Electricity in the air

July 3 2012, By Bob Silberg

The system developed at Langley flies a kite in a figure-8 pattern to power a generator on the ground.

(Phys.org) -- The faster a wind turbine's blade spins, the more energy you can get from it. And the farther you get from the hub, the faster that part of the blade is traveling. So the tips of the blades generate most of the turbine's power—as much as 90 percent, according to David North, an engineer at NASA's Langley Research Center in Virginia.

"What if I had a machine that was just the tip of the blade?" North said.

"That's really the idea of airborne wind energy—get rid of 400 tons of tower and concrete, and just fly the blade tip. Basically, it's flying kites to create power."

A wind turbine that's flying at the end of a tether instead of fixed to a concrete foundation has big advantages. For one, it's highly portable—an attractive feature for potential users such as the military, which is eyeing the technology for war-zone bases where importing fuel comes with great risk and expense.

Another huge advantage is that an airborne system can go much higher, up to altitudes where the wind blows faster and more steadily. And with greater speed comes much greater energy. Moving twice as fast produces eight times the power. Moving three times as fast produces 27 times the power.

Aiming for the energy sweet spot

According to North, most tower turbines are about 80 to 100 meters (roughly 300 feet) high, which he says is "pathetically down in the boundary layer of Earth." The boundary layer is where friction from Earth's surface keeps the wind relatively slow and turbulent.

The sweet spot for wind energy starts around 2000 feet up. To use wind at that altitude to generate electricity, you'd have to build a turbine tower taller than the Empire State Building. Or you can fly a kite.

There are two basic types of airborne wind-energy systems. One, known as "flygen," is literally a flying generator, with turbines built into the kite. The resulting electricity travels by tether to a storage or distribution device on the ground.

In the other kind of system, the generator sits on the ground, powered by the reeling out of the tether as the wind catches the kite. By maneuvering the kite like a sailboat tacking upwind, the periodic reeling-in phase can take only about 10 percent of the energy produced by the reeling-out phase, for a 90 percent net gain.

Several private companies are trying to get airborne wind energy ready for market. NASA's contribution focuses on two aspects of the technology: autonomous flight control and aerodynamics.

"A lot of the systems that are flying have pretty cruddy aerodynamics," North said. He explained that companies under deadline pressure from investors aren't able to spend much time on the difficult challenge of optimizing the kite's efficiency. "Here at NASA," he said, "we have the luxury of focusing very specifically on problems and not have to worry about getting a commercial product fielded by a certain date."

Autonomy—the ability to set it and forget it for long stretches of time—is crucial to the airborne wind industry. It's fun to fly a kite manually, but 24/7 for months at a time is a little much to ask of a human operator, even if he or she could manage the precise maneuvers that are required over and over again. And the likelihood that airborne wind farms would be located far offshore, where air traffic tends to soar high above the altitude where these kites would fly, makes autonomy all the more desirable.

Fast, cheap and under control

The companies that have demonstrated autonomous flight so far have relied on sophisticated onboard electronics and flight-control systems, comparable to autopilot systems for commercial aircraft, according to North. "Our goal is to simplify the whole thing," he said, "especially if we are only flying at 2,000 feet, which is in most cases below the clouds."

On March 1, 2012, North and his colleagues at Langley achieved the world's first sustained autonomous flight using only ground-based sensors. "The breakthrough we've made," North said, "is we are basically using a cheapo digital webcam tied into a laptop computer (on the ground) to track the motion of the kite and keep it flying autonomously."

Langley's system operates much like Microsoft's Kinect gaming system, which tracks the body movement of players. "It's pattern recognition software," North said. "The software is basically determining where the kite is, how the kite is oriented and how fast the kite is going, and using all that data to feed into the flight-control system."

The Langley prototype was small, with a wingspan of about 10 feet. But the devices the industry ultimately produces are likely to be much bigger. "Some people are talking very large, like wings the size of Boeing 747 airliners," North said.

Ironically, the biggest challenge the Langley team faces is having their test flights limited to low altitudes, to avoid interfering with aircraft. They are currently trying to work out a deal that would enable them to fly at 2,000 feet for long periods of time in the restricted airspace reserved for NASA above Wallops Island, Virginia.

Given a chance to develop this technology, who knows? We might see a day when those who scoff at green energy alternatives could be given this friendly piece of advice: Go fly a kite!

Provided by NASA