

SCIENTIFIC AMERICAN FRONTIERS PROGRAM

#1403 "Future Car"

AIRDATE: May 19, 2004

Why Cars Must Be Green

Goodbye Gasoline

Hydrogen Ahead

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ALAN ALDA On July 3rd, 1886, Karl Benz introduced to an astonished public in Mannheim, Germany, the world's first automobile. That same year Gottlieb Daimler also put an internal combustion engine into a vehicle. For the remaining years of the 19th century, Benz and Daimler independently designed and built several other what were, in essence, "horseless carriages." Among European aristocrats, it soon became fashionable to race their new automobiles in events such as the Tour de Nice in the south of France. The winner of the first Tour de Nice in 1899, Emil Jellinek, encouraged the Daimler-Motoren-Gesellschaft to build for him a bigger, more powerful automobile for the next year's race. At a stroke, the horseless carriage was transformed into what is still, a hundred years later, recognizably a car, complete with an internal combustion engine under a hood, a radiator, wheels with inflatable rubber tires and a slanted steering wheel. Jellinek was so taken with the car that he put in an order for 36, worth 550,000 gold marks - that's something almost \$3 million today. But Jellinek added two conditions. First that he be made the sole agent for the car in the Austria-Hungary, France and the United States. And second, that the car be named after his then 12-year-old daughter, Mercedes. But if Germany was where the car was born, it was in America that it came of age - where it went from being a plaything of the rich to a vehicle for the common man - reshaping the country, and the century, in the process. And this is the car that did it, Henry Ford's Model T.

ALAN ALDA (NARRATION) The first Model T was built in 1908, in much the way that all cars were built at the time, by a small group of workers assembling everything by hand. But Ford had a different vision -- "I will build a car for the multitude," he used to say - and so he invented a different way to make cars: the moving assembly line. In the years that followed, both the time it took to make a Model T and the price it could be sold for fell and fell again. By introducing in 1914 the then startling wage of \$5 a day, Ford also ensured that for the first time in history, the workers who built a complicated machine were among those who could afford to buy the thing they were making.

ALAN ALDA And buy it they did - over 15 million Tin Lizzies were built before it finally went out of style. But for all the design refinements since, cars still have an internal combustion engine up front, burn gasoline, they have a steering wheel and controls linked mechanically to the wheels - and are not only among the most useful machines we've ever invented, but they're also among the most dangerous and dirty. A century after Gottlieb Daimler built the first Mercedes and Henry Ford founded his car company, the car industry has finally realized that the technologies it's relied on for those one hundred years are as quaintly outdated today as was the Model T back in 1927.

ALAN ALDA (NARRATION) A vision of the car of the future was first unveiled - with all the glitz and glamour of a Hollywood premier - at the Detroit motor show in 2002. Called the Autonomy, it does away with almost everything that's characterized a car for the last 100 years. It has no engine. It doesn't use gasoline. There are no mechanical links between the controls and the wheels. It doesn't even have a steering wheel. And its tailpipe emits only a few drops of very clean water. General Motors is placing a billion dollar bet that this is the prototype of the car of the future. It's the brainchild largely of two men.

ALAN ALDA Now, this is called the Innovation Zone?

CHRIS BORRONI-BIRD It is, this is where we do a lot of brainstorming about coming up with new ideas to help the vehicles...

ALAN ALDA (NARRATION) Chris Borroni-Bird doesn't fit the stereotype of a Detroit auto engineer.

CHRIS BORRONI-BIRD This is the most profound, in terms of what it can do for society and the customer and it's the furthest out in time as well.

ALAN ALDA (NARRATION) He's English, educated as a physicist - and he's an avowed environmentalist. He wants to do nothing less than to re-invent the car.

ALAN ALDA How did you get a chance to do this? I mean, you're obviously doing something that you love doing, it's very exciting to you. How did you get this chance?

CHRIS BORRONI-BIRD Well, I have to thank Larry Burns, who is the vice-president for R and D at General Motors. He hired me three years ago when I approached him with this idea of design and technology fusion - looking at how we can take technology and enable new designs. And he liked that idea a lot.

LARRY BURNS Chris had this vision of bringing design and technology together almost as if we could genetically re-engineer the car. And I thought that was a great opportunity for us. We had to do something because only 12 per cent of the people in the world own a car today. The other 88 per cent aspire to...

ALAN ALDA What's going to happen? What's going to happen if the other 88 percent of the people in the world buy cars, or if only half of them do, how are we going to manage?

LARRY BURNS That's a critically important question, that's where the environmental issues really come in. Environmental sustainability is absolutely central to the future of the auto industry for business reasons. It's the right thing to do from the societal standpoint, but it's also the right thing to do for the business.

ALAN ALDA (NARRATION) Achieving environmental sustainability means making cars that consume less oil and produce less pollution. Parading across the Golden Gate Bridge last September, and winding its way through the California wine country, was a motorcade of vehicles from around the world. They're here to show off their manufacturers' latest environmentally friendly technology at an event called the Challenge Bibendum. The star of the Challenge Bibendum is a drivable version of the Autonomy concept car General Motors unveiled with such fanfare in 2002. Now called the Hywire, its been heavily promoted for the past year to the automotive press. But not everyone here is convinced.

