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The right size matters
Investigating the offshore wind turbine market equilibrium

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Objective

Although early experiences indicate that the maturity of deployed technology might not be sufficient for operating wind farms in large scale far away from shore, the rapid development of offshore wind energy is in full progress. Driven by the demand of customers and the pressure to keep pace with competitors, offshore wind turbine generator (OWTG) manufacturers **continuously develop larger wind turbines instead of improving the present ones** which would ensure reliability in harsh offshore environment. Pursuing the logic of larger turbines generating higher energy yield and therefore achieving higher efficiency, this trend is also supported by governmental subsidies under the expectation to bring down the cost of electricity from offshore wind. The objective of this paper is to demonstrate that **upscaling offshore wind turbines beyond the size of 10 MW (megawatt) is not reasonable** from a market point of view.

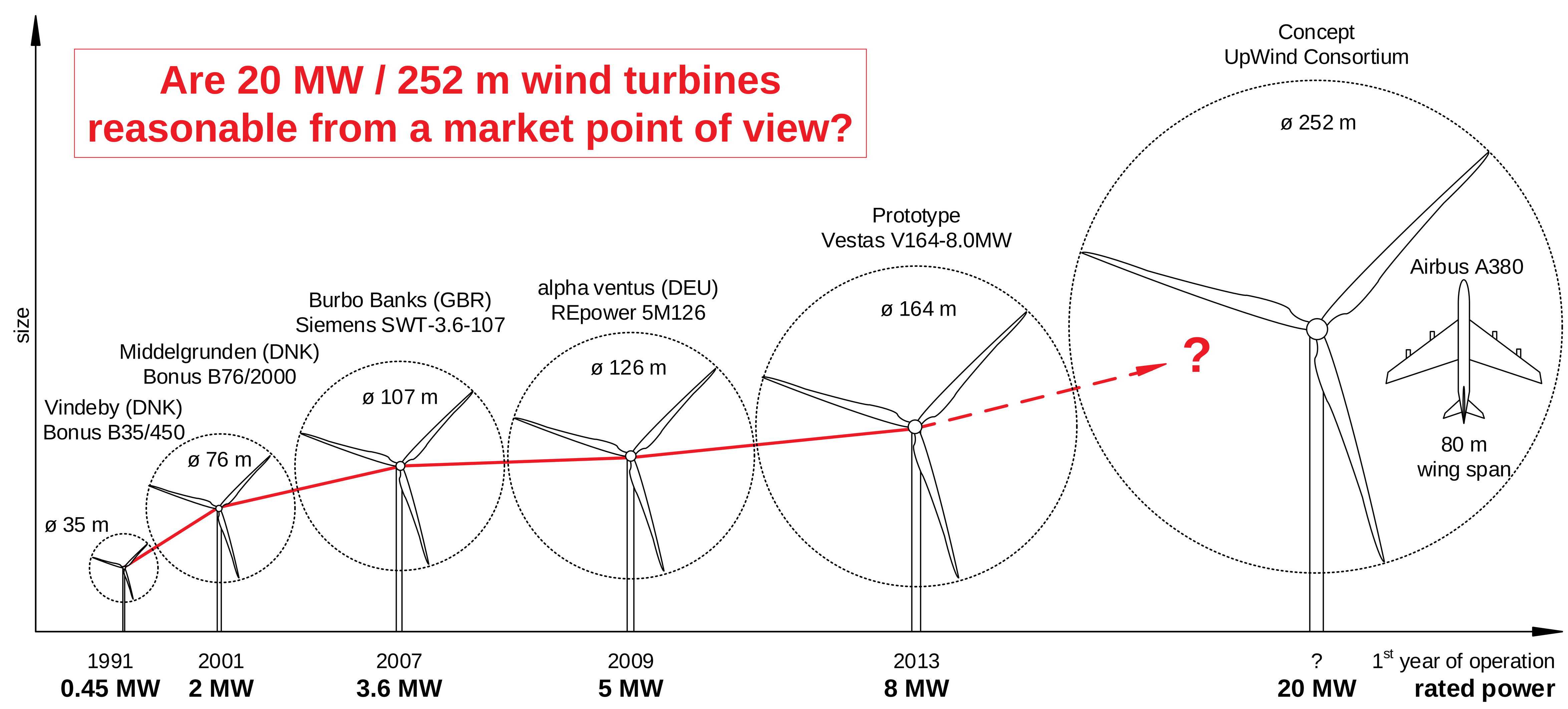


Figure 1: Evolution of offshore wind turbines. (cf. UpWind Consortium. UpWind – Design limits and solutions for very large wind turbines. 2011.)

