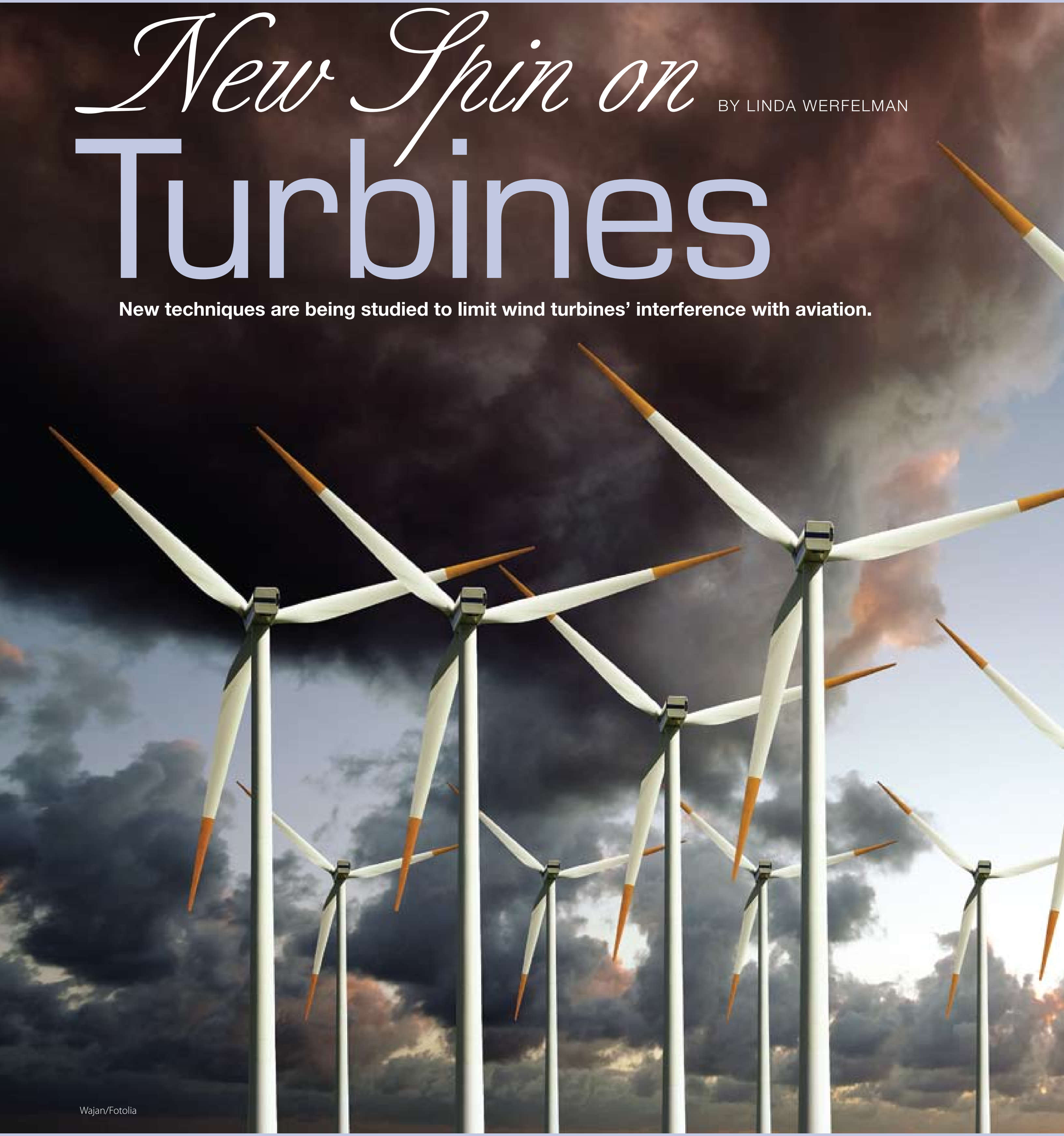
# New Spin on Turbines

BY LINDA WERFELMAN

**New techniques are being studied to limit wind turbines' interference with aviation.**



Wajan/Fotolia

The aviation industry and advocates of wind energy — sometimes at odds because of the unintended interactions of spinning wind turbine blades and aviation radar — are seeking ways to allow the two technologies to coexist.

