

OFFICE OF  
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RENEWABLE  
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TRANSPORTATION  
TECHNOLOGIES

An introduction by the U.S. Department of Energy to commercially available advanced vehicle technologies

# TECHNOLOGY SNAPSHOT

*featuring the Honda Insight*



## *What's Inside...*

What Is a Hybrid  
Electric Vehicle?

Why the Insight?

How Does the  
Insight Compare with  
Conventional Vehicles?

# Welcome to the Clean Cities Advanced Vehicle Information Series

Dear Reader,

Twenty-first century transportation is not just a vision for the future — it's here today. Clean, fuel-efficient hybrid electric vehicles (HEVs) are now available, joining the alternative fuel vehicles already on the road. You may have seen HEVs in the news, at your local dealership, and even in your neighborhood. This brochure is the second of the U.S. Department of Energy's (DOE's) *Technology Snapshots*, a suite of publications in the Clean Cities Advanced Vehicle Information Series that is designed to introduce the latest commercially available vehicle technologies to consumers across the country. Each Snapshot features a different vehicle and offers an objective, "plain English" explanation of how it works and how it differs from conventional vehicles. The web sites listed on the back cover of this brochure provide additional information about advanced transportation technology programs.

Although nothing can compare to sitting behind the wheel, each Snapshot gives you a feel for the featured vehicle by highlighting performance, vehicle safety, and the benefits the new technology delivers to you and your community. Are **you** ready to drive a cleaner, "greener," and more fuel-efficient vehicle?



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## What Is a Hybrid Electric Vehicle?

A hybrid vehicle uses two or more sources of power — in today's hybrid electric vehicles (HEVs), the two sources are electricity (from batteries) and mechanical power (from a small internal combustion engine). HEVs can offer low emissions similar to those of electric vehicles, with the power and driving range of gasoline vehicles. Compared to conventional gasoline-powered vehicles, HEVs achieve up to 30 more miles per gallon, perform as well or better, and are just as safe — and they are self-charging. Widespread use of HEVs would help reduce our nation's growing dependence on imported oil and cut greenhouse gas emissions by one-third to one-half.

## How Do HEVs Work?

Hybrids can provide tremendous fuel economy and emissions benefits because they operate differently than conventional gasoline-fueled vehicles.

**Gasoline Vehicle:** The heat energy obtained by burning gasoline powers the engine, which drives the transmission that turns the wheels.

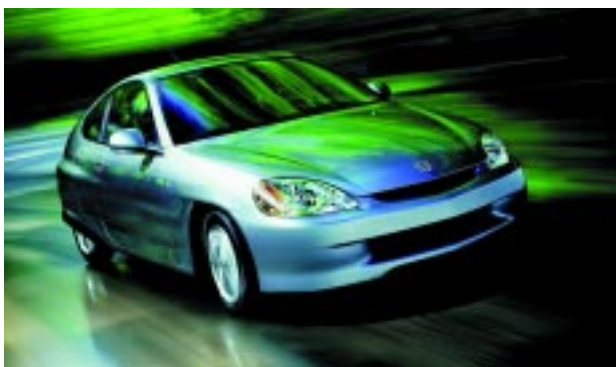
**Electric Vehicle:** A set of batteries provides electricity to an electric motor, which drives the wheels.

**Hybrid Electric Vehicle:** Not all hybrids are alike. There are many ways to combine the engine, motor/generator, and battery. Three basic hybrid configurations are the series, parallel, and split (or through-the-road) designs.

**Series.** The engine never directly powers the car. Instead, the engine drives the generator, and the generator can either charge the batteries or power an electric motor that drives the wheels.

**Parallel.** The engine connects to the transmission, as do the batteries and the electric motor. So both the engine and the generator/motor can supply power to the wheels, switching back and forth as driving conditions vary.

**Split.** The engine drives one axle and the electric motor drives the other. There is no connection between the engine and the electric components except "through the road."



