Technology challenges for future offshore renewables

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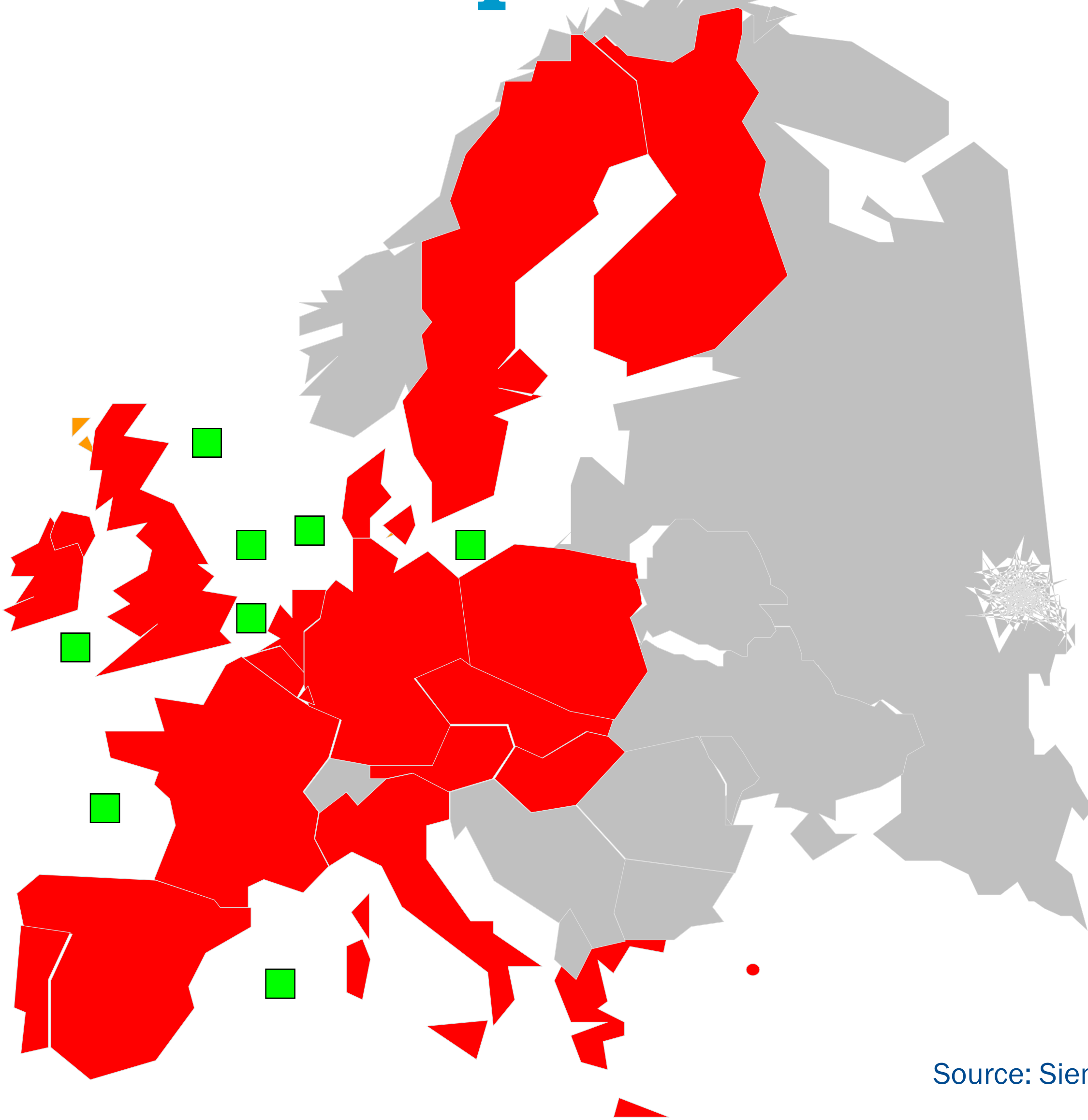
DUWIND
DELFT UNIVERSITY WIND ENERGY RESEARCH INSTITUTE

Content

- Offshore Wind Power
  - current status in Europe
  - operational experiences
  - design challenges

- Wave and Tidal energy developments in The Netherlands

Europe's offshore WE potential

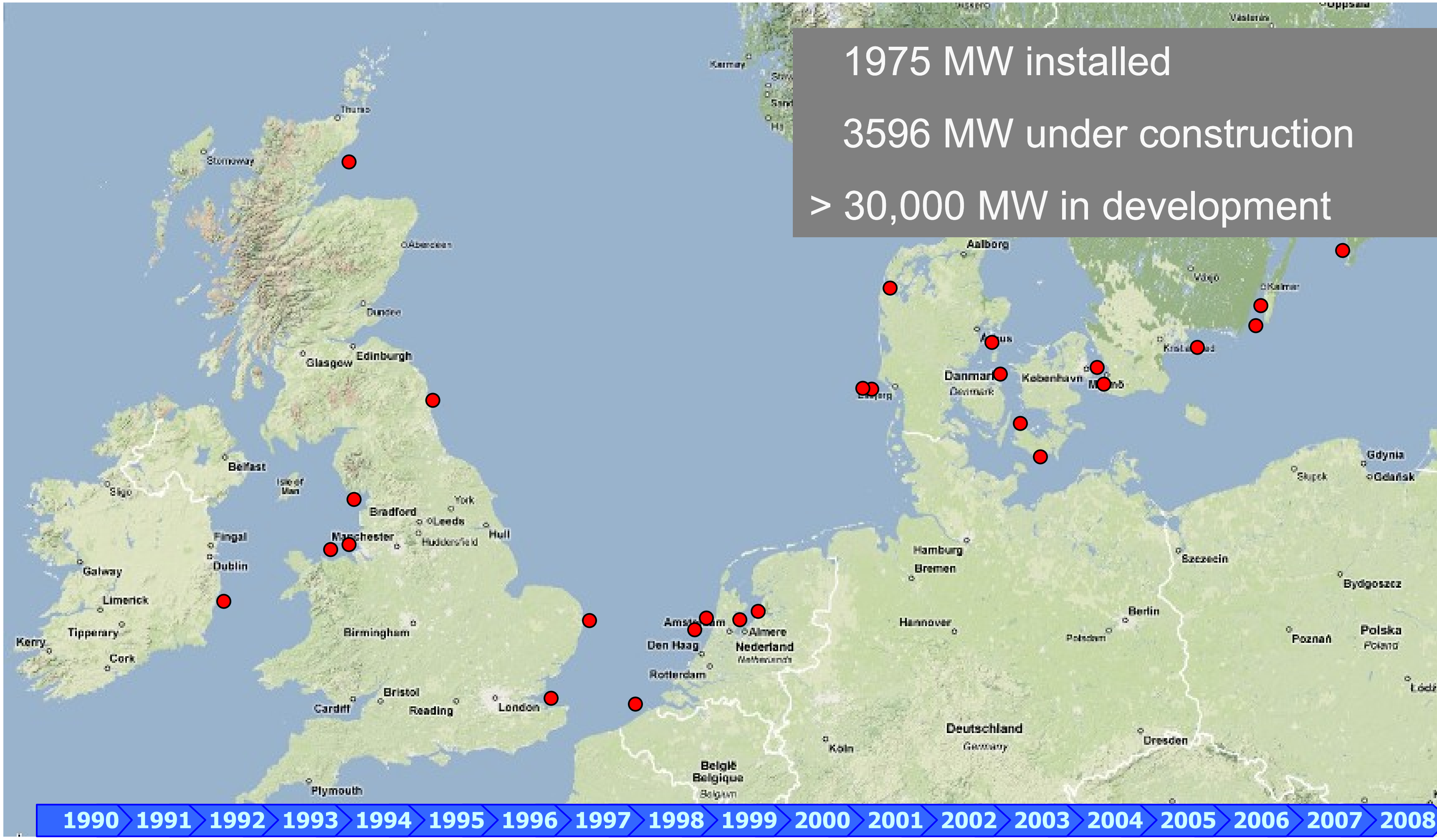


Eight 100x100 km offshore wind farms can produce 3,000 TWh annually.

≈ equal to present use of electricity in EU

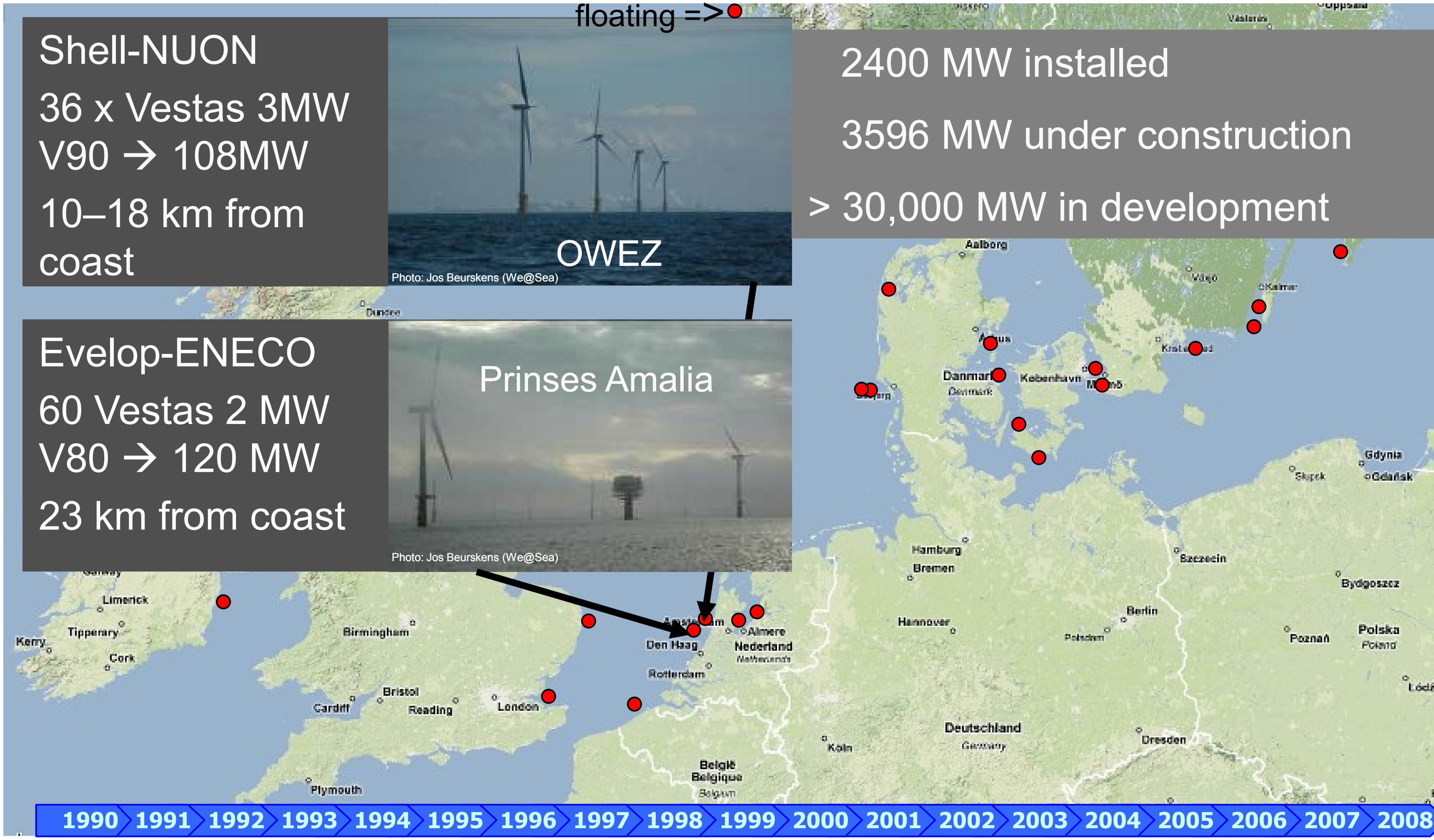
Source: Siemens

Offshore wind farms in operation in EU



Source: TUDelft Offshore Engineering

Offshore wind farms in operation in EU



Source: TUDelft Offshore Engineering

OWEZ: Offshore Wind farm Egmond aan Zee (NL)

