Offshore grid developments TenneT

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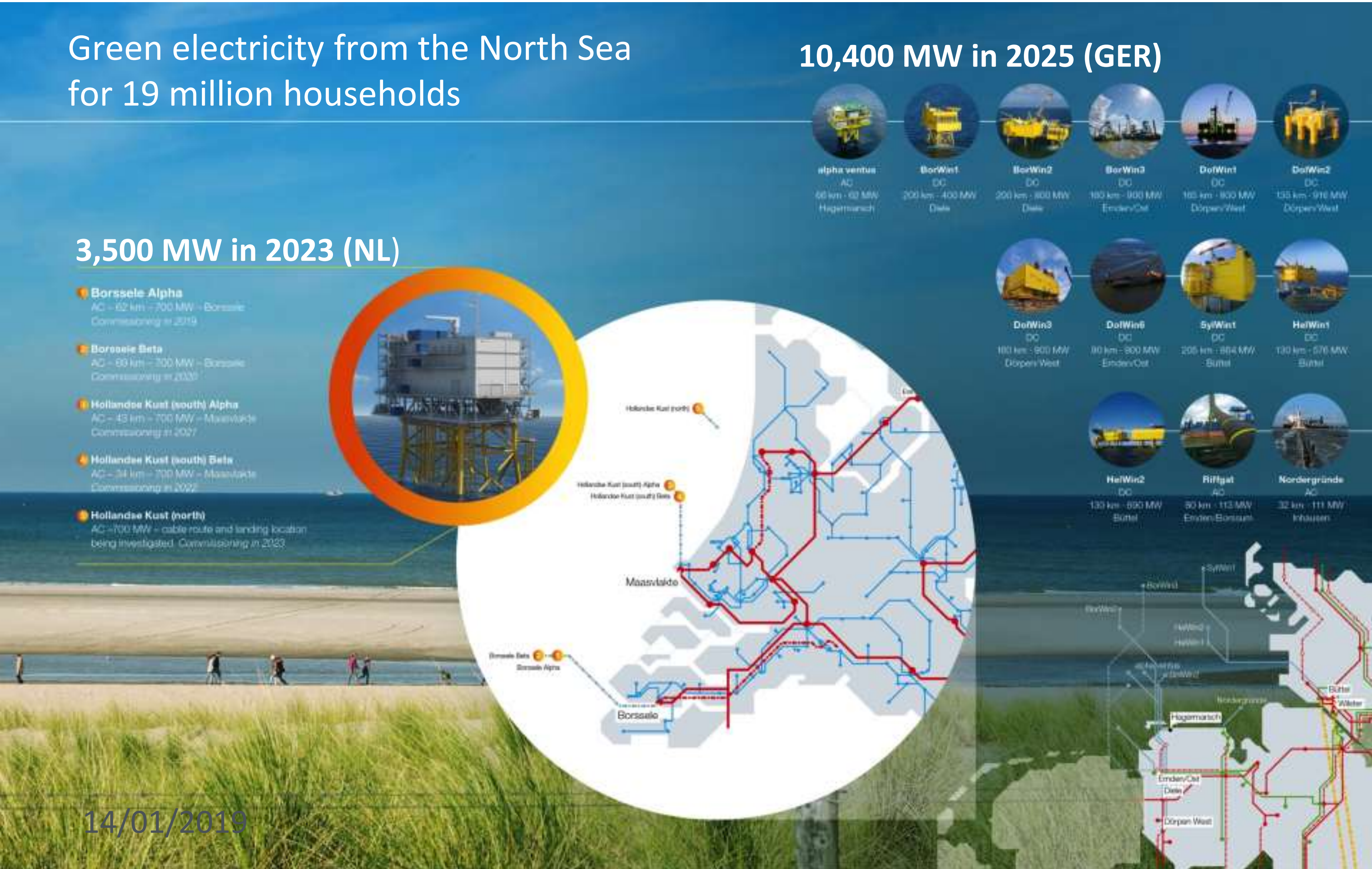
Program of today!

- Introduction
- TenneT connecting offshore wind energy
  - Phase I, Now-2023
  - Phase II, 2023-2030
  - Phase III 2030-2050
- Challenges and opportunities for a new energy system
- Opportunities for students/graduates withint TenneT

TenneT at a glance

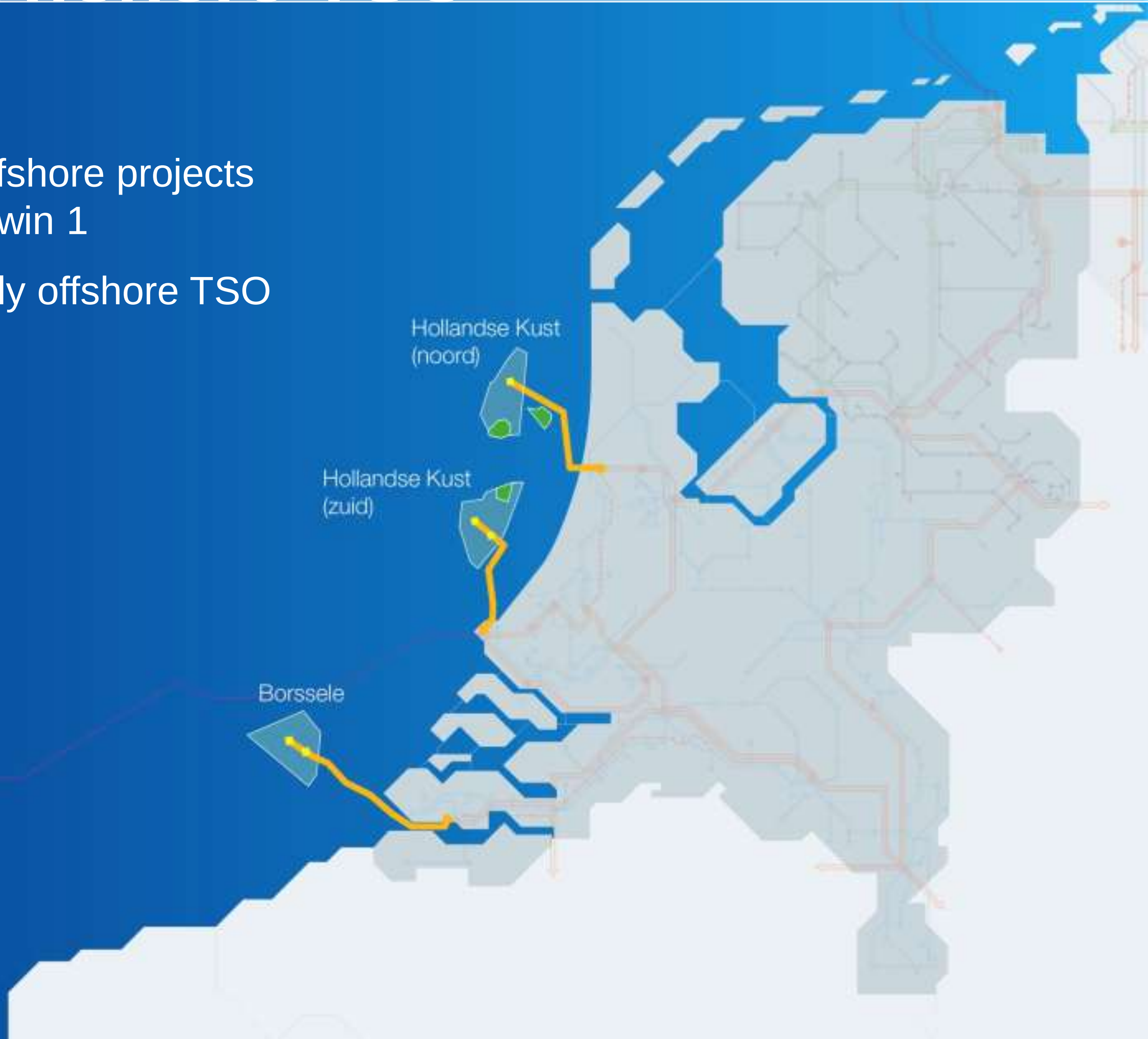
- Europe's first cross-border grid operator for electricity
- Top five grid operator in Europe
- International offshore division
- 23.000 km high-voltage lines
- 4.700 km offshore cable
- 41 million end-users
- ~4.000 employees
- Asset base: EUR 20.4 bn
- 99,9986% security of supply
- 10-year investment portfolio : EUR 28 bn

