Stiesdal Offshore Technologies

TetraSpar

Solving the Logistical Challenge of Floating Offshore Wind Power

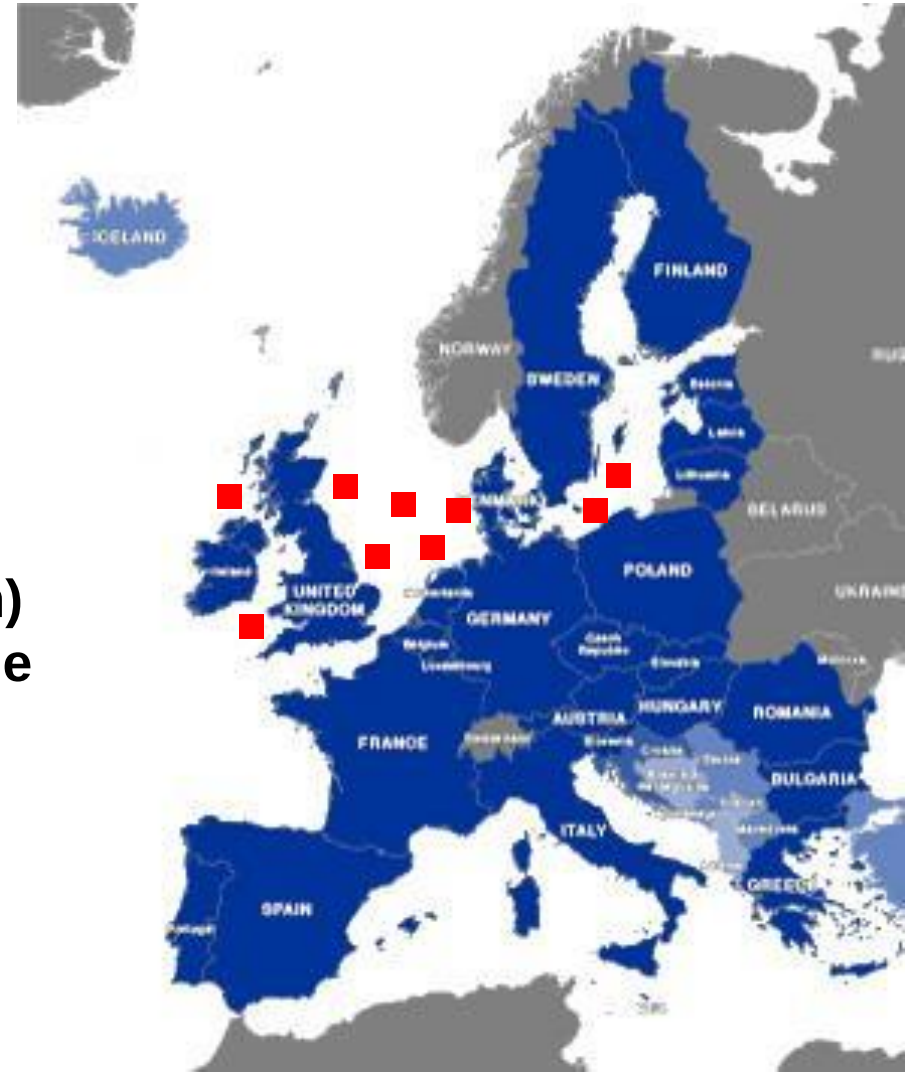
Henrik Stiesdal, December 3, 2018

Offshore wind can deliver all the electricity we need

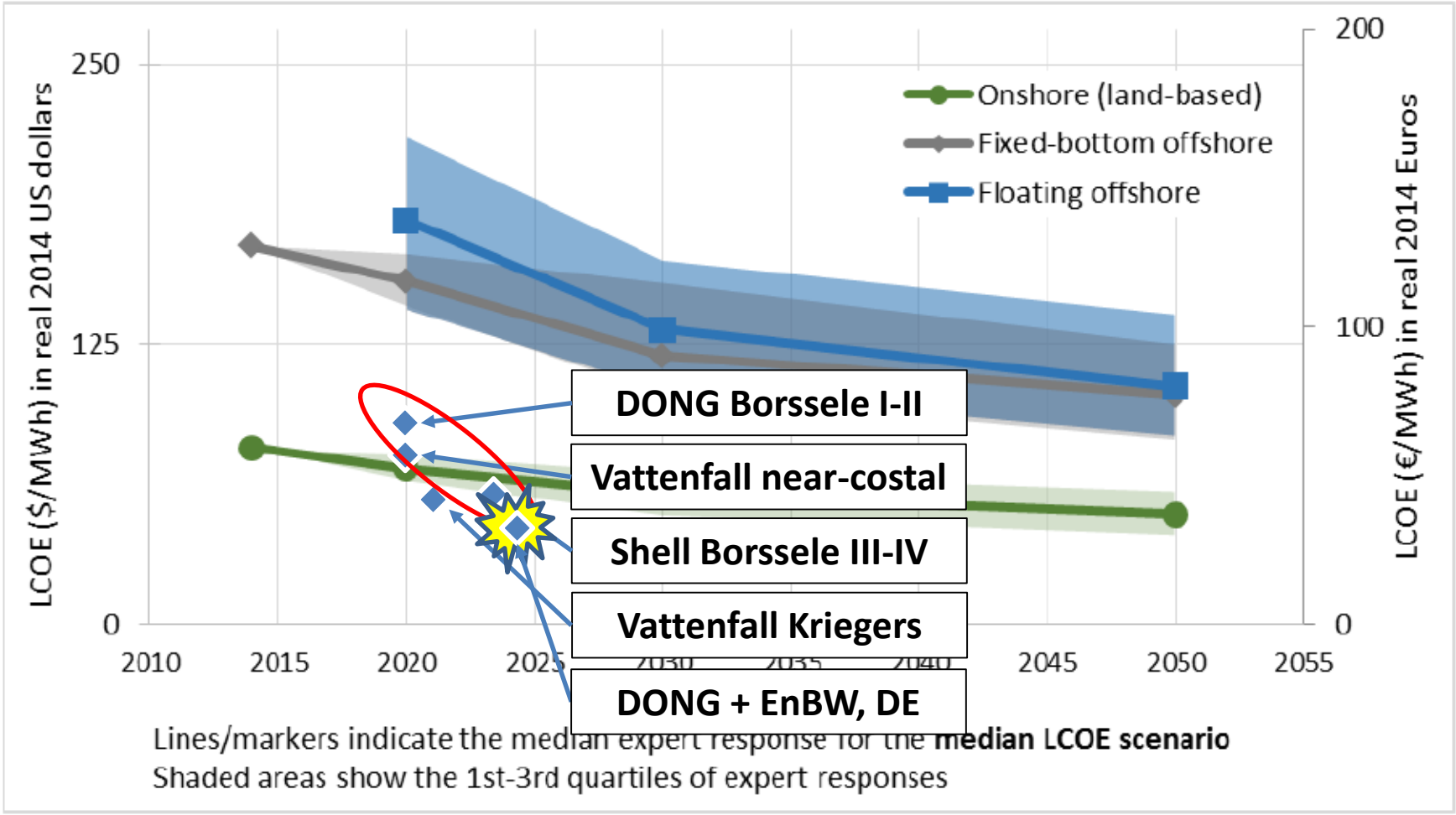
If offshore wind in Northern Europe would be the only source of electricity for the EU …

- EU load: 2.800 Bn. kWh/year
- Offshore wind energy per sea surface area: 30 kWh/m^2/year
- Area required: 90.000 km^2

- **Pre-Brexit EU (pop. 500 million) could be supplied 100% by nine offshore wind farms, each measuring 100 km x 100 km**

