

DRAFT COMPETITION GUIDELINES

VERSION 6.0

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INTRODUCTION

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

AXP is a new prize that is currently under development by the [X PRIZE Foundation](#). Prior to making a final decision on launching the prize, we are entering a sixty-day public comment period on the Guidelines contained in this document. Our goal in doing so is to obtain valuable feedback that will help us to create final, detailed prize rules and inform the launch decision.

To comment on these draft Competition Guidelines, please use this [form](#) on our website.

GUIDING PRICIPLES

Throughout the [prize development process](#), we have been guided by the principles that the AXP must:

- 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
- Be simple to understand and easy to communicate
- Benefit the world - this is a global challenge
- Result in real cars available for purchase, not concept cars
- Remain independent, fair, non-partisan, and technology-neutral
- Provide clear technical boundaries (i.e., for fuel economy, emissions, safety, performance, cost, features, feasibility, etc.)
- Offer a "level playing field" that attracts both existing automobile manufacturers and newcomers
- Attract a balanced array of private investment, donors, sponsors, and partners to help competitors succeed (e.g., manufacturing assistance, testing resources, etc.)
- Make heroes out of the competitors and winner(s) through unprecedented exposure, media coverage and a significant cash award
- Educate the public on key issues

Simplicity is paramount. Every additional complexity makes the competition harder to understand, harder to manage, and harder to promote. Complexity also invites gaming by competitors. We must resist the tendency to over-engineer the AXP rules – this is a case where perfection is the enemy of the good.

Overall, we are looking for a balance that makes the AXP simple, fair, technology-neutral, and likely to result in a vehicle that is feasible to bring to market. We need this balance to attract strong teams and engage the public. Our principles will sometimes be in conflict, and we hope that all involved will understand the need for flexibility and compromise.

We hope that the public will keep these principles in mind when commenting on these Guidelines, as we will continue to be guided by them throughout the development and administration of the AXP.

OVERVIEW OF THE AUTOMOTIVE X PRIZE

Here we give an overall summary of the AXP. Details are covered elsewhere in this document.

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

A multi-million dollar¹ cash purse will be awarded to the teams that win a long-distance stage race for clean, production-capable vehicles that exceed 100 MPG equivalent (MPGe)².

The AXP will encourage production-capable vehicles and products (not concept cars) through tough entrance requirements, judging criteria, and race courses that test and reward manufacturability, marketability, safety, durability and performance.

The AXP will devote considerable traditional and online media resources to public outreach, education, and involvement.

ENERGY AND EMISSIONS REQUIREMENTS

AXP winners must achieve the following energy and emissions requirements:

- Fuel economy (energy efficiency): at least 100 MPGe
- Total (wells-to-wheels³) Greenhouse Gas (GHG) emissions expressed as equivalent grams of CO₂ per mile: no more than 200 g/mi
- Criteria emissions: no worse than US EPA Tier II, bin 5 standards
- GHG emissions from vehicle production no worse than typical vehicles in production today

PRODUCTION CAPABLE VEHICLES

Our goals require that AXP vehicles be designed to reach the market. Accordingly, all vehicles entered into the AXP competition must be “production capable” as judged by the following criteria:

- **Safety:** Vehicles must be designed to meet safety regulations in the U.S. and other markets

¹ The size of the purse is still being determined and will be announced at a later time. It will likely be in excess of \$10M.

² Pump-to-wheels energy efficiency in terms of petroleum-based gasoline MPG. Conversions will be based on energy equivalency.

³ Total emissions including all contributions from fuel extraction, production, distribution, and consumption.

- **Cost:** Vehicle cost at a production rate of 10,000 units per year must be within levels that the market is likely to bear
- **Features:** Vehicles must be desirable, addressing the most important features and factors consumers consider when purchasing an automobile
- **Business Plan:** Teams must articulate clear and viable business cases for bringing their vehicles to market

VEHICLE CLASSES

The AXP 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 – 4+ passenger vehicles with 4+ wheels that meet conventional expectations for size and capability
- Alternative class – An outlet for innovative ideas that push forward today's conventions about automotive transportation (2+ passengers, no requirement on number of wheels)

RACE SERIES

The key AXP public events will be two dramatic, long-distance stage races to be held in 2009 – the Qualifying Race and the Grand Prize Final. The race courses will reflect typical consumer driving patterns during numerous stages, in varied terrain, communities, and weather conditions. The courses will enable fair, technology-neutral evaluation of competing vehicles while maximizing public impact. Vehicles will use AXP-supplied fuel.

To complete a race successfully, vehicles must complete all race stages with a minimum average speed (maximum allowable time) while meeting the AXP requirements for fuel economy and emissions averaged over all scoring stages. For those vehicles that successfully complete the race, race placement will be determined by the total race time averaged over all scoring stages. Thus, the fastest vehicle will be the winner. Vehicles that do not maintain the AXP requirements for MPGe fuel economy will be disqualified.

Winners of the Qualifying and the Grand Prize Final Races will share multi-million dollar purses. The purse for the Grand Prize Final will be significantly larger than the purse for the Qualifying Race. In both cases, the purse will be split 3:1 between the Mainstream and Alternative classes

OTHER OPPORTUNITIES FOR TEAM RECOGNITION

Our long term vision is that many AXP Finalist vehicles and technologies go into production and become available to the general public, directly or indirectly. To this end, we will promote all AXP teams and provide many opportunities for team and vehicle recognition – not just recognition of the AXP Final Race winners.

All teams will receive significant public exposure and promotion to potential partners, sponsors, investors, manufacturers, distributors and customers.

Examples include:

- The “AXP Certified” mark that is available for vehicles that successfully complete the AXP Final Race
- “AXP Awards” for vehicles in various categories that demonstrate significant progress towards AXP goals

- Special recognition for production-intent vehicles – production prototypes that will be brought to market within a year
- Aggressive web-based and traditional media outreach promoting teams and vehicles, including documentary and live event coverage

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

PROPOSED TIMELINE⁴



- **Public Comments on Competition Guidelines** *[through June, 2007]*
We welcome questions and comments from prospective teams, from the general public, and from the media. Your feedback will help shape the final competition rules.
- **Letter of Intent Program** *[through September, 2007]*
We encourage prospective teams to sign our non-binding [Letter of Intent](#). Teams that do so will have benefits as these Guidelines evolve into final rules.
- **Registration** *[mid-2007 through early 2008]*
Teams submit applications, a signed Master Team Agreement, and a registration fee (currently expected to be \$5,000). Teams will be accepted for further consideration based on preliminary information about their vehicle design and business plan.
- **Formal Launch Event** *[late 2007]*
High-profile “let the games begin” event with key sponsors, partners, supporters, initial teams, and possibly vehicles on stage. The focus will shift from AXP prize development to the competing teams.
- **Plan Submissions** *[mid-2008]*
Accepted teams choose a vehicle class (Mainstream or Alternative) and submit material for judging production capability and expected performance.
- **Qualified Team Selection** *[late 2008]*
Expert judging panels will select teams to race vehicles in the AXP Qualifying Race.
- **Qualification Race** *[early 2009]*
To remain eligible for the Grand Prize Final, vehicles must prove at least 75 MPGe fuel economy and low emissions. The Mainstream and Alternative vehicles that successfully complete the race with the best overall time will be declared Qualifying Race Winners and will split a multi-million dollar purse in a 3:1 ratio.
- **Finalist Selection** *[mid-2009]*
Teams with vehicles that successfully complete the Qualifying Race can apply for the Grand Prize Final Race. Finalist selection will be based on revised team submissions. Selection standards will be more rigorous than for the Qualifying Race.

⁴ Timeline subject to change.

- **Grand Prize Final Race** [late 2009]
Vehicles must prove at least 100 MPGe fuel economy, less than 200 g/mi GHG emissions, and no worse than Tier II, bin 5 criteria emissions. The Mainstream and Alternative vehicles that successfully complete the Final Race with the best overall time will be declared AXP Grand Prize Winners and will split a multi-million dollar purse in a 3:1 ratio. The purse for the Grand Prize Final will be significantly larger than the purse for the Qualifying Race.

REGISTRATION

LETTER OF INTENT PROGRAM

Prior to the completion of the AXP final rules and Master Team Agreement (MTA), teams may join our Letter of Intent (LOI) program. The LOI gives teams that plan to enter the competition a way to officially announce their intent to do so, and provides them with additional insight into the AXP rules as they are refined.

Teams that sign a non-binding letter of intent and submit a refundable registration fee will receive:

- Permission to use the official "Automotive X PRIZE Contender" logo on their website(s) and materials
- Priority attention to comments and questions about AXP Guidelines and a guaranteed response to those comments from the AXP Team
- Timely updates on competition developments
- Invitations to competition kick-off and other special pre-competition events

To learn more about and participate in the Automotive X PRIZE Letter of Intent Program, please complete the form available on the AXP website [here](#).