Connecting offshore wind energy



TenneT: Offshore TSO

- Initially German offshore projects alpha ventus / Borwin 1
- Since 2016 officially offshore TSO in Netherlands



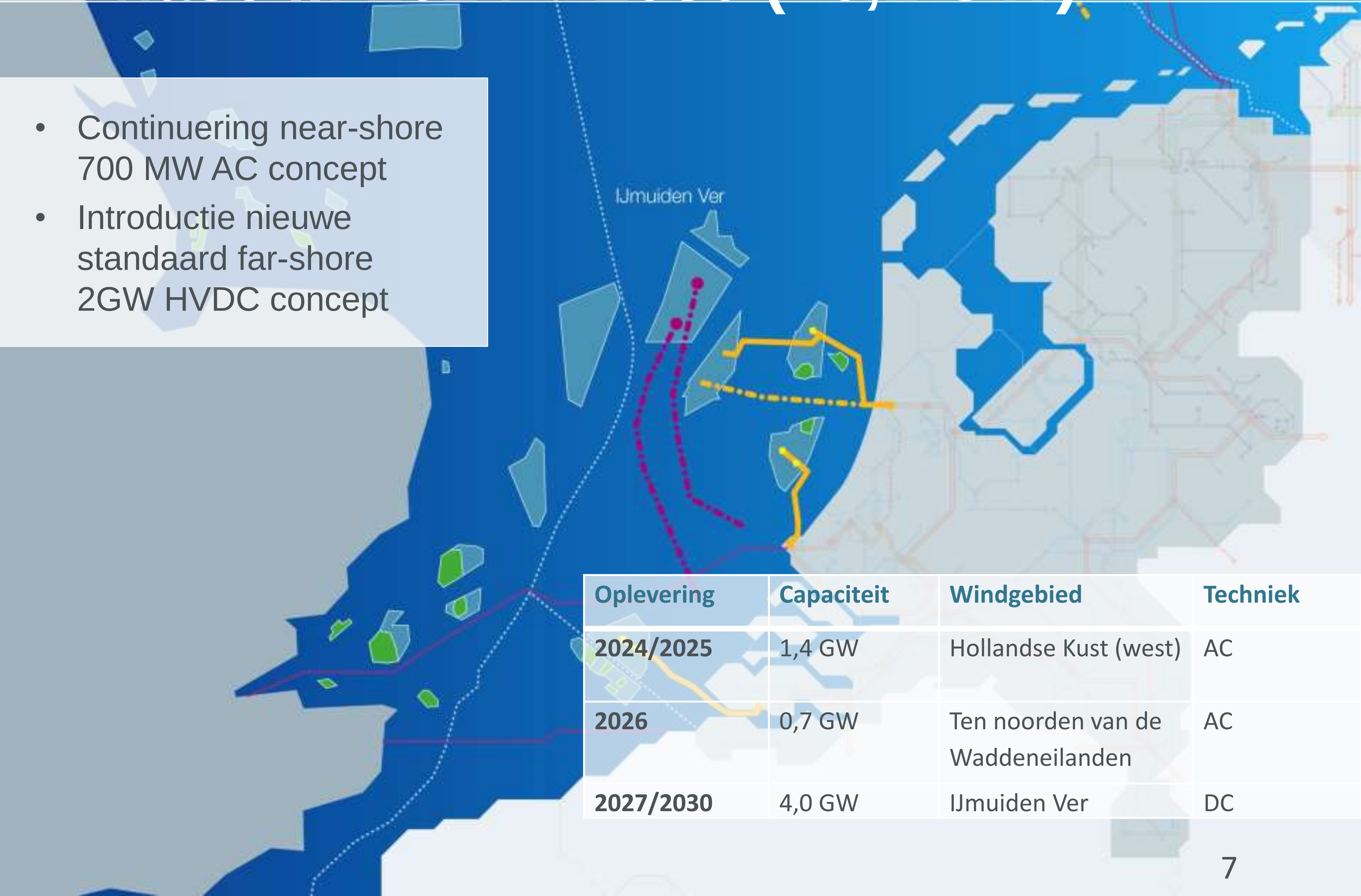
Phase I: 2019 – 2023 (+3.5 GW)

- 3.5 GW: 5 x 700 MW
- Standardized concept
- AC connections

Year	Capacity	Area
2019	700 MW	Borssele
2020	700 MW	Borssele
2021	700 MW	Hollandse Kust (zuid)
2022	700 MW	Hollandse Kust (zuid)
2023	700 MW	Hollandse Kust (noord)

