Hybrid-Electric Transit Buses

Produced for the
U.S. Department of Energy (DOE)
by the National Renewable
Energy Laboratory (NREL),
a U.S. DOE national laboratory

NYCT Diesel Hybrid-Electric Buses

Program Status Update

New York City Transit

Diesel Hybrid-Electric Buses

The Cleanest Bus Fleet in the World

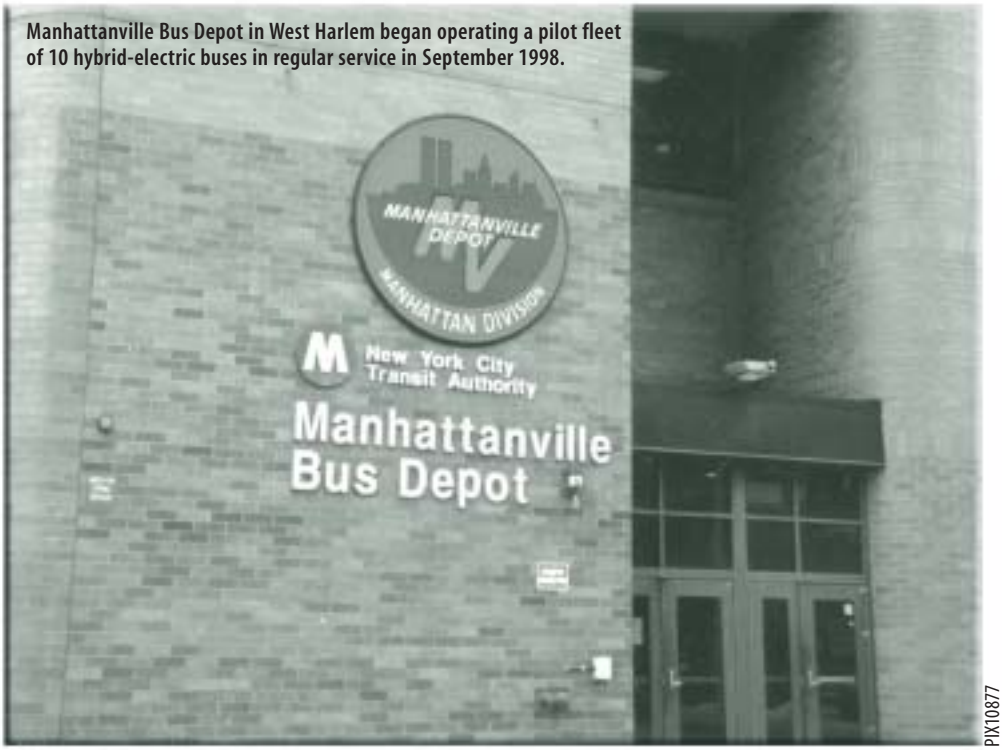
The New York City Metropolitan Transportation Authority (MTA), which includes New York City Transit's (NYCT's) Department of Buses, has committed to establishing the cleanest bus fleet in the world and dramatically reducing air pollution in New York City. That commitment is supported by investments of over $300 million in the MTA's 2000–2004 Capital Program.

The continuing development and deployment of diesel hybrid-electric buses is one part of NYCT's multi-faceted plan to achieve exhaust emission levels below U.S. clean air mandates. This plan includes the following elements:

- The expansion of the compressed natural gas (CNG) bus fleet from the current 221 buses at Jackie Gleason Depot in Brooklyn to 646 buses at three depots by 2006
- The retirement of all two-stroke diesel engines by the end of 2003
- The use of ultra-low sulfur diesel fuel (less than 30 ppm) in all diesel buses, which has already been accomplished
- The installation of diesel particulate filters on all diesel buses by the end of 2003 (see "About Diesel Particulate Filters and Engines" on page 9).

Testing Clean Fuel Buses

As the largest bus fleet in the United States, operating in the most densely populated area, NYCT recognizes its responsibility to be a leader in developing and testing technologies to reduce exhaust emissions. For example, NYCT purchased two CNG buses (and a methanol bus) in 1990. Another 32



Manhattanville Bus Depot in West Harlem began operating a pilot fleet of 10 hybrid-electric buses in regular service in September 1998.

PIX10877

MTA Operations

MTA operates the largest public transportation system in the United States and transports nearly 7.8 million weekday passengers via bus and rail. NYCT's 4,871 buses carry more than 2 million of those passengers each weekday along 235 bus routes. The buses operate from 18 depots 24 hours a day, average 1,871 miles of routes daily, and travel over 115 million miles annually in revenue service. MTA estimates that, by taking the subway or bus instead of driving cars, New York City residents are already significantly reducing the area's annual air pollution levels.

