ENERGY

Scaling up floating wind

Investigating the potential for platform cost reductions

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21 January 2016

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Agenda

- Introduction
- Optimisation tool
- Case studies
- Results: Costs
- Results: Optimisation
- Conclusions

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Introduction

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Cost Reduction for Offshore Wind

Our promise to the industry:

- Do things RIGHT
- Do things BETTER
- Do things DIFFERENTLY

- "DNV GL is committed to help drive the commercialisation of floating wind power technology"

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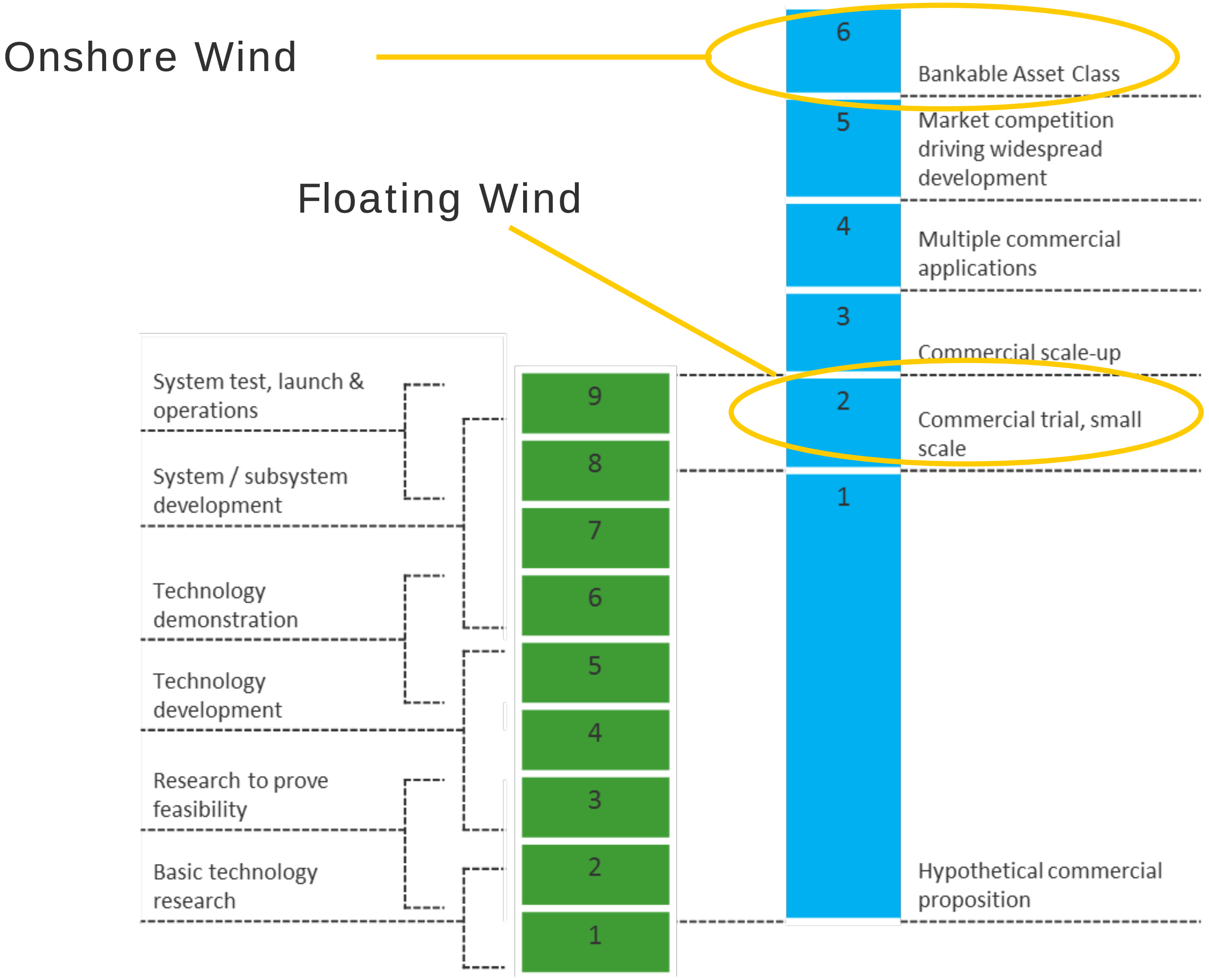
Technically ready does not mean it's commercial