APPLICATIONS

The AXP application will be simple and open enough to encourage a wide range of entrants. However, registrants will be required to submit credible, initial plans for a production capable vehicle or product that could meet the performance criteria of the prize. Judging of these initial applications will be intentionally lenient, but review of additional submissions will increase in rigor as the competition progresses.

MASTER TEAM AGREEMENT (MTA)

In order to participate, all teams must sign the MTA. The MTA is a non-negotiable legal agreement between each participating team and the AXP. The MTA will govern all aspects of participation, including detailed rules, judging, insurance, liability and indemnification, confidential information, safety, AXP sponsor rights, team sponsorship constraints, logos, team obligations, etc.

FEES

The non-refundable registration fee is expected to be \$5,000 USD per vehicle. For those vehicles that successfully complete the Qualifying Race, an additional fee (same amount) will be due with the Grand Prize Final Race Submissions.

VEHICLE CLASSES AND DESIGN REQUIREMENTS

In order to encourage a wide range of realistic, production-capable vehicles and products, the AXP purse will be awarded in two vehicle classes: Mainstream and Alternative.

The *Mainstream Class* has minimum design requirements based on the characteristics and combined city and highway driving profile typical of today's popular, mixed-use vehicles.

The *Alternative Class* is intended to encourage wider-ranging innovations in vehicle design, as well as alternative but realistic visions of how future vehicles will be used for personal and family transportation. Accordingly, the Alternative Class has fewer design constraints.

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

MINIMUM REQUIREMENTS FOR ALL VEHICLES

All vehicles or products must be designed to achieve AXP energy and emissions requirements, i.e.:

- Fuel economy: at least 100 MPGe
- Total (wells-to-wheels) Greenhouse Gas (GHG) emissions expressed as equivalent grams of CO₂ per mile: no more than 200 g/mi
- Criteria emissions: no worse than Tier II, bin 5
- GHG emissions from vehicle production: no worse than typical vehicles in production today

All vehicles will be required to have a minimum set of features. Those features include but may not be limited to:

- Enclosed cabin (or convertible), with windshield and windows
- Windshield wipers and washers
- Seat belts and restraints
- Rear and side view mirrors
- Feedback mechanisms to provide essential data to the driver (speed, fuel remaining, range, etc.)
- Lamps, lighting, horn, indicators, brake lights and reflective devices consistent with safety regulations

Furthermore, the following features are required to accommodate AXP requirements for vehicle testing and monitoring:

- Sufficient ground clearance, cooling and attachment points to facilitate dynamometer testing
- Marmon flange for connection to emissions sampling equipment
- A standard, AXP-supplied on-board data acquisition and telemetry package that captures and transmits at a minimum: fuel-flow (for liquid and gaseous fuels), amp-hours (for electrical fuels), GPS data (for location and speed)

MAINSTREAM CLASS REQUIREMENTS

- *Capacity:* 4 or more passengers (95th percentile adult male) and 10 cubic feet of useful cargo space
- *Wheels:* 4 or more wheels
- *Performance:* 0-60 mph acceleration in less than 12 seconds, minimum top speed 100 mph, minimum range 200 miles, 60 - 0 MPH braking in no more than 170 feet, lateral acceleration (300-ft-dia skidpad) 0.70 g, 600 ft slalom (Motor Trend) speed 55 MPH, gradeability 55 MPH on a 7.5% grade, noise levels within drive-by standards (74 decibels max)
- *Features:* Heater, air-conditioner, audio system, real-time eco-feedback display⁵

ALTERNATIVE CLASS REQUIREMENTS

- *Seating Capacity:* 2 or more passengers seated side-by-side (95th percentile adult male) and 5 cubic feet of useful cargo space
- *Wheels:* No minimum requirement
- *Performance:* 0-60 mph acceleration in less than 12 seconds, minimum top speed 80 mph, minimum range 100 miles, 60 - 0 MPH braking in no more than 170 feet, lateral acceleration (300-ft-dia skidpad) 0.70 g, 600 ft slalom (Motor Trend) speed 55 MPH, gradeability 45 MPH on a 7.5% grade, noise levels within drive-by standards (74 decibels max)
- *Features:* Real-time eco-feedback display

The AXP reserves the right to modify and expand these requirements while preserving their basic intent.

TEAM SUBMISSION REQUIREMENTS

All registered teams will be required to submit the following materials for judging production capability. Based on these submissions, the AXP Judges will determine whether or not teams may enter their production-capable vehicles in the AXP Qualification Race and, later, the AXP Grand Prize Final Race.

The AXP will provide a submission template for teams to work from, or teams may choose to independently create their submissions.

The AXP will make industry resources available to teams to assist them throughout this process and to provide a standardized method of evaluation. However, the cost and onus of complying with AXP requirements will remain the sole responsibility of each team.

QUALIFYING RACE SUBMISSIONS

Teams that demonstrate reasonable, credible plans to meet the requirements of their vehicle's class will be selected to race vehicles in the AXP Qualifying Race. Required submissions include:

⁵ A device that provides real-time and cumulative feedback to the driver concerning fuel-economy, drive-train efficiency, emissions, etc.

PRODUCT

- Vehicle design renderings
- Preliminary systems-level bill of materials (BOM)
 - A “checklist” template will be provided by the AXP
 - Teams will need to provide detail where they deviate from industry norms; e.g. for the power train and body structure
- Data providing reasonable evidence that AXP safety, cost and feature requirements can be met
- Data providing reasonable evidence that AXP energy and emissions requirements can be met
- Description of critical characteristics or unique features of the entry

BUSINESS PLAN

A business plan template will be provided by the AXP. Teams should expect to submit:

- List of team members with biographies
- Financing sources
- Detailed design and engineering plan: timeline, activities, resources leading to first prototype, safety compliance
- Rough marketing plan: target market description, value proposition, sales and service strategy (including estimated costs of ownership), fit with existing fuel infrastructure
- Rough 3-year P&L: volumes, prices, variable and fixed cost, capital expenditures, margins

GRAND PRIZE FINAL RACE SUBMISSIONS

All vehicles that successfully complete the AXP Qualifying Race can apply to compete in the AXP Grand Prize Final Race. To apply, qualified teams must submit more detailed revisions of the initial requirements listed above, as well as the following additional materials:

PRODUCT

- CAD drawings & 3D vehicle models in the Adobe Acrobat 3D file format
- Simulated crash testing results, with resulting torsion and bending statistics
- Detailed BOM (template will be provided by the AXP)

JUDGING TEAM SUBMISSIONS

While the AXP will not certify or represent that any competing vehicle is in fact production capable, and while the burden of proof to establish safety, cost, features and viable business plan lies with the entrants, our due diligence will determine that competing vehicles have a reasonable chance of being so, in the sense that they could be successfully manufactured and brought to market within a reasonable time frame. For additional background and information, see the relevant [Frequently Asked Questions](#).

SAFETY

Occupant safety is perhaps the single characteristic consumers are not willing to sacrifice, and is essential for mass market adoption of super-efficient vehicles. All vehicles that qualify to compete in the AXP must be designed with the intent to meet current safety standards.

Ultimately, certifying the safety and legality of vehicles brought to market during or after the AXP competition will be sole responsibility of the vehicle manufacturers. We will not require physical crash-testing of vehicles, but teams are free to submit crash-testing data.

BROAD MARKET STANDARD

The AXP will impose a broad standard for vehicle safety. It will be consistent with the regulatory standards for the US and similar markets (such as the E.U.) but will be at a level above detailed homologation specifications. It will be informed by both UNECE regulations for Safety and US FMVSS Crashworthiness and Post Crash Standards, with a focus on:

- Protection of occupants in the event of a frontal collision
- Protection of occupants in the event of a lateral collision
- Fuel system integrity

Where new or unproven technologies are introduced, teams must submit a Failure Modes Effect Analysis (FMEA) demonstrating that all reasonable safety precautions have been taken to prevent injury or damage should the system malfunction or fail.

For vehicles that are legally classified as motorcycles, the AXP expects teams to demonstrate due care for occupant safety as outlined in the section [Vehicle Classes and Design Requirements](#).

In addition to the broad standard for occupant safety, AXP expert judges will also make assessments of vehicle compliance with full UNECE or US FMVSS standards, red-flagging gross errors and omissions.

