High-performance hybrids

Since Toyota introduced the Prius hybrid-electric vehicle to the Japanese market in 1998, hybrids available to the public have focused on maximizing fuel economy. But vehicles such as the Prius, and Honda’s Insight and Civic hybrids, typically replace economy cars that already get impressive fuel economy, so the net fuel saving is small.

A more attractive target for saving fuel is vehicles that consume a lot of gasoline, such as sports cars, luxury cars, and light trucks. Light trucks and SUVs (sport utility vehicles) sell in very large numbers, so improving the fuel economy of such relatively thirsty vehicles will provide more meaningful reduction in overall fuel consumption and carbon dioxide production.

“There are far more customers for minivans, sport utilities, and pickup trucks than there are for the smaller sedans that get better fuel economy,” said Pete Savagian, Engineering Director for Hybrid Powertrain Systems at General Motors. “You can use hybrid power to increase fuel mileage on a car that gets 40 mpg to 50 mpg,” he said. “But how much fuel does that really save [compared] to a vehicle that got 20 mpg and now gets 25, even though a number like 25 isn’t as impressive as a number like 50? If you are really interested in saving fuel, you might look at your highest-consumption vehicles.”

More haste less waste

High-consumption vehicles being typically more expensive means the added cost of the hybrid-electric powertrain is less burdensome than it is on cars that sell on their low price. Of course customers are reluctant to pay extra for vehicles that deliver an inferior driving experience, but the smooth low-end torque delivery of electric motors and premium vehicles deliver an enhanced driving experience. That is the idea driving companies such as Mercedes-Benz and Toyota’s Lexus division to drive hybrid versions of luxury vehicles.

The new hybrids will appeal to customers that like the idea of improving fuel economy while preserving the power and acceleration to which they are accustomed.
acustomed. Rather than boosting the performance of a four-cylinder engine with a supplemental electric motor, this new generation of vehicles uses the electric motor to improve the fuel economy of a six- or eight-cylinder engine while retaining its power characteristics.

While luxury customers may not have fuel economy in mind when they buy their cars, driving a gas hog does annoy them when they have to fill up, as was demonstrated by the Hummer H2’s poor rating in the J.D. Power customer satisfaction survey. “Fuel economy doesn’t play much of a role in the purchase decision, but it can be a significant source of dissatisfaction after the purchase,” said Dave Hermane, Executive Engineer of Environmental Engineering at the Toyota Technical Center. “So we will market the performance aspects and provide the fuel economy to keep them happy.”

SUVs get a boost

Lexus unveiled its production hybrid RX400h mid-size luxury SUV at the North American International Auto Show (NAIAS) in January, for delivery to customers this fall. Toyota announced its hybrid version of the Highlander SUV using the same powertrain, and company officials hint that the Sienna van could be next in line for hybrid power. Toyota showed a concept full-sized pickup truck that will be powered by a V8 engine upon arrival in 2006, but could receive hybrid-electric power later.

The Toyota and Lexus SUVs share a powertrain that employs an Atkinson-cycle version of the same 3.3-L DOHC V6 used in the conventional version, the modified engine is mated to the company’s Synergy hybrid-electric motor and an electric controller that continuously varies the transmission that powers the 2.4Prius SUVs are expected to offer all-wheel drive (AWD), and Toyota provides that its hybrid vehicles with an electric rear drive to supplement the gas-electric front wheel-drive (FWD) system.

Both the AWD and FWD systems use the same battery, so maximum power is limited by the battery’s output, even though the additional electric motor produces additional power. For specifications haven’t been set, but combined V6 gas-electric Synergy drive will produce at least 150 kW, at the rear electric motor—which is integrated into the rear differential housing—produces 50 kW, for a combined total of at least 200 kW. The nickel-metal-hydride battery, developed in joint venture with Matsushita, is denser and more compact than the battery used in the Prius.

“The majority of these [hybrid SUVs] will go to people who are considering a V8 variant,” said Hermane. “We don’t currently have a V6 in that type of vehicle, but with the hybrid we have level performance and 50% better fuel economy,” he said. “Mid-range acceleration will also be significantly better.”

The AWD RX400h and Highlander provide better acceleration in fuel economy than the FWD version, because...
having an electric motor/generator on both axles improves both off-the-line acceleration and regeneration under braking.

Combined city/highway EPA (Environmental Protection Agency) fuel economy for the RX and Highlander is better than the 27.6 mpg (8.5 L/100 km) combined average for compact sedans, with a range of more than 600 mi (966 km) on a tank of gas. Low-speed acceleration is better than the conventional SUVs', taking less than 8 s to reach 60 mph (97 km/h).

In addition to the economy and acceleration, Toyota's hybrid SUVs offer an improved driving experience, said Hermance, with smooth acceleration off the line and improved electronic vehicle stability control. The new technology, called Vehicle Dynamic Management, uses direct computer control of the electric motors to give better control with less intrusion than Toyota's conventional vehicle stability control.

Because of the engine stop/start function, hybrids must have electric power steering to preserve steering assist when the gasoline engine isn't running. The hybrid powertrain provides the high-voltage current that works best with electric power steering, and switching to electric power opens up additional opportunities.

"Once you pay the price [to change to electric power steering], you can do other things with it as well," said Hermance. Fully electric steering could be used to give cars the ability to steer their way out of trouble automatically, but electrically assisted power steering can provide some of that benefit. On the RX400h, to help drivers recover from a slide, "it will make it easier to turn the right way, and will not help you turn the wrong way," he said.

