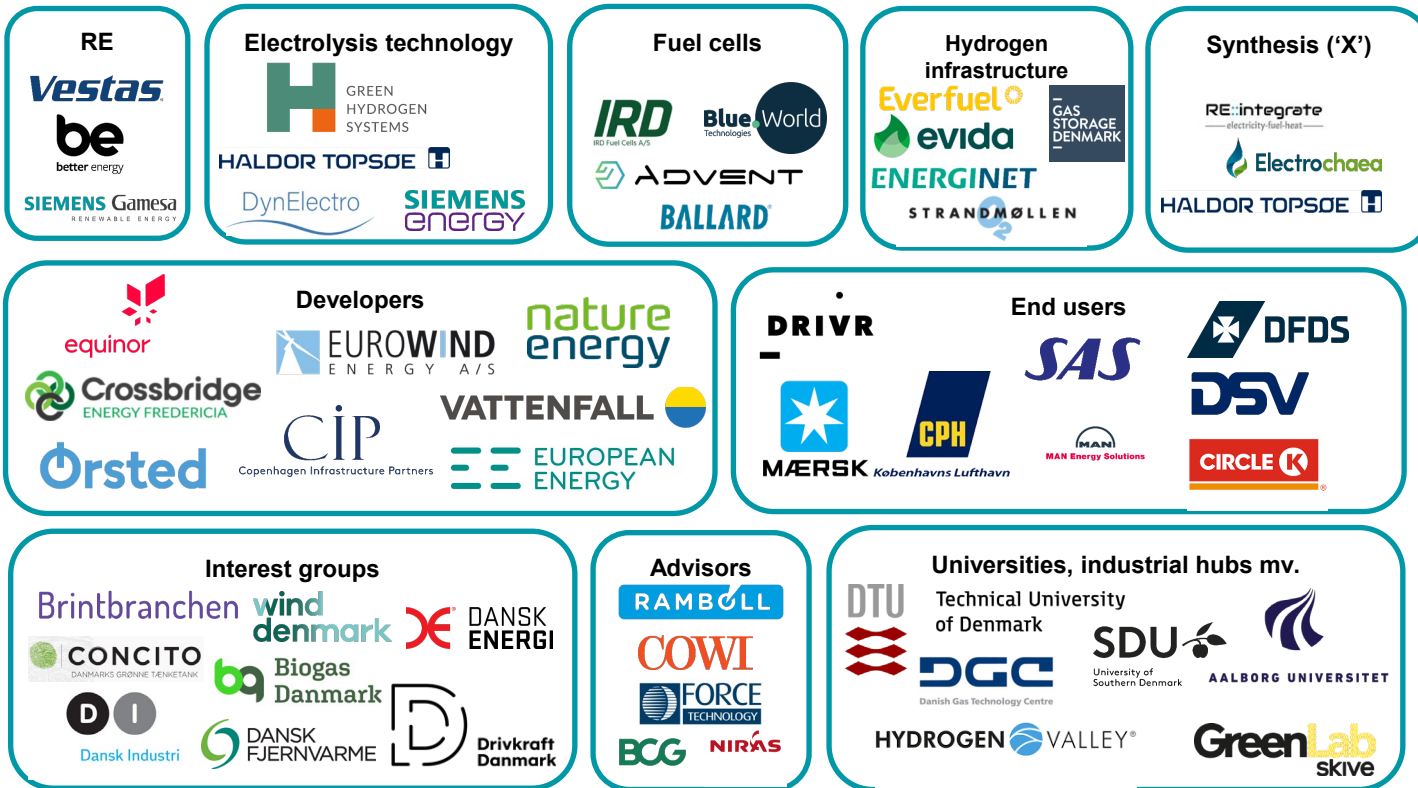


CARBON REDUCTION
IN 2050





A STRONG POWER-TO-X & HYDROGEN ECOSYSTEM



The list is illustrative and not exhaustive

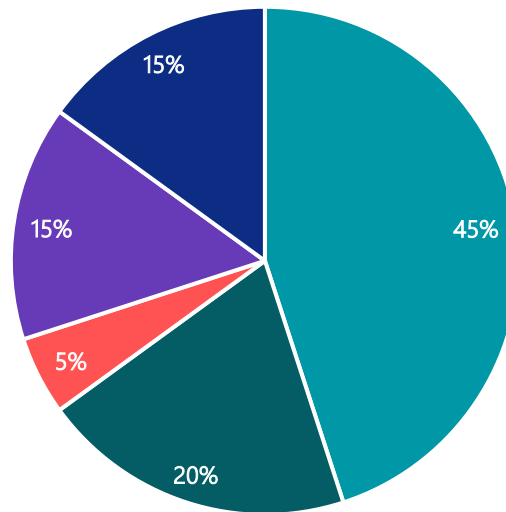


STATUS ON DANISH POWER-TO-X PROJECTS

Announced Power-to-X Projects

Commissioning	2023 - 2030
Number	> 35
Capacity	5 MW – 1.300 MW
Accumulated capacity	~7,5 GW

Power-to-X focus



■ Hydrogen ■ Methanol ■ Metane ■ Ammonia ■ Kerosene



FLAGSHIP PROJECT EXAMPLE

"Green fuels for Denmark"



