

# Competition Guidelines

Version 1.3

21 December 2009

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### Introduction

The goal of the Progressive Insurance Automotive X PRIZE is to inspire a new generation of super-efficient vehicles that help break our addiction to oil and stem the effects of climate change. The Progressive Insurance Automotive X PRIZE project is a subsidiary of the [X PRIZE Foundation](#).

These Guidelines summarize the high-level requirements and rules of the competition and are binding as referenced in the overall Master Team Agreement. We will be resolving and publishing many lower-level details as appropriate. There may also be unanticipated issues that arise and require modifications to these Guidelines; thus, we reserve the right to revise as appropriate. In all cases, we will endeavor to remain true to the spirit of these Guidelines, and to the guiding principles summarized in the next section. Please note, in addition to this document, there is also a Technical Specifications document that outlines technical requirements and information related to the competition.

### What's New in Version 1.3?

The following lists significant changes from Version 1.2:

- Details of the competition schedule are included (see "[Overview of Competition Schedule](#)")
- Details of "[Pre-Competition Events](#)" are added including potential dates
- The description of design judging procedures in [Appendix II](#) is updated
- The Demonstration Division is revised, and is now called the Demonstration Division (for a summary see the Section "[Demonstration Division](#)")
- More information about electricity and other fuels is provided (see "[Vehicle Fuels](#)")
- We have clarified that extreme "hypermiling" techniques will not be allowed (See "Measuring Range" section)
- We have clarified the policies regarding conflicts of interest (see "[Prize Development Process](#)")

### Guiding Principles

Throughout the [prize development process](#) we have been guided by the principles that the Progressive Insurance Automotive X PRIZE should:

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- Achieve our main goals - inspire a new generation of super-efficient vehicles that help break our addiction to oil and stem the effects of climate change
- Stimulate the development of many new options for consumers
- Be simple to understand and easy to communicate
- Remain independent, non-partisan, and technology-neutral – treating competitors with equality and fairness
- Result in production-capable new vehicles and existing-vehicle modifications, not concept cars
- Provide clear technical boundaries (i.e., for fuel economy, emissions, safety, performance, cost, features, feasibility, etc.)
- Attract both existing automobile manufacturers and newcomers
- Attract competitors from around the world
- Attract a balanced set of donors, sponsors, and partners to help competitors succeed
- Provide many opportunities for recognition so that it's worthwhile to compete, and not just for first place
- Make heroes out of the competitors and winner(s) through widespread exposure, media coverage and a significant cash award
- Educate the public on key issues related to the energy costs and environmental impact of transportation, and on the benefits of different vehicles and technologies represented in the competition

Simplicity is paramount. Every additional complexity makes the competition harder to understand, harder to manage, and harder to promote. Additional complexity also makes it more difficult to compete. Complexity also invites gaming by competitors. We have tried to resist the tendency to over-engineer the Progressive Insurance Automotive X PRIZE rules – this is a case where perfection is the enemy of the good.

In particular, while there are numerous important considerations regarding the environmental and societal impact of automobiles, our main focus is on fuel economy and carbon emissions. For example, while we address vehicle safety as an essential aspect of production-capability, and while safety innovations may indeed result, safety is not our main focus. Similarly, while vehicle production and destruction (recycling) have important environmental implications, we remain focused on fuel economy and emissions.

Another example is that, for practicality and simplicity, we are guided primarily by U.S. regulatory and market considerations. But we welcome entries from around the world and have tried to incorporate sufficient flexibility to accommodate them.

Overall, we are looking for a balance that makes the Progressive Insurance Automotive X PRIZE simple, fair, technology-neutral, and likely to result in production-capable vehicles and vehicle modifications. We need this balance to attract strong teams and engage the public.

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Our principles will sometimes be in conflict, and we hope that all involved will understand the need for flexibility and compromise.

The Progressive Insurance Automotive X PRIZE organizers and sponsors are entering into this competition in good faith. We expect and require the same attitude from all competitors and participants, so that together we can provide the most favorable experience for all.

### Overview of the Progressive Insurance Automotive X PRIZE

The goal of the Progressive Insurance Automotive X PRIZE is to inspire a new generation of viable, super-efficient vehicles that help break our addiction to oil and stem the effects of climate change.

A ten million dollar cash purse will be awarded to the teams that win a long-distance stage race for clean, production-capable vehicles that exceed 100 miles-per-gallon energy equivalent (MPGe – see [below](#)). Both new vehicles and modifications of existing vehicles may enter.

The Progressive Insurance Automotive X PRIZE will encourage production-capable vehicles and vehicle modifications (not concept cars and experimental products) through tough entrance requirements, judging criteria, performance tests, and a stage race that together evaluate manufacturability, marketability, safety, durability and performance. The Progressive Insurance Automotive X PRIZE will devote considerable traditional and online media resources to public outreach, education, and involvement.

### Energy and Emissions – Figures of Merit and Requirements

Here we summarize the Progressive Insurance Automotive X PRIZE approach to energy and emissions. For details, see Sections [“Figures of Merit for Energy and Emissions”](#), [“Measuring Fuel Economy, Range, and Emissions”](#), and [“Competition Events”](#).

The Progressive Insurance Automotive X PRIZE uses two principal figures of merit – one that focuses solely on the efficiency of the vehicle itself, and one that focuses on total carbon emissions (affected by vehicle efficiency, fuel-production, and fuel distribution).

#### Energy Efficiency (Fuel Economy) – MPGe

Miles-per-gallon equivalent (MPGe) is a pump-to-wheels energy efficiency figure of merit measure that expresses fuel economy in terms of the energy content of a U.S. gallon of gasoline. Calculations are based on the energy equivalence of all fuel(s) consumed.

Basically we ask: how much energy was delivered to the vehicle, and how far did it go? We convert the energy to the number of gallons of gasoline containing equivalent energy, and we express the result as miles per gallon:

$$\text{MPGe} = (\text{miles driven}) / [(\text{total energy of all fuels consumed})/(\text{energy of one gallon of gasoline})]$$

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A spreadsheet for MPGe calculations is available [here](#) and described [in this blog post](#).

### Greenhouse Gas Emissions

As a figure of merit for greenhouse gas (GHG) emissions, we use the total emissions expressed as equivalent grams of CO<sub>2</sub> per mile. This is a so-called “wells-to-wheels” (WTW) estimate, including all contributions from fuel extraction, production, distribution, and consumption. To compute the estimated GHG emissions, we use the [DOE-Argonne GREET model](#) from [Argonne National Laboratory](#).

### Progressive Insurance Automotive X PRIZE Energy and Emissions Requirements

In accordance with our main goals, Progressive Insurance Automotive X PRIZE winners must achieve the following energy and emissions requirements:

- Fuel economy (energy efficiency): at least 100 MPGe
- Total (wells-to-wheels) greenhouse gas (GHG) emissions: no more than 200 g/mi CO<sub>2</sub> equivalent

In addition, the vehicle must be designed to meet criteria emissions standards no worse than US EPA Tier II, Bin 5; the race vehicle must meet at least US EPA Tier II, Bin 10 in road testing and Tier II, Bin 8 in chassis dynamometer testing.

### Production-Capable Vehicles

Our goals require that Progressive Insurance Automotive X PRIZE vehicles and vehicle modifications be designed to reach the market. Accordingly, all vehicles entered into the Progressive Insurance Automotive X PRIZE competition must be “production-capable”, as judged by expert panels in four areas:

- **Safety, Emissions:** Vehicles must be designed so that a production vehicle would likely be able to meet U.S. safety standards (FMVSS) and U.S. emissions standards (Tier II, Bin 5)
- **Manufacturability, Cost:** Vehicles must be capable of being manufactured in quantities of 10,000 per year, with vehicle production costs within levels consistent with historical examples of comparable vehicles
- **Features:** Vehicles must be desirable, addressing the most important features and factors consumers consider when purchasing an automobile
- **Business Plan:** There must be a credible plan to manufacture, sell, and service 10,000 vehicles (or conversions) per year by 2014; The plan must show that the national fuel infrastructure will support the vehicles, especially if any non-standard fuels or fueling-methods are to be used



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For details, see [“Vehicle Safety”](#), and [“Data Submissions and Judging”](#).

Actual production vehicles (as opposed to production-capable vehicles) will be highlighted as such during the competition.

### Vehicle Classes

The Progressive Insurance Automotive X PRIZE will offer two vehicle classes: Mainstream and Alternative. The classes have the same requirements for fuel economy and emissions, but different design constraints.

- **Mainstream Class** – Specifications derived from typical existing small, 5-passenger economy mixed-use vehicles
- **Alternative Class** – An outlet for innovation, with fewer performance & design restrictions

Vehicles that are designed to achieve Progressive Insurance Automotive X PRIZE goals by modifying an existing popular vehicle may be entered in either class, provided that all Progressive Insurance Automotive X PRIZE requirements are met.

For details, see [“Vehicle Design Requirements”](#).

### Vehicle Divisions

The Progressive Insurance Automotive X PRIZE will offer two Divisions.

#### Competition Division

The Competition Division is for production-capable vehicles and vehicle modifications that will compete for the \$10M Progressive Insurance Automotive X PRIZE purse. Entries may be in the Mainstream Class, the Alternative Class, or both.

The Competition Division is the main focus of the Progressive Insurance Automotive X PRIZE.

#### Demonstration Division

A separate Demonstration Division is available for manufacturers of high-efficiency vehicles that are currently in production or are committed to production in the very near future.

Nevertheless, in keeping with our goals, we believe it is important for them to participate in the Progressive Insurance Automotive X PRIZE in order to:

- Provide technical demonstrations of the actual energy and emissions progress that is being made by today’s major manufacturers
- Help build the general market for high-efficiency vehicles
- Help consumers choose high-efficiency vehicles that are appropriate for them

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There is no purse in the Demonstration Division. Demonstration Division vehicles must meet the specifications and requirements of Alternative or Mainstream Class vehicles. Demonstration Division vehicles could be tested under similar conditions as Competition Division vehicles in order to demonstrate their capabilities and performance.

To reinforce, distinguish, and provide incentives for entries in the Demonstration Division, special promotional opportunities will apply to companies that enter this Division. For more information, see "[Demonstration Division Requirements, Participation, and Benefits](#)".

### **Outline of Competition Events and Determination of Winners**

Competition Division winners will be determined by a dramatic series of competition events.

Teams will be accepted for the Progressive Insurance Automotive X PRIZE competition based on preliminary information about their entry. Accepted teams will then provide evidence that their vehicle or vehicle modification designs are production-capable, in the form of detailed Data Submissions that will be judged on a pass/fail basis as described briefly [above](#). Those that pass will be invited to bring their vehicle(s) to the competition events.

An initial series of technical reports, technical inspections, and active safety performance tests will eliminate unsafe vehicles. Those that pass will participate in the remaining competition events, which include the Progressive Insurance Automotive X PRIZE Stage Race, additional active safety performance tests, and a dynamometer test.

The Stage Race is a high-mileage race comprising stages with courses that will reflect known consumer driving patterns, incorporating a variety of realistic and performance-illustrating driving conditions, terrains, and trip profiles. Vehicles will race over closed track facilities. Vehicles must obey all simulated traffic regulations, including speed limits. The Stage Race will enable fair, technology-neutral comparisons of vehicles while maximizing public impact.

Vehicles will use Progressive Insurance Automotive X PRIZE-supplied fuels. Available fuels will include gasoline (E10), fuel ethanol (E85), bio-diesel (B20), compressed natural gas (CNG), and electricity. Additional fuels may be made available if justified by team business plans. For details, see "[Vehicle Fuels](#)".

In the case of electricity, up to 10 hours overnight or simulated-overnight charging will be permitted up to 240 V and 40 A (AC continuous) prior to any maximum-range stage. If there is more than one stage per day, the total daily mileage will not exceed the maximum range requirement.

Following a 2-3 week hiatus after the initial race stages that will serve as a shake-down period, a "knockout" qualifying event will be held to admit vehicles to the final race stages. To advance, vehicles must pass a full set of active safety performance tests, demonstrate Tier 2, Bin 10 criteria emissions, and demonstrate at least 67 MPGe (i.e., two-thirds of the 100 MPGe target) over a road course based on a composite of the Urban Dynamometer Drive Schedule (UDDS) and the Highway Fuel Economy Driving Schedule (HWFET) test cycles. The

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knockout event will be conducted at a suitable test track or proving ground, and may be open to the public and the media at selected periods.

After the “knockout” event, there will be at least a 2-week hiatus to allow the surviving teams to apply what they have learned during the shake-down stages and knockout event before the final stage. At the end of the final stage, there will then be a coast-down stage followed by the chassis dynamometer stage that will conclude the competition events.

In addition to widespread publicity in both traditional and new media, we will provide real-time event coverage via an online Progressive Insurance Automotive X PRIZE competition tracker driven by vehicle telemetry featuring a GPS-driven map with interactive vehicle icons and virtual instrument displays.

To complete the Progressive Insurance Automotive X PRIZE Stage Race successfully, vehicles must maintain a minimum average speed (maximum allowable time) while meeting Progressive Insurance Automotive X PRIZE requirements for fuel economy and emissions – determined by averaging the dynamometer test results with the overall scoring-stage averages. For those vehicles that successfully complete all of the Stage Race requirements, placement (ranking) will be based on the total of the stage completion times. Time penalties will be applied for infractions and equipment failures. Final ranking will be determined by the adjusted total time – i.e., the fastest vehicles are the winners.

Half of the \$10M purse will be awarded to the fastest Mainstream Class vehicle. The remaining \$5M will be split between two winners in the Alternative Class – the fastest vehicle with side-by-side seating, and the fastest-vehicle with tandem seating.

All vehicles that successfully complete the Progressive Insurance Automotive X PRIZE Race will be named as “Progressive Insurance Automotive X PRIZE Qualified”.

For more information and details, see [“Competition Events”](#) and [“Vehicle Data Collection and Telemetry”](#).

### Education Program

The U.S. Department of Energy (DOE) has funded a \$3.5M Progressive Insurance Automotive X PRIZE Education Program to address the following goals:

- To engage students and the public in learning about alternative fuels, energy efficiency, climate change, and the science, technology, engineering, and math behind advanced vehicle development
- To inspire youth to learn more about and pursue careers in advanced vehicle development
- To generate enthusiasm about the energy-efficient vehicle options of the near-future

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- To showcase the 21<sup>st</sup> century learning skills needed to succeed in work and life, including creativity and innovation, critical thinking and problem solving, communication and collaboration

Key components of the program include:

- **Online Interactive Knowledge Center = [FuelOurFutureNow.com](http://FuelOurFutureNow.com)**
  - Contains educational content/curriculum, tools, resources, and programming in multiple formats for K-12 students and their grownups
  - Will feature a vehicle telemetry-based Competition Tracker with dashboard, team, and social media gadgets
- **National High School Student Contest = *DASH+***
  - Challenges teams to design the dashboard of the future with eco-feedback indicators
  - Involves expert judging and public online voting
  - Yields student presentations to be showcased at educational outreach events
- **Educational Outreach Events**
  - Engages K-12 students and their grownups in a series of fun, hands-on, minds-on, interactive, learning activities
  - Welcomes participation from area schools, out-of-school time organizations, colleges and universities, as well as the science/citizen-scientist community
  - Encourages youth to learn more, take action, and contribute to local service-learning projects
  - Includes student reporters covering the events

Included will be a Progressive Insurance Automotive X PRIZE Competition Tracker portal driven by near real-time vehicle telemetry featuring a GPS-driven map with interactive vehicle icons and virtual instrument displays. Viewers will be able to follow the teams, competition events, monitor specific vehicles or vehicle types, and observe how vehicle technologies and driving styles affect various important current and cumulative figures-of-merit such as:

- Fuel Economy
  - Instantaneous energy equivalent fuel consumption (MPGe and GPM<sub>e</sub>)
  - Fuel cost (\$/mile)
- Environmental Impact
  - Wells-to-wheels greenhouse gas equivalent emissions (gCO<sub>2e</sub>/mile)
  - Carbon footprint (tones CO<sub>2e</sub>)
  - Amount of petroleum used, wells-to-wheels (gallons)
- Vehicle Status

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- Vehicle speed (mph)
- Event average speed (mph)
- Total distance traveled by vehicle (mile)
- Vehicle position (decimal)
- Event elapse time (h/m/s)

For more information about the DOE-sponsored Education Program, see [“Education and Internet Reporting”](#).

### **Diverse Opportunities for Team and Vehicle Recognition**

Our long term vision is that many Progressive Insurance Automotive X PRIZE vehicles or technologies will go into production and become available to the general public, directly or indirectly. To this end, we will provide many opportunities for exposure to potential partners, sponsors, investors, manufacturers, distributors and customers. It will be worthwhile for all teams to compete, not just for those teams that win.

