The GREENING of the SUPERCAR

Ferraris, just like Fords, must now conform to environmental regulations

By Lawrence Ulrich

TAVIS COBURN

SOMEDAY SOON THERE WILL BE AN AFFORDABLE and clever electric vehicle that will conquer the world, as the Model T and Volkswagen Beetle did in their day. In the meantime, there's the Tesla Roadster, a US $109 000, 300-horsepower, two-seat toy for rich, environmentally conscious gadget hounds. Yes, for every Nissan Leaf or Chevy Volt with mainstream pretensions, there's a battery-powered land rocket that's way more Bugatti than Beetle.

Makers of automobiles more associated with tearing up the earth than with saving it are suddenly rushing to outdo each other in the automotive industry's next big battleground: electric and plug-in hybrid cars. Their pitch is the familiar best of all worlds: cars that look hot, go fast, run clean, and consume either no gasoline or very little.

But really now, does a man who buys a six-figure missile on wheels really fret over fuel bills or global warming? Probably not, but carmakers say that affluent buyers increasingly want to make a green statement anyway. In a world where a fuel-sucking V-12 engine seems not just passé but nearly pathological, an electric

AUDI e-TRON

In the movie *Iron Man*, billionaire adventurer Tony Stark drives an Audi R8 supercar. But even Iron Man has yet to get his metal mitts on the e-Tron, which Audi will bring to market around 2012 at an estimated US $150 000. Looking like a scaled-down R8 but sharing its aluminum Audi Space Frame construction, the e-Tron takes advantage of four electric motors—two each at the front and rear axles—to offer a torque-vectoring take on its trusty Quattro all-wheel-drive system. Those motors send a total of 230 kilowatts (313 horsepower) and 681 newton meters (502 foot-pounds) of torque to all four wheels, urging the Audi from 0 to 100 kilometers per hour (62 miles per hour) in 4.8 seconds—not quite as quick as the V-10 powered R8 but impressively swift for an electron-enabled sports car. And while the standard R8 is guzzling from a premium nozzle, the e-Tron can draw from its 53-kilowatt-hour battery to cover 248 km (154 miles) on a charge.

Like other EV sports cars, the Audi is limited to a modest top speed—in this case, 200 km/h (120 mph)—because of how quickly precious electrons are used up at autobahn speeds. "You could take out the high-speed limiter, but you'd only travel a few miles," Audi head of electromobility strategy Frank Van Meel says; at high speed, "the electric motor has a tendency to suck the battery dry." Weight is another enemy of EV range and performance: At 2000 kilograms (4400 pounds), the e-Tron prototype weighs as much as a full-size luxury sedan. Audi insists it will chop up to 408 kg (900 pounds) from the finished product. But it won't be easy: the lithium-ion battery,

Continued on next page

sports car marks its owner as not just loaded but also progressive, ahead of the curve in both auto technology and fashion. Auto execs, of course, are only too happy to propagate this perception. "In the long run, we're either going to run out of oil or the price will go up dramatically," says Frank Van Meel, head of electromobility strategy for Audi. "There's a need to act right now."

And yet, it's not really the warming planet that's spurring the supercar makers. It's the heated rhetoric, and the forging of new government regulations. This is quite a change for a niche market that has obsessed over miles per hour while largely ignoring miles per gallon.

Under a controversial European Commission plan, new cars in Europe may be required by 2015 to meet a strict fleetwide average of 130 grams of carbon dioxide per kilometer driven. The United States is expected to adopt similar CO_2 standards and has already mandated a 22 percent improvement in fleet average fuel economy, to about 35 miles per gallon (6.7 liters per 100 kilometers) by 2016. Because CO_2 emissions are a remorseless function of how much fuel you burn, the EU target means that a gasoline car would need to consume just 5.1 L/100 km, or achieve 46 mpg.

There's just one problem: No conventional sports car in the world today achieves that kind of fuel economy or squeaky-clean emissions, let alone supercars like the 21.4 L/100 km (11 mpg) Lamborghini Murciélago, among the industry's worst offenders, belching 480 grams of CO_2 per kilometer. Even Lotus's tiny Elise, soon to be equipped with a shrimpy new 1.6-L four-banger, will emit 155 g/km. That's less than any current gas-driven sports car but still above the proposed target.