HALDOR TOPSOE  Everfuel  nel 

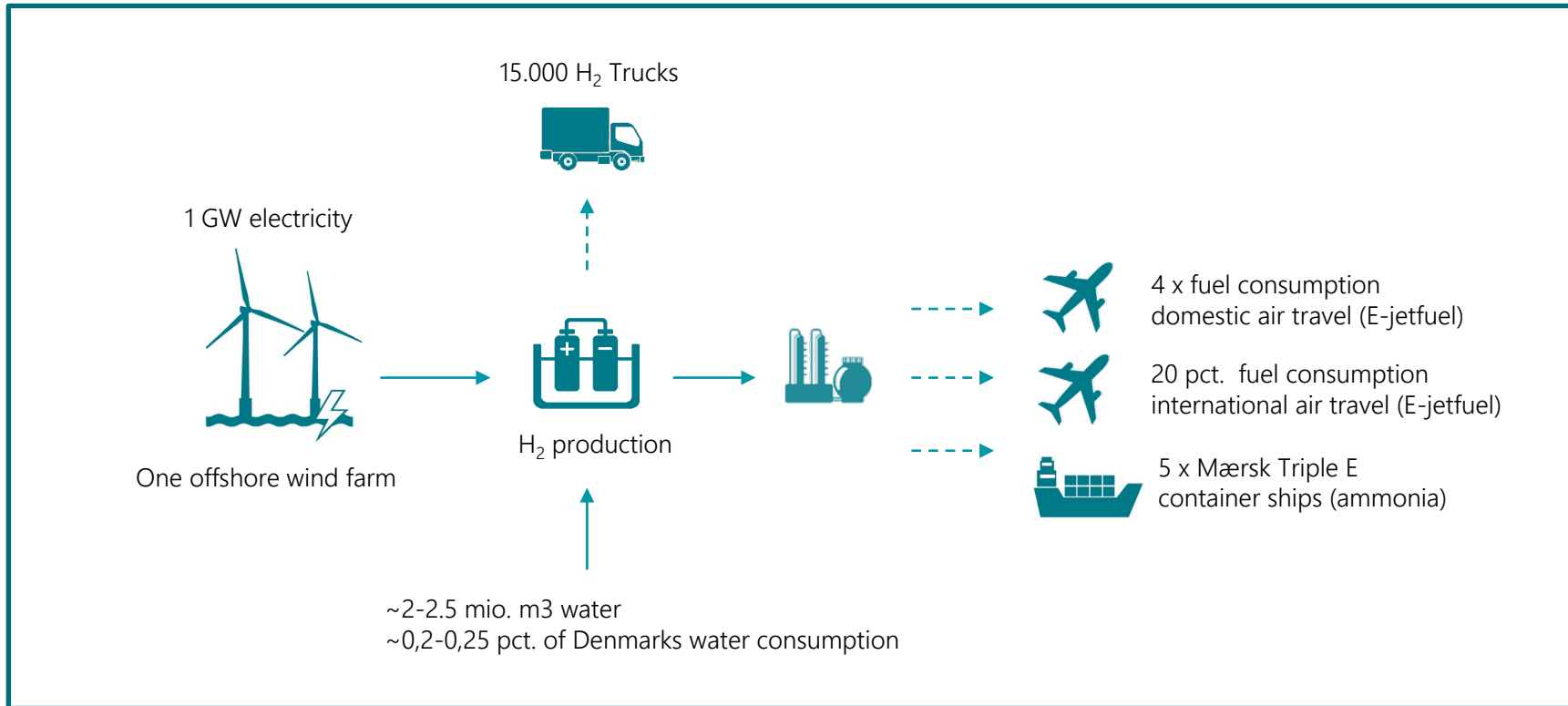
 Region Hovedstaden  COWI  BCG 

<https://orsted.com/en/media/newsroom/news/2022/02/20220204476711>



ENERGY CONSIDERATIONS

Annual consumption



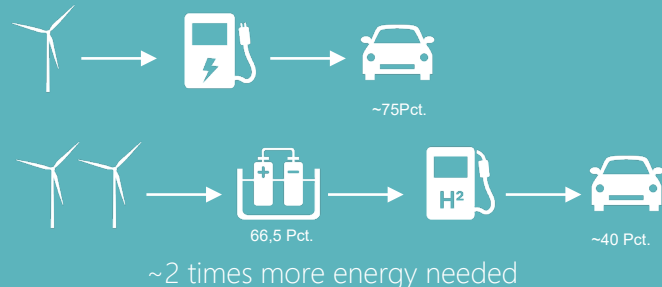
POWER-TO-X VS. DIRECT ELECTRIFICATION?

Examples of energy efficiency through electrification

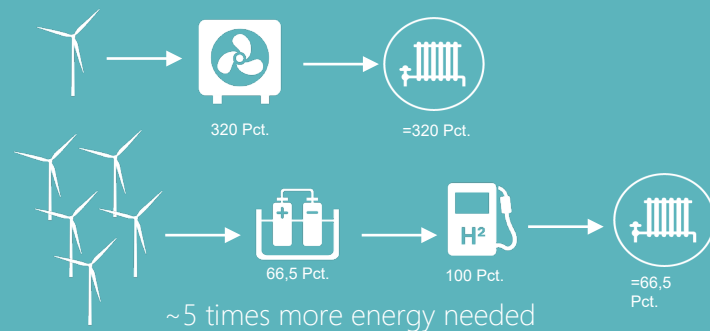
- Energy demand for electrification and Power-to-X
 - A hydrogen powered vehicle requires more than double the energy compared to an electrical vehicle
 - A hydrogen boiler for space heating requires approx. five times the energy compared to a heat pump
- More efficient Power-to-X technologies are being 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





HIGHLIGHTS FROM THE DANISH POWER- TO-X STRATEGY



THE DANISH POWER-TO-X STRATEGY

A new and rapidly developing agenda

- The Government's strategy for Power-to-X was released in December 2021.
- Based on more than 20 analyses totalling more than 500 pages.
- Targets 4-6 GW electrolysis capacity by 2030
- Simultaneously the PtX agenda has accelerated





COMPETITIVENESS WITH BIOFUELS (MEDIUM-LONG TERM)

"Costs of electricity consumption dominate hydrogen production costs"

Estimated costs of green hydrogen production

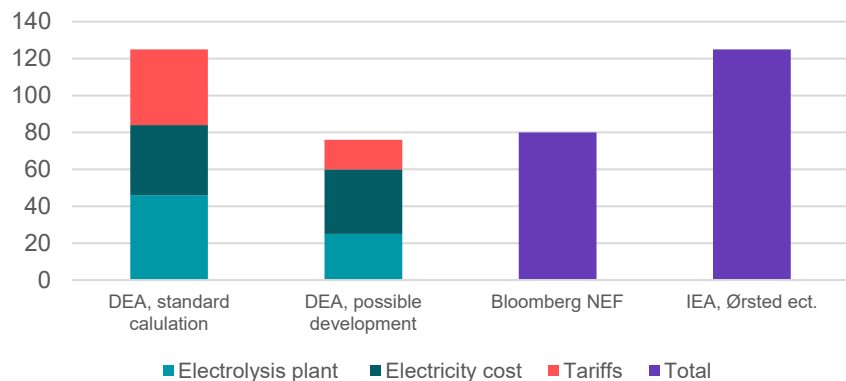
Considerable potentials for lowering production costs through:

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

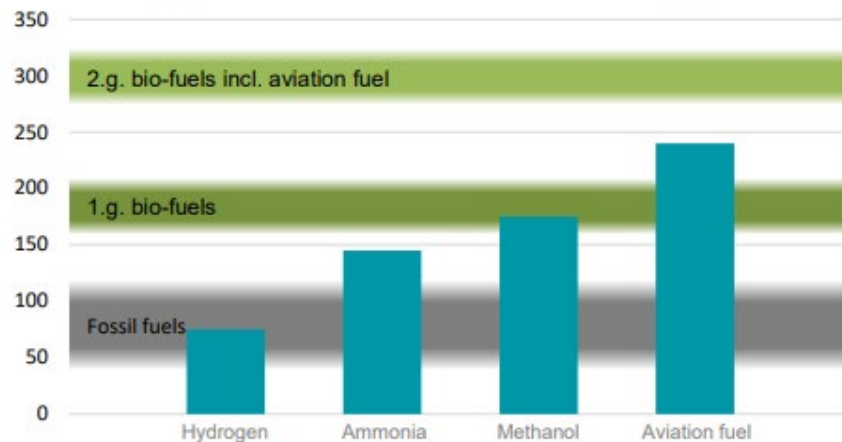
Competition with other fuels

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

Production cost for green hydrogen (DKK/GJ)



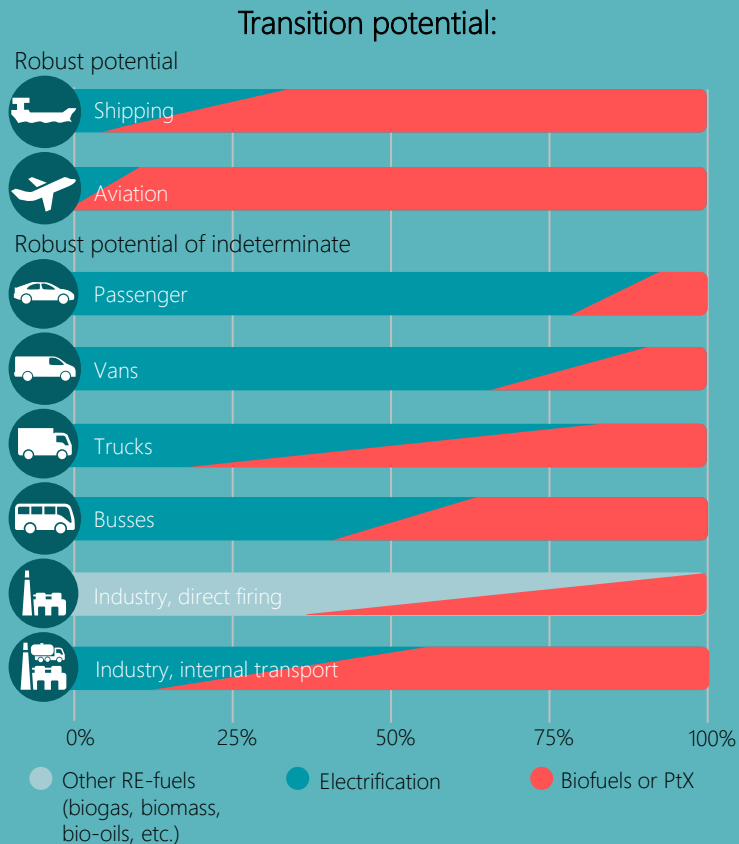
Long-term forecast of production costs for PtX fuels (DKK/GJ)





UTILIZATION OF PTX IN DENMARK

- 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






OUTLOOK



RECOMMENDATION TO POWER-TO-X



Renewable electricity is used most efficiently for direct electrification both in terms of energy and economically



Power-to-X should contribute to the green transition



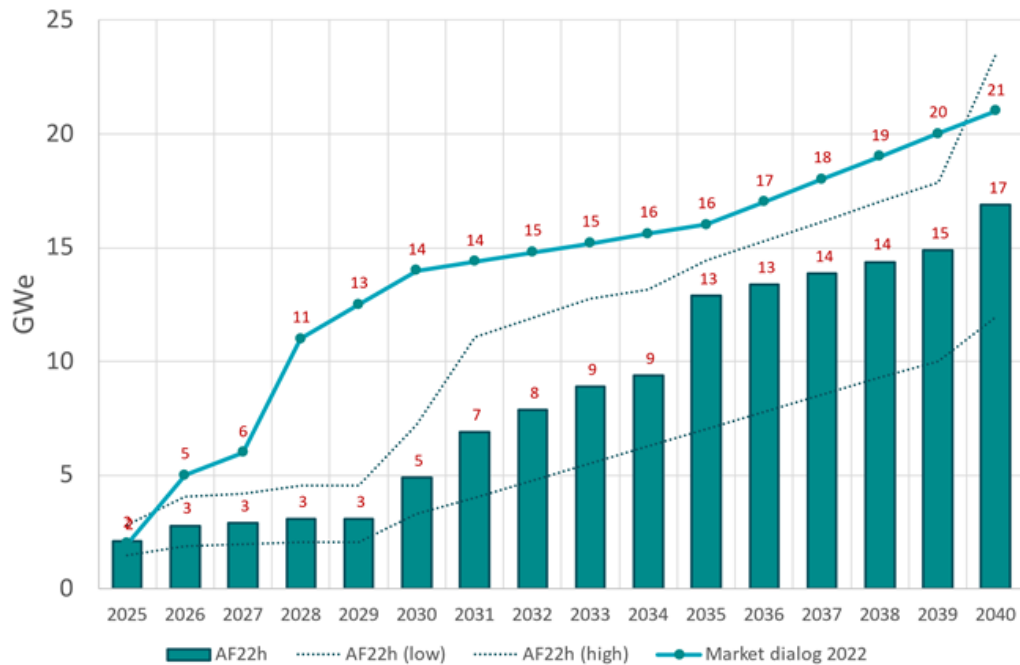
Power-to-X is suitable for countries with high share of renewable electricity and a well developed electricity grid



Countries with high CO₂ intensity should prioritize renewable electricity productions first

THE BIG PICTURE

Forecast: Requirement for electricity capacity for Power-to-X



https://ens.dk/sites/ens.dk/files/Hoeringer/af22_-_sammenfatningsnotat.pdf
<https://energinet.dk/om-publikationer/publikationer/markedsdialog-om-brintinfrastruktur-2022/>



Thank you





Denmark's Energy Islands

Kristian Sten Holst



With the energy islands, Denmark is leading the way in Europe by contributing to the green transition among our neighbouring countries, through the export of green and renewable energy, and by continuing to support green innovation and commercial potential.

