A REPORTER AT LARGE

THE CAR OF TOMORROW

Why hydrogen-powered vehicles are attracting some unlikely supporters

BY ELIZABETH KOLBERT

Capitol Hill is a lousy place to sell a car but a good place to sell the idea of one, which is why on a muggy afternoon not long ago Rick Wagoner, the chairman and C E O of General Motors, was standing on First Street next to a hydrogen-powered minivan Every few minutes, a new senator would show up, trailing a cloud of aides, and Wagoner, smiling fixedly, would pop open the hood or offer to take him for a ride His solicitude was in most cases unnecessary "I believe that my kids and for sure my grandchildren will be driving these," Senator George Voinovich, of Ohio, announced to no one in particular before climbing into the driver's seat Senator Byron Dorgan, of North Dakota, arrived at the event with a pro-hydrogen—and pro-Dorgan—news release already in hand The Senator's plan to "help free Americans from the grip of foreign oil by developing hydrogen fuel-cell technologies to power much of the nation's automobile fleet" was "gaining ground and picking up steam in Congress "

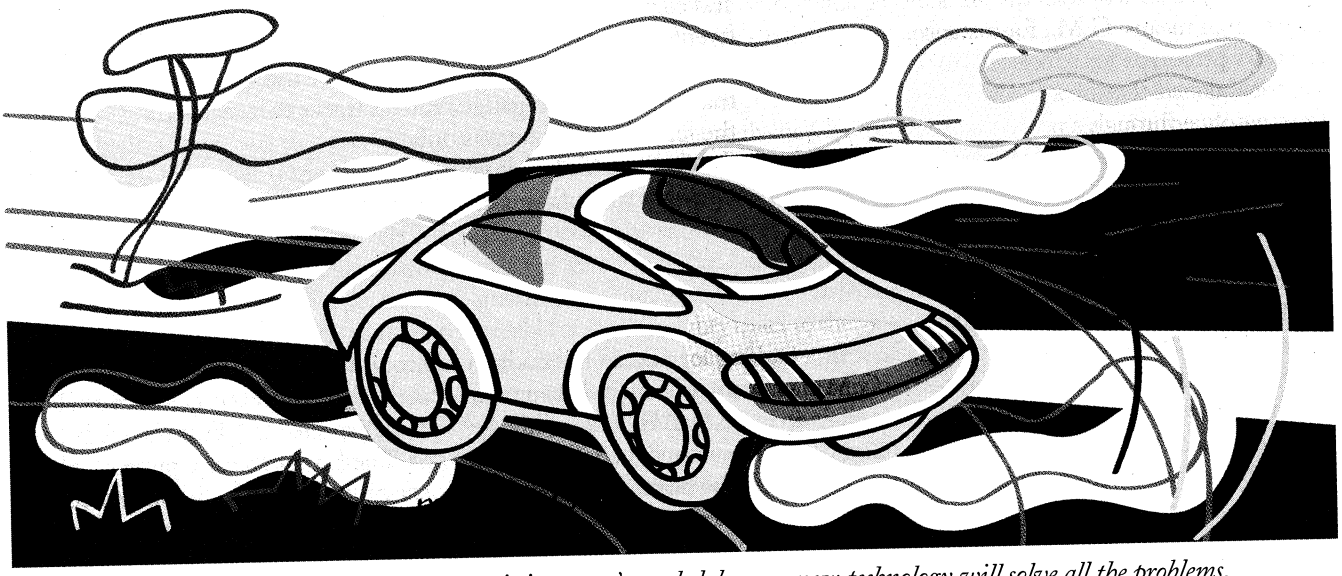
Outside of science fiction, the hydrogen car is probably the most radical reinvention of the automobile that has ever been imagined It runs cool and basically silent—the G M minivan makes a faint whirring sound—off an inexhaustible fuel supply, though even referring to hydrogen as a fuel betrays the limits of the old terminology It produces no emissions except water, which, upon emerging from the tailpipe, is, in principle at least, clean enough to drink. It does not need to be plugged in It can even serve as a source of electricity: at night, a hydrogen-car owner can use his vehicle to light his home, or connect it to the grid and sell power to his neighbors Sometime in the past year or so, the hydrogen car moved out of the laboratory and, if not quite onto the road, into the bright showroom of public relations