Additional opportunities for recognition include:

- [Demonstration Division](#) showcasing the performance of high-efficiency non-competition vehicles, and associated special promotions
- Aggressive PR exposure via general promotion of the Progressive Insurance Automotive X PRIZE in traditional and new media
- Robust online technology, including
  - Team websites and reporting (with special identification of actual production vehicles)
  - Education Program knowledge center (see above)
- Progressive Insurance Automotive X PRIZE Awards determined by special judging panels and the general public; possible examples include:

|                     |   |
|---------------------|---|
| <i>Broad:</i>       | “People’s Choice” (based on Internet voting), Best Demonstration Division Vehicle, Best Modified Vehicle, Most Innovative, Most “Green”, Most Educational |
| <i>Performance:</i> | Highest MPGe, Fastest, Longest Range, Best Overall Performance  |
| <i>Application:</i> | Best Commuter, Best Multi-Purpose, Most Fun, etc.   |
| <i>Technology:</i>  | Best EV, Best PHEV, Best Diesel, etc.   |

In addition, we intend to sponsor a variety of networking and consumer marketing events to bring key constituents together, engage the public, and showcase vehicles.

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### Overview of Competition Schedule

*\*Please note that the competition schedule below is subject to change. The event dates, locations, and venues are for information only until such time that the competition organizers notify otherwise.*

|                             |  |
|-----------------------------|--|
| <b>28 February 2009:</b>    | Deadline for Initial Applications  |
| <b>15 June 2009:</b>        | Deadline for Data Submissions  |
| <b>19 October 2009:</b>     | <p>Media event including:</p> <ul style="list-style-type: none"> <li>• Announcement of Competing Teams - the Registered Teams that passed Design Judging and are invited to bring vehicles to the competition events</li> <li>• Announcement of the <i>DASH+</i> National High School Contest</li> <li>• Display of representative vehicles</li> </ul> <p>Location: New York City</p>  |
| <b>1 – 3 November 2009:</b> | <p>Team Summit in conjunction with the SEMA convention (with some vehicles on public display)</p> <p>Location: Las Vegas</p>   |
| <b>April - July, 2010</b>   | <p>Progressive Insurance Automotive X PRIZE vehicle competition events</p> <ul style="list-style-type: none"> <li>• Shakedown Stage (26 April – 7 May 2010)</li> <li>• Knockout Qualifying Stage (20 – 28 June 2010)</li> <li>• Finals Stage &amp; Coast Down Test (19 – 30 July 2010)</li> </ul> <p>Promotional and public events highlighting competition</p> <p>Location: TBD (Specific location to be announced publicly at the Detroit Auto Show)</p> |

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| <b>2 – 21 August 2010</b>   | Validation Stage (Dynamometer Tests)<br><br>Locations: Ann Arbor (EPA National Vehicle and Fuel Emissions Laboratory), and Chicago (DOE Argonne National Laboratory)   |
| <b>27 – 28 August 2010:</b> | A public festival and recognition of Progressive Insurance Automotive X PRIZE finalists hosted by title sponsor Progressive Insurance (Currently under consideration as an optional event.)<br><br>Location: Cleveland |
| <b>September, 2010:</b>     | Awards ceremony announcing winners<br><br>Location: Washington, DC   |

### Summary of Registration, Selection and Elimination Process

#### Registration, Applications and Fees

To become a Progressive Insurance Automotive X PRIZE Registered Team, prospective teams provide an application with basic information about the team, the technical approach, the vehicle, and the development plan. Based on this information, the Progressive Insurance Automotive X PRIZE will accept or reject the application, with one opportunity for appeal. The purpose of this step is to eliminate teams that are clearly unqualified – i.e., have virtually no chances of passing the Judging Panels (the next step). This is both to maintain the overall level of the competition (we will publicize the Registered Teams) and to avoid unreasonable burdens to the Judging Panel review of Data Submissions. There will be a low threshold for acceptance.

Teams must also sign a Master Team Agreement, which will cover the legal aspects of a Team's participation in the Progressive Insurance Automotive X PRIZE, including detailed rules, judging, insurance, liability and indemnification, confidential information, safety, Progressive Insurance Automotive X PRIZE sponsor rights, team sponsorship constraints, logos, team obligations, etc.

The registration fee per vehicle is \$5,000 for applications received prior to 1 November 2008, and \$7,500 for applications received later. If an application is denied, the registration fee will be refunded in full (without interest).

***STATUS: Registration for the Competition Division closed 28 February 2009.***

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### Design Judging Based on Data Submissions

Next, Registered Teams provide a Data Submission package that will be the basis for the design judging phase. Teams with vehicle entries that pass this phase will be deemed “Qualified Teams” and may progress to the next phase of the competition. The Data Submission will include detailed information about vehicle technology, specifications, features, safety, cost and manufacturability, as well as the overall business plan. The Progressive Insurance Automotive X PRIZE will provide a template for the Data Submission. For more information, see the Section [Data Submissions and Judging](#).

Judging Panels will evaluate the Data Submissions on a Pass/Fail basis (with one opportunity for appeal) in four areas:

- Safety, Emissions
- Manufacturability, Cost
- Features
- Business Plan

***STATUS: Data Submissions and Design Judging are complete. Qualified Teams that passed the Design Judging phase were announced on 19 October 2009.***

### Pre-Race Technical Reports

In the interest of competition safety, and to facilitate having a maximum number of competitive vehicles, we will require certain pre-Race technical progress reports. Teams will be provided sufficient advance notice (minimum 45 calendar days) of these requirements. Failure to provide the reports by the deadlines indicated may be cause for disqualification.

### Eliminations during Competition Events

Vehicles may be eliminated at various points during the sequence of competition events.

#### **Safety**

The first competition stage comprises detailed safety-related vehicle inspections and active safety performance tests. Vehicles that fail these inspections and tests will be disqualified.

Safety-related vehicle inspections will also be performed before each stage of the Progressive Insurance Automotive X PRIZE Competition Series. Unresolved safety problems will result in disqualification for that stage.

The Progressive Insurance Automotive X PRIZE will work with the teams to resolve any safety-related issues, but reserves the right to disqualify vehicles at any time for safety violations.



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### Knockout Qualifying Event

After the Shakedown Stage, a closed-course “knockout” qualifying event will be held to admit vehicles to the final race stages. To advance, vehicles must pass a full set of active safety performance tests, demonstrate Tier 2, Bin 10 criteria emissions, and demonstrate at least 67 MPGe (i.e., two-thirds of the 100 MPGe target) over a road course based on a composite of the Urban Dynamometer Drive Schedule (UDDS) and the Highway Fuel Economy Driving Schedule (HWFET) test cycles. The knockout event will be conducted at a suitable test track or proving ground, and will be open to the public and the media during selected periods.

### Vehicle Design Requirements

Here we summarize the basic requirements for Progressive Insurance Automotive X PRIZE vehicles. Race vehicles have additional, safety-motivated requirements that are covered elsewhere.

Note that these are minimum requirements – in most cases not stringent in order to encourage a wide range of technical tradeoffs and resulting vehicles. Thus, the requirements do not reflect specifications of ideal high-efficiency vehicles, and indeed we expect most vehicles to exceed these specifications in various respects. The Progressive Insurance Automotive X PRIZE reserves the right to modify and expand these requirements while preserving their basic intent.

### Minimum Requirements for All Vehicles

Vehicles must be designed to meet Progressive Insurance Automotive X PRIZE energy and emissions requirements (see above, [“Energy and Emissions Requirements”](#)), and must be designed to be production-capable (see above, [“Production-Capable Vehicles”](#), and below, [“Vehicle Safety”](#)).

As mentioned earlier, vehicles must use Progressive Insurance Automotive X PRIZE-supplied fuels. Available fuels will include gasoline (E10), fuel ethanol (E85), bio-diesel (B20), compressed natural gas (CNG) and electricity (overnight or simulated-overnight charging up to 240 V, 40 A continuous AC maximum); additional fuels may be made available if justified by team business plans.

### Features

- Enclosed cabin (or convertible), with windshield and windows
- Operating windshield wipers and washers
- Seat belts and head restraints
- Rear and side view mirrors (per FMVSS), but external mirrors may be retracted or removed during the Races if a camera system with equal or better coverage is operating

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- Fully functioning headlights, internal lighting, horn, indicators, speedometer, brake lights, and reflective devices
- Roadtrains (multiple, hitched vehicles) will not be permitted, but a towed auxiliary power unit may be considered provided that safety, stability, and emissions requirements are met (For Progressive Insurance Automotive X PRIZE testing purposes, vehicles may be required temporarily to tow an instrumentation trailer)
- Vehicles with high-voltage electrical systems must have a ground-fault detection system, an emergency high voltage system disconnect system from inside and outside the vehicle, and an inertia-switch disconnect system (For additional safety-related race requirements, see [“Pre-Race Inspections and Dynamic Safety Tests”](#))
- Vehicles using lean-burn engines must have a functioning particulate filter; No vehicles can emit visible smoke during competition events

### Controls and Displays

- Feedback mechanisms to provide essential data to the driver (speed, fuel remaining, etc.)
- Single control (e.g., foot pedal) for vehicle braking
- Parking brake capable of holding the vehicle's weight at rest on a 20% grade *and* that can be used while driving in the event the primary brake system fails
- Single control for vehicle acceleration
- Single control for directional commands, though it need not be a traditional steering wheel (The direction of operation of the steering control shall correspond to the intended change of direction of the vehicle and there shall be a continuous relationship between the steering control deflection and the steering angle; These requirements do not exclude automatic systems to enhance vehicle stability by correcting the steering angle of one or more wheels)
- All manual or automatic control systems (engine, braking, drive-train etc.) must be contained on the vehicle and may not be operated by remote (off-board) control (However, telemetry systems may be used for data acquisition and monitoring)

### Vehicle Performance

- Vehicles must be highway-capable, as determined by two tests: able to maintain 65 MPH on a 4% grade, and able to accelerate from 40-65 MPH in no more than 9 seconds (grade testing will be performed with a towing dynamometer)
- Braking: 60 - 0 MPH in no more than 170 feet
- Noise levels within drive-by standards (74 decibels maximum according to ISO 5130:2007)
- DOT approved tires with a minimum traction rating B and a tread wear rating 100 under the Uniform Tire Quality Grading Standard (UTQGS), 49 CFR 575.104 (Alternative Class vehicles that are technically motorcycles may use but are not

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required to use motorcycle tires regulated by FMVSS No. 119; If passenger car tires are used, they must comply with FMVSS No. 109, 129, or 139, as applicable)

### Vehicle Stability

All entries must address the following stability concerns. This is particularly critical for 2- and 3-wheel entries, and also 4-wheel entries with narrow track in the Alternative Class, but the requirements apply to all vehicles.

- *Static stability:* Does the vehicle stay upright when stopped?
- *Dynamic stability:* Does the vehicle fall over when traction is lost? Does staying upright when in motion depend on balancing skills of the driver?
- *Rollover:* Does the vehicle have adequate protection against rollover?

Accordingly, all vehicles will have to satisfy the following requirements:

- Vehicles must automatically remain upright when stopped, with no driver inputs required
- Vehicles will have to pass the Consumer's Union emergency lane change test
- For vehicles with more than three wheels, at least three wheels in a plane must remain in contact with the road surface, with other wheels no higher than 2 inches from the road surface when tested using the Consumers Union avoidance-maneuver test
- The Static Stability Factor<sup>1</sup> (SSF) for four-wheel vehicles must be greater than 1.3

### Vehicle Testing

To facilitate testing, Progressive Insurance Automotive X PRIZE vehicles must satisfy the following requirements:

- Liquid fuels must be contained in removable tanks (for accurate measurement of fuel usage)
- Vehicles with liquid fuels must have sealed fuel systems or functioning evaporative emissions control systems
- Progressive Insurance Automotive X PRIZE vehicles using gaseous fuels must have a pressure gauge and temperature sensor in each fuel tank or at the neck of each tank before the pressure regulator to allow fuel level calculations; Pressurized tanks will not be removed and shall be permanently installed in the vehicle

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<sup>1</sup> The Static Stability Factor (SSF) "is calculated using the formula  $SSF=T/2H$ , where T is the "track width" of the vehicle and H is the "height of the center of gravity" of the vehicle. The track width is the distance between the centers of the right and left tires along the axle" (see <http://www.safercar.gov>, in particular <http://www.safercar.gov/portal/site/safercar/menuitem.13dd5c887c7e1358fefe0a2f35a67789/?vgnextoid=5278e66aeee35110VgnVCM100002fd17898RCRD#ssf>).

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- A standard, Progressive Insurance Automotive X PRIZE-supplied on-board Data Acquisition System (DAS) that captures, stores, and transmits such data as fuel-flow (for liquid and gaseous fuels), voltage and current (for electrical energy), GPS data (for location and speed), etc. (There will be two interface options for providing access to the data – a CAN bus interface, or a set of analog inputs that converts to CAN, with scaling and calibration information to be implemented by the teams)
- Vehicles using liquid fuels must continuously communicate an accurate instantaneous rate of fuel use to the Data Acquisition System (DAS) in real time
- Vehicles using gaseous fuels must have accurate temperature and pressure readings of the fuel at the regulator of every storage tank transmitted continuously in real time to the DAS
- Exhaust systems must be leak-free
- Exhaust systems, if present, must have a single-pipe at the rear of the vehicle with a 2.25" (57.15 mm) Marmon flange for connection to emissions sampling equipment
- Sufficient ground clearance to clear typical road-rated driveways and transporter ramps; the exact amount is dependent on wheelbase and front and rear overhangs (For purposes of the competition, a minimum ground clearance of 4" is required)
- Sufficient cooling and attachment points to facilitate dynamometer testing
- All vehicles with a fuel system that produces exhaust emissions must incorporate a switch that forces the engine on in order to facilitate emissions testing (a manual on-engine switch)
- All vehicles must have a neutral position to disengage the motor from the vehicle to allow accurate measurement of vehicle losses during a coast-down test prior to chassis dynamometer testing
- Vehicles must have Class I trailer hitch for towing instrumentation to facilitate testing for emissions, speed under load, etc.

### Mainstream Class Requirements

- *Capacity:* 4 or more occupants (front passengers 95<sup>th</sup> percentile adult male<sup>2</sup>, rear passengers 75<sup>th</sup> percentile adult male) plus 10 cubic feet of useful cargo space (when the vehicle has four occupants); cargo space must be in one contiguous location, have a reasonable opening (approximately 24" x 16" x 9") and access and needs to be sufficiently enclosed so that cargo is not a safety hazard during abrupt maneuvers
- *Seating:* At least two side-by-side front seats
- *Wheels:* 4 or more wheels
- *Minimum Range:* 200 miles over a mix of city and highway driving

<sup>2</sup> See [http://edocket.access.gpo.gov/cfr\\_2004/octqtr/49cfr571.209.htm](http://edocket.access.gpo.gov/cfr_2004/octqtr/49cfr571.209.htm)

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- *Acceleration:* 0-60 mph acceleration in less than 15 seconds, lateral acceleration (300 ft.-diameter skid pad) .7 g
- *Features:* Heater, air-conditioner, audio system

### Alternative Class Requirements

- *Capacity:* 2 or more occupants (95th percentile adult male)
- *Seating:* No constraints (i.e., tandem allowed)
- *Wheels:* No minimum requirement
- *Minimum Range:* 100 miles over a mix of city and highway driving
- *Acceleration:* 0-60 mph acceleration in less than 18 seconds, lateral acceleration (300 ft. diameter skid pad) .7 g
- *Features:* No minimum requirements

### Requirements for Vehicle Modifications

Entries in either Class may be created by modifying existing popular production vehicles.

- As with new Progressive Insurance Automotive X PRIZE entries, the business plan must provide evidence that it is feasible to manufacture, sell, and services 10,000 modifications per year (If the modification is available to vehicles that are still under the original manufacturer warranty, the plan should explain why such warranties will not be voided or otherwise how warranty coverage equal to or better than that of the original vehicle will be addressed)
- Modified vehicles must satisfy all relevant requirements for features and performance for the class in which they are entered
- Modified vehicles entered in the Mainstream Class must continue to satisfy all safety standards that applied to the original vehicle (i.e., they do not have to be brought up to current standards); Structural modifications must not compromise vehicle safety and occupant protection
- Modified vehicles entered in the Alternative Class must satisfy Alternative Class safety requirements

### Vehicle Safety

The main focus of Progressive Insurance Automotive X PRIZE is fuel economy and carbon emissions, not safety. However, we also require that vehicles be production-capable and be designed to reach the market. With respect to safety, this means that resulting production

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vehicles sold in the U.S. must be fully-compliant with the [Federal Motor Vehicle Safety Standards \(FMVSS\)](#)<sup>3</sup> and other applicable NHTSA requirements.