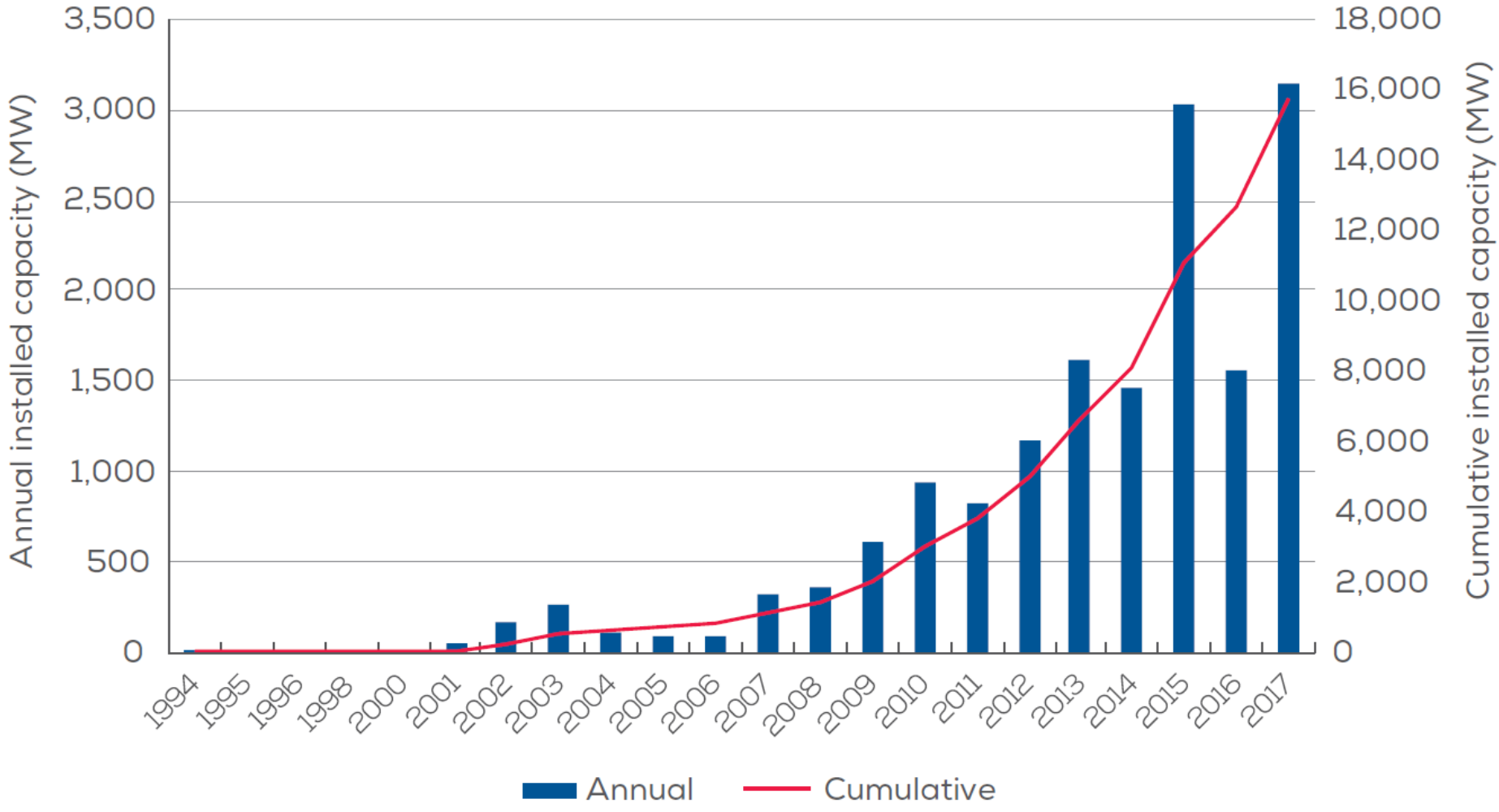


Disruptive 2016 cost reductions in bottom-fixed offshore wind



Source: Berkeley National Lab

The European offshore wind market develops accordingly

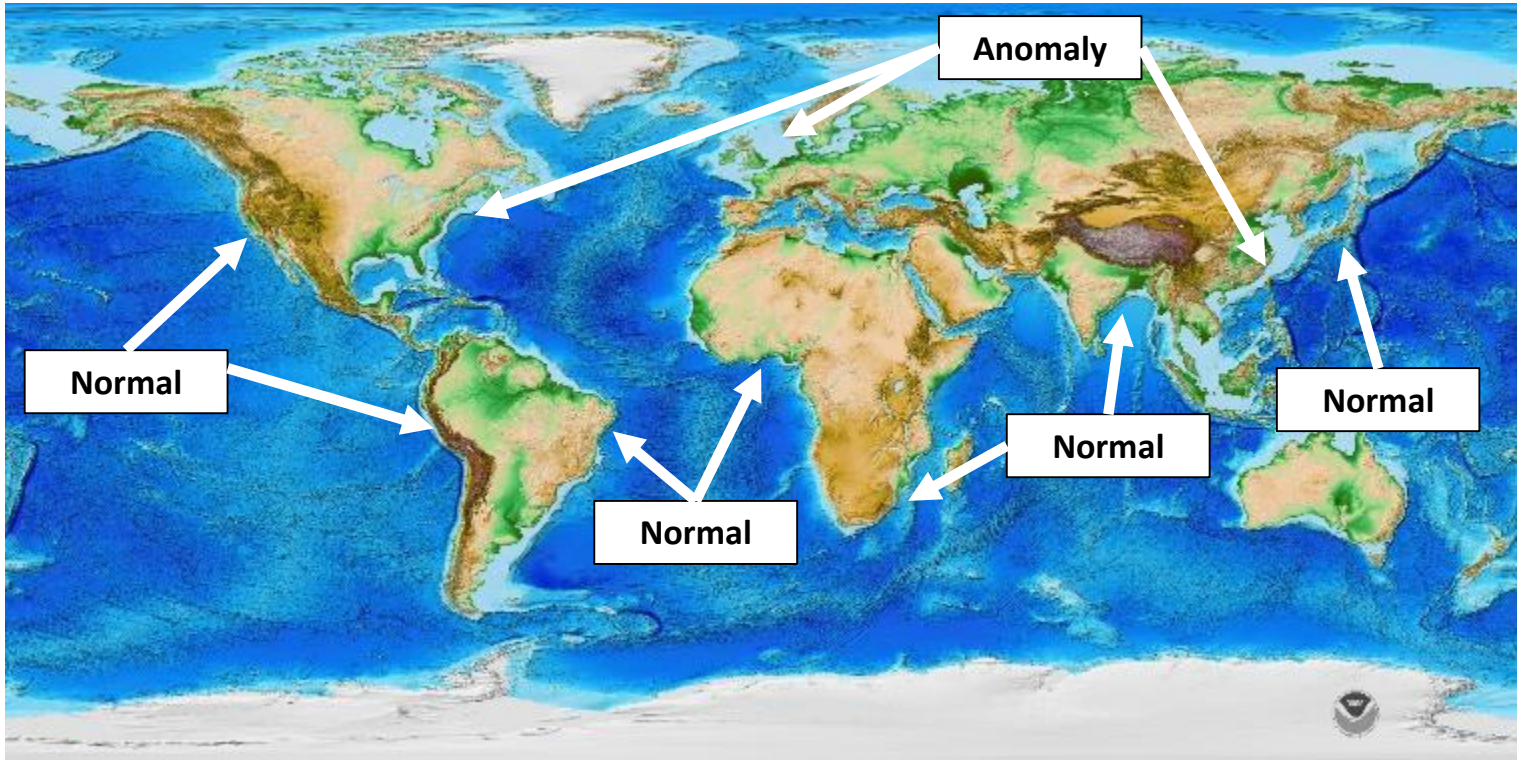


Source: WindEurope

But there is a snag -

Offshore wind as we know it is only applicable in selected locations

- Maximum water depth of fixed foundations 40-50 m
- Can be applied in Northern Europe, off China and off US East Coast
- Most other population centers have much too deep nearshore waters



Source: NOAA

The solution – floating offshore wind power

Source: Statoil, Principle Power, Hitachi, MHI

But again – there is a snag: Floaters are not industrialized

Shared characteristics

- Very heavy – from 2500 tons to 10.000 tons for 7 MW class turbines
- Construction methods from shipbuilding and offshore oil and gas sector
- Fabrication typically at port of floater launch
- Build times typically measured in months
- Tens of thousands of man-hours per foundation for steel cutting, fitting, welding, handling, etc.





