appliances, and then have Duke Energy maintain and service every aspect of that network.

"For a hundred years we defined the boundaries of our market as being from the generator to the meter on the wall outside your house," said Rogers. Going forward, "I want that market to be from the generator to our customers' rooftops and to the energy applications and energy networks embedded in our customers' homes and offices and cars. That is where the real savings will come—from optimizing those energy networks and applications . . . I have to take my grid and make it smart and make everyone's home into a smart home and everyone's factory into a smart factory and then optimize them all so everyone gets the most service for the least money and least amount of CO_2."

That would be a very different job for utilities—from running an all-you-can-eat-for-five-dollars electron buffet to optimizing an Energy Internet. But that is the future.

And as Jeff Wacker, the EDS strategist, likes to say: "The future is with us, it's just not widely distributed yet." He is right in the sense that we can see today what the future could look like. We can see the technologies taking shape that could make it happen, but we still need a few key breakthroughs to get that future widely distributed.

The Energy Internet I've described, if we can get it built, has the potential to give us more growth with fewer power plants, better energy efficiency, and more renewable energy, like wind and solar, by smoothing out the peaks and valleys in energy demand. If we could just add another breakthrough on top of that—inventing a source of energy that would give us abundant, clean, reliable, and cheap electrons to power this Energy Internet and that would dramatically reduce our usage of coal, oil, and natural gas—the revolution would be complete. Then you would be feeding clean electrons into an energy-saving smart grid, into a smart home, and into a smart car.

That, when it happens, will be the great energy transformation. It will be like two giant rivers coming together—the IT revolution and the ET revolution. And when it happens—when it *really* happens—it will unlock more human potential, more innovation, more possibilities to lift people out of poverty in a sustainable way, than you can possibly imagine. I just want to live long enough to see that day dawn. The next chapters describe how we can make it happen.

ELEVEN

The Stone Age Didn't End Because We Ran Out of Stones

Recently reports have been current in certain newspapers that Mr. Thomas A. Edison, the inventor, has at last perfected the storage battery, and that within a few months electrically propelled vehicles, costing little to buy and next to nothing to maintain, will be on the market. The same story has appeared regularly for years and yet matters do not appear to have advanced much.

—*International Herald Tribune*, November 1, 1907

If I'd asked my customers what they wanted, they'd have said a faster horse.

—Henry Ford

The city of Tianjin, China, is home to many of China's big automakers, and in September 2007 I was invited to speak at the China "Green Car Congress" there. Yes, China, which has been steadily improving its own auto mileage and pollution standards, now holds a conference to talk about the latest in green-car technologies. Who knew? The venue was the Marriott in Tianjin and the audience was mostly Chinese auto industry executives—some pretty tough-looking car guys—who listened to my remarks, via translation, on headphones. I thought hard and long beforehand about what to say to this group that might stimulate their thinking and give them a perspective they hadn't heard before. In the end, I decided to go right for the jugular. The basic thrust of my talk was as follows:

"Every year I come to China and young Chinese tell me, 'Mr. Friedman, you Americans got to grow dirty for 150 years—you got to have your

Industrial Revolution based on coal and oil—now it is our turn.' Well, on behalf of all Americans, I am here today to tell you that you're right. It's your turn. Please, take your time, grow as dirty as you like for as long as you like. Take your time! Please! Because I think my country needs only five years to invent all the clean power and energy efficiency tools that you, China, will need to avoid choking on pollution, and then we are going to come over and sell them all to you. We will get at least a five-year jump on you in the next great global industry: clean power and energy efficiency. We will totally dominate you in those industries. So please, don't rush, grow as dirty as you like for as long as you want. If you want to do it for five more years, that's great. If you want to give us a ten-year lead on the next great global industry, that would be even better. Please, take your time."

At first, I could see a lot of these grizzled Chinese car guys adjusting their earpieces to make sure that they were hearing me right: *"What the hell did he just say? America is going to clean our clock in the next great global industry? What industry is that?"* But as I went on, I could also see some heads nodding and some wry smiles of recognition from those who got my point: Clean power *is* going to be the global standard over the next decade, and clean power tools are going to be the next great global industry, and the countries who make more of them and sell more of them will have a competitive advantage. Those countries will have both the cleanest air and the fastest-growing businesses—not a bad combination.

That is the point I was trying to drive home in Tianjin, by making it into a competitive issue: The longer China focuses on getting its share from a world that no longer exists—a world in which people could use dirty fuels with impunity—and the longer it postpones imposing the policies, prices, and regulations on itself that will stimulate a clean power industry at scale, the happier I am as an American.

America wins! America wins! America wins!

If only . . .

If only our country understood this moment and was doing everything it could to put in place the winning formula—an REEF-IGDCPEERPC < TTCOBCOG—a renewable energy ecosystem for innovating, generating, and deploying clean power, energy efficiency, resource productivity, and conservation < the true cost of burning coal, oil, and gas. Then we really would be able to clean China's clock. But we don't understand this moment and we're not doing all we can, which is why China could still end up cleaning ours.

The Energy Internet I described in the previous chapter would be at the core of such a revolutionary new clean power system. That smart grid is vitally necessary to drive energy efficiency, to reduce demand, and to reduce emissions, but it alone is not sufficient. We also need abundant, clean, reliable, and cheap electrons to feed into that smart grid and create a complete Clean Energy *System*—from the power plant, to the transmission line to your home and business, to your car.

Unfortunately, as noted earlier, we have not found that magic bullet—that form of energy production that will give us abundant, clean, reliable, cheap electrons. All the advances we have made so far in wind, solar, geothermal, solar thermal, hydrogen, and cellulosic ethanol are incremental, and there has been no breakthrough in any other energy source. *Incremental breakthroughs are all we've had, but exponential is what we desperately need.*

That is why the green revolution is first and foremost an innovation challenge—not a regulation challenge. "Ultimately, this problem is going to have to be solved by the engineers," said Craig Mundie, Microsoft's chief research and strategy officer. But how could it be that, with all the green talk and all the green hype, we have not made such an exponential innovation/engineering breakthrough yet?

The answer is twofold. First, real energy innovation is hard. We are bumping up against the current limits of physics, chemistry, thermodynamics, nanotechnology, and biology, and we need to push out the frontiers in each of these disciplines.

But second, more important, and the subject of this chapter and the next: We haven't really tried. That's right, *we haven't really tried.*

We have not put in place the basic requirement for trying: a coordinated set of policies, tax incentives and disincentives, and regulations that would stimulate the marketplace to produce an Energy Internet, to move the clean power technologies we already have—like wind and solar—down the learning curve much faster, and to spur the massive, no-holds-barred-everybody-in-their-garage-or-laboratory innovation we need for new sources of clean electrons.

