FTA RESEARCH

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REPORT SUMMARY

Wayside Charging and Hydrogen Hybrid Bus: Extending the Range of Electric Shuttle Buses

Background

The Center for Energy, Transportation and the Environment (CETE) at the University of Tennessee at Chattanooga (UTC), in partnership with the Chattanooga Area Regional Transportation Authority (CARTA), conducted research and outreach tasks aimed at increasing the range of electric shuttle buses.

Objectives

The primary objectives for this work program were the following:

- Demonstrate the use of wireless charging using Inductive Power Transfer (IPT) to increase the range of electric shuttle buses.
- Demonstrate the use of advanced batteries and an Auxiliary Power Unit (APU) powered by an Internal Combustion Engine (ICE) running on hydrogen to increase the range of an electric shuttle bus.
- Provide assistance to Emory University to improve operation of its fleet of electric shuttle buses.
- Complete procurement and installation of a hydrogen fueling station needed to provide fuel for the APU.

Findings and Conclusions

Advanced batteries, in combination with wayside charging, have the potential to greatly expand the opportunity for electric buses by making it possible for larger electric buses to travel over longer routes.

In the first research effort, the range of an electric shuttle bus was increased from less than 50 miles on batteries alone to more than 120 miles by wireless charging during the period when passengers are normally boarding the bus. CETE, in partnership with CARTA, demonstrated wireless charging for electric shuttle buses using IPT technology provided by Conductix Wampfler, AG. The system includes a track supply that provides power at 20 kHz to a coil embedded in the roadway. The power is transferred to the bus through an air gap to pick-up coils mounted on a mechanism under the bus that drops the coil into position 40 mm above the embedded coil. This short "opportunity" charge of 3 minutes duration at 60 kilowatts provides enough traction energy to power the bus for approximately 3 miles, thereby eliminating the normal range constraint that, until now, has required battery swapping during the day to cover the required daily route of 100 miles. Overall efficiency from the grid to the vehicle was found to be more than 90%, resulting in an energy cost per mile of less than $0.10 while producing zero tailpipe emissions. Measurements of electromagnetic field strength at the edge of the coils near street level and at all locations inside the bus were found to be well below draft international standards for exposure.
In the second research effort, the range of a battery-centric electric shuttle was increased from less than 50

miles to more than 120 miles by a combination of improved batteries and the addition of an on-board generator powered by a hydrogen-fueled ICE. Because of recent interest in compressed natural gas (CNG) as a fuel for transportation, the ICE controls were made to be switchable between hydrogen and CNG which produced an increase in range to more than 170 miles when running on CNG with a fuel cost significantly less than hydrogen. However, it should be noted that replacing the original Ni-Cd batteries with $LiFePO_4$ batteries alone increased the range from less than 50 miles to more than 100 miles. Since this exceeded the daily range required by CARTA, the added complication and cost of having to establish hydrogen or CNG fueling capability and maintain a unique hybrid bus resulted in a decision by CARTA to remove the generator and deploy the shuttle with the new batteries alone. Perhaps more significantly, this research demonstrated that these new batteries, in combination with wayside charging, have the potential to greatly expand the opportunity for electric buses by making it possible for larger electric buses to travel over longer routes than previously possible.

At Emory University, CETE discovered that the performance of the university's fleet of electric shuttle buses had deteriorated to such an extent that the operational range had been reduced to less than 25 miles with fully-charged batteries. It was determined that the batteries were in severe need of reconditioning and that the battery chargers being used were the proximate cause of the problem. With assistance from FTA, Emory's fleet of five electric shuttle buses was transferred to CARTA. One of these buses was equipped with wireless charging equipment and used to demonstrate wayside charging as described above. A second was converted into a hydrogen hybrid bus as part of the second research effort described above. A third was put into regular service after an extensive effort to recondition the batteries. The other two are being held in reserve for possible deployment by CARTA.

The hydrogen fuelling station was completed and commissioned in December 2009. It is now capable of producing 2 kg per day and storing 10 kg of hydrogen at 6,000 psi.

Benefits

The demonstration of wireless charging has opened up new opportunities for deployment of electric buses with larger buses over routes heretofore impossible for electric buses. The demonstration of an inexpensive APU as a means of building a battery centric bus could open up opportunities for deployment, especially where transit operators already use hydrogen or compressed natural gas.

Project Information

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