Picture credits: Siemens, Principle Power, Hitachi, U.Maine, MHI, Mitsui

The first truly industrialized product – Ford Model T

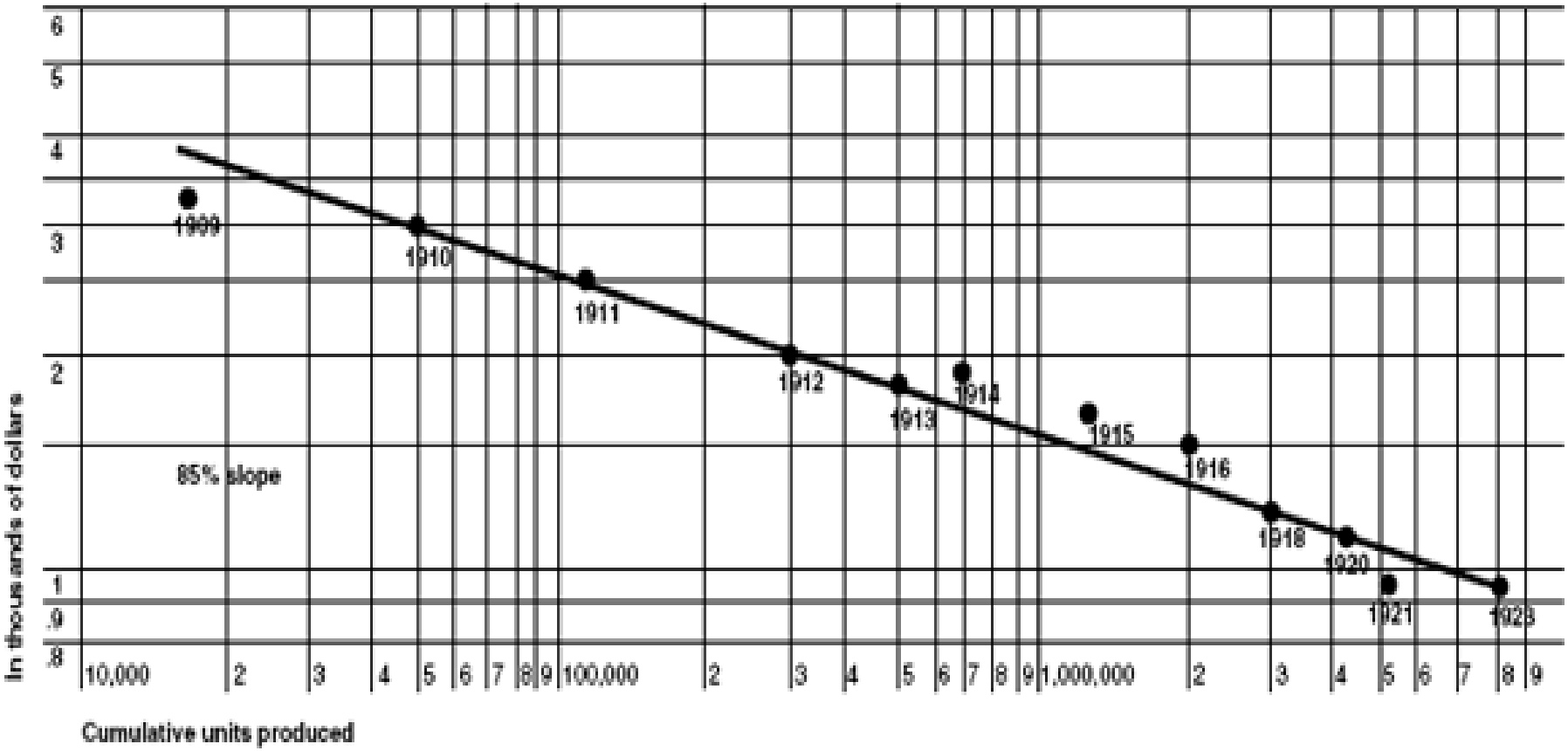
1909

1923

Source: Ford Motor Company

The power of industrialization is huge

EXHIBIT I Price of Model T. 1909–1923 (Average List Price in 1958 Dollars)



Source: Ford Motor Company

Taking advantage of a world champion …

The humble wind turbine tower

- Probably the world's lowest cost per kg of any large steel structure
- High quality welds and surface protection
- More than 20,000 towers manufactured annually in highly industrialized processes

How did we get there?

- Separation of fabrication and installation
- Modularization and standardization
- No IP of any significance – costs kept low through open competition

Picture credit: Danish Wind Turbine Manufacturers' Association

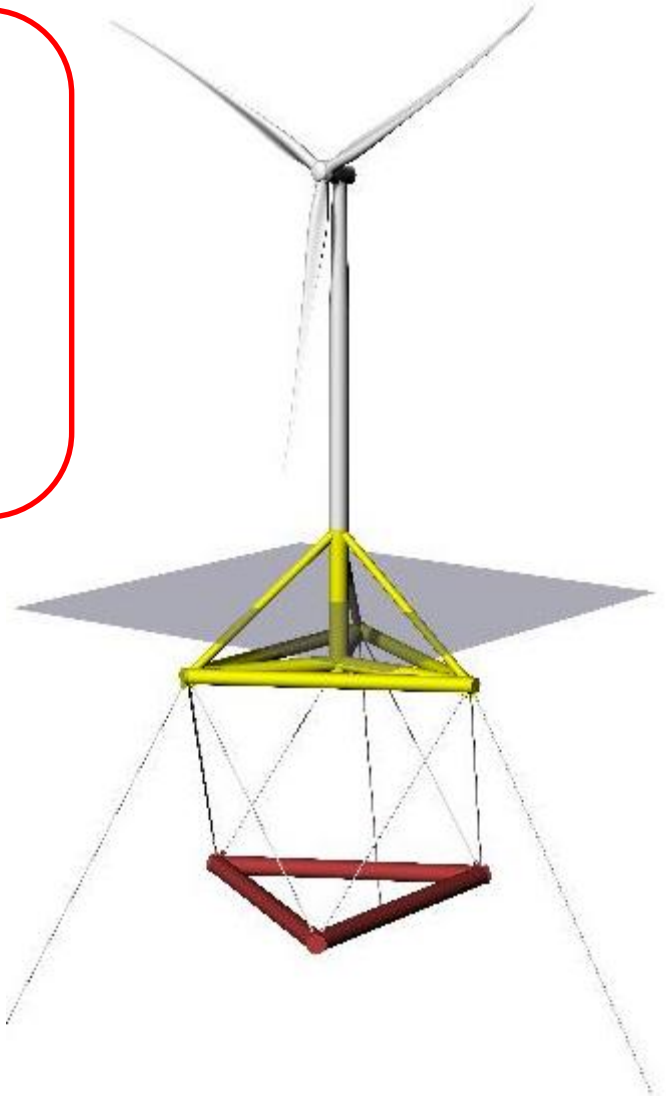
Enter TetraSpar – floating wind power industrialized the onshore way

Mindset

- Conventional thinking
  - We have designed this structure – now, how do we build it?
- TetraSpar thinking
  - We need to manufacture this way – now, how do we design it?

Concept

- Modular – components from existing wind turbine tower supply chain
- Components transported by road
- Components assembled at quayside, just like the turbine is assembled
- Turbine mounted in harbor and towed to site, no installation vessels



Road transportation is easy and low-cost!

