



HUBS AND SPOKES AS A NEXT STEP IN EUROPEAN COLLABORATION TO INTEGRATE OFFSHORE WIND

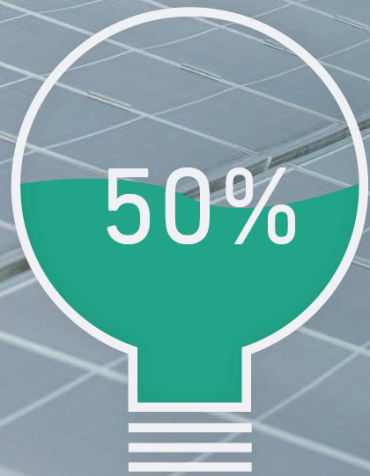
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TRANSMISSION SYSTEM OPERATER FOR ELECTRICITY AND GAS IN DENMARK



WE NEED MORE GREEN POWER



2021



2030



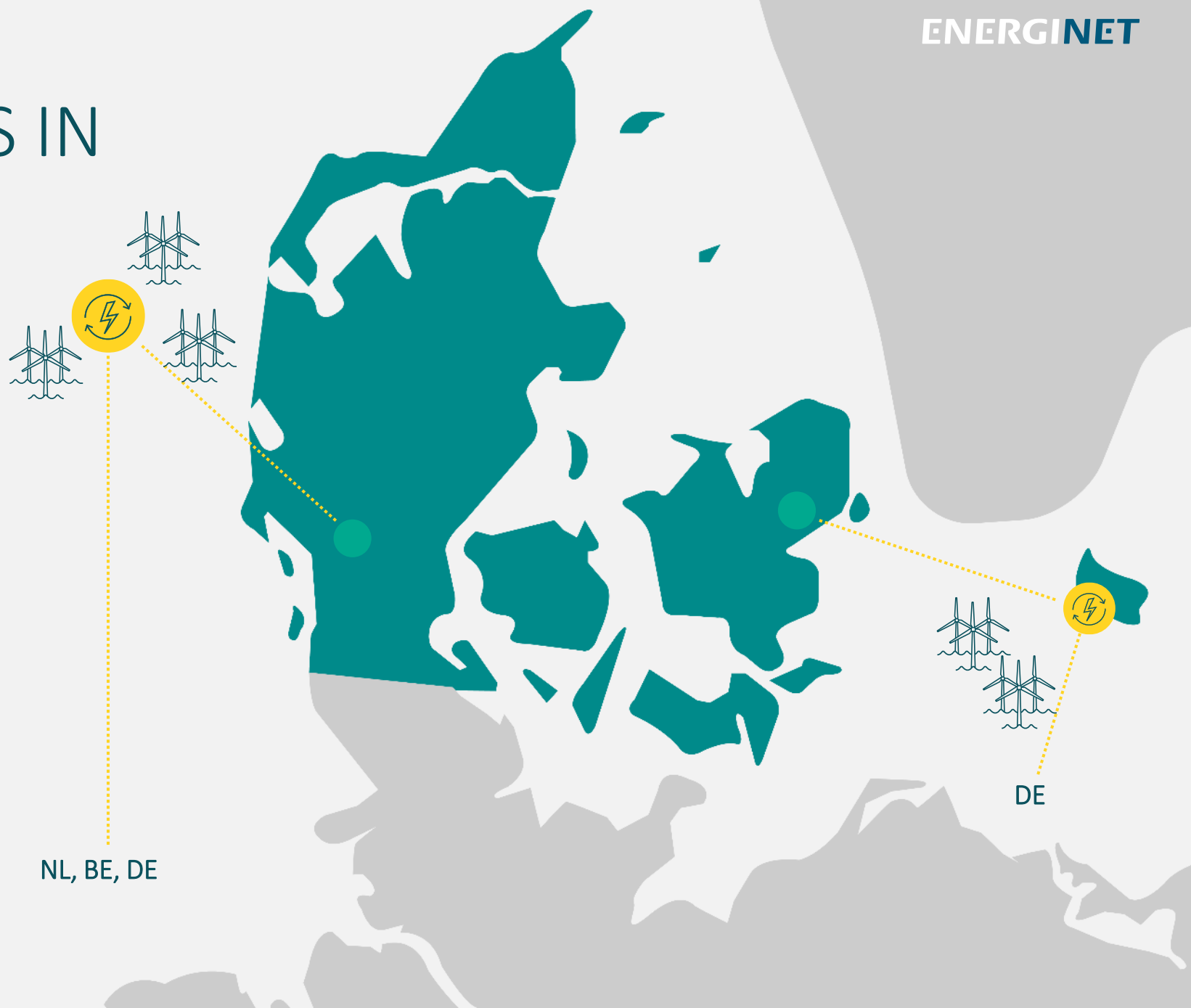
ENERGY ISLANDS IN DENMARK

The North Sea:

3 GW offshore wind by 2033, later 10 GW.

The Baltic Sea:

3 GW offshore wind by 2030.





North Sea
Wind Power Hub
Programme

Green energy from the North Sea can power Europe

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North Sea Wind Power Hub feasibility and preparation studies (1.19-0001-NLDE-S-M-20) is co-financed by the Connecting Europe Facility of the European Union.



Our multi-year programme has delivered knowledge of vital importance and de-risked the offshore infrastructure roll-out



