HYBRID VEHICLES

Lean *and* Mean

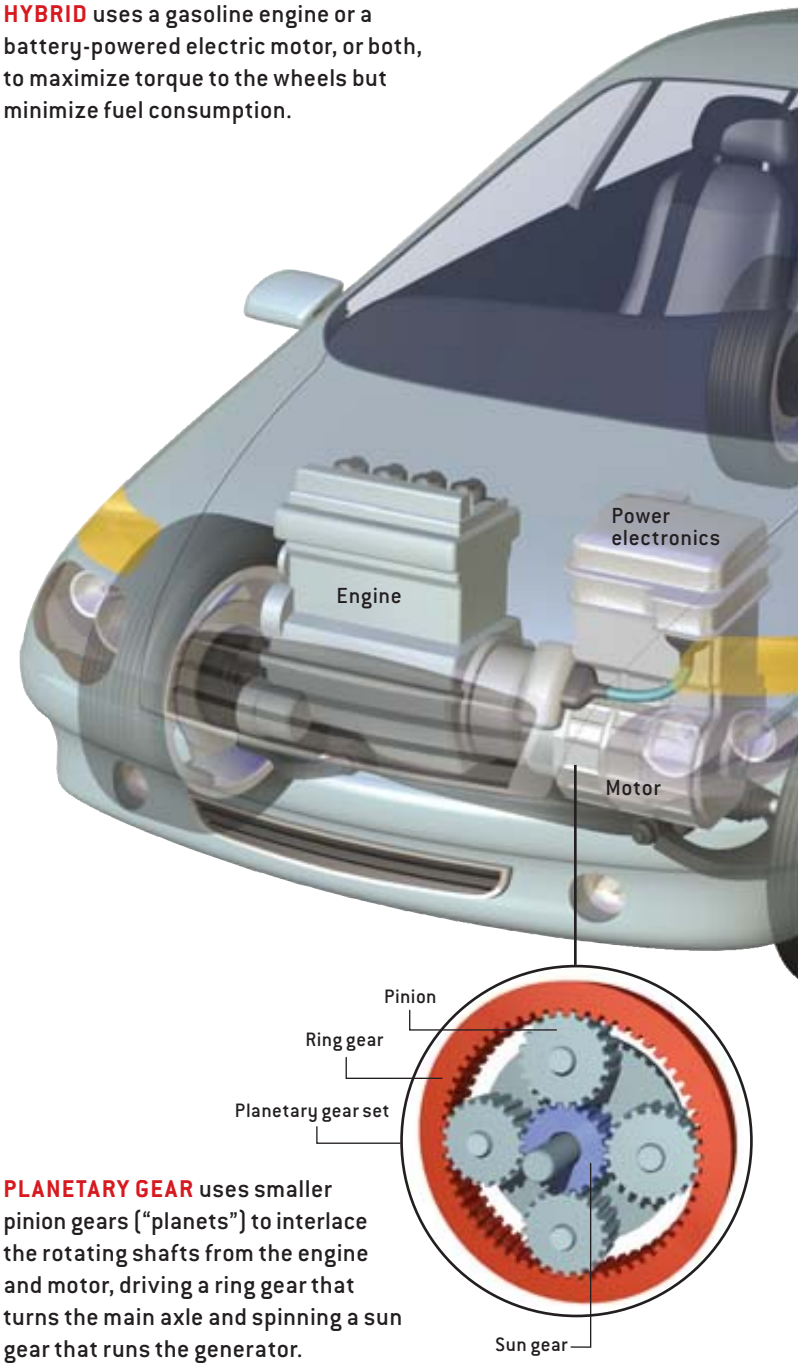
Hybrid cars made a dent in the market by offering superior fuel economy. Now they're poised for a bigger impact based on performance.

