Course 072: Hybrid System Diagnosis

Overview

Welcome to Course 072: Hybrid System Diagnosis. This course covers advanced operational theory and diagnosis of all Toyota hybrid systems.

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Toyota Hybrid Vehicles

First-generation Prius
(2001–2003)

Second-generation Prius
(2004 and later)

Camry Hybrid
(2007 and later)

Highlander Hybrid
(2006–2007)

Highlander Hybrid
(2008 and later)

Note: The Appendix includes a chart that identifies which systems are used on specific models.

Introduction

This course covers systems used on four current Toyota models:

- First-generation Prius (2001–2003)
- Second-generation Prius (2004 and later)
- Highlander Hybrid (2006 and later)
- Camry Hybrid (2007 and later)

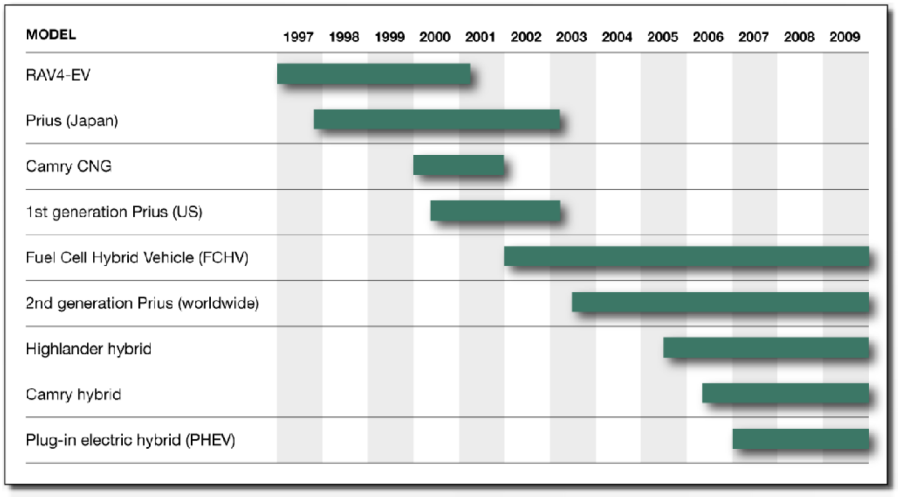
NOTE *A chart in the Appendix identifies which systems are used on specific models.*

Objectives

Objectives for this section:

- Describe Toyota advanced technology vehicle research
- Describe the "well to wheel" approach to vehicle efficiency
- List CARB requirements and emission groupings
- Describe how changes to EPA fuel economy test methods affect hybrid's estimated fuel economy figures

Toyota's Advanced Technology Vehicles



Advanced technology vehicles

While Toyota has identified hybrid vehicle technology as the most effective way to meet or exceed current emissions and fuel economy requirements, research into alternative technologies continues. A wide range of power sources are under investigation, including electricity, clean-burning internal combustion gasoline and diesel engines, compressed natural gas (CNG), hydrogen, and propane. In addition to its pioneering work with gasoline-electric hybrid vehicles, Toyota's on-the-road alternative powertrain applications include:

- **RAV4 EV:** Using technologies that have been incorporated into Toyota's hybrid vehicles, RAV4 EV features advanced nickel-metal hydride batteries, an early form of regenerative braking, and a computerized power management system for its electric drivetrain.
- **Camry CNG:** CNG has a 4-cylinder engine powered by compressed natural gas (CNG). This vehicle was sold only to fleet customers in certain regions of the U.S.
- **FCHV (Fuel Cell Hybrid Vehicle):** FCHV features four hydrogen fuel tanks, an electric motor, and a nickel-metal hydride battery. Electricity from a chemical reaction between hydrogen and oxygen powers the electric motor and charges the battery. Based on the Highlander platform, 18 FCHVs have been produced for testing by U.S. and Japanese universities, private companies, and government agencies.
- **Plug-in electric hybrid (PHEV):** A limited number of experimental vehicles (based on Prius) have been produced to determine the emissions benefit of hybrids that allow secondary battery charging through ordinary household current. These models can run in electric-only mode for a longer period and at higher speeds than current hybrids, but emissions measurements must account for the upstream emissions from electricity generation.