Small-scale sports-car builders such as Ferrari and Porsche have long been excused from meeting the United States' Corporate Average Fuel Economy rules. Other purveyors of power and luxury have paid fines for missing fuel-consumption standards, with Mercedes shelling out nearly $300 million since 1983—a practice the company has vowed to end by boosting efficiency.

Yet a fast-car fan might ask: In a world steaming with emissions from coal-fired power plants and hundreds of millions of cars, who cares if a Lamborghini guzzles gasoline more greedily than a Citroën? For years, sports-car makers have offered precisely that defense of their guzzling: These exclusive cars sell in such tiny quantities—and are driven so lightly, as weekend toys—that their environmental impact is negligible. Ferrari sells fewer than 10 000 new cars a year around the world, compared to the millions of a GM or Toyota. Ferrari officials say their exotic baubles tend to be driven less than 10 000 km a year on average, about half as much as a typical passenger car. Even so, regulations may limit the free passes and no longer allow major companies to buy indulgences for green sins.

Colin Peachey, Lotus's chief engineer, frankly allows that political and social forces are driving the industry. "In an ideal world, where burning fuel didn't damage the planet, there wouldn't be a case for electric cars. We'd carry on with our V-8s and V-12s and have all the performance and convenience that gas gives you."

It's hard to imagine a world in which wealthy car buyers can't have the cars they want—or one in which carmakers can't even make the cars they want. Peachey insists that sports-car builders could be effectively legislated out of existence if they don't hybridize or otherwise green their lineups. "The emissions may be a relative drop in the ocean, yet legislators are saying we're going to tax you until it hurts, and above a certain emissions level, you just won't be able to sell the car," he says.

The writing on the wall is even being translated into Italian: Ferrari has unveiled the 599 HY-KERS hybrid supercar concept, which combines a V-12 engine with an 80-kilowatt (107-horsepower) electric motor—and a 3-kilowatt-hour lithium battery said to be just 2.5 centimeters (1 inch) thick—boosting fuel efficiency to as much as 9.4 L/100 km (25 mpg) and reducing CO_2 emissions to 270 g/km.

The car adopts energy-capturing regenerative-braking technology from Ferrari's KERS (Kinetic Energy Recovery System, used in Formula One race cars), delivering an estimated 1.5 percent gain in fuel efficiency. And as if that weren't surprising enough to traditionalists, Ferrari chairman Luca di Montezemolo said recently that every car in Ferrari's lineup will adopt hybrid technology within three to five years. (Note to collectors: Now's the time to buy up the soon-to-be "classic" gas-burning models.)

Colin Chapman, the engineer, Formula One genius, and founder of Lotus, created the most enduring mantra of sports- and racing-car design: Add lightness. And for today's performance geniuses, electrified cars pose a tremendous challenge: how to reduce emissions and keep cars fast and razor sharp in handling—as customers demand—even as batteries and electric motors add weight and greatly complicate the pursuit of perfectly balanced (roughly 50-50) weight distribution between front and rear axles.

In a briefing on Ferrari's environmental issues, technical director Roberto Fedeli expressed confidence that the company would dramatically reduce CO_2 emissions while "keeping its soul" and honoring all its performance and fun-to-drive traditions. Yet further gains in engine efficiency won't be enough,

Continued from previous page

power inverter, and control electronics saddle the Audi with more than 470 kg (1040 pounds).

To boost efficiency, Audi adds an automotive first: A heat pump, typically used in buildings, that can scavenge heat or cold from one part of the car and send it to another, without the energy-sapping electric climate control found in other hybrids and EVs. Audi cites a 2.5-hour waiting time for a high-voltage charger, or up to 8 hours on household current. Audi is also developing a wireless inductive charger, akin to an electric toothbrush setup, that can begin charging as soon as the car is parked, no plug required. Owners can use a smartphone to manage and monitor charging remotely, including preheating or precooling the cabin and drive system using juice from the grid instead of drawing from the car's battery.