Credible voice and knowledge builder in North Sea **offshore wind** development



+40 publications of technical **studies** and discussion **papers**



+50 presentations at international events and conferences



+200 engaged stakeholders across Europe

Three vital system functions can be reached through multiple configurations



Current approach

Radial



● Collect ○ Connect ○ Convert

New configurations

Radial + conversion



● Collect ○ Connect ● Convert

Meshed grid



● Collect ● Connect ○ Convert

Whole system configuration

Meshed grid + conversion

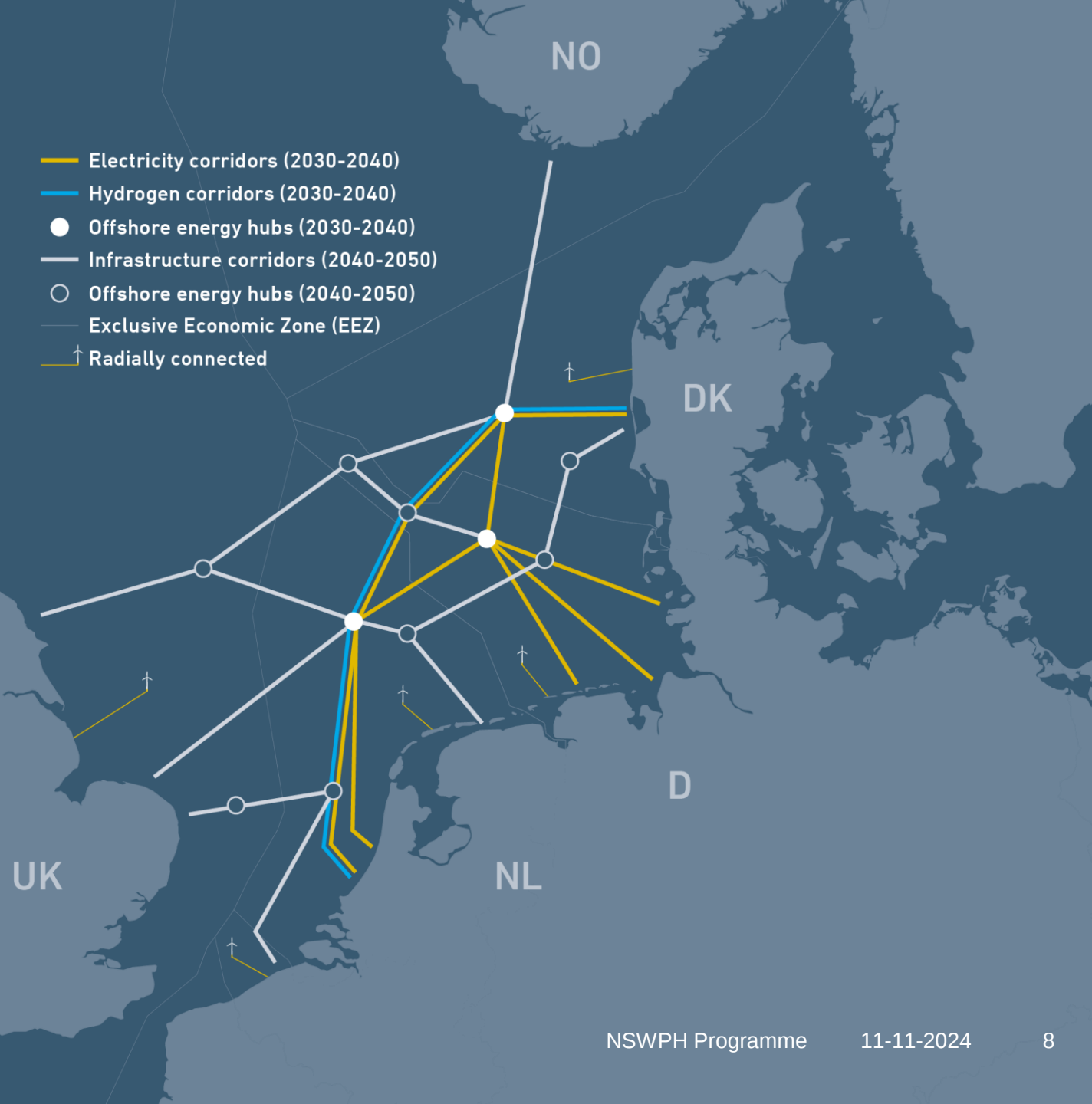


● Collect ● Connect ● Convert

A hubs-and-spokes concept for 2050

- ⤴ A common energy resource with 300 GW generation capacity
- ⤴ A robust and integrated system combining strategic offshore hubs and offshore electrolysis
- ⤴ Secure energy supply with a high degree of European energy independence

- Electricity corridors (2030-2040)
- Hydrogen corridors (2030-2040)
- Offshore energy hubs (2030-2040)
- Infrastructure corridors (2040-2050)
- Offshore energy hubs (2040-2050)
- Exclusive Economic Zone (EEZ)
- ↑ Radially connected





Benefits of the hubs-and-spokes concept

Hubs-and-spokes



Collect
vast amounts of
North Sea offshore
wind power



Connect
hubs in a flexible
network across
North Sea countries



Convert
renewable electricity
from offshore wind
into hydrogen

unlock offshore wind,



offer system benefits



& are cost competitive





What is needed now



Intensified international collaboration is crucial to realise the set-out 2050 vision.