ROLAND HWANG Well, it's a great vehicle obviously. It's a technological tour de force, a Buck Rogers 21st century vehicle, and it's tremendous technology. But we have to ask ourselves the question, is this a reality or is it some sort of smokescreen? What we're talking about before this kind of vehicle might be in widespread commercial use and available to you when you shop for your vehicle, we're probably talking 20 years. It's not just that there are 300 million cars and trucks are going to be sold before that kind of vehicle can be purchased by you or me, it's also that those vehicles, in the current trend, are getting worse, in terms of fuel economy and global warming pollution performance. We're going backwards.

ALAN ALDA (NARRATION) That's because while today's engines are actually cleaner and more efficient than ever before, they're also bigger and more powerful. In fact, while GM's Larry Burns dreams of more environmentally friendly vehicles, his and every other car company is building and advertising cars that are larger and faster.

LARRY BURNS We're in business and we have to generate a sufficient return on our investment to earn the right to invest the capital in the next generation of products. And if we don't compete in the segments of the market where we can sell products we're not going to earn that kind of return and we're not going to be a viable company. So that's quite important. We believe that removing the automobile from the environmental debate is going to open up new opportunities for our industry beyond what we have today.

ALAN ALDA (NARRATION) We explored this disconnect between today and tomorrow here at the Challenge Bibendum, with a car that's among the first real production vehicles to break with the last 100 years of convention. The Toyota Prius is the most radical of a new generation of cars that supplement their gas engines with electric motors - so-called hybrid vehicles. Beneath the hood there's a small internal combustion engine, connected to an electrical generator. There's also a cluster of control computers... an electric motor... and a large capacity battery. Getting into a Prius, the most obvious difference from a conventional car is the start button.

ALAN ALDA ...and I press the button.

ALAN ALDA (NARRATION) This sends an electric current from the battery via the control computers to the electric motor, which when I press the accelerator obligingly turns the wheels. At this low speed the gas engine isn't even running - in effect, I'm driving an electric car.

ALAN ALDA Except for these controls, I wouldn't know I wasn't driving any other kind of car, except that it's very quiet.

ALAN ALDA (NARRATION) But as I speed up, the gas engine -- almost imperceptibly -- kicks in.

ALAN ALDA So now it looks like energy is coming in from the engine because I have my foot on the accelerator.

ALAN ALDA (NARRATION) The gas engine is now powering the car both directly -- to the front wheels - and indirectly, powering up the generator and supplying extra current to the electric motor.

DAVID HERMANCE Now you have a combination of gas and electric providing drive up this hill.

ALAN ALDA (NARRATION) And as the hill gets steeper, the battery also starts feeding power to the electric motor. At this point, I'm drawing on all the car's

resources. But as I turn around and start back down the hill, not only does the gas engine quit, but I begin getting back some of the energy I used going up.

DAVID HERMANCE Now the engine's off and it's regenerating, filling up the battery again.

ALAN ALDA So it's not expending any energy.

DAVID HERMANCE No, it's actually converting vehicle motion that would ordinarily be lost as heat in the brakes and putting it back into the battery and giving you free energy for the next time you want to accelerate.

ALAN ALDA (NARRATION) Toyota claims that the Prius gets about 55 miles per gallon, thanks to it's ability to recapture braking energy, a low drag body and above all its ability to get the best out of both its engine and its motor.

DAVID HERMANCE Gasoline and electric have operating ranges that differ from one another, and are not efficient in some areas but very effective in others. So that when you can ideally mix the gas and electric you can get an overall system that's more efficient.

ALAN ALDA Because the gasoline engine is less efficient at low speeds...

DAVID HERMANCE Right, and electric is less efficient at high speeds.

ALAN ALDA I see.

DAVID HERMANCE So it allows you to switch back and forth to pick the best combination.

ALAN ALDA So you could probably get really great efficiency out of a gasoline engine, get great mileage, if you could just get into it when it was going 60 miles an hour.

DAVID HERMANCE That would be great. They're very efficient in that operating range. In the 40 to 70 mile an hour range, the gasoline engine is actually quite an efficient machine. It's just trying to make it run at all the other speed extremes that compromise it's efficiency.

ALAN ALDA (NARRATION) The Prius costs perhaps \$1500 more than a similar size conventional car, but its much better gas mileage is likely to save money in the long run. Toyota is planning to sell 20,000 in the next year - but that's out of a total fleet of some 2 million.

ALAN ALDA If this is so good, why don't you just say to them, here's the car for you, and this is the one you're going to get because this gets the best mileage, it performs just like the car you've been driving, only this is better. Costs about the same and so now that's the car that you can buy. Why offer them others that are not as good?

DAVID HERMANCE Well, in the US, sad to say, folks don't largely value fuel economy. Most of the population of the US is not convinced that global warming is real or that cars have anything to do with it.

ALAN ALDA Isn't it just a question of explaining it to them? Of educating them, advertising it? Why are we still advertising - why do we have commercials where you can't even tell what the car is being advertised, all you know is being advertised is speed? These cars are zipping through these mountain roads at speeds that would kill a normal driver. Why are we advertising that instead of explaining what you've got to sell here?

DAVID HERMANCE Well, you have to strike a balance. Right now in the US market, customers value performance, they will actually pay premium money for performance, whether or not they ever use it, and so if you don't...

ALAN ALDA But that's what you're selling them You're selling them these pictures - I'm not blaming you personally, you seem like a nice guy, but why do you have these ads that are only selling speed when speed is costing them money? You could do them a big favor with this car.

