FutureDrive

Volume 4, Number 1 **DOE/Industry Competitions Advancing Automotive Technology** Winter 1998

TECHNOLOGY FEATURE

# Ethanol Vehicles Will Face Tough Tests at GM's Milford Proving Ground

General Motors has offered its world-renowned proving grounds at Milford, Mich., as the site of the 1998 Ethanol Vehicle Challenge. The Milford Proving Ground has become the chief installation in a network of GM facilities designed to test, under a wide variety of conditions, the performance, emissions, safety, and environmental acceptability of GM vehicles and their 15,000 parts.

Milford's state-of-the-art equipment, especially its emissions laboratory, will be used for 6 days of testing in the Ethanol Vehicle Challenge (May 26–June 1). Student teams will drive 1997 Chevrolet Malibu sedans that they have converted to run on E85 fuel.

Built in 1924 just northwest of Detroit, the Milford Proving Ground has been expanded and enhanced over the years to accommodate the increasingly complex technology used in passenger cars, trucks, and even buses and military vehicles. Milford now encompasses almost 4,000 acres, with 132 miles of test roads and 107 buildings. It contains a wealth of laboratory equipment, much of it specially designed, developed, and built in-house. The facility employs 4,800 in a round-the-clock operation.

One of the primary activities at the facility is evaluating the lifetime durability of vehicle components by means of complex computer programs that can compress 100,000 miles of certain driving experiences (such as driving over potholes or salted highways) into a few months. Milford also has special equipment that simulates roadway forces and accident conditions to predict tire handling and test the safety of passenger restraint systems. About 300 cars are destroyed each year in various crash tests.

*Performance testing at Milford*

Sophisticated technology at Milford can measure the electromagnetic effects of radios, mobile phones, and high-voltage lines on today's on-board control systems. And a new $100-million center is designed to help minimize vehicle vibration and noise.

In addition to hosting vehicle tests, Milford reduces the possibility of accidents through its driver training programs and its roadway designs, many of which are implemented when new highways are built.

For more information on Milford Proving Ground, contact Gerald Wilson, Communications Manager, GM Proving Grounds, (248) 685-6171.

Marita Moniger

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**FUTUREDRIVE**
**Volume 4, Number 1, Winter 1998**

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

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# CARAT Seeks to Fund University and Small-Business Research Gems

In previous FutureDrive columns I have written about several commercial automotive products that got their starts in our series of vehicle competitions. I have also reported on some impressive research grants that schools have received for follow-on work after debuting vehicle concepts in our competitions. Now I am excited to report that the innovations that universities and colleges have brought to events like the FutureCar Challenge have inspired a new DOE research and development program called CARAT.

DOE launched the Cooperative Automotive Research for Advanced Technology (CARAT) program last October. The program is open to colleges, universities, and small businesses. CARAT is unique because it funds not only the research but also the development and validation of technically advanced vehicle components and systems. (An industry partner is added once the component or subsystem moves to the vehicle-scale validation stage.)

Any project that DOE funds under CARAT must start with a firm technical basis supported by test or modeling data and show a strong potential for success in automotive applications. Projects will help eliminate barriers that prevent us from producing the 80-mpg vehicle envisioned by President Clinton's Partnership for a New Generation of Vehicles.

CARAT is the first of several DOE programs being contemplated that would build on the expertise of students and entrepreneurs to create tomorrow's vehicles today.

Shelley Launey
Manager of Vehicle Competitions
DOE Office of Transportation Technologies

- **CARAT proposals are due on March 10.**
- **For more information on CARAT, a copy of the solicitation, and a list of eligible research topics, visit our web site at http://www.ipd.anl.gov/carat.**

# University of Tennessee Looking to Planetary Influence for FutureCar Win

The University of Tennessee at Knoxville has something to prove. After nearly a decade of fielding winning cars in alternative fuel contests, the widely respected school did not qualify for the last two FutureCar Challenges (only a fraction of applicants do). This year UT's proposal to participate was accepted, and 25 mechanical engineering students plan to win the Challenge by doing something no student team has done before.