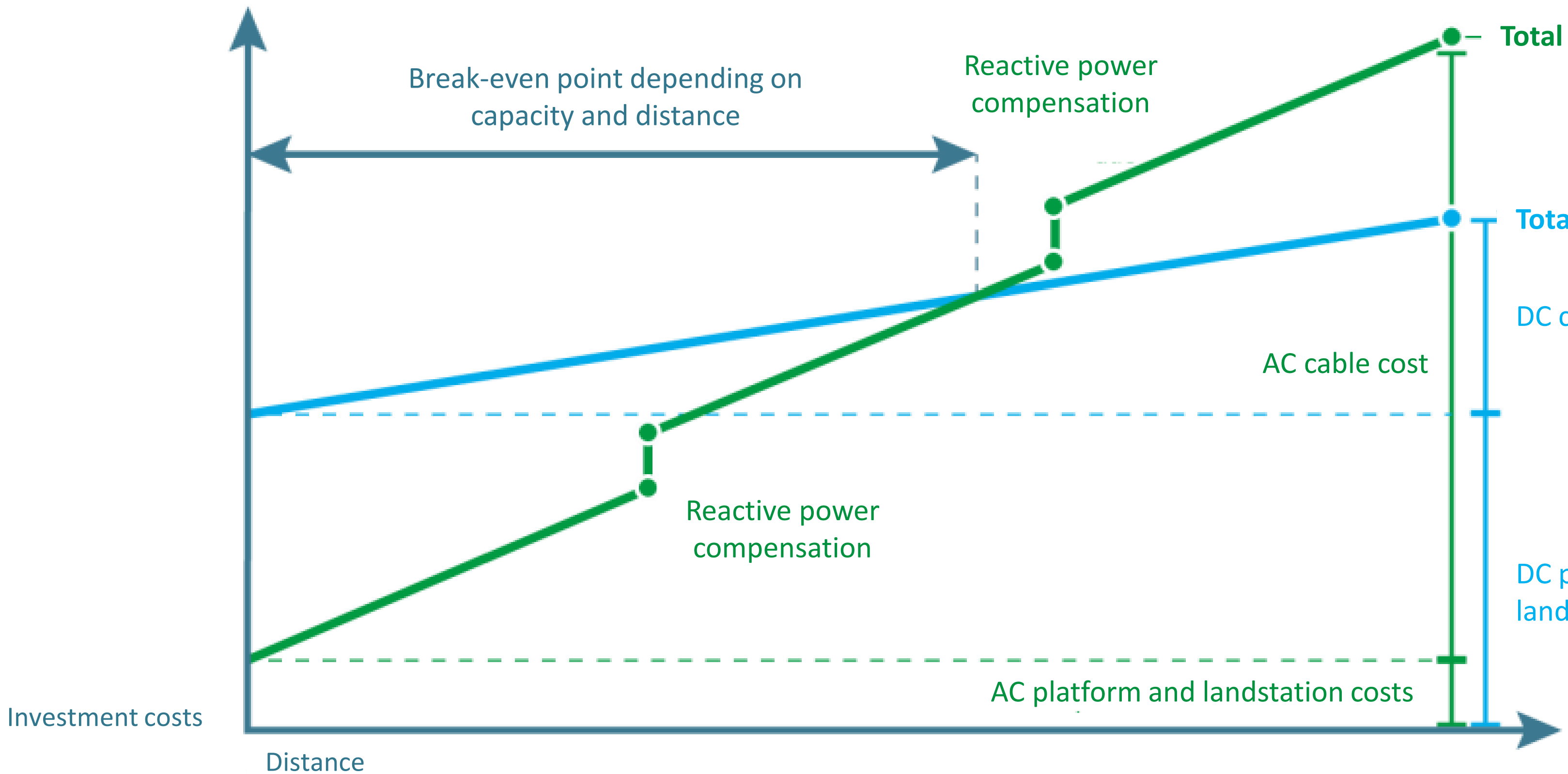
Phase II: 2024 – 2030 (+6,1 GW)

- Continuering near-shore 700 MW AC concept
- Introductie nieuwe standaard far-shore 2GW HVDC concept



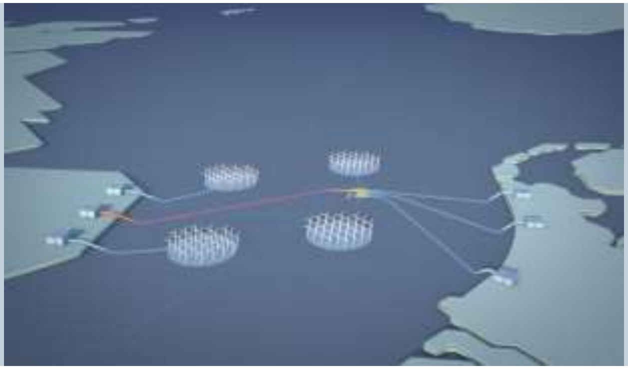
Oplevering	Capaciteit	Windgebied	Techniek
2024/2025	1,4 GW	Hollandse Kust (west)	AC
2026	0,7 GW	Ten noorden van de Waddeneilanden	AC
2027/2030	4,0 GW	IJmuiden Ver	DC

From AC to DC

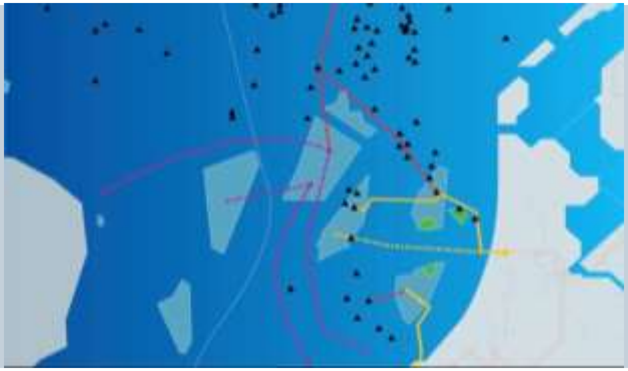


Break-even point depending on capacity and distance
Reactive power compensation
Total cost AC
Total cost DC
DC cable cost
AC cable cost
Reactive power compensation
DC platform and landstation costs
AC platform and landstation costs
Investment costs
Distance

