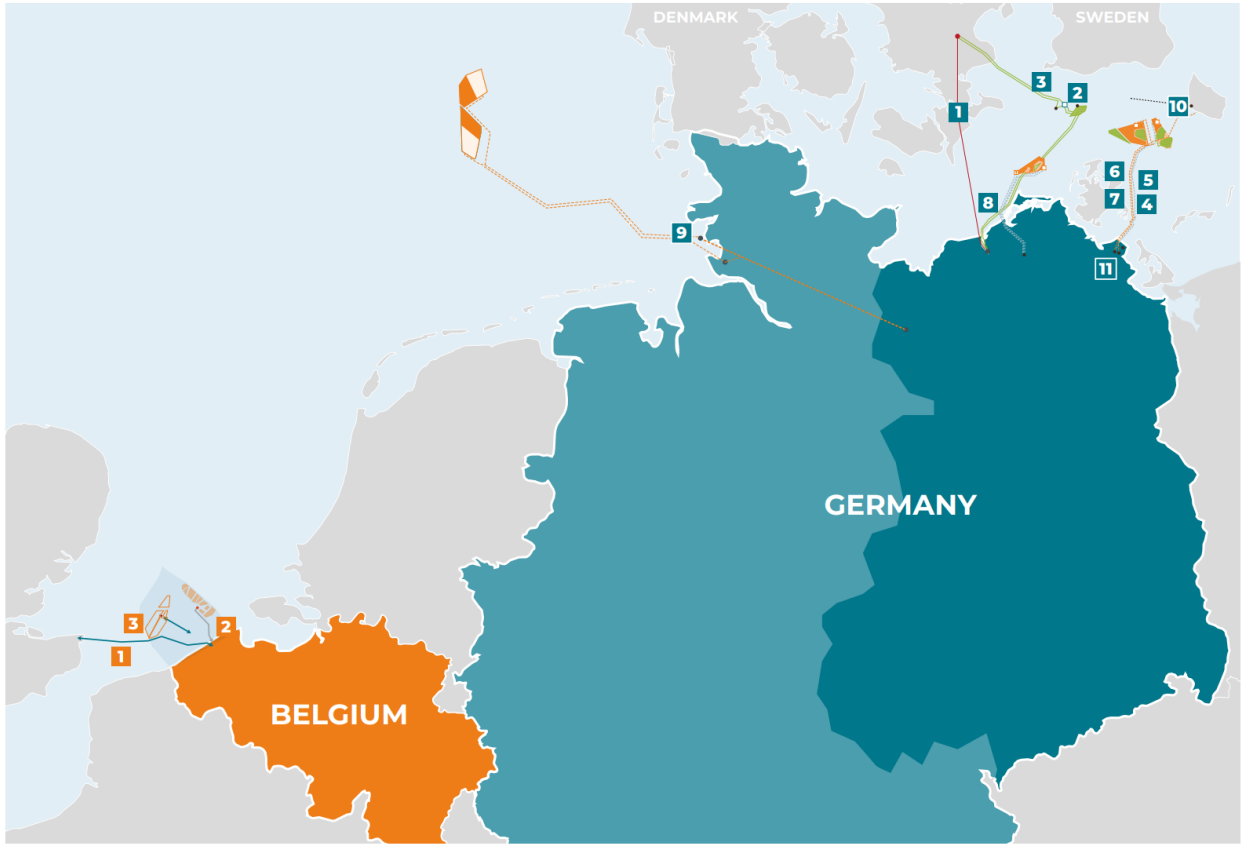
Harvesting offshore wind

A TSO view on international offshore grid development in Europe

Felix Fliegner // 50Hertz // 16.05.2025 Strommarkttreffen

Elia Group is pioneering projects in Baltic Sea and North Sea

Our offshore activities and recent publications



ELIA'S OFFSHORE PROJECTS IN BELGIUM

1. NEMO LINK
2. MOG
3. PRINCESS ELISABETH ISLAND

50HERTZ'S OFFSHORE PROJECTS IN GERMANY

1. KONTEK INTERCONNECTOR
2. BALTIC 1/BALTIC 2
3. KRIEGERS FLAK - CGS
4. OSTWIND 1
5. OSTWIND 2
6. OSTWIND 3
7. OSTWIND 4
8. OST-6-1
9. NORTH SEA CONNECTOR
10. BORNHOLM ENERGY ISLAND
11. BALTIC WINDCONNECTOR

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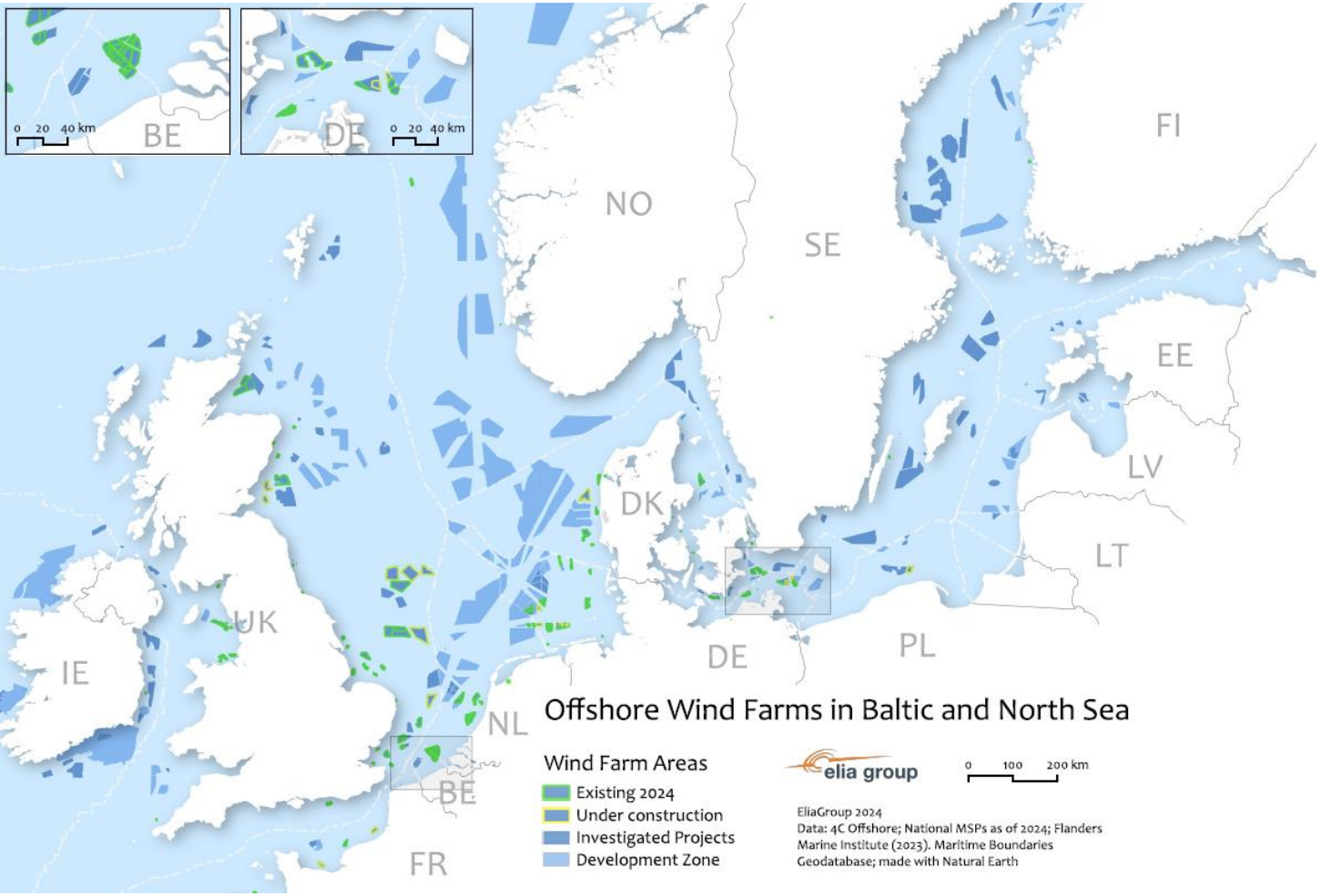
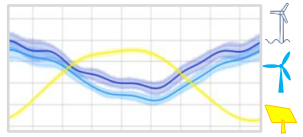
Topics of today

1. Key challenges of offshore wind development in Europe
2. Importance of cross-border cooperation
3. Forums of offshore grid planning
4. Wrap-up and outlook

