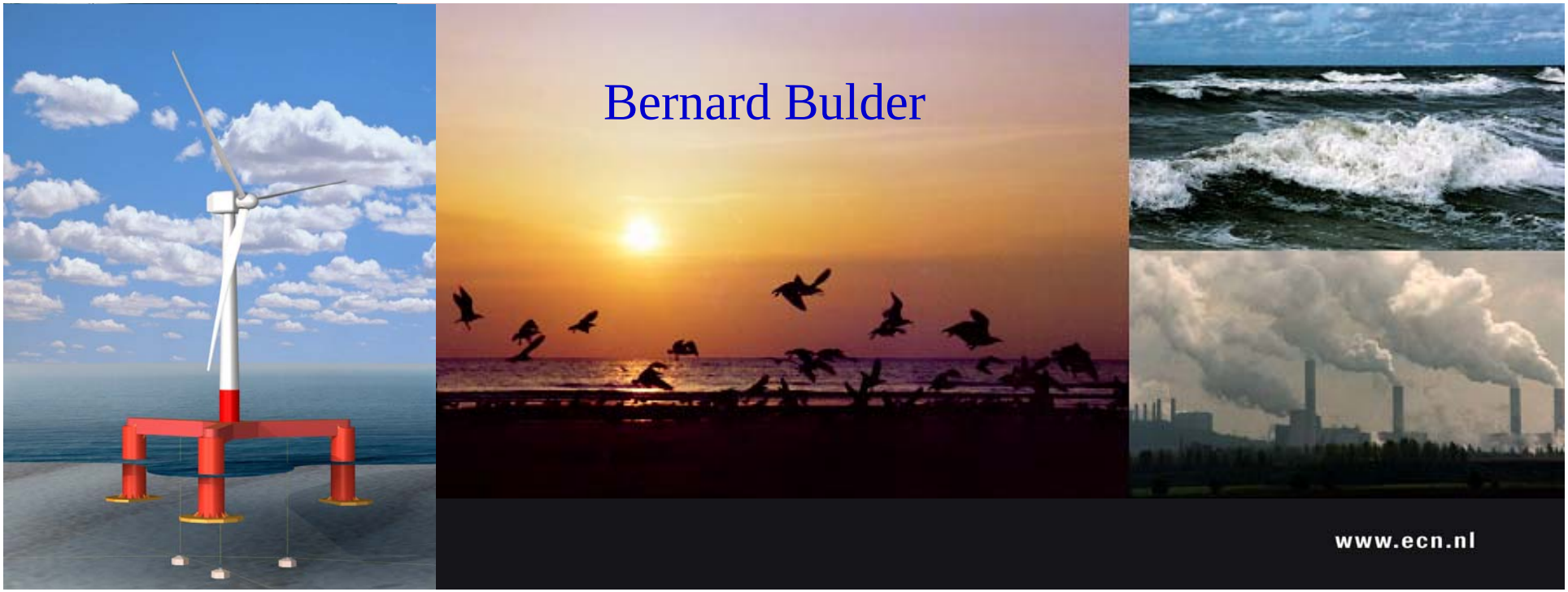
ECN

Energy research Centre of the Netherlands

Future Innovative Solutions

Is it Worth looking for Floating Systems?



Content of Presentation

- Introduction, what has been done in the past
- What are the options
- Pro's and Con's
- Concepts evaluation
- Economics
- Conclusion