Welcon A/S

- Leading manufacturer of offshore wind towers
- Has supplied around 50% of all offshore wind towers in the world
- Located about as far from the sea as you can get in Denmark

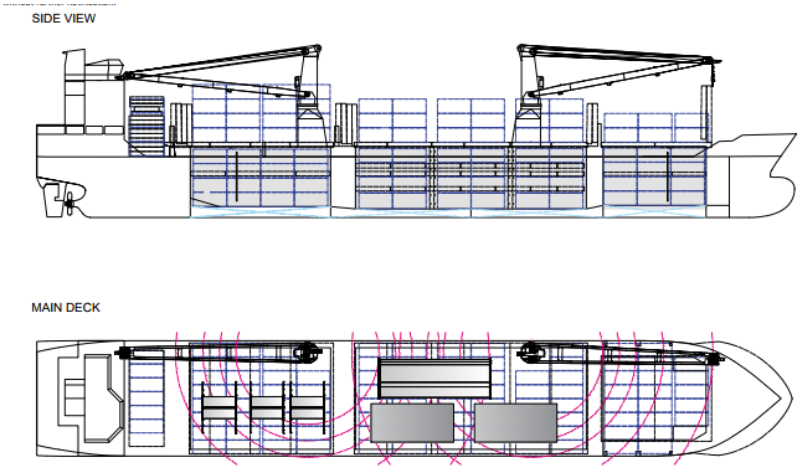
Conclusion

- Other factors (stable work force, easy expansion) are more important than transportation distance