Offshore wind is a key ingredient to Europe's energy mix

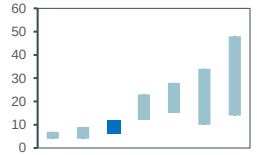


Status quo



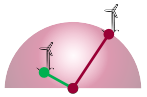
Key contribution to energy mix

Unequal wind potential



Competitive LCOE

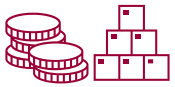
Challenges ahead



Longer cable runs

Limited space

Lead time



Resources

Our contribution

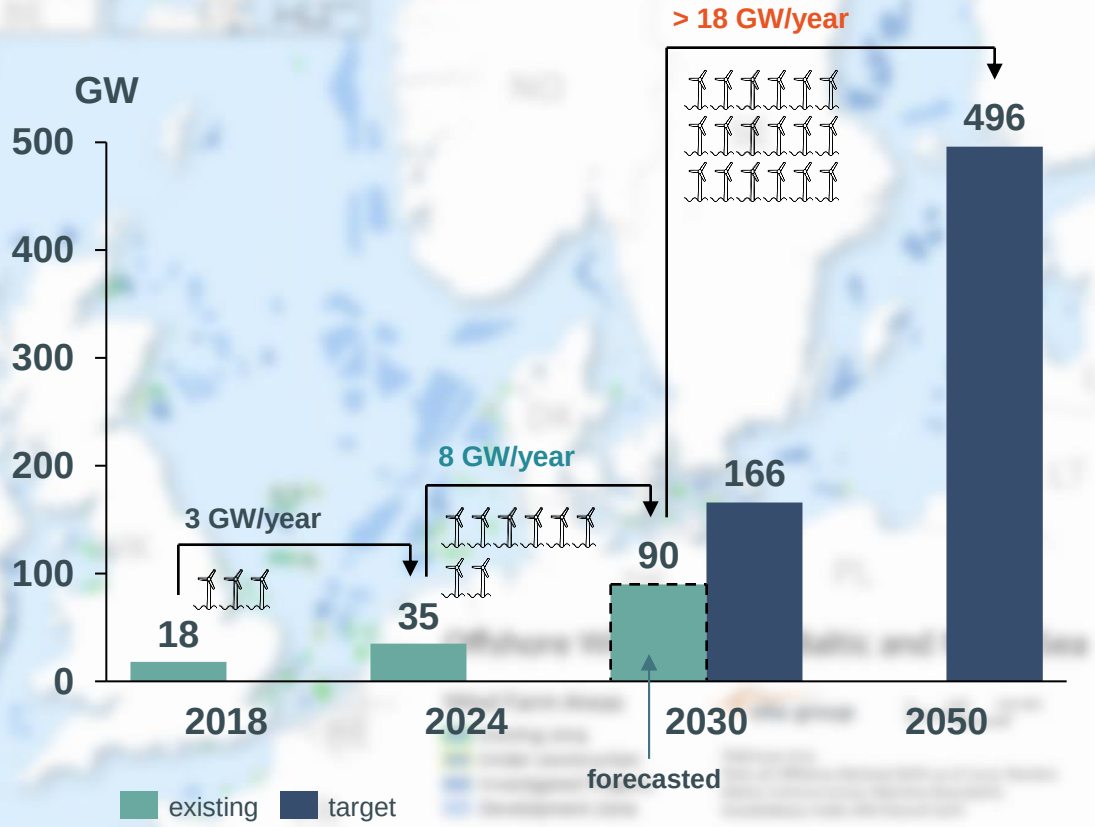
- Conduct integrated long-term planning
- Facilitate financing and funding solutions
- Advocate for efficient and affordable system development

Data: WindEurope annual statistics, BNEF Wind Market Outlook 2H 2024, ONDP 2024
Net capacity additions, retrofit or decommissioning not considered

Offshore wind is a key ingredient to Europe's energy mix

Offshore wind targets

European Union + United Kingdom + Norway



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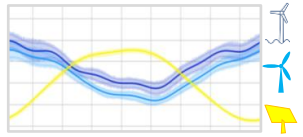

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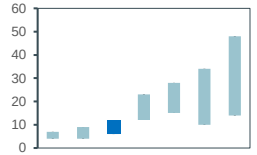
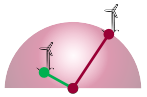


Competitive LCOE

Challenges ahead



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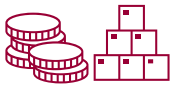

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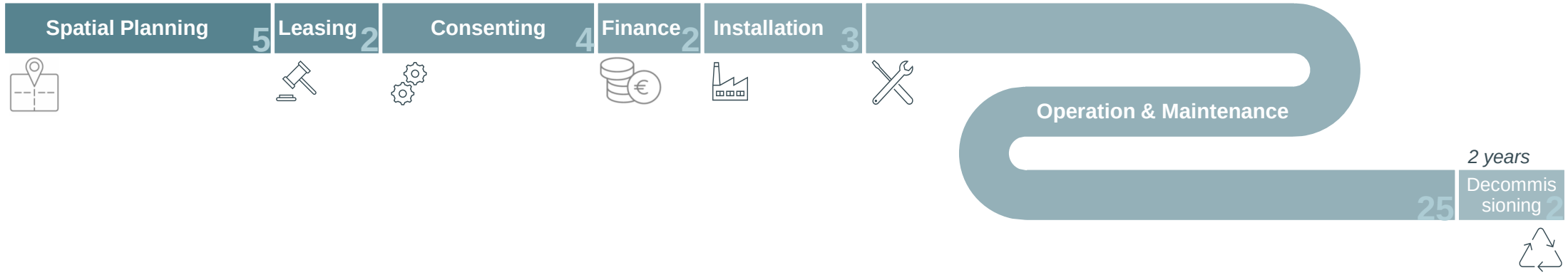
Life-Cycle of an offshore wind farm

Steps and duration in years



Challenges for offshore grid development

Timing & Lifetime

For interconnection of potential cluster neighbours and installation

Supply Chain

Availability of manufacturing capacity, import of materials and technology readiness

Security

Offshore assets and system operation

Spatial Planning

For designation of infrastructure corridors, management of power densities as well as shading (wake)

