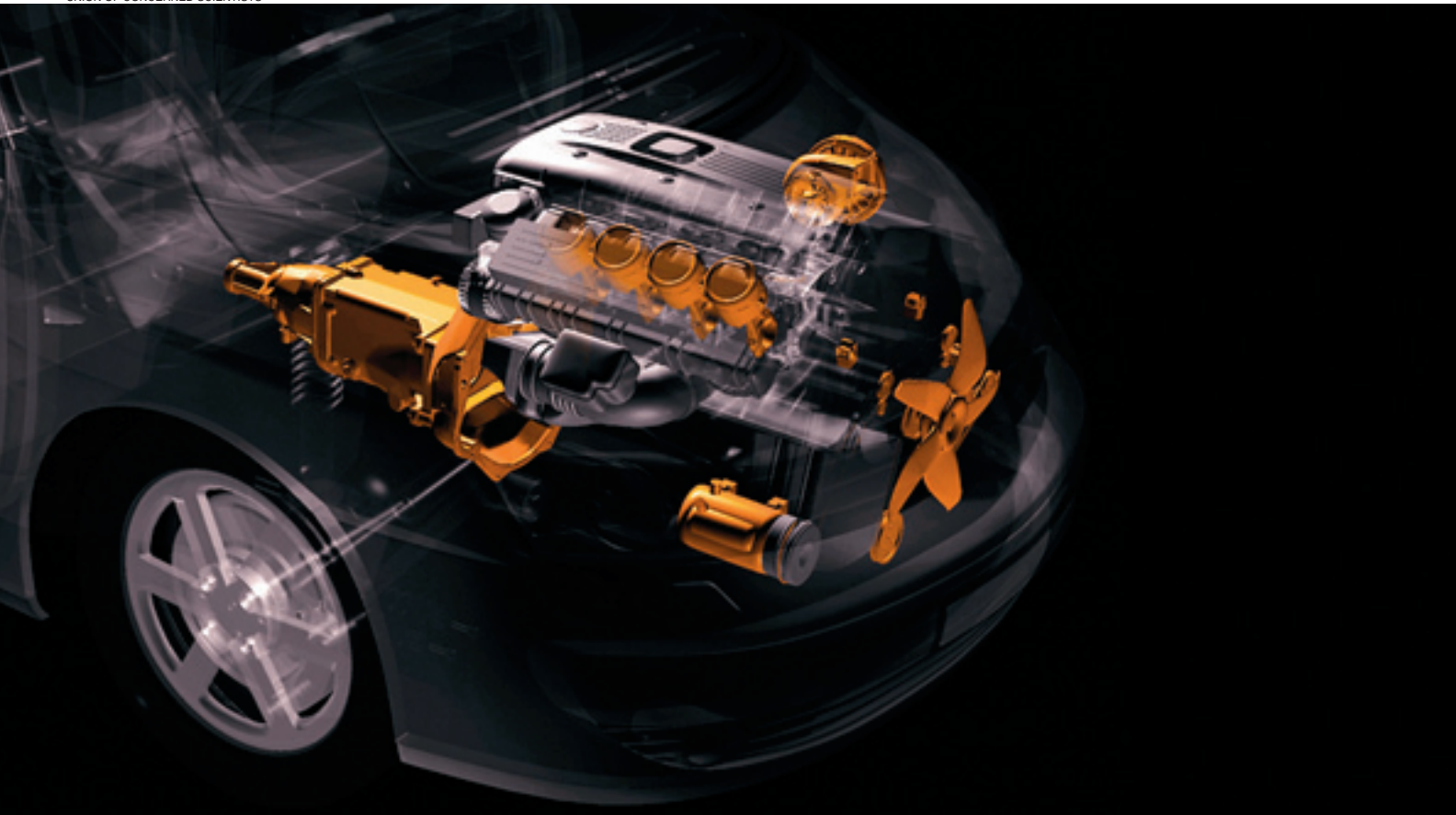
High gas prices and shifting consumer sentiment point to bright prospects for hybrid cars.

By Norma Carr-Ruffino and John Acheson

The Hybrid Phenomenon

UNION OF CONCERNED SCIENTISTS



A cutaway shot of the Union of Concerned Scientist's Vanguard hybrid design.

HONDA

The Honda FCX concept car will go into limited production in Japan and the United States by the end of 2008. The car utilizes a hydrogen/electric fuel cell and, according to Reuters, has a driving range of 354 miles and can reach a maximum speed of 100 miles per hour.

Automakers are facing energy instability and higher gas prices, and customers are pushing for cleaner and more efficient solutions. New vehicles and fuels are gaining traction as Americans seek to address the world's most pressing concerns—terrorism (financed by Persian Gulf petro-dollars) and global warming. These forces have converged in the Hybrid Phenomenon—millions of automobile owners choosing hybrid and alternative fuel platforms to promote the greening of the automobile business. American manufacturers, late to the game, are working overtime to catch up to, and eventually surpass, their Japanese competitors.

