A corrector for wind power estimation and its usage in estimating icing losses

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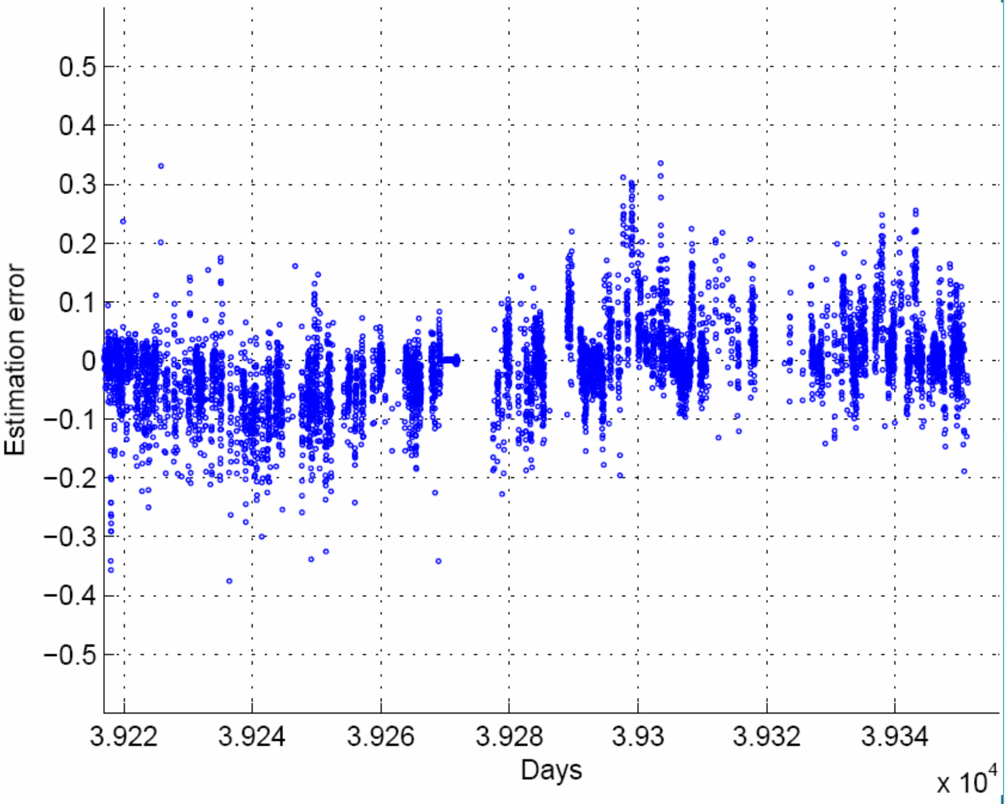
Problem

- Estimation of losses due to icing has large uncertainty.
- Standard method of power estimation gives large errors even during ice free periods.
- This means only relatively large losses can be quantified.



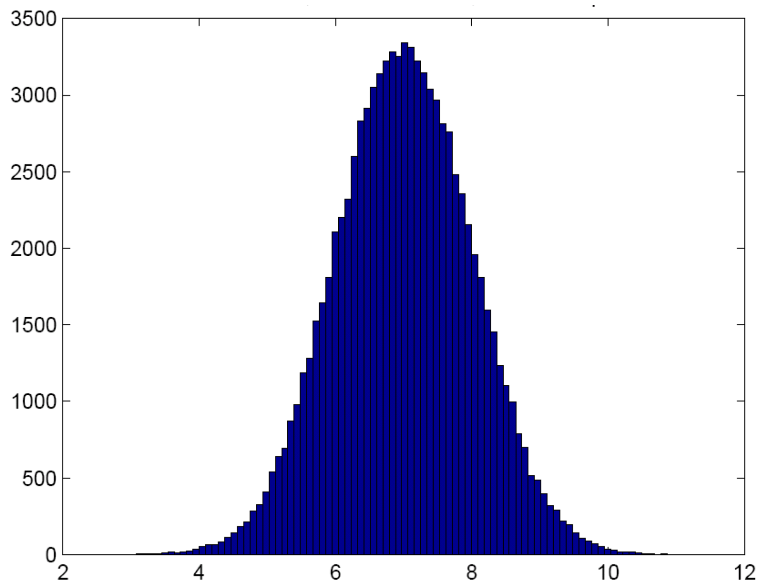
Power estimation of summer data shows errors regularly exceeding 10%.

