

# REQUEST FOR PROPOSALS



## Overview

Personal transportation in North America is facing revolutionary change in the near future. A number of interrelated events are converging to create the conditions for unprecedented change: the world's demand for oil is pushing prices over the \$90/bbl level; greenhouse gas (GHG) emissions from transportation continue to grow; and many of North America's capitol are debating mandates to increase vehicle fuel economy, the use of renewable fuels, and the production of specific vehicle technologies. In combination, all of these factors create the need to develop sustainable personal transportation — cars and light trucks with dramatically higher energy efficiency and a smaller carbon footprint.

*EcoCAR: The NeXt Challenge* — the latest in a 19-year series of Advanced Vehicle Technology Competitions (AVTC) for university and college engineering students sponsored by the U.S. Department of Energy (DOE) — is aimed at demonstrating technologies that address the critical need for sustainable personal transportation. DOE is joining with General Motors Corporation (GM), Natural Resources Canada, and many other organizations to sponsor this new three-year collegiate Advanced Vehicle Technology Competition (AVTC). Based loosely on the categories of California's Zero Emissions Vehicle<sup>1</sup> (ZEV) regulations, *EcoCAR: The NeXt Challenge* seeks to build and test advanced vehicles with a wide range of potentially feasible production technologies that can be used in future cars and light trucks to achieve much higher energy efficiency and lower GHG emissions.

Participation in *EcoCAR: The NeXt Challenge* will be determined by this Request for Proposal process, which is open to accredited<sup>2</sup> engineering schools in Canada, Mexico, and the United States. The organizers anticipate selecting up to 16 schools from North America to participate in *EcoCAR: The NeXt Challenge*. Schools wishing to be considered for participation in the competition must complete a modeling problem, develop and submit conceptual designs for two allowable vehicle categories detailed in this Request for Proposal, and provide high levels of support from their schools. The organizers will then select schools for participation in *EcoCAR: The NeXt Challenge* on the basis of multiple factors, including the quality of their proposal, their available facilities, their level of school support, their financial support, their technical expertise and experience, and their geographic diversity. Detailed proposal evaluation criteria are included later in this document. For the actual competition, the organizers intend for the whole range of allowed technologies to be implemented in a midsize-vehicle platform. In addition to the advanced powertrain technologies described below, *EcoCAR: The NeXt Challenge* also

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<sup>1</sup> Final Regulation Order "THE 2003 AMENDMENTS TO THE CALIFORNIA ZERO EMISSION VEHICLE REGULATION," Jan. 9, 2004, <http://www.arb.ca.gov/regact/zev2003/fro.pdf>.

<sup>2</sup> Schools must be accredited by the Accreditation Board for Engineering Technology (ABET) or the Canadian Engineering Accreditation Board (CEAB) or The Council of Accreditation of the Education of Engineering (CACEE) in Mexico

encourages the use of lightweight materials, improved aerodynamics, and reduction of parasitic power drains to achieve its technical goals and targets.

## ***EcoCAR: The NeXt Challenge: The NeXt Challenge Vision and Goals***

The overall vision of *EcoCAR: The NeXt Challenge* is to provide an opportunity for college and university students to participate in hands-on automotive research and development at the leading edge of technology by using contemporary industrial practices. Our detailed vision and technical goals for the competition are listed below.

### **Vision**

- Demonstrate the potential of advanced technologies and renewable fuels to dramatically reduce the energy consumption and environmental impact of future vehicles.
- Provide a hands-on, real-world engineering experience that incorporates the use of math-based tools to improve engineering education; fosters practical learning; and better prepares students to work in the domestic automotive, energy, and electronics industries.
- Develop highly skilled engineers with a strong understanding of advanced vehicle technologies and development techniques that will prepare them to lead the automotive industry into the 21<sup>st</sup> century and enable North America to remain competitive in the global marketplace.
- Integrate advanced propulsion technologies, systems integration techniques, and renewable fuels into engineering curriculums at an elevated level.
- Promote a higher level of public awareness of the need to transition to a sustainable transportation future and the potential of advanced technology vehicles to achieve large gains in efficiency with acceptable performance levels.
- Demonstrate market acceptability of future vehicles with dramatically improved energy efficiency.

### **Technical Goals**

The technical goals are to construct and demonstrate vehicles that, when compared to the stock production vehicle:

- Incorporate technologies that reduce petroleum energy consumption on the basis of a total fuel cycle (well-to-wheel [WTW]) analysis;
- Increase vehicle energy efficiency;
- Reduce criteria and WTW GHG and criteria emissions; and
- Maintain consumer acceptability in the areas of performance, utility, and safety.

## Performance and Utility Targets for *EcoCAR: The NeXt Challenge* Design Proposals

The following performance and utility targets are non-inclusive parameters that are part of the *EcoCAR: The NeXt Challenge* proposal process and therefore should be used when developing vehicle configurations for this proposal. The performance and utility targets for the actual competition will be provided after *EcoCAR: The NeXt Challenge* schools are selected, the competition begins, and the components available to participants are finalized.

