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The GICON®-TLP for wind turbines

Experimental Studies and numerical Modelling of structural Behavior of a Scaled Modular TLP Structure for Offshore Wind turbines

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Main partners:

GICON® Firmengruppe

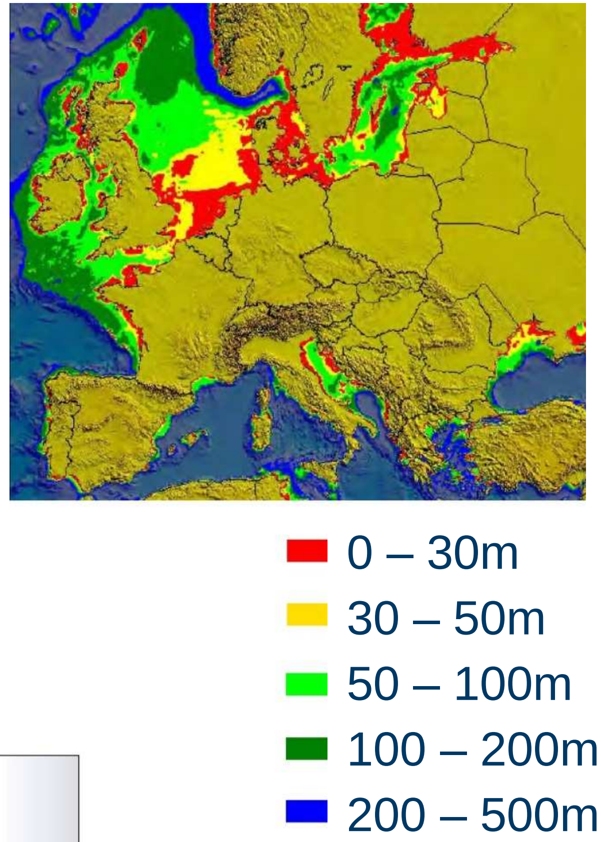
ESG Edelstahl und Umwelttechnik

Universität Rostock – Traditio et Innovatio

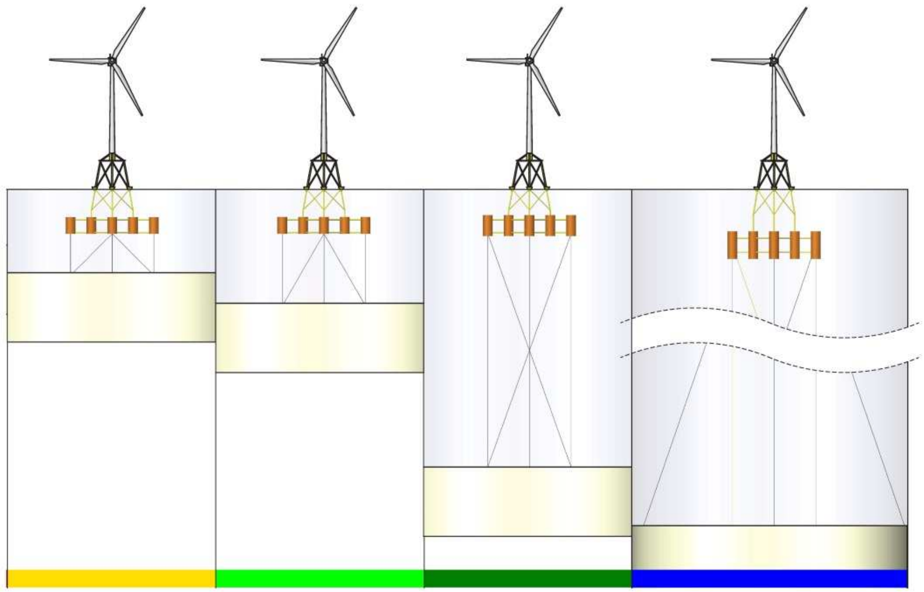
TECHNISCHE UNIVERSITÄT BERGAKADEMIE FREIBERG – The University of Resources. Since 1765.

Motivation

- Globally found wind resources present a great and ecological opportunity for power generation
- Floating foundations are economical for water depths > 60 m [Musial et al, 2006]
- Founding depths for the GICON®-TLP are:



Source: ORECCA



Outline

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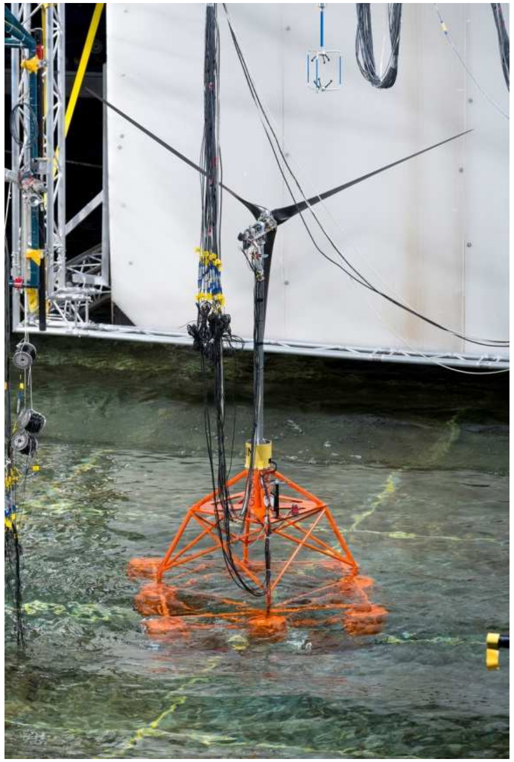
- Revenue
- Partners