I cannot stress this point enough. If you take only one thing away from this book, please take this: We are not going to regulate our way out of the problems of the Energy-Climate Era. We can only innovate our way out, and the only way to do that is to mobilize the most effective and prolific system for transformational innovation and commercialization of new products ever created on the face of the earth—the U.S. market-

place. There is only one thing bigger than Mother Nature and that is Father Profit, and we have not even begun to enlist him in this struggle.

We don't need a Manhattan Project for clean energy; *we need a market for clean energy*. That's what we're missing. We don't need a secret government-led initiative involving a dozen scientists in a remote hideaway to come up with a single invention. We need 10,000 innovators, all collaborating with, and building upon, one another to produce all sorts of breakthroughs in abundant, clean, reliable, and cheap electrons and energy efficiency. And we need to create demand, huge demand—*crazy, wild, off-the-charts demand*—for existing clean power technologies, like wind and solar, in order to reduce the cost of these technologies and make them competitive with conventional fossil fuels—coal, oil, and natural gas. We could make these already existing clean power technologies so much cheaper and so much more effective today if we created the market pull that would demand their mass production all over the country. They would move quickly down the learning curve. We could do for solar and wind what China did for tennis shoes and toys.

But the only thing that can stimulate this much innovation in new technologies and the radical improvement of existing ones is the free market. Only the market can generate and allocate enough capital fast enough and efficiently enough to get 10,000 inventors working in 10,000 companies and 10,000 garages and 10,000 laboratories to drive transformational breakthroughs; only the market can then commercialize the best of them and improve on the existing ones at the scope, speed, and scale we need.

But markets are not just open fields to which you simply add water and then sit back in a lawn chair, watch whatever randomly sprouts, and assume that the best outcome will always result. No, markets are like gardens. You have to intelligently design and fertilize them—with the right taxes, regulations, incentives, and disincentives—so they yield the good, healthy crops necessary for you to thrive.

Up to now, we have not designed our energy garden to get the maximum amount of innovation in clean power—not at all. To the extent that we have designed it, we have designed it to produce energy from cheap, dirty fuels, primarily from oil, coal, and natural gas. And then we sat back and let all those in Congress and the private sector who benefited from the use of those fuels to water and fertilize this garden like crazy with government supports—while paying scant attention to everything else. There has been only one rule in our energy garden: It was, to use a term coined by the British economist Paul Collier, "survival of the fattest"—those with the biggest lobbies and deepest pockets make policy.

Now our energy garden is overrun with a tangle of coal, oil, and natural gas pipelines, refineries, and gas stations, and it is very hard for anything new to grow there without getting choked. Have no doubt: Our garden has been designed by the oil, coal, and natural gas interests to suit their needs—to keep these fuels cheap and abundant and difficult to supplant. And the global garden has been designed by the OPEC oil cartel and the petrodictators to suit their interests too. There is no "free market" in energy, where everyone is competing on a level playing field. That is a complete fantasy.

In what free market would you find the U.S. government slapping a 54-cent-a-gallon tariff on sugarcane ethanol imported from Brazil, a democratic ally of the United States, while imposing only a 1.25-cent-a-gallon tariff on crude oil imported from Saudi Arabia, the home of most of the 9/11 hijackers? Only in a market where the American corn lobby has enough clout in Congress to prevent Brazilian sugar ethanol from competing with American corn ethanol—even though sugar ethanol packs seven or eight times more energy—and only in an America where at least some elements of the Big Oil lobby are so bent on keeping us dependent on gasoline for transportation fuels that they always want to make it difficult for any alternatives to undercut them on price. In what free market would we give billions in permanent or long-term tax incentives to the oil, coal, and gas industries, but stop and start every two or three years—for three decades—the puny tax breaks for wind and solar power, making long-term investing in these areas very precarious? Only in a market *designed* to keep fossil fuels cheap and renewables expensive and elusive. No wonder that, as my *New York Times* colleague Jad Mouawad wrote (November 9, 2007) when oil was approaching $100 a barrel, "even at today's highs, oil is cheaper than imported bottled water, which would cost $180 a barrel, or milk, at $150 a barrel."

You are not going to get energy innovation at scale when a barrel of oil is cheaper than a barrel of water or a barrel of milk.

If we want to see the innovation we need in clean electrons, smart grids, and energy efficiency, we need to intelligently redesign the garden—i.e., the market. When it comes to developing the next generation of clean power, "I don't believe in evolution—I only believe in intelli-

gent design," says Amos Avidan, a principal vice president of Bechtel Corporation and an expert on building big power systems. "We need intelligently designed policies to give us the best chance possible to produce the breakthroughs we need."

People often ask me: "What's your favorite renewable energy? Are you a solar photovoltaic guy? A wind guy? A geothermal guy? A solar thermal guy?" My answer today is very simple: "My favorite renewable energy is an ecosystem for energy innovation. I'm an ecosystem for innovation guy." That's what we need above all else—an intelligently designed *system* of policies, tax incentives and disincentives, and regulations that will get every promising source of clean electrons and energy efficiency that we already have down the learning curve faster and will move every new idea for generating clean electrons out the lab door quicker. Only that kind of ecosystem for innovation can give birth to an Energy Internet–smart grid, fed by abundant, clean, reliable, and cheap electrons. It takes a system to make a system.

A single Manhattan Project wouldn't cut it now—not even close. "We need the government to be stimulating exponential innovation by reshaping the market," said Curt Carlson, the president and CEO of SRI, the Silicon Valley research firm, and coauthor of *Innovation: The Five Disciplines for Creating What Customers Want*. "If the government just did the reasonable things, the rest would come into place." Many other major industrial countries in the free world seem to understand this and have begun to take at least some intelligently designed steps to promote energy and environmental innovation and deployment. America has not kept pace. "The only thing we have an industrial policy in place for in this country is agriculture—a nineteenth-century industry," Carlson added. "We certainly don't have an intelligently designed national strategy for energy innovation and commercialization."

We don't want government to be picking the winners, added Carlson. (That is how we got too deep into corn ethanol.) We want government setting the right tax policies, regulatory policies, and education policies, and funding the basic research that pushes out the boundaries of materials science, chemistry, physics, biology, and nanotechnology—preparing all the soil, so the market and venture capitalists can pick off whichever sprouts look most likely to make the difficult transition from drawing board to marketplace. That's what intelligent design is all about. In the short term, a transformational breakthrough is unlikely, said Carlson, "but in the long term, if we do the right things, [clean energy] is a very solvable problem that will put the world in a better place . . . But it is not going to happen with an unintelligent design."

