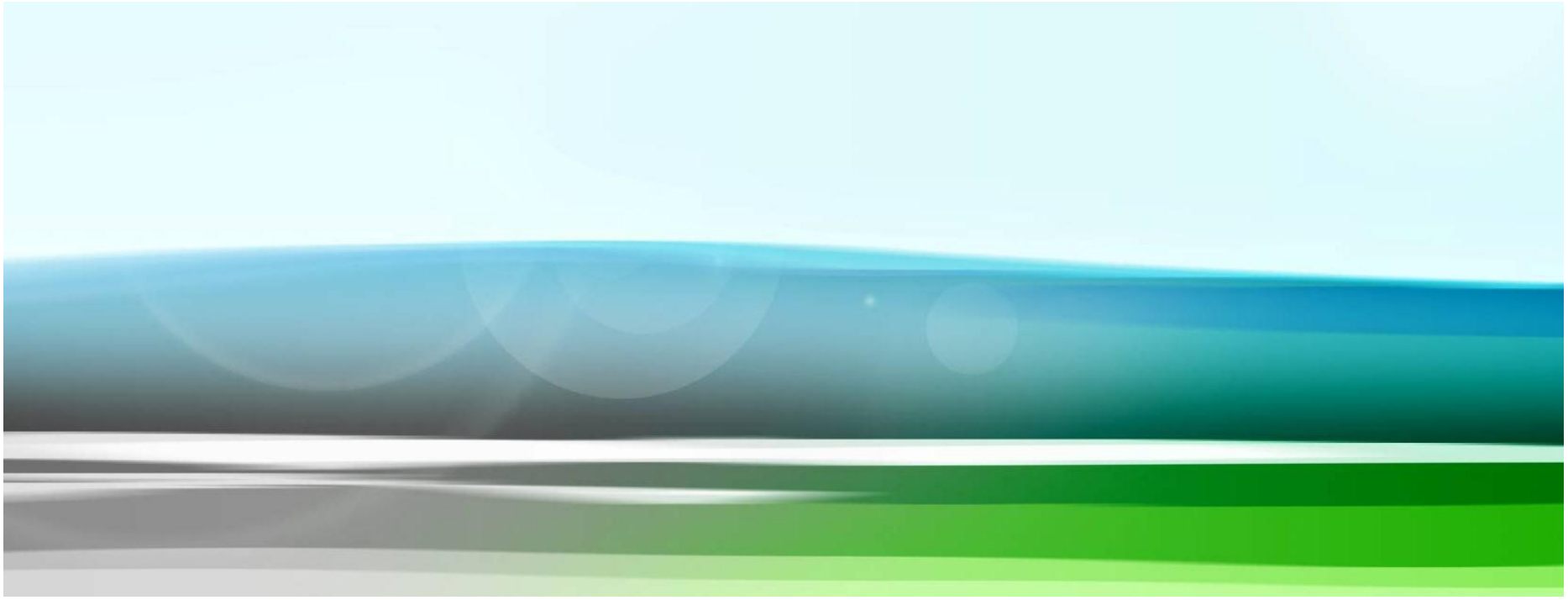


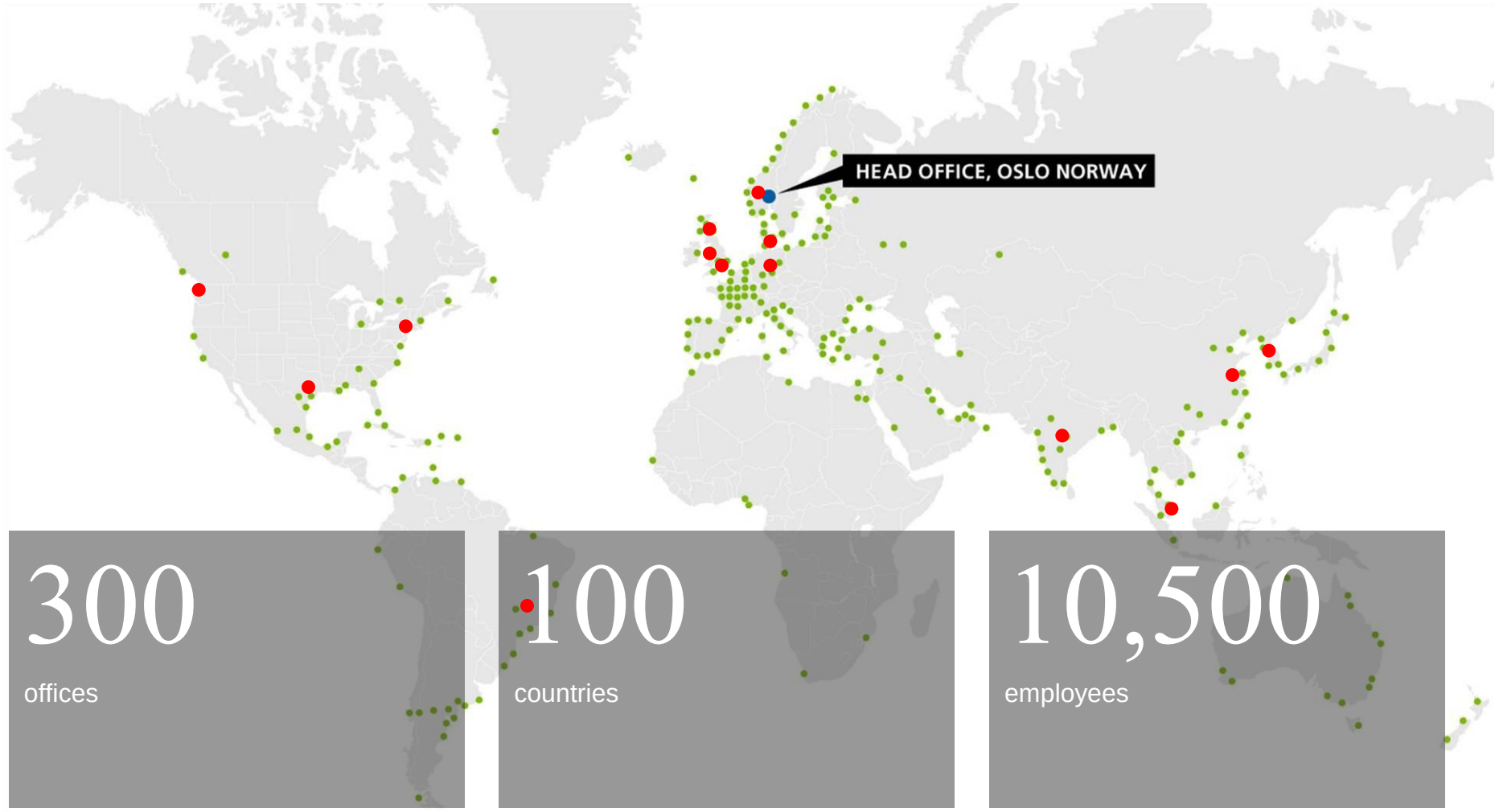
The potential for windpower in the Baltic Sea

4th September 2013

Stanisław Paszkowski/Michał Gronert

MANAGING RISK DNV

DNV – An Independent Foundation



300
offices

100
countries

10,500
employees

Offshore Wind - Combining DNV competences

25+ years of hands-on experience with wind turbines

+

40+ years of offshore oil & gas experience

=

Global leader in project risk and certification of offshore wind projects

Baltic Sea Environment

- Stable wind conditions
- Better wave condition in comparison to the North Sea
- Longer Weather Window
- Water depths 25 – 40+ meters
- Limited icing

