COMPETITION RESULTS ISSUE!

FutureDrive

Volume 4, Number 3 **DOE/Industry Competitions Advancing Automotive Technology** Summer 1998

TECHNOLOGY FEATURE

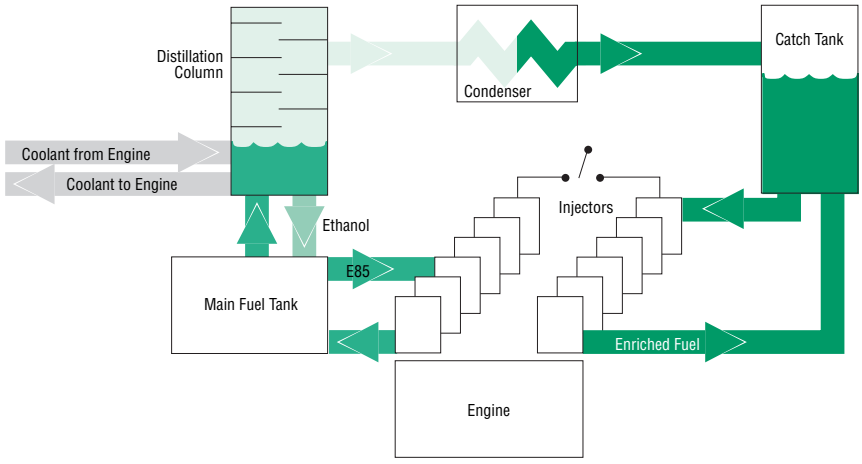
Student Ethanol Vehicles Feature On-Board Distillation

High-ethanol fuels are great for lowering harmful emissions and our dependence on fossil fuels, but until the first Ethanol Vehicle Challenge (EVC) was held this spring, a key drawback to wider use of these "greener" fuels was their inability to efficiently and seamlessly get a cold engine started. Ethanol's low vapor pressure and high heat of vaporization were the culprits.

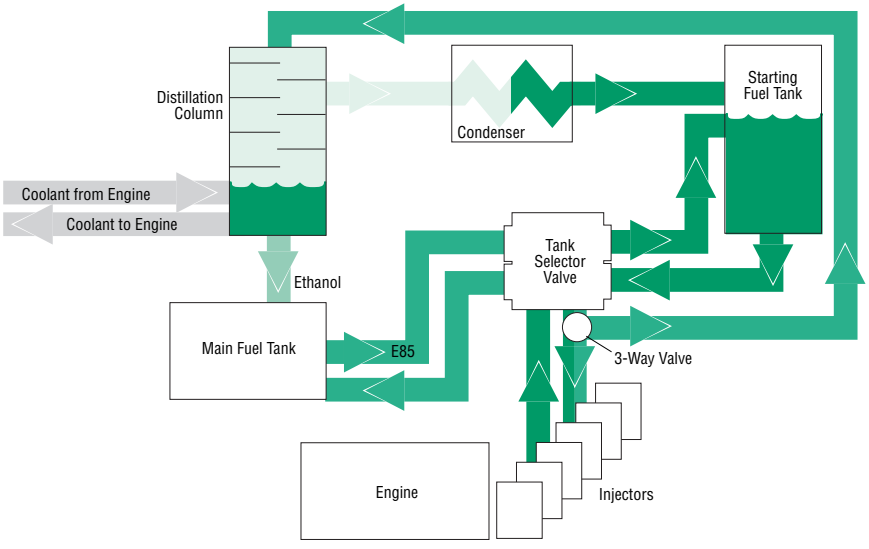
EVC teams from the University of Texas at Austin (UT) and the University of California, Riverside, (UCR) independently came up with the same idea to combat ethanol's cold start problem: they equipped their Chevy Malibus with miniature stills that prepare a more concentrated fuel to be used only during cold starting. The systems employ rejected heat from the engine (via engine coolant) to separate a small amount of E85 into its component gasoline-like hydrocarbon primer (15%) and denatured ethanol (85%). Hydrocarbon-based fuels are more dense and volatile than ethanol, and vastly improve cold startability when used in their pure form.

