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It feels like 1977 all over again: economy in the doldrums, crisis in the Middle East, and a charismatic new Democrat in the White House preaching the gospel of clean energy. Can Obama succeed where Carter did not? Yes—but only if we've learned the lessons of three decades of failure.

by Joshua Green

The Elusive Green Economy

IMAGE: MORTON BEEBE/CORBIS Better Luck This Time

IN OCTOBER 1977, this magazine ran a cover story on the promising field of renewable energy. From today's vantage point, the article is noteworthy mainly for how uncannily its description of the country's energy crisis and possible solutions applies to the crisis we're in now.

The article took as its starting point the national debate that had arisen over a 29-year-old physicist named Amory Lovins, who had come to prominence a year earlier, when he published an essay in *Foreign Affairs* called "Energy Strategy: The Road Not Taken?" Lovins argued that the country had arrived at an important crossroads and could take one of two paths. The first, supported by U.S. policy at the time, promised a future of steadily increasing reliance on dirty fossil fuels and nuclear fission, and it carried serious environmental risks. At a time before Al Gore was even in Congress, Lovins noted: "The commitment to a long-term coal economy many times the scale of today's makes the doubling of atmospheric carbon dioxide concentration early in the next century virtually unavoidable, with the prospect then or soon thereafter of substantial and perhaps irreversible changes in global climate." He dubbed this "the hard path."

The alternative, which Lovins called "the soft path," favored "benign" sources of renewable power like wind and the sun, along with a heightened commitment to meeting energy demands through conservation and efficiency. Such a heterodox blend of clean technologies, Lovins argued, would bring a host of salutary effects: a healthier environment, an end to our dependence on Middle East oil, a diminished likelihood of future wars over energy, and the foundation of a vibrant new economy.

The *Atlantic* cover story went on to examine emerging technologies, like solar energy, that lay at the heart of Lovins's vision. While refraining from outright prediction, the author's hopes were clear. In 1977, the country appeared poised on the brink of a new age, with recent events having organized themselves in such a way as to make a clean-energy future seem tantalizingly close at hand. A charismatic Democrat had come from nowhere to win the White House. Reacting to an oil shock and determined to rid the country of Middle East entanglements, he was touting the merits of renewable energy and, for the first time, putting real money into it— $368 million.

But things peaked soon afterward, when Jimmy Carter installed solar panels on the roof of the White House. "A generation

from now," Carter declared, "this solar heater can either be a curiosity, a museum piece, an example of a road not taken—or it can be a small part of one of the greatest and most exciting adventures ever undertaken by the American people; harnessing the power of the sun to enrich our lives as we move away from our crippling dependence on foreign oil."

NOW WE HAVE our answer: museum piece. In one of the great acts of humiliating political symbolism, Ronald Reagan tore down the solar panels, which spent many years in purgatory before eventually finding their way to the Jimmy Carter Library and Museum in Atlanta, where they sit on display in silent reproach to all who drive Hummers and own high-wattage plasma television sets.

But having mostly followed the hard path since 1977, the world has started to register the dire climatic effects Lovins warned of. The concentration of atmospheric carbon, an important indicator of global warming, has shot from 280 parts per million in pre-industrial times to 386 ppm last year and appears to be accelerating. Most scientists agree that beyond some critical threshold, climate change is irreversible and probably catastrophic. But no one knows just where the threshold lies. The Intergovernmental Panel on Climate Change takes 450 ppm as the benchmark, a level we're on pace to reach by mid-century—although the prognosis is grimmer than that would imply. Because the effects of atmospheric carbon take years to show up as higher temperatures, limiting concentration to 450 ppm requires halting emissions at current levels. This sudden imperative, coupled with the unlikelihood of action absent a major government intervention, has thrust national energy policy to the forefront of public debate for the first time since Lovins's heyday.

At least on a rhetorical level, a good portion of the country now seems eager to commit to the soft path. It probably helps that the last administration was synonymous with oil and coal. But last summer's spike in oil prices gave a nudge even to some who harbored Cheney-esque views of renewable energy. The recent changes in Washington have made a significant shift in the nation's energy policy a real possibility for the first time in years.

