Baltic InteGrid

Integrated Baltic Offshore Wind Electricity Grid Development

Pre-feasibility study – Case study 1

Warsaw, June 7th

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Lund University

EU Strategy for the Baltic Sea Region Flagship

Interreg Baltic Sea Region

European Union European Regional Development Fund

Outline

- Approach
- Technical assumptions
- Scenario structure
- High & Low offshore wind energy development
- Various HVDC-integration levels
- Scenarios designs and roadmaps
- Scenario comparison
- Extended analysis

Approach

- Technology assumptions
- Localizations and Design of OWE
  - Wind Turbine & foundation layouts
  - Cable layouts & Transformator stations
  - 2 visions, high and low
- Localisation and Design of offshore network
  - Onshore connection points
  - Offshore substations
  - Various levelsof HVDC-integration Zero, Partial, Max
- Component list/Cost-benefit
- Grid functions and services
- Power flow and DC-protection analysis
- Input to market analysis, spatial planning, regulatory questions, etc.

Technology assumptions

Technology Catalogue by DTU

Wind tubrines
Pre-2030: 8 MW
Post-2030: 12 MW

Inter-array voltage
Pre and post 2030: 66 kV AC

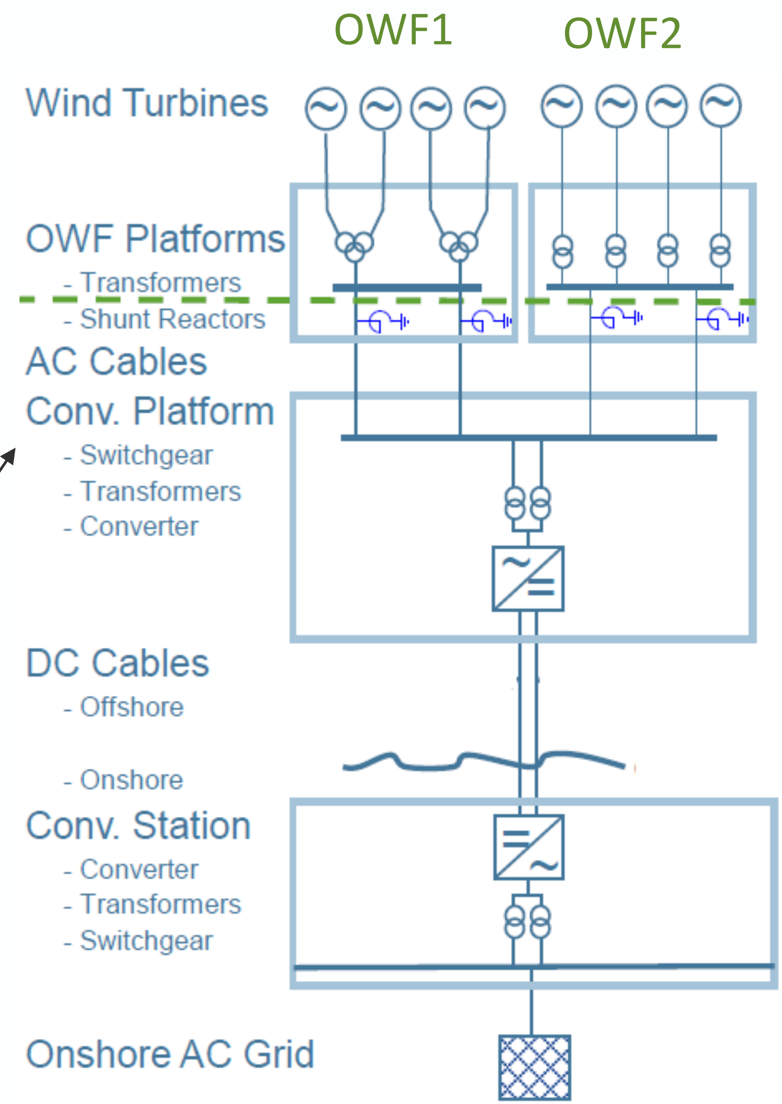
AC transformer substations
Pre and post 2030: 600 MW

AC export cables
Pre and post 2030: 300 kV AC

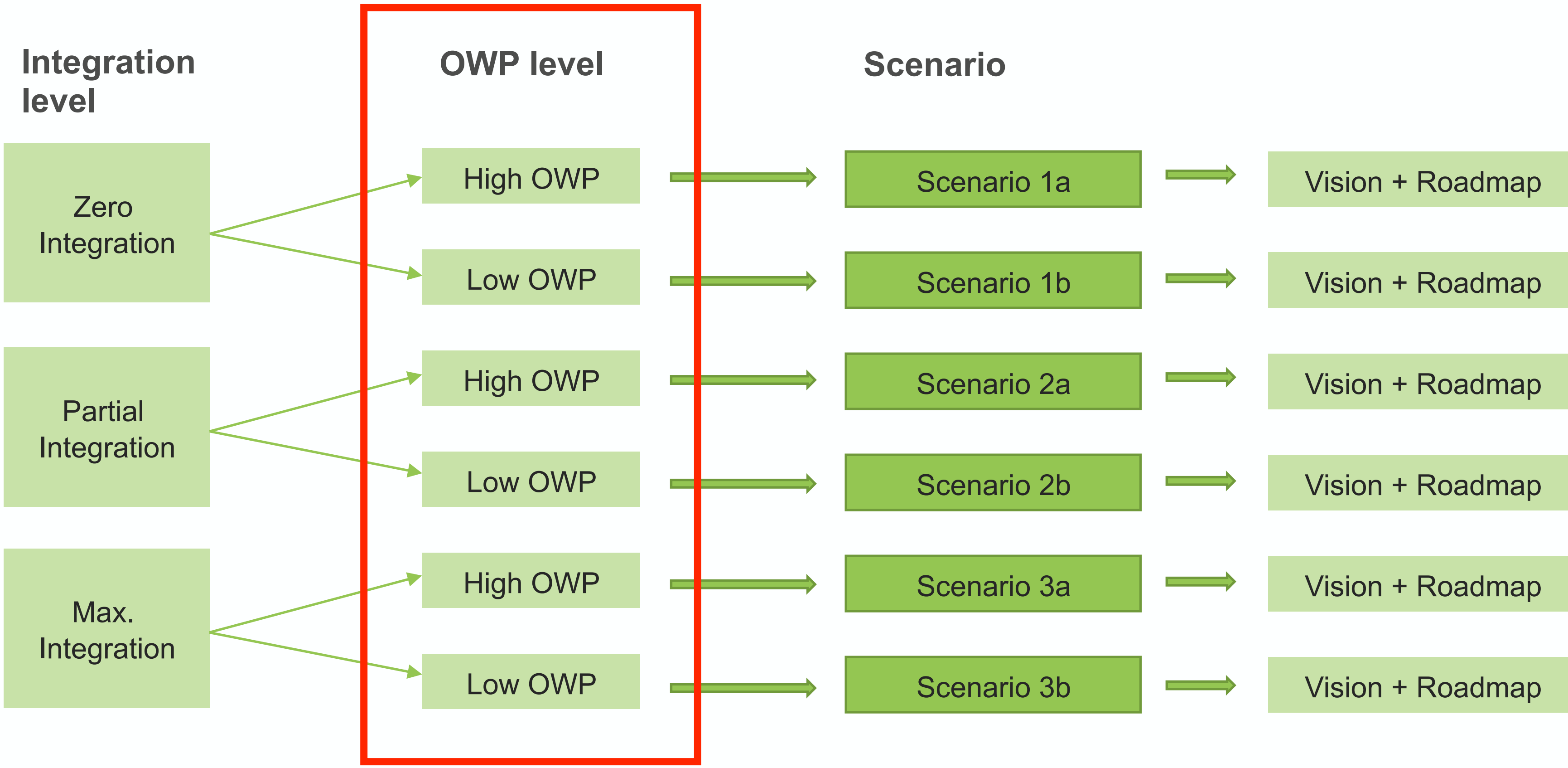
Converter technology
VSC: Modular Multi level
System: Symetrical Monopole or Bipole

