VEHICLES

> FUEL EFFICIENCY & GHG EMISSIONS
> CRITERIA POLLUTANT TAILPIPE EMISSIONS
> FUTURE TRANSPORTATION
For more than 35 years, Toyota’s North American engineering and research and development activities have been headquartered in Ann Arbor, Michigan.

Team members at our design and research centers are engaged in engineering design, prototype building, vehicle evaluation, evaluation and design of parts and materials, regulatory affairs, emissions certification and technical research. Toyota’s Ann Arbor technical center is widely regarded as Toyota’s leading technical center outside Japan.

A fundamental step in the design of our vehicles is yokoten – sharing knowledge and lessons learned between vehicle development teams. Each time we undertake a vehicle redesign or begin the development of a new vehicle, we take into account
what we’ve learned from previous projects, then find better ways to apply or improve on that knowledge.

By applying yokoten and other principles of the Toyota Way, we are finding ways to innovate more “green” into our products – for example, by finding ways for our vehicles to go longer distances on fewer gallons of fuel. We are also building a portfolio of advanced technologies to reduce emissions and meet future mobility needs.

Our efforts to make fuel-efficient vehicles with low emissions stem from our commitment to eliminate waste in all aspects of our business. Vehicles with poor gas mileage are inefficient – they “waste” fuel and money. So during the vehicle design stage, we set targets for a vehicle’s fuel economy and tailpipe emissions levels.

The lighter the vehicle, the more fuel-efficient it can be. This past year, we introduced the all-new Avalon Hybrid, the first Toyota vehicle to be fully styled, developed and built in North America. Thanks in part to its low mass, the Avalon Hybrid achieves an impressive EPA-estimated 40 miles per gallon combined.

Throughout this report, we highlight examples of our efforts to eliminate waste. The many awards won by our vehicles for outstanding fuel efficiency and low tailpipe emissions are further examples of our commitment to efficiency and waste reduction.

**SHARING**

The Japanese word *yokoten* is translated loosely as sharing lessons learned. When a project finishes at Toyota, we methodically try to preserve what went well and create countermeasures for what did not. Lessons learned are incorporated into the standard process so that when we repeat it, we improve over the last time. When we practice *yokoten*, we share not only the methods and procedures, but also the reasons changes were made and what mistakes were made. By openly communicating and sharing this information horizontally across the organization, we foster a learning organization.
FUEL EFFICIENCY & GHG EMISSIONS

Toyota is pursuing multiple technology paths to reduce fuel consumption and greenhouse gas emissions in our global markets. We try to match technologies to best meet customer needs in each specific region. This means evaluating vehicle powertrains, weight, aerodynamics and other design factors to boost vehicle efficiency while preserving the vehicle size, power, driving range and affordability that customers demand – and without sacrificing world-class vehicle safety and performance. Hybrid technology is becoming increasingly important in satisfying this vast array of sometimes conflicting requirements across different regions, and hybrids remain at the core of our technology portfolio as well as our compliance strategy.

In the United States, the Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) have established fuel economy and greenhouse gas (GHG) emissions standards for passenger cars and light trucks through the 2025 model year. By 2016, the new vehicle fleet must meet a GHG standard of 250 grams of CO₂ per mile, equivalent to a Corporate Average Fuel Economy (CAFE) standard of 35.5 miles per gallon; by 2025 cars and light trucks are required to yield a combined 54.5 mpg. While overall compliance is based on a fleet average, each vehicle has a fuel economy/GHG target based on its footprint. Many of our hybrid products are already capable of meeting their respective future targets for fuel economy and GHG standards.

One significant challenge to meeting these standards will be having technology options available that consumers are able and willing to purchase in sufficient quantities. At this point, it is nearly impossible to predict such outcomes so far into the future, since preferences will largely be determined by factors such as fuel price, economic conditions and infrastructure development – most of which are beyond an auto manufacturer’s control. These factors have begun to be monitored under the mid-term review process, which will re-evaluate the feasibility of the 2022-2025 model year standards. A determination on feasibility will be made by 2018.

Toyota believes any evaluation should treat vehicles and fuels as a system. Higher octane and/or reduced sulfur can enable additional greenhouse gas emissions reductions and fuel savings from several engine technologies, while biofuels have the potential to reduce the carbon intensity of the fuel.

In Canada, Toyota supports a harmonized approach with the United States to setting emissions standards. The Canadian federal government introduced a greenhouse gas emissions regulation under the Canadian Environmental Protection Act for the 2011 through 2016 model years, and is in the process of proposing greenhouse gas emissions regulations for the 2017-2025 model years.