Charing costs and benefits

Among countries as well as operators and developers

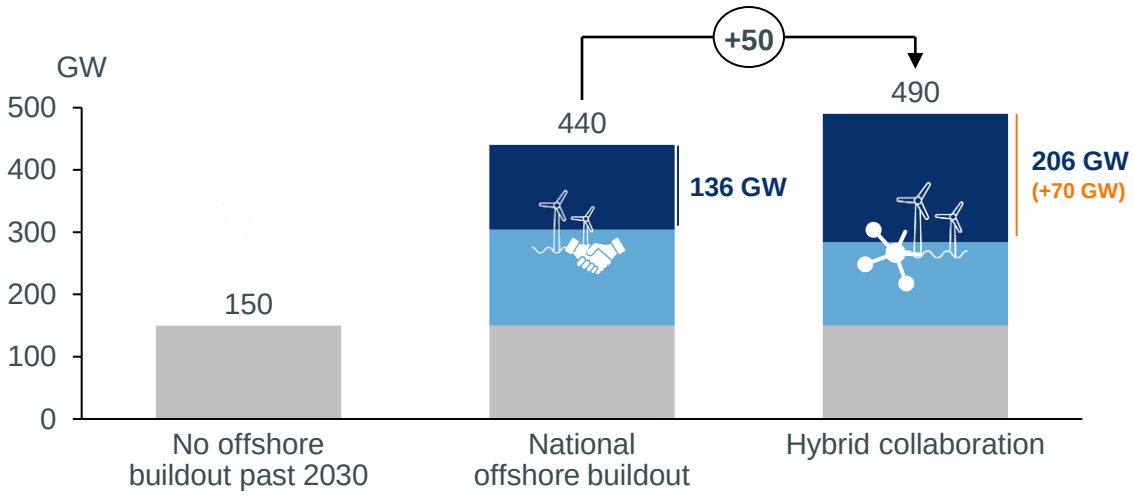
Sustainability

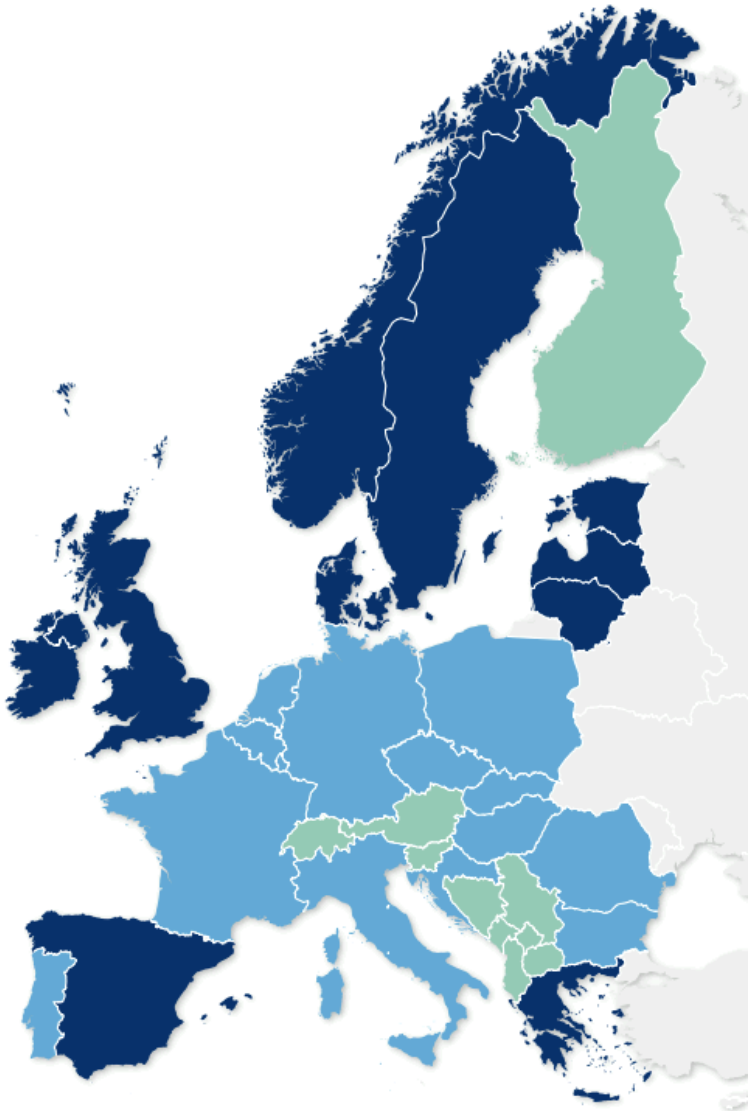
For natural environment and end of life decisions (repowering?)

Years and steps simplified and only for illustration

Offshore excess and deficit regions need to be brought together to make offshore ambitions conceivable

Simulation results for offshore buildout in exporting and importing countries across the scenarios for 2050





An **energy system study** for the Europe in 2050 has been conducted on the basis of the TYNDP 2024. It minimised the **system cost**, i.e. the total cost of investments in generation and transmission, operations, fuel and imports following different scenarios.

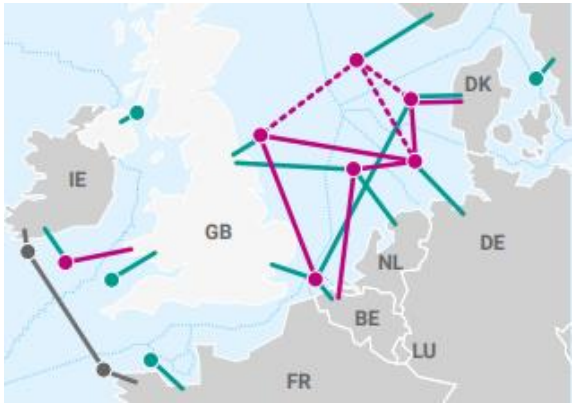
Analysis assumptions and results published in Elia Group 2024: “Going like the Wind”

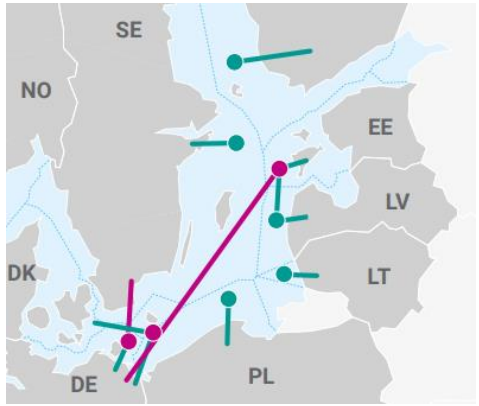
ONDP-Findings

For North Sea and Baltic Sea 2040 and 2050

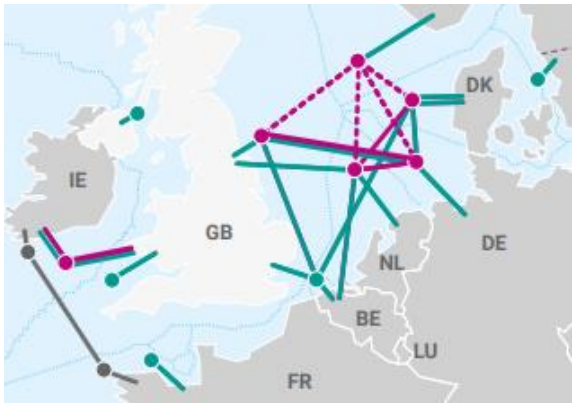
North Sea | Baltic Sea

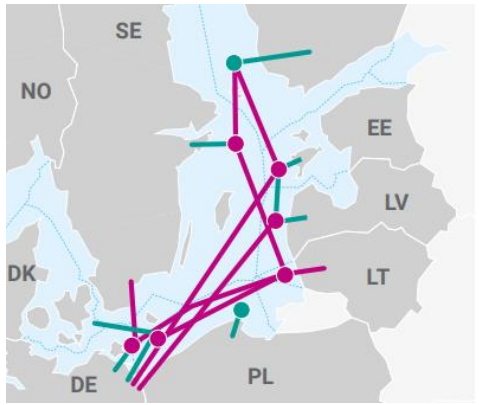
2040





2050





Corridors identified in ONDP
Starting grid (existing + planned + identified in 2040 [hybrid + radial links])
Corridor identified in neighbour SB
Potential corridors identified in ONDP

Offshore interconnection from DE to … [MW]	2040	2050
North Sea		
DK	4.000	-
NL	2.000	-
NO	2.000	-
UK	4.000	2.000
Baltic Sea		
DK	-	-
EE	2.000	-
LV	-	2.000
LT	-	1.000
PL	-	-
SE	1.000	2.000

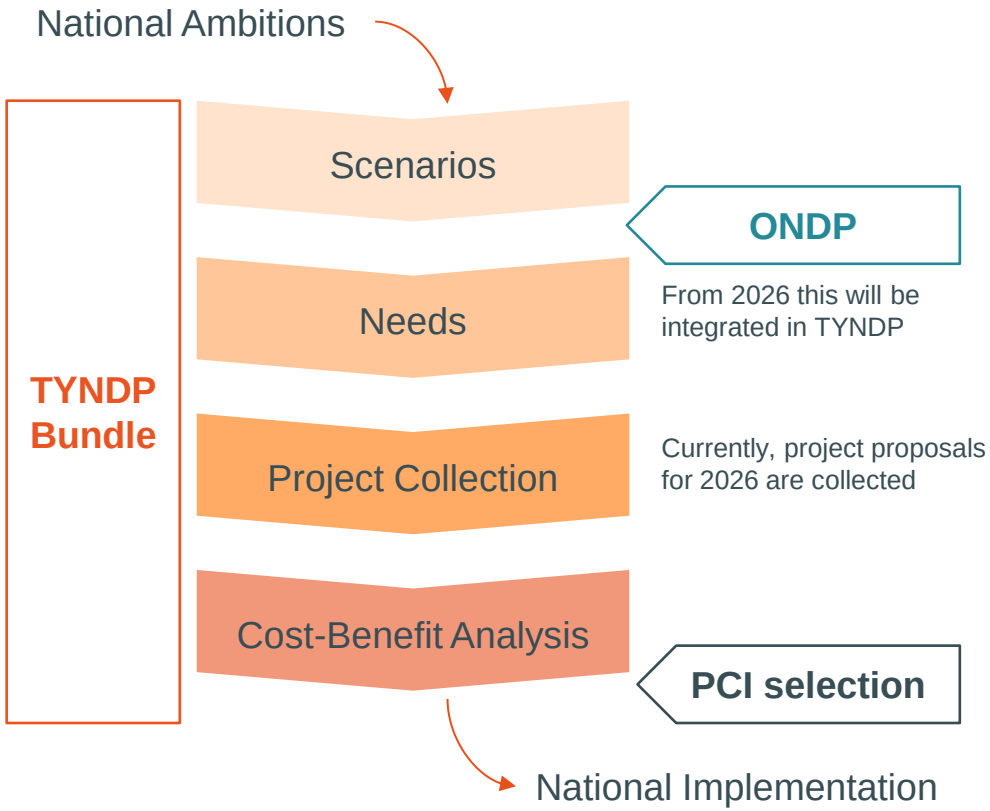
*Data and maps for scenario „With DC breaker“ and “lower cost assumptions”

