Final report

1.1 Project details

Project title	Cost-efficient lidar for pitch-control
Project identification (program abbrev. and file)	64014-0160
Name of the programme which has funded the project	EUDP
Project managing company/institution (name and address)	Windar Photonics A/S
Project partners	DTU Photonics & DTU Wind Energy
CVR (central business register)	32157688
Date for submission	12-03-2018

1.2 Short description of project objective and results

The objective of the new project is to develop the WindEye technology by increasing the number of measuring points whereby the sensor data can be used for an efficient Blade Pitch Control as well. By doing this, the full effect in respect of load reductions on turbines can be even further improved compared to the current two beam system. However, the challenge is to maintain the current low-cost position and at the same time be able to maintain the robustness of the current system without integrating any mechanical moving parts.

In Danish:
Målet med det nye projekt er at videreudvikle WindEye teknologien til at kunne måle i 4 rumligt separerede målepunkter – mod 2 i dag - hvor de ekstra data kan bruges til en effektiv Blade Pitch Control. En forbedret pitch-kontrol leder til reduceret spidsbelastning og dermed forbedret levetid. Alternativt kan vindmøllen opereres mere aggressivt uden overbelastning, dvs. med øget vindudbytte. Udfordringen er opnå denne forøgede funktionalitet, men med de nuværende lave produktionsomkostninger og robusthed fasteholdt. Det er specielt vigtigt, at der ikke må indgå mekaniske bevægelige dele i det endelige produkt

1.3 Executive summary

The project ”Cost-efficient lidar for pitch control” is an EUDP project with the main goal of developing and demonstrating the usefulness of wind turbine mounted lidar sensors for load reduction. This has been achieved with the design, development, production and testing of the WindVision™ four-beam sensor. The work is a collaboration between Windar Photonics A/S, DTU Photonics, and DTU Wind Energy. The accuracy of the wind measurements from the lidar was confirmed by comparison with mast data. Taking into account the effect of induction by the wind turbine was necessary for a good comparison. The WindVision™ was tested on the V52 test turbine acquired by DTU Wind Energy and installed on several commercial wind turbines. Pitch control algorithms were developed and demonstrated via computer simulation of wind turbine model. The work shows promising results in terms of load reduction using lidars.

1.4 Project objectives

Main goal of developing and demonstrating the usefulness of wind turbine mounted lidar sensors for load reduction. There were some timing issues – the project was prolonged due to the V52 test.

1.5 Project results and dissemination of results

Exposure and dissemination of our technology will come in the form of publications, conference presentations, exhibits and field demonstrations. We will publish results in scientific peer reviewed journals, conference proceedings and as technical seminar contributions. We will include the results as well as the "project" in entrepreneurial courses such as PhD summer schools and bachelor/master programs. We will participate in technical exhibitions where we can invite potential customers and demonstrate our low-cost lidar technology.

1.6 Utilization of project results

The initial market for a multi-beam wind sensor is expected to be the OEM segment totalling an annual production of turbines of roughly 25,000 units globally. At a later stage when the OEM's have integrated forward looking pitch control algorithms in new designs, the retro-fit segment could also be a potential market via the OEM manufactures. The overall sales target for a new multi-beam wind sensor is to get at least 10-15 design wins (designed into new wind turbine models) over the coming 5 years., which is expected to generate an annual sale of 2,000-3,000 sensors p.a. corresponding to an annual revenue of DKK 280-350 millions.

1.7 Project conclusion and perspective

The project was built around nine milestones. The main goal of the project which was to develop and demonstrate the usefulness of the WindVision™ sensor has been achieved. The WindVision™ is now on the market and an important part of Windar Photonics portfolio. The work towards the final design was covered via milestones M2, M3, M7 and M8. The results connected to the mile stones was covered in Chapter 2 of the attached annex. This effort resulted from collaboration between all project partners (Windar Photonics, DTU Photonics, DTU Wind Energy). Milestones M1 and M5 concerned the accuracy of the wind measurements from the lidar. After taking the effect of induction by the wind turbine into account, the comparison was good as demonstrated in Chapter 3 of the attached annex. Here, we also extended the work relative to the work plan by including the focus on the rotor effective wind speed, which is a key variable for turbine control. The WindVision™ was tested on the V52 test turbine acquired by DTU Wind Energy and installed on commercial windturbines (M6). The option of using this turbine in the project was not evident when writing the proposal, but it was immediately recognized as a very desirable choice by all project participants. The reason was that it is hard (or impossible) to acquire all wind and turbine data needed for extracting the rotor effective wind speed from the turbine performance, which was needed to make the comparison with the wind field estimate by the lidar. The work towards mile stones M4 and M9, which concern pitch control algorithms, were demonstrated in Section 5 of the attached annex. This work used numerical simulations on a computer and a standard fictive wind turbine model, that many researchers in the field use to test new control algorithms. The work shows promising results in terms of load reduction using lidars. With the conclusion of the current project, we see a next step in our work. This step is a "test and validation phase", in which the demonstrated likelihood of load reduction (Chapter 5 of the attached annex) is validated by including the lidar data (Chapter 3 of the attached annex) in the turbine controller. Such a step will hopefully be made possible on the V52 turbine at Risø, since a new open-access controller has been acquired.

Annex

EUDPsummaryCostEfficient-2.pdf

Relevant links