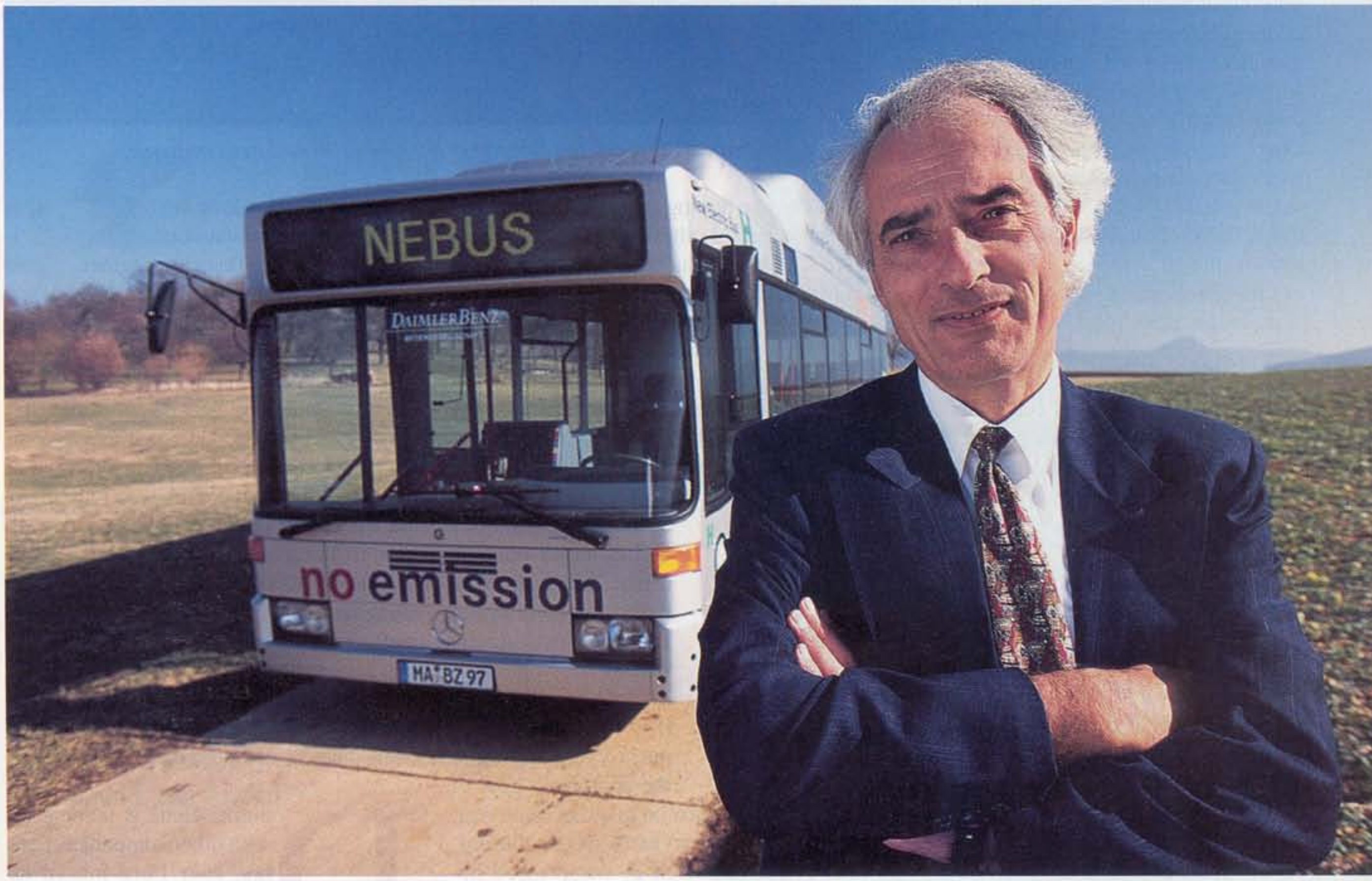
THE AUTOMAKERS' BIG-TIME BET ON FUEL CELLS

They're putting more than $1 billion into a revolutionary power system. Daimler-Benz wants to be out first, and GM is "totally serious."



Dr. Ferdinand Panik, who runs Daimler-Benz's fuel-cell program, foresees cleaner, fuel-saving buses and cars.

