## REVISED STAFF REPORT

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| **Agenda Item:** | 10 | **Name:** | Jenny Giambattista |
| **Proposed No**.: | 2017-0089 | **Date:** | April 18, 2017 |

**COMMITTEE ACTION**

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| ***Proposed Substitute Motion 2017-0089.1 adopting a feasibility report for achieving a carbon-neutral or zero-emission transit fleet, passed out of committee on April 18, 2017 with a “Do Pass” recommendation. The motion was amended in committee with Amendment 1 to clarify that Attachment A, Feasibility of Achieving a Carbon-Neutral or Zero-Emission Fleet, fulfills the requirements of Motion 14633 and the expenditure restriction in the 2017-18 Budget (Ordinance 18409), Section 132, ER2.*** |

**SUBJECT**

A motion adopting a feasibility report for achieving a carbon-neutral or zero-emission transit fleet.

**SUMMARY**

Motion 2017-0089 adopts a report on the feasibility of achieving a carbon-neutral or zero-emission transit fleet. The report was requested by Motion 14633 and was required by a budget proviso in the 2017-2018 budget.

The feasibility study is a long-range aspirational plan that meets the requirements of both the motion and the proviso. Based on the feasibility study, the Executive is recommending transitioning to a 100 percent zero-emissions fleet powered by renewable energy as early as 2034 depending on technology advancements and ability to meet service requirements.

Given that the battery bus technology is rapidly changing, the analysis relies on assumptions about the availability, range, and charging times of battery buses. As Metro takes steps to implement its vision of a zero-emission fleet by 2034 and battery bus technology evolves, further evaluations and more detailed analysis will be needed by Metro.

The staff report also includes a discussion of Metro’s near term (between now and 2020) plan for the purchase of 120 electric vehicles.

**BACKGROUND**

**Motion 14633**

In April 2016, the King County Council adopted Motion 14633, expressing support for achieving the goal of either a carbon-neutral or zero emission vehicle fleet in all of Metro Transit’s service area as expeditiously as possible. Motion 14633 requested the Executive to transmit a feasibility report that identifies and analyzes strategies for and barriers to achieving a carbon-neutral or zero emission vehicle fleet, including the vanpool fleet. The specific requirements of the feasibility study are outlined in the Analysis section of this staff report.

**Budget Proviso**

The 2017-2018 Budget (Ordinance 18409) included the following proviso related to battery buses:

*Of the appropriation for capital project 1129299, Electric Bus Charging Infrastructure, $15,000,000 shall be expended or encumbered solely for capital infrastructure and vehicles needed to operate at least two additional bus routes as all electric battery bus routes that would be in addition to the routes 226 and 241 that were originally in the Executive’s budget proposal, and only after the Council passes a motion approving the feasibility report requested at Motion 14633.*

*The Executive should file the report and the motion required by this proviso by March 1, 2017, in the form of a paper original and an electronic copy with the clerk of the Council, who shall retain the original and provide an electronic copy to all councilmembers, the Council chief of staff and the lead staff for the transportation, economy and environment committee or its successor.*

**ANALYSIS**

The transmitted report, Feasibility of Achieving a Carbon-Neutral or Zero Emissions Fleet generally meets all of the requirements of Motion 14633 as outlined in the table below. The report considered service needs, costs, necessary supporting systems, environmental results, and social equity benefits. The feasibility study also meets the requirements of the budget proviso.

In accordance with Motion 14633, Transit convened a group of stakeholders to review the draft and final feasibility assessment. The stakeholder group included representatives from Puget Sound Sage, Got Green, Puget Sound Clean Air Agency, Transportation Choices Coalition, Climate Solutions, Puget Sound Energy, and City of Kent.