Performance/Utility Category	<i>EcoCAR: The NeXt Challenge</i> Proposal Design Targets*
Fuel Consumption (unadjusted state of charge-corrected miles per gallon gasoline equivalent [mpgge] on FTP City and Highway Cycles)	27.5 to 38.5 mpgge City 37.5 to 57.5 mpgge Highway
GHG Emissions	176 to 356 CO <sub>2</sub> equivalent g/mi
Interior Size/ Number of Passengers	4 Passenger
Luggage Capacity	Equal to stock vehicle ~ 425 L (15 cu ft)
Minimum Range (on FTP City and Highway Cycles)	327 km (200 mi)
0-100 kph Acceleration Time, s	12 s
Top Speed	145 kph (90 mph)

\* The organizers reserve the right to change these targets for the competition.

## About the Competition

### Vehicle Technologies Supported

*EcoCAR: The NeXt Challenge* is seeking to develop and demonstrate advanced vehicle technologies loosely based on categories from the California Air Resources Board (CARB) regulations. The following four vehicle categories will be supported:

- ⇒ Hybrid electric vehicle — < 50-kW peak electric motor power
- ⇒ Hybrid electric vehicle — > 50-kW peak electric motor power
- ⇒ Range-extending and full-function electric vehicles
- ⇒ Hydrogen fuel cell vehicles

These four categories are similar to vehicle types D, E, II, and III in the CARB ZEV regulations. Both charge-sustaining and charge-depleting (plug-in) versions of these vehicle types will be considered for *EcoCAR: The NeXt Challenge*. Manual transmissions and through-the-road parallel hybrid electric vehicle configurations are not allowed.

### Approved *EcoCAR: The NeXt Challenge* Fuels and Energy Carriers

The allowable fuels for *EcoCAR: The NeXt Challenge* are limited to those with renewable content that meet the California Low Carbon Fuel Standard: E10 (90% California Phase II reformulated gasoline and 10% denatured ethanol), E85 (85% denatured ethanol and 15% California Phase II reformulated gasoline), and B20 (80% ultra-low sulfur diesel and 20% bio-diesel), along with the energy carrier hydrogen (in its gaseous form) and the energy carrier

electricity. Any of the designs proposed can employ electricity generated onboard or from the grid. However, the electrical energy used will be counted in the well-to-wheel petroleum, energy, and GHG emission impacts of the vehicles for assessing and scoring the vehicles. The type of fuel and energy carrier(s) the teams propose to use in their vehicle design(s) and its containment method must be specified in the proposal, along with the rationale for selecting the fuel. The following restrictions apply to the *EcoCAR: The NeXt Challenge* competition:

- ☞ The use of any fuel additives that change the chemistry or energy content of the fuels will not be allowed and
- ☞ The use of a consumable liquid without utilizing its energy content for propulsion (such as urea for exhaust emissions control) will be allowed *only* with prior notification of and approval from the organizers.

Descriptions of nonstandard or exotic energy-storage devices or energy converters must be specified in proposals and a rationale for their use provided. *This information will not negatively affect a team's chance of acceptance into the competition.*

## ***EcoCAR: The NeXt Challenge* Competition Format**

### Process and Tools

*EcoCAR: The NeXt Challenge* is based on a real-world integrated vehicle design and development process. Teams of student engineers from the selected schools will develop their vehicles following a modified GM Global Vehicle Development Process (GVDP) for each phase of the three-year competition. While applying proven methods for engineering successful prototype vehicles, students will learn real-world engineering skills that will make them highly effective in the automotive and other industries. At the conclusion of each of *EcoCAR: The NeXt Challenge's* three years, a week-long competition involving all of the participating schools will take place in June at a GM vehicle proving ground or other appropriate location in North America. By the end of the three-year competition, the sponsors expect fully developed vehicles equivalent to prototypes ready for a production decision.

### Global Vehicle Development Process

The GVDP provides GM with a competitive global process that integrates best practices from all regions and is based on several fundamentals of vehicle development, including the following:

- Major programs are led by advanced vehicle development to reduce the risk and uncertainty from program timing.
- Verified and correlated mathematical models are used as the basis for the vehicle development program.
- Specific subsystem “decoupled development” is employed to reduce risk and remove uncertainty from the program timing.
- Virtual or analytical simulations of product and process precede any physical property evaluations.
- The use of physical prototypes as the primary method of validation is minimized and, where possible, eliminated. There is strict adherence to the timing and prototype use requirements outlined in the learning analysis, development, and validation plan.

- Product and process development and validation are based on only three physical prototypes:
  - Underbody and subsystem mules,
  - Integration vehicle, and
  - Manufacturing validation vehicle.

While using and following a structured plan mimicking GM's GVDP, *EcoCAR: The NeXt Challenge* teams will design and develop a vehicle that minimizes energy consumption, criteria emissions, and GHGs on a well-to-wheels basis while maintaining stock vehicle utility and performance.

#### The Greenhouse gas, Regulated Emissions, and Energy in Transportation (GREET) Model

*EcoCAR: The NeXt Challenge* competition participants will use a WTW analysis to determine the energy consumption and emissions production for both GHG and criteria pollutants associated with their competition vehicles. This fuel-cycle analysis, completed in the GREET model, will quantify the amount of energy consumed and emissions generated from the following steps in the fuel cycle:

- Collection of fuel feedstock,
- Processing of the feedstock into a vehicle fuel,
- Transportation of both fuel and feedstock, and
- Final consumption of the fuel.

