



UNIVERSITY OF DELAWARE FUEL CELL TRANSIT VEHICLE PROGRAM, PHASES 1 – 5

Background

The University of Delaware's Fuel Cell Transit Vehicle Program was initiated in September 2005 and ended in November 2022. A total of five phases were executed during this 17-year period. Phase 1 was initiated in September 2005 with a consortium led by the University of Delaware (UD). Additional members included the Electric Power Research Institute (EPRI), Ballard Inc., Ebus, Air Liquide, and Delaware Transit Corporation (DTC). UD, EPRI and DTC were signatories to the consortium agreement, and Ballard Inc., Ebus, and Air Liquide were consortium partners. Subsequently, Phase 2 was initiated in September 2006; Phase 3 in September 2007; Phase 4 in September 2008; and Phase 5 in September 2010.

Objectives

The overall goal of the Program was to research, build, and demonstrate a fleet of fuel cell powered buses and hydrogen refueling infrastructure in Delaware. The specific objectives were to conduct basic research to improve fuel cell performance, efficiency, and durability through experiments and modeling; perform design analysis and configuration of the fuel cell stack, hydrogen storage system, delivery and refueling infrastructure, batteries for hybrid operation, control systems and hybrid operation, and sensors for real-time monitoring; participate in vehicle build and integration of systems; deploy buses in Delaware; develop infrastructure for maintenance and refueling; collect data on vehicle performance, efficiency, emissions, reliability, serviceability, and maintainability; and conduct public education and outreach as well as technology transfer to DTC.

Findings and Conclusions

The major accomplishments of the Program were as follows. The Phase 1 fuel cell/battery hybrid bus was delivered and deployed on the UD campus in April 2007. It was a 22-foot, 22-passenger bus, equipped with a 20 kW Mark 9 SSL Ballard stack, 60 kWh of Nickel-Cadmium batteries, 12.8 kg of hydrogen in twin composite tanks (5000 psi), and with a 140-mile range. The Phase 1 Bus was operated on the UD campus for several years with a ridership of hundreds of students per day. The Phase 1 Bus also participated in the first-ever demonstration of vehicle-to-grid (V2G) technology, which subsequently became a landmark achievement of UD.

The Phase 2 Bus was identical to the Phase 1 Bus, except that it was equipped with twin Mark 9 SSL Ballard stacks for a total of 40 kW of propulsive power. The Phase 2 Bus began operation in October 2009, and also transported hundreds of students across campus every day.

The Phase 3 Bus was a 40-ft Gillig glider equipped with a triple-Mark 9 SSL Ballard stack (total of 60 kW), 33 kWh of Lithium-Titanate batteries, and 19.2 kg of hydrogen storage (5000 psi). The Phase 3 Bus was delivered in 2015 and was used primarily as a test vehicle. In addition, a hydrogen refueling station was built at Air Liquide's R&D Innovation Campus in Newark, DE in 2007 and served as the filling station for the UD fuel cell buses throughout the duration of this project.

A major accomplishment of Phase 4 was the launch of a start-up company Sonijector LLC which provides fuel cell balance-of-plant solutions to automotive companies worldwide based on the patents developed during the Program.

Phase 5 continued with vehicle testing and demonstration, research tasks aimed at improving fuel cell component life and reliability, and the development of intelligent power management strategies to improve the fuel economy and lifetime of fuel cell vehicles through vehicle modeling and simulation.

Benefits

This Program was instrumental in helping to create the Center for Fuel Cell Research on the UD campus in 2009, whose mission was to promote basic and applied research to improve fundamental understanding of fuel cells; provide students with the opportunity to participate in fuel cell research and demonstration projects; support companies in the region that are engaged in the development of fuel cells, as well as firms engaged in hydrogen production, storage and distribution; and create an opportunity for national and international recognition and a platform for economic growth. The Center for Fuel Cell Research was renamed the Center for Fuel Cells and Batteries in 2017. Through this center, over 50 undergraduate and graduate students, as well as post-docs, were trained in fuel cell science and technology, and over 80 book chapters, patents, and papers were published in top scientific journals.

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