A "full hybrid" like the Toyota Prius saves gasoline in several ways. When the car stops—at a light or in traffic—the engine shuts off, and the batteries and electric motor run the vehicle's systems. When it is time to proceed, the motor propels the vehicle until efficient engine operation is possible, from 10 to 40 miles per hour. During hard acceleration or at higher speeds, the motor and engine operate together; a computer controller adjusts gear ratios between them so the transmission works at maximum efficiency, saving fuel. "The key is the controller, which makes sure all the pieces play nice together," says David Hermance, executive engineer for environmental engineering at the Toyota Technical Center in Los Angeles. In a "mild hybrid" or "hybrid assist," like the Honda Insight, a small motor helps the engine but cannot propel the car on its own. (Illustrations represent full hybrids.)

The downside is price. Hermance says the Toyota, Honda and Ford vehicles cost $2,500 to $3,500 more than comparable, nonhybrid models. This premium has limited sales to U.S. consumers, because few have shown they will pay up front for fuel savings later. But the equation is changing. The 2005 Prius averages 55 miles per gallon. For gasoline at two dollars a gallon, an owner will recover the added purchase expense in about four years and save money afterward—a more tempting deal.

More important to U.S. drivers, engineers are using the improving electronics, motor and gearing to add muscle. Earlier hybrids were sluggish, but Hermance says the 2005 Prius accelerates just as quickly as conventional competitors. The 2006 Lexus RX400h hybrid goes from zero to 60 miles per hour in under seven seconds—a full second faster than the nonhybrid. According to *Consumer Reports*, the 2005 Honda Accord hybrid reaches 60 miles per hour a half-second faster and has 15 more horsepower than the regular model, even with the added battery and motor weight. "Americans value performance and will pay for it," Hermance says. —*Mark Fischetti*

HYBRID uses a gasoline engine or a battery-powered electric motor, or both, to maximize torque to the wheels but minimize fuel consumption.



PLANETARY GEAR uses smaller pinion gears ("planets") to interlace the rotating shafts from the engine and motor, driving a ring gear that turns the main axle and spinning a sun gear that runs the generator.