Introduction

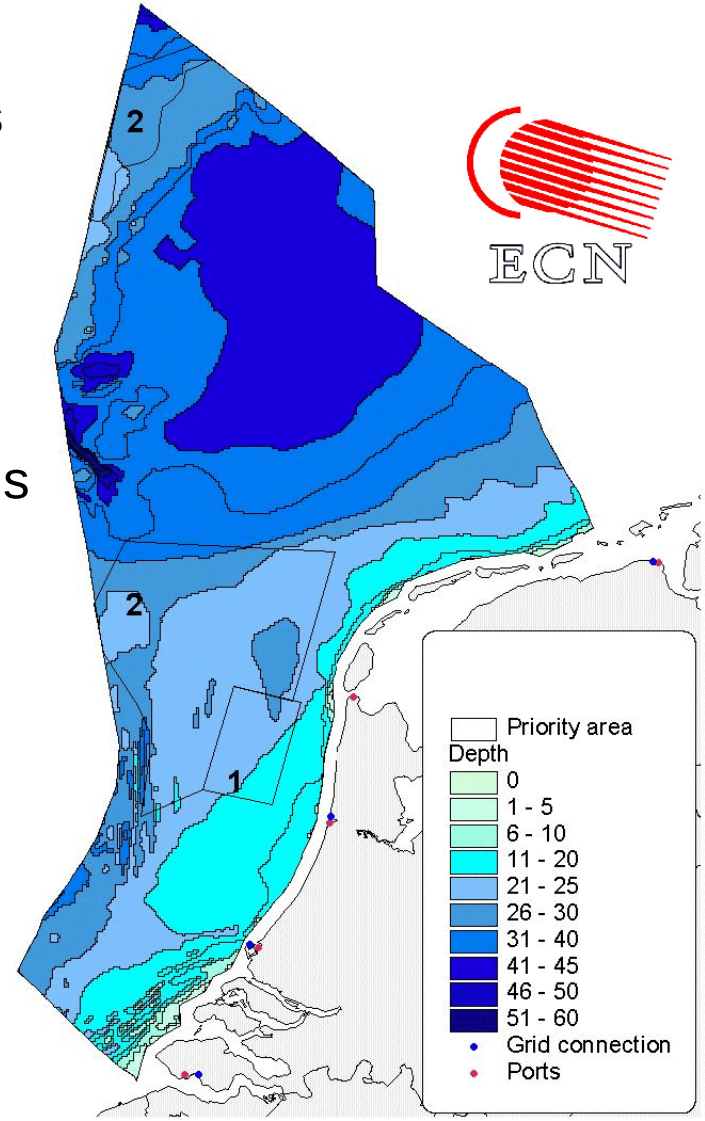
Some of the studies concerning floating wind turbines that have been performed

- Work by Prof. Heronemus in 1970s, including floating multi rotor concepts
- In 1993 several studies have been reported at a BWEA/DTI seminar Prospects of Off Shore Wind Energy (FLOAT by GH et.al.)
- In the middle/late 1990s University College of London in cooperation with WS Atkins resulting in a few thesis reports
- ELOMAR, mid 1990s, Italian study
- 2001/02 Feasibility study performed by TNO/TUD/MARIN/ ECN/MSC called DrijfWind (FloatWind) (specifically shallow water)
- 2003, Feasibility of Floating Platform Systems for Wind Turbines, by NREL

What are the other options

Why use Floating support structures for wind turbines when there are other options?

- On land not sufficient free capacity for wind turbines, especially in/near densely populated area's, near the "load centres"
- Shallow off shore (initially) sufficient locations (UK, Den Mark, Germany, The Netherlands, east coast of the US)
- Other locations, e.g. South Europe, west coast of the US or Japan have no or few shallow locations



