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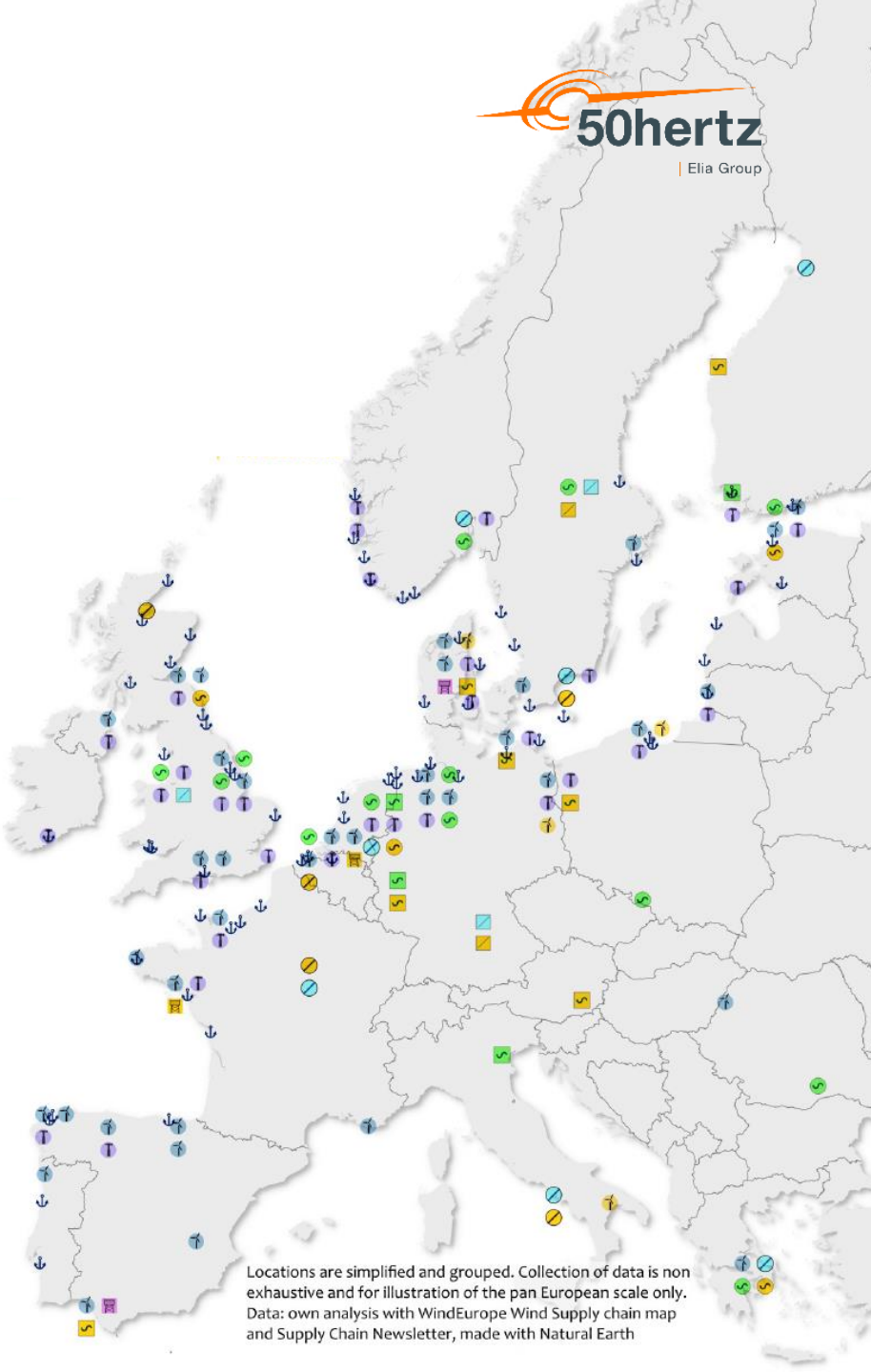
# The weakest link?

*Assessing supply chain risks for Europe's offshore wind ambitions*

IEWT, TU Wien // 28.02.2025



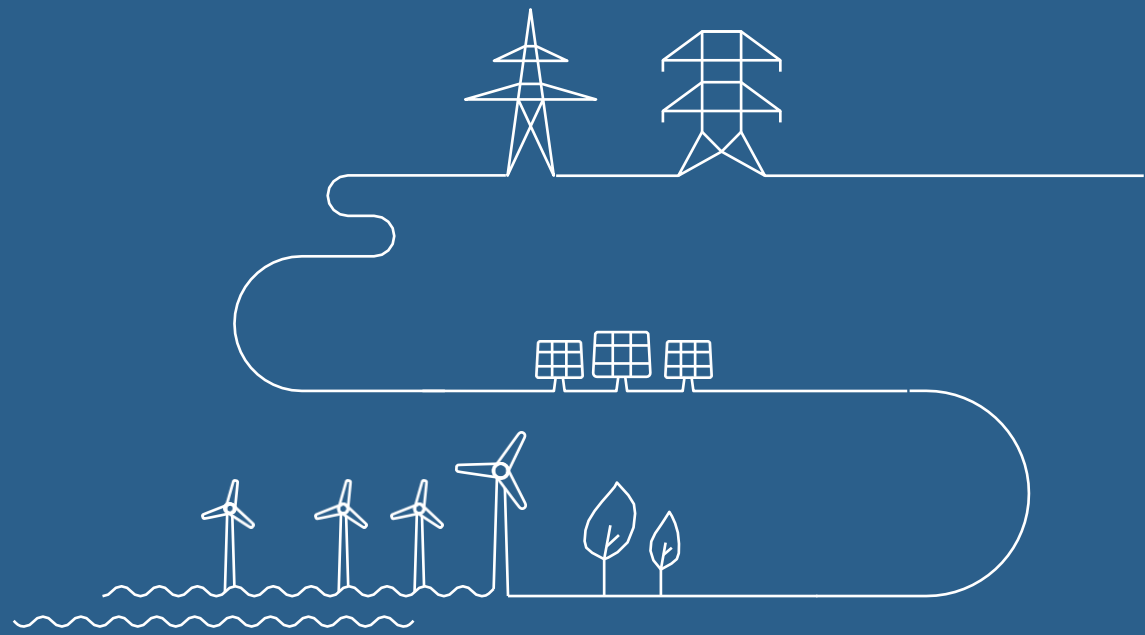


# Content

1. Why and how: Offshore wind development in Europe today
2. Main components of the supply chain and material flow
3. Estimation of demand through a spatial planning exercise
4. Sensitivities and Conclusions

