

**COUNTY OF MILWAUKEE
INTEROFFICE COMMUNICATION**

DATE: November 13, 2019

TO: Theodore Lipscomb, Sr., Chairman, Milwaukee County Board of Supervisors

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

SUBJECT: Informational Report - MCTS Battery Electric Bus & Facility Improvements Analysis Final Report

POLICY

The 2019 Capital Improvement Budget directed the Milwaukee County Transit System (MCTS) to initiate the transition of its vehicle fleet to battery electric buses (BEBs) and away from fossil fuels to lessen exposure to volatile diesel fuel prices, achieve savings over the total lifecycle of the new vehicles, provide cleaner air and quieter operational benefits to the citizens and neighborhoods in which the County operates our transit fleet and wider community.

BACKGROUND

To facilitate this transition, MCTS has engaged M.J. Bradley & Associates' (MJB&A) Transportation Group, which has extensive experience conducting strategic analysis, feasibility studies, economic and life cycle cost analyses, safety analysis, emissions testing, emissions inventory development, technology assessments, and management of prototype deployments and retrofit programs for a wide range of vehicle types, including commercial trucks, transit and school buses, construction equipment, locomotives, and marine vessels.

EXECUTIVE SUMMARY

Milwaukee County's adopted 2019 Capital Improvement Budget also specifies that the expected East-West Bus Rapid Transit (BRT) route, currently in the planning stages and scheduled to begin construction in mid-2020, upon approval of a Federal Transit Administration (FTA) grant, will operate with battery electric buses.

To comply with these policies, MCTS envisions purchasing a small fleet of up to 15 battery electric buses in the near term, which will both operate on the BRT route and be used as a pilot fleet to test the technology on other MCTS routes. This will be followed by future purchases of additional electric buses to replace retiring diesel buses, likely beginning in the 2025 timeframe.

For this project MJB&A was tasked to determine the financial and operational changes required for MCTS to transition to electric buses, to include:

- Evaluation of the capability of commercially available battery buses in MCTS service

- Determination of infrastructure requirements for battery bus charging
- Estimating the capital and operating costs associated with fleet transition,
- Identifying necessary changes to bus maintenance, bus scheduling, and other operating practices to accommodate electric buses, and
- Development of a *Fleet Electrification Business Plan* to guide the transition

Battery Electric Bus Pilot Program

MJB&A recommends that for the BRT route and electric bus pilot program MCTS procure a fleet of 15 identical battery electric buses, that can be used interchangeably on the BRT route and on select daily bus assignment blocks on all other MCTS routes. These fifteen buses can be supported by two 450-kW SAE J3105-1 overhead conductive pantograph chargers. One charger will be located at the western terminus of the BRT route, at the Watertown Plank Park & Ride lot. The other may be located at the depot which will house the electric buses.

Each weekday nine electric buses will be required on the BRT route, leaving up to six electric buses for use on other routes. Buses operating on the BRT route will utilize in-route charging; every time a bus arrives at Watertown Plank Park & Ride it will charge for approximately 8 minutes, during normally scheduled lay-over time. This will allow buses to stay in service all day, while maintaining a consistent charge state in their on-board battery. Electric buses not required for BRT operations will be utilized on other MCTS routes and will be charged while stored overnight at the depot.

This configuration will provide maximum flexibility for deployment of the electric buses; it will ensure that the BRT route can continue to operate with electric buses even in the event of bus or charger problems, while also allowing MCTS to test electric bus and depot-based charging operations on other MCTS routes.

The pilot program will require \$15.2 million in capital funding for purchase of the 15 electric buses and two chargers. It is expected that the pilot electric bus fleet will accumulate up to 675,000 annual miles in service, saving \$150,000 annually on fuel costs compared to operating diesel buses.

Funding for the pilot program has been approved in Milwaukee County's adopted 2019 Capital Improvement Budget through Projects WT083 – Bus Rapid Transit and WT124 – Battery Electric Bus Acquisitions. An additional \$1.7 million has been requested in the recommended 2020 Capital Improvement Budget to support charging infrastructure. It is also intended that the pilot program be supplemented with a \$1.7 million grant from the FTA's Low or No Emission Vehicle Program, recently awarded to Milwaukee County.

Full Fleet Electrification

Further electrification of the MCTS bus fleet could begin as early as 2025, with the entire fleet converted to battery electric buses as early as 2040. MJB&A recommends that MCTS implement in-route charging if pursuing full fleet electrification, which would require an additional \$159 million in capital funding (nominal \$) compared to continued replacement of retiring buses with new diesel buses, or an average of \$10 million per year for aggressive electrification by 2040. Net operating

cost savings are projected to be \$1.7 million per year, or a total of \$27 million between 2025 and 2040.