Key offshore infrastructure design elements need to be anticipated. Considering system integration and modular designs generates optionality for an effective roll-out.



Maintaining momentum in the roll-out requires a **stable investment framework** that balances short term actions and long-term strategy.

Highlights

- ⌵ Consider the North Sea as joint resource
- ⌵ Strong collaboration needs a strong forum and mandate
- ⌵ Ensure fair cost sharing and a fair financing framework

Highlights

- ⌵ An integrated design for electricity and hydrogen infrastructure
- ⌵ System functions and interfaces standardised and modular
- ⌵ Decisions for infrastructure post-2030 need to be made now

Highlights

- ⌵ Align tender designs and create long-term certainty
- ⌵ Incentivise new demand and investments in the supply chain
- ⌵ Implement offshore bidding zones



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Thank you

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Extra slides



What will take us there?

1

A hubs-and-spokes based infrastructure roll-out to harvest far offshore wind cost competitively

2

Hubs-and-spokes allow for an additional 39 GW of installed offshore wind capacity

3

Offshore and landing zone electrolysis that can convert up to 44% of wind energy to hydrogen in 2050

4

Anticipatory investments will pay off in the long run by enabling a modular, internationally coordinated roll-out

5

Implementation of offshore bidding zones with appropriate political decisions to be made