Location

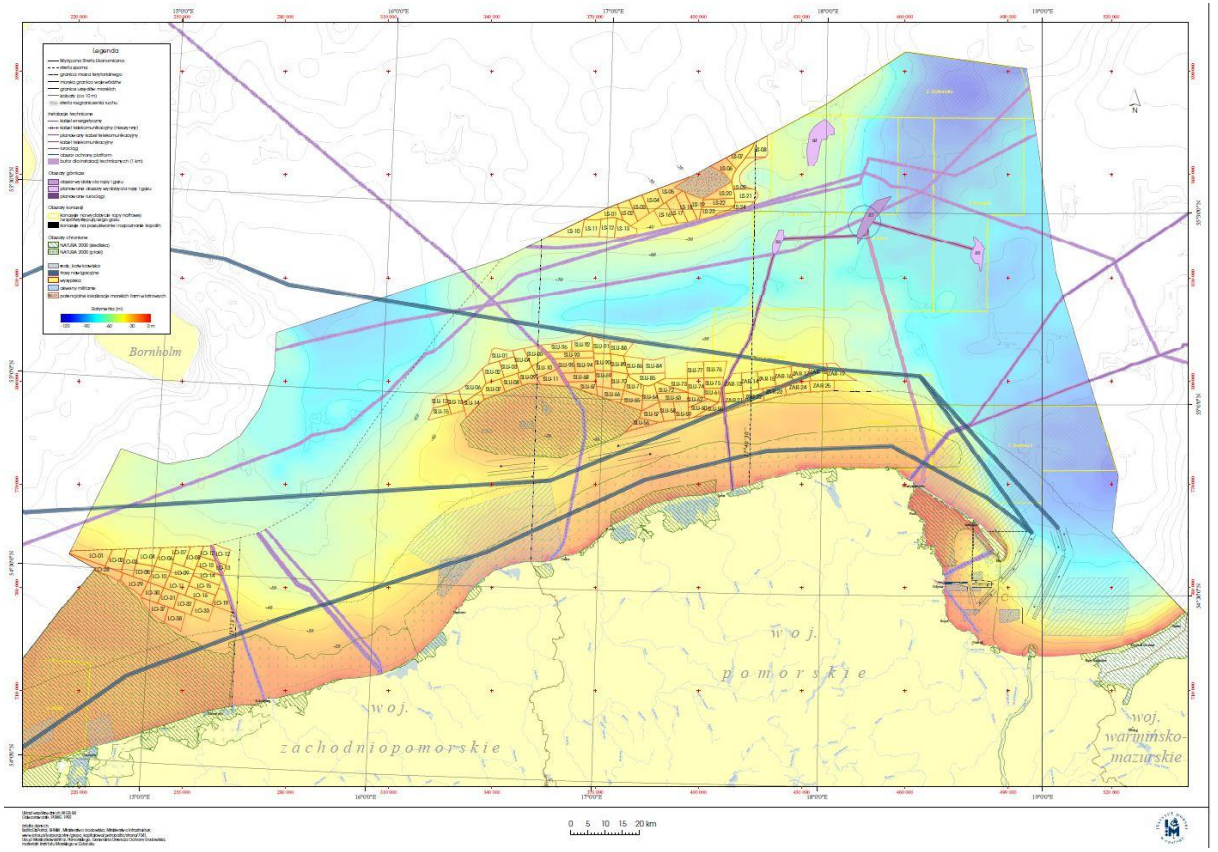
- 33 000 km^2

Total area

- 2 500 km^2

Potential area for offshore wind farms

- Limitations:
  - Natura 2000
  - Significant distance to shore
  - Military zones
  - Oil & gas licences
  - Traffic routes



Source: http://www.transport.gov.pl/

Infrastructure

- Harbours
- Storage areas
- Shipyards / manufacturing
- Engineering services
- Technical Universities

Source: PTMEW „Perspektywy rozwoju MFW w Polsce”