By 2006, more than 250,000 U.S. drivers had bought Toyota hybrids to reduce oil dependence and help the environment. Globally, Toyota has reported more than 500,000 hybrid sales to date, and the company's one million sales target, set for 2010, appears more reachable all the time. The company has cut the extra costs associated with building hybrids almost in half since 1997.

The Hybrid Phenomenon is about saving time and money at the fuel pump, but it's also about saving a part of the world every day. Transportation is responsible for about a quarter of the greenhouse gases released into the atmosphere, and the United States is the greatest greenhouse gas contributor on the planet. Hybrids have saved more than an estimated one million barrels of crude oil, three million pounds of smog-forming gases, one million metric tons of carbon dioxide and 125,000 gallons of gasoline.

The Hybrid Phenomenon is allowing drivers to change the world and feel good about it. In business and commerce, hybrid dollars help stimulate economies and create jobs. The movement also is creating global virtual communities and empowering people to promote environmental sustainability. The Phenomenon shouts globally and acts locally every day. Yet, few people appreciate what a large role this technology will play in the future of the transportation sector, how intense the coming industrial battle over the hybrid market will be, and how, indeed, the Hybrid Phenomenon has only just begun.

BACK TO THE FUTURE

It's amazing to think that the Hybrid Phenomenon emerged primarily from the Toyota Prius, originally an odd-looking concept car developed in the 1990s. Approximately 1,000 Toyota engineers drew up and then abandoned 80 designs to reduce gas consumption, only to settle on a 100-year-old technology, the hybrid, which simply increased efficiency and doubled mileage.

In the 1890s, when horseless carriages were as likely to run on steam or electricity as on gasoline, a young engineer named Ferdinand Porsche was asked by his boss, Jacob Lohner, to design a better electric car. Lohner-Porsche successfully offered a hybrid alternative a few years later. It filled up on gasoline, but electric motors turned the wheels. The hybrid solved the electric-vehicle problem of limited speed and range. The world's first hybrid was about four times more efficient than today's average cars.

Gasoline-powered cars had taken over the passenger car market by the 1920s, thanks to the electric starter and Henry Ford's assembly line, which made Model Ts affordable for most families. Still, industrial uses for hybrids flourished during the rest of the twentieth century. Diesel-electric hybrid trains and heavy equipment helped to industrialize America. As for cars, many incarnations of hybrid concepts were built, but none took significant market

PINCHING PENNIES: THE COSTS AND BENEFITS OF BUYING A HYBRID

What do hybrids have to offer car owners and society in general?

- Hybrids are twice as efficient as conventional vehicles.
- They are 50%–100% cleaner than the majority of vehicles on the road.
- Average hybrids get 30%–60% better mileage than their counterparts.

In actual use reported by drivers, hybrid mileage varies widely because of many factors—driving style, terrain, tire pressure, wind, weight, type of gas, temperature, and condition of vehicle. Optimists view hybrid mileage as a challenge, urging them to find the "sweet spot" mph range. Pessimists criticize automakers because the mileages they experience fall below EPA ratings.

Many governmental and some private organizations offer free parking and tolls and sales tax credits that lower costs even further. Statistics show that hybrid drivers tend to have comparatively good safety records and some insurance companies offer hybrid discounts.

—Norma Carr-Ruffino and John Acheson

TOYOTA

This Toyota plug-in concept car builds on the success of the company's popular Prius, full hybrid.

share until the Prius, which emerged out of Japan in 1997 and hit the United States in 2000. The Honda Insight 2000 was actually the first mass-produced hybrid vehicle, but the 2001 Prius and its successors have been the runaway best sellers.

Providing efficiency and flexibility, hybrids are sustaining an auto industry in crisis. More-efficient power management and the ability to recycle energy serve to increase fuel efficiency and reduce emissions.

From 1997 through the first half of 2006, aggregate global hybrid sales for new cars and light trucks totaled 820,000 units. In 2005, 20% of sales took place in Japan, and 68% went to the largest market, the United States. Toyota dominated the aggregate market with more than 720,000 units sold by July 2006, or almost 9 of every 10 hybrids in the world. The demand for the Prius exceeded everybody's expectations, and the hybrid market grew faster than any other.

Hybrids have become the most efficient, business-disruptive and flexible transportation platforms ever invented, compatible with just about any fuel and vehicle. For example, hybrids are compatible with gasoline, diesel, ethanol blends (E10, E85, E100), electricity, hydrogen, natural gas, hydraulic gas, air, steam, nuclear, and alternative fuels, such as biofuels made from garbage to plant material to wood. Also, hybrid technology can be implemented not only in cars but also in trucks, trains, buses, ships, submarines, and spacecraft.

ONE SIZE DOES NOT FIT ALL

While the Prius remains the best-known hybrid model, these car actually come in all sorts of shapes and sizes. Hybrids fall into four main platforms: full hybrids, mild hybrids, light hybrids, and plug-in hybrids.

FULL HYBRIDS. The most efficient and widely used hybrids are called full hybrids, which can run on electricity alone. At low speeds, full hybrids can use batteries, computers, and a complicated transmission to move the car without burning any fuel. The Prius has enough technology to run electrically for several miles. This feature increases gas mileage and eliminates smog and noise pollution, which impresses consumers.

