Network Interconnection of Offshore Wind

Prepared for REOLTEC

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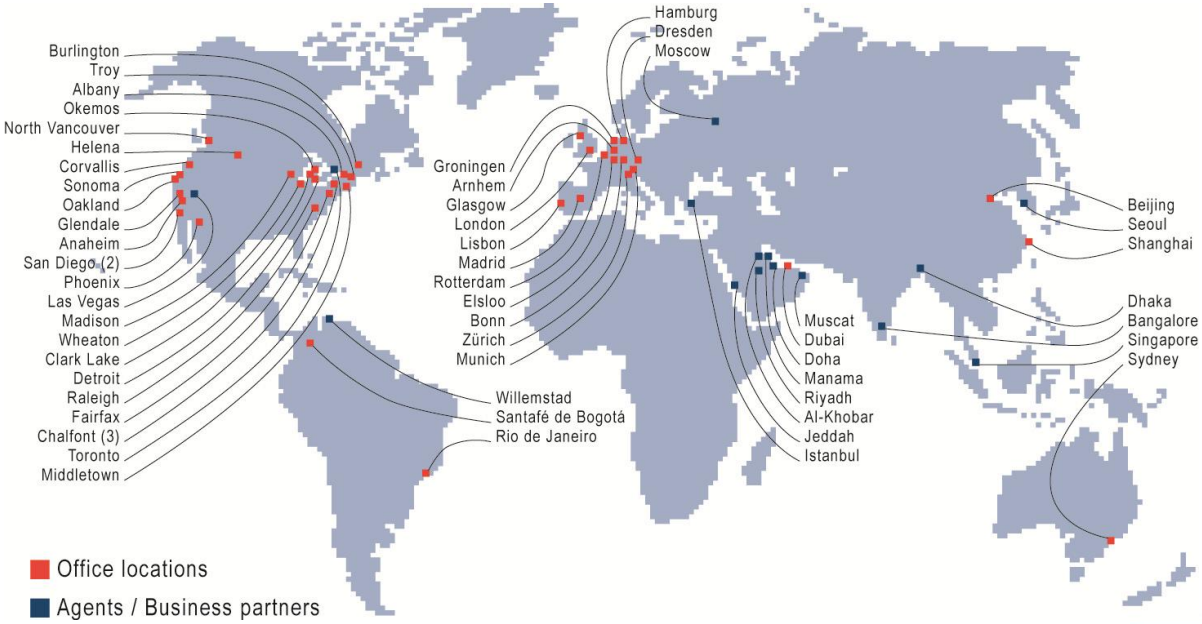
Madrid, December 3rd

Introducing KEMA

A trusted independent partner providing advise throughout the entire chain of Energy



