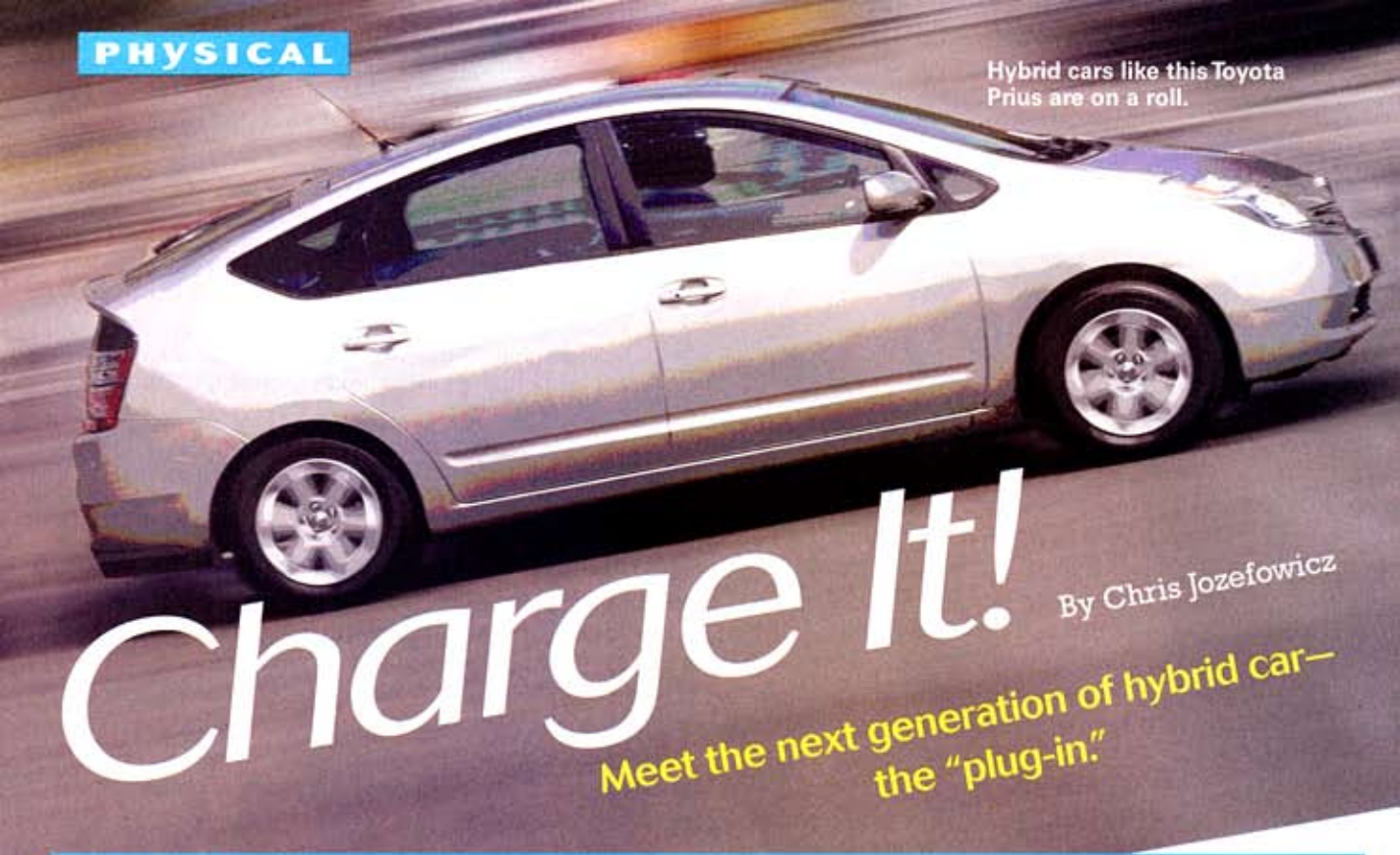


Hybrid cars like this Toyota Prius are on a roll.

Charge It!

By Chris Jozefowicz

Meet the next generation of hybrid car—the "plug-in."