Both full and mild hybrids recycle electricity through regenerative braking, a system that converts a vehicle's kinetic energy into electrical energy, thereby increasing energy efficiency. Additionally, the transmission system juggles two fuels to deliver one smooth connection to turn the wheels. The extra costs associated with the computerized drivetrain transmission make full hybrids the most difficult and expensive to manufacture of all hybrid types. However, leading automakers have provided an array of consumer benefits through hybrid drivetrains. Toyota has branded its Hybrid Synergy Drive to several models, and licensed technology to Ford and Nissan, which also produce full hybrids.

MILD HYBRIDS. Hybrids that rely primarily on an internal combustion engine are called mild hybrids. The electric motor increases efficiency by assisting the engine. But it cannot move the vehicle on electricity alone. Mild hybrids provide the same driver benefits as full hybrids, but to a lesser degree. They use conventional transmissions and are cheaper to manufacture than full hybrids so they cannot be converted to plug-ins. The Honda Civic Hybrid, Saturn Vue Green Line, and the Hyundai Accent Hybrid are all examples of this popular type of vehicle.

LIGHT HYBRIDS. Light hybrids do not recycle energy, although they perform as typical hybrids in other

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The Saturn Vue Green Line from GM,
a mild hybrid, uses a conventional transmission and is thus less expensive to manufacture than a full hybrid.

GENERAL MOTORS

EFFICIENCY: "WELL-TO-WHEEL" ANALYSIS

"Well-to-wheel" analysis is the leading holistic approach in measuring the impact of fuel and vehicle choices. A conventional car uses only about one barrel of oil (well) of every 100 extracted from the earth to move its driver down the road (wheel). Since only about 15% of any fuel power ends up turning wheels, efficiency analysis is very insightful.

Well-to-wheel measures everything from fuel extraction to the turning of the wheels. In a conventional vehicle, value chain activities might include oil extraction, pipeline or truck delivery to a port, tanker delivery to another port, truck transportation to a refinery, gasoline delivery to a station, and finally the burning of gasoline to provide propulsion.

Measuring energy loss that occurs before the gas station is called "well-to-pump" or "well-to-station" analysis. Vehicle efficiency measures everything from the pump or station to the turning of the wheels: "pump-to-wheel" or "tank-to-wheel" analysis.

Value chains differ around the world, but generally, most well-to-pump/station studies rank diesel as number one in efficiency, followed closely by gasoline. Electricity almost always ranks last. In summary, it can be estimated that diesel value chains deliver 8 or 9 units of energy to the pump for every 10 extracted to the pump, with gasoline at 7 or 8 units and electricity at about 5 units. So for every 10 barrels of oil extracted from the earth, one to five are lost along the way to the gas station or electric outlet.

R.E. West and Frank Kreith of the American Society of Mechanical Engineers conducted a comprehensive study that included hybrids, which was published in *Mechanical Engineering Power.* The study compared gasoline, hydrogen, diesel, and electricity using the same natural gas input, whereas in actuality, gasoline and diesel come from oil.

The analysis compared efficiency across 12 energy and vehicle combinations. Interestingly, the top four technologies were all hybrids—two diesel hybrids, a natural gas hybrid, and a hydrogen hybrid. Not surprisingly, other vehicles ranked near the bottom at 19% for diesel and natural gas and 14% for hydrogen. Theoretically, most of the hundreds of millions of vehicles on earth spit 8 to 9 units of fuel into the air as heat or smog.

According to a Toyota well-to-wheel analysis, the Prius gasoline hybrid nearly matched the diesel hybrids. Toyota reported the Prius at 37% vehicle efficiency, and when they included fuel efficiency, they got a comparable well-to-wheel result. Toyota's gasoline value chain was 79% efficient. Multiplying vehicle efficiency by well-to-pump efficiency produced the well-to-wheel rating for the Prius as 29% efficient overall.

—Norma Carr-Ruffino and John Acheson

Source: *Transportation Quarterly*, Vol. 56, No. 1, Winter 2002 (pp. 51-73).

While Toyota sells a kit that allows drivers to convert their Prius cars into plug-ins, the **GM Volt** (left) is the world's first production plug-in hybrid.

GENERAL MOTORS

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ways. They reduce fuel consumption by shutting the engine down when the vehicle is stopped. The stopping and restarting of the engine is computerized so the driver need not be bothered with this process.

General Motors (GM) is the leader in this technology and markets light-hybrid trucks to contractors and similar businesses. Light hybrid versions of the Silverado and Sierra use oversized starter/generator technology that produces 120-volt electricity, accessible via electrical outlets for power tools and offering additional fuel savings.

PLUG-INS HYBRIDS. Plug-in technology is the next step in making full hybrids into electric vehicles. Plug-ins use larger battery packs that can tap into external electricity. Drivers enjoy all the benefits of full hybrids to a greater degree and can fill up with electricity. This provides the flexibility to be able to rely on two fuel sources, including high voltage electricity that is available free by many governmental and some private organizations. Full gasoline electric hybrids are the most prevalent hybrids, followed by mild then light. Plug-ins that use more electricity are expected to hit showrooms within the next few years.

