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HYBRID VEHICLES

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GM TO OFFER 12 HYBRID MODELS

The most significant announcement involving advanced vehicle propulsion systems by any automaker at the 2003 North American International Auto Show (NAIAS), the world's largest annual automobile exhibition, was made by the world's largest automaker, General Motors Corporation (GM). The company revealed a program to offer various hybrid electric drivetrain systems as options on up to 12 vehicle models by 2007.

The NAIAS announcement by GM that it will produce a full line of hybrid electric light duty vehicles represents a major shift in corporate policy. Until now, GM has favored early applications of hybrid technology in medium and heavy duty vehicles. This approach was reflected in its ParadiGM program, unveiled at the 2000 NAIAS (see *Hybrid Vehicles*, February 2001).

If fully implemented, the new GM program could result in sales of one million hybrid electric vehicles (HEVs) by GM before the end of the decade. This is more than three times the 300,000 HEVs that Toyota Motor Corporation has established as its corporate goal for 2005. Toyota is currently the world's leading manufacturer of HEVs.

The GM announcement identified five models that will include hybrid drive options. The company said it would reveal seven other HEV models at a later date. Although prices have not been set, the company said adding the hybrid technology option would cost consumers between $1,000 and $5,000 more than the same model with a conventional drive.

Four "Mild" HEV Models

GM will offer optional hybrid powertrains on several of its most popular trucks, sport utility vehicles (SUVs) and midsize sedans starting in late 2003. The first two hybrid models will be the GMC Sierra and Chevy Silverado pickup trucks. Sales of the hybrid pickups will begin for fleet vehicle customers in late 2003 and for retail consumers in 2004.

The drive system to be installed on the pickups is a "mild" hybrid configuration, only capable of improving fuel economy 12 percent. Each Chevy Silverado and GMC Sierra will be equipped with a 5.3 liter Vortec V-8 engine, the same as the conventional versions of the truck. Instead of a conventional starter motor and alternator, however, the HEV versions include a 14 kilowatt electric motor that is integrated between the engine and transmission.

The electric motor provides power during vehicle startup and acceleration. The electricity can be generated using power from the engine or it can be obtained from the onboard 42 Volt battery storage system. The batteries are continuously recharged from the regenerative braking system when the engine is operated and.

At a stoplight, the gasoline engine stops running, but the acces-

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FORD'S MODEL U FIRST HYDROGEN HYBRID

Ford Motor Company unveiled the world's first supercharged hydrogen internal combustion engine (ICE) powered hybrid electric automobile at the January North American International Auto Show in Detroit. The concept small sport utility vehicle (SUV) is called the Model U. It is heralded by Ford as a major innovation of the 21st century, in the same way that its Model T was the company's major automotive innovation early in the 20th century.

Like Ford's other hybrid electric vehicle (HEV) developed to date, the Hybrid Escape SUV now scheduled to enter the consumer market in 2004, the Model U is a parallel, "full" hybrid equipped with a 300 Volt hybrid traction powertrain. Unlike the Escape, which has a gasoline powered ICE, the Model U is fueled by pure compressed hydrogen. Ford believes the use of hydrogen in an HEV is an important stepping stone to fuel cell vehicles (FCVs), which can also be powered by hydrogen. Moreover, should the Model U ultimately be commercialized, their widespread use could help build a hydrogen fueling infrastructure for future FCVs.

Hybrid Powertrain

The Model U is powered by a supercharged and intercooled ICE that is optimized to run on hydrogen. Emissions are nearly zero, and the engine is up to 25 percent more fuel efficient than a comparable gasoline engine. The hydrogen ICE is based on Ford's 2.3 liter, I-4 engine used in the Ford Ranger, the European Ford Mondeo and a number of Mazda vehicles. The engine has been optimized to burn hydrogen with 12.2:1 high compression pistons, fuel injectors designed to handle

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hydrogen gas, a coil-on-plug ignition system, an electronic throttle and new engine management software. Select specifications of the Model U appear in the table below.

Ford researchers believe that the hydrogen ICE with supercharging can deliver the same power as its gasoline counterpart and still provide near zero emissions and high fuel economy. The centrifugal type supercharger in the Model U provides nearly 15 pounds per square inch (psi) of boost on demand. The Model U also uses a novel dual stage intercooling process. After leaving the supercharger, the intake air passes through a conventional air-to-air intercooler, then through an air conditioning-to-air intercooler for a further reduction in temperature. Power losses up to 50 percent that have plagued the performance of many other hydrogen powered automobile engines are eliminated in the Model U.

The hydrogen ICE is coupled to an advanced hybrid electric transmission technology called the Ford Modular Hybrid Transmission System (MHTS). The torque converter from a conventional transmission is replaced with a high-voltage electric motor and two hydraulic clutches that permit the motor to operate independently of, or in concert with, the engine. The electric motor simultaneously fills the role of flywheel, starter, alternator and hybrid traction motor.