Wind farms, which can consist of hundreds of wind turbines, are expected to generate 200 gigawatts (GW) of power worldwide in 2010; that amount is expected to increase to 1,000 GW by 2020 — equivalent to about 12 percent of global power demand, according to data from the Global Wind Energy Council (GWEC).[1]

Wind turbines convert the wind's energy into either mechanical energy — most often for pumping water in rural areas — or electrical energy, which can be used locally or, on a broader scale, sold to electric utilities (see "How Wind Turbines Work," p. 42).

In addition to generating energy, however, wind turbines generate interference with ground-based aviation and weather radar, either by blocking radar signals or by creating false images on air traffic control (ATC) radar screens.

"Aircraft targets, and to some extent, weather features seen by NOAA [the U.S. National Oceanic and Atmospheric Administration] radars can be temporarily lost, fail to be located, shadowed by the radar signature of the turbine farm or misidentified," said a 2008 study conducted by Mitre Corp. for the U.S. Department of Homeland Security (DHS).[2]

The study cited three examples:

- "A wind farm located close to a border [between ATC sectors] might create a dead zone for detecting intruding aircraft."
- "Current weather radar software could misinterpret the high apparent shear between blade tips as a tornado."
- "Current air traffic control software could temporarily lose the tracks of aircraft flying over wind farms."

The problem is exacerbated by the continuing use of aging radar technology, according to the study and other analyses of radar interference. Older, analog radar systems are not able to

## How Wind Turbines Work

Wind-electric turbine generators — or wind turbines — that generate electricity for sale to utilities typically consist of rotor blades, which rotate around a horizontal hub to convert wind energy into rotational shaft energy.[1,2]

The hub connects to a gearbox and often to a generator,[3] housed in a nacelle, located beneath or behind the blades. The rotor and nacelle typically are mounted at or near the top of a steel tower. Turbine systems also include controls, electrical cables and interconnection equipment.

Rotor diameters vary, and newer models can be as long as 80 m (262 ft). Most wind turbines have three rotor blades made of fiberglass-reinforced polyester or wood-epoxy; some turbines have only one or two blades, however.

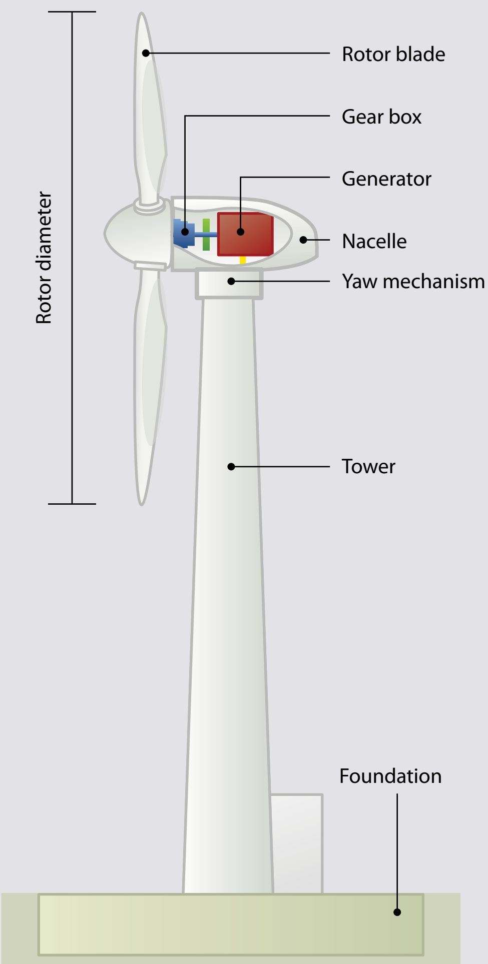
Wind turbines have a yaw mechanism that turns to align the top of the tower with the wind. Most wind turbines face into the wind, with the nacelle and tower behind them; others are downwind designs.

Most rotor blades operate at a constant speed of 10 to 30 rpm, but some rotate at a variable speed.

As wind passes the blades, the blades rotate, and the rotation drives the shaft of the generator, producing electricity that then is delivered to a utility's transmission lines — sometimes thought of as pipelines that carry electricity to areas where it is most in demand.