108 MW

(36 x 3 MW)

Princess Amalia Wind Farm (Q7) (NL)

120 MW
(60 x 2 MW)

Offshore wind farm design
=
Design for availability

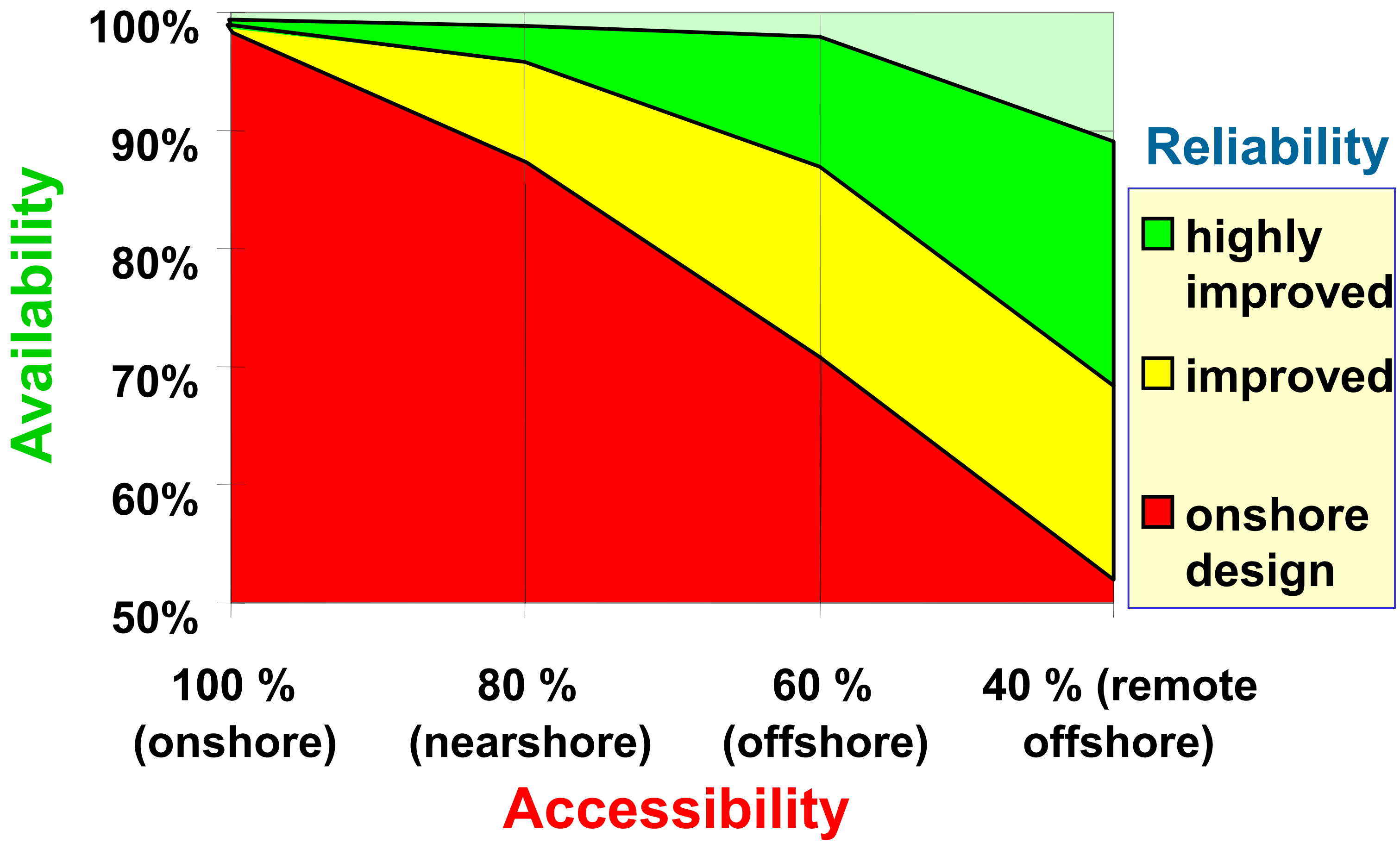
Offshore RAMS design inevitable

Offshore RAMS design

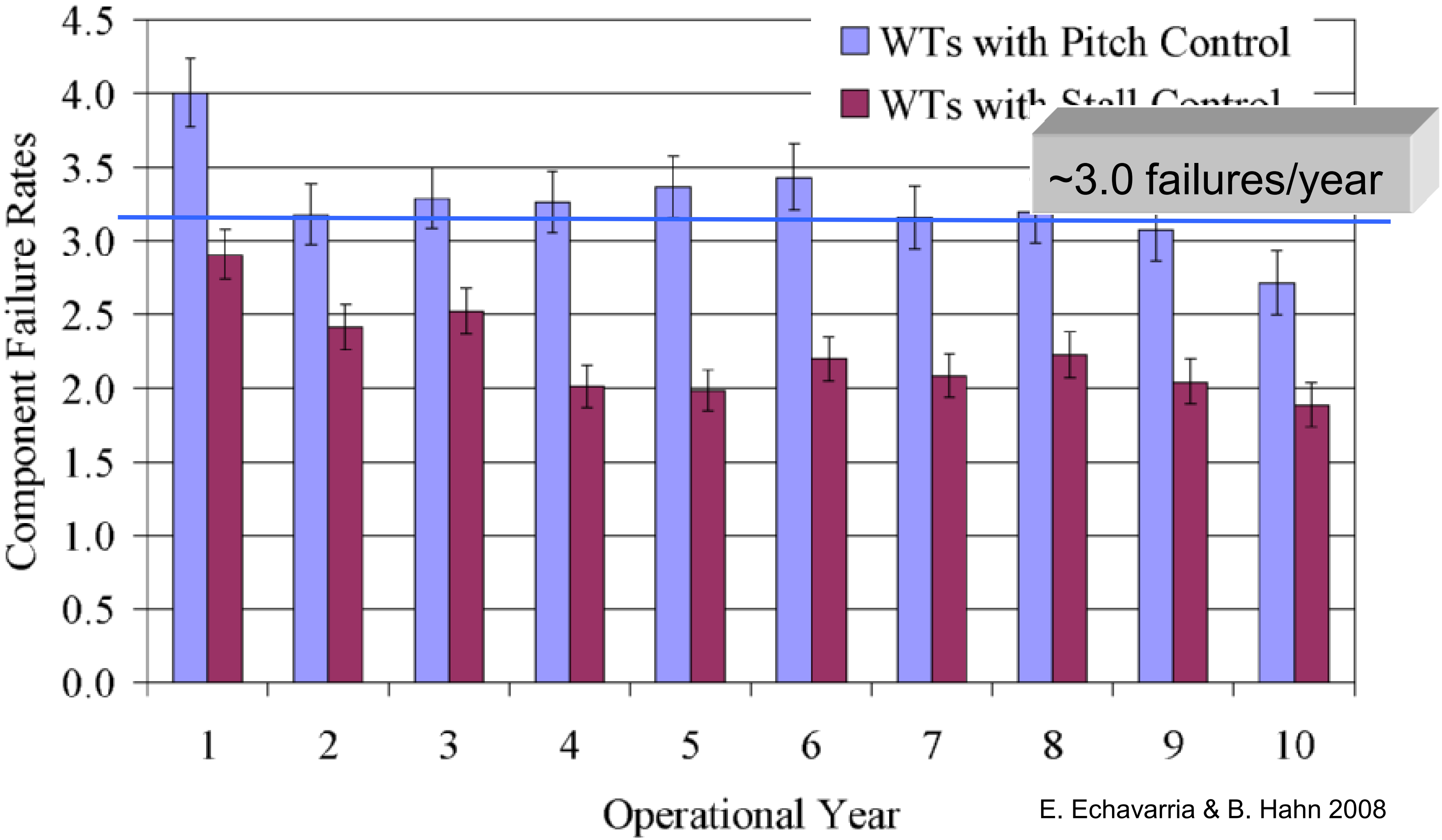
R eliability →	# failures per year
A vailability →	# hours available for production
M aintainability →	# hours needed for repair
S erviceability →	# hours needed for service

