FTA RESEARCH

REPORT SUMMARY

Transit Bus Applications of Lithium Ion Batteries: Progress and Prospects

Background

The publisher Elsevier Science and Technology (ES&T) invited the author to prepare a chapter for its 2012 Handbook of Lithium Ion Batteries Applications that will highlight the range of recent transit bus applications of advanced lithium ion batteries (LIBs) integrated into Rechargeable Energy Storage Systems (RESS). While the handbook chapter was intended to inform a broad, interdisciplinary, and international technical audience, the Federal Transit Administration (FTA) supported the preparation of this report as an open source, Web-postable version, available to all public transit stakeholders.

Objectives

The purpose of this report is to provide an overview of the diverse LIB-based chemistries and rechargeable energy storage system architectures that were successfully deployed in operational hybrid, electric, and fuel cell transit buses. The report also discusses the successful federal programs that developed, demonstrated, and deployed advanced, fuel efficient, and environmentally-friendly transit buses using LIBs. Another objective is to derive lessons learned from the operational experience of advanced electric drive buses concerning safe operability, durability, reliability, and cost, which shed light on the major challenges and prospects for large-scale LIB commercialization and adoption into urban bus fleets.

Findings and Conclusions

LIBs are lighter and smaller and have greater storage capacity and density, increasing the energy effiency and environmental performance of advanced buses.

Transit bus fleets serve as a technology demonstration platform and a proven early-adopter market niche for deploying advanced hybrid and electric drive trains with RESS. As fuel prices rose and stricter environmental regulations were enforced in the past decade, diesel urban transit bus fleets became cleaner and "greener" through adoption of alternative fuels (natural gas, biodiesel) and/or the advanced power trains of hybrid-electric buses (HEB), electric buses (EB), and fuel cell buses (FCBs). Due to operation on fixed routes and schedules, professional drivers, and scheduled maintenance and repair in central depots, transit bus fleets proved to be a good test-bed for evaluating new LIB battery performance. By storing and delivering captured regenerative braking energy, the lighter and smaller LIBs with greater storage capacity and energy density have improved the energy efficiency and environmental performance of advanced buses.

Commercially-available HEBs, EBs, and FCBs provide 30–50 percent better fuel efficiency in city operation over their diesel counterparts, albeit at higher initial cost, but lower lifecycle fuel and maintenance costs. The report illustrates the successful integration of LIB chemistries and RESS configurations for several operational and emerging U.S. commercial transit bus applications. External infrastructure and on-board RESS re-charging and Auxiliary Power Units (APUs) options for range extension of plug-in hybrids and all electric buses are also illustrated. The LIB chemistries with respective electrical and thermo-mechanical properties and their power management and control technologies are rapidly evolving.

FTA research and technology (R&T) and multi-year competitive grant programs such as the National Fuel Cell Bus Program (NFCBP), the Clean Fuels Program, and the Transit Investments for Greenhouse Gas and Energy Reduction (TIGGER) program enabled the development, demonstration, and nationwide deployment of advanced electric-drive buses based on LIBs in transit fleets. These programs are essential for enhancing LIB commercial viability in public transit fleets.

Key lessons learned and remaining challenges regarding LIB operational safety, performance, reliability, durability and cost, and barriers to large-scale deployment of LIBs in urban bus fleets are also discussed. There are remaining challenges related to cost, safety, reliability, and durability. Currently, the best LIB warranty coverage of 5–6 years is only half of the 12-year minimum required transit bus service life. Thanks to federal investments and incentives, there is rapid progress in improving LIB chemistry, energy capacity, power density, life-cycle performance, and reducing cost. Therefore, accelerated LIB deployment in advanced bus fleets and other heavy-duty applications is expected in the near term.

Benefits

This report provides a comprehensive snapshot of various electric drive buses with on-board rechargeable energy storage systems that benefit from integration of lighter, smaller, and more powerful Lithium Ion Batteries, complemented as needed by Auxiliary Power Units (APUs). This assessment of lessons learned regarding LIB safe operability, reliability, durability, and cost will assist in addressing remaining research needs to ensure the commercial viability of LIBs for national and global transit bus markets.

Project Information

FTA Report No. 0024

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