6

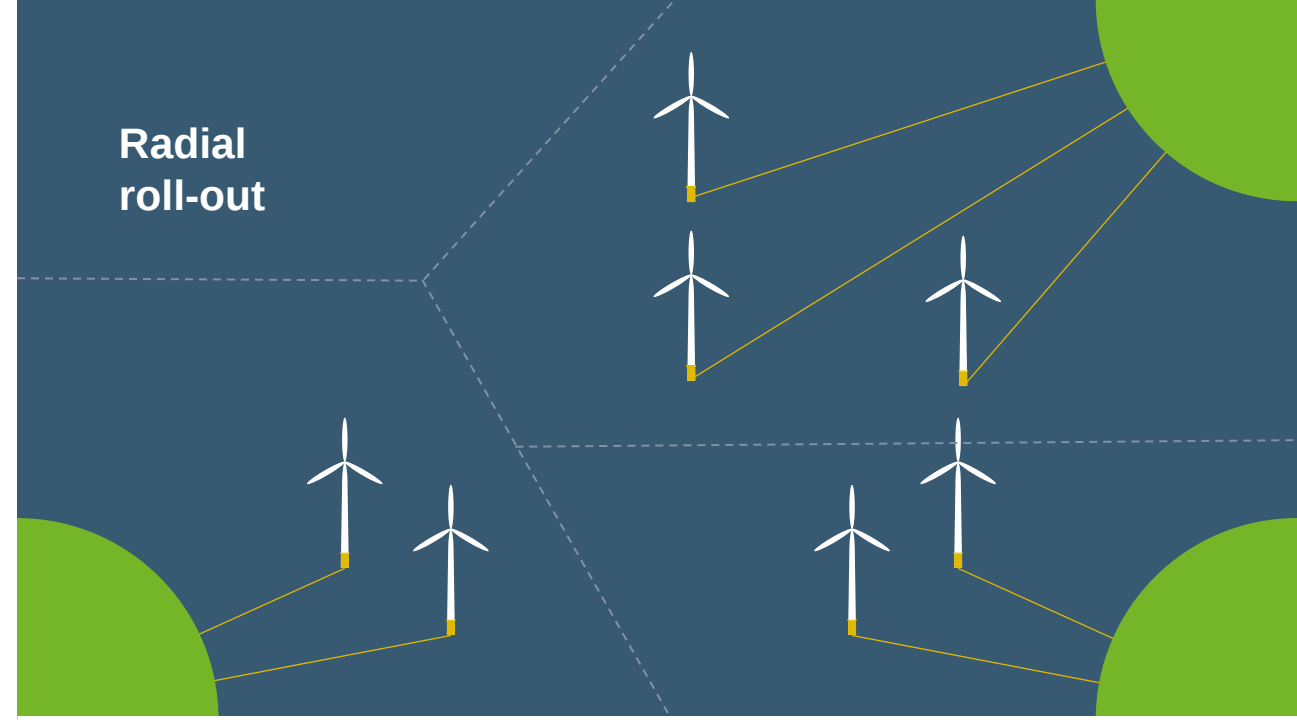
Enforcement of a DC grid code and compatibility between systems

1

A hubs-and-spokes based infrastructure roll-out to harvest far offshore wind cost competitively

- ⌋ Hubs-and-spokes infrastructure requires an integrated CBA methodology and evaluation of multiple time horizons
- ⌋ A meaningful CBA requires early definition of configurations (factuals) and reference cases (counterfactuals)
- ⌋ Hubs-and-spokes configurations are a cost-competitive alternative compared to a pure radial roll-out...
- ⌋ ... and can offer system benefits, including modularity and optionality, flexibility, and reduction of landing zone areas