JUDGING SAFETY

For admission to the AXP Qualification Rally: AXP Judges will assess the general and occupant safety of vehicles on a Pass/Fail basis:

- Passing vehicle designs will be approved for entry into the AXP Qualification Race, provided they meet all other AXP qualification requirements
- Teams with failing vehicle designs will have one opportunity to re-submit designs for compliance
- Non-compliant vehicles will be eliminated from the competition

For admission to the AXP Grand Prize Final: Teams that successfully complete the AXP Qualification Race must submit software-based crash simulation results using 3D CAD models to become eligible for the AXP Grand Prize Final. Teams are welcome to provide crash-simulation data prior to the AXP Qualification Race, but it is not required. Teams will be judged on a Pass/Fail basis:

- Passing vehicles will be approved for entry into the AXP Grand Prize Final Race, provided they meet all other AXP requirements
- Teams with failing vehicle designs will have one opportunity to re-submit data
- Non-compliant vehicles will be eliminated from the competition

COST

The AXP will assess vehicle cost as one measure of market viability. In essence, vehicle cost must be reasonable enough to justify sales of 10,000 units per year in the intended market(s).

The AXP will rely on cost and pricing data about the historic success of similar vehicles in the market for judging what consumers may be willing to pay for vehicles.

Vehicle cost will be estimated via the BOM and investment costs from the business plan. All costs will be based on current market prices for materials and components. Teams that utilize advanced materials or components for which there is insufficient market history to judge current cost will be required to provide verifiable market pricing. Judges may also take into account extraordinary vehicle lifetime ownership costs.

JUDGING COST

AXP Judges will issue a Pass/Fail assessment:

- Vehicles that pass will be approved for entry into the AXP Qualifying Race, provided they meet all other AXP requirements
- Teams with plans that exceed reasonable costs will have one opportunity to re-submit revised plans for approval
- Rejected plans will be eliminated from the competition

FEATURES

Vehicle features must resonate with experts and the public in terms of desirability. By desirability we mean the most important factors that consumers consider when buying a vehicle.

Some key factors that influence desirability are already embedded throughout the AXP guidelines, including measuring fuel economy and assessing environmental impact. Safety review is outlined in the [Vehicle Classes and Design Requirements](#) section above. Performance, of course, will be validated and measured in both the AXP Qualifying and AXP Grand Prize Final Races.

The remaining factors that influence desirability guide this category, which we will judge in an attempt to forecast likely customer acceptance. These factors include but may not be limited to the following vehicle features:

- Interior Comfort
- Ingress / Egress
- Interior Noise Levels
- Quality of Workmanship
- Exterior Styling & Vehicle Image
- Passenger Capacity
- Cargo Capacity
- Advanced Technology
- AWD/4WD Capacity

Because relevance with consumers and generating demand are so important to ensuring market adoption of super-efficient vehicles, all entries will be judged on features through a combination of public voting and review by opinion-leaders and design experts.

Often these factors mark the key differences between successful and unsuccessful vehicles in the marketplace and therefore represent the “price of entry” for releasing a vehicle into the market.

JUDGING FEATURES

The AXP Judges will issue a Pass/Fail assessment:

- Vehicles with passing designs will be approved for entry into the AXP Qualifying Race, provided they meet all other AXP requirements
- Failing designs will have one opportunity to re-submit designs for approval
- Rejected designs will be eliminated from the competition

BUSINESS PLAN

Teams must articulate clear and viable business cases for bringing their vehicles to market. While all teams must submit plans, it is essential for teams that do not have a proven history of bringing a vehicle to market in quantities of 10,000 units per year to prove that they understand what it takes to make, sell and service vehicles in quantity.

JUDGING PLANS

AXP Judges will issue a Pass/Fail assessment:

- Vehicles with sufficient business plans will be approved for entry into the AXP Qualifying Race, provided they meet all other AXP requirements
- Teams with insufficient business plans will have one opportunity to re-submit revised plans for approval
- Teams with rejected plans will be eliminated from the competition
- Business plans will be re-assessed for teams that successfully complete the AXP Qualification Race (additional requirements for admission into the AXP Grand Prize Final Race are outlined above in the section [Team Submission Requirements](#))

FIGURES OF MERIT FOR ENERGY & EMISSIONS

Here we give details about how AXP will handle energy and emissions. For additional background and information, see the relevant [Frequently Asked Questions](#).

ENERGY (FUEL ECONOMY) – 100 MILES PER GALLON OF GASOLINE ENERGY EQUIVALENT (MPGe)

The AXP figure of merit for fuel economy will be Miles per Gallon of Gasoline Equivalent (MPGe), a measure that expresses fuel economy in terms of the energy content of a gallon of petroleum-based gasoline. That is, vehicle fuel economy is expressed as miles-per-gallon of energy-equivalent gasoline.

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.

AXP vehicles will be required to demonstrate a minimum of 100 MPGe fuel economy via a combination of fixed-cycle EPA (CAFE-based) dynamometer testing and actual performance in the AXP races. 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 AXP fuel economy and GHG emission requirements is available in a [spreadsheet](#), described [here](#), prepared by the [Natural Resources Defense Council](#) (NRDC) with assistance from [Argonne National Laboratory](#) (ANL) and data from ANL's [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 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 in the “tank” (the battery). To be clear, what counts is the energy in the fuel delivered 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 offboard inductive charger) to be part of the drive train - i.e., they are accounted for in measuring how far the vehicle goes per unit energy from a pump nozzle or wall plug delivered to the vehicle.

GREENHOUSE GAS EMISSIONS – MAXIMUM 200 g/mi TOTAL CO₂ EQUIVALENT (CO₂E)

The AXP figure of merit for greenhouse gas emissions will be the total for all significant wells-to-wheels emissions of Greenhouse Gas (GHG) emissions – including tailpipe, HVAC, and upstream contributions,– expressed as equivalent grams of CO₂ emitted per mile (CO₂e). For the AXP, 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. In the case of electricity, GHG emissions will be based on the current national grid – however, we will publicize in various ways how cleaner electricity production generally (and renewable energy sources in particular) can significantly reduce wells-to-wheels GHG emissions (for example, see the section [Education Program](#)).

Greenhouse gases other than carbon dioxide will be expressed in terms of equivalent CO₂ based on the IPCC's 100-year Global Warming Potential measurements. Currently, the values are: 1 for CO₂, 23 for CH₄, and 296 for N₂O.

As mentioned [above](#), a detailed analysis of the AXP fuel economy and GHG emission requirements is available in a [spreadsheet](#) described [here](#).

We also require that GHG emissions arising from vehicle production are no worse in this respect than typical vehicles in production today. The [DOE-Argonne GREET 2 Series model](#) is available for estimating this contribution.

CRITERIA EMISSIONS – Tier II, bin 5

All AXP vehicles must meet U.S. EPA Tier II, bin 5 standards to be legal in all 50 U.S. states. Vehicles will be tested for compliance prior to the AXP races and randomly during the races using remote emissions sensing technology. Although we will not require full 120K lifetime emissions confirmation, vehicles must be designed to achieve full 120K compliance. During the admissions process teams will be required to present evidence that their vehicle is likely to pass 120K testing.

MEASURING FUEL ECONOMY

For details on how fuel economy and emissions will be measured, see the sub-section [Fuel Economy and Emissions Requirements](#).

We recognize that holding entrants accountable to the basic AXP requirement of 100 MPGe presents difficulties, including:

- For measurements on a fixed-test cycle, establishment of a fair and accurate test cycle
- For measurements based on race performance, issues in course design and driving constraints
- Gaming by competitors (whether in the fixed test cycle or during races)

These issues will be reviewed again after the public comment period.

To guard against unintended consequences, we are supplementing the 100 MPGe requirement with several "corralling" standards and features to ensure that the results are consistent with our goals. For example:

- Maximum 200 g /mi wells-to-wheels GHG emissions
- Course design requirements that normalize gross drivetrain advantages (pure ICE, pure electric, etc.)

Note also that we intend to provide additional energy and emissions data as part of the AXP Education Program, as mentioned [below](#).

PERMITTED FUELS

Vehicles must use AXP-supplied fuel during performance tests and races. A limited number of representative fuels will be provided. This will neutralize fuel gaming, and allow us to focus on viable fuels that are available in the marketplace to a level of our satisfaction. At this point, we expect to provide gasoline, diesel, electricity, natural gas, bio-diesel, and E85; the final list will be determined after initial applications are reviewed (additional fuels will require a clear business case that a vehicle using a non-mainstream fuel can succeed in the marketplace within a few years).

However, since there is only a threshold requirement on GHG emissions (200 g/mi maximum), there would be no particular race scoring advantage to using a non-mainstream fuel just because it is low in CO₂ emissions. We expect most AXP vehicles to use gasoline, diesel, bio-diesel, electricity, and ethanol – because these will be the predominant available fuels in the near future.