# Why and How?

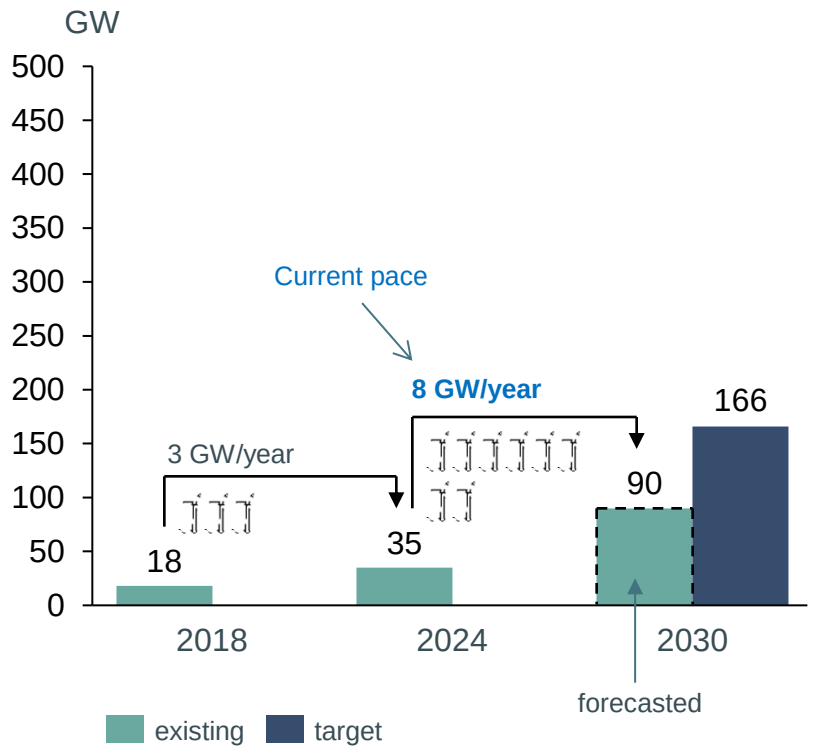
Offshore wind development in Europe today



# What about offshore wind?

## Offshore wind targets

European Union + United Kingdom + Norway




**Status quo**


Key contribution to energy mix

Unequal wind potential

Competitive LCOE

**Challenges ahead**

Longer cable runs

Limited space

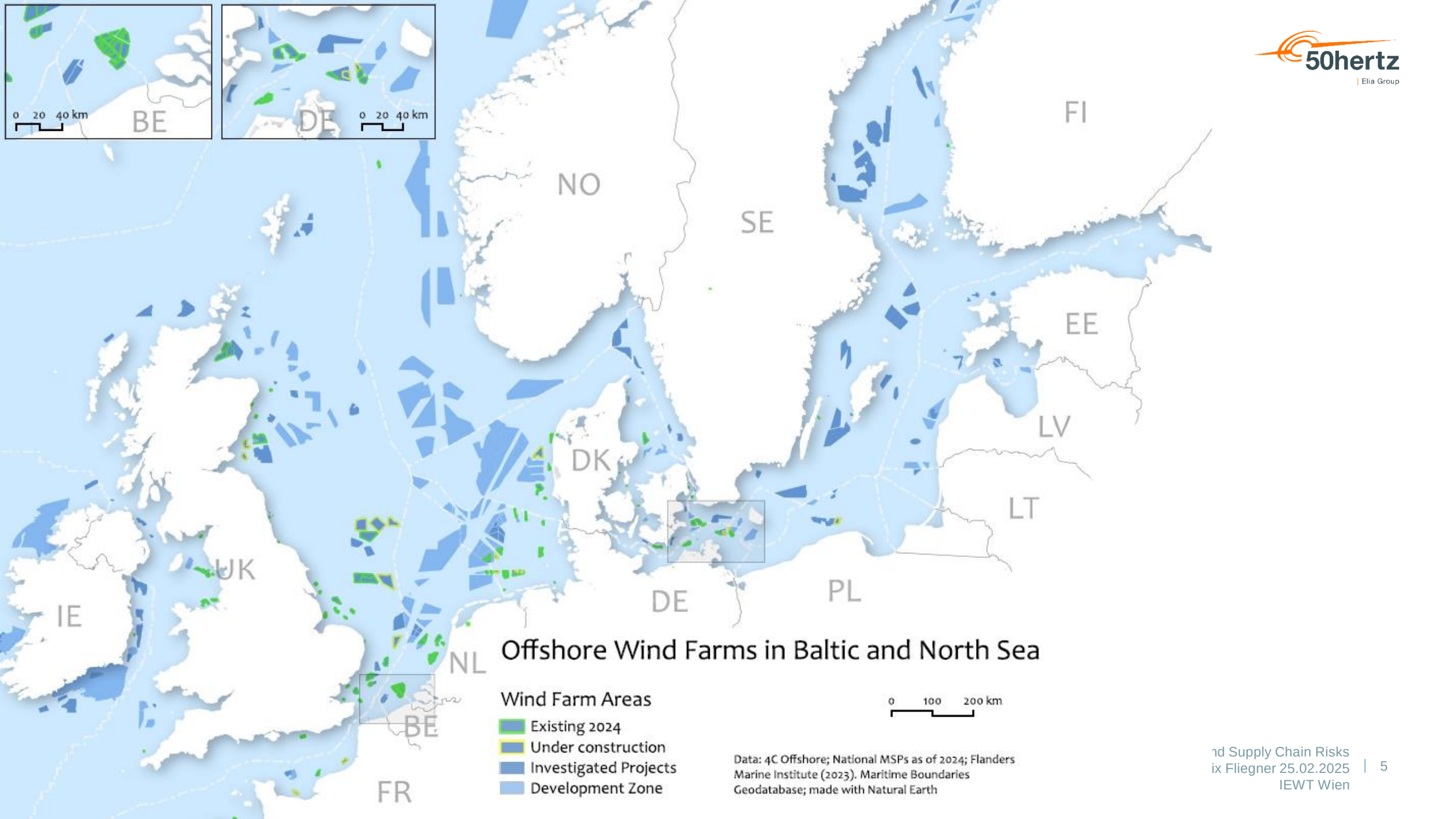
Lead time

Resources

**Contribution of this analysis**

- Map political ambitions into possible locations and routes
- Estimate the resulting demand for supply chain