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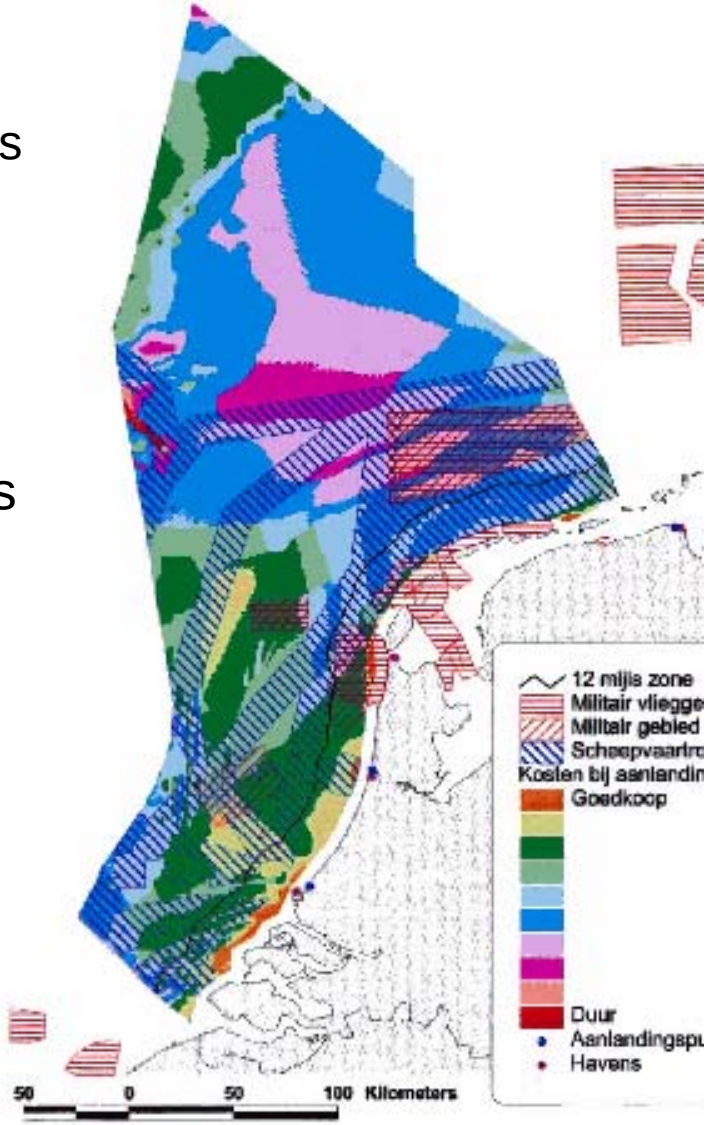
- Shallow off shore (initially) sufficient locations (UK, Den Mark, Germany, The Netherlands, east coast of the US)
- Other locations, e.g. Mediterranean, west coast of the US or Japan have no or few shallow locations
- Wind has to compete with many other usages for the near shore sites



Pro's & Con's

Pro's

- Easier installation and decommissioning?
- Deeper water possible, more opportunities!
- Easier maintenance?
- Better wind conditions when further from shore!

Con's

- Not only a floater is needed also an expensive anchoring system!
- Difficult transfer of electricity to shore!
- Further from shore higher transfer losses and maybe an DC electrical system?
- Further from shore maybe more down time?

Pro's, Easier installation and decommissioning

- Turbine can be assembled on shore then float/towed to the location

Pro's - Deeper water possible, more opportunities!

- This needs no clarification

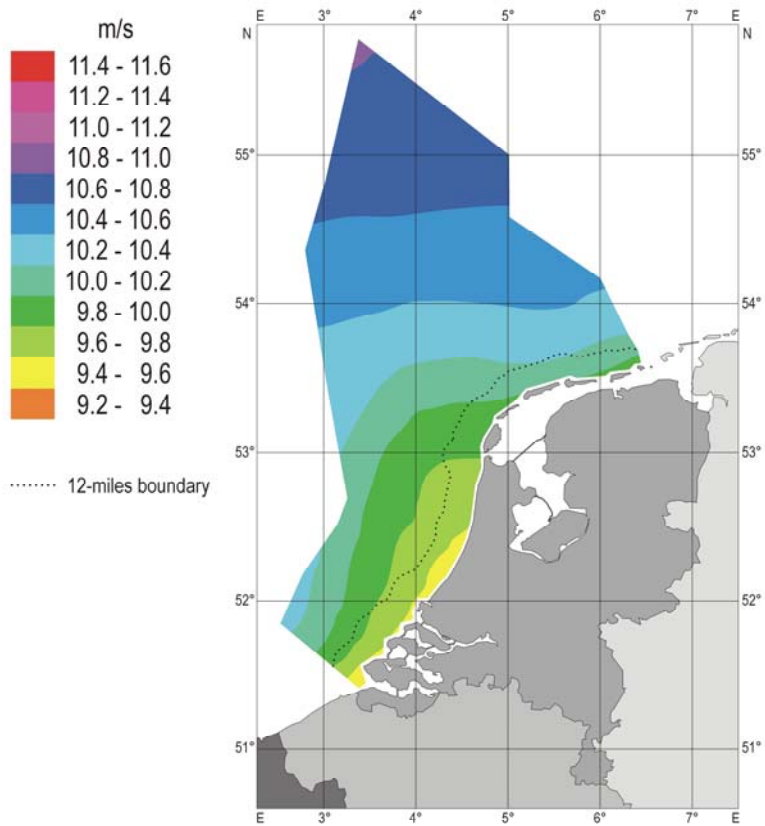
Pro's – Easier maintenance?

