Trolley Bus System Evaluation

Preliminary Findings

April 2011

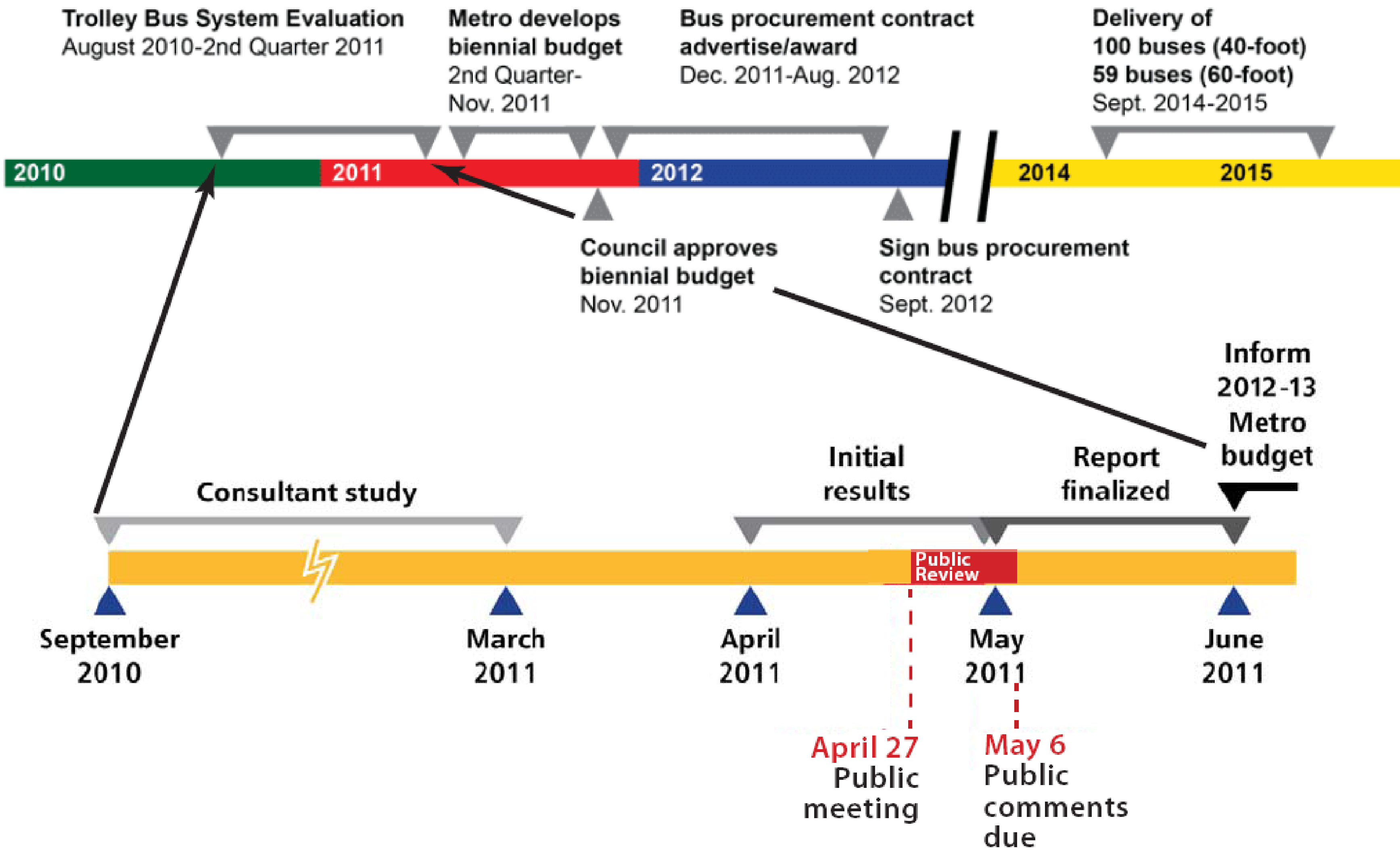
Presentation Agenda

1. Background / Purpose of Evaluation
2. Auxiliary Power Unit (APU) Review
3. Environmental Analysis Summary
4. Life Cycle Cost Analysis Summary
5. Preliminary Findings
6. Next Steps

Purpose of the Evaluation

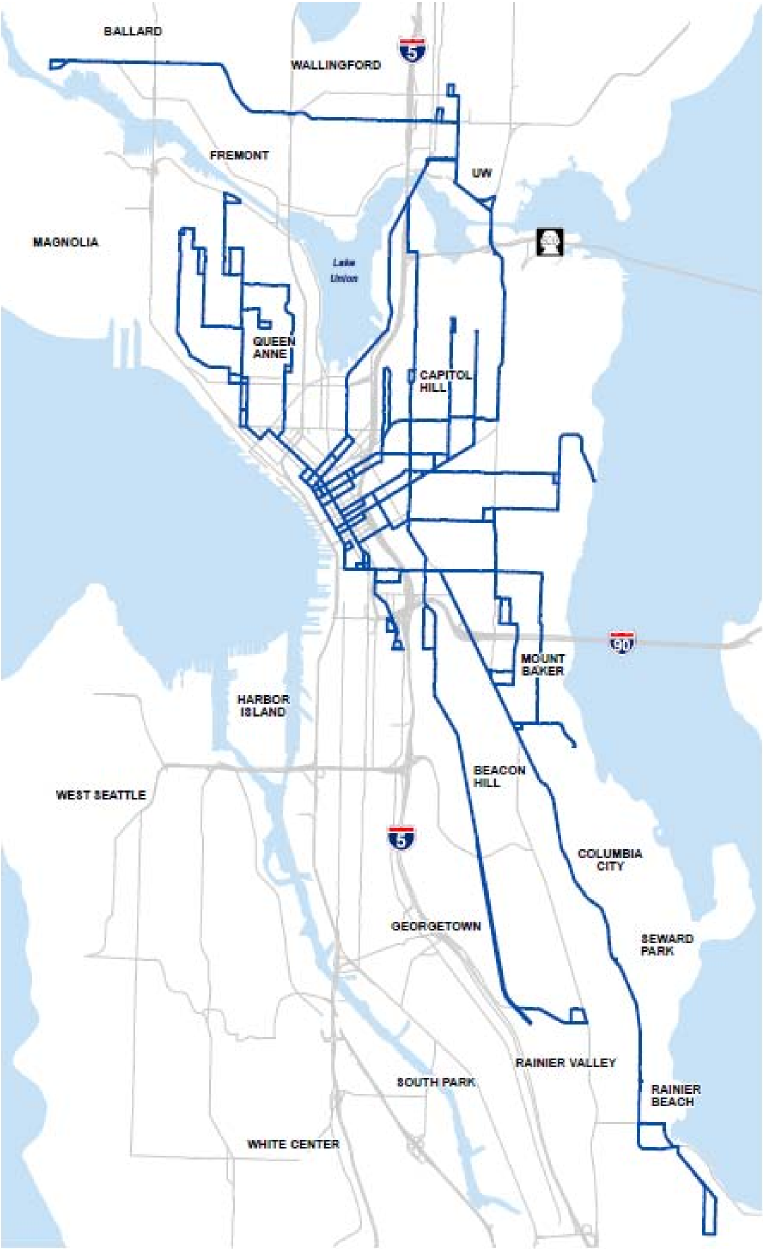
- 2009 transit performance audit required evaluation
- Establish budget plan for fleet replacement (2012-2013 biennial budget)