Addendum to the climate agreement on energy and industry of 22 June 2020, regarding the ownership and construction of energy islands etc., 4 February 2021

The energy islands mark the start of a new era of offshore wind development



Draws on the extensive Danish expert experience within offshore wind



Enables the utilization of large wind resources at sea



Large-scale production that contributes to the electrification of society



Supports a regional expansion and electricity market integration

Strong political support

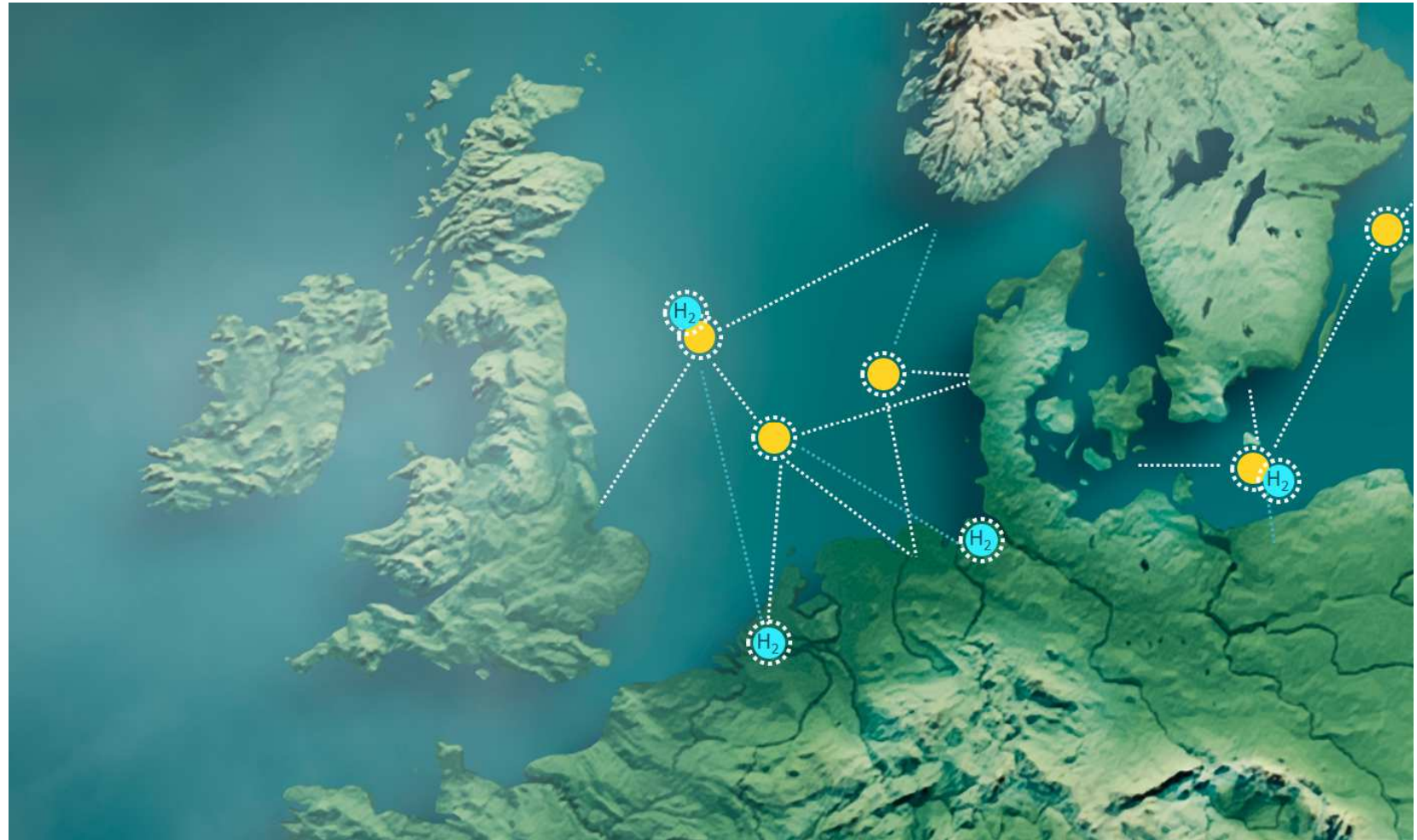
- Broad agreement behind the energy islands in the North Sea and at Bornholm
- The Esbjerg Declaration: "The North Sea to be Europe's green power house"
- Belgium, Denmark, Germany and the Netherlands had agreed to jointly develop 150 GW in their North Sea territories
- Baltic Sea Countries Agree to increase offshore wind capacity sevenfold by 2030



Joint European offshore
wind ambitions

Long-term vision

- Very significant in achieving a carbon neutral society
- Several energy islands and a large scale power grid
- Sector coupling and regional integration
- Green electricity and e-fuels from renewable energy
- Energy independence and lower electricity prices



Status on foreign connections to the energy islands



Denmark and Belgium are collaborating on a hybrid interconnector in the North Sea from the Danish energy island to a Belgian energy island with expected operationalization in 2033 and with a cable capacity of 2GW.



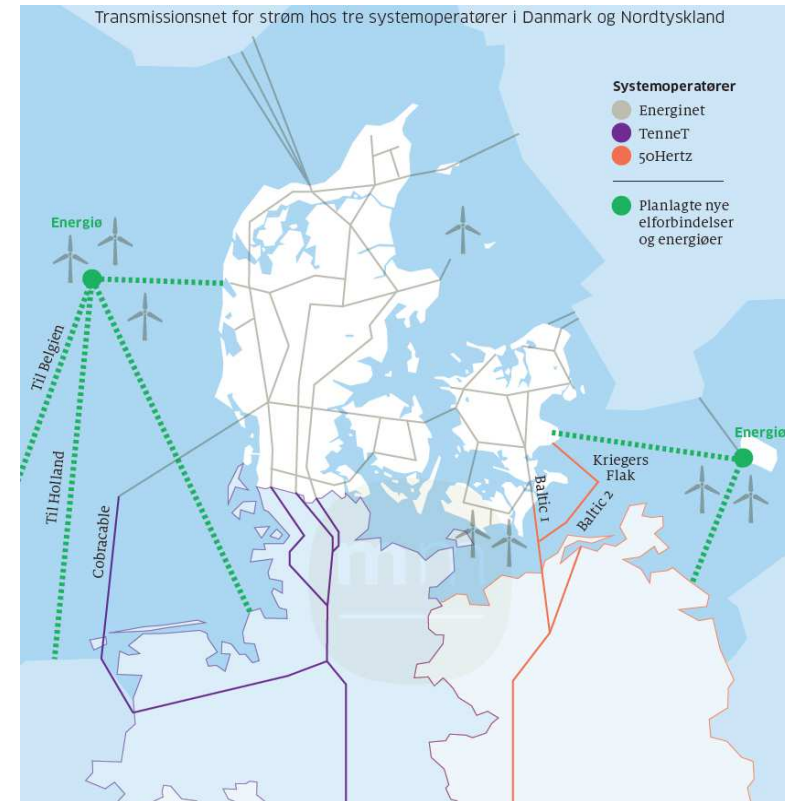
The cooperation with the Netherlands aims at an overseas connection between the Danish energy island and the Dutch hub in a later offshore wind phase of the energy island, i.e. around 2035.