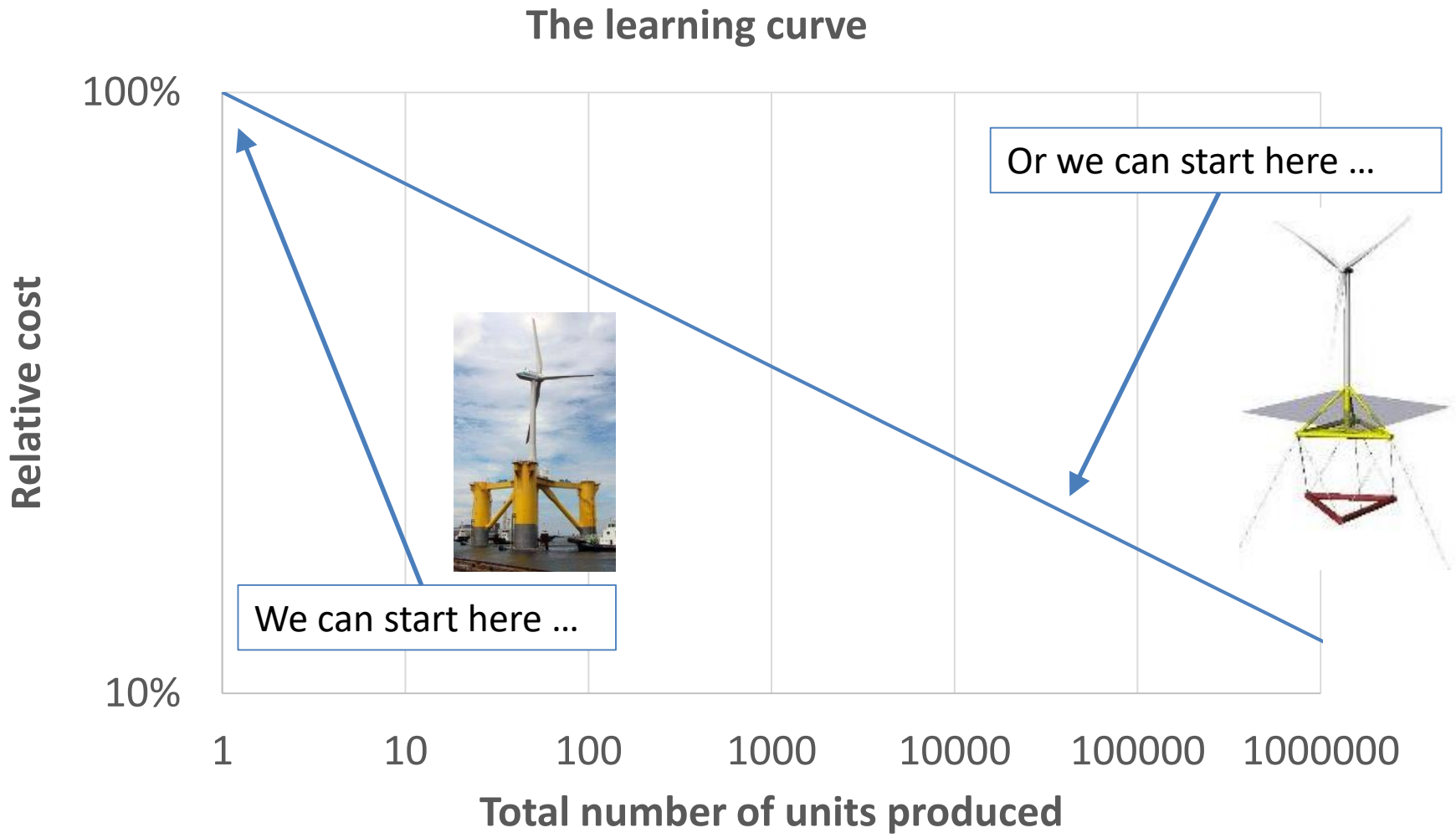
Solution for overseas ports

Multipurpose vessel type

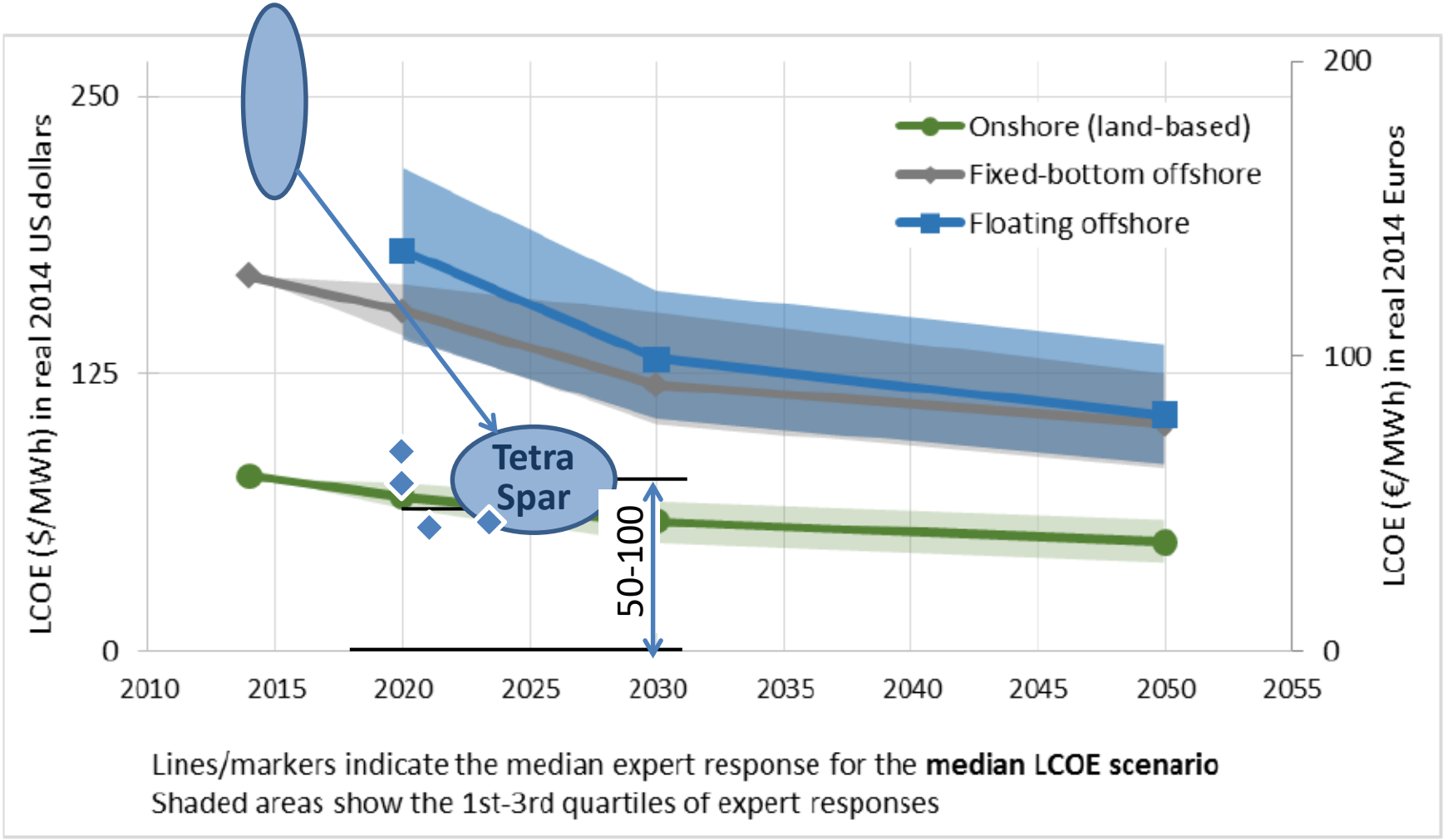
- Gross tonnage 10.000 t
- Draft 7 m
- 960 vessels with necessary crane capacity
- 15 carriers operating globally, none with more than 15% market share
- Capable of carrying both tower and floater for 10 MW turbine
- Esbjerg – Brest round trip duration 10 days including loading/unloading and 2 days weather contingency