GICON®-TLP

- Path of development
- Design (2.0 MW, 6.0 MW, comparison)

Scaled tests (2.0 MW)

- HSVA (Feb. 2012), MARIN (June 2013), VWS (Sep. 2013)



Conclusion and Outlook

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GICON® Group

An independent engineering and consulting group

1994:
GICON – Grossmann Ingenieur Consult GmbH established in Dresden, Germany, as a privately held engineering company with 20 employees by CEO Prof. Jochen Grossmann

Today:
The GICON Group's 300 full-time employees across 12 companies Average revenue growth 10 % p.a.; 23.4 Mio €. ↗

On average 30 ongoing applied R+D projects in all departments

Over 80 German and international patent applications for processes or technology have arisen from research conducted by GICON engineers

Sample of national and international cooperation partners:

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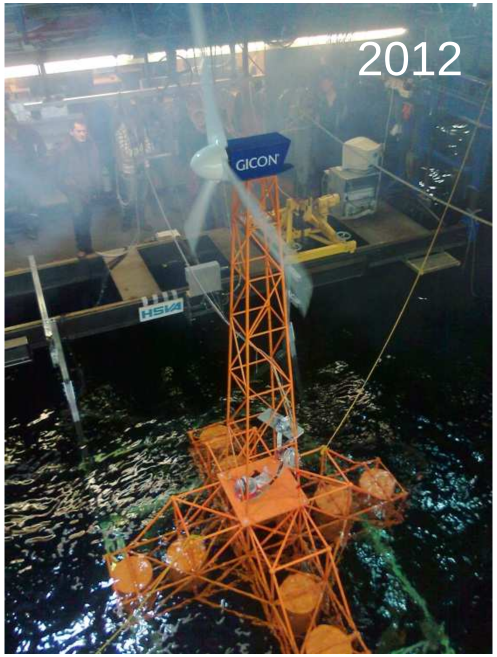
GICON®-TLP

A development of private industry in cooperation with academic institutions

Path of development

→ the development comprises: 10 Patent families in 22 countries

First concept



HSVA tank model
high redundancy
principle tests
~ 1500 t

MARIN tank model
optimized design
high redundancy
test of dynamic behavior of the pilot plant
~ 1200 t

pilot plant
modified design
adequate redundancy
economical solution
~ 670 t

The concept of the GICON®-TLP in general

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Advantages of the GICON®-TLP:

- Deployable from 20 meters to 300 meters
- Portside assembly and transport of the entire structure to the deployment location
- Modular construction resulting in more flexibility in the supply chain
- Depending on the geology - anchoring via piles, micro piles or gravity foundations

Wind Turbine	Weight/MW
2.0 MW	≈ 291 t /MW
4.0 MW	≈ 248 t /MW
6.0 MW	≈ 214 t /MW

Concept for prototype (2.0 MW)

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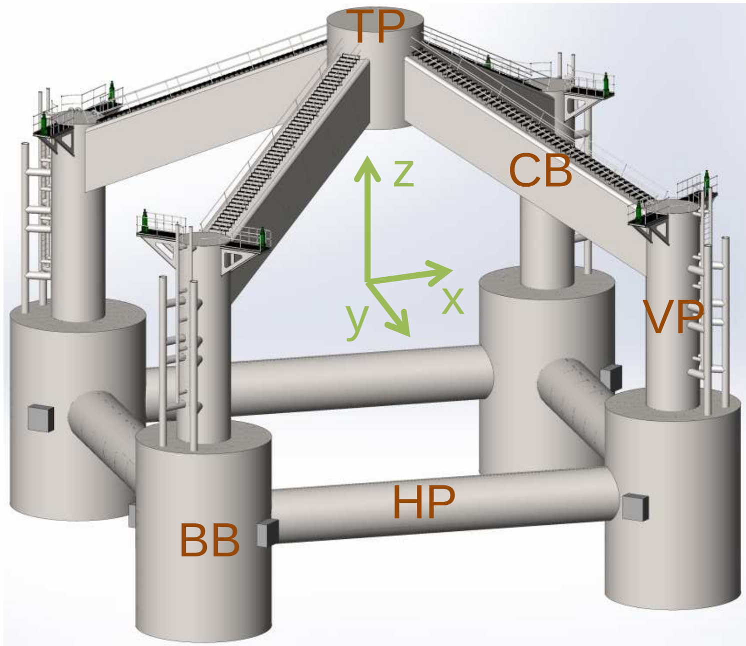
Components of the platform:

- cylindrical buoyancy bodies (BB)
- horizontal pipes (HP) for structural base
- vertical pipes (VP)
- cantilever beam (CB)
- transition piece (TP)