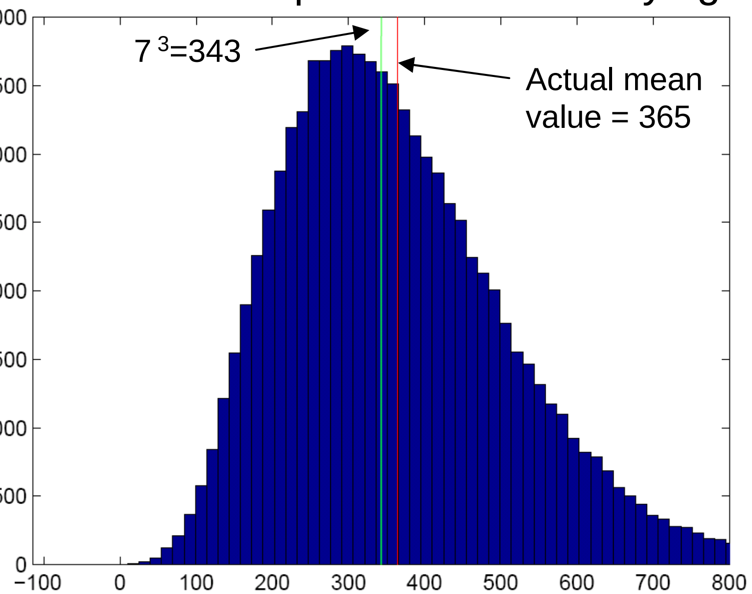
Høgskolen i Narvik

One possible source of error

- Wind can be modelled as a constant component plus a stochastic component.
- For example, a period with a 7 m/s mean wind and 1 m/s standard deviation has a 6% higher energy content then a 7 m/s constant wind.

Distribution becomes skewed upward and the mean increases compared to a non-varying wind.





Theory

- Therefore, the 10 minute mean wind velocity does not properly quantify wind energy content
- Meaning...

$$W \neq k\mu^3$$

- A corrector was found that represents the energy in the wind variance, assuming a Gaussian distribution.
- So the energy in the wind is...

