FutureDrive

Volume 2, Number 3 **DOE/Industry Competitions Advancing Automotive Technology** Winter 1996-97

TECHNOLOGY FEATURE

The FutureCar Challenge — A Look at What's Up the Road in 1997

Buckle up and keep an eye out for the starting flag — the 1997 FutureCar Challenge is coming in June! June 3-11 in Warren, Michigan, to be exact. Students from top universities in North America are already gearing up for the '97 Challenge, the second year of a two-year student competition aimed at tripling the fuel economy of today's mid-sized family sedans — without sacrificing affordability, performance, and safety. As in '96, the '97 Challenge will evaluate the vehicle in its entirety. But in '97, teams will focus on improving their vehicles' powertrains and other innovations, such as reducing vehicle weight and enhancing aerodynamics (see related article, p. 3).

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1997 FutureCar challenge

The FutureCar Challenge is 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 goals of the Challenge parallel those of the Partnership for a New Generation of Vehicles (PNGV), a cooperative research and development program of the federal government and USCAR.

For the competition, students apply creative engineering to convert a Chevrolet Lumina, Dodge Intrepid, or Ford Taurus to run on one of several "high-tech" alternative powertrains and fuels. Participating teams come from universities across North America: California State University at Northridge, Concordia University, Lawrence Technological University, Michigan Technological University, Ohio State University, University of California at Davis, University of Illinois at Chicago, University of Maryland, University of Michigan, University of Wisconsin-Madison, Virginia Tech, and West Virginia University. Of the 12 vehicles in the '96 competition, 10 were hybrid-electric vehicles (HEVs). "The '96 event was a 'peek' at what these technologies may offer; '97 should give the teams more time to perfect their strategies for better results," says Scott Sluder, Argonne National Laboratory. New events for '97 include an over-the-road endurance event and a gradeability test, which evaluates the power of the vehicle required to sustain a constant speed while on an incline. Notes Sluder, "This [event] is related to a PNGV goal of having a vehicle that can sustain highway speed (55 mph at gross vehicle weight) up a 6% grade for at least 20 minutes. This goal has a really important effect on the sizing of the energy storage device and the heat engine/generator combination."

The Manufacturing Potential and Cost Event — a trial event in '96 — has been incorporated into the point structure. The objective of this event is to determine how well individual teams make decisions about the cost and manufacturability of the technologies they install in their vehicles.

Claims one student from the University of Illinois at Chicago of the experience, "You don't know cars until you've built, broken, rebuilt, rebroken, rebuilt, and finally put them back together — just in time. Working with a large group of students, professors, and companies is an excellent real-life experience."

For more details on the 1997 FutureCar Challenge, contact Scott Sluder at Argonne National Laboratory (phone: 630/252-6489; fax: 630/252-3443; e-mail: Scott_Sluder@qmgate.anl.gov).

Kevin Brown
Technical Communicator
Argonne National Laboratory

FUTUREDRIVE
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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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Auto Industry's Prototype Hybrid-Electric Vehicle Parallels University of Maryland's Saturn HEV

Although the Department of Energy (DOE) and the U.S. auto industry have been intrigued by the potential fuel economy benefits offered by hybrids for some time, no car manufacturer has formally announced production plans to date. But interestingly, a vehicle designed and built by the University of Maryland for the DOE/Saturn-sponsored Hybrid Electric Vehicle Challenge in 1994 is similar to a Toyota prototype hybrid-electric vehicle (HEV).

The prototype, named the Prius, is a four- to five-passenger car with an innovative powertain, that, according to Toyota, achieves a fuel economy of about twice that of a similarly sized conventional vehicle. The Prius uses a new direct-injection, D-4 gasoline engine, a belt-driven continuously variable transmission (CVT), and an induction motor/generator that both stores and receives power from a bank of capacitors. The vehicle is a parallel HEV in that it uses electrical energy for starting and accelerating, and its motor/generator acts as a generator, regenerating braking energy and storing it in the capacitor as electricity when decelerating. This power-assist configuration enables the internal combustion engine to operate at peak efficiency, while the motor/generator is used to load-level the rest of vehicle demands. The CVT continuously controls the engine so that it automatically operates at its highest efficiency.