The team is fashioning a Chrysler Intrepid body and a converted Saturn engine into the first dual hybrid-electric vehicle of its kind to be entered into a student-level competition. Using two electric motors and an internal combustion engine, the students are taking an innovative approach that combines series and parallel configurations. (Toyota says it will launch a similar vehicle in the U.S. within the next few years, in what the auto giant realizes will be a test drive.)

"We're looking to push the envelope," says Brian Moore, a UT team leader.

The team is focusing on the design of a planetary gear train that, responding to an on-board controller that processes second-by-second information about the power needs and battery charge state of the vehicle, allocates which power sources will function at a given time, and how.

**"The merit of a dual HEV is its flexibility. The generator motor can be recharging, supplying power, or both."**

Bill Hamel, Co-Faculty-Advisor

"The merit of a dual HEV is its flexibility," explains co-faculty-advisor Bill Hamel. "The generator motor can be recharging, supplying power, or both, instantaneously matching the drive train's performance to road conditions."

The planetary gear train is crucial to winning the fuel efficiency and emissions tests of the FutureCar Challenge. Its job is to coax the most power out of the least energy by juggling the assignments (drive or charge) and functional configuration (series, parallel, or a combination of both) of the engine group. UT's design specs call for a fuel efficiency of 82%, which is equivalent to 60 miles per gallon in a combustion engine. Harmful emissions would be just one fifth those of today's standard cars.

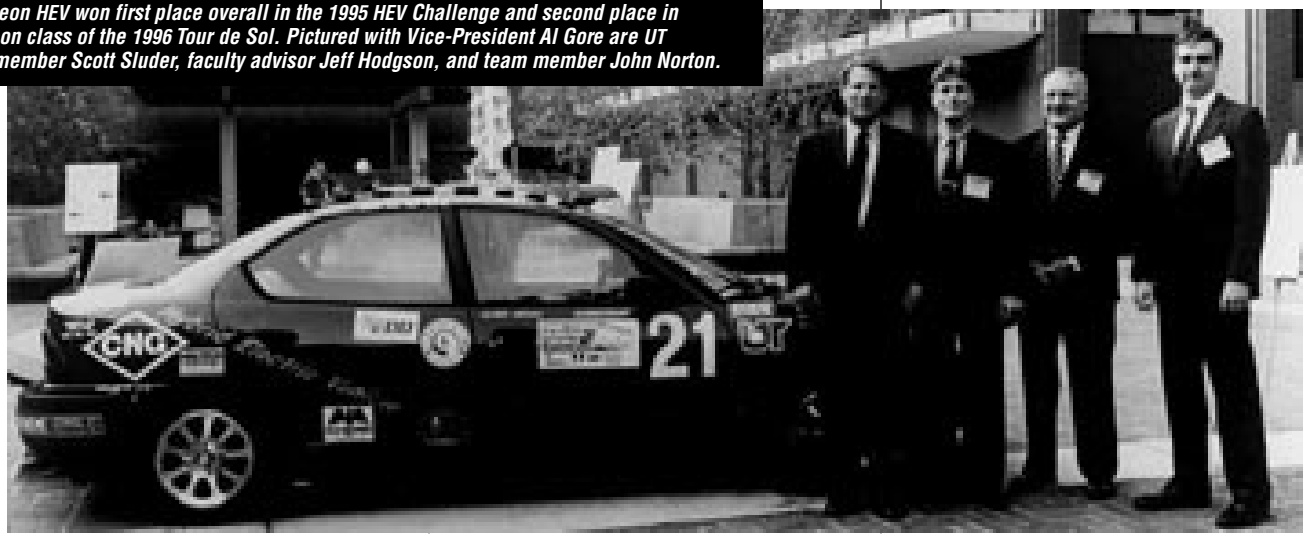
Some other components of this year's entry build on technologies used in previous UT competition vehicles: the internal combustion component will be fueled with compressed natural gas, long a subject of research and expertise at UT, and the controller design is adapted from the school's winning 1995 HEV Challenge entry. However, in all other aspects the students must begin from ground zero. That's one of the most challenging things about the competitions, says Jeff Hodgson, co-advisor to UT's 1998 FutureCar team.