Source: http://arena.gov.au/files/2014/02/Commercial-Readiness-Index.pdf

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Optimisation tool

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Motivation

- What are the cost drivers for floating wind turbines?
- How does a platform scale with larger turbines?
- What is the impact of various turbine parameters on the platform design?
  - Tower top mass
  - Maximum thrust force
  - Hub height
- How to change the geometry of the platform to obtain a cost-optimized structure?

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Semi-submersible optimisation

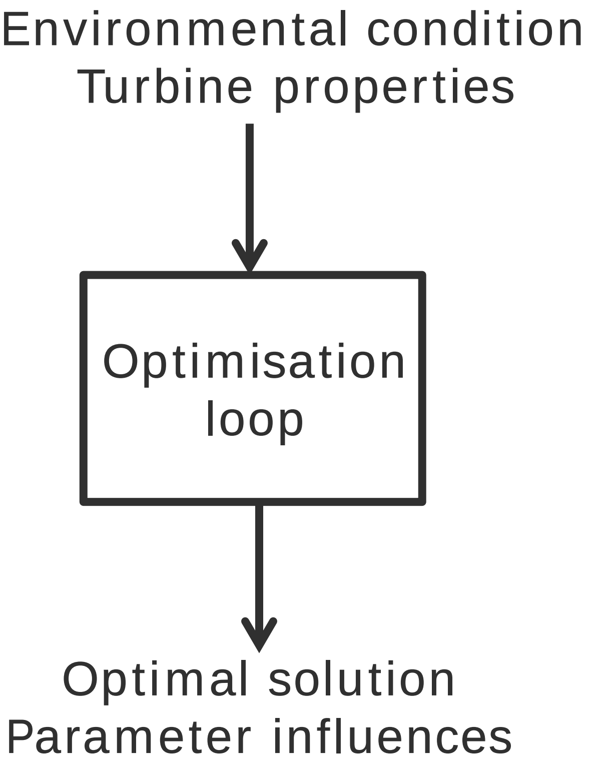
- Iterates through a large space of variables:
  - Column diameter
  - Column spacing
  - Draught
  - Heave plate size

- Constraints for the design:
  - Surge, heave and pitch periods
  - Maximum static tilt in operation
  - Maximum dynamic tilt in survival
  - Maximum tower base bending moment
  - Nacelle acceleration

- Cost rates per steel mass unit based on type of structural element

Optimisation tool

- Developed in collaboration with master student Alexander Steinert
- Optimisation with respect to unit cost
- Parameter influences
- Turbine rating influence