As before, a new Democratic president is touting clean energy, not only as the path to the future but as the key to economic revival. "To truly transform our economy, protect our security, and save our planet from the ravages of climate change," President Obama told Congress in February, "we need to ultimately make clean, renewable energy the profitable kind of energy." Like Carter, he's putting federal money into the effort, but in an amount several orders of magnitude greater. The stimulus alone dumped $167 billion in grants and loan guarantees for clean-energy and other projects onto the Department of Energy, dwarfing its $27 billion annual budget to such a degree that its inspector general frantically warned that the department could buckle under the strain. There's even talk of refitting the White House with solar panels. In all sorts of ways, it feels like 1977 again.

Shortly after the inauguration, a friend up for several jobs in the new administration confessed that he yearned to wind up at the Department of Energy. "It's like NASA in the '60s," he told me. "All the best and brightest want to be there." Obama's choice of Steven Chu, the Nobel laureate physicist, as secretary of energy only heightened the allure. In the early Obama era, romantic notions about making one's mark on history tend to take the form of helping recast America's economy, and by extension the world's, in a way that will head off global catastrophe. So we're back at the old crossroads, only with less time and more urgency to act.

Most talk of the climate problem takes place at the abstract level of a Davos panel—all global diagnoses and moral imperatives. The gritty practicalities of addressing it tend to get obscured. But any effort to engineer change on such a grand scale will be an unprecedented feat of business and government, and the spotty results of earlier attempts might give pause were they better known. Given how large our energy policy looms today, what has happened over the 32 years since *The*

Atlantic first raised the issue of clean energy still draws surprisingly little notice.

On one level, this is understandable. Talking about conservation and energy efficiency in the context of the 1970s summons up images of monkish self-denial, a lifestyle of bulky sweaters and humiliatingly small foreign cars that's a lousy advertisement for the world of tomorrow. It's important to look back, though: Carter's efforts failed because of the way the government encouraged clean energy, not because it tried. And the effects of decisions he made could be felt as recently as last fall. The NASA -in-the-'60s analogy would be more apt had the moon landing followed several decades of misfires and crashes.

In the spirit of the original *Atlantic* article, I traveled to California—now, as then, the heart of the renewable-energy industry—to get a sense of what it will take to bring a green economy into being and meet President Obama's goal of reducing carbon emissions to 80 percent below their 2005 levels by mid-century.

THE BEST WAY to get an idea of what a green future might look like is to visit Silicon Valley. It's impossible to convey how otherworldly the place felt this spring. While the rest of the country suffered beneath the blackening clouds of recession, Silicon Valley buzzed with giddy anticipation that "cleantech," in local parlance, represents the next great economic boom. In a place that reveres its idols the way ancient Rome did, no less than the famed venture capitalist John Doerr has pronounced cleantech "the biggest economic opportunity of the 21st century." Today, Silicon Valley is the anti-Detroit.

The organizing principle behind clean technology is that the growing scarcity and higher cost of fossil fuels, coupled with environmental concerns, will drive society toward alternative sources of energy, with enormous wealth accruing to whoever can supply them. For the past century, U.S. energy policy aimed to promote cheap and abundant electricity, and the nation achieved this mainly by burning coal. More demand led to more power plants, built with little heed to pollution or performance. This gave rise to a modern power industry that not only emits enormous amounts of greenhouse gases but does so with remarkable inefficiency. (A typical coal-fired plant burns three lumps of coal to produce one lump's worth of electricity; the rest goes up the chimney as waste heat.) Because coal, oil, and natural gas generate most of our electricity and won't disappear soon, cleantech is generally understood to consist of a "supply" side and a "demand" side. While one half of Silicon Valley is busy developing clean supplies of energy, the other half is working out ways to reduce demand for the dirty kind.

In the popular imagination, *green economy* evokes towering wind turbines, sleek electric cars, and acres of mirrors shimmering in the desert. Immediately upon arriving in the Valley, I felt it my professional duty to test-drive a cerulean-blue Tesla Roadster, the much-discussed plug-in electric sports car that does, indeed, go from zero to 60 in 3.9 seconds and turns heads like a Ferrari. It can also top 140 miles per hour on the highway. I hear.

But cleantech takes a seemingly endless array of forms, and a useful way to think about them is by their proximity to commercial readiness. On the supply side, wind and solar-thermal are the most advanced. In the right climate, both can be deployed at "utility scale," meaning that if it's breezy or sunny enough, a wind or solar farm can produce as much power as a coal-fired plant. "These are the technologies that are commercially available, ready to scale, and set to go today," Peter Le Lièvre, the co-founder of Ausra, a solar-thermal company in Mountain View planning a 177-megawatt facility in central California, told me. BrightSource, an Oakland competitor, is licensed to build 2,600 megawatts of capacity across 14 plants. Upon their completion, these solar-thermal plants will produce more energy in California than either of the state's nuclear

facilities. And wind is among the most mature technologies: established companies like Vestas and GE operate vast wind farms, particularly in the West and Midwest. Burning of biomass, such as agricultural by-products, is another technology being put to use on a more limited scale.