DAVID HERMANCE I agree with you. However, those that do "market research" say that customers value performance. If I - I as a manufacturer - don't market performance, then I'll lose market share.

JOHN MOULTON Yeah, let's go check this out. I think you'll really be impressed.

ALAN ALDA (NARRATION) And speaking of marketing performance...

JOHN MOULTON OK, this is the new Taureg for Volkswagen. With a V10 diesel.

ALAN ALDA Quiet. And it starts right up.

JOHN MOULTON Starts right up instantly, you don't have to wait...

ALAN ALDA Yeah, the last time I drove a diesel I had to have a sandwich before the car would go.

JOHN MOULTON That's all gone now. Basically an instantaneous start.

ALAN ALDA Here I go. Watch yourself.

JOHN MOULTON Watch out for this power.

ALAN ALDA Wow!

JOHN MOULTON This is a pretty heavy SUV, so this is... now we're going up hill, you can really feel that torque from a diesel engine. Step on it, straight uphill. Not the diesels of yesteryear, uh?

ALAN ALDA No, you're right. I mean, this is very responsive.

ALAN ALDA (NARRATION) OK, I know, here I am having fun driving too fast in a car much bigger than most of us need. But at least I'm wasting less gas than I might be. In the last few years, new cleaner burning, more powerful diesel engines have taken over 40 per cent of the car market in Europe. Diesels get about 30 percent better mileage than gasoline-powered cars.

JOHN MOULTON And will get about 15 to 20 percent less carbon dioxide, which most of us feel contributes to greenhouse gases. So you're doing something good for the environment and you're saving some money.

ALAN ALDA (NARRATION) But while diesels are more efficient and emit less carbon dioxide, they also put out more smoke than gas-powered cars. The new diesel engines are cleaner, but they still don't meet the United States' emission standards, which are stricter than Europe's. Here at the Challenge Bibendum, some half-dozen diesel-powered cars are being put through their paces. And several European car companies are planning to market diesel cars in the US in the next few months. Among US manufacturers, Ford has great hopes for a diesel version of its Focus model. We visited the emissions control lab at Ford to see how a diesel's exhaust can be cleaned up. It turns out that the plan is to employ a modified version of the device most of us already use in our car every day - and take for granted.

ALAN ALDA This is a way of testing the efficiency of a catalytic converter?

GUNTHER SCHMIDT Yeah, yeah, you're right. Testing the efficiency of the different components of a catalytic converter. The main component is the so-called catalyst, this is the material which is on the surface of the ceramic...

ALAN ALDA Can you show me a catalytic converter?

GUNTHER SCHMIDT Ah, I like to do it. This is the ceramic and you can look right through. All these small chambers are coated with a mixture of platinum, rhodium and palladium.

ALAN ALDA So that's all it is?

GUNTHER SCHMIDT Really, this is one of the breakthrough innovations of our century. This brings down emissions from combustion engines by two magnitudes, a factor of a hundred, sometimes a factor of a thousand even. This is really a magical thing. Therefore it is a key explanation why combustion engines are so successful. In diesel engines you have a little different type of combustion in the engines, therefore you create some soot, or particulates. And this is a different device, this is a diesel particulate filter. And you can try to look through, again you are able to look through, but every second channel is closed.

ALAN ALDA (NARRATION) The idea is that the soot particles in the exhaust will be trapped. As they accumulate, they will be burned off with the aid of a catalyst. The hope of diesel enthusiasts like Gunther Schmidt is that devices like those being tested here will allow diesel cars to meet US emission requirements.

ALAN ALDA So is Ford going to start making diesel cars?

GUNTHER SCHMIDT Yeah, actually, we are working hard to make it happen.

ALAN ALDA (NARRATION) Between them, the clean diesel cars favored by European-based manufacturers, and the gas-electric hybrids being pushed mainly by the Japanese car companies, could save their owners money at the pump and reduce the emissions of carbon dioxide, the principle greenhouse gas produced by cars. But at the Challenge Bibendum, the car on its way to capturing most of the environmental awards is a little sports car called the tzero. Powered entirely by batteries, it produces no emissions at all - and can rocket from zero to 60 in under 4 seconds. I took a ride in the tzero with a big fan of electric cars, Dan Kammen of the University of California, Berkeley.

ALAN ALDA What's the problem with getting electric cars to be the standard?

DAN KAMMEN Well, one thing is that battery technology, for a long time, didn't evolve very quickly. And there is important discussion about the degree to which this was a hard technology to work on and that there was a little bit of collusion by the big auto manufacturers to slow down battery work. So batteries didn't evolve...

ALAN ALDA Was any of that true?

DAN KAMMEN You get multiple stories. I have one version on pretty good faith that looks like there was a little bit of patenting, not to advance the field but to keep others, notably Volvo, out of some of the technologies they wanted to get into. That aside, with the advent of new battery technologies for cell phones and all manner of electronics, there's been a whole revolution in batteries. So this now has lithium ion batteries in it which more than doubles the range, which makes it go zero to sixty considerably faster. And so lighter, faster, and much higher power density...

ALAN ALDA So how far could you go in this before you'd have to recharge it?

DAN KAMMEN Well, this guy's now got a 300 mile range...

ALAN ALDA Three hundred miles?