Radial roll-out

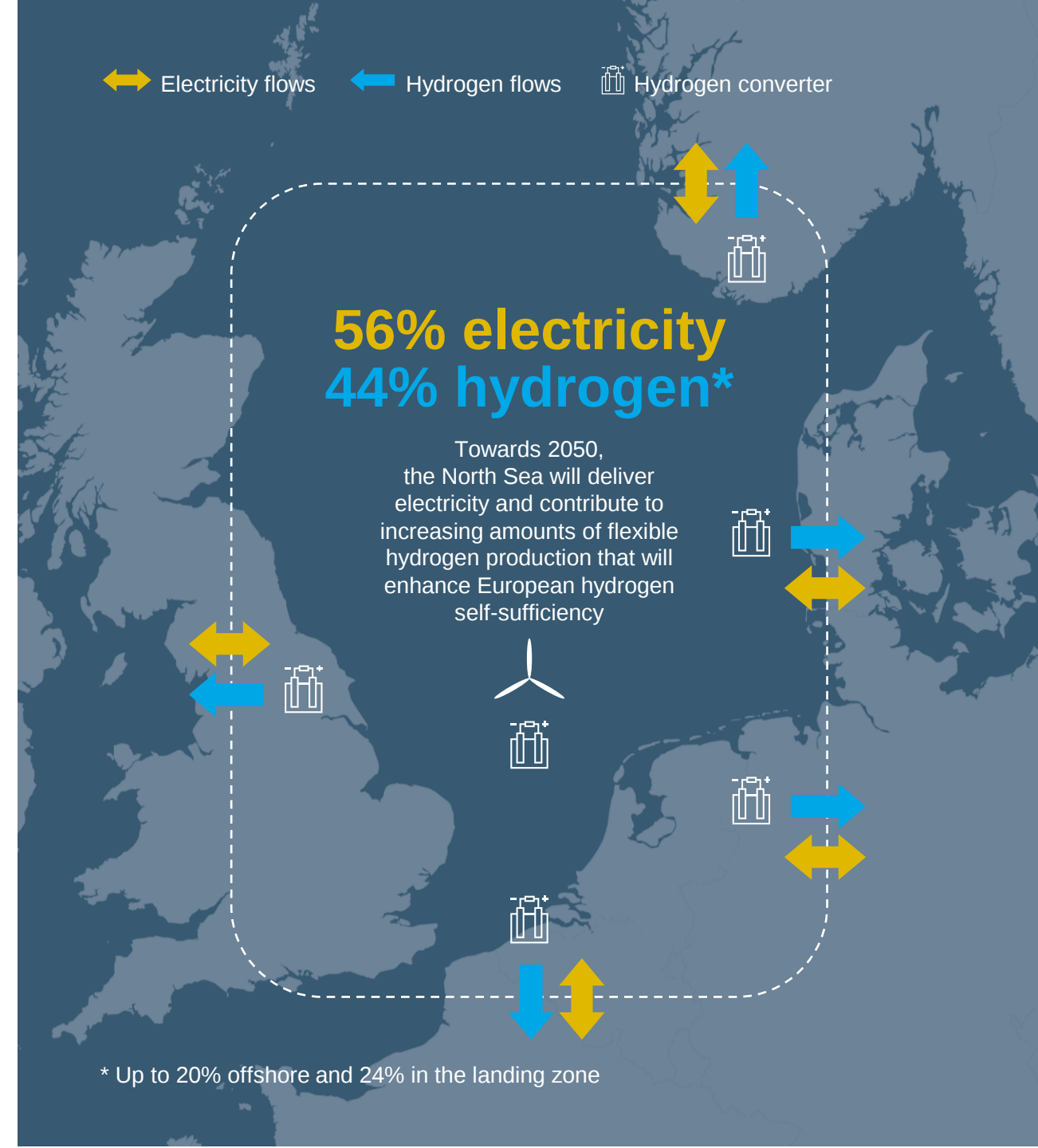


Roll-out with hubs and spokes



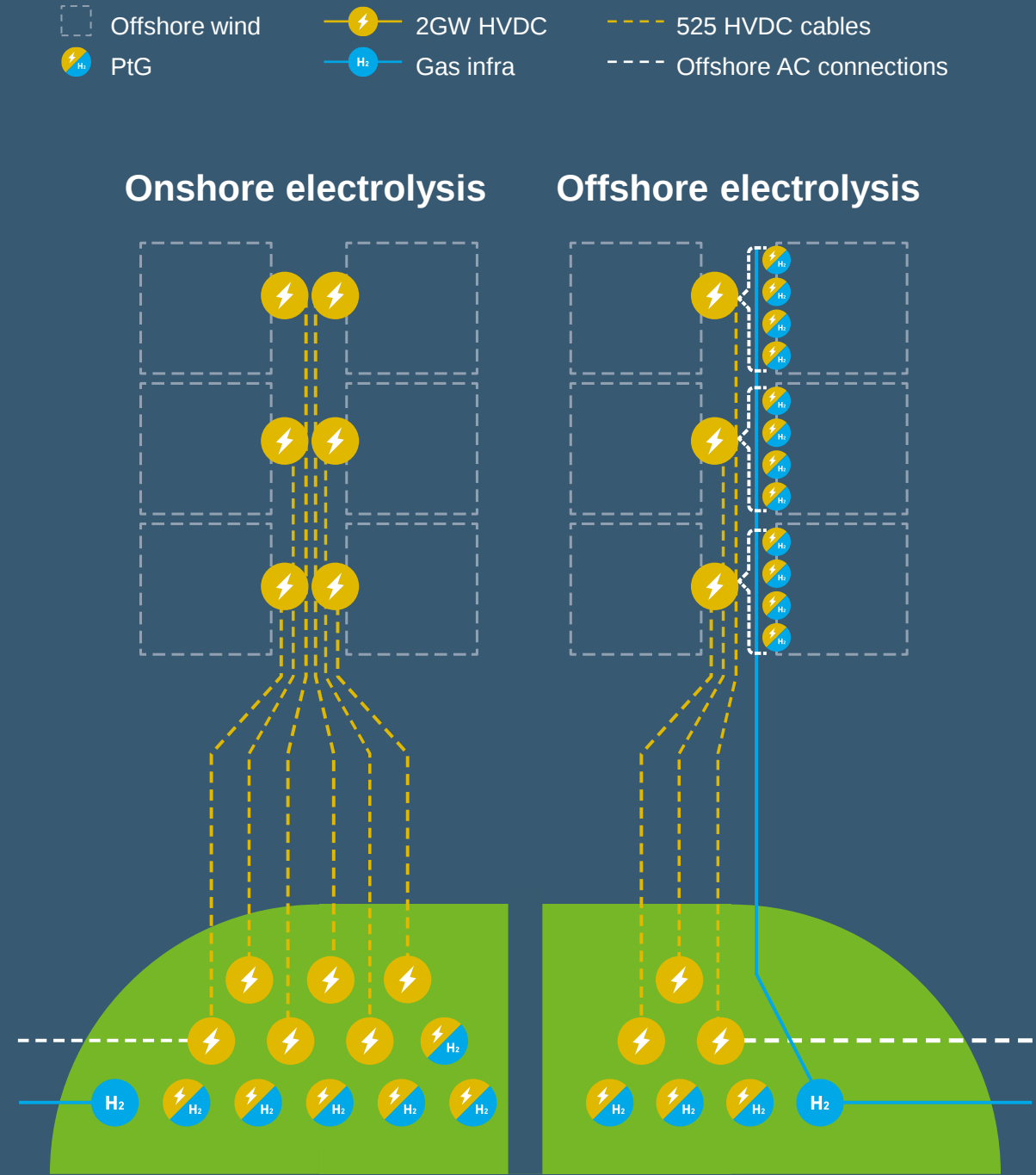
Hubs-and-spokes allow for an additional 39 GW of installed offshore wind capacity

- ⌘ A hubs-and-spokes roll-out with offshore and landing zone electrolysis is necessary to harvest the potential
- ⌘ Hub-connected offshore wind increases reliability and self-sufficiency at a €1 billion/year system cost reduction
- ⌘ Hub and spoke infrastructure results in a high utilisation rate of interconnectors (up to 70%)
- ⌘ Spokes and sector coupling reduce landing capacity needs with 24% in the North Sea



Offshore and landing zone electrolysis that can convert up to 44% of wind energy to hydrogen in 2050