ONDP 2024

TYNDP is our key planning process for offshore wind

Ten-Year Network Development Plan

Formal process by ENTSO-E.
Every two years. Current version: 2024



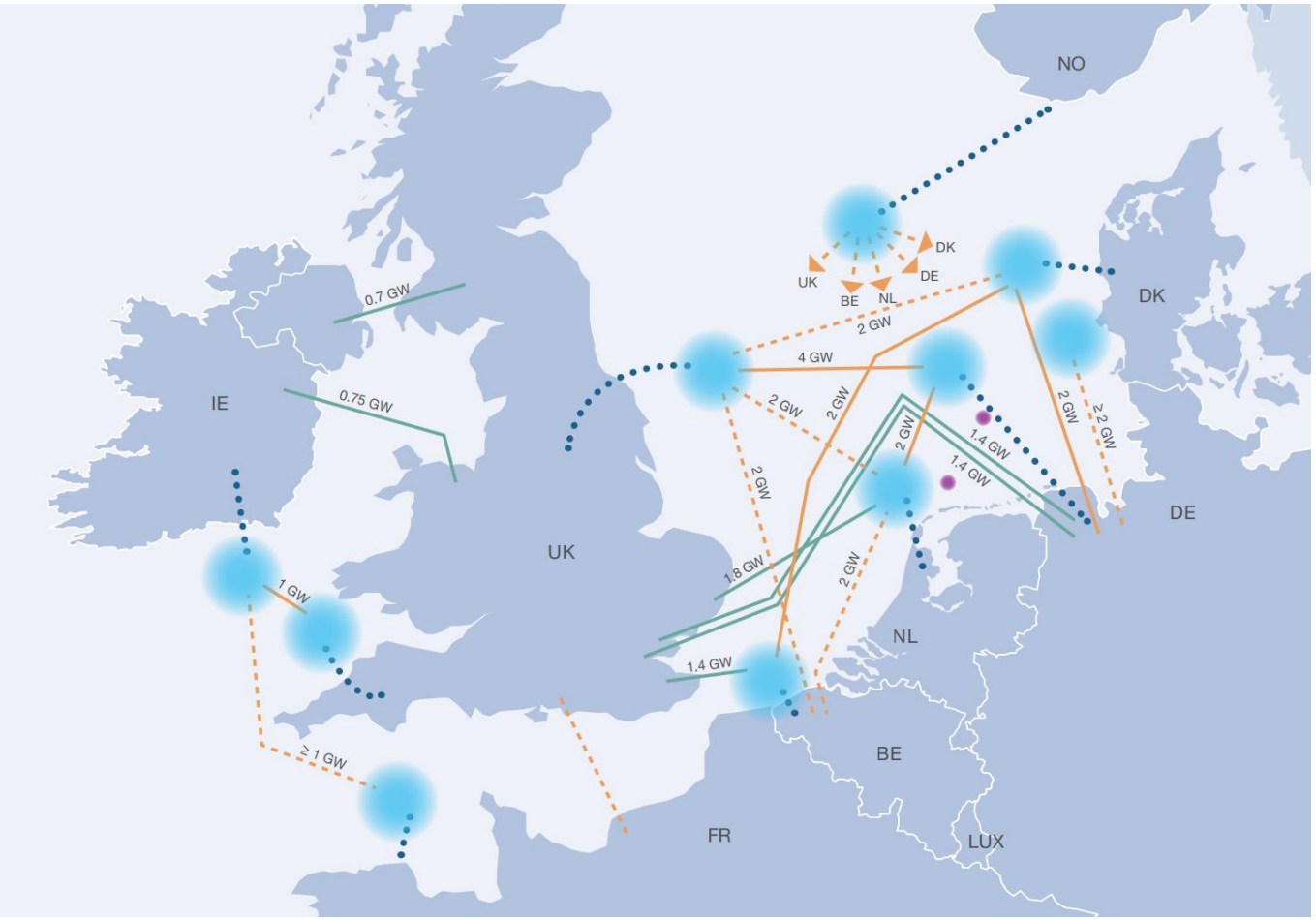
NEP Szenariorahmen 2025 considers TYNDP 2024 results

Offshore TSO Collaboration process, North Sea Region

TSO working group on behalf of Heads of States since 2022
Expert papers with selected focus topics

[OTC expert paper III 2025](), [OTC expert paper II 2024](), [OTC expert paper I 2023](), [ONDP 2024](), [TYNDP 2024](),

OTC Grid Map 2025



OTC Grid Map 2025

Cross border projects around 2040

- Offshore wind area with radial connections, hybrid interconnectors and/or energy hubs
- Connection to shore
- Planned cross-border projects
- Promising cross-border projects
- Cross-border candidates for further investigation
- Planned hydrogen demonstrator projects

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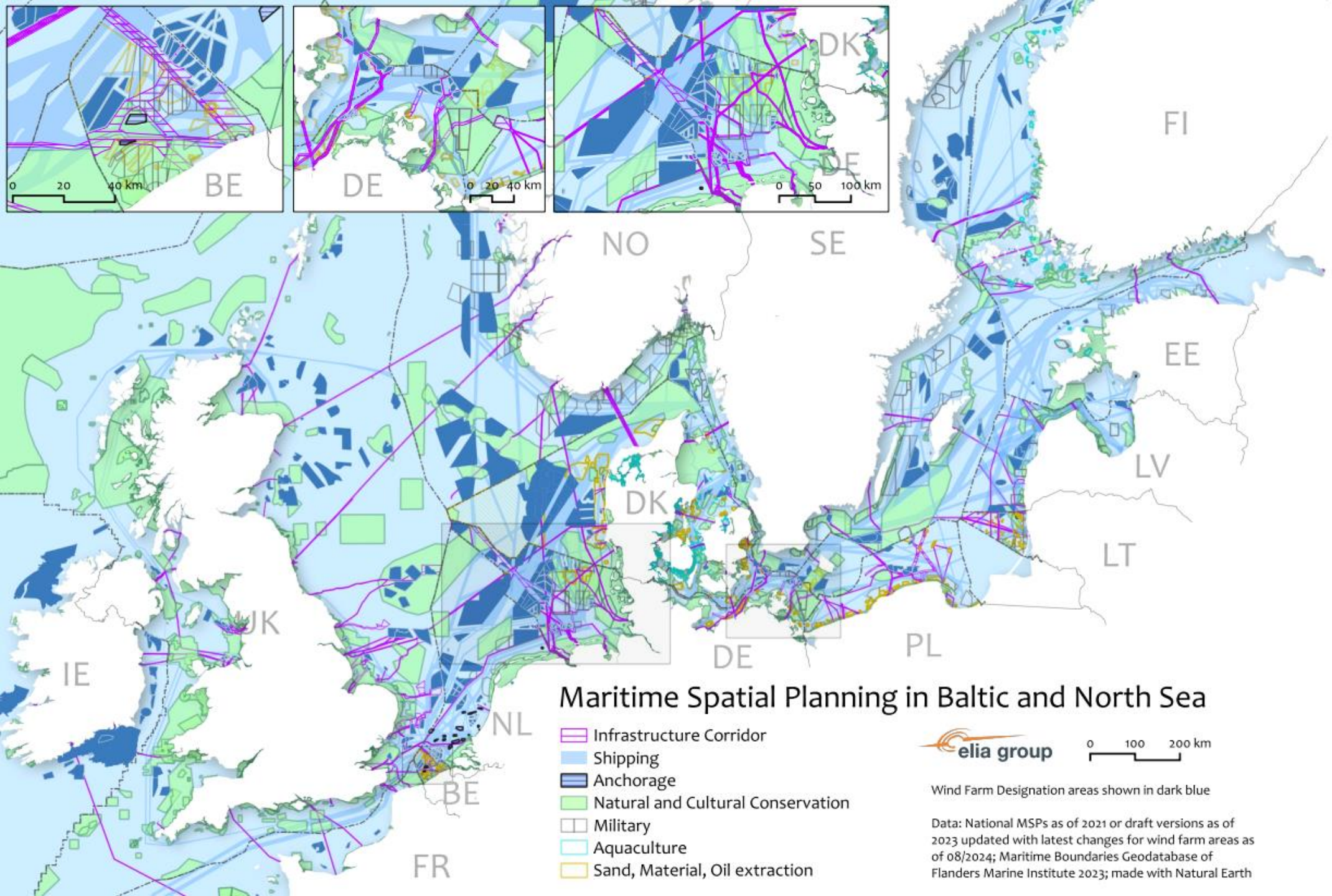
[OTC expert paper III 2025]


BE
0 20 40 km
DE
0 20 40 km
DK
DE
0 50 100 km
NO
SE
FI
EE
LV
LT
PL
DK
DE
NL
BE
FR
UK
IE
Maritime Spatial Planning in Baltic and North Sea
Infrastructure Corridor
Shipping
Anchorage
Natural and Cultural Conservation
Military
Aquaculture
Sand, Material, Oil extraction
elia group
0 100 200 km
Wind Farm Designation areas shown in dark blue
Data: National MSPs as of 2021 or draft versions as of 2023 updated with latest changes for wind farm areas as of 08/2024; Maritime Boundaries Geodatabase of Flanders Marine Institute 2023; made with Natural Earth