A bit further out on the horizon are solar-photovoltaic, silicon-wafer, and thin-film technologies, all chasing what could become a $1 trillion market for solar energy. Projecting commercial viability gets dicey here. But further out still are options like geothermal energy and biofuels, which might someday replace oil. At Solazyme, a South San Francisco company that engineers advanced biofuels from algae, I was shown a 55-gallon drum of algal jet fuel and then invited to sample a vial of more algae, which had been tweaked to make a tasty cooking oil.

Aside from the Tesla and a few other electric cars, demand-side cleantech lacks supply-side sex appeal. Not much of it would make the cover of *Popular Mechanics* . But measures like efficiency improvements hold the greatest potential for immediate impact. For instance, slightly more than half of the energy consumed in the United States goes to buildings: 12 percent for constructing them, and 39 percent for heating, cooling, and lighting them. “The easiest, fastest, most effective way to reduce energy demand is to hit buildings,” Marc Porat, a serial entrepreneur in the “built environment” sector, told me. Porat’s Serious Materials makes high-efficiency windows and low-energy drywall; CalStar Cement uses fly ash to make low-carbon bricks and cement; ZETA Communities puts up town houses with minimal carbon footprints.

Mundane though they may seem, improvements in commercial lighting, programmable thermostats, televisions, and refrigerators could yield enormous savings in cost and carbon. Modest improvements in auto fuel efficiency could save as much oil as we import annually from the Persian Gulf.

Most of these gains would be imperceptible to consumers; others would register as lower utility bills and better service. At Silver Spring Networks in Redwood City, Raj Vaswani, the chief technology officer, showed me one of the company’s smart meters, which “talk” to the grid and can moderate energy consumption during periods of peak demand—by, for instance, letting your refrigerator warm up by a degree or two—thus heading off blackouts and lowering your electric bill. When we met, Vaswani was excited because a West Coast storm had knocked out power in an area outfitted with Silver Spring meters. Alerted to the outage by the meters, the power company had a truck on the road eight minutes before the first customer called. Previously, trucks had to wait until enough calls came in to let them triangulate the location of an outage.

Someday, all these technologies will come together. The Buck Rogers vision of the future is an electricity “ecosystem” built on a smart grid through which bountiful forms of clean, domestic power course into stylish electric vehicles and abstemious buildings outfitted with smart appliances that can run the dishwasher or dry the laundry at whatever time of day power is cheapest (in the future, rates will float to reflect demand), thereby lowering your already scandalously low and guilt-free energy bill even farther. Blackouts and price spikes, like Dick Cheney and Enron, will be relics of a distant age, and Jimmy Carter will be fondly recalled as a man ahead of his time.

“The problem 30 years ago was that doing something environmentally sound required asceticism and sacrifice,” Vaswani said. “That’s no longer required. No one’s asking you to huddle in the dark, shivering and eating beans by candlelight, to save the planet. As technology advances, giving us this command-and-control network and lowering the cost of renewables, we can reach a scale where you can use all the power you want. We’ll make more.”

The boundless optimism in Silicon Valley recalls the early days of the Internet boom. “Think of the smartest guy you’ve ever met and then imagine 50,000 more just like him innovating all at once,” Mike Danaher, a partner and cleantech specialist at

the law firm Wilson Sonsini Goodrich & Rosati, told me. “Just as they did with telecom in the ’90s, they’re attacking every component of every kind of alternative energy to improve it.”

Last year, cleantech was the third-largest recipient of venture funding, after IT and biotechnology, with investments of $5.8 billion. But that statistic doesn’t begin to convey its psychic significance. It’s all anyone wants to talk about.