Future outlook: Innovations



WindConnector



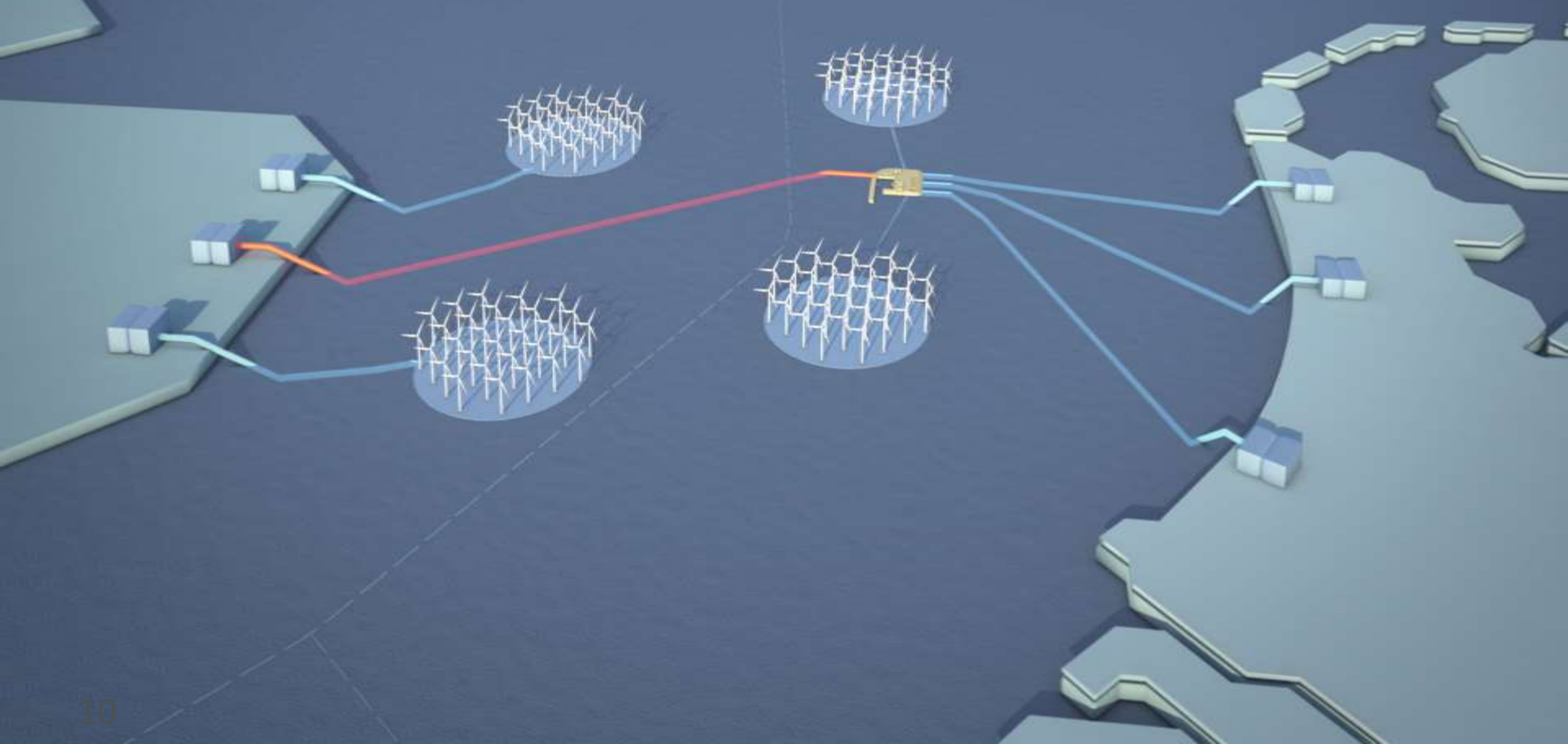
Connecting Oil and Gas platforms

Platform or Island

Additional offshore wind

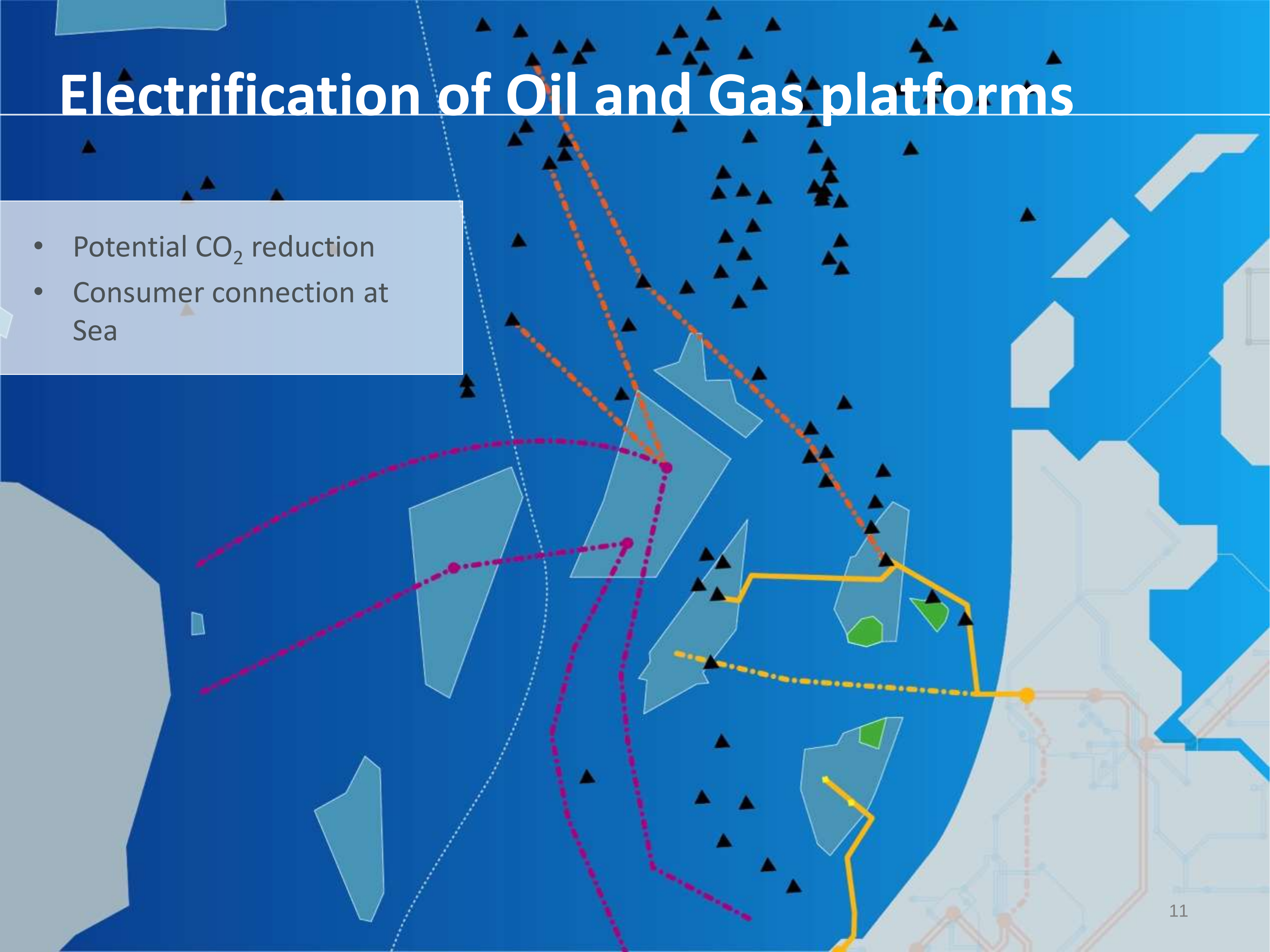
Windconnector NL and UK

- Increase usage of infrastructure
- Integration of electricitymarkets NL and UK
- Cost saving potential on offshore connections



