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The Global Race to Fuel the Car of the Future

Iain Carson  
and  
Vijay V. Vaitheeswaran



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Twelve  
Hachette Book Group USA  
237 Park Avenue  
New York, NY 10017

Visit our Web site at [www.HachetteBookGroupUSA.com](http://www.HachetteBookGroupUSA.com).

Printed in the United States of America

Originally published in hardcover by Hachette Book Group USA.

First International Trade Edition: October 2007

10 9 8 7 6 5 4 3 2 1

Twelve is an imprint of Grand Central Publishing.

The Twelve name and logo is a trademark of Hachette Book Group USA, Inc.

ISBN 978-0-446-19962-9 (pbk.)

*Book design by Charles Sutherland*

332.476 29222  
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*For Sarah and Michelle*

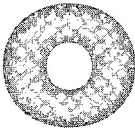





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## The Great Awakening

*Oil is the problem; cars are the solution*

If you want to see the future of automobiles and energy, you don't need to travel to Japan. Look no further than Troy, Michigan, where a latter-day Thomas Edison is forging the path.

“The ages of mankind have been classified by the materials they use—the Bronze Age, the Iron Age, the Age of Silicon. We are at the dawn of the Hydrogen Age.” So proclaims Stanford Ovshinsky, cofounder of Energy Conversion Devices (ECD). “What is more, the hydrogen economy is happening already.”

It is refreshing to find a hydrogen advocate who has actually come up with the goods. After all, plenty of grandiose but unsubstantiated claims have been made over the past few years about the potential for hydrogen to replace fossil fuels as an energy carrier, so some skepticism is certainly in order. In particular, George Bush and the big car manufacturers have crowned fuel cells as the long-awaited replacement for the internal-combustion engine, but the date of commercialization for those automotive fuel cells somehow keeps slipping just beyond the horizon. Many argue that hydrogen is just a cynical long-term diversion used by Bush and Detroit to avoid short-term action

on fuel-economy standards, plug-in hybrids, or other here-and-now options.

And yet, here is Stan Ovshinsky, still trumpeting the virtues of hydrogen. Ovshinsky is no hydrogen hypester. He first outlined his vision for what he calls a hydrogen loop some five decades ago as an alternative to fossil fuels. It starts with water, broken down by solar-powered electrolysis into useful hydrogen fuel that is stored in solid form or in batteries. That hydrogen is then used to power fuel cells, which release nothing but perfectly pure water vapor back into the atmosphere: “The loop goes from water to water!” he explains. Ovshinsky’s green credentials are impeccable. He and his wife Iris founded ECD in 1960 with the goal of “using creative science to solve societal problems.” They foresaw—long before the oil shocks of the 1970s—that the world’s addiction to oil would lead to unacceptable side effects, ranging from resource wars to climate change.

Unlike hydrogen dreamers, he had actually developed products that overcome many (though not all) of the obstacles facing hydrogen. Billions of his breakthrough nickel-metal hydride batteries are now found in consumer devices, ranging from cell phones to game devices to laptops. The solid hydrogen storage system in his batteries is also used by Toyota in all of its Prius models, as well as in hybrid cars made by General Motors (GM), Honda, and other manufacturers. In other words, his quiet but dramatic work on hydrogen energy systems has made the single most important advance in automotive technology—hybrid electrics—commercially possible.

Ovshinsky’s vision describes an arc that takes us from hydrogen batteries today to those superclean hydrogen-fuel cars twenty years into the future. He has delivered the key technology that is getting alternative cars on the move; his vision offers

the ultimate solution, if it can clear the hurdles in its path. All along this trajectory, alternative engines and fuels will come and go as car and energy companies vie in the race to be first with the new technology that will serve the needs of a world worried about energy security and global warming. *Zoom* will tell you how the world came to be faced with this particular challenge, how we got into such a mess. It will chart the future challenge as billions of Chinese and Indians get wheels. It will mark your card on the runners and riders in the new global race to make the cars of the future.