Evaluation Schedule



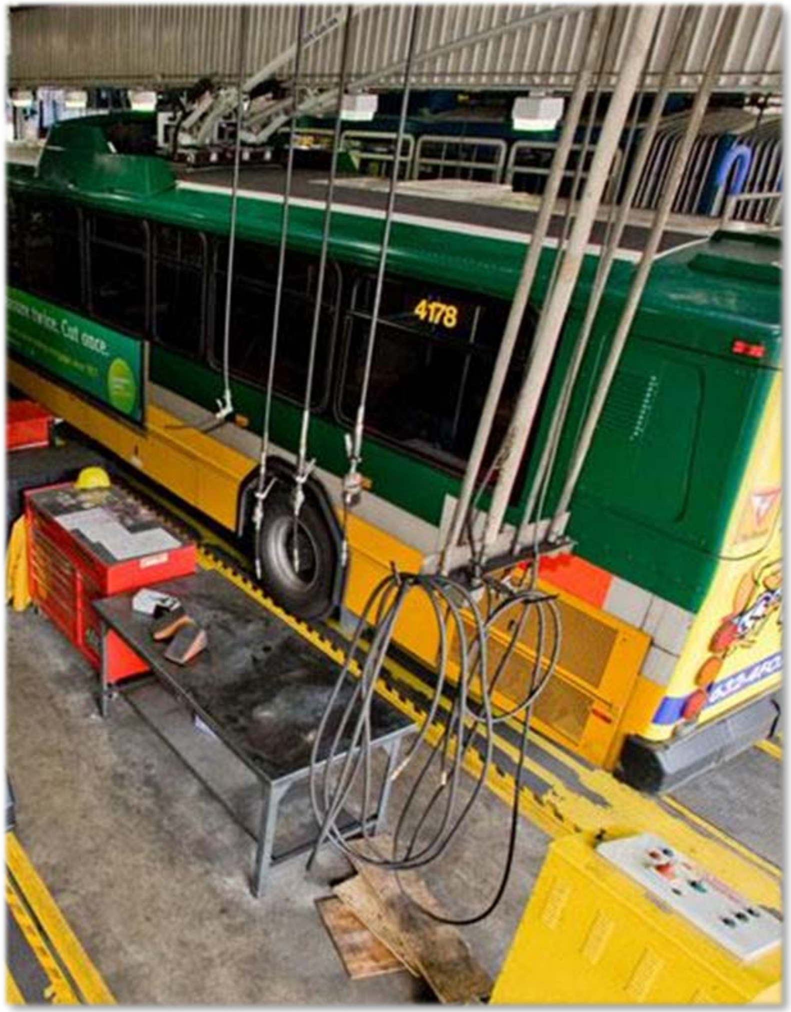
Metro’s Trolley Bus Network

- 14 routes and 159 trolley buses
- 70 miles of two-way overhead wire
- Carries 20% of Metro’s weekday riders
- One of five trolley systems in USA
    1. Seattle, WA
    2. San Francisco, CA
    3. Dayton, OH
    4. Philadelphia, PA
    5. Boston, MA



Status of Metro's Trolley Buses

- Buses need to be replaced
- Outdated electrical systems
- Cracked trolley bus frames
- Obsolete parts



Bus Technologies Eliminated from Further Consideration

Diesel	Less fuel efficient Greater environmental impact than diesel hybrids
Electric Battery	Not commercially available Reduced travel range
Compressed Natural Gas	High costs Greater environmental impacts than diesel hybrids
Hydrogen Fuel Cell	Not commercially available High costs Reduced travel range Reduced reliability

Bus Technologies Included in the Evaluation

Diesel Hybrid Bus

Reworked transmission to travel on steep grades

Electric Trolley Bus

Photo by John Perlic

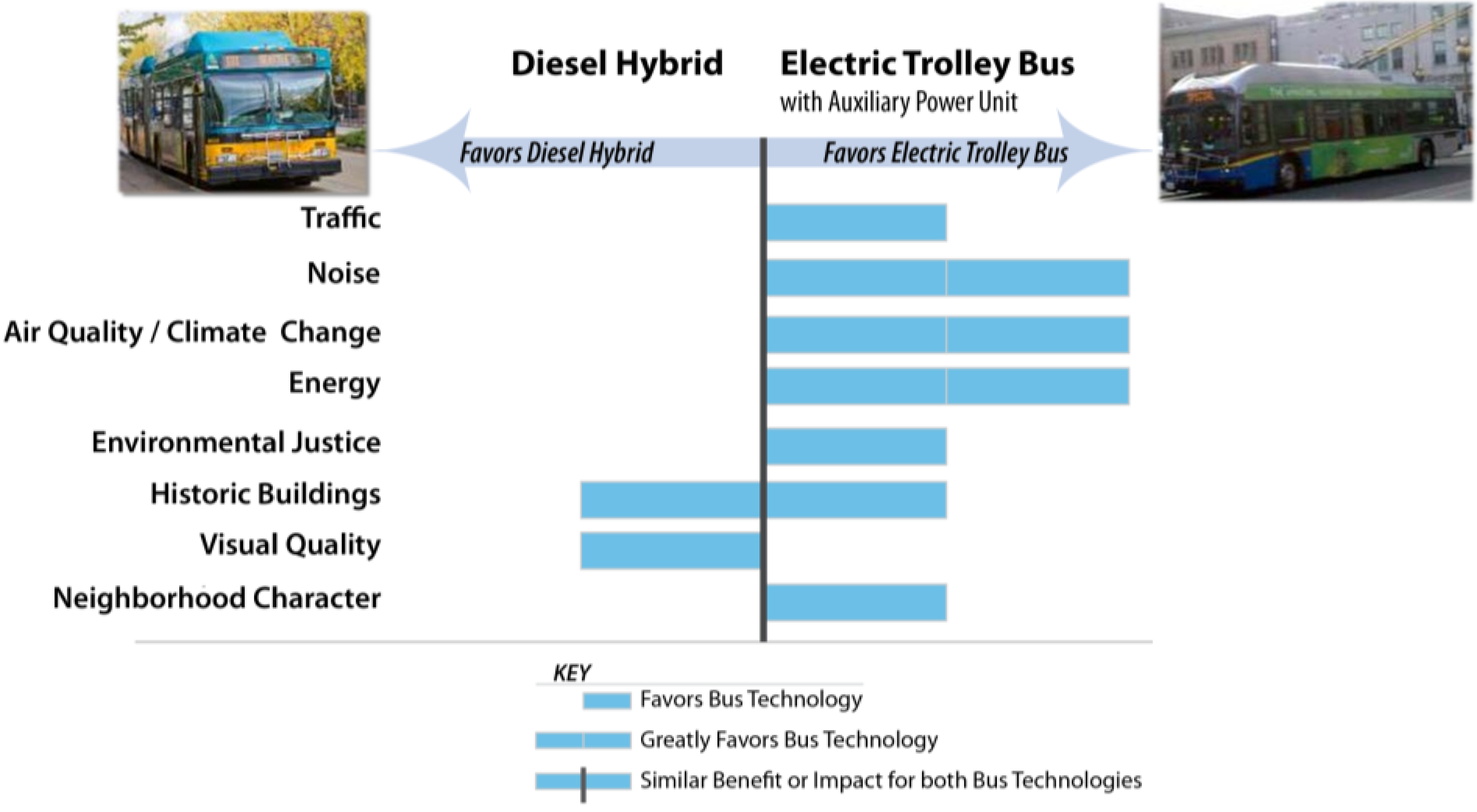
Added auxiliary power unit (APU) for off-wire travel