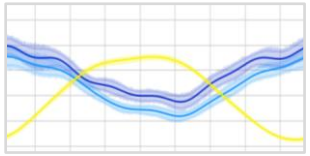
Offshore wind development…

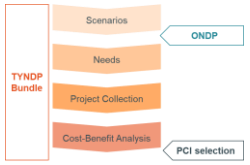
… historically nationally focussed on lowering costs, maximizing efficiency…

… will increasingly become a quest of cross-border collaboration to secure (cost) efficiency and reachability of targets…

… needs to integrate maritime spatial planning, national security and sector coupling …

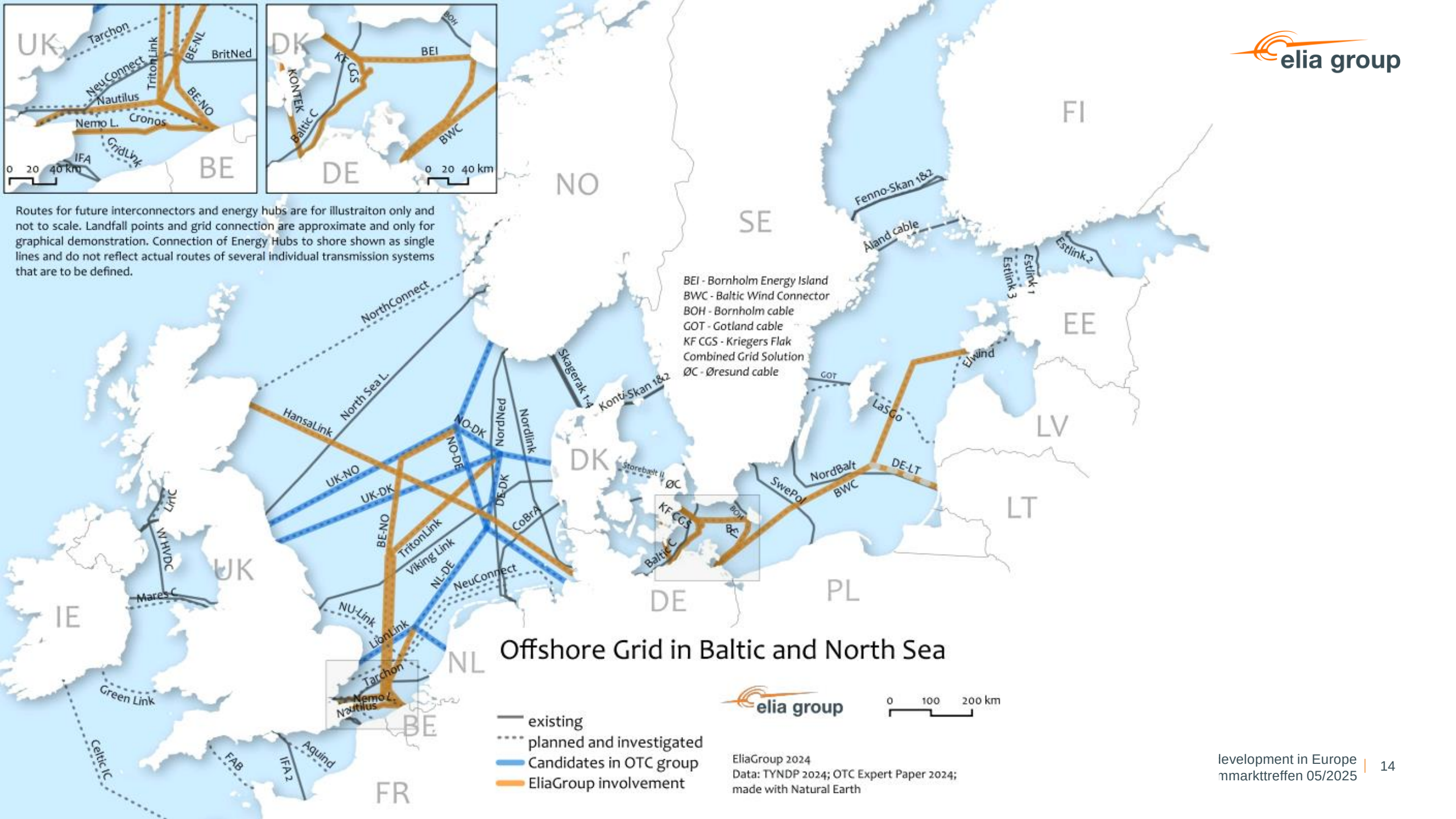
… through a stronger integration of processes for European and Sea Basin planning, funding, and development.

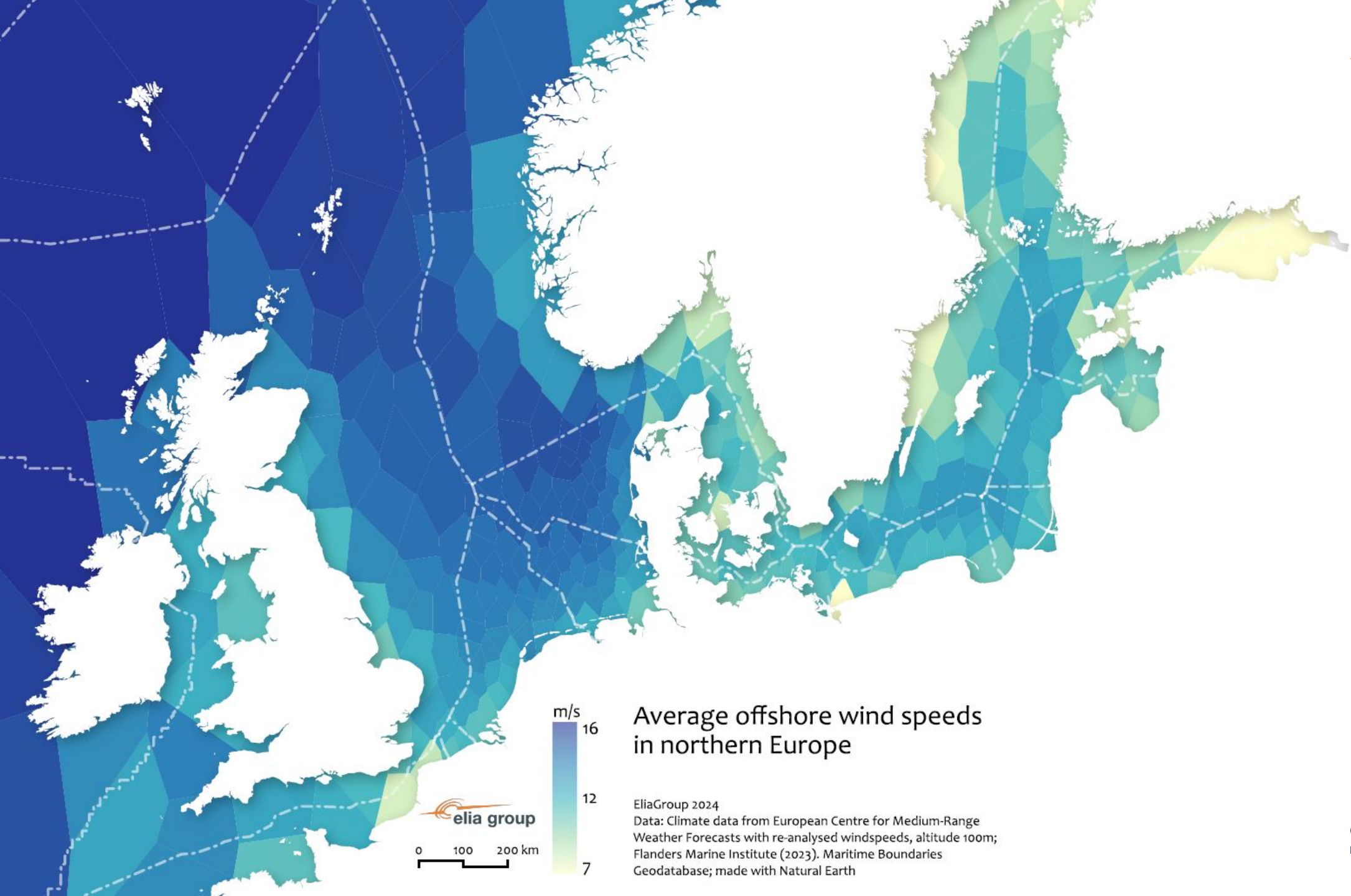




…is not only self-serving but facilitates domestic value creation and energy independence.