TAVIS COBURN

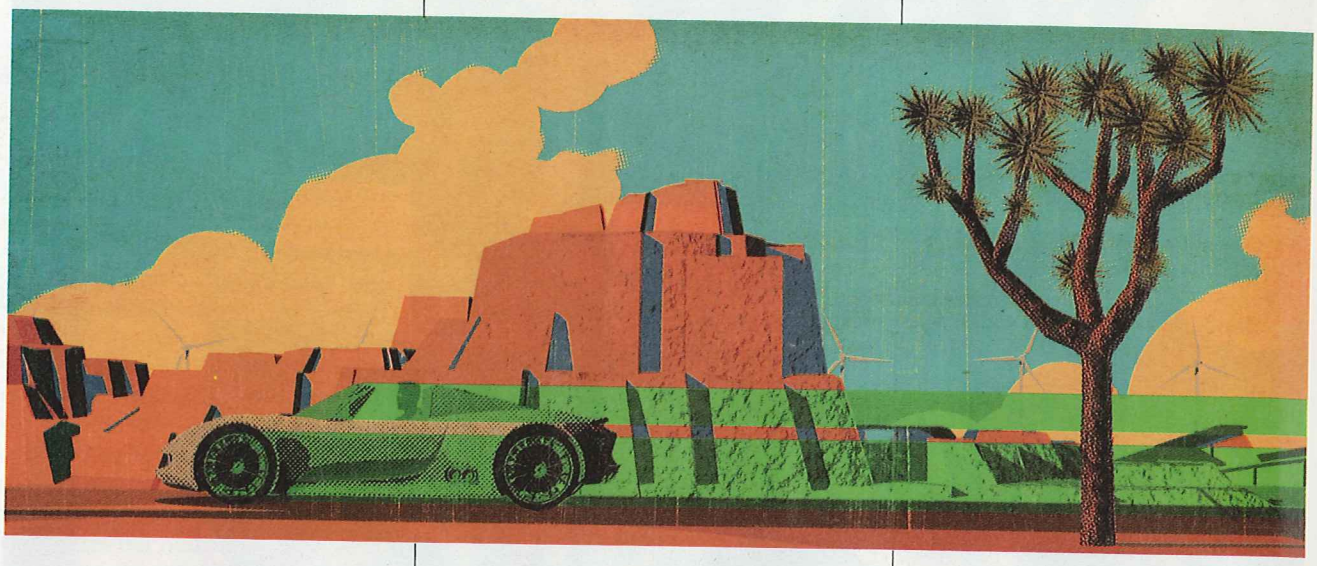
he said. Ferraris and other models will begin to adopt the start-stop functions of hybrids, shutting engines down automatically at stoplights to save fuel.

Ferrari's performance strategy is to add 1 additional horsepower for every kilogram of mass added to its hybrid cars. In fact, its recently unveiled hybrid concept car actually accelerates more quickly than the standard 599 GTB Fiorano model. Critically, that extra weight must be distributed in a way that doesn't spoil a car's handling balance or intrude unduly on passenger and cargo space. Virtually every sports-car maker is designing batteries and hybrid components to fit into a thin "skateboard" entirely under the car's floor, lowering the vehicle's center of gravity.

The Tesla Roadster, which is based on the gasoline-powered Lotus Elise, proved that EVs can be fast and fun. But they still don't outperform comparable gasoline models, especially in handling. That goes for hybrids, too. Much has been made of an electric motor's ability to deliver its full monty of torque the instant you mash the gas—er, throttle. But for pure EVs, those motors must counteract hundreds of kilograms in batteries, cooling systems, and electronic controls. Take the Elise, a featherweight at less than 910 kilograms (2000 pounds). It gains more than 300 kg (660 pounds) of electric fat in its transformation to the electric Tesla Roadster. And because batteries run out of energy so quickly, especially at higher speeds—a single gallon of gasoline contains 33 kWh of energy, about two-thirds of the energy stored in the entire battery pack of a typical EV—electric