This chapter will look at the price signals that would have to be part of such an intelligently designed system.

Before I go into what sort of price signal we need, though, let me underscore for a moment just how feeble the American system has been during the last fifty years when it comes to stimulating clean energy innovation. Let's start with a statistic. The total investment in research and development by electric utilities in the United States in 2007 was about 0.15 percent of total revenues. In most competitive industries, the figure is 8 to 10 percent. If your total investment in R & D is 0.15 percent of revenues, that's not going to buy you much more than a few subscriptions to *Popular Mechanics* and *Scientific American*. In fact, the American pet food industry spends more each year on R & D than the American utilities industry does.

Another way to underscore this point is with a question: When was the last big breakthrough in clean energy production in the United States? Answer: 1957—with the opening of the world's first central station commercial nuclear reactor, located in Shippingport, Pennsylvania. That's right—we have not had a scale breakthrough in clean energy since the days of filterless cigarettes and segregation.

Still looking for more proof of how uninnovative we've been in the energy field? Ask Jeffrey Immelt, chairman and CEO of General Electric, one of the world's premier manufacturers of power systems. He told me the following story: He has worked for General Electric for twenty-six years. In those twenty-six years, he has seen "eight or nine" generations of innovation in medical technology in GE's health care business—in devices like X-ray equipment, MRIs, or CAT scans—because the government and the health care market created prices, incentives, and competition that drove a constant flow of invention. It was very profitable to innovate in this field and fairly easy to jump in. But in power? said Immelt. One—one generation of real innovation is all that he has seen.

"Today, on the power side," said the GE chairman, "we're still selling the same basic coal-fired power plants we had when I arrived. They're a little cleaner and more efficient now, but basically the same model."

Nine generations of innovation in health care—one in power systems. What does that tell you? It tells you that you have a market that simply has not been shaped to produce clean energy innovation. "You can't look back at the last thirty years," concluded Immelt, "and say that the market in energy has worked."

Between regulated electricity and gas utilities that operate in a monopoly environment and oil companies who had a tacit monopoly over transportation fuels, the key players in the energy market had little incentive to innovate and the new start-ups had little room to emerge. "Energy fundamentally has been underinvested in from the technology standpoint," said Immelt. "The health care industry basically puts about 8 percent of revenue back into R & D every year, and the [entire] energy industry puts about 2 percent back into R & D every year."

Edward Goldberg, president of Annisa Group, business consultants, and adjunct professor at the Zicklin School of Business at Baruch College of the City University of New York, told the story in a succinct little essay he published in *The Baltimore Sun* (February 23, 2007). "Modern American capitalism," he noted,

> is the world's envy of growth. It successfully harnesses the human drive for competitiveness with the human need to create and innovate. Apple booms with the iPod, and Microsoft works day and night to create a better version. But when competition becomes muted and market innovation is deemed not essential, the cornucopia that we call today's capitalism stalls and society is harmed. This is exactly what has happened within our energy giants. The most efficient way of developing new energy resources should be through private enterprise. But our major energy companies have not been pressured by the forces of modern market capitalism to give anything but lip service to the development of new energy sources. While capitalism in America is constantly evolving, creating more efficiencies and innovations, the energy industry appears to be stuck in a mercantilistic mode . . . If this occurred in a small industry, few people would really care. But when the market becomes complacent in its role of innovator in our most vital industry, the government as the guardian of our nation's independence must become the catalyst for innovation . . . In the energy industry, the need to compete for consumers—and thus to innovate—has not been an obligation for years. When was the last time anyone has seen an oil company advertising on TV that its products or services were better than the competition's? Although not monopolies, the energy companies are in effect large, privately owned utilities and delivery systems. Under the premise that energy is so important to the nation that it must be treated differently, these companies are supported unlike any other industry with massive American military investments to protect their supply lines and sourcing. Unlike modern high-tech companies, energy companies are free to ignore Harvard business professor Clayton Christensen's maxim of "disruptive technologies": that new technologies replace existing ones because they are cheaper and more consumer-friendly. Able to disregard this need to create "newness" in the marketplace, energy companies primarily invest in growing and maintaining their supply systems. Without market pressure to innovate to find alternative sources of energy, society receives a much-reduced benefit from the existence of these companies . . . If Toyota takes market share from Ford by manufacturing hybrids while Ford is still making SUVs, Ford is punished by the market. But because they derive most of their profits from sourcing, the energy companies do not need competitive innovation to survive. And because their profits have been extraordinary, they are not punished by the market for a lack of innovation; in fact, they are rewarded—while at the same time, they are at liberty to ignore the market-driven changes that have moved American capitalism forward. The energy majors know that if oil, year in and year out, remains cheaper than competitive energy products, there will be little pressure to invest in new forms of energy. And when the oil market falls . . . it reinforces this corporate stagnation . . . In a world of energy shortages, America no longer can afford the luxury of allowing old-fashioned, non-innovative capitalism to be at the heart of its industrial system, distorting and threatening the system as a whole.

The only way to change this situation and set off the forest fire of innovation in energy that we need is by reshaping the market in a way that will make it much easier for clean power technologies to compete and challenge the incumbent dirty fuels. And the only way to do that is with

taxes and incentives that will stimulate more demand for the clean power technologies that already exist, like wind and solar, and pull them down the learning curve to the "Chindia price," with taxes and incentives that will stimulate more research and development by private companies and universities, and with taxes and incentives that will encourage more investors to quickly commercialize any breakthroughs that government or university or private sector labs might produce.

"No matter how much you tell the market what you want it to do, it is the price signal that markets respond to," said Dan Kammen, the University of California, Berkeley, expert on energy innovation. Therefore, "anyone who invokes markets and doesn't want to invoke a price signal failed Econ 101. We invoke the market in energy, but we don't use it. If you want a market to produce something and there is no price signal, you don't have a market. You have to have a price signal."

Prices and Innovation

The person who best expressed the critical importance that relative prices play in stimulating innovation in renewable energy was none other than the late great Saudi Arabian oil minister Sheikh Ahmed Zaki Yamani. Back in the 1970s, as OPEC was just starting to feel its oats, Yamani used to warn his colleagues not to raise oil prices too high, too fast, for fear of causing a government and market reaction in the West that would trigger massive innovation in wind, solar, and other forms of renewable energy.