Source: http://www.gdanskshipyard.pl

Estimated prospect grid capacity for offshore wind

- Year 2020

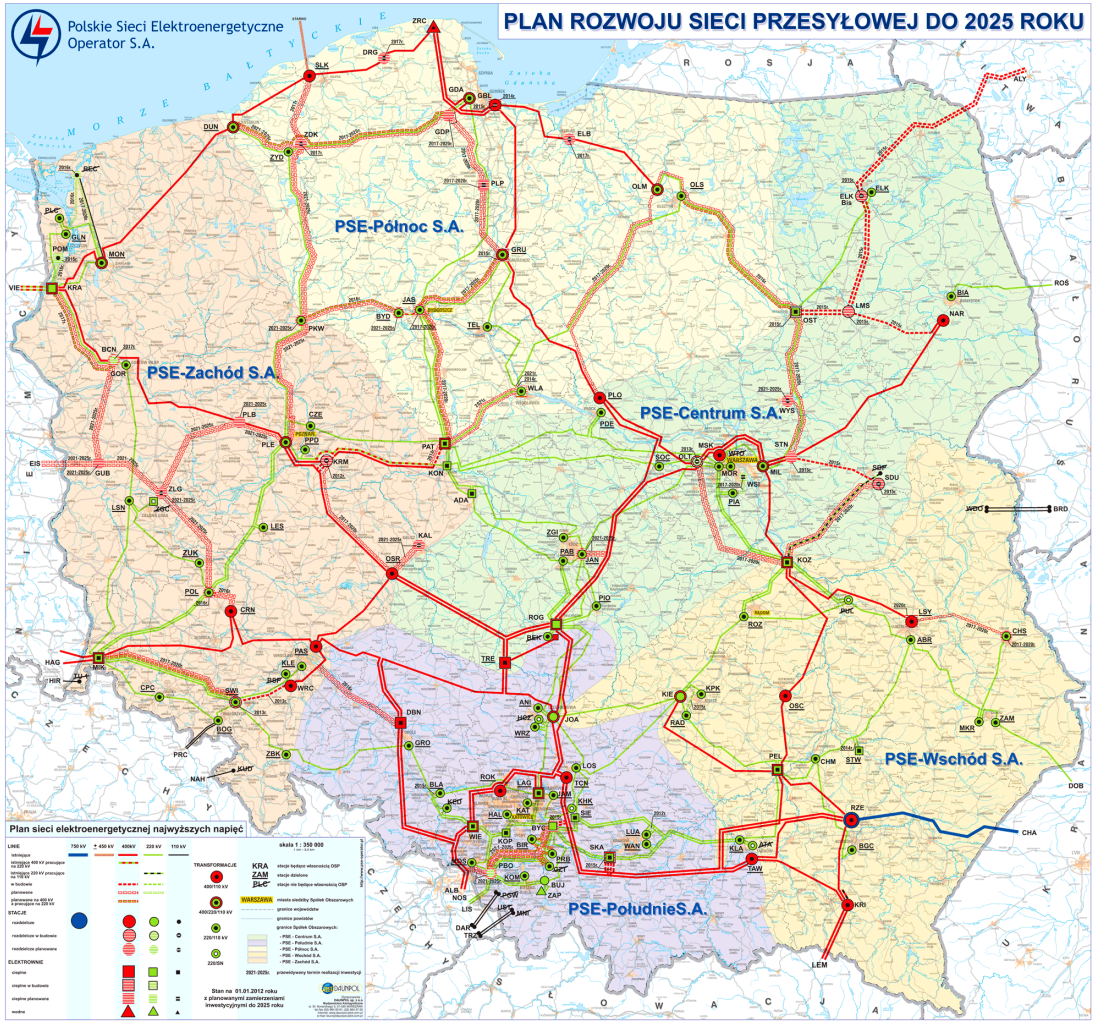