DAN KAMMEN So they drove up here from LA with one stop at an RV park and they plugged in, and so this really is getting in a very interesting way at plugging into the normal economy in ways that the older electric vehicles really couldn't do.

ALAN ALDA (NARRATION) One of those older electric vehicles was built by General Motors, in collaboration with a man more famous for making electric powered airplanes than cars. We got to see the EV1 a few years ago when we visited Paul MacCready at his company, Aerovironment. Bigger and heavier than the tzero, the EV1 was a showcase for all-electric power. PAUL MACCREADY It doesn't have to measure pressures and decide which gear to change into in the automatic transmission. You just put your foot down and zip, you feel the pressure against you back I've never seen anyone get out of it with out a big smile on his or her face.

ALAN ALDA (NARRATION) But although the EV1 was introduced with great fanfare five years ago, General Motors actually built just over a thousand, the great majority being leased to drivers in California. In the last few months, GM has been demanding the vehicles back - much to the distress of their temporary owners, most of whom loved the car passionately.

ALAN ALDA I'm smiling.

ALAN ALDA (NARRATION) While the EV1 proved to many electric car enthusiasts that Detroit could have been building zero-emission, high performance cars for over a decade now, the weak point remained their limited range. So even as newer battery technology has apparently solved this problem for a small, light car like the tzero, General Motors - and the rest of the industry - has all-but abandoned storing electricity in batteries and has instead turned to the on-board generation of electricity using a new fuel, hydrogen.

CHRIS BORRONI-BIRD The car industry as a whole has come to the conclusion that battery powered vehicles just don't get the range that people want. And that the only chance we have to provide zero emissions completely renewably is to use hydrogen as an energy carrier as opposed to electricity. I think everybody in the car industry is now beginning to converge on the idea that hydrogen is the long-term fuel, the fuel of the future.

ALAN ALDA (NARRATION) And so we are taking a trip to visit one of the pioneers of hydrogen-powered vehicles here in the German countryside, just a few miles from where the automobile was born. If the visionaries in the auto industry are right, we're to see a technology that will not only change what you drive, but also the future of the planet.

Goodbye Gasoline

ALAN ALDA (NARRATION) We're just outside Stuttgart in Germany, with DaimlerChrysler's director of fuel cell development, Andreas Truckenbrodt.

ANDREAS TRUCKENBRODT So they started with fuel cells in the spacecraft application, and then it was decided to go into the car. And this was the very first car in 1994 where we put a fuel cell system on wheels.

ALAN ALDA (NARRATION) Fuel cells make electricity from hydrogen and oxygen. Typically, fuel cells are arranged in a stack. Each individual cell consists of a membrane between two plates, with hydrogen fed to one side and oxygen to the other. Hydrogen molecules - pairs of atoms - give up their protons to the membrane, while their electrons stream off as an electric current. Their work done, the electrons reunite a split second later on the other side of the membrane with the protons that passed through and with an oxygen atom to form water. The power of a fuel cell stack depends on the size and number of individual cells. With oxygen free from the air, all that's needed to make electricity is a supply of hydrogen.

ANDREAS TRUCKENBRODT This is the fuel tank, hydrogen tank. So with this type of tank it could go 150 km roughly, but it only had 50kW, which is not a lot for this type of car, and of course all the... there was just the two passengers in there but there was no cargo space anymore, what is not a great idea for a delivery van like this.

ALAN ALDA (NARRATION) Fifty kilowatts by the way translates to about 67 horsepower - about the power of a motorcycle engine.

ALAN ALDA It's a gigantic piece of machinery.

ANDREAS TRUCKENBRODT People didn't really care about minimizing space, they just made it that it worked.

ALAN ALDA Just looking at a big tank of hydrogen like that, you'd think, I don't know if I'd like to be in here if this gets hit by a truck. Am I right to be worried about that?

ANDREAS TRUCKENBRODT Well, that's of course one of the big issues, one of the concerns people often raise about safety of hydrogen, that's for sure. So we have a lot of sensors in there, so whenever something goes wrong and hydrogen is starting to leak - well, it never happens, but if it would leak, then of course we shut it off. And the hydrogen has one advantage, as it is so light it just, when it starts leaking or exploding, it just goes up there in the air and nothing stays where you are. So there were some tests, just intentionally made tests, where they ignited hydrogen and they ignited a gasoline car. And the hydrogen burned, but it went off and it was done. Where the gasoline car burned and kept burning. So that's why we feel very comfortable with the safety of hydrogen.

ALAN ALDA (NARRATION) Parked nearby is another delivery van, built just a couple of years ago.

ANDREAS TRUCKENBRODT So just have a look maybe, how it developed.

ALAN ALDA Oh wow, where did it all go?

ANDREAS TRUCKENBRODT All the technology is just underneath the floor, and that's how in just eight years we could really compress the technology to make it fit in there. So this is the development from filling the whole cargo bay of the trunk, to where we are today. The other one had 50 kW, this is a 70 kW system. This is made for our A class, and the A class has a nice design anyway. This is a production car so it's not specifically designed for the fuel cell system. But we have a double floor in here, so you see the fuel cell system is fitting in this part of the car from underneath. We also have the fuel tanks underneath. So for today, we are taking normal production cars to fit the fuel cells in, because that's for us the most efficient way to make a car running.

ALAN ALDA And then once you sell a lot of those, you'll have a market for them and then you'll start designing a different kind of car around the fuel cell.