For example:

- Hydrocarbons are reduced by 22 million pounds,
- Soot and particulate matter are reduced by 900,000 pounds,
- Nitrogen oxides are reduced by 19 million pounds, and
- Carbon monoxide emissions are reduced by 310 million pounds.

CNG buses were purchased in 1994 and tested in NYCT service. After testing the 34 CNG buses, 190 additional CNG buses were purchased in 1999. Currently, 221 CNG buses are operating, primarily in Brooklyn.

The development of a hybrid-electric transit bus began with an NYCT project that resulted in NovaBUS and General Motors successfully demonstrating a prototype bus in 1998. Based on the success of that project, NYCT purchased a pilot fleet of 10 Orion VI diesel hybrid-electric buses with propulsion systems by BAE SYSTEMS (formerly Lockheed Martin). Those buses began operating in September 1998, providing regular revenue service primarily in Manhattan. (See "More About NYCT's Hybrids" on page 7.)

Bill Parsley, NYCT's Director of Research and Development, recalled what made the hybrid technology attractive. "We could see that hybrid-electric buses are fundamentally more energy-efficient. We looked forward to having cleaner emissions and, at the same time, increased fuel economy; and the diesel hybrid-electric technology could be deployed rapidly without much additional infrastructure." Dana Lowell, Assistant Chief Maintenance Officer for Research and Development, added, "We still feel that way, because the hybrids have [proven] to be better in terms of cost of fueling infrastructure."

"How We're Kicking The Smoking (Bus) Habit"

Headline in the June 2000 issue of The Leader, *NYCT's Department of Buses employee newsletter.*

Deciding to Buy More Hybrid Buses

"We realized the 10 hybrids were built in an R&D shop, not off the assembly line," Mr. Lowell said, "and prototypes suffer from being unique." He added: "You can't do everything with one or even 10 newly designed buses, but we learned a lot during

The entrance to the bus maintenance area on the first floor of Manhattanville Depot. Approximately 200 buses are parked indoors on the second and third floors.

the demonstration and—together with Orion and BAE SYSTEMS—helped the technology mature."

Mr. Lowell identified the top three challenges with the hybrids as being energy storage, safety and training, and standardizing fleet issues, i.e., integrating the hybrids with other buses at the depot. "We look at how far we have come in accelerating the development of hybrid-electric technology and how close our new hybrids will be to 'off-the-shelf' vehicles," he said.

In 2002, an additional 125 new 40-foot Orion diesel hybrid-electric buses (model VII) will arrive at Mother Clara Hale and Queens Village depots. This event was noted as the "largest acquisition of hybrids in the nation" by *Bus Tech,* a publication for the transit and motorcoach industry. NYCT recently ordered an additional 200 diesel hybrid-electric buses for delivery in 2003 and 2004 and plans to order 50 more.

Mr. Parsley said that the hybrid technology is maturing, but there is a clear need for advanced energy storage devices and future hybrids (Orion VII) that are more reliable and cost less. "Taking the state of the technology into consideration," he added, "we think hybrid-electric buses are going to make a very positive impact on our fleet."

"If we weren't happy with the hybrid-electric buses, we wouldn't be buying 375 more," Mr. Lowell said. When they all arrive, the hybrid-electric buses will represent 30% of the fleet at the five depots to which they are to be assigned. The pilot fleet of 10 hybrid buses and the first order of 125 Orion VII hybrid buses are planned to be split between the Mother Clara Hale and Queens Village depots.

NYCT's Commitment to Cleaner Air:

NYCT has committed to use ultra-low sulfur diesel fuel (less than 30 parts per million sulfur content) in its entire diesel fleet, including the hybrids, and to convert all diesel buses to passive regenerative catalyzed diesel particulate filters by the end of 2003.

By 2006, the agency expects to be operating 646 buses powered by CNG and 385 buses using diesel hybrid-electric propulsion (see the "NYCT Clean Bus Timeline" on page 6). Those 1,031 clean fuel buses will represent nearly 23% of NYCT's bus fleet. The internal combustion engines of the hybrid buses are also powered by ultra-low sulfur diesel fuel. All future buses purchased will be powered either by CNG, hybrid-electric systems, or clean-burning

PIX10879

PIX10880

Interior and exterior of an Orion VI low-floor hybrid-electric bus.

ULSD diesel fuel. All future bus depots and maintenance facilities will be compatible with alternative fuels.

Operating Hybrid Buses

Using ultra-low sulfur diesel fuel and hybrid electric technology is only part of the picture. NYCT recognizes that the success of its hybrid bus program relies on the commitment of its people—including the operators,* technicians, maintainers,** support personnel, and line managers. Together with the equipment manufacturers (engineers and field service personnel), teams of people are working hard to meet the challenges, which includes learning about the new technologies, training to troubleshoot and maintain the different bus systems, and developing new fleet maintenance procedures and manuals.