Exhilaration over clean energy has so thoroughly swept Silicon Valley that it has transformed the local culture. Conspicuous consumption has given way to conspicuous conservation. The favored status symbol is no longer the giant yacht or the sprawling mansion but the home designed to be so ruthlessly energy-efficient that it generates its own power *and* produces a surplus that can be selflessly fed back into the grid. One top venture capitalist who showed me his Portola Valley home had embarked on such a project and then, after choosing the reclaimed stone and composting toilets, had succumbed completely to environmentalist fervor and kept right on going, contracting with a local nursery to grow the flora necessary for a “native play meadow” and bringing in a team of wildlife biologists, equipped with motion-sensitive night-vision cameras, to lure back to their natural habitat the elusive riverine tortoise and dusky-footed wood rat that once roamed the property. A documentary film is in the works.

The excitement extends to President Obama’s early emphasis on renewable energy, which has convinced Silicon Valley’s leading minds that here, at last, is a president who understands. “California is the new Texas,” Danaher exulted. “There’s a mind-set [in the White House] that innovation and entrepreneurship really can change things.”

Everyone shares this excitement. But one thought tempers their enthusiasm. The Internet and social-networking booms of the ’90s and ’00s were self-contained affairs, whereas cleantech involves energy policy—which means Washington will have a lot to say about how things shake out. And they view Washington beyond Obama with profound ambivalence.

When I visited, Congress had just allotted billions to clean energy in the stimulus. Yet the trepidation was palpable. Into this precise, rational world of efficiency metrics and yield curves, a “beta factor” was about to be introduced, in the form of a government overhaul of energy policy. To the free-market idealists of Silicon Valley, the prospect of government’s upending the marketplace—even a government run by one of the good guys—made people squirm. “Government shouldn’t pick winners and losers” was their constant refrain.

Given the 32-year history of the country’s fitful attempts to grow a green economy, the skepticism was just as rational as the science behind clean technology. Maybe more.

JUST OUTSIDE PALM SPRINGS, California, where the mountains part to create the San Gorgonio Pass, cool Pacific air sweeps toward the inland desert through acre after acre of rusting, derelict wind turbines that stretch to the horizon in orderly columns like soldiers in formation. They’re remnants of Jimmy Carter’s attempt to go green.

Adherents of clean energy usually explain its evolution in terms of technological advancements. But a better way to see the full picture is through the lens of bankruptcy. The corporate histories of the major manufacturers of clean technology—companies like Vestas, GE, and BrightSource—are littered with bankruptcies, sometimes several in succession, and most can trace their lineage to a specific act (or inaction) of government.

When the Arab oil embargo touched off concerns about energy security, two major impediments hindered the development of a domestic clean-energy industry. The first was that electric utilities controlled transmission lines and wanted no competition. The second was the prohibitive cost of developing and deploying the technologies. Carter addressed both

problems in 1978 with an energy plan he characterized as “the moral equivalent of war.” He compelled public utilities to accept power from independent companies, such as those that might draw on wind or solar; and he made available, for the first time, subsidies for renewable energy in the form of an investment tax credit. Congress increased the subsidies two years later, after the second oil shock.

To these federal incentives, states added their own. None surpassed California’s combination of additional tax credits and regulatory arm-twisting—the law not only forced big utilities to buy power from renewable providers but made sure they did so at favorable rates. If you lived in California in the early 1980s, government would cover half the cost of a windmill and guarantee generous recompense for the power you produced. Soon enough, wind took off.

The first wind farms went up in the San Gorgonio Pass in 1981. Others soon followed. Turbines dotted the country, but in particular California. The demand led to a manufacturing boom, and new companies sprang up to meet it. “It was like the car industry in 1912,” Ed Zaelke, a project-finance partner specializing in renewable energy at the law firm of Chadbourne & Parke in Los Angeles, told me. “Everybody had a new invention.” Sales of wind power leapt from $21 million in 1981 to $748 million in 1985.

But the industry encountered serious quality-control issues, and one reason was the nature of the government’s support. A tax credit on investment created an incentive to put up turbines quickly and plentifully and collect a check. But the tax code had nothing to say about how those turbines performed. And many of them did not. “If you look at Palm Springs,” Zaelke said, “the turbines are set one alongside the other in corn rows because you got paid by how many you installed, not by how well they produced. Well, the ones in back don’t spin, because the ones in front absorb all of the wind and disperse it. That’s why today we space them and put them on ridgelines.”

These, at least, were good-faith efforts. Across California, wind became a popular tax shelter. Doctors, lawyers, and dentists began throwing up turbines or buying shares in hastily erected wind farms to take easy advantage of the benefits. “People were sawing surfboards in half and sticking them on a rotor to claim the tax credit,” Zaelke said.