Bright-eyed, his silver hair a little wild at the fringes, Dr. Ferdinand Panik, 56, clearly relishes piloting a very special Mercedes vehicle briskly past the apple orchards on the outskirts of Nabern, Germany. The 40-foot ultramodern Nebus (for "new electric bus") is virtually silent under way. In the engine bay normally occupied by a growling diesel are several "stacks" of fuel cells that, without combustion, make electricity to drive the motors that turn the wheels. From a hilltop nearby, a castle looks down on new labs and workshops that automaker Daimler-Benz is equipping for a top-priority fuel-cell development program that could make the noisy, polluting piston engines that power the world's cars, trucks, and buses as obsolete as the steam locomotive.

The work at Nabern is the most visible evidence of an accelerating wave of R&D by automakers and component suppliers around the world that have committed

BY STUART F. BROWN

PHOTOGRAPH BY THOMAS KLINK—ZEITENSPIEGEL more than $1 billion to fuel-cell power systems. The concept has always had an arresting simplicity. Remember the high-school chemistry experiment in which, through the addition of a bunch of electricity, water is electrolyzed into its constituent hydrogen and oxygen gases? A fuel cell is a device that accomplishes precisely the reverse. Without burning anything, it combines hydrogen and oxygen electrochemically to form water, giving off heat and electricity. The juice can power whatever you want to plug into it.

Fuel cells have long supplied electricity on spacecraft, but they are priced like crown jewels, hopelessly beyond the pocketbooks of the motoring public. In the last decade, however, development work has shrunk the bulkiness and price of a version suitable for ground vehicles by roughly a factor of ten. The cost is still more than ten times too high. But encouraged by the progress to date, industry is hoping that all the big-ticket R&D support will bring down the cost much further, along with that of related drive-train hardware such as fuel-processing devices, electronic controls, and motors.

Those who love the macho roar of piston engines needn't fear for their imminent demise, for the fuel cell's success is definitely not guaranteed. Nevertheless, executives at Daimler-Benz and other automakers are confident they can pull off the remaining development work and apply the needed mass-production wizardry. Panik, a senior VP who has been running Daimler-Benz's fuel-cell effort full-time for the past year, says he has few doubts on that score. He foresees power sources with far fewer moving parts than today's internal combustion engine, with its crankshaft, camshafts, pistons, connecting rods, and valves. Says Panik: "In the end I believe the fuel cell can be done for the same price as the piston engine, or lower. And I believe it can let the owner travel 50% farther for the fuel used, with an engine that will be truly maintenance-free."

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It will also pollute less, auto folks point out. They're hoping that fuel-cell cars will be an acceptable alternative in jurisdictions like California that have mandated that substantial numbers of "zero-emissions vehicles" be available early in the next century. And carmakers are confident that fuel-cell cars will undersell and outperform other environment-friendly vehicles—the battery cars and battery-piston hybrids that automakers are starting to produce.

The latest Mercedes fuel-cell test car makes hydrogen onboard from methanol.

Daimler is so stoked about the efficiency and clean-air benefits of the fuel-cell drive train that it plans to have production versions of the Nebus rolling off an assembly line in 2004. Even more eye-popping is the company's goal of having fuel-cell *cars* on sale that same year. That will require an extra set of solutions. The Nebus is fueled by compressed hydrogen carried in roof-mounted tanks. That's okay for bus fleets that return to a central garage for refueling. But the family flivver will need to run on a liquid fuel such as gasoline or methanol, available at ubiquitous filling stations. To do this the car will need a micro-chemical plant onboard capable of extracting hydrogen from the fuel as the car rolls along. We're working on that too, say Panik and his colleagues as they escort a visitor to a demonstration model of a fuel-cell car, the methanol-powered Necar 3, which has already logged time on the road.

The Necar 3, along with the Nebus, is one of four demonstration fuel-cell vehicles that Daimler-Benz has engineered and put on the road in just three busy years. The largest such collection any motor company is known to have, it underscores the seriousness of Daimler-Benz—one of whose founders in 1885 invented the first automobile, powered by a piston engine of his own design—as it proclaims its goal of being the first auto company to mass-market the piston engine's successor. A walk around the labs and offices of the company's Fuel Cell Project Center, where 135 researchers are converging from previously scattered locations, gives further evidence that Daimler means business. So do statements from its executives badmouthing battery-powered and hybrid cars. Snaps one: "They're not close to competing."