# Introducing the Honda Insight

The Honda Insight is the first mass-produced gasoline-electric hybrid vehicle to be sold in the United States. The Insight, a parallel hybrid, combines an advanced powertrain with lightweight materials to achieve extraordinary aerodynamics and ultra-low emissions. The heart of the hybrid system is Honda's Integrated Motor Assist (IMA™), which combines a compact 1.0-liter, 3-cylinder engine and an ultra-thin permanent magnet electric motor for outstanding efficiency.

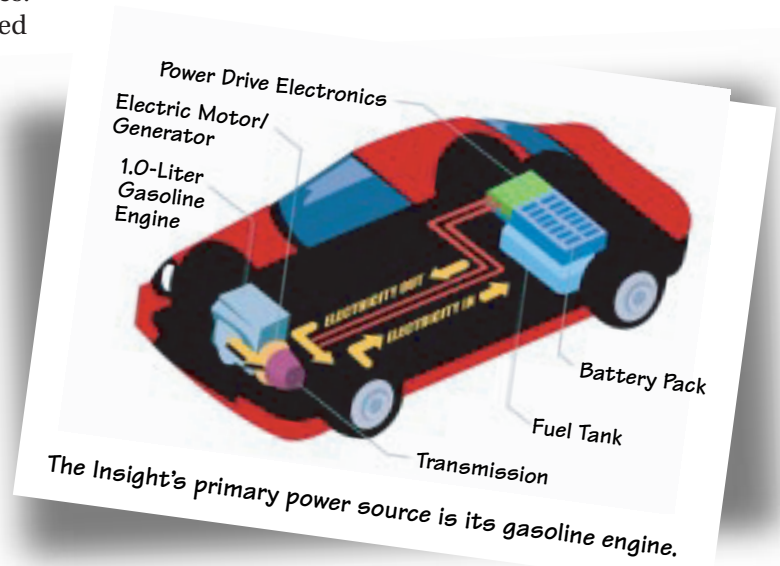
The IMA™ system, combined with a rigid aluminum body structure and highly aerodynamic design, allows the Insight to travel as far as 68 miles per gallon of gasoline and meet California's ultra-low emissions vehicle (ULEV) standards — making it one of the cleanest and most fuel-efficient gasoline-powered vehicles available today.

The Insight offers many innovative features:

- ▶▶ Advanced power control system that efficiently manages the power of the engine, assist motor, charging system, and nickel-metal hydride (NiMH) batteries
- ▶▶ Compact and efficient 5-speed manual transmission or a continuously variable automatic transmission
- ▶▶ "Idle stop" feature that shuts off the engine when the car is coming to a stop to conserve fuel and reduce exhaust emissions
- ▶▶ Lightweight aluminum body and reinforced frame that is 40% lighter than a comparable steel body
- ▶▶ Highly aerodynamic body — one of the lowest coefficients of drag of any mass-produced vehicle
- ▶▶ Electronic display that shows real-time trip and lifetime fuel economy

## A Different, Yet Familiar Driving Experience

The Insight's hybrid system is **seamless and transparent** — you just fill the car with unleaded gasoline and drive it like any other car. With the highest fuel economy of any car on the road, the Insight represents a different approach to passenger car technology. The car looks and feels sporty, but it offers important environmental and economic advantages.



## Going the Distance

Insight drivers can go from Washington, D.C., to any one of these cities on a single tank of gas:



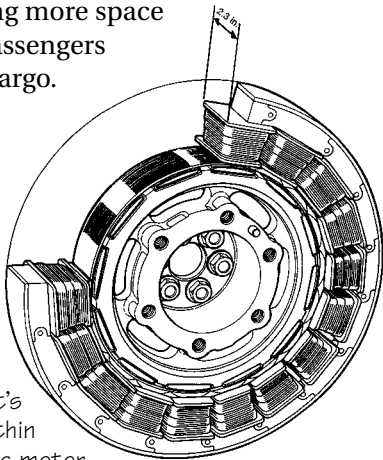
The Insight and other hybrids can show the American public that advanced technology can be both affordable and convenient. The next few pages offer more details on the technology used in these vehicles and illustrate how HEVs can deliver a cleaner, more comfortable drive today.



