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Enhanced site-assessments to support building permits in Germany

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Abstract

In Germany formal building regulations often request site-specific assessments of all Wind Turbine Generators (WTGs) including new and existing ones. When using the current technical methods and guidelines for site-assessments (1), the assessment cannot be completed for all WTGs, if the wind farm consists of different WTG types (produced by different manufacturers). In many cases the wake-induced effective turbulence is exceeding the design parameter of the existing, down-stream WTG (e.g. IEC A). In such a case, a detailed load analysis is required for the final capacity check, which is usually carried out by the manufacturer of the WTG. If such an analysis is not available, the operator of the new, up-stream WTG can – alternatively – curtail the power output and reduce the turbulence emissions on the down-stream WTG. By doing so, he complies with the regulations and can obtain a building permits for the new WTGs (see Figure 2).

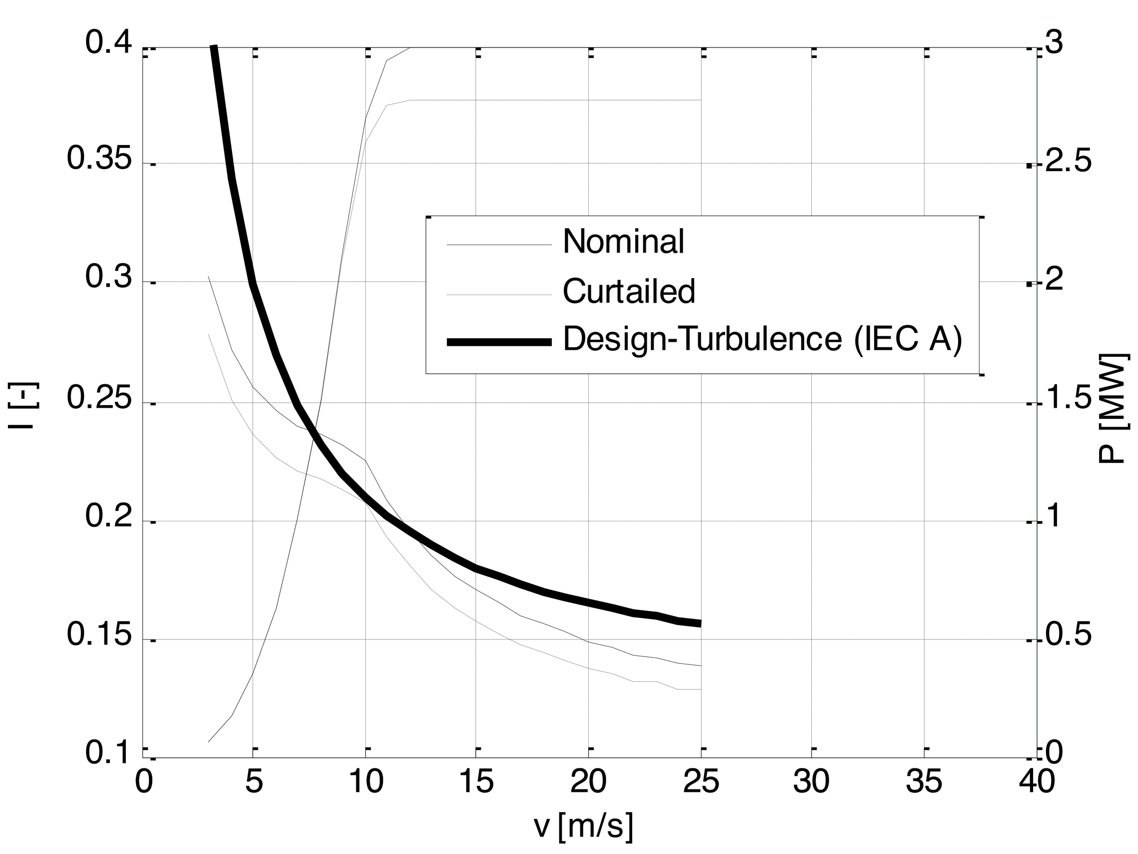

Figure 1: Comparison of site-specific turbulence with design turbulence; normal and curtailed operation

In the present project a technical method is described which extends the existing methodology for site-specific assessments according to DIBt 2012 (1). The technical method describes a simplified load estimation model, which would enable independent engineers – not only the manufacturer of the WTG – to carry out capacity checks. As a result, power curtailments can be avoided.