"One of the neat things about FutureCar is that you can choose from so many different technologies," Hodgson says. "Students have the final reports from previous UT teams, but they don't feel constrained by them."

Besides placing first in the Neon Class of the 1995 HEV Challenge,

(continued)

*UT's Neon HEV won first place overall in the 1995 HEV Challenge and second place in the Neon class of the 1996 Tour de Sol. Pictured with Vice-President Al Gore are UT team member Scott Sluder, faculty advisor Jeff Hodgson, and team member John Norton.*



(continued)
UT teams won the 1989 and 1990 Methanol Marathons and the 1991 Natural Gas Vehicle Challenge. They placed second in their class in the 1996 Tour de Sol, despite a detour back through Knoxville to fix a mechanical problem.

UT graduates of the competitions have gone on to make their mark in the industry. One designed the emissions calibration of Chrysler's E85 ethanol-powered flexible-fuel minivans. Another holds a patent for a variable valve-timing device for GM's Delphi Energy and Engine Management Systems.

Catherine Kaicher and
Mary Fitzpatrick

## Student Teams: A Proving Ground for More than Vehicles

The months students spend working together to create a vehicle for competition are by all accounts filled with challenges, stress, intense labor, and exhilaration—everything corporate engineers encounter when they launch a new product. For two former University of Tennessee students, their experience on UT's 1995 HEV Challenge team indeed helped prepare them for the engineering jobs they now hold at John Deere. But even more importantly, say Jennifer and Brock Fraser, those mercurial months helped equip them for their marriage.

The couple met at a chapter meeting of the Society for Automotive Engineers shortly before they began working together on the emissions crew of the Challenge team. As work on the Neon HEV progressed, so did their love—and their lessons in cooperation. UT's entry won first prize, and so, say the Frasers, did they.

*Brock and Jennifer Fraser*

# Fuel-Cell First for FutureCar

For the 1998 FutureCar Challenge, two student teams are boldly going where few professional engineers have gone before. They've decided to power their cars with fuel cells. Their choice marks a first for this competition.

*energy partners, inc.*

Student teams at Texas Tech and Virginia Tech will each be converting a Chevrolet Lumina to run on a 20-kW proton-exchange-membrane fuel cell. The fuel cells are being purchased by the U.S. Department of Energy and built by Energy Partners of West Palm Beach, Fla.

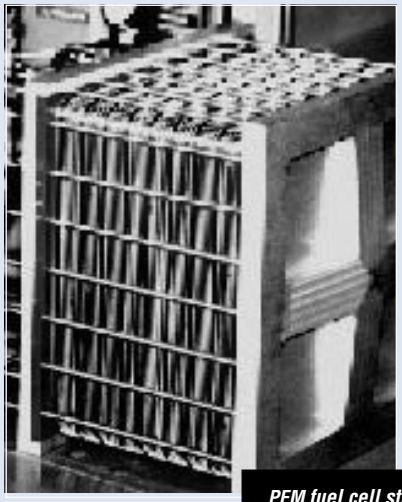
"We're excited about this opportunity to use a new, advanced technology that's very, very fuel efficient and has zero emissions," says Doug Nelson, faculty advisor at Virginia Tech.

Scientists discovered the science behind fuel cells (that combining hydrogen and oxygen produces electricity) more than 150 years ago. Fuel cells were first developed for practical use during the space program in the 1960s. When they run on pure hydrogen, the only by-product is water. With appropriate fuel processors, they can also run on methanol, ethanol, and gasoline, still with low emissions.

"The purpose of FutureCar is to use cutting-edge technology to meet PNGV [Partnership for a New Generation of Vehicles] goals for fuel efficiency and emissions," says Shelley Launey, Manager of Vehicle Competitions for DOE's Office of Transportation Technologies. However, she also says, "There are very few examples of fuel-cell vehicles operating anywhere in the world today. This gives us an opportunity to demonstrate the technology we support."

So far, only a dozen fuel-cell vehicles have been built. Most are buses, which have no significant size or weight restrictions on the powertrain, or small golf cart or utility vehicles, which have modest power requirements. (Several of the latter have been built by Energy Partners.)