MERCEDES SLS AMG eDRIVE

From its shape to its fanciful gull-wing doors, the US $186 000 Mercedes SLS AMG harks back to the classic SL gull-wing of the '50s. But the zero-emissions version of the SLS casts an eye toward a distant gas-free future, even as Mercedes readies its lithium-ion supercar for sale around 2013. Using the same lightweight aluminum body as the standard model, the Mercedes ditches its massive V-8 in favor of four electric motors with a total of 392 kilowatts and 880 newton meters of torque. It thus loses 7 percent of the power (420 to 392 kW) but more than makes up for it by adding 35 percent more torque (649 to 880 Nm). Mercedes is targeting the same 3.8-second squirt from 0 to 100 kilometers (62 miles per hour) achieved by the fossil-fueled version—albeit with the far lower top speed of roughly 200 km/h (125 mph), versus 317 km/h (197 mph) for the gas burner. A 48-kW modular battery is divided into three 16-kW units, one mounted below the elegantly stretched hood, another along the center tunnel, and the third behind the passenger compartment. An intelligent all-wheel-drive system features the torque-vectoring capability of other sports-car EVs. Mercedes figures the electric SLS will cover from 150 to 180 km (93 to 112 miles) on a charge, with 8 hours required to juice the batteries on household current, or 5 hours on a high-density charger—plenty of time for its owner to chat up admirers.



cars are generally limited to 200 km/h (125 mph) or less; your mom's Toyota Camry can go faster.

Fortunately, electric motors themselves are much more efficient than internal combustion engines, losing much less power between the motor and pavement. That's why an electric vehicle can travel 25 or more kilometers on the energy equivalent—from its batteries—of barely a liter of gas. Of course, those batteries are heavy and can't store nearly as much energy per cubic centimeter as gasoline does. "If you're carrying enough battery for a 200-mile range, a lot of the time you're dragging that battery as deadweight and actually hurting your handling and fuel economy," says Peachey, the Lotus engineer. So in real life, your choice comes down to limited range or a hybrid drivetrain. Lotus, Porsche, and Ferrari are all going the hybrid route. They can travel, say, 55 km (about 34 miles), on electricity alone. A supplementary engine eliminates the "range anxiety" of a pure EV, allowing smaller, lighter batteries and a less-powerful electric motor.

But electrics hold intriguing advantages as well. Multiple electric motors allow "torque vectoring"—independent control of the drive speed of each individual wheel to improve cornering, stability, and safety—with no need of complex mechanical or hydraulic differentials to divvy the power among the wheels (BMW and other manufacturers are already applying torque vectoring to their gasoline-powered all-wheel-drive cars).

Next up will be electric wheel-hub motors, which will push the performance envelope even farther. Michelin, for example, has been developing its Active Wheel system for over a decade. It puts a motor, a brake, and suspension control in each of a car's four wheels, eliminating the need for an engine, traditional suspension, gearbox, and transmission. This offers formidable performance: A typical sports car takes roughly 6 seconds to stop from 100 km/h; Michelin's concept system can do it in 2.8 seconds.

Gearheads may worry that today's speed merchants will be shackled by environmental demands, just as the original '60s muscle cars were driven to extinction by the first-ever emissions rules. Yet a modern sports car like the Corvette Z06 somehow manages to combine an impressive 26 mpg with 505 hp and a 198-mph top speed, figures that shame any car of the '60s. (For those of you in the metric realm, that translates as 9 L/100 km, 377 kW, and 319 km/h.)

An optimist might gather that there's nothing to fear: Ferraris and Corvettes will still be duking it out, going faster and handling better than ever. This time, though, the drivers will have a new metric to brag about: fuel efficiency. ❑

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TAVIS COBURN (2)

PORSCHE 918 SPYDER

When Porsche designs a concept car, it's not fooling around—the company reliably follows through with a production model. And that's what makes the 918 Spyder such catnip for speed demons and green demons alike. This heart-stopping, roughly US $630 000 successor to the Carrera GT ditches that supercar's V-10 guzzler for the one-two punch of a plug-in hybrid.

The all-wheel-drive Spyder starts with the small-but-mighty 3.4-liter V-8 from the RS Spyder racer, with 367 kilowatts (500 horsepower) and a symphonic 9200-rpm redline. That midmounted engine is mated to a fluid-cooled lithium-ion battery pack and a pair of electric motors—one for the front wheels, one for the rears—that spool up another 160 kW (218 hp). It's an extravaganza of thrust, good for a 3.2-second trip from 0 to 100 km/h (that's 62 mph), a 319-km/h top speed, and a Porsche-tested lap time that breaks 7 minutes, 30 seconds around the famed Nürburgring Nordschleife circuit in Germany's Black Forest—faster than the Carrera GT.