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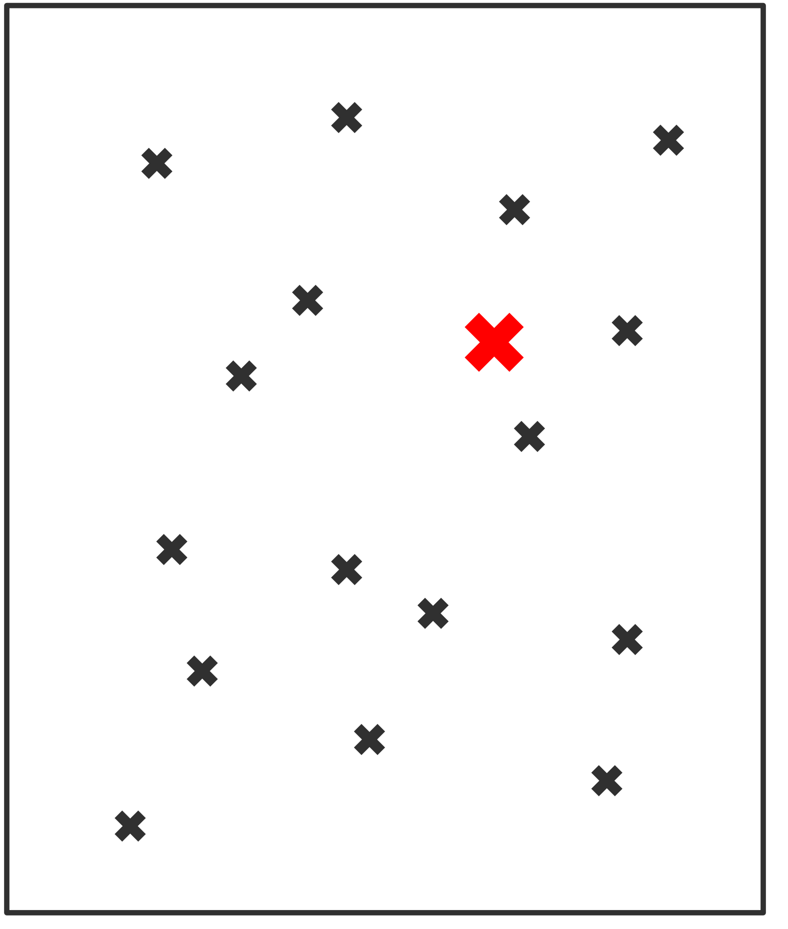
Particle Swarm Optimisation (PSO)

- Find: Optimal solution (✖)
  - Minimise cost (objective function)
  - Satisfy design criteria (constraints)

- Stochastic process

- 1 swarm particle = 1 Platform



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Current limitations

- Currently only tested for a semi-submersible type floater
- Linear or linearized theory
- Limited structural check
- No fatigue limit state

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Case studies

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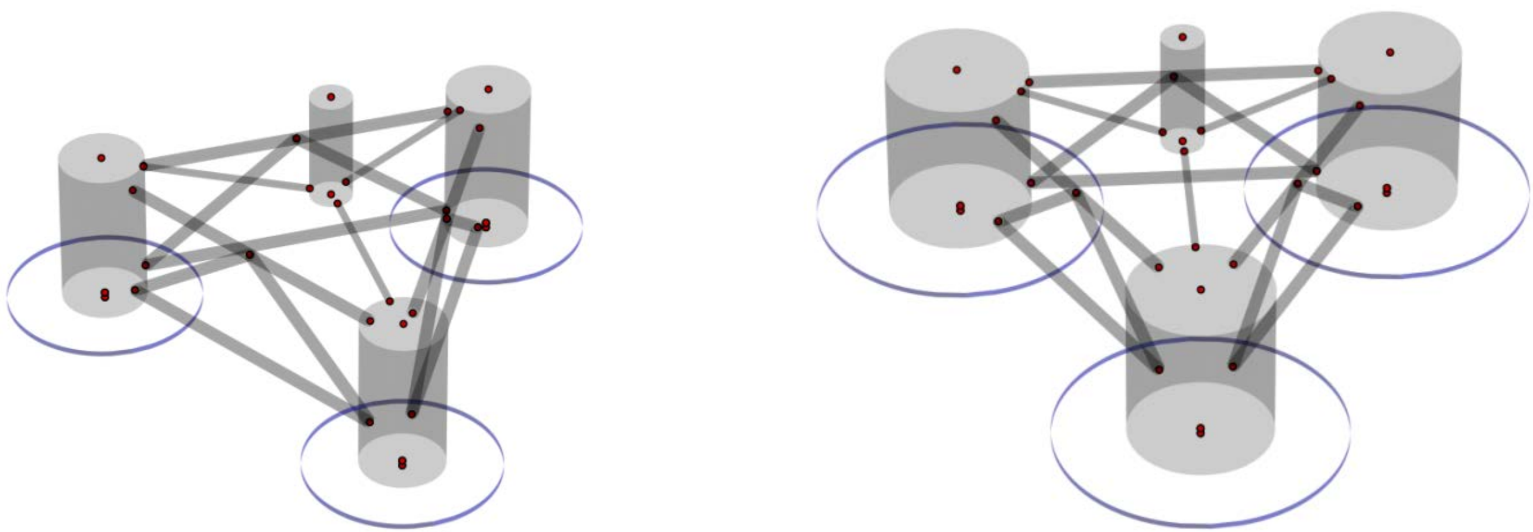
Scaling up platforms for 10 and 20 MW turbines