The way Yamani put it to his OPEC colleagues reportedly went something like this: "Remember, boys, the Stone Age didn't end because we ran out of stones." It ended because people invented alternative tools made of bronze and then iron. Yamani knew that if the oil-consuming countries actually got their acts together to produce renewable energy at scale or to drive energy efficiency breakthroughs exponentially higher, the oil age would end with millions of barrels of oil still underground, just as the Stone Age ended with a lot of stones still on the ground. Yamani knew that the price signal—the price of oil versus the price of renewables—was everything, and OPEC needed to keep its crude prices exactly at the level where the cartel could earn the maximum returns without spurring the West to innovate any scale alternatives to oil.

Our goal needs to be to make Yamani's nightmare come true.

The way to do that is by creating our own price signal to trigger the market to launch those 10,000 innovations in clean energy in 10,000 garages and 10,000 laboratories. The market will give us what we want, but only if we give the market the signals it needs: a carbon tax, a gasoline tax increase, a renewable energy mandate, or a cap-and-trade system that indirectly taxes carbon emitters—or some combination of all these.

Nate Lewis, the Caltech energy chemist, employs a very useful analogy to explain why exactly taxing the dirty fuels is so critical in order to stimulate massive innovation in and deployment of clean power. It goes like this: Let's say I invented the first cell phone. And I came to you, dear reader, and said, "Have I got a deal for you! I have just invented a phone that you can carry in your pocket!"

You would probably say, "Wow, a phone that I can carry in my pocket? Really! That would change my life. I'll buy ten and pass them out to all my employees."

I'd say, "Ten it is! But I have to warn you: This is the first-generation model. They're going to cost you $1,000 each." You would no doubt say, "Sounds like a lot, but it'll be worth it—like I said, a phone that I could carry in my pocket would change my life."

So I sell you ten, and I sell the next reader ten, and the next reader ten . . . Six months later, guess what? I am back with a new version of my little cell phone. It's smaller, lighter, and costs only $850. I'm on my way down the learning curve.

Now I am on a roll. So I go back to my innovation lab and this time I invent a solar-powered light. I come back to you again, dear reader, and say, "Remember that cell phone I sold you? Worked out pretty well for you, right? Well, now I have another deal. See that light fixture above your head? I am going to power it with electrons created by the sun. But this is brand-new technology, and it's not cheap: It will cost you an extra $100 each month to power your light fixture that way."

And what would you say back to me, dear reader? You would probably say, "Tom, um, remember that cell phone you sold me? Now, that changed my life. I had never had anything like it. But in case you haven't noticed, there's already light coming from that fixture above my head. It works just fine, and, frankly, I really don't care where the electrons come from. Sorry, Tom, but I will pass."

There is only one way to change that outlook. The government needs to come in and tell you, dear reader, that from now on you are going to pay the full cost of all the CO_2 and pollution from your incandescent,

coal-powered light fixture, and therefore it is going to cost you $125 more a month to turn on that light. Then my solar-powered light for only $100 more a month looks like a bargain, and you'll take ten and so will all the other readers of this book, and six months later, guess what? I will be back with the same solar lighting system for only $75 more a month. I will be down the cost-volume learning curve, and, innovation being what it is, I will eventually get that solar light cost below that of the coal-powered one. I will have taken my new innovation to scale.

Everyone says that building a renewable energy infrastructure is the moon shot of our generation. I wish.

"Building an emissions-free energy infrastructure is not like sending a man to the moon," explains Nate Lewis.

> With the moon shot, money was no object—and all we had to do was get there. But today, we already have cheap energy from coal, gas, and oil. So getting people to pay more to shift to clean fuels is like trying to get funding for NASA to build a new spaceship to the moon—when Southwest Airlines already flies there and gives away free peanuts! I already have a cheap ride to the moon, and a ride is a ride. For most people, electricity is electricity, no matter how it is generated. Making [cleaner] energy doesn't provide them with something new. So you are asking them to pay for something they already have *that does the exact same thing*. Nobody would be buying iPods in the numbers they have if their cell phones could already download music.

The critical thing to remember is that clean energy gives you a new environment, but not a new function. "Electrons are electrons—not blue or green electrons," notes Lewis. "They all just make the lightbulb white. They don't search your e-mail, and they won't correct your spelling."

Therefore (I repeat) if we want to get both forms of innovation at a large scale—breakthroughs that lead to whole new ways of generating clean electrons and breakthroughs that come by getting the clean power technologies we already have down the learning curve faster—we need the government to level the playing field by taxing what we don't want (electricity from carbon-emitting sources) and subsidizing what we do want (clean power innovation). That's what will create the market demand we need at the scale we need.

In 2000, the International Energy Agency produced a report, "Experience Curves for Energy Technology Policy," that underscored how, if government increases demand by using price signals, it can move existing technologies quickly down the learning curve and get much bigger deployment at lower costs much sooner. "With historical annual growth rates of 15. percent, photovoltaic modules will reach break-even point around the year 2025," said the IEA study. "Doubling the rate of growth will move the break-even point 10 years ahead to 2015 . . . If we want cost-efficient, CO_2-mitigation technologies available during the first decades of the new century, these technologies must be given the opportunity to learn in the current marketplace."

In other words, we need new stuff, we absolutely do. But the old stuff—wind, solar, solar thermal, and geothermal—is here, and it works. If we can just stimulate the market with the right price signals to get them down the learning curve faster, they could make a very big dent right now. All you have to do is watch how prices of solar panels and wind power have steadily fallen around the country as the market demand for them has expanded. Manufacturers take advantage of economies of scale and learn new ways to produce solar panels or wind turbines more efficiently. But they still have a ways to go to be competitive with coal. That's why we want to expand the market for these existing renewables even more. And that is why I focus on the market, not on a Manhattan Project.

"The analogy of a massive government Apollo program or Manhattan Project is so flawed," argues Joseph Romm, the energy physicist. "Those programs were to create unique noncommercial products for a specialized customer with an unlimited budget. Throwing money at the problem was an obvious approach. To save a livable climate we need to create mass-market commercial products for lots of different customers who have limited budgets." Only a properly shaped market can do that, added Romm, and we should be creating that market "right now"—rather than just hoping and praying and betting the farm on some magic, totally new breakthrough for generating clean electrons. I love magic. We need a magic breakthrough. Close your eyes and pray that we will find one soon. But in the meantime, let's open our eyes and see all the clean electrons that can be generated from existing technologies hiding in plain sight—if we create the right price signals in the marketplace to get them to scale.

The price signal we use may not even have to be a tax. It could just be a floor price. When crude oil was $50 a barrel, the U.S. Congress wouldn't have dared to impose a $50-a-barrel tax and make it $100 a barrel. But now that it is over $100, and this is stimulating more investments in alternatives, the government could declare that it is imposing a floor price of $100 a barrel. If oil stays above that, fine. If it goes down to $90 a barrel, the government will add a $10 tax. It could fix a similar floor under gasoline at $4.50 a gallon.

