Solving the Other Emergency: Wind Farm Analytics – Spring 2020

With New Customer Case Study

Which is the bigger emergency – covid-19 or climate change?

It could be an interesting debate but at Wind Farm Analytics (WFA) we believe in tackling more than one emergency in parallel.

WFA is maintaining a steadfast focus on our mission. Our mission is to assist the global wind energy industry to improve current and future wind farm assets by increasing their annual energy production and to increase their green generation lifetime.

Latest developments at WFA

- In response to investor challenges for evidence to back up WFA claims, a *customer case study* (please see below) was produced showing evidence for 10% potential gains by use of converging beam LIDAR for improved micro-siting (the detailed positioning of turbines across wind farm terrain, decided in project development)
- *A USA patent* has been granted covering converging beam LIDAR on turbines
- *A Japanese patent* has been granted covering converging beam LIDAR on turbines
- The *Actuary Magazine* published an article "Machine Learning with Laser Focus" about laser wind measurement for insurance and investment risk assessment, co-authored by WFA founder, Dr Theodore Holtom
- Mathematics collaboration with Birkbeck, University of London has led to a paper "Error propagation analysis for a static convergent beam triple LIDAR" being published by the journal *Applied Numerical Mathematics*, from Elsevier
- Application of LIDAR in crane systems was found to be feasible; maybe aviation runways and helicopter pads are also possible customer applications?

The shift in political landscape

The wind industry has grown for the last twenty years, despite naysayers arguing it would never amount to anything. Policies long argued by the green movement have become mainstream political thinking, supported by international agreements notably at Kyoto (1997) and Paris (2016). The Intergovernmental Panel on Climate Change has gathered more and more evidence on the need for action. But in the last year the consensus seems stronger than ever before. This bodes well for the wind industry until 2050 and beyond.

Companies are adopting the UN Sustainability Goals. The political landscape has also been changing further in favour of wind energy and clean tech including Net Zero target announcements and Climate Emergency announcements from various governments. Many financial asset managers and investors are prioritising fossil fuel divestment and refocusing on technologies to assist de-carbonisation. Climate change and sustainability were central themes at the World Economic Forum meeting at Davos in January 2020.

Many people worldwide, especially the younger generations, have been supporting Greta Thunberg and protests of the Extinction Rebellion movement. The COP26 climate meeting is now postponed until 2021 here in Glasgow – what better occasion to showcase, subject to covid-19 safety measures, and to invest in clean tech for green jobs #MadeInGlasgow?

Meanwhile it is reported that the UK government will allow onshore wind, previously excluded, to be included in the next round of CFD (Contract for Difference) support. We still need (clean) electricity so wind farms are good assets even during a pandemic.

The new normal of onshore wind in complex terrain

The low hanging fruit of windy development sites in simple flat land with feasible planning constraints has mostly been harvested already. Many wind farm developers and financial investors will be looking to complex or at least moderately complex terrain. This process is occurring globally, not just in the UK. Also, many wind farms are now being built world-wide with reduced or no subsidies. In this evolving market wind farm investors and developers will have to take even greater care in order to ensure successful projects.

The following customer case study of operational wind turbine data shows an example of the extent to which micro-siting of wind turbines can have an impact on their annual energy yield. This is significant even where terrain complexity is only moderate (gentle rolling hills). Firstly, the average wind speed, and therefore electricity production, varies substantially across a complex terrain wind farm. Secondly, the quality of the wind in terms of measurable characteristics can cause substantial complex flow losses per micro-site. Overall, the cost of more detailed converging beam LIDAR data collection at each wind turbine micro-site is justified in order to highlight the best micro-sites and eliminate wasteful future losses.

Govern your turbine micro-siting by direct 3d measurements instead of computer models which are not fully validated, whose annual production uncertainty rises in complex terrain!

Seeking investment and collaborations

Friends and family low cost micro-SME Wind Farm Analytics has already come a long way on a difficult journey and after approximately £2 million of InnovateUK funding to design, build and successfully test prototypes we now need further investment for making sales, creating green jobs, increasing global wind farm production and repaying the UK taxpayer.

Do you agree with our objectives? Maybe you can help? Wind farm owners, developers, operators or equipment manufacturers please see the customer case study on the next page and please consider hiring us for a wind farm improvement project. Can you provide us a (conditional) letter of intent to use converging beam LIDAR, for showing to investors?

Would you like to invest for shares in WFA or do you know someone who might? Big or small investors (£100 - £3 million) who understand investment risks but also see the possibility of sharing 100x rewards if our tech becomes standard, please do get in touch! We will be glad to answer your questions, financial or technical. Join us on our journey!

New technology development is not easy. However, we are nearly there. Maybe your investment (between £100 - £30k) can contribute to ongoing patent costs, as we must maintain multiple patents with annual fees in multiple territories. Perhaps your investment (£10k) can help us with re-branding and a new website, to help us reach customers better. Your investment could help produce first sales LIDARs (£250k one-off, £70k per triple LIDAR at 100x scale) so we can get out and start selling which is the key. Or maybe you are an industry strategic / big money investor with £3 million, allowing us to really go directly for those annual green billions in a global market which is growing until 2050 and beyond?

Customer Case Study:

Evidence of Complex Flow Losses from Operational Analysis

Almost everyone we speak to in the wind industry and within the investor community appreciates that converging beam LIDAR has multiple wind measurement benefits. However, the big question is how much is that worth? Does benefit outweigh the cost?

Wind Farm Analytics identified and contacted the owner of a typical UK wind farm operating in *moderately* complex terrain using turbines in the commonly employed 2.0-2.5 MW category. From experience it was expected that significant under-performance of around 10% would manifest itself on this wind farm, due to complex flow arising from the complex terrain. It was agreed to evaluate this purely from operational (SCADA) data.