GREET has developed a path for individual fuels that defines the energy consumption and emissions associated with the WTW analysis. *EcoCAR: The NeXt Challenge* will use the assumptions provided in GREET for the paths associated with the four competition fuels. For more information regarding GREET, see <http://www.transportation.anl.gov/software/GREET/>. Proposing schools are encouraged to include a GHG analysis using the technology(ies) and fuel choices in their conceptual designs in response to the this RFP using GREET or another similar GHG total life cycle analysis program (e.g., GHG Genius, etc.)

#### *EcoCAR: The NeXt Challenge* Yearly Focus

The first year of *EcoCAR: The NeXt Challenge* is an essential foundation for establishing a successful vehicle by emphasizing the use of math-based design tools, such as the Powertrain Systems Analysis Toolkit (PSAT<sup>3</sup>) or similar vehicle models, and the development of software-in-the-loop (SIL) and hardware-in-the-loop (HIL) simulation techniques. These first-year activities will form the basis for the Year One competition, as well as establish useful tools for the vehicle development and refinement tasks in subsequent years of the competition.

Students will install the powertrain components and controllers selected by the schools, along with the communication protocols developed by each team in the first year, in a vehicle donated by GM for Year Two of *EcoCAR: The NeXt Challenge*. During Years Two and Three, students will build the vehicle designed through their modeling efforts in Year One and continue to refine their simulation, testing, and hardware control efforts while improving vehicle efficiency and function. The educational emphasis during the second and third years of *EcoCAR: The NeXt*

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<sup>3</sup> Powertrain Systems Analysis Toolkit, <http://www.transportation.anl.gov/software/PSAT/index.html>.

*Challenge* will be on improving the operation of the team's vehicles through an iterative test and refinement procedure using the tools developed in the first year of the competition.

The following diagram illustrates the elements of the *EcoCAR: The NeXt Challenge* competition showing three tracks for mechanical, electrical, and controls development over the three years of the competition.