In his State of the Union address, in January, President Bush praised the hydrogen car as a means of making the country "much less dependent on foreign sources of energy" and called for a $1 2-billion research effort, "so that America can lead the world in developing clean, hydrogen-powered automobiles " (The Administration has dubbed the hydrogen-car initiative "FreedomCAR," and was planning to call the hydrogen-fuel program "FreedomFUEL" until it was informed that this name was already being used by, among others, Amway, a big Republican donor) Environmentalists, who have long been pressing automakers to produce zero-emission vehicles, have endorsed the hydrogen car, and so have the automakers, who have long been trying to fend off environmental regulation Such is the level of interest in hydrogen technology these days that the opening of a hydrogen filling station on the outskirts of Reykjavík, in April, was treated as an event of international significance For the occasion, Shell Hydrogen, a division of Royal Dutch/Shell, which operates the station, handed out bottles of water with labels that read "The Ultimate Fuel "

General Motors has taken up the cause with much well-publicized zeal The congressional "ride and drive" coincided with the opening of a new G M office in Washington devoted entirely to promoting fuel-cell technology The company claims to have already spent more than a billion dollars on research and development, and says that it wants to be selling hydrogen cars at the rate of a million a year by the middle of the next decade. In D C , I met several of the corporation's top executives, all of whom told me—often in exactly the same words—that the internal-combustion engine's time had passed "You've got to get yourself to an endgame that removes the automobile from the environmental debate," Larry Burns, G M 's vice-president for research and development, and planning, said So much enthusiasm from the world's largest and, by many accounts, most recalcitrant car manufacturer for such a revolutionary technology is unprecedented But

whether it means that G.M.—or, for that matter, Shell or George Bush—truly believes in the promise of hydrogen or just the opposite is difficult to say.

A car that runs on hydrogen does not, or at least need not, look in any way out of the ordinary. For instance, on the outside the HydroGen 3 minivan that G.M. brought to Capitol Hill is indistinguishable from an Opel Zafira, a vehicle popular in Europe, and, from the driver's perspective, operates in much the same fashion. But where a normal Zafira would have a gasoline tank the HydroGen 3 is equipped with a vacuum-insulated stainless-steel cannister built to keep liquid hydrogen supercooled at -253°C. And where a normal Zafira would have an engine a HydroGen 3 has a fuel cell, or really an assembly of fuel cells, called a stack.



Automakers argue that stiffer regulations on emissions aren't needed, because new technology will solve all the problems.

JAVIER MARISCAL

The basic idea behind the fuel cell—that hydrogen can be used to produce electricity—is generally credited to an English polymath named William Grove, a friend of the pioneering physicist Michael Faraday. Grove, by training a barrister—his most famous client was the so-called "Rugeley poisoner," who plied his victims with strychnine—was an enthusiastic experimenter in his own right. Intrigued by studies of electrolysis, Grove reasoned that if it was possible to break water down into its constitutive elements using an electric current, it might also be possible to do the reverse. In 1839, in his London laboratory, he built a device that, by combining hydrogen and oxygen across a pair of platinum electrodes, produced a small current. A few years later, he increased the electrical output by stringing together a series of such devices, but he seems never to have pursued the idea much further. "For my part, I must say that science to me generally ceases to become interesting as it becomes useful," Grove once observed.

Not much practical use was made of Grove's invention until the nineteen-sixties, when General Electric developed fuel cells to provide electric power for the Gemini space flights. These days, fuel cells can be found on board the space shuttle and also in a variety of more mundane locations, including the basement of 4 Times Square. (The stack at 4 Times Square, where this magazine has its offices, provides fifteen per cent of the building's electricity.) Enthusiasts predict a variety of new applications for the technology in the very near future. Engineers at Intel, Motorola, and 3M, for example, are busy trying to produce a fuel cell small enough to fit inside a video camera or a mobile phone. At a recent trade show, Toshiba demonstrated a cell for laptops which it said could come on the market as early as next year. Assuming that the kinks can be worked out, such miniature fuel cells could last six times longer than conventional batteries.