Where the amount of fuel energy available after fueling depends on the fueling conditions and procedures (e.g., for recharging batteries), AXP will specify sufficient details to ensure a fair representation of energy consumption.

Because we do believe that alternative fuels are important for the future, but cannot predict which alternatives will emerge as the best choices (availability, GHG emission characteristics, etc.), the AXP will provide some sort of general incentive for vehicles that can optionally be powered by more than one fuel, whether or not those fuels are currently mainstream (for our purposes, examples of flex-fuel vehicles include plug-in hybrids, vehicles that can run on gasoline or ethanol, etc.). The form of this flex-fuel incentive is yet to be determined.

RACE CONCEPT AND COURSE DESIGN

The key public events of the AXP will be two long-distance stage races – Qualifying and Final – to be held in 2009. 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 additional background and information, see the relevant [Frequently Asked Questions](#).

The detailed course design will be specified after local support, sponsors, media partners, and other factors are finalized. In the interim, we provide course design guidelines – i.e., the high-level specifications that the actual course design(s) will have to meet. These guidelines characterize the challenges that the AXP vehicles will face, and they will constrain the detailed course design.

At the highest level, the guidelines are simply that the courses should both engage the public and reflect typical consumer driving patterns.

AXP STAGE RACE STRUCTURE

GOALS

The goals of the AXP Qualifying and Final Races include:

- Testing vehicles under varied driving conditions that reflect real-world consumer needs
- Proof that vehicles meet the AXP requirements for fuel economy and emissions
- Demonstration that vehicles are durable over many days and many end-to-end trips
- Exposure of the vehicles to many local communities and to an international media audience
- Education about fuel economy, emissions, alternative fuels, and the impact of driving styles

The races will cover a significant distance (perhaps from coast to coast or over international regions) to prove vehicle endurance and maximize public exposure. Regardless of the final geographic scope, the race will include numerous stages, over varied terrain, in varied communities, in weather conditions that will likely vary, and will require varied driving patterns. Accumulating high total mileage under diverse conditions is important. It will help to “average out” various local and short-term effects (including the fact that competitors may encounter different conditions at different times), help to minimize gaming, and generally help to produce a reliable measurement of average fuel economy.

SUCCESSFUL RACE COMPLETION, RACE PLACEMENT, AND WINNERS

To complete a race successfully, vehicles must complete all race stages with a minimum average speed (maximum total time) while meeting the AXP requirements for fuel economy and emissions averaged over all scoring stages. For vehicles that successfully complete the race, their overall race completion time will be the sum of the vehicle's time for every scoring stage.

Not all stages will be scoring stages. Showcase stages (see [below](#)) will not contribute to the fuel-economy and overall race time measurements for purposes of determining race placement, although vehicles will still be required to complete all stages within a maximum time. In the event of exceptional real-time circumstances, the Judges will have the right to change the status of particular stage or stage portion from scoring to non-scoring.

For those vehicles that successfully complete the race, race placement will be determined by total overall race time in scoring stages. Thus, the winner in each class will be the vehicle that successfully completes all scoring stages in the shortest total time while still achieving the AXP fuel economy and emissions requirements.

FUEL ECONOMY AND EMISSIONS REQUIREMENTS AND MEASUREMENT

Qualification Race

There will be no fuel economy or emissions testing prior to the Qualification Race. Instead, vehicles will be admitted to the Qualification Race based on judging criteria discussed elsewhere. During the Qualification Race, fuel-economy and emissions will be tested by means of on-board data acquisition and testing equipment. Vehicles will be eliminated at the end of the Qualification Race if any of the following are true, even if they have completed the course in the time allowed:

- Average fuel economy is less than 75 MPGe averaged over all race scoring stages
- GHG emissions are significantly worse than 200 g/mi (detailed criteria to be determined; the pump-to-wheels contribution will be calculated from fuel consumption, and upstream, wells-to-pump, contributions will be estimated by the [DOE-Argonne GREET model](#) with average default values that reflect fuel production today and in the near future)
- Criteria emissions are significantly worse than the US EPA Tier II, bin 5 standard (detailed criterion to be determined)

Final Race

Vehicles must achieve 100 MPGe fuel economy, less than 200 g/mi GHG emissions, and Tier II, bin 5 criteria emissions.

Prior to the AXP Final Race, fuel economy will be measured in standard, (CAFE-based) EPA fixed-cycle dynamometer tests. Fuel economy during the race will be measured by on-board data acquisition equipment.

Compliance with the 100 MPGe requirement will be determined by a blend of the fuel economy measured in fixed-cycle dynamometer tests and the average fuel economy measured during all scoring stages in the AXP Final Race. We will give equal weight to the fuel economy demonstrated in the pre-race dynamometer test and the average fuel economy demonstrated in the race. The average of these two quantities must be at least 100 MPGe.

For compliance with the GHG emissions requirement (200 g/mi), the pump-to-wheels contribution will be calculated from fuel consumption, and the upstream, wells-to-pump, contributions will be estimated by the [DOE-Argonne GREET model](#) with average default values that reflect fuel production today and in the near future.

Prior to the AXP Final Race, vehicles will have to demonstrate Tier II, bin 5 compliance during a full fixed-cycle EPA test. Vehicles will also be subject to random emissions testing during the race.

TYPES OF RACE STAGES

There will be three types of stages – showcase, speed-constrained, and track. Only the speed-constrained and track stages will be scoring stages.

Vehicles in the Mainstream and Alternative classes will have different race courses, with the course for Alternative vehicles likely being a subset of the Mainstream class.

Speed-Constrained Stages

Speed-constrained stages will be run on public roads that will be closed briefly while the event passes (similar to bicycle races and running races). Vehicles will race in "time trial" style, starting one at a time and timed separately. During the speed-constrained stages, vehicles must obey all traffic laws (including speed limits), but must also complete the stage within a maximum time.

Track Stages

Track stages will be run on closed test tracks and racetracks (both road race courses and speedways). Track stages will have no speed limits. Vehicles will be required to yield to faster vehicles that wish to pass – thus, there will be no aggressive side-by-side racing.

Showcase Stages

Showcases are ceremonial or transitional stages that will not count in the race scoring, including:

- Highly atypical conditions, such as extremely steep or long climbs, very high altitudes, etc.
- Logistical difficulties
- Safety issues
- Special opportunities for public or media exposure
- Opportunities to win special prizes (for example, one suggestion we have had is for a stage in which vehicles go as far as possible on a fixed amount (energy content) of fuel)

Vehicles must complete all showcase stages, thereby contributing to the demonstration of vehicle reliability, and they must do so within a maximum time for each stage. Although showcase stages will not contribute to race scoring, fuel economy will still be tracked and published. Thus, for example, if the race is coast-to-coast but only certain stages determine the winner, the public will still be able to follow the coast-to-coast fuel economy as it unfolds.

FUEL

Vehicles must use AXP-supplied fuel during performance tests and races. A limited number of representative fuels will be provided for use during the races. We expect to provide gasoline, diesel, bio-diesel, electricity, natural gas, and E85. This approach will neutralize fuel gaming, and allow us to focus on viable fuels that are available in the marketplace to a level of our satisfaction. For more information, see the section "[Permitted Fuels.](#)"

We will likely allow vehicles to be refueled during the entire time between stages (i.e., there will be no separate constraints on refueling times). Stage intervals will reflect a realistic mix of expected real-world driving patterns.

TECHNICAL INSPECTIONS AND TESTING

Vehicles will undergo rigorous pre-race technical inspections to verify compliance with AXP safety and other requirements.

Prior to and during both the Qualifying and Final AXP Races, vehicles will be tested to verify that AXP Mainstream or Alternative class performance requirements are met (acceleration, slalom, skidpad, braking, gradeability, etc.).

As mentioned earlier, fuel-economy and criteria emissions will be measured in fixed-cycle test prior to the start of the AXP Final Race.

DISQUALIFICATION, PENALTIES, AND INCENTIVES

Disqualification

In addition to scheduled inspections and tests, vehicles will be subject to real-time monitoring as well as such additional spot-check inspections and tests as the Race Judges deem appropriate for detecting:

- Safety violations
- Fuel tampering
- Equipment violations
- Speed violations or dangerous driving
- Other violations

Vehicles that violate AXP specifications and rules will be subject to immediate disqualification, especially in cases where vehicle safety or performance could be affected.

Time Penalties

The Race Judges will also have the discretion to apply time penalties for violations. Time penalties will be enforced by holding the penalized vehicle at the start for the specified time penalty, with the hold-time being included in the vehicle's time for that stage.