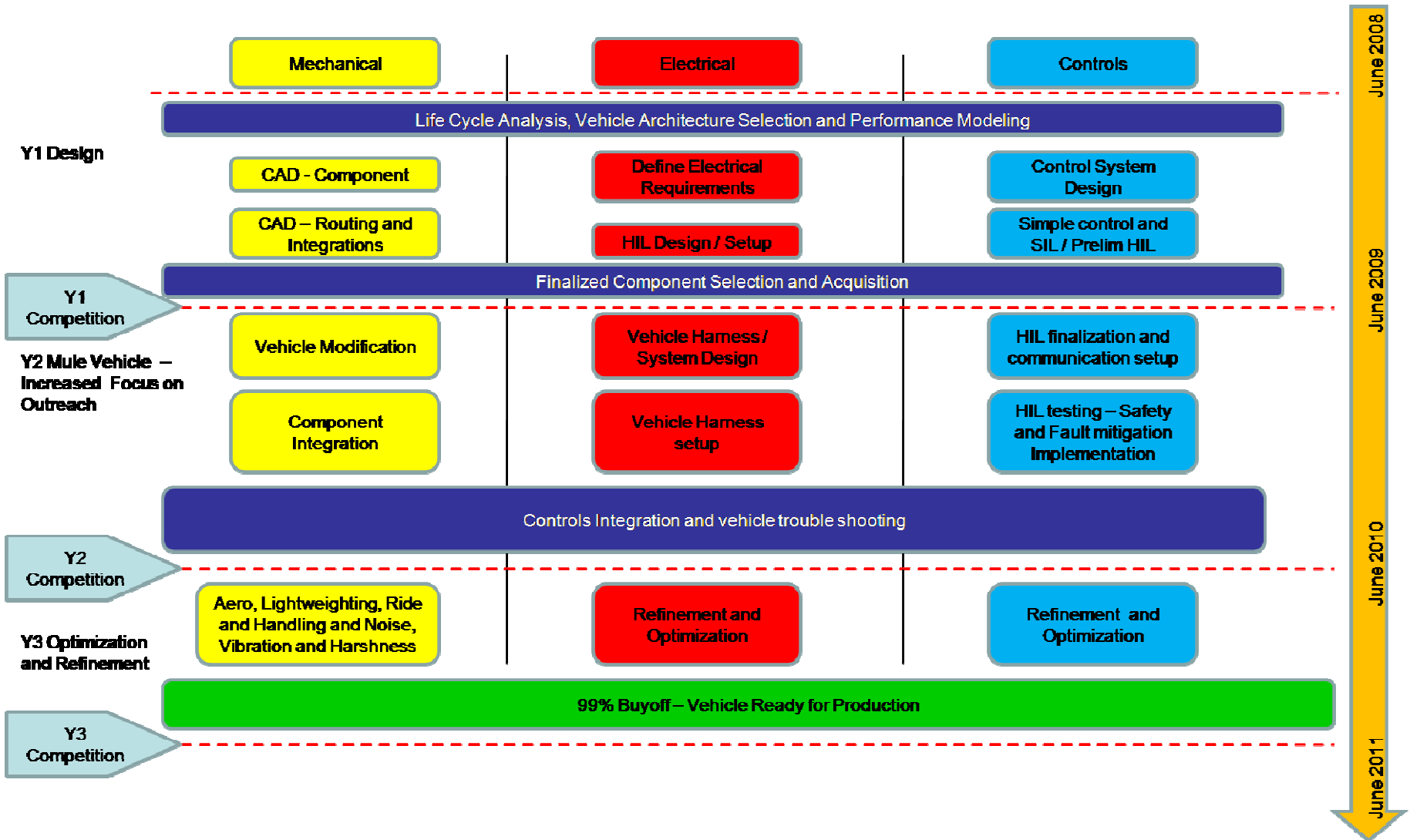


Figure 1: EcoCAR: The NeXt Challenge Simultaneous Design and Integration Paths

### Annual *EcoCAR: The NeXt Challenge* Competition Events

In year one of *EcoCAR: The NeXt Challenge*, teams will be required to develop their vehicle design and demonstrate it through vehicle and control system modeling. During the fall 2008 academic semester, each team participating in *EcoCAR: The NeXt Challenge* will develop and submit two detailed vehicle design proposals, including proposals that describe components available for donation. The proposals will include the team's packaging diagrams, performance models, electrical system design, control strategy design, and vehicle system models. A limited number of proposals will be selected for each of the *EcoCAR: The NeXt Challenge* vehicle categories on the basis of the designs submitted and the hardware available for donation. Each team will be placed into one of the four vehicle categories in *EcoCAR: The NeXt Challenge*. Once placed into that vehicle category, the team's vehicle must remain within that category, although minor component changes will be permitted.

In years Two and Three, *EcoCAR: The NeXt Challenge* vehicles will be brought together in the May–June timeframe for competitions consisting of a series of rigorous events to measure the performance, design, reliability, and utility of the vehicles. Teams will garner points in each of these events; the team that scores the most points will win that year's *EcoCAR: The NeXt Challenge* competition. Approximately \$50,000 in awards will be presented at each annual competition. During each year of the competition, vehicles and powertrains will undergo strict safety inspections and dynamic qualifying events to ensure that they are safe and meet vehicle safety requirements.

#### **Sample Competition Events for Years Two and Three of *EcoCAR: The NeXt Challenge***

<b>Events</b>	<b>Description (Measurements)</b>
Vehicle Performance	Acceleration, handling, braking
Tank-to-Wheels Fuel Efficiency	On-road driving and dynamometer driving
Well-to-Wheels Emissions	GHG and criteria pollutant emissions control
Written Report	20-page technical report
Oral Presentation	30-minute formal oral design presentation
Vehicle Design Process Review	Vehicle inspection and design review
Consumer Appeal	Consumer acceptability review and static vehicle utility
Inspections	Mid-year deliverables, inspections, homework

#### **What the Organizers Will Provide to Schools Selected to Participate in *EcoCAR: The NeXt Challenge***

Schools will receive \$10,000 in seed money from GM in Year One, a wide range of donated software and powertrain components, a vehicle donated by GM, and a significant amount of technical support and mentoring from the competition sponsors.

Powertrain components that may be provided to the teams include state-of-the-art traction batteries, a range of production spark-ignited and diesel engines and transmissions, GM 2 Mode hybrid electric vehicle transmissions and transaxles, a selection of different-sized electric motors and controllers, and a limited number of automotive-grade fuel cells and hydrogen storage systems. Some components may not be provided to schools. Schools are not required to use the

components made available by the organizers; they may use any components that are reasonable and can be used safely.

In addition to these specialized components, the organizers plan to offer each school a limited amount of “GM Blue Dollars” that can be used to obtain any production GM component required in support of their designs. Also, many other AVTC sponsors in the past have offered no- or low-cost parts, controllers, and components to participating schools, greatly leveraging the ability of participating schools to develop and implement the complex systems and subsystems required for the competition. We expect to build on and expand that heritage of sponsorship for *EcoCAR: The NeXt Challenge*.

Because there is a heavy emphasis on math-based design and simulation in *EcoCAR: The NeXt Challenge*, the organizers anticipate providing an impressive array of computer-based tools and training to enable accurate and rapid design, control, and testing of systems and subsystems. A significant amount of information about the vehicle to be donated to each school will enable detailed component location packaging and structural analysis of vehicle modifications. All significant vehicle modifications will require organizer approval before the actual modification to ensure adequate safety margins. There will be significant areas of the vehicle that may not be modified to ensure that all competition vehicles remain safe for operation on public roads.

*EcoCAR: The NeXt Challenge* teams will also be assigned a GM engineer as a Team Mentor. Each Mentor will be knowledgeable in automotive technologies and will function as a team liaison to GM and the other competition organizers throughout the competition. In addition, subject matter experts will be available to participating teams through technical workshops and when specific issues arise. Typically, two intensive, interactive technical workshops are planned each academic year; attendance by at least two team members and a faculty advisor is mandatory. Travel stipends to offset the majority of the cost of attending these workshops and the annual competitions will be provided to participating schools.

In prior AVTCs, each school has benefited from over US\$700,000 in cash, components, and in-kind support over the competition’s duration. *EcoCAR: The NeXt Challenge* expects to exceed this level of support over the three years of the competition. Also, participating teams have typically been successful in leveraging support from AVTC sponsors into additional state and local support and sponsorship for their programs. The competition also expects to provide substantial seed money to each university to support a full-time graduate student to provide the team with leadership and continuity over the three-year program.

## **What is Required for Schools Accepted into *EcoCAR: The NeXt Challenge***

Schools participating in *EcoCAR: The NeXt Challenge* must be committed to working in partnership with the competition organizers to provide their team with the resources and support that will enable them to take full advantage of the competition’s extensive benefits. Schools will be required to match cash donations from *EcoCAR: The NeXt Challenge* with cash, as well as provide class credit for students participating in the competition, release time equal to at least one class per semester for at least one engineering faculty advisor (or an organizer-approved equivalent), and logistical and promotional support for their team. A signed letter of support will be required from the institution’s President or Dean of Engineering with each proposal. In

addition, telephone interviews with the Dean and Faculty Advisor(s) may be required before a proposal is accepted for *EcoCAR: The NeXt Challenge*.