"In the beginning (1998), it was almost like we had two separate fleets—the 10 Orion hybrids and the 240 other RTS-model buses," said Art Hidalgo, General Superintendent of Maintenance at the Manhattanville Depot. "The buses and the technology were unfamiliar to the maintainers. Procedures and manuals were scarce, and there were few parts in stock," he recalled. "However, we made the commitment that these new buses were our responsibility and we were not to treat them as 'emerging technology' or 'research and development' vehicles that could be set aside if things weren't going well," Art said, "they were to be part of our usual operations."

Initially, familiarity with the standard RTS-model diesel buses made it easy for the maintainers to work on those first, while the hybrids were parked awaiting troubleshooting. "It was a case of human nature versus a new

* NYCT refers to bus drivers as operators.
** Its maintenance personnel are called maintainers.

New York State's Spending Plan

The plan to more aggressively convert to cleaner fuels was accelerated in early 2000, when New York Governor George Pataki and the New York State Legislature agreed to an expanded capital spending plan for the 2000 to 2004 period to fund a clean fuel bus program in the New York City metro area. This plan provides funding for NYCT to:

- Purchase CNG and hybrid-electric technology buses for 44% of new acquisitions
- Use ultra-low sulfur diesel fuel and special pollution filters on the exhaust pipes of every bus in the entire diesel fleet—currently more than 4,000 vehicles—by 2003. In August 2000, NYCT agreed to purchase up to 40 million gallons of 30 parts-per-million sulfur fuel per year for three years.
- Retrofit existing diesel buses with catalytic diesel particulate filters (see "More About Diesel Particulate Filters" on page 9).
- Speed up the retirement of older diesel buses with two-stroke engines by the end of 2003.
- Construct and renovate several fueling depots and shops to accommodate the CNG buses.

Since the summer of 2000, the maintainers have been retrofitting the remaining diesel-powered buses with new emissions-reduction devices called catalyzed exhaust particulate filters. Maintenance managers said when these filters are used with low-sulfur fuel (30ppm) on Series 50 diesel engines, particulate matter (PM) emission levels can be as low as those for CNG buses.

NYCT expects that, when its cleaner fuel bus fleet is complete, it will be the next significant step in improving the air its riders and pedestrians along the routes breathe.

"This historic plan will ensure that the MTA has the cleanest bus fleet, not only in the nation, but in the world.... New York is the capital of the world, so it is only fitting that we are ensuring it has the cleanest bus fleet in the world.... With this plan, New York has once again set the standard for the rest of the country and the world in environmental protection."

Governor George E. Pataki
April 12, 2000

prototype in the shop," Mr. Hidalgo said. "Once it became clear to everyone that these hybrids were ours to work on, a lot of people learned to love them," he added.

A trainer, two maintainers, and the floor supervisor said the biggest challenges were the learning curves on the new technologies and methods. The most common obstacles were learning the diagnostics and troubleshooting techniques and the delays in getting the correct parts. The two maintainers assigned to the hybrid buses agreed that everything about working on the new buses was different from the standard diesel buses and they had to rely on vendor support frequently. For example, they said that the hybrid control software was not at the final stage yet and they needed better training in how to use their laptop computers to make accurate diagnoses.

Differences in the design of the Orion buses compared with the RTS-model buses slowed the process because working on common components—such as brakes and filters—was different. The batteries in the hybrids posed another new challenge. The battery system weighs 3,500 pounds and is stored in two "tubs" mounted on the roof of each bus. So a crane in the ceiling of the maintenance area must be used to replace a battery tub. The batteries, traction generators, and traction motors underwent design upgrades and were removed and replaced on each bus at least once, resulting in more maintenance activity than normal.

Despite these experiences, the two lead maintainers said that they liked the new technology and, when the bus designers "get the bugs out," they'll be even better. "We all have to work together to make this happen," said one maintainer who hopes to be reassigned to the depot where the next generation of hybrids will be stationed.

Two of the operators who frequently drive the hybrid buses agreed that they prefer driving the hybrids because they have more convenient instrument panels, accelerate faster, have better suspension, handle better, don't seem to slide as much in bad weather, and, as one operator emphasized, "they are easier on my back."

The operators had learning curves too. The configuration of the Orion buses required some getting-acquainted time. For example, the Orion buses have an extended rear overhang, due to a shorter wheelbase—compared with the RTS-model buses at Manhattanville Depot—so the operators must be careful not to cut the corners too sharply. Although not a characteristic of the hybrid propulsion system, the operators said that many passengers like the low-floor design and their handicapped passengers prefer the new entry ramp rather than the lift they use on high-floor buses. In general, the riders like the quieter ride and softer seats in the hybrids. They also like the performance and several have asked, "Is this really electric?"