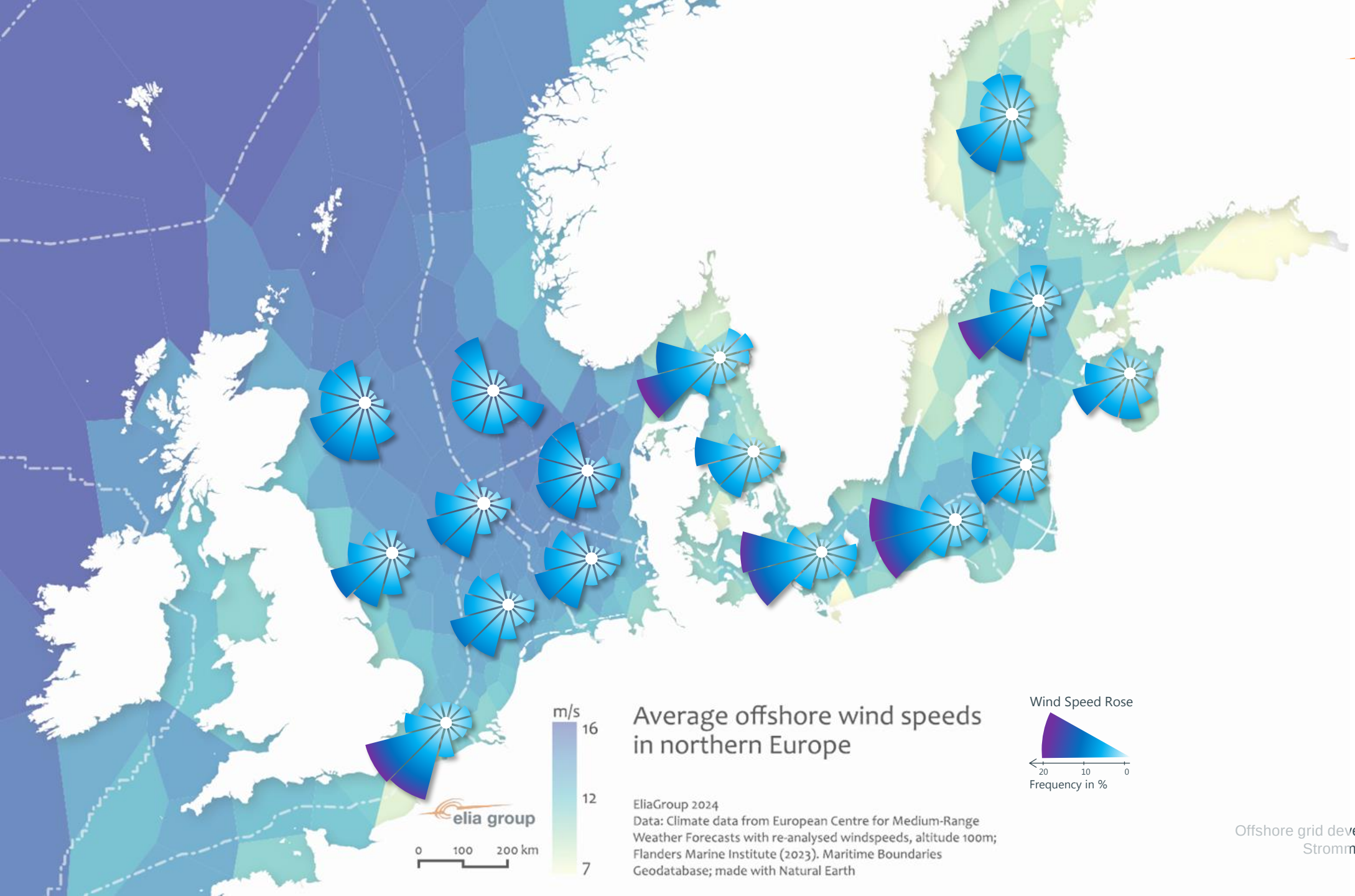
Backup


Routes for future interconnectors and energy hubs are for illustraiton only and not to scale. Landfall points and grid connection are approximate and only for graphical demonstration. Connection of Energy Hubs to shore shown as single lines and do not reflect actual routes of several individual transmission systems that are to be defined.
BEI - Bornholm Energy Island
BWC - Baltic Wind Connector
BOH - Bornholm cable
GOT - Gotland cable
KF CGS - Kriegers Flak Combined Grid Solution
ØC - Øresund cable
Offshore Grid in Baltic and North Sea
existing
planned and investigated
Candidates in OTC group
EliaGroup involvement
EliaGroup 2024
Data: TYNDP 2024; OTC Expert Paper 2024;
made with Natural Earth
0 100 200 km
0 20 40 km
UK
IE
BE
NL
DE
DK
NO
SE
FI
EE
LV
LT
PL
FR
Tarchon
TritonLink
BE-NL
BritNed
NeuConnect
Nautilus
BE-NO
Nemo L.
Cronos
GridLink
IFA
KONTEK
Baltic C
KF CGS
BEI
BOH
BWC
NorthConnect
North Sea L.
HansaLink
UK-NO
UK-DK
NO-DK
NO-DK
NordNed
Nordlink
DE-DK
CoBrA
Skagerak 1-4
Konti-Skan 1&2
Storebælt II
ØC
Fenno-Skan 1&2
Åland cable
Estlink 2
Estlink 1
Estlink 3
GOT
LaSoCo
Eiwind
NordBalt
DE-LT
SwePol
BWC
LirIC
W.HVDC
Mares C
Viking Link
NL-DE
NeuConnect
NU-Link
LionLink
Green Link
Celtic IC
FAB
IFA2
Aquind



Average offshore wind speeds in northern Europe

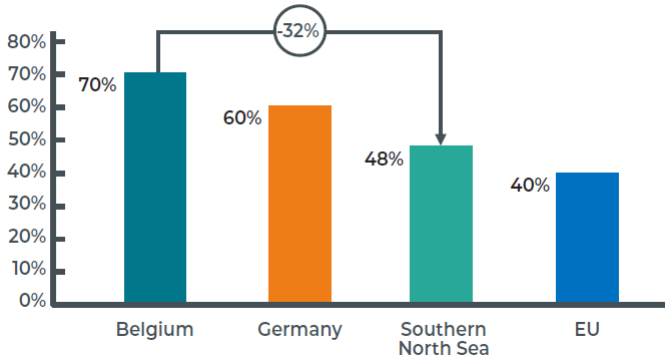
EliaGroup 2024
Data: Climate data from European Centre for Medium-Range Weather Forecasts with re-analysed windspeeds, altitude 100m; Flanders Marine Institute (2023). Maritime Boundaries Geodatabase; made with Natural Earth


Average offshore wind speeds in northern Europe
m/s
16
12
7
Wind Speed Rose
20
10
0
Frequency in %
0
100
200 km
EliaGroup 2024
Data: Climate data from European Centre for Medium-Range Weather Forecasts with re-analysed windspeeds, altitude 100m; Flanders Marine Institute (2023). Maritime Boundaries Geodatabase; made with Natural Earth