You might wonder why this earnest and innovative do-gooder is fiddling around, trying to improve the automobile. After all, aren't cars the problem in the first place? Cars are often scorned as the most intractable source of global warming. Our utter reliance on automobiles exposes the economy to potential economic shocks from volatile oil prices. To judge by the backlash against gas-guzzlers in recent years, many Americans seem to be convinced that sports-utility vehicles (SUVs) are the work of the devil. So perhaps it makes sense to get rid of the problem altogether.

### ***The Real Trouble with Cars***

Just imagine a world without cars. Suddenly, it might seem that three great evils widely associated with automobiles—environmental harm, economic pain, and geopolitical insecurity—would vanish. But realistically, a world without cars would be a dim, joyless place with much-diminished freedom, mobility, and prosperity.

This is especially true for America, the birthplace of the modern automobile industry and most of the policy, technological, and cultural developments behind mass motorization. From

drive-through banks, to drive-in churches, to roadside Holiday Inns, car culture permeates American life.

After a century of motorization, America crossed a threshold in 1995, when cars and light trucks first outnumbered driver's licenses in the country. Today, there are often more cars in the average American household's driveway than there are drivers inside, and three-car garages are becoming the norm. Inspired by the American example, such developing giants as China and India are now taking to the roads too. Soon, we will be a world of a billion cars.

Oil is the problem, not cars. That is why we must reinvent the automobile. As engines of change, the clean cars of the future can help speed the world toward a more sensible approach to transportation. The snag is getting from here to there. Big Oil clearly has no interest in seeing its main product fall by the wayside, and the Detroit car industry has shown few signs of real innovation or long-term vision.

Stan Ovshinsky and a growing band of entrepreneurs, innovators, and outsiders are now working furiously to spur the sorts of innovations that the established industry powers, Big Autos and Big Oil, simply refuse to develop. The incumbents are doing precious little to save the planet, only perhaps changing a little to kill it less quickly. The energy industry has long had the knowledge needed to pursue petroleum substitutes but has chosen to defend and milk its existing gasoline assets. The car industry has also had the technical ability to produce cars with much greater fuel efficiency but has chosen to build gas-guzzlers instead. Believe it or not, Henry Ford's Model T was a "flex-fuel" car that could run on either ethanol or gasoline and got better gas mileage than the average new vehicle sold in America today. Worse yet, both industries have bitterly fought government efforts to encourage the development of more ef-

ficient cars and alternative fuels or co-opted and corrupted such efforts to the point that they became meaningless.

Now the modern world's most important energy visionary believes that we are on the cusp of a clean-energy revolution. Ovshinsky's vision for a hydrogen loop was just a blackboard exercise when unveiled five decades ago. But since then, he has invented a new field of science (amorphous materials, named Ovonics in his honor) and produced innovations to bring that loop closer to reality. Joachim Doehler, a senior scientist at ECD, says, "Stan starts with a vision—say, 'The computer must work like the mind does'—and then goes out to invent what we need to get from here to there." It is a systems approach.

The best evidence of this at work is Ovshinsky's new solar factory in Michigan. Several decades ago, he argued that solar panels must be made not as brittle crystalline panels in costly batch processes—how almost everyone else does it today—but "by the mile." He was ridiculed. Ovshinsky refused to yield, demanding his team come up with processes for producing miles of thin-film solar material. Doehler, a veteran of AT&T's legendary Bell Labs, recalls telling him it was impossible. The boss proved him wrong, personally designing much of the solar factory from scratch using unusual industrial gases.

Some challenge his record. An article in *Forbes* asked in 2003 why investors "keep giving money to an inventor who can create anything but profits." ECD has lost money for most of the forty-plus years it has been public. As even one of his loyal lieutenants confesses, "This company would have gone bust six times already if it were not for the personal loyalty people felt for Stan; we went the extra mile because this place is unique."

That revelation points to one big way in which the two great geniuses of energy differ. Thomas Edison was a hard-charging man whose pursuit of profit, product, and prosperity drove GE

to commercial success. Contrast that with the Ovshinsky vision and ECD's corporate culture. "We're here to change the world. No more war over oil," he has argued for decades. ECD is clearly committed to clean energy—and Ovshinsky is clearly not motivated by money. The *New York Times* analyzed executive pay in America and found that heads of companies typically get five hundred times the salary of the average worker at their firms; the ratio at ECD is five to one.