Transit Bus Evaluation Project

Since July 2000, the hybrids have been participating in the Transit Bus Evaluation Project, funded by the U.S. Department of Energy's (DOE's) Office of Heavy Vehicle Technologies (OHVT) and the Office of Technology Utilization (OTU). The National Renewable Energy Laboratory (NREL) managed the 12-month data collection project, which was completed in September 2001 when NYTC's 10 diesel hybrid-electric buses

Hybrid Bus Fleet Facts

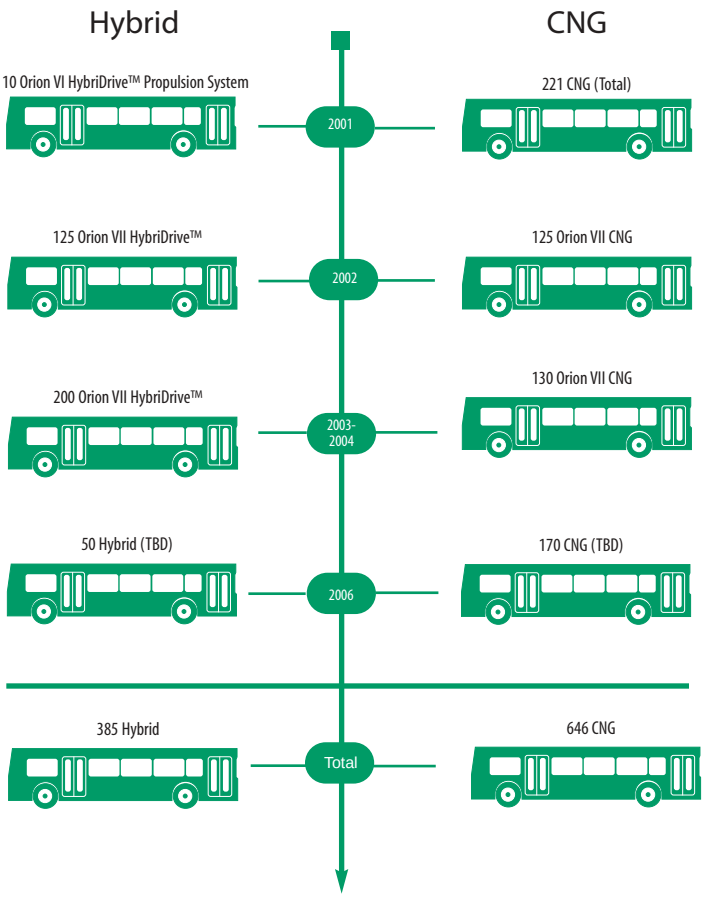
Buses	10 Orion Models VI
Model Year	1998,1999
Length/Width/Height	40 ft/102 in/125 in
GVWR/Curb Weight	41,640/31,840 pounds
Seats/Standees	31/32
Service	Manhattan
Engine	DDC Series 30 Diesel
Rating	• 230 bhp@2300 rpm • 605 ft-lb@1500 rpm
Calibration	MY 2000
Diesel Fuel Storage	100 gallons
Hybrid Propulsion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

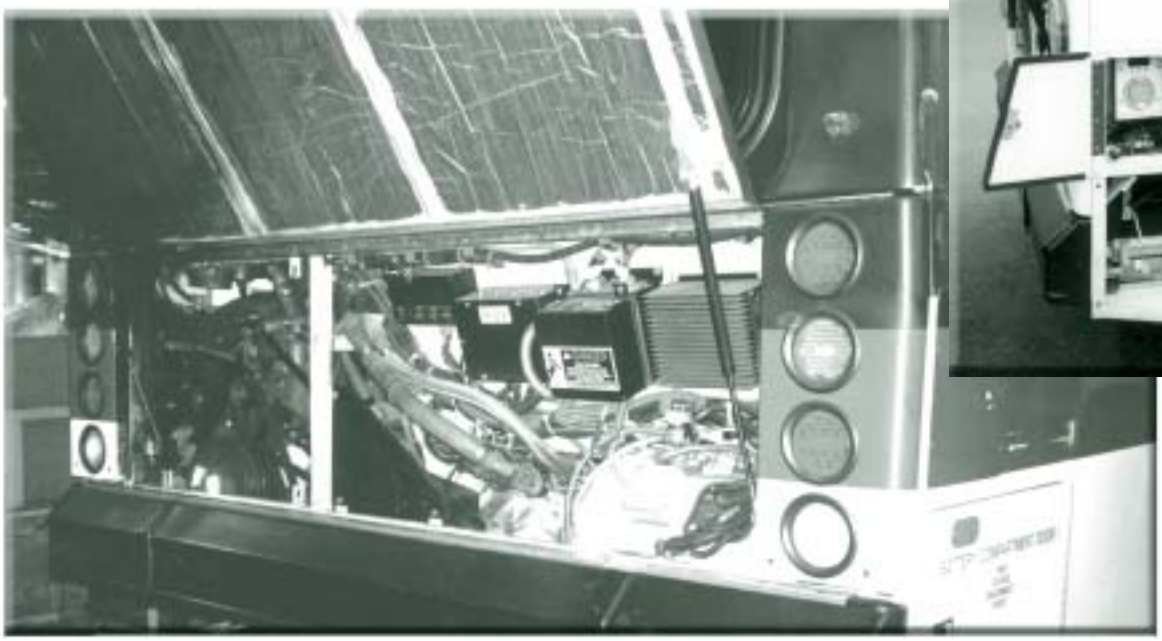
had completed more than 280,000 miles of passenger service. The objective of this evaluation is to provide a comprehensive, unbiased comparison between currently available advanced propulsion technology and standard diesel transit buses.