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


0 20 40 km
BE
0 20 40 km
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NO
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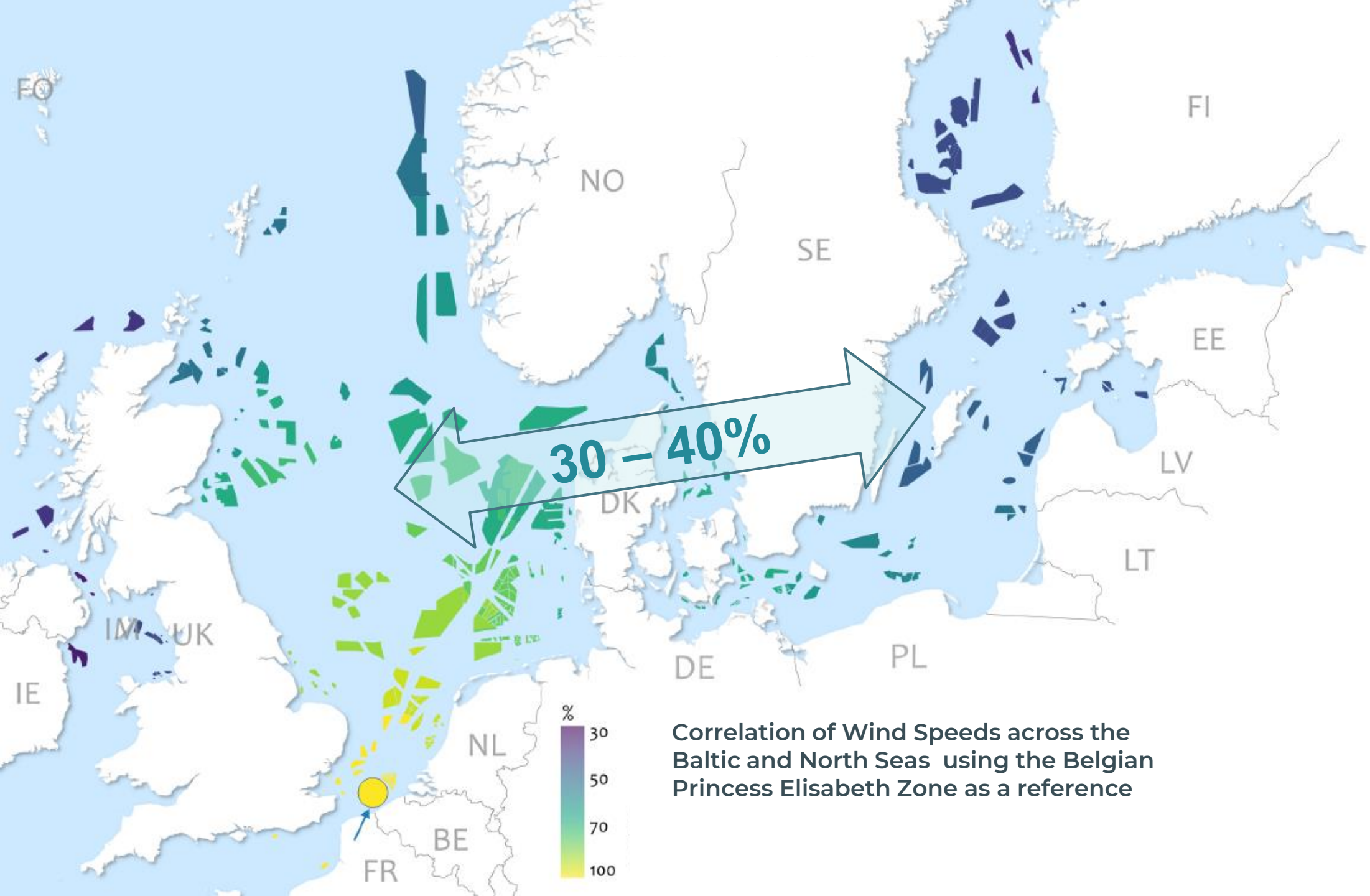
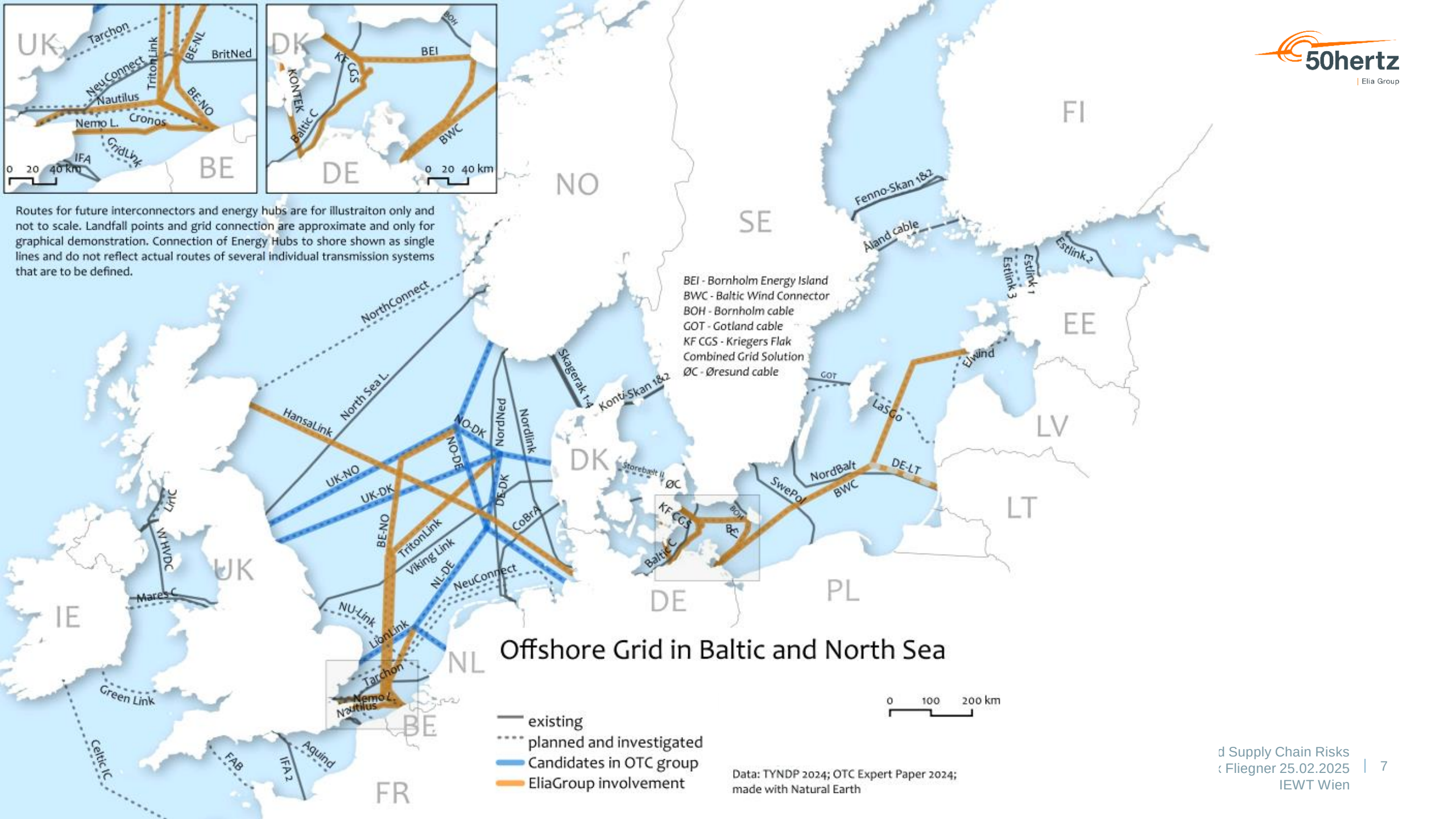
DE
PL
NL
BE
FR
Offshore Wind Farms in Baltic and North Sea
Wind Farm Areas
Existing 2024
Under construction
Investigated Projects
Development Zone
0 100 200 km
Data: 4C Offshore; National MSPs as of 2024; Flanders Marine Institute (2023). Maritime Boundaries Geodatabase; made with Natural Earth