Race Incentives

In order to encourage particular design or performance characteristics, we are considering the occasional use of scoring adjustments such as time bonuses. Examples include incentives for using non-petroleum-based fuels, for using multiple alternative fuels, for low refueling times, for high fuel economy, for high public opinion, etc. These incentives, if any, will be integrated in a manner that reinforces our core goals and [guiding principles](#).

TELEMETRY AND REPORTING

All vehicles will be required to carry an on-board data acquisition and telemetry package that captures and transmits fuel-flow (for liquid and gaseous fuels), amp-hours (for electrical fuels), and GPS data (for location and speed). A standard package will be specified and supplied by AXP. We intend to publish these data in real time using a map-based format that shows vehicle position and associated data. Associated data might include:

- Elapsed time for current state
- Current instantaneous fuel economy
- Current stage average fuel economy and average speed
- Current overall average fuel economy and average speed
- Current overall wells-to-wheels oil consumed
- Current overall average wells-to-wheels fuel economy
- Current overall average wells-to-wheels carbon emissions
- Real-time streaming video

See this recent example from [Amgen Tour of California](#).

To ensure realistic measurements of fuel-economy in vehicles where batteries provide drive-train power, batteries will be subjected to State of Charge (SOC) corrections in a manner to be specified by the AXP based on consultation with experts at DOE, EPA, and elsewhere.

Vehicles must also satisfy AXP equipment requirements to facilitate vehicle testing and monitoring, discussed [earlier](#).

OTHER RACE REQUIREMENTS

All drivers must be professionally trained, with detailed requirements to be provided.

RACE COURSE DESIGN GUIDELINES

Actual race routes will not be determined for some time as the details will depend on local support, sponsors, media partners, and other factors. However, we can specify high-level requirements that the actual course design(s) will have to meet. These requirements characterize the challenges that the AXP vehicles will face, and they will guide the detailed course design.

The detailed course must provide a fair, technology-neutral evaluation and comparison of competitors, while maximizing public impact. At the highest level, the specification is simply that the courses should reflect typical consumer driving patterns, incorporating a variety of realistic and performance-illustrating driving conditions and trip profiles, for example:

- City driving
- Errands
- Commuting
- Hills
- Driving in heavy traffic (will be simulated)
- Very long stages, with refueling permitted *en route*
- A series of stages with overnight stops
- A series of stages separated by one or more days of outdoor, vehicle rest (during which no maintenance or fueling would be permitted)

Certain race stages will be conducted on existing test tracks or test routes – i.e., tracks or routes that were designed or selected specifically for use in vehicle development and testing. Other race stages and the overall race profile will be designed to reflect Department of Transportation and other data on how people use their vehicles, as well as data on the supporting infrastructure. Showcase and speed-constrained stages will predominantly follow roads of the US [National Highway System](#), since considerable data is available to support course design.

In designing the actual race courses, the AXP will be assisted by experts from the US [Federal Highway Administration](#) (FHWA) and experts in vehicle testing.

COURSES FOR MAINSTREAM AND ALTERNATIVE CLASS VEHICLES

Alternative class vehicles have a shorter range requirement, so cannot be required to compete on exactly the same course as Mainstream vehicles. To simplify course design and race management, the course for

Alternative class vehicles will be a subset of the course for Mainstream vehicles. That is, Alternative class vehicles will be exempt from having to complete certain stages.

BASELINE DESIGN DATA

The detailed course design will be required to be consistent with known distributions of such data as:

- Trip length
- Number of passengers
- Trip frequency
- Intervals between trips
- Cargo
- Trip speeds, start-stop cycles (city/highway, etc.)
- Refueling frequency
- Cold starts
- Terrain (frequency of climbs, length of climbs, grades)
- Congestion
- Road roughness
- Road surface

Some preliminary data of this type is contained in a document that was prepared for the AXP by the [Department of Transportation, Federal Highway Administration](#), and is available [here](#).

VEHICLE PERFORMANCE SIMULATION

The AXP intends to provide teams with access to vehicle modeling and performance simulation software. The software will have the ability to load the actual AXP race courses, thereby giving teams a tool to help predict the performance of their vehicles in the AXP races.

MANY OPPORTUNITIES FOR RECOGNITION

Our long term vision is that many AXP Finalist vehicles go into production and become available to the general public, directly or indirectly.

To this end, the AXP will provide many opportunities for recognition of teams and their vehicles. In general, teams will be encouraged to use their AXP Race Series performance in furthering their business development.

In addition, all participants in the AXP Race Series can expect significant public exposure and promotion to potential partners, sponsors, investors, manufacturers, distributors and customers via:

- Significant PR exposure
- Robust online technology and media presence for global engagement, audience traction, and team development including:
 - Green vehicle marketplace

- Webcasts
- Hosted team “home pages”
- Talent, technology & services exchange
- Plans for documentary, television drama and live event coverage to leverage traditional media

“AXP CERTIFIED” MARK

All vehicles that successfully complete the Grand Prize Final will be awarded the "AXP Certified" mark and logo. Teams will be allowed to use this mark in furthering their business development & future vehicle sales.

However, once such vehicles actually go into production and are offered for sale, the AXP Certified mark cannot be used unless the vehicle still meets the AXP energy and emissions standards when tested officially by the EPA (including 120,000 mile testing), and successfully undergoes crash testing to applicable FMVSS standards.

PRODUCTION-INTENT DESIGNATION

Applications for the AXP Final Race may be accompanied by a request for designation as "production-intent" (rather than just "production-capable"). "Production-intent" means that the team has the capability and intention to manufacture and sell the vehicle in the year after the Final Race. The corresponding Manufacturing and Business Plans must contain sufficient information to show that production in that time frame is in fact intended and feasible.

To further reinforce, distinguish, and reward the production-intent designation, certain additional requirements and opportunities would apply to teams with production-intent vehicles. Here are some examples that have been suggested:

- Production-intent teams make a public commitment to production, and accept deposit-backed orders for the vehicle during the AXP Final Race
- Production-intent teams post a bond that would be forfeited if in fact the vehicle is not offered for sale that year (i.e., it must pass physical crash testing, EPA certification, etc.)
- An electronic market in the style of the [Iowa Electronic Markets](#) (contract payoffs would be based on actual future sales of the AXP production-intent vehicles)
- Production-intent vehicles would get additional media coverage
- A special award would be awarded to the production-intent vehicle AXP Finalist with the highest fuel economy

THE AXP AWARDS

In addition to an award for sustainable production methods, we are considering second-tier AXP Awards to recognize and highlight progress in other areas that are relevant to our desired outcomes. All vehicles that successfully complete either a Qualifying Race or Grand Prize Final would be eligible for the AXP Awards. Examples might include:

- Lowest lifetime estimated cost
- Highest MPGe
- Lowest CO₂e
- Lowest Tailpipe Emissions

- Lowest non-vehicle emissions from vehicle manufacturing and operation (see [Sustainability](#)), or perhaps a more-general “Cradle to Cradle” award⁶
- “People’s Choice”
- “Best Urban Commuter”
- “Best Family Sedan”
- “Best Utility Vehicle”, etc.

SUSTAINABILITY

The AXP focuses on fuel energy efficiency (fuel economy) and emissions, and is not a sustainability or renewable-energy prize. Accordingly, and also because simplicity is paramount, AXP admissions and scoring will not depend on details of vehicle production, recycling, and destruction.

However, given the importance of GHG emissions that can arise from vehicle production, we will require that teams provide baseline data to support an admissions requirement that their vehicles will be no worse in this respect than typical vehicles in production today, as discussed earlier.

Furthermore, teams may voluntarily document exceptionally low GHG emissions that would be associated with their vehicle’s production, and AXP will create an AXP Award to recognize the design that is most innovative from this viewpoint. The [DOE-Argonne GREET 2 Series model](#) will be offered to individual teams to evaluate their vehicle production carbon emissions. We will also encourage teams to report on other sustainability aspects of their design; see [Education Program](#) section.

EDUCATION PROGRAM

In order to maintain the focus on the AXP’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 AXP energy and emissions requirements.

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.

Accordingly, we intend to address such issues in the AXP Education Program, as discussed in the following sections.

REAL-TIME VEHICLE DATA

Real-time vehicle data that is available during the AXP stage races will be integrated with the online race tracker that will be available to the public. Where substantial reasonable changes in fuel production and availability would result in significant improvements, we will highlight the opportunities by presenting wells-to-wheels data with different upstream assumptions that are supported by future predictions.

An important example is how wells-to-wheels carbon emissions could change with changes in electricity production and biofuel availability. We will offer similar data presentations for cases where local markets are significantly different from national markets (an example is electricity production in California).