The evaluation results of the 10 diesel hybrid-electric buses are being compared with seven Orion V diesel buses (operating from Amsterdam Depot) and seven NovaBUS RTS-model diesel buses (operating from Manhattanville Depot). All buses are using ultra-low sulfur diesel fuel. Information was collected on fueling, operations, maintenance, performance, and emissions.

The final reports will be available through NREL's Alternative Fuels Data Center (AFDC) Web site (http://www.afdc.doe.gov). Results and data collected during the NYCT evaluation will help other fleet managers make informed decisions about adding advanced clean fuel technology buses to their fleets.

NYCT Clean Bus Timeline





The engine compartment of the Orion VI hybrid bus.

PIX10881

The traction battery conditioning port is above the cranking battery compartment.

PIX10882

More About NYCT's Hybrids

New York City Transit

In September 1998, NYCT put its first full-sized new diesel hybrid-electric buses into full-time service—Orion Bus Industries Orion VI low-floor models. It currently has 10 hybrid-electric buses in routine service. NYCT chose the hybrid-electric buses after the first prototype demonstrated that hybrids can perform in the transportation fleet, and that they have the potential to use less fuel and emit less toxic exhaust.

The pilot fleet of 10 hybrid-electric buses operate from the Manhattanville Depot, as do seven of the 14 diesel-powered buses being compared with the hybrids in the evaluation. The other seven diesel-powered buses operate from the Amsterdam Depot. Plans are in progress to divide the 10 hybrid-electric buses and the additional 125 hybrid buses to be delivered in 2002 between two other depots—the Mother Clara Hale Depot in Manhattan and the Queens Village Depot in Queens.

The hybrid buses have a curb weight of 32,200 pounds and a range of 350 miles, limited only by fuel on board. Orion Bus Industries provides the chassis and assembles the transit buses, including the battery enclosures and assemblies* and exhaust/cooling systems. They are equipped with BAE SYSTEMS Controls' HybriDrive™ propulsion system (see graphic on page 8), which includes the propulsion control system, motor, generator, energy storage electronics, diagnostic system, on-board battery chargers, and off-board battery conditioner. The Series 30 engines for the pilot fleet were supplied by the Detroit Diesel Corporation. The engines for the 125 hybrid-electric buses on order are being manufactured by the Cummins Engine Company and will be 5.9 liter ISB engines.

NYCT's pilot fleet of 10 diesel hybrid-electric buses represents the future of transit vehicles. An electric motor drives the wheels of the buses, and they have a smaller than standard diesel transit bus engine, which uses ultra-low sulfur fuel. The diesel engine operates within a narrow speed range, so it uses less fuel—hybrids, in general, are expected to get 20% to 50% better fuel economy than a conventional diesel vehicle. Hybrid buses are capable of producing virtually no particulate or soot and 50% fewer smog-causing nitrogen oxides (compared with conventional diesel buses), and significantly fewer hydrocarbons and less carbon monoxide than CNG-powered buses according to some studies**.

The propulsion system may also reduce maintenance needs. For example, 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 traditional stop-and-go vehicles. The "regenerative braking" system in the hybrid buses helps slow the vehicle while producing additional electric power and reducing brake wear. The diesel engine operates within a narrow speed range, which allows it to operate more efficiently and could also reduce maintenence needs.

Mark Brager, Director of Sales for Orion Bus Industries and project manager for the original 10 vehicle prototype bus project, is very positive about the hybrid's future as a transit bus. "Our objective with the pilot fleet was to prove the viability of the technology and the best evidence of its future success is NYCT's order for additional hybrids," he said.

He identified three major challenges to turning the hybrids from a pilot fleet into dependable workhorses: better-performing batteries, continued improvement of the engines and propulsion systems, and implementation of promising new technologies; e.g., ultracapacitors in the near-term and fuel cells in the long-term. Another challenge is to prepare the engine systems to meet the stricter emissions regulations of the future. "We have to consider the diminishing returns of current technologies and how far we can take them," he said.

