


KING COUNTY AUDITOR'S OFFICE

AUGUST 24, 2020

King County Metro Transit Bus Electrification: Best Practices Review

This report is a review of best practices. We have not yet completed our assessment of Metro Transit's bus electrification efforts and are not yet making recommendations due to current uncertainty around budget and timeframes caused by the COVID-19 pandemic. When the Auditor's Office completes the full audit of electrification in the future, we will use information in this document as a starting point for our evaluation.

King County's goal to electrify its bus fleet will take years to implement. This long timeframe means that, to be successful, Metro Transit will need to address inherent uncertainties and challenges over the next 15 or more years. For example, Metro Transit will have to make decisions using sometimes incomplete information about emerging technology and make large upfront infrastructure investments. The COVID-19 pandemic and its economic consequences have exacerbated some existing challenges and introduced new ones, such as creating potentially significant changes to revenue and ridership assumptions on which previous planning had been based. As a result, Metro Transit is likely postponing some of its planned electrification-related projects for 2021-2022, but maintains its goal of full electrification in the future.

Compared to many other U.S. transit agencies, King County is further along in its progress toward a full electric bus fleet. For example, Metro Transit has conducted some initial analysis, run a pilot, is testing coaches from several manufacturers, and has a goal for mass adoption of electric buses. At this stage, Metro Transit should be conducting detailed analysis and developing long-term plans for its transition to an all-electric fleet. This planning will help ensure Metro Transit and the County are able to reach their goals within the timeframe they chose.

This report summarizes key areas that Metro Transit should include in its planning, and county decision-makers should consider as part of oversight of electrification efforts, including:

- evaluating the impacts of electrification and service expansion/reduction on greenhouse gas emissions
- tracking and reporting on changes in key inputs and assumptions to assess how they affect the projected cost of electrification
- developing and documenting plans for service, capital project and charging infrastructure, workforce, fuel, and finances.

King County

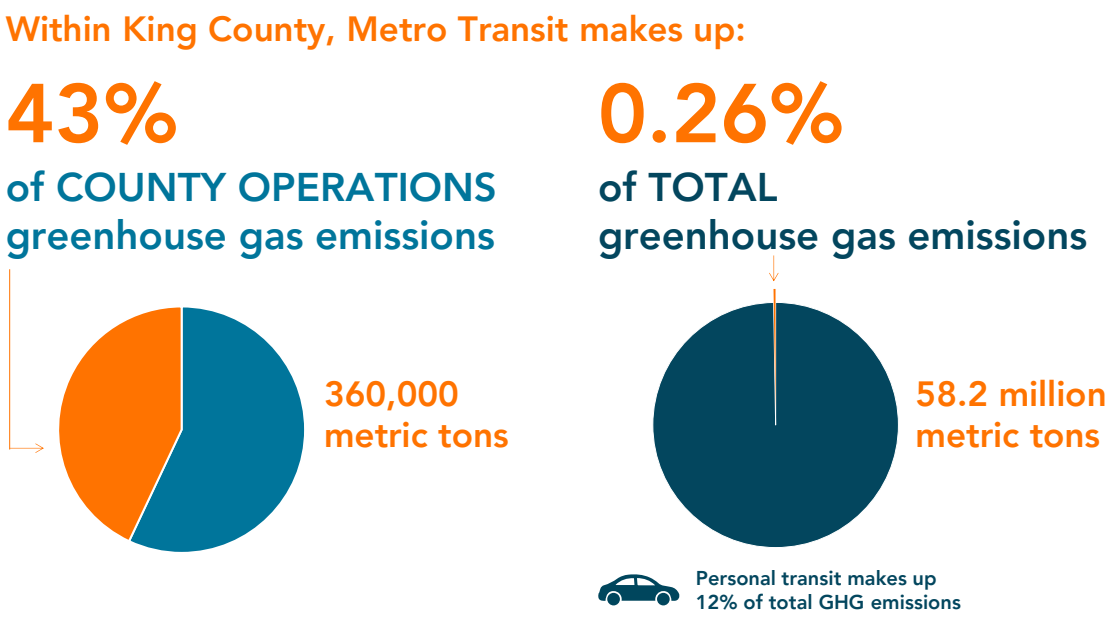
What factors influence the extent to which electrification would effectively and efficiently help the County achieve its goals to reduce greenhouse gas emissions?

Given budgetary constraints, Metro Transit will have to balance bus service and electrification in order to work toward climate goals. One of Metro Transit's main reasons for electrifying the bus fleet is to reduce greenhouse gas emissions. However, if electrification funding comes at the expense of expanding or keeping existing bus service, the overall impact could be a net increase in overall carbon emissions countywide. This is especially important in the context of the current budget emergency in which Metro Transit and King County will have to make tough budgetary decisions. Metro Transit has two main methods at its disposal to reduce emissions:

- transitioning from a diesel-hybrid fleet to a battery-electric fleet, which directly reduces emissions from county operations
- encouraging residents to switch from driving to taking the bus by expanding or increasing the frequency of bus service, an indirect method to reduce overall county emissions from transportation.