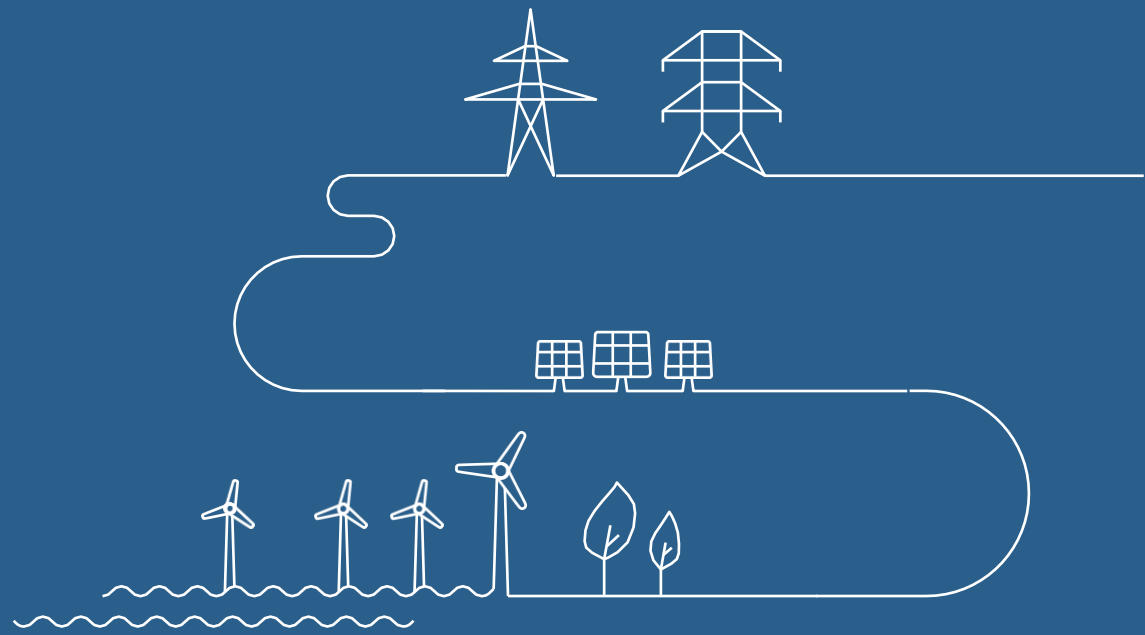



**Correlation of Wind Speeds across the Baltic and North Seas using the Belgian Princess Elisabeth Zone as a reference**


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
0 100 200 km
0 20 40 km
Data: TYNDP 2024; OTC Expert Paper 2024; made with Natural Earth
UK
IE
NL
BE
DE
DK
NO
SE
FI
EE
LV
LT
PL
FR
Tarchon
TritonLink
BE-NL
BritNed
NeuConnect
Nautilus
BE-NO
Nemo L.
Cronos
GridLink
IFA
BEI
KF CGS
KONTEK
Baltic C
BOH
BWC
NorthConnect
North Sea L.
HansaLink
UK-NO
UK-DK
NO-DK
NO-DE
NordNed
Nordlink
DE-DK
CoBrA
Viking Link
NL-DE
NeuConnect
NU-Link
LionLink
LirIC
W.HVDC
Mares C
Green Link
Celtic IC
FAB
IFA2
Aquind
Skagerak 1-4
Konti-Skan 1&2
Storebælt II
ØC
Fenno-Skan 1&2
Åland cable
Estlink 1
Estlink 3
Estlink 2
GOT
LaSGo
Eiwind
NordBalt
DE-LT
SwePol
BWC

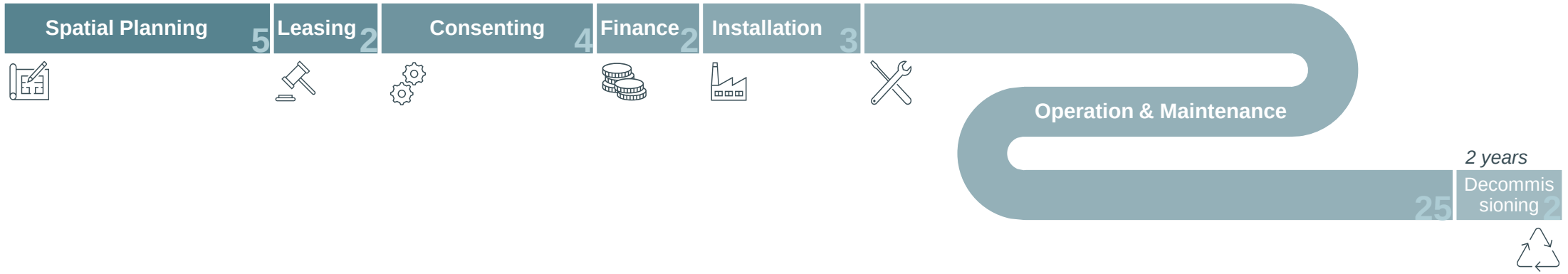
# What?

Main components of the supply chain and material flow



# Value chain for offshore wind development

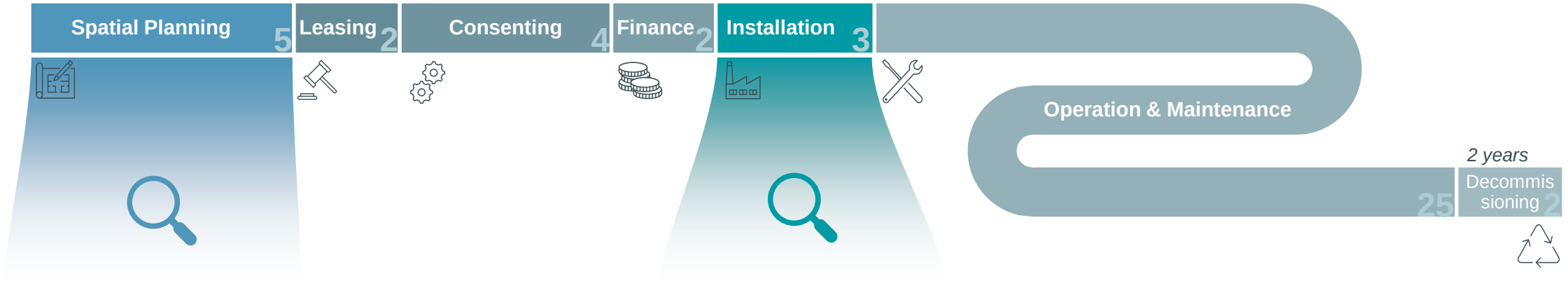
*Steps and duration in years*




**Offshore wind projects have a lead time of 10+ years, requiring long term policy measures to optimise it**

# Value chain for offshore wind development

*Steps and duration in years*




- Climate and Energy strategy
- Offshore wind potentials
- Competing maritime interests
- Co-use, -location, -existence

*What is the impact of spatial planning on the supply chain?*

*How can planning and installation enhance resilience?*

- Raw & Processed Materials
- Manufactured Components
- Assemblies
- Installation
- Commissioning