⁶ i.e., based on renewable design principles articulated by William McDonough and Michael Braungart in *Cradle to Cradle*, North Point Press, New York, 2002

Here are some examples under consideration for presenting real-time vehicle data:

- Average fuel economy and average speed (for current stage and total race)
- Average wells-to-wheels fuel consumption
- Wells-to-wheels energy efficiency
- Wells-to-wheels total oil consumed
- Total fuel cost (based on existing market prices)
- Wells-to-wheels total GHG emitted
- Wells-to-wheels GHG emitted per mile (This would be shown as a function of the two contributing factors: wells-to-pump GHG/gallon (equivalent) and pump-to-wheels fuel efficiency (MPGe) – wells-to-wheels GHG per mile is the ratio of these)

FUELS

The AXP Education Program will address fuels in the following ways:

- We will highlight the pros and cons of all fuels fairly, openly and honestly, so that the public and policymakers can determine what the right choices are for their needs, and for their geographic region. Topics would include:
 - How various alternative fuels are made or could be made, since fuel production tends to be “out of sight, out of mind” (for example, in many parts of the world, electricity is produced by GHG-intensive coal-burning power plants)
 - A full accounting of the costs of fuel production and consumption, including the significant technical, economic, and environmental challenges and tradeoffs
 - The benefits and trade-offs of renewable fuel production, since local production of and increasing national introduction of renewable fuels and energy can have a huge effect
- We will weave fuel storylines throughout all AXP web and video productions
- Teams will be free to promote their favorite fuel or fuel production method if they see it as central to their business and marketing plans
- We will highlight geographic regions with natural resources particularly suited to particular alternative fuels

PERSONAL DRIVING BEHAVIOR

The AXP Education Program will address the relevance of driving styles in the following ways:

- We will show dramatically via the AXP stage races how driving behavior strongly affects fuel economy
- We will provide information to help consumers match their driving patterns to vehicle choices (commuters, local errands, long-distance, etc.)
- We may demonstrate the fuel economy achieved by driving existing popular vehicles over the AXP stage race courses, which would also highlight advances made by AXP vehicles

TRANSPORTATION INFRASTRUCTURE

While the AXP itself addresses innovation in vehicles that can be brought to market within five years, the AXP Education Program will highlight other aspects of transportation. For example:

- We will encourage debate about needed long-term changes in our energy and transportation infrastructure
- We will encourage behavioral changes in the use of cars and transportation alternatives (car sharing, specialized vehicles, public transportation, biking, walking, etc.).

SUSTAINABILITY

We will encourage teams to publicize any special sustainability aspects of their vehicle designs (e.g., innovative production methods, reducing toxicity, reducing non-fuel life-cycle emissions, etc.).

ADDITIONAL OUTREACH

We intend to engage in a variety of networking and showcase events to facilitate the formation, financing, support and exposure of teams, including:

- A web-based “talent marketplace” to connect individuals and teams
- A web-based “services & technology” marketplace to connect teams with the help they need
- Networking events for teams, suppliers, and investors
- “Road show” events where consumers can physically experience competing vehicles

IDEAS FOR PUBLIC PARTICIPATION

The AXP will devote considerable online and traditional media resources to public outreach, education, and involvement. We would also like to include mechanisms for incorporating public opinion as well as mechanisms for more direct public participation. Here are some ideas that have been proposed:

- Regular publication of ad hoc and professional polls on issues, features, vehicles, teams, etc. (both online and via telephone)
- Public polls/votes and market research to define standard driving behavior and key desired vehicle components (safety, number of seats, cup holders, etc.) could be used in judging applications
- An online market of some kind, for example where the public could trade options to buy production vehicles (see also the discussion under [Production-Intent Designation](#))
- Public votes for vehicles heading into the Qualification and Final Races (vehicles with the lowest public rating are eliminated from the competition)
- AXP-sponsored petitions asking for efficient/clean cars and alternative fuels; results posted and given to government, auto manufacturers, energy providers, etc.
- Individual donations and investment, including several possible variations:
 - Individual donations go into “investment pools” given to each team at end of competition, with ability to move donation from team to team

- “People’s Choice” award, where individual donations are pooled in a separate purse to be awarded to the most popular finalist, with individually controlled accounts for people to move their "votes" from one competitor to another, until the final day of the competition, thus increasing involvement and also suspense.

Individual donations go into an unlimited prize purse with matching grants from large sponsors & donors

AXP PRIZE DEVELOPMENT PROCESS

These guidelines have been developed over the past twelve months with the generous help of hundreds of individuals, organizations, companies, and government agencies. Some attended our [Automotive X PRIZE Brainstorm Session](#). Others have served formally as members of our [Prize Development Advisory Board](#). Others have served on various AXP Working Groups or in other capacities.

We recognize that some of those advising on AXP Guidelines may end up competing, 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 input from those unlikely to have a future interest in the AXP, the result would have been poor Guidelines.

Our process is open, and we do not hide our involvement with any party. Now the general public and any other interested party will have an opportunity to advise us on the Guidelines.

We will reverse course and adopt a strict no-conflict policy once the rules are finished. The Prize Development Advisory Board will be disbanded and we will appoint a conflict-free Prize Administration Advisory Board.

These Guidelines have particularly benefited from three AXP Working Groups, – for a list of participants, see Appendix I.

COMPETITION FAIRNESS AND EQUITY

JUDGES

The AXP is an independent, non-profit competition with no political, technological, bureaucratic or industrial bias.

To ensure fairness and equality for all teams, we will form and use diverse panels of expert individuals and organizations to assist with potentially contentious aspects of the competition.

Our goal is to stimulate innovation while requiring practicality. In general, our decisions will lean in favor of accepting reasonable arguments from competing teams. However, in all cases the judgment of the AXP prize administrators will be final.

Panels of AXP Judges will include fair and unbiased representation from relevant organizations as follows:

- **Safety:** Qualified experts from relevant industrial, regulatory, and non-profit organizations (e.g., Tier 1 Manufacturers, NHTSA, IIHS, SAE, SAE International, JSAE, FISITA, VDA, SIA, IEEE, etc.)

- **Cost:** Industry professionals and/or representatives of relevant organizations (e.g., Tier 1 Manufacturers, Automotive Suppliers, SAE, SAE International, JSAE, FISITA, VDA, SIA, IEEE, etc.)
- **Features:** Opinion-leaders and design experts as well as representatives of relevant organizations (e.g., Consumer Reports, JD Powers, AAA, Environmental NGOs, etc.)
In addition to these official judges named by the AXP, the public will hold a seat at the judging table, adding an important voice to the conversation. That “public seat” will likely be informed by public voting on the vehicle design renderings.
- **Business Plan:** Industry professionals and/or representatives of relevant organizations (e.g., Tier 1 Manufacturers, Venture Capital Firms, Retired OEM executives, Fuel Suppliers, Governments, etc.)
- **AXP Races:** Professionals and/or representatives of relevant testing and racing organizations (NASCAR, FIA, F1, etc.)

Decisions of AXP Judges and administrators will be final, and major decisions will include an appeal mechanism.

X PRIZE FOUNDATION

X PRIZE Foundation employees and their families may not participate in nor have a financial interest in AXP teams or vehicles.

The X PRIZE Foundation Conflict of Interest Policy covers Officers and Trustees that may have a direct or indirect financial interest in prizes under development or offered by the Foundation. Officers or Trustees are required to disclose possible conflicts and recuse themselves from any relevant deliberations or decisions.

FREQUENTLY ASKED QUESTIONS

ENERGY AND EMISSIONS

ENERGY AND FUEL ECONOMY

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 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?

Vehicle designers have little control over wells-to-pump efficiencies. Upstream fuel efficiencies and related issues involve highly-controversial assumptions and predictions. A main AXP focus is to stimulate innovation in vehicles. Furthermore, wells-to-pump efficiencies are in many cases addressed indirectly by the AXP requirement on total wells-to-wheels CO₂ emissions (see below).

Why MPGe rather than some other measurement of fuel economy?

