Leslie Eudy, NREL/PIX 12238

Advanced Technology Vehicles in Service

Advanced Vehicle Testing Activity
U.S. Department of Energy
FreedomCAR & Vehicle Technologies Program

Diesel Hybrid Electric Buses

MTA New York City Transit

THE ROLE OF THE U.S. DEPARTMENT OF ENERGY'S (DOE) Advanced Vehicle Testing Activity (AVTA) is to bridge the gap between R&D of advanced vehicle technologies and commercial availability. AVTA supports DOE's FreedomCAR and Vehicle Technologies Program goal of advancing these technologies 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 (FT&E) team at the National Renewable Energy Laboratory (NREL) supports AVTA by conducting evaluations of medium- and heavy-duty advanced technology vehicles. Depending on a technology's stage of development, the team employs three evaluation strategies: early demonstration, limited evaluation, and full evaluation. An early demonstration involves prototype vehicles in small numbers and a cursory data collection. A limited evaluation typically focuses on on-road prototypes in larger numbers and includes a six-month collection of more detailed data. A full evaluation applies to vehicles closer to commercialization and includes a year's worth of detailed operational data, which is compared to conventional vehicles. The resulting information helps fleets stay aware of developments in new technologies and evaluate possible options for their operations.

AVTA WILL SOON BEGIN A FULL EVALUATION of Metropolitan Transportation Authority (MTA) New York City Transit's (NYCT) new fleet of 125 Orion VII diesel hybrid electric buses. Featuring BAE SYSTEMS' HybriDrive™ propulsion system, the new Orion VIIs follow NYCT's 1998 deployment of 10 Orion VI diesel hybrid electric buses. So far, the Orion VIs have accumulated more than 500,000 miles in revenue service.

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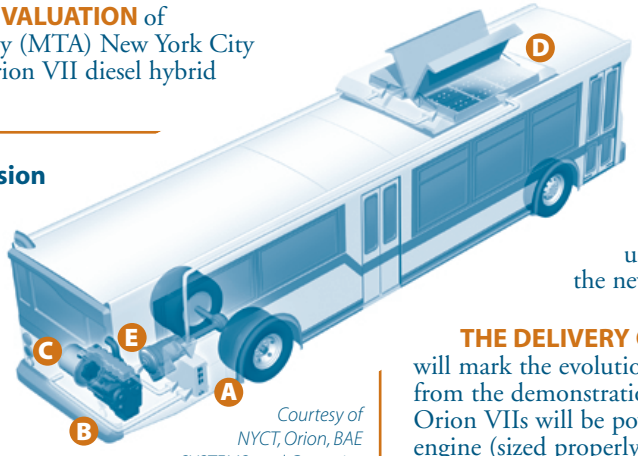
During the successful demonstration of the Orion VI buses, NYCT determined that the diesel hybrid electric propulsion system met the goals of both the bus agency and DOE: It reduced toxic emissions, increased fuel economy, and performed as well as or better than conventional diesel-powered buses.

The first of NYCT's 125 Orion VII buses recently completed three months and 10,000 miles in revenue service. The remaining Orion VIIs will be delivered in the second half of 2003. Once the new buses arrive, NYCT plans to deploy them at the Mother Clara Hale Depot in Manhattan and the Queens Village Depot in Queens. The AVTA evaluation will be conducted on a sample of the new buses.

THE DELIVERY OF NYCT'S 125 ORION VII BUSES will mark the evolution of diesel hybrid electric technology from the demonstration phase to a commercial product. The Orion VIIs will be powered by a Cummins 5.9 liter ISB engine (sized properly for the hybrid electric buses) and equipped with a diesel particulate filter to remove particles from the exhaust.

These hybrid electric vehicles combine an engine/generator set (or power unit) such as an internal combustion engine, with batteries and an electric motor—a combination that can result in lower emissions and higher fuel economy than conventional vehicles. Compared to conventional diesel buses, the new hybrid electric buses are expected to reduce emissions of particulate matter by 90%, oxides of nitrogen by 60%, nonmethane hydrocarbons by nearly 90%, and carbon monoxide by more than 90%.