For the FutureCar Challenge, in contrast, the students face severe constraints: they must modify a family sedan to achieve 80 mpg and low emissions without sacrificing the affordability, performance, utility, and safety that buyers expect. To date, only major manufacturers (such as Daimler-Benz and Toyota) have successfully built and demonstrated prototype fuel-cell cars based on current production vehicles.



*PEM fuel cell stack*

As if that weren't enough of a challenge, the teams won't get their fuel cells until April, two months before the competition. Energy Partners will fabricate the 100-cell, 20-kW fuel-cell stacks this spring, using an electrode design they developed for a 10-cell, 2-kW unit built as part of a current DOE contract. Making them is slow business: each of the 100 plates in the fuel cell takes a full day to machine.

In the meantime, the students have to design the rest of the fuel cell system and powertrain. And therein lies the biggest challenge: system integration. The students must develop fuel supply and power electronics systems under severe space constraints, but without the fuel cell. Because the range of design possibilities depends on the response characteristics of the fuel-cell system, another layer is added to the challenge.

Fortunately, both schools are successful veterans of previous contests: Virginia Tech placed first and second in the 1996 and 1997 FutureCar Challenges, respectively, with a hybrid-electric Lumina. Texas Tech took second place in the 1997 Propane Vehicle Challenge, with a triumphant comeback from an engine burnout (FutureDrive, Summer/Fall 1997).

They will need every bit of their experience. They'll need to develop both an air system and a hydrogen system, with appropriate compressors, humidifiers, and regulators and storage for the hydrogen; a thermal control system to deal with the heat generated by the oxygen-hydrogen reaction; output power processors to get a usable voltage for the electric drive motors; and power controls. Remember that all this has to fit under the hood of a Lumina, with room left for the fuel cell, which is about the size of a 2-foot stack of license plates.

"The most interesting thing for me is the overall control system," says Texas Tech team leader Brian D'Souza. "There are many fabulous devices that individually can't meet the PNGV requirements. Getting all the gadgets and problems (electrical and mechanical) organized for maximum performance is a big challenge."

**"There are very few examples of fuel-cell vehicles operating anywhere in the world today. This gives us an opportunity to demonstrate the technology we support."**

Shelley Launey, Manager
Vehicle Competitions, DOE Office
of Transportation Technologies

To deal with the late arrival of the heart of the system, the Virginia Tech team is relying on a detailed schedule. "We're focusing on preparing it as a pure electric vehicle, on getting the battery and electric drive train mounted," Doug Nelson says. "We're also working on procuring the long-lead-time items such as air compressors."

Both teams are being advised by the fuel cell supplier. "Energy Partners has been a tremendous help in guiding us," D'Souza says. "At their suggestion, we are building a test stand to test and study a single-layer fuel cell. Meanwhile, we are also converting a small, three-cylinder Geo engine to compressed natural gas for use with a generator just in case the fuel cell isn't ready in time."

Despite the major challenges, "we feel that the fuel-cell technology is the only means currently available to approach 80 mpg for a mid-size vehicle," says Texas Tech advisor Tim Maxwell.

"Even if an internal combustion engine approaches 40% efficiency, it will be difficult to attain 80 mpg," Maxwell says. "The fuel cell can potentially attain efficiencies above 50%, making it possible to get an overall drive-train efficiency of 45% or greater."

Frano Barbir, a principal research engineer at Energy Partners, is anxious to see the teams succeed: "We hope we learn something from the students that will help us build a better fuel cell system in the future."