Coupling the MHTS to the hydrogen engine produces a major boost in fuel economy. According to Ford, the Model U has a fuel economy of 45 miles per equivalent gallon of gasoline and a range of about 300 miles.

The Model U can carry up to 7 kilograms of compressed hydrogen gas onboard. Its four compressed gas fuel tanks, made of a 3 millimeter aluminum pressure barrier with a carbon fiber structural casing, are rated to an operating pressure of more than 10,000 psi. The fuel tanks are located under the floor board beneath the passenger seats in the middle of the vehicle.

The Model U can operate on either the hydrogen ICE engine or electric motor, or both for extra power. A regenerative braking function reclaims energy that would otherwise be lost as heat, storing it in the 300 Volt, air cooled battery pack for the next acceleration, passing maneuver or hill climb.

When the driver comes to rest at a traffic light, the engine is automatically switched off to save fuel. When the accelerator is applied, the electric motor instantly starts the engine, the clutch to the transmission engages and the vehicle begins to pull away, all within 300 milliseconds.

Small amounts of nitrogen oxides are produced by the combustion process and even smaller quantities of hydrocarbons result from the burning of lubricating oil. Even so, Ford believes the Model U will easily comply with California's partial zero emission vehicle (PZEV) standards, while also demonstrating a 99 percent reduction in carbon dioxide compared to a gasoline engine.

Green Construction

The Model U features advanced materials designed to minimize the environmental effects of automotive manufacturing and disposal after consumer use. Eco-effective polyester is used inside the Model U on its seats, dash, steering wheel, headrests, door trim and armrests. This fabric can be recycled into base elements and reprocessed into material fiber without losing any performance qualities, and it is made from renewable resources.

The Model U also uses a potential "biological nutrient" called polylactide, or PLA, in the Model U's canvas roof and carpet mats. Renewable, plant based components are used to replace petroleum based materials. The tires, for example, use corn based fillers in place of carbon black. There are also several soy based components in the Model U, including polyurethane seating foam. Environmental concerns in manufacturing are addressed with a new UV-cure clearcoat system developed by Akzo Nobel.

Access: Ford, web www.media.ford.com

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THE FORD MODEL U HYDROGEN HYBRID

Parameter	*Specification*
Dimensions	4,230 x 1,810 x 1,651 Millimeters
Wheelbase	2,685 Millimeters
Front Track	1,583 Millimeters
Rear Track	1,583 Millimeters
Front Overhang	780 Millimeters
Rear Overhang	764 Millimeters
Fuel Type	Hydrogen
Fuel Capacity	7.0 Kilograms
Engine	2.3 Liter Supercharged and Intercooled ICE
Engine Power	88 Kilowatts at 4,500 rpm
Hybrid Drivetrain	Modular Hydrogen Transmission System
MHTS Power (peak)	35 Kilowatts
MHTS Power (continuous)	25 Kilowatts
Torque	154 Foot Pounds at 4,000 rpm
Fuel Economy	45 Miles per Equivalent Gallon
Emissions	PZEV or Better

IEA SAYS OIL TO LEAD WORLD ENERGY THROUGH 2030

The 2002 edition of the *World Energy Outlook (WEO)* has been released by the International Energy Agency (IEA), based in Paris, France. This biennial compendium of energy statistics and forecasts includes long range energy supply and demand forecasts.

A 2002 *WEO* report concludes that the key result in the shifting terrain of major energy producing and consuming countries will be a rapid expansion in international energy trade and a major increase in imports, particularly oil, by nations, including the U.S. and China, that are already heavily dependent on imports.

The 2002 *WEO* predicts that world energy use will increase an average of 1.7 percent annually through 2030, although transportation demand, almost entirely fueled by oil, will grow by 2.1 percent annually, the most rapid rise of any energy sector. The transport sector is projected to overtake industry as the world's largest energy consuming sector sometime in the 2020s. The fastest growth in oil use will occur in the rapidly expanding Asian economies, particularly in China and India. In absolute terms, the largest growth in oil demand will occur in China and in North America.

Projected world oil production is projected to increase from about 75 million barrels per day now to 120 million barrels per day in 2030. The 2002 *WEO* predicts that oil production will remain highly concentrated in a small number of energy producers, although the role of some smaller producers will grow. Members of the Organization of Petroleum Exporting Countries (OPEC), particularly those members in the Middle East, will markedly increase their share as output from such mature oil producing regions as the U.S. and the North Sea declines. The Middle East holds well over half the world's proven reserves of crude oil and natural gas liquids and 40 percent of the projected undiscovered resources. OPEC nations are expected to produce well over half the world's oil in 2030.

Access: IEA, web www.oecd.org