This would remove a big source of uncertainty from the shoulders of energy investors. If inventors and venture capitalists believe that the price of their new clean energy invention can always be undercut by the dirty old alternative, we are not going to get new innovation at the scale we need. And we are not going to get existing clean power technologies down the learning curve at the scope we need. After the oil price spikes in the 1970s stimulated enormous innovation in solar and wind power, the OPEC price collapse a decade later wiped out all these investments and governments lost interest in supporting them. Companies and investors have just seen this play too many times. They are still wary, even at the current price of oil, that they will make a big bet on renewable energy and then the benchmark oil price (now over $140 a barrel) will fall to $75 or even $50 a barrel next year, the market for alternatives will disappear, and their company will look very foolish to its shareholders.

Consider Toyota. As I write this book, there is a three-month waiting list to buy a Prius hybrid in America. Why? From the beginning, Priuses have been manufactured in Japan and then shipped here. Sales of the Prius go up and down in tandem with the price of gasoline. When the price of gasoline soared to $4.50 a gallon across America, demand for Priuses went through the roof. Yet only in July 2008 did Toyota announce that it intended to expand some of its Prius production to America—but not until 2010, at a plant in Mississippi originally designed to build SUVs. I guarantee you, if the White House had instituted a Patriot Tax on gasoline after 9/11 or set floor prices for oil and gas, there would be Prius factories in three different states in America today—plus, the U.S. Treasury, not the world's petrodictators, would have gotten the extra dollar or two a gallon.

That lingering uncertainty about the long-term price of oil is why some of our biggest energy companies, the kind you want to be "all in" on clean-tech innovation, are not all-in. You've seen those poker games

on TV when the guy from Las Vegas wearing sunglasses and his baseball cap backward takes his whole pile of chips and says, "All in," and everyone around the room gasps. That is what we want to see America's best industrial-innovation companies doing—pushing their piles of chips all in for innovation of clean electrons and energy efficiency systems. Yes, venture capitalism is important, but what is just as important are the bets that these giant companies make, because when they see a lasting, durable, and lucrative market for renewables they can mobilize thousands of engineers, scientists, and researchers behind it, and with their global manufacturing and marketing abilities they can get products to scale farther, wider, and faster than anyone.

General Electric, DuPont, and Microsoft are America's premier engineering, chemical/biosciences, and software companies. And yet if you interview executives at all three, they will tell you that when it comes to renewable energy, or in the case of Microsoft, energy efficiency software, they have not been all in. Too bad. Microsoft's research budget alone is about $6 billion—which is more than all the venture capital money that went into clean energy technologies in 2007—and *triple* the federal government's combined investments in energy efficiency and renewable energy R & D.

All three of these companies are making bets on clean power and energy efficiency innovation, but they are still not as big as they could be. While they are all certainly intrigued and enticed to some degree by the ceiling price that crude oil has shot through—$140 a barrel—what will make them go all in would be a floor price on crude oil or carbon content that would tell them and their investors that the price of these fossil fuels will never again fall below a certain level. As Kenneth Oye, the MIT expert on innovation, likes to say: "Price fluctuations are not the same as high prices." Just because oil may have soared to $140 a barrel doesn't mean that one good recession, or one big discovery off the coast of Brazil, can't send the price tumbling again and wipe out investments in alternative energy. It's why companies like GE and DuPont focus not on the ceiling price of oil, but on the floor.

GE's Jeffrey Immelt put it best: The big energy players are not going to make "a multibillion-dollar, forty-year bet on a fifteen-minute market signal. That just doesn't work." Big industrial players like GE need some price certainty if they are going to make big long-term bets on clean power, and to those market dogmatists who say that the government

should not be in the business of fixing floor prices or other incentives to stimulate clean power, Immelt says: Get real. "Don't worship false idols. The government has its hand in every industry. If we have to have them, I'd prefer they were productive rather than destructive."

Those governments that have figured this out have benefited enormously already. The one clean power area where GE is now into a third-generation innovation is wind turbines, "thanks to the European Union," Immelt said. Countries like Denmark, Spain, and Germany imposed portfolio standards for wind power on their utilities—requiring them to produce a certain amount each year—and offered long-term subsidies. This created a big market for wind-turbine manufacturers in Europe in the 1980s, when America abandoned wind because the price of oil fell. "We grew our wind business in Europe," said Immelt.

Right now about half the states in the United States have renewable energy mandates that require their utilities to acquire a certain amount of power from solar, wind, hydro, geothermal, or biofuels, but each state has a different standard! Congress tried to pass a uniform national standard for the whole country in 2007, but it was defeated.

"If you had a national renewable energy mandate that covered all fifty states, that would tell me that there is going to be so much demand for wind or solar or geothermal [so] you can really make a big bet," said Immelt.

> When the minister of energy and environment in Europe said to me in 2000, there was going to be 10 percent renewables all across Europe, that is what got the wind industry going there. You have to build the certainty that demand is going to be there. We will take the technical risk, we will fund the technology breakthroughs, but I have to know that if I make it work there is a $20 billion market that I can step into. That is what has not existed in energy but has existed in health care and in aviation—you know you have a market . . . This has been a big problem holding back nuclear power. What scares us is making these big R & D bets and not knowing if we will ever get an order.

It doesn't much matter where the government sets a floor price for crude oil or gasoline—whether it is $80 a barrel or $4 a gallon, said Chad Holliday, the DuPont CEO. The important thing is that it be a credible floor.

> Then my investors say, "I know that you are not wasting my money—the market is certain." If they set the market, all I have to do is to show the investor that the technology is real. That takes away half the problem. I am talking to investors all the time. [They] keep saying to me: "What if all this goes away?" We need some reasonable certainty . . . We used to own an oil company [Conoco] and we concluded that we could not be a great oil company and a great science company, so we decided to sell [Conoco]. I paid the three best consulting companies in the world to tell me what the price of crude oil was going to be. They assured me that it could not go over $24 a barrel—or that the probability was very small. [Today,] the market is not sure where the oil price is going to go. Just like it is way up there now, no one can assure it will not go back down. That is why Jeff [Immelt] and I are arguing that there has to be a cost for carbon, no matter how you create it. There has to be a simple price signal.