The output of an individual wind turbine varies, depending on the size of the turbine and the speed of the wind through the rotor. Wind turbines being manufactured now can produce as much as 5 megawatts of electricity, enough to provide electricity for one year to more than 1,400 households in the United States, where the American Wind Energy Association (AWEA) estimates average household consumption at 10,000 kilowatt hours.

— LW




Arne Nordmann/Wikimedia and Susan Reed

**Notes**

1. AWEA. *Wind Web Tutorial*. <www.awea.org/faq/wwt_basics.html>.
2. Renewable UK. *Wind Energy Technology*. <www.bwea.com/ref/tech.html>.
3. Some newer wind turbines have direct drive and do not require a gearbox.

differentiate between wind turbines and aircraft — or, in some cases, between wind turbines and weather systems.

Nancy Kalinowski, vice president of system operations services for the U.S. Federal Aviation Administration (FAA), said that the spinning blades of wind turbines can be "picked up by radars with a signal strength greater than a Boeing 747." The danger, she said, is that "because the radar repeatedly sees this large return, the radar will not pick up actual aircraft in the area."

Kalinowski's office is responsible for evaluating plans to build structures — including wind turbines — that are 200 ft (61 m) tall or taller that might interfere with safe use of navigable airspace. In testimony delivered in June 2010 before a subcommittee of the U.S. House of Representatives Armed Services Committee, Kalinowski said that the number of wind turbine cases presented to the FAA has increased dramatically in recent years — from 2,030 in 2004 to 25,618 in 2009. In the first six months of 2010, there were 18,685 cases, she said.

"There are real and significant issues that must be evaluated by the government prior to the approval of wind turbines," she said, noting that after the FAA receives a notice of proposed construction of a wind turbine, the agency conducts an initial study that typically takes 30 days. "The notice provides the FAA with the opportunity to identify the potential aeronautical hazards to minimize any adverse effects to aviation."

If the FAA — or the Department of Defense, NOAA or any of several other federal offices that may be required to evaluate a proposal — has an objection, that office describes the objection, and the person or company that filed the proposal offers a mitigation strategy.[3] If there is no objection, the FAA issues a Determination of No Hazard — a go-ahead for construction to begin.

In recent years, the FAA and other federal agencies contested plans for a number of proposed wind turbines near radar installations — actions that the U.S. Department of Energy said stalled the development of wind farms that would have produced thousands of megawatts of wind energy.

## 'Mitigation Toolbox'

A number of mitigation strategies already have been implemented for various wind turbine sites across the country, the American Wind Energy Association (AWEA) said, adding that there is "not a silver-bullet solution that can solve every potential conflict."[4]

AWEA said its goal is to establish a "mitigation toolbox" of workable solutions to provide the best solution in each individual case. These mitigation measures may call for modifications to a radar system, wind turbines or the layouts of wind farms, the AWEA said, adding that some of these possibilities require further research before they can be widely used.

"For example, in some cases, upgrading older radars with new radars or upgrading software has been shown to address concerns and accommodate additional wind energy development," the AWEA said, citing the Mitre study, which reported that 80 percent of U.S. radars were manufactured in the 1950s through the 1980s.

Stu Webster, a representative of the AWEA and director of permitting and environmental for Iberdrola Renewables, a major U.S. wind power generator, told the House Armed Services subcommittee that mitigation strategies range from providing air traffic controllers with additional training to help them differentiate between aircraft and radar screen "clutter" produced by wind farms to changing the location of some wind turbines and developing radar-absorbing materials for wind turbine blades.

The Mitre study said that several modifications have been proposed to alter the appearance of wind turbines on radar screens.

"One proposal is to put an active layer on the outside of the turbine blades to modulate dynamically the blade … signature [on Doppler radar]," the study said. "These modulations, it is claimed, could shift the Doppler frequency spectrum from the blades to lie outside the range of frequencies processed by the radar."

The study said it was unclear whether the modifications would affect the blades' aerodynamic properties, and how long the modifications might last.

Another proposal — developed by technology provider QinetiQ and Vestas Wind Systems, a wind turbine manufacturer — modifies the inside of wind turbine blades by installing layers of circuits and reflectors to dilute the strength of their radar return.