In Mexico, the government has proposed GHG standards modeled after the U.S. requirements. The standards require automakers to meet a single sales-weighted fleet average over the period 2014 through 2016, and allow credits generated in 2012 and 2013 to be used toward compliance. These standards have been appropriately tailored to the unique driving conditions and product mix associated with the Mexican market, and contain similar compliance flexibilities and lead
time as those offered in the United States. Starting with model year 2014 implementation, we will begin reporting on Toyota’s performance in this program.

FUEL ECONOMY AWARDS

Toyota offers several models that achieved best-in-class fuel economy ratings in 2013.
FG7 • Best-in-Class Fuel Economy Ratings

Our CAFE and CAFC performance is driven by high volume sales of our most fuel-efficient vehicles. Toyota offers several models that achieved best-in-class fuel economy ratings in 2013, according to a number of sources:

Natural Resources Canada's ecoENERGY Awards for 2013

<table>
<thead>
<tr>
<th>CLASS</th>
<th>LEADER IN MPG COMBINED</th>
</tr>
</thead>
<tbody>
<tr>
<td>mini-compact</td>
<td>Scion iQ 37</td>
</tr>
<tr>
<td>compact</td>
<td>Prius c 50</td>
</tr>
<tr>
<td>midsize</td>
<td>Prius Liftback 50</td>
</tr>
<tr>
<td>midsize station wagon</td>
<td>Prius v 42</td>
</tr>
<tr>
<td>small pickup truck</td>
<td>Tacoma 2WD 23</td>
</tr>
<tr>
<td>small sport utility (front wheel drive)</td>
<td>Lexus RX 450h 30</td>
</tr>
<tr>
<td>standard sport utility</td>
<td>Highlander Hybrid 28</td>
</tr>
</tbody>
</table>

(The segment classifications are determined by EPA's measurement of a vehicle's interior volume; ratings exclude PHEV and pure EV vehicles.)

The U.S. Department of Energy’s www.fueleconomy.gov

<table>
<thead>
<tr>
<th>CLASS</th>
<th>LEADER IN MPG COMBINED</th>
</tr>
</thead>
<tbody>
<tr>
<td>mini-compact</td>
<td>Scion iQ 37</td>
</tr>
<tr>
<td>compact</td>
<td>Prius c 50</td>
</tr>
<tr>
<td>midsize</td>
<td>Prius Liftback 50</td>
</tr>
<tr>
<td>midsize station wagon</td>
<td>Prius v 42</td>
</tr>
<tr>
<td>small pickup truck</td>
<td>Tacoma 2WD 23</td>
</tr>
<tr>
<td>small sport utility (front wheel drive)</td>
<td>Lexus RX 450h 30</td>
</tr>
<tr>
<td>standard sport utility</td>
<td>Highlander Hybrid 28</td>
</tr>
</tbody>
</table>

(The ratings exclude PHEV or pure EV vehicles.)

U.S. Department of Energy’s Top 10 EPA-Rated Fuel Sippers for 2013

<table>
<thead>
<tr>
<th>Prius</th>
<th>Prius c</th>
<th>Prius v</th>
<th>Lexus CT 200h</th>
<th>Lexus ES 300h</th>
</tr>
</thead>
<tbody>
<tr>
<td>tied for 1st, 51 city/48 hwy</td>
<td>tied for 1st, 53 city/46 hwy</td>
<td>tied for 4th, 44 city/40 hwy</td>
<td>ranked 8th, 40 city/39 hwy</td>
<td></td>
</tr>
<tr>
<td>tied for 4th, 43 city/40 hwy</td>
<td>ranked 9th, 40 city/39 hwy</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(The ratings exclude PHEV or pure EV vehicles.)

Kelley Blue Book

• Ranks the Toyota Avalon Hybrid and Toyota Prius Plug-in as two of the 10 Best Green Cars of 2013.

• Ranks the Lexus RX 450h (in first place), Toyota Highlander Hybrid and Toyota RAV4 as three of the 10 Most Fuel-Efficient SUVs of 2013.
PERFORMANCE

Fuel economy is the distance a vehicle can be driven using a certain amount of fuel, measured in the United States as miles per gallon (mpg). Fuel consumption is the quantity of fuel burned over a defined distance, and in Canada is measured as liters of fuel burned per 100 kilometers traveled (L/100 km). The amount of fuel burned is directly related to emissions of carbon dioxide (CO₂), a greenhouse gas: The more fuel burned, the more CO₂ emitted.

In the United States, Toyota is the most fuel-efficient full-line automotive manufacturer. In the United States, Toyota’s model year 2013 fleet achieved the required U.S. Corporate Average Fuel Economy (CAFE) standards. Toyota met the required GHG standards in both the United States and Canada.