BUT: offshore availability strongly influenced by <u>accessibility</u>

Importance of *Reliability* and *Accessibility*

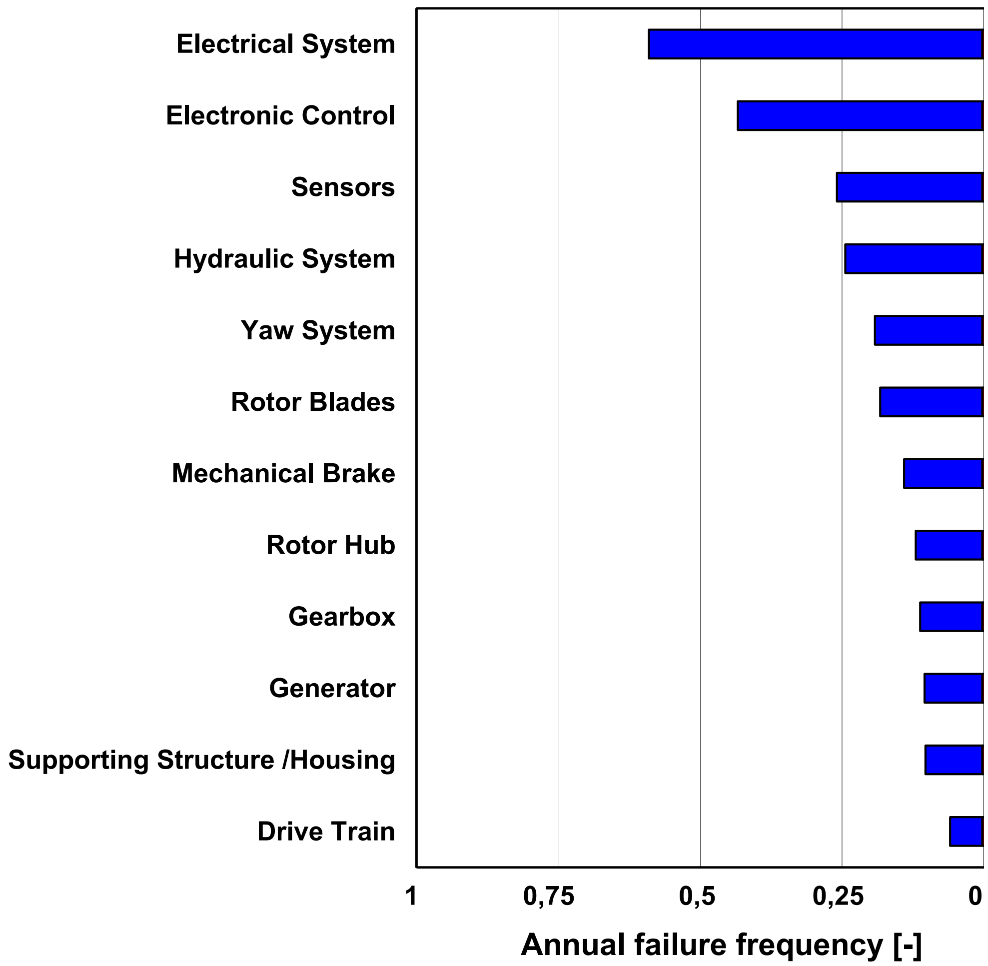


Wind Turbine Data Base (MWEP)