A consortium of schools may submit a combined proposal to participate in *EcoCAR: The NeXt Challenge*. All participants of a consortium must be educational institutions; trade schools, junior colleges, or other two-year educational institutions may be a part of a consortium. The lead institution in the consortium must have an accredited engineering program. Proposals from a consortium of schools must clearly define each school's role in *EcoCAR: The NeXt Challenge* if they were to be selected to be in the competition. Each school in the consortium must submit a signed letter of support from the President or Dean of Engineering in the proposal and explain in detail how it will support the competition on its campus and participate in the educational and outreach aspects of the *EcoCAR: The NeXt Challenge*.

If accepted into *EcoCAR: The NeXt Challenge*, each participating school will be required to sign a Good Faith Agreement (GFA) affirming the school's full support of its team and explicitly stating its willingness to participate in all *EcoCAR: The NeXt Challenge* activities with at least one faculty advisor in attendance. Annual renewal of the GFA will be required. Because of the extensive transfer of technical information and technologies to them, participating schools must be able to execute confidentiality and hold-harmless donation agreements with the organizers and sponsors of *EcoCAR: The NeXt Challenge*.

Schools that have benefited the most from past AVTCs have fully supported the participation of their school, often involving faculty from multiple departments because the high level of technical content in *EcoCAR: The NeXt Challenge* requires expertise from and integration of several engineering disciplines. For example, schools are advised to involve faculty from Mechanical, Electrical, and Computer Engineering in their teams, the latter as a result of the heavy emphasis on LAN communications and embedded control of components and subsystems. Faculty support from the schools of Business and Communications will also be helpful because competition organizers have high expectations for public outreach and communications from every school. Throughout *EcoCAR: The NeXt Challenge*, each school is expected to develop and implement an aggressive program of public outreach and education about the need to improve energy efficiency of personal mobility, reduce petroleum use, and other issues of sustainable transportation. This element of the competition should include a K–12<sup>th</sup> grade educational initiative and an extensive web-based communication effort and will be part of the judged events at each annual competition.

### **Safety is Paramount in *EcoCAR: The NeXt Challenge***

Building and operating a safe vehicle is of paramount importance when competing in *EcoCAR: The NeXt Challenge*. Vehicles that do not pass periodic rigorous safety inspections or are deemed unsafe will not be allowed to participate in the competition. Teams will not be permitted to make any modifications to their vehicles that would compromise safety or crashworthiness. All participants are required to adhere to stringent requirements to ensure the safety of added subsystems (such as high-voltage traction batteries). Participating schools must develop and submit safety plans for their *EcoCAR: The NeXt Challenge* efforts, and the plans must include processes and procedures for safe operations in their facilities. Participants must wear appropriate personal protective equipment whenever they perform work on *EcoCAR: The NeXt Challenge* vehicles at the schools and at all *EcoCAR: The NeXt Challenge* activities.

## ***EcoCAR: The NeXt Challenge Proposals***

### **Proposal Content**

Each school wishing to be considered for acceptance into *EcoCAR: The NeXt Challenge* must prepare and submit a proposal conforming to the outline below. *EcoCAR: The NeXt Challenge* proposals are to be written by students with faculty advisor guidance; each proposal must be signed by all the student authors and the faculty advisor(s). The proposal must include the following technical content:

1. A ranking of the four vehicle categories according to the school's preference for placement in those categories if selected to be in the competition. Include an explanation for the order chosen.
2. A completed vehicle modeling exercise, as described in the Appendix.
3. A conceptual design for a hybrid electric vehicle with less than 50 kW of peak electric motor power based on the vehicle assumptions contained in the modeling exercise.
4. A conceptual design for the highest-ranked vehicle type from item 1, if different from the less-than-50-kW hybrid electric vehicle design in item 3. Use the same vehicle assumptions contained in the modeling exercise in item 2.

The conceptual designs must include the fuel and/or energy carriers to be used, as well as an explanation of the choices. Proposing schools should understand that the information for the modeling exercise and conceptual designs in the proposal process is similar but not identical to the vehicle to be used in the actual competition. Through the proposal process, schools not only communicate to event organizers their ability to compete in a high-level engineering design competition but gain important insight into the competition's content and complexity and the results expected from schools participating in *EcoCAR: The NeXt Challenge*.

