FutureDrive

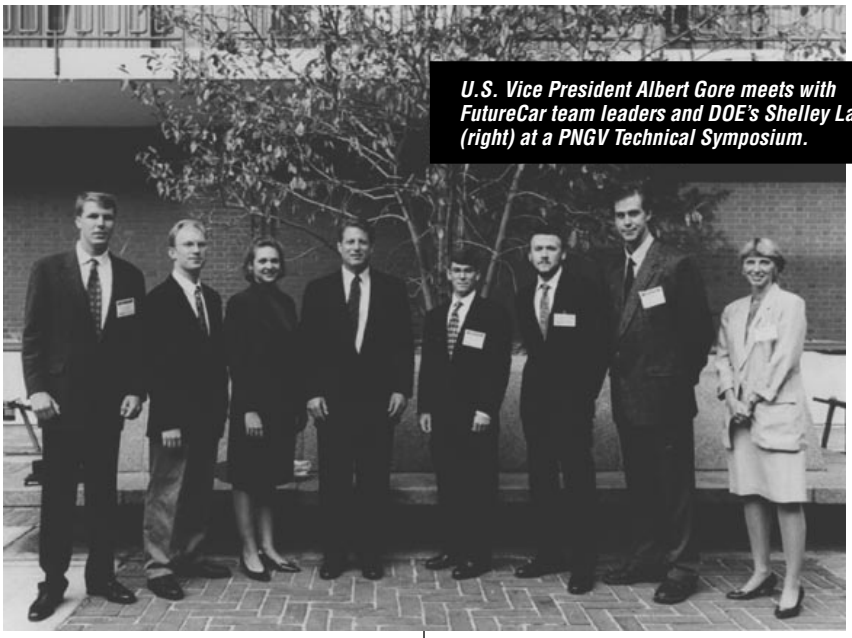
Volume 1, Number 4 **DOE/Industry Competitions Advancing Automotive Technology** Winter 1995-96

TECHNOLOGY FEATURE

1996 FUTURECAR challenge

FutureCar Challenge Is Toughest Competition Yet

Students from 12 North American engineering universities have begun preparing for the FutureCar Challenge, a two-year competition aimed at designing and building a mid-size passenger car capable of achieving up to 80 miles per gallon. Sponsored jointly by the U.S. Department of Energy (DOE) and the United States Council for Automotive Research (USCAR)—a research venture of Chrysler Corp., Ford Motor Co., and General Motors Corp.—the competition challenges student teams to meet goals paralleling those of the Partnership for a New Generation of Vehicles (PNGV) (see article on p. 4) while maintaining the price, performance, manufacturability, and consumer acceptability of cars currently available. Specifically, the vehicles will be judged by a panel of government and automotive industry representatives on the basis of their energy efficiency, reliability, range, acceleration, handling, design, emissions, manufacturability, cost, and consumer acceptability.



U.S. Vice President Albert Gore meets with FutureCar team leaders and DOE's Shelley Launey (right) at a PNGV Technical Symposium.

Each team received $10,000 in seed money and either a 1995 Dodge Intrepid or a 1996 Ford Taurus or 1996 Chevrolet Lumina as a conversion platform. The students are free to choose from seven different fuels (see article on p. 3) and whatever drivetrain they feel will best meet the 80-miles-per-gallon goal, including hybrid technologies, advanced batteries and ultracapacitors, flywheels, and direct-injection diesel engines. However, the chosen approach must have the potential for mass production by 2004.

The participating schools are California State University at Northridge, University of California at Davis, Concordia University of Montreal, Lawrence Technological University, University of Michigan, Michigan Technological University, University of Illinois at Chicago, University of Maryland, Ohio State University, University of Wisconsin-Madison, Virginia Tech., and West Virginia University.

Week-long design and performance competitions will take place in June 1996 and 1997. The 1996 events are scheduled for June 17-24 in Dearborn, Michigan. Awards will be given both in 1996 and 1997.