Requiring full compliance with FMVSS (or equivalent) is not practical for vehicles that are not ready for production – it would limit the field and would reduce the extent of innovation. On the other hand, compliance with most FMVSS (or other comparable safety standards) cannot be addressed reliably after the fact – i.e., many safety features must be designed-in at the outset. But, if they are designed in at the outset, such features can be added via routine (albeit expensive) engineering prior to production. Because of the time and expenses involved, we will not require that such designed-in equipment be installed in the Race vehicles (examples include airbags and ESC).

Consequently, the Progressive Insurance Automotive X PRIZE takes the following approach:

- While we do not require full compliance, we do require that the detailed Data Submissions explain how the vehicle design addresses certain critical sections of the FMVSS (see [Appendix I](#)), and is consistent with the Bill of Materials (BOM) and business plan for manufacturing at least 10,000 vehicles per year; Race vehicles must carry additional weight to compensate for missing equipment (such as airbags)
- For vehicles being developed for the E.U. market (with later potential for U.S. introduction), it should be straightforward to show that the design addresses the critical sections of the FMVSS, provided that the design includes front airbags and is intended to earn at least a four-star EuroNCAP adult crash test rating (the same point may apply to vehicles being developed for other markets)
- Although Alternative Class vehicles with fewer than four wheels would be classified legally as motorcycles, the safety requirements for the Alternative Class are inspired by those of the Mainstream Class and go well beyond the FMVSS requirements for motorcycles (see Appendix I); The Progressive Insurance Automotive X PRIZE will not encourage the sacrifice of safety to achieve fuel-economy as our goal is to stimulate a new generation of safe, fuel-efficient passenger-carrying vehicles
- Many Progressive Insurance Automotive X PRIZE entries are likely to use innovative or non-standard technologies that are not addressed by existing FMVSS sections; Therefore, we will also require that the initial Data Submissions include a write-up explaining how the occupant compartment is designed for crashworthiness (including appropriate energy absorbing features) to provide adequate protection in frontal, side and rollover crashes, as well as to prevent occupant ejection
- There will be no minimum vehicle weight, but we will give special scrutiny to technologies and design features (including super light-weighting) that may compromise structural integrity and safety
- To ensure occupant safety during the Races, we may require certain vehicles to be equipped with additional equipment not mandated by the FMVSS on a case-by-case basis (example: four- or five-point seat belt system) in cases where it is deemed necessary

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<sup>3</sup> <http://www.nhtsa.dot.gov/cars/rules/standards/>

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### Safety Inspections and Testing

To facilitate and encourage the development of Race-worthy vehicles, and to ensure spectator safety during the Stage Race, we will require that race vehicles undergo detailed inspections and demonstrate adequate braking and stability performance in pre-Race active testing. (Note that some demonstration events may be conducted on public roads; the roads may or may not be closed to other traffic, but vehicles at all times will be required to obey speed limits and other traffic regulations.) To facilitate the development of competitive vehicles, the Progressive Insurance Automotive X PRIZE may also specify that certain vehicles comply with additional requirements for pre-Race data submissions and inspections.

Pre-Race active safety tests will be conducted with advice from Consumers Union and certain tests will be performed in accordance with procedures developed by Consumers Union (CU). These tests include:

- 60 mph (97 kph) – 0 brake test: must be accomplished in no more than 170 feet (51 meters) with good straight-line stability (cones demarking a lane 12 feet [3.7 m] wide must not be dislodged during the stop)
- Multiple braking test based on CU procedures
- Low-speed stability testing – tight serpentine course to be completed at 30 mph (48 kph) to demonstrate stable handling and linear response to steering inputs
- CU emergency double lane change maneuver – abrupt double lane change and handling test at 50 mph (80 kph); Cones will be set 60 feet (18.3 m) apart and 12 feet (3.7 m) from the center line to the right and left; Vehicles must demonstrate good stability when traversing 24 feet (7.4 m) from right to left within 60 feet (18.3 m) at the designated speed
- 0 – 60 mph (97 kph) acceleration – must be accomplished in no more than 15 seconds for the Mainstream class and no more than 18 seconds for the Alternative class

For details about the pre-Race inspections and active safety tests, see "[Pre-Race Inspections and Dynamic Safety Tests](#)".

### Progressive Insurance Automotive X PRIZE Vehicle Modifications

As discussed earlier, vehicles that are designed to achieve Progressive Insurance Automotive X PRIZE goals by modifying an existing popular production vehicle may be entered in the Mainstream and Alternative Classes. In general, such vehicles must continue to comply with the FMVSS and other applicable requirements that were in effect when the vehicle was produced.

For vehicle modifications, the Data Submission should explain why the proposed modifications do not compromise vehicle safety, as well as any steps taken to mitigate the effects of the modifications. Relevant FMVSS sections should be cited (see [Appendix I](#)). As is generally the case with Data Submissions, the Progressive Insurance Automotive X PRIZE reserves the right to request additional information.



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### Fuel System Safety Requirements

The FMVSS address some aspects of fuel system safety (Sections 301, 303, 304, and 305, cited in [Appendix I](#) (see in particular [Note 12](#)). However, many Progressive Insurance Automotive X PRIZE entries are likely to use innovative drivetrains and fuels that are not addressed by regulatory standards. Therefore, we will require that the Data Submissions include a general write-up sufficient to demonstrate that the design approach adequately addresses fuel-system safety, including high-power electrical system safety.

Regarding electric vehicles, some information about good design practices is available in the following [SAE Standards](#)<sup>4</sup>:

- J1772 – Electric Vehicle Conductive Charge Coupler
- J1766 – Recommended Practice for Electric and Hybrid Electric Vehicle Battery Systems Crash Integrity Testing
- J2464 – Electric Vehicle Battery Abuse Testing
- J1797 – Recommended Practice for Packaging of Electric Vehicle Battery Modules
- J2758 – Determination of the Maximum Available Power from a Rechargeable Energy Storage System on a Hybrid Electric Vehicle

### Operation of Race Vehicles on Public Roads

We have worked with NHTSA to develop a waiver under which Progressive Insurance Automotive X PRIZE race vehicles will be permitted to operate on closed public roads during race stages and demonstrations, even though they will not be in full compliance with the FMVSS. Note that, although the public roads may be closed to other vehicles, Progressive Insurance Automotive X PRIZE vehicles must obey all speed limits and other traffic regulations.

### Requirement to Wear Helmets During the Stage Race

During the Stage Race, any vehicle occupants must wear a helmet that complies with and is certified to FMVSS No. 218. Teams may request permission to use helmets that meet alternative standards (ECE, Snell, FIA). Open-face helmets are acceptable.

### Driver Qualifications

To further increase safety for drivers, officials, and spectators, we will require that all drivers have professional training, as evidenced by a sanctioned racing license or attendance at a 2-day performance driving course from a reputable organization (Skip Barber, Bondurant, BMW,

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<sup>4</sup> See <http://www.sae.org/technical/standards/> and [http://www.sae.org/technical/standards/ground\\_vehicle/](http://www.sae.org/technical/standards/ground_vehicle/)



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Porsche or the equivalent). Scored stages may require competition-sanctioned professional test drivers to perform on-road testing of team vehicles.

### Data Submissions and Judging

As discussed earlier, registered teams must provide confidential (under NDA) Data Submissions for Design Judging on a Pass/Fail basis (with one opportunity for appeal) in these areas:

- Safety, Emissions
- Manufacturability, Cost
- Features
- Business Plan

Vehicle designs that passed Design Judging were invited to move on to the next stage of the Progressive Insurance Automotive X PRIZE, and were announced to the public on 19 October 2009.

### Data Submission Requirements

Data Submissions were due on 15 June 2009, and were based on templates provided to the teams. In general, the Data Submissions covered the following:

- A summary of the specifications, features, and expected performance of the proposed vehicle, including a description of critical characteristics or unique features of the vehicle
- A description of the drive train (including fuels) and an estimate of the likely MPGe fuel economy
- For vehicles that use batteries for drive power, detailed information about the batteries, including battery chemistry and projected cycle life under stated assumptions (temperature range, depth of discharge, rate of discharge, and frequency of discharge); Note that battery usage during competition events will be monitored for consistency with the stated assumptions (the Progressive Insurance Automotive X PRIZE reserves the right to introduce reasonable battery stress tests to confirm that cycle life assumptions are plausible)
- For vehicles that have fuel converters, information on the design of the tailpipe and evaporative emission control system sufficient to show that a production vehicle could meet the US EPA Tier II, Bin 5 standard, and furthermore has been designed to pass 120K testing
- Design and engineering information, including timeline
- Systems-level bill of materials (BOM) and estimated production costs; Teams will need to provide detail where they deviate from industry norms; e.g. for the power train and body structure

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- Vehicle design renderings
- Business plan, including team description and financing, summarizing a credible plan to manufacture, sell, and service 10,000 vehicles (or conversions) per year by 2014; The plan must show that the national fuel infrastructure will support the vehicles, especially if any non-standard fuels or fueling-methods are to be used
- For the FMVSS sections identified as being required in vehicle designs (see [Appendix I](#)), general information showing basic a understanding of the FMVSS, and demonstrating to the satisfaction of the judging panel that production vehicles would be likely to comply
- A general write-up explaining how the design approach addresses fuel system safety
- A general write-up explaining how the occupant compartment is designed for crashworthiness (including appropriate energy absorbing features) to provide adequate protection in frontal, side and rollover crashes, as well as to prevent occupant ejection; For four-wheel vehicles, the write-up should include the predicted Static Stability Factor<sup>5</sup> (SSF)
- A list of those FMVSS and other safety-related aspects of the vehicle design that will not be implemented in the race vehicle, and an estimate of the amount of additional weight that would likely result from full implementation and compliance
- For vehicle modifications, an explanation of why the proposed modifications do not compromise vehicle safety, and a description of any steps being taken to mitigate the effects of the modifications; Relevant FMVSS sections should be cited
- Since consumers expect a minimum warranty of 3 years, 36,000 miles on all major components, a discussion of how the vehicle or vehicle modification is designed to achieve that (note that in some cases – e.g. emissions – the law mandates a considerably longer warranty)

Teams may petition the Progressive Insurance Automotive X PRIZE to waive certain Data Submission requirements or even specific vehicle requirements based on exceptional circumstances. For example, innovative technologies might result in certain Progressive Insurance Automotive X PRIZE requirements being inapplicable or inappropriate. Waiver requests should be accompanied by an analysis sufficient for experts to make an informed judgment.

### Design Judging

Design Judging has been completed on a Pass/Fail basis in accordance with the procedures described in [Appendix II](#), and Registered Teams have been notified of the results. Teams that did not pass the data submissions had one opportunity to appeal, and all appeals have been reviewed and completed.

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<sup>5</sup> The Static Stability Factor (SSF) "is calculated using the formula  $SSF=T/2H$ , where T is the "track width" of the vehicle and H is the "height of the center of gravity" of the vehicle. The track width is the distance between the centers of the right and left tires along the axle" (see <http://www.safercar.gov>, in particular <http://www.safercar.gov/portal/site/safercar/menuitem.13dd5c887c7e1358fefe0a2f35a67789/?vgnnextoid=5278e66aeee35110VgnVCM100002fd17898RCRD#ssf>)

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The Judges will continue to give special scrutiny to technologies and design features (including super light-weighting) that may compromise structural integrity and safety. They may require that additional mass be carried by race vehicles to reflect weight increases that would likely be needed to make production vehicles sufficiently safe.

In certain cases, the Judges have passed a vehicle on a provisional basis, requiring that specified deficiencies be addressed and resolved.

In cases where total compliance with the FMVSS is not required in the Race vehicle, the Judges may require that certain vehicles implement additional safety measures.

### Vehicle Fuels

Accepted Progressive Insurance Automotive X PRIZE vehicles require a refueling infrastructure that is available today or in the near future. In the case of electricity, this means readily-available plug types and circuit capacities would be in place by that date.

Vehicles must use Progressive Insurance Automotive X PRIZE-supplied fuel during performance tests and races. A limited number of representative fuels will be provided based on what we expect to be commercially available in 2014. Detailed fuel specifications will be made available to teams a minimum of six months ahead of the start of the race. The organizers will provide reformulated regular gasoline with up to 10% ethanol, fuel ethanol (E85), bio-diesel (B20), compressed natural gas (CNG), and electricity. At the current time, we do not believe that sufficient infrastructure to support hydrogen vehicles will be available by 2014, and therefore have not accepted hydrogen-fueled vehicles. If a team believes that our assessment is incorrect, they should provide a detailed rebuttal. For example, if a team has a credible plan to provide a safe and effective home hydrogen reforming unit with every vehicle, we would reconsider (but note that we would need strong evidence that such a reforming unit will be available and will be production-capable in quantities of 10,000 per year).

Detailed fuel specifications have yet to be determined, however the fuels specifications will be similar to what is sold to consumers today. Teams should plan on having a minimum 87 octane (R+M/2) unleaded gasoline with up to 10% ethanol and minimum 91 octane (R+M/2) E85. These fuels will have very low sulfur content – around 10 ppm – so lean-burn spark-ignited engines can be used with appropriate emissions after treatment. Assume a Reid Vapor Pressure of 10 psi for these fuels. For the bio-diesel, teams should plan for a 45 cetane fuel with 10 ppm sulfur. For the purposes of planning fuel tank sizes, teams should assume 75,000 BTU/gallon for E85; 112,000 BTU/gallon for E10, and 127,000 BTU/gallon for B20 as lower heating values. For CNG, assume a minimum methane number of 80, a motor octane of 115, a maximum Wobbe Index of 1400, and a maximum pressure of 3600 psi (24.82 MPa).

For electricity, Progressive Insurance Automotive X PRIZE will provide standard 240V/50A charging receptacles, but the teams are required to provide their own chargers. Teams requiring up to 70A continuous AC must notify the organizers as special provisions must be made to handle the higher current. Fast-charging of ESSs that require electric power in excess of 240V 70A continuous AC will not be permitted. Up to 10 hours of charging will be

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permitted prior to any maximum-range stage. If there is more than one stage per day, the total daily mileage will not exceed the maximum range requirement.

Note that electrical fuel will be measured at the AC plug, i.e., before delivery to any on-board or off-board charger.

A Progressive Insurance Automotive X PRIZE vehicle can use more than one fuel as long as accurate measurement of total energy consumption can be performed accurately and consistently. Water with no additives and electricity generated from on-board solar cells can be used without being counted in MPGe and GHG calculations – see below. However, all energy consumed by the vehicle and generated on board must be measured to the accuracy requirements specified by the organizers. Under no circumstances may teams use additional energy that is not accounted for during the competition.

### Figures of Merit for Energy and Emissions

The Progressive Insurance Automotive X PRIZE uses two principal figures of merit – one focusing on energy efficiency (MPGe), and one focusing on total greenhouse gas (GHG) emissions. For background information about these choices see the following FAQs in [Appendix III](#).

[What is the basic reasoning behind the two figures of merit?](#)

[Why use MPGe rather than a more direct measure of how much petroleum is used?](#)

[Why measure fuel economy pump-to-wheels rather than wells-to-wheels?](#)

[Don't Electric Vehicles have a huge advantage?](#)

[Why 100 MPGe, why not reward greater fuel economy?](#)

[Why isn't MPGe defined in terms of "utility factors" or other drive cycle variables?](#)

[What is the justification for the cap value of 200 g/mi CO<sub>2</sub>e?](#)

[Why not judge vehicles based on operating costs?](#)

[Why cap CO<sub>2</sub>e emissions rather than scoring the competition using CO<sub>2</sub>e, so as to reward vehicles with a lower carbon footprint?](#)

[Why use both MPGe and a CO<sub>2</sub> cap rather than a single, carbon-based figure of merit?](#)

### Energy (Fuel Economy) – 100 Miles per Gallon of Gasoline Energy Equivalent (MPGe)

The Progressive Insurance Automotive X PRIZE figure of merit for fuel economy is Miles per Gallon equivalent (MPGe), an energy efficiency measure that expresses fuel economy in

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terms of the energy content of a U.S. gallon of petroleum-based gasoline. Calculations are based on the energy equivalence of all fuel(s) consumed:

$$\text{MPGe} = (\text{miles driven}) / [(\text{total energy of all fuels consumed})/(\text{energy of one gallon of gasoline})]$$

MPG determined through the application of utility factors as proposed in SAE J1711 is not used (for further discussion, see the FAQ “Why isn’t MPGe defined in terms of “utility factors” or other drive cycle variables?”). Basically we ask: how much energy was delivered to the vehicle, and how far did it go? Thus, the fuel economy measure may be described as pump-to-wheels or plug-to-wheels.

Different fuels have different pros-and-cons, but in all cases it is valuable to increase efficiency (increase MPGe), which conserves energy. This is even true, for example, if the fuel is electricity generated from alternative energy sources. Alternative energy is not infinite energy. Increasing electric vehicle efficiency will result in more energy available for other purposes.