In 2005, Toyota made aftermarket kits available for Prius owners who wanted to convert their full hybrids into plug-ins, which achieve over 100 miles per gallon (mpg). Toyota is developing a plug-in Prius for the showroom, but they were beat to market by GM, who recently debuted the world's first production plug-in, the Volt.

COLLABORATION OR TRADE WAR ON THE HORIZON?

Car manufacturing, the world's farthest-reaching industry, changed drastically from 2000 to 2006. Markets, technologies, and consumer behaviors all evolved seemingly overnight. More than 40 different hybrid and alternative fuel models—8 million cars and light trucks—suddenly appeared on American roads. Thirty-five more models will be introduced through 2007.

Automakers, particularly in the United States, are scrambling to find new strategies in an industry that is evolving rapidly in response to several macro forces:

- Cheap oil has reached peak production.
- Governmental regulators are beginning to encourage green consumption.
- Information technologies are disrupting the manufacturing sector by making corporate behavior more transparent and allowing fuel-efficiency advocates to better collaborate, share information, and influence policy.
- Innovations are helping consumers to choose green.
- More people have become familiar with the energy issues surrounding global warming.

Hybrid makers are constantly changing strategies as consumers switch to new vehicle platforms and fuels. CEOs are being challenged to bet on numerous new technologies and vehicles. Increasingly, innovation in fuel efficiency is being driven by parties outside of the boardroom. Engineers are hacking hybrids and increasing gas mileage. Entrepreneurs are starting up battery, electric car, and fuel companies. Environmentalists are collecting used cooking oil and filling up old diesels. Farmers are increasing corn production for trucks, vans, and SUVs that can run on ethanol. Homeowners with battery chargers or natural gas units can fill up in their own garages. Venture capitalists are sinking billions into alternative fuel industries and clean technologies. Politicians are planning energy and oil independence and a cleaner future.

On November 14, 2006, President Bush met with the CEOs of the Big Three U.S. auto manufacturers (GM, Ford, and DaimlerChrysler) to address the financial crisis in the U.S. auto sector. The Big Three emphasized Detroit's impact on America's economy, and GM CEO Rick Wagoner said in a speech to the president and American people: "In June, we (the Big Three) also agreed collectively to double annual production of vehicles capable of running on renewable fuels to two million cars and trucks by 2010."

Why did these powerful CEOs, whose companies are responsible for one in every three new vehicle sales, decide not to mention the word *hybrid* in this crucially important meeting? Only months earlier two of the Big Three, DaimlerChrysler and GM

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THE CAR MAKERS: WHO IS IN THE LEAD AND WHO IS CATCHING UP?

TOYOTA

Hyrbid leader Toyota is continuously improving the quality of its cars and boasts some of industry's lowest manufacturing costs. Toyota's hybrid technology is the most advanced. The company recently became the number-one auto manufacturer in the world, thanks, in part, to its attention to fuel efficiency. It is two generations of patents ahead of its rivals and has been able to increase efficiency while bringing down the hybrid cost premium. Ford, the current number-three, collaborated with Toyota in 2004, and Nissan's hybrid also relies on borrowed Toyota technology. Toyota used more than 650 patents on the Prius.

Toyota has several hybrid models available for sale around the world. In April 2006, Toyota's Kentucky plant rolled out the company's first "Made in USA" hybrid, the Camry. Toyota has just released a performance hybrid to the U.S. market as well as a minivan to the Japanese. In the next few years, the company will release a hybrid truck and expand the Prius into a product line including a mini-car, a wagon, and a crossover utility vehicle (CUV) as well as a plug-in.

The second-generation Prius made for Japan came with an electric-only button. By 2005, in the United States, aftermarket kits were available for Prius owners who wanted to convert their full hybrids into plug-ins. Plug-in Prius drivers have reported more than 100 miles per gallon mileage rates on daily trips. Toyota is developing a plug-in Prius for the showroom.

Toyota plans to produce one million hybrids annually by 2010 and to operate 15 manufacturing plants in North America by 2008.

HONDA

Unknown to many auto-market watchers is the fact that Honda beat Toyota as the first automaker to sell hybrid passenger cars in the United States with the 2000 Insight released in 1999. It was the highest mileage car rated by the EPA that year, with up to 70 mpg on the highway.

This Japanese company makes more internal combustion engines than any other company in the world (over 20 million per year). Honda's core competency delivers engines to a variety of vehicles from lawn mowers to airplanes. The strategy is to focus on the most efficient and versatile gasoline engine, whereas Toyota's strategy is to focus on the hybrid transmission. The engine leader is also developing clean diesel technology.

The first Japanese automaker to build a factory in America offers a handful of hybrid models, including the Civic, Accord, and FCX fuel cell vehicle in limited quantities. Future models include the CR-V, Fit, and Ridgeline. Honda has run second place to Toyota in hybrids sold almost every year since Toyota entered the U.S. hybrid market.