That ended abruptly in 1985. Ronald Reagan, well on his way to slashing his predecessor’s largesse toward clean energy, killed the investment tax credit. Evidently, Reagan despised wind power. Having previously instructed the IRS to challenge the credit, he singled out California’s turbines as evidence of the need for reform when he sent Congress the 1986 Tax Reform Act. With oil flowing cheaply again, the industry swiftly collapsed.

Solar power benefited from the same credits and, beginning in 1980, had the additional sweetener of a California property-tax exemption to defray the cost of acres of mirrors. Motivated by these incentives and the emergence of “peak oil” theory, companies like Shell, Exxon, and Amoco became some of the largest investors in solar technology.

The great pioneer in the field was Arnold Goldman, an engineer lured to California from Israel by the promising economic climate. Goldman was an inventor, but a practical one. Rather than tinker in the lab, he studied Department of Energy research reports (a product of Jimmy Carter’s initial investment) to find the technology with the most potential. Goldman founded Luz International and got Southern California Edison to agree to buy power. With financing from Phillips Petroleum and Bank of America, he built the first utility-scale solar farm in the United States in 1984, a $62 million facility that could generate 14 megawatts.

Part of the adventure for entrepreneurs like Goldman lay in continually refining the technology to drive down cost. Luz was

strikingly successful, and Goldman managed to keep building larger facilities even as the state and federal tax credits disappeared and the oil companies lost interest. “We were improving at a fast enough pace that each time one of the credits went away, we made up for it with cost savings from the new technology,” he told me.

By 1991, Luz was operating nine facilities and had begun construction on a tenth when the California property-tax exemption—the one subsidy the company could not do without—came up for renewal. At the time, Luz’s 354 megawatts of capacity represented 90 percent of the world’s solar energy. Luz was literally peerless. But from a political standpoint, this created a problem: the solar property-tax exemption appeared to benefit a single company. “It was absolutely crazy,” Goldman said. When the Republican governor vetoed the renewal, Luz went bankrupt. Its nine plants, now owned by Florida Power & Light, still run today. Goldman is now a principal behind BrightSource.

For the dwindling few companies that struggled on, the trouble didn’t let up, arriving not only from the political right but also from the left. Kenetech Windpower, for instance, struggled with what the industry delicately refers to as “avian mortality.” Remote, windy places like California’s Altamont Pass are home to rare birds like the golden eagle, which nature did not equip to survive an encounter with a Kenetech turbine. In contrast to sensible Europeans, whose blades churned slowly, Americans, with our predilection for speed and power, produced windmills of such fearsome torque that they became, as one outraged Sierra Club lobbyist put it, “Cuisinarts of the air.” To the horror of avian-minded environmentalists, eagle carcasses began piling up in the Altamont Pass. To those whose sympathies lay with wind, liability was the concern: mutilating golden eagles violated the Migratory Bird Treaty Act. Kenetech first negotiated “killing permits” from the U.S. Fish and Wildlife Service, then settled on the more permanent solution of going bankrupt.

Wind and solar didn’t die when the tax credits dried up. They moved overseas. Denmark offered robust government support, and came to dominate the wind industry. Germany and Spain found success with solar energy by requiring utilities to pay hefty “feed-in tariffs”—above-market rates—to anyone who sent electricity to the grid. Japan also built a vibrant solar market.

Though its manufacturing base was devastated, the U.S. remained one of the world’s largest markets for wind power. In 1992, Congress moved to rebuild the industry, this time basing the tax credit on production rather than investment. Again, the market took off—and collapsed, when the credits were allowed to expire. This boom-and-bust cycle repeated itself three more times over the next decade, and very nearly a fourth. Last fall, after 18 attempts to extend the production tax credit, Congress, in one of its final acts before adjourning, allowed a one-year extension to squeeze through.

Plotted on a graph, the history of clean-energy production in the United States resembles the blade of a saw, rising and falling each time subsidies came and went. Japan, Germany, Spain, and Denmark show smooth, upward-sloping yield curves, a reflection of consistent government policy.

DESPITE THESE PROBLEMS, new technologies gradually emerged, and caught the attention of investors whose patience exceeded Congress’s fickle attention span. Flush from the Internet boom and intrigued with the opportunities presented by rising fuel prices, venture capitalists started betting on clean technology. The proliferation of states that require a portion of electricity to come from renewable sources suggested a growing market. Though it will have to compete for space in his obituary, George W. Bush, encouraged by Texas businessmen, signed what is regarded as a model renewable-energy standard while governor of Texas, in 1999; Texas easily beat it and now produces more wind power than Denmark.