HVDC cable voltage (available)
Pre-2030: ± 525 kV → 2500 MW
Post-2030: ± 640 kV → 3000 MW

AC onshore grid
Pre and post 2030: 300-400 kV AC



Scenarios


Integration level
OWP level
Scenario
Zero Integration
Partial Integration
Max. Integration
High OWP
Low OWP
High OWP
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Scenario 1a
Scenario 1b
Scenario 2a
Scenario 2b
Scenario 3a
Scenario 3b
Vision + Roadmap
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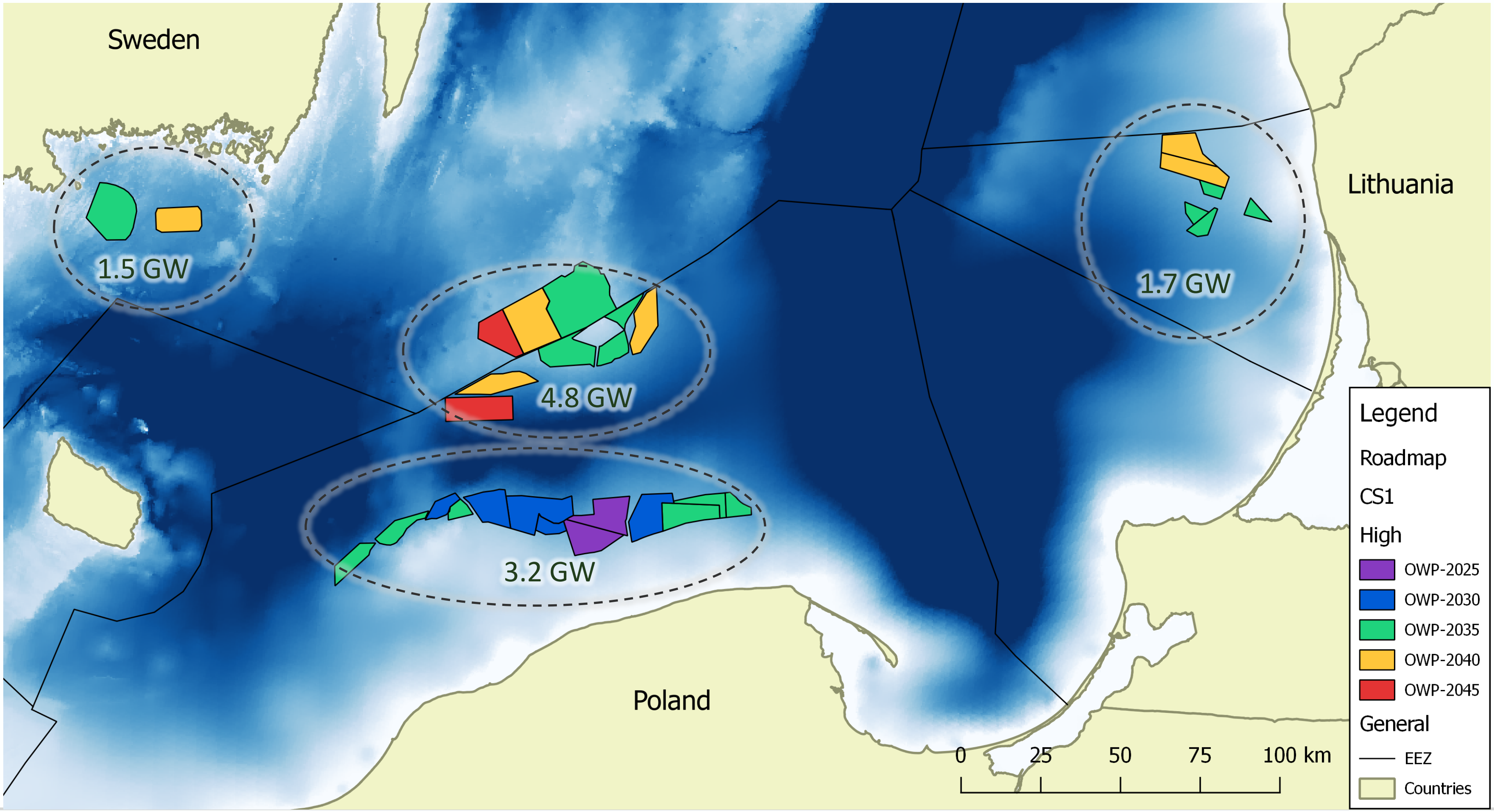
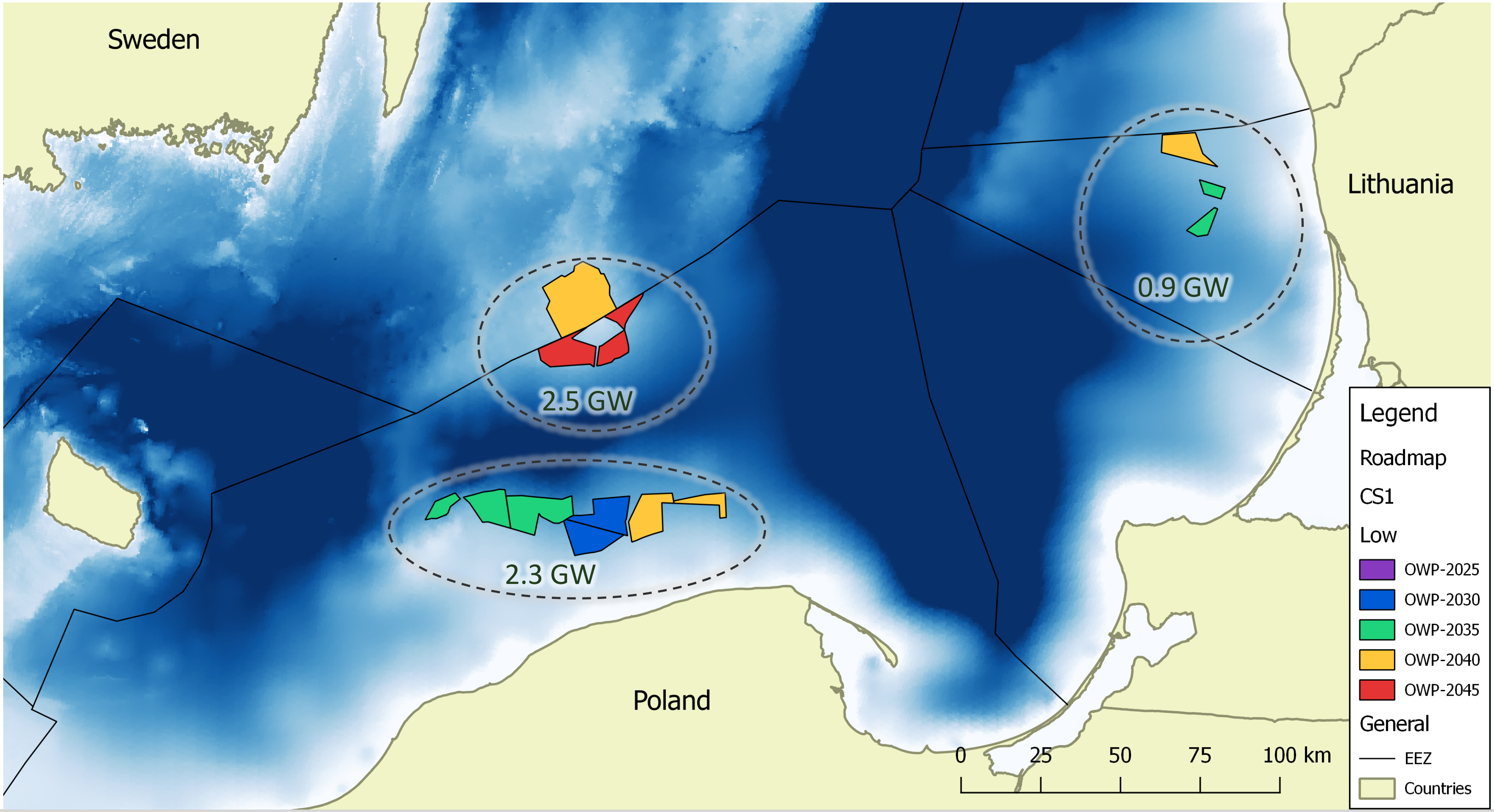
High OWP – 2045