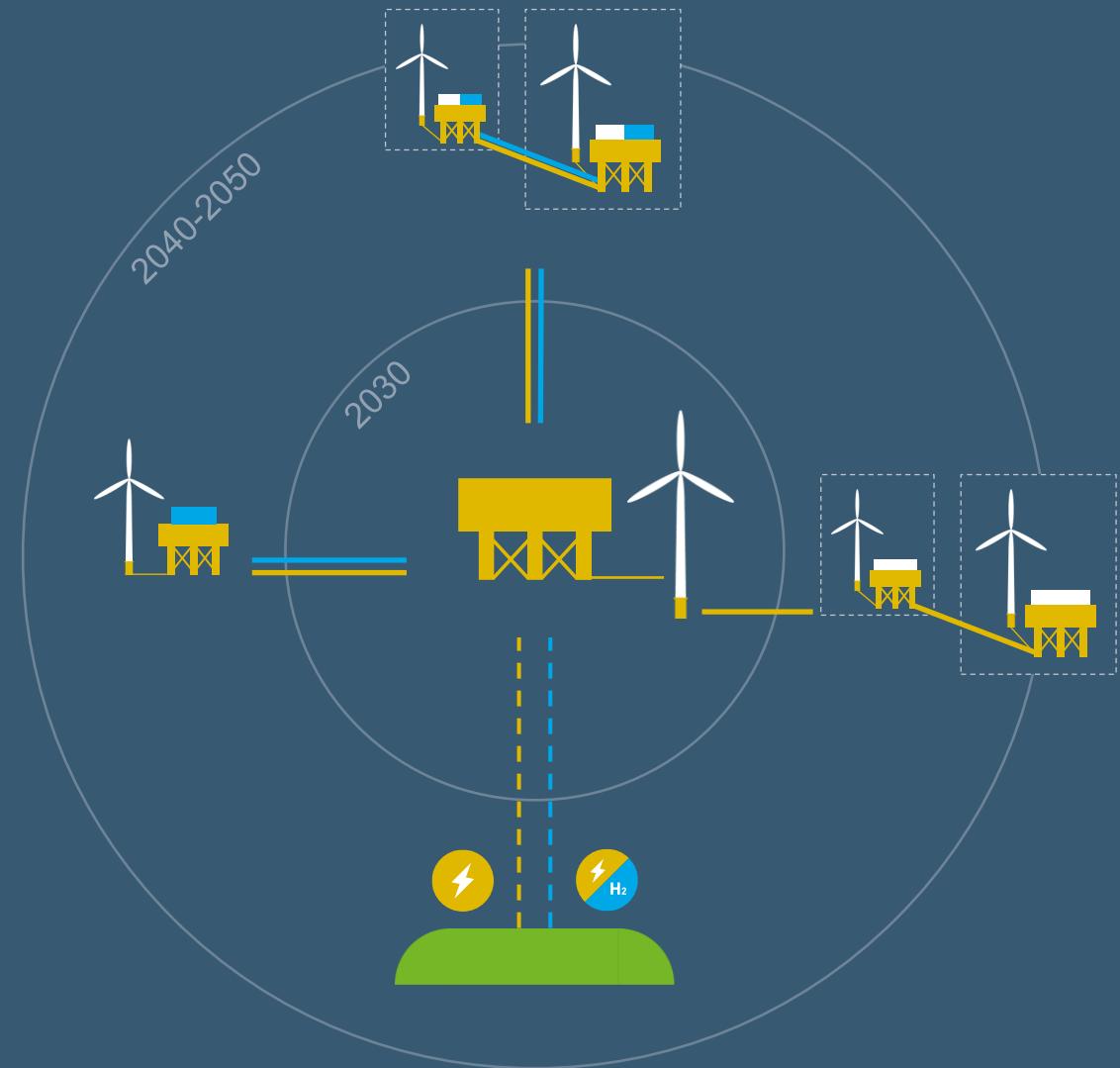
- ⌋ Offshore electrolysis is feasible from a technical and socio-economic perspective
- ⌋ Compared to “stand-alone” offshore electrolysis, grid-integrated systems increase system efficiency with 25%
- ⌋ Platforms offer an intermediate level of centralization, enabling a practical, modular and cost-effective hub solution
- ⌋ A clear outlook on offshore electrolysis (e.g., via tenders) is required to scale up the market across the value chain



Anticipatory investments will pay off in the long run by enabling a modular, internationally coordinated roll-out