KEMA… Experience you can trust

Offshore Wind Experience in Europe

Offshore wind has grown dramatically in the last years

Ireland

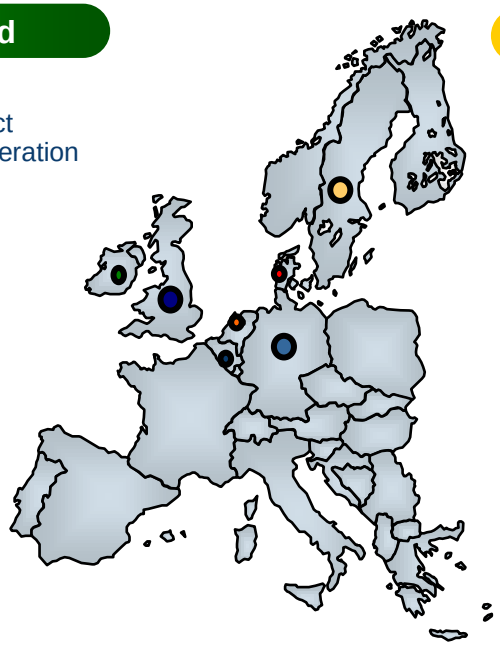
1 Project
25 MW in Operation

United Kingdom

8 Projects
598 MW Installed
1,392 MW Pending

Belgium

1 Project
30 MW Installed



Germany

728.3 MW Pending

Sweden

4 Projects
132.5 MW Installed
30 MW Pending

Denmark

8 Projects
426.15 MW Installed
428.2 MW Pending

Netherlands

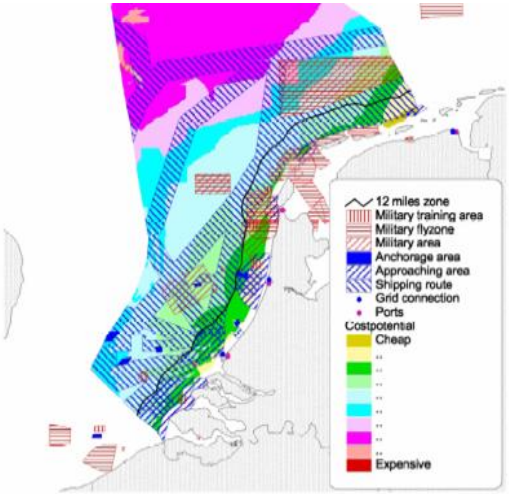
4 Projects
244.8 MW Installed

	Country	MW	#	Avg Size (MW)
Operating	UK	598.00	8	74.75
	Denmark	426.15	8	53.27
	Netherlands	244.80	3	81.60
	Sweden	132.50	4	33.13
	Belgium	30.00	1	30.00
	Ireland	25.00	1	25.00
Totals		**1456.45**	**25**	**58.26**
Pending	UK	1,392.00	8	174.00
2009-12	Germany	728.30	4	182.08
	Denmark	428.20	4	107.05
	Sweden	30.00	1	30.00
Totals		**2,578.50**	**17**	**151.68**

Strategy on offshore wind energy – The Netherlands

- The Dutch government set a target of realizing 6.000 MW of offshore wind energy before 2020 (i.e. 25% of the expected maximum load - 10.000MM€)
- North Sea favourable place for offshore wind power: high average wind speeds, shallow waters, etc

- KEMA performed a study for the Dutch Government to evaluate technical and economic, financial and legal impacts:
  - The target was technically and economically feasible
  - But was dependant on adaptations to the electricity grid