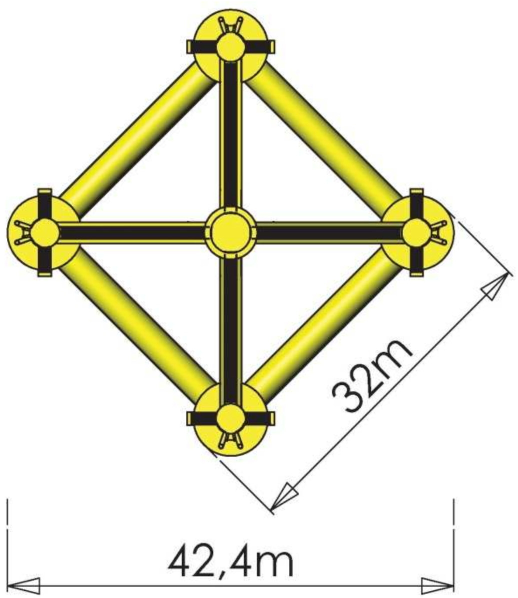


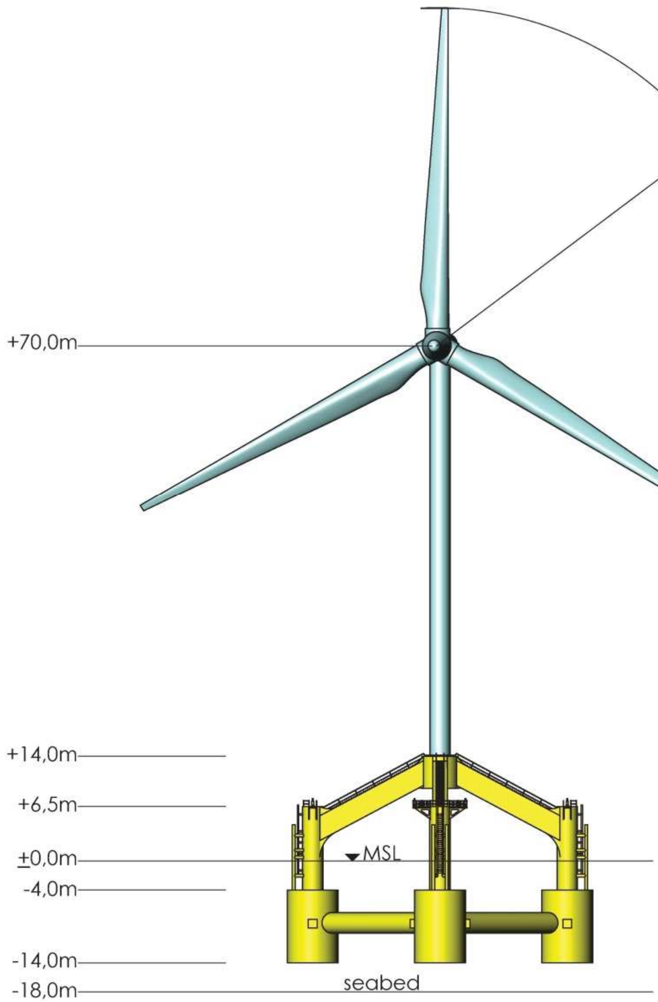
Dimensions (L x B x H)	32m x 32m x 28m
Displacement	2070 m³
TLP Weight incl. sec. Steel	**≈ 670 t (590t + 80t)**
Total weight incl. WT	**≈ 972 t**
min. # of Anchor points	4

Concept for prototype (2.0 MW)

Characteristics:

- Modular construction
- Structure width < PanMax
- Also usable for 4.0 MW
- Fabrication: 2 TLP per week (one shipyard)





Comparison of both concepts (2.0 and 6.0 MW)

