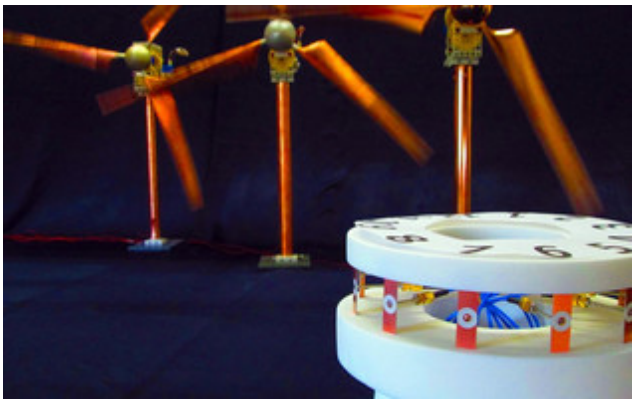

Wind turbines and an omnidirectional radio range beacon supplement the miniature airfield in Braunschweig.

Wind energy and air traffic 27.08.2015

Safely navigating jets close to wind farms

Until now, it has been difficult or even impossible to construct wind turbines near radio range beacons or radar systems used for navigating air traffic. These systems block what would otherwise be suitable locations. The extent to which rotors deflect or change signals has, however, not yet been studied in any scientific detail. Two research teams in Braunschweig are therefore working in separate projects on these basic data.

Using a so-called octocopter (pictured), the miniaturised system for measuring radar installations can fly through wind farms and carry out measurements at any point within the space.

When deciding whether to approve new wind turbines, their possible impact on air traffic safety is always an issue. In the past, many plans have failed in Germany as a result of this factor. In most cases this is due to the 15-kilometre protection zone surrounding the around sixty VHF omnidirectional radio range (VOR) beacons used by civil and military aviation, which are distributed throughout Germany. It is usually not possible to erect wind turbines within these zones, although permits for individual turbines are sometimes granted following detailed examination. A second issue is the impact of wind turbines on radar systems used by civil and military aviation as well as by the weather services. Two research teams in Braunschweig are now investigating these aspects: Scientists at Braunschweig Technical University are supplementing a model airport built to a scale of 1: 144 with models of wind turbines and a radio range beacon. This scaled-down test environment enables them to easily measure a diverse range of characteristic situations between the beacon and the wind turbines. The work in the "min-VOR-win" project is currently starting.
In the second project, called WERAN, staff at the Physikalisch-Technische Bundesanstalt (PTB) have been investigating the interactions between terrestrial navigation and radar systems as well as wind turbines since 2013. Together with FCS Flight Calibration GmbH, the researchers have developed a measurement system that enables systematic measurements in wind farms using a helicopter and, in miniaturised form, an octocopter.

In order to assess the actual interference caused to radio range beacons, there is still a need to investigate the causal relationship between different wind turbine configurations and operating conditions – such as the geometry of the rotors and their rotational speed – and the respective signal deviations. The specified radius of 15 kilometres for the protection zone is also being reviewed. The German Federal Ministry for Economic Affairs and Energy is funding both projects.

Measurements made at a miniature airport

In the min-VOR-win project, the interactions between radio range beacons and wind turbines are being systematically investigated using a miniaturised airport. Robert Geise, project manager at TU Braunschweig, explains the advantages of this approach: "As demanded by the systematic measurements, the model enables wind turbines to be easily added or removed, aircraft to approach from specific directions as often as required and the wind to blow from any desired direction. This is impossible to achieve in reality or only with a disproportionate amount of effort." Angular errors in approaching model aircraft can therefore be measured and compared with different wind turbine states. The tests will begin with individual wind turbines and will then be followed with entire wind farms. This will therefore enable compatibility analyses for planned wind farms and repowering measures to be already conducted during the planning stage. The aim of the investigations is to identify critical constellations and to only verify these as part of complex flight measurements.

Omnidirectional radio range beacons and aircraft navigation

Aircraft generally navigate these days using satellite navigation systems, for example GPS, although these are not mandatory instruments. Mandatory is a receiving system for the VHF omnidirectional radio range (VOR) beacon, which has proved itself for the last 80 years and is still in operation as a secure, redundant navigation system. Internationally it is recommended that technical errors or reflections on obstacles should not cause the signal to deviate by more than three degrees. In a survey conducted in 2013, the German Wind Energy Association discovered that a potential wind turbine capacity amounting to around 1,700 MW has been prevented as a result of protection zones around VHF omnidirectional radio range (VOR) beacons in Germany.

Octocopter in wind farms

In the WERAN project, the Physikalisch-Technische Bundesanstalt (PTB) and partners have developed a new measuring system in order to determine, with a high data quality, the impairments to terrestrial navigation systems and radar signals caused by wind turbines. An antenna and receiving system newly developed for this purpose measures electromagnetic field strengths and stores time-synchronous measurement and GPS data with a very high sampling rate.

The measurements will be carried out on actual wind turbines by flying through wind farms as well as in terrain without wind turbines. The results will be incorporated into the requirements stipulated by the International Civil Aviation Organisation. The measurement system consists of a box that can be hung beneath a helicopter. A smaller version of the system with precision navigation for flights with an automatically flying measuring platform – the octocopter – is nearing completion. The first test flights were successful. Dr Thorsten Schrader, project manager at the PTB, emphasises the advantages of the system: "The small flying devices enable precise measurements to be made cost-effectively at existing and planned wind farms, and in particular on actual wind turbines. For the first time we are collecting data on the field strength and signal changes at any point in the respective space with long observation periods. That is taking place on site, directly where it counts."

Basic assessment methods

The WERAN project marks the first time that individual signal components from VHF omnidirectional radio range (VOR) beacons have been measured separately in airspace. A systematic analysis of possible error sources for the overall VOR system, which extends as far as the aircraft cockpit, shows that totally different factors than more distant wind turbines may possibly determine the safe functionality of VOR. Numerical simulations at the project partner, the University of Hanover, have enabled them to gain a comprehensive understanding of the transmission channel for VOR and radar systems. "The parallel measurement and numerical simulation provide a basic evaluation method that also takes aviation needs into account," says Schrader.

In addition to terrestrial navigation systems, wind turbines can also scatter signals from radar stations. If new wind turbines are planned in the vicinity of radar installations, it was previously only possible to estimate the disruption effects with simulation calculations. These calculations are based, however, on numerous assumptions, which have not yet been confirmed by measurements. The survey conducted by the German Wind Energy Association (BWE) in 2013 came to the conclusion that a potential wind turbine capacity of roughly 1,400 megawatts has been

blocked as a result of conflicts with radar installations.

(mi)