Electrification of Oil and Gas platforms

- Potential CO_2 reduction
- Consumer connection at Sea

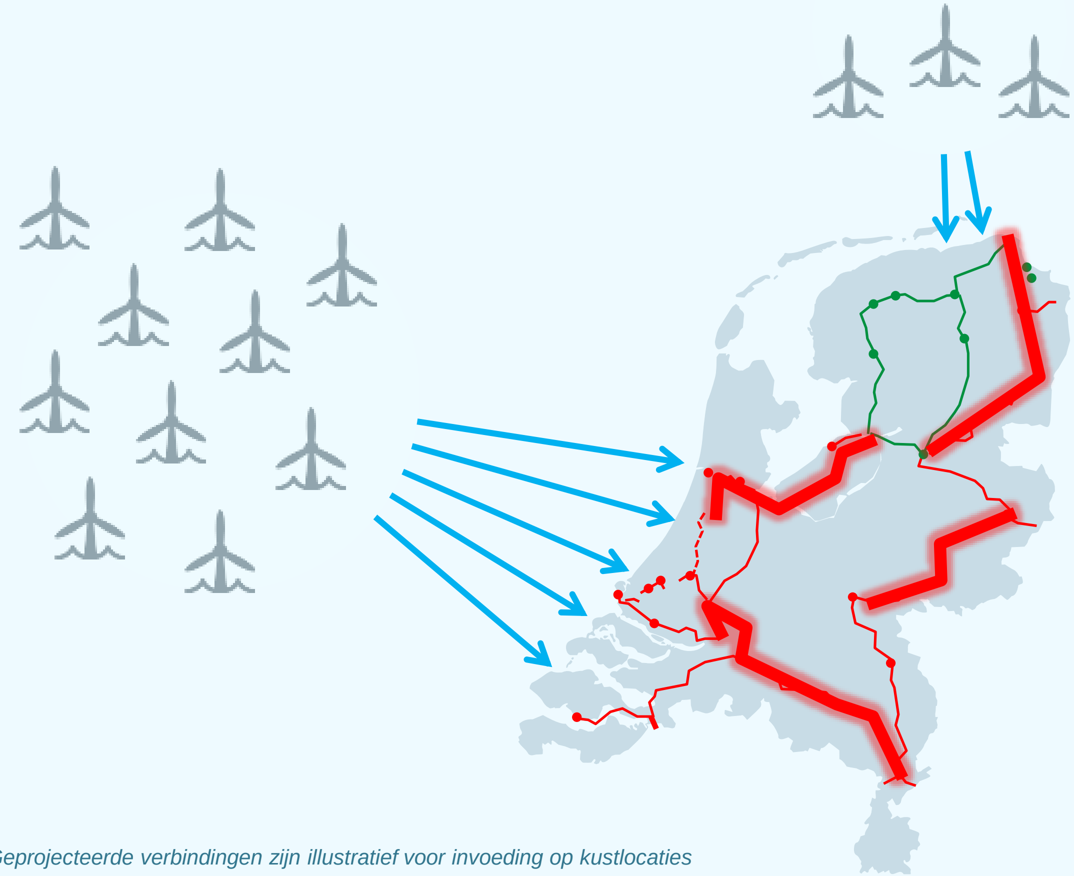


Converters: jacket or island?

Artificial island as hub for DC offshore infrastructure

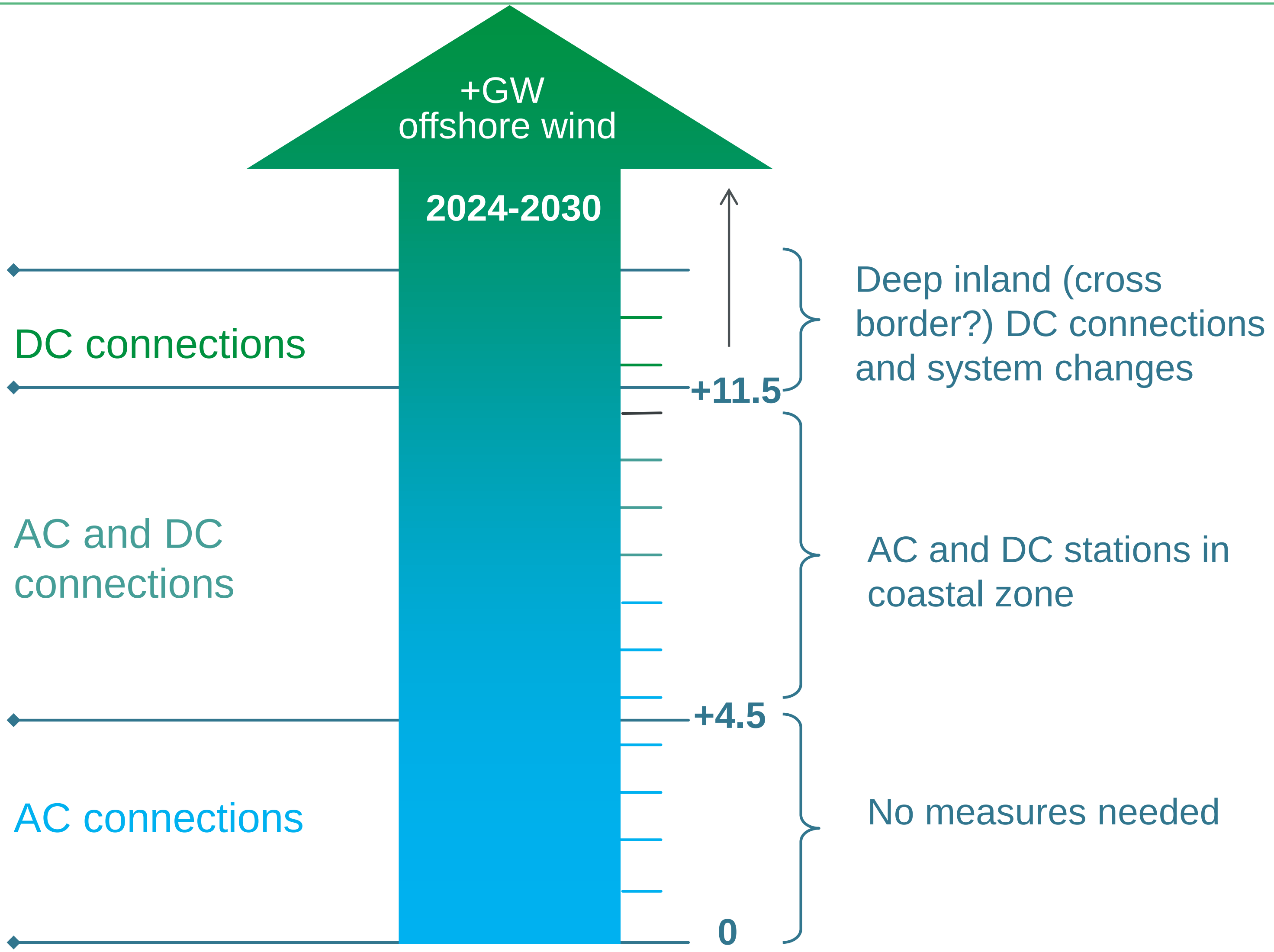
More offshore wind?

To accommodate more offshore wind a change in the energy system is needed



Geprojecteerde verbindingen zijn illustratief voor invoeding op kustlocaties

Conclusion: grid analysis 2024 - 2030



Additional measures needed

- Preventing long-distance transport (deep inland crossings)
- Stimulate demand
- Security of Supply
- Balancing

1. Electrification industrial processes
2. Conversion

1. Electrification industrial processes

- Growth of supply of sustainable energy in balance with new demand for energy
- Accelerating in coastal areas; where wind energy comes ashore, less transport capacity
- Hybrid systems create flexibility

2. Conversion

- In 2030: production green hydrogen of approx. 3 - 4 GW
- Hydrogen contributes to (further):
  - Balancing
  - Security of Supply
  - Stimulates power demand, supports price
  - Making other sectors more sustainable

Phase III: 2030 – 2050

- Increased distances
- Much larger wind area's
- How to keep LCOE low
- How to feed in RES efficiently

Energy Transition

Climate change & Paris agreement:

- Limit global temperature rise below < 2ºC, pursue < 1.5ºC

EU Goals:

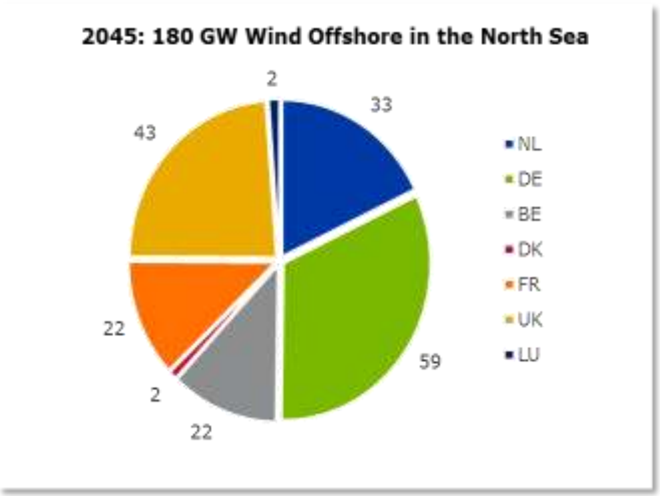
- 2030 (ref 1990): 40% CO_2
- 2050: 80-95% CO_2
- ***Power sector decarbonized***