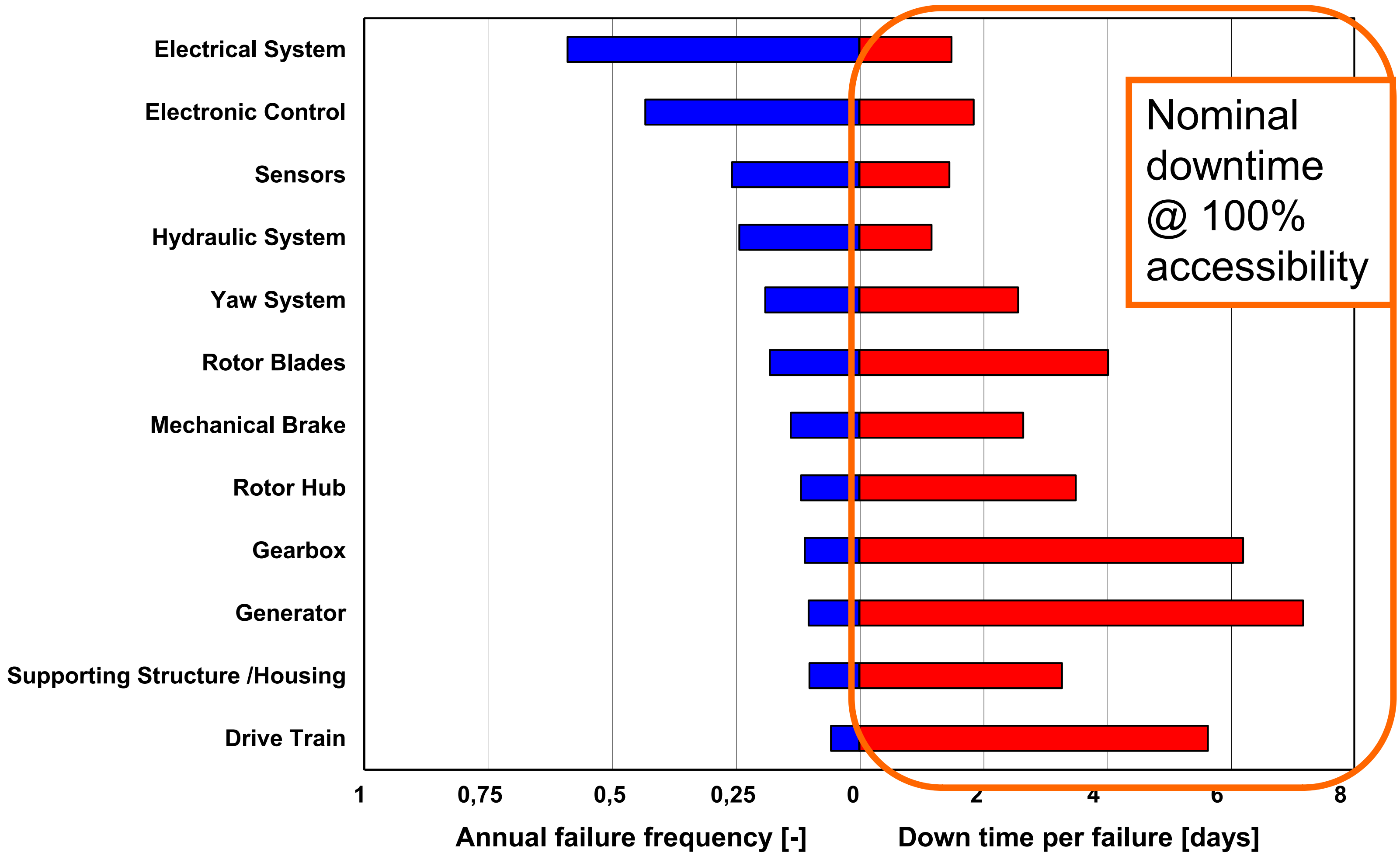


E. Echavarria & B. Hahn 2008

Failure rates per sub system

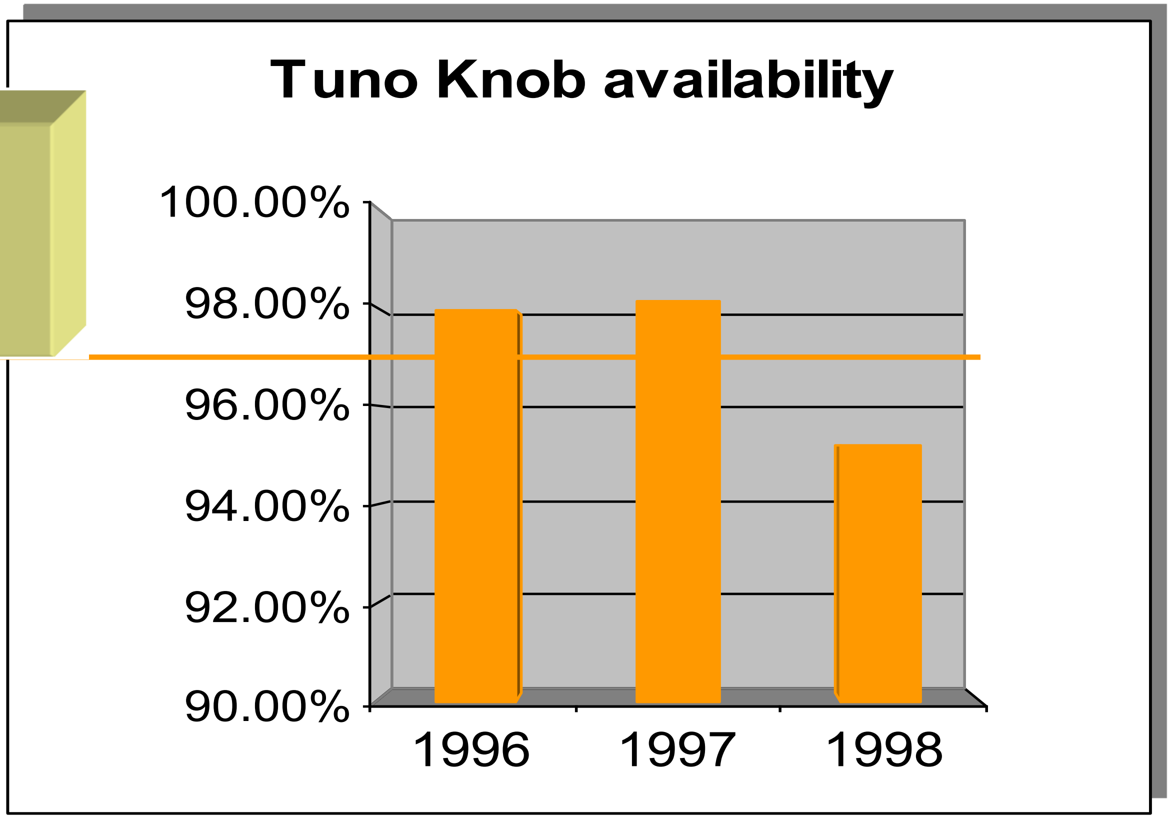


Failure rates per sub system

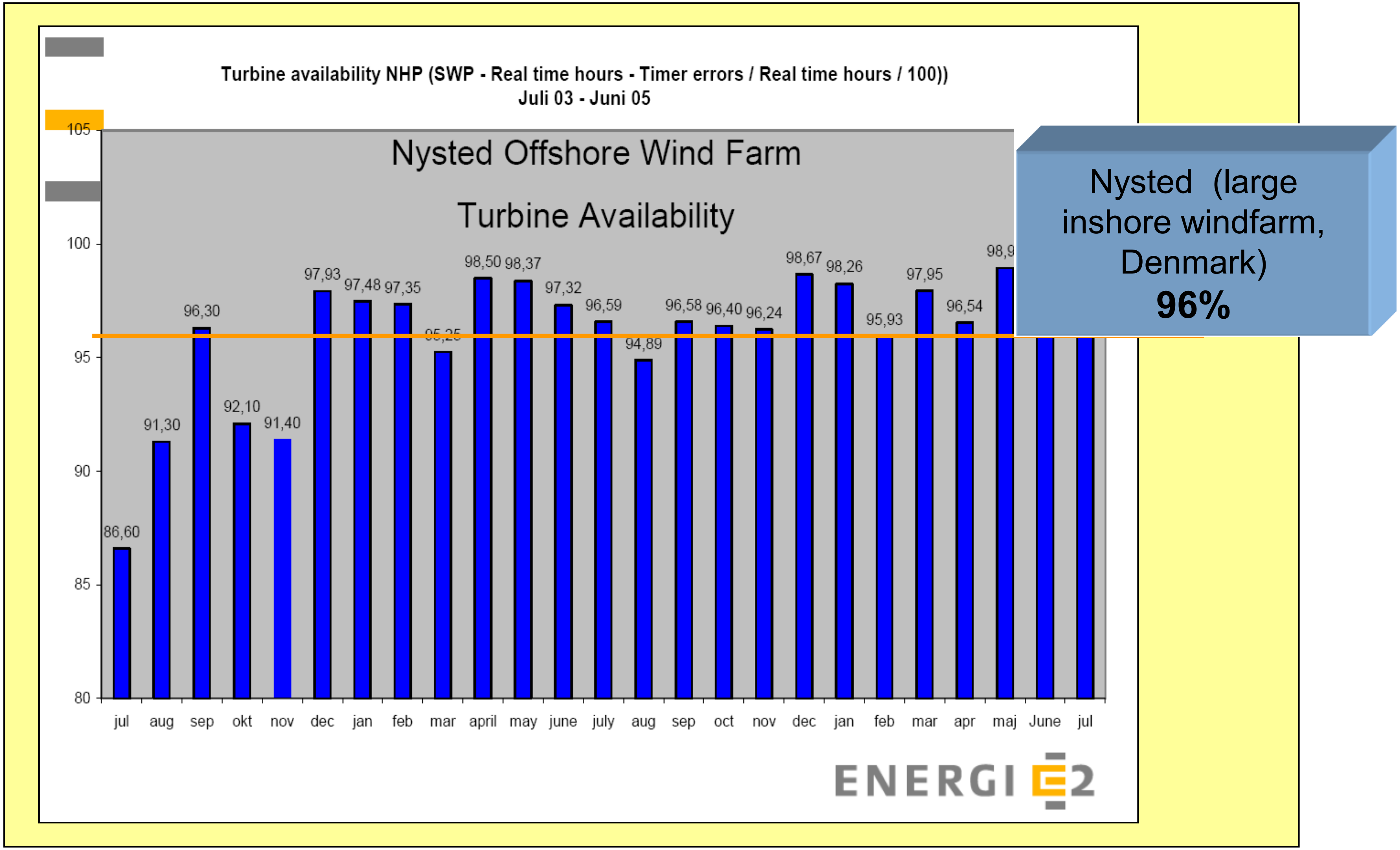


Experienced Availability
(small "inshore" wind farm DK)

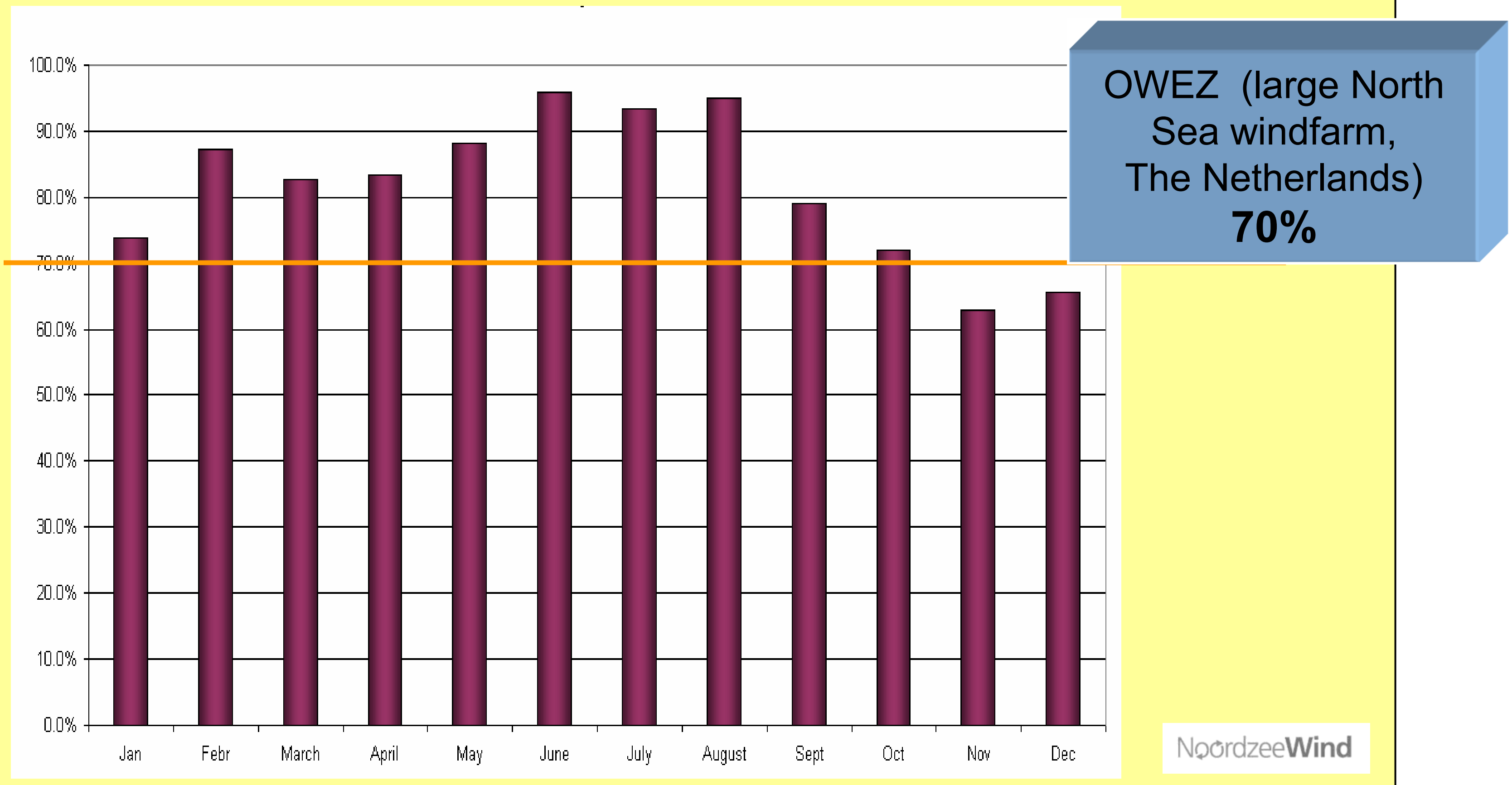
Tuno Knob
(inshore,
Denmark)
97%



Experienced Availability
(large “inshore” wind farm DK)



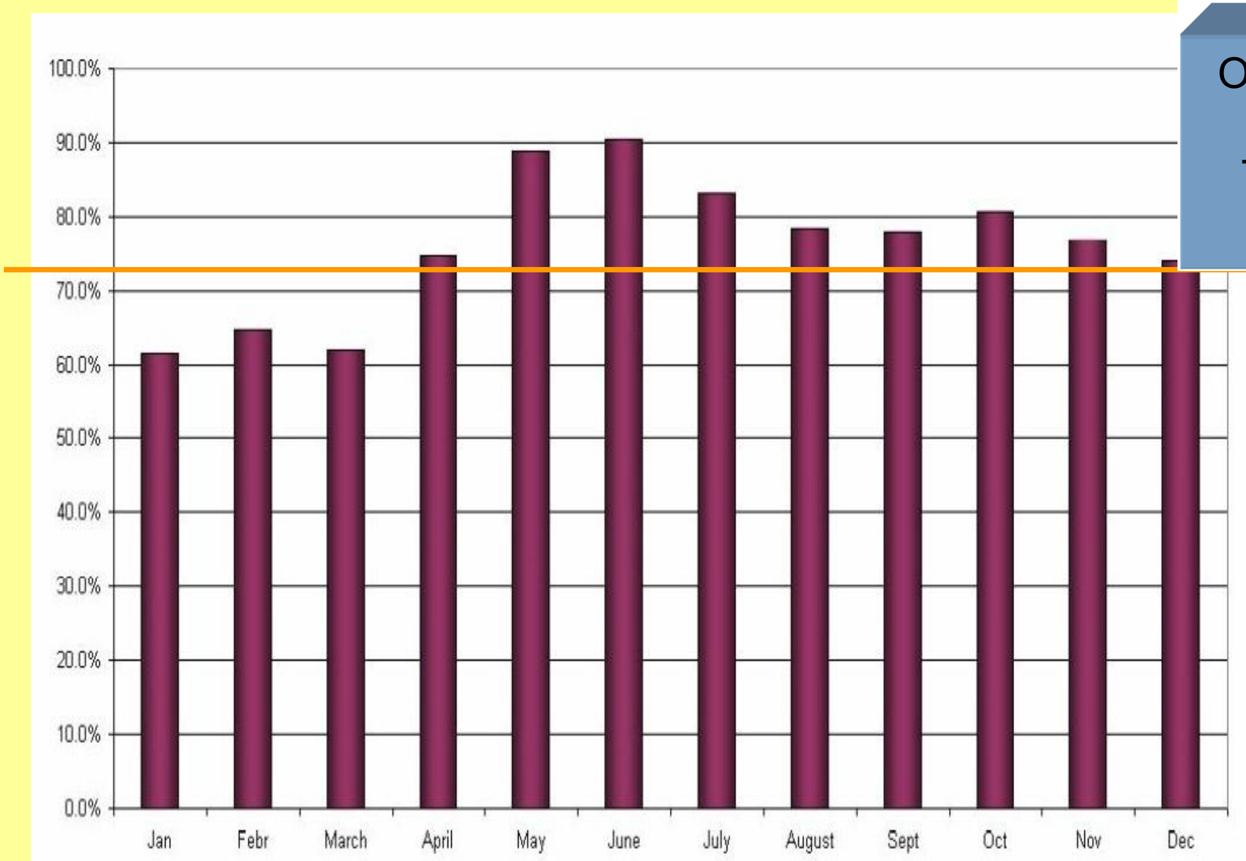
Experienced Availability
(large offshore Wind Farm inNorth Sea NL)



OWEZ availability over the year 2007 (10 gearboxes exchanged)

Experienced Availability

(large offshore Wind Farm inNorth Sea NL)