FORD

Ford was the third automaker to enter the American hybrid market. In 2004, Ford released the world's first "Made in USA" hybrid, the Escape, which was also the first hybrid sports utility vehicle (SUV). GM followed a year later with two of the first hybrid pickup trucks. Ford's foray into hybrids was the result of the company's newfound commitment to the environment under the lead of Bill Ford, Henry Ford's great grandson.

The Escape hybrid is certainly more environmentally friendly than any of the company's other vehicles, getting up to 60% better mileage and producing up to 80% less smog than similar gas vehicles. To help build the Escape, Ford licensed diesel technology to Toyota in exchange for 20 full-hybrid patents. Ford relies on more than 350 patents for the Escape.

Ford has since expanded the Escape to be ethanol compatible. In addition, Ford produces a luxurious hybrid SUV under its Mercury make. Ford's future plans include more SUVs and family sedans, while concept-designers work toward hydrogen and diesel platforms. The company is working to produce 250,000 alternative-fuel and hybrid vehicles annually.

GENERAL MOTORS

In 2004, GM rolled out the world's first hybrid truck to fleet customers. In 2005, consumers were presented with the Chevy Silverado hybrid and the GMC Sierra hybrid, which are "light hybrids" that come with electric outlets.

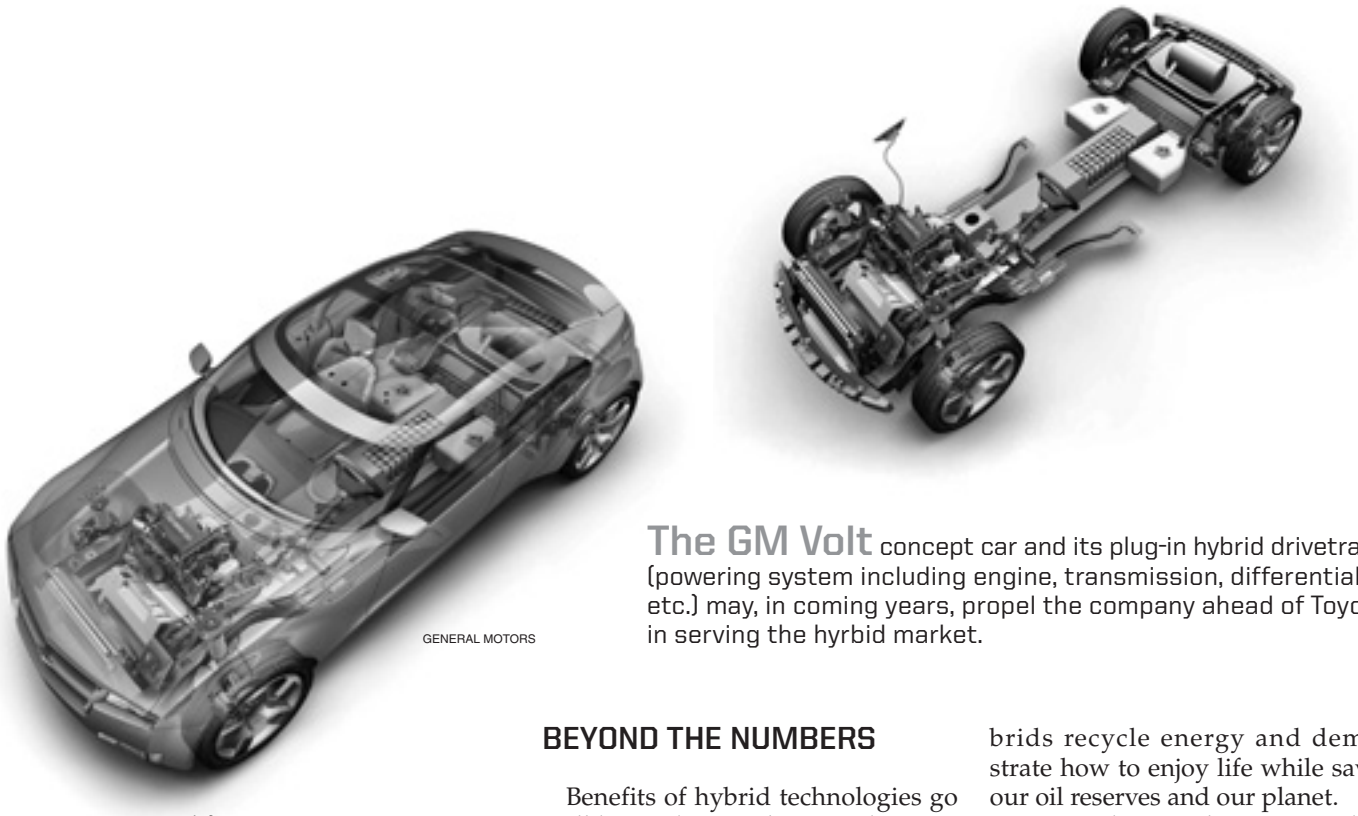
GM's strategy was to start with the biggest vehicles first: buses, trucks, and SUVs. The company has offered hybrid buses and trucks since 2004. In addition to being the world's largest auto manufacturer, GM is the number-one producer of ethanol-compatible vehicles. In terms of hybrids, the company is looking to build on the success of the Saturn Vue Green Line and broaden its scope of hybrid models.