- Not sure whether that is true, boarding a floating device might be more difficult than boarding a fixed structure
- Towing the system to shore for large maintenance often not possible or not economical

Pro's - Better wind conditions when further from shore!

An example of the variation of the mean wind speeds further from shore.

Mean Wind Speed at the Netherlands' Exclusive Economic Zone (NEEZ)
Period: 1997 - 2002
Height: 90 m above mean sea level



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Con's - Not only a floater is needed also an expensive anchoring system

- Strangely enough is a mooring system more expensive for less deep water

Con's - Difficult transfer of electricity to shore

- Due to platform movement, standard electrical connections and cables are not designed for this.

Con's – Further from shore higher transfer losses and maybe an DC electrical system

- When deeper water means further from shore the transport losses increase and
- Above 200 km a DC system is more economical

Con's - Further from shore maybe more down time?

- Longer reaction time, weather window needed will increase with extra travel time.

Concept evaluation

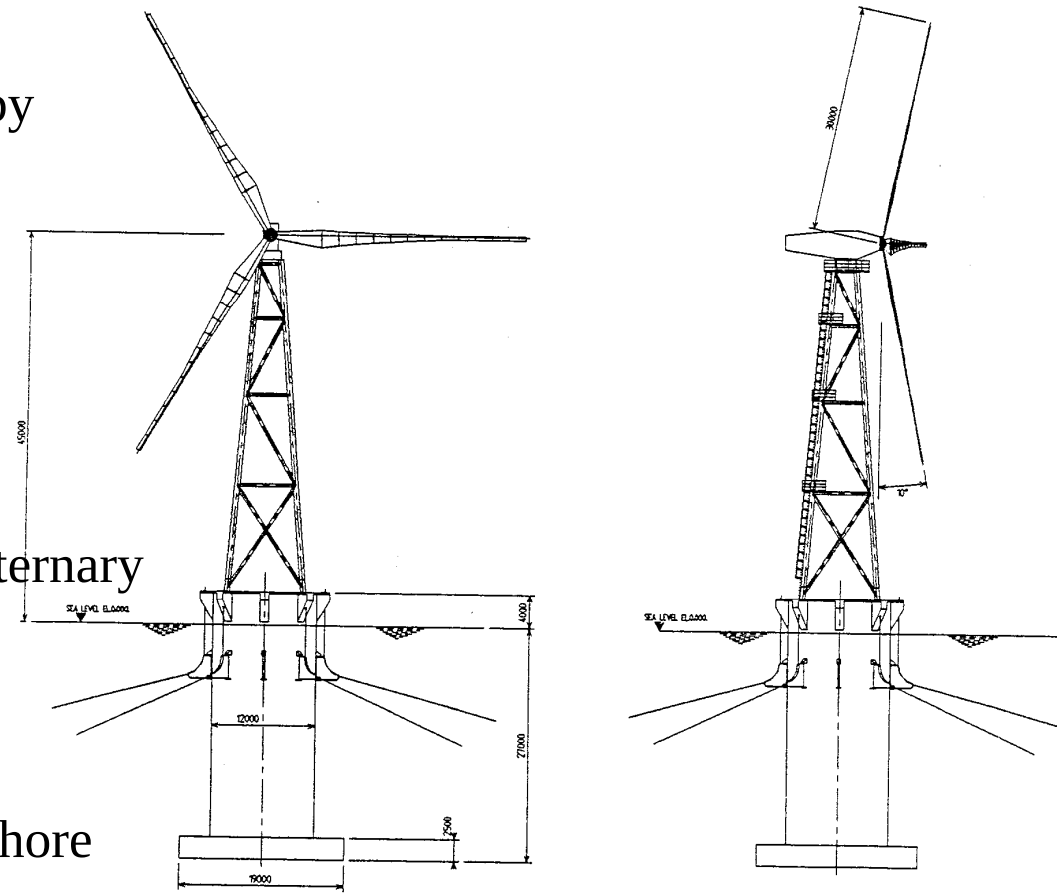
Some concepts that resulted from the previous studies.