According to Team Advisor Kent Johnson, UCR students also considered separating the hydrocarbon primer from E85 with a membrane or a silica gel. They modeled their alternatives using the ASPEN computer program and settled on distillation because, while the resulting vapor pressure was lower than that produced by silica gel separation, it was adequate for the job and required fewer mechanical components. Their car started in 8 seconds at a simulated 0°F during the Challenge, which is close to the cold start times of most gasoline vehicles. (continued on page 7)

Batch-distillation system designed by the University of California-Riverside.



Continuous-distillation system designed by the University of Texas at Austin.



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FUTUREDRIVE
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Purpose
To inform past, present, and potential sponsors, participants, organizers, volunteers, and others interested in DOE-sponsored vehicle competitions.

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Over Half of 1998 Challenge Graduates Now Work in Auto Industry

I asked the faculty advisors for this summer's FutureCar Challenge and Ethanol Vehicle Challenge teams how the graduating members of their teams were faring in the job market. The advisors were delighted to report that more than half of their Challenge graduates had taken jobs in the auto industry, and that nearly one in three of these had joined a "Big Three" company.

Inasmuch as student vehicle competitions are one way that the U.S. Department of Energy and other interested parties hope to help mainstream advanced automotive technologies and alternative fuels, I'd say we have reason to celebrate.

By applying advanced propulsion and materials technology along with alternative fuels, students that participate in the FutureCar, Ethanol, NESEA Tour de Sol, Formula SAE, and other contests become experts in these technologies. This, combined with their enthusiasm when their innovative vehicles meet or come close to meeting the twin goals of President Clinton's Partnership for a New Generation of Vehiclesætriple fuel efficiency and lower emissionsæmakes graduates of the competitions an ideal conduit for transferring working knowledge of advanced-automotive and alternative-fuel technologies to the commercial world.

Thanks in big part to student vehicle competitions and their sponsors, these graduates believe we can have affordable family cars that don't pollute the air and that stem our depletion of fossil fuels. And they have the expertise to help make it happen.

The careers of these advanced-technology ambassadors are the ultimate outcome of the DOE-sponsored vehicle competitions. All of us at DOE wish them success and satisfaction as they guide the transportation industry into the future.

Shelley Launey
Manager, DOE Office of Transportation Technologies

FutureDrive
DOE/Industry Competitions
Advancing Automotive Technology

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Winners of FutureCar Challenge Will Be Showcased at World Energy Congress

The top three schools from this summer's FutureCar Challenge will demonstrate their alternative fuel vehicles at the 17th Congress of the World Energy Council, to be held in Houston on September 13–17. Student engineers from the University of Wisconsin-Madison, Virginia Tech, and Lawrence Technological University will present their winning design strategies to business and government leaders from around the world. Attendees will have the opportunity to try out the vehicles, which look no different than gasoline-powered vehicles, in several special "ride-and-drive" sessions to be held outdoors during the Congress.

The World Energy Congress is being hosted by the United States this year for the first time in more than 20 years. Attendees will represent all facets of the global energy industry: oil, gas, coal, nuclear, electric, and renewables. Plans are for President Clinton to speak at the opening ceremony Sunday and for Secretary of Energy Bill Richardson to present the opening address Monday.

Through the FutureCar display, the U.S. Department of Energy is hoping to gain new partners and support for its FutureCar initiative. As the need for cleaner, energy-efficient transportation grows more urgent—with energy sources becoming scarcer, demand for energy increasing, and pollution problems worsening—DOE is hoping to make a wider audience aware of the important contribution that sophisticated, advanced-technology vehicles can make in the near term.