$$W = k\mu^3 + 3k\mu\sigma^2$$

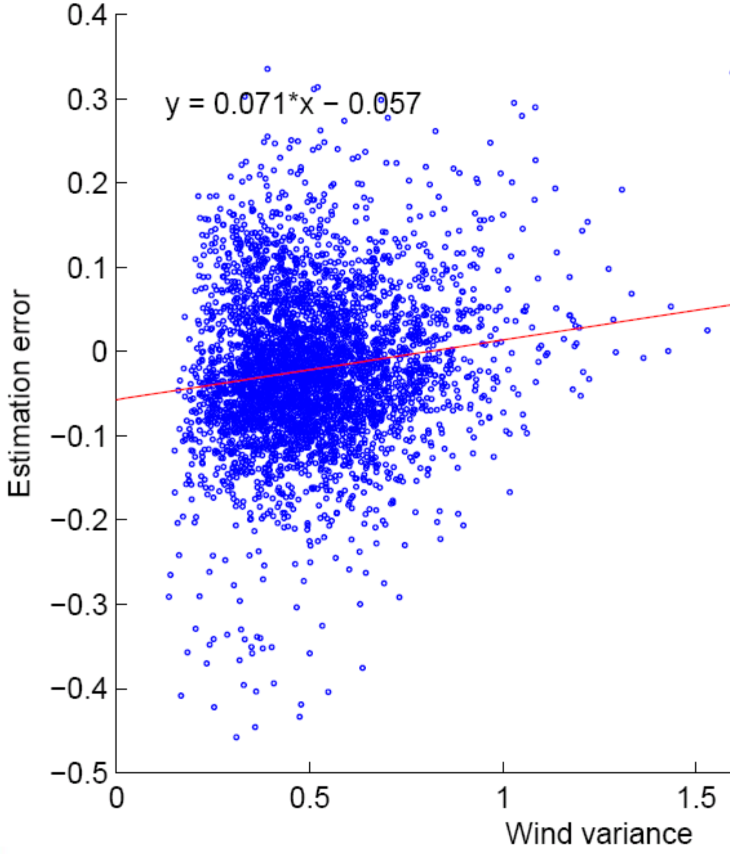
W = Energy in the wind

μ = 10 minute mean wind speed

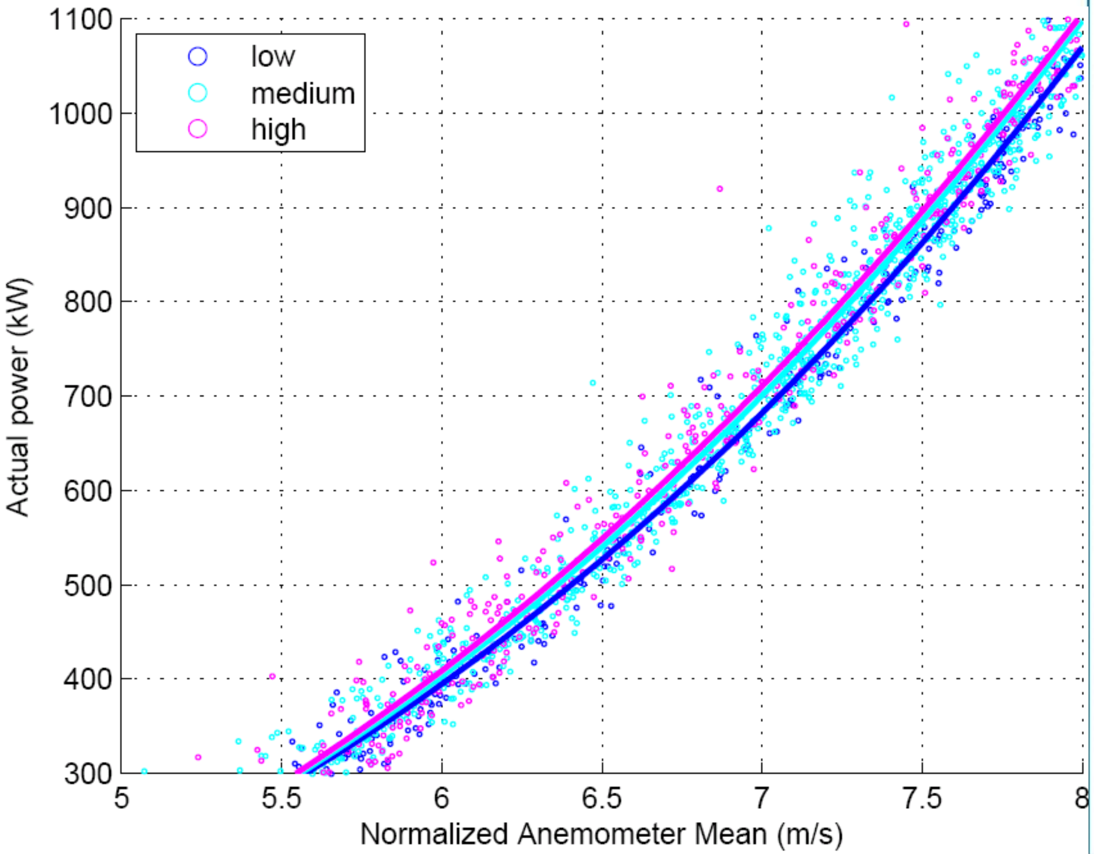
σ = 10 minute wind speed variance (standard deviation)

Verification with turbine data: Without corrector

Estimation error vs. wind speed variance, and linear best fit.

