Aeerstatica Energy Airships - Tethered aerostat wind generator

Peter Lobner, 19 June 2023

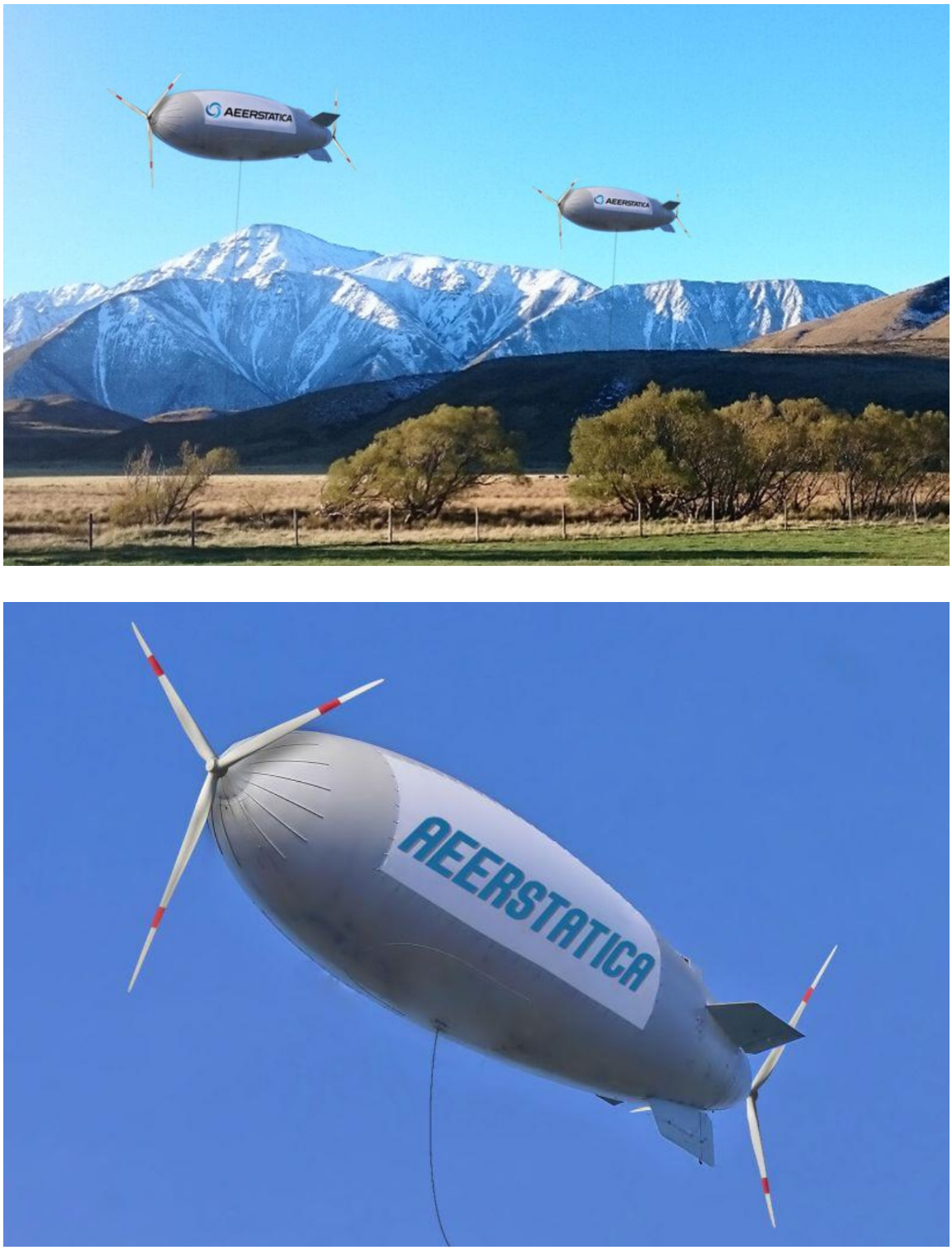
1. Introduction

Aeerstatica Energy Airships was founded in 2020 in Ravensburg, Germany, by brothers Johannes and David Gerber after developing for many years their concept for a tethered aerostat wind generator. The firm's website is here: https://www.aeerstatica.de

Aeerstatica's tethered aerostat wind generator is designed to be deployed at an altitude of about 300 m (984 ft) above ground level, where stronger prevailing winds offer more energy for harvesting than at ground level (Aeerstatica estimates up to eight times more energy). This gives an airborne generator a potential performance advantage over wind generators built on the ground.