- Extreme wind speed: 50 m/s
- 50 year significant wave height: 18 m



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Platform optimisation for different turbines

	NREL	FORCE	DTU
Rating	5 MW	7 MW	10 MW

Environmental Condition

- 50-year event
- Location: West of Norway
  - $H_s = 10.96\,m$
  - $T_P = 11.06\,s$
  - $U_{10} = 39.49\,\frac{m}{s}$

Turbines

- Adapted for floating support structure
  - Reinforced tower base
- Scaled thrust force, based on NREL turbine using rotor swept area

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Results: Cost

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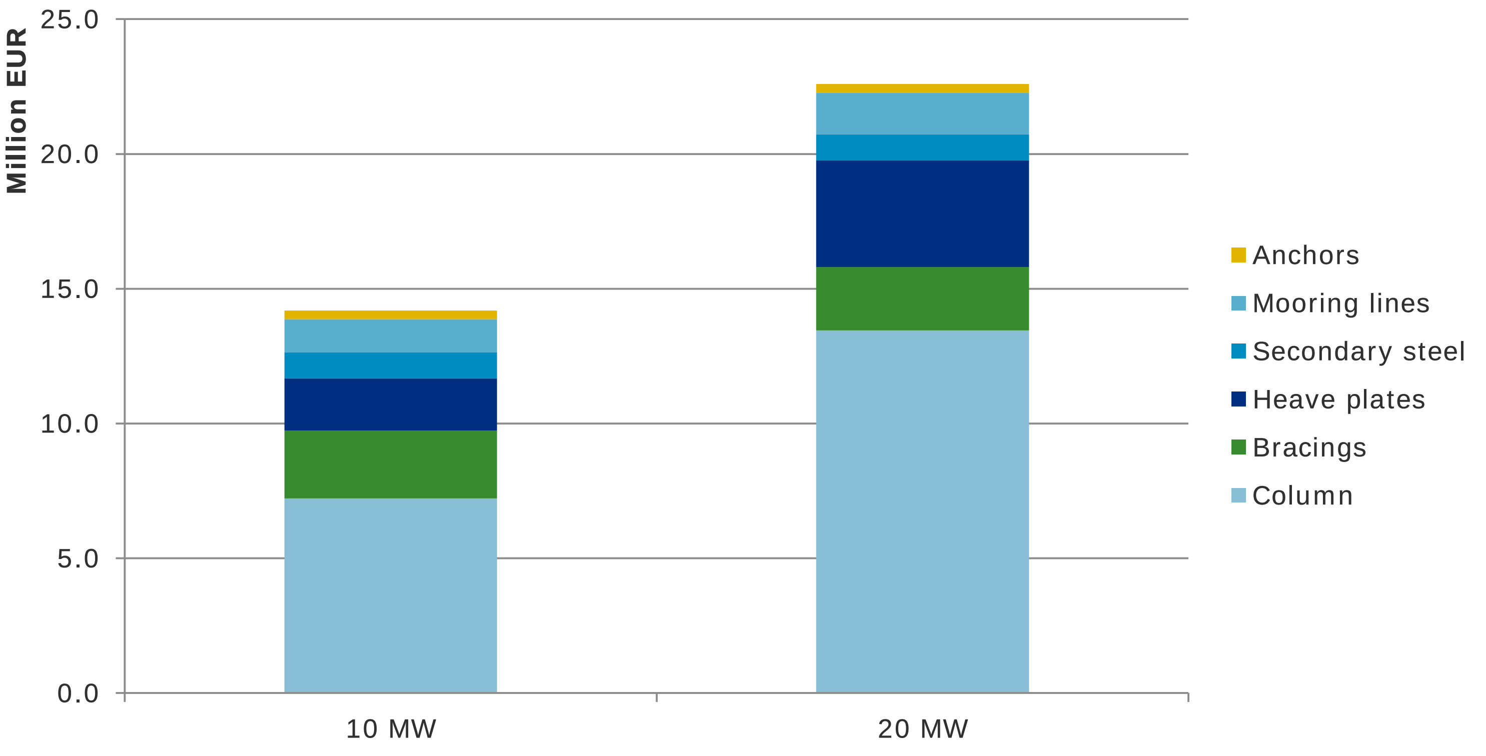
Support structure cost