The nature of venture-capital investing, which involves placing many bets in the hope that a few pay off, helped create today's array of clean technologies. But venture capitalists have been unable to replicate the explosion of growth in the Internet sector, because they aren't big enough to compete in the $5 trillion U.S. energy market. Google required only $25 million in venture capital to become the company it is today. A large wind or solar facility can cost upwards of $500 million just to get started. "When you're talking power infrastructure, you're talking thousands of tons of steel and glass and giant turbines," says Peter Le Lièvre, the co-founder of Ausra. "All the investors in Silicon Valley combined cannot put $500 million into a project."

This poses a problem. Venture capitalists can bring an idea from the lab to pilot scale. But sooner or later the limitations of their balance sheets kick in. Many start-ups have made it this far only to die searching for additional financing. Venture capitalists have a term for this. They call it the "Valley of Death."

The nut of the problem traces all the way back to Jimmy Carter's choice of tax credits as the vehicle for subsidizing renewable energy. Direct grants would have been simpler. But Congress had recently changed the federal-budget process to keep closer track of how much money was being spent. It suddenly became easier to spend indirectly, by manipulating the tax code. Although no one realized it at the time, Carter's decision to use tax credits lit the very long fuse on a bomb that detonated last fall and nearly took down the entire renewable-energy industry in America.

The trouble with tax credits is that in order to make use of them, you must owe taxes, and most start-ups struggling toward profitability do not. So while a company looking to build a wind or solar facility would qualify for valuable benefits, it had no means of realizing this "tax equity." The work-around was to partner with someone who did, someone large enough to finance a $500 million facility and profitable enough to incur a large tax bill. Having witnessed two decades of busts and bankruptcies, traditional U.S. banks wanted no part of this. European banks, going by their more positive experience, were comfortable funding large renewable projects, but didn't qualify for U.S. tax credits. The perversity of the government's incentives demanded a big balance sheet, huge profits, and an indifference to risk. Enter Wall Street.

Investment banks and hedge funds stepped in to fill the void, engineering tax-equity vehicles with suspiciously complicated-sounding names, like "partnership flip structure" and "inverted passthrough lease," to exploit the tax benefits. These deals amounted to financing agreements for large infrastructure projects, given in exchange for tax credits, often worth hundreds of millions of dollars, that could be applied against profits earned primarily on other investments (like mortgage-backed securities). For renewable-energy companies, tax-equity deals meant life or death: the combination of credits could offset two-thirds of the capital cost of a project. Companies like Lehman Brothers, Wachovia, and AIG became an integral part—even *the* integral part—of the renewables industry, because the utility-scale projects they financed produce the overwhelming majority of clean energy in the United States.

Basing the entire system of federal incentives on tax equity had two weaknesses, one that has always been clear and another that became clear only recently. Forcing renewables companies to route government support through Wall Street, thereby sacrificing a portion of it, was needless and inefficient. But it also tied the industry's fate to that of the financial world's most aggressive players. Just as Wall Street bankers bet that housing prices could never fall and got wiped out when proved wrong, Congress seems never to have imagined that Wall Street might someday have no profits and need no tax equity. Early last year, the multibillion-dollar tax-equity universe consisted of 18 providers. After September's record carnage, the number dropped to four. Credit froze, and most projects ground to a halt. All of a sudden, not just a few start-ups but the entire renewable-energy industry was staring into the Valley of Death.

WHEN OBAMA TOOK office, the climate-change issue had a short-term and a long-term component. The immediate imperative was to find a way of rescuing the renewables industry from Wall Street's collapse. This was important not just as a means of mitigating the recession but also because getting clean technology rapidly to scale is probably the only way to meet the larger goal of reducing carbon emissions enough to limit climate change. Another setback could make the difficult impossible.

The stimulus was the first of three major initiatives intended to steer the economy toward something more like Amory Lovins's soft path. To fill the tax-equity gap, the stimulus provides $32.7 billion in direct grants and another $134 billion in loan guarantees to attract new investors to large projects. To impose stability, it extends a variety of tax credits by anywhere from three to eight years. Most striking of all, it instructs the Department of Energy to invest directly in promising cleantech companies (though the payoff comes in jobs and environmental gains, not equity). By a stroke of his pen, President Obama made a federal agency the world's largest venture capitalist. When the official in charge of the program appeared at a Santa Barbara energy conference in March, he was mobbed by eager CEOs.