MPGe is an attractive figure of merit because it is a direct measure of overall pump-to-wheels efficiency, because it is technology-neutral, and because it relates nicely to consumer intuition – i.e., it reduces to the familiar MPG if the fuel is in fact gasoline. MPGe is also attractive because it applies to any combination of fuels (including ones we may be thinking about yet). A spreadsheet for MPGe calculations is available [here](#) and described [in this blog post](#). For a detailed example of how MPGe applies to plug-in-hybrid electric vehicles (PHEVs), see [this blog post](#)<sup>6</sup>.

Note that, in the case of pure compressed-natural-gas (CNG) vehicles, MPGe reduces to the GGE (gasoline-gallons-equivalent) figure of merit that the CNG industry chose so that consumers could compare the fuel economy of CNG vehicles with gasoline vehicles.

Progressive Insurance Automotive X PRIZE vehicles will be required to demonstrate a minimum of 100 MPGe fuel economy via a combination of fixed-cycle dynamometer testing and actual performance in Progressive Insurance Automotive X PRIZE competition events. We believe that this is a difficult, but feasible goal. It is more difficult for the Mainstream vehicle class than for the Alternative class. For various fuels and drive trains, a detailed analysis of the Progressive Insurance Automotive X PRIZE fuel economy and GHG emission requirements is [available in a spreadsheet](#), described [here](#), which was prepared by the [Natural Resources Defense Council](#) (NRDC) with assistance from [Argonne National Laboratory](#) (ANL) and data from the [DOE-Argonne GREET model](#).

In many cases – e.g., gasoline internal combustion engines (ICE) – pump-to-wheels is the same as tank-to-wheels. That is, essentially all of the energy delivered to the vehicle goes into and is stored in the tank. In others – e.g. battery electric vehicles (BEV) – there is an energy loss between delivery to the vehicle (i.e., the wall plug) and the energy that ends up stored in the “tank” (the battery). To be clear, what counts in the MPGe calculation is the energy in the fuel delivered from the pump (or plug) to the vehicle (i.e., what the consumer pays for). We consider “fuel-plug-to-tank” energy conversion or storage losses (such as during battery charging via an onboard or off-board inductive charger) to be part of the drivetrain – i.e., they

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<sup>6</sup> <http://autoxprize.typepad.com/axp/2008/01/computing-mpge.html>

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are accounted for in measuring how far the vehicle goes per unit energy delivered from a pump nozzle or wall plug.

On-board sources of solar power (that operate while driving or when parked) will not be counted when computing MPGe, in the sense that the energy in the MPGe calculation will be based only on the energy transmitted to the vehicle at the pump. Thus, from the viewpoint of the MPGe calculation, such power sources are “free,” but of course they come at the expense of weight, complexity and cost.

Some prospective competitors have asked about water (e.g., for water injection). Regardless of its intended use, water would be considered to be a “fuel,” in that a water tank may be refilled only when refueling is permitted. Water without additives would not have an upstream GHG “charge” and it would not have an “energy charge” (gasoline equivalence) in pump-to-wheel calculations of MPGe fuel economy. (Of course, the water’s weight would affect fuel economy, and any on-board conversion of water to combustible fuel by known methods would involve energy consumption.)

### **Greenhouse Gas Emissions – Maximum 200 g/mi Total CO<sub>2</sub> Equivalent (CO<sub>2</sub>e)**

The Progressive Insurance Automotive X PRIZE figure of merit for greenhouse gas emissions is the total wells-to-wheels (WTW) Greenhouse Gas (GHG) emissions resulting from consumption of all fuels – including tailpipe and upstream contributions,– expressed as equivalent grams of CO<sub>2</sub> emitted per mile (CO<sub>2</sub>e). For the Progressive Insurance Automotive X PRIZE, this figure must be less than 200 g/mi.

The upstream (wells-to-pump) contributions of GHG emissions will be estimated by using the [DOE-Argonne GREET model](#) using average default values that reflect fuel production today and in the near future. For vehicles that can be powered by more than one fuel, this estimate will be based on all of the vehicle’s possible fuels, weighted by their current mix in the marketplace.

As mentioned [above](#), a detailed analysis of the Progressive Insurance Automotive X PRIZE MPGe fuel economy and GHG emission requirements is available in a requirements is [available in a spreadsheet](#), described [here](#).

In the case of electricity, GHG emissions are based on the 2005 national grid, reduced to reflect the increase in renewable energy sources that would be required under national policies to control global warming. We chose 2014 as the target year as that is a reasonable estimate of when tens of thousands of grid-powered vehicles could be on the road. The resulting reduction in GHG intensity is 14% from the 2005 values, as determined from the Energy Information Administration’s evaluation of the Lieberman-Warner Climate Security Act (S. 2191). Note that the [spreadsheet](#) has an option to use the even-cleaner California grid, but Progressive Insurance Automotive X PRIZE estimates will be based on the national grid.

Among other things, the DOE-sponsored Progressive Insurance Automotive X PRIZE Education Program will publicize in various ways how cleaner electricity production generally (and renewable energy sources in particular) can significantly reduce wells-to-wheels GHG emissions.

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Greenhouse gases other than carbon dioxide will be expressed in terms of equivalent CO<sub>2</sub> based on the IPCC's 100-year Global Warming Potential measurements. Currently, the values are: 1 for CO<sub>2</sub>, 23 for CH<sub>4</sub>, and 296 for N<sub>2</sub>O. Emissions from vehicle heater or air conditioner systems will not be included in the calculation.

### Criteria Emissions

As mentioned earlier, Progressive Insurance Automotive X PRIZE vehicles must be designed to meet criteria emissions standards no worse than US EPA Tier II, Bin 5 and the Race vehicles must meet at least US EPA Tier II, Bin 10 in on-road testing and Tier II, Bin 8 in chassis dynamometer testing. Although we will not require full 120K lifetime emissions confirmation, vehicles must be designed to achieve full 120K compliance.

Vehicles will be tested for criteria emissions compliance during the knockout stage and the chassis dynamometer stage.

## Measuring Fuel Economy, Range, and Emissions

### Measuring Fuel Economy (MPGe)

All energy sources used to propel Progressive Insurance Automotive X PRIZE vehicles will be measured to generate fuel economy compared to miles per gallon of unleaded gasoline (MPGe, see [above](#)). The amount of fuel consumed on board will be measured at the end of each race stage by mass for liquid fuels and by temperature and pressure readings from gaseous fuels. The amount of electricity consumed will be measured from the plug (AC) to return the vehicle to the state of charge it started the stage with. AC electricity will be converted to BTUs at a rate of 3412 BTU/kWh and added to the energy content of the consumable fuel used for each race stage. The total number of BTUs will be divided by the energy content in the gasoline used in the Progressive Insurance Automotive X PRIZE (approximately 112,000 BTUs per U.S. gallon) to get gallons of gasoline equivalent (GGE). The GGE used for each stage will then be divided into the miles of the stage to produce the MPGe fuel economy result for each stage. This general approach will be used in all on-road and on-track stages.

Procedures for measuring fuel economy during the chassis dynamometer stage are different. See the ["Dynamometer Tests"](#) section below for more details.

### Measuring Range

On-road and on-track scoring events will be conducted to verify the minimum range requirement of 200 miles (322 km) for the Mainstream class and 100 miles (161 km) for Alternative class. These events will be laid out to represent the California Unified Cycle (LA-92) with comparable accelerations and speed profiles. All vehicles will start out with full fuel tanks and any energy storage system (ESS). No refueling or recharging will be allowed during these events.



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Range will also be computed for the Dynamometer Stage based on the energy efficiency results obtained from those tests. See the "[Dynamometer Tests](#)" section below for more details.

Vehicles must attain the minimum range requirement for their class in each of these range tests to be eligible to win the grand prize.

Extreme, so-called hypermiling techniques will not be allowed and will be penalized by the race referees if detected via telemetry or observation.

### Criteria Emissions

Criteria emissions will be measured both on-road during the knockout qualifying event and also on the chassis dynamometer under controlled conditions.

On-road emissions testing will use Semtech portable emissions testing devices that measure total hydrocarbons, methane, carbon monoxide, carbon dioxide, oxides of nitrogen, and ammonia. Competitors must demonstrate Federal Tier 2, Bin 10 emissions levels over an on-road drive cycle using comparable accelerations and speed profiles from the Urban Dynamometer Driving Schedule (UDDS) and the Highway Fuel Economy Driving Schedule (HWFET) from a hot start. In some circumstances, where applicable, the Engine-on Mode Switch may be engaged. Progressive Insurance Automotive X PRIZE vehicles must have enough on-board storage space to hold the emissions testing instrumentation (approximately 457 mm (18") high x 762 mm (30") wide x 686 mm (27") deep). Vehicles unable to carry this size device inside with easy access must have a Class 1 trailer hitch installed capable of 150 lb. (68 kg) tongue weight to tow the emissions testing instrumentation mounted in a trailer behind their vehicle.

For all vehicles with a fuel system that produces exhaust emissions, the engine must remain on during the on-road emissions testing (hence the "[Vehicle Testing](#)" requirement for an engine-on switch).

Chassis dynamometer testing will occur under controlled conditions on a state-of-the-art chassis dynamometer using certification test fuels. The vehicles will be placed on the dynamometer for one or two test cycles to condition them for testing before they are parked ("cold soaked") at approximately 70° F (21° C) for a minimum of 12 hours to equalize all temperatures. Each vehicle will be placed on the rolls for testing on the Federal Test Procedure (FTP) to determine criteria emissions levels. In some circumstances, where applicable, the Engine-on Mode Switch may be engaged. Each vehicle with a fuel converter (typically an engine) will have to meet Federal Tier II, Bin 8 emissions levels in order to be eligible to win the grand prize. Teams are required to be in attendance when their vehicle is being tested but can depart as soon as testing is complete. Emissions testing will not be open to the public.

### GHG Emissions

GHG emissions will be measured during the on-road and chassis dynamometer emissions testing events. Measured carbon dioxide and methane emissions from a fuel converter (if



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applicable) will be added to upstream GHG estimates as discussed [above](#). Total GHG emissions must not exceed 200 g/mi for vehicles to be eligible to win the grand prize. Note that nitrous oxide emissions will not be measured from the vehicle's fuel converter for this calculation. Our past experience has shown that these levels are vanishingly small from vehicles and would not significantly impact the results while complicating emissions measurement.

### Promotional and Non-Scored Events

#### New York Media Event (19 October 2009)

A press conference in New York City announced the official list of the Qualified Competing Teams – those Registered Teams that passed Design Judging and were invited to bring vehicles to the qualifying events. Representative vehicles were also on display. The event also announced the kick-off of the **DASH+** National High School Competition to design the dashboard for the super efficient car of the future.

#### Las Vegas Team Summit (1 – 3 November 2009)

A mandatory technical Team Summit for Qualified Competing Teams was conducted in conjunction with the SEMA convention in Las Vegas. Competition vehicles were on public display at SEMA. Competition organizers worked with SEMA to identify space on the floor at the convention, passes for the conference, speaking engagements, and other ways to integrate the Team technical workshops with SEMA through a focus on environmentally friendly after-market products.

***\*Please note that the narratives that follow are notional at this time and represent our best approximation of the intended event plan, but they are by no means final. Discussions with stakeholders regarding Competition Series phase events and their associated locations, venues, and dates remain ongoing. All technical and public-facing events are subject to change or even cancellation.***

#### North American International Auto Show (NAIAS)

The Progressive Insurance Automotive X PRIZE will formally announce the final Competition Schedule, venues, and location of all scored, non-scored, and promotional events at the North American International Auto Show in Detroit, Michigan. Competition organizers will also display approximately 6-8 competition vehicles in a new area on the main show floor called Electric Avenue where smaller auto manufacturers will be featured. Electric Avenue will be located right behind the GM and Ford display areas. Only OEMs will be allowed to display vehicles on the main show floor area (no suppliers). Progressive Insurance Automotive X PRIZE staff and vehicle teams will be on hand to answer questions and pass out Progressive Insurance Automotive X PRIZE information. Additional zero emission competition vehicles may be exhibited on the indoor EcoX track on the lower floor of the convention center. The track is designed to showcase emission free vehicles and will display the vehicles as they make their way around the indoor track.

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### **Opening Ceremony Event (Location to be announced)**

Surrounded by as many as a dozen competition vehicles, a celebratory presentation will outline the importance of the Progressive Insurance Automotive X PRIZE competition and emphasize the potential benefit to the public and private sectors of the state. Welcome remarks from dignitaries and notables will capture the excitement of the event. Vehicles will be on display for the public and media to view and ask questions of the teams. Following the presentation event, a VIP reception will allow invited guests a chance to better understand the Progressive Insurance Automotive X PRIZE goals and the potential business development opportunities that abound.

**Executive Summit (Location to be announced)** An exclusive group of invited guests will join together in a purpose-built executive summit to be hosted at a location to be announced. Executives, educators, venture capitalists, politicians, benefactors and philanthropists will be invited to speak, listen, learn and teach in this collaborative setting. Additionally, the winners of the **DASH+** national high school contest could be invited to participate and showcase their concept for the dashboard of the future. The Executive Summit will include an on-site experience with live vehicle scoring, vehicle introductions, ride and drives and other “kick the tires” events.

### **Open House (Location to be announced)**

For one day the general public, media and dignitaries will have a chance to witness scored, on-track competition challenges. Access to the Progressive Insurance Automotive X PRIZE competition technical team will provide insight into the design of the stage, the scoring protocol for each leg, and how the competitors are challenged to prove that their vehicle can average the targeted fuel economy of 100 MPGe. Following the public open house activities, an invitation-only event will allow industry, government, and academic professionals from the area and beyond to further explore the potential use of the technologies displayed during the day.

### **Finalist Recognition Event**

*Note: This event is currently under review by the Progressive Insurance Automotive X PRIZE organizers. The below narrative reflects a notional concept and may be amended to reflect updated objectives for this market.*

The focus of the Final Recognition event, likely in Northeast Ohio, will be the public introduction of up to 20 finalists who have emerged from the scored phases. The region’s status as the home town of our title sponsor, Progressive Insurance, as well as its long history in automobile manufacturing makes for an ideal spot to showcase the competition finalists, likely at Cleveland’s Progressive Field. There will also be educational outreach to engage K-12 students and their parents in a series of fun, hands-on, minds-on, interactive, learning activities. Participation from area schools, out-of-school time organizations, colleges and universities, as well as the science/citizen-scientist community would be welcomed. Student reporters would cover the events and blog within FuelOurFutureNow.com. Additionally, regional, finalist, and winning entries in the **DASH+** national high school contest would be on display. A VIP reception during the Cleveland Indians’ home stands against the Royals is also possible.

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### Washington, DC Awards Ceremony

The top 10 finalists in both Mainstream and Alternative Classes will receive an invitation to Washington, DC for the final awards ceremony. X PRIZE Foundation and Progressive Insurance executives, senior Administration and Congressional leaders, and other invited VIPs and guests will witness the presentation of the Mainstream and Alternative Class X PRIZE grand prize awards and other potential prizes, awards, and recognition.

### Pre-Race Technical Deliverables

The requirement for pre-Race reports is to increase the safety and reliability of Progressive Insurance Automotive X PRIZE vehicle entries, and also to facilitate the development of competition-ready vehicles. The three technical readiness reports will be designated as First Technical Deliverable, Second Technical Deliverable, and Third Technical Deliverable. The due date for each report is listed below:

**First Technical Deliverable – Due 15 December 2009**

**Second Technical Deliverable – Due 30 January 2010**

**Third Technical Deliverable – Due 30 March 2010**

All pre-race Technical Deliverables will be submitted through designated, web-based templates into which information, diagrams, and images are inserted and submitted electronically. Along with other items, required information will include:

- High-voltage system schematic and component details including the specifications of the Energy Storage System (ESS)
- Design for ESS enclosures and hold-downs for 15 G lateral and 8 G vertical loads
- Fuel storage tank(s) and location(s)
- Specifications and location(s) of any source of on-board energy used for propulsion
- One or more pre-competition reports with photos detailing vehicle construction progress and the location of critical safety-related sub-systems
- Each competing vehicle will be required to accumulate a minimum of 500 miles or 800 km (several thousand miles or km would be better) as an indication of their level of preparedness before the first competition event; At least one trip in excess of 50 miles (80 km) needs to be documented in which the vehicle must demonstrate at least 50 MPGe; These minimum performance levels need to be documented to the satisfaction of the Progressive Insurance Automotive X PRIZE, typically attested to by the stamp and signature of a Professional Engineer; More details will be forthcoming at the Team Summit

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### Competition Events

In all competition events, vehicles will have a driver and no passengers. If the driver weighs less than 200 pounds, additional compensating weight will be added to the vehicle.

Competition events will take place primarily at and around a single TBD location.

