



The road to acceptance of LiDAR-based Wind Measurements in Poland

Position paper

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1 Streszczenie

Technologia LiDAR (Light Detection and Ranging) stała się kluczowym narzędziem w ocenie zasobów wiatrowych na całym świecie. Jego wykorzystanie wsparło już ponad 170 miliardów euro inwestycji w zieloną energię na całym świecie, zastępując setki milionów ton emisji CO₂. Technologia ta jest szczególnie istotna dla morskiej energetyki wiatrowej, gdzie tradycyjne maszty meteorologiczne nie są już praktyczną opcją, a LiDAR wiatrowy stał się standardowym podejściem pomiarowym. W Polsce integracja systemów LiDAR z kampaniami pomiarowymi wiatru również znacząco przyspieszyła rozwój projektów energetyki wiatrowej zarówno na lądzie, jak i na morzu. W artykule przeanalizowano zastosowanie technologii LiDAR w Polsce, podkreślając jej rolę w zwiększaniu dokładności ocen zasobów wiatrowych, wspieraniu rentowności finansowej projektów oraz przyczynianiu się do realizacji celów Polski w zakresie energii odnawialnej.

2 Executive Summary

LiDAR (Light Detection and Ranging) technology has emerged as a crucial tool in the assessment of wind resources worldwide. Its use has already supported more than EUR 170 billion of green energy investments globally, displacing hundreds of millions of tonnes of CO₂ emissions, according to industry providers. The technology is particularly critical for offshore wind, where traditional meteorological masts are no longer a practical option and wind LiDAR has become the standard measurement approach. The integration of LiDAR systems into wind measurement campaigns has significantly advanced the development of both onshore and offshore wind energy projects in Poland too. This paper examines the application of LiDAR technology in Poland, highlighting its role in enhancing the accuracy of wind resource assessments, supporting the financial viability of projects, and contributing to Poland's renewable energy objectives.



Figure 1 Aerial photograph of wind farm Krzecin in West Pomperanian Voivodeship, the region with the largest capacity of installed onshore wind farms in Poland. Photo: Author.

3 Introduction

Poland's commitment to increasing its renewable energy capacity has led to a surge in wind energy projects, certainly combined with recently easing of the minimum distance to residential livings (the former '10H-rule'). Traditional methods of wind measurement, such as meteorological masts, are being more and more complemented or replaced by LiDAR systems due to their ability to provide data without considerable land use and time-delaying permitting. There seem to be, however, still barriers to the acceptance of LiDARs by traditional financial institutions in Poland, leading to higher-than-needed development costs and larger project uncertainties. In this paper, we aim to address the most important ones of these.

4 The Problem

In Polish onshore wind energy projects, LiDAR technology is being applied, but primarily by large international developers who in some cases pool close to 100 LiDARs in their combined German/Polish fleet. They bring with them a large amount of international experience in using LiDAR and are used to attract financing on global markets. On these

markets, a LiDAR measurement campaign, when conducted under standardized, quality-controlled conditions (think IEC or MEASNET) leads to a better accuracy on the energy yield (in banking terms the 'P₅₀-P₉₀ ratio') and hence lower interest-rates for the necessary equity.

Interesting enough in this market entrance these developers also bring the German TR6 regulations, which are strictly speaking only needed inside Germany obtain project-subsidy but are for any other purposes or countries overly strict and not really useful or needed.

Smaller, local Polish project developers and initiatives without access to these international money-streams are however struggling more to get LiDAR to aid their projects: typically Polish banks and/or lenders seem to not appreciate the lower uncertainties LiDAR can bring with better lending terms. The same, interestingly enough, seems to hold for Polish subsidiaries of international banking firms.

As a consequence, more than in other countries in Europe, Polish projects are developed using met masts. However, the current international tensions lead to more restrictive use of land-area, as airspace is blocked pre-liminary for low-flying areas. Though obviously also applicable for future wind farms itself, it also currently limits the use of met masts and therefore favours the use of LiDARs.