The University of Maryland Saturn operated in much the same way in the 1994 HEV Challenge. Also a parallel HEV, its 3-cylinder methanol-fueled SI engine was the primary power source that received a power assist from a permanent magnet DC motor. Although Maryland, by necessity, used a less sophisticated engine and 2.9 kW/h nickel-cadmium batteries, it's clear the engineering strategy was very similar. Like Toyota, Maryland used a CVT (and was the first student competitor to do so) and a sophisticated drive-by-wire control system to ensure optimal operation of both motor/generator and internal combustion engine. With a curb weight of 3,215 lb during the 1994 HEV Challenge, the Maryland Saturn achieved 51.9 mpg (gasoline equivalent of electricity plus fuel) during the range event, won the design events, and placed second in the acceleration event for the Saturn class. My point here is not that Toyota took its cue from the University of Maryland, but rather that many of the competitors in our advanced vehicle competitions — like the auto companies they parallel — are on the cutting edge of vehicle technology and engineering. University teams have been undeniably successful at meshing ambitious technical objectives (e.g., high fuel economy and reduced harmful emissions) with innovative mechanical and electrical strategies. And they have shown remarkable insight in predicting and developing approaches that work.

For those who want even more proof, keep your eyes open this June when 12 FutureCar teams travel from the GM Technical Center in Warren, Michigan, to Washington, D.C. I'm betting that you'll see performance and fuel economy from these prototype vehicles that even the Toyota HEV would be hard-pressed to match!

Shelley Launey
Manager of Vehicle Competitions
DOE Office of Transportation Technologies

Students Build on Success of 1996 FutureCar Challenge

To encourage involvement in the Partnership for a New Generation of Vehicles program at the university level, the U.S. Department of Energy and USCAR introduced the multi-year FutureCar Challenge (see article on p.1). The Challenge enables students to participate in the PNGV program and showcases the cooperative work among industry, government, and academia.

In 1996, the first year of the competition, students from 12 schools focused on developing energy-efficient alternative powertrains for hybrid-electric vehicles, which accounted for most of the entries. To prepare for the 1997 FutureCar Challenge, student teams are building on their successes in last year's competition and making improvements where needed.

Virginia Tech, which won first place overall in the 1996 FutureCar Challenge, integrated many existing technologies, such as a high-efficiency electric drivetrain (three-phase AC induction motor), into its winning Chevrolet Lumina. This drivetrain is similar to the one that powers General Motors' electric vehicle, EV1. The team is using the latest in lead-acid battery technologies and working with researchers at the school to reduce the size, weight, and cost of the vehicle's inverter; reduce cold-start emissions by means of thermal management catalysts; and develop and test alternative hybrid control strategies.

The University of California at Davis FutureCar is a prime example of the application of sound engineering to increase the fuel economy of modern vehicles. The car was a parallel hybrid-electric vehicle designed to qualify for partial ZEV credits under California regulations. The vehicle was radically redesigned to reduce its aerodynamic loads as much as possible within the constraints of the FutureCar Challenge rules. The team reshaped the front and rear ends of the car with panels constructed from lightweight carbon-fiber composites, used electronic cameras to replace the car's rear-view mirrors, and eliminated the door handles. The UC-Davis team also focused on reducing the weight and the number of moving parts in its vehicle—the engine powertrain had about the same number of parts as a 1925 Model T Ford, and the team believes that further reductions will be possible when new transmission concepts are introduced next year.