### ***The Next American Revolution***

A powerful grassroots movement—call it the Great Awakening—is clearly under way that is sparking a great global race to fuel the car of the future. People are increasingly fed up with the car companies and oil titans, and they are all too aware that these industries have lobbied politicians into gridlock over energy policy. As Ovshinsky and his upstart collaborators were busy developing innovative hydrogen technologies for cars, a separate nationwide coalition of companies and local governments was coalescing around the idea of "plug-in" hybrid cars. Unlike the hugely successful Toyota Prius, a hybrid-electric car that can never be plugged in, these hybrids charge up a battery overnight that can power the first 20 or 30 miles of travel each day. The rest of the day's travel would use gasoline (or, in the future, hydrogen or ethanol fuel). Fed up with the federal government's refusal to enact mandatory curbs on greenhouse gases, local and state governments are forging ahead with their own. Revealingly, today's push for cleaning up carbon and cars is a bipartisan movement: its leaders are Republicans like California's Arnold Schwarzenegger and New York's George Pataki, as well as Democrats like Iowa's Tom Vilsack and Illinois's Barack Obama.

The world is at an energy crossroads, and the decisions made

about cars and oil in America and China over the next decade or so will set the course for the coming century. That is because energy infrastructure can last for decades, and the carbon emitted can last even longer. If we are to set our energy system on the right course before real crisis hits in a decade or two, we need to start that transition now.

Even Detroit could yet prove to be the automotive superpower of the twenty-first century, if Ovshinsky has his way. He is an inspiration in his own right, but there is a larger lesson to be drawn from his extraordinary life that is relevant to the future of cars and oil. And despite the persuasive case he makes for it, that lesson is not that the future belongs to hydrogen and only hydrogen. That may well turn out to be right, especially when the hydrogen economy is defined not merely as automotive fuel cells but as a holistic “water to water” energy loop of the future. The history of energy over the centuries has been decarbonization: man progressed from burning wood and peat to using coal, oil, and natural gas and now to hydrogen. In doing so, we are shifting from carbon-heavy, dirty hydrocarbons to hydrogen-heavy, cleaner ones.

Take the very long view, and hydrogen is clearly the ultimate zero-emissions energy carrier. Even so, the more important (and certainly more immediate) lesson to be drawn here is this: Detroit may be down, but it does not have to be out. And it does not have to bow to Japanese or other foreign rivals. For proof, look no further than Akron, Ohio.

Most Americans probably consider Akron the most ordinary of cities, but not Don Plusquellic. The city’s long-serving mayor has a vision for transforming Akron from a washed-up industrial wasteland into a city of the future. A few years ago he thought of putting solar panels on the roof of the National Inventors Hall of Fame, housed in the city. As he looked into that

project, he came across the Ovshinskys. “Meeting them had a huge impact on me,” he told Ovshinsky’s biographer, George Howard, a professor at the University of Notre Dame. “Seeing Stan’s hydrogen loop made me think I had actually seen the future. I thought, ‘Why not Akron?’ Let’s get into the hydrogen business.”

Why not indeed. It is not only far-flung island states—ranging from Iceland to Hawaii to Vanuatu—concerned about pricey petroleum imports that can embrace a clean-hydrogen future. And it is not just places with hypergreen economies like California and Sweden that can declare a firm goal of becoming completely independent of petroleum. America’s industrial heartland can leapfrog ahead too. ECD and Akron have started with hydrogen testing and storage, but the plans go much further. Using the ample water that the city once used to make rubber (back when it was the tire capital of the world), Ovshinsky plans to make hydrogen using the abundant, cheap, off-peak electricity available from the grid utilities at night. He saw potential for using the city dumps as a source of both biofuel to produce electricity and methane that can make hydrogen: “We can make Akron the ‘Saudi Arabia’ equivalent of the world . . . it’ll be a working example of what needs to be, and can be, accomplished throughout the United States.”

