

Getting Charged Up



by Guy Marsden

with
Chevy's Volt

Courtesy Rebekah Younger

The Volt is a new breed of mainstream-marketed vehicle that falls outside the existing paradigms of gas, electric vehicles (EVs), and hybrids as we know them. Unlike other hybrid-electric vehicles, the Volt can run exclusively on its electric motor—up to 40 miles of range—before its gasoline-powered generator kicks in to provide electrical energy for propulsion and to keep the battery maintained.

Aiming for the Middle

The General Motors (GM) design team wanted to create a vehicle that looked and felt comfortable and familiar. They were not targeting the fringe market of early adopters, but rather middle America—and the Volt hits this head-on. Although GM says it's the most efficient shape they've ever designed, the four-door sedan is styled typically for its class. Perhaps too much so—like the needless chrome grill on the front.

Bucket seats, two in front and two in back, seat four adults, each roomy enough to comfortably accommodate my 6-foot-1-inch frame. The rear seats fold down flat for useful cargo capacity, easily accessible through the hatchback.

The inside controls look like they were designed by aerospace engineers—with two graphic displays replacing traditional controls, the dash feels more like a 747 aircraft cockpit. The center console controls are backlit buttons that are all touch-sensitive—no “click” buttons here, it's digital driving!

web extra

I jumped at the chance when I heard that *Wired* magazine teamed up with Chevrolet Volt for a competition that allowed winners to test-drive its new car. My path to the winner's circle? A two-minute video that showed how my wife Rebekah and I use technology to reduce our carbon footprint: our solar heating, solar-electric system, and solar water heater; our two hybrid vehicles—a 2001 Honda Insight and 2006 Ford Escape Hybrid; plus my solar-charged electric lawn mower.

Check out Guy and Rebekah's solar tech at their Maine home by visiting www.homepower.com/webextras.



What Makes It Go

The Volt's propulsion is powered by a 400-pound, lithium-ion (Li-ion), liquid-cooled "T-pack" battery, developed and tested by GM, and manufactured by South Korean LG Chem in a new plant in Detroit. Li-ion compares favorably with the nickel metal hydride (NiMH) batteries used in most hybrid vehicles as it has more power and energy density, and longer cycle life. The T-shape places the battery down the center console from the engine compartment to behind the rear seats, where it spreads out under the rear cargo section.

GM worked with LG Chem on a proprietary chemistry and configuration for the battery. The 360-volt battery is assembled from more than 200 cells arranged in rectangular packs. Computers monitor at the cell level, allowing bad cells to be bypassed if they fail. (Most hybrid vehicles today use 1.2 V NiMH C cells wired in series/parallel to reach their operating voltage.) The batteries are kept at optimal operating temperatures by a liquid thermal-management system that both heats and cools the pack as needed.

The Volt's complete, T-shaped battery pack.



This cutaway shows the Volt's battery placement—in the center channel of the chassis.



Courtesy www.gm.com (4)



Fold-down seats and hatchback access provide ample cargo room. The Volt's charging cord tucks away neatly under the rear cargo area.

The charging plug makes sure the polarities are correct, and includes a small light for helping find the socket at night.



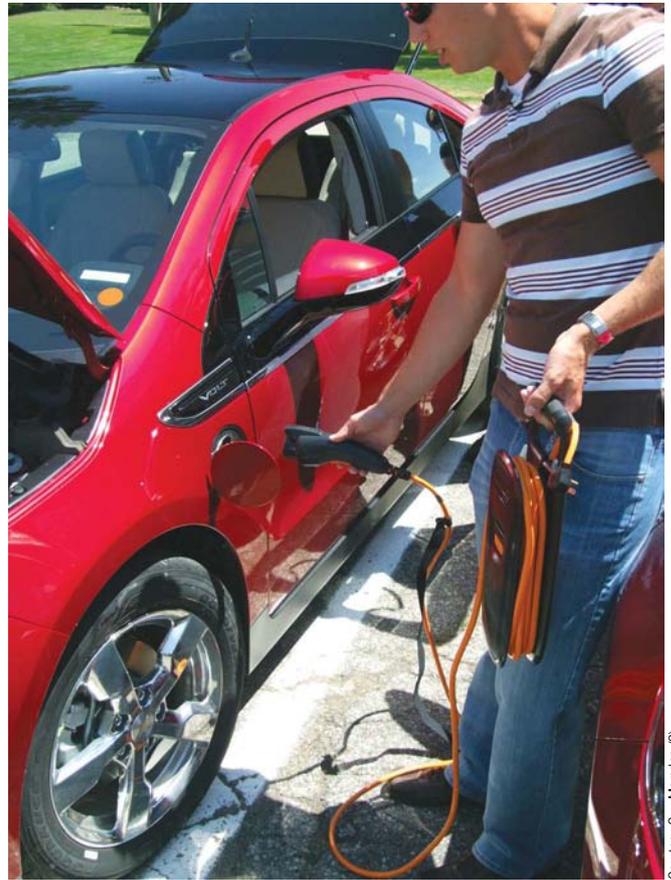
The Volt uses 8.8 kWh of its total 16 kWh battery, at which point the generator comes on. When battery capacity drops below 77% of what it was when new, it is no longer considered “automotive-grade.” The company is investigating secondary markets for used batteries. The battery lab tests the batteries to extremes in environmental test chambers that can cycle from -90°F to 185°F and 10% to 98% humidity. They can simulate four seasons in two weeks and also do rigorous vibration testing on giant shake tables. This is one robust battery! It bolts to the chassis from underneath, and connects to the vehicle via a number of electric, computer, and coolant ports.