IN Hollywood, hybrids are hip. Leonardo DiCaprio and Cameron Diaz rave about their hybrid cars that combine electric and gasoline power. Hybrids use less gas and produce less pollution than regular cars do.

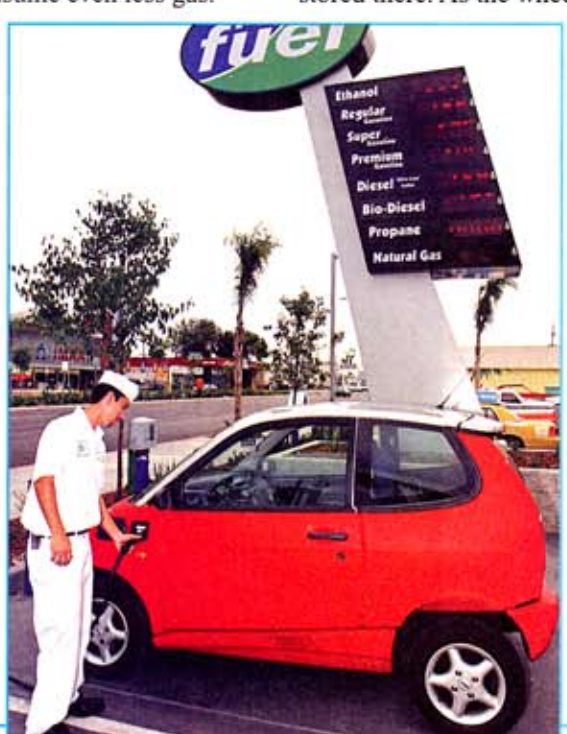
But for some Californians, hybrids aren't hip enough. Felix Kramer, the founder of the California Cars Initiative (CalCars) in Palo Alto, thinks hybrids are still too dependent on gasoline. The CalCars team has modified a hybrid so that it can be plugged right into a normal electrical outlet and will consume even less gas.

LOST ENERGY RECAPTURED

A normal car has a gas-driven internal combustion engine. A hybrid has an internal combustion engine and an electric motor, each of which runs part of the time.

The electric motors in hybrids run on batteries that are charged by the gas engine and by power that is normally lost in most cars through braking. Energy lost through braking is among the largest wastes of energy in a conventional car. Every time a driver hits the brakes, the car's energy of movement, or *kinetic energy,* turns into heat.

A hybrid has a kind of electronic brake that recaptures that kinetic energy. Every time the driver hits the brake pedal, a computer switches off the electricity going to the electric motor. At that point, the wheels no longer receive power from the motor; they make it. Like turbines in a hydroelectric dam, the spinning wheels generate electricity, which is sent to the battery and stored there. As the wheels make electricity, they slow down. The hybrid's kinetic energy, instead of being lost as heat, is turned back into usable power. This process is called *regenerative braking.*



California leads the way in clean-car technology. Drivers can buy a range of alternatives to gasoline at this fuel station in San Diego. This cute little car is filling up on electricity.

OPTIMAL SPEED

Recapturing lost power to generate electricity is not the only way hybrids save fuel. Conventional internal combustion engines waste a lot of gas accelerating from zero to highway speeds. In the Toyota Prius, the hybrid that Diaz and DiCaprio drive, the electric motor provides the initial acceleration. When the car reaches between 15 and 30 miles per hour (mph), the gas engine starts up, and the car uses electricity and gasoline.

Top: David Paul Morris/Getty Images; Bottom: AP/Wide World Photos

Hybrid cars are increasing in popularity. The number sold in the United States more than doubled from 2004 to 2005.

At speeds higher than 40 mph, most of the power comes from the gas engine. The Prius's engine is built to work most efficiently—consume less gas—above 40 mph. When drivers need more power to accelerate at highway speeds, the electric motor comes on again, giving the car extra oomph.

Regenerative braking and efficient engines help hybrids cut energy costs. A Prius gets more than 45 miles per gallon; a similar-sized gasoline-powered car gets less than 35. Cars that run on less gas contribute less harmful exhaust to the atmosphere. They emit less *carbon dioxide,* a greenhouse gas, and fewer *nitrogen oxides,* gases that react with sunlight to form smog.