As many as 10,000 industry and government leaders from more than 100 nations are expected to participate in the Congress. They will discuss key issues that will guide policies for developing and using both conventional and unconventional energy resources for the next 100 years. Delegates will include heads of state, energy ministers, CEOs, specialists, managers, and reporters. They will come from organizations as diverse as Shell Oil, General Electric, the National Mining Association, Continental Airlines, the Gas Research Institute, Ford Motor Company, OPEC, and the International Energy Agency.

Marita Moniger

Teams from the University of Wisconsin–Madison and Virginia Tech will join the Lawrence Technological University team at the 17th Congress of the World Energy Council in September.

NESEA American Tour de ~~Rain~~ Sol

The 10th Annual NESEA American Tour de Sol took place May 8–14. Record rains throughout the week of competition helped show that EVs can be successful participants in the real world. The 350-mile road rally began in New York City and finished in Washington, D.C. Electric, hybrid electric, and solar-assisted electric vehicles of all types participated, making information stops in communities along the way. Organized by the Northeast Sustainable Energy Association, the 1998 NESEA American Tour de Sol was sponsored by the U.S. Department of Energy, Toyota Sales, and several other government and corporate entities.

Federico Peña, former Secretary of Energy, and race founder Robert Wills celebrate with the Electric Matadors, winners in the commuter category.

Forecast for Ethanol Vehicles: Sunny, Thanks to the 1998 Ethanol Vehicle Challenge

Can a student competition win consumers over to ethanol-fueled vehicles? Michael Svestka, Team Leader for the University of Illinois at Chicago, thinks so.

"The 1998 Ethanol Vehicle Challenge proved that an ethanol vehicle can perform as well as a gasoline vehicle, if not better," Svestka says. "Driving both types of vehicles, most consumers wouldn't know the difference between them."

General Motors agrees, but with a caveat. "An ethanol vehicle can match the performance of conventional gasoline vehicles," Dr. Jerry Barnes, manager of clean fuels activities at GM's Public Policy Center, says. But, he continues, gasoline-powered vehicles are always improving, "making it difficult to draw definitive conclusions about which is 'better' at any point in time."

"The 1998 Ethanol Vehicle Challenge proved that an ethanol vehicle can perform as well as a gasoline vehicle, if not better."

Michael Svestka, Team Leader
The University of Illinois at Chicago

Student teams from 14 U.S. and Canadian universities participated in the first-ever Ethanol Vehicle Challenge, which was held from May 26 through June 1. The competition, sponsored by General Motors, the U.S. Department of Energy, and Natural Resources-Canada, required participants to convert a 1997 Chevrolet Malibu donated by GM to run on E85 fuel (a blend of 85% denatured ethanol and 15% gasoline-like hydrocarbon primer).

EVC teams strive to build vehicles that, in the hands of the consumer, seem no different than gasoline-powered vehicles—except that they get better mileage, emit fewer pollutants, and offer equal, or better, drivability and performance. Over four grueling days, the teams' vehicles were tested and scored in events including dynanometer fuel economy, exhaust emissions, on-road fuel economy, cold- and hot-starting performance, drivability, acceleration, handling, and range.

The results of the competition were outstanding. Compared with the stock gasoline-powered Malibu, most vehicles were as fuel efficient and many started as quickly at a simulated 0°F. Most accelerated just as quickly or faster than the stock Malibu. Eight of the vehicles met federal emission standards for passenger cars.