The key obstacle now is Washington’s backward-looking, obstructionist approach to energy—a pork-barrel fiesta that Senator John McCain has called the “leave no lobbyist behind” approach. That has led some to despair that nothing good can ever come out of Congress on energy, given the power of the oil and car lobbies. Techno-utopians argue that magical new technologies will save us, while market fundamentalists say that the invisible hand will do the trick. Well-intentioned corporations keen on clean energy and carbon-free technologies make the ar-

gument that “corporate social responsibility,” not public policy, is the key. And small-government types are anyway suspicious of Washington.

Even the eternally optimistic Ovshinsky seems to share such doubts. “Forget great ideologies! Politics can’t live up to its promise of a better world—but value-driven science and technology can, by improving the material base. The key is practically improving the lives of ordinary people.”

Here is why all of these groups are wrong. When it comes to the thorny geopolitical, environmental, and economic complications involved with cars and oil, America’s federal energy policies do matter. The heady mix of perverse subsidies for fossil fuels and the absence of proper “externalities” taxation of gasoline leaves the game rigged in favor of Detroit and guarantees continued oil addiction. This will not change magically unless the incentives facing entrepreneurs and innovators change: clean technologies will not get their just rewards in the marketplace, and new markets for carbon-free energy will not take off, unless we fix what’s wrong with energy policy so that the playing field is level.

After all, the business of business is business—as it should be. Contrary to what some critics claim, there is nothing inherently evil about oil companies pumping oil or carmakers selling cars. That is, in fact, their job—and for decades, it was socially acceptable for them to do so. The difference today is that society’s expectations are changing: a richer, greener, better-informed world is demanding much more from its energy and transportation industries. The social contract is evolving—but public policies have not yet changed to reflect that progress.

That, in sum, is why government still matters. Only sensible and courageous action by government to take account of the external costs of burning oil can set things on the right

course. Those external costs are not reflected in the pump price of gasoline, but of course we pay for them through the Pentagon budget, the suffering of asthmatic children, and the pain of economic shocks. Only if the federal government spurs change, either through market-based regulation or better yet through carbon taxes, will we level the playing field and give clean cars and carbon-free energy a fighting chance.

That will happen only if everyone is ready to abandon the myth of cheap fossil fuels and pay an honest price for gasoline. There are signs that the Great Awakening is changing consumer attitudes on this crucial issue too. Ask ordinary Americans if they will simply support a hike in gasoline taxes, as the *New York Times* did in 2006, and the majority say no. But when the pollsters asked whether those same people would be willing to support higher gasoline taxes if the money went to reduce oil imports or to fight global warming, a strong majority responded yes.

That suggests that the country is just ripe for a new approach to this issue. Americans will follow political leaders with vision and courage, who put forth a comprehensive, bipartisan, long-term strategy to tackle oil addiction and global warming. No one likes to pay taxes, but Americans do respect straight talk and have always had a strong sense of fair play. If political leaders take the trouble to explain the notion of oil's external harms and make the case for subsidy and tax reform, citizens will rally to the cause.

And if the next president and Congress really do embrace an innovative policy and stop propping up the tired old giants of the fossil-fuel and automobile businesses, then radical change will be possible. Entrepreneurs and innovators would then ramp up their investments, and we could see a technological revolution that makes clean, efficient, gasoline-free cars possible so

that the developing world's legitimate needs for energy and aspirations for mobility can be satisfied, while the rich world's concerns about the environment are met too.

But Washington, D.C., will act only if ordinary Americans—voters, consumers, drivers one and all—speak up, step out, and demand an end to business as usual. As Saint Thomas More argued five centuries ago, government is simply too important an enterprise to leave to the scoundrels; it is the duty of honest, everyday folk to get involved and to make sure our country heads in the right direction.

By taking the real problems posed by cars and oil seriously while debunking wild-eyed claims made by the chorus of despair, the authors hope this book will serve as a call to arms. The challenges are daunting, but the solutions are within grasp if readers mobilize and energize the political process in favor of clean energy. Indeed, there is every chance that they can turn this crisis into opportunity, transforming the grease and grime, soot and sulfur industries that built the twentieth century into the clean, sustainable building blocks of the twenty-first century.

