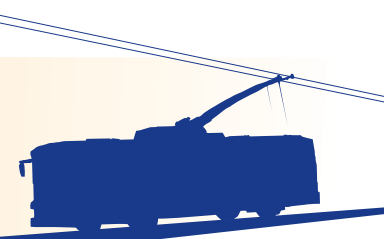


KING COUNTY TROLLEY BUS EVALUATION



MAY 2011



We'll Get You There

King County Trolley Bus Evaluation
May 2011

Prepared by:

Parametrix

LTK Engineering Services

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Acronyms and Abbreviations

ac	alternating current	kW	kilowatts	SEPTA	Southeastern Pennsylvania Transit Authority
ADA	Americans with Disabilities Act	kWh	kilowatt-hours	SFMTA	San Francisco Metropolitan Transit Authority
AEO	Annual Energy Outlook	LNG	liquefied natural gas	TES	traction electrification system
APR	annual percentage rate	Metro	King County Metro	TOH	trolley overhead (system)
APU	auxiliary power unit	mpg	miles per gallon	U.S.C.	United States Code
ATC	automatic traction control	mph	miles per hour	VOC	volatile organic compound
BRT	bus rapid transit	NEPA	National Environmental Policy Act	WSST	Washington State Sales Tax
CAA	Clean Air Act	NHPA	National Historic Preservation Act		
CE	Categorical Exclusion	NiCad	nickel cadmium		
CMBC	Coast Mountain Bus Company, Vancouver, B.C.	NiMh	nickel metal hydride		
CNG	compressed natural gas	NRHP	National Register of Historic Places		
CO ₂	carbon dioxide	NTD	National Transit Database		
CO ₂ e	carbon dioxide equivalents	NO	nitric oxide		
CPI	Consumer Price Index	NO ₂	nitrogen dioxide		
dba	A-weighted decibel	NO _x	nitrous oxides		
dc	direct-current	O ₃	ozone		
DCE	Documented Categorical Exclusion	O&M	operation and maintenance		
EIA	Energy Information Administration	OCS	overhead contact system		
EPU	emergency power unit	PSCAA	Puget Sound Clean Air Agency		
ETI	Electric Trolley, Inc.	RTA	Greater Dayton Regional Transit Authority		
FHWA	Federal Highway Administration	SAFETEA-LU	Safe Accountable Flexible Efficient Transportation Equity Act: A Legacy for Users		
FTA	Federal Transit Administration	SCL	Seattle City Light		
GHG	greenhouse gas	SEPA	State Environmental Policy Act		
HVAC	heating, venting, and air conditioning				
hybrid	diesel hybrid				

Appendices

Appendix A: Public Involvement Report: Trolley Bus
System Evaluation

Appendix B: Interview Questions for Manufacturers and
Other Transit Agencies

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.

