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# DETROIT AUTO SHOW; All the Technology Needed for 100 M.P.G. (Batteries Not Included)

**By LINDSAY BROOKE**

WHEN General Motors unwraps the Chevrolet Volt for the press today at the North American International Auto Show, it will be revealing much more than the latest fantasy from its styling studios.

Beyond its striking coupelike lines, the Volt is also a declaration of G.M.'s intent to mass-produce a new type of hybrid-electric vehicle, one that can drive up to 40 miles on batteries alone and recharge itself with an onboard generator -- or by plugging into a standard 110-volt household outlet.

The Volt is also less than it appears. The batteries to make it roadworthy do not yet exist, a shortcoming G.M. acknowledges.

This squat four-seat hybrid sedan previews a new family of plug-in electric drive systems that G.M. calls E-Flex. The system, which the company plans to begin installing globally when the battery technology is mature, will be capable of delivering the equivalent of 100 miles a gallon or more in urban driving, G.M. officials said. The Volt's total range is 640 miles using the combined capacity of fully charged batteries and a built-in gasoline-powered generator.

Plug-in hybrids have drawn a great deal of attention recently, and several automakers have built prototypes to test their feasibility. G.M. announced last fall that it was developing a plug-in version of the Saturn Vue hybrid and last week awarded contracts for advanced lithium-ion batteries.

But the E-Flex design goes further, and it differs from any gasoline-electric hybrid in showrooms. While hybrids like the Toyota Prius can drive short distances on battery power and make longer trips using a thrifty gasoline engine -- and if needed, draw on both power sources -- the Volt's gas engine is not connected to the wheels. It turns only a generator to charge the battery pack, a design typically called a series hybrid, and operates in a narrow r.p.m range for maximum efficiency.

In the Volt, the E-Flex drive system consists of a small three-cylinder gas engine, a 53-kilowatt generator and a long lithium-ion battery pack that forms a spine down the center of the car's floor. The battery supplies electricity for the 120-kilowatt (160 horsepower) motor that drives the car's front wheels.

To maximize battery life, the engine that drives the generator automatically kicks in when the battery's charge falls below 30 percent of capacity and shuts off when the battery charge reaches 80 percent of maximum; at that point E-Flex reverts to pure electric mode.

"We've dubbed this feature a 'range extender,' " said Robert A. Lutz, G.M.'s vice chairman for product development. "It also provides a steady flow of electricity to get the vehicle home or to the nearest charging plug," he said, as long as there is fuel in the Volt's twin six-gallon tanks.

Mr. Lutz added that for the 78 percent of commuters in the United States whose daily round trip to work is 40 miles or less, according to the Department of Transportation, a Volt-size vehicle with E-Flex would make the commute using only the battery, "without burning a drop of petroleum." Some type of fuel will be consumed

to generate the electricity, of course.

For a 60-mile round trip, Mr. Lutz reasoned that the Volt would get the equivalent of 150 m.p.g. over all; the first 40 miles in pure-electric mode and the last 20 miles with the gas engine sipping fuel at a rate of 50 m.p.g. as it charges the battery.

G.M. engineers, who estimated the Volt's performance using computer simulations, said charging the battery from a 30 percent level would take about a half-hour while under way and up to 6.5 hours when plugged into a standard 15-amp household outlet.

Similar overall ratings of more than 100 m.p.g. are claimed by advocates of plug-in hybrids. According to Calcars.com, the Web site of the California Cars Initiative and an independent advocate of plug-ins, 30 miles of battery-only driving at the average cost of 9 cents a kilowatt-hour in the United States would cost 81 cents, compared with the average $2.40 gallon of regular gasoline required to propel a relatively miserly conventional car the same distance.

The Volt's estimated annual fuel savings of about 500 gallons, compared with a similar size 30-m.p.g. vehicle driving 15,000 miles a year, equate to $900, even considering the cost of the electricity, said Tony Posawatz, an engineering manager in the Volt program.

He added that while switching the United States to plug-in hybrids over time would increase overall electricity use and that rates would increase, the price of powering vehicles from the grid during off-peak hours would be roughly one-third the equivalent price of gasoline.

G.M. is planning to offer E-Flex power systems in all major world markets, according to Jonathan J. Lauckner, vice president for global vehicle programs. He said the company's next-generation compact-car platform, due in 2009, had been designed to accept an E-Flex battery pack, generator and related hardware.

For some applications, E-Flex would not require any range-extending engine. Instead, it could be a pure-electric vehicle used for local deliveries and charged directly from the power grid. G.M. is also developing a hydrogen version, with a small fuel-cell stack replacing the combustion engine for electricity generation.

While development of the new electric drive system has already begun, the company cannot set a production schedule until the proper batteries are ready, said Nick Zielinski, the Volt's chief engineer.

"We believe lithium-ion will begin replacing today's nickel-metal hydride as the battery chemistry for hybrid use around 2010," he explained. Lithium-ion offers two to three times the energy storage and power density of nickel-metal hydride, said Martin Klein, engineering director of Compact Power, a division of LG Chemical of South Korea that is developing lithium-ion batteries.

He said achieving the Volt's goal of 40 miles of pure-electric operation was feasible. But Mr. Klein said he believed the challenge would be in developing small, light batteries that still met the target for driving distance between charges.

Battery weight, the Achilles' heel of hybrids, hurts vehicle performance, so G.M. is keen to trim some of Volt's hefty 3,200 pounds. Mr. Zielinski winced as he noted that early projections for Volt included a 400-pound battery pack, though that is still less than half the weight of the nickel-metal hydride batteries used in G.M.'s EV1. G.M.'s cancellation of its EV1 electric car stirred up environmentalists, but Mr. Lutz said the project's results were paying off.

"The EV1 was a great engineering achievement, but it was severely limited in operating range by its battery," he said. "We learned that customers did not want to plan their lives around the next battery charge."

Battery development and production costs are likely to add thousands to the price of the early E-Flex vehicles, G.M. admitted. But the company was optimistic that incentives offered by local governments and electric utilities would help drive sales.

Skeptics include John German, environmental analysis manager for Honda in the United States. In Congressional testimony last year, he said that a business case for plug-in hybrids would not exist unless fuel prices were above $3 a gallon, shortages had occurred, technology was subsidized or a breakthrough in energy storage emerged.

None of that deters Mr. Lauckner, the G.M. vice president. "This program is not a public relations ploy," he said. "We are dead serious about taking this technology into high-volume production."

**Correction:**
January 21, 2007, Sunday An article about the Chevrolet Volt electric car on Jan. 7 gave the incorrect Web site of the California Cars Initiative, an advocate of such cars. It is CalCars.org, not Calcars.com.