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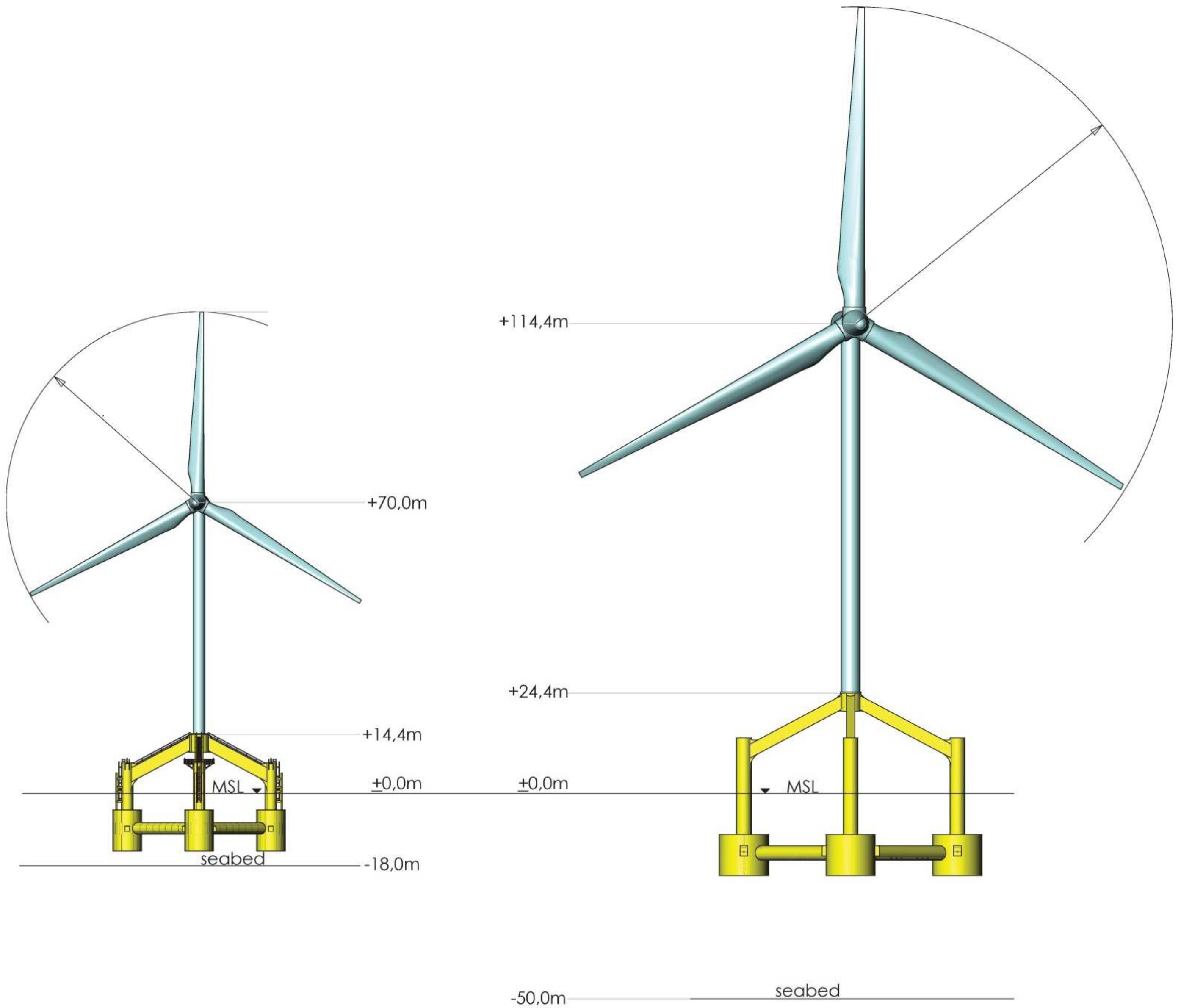

Scaled tests

HSVA Hamburg, MARIN Wageningen, TU Berlin

HSVA – Operation and transit 2.0 MW (Feb. 2012)