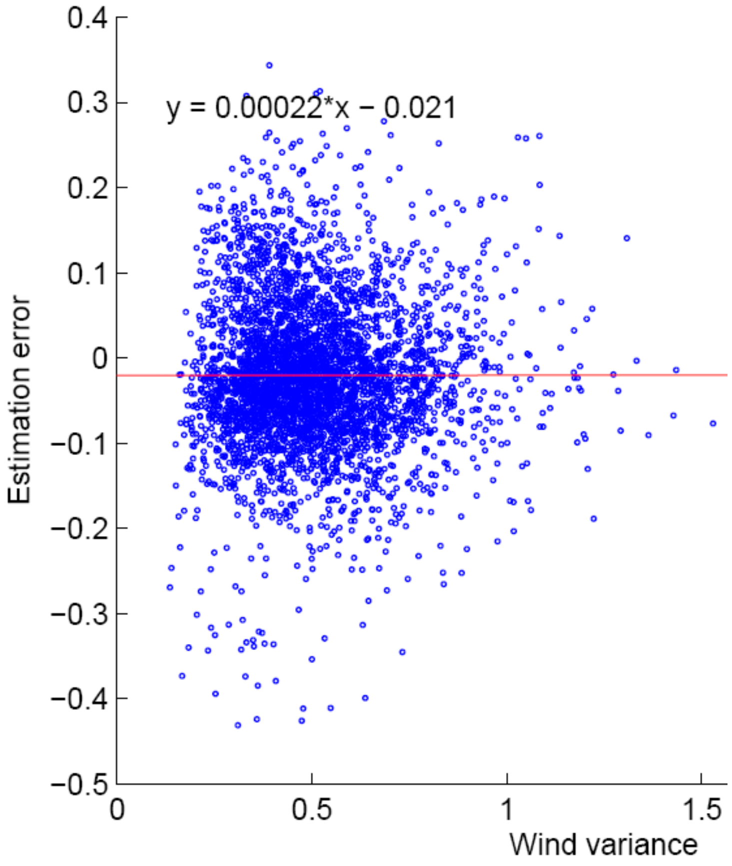


Power vs. wind speed datapoints seperated into 3 groups of low, medium and high variance and 3rd order best fit curves.



Verification with turbine data: With corrector applied

Estimation error vs. wind speed variance, and linear best fit.