The global race to fuel the car of the future is on.



# I

## HIGHWAY ROBBERY

*America's car and oil industries got the world into the current energy crunch and in the process may have killed off their own future*





## The Terrible Twins

*Cars and oil wrote the history of twentieth-century  
American capitalism*

**A**fter a century of prosperity and power, the industries that shaped America more than any others are now at a crossroads. The age of oil and cars is giving way to something new. Together these two industries dominate world business because of their sheer size. The big five of oil—ExxonMobil, Royal Dutch/Shell, BP, Chevron, and ConocoPhillips—and the world’s automobile giants—General Motors, Toyota, Ford, Daimler, and Volkswagen Group—dominate the lists of the global top-fifty corporations. Each has sales between \$100 billion and \$200 billion.

They spend huge sums each year looking for oil, extracting it, making today’s cars, and developing technologies for the cars of tomorrow. GM in the past five years has spent the seemingly awesome sum of \$1 billion on research into clean cars with hydrogen-fuel-cell engines, with no prospect of making a profit on this in the foreseeable future. But even \$1 billion is barely two days’ revenue for a company GM’s size. That shows how high the stakes are now, as the car industry faces a revolution.

The really big spenders in global research and development are not the white-coated scientists of Big Pharma and biotech or the geeks of Campus Microsoft. They are the legions of engineers, chemists, physicists, and geologists employed by the oil and auto industries. The automobile manufacturers are the biggest spenders worldwide on R & D. As pressure now mounts for them to make cleaner cars, the pace of the race for new technology is picking up.

Since even America has woken up to the threats of climate change caused by the rising emissions of global-warming gases, the car industry is in the front line of the battle against carbon. About a quarter of the man-made greenhouse-gas problem comes from surface transportation, including ships and trains. (Air travel adds another 3 percent.) Cars and light trucks make up the lion's share of such mobile pollution sources. As the oil industry starts tapping the vast but carbon-intensive reserves of "unconventional" hydrocarbons like Canada's tar sands and America's shale, which can be converted into gasoline at great environmental cost, the impact of transportation on global warming may rival even that of coal-fired electricity production.

What is more, because everyday life in most rich countries is built largely around the car, it is sure to be the most difficult source of carbon emissions to moderate. Over its decades of fighting smog, Los Angeles has discovered that it is really hard to change individual behavior to reduce consumption of gasoline, and so it turned to techno-fixes like catalytic converters, which reduced the emissions associated with such gas-guzzling instead. That painful experience explains why technological solutions to tackle the carbon from automobile tailpipes are the key.

Today the problem is greatest in America, Europe, and East

Asia; these three markets account for three-quarters of the greenhouse gases pushed out the tailpipes of the entire global new-car fleet of more than sixty million cars and trucks each year. On average, American vehicles emit around 480 grams per mile, just over double the European level. For Asia, the figure is halfway between the two. The European figure has come down because of the increase in the use of inherently more fuel economical diesel engines, which now power about half of all new cars. The rise of diesel, in turn, is itself the result of European governments placing heavy taxes on gasoline (the retail price for a gallon at the European pump can be two or three times that paid in America) and lower taxes on diesel.

That European models such as Mercedes are now being launched in America with diesel engines is one early indication of technological improvement spreading around the world in response to the global-warming challenge. But that is incremental and inadequate; the scale of the global oil and carbon challenge demands a much bigger response. Any such revolution must be on a huge scale because of the sheer size of the global auto industry.

And Amory Lovins, a farsighted energy thinker who lives atop a mountain in the Rockies, has been arguing for some years now that the car and energy industries must embrace radical change—and, much to the annoyance of industry bosses, has been showing them how to do it.

### ***Ripe for Revolution***

It is a rare company prospectus that begins with a quotation from Goethe: “Whatever you can do, or dream you can, begin it. Boldness has genius, power, and magic in it.” But Lovins is not a normal entrepreneur, as anyone who has met this eccentric and disheveled but unmistakably visionary thinker knows.