# Focus on Technology

## IMA™ Captures Energy to Charge the Battery

The Insight's IMA™ system depends on its gasoline engine to supply primary power for driving. An ultra-thin electric motor provides additional power only when needed, such as when the car is accelerating or climbing a hill. When braking or coasting, the car's momentum drives the generator, which recharges the battery. If the battery charge is low, the motor/generator will also kick in while cruising. The benefit of Honda's IMA™ approach is that it does not require a large onboard electrical generating system, thereby reducing vehicle weight and leaving more space for passengers and cargo.



Insight's ultra-thin electric motor.



Electronic display provides real-time information.

## Vehicle Carries on Constant "Conversation"

The Insight has an electronic control system that "talks" to the car's key components and ensures that the car always operates in its most fuel-efficient mode. An onboard electronic display provides the driver with real-time information about fuel economy and, in the manual transmission model, suggests the most economical time to shift gears. This display also provides information about battery charge status and tells the driver whether the IMA™ electric motor is in use.

## Engine Employs Innovative Technologies and Materials

The Insight's efficient Variable Valve Timing and Lift Control for Economy (VTEC™-E) engine is built with ultra-lightweight materials like aluminum, magnesium, and plastic. The engine incorporates a catalytic converter that adsorbs nitrogen oxides (NO<sub>x</sub>) so they are not released with exhaust emissions. Several friction-reduction techniques minimize power losses caused by friction.

## Intelligent Transmission Design Maximizes Power and Mileage

The Insight is available with a specially designed manual transmission or a continuously variable transmission (CVT) (automatic model). These new transmissions have been sized to meet the power requirements of the car while also reducing weight and physical dimensions. The manual transmission incorporates gears designed to reduce power loss and make shifting easier. The CVT provides two driving modes: *sport*, which maximizes power but reduces fuel economy (for acceleration), and *drive*, which reduces power but improves fuel economy (for cruising).



Honda's Integrated Motor Assist (IMA™) system **starts** out using the gasoline engine. As the car **accelerates**, power from the gasoline engine is boosted by the electric motor.

Under normal **driving** conditions, the electric motor is not required — the gasoline engine powers the car unless additional power is needed for passing.

## Lightweight, Aerodynamic Design Minimizes Drag and Maximizes Safety

The Insight has an aerodynamic “teardrop” shape that is designed to part the air with a minimum of turbulence. The car is wider at the front with a Kamm back (cuts off abruptly at the rear of the car to minimize drag) and a flat underbody. These design features contribute to the car’s low coefficient of drag (0.25 — about 70% less than that of a comparably sized vehicle like the Honda Civic hatchback).



Aerodynamic features reduce drag.

All of the Insight’s major body panels are made of a lightweight aluminum alloy, and the remaining body components are made of plastic, making the Insight’s body 40% lighter than that of a Honda Civic hatchback. Lighter weight requires less power and less fuel consumption to provide responsive acceleration in traffic — 32% less than that needed for a Honda Civic hatchback to operate at the same speed.

Still, lighter does not mean weaker — the Insight’s body has 13% greater bending rigidity and 38% more torsional rigidity than the Civic’s. A G-Force Control (GCON) safety engineering optimizes each part of the Insight’s aluminum body and frame to best absorb specific types of impact.



The body of the Insight is 40% lighter than those of comparable cars.