OWP capacity: **11.2 GW, 47 TWh/y**

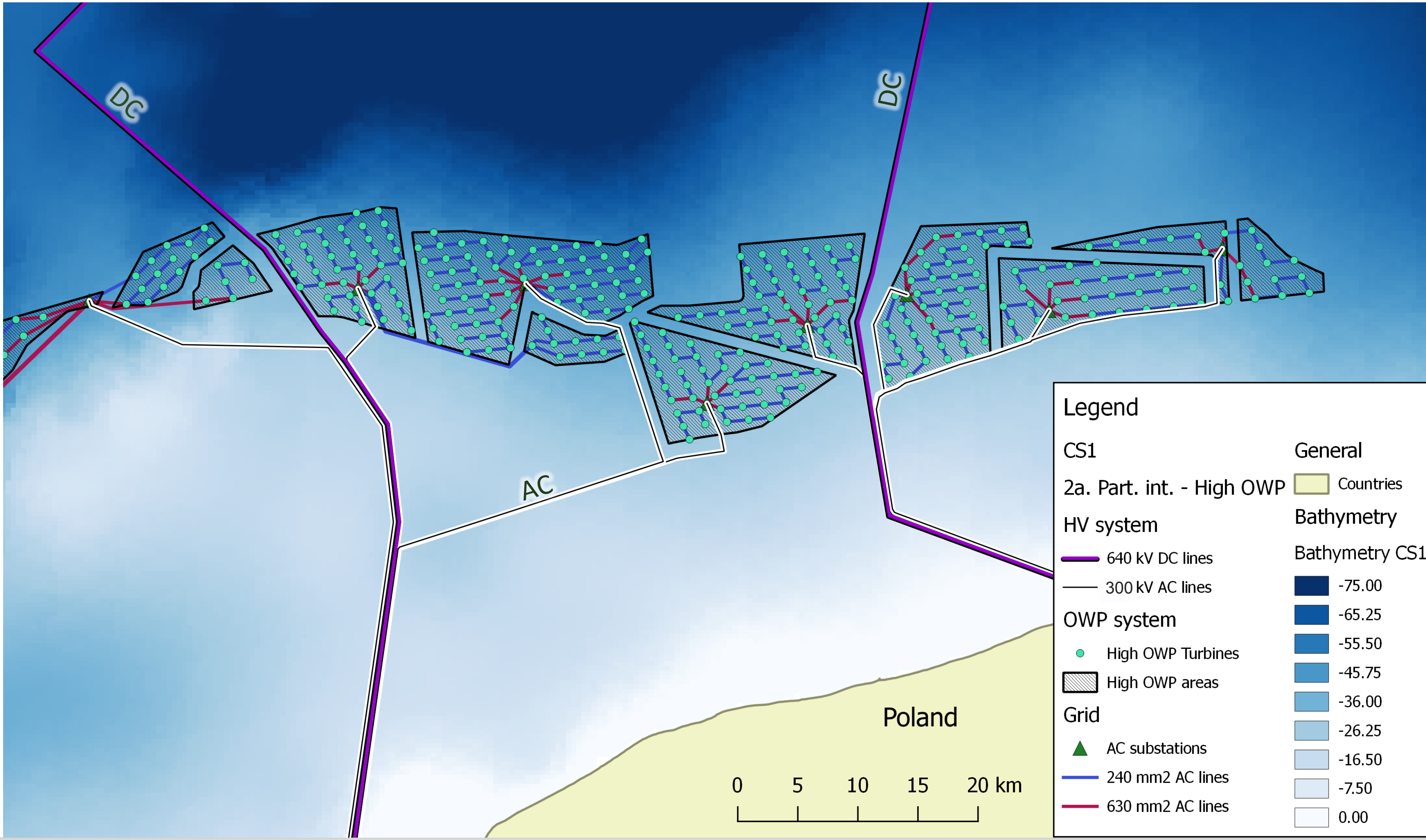


Low OWP – 2045

OWP capacity: **5.7 GW, 24 TWh/y**



High OWP – Wind turbine & cable layouts – Detailed view Slupsk



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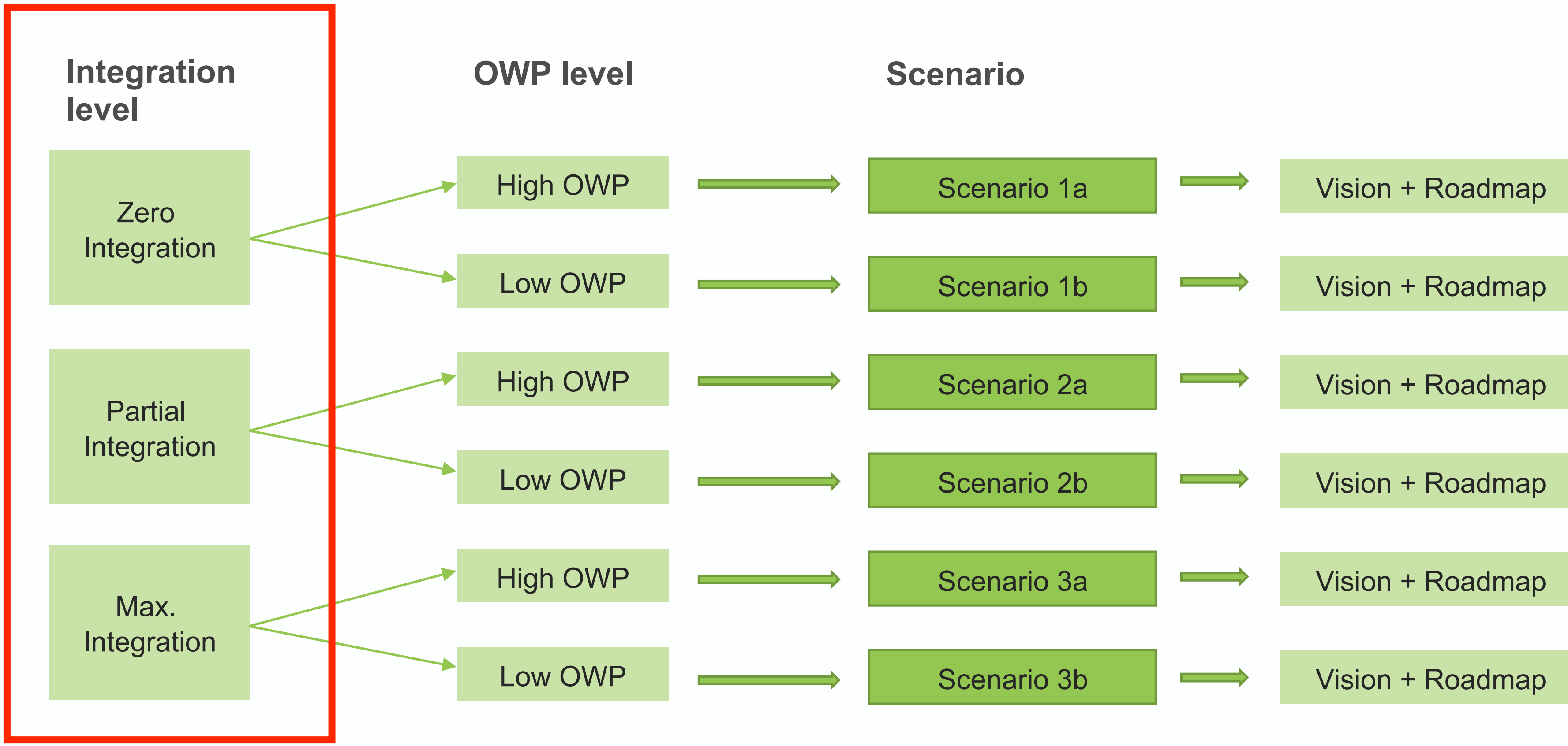
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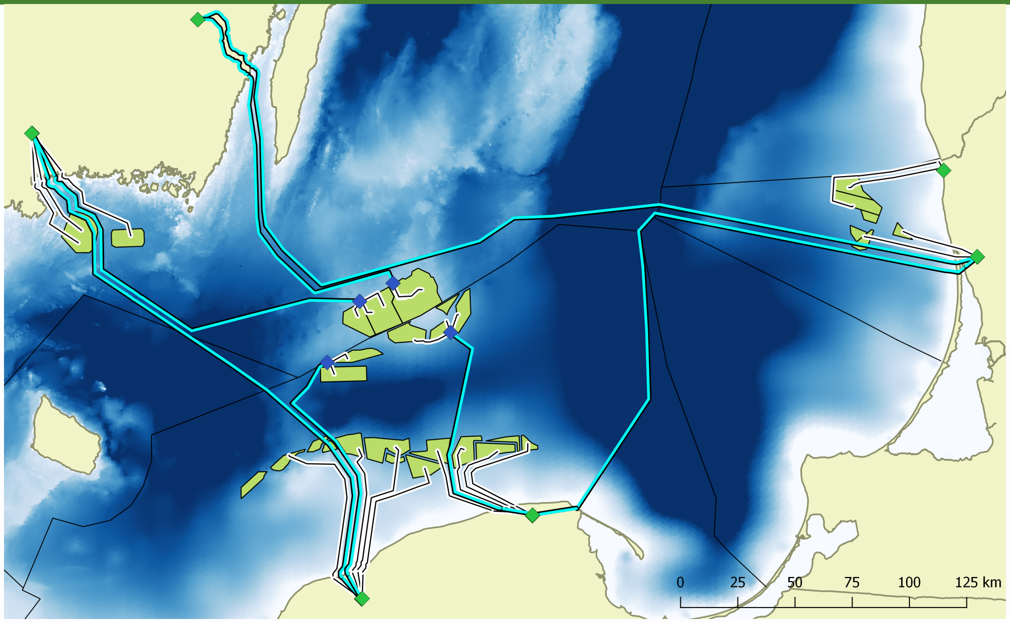
Scenario concept – Integration level