Electric Trolley Bus Auxiliary Power Unit (APU) Review

	Battery APU	Diesel APU
APUs in operation	San Francisco, CA Dayton, OH Boston, MA Vancouver, BC	Philadelphia, PA
Range (Miles)	Up to 2.5	Up to 150
Max speed, Level	40 mph	25 mph
Max grade	As required	6%
Acceleration	Better	Worse
Switch from electric power	Faster	Slower
Fuel required	None	Yes

Measures

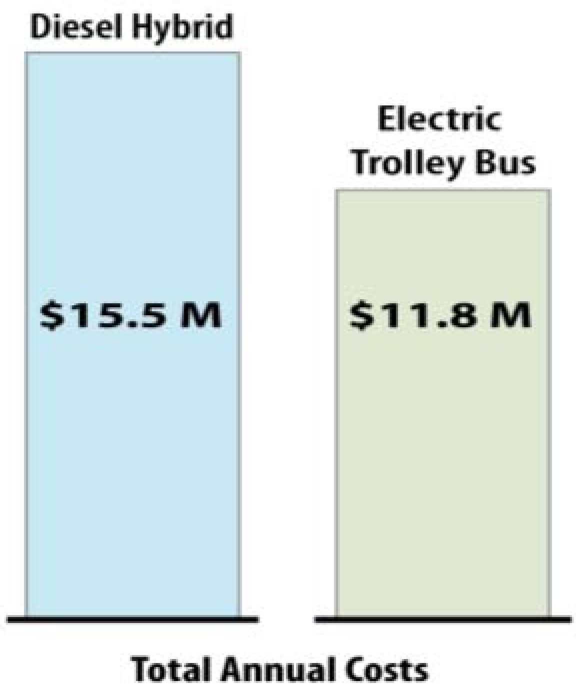
Environmental Comparative Analysis Summary



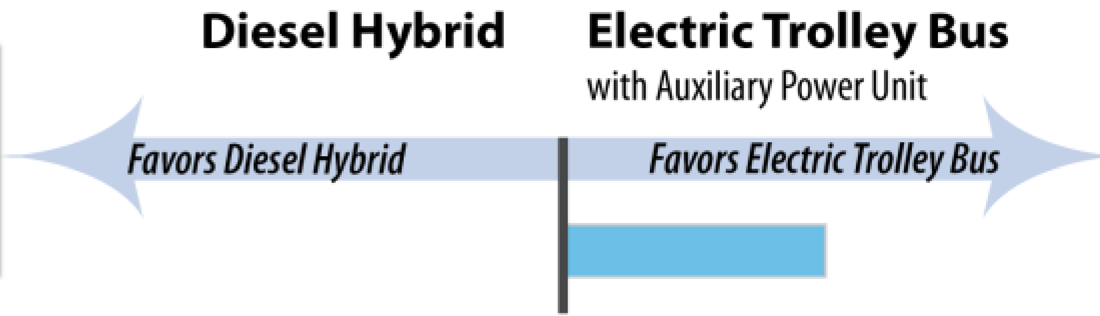
Annualized Life-Cycle Cost Summary

Diesel Hybrid | **Electric Trolley Bus** with Auxiliary Power Unit

Electric Trolley Bus technology costs $3.7 million less than Diesel Hybrid



Traffic

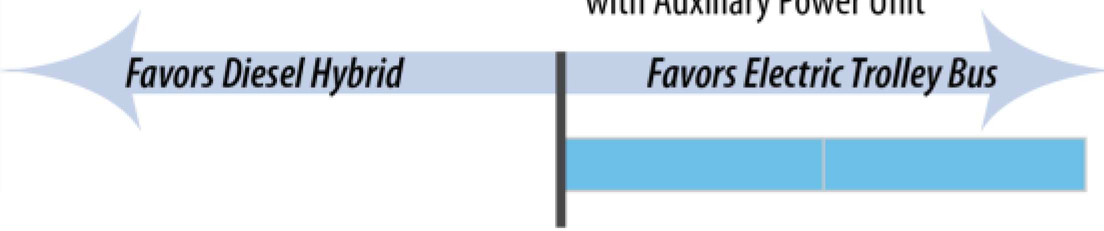


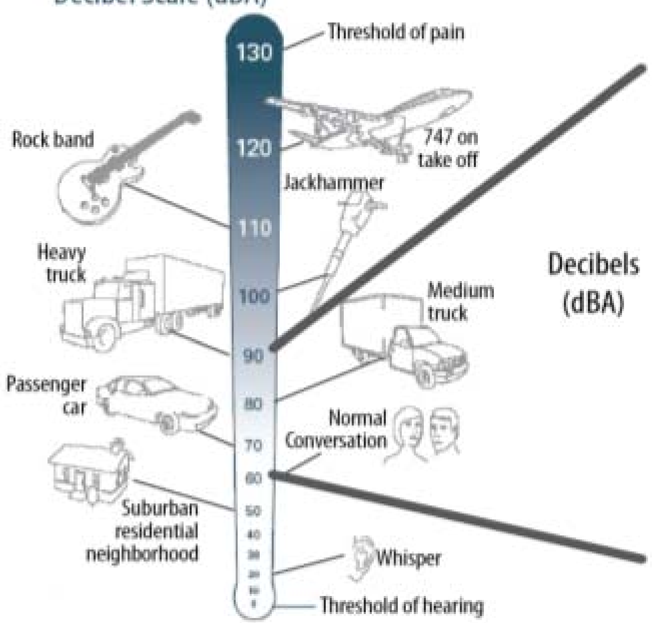
Diesel Hybrid	Electric Trolley Bus
+ No travel limitations from trolley wire	− Off-wire travel limited by APU range
− May operate at slower speeds on steep grades	+ Can operate at faster speeds on steep grades
− Low gearing for steep hills limits top speed on level grades	+ No speed limitations on level grades