GM is researching a range of future technologies (including hybrids) that can provide towing power and high mileage, hydrogen fuel-cell vehicles, electric cars, and plug-in hybrids that can run on electricity alone.

GM recently debuted its first plug-in hyrbid, the Volt.

Other car companies looking to build their own hybrid portfolios include Nissan, which has collaborated with Toyota in the past, and BMW, working with GM and DaimlerChrysler. Audi, Porsche, and Volkswagen are working on hybrids as well. Mazda plans to release a hybrid using Ford's hybrid technology within the next few years.

—Norma Carr-Ruffino and John Acheson



GENERAL MOTORS

The GM Volt concept car and its plug-in hybrid drivetrain, (powering system including engine, transmission, differentials, etc.) may, in coming years, propel the company ahead of Toyota in serving the hyrbid market.

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(along with BMW), invested more than $1 billion in a joint Hybrid Development Center. They deployed over 500 engineers to focus on the development of a next-generation hybrid for trucks and larger vehicles. The alliance was intent on leapfrogging Toyota.

Yet, many observers think that the Big Three U.S. automakers are so far behind in the Hybrid Phenomenon that the situation is likely to result in the largest trade war ever to invade the U.S. auto industry.

Both U.S. and Japanese automakers directly impact the world's two largest economies—the United States and Japan. Every car or truck sold goes straight to the trade war's bottom line. Every slow-selling vehicle is a casualty in a long-unfolding battle, as plants are shuttered and model lines replaced. Fast-selling alternatives and hybrids promise market share, new jobs, and a new future.

Clearly, the Hybrid Phenomenon is playing a major role in the future of jobs, companies, economies, and countries—as well as in our worldview of energy, transportation, and the environment. After all, our cars connect everything in our lives, from family to work to entertainment to the environment, and trucks deliver almost everything we consume.

BEYOND THE NUMBERS

Benefits of hybrid technologies go well beyond gas mileage and saving money. They lead toward new applications and platforms. The hybrid has the potential to lead to greater innovations for a growing number of products and services.

For example, Australian researchers have produced a prototype of a home hydrogen fueling station. It's the size of a filing cabinet and can run on electricity generated by standard rooftop solar panels or a home wind turbine to turn water into hydrogen gas. The prototype can power a fuel cell vehicle or a hybrid with an engine converted to run on the hydrogen gas. The vehicle can then cruise for 100 miles per fill-up, producing no pollution.

Hybrid platforms can potentially increase the efficiency of almost any fuel and type of vehicle. The trade-off in cost seems minimal compared with the growing number of benefits. If users continue their present rate of investment, hybrid technology will surely become the core technology of the automobile industry.

Surveys indicate that many hybrid owners joined the Hybrid Phenomenon not only to help themselves, but also to help the world. Drivers save money on gas, leaving more oil for other purposes. They enjoy quiet rides allowing others to breathe cleaner air. They get to feel good about the car they drive. Their hybrids recycle energy and demonstrate how to enjoy life while saving our oil reserves and our planet.

Automakers, politicians, and scientists are all fueling the Hybrid Phenomenon. But what will really accelerate this transition are those everyday choices that we, as consumers, make in terms of demanding new vehicle platforms and alternative fuel choices. Such choices are what really matter in the quest for sustainable ways to live the good life—for everyone, not just the affluent few. The Hybrid Phenomenon represents millions of consumers making the decision to move away from oil dependence and toward a cleaner world.

Carr-Ruffino **Acheson**

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By Elizabeth Lowery

ENERGY DIVERSITY AS A BUSINESS IMPERATIVE

A GM VICE PRESIDENT OUTLINES THE COMPANY'S ENERGY ACCOMPLISHMENTS AND FUTURE STRATEGIES.

These are momentous times for the global automotive industry. Extraordinary economic growth in China and India, regional conflicts in the Middle East, population growth, climate change, and natural disasters have converged in recent years; it has underscored the profound need to secure our energy future through advanced technology.

It is highly unlikely that oil alone can supply the world's rapidly growing automotive energy requirements, even with continued improvements in fuel efficiency, so the global auto industry is challenged to develop alternative sources of propulsion, based on alternative sources of energy. The need for action is underscored by the fact that there are currently 800 million vehicles on the world's roads today. In 15 years, that number will grow to 1.1 billion cars, trucks, vans, SUVs, etc.

At General Motors, we believe the key is energy diversity, which can help us displace substantial quantities of oil consumed by vehicles today.

Energy diversity offers an opportunity to alleviate many of the issues surrounding oil availability. We will be able to better cope with future increases in global energy demand. We will minimize the automobile's impact on the environment.

For GM, building vehicles with industry-leading fuel economy and reduced emissions is a business imperative, crucial to our turnaround. In fact, during the past 30 years, GM has improved passenger car fuel economy by 133% and truck fuel economy by more than 75%.

Today, we are embracing multiple energy sources because there is no single answer available for the mass market. This is a huge assignment. But it is also an extraordinary opportunity.