**Figure 1**

| **Requirements of Motion 14633** | **Included?** |
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| Analysis and recommendation on whether a carbon-neutral or zero emission fleet should be the preferred goal for Metro Transit and a range of possible dates for achieving the recommended goal. | 🗹 |
| The analysis should identify opportunities for partnerships with cities and other stakeholders to implement pilot projects and build the electric vehicle infrastructure necessary to reduce emissions of greenhouse gases and criteria pollutants. | 🗹 |
| An analysis of any changes necessary to the strategic plan for public transportation, or the long range plan in order to achieve recommended goals. The analysis shall also identify any conflicts with or implications to the goals in the 2015 Strategic Climate Action Plan, the Vision 2040 Plan, or the Metro service guidelines. | 🗹 |
| An evaluation of the battery bus pilot | Brief discussion included, longer analysis from U.S. Department of Energy expected soon |
| Identify the associated fleet and infrastructure needs for a carbon-neutral or zero-emission fleet | 🗹 |
| An analysis of how the King County Metro transit carbon offset program established in Ordinance 17971 can be implemented to achieve the goal | Report briefly mentions Transit has submitted an application with the EPA to sell the environmental attributes from powering electric vehicles with renewable energy |
| An analysis of any gaps in available technologies or products that would need to be addressed in order to meet the goal | 🗹 |

**Major Findings of the Feasibility Study**

**Summary:** The report, Feasibility of Achieving a Carbon-Neutral or Zero-Emission Fleet recommends Metro gradually transition to a zero-emission fleet powered by renewable energy as the best option for directly reducing GHG emissions and air pollutant emissions. Based on the findings of the feasibility study, Metro is committing to completing the transition to a zero-emission fleet by as early as 2034, or by 2040 at the latest, depending on technology requirements and other implementation considerations. Metro plans to focus initial large scale deployment in South King County to provide the air quality benefits to those communities most vulnerable to air pollution.

The feasibility analysis identifies significant risk factors discussed in the staff report. However, Transit is confident with moving forward with plan for a zero-emission fleet based on the cost analysis, the expected ability of battery buses to meet service needs as buses are retired over time, the environmental benefits, and a strategy to address risks.

Additionally, Metro’s transition to a zero-emission fleet could have benefits of serving as a model for transit agencies across the nation and helping to develop the battery bus industry. Much like the initial purchases of hybrid buses, Metro hopes its early engagement in the battery bus industry will give it leverage to influence product development and thus the development of buses that better meet Metro’s needs.

**Current state of the battery-electric bus market and technology**

According to the feasibility analysis, battery-electric bus manufacturing and technology are still in their development stages, but they are progressing rapidly. The National Renewable Energy Laboratory considers battery-electric bus development to be in the technology demonstration, or commissioning, phase—meaning battery-electrics should not be considered fully commercial products. Battery-electric buses are a fraction of the overall transit vehicle industry today. Large established manufacturers have yet to fully commit to battery-electric buses, although New Flyer has one model in the market. Companies focusing on battery-electrics, including Proterra, BYD, and Green Power, are relatively new to the market and have much smaller manufacturing footprints in the United States than the established bus manufacturers.

According to the feasibility study, there are generally two types of charging technologies:

1. **Slow chargers** refill the battery slowly, typically using a cable and a plug similar to those used to charge electric cars, although designs vary by manufacturer. The term “extended-range” is also used for this type of battery technology. Slow chargers are generally paired with larger batteries and buses with a longer range and can travel up to 140 miles between charges. Charging is typically done over longer periods—two to five hours during the night or long midday layovers at the bus base. The feasibility analysis conservatively assumes two buses per slow charger. Metro has not tested 40 or 60 foot slow charge buses, but expects to start testing in late 2017.
2. **Fast chargers** refill the battery very quickly, typically using an overhead contact with the bus and little or no interaction needed by the driver. Designs for these systems also vary by manufacturer. The term “quick-charge” is also used for this type. Fast chargers are typically paired with buses that have a smaller battery designed to accept a lot of power in just five to 10 minutes. The operational concept for fast-charge buses is to recharge the battery multiple times a day during a layover period or between trips. Fast charge buses travel less than 25 miles and charge in 10 minutes or less but require much more expensive charging infrastructure. The feasibility analysis conservatively assumes four buses per fast charger. Fast chargers are generally located along the route at layover locations.

**Will existing technology meet current route needs?**

The feasibility study analyzed how Transit’s current service requirements and ratio[[1]](#footnote-1) of 40-foot to 60-foot buses matches the operational characteristics of new battery-electric buses in order to determine the number of buses that could potentially transition to battery-electric buses.