ANDREAS TRUCKENBRODT But that's an interesting question. We think that it is also important to demonstrate to the people that this is a normal car.

ALAN ALDA Yeah

ANDREAS TRUCKENBRODT So the car doesn't need to look very fancy and specific, it's just a car.

ALAN ALDA This is going to be fun.

ALAN ALDA (NARRATION) The A class Mercedes is a popular small car in Europe, normally powered of course by an old-fashioned internal combustion engine - unlike this one.

ALAN ALDA Just push this all the way down to drive?

ANDREAS TRUCKENBRODT Like in your normal car.

ALAN ALDA It's nice and smooth, uh? How about the range of this car?

ANDREAS TRUCKENBRODT Well, this range is 150km. We didn't want to have any impact on the passenger space here so that's why we only put two bottles of hydrogen in it. If we would like to increase the range... be careful, there is a camera there, a speeding camera.

ALAN ALDA Oh yeah. I have one back here too.

ANDREAS TRUCKENBRODT You can be so fast. The most amazing feature here is acceleration. You can try a little bit once we've left this village here.

ALAN ALDA (NARRATION) Running on its electric motor under the hood, the F-Cell is certainly peppy enough. But of course its most dramatic feature is trailing behind us - a trickle of water and water vapor - and nothing else -- coming from the tailpipe. Andreas Truckenbrodt plans for DaimlerChrysler to be selling fuel cell vehicles to commercial fleet operators by 2010, with the first private vehicles going on sale a few years later.

ANDREAS TRUCKENBRODT And that's interesting, we are just thinking, defining what would be our customer profile ten years from now. And we would certainly expect some technology freaks.

ALAN ALDA Here we are back home. Nice. Nice drive.

ALAN ALDA (NARRATION) Most of the major manufacturers have similar plans to DaimlerChrysler's, moving cautiously toward offering fuel cell vehicles to the public five or ten years from now. And most of them see also these first fuel cell cars' being based on existing models retrofitted with fuel cells and hydrogen tanks. But this approach doesn't satisfy General Motors' Chris Borroni-Bird.

CHRIS BORRONI-BIRD Fuel cells in a conventional vehicle, I associate with a rational approach. You know, there's a certain number of people who are going to want to buy those because they care about the environment. But it's not enough to really help the environment. To really help the environment we've got to create vehicles that people lust over. So we said, what if we design a vehicle around the fuel cell. We're taking this technology, and let's really take advantage of it from a styling standpoint and create a vehicle that is safer, looks more beautiful, it's got more interior space, more comfort, greater performance, and we can do all that when we design a vehicle around the technology.

ALAN ALDA (NARRATION) It took Chris Borroni-Bird and his new design and technology team just two years to come up with the Autonomy concept car that made such a splashy debut in Detroit early in 2002. It's key feature is what its designers call its skateboard - a six-inch thick platform that contains all the car's systems - it's fuel cell, electric motors, computers and controls.

CHRIS BORRONI-BIRD This is the Autonomy skateboard.

ALAN ALDA So the idea is to make a lot of these...

CHRIS BORRONI-BIRD Yes, millions of these, mass produce them, get the costs right down, and then be able to ship it to plants all over America and all over the world in fact and put different bodies on using local labor, local materials, local design, local engineering and really have customized bodies on a mass produced chassis.

ALAN ALDA (NARRATION) The body design they produced for the auto show was strictly for bragging rights only.

CHRIS BORRONI-BIRD We're conveying two messages. One a very futuristic, exciting looking vehicle and that fuel cells in the future aren't just going to be appliance-like vehicles, they're going to be exciting vehicles that people can get emotional about. And secondly, the design is such that it communicates the fact that there's no engine in the body itself.

ALAN ALDA (NARRATION) Since the Autonomy's public unveiling, Chris and his team have been hard at work trying to make the concept a reality - or at least to build a drivable version. They've got the skateboard down to about 11 inches thick -- on their way to their goal of six inches -- and have developed a body that can be simply dropped into place on top of it. Making this separation of guts and body possible is the fact there are no mechanical links between the driver's controls and the wheels. It's all done electronically - so-called drive-by-wire. Sitting behind what we used to call the wheel with no engine in front is a slightly

unnerving experience - especially with the company vice-president responsible for the car riding in the passenger seat.

LARRY BURNS Most people would have hit the pole by now.

ALAN ALDA I don't think you let people hit the pole.

ALAN ALDA (NARRATION) With no mechanical links to constrain them, the Hywire's designers have come up with controls that are more like a Nintendo game's than a car's: no foot pedals, and the brakes and accelerator in the hand grips.

LARRY BURNS We suspect that the best implementation of by-wire technology will be with more of a conventional interface for the vehicle, but to give you a sense of what might be possible we put everything in your hands.

ALAN ALDA I see my right foot is driving a phantom car here. I'm going to put it into this parking spot. Oh!

LARRY BURNS Well, I can see the feedback system got to you a little bit.

ALAN ALDA Let me see what it's like to go backwards.

ALAN ALDA (NARRATION) One simple little trick is having video cameras in place of rear view mirrors.

ALAN ALDA One mirror here and there's another one over there.

LARRY BURNS So this doesn't feel like those jeeps you used to drive on MASH, uh?

ALAN ALDA That does!