- 60% increase in cost from 10 to 20 MW.

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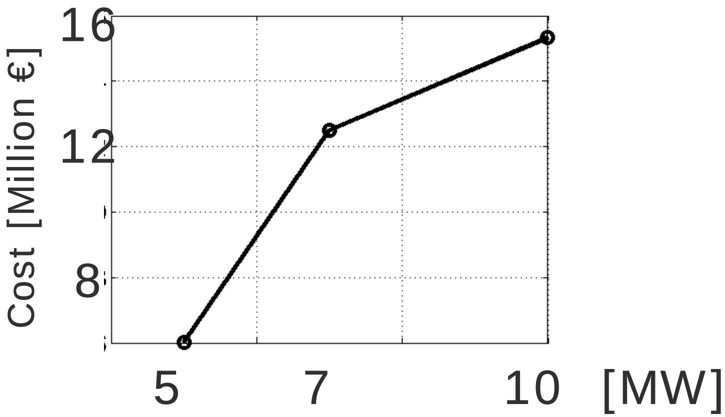
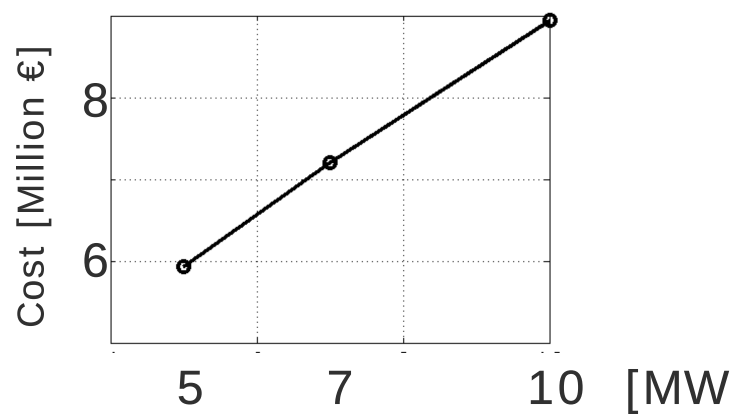
Cost development