### Pre-Race Inspections and Dynamic Safety Tests

These inspections will be performed before any Progressive Insurance Automotive X PRIZE vehicle is allowed to participate in each of the competition events. This list below shows some of the inspections, but not necessarily all of the pre-race inspection requirements.

- On the ground:
  - Exhaust leak check (if applicable)
  - Operation of lights, wipers, horn, rear-viewing system, etc.
  - Vehicle completeness, high voltage labeling, decal placement
  - Emergency-stop location and function
  - Ground-fault detection system
  - Vehicle mass and weight distribution
  - ESS hold-downs and connectors, fusing, contactor locations; and other electrical safety requirements
  - ESS enclosures and high voltage system component cover(s) and integrity
  - ESS charging and battery management system safety requirements
  - Progressive Insurance Automotive X PRIZE-supplied data acquisition system connections and in-car functions
  - Operation of the Engine-on Mode Switch (In the engine-on mode, the engine is forced to start and stay on all of the time regardless of whether or not it is supplying motive force, generating electricity, or idling. This switch is required to assist with exhaust emissions testing.)
  - FMVSS requirements
  - Chassis structural integrity
- On a lift: basic mechanical inspection
  - Fuel system fuel routing, integrity, capacity, and fuel safety requirements (if applicable)

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- Fuel tank(s), quick disconnects and fuel lines, drain, refill, and capacity check (if applicable)
  - Suspension and steering attachments; tire clearance at lock
  - Brake components and lines
  - Wheels and tires
  - High voltage line routing and labeling
  - Inertia kill switch and contactor box with appropriate current measurement shunt
  - ESS enclosure construction, mounting, and material integrity
- Fuel drain and re-fill using Progressive Insurance Automotive X PRIZE approved fuel (if applicable)
  - On-road data acquisition system and telemetry check
  - 5-gas analyzer emissions screening (gross-emitter elimination, if applicable)
  - Active safety tests as described earlier in "[Safety Inspections and Testing](#)"

### **Shakedown Stage (likely between 26 April – 8 May 2010)**

Teams undergo rigorous safety inspections (see above) and are afforded the opportunity to put their vehicles through a number of challenges simulating final race conditions to shake out any problems, make final adjustments, and verify competition readiness. Both energy efficiency and stage time will be measured at these stages but will not count towards the grand prize. Teams will be split into two waves to balance the work across a two-week period. Teams can expect to be on the ground for 4-6 days. In addition, the public will have the opportunity to become familiar with the competing teams and teams will be able to showcase their technology to sponsors, investors, and the media.

### **Knockout Stage (likely between 20 – 28 June 2010)**

This stage is the filter for competing in the final race stages that contribute to winning the grand prize. All vehicles that intend to advance from the qualifying stages to the race stages must successfully pass the requirements of the "knockout" event. The knockout qualifying event will be conducted at a suitable test track or proving ground over the course of 8-10 days and. It will comprise the following:

- Repeat pre-race safety inspection and dynamic safety testing described [above](#)
- Vehicle testing to confirm compliance with minimum specifications in the Progressive Insurance Automotive X PRIZE
- A combined on-road energy efficiency and range event of 134 miles for the Mainstream class and 67 miles for the Alternative class will be conducted (this event will be laid out to represent the California Unified Cycle (LA-92) with comparable acceleration and speed profile. Vehicles must finish the total distance within the

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maximum time while also demonstrating a minimum of 67 MPGe. Note that the fuel economy and range requirements are two-thirds of the target goals; vehicles must meet these reduced goals in the Knockout event and meet the minimum range for the applicable class in order to be eligible to compete for the grand prize. Energy efficiency will be measured in the same fashion as the on-road stages; no refueling or recharging will be allowed.)

- On-road emissions testing as described earlier within "[Measuring Fuel Economy, Range, and Emissions](#)" (The vehicles that pass these tests will have their vehicle configuration frozen: no major hardware (mechanical, electrical, or ESS) changes will be allowed for the rest of the Progressive Insurance Automotive X PRIZE unless to repair failed components or to improve emissions performance.)

### Performance Tests

A number of vehicle performance tests to confirm compliance with minimum specifications in the Progressive Insurance Automotive X PRIZE rules will be conducted during the knockout stage. They will include:

- 0 – 60 mph (97 kph) acceleration from a standing start (15 seconds maximum for the Mainstream class; 18 seconds maximum for the Alternative class)
- 40 - 65 mph (64 – 105 kph) 9 second maximum acceleration time confirmation
- Minimum 0.7 G lateral acceleration on a 300' (91 m) diameter skid pad
- Vehicle noise test according to ISO 5130:2007 modified for the testing location (74 dB maximum); NB: this test measure total vehicle noise, not just exhaust noise
- 55 mph (105 kph) constant speed at a simulated 4% grade using a towing dynamometer for 1/2 hour for the Mainstream class; 15 minutes for the Alternative class
- A combined on-road energy efficiency and range event of 200 miles (322 km) for the Mainstream class and 100 miles (161 km) for the Alternative Class (Energy efficiency will be measured in the same fashion as the on-road stages; no refueling or recharging will be allowed.)

### Final Race Stages (likely between 19 – 30 July 2010)

The race structure and race courses are intended to test the vehicles under realistic driving conditions, so that the fuel economy and emissions performance are as meaningful as possible.

For practical reasons, the detailed race courses cannot be specified until much closer to the events themselves, when local support, local sponsors, media partners, and other factors are known. Indeed, even if we knew the detailed courses today, as a matter of principle we would not announce them as they should not to be the focus of vehicle design. When specifying the course details, the Progressive Insurance Automotive X PRIZE will be assisted by experts from the US Federal Highway Administration (FHWA) and experts in vehicle testing.

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If any race stages are conducted on public roads, the roads will be closed to other traffic. Whether held on public roads or on closed tracks, driving in traffic will be simulated. Vehicles at all times will be required to obey speed limits and other actual or simulated traffic regulations. Progressive Insurance Automotive X PRIZE will also impose maximum cornering speeds. For reasons of safety and consumer relevance, there will be no unlimited-speed events or top speed tests. However, we may include an extended acceleration test (see [“Performance Tests”](#)), and we may include a closed-track stage with a speed limit that is higher than 65 mph.

Vehicles will leave the start at intervals, and will be timed separately over each stage for scoring purposes (in the style of automotive rallies or bicycle time trials). Stage timing will be recorded from when each vehicle leaves the start line until it crosses the finish line. Vehicles must finish within a window of a minimum time (set to approximate traveling the speed limit over the length of the stage) and a maximum time (set to approximate 80% of the speed limit over the length of the stage). Speed will be monitored via the DAS in real time and analyzed after the stage for compliance to specified limits. Penalties may be assessed to accumulated race time based on speed violations. Periodic radar checks may also be made on the road to enforce speed limits. Drafting will not be permitted, and vehicles will be required to yield to faster vehicles that wish to pass – thus, there will be no aggressive side-by-side racing.

The length of stages will be determined based on the statistical distribution of trip lengths in the U.S. according to data from the 2001 National Household Transportation Survey. Some data from that survey was prepared for the Progressive Insurance Automotive X PRIZE by the [Department of Transportation, Federal Highway Administration](#), and is available [here](#). Typically, stages will be between the 50<sup>th</sup> percentile (about 30 miles or 48 km) and the 80<sup>th</sup> percentile (about 90 miles or 145 km) of average trip lengths; see the table below for more information. Distance traveled will be determined by measuring the route and from the vehicle's DAS.

**Distribution of Trips and Miles by Trip Lengths**

| Trip Length in Miles | Distribution of Trips | Distribution of Daily Miles |
|----------------------|-----------------------|-----------------------------|
| 0-5                  | 61.0%                 | 13.5%                       |
| 6-10                 | 17.1%                 | 14.8%                       |
| 11-15                | 8.1%                  | 12.2%                       |
| 16-20                | 4.4%                  | 9.3%                        |
| 21-30                | 4.3%                  | 12.8%                       |
| 31-40                | 1.9%                  | 7.5%                        |
| 41-50                | 1.0%                  | 5.3%                        |
| 51-75                | 1.0%                  | 6.5%                        |
| 76-99                | 0.3%                  | 3.0%                        |
| 100 and over         | 0.9%                  | 15.3%                       |



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|       |        |        |
|-------|--------|--------|
| Total | 100.0% | 100.2% |
|-------|--------|--------|

Source: 2001 National Household Travel Survey  
 Note: Totals may not sum to 100 percent due to rounding

The minimum required range of the vehicles (100 miles or 161 km for the Alternative Class; 200 miles or 322 km for the Mainstream Class) will be tested during the knockout event and at least once during the stages. Performance over all stages will be combined as described [below](#). In choosing the final courses, the average speeds of the stages (estimated from the posted speed limits) will also be based on the 2001 (or 2008, if available) National Household Transportation Survey data. In general, the average speed of each stage will range from the 50<sup>th</sup> percentile (24 mph or 39 kph) to the 90<sup>th</sup> percentile (48 mph or 77 kph). However, there may be a stage at the 95<sup>th</sup> percentile speed (57 mph or 92 kph average). Note that these are average speeds; instantaneous speeds will range from 0 to 65 mph based on the speed limits along the specific route. Teams should be aware of our intention to use the 2008 NHTS data to be released in January 2010 in the final design of the competition courses. We expect the 2008 data to be very similar to the above data. Using the best available data in the development of our competition courses is completely consistent with our desire to ensure our events are as representative of real driving as humanly possible.

Vehicles that do not finish a race stage will not be able to win the energy efficiency award for that stage and will have a penalty added to their time. Vehicles must finish 70% or more of the race stages to be eligible for the grand prize.

Heaters and air-conditioning systems must be operational during the race stages, but drivers will not be required to turn them on. However, temperature in the passenger compartment must always remain below 95 degrees F. Interior temperatures will be monitored and teams will be penalized for non-compliance with this regulation. In addition, if conditions produce fogging on the windshield, interior windows or backlight, defrosting must be engaged to clear the windows to allow safe vehicle operation.

In addition, a number of non-scoring showcase stages may be conducted in conjunction with other stages or events to highlight the performance of Progressive Insurance Automotive X PRIZE race vehicles. Special prizes may be made available for these stages. Participation in some of these tests may be optional. After all scored on-road stages are complete, Progressive Insurance Automotive X PRIZE organizers will identify the Top 10 finishers in each class in preparation for the Coast-down stage.

### **Coast Down Stage (likely between 26 – 30 July 2010)**

In preparation for dynamometer testing, the cars need to be “coasted.” This essential test is critical for successful objective dynamometer testing by gathering data to set the dynamometer to accurately represent the road loads of Progressive Insurance Automotive X PRIZE cars. The cars will be instrumented and then accelerate to 80 mph (129 kph) or their top speed on a level, straight road and be placed in neutral. Data will be taken as they coast to a stop; the process will be repeated going the other direction and the results averaged. This test establishes the aerodynamic and mechanical drag of the vehicles combined with the rolling resistance of the tires.



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Note that all vehicles will need a system to disconnect the motor or engine from the wheels (a “neutral” position) in order to eliminate mechanical drag from the powertrain. If vehicles do not have this feature, teams will either have to disconnect their electric drive from the wheels and be pushed to 80 mph or have to accept the drag that their drivetrains add to their coast down times and dynamometer road loads.

Since coast down testing can only take place a few hours a day when temperatures are moderate and the wind is below certain levels, this stage will take up to a week. Teams must be attendance when their vehicles are being tested but will be able to leave after testing is complete.

At the end of this stage, the vehicles will be impounded in advance of dynamometer testing, so all vehicles must have completely functioning drivetrains and emission controls and in the form required for dynamometer testing. Battery State of Charge (SOC) may be adjusted before impounding, as well as before and after emissions testing. The dynamometer stage will not be open to the public. Teams are put on notice that after coast-down testing no calibration changes or any modifications can be made to their vehicles for the remainder of the race.

### **Dynamometer Tests (likely between 2 – 21 August 2010)**

The top 10 finalists from both Mainstream and Alternative Classes will be tested under controlled conditions on a state-of-the-art chassis dynamometer. This testing will take place at the U.S. Environmental Protection Agency in Ann Arbor, Michigan or at Argonne National Laboratory in the suburbs of Chicago, Illinois. These laboratories use 48” dynamometer rolls and sophisticated and sensitive emissions and energy consumption measurement systems. Each vehicle will be safety inspected and the fuel drained and refueled with certification test fuels for the dynamometer testing: indolene clear for SI engines and ULSD test fuel for CI engines.

Each vehicle will be placed on the dynamometer for one or two test cycles to condition it for testing before they are parked (“cold soaked”) at approximately 70° F (21° C) for a minimum of 12 hours to equalize all temperatures. Each vehicle will be placed on the rolls for testing on the Urban Dynamometer Driving Schedule (UDDS or city cycle) and the Highway Fuel Economy Driving Schedule (HWFET or highway cycle).

An average of city and highway results will be used to calculate the fuel economy of Progressive Insurance Automotive X PRIZE vehicles. The results of this testing will be combined with the on-road Final Stages fuel economy data on a 50/50 basis to determine if the 100 MPGe eligibility criteria for the Progressive Insurance Automotive X PRIZE grand prize has been achieved.

Each vehicle with a fuel converter (typically an engine) will also have to meet Federal Tier II, Bin 8 emissions levels from a cold start over a Federal Test Procedure certification test cycle in order to be eligible to win the grand prize. In some cases, where applicable, the Engine-on Mode Switch may need to be used for the emissions testing portion of the dynamometer test. Vehicles with emissions lower than Bin 8 will receive race time bonuses in proportion to their emissions levels to be specified at a later date.

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Charge-depleting hybrid electric vehicles (e.g. Plug-in Hybrid Electric Vehicles) will need to begin testing at a State of Charge (SOC) that will reach a transition to charge-sustaining operation within pairs of alternating UDDS and HWFET cycles repeated two times (70 miles maximum) due to time constraints. It is up to each team to determine what SOC to begin testing with; recharging time will be limited to 10 hours at J 1772 Level 1 charging rates. Once achieving charge-sustaining operation, one pair of UDDS and one pair of HWFET cycles will be conducted and the test will conclude.

The energy efficiency of these vehicles will be calculated by determining the rate of energy consumption per mile in charge-depleting mode (extrapolating their charge-depleting range based on the useable capacity of the ESS if necessary) and combining that with the energy consumption in charge-sustaining mode over a 200 mile (322 km) trip for Mainstream class vehicles and 100 mile range (161 km) for Alternative class vehicles. The results will be converted to fuel economy in MPGe for use in Progressive Insurance Automotive X PRIZE scoring.

Teams are required to be in attendance when their vehicle is being tested but can depart as soon as testing is complete. Three chances at dynamometer testing will be given to each team; if the vehicle cannot complete all the test cycles with three tries it will be excluded from this stage and ineligible to win the grand prize.

Note that chassis dynamometer testing is very stressful on vehicles due to limited air flow through heat exchangers. Many advanced technology vehicles do not have adequate cooling of primary and secondary subsystems to successfully complete this testing; teams should make sure to provide sufficient cooling for all drivetrain components and all electronics before coast-down and dynamometer testing. Also be aware that team members cannot drive their vehicles on the dynamometer; professional test drivers will be used for this testing. Your vehicle must have easy to use controls and very clear driving instructions if the vehicle is to achieve a good result. Any unusual vehicle operating instructions must be clearly written down in a form that the drivers can understand and implement during the tests. It is highly encouraged that all aspects of vehicle operation be automatic and not require any special driver intervention.

Once the vehicle has been received for dynamometer testing, all electronic ports will be sealed and no hardware and software changes can be made to the vehicles for the rest of the Progressive Insurance Automotive X PRIZE (two to three stages). No computers may be attached to the vehicles for the remainder of the race stages; data collection must be accomplished through the Progressive Insurance Automotive X PRIZE Data Acquisition System (DAS) – see [“Vehicle Data Collection and Telemetry”](#)). The vehicles will be impounded between stages to discourage any changes to the vehicles for the rest of the race.

### Winning the Grand Prize

Only vehicles that successfully complete the Final Stages are eligible to win the grand prize. Successful completion means that vehicles have achieved a fuel economy in excess of 100 MPGe when their dynamometer fuel economy results are averaged with the fuel economy results in the Stages. In addition, the vehicle's GHG emissions as measured in the dynamometer testing and from their electricity consumption on-road in the Final Stages must

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not exceed 200 g/mi and they must have demonstrated compliance with Tier II, Bin 8 emissions, where applicable.

All vehicles that successfully complete the Final Stages (as defined above) will be named as "Progressive Insurance Automotive X PRIZE Qualified". The Progressive Insurance Automotive X PRIZE Qualified vehicles from the Mainstream and Alternative Classes with the lowest elapsed time in the Final Stages will be Grand Prize winners.