"One advantage that ethanol has is reduced greenhouse gas emissions compared with gasoline and diesel

1998 EVC Results

1st Place	Wayne State Univ.		
2nd Place	Univ. of Waterloo		
3rd Place	Univ. of Illinois at Chicago		
4th Place	Univ. of California, Riverside		
5th Place	Cedarville College		
Best Oral Presentation	Univ. of California, Riverside		
Best Ethanol Conversion	Mankato State		
Lowest Emissions	Univ. of Waterloo		
Most Innovative Component	Idaho State		
Simon Vega Sportsmanship	Cedarville College		
Best Fuel Economy	Wayne State Univ.	**Best Handling**	Mankato State
Best Engine Out Emissions	Kettering Univ.	**Best Acceleration**	Wayne State Univ.
Best Vehicle Appearance/1st	Mankato State	**Best Cold Start Performance**	Univ. of Illinois at Chicago

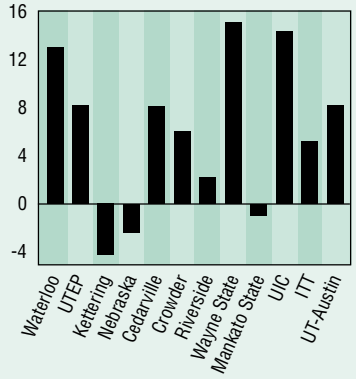
vehicles, because the carbon in ethanol is recycled from the earth's atmosphere," notes Barnes.

A key technical hurdle was to improve cold-starting performance (see related story on page 1). Unlike gasoline, E85 does not start easily in cold weather, and most consumers won't accept that shortcoming. Says Svestka, "For all of the teams, the cold starting event was the biggest technical challenge. Because you couldn't alter the fuel to aid cold starting, you had to alter the vehicle's components. *That* was a challenge."

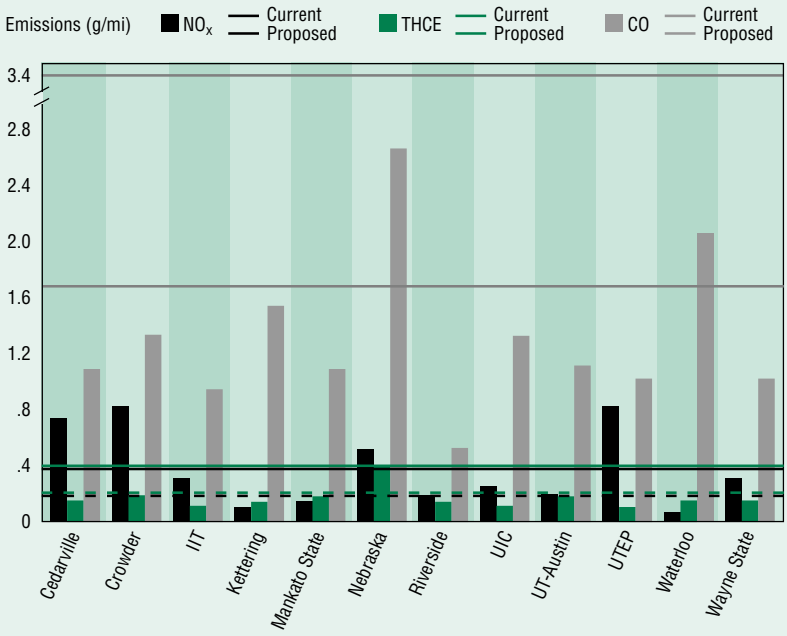
Another drawback is that E85 has less energy per gallon than gasoline, which at first glance would mean more frequent trips to the fuel pump. But with some creativity and innovative thinking, the students found ways to modify key components in the vehicles' engine and fuel systems, overcoming the inefficiencies associated with ethanol and making the vehicles more energy efficient—and thus more attractive to consumers.

The University of Nebraska-Lincoln car placed second in the vehicle appearance category.

Percent Improvement in Fuel Economy: E85-Fueled Vehicles vs. Gasoline Stock Vehicle



Emissions Measured at EVC vs. Current and Proposed Federal Emissions Standards for Passenger Cars



The EVC wrapped up with a 2-day, 600-mile road rally from GM's Milford Proving Ground in Michigan to Washington, D.C. Teams displayed their vehicles on Capitol Hill and at the Clean Cities Conference.