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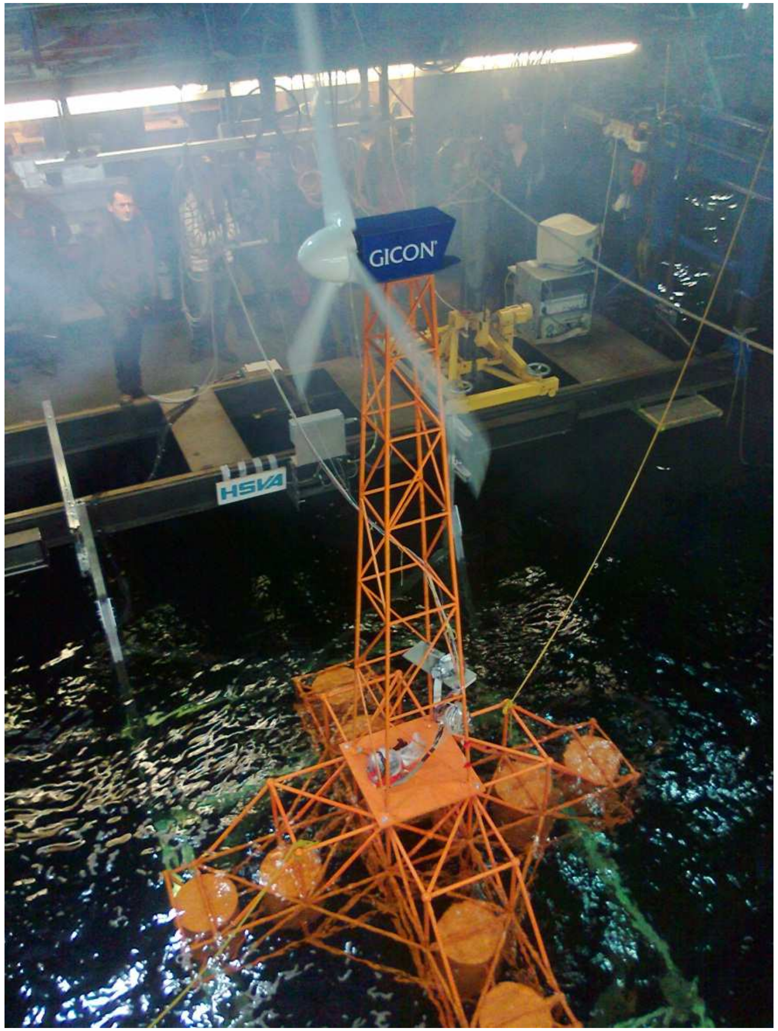
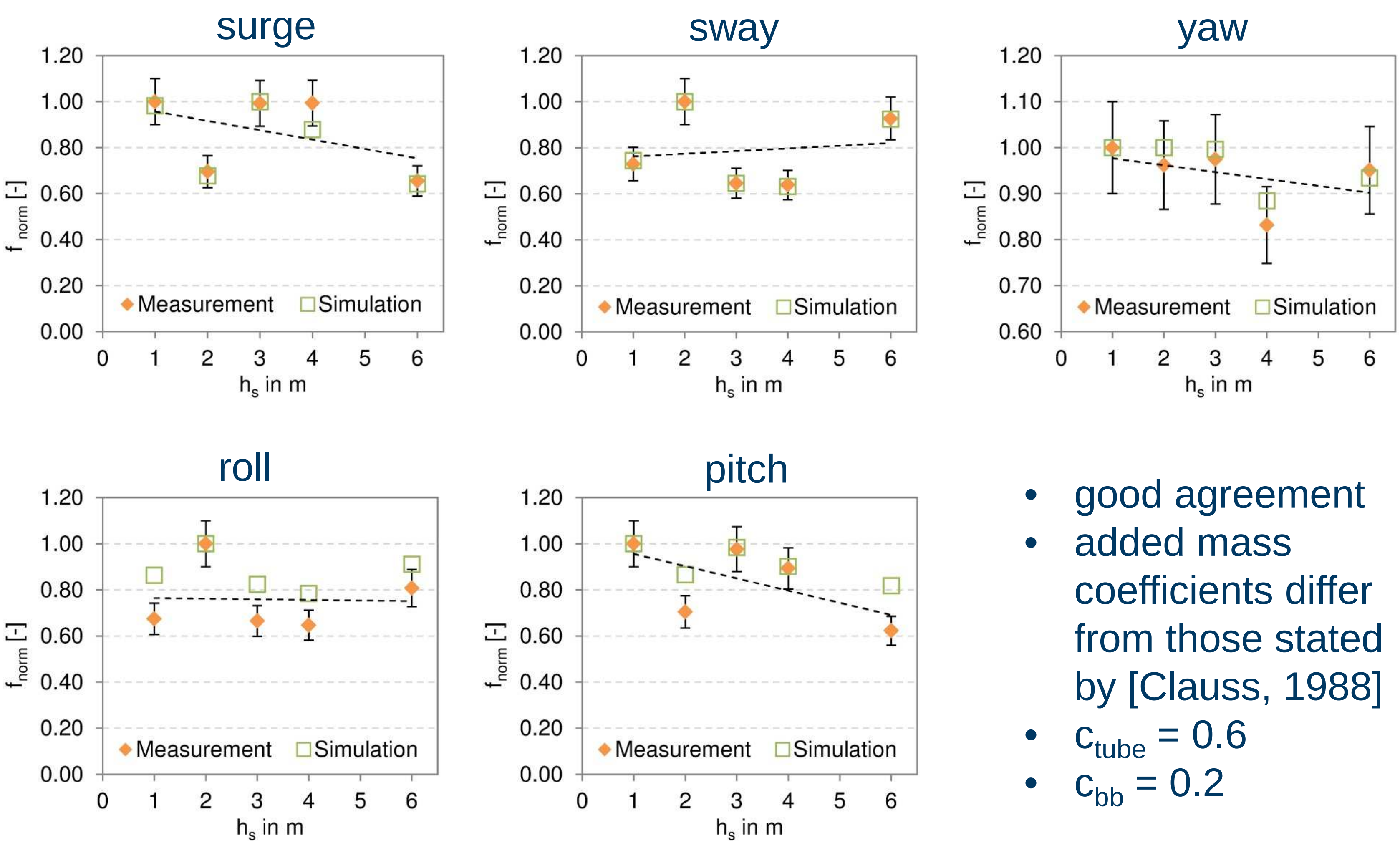
- Scaling after FROUDE
- Scaling factor $\lambda = 25$
- Incoming flow angle 0.0°, 22.5° and 45.0°
- Only wave loads
- Depth of water 30 m

- Testing conditions:

h_s in m	T_p in s
1	4.5
2	5.9
3	6.9
4	8.0
6	9.8



HSVA – Comparison eigenfrequencies 2.0 MW



- good agreement
- added mass coefficients differ from those stated by [Clauss, 1988]
- $c_{tube} = 0.6$
- $c_{bb} = 0.2$

Details on the calculation model: Adam et al: “GICON®-TLP for wind turbines - Validation of calculated results”. Proc. ISOPE 2013 Anchorage.