Points will not be given for manufacturability and cost during the 1996 competition, because of the newness of these events. The designs will be evaluated during the 1996 competition, providing contestants with feedback and allowing organizers to fine-tune the structure of the events. Points will be awarded for manufacturability and cost in 1997.

Vic Comello
Senior Technical Writer
Argonne National Laboratory

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FUTUREDRIVE
Volume 1, Number 4, Winter 1995-96

Purpose
To inform past, present, and potential sponsors, participants, organizers, volunteers, and others interested in DOE-sponsored vehicle competitions about the plans for and results from the competitions.

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What Happens to Emerging Transportation Technologies?

Often the most far-reaching impacts from our student competitions occur long after the competitions are over. Not only do the students who develop the advanced, alternative-fueled vehicles for the competitions gain a wealth of knowledge and experience in the process, which they then carry into their careers, but sometimes the promising transportation technologies they help design become advanced further through additional corporate or government research grants or through introduction into the marketplace. The latter has happened many times since 1987, when the U.S. Department of Energy (DOE) first began sponsoring the student automotive competitions.

Key transportation technologies that have "gone the extra mile" include:

- Northwestern University developed a compressed natural gas (CNG) fuel-quality sensor for the 1991 Natural Gas Vehicle (NGV) Challenge that optimizes engine operation on CNG vehicles. Further development of the sensor was subsequently supported by the Gas Research Institute.
- The University of Wisconsin and Kohler Engines are reducing small engine emissions, thanks to improved Kohler engine performance in the 1994 Hybrid Electric Vehicle (HEV) Challenge.
- Old Dominion University and Siemens Automotive are converting a production gasoline fuel injector to a multi-alternative-fuel injector (CNG, LNG, and LPG). Developed for the 1992 NGV Challenge, the injector was also used by the University of Tennessee in the 1995 HEV Challenge to attain Ultra-Low Emissions Vehicle (ULEV) levels. As a result, the university's vehicle placed first in the Neon Class and had the lowest emissions levels of any vehicle in the three-year history of the HEV Challenge. The injector is now in the post-prototype, pre-manufacturing phase of development. Chrysler plans to use it in its 1998 CNG production vehicles, and Ford and Mercedes are also considering it for their vehicles.
- For an NGV Challenge, Texas Tech University developed a CNG conversion system for light-duty vehicles that Mesa put into production.
- In 1990, the University of Tennessee converted a 1988 Corsica in the Methanol Challenge to operate on M-85 fuel (methanol). The vehicle achieved ULEV levels while simultaneously increasing power by 50% and fuel efficiency by 15%.
- HEVs built by the University of Illinois, the University of Maryland, and the University of California-Davis were used to evaluate the Society of Automotive Engineers' draft HEV emissions test procedures (J1711).
- The HEV Challenge vehicles have expanded our understanding of HEV design and control strategies. We've learned that many more hybrid options than simple parallel or series configurations work—that selecting the "right" configuration really requires matching components and HEV configuration with an appropriate car-control strategy.

While impressive, these are only a few of the benefits evolving from our past competitions. Our 1996 competitions are sure to produce even more.

Shelley Launey
Manager of Vehicle Competitions
DOE Office of Transportation Technologies

Fuel Economy Measurement Challenges During the 1996 Competition Season

The 1996 competition season will present new challenges to organizers gathering fuel economy data, because of the number and variety of fuels that will be allowed, particularly in the FutureCar Challenge. FutureCar Challenge officials must be prepared to accurately measure and dispense methanol (85%), ethanol (85%), reformulated gasoline, dimethyl ether, propane, diesel, and compressed natural gas.

Ideally, data on fuel economy should be measured by a chassis dynamometer as a vehicle is put through its paces in accordance with the Federal Test Procedure (FTP) or some similar regimen. FTP testing gives a very controlled look at fuel economy because test drivers must keep their vehicles on the "trace," which is a speed-vs.-time graph defining a sequence of driving intervals at different speeds. The amount of energy needed to complete the test determines both the city and highway mileage of the vehicle.