The HybriDrive™ propulsion system was designed by BAE SYSTEMS Controls, which is supplying its systems to Orion Bus Industries. The hybrid propulsion system is described as being cleaner, more efficient, providing a more comfortable ride

* *Battery assemblies were manufactured by BAE SYSTEMS on the Orion VI pilot fleet.*

** *MJ Bradley & Associates' 2000 "Hybrid-Electric Drive Heavy-Duty Vehicle Testing Project, Final Emissions Report" (www.navc.org/navc/837.pdf)*

(smooth, quiet acceleration), and being diesel compatible.

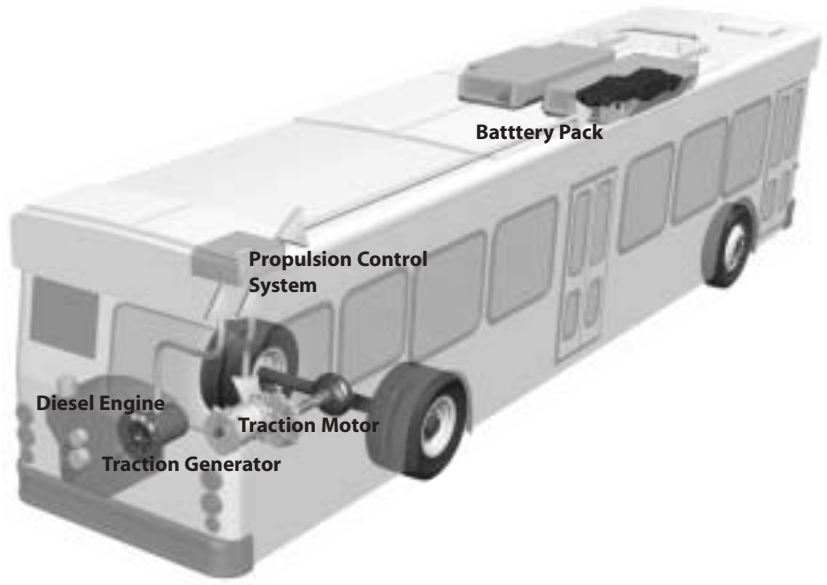
"We at BAE SYSTEMS are very proud of the partnership with Orion and NYCT in demonstrating that the hybrid will be a viable propulsion system for commercial use," said Tom Webb, BAE SYSTEMS' Marketing Manager for Transit Buses. "We learned a tremendous amount about the HybriDrive™ propulsion system's capabilities and changes needed from NYCT's experience with the first 10 buses," Mr. Webb said.

Looking to the future, NYCT's Dana Lowell was also positive. "Using the Cummins ISB engine and the new hybrid propulsion system, the Orion VIIs will be better because BAE SYSTEMS and Cummins have learned and they have invested in understanding the issues and problems," he said.

Experience to date indicates that bus operators and passengers like the hybrids. The buses are quieter and smoother than buses propelled by conventional diesel, yet they "feel like" a standard bus. The hybrids do not roll back on hills like some early electric vehicles did. Little operator training is required and the hybrids can be used on all of NYCT's routes. Operators praise their new buses' excellent acceleration and smooth braking.

More About the HybriDrive™ Propulsion System*

1. Batteries provide electricity to a traction motor.
2. The electricity-powered traction motor drives the wheels.
3. The diesel engine powers a traction generator that provides additional electricity and also recharges the batteries.
4. The propulsion system controls the flow of electricity to control movement of the bus and uses "regenerative braking" to slow the bus and simultaneously recharge the batteries. (Note: Hybrid buses also have conventional brakes.)
5. It's an integrated system. During acceleration, power flows from the traction generator and battery pack to the traction motor; during cruise mode, power flows from the traction generator to recharge the batteries; and during braking, the traction motor acts as a generator, sending power to the batteries, recharging them.
6. The smaller diesel engine, operating within a narrow speed range and with better overall fuel economy, has the potential to significantly reduce emissions compared with a conventional propulsion system.



The HybriDrive™ propulsion system was originally developed for the U.S. Army's tanks and trucks, so they could operate for short periods in an all-electric "stealth mode." Tanks and buses have similar power requirements, so the same components can be used on both military and commercial trucks and buses.

** HybriDrive™ propulsion system is a trademark of BAE SYSTEMS Controls.*

More About Diesel Particulate Filters

The function of diesel particulate filters (DPFs) is to remove particles from the buses' exhaust. The original pilot fleet of Orion VI hybrid buses was equipped with a passive regenerative catalyzed DPF from NETT Technologies. The new order of 125 hybrid buses (Orion VII) will be equipped with an Engelhard DPX DPF.