  1 GW

- Year 2025

  another **2 GW**

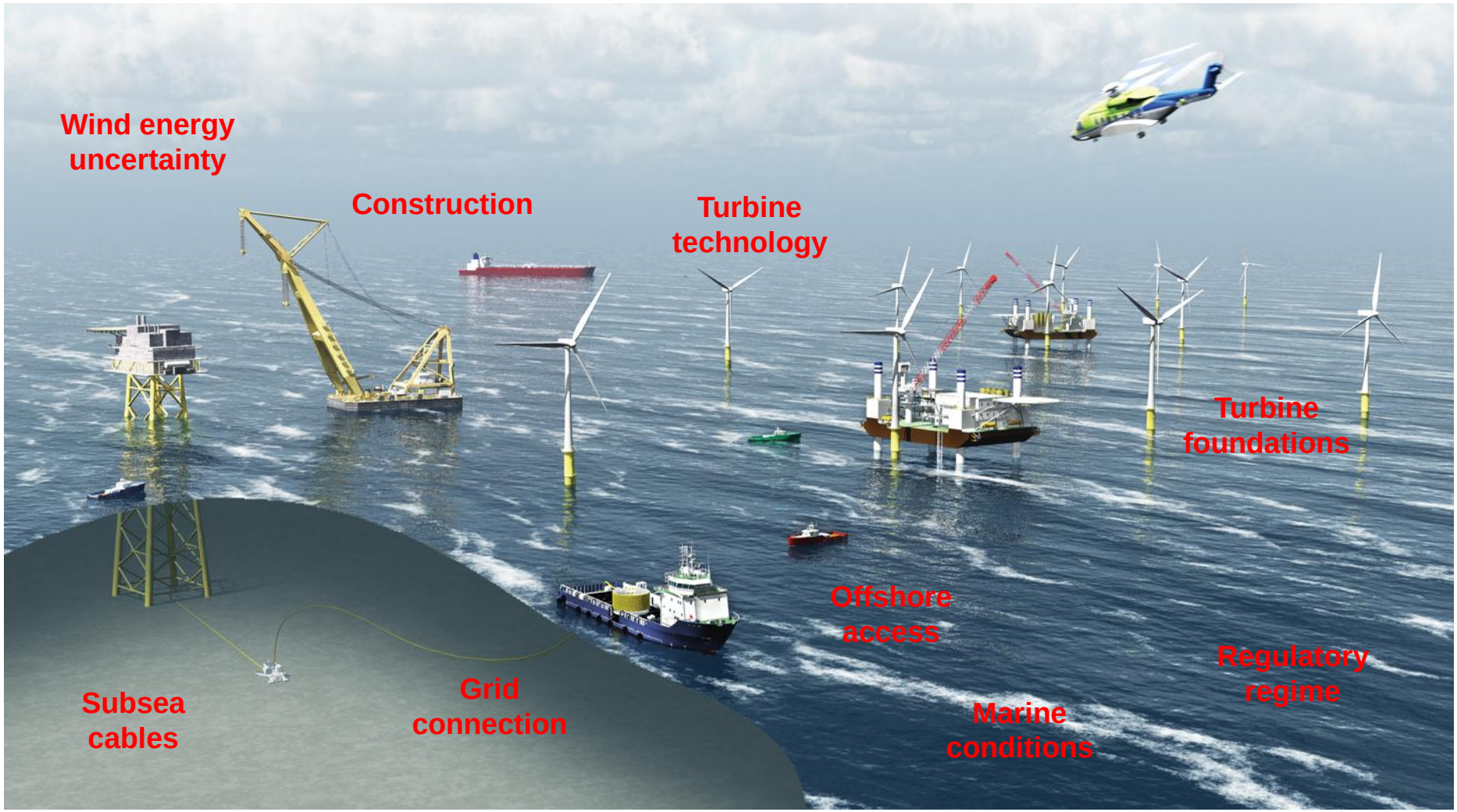
- **3 GW** without investments dedicated for OWF

