

DRIVING CHANGE

ADVANCED TECHNOLOGIES AND FUELS ARE DEFINING THE AUTOMOBILE'S FUTURE... ALL TRANSPARENT TO THE DRIVER



The road to the future has always been one of twists and turns, with vehicles and technologies evolving to fit the needs of the day. These days are no different, though the challenges we face and the solutions required seem more complex.

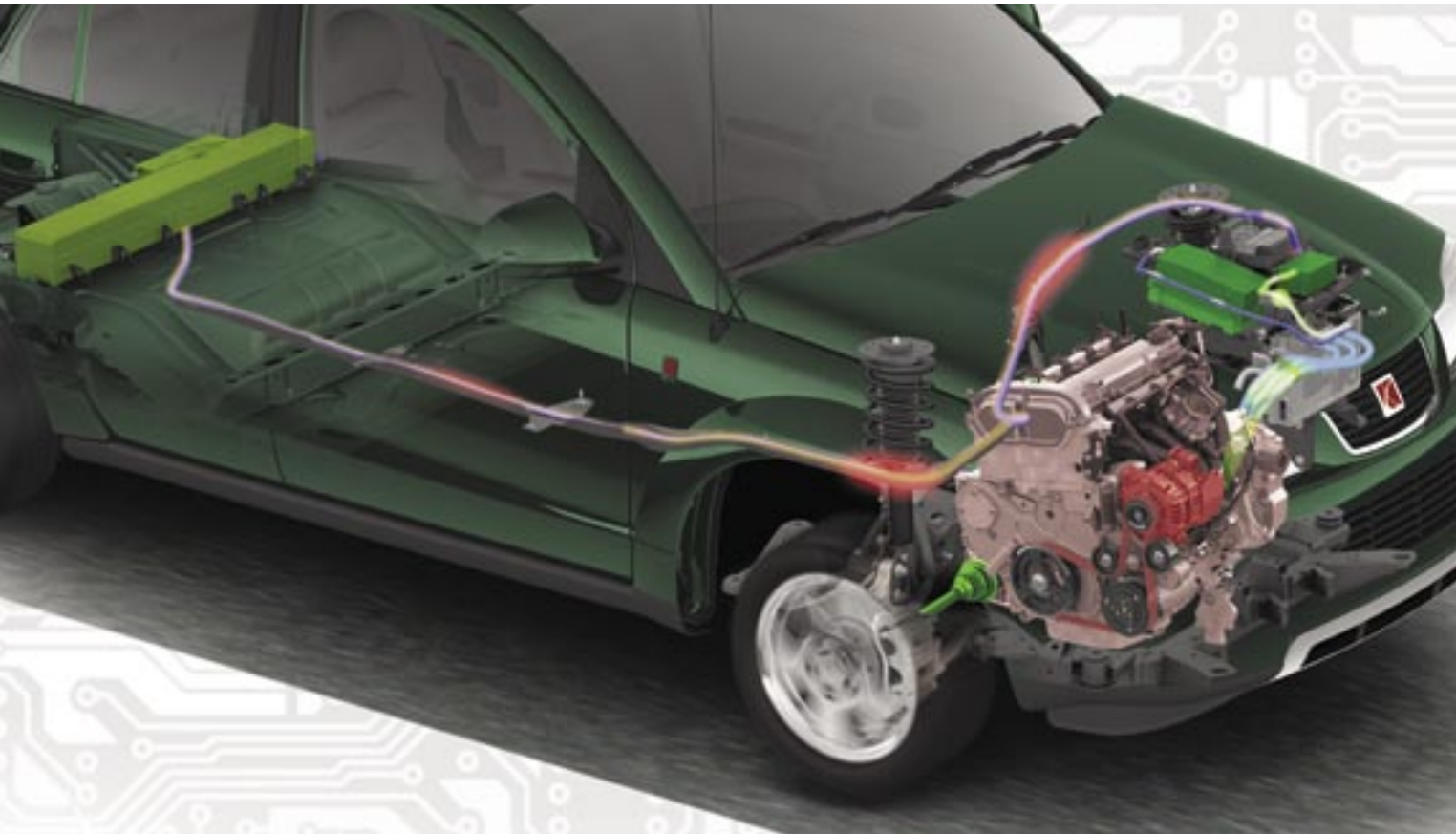
This is driving new and innovative solutions that are bringing increasingly diverse cars, trucks, and SUVs to American highways.