In July 2022, Denmark and Germany reached a political agreement to establish of a cable from the energy island on Bornholm to Germany. The agreement with Germany is a new type of cooperation, where costs and benefits associated with the energy island are shared equally between the parties. Awaiting agreement etc. The TSOs – Energinet and 50Hertz – are currently negotiating the further details.



Energistyrelsen
Danish Energy Agency



The Danish Energy Agency's role

The Danish Energy Agency is leading the planning of the world's first energy islands

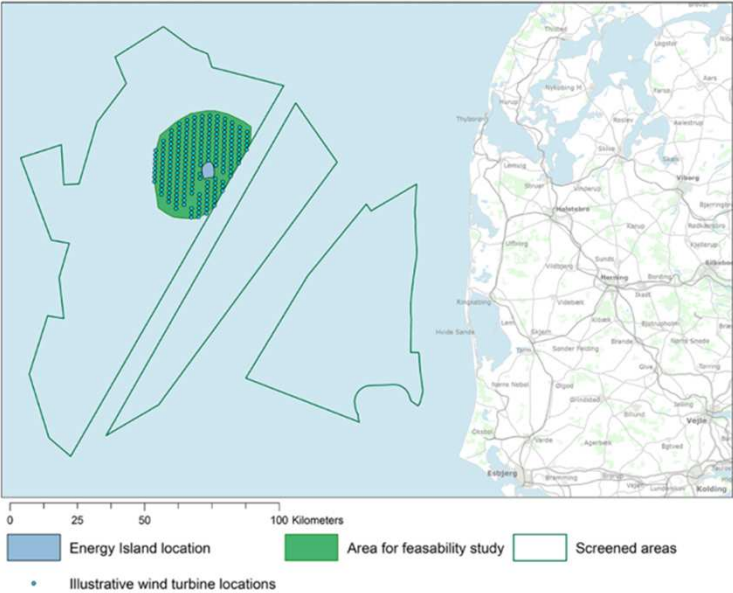
We are securing political support and optimal framework for development and construction

We enable smooth collaboration with authorities and limiting governmental bureaucracy

We share our experience and knowledge with the world

Where will the Energy Islands be located?