- **6 GW** potential capacity followed by further investments



Source: http://www.pse-operator.pl/

Offshore Wind Farms – Challenges



Wind Energy Uncertainty

- Issue
  - Non real on-site wind data
  - Cost of fixed met mast installation are high
  - Wind resource estimates have large uncertainty
  - Aerodynamics loss factors are not well understood (e.g. wakes and turbulence)

- Mitigation
  - Offshore measurement (fixed tower, novel solutions) over sufficient period of time (> 2 years)
  - Data sharing
  - Transparency of energy estimates

Site Conditions – Marine Environment

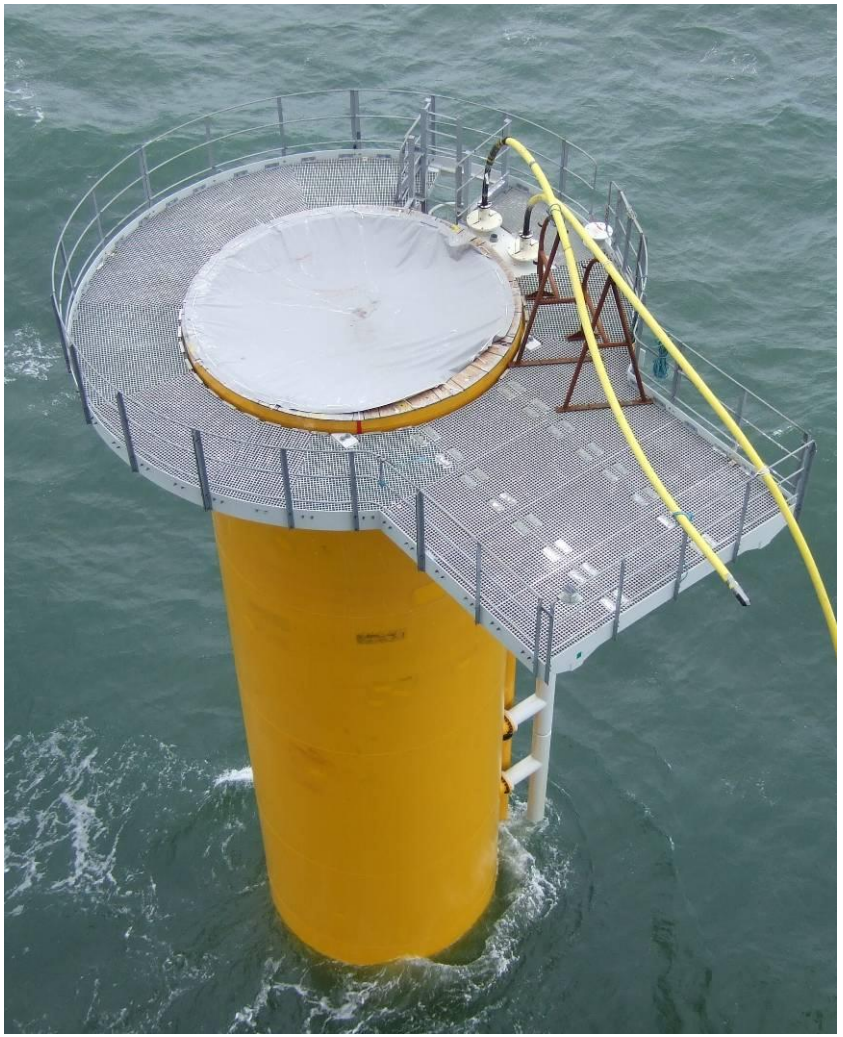
- Issue
  - The weather and sea conditions data
  - Weather window for offshore work
  - Distance to shore grater than 12 NM
  - Varying water depths and sea bed conditions across a site