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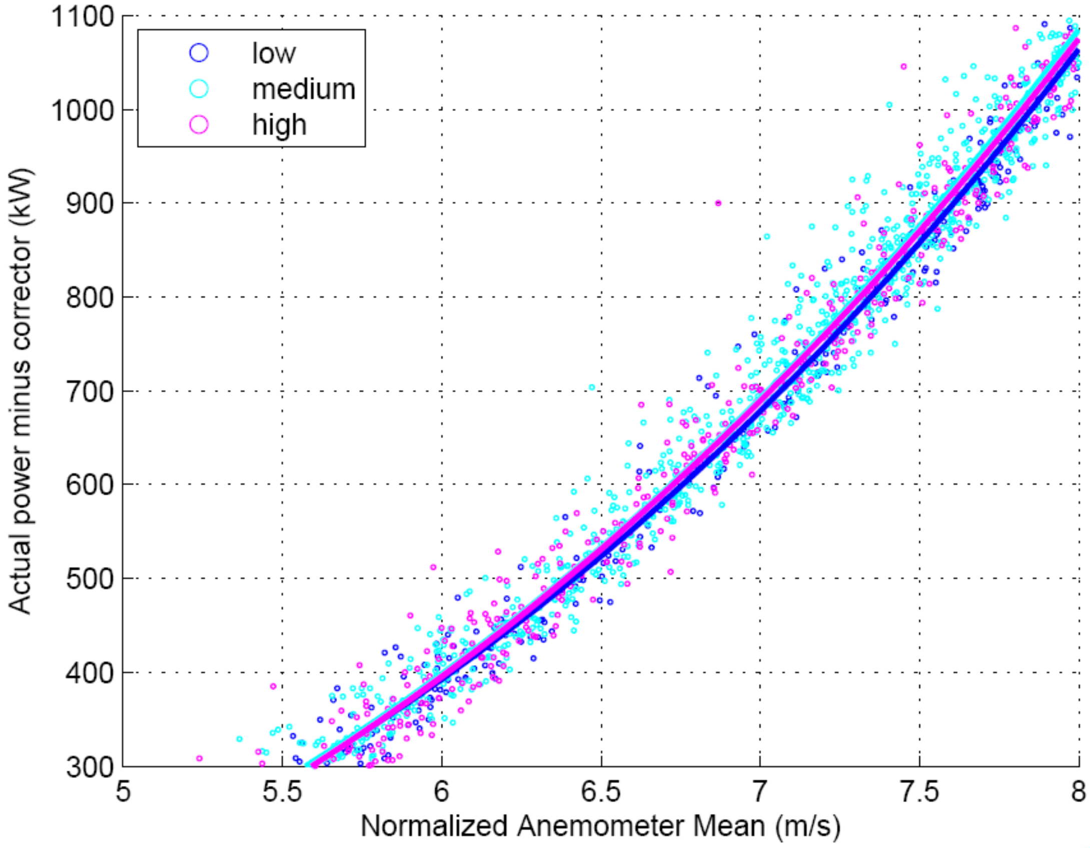
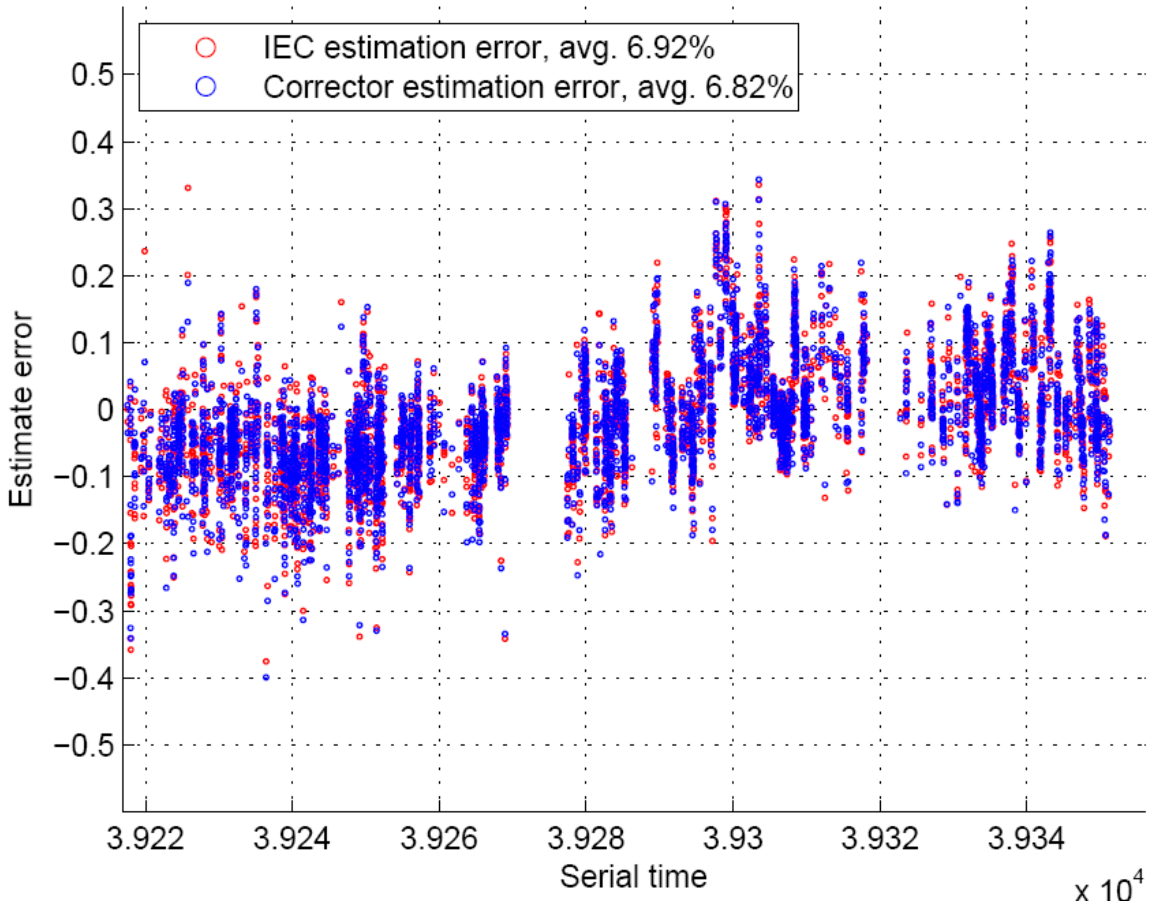


Implementation:
Power estimation with and without corrector

Power estimation is improved, but only slightly.



Conclusions

- The corrector improves the power estimation in the wind speed range between cut-in and rated production.
- The wind speed variance was not the primary cause of estimation error.

Comments

- The corrector can not be directly applied at speeds near cut-in and rated speed due to the turbines nonlinear operation near these speeds.
- All data was normalized to standard air density.
- A Gaussian distribution of wind turbulence was assumed.
- Power estimation errors were only calculated for wind speeds above 5 m/s, as low wind speeds can result in very large relative errors.