The analysis did not consider available base capacity or space at layover locations needed for charging infrastructure. Additionally, the analysis **assumed that both 40-foot and 60-foot battery-electric buses would be available. However, currently Metro has only tested and proven 40-foot fast-charge battery-electric bus technology meets its performance requirements, but has not yet done so for 60-foot buses. While 60 foot slow charge buses exist, a fast charge model has not yet been manufactured.**

**The analysis reports that *if* the currently available 60-foot battery bus can meet Metro’s performance standards**[[2]](#footnote-2)**, then slow-charge/extended range battery-electric technology in its current state could meet the service needs of nearly 70 percent of Metro’s operations. (840 of an anticipated fleet of 1,216 buses have a total daily mileage of 140 miles or less and thus can be served by battery buses.) The feasibility report shows the percentage of service that could be covered using battery buses increases as the battery range increases in the future.**

**The feasibility analysis also considered the feasibility of currently available fast charge technology to meet service needs. According to the analysis,** between 140-187 (35 to 47 percent) out of the 392 40-foot buses could be transitioned to fast charge battery buses. The feasibility reports that while, current fast-charge technology would allow for 35 to 47 percent of 40-foot buses to be transitioned to battery-electric buses, the significant infrastructure costs and siting constraints means it is likely a smaller subset would be feasible to replace.

**Risks**

The feasibility analysis notes the primary risks associated with transitioning to a battery bus fleet are related to the fact that the battery bus industry is in its development stages and thus the analysis reports the “business-related risks of procuring battery-electric buses are high.”

The report notes:

*As the industry scales up manufacturing, bus cost and reliability will be greatly improved. Until that time, battery-electric technology will pose risks, which have been addressed in several recent technical reports. The main risk concerns the choice between fast-charge/low-capacity battery buses and infrastructure, and slow-charge/higher-capacity battery buses and infrastructure. The danger is that a transit agency could select a charging technology that either does not meet its long-term needs, or is not adopted broadly by the industry and eventually becomes unsupported by manufacturers. A compounding risk is the current lack of standardization in the industry.*

**Additionally,currently Metro has tested 40-foot fast-charge battery-electric bus technology, but the one model of a 60-foot battery-electric bus currently available has not yet proven it can meet Metro’s quality standards.**

**According to the report, service reliability is another key risk in transitioning to a fast-charge technology. If a bus is often running later, there may not be enough time to charge its battery during a layover without causing further delays or requiring investment of additional service hours to ensure adequate layover time.**

To address these risks, Metro assumes a phased approach to transitioning and plans to continually evaluate the industry and the implementation as it moves forward.

**Timelines for fleet replacement**

The transition plan to an all-electric fleet will be gradual as shown in the Figure below from the report. The gradual nature of the transition plan is driven both by limitations in the current technology, an assumption that the existing vehicles fleet will only be transitioned at the end of their current lifecycle[[3]](#footnote-3), and the time required to transition operations and develop infrastructure.

**Figure 2: Fleet Replacement Plan: Potential for Zero-Emission Fleet[[4]](#footnote-4)**



The transition to all electric fleet will happen by gradually transitioning all new bus purchases to electric vehicles. Transit anticipates that by 2020, any new buses put into operations would be zero-emissions.

Prior to 2020, Metro’s plans significant new investments in hybrid diesel buses as well as battery buses. Metro expects delivery of 408 hybrid diesel buses prior to 2020. Metro’s near term purchasing plans for battery buses is discussed later in the staff report.

**Environmental Benefits**

Reducing direct, operational emissions from fuel used in Metro’s fleet is an important climate goal in SCAP. According to the feasibility analysis, Metro’s bus fleet consumes about 10 million gallons of diesel fuel annually and emits approximately 80 percent of King County government’s GHG (greenhouse gas emissions) emissions from fossil fuels.

A zero-emission bus powered by renewable energy eliminates all GHG and air pollutant emissions from the tailpipe and from electricity production. Additionally, the external noise for bus operations would reduce significantly, as battery bus are close to the noise levels of private autos.

**Near Term Purchasing Plans for Battery Buses**

In January 2017, the Executive announced that Transit will acquire 120 all-electric battery buses by 2020.[[5]](#footnote-5) As part of this commitment, Metro will purchase up to 73 battery buses from Burlingame, California-based Proterra. The first 8 of those are scheduled to go into service this year and 12 more fast charges in 2019. Up to eight of the new 40-foot fast-charge battery buses will likely operate on Metro Routes 226 and 241 in Bellevue.