From the perspectives of land use and environmental impact, Aeerstatica's tethered aerostat wind generator requires very little land development and construction at a deployment site, where an anchored mooring / winch system and other ground support equipment will be located. In comparison, conventional wind turbines require road access for heavy vehicles transporting material for massive foundations and then assembling the large wind turbine generator components on site. Both types of wind turbine generators require similar electrical connectivity to a nearby electric power grid.

Four tethered aerostat wind generators deployed in a rural setting.
Source: Aeerstatica Energy Airships



Aeerstatica's tethered aerostat wind generators face into the wind when deployed, with the bow and stern rotors rotating in opposite directions. Source, both graphics: Aeerstatica Energy Airships

I am grateful to Aeerstatica for their thoughtful input for article.

2. Tethered aerostat wind generator patent

The basic design and operational characteristics of the Aeerstatica airborne wind generator are presented in German patent DE102020120769B3, which was granted in September 2021, and World Intellectual Property Organization (WIPO) document WO2022/028802A1, which was published on 10 February 2022.

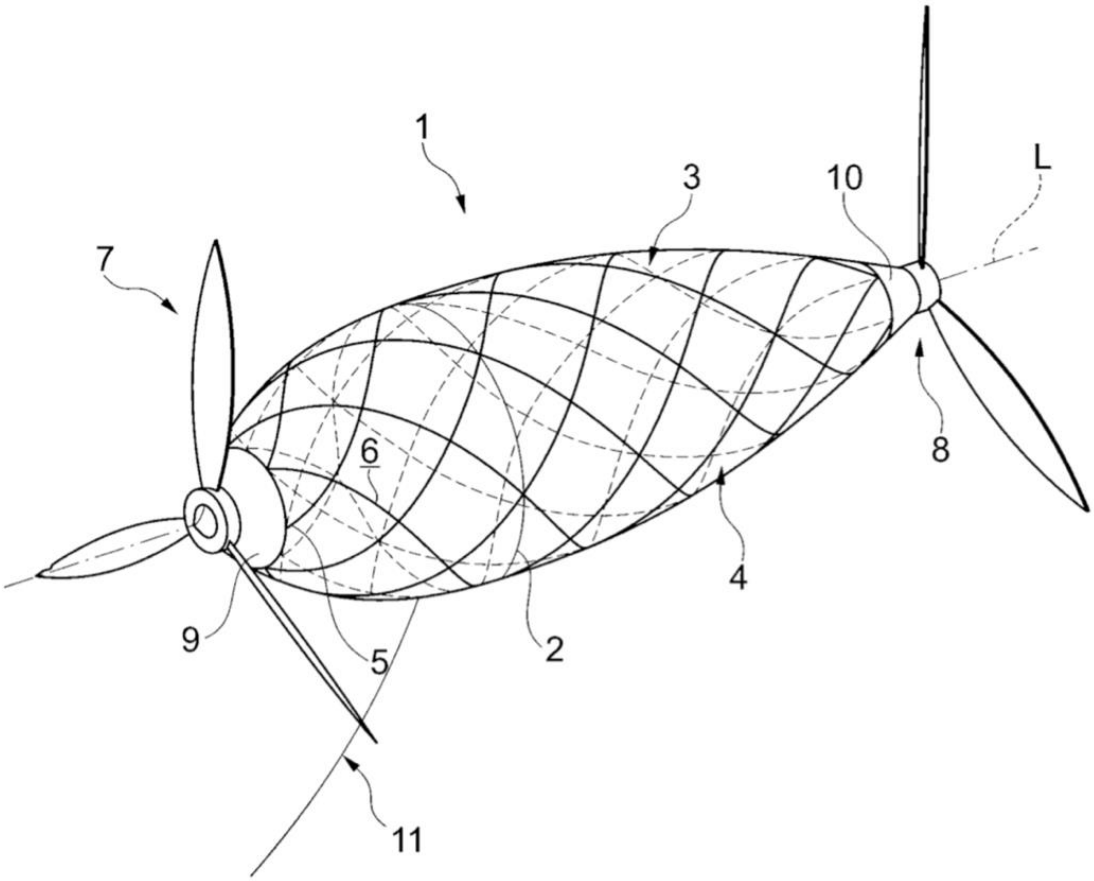


Fig. 1

Legend: The airborne tethered wind generator (1) is comprised of a buoyant body (2) with a suitable outer skin to retain the lifting gas (3). The shape of the buoyant body is established by a rigid helical structure (4, 5, 6) terminating at hubs (9, 10) at the bow and stern, which support and house the bearings for rotors (7, 8). The rotors rotate perpendicular to the longitudinal axis, in opposite directions, and mechanically drive one or more generators to produce electricity that is delivered to an anchored ground station via an electrical cable attached to the tether (11).

General arrangement of Aeerstatica's tethered aerostat wind generator. Source: DE102020120769B3

The patent notes, "…the buoyant body can have a cigar shape or have the characteristic shape of airships. This shape offers the advantage that the buoyancy body can align itself more defined in the air flow. A corresponding streamline shape can ensure advantageous aerodynamics so that the rotors are illuminated by the air flow as effectively as possible." In Aeerstatica's 2022 concept artwork, the airborne wind generator is shown with conventional cruciform tail fins, which are not addressed in the patent. The addition of the tail fins provides a stronger turning moment to help keep the streamlined buoyant body pointing into a fluctuating air stream.

The exterior shape of the buoyant body is established by a rigid helical exoskeleton installed over transverse ribs. The helical exoskeleton is comprised of at least two helical substructures that are wound in opposite directions. This design feature enables the rigid hull to better absorb the torque loads transmitted into the hull by the large rotors that are rotating in opposite directions at each end of the hull.