**Offshore wind projects have a lead time of 10+ years, requiring long term policy measures to optimise it**

# Tailormade in harsh conditions…

*How to bring Offshore Wind ashore*

Offshore Wind Farm

Collection / HUB

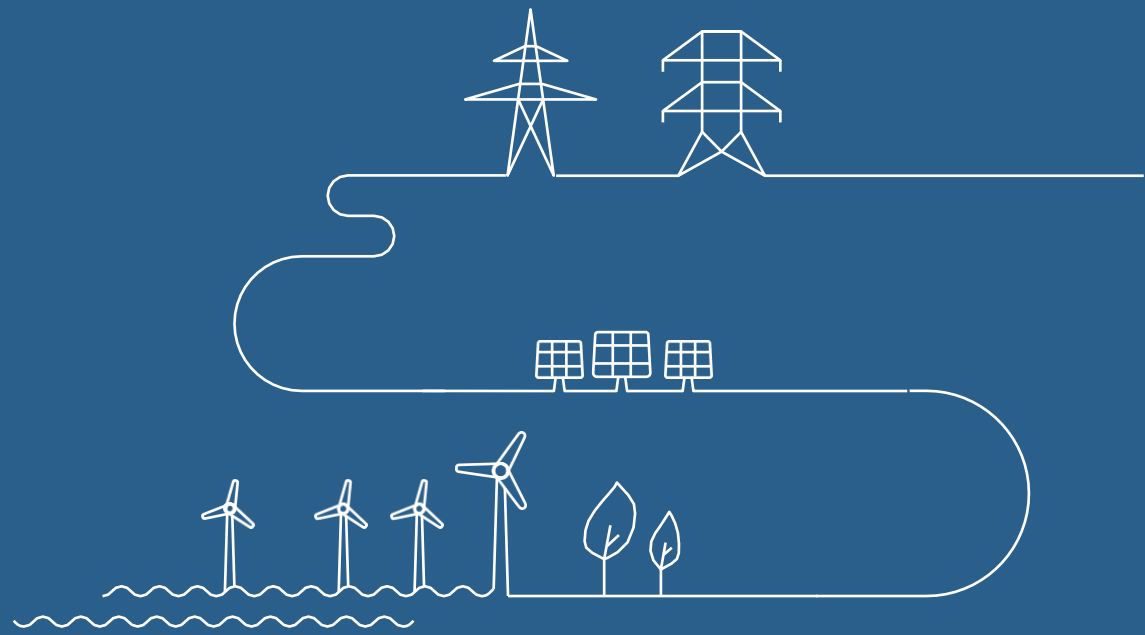

Sea cable

Point of Connection

Pictures: 50Hertz

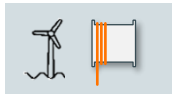
# How much do we need?

Estimating material needs through a GIS analysis

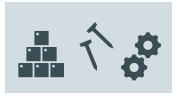


# Approach of this study

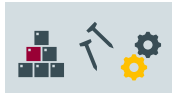
## Objectives



- Map offshore targets into projects and cable corridors



- Quantify material and component needs



- Assess bottlenecks for offshore wind supply chains in Europe

- Investigate what impact spatial planning can have

## Approach of the study

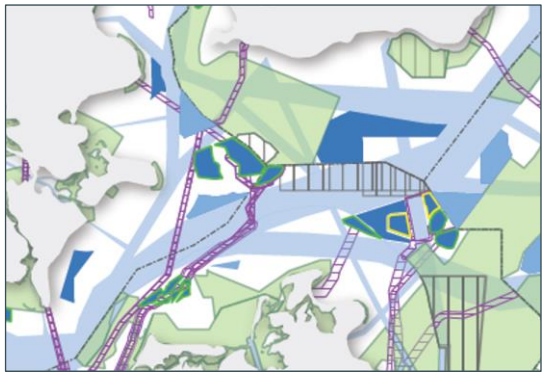
1. Review of published literature and data
2. Expert interviews with manufacturers, grid operators, NGOs, industry societies
3. Spatial planning analysis in a geographical information system

## Period and Scope of analysis

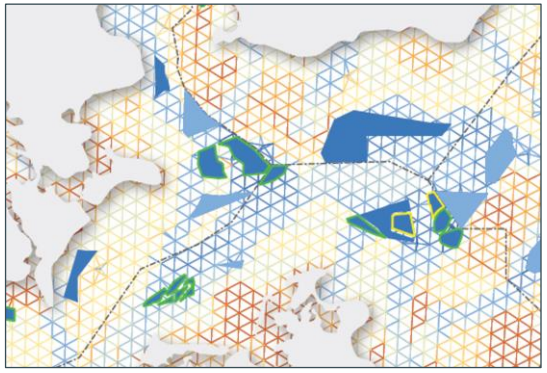
- Project duration: March till September 2024
- Covering entire Europe with focus on Baltic and North Sea
- Long term view towards 2050

# Input and output

## Input



- MSP data
- Existing Infrastructure
- Geographic base information
- Grid hosting capacity
- Asset cost assumptions



**1| Business as usual**

**2| Nature First**

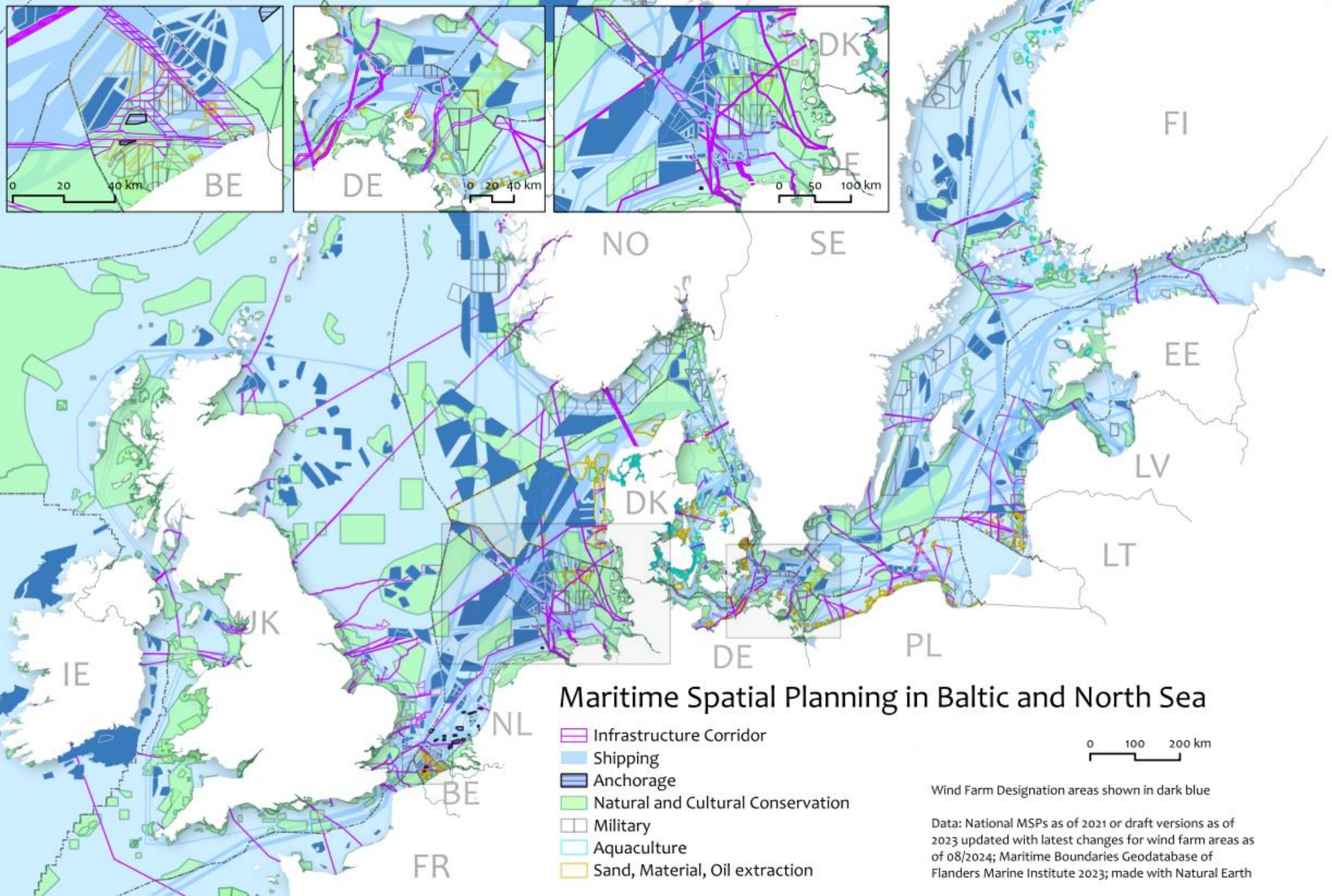
**3| High resilience**

## Subject to

- Satisfy expansion target for each country and hosting capacity target for each point of connection
- Prioritise crossings at the edge and avoid them through the middle of protected areas
- Bundle paths, where it deviates the routes not too much