"Well to Wheel" Vehicle Efficiency

	Well-to-Tank[1] (fuel production efficiency) (%)	Tank-to-Wheel[2] (vehicle efficiency) (%)	Overall efficiency (Well-to-Tank x Tank-to-Wheel) (%)
Recent Gasoline Car	88	16	14
Previous Prius	88	32	28
New Prius		37	32
Toyota FCHV[3]	58	50	29
FCHV Target[3]	70	60	42

1. Source: Toyota study, Japanese energy conditions 2. Source: Toyota in-house testing, Japanese 10/15 mode 3. Hydrogen from CNG

"Well to wheel" vehicle efficiency

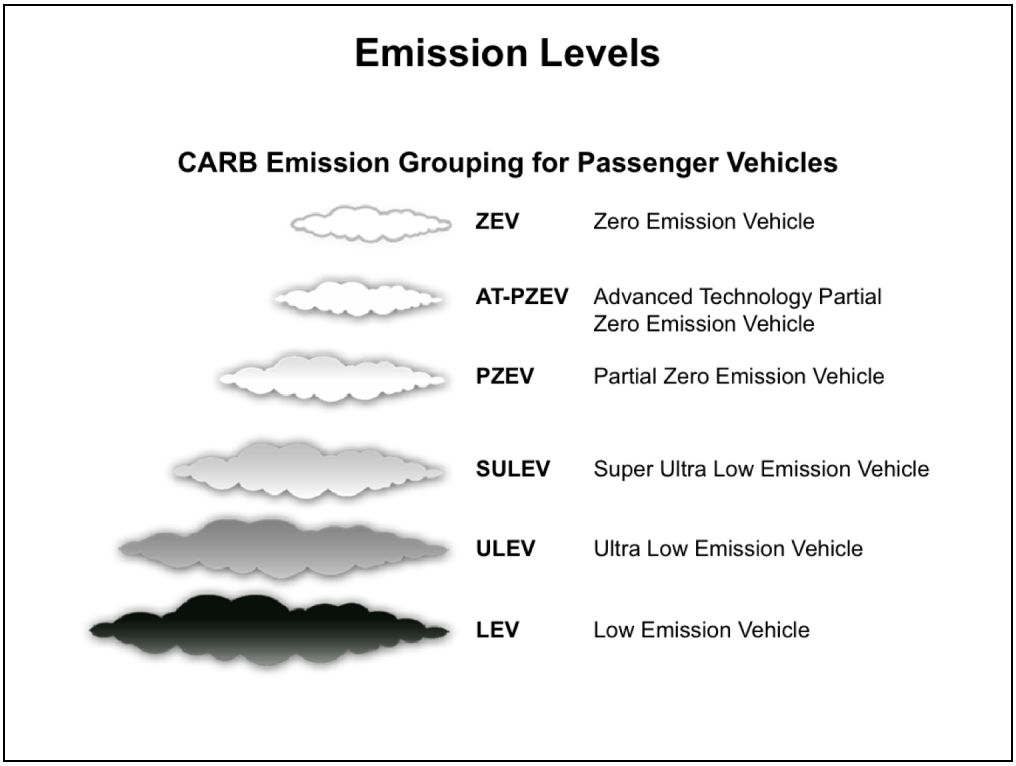
The most complete picture of vehicle efficiency comes from a "well-to-wheel" approach. This looks at the entire cycle of a fuel source from the time it's extracted or refined until it is used in the vehicle.

Hybrids are current environmental and market successes, and FCHVs are one promising zero-emission solution for the future. In theory, fuel cells are more efficient than gasoline engines, yet today's Prius is more efficient than today's FCHV because of the cost of fuel production.