Jane Andrew

*Shown in Detroit to kick off preparations for the 1998 FutureCar Challenge are Virginia Tech team advisor Doug Nelson, Frano Barbir of Energy Partners, Shelley Launey of DOE, Elizabeth Brueckner of USCAR (Challenge co-sponsor), Virginia Tech team members Chris Pare and Mike DeBurn, and Pat Hilber of General Motors.*

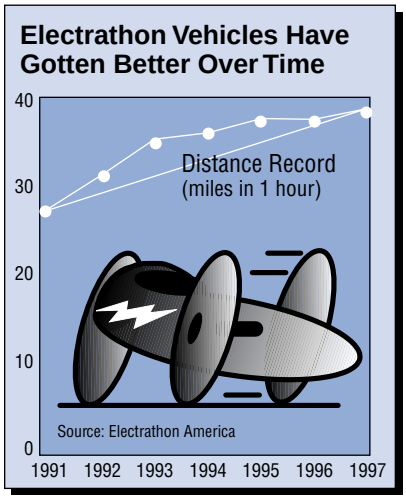
# Electrathon Teaches High School Students Real-World Science and Teamwork

Some call it a hobby. Others call it a sport. But as high school students and teachers across the country know, the Electrathon—an increasingly popular electric vehicle competition—blends fun, learning, and serious science.

Students learn what makes vehicles efficient by constructing, from the ground up, a lightweight car that can travel more than 30 miles in one hour. The winning car is the one that goes the most miles, usually around a small track, in one hour.

Most Electrathon vehicles are powered by a 1- to 3-horsepower permanent-magnet motor with a pulse-width speed controller. The batteries may be any voltage, as long they are lead-acid, weigh 64 pounds or less, and are commercially available.

Electrathon races are among the fastest growing vehicle competitions in the United States, according to Phil Patterson of the U.S. Department of Energy. An estimated 200 high schools are involved in regional and national Electrathon competitions today, and the number is growing. Part of the Electrathon's popularity comes from the relative simplicity of the vehicles. And unlike the alternative vehicles used in many other competitions, Electrathon cars can be relatively inexpensive to construct. Even so, vehicle design possibilities are nearly limitless.




Entries are becoming more sophisticated each year. In the Pentad National Electrathon Competition held in Marne, Mich., last July, four cars broke the existing distance record of 37.03 miles set in 1996, and 13 of the vehicles traveled more than 30 miles in one hour.

Because vehicle weight significantly affects performance, students must find ways to engineer and construct their cars to minimize bulk. Some vehicle bodies have been a frame covered with shrink wrap; others have been constructed more elaborately of aluminum, fiberglass, and even carbon fiber. The chassis is usually constructed of steel or aluminum. A typical Electrathon vehicle has three or four wheels, each of which must be at least 16 inches in diameter.

"The competition allows students to get a taste of real-world problems while designing, fabricating, testing, and racing a car," says Paul E. Zellar, Manager of the Great Lakes Electrathon Association.

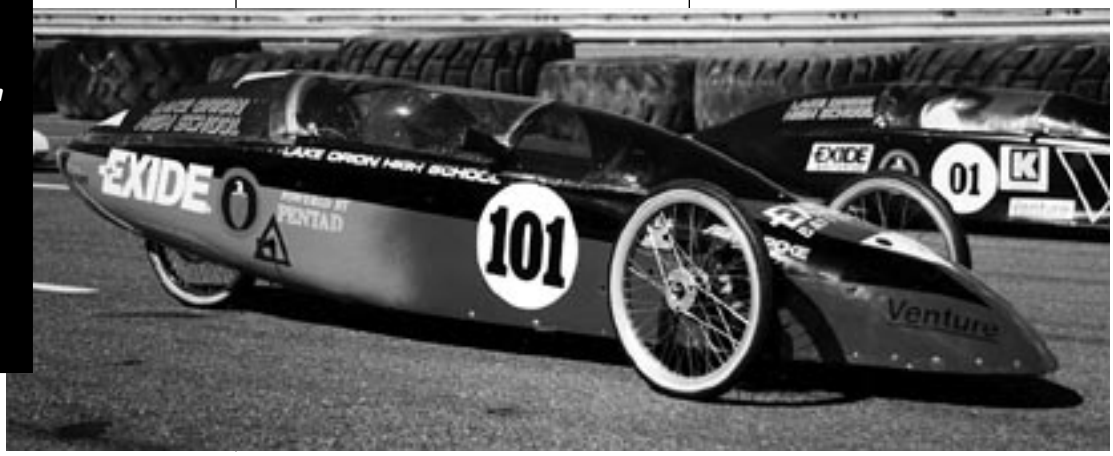
"Teamwork is essential, and networking pays great dividends. Once teachers learn how this event motivates students to learn more about science, math, and technology, they promote it," Zellar says.

