KING COUNTY TROLLEY BUS EVALUATION

MAY 2011

King County
METRO

We'll Get You There

King County Trolley Bus Evaluation

May 2011

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LTK **Engineering Services**

Contents

Exhibits

Acronyms and Abbreviations

ac	alternating current
ADA	Americans with Disabilities Act
AEO	Annual Energy Outlook
APR	annual percentage rate
APU	auxiliary power unit
ATC	automatic traction control
BRT	bus rapid transit
CAA	Clean Air Act
CE	Categorical Exclusion
CMBC	Coast Mountain Bus Company, Vancouver, B.C.
CNG	compressed natural gas
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalents
CPI	Consumer Price Index
dBA	A-weighted decibel
dc	direct-current
DCE	Documented Categorical Exclusion
EIA	Energy Information Administration
EPU	emergency power unit
ETI	Electric Trolley, Inc.
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GHG	greenhouse gas
HVAC	heating, venting, and air conditioning
hybrid	diesel hybrid
kW	kilowatts
kWh	kilowatt-hours
LNG	liquefied natural gas
Metro	King County Metro
mpg	miles per gallon
mph	miles per hour
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NiCad	nickel cadmium
NiMh	nickel metal hydride
NRHP	National Register of Historic Places
NTD	National Transit Database
NO	nitric oxide
NO_2	nitrogen dioxide
NOx	nitrous oxides
O_3	ozone
O&M	operation and maintenance
OCS	overhead contact system
PSCAA	Puget Sound Clean Air Agency
RTA	Greater Dayton Regional Transit Authority
SAFETEA-LU	Safe Accountable Flexible Efficient Transportation Equity Act: A Legacy for Users
SCL	Seattle City Light
SEPA	State Environmental Policy Act
SEPTA	Southeastern Pennsylvania Transit Authority
SFMTA	San Francisco Metropolitan Transit Authority
TES	traction electrification system
TOH	trolley overhead (system)
U.S.C.	United States Code
VOC	volatile organic compound
WSST	Washington State Sales Tax

Appendices

1. Executive Summary

REPLACING THE TROLLEY BUSES

King County Metro's (Metro) electric trolley bus fleet is scheduled to begin replacement in September 2014. Before purchasing new buses, an in-depth, interdisciplinary evaluation of vehicle options was conducted by Parametrix to determine relative costs, limitations, environmental impacts, and benefits and is summarized in this report. The study evaluated each technology using the current route structure as a base. The findings from this evaluation will inform the technology decision for replacement of the trolley buses.

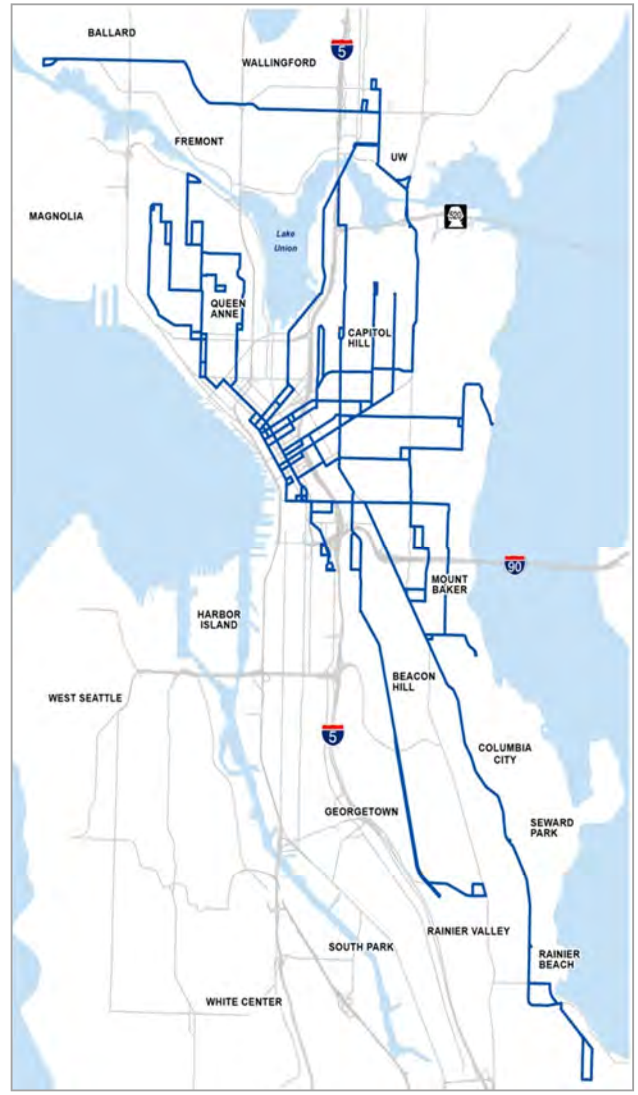
KING COUNTY METRO'S TROLLEY BUS NETWORK

The 14 trolley bus routes carry 20 percent of Metro's weekday riders on 159 trolley buses. The routes have 70 miles of two-way overhead wire. Exhibit 1-1 shows the trolley bus service area in Seattle. Currently, five trolley bus systems are operating in the United States: Seattle, San Francisco, Dayton, Philadelphia, and Boston.