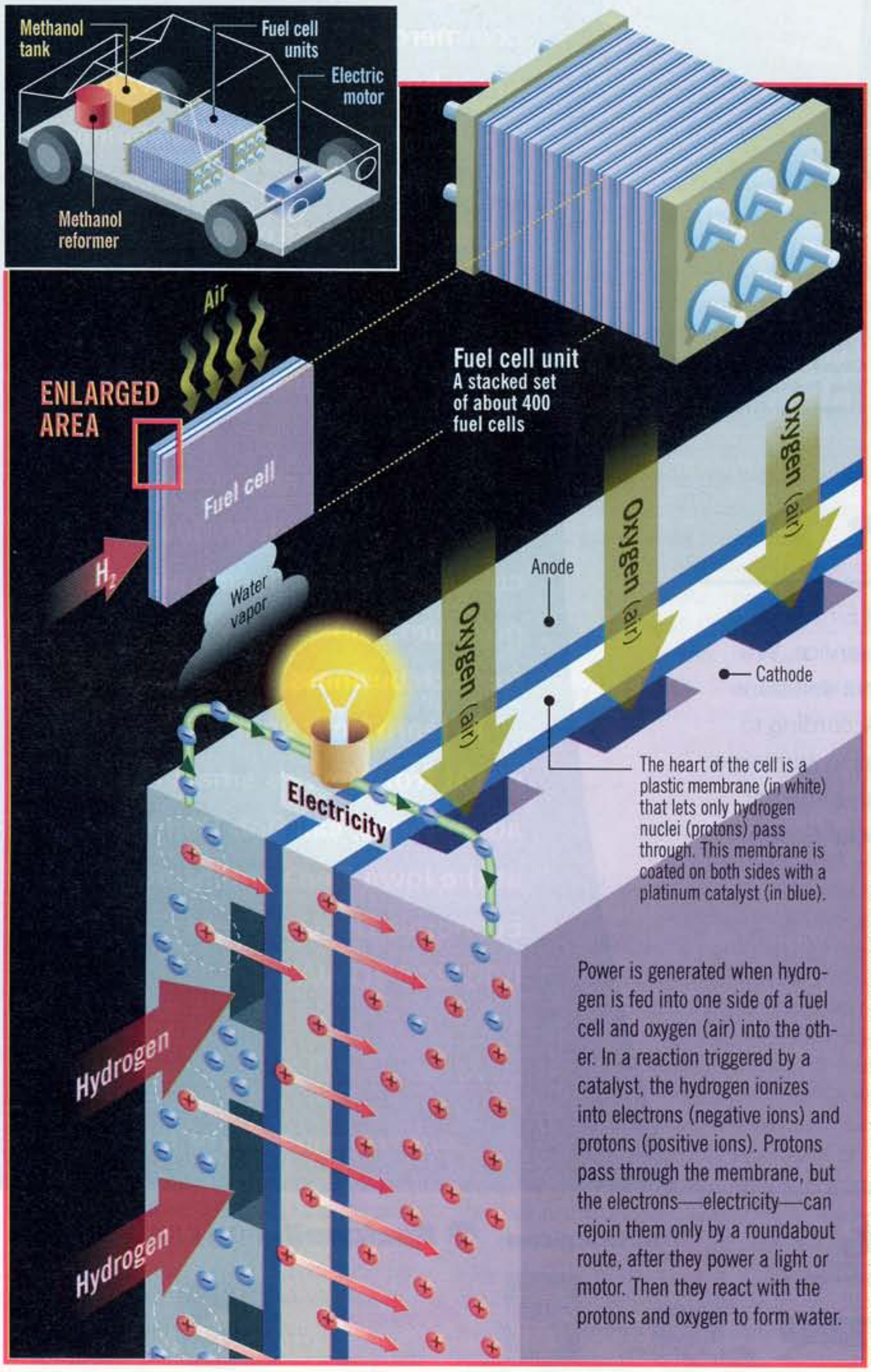
Daimler-Benz is teamed up with other companies. Late last year Ford joined its partnership with Ballard Power Systems of Vancouver, B.C., which has done some of the most impressive work in improving fuel cells. The three-company alliance will jointly develop and build fuel-cell "engines" and electric power trains, which the automakers will use in their own vehicles and sell to other car companies. Ford's commitment of $430 million to the alliance comes on top of the $320 million Daimler has already allocated to its longer-running partnership with Ballard. "We want to be leaders in bringing these fuel-cell vehicles out," says Gary Heffernan, Ford's corporate technology manager.