"The road rally was a terrific public relations tool," says Shelley Launey, DOE's manager of vehicle competitions. "Along the way, today's brightest engineering students got people interested in alternative-fuel vehicles."

Kevin Brown

Perseverance Pays Off for Lawrence Tech: Last Place in Tour de Sol Becomes Third Place in FutureCar

Lawrence Technological University has shown that inner drive can be just as important as vehicle drivability when it comes to winning competitions. After suffering through a series of setbacks at the American Tour de Sol in May, which saw Lawrence Tech literally pushing its car over the finish line, the Michigan team overcame the odds to win third place overall in the FutureCar Challenge just 1 month later.

The electric-diesel parallel hybrid design of the Ford Taurus, dubbed "ED," allows it to run on either an electric motor, a diesel engine (modified Volkswagen 1.9-liter direct-injection turbo-diesel), or both. A powerful nickel-metal hybride battery completes the engine compartment. Lawrence Tech selected a combination fuel made of 20% soybean oil and 80% low-sulfur diesel, designed to lower emissions of carbon dioxide, hydrocarbons, and particulate matter by 40%.

To counter the weight added by having a battery on board, the students replaced steel body parts with carbon fiber and aluminum. Other aerodynamic aids include an aerotail on the trunk to eliminate vortex shedding from the rear, ground-effect skirts on all four sides to help distribute airflow around the vehicle, tiny prismatic side mirrors that bend light to mirrors inside the vehicle, and a lack of other protrusions such as radio antennae, which are replaced by antennae on the inside front windshield. ED's "smart" suspension adjusts its ride height to the speed of the vehicle to further reduce drag.

Despite its sophistication, poor ED did not do well at the American Tour de Sol. From day one there were problems with the transmission shifting plate. The team members managed to solve each problem that arose, sometimes by working into the early morning hours. They took heart from the fact that despite setbacks, they managed to increase their mileage on each leg of the road rally.

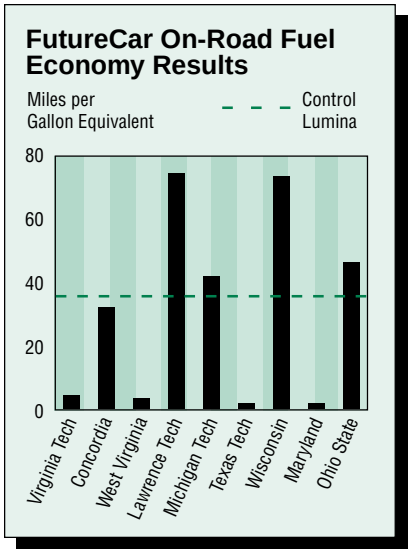
ED traveled about 6 miles out of New York on the first day, went about 12 miles the second day, and tripled that distance to achieve 36 miles on day three. However, in Delaware, the car went through 18 inches of standing water from the almost constant rain that plagued the event this year. This shorted the DC-to-AC inverter and, since the only spare inverter was in Michigan, nothing could be done except to continue the race running on diesel fuel.

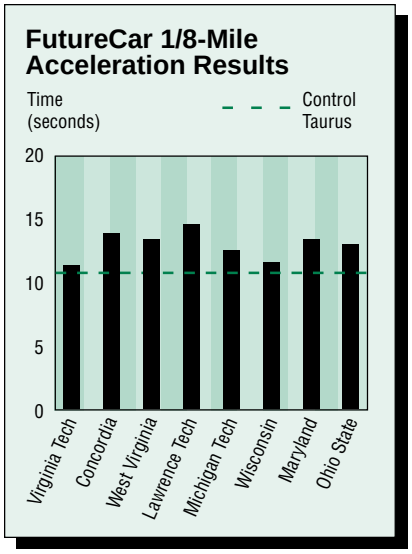
Lawrence Tech students push a beleaguered "ED" across the finish line in the NESEA American Tour de Sol.