Because FTP testing is conducted under strictly controlled conditions, accurate comparisons can be made between competing vehicles and with conventional vehicles that must be emissions-certified using the same test procedure. Over-the-road testing provides a snapshot of vehicle performance under more typical driving conditions. For that reason, over-the-road testing often supplements FTP testing or substitutes for it when FTP test facilities are unavailable. The FutureCar Challenge, the American Tour de Sol, and the Propane Vehicle Challenge use FTP testing in conjuction with over-the-road events.

There are three common types of over-the-road events in DOE competitions. One type involves driving vehicles for a given amount of time with a limited amount of fuel, over a specified route at speeds that remain within an upper and lower average lap speed. A second type specifies that vehicles be driven at set speeds for five or more miles. The speeds are representative of city, suburban, and highway driving (e.g., 25, 40, and 50 mph). The third type is the road rally, which involves driving vehicles to specified locations within time limits determined by the mandated driving speeds and the distances involved. Whenever possible, a production-model gasoline vehicle is tested along with the competition vehicles to show how the vehicles compare with their gasoline counterpart.

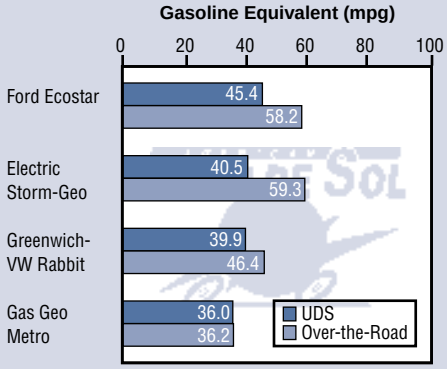
To make such measurements, a conversion factor that relates the energy in a gallon of gasoline either to produce electricity or be burned in a vehicle is applied to allow a direct comparison of fuel economy between electric and conventional vehicles. This conversion factor takes into account the losses due to production and distribution of electricity and gasoline. The result is expressed in equivalent miles per gallon (mpg) as shown in the figures below.

These figures offer a sampling of performance information taken from the 1994 and 1995 American Tour de Sol road rallies for electric and gasoline-control vehicles. The data gleaned from all of the competitions comprises the largest U.S. database on the performance of prototype alternative-fueled vehicles, providing crucial baseline information on promising technologies.

Nicole LeBlanc
Engineering Associate
Argonne National Laboratory

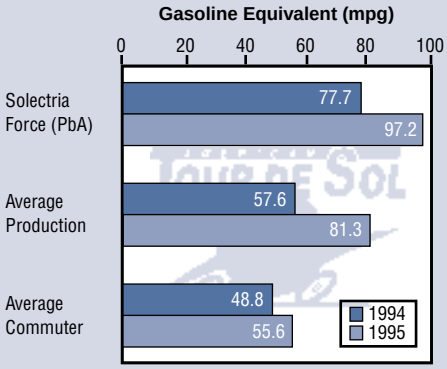
Fuel Economy Data from the American Tour de Sol

URBAN DRIVING SCHEDULE TESTING VERSUS OVER-THE-ROAD TESTING IN 1994



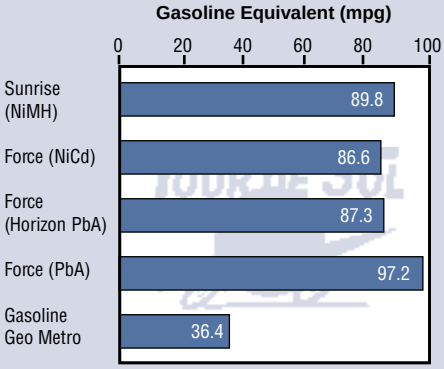
Values reflect application of 33.4 kWh/gallon and 0.321 powerplant efficiency conversion factors.

ELECTRIC VEHICLES MORE EFFICIENT IN 1995



Values reflect application of 33.4 kWh/gallon and 0.321 powerplant efficiency conversion factors.