For some students, it may be just the spark they need.

"If it hadn't been for my experience with the Electrathon, I probably wouldn't have gone on to the 12th grade," one student admits.

Building electric vehicles from the ground up takes creativity, ingenuity, and talent. Bringing these vehicles to the road demonstrates sound physical, engineering, and chemical principles, and that's exactly what the Electrathon allows high school students to do. Says another high school student, "I had taken every math course offered at my school, but I never saw a practical use for it until the Electrathon."

Kevin Brown




*Lake Orion High School's vehicles placed first and second overall in the Pentad National Electrathon Competition held in Marne, Mich., last July. Both car bodies were constructed of carbon fiber. Car 101 traveled 37.98 miles in one hour, and car 01 traveled 38.39 miles. Two other entries also broke the existing distance record of 37.03 miles.*

## Electrathon Competitions

Sponsored by various regional and local organizations, most Electrathons are aimed at high schools but will accept all applicants that meet the rules. Students build lightweight vehicles powered by lead-acid batteries. The winner travels the farthest in one hour.

***Electrathon America National Championship / April 17–19 Los Angeles, CA***

- *Contact:*
  Gary Raymond, Box 1722
  Thousand Oaks, CA 91358
  Ph: (805) 492-5858
- *Web site:*
  http://www.pioneer.net/~kirk

## Other Electrathons

***May 16 / Cedar Rapids, IA***

***May 23 / Springport, MI***

***May 30 / Ottawa, Ontario***

***June 6 / Marne, MI / Regional***

***July 13–15 / Marne, MI / National***

***September 26 / Springport, MI***

- *Iowa event contact:*
  Matt Lorenzen, Ph: (319) 273-6912
  E-mail: electrathon@uni.edu
- *Michigan events contact:*
  Jim Nicolas, Ph: (616) 837-9753
- *Ontario event contact:*
  EVCO, Box 4044, Station E
  Ottawa, Ontario K1S5B1

## Ethanol Vehicle Challenge

Sponsored by DOE, GM, and Natural Resources Canada. Fourteen teams of college students from the U.S. and Canada will convert 1997 Chevrolet Malibus to run on E-85 fuel. The goal is to improve fuel economy, lower exhaust emissions, and provide excellent cold-startability while maintaining performance and drivability. After testing at GM's Milford Proving Ground, the cars will embark on a road rally to Washington, DC, for exhibition at the Clean Cities Conference.

***May 25–June 1 / GM Milford Proving Ground, MI, and Washington, DC***

- *Contacts:*
  Carlos Buitrago
  Transportation Technology Center
  Argonne National Laboratory
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  Office of Transportation Technologies, U.S. Dept. of Energy
  Washington, DC, Ph: (202) 586-1573
  Fax: (202) 586-1600
  E-mail: shelley.launey@hq.doe.gov

## EVent Electric Vehicle Competition

***May 2 / Richmond, VA***

- *Contact:*
  Jeff Liverman, Ph: (804) 367-8867
  Science Museum of Virginia
  E-mail: jliverman@smv.mus.va.us

## EVTC Events – ABB University Spec Series

Electric Vehicle Technology Competitions, Ltd., sponsors various competitions for high school and university students and other participants each year. The ABB University Spec Series for the 1997/98 season involves 13 teams that are awarded points for each of four events, the first one of which was the Indy Electric Classic held in August 1997. The other events in the series are:

***APS Electrics***
***March 6–8 / Phoenix, AZ***

***Indy Electric Classic***
***May 16 / Indianapolis, IN***

***Tustin Thunder***
***July 17–19 / Tustin, CA***

- *Contact:*
  Mike Shaw, Phoenix, AZ
  Ph: (602) 256-2599
  Fax: (602) 256-2606
  E-mail: info@evrace.com
- *Web site:*
  http://www.evrace.com