Scenarios

Integration level

Zero Integration



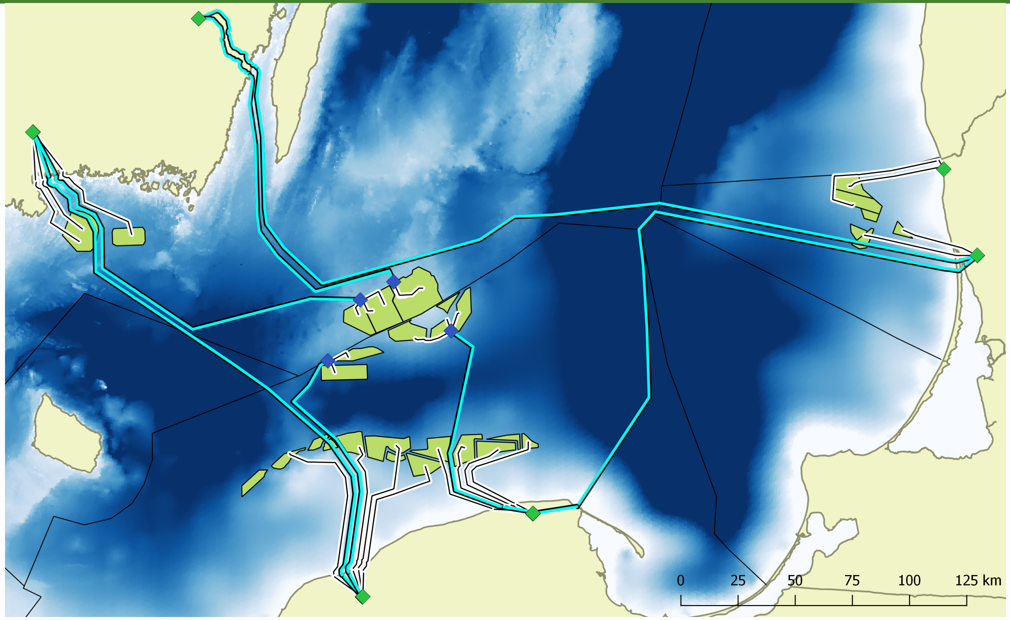
Onshore AC- & DC connection points

Scenario concept – Integration level

Scenarios

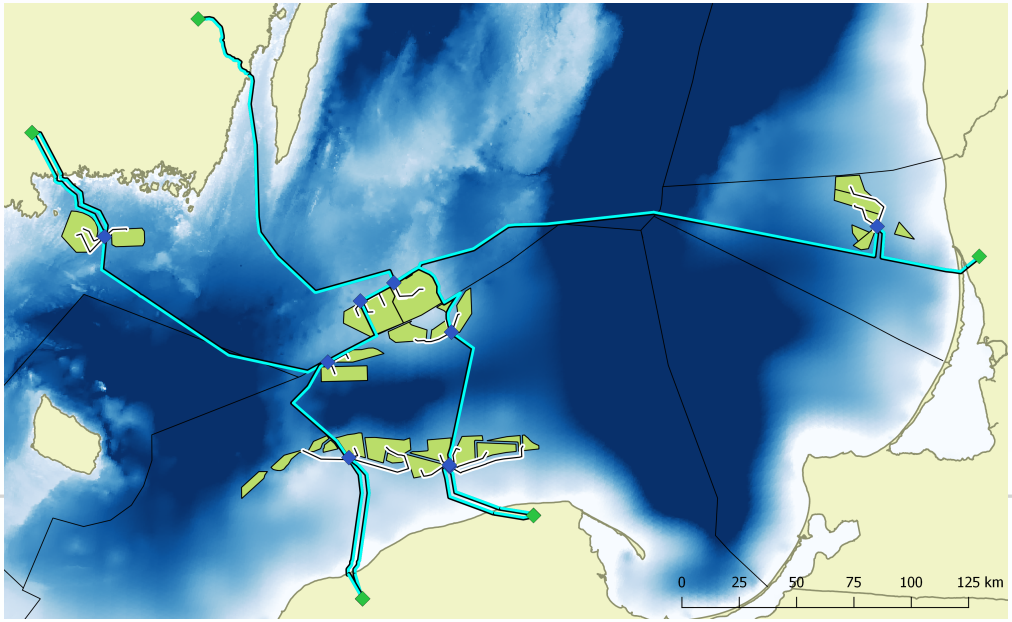
Integration level