Hoping not to be left behind, other carmakers and technology companies have large-scale development programs under way:

- General Motors has a fuel-cell program "at least as big as" its research into hybrid and battery-electric cars, says Byron McCormick, executive director for global alternative propulsion. He won't cite a number but says that the program represents "significant dollars." He adds, "We are totally serious. The fuel cell is so compelling because of its enhanced efficiency and low pollution that we just have to go after this aggressively."
- Toyota, which already sells a hybrid car in Japan, has a development program under way there that's estimated by outsiders to involve some 200 researchers. Last year at two major auto shows, the company exhibited a version of its RAV4 sport-utility vehicle, equipped with a demonstration fuel-cell electric power train of its own design.
- International Fuel Cells, part of United Technologies' Hamilton Standard unit, is launching a venture to commercialize fuel cells for cars. Already a builder of fuel-cell systems for the space shuttle and for stationary power generation (see box), IFC has 60 people in its automotive program and will soon add more.

Tomorrow's Car Engine?

How a Fuel Cell Works



FORTUNE DIAGRAM BY SAMUEL VELASCO / SOURCE: INTERNATIONAL FUEL CELLS

The operating principle of the fuel cell is old news, having been discovered in 1839 by British scientist Sir William Robert Grove. While electrolyzing water, Grove noticed that if the resultant gases were allowed to recombine, they created an electric current. Nobody other than tinkering chemists paid much attention to this interesting phenomenon until the early 1960s, when General Electric developed fuel cells to provide onboard electricity for NASA's Gemini spacecraft.

IFC developed much higher powered fuel cells for the Apollo program that followed. A system connected to the fuel cell—but not the device itself—was at fault in the Apollo 13 mishap in which three astronauts narrowly escaped death in the icy vacuum between earth and the moon. A wrongly installed sensor created a spark that caused an oxygen-tank explosion and crippled the spacecraft.

Today NASA's space shuttles each rely on a trio of 15-kilowatt IFC fuel cells to generate onboard power and provide drinking water for the crew. Fuel cells are the ideal power-generating device for a spacecraft like the shuttle, which is equipped with a supply of chemically pure hydrogen and oxygen. But they cost a forbidding $300,000 to $400,000 per kilowatt of generating capacity. They also are made with a liquid, highly efficient alkaline electrolyte, or conducting material, that is unsuitable for use in cars. It can't tolerate impure gases such as those in the atmospheric cocktail that auto engines must breathe.

The car people are excited about a different fuel cell. At its simple heart is a solid electrolyte consisting of a sheet of metal-coated plastic known as a proton-exchange membrane, or PEM. This type of fuel cell was invented by GE and used in the Gemini program but had a polystyrene membrane that wasn't very efficient at permitting the flow of positive hydrogen ions, or protons, which takes place when power is generated. The space program switched over to alkaline electrolytes because they enabled the cells to pack much more punch for their size and weight. Engineers call this power density. Since then a Du Pont fluorinated polymer membrane material called Nafion, originally developed for use in manufacturing chlorine, has become available. Nafion and competing materials hugely improve the PEM cell's efficiency.

A PEM fuel cell consists of an electrolyte sheet coated on both sides with a small amount of platinum catalyst material. The membrane is sandwiched between sheets of gas-permeable graphite paper that serve as a negative electrode (anode) and a positive electrode (cathode). The membrane-electrode assembly is in turn sandwiched between "flow-field plates" that have gas-channeling grooves in their surfaces.

> ***When the environmental cleanliness of fuel cells is factored in, the excitement becomes almost unbearable for auto-industry planners.***

Current is produced when hydrogen is fed into the grooved plate on one side of the membrane and air, which contains oxygen, is fed into the other side (see diagram). The hydrogen ionizes in the presence of the catalyst to form positive hydrogen ions (protons) and negative ions (electrons). True to its name, the proton-exchange membrane permits the protons to pass through the electrolyte to the other electrode while barring the door to electrons. Think of it as an electron sieve. Now the electrode on the electron side has become negatively charged, the electrode on the proton side is positively charged, and an electrical potential exists across them.

