Project title	Reconfigurable LIDAR-system for wind measurement to support systems optimization of wind power plan
Project number	TG1-6
Organisation	WindVector AB
Project leader	Stellan Wickström
Other participants	Carl-Johan Cederstrand, Johan Sehlstedt, Lena Klasén
Report for	2011-01-01 to 2014-06-30
Participating companies	

Project description

In order to improve the performance of a wind power station, introduction of a LIDAR to measure the upcoming wind, distribution and speed, was proposed. By having a LIDAR with a configurable performance, the ability to predict the upcoming wind conditions was considered as an improvement with respect to the existing systems.

The current system, i.e. an anemometer mounted on the wind power nacelle, measures the direction and speed of wind with very good accuracy. However, the information is based on the wind conditions after the turbine blades and gives no warning in case of a strong upcoming wind gust. The wind conditions are also severely disturbed by the turbine blades, so it is likely that the wind conditions, let say 100m in front of the wind turbine, differs from after the blades where the anemometers usually are placed.

A design, manufacturing and delivery of a LIDAR with the possibility to measure wind in front of the turbine blades and in different directions to compensate for yaw and shear was decided as the main goal of the project. In addition, an installation on the 4MW wind power station Big Glenn in the Gothenburg harbour area in order to measure the upcoming wind conditions was an additional goal within the project.

The design was based on rather straightforward technology, with several modules and components from the telecom industry. The configurability consisted in having the possibility to measure the horizontal and the vertical direction of the upcoming wind simultaneously at 100m since the LIDAR emits in five different directions. However, it is also possible, by reconfiguration, to measure at shorter ranges in one or more directions. By further reconfiguration, even additional directions are possible to achieve.

By this configurability, it is possible for the first time to assess data from the LIDAR in order to simulate the influence of upcoming wind distribution in the control loop for the wind power station.

Summary goal for the project

- What aspects of mounting on the nacelle that have to be considered, and how mounting affects data quality.
- How geometry, distance and number of measuring points affect information quality into the control loop.
- What degree of data processing is needed to extract sufficient data duality for the control loop.

The project, which was a part of the Control project (TG1-1) run by Chalmers, has cooperated with Chalmers, the division for Automatic control, Automation and Mechatronics.

Results

A LIDAR to measure the speed of wind has been designed, constructed and, eventually mounted on the Big Glenn.

Initially, the first test of the LIDAR, performed roughly one year after the start of the project, showed promising results when testing on aerosols. However, it was later understood that the aerosols at that time were small ice crystals with high reflectivity, indicating the sensitivity for the LIDAR was very poor.

Further work disclosed several sources to the lack of sensitivity and once these shortages were erected, it was possible to measure against regular aerosols and thereby measuring the speed of wind. Additional signal processing algorithms were implemented and tested in the lab and in the field in order to improve the sensitivity.

In order to secure measuring, several field tests were performed at the Chalmers test station on the island Hönö. Results from these tests showed a very good correspondence between the results from the test station anemometer and the LIDAR. Eventually, the LIDAR was mounted on Big Glenn and instantly provided wind speed data by the remote data system installed by WindVector.

After some months in operation, it was clear the performance of the LIDAR was poor and only occasionally delivered reliable wind data. In some cases the processor board stopped to work due to overheating. But the most critical result during the installation period on Big Glenn was the suddenly reduced performance. The conclusion from WindVector was that the humidity in the air went down to too low level for the LIDAR to be able to detect the aerosols. The reasons are likely the following.

To low sensitivity in the system due to losses and actions taken to improve the system:

- New mirrors are installed and has showed an improvement of 3dB
- The electrical shielding of the device will be increased in order to be able to run the more sensitive algorithms
- Common mode voltage will be suppressed by upgraded internal electrical architecture.

The LIDAR has a five-beam performance and spreads the laser beams as for a dice with an individual separation of 20 degrees. The laser beams are focused at 100m and the speed of wind is measured in a volume limited to 10 meters. Due to eye safety considerations, only four of the laser beams were active during mission on the Big Glenn.

Fulfilment of SWPTC's goals

The overall goal of the project is to provide knowledge of:

- turbine load reduction,
- turbine weight reduction,
- turbine cost reduction,
- how much turbine effect can be increased

when a LIDAR is in the control loop for the wind turbine.

The SWPTC's goals have only partially been fulfilled since the LIDAR, installed on the Big Glenn, needs further improvements to deliver reliable data. And in addition, the data delivered from the LIDAR arrived too late for a reasonable evaluation within the control project since the development of the LIDAR was severely delayed.

Deviations from project plan

The most critical deviation from the project plan was of course the severe delay in installing the LIDAR on Big Glenn. In addition, the data is currently too unreliable due to lack of sensitivity and, most likely, EMC noise from the generator on Big Glenn.

Due to EMC disturbances the LIDAR has suffered from on Big Glenn, as described in the annual report for TG1-6, the amount of data from the different meteorological conditions is very limited. However, test with an unconfirmed visibility and with the LIDAR installed on Big Glenn, showed an acceptable performance down to 60-70% RH. Below this figure, the test result was unreliable. Test in the WindVector noise free laboratory, showed promising results down to 40%RH, without introducing any improvements of sensitivity or sustainability against external induced noise.

Publications

No publications are produced or published.

External activities

No external activities are reported.