FG8 • U.S. Car Corporate Average Fuel Economy, or CAFE

![Graph showing U.S. Car Corporate Average Fuel Economy from MY03 to MY13](image)
 FG9 • Annual CO$_2$ per Kilometer, Toyota U.S. Fleet

|^ INDICATES BETTER PERFORMANCE |

This data represents CAFE fuel economy performance in terms of CO$_2$ (grams per mile) and does not reflect provisions in the U.S. EPA GHG program (starting 2012 model year) such as air conditioning credits.
FG10 • Canadian Car Company Average Fuel Consumption, based on GHG Emission Regulation

*This data is based on CO₂ emissions data reported to Environment Canada.

**RELATED TOPICS**

- For more information on our advanced technology vehicles including our hybrid fleet, please visit [Future Transportation](#).
- For information on how we manage CO₂ emissions in operations, please visit [Operations/Carbon](#).
CRITERIA POLLUTANT TAILPIPE EMISSIONS

Hydrocarbons, nitrogen oxides (NOx) and carbon monoxide – all byproducts of fuel combustion – are linked to various air quality issues, including smog and acid rain, as well as a number of health effects. Limiting these emissions from our vehicles helps to reduce some of the environmental impacts of driving.

The U.S. Environmental Protection Agency (EPA) and the state of California have certification programs to categorize vehicles in terms of their level of tailpipe emissions. EPA’s certification program categorizes vehicles into Tier 2, Bins 1 through 8. Lower bin numbers correspond to vehicles with lower tailpipe emissions; Bin 1 is for vehicles with zero tailpipe emissions. This program requires a manufacturer’s fleet average to meet a Tier 2 NOx standard of 0.07 grams per mile (gpm). (The Canadian and U.S. federal programs have equivalent standards.)

In California, the Low-Emission Vehicle II (LEV II) regulations categorize vehicles as LEV (Low Emission Vehicle), ULEV (Ultra Low Emission Vehicle), SULEV (Super Ultra Low Emission Vehicle), ZEV (Zero Emission Vehicle), or AT-PZEV (Advanced Technology Partial Zero Emission Vehicle). For the 2013 model year, the California LEV II regulations required an auto manufacturer’s fleet average to meet an emission standard for non-methane organic gas (NMOG) of 0.035 gpm for passenger cars and light-duty trucks up to 3,750 pounds, and 0.043 for other light-duty trucks.

The LEV II standards are in effect through the 2014 model year. LEV III was adopted in California on December 31, 2012, and will be effective in the 2015 model year.

We expect the current federal vehicle emission standards to change, based on EPA’s anticipated issuance of their Tier 3 rule. Environment Canada has announced they will also pursue Tier 3 regulations aligned with the proposed U.S. Tier 3 rule.

Toyota, along with other auto manufacturers, supports efforts to harmonize the new California LEV III and federal Tier 3 programs. We are working with federal and state agencies, through their regulatory processes, to help develop rules that are both effective and feasible. Our goal is to maintain the flexibility to build vehicles based on customer preferences. In setting tailpipe emission regulations, we believe standards should be performance-based and take into account the interaction with other vehicle rules – such as fuel economy/greenhouse gas standards – to ensure the total package of requirements is effective and acceptable to the consumer. As with greenhouse gas emissions, fuels must be considered with vehicle technologies as a holistic system. Reduced sulfur levels in gasoline, already available for the LEV III program, are needed to enable the after-treatment systems being designed for Tier 3 compliance.
PERFORMANCE

Toyota annually complies with the state of California, U.S. and Canadian federal vehicle emissions programs, and we have met the requirements for the 2013 model year.

The Toyota Prius c earned the title of Greenest Car of the Year from the American Council for an Energy Efficient Economy (ACEEE) in their “Greenest Vehicles of 2013” list. The list is notable in that it takes into account a variety of criteria when determining the greenest car, including the car’s emissions, emissions from the electric grid on which it charges, and energy necessary to build and dispose of the car.

The Scion iQ was one of only two all-gasoline cars to make the ACEEE “Greenest Vehicles of 2013” list.

Prius (shown here) and Prius Plug-in Hybrid tied for third place on ACEEE’s “Greenest Vehicles of 2013” list.
More information about the emissions performance of Toyota, Lexus and Scion vehicles sold in the United States can be found in EPA’s Green Vehicle Guide.