OWEZ (large North Sea windfarm, The Netherlands)
73%

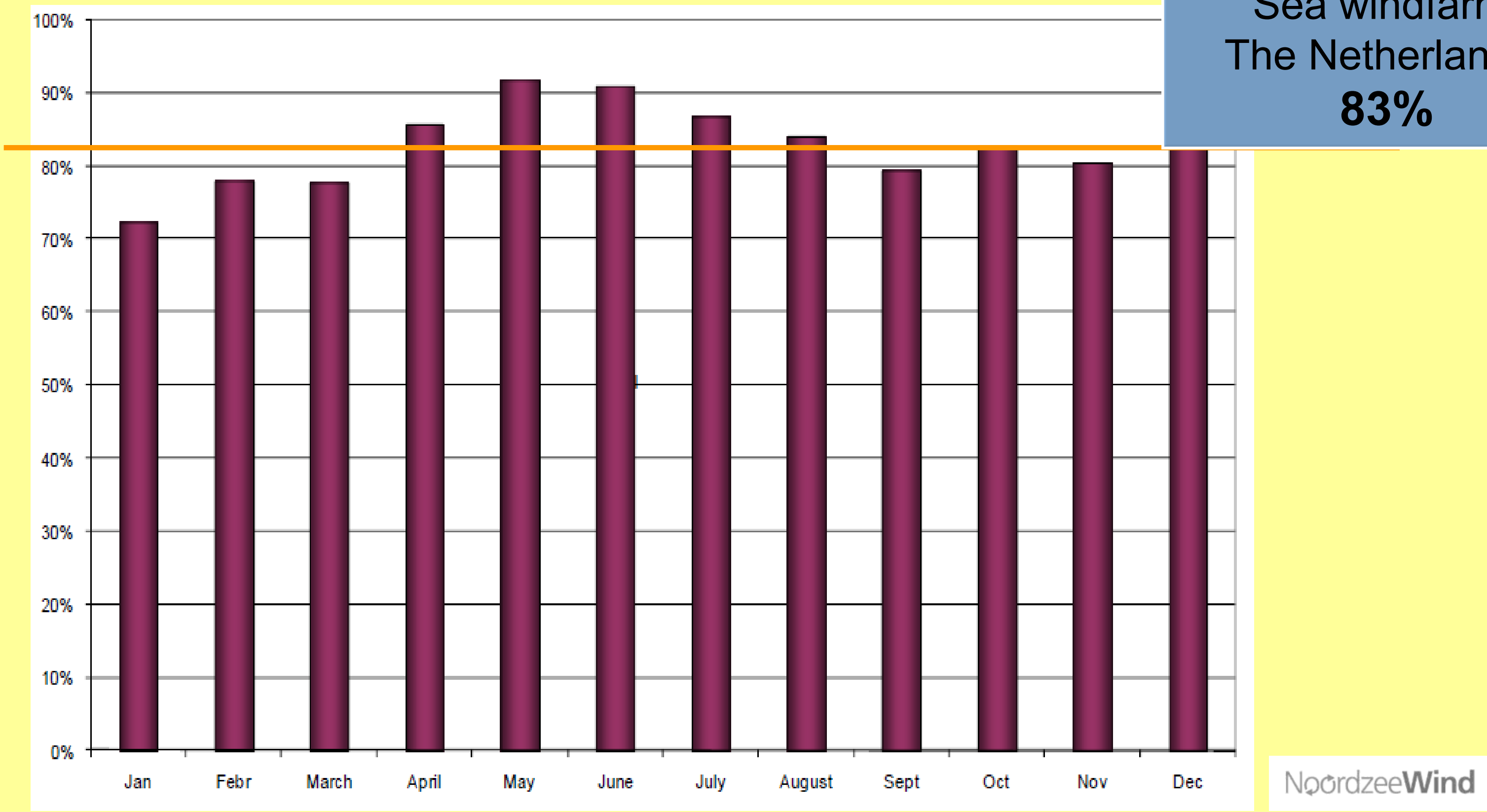
NoordzeeWind

OWEZ availability over the year 2008 (12 gearboxes exchanged)

Experienced Availability

(large offshore Wind Farm inNorth Sea NL)

OWEZ (large North Sea windfarm, The Netherlands)
83%



OWEZ availability over the year 2009 (8 generators replaced)

Experiences in the real world

Scroby Sands (UK):

30 V80 wind turbines in operation since Jan. 2005

- **Key figures:**

	2005	**2006**
Accessibility	60 %	79 %
Availability	89.4 %	81.4 %
Capacity factor **(projected 0.301)**	0.284	0.246

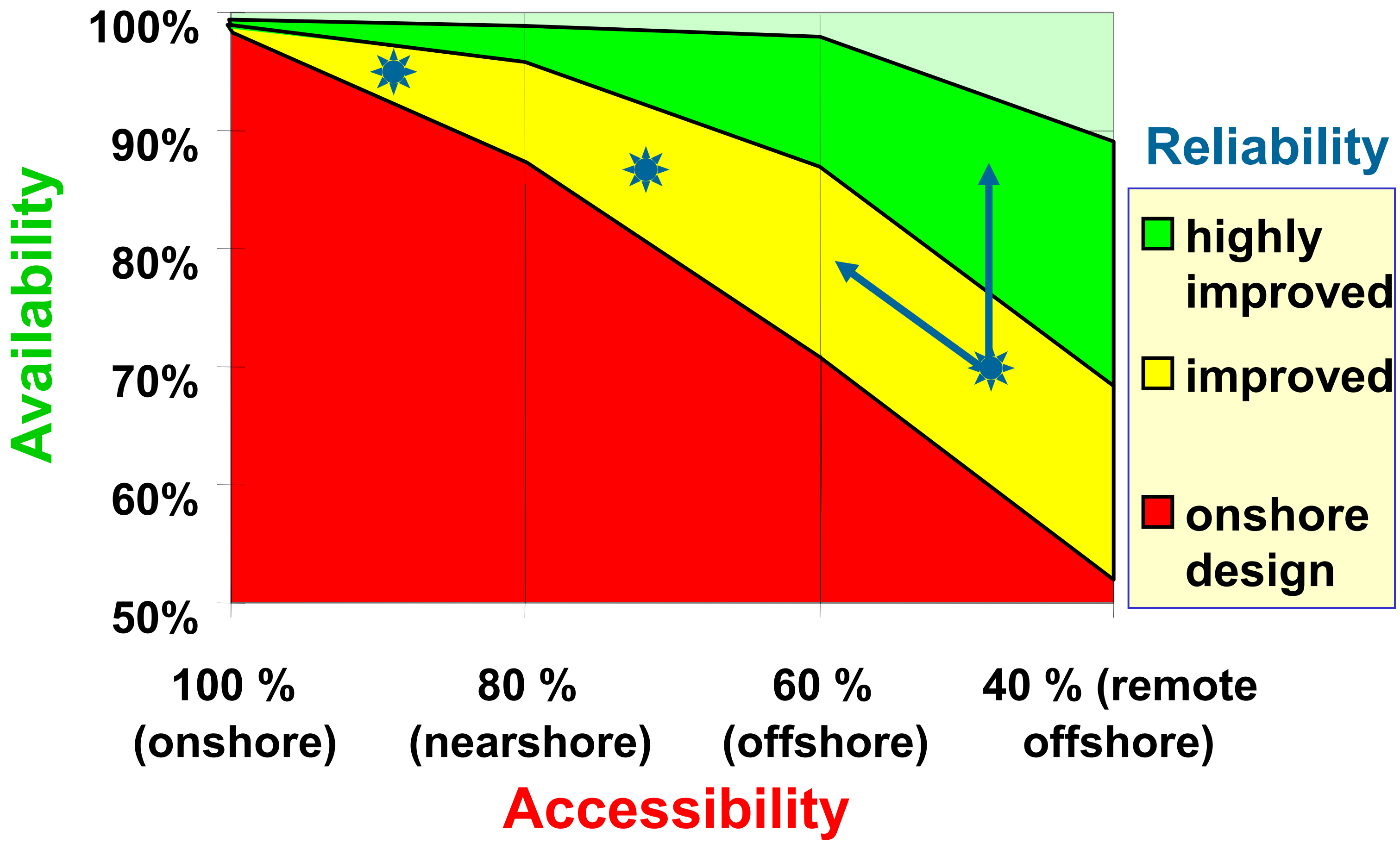
- **1500 wind turbine visits per year**

(8 wind turbines visited each working day)

- **4000 transfers of crew per year**

Source: ODE

Importance of ***Reliability*** and ***Accessibility***



Improving Accessibility

“WindCat” “SWATH”

Twin hull access boats

“Ampelmann”

Access platform with wave compensation

Improving availability

By improving reliability?

- Improving component reliability expensive ☒
- Up scaling (less components per MW) ☑
- Reducing nr. components (lean design) ☑

Improving availability

By reducing downtime??

- Optimise O&M operations experience ☑
- Develop Smart Maintenance Machines using redundancies ☑
- (Design for) re-configuration ☑

What is re-configuring?

Modify system to maintain the required functions to keep wind turbine operational.

How? Design for using (or use existing) functional redundancies.

Informational level

Wind speed → Modify controller to use alternative input

Physical level

multi-phase-generator → New design?
Few extra connections?
Modify el. controller

Behavioral level

Pitching ⇔ yawing… → Additional control strategy

Reliability vs. turbine design

Turbine designs gets more complex:

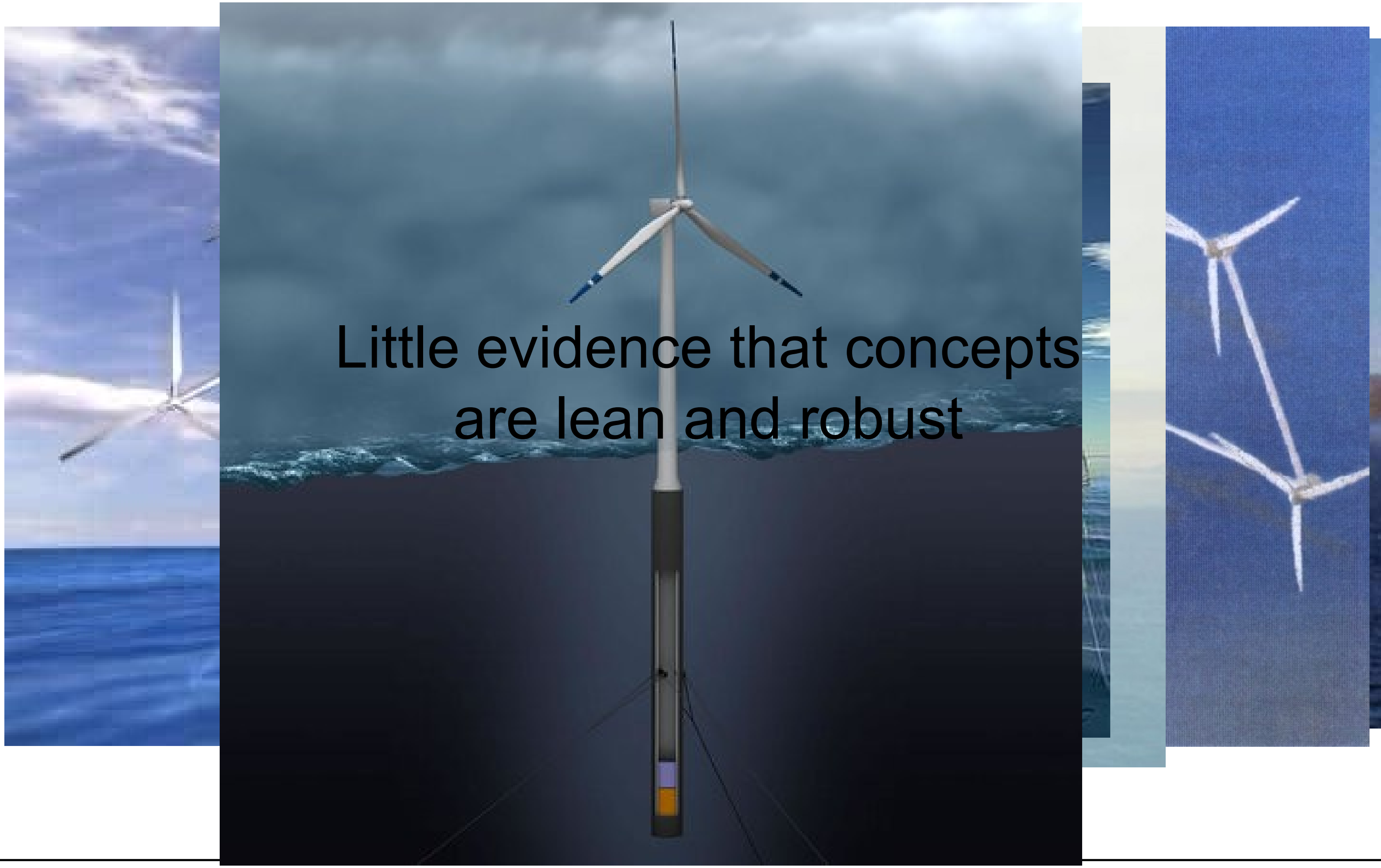
- Three bladed, variable speed pitch control
- Doubly fed generators, Inverters