THE LONG DISTANCE (INTER-)CONNECTION OF OFFSHORE WIND FARMS TO THE SHORE REDUCES VARIABILITY

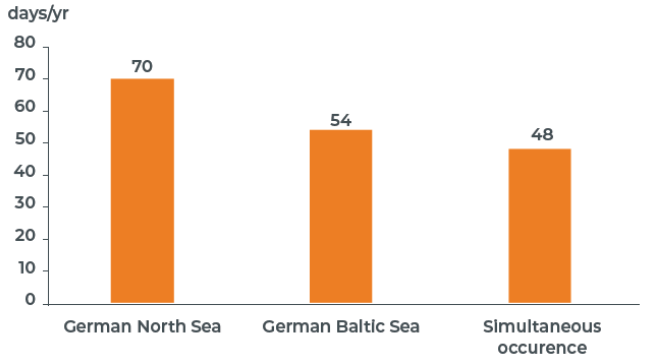
Weekly variability of offshore wind*

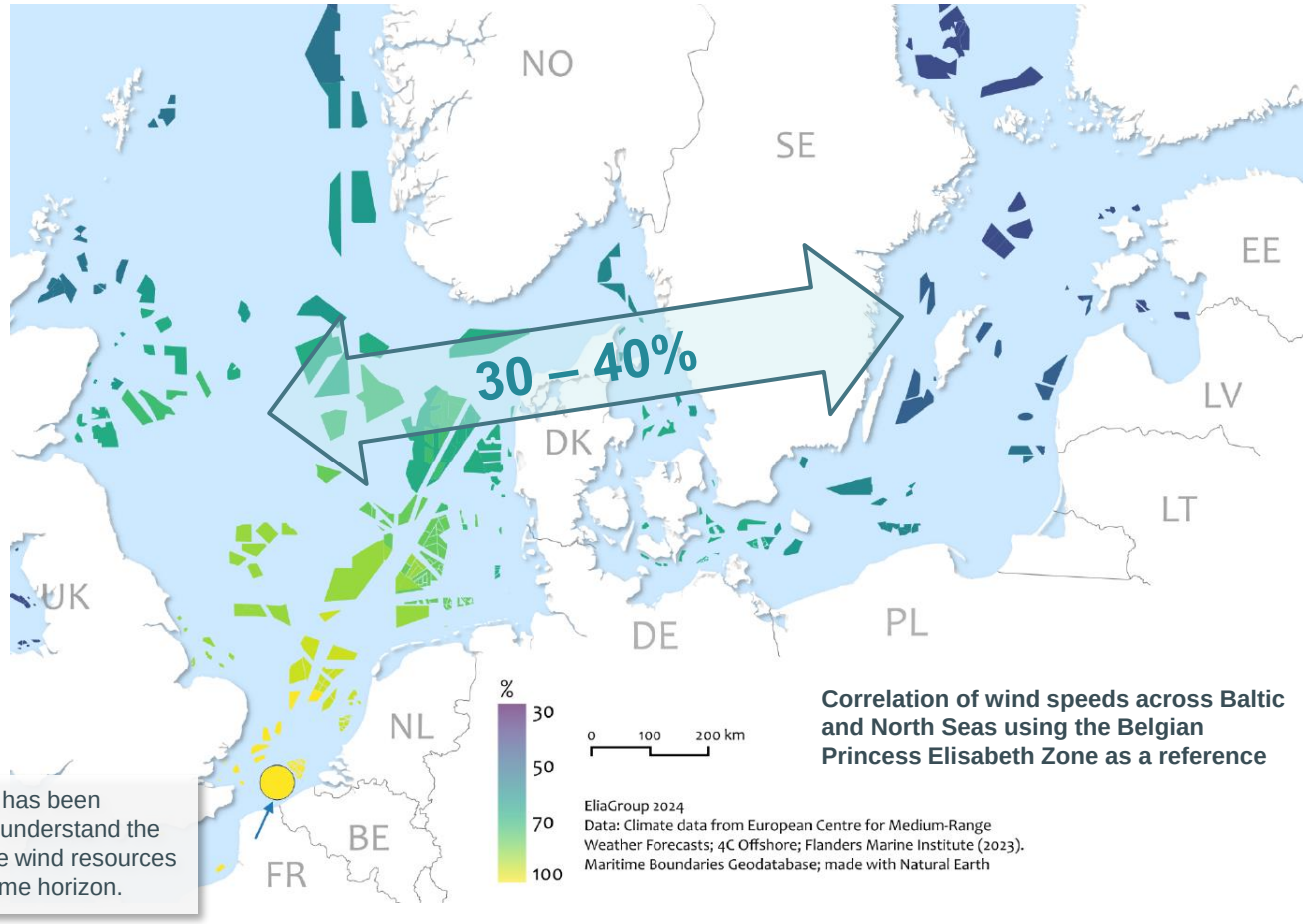
In % of installed capacity, covering p99.97 percentile



Days with low offshore wind capacity per year

Average over the period 1979-2023





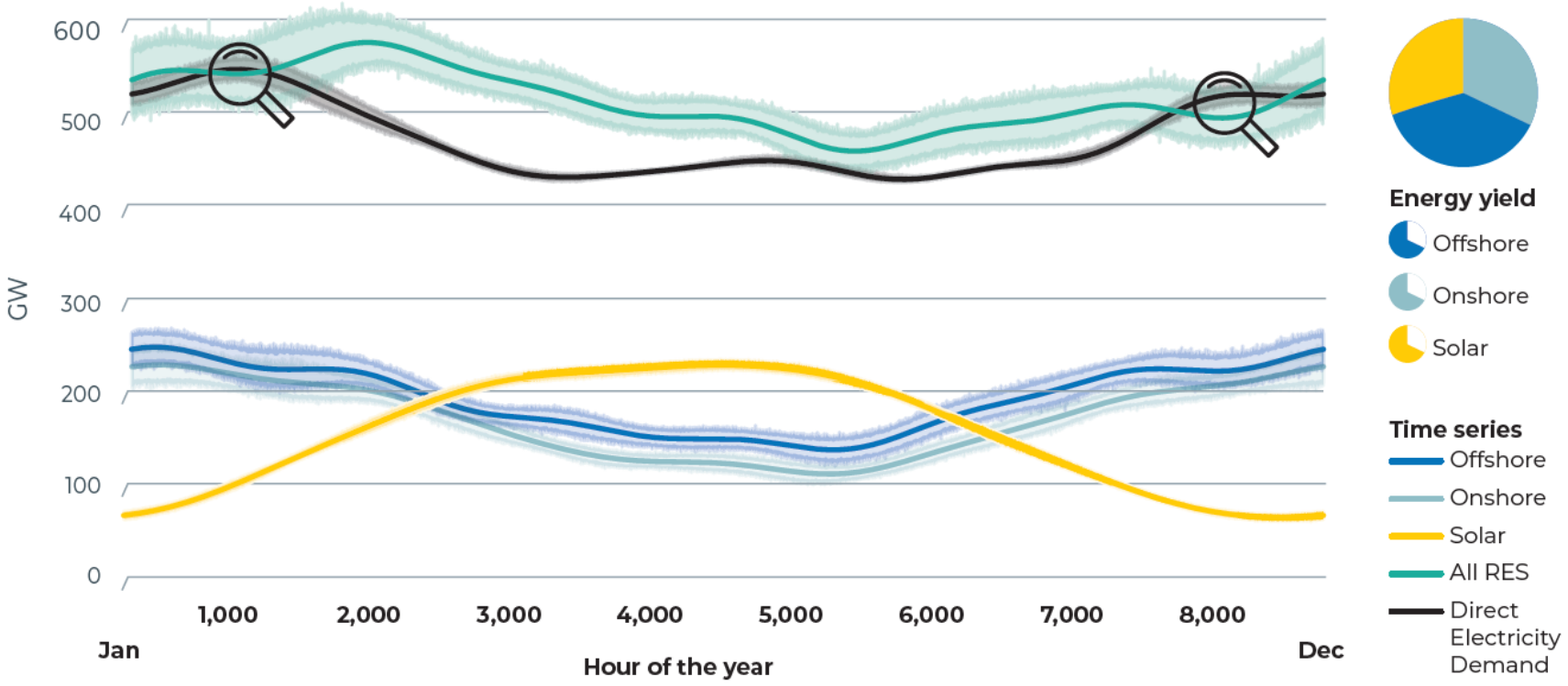
Correlation of wind speeds across Baltic and North Seas using the Belgian Princess Elisabeth Zone as a reference

A **Fourier analysis** has been conducted to better understand the variability of offshore wind resources across the weekly time horizon.

*The findings should be regarded as theoretical optima (with the assumption of perfect interconnection), which will not entirely be reached

