Hybrid Cars

Renewed pressure for fuel-efficient vehicles

By CORINNA WU

The moment automobiles rolled into people's lives, forward-thinking engineers began to dream about "the car of the future." For some, the phrase conjured up an image of a vehicle replete with all the comforts of home: a television, a refrigerator, a bed—maybe even the kitchen sink. For others, the car of the future resembled a sleek, aerodynamic egg zooming around in eerie silence.

The cars we actually end up driving by the turn of the century might not seem like anything special on the outside, but they'll have radical differences—as the salesmen say—under the hood.

In response to government mandates, auto companies are racing to manufacture cars that get markedly increased fuel efficiency and emit fewer pollutants than today's cars. To achieve these goals, researchers are assessing ways to power automobiles with electricity and alternative fuels. So far, though, all such systems have failed to meet drivers' needs.

Many engineers believe that the most promising, environmentally friendly car will be the hybrid electric vehicle (HEV), a car equipped with both a gas engine and an electric motor. Universities, federal and state governments, and automakers are already collaborating to build commercially acceptable HEVs by 1998.

Several years ago, the California legislature adopted a resolution requiring the seven automakers selling the most cars in the state to make 2 percent of those vehicles emissions-free by 1998. By 2003, that mandate will rise to 10 percent. Only electric cars are truly emissionsfree, but they carry the stigma of being practical only for short trips.

Alternative fuels such as methanol and natural gas produce fewer harmful emissions than gasoline, and researchers have built engines and cars that use them. Scientists are also looking seriously at fuel cells, which combine hydrogen and oxygen to produce energy, as a clean source of vehicle power. But even if automakers modify commercially produced cars to run on alternative fuels, the cars won't catch on in a big way until drivers can fill them up at the corner gas station. Currently, over 33,000 vehicles in the United States run on natural gas. By 1997, the Department of Energy plans to have 250,000 alternative fuel vehicles of all types in federal, state, and local fleets and—equally important—over 1,000 refueling stations.

For the near future, the combination of a gas engine and an electric motor may make the HEV the best of both worlds. For those family trips to Yellowstone National Park, an HEV's gas engine gives it the range of a regular car, but during the daily rush-hour commute, its clean electric motor keeps pollution to a minimum. And refueling is no problem; it simply means a visit to a gas pump and an electric outlet. Still, engineers must surmount many technical challenges before HEVs can find their way into the average garage.

HEVs come in two basic types, depending on whether their gas engine and electric motor work together in series or in parallel. In a series hybrid, the electric motor powers the vehicle and the gas engine runs mainly to charge the battery. In a parallel arrangement, both the engine and the electric motor can drive the car.

Each design has advantages and disadvantages. For a series hybrid, "the electric motor has to be big enough to achieve the kind of performance you want from your car," says Jeffrey W. Hodgson of the University of Tennessee in Knoxville. "In the parallel arrangement, the car can be driven by the electric motor and by the engine, so you don't need as large or as powerful an electric motor . . . as you would with the series arrangement."

The location of the components is a bit trickier in the parallel hybrid, since both the engine and the motor have to drive the car's wheels. And coordinating the switch between the two mechanisms requires more sophisticated computer controls.

In June, 32 university groups competed in the 1995 Hybrid Electric Vehicle Challenge in Auburn Hills, Mich., sponsored by DOE, Natural Resources Canada, and Chrysler Corp. Students convert-

credit to come

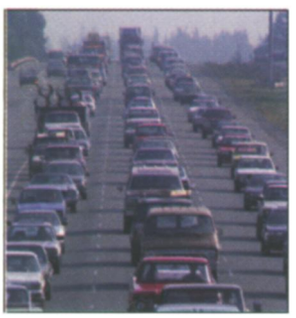
Fiberglass and other composite materials form the lightweight body of AfterShock, a two-seater hybrid electric vehicle built at the University of California, Davis. AfterShock can travel 500 miles on less than 6 gallons of gas, and its battery pack recharges in 6 hours—at a cost of 80 cents.

ed either a Ford Escort, a Chrysler Neon, or a Saturn SL2 sedan into an HEV, which was then judged on performance and emissions. Hodgson and his students, who converted a Neon, earned first place in their category.

They chose a parallel arrangement with a switching mechanism known as electric-assist. The vehicle ran on compressed natural gas—one of the rules for the category—and its electric motor kicked on when the engine needed extra power, for example when climbing a hill or passing another car.