## Output

- Cost minimal connection of offshore wind farms to satisfy targets
- Sum of required cable lengths and platforms
- Spatial footprint of infrastructure


BE
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0 50 100 km
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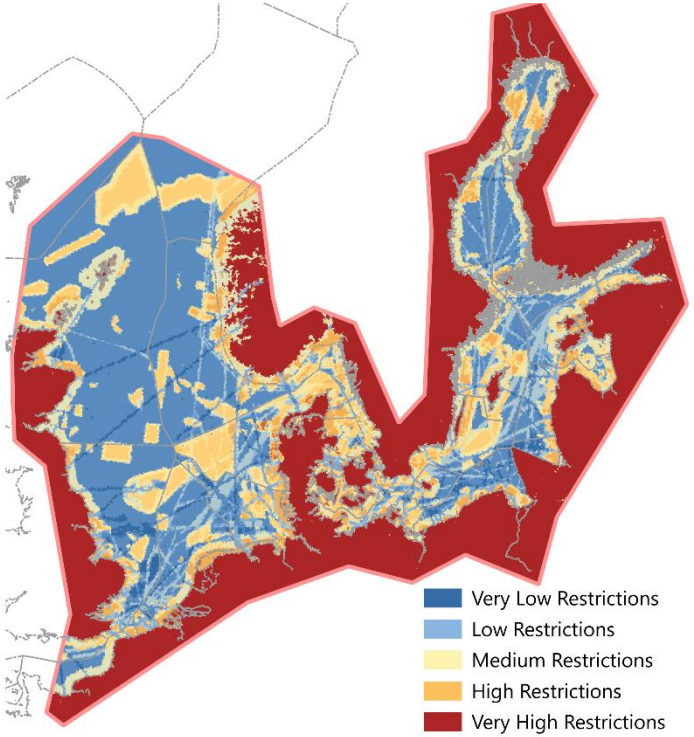
UK
IE
NL
BE
FR
Maritime Spatial Planning in Baltic and North Sea
Infrastructure Corridor
Shipping
Anchorage
Natural and Cultural Conservation
Military
Aquaculture
Sand, Material, Oil extraction
0 100 200 km
Wind Farm Designation areas shown in dark blue
Data: National MSPs as of 2021 or draft versions 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

# Impact of penalty cost structure on results

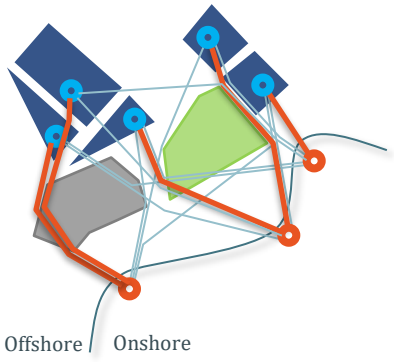
## Exemplary penalty cost raster

For scenario: Business as usual

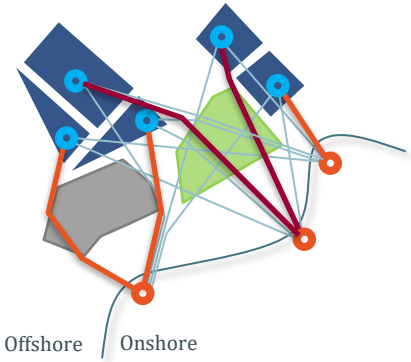



## Illustration of objective function

Business as usual




Nature First





$$Minimize: Z = \sum_{i=1}^{m}\sum_{j=1}^{n} cost_{i,j} \cdot conn_{i,j}$$

**Main constraints:**

$s.t.$ *Capacity of wind parc constraint* $\sum_{i=1}^{m} conn_i \leq CapacityWEA_i$

*POC constraint* $\sum_{j=1}^{n} conn_j \geq POCdemand_j$

*Expansion Target Constraint* $\sum_{j=1}^{n}\sum_{c=1}^{p} conn_{j,c} \geq$ **Expansion target**$_c$

*Non-negativity constraint* $conn_{i,j} \geq 0$

**Where:**

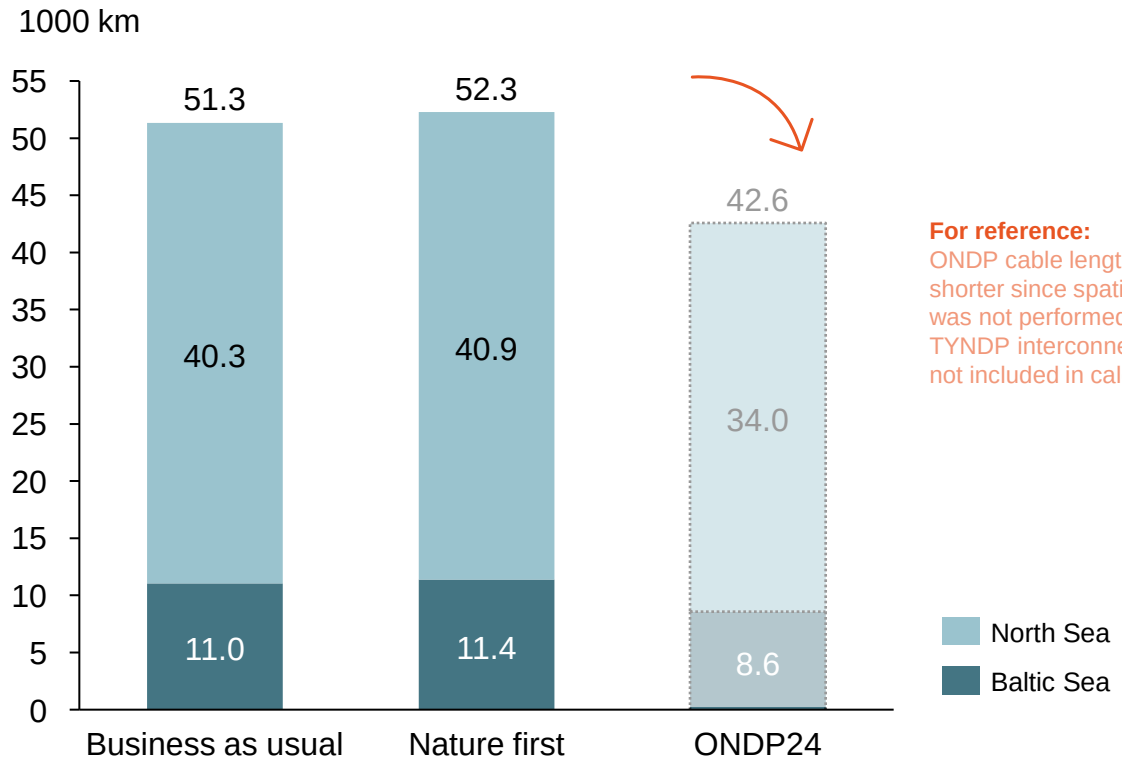
$conn_{i,j}$ = *amount of GW that can be transported from i to j*