## Other EVTC Competitions

***East Valley Electric Classic***
***February 7 / Chandler, AZ***

***APS Electrics***
***March 6–8 / Phoenix, AZ***

***Yankee Electrics***
***April 18 / Hartford, CT***

***Northern Arizona Electric Classic***
***May 2 / St. Johns, AZ***

## FutureCar Challenge

Annual competition sponsored by DOE and USCAR (representing Chrysler, Ford, and GM) gives students from more than a dozen universities the opportunity to convert a Dodge Intrepid, Chevrolet Lumina, or aluminum-bodied Ford Taurus into a car of the future with up to three times the fuel efficiency and the same performance, utility, safety, and affordability as today's vehicles. Students select advanced technologies and varying fuels for meeting the 80-mpg goal.

***June 4–11 / Auburn Hills, MI***

- *Contact:*
  Shelley Launey
  Office of Transportation Technologies, U.S. Dept. of Energy
  Washington, DC, Ph: (202) 586-1573
  Fax: (202) 586-1600
  E-mail: shelley.launey@hq.doe.gov
- *Web site:*
  http://www.uscar.org/futurecar/

## Junior Solar Sprints

DOE program open to 6th, 7th, and 8th graders. Participants receive a kit with a photovoltaic panel and motor and must design and build a model vehicle that will compete in a 20-meter, wire-guided race. Interested parties are welcome to start their own regional competitions. A sponsor is sought for a national event.

- *Web site:*
  http://www.nrel.gov/business/education/SprintWeb/

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***Colorado Junior Solar Sprint***
***May 16 / Golden, CO***

- *Contact:*
  Linda Lung
  National Renewable Energy Laboratory, Golden, CO
  Ph: (800) 639-3649
  E-mail: linda_lung@nrel.gov

***Chicago Junior Solar Sprint***
***May (Date TBD) / Hinsdale, IL***

- *Contact:*
  Christine McGhee
  Argonne National Laboratory
  Argonne, IL, Ph: (630) 252-8677
  Fax: (630) 252-3433
  E-mail: christine_mcghee@qmgate.anl.gov

## SAE Events – Formula SAE

College students design and build formula-style racing cars. Restrictions are placed on the car frame and engine to test participants' creativity. Four-cycle engines up to 610 $cm^3$ can be turbocharged or supercharged. Cars are judged in three categories: static inspection and engineering design, solo performance trials, and track endurance. Formula SAE cars compete in two classes: gasoline and methanol. Sponsored by the Society for Automotive Engineers. The methanol class is also sponsored by DOE.

***May 27–31 / Pontiac, MI***

- *Contact:*
  Tony Androsky, Ph: (412) 772-8535
  E-mail: androsky@sae.org
- *Web site:*
  http://www.sae.org/STUDENTS/student.htm

## SAE Supermileage

University teams develop and build a single-person vehicle with the goal of setting a world fuel economy record. Engines are donated by Briggs & Stratton.

***June 12–13 / Kalamazoo, MI***

- *Contact:*
  Fred Kinney
  Transmission Div., Eaton Corp., Kalamazoo, MI, Ph: (616) 342-3314
  Fax: (616) 383-5508
  E-mail: fredriclkinney@eaton.com
- *Web site:*
  http://www.sae.org/STUDENTS/student.htm

## 10th Annual American Tour de Sol

Seven-day, 350-mile road rally for electric, hybrid electric, or solar-assisted electric sedans, utility vehicles, mass transit vehicles, and motorcycles. Free public events featured in communities along the way. Open to a fixed number of manufacturers, students, or hobbyists. A two-day conference sponsored by NESEA and SAE opens the tour in New York City. DOE is also a title sponsor.

***May 8–14 / New York City to Washington, DC***

- *Contact:*
  Nancy Hazard
  Northeast Sustainable Energy Association
  Greenfield, MA
  Ph: (413) 774-6051, ext. 18
  Fax: (413) 774-6053
  E-mail: nhazard@nesea.org
- *Web site:*
  http://www.nesea.org/98ATDS/98atds_home.html

If we haven't included your event, please contact FutureDrive at (630) 252-9148 or ckaicher@anl.gov.

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