The lifting gas is stored in several lifting gas cells within the buoyant body. The patent notes, "…this has the advantage that there is still a buoyancy force if, for example, one of the lifting gas cells leaks and gas escapes from it."

Patent DE102020120769B3 does not address deployment and recovery of the airborne wind generator.

3. Concept of operation

Lifting gas

Aeerstatica plans to operate their unmanned tethered aerostat wind generators initially with helium lifting gas. However, as a long term goal, Aeerstatica envisions using hydrogen as the lifting gas for their large production aerostat wind generators, taking advantage of the greater lift and the lower costs of hydrogen, particularly as hydrogen becomes more widely available for use in transportation systems. The unmanned nature of the tethered aerostat should help alleviate most safety concerns about the use of hydrogen.

The lifting gas cells in Aeerstatica's rigid aerostat are at atmospheric pressure. This will result in a lower lifting gas leak rate than a conventional, non-rigid aerostat that operates at a slight superpressure, and typically requires regular additions of lifting gas to make up for leakage. Aeerstatica is evaluating options for replenishing lifting gas when needed, but without hauling the aerostat down to a mooring on the ground.

Safety systems to contain an aerostat that slipped its mooring will be provided. This will include an emergency lifting gas vent system.

Deployment to, and retrieval from, a remote site

Aeerstatica is developing means for deploying an aerostat to a new site, connecting to installed ground systems, and commencing operation as a power generator.

One option being considered is to tow the aerostat to the remote site with a helicopter or drone, lower a tether and connect to the anchored ground station, and then disconnect from the tow vehicle. During the tow, the aerostat's buoyancy would be reduced to near neutrally buoyancy, as opposed to its highly buoyant state while operating as a power generator.

Applying this process in reverse, an aerostat could be removed from one site and delivered to another site (i.e., for reassignment, for maintenance that can't be performed onsite, or for decommissioning).

Ground station

Like other large tethered aerostat systems, Aeerstatica's tethered aerostat wind generator is connected to ground via an anchored ground station that performs a variety of functions, including:

- The ground station is the interface between the aerostat wind generator and a local substation that connects to the electric power grid.
- The winch on the ground station can adjust the length of the tether, and thereby optimize the aerostat's operating altitude based on wind conditions.