FLOAT study, performed, in 1993, by

- Technomare
- Garrad Hassan & Partners
- Offshore

Results:

- Study included model test
- Concept spar buoy, with 8 point caternary mooring
- Minimum depth > 75 m
- 1.4 MW wind turbine
- Cost estimate to twice the cost on shore



Concept evaluation cont.

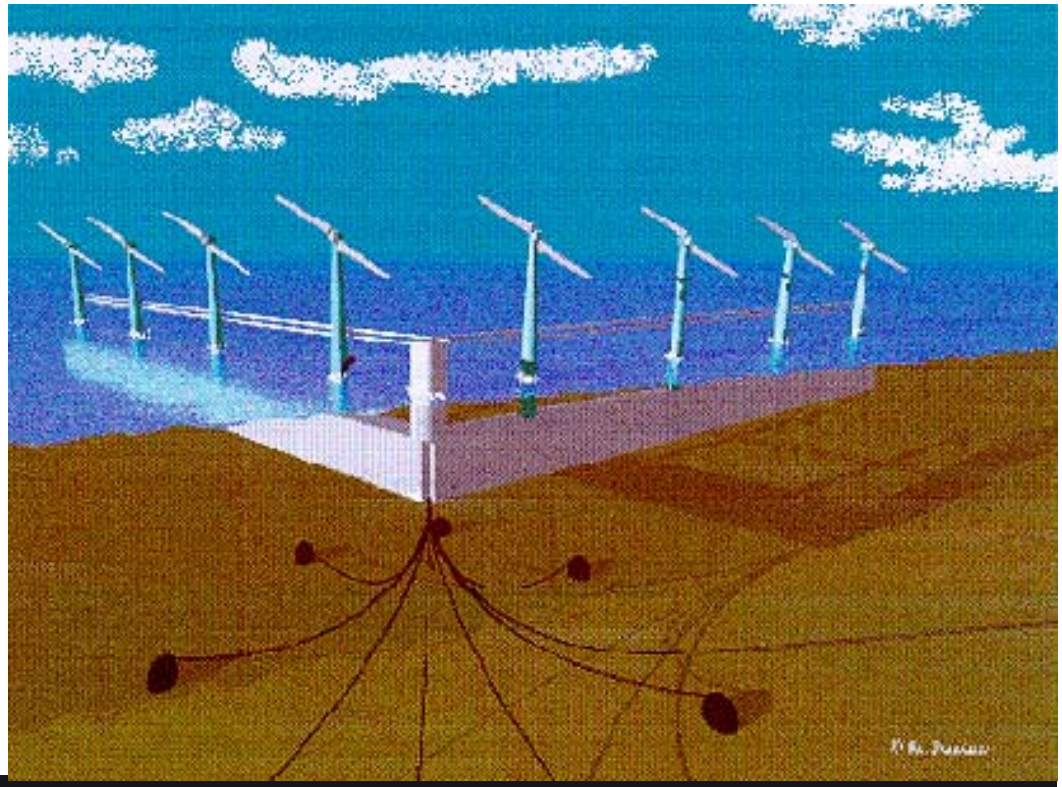
Multi Unit Floating Off Shore Wind Farm (MUFOW), late 1990s,

Investigated by:

- University College of London
- WS Atkins

Results:

- Technically feasible but
- COE too high (around 3 times the price for land based systems)



Concept evaluation cont.

ELOMAR

Performed by:

•ENEL

•AIOM

Directed towards technical feasibility, included a model test.

Results, model (A) has the necessary stability to be used as a wind turbine platform.

For a minimum depth of 50 m.

