

Next-generation batteries to enable electric aviation

By Bruno Vanzielegem (Cuberg)

Introduction

Cuberg is developing a next-generation battery technology to power the rise of electric mobility, particularly addressing growing demand in electric aviation. Early developments in electric aviation include both the emerging electric vertical take-off and landing (eVTOL) market and electrification of conventional take-off and landing aircraft (eCTOL). Both applications need next-generation battery technology to provide competitive range and payload capacities. Cuberg's batteries deliver a step-change improvement in energy density and safety compared to the best lithium-ion (Li-ion) batteries in the world today. When equipped with our technology, electric aviation solutions will deliver greatly improved flight range, payload capability, and operational cost, providing better capabilities for firefighting, cargo delivery, urban and regional transportation, search-and-rescue efforts, logistics missions, and monitoring for agriculture, oil and gas, and utilities. Cuberg's batteries will enable the commercialisation and democratisation of clean aviation services based on renewable technologies.

Cuberg technology

Cuberg's technology addresses the shortcomings of conventional Li-ion batteries in two ways. First, Cuberg's batteries combine a high-energy cathode with an energy-dense Li metal anode to dramatically increase energy density by about 80% compared to the best Li-ion battery technology. Second, Cuberg has developed a non-flammable and thermally stable liquid electrolyte, thus replacing flammable organic solvent-based electrolytes responsible for the poor safety profiles of Li-ion batteries. Cuberg's proprietary electrolyte chemistry lies at the heart of our innovation. The chemical stability and

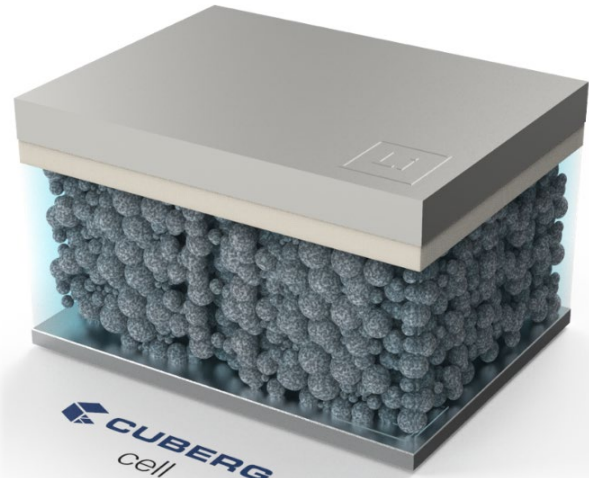


FIGURE 1: Conceptual Cuberg cell architecture

unique properties of our electrolyte lead to enhanced compatibility with both high-capacity metal oxide cathodes and lithium metal anodes.

In 2019, Cuberg performed the world's first eVTOL drone flight with a lithium metal battery, increasing flight time by 70% to 90% compared to a similar drone powered by Li-ion batteries. Also, the Cuberg battery performance was independently validated by the Department of Energy in 2020. Three key battery performance measures need to be optimised in balance for successful aviation commercialisation: specific energy, which allows for longer flight times and ranges at a given weight; specific power output, which enables greater aircraft weights and payload capacity; and cycle life, which impacts cost of ownership. The testing by the Department of Energy's Idaho National Laboratory on Cuberg's 5-Ah (amp-hour) battery cells indicated specific energy of 369 Wh/kg, specific power of 2,000 W/kg, and 370 cycles with C/2 charging before the cells reached end of life at an 80% capacity cut-off.



FIGURE 2: Cuberg 5Ah pouch cell batteries

Cuberg's batteries, based on its breakthrough lithium metal technology, are optimally designed for successful commercialisation. Cuberg has achieved industry-leading results in a pouch cell using technology that capitalises on the scale and quality of the existing Li-ion manufacturing ecosystem. These strengths allow Cuberg to bring next-gen batteries to the aviation market, delivering significant improvements in range and payload while preserving the substantial deployed capital base of Li-ion manufacturing.

While Cuberg has demonstrated a pouch cell battery with exceptional performance, it is crucially important to integrate the cell into, and manufacture a lightweight, high-performance battery module for validation by aviation customers. Cuberg is carrying out an ambitious work plan consisting of cell component studies, pilot production set-up, module design and engineering, module prototype manufacturing, and customer validation. The modules are being designed to incorporate in eVTOL and eCTOL applications, powering the early forays into electric aviation over the next few years.

What Benefits Are Expected?

The electric aviation sector is still nascent, and direct benefits are difficult to estimate, especially for the emerging urban air mobility applications. However, a comprehensive study by the National Renewable Energy Laboratory (NREL)¹ highlighted the potential of electric aviation to reduce operational costs, open previously uneconomical regional destinations, reduce emissions, reduce noise, increase accessibility, and be a driver for economic development activity. Cost reductions can be attributed to a significant decrease in fuel costs and a reduction in maintenance costs. Emissions reductions are a second key drivers for electrifying aviation. The replacement of fossil-fuel powered short-haul aircraft with their electric equivalent promises significant emissions reductions, including green-house-gas reductions. A case study in the NREL report evaluated the impact of electrifying routes within 300 miles of Denver International Airport. One of the key conclusions showed that replacing a fossil fueled aircraft with a similar electric aircraft would reduce fuel cost from approximately \$400 to \$50, combined with a reduction in CO₂ emissions as much as 95%. While no mandates have been put in place in the United States yet, Norway is one of the countries taking a lead in this area, mandating that by 2040 all civil domestic aviation will be electric.²

The Next Three Years

For Cuberg, the next three years promise to be a period of accelerated growth, with a singular focus on maturing the Cuberg battery into a viable product for storing energy to power electric aircraft. Hand in hand with maturing the battery, it is critically important to mature the battery module and pack towards a system that can be used safely in an aircraft and deliver the performance parameters to enable this new era of electric aviation. This development is happening in close collaboration with our eVTOL and eCTOL partners.

¹ Electrification of Aircraft: Challenges, Barriers, and Potential Impacts <https://www.nrel.gov/docs/fy22osti/80220.pdf>

² Electric aviation ready for take-off in Norway by 2030, report says <https://thebarentsobserver.com/en/travel/2020/03/electric-aviation-should-be-ready-take-norway-2030>