In 2007, Holliday gave me a concrete example: "We have about a hundred scientists working on cellulosic ethanol," which is ethanol made from waste or switchgrass, not from food crops. "My guess," he added, "is that we could double the number and add another fifty to start working on how to commercialize it. It would probably cost us less than $100 million to scale up. But I am not ready to do that. I can guess what it will cost me to make it and what the price will be, but is the market going to be there? What are the regulations going to be? Is the ethanol subsidy going to be reduced? Will we put a tax on oil to keep ethanol competitive? If I know that, it gives me a price target to go after. Without that, I don't know what the market is, and my shareholders don't know how to value what I am doing . . . You need some certainty on the incentives side and on the market side, because we are talking about multiyear investments, billions of dollars, that will take a long time to take off, and we won't hit on everything."

Some will dismiss this as corporate whining. I don't. Energy innovation is hugely expensive and you are always competing against an existing cheap—dirty—alternative. Put in a floor for crude oil, natural gas, and gasoline in America, or a permanent tax on carbon to lift the price of coal, and you will see the ceiling that has existed on energy innovation blow right off. "Government is a huge player in health care, with huge

subsidies," said Immelt. "Cancer will be cured in our lifetime because of that. Why not in [renewable] energy?" Other countries have certainly figured that out.

"We would like to go quickly to next-generation photovoltaics for solar," said Holliday. "The governments of Hong Kong and Singapore found out about it, and both are pursuing us heavily [with incentives] to build the plant in their cities. Why isn't the United States doing that? I'm out in Hong Kong, and the new governor of Hong Kong shows up at our meeting, uninvited ahead of time, just to tell us: 'This is really important. You have to be in Hong Kong. I know Singapore is talking to you, but you need to be here.' The U.S. bureaucracy is just not doing this kind of thing."

Bottom line: America needs an energy technology bubble just like the information technology bubble. In order to get that, though, the government needs to make it an absolute no-brainer to invest in renewable energy. Sure, we'll waste some money; yes, there will be plenty of people who go bust along the way; but in the end we will transform our economy and save ourselves from so many other problems in the process.

Right now, in America, we have a bubble in "stories" about clean energy, but we do not have a clean energy bubble. The amount of venture capital in clean energy in 2007 was less than $5 billion. The amount of venture capital that went into the dot-com boom at its height in 2000: $80 billion. If $5 billion fell off the table in the dot-com bubble, nobody even bothered to pick it up.

I first learned about the value of bubbles from Bill Gates at the Davos World Economic Forum in 1999. I wrote about the impromptu tutorial he delivered there in my book *The Lexus and the Olive Tree*. Gates was giving his annual Davos press conference on the state of Microsoft and technology innovation. At the time, the Internet bubble was at gale force. All the reporters there kept asking him variations on the question, "Mr. Gates, these Internet stocks, they're a bubble, right? Surely, they're a bubble. They must be a bubble?" Finally, an exasperated Gates said to the assembled reporters: "Of course they're a bubble. But you're all missing the point. This bubble is going to attract so much new capital to this Internet industry that it is going to drive innovation faster and faster." Indeed, it was precisely the overexuberance of the dot-com bubble that led to the overinvestment of billions of dollars into fiber-optic cable from the late 1990s to the early 2000s, which accidentally wired—and flattened—the world, making Internet connectivity virtually free for everyone. That

infrastructure was paid for largely by American and European investors. Many of them ended up losing their shirts in the dot-com bust, but the wired world they left behind made it possible for Indians, Chinese, Brazilians, and others from the developing world to compete, connect, and collaborate more cheaply and easily than ever before in history. The dot-com bubble funded so much innovation during the 1990s that in just a decade it spawned the Internet–World Wide Web–e-commerce ecosystem that became the IT revolution.

Economists have long known that bubbles, despite the money they waste and the grief they cause, can drive innovation at a fever pitch and finance the wires and plumbing that pave the way for the next big boom, bubble, and bust. The *Newsweek* economic writer Daniel Gross wrote a book about this phenomenon, called *Pop!: Why Bubbles Are Great for the Economy*, which underscores the economic logic of bubbles and makes the argument that they have actually been a key driver of "America's remarkable record of economic growth and innovation." Sure, he argues, most early investors went bust in the railroad or telegraph bubbles, but the infrastructure they left behind vaulted our economy forward. Gross, not surprisingly, also contends that the best way to trigger a real breakthrough in alternative energy would be to trigger a real energy bubble. It worked with IT. It can work with ET.

Prices as a Brake on Bad Behavior

But there is another reason, beyond the necessity of innovation, for a healthy society to want to reshape the energy market with taxes and regulations. It's called life and death, or stability and instability. This is becoming a survival issue. Quite simply: Continuing with the Dirty Fuels System, in a world that is hot, flat, and crowded, will drive all five trends shaping the Energy-Climate Era—energy supply and demand, climate change, petrodictatorship, biodiversity loss, and energy poverty—to unmanageable extremes. We need the market to send different signals. The legendary environmentalist Lester Brown, in his excellent book *Plan B 3.0*, quotes Oystein Dahle, former vice president of Exxon for Norway and the North Sea, as observing: "Socialism collapsed because it did not allow the market to tell the economic truth. Capitalism may collapse because it does not allow the market to tell the ecological truth."

What he meant, of course, is that the basic paradigm of modern, industrial-age capitalism, which flowered in the nineteenth and twentieth centuries, treated things like pollution, waste, and CO_2 emissions as essentially irrelevant "externalities" that could be ignored. As any economics textbook will tell you, an externality is any cost or benefit resulting from a commercial transaction that is borne by or received by parties not directly involved in the transaction. A factory that pours pollution and CO_2 into the atmosphere and toxic waste into the river is a classic example. Let's say that the factory makes toys. Those toys will be priced at the cost of labor and materials, plus a markup for profit. The two parties in the transaction are the manufacturer and the consumer. But there is an "externality" that is being paid for by some third parties—global society and planet earth—and that externality is the short- and long-term health consequences of polluting the air, poisoning the river, and intensifying global warming by making those toys with coal-fired power and toxic chemicals.

We have been fooling ourselves with fraudulent accounting by not pricing those externalities. As Lester Brown put it, we as a society "have been behaving just like Enron, the rogue energy giant, at the height of its folly." We rack up stunning profits and GDP numbers every year, and they look great on paper "because we've been hiding some of the costs off the books." Mother Nature has not been fooled. That is why we are having climate change. That which is not priced is not valued, and if our open lands, clean air, clean water, and healthy forests are not valued, the earth, when it is this flat and this crowded, will become a very hot, no-cost landfill very fast. When markets underprice goods and services by failing to price their externalities, and the impact of that underpricing has highly negative economic, health, and national security implications, it's the job of government to step in and shape the market to correct that failure.

"How can the invisible hand [of markets] be a rational allocator of resources if it is blind to the externalities?" asks Ray Anderson, founder and chairman of the eco-sensitive carpet manufacturers Interface Inc.