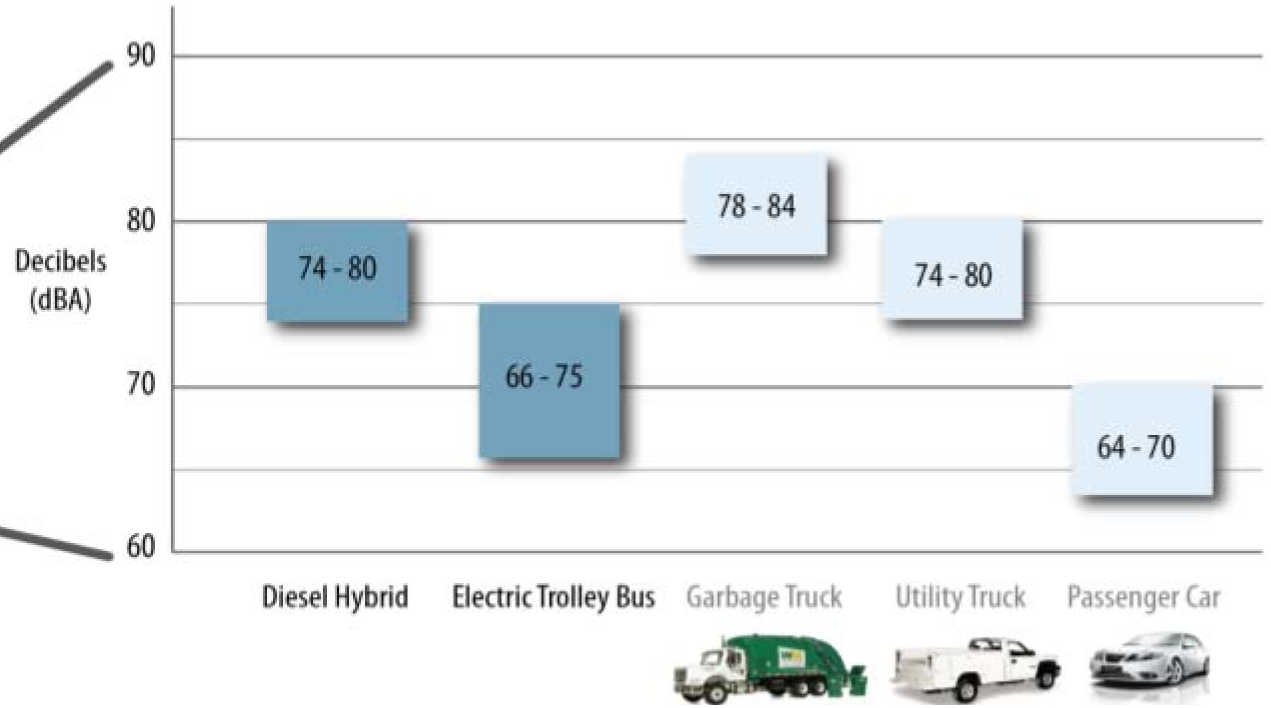
Noise

Diesel Hybrid

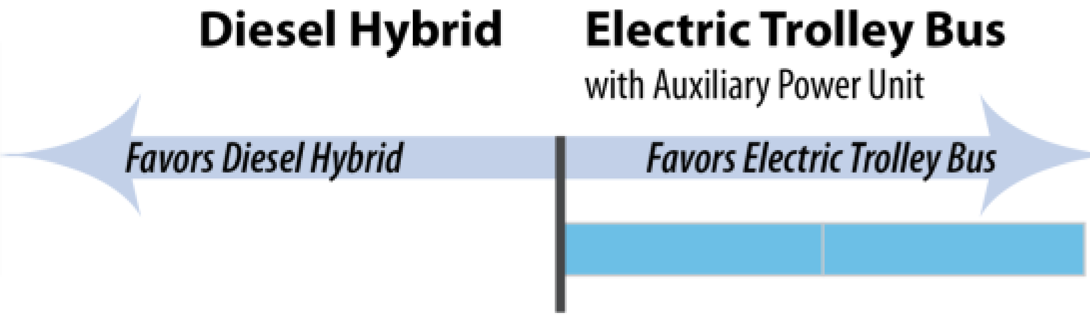
Electric Trolley Bus
with Auxiliary Power Unit