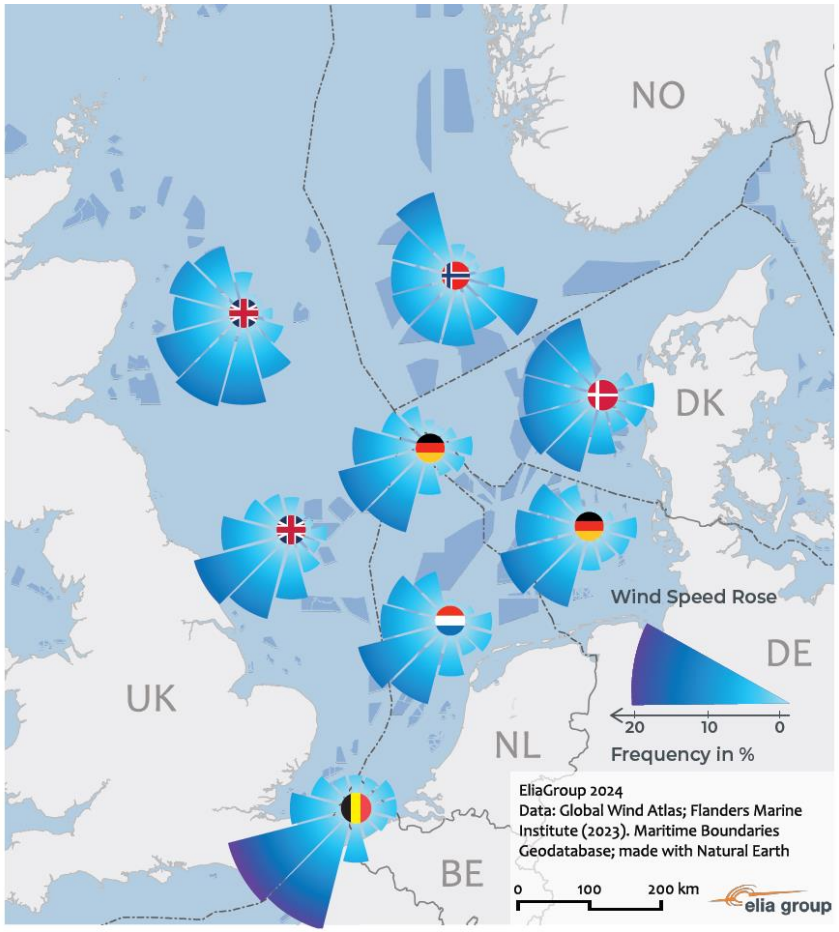
OFFSHORE WIND COMPLEMENTS ONSHORE WIND AND SOLAR POWER

A TYPICAL SEASONAL PATTERN OF ELECTRICITY GENERATION AND DEMAND IN EUROPE 2050



Source: 'Roadmap to Net-Zero, Elia Group Viewpoint Study 2021

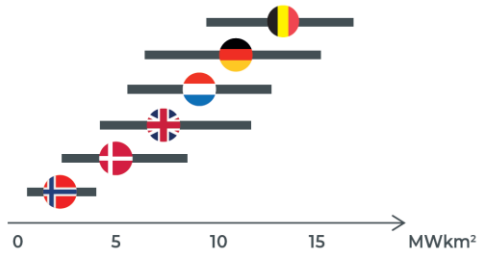
WIND FARM AREAS AND MAIN WIND DIRECTIONS IN THE NORTH SEA ALONGSIDE THE RANGES OF OFFSHORE WIND FARM POWER DENSITIES ASSOCIATED WITH EACH COUNTRY'S SEA

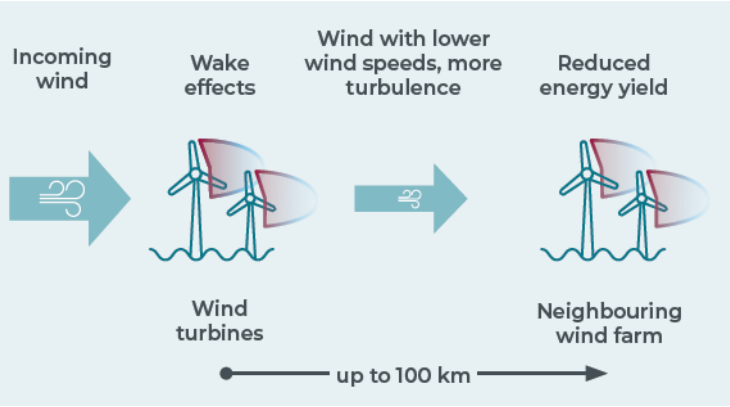


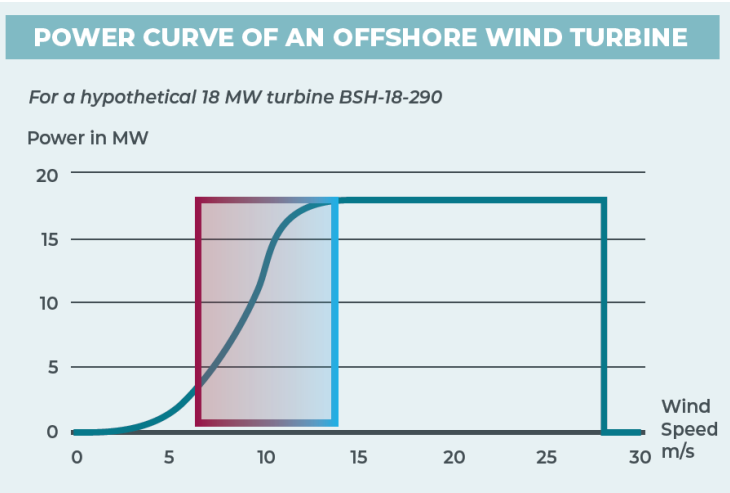
Wind farm power densities, sizes and distances (refreshment area) impact wake losses

About 30% of the future offshore wind capacity in the North Sea will be located in the same wind corridor.

Wake losses are larger during low and medium wind speeds



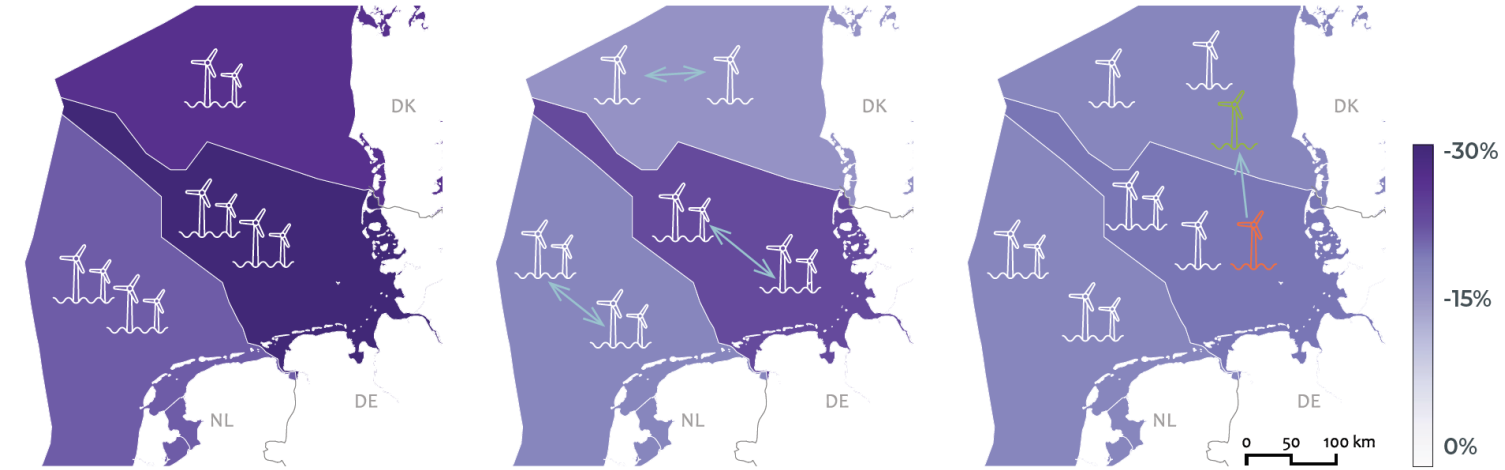




The wind does not care for borders

Cross border coordination is key to ensure high production efficiency

MITIGATION OF FULL LOAD HOUR REDUCTIONS DUE TO WAKE EFFECTS IN THE GERMAN BAY OF THE NORTH SEA FOR THREE SIMULATED 2050 SCENARIOS



Base case with current planning | More space for wind farms | Cross-border cooperation

Wake losses are unavoidable in offshore wind development. They are a result of wind turbines extracting some energy from the air and creating turbulences further downstream. Smarter wind farm designs and placements can reduce (but not eliminate) losses.

8-9 GW

1

- ► 35 GW
- ► 66 GW
- ► 72 GW

Base case (business as usual)
Power density:
Between 5 and 12 MW/km²

2

- ► 35 GW
- ► 66 GW
- ► 72 GW

More space for wind farms
Power density:
Between 1 and 3 MW/km²

3

- ► 50 GW
- ► 51 GW
- ► 72 GW

Cross-border cooperation
15 GW shifted from Germany to Denmark

- ► The savings that can be achieved for the German Bight amount to **about 30 TWh, which is equivalent to 8-9 GW** of offshore wind capacity
- ► This equals approx. €20 bn in CAPEX

Current offshore planning process and ideas for further developments

Main steps in planning process today in Europe

0 Ambitions
Definition of offshore potential/ambitions/targets

1 Scenario definition
Scenario creation (demand, generation, grid) on the evolution of European energy system.
Rem: From 2026, Central scenario will be used for the assessment and sensitivities in TYNDP

2 Need identification
Identify where and when future grid developments are required to ensure the reliable and efficient operation of European system

3 Project collection
Gather list of proposed projects aimed at addressing the identified needs (bottom-up)

4 Cost-Benefit Analysis
Evaluate the proposed projects to ensure that they deliver net benefits to the European energy system.

5 Project selection
Selection key infrastructure projects that are essential for achieving the European energy policy objectives (Project Common Interest process – EU)

6 National approvals & Implementation
National approval of identified projects and effective execution

Opportunities for further development

1. **Strengthening cross-border optimization of offshore wind development**
2. **Increasing consistency between EU/TYNDP scenarios and national scenarios** (reference & update frequency) used for project assessment
3. **Matching system needs** with projects in the pipeline
4. **Increasing multi-country optimization of offshore grid development by stronger regional coordination**
5. **Incentivizing political buy-in and willingness, especially from non-hosting countries** to fund non-hosted projects
6. **Enabling negotiations** on project cost sharing
7. **Increasing certainty on the project pipeline** for market participants
8. **Complementing national-level planning to achieve offshore wind targets** at national and regional level