1995 ELECTRIC VEHICLES MORE THAN TWICE AS EFFICIENT AS GASOLINE COUNTERPART

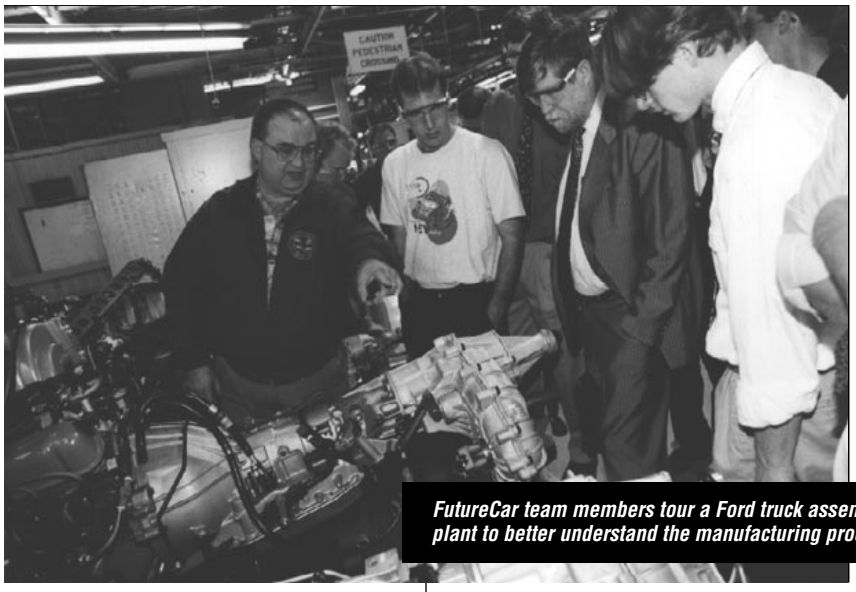


Values reflect application of 33.4 kWh/gallon and 0.321 powerplant efficiency conversion factors.

USCAR's Commitment to PNGV Goals Is Producing Technical Advances

In the fall of 1993, the United States Council for Automotive Research (USCAR) and eight agencies of the federal government formed an historic partnership to jointly pursue automotive research. The so-called Partnership for a New Generation of Vehicles (PNGV) committed the government and the "Big Three" automakers to fostering research in three primary areas: advanced automotive manufacturing, technologies that increase the efficiency of standard vehicle designs, and development of a revolutionary new class of vehicles having up to three times the fuel efficiency of current models. After only two years, this commitment is starting to pay off.

One way to make cars more fuel-efficient is through increased use of lightweight materials, such as aluminum and composites. Use of aluminum has been limited in the past, partly because it resists welding, even with lasers. Aluminum is so highly reflective that it tends to scatter most laser light. However, welding techniques being developed at Los Alamos National Laboratory promise to skirt this problem, yielding high-quality aluminum joints. The novel computer-controlled welding techniques are being considered for pilot installations.



FutureCar team members tour a Ford truck assembly plant to better understand the manufacturing process.

Another significant PNGV advance has just gone on-line in a production facility. This closed-loop, computer-controlled induction hardening process developed at Sandia National Laboratories strengthens steel auto parts by heating them electrically and then quench-cooling them in a water spray. The process is being tested at Delphi Saginaw Steering Systems on intermediate driveshafts for Saturn products. The new process not only makes parts more uniformly and reproducibly, it is more energy efficient and environmentally benign than conventional processes.

Environmental responsibility is an important issue at the USCAR Vehicle Recycling Development Center, where recycling methods for separating and salvaging materials from discarded vehicles are being evaluated. One of these—under development at Argonne National Laboratory—recycles plastic auto components derived from automotive shredder residue (ASR). Auto shredders generate 3-5 million tons of waste each year, about 20-30% of which consists of plastic materials.

The Argonne recycling technique begins with mechanical/physical separation of the ASR into several fractions, including polyurethane foam and a plastics-rich stream from which Argonne recovers heat-formed plastics (thermoplastics). A demonstration plant at a shredder site is now recovering four different plastics in addition to polyurethane foam. Argonne researchers estimate that the relatively low cost of the recovery process could make reuse of the recovered plastics economically attractive for a variety of applications.