At the University of Illinois at Chicago (UIC), students came up with a different kind of alternative drivetrain. The team's vehicle was powered by a small, 3-cylinder engine supplemented by an air-injected superbooster. Compressed air stored in cylinders in the vehicle provided extra power to match that of the stock engine. A custom coupler between the transmission and the engine generated higher rpm in the smaller engine to match the shifting speeds of the stock engine. In the 1997 competition, UIC plans to use an oxygen-enrichment membrane developed at Argonne National Laboratory to help improve engine combustion and reduce hydrocarbons and carbon monoxide.

As these examples illustrate, students involved in the competition are demonstrating creative engineering solutions that will help U.S. automakers lead the way in the 21st century.

Mary Fitzpatrick
Technical Communicator
Argonne National Laboratory

Texas Railroad Commission Hosts 1997 Propane Vehicle Challenge

The 1996 Propane Vehicle Challenge set a precedent for success that will be tough for this year's event to beat. But the Texas Railroad Commission (TRRC) plans to give it the old college try. The 1997 Challenge will be held May 14-19, with support from the TRRC's Alternative Fuels Education and Promotion Program. The competition will begin in San Antonio, travel through College Station, then end in Austin, Texas. Students will convert Chrysler minivans and Dakota pickup trucks to propane-powered vehicles. "The people who put on the '96 Challenge in Canada have got it down to a science," says John Cagle, Director of the TRRC program. "We were extremely impressed, and we hope we can do half that well."

In addition to the U.S. Department of Energy and the TRRC, sponsors include Chrysler Corp. and Natural Resources Canada. Other supporters to date include the Texas State Energy Conservation Office, Southwest Research Institute, Sea World of Texas, Conoco, National Propane Gas Association, Sleegers Engineering, Thiokol Corp., LaQuinta Inns, ExproFuels Inc., Carburetion Equipment, Impco Technology, and Rochester Gauges.

If propane vehicle experience is any help, the TRRC will do a great job. Through its alternative fuels program, the Commission has been promoting the use of propane in vehicles for several years. "Texas provides about one-fifth of all the propane produced in the U.S.," explains Cagle. "But many propane dealers are small operators, and there's not a lot of money dedicated to getting engineers interested in propane as an alternative fuel. This is a great way to encourage development of the propane industry."

The primary advantage of propane as an alternative vehicle fuel is the existing infrastructure. "There are more propane refueling facilities out there than for all other alternative fuels put together," notes Cagle.

Performance events in this year's Challenge will be very similar to those held in '96, including a long-distance event (about 250 miles), a handling competition, in which drivers maneuver around pylons, and measurements of noise and emissions. Emissions testing will take place May 5-13. For the acceleration test (clocked one car at a time), the TRRC is considering a 1/4-mile distance instead of the previous 1/8 mile. Plans also include a design competition, which will look at how the vehicle was modified from gasoline, along with oral presentations, which Cagle views as a highlight of the '96 Challenge. "After individual judging, the two winners gave their presentations to the Windsor Workshop on Alternative Fuels. We hope to find a similar venue."

Currently, the TRRC is coordinating with Argonne National Laboratory and other sponsors in Texas to tackle the logistics of the event — things like travel arrangements, tent accommodations, and pit stops for refreshments. The TRRC has budgeted $50,000 of the total for this year's competition.

Although the TRRC views the '97 Challenge as an opportunity to publicize propane, the future of the young engineers themselves was the over-riding motivation. "We want to encourage them to continue their careers in the propane industry when they leave college," Cagle asserts. "When you see those students and what they're accomplishing — not just their engineering ability, but also their character — you feel like the world's in good hands."

For more information on the 1997 Propane Vehicle Challenge, contact Carlos Buitrago, Argonne National Laboratory (phone: 630/252-7261; fax: 630/252-3443; e-mail: carlos_buitrago@qmgate.anl.gov), or John Cagle, Alternative Fuels Education and Promotion, Texas Railroad Commission, Austin (phone: 512/763-7358; fax: 512/763-7292 or -6702; e-mail: jcagle@rrc.state.tx.eus).