TODAY, THESE ADVANCES ARE EVIDENT IN MANY WAYS. Perhaps most obvious is the application of technologies that address multiple goals, such as performance that also comes with lower emissions, or an accommodating sedan that offers increased fuel economy. No longer must these competing attributes exist in isolation, an especially important consideration with today's high fuel costs and an increasing interest in energy efficiency.

GM already offers more cars and trucks with EPA estimates of 30 miles-per-gallon or more on the highway than any other manufacturer. "We offered 14 vehicles that achieve 30 mpg on the highway in 2006 and that number has risen to 23 for 2007," says Elizabeth A. Lowery, GM vice president, Environment and Energy. Indeed, GM's comprehensive portfolio of fuels and technologies aims to address the needs of a changing world by improving the efficiencies of today's engines, while also bringing more advanced powerplants to the highway. Let's take a closer look.



ADVANCING HYBRID TECHNOLOGY



acceleration feel is part of the package with the hybrid version's 170 horsepower powertrain, a rating 27 horsepower greater than the standard Vue. Bottom line: Saturn Vue Green Line drivers not only enjoy improved fuel efficiency, but better overall performance as well.

This performance advantage is making its way to midsize sedans next year, with the same hybrid system used in the Vue Green Line to be offered next year in the Chevrolet Malibu and Saturn Aura Green Line. A new generation of "strong" hybrid models powered by a two-mode hybrid system, being jointly developed with BMW Group and DaimlerChrysler, will debut in the Chevrolet Tahoe and GMC Yukon full-size SUVs next year, followed by the Cadillac Escalade two-mode Hybrid in 2008.

THREE HYBRID APPROACHES

Many drivers are drawn to performance. Others favor comfort, luxury, or affordability. Increasing interest is being shown in fuel efficiency and low emissions. Hybrid vehicles must ultimately appeal to all of these prefer-

HYBRID TECHNOLOGIES CAN BE APPLIED ACROSS A WIDE RANGE OF VEHICLES, FROM SMALL SEDANS AND FULL-SIZE SUVs TO TRANSIT BUSES MOVING LARGE NUMBERS OF PEOPLE.

offering onboard 120-volt AC power, ideal for contractors and others who benefit from ready access to mobile power in the field.

NEW SATURN VUE GREEN LINE HYBRID

The next step in GM's hybrid evolution is bringing the lowest-price hybrid SUV to new car showrooms. The 2007 Saturn Vue Green Line Hybrid starts at under \$23,000 and offers 27 mpg in city driving and 32 mpg on the highway based on EPA estimates – the best highway fuel economy rating of any SUV.

A fuel efficiency increase of about 20 percent compared to its gasoline counterpart is achieved through a simple and flexible hybrid design that integrates an electric motor/generator with Saturn's 2.4-liter VVT four-cylinder engine and 4T45-E 4-speed transmission. Like GM's hybrid pickup models, this hybrid SUV provides engine shut-off at idle and fuel cut-off during deceleration to save fuel, while also incorporating regenerative braking to recapture energy while decelerating to recharge on-board batteries.

The Vue Green Line's hybrid system is different from the system in the full size pickups since its motor/generator provides additional propulsion power during launch and at wide-open throttle. Noticeably improved

ences, and more. GM is responding with a multi-faceted hybrid strategy that, over time, will see the launch of a dozen hybrid models using varying hybrid technologies.

The reason is simple: Buyers have differing perspectives regarding the features and benefits that hybrid systems should offer and how much they should cost. The Chevrolet, Cadillac, GMC, and Saturn hybrids now on the market and soon to come will offer plenty of choices to fill these diverse expectations.



