

# Wind-turbine placement produces tenfold power increase, researchers say

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(PhysOrg.com) -- The power output of wind farms can be increased by an order of magnitude -- at least tenfold -- simply by optimizing the placement of turbines on a given plot of land, say researchers at the California Institute of Technology (Caltech) who have been conducting a unique field study at an experimental two-acre wind farm in northern Los Angeles County.

A paper describing the findings -- the results of field tests conducted by John Dabiri, Caltech professor of aeronautics and bioengineering, and colleagues during the summer of 2010 -- appears in the July issue of the *Journal of Renewable and [Sustainable Energy](#)*.

Dabiri's experimental farm, known as the Field Laboratory for

Optimized [Wind Energy](#) (FLOWE), houses 24 10-meter-tall, 1.2-meter-wide vertical-axis wind turbines (VAWTs)—turbines that have vertical rotors and look like eggbeaters sticking out of the ground. Half a dozen turbines were used in the 2010 field tests.

Despite improvements in the design of wind turbines that have increased their efficiency, [wind farms](#) are rather inefficient, Dabiri notes. Modern farms generally employ horizontal-axis wind turbines (HAWTs)—the standard propeller-like monoliths that you might see slowly turning, all in the same direction, in the hills of Tehachapi Pass, north of Los Angeles.

In such farms, the individual turbines have to be spaced far apart—not just far enough that their giant blades don't touch. With this type of design, the wake generated by one turbine can interfere aerodynamically with neighboring turbines, with the result that "much of the wind energy that enters a wind farm is never tapped," says Dabiri. He compares modern farms to "sloppy eaters," wasting not just real estate (and thus lowering the power output of a given plot of land) but much of the energy resources they have available to them.

Designers compensate for the energy loss by making bigger blades and taller towers, to suck up more of the available wind and at heights where gusts are more powerful. "But this brings other challenges," Dabiri says, such as higher costs, more complex engineering problems, a larger environmental impact. Bigger, taller turbines, after all, mean more noise, more danger to birds and bats, and—for those who don't find the spinning spires visually appealing—an even larger eyesore.

The solution, says Dabiri, is to focus instead on the design of the wind farm itself, to maximize its energy-collecting efficiency at heights closer to the ground. While winds blow far less energetically at, say, 30 feet off the ground than at 100 feet, "the global wind power available 30 feet off

the ground is greater than the world's electricity usage, several times over," he says. That means that enough energy can be obtained with smaller, cheaper, less environmentally intrusive turbines—as long as they're the right turbines, arranged in the right way.

VAWTs are ideal, Dabiri says, because they can be positioned very close to one another. This lets them capture nearly all of the energy of the blowing wind and even wind energy above the farm. Having every turbine turn in the opposite direction of its neighbors, the researchers found, also increases their efficiency, perhaps because the opposing spins decrease the drag on each turbine, allowing it to spin faster (Dabiri got the idea for using this type of constructive interference from his studies of schooling fish).

In the summer 2010 field tests, Dabiri and his colleagues measured the rotational speed and power generated by each of the six turbines when placed in a number of different configurations. One turbine was kept in a fixed position for every configuration; the others were on portable footings that allowed them to be shifted around.

The tests showed that an arrangement in which all of the turbines in an array were spaced four turbine diameters apart (roughly 5 meters, or approximately 16 feet) completely eliminated the aerodynamic interference between neighboring turbines. By comparison, removing the aerodynamic interference between propeller-style wind turbines would require spacing them about 20 diameters apart, which means a distance of more than one mile between the largest [wind turbines](#) now in use.

The six VAWTs generated from 21 to 47 watts of power per square meter of land area; a comparably sized HAWT farm generates just 2 to 3 watts per square meter.

"Dabiri's bioinspired engineering research is challenging the status quo

in wind-energy technology," says Ares Rosakis, chair of Caltech's Division of Engineering and Applied Science and the Theodore von Kármán Professor of [Aeronautics](#) and professor of mechanical engineering. "This exemplifies how Caltech engineers' innovative approaches are tackling our society's greatest problems."

"We're on the right track, but this is by no means 'mission accomplished,'" Dabiri says. "The next steps are to scale up the field demonstration and to improve upon the off-the-shelf wind-turbine designs used for the pilot study." Still, he says, "I think these results are a compelling call for further research on alternatives to the wind-energy status quo."

**More information:** This summer, Dabiri and colleagues are studying a larger array of 18 VAWTs to follow up last year's field study. Video and images of the field site can be found at [dabiri.caltech.edu/research/wind-energy.html](https://dabiri.caltech.edu/research/wind-energy.html)

Provided by California Institute of Technology

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