Becky Busby

'97 PROPANE VEHICLE CHALLENGE

Virginia Tech's Hybrid-Electric Vehicle Team Redoubles Its Efforts for 1997

Virginia Tech's Hybrid-Electric Vehicle Team hopes to come up with a pair of winners in 1997. Last year, their electric/propane-powered Chevrolet Lumina appeared in the American Tour de Sol and then captured first place in the FutureCar Challenge. Now the team is designing a Dodge Dakota pickup truck for the 1997 Propane Vehicle Challenge as they refine the Lumina for the second phase of the FutureCar Challenge. Faculty advisor Doug Nelson, Associate Professor of Mechanical Engineering, says they'll succeed at both because of teamwork and support from sponsors and the university.

Managing a team of more than 60 students preparing for two different competitions could be a logistical nightmare, but Doug Nelson's got it covered. Two graduate students, Randy Senger and Matt Merkle, serve as team managers.

The students apply their efforts simultaneously to both competition vehicles, because the two share many of the same design elements and challenges. Each team member signs up for a small group that concentrates on a different aspect of vehicle design. The students use knowledge gained from previous experience as they design and build new systems. A Dodge Neon, Virginia Tech's entry in its first competition, the 1995 Hybrid Electric Vehicle Challenge, serves as a test bed for ideas before they're incorporated into the Lumina or Dakota.

In the 1996 version of the Lumina, the team concentrated on the electric drivetrain and control systems and used a stock commercial propane engine as the backup. Although they placed first in energy efficiency, lowest emissions, and best use of alternative fuel in 1996, they'll continue to improve emission control, fuel economy, and aerodynamics for 1997. They're also reducing the weight of the car — it was the heaviest vehicle in the 1996 FutureCar Challenge.

Lessons learned in preparing the Lumina for the 1996 FutureCar Challenge are also being applied to the Dakota. Background work began last summer, and many of the Dakota's systems were already being designed and tested before the truck arrived on campus. The team plans to design a new engine and a fuel system that uses liquid injection for the propane-powered vehicle.

The team maintains a high profile on campus and in the community. As Randy Senger says, "We want to educate the public on what we're doing — not just having fun, but making a difference."

The vehicles are often seen on the road as team members test drive them around campus. The Lumina, which is equipped with a propane-fueled barbecue grill, was taken to the Orange Bowl and a Hokie football game and attracted the attention of a local supermarket which helped sponsor the latter event. The team also attends open houses at local high schools to encourage students to consider engineering careers. With an enticement like a hybrid-electric vehicle, who could resist?

For more information about Virginia Tech's team and competition vehicles, contact Doug Nelson (phone: 540/231-4324), or visit their Web page (http://www.vt.edu:10021/org/hybridcar/index2.html).

Betty Waterman
Technical Communicator
Argonne National Laboratory

Recap of 1996 Automotive Technology Competitions

Did you know that competition teams are judged on criteria such as design, cost-effectiveness, fuel economy, and even video production? Performance counts, but so do engineering talent, mechanical skill, imagination, and ingenuity.

College and high school students from around the country participated in a variety of events in 1996. They created cars that ran on ethanol, natural gas, electricity, propane, solar power, and other alternatives to gasoline. They re-engineered production vehicles to run on alternative fuels. They combined technologies to build hybrid or bi-fuel vehicles that stretch the range of the fuel used over tremendous distances. These young people are already contributing to tomorrow's automotive technology. Let's encourage them to keep on trying.

Betty Waterman
Technical Communicator
Argonne National Laboratory

1996 FUTURECAR CHALLENGE

(5- to 6-passenger vehicle conversions, June 17-24, Dearborn, MI)

During the debut of the two-year competition to build an 80-mpg car, 12 student teams gave their converted vehicles a thorough testing. Now they're back in the shop refining their vehicles for 1997's competition.

