WIND TUNNEL EXPERIMENTAL VARIABILITY OF AERODYNAMIC LOADS FOR WIND TURBINE BLADES

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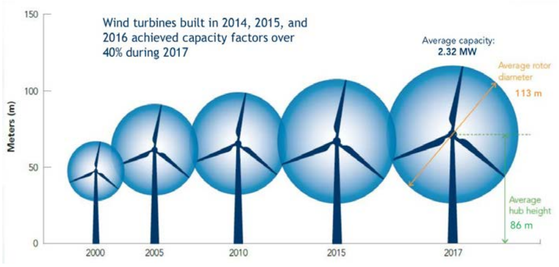
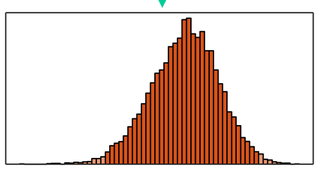
1. Introduction



Evolution of wind turbine technology
(Source: *AWEA U.S. Wind Industry Annual Market Report Year Ending 2017*)

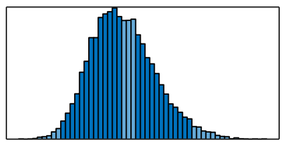
Longer and more flexible blades

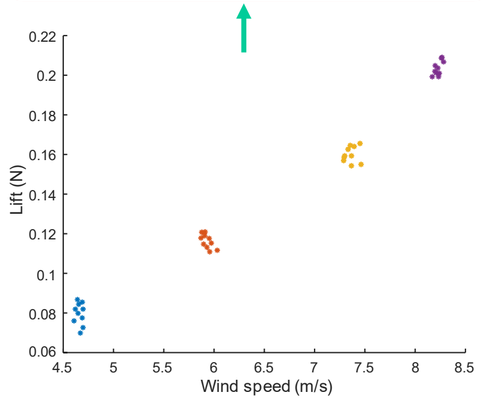
Onset of Flutter: aeroelastic coupling of flapwise and torsional modes



Distribution of flutter speed is predicted by including various **uncertainty** sources **(aerodynamic loads,** structural properties, etc.**)**

Objective: Quantify uncertainty of input aerodynamic loads by wind tunnel tests





Aerodynamic loads are determined through wind tunnel tests accounting for **experimental variability** (example: lift measured in NEU's wind tunnel)

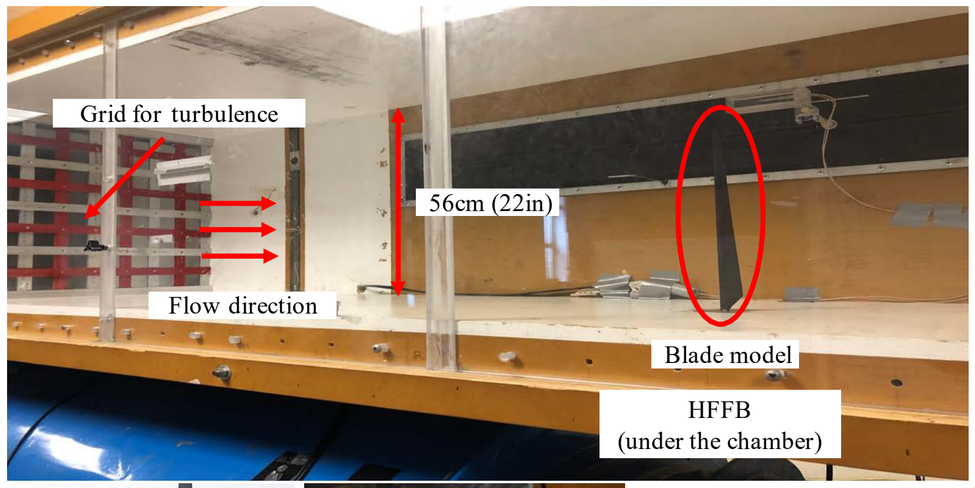
2. Experimental details

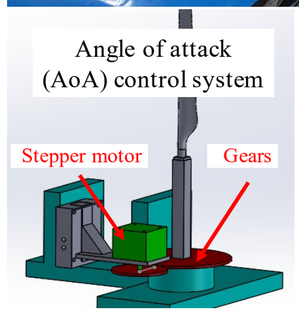
Blade specifications

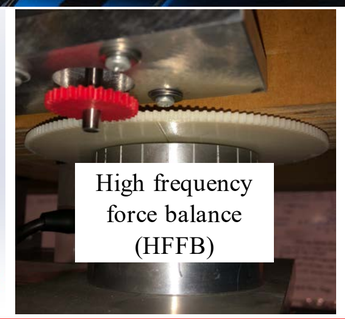
- Reference blade: **NREL 5MW**
- Geometric scale = **1:200**
- Length (radius) = **330 *mm***

Test procedure

- Angle of attack = $-15^{\circ} \sim 15^{\circ}$
- Wind speed = **10 *m/s***
- Duration of each test = **20 seconds**
- Number of tests in each case = **30**
- Turbulence intensity = **14.0%**







(Top)
NEU's small-scale wind tunnel

(Left)
(a) Schematic of angle-of-attack control system
(b) HFFB under the chamber

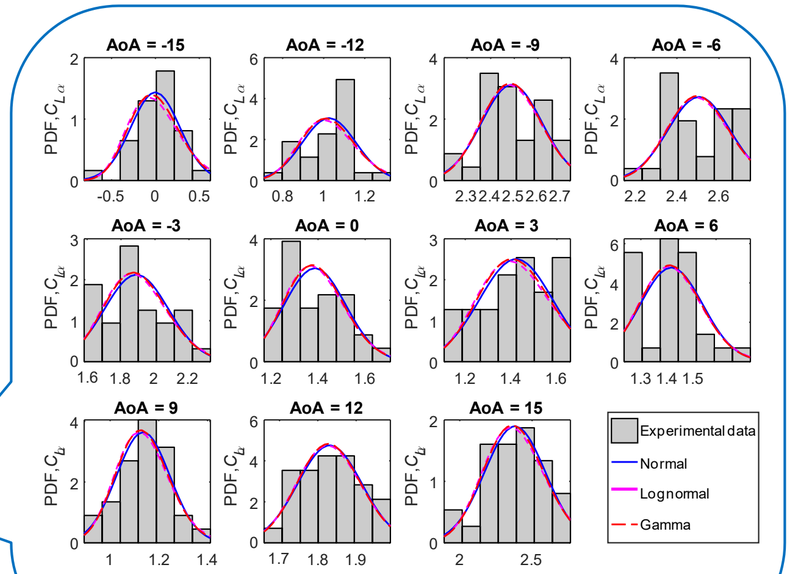
3. Variability analysis

Experimental datasets

1. Statistical analysis
   - Moments
   - Intervals
2. Fitting empirical histogram
   - Parametric distribution models
   - Hypothesis testing

Variability of the loads (lift coefficient $C_{()}$ & lift coefficient derivative $C_{()}$)

1. Synthetic generation of a larger sample of input
2. Predicting the distribution of flutter speed



(Example) Empirical histogram of $C_{()}$, compared with fitting distribution models

Flow chart of variability analysis in wind tunnel experimental datasets

4. Conclusions and future work

- 3D blade model (NREL 5MW with scale of 1:200) was tested in NEU's small-scale wind tunnel under different cases.
- A framework of variability analysis in wind tunnel experimental datasets was proposed.
  - Various blade models will be tested to provide satisfactory datasets.
  - Larger sample size of test results will be considered to support the variability analysis.
  - Influence of turbulence effects on uncertainty will be examined.

5. References

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