As part of NYCT's clean bus program, the NYCT maintainers are in the process of retrofitting approximately 3,000 diesel-powered buses with the Engelhard DPX or Johnson Matthey's Continuously Regenerating Technology (CRT™) DPF. The Engelhard and Johnson Matthey DPF technologies are described here, along with the Cummins ISB diesel engine used in the Orion VII hybrid bus.

ENGELHARD

Engelhard's DPX™ Catalytic Soot filter uses a patented catalytic technology to burn particulates at normal diesel operating exhaust temperatures. The company indicates this filter is 90% effective in reducing particulate matter, 98% effective against soluble organic fractions, and helps reduce carbon monoxide and hydrocarbon emissions by up to 90%.

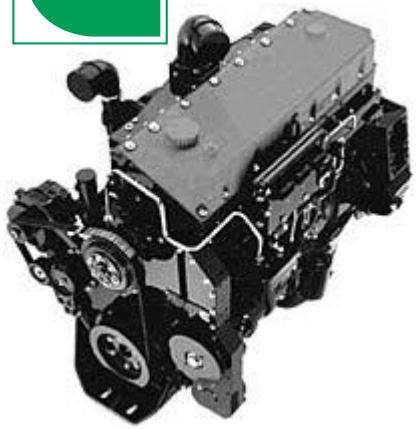
Johnson Matthey's Continuously Regenerating Technology (CRT™) has two chambers where an oxidation step in the inlet is followed by a soot collection/combustion process. The first chamber contains an oxidation catalyst consisting of a ceramic honeycomb substrate coated with a proprietary, highly active, metal. In the second chamber, the exhaust flows through a bare ceramic wall flow filter. The exhaust is forced to flow through the walls of the filter where gaseous components pass through, but soot is trapped.

JM Johnson Matthey

The Cummins Engine Co., Inc., is supplying the engines (ISB 270) to power the hybrid drive system in NYCT's new buses. They are equipped with a catalyzed diesel particulate filter from Engelhard. The combined technologies enable the buses to meet NYCT's emission targets of 15 grams per mile of NO_X and 0.06 grams per mile of particulate matter. The ISB 270 model engine has:

– A maximum horsepower of 270 bhp
– Peak torque of 660 lb-ft
– Governed speed of 2300 rpm
– Six cylinders
– Engine displacement of 359.0 cu in
– Compression ratio of 16.5:1
– Four operating cycles
– Oil system capacity of 4.0 U.S. gal
– Net weight of 962 pounds

Cummins



More About HEVs

A hybrid-electric vehicle (HEV) combines an auxiliary power unit, such as an internal combustion engine, with batteries and an electric motor, which can result in lower emissions and higher fuel economy than conventional vehicles.

The NYCT's hybrid-electric buses are propelled by an electric motor that draws its power from an onboard, small diesel engine using ultra-low sulfur diesel fuel.

Hybrids are not zero-emission vehicles because of the internal combustion engine, but they significantly reduce emissions compared with emissions from the internal combustion engine alone. Other advantages of HEVs are:

Regenerative braking capability helps minimize energy loss and recover the energy used to slow down or stop a vehicle.

HEVs are fuel neutral. They can be designed with engines that use conventional or alternative fuels, or with fuel cells.

Fuel efficiency is increased (hybrids consume significantly less fuel than conventional propulsion systems regardless of type of fuel used).

No special infrastructure is required for diesel HEVs.

HEVs have superior fuel efficiency, so hybrids could have the same or greater range than traditional combustion engines in similar chassis designs.

HEVs can reduce dependency on fossil fuels because they can use alternative fuels or simply use less conventional fuel.

Engines can be sized to accommodate an average load, not a peak load, which reduces the engine's weight.

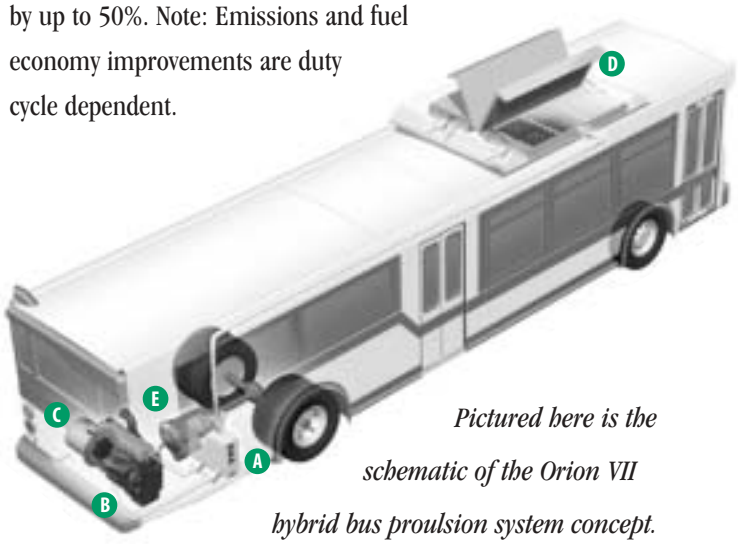
HEVs are hoping to eventually be cost competitive with similar conventional vehicles from a total life cycle operating cost perspective.

