



Advanced Technology Vehicles in Service

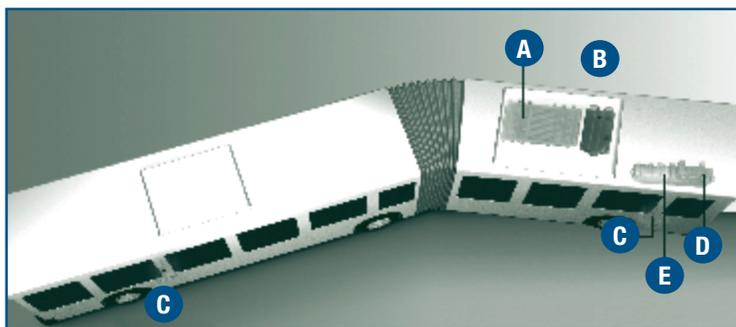
Advanced Vehicle Testing Activity



King County Metro Transit

DIESEL HYBRID ELECTRIC BUSES

KING COUNTY METRO TRANSIT provides transit service in King County, Washington. Its 1,300 buses, trolleys, and streetcars are used by 100 million passengers each year. Metro long has been committed to providing efficient, environmentally friendly transportation. Since 1990, it has operated dual-mode transit buses in the Metro Bus Tunnel, a 1.3-mile route underneath downtown Seattle. These 60-foot, articulated buses use diesel power on the surface streets. When they enter the tunnel, they connect via catenary poles to overhead wires and use electric power while underground. Using the tunnel shortens the buses' route times and reduces congestion aboveground. Running in electric mode reduces noise and fumes in the tunnel.



The Allison EP50 System™

Courtesy of Allison Transmission, a Division of General Motors

- A:** The **energy storage system** supplies electricity to the E^V50 Drive's electric motors. It stores electricity during normal operation and regenerative braking.
- B:** The **dual power inverter module** converts electricity into alternating or direct current. This enables transfer, storage, and use of energy between the E^V50 Drive, which uses and produces alternating current, and the energy storage system, which can only store direct current.
- C:** The **hybrid control modules** process information from system components and driver inputs. They control vehicle propulsion and energy production and include diagnostic and reprogramming features.
- D:** The **engine** produces power, which is used to propel the bus and to produce electricity that is stored in the energy storage system.
- E:** The **E^V50 Drive** converts electricity from the energy storage system into power to propel the bus, and it converts power from the engine and regenerative braking into electricity that is stored in the energy storage system.

TESTING ADVANCED VEHICLES

The role of the U.S. Department of Energy's (DOE) Advanced Vehicle Testing Activity (AVTA) is to bridge the gap between R&D and commercial availability of advanced vehicle technologies. AVTA supports DOE's FreedomCAR and Vehicle Technologies Program in moving these technologies from R&D to market deployment by examining market factors and customer requirements, evaluating performance and durability of alternative fuel and advanced technology vehicles, and assessing the performance of these vehicles in fleet applications.

The Fleet Test & Evaluation team at the National Renewable Energy Laboratory (NREL) supports AVTA by conducting medium- and heavy-duty vehicle evaluations. The team's tasks include recommending types of alternative fuel and advanced technology vehicles to test, identifying fleets to evaluate, designing test plans, gathering on-site data, preparing technical reports, and communicating results on its Web site and in print publications.

THE DUAL-MODE BUSES ARE APPROACHING THE END

of their useful lives. Metro wants replacements that can achieve low emissions and a quiet ride without using the catenary system, while reducing operational and maintenance costs compared with the dual-mode buses. They have selected 60-foot New Flyer articulated buses with hybrid electric systems made by Allison Transmission, a division of General Motors. These are the first hybrid electric articulated buses in North America. Metro received and began testing the first of these buses in 2002. Based on this experience, Metro ordered 213 of the buses and began taking delivery in 2004. Twenty-two additional hybrid buses were ordered for Washington's Sound Transit for use in routes that pass through the Metro Bus Tunnel, making a total order of 235 hybrid buses. Sound Transit's service connects Snohomish, Pierce, and King Counties.

METRO'S HYBRID ELECTRIC BUSES use the Allison Electric Drives EP50 System™. This is a parallel hybrid system, in which the engine is used primarily for highway driving, and the electric motor provides power during hill climbing, acceleration, and other periods of high demand. The engine charges the energy storage system that supplies electricity to the motor, and energy released during deceleration is captured via regenerative braking and stored.

KING COUNTY METRO TRANSIT ♦ DIESEL HYBRID ELECTRIC BUSES



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NREL/PIX 13614

This system provides several advantages over conventional propulsion systems. More efficient engine operation and regenerative braking increases fuel economy. Partitioning of power between the engine and electric propulsion lowers emissions. For example, electric power predominates when the bus accelerates from a stop, eliminating the exhaust cloud typically produced by rapid acceleration of conventional buses. The electric power also makes acceleration quicker, which is beneficial for city driving.

The hybrid buses have a feature unique to Metro's operation: "Hush Mode." Hush Mode fulfills Metro's need for an operating mode to minimize noise and engine emissions while in the Metro Bus Tunnel. The hybrid buses operate in an electric-only mode in the station areas of the tunnel and in a reduced engine power mode in between stations.

NREL'S EVALUATION OF THE METRO BUSES began in 2004 and will continue for 1 year. Nearly identical conventional articulated buses in Metro's fleet also are being evaluated, which will yield an exceptional comparison of hybrid electric and conventional bus technologies. Information being collected and analyzed includes operational data such as vehicle use, fuel consumption, and maintenance performed,

Buses: New Flyer DE60LF	
Model Year	2004
Length/Width/Height	60.7 ft /102 in/132 in
GVWR/Curb Weight	66,790/44,600 lb
Seated Passenger Capacity	58 (or 50 and 2 wheelchairs)
Service	King County, Washington
Engine: Caterpillar C9	
Displacement	8.8 L
Rating	330 hp @ 2,100 rpm 1,150 ft-lb @ 1,300 rpm
Emission Certification	2.5 g/bhp-hr NO _x + HC, 0.05 g/bhp-hr PM
Fuel Storage	125 gal
Fuel	Ultra-low sulfur diesel
Propulsion: Allison Electric Drives E²50 Parallel Hybrid System	
Motor/Generator	75 kW nominal, 150 kW peak
Drive Unit	E ² 50 Drive: 246 kW input rating, 1,050 ft-lb torque
Controls	Allison (proprietary)
Energy Storage	Nickel metal hydride batteries, 600 VDC
Regenerative Braking	Yes
Emission Control Equipment: Engelhard DPX™	
Exhaust Aftertreatment	Diesel Particulate Filter

as well as descriptions of Metro's experience implementing this new technology and the public's perception of it. The objectives are to provide credible data and results that show the progress of hybrid electric technologies toward wide-spread commercialization. This will provide vital information to transit agencies considering use of hybrid buses.

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Web Sites

King County Metro: <http://transit.metrokc.gov>
Allison Transmission: www.allisontransmission.com
NREL: www.nrel.gov/vehiclesandfuels/fleettest

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