But—and here's the change from yesteryear—if you drive the 918 Spyder more economically, it can sip as little as 3 liters of petrol per 100 kilometers on the latest European Driving Cycle—or 78 miles per gallon. That puts the Porsche's CO_2 emissions at just 70 grams per kilometer. By way of comparison, the Toyota Prius, among the greenest cars sold around the world, emits 89 g/km. (As for gas-powered supercars, the Lamborghini Murciélago, among the worst CO_2 offenders, blows out 480 g/km).

One reason for the economy is a diet of carbon fiber, magnesium, and aluminum that keeps the Porsche light on its toes, at just 1490 kilograms (3300 pounds). Another is the Spyder's good-cop, bad-cop personality, enabled by four driver-selectable modes: Toggle up to E-Drive and the Porsche can travel up to 25 km (16 miles) on electricity alone, drawing juice from its battery, supplied in part by the regenerative brakes. The Hybrid mode mixes and matches power as needed from the electric motors and gas engine. Sport Hybrid employs both drive systems but sends more power to the rear wheels, with a torque-vectoring unit to boost handling by speeding or slowing individual wheels. Finally, the Race Hybrid setting kicks performance to warp-speed limits, including the push-to-pass E Boost, which feeds a jolt of current to shoot past competitors. It's the equivalent of a nitrous oxide tank from the 2001 film *The Fast and the Furious*, but without the environmental baggage.

LOTUS 414E HYBRID CONCEPT

Lotus's tiny, two-seat Elise provided the backbone for the groundbreaking Tesla Roadster EV. Yet with the concept 414E, Lotus has adopted the plug-in hybrid approach of the Chevy Volt and Fisker Karma: pairing a smaller, lighter, and less-powerful battery pack with a tiny, range-extending gasoline engine—which Lotus insists will deliver a smaller carbon footprint over the vehicle's life than a full Tesla-type EV. Lotus reaches that conclusion by taking into account not simply energy consumption and emissions but also the energy used to manufacture the vehicle and, above all, the battery.

Based on the slinky new two-plus-two Evora, the 414E gets 306 kilowatts (408 horsepower) and 800 newton meters (590 foot-pounds) of torque from lithium-polymer batteries, dual electric motors, and a 1.2-liter midmounted engine that burns either gasoline or alcohol. Lotus figures the 414E will travel 56 kilometers (35 miles) on electricity alone and more than 480 km (300 miles) once its gas engine kicks in, while hitting 96 kilometers per hour (60 miles per hour) in less than four seconds.

Coming from Lotus—the British company dedicated to sports cars in their purest form—the 414E plug-in hybrid is also a rolling rejection of the idea that electric cars can't be fun. For one thing, it lets the driver shift gears, as all true sports cars should. Most EVs deprive you of that connection because they don't need a multigeared transmission to maximize power; that's because an electric motor delivers explosive, instant-on torque no matter how fast it's turning. (That's why EVs like the Tesla Roadster can get away with a mere single-speed transmission.) In the Lotus, though, the gearbox can mimic the driver-selected gears of a conventional transmission, heightening the fun.

Lotus also designed its regenerative braking—which captures kinetic energy and converts it into electricity to charge the battery—to mimic the "engine braking" effect of a conventional six-speed gearbox. Drivers can downshift through paddle-selected gears to slow the vehicle without using the brakes—a key technique when heading into corners on road or track—with the electric motors varying their electrical resistance to do so. And the more regenerative braking you engage in, the more electricity there'll be to pour back into rpm's.

The Lotus also gains a big edge in traction and handling from its motors' ability to power individual wheels. By speeding up the outside rear wheel in a turn, the Lotus is able to pivot through the corner at a higher speed. Such torque vectoring also allows sophisticated control of the car to boost stability in emergency situations. And it's all done without the weighty clutches and differentials used by torque-vectoring gasoline cars, such as the Porsche Panamera.

"The car becomes even more like a go-kart," Lotus chief engineer Colin Peachey says.

TAVIS COBURN (2)