- Mitigation
  - Solid, site-specific information
    - Measurement campaigns
    - Data mining
    - Geotechnical investigation
    - Safety factors in design
  - Relevant learning from oil and gas
  - Development / use of equipment / methods suitable in adverse conditions

Wind Turbine Foundations

- Issue
  - Costly foundation designs due to:
    - Deeper water: 40m and beyond
    - Larger turbines
  - Shallow-water solutions are not applicable on the Baltic Sea (12 NM from shore)
  - Choice between: Jackets, Tripods

- Mitigation
  - Utilization of Polish industry manufacturing experience and potential
  - Standardization
  - Quality control during manufacturing
  - Sea bed data



Construction

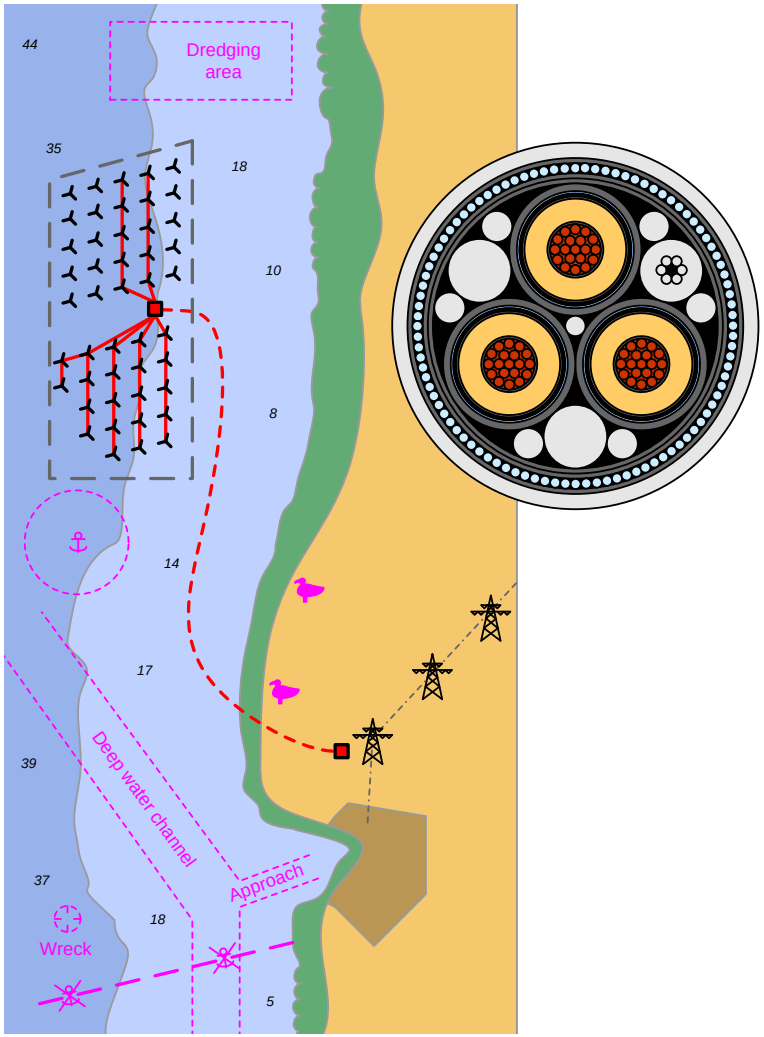
- Issue
  - Major project size – complexity
  - Construction vessels availability
  - Weather window challenge
  - Contract strategy selection
  - Supply chain and facilities
  - Hiring experienced staff could be challenge