IN RECENT YEARS, GM HAS FOCUSED on developing hybrid technology as an important evolutionary step toward better efficiency and environmental performance. Since this advanced propulsion technology is scalable from the largest vehicles to the smallest, initial efforts have focused on applications with potential for the greatest impact.

This logic has found GM applying its innovative two-mode hybrid technology to one of the highest fuel consuming vehicles on the road: mass transit buses. Since 2003, these efforts have brought more than 550 highly-efficient buses powered by General Motors' diesel-electric hybrid technology to 42 communities in the U.S. and Canada, with another 78 scheduled to be delivered by the end of 2006.

While most tend to think of hybrids in terms of light-duty vehicles, all it takes is a look at the numbers to see why buses are such a logical early application for this technology. Buses powered by GM's diesel-electric hybrid powerplants achieve an estimated combined fuel savings of about

700,000 gallons annually. With just 1,000 GM hybrid powered buses in service, fuel savings would be approximately 1.5 million gallons every year.

MORE EFFICIENT PICKUPS

A cost-effective way to introduce the benefits of hybrid power in light-duty vehicles is through the use of gasoline-electric hybrid systems offering moderate but important fuel efficiency increases, at affordable cost. Such hybrid systems were introduced to consumers in 2WD Chevrolet Silverado and 2WD GMC Sierra 1500 full-size pickups (EPA estimated 18 city, 21 highway mpg) in 2006, and earlier to fleets, with an incremental cost of just \$1,500.

Increased efficiency is made possible with a 14 kW electric induction motor used in place of a separate starter motor and alternator. Located between a pickup's Vortec 5.3-liter V-8 engine and 4-speed Hydra-Matic 4L60 transmission, this compact starter-generator brings fuel economy gains

A FLEXIBLE APPROACH

WHAT IF THERE WAS AN OPTION for operating vehicles we drive every day on a fuel that's easier on the environment, good for national and local economies, and reduces dependence on petroleum? This isn't wishful thinking. That fuel is here today in the form of E85 ethanol, an alternative to gasoline that helps address immediate energy needs and can contribute toward long-term energy diversity for generations to come.

Over two million GM E85 compatible vehicles are on the road already that can run on E85 ethanol, a blend of 85 percent ethanol and 15 percent gasoline. Moving forward, GM will produce more than 400,000 FlexFuel cars and light trucks on an annual basis. For the 2007 model year, GM is offering FlexFuel capability on 16 different models across the Buick, Chevrolet, GMC, and Pontiac brands, providing a greener option for a diverse range of driving needs.

GROWING FUEL CHOICES

Ethanol isn't pumped from the ground and doesn't have to be imported from distant sources. Rather this alternative fuel is produced by fermenting plant sugars from a variety of mostly domestically grown crops here in the U.S. Corn is a preferred grain today due to its abundance, but other grains, plant materials, and even biomass sources such as woody grasses and agricultural waste can be used to produce ethanol. While ethanol does hold less energy per gallon than gasoline – and drivers may experience

MORE THAN TWO MILLION GM VEHICLES ON THE ROAD CAN RUN ON E85 ETHANOL FUEL.

a 25 percent shorter driving range than with gasoline, depending on a particular vehicle and driving conditions or driving habits – this alternative fuel's flexibility and diversity of energy sources make it very appealing as one of many long-term transportation solutions.

Importantly, ethanol is a renewable and sustainable motor fuel since it's produced from agricultural resources that can be managed and replanted season after season. In addition, this mostly home-grown fuel reduces dependence on foreign oil and also decreases the energy needed for transporting the fuel to market.



GM is partnering with state and local governments, ethanol support groups, fuel makers, and retailers to advance E85 production, awareness, and availability. Public education is central to this effort and the driving force in GM's "Live Green, Go Yellow" campaign, which offers a high profile for this fuel and the GM vehicles that run on it, using such simple reminders as yellow E85 ethanol fuel caps on FlexFuel models.