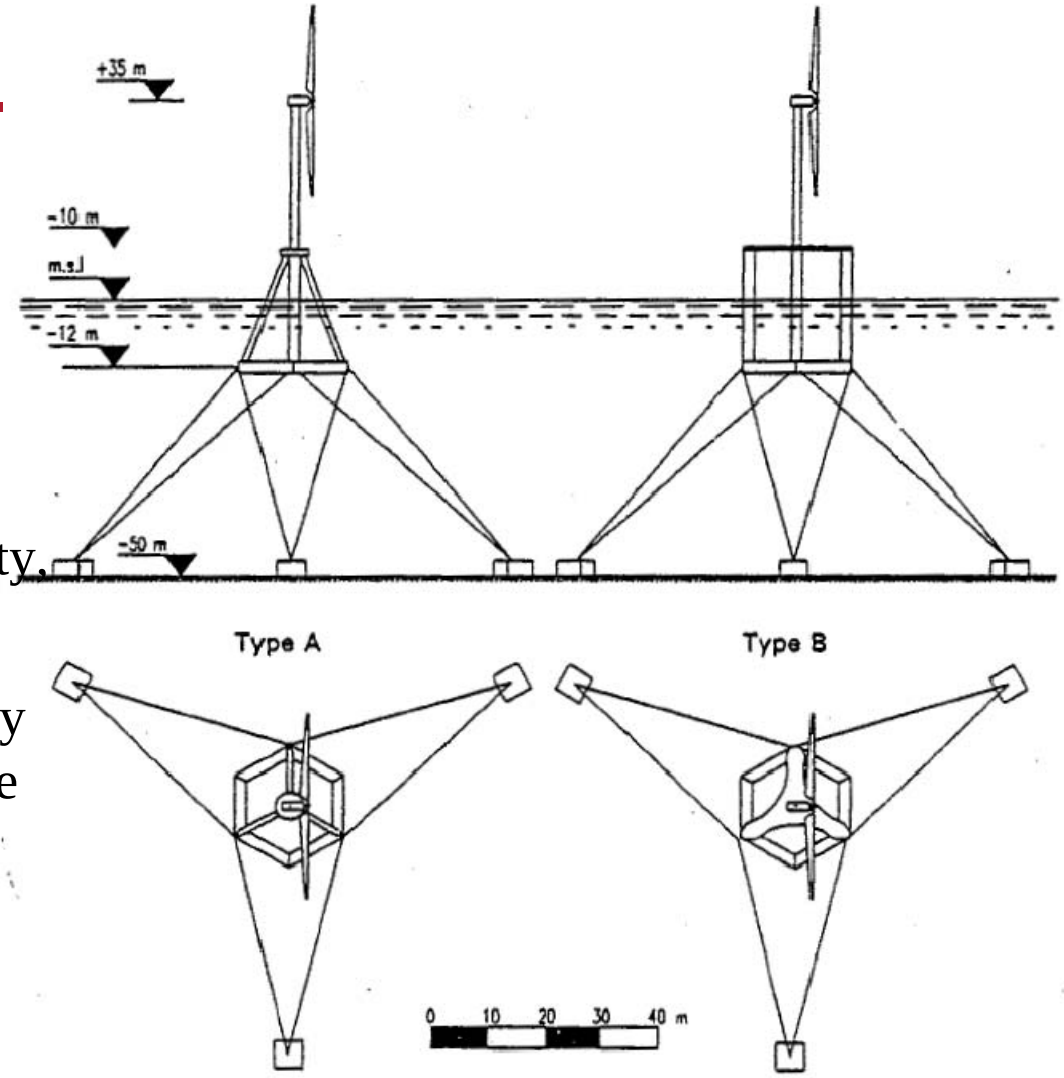


Figure 2. EOLOMAR structures tested in the wave flume.

Concept evaluation cont.