Fleet electrification is projected to produce significant annual savings in bus maintenance and fuel costs, but these will be offset by additional costs for charger location acquisition, permitting and maintenance, mid-life battery pack replacements, and bus operator labor.

Fleet electrification using in-route charging is projected to be significantly less expensive than depot charging. Compared to in-route charging full fleet electrification using depot charging would require an additional \$69 million in capital funding while producing \$12 million less in operating cost savings between 2025 and 2040; between 2025 and 2040 net costs for electrifying the fleet using depot charging are projected to be \$82 million higher than full fleet electrification using in-route charging. While in-route charging will incur higher capital costs for charging infrastructure, and higher incremental operating costs for charger maintenance, bus operator labor, and electricity (resulting in lower net fuel cost savings), there will be significantly lower capital costs for bus purchase, and lower operating costs for mid-life battery pack replacement.

Bus purchase costs for depot charging are projected to be higher than for in-route charging due to both more expensive buses (larger battery) and the need to purchase additional buses due to limitations on the size or on-board batteries and resulting limitations in daily range. The analysis projects that fleet electrification using depot charging will require the fleet to increase by 58 buses (+15%) and will also reduce bus parking space at the two existing depots by 111 buses to accommodate depot chargers. Full fleet electrification using depot charging will require MCTS to develop or acquire a third depot with the capacity for 170 buses.

If full electrification proceeds using in-route charging MCTS will not need an additional depot but over time will need to install approximately 50, 450-kW in-route chargers at up to 44 different locations throughout the MCTS service area. This will require acquisition/lease of land or usage rights, design, and permitting.

Fleet electrification will also require significant changes to bus operations to accommodate electric bus technology. Changes will be required to bus schedules, bus maintenance programs, and cold weather operations. MCTS will also need to develop completely new capabilities to regularly monitor bus charging activities, and to maintain and repair charging infrastructure. MCTS should also develop contingency plans to maintain bus charging in the event of loss of grid power at one or more charging locations.

The above discussion addresses estimated costs for an aggressive fleet electrification schedule. Fleet electrification with in-route charging could also proceed at a more measured pace, by converting individual routes to electric operation as funding becomes available. The most heavily used routes in the MCTS system are the Blue, Gold, Red, Green, and Purple express routes. Estimated incremental capital costs to electrify these routes using in-route charging range from \$2.9 million (Blue route) to \$5.6 million (Purple Route) per route, including the cost of required in-route chargers and the incremental cost of electric buses compared to new diesel buses.

Emissions

The current MCTS diesel bus fleet is estimated to emit 52,500 metric tons (MT) of GHGs including 12.8 tons of NOx and 0.38 tons of PM per year in the Milwaukee metro area. Once the fleet is converted to all electric buses annual GHG emissions will fall to 29,100 MT, a reduction of 45 percent. Electric buses have no tailpipe emissions, annual fleet NOx and PM emissions will fall to zero as the MCTS fleet is electrified. As such, MCTS fleet electrification could contribute to improvements in local air quality in Milwaukee, with associated reductions in negative health effects. This estimate is based on the current electric generation mix; if the electric grid in Wisconsin is further de-carbonized by replacing coal and natural gas generation with renewable sources (solar, wind), total GHG emissions associated with MCTS electric buses will be even lower.

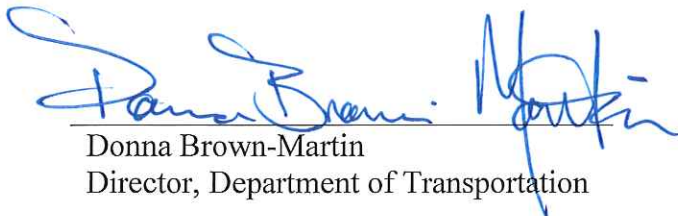
If fleet electrification proceeds at a modest pace, over the next ten years MCTS will need to replace some retiring diesel buses with new buses that are not battery buses. A complementary approach to consider is replacement of these retiring buses with hybrid-electric buses, until funding is available to commit to 100 percent replacement of diesel buses with battery-electric buses. Hybrid electric buses do not reduce GHG emissions as dramatically as battery electric buses, but they are also less costly to implement. In MCTS service, hybrid-electric buses are projected to use at least 17 percent less fuel than diesel buses and to emit 17 percent fewer greenhouse gas (GHG) emissions. Average life-cycle costs of hybrid-electric buses are projected to be 6 percent higher than life-cycle costs for diesel buses, including both capital and operating costs. Replacement of some retiring diesel buses with hybrid-electric buses is a potential complementary interim strategy to full fleet electrification.

RECOMMENDATION

This Report is for Informational Purposes Only.

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