Simulating the response of a small horizontal-axis wind turbine during wind gust

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Introduction

Small wind turbines (SWT) are often installed in urban environments and are subject to highly turbulent wind flows. Wind gust events are more common in urban environments than assumed by the International Electrotechnical Commission (IEC) standard, IEC 61400.2-2013 [1, 2]. Here we compared the predicted energy captured by a small wind turbine subject to measured wind gust events and the gust event assumed in the IEC standard.

Objectives

- Analysing detail wind measurements from a site in an urban environment to identify wind gust events.
- Predicting the energy extraction from measured and IEC assumed gusts using a FAST model of a 5 kW HAWT.

Experimental details

Figure 1. Measuring urban wind resources. Location and overview of the 5 kW Aerogeneis wind turbine

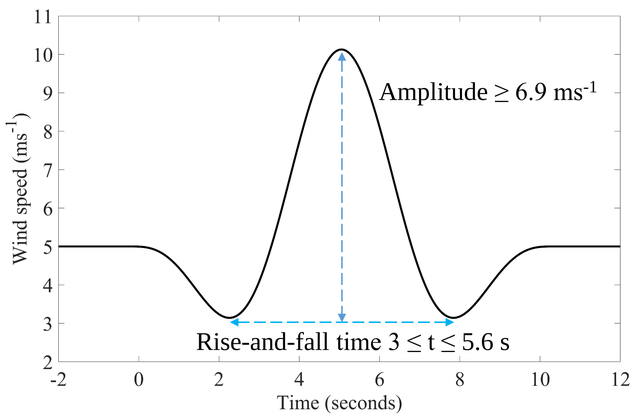


Figure 2. Identifying extreme operating gust (EOG) events

FAST simulation

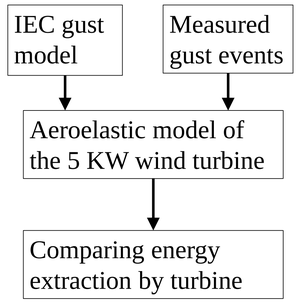


Figure 3. Simulating the response of the 5kW HAWT during wind gust

Results

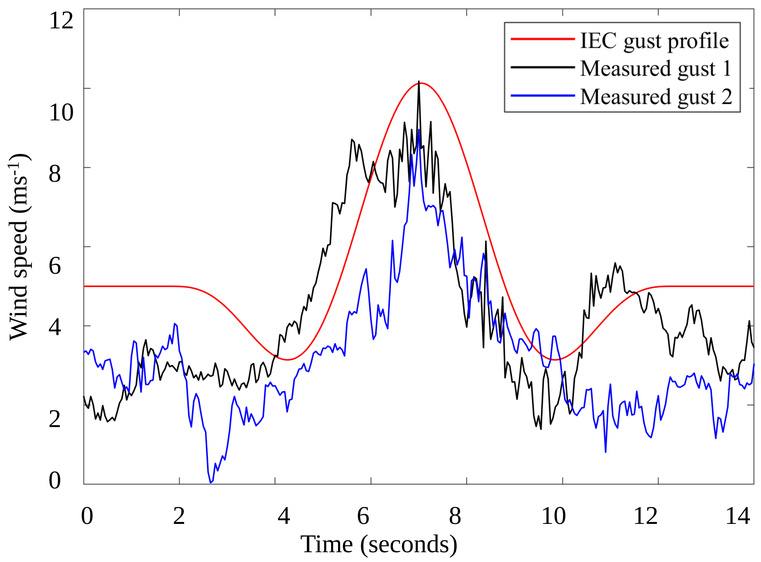


Figure 4. IEC prescribed EOG and measured gust at Callaghan site.