The government used a combination of taxes and education to get millions of people to stop smoking cigarettes and guzzling alcohol, and it needs to do the same thing to get the economy to stop smoking carbon and guzzling gasoline. Our economic, physical, and geopolitical health depends on it.

What Kind of Price Signal?

So if those are all the reasons to create a price signal, what are the strengths and weaknesses of each option? The options discussed most often are a carbon tax, a gasoline tax, "feebates," an indirect tax through a cap-and-trade system, and a renewable energy mandate. I would be happy to see us move in any of these directions, as long as the effective tax is high enough and long-term enough to really change behavior.

Under a cap-and-trade program, the government sets an overall cap on the level of CO_2 emissions the United States economy would put into the atmosphere by a certain date. This cap would define the absolute maximum amount of CO_2 that could be emitted in the United States. Over time this cap would be reduced, resulting in fewer CO_2 emissions and higher CO_2 emission costs. Each business would receive, either through issuance or auction, tradable allowances equal to their maximum allowable level of CO_2 emissions. Those firms that can reduce their emissions more cheaply and efficiently could sell their unused allowances to others who would otherwise have to pay more to comply. A cap-and-trade system was how the U.S. eventually controlled acid rain pollution—although there were far fewer players involved.

Eileen Claussen, president of the Pew Center on Global Climate Change, argues that cap-and-trade is preferable to a carbon tax on a number of grounds. To begin with, "while a tax provides for cost certainty, cap-and-trade provides for environmental certainty," she said. The cap is fixed by the government on the basis of what scientists tell us is the level of emissions we need to get to in order to protect the climate. The danger with a tax, Claussen argued, is that some people will just pay it, as they now pay higher gasoline prices, and still go out and buy a Hummer that pours more CO_2 into the atmosphere. And, as everyone knows, new taxes are also very difficult to get through Congress—especially a tax that might actually bite enough to make a difference on CO_2. Also, a cap-and-trade system does give the government a little more flexibility. It can, initially, adjust the allocations to utilities and businesses that are heavily dependent on coal—and therefore would get hit hardest—to ease their transition to a low-carbon economy. For a cap-and-trade system to work, though, you also have to have a serious price tag on spewing carbon—at least $30 per ton of CO_2 emissions.

Advocates of a carbon tax see things differently. (I lean their way.)

They argue that a tax is preferable to a cap-and-trade regime because it is simpler, more transparent, and easier to calculate, and that it would cut across the whole economy and could easily be adjusted to ease the burden on at least lower-income workers by lowering or eliminating their payroll taxes. Tax advocates argue that an economy-wide cap-and-trade system would be more complicated to implement and would invite all kinds of lobbying for special exemptions.

Beyond the complexity, the big thing that bothers me about cap-and-trade is that it feels like a "hide-the-ball" strategy, which is precisely the kind of thinking that has gotten us into this problem. People need to know that we are in a new era that will require systemic change. But the whole point of a cap-and-trade regime is to disguise any pain and pretend that we aren't even imposing a tax. To my ear, it is like trying to desegregate the University of Mississippi, Ole Miss, in 1962 by letting James Meredith go to night school. That never would have worked. He needed to march right through the front door in broad daylight—and people needed to see that. It changed everything. So it is with the carbon tax. The price signal we need on carbon is not just about financial engineering to change economic behaviors. It is also meant to change the perception of where we are as a country and a species. It can't be disguised. We have to go from "this is the best we can do" to "this is how we are going to do it best."

That said, whichever system can get through Congress quickest, *without being watered down*, I will gladly embrace.

Some have argued that a carbon tax would disadvantage the American economy by making our exports more expensive and less competitive. I disagree. To begin with, there are many things that go into the price of exports, most important the value of your currency. Second, several European countries, like Denmark and Norway, have long had CO_2 taxes. Denmark today is the world's leading exporter of wind turbines and has an unemployment rate of about 2 percent—in part because the way it has taxed energy has helped to stimulate a whole new clean-tech industry there. Finally, if America were to put on a carbon tax and, say, China didn't soon follow suit, it would not take long for Congress to impose a "carbon tariff" on Chinese exports made with dirty fuels.

As for gasoline, there are several sensible approaches. One is the price floor I suggested earlier. The energy economist Philip Verleger, Jr., has proposed phasing in a gasoline tax, $5 or $10 a gallon, and using that money to reduce payroll taxes and to create a government fund that

would buy back gas guzzlers and crush them. Many consumers are now stuck with big cars that they cannot afford to trade in for smaller, more fuel-efficient ones. "The best monument to 9/11 we could erect would be a mountain of crushed gas guzzlers," said Verleger.

Amory Lovins, the renowned environmentalist who cofounded the Rocky Mountain Institute, has proposed a system of "feebates" on automobiles to discourage people from buying gas guzzlers and to encourage them to purchase fuel-efficient cars instead. "Within each size class, new-car owners pay a fee or get a rebate—which and how big depend on a car's efficiency—and the fees pay for the rebates," said Lovins. "The increased price spread encourages a buyer to buy an efficient model of the size he or she prefers. The buyer saves money; automakers make more profit; national security improves."

It is hard to imagine anything with more positive impacts than increasing the gasoline tax in the United States, where gasoline still costs less than half of what it does in Europe—thanks to the heavy taxes there. Gasoline taxes help reduce consumption, shift people to more fuel-efficient vehicles, shrink the amount of money we send to petrodictators, improve the air quality, strengthen the dollar and the balance of payments, help mitigate global warming, and give citizens a feeling they are contributing something to the war on terrorism.

"This is not just a win-win," said the Johns Hopkins foreign policy expert Michael Mandelbaum. "This is a win-win-win-win-win."

Another effective price signal, as Jeffery Immelt noted, would be a national—*a national*—renewable energy mandate. Such a mandate would tell power companies in every state that by a certain date—say 2020—they would by law have to generate 20 percent of their power from renewable energy: solar photovoltaic, solar thermal, hydro, wind, wave, or any other clean process. A renewable mandate like that would stimulate massive amounts of innovation, because it would take existing technologies, like wind and solar, and push them quickly down the learning curve by creating a huge national market that would be a sure thing for investors to dive into. The politician who actually proved that best was a guy named George W. Bush, when he was govenor of Texas. He pushed and signed the Texas Renewable Portfolio Mandate in 1999. The mandate stipulated that Texas power companies had to produce 2,000 new megawatts of electricity from renewables, mostly wind, by 2009. What happened? A dozen new companies jumped into the Texas market, including one from Ireland, and built wind turbines to meet

the mandate—so many that the 2,000-megawatt goal was reached by 2005. So the Texas legislature upped the mandate to 5,000 megawatts by 2015, and everyone knows they will beat that too. Renewable energy mandates work.