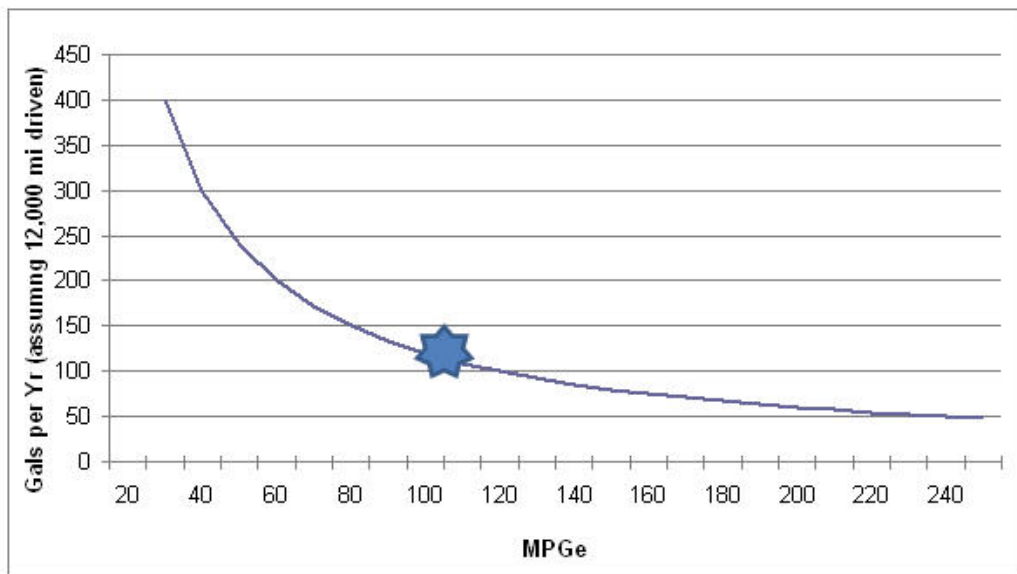
For the important case of gasoline-fueled cars, MPGe becomes just MPG, which has the advantage of public familiarity and broad understanding.

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:



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 wouldn't 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.

Don't Electric Vehicles have a huge advantage?

While electric vehicle (EV) drivetrains do have a pump-to-wheels efficiency advantage, they also have significant disadvantages: range, recharge time, and battery cost. Teams that enter electric vehicles in the Mainstream class (200 mile range) will find it difficult to meet market viability requirements (priced for reasonable market acceptance at 10,000 units/year). Furthermore, AXP course design will further equalize technologies and highlight the pros/cons of each. For example, recharge time for EVs will be a factor in the races.

GREENHOUSE GAS EMISSIONS

Why cap CO₂e emissions rather than scoring the competition using CO₂e, so as to reward vehicles with a lower carbon footprint?

In principle, it makes sense to score vehicles based on actual total CO₂e, but there are many reasons why doing so is not practical and could distract from the main AXP 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 AXP 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 CO₂e 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 CO₂ cap rather than a single, carbon-based figure of merit?

We chose to use both MPGe and a CO₂ cap as AXP 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 don't 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 CO₂e emissions rather than scoring the competition using CO₂e, so as to reward vehicles with a lower carbon footprint?](#)"
- The CO₂e cap will make sure that AXP winners help to promote a future low-carbon transportation sector.
- Fuel economy and carbon emissions are not always linked. 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 a large scale in the AXP 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 CO₂e?

As one AXP advisor put it, "*There can not be a bad CO₂ outcome from 100 MPGe.*" Nevertheless, having an additional cap on CO₂e 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.

CRITERIA EMISSIONS

California standards are lower. Shouldn't AXP vehicles be cleaner than any car today on the road?

Since great advances have been made and continue to be made in criteria emissions, this is not a main focus of the AXP. In contrast, there has been markedly less progress on fuel economy and carbon emissions, which is why these are our main focus. We chose Tier II, bin 5, since this standard qualifies vehicles for sale in all U.S. states. Furthermore, a stricter standard could stifle competition from diesels, which would be unfortunate since diesels can yield significant fuel economy gains and since we expect to see future reductions in criteria emissions from diesel. We are trying to strike a balance between sufficiency and significance.

PRODUCTION CAPABILITY

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

There are significant disadvantages to making the AXP a "sales race," including:

- 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 AXP 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 AXP (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 AXP 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

Why aren't SUVs included in the competition?

SUVs are welcome to compete if they can meet our core requirements, since we place no restrictions on fuel, body type or design that would prevent SUVs from competing.

Why require a 2-passenger minimum for the Alternative class? Why not allow single-passenger vehicles to compete?

Our goal is to inspire viable vehicles that people want to buy. While there could be a market for single-passenger vehicles, the vehicle mass, weight and fuel required to transport a single passenger can usually accommodate two passengers while sacrificing little in the way of efficiency. Research shows that two-passenger vehicles offer significantly more utility to consumers. Even scooters and motorcycles, which typically travel with only one person, are rarely sold without two-passenger capability.

Why not judge vehicles based on operating costs?

Cost per mile is a valid metric, and one we will likely highlight during the competition. However, our main focus will be on MPGe because:

- The public easily grasps the concept of MPG, and enhancing the meaning via MPGe is a straightforward proposition. However, consumer 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 is a metric that will vary over the life of the Automotive X PRIZE according to market forces (price of oil among them), making it difficult if not impossible for teams to predict how their entry will perform
- Cost per mile is not related to emissions performance – in many ways it is cheaper to run a polluting car than a clean one

How will you ensure that any of these cars reach the market?

The AXP *cannot* ensure that this happens. What we can do is give the greatest possible amount of positive publicity to the widest array of excellent solutions to our transportation fuel problems, and then let the forces of the market and government make their way. Some winning cars may make it to the marketplace as entered. Others may see their prize-winning technology packaged and licensed to a range of carmakers around the world. Any route that gets the solution onto the road is valued.

One attractive approach is for governments and large companies around the world to establish advance market commitments in the form of guaranteed fleet sales for vehicles that meet AXP requirements and their requirements. We hope to explore this possibility.

Judging design is too subjective... what makes you think you can possibly judge what will succeed in the market?

We cannot predict what will succeed in the market. But we can ensure that AXP vehicles have features that are typical of vehicles that do succeed.

Our approach to design is to focus on the top features that consumers look for when purchasing a new vehicle. In total, these features are more objective and easier to measure than "good looks." Only a small part of the design review is based vehicle image, or aesthetics, which is the most subjective area of design.

We will also rely on the public to tell us what they want and like, or do not want and do not like, so that teams can focus on the features that will help them succeed in the market.

What is the ceiling for vehicle price (MSRP)?

Our cost requirements are designed to eliminate vehicles that are too expensive to support mass market adoption. For instance, the million-dollar fuel cell concept vehicle would not qualify. We do recognize that there are different pricing tolerances out there for different groups of consumers – from economy to luxury – and want to support innovation for all segments.

It is doubtful that any vehicle priced over \$75,000 - \$80,000 could prove there is a market of at least 10,000 customers per year. If competing vehicles are priced toward the top end of the range of acceptability, they will need to also have the features that are expected from a luxury model.

Why not require that vehicles be crash tested?

Crash testing is an expensive process, and something that any vehicle will need to complete before it goes into mass production.

Since our requirements stop just short of actual production, and we do not want to create unnecessary barriers for teams to fairly compete, we can fairly judge progress toward legal safety compliance through expert assessment and simulated computer crash testing software.

Why require business plans? How can you expect teams of engineers to know how to sell and service thousands of vehicles?

The AXP is not simply about engineering innovations in vehicle efficiency, it is also, and equally, about bringing that innovation to market. Teams that do not have business expertise will need to enlist the help of those that do in order to create a solid business plan.

We are not requiring teams to actually bring the vehicles to market, but we are requiring all teams to demonstrate that their vehicles are designed so that they *could* reasonably be brought to market.

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 AXP. 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. 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).

What about hydrogen?

We have not included hydrogen as a permitted fuel because it does not appear that the requisite fueling infrastructure will exist within the time frame of the AXP. However, we are open to including hydrogen (or other fuels) if there is a clear business case that the vehicle can succeed in the marketplace within a few years. In the case of hydrogen, this could occur, for example, if there is a breakthrough in the safe, affordable and local production of hydrogen.