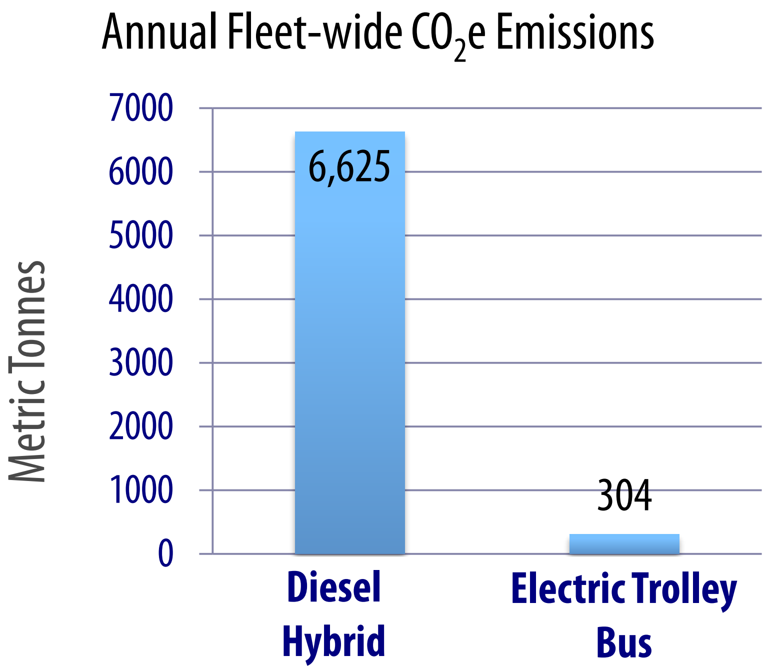






Climate Change

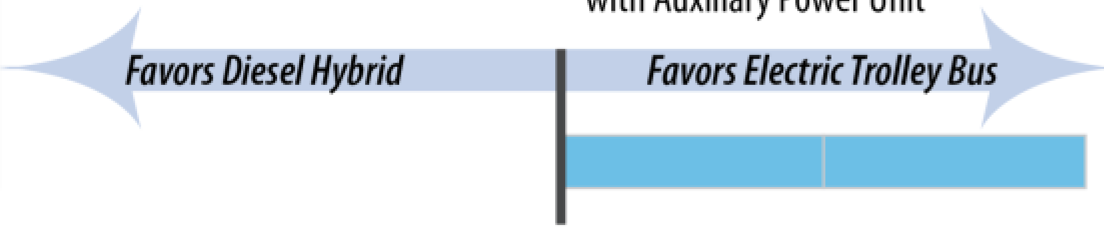




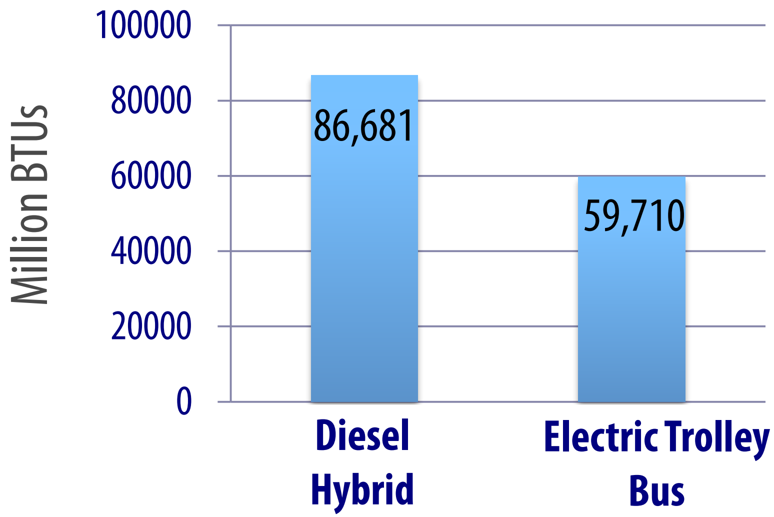
Energy

Diesel Hybrid

Electric Trolley Bus
with Auxiliary Power Unit

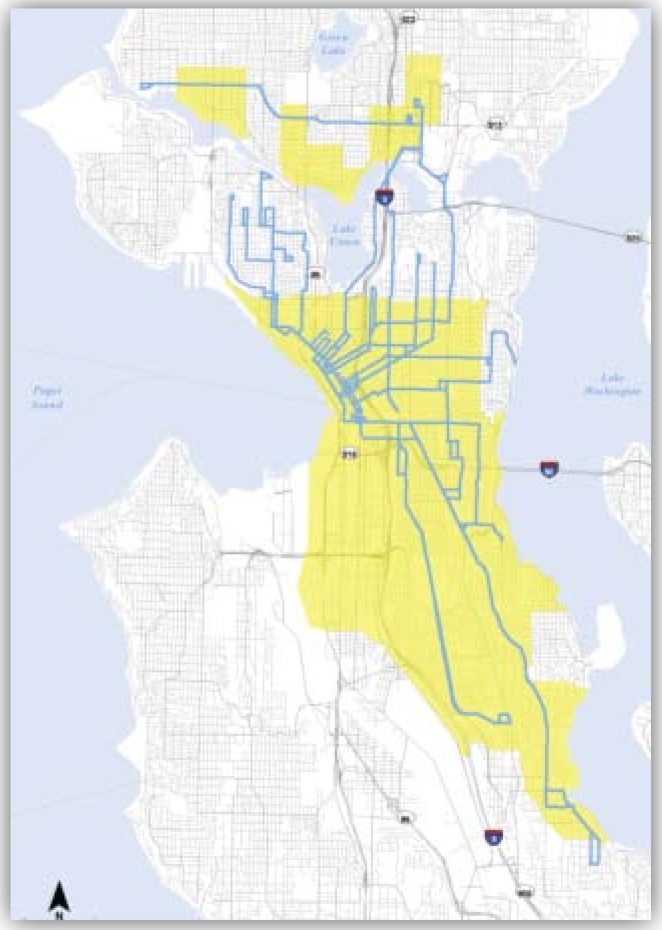


Annual Fleet-wide Energy Consumption
(million BTU)



Environmental Justice: Minority and Low-Income Population Distribution along Electric Trolley Bus Routes

Areas with high concentrations of low-income population

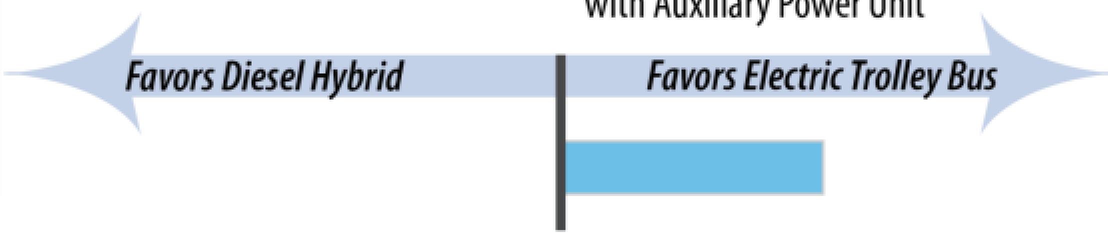


Areas with high concentrations of minority population

Environmental Justice: Impacts to Low-Income and Minority Populations

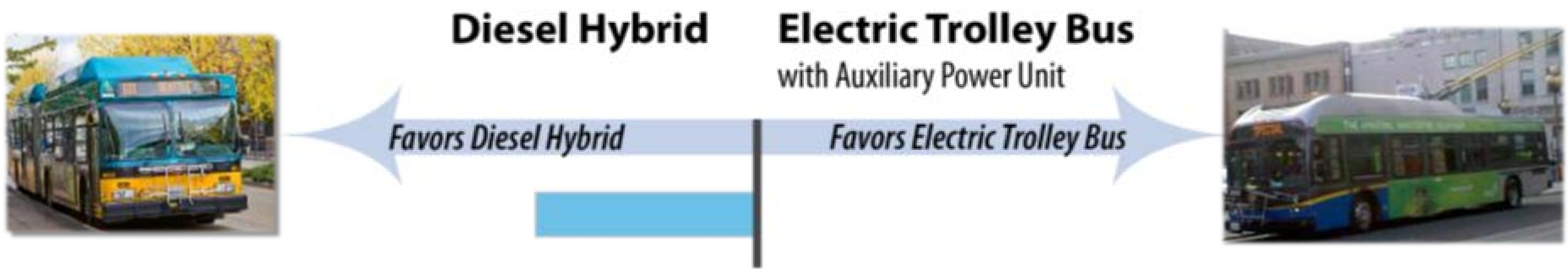
Diesel Hybrid

Electric Trolley Bus
with Auxiliary Power Unit



Diesel Hybrid	Electric Trolley Bus
− Higher impacts from noise and air pollution	+ Lower impacts from noise and air pollution
+ Lower visual impacts with wire removal	− Higher visual impacts from wires and power supply system

Visual Quality



+ Improved visual quality with removal of wires

(Varies depending on location)

− Impacts from trolley wires

(Highest in view corridors and residential neighborhoods)