Top Finishers

- *1st* Virginia Tech
- *2nd* Ohio State University
- *3rd* Lawrence Technological University

Event Awards

- Most Energy-Efficient Vehicle
  Virginia Tech
- Best Acceleration
  Ohio State University
- Best Dynamic Performance
  Ohio State University
- Best Over-the-Road Range
  University of Wisconsin - Madison
- Lowest Emissions
  Ohio State University
- Best Technical Report
  University of California, Davis
- Best Engineering Design
  Lawrence Technological University

- Best Overall Dynamic Performance
  Virginia Tech
- Best Consumer Acceptability
  Concordia University of Montreal
- Best Application of Advanced Technology
  Lawrence Technological University

Special Awards

- Manufacturing and Cost
  University of Illinois at Chicago
- Lowest Vehicle Driving Losses
  Ohio State University
- Best Safety
  University of Maryland
- Best Development/Application of Special Materials
  Lawrence Technological University
- Best Use of Alternative Fuels
  Virginia Tech
- Best Workmanship
  Virginia Tech
- Best Teamwork
  University of California, Davis
- Sportsmanship
  University of Wisconsin - Madison
- Spirit of the Challenge
  University of Maryland

AMERICAN TOUR DE SOL

(Electric and hybrid cars, May 10-17, New York, NY, to Washington, DC)

The 8th annual electric and hybrid-electric vehicle rally attracted 51 cars sponsored by corporations, colleges, high schools, and even some individuals. Here are the student winners in several categories.

ANL Staff to Give Presentations at SAE Congress

Argonne National Laboratory staff members from the Center for Transportation Research are presenting two papers at the 1997 SAE International Congress and Exposition, being held February 24-27 in Detroit, Michigan.

The first paper is a technology summary of the FutureCar Challenge titled "Evaluation of High-Energy-Efficiency Powertrain Approaches: The 1996 FutureCar Challenge," co-authored by Scott Sluder, Mike Duoba, and Bob Larsen. Sluder will be the presenter.

The second paper, "Emissions Analysis for Dedicated Propane Minivans," relates to the Propane Vehicle Challenge. It is co-authored by Carlos Buitrago, Scott Sluder, and Bob Larsen and will be presented by Buitrago.

In addition, a variety of papers will be presented by student competition teams at the Congress in several different sessions. For further details, refer to the final program for the event, or call SAE (1-800-TEAM-SAE).

DOE Commuter Category

- *1st* Sungo (purpose-built): New Hampshire Technical Institute Electric Car Team, NH
- *2nd* George the Geo (Geo Metro): Fall Mountain Regional H.S. Solar Electric Racing, Langdon, NH
- *3rd* Electric Bull (Porsche 914): Shadow Mountain H.S. Electric Matadors, Phoenix, AZ

Chrysler Hybrid Category

- *1st* Paradigm (Ford Escort Wagon): Team Paradigm, University of Wisconsin - Madison
- *2nd* VT Animul SL (Chevrolet Lumina): Virginia Tech HEV Team, Blacksburg, VA
- *3rd* Viking 23 (Purpose-Built): Western Washington University, Bellingham, WA

Chrysler Hybrid Neon Category

- *1st* Viking 25: Western Washington University, Bellingham, WA
- *2nd* Hy Potential IV: University of Tennessee, Knoxville, TN
- *3rd* HEVy Gator: University of Florida HEV Society, Gainesville, FL

Open Category

Sunpacer (purpose-built): Cato-Meridian H.S. Tech Team, Cato, NY

PROPANE VEHICLE CHALLENGE

(Converted minivans, May 30-June 3, Windsor to Toronto, Ontario, Canada)

Twelve college teams converted Chrysler minivans to propane operation for this first-time event. Vehicles were judged on range, fuel economy, emissions, acceleration, design, and driveability.

- *1st* Texas A&M University
- *2nd* GMI Engineering & Management Institute
- *3rd* University of Texas at El Paso

SUPERMILEAGE

In this SAE Collegiate Design Competition, student teams are challenged to build a fuel-efficient, one-person vehicle in an attempt to set a world fuel economy record.