FG11 • **Toyota and Lexus SULEVs**

Specifically for vehicles offered in the 2013 model year, 40 percent of all Toyota, Lexus and Scion passenger car vehicles and 13 percent of truck vehicles are certified to SULEV or better. These vehicles include:

- Avalon Hybrid
- Prius
- Prius c
- Prius v
- Prius Plug-In Hybrid
- Camry Hybrid
- Camry PZEV
- Highlander Hybrid
- RAV 4 EV
- Lexus ES 300h
- Lexus GS 450h
- Lexus RX 450h
- Lexus LS 600h L
- Lexus CT 200h

*Data is U.S. only and is not sales-weighted.*
FUTURE TRANSPORTATION

Toyota’s approach to future transportation focuses on developing a suite of technologies to meet the world’s mobility needs sustainably and with flexibility. We acknowledge that one technology will not be the “winner,” and that a mobility system in New York could look very different from systems in São Paulo, Toronto, London or Shanghai. So Toyota is rolling out conventional hybrids across our entire lineup and improving the efficiency of our conventional engines and powertrains, while also investing in a portfolio of advanced technologies – battery electric, plug–in hybrid and fuel cell.

Toyota addresses customers’ needs for driving distance and vehicle size using different portfolio technologies. Our vision for battery electric vehicles, for example, is based on short trips originating from home, while our Plug–in Hybrid and Fuel Cell Vehicles (FCVs) are meant for longer driving distances.

Our investments in advanced technology address all aspects of the vehicle life cycle. Our commitment to yokoten – sharing learning across the organization – has resulted in significant improvements with each generation of our advanced technology vehicles. We continue to innovate for better fuel efficiency and lower emissions.

FG12 • Energy Sources for Toyota’s Advanced Technology Vehicles

The vehicles shown from left to right are: Scion iQ EV, RAV4 EV, Lexus CT 200h, Prius, FCHV-adv and a fuel cell hybrid bus.
FG13 • Advanced Technology Vehicle Milestones

2012
The Avalon Hybrid debuts, the first Toyota vehicle to be fully styled, developed and built in North America.

2012
The Lexus ES 300h debuts, the fifth Lexus hybrid to be launched in North America.

2012
Toyota launches the Prius Plug-in Hybrid, available in both the U.S. and Canada.

2008
Toyota announces FCHV-adv, which achieves cruising range of approximately 780 km.

2006
The Camry Hybrid launches, the first hybrid vehicle to be assembled in the U.S.

2007
The prototype Prius plug-in hybrid vehicle debuts, powered by a double Ni-MH battery pack.

2003
The second-generation Prius is introduced with Hybrid Synergy Drive.

2000
The first mass-produced hybrid passenger vehicle in the world, the Prius, is introduced in the U.S. (launched in Japan in 1997).

1998
The CNG Camry debuts in the U.S. Vehicle is sold for fleet applications.

1997
Toyota develops FCEV equipped with original fuel cell stack and hydrogen-absorbing alloy tank.

1997
Toyota eCom car debuts at the Tokyo Motor Show.
Advanced Powertrains + Alternative Fuels

Our portfolio approach takes into account the diversity of alternative transportation fuels currently available, as well as those on the horizon. Ethanol, biodiesel, natural gas and electricity are already in the marketplace here in North America, while hydrogen will be arriving soon. The availability and diversity of these alternatives to gasoline and diesel play a key role in helping countries realize their energy security and greenhouse gas emissions reduction goals.

The National Petroleum Council recently released a report, “Advancing Technology for America’s Transportation Future.” The study responds to the U.S. Department of Energy’s request for advice on accelerating development of alternative fuel vehicles through 2050 for passenger and freight transport, with an eye toward economically reducing the U.S. transportation sector’s 2050 petroleum use and life-cycle greenhouse gas (GHG) emissions. Research was conducted over a period of two years and with the participation of a number of companies, including Toyota. Key findings include:

• Existing technologies can substantially increase vehicle fuel economy.
• Overcoming 12 priority technology hurdles, such as increasing battery energy density and reducing the cost of vehicle light-weighting, is essential for commercialization of advanced fuels and vehicles.
• Increasing the diversity of economically competitive fuels and vehicles will bolster the nation’s energy security.
• Continued investment in multiple combinations of advanced fuels and vehicles could yield solutions that benefit American consumers and significantly reduce GHG emissions.

A number of Toyota’s advanced technology vehicles are designed to use alternative fuels such as electricity and hydrogen. But as the study notes, there are several hurdles to overcome before these vehicles can realize full-scale commercialization. Infrastructure development is one of these hurdles.

Through the California Fuel Cell Partnership (CaFCP), the Fuel Cell and Hydrogen Energy Association (FCHEA), and the California Plug-in Electric Vehicle Collaborative, Toyota is working with government agencies (including the U.S. Department of Energy), other auto manufacturers, utilities and other key stakeholders to support the development of necessary infrastructure for advanced technology vehicles.
PARTNERSHIP: CREATING A CLOSED-LOOP SYSTEM FOR BIODIESEL

Toyota Motor Manufacturing, Alabama builds four-cylinder engines for Camry, RAV4, Venza, Sienna and Highlander, and V6 and V8 engines for Tacoma, Tundra and Sequoia. The plant is located in Huntsville, less than 10 miles from Alabama A&M University.