The North Sea - approx. 100 km off the coast at Thorsminde



The Baltic Sea - approx. 15 km south-southwest from Bornholm



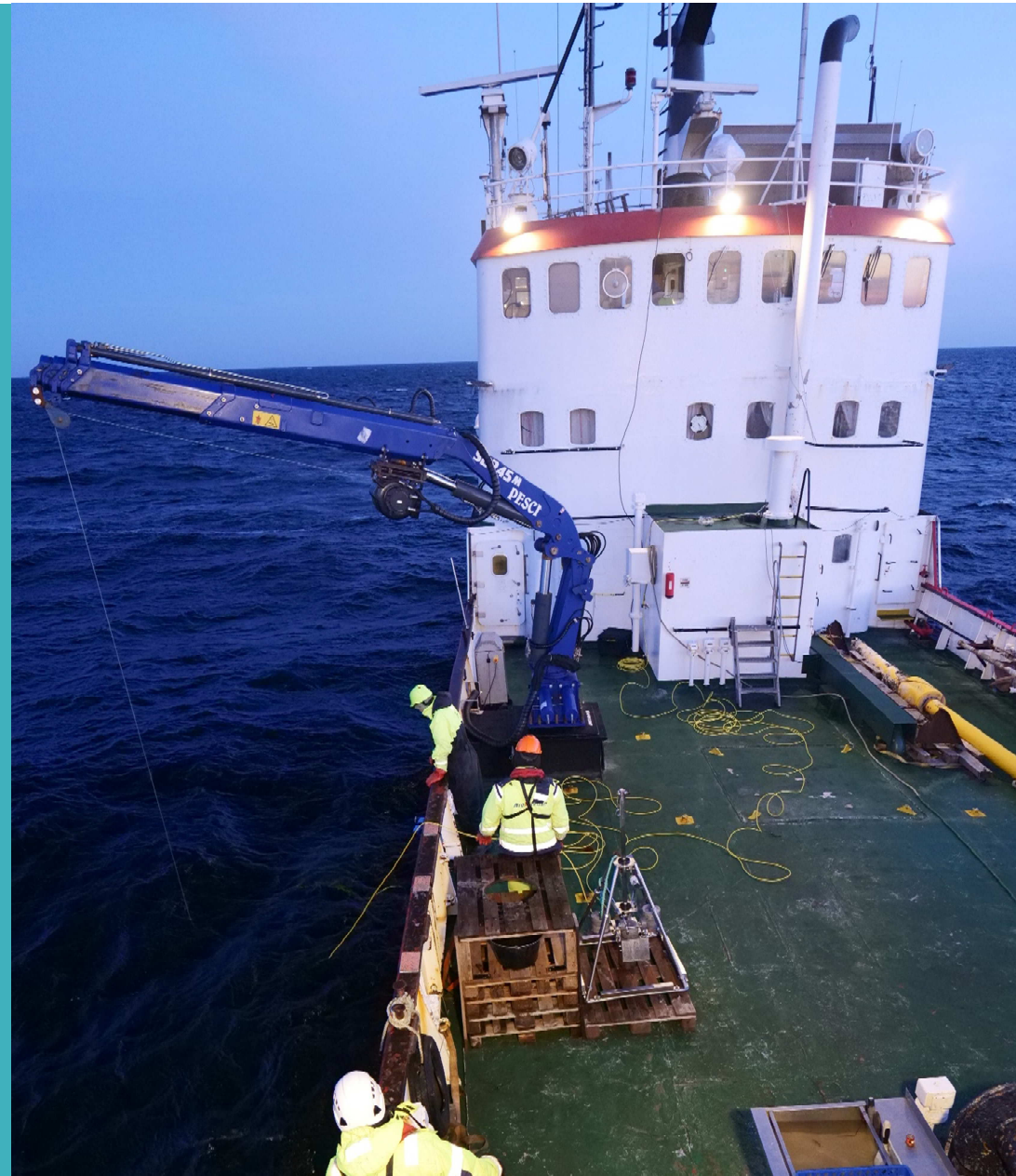


Energistyrelsen
Danish Energy Agency

Environmental studies

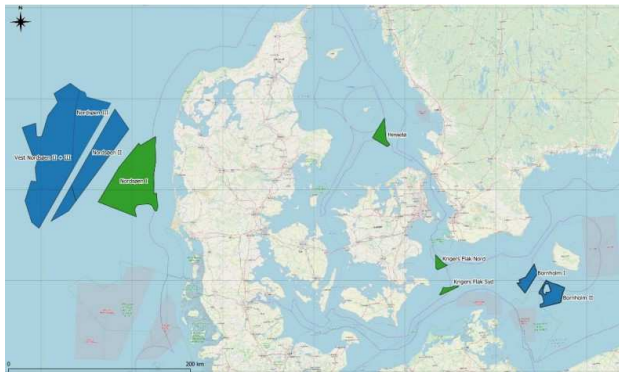
Feasibility studies are an essential part of implementing the construction of energy islands, include:

- surveys (e.g. seabed sonar surveys)
- geotechnical surveys (e.g. seabed drilling)
- environmental surveys (e.g. fish, birds).
- Results will form the basis for a future Strategic Environmental Assessment (SEA) of the energy island

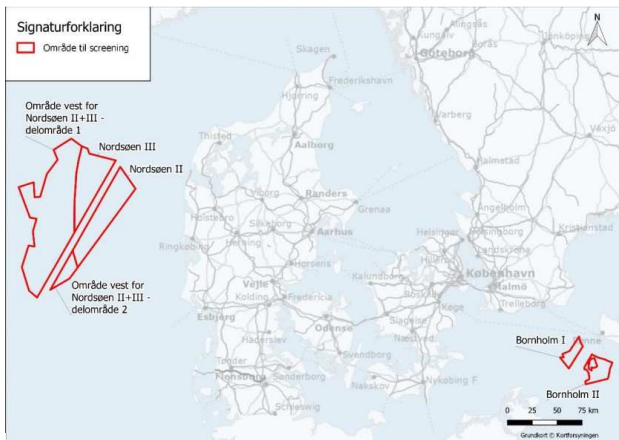


Danish Energy Agency's screening of marine areas

2018



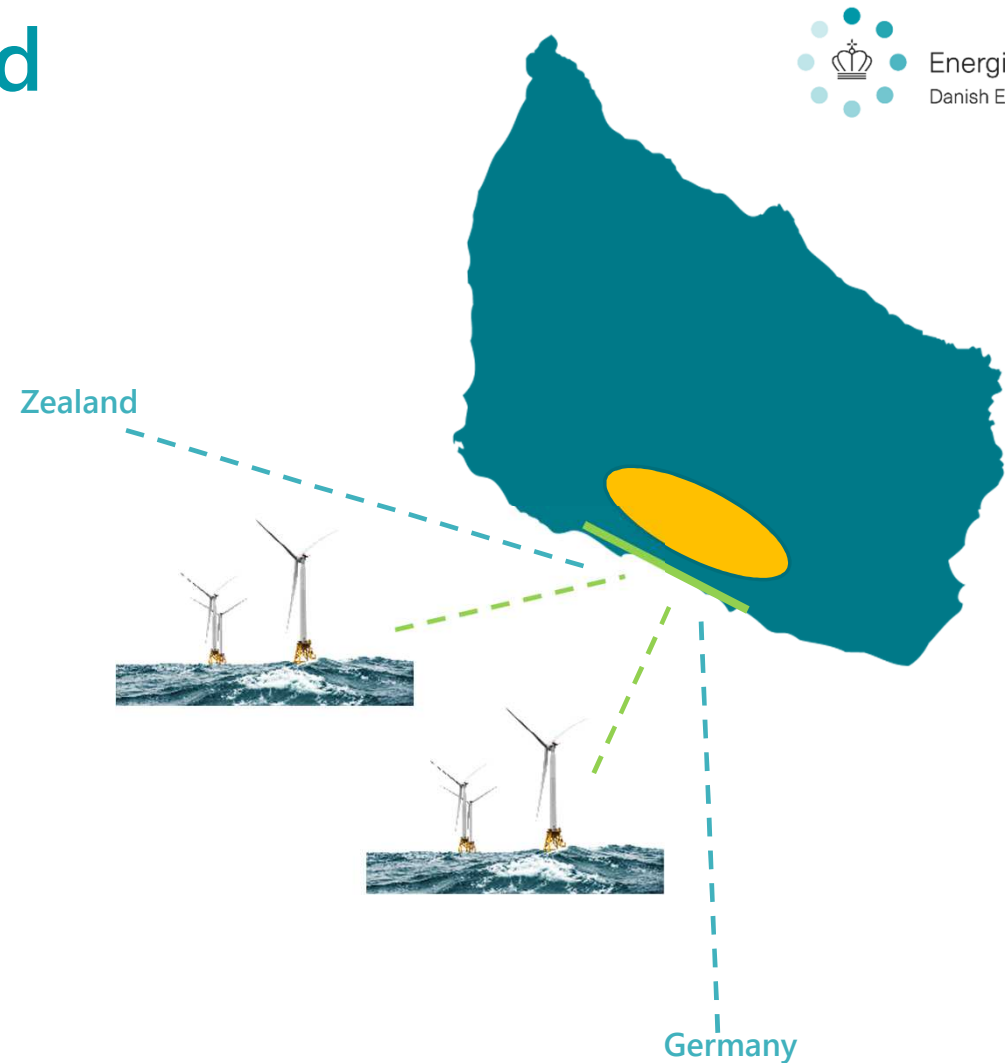
2020



*All reports are available at ens.dk/en

Bornholm Energy Island

- 3 GW of offshore wind, instead of the initially planned 2 GW by 2030
- Several offshore wind farms with onshore facilities on Bornholm
- Connection to Zealand and Germany
- Subsea cable connecting Denmark and Germany will have a length of approx. 470 km
- Provides enough green power to supply the electricity needed by 3.3 million Danish or 4.5 million German households