PLUG-INS

Kramer thinks hybrids can do even better. CalCars has customized a Prius. They call it the Prius+ or simply a plug-in hybrid because it can be plugged into any electrical socket. Doing that fully charges its batteries without the use of the gasoline engine.

The plug-in also has extra batteries, so the electric motor can run farther without any help from the gasoline engine. "There's enough battery power to go electric only," Kramer says.

The Prius+ can cover a distance of 10 miles at under 35 mph without ever turning on the gasoline engine. When plug-ins become available for sale, people who use them for short trips close to home could plug them in each night and go for months between trips to the gas station, says Kramer. He estimates that a plug-in hybrid costs between 2 and 4 cents per mile to run, versus about 5 cents for a normal hybrid and 8 to 20 cents per mile for a regular gasoline-powered car.

Kramer sees plug-in hybrids as the first stop on a road leading to cars of the future that burn almost no gasoline at all.

100 MILES PER GALLON . . . OR MORE

CalCars has built just one Prius+, but Kramer says the group plans on making more soon. A California company called EDrive Systems also plans to begin converting regular hybrids to plug-ins early this year. EDrive plug-ins will have even better batteries so a car can go for 30 miles without using gasoline. The conversions won't come cheap, however. Kramer expects EDrive to charge between $10,000 and $12,000 per upgrade.

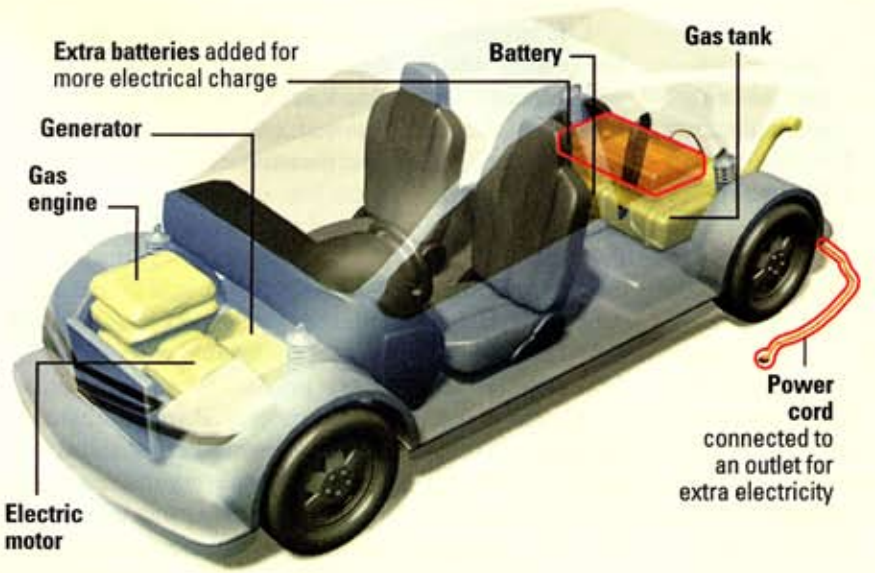
Despite that expense, Kramer thinks many people will buy plug-ins to conserve fuel and help the environment. "The payback is to society as a whole," he says.

Kramer sees plug-in hybrids as the first stop on a road leading to cars of the future that burn almost no gasoline at all. Because much of the technology needed to make plug-ins already exists, companies could concentrate on making more-efficient versions of that technology. The cars could be made lighter, says Kramer. Their internal combustion engines could also be outfitted to run on a mixture of *ethanol* and gasoline. Ethanol, a fuel derived from grain and corn, burns cleaner than gasoline does.

With changes like those in place, Kramer believes, cars could eventually run 500 miles on a gallon of gasoline. "We think this is the way things are going," he says, "and we can get there without any new technology." **CS**

HOW A PLUG-IN GETS ITS POWER

A hybrid car is powered by an engine that runs on gasoline and by an electric motor that runs on batteries. A modified hybrid, like the Prius+ plug-in, has an extra battery that can be charged from a wall socket. The result is a vehicle that can can run even longer on electricity than a standard hybrid.



Top: B. Vander Heyden, Source: J. D. Power and Associates; Bottom: AP/Wide World Photos