North Sea Political Declaration

Translate COP 21 Study

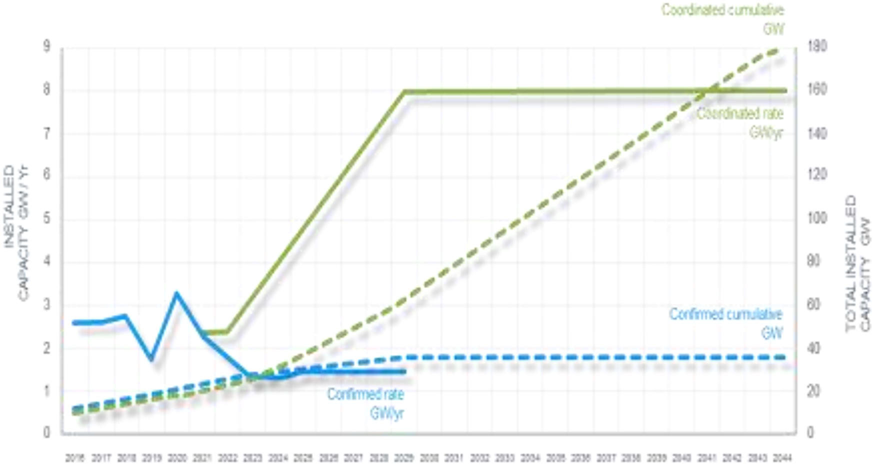
Key assumptions:

- Total energy demand in 2050: 50% reduction compared to 2010
- Level of electrification in 2050: 45%
- 100% CO_2 neutral electricity generation in 2045

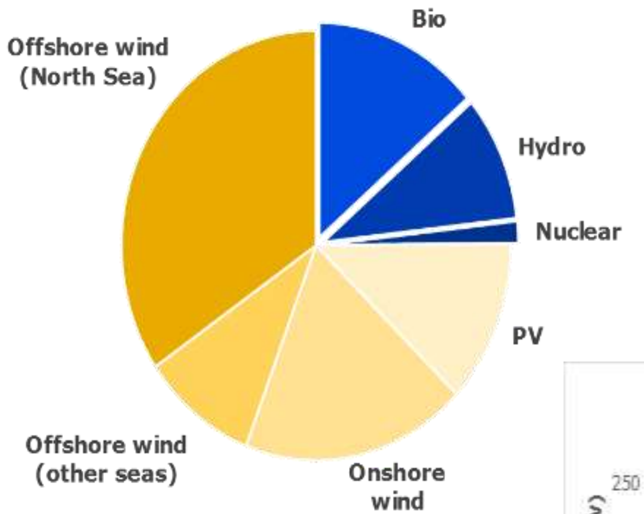


Key Results:

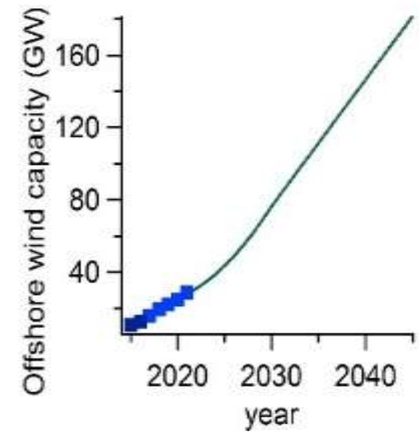
- North Sea requires ~ 180GW of offshore wind by 2045 to meet COP21.
- Interconnection requirements in North Sea ~ 50 GW (adequacy)
- To reach 180 GW in 2045 a significant ramp up in installation rate is required (installation rate show in graph)
- Space exists in the North Sea to accommodate 180GW.



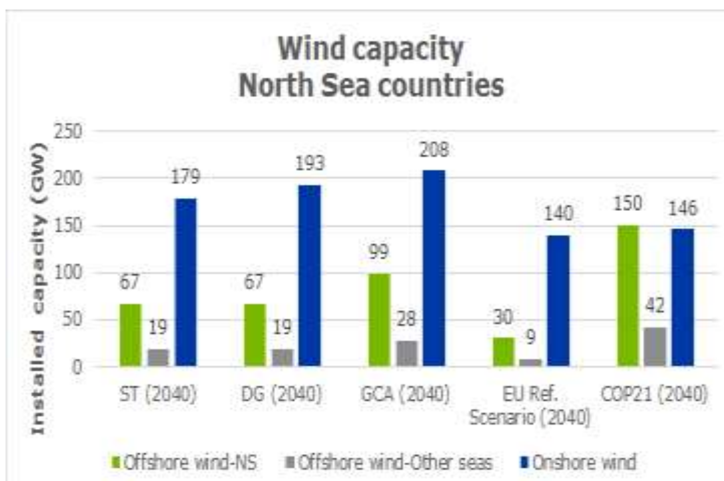
Offshore wind is essential to realise 100% decarbonisation of the electricity supply



The installed offshore wind capacity for the North Sea countries is expected to grow significantly to an estimated 70-150 GW



Offshore wind will provide a significant share of the RES needed for the North Seas countries to meet the Paris Agreement goals



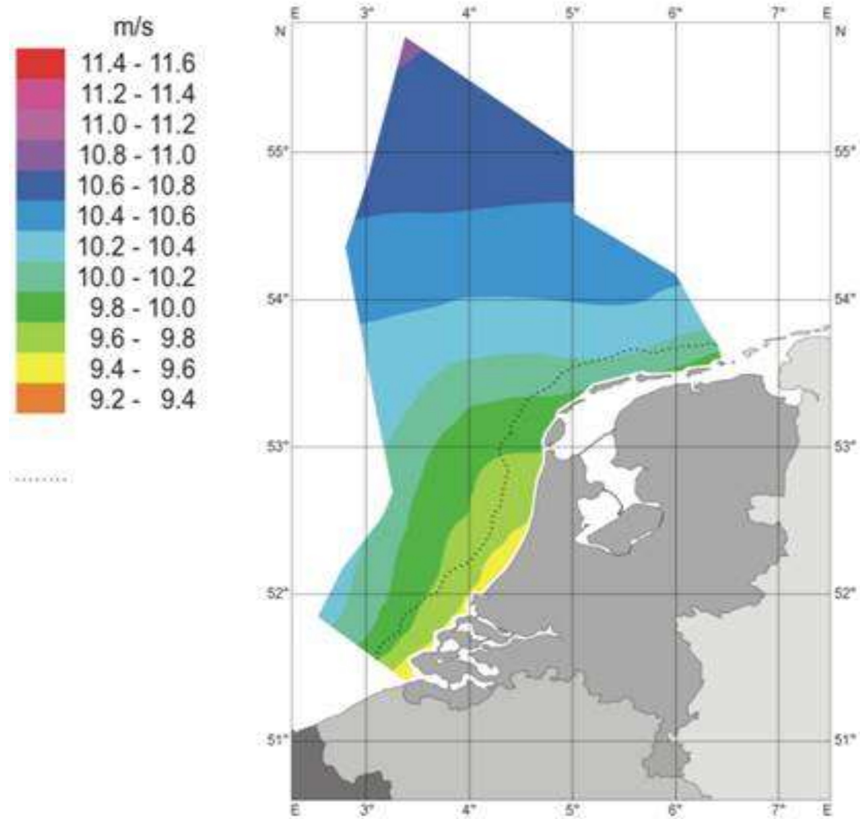
The offshore wind deployment rate needs to increase towards 2-7 GW/year over the period 2023-2040

Solution: location

- Shallow waters
- Water depth has a significant impact on the development for offshore wind.
- A development in shallow waters contributes significantly to cost reduction.