Important considerations in the selection process for inclusion in *EcoCAR: The NeXt Challenge* will be the extent of school support provided, the commitment of the faculty advisor(s), the facilities available to the proposing team, and documented team experience and expertise in areas applicable to the vehicle design. Proposals must also:

1. Include a letter of support from the college or university President or Dean of the Engineering School;
2. Explain provisions for class credit for student participants;
3. Confirm faculty release time equivalent to one class per semester or quarter for at least one engineering faculty (or an organizer-approved equivalent);
4. Confirm availability of sufficient access to laboratory and garage facilities and access to a safe outdoor testing area for the *EcoCAR: The NeXt Challenge* vehicle;
5. Confirm cash matching for direct cash grants from all *EcoCAR: The NeXt Challenge* sponsors;
6. Confirm availability of the Dean of Engineering, faculty advisor(s), and primary proposal authors for a telephone interview as part of the proposal screening process;
7. Affirm the school's commitment to sign annual Good Faith Agreements that bind the school to abide by the requirements of the competition organizers;
8. Affirm the school's commitment to execute intellectual property confidentiality and vehicle donation hold-harmless agreements;
9. Adhere to the required format, style, and page limits; and

10. Adhere to the required due date and other submittal requirements.

Participants in this competition become collaborators with the organizers and other teams in a multi-million dollar three-year program to design and build the vehicles of tomorrow. A significant factor in the success of schools in prior competitions is a team's desire to take advantage of all the opportunities offered in the competition. Knowledge, capability, facilities, and experience are necessary but not sufficient for success in *EcoCAR: The NeXt Challenge*. The commitment of the school, faculty, and students and the desire to become part of the *EcoCAR: The NeXt Challenge* team are essential to success. This intangible but essential attribute must be part of and be evident in each *EcoCAR: The NeXt Challenge* proposal.

### **Proposal Review Process and Criteria**

*EcoCAR: The NeXt Challenge* proposals will be reviewed by a team of organizers and sponsors with appropriate technical backgrounds and experience. Each proposal will be independently evaluated by at least four reviewers according to the content of the proposals. In addition, the organizers may interview schools by telephone during the review process. The Dean of Engineering, faculty advisor(s), and lead student authors must be available for these interviews. Every effort will be made to schedule these interviews at times mutually acceptable to the interviewers and schools to be interviewed. These interviews will be approximately 30–60 minutes long.

The proposals will be evaluated on the basis of the content in each of the five key sections of the proposal listed below. Each section will be weighted, as shown below:

1. Vehicle technology, modeling exercise, and conceptual vehicle designs (20%);
2. Organization, program management, and safety (20%);
3. Team facilities and resources (20%);
4. Financial planning (15%); and
5. Experience, education/outreach program, and discretionary factors (25%).

### **Proposal Outline**

Use this outline for writing your proposal. Include responses to all of the topics below. Remember that your objective is to convince the reviewers that your school has the knowledge, experience, facilities, school support, and desire to compete in the premier collegiate automotive engineering competition in North America.

**A. Abstract:** In 500 words or less, describe why your team should receive an invitation to participate in *EcoCAR: The NeXt Challenge*.

#### **B. Vehicle technology, modeling exercise, and conceptual vehicle designs (20%)**

1. *Your Team's Ranking of Preferred Vehicle Design:* Rank in order of most to least desirable your school's preference of the four vehicle categories supported in *EcoCAR: The NeXt Challenge*. Briefly discuss the technologies your team would use

for each vehicle category given the proposal design targets for *EcoCAR: The NeXt Challenge* and your team's technical expertise, experience, and resources. Present a rationale for your ranking in the context of the competition's goals and your team's capabilities, experience, resources, and facilities.

2. *Completed Modeling Exercise:* Each proposing school must complete the modeling exercise described in the Appendix. This exercise is intended to allow the organizers to evaluate a school's modeling expertise at a fundamental level while minimizing the required software and vehicle information needed to complete this exercise. Vehicle modeling and simulation is a critical component of *EcoCAR: The NeXt Challenge*; teams selected for the competition should expect that the basic vehicle performance and life-cycle evaluations required here will be expanded on considerably to meet the actual requirements of the competition. Use the vehicle parameters provided for this exercise to support your responses to items 3 and 4 below.
3. *Conceptual Design of a Hybrid Electric Vehicle with less than 50-kW Peak Electric Motor Power and Performance Estimates:* Each proposing school must submit a conceptual design for a hybrid electric vehicle with less than 50-kW peak electric motor power that achieves the *EcoCAR: The NeXt Challenge* performance proposal design targets. Explain how your design would address the proposal design targets, including (but not limited to) acceleration, top speed, fuel economy (mpgge), GHG emissions (g/mile), and range. Use the results and vehicle parameters from the design exercise above as the starting point of your design.
4. *Conceptual Design of Your School's Preferred EcoCAR: The NeXt Challenge Vehicle:* If the less-than-50-kW hybrid electric vehicle is not your team's first-ranked vehicle type from item 1, develop a conceptual design for the *EcoCAR: The NeXt Challenge* vehicle your team most prefers to build given your team's technical expertise, experience, facilities, and resources. Explain how your design would address the proposal design targets, including (but not limited to) acceleration, top speed, fuel economy (mpgge), GHG emissions (g/mile), and range. Use the vehicle parameters from the design exercise above as the starting point of your design. If you submit this design, explain how the differences in your two designs affect the ability of your conceptual vehicle to meet the proposal design targets.