USES E85 ETHANOL OR GASOLINE

The flexibility that comes with driving a GM FlexFuel vehicle is an essential element in these vehicles' success. Drivers can run on 100 percent E85 ethanol, straight gasoline, or any combination of the two fuels in the same tank. On-board systems recognize the percentage of ethanol in a vehicle's fuel line and adjust engine calibration accordingly, making the process transparent to the driver and passengers. This flexibility allows using E85 ethanol fuel when convenient and available or gasoline when it's not, an important consideration since E85 ethanol stations are not as plentiful as those dispensing gasoline.

There are currently over 1,000 E85 filling stations in the U.S. and that number is growing at a steady pace. GM is working with ethanol producers, retailers, and organizations to help make E85 ethanol fueling more accessible in many states across the country. Since mid-2005, GM has announced partnerships in 11 states to locate up to 171 new E85 ethanol fueling locations by the end of 2006, and up to 181 after the beginning of 2007. To find out where E85 filling stations are currently available, visit www.livegreengoyellow.com. GM has also pledged support for a "25 x 25" initiative to get 25 percent of the nation's transportation energy needs met by primarily domestically-produced renewable fuels like ethanol by 2025.

LOWER GHG EMISSIONS

E85 ethanol offers less smog-forming emissions. It also reduces greenhouse gas emissions compared to gasoline. While CO2 is released in the production and burning of ethanol, some of this is offset by the carbon dioxide that's recycled into the environment as a nutrient for crops grown to produce this fuel.

One of many paths leading toward a future of cleaner transportation that does not rely on petroleum products, E85 ethanol has a lot to offer. GM already has more E85 capable FlexFuel vehicles on the road than any other manufacturer and this trend will continue. Taking a leadership position with vehicles that operate on this domestic fuel, and working with strategic partners to improve E85 ethanol availability, are key elements in GM's plan for a safer and cleaner tomorrow.



THE ROAD TO HYDROGEN



FUEL CELLS ARE INHERENTLY EFFICIENT. WHEN RUNNING ON HYDROGEN, THEY EMIT WATER VAPOR AND PRODUCE NO CO₂ GREENHOUSE GASES... AN AMAZING ACHIEVEMENT.

GM'S VISION IS TO REINVENT THE AUTOMOBILE in ways that make it highly efficient, sustainable, and in sync with the needs of a changing world. This means a sharp departure from the use of fossil fuels that drive most vehicles on the road today. It also requires developing vehicles that more efficiently transform fuel into motive power, and do so in ways that greatly reduce CO₂ greenhouse gas emissions. To do this requires more than adapting the internal combustion technology that's driven the automotive field for more than a century. New thinking is required.

INVENTING THE FUTURE

This thinking has led GM to develop one of the most technologically advanced vehicles on the planet – the Chevrolet Sequel. It's the result of

years of research and development in a focused effort to leapfrog today's vehicles using the most advanced technologies in GM's portfolio, and those being developed in GM labs around the world. The Sequel builds on the advanced hydrogen fuel cell technologies showcased in previous GM concept vehicles, along with the many HydroGen3 fuel cell vehicles that have been undergoing real-world use on public highways in the U.S., Europe, and Asia in recent years.

The Sequel carries forward the revolutionary approach in automotive design first shown in GM's innovative "skateboard" chassis that debuted five years ago. This self-contained, low-profile chassis efficiently integrates a fuel cell, drive motors, controllers, hydrogen fuel storage, and all primary drive system components into a self-contained unit. It makes extensive

use of advanced control systems like steer-by-wire and brake-by-wire technology to improve the vehicle's overall responsiveness and versatility.

Compared to other fuel cell vehicles, Sequel has an unprecedented estimated range of up to 300 miles on a tank of fuel. The latest generation Sequel incorporates the many important advances that GM has made in fuel cell development since the introduction of the Sequel show car in 2005. Along with the kind of driving range expected of many production vehicles, the Sequel showcases packaging efficiencies that come with a 25 percent reduction in fuel cell stack size from the previous generation. This latest Sequel also brings with it fuel cell vehicle improvements crucial to commercialization like the ability to operate in sub-freezing weather, reduced fuel cell cost, and greater durability.