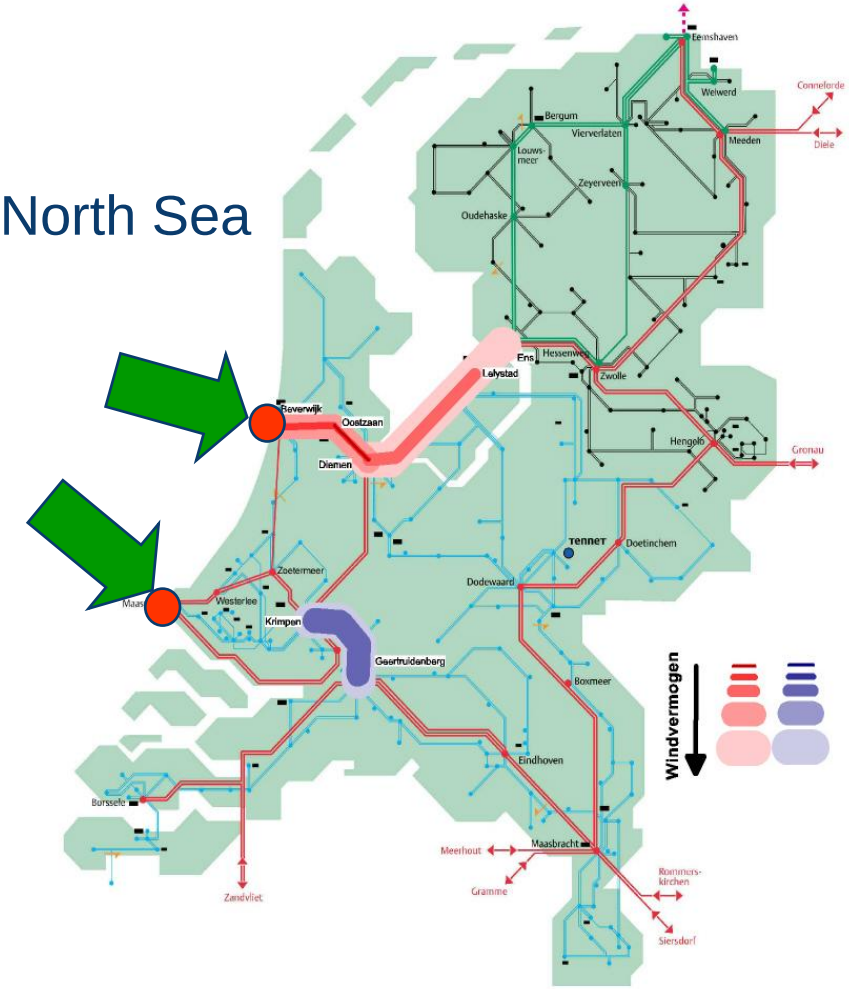


Strategy on offshore wind energy – The Netherlands

How to connect 6 GW offshore wind power to the Dutch Transmission Network ?

Dutch transmission network, offshore …

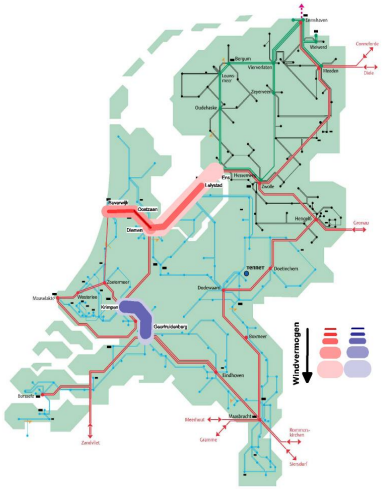
North Sea



- Peak load ~20 GW (2010)
- 380/220 kV double-circuit rings
- 2 favourable feed-in locations have been chosen
- Offshore transmission distance to shore 25-70 km

… and onshore

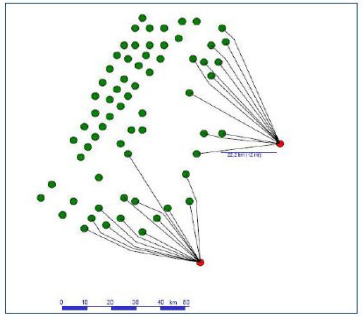
- Consumption ~130 TWh, peak load ~20 GW (2010)
- 380 kV substations and large cities close to the shore
- Grid reinforcements are necessary to enable power transmission
- Grid investments on mainland are needed and amount some 4% of wind park investments (350-650 MM€)
- System balance needs to be secured

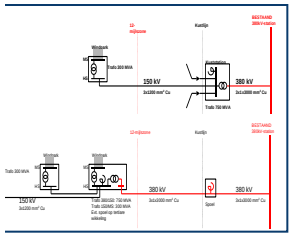


(*) Additionally trading and regulation mechanisms and legal issues in implementing such a wind resource

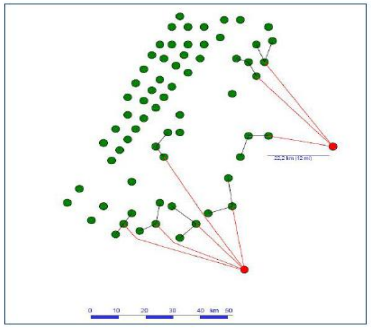
Types of grid connexion – different alternatives

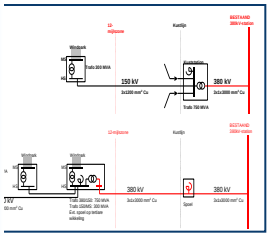
Alternative 1: radial networks (150kV)



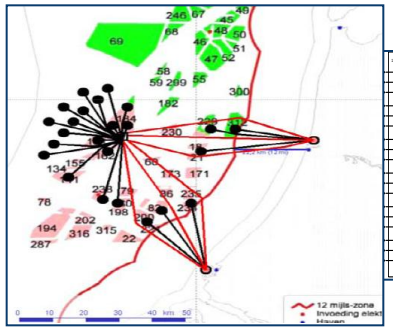


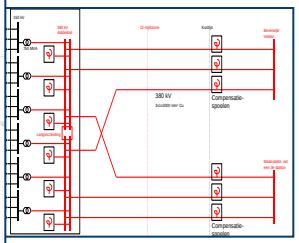
Alternative 2: radial networks (380/150kV hub)