1998 FutureCar Results

1st Place (tie)	Virginia Tech Univ. of Wisconsin-Madison
3rd Place	Lawrence Tech
4th Place	Michigan Tech
5th Place	Univ. of Maryland
6th Place	Concordia Univ.
Most Energy-Efficient Vehicle	Ohio State Univ.
Best Acceleration	Virginia Tech
Best Dynamic Handling	Virginia Tech
Best Endurance (tie)	Lawrence Tech and Univ. of Wisconsin-Madison
Best Overall Engineering Design	Virginia Tech
Lowest Emissions	Univ. of Maryland
Best Technical Report	Univ. of Maryland
Best Vehicle Design Inspection	Virginia Tech
Best Oral Design Presentation	Lawrence Tech
Best Consumer Acceptability	Virginia Tech
Best Appearance	Univ. of Illinois
Lowest Vehicle Driving Losses	Univ. of Wisconsin
Best Use of Advanced Materials	Univ. of Wisconsin-Madison
Innovations in Aluminum	Univ. of Wisconsin-Madison

1998 FutureCar challenge





The final straw occurred when the clutch burned up in heavy Washington traffic. The team still wouldn't give up and, in order to finish, found itself pushing the car over the finish line. Lawrence Tech received an honorable mention for team spirit in the face of adversity.

Although disappointed, the team looks back on the experience in a positive light—"as a great opportunity for road testing the vehicle to see what could break down," says team member Gary Madar. Becky Steketee, the team leader, agrees, "We broke it. We fixed it. We worked the bugs out," she says.

Lawrence Tech's hard work and positive attitude were rewarded only 4 weeks later at the FutureCar Challenge near the school's suburban Detroit hometown. Here, claims Madar, "ED performed tremendously—there were no major breakdowns, and the car didn't have to go on the hoist once."

Lawrence Tech won the design oral presentation event—an important victory, Madar believes, because today's engineers need communication skills as well as technical skills.

Perhaps the sweetest victory was tying for first in the endurance competition, in which ED was the last car left running on an 1.8-mile track. It was one of two cars that ran for over an hour longer than expected and came very close to achieving the goal of the FutureCar Challenge: to triple the over-the-road fuel efficiency of a mid-size American car (to 80 mpg) without giving up safety, comfort, or performance. ED registered 77 mpg equivalent, covering 175 miles and running for about 4 hours on the combination of 1 gallon of biodiesel fuel and available energy from the battery pack.

"It just kept going," says John Michelini, the driver. "The Ovonic batteries amazed us."

As a result of finishing in the top three, the team will take an all-expenses-paid trip to the World Energy Congress in Houston this September (see story, page 3). To the exuberant Madar—who claims that "once you see the vehicle running the way it should, there's nothing that can beat that feeling!"—that can only be the icing on the cake.

Marita Moniger

On-Board Distillation…

(continued from page 1)

UT had less success in the competition because of a loose wire and a sensor malfunction. Due to time constraints, said Team Advisor Ron Matthews, the competition was the first test drive for the UT vehicle, which had performed beautifully in the laboratory.

In both the UT and UCR systems, the distillation process is the same. E85 is captured and heated, and heavy components are flushed back to the main fuel tank, leaving a stockpile of primer in the catch tank ready for use. The two schools' distillation systems differ in that UCR's uses primer only for cold starts and UT's uses primer during all starts.

In the UCR batched system, separate fuel lines and injectors are used for the primer. Temperature sensors indicate engine temperature to the fuel delivery system. If the engine temperature is low, the secondary fuel system (which holds the primer) is engaged until the engine becomes warm and the cold start system is disengaged.

In the UT continuous system, when the key is turned off, the fuel left in the injector rail is flushed back to the fuel tank and replaced with primer. Upon starting, the engine is supplied with primer until it can run well on normal fuel; cold starts simply use more primer. Instead of a separate fuel injection system, UT's design relies on a solenoid-controlled valve that switches from one fuel tank to the other and allows the same injector rail and injectors to be used for both fuels.