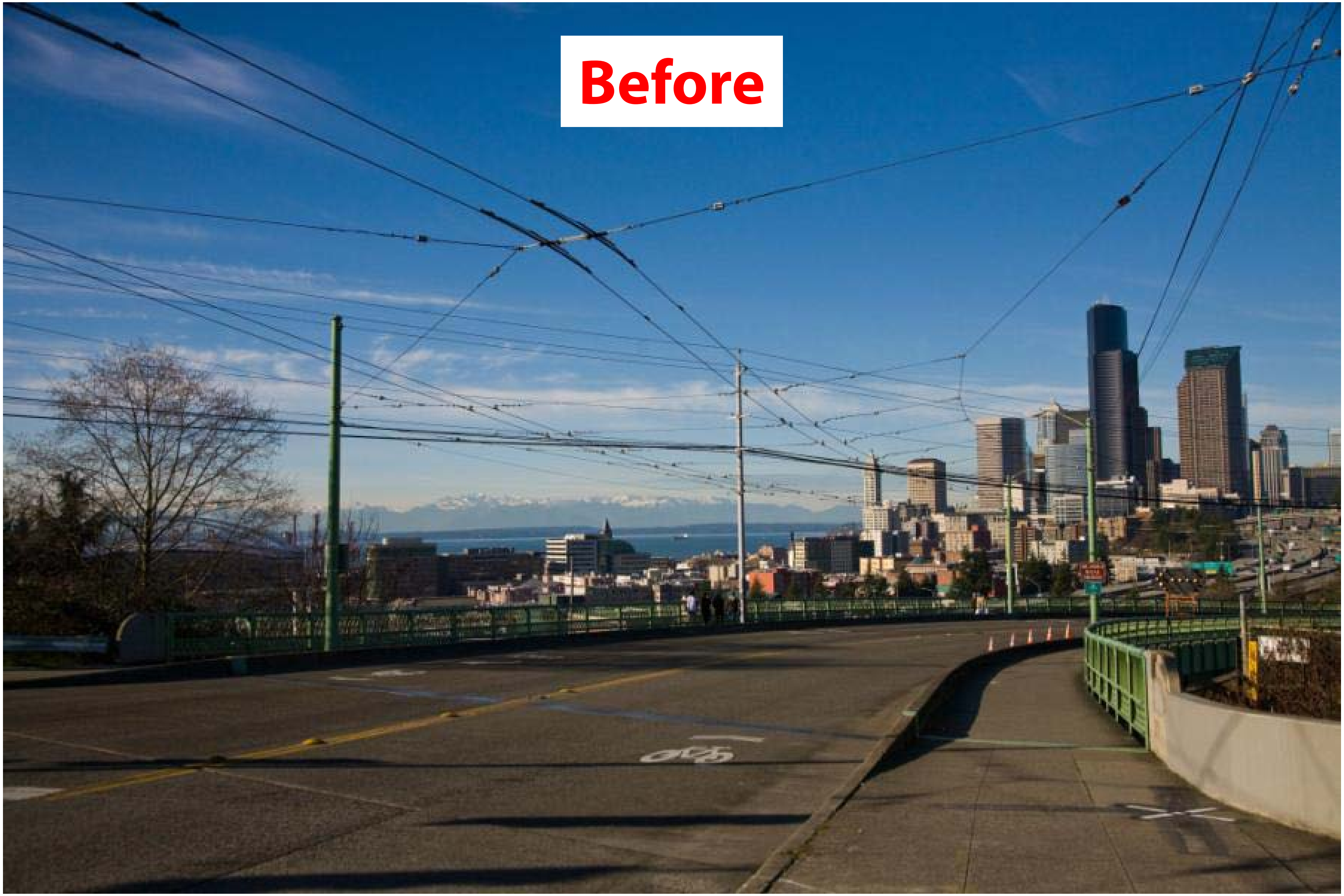
Visual Simulation: Rainier Valley

Before

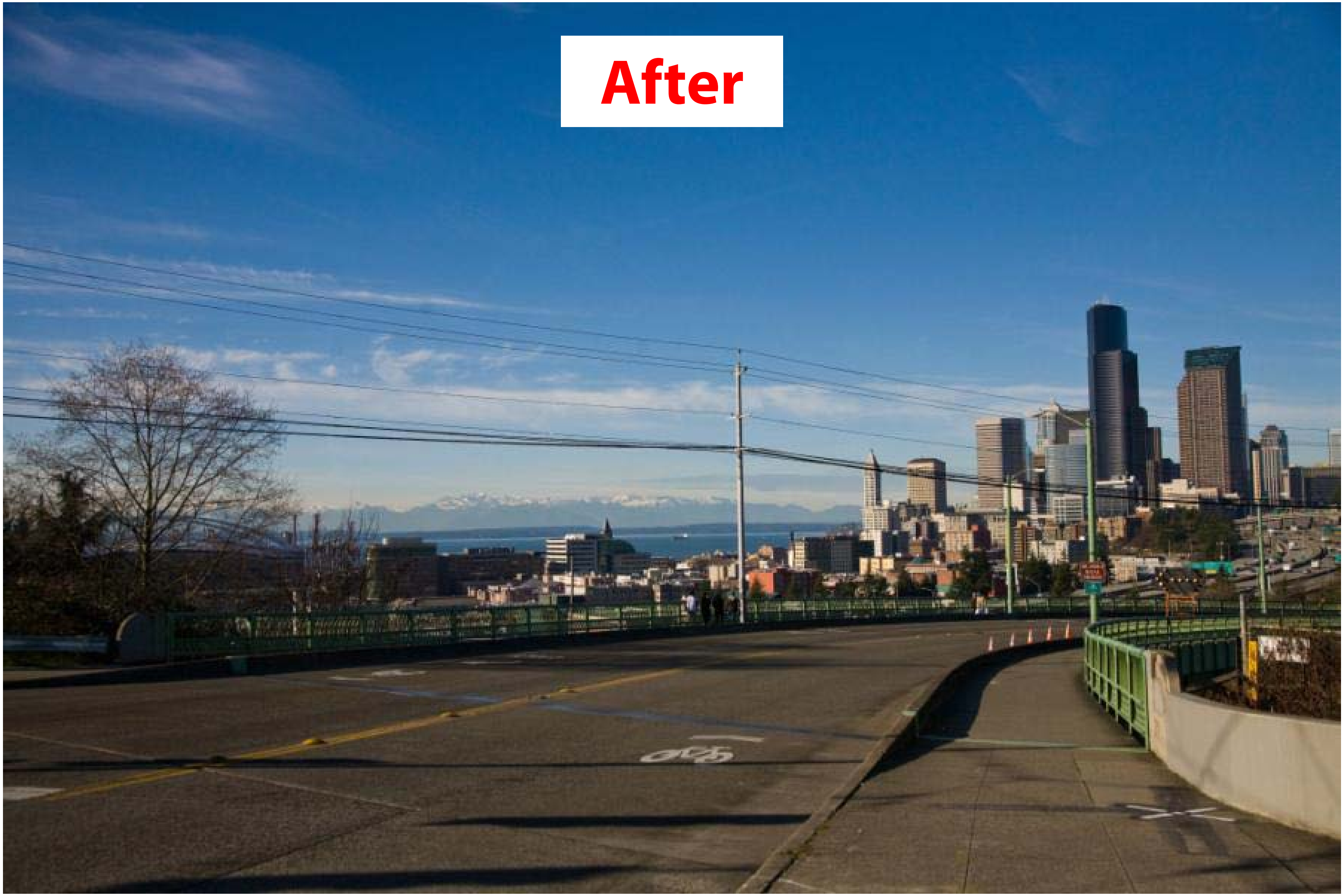
Visual Simulation: Rainier Valley

After

Visual Simulation: Downtown from Beacon Hill



Visual Simulation: Downtown from Beacon Hill



Life-Cycle Cost Model Data

1. Operating environment
   a. Current service
      i. Miles of trolley overhead wire
      ii. Actual annual trolley service miles
      iii. Magnitude and frequency of dieselization
   b. Projected future service
      i. Miles of trolley overhead wire
      ii. Projected annual trolley service miles
      iii. Magnitude and frequency of dieselization
         -Effect of APUs if and when implemented
2. Vehicle
   a. Vehicle types
   b. Vehicle life span
   c. Fleet size
   d. Capital costs
      i. Historic Base Price
         -Escalation
      ii. Current Base Price
      iii. Cost adjustments
         - sales tax
         - additional equipment
         - special tools
         - diagnostic equipment
         - service preparation
         - training & manuals
         - project management
         - inspection
         - contingency
         - salvage value
      iv. Total Capital Cost
3. Operating costs
   a. fuel/electricity
      i. basis for operating cost assumptions
      ii. caling average fleet operating costs to reflect KC Metro trolley service environment
   b. staff labor and overhead
4. Maintenance costs