Methodology

Offshore wind farm (OWF) project developers, who determine the demand for OWTGs, are faced with contrary economic and technical relations when planning a plant and selecting a wind turbine. Hence the idea was to apply the **planning methodology of an OWF project developer** to a **case study wind farm in the German North Sea**. Assuming that the only decision criteria for selecting a wind turbine of a specific size is the **profitability (Internal rate of return (IRR))** of the plant over its whole life cycle reveals a market equilibrium, where OWF developers do not have an incentive to purchase larger wind turbines as this would not increase profitability. In addition to this analysis investigating the demand side, also the optimal size of OWTGs from the view of energy policy planners was analysed assuming that their objective is to exploit sea areas as efficiently as possible. Thus also the **levelized cost of electricity (LCOE)** for different OWTG sizes was assessed.

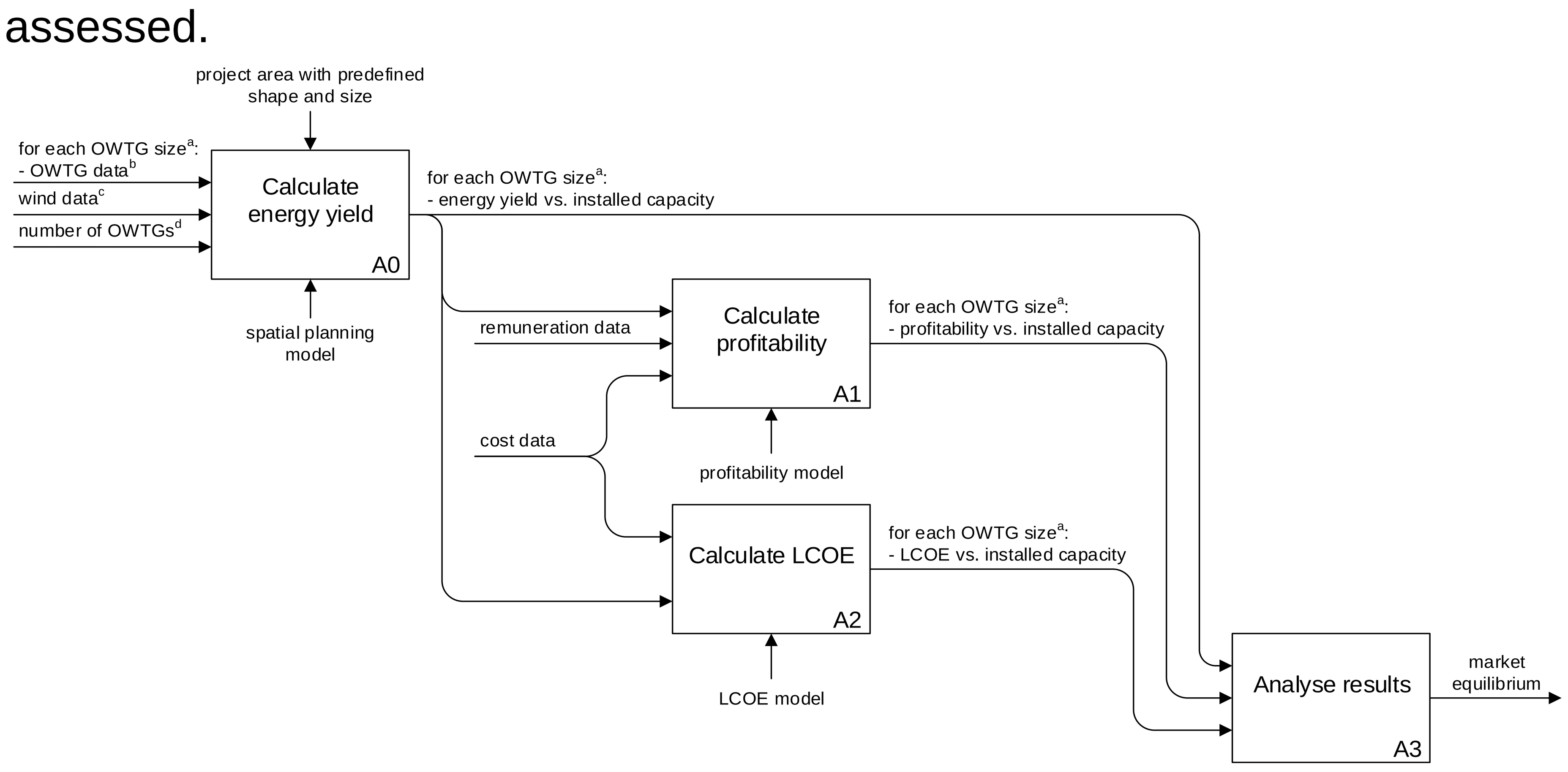
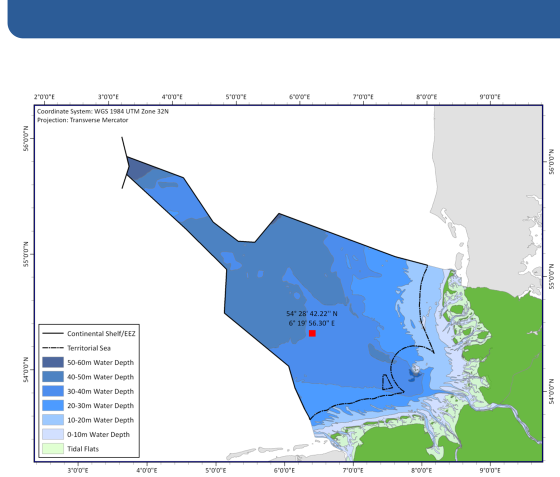
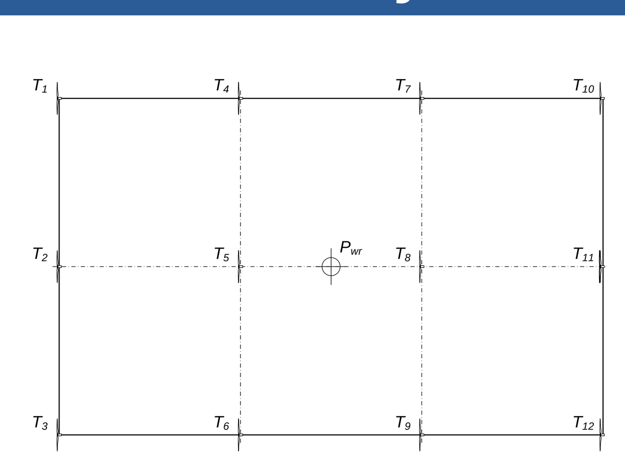
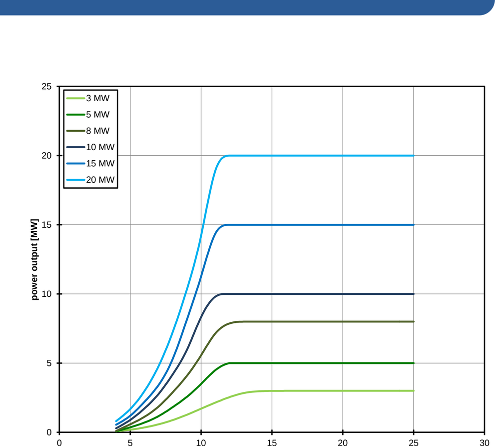