North Sea Energy Island

3-10 GW = 10 millions households



Artificial island



Offshore windfarms



Transmission system



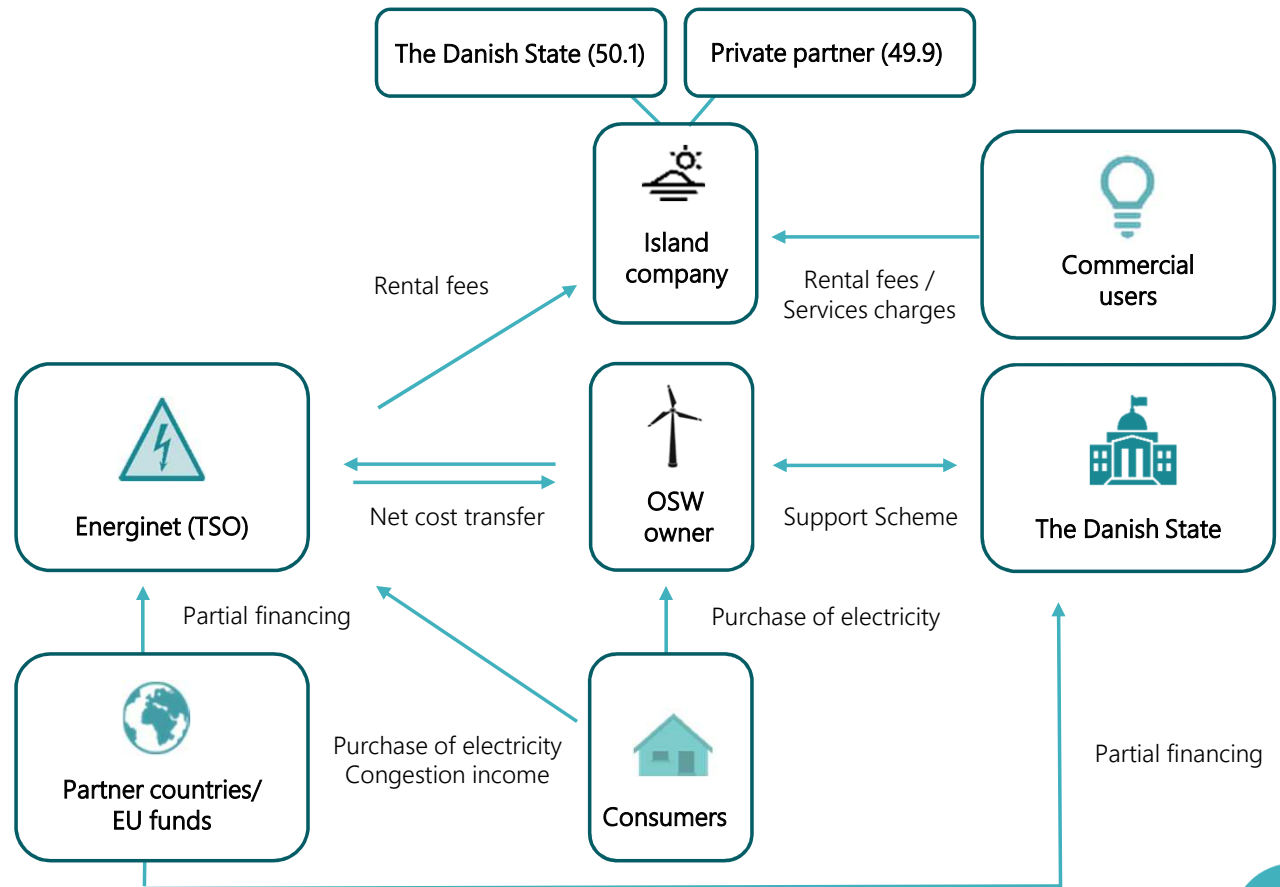
Power-to-X innovation



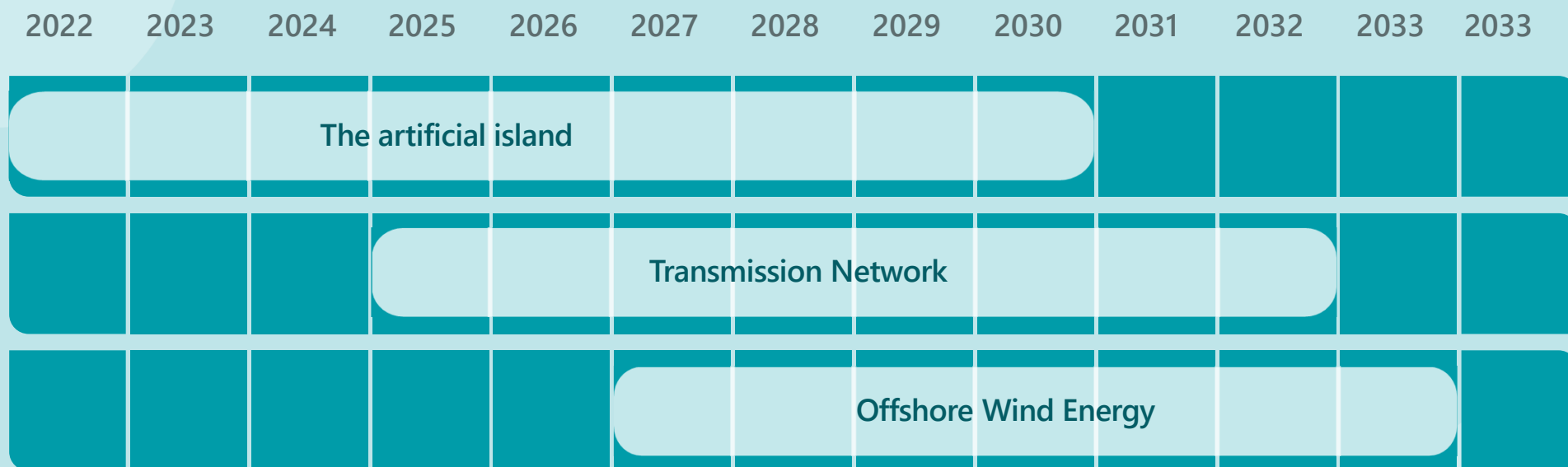
Private partnership

BUSINESS MODEL FOR THE ENERGY ISLAND CORP.

