COUNTY OF MILWAUKEE
INTEROFFICE COMMUNICATION

DATE: June 17, 2020

TO: Supervisor Marcelia Nicholson, Chair, County Board of Supervisors

FROM: Donna Brown-Martin, Director, Department of Transportation

SUBJECT: Informational Report - MCTS Hybrid-Electric Bus Analysis Final Report

POLICY

Amendment 1A012 of the 2020 Capital Improvement Budget directed the Milwaukee County Transit System (MCTS) to study and develop a plan for the eventual replacement of its entire fleet of diesel buses with battery-electric buses (BEBs) and/or electric-diesel hybrid buses as a bridge to a BEB fleet.

BACKGROUND

MCTS' Battery Electric Bus and Facility Improvement Analysis was presented to the Transportation, Public Works and Transit Committee during its December 4th, 2019 meeting by M.J. Bradley & Associates' (MJB&A) Transportation Group.

MJB&A's analysis of vehicle and charging infrastructure requirements for conversion of the MCTS fleet to battery-electric buses identified a need for an additional $10 million per year in capital funding to accommodate a complete transition to battery buses over the next 15 years. Using grant funding from the Federal Transit Administration's Low or No Emission Vehicle program, MCTS intends to move forward with the purchase of 15 battery-electric buses in 2020, which will both operate on the BRT route and be used as a pilot fleet to test the technology on other MCTS routes. However, given current fiscal constraints it is unlikely that MCTS will be able to procure necessary funds to replace all retiring diesel buses with battery buses in the near term and will therefore need to continue to purchase conventional buses for a portion of fleet replacements.

MCTS therefore requested MJB&A to evaluate the introduction of diesel hybrid-electric buses to the fleet, as replacements for retiring diesel buses, until funding is available to commit to 100 percent replacement of retiring buses with battery-electric buses. The environmental benefits of hybrid-electric buses are not as great as those of battery buses, but they are less costly to implement; as such, replacement of some retiring diesel buses with hybrid-electric buses in the near term is a potential complementary interim strategy to full fleet electrification.

EXECUTIVE SUMMARY

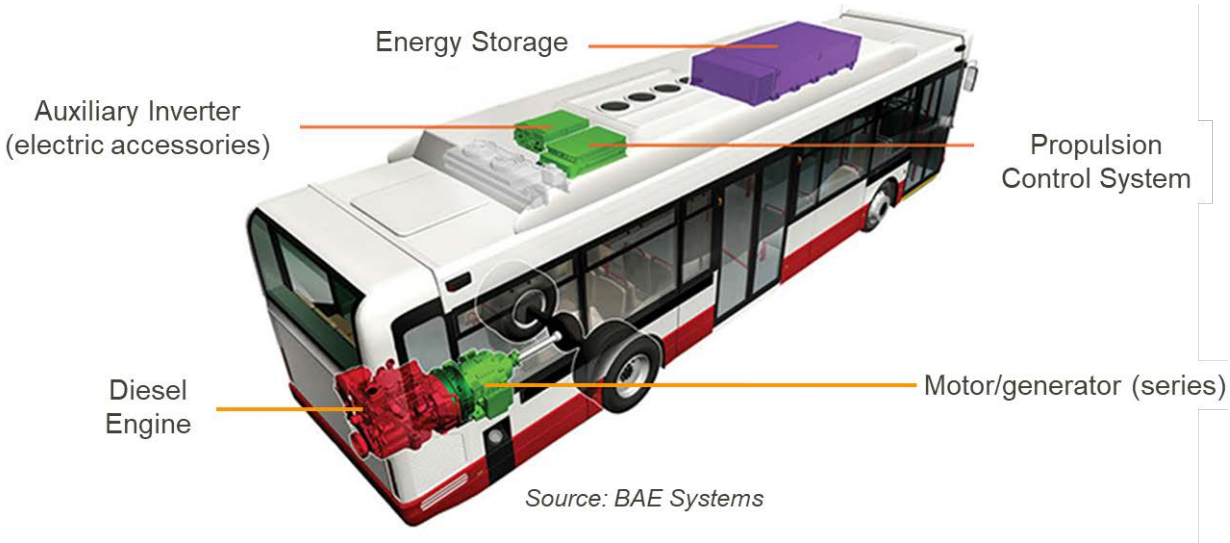
For this project MJB&A was tasked to evaluate the costs and benefits of diesel hybrid-electric buses, as replacements for retiring MCTS diesel buses over the next five to ten years. MJB&A's scope pf work included:

- Evaluate the status of hybrid-electric bus technology in the North American Market
- Evaluate capabilities, options, and cost of commercially available hybrid-electric buses
- Estimate the capital and operating costs associated with replacement of diesel buses with hybrid-electric buses
- Estimate fuel and emissions reductions from replacement of diesel buses with hybrid-electric buses
- Identify necessary changes to bus maintenance and other operating practices to accommodate hybrid-electric buses

Hybrid-Electric Bus Technology and Commercial Status

Diesel hybrid-electric transit buses have been in use for over 25 years. Over 25,000 hybrid buses have been delivered world-wide, including 8,742 hybrid buses currently in-use at 162 different U.S. transit agencies (14 percent of U.S. bus fleet). The largest hybrid fleet is at MTA New York City Transit (1,264 buses), followed by King County Metro in Seattle (972 buses), Washington Metropolitan Area Transit Authority (933 buses), and SEPTA in Philadelphia (914 buses). There are 13 U.S. agencies that operate 100 or more hybrid buses and 65 agencies that operate 20 or more hybrids[1].