LARRY BURNS The by-wire system's going to give us a chance to do some very exciting things in our future cars. We'll be able to distinguish our brands - a Cadillac versus a Chevrolet -because of the way in which we'll tune the steering, the braking and the acceleration just with computer algorithms rather than having to change mechanical parts.

ALAN ALDA Wouldn't everybody want to drive a Cadillac if you could give them software that made them...

LARRY BURNS Oh, I think that's a very important observation. The things that will differentiate the brands will become very important. I'm not saying that the Cadillac feels better, but it could feel different.

ALAN ALDA Oh, right, I've got one hand for the accelerator, the other hand for the brake, I'm driving like a million bucks. Well, you must be relieved I didn't crash this.

LARRY BURNS Oh, you did a wonderful job.

ALAN ALDA (NARRATION) For the last 12 months, the Hywire has been everywhere on the public relations circuit - including here at the Challenge Bibendum, where I got a second shot at its unconventional controls. Ironically, these have tended to eclipse the real revolution the Hywire represents: that it doesn't burn oil and that it doesn't pollute. The Hywire certainly scores points for novelty. The challenge Larry Burns and his team now face is to make its technology commonplace.

LARRY BURNS If we invent this great technology but it's too expensive and only a few people can afford it, it's not going to solve the energy and emission issues that we want it to solve. So you have to get to very, very low cost and very, very high volumes in order to realize the benefits of fuel cell vehicles and hydrogen. That will only happen if the car is compelling, affordable, environmentally sustainable and gives companies an opportunity to generate a yield on their investment. That's really what we're driving to.

ALAN ALDA (NARRATION) It's a destination all the car companies would dearly like to reach before either skyrocketing oil prices or stricter environmental regulations stop them in their tracks. We'll look at what has to happen along the way to the car of the future, next.

Hydrogen Ahead

GUNTHER SCHMIDT That is an engine test lab...

ALAN ALDA (NARRATION) While most of the major car companies are looking ahead to hydrogen's replacing gasoline, not all of them are waiting for fuel cells to be perfected. Here at Ford's research center, for instance, is a car undergoing emissions testing that looks exactly like an every day car - even under the hood.

ALAN ALDA Is this a regular internal combustion engine?

GUNTHER SCHMIDT Looks like a regular engine, but this is much more sophisticated because this uses hydrogen. Therefore, the base engine is, or was, designed to use gasoline, but this is now equipped with hydrogen...

ALAN ALDA So this burns hydrogen instead of gas?

GUNTHER SCHMIDT Yes, you're right, this is a bridging technology finally, which will enable us in the future to go the next step to fuel cell powered cars. Because this has one significant advantage, we can use existing manufacturing facilities, we can partially use existing parts, ignition systems, injectors...

ALAN ALDA How much do you have to change? I mean, is it very costly to switch to this kind of motor from a regular internal combustion?

GUNTHER SCHMIDT Actually it's more expensive, but significantly less expensive compared to a fuel cell powered car.

ALAN ALDA So you'll take it out, huh?

BOB NATKIN Yeah, I'll take it out.

ALAN ALDA (NARRATION) Bob Natkin is the engineer in charge of the hydrogen internal combustion engine. He and his team have spent months tweaking and tuning a regular Ford Focus engine to run on hydrogen instead of gasoline.

ALAN ALDA So I guess you're demonstrating the fast pick-up?

BOB NATKIN Well, the idea...

ALAN ALDA Or is this just the way you drive?

BOB NATKIN A little of both. Eventually the idea is this should be relatively transparent to a normal customer. This should act and feel like a regular car that you're used to driving every day.

ALAN ALDA (NARRATION) With one significant difference...

ALAN ALDA It smells good, you know? Really, it smells like a laundry room.

BOB NATKIN Fresh laundry is what we call it.

ALAN ALDA Moist air, yeah, really nice. That'll turn out to be like a thing that people do, you know, smelling each other's tail pipes.

ALAN ALDA (NARRATION) The car I was sniffing is actually a hydrogen-powered car that's also equipped with hybrid technology. Like regular hybrids, it has an electric motor to supplement the engine - so when the car stops, seconds later the engine does too.

ALAN ALDA OK, now I'm going to stop. One thousand one, one thousand two... wow, the silence is wonderful.

BOB NATKIN Yeah, I know. It's a little disconcerting.

ALAN ALDA Boy, and it's ready to go immediately.

BOB NATKIN Yeah, we have races to see who can take their foot off the brake and get to the gas pedal before the engine starts and nobody's been able to do it yet.

ALAN ALDA You've got hybrids on the road now that use gasoline and electricity. But here, electricity and hydrogen, that seems like, it seems like we're standing next to a car of way in the future. I mean, how far in the future is this car?

BOB NATKIN The technology here is all conventional technology utilizing a new fuel. If we had fuel available this car would be out in a very short period of time.

ALAN ALDA (NARRATION) "If we had the fuel available..." In other words, if hydrogen was as easy to create, distribute, dispense and store in the car as gasoline is today. It turns out that dispensing hydrogen is the easy part - though here at Ford the guys at the pump have to wear special suits to reduce the risk of sparks. This car, like most of the hydrogen-powered research vehicles we've seen, uses hydrogen gas stored in high-pressure tanks under the floor.

BOB NATKIN High pressure isn't necessarily... it's a storage answer, it's not necessarily the only or the best, it's the one we're using currently. And there's a lot of other people that have ideas about unique or different storage capabilities or storage technologies that they're developing. And as one clearly becomes better than all the rest, what will happen is what happens in every free market is people will migrate to whatever one's the best.