- Mitigation
  - Previous project experience – cooperation with experienced partner
  - Project lifecycle engineering supervision
  - Installation concept studies
  - Plan A, B and C
  - Project Verification and Certification

Subsea Cables and Power Transmission

- Issue
  - Many problems during cable installation, e.g. improper cable handling
  - Human introduced hazards (e.g. anchoring)
  - Unplanned downtime not considered in energy estimates

- Mitigation
  - Cabling
    - Understand site-specific conditions
    - Chose appropriate cabling design (e.g. armour, burial depth, scour protection)
    - Work with experienced partners
    - Plan with contingencies
  - Electrical Substation
    - Realistic expectations for annual maintenance time
    - Include unplanned outages
    - Diligent inspections and maintenance



Grid Connection

- Issue
  - HVAC or HVDC
  - Limited infrastructure onshore
  - Grid connection is a developer responsibility
  - Uncertainty about ownership / operation of assets
  - Long distance / high power will require (less proven) offshore HVDC solutions

- Mitigation
  - Early dialogue between developer and grid operator
  - Careful evaluation of various options

Busy day at work…

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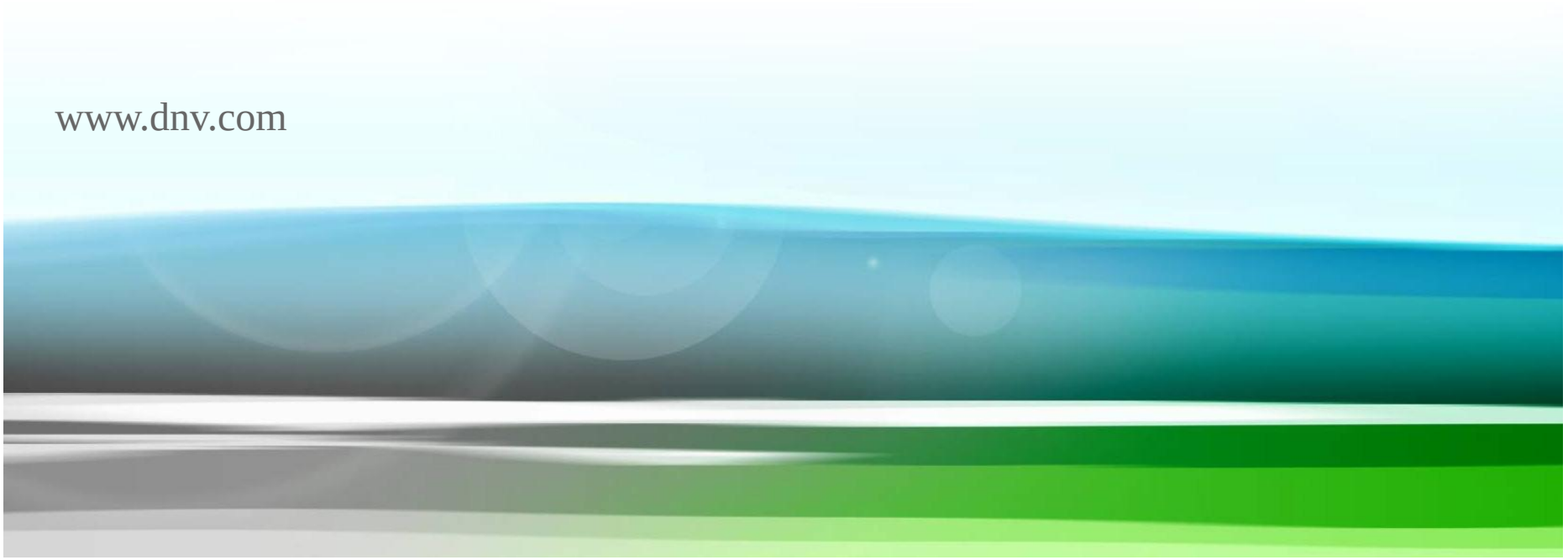

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