The Volt can be charged from a standard 120 V outlet in about 10 hours, and from a 240 V outlet in about four hours. A 120 V charging cable is provided under the rear hatch on a storage spool. The vehicle end of the cable is a SAE standard connector that incorporates an LED light to help you locate the port at night. A full charge requires 8 kWh, costing 80 cents, (at 10 cents per kWh). GM estimates that 35% of all Volts will be used in EV mode only, and 65% will need a partial charge each day to top off the battery. At 10 cents per kWh, Chevrolet estimates that driving costs for a Volt will be about one-sixth the cost of driving a gasoline-fueled vehicle. This battery charging could be provided by a solar-electric system as well.

Beyond Batteries

To satisfy many folks’ desire for more than the Volt’s 40-mile range, Chevy incorporated a gas-powered “range extender” to provide propulsion energy once the battery is depleted. The 53 kW gasoline generator does not recharge the battery, but maintains it at its minimum charge. Like other hybrids, the Volt seamlessly transitions from battery to engine/generator. So long as there’s gas in the tank, you can continue driving, getting about 40 to 50 mpg. On a full tank of gasoline, the Volt can travel at least 300 miles after the battery is depleted.

Realizing that the gas could go bad in Volts that are driven less than 40 miles a day, engineers pressurized the fuel tank and programmed the car to run the gasoline engine occasionally to clear the lines and circulate engine fluids.



Courtesy Guy Marsden (2)

While operating in EV mode and before the engine turns on, a warning appears on the console. The driver has the option of delaying this two times before the vehicle “insists” and runs the engine to lubricate parts and pressurize the system.

Efficiency in Design

We met with the Volt’s exterior design manager, Young Kim, and the interior design manager, Tim Greig. Kim explained that weight was of secondary consideration to aerodynamics since you get better fuel economy improvements by improving airflow than by reducing weight. Although the chassis is steel, the use of plastics and carbon fiber materials keep the curb weight to about 3,500 pounds (average U.S. passenger vehicles weigh about 5,000 pounds). Unlike the 2,000-pound Honda Insight (the older, two-seat hybrid), which has an all-aluminum chassis and body, the Volt has an aluminum hood and a few other aluminum parts.

The Volt uses special 17-inch, all-weather tires to decrease rolling resistance, which increases fuel economy. Traction control and ABS brakes are standard. The braking system is responsive and aggressive. The regenerative braking is well-balanced with the standard disk brakes and feels as natural as in other hybrids. Regenerative braking helps extend battery life by making the propulsion motor act as a generator, slowing down the car while helping charge the battery, which also reduces brake wear. Drivers who have learned to optimize energy usage in hybrids will have no trouble adapting to the Volt.



Courtesy Guy Marsden (5)



The console display shows performance and the Volt's accessories operation.

The dashboard display covers the operational items needed by the driver, and includes a performance-efficiency "orb."



In many ways, the Volt drives just like any ordinary sedan. Despite its lighter weight and special tires, the engineers assured us the Volt could handle our Maine winters. Our 2001 Honda Insight has done well in our northern neck of the woods, but we do fit it with snow tires in the winter. The only other issue is low ground clearance that can be a concern as snow piles up.