### Vehicle Data Collection and Telemetry

#### Data Collection Hardware and Requirements

All Progressive Insurance Automotive X PRIZE vehicles must have a properly functioning Data Acquisition System (DAS) supplied by Progressive Insurance Automotive X PRIZE organizers installed in their vehicles. The DAS will be CAN bus compatible; those teams that do not use CAN for vehicle communications will be required to install an analog-to-CAN converter. Progressive Insurance Automotive X PRIZE will supply this converter but it is the team's responsibility to provide it with the appropriate signals and calibrate the signals so that the correct data is supplied to the DAS. Definition of these signals and levels will be provided at a later date.

All teams are responsible for ensuring all the required data is correctly and continuously sent to the DAS. The proper functioning of the DAS will be checked at the first vehicle inspection and anytime there is a question concerning the proper operation of this key competition component. It is expected that the DAS and all associated components will be sent to the teams at least ten weeks before the start of the first scored stage. The DAS will record the status of the ESS, on-board fuel consumed, vehicle location and speed, and other vehicle attributes (throttle position, brake position, engine operation, etc.). A complete and detailed list of required DAS signals will be provided at a later date.

#### Telemetry and Reporting

Real-time communication of vehicle position, speed, energy consumption, and other pertinent data is expected to be maintained over all the stages. The DAS will include communications capability for wireless and/or cell phone data communication. Information from all Progressive Insurance Automotive X PRIZE vehicles will be used for race control, scoring, media, and educational purposes (see "[Education and Internet Reporting](#)"). Vehicle data will also be recorded on board throughout each competition day and downloaded to the organizer's and team's computers after each stage. This data will be used for scoring and for ensuring compliance with all Progressive Insurance Automotive X PRIZE procedures and regulations. After the coast-down test, this data will be the only data available to competitors to monitor the functioning of their vehicles.

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### Demonstration Division Requirements, Participation, and Benefits

A separate Demonstration Division is available for manufacturers of high-efficiency vehicles that are currently in production or committed for production and sale in the U.S. or E.U. (and, possibly, other markets).

Here is a summary of the Demonstration Division:

- There is no purse in the Demonstration Division
- Demonstration Division vehicles must be either in production or committed for production and sale in the U.S. or E.U., with production volumes of at least 10,000 vehicles per year (For vehicles not yet in production, there must be a public commitment for production, as well as evidence that production and marketing have been approved and funded)
- As in the Competition Division, vehicle conversions may be entered in the Demonstration Division, again provided that the conversions are either in production or committed for production and sale in the U.S. or E.U., with production volumes of at least 10,000 conversions per year
- Entrance to the Demonstration Division is restricted to vehicles with fuel efficiency of 50 MPGe or greater, as evidenced by official government certifications or sufficient test data (to the satisfaction of the Progressive Insurance Automotive X PRIZE); Demonstration Division entrants must otherwise meet the same specifications and standards as Alternative or Mainstream Class vehicles in the Competition Division
- Demonstration Division vehicles will be tested in substantially the same way as Competition Division vehicles – i.e., they will participate in a significant subset of Progressive Insurance Automotive X PRIZE competition events under the same rules in order to demonstrate and showcase their capabilities and performance
- Vehicles presented as production vehicles in the Demonstration Division must be strictly stock (To the satisfaction of the Progressive Insurance Automotive X PRIZE judges, pre-production prototypes would have to carry the predicted weight equivalent of production vehicles, use production tires, and in general be engineered to perform as expected for the production vehicle; Note that if there is a large subsequent discrepancy in the performance of the production vehicle, the press and the public will take notice.)
- E.U. vehicles in the Demonstration Division must be equipped with front airbags and must have obtained at least a four star EuroNCAP adult crash test rating; In the case of pre-production prototypes, there must be evidence to the satisfaction of Progressive Insurance Automotive X PRIZE judges that the vehicle is likely to obtain at least a four star EuroNCAP adult crash test rating – e.g., based on simulations and engineering calculations and simulations

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### Non-U.S. Vehicles in the Demonstration Division

The restriction that only U.S. and E.U. production vehicles may enter the Exhibition Class arises from the Progressive Insurance Automotive X PRIZE focus on vehicles that are production-capable for the U.S. market, with its strong safety and emissions standards. E.U. vehicles with airbags and a four star EuroNCAP adult crash test rating typically can be adapted for U.S. sale.

The Progressive Insurance Automotive X PRIZE will consider other non-U.S. vehicles for the Exhibition on a case-by-case basis, with the requirement that they are readily adaptable for U.S. sale.

### Demonstration Division Benefits

In general, Progressive Insurance Automotive X PRIZE messaging will promote the Demonstration Division as featuring vehicles or products that are already being sold or will be on the market by the end of 2011.

To reinforce, distinguish, and reward entries in the Demonstration Division, special promotional opportunities will be available:

- Promotion on the Progressive Insurance Automotive X PRIZE website and in Progressive Insurance Automotive X PRIZE materials
- Possibility to display and promote currently-available high-efficiency vehicles at the Progressive Insurance Automotive X PRIZE competition events
- An additional Demonstration Division logo will be provided for use on the vehicle, uniforms, websites, and other promotional materials
- Flagging of Demonstration Division vehicles in all general lists of vehicles on Progressive Insurance Automotive X PRIZE websites and distributed materials, including real-time vehicle tracking and vehicle standings during the Progressive Insurance Automotive X PRIZE Races
- Inclusion on a separate list of Demonstration Division vehicles on Progressive Insurance Automotive X PRIZE websites, including real-time vehicle tracking and vehicle standings during the Progressive Insurance Automotive X PRIZE Races
- Materials about Demonstration Division vehicles would include complete specifications and capabilities, so that consumers can make broadly-informed evaluations of available high-efficiency vehicles
- Website forms or links to submit deposit-backed pre-orders for Demonstration Division vehicles, if available
- One or more [Progressive Insurance Automotive X PRIZE Awards](#) for Demonstration Division vehicles that are tested in Progressive Insurance Automotive X PRIZE competition events
- Additional promotional benefits may also be made available

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### **Demonstration Division Applications, Fees, and Data Submissions**

Applications for the Demonstration Division are welcome from any automotive company that are producing or will be producing high-efficiency vehicles in the very near future.

In recognition of the benefits and promotional opportunities of the Demonstration Division, the entry fee is substantially higher than the entry fee for the Competition Division but can be offset by in-kind contributions that are of relevance and value to the Progressive Insurance Automotive X PRIZE. For more information, [contact](#) the Progressive Insurance Automotive X PRIZE.

Applications for Demonstration Division must contain sufficient information to show that production is in fact intended and feasible. Furthermore, Demonstration Division entrants must make a public commitment to production. Ideally, they should be prepared to accept deposit-backed pre-orders for the vehicle during the course of the Progressive Insurance Automotive X PRIZE, although we recognize that some manufacturers have a general policy not to accept pre-production orders.

Applications must be substantiated by Data Submissions that support vehicle qualification. For existing production vehicles, the data submission must include:

- Specifications showing that the vehicle meets requirements of the Progressive Insurance Automotive X PRIZE Alternative or Mainstream Class (except for MPGe and GHG emissions)
- Evidence that the production vehicle achieves or will achieve at least 50 MPGe
- For existing production vehicles: Evidence of production at a quantity greater than 10,000 per year; If sales are in the U.S., this means that the vehicle complies with applicable NHSTA and other safety requirements, and has passed EPA emissions testing; If sales are in the E.U., this means that the vehicle or modified vehicle complies with all E.U. standards; Furthermore, E.U. vehicles must be equipped with front airbags and have obtained a four star EuroNCAP four star crash test rating
- For planned production vehicles: internal and public commitments for production and sale in quantities of at least 10,000 vehicles per year; for vehicles intended to be sold in the E.U., design evidence that the vehicle will have front airbags and will likely receive a four star EuroNCAP crash test rating

### **Education and Internet Reporting**

In order to maintain the focus on the Progressive Insurance Automotive X PRIZE's high-level goals and to avoid an overly complicated scoring system, various aspects of energy and emissions are not directly addressed in the basic competition requirements and scoring.

With this simplicity come risks that the public will not be exposed to complicated but important underlying issues, and that we could reinforce existing misconceptions.

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Accordingly, we intend to address such issues in the [Progressive Insurance Automotive X PRIZE Education Program](#), which has been funded by a \$3.5M grant from the U.S. Department of Energy (DOE). Key components include:

- Online Interactive Knowledge Center ([www.FuelOurFutureNow.com](http://www.FuelOurFutureNow.com)), which includes a vehicle telemetry-based experience with dashboard, team, and social media gadgets
- National High School Student Contest (*DASH+*)
- Educational Outreach Events

### Prize Development Process

These Guidelines have been developed with generous help from hundreds of individuals, organizations, companies, and government agencies. We solicited input and feedback directly, and we also published Draft Guidelines for public comment. We received well over 1000 comments from the general public, and a number of substantial changes included in these Guidelines are the result of the public's input.

We recognize that some contributors may end up competing, or perhaps advising those who compete, but that is an unavoidable result of engaging with so many experts who have real-world knowledge of the automotive industry. We believe that the Guidelines published here are balanced and credible, and that this would not have been possible without seeking as much feedback as possible from diverse parties, without regard for future possible conflicts. Had we only sought or accepted input from those unlikely to have a future interest in the competition, the result would have been poor Guidelines. Our process has been open, and we do not hide our involvement with any party.

With the publication of these Guidelines, we are adopting a strict no-conflict policy. For example, the Prize Development Advisory Board will be disbanded and we will appoint a conflict-free Prize Administration Advisory Board.

X PRIZE Foundation employees and their families may not participate in nor have a financial interest in Progressive Insurance Automotive X PRIZE teams or vehicles. The X PRIZE Foundation Conflict of Interest Policy covers Officers, Trustees and Vision Circle donors that may have a direct or indirect financial interest in prizes under development or offered by the Foundation. Officers, Trustees and Vision Circle donors are required to disclose possible conflicts and recuse themselves from any relevant deliberations or decisions.

### Acknowledgements

We could not have developed these guidelines without the help of hundreds of individuals, organizations, companies and government agencies (especially the U.S. Department of Energy and Argonne National Laboratory, the U.S. Environmental Protection Agency, and the





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U.S. Department of Transportation). To everyone involved: The Progressive Insurance Automotive X PRIZE team is immensely grateful for your essential and generous assistance.

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# Appendix I – FMVSS-based Vehicle Safety Requirements

### Specific FMVSS-derived Safety Requirements

As mentioned earlier, compliance with certain FMVSS sections cannot be addressed reliably in late stages of design and development – the relevant safety features should be designed-in at the outset. Thus, to assure production capability, the data submissions will need to include design information that addresses relevant FMVSS sections. (Reminder: the data submissions will determine whether or not Progressive Insurance Automotive X PRIZE entrants are admitted to the competition events – see [Summary of Registration, Selection, and Elimination Process](#)).

Note that, for vehicles being developed for the E.U. market (with later potential for U.S. introduction), it should be straightforward to show that the design addresses the critical sections of the FMVSS, provided that the design includes front airbags and is intended to earn at least a four-star EuroNCAP adult crash test rating.

The table at the end of this Appendix lists relevant FMVSS sections and columns that indicate if the section is required for Mainstream Class designs, Alternative Class designs, and Race vehicles.

#### Required for Mainstream or Alternative Class Vehicle Design

A “no” in either or both columns means that compliance is considered to be relatively straightforward, and need not be addressed in the data submissions.

A “yes” in either or both of these columns means that the corresponding data submission for the Qualifying Race must include general information showing knowledge of the FMVSS standard, and demonstrating to the satisfaction of the Safety Judging Panel (SJP) that production vehicles are likely to comply.

Furthermore, a “yes” in either or both of these columns means that the corresponding data submission must include additional information, including:

- [Qualifying Race and Final Race] A list of those FMVSS and other safety-related aspects of the vehicle design that will not be implemented in the race vehicle, and an estimate of the amount of additional weight that would likely result from full implementation and compliance;
- [Final Race] Details on how compliance with the FMVSS section is reflected in the BOM and consistent with a plan for manufacturing at least 10,000 vehicles per year, including available engineering test or simulation data where appropriate

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- [Final Race] Data or other evidence that a crashworthiness analysis has been performed – e.g., calculations or other analysis of the energy that would have to be absorbed in a crash and how it would be absorbed

### Required for Race Vehicles

As mentioned earlier, certain mandated safety equipment can be added via routine engineering prior to production, provided that it has been designed in at the outset. Because of the time and expenses involved, we will not require Race vehicles to include all such equipment. This column indicates the extent to which Race vehicles must comply with the FMVSS section.

In some cases where compliance is not required, the judges may require additional equipment or features that provide partial compliance or otherwise compensate for the lack of FMVSS compliance; the primary objective is to ensure safety during the Races (for example, see [Note 11](#)). Thus, data submissions must be specific about which aspects of the vehicle design will not be implemented in the race vehicle.

Some descriptions of required compensating equipment or features in [Appendix II](#) are informal (“to the satisfaction of the SJP and Race Officials”). We intend to provide more details well in advance of the Races, but in all cases the judgment of the SJP and Race Officials will be final.

In all cases where compliance is required in the vehicle design but not in the Race vehicle, the Race vehicle must carry additional weight to compensate for missing equipment.

## Table of FMVSS-derived Safety Requirements

|   | Required for Mainstream Class Vehicle Design | Required for Alternative Class Vehicle Design | Required for Race Vehicles   |
|---|--|---|--|
| <b>FMVSS - 100 Series (Crash Avoidance)</b>     |  |   |  |
| 101 Controls and Displays                       | No   | No  | No<br>(see <a href="#">Note 1</a> )  |
| 102 Transmission Shift Lever Sequence<br>PRNDL  | No   | No  | No, but must have some indication of current gear                                  |
| Shift Lock                                      | Yes  | Yes   | No   |
| Coast Down                                      | No   | No  | No   |
| 103 Windshield Defrosting and Defogging Systems | Yes  | Yes   | No, but must have satisfactory (see <a href="#">Note 2</a> ) defrost and defogging |

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|  | Required for Mainstream Class Vehicle Design | Required for Alternative Class Vehicle Design           | Required for Race Vehicles   |
|--|--|---|--|
|  |  |   | performance  |
| 104 Windshield Wiping and Washing Systems                      | Yes  | Yes   | No, but must have satisfactory windshield wiper performance  |
| 106 Brake Hoses  | Yes  | Yes   | Yes  |
| 108 Lamps, Reflective Devices and Associated Equipment         | Yes  | Yes   | No, but must have certain basic lighting equipment with satisfactory performance (see <a href="#">Note 3</a> ) |
| 109 New Pneumatic Tires (and 119, 129, and 139, as applicable) | Yes  | Yes (see <a href="#">Note 4</a> )                       | Yes (see <a href="#">Note 4</a> )  |
| 110 Tire Selection and Rims (and 120)                          | Yes  | Not Applicable (except for 4-wheel vehicles)            | Yes (see <a href="#">Note 5</a> )  |
| 111 Rearview Mirrors   | Yes  | Yes   | Yes (see <a href="#">Note 6</a> )  |
| 113 Hood Latch System  | Yes (if hood could block view)               | Yes (if hood could block view)                          | Yes (if hood could block view)   |
| 114 Theft Prevention   | No   | No  | No   |
| 116 Hydraulic Brake Fluids                                     | Yes  | Yes   | Yes  |
| 118 Power-Operated Window Systems                              | No   | No  | No   |
| 119 Motorcycle Tires (for motorcycles)                         | Not Applicable                               | See 109   | See 109  |
| 120 Tire Selection and Rims                                    | Not applicable                               | See 110   | See 110  |
| 122 Motorcycle Brake Systems                                   | Not applicable                               | Yes (for vehicles with fewer than 4-wheels)             | (see <a href="#">Note 7</a> )  |
| 123 Motorcycle Controls and Displays                           | Not applicable                               | No  | See 101  |
| 124 Accelerator Control Systems                                | No   | No  | No   |
| 126 Electronic Stability Control                               | Yes (see <a href="#">Note 8</a> )            | Yes, for 4-wheel vehicles (see <a href="#">Note 8</a> ) | No, but must have satisfactory stability   |
| 129 New Non-Pneumatic Tires for Passenger Cars                 | See 109                                      | See 109   | See 109  |
| 135 Passenger Car Brake Systems                                | Yes  | Yes, for 4-wheel vehicles                               | (see <a href="#">Note 9</a> )  |
| 138 Tire Pressure Monitoring Systems                           | No   | No  | No   |
| 139 New Pneumatic Radial Tires for Light Vehicles              | See 109                                      | See 109   | See 109  |
| <b>FMVSS - 200 Series (Crashworthiness)</b>                    |  |   |  |
| 201 Occupant Protection in Interior                            | Yes  | Yes   | No   |

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|   | Required for Mainstream Class Vehicle Design | Required for Alternative Class Vehicle Design | Required for Race Vehicles   |
|---|--|---|--|
| Impact  |  |   |  |
| 202a Head Restraints  | No   | No  | No, but must have satisfactory head restraints                                 |
| 203 Impact Protection for Driver Steering Controls                            | No   | No  | No   |
| 204 Steering Control Rearward Displacement                                    | No   | No  | No, but must have satisfactory basic protection (see <a href="#">Note 10</a> ) |
| 205 Glazing Materials   | Yes  | Yes   | No   |
| 206 Door Locks and Retention Components                                       | No   | No  | No   |
| 207 Seating Systems   | No   | No  | No   |
| 208 Occupant Crash Protection (e.g., seat belts, air bags, advanced air bags) | Yes  | Yes   | No, other than seat belts (see <a href="#">Note 11</a> )                       |
| 209 Seat Belt Assemblies  | Yes  | Yes   | No, other than seat belts (see <a href="#">Note 11</a> )                       |
| 210 Seat Belt Assembly Anchorages   | Yes  | Yes   | No   |
| 212 Windshield Mounting   | Yes  | Yes   | No   |
| 214 Side Impact Protection  | Yes  | Yes   | No   |
| 216 Roof Crush Resistance   | Yes  | Yes   | No   |
| 219 Windshield Zone Intrusion   | No   | No  | No   |
| 225 Child Restraint Anchorage Systems   | No   | No  | No   |
| <b>FMVSS - 300 Series (Post Crash Protection)</b>                             |  |   |  |
| 301 Fuel System Integrity   | Yes (if applicable)                          | Yes (if applicable)                           | No, but must have satisfactory protection (See <a href="#">Note 12</a> )       |
| 302 Flammability of Interior Materials  | No   | No  | No   |
| 303 Fuel System Integrity of Compressed Natural Gas Vehicles                  | Yes (if applicable)                          | Yes (if applicable)                           | No, but must have satisfactory protection (See <a href="#">Note 12</a> )       |
| 305 Electric Powered Vehicles   | Yes (if applicable)                          | Yes (if applicable)                           | No, but must have satisfactory protection (See <a href="#">Note 12</a> )       |
| 401 Interior Trunk Release  | No   | No  | No   |

#### Notes to the Table of FMVSS-derived Safety Requirements

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**Note 1:**

Race vehicles must have basic interior displays, including: fuel supply indicator(s), turn signal indicator(s), speedometer, and illumination for night driving.

