



# Advanced Technology Vehicles in Service

Advanced Vehicle Testing Activity



## Knoxville Area Transit

PROPANE HYBRID ELECTRIC TROLLEYS

**KNOXVILLE AREA TRANSIT (KAT)** is recognized nationally for its exceptional service to the City of Knoxville, Tennessee. KAT received the American Public Transportation Association's prestigious Outstanding Achievement Award in 2004. Award-winning accomplishments included KAT's increase in annual ridership to 3.2 million passengers—the highest ridership in 20 years—and the advancement of its Clean Fuels Program. The objective of the Clean Fuels Program is to improve air quality in the Knoxville metropolitan area by reducing vehicle emissions.

As part of the Clean Fuels Program, KAT is deploying four propane hybrid electric trolleys on its new Red Line Trolley Route. Designed to reduce downtown congestion, the Red Line starts at the Knoxville Civic Coliseum on the edge of downtown and continues through northern downtown, including Market Square, the Tennessee Valley Authority, and Gay Street. The route is intended primarily for downtown employees who take advantage of Knoxville's Unparalleled Parking Program by parking at the Coliseum and using public transit to get to work. The Red Line circulates every seven minutes during peak times on weekday mornings and afternoons. Like all Knoxville trolley routes, it is free of charge.

More than 90% of KAT's 100 vehicles now use alternative fuels. In addition to the hybrid electric trolleys, KAT's transit fleet includes 16 propane vans. All of its diesel vehicles use a 20% biodiesel blend (B20), and it has four light-duty hybrid electric vehicles.

### 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 website and in print publications.

The Clean Fuels Program also uses incentives to promote cleaner air and reduce congestion. All KAT services are free on summer ozone alert days, and free bus passes are given to select downtown employees to encourage public transit use.

The Clean Fuels Program is supported by Congestion Mitigation and Air Quality (CMAQ) grants. The CMAQ program, jointly administered by the Federal Highway Administration and the Federal Transit Administration, aims to alleviate traffic congestion and emissions in non-attainment air quality areas. The Chattanooga, Tennessee-based Advanced Transportation Technology Institute provided KAT with technical assistance in acquiring the hybrid electric trolleys.



KNOXVILLE AREA TRANSIT ♦ PROPANE HYBRID ELECTRIC TROLLEYS



U.S. Department of Energy

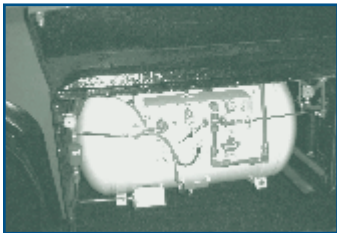
Energy Efficiency and Renewable Energy

Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

<b>Trolleys: Ebus, Inc. Trolley</b>	
Model Year	2003
Length/Width/Height	22 ft /92 in/120 in
GVWR/Curb Weight	19,500/14,500 lb
Passenger Capacity	22 (1 wheelchair)
Maximum Forward Speed	40 mph
Service	Knoxville, Tennessee
<b>Propulsion: Series Hybrid-Electric</b>	
Motor	Reliance AC Induction, air cooled
Energy Storage	48 NiCd, liquid-cooled, "fast charge" batteries, 288 V total
Opportunity Charging	SAE J-2293 Fast Charging
Regenerative Braking	Yes
<b>APU: Capstone Model 330 MicroTurbine</b>	
Rating	30 kW, 250-700 V DC
Fuel	Propane
Fuel Storage	50 gal

### KAT SELECTED 22-FOOT, LOW-FLOOR SERIES HYBRID ELECTRIC trolleys manufactured by Downey, California-based Ebus, Inc. for the Red Line. The Ebus hybrid electric

system propels the trolleys using an electric motor powered by a battery pack. The nickel-cadmium (NiCd) batteries are recharged by a low-emission, propane-fueled Capstone MicroTurbine™ auxiliary power unit (APU), which extends the range of the trolleys. A digital power controller monitors and controls recharging of the



NREL/PIX 13798

Propane tank in KAT hybrid electric trolley

batteries by the MicroTurbine. This system is charge sustaining, meaning that the batteries will have power as long as the APU has fuel.

The trolley design also incorporates regenerative braking, which provides additional energy to recharge the battery pack. In this system, the electric motors that drive the trolley become generators during deceleration, and the electricity produced by the generators is stored in the batteries. This technology is particularly effective for routes, such as the Red Line, that encounter stop-and-go traffic. When the trolley is not in operation, it can be plugged into a fast charging station to "top off" the batteries in approximately one hour.

Ebus also offers this hybrid electric system with a diesel-powered APU. KAT selected propane because of this fuel's low emissions and because propane infrastructure was already established in Knoxville.

### NREL'S EVALUATION OF THE KAT RED LINE TROLLEYS

began in 2004 and will continue for approximately 6 months. Information being collected and analyzed includes operational data such as vehicle use, fuel consumption, and maintenance performed, as well as descriptions of KAT'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 these hybrid electric trolley and infrastructure technologies.

The final results will be published upon completion of the evaluation on the AVTA website, [www.eere.energy.gov/vehiclesandfuels/avta](http://www.eere.energy.gov/vehiclesandfuels/avta).



NREL/PIX 13796

KAT fast charging station

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**KAT:** [www.ci.knoxville.tn.us/kat](http://www.ci.knoxville.tn.us/kat)  
**Capstone Microturbine:** [www.capstoneturbine.com](http://www.capstoneturbine.com)  
**NREL:** [www.nrel.gov/vehiclesandfuels/fleettest](http://www.nrel.gov/vehiclesandfuels/fleettest)  
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