$cost_{i,j}$ = *costs of transporting 1GW from i to j*

# Corridor length is main driver for cost and material demand

## Cable corridor length

For both scenarios



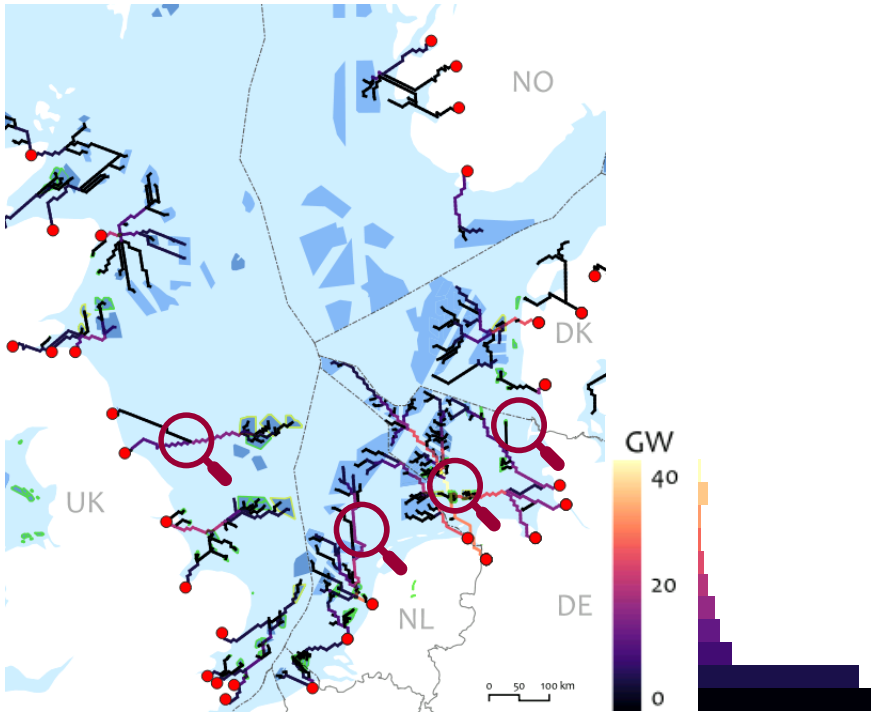

**For reference:**
ONDP cable lengths are shorter since spatial routing was not performed and TYNDP interconnectors were not included in calculations


ENTSOE, 2024: Offshore Network Development Plan

# Reducing the power density of transmission corridors at the cost of longer cable runs

## Cable corridor density

Base case “radial national connection”



# Material and manufacturing demand

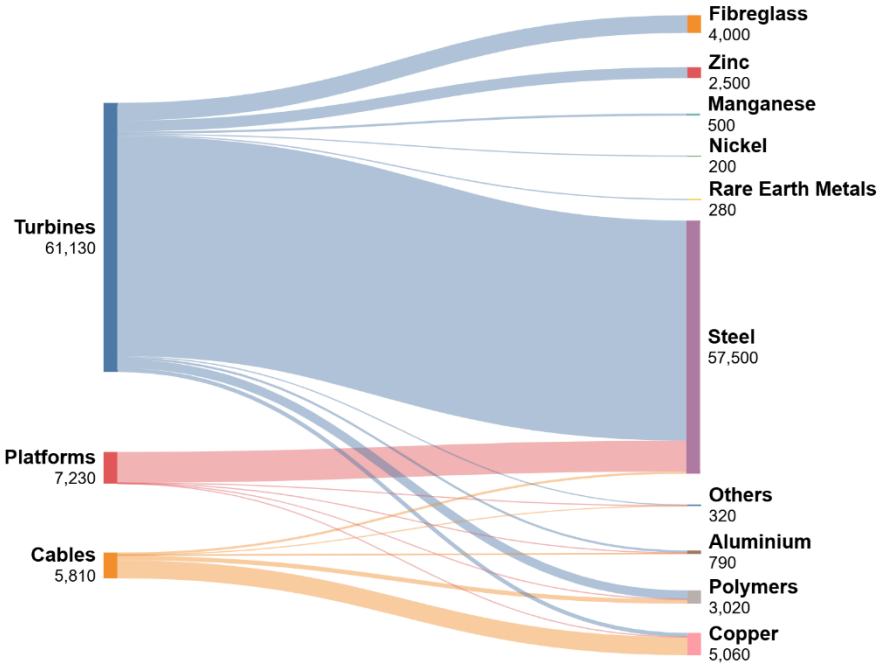
## Manufacturing demand and current capacity

Annual values for Europe

| Component | Current annual capacity, Europe | | Annual demand 2030-2050 | |
|---|---|---|---|---|
| Offshore Wind Turbines 10-20 MW each | 8 – 9 GW | x2 | 20 GW | [8] & Own calc. |
| Platform topsides for 2 GW converter each | 2 | x5 | 10 | Own calc. |
| Converters HVDC on- & offshore | 6 – 8 GW | x3 | 20 GW | Own calc. |
| Export cables HVDC 525 kV | 4,000 km | x2 | 5,000 – 7,500 km | [9] Own calc. |
| Inter-Array cables MVAC 66 kV | 2,000 km | x2 | 3,000 – 4,000 km | Own calc. |
| Vessels for turbines Wind turbine installation | 12 vessel years | x2 | 26 vessel years | [10] |
| Vessels for cables Cable laying | 6.500 km | x2 | At least 10,000 km | Own calc. |

## Raw material demand for 2050

Total values for Europe




[1] "Dragados" is currently the only supplier in Europe: https://tinyurl.com/2upjmhke and "Allseas" is offering the only crane ship in Europe capable of lifting more than 15 kt at a time: https://tinyurl.com/k6d7n4n9
[2] Currently three manufacturers in Europe: GE Vernova https://tinyurl.com/4ew493uz, Hitachi Energy https://tinyurl.com/y6dkvr5t, Siemens Energy https://tinyurl.com/yzjmx49y
[3] Only a low estimate as many onshore cable production lots could serve offshore demand if needed
[4] Currently, five suppliers for HVDC cable laying exist in Europe: Prysmian https://tinyurl.com/y36j59m2, Jan de Nul https://tinyurl.com/bdh7j56p, Nexans https://tinyurl.com/ycx79v5y, NKT https://tinyurl.com/5u69688k

# Criticality of raw material supply is high

**FUTURE RAW MATERIAL DEMAND INCREASE IN EUROPE**

Not significant Medium Substantial

| Raw material | Demand increase in the lead-up to 2050 (compared with 2022) | Criticality ranking[7] |
|---|---|---|
| Steel and Iron | 8x | |
| Copper | 8x | |
| Fibreglass | 7x | |
| Polymers | 3x | |
| Zinc | 2x | |
| Aluminium | 6x | |
| Manganese | 5x | |
| Nickel | 5x | |
| Rare earth metals[8] | 8x | |

**Risk mitigation strategies include...**
material substitution, increased recycling quotas, decreasing material intensity per capacity, standardisation of assets

## Measures to moderate criticality

- Material substitution
- Standardisation (size caps?)
- Increased circularity
- Optimisation for lifetime versus short term efficiency
- Best locations versus easiest locations