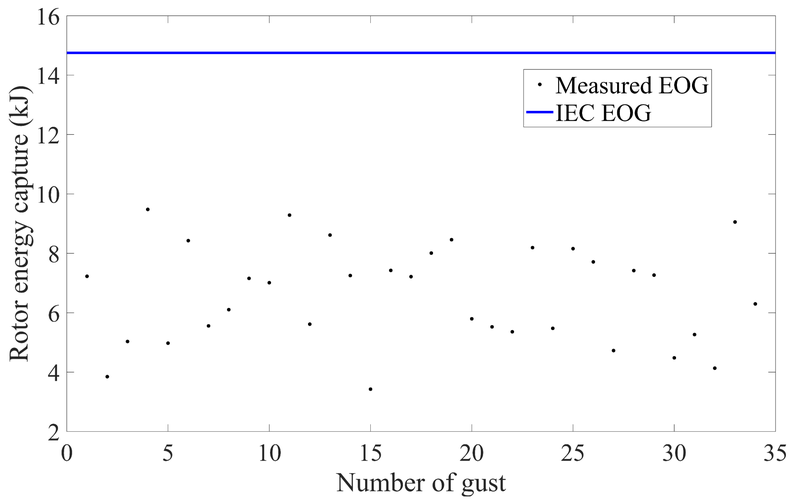
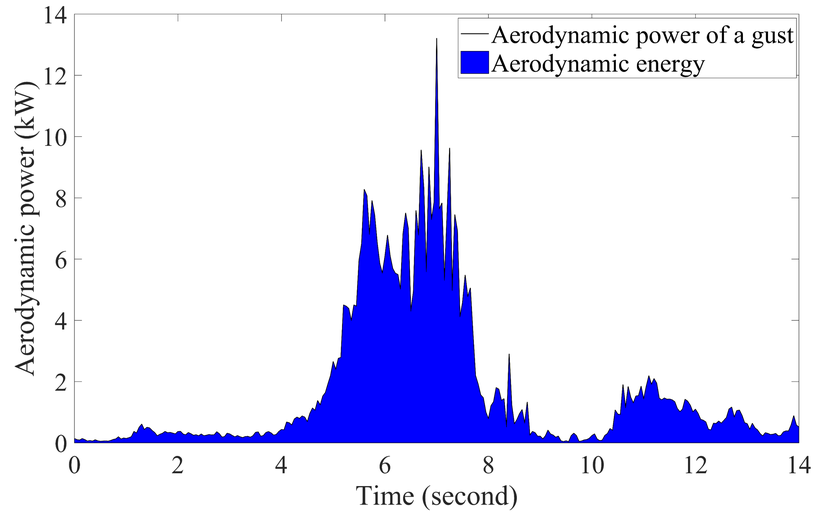


Figure 6. Predicted energy capture by rotor during ideal gust and measured gusts.

Results



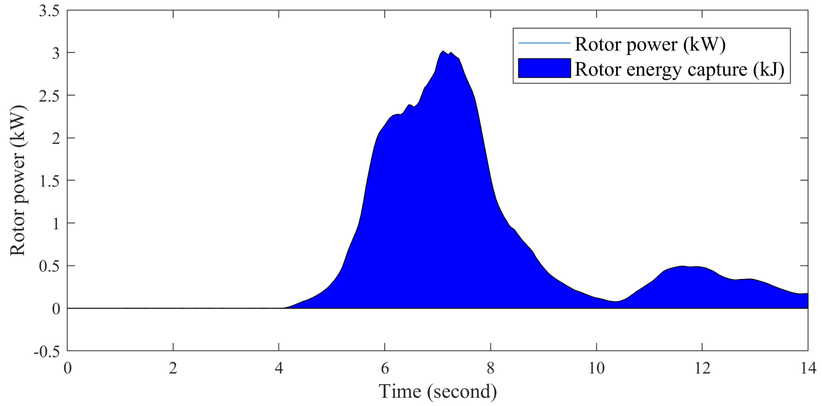


Figure 5. An example of calculating the availability of aerodynamic energy of a measured wind gust (23.4 kJ) and predicted maximum energy extraction by the rotor from the gust (9.3 kJ).

Conclusions

An analysis of 34 measured wind gust events at the Callaghan site shows:

1. The energy content for a measured gust is between 24 kJ and 10.7 kJ; the IEC prescribed ideal gust energy content is 38 kJ.

2. Rotor is predicted to extract less than 10 kJ from the measured gusts and 14.7 kJ of energy from an ideal gust .

3. Turbine rotor is predicted to extract on average 35% of energy available during a measured gust event compared to 39% for the IEC gust event.

References

[1] IEC 61400.2-2013 Wind turbines - design requirements for small wind turbines, 2013

[2] Rakib, M. I., Evans, S. P., & Clausen, P. D. (2019). Measured gust events in the urban environment, a comparison with the IEC standard. Renewable Energy. 146, 1134-1142

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