Orion VII's HybriDrive™ Propulsion System: How It Works



Courtesy of NYCT, Orion, BAE SYSTEMS, and Cummins

- **A** The propulsion control system directs the power flow, using information from the driver controls and all system components.
- **B** The engine, controlled by the HybriDrive™ system, drives the generator.
- **C** The generator supplies electricity to the traction motor and recharges the battery storage system.
- **D** The traction battery system stores generator power and energy recovered during braking and supplies power for acceleration or hill climbing.
- **E** The traction motor uses electrical power to drive the wheels. During braking, the motor acts as a generator to return deceleration energy to the system by recharging the batteries. This "regenerative braking" system also reduces conventional brake wear.

Orion VII Bus Specs	
Bus: Orion VII	
Model Years	2003, 2004, 2006
Length/Width/Height	40 ft./102 in./132 in.
GVWR/Curb Weight	42,540/31,840 lbs.
Seats	38 to 44 passengers
Service	Manhattan, Queens, the Bronx
Engine: Cummins ISB5.9 liter	
Rating	270 bhp @ 2,500 rpm 660 lb-ft @1,600 rpm
Fuel Storage: Diesel	100 gallons
Fuel	Ultra-low sulfur diesel (less than 30-ppm sulfur content)
Propulsion: BAE SYSTEMS HybriDrive™	
Motor and Internal Gear Reduction	*Type:* AC induction, high-power density *Horsepower:* 250 hp continuous (320 hp peak) *Torque:* 2,700 ft. lbs. @ 0 rpm
Generator	*Type:* Permanent magnet *Horsepower:* 160hp continuous
Energy Storage System	*Type:* Sealed lead acid *Voltage:* 520-700 VDC
Controls	*Type:* Integrated power electronics and controls *Horsepower:* 250 hp continuous (320 hp peak), J1939 CAN interface
Regenerative Braking	Yes
Auxiliary Power	Diesel engine
Emissions Equipment: Englehard DPX	
Exhaust Aftertreatment	Diesel Particulate Filter

NYCT's Hybrid Electric Buses		
Amount	**Bus Type**	**Acquisition Year**
10	Orion VI HybriDrive™	1998-2000
125	Orion VII HybriDrive™	2003
200	Orion VII HybriDrive™	2004
50	Hybrid electric buses proposed	2006
Total: Up to 385 hybrid electric buses by 2006		

NYCT IS THE LARGEST PUBLIC TRANSPORTATION SYSTEM in the United States. More than 2 million passengers use its 235 bus routes everyday. NYCT currently has more than 4,500 buses operating from 18 depots, serving more than 1,800 miles of routes daily. Since 1992, NYCT has tested and evaluated a variety of clean-fueled buses in revenue service.

In 2000, New York Gov. George Pataki approved a five-year capital-spending plan that funds the purchase of hybrid electric and compressed natural gas (CNG) buses. The plan provides for new clean-diesel engines with particulate filters and the use of ultra-low sulfur (30 parts per million sulfur content) diesel fuel for the entire diesel fleet. A new capital-spending plan will be finalized in 2004 for bus purchases for 2005–2009. The plan is expected to include more clean-fuel buses—and a continued effort by NYCT to reduce bus fleet emissions and improve air quality.

Besides its current 125 buses on order, NYCT has agreed to purchase another 200 Orion VII hybrid electric buses for delivery in 2004, and it plans to acquire 50 more for delivery by 2006. This will bring the total hybrid electric fleet to 385 buses—about 8% of the agency's overall fleet. NYCT also expects to be operating 646 CNG buses by 2006, bringing its combined clean-fuel fleet to 1,031 buses—nearly 24% of its total fleet.

BAE SYSTEMS TEAMED WITH ORION to design, build, and test the new Orion VII models, with the intent of creating a diesel hybrid electric system that runs as clean as CNG. Compared to conventional diesel, diesel hybrid electric buses also use less fuel, have no transmission or clutch to maintain, offer reduced brake maintenance and better traction, accelerate more quickly and smoothly, provide a quieter ride, and are reliable, safe, and commercially available. The engine is smaller than that of a conventional bus and runs more efficiently, thus producing significantly fewer emissions and improved fuel economy.

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NYCT: www.mta.nyc.ny.us/nyct
BAE SYSTEMS: www.hybridrive.com
Orion: www.orionbus.com
Advanced Vehicle Testing Activity: www.ott.doe.gov/otu/field_ops/

Sponsored by the
U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy

Produced by the
National Renewable Energy Laboratory (NREL)
NREL is a U.S. Department of Energy National Laboratory
Operated by Midwest Research Institute • Battelle • Bechtel

NREL/FS-540-33397 • March 2003

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 20% postconsumer waste.