ALAN ALDA I keep having to buy these cars. I'll have to get a bigger garage. I'll take it!

STANLEY OVSHINSKY OK.

ALAN ALDA (NARRATION) Back at the Challenge Bibendum, we ran into a husband and wife team who believe they already have the best way to store hydrogen - as a solid.

ALAN ALDA What exactly did you work on with regard to this?

STANLEY OVSHINSKY The whole thing. In other words, our batteries...

ALAN ALDA (NARRATION) A decade ago, Stanley Ovshinsky invented the nickel metal hydride rechargeable battery used today in everything from computers to the Toyota Prius hybrid he and his wife Iris are so proud of.

IRIS AND STANLEY OVSHINSKY Normally this runs on gas but we converted it to run on hydrogen.

STANLEY OVSHINSKY And instead of using hydrogen from a high-pressure tank or liquid hydrogen, both of which are not really going to make it in terms of volume production, then we put our hydrogen as we do in our batteries in a solid form. So hydrogen goes into... You fill it up, we fill it up at a station with a pump that's got our hydrides in it, fills it up in less than five minutes if you like and you then take that and it feeds into the engine and you have an all hydrogen car with solid hydrogen.

ALAN ALDA Now what's Iris getting? IRIS OVSHINSKY I brought a piece of your solid...

ALAN ALDA (NARRATION) The sample Iris has brought over is a proprietary metal alloy that soaks up hydrogen gas like a sponge soaks up water.

ALAN ALDA How do you get the hydrogen out of this and into the car?

STANLEY OVSHINSKY Very easily, because we put it into a tank back here...

ALAN ALDA (NARRATION) Stan and Iris claim their Ovonics tank can store twice as much hydrogen as a typical high-pressure tank containing hydrogen gas.

ALAN ALDA What's keeping us from having these either in our cars or at the gas station to produce hydrogen? What's the roadblock?

STANLEY OVSHINSKY Ah, we're the best-kept secret. Now that we're on television, maybe that will change!

ALAN ALDA (NARRATION) In fact, Stan Ovshinsky had already unveiled his solid hydrogen car to the press a few weeks earlier - and Ovonics is also already in partnership with one of the big oil companies, ChevronTexaco. What's more, they are far from the only group exploring the storage of hydrogen as a solid rather than as a gas or liquid.

LARRY BURNS Now why is that ideal? Well, first of all, if there happened to be any rupture at all in the tank and if it was stored solid state, it's bonded in the material so it's not going to escape. And I think more important for the automobile industry, the structure of our vehicles is oftentimes made out of hollow tubes and we could fill those hollow tubes with this solid-state material perhaps someday. Or you could use that sponge-like material as an energy absorbing material in the front of the vehicle and it could serve the purpose of absorbing energy in a crash as well as storing hydrogen.

ALAN ALDA So you're cushioning your crash with you gas tank!

LARRY BURNS That's right. Isn't that an interesting turn around? That could be a possibility. Now you have to keep in mind, I'm a scientist, I'm head of an R and D laboratory and I'm paid to be optimistic about technology and to think about the future, and to think about the possible opportunities for the world. Solid-state storage of hydrogen, if that breakthrough comes through, this game is going to change very, very fast.

ALAN ALDA (NARRATION) Nowhere is the dream of hydrogen's becoming the fuel of the future more alive than here - perhaps one of the last spots on earth you'd expect such a revolution to unfold. We're in Iceland, whose tiny population of less than 300,000 is entirely dependent on imported oil - oil that provides the fuel for its large fishing fleet as well as its cars, trucks and buses. But if Iceland has no oil of its own, it does possess another underground resource -- hot magma from the earth's mantle welling up beneath a surface that is itself the product of volcanic oozings in the not-too distant past. In many places the magma comes close enough to the surface to heat the groundwater to well above its boiling point. We're walking in one of those spots now, where a borehole was recently drilled to test the potential of the geothermal energy just under our feet.

ALAN ALDA This is just one of many boreholes in the country?

JON BJORN SKULASON Yup.

ALAN ALDA And you could make many more, you could put one pretty much anyplace?

JON BJORN SKULASON Well I wouldn't say anyplace. It's more or less around the crack where the Atlantic Ridge goes through the island. It's remote control. You can open the borehole from far away. Just push the red button and you will see.

ALAN ALDA (NARRATION) The noise is shattering - and a dramatic reflection of the power Iceland is sitting on - power in the last 50 years it has increasingly tapped, first to provide hot water for heating homes, more recently to produce electricity. In fact, one of the country's major tourist attractions - the Blue Lagoon, packed year-round with bathers - is actually the waste pond for one of a half-dozen or so geothermal power plants in Iceland.

JON BJORN SKULASON We have tapped a very small fraction of the geothermal resource. We estimate actually that we have only used about one or two percent of the geothermal source for both heating or electric production. And this is more or less 100 percent renewable power and then we can actually use that to make hydrogen. So we have a big resource to make a lot of hydrogen to power our own vehicles and our own ships and then in the future maybe vehicles and ships in some other countries.

ALAN ALDA You'll be able to transport the hydrogen, which is a way of transporting...

JON BJORN SKULASON Electricity.

ALAN ALDA Electricity, and in turn that's a way of transporting your geothermal resource.