The founder of the Rocky Mountain Institute, a leading green think tank based in Old Snowmass, Colorado, thinks the car industry's incremental approach to cutting emissions and improving fuel efficiency will never amount to much. He wants a complete redesign of the automobile, from the bottom up, and intends to show the big boys how it should be done.

This is not the first time the Sage of Snowmass has challenged conventional wisdom. Back during the gloom and doom of the 1970s oil shocks, most energy pundits were convinced that energy consumption and economic growth could proceed only in lockstep, thus making scarcity and future shocks inevitable. In a controversial article in *Foreign Affairs*, Lovins argued back then that there was an alternative “soft” path: if governments, companies, and individuals embraced energy efficiency and other demand-related approaches, then economic growth could be decoupled from gas-guzzling. He was widely ridiculed at the time as naïve or worse, but history has vindicated him. Thanks to public policies like gasoline taxes in Europe and automobile fuel-efficiency standards in America, the world did indeed embrace a soft energy path, and another oil shock was avoided for two decades.

But as the memories of those earlier oil shocks have faded in America, so too have those virtuous policies. The American economy is now much less energy efficient than its chief international rivals, and the average fuel economy of new cars in the country is close to a twenty-year low. Even Henry Ford's Model T got better gas mileage a century ago than today's average new car! The oil and car industries may be spending a fortune on R & D, but their mind-set remains incremental and risk-averse. They are clearly not innovating with the vision and verve they showed back during the golden age of the automobile a century ago.

But now, Lovins has devised a concept car that he hopes will spark a revolution in the motor industry and “revive the spirit of Henry Ford and Ferdinand Porsche.” For a decade, a crack team of engineers brought together by Lovins beavered away in a hideout high in the Rocky Mountains. They came up with the Hypercar, a sleek new automobile powered by a fuel-cell, zero-emissions engine. This engine takes oxygen from the air and hydrogen from its tank to create a chemical reaction that produces electricity and water, the only by-product.

This alone would be unremarkable, given that all the world’s carmakers are now into fuel cells. The difference with the Hypercar vision is that it takes a holistic approach. The entire body is to be made of composite plastics. The transmission and steering are entirely electronic, which removes the need for clunky mechanical parts. Instead of a steering column and wheel, there will be game-machine joysticks, as in the cockpit of the latest Airbus jets—where a “fly-by-wire” system largely replaces heavy hydraulic and mechanical controls. The result is a big car with a fuel economy comparable to 100 miles per gallon of gasoline, far higher than today’s most economical diesel or hybrid-electric cars can achieve.

Can this be serious? Actually, the technologies that Lovins champions are not really far-fetched. Carbon composites, electronic controls, and even fuel cells are feasible today. The reason they have not been much used in cars is that established carmakers have invested vast sums in conventional manufacturing technology, plants for stamping old-fashioned steel assemblies, and the like. This has made them reluctant to embrace radical approaches; they pooh-pooh the Hypercar as fanciful and irrelevant. Undaunted, Lovins has put the key concepts for his car up for grabs as open-source material, hoping that fresh thinkers outside the conventional car industry will pick them up. He has

*"The barbarians aren't at the gates, they're dining with us.*

*Their names are J.Lo, Ja Rule, and Paris Hilton."*

—from **Th!nk**

In a bracing wake-up call to America, Michael R. LeGault mourns the decline of intellectualism, in favor of feel-good fixes and instant gratification in our popular, political, and social cultures—and delivers a no-holds-barred prescription for reversing the erosion of American civilization.

**Has your mind been fed intellectual junk food?**

Americans are abundantly gifted with the ability to lead an intellectual life, but pervasive commercialism, a reluctance to embrace personal responsibility, and a politically correct culture of mindless dependence on received ideas have robbed many Americans of their ability to think.

**It's time to wake up, America.**

**It's time to**

**THINK!**

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ISBN-13: 978-1-4165-2378-9  
ISBN-10: 1-4165-2378-2



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