Organizers of the EVC are excited about the iimplications for dedicated ethanol vehicles, and even for gasoline-fueled vehicles, because most harmful emissions are released during cold start.

"With this innovative approach, we can also start to rethink how we cold start with gasoline," EVC Director Bob Larsen said.

Ford Motor Company is doing just that. Talks are underway between UT and Ford for joint research that may make on-board distillation routine in both gasoline- and E85-powered Ford vehicles.

Cathy Kaicher and Cindy McFadden

COMPETITION RESULTS

ABB University Spec Series
(Combined results of the APS Electrics, Indy Electric Classics, and Tustin Thunder races)

- *1st* Bowling Green State Univ.
- *2nd* Kettering Univ.
- *3rd* The Ohio State Univ.

APS Electrics

- *1st* Strait Area Education and Recreation Center, Nova Scotia

Chicago Junior Solar Sprint

Design Category

- *1st* Plum Grove Jr. High, Rolling Meadows
- *2nd* Chas. J. Sahs School, Chicago
- *3rd* Jerling Junior High, Orland Park

Race Category

- *1st* Bryan Middle School, Elmhurst
- *2nd* Chas. J. Sahs School, Chicago
- *3rd* Madison Jr. High, Naperville

Colorado Junior Solar Sprint

Design Category

- *1st* Bell Middle School, Golden
- *2nd* Deer Creek Middle School, Littleton
- *3rd* Huron Middle School, Northglenn

Race Category

- *1st* Maplewood Middle School, Greeley
- *2nd* Riverview Christian Academy, Greenwood Village
- *3rd* Huron Middle School, Northglenn

Ethanol Vehicle Challenge
(See page 4)

Formula SAE

- *1st* Cornell Univ.
- *2nd* Univ. of Texas-Arlington
- *3rd* Univ. of Akron

FutureCar Challenge
(See page 6)

NESEA American Tour de Sol

Production Category

- *1st with Advanced Battery* Ovonic Battery, Co., Troy, MI
- *1st with PbA Battery* Connecticut EV/NAVC, Winsor, CT
- *1st Consumer OK* New York Power Authority
- *1st Truck* NAVC/BECO/UCBC/ Solectria, Wilmington, MA

Commuter Category

- *1st Overall* Shadow Mtn. Electric Matadors, Phoenix, AZ
- *2nd Overall* Pirates, Cinnaminson, NJ
- *1st Autocross* Triple Crowne Motorworks, Tallahassee, FL

Hybrid Category

- *1st* Western Washington Univ.
- *2nd* Hurricane Motor Works, Tulsa, OK
- *3rd* Swarthmore HEV Team, Swarthmore, PA

Solar Commuter Category

- *1st* Team Solarcat, Villanova, PA
- *2nd* Sol Survivor, Peterborough, NH

One-Person Category

- *1st Overall* Ovonic Battery Co.
- *Best Bike* Mhyee/CTC, Westboro, MA
- *Best Production Bike* Team Charger, Monrovia, CA
- *Most Innovative* Project e-2, Sheffield, MA
- *Best Commuter* Cato-Meridian High School, Cato, NY

Northern Arizona Student Electrics

- *1st* St. Johns High School, St. Johns
- *2nd* Cortez High School, Phoenix
- *3rd* Palo Verde High Magnet School, Tucson

SAE Supermileage

- *1st* Universite de Sherbrooke
- *2nd* Univ. of Massachusetts
- *3rd* Technical Univ. of Nova Scotia

Yankee Electrics

- *1st* Miramar High School, Miramar, FL
- *2nd* Bolton High School, Bolton, CT
- *3rd* Greater New Bedford Regional Vocational Technical High School, New Bedford, MA

For information about these and other student vehicle competitions, visit the DOE Office of Transportation Technologies web site at www.ott.doe.gov student.html.

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