West Coast

(M85 and iso-octane vehicles, June 8-9, Sacramento, CA)

M85

- *1st* Wolverine: Sierra College 948 mpg
- *2nd* Ursa Major: University of California, Berkeley 263 mpg

Iso-Octane

- *1st* Wolverine: Sierra College 1,317 mpg
- *2nd* Politically Incorrect: California State University-Fresno 353 mpg
- *3rd* Ohlone 1: Ohlone College 222 mpg

FORMULA SAE COMPETITION

(Formula-style racing cars, May 15-18, Pontiac, MI)

About 80 student-designed and -fabricated autocross racing cars are judged on three criteria: static inspection and engineering design, solo performance trials, and track endurance.

Spirit of Excellence (Top Finishers)

- *1st* University of Texas at Arlington
- *2nd* Rochester Institute of Technology
- *3rd* École de technologie supérieure

U.S. Department of Energy M85 Awards

- *1st* University of Texas at Arlington
- *2nd* University of Akron
- *3rd* Pennsylvania State University

1996 West Coast Supermileage ISO-Octane Results

School	Miles per Gallon
Sierra College	1,317
California State University-Fresno	353
Ohlone College	222
California State University-Fullerton	127

1996 West Coast Supermileage M85 Results

School	Miles per Gallon
Sierra College	948
University of California-Berkeley	263

Best M85 Fuel Economy

University of Texas at Arlington

Best M85 Design/Conversion

University of Texas at Arlington

U.S. Department of Energy Teamwork Award

Dartmouth College

EV GRAND PRIX

(April 26-27, Richmond, VA)

Fifteen teams consisting of about 300 high school students and teachers participated in this 35-lap race. Entrants were also judged on handling/braking, range, questions and answers, acceleration, design, and a video promoting EV technology.

- *1st* Gloucester H.S., Gloucester, VA
- *2nd* Northampton County/ Halifax/Weldon Schools, Conway, NC
- *3rd* Central Shenandoah Valley Regional Governor's School, Fishersville, VA

COMPETITION CALENDAR

1997 EVENTS

March 7–9

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 24-26

EV Grand Prix
High School Electric Conversions
Richmond, Virginia

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

May 3 (Tentative)

Chicago Junior Solar Sprint
Middle School Competition
Chicago, Illinois

- *Contact:*
  Christine McGhee
  Argonne National Laboratory
  Phone: (630) 252-8677

May 14-19

Propane Vehicle Challenge
Chrysler Minivans and Dakota Trucks Converted to Propane Operation
Austin, Texas

- *Contact:*
  Shelley Launey
  U.S. Department of Energy
  Fax: (202) 586-1600
  E-mail: shelley.launey@hq.doe.gov

May 15-18

Formula SAE
Formula-Style Racing Cars
Pontiac Silverdome, Michigan

- *Contact:*
  Tony Androsky,
  SAE Educational Relations
  Phone: (412) 772-8535

May 17

Colorado Junior Solar Sprint
Solar Cars by 7th- and 8th-Graders
Golden, Colorado

- Contact:
  Linda Lung
  NREL
  Phone: (800) NEW-ENGY

May 17–24

9th Annual American Tour de Sol Road Rally for Electrics
Waterbury, Connecticut, to Portland, Maine

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

June 3-11

FutureCar Challenge
Mid-Sized Vehicle Conversions
Warren, Michigan

- *Contact:*
  Shelley Launey
  U.S. Department of Energy
  Fax: (202) 586-1600
  E-mail: shelley.launey@hq.doe.gov

June 19–28

Sunrayce 97
Biennial Intercollegiate Solar Race across America
Indianapolis, Indiana, to Colorado Springs, Colorado

- *Contact:*
  Sunrayce 97 Headquarters
  8040 Ortonville Road, Suite A
  Clarkston, Michigan
  Phone: (800) 606-8881
  Fax: (810) 620-1547

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