EPRI | ELECTRIC POWER RESEARCH INSTITUTE

TECHNOLOGY INSIGHTS

A Report from EPRI's Innovation Scouts

TETHERED, AIRBORNE WIND TURBINES COULD DELIVER MORE POWER PER TURBINE

THE TECHNOLOGY

Airborne wind turbines could capture winds at higher altitudes, greater speed, and produce more electricity

THE VALUE

Advantages in power production, siting, and harnessing sub-optimal wind conditions could make airborne turbines a viable part of the energy mix

EPRI'S FOCUS

Assessing the technology and accelerating its development

TECHNOLOGY OVERVIEW

An airborne wind energy system is a design concept for a wind turbine generator that is supported in the air without a tower. For supporting the wind collection elements, two types are considered the primary options, both of which are tethered to the ground: aerodynamic systems that rely on wind for support (i.e. kite- or wing-based), and aerostat systems that rely, at least in part, on buoyancy.

Generally, airborne wind energy systems may operate in low (250ft/76m) or high (2,000ft/610m) altitudes. Their advantage is in tapping higher-speed winds without requirements for airborne slip rings or yaw mechanisms, and without the expense of tower transportation and construction.

This Technology Brief focues on the aerostat design, and specifically on the Boston-based Altaeros Energies, Inc. concept.

Source: Altaeros [1]

BASIC SCIENCE

The Altaeros Energies Airborne Wind Turbine combines the high altitude lifting capability of an aerostat with the efficient power generation of conventional wind turbines. Using a helium-filled shell, the system elevates a horizontal-axis wind turbine to high altitudes. Tethers connect the inflatable shell and turbine to a base station and conducts the electricity to the ground. The technology is adapted from tethered aerostats, large tethered balloons familiarfor decades in carrying surveillance and telecom payloads aloft.

Modern aerostats are rated to survive hurricane level winds and have safety features that ensure a slow descent to the ground in the event of a malfunction.

POTENTIAL IMPACT

The world's stronges, most consistent winds are higher above the surface than conventional towers can reach. Airborne turbines can be positioned at higher altitudes (~2,000ft/610m) to take advantage of wind speeds that generally increase with altitude, as surface friction diminishes. With each doubling of the wind speed the amount of theortetical energy or power density increases roughly eight times.

High altitude wind companies are focusing for now below a 2,000 foot ceiling, where winds may be up to 2 1/2 times stronger than those reached by a tower-mounted wind turbine with a 350-foot hub height. [1]

The Federal Aviation Administration (FAA) released draft notice of policy in December 2011 that would allow the new class of airborne wind energy systems to be sited under existing FAA regulatory code (Part 77).

According to Altaeros, this potential breakthrough technology has potential applications for sites with:

- Low ground-level winds-In areas with weak ground winds (i.e. Southeast US) this technology could harness winds that average two times stronger, achieving capacity factors greater thanr 50%
- Distributed/Remote/Off-grid-In areas where the cost of energy is high and the logistics and costs of crane installation are prohibitive, this technology could offer a lower cost solution
- Environmentally Sensitive-In areas with avian, radar, or noise restrictions, this technology could reduce such impacts
- Arctic-In areas where permafrost and weather limit ability to mount turbines onto foundation, this technology could bring the opportunity to reduce costs substantially (~50%)
- Mobile-For sites not suitable for a 20 year+ installation, the technology could offer the option for a timely relocation if if power demands or community acceptance change, or if wind speeds do not meet expectations.
- Deep Water Offshore-At utility scale, this technology holds the potential to significantly reduce the cost of the underwater foundations and logistics, and open up new off-shore resources on the US west coast and beyond in waters with over 60m depth.

VALUE TO THE INDUSTRY

Compared with traditional offshore structures and wind turbines towers, airborne wind energy system developers say that their turbines will produce more cost-effective energy in situations such as those described above.

The horizon for commercial deployment is estimated to be at least three years.

STATE OF THE TECHNOLOGY

In February-March 2012 Altaeros tested a 35-foot-long "proof of concept" airborne wind turbine functional prototype at the Loring Commerce Center in Limestone, Maine, using a modified off-the-shelf Skystream 2.5kW 3.7m turbine. The prototype included an inflatable shell, the SkyStream turbine, 600ft/180m-long tethers, and a towable base station, as well as a multi-node control, communications and measuring system. The advanced results were reported in [3]

The prototype repeatedly climbed to about 350ft/105m, produced power at altitude and landed in an autonomous cycle. It demonstrated increased (2x) power production compared with ground level winds. [3]

Another technology, the Magenn Air Rotor System (MARS) from Ontario, Canada,[4] uses a lighter-than-air tethered device that rotates about a horizontal axis in response to wind to generate power from airborne generators. The Twind Technology concept, developed in Europe, [5] uses a pair of captive balloons, each with a sail connected to it, at an altitude of 800 meters. None of the three technology developers mentioned in this brief have delivered production units at this time.

PUBLIC LITERATURE

www.youtube.com/watch?v=rsHUALU--Wc

http://entrepreneurship.mit.edu/article/altaeros-team-builds-its-first-prototype-airborne-wind-turbine

http://www.bing.com/images/search?q=altaeros+energies+airborne+wind+turbine&qpvt=altaeros+energies+airborne+wind+turbine&FORM=IGRE

NEXT MILESTONES

Altaeros Energies is working to achieve these milestones:

1. Complete a detailed engineering study on the design of a larger commercial-scale airborne wind turbine that includes dynamic modeling of power performance and wind tunnel testing to demonstrate stability in strong winds.
2. Fabricate, test, and deploy a commercial-scale demonstration unit of a small system at a customer site at an altitude of over 1,000ft/300m. The demonstration would seek to prove long-term reliable, autonomous operations in various real-world weather conditions, and improved capacity factor of power generation relative to conventional tower-mounted wind turbines over an extended period.
3. Complete a feasibility study on a larger design that can produce utility-scale power in wind farms with multiple systems deployed.
4. Work with industry partners to design verification and certification standard for airborne wind energy systems, gain addition public feedback on visual impacts of high altitude systems, and to continue to work with the FAA, U.S. Fish and Wildlife Service, and U.S. Department of Defense to demonstrate expedited permitting processes.

COLLABORATION

Altaeros Energies won the 2011 Conoco Phillips Energy Prize and has received funding from the U.S. Department of Agriculture, the California Energy Commission and the Maine Technology Institute. EPRI is considering collaboration on future assessments.

NEXT STEPS

Based on the proof-of-concept prototype and development plan, it appears that there is high project feasibility of airborne wind turbines to reduce the levelized cost of electricity of mid-scale wind power, and to extend wind development to areas with limited winds.

EPRI participation in technology acceleration may accelerate the commercial application to small wind and community wind systems in the short term and to the offshore wind sector in the long term.

REFERENCES

1. Altaeros Press release **http://www.altaerosenergies.com/AltaerosPressRelease032712.pdf**
2. Altaeros Energies High Altitude Wind Energy Presentation
3. Altaeros Airborne Wind Turbine Proof of Concept Prototype Test Summary (Proprietary)
4. **http://www.magenn.com/products.php**
5. **http://www.youtube.com/watch?v=d9bY-w7pRxs**

1026706 November 2012

Electric Power Research Institute
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com