MARIN – Operation 2.0 MW (June 2013)

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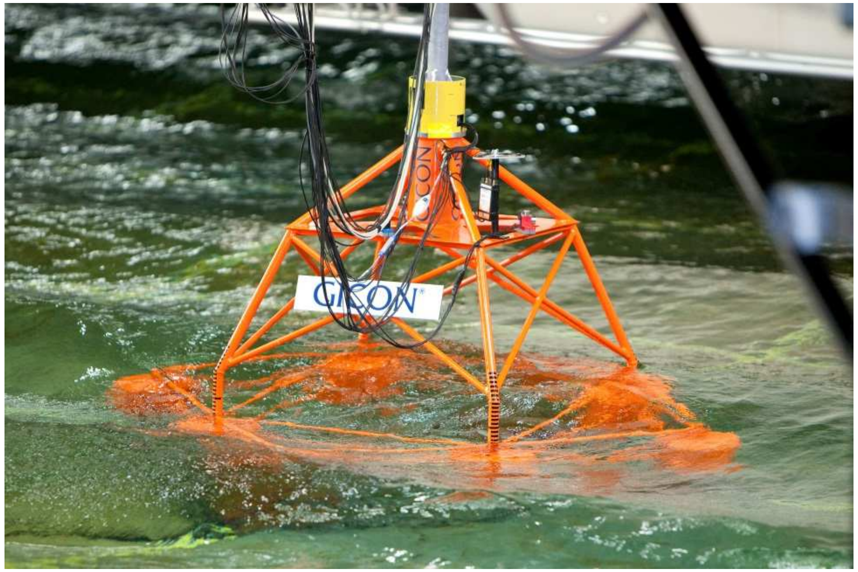
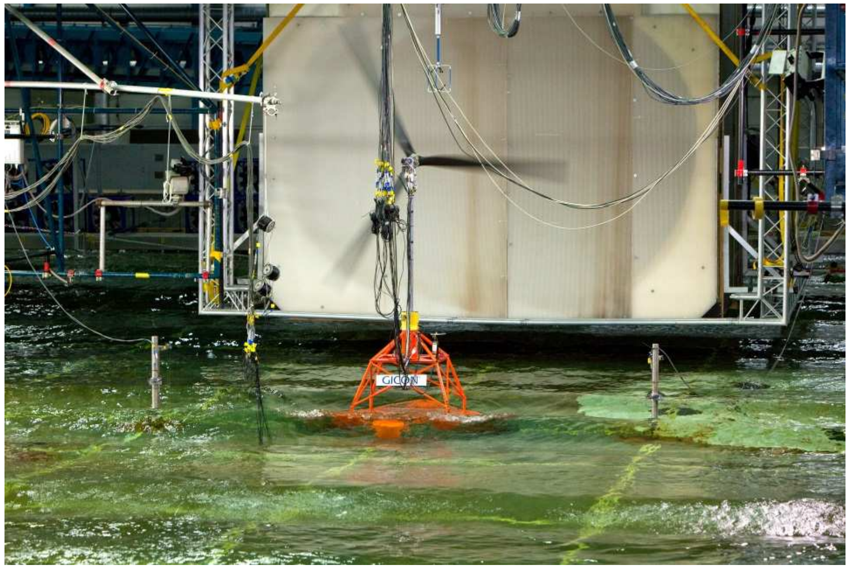
- Scaling after FROUDE
- Scaling factor $\lambda = 37$
- Incoming flow angle 0°, 22.5° and 45°
- Exposure to wind, wave and coupled wind/wave loads
- Fixed (α = 35 °; θ = 90 °) and towing states
- Water depth 20 m

- Testing conditions:

v_w in m/s	h_s in m	T_p in s
12.0	2.30	0.83
25.0	4.72	1.00
36.5	5.30	1.44





MARIN – Operation 2.0 MW (June 2013)

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- Comparison eigenfrequencies for h_s = 4.72 m

Comment	#	f_m in Hz	f_c in Hz	f_m/f_c in %
Surge	f_1	0.637	0.625	1.9
Sway	f_2	0.637	0.625	1.9
Heave	f_3	2.111	1.955	8.0
Roll	f_4	1.150	1.160	0.9
Pitch	f_5	1.150	1.160	0.9
Yaw	f_6	1.308	1.304	0.3

- good agreement
- added mass coefficients differ from those stated by [Clauss, 1988]
- c_{tube} = 0.6
- c_{bb} = 0.2

VWS – Transit 2.0 MW (Sept. 2013)

