DTU Wind Energy
Department of Wind Energy

Design optimization of jacket structures for mass production

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Abstract

The aim of this PhD project is to reduce levelized cost of energy from offshore wind by designing jackets (Fig.2) that have a lower life time cost. This will be achieved by developing

- State of the art structural optimization tools.
- Cost models that include installation and manufacturing constraints.
- Learning curves that motivates repeated structures and/or modules.

The PhD is part of the research project ABYSS.

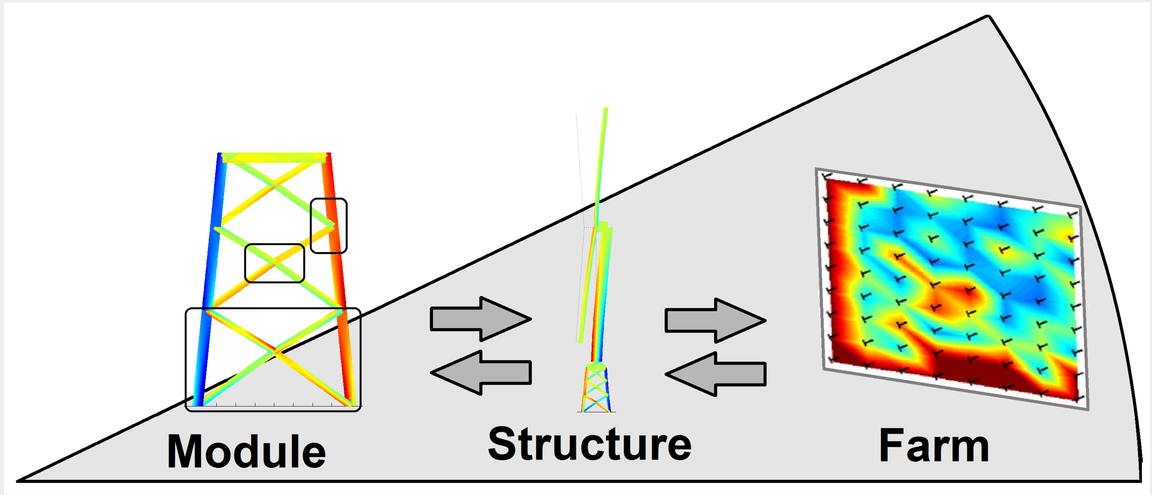

Figure 1: There are many possibilities for mass production if the design optimization takes both the smaller and bigger picture into consideration.

Methodology

Truss topology optimization is used to develop conceptual jacket designs. The inner problem

$$\begin{aligned} \underset{a\in\boldsymbol{R}^n, u\in\boldsymbol{R}^d}{\text{minimize}} \quad & l^T a && (mass)\\ \text{subject to} \quad & Ku - P = 0 && (equilibrium)\\ & \underline{a} \preccurlyeq a \preccurlyeq \overline{a} && (cross\ section\ area)\\ & \underline{u} \preccurlyeq u \preccurlyeq \overline{u} && (displacements) \end{aligned}$$

is solved with Matlab's fmincon. The outer problem determines bottom and top leg distance and is solved with patternsearch.

Results

A four-legged jacket has been subjected to realistic loads (DTU 10MW RWT), and optimized for minimum mass with constraints on the displacements. Variables have been:

- Number of sections (X-joints)
- Bottom and top leg distance
- Cross sectional areas

Results of the minimum jacket mass vs jacket height and number of sections is given in Fig. 3

