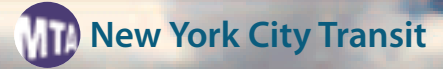




Advanced Technology Vehicles in Service

Field Operations Program
U.S. Department of Energy
Office of Technology Utilization



Diesel Hybrid Electric Buses

NEW YORK CITY TRANSIT is the largest public transportation system in the United States. The 235 bus routes carry more than 2 million passengers daily. The agency has 4,489 buses operating from 18 depots, with an average of 1,871 miles of routes each day. Since 1992, NYC Transit has tested and evaluated a variety of clean fuel buses in revenue service. NYC Transit introduces new bus technologies through a three-step process of demonstrating the new technology by (1) operating a single bus prototype in non-revenue service, (2) operating a small pilot fleet of buses in revenue service, and then (3) expanding the fleet for full-scale implementation. The department now has 221 buses powered by compressed natural gas (CNG) and a pilot fleet of 10 Orion model VI diesel hybrid electric buses, which started testing in revenue service in 1998.

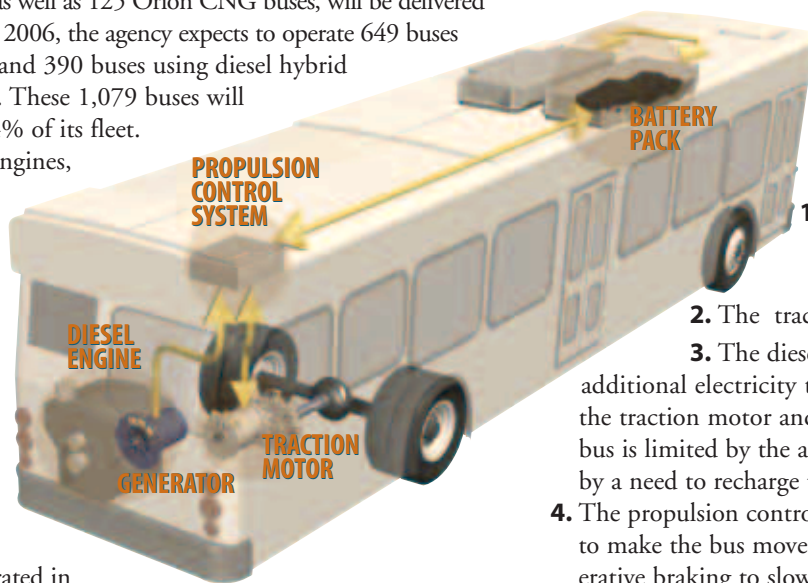
THESE CLEAN FUEL BUSES represent about 5% of NYC Transit's fleet. By early 2002, 125 more Orion diesel hybrid electric buses (model VII), as well as 125 Orion CNG buses, will be delivered to NYC Transit. By 2006, the agency expects to operate 649 buses powered by CNG and 390 buses using diesel hybrid electric propulsion. These 1,079 buses will represent nearly 24% of its fleet. All the diesel bus engines, including the hybrid buses, use low-sulfur diesel fuel (less than 30 parts per million sulfur content).

THE PLAN to more aggressively convert NYC Transit's fleet to cleaner fuels accelerated in early 2000, when New York Governor George Pataki agreed to a capital spending plan for the 2000 to 2004 period. This plan provides funding for NYC Transit to

- Purchase additional CNG and hybrid buses.
- Use ultra-low sulfur diesel fuel for the entire diesel fleet.
- Retrofit diesel buses with catalytic diesel particulate filters.
- Construct and renovate several depots and shops for the use of CNG buses.

THE NEW DIESEL HYBRID ELECTRIC BUSES are very different from any other buses in the fleet. The diesel engine is smaller and operates at a more constant speed, so it uses less fuel and produces a fraction of the emissions of a standard diesel engine while providing faster and smoother acceleration. The diesel engine uses ultra-low sulfur fuel, and an electric motor drives the wheels.

THE PILOT FLEET OF 10 HYBRID ELECTRIC BUSES now operates from the Manhattanville Depot. Plans include splitting the 10 hybrid electric buses currently in the fleet and the 125 hybrid electric buses on order between two operating locations: Mother Clara Hale Depot and Queens Village Depot. Orion provides the chassis and assembles the buses. They are equipped with BAE SYSTEMS' HybriDrive™ propulsion system and engines manufactured by Detroit Diesel Corporation (for the pilot fleet) and Cummins Engine Company (for the 125 hybrid electric buses on order). NYC Transit chose the hybrid electric buses after a prototype project demonstrated that they have the potential to use less fuel and have lower toxic exhaust emissions.