For a number of reasons—primary among them the inefficiency of the internal-combustion engine—automobiles represent a particularly promising fuel-cell application. Fuel cells produce electrical, rather than mechanical, energy—in this way, fuel-cell cars are similar to battery-powered vehicles—and, using the same amount of energy, a fuel cell can propel a car nearly three times as far as an ordinary combustion engine. At the same time, cars represent a peculiar challenge: they require a great deal of power, are expected to travel long distances between refuellings, and are called on to last for ten years or more. Among the many obstacles to commercial production are cost (most fuel cells today are made with platinum), durability (fuel cells tend to degrade after a relatively short time), and fuel storage (hydrogen is so light that it is generally kept under extremely high pressure or at a very low temperature). There are also concerns about safety, although fuel-cell advocates maintain that, owing to misunderstandings about the Hindenburg, the dangers of hydrogen have been greatly exaggerated. (In a recent paper titled "Twenty Myths About Hydrogen," the physicist Amory Lovins argues that hydrogen is "at least as safe as natural gas or LPG"—liquefied petroleum gas—"and arguably is inherently safer than gasoline.")

Finally, there is the problem of obtaining hydrogen in the first place. Although it is the most plentiful element in the universe, hydrogen on earth exists almost exclusively in combination with other substances. As a result, it must be extracted, a process that can itself require a considerable amount of energy. (In the case of hydrogen obtained from

water, the energy consumed by electrolysis is actually greater than the energy produced by a fuel cell.) For this reason, hydrogen is considered not an energy source but an energy carrier, which helps explain why so many people with so many conflicting agendas find it attractive. Hydrogen can be produced using renewable energy sources, like wind, but it can just as easily—in fact, perhaps more easily—be extracted by less environmentally benign means. G.M., for instance, created a prototype for a fuel-cell truck, since abandoned, that extracted hydrogen from gasoline through a process known as "reforming." This approach obviates the need for a whole new hydrogen-delivery infrastructure, but since it produces substantial amounts of carbon dioxide, it also obviates much of the reason for switching to fuel cells. Similarly, hydrogen can be produced from coal; once all the emissions of that process are taken into account, it's debatable whether fuel-cell cars yield any environmental benefit at all. In the budget that President Bush presented in February, he proposed that the federal government spend twenty-one million dollars researching hydrogen production using coal, natural gas, and nuclear energy.

The day after the congressional ride-and-drive, I attended a second fuel-cell event, this one staged by G.M. for reporters and officials of agencies like the National Highway Traffic Safety Administration. The program began in a meeting room at Washington's Union Station, with a presentation by Beth Lowery, the company's vice-president for energy and environment. Stationed between two flat-screen monitors mounted on silver poles, Lowery described G.M.'s goal as "reducing and eventually eliminating" emissions both from its cars and from its factories; as she spoke, the words "Path to Zero" flashed in synchrony across the screens. Lowery acknowledged that it might be "confusing" for some people to hear this, given G.M.'s long-standing opposition to raising federal fuel-economy standards. But, she announced cheerfully, "we don't think it's contradictory at all." After she was done, we all boarded a special, superefficient bus plastered with photographs of snow-covered mountains and fields of wildflowers, and headed out to R.F.K. Stadium.

DORIS

Never went to Birdland, so what, went to the Y
danced all night for a quarter, girls sat down
on bridge chairs, can't remember if they were smoking,
men wore jackets and ties, I know the name of
one, I'll call her Doris—that was her name—
her grandfather was a rabbi from Bialystock
and over ninety, she was twenty. I was
twenty-one, I guess, he had to be born
before the Crimean War and who were the gangs
that built the wide-gauge railroad tracks that reached
the Urals in 1860, he was only
five feet tall, his hands you can't imagine
nor what the sofa was like and what our struggle was.