Our approach to energy diversity includes hybrids, electric plug-ins, biofuels, and fuel cells, in an effort to provide our customers with a variety of options for their needs and wants. It also focuses on developing more-efficient internal combustion engines. We have products in market or coming to market across the spectrum of cars, crossovers, SUVs, and trucks. For example:

- Our 2007 model-year lineup offers more vehicles that achieve 30 mpg or higher on the highway than any other automaker—23 in all.
- In 2007, GM will debut four hybrid models—with many more in the years to follow. This year we will introduce the Saturn Aura Green Line and Chevy Malibu midsize sedans, and, in a major leap, our new two-mode hybrid system will debut on the Chevy Tahoe and GMC Yukon—increasing their overall fuel efficiency an additional 25%.
- GM has put more than 2 million cars and trucks capable of running on E85 ethanol on the road, and we continue to work with governments and fuel distributors to expand the availability of this promising alternative fuel.
- GM is a leader in fuel-cell research. A test fleet of 100 fuel-cell powered Chevy Equinox crossover vehicles just went into production in a program we call Project Driveway, and will hit the roads in three U.S. cities this year.
- GM has committed to producing a Saturn Vue Green Line plug-in hybrid, which has the potential to achieve double the fuel efficiency of any SUV. It will combine the two-mode system with a lithium-ion battery pack and powerful electric motors.
- We also recently unveiled the Chevrolet Volt concept sedan powered by GM's innovative E-flex System, a next-generation electric propulsion system that could nearly eliminate trips to the gas station if it is recharged every night and driven less than 40 miles per day. The Volt can be fully charged by plugging it into an ordinary wall outlet.

Minimizing dependence on oil is a challenge we all face. How our global community responds is the defining question of our era. At GM, we are taking on this challenge with passion and enthusiasm, and we are offering part of the solution.

About the Author
Elizabeth Lowery is the vice president for environment and energy for General Motors.

By Scott Nathanson

NOT ALL HYBRIDS ARE CREATED EQUAL

POWER STILL MATTERS TO CONSUMERS, BUT EFFICIENCY WILL MATTER MORE.

My father-in-law is a retired policeman who drove souped-up Crown Victoria patrol cars, big Cadillacs, Lincoln Town cars, and other fuel-thirsty vehicles all his life. But not long ago, he took a spin in my Toyota Prius, and it was a revelation to him. Not only has he said that his next vehicle will be a hybrid, but he's now looking at ways to make his family home more energy efficient, seeing both the vehicle he drives and the home he keeps as a legacy to his grandchildren. Sometimes it just takes a little test spin to start changing a point of view. And I'm happy that the Union of Concerned Scientists and our HybridCenter.org Web site can play a part in that.

The emergence of hybrids on the market has given voice to a "silent majority" of American consumers who have wanted more fuel-efficient, less-polluting vehicle options for years, but have not been given that choice by the automakers. For the past 20 years, automakers have used advances in engine technology to boost power and size instead of fuel economy.

This has, in turn, presented American drivers with a false choice, forcing them to sacrifice fuel economy for size and performance. The auto industry has the technology to make conventional cars and trucks go farther on a gallon of gas. Unfortunately, automakers aren't deploying existing technology across a range of vehicle types. Hybrid technology is one way in which drivers can finally get a "no compromises" vehicle that delivers performance, safety, and fuel economy. But whether the consumer ever sets foot in a "no compromises" hybrid depends on whether automakers compromise the promise of hybrid technology.

Like many other advances in engine drivetrain technology, hybrids' ability to boost performance while improving efficiency can be used to maximize fuel economy or to maximize acceleration. For example, the most popular hybrid vehicle, the Toyota Prius, married the battery-electric motor with a four-cylinder engine, seeking to maximize fuel economy. Toyota did the same thing with its Camry hybrid model, as did Honda with its Civic hybrid. Honda, however, decided to use a six-cylinder engine for its Accord hybrid, despite the fact that most conventional Honda Accord consumers were buying the four-cylinder model. The fuel economy of the Honda Accord hybrid, therefore, barely improved over the conventional four-cylinder. The Accord hybrid's lackluster sales show that hybrid buyers expect more miles per gallon out of their vehicles, not just more miles per hour.

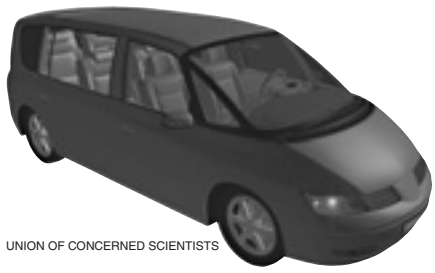
Unfortunately, those trying to catch up in the hybrid game seem reluctant to learn this lesson. GM, DaimlerChrysler, and BMW have teamed up to create a "two-mode" hybrid system that will attempt to maximize the performance of a hybrid drivetrain both in city and highway driving. (A traditional "full hybrid" system like Toyota's Hybrid Synergy Drive primarily boosts fuel economy in city driving, because it cannot take as full advantage of its idle-off or regenerative breaking technologies on the highway.)