Just route those electrons—also known as electricity—through an external circuit to a motor or light bulb where they do mankind's bidding. After the electrons perform their work and complete the circuit by flowing to the fuel cell's positive side, they combine with the protons and the oxygen to produce heat and water vapor. Each cell produces somewhat less than one volt, so piling them up into a stack is the way to get the voltage needed to power a particular device.

Conveniently, the heat given off by a fuel cell is about 180° F., just high enough to warm a car's passenger compartment. There's no need to throw away the torrent of waste heat that an internal-combustion engine produces. Today's car engines, which repeatedly create and dismantle the conditions for combusting fuel as pistons hustle furiously up and down, are inefficient because they pour out a relatively large amount of heat in relation to useful work. That's because they are subject to unyielding thermodynamic limits first described in 1824 by French scientist Sadi Carnot.

In theory a piston-engined power train could transform as much as 35% of a fuel's chemical energy into useful work where the rubber meets the road. In practice most of today's vehicles have an energy efficiency of 20% or less, with the remainder thrown away as waste heat and brake dust. Because fuel cells function electrochemically, they aren't subject to thermodynamic limits. A fuel-cell power train is theoretically 1.5 times as efficient as its piston-engine counterpart. This inherent advantage has caused many engineers to fall in love with the fuel cell. When the environmental cleanliness of fuel cells is factored into the equation, the excitement becomes almost unbearable for auto-industry planners worried about antipollution regulations and the vagaries of future fuel supplies.

Researchers at Daimler-Benz got truly religious about fuel cells as the engine of the future in 1996. That's when they calculated the energy efficiency of an experimental vehicle called Necar 2, a minivan fueled with compressed hydrogen, at 28.8%. A comparably sized current-generation Mercedes diesel vehicle scored 24% energy efficiency. When the engineers look ahead to 2003, they can see improving the diesel's efficiency by just two points, to 26%, while they project 40% to 50% for a fully developed, hydrogen-fueled fuel-cell vehicle. Wow.

Daimler's experimental vehicles use stacks supplied by Ballard, which began working with the automaker in 1991. Ballard is a rigorously focused technology-development company that is betting everything on the belief that fuel cells are ready to go big time.

Founded by Geoffrey Ballard, a geologist with a business bent who's now retired, the company originally worked on developing exotic, high-performance batteries for military applications. In the late 1980s the Canadian defense department announced that it wanted a portable electric generator that didn't make noise or throw off a lot of excess heat as a diesel does. Ballard signed a development contract and began looking into meeting the military's need with PEM fuel cells, which looked promising to scientists.

Around that time local venture capitalists sniffing around for hot new technologies got wind of Ballard's work and decided to back it. To manage the growing effort, they brought in Firoz Rasul and Mossadiq Umedaly, marketing and financial guys of Indian descent who were born in Kenya and Uganda, respectively, and later emigrated to Canada.

In 1990, Ballard decided to concentrate solely on making PEM fuel cells viable for small-scale stationary power generation, which deregulation promised to stimulate, and for efficient low-emission cars. Vehicles seemed to offer an opportunity because, in the company's view, battery-powered cars looked as if they were doomed to fail in the marketplace. Ballard expanded its labs—it now employs 330 people—and went to work building up the asset it possesses today: practical experience with the nuances of fuel-cell design and manufacture, protected by 210 patents granted or filed. In its last fiscal year Ballard, which trades on the Nasdaq, lost \$4.3 million on revenues of \$17 million.

Today at Ballard's labs, researchers busily put new generations of fuel-cell components though their paces on row after row of instrumented test benches plumbed with the necessary gases. Sensitive hydrogen sniffers on the ceiling stand ready to shut down the distribution system should they detect a leak of the flammable gas. The staff plugs away at raising the performance of cell stacks while tinkering with pilot production lines designed to drive down the cost of components. The power-density improvements they've made in just a few years are enough to make a battery chemist gasp with envy.

When Ballard first started shopping its PEM stacks around to automakers in 1989, they were capable of generating three kilowatts of power per cubic foot of volume. Within a few years power density was up to ten kW per cubic foot, and by the end of 1995 it reached 30 kW. A fourth generation now being developed will have a 50-kW power density, promises financial vice president Umedaly. These gains come from improving the flow of gases through the plates, extracting water more quickly as it forms, and massaging the chemistry of the membrane and catalyst.