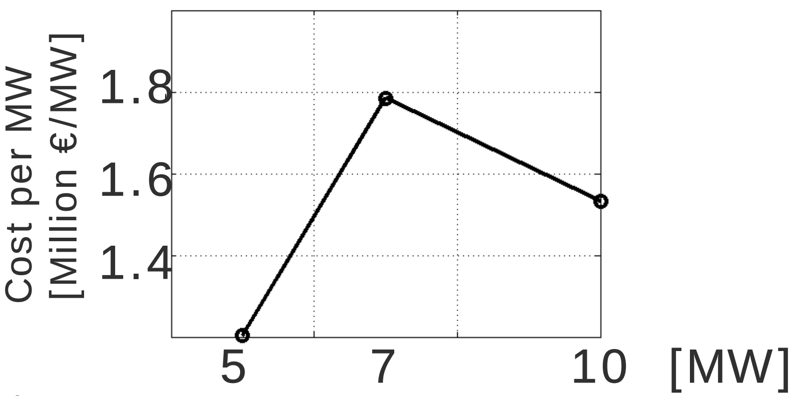
Steinert, 2015, Master thesis TUHH

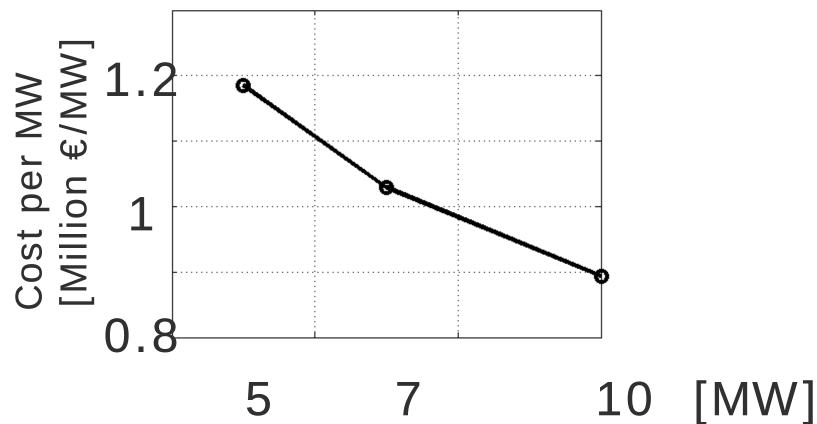
With slenderness ratio

Without slenderness ratio









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Results: Optimisation

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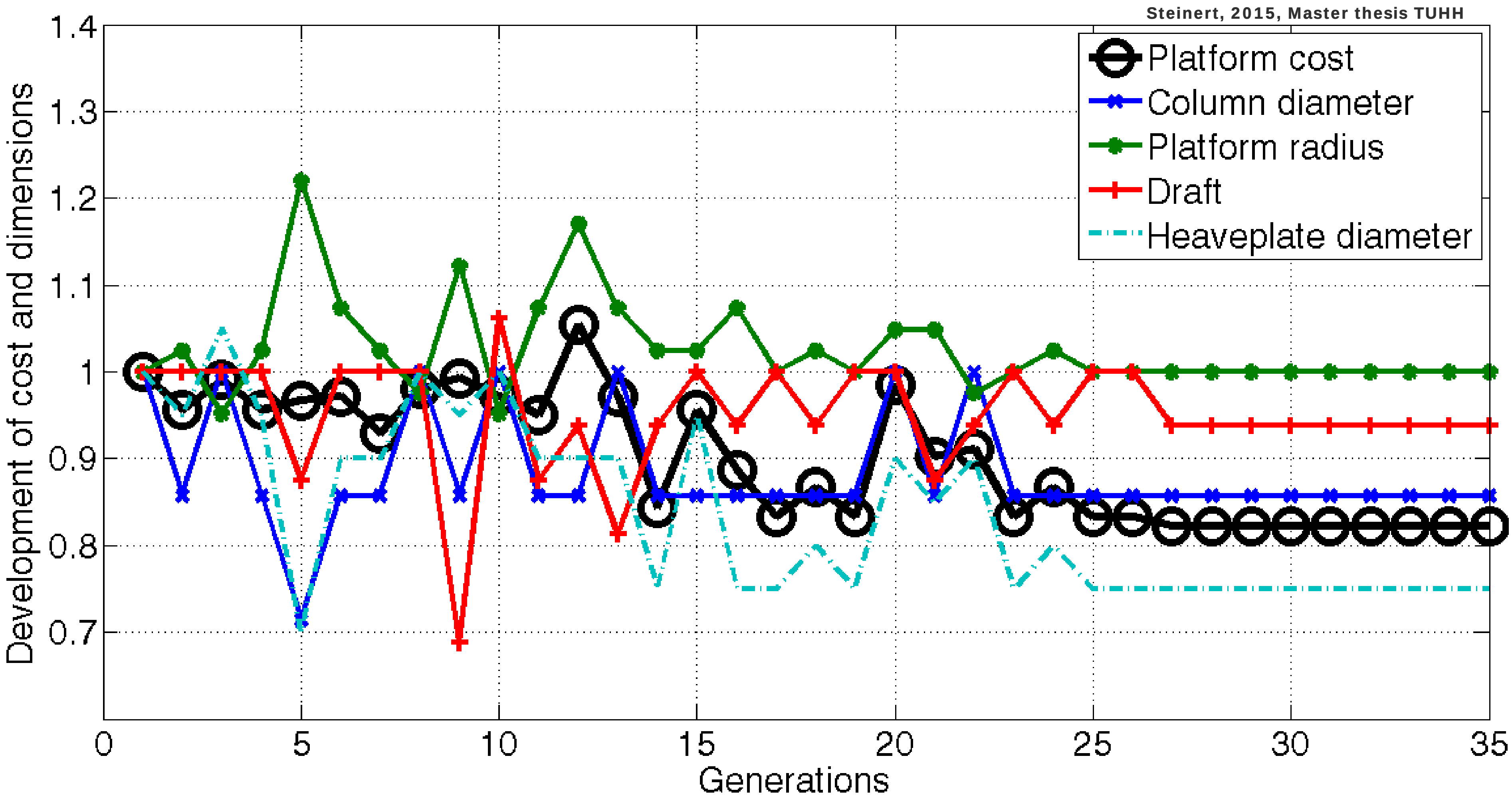
Optimisation progression