Alabama A&M University is committed to searching for new knowledge through research and its applications. In 2010, our Alabama plant formed a partnership with the university to learn about possible applications of biofuel at our North American manufacturing plants. Under the leadership of Dr. Ernst Cebert, a professor in the Department of Biological and Environmental Sciences, A&M University students are using diesel engines from our parts delivery trucks as a real-world laboratory. Together, we are working toward creating a closed-loop system, where waste oil from our cafeteria eventually comes back to us as biodiesel for use in on-site shunt trucks.

Biodiesel is a cleaner-burning alternative fuel often produced from renewable resources such as plant oils, animal fats, used cooking oil and even algae. Biodiesel itself contains no petroleum, but is typically blended at various levels with petroleum to create a biodiesel blend that works in diesel engines over a wide range of temperatures, with few modifications. When compared to burning regular diesel, burning biodiesel-gasoline blends results in lower exhaust emissions of the pollutants that form smog, ozone and acid rain.

The Huntsville plant delivers between 55 and 100 gallons per month of used cooking oil to Alabama A&M University, where the waste oil is converted to biodiesel using a Springboard Biodiesel BioPro™190 unit. The unit is designed to produce ASTM-quality fuel, and is about the size of a stand-up arcade game. One 55-gallon drum of waste oil from Toyota’s plant makes approximately 30 gallons of biodiesel.

The volume of biodiesel is still quite small, but the opportunity for the university to use Toyota’s equipment in a real-world setting is priceless. “You never know where the next great idea is going to come from,” said David Absher, Manager at Toyota North American Environmental. “Dr. Cebert works in the George Washington Carver building at the University. Dr. Carver suggested using peanut oil to power automobiles over 100 years ago. One of Dr. Cebert’s students might discover the key to improving the biodiesel process.”

There are many players in this partnership, from team members at Toyota, to professors and graduate students, to the makers of the BioPro 190. And everyone involved is learning. We are learning about the biofuel specifications and what it takes to convert waste oil into a workable fuel. This gives us a better understanding of the technological implications of scaling up a project like this, or even of sharing it – practicing yokoten – with another Toyota plant. Small projects like this may eventually lead us to our next great breakthrough.
Dr. Cebert and his students at Alabama A&M University are working with team members at our Huntsville plant to create a closed-loop system, where waste oil from our cafeteria eventually comes back to us as biodiesel for use in on-site shunt trucks.

**RELATED TOPICS**

- Watch a short video about TOYOTA’s innovative partnership with Alabama A&M University.
Hybrid Vehicles

Toyota and Lexus have 12 hybrid vehicles currently on the market, all using our unique series-parallel hybrid system. Hybrid technology is the foundation of Toyota’s approach to minimizing the environmental impacts of gasoline-powered vehicles. Knowledge gained from hybrid development and deployment is helping Toyota accelerate the introduction of future powertrains that can utilize a wide variety of energy sources and fuels, including hydrogen, biofuel, natural gas and electricity.

FG14 • Toyota Hybrid System and Fleet

Depending on driving conditions, the engine and the electric motor(s) can work together, or the motor(s) alone can propel the vehicle.

Hybrid Fleet

The current fleet of Toyota and Lexus hybrids includes:

<table>
<thead>
<tr>
<th>MODEL</th>
<th>YEAR LAUNCHED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prius</td>
<td>2000</td>
</tr>
<tr>
<td>Highlander Hybrid</td>
<td>2005</td>
</tr>
<tr>
<td>Lexus RX 400h/RX 450h</td>
<td>2005</td>
</tr>
<tr>
<td>Camry Hybrid</td>
<td>2006</td>
</tr>
<tr>
<td>Lexus GS 450h</td>
<td>2006</td>
</tr>
<tr>
<td>Lexus LS 600h L</td>
<td>2006</td>
</tr>
<tr>
<td>Prius v</td>
<td>2011</td>
</tr>
<tr>
<td>Lexus CT 200h</td>
<td>2011</td>
</tr>
<tr>
<td>Prius c</td>
<td>2012</td>
</tr>
<tr>
<td>Prius Plug-in Hybrid</td>
<td>2012</td>
</tr>
<tr>
<td>Lexus ES 300h</td>
<td>2012</td>
</tr>
<tr>
<td>Avalon Hybrid</td>
<td>2012</td>
</tr>
</tbody>
</table>

*Launch dates refer to North American launches of the first generation of these vehicles.
Toyota reached a milestone at the end of March 2013, when global hybrid sales topped the five million mark. Since introducing the first hybrid vehicle in 1997, Toyota’s global fleet of 20 hybrid models has resulted in an estimated 34 million fewer tons of CO₂ emissions than those emitted by gasoline-powered vehicles.