The federal government and many states offer incentives (go to http://www.fleets.doe.gov/fleet_tool.cgi?$$.benefits.1).

Coming Next: The Orion VII Hybrid Bus

NYCT's next delivery of hybrids will be the Orion VIIs, as pictured and described below. This model's diesel hybrid engine comes equipped with a diesel particulate filter. Compared with a conventional diesel bus, the Orion VII hybrid hopes to reduce particulate matter by more than 90%, oxides of nitrogen by nearly 60%, nonmethane organic carbon by nearly 90%, and carbon monoxide by more than 90% over conventional diesel buses. Fuel economy is also expected to improve by up to 50%. Note: Emissions and fuel economy improvements are duty cycle dependent.

- **A** The controller directs the power flow, using data from driver interfaces and all HybriDrive™ propulsion system components.
- **B** The engine is controlled by the HybriDrive™ propulsion system to run the generator.
- **C** The generator provides electricity to the batteries and the electric motor via the controller.
- **D** The battery pack stores generator power as well as captured power recovered during vehicle braking. This reserve power is available to the electric motor on demand for acceleration or climbing.
- **E** The traction motor uses electrical power to drive the differential and propel the vehicle. During braking, this motor acts as a generator to return deceleration power to the system by recharging the batteries and saving brake wear.



Pictured here is the schematic of the Orion VII hybrid bus proulsion system concept.

The Transit Bus Evaluation Project

This report is part of an ongoing Department of Energy (DOE), Office of Heavy Vehicle Technologies program to study heavy-duty alternative fuel and advanced technology vehicles in the United States. DOE's National Renewable Energy Laboratory (NREL) is conducting the Transit Bus Evaluation Project to compare alternative fuel or advanced technology and diesel fuel buses. Information for the comparison comes from data collected on the operational, maintenance, performance, and emissions characteristics of alternative fuel or advanced technology buses currently being used in vehicle fleets and comparable diesel fuel buses serving as controls within the same fleet.

This report highlights the New York City Transit (NYCT) alternative fuel and advanced technology programs including its diesel hybrid-electric buses. As part of the NREL Transit Bus Evaluation Project, data collection and evaluation of the Orion VI diesel hybrid-electric buses at NYCT are nearly complete. Final reports from the evaluation are being prepared by NREL and Battelle (NREL's support contractor for the project) and will be available in early 2002. If you want to know more about this transit bus program, its components, advanced technology vehicles, or incentive programs, contact any of the following personnel or visit the Web sites listed.

NREL

Kevin Walkowicz, Senior Project Engineer
1617 Cole Boulevard
Golden, CO 80401
Phone: 303-275-4492
Fax: 303-275-4415
E-mail: kevin_walkowicz@nrel.gov

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

NYCT

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

Orion Bus Industries

Mark Brager, Director of Sales
350 Hazelhurst Road
Mississauga, Ontario
Canada L5J 4T8
Phone: 905-403-7806
Fax: 905-403-8600
E-mail: mbrager@orionbus.com

BAE SYSTEMS

Thomas Webb, Marketing Manager,
Transit Bus
600 Main Street
Johnson City, NY 13790
Phone: 617-628-7585 (Direct)
Fax: 617-628-1744
E-mail: thomas.webb@baesystems.com

Battelle

Kevin Chandler, Project Manager
505 King Avenue
Columbus, OH 43201
Phone: 614-424-5127
Fax: 614-424-5069
E-mail: chandlek@battelle.org

Web Sites

NYCT: www.mta.nyc.ny.us/nyct; **BAE SYSTEMS:** www.hybridrive.com; **DOE/NREL:** www.ctts.nrel.gov/heavy_vehicle; **DOE/FOP:** www.ott.doe.gov/otu/field_ops; **DOE/OTT:** www.ott.doe.gov; **Incentives:** www.fleets.doe.gov/fleet_tool.cgi?$$.benefits.1.

For more information and for copies of program reports, visit the Alternative Fuels Data Center on the World Wide Web at ***http://www.afdc.doe.gov,*** *or call the Alternative Fuels Hotline at* ***1-800-423-1DOE.***

Published by the Center for Transportation Technologies and Systems at the National Renewable Energy Laboratory, a DOE national laboratory

NREL/BR-540-31668
December 2001
1617 Cole Boulevard
Golden, CO 80401-3393

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