- In normal operation, the tether will operate with a relatively high tension because the aerostat will be trimmed for high aerostatic buoyancy and the large diameter rotors create significant aerodynamic drag. These forces are countered by the tension in the tether.
- The ground station has real-time monitoring and control systems for aerostat lifting gas, air and electric power systems.

In-service inspections and maintenance

Aeerstatica is evaluating several alternatives for performing periodic maintenance and inspections aboard a deployed aerostat. Onsite servicing options include crew delivery via a cable car that climbs the mooring cable to the aerostat, or a helicopter shuttle that lands the crew on the deployed aerostat. Alternatively, the aerostat could be disconnected from its ground station and transferred by air to a remote servicing point.

Contingency landing

The aerostat, tether and ground station will be designed to enable the aerostat to ride out high winds aloft, and thereby avoid ground-level buffeting while moored during a storm. If needed, the winch system at the ground station will be able to haul in the aerostat for an automated contingency landing at the deployment site. In classical rigid airship fashion, a mooring mast would be used. To accomplish this, the rotors would have to be moved in position to allow clearance for landing (i.e., so as not to “pin” the airship into the ground with a downward pointing rotor blade). Space considerations on the ground for emergency landing will establish distances between ground stations.

4. The Aeerstatica industrial team

Aeerstatica's tethered aerostat wind generator is a scalable design that has the potential for widespread on-shore deployment, including areas where large, modern terrestrial wind turbine generators can't be installed (i.e., due to limited transportation access, sensitive environmental area, etc.).

In a 21 March 2022 press release, the firm announced: "Aeerstatica, Ballonbau Wörner, FormTL and PTS have joined into a strategic partnership to build a prototype of a new, highly economic and efficient wind power generation system. The companies aim to make available renewable energy cheaply and around the clock, to help keep the environment safe and healthy and to reduce the dependency on fossil fuels." The team members have the following roles in the strategic partnership:

- Aeerstatica UG (Haftungsbeschränkt) is aiming to support the energy transitions through building and operating aerial power generation.
- Ballonbau Wörner GmbH from Augsburg is an innovator for technical textiles in Aeronautics in the design and manufacture of gas cells and envelopes for aerostats. Their website is here: https://www.ballonbau.de
- FormTL ingenieure für tragwerk und leichtbau Gmbh, of Radolfzell near lake Constance, have experience with simulation for loads and structural design. Their website is here: https://www.form-tl.de
- PTS Maschinenbau GmbH of Dillingen on the Danube has extensive lightweight structure experience. Their website is here: https://www.ptsmaschinenbau.de

5. Development schedule

Aeerstatica has demonstrated the basic mechanical and electrical operating principles of their tethered aerostat wind generator with a sub-scale, non-buoyant model.

Subscale proof-of-principle demonstrator. Source: Screenshot from Aeerstatica Energy Airships video (2 March 2023).

The first flight of a buoyant prototype tethered aerostat wind generator originally was planned for summer 2022 at the Innovationspark in Augsburg, Germany. That date has slipped into 2023.

The flying prototype has an important role in validating the design and expected performance of the tethered aerostat wind generator and helping to establish operating and maintenance practices to ensure high availability and long operating life.

6. For more information

- “Strategic Partnership to build a prototype,” Aeerstatica, 21 March 2022: https://www.aeerstatica.de/20220321_PMv3.pdf
- Dr. Katja Reisswig, “Airship to Use High Winds to Generate Wind Electricity,” technewable, 24 May 2022:
    - Original article in German: https://technewable.com/luftschiff-zur-erzeugung-von-windstrom/
    - Article translated to English: https://lynceans.org/wp-content/uploads/2022/12/a6625e6bc9f4e7fc34b71588d003b61f.pdf

Patents

- DE102020120769B3, “Device for using wind energy,” Inventors: David Gerber & Johannes Gerber, Filed 6 August 2020, Granted 23 September 2021, Assigned to Aeerstatica Ug Haftungsbeschraenkt: https://patents.google.com/patent/DE102020120769B3/en
- WO2022/028802A1, “Device for using wind energy,” Filed 7 July 2021, Published 10 February 2022: https://patents.google.com/patent/WO2022028802A1/en

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