Between January 2013 and the end of 2015, Toyota plans to introduce 18 new hybrid models worldwide and expects global sales of its hybrids to be at least one million units a year. About one third of these will be sold in North America.

Over two million Toyota and Lexus hybrids – including more than 1.4 million Prius Family vehicles and 229,000 Lexus hybrids – have been sold in North America (hybrid sales data YTD as of June 2013).

**SPOTLIGHT: THE 2013 AVALON HYBRID**

Toyota’s all-new 2013 Avalon Hybrid is the first Toyota vehicle to be fully styled, developed and built in North America. This is also the first time vehicle crash testing was performed in North America, at our facility in York, Michigan, and the first time a prototype was built in North America, also in Michigan. The Avalon Hybrid is assembled at our plant in Georgetown, Kentucky (using U.S. and globally sourced parts).

While the 2013 Avalon Hybrid is noteworthy for its distinctive styling and performance, it is also one of the more fuel-efficient vehicles in the mid-size segment. The key to the Avalon’s superior fuel efficiency is its low mass.

Avalon Chief Engineer Randy Stephens and his development team at Toyota Technical Center in Ann Arbor, Michigan, worked toward a goal of making Avalon lighter, yet more rigid, to help improve overall driving performance. “Our target was to dramatically improve all aspects of dynamic performance,” Randy explained, “especially in the areas of fuel efficiency, handling and performance.”

Engineering for weight reduction requires examination of all elements of vehicle design and componentry. By installing a higher class of high-performance polypropylene resin, we were able to decrease the general thickness – and weight – of the front and rear bumpers. Also, by
using a higher content of high-strength steel in various vehicle parts, we were able to conserve mass while maintaining crash performance targets.

Our suppliers also played a role in helping us reduce the overall weight of the vehicle. Thanks to Johnson Controls and Superior Wheels, the weight of the seats was reduced by 20 pounds, and the weight of the wheels was reduced by 11 pounds.

As a result of these efforts, the new 2013 Avalon is 110 pounds lighter than the 2012 model. The lighter weight of the 2013 Avalon Hybrid helps it achieve an impressive EPA-estimated 40 miles per gallon combined.

The 2013 Avalon Hybrid is noteworthy for its distinctive styling and performance. It also achieves an impressive EPA-estimated 40 miles per gallon combined.
Plug−in Hybrid Vehicles

Plug−in hybrid vehicles use electricity from the power grid to partially offset the use of gasoline. As such, these vehicles typically release fewer emissions while in operation than a conventional vehicle. While the life cycle implications vary, based on the source of the electricity, Toyota views the plug−in hybrid vehicle as a way to reduce fuel consumption and tailpipe emissions (including CO$_2$) beyond a standard gasoline-electric hybrid vehicle.

In 2012, we launched the Prius Plug−in Hybrid, available in both the United States and Canada. Toyota’s Prius Plug−in offers all the advantages and utility of a conventional hybrid vehicle. Its 4.4 kWh lithium-ion battery can be charged using a 120V outlet in about three hours (with a dedicated 15 amp circuit). Depending on the driving profile, regular recharging can reduce gasoline consumption by up to one third over a conventional Prius, which in turn reduces both greenhouse gas and tailpipe emissions.

The Prius Plug−in can operate on battery power alone at speeds up to 62 miles per hour and is rated by the U.S. EPA with an EV Mode range up to 11 miles. For longer distances and at speeds above 62 miles per hour, the Plug−in automatically switches to hybrid mode and operates like a regular Prius.

The EV mode fuel economy for the Prius Plug−in is EPA-rated at 95 mpge (miles per gallon equivalent). In hybrid mode, the Prius Plug−in has a combined EPA rating of 50 miles per gallon. The total EPA-rated driving range is 540 miles on a single charge and single tank of gasoline. Drivers who charge the vehicle regularly and use it for street driving on frequent short trips will realize the biggest reduction in gasoline usage.

**FG15 • Plug—in Hybrid Vehicle Characteristics**

- Use in EV Mode for short distances, in Hybrid Mode for long distances
- No concern for battery running out
- Can be recharged easily with household current

A Plug—in Hybrid Vehicle is the integration and innovation of HV and EV technologies
PLUG-IN HYBRID BATTERIES
The lithium-ion (Li-ion) batteries powering the Prius Plug–ins are built in conjunction with PEVE (Panasonic EV Energy Company, LTD), a joint venture with Toyota. Toyota designed the Prius Plug–in Hybrid around a battery pack smaller than competitive plug–ins or EVs for several reasons. A smaller battery, while providing less EV-only range, weighs less, which maintains the high fuel economy of a hybrid vehicle once the vehicle is no longer in EV mode. In addition, a smaller battery is easier to package in the vehicle, can quickly charge using a standard household outlet, and costs less to build.