QinetiQ and Vestas say their solution uses radar-absorbing materials in a "stealth turbine" technology that also calls for radar-absorbing materials to be sprayed directly onto a wind turbine tower.[5]

Mark Roberts, QinetiQ's strategic business director for energy and environment, characterized the technology as a "genuine game-changer," which could remove a major barrier to the development of the renewable energy industry.

The Mitre study suggested that sophisticated radar data processing might be capable of "blanking out" radar returns from wind turbines, but "it would seem much easier to do so if the actual configuration of the turbines were known at every instant." This potential solution deserves further investigation, the study said.

Other proposals for solving the problem have recommended modifications of radar


© Haneck/Fotolia.com



system hardware and/or software; most of these proposals are aimed at digital radar — not the older analog systems. Proposals also have called for radar design modifications, such as changes in the length and frequency of pulses, and for installation of a supplemental "gap filler" radar to compensate for a loss of radar coverage caused by wind turbine interference.

Other suggestions have included rerouting aircraft to avoid, when possible, areas affected by wind turbine radar interference; repositioning radar installations, often by increasing their height; and simultaneously using two radar beams to differentiate between aircraft and wind turbines.[6]

Radars that cannot be modified to handle wind turbine interference could instead be replaced, "in a phased upgrade," the Mitre study said, estimating the cost to replace a radar installation at between $3 million and $8 million, compared with the cost of a wind turbine — $2 million to $4 million.

## Planned Upgrade

Renewable UK, a trade organization representing wind and marine renewable energy, said that this year in the United Kingdom, there are 270 operational wind farms made up of a total of 3,088 turbines. The organization estimated that half of all wind farm development proposals will be met with objections from the aviation industry because of interference with radar or with flight at low altitudes.

The organization is working with the U.K. Civil Aviation Authority, U.K. NATS (formerly known as National Air Traffic Services) and others to address these concerns.

NATS, in an effort to avoid a proliferation of numerous site-specific mitigation plans, has endorsed a plan based on its upgrade of all primary radars to a common standard. Older NATS En-Route Ltd. (NERL) primary surveillance radars of varying types and ages are being replaced with products manufactured by Raytheon Canada. Although these new radars "do not satisfactorily mitigate the wind turbine effects where they occur," NATS said in a 2008 report, a study has identified radar system modifications that will be implemented across the board.[7]

The benefits of the changes "would be negated if only a small number of radars were modified," the report said. "In addition, while there may be a small number of primary radars which are not currently subject to wind turbine interference, it is clear that this situation is very likely to change over the lifetime of these facilities."

## 'No Physical Constraint'

The Mitre study concluded that, despite the pending issues, "there is no fundamental physical constraint preventing detection and mitigation of windmill clutter" — and no reason that wind turbines and radar cannot coexist.

The study added that resolving the problem requires — in addition to the creation of mitigation strategies — the development of quantitative evaluation tools to determine when radar interference requires corrective action.

### Notes

1. GWEC. *Wind Power to Provide a Fifth of World's Electricity by 2030*. <www.gwec.net/index.php?id=97&L=0%252525B4>.
2. Brenner, Michael et al. *Wind Farms and Radar*. Project No. 13089022. Report prepared by Mitre Corp. at the request of DHS. January 2008.
3. A related issue that Kalinowski said is not considered in the FAA's review process involves competition for land where primary aviation radars are located. Landowners have been offered "substantial financial incentives" not to renew leases with the FAA for radar installations and instead to sign agreements with companies planning to install wind turbines. Suggestions that the FAA relocate radar equipment to accommodate wind farms are "costly, disruptive, unacceptable and unworkable," Kalinowski said.
4. AWEA. *Airspace, Radar and Wind Energy*. <www.awea.org/pubs/factsheets/04-10_Radar_factsheet.pdf>.
5. QinetiQ. *QinetiQ and Vestas Claim World First in Radar Mitigation Wind Turbine Technology*. <www.qinetiq.com/home/newsroom/news_releases_homepage/2009/4th_quarter/stealth_turbine_trial.html>.
6. Webster, Stu. Testimony on behalf of AWEA before the readiness subcommittee of the U.S. House of Representatives Armed Services Committee. June 29, 2010.
7. NATS. *Mitigating the Effects of Wind Turbines on NATS En-Route Ltd (NERL) Operations*. Sept. 10, 2008.