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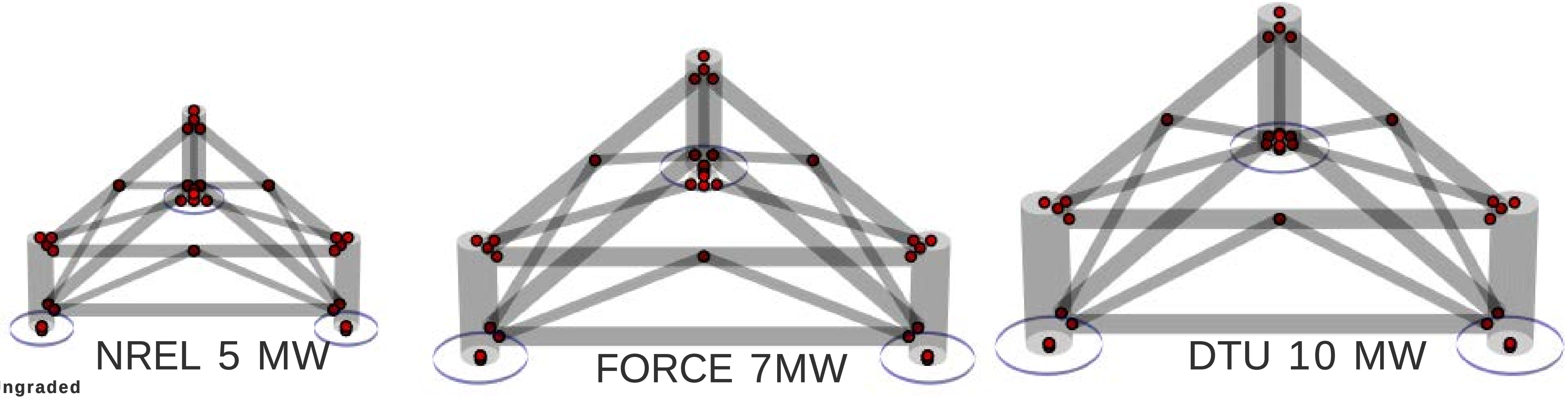
Resulting optimal solutions

Steinert, 2015, Master thesis TUHH

	NREL 5 MW	FORCE 7 MW	DTU 10 MW
Column diameter [m] (D_C)	6	9	11
Heave plate diameter [m] (D_{HP})	15	22	25
Draft [m]	15	22	29
Platform radius [m] (R)	41	60	62
D_{HP}/D_C	2.5	2.4	2.3
R/D_C	6.8	6.7	5.6



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Conclusions

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Observations

- Numerical optimisation is a useful tool for initial assessments
- Column spacing prevailing parameter
- Sensitive to structural component type prices
- Structural design should be included in the optimisation loop
- Will the cost per MW go down with increasing turbine size?

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Industrialisation of floating wind – IN-FLOAT

- Large potential for cost reduction through industrialisation
- Large potential for learning from onshore wind towers
- Large opportunities with bolted connections, casted nodes, and lightweight modules
- Expanded supply chain – increased competition

Open source concept. Improve it!

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