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**Note 2:**

Here and elsewhere in the Table, the term “satisfactory” means generally to the satisfaction of the SJP and Race Officials. We intend to provide more details well in advance of the Races, but in general and the SJP and other Race Officials will have the authority to require teams to modify their vehicles to assure an adequate level of safety in Race vehicles. The judgments of the SJP and Race Officials will be final.

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**Note 3:**

Minimum lighting equipment includes headlamps, tail lamps, brake lamps, front and rear turn signals, and corner reflectors. Some portions of the Races will be run with lights on.

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**Note 4:**

To ensure the use of tires that would be acceptable to consumers, in addition to complying with FMVSS No. 109, 119, or 139 as applicable, pneumatic tires used on Race vehicles must at a minimum have a traction rating of B and a treadwear rating of 100 under the Uniform Tire Quality Grading Standard (UTQGS), 49 CFR 575.104.

Alternative Class vehicles that are technically motorcycles may use but are not required to use motorcycle tires regulated by FMVSS No. 119. If passenger car tires are used, they must comply with FMVSS No. 109, 129, or 139, as applicable.

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**Note 5:**

Tire pressures must be within the range specified by the tire manufacturer.

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**Note 6:**

Although NHTSA is aware of the technical developments regarding cameras for side and rear views, and it recognizes the potential fuel-economy benefits of dispensing with external mirrors, the agency has advised the Progressive Insurance Automotive X PRIZE that it is

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unlikely that FMVSS No. 111 will be amended accordingly within the next few years, in part due to the absence of data demonstrating that there will be no adverse safety consequences.

We therefore require that vehicles be equipped in accordance with FMVSS No. 111. However, external mirrors may be retracted during the Race if the vehicle is equipped with a camera system that provides the required field of view to the driver. Information derived from the operation of such dual-mode systems may provide data to support future rulemaking changes to FMVSS No 111.

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### Note 7:

For Alternative Class vehicles with fewer than 4 wheels, race vehicles must meet the fade and recovery and other performance tests specified by FMVSS No. 122 **except** :

#### *S5 Requirements*

- S5.1.2.2 Reservoir labeling
- S5.7.2 Water recovery test
- S7.10 Service brake system – water recovery test

See also the braking requirements in "[Vehicle Performance](#)".

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### Note 8:

Although the phase-in provisions for FMVSS No. 126 do not require compliance until August 2011 (one year after the Final Race), 4-wheel production vehicles based on Progressive Insurance Automotive X PRIZE entries will likely have to comply. We therefore require that compliance be designed-in. See also "[Vehicle Stability](#)".

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### Note 9:

Mainstream and Alternative race vehicles with 4 wheels must meet a fade and recovery and other performance tests specified in FMVSS No. 135 (Progressive Insurance Automotive X PRIZE will use the Consumers Union brake fade test), **except**.

#### *S5 Equipment requirements*

- S5.2 Parking brake
- 3.2 Race vehicles may be equipped with a separate control for ABS
- S5.4.3 Reservoir labeling
- S5.5.1 (c) Parking brake
- S5.5.1 (d) brake lining wear



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### *S6 General test conditions*

#### S6.3.1.1 GVWR

S6.4.2 Brake line pressure measurement for torque wheel test

S6.4.3 Brake torque measurement for torque wheel test

### *S7 Road test procedures and performance requirements*

S7.2 Wheel lock sequence

S7.3 ABS

S7.4 Adhesion utilization

S7.5 Cold effectiveness (GVWR)

S7.6 High Speed Effectiveness (GVWR)

S7.7 Stops with engine off

See also the braking requirements in "[Minimum Requirements for All Vehicles](#)".

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#### **Note 10:**

FMVSS No. 204 is not critical for safety in modern vehicles, primarily due to the existence of air bags in those vehicles. However, since we are not requiring Race vehicles to be equipped with air bags, we will require some protection (satisfactory to the SJP) to reduce steering wheel and column movement during a frontal impact. This could perhaps be accomplished with a simple collapsing column or by adding some U-joints and intermediate shafts to the steering system.

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#### **Note 11:**

At the discretion of the SJP (during the consideration of data submissions), Race vehicles may be required to have an approved 4- or 5-point restraint system for the driver and one passenger from a reputable firm that is manufactured in accordance with SFI 16.1.

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#### **Note 12:**

As indicated, Race vehicles will not be required comply with FMVSS Nos. 301, 303, or 305, but will have to provide fuel-system protection to the satisfaction of the SJP and Race Officials (in particular, with respect to possible leakage in a crash). Note that Section 305 is being revised.

Moreover, with respect to newer technologies that were not mature when the current FMVSS sections were adopted (e.g., Lithium-Ion batteries and fuel cells), the SJP and Race Officials

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will consider factors and criteria that are not covered in the existing standards. See the Section "[Fuel System Safety Requirements](#)"

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# Appendix II – Outline of Judging Procedures for Data Submissions

### Introduction

Admission to the competition events will be based on the decisions of Progressive Insurance Automotive X PRIZE Judging Panels that evaluate the team Data Submissions.

Certain vehicles that complete the Progressive Insurance Automotive X PRIZE competition events will be eligible for the Progressive Insurance Automotive X PRIZE Awards and a set of second-tier awards to recognize and highlight progress in specific areas that are relevant to our desired outcomes.

Here we describe the Judging Panels and judging procedures, with a general framework that is common to the judging of both the Data Submissions and the Progressive Insurance Automotive X PRIZE Awards.

In formulating the Progressive Insurance Automotive X PRIZE judging procedures, we have drawn substantially from the process for committee membership and deliberations developed by ASTM International (<http://www.astm.org>).

### Goals for Progressive Insurance Automotive X PRIZE Judging

Our goals are as follows:

- There should be a small number of Panels
- The area of responsibility (domain) of each Panel should be clearly defined
- There should be a clear (and accepted) responsibility for the considerable work that will be needed to evaluate team submissions and form an initial recommendation
- Diverse viewpoints should contribute to a Panel's decisions
- Judging procedures should be simple and easy to administer
- Judging procedures should facilitate reaching consensus, with disagreements and objections aired and processed in a fair and a disciplined way
- There should be an appeals procedure

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### Progressive Insurance Automotive X PRIZE Competition Judging Panels and Procedures

#### Competition Judging Panels

To select vehicles for the competition events, there will be two Progressive Insurance Automotive X PRIZE Judging Panels, the Technical Panel and the Business Panel, covering the following topics:

##### Technical Panel

- Safety, Emissions
- Manufacturability, Cost
- Features

##### Business Panel

- Business Plan

#### Panel Members

Panel members, referred to as Judges, will be responsible for reviewing and analyzing the team submissions, making recommendations, and voting in final selections (Pass or Fail).

The Panels will be comprised of representatives of Progressive Insurance Automotive X PRIZE, and of recognized domain experts. Progressive Insurance Automotive X PRIZE will endeavor to achieve a balanced representation from commercial, non-profit, academic, and government organizations. In order to insure real-world expertise, Panel membership will include individuals with experience in the automotive industry, in advanced vehicle powertrain technologies, and in conducting automotive competitions. Panel members may not have a direct conflict of interest.

#### Admission to the Progressive Insurance Automotive X PRIZE Races

Each Panel will evaluate the team Data Submissions on a Pass/Fail basis with respect to the Panel's domain. To be admitted to the next stage of the competition, a team must achieve an unconditional Pass from both Panels.

#### Judging Procedure

To evaluate a Team's vehicle Data Submission, each Panel will work towards a Pass/Fail result by means of the following procedures:

The individual Panel Members will begin by independently reviewing the Data Submissions of the teams assigned to them, and rating their section(s) of the submission with a points system

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as well as assigning an overall Pass or Fail. Every section of each data submission will be reviewed individually by at least three Judges, without dialog between the Judges.

The results of these multiple, individual Pass/Fail evaluations will be tallied and readied for review within the larger pool of Judges.

Next, the entire group of Judges is convened to review those results, focusing on one team at a time. The three or more Judges who had reviewed that particular team independently will then present the rationale for their Pass/Fail decision to the entire group.

If all of the Judges from both the Technical and Business Panels who had reviewed that particular team are in agreement as to either Pass or Fail, and there are no dissensions among the other Judges, then the unanimous Pass or Fail will hold.

If the Judges reviewing the Team data independently do not come to the same conclusion re Pass/Fail, then there will be further discussion. To establish a Pass, all Judges must ultimately agree on a Pass vote. A Pass may also be granted when all Judges agree, but with the understanding that certain requirements must also be met by the Team, within a reasonable amount of time. Such requirements may include supplying of additional information, or making simple revisions to the vehicle. The Team will be notified of Pass status, but also are put on notice for being "Deficient" in certain areas, and the requirements, including timing, for correction. Failure by the team to follow-through as requested will reverse their Pass status to Fail and result in their disqualification from the Competition.

If all Judges cannot come to a Pass agreement in their discussions within their Panel, that Panel's vote will be a Fail. A Fail from one or both panels will give the Team an overall Fail.

### **Appeals**

Teams that receive a Fail from one or both Panels, and thus an overall Fail decision, can appeal the decision in writing. Each appeal will be reviewed by the Technical and/or Business Panel as required.

If the appeal is accepted as Pass by both of the Panels, then the Team will Pass overall, and will be allowed to move on to the next stage of the competition.

If an appeal is rejected by either or both of the Panels, the team will have no further right of appeal, and the original Fail decision will hold. That team will NOT be allowed to move on to the next stage of the competition.

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### Progressive Insurance Automotive X PRIZE Awards Judging Panel and Procedures

#### Progressive Insurance Automotive X PRIZE Award Nominations

The Progressive Insurance Automotive X PRIZE Administration will nominate up to [3] vehicles as candidates for each Progressive Insurance Automotive X PRIZE Award. The nomination process is yet to be determined, but will be based on the input from the Competition Judging Panel, other experts as appropriate, and possibly the general public.

#### Progressive Insurance Automotive X PRIZE Awards Judging Panel

Special Judging Panels will be formed to review Progressive Insurance Automotive X PRIZE Awards candidate vehicles in the various categories, and to determine award winners.

#### Panel Members

Each Progressive Insurance Automotive X PRIZE Awards Judging Panel will comprise representatives of Progressive Insurance Automotive X PRIZE and recognized subject-matter experts. The mix of selected Panel members will be appropriate to the individual award category. Progressive Insurance Automotive X PRIZE will endeavor to achieve a balanced representation from commercial, non-profit, academic, and government organizations. Panel members may not have a direct conflict of interest

#### Judging Procedure

The Panel will determine the winner using a judging procedure similar to that outlined [earlier](#) for Competition Judging Panels: Judges will initially review and evaluate each candidate independently, before entering into shared discussion with the other Judges and voting.

There will be no right of appeal for Progressive Insurance Automotive X PRIZE Awards.

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### Appendix III – Frequently Asked Questions

#### Energy and Emissions

##### Energy and Fuel Economy

###### What is the basic reasoning behind the two figures of merit?

No approach is ideal in every respect, so compromises were needed. There were pros and cons for all proposed figures of merit. In general we would have liked to have a single figure of merit that:

- Has a sound technical basis
- Is simple to explain
- Is simple to justify
- Is consistent with our high-level goals
- Is consistent with existing consumer intuition
- Has a numerical goal that is a stretch goal but achievable, ideally a nice round number

We did not find a suitable single figure of merit. We considered how we might have a single figure derived in a specified way from a small number of independent figures of merit, but also did not find a suitable approach. We also considered various point-accumulation schemes but decided that was too complicated to explain and justify. We settled on the two figures of merit as a reasonable combined approach.

A main Progressive Insurance Automotive X PRIZE focus is to stimulate innovation in vehicles. Vehicle designers strongly urged us to have at least one figure of merit that depends only on things they can control - thus, they were in favor of pump-to-wheels (PTW) rather than wells-to-wheels (WTW) efficiency. Designers have little or no control over wells-to-pump efficiencies. Furthermore, estimating upstream fuel efficiency is complicated and involves controversial assumptions and predictions.

We settled on the combination of pump-to-wheels (PTW) MPGe and wells-to-wheels (WTW) GHG emissions for these reasons, and also because wells-to-pump efficiencies are in many cases addressed indirectly by the WTW GHG requirements.

###### Why use MPGe rather than a more direct measure of how much petroleum is used?

Accounting for total petroleum usage is difficult – it depends on many debatable assumptions about the economics, production methods, and availability of alternative fuels. Regardless, gasoline will likely be the primary automotive fuel for the short term. Higher MPGe will in fact mean lower petroleum use. In the long term, a mixture of energy sources will fuel transportation, and we will need to use ALL of them as efficiently as possible. In short, this is



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about doing more with less – vehicles using energy efficiently, wherever that energy comes from.

### Why measure fuel economy pump-to-wheels rather than wells-to-wheels?

Consumers understand pump-to-wheels measures – nobody does a wells-to-wheels calculation when they refuel. Furthermore – from a technical viewpoint – we wanted to have an unambiguous, soundly-based, figure-of-merit that depends only on things the vehicle designer can control. A main Progressive Insurance Automotive X PRIZE focus is to stimulate innovation in vehicles, and vehicle designers have little control over wells-to-pump efficiencies. Also, upstream fuel efficiencies are ambiguous as they involve controversial and changing-in-time assumptions and predictions on which proponents of different fuels rarely agree. . An additional point is that wells-to-pump efficiencies are in many cases addressed indirectly by the Progressive Insurance Automotive X PRIZE requirement on total wells-to-wheels CO2 emissions (see below).

### Don't Electric Vehicles have a huge advantage?

A common criticism of MPGe is that it gives electric vehicles (EVs) an inherent advantage because it does not account for the low efficiency of the current electric grid, an advantage exacerbated by the inherent high efficiency of electric motors. There's validity to this criticism (addressed below), but it's specious to base it on the assertion that – unlike other fuels – electricity is just an energy carrier resulting from burning fuel (e.g., coal) upstream.

Yes, electricity is an energy carrier. But so is every other fuel, by definition; that's just physics. Fuels of any type provide potential energy that is converted to kinetic energy by a vehicle's engine, be it an electric motor, an internal combustion engine, a steam engine, etc.

Furthermore, every practical vehicle fuel today results from upstream energy conversions that involve burning some other fuel. Gasoline, for example, is produced from crude oil in refineries that burn and pollute (obvious to anyone who has driven by a refinery); additional fuel is burned during the extraction of crude oil, during its transportation to a refinery, and during the transportation of the gasoline to a station near you. Producing ethanol from corn seeds involves burning fuel during farming, during the production and distribution of fertilizer, etc.