—*Gerald Stern*

In a parking lot next to the stadium, G.M. had set up two tents where presentations on topics like "Hydrogen Storage" and "Infrastructure and Stationary Applications" could be heard. Ignoring these, everyone crowded around the prototype of a car that G.M. calls the Hy-Wire, which was parked next to a makeshift track fashioned out of traffic cones. Sleek and low, with a sloping windshield and a see-through trunk, the Hy-Wire suggests a vision of the future that is part "Matrix Reloaded," part "Sleeper." (Before test-driving it, I had to sign a waiver stating that I understood that there were "certain risks involved in driving and riding non-production GM vehicles" and that I "knowingly" had decided to assume them.) Although the Hy-Wire is powered by compressed hydrogen, its snazziest features—small video screens, for example, in place of sideview mirrors—have little or nothing to do with fuel-cell technology. When it was my turn to take it around the track, I started out by nearly ramming into a concrete barrier, but by my second lap I started to get the hang of things. The Hy-Wire doesn't have an accelerator or a brake, at least in the familiar sense of these terms; to speed up or slow down, you rotate handles on the steering wheel. And when you sit in it your feet stick out in front of you, go-cart style. Fuel cells have no moving parts, so the Hy-Wire offers an almost uncannily smooth ride, as if the car were floating. When my turn was over, one of the many G.M. public-relations agents hovering around asked me how it had gone. I couldn't help answering exactly as I knew I was expected to: "That was really cool."

The hydrogen car represents what is sometimes called a "leapfrog" technology: it does not merely improve on something that exists but vaults over all possible improvements to achieve something totally new. Given the many risks inherent in such a technological leap, one of the obvious questions about G.M.'s strategy is: Why gamble? A far surer way to reduce emissions—and to set out along the "path to zero"—would be simply to produce smaller cars, or, barring that, to use already proven energy-saving technologies. Toyota and Honda, for example, have begun commercially producing hybrid cars, which are equipped with both an internal-combustion engine and an electric battery that recaptures energy ordinarily lost to friction.

G.M. offers several explanations—some of them contradictory—for its strategy. On the one hand, company executives point to the demands of the marketplace, where fuel efficiency is evidently a low priority. As Beth Lowery put it, the makeup of the American auto fleet reflects "what people buy, and not what we offer." On the other hand, G.M. maintains that the problem with innovations like hybrids is that they are not, by its standards, fuel-efficient enough. To the extent that the company's position has a logic, it might be summed up as: Why settle for half a loaf when one day a whole loaf may be available? (Fur-

ther complicating G.M.'s position is the fact that even as its executives continue to criticize hybrid technology the company has announced that it will begin offering optional hybrid engines in some of its cars and trucks.)

Chris Sloane is the director of G.M.'s FreedomCAR and Technology Strategy. I met her after my ride in the Hy-Wire in the R.F.K. Stadium parking lot. "If we took the whole transportation sector, and everybody in the whole country went to hybrids and small cars immediately, and say you got your thirty-per-cent gain, which is huge," she told me. "Then you look at what that does to CO_2 in the atmosphere. All you did is move the point where we hit certain levels by twenty, thirty, forty years. That's all you did. So now you've said, 'I like my third-generation grandchild more than my fifth'? Well, do you know those people? I just went through all of this—I feel good about my activity—but I didn't solve anything. What happens if you go to a non-carbon fuel? Now we're talking about a real solution."

For more than thirty years now, Detroit has been trying to grapple with—or, by many accounts, simply evade—the problem of automobile emissions. In the early nineteen-seventies, when Congress began debating the need for stricter clean-air standards, the Big Three organized a massive public-relations campaign. They insisted that the proposed rules were superfluous—one ad declared that General Motors had already made "a public pledge to solve the problem"—and, at the same time, impossibly unrealistic. In a November, 1970, speech, Ed Cole, G.M.'s president, declared that the new standards "simply aren't attainable." No sooner had the standards been passed than automakers launched a second campaign to get them rolled back.