WHY THE TROLLEY BUSES NEED REPLACEMENT

Metro's 159 electric trolley buses are reaching the end of their useful lives. The buses have outdated electrical systems, cracked non-structural overhead frames, and some parts that will be difficult to replace once they fail. There is no longer manufacturer support for the existing propulsion systems.

Exhibit 1-1. Trolley Bus Service Area in Seattle



PROPULSION TECHNOLOGIES EVALUATED

Six propulsion technologies were evaluated as part of the initial screening analysis. Two were selected for further evaluation as follows:

Diesel Hybrid Bus

Diesel hybrid buses are common and currently comprise a growing portion of Metro's fleet. Bus maintenance facilities currently exist to perform necessary maintenance, although additional fueling capacity would be needed to accommodate the increased fleet size.

This technology was selected, but may require modification to the drive train system for travel on the steep hills in Seattle, which would limit the hybrid bus' top speed on level grades.

Electric Trolley Bus

Electric trolley buses have been operating on urban routes in Seattle since the 1940s. The electric power and overhead wire system is in place to support this technology on existing routes. Electric trolley buses operate efficiently on routes with steep grades such as Capitol Hill and Queen Anne.

The electric trolley bus would be equipped with an auxiliary power unit (APU) to increase flexibility by permitting off-wire travel. This study evaluated both diesel and battery APUs—the battery APU was recommended based on performance and cost.

Bus Technologies Eliminated from Further Evaluation

The diesel technology was eliminated from further evaluation because it is less fuel efficient and has a greater environmental impact than diesel hybrid buses.

Electric Battery

The electric battery technology was eliminated because the propulsion system is not commercially available, vehicles have a reduced travel range, and the technology has not been proven to accommodate steep grades on the Seattle trolley routes.

Compressed Natural Gas

The high costs of compressed natural gas (CNG) and the greater environmental impact than diesel hybrid buses were reasons this propulsion technology was eliminated.

Hydrogen Fuel Cell

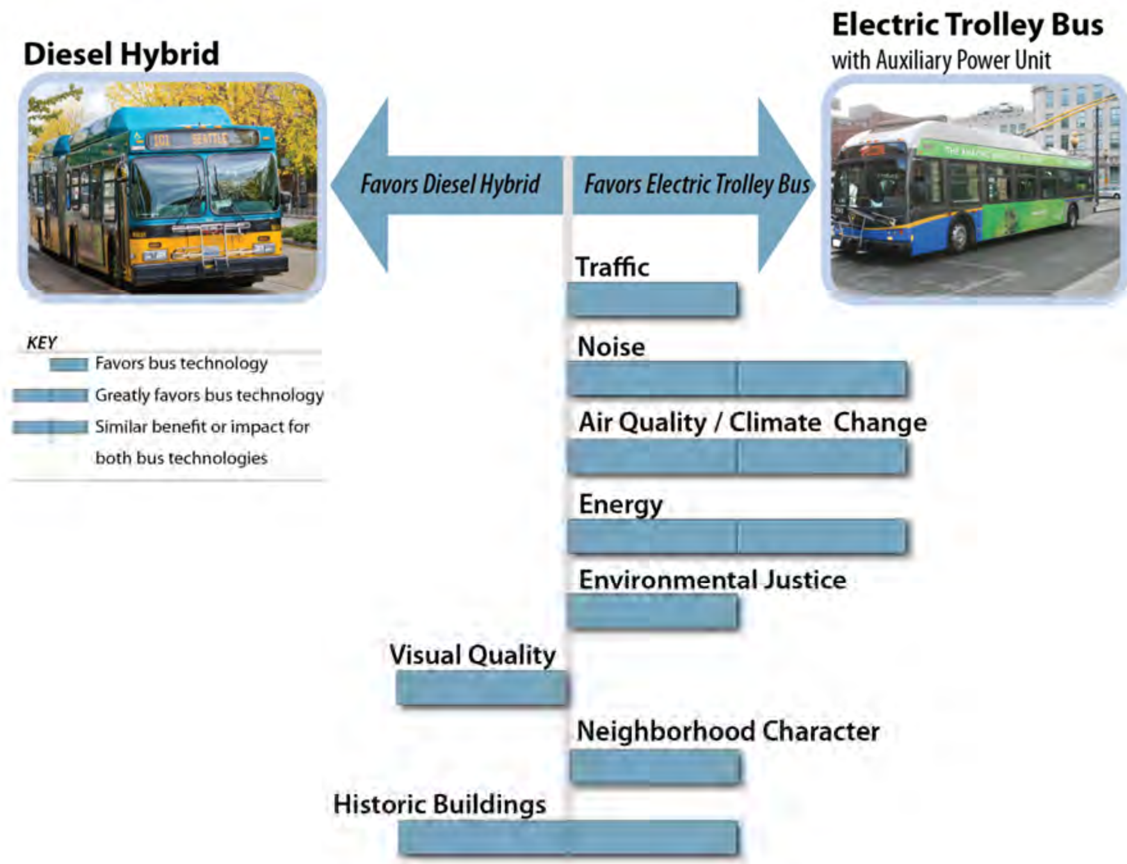
Hydrogen fuel cell propulsion systems were removed from further evaluation because hydrogen fuel is not commercially available, it is expensive, and it has a reduced travel range and reduced reliability.