## Technical Specifications\*

▶▶ Gasoline engine: 1.0-L, 3-cylinder, SOHC 12-valve aluminum engine block with multi-point fuel injection, 10.8:1 compression ratio, 67 hp at 5,700 rpm, 66 lb-ft of torque at 4,800 rpm	Max. range: 646 mi (city)/720 mi (highway) (manual transmission)*** 600 mi (city)/594 mi (highway) (CVT-automatic transmission)***
▶▶ Electric motor: Permanent-magnet with peak power of 13 hp at 3,000 rpm, and 36 lb-ft of torque	Passengers: 2
▶▶ Battery: Sealed nickel-metal hydride (NiMH), 144 volts	Length: 155.1 in.
Transmission: Front-wheel drive, manual (5-speed) or continuously variable transmission (CVT-automatic transmission)	Width: 66.7 in.
Acceleration: 0–60 miles per hour in 11.3 seconds (manual transmission) or 11.2 seconds (automatic transmission)	Height: 57.6 in.
Fuel efficiency: 61 mpg city/68 mpg highway (manual transmission)** 57 mpg city/56 mpg highway (CVT-automatic transmission)**	Wheelbase: 94.5 in.
Emissions: Meets California Ultra Low Emissions Vehicle (ULEV) standards (manual transmission) or Super Ultra Low Emissions (SULEV) standards (CVT-automatic transmission)	Weight: 1,856 lb (manual transmission without air conditioning) 1,887 lb (manual transmission with air conditioning) 1,964 lb (CVT-automatic transmission; air conditioning standard)
Fuel tank: 10.6 gallons	Cargo: 16.3 ft <sup>3</sup>
	Braking: Power-assisted front disk/rear drum brakes with integrated regenerative system and 4-wheel ABS
	Steering: Variable-assist rack and pinion
	Turning circle: 31.4 ft
	Suspension: Front: MacPherson strut Rear: twist beam

\* Specifications provided by Honda Motor Company

\*\* EPA label values

\*\*\* Based on 10.6-gal fuel tank and 61 city/68 highway mpg or 57 city/56 highway mpg, depending on transmission.



When **slowing down and/or braking**, the Insight’s electric motor acts as a generator to recharge the battery pack.

The **idle-stop** feature shuts off the gasoline engine when the Insight is stopped in traffic to conserve fuel and further reduce exhaust emissions. The engine is instantly and smoothly restarted when the car moves forward.

# Independently Tested by the DOE and EPA

Starting in March 1999, DOE began independent testing of HEVs at Argonne National Laboratory and the National Renewable Energy Laboratory (NREL). The testing goals included determining the operating performance of the hybrid technology and collecting data to determine the overall energy management performance. Argonne researchers have focused primarily on powertrain control and energy management systems. NREL researchers have focused on battery thermal management performance.

In the fall of 2001, DOE's Field Operations Program began conducting baseline performance, accelerated reliability, and fleet testing of currently available HEVs, including the Insight. These three types of tests, similar to those conducted on battery electric vehicles in the EV America Program, will provide performance,

safety, maintenance, reliability, and cost of operation data to fleets and individuals who are considering buying an HEV. The program will test new HEV models as they become available, and all testing results will be featured on the Field

Operations Program web page at [www.ott.doe.gov/otu/field\\_ops/](http://www.ott.doe.gov/otu/field_ops/), in the light-duty hybrid and fuel cell vehicles section.



The Insight has been tested by DOE and EPA in the laboratory and on the road.

## Insight Tops Fuel Economy Guide List

The *Model Year 2002 Fuel Economy Guide* rated the Honda Insight the most fuel-efficient vehicle available. Achieving 61 mpg in city driving and 68 mpg in highway driving, the 2002 Insight (with manual transmission) could offer drivers as much as \$1,500 in annual fuel savings, compared with some of the other vehicles in its class. DOE and the U.S. Environmental Protection Agency (EPA) work together to prepare the *Fuel Economy Guide*, which is available on-line at [www.fueleconomy.gov](http://www.fueleconomy.gov) and in print at new car dealerships, public libraries, and credit unions nationwide.