Facing mounting criticism for such tactics, the Big Three a decade or so ago adopted a new approach. Government intervention wasn't needed, they argued, because an imminent breakthrough would render the whole issue moot. Before taking up hydrogen, G.M. made a heavy investment, at least rhetorically, in electric vehicles. The company's showcase car, the EV1, ran off a battery that consumers were supposed to plug in and recharge at night. Speaking at the Greater Los Angeles Auto Show in January, 1996, Jack Smith, G.M.'s chairman, declared, "It's time to get electric vehicles out of the lab, into the showroom, and onto the road." He went on to observe, "When auto historians look back, they will see this car as the first in the new generation of vehicles. And they will note that G.M. made it." The company managed to lease only eight hundred EV1s in California and Arizona before quietly abandoning the project. Also in the mid-nineties, G.M., together with Ford and Chrysler—now DaimlerChrysler—formed a joint venture with the Clinton Administration known as the Partnership for a New Generation of Vehicles. The goal of this venture, which was popularly referred to as the "super car" program, was to engineer a family-size sedan capable of getting eighty miles to the gallon. All told, the federal government spent some $1.5 billion on the program. By the time the Bush Administration terminated it, last year, it had yielded a grand total of three prototype vehicles.

Meanwhile, as one reinvention effort after another has failed, the cars that Detroit has actually been selling have grown increasingly inefficient. According to a report released recently by the Environmental Protection Agency, passenger vehicles sold in this country last year averaged only 20.4 miles to the gallon, the worst performance in twenty-two years. As the E.P.A. dryly noted, the trend has significant public-policy implications: "Fuel economy is directly related to carbon dioxide emissions, the most prevalent greenhouse gas." G.M. cars and trucks performed particularly poorly, according to the E.P.A.'s data: of the world's seven major automakers, only Ford had a worse over-all fuel-economy record. It is a striking fact that at the same time that G.M. was abandoning the "super car" as too pricey and impractical, it was bringing out the H2, its new version of the Humvee, the military vehicle now marketed to suburban drivers. The H2 costs fifty thousand dollars, weighs more than four tons, and gets just over ten miles to the gallon. It is so heavy that, by the bizarre logic of federal fuel-efficiency standards, the E.P.A. doesn't even count it against G.M.'s required fleet average.

Not long after I took the Hy-Wire for a drive, I went to visit the Natural Resources Defense Council, one of the nation's leading environmental groups. When I arrived at the organization's Washington office, the first thing I noticed was a little basket filled with cardboard cutouts that were supposed to look like burned pieces of toast. "Some mistakes are no big deal," the toast warned. "Global warming isn't one of them." On the back, the toast advised, "Drive smart, drive less."

For the past several years, the N.R.D.C. has been lobbying, unsuccessfully, for an across-the-board increase in the federal fuel-efficiency standards, to forty miles per gallon. I met with Jon Coifman, one of the group's communications directors, and, via speakerphone from San Francisco, Roland Hwang, one of its auto-industry analysts. I asked them about G.M.'s contention that hydrogen cars, as opposed to higher standards, were the answer.

"I'll throw out a very cynical perspective, which happens to match what we have seen from General Motors over the past several years," Hwang said. "They're trying to bedazzle us with very fancy prototypes to get us hooked on the fact that they're working very hard on a technology that we all agree is ultimately the prize—a zero-pollution motor vehicle. At the same time, General Motors is on record saying, 'Please don't make us improve the fuel economy of our current gasoline-vehicle fleet.' They're trying to undermine political momentum to do something that is going to have a real impact over the next decade or two."

In the course of a year, the average car on the road today consumes six hundred gallons of gasoline and produces six tons of carbon dioxide. Coifman noted that between now and 2020, when, according to the most optimistic projections, fuel-cell cars could be expected to become competitive, Americans will buy some three hundred million new vehicles. "Those vehicles are going to be with us ten, twelve, fifteen years each," he said. "They're going to burn a lot of gas, and they're going to be emitting a lot of pollution. And we need to be focussing on those."

He went on, "There's two questions:

Is this a political red herring that the industry and the Administration are throwing out there, and are fuel cells ultimately a real solution? And I think the answer to both questions is yes."