It takes electricity to manufacture hydrogen, and today most electricity comes from fossil-fuel-powered generating plants. Hydrogen also requires a completely new and different distribution system to reach the consumer. As a result, more energy is needed to produce and distribute hydrogen than is released when it is consumed in a fuel cell. In contrast, gasoline releases more energy in a car's engine than is needed to pump, refine, and transport it.

Toyota estimates that the efficiency of fuel production and delivery to the vehicle's tank is 79% for gasoline versus 58% for hydrogen (when manufactured from natural gas). In the future, it may be possible to produce large amounts of hydrogen using renewable energy, including solar and wind-generated electricity. This would eliminate fossil fuels from the production process and improve hydrogen's efficiency as a fuel source.

Toyota and other companies are working steadily and investing millions of dollars in FCHV research but, for the foreseeable future, hybrids are an effective and available solution for maximizing fuel economy and reducing emissions at an affordable price.



CARB requirements

Since the first emission standards appeared in the early 1960s, the state of California has set standards stricter than those enacted by Federal law. In 2000, California announced that a specific percentage of each auto manufacturers' vehicles sold in the state in 2003 must meet zero-emission standards. Toyota chose hybrid vehicle technology as the most effective way to meet these requirements.

Emission groupings

The California Air Resources Board (CARB) defines vehicles by emission groupings ranging from "low" to "zero." Current Toyota hybrid vehicles are classed as either SULEV or AT-PZEV (depending on where they are initially sold). The vehicle emissions classification is listed on an under-hood sticker.

- **Super Ultra Low Emission Vehicle (SULEV)** standards for exhaust emissions are about 75% more stringent than ULEV and nearly 90% cleaner than LEV. SULEV vehicles will emit less than a single pound of hydrocarbons during 100,000 miles of driving (about the same as spilling a pint of gasoline).
- **Partial Zero Emission Vehicles (PZEV)** meet SULEV tailpipe emission standards, have zero evaporative emissions, and carry a 15-year / 150,000 mile warranty on emissions equipment. Zero evaporative emissions means that the vehicle has fewer emissions while being driven than a typical gasoline-powered car has while idling.
- **Advanced Technology Partial Zero Emission Vehicles (AT-PZEV)** meet PZEV requirements and use advanced technology (such as a hybrid drivetrain) to produce zero emissions during at least part of the vehicle's drive cycle.

EPA Fuel Economy Testing

	COMBINED MPG			CITY/HWY MPG		
	2007	2008	% Decrease	2007	2008	% Decrease
Prius	55	46	**16**	60/51	48/45	**20/12**
Yaris	36	31	**14**	34/39	29/35	**15/10**
Highlander HV 4WD	29	26	**10**	31/27	27/25	**13/7**
Highlander 4WD	21	19	**10**	18/24	16/22	**11/8**
Camry HV	39	34	**13**	40/38	33/34	**18/11**
Camry 4 cylinder	27	24	**11**	24/33	21/30	**13/9**

Source: www.fueleconomy.gov

EPA fuel economy testing

Hybrid vehicles often provide their highest fuel economy in city driving, where they are able to spend more time in full-electric mode.

Beginning with 2008 model year vehicles, the Environmental Protection Agency (EPA) changed the way it tests vehicles to establish fuel economy estimates. To better represent real-world driving conditions, city and highway testing now includes more aggressive driving (higher speeds and faster acceleration), air conditioner use, and cold temperature operation. Details of EPA testing methods are available at www.epa.gov/fueleconomy.

The vehicle window sticker was also changed, making it easier for consumers to read and compare information on vehicle fuel economy estimates.

NOTE

Fuel economy estimates from 2007 and earlier cannot be directly compared to 2008 and later test results. The EPA Web site shows, for example, that a 2007 Prius originally estimated at 60/51 city/highway mileage would be rated 48/45 city/highway mileage under the new test methods.


University
of Toyota