BUT

Offshore environment demands a robust, lean design:

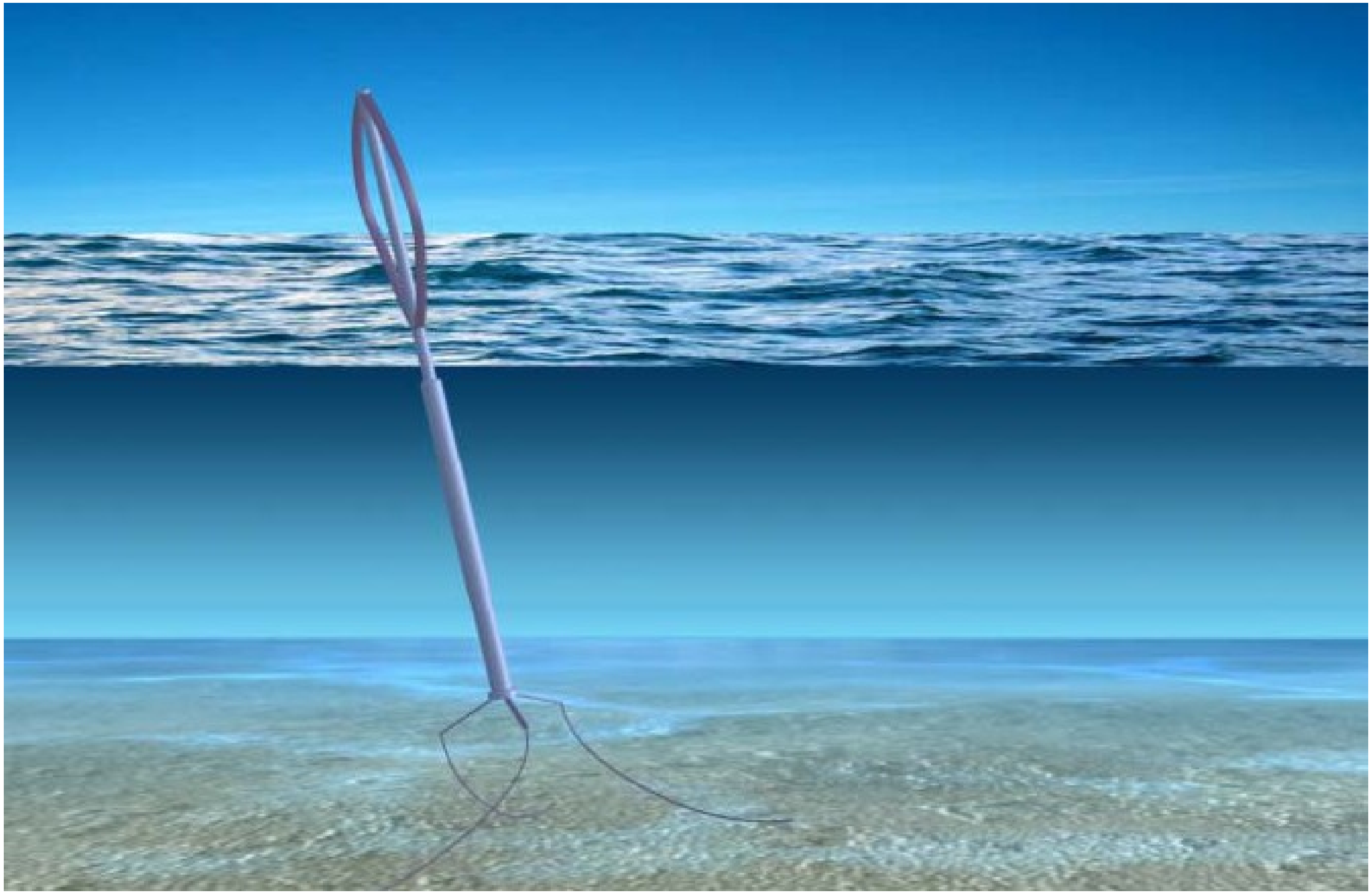
- Two blades !?
- Stall control !??
- Direct drive generator !?
- Vertical axis !?

Future offshore wind turbines



Little evidence that concepts are lean and robust

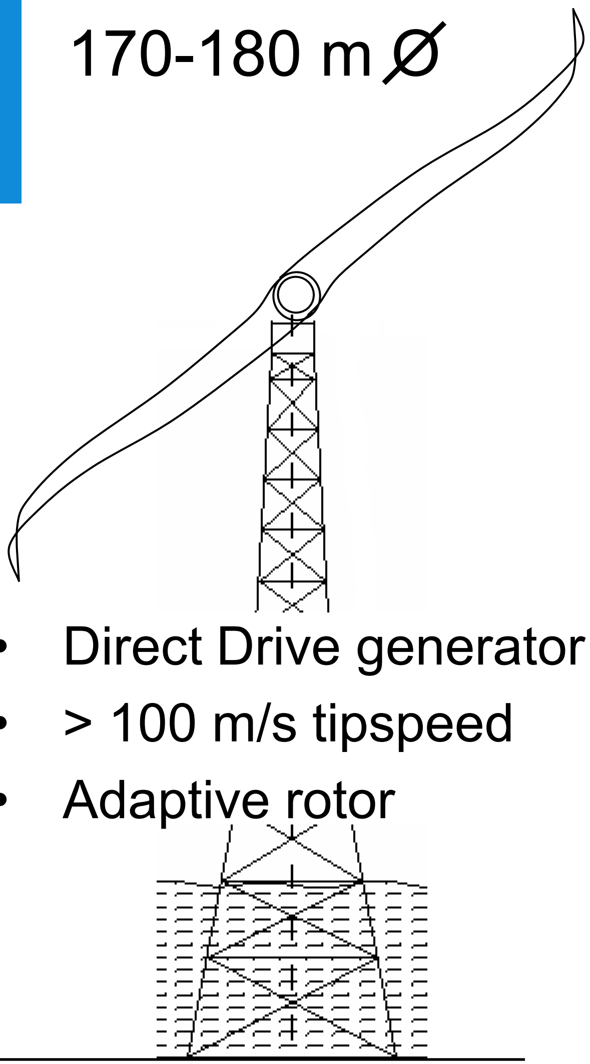
Except perhaps.....