ALAN ALDA (NARRATION) In the last few years, Iceland as a nation has committed itself to this vision of becoming the world's first hydrogen economy, freeing itself entirely from imported oil. Jon Bjorn Skulason heads a venture jointly owned by the government and several major companies with an interest in hydrogen. It has as its symbolic beginning a rather lonely fuel station on the outskirts of the country's capital, Reykjavik.

ALAN ALDA It looks like you are all set up for a car to pull up and fill up.

JON BJORN SKULASON It's actually ready. We can actually... the station is full of hydrogen and if we had vehicles here we could actually fill up vehicles right now. So it's ready for use.

ALAN ALDA Watch where you point that thing!

JON BJORN SKULASON It's fully automatic.

ALAN ALDA Now I saw them putting hydrogen into a car someplace else and they were wearing antistatic suits and they were kind of careful about it. You mean anyone can pull up and jam this in their tank?

JON BJORN SKULASON Well of course you need a little bit of training, we have to think about how to use this. But in the future, you will just drive your vehicle up here, you will plug this into your car, you'll push the button or put your credit card in or whatever, how it's used today, fill your vehicle with hydrogen, put it back again and drive away, it will be no different whatever.

ALAN ALDA Now where is this coming from when it comes out of here?

JON BJORN SKULASON Well we've got to go inside and show you where all the machinery is. So inside here you have all the major components of the electrolyzer, actually the mother of the station as we can call it.

ALAN ALDA (NARRATION) The electrolyzer is actually simply a reverse fuel cell stack, producing hydrogen from electricity and water instead of electricity and water from hydrogen.

ALAN ALDA This is right next to or part of a regular filling station where they sell gasoline, right? And you can add a little building like this and produce hydrogen at a filling station and sell it.

JON BJORN SKULASON Yup. That's what we think actually will be part of the future is actually on-site production of hydrogen. You can see all these oil tankers driving around all over the world. If we designed the future like this we don't need oil tankers driving around anymore. We still need the wires in the air with the electricity, and of course, the water system and pipeline system for the water system, but the distribution is on site.

ALAN ALDA (NARRATION) A few weeks after our visit to Reykjavik's hydrogen filling station, it had a customer - the delivery van we'd seen in Germany, loaned for the ceremonial opening of the station by one of the partners in the venture, DaimlerChrysler. But while Iceland is bullish on becoming a hydrogen economy, it has unique advantages most of the rest of the world lacks - a small, politically cohesive population, and above all of course, an abundant, cheap, clean and renewable source of electricity that can be made into hydrogen on site in stations like this one. In the United States, the questions surrounding both where the hydrogen will come from and how it will be distributed -- so-called infrastructure issues -- are much more difficult to solve. But hydrogen can be made directly from natural gas or from coal or even petroleum. And of course, as in Iceland, it

can be also be made with electricity - which itself can be generated in many different ways.

LARRY BURNS That's the beauty of hydrogen, it comes from so many different sources. Today, we're 98 percent dependent on the petroleum industry for automobile transportation. That's not a good place for our industry to be in. We're pretty much held hostage to whatever is going to happen with the petroleum industry in the future.

ALAN ALDA (NARRATION) Larry Burns has staked his future - and maybe the future of his company - on developing a car that breaks free of its historical dependence on oil.

LARRY BURNS If we can create this vehicle that we envision, we call it a compelling vehicle, one that you're going to want to buy because it's so exciting to own, it's affordable, and it's sustainable environmentally, and we can make money off of it - so you combine these four together and that sets the basis for this change. We're targeting to have that type of vehicle developed by 2010. Then it's kind of like that movie, Field of Dreams --- if you build it, they will come. Now I think the infrastructure will come, Alan, because the vehicle is so compelling and the entrepreneurial spirit of people so strong they are going to want to make the transition happen.

ALAN ALDA (NARRATION) But before that transition happens, and with gas still costing less than \$2 a gallon, we are all going to be tempted by vehicles that are compelling for reasons other than their environmental friendliness. We're at an unused airfield near Stuttgart in Germany, watching something curious about the weaving approach of DaimlerChrysler's F400 Carving concept car.

ALAN ALDA Now, I see one thing that this did on the way up here - I saw the wheels go out like this when it was swerving from side to side.

ENGINEER The wheels go out like that if you are cornering. You are able to have much higher lateral forces. You can drive cornerings very fast.

ALAN ALDA Fast. You can take a corner...

ENGINEER Faster than before.

ALAN ALDA OK, so this would make a good getaway car.

ENGINEER That's right. It's a very sporty car.

ALAN ALDA (NARRATION) Every year, the car companies show off their concept cars - cars unlikely ever to be put into production, but that explore new designs and technologies. The F400 Carving, along with its tilting wheels, has a lightweight carbon fiber body and drive by wire steering and brakes that require as much onboard computing power as a high-end PC. And as the industry confronts the need to discard much of the technology that has sustained it during its first 100 years, cars like this are a reminder that when we customers choose what future car to buy, reason will still have to compete with raw emotion.

ALAN ALDA You know something: I am emotional about this. This is nice, it's fun.

ENGINEER Yeah, it's much more fun if you had the opportunity to drive faster.

ALAN ALDA Yes, well I've got to get to know it better. We're not, you know, we're not on close terms like that yet. How do you turn it off? Ah. Just like a computer, you have to press start to turn it off.