Drijfwind (FLOATWIND)

Study performed by:

- TNO
- TUD
- MARIN
- Lagerwey (part time)
- MSC

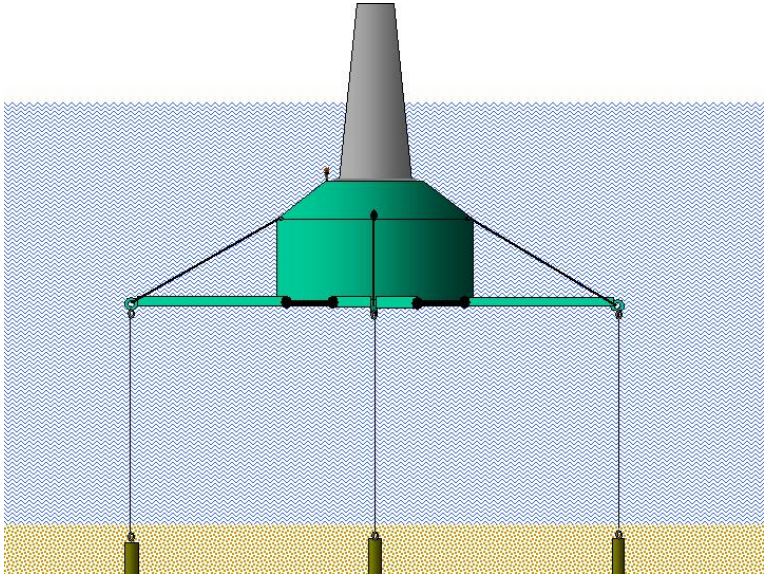
Results:

- Tri-floater concept, with 6 point catenary mooring system
- Wind turbine 5 MW, Diameter 115 m
- Minimum depth of 50 m

Concept evaluation cont.

TLP Study performed by:

•NREL



Emphasis of the study on mooring systems, to reduce the cost of the mooring/anchoring system.

Resulted in a TLP, consisting out of a cylindrical buoyancy tank with three radial arms

Economics, DRIJFWIND versus NREL TLP study

		Dutch Tri-Floater Concept			NREL TLP Concept		
		Weight (1000 lbs)	Specific Cost (U.S.D/lb)	Cost (million U.S.$)	Weight (1000 lb)	Specific Cost (U.S.$/lb)	Cost (million U.S.$)
FLOATING STRUCTURE	Buoyant tanks	1068.5	1.14	1.22	394.7	1.00 to 2.00	.39 to .79
	Braces	866.9	1.46	1.27	115.9	1.00 to 2.00	.12 to .23
	Upper hull deck	345	1.37	0.47	NA	NA	NA
	Support column	179.2	1.6	0.29	NA	NA	NA
	Upper tank/turbine connection	NA	NA	NA	100	2	0.2
	Arms	NA	NA		103.3	1.00 to 2.00	.10 to .21
Platform Structure Subtotal 1				**1.94 to 3.24**			**.81 to 1.43**
MOORING SYSTEM	Mooring chain	1120	0.91	1.02			
	Mooring wire	302.4	0.91	0.28			
	Anchors	448	1.37	0.61			.60 to 1.80
	Vertical tendons (600-ft depth)				360	1.00 to 2.00	.36 to .72
	Installation of suction anchors and platform			0.61			.30 to 1.20
Mooring System Subtotal 2				**1.51 to 2.52**			**1.26 to 3.72**
ANCILLARY ITEMS	Mooring reinforcement	112	1.37	0.15			0.15
	Paint	56	11.41	0.64			0.64
	Cathodic protection	56	4.56	0.26			0.26
	Miscellaneous	112	1.83	0.2			0.2
	Installation of wind turbine			0.1			0.1
	Ancillary Subtotal 3			**.81 to 1.35**			**.81 to 1.35**
TOTAL COST $M				**4.26 to 7.11**			**2.88 to 6.50**

COE DrijfWind approx. € 0.07, NREL TLP cost target $0.05 /kWh possible (in 2015, approx. 1.5 more expensive than shallow water off shore wind turbines

Conclusion

- Floating wind systems are technically feasible, although there are still many technical challenges and risks involved.
- Single units seem to be more economical than multi unit concepts
- Cost of Energy from deep water (> 50 m depth) ~1.5 times more expensive than shallow water (< 30 depth) off shore wind turbines or twice the cost of land based wind turbines.
- The break even depth, i.e. where a bottom mounted system equals the cost of a floating system is depending on external conditions.
- Floating systems could be an option for load centres near the coast with a water depth of more than 50 m

Conclusion

- Perhaps a fundamental study where an integral concept evaluation is made could result in better, more economical results.

Thank you for your attention