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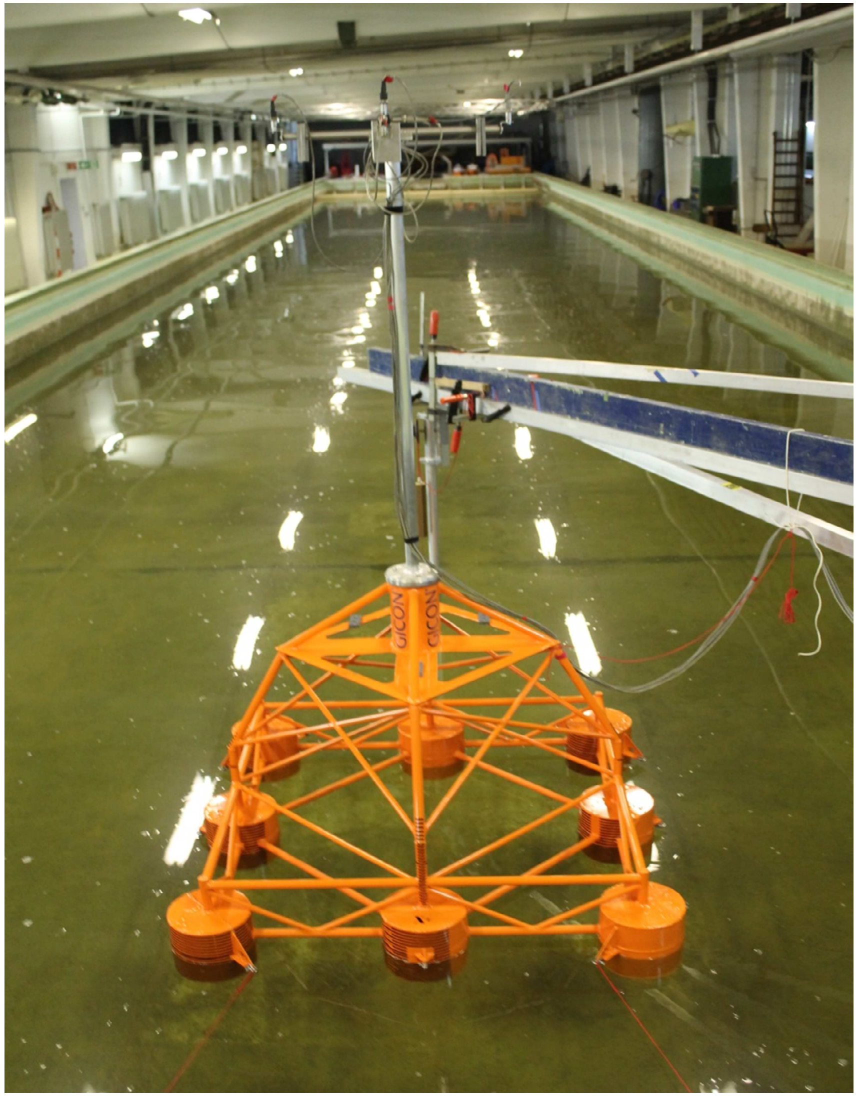
- Scaling after FROUDE
- Scaling factor $\lambda = 37$
- Incoming flow angle 0° and 45°
- Water depth 20 m
- Regular waves
- Towing velocities 3.5, 5.3 and 7.0 kn

- Testing conditions:

h_s in m	T_p in s
0.0	0.0
2.3	6.5
3.8	7.2



VWS – Transit 2.0 MW (Sept. 2013)