Converting an existing car poses unique design problems, the biggest one being packaging all of the required components in the space available, Hodgson says. Creating a whole new car from scratch, on the other hand, would afford the engineer more flexibility.

Nevertheless, most car manufacturers are focusing on modifying their existing models into hybrids, as opposed to creating radically new designs. Last year's contest featured a category for vehicles built from the ground up, but DOE decided to move those cars to a separate competition this year. Shelley Launey, manager of vehicle competitions at DOE in Washington, D.C., says that at this point, the auto industry is more interested in getting ideas for new components than advice on body panels and fenders, things in which they've had "a hundred years of experience."



However, DOE sees "a lot of value in a ground-up competition," Launey says, "just because a student can redesign and repackage the entire vehicle. The schools have shown us that there are really a lot of different ways you can structure a hybrid vehicle."

Indeed, if automakers want to create cars for the 21st century, they may eventually have to redesign them substantially. In September 1993, President Clinton outlined an initiative called the Partnership for a New Generation of Vehicles, a collaboration between automakers and researchers to create by 2004 a vehicle with three times the fuel efficiency of current automobiles.

In the opinion of many, hybrids will reach that goal first, Hodgson says. But to get there, engineers will have to find ways to reduce the weight of the car and to improve the lifetime and storage capacity of batteries.

Already, some groups have almost achieved the 80-miles-per-gallon fuel efficiency required by the partnership. In 1994, a team at the University of California, Davis, built an HEV that got 77 miles per gallon during a 440-mile trek from Northern to Southern California. Using only 5.7 gallons of gas and half of the battery charge, the car, called AfterShock, cruised over both mountain roads and flat highways.

The secret of AfterShock's amazing gas mileage lies in a design principle called charge depletion. The car alternates between gas and electric operation, depending on how much charge remains in the battery. When the battery is fully charged, the car runs solely on electricity, except at speeds over 60 miles per hour. As the battery becomes depleted, the gas engine kicks in at lower and lower speeds. By the time only 1 percent of the charge remains, the gas engine turns on at about 5 to 10 miles per hour.

During city driving, the car uses only electricity, thus emitting no pollution at all. Cars spew gases such as carbon monoxide into the air mostly during stop-and-go traffic, when they spend a lot of time idling. "This engine never idles," says Andrew A. Frank of U. C.- Davis. "Because it never idles, it never makes any bad stuff." When AfterShock reaches highway speed, its gas engine comes on. At high speeds, gas engines become more efficient and release fewer contaminants into the environment.

Over the next 2 years, U.C.-Davis and 11 other universities will participate in a competition associated with the New Generation initiative, converting one of three autos into HEVs. In the first year, the cars will be judged on their powertrains, the mechanisms that make them move. The following year, the cars will have to be finished, with all the amenities a consumer would expect.

Frank and his students plan to retain charge depletion as they redesign their vehicle. The most critical problem they face is figuring out how to reduce the weight of the auto drastically. "It's not possible to improve the fuel efficiency by a factor of 3 without taking 1,000 pounds out," Frank says. "Basically, we're replacing all the heavy components with much lighter components."

Often, the most important components—the batteries—are the heaviest part of the car. "You have to remember when you build an electric car that a fully charged battery pack is equivalent to a gallon of gas," Frank says. In other words, a pound of gas gets the car farther than the energy in a pound of battery. The bundle of 26 nickel-cadmium batteries in AfterShock weighed 800 pounds and carried enough charge for a drive of about 100 miles. Frank hopes that in the not-too-distant future, technological improvements will bring the weight of batteries down to less than 400 pounds without compromising storage capacity and lifetime.

California hasn't decided yet whether to include HEVs in its 1998 zero-emissions vehicle requirement. The state's Air Resources Board is evaluating a proposal to certify hybrids as equivalent zero-emissions vehicles. Essentially, if the car produces no more pollutants than the average power plant would in charging the batteries, then the companies could receive credit for the car.

Some proponents of pure electric vehicles find this logic a bit convoluted. They say the point is to increase the number of cars that don't produce any pollutants at the point of operation, Hodgson says. "It depends on how global your perspective is," he comments. But as things stand now, all-electric vehicles still cost more than consumers are willing to pay, so accepting HEVs might serve as the only compromise.

Hybrid vehicles may represent a step toward pure electric cars, or they may be an end in themselves. But the pace of current research suggests that someday soon, drivers will pull into a local gas station not only to fill 'er up but also to plug 'er in. □