   a. fueling & servicing
   b. spare parts
   c. tires
   d. routine maintenance
   e. trouble calls
   f. staff labor and overhead
5. Maintenance Facilities
   a. Fueling facility and infrastructure
   b. Efficiencies of work flow, scheduling, spares storage
6. Trolley Overhead (TOH) Wire
   a. Annual maintenance and inspection
      i. Materials and repair
      ii. Cleaning and landscaping
      iii. Utilities and Taxes
   b. Capital Improvements
      i. System Modifications
      ii. Future Rectifier Replacements
      iii. Substation Enclosures
      iv. Contractor Replacement
      v. Substation Batteries and Enclosure
      vi. Substation AC Cubicle
      vii. TAMP: Trolley Overhead Pole And Switch Maintenance
      viii. Influence of TOH lifespan on life cycle cost analysis
   c. Decommissioning

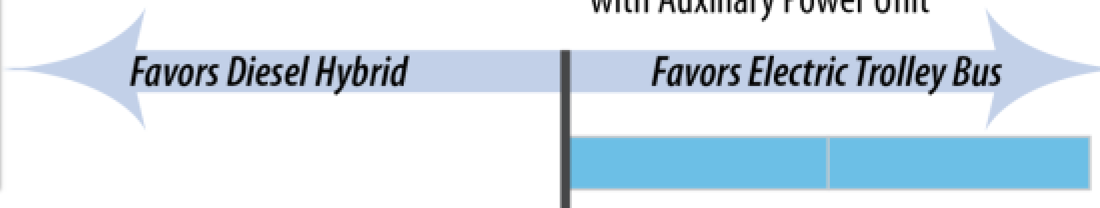
Key Life-Cycle Cost Model Assumptions

- Vehicle useful life (FTA, 2008)
  - Electric Trolley Bus: 15 years
  - Diesel Hybrid: 12 years
- 60 foot vehicle costs
  - Electric Trolley Bus: $1,285,000
  - Diesel Hybrid: $785,000
- Real Discount Rate (King County): 7% future value of today's dollars
- Annualized cost is calculated over one life-cycle for each vehicle type.
- Differential in fixed guideway grant amount is assumed in the analysis.
- Decommissioning trolley infrastructure: $37 million
- Expanding fuel capacity at base for hybrids: $5 million