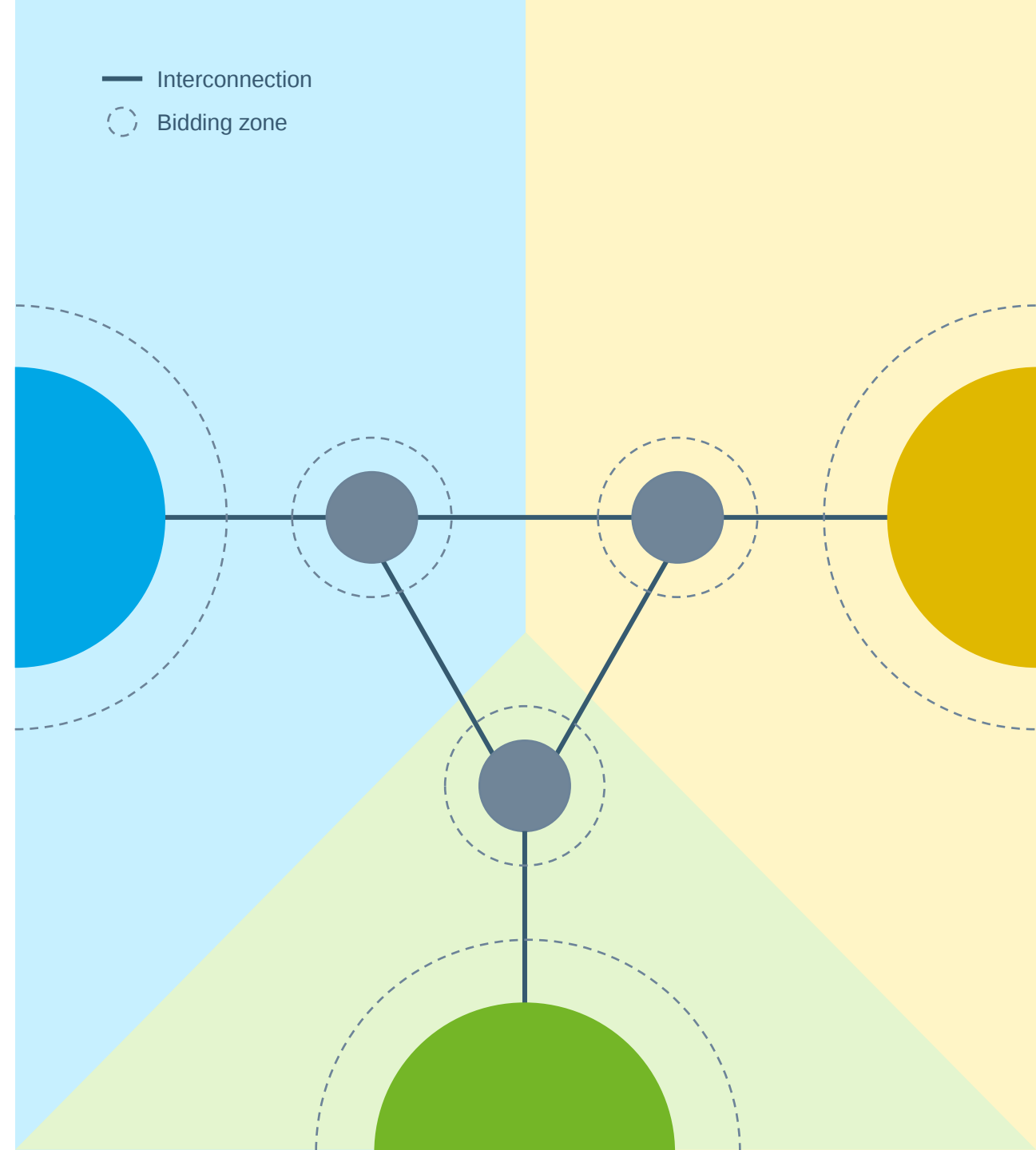
- ⌋ North Sea countries must envision hubs-and-spokes in spatial planning
- ⌋ Modularity allows adding components for flexible future design, adapting to uncertain market developments
- ⌋ Modularity is required at system, hub, and component level and requires anticipatory investments
- ⌋ A policy on the level of anticipatory investments could further enable a modular roll-out

Modularity allows for flexibly adding components



Implementation of offshore bidding zones with appropriate political decisions to be made

- ⌋ OBZ optimise electricity market and operational efficiency while reflecting the physical limitations of the grid
- ⌋ A suitable governance model for national hubs-and-spokes can largely be based on existing frameworks
- ⌋ National governments are best equipped to mitigate risk for a continued offshore wind roll-out under an OBZ setup
- ⌋ Clarity on the market setup and a full understanding of the risks is required before the wind farm tender



Enforcement of the DC grid codes and compatibility between systems

- ⌋ NSWPH delivered requirements for the HVDC building blocks which can be used as specifications in tenders
- ⌋ TSOs and vendors are responsible for multi-vendor and compatibility with the existing AC system
- ⌋ Plan for compatible and expandable HVDC grids to accelerate technical development of multi-vendor systems