5 LiDAR Technology Overview

LiDAR systems send out laser light (pulsed or continuous wave) to measure any frequency shift in the reflection of that after hitting air-borne particles (think aerosols, water droplets). This allows for precise speed measurements (Doppler-effect). In wind resource assessments, LiDAR devices can measure wind speed and direction at various heights, providing a detailed vertical wind profile (10 up to 400 m height, depending the LiDAR brand and model). This capability is particularly advantageous in offshore environments where traditional masts are impractical and very expensive.

As of late, the use of LiDARs for onshore projects is accelerating in Poland, in line with the rest of Europe, as developers with international experience and ditto financing bring with them their own practices (think German developers introducing TR6 as a quality standard in Poland). Globally, China represents the largest market for wind LiDAR deployment, with North America following as the second largest, even during periods of political uncertainty around renewable energy. These regions are building extensive experience in

LiDAR-based wind measurements, often supported by financial institutions eager to embrace the technology's advantages.



Figure 2: Samples of LiDARs, ready for verification testing at a 120 m tall mast in The Netherlands. Left: ZX300M, right a WindCube V2.1M (both offshore versions). Photo: courtesy of Pondera/Haskoning.

In Poland this experience is accelerating, but still lagging behind the international push: keeping pace with these global developments is essential to remain competitive and to ensure that its projects attract both the expertise and the capital flowing into markets where LiDAR has already become the norm.

The current market acceptance of LiDAR in benign and even semi-complex terrain is supported by numerous internationally renowned consultants and research bodies, such as DWG, DNV, Ramboll and Bureau Veritas.

6 Known applications in Polish Wind Projects

Although in onshore wind farm development in Poland, LiDAR is still in its early stages, in offshore projects it is by now very common and factually the only applied tool. As such there is no lack of knowledge of or experience with LiDARs in Poland.

Several offshore wind projects in Poland have utilized LiDAR technology in their development phases:

- **Baltica Offshore Wind Farm:** PGE Energia Odnawialna deployed an EOLOS FLS200 LiDAR system in the Baltic Sea to collect wind data for its planned 1 GW

wind farm. The data informed wind turbine selection and layout optimization ([1], 2018).



Figure 3: Left: the 'inside' of an RPS floating LiDAR prior to deployment in The Netherlands. Clearly visible is the ZX300 LiDAR in the centre of the picture. Right: the traditional way of measuring the wind, using a tall mast or tower. Photos: Author and Pondera/Haskoning.

- **Baltic Power Project:** Part of the Orlen Group, Baltic Power deployed a floating LiDAR buoy to assess wind conditions and environmental impacts, aiding in the project's development and financing decisions ([2], 2019).
- **Balttyk I Project:** A floating LiDAR buoy named "Anna" was deployed by Equinor and Polenergia to study wind and wave intensity, contributing to the project's environmental impact assessment and design considerations ([3], 2023).

7 Benefits in Wind Resource Assessment

LiDAR measurements are bankable. For the majority of situations (called 'benign' in scientific terms), most LiDAR-brands & makes available provide similar or better results than met masts. The benefits are easily summarized:

- **Lower HSE or environmental impact:** no need to construct tall structures with ditto high HSE-risks, no need to create large forest or crop clearings and lower CO₂-emissions needed due to avoided mast-steel.
- **Full rotor data:** LiDAR systems provide detailed vertical wind profiles up to 400 m nowadays, compared to a typically practical mast height of 150 m maximum. This enhances the accuracy of energy yield predictions, specifically with ever larger hub heights and increasing rotor diameters.
- **Flexibility:** LiDAR systems can be (re-)deployed in challenging sites, where with traditional masts this is not feasible. This allows for a strong reduction of the horizontal wind speed uncertainty in such cases. And, not to forget, LiDARs typically don't need a permit to be installed, hence they can be placed on short(er) notice and removed if project development or wind resources play out differently than expected.
- **Cost Effectiveness:** By eliminating the need for steel masts, certainly above around 150 m, LiDAR reduces capital expenditures in the DEVEX-stage of your project. With the price of LiDARs having fallen by close to 30% in the past decade, compared to a doubling of that of steel, the difference becomes even more pronounced.
- **Regulatory Compliance:** LiDAR measurements are recognized by international standards (MEASNET, IEC) and financing institutes. For some more extreme terrains, e.g. steep ridges (not very common in Poland), there is still research work in progress (see the IEA-working groups [5]), but LiDAR functionality in most NW-European terrains is proven and accepted.
- **Future-proof measurements:** Ground-based LiDARs capture the full vertical wind profile above the device, ensuring data remains relevant even if wind turbine hub heights or blade lengths change during project development, whether extending to higher heights or making use of lower heights on height-restricted sites. Also the larger profile allows for better integration with advanced flow models such as CFD and LES-tools, which create a better and more detailed understanding of a projects wind climate.

8 Financial impact

Obtaining financing for a Renewable Energy project in Poland, is typically harder than in other European countries. According to the Polish Wind Energy Association (PSEW [6]), for projects in Poland typically a 60-70% external financing can be obtained compared to up to 80% elsewhere. The main reason for this, is the greater risk perceived by Polish institutes with respect to the business case and financial structures covering PPA-risks. This in turn, leads to higher interest rates.

The application of LiDAR leads to lower uncertainties compared to that of met masts as shown in [4], thereby bringing down costs-of-financing. This has been proven on a large scale across European wind farms, with the earliest projects financed already operational since 2013 in e.g. The Netherlands.

9 Challenges and Considerations

The large international developers and installation companies are technically convinced of LiDAR's benefits, both globally and in Poland. However there are some challenges remaining:

- **Acceptance by banks:** Whereas the rest of Europe has come to adapt the LiDAR as a respected stand-alone source for providing AEP-figures for financing, Polish banks are more conservative. A better information position and show-casing successfully build projects (in Poland and abroad) might help. International banks with Polish branch-offices, could be the linchpin that bring positive experiences on LiDAR usage & accompanying better financing rates with them to the Polish market.
- **Technical data Validation:** Ensuring the accuracy and reliability of LiDAR data requires rigorous validation in line with applicable international standards against tall met masts. Building up a representative portfolio of projects, ideally show-cased in the public domain, will help to address concerns about losing face and business by being the first to apply 'new technologies'.
- **Environmental Conditions:** Mountainous terrain and inhomogeneous flow (though applicable in only a very few number of projects) might disturb the outcome of measurements for (very) limited areas, but advancements in CFD and related LES modelling techniques will rapidly mitigate these vulnerabilities.

- **Regulatory Framework:** The evolving regulatory landscape necessitates continuous adaptation to ensure compliance and project success. The blocking of new wind farms (and pre-dating these, met masts) due to low-flying zones all over Poland, forces developers and consultants alike to think about their opportunities.

10 Future Outlook

The continued advancement of LiDAR technology, coupled with Poland's commitment to renewable energy, suggests a growing role for LiDAR in wind resource assessment. Future developments may include enhanced data analytics, integration with other remote sensing technologies, and broader adoption across various wind energy projects.

It is the author's expectation, based on over 24 years of remote sensing measurements for wind farm financing purposes worldwide, that (also) in Poland LiDAR will replace met masts for all but the most complicated sites and specific applications such as PV-curve certification.

11 Conclusions

LiDAR technology has proven to be an indispensable tool in the development of wind energy projects globally, spearheaded by usage in Europe. Its ability to provide cost-effective, accurate, high-resolution wind data supports informed decision-making, optimizes project design and better financing conditions, contribute to the achievement of renewable energy goals.

In Poland, LiDARs are currently being used at scale, but acceptance by (Polish) banking institutions needs further advancement. As the technology continues to evolve, its application is expected to expand, further enhancing the efficiency and sustainability of wind energy development in Poland.

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