### **C. Organization, Program Management, and Safety (20%)**

1. *Personnel Recruiting Plan:* Discuss how your school will recruit and retain the necessary team members from electrical, mechanical, and computer engineering disciplines, as well as business and communications disciplines. The proposal should address how your team will ensure continuity over the three-year competition. Identify the graduate research assistant that the competition will help fund, as well as the faculty advisor(s), and describe their qualifications and their roles over the three-year program. If there is no graduate program at your school, explain how you would use the equivalent support for undergraduate education at your school.
2. *Engineering Curriculum:* Describe classes available to students that could support automotive-engineering-related content. Include advanced vehicle propulsion systems and vehicle technology, as well as control and mechatronics classes. Provide details

- of how the various engineering departments in your school will support this program (mechanical, electrical, computer engineering, etc.). If your school has special institutes or relevant areas of excellence, describe how they will be used to support the *EcoCAR: The NeXt Challenge* competition program. Explain how the *EcoCAR: The NeXt Challenge* competition will be integrated into existing and planned courses.
3. *Extent of School Support:* Present a detailed description of the extent of support from your school, including the following:
    - Overall rationale for your school's participation in *EcoCAR: The NeXt Challenge*, including goals and objectives of the Engineering school and how these goals and objectives will be met;
    - Mechanism for earning academic credit for students working on the program;
    - Teaching release time for faculty advisor(s); and
    - Description of any dedicated graduate student support funded by the university or an outside sponsor.
  4. *Use of Graduate Student Support:* The organizers expect to be able to provide some level of graduate student support to most schools in the United States. If this support was provided, describe how your school would take advantage of it, if applicable.
  5. *Team Organization and Duties:* Describe how team members will be organized and managed. Include an explanation of your basic team structure (team leader, controls leader, etc.)
  6. *Safety Processes*
    - **Team Operations:** Describe how safety will be built into the school's plans and procedures throughout the competition. Provide an overview of the required safety plan for on- and off-campus *EcoCAR: The NeXt Challenge* activities.
    - **Vehicle Design:** Include an explanation of how analytical techniques will be used to ensure that safe designs and working procedures are employed in all competition-related activities.
    - **Facilities & Protocol:** Identify who is responsible for defining and enforcing laboratory safety practices relative to testing of mechanical systems, high-voltage electrical systems, liquid hydrocarbon fuels, and gaseous fuels per standard college or university procedures.

#### **D. Team Facilities and Resources (20%)**

List the facilities available at the college or university that could be used to accomplish the goals of *EcoCAR: The NeXt Challenge*. Label the facilities as on-site and for student use or as professional (paid) facilities that will be accessible to the student team. Facilities may include (but are not limited to) the following:

- Simulation and computing facilities,
- Vehicle and powertrain fabrication and testing,
- Machine shop and fabrication,
- Electronics lab and fabrication,
- LAN communication and computer control laboratories,

- Vehicle and engine dynamometer(s) and test facilities,
- Vehicle work area, and
- Student/team office(s).

#### **E. Financial Planning (15%)**

1. *Budget Planning*: Provide a realistic overall budget needed to support successful participation in *EcoCAR: The NeXt Challenge*. Elements to consider include funding for vehicle parts, subsystems, and components; fabrication and finishing; possible testing fees; team travel not provided by the organizers (to workshops, competition events); and community outreach.
2. *Fund-Raising Plan*: Document what will be provided by university and/or outside sponsors and provide a plan for acquiring additional contributions (product donations, cash, technical support, etc.). Provide successful examples of fund-raising plans from a previous program and include letters of support from potential or confirmed sponsors, if possible.

#### **F. Education/Outreach Program, Experience, and Discretionary Factors(25%)**

1. *Relationships and Outreach*: Describe the team's relationships to the educational program at your school or in your community and/or state. Detail any educational outreach activities that would be part of your program (e.g., middle school, high school, trade school programs). Also describe current partnerships with automotive manufacturers and suppliers in the field/market of advanced vehicle technology, as well as other government and private organizations that may provide additional resources, expertise, and visibility to the team. Highlight centers on campus and institutes and facilities off campus that will support the team's efforts.
2. *Experience*: Provide details about your school's experience with other major vehicle or engineering projects, including team members or faculty who have participated in any previous DOE AVTCs, the SAE collegiate design competition series, or other competitions. Also provide a summary of any related research experience from faculty and Ph. D. or Master's students who would be working on the project.
3. *Summary and Discretionary Factors*: Include here any other considerations that would convince the reviewers that your school is capable and committed to the success in the *EcoCAR: The NeXt Challenge* competition. What can you tell us to convince us that your school has what it takes to be a successful *EcoCAR: The NeXt Challenge* participant?

### **Notification of Acceptance or Rejection**

Schools submitting a proposal will be notified by April 18, 2008, whether they will be accepted into *EcoCAR: The NeXt Challenge*. The President, Dean of Engineering, and the Faculty Advisor(s) of accepted schools will receive an official acceptance letter and an invitation to the public announcement of the participating teams on May 21, 2008, in Washington, D.C. News

about the schools participating in *EcoCAR: The NeXt Challenge* will be strictly embargoed until then.

## Administrative Considerations

Proposals are limited to 20 pages total, including all diagrams, attachments, and appendixes. The required letter of support from the school's administration (or from government entities or private-sector organizations) is not included in this 20-page limit. Only one proposal per school will be considered. An electronic PDF version must be **uploaded no later than March 3, 2008**, to [www.challengex.org](http://www.challengex.org)<sup>4</sup>. The PDF version of the proposals must be able to be viewed and printed correctly; the organizers take no responsibility for, and will make no efforts to correct, errors in the proposals or its PDF form. If any uploaded proposal contains PDF errors that will not allow it to be viewed and/or printed properly, it will be returned to the school and not be reviewed.

This section describes the limitations on the proposal. Compliance with these limitations is **mandatory**.