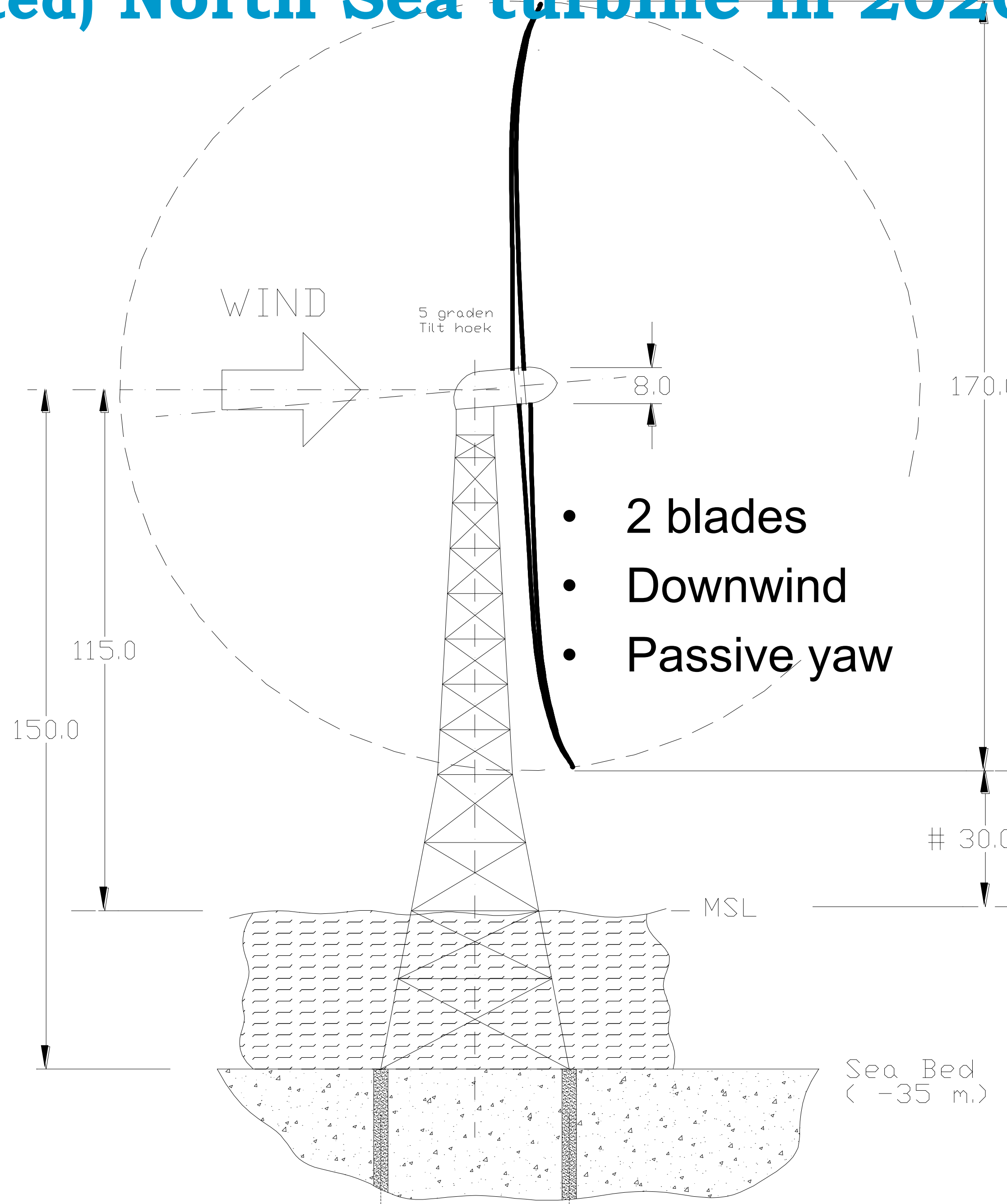
The Deepwind Floating Concept

My (bottom mounted) North Sea turbine in 2020

8 - 10 MW
170-180 m Ø

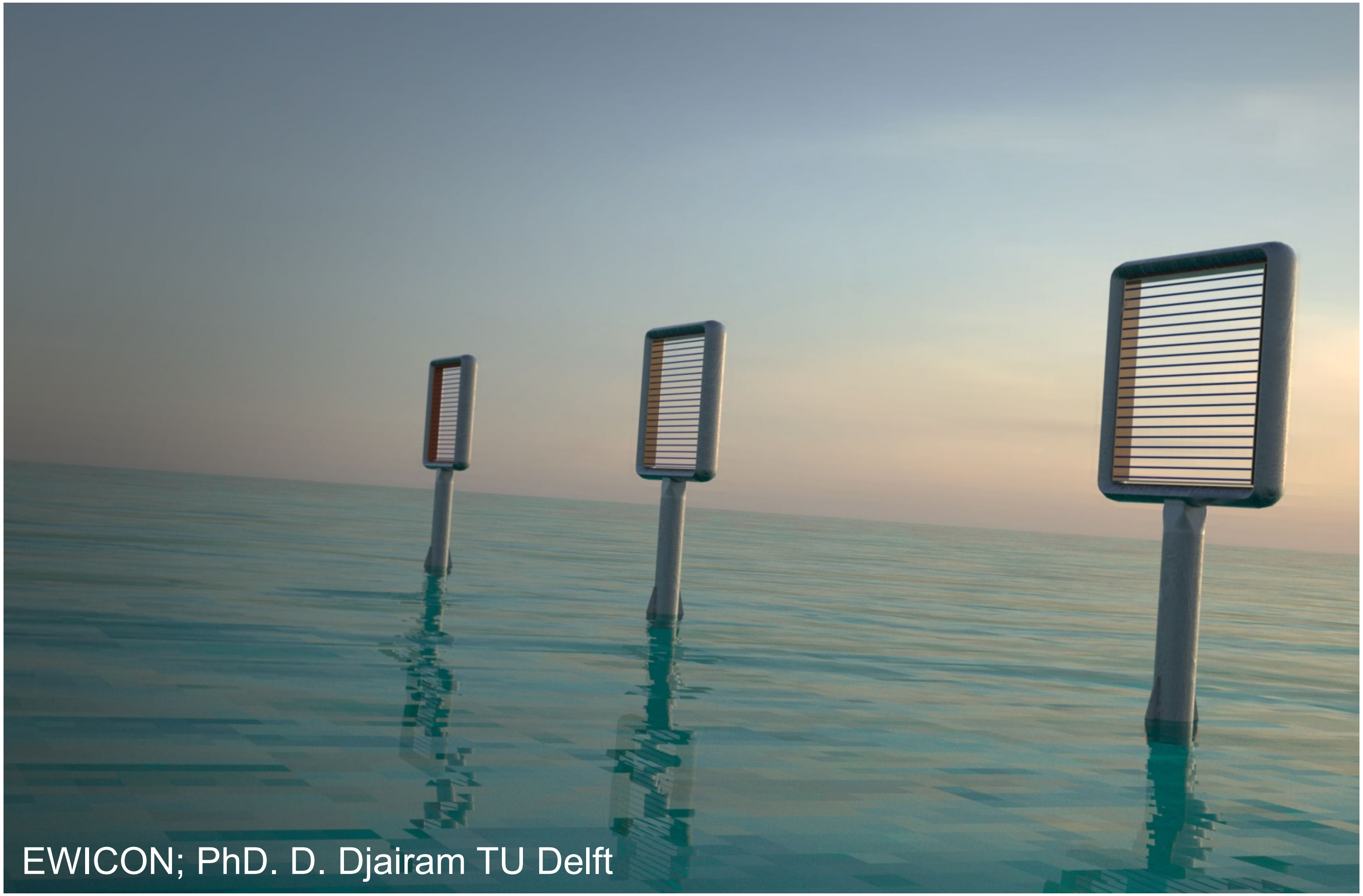


- Direct Drive generator
- > 100 m/s tipspeed
- Adaptive rotor



- 2 blades
- Downwind
- Passive yaw

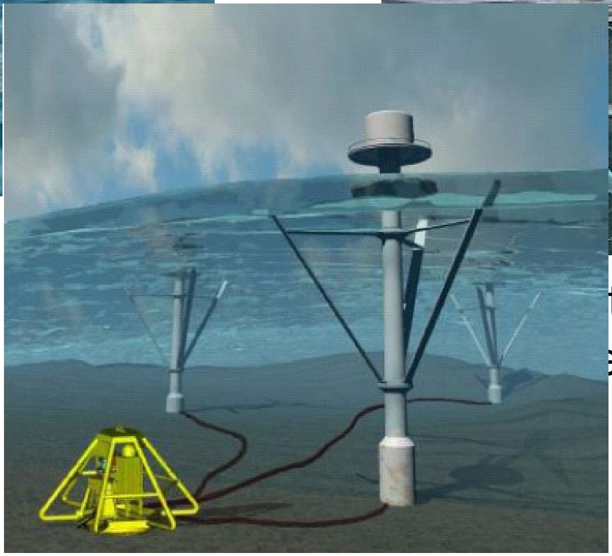
The ultimate offshore turbine in 2030?



Wave and (Tidal) Current Energy Converters

(Wave energy device
(Pelamis Wave Power)

t energy device
ent Turbines)



Wave & current energy device
(Wave Rotor, Eric Rossen)

Tidal energy demonstration plants in NL

- Tocardo tidal energy
- 50 kW
- Afsluitdijk

- C-Energy wave & tidal energy
- 30 kW
- Westerschelde

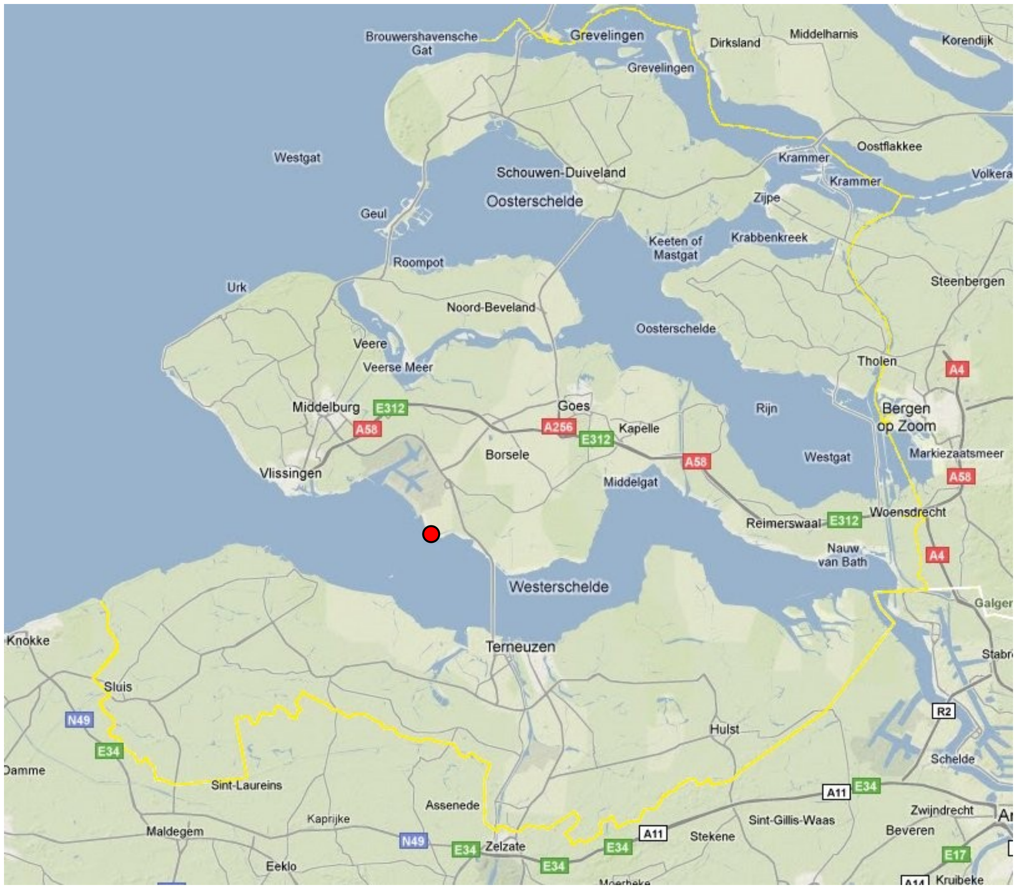
Tidal energy

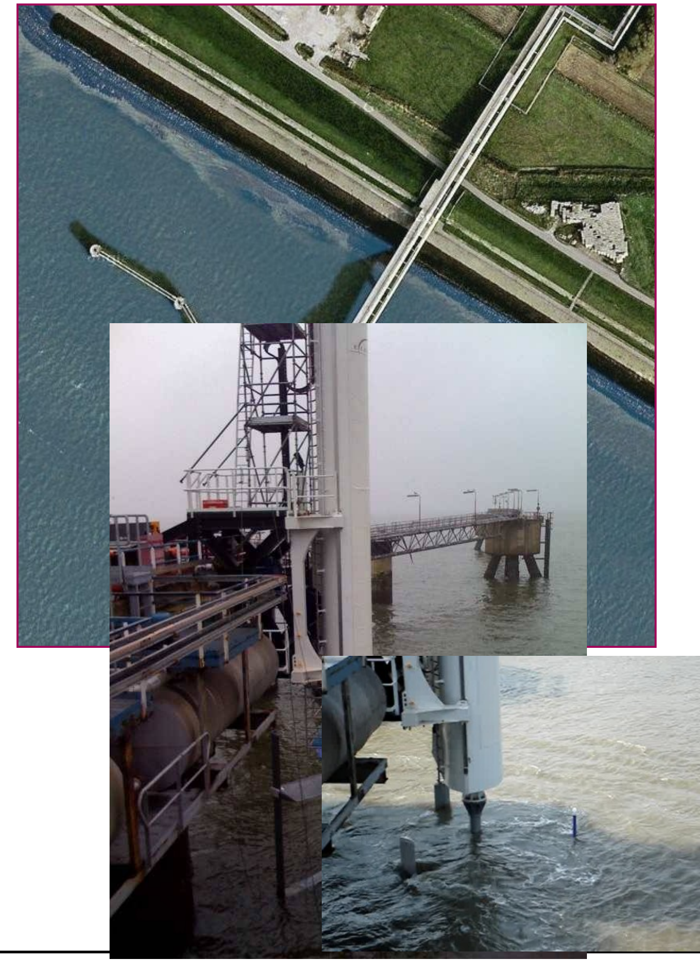
Tocardo T50-A

Tocardo T50-A: 50 kW 2.8 m diam.