Figure 2: Methodology. [a]OWTG sizes under investigation: 3 MW, 5 MW, 8 MW, 10 MW, 15 MW and 20 MW. [b]OWTG data: power curve, thrust curve, rated power, rotor diameter and hub height. [c]wind data: weibull distribution and probability for each direction sector. [d]number of turbines: varying between 300 – 600 MW installed capacity

Case Study







Reference

Nikolaus Ederer, The right size matters: Investigating the offshore wind turbine market equilibrium, *Energy*, Volume 68, 15 April 2014, Pages 910-921, ISSN 0360-5442, http://dx.doi.org/10.1016/j.energy.2014.02.060.

Results & Conclusions

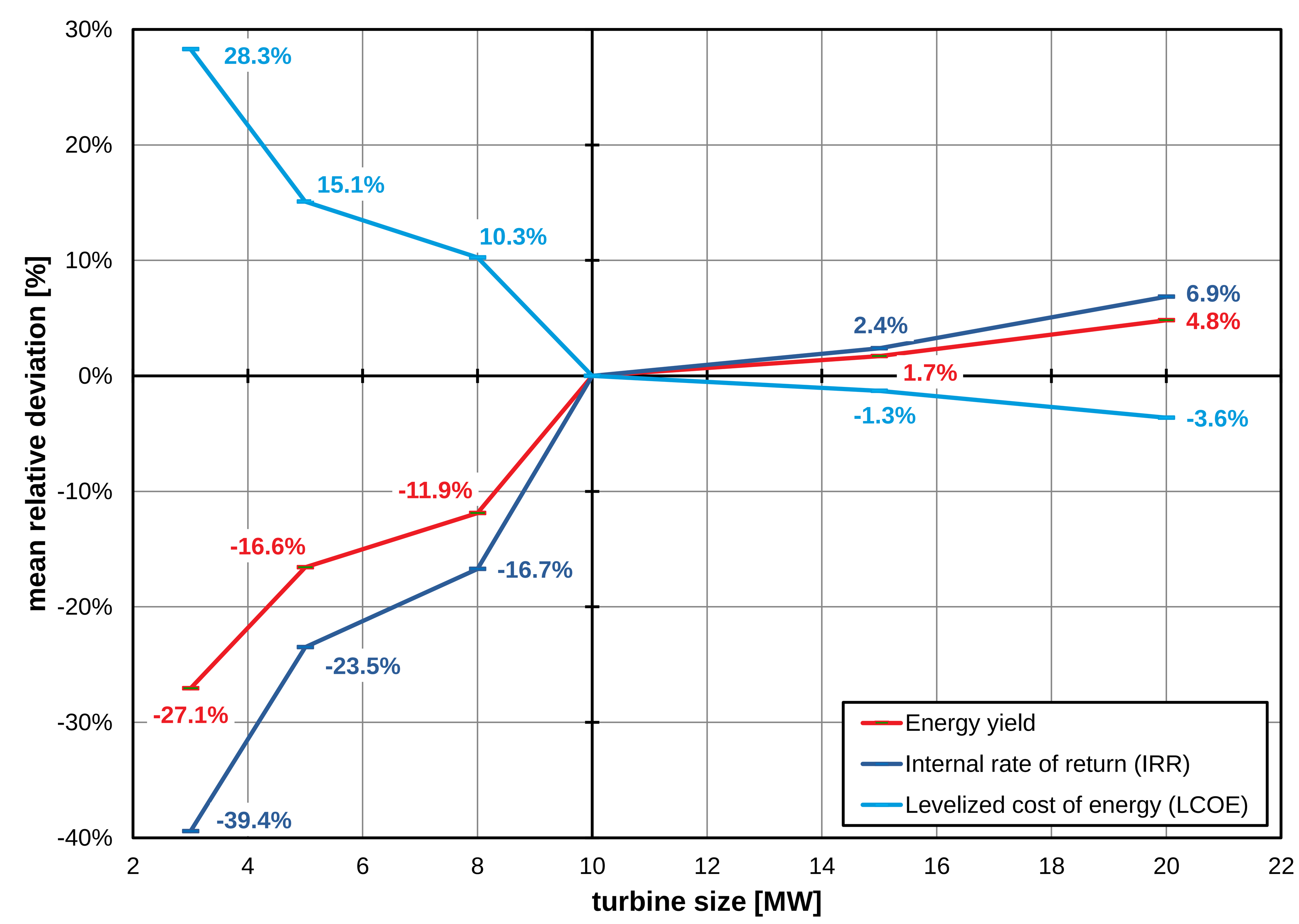


Figure 3: Mean relative deviations of energy yield / IRR / LCOE subject to OWTG size using 10 MW as a benchmark.

The results indicate a **market equilibrium for 10 MW OWTGs** and a comprehensive sensitivity analysis verified the robustness of this statement. This is highly interesting for stakeholders in the offshore wind industry and allows individual conclusions:

- **OWTG manufacturers and the supplying industry:** the strategic focus on the 10 MW size might promise a sustainable competitiveness
- **Energy policy:** support of research projects that aim for improving the 10 MW range instead of the development of OWTGs that do not gain a significant yield and efficiency increase
- **Spatial planning:** specific installed capacity (MW/km^2) is independent of turbine size and specific energy yield (MWh/km^2) is flattening with increasing turbine size

OWTG size	Maximum number of turbines[a]	Maximum installed capacity[a]	Average installed capacity per unit area	Average annual energy yield per unit area
MW	-	MW	MW/km²	MWh/km²
3	182	546	13.7	46.9
5	90	450	11.3	45.0
8	64	512	12.8	53.5
10	49	490	12.3	58.4
15	36	540	13.5	65.0
20	25	500	12.5	62.3

[a]within 40 km^2 assuming minimum horizontal distance of seven and vertical four rotor diameters

Table 1: Average installed capacity and energy yield per unit area.