Detroit Edison to Furnish Charging Stations for FutureCar

Detroit Edison will install electric charging stations for the 12 teams competing in the 1996 FutureCar Challenge competition. Additionally, Edison will provide safety training and station monitoring. FutureCar will help Detroit Edison assess the impact that multiple charging stations have on the power quality each station delivers. This type of information will help electric utilities prepare to support electric vehicles when they are mass produced.

Edison also furnished safety training, charging stations, and monitoring during each year of the HEV Challenge. It provided 30 stations in 1993 and 1994 and 24 stations in 1995.

Team Paradigm Recalls Its Achievements as It Prepares for the FutureCar Challenge

Team Paradigm came into existence in 1991 to compete in the HEV Challenge. The student organization at the University of Wisconsin-Madison entered the three-year competition when it began in 1992 and now looks ahead to the FutureCar Challenge with plans for a new hybrid electric vehicle powered in part by a direct-injection diesel engine. Team members hope to build on their accomplishments at the 1995 HEV Challenge.

"I am very pleased with the results we obtained with the converted Ford Escort wagon," says Wayne Milestone, the team's faculty advisor and professor of mechanical engineering at the university. "We received First Place in four of the eight events for which points were given and finished third overall."

The First Place awards were for consumer acceptance, the engineering design review, the dynamic performance event, and the team's technical report. The team also received awards for best teamwork and the most efficient zero-emissions vehicle.

It was no accident that Team Paradigm won the consumer acceptance event. Consumer acceptability had become an important goal following the second year of competition.

"We were the only school to successfully implement 'turnkey operation,'" says Patrick Maguire, Team Paradigm's student FutureCar team leader. Turnkey means that the vehicle starts at the turn of a key, much like a stock Escort would. The car also handles well and is easy to drive. Because of its series design, its only controls are a steering wheel, accelerator, brake pedal, and drive selector.

Team Paradigm chose the Command 25 engine, which was manufactured by Kohler Corp. of Kohler, Wisconsin. As it happened, the team was looking for much the same sort of fuel-injected engine that Kohler had been working with Bosch and other companies to design. A joint development program between the team and Kohler accelerated the development of a prototype fuel-injected engine that included a custom-made catalytic converter to achieve ultra-low emissions.

In attempting to achieve the FutureCar Challenge goal of 80 miles per gallon, Team Paradigm opted for a diesel engine from another manufacturer. However, team members will long remember the helpfulness of the Kohler Corporation. "They were extremely good sponsors for us," says Maguire. "They were always willing to help us out."

Although attention has shifted to the FutureCar Challenge, the converted Ford Escort wagon continues to play an active role in Team Paradigm's outreach program. Since the 1995 HEV Challenge, it has been used 24 times in various promotional capacities. One of these involves helping students at Madison West High School to build an electric car. In doing so, the team hopes to encourage the students toward continued involvement at the college level, or at the very least, to prepare them to become more accepting of alternative-fueled vehicles when these vehicles enter the marketplace.

Chrysler Minivans Transformed into AFVs for 1996 Propane Vehicle Challenge

What do you get when you convert a gasoline-fueled 1996 Chrysler minivan to dedicated propane operation? An advanced alternative-fueled vehicle. College engineering students are effecting this transformation in preparing for the 1996 Propane Vehicle Challenge, to be held May 29 through June 4 in Windsor and Toronto, Ontario, Canada. This is the first DOE-sponsored automotive technology competition to focus on propane as a transportation fuel and to be held mainly in Canada.

While converting the minivans, students face real-life engineering problems and participate in complex decision making. Competition goals are to:

- Develop advanced propane vehicle technology,
- Achieve ultra-low exhaust emissions,
- Attain a minimum range of 400 kilometers (about 250 miles), and
- Demonstrate performance equal to or better than that of an equivalent conventional gasoline-fueled vehicle.