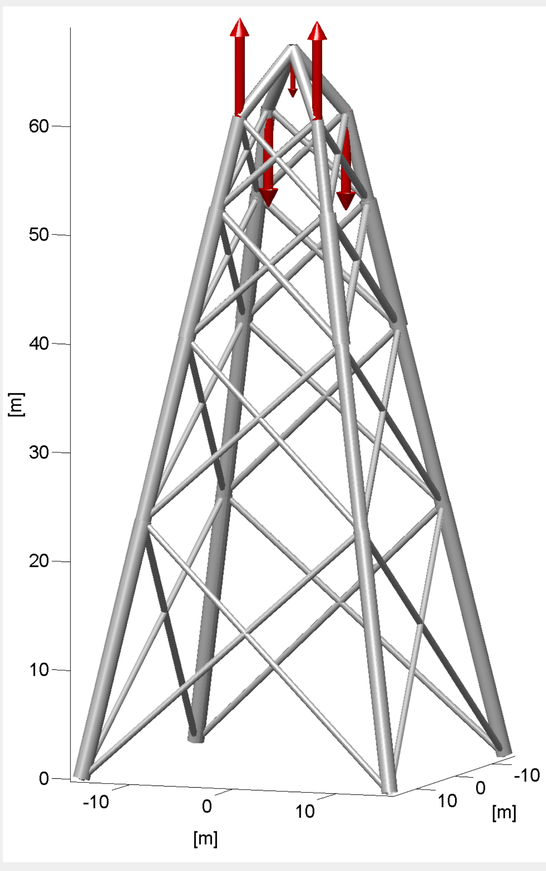

Figure 2: Jacket support structure. The loads on the top are taken from the extreme loads of a 10 MW offshore wind turbine. The two vertical force pairs describes the moment generated by the thrust force at hub height, and the weight and horizontal force from the tower is applied at the top of the structure. Self-weight is neglected.

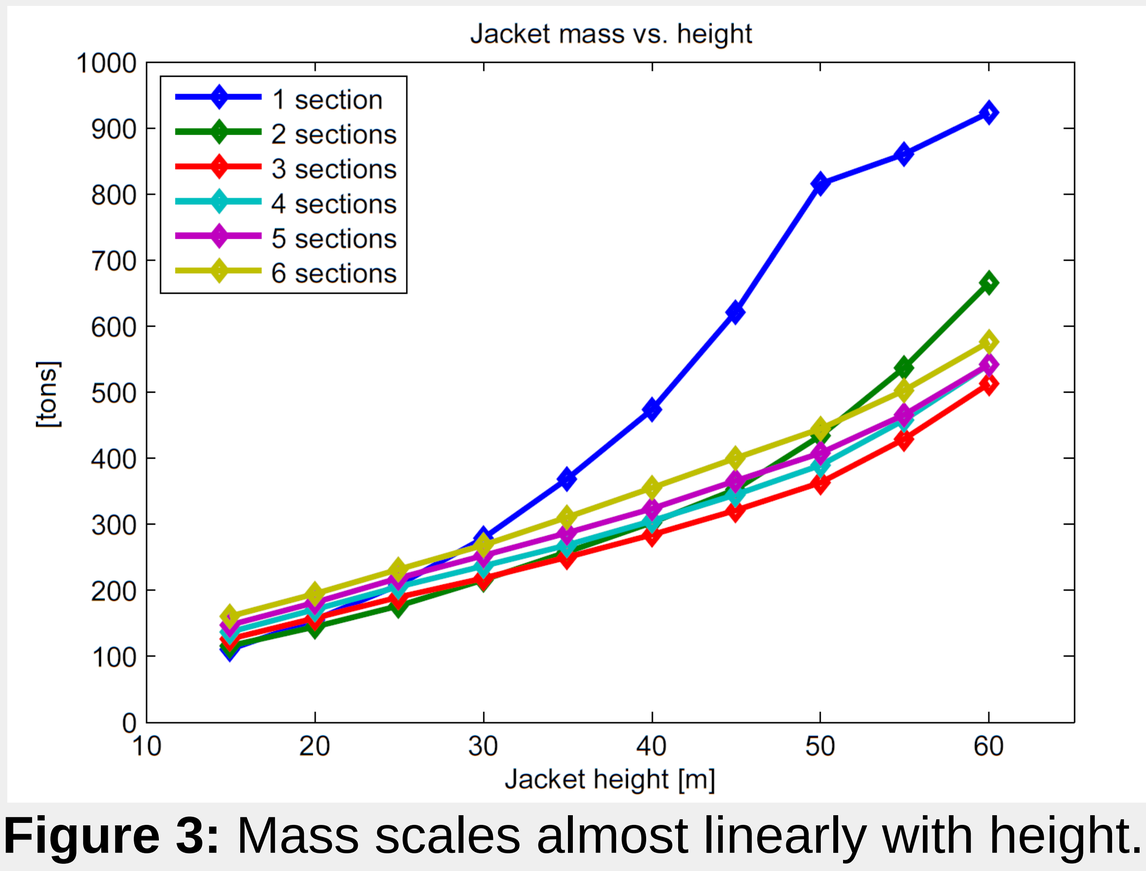

Figure 3: Mass scales almost linearly with height.

Future work

The current optimization tool will be improved with stress and buckling constraints. However, one can only come so far with trusses, and therefore future research will be with beam elements.