Development of a High Voltage Lithium BATtery

Reporting

Project Information

LiBAT
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Closed project

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€ 584 225,00

Coordinated by
TWT GMBH SCIENCE & INNOVATION
Germany

Periodic Reporting for period 1 - LiBAT (Development of a High Voltage Lithium BATtery)

Reporting period: 2018-11-01 to 2020-10-31

Summary of the context and overall objectives of the project

With the urgent need for cleaner transport – be it in the air, on the street or anywhere else – a central path pursued is the transition from fossil fuels towards electrification. Using electricity from renewable energy sources to power airplanes can cut overall greenhouse gas emissions drastically. But state-of-the-art batteries are still relatively heavy, posing a serious obstacle for the breakthrough of electrically propelled aviation.
This is where the EU-funded Clean Sky 2 project LiBAT took off. The LiBAT team designed and prototyped an outstanding lithium battery. The target was to reach superior overall energy and power density based on an intelligent pack concept rather than new cell technology. The battery system consists of two parts of elongated shape to be placed in the two wings of an electrified glider, each powering one of the two motors of the glider. The combination of energy, power and weight targets posed an ambitious challenge: The maximum weight of the battery pack was to be kept below 55 kg and an energy density of 200 Wh/kg or more at 1C discharge while 10 kW of power should be provided continuously per motor, with even higher values at peak. With further applications in mind, connection of the battery to AC aircraft networks was to be considered. Special attention was to be placed on a clear definition of the interfaces to current aircraft architectures. The thermal conditions of the battery system were to be considered to ensure a safe and efficient operation.

The potentially game-changing LiBAT battery system addresses the weight problem by an extraordinary level of integration and a combination of advanced technologies. By integrating multi-level-inverter technology into the battery, the LiBAT team created a unique, tuneable AC battery system that eliminates the need for additional charging or motoring power electronics and saves extra weight. Combined with a powerful immersive thermal management and a suitable cell choice, both excellent energy and power performance are realized, given the low weight and volume of the pack. The modular design guarantees a scalable system. Connected to an electric propulsion unit, the prototype battery that was built in LiBAT demonstrated powers of up to 3,25 kW in a lab setting – enough to maintain level flight for the targeted application, an electrified glider. With the identified design improvements, take-off will be feasible as well. Due to an exceptional commitment of the partners, LiBAT succeeded even though it faced extraordinary circumstances with the COVID-19 pandemic.

For future developments, a reasonable next objective would be to implement identified improvements and implement the battery in an actual glider prototype. On the other hand, the design could be advanced to a new level by integrating the battery structurally into aircraft architectures. Furthermore, new battery cell technologies could be considered.

Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far

To develop the LiBAT design a detailed set of requirements was derived and central design choices were made, upon which geometrical models and weight estimations were set up. Fluid dynamics and system simulations confirmed the electrical and thermal performance of the battery in charging, motoring and AC network supply. They raised critical questions early to improve the design iteratively and develop suitable control strategies for the power electronics and battery management. In parallel, the construction of the battery demonstrator was pursued. After the initial planning phase, relevant components were ordered. The demonstrator was assembled and commissioned step-by-step with accompanying tests to confirm functionality for each subcomponent. Finally, the battery was integrated into a laboratory test rig including a motor and attached propeller. The battery successfully powered the propulsion unit at high speed, providing 3,25 kW of power - sufficient to maintain level
flight for the glider. Unfortunately, the power required for take-off could be reached only in simulations due to the lack of a suitable motor.

The LiBAT team developed an outstanding compact and lightweight lithium battery. It is unique in the level of integration, and has a strong performance in terms of both power and energy. The combination of thermal management, power electronics and battery management provides exceptional safety properties. The central results can be used for further developments or transferred to other contexts:

- The LiBAT battery design
- The battery demonstrator
- Modular simulation models
- Measurement data
- The battery test setting

A row of activities has been initiated to ensure that LiBAT results and insights are further utilized. The consortium members use them in various ways to maximize the direct business impact:

- Evolution of the LION Smart LIGHT Battery concept
- Expansion of TWT model library by electrothermal models of battery pack
- Simulation and consultancy services of TWT for early stage HV system and/or battery development
- Improvement of LION Smart’s test benches
- Expansion of LION Smart’s business fields

Furthermore, the partners make the results available to the public and promote them:

- Promotion of LiBAT in oral presentations on 3 conferences. Further were cancelled due to COVID-19
- Further conference contributions and exhibitions planned
- Publication of LiBAT results currently in preparation, submission in Jan 2021
- Promotion through the project website, social media and several press releases
- LiBAT video, to be published in Jan 2021

**Progress beyond the state of the art and expected potential impact**

*including the socio-economic impact and the wider societal implications of the project so far*

The AC battery developed in LiBAT is novel in its high degree of integration, with progress beyond the state-of-the-art in:

a) Integration of electric storage and power converting functions. Batteries including multi-level inverters are known from stationary storage solutions but for mobile applications in (airborne) vehicles, development is still in very early stages. The joint use of thermal management in the integrated system taps even more synergy potential.

b) Innovative packaging concepts. The high level of integration allows for a joint housing, shorter connectors, cables and pipes, and less cooling liquid. It thus reduces internal resistances, weight, and resources used.

c) Advanced management functions. Combining conventional battery management with system
management functions for charging and motoring, synergies can be used to reach a new level of control.

LiBAT brings electrification one step further. The advanced technologies developed for electrified aircrafts offer simplified power networks with easy maintainability, reduced total weight at aircraft level, and a good quality of AC and HVDC power networks. It brought added value to aircraft design and testing capabilities. Thus, LiBAT results strengthen the cooperation, innovation and competitiveness of the European aviation industry and its suppliers. The modular and scalable design facilitates the transfer of LiBAT technology to other applications, including electrified street vehicles. LiBAT will have a long-term impact in the following areas:

• Environmental: The weight savings will have a positive effect on fuel consumption
• Competitiveness: Reduction of operative costs through better electrical network integration by reducing equipment needed and number/length of power cables
• Societal: New opportunities for research and future business for the European industrial supply chain and Academia