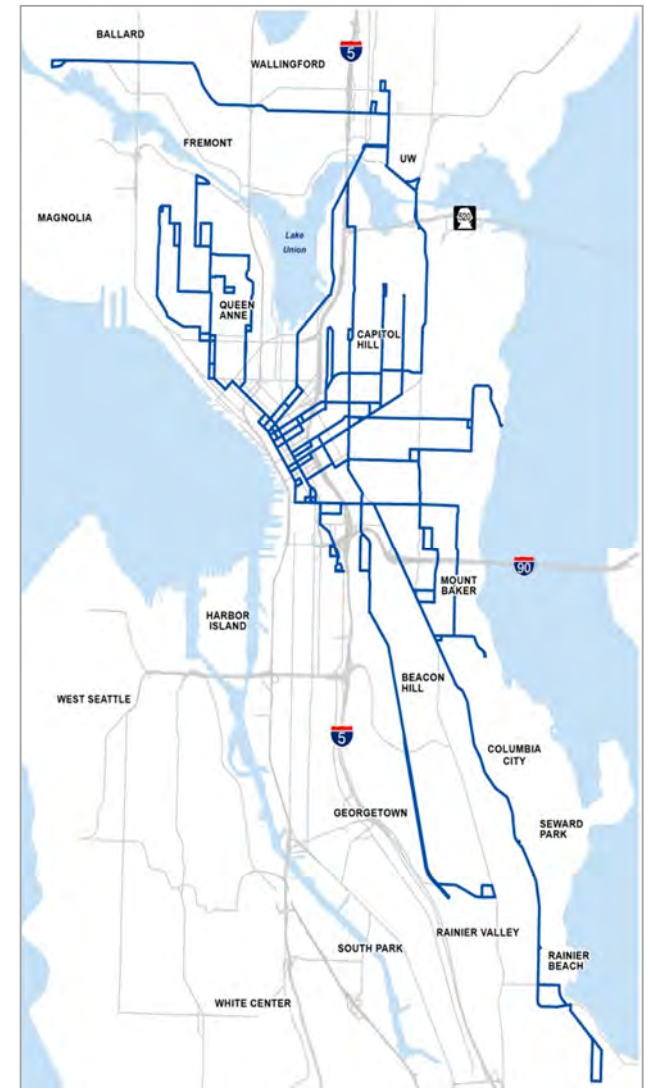
KING COUNTY METRO'S TROLLEY BUS NETWORK

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

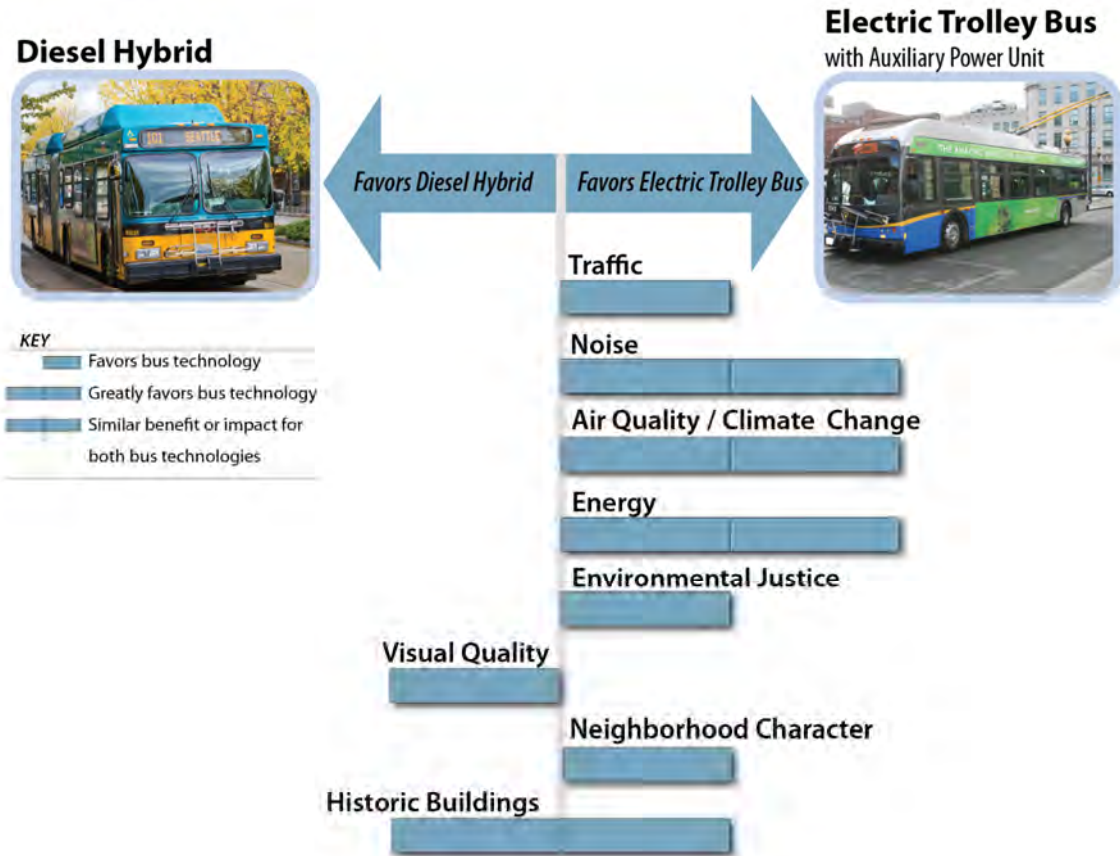
Hydrogen fuel cell propulsion systems were removed from further evaluation because hydrogen fuel is not commercially available, it is expensive, and it has a reduced travel range and reduced reliability.

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

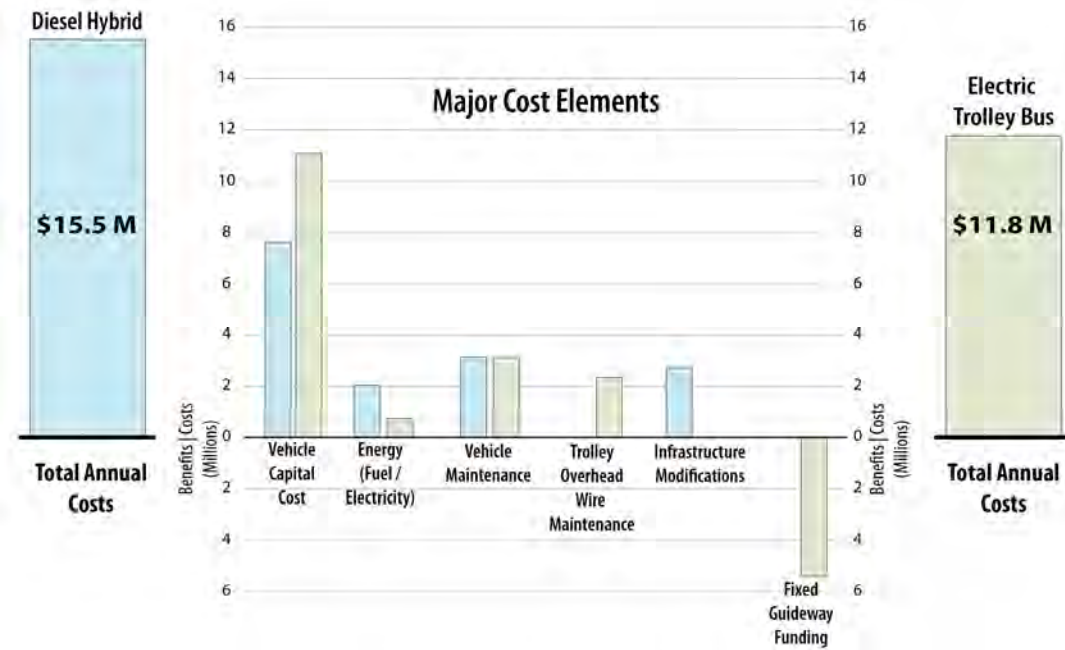


Exhibit 1-4. Fixed Guideway Funding Influence on Life-Cycle Cost



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.