Although Metro Transit's emissions make up a relatively large portion of overall greenhouse gas emissions produced by county operations, they are a very small portion of overall emissions countywide (see Exhibit A). Looking at King County as a whole, Metro Transit emissions make up less than one percent of consumption-related emissions. By comparison, personal private transportation emissions make up about 12 percent of consumption-based emissions. Since improved bus service has the potential to incentivize less use of private vehicles, Metro Transit service expansion has the potential to decrease emissions by a greater amount than electrification. However, Metro Transit relies on individual decisions made by county residents and presumes that the reduced emissions from these behavior changes can outweigh the increased emissions from additional bus service.

EXHIBIT A: Metro Transit greenhouse gas emissions make up a large portion of county government emissions but a small portion of overall emissions within the County.



Source: 2020 Draft King County Strategic Climate Action Plan, based on 2017 data.

Note: Metro Transit emissions include both revenue and non-revenue fleets. Personal transit refers to non-commercial transportation.

Just as service expansion can reduce emissions from private cars, service reductions can have the opposite effect and increase emissions.[1] If the County chooses to fund electrification efforts through service cuts, overall emissions across the County could actually increase as more people travel by car. Weighing the anticipated emissions impacts of different priorities can help ensure that the County uses its limited budget resources effectively to contribute toward its climate goals.

What assumptions will impact the cost of electrification compared with maintaining the status quo?

Tracking and reporting on key cost inputs over time will allow Metro Transit staff and policy-makers across King County to more effectively make decisions on the pace of electrification. This information helps decision-makers respond nimbly in an uncertain environment. The projected costs of electrifying Metro Transit's bus fleet are based on a number of interconnected assumptions that can change over time based on factors within and external to the County. For example, diesel-hybrid buses can be about 25 percent cheaper than battery-electric buses. In the future, technological improvements may drive down the cost of electric bus batteries, thus reducing this difference. Alternatively, whether to rely primarily on battery charging in-route versus on-base could significantly impact the number, type, and location of battery chargers as well as impact the cost Metro Transit pays for electricity. These inputs can be grouped into the following categories (see Exhibit B):

- capital costs (bus procurement and infrastructure development)
- operating costs (fuel[2] and maintenance).

[1] This relationship assumes normal customer behavior. The COVID-19 pandemic may change this relationship in the short-term.

[2] We use fuel in this letter to refer to multiple sources of propulsion, including both diesel and electricity.

EXHIBIT B: Multiple assumptions will impact the difference in cost between an electric bus fleet and the status quo.

	CAPITAL COSTS LIKELY HIGHER FOR AN ELECTRIC FLEET		OPERATING COSTS POTENTIALLY LOWER FOR AN ELECTRIC FLEET	
TOTAL NET COST	DIFFERENCE IN COST OF BUSES	INFRA-STRUCTURE COSTS	DIFFERENCE IN COST OF FUEL	DIFFERENCE IN MAINTENANCE COSTS
	40-foot battery-electric bus cost 60-foot battery-electric bus cost Battery cost 40-foot diesel-hybrid bus cost 60-foot diesel-hybrid bus cost	Base-charging infrastructure (capital and installation) In-route charging infrastructure (capital and installation)	Electricity rates Battery efficiency (fuel economy) Diesel fuel rates Diesel efficiency (fuel economy)	Preventative maintenance and replacements for battery-electric buses Unscheduled maintenance and replacements for battery-electric buses Preventative maintenance and replacements for diesel-hybrid buses Unscheduled maintenance and replacements for diesel-hybrid buses

Source: King County Auditor's Office compilation of information from multiple sources, including King County Metro Transit, U.S. Public Interest Research Group, Columbia University, and California Transit Association.

Metro Transit has initial estimates for many inputs, but assumptions are likely to change over time. Changes in these assumptions can greatly impact the cost of electrification. In general, studies of electrification costs in the United States find that capital costs (bus procurement and infrastructure development) are higher for battery-electric buses compared to diesel or diesel-hybrid buses, while operating costs are generally lower due to greater fuel efficiency and potentially lower fuel prices for battery-electric buses. Given the novelty of the electric bus market in the United States, however, many of these studies are based on small sample sizes or limited timeframe. This increases the uncertainty about the costs of electrification, especially over the full lifespan of a bus. The following examples of inputs could largely impact overall cost of electrification:

- **Upfront capital infrastructure costs are a major driver of high electrification costs relative to maintaining the status quo[3].** Therefore, this is a particularly important area to pay attention to. As Metro Transit focuses on building this infrastructure at selected bases, it can track how actual costs compare with projected costs to inform decisions about expanding electrification to other areas of the County.
- **Electricity is a potentially less-expensive fuel source than diesel fuel.** Although multiple studies have found fuel cost savings from electrification, Metro Transit's experience so far illustrates that these savings depend on a strategic charging approach. During a pilot study using fast-charging electric buses, Metro Transit found its fuel costs for battery-electric buses were actually higher than for its diesel-hybrid buses. This was due in part to recharging buses during peak hours when electricity was more expensive. Additionally, the small scale of the study did not provide Metro Transit with strong leverage to negotiate favorable rates with public utility companies. Going forward, Metro Transit has the potential to realize lower fuel rates through electrification due to emerging partnerships with public utilities and the ability to charge the newest fleet of electric buses overnight. Metro Transit noted that it has already begun applying its lessons learned in order to reach a tentative pilot rate with the utilities.

Tracking how Metro Transit's decisions and actions change the assumptions can help the County work toward an optimal electrification strategy that both achieves county goals and manages costs.

[3] We are not considering the past expense of building diesel fueling infrastructure in the cost comparison above because it is a sunk cost for the County.

What can Metro Transit do to manage uncertainty and move forward with electrification?

At this stage, Metro Transit should be developing detailed analyses and long-term plans for its implementation period to transition to zero emissions buses. This planning will help ensure Metro Transit and the County are able to reach their goals within their chosen timeframe and make adjustments as needed.

Detailed analyses and long-term planning include considerations for performance management, service planning, capital project and space planning, workforce planning, and financial planning.[4] For each area, there are analyses, actions, or decisions which can be time-sensitive or dependent on each other.

For example, the type of charging technology chosen has implications for cost, capital and base planning, fuel needs, and workforce needs. Metro Transit is planning to use both base and in-route charging. In order to implement that technology, Metro Transit will need to:

- plan for where to integrate charging stations and identify space for charging at the base
- plan for where to install infrastructure for in-route charging
- plan for capital work needed to implement charging infrastructure
- implement capital work on time in order to put coaches in service
- work with electric utility companies to ensure enough power will be available
- ensure staff have skills needed to use and maintain coaches and infrastructure
- estimate and monitor costs and use actual costs to update total cost of ownership analysis.

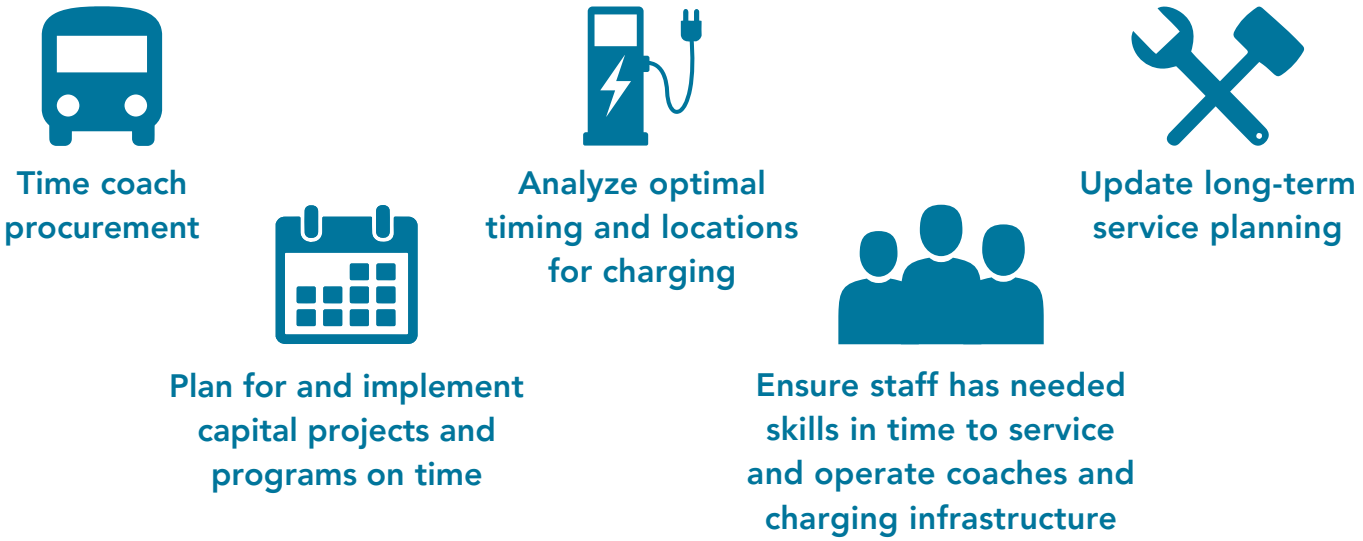
In order to plan for full electrification, Metro Transit will need to expand its understanding of these types of dependencies among all of its operations. While doing this, Metro Transit will need to make some decisions years before becoming fully electric despite the uncertainties it faces. For example:

- **Time coach procurement:** Metro Transit needs to stop buying hybrid coaches at least 12 years before the date by which it wants to be fully electric or analyze the cost of repaying federal grant dollars used to purchase diesel-hybrid coaches.[5]
- **Plan for and implement capital projects and programs on time:** Metro Transit cannot operate electric coaches without sufficient space at bases and charging infrastructure.
- **Analyze optimal timing and locations for charging:** Metro Transit needs to conduct analyses to prevent negative service impacts and avoid higher fuel costs associated with peak charging times.
- **Ensure maintenance staff and transit operators have needed skills in time to service and operate coaches and charging infrastructure:** Since vehicle maintenance staff tend to work at the County for 15 years or more, Metro Transit's hiring and training efforts will need to consider its future skill needs as the fleet transitions.
- **Update long-term service planning:** Metro Transit needs to include flexibility in its service and capital planning in order to respond to the potential changes needed over its implementation timeline resulting from external sources, such as future technological improvements or revenue impacts.

[4] Appendix 1 provides a more detailed breakdown and summary of the various areas we identified in guidance from academic, non-profit, and industry sources for transit agencies seeking to transition fleets to electric buses.

[5] Federal grant funds Metro Transit uses to purchase coaches have a requirement to keep the coaches for at least 12 years or funds must be returned.

EXHIBIT C: In order to plan for full electrification, Metro Transit will need to expand its understanding of dependencies within its operations



Source: King County Auditor's Office analysis

Conclusion

Electrification will take years to implement. There is considerable uncertainty that could impact Metro Transit's ability to fully electrify its fleet over a long implementation period. This means that planning efforts described herein need to be set up as a framework that can be regularly revisited and updated as Metro Transit learns more and as technology, market conditions, or outcomes change. This planning will help ensure Metro Transit and the County are able to reach their service, financial, environmental, and equity goals within their chosen timeframe.

Elise Garvey, Mia Neidhardt, and Ben Thompson conducted this review. If you have any questions or would like more information, please contact the King County Auditor's Office at KCAO@KingCounty.gov or 206-477-1033.

Appendix 1

Electrification Guidance

The checklist below summarizes guidance from academic, non-profit, and industry sources for transit agencies seeking to transition their fleets to electric buses. Each area includes topics highlighted within the guidance. Metro Transit will need to include these areas in its documented planning to fully electrify the fleet or change course to reach service, financial, environmental, and equity goals.

☐ Capital project and infrastructure planning

- ☐ **Charging infrastructure**: Agencies should be planning for how they will afford and deliver charging infrastructure; this may include working with other jurisdictions, utility companies, vendors, etc.
- ☐ **Space**: Agencies should be planning for changes to space needed for new infrastructure, charging stations, flow, parts, parking, etc.

☐ Financial planning

- ☐ **Rate structures:** Agencies should be working internally and with the utility companies to have cost data to help with financial and charging planning.
- ☐ **Total cost of ownership:** Agencies should be analyzing detailed financial needs over the lifetime of the vehicles and should include sensitivity analysis to help identify cost-effective operations changes.

☐ Fuel planning

- ☐ **Electricity supply**: Agencies should be working with utilities to make sure there will be enough electricity and grid infrastructure to supply needed power for charging.

☐ General planning

- ☐ **Performance metrics**: Agencies should have performance metrics for electrification efforts to guide decision-making as it relates to strategic goals (e.g. environmental, financial, equity, etc.).

Service planning

- ☐ **Fleet size**: Agencies should be considering how many buses will be necessary for regular and contingency needs.
- ☐ **Technology choice, routes, and schedule planning:** Agencies should be working to analyze, model, and understand how routes and schedules may need to change to accommodate charging time, battery capacity, including understanding of weather change impacts.

Workforce planning

- ☐ **Maintenance**: Agencies should be planning for meeting its maintenance workforce needs while operating multiple propulsion systems and being able to fully move to electric coaches.
- ☐ **Operator training**: Agencies should be planning for how it will train transit operators to use new technology correctly and efficiently (as driver habits can affect battery capacity).
- ☐ **Operations staff training**: Agencies should plan for how to transition other operations staff (e.g. dispatchers, on-street supervisors, control room personnel) to be more conversant with specific vehicle characteristics to avoid service disruptions.

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INTERIM REPORT

This product is an interim report, as defined in GAGAS 9.17.g, for an audit that complies with Government Auditing Standards.