Coming next is the roll-out of the world's largest fuel cell fleet, which will involve more than 100 Chevrolet Equinox Fuel Cell vehicles driven

daily in a market test program by consumers and fleets in California, the New York metro area, and in Washington, D.C. beginning in the fall of 2007. This extensive market test, which will find Equinox Fuel Cell drivers experiencing the unique characteristics of fuel cell vehicles including near-silent operation and fueling with hydrogen gas, will provide GM with important operator feedback that will aid in refining the fuel cell vehicles coming to market in the short years ahead. These fully-functional crossover SUVs will use GM's fourth-generation fuel cell propulsion system – GM's most advanced propulsion system to-date – and be equipped with sought-after features like OnStar and StabiliTrak stability enhancement technology. The Equinox Fuel Cell is being designed to meet all applicable 2007 U.S. Federal Motor Vehicle Safety Standards.

HYDROGEN'S MANY BENEFITS

It's no mystery why hydrogen is such an imperative at GM. Hydrogen fuel cell vehicles emit only water vapor as a tailpipe emission, and because power is created through an electrochemical process and not combustion, no CO₂ greenhouse gases are produced. Hydrogen is all around us and can be separated, or produced, from other resources through processes like steam reforming natural gas or electrolyzing water. This will lead to new and innovative ways of creating and distributing this zero-emission fuel while also promoting energy diversity and energy security. Plus, hydrogen fuel cells are about twice as efficient as internal combustion in creating power from fuel. That means making more out of our resources while also severely curtailing emissions. Taken together, these are significant advantages that paint a bright future for hydrogen and the vehicles that run on this renewable fuel.



THE TECHNOLOGY EDGE



brought by technologies like these are important because they apply to a wide range of vehicles, often in very large numbers.

GROWING HYBRID MOMENTUM

Even as conventional engines and transmissions continue to improve, GM's roll-out of hybrid technology is picking up momentum. What's next is an important new step in the evolution of the gasoline-electric hybrid: applying this efficient propulsion technology to a wide variety of high volume, larger vehicles. The challenge in bringing substantial fuel economy improvement to larger vehicles is significant, yet that's just what GM's coming two-mode hybrid system is setting out to accomplish.

The two-mode hybrid system uses a pair of compact and powerful electric motors with four fixed gears within the space normally occupied by

THERE IS NO SINGLE ANSWER. CONTINUAL IMPROVEMENT OF TODAY'S DRIVETRAINS IS IMPORTANT, WHILE INNOVATION AND A FOCUS ON A MORE EFFICIENT FUTURE IS KEY.

THE QUEST FOR EFFICIENCIES drives research and development in many areas at GM, with diverse technology solutions and fuels emerging that could play major roles in the marketplace. While the need to improve fuel efficiency and reduce emissions is clear, it's equally clear this cannot be done in isolation. New car buyers demand more than fuel economy and low emissions. They also want vehicles offering a satisfying driving experience as well as high levels of safety, quality, and value.

MORE EFFICIENT DRIVETRAINS

Internal combustion gasoline powered engines and transmissions are continuing to be further refined to improve fuel economy and performance, and reduce exhaust emissions. Powertrain technologies available today include cylinder deactivation, cam phasing, port deactivation, direct injection, diesel particulate filters, and 6-speed automatic transmissions. Today, GM has 15 models with Active Fuel Management – or cylinder deactivation – technology that allows engines to operate on only half their cylinders under certain low-load conditions. Efficiency improvements

an automatic transmission. That packaging efficiency means widespread applicability among many models. It's also an evolutionary leap forward because it's designed to improve both highway and city fuel economy, reflecting the way that people drive every day.

GM's Silverado and Sierra Hybrids introduced in 2004 signaled an unfolding strategy driven by the needs of the market. The Saturn Vue Green Line Hybrid has emerged in 2006 with an affordable hybrid system that will also be offered in other models. The two-mode hybrid will be introduced first with the Vortec V-8 powered 2008 Chevrolet Tahoe and 2008 GMC Yukon in 2007, with both expected to offer an estimated 25% improvement in overall fuel economy. Others will follow as GM continues to drive the future with an expanding hybrid lineup and an array of advanced technologies that bring greater efficiency and energy diversity to the highway.



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