Zero Integration



Onshore AC- & DC connection points

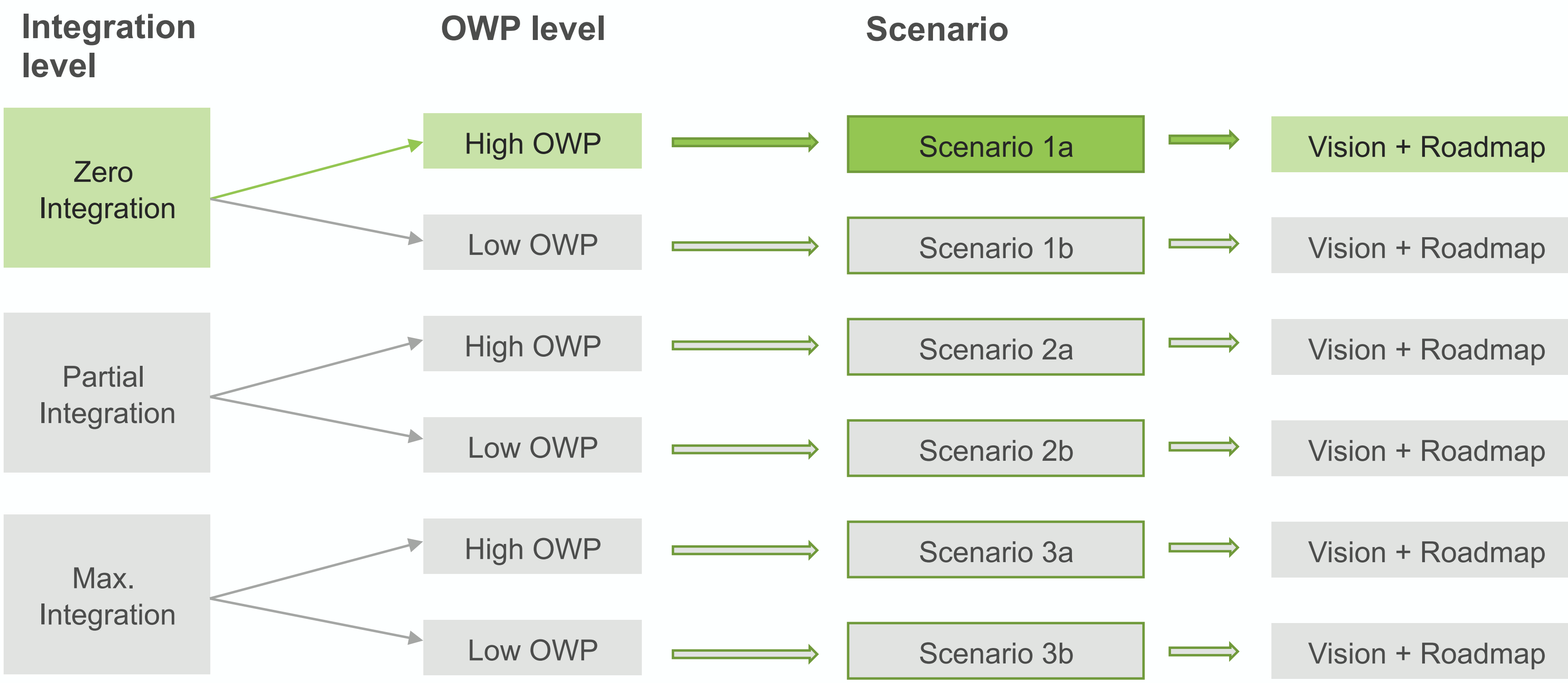
Max. Integration



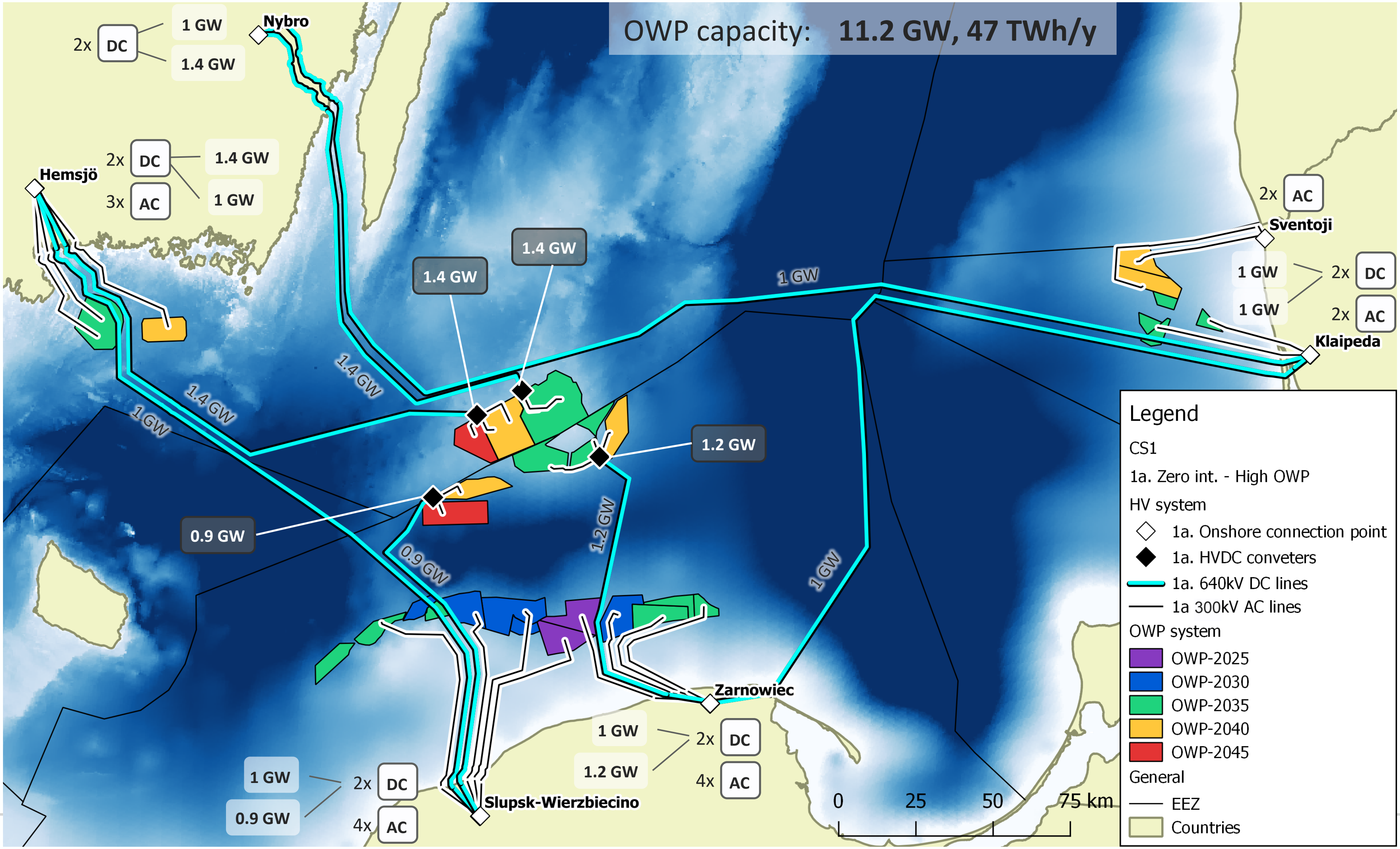
Only onshore DC connection points

Scenarios

Focus on High OWP for this presentation!