To further improve the ease of vehicle charging, we recently began working on wireless battery charging technology so that eventually, there will be no need to plug in.

A STUDY OF PLUG–IN HYBRID VEHICLE CHARGING BEHAVIOR
As with other alternative fuel-vehicle systems, Toyota studies the entire vehicle ecosystem. For plug–in hybrids, enabling wide-scale vehicle charging will require smart charging, such that all vehicles are primarily charged off-peak, and not all at the same time. To study this in the real world, Toyota partnered with the Renewable and Sustainable Energy Institute (RASEI) at the University of Colorado Boulder and Xcel Energy to examine customer response to various types of managed charging and electricity pricing. All of the project partners gained valuable insight into wide-scale vehicle charging and how to minimize the impact to the grid.

The SmartGridCity® Program is a technology pilot in Boulder, Colorado, exploring smart-grid tools in a real-world setting. This pilot provided the study partners with a unique opportunity to evaluate plug–in hybrid vehicle charging. The study wrapped up in 2012, with some interesting results.

Data was collected from 27 Prius Plug–in Hybrid vehicles rotated through 138 Boulder households that, combined, took 12,000 vehicle trips totaling 91,000 miles. The average fuel economy during the study was just under 68 miles per gallon. Households averaged three trips per day, where each trip averaged 7.5 miles. Fuel economy peaked at over 90 mpg for trips of five miles or less. When charging, the average amount of electricity consumed per charge was 2.3 kilowatt-hours. Electricity displaced up to 30 percent of total energy consumed per mile.

One-on-one interviews were conducted both before and after the six-week driving rotation. By and large, households actively managed their charging; however, most were not interested in using a website to check their electricity usage or manage their smart-chargers. Customers wanted an easy and seamless “set it and forget it” method to manage charging, and electricity pricing, more than any other factor, drove charging management behavior.
SPOTLIGHT: TOYOTA PLUG-IN IS MOST FUEL-EFFICIENT HYBRID IN GREEN RALLY

Toyota Canada’s Prius Plug-in entry in the 2013 Rallye Monte Carlo des Energies Nouvelles earned the title of most fuel-efficient hybrid and finished fifth overall, out of a total of 113 entries. The Monte Carlo rally is the world’s oldest and most prestigious green rally, and is one of 13 rallies around the world in the Fédération Internationale de l’Automobile (FIA) Alternative Energies Cup series. Drivers were challenged to consider driving behavior, fuel use and energy regeneration.

Over the course of the four day rally, Toyota Canada’s Prius Plug-in traveled more than 1,500 kilometers (930 miles) through Monaco, France and Italy, climbing and descending mountain elevations of more than 960 meters (3,150 feet).

Toyota’s Prius Plug-in was driven by Vinh Pham, an Advanced Technology and Powertrain Engineer at Toyota Canada. Vinh also competed in the 2012 Rallye Monte Carlo des Energies Nouvelles, placing 21st of 149 competitors, and in the 2011 and 2012 Rallye Vert de Montreal races, where he won both times. Navigator Alan Ockwell is a multiple Canadian national champion. Since his debut, he has established himself as one of the top co-drivers in Canada, with two national titles and a dozen event victories.

Our Prius Plug-in achieved a consistent average fuel consumption of 3.9 L/100 kilometers (60 mpg) during the rally. “We’re proud the Prius Plug-in’s real-world fuel efficiency was proven on such an aggressive course,” said Stephen Beatty, Vice President at Toyota Canada Inc. “We’re also extremely proud of Vinh and Alan for their commitment to showcasing what’s possible with a Prius.”
Electric Vehicles

Toyota engineers have been studying electric vehicles (EVs) for nearly 40 years. Alongside the company’s groundbreaking hybrid, plug-in hybrid and fuel cell vehicles, EV technology represents another component of Toyota’s long-term vision for future mobility.

Toyota’s latest entry into the EV market is the second-generation RAV4 EV, developed in partnership with Tesla Motors, Inc. The RAV4 EV – the only all-electric SUV on the market in North America – went on sale in September 2012 through select California dealers, focusing on four major metropolitan markets. Tesla builds and supplies the battery as well as other related powertrain parts and components; the vehicle is built at Toyota’s manufacturing plant in Woodstock, Ontario.