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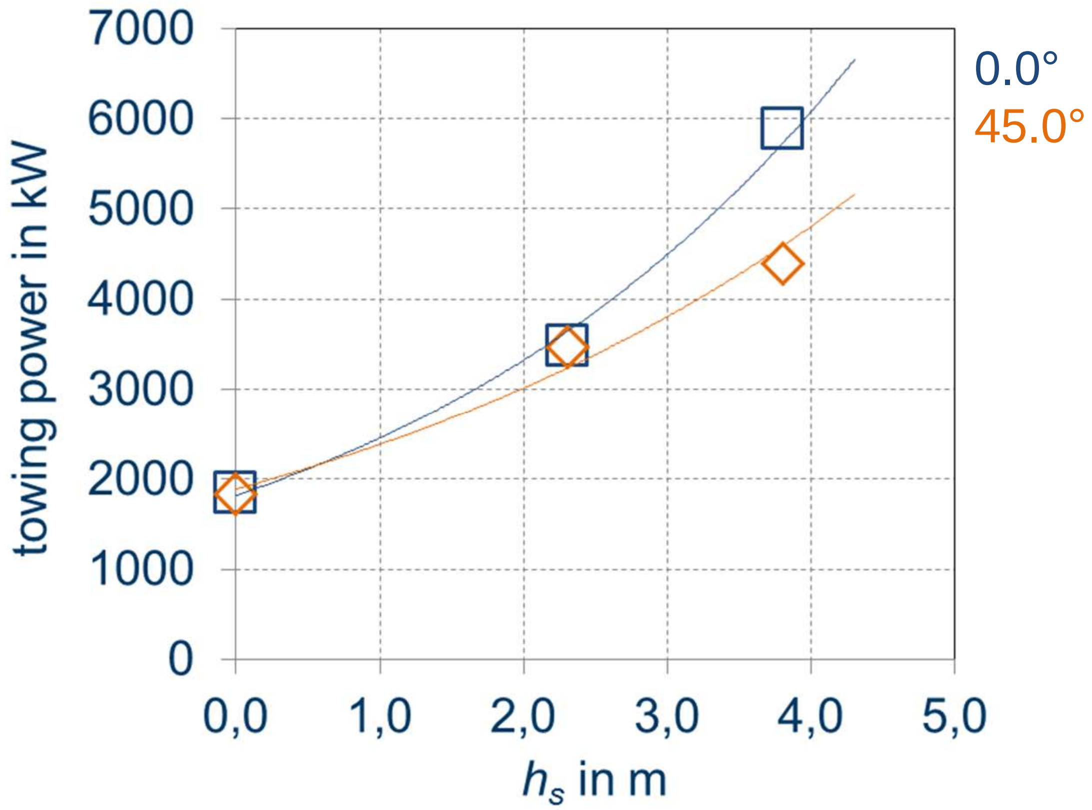
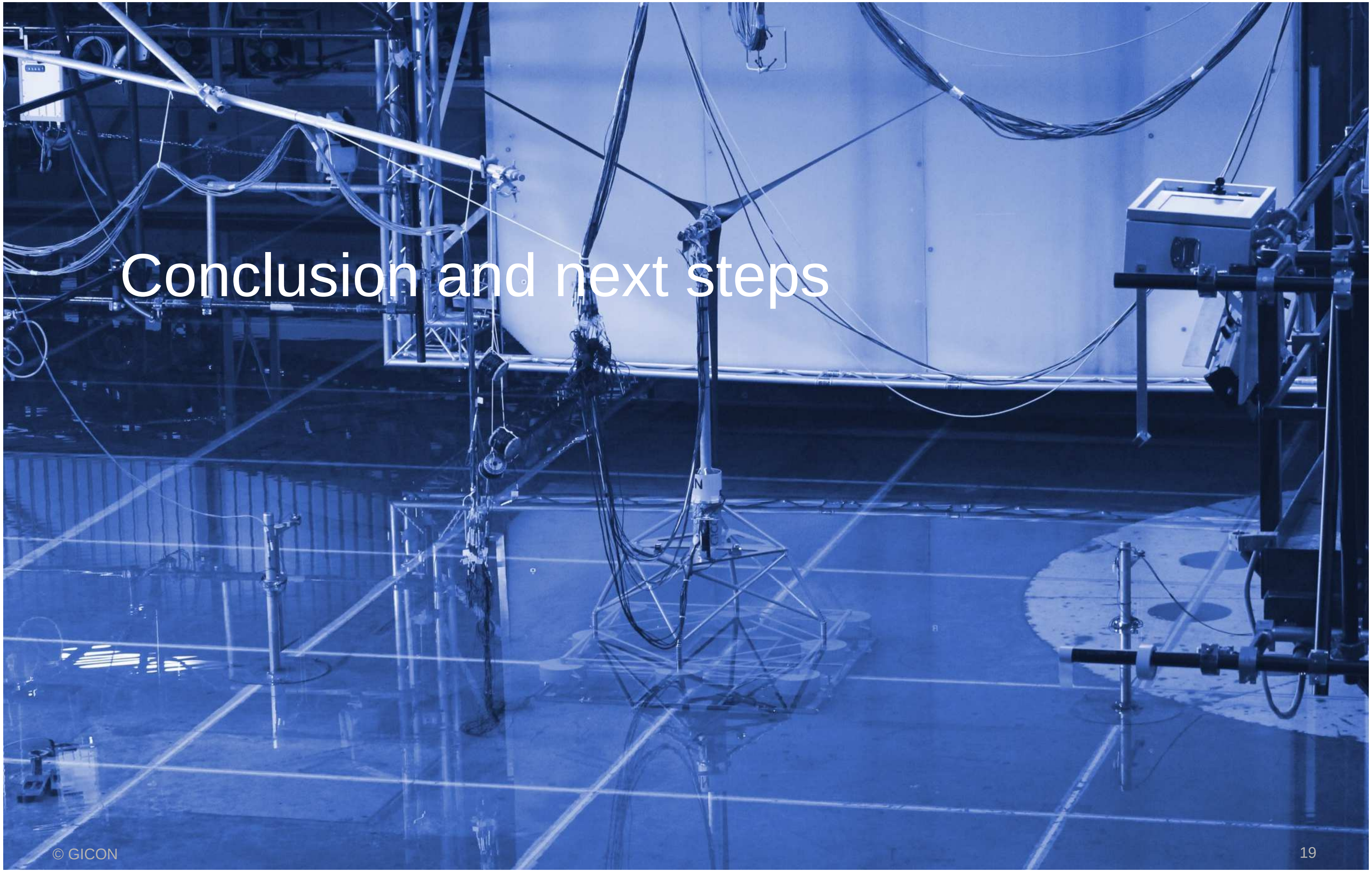
Towing power for 5.3 kn and different sea states



Conclusion and next steps



Outlook and next steps

- 2009 First concept
- 2012 First tank tests (HSVA)
- 2013 Tank tests with modified design (MARIN/VWS)
- 2013 Optimizing design for pilot plant (optional: additional tests 2014)
- 2014/15 Prototype (2.0 MW) in the German Baltic Sea
- 2015/16 Prototype (6.0 MW) in the German North Sea
- 2017/18 Serial production (6.0 MW)

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Full scale prototype for the German Baltic Sea in 2014/2015

Further literature

Adam et al.: **“Non-Linear Dynamic of a TLP for Wind Turbines – Verification of Calculated Results”**. *Proc. NWC 2013 Salzburg*.

Adam et al.: **“GICON®-TLP for wind turbines - Validation of calculated results”**. *Proc. ISOPE 2013 Anchorage*.

Adam et al.: **“Evaluation of internal force superposition on a tlp for wind turbines (accepted: 08.01.2014)”**. *Journal Paper Renewable Energy 2014*.

Adam et al.: **“Scale tests of the GICON®-TLP for wind turbines (submited: 06.01.2014)”**. *Proc. OMAE 2014 San Francisco*.

Adam et al.: **“Scale tests of the GICON®-TLP for wind turbines (submited: 20.01.2014)”**. *Proc. ISOPE 2014 Busan*.

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