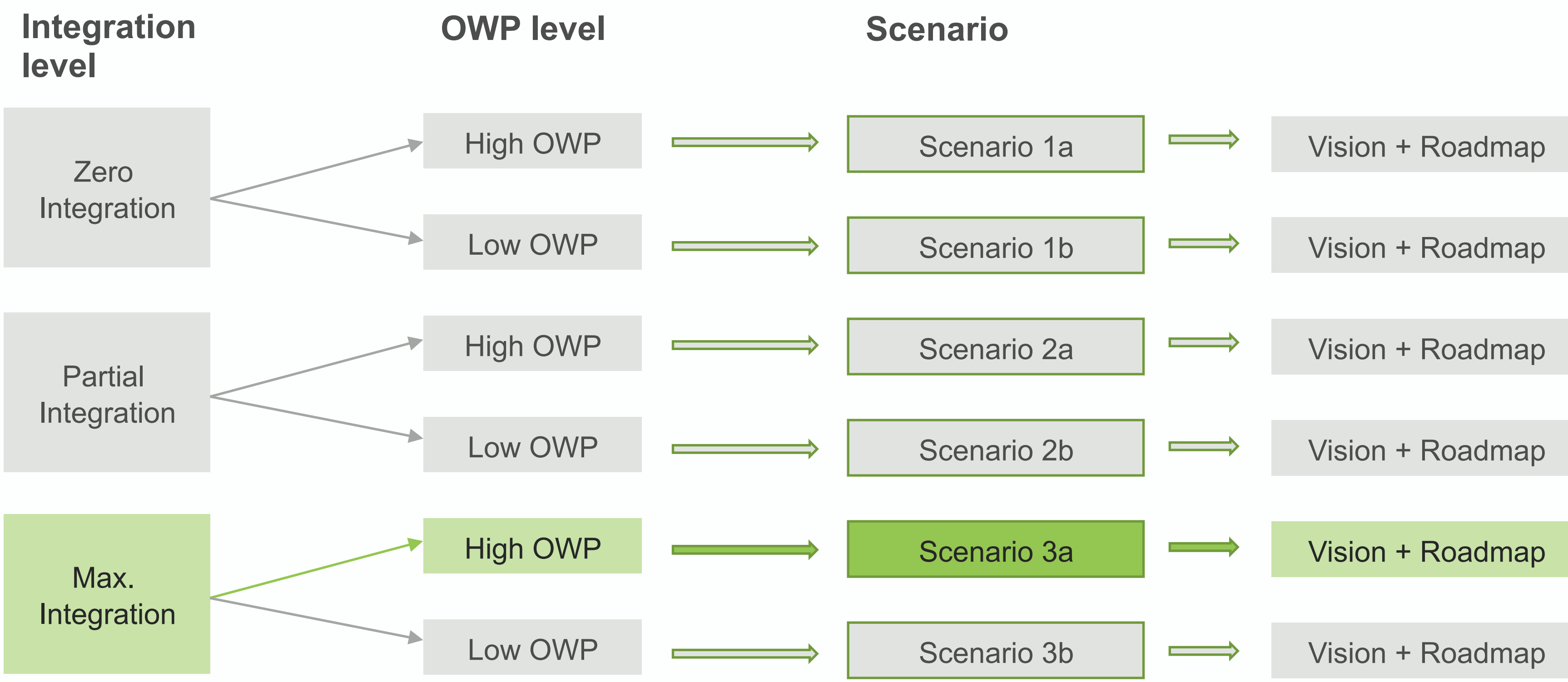


1a. High OWP, Zero integration – DC Overview



Cables viewed schematically

Scenarios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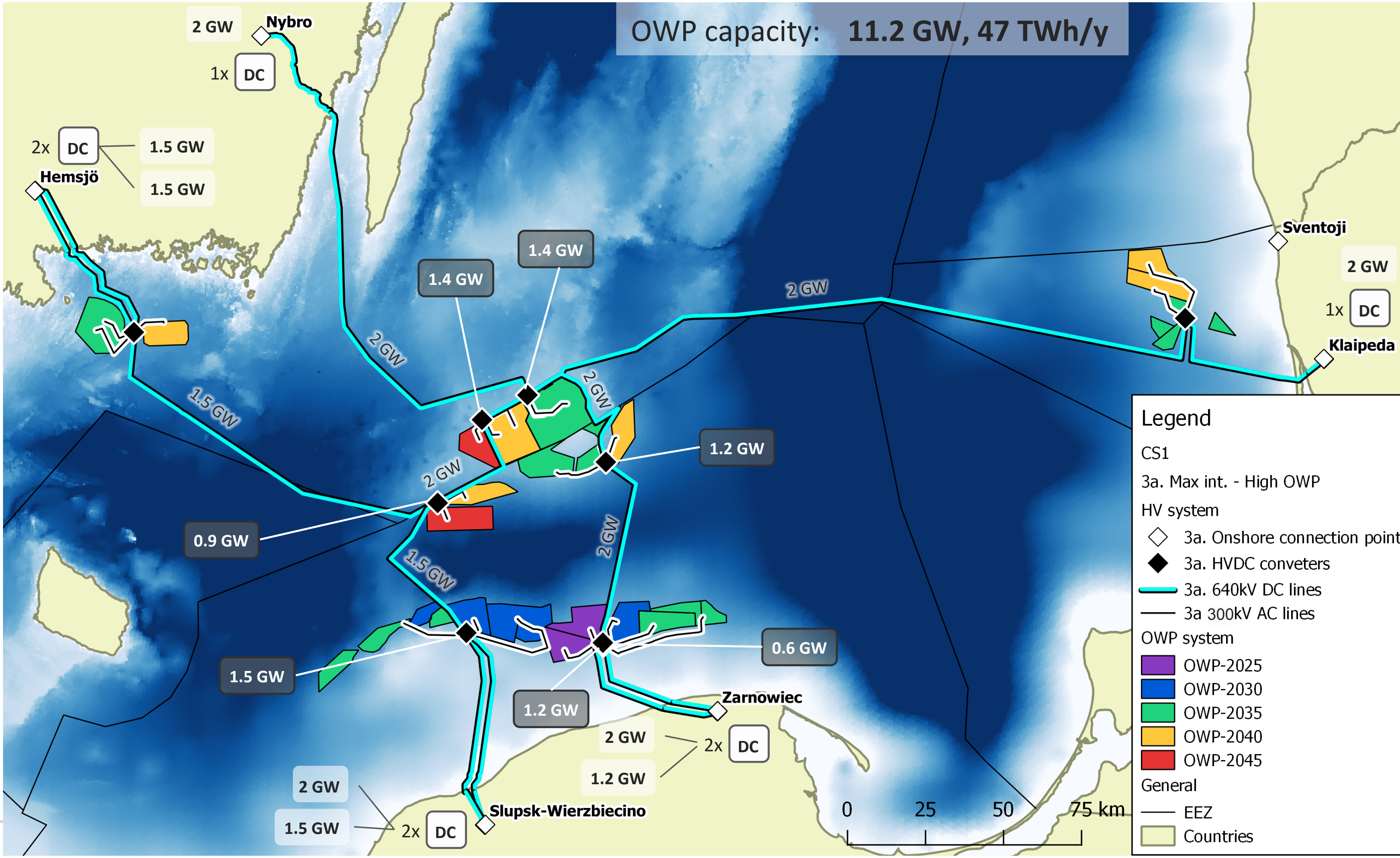
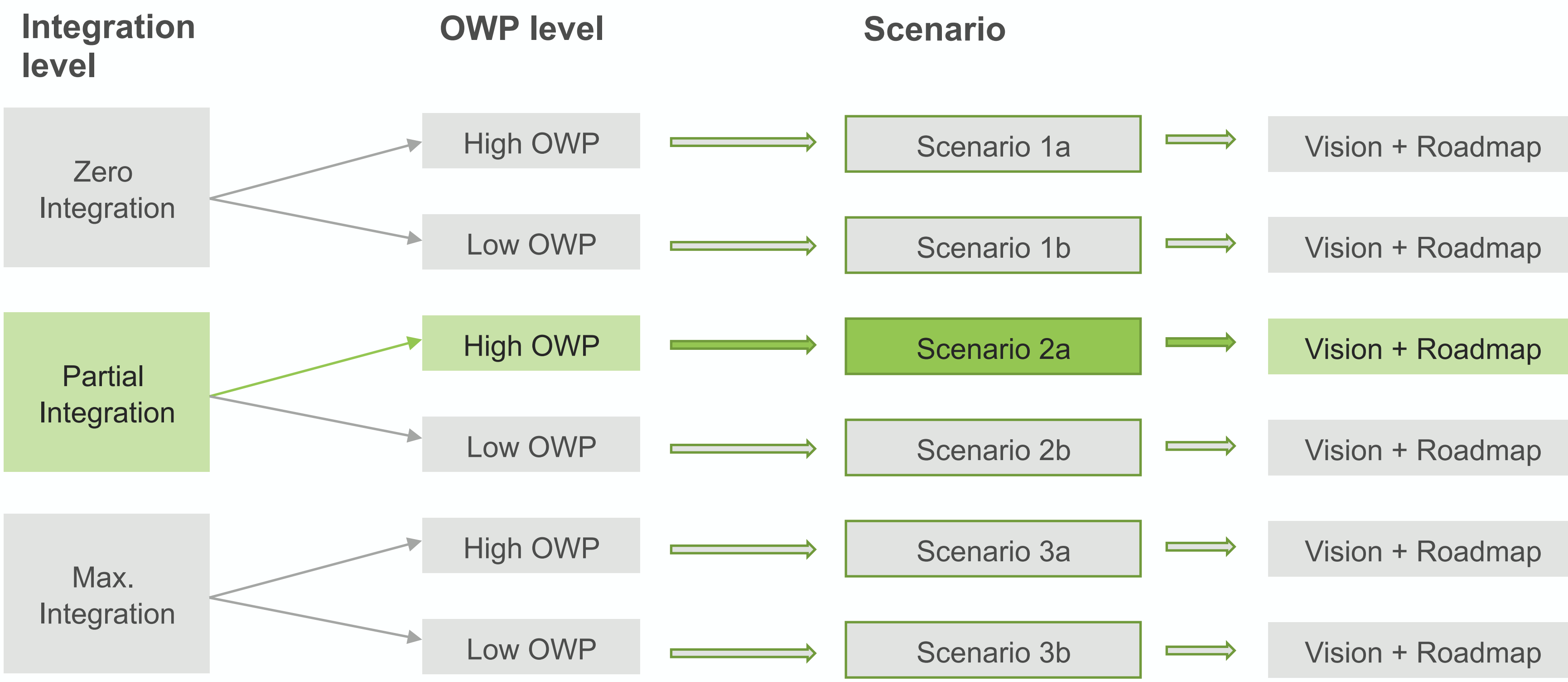
Vision + Roadmap