Power densities of 30 kW or better are enough to interest car engineers, for they imply a set of stacks for a midsized car that would take up no more room than a large suitcase. Once the size problem is out of the way, automakers start asking about cost, which for now is "about an order of magnitude too high," as Umedaly readily admits. But it has fallen drastically, he says, from $5,000 per kW in 1990—a figure that covers the fuel cell only, not the rest of the power train—to less than $500 today.

The automotive types want to see that number down around $25 to $30. That would require production economies achievable only in a market of 250,000 vehicles a year, Umedaly says, which doesn't look likely before 2008. But significant further cost reductions are achievable, he asserts: "The plates, the membranes, and the platinum account for about 75% of the stack's total cost, and we are making giant steps in making them cheaper."

First-generation flow-field plates, for example, were made of heavy carbon material with channels milled into them by machine tools. The material cost alone was $100 per plate, and a stack can contain several hundred. Now Ballard is using a moldable material that costs only $1 per plate. Making the PEM membranes cheaper involves reducing the cost of both the plastic material and the platinum catalyst. Working with Johnson Matthey, a British supplier of catalysts used in car-exhaust systems, Ballard mastered a screen-printing method for applying the costly material in the thinnest possible layers. The amount of platinum used went from a profligate nine to ten milligrams per square centimeter to a commercially viable one milligram. Automakers now believe that a midsized car would require only $225 worth of platinum.

Ballard has also set up a pilot-scale plant for making its own membranes. Plastic membrane material from Du Pont or Dow costs about $150 per square foot, which is only enough for one cell. A much thinner gauge homemade membrane now costs about $20 per square foot. That could drop to about $5 in volume production, Umedaly claims, grabbing a marker pen and heading for the whiteboard.

CHRIS SCHRAMECK

Under VP Mossadiq Umedaly (left) and CEO Firoz Rasul, Vancouver's Ballard Power Systems has increased the kilowatts packed into its fuel cells (foreground) tenfold.

The components that go into a fuel-cell stack are flat, he explains, and lend themselves to highly automated production. Umedaly sketches rollers dispensing sheets of membrane and carbon electrode material into embossing, coating, and laminating stations that will make modules. In megavolume production, he says, robots will assemble the modules into stacks. He isn't daydreaming. The big deal with Mercedes and Ford means their production expertise will soon be brought to bear on spitting out fuel cells and the rest of the stuff needed to make the next-generation power train.

Executives of the three companies chuckle when it is suggested that they are constructing a fuel-cell *keiretsu* like one of those interwoven Japanese business alliances. Some final details remain to be settled, but it appears likely that the German–North American fuel-cell enterprise will consist of three entities. One will be Ballard Power Systems, which will make the fuel-cell stacks, with Daimler-Benz taking a 20% interest and Ford 15%. The second, DBB Fuel Cell Engines, will integrate the stacks with fuel systems and other necessary peripherals; Daimler will own 51%, Ballard 26%, and Ford 23%. Finally, E-Drive will supply complete power trains, including electric motors and the electronic black boxes that control them. Ford will hold a 60% share, Ballard 20%, and Daimler 20%.

Aside from Ford's hefty presence in the North American market, an asset it brings to the table is experience with electric-drive componentry, which it now produces in low volumes for a battery-electric version of the Ranger pickup truck. Panik says the initial goal for DBB Fuel Cell Engines is to produce 40,000 "engines" in 2004, ramping up to 100,000 in 2006, with the power plants going into Mercedes and Ford vehicles and also to outside customers. "To be successful, we can't just be captive," Panik says. "We'll need to sell engines to other companies."

A ride in the Nebus, with Panik at the wheel, gives a taste of what Daimler is preparing for future mass-transit passengers. As the holder of one of Germany's very few special licenses to drive a hydrogen-fueled bus, Panik complains with a grin that he is asked to chauffeur more test drives than he has time for. The bus needs fancy underpinnings to counter the top-heaviness caused by its array of roof-mounted hydrogen tanks. Thanks to a computerized system that prevents body roll by stiffening up the right side's suspension during a left turn, or vice versa, the boxy Nebus corners with almost sporty composure. Sniffing the "exhaust" pipe when the Nebus is running is like sampling the moist, warm air above a mug of hot water before you toss in a tea bag.