Objectives

The scope of this research project was to solve two important problems in the German wind market:

- Simplification of site-specific load assessments for building permits
- Prevention of power curtailments and AEP losses in wind parks with different WTGs (e.g. park extension)

In order to achieve this, a simplified load estimation model for WTGs had to be developed and established in the German wind market. In order to introduce this model the following objectives needed to be fulfilled:

- Model can be used by independent engineers during the site-assessment according to DIBt 2012
- Model shall estimate fatigue loads – not extreme loads
- Limited information of WTG needed to use model during the site-assessment (e.g. information given in type approval).
- Short computational time
- Conservative results compared to detailed load simulation

Methods

The simplified load estimation model (EqLR-Model, Equivalent Load Ratio) is based on the assumption that there is a linear relation between turbulence *σ(v)* and fatigue loading *STEL(v)* at a given wind speed.

$$STEL(v) = c \cdot \sigma(v)$$

The same assumption is already being used for calculating the effective turbulence within a wind farm according to (1) (3) (4). Here, the effective turbulence $I_{eff}(v)$ is computed by integrating the turbulence over all sectors at a given wind speed *v*. The turbulence *σ(v)* is weighted with the Wöhler slope *m* of the considered component. For the EqLR-Model, the effective turbulence is integrated over all wind speeds. Again, the turbulence is weighted with the Wöhler slope *m*, which results in a pseudo-equivalent fatigue load PEL_{tot}.

$$PEL_{tot} = \sqrt[m]{\sum_{v=v_{in}}^{v_{out}} \sigma(v)^m \cdot p(v)}$$

The EqLR is computed by taking the ratio between site-specific and design loading.

$$EqLR = \frac{PEL_{tot,ss}}{PEL_{tot,Design}} \cdot 100\%$$

A value below 100% indicates that the site-specific conditions do not cause an increase in fatigue loading. The structural integrity of the considered component is given. If the EqLR exceeds a value of 100% further assessments need to be carried out. The check needs to be carried out for all components / Wöhler slopes individually.

Results

The EqLR-Model was verified by means of load simulations with aero-elastic simulation models. The study was supported by several manufacturers (Enercon, Siemens, Nordex, Senvion, Vestas). The EqLR-Model shows very good results when comparing the aero-elastic simulations. *STEL* scales very well with load components which are driven by turbulences.