<b>Language</b>	Proposals must be written in English.
<b>Length</b>	Proposals are limited to 20 single-sided pages of text, figures, and appendixes. The page size must be 8.5 in. × 11 in., and the font size must be 12 point. Margins shall be at least 1 in. Support letters from the school, government entities, or private-sector organizations will not count toward the page limit.
<b>Authors</b>	Proposals must be written by students.
<b>Signatures</b>	Proposals must be signed by all authors and the faculty advisor(s).
<b>Letter of Support</b>	Proposals must be accompanied by a letter of support from the President of the college or university or the Dean of the School of Engineering. The letter should cover all the required school support, as described on page 10.
<b>Due Date</b>	An electronic copy of all proposals must be <b>uploaded to</b> <a href="http://www.challengex.org">www.challengex.org</a> <sup>4</sup> by 11:59 p.m. Eastern Time on March 3, 2008, in Adobe Acrobat PDF form or they will not be considered.

**Questions Concerning the RFP and *EcoCAR: The NeXt Challenge*:** General questions should be sent to [ecocar@anl.gov](mailto:ecocar@anl.gov). Consult the FAQs and related discussions at [www.challengex.org](http://www.challengex.org)<sup>4</sup>.

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<sup>4</sup> The *EcoCAR: The NeXt Challenge* website is currently under construction and will be released shortly via [www.challengex.org](http://www.challengex.org)

## ***EcoCAR: The NeXt Challenge Schedule***

The following table lists the dates for *EcoCAR: The NeXt Challenge* competition milestones.

### **Key Dates\* for Year One of the *EcoCAR: The NeXt Challenge* Competition**

November 2, 2007	Notice of Program Interest distributed
December 3, 2007	Competition officially announced at EVS 23
December 10, 2007	RFP released and distributed to schools based on Notice of Program Interest responses
January 17, 2008	RFP informational web broadcast – details TBA on website
March 3, 2008	Proposals due to Argonne National Laboratory (13 weeks)
March 7–April 7, 2008	Proposal reviews
March 17–April 4, 2008	Telephone interviews with selected proposing schools
April 11, 2008	School selection meeting
April 18, 2008	Selected schools notified and travel arrangements made for <i>EcoCAR: The NeXt Challenge</i> announcement
May 21, 2008	Teams announced to media, public in Washington, D.C.
August 2008	Modeling Boot Camp for teams
September 18–20, 2008	Mandatory Fall Workshop; final safety and design rules released
November 3, 2008	Teams finalize vehicle designs
June 2009	Year One <i>EcoCAR: The NeXt Challenge</i> competition

\*The competition organizers reserve the right to make changes to these dates.

## APPENDIX

### **Modeling Problem for EcoCAR: The NeXt Challenge**

- Using the following vehicle characteristics, typical of a midsize sedan, determine the total energy used by the vehicle for positive propulsion over a 1 Hz urban dynamometer driving schedule (UDDS)<sup>5</sup>. Also determine the average positive propulsion power (at the wheels), the peak power output (at the wheels) and the percent idle time (percent of time when vehicle speed and acceleration are 0). Assume 0% grade. Reference all data and equations used. A good source is: SAE 2003-01-2070<sup>6</sup>.

Vehicle Weight	1705 kg
Gross Vehicle Weight Rating	2141 kg
Road Load Coefficients	$F_0 = 93.45 \text{ N}$ $F_1 = 3.58 \text{ N/(m/s)}$ $F_2 = 0.42 \text{ N/(m/s)}^2$
Cd, CdA, C <sub>rr</sub>	0.330
Af	2.209 m <sup>2</sup>
C <sub>rr</sub>	0.0056

The road load equation used is:

$$F_{NET} = F_0 + F_1 v + F_2 v^2 + F_{inertial}$$

Where:  $v$  is the vehicle speed in mph

$$F_{inertial} = ma$$

Responses should be summarized in the following table format:

<b>Metric</b>	<b>Response</b>
Total Positive Propulsion Energy Required [kWh]	
Average Positive Propulsion Power at the Wheels[kW]	
Peak Power Output at the Wheels [kW]	
Percent Idle Time (%)	

- Referencing the previous vehicle characteristics and response, propose a design for a midsize sedan hybrid electric vehicle with a peak electric motor power of less than 50 kW. Demonstrate how your proposal would address each of the EcoCAR targets including, acceleration, top speed, fuel economy (mpgge), GHG emissions (g/mile) and range. Stipulate the fuel/energy carriers you would use and why. A good paper source is: SAE 2006-01-1502<sup>7</sup>. Reference all data and equations used
- Propose a design that you think your team would like to build that meets the criteria of an EcoCAR vehicle. Again demonstrate how your proposal would address each of the EcoCAR targets including, acceleration, top speed, fuel economy (mpgge), GHG emissions (g/mile) and range. Stipulate the fuel/energy carriers you would use and why. Reference all data and equations used. Teams are encouraged to evaluate their design on a well-to-wheel basis using tools such as the GREET Model.

<sup>5</sup> <http://www.epa.gov/nvfel/testing/dynamometer.htm#vehcycles>

<sup>6</sup> Sovran, G., Blaser, D, "A Contribution to Understanding Automotive Fuel Economy and Its Limits," SAE 2003-01-2070

<sup>7</sup> Tamai, G., et al, "Development of the Hybrid System for the Saturn VUE Hybrid," SAE 2006-01-1502

Teams proposing Hydrogen, may assume a fill pressure of 700 bar.