Once the two SUVs have been launched, Toyota won't have to look far for another candidate to use the Synergy powertrain, since the RX400h and Highlander share a platform with the popular Sienna van. "The logic of doing a Sienna with an RX-type powertrain is pretty strong," said Hermance. The company is already selling all of the Siennas it can build, so it may not hurry to add hybrid power to the van. When sales do start to cool, electric power could spark renewed interest from customers. "When we need the incremental volume, that would be a good way to do it."

**Cars power up**

Honda believes that it can use hybrid-electric technology to deliver V6-like performance from a V6 engine in its upcoming NSX replacement, as shown in its HSC concept car at the Tokyo Motor Show. The mid-engine sports car concept foreshadows the company's plan to roll out the first production sports car propelled by both gasoline and electricity. The combined output of the gasoline and electric motors will top 224 kW, which should help put to rest the image of hybrid vehicles as sluggish economy cars.

Honda moves its integrated motor assist hybrid-electric powertrain into the V6-powered Accord mid-sized sedan this year. The electric motor makes the hybrid Accord even faster than the conventional V6 car, while variable cylinder management technology lets the engine run on three cylinders to save gas when less power is needed.

Ford's first production hybrid vehicle is the compact Escape SUV that promises six-cylinder acceleration with four-cylinder gas mileage.
At the NAIAS, Honda announced the production version of a hybrid V6 Accord for delivery this year. The Accord sedan will use Honda’s variable displacement technology—which it terms variable cylinder management (VCM)—in conjunction with its integrated motor assist electric drive. The company hasn’t released detailed specifications, but says that the hybrid Accord will provide better performance than the conventional 240 hp (179 kW) V6 version, while matching the fuel economy of the four-cylinder compact-class Civic.

Honda promises a second VCM V6 application later this year, to appear in a new light-truck vehicle in the fall. The obvious candidate is the Odyssey van, although a Honda spokesman wouldn’t confirm that it is planned. The ASM van concept introduced at the Tokyo Motor Show featured the VCM engine and hybrid system.

Luxury power enhanced

Mercedes showed diesel-electric power in the F500 Mind concept car at the Tokyo Motor Show, and the concept Grand Sports Tourer as well as a gasoline-electric S-Class hybrid at the NAIAS, strongly suggesting that hybrid-electric power isn’t far from production. The company cited its “golden rule” for hybrid power at the introductions: “Safety, driving dynamics, comfort, and driving enjoyment must not be compromised.”

The Grand Sports Tourer is the concept version of a planned tall wagon vehicle rumored to be called the R-Class. The concept version is powered by a diesel-electric powertrain, a combination of a 134-kW (184-hp) V8 diesel engine (from the S-Class) and a 50-kW electric motor that together produce 234 kW. The electric motor’s 300 N•m (221 lb•ft) torque assures strong off-the-line acceleration. Combined with the diesel engine, maximum torque is 860 N•m (634 lb•ft). Zero to 62 mph (0-100 km/h) acceleration takes just 6.6 s.

The company claims 30 mpg (7.8 L/100 km) for the six-passenger luxury wagon, and projects that a future improved diesel will trim consumption to 33 mpg (7.1 L/100 km). “With innovations like our latest diesel technology, the Mercedes-Benz interpretation of hybrid technology, and attractive new product concepts, we will inspire America,” promised Jurgen Hubbert, Member of the DaimlerChrysler Board of Directors responsible for Mercedes-Benz.

Another Mercedes product concept is the gasoline V6 hybrid S-Class. “The combined power output of 309 horsepower makes for stunning acceleration from 0-60 [mph] in about 7.5 seconds,” Hubbert said. With a new S-Class on the horizon, hybrid power seems like a good bet for the new model.

Truck benefits add on

The domestic manufacturers are planning hybrid power to boost the efficiency of their popular and profitable light trucks. Ford is looking to maximize the fuel economy of its Escape compact SUV by combining a four-cylinder engine with an electric motor to deliver V6-like acceleration in a vehicle that improves on the four-cylinder’s fuel efficiency. General Motors and DaimlerChrysler’s Chrysler Group have both announced mild-hybrid light trucks that will use flywheel alternator-starters for engine stop/start functions and to recapture energy under deceleration, but not for propulsion.

GM’s system employs its displacement-on-demand technology with a gasoline V8 engine and a flywheel alternator-starter, while Dodge uses the Cummins six-cylinder turbocharged diesel engine in its mild hybrid system. A key aspect of both designs is that the trucks’ towing and hauling power is no way diminished by the additional electric components, so users will see the electric components as something that adds to, rather than detracts from, the truck’s capabilities.

While GM is coming to market with a mild hybrid, it has plans for more advanced systems for high-volume full-size SUVs. “We have two different systems,” said Savagian. “The first is a milder, 42-V hybrid. It has lower electric power and lower battery capacity. It is a single-motor parallel hybrid with a four-speed automatic transmission.”

“What we will introduce in 2006 is a stronger 300-V hybrid with more electric power and more battery capacity and a custom hybrid transmission. We call it an EVT—an electric variable transmission. It has planetary gears in it, but we run it though a continuous ratio,” said Savagian. The design is similar to Toyota’s, but GM also uses the same configuration in its hybrid commercial buses now, so the company is confident it will easily meet the durability requirements of light-truck customers.

The Tahoe and Yukon full-size SUVs are the planned vehicles to carry the strong hybrid. GM could add the mild hybrid powertrain to these SUVs as well as other vehicles that share the pickup trucks’ platform earlier than the strong hybrid’s 2008 arrival, but isn’t interested in doing so because the company is primarily interested in gaining experience with the technology. “Putting [hybrids] in more markets doesn’t provide us more experience with them,” Savagian said.