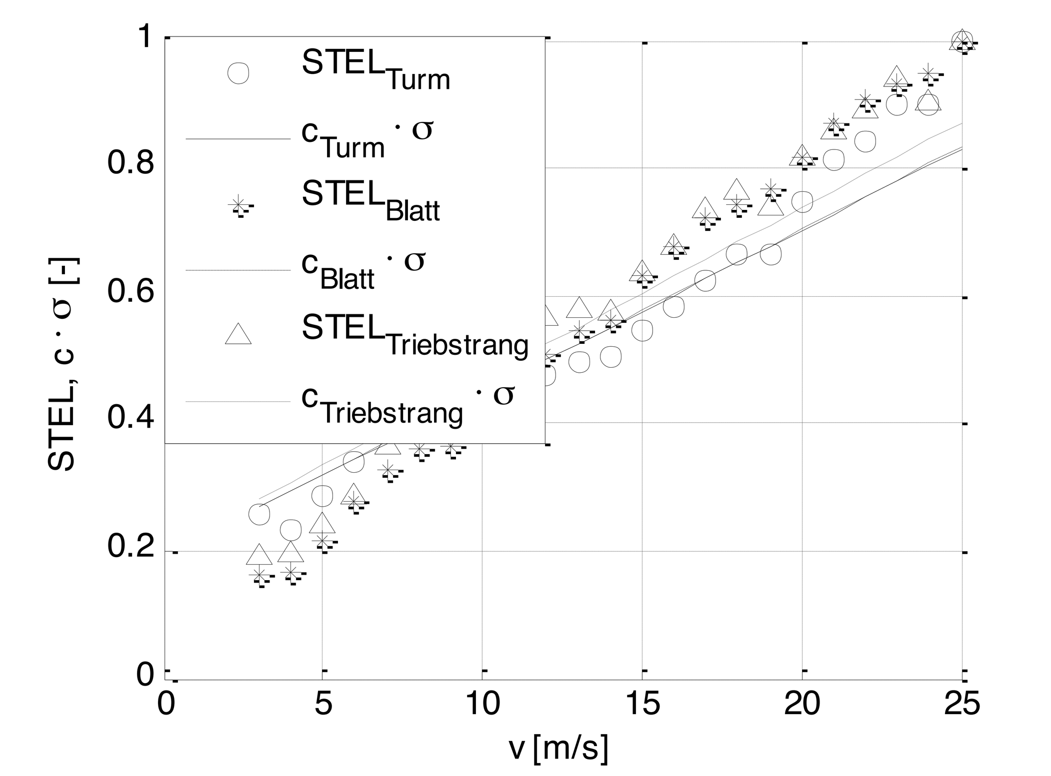

Figure 2: Comparison of turbulence and fatigue loading of several components (2)

During the parameter study a model error in the range between -10 % and 10 % was found.

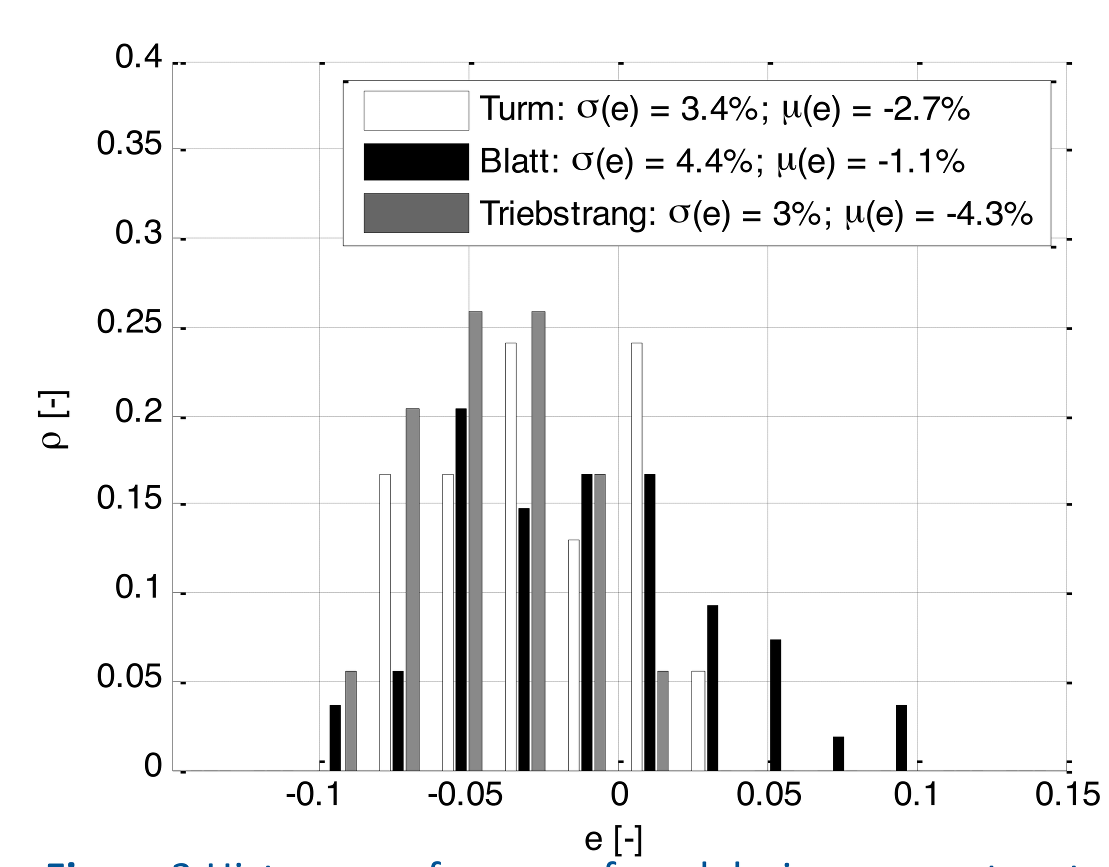

Figure 3:Histogram of error as found during parameter study (2)

Conclusions

By using the EqLR-Model it is possible to verify the fatigue loading and structural integrity of a WTG without running detailled load simulations. The model could potentially ease site-specific assessments when WTGs of different manufacturers need to be considered. AEP losses can be avoided. Building permits can be accelerated.

References

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