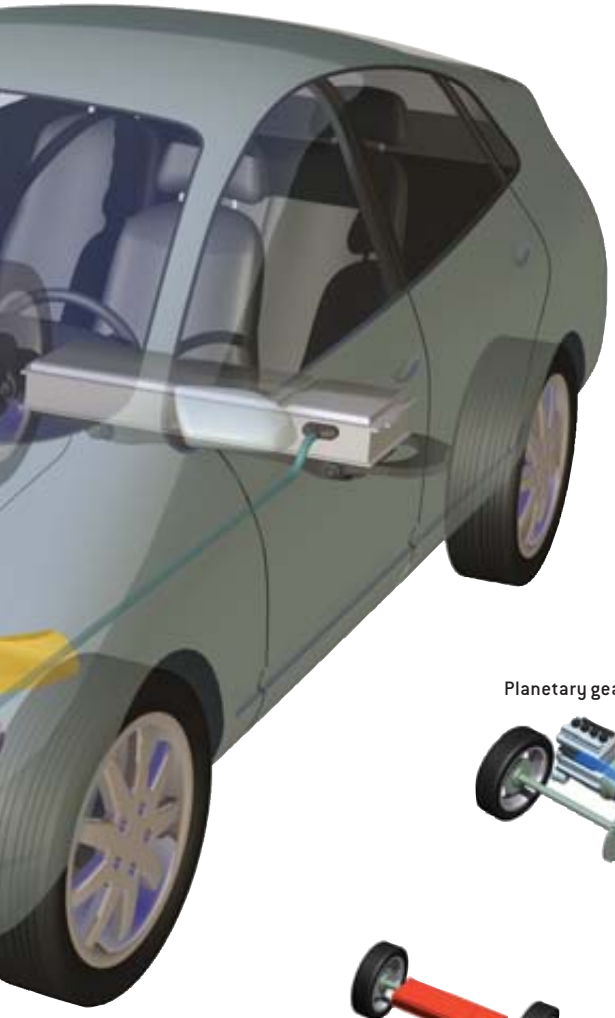
GEORGE RETSECK

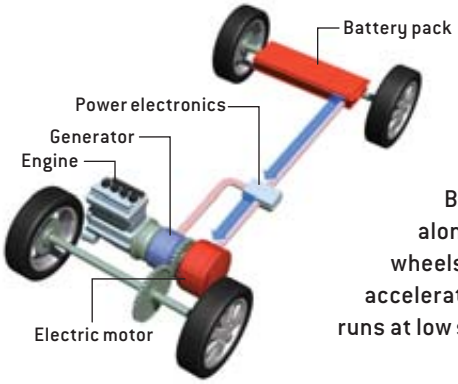
DID YOU KNOW...

- PICK A VOLTAGE: Batteries in the Honda Insight and Civic hybrids produce direct current at 144 volts, those in the Toyota Prius at 202 volts, the Lexus RX at 288 volts and the Ford Escape at 300 volts. The motors and generators typically operate at battery voltage but in some models function at around 500 volts, so power-integrated circuits boost the supply. A converter also steps the battery feed down to the 12-volt level at which most interior amenities operate.

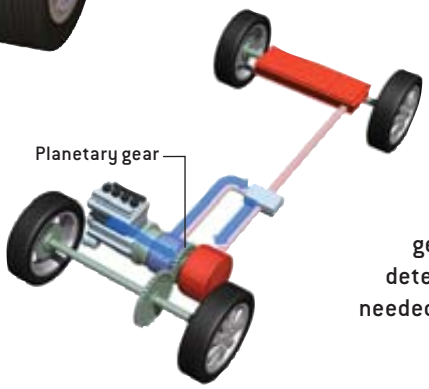
- COOL CHEMISTRY: Hybrid battery packs consist of many small cells connected in series, bound tightly into a block the size of a small suitcase that is stuffed behind or underneath the backseat. Most systems are nickel metal hydride and are cooled with air drawn from the passenger compartment with a fan. In cold weather, heat is pulled in instead. "Batteries prefer 20 to 30 degrees Celsius," Toyota's Hermance says, "just like people."

- WELL-TO-WHEEL: The overall fuel efficiency and environmental impact of any transportation mode include extracting or producing the fuel, getting it to the vehicle and consuming it on board. Calculations of this so-called well-to-wheel efficiency by various experts put hybrids at the top of automobile types. Representative numbers from the American Society of Mechanical Engineers tell the tale: gasoline, 19 percent; all-electric, 21 percent; hydrogen fuel cell, 27 percent; gasoline-electric hybrid, 32 percent.

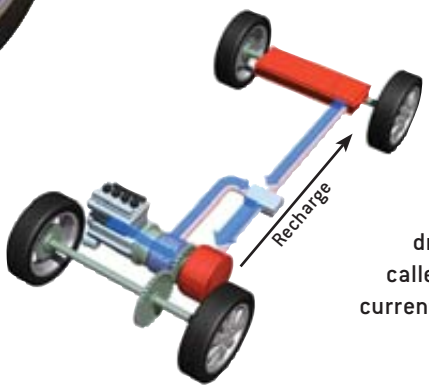




START-UP: Batteries and motor alone power the wheels when a hybrid accelerates from a stop or runs at low speeds.



CRUISING: During routine driving, engine output is split via planetary gear to the wheels and to a generator that powers the motor. A computer controller determines which mix maximizes the efficiency or torque needed, adjusted by power electronics.



ACCELERATION: For hard acceleration, the batteries add extra boost to the motor. During deceleration the motor reverses, becoming a generator that adds drag to the drivetrain and turns friction into current that recharges the batteries (a procedure called regenerative braking). The generator converts some engine power into recharging current if batteries become too depleted.

Topic suggested by reader Shwetal Patel.
Send ideas to workingknowledge@sciam.com