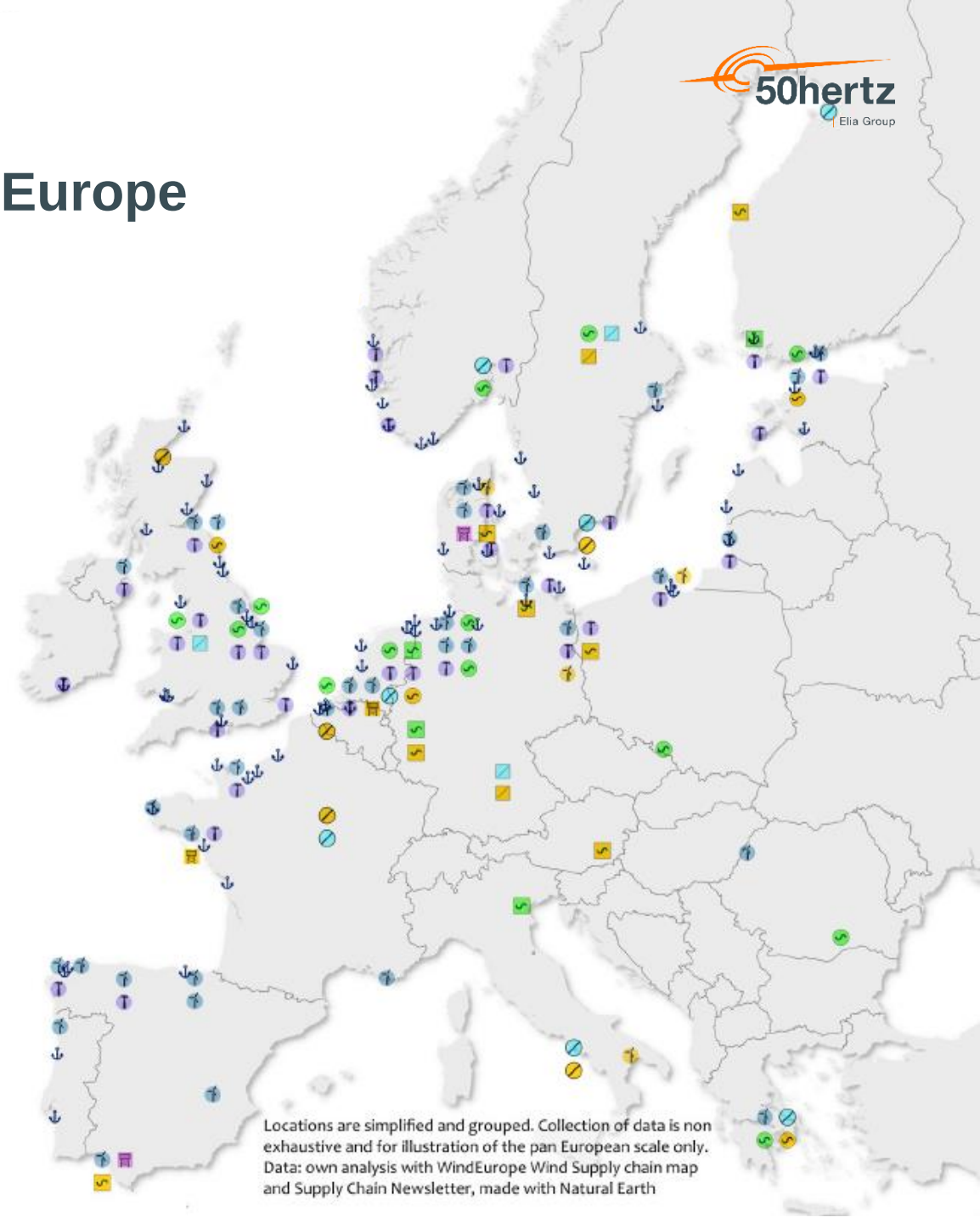
# Offshore supply chain locations across Europe

Sea Port

Existing
- Wind turbines components
- Assembly, Logistics, O&M
- Substations
- Other Cables
- HVDC cables
- DC Substations
- Platforms

Recent investments
- Wind turbines components
- Substations
- Other Cables
- HVDC cables
- DC Substations
- Platforms*

*including caisson manufacturing for artificial islands



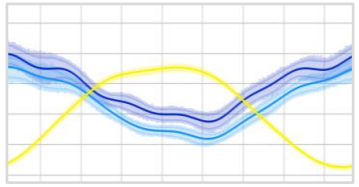
# Offshore wind power…

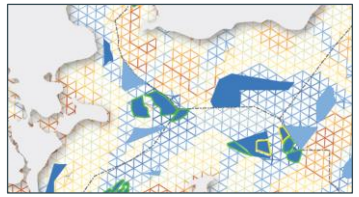
*… is bound to make a crucial contribution to Europe's energy mix of the future …*

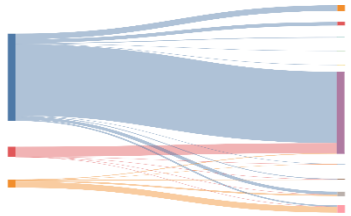
*… with high interdependence with spatial planning priorities …*

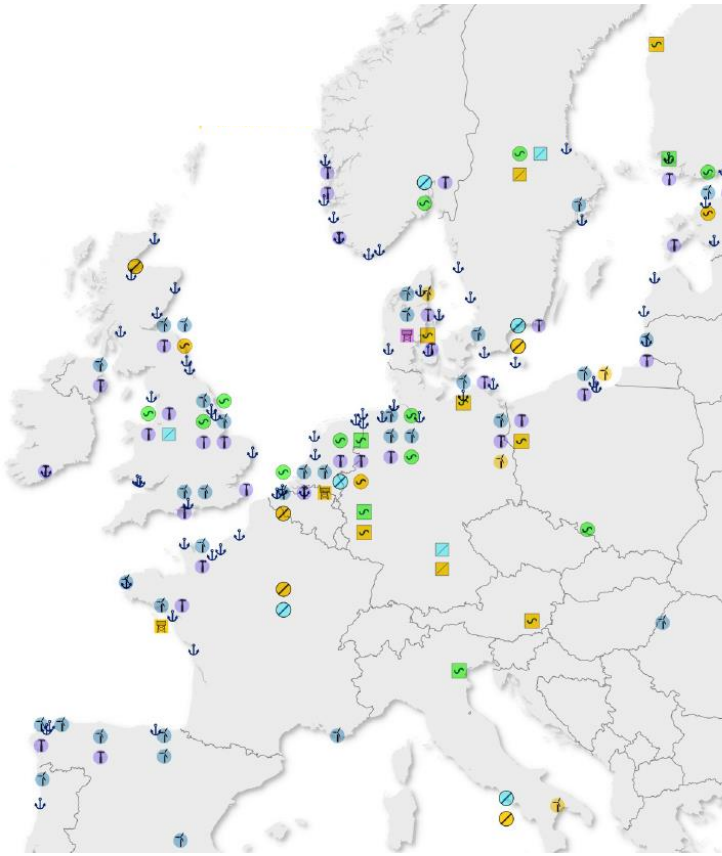
*… facing huge but not unprecedented demand increases and material dependencies …*

*Addressing them can be both a liability and chance for economic growth for Europe.*









# Backup