3a. High OWP, Max integration – DC Overview



Cables viewed schematically

Scenarios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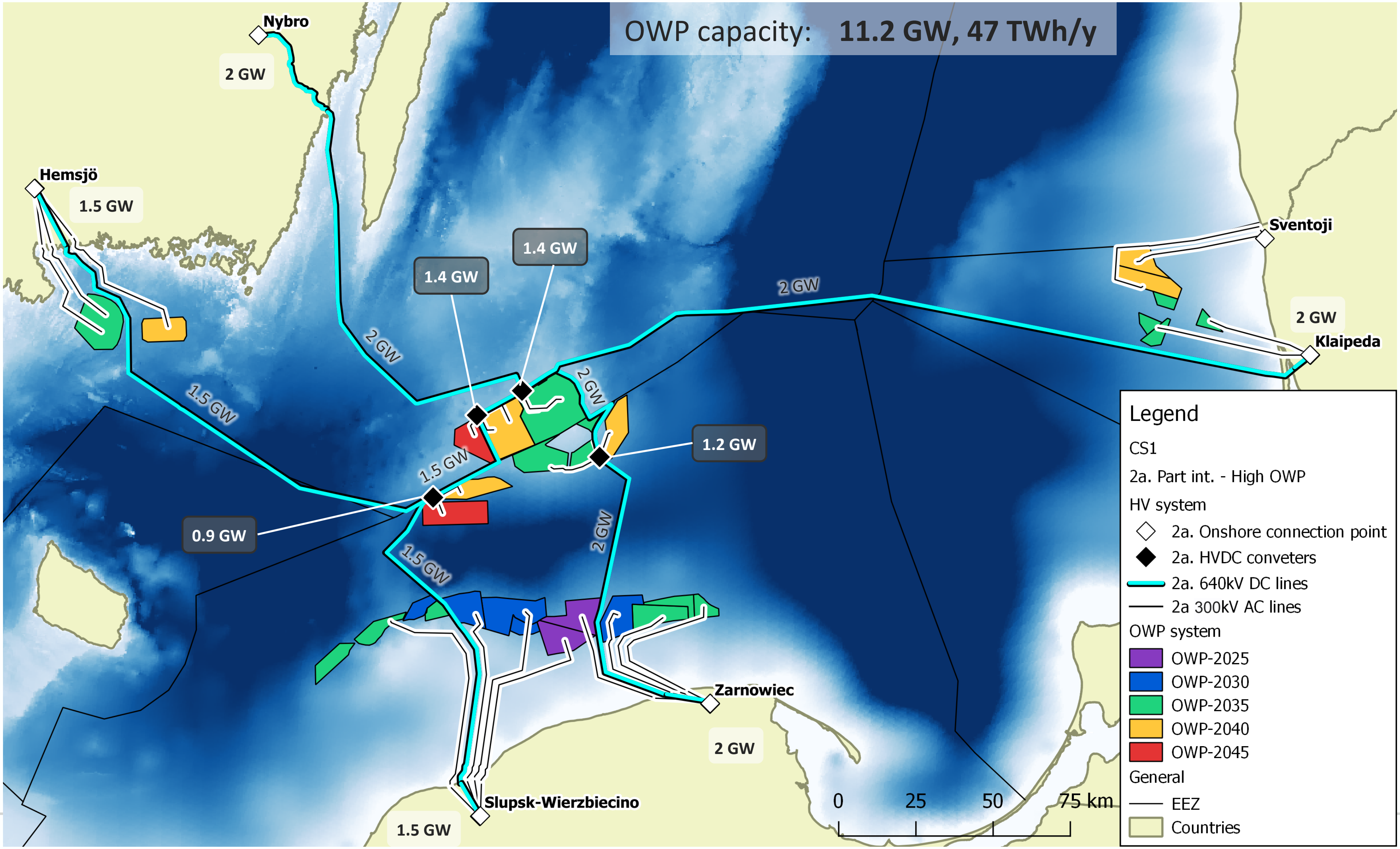
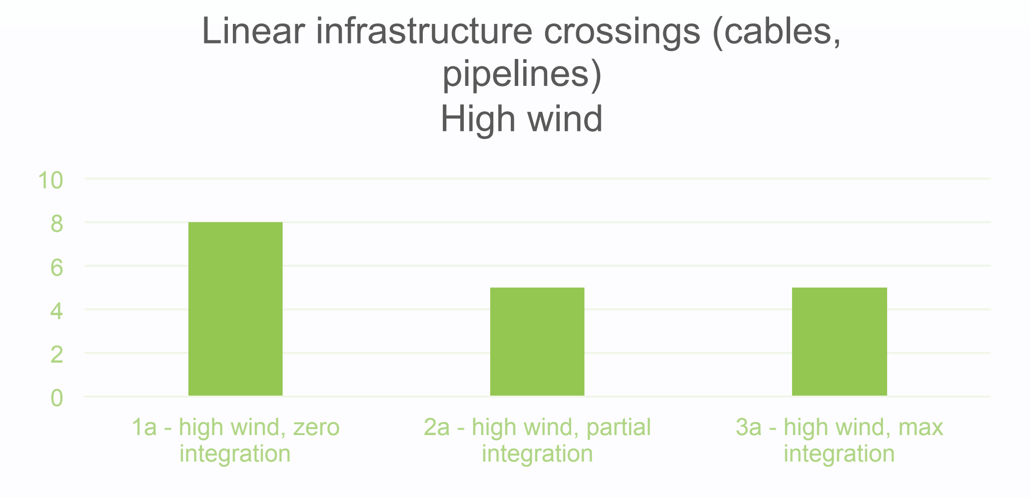
2a. High OWP – Part integration – Overview Grid



Cables viewed schematically

Zero vs Partial vs Max grid integration

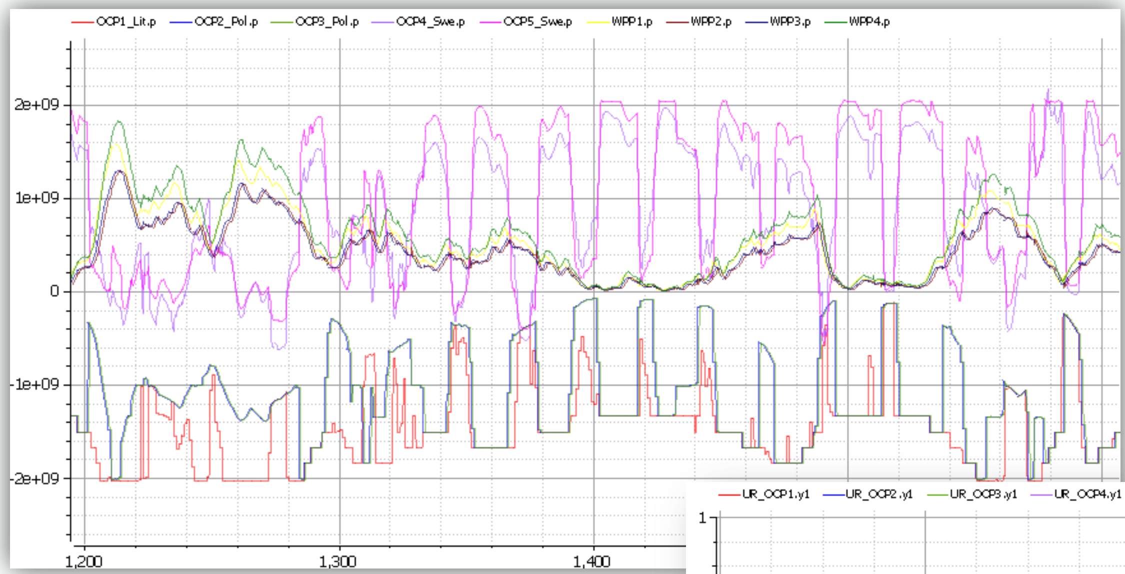
Feature / Integration	Zero (1a)	Partial (2a)	Max (3a)
DC converter substations	14	9	17
DC cable length (km)	3 283	1 979	2 378
DC conductor volume (km*mm^2)	3.8*10^6	4.8 *10^6	6.4*10^6
OWP on DC system (GW)	4.8	4.8	11.2
Onshore AC transformers	15	15	0
AC export cable length (km)	1 073	1 073	354
AC export cond. vol. (km*mm^2)	1.7*10^6	1.7*10^6	0,6*10^6