The HybriDrive™ propulsion system works like this (see graphic*):

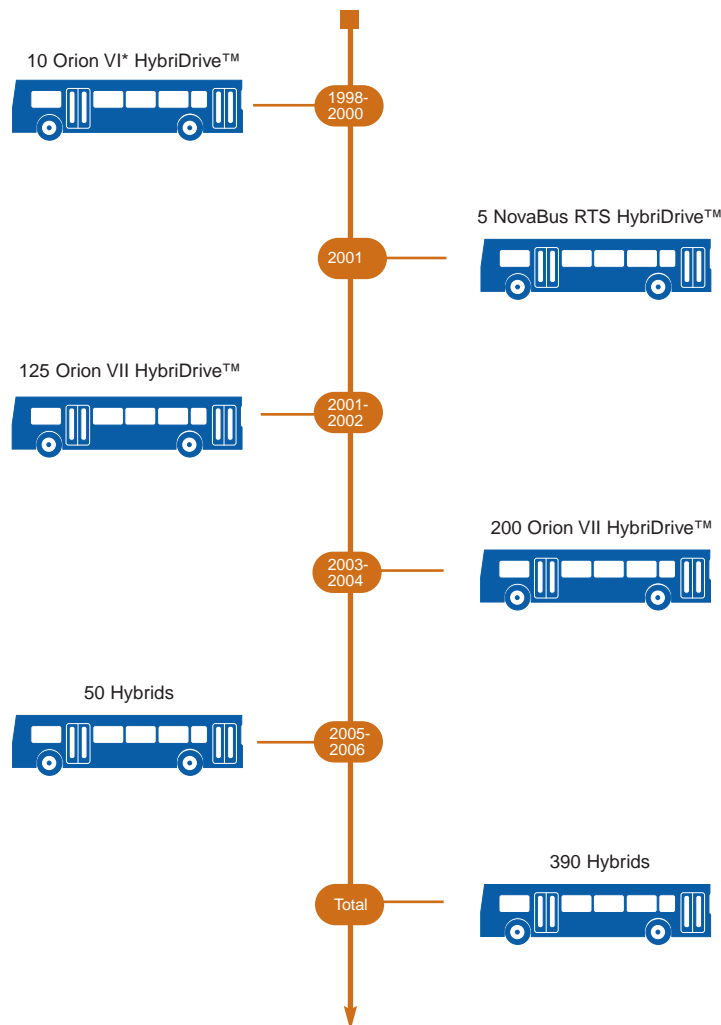
1. Batteries provide electricity to a traction motor through the propulsion control system.
2. The traction motor drives the wheels.
3. The diesel engine powers a generator that provides additional electricity through the propulsion control system to the traction motor and recharges the batteries. The range of the bus is limited by the amount of diesel fuel stored onboard, not by a need to recharge the batteries.
4. The propulsion control system manages the flow of electricity to make the bus move as the driver commands and uses regenerative braking to slow the bus and simultaneously recharge the batteries. (Hybrid buses also have conventional brakes.)
5. It's an integrated system. During acceleration, energy flows from the generator and battery pack to the traction motor; during cruise mode, energy flows from the generator to recharge the batteries; and during braking, the traction motor acts as a generator, sending energy to the batteries for recharging.
6. The smaller diesel engine, operating at a more constant speed and with better overall fuel economy, can significantly reduce overall bus emissions.

*Bus/propulsion diagram courtesy of BAE SYSTEMS.

The propulsion system will likely reduce maintenance needs in three ways. Hybrid buses are propelled by an electric motor, so there is no traditional transmission, only a gearbox. (A traditional transmission is a major maintenance item for most stop-and-go vehicles.) The regenerative braking system helps slow the vehicle, while producing additional electric power and reducing brake wear. The diesel engine operates at a more constant speed in revolutions per minute, which may reduce maintenance needs.

The pilot fleet of 10 diesel hybrid electric buses is currently participating in a year-long evaluation project being conducted by the U.S. Department of Energy's Office of Technology Utilization and Office of Heavy Vehicle Technologies. Information is being collected on fueling, maintenance, performance, and emissions of the diesel hybrid electric buses. The performance of the initial fleet of hybrid buses will be compared with results from seven NovaBUS diesel-powered buses. Both fleets are based at the Manhattanville Depot.

Buses	10 Orion VI
- Model Year	1998, 1999
- Length/Width/Height	- 40 ft /102 in./125 in.
- GVWR/Curb Weight	- 41,640/31,840 lb
- Seats/Standees	- 31/32
- Service	- Manhattan
Engine	DDC S 30 Diesel
- Rating	- 230 bhp@2300 rpm
	- 605 ft-lb@1500 rpm
- Calibration	- MY 2000
Diesel Fuel Storage	100 gallons
Hybrid Propulsion	BAE SYSTEMS HybriDrive™ Series
- Traction Generator	- 170 kW@2000 rpm
- Traction Motor	- 187 kW 346 Vrms@500 Hz
- Traction Batteries	Sealed lead acid 2 Roof mounted battery tubs 23 (12V) batteries in each tub 580V Total
- Regenerative Braking	Yes
Emissions Equipment	NETT Technologies catalyzed particulate filters



FOR FURTHER INFORMATION, CONTACT

New York City Transit
William Parsley, Director
Research & Development
25 Jamaica Avenue
Brooklyn, NY 11207-1817
Phone: 718-927-7707
Fax: 718-927-8094
E-mail: wiparsl@nyct.com

National Renewable Energy Laboratory
Leslie Eudy, Project Leader
1617 Cole Boulevard
Golden, CO 80401
Phone: 303-275-4412
Fax: 303-275-4415
E-mail: leslie_eudy@nrel.gov

Web Sites

NYCT: www.mta.nyc.ny.us/nyct • BAE SYSTEMS: www.hybridrive.com • DOE/FOP: www.ott.doe.gov/otu/field_ops

Sponsored by the

U.S. Department of Energy, Energy Efficiency and Renewable Energy
Office of Transportation Technologies

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-540-30736 • September 2001

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

Neither the United States government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.