- Wind conditions
- Wind conditions get better further at sea, which partially compensates the increase in cost for distance.

- Central location
- For a European coordinated roll-out, a central location is important.



Strong development offshore wind

COP21 : radical change in electricity generation mix

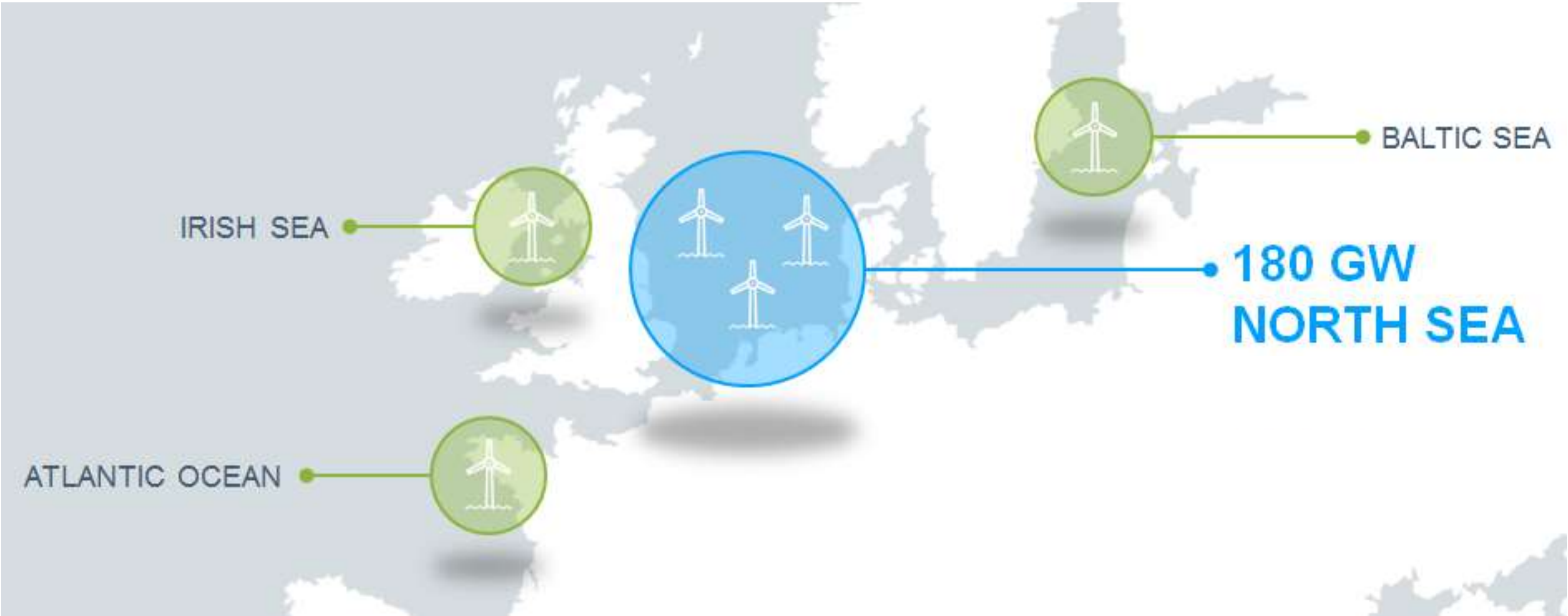
- **230** GW offshore wind capacity, **180** GW to be developed in the North Sea in 2050

WindEurope forecast

- **70** GW offshore wind capacity in Europe

PBL forecast

- **60** GW offshore wind capacity in the Dutch part of the North Sea in 2050



Phase III: 2030 – 2050 (+ 48 GW?)

- Large scale wind farms
- Location: depth & wind
- Power Link Island
- Wind Connector
- Hub & Spoke

North Sea Wind Power Hub

Power to Gas

- System integration required/expected in future energy system.
- Outlook in future developments, finding the optimal value in synergies between electricity and molecules.

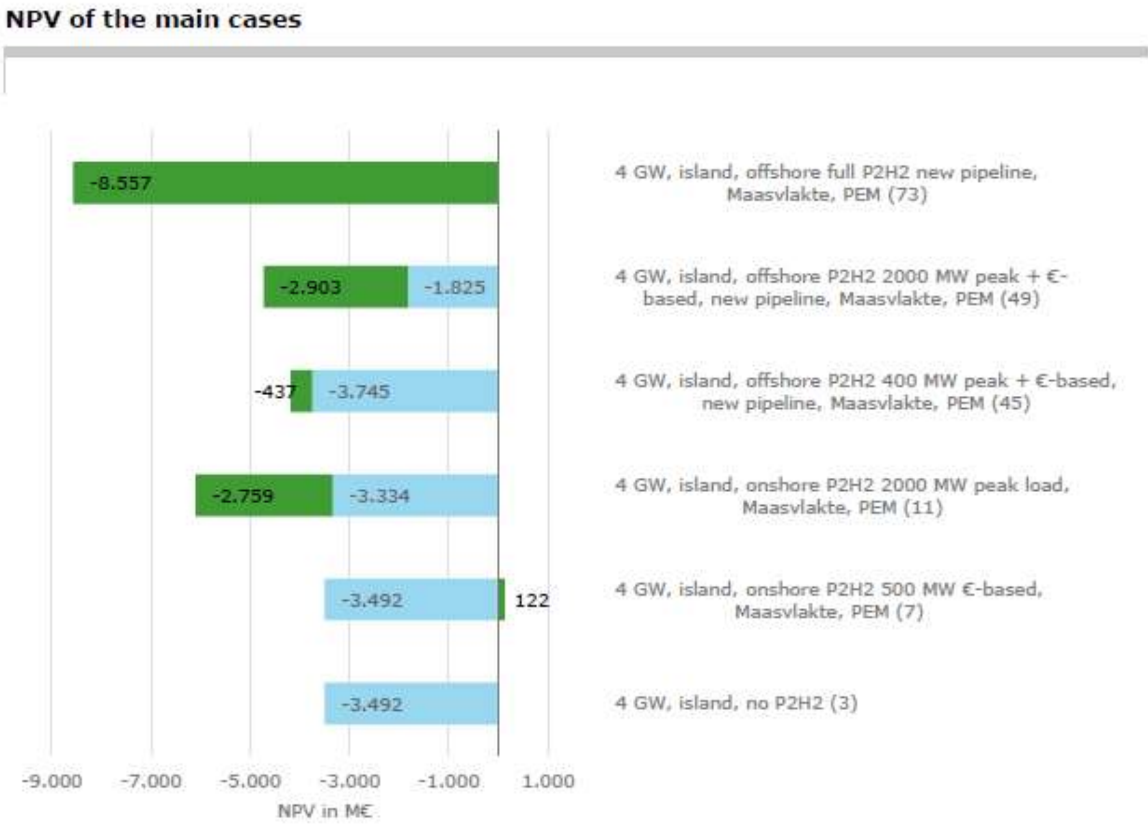
Power to Gas – IJmuiden ver

- Study on technical/economic feasibility of Power to Hydrogen for IJmuiden ver

- Offshore vs onshore Power to Hydrogen

Power to Gas – IJmuiden ver (Results)