So, in terms of upstream energy conversions, there is no fundamental difference between electricity and gasoline – there's just a difference of degree. Indeed, as mentioned above, the difference is substantial for the current electric grid, so from this single viewpoint electricity has an MPGe advantage. But there are balancing factors.

As many have pointed out, one could avoid the issue by including estimates of upstream energy conversion losses in the definition of MPGe – i.e., defining it on a wells-to-wheels basis rather than a pump-to-wheels basis. We decided against this for several reasons.

For one thing, consumers understand pump-to-wheels measures – nobody does a wells-to-wheels calculation when they refuel. For another – from a technical viewpoint – we wanted to have an unambiguous, soundly-based, figure-of-merit that depends only on things the vehicle

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designer can control. This is because a main focus of the Progressive Automotive X PRIZE is to stimulate innovation in vehicles, and vehicle designers have little control over wells-to-pump efficiencies. Furthermore, upstream fuel efficiencies are ambiguous as they involve controversial and changing-in-time assumptions and predictions on which proponents of different fuels rarely agree. So, a wells-to-wheels definition of MPGe would result in estimates rather than measured values.

Finally, we do not ignore wells-to-pump efficiencies and upstream fuel burning – these are addressed directly and indirectly by the second X PRIZE figure of merit, a cap of 200 g/mi on total wells-to-wheels greenhouse gas (GHG) emissions. Relative to gasoline vehicles, this GHG requirement is a disadvantage for EVs. To meet the GHG requirement, EVs will have to exceed our 100 MPGe threshold by about 20%. Critics of EVs point out that a 100 MPGe gasoline vehicle has even lower WTW GHG emissions (roughly 115 g/mi). However, a 3.75 mi/kWh (128 MPGe) EV running off the estimated 2014 California grid can match this (see the Progressive Insurance Automotive X PRIZE [energy and emissions spreadsheet](#), described [here](#)).

While electric motors are inherently more efficient than internal combustion engines (roughly twice as efficient), EV battery-packs are heavy (especially for longer range vehicles), which reduces overall efficiency. And EVs have a variety of other disadvantages (range, recharge time, and battery cost) that make the Mainstream Class requirements a stretch goal (including 200 mile range, production-capable at reasonable costs for 10,000 units per year).

It is difficult to be certain how these advantages and disadvantages balance out, and EV critics may believe that EVs retain an overall advantage. On the other hand, EVs have great value in displacing petroleum (one of our goals) – indeed, the wells-to-wheels use of petroleum by EVs is roughly 90% less than that of gasoline.

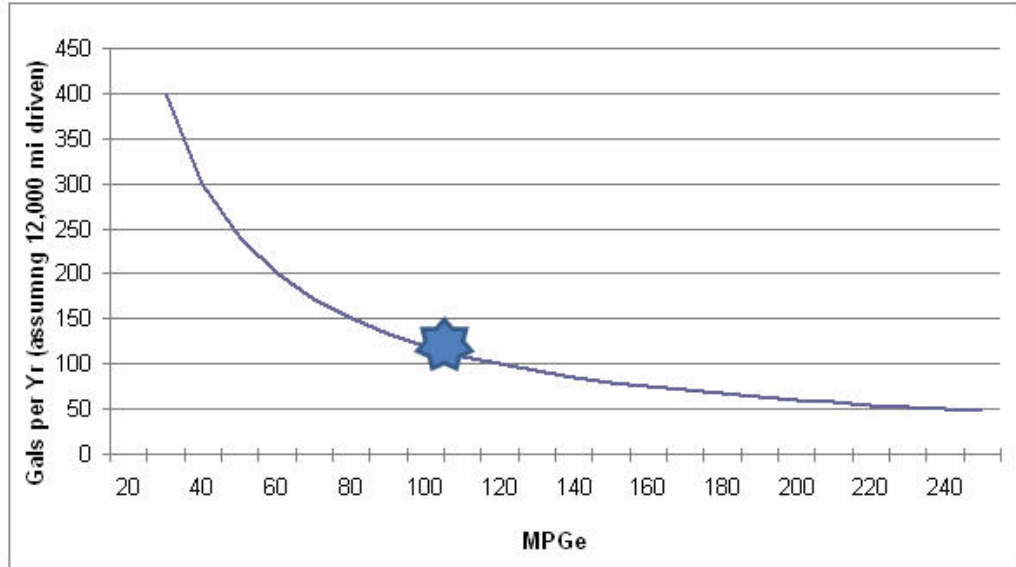
### Why 100 MPGe, why not reward greater fuel economy?

It is true that an increase in fuel economy (more miles per gallon) saves fuel (gallons per mile). But the inverse relationship means that greater fuel economy yields diminishing returns.

Here is an example: At 20 MPG, it takes 5 gallons to go 100 miles. At 100 MPG it takes 1 gallon so you save 4 gallons. Double it to 200 MPG and it takes ½ gallon, so you save only ½ gallon more. In fact, an 80 MPGe vehicle achieves 94% of the energy savings as a 100 MPGe vehicle.

Another way to look at this is in terms of the amount of gas used in typical 12,000 miles of annual driving:

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Thus, for example, achieving 150 MPGe, offers only a relatively modest increase in fuel saved, but likely at the expense of the features, performance, and safety that are needed to make these cars attractive to consumers.

Consumers increasingly want cars that are extremely fuel-efficient and environmentally-friendly, but they don't want to sacrifice performance. By having a 100 MPGe threshold with a speed race as the basic challenge, we are assuring that the winning vehicle will have close to 4x today's CAFE fuel economy standard, but are also encouraging designers to focus on comfort, performance, and safety.

If we set the bar much higher (say 150 MPGe), there would not be a drastic increase in fuel saved, but (given our understanding of today's technology) there would be significant increased development costs and time-to-market, as well as likely reduction in comfort and other customer-focused features. We would prefer to see many teams bring desirable vehicles to market soon that are 4x more efficient than today's vehicles than very few entrants bring undesirable vehicles to the market far in the future even if they are 6x more efficient.

### Why isn't MPGe defined in terms of "utility factors" or other drive cycle variables?

Replacing the traditional MPG (miles-per-gallon of gasoline) is not straightforward – in addition to the complexities introduced by the new fuels and vehicle technologies, the fuel economy that a consumer can expect will become a stronger function of how they drive and how far they drive ("drive cycle"). For example, measuring fuel economy over the traditional EPA city and highway drive cycles does not suffice for plug-in-hybrid electric vehicles (PHEVs) because the fuel economy of PHEV's depends very strongly on driving distance – driving 30 miles in the city typically will result in vastly different fuel economy than driving 70 miles in the city (which is not the case for pure gasoline-powered vehicles).

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One approach to dealing with these issues is to define a new “MPG” in a manner that incorporates aspects of the drive cycle (“MPG” in quotes to distinguish it from the traditional MPG that consumers understand). An example is the J1711 standard under development by SAE International, which includes “utility factors” that distinguish between periods when vehicles are in charge-depleting (vehicle running on battery power only) vs. charge-sustaining (gasoline fuel consumed) modes.

For the Progressive Insurance Automotive X PRIZE, we are not taking this approach. We think it is very important that the basic figure of merit for fuel economy has a simple definition, so that consumers can understand it. MPGe is easy to explain, it accounts in a neutral manner for any combination of fuels, and it reduces to the familiar MPG in the case of gasoline fuel only.

Another advantage of MPGe is that it is defined independent of any particular drive cycle. This also makes MPGe relatively simple to explain. And it allows the drive cycle to be reported as additional information, which is appropriate given the increasing complexity and importance of drive cycles mentioned above.

Here’s an analogy based on the traditional MPG for pure gasoline cars: Consumers understand MPG easily, as it only depends on how far they drive and how much gas they use – just divide the miles driven by the gallons of gas consumed. When EPA publishes city and highway MPG numbers, the MPG is computed in exactly this way, but based on driving carefully-chosen city/highway drive cycles. Similarly, MPGe is a simple efficiency measure that’s computed independent of drive cycle, and can be reported together with information about the drive cycle over which it is measured.

In the Progressive Insurance Automotive X PRIZE, we will measure fuel economy using MPGe, but will be choosing competition stage lengths and other driving constraints that in effect achieve drive cycles that are good representations of consumer driving.

### Why not judge vehicles based on operating costs?

Many have suggested that we use cost-per-mile rather than MPGe as the primary figure of merit for judging Progressive Insurance Automotive X PRIZE vehicles. That is appealing, since out-of-pocket costs are a primary concern of most consumers (although we hope they are also concerned about the costs to society of fuel-related energy consumption and emissions). But while cost-per-mile is appealing in principal, in practice there are disadvantages, including:

- The traditional (gasoline only) MPG is well understood by the public (and generalizing the concept via MPGe is a straightforward proposition), but studies have shown that translating MPG into cents/mile takes place in less than 5% of households
- 100 MPGe is a meaningful, round number – it is hard to imagine too many headlines about 3 cents per mile
- Cost-per-mile does not just depend on a vehicle’s efficiency – it depends very much on when you buy fuel and where you buy fuel, making cost-per-mile figures

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problematic for consumers, and problematic as a means for comparing vehicle technology

We chose MPGe because it makes sense as a generalization of the familiar MPG, and because we wanted an unambiguous, soundly-based, figure-of-merit that depends only on things the vehicle designer can control. We then supplemented MPGe with our second figure-of-merit, "wells-to-wheels" greenhouse gas (GHG) emissions, which addresses environmental and other concerns.

That said, during the competition we will publish numerous figures of merit in order educate consumers about many aspects of the competition vehicles, likely including:

- MPGe (also used for scoring)
- GHG emissions (also used for scoring)
- GPM<sub>e</sub> – gallons-per-mile energy equivalent (this is 1/MPGe)
- MPG – miles-per-gallon of liquid fuel, typically gasoline
- GPM – gallons-per-mile of liquid fuel, typically gasoline (this is 1/MPG)
- Amount of petroleum used (wells-to-wheels – i.e., including production and distribution)
- Amounts of all fuels used
- Fuel cost per mile (based on current national average prices)

### What is the justification for the vehicle range requirements?

For the Alternative Class, some have argued that our range requirement should only be 50 miles, which is roughly the average for daily driving miles. However, we believe strongly that the range has to be significantly more than average daily miles or the market will be very limited. Most people want reserves in case of traffic, changed plans, emergencies, and the like.

The situation is different for trips over 200 miles - those are rarely done on the spur-of-the-moment. As for why existing mainstream vehicles tend to have 300-400 mile ranges, the cheeky but true answer is "cause they can" - gasoline is energy-dense. Manufacturers offered and people bought those cars because there's no huge penalty for the extra range, as has also been the case for the ability to tow a boat or trailer.

Thus, we feel that 200 miles minimum range is the right number for the Mainstream Class. It's true that higher-range vehicles are attractive for some consumers, but the same is true for vehicles that exceed our requirements for braking, acceleration, cargo capacity, etc.

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### Greenhouse Gas Emissions

Why cap CO<sub>2</sub>e emissions rather than scoring the competition using CO<sub>2</sub>e, so as to reward vehicles with a lower carbon footprint?

In principle, it is attractive to score vehicles based on actual total CO<sub>2</sub>e, but there are many reasons why doing so is not practical and could distract from the main Progressive Insurance Automotive X PRIZE goals, for example:

- Accounting for upstream carbon emissions involves controversial, uncertain assumptions and predictions, especially for electricity, biofuels, and generally for renewable energy sources. It would be difficult to address infrastructure issues (fuel availability and cost) and differences in fuel production methods.
- We do not want to bias the Progressive Insurance Automotive X PRIZE towards any particular fuel or drive train. Using today's national averages for upstream GHG contributions could provide an unfair advantage for ethanol and biofuels and an unfair disadvantage for diesel and electricity.
- Scoring wells-to-wheels CO<sub>2</sub>e would stimulate gaming based on fuel choices, and raise the probability that the winner may win using fuel not generally available to the public and furthermore may not be the most efficient vehicle.

Why use both MPGe and a CO<sub>2</sub> cap rather than a single, carbon-based figure of merit?

We chose to use both MPGe and a CO<sub>2</sub> cap as Progressive Insurance Automotive X PRIZE figures of merit for several reasons, including:

- We want to highlight the importance of energy efficiency (see the FAQ "[Why use MPGe rather than a more-direct measure of how much petroleum is used?](#)")
- As a measure that is directly meaningful to consumers, we want to popularize MPGe as a replacement for MPG
- 100 MPGe is a nice round number; it will resonate with the public and press, so we do not want to give it up (see also the FAQ "[Why not judge vehicles based on operating costs?](#)")
- A single, carbon-based figure of merit would introduce the contentious issues discussed in the FAQ "[Why cap CO<sub>2</sub>e emissions rather than scoring the competition using CO<sub>2</sub>e, so as to reward vehicles with a lower carbon footprint?](#)"
- The CO<sub>2</sub>e cap will make sure that Progressive Insurance Automotive X PRIZE winners help to promote a future low-carbon transportation sector
- Fuel economy and carbon emissions are not always linked and lower wells-to-wheels GHG emissions do not necessarily mean higher fuel economy (For example, biofuels tend to have low GHG emissions and can even have negative GHG emissions, yet may power energy-inefficient vehicles; Thus – although this would not be practical on

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a large scale in the Progressive Insurance Automotive X PRIZE time frame – GHG emissions could be lowered by switching fuels even if MPG is not improved.)

### What is the justification for the cap value of 200 g/mi CO<sub>2</sub>e?

As one Progressive Insurance Automotive X PRIZE advisor put it, "*There cannot be a bad CO<sub>2</sub> outcome from 100 MPGe.*" Nevertheless, having an additional cap on CO<sub>2</sub>e will prevent unintended consequences, and is consistent with goals for public education. We believe the value of 200 g/mi provides a good balance – it is high enough to permit electricity and diesel to compete fairly, and low enough to ensure that winning (100 MPGe) vehicles will have a carbon footprint considerably lower than the average vehicle today.

### **Race Concept and Course Design**

#### Doesn't "speed wins" send the wrong message?

We want designers to create cars that are not only efficient, but perform well and are fun to drive. People will not buy cars that don't perform well. Our goal is to influence the market. Negative reactions to our "efficiency plus performance" message come primarily from people who don't approve of America's car culture; but that culture is the context for the Progressive Insurance Automotive X PRIZE. Some related points:

- Beyond 100 MPGe, increased efficiency does not yield proportionally more benefits (oil addiction, climate change); (see the question "[Why 100 MPGe, why not Reward Greater Fuel Economy?](#)")
- Efficiency only is boring to the media and public; Having a car "race" as part of the prize concept is important for sponsorship, media partners, and public interest
- We are not just pandering – we expect teams will have to make tradeoffs throughout the race between speed and fuel efficiency (This is highly educational and we think that our "go as fast as you can, provided you maintain a high average MPGe" provides a great balance while retaining creativity)
- The fastest car that gets high mileage will likely get even better mileage at lower speeds, so in fact it will probably also be the best car from the efficiency viewpoint
- If we were to specify a minimum average speed and have the highest mileage car win, the vehicle designs would be more likely to be gamed (by designing them to have maximum efficiency at the given required average speed and then driving them carefully to stay close to that speed)

### **Production Capability**

#### How can you influence the market without requiring actual vehicle sales?

There are significant disadvantages to making the Progressive Insurance Automotive X PRIZE a "sales race," including:



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- If the sales race were held in the near term, it would limit innovation (Risk aversion, traditional vehicle development cycles, and regulatory-approval cycles are such that we would get little innovation beyond what is already emerging from the laboratory today.)
- Unfortunately, the concept of a sales race is not compelling to the media, and not nearly as compelling as a real-world stage race (To have maximum market impact, we must maximize media engagement in, and exposure of, the Progressive Insurance Automotive X PRIZE competition. Thus, a sales race would make it harder to attract sponsors and media partners, which in turn would limit the substantial indirect benefits of the Progressive Insurance Automotive X PRIZE – publicity that attracts entrants, public education, private investment, acquisition, recruitment, etc.)
- A sales race creates an unfair advantage for established automobile manufacturers (momentum and experience, supplier and distribution relationships, fleet sales, sales networks, budgets for sales incentives and advertising, etc.), and would run counter to our goals of providing a fair and level playing field for all competitors

In addition, we believe the Progressive Insurance Automotive X PRIZE will have significant, indirect market influence that leads to vehicle sales, including:

- Fostering conditions that make investments more likely, whether in startups or at existing companies
- Providing a stage for competing vehicles to establish or build a brand and reputation
- Teams being recruited and vehicles being acquired by established companies, leading to their innovations being built and sold
- Inspiring the next generation of automotive engineers
- Pushing innovation, whether through new technologies and materials or through novel methods of production and distribution
- Inspiring the existing automotive industry to adopt a more entrepreneurial spirit and risk innovation
- Changes in public perceptions and value systems, making efficiency a value worth spending money on