ENVIRONMENTAL COMPARISON

Environmental components are an important consideration for selecting the appropriate bus technology. After the King County Council selects the preferred fleet replacement option in the 2012 to 2013 biennial budget, Metro staff will conduct a more detailed environmental review if the diesel hybrid technology is selected.

The adjacent chart (Exhibit 1-2) shows why the environmental findings favor the electric trolley bus over the diesel hybrid technology. Electric trolley buses perform better on steep grades (shown in Exhibit 1-2 as a traffic benefit), are quieter, have lower greenhouse gas (GHG) emissions, and consume less energy on a yearly basis.

Exhibit 1-2. Environmental Impacts and Benefits Summary



LIFE-CYCLE COST COMPARISON

A life-cycle cost comparison was prepared to evaluate the full capital and operating costs of each bus technology. Because the estimated life-spans of the electric trolley bus (15 years) and diesel hybrid (12 years) are different, the costs were annualized and discounted to today's dollars to provide a valid comparison. With the current Federal Transit Administration (FTA) funding, the electric trolley bus option annualized life-cycle cost is $11.8 million compared to $15.5 million for the diesel hybrid bus option, or $3.7 million less per year (Exhibit 1-3).

An important component of the cost comparison between diesel hybrid and electric trolley bus is the level of the FTA fixed guideway funding. The level of fixed guideway funding would have to drop to 31 percent of current funding levels before the diesel hybrid bus technology would have a cost advantage (Exhibit 1-4).

Exhibit 1-3. Life-Cycle Cost Analysis Summary

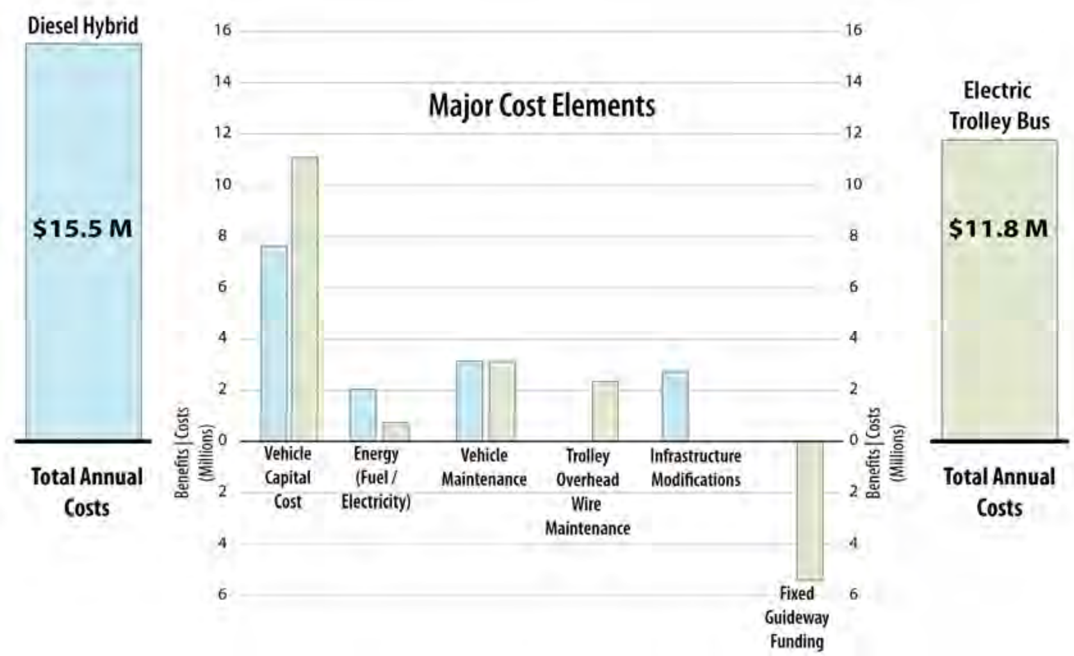


Exhibit 1-4. Fixed Guideway Funding Influence on Life-Cycle Cost

CONCLUSIONS

After considering the environmental and life-cycle cost comparison, this evaluation concludes the electric trolley bus is the preferred technology (Exhibit 1-5) for the following reasons:

- It is more cost-effective to replace the existing fleet with electric trolley buses based on reasonable federal fixed guideway funding scenarios.
- The electric trolley bus generates significantly lower GHG emissions and has a lower total annual energy consumption. Seattle City Light generates 98 percent of Seattle's electricity from non-GHG emitting sources (hydroelectric, nuclear, wind, and biomass).
- The environmental comparison favors the electric trolley bus regarding traffic, noise, air quality/climate change, energy, and environmental justice.

Exhibit 1-5. New Electric Trolley Bus Operating in Vancouver, B.C.