The fundamental choice on the supply chain thinking



Target cost trajectory for TetraSpar

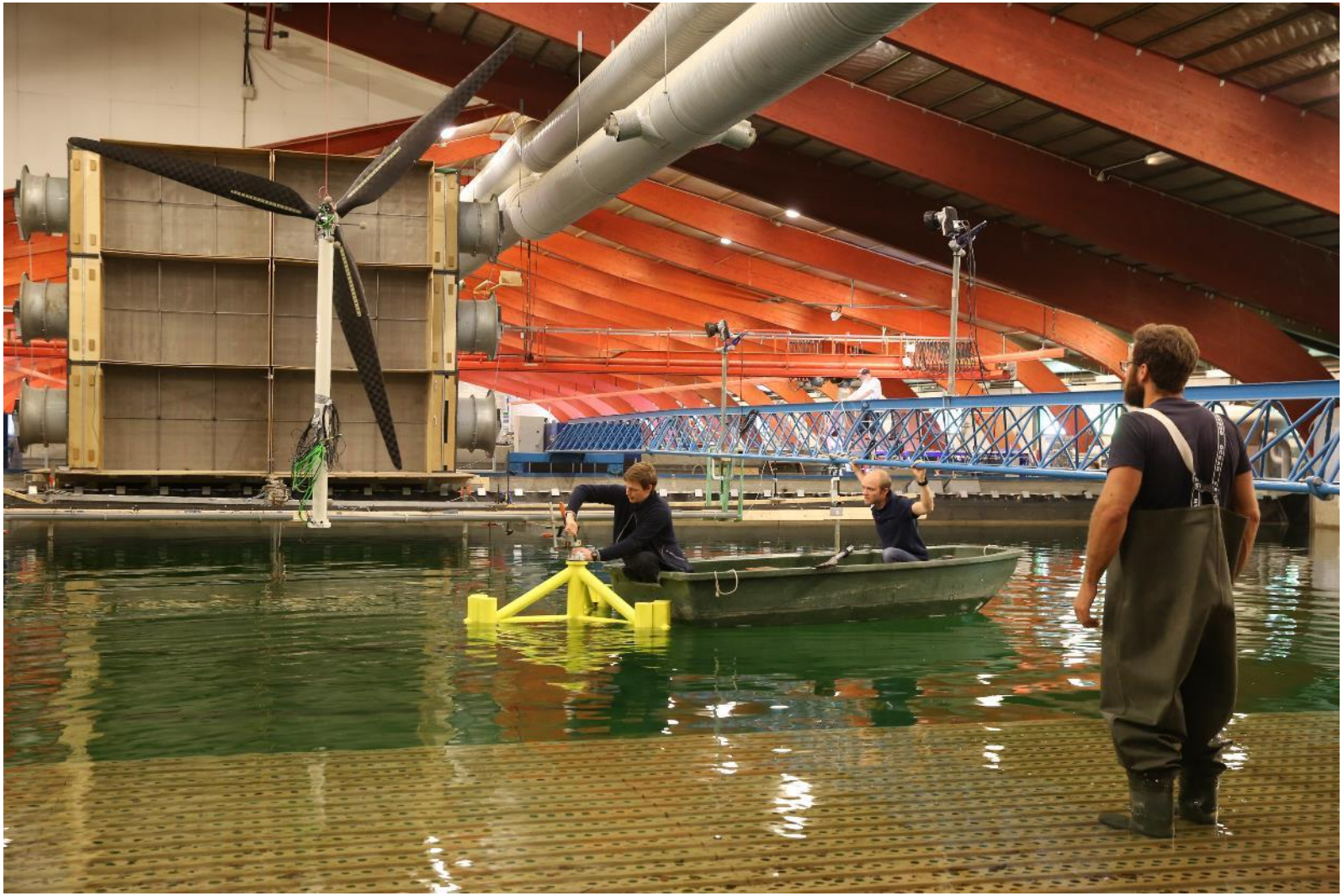


Source: DoE, NREL, IEA

TetraSpar offers quantum leap in cost

Technology	Concept name	Location	Year	MW	m€/MW
Statoil	Hywind 1	Norway	2009	2.3	22.2
Principle Power	WindFloat 1	Portugal	2011	2.0	11.5
IDEOL 1	Floatgen	France	2017	2.0	18.0
Hexicon	Tri	Scotland	2018	10.0	11.3
Statoil	Hywind 2	Scotland	2017	30.0	7.1
KOWL	ACS Cobra	Scotland	2018	49.6	7.6
IDEOL 2	Floatgen	France	2021	24.0	8.3
Eolfi	DCNS	France	2021	50.0	7.6
Principle power	WindFloat 2	France	2021	24.0	5.0
SBM	SBM	France	2021	24.0	6.0
Principle power	WindFloat 2	Portugal	2019	25.0	5.0
Stiesdal	**TetraSpar**	**Norway**	**2019**	**3.6**	**5.0**

2017 model tests, carried out by DTU in DHI wave basin



TetraSpar Project stages

Stage 1 - 2016
- Concept
- Initial validation

€ 0.2m

Stage 2 - 2017
- Design
- Tank test OK

€ 18m

Stage 3 - 2019
- Prototype
- Full validation

Stage 4 - 2021
- Pilot project
- Release

Thanks for your attention

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