What is being billed as the world's first "commercially integrated" hydrogen station sits on the side of the Vesturlandsvegur highway on the eastern outskirts of Reykjavík, next to a brewery decorated with forty-foot-high plastic beer bottles and a minimart where, in keeping with Icelandic prices, a cup of vending-machine coffee costs more than three dollars. Next month, for the first time, city buses, built by DaimlerChrysler, are supposed to fuel up on hydrogen produced at the station through electrolysis.

Iceland generates virtually all of its electricity from renewable sources—hydropower supplies eighty-four per cent, and the rest is geothermal. In addition, residents of Reykjavík heat their homes using water that emerges from underground springs at 100° C. Still, the country imports some six and a half million barrels of oil annually to power its cars, trucks, and commercial fishing fleet. Ten years ago, Bragi Arnason, a chemistry professor at the University of Iceland, proposed that the country, which has only two hundred and eighty thousand inhabitants, wean itself from imported oil by converting to hydrogen. Arnason kept pushing the idea in academic journals and newspaper articles, in the process earning the nickname Professor Hydrogen. At first, the notion was dismissed as eccentric; then, in 1999, Iceland's government, together with its university and its technological institute, formed a company, Icelandic New Energy, with the stated goal of eventually using hydrogen in place of all fossil fuels. DaimlerChrysler, Shell Hydrogen, and Norsk Hydro, a producer of electrolyzers, bought stakes in the company.

Arnason is a stocky sixty-seven-year-old with snow-white hair and a florid complexion. When I went to see him a few weeks ago in his spartan office in Reykjavík, he told me that he saw Iceland as a "pilot country," where companies will come to test out new technologies before trying to market them elsewhere. "You see, we are a very small society, but we are a real society," he said. "So that if we can develop this technology here in the next twenty or thirty years it can be moved over to larger societies."

Engineers from all over the world have already started showing up in Iceland, and, when they do, often they end up in Arnason's office. "The Japanese are coming here very frequently," he told me, rummaging through a stack of business cards. He said that he expected to see hydrogen cars introduced on the island sometime in the next decade or so, but that he didn't anticipate being around to see them in general use. "From the year I started until we have this transformation completed will be at least fifty years, and that seems to be quite normal," he said. "If you look back in history, it has usually taken half a century to change from one type of energy to another—from wood to coal and coal to oil. My generation will see the first steps."

After a while, Arnason took me next door to see his lab. On the counter was a device with a photovoltaic cell on one end and a little fan on the other. In between was a cylinder of water, some clear plastic tubes, and a fuel cell, which looked like two sheets of cellophane stretched over some wire mesh. When Arnason turned on a desk lamp, the photovoltaic cell began to produce electricity, which electrolyzed the water. Hydrogen and oxygen ran through the tubes to the fuel cell, where they recombined to produce more water, in the process turning the fan. It was an impressive display. Arnason told me that the device had been constructed "to show politicians whenever we need money."

The elegance of hydrogen technology is hard to resist: as Arnason points out, you almost have to believe in it. But this is precisely the trouble with hydrogen. It may turn out to be the future, as G.M. insists, or merely a distraction from it.

As it happens, the master of imaginary futures, Jules Verne, already proposed a hydrogen-powered world back in the eighteen-seventies. In his novel "The Mysterious Island," a group of Union officers escape by balloon from a Confederate prison, only to crash-land on a deserted isle in the Pacific Ocean. Before meeting up with Captain Nemo, they while away the hours discussing, among other topics, the Union's dependence on dwindling supplies of coal. One of the officers insists that there is "nothing to fear."

"Yes, my friends, I believe that water will one day be employed as fuel, that hydrogen and oxygen which constitute it, used singly or together, will furnish an inexhaustible source of heat and light," he declares. "I believe then that when the deposits of coal are exhausted, we shall heat and warm ourselves with water. Water will be the coal of the future."

"I should like to see that," one of his companions replies. ♦

"Do you think those less fortunate are at least having better sex?"