The first application of the two-mode system will be on the GMC Yukon and Chevy Tahoe large SUV models. This would have been an ideal place to show that hybrid technology can lead to meaningful reductions in gas costs and global warming pollution. But instead, GM decided to wed the hybrid system to an engine even larger and thirstier than the version used on 70% of the conventional Yukons and Tahoes it currently sells. The effect is a serious boost in horsepower, but a meager 25% improvement in fuel economy.

But all of the automakers have now awakened to the reality that hybrid technology is a needed component in their vehicle fleet, both for public relations reasons and for the driving public, which has come to understand it has been compromising on vehicles where compromises were not necessary.

TAPPING TECHNOLOGIES OF PROMISE

The challenge for the U.S. domestic automakers, which have made their reputation on vehicles with utility and muscle, and the German automakers, which have focused


UNION OF CONCERNED SCIENTISTS

The Vanguard, designed by the Union of Concerned Scientists. The protype shows how, for an extra $300 in manufactoring costs, automakers could eliminate more than 40% of their vehicles' greenhouse gas emissions.

much of their time on performance and power, is to reorient themselves to this emerging understanding. They should use hybrids and other new technologies to satisfy new consumer demands and expectations. The Japanese automakers, while currently in the lead, need to continue to both advance the technology and widen its application in order to retain and expand their market share.

Drivers should be wary of putting too much faith in one technology to solve the environmental, economic, and political challenges that the automakers have helped create. There are no silver bullets for global warming and oil dependence. Hybrids and advanced vehicle technologies are a path toward true zero-emission vehicles, but automakers can do more in the short term to improve fuel economy by using off-the-shelf conventional technologies throughout their vehicle fleets. For example, engineers at the Union of Concerned Scientists (UCS) created a new vehicle design, called the Vanguard. It's a minivan based on the Chrysler Town and Country. For an extra $300 in conventional technologies, automakers could eliminate over 40% of the vehicle's global warming pollution and drivers could save over $1,300 in fuel costs over the lifetime of the vehicle. Automakers could achieve similar reductions at low cost in all types of passenger vehicles.

Pushing the hybrid market is a vital component, but cannot be seen as a replacement for a more widespread improvement in conventional vehicle efficiency. Consumers and lawmakers should never confuse an expanding hybrid selection with a "problem solved" mentality. The same holds true with biofuels. This is why strong, performance-based standards, such as an improvement in Corporate Average Fuel Economy (CAFE) standards and the expansion of the California standards on vehicular global warming emissions, are needed. Right now, the Markey-Platts fuel economy bill in the House would deliver needed increases in CAFE standards.

At the same time, automaker lawsuits are attempting to undermine California's global warming standards for cars and trucks (now adopted by 11 states), though their case took a blow with the Supreme Court decision mandating that the EPA regulate global warming pollution from autos. Both these standards would make sure that hybrids contribute to an overall improvement in the vehicles we drive, instead of a PR tool used to obscure the fact that automakers are making no real progress in reducing oil dependence and curbing automotive pollution.

The government and the automakers can create real solutions to global warming and oil dependence. But right now, drivers can help, too. Many hybrid owners have noticed that those EPA fuel economy estimates are just that—estimates. Driving style, terrain, and weather all have impacts on your fuel economy. Hybrid drivers in UCS's HybridCenter.org Driving Change Network and in other hybrid driving networks spend a lot of time talking about how to maximize the fuel economy of their vehicles. I think hybrid technology has brought that discussion back to the table for all drivers. That, in itself, is a positive thing. What drivers should know is that for most people, the biggest contributions they make to global warming and oil consumption are from the cars they drive. People should buy the most efficient vehicle that meets their everyday needs. And no matter what car they drive, drivers should try to combine trips to cut down on the miles they need to drive. And they should accelerate evenly instead of flooding the engine with gas as they take off from red lights and stop signs.

There is no doubt that hybrid technology will become more pervasive. Toyota and DaimlerChrysler have both said that they eventually want hybrid options for all their vehicles. When the technology is used on a larger scale, the cost will decrease, making hybrids affordable to all consumers. Hyundai/Kia will be entering the hybrid market within the next few years, bringing more price-point competition with a vehicle that they estimate will get over 50 mpg.

There is still much to be done with hybrid technologies to maximize their fuel economy and performance, and many questions remain to be answered. Lithium ion battery development, giving the electric motor more power and storage capacity at less weight, is promising, but uncertain, when taking into account cost and resource availability for mass production. The introduction of ultracapacitors as a potential complement to batteries, or hydraulic hybrid systems that could even replace batteries, may push that technological envelope even further over the course of the next decade. The growing interest in plug-in hybrid technology to enable longer and higher speed driving only on battery power will depend on battery advances, but they're expected to be on the market by the middle of the next decade.

At the end of the day, the success of hybrid technology in total will be in how much the technology is used to improve fuel economy and maintain the power of the vehicle, rather than just make a car go faster on the same gallon of gas. Hybrids are just one of the first steps in the larger sea change taking place in vehicle efficiency and in finding solutions to global warming and dependence on oil. □

About the Author
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