For two weeks in September 2012, we introduced the vehicle to the public during an innovation tour along the coast of California. At the wheel was Graham Hill, founder of two of the sustainability movement’s most respected websites: Treehugger.com and LifeEdited.com. During his trip, Graham gave Californians a chance to test-drive the RAV4 EV at events like National Plug-in Day and Green Drive Expo.

The RAV4 EV has an EPA-rated driving range of 103 miles and a fuel economy of 76 combined miles per gallon equivalent (MPGe).*

The vehicle has a 41.8 kWh lithium-ion battery pack. When plugged into a Level 2, 40-amp, 9.6-kW output charging unit, the RAV4 EV’s battery pack can be fully replenished in as little as five hours.**

The vehicle comes equipped with a 120v charging cable for use when Level 2 charging is not available.

* EPA-rated driving range when vehicle is fully charged. Excludes driving conditions. Actual mileage will vary.

MPGe based on 2013 EPA ratings. Actual MPGe will vary based on driving habits, charging practice, battery age, weather, temperature, and road/traffic conditions. Battery capacity will decrease with time and use. For more information on MPGe and range, please see www.fueleconomy.gov.

**Charging times when vehicle is in Normal Mode and ambient temperature is at 77 degrees F. Charging times will vary with ambient temperature.
EV consumers embrace the technology for its smooth drive, excellent acceleration and zero tailpipe emissions, yet they represent a small percentage of the overall vehicle market. For most consumers, limited vehicle range and battery recharge time remain barriers to consideration. As such, Toyota has active research in battery technology – both lithium-ion and “beyond lithium.” While EVs may not be the solution for every customer, they are one option in our portfolio of advanced technologies.

In early 2013, we announced our first fleet program partner for the Scion iQ EV. The University of California Irvine has placed 30 iQ EVs for use in their ZEV NET car sharing program. Car sharing is an increasingly viable mobility model in urban areas. The Scion iQ EV is a fleet-only vehicle, and only 100 of these vehicles have been produced.
Fuel Cell Vehicles

Toyota’s fuel cell vehicles are powered by fuel cells that generate electricity from hydrogen. Hydrogen gas is fed into the fuel cell stack where it’s combined with oxygen from air. The electricity produced by this chemical reaction is used to power the vehicle’s electric motor and charge the battery.

We believe hydrogen holds great potential as a clean, renewable, economically-viable fuel. A fuel cell vehicle emits only water vapor; the exhaust contains no particulate matter, hydrocarbons or other pollutants. Hydrogen can be manufactured using natural energy sources like solar, wind, and landfill and bio-gases, helping to break society’s reliance on oil.

Since the 2002 introduction of the first-generation Fuel Cell Hybrid Vehicle (FCHV), Toyota engineers have continued to improve the FCHV’s range, durability and efficiency through advances in the fuel cell stack and the high-pressure hydrogen storage system, while achieving significant cost reductions in materials and manufacturing processes. The latest FCHV iteration, the FCHV-advanced (FCHV-adv), was introduced in 2008 and boasts an estimated range increase of more than 150 percent over the first-generation FCHV. The FCHV-adv fuel cell system features four compressed hydrogen fuel tanks, an electric motor, a nickel-metal hydride battery and a power control unit. Toyota has deployed more than 100 FCHV-adv vehicles with universities, private companies and government agencies in California, Connecticut, Massachusetts and the New York metro area as part of a national demonstration program.

Last year, Toyota Motor Corporation (our parent company in Japan) unveiled a new fuel cell stack with more than twice the power density compared to the stack currently used in the FCHV-adv, at approximately half the size and weight. The new stack has an output power density of 3.0 kW/L.

The performance of the fuel cell system as a whole has been further improved by using a newly-developed, high-efficiency boost converter. Increasing the voltage has made it possible to reduce the size of the motor and the fuel cell stack.
We want to ensure our customers will have sufficient access to hydrogen fuel when we launch our fuel cell vehicle in 2015. To that end, we continue to partner with industry and government to support the growth of the hydrogen fueling infrastructure.

In the spring of 2013, we completed the expansion of our Technical Training Center in Glen Burnie, Maryland, which serves Toyota’s Central Atlantic region. This facility is Toyota’s first technical training center in the United States with the majority of the required infrastructure to train on future fuel cell vehicles. Currently, Toyota’s FCHV-adv vehicles throughout the United States are serviced by staff out of our engineering and development technical centers. When we bring a sedan-based fuel cell vehicle to market in 2015, we will need to ensure dealership service center technicians are trained to work on this technology. With this center’s expansion, we are getting a jump on the 2015 date by integrating special features to allow for an easy transition to hydrogen vehicle service.