So what's it like to drive a fuel-cell vehicle? In brief, not traumatic. Necar 2, also fueled by compressed-hydrogen tanks, is a minivan with room for six passengers. The tanks, concealed by a camper-style fairing atop the roof, provide nourishment for fuel-cell stacks nestled under the cargo deck, while an electric motor supplies power to the front wheels through a two-speed automatic transmission.

A brief test spin on the roads around Nabern shows Necar 2 to be smooth and quiet, like any well-engineered electric vehicle. The only noticeable sound comes from a compressor that varies the rate of gas flow into the stacks as the accelerator pedal is pressed or released. The power train responds briskly when the pedal is floored. The back of the van boasts usable passenger seats instead of an electric car's space-hogging pallet of batteries. Driving range between hydrogen fill-ups is an acceptable 155 miles.

Wait a minute. What "hydrogen fill-up?" This is no problem for the techies at the Daimler-Benz lab, who have a great big cryogenic tank of liquefied *Wasserstoff* (hydrogen) out back. Expanded through heat exchangers into gaseous form, the H2 is then compressed into the glass-fiber-wrapped aluminum tanks that fuel Nebus, Necar 2, and its bulkier 1994 predecessor, Necar 1.

Hydrogen is not sold at any gas stations near me, you might object. Which helps explain Necar 3, Daimler's third-generation prototype that runs on methanol. To build it, the engineers removed the piston-engine power train from a Mercedes A-class car, a charming little urban four-seater sold in Europe. An electric motor resides between the front wheels of this car, which recently was back in the lab for dynamometer tests. Under the floor and where the rear seat would normally be, Daimler engineers have crammed in fuel-cell stacks, a tank for methanol, and a mess of boxy hardware making up a "reformer" for extracting hydrogen from the go-blind-if-you-drink-it alcohol. The reformer, a hand-built affair taking up far more room than a production version would, adds little to a fuel-cell vehicle's low noise level.

Necar 3 isn't the only methanol-reformer car out there. Toyota's fuel-cell SUV, as well as a GM demonstration car, run on the stuff. Being rich in hydrogen, and containing only one carbon atom, methanol is relatively easy to "reform" in a low-temperature process that uses steam to break up the molecules over a nickel catalyst bed. The resulting products are hydrogen gas and carbon monoxide. The latter must be gotten rid of, both because it is a pollutant and because it will poison the fuel cell's catalyst. So a further step called selective oxidation converts the carbon monoxide to carbon dioxide. Although this is a greenhouse gas, a methanol-reformer fuel-cell car would emit much less of it—on the order of 50% less than piston engines.

But methanol isn't sold at stores near me either, you might further protest. You would be right again unless you live in Southern California, where there's a nascent methanol distribution network for alternative-fuel vehicles. Most engineers agree that it would be ideal to convert part of the country's gasoline infrastructure over to methanol for fuel-cell cars, but they also worry that the petroleum industry won't willingly make the investment. Therefore Daimler and other carmakers around the world are struggling to learn how to economically perform onboard extraction of hydrogen from gasoline, the one fuel sold everywhere.

Researchers at Daimler, GM, International Fuel Cells, and Arthur D. Little, the consulting firm in Cambridge, Mass.—and quite likely at Toyota too—are at work on systems for onboard gasoline reforming. It's a complicated task involving higher temperatures and more steps than methanol reforming. ADL announced last year that it had demonstrated a gasoline- reforming process in the lab that could be adapted to cars. That work was done with funding from the U.S. Department of Energy. In late February, ADL launched a new company called Epyx, with a staff of 30, that will work on a reformer that can handle a variety of fuels.

Chrysler has said it will have a gasoline-reforming fuel-cell demonstration vehicle by the end of 1999, with the critical reformer system, interestingly enough, being built under contract by GM's Delphi Energy & Engine Management unit. To round up the expertise needed to build a gasoline reformer for Chrysler and parent GM, Delphi has been working in a research pact with Exxon and Arco. After all, onboard reformers have a lot in common with petroleum refineries.

A gasoline reformer has lower efficiency than a methanol reformer because it must use more of the fuel's energy to generate the heat needed to disassemble the complex brew of X-, Y-, chain- and ring-shaped hydrocarbon molecules found in gasoline. Still, a car with a gasoline reformer would come out ahead of the piston engine, by about one-third, in fuel efficiency and carbon dioxide emissions.