Metro will also acquire up to 12 slow-charge long-range electric buses from different manufacturers to test the battery technology with a range of about 140 miles. These slow-charge, extended-range would operate out of South Base and are expected to be in service by the middle of 2018. Once testing is complete Metro will decide whether the remaining portion (88 buses) of the order should be fast or slow-charge technology, from which manufacturer(s)[[6]](#footnote-6) they should be ordered, and where they will be located. The remaining 88 buses are expected to be in service by 2020. The feasibility report recommends focusing initial deployment at no more than three bases for economies of scale and prioritizing South Base deployment for the greatest equity and social justice benefits.

**Equity and Social Justice Considerations**

The report includes a detailed discussion on equity issues. The analysis focused on how the air pollution benefits of zero-emissions technology could advance social equity by first serving communities most vulnerable to air pollution. Transit recommends prioritizing the deployment of zero-emission buses in areas that have both poor air quality and populations with a relatively high prevalence of respiratory and cardiac health issues who are generally less able to move or to receive treatment for these conditions. Transit conducted an in-depth analysis to determine which bus routes had the highest vulnerability to air pollution and would most benefit from zero-emission technology.

The analysis considered the following indicators:

1. Poor air quality: diesel emissions, permitted point-source air pollution, proximity to high traffic, and use of wood for heating
2. Existing health conditions that may be caused by or exacerbated by poor air quality: chronic obstructive pulmonary disease, asthma and heart disease
3. Social factors that suggest a population may be less well-equipped to deal with such health effects: low-income, communities of color, under age 18 and above age 64, linguistically isolated, households headed by single females, and low rates of high school completion

Based on the analysis, Metro concluded that deploying zero-emission buses to South Base would have the greatest positive impact on equity.

**Costs**

The life-cycle cost analysis found that over the next 30 years transitioning to a zero-emission fleet according to the timeline discussed above would come at an incremental cost of about 6 percent, or about $194 million in 2016 dollars, when compared to current fleet replacement plan. The incremental cost is 2 percent higher for transitioning to battery-electric bus fleet when the societal costs from emissions and noise pollution are considered.

The feasibility analysis uses a life-cycle cost analysis approach to look not only at initial capital costs of bus purchases, but also at the costs over the multi-decade life-cycle of the fleet. This analysis included both the cash costs to Metro (i.e. capital, operating, maintenance, and disposal) and the societal costs from environmental pollutants (i.e. greenhouse gases, air pollutants, and noise).

The increased cost of battery buses when compared to the current fleet plan is largely due to the charging infrastructure. According to the analysis, the per-vehicle fueling infrastructure costs for diesel-hybrid fleets are three to 14 times less than the charging infrastructure costs for battery-electric fleet. Bus-capital costs for diesel-hybrid and battery electric buses fall within the same range.

Figure 4 compares total cost of transitioning to a zero-emission fleet with the continuation of current fleet practices by major category of costs.

**Figure 4: Total Fleet Replacement Costs[[7]](#footnote-7)**

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| 2016-2047 Fleet Replacement Cost Comparison (2016 $ million) | | Transition to Zero-Emission Fleet | Continuation of Metro’s Current Fleet Practices |
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| Capital | Vehicle purchase price | $1,548 | $1,397 |
| Modifications and contingency | $232 | $197 |
| Charging/fueling Infrastructure | $136 | $23 |
| *Total capital costs* | *$1,915* | *$1,617* |
| Operating | Vehicle maintenance | $707 | $843 |
| Vehicle tires | $65 | $65 |
| Vehicle fuel costs | $369 | $450 |
| Charging/fueling Infrastructure maintenance | $5 | $1 |
| Battery replacement | $100 | $8 |
| *Total operating costs* | *$1,246* | *$1,365* |
| Disposal | Battery recycling/disposal | $4 | $1 |
| Bus disposal | $49 | $38 |
| *Total disposal costs* | *$53* | *$38* |
| Total cash costs | | **$3,214** | **$3,020** |
| *Comparison to Base* | *Dollars* | *$194* | *-* |
| *Percent* | *6 percent* | *-* |
| Total cash cost per mile | | **$3.07** | **$2.88** |
| Societal | Emissions – tailpipe | $18 | $71 |
| Emissions - refining/utility | $20 | $94 |
| Noise | $36 | $43 |
| *Total societal costs* | *$74* | *$20* |
| Total cash and non-cash costs | | **$3,288** | **$3,228** |
| *Comparison to Base* | *Dollars* | *$60* | *-* |
| *Percent* | *2 percent* | *-* |
| Total cash cost per mile | | **$3.14** | **$3.08** |