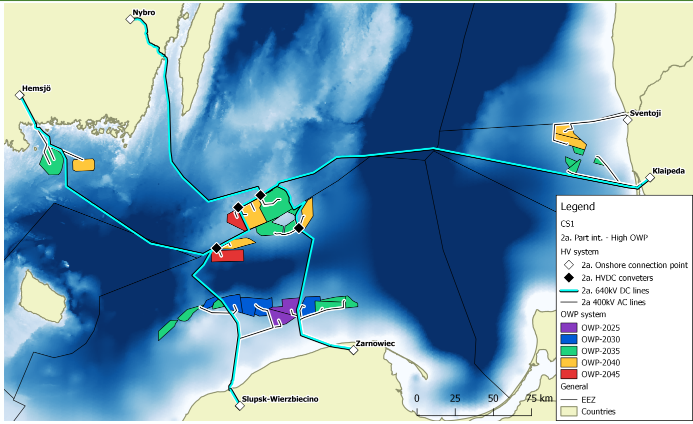


Extended analysis

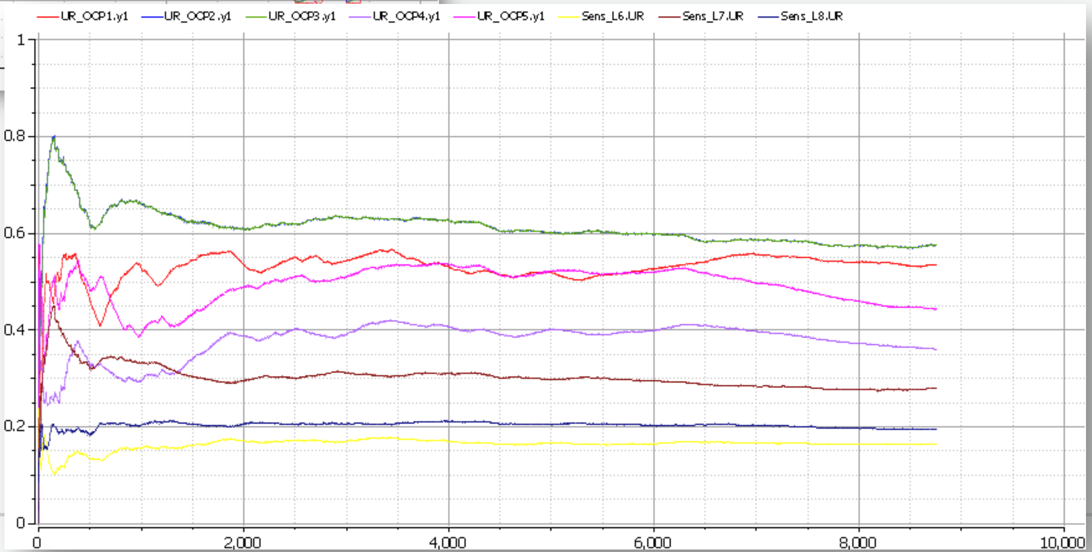
Integrated power trade with wind

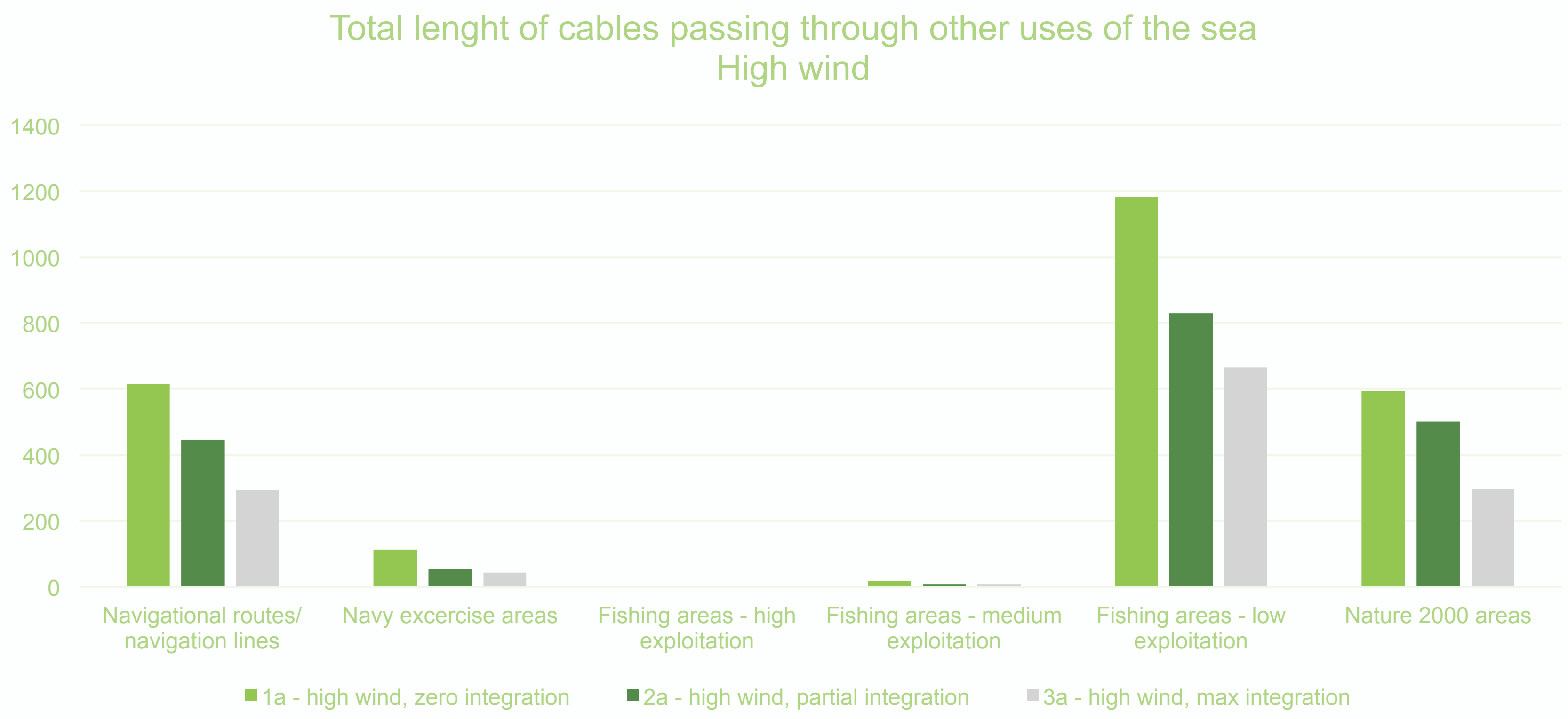
Intra hour power flow





Utilization rates




Total lenght of cables passing through other uses of the sea
High wind
1400
1200
1000
800
600
400
200
0
Navigational routes/ navigation lines
Navy excercise areas
Fishing areas - high exploitation
Fishing areas - medium exploitation
Fishing areas - low exploitation
Nature 2000 areas
1a - high wind, zero integration
2a - high wind, partial integration
3a - high wind, max integration

Contact & Disclaimer

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Green Advisor to four National Olympic Committees