As the organizer of the competition, Argonne National Laboratory is establishing a technical support system to assist student teams in achieving a high level of safety and innovation. All vehicles entered in the competition will undergo a thorough safety inspection. The design and performance of the converted minivans will be evaluated during the following events: Noise, Acceleration, Exhaust Emissions Testing, Solo (drivability and handling), Range, Fuel Economy, Written Design Report, and Oral Presentation.

The Challenge aims to optimize vehicle efficiency and minimize exhaust emissions without sacrificing overall vehicle performance. Fuel economy will be measured as the vehicles travel from Chrysler Canada Ltd. facilities in Windsor to Toronto. The university teams will arrive at the Windsor Workshop on Alternative Fuels in Toronto, where the top-rated teams will give talks on their vehicle design strategies to conference participants.

A partnership formed among industry, government, and universities brings the best of each sector's strengths and resources to the competition. The Challenge is being sponsored by Natural Resources Canada, the U.S. Department of Energy, and Chrysler Canada Ltd. The National Propane Gas Association, the Propane Gas Association of Canada, and Conoco, Inc. are also supporting the competition; the University of Windsor and Chrysler Canada Ltd. are hosts.

For more information, or if interested in supporting the competition, contact Shelley Launey, Fax: (202) 586-9815 (E-mail: shelley.launey@hq.doe.gov) or Carlos Buitrago, Phone: (708) 252-7261, Fax: (708) 252-3443 (E-mail: carlos_buitrago@qmgate.anl.gov).

Cheryl Drugan
Senior Technical Writer
Argonne National Laboratory

NREL Develops HEV Web Site

The National Renewable Energy Laboratory has developed a site on the World Wide Web as a means of providing the public with hybrid electric vehicle (HEV) information while allowing program managers on-line access to HEV program updates, schedules, and financial summaries. The site is the most comprehensive accumulation of HEV information available on-line. Some of the key features of the site include HEV program background, HEV world news, HEV component information, national suppliers that are working with General Motors and Ford, HEV social and economic benefits, competitive technology assessments of foreign car manufacturers, and a working HEV simulation. The HEV simulation applies fundamental physics to measured component performance data in estimating the emissions, fuel economy, and maximum acceleration effort for the designed hybrid electric vehicle. The simulation can model both parallel- and series-configured vehicles.

The simulation was introduced in bare form, allowing the user to modify only a few parameters. However, the interface between the user and the HEV simulation is being fleshed out and should be fully functional by January 1996. The on-line simulation is based on a detailed, fully functional simulation model now being used by industry to develop HEV components.

The HEV Web site address is: http://www.nrel.gov/research/hev.

CORRECTION

École de Technologie Supérieure and California State University at Chico tied for second place in the Saturn Category of the 1995 HEV Challenge.

APS Electrics

APS Electrics will be held March 1-3 in Phoenix, Arizona. It is open to electric and hybrid electric vehicles. The hybrid events are designed to conform with DOE 1995 HEV Challenge rules.

Electra Challenge

The Electra Challenge is a high school electric vehicle competition to be held in conjunction with the 1996 Spring Auto Fair at the Charlotte Motor Speedway on April 11 through April 14. Students must convert a conventional internal combustion engine vehicle to an electric vehicle and be actively involved in the vehicle's design.

EV Grand Prix

The EV Grand Prix will be held April 25-27 at the Richmond International Raceway in Richmond, Virginia. This high school competition will involve gasoline-powered vehicles (cars and trucks) that have been converted to electric operation.

American Tour de Sol

The eighth annual American Tour de Sol will be held May 10-17. The eight-day electric vehicle road rally will run from New York City to Washington, D.C., with pit stops and free displays in New York, New Jersey, Pennsylvania, Maryland, and Washington, D.C.

Formula SAE

Planning continues for the Formula SAE 1996. The competition will again be held at the Pontiac Silverdome in Michigan. The competition is tentatively scheduled for May 15-18, with registration on the 14th and the awards banquet on the 19th. DOE will again sponsor the awards for the M-85 class and Outstanding Teamwork Award.