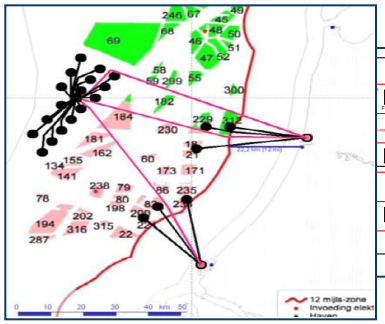


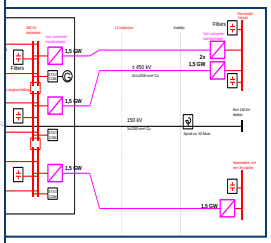
Alternative 3: AC ring structure





Alternative 4: HVDC ring structure



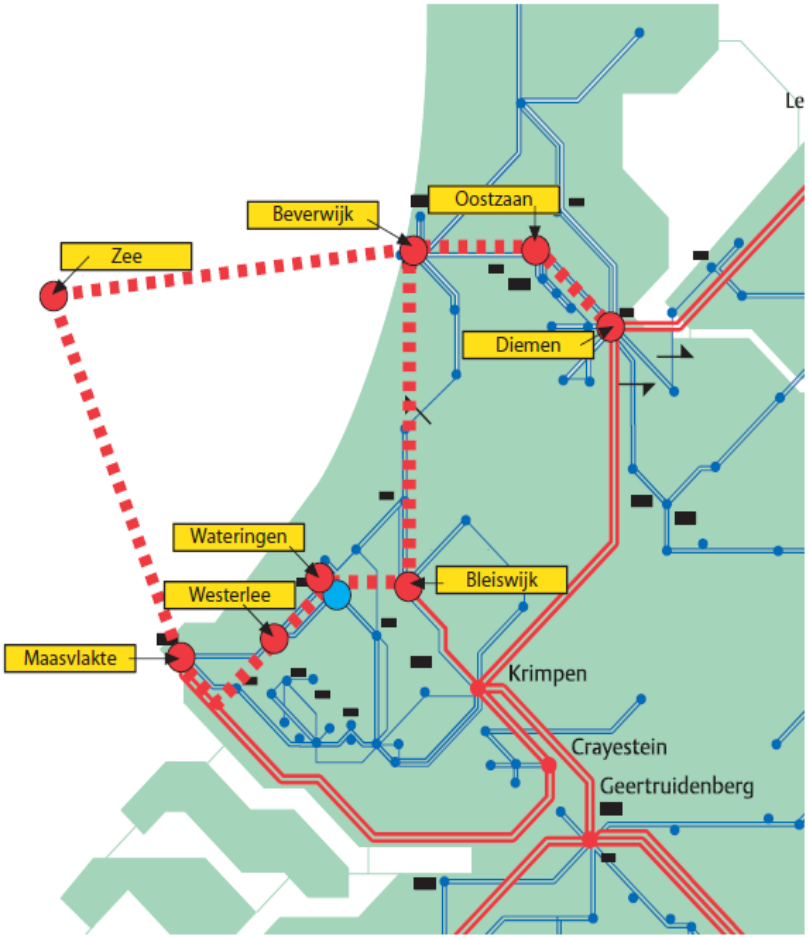


Break-even distance AC/DC

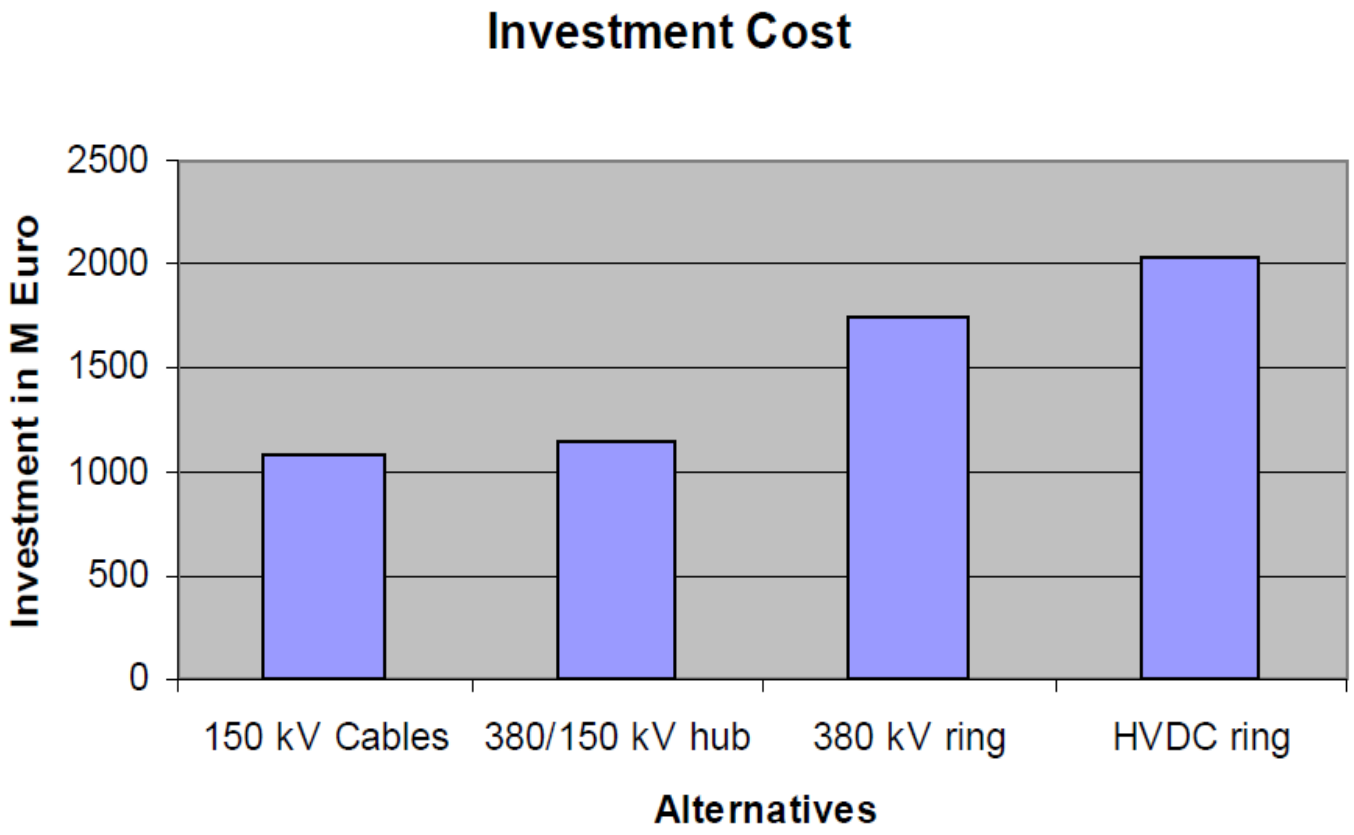
- Low power density energy source
- Large spacing of available locations. Forbidden areas:
  - military area
  - shipping routes
  - offshore platforms
  - piping routes
  - anchoring places
- Large offshore DC terminal substation
- Low-capacitance XLPE cables

Ring power flow

- 380 kV AC ring
  - quickly overloaded
  - FACTS required
  - additional value?
- HVDC ring
  - Controllable loop flows
- Hybrid (AC + DC) ring



Cost comparison



Conclusions

- Growth of wind power might be limited by mainland **grid transmission capacity** - managing the consequences for the stability of the network
- Bundling individual 150kVAC offshore wind farm connections into **380 kV hubs**: yields no significant economies of scale but reduces the number of shore crossings
- If a ring structure with the mainland network would help mitigate problems in the mainland network, a HVDC or **hybrid (AC + DC)** network is expected to be the preferred solution

Thank you for your attention.

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