Our analysis

1. Firstly, in order to estimate micro-siting production variability the production history was compared for each turbine. Maintenance records were checked for any known reasons that could explain production variability. Production deficits relative to the most productive turbine were compared against the predictions of industry standard computer models used for investment decisions.

2. Secondly, to understand performance variability with wind direction, we calculated the average power curve per nacelle angle 30° angle sector (12 sectors span 360° ; in operation the turbine nacelle direction is controlled to align with the wind direction).

3. We then calculated, in each sector, the energy that would be produced within the wind speed range 2-12 m/s (the power curve rise) given the wind speed distribution as recorded for the study data period (in this case two years of data were analysed).

4. We subsequently compared this energy calculated in step 3 with the energy which would have been produced by the power curve rise (2–12 m/s) of the best performing angle sector. This led us to calculate relative efficiency per angle sector.

5. Finally, we summed the complex flow losses over all angle sectors in order to arrive at total estimated losses per year.

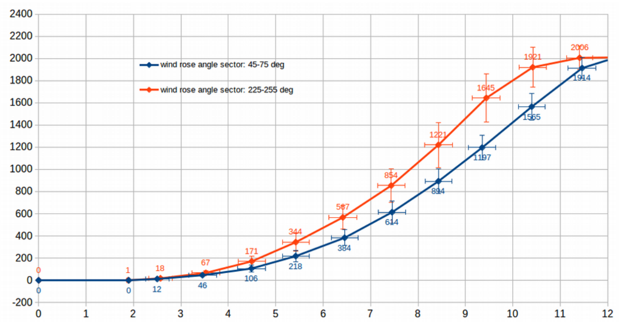

Figure 1: comparing the power curve rise (windspeed 2-12 m/s) for opposite angle sectors centred at 60 (blue) v 240 (red) deg for one of the turbines

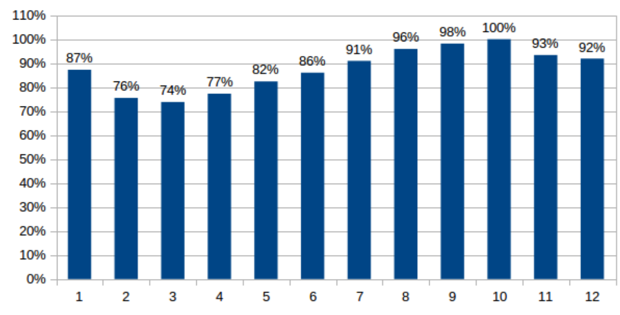

Figure 2: complex flow losses per 30 deg angle sector, relative to best performing sector for wind speeds (2-12 m/s); note main losses are not in direction of wakes from other turbines

Our findings

Firstly, the historic production data for the wind farm was compared for all the turbines and also compared with the pre-construction site assessment employing industry-standard computer simulation models. In real life the overall production varied by 12% between best and worst operating turbines whereas modelling predicted a 1.4% difference (and in the opposite sense). There was no known explanation, for instance a major maintenance event.

One might try to defend the computer models by suggesting that this mismatch is down to annual weather fluctuations. However the difference in energy production was observed to be steadily increasing over the entire history of these turbines. Therefore this indicates that some of the micro-sites are persistently windier than others and that industry standard computer simulations do not evaluate complex flow sufficiently in order to calculate per micro-site windiness deficit, and therefore per micro-site production deficit.

Secondly, the calculation of complex flow losses was undertaken for operational turbines based on the last two years data. For the worst case of the turbines studied, we calculated that complex flow losses were 8.4% of the expected annual production (known as “P50”). On average for this wind farm in moderately complex terrain, we calculated that the complex flow losses were 6.1% of its expected annual production. Much higher losses can be possible in severe complex terrain typical of many wind farm developments worldwide.

Combining (a) micro-site production deficit, with (b) complex flow losses, we see that wind turbines can suffer losses of approximately 10% in annual production in complex terrain.

Furthermore it is well known that fatigue loading increases significantly for turbines operating in complex flow. Complex terrain wind farm investors, whether purchasing an existing operational asset or developing a new wind farm, ought to employ converging beam LIDAR complex flow analysis within their due diligence to avoid early asset death.

Over a 30-year lifetime, a 2.5 MW wind turbine with typical capacity factor of 30%, earning an average of £100/MWh, would generate revenue of £19.7 million. Therefore, 10% gains would be worth almost £2 million for a single turbine. This single turbine would generate an extra 19710 MWh of energy, thereby avoiding 8870 tonnes of carbon dioxide emission if we assume carbon dioxide intensity of 450 kg/MWh. Gains will double for 5 MW turbines.

What can we do to avoid such revenue losses?

Existing wind farm owners in complex terrain: hire us to quantify complex flow losses for your turbines initially through low-cost SCADA data analysis only. Where justified we can deploy converging beam LIDAR for direct 3d flow measurements to prove reasons for loss.

If you have under-performing turbines not all is lost! Retrofitting forward-looking converging beam LIDAR eliminates losses during remaining turbine lifetime. Corresponding improved yaw control harvests more energy by accounting for full rotor wind direction, and fatigue reduction enables wind turbines to live longer. We can reduce annual operating costs too.

Wind farm developers in complex terrain: please contact us about how converging beam LIDAR measurements (costing £25k per turbine micro-site based on a £250k deployment / 10 micro-sites) can avoid these losses on future wind farms, potentially earning millions of pounds extra green revenue per turbine by avoiding poor micro-siting.

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