The good news is that these reformers could happily run on fuel from further down the food chain than today's gasoline. Since a reformer isn't subject to the "knock" that can trash piston engines, expensive antiknock ingredients don't need to be added to its fuel. In fact, reformers could slurp unfashionable hydrocarbons such as naphtha—lighter fluid, more or less—that refineries now pour out in superfluous quantities.

The various teams noodling onboard reforming hope that the process can be made reliable and shrunk down into simple metal vessels that could be stamped out as mufflers are today. The consensus: Getting there will take serious work. One huge challenge, especially in gasoline reformers, is shrinking the ten minutes or so it takes for a reformer to warm up before the driver can be on his way.

Another item on the agenda is achieving good throttle response, which will require a reformer to deliver hydrogen when the driver presses the accelerator. Daimler acknowledges that Necar 3 is too boggy in this respect, as British motorheads would say of a sluggish car. If reformer response time can't be shortened enough, fuel-cell cars could end up with gas accumulators for storing a modest buffer supply of hydrogen, or with a few batteries to keep the drive motor nourished until the onboard refinery catches up with demand. But that would add to cost and weight.

One way to save space would be to use an entirely different type of fuel cell that reforms methanol in the stack itself, without bulky external vessels. NASA's Jet Propulsion Laboratory in Pasadena, Calif., International Fuel Cells, and Ballard are among those exploring this approach, which so far appears to promise only half the power density of a hydrogen-fueled stack. Direct reforming of gasoline in a fuel cell is not considered feasible.

Differences of opinion exist regarding how to solve some of the design challenges that come with hydrogen fuel cells. One is how to pump gases, cooling water, and water created by the chemical process through the stack. The stacks Ballard builds run at an internal pressure of about 30 pounds per square inch, which is provided by an accessory compressor. Designers at IFC view the compressor as a greedy parasite that could suck up as much as a fifth of the kilowatts the stack generates. Instead they advocate an "ambient-pressure" system they have developed that uses less than one psi of pressure.

Ford and Daimler-Benz both say they will wait until late next year to determine which fuel—methanol or gasoline—is going to be the winner for fuel-cell cars. Then they will get to work designing the systems needed for a run of production cars in 2004. Ford's Heffernan and Daimler's Panik believe the world's first market for a fuel-cell car will be California, where current regulations dictate that 10% of the vehicles sold in 2003 must put out "zero emissions."

Although fuel-cell cars can't strictly qualify, it is possible the California Air Resources Board will amend its rules to encourage the use of cars that are at least very low emitters, and which the public might actually buy. The battery-electric cars offered in California and Arizona have been dismal sellers so far, at least partly because of their limited driving range between recharges.

Fuel-cell cars won't need to be plugged in for time-consuming recharges, and they'll go at least as far on a tankful of fuel as a piston vehicle. But buyers won't even venture into the showrooms unless the cars are affordable. For a fuel-cell power train to compete against those with piston engines, its cost will have to be no more than $5,000, says GM's McCormick. Daimler believes the power-train cost must be a maximum of $65 per kW, or $3,250 for the 50-kW system needed for a small car.

Getting all the way there will take more than the huge amount of R&D money that industry has put behind the effort. It will take blood, sweat, tears, and repeated frustration. But if the fuel cell makes it, the piston engine could wind up in museums. Except, of course, for a few cars kept running by those who see the same romance in motors that go vroom that steam locomotive buffs see in the old choo-choo. F

Fuel Cells for Times Square

ROBERT CLARK

Rising: a new building with novel power

A NEW OFFICE TOWER THE DURST Organization is putting up in New York's heart is packed with environmentally friendly features, including two fuel cells that will supply 400 kilowatts of juice to light up the building's signs. Built by ONSI Corp., a joint venture of United Technologies and Toshiba, the units incorporate reformers that extract hydrogen fuel from natural gas.

Priced at a costly $3,000 per kilowatt (partly offset by a $1,000 federal subsidy), ONSI's phosphoric acid-type fuel cells make sense only where extreme quietness or ultrastable electrical output are primary concerns. If their price fell to $1,000 per kW, makers of diesel generators would start worrying. In pursuit of this goal, ONSI plans a new generation of stationary fuel cells using the same less-expensive proton-exchange-membrane (PEM) technology that has carmakers excited. A unit of Vancouver's Ballard Power Systems is chasing the same market.