Figure 1 Series Hybrid Drive System



A hybrid-electric bus combines a diesel engine with electric drive components, including an electric motor, a generator, and a battery or energy storage device, to reduce total energy use for vehicle

[1] This data is from the National Transit Database, 2018

operation. There are two system architectures possible – series and parallel configuration. In a series configuration the diesel engine drives a generator which either charges the battery or powers an electric drive motor to propel the bus. In a parallel configuration the bus has a mechanical/electric transmission; there are times when the diesel engine powers the wheels directly via the mechanical transmission (like a standard bus) and times when engine power is used to generate electricity and the bus is driven by an electric motor incorporated into the transmission.

The main benefit of a hybrid system (series or parallel) is the ability to recover energy normally wasted in braking and store it in the battery for re-use the next time the bus accelerates. Hybrid-electric buses also typically have a smaller diesel engine than a standard diesel bus, which reduces fuel use further. If equipped with electrically driven accessory equipment (air conditioning, air compressor, power steering) hybrid-electric buses can also operate with the engine off while the bus is stationary (i.e. at bus stops). In the last few years, hybrid manufacturers have also started to offer limited electric-only driving (EV mode), where the bus can drive with the engine off for a few miles at a time, totaling about one third of the daily route[2].

There are two manufacturers that supply hybrid drive systems to the U.S. market: BAE Systems (HybriDrive™) and Allison Transmission (H 40/50 EP™)[3]. Every North American bus manufacturer offers 40-ft hybrid buses with either the BAE or Allison system.

Hybrid-Electric Bus Capital and Operating Costs

Over the past 20 years, the average price of hybrid buses has been $200,000 - $250,000 more than the price of diesel buses (current dollars)[4]. Based on this historical data, and recent bid results, MJB&A estimates that for MCTS the incremental cost of hybrid-electric buses compared to diesel buses will be $190,000 for a "base" hybrid with electric accessories and idle engine-off capability. The incremental cost could be as high as $230,000 for hybrid buses with EV-mode capability. Average fuel use in MCTS service is projected to be 20 percent lower for hybrid-electric buses than for diesel buses.

For buses purchased in the next few years, total life-cycle costs are projected to be $0.24 - $0.33 per mile (2020$) higher for hybrid-electric buses than for diesel buses, an increase of 4.5% - 6.3%. The cost difference between hybrid-electric and diesel buses is projected to narrow slightly for buses purchased in future years, as the cost of diesel fuel increases and the cost of electric drive systems and energy storage falls. However, hybrid-electric buses are projected to continue to have slightly higher life cycle costs than diesel buses for the foreseeable future.

To convert the entire MCTS bus fleet to hybrid-electric buses would require $76 - $89 million (nominal $) in additional capital funds over the next 15 years, compared to continued purchase of diesel buses to replace retiring buses. Over that time period operating cost savings are projected to be

[2] EV-mode operation requires a larger battery than standard hybrid operation. Even in EV-mode all energy required to operate the bus is produced by the on-board diesel engine. Hybrid-electric buses do not need to be plugged into the grid to recharge their batteries.

[3] In 2020 Allison is expected to introduce a new system called Flex EV™ with EV-mode capability

[4] Based on data reported to the American Public Transportation Association Transit Vehicle Database.

$1 million - $9 million, based on fuel cost savings, net of increased maintenance costs, mostly for mid-life battery replacement.[5]

Complete replacement of diesel buses with hybrid-electric buses would reduce annual bus fleet emissions of greenhouse gases (GHG) by 26 percent, would reduce annual fleet emissions of nitrogen oxides (NOx) by 24 percent, and would reduce annual fleet emissions of particulate matter (PM) by 14 percent.

Unlike battery-electric buses, which require development of extensive charging infrastructure, and changes to bus operations to accommodate charging, integration of hybrid-electric buses will not require significant changes to MCTS depots or bus operations. Hybrid-electric buses do not need to be charged from the grid, so no charging infrastructure is required. Changes will be required to MCTS maintenance programs, to develop procedures and capabilities to maintain high voltage electric drive systems and components. In addition, MCTS will need to plan and budget for mid-life replacement of hybrid-electric bus batteries and will need to plan and budget for occasional repair/replacement of drive system components with significantly higher cost than typical replacement parts for standard diesel buses.

RECOMMENDATION

This Report is for Informational Purposes Only.

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[5] The higher capital cost and lower operating cost savings result from hybrid-electric buses with EV-mode capability.