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APPENDIX I – AXP BRAINSTORM SESSION AND WORKING GROUPS

The following individuals participated in the AXP Brainstorm Session and Working Groups, either through attendance at meetings and/or significant input and feedback:

AXP BRAINSTORM SESSION (July 2006)

- **Eric Adams**, Automotive Editor, *Popular Science*
- **John Boesel**, President & CEO, *CALSTART*
- **Martin Eberhard**, CEO, *Tesla Motors*
- **Shannon Eddy**, Advisor to Governor Schwarzenegger
- **Elyssa Elbaz**, Assistant US Attorney
- **Don Foley**, Founding Partner, *Prism Public Affairs*
- **Andrew Friendly**, Director, Energy Ventures, *Idealab*
- **Bill Gross**, CEO, *Idealab*
- **Chris Grundler**, Deputy Director, Office of Transportation and Air Quality, *US EPA*
- **Roland Hwang**, Senior Policy Analyst, *NRDC*
- **Ben Knight**, VP, Automotive Engineering, *Honda R&D Americas*
- **Barry Layne**, EVP, *National Lampoon*
- **Marques McCammon**, General Manager, West Coast Design & Technical Center, *ASC*
- **Bill McDonough**, Principal & Founder, *William McDonough & Partners*
- **Glenn Mercer**, Former Senior Auto Practice Expert, *McKinsey & Co.*
- **Norm Meyrowitz**, Principal, *NKM Advisors*
- **Dave Moore**, Senior Analyst, *Vulcan Ventures*
- **Richard Newell**, Associate Professor, *Nicholas School, Duke Univ.*
- **Phil Recht**, Partner, *Mayer, Brown, Rowe & Maw*
- **Alex Sessions**, Professor of Geobiology, *Caltech*
- **SM Shahed**, Corporate Fellow, *Honeywell Turbo Technologies*
- **Vijay Vaitheeswaran**, Environment and Energy Correspondent, *The Economist*
- **David Wagner**, Research and Advanced Engineering Group, *Ford*
- **Geoff Wardle**, Associate Chair & Director of Mobility Research, *Art Center College of Design*
- **Jan-Olaf Willums**, Chairman, *Inspire Invest*
- **Ron York**, VP, Aerospace, *SAE International*

ENERGY AND EMISSIONS WORKING GROUP (February 2007)

- **Jeff Alson**, Senior Policy Advisor, *US EPA*
- **Feng An**, Executive Director, *Auto Project on Energy and Climate Change*

- **Michael Arny**, President, *Leonardo Academy*
- **Gale Banks**, President, *Gale Banks Engineering*
- **Alec Brooks**, Chief Engineer, *AeroVironment*
- **Andre Brown**, Strategic Business Development, *Auto Research Center*
- **Axel Friedrich**, Head of Environment and Transport, *UBA Germany*
- **Stephen Gurski**, Research Engineer, *Argonne National Laboratory*
- **Nancy Hazard**, Former Director of the Tour de Sol
- **Ben Knight**, VP, Automotive Engineering, *Honda R&D Americas*
- **Jane Long**, Associate Director of Energy and Environment, *Lawrence Livermore National Laboratory*
- **Spencer Quong**, Senior Vehicles Analyst, Clean Vehicles Program, *Union of Concerned Scientists*
- **Jeff Ronning**, Senior Consultant, *Rocky Mountain Institute*
- **Alex Sessions**, Assistant Professor of Geobiology, *Caltech*
- **Fujio Takimoto**, General Manager, R&D Planning Group, *Subaru*
- **Luke Tonachel**, Vehicle Policy Analyst, *NRDC*
- **John Voelcker**, Journalist, *IEEE Spectrum*
- **Michael Wang**, Environmental Analyst, *Center for Transportation Research at Argonne National Laboratory*
- **Paul Wennberg**, R. Stanton Avery Professor of Atmospheric Chemistry and Environmental Science and Engineering, *Caltech*
- **Ian Wright**, Founder, *Wrightspeed*
- **Kathryn Zyla**, Research Fellow, *Pew Center on Global Climate Change*

RACE STRUCTURE AND COURSE DESIGN WORKING GROUP (March 2007)

- **Gale Banks**, President, *Gale Banks Engineering*
- **Andre Brown**, Strategic Business Development, *Auto Research Center*
- **Heather Contrino**, NHTS Program Manager, *Federal Highway Administration, Office of Highway Policy Information*
- **Don Foley**, Founding Partner, *Prism Public Affairs*
- **David Ganss**, Office of Transportation and Air Quality, *U.S. EPA*
- **Pat S. Hu**, Director, Center for Transportation Analysis, Engineering Science & Technology Division, *Oak Ridge National Laboratory*
- **Ben Knight**, VP, Automotive Engineering, *Honda R&D Americas*
- **Bob Larsen**, Center for Transportation Research, *Argonne National Laboratory*
- **Nancy McGuckin**, Travel Behavior Analyst, *Federal Highway Administration, Office of Highway Policy Information*
- **Spencer Quong**, Senior Vehicles Analyst, Clean Vehicles Program, *Union of Concerned Scientists*

- **Robert Rozycki**, Transportation Specialist, *Federal Highway Administration, Office of Highway Policy Information*
- **Ian Wright**, Founder, *Wrightspeed*

PRODUCTION CAPABILITY WORKING GROUP (March 2007)

- **Jim Boyd**, Commissioner, *California Energy Commission*
- **David Cole**, Chairman, *Center for Automotive Research*
- **David Greenwood**, Chief Engineer, Advanced Technology, *Ricardo UK, Ltd.*
- **Stephen Gurski**, Research Engineer, *Argonne National Laboratory*
- **Roland Hwang**, Senior Policy Analyst, *NRDC*
- **Ben Knight**, VP, Automotive Engineering, *Honda R&D Americas*
- **Joel Makower**, Founder, *GreenBiz.com, ClimateBiz.com, and GreenerBuildings.com*
- **Glenn Mercer**, Former Senior Auto Practice Expert, *McKinsey & Co.*
- **Norm Meyrowitz**, Principal, *NKM Advisors*
- **Chris Theodore**, Vice Chairman, *ASC Incorporated*
- **Paul Wilbur**, President and CEO, *ASC Incorporated*

APPENDIX II – ACRONYM GLOSSARY

AAA	:	American Automobile Association
ANL	:	Argonne National Laboratory
AXP	:	Automotive X PRIZE
BEV	:	Battery Electric Vehicle
BOM	:	Bill of Materials
CAD	:	Computer-Aided Design
CAFE	:	Corporate Average Fuel Economy regulations
CH ₄	:	Methane
CNG	:	Compressed Natural Gas
CO	:	Carbon Monoxide
CO ₂	:	Carbon Dioxide
CO _{2e}	:	Carbon Dioxide Equivalent, where other greenhouse gases (methane, nitrous oxide, etc.) are equated to carbon dioxide via a Global Warming Potential (GWP) score.
DOE	:	US Department of Energy
E85	:	Alcohol fuel mixture of 85% ethanol and 15% gasoline
EPA	:	US Environmental Protection Agency
EV	:	Electric Vehicle
Evap HC	:	Evaporative Hydrocarbon Emissions
FCV	:	Fuel Cell Vehicle
FFV	:	Flexible Fuel Vehicle
FHWA	:	US Federal Highway Administration
FMEA	:	Failure Modes Effect Analysis
FIA	:	Fédération Internationale de l'Automobile
FMVSS	:	US Federal Motor Vehicle Safety Standards
g/mi	:	Grams per Mile
GH ₂	:	Gaseous Hydrogen
GHG	:	Greenhouse Gases (e.g., carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, perfluorocarbons, chlorofluorocarbons, etc.)
GPS	:	Global Positioning System
GREET	:	Greenhouse gases, Regulated Emissions, and Energy use in Transportation – this is a model developed by Argonne National Lab that enables evaluation of various vehicle and fuel combinations on a full fuel-cycle basis
GWP	:	Global Warming Potential, or a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming when comparing the gas in question to the same mass of carbon dioxide
HCHO	:	Formaldehyde

HEV	:	Hybrid Electric Vehicle
HVAC	:	Heating, Ventilating, and Air Conditioning
ICE	:	Internal Combustion Engine
IIHS	:	Insurance Institute for Highway Safety
IPCC	:	Intergovernmental Panel on Climate Change
LH2	:	Liquid Hydrogen
LOI	:	Letter of Intent
LPG	:	Liquefied Petroleum Gas
MPG	:	Miles per Gallon
MPGe	:	Miles per Gallon of gasoline energy Equivalent, or drivetrain energy efficiency based on distance traveled and fuel energy delivered to the vehicle.
MPH	:	Miles per Hour
MTA	:	Master Team Agreement
N2O	:	Nitrous Oxide
NGO	:	Non-Governmental Organization
NHTSA	:	US National Highway Traffic Safety Administration
NMHC	:	Non-Methane Hydrocarbons
NOx	:	Oxides of Nitrogen
NRDC	:	Natural Resources Defense Council
OEM	:	Original Equipment Manufacturer
P&L	:	Profit and Loss
PHEV	:	Plug-in Hybrid Electric Vehicle
PM	:	Particulate Matter
PTW	:	Pump-to-Wheel, or the downstream portion of overall transportation fuel efficiency
SAE	:	Society of Automotive Engineers
SCF	:	Standard Cubic Foot
SOC	:	State of Charge
SULEV	:	Super Ultra Low Emission Vehicle
ULEV	:	Ultra Low Emission Vehicle
UNECE	:	United Nations Economic Commission for Europe
VDR	:	Vehicle Design Requirements
VMT	:	Vehicle Miles Traveled
WTP	:	Well-to-Pump, or the upstream portion of overall transportation fuel efficiency
WTW	:	Well-to-Wheel, which refers to overall transportation fuel efficiency
XPF	:	X PRIZE Foundation
ZEV	:	Zero Emission Vehicle