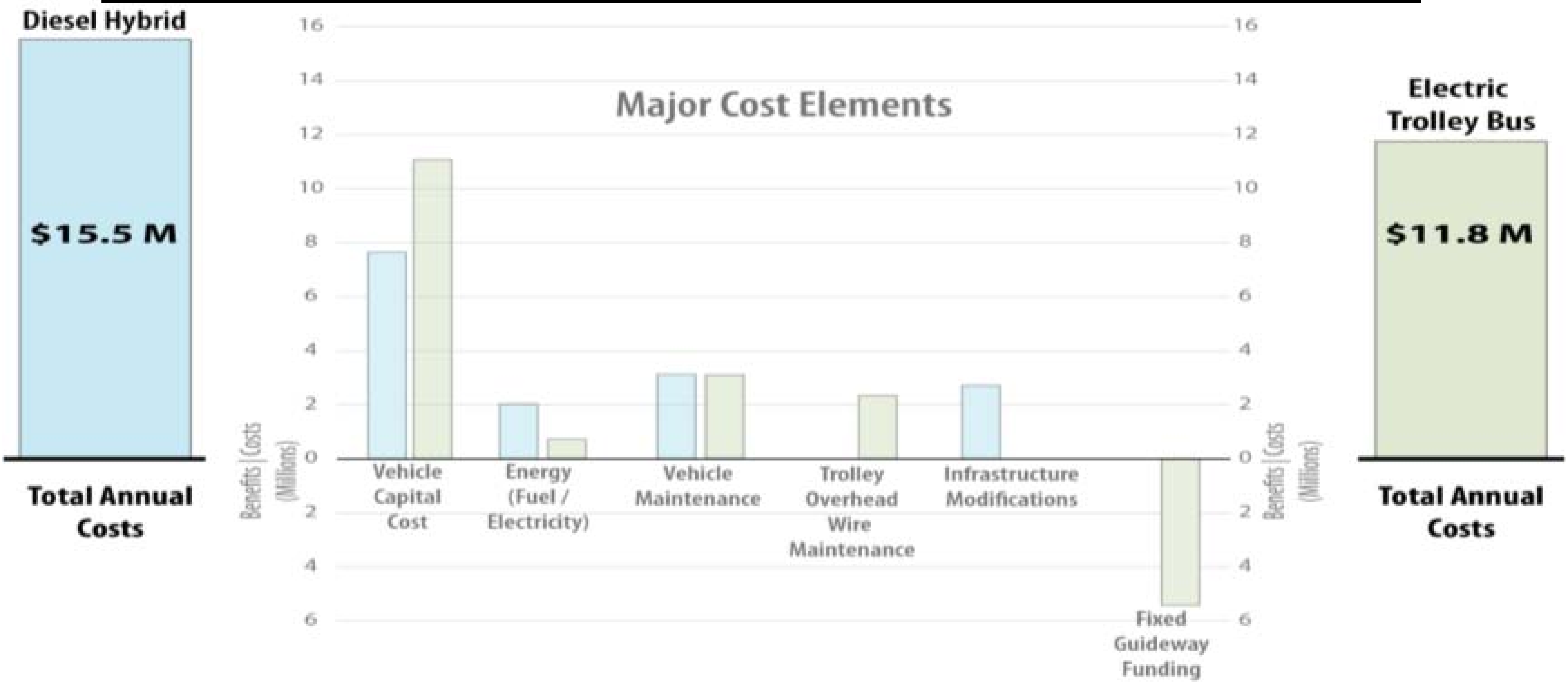
Annualized Life-Cycle Cost Summary

Diesel Hybrid

Electric Trolley Bus
with Auxiliary Power Unit

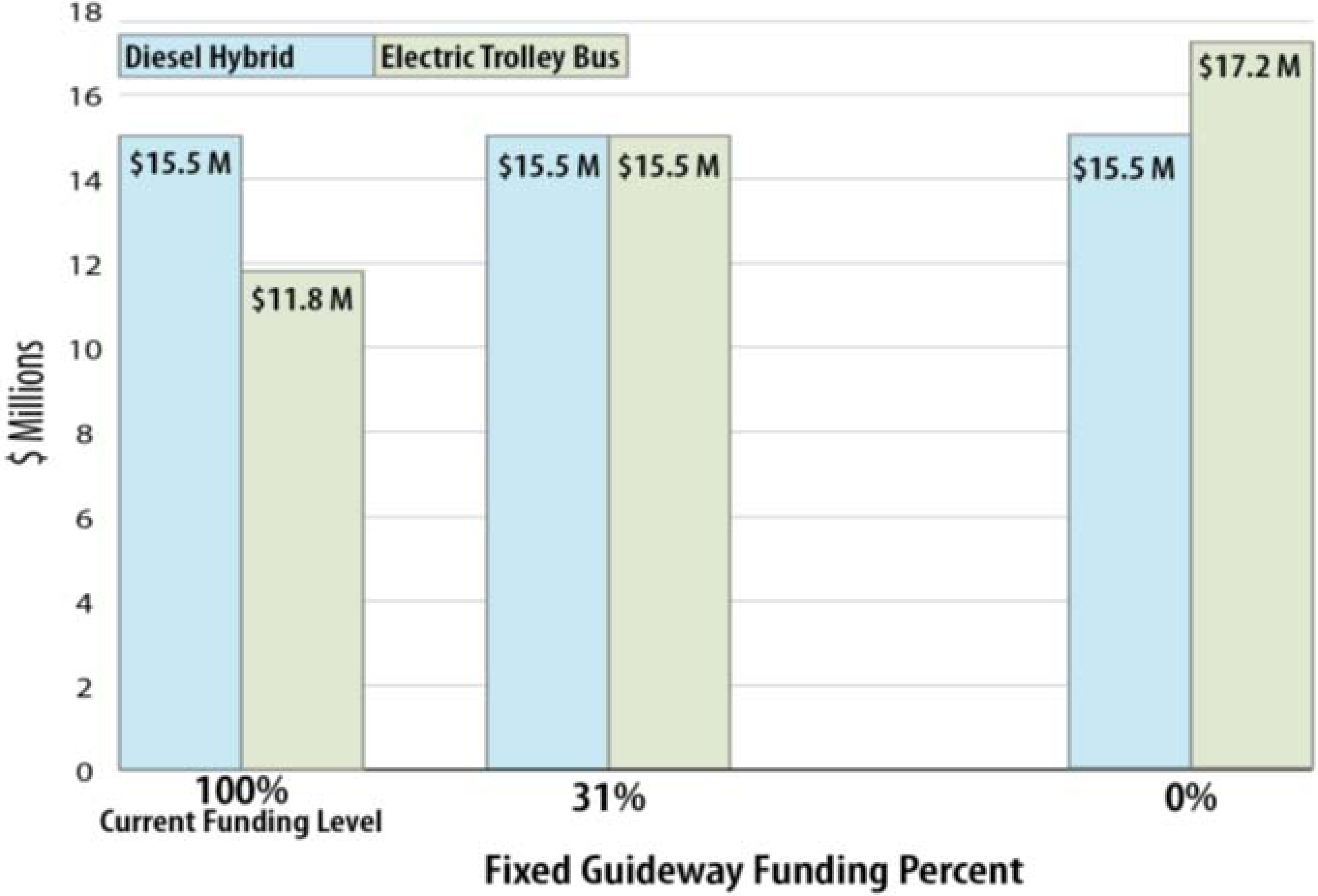


Electric Trolley Bus technology costs $3.7 million less than Diesel Hybrid



Influence of Fixed Guideway Funding on Total Annualized Cost

If FTA fixed guideway funding falls below 31% of current funding, the Diesel Hybrid technology is favored

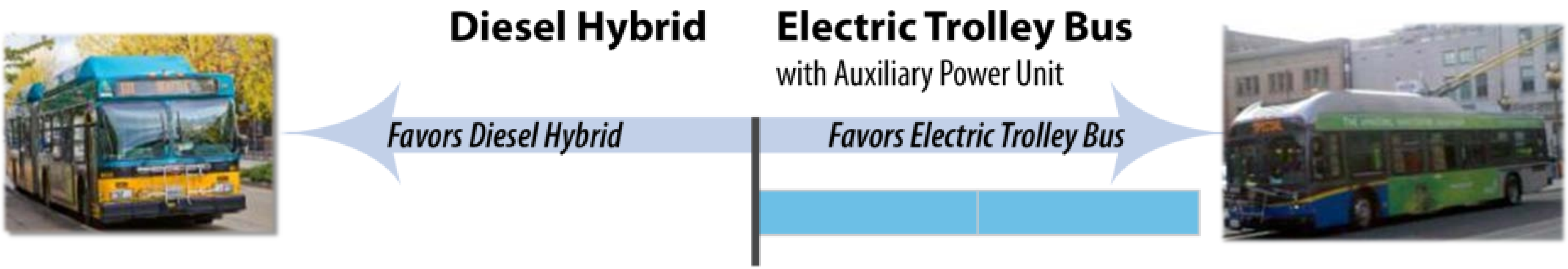


Sensitivity of Major Cost Variables

Base Case

What would be required to make Diesel Hybrid more cost effective?	
Input	**Ability to Switch Results**
Fixed guideway funding	Reduce to 31% of current level
Gas price	Not possible
Electricity price	Increase 20% per year
Diesel Hybrid life span	Increase from 12 to 17 years
Electric Trolley Bus purchase price	Increase by 34%
Diesel Hybrid purchase price	Decrease by 48%

Wrap-up



Built environment elements favor Electric Trolley Bus
Cost elements favor Electric Trolley Bus

Metro preliminary findings favor Electric Trolley Bus

Next Steps

- **April 27:** Public meeting
- **April and May:** Collect public feedback and finalize report
- **June:** Study findings incorporated into Metro’s 2012 – 2013 budget