## Why Drive a Hybrid Electric Vehicle?

*As the information in this brochure illustrates, the Insight and other HEVs are mechanically innovative, sophisticated vehicles. Many people might ask why they should drive these technological marvels when their current car does everything they want it to do. The two best reasons are (1) to save money and (2) to help clean the air.*

## The Outlook on Oil

*Most people dislike having to pay \$20 or \$30 or more for a tank of gas. Yet, the United States depends on petroleum for nearly 95% of its transportation energy — about 8 million barrels per day of petroleum products are used to fuel light trucks and cars. More than half of our petroleum is imported, and this percentage is growing, which is why oil imports represent one of the largest components of the U.S. trade deficit. And the demand for oil used for transportation will grow as the number of people and the number of miles they drive increase.*

## Emissions

*Growing scientific evidence suggests that greenhouse gas emissions could contribute to a change in the earth's climate — and transportation, specifically the combustion of fossil fuels in our vehicles, accounts for a large portion of greenhouse gases. Moreover, EPA considers a number of other pollutants in vehicle emissions to be harmful to public health and the environment. Despite the substantial reductions in individual vehicle emissions over the last few decades, the millions of vehicles on our roads — which burn thousands of gallons of petroleum every second — account for a third of the country's air pollution.*



## Insight Testing Reveals Strong Performance, Impressive Fuel Economy

DOE tested the Insight at the Route 66 Raceway in Joliet, Illinois, in August 2001. Argonne engineers evaluated both the manual transmission and CVT-automatic transmission versions of the Insight, with the following results.

Test	Insight w/Manual Transmission	Insight w/CVT-Automatic Transmission
Slalom (average speed – mph)	29.3	29
Skidpad (G)	0.693	0.685
Acceleration, 0-60 mph (sec)	11.2	11.2 sport mode 13.1 drive mode
Braking (ft from 60-0 mph)	143	151.5
On-Road Fuel Economy (mpg)	78.2	69.0
EPA Fuel Economy (city/highway) (mpg)	61/68	57/56



Engineers at Argonne National Laboratory performed fuel economy, braking, acceleration, and handling tests on both the manual and the CVT versions of the Insight.

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The U.S. Department of Energy's mission is to foster a reliable energy system that is environmentally and economically sustainable, to be a responsible steward of the Nation's nuclear weapons, to clean up our own facilities, and to support continued United States leadership in science and technology.



The Office of Transportation Technologies works in partnership with the domestic transportation industry, energy supply industry, and research and development organizations to develop and promote user acceptance of advanced transportation vehicles and alternative fuel technologies that will reduce oil import requirements and reduce criteria pollutant emissions and greenhouse gases.

## Insight Honors, Awards, and Commendations

- ▶▶ "Greenest Vehicle of 2001"  
— American Council for an Energy-Efficient Economy
- ▶▶ "Climate Protection Award for Leadership and Technical Innovation"  
— U.S. Environmental Protection Agency (2000)
- ▶▶ "Excellence in Environmental Engineering Award"  
— Sierra Club (2000)
- ▶▶ "International Engine of the Year"  
— Engine Technology International Magazine (2000)
- ▶▶ "Technology of the Year"  
— Automobile Magazine (2000)
- ▶▶ "Most Likely to Change the World"  
— American Woman Motorscene (2000)
- ▶▶ "Clean Car Salute for Environmental Progress Award"  
— Clean Car Coalition (2000)
- ▶▶ "Design & Engineering Award"  
— Popular Mechanics (2000)
- ▶▶ "4-Star Safety Rating for Both the Driver and Passenger in Frontal Impacts"  
— U.S. National Highway Traffic Safety Administration
- ▶▶ "Environmental Sensitivity Award"  
— Edmunds.com (2000)



## Related Web Sites

<http://www.ott.doe.gov/>

*The U.S. Department of Energy's Office of Transportation Technologies (OTT) develops and promotes advanced transportation and alternative fuel vehicles and technologies.*

<http://www.ccities.doe.gov/>

*OTT's Clean Cities Program supports the deployment of alternative fuel vehicles and supporting infrastructure.*

<http://www.ott.doe.gov/hev/>

*OTT's Hybrid Electric Vehicle Program.*

[http://www.ott.doe.gov/otu/field\\_ops/](http://www.ott.doe.gov/otu/field_ops/)

*OTT's Field Operations Program tests advanced technology vehicles to support commercial deployment.*

<http://www.fueleconomy.gov>

*The web-based version of the DOE/EPA Fuel Economy Guide.*

<http://www.honda.com>

*American Honda Motor Co., Inc., web site.*

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