Propane Vehicle Challenge

Twelve college teams from the United States and Canada will compete in the 1996 Propane Vehicle Challenge to be held May 29-June 4 in Windsor and Toronto, Canada (see article on p. 6). The competition will give students the chance to convert gasoline-fueled 1996 Chrysler minivans to dedicated propane operation.

Midwest Supermileage

The Midwest Supermileage competition will be held at the Eaton Corp. Proving Grounds in Marshall, Michigan, on May 31 through June 1. The event is open to one-person vehicles running on straight iso-octane fuel, and is judged strictly by fuel economy. Several cash prizes are awarded. The First Place prize is guaranteed to be at least $750.

West Coast Supermileage

The 1996 West Coast Supermileage competition will be held June 8-9 at the California Highway Patrol Academy in West Sacramento, California. It is open to one-person vehicles fueled by either iso-octane or a methanol/gasoline blend consisting of 85% methanol and 15% gasoline. DOE will again sponsor the awards for the M-85 class. The Supermileage competition offers engineering students real-world experience by giving them a chance to design their own fuel-efficient vehicles.

FutureCar Challenge

The FutureCar Challenge is a multi-year competition aimed at designing and building a mid-size passenger car capable of achieving up to 80 miles per gallon (see article on p. 1). Student teams from 12 North American universities have been selected to participate. The competition is scheduled for June 1996 and 1997, with the 1996 events taking place June 17-24 in Dearborn, Michigan.

Cleveland Electric Formula Classic

The 1996 Cleveland Electric Formula Classic will be held at Lakefront Airport, Cleveland, June 28-29. Open only to open-wheeled electric race cars, it is sponsored by the Cleveland Electric Illuminating Co. This is the third year of the competition.

COMPETITION CALENDAR

March 1-3

APS Electrics
Electrics and HEVs
Phoenix, Arizona

Contact:
Donald Karner
Electric Vehicle Technology
Competitions, L.C.
Phone: (602) 256-2599
Fax: (602) 256-2606

April 11-14

Electra Challenge
High school electric vehicles
Charlotte, North Carolina

Contact:
Bob Kosak
York Technical College
Phone: (803) 325-2865

April 25-27

EV Grand Prix
High school electric conversions
Richmond, Virginia

Contact:
Cindy Dickerson
Virginia Power
Phone: (804) 775-5624

May 10-17

8th Annual American Tour de Sol
Road rally for electrics
New York City to Washington, D.C.

Contact:
Northeast Sustainable
Energy Association
Phone: (413) 774-6051
Fax: (413) 774-6053

May 15-18

Formula SAE
Pontiac Silverdome, Michigan

Contact:
Educational Relations
Phone: (412) 776-4841, ext. 224
Fax: (412) 776-1615

May 29-June 4

Propane Vehicle Challenge
Chrysler minivans converted
to propane operation
Windsor and Toronto, Canada

Contact:
Shelley Launey
U.S. Department of Energy
Fax: (202) 586-9815
E-mail: shelley.launey@hq.doe.gov

May 31-June 1

Midwest Supermileage
One-person iso-octane vehicles
Marshall, Michigan

Contact:
Fred Kinney
Eaton Corp.
Phone: (616) 342-3314

June 8-9

West Coast Supermileage
One-person alternative-fueled
and iso-octane vehicles
Sacramento, California

Contact:
Jon Manji
Caltrans
Phone: (916) 227-9683

June 17-24

FutureCar Challenge
Mid-size production
vehicle conversions
Dearborn, Michigan

Contact:
Shelley Launey
U.S. Department of Energy
Fax: (202) 586-9815
E-mail: shelley.launey@hq.doe.gov

June 28–29

Cleveland Electric
Formula Classic
Open-wheeled electric race cars
Cleveland, Ohio

Contact:
Donald Karner
Electric Vehicle Technology
Competitions, L.C.
Phone: (602) 256-2599
Fax: (602) 256-2606

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