Monitoring

A 7-inch-diagonal LCD display replaces a typical instrument panel. According to GM, it's cheaper than a traditional instrument cluster. Graphics on the screen convey speed and range in miles for both electric and gas-supplemented modes. A green bar graph on the left shows miles remaining in EV mode. The graph color changes to blue when the range extender kicks in, at which point the range for the gas remaining in the tank is shown.

The Volt's efficiency monitor—an "orb" with three leaves on it—shifts up or down along a vertical axis, changing to amber at the extremes. The axis top represents acceleration; the bottom, braking. Accelerating or braking too aggressively causes the orb's position and color to change, giving you real-time feedback on your driving. (The ideal is to keep the orb green and in the middle.)

The center console's 7-inch display shows performance stats, such as miles driven in gas and electric modes, and combined miles driven per charge, along with miles per gallon per trip and cumulative miles driven. The screen is the entertainment center and climate-control user interface. An option includes a rear camera and parking assist package. When you back up, a grid overlay appears on the display, showing the vehicle's extrapolated track. As you turn the wheel, this track indicates where you will end up as you move back. Four proximity sensors along front and rear fenders activate a screen warning if you are closing in on an object below your line of sight. Getting used to looking at the console while backing up, rather than over your shoulder, will take some getting used to for most people.

Driving Performance

Driving the "crystal claret red" pre-production Volt on the Milford, Michigan, proving grounds was a blast! I experimented with all four driving "modes," starting with dropping into Low so I could optimize regenerative braking.

Like any other vehicle, low gear is accessed from the shifter, but does not affect acceleration in any obvious way—when you let up on the accelerator, it just slows the vehicle aggressively using the regenerative braking.

The other modes are accessed from the Drive Mode button on the left of the center console. Two taps gets you from Normal into Sport Mode. In Normal, the car handles very well, but in Sport, you can pass with ease and leap onto the freeway like a sports car (0 to 60 mph in 8 to 9 seconds)—with the accompanying loss of battery reserve. It's no Tesla Roadster, but the change in power is palpable. Mountain Mode—three taps of the Drive Mode button from Normal—optimizes the Volt for long hill-climbing, activating the engine generator to maintain the battery. The sound of the gas engine was more noticeable in this mode and seemed to center at 3,000 to 4,000 rpm, distinct as a higher whine than in the normal range-extender mode.

The Volt takes hard turns very well and feels glued to the road due to its low center of gravity. The suspension is firm and responsive with minimal sway, balancing sedan comfort with a slightly sporty feel.

Although there's no operational reason for the range extender generator to vary its rpm, the design team felt that it was important to create a driving experience that felt familiar, so the rpm ramp up when you accelerate and wind down as you slow. I suggested that they create a user-accessible mode for "informed consumers," in which the generator speed is more stable and tracks battery level—and not user behavior.

Bells & Whistles

The Volt comes with a five-year OnStar package, GM's in-vehicle security, communications, navigation, and diagnostics system. GM's smartphone app (for Android, iPhone, and Blackberry) allows Volt users to check the charge level and to program plug-in charging times for off-peak rates. The smartphone interface also allows control of the climate

control and locks, and gives stats like lifetime EV range, total range (with gas), average mpg, and total EV miles. For those without smartphones, OnStar will email a monthly diagnostic status report—it can even tell you if one of the tires is low.

Besides lock and unlock buttons, the remote key fob has two additional controls. One activates the charger, and the other activates the climate control to the last setting used. If the last setting was "economy," for instance, you can pre-warm (or cool) the car from the comfort of your home, just by pressing a button. The Volt is programmed to warm the seats first, then heat the cabin, all while plugged in and using grid power. That means no high-pollution engine idling to pre-warm the vehicle. One GM staffer said he felt that they had actually over-engineered the Volt. There are many nice touches that are only expected in luxury cars. These include USB charging ports and an MP3 port. Bose even designed a custom stereo system for the Volt that is both physically lighter and more efficient than traditional stereos.

On the downside, the list price of \$41,000 could put the brakes on the Volt's potential to reach a wide market. Even after the \$7,000 federal tax credit, a \$34,000 car will have hefty monthly payments. However, GM is offering a three-year, lease-to-purchase option for \$350 per month, which is quite competitive. The company anticipates the price dropping as larger-scale manufacturing helps decrease battery costs. And when the Volt becomes available in Maine in a year or more, we'll be first in line to lease one.

Access

Guy Marsden (guy@arttec.net) develops electronic products from his solar home. He operates ART TEC Solar, making differential temperature controllers for PV-powered solar thermal systems. See www.arttec.net for details of his sustainable lifestyle and business.

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