Challenges with Forecasting:

The report notes that forecasting costs, inflation, and price fluctuations for over a multi-decade time frame is difficult and requires numerous assumptions. In this analysis, the difficulty was compounded by the relatively young state of the battery-electric bus industry and the lack of actual data. For example, the transit industry has limited experience with large scale deployments of charging infrastructure, so the costs of doing so are less certain. Additionally, while the feasibility reports high confidence in the data for diesel-hybrid operations based on years of experience and a large fleet, it was more difficult to and less certain to extrapolate the costs from the fleet of only three battery-electric buses over only a few months of operation.

The charging capital costs are dependent on the number of vehicles each charger can serve. Given the evolution of charging infrastructure and the current lack of standardization, there is a risk that equipment could become obsolete and challenges with scaling up the deployment of charging infrastructure could occur, making the costs less certain.

Assumptions in cost estimates

* Both scenarios include the planned purchase of 120 battery buses and the necessary supporting infrastructure.
* Both scenarios exclude the trolley infrastructure as the trolley fleet is assumed to maintained at its current level in both scenarios.
* All buses and chargers will have a 14-year lifespan based on Metro’s current fleet experience with hybrid-diesel buses.
* The current ratio of 45 percent 40-foot to 55 percent 60-foot buses was maintained over the analysis period.
* Battery costs will decline at approximately 3.4 percent per year through 2030 based on recent analysis of the bus battery market by the California.
* Back-up power generation, upgrading power supply to bases, and workforce training and development would be required as part of a transition to a battery bus fleet but are not included in the cost analysis.
* The analysis covered the full life-span of all buses expected to be purchased from 2016 to 2032 and in service from 2017 to 2034 under both scenarios. This means it covered total costs from the first year of fleet purchases in 2016 through the final year of operations in 2047—the end of life for buses purchased in 2032 and in service in 2034. All results in the model are provided in 2016 dollars and for an average bus within a fleet of buses (diesel-hybrid or battery-electric), and are based on a 4.5 percent discount rate.

Sensitivity tests that changed assumptions to be more or less favorable for battery-electric buses found that the battery-electric bus life-cycle cost might range from 27 percent lower to 10 percent more expensive than diesel-hybrids, depending on whether the assumptions are favorable to battery-electric buses or diesel-hybrids.

**Issues for Committee Consideration**

Given the emerging technology and additional evaluations planned by Metro, the Committee may wish to consider scheduling future briefings and/or reporting by Metro at key milestones.

**AMENDMENT**

The amendment would clarify that Attachment A, Feasibility of Achieving a Carbon-Neutral or Zero-Emission Fleet, fulfills the requirements of Motion 14633 Section C and the expenditure restriction in the 2017-2018 Budget Ordinance (Ordinance 18409), Section 132, ER2.

1. Current ratio is 45 percent 40-foot buses to 55 percent 60-foot buses. [↑](#footnote-ref-1)
2. Metro expects to know whether the currently available buses will meet its needs after testing four 60-foot buses starting in the second half of 2017 and taking 12 to 18 months to test. [↑](#footnote-ref-2)
3. Metro currently replaces 5 to 7 percent of its fleet annually. [↑](#footnote-ref-3)
4. From *Feasibility of Achieving a Carbon-Neutral or Zero-Emission Fleet*  [↑](#footnote-ref-4)
5. King County Executive Dow Constantine. 2017. Available at: http://kingcounty.gov/elected/executive/constantine/news/release/2017/January/10-battery-buses.aspx [↑](#footnote-ref-5)
6. 50 of the buses the approximately 88 will be from Proterra and 38 from undermined manufacturer(s). [↑](#footnote-ref-6)
7. This figure is from *Feasibility of Achieving a Carbon-Neutral or Zero Emission Fleet, page 42* [↑](#footnote-ref-7)