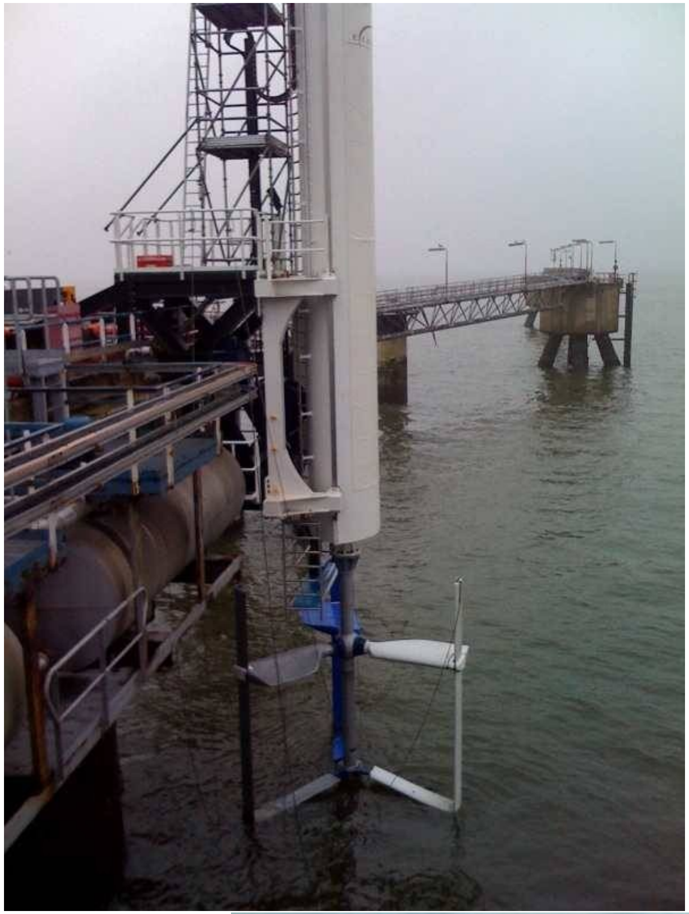
Tidal & Wave energy

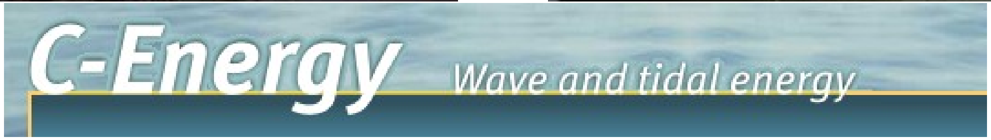
C-Energy Wave and tidal energy





C-Energy Technology





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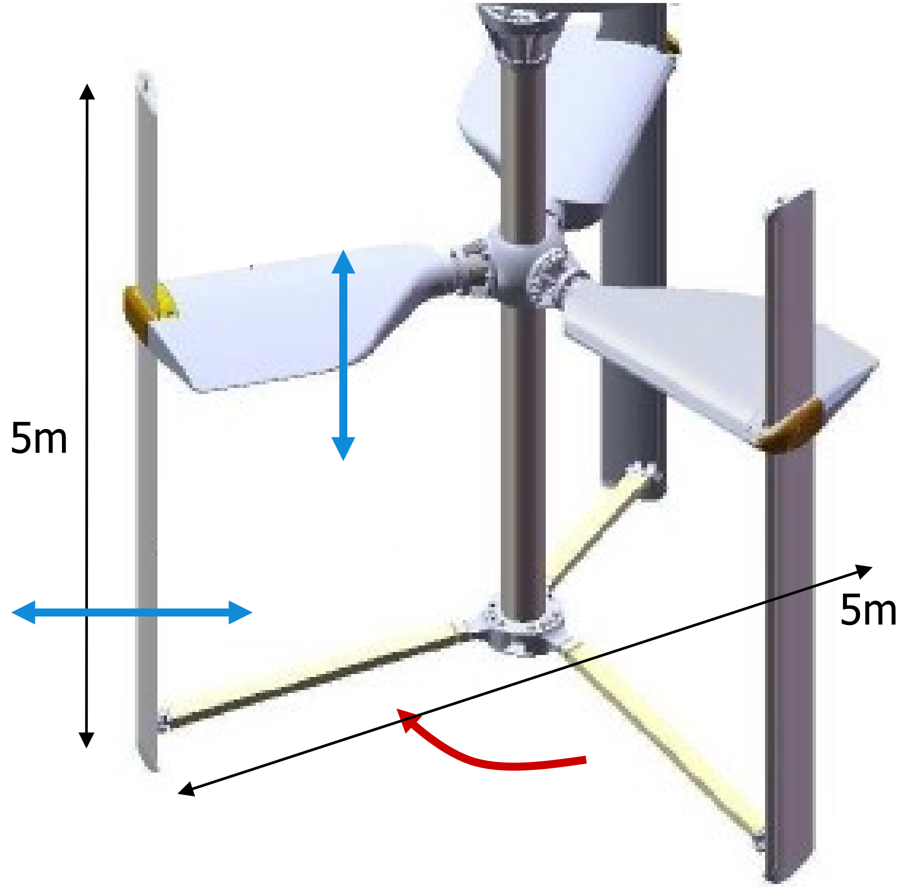
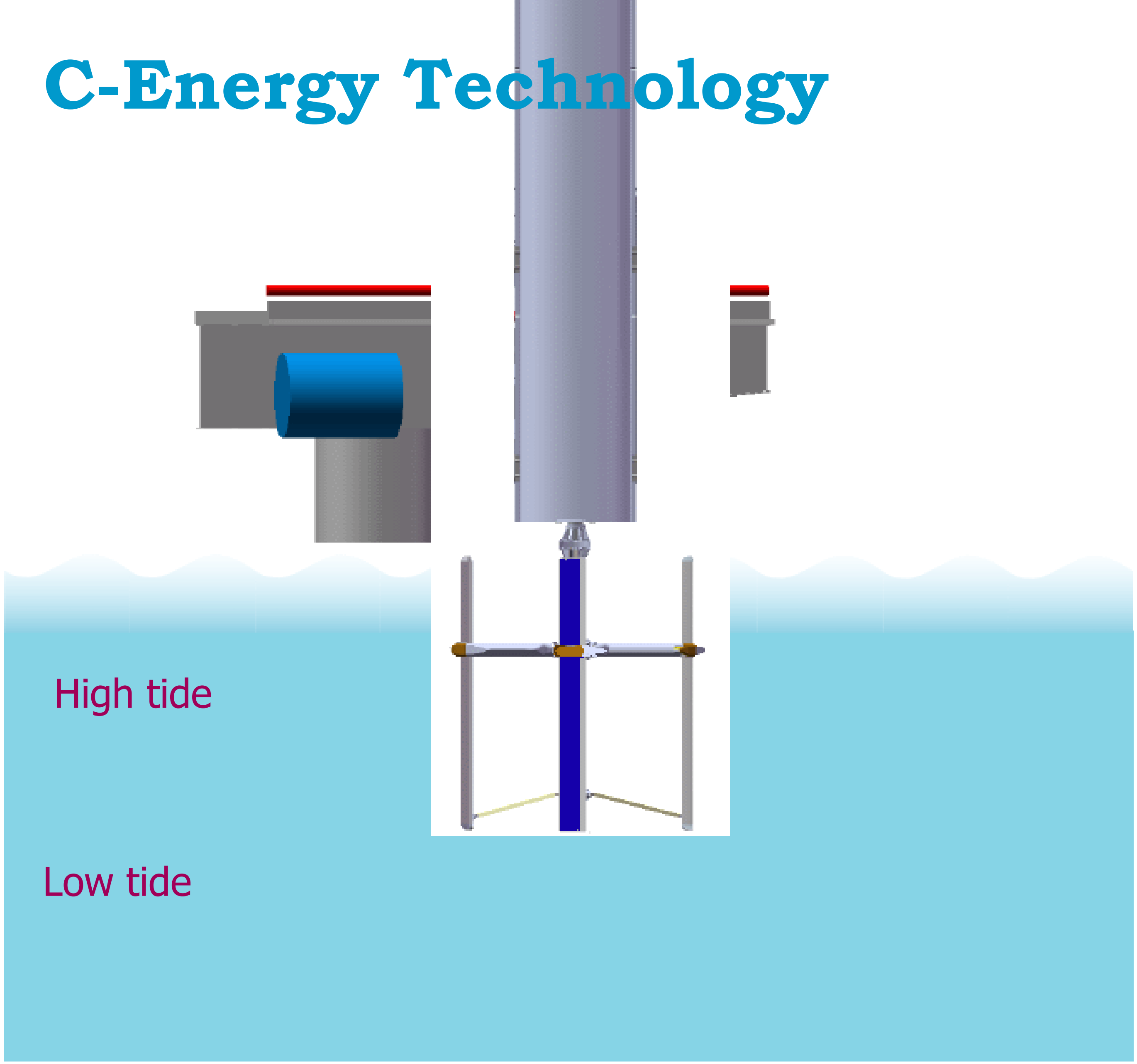


C-Energy Technology



Conclusions

Offshore wind energy needs a different design and a different maintenance approach:

- Big wind turbines
- New access systems
- Lean design (not yet implemented)
- Improved reliability
- Smart maintenance systems (re-configuration)
- Wind turbines as elements of an integral plant design

Wave and Tidal energy: first demo projects operational

- Though not (yet) in a real offshore environment (in NL)