- Power to gas economically viable
- Highly dependent on hydrogen/electricity price
- Offshore placement is interesting for higher capacities



The way forward

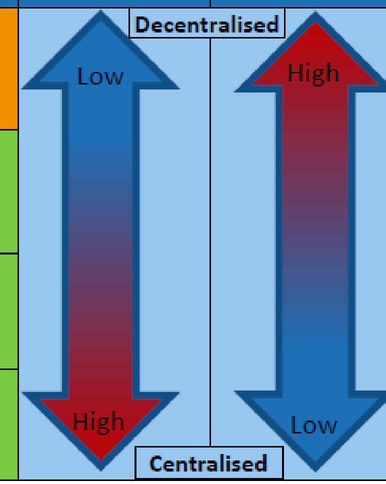
System choices

Timely decision making, structure and commitment	International coordination	Alignment between North Sea users
• Electrification industry • Stimulate flexibility and storage • Development hydrogen	• With neighboring countries on electricity highways in the direction of centers with high consumption	• Spatial planning • Ecology

Policy choices

Table 3. Approaches to offshore wind site development

	Zone identification	Site selection	Site investigation	Consenting/ permitting	Grid application	Grid design & construction	Government risk/control	Developer risk/control
	Crown Estate	Developer	Developer	Developer via PINs	Developer / National Grid	Developer/ OFTO		
 EEG 2014	Government	Developer	Developer	Developer via BSH	TSO	TSO		
 EEG 2017	Government	Government	Government	Developer via BSH	TSO	TSO		
	Government	Government	Government	Government	Government /TSO	TSO		

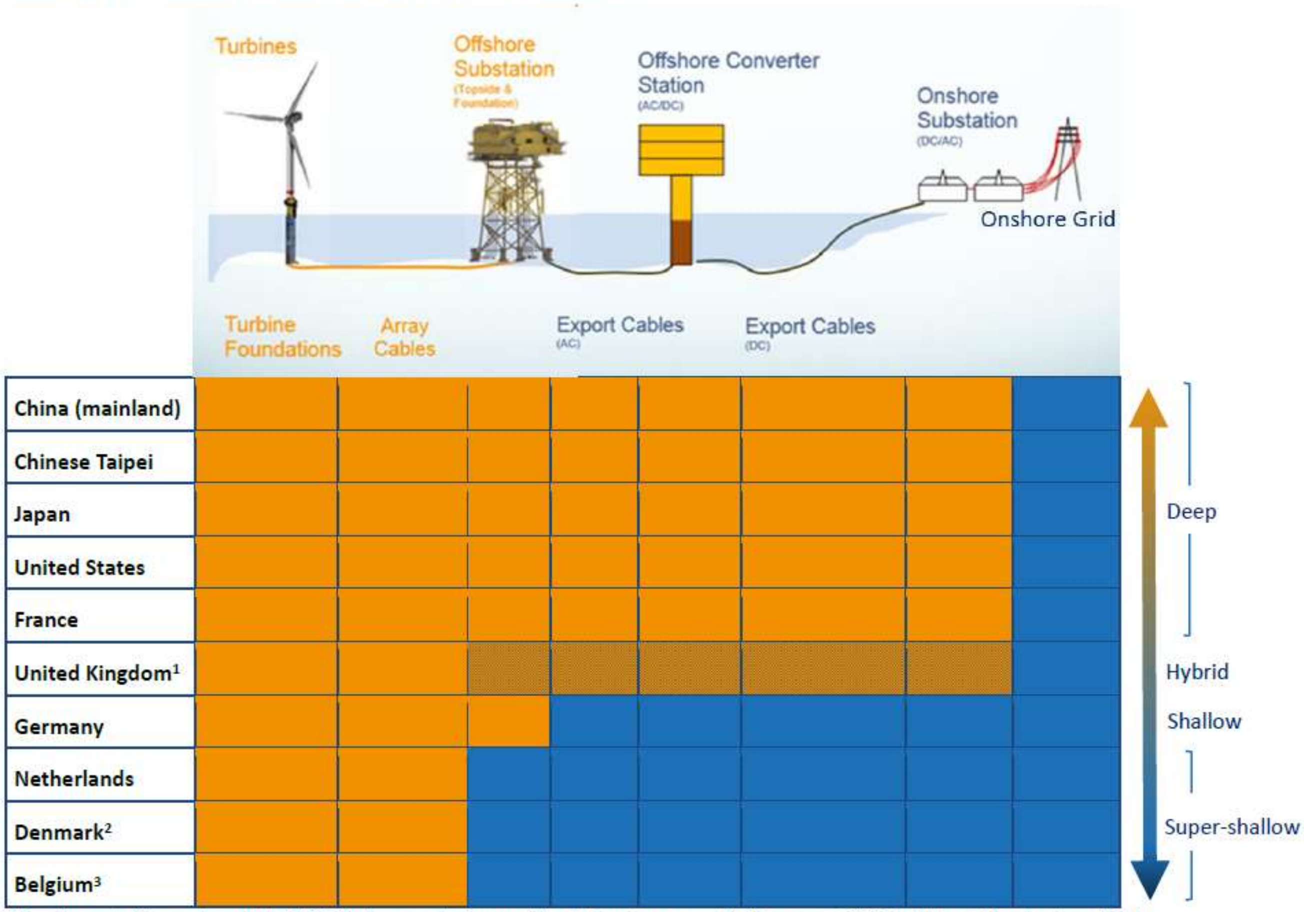


Note: Green indicates government/TSO responsibility; orange indicates developer's responsibility. The sequence of steps can vary by country (see below).

Source: (IEA- RETD, 2017)

Transmission asset responsibility

Figure 11. Overview of responsibility for construction and operation of offshore transmission assets (orange: developer responsibility; blue: TSO/third party responsibility)



[1] Developer builds assets, sells to OFTO (who operate the asset), and developer pays fee for usage. OFTO-build model, whereby a third party constructs the offshore assets, is also available but has yet to be implemented.

[2] Official offshore tender – TSO responsibility for grid connection; Open door or Nearshore – developer responsibility.

[3] Developer can choose to build grid connection and receive higher FIT (€150/MWh vs. €138/MWh).

Source: (IEA- RETD, 2017)

www.tennet.eu

TenneT is a leading European electricity transmission system operator (TSO) with its main activities in the Netherlands and Germany. With approximately 22,500 kilometres of high-voltage connections we ensure a secure supply of electricity to 41 million end-users.

Taking power further