- Responsible co-ownership – pre-qualification criteria's will be define for the private bidders
- Private partner will plan and build the energy island. Public-private partnership will be established when the island is finalized. The Danish state purchases 50,1% of the island
- The private partner carries most of the construction risks
- Primary income via leasing of land to state-owned Danish TSO Energinet
- Energinet's cost is expected to be passed on to offshore wind farms connected to the island



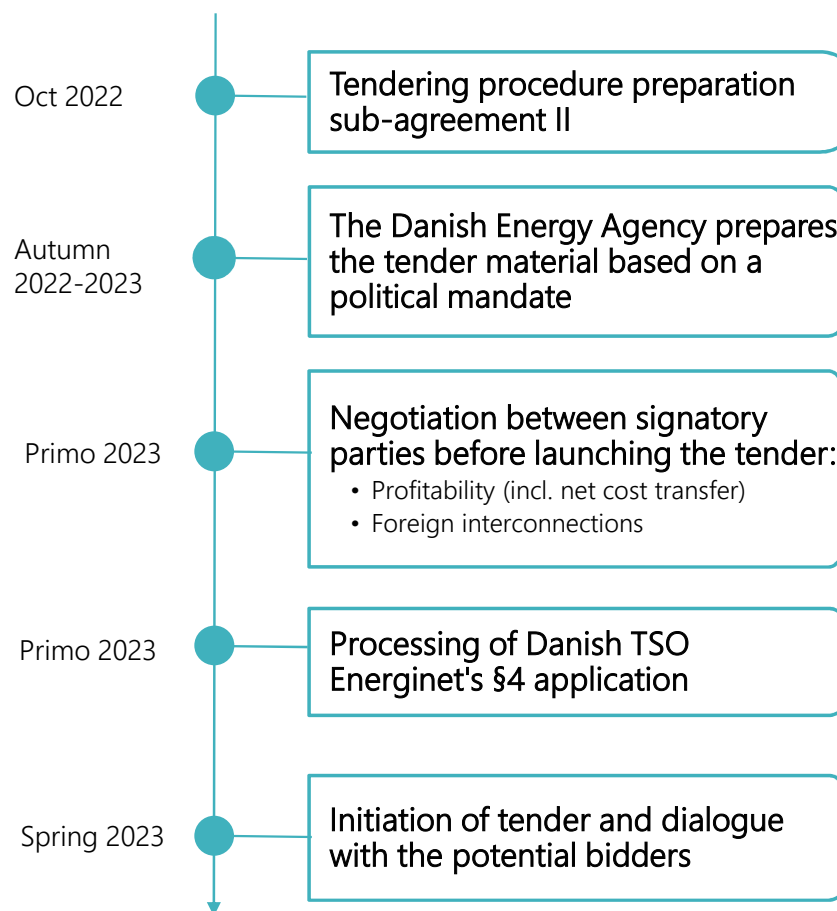
Preliminary time table for the energy island project





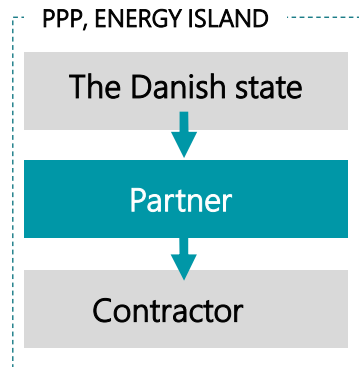
Questions?

Short-term process towards initiation of the tender



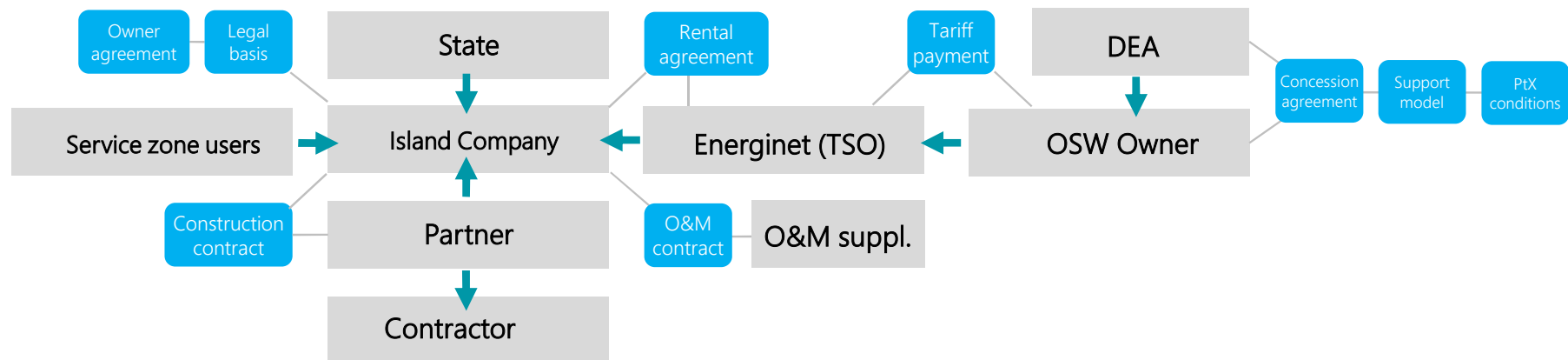
Public/private company

TENDER,
CONSTRUCTION/PARTNER



- Energy island as a new element requires private innovation
- Joint operating company, which can operate/develop the energy island on commercial terms
- Private partner bears construction risks
- Private partners incentives
 - Cheap island (award criteria)
 - Robust construction (co-ownership)
 - Island-delivered-on-time (payment model)
 - First mover (concept export)

OPERATION SET-UP



Coming Next:

February 15, 1:00 p.m. ET

Emergency

**Response Planning
for Offshore Wind**

John Mansolillo, Ørsted

Visit wind.ny.gov to register

We want your feedback! Send suggestions for future webinar topics to offshorewind@nyserda.ny.gov



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