Finally, we built over a hundred nuclear power plants in the quarter century before 1979, when the accident at Three Mile Island brought a halt to all nuclear plant building in America. We need to do the same thing again, and we need to go on a crash program to extend the life of those nuclear plants we've already built. The threat of a nuclear leak, with today's new technology, is much less serious than the threat from climate change. But to build a new nuclear plant costs a minimum of $7 billion today, and would take probably eight years from conception to completion. Most CEOs have about eight years in office, and there are not a lot of utility CEOs who would bet $7 billion—which might be more than half their company's market cap—on one nuclear project. For many utilities in prior decades, the construction of nuclear plants became a "you bet your business" proposition, leading to the demise or economic crippling of utilities like the Long Island Lighting Company and the Public Service Company of Indiana. Therefore, because of the risks of lawsuits and delays, it is probably going to take at a minimum government loan guarantees to relaunch America's nuclear industry.

Read My Lips

The best way to fully appreciate the scope of the challenge we face in shifting to a Clean Energy System is to reread your Machiavelli. My favorite passage in *The Prince* goes like this: "It ought to be remembered that there is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in introducing a new order of things, because the innovator has for enemies all those who have done well under the old conditions, and lukewarm defenders in those who may do well under the new. This coolness arises partly from fear of the opponents—who have the laws on their side—and partly from the incredulity of men, who do not readily believe in new things until they have had a long experience of them."

This is one more reason we need government to set a price signal to stimulate energy innovation. When you're moving from one system to another, the first step is always painful and more expensive than the status quo—and in a world that is hot, flat, and crowded, it is going to become more painful and more expensive every year that we wait. A price signal would spur the public and businesses to make the transition sooner rather than later. But our leaders have been afraid to lead. As a result, we have really moved only when external forces—like the 1970s Arab oil embargo—have caused enough pain (and long enough gas lines) that our leaders felt they had the political cover to do the right thing and order a doubling of fuel economy for American cars.

Who will tell the people? Yes, I know the experts say that asking the public to pay a tax without a short-term benefit is a political impossibility. Yet in the past, on the big issues like women's suffrage and civil rights, the public was out ahead of the politicians—and politicians can underestimate the public's willingness to do the right thing when it's clear what the right thing is and what the true costs and benefits of the alternatives really are.

It's all about framing. Let's imagine an election campaign in which one candidate favors a gasoline tax and the other opposes it. The anti-tax candidate would say what such candidates have been saying for decades:

"There goes my liberal opponent again—demanding yet another tax. He's never seen a tax he didn't like. Now he wants to raise your gasoline taxes or impose some crazy tax on carbon dioxide. God bless our country, the American people have been taxed quite enough, thank you!"

But there is an answer to that, and a true green candidate would not shy away from it. He or she would say this: "The American people certainly have been taxed quite enough. I totally agree. Right now they are being taxed by Saudi Arabia, taxed by Venezuela, taxed by Russia, taxed by Iran, and, if we stay on this track, they'll soon be taxed by Mother Nature. And when Mother Nature starts taxing us there will be no politician you can call on the phone to get relief. So let's get one thing straight: My opponent and I are both for a tax. I just have this quaint, old-fashioned view that my taxes should go to the U.S. Treasury, not the Saudi Treasury, not the Iranian Treasury, not the Venezuelan Treasury, and not the Russian Treasury. It's just a little tic I have. I like my tax dollars to go to build my own country.

"Think about this: The price of gasoline on the morning of September 11, 2001, was between $1.60 and $1.80 a gallon in America. Had President Bush imposed a $1-a-gallon 'Patriot Tax' the next day, gasoline would have been close to $3 a gallon. The U.S. government would have gotten the revenue boost, demand for gasoline would have fallen, and

demand for more fuel-efficient vehicles would have soared. It would not be out of bounds to speculate that even with the rising demand from China and India over the past seven years, gasoline at the pump in America today would be $3 to $4 a gallon, but we would already have been through the transition. Many more Americans would be driving much more fuel-efficient cars, like Europeans do, so their actual mileage per tank of gasoline would be dramatically better. And the U.S. Treasury rather than the Iranian Treasury would be getting the extra dollar in the gasoline price. But because we did not have the courage to make that transition on September 12, 2001, gasoline on September 12, 2008, was more than $4 a gallon, the fuel economy of American cars was still lousy, and the billions of dollars we've paid out due to the doubling of gasoline prices since September 11 has all gone to the oil producers, including governments that have drawn a bull's-eye on our backs.

"If we continue to do nothing in a world that is hot, flat, and crowded, we could easily see gasoline go to $5 or $6 a gallon in America. That will certainly stimulate a transition—a real spur to innovation, a real change in consumer buying habits, and probably even more mass transit. But, precisely because we have waited so long to act, the cost of this transition to the average American will be wrenching—it already is—and politically destabilizing. Lord only knows what the impact will be in poor and developing countries. Every decade we look back and say, 'If only . . . If only we had done the right thing ten years ago.' Well, my fellow Americans, all we need to do to guarantee that we slowly become a second-rate country is to once again keep postponing doing the right things for another decade. We baby boomers grew up in an age when all we had to do to maintain our way of life was leverage and exploit the abundant natural resources we inherited. Going forward, if we want to maintain our way of life, we will have to leverage and exploit our intellectual resources through innovation and technology. And the only way to do that is to shape the market differently. I am convinced that most Americans will pay more for energy if they are convinced that doing so will give them cars, homes, and appliances that will dramatically lower their energy consumption—and contribute to a real nation-building strategy."

If that argument can't carry the day, then we really are lost.

TWELVE

If It Isn't Boring, It Isn't Green

So here's a little news quiz:

Which city in Pennsylvania has a trade surplus with China, Mexico, and Brazil?
ANSWER: Erie.

How could an old-line, blue-collar manufacturing city like Erie have a trade surplus with China, Mexico, and Brazil?
ANSWER: One company, GE Transportation.

Well, what does GE Transportation make in Erie that is so exportable?
ANSWER: It makes big ol' locomotives—those huge industrial-size diesel engines that pull long trains!

So how did GE Transportation, located in the former heartland of American manufacturing, now the heartland of America's rust belt, become the most profitable maker of locomotives in the world?
ANSWER: A combination of great engineering by a traditional American company in a traditional American town, a global market looking for cleaner locomotives, and a U.S. government that demanded higher and higher standards. Those high standards helped to drive the innovation of a big train engine that spewed out less pollution, while also increasing fuel economy