So far, so good. "The stimulus package essentially saved the renewable-energy industry in the United States," says Raj Atluru, managing director of the venture-capital firm Draper Fisher Jurvetson.

The second part of the Obama plan, which Congress will consider as part of the energy bill this summer, is to make renewable-energy standards, like those already in place in Texas, California, and other states, national policy. This would put the force of law behind the effort to advance clean energy, and eliminate the possibility of another Reagan-esque reversal of course. The final and most significant component, also part of the energy bill, will be putting a price on carbon emissions, possibly by establishing a cap-and-trade system like the one featured in Obama's budget.

All of this could be achieved and still fail to stop climate change—we won't know for years. Beyond a broad consensus on the urgency of the threat, the inability to know precisely what can contain it has produced a range of expert opinion, from optimists convinced that steady government support of existing technology will suffice, to pessimists (they'd say "realists") who consider such support a necessary precondition, to which a great deal more will have to be added. Nathan Lewis, for instance, an energy chemist at the California Institute of Technology, foresees the need to develop 13,000 gigawatts of carbon-free power if we're to limit atmospheric carbon concentration to 450 ppm. (Current global solar-power production is 10 gigawatts.) And it will need to be cheap enough to persuade major polluters like China and India to go along. Steven Chu believes this will require "Nobel-caliber" scientific breakthroughs.

Everyone agrees on the need for the sustained focus missing from every earlier attempt to go green. But if that's not enough, then the important question becomes: Where is a Nobel-caliber breakthrough most likely to be made and what might be done to bring it about?

The U.S. record on renewable energy provokes a kind of sheepish embarrassment among many veteran adherents. The mid-1980s collapse brought down not just the domestic industry but many of the major foreign companies that had invested here. "You can certainly make the case that the policy the U.S. has followed over the last 30 years is exactly the policy you would *not* want to follow," Randy Swisher, the former director of the American Wind Energy Association, told me. Thus the tendency is to regard Carter as a naive optimist and the years between his presidency and *An Inconvenient Truth* as a kind of Dark Ages best forgotten.

But Carter's efforts can also be viewed as a qualified but important success. Despite its epic travails, the United States in the mid-1980s was the overwhelming leader in clean technology, with more than 80 percent of the world's wind capacity and 90 percent of solar. The entrepreneurial culture of California in particular drew the best minds from around the world. One of them, Arnold Goldman, was already building toward scale when it all came apart.

The United States has fallen back dramatically since then, both in a moral and an economic sense. As awareness of the climate threat has taken hold, we've drawn contempt, as much for President Bush's truculent dismissal of the Kyoto Protocol as for the amount of greenhouse gases we emit. Even President Obama's sharp change of course seems likely to win us, at best, a prodigal son's wary reception when representatives of 170 nations meet in Copenhagen in December to negotiate the next climate treaty. Meanwhile, the benefits of the developments that emerged in the 1980s have mostly accrued to others. "We sent the wind and solar industry to Europe for three decades," Raj Atluru says. "As a result, they have both a huge consumption market for renewable energy and the biggest companies that export the technology."

Europe offers a model of how governments can lead the transition to clean energy and thereby reduce demand for fossil fuels. Denmark, which also suffered the shocks of the 1970s, no longer needs to import oil. But missing from Europe's decades of leadership are big breakthroughs in creating renewable energy. The lack of an entrepreneurial culture is a big reason, and it is also why, despite commendable progress, Europe shouldn't be counted on to play the role of savior in the event that Scandinavian practicality alone can't do the job. As an indicator of where a solution might emerge instead, venture-capital investments in clean technology last year reached $5.8 billion in the United States, compared with $1.8 billion in all of Europe and Israel. And that was before Obama's enormous ante.

American capitalism—even when it's working—is not without its limitations, one being that promising ideas rarely get funding if their commercial potential lies beyond venture capitalists' 10-year investment horizon. The Energy Department research budget has never recovered from Reagan's cuts. And the private industry that would seem to have the most at stake in finding and controlling clean-energy advances—electric utilities—has never seriously pursued them, since a century of government policy has made the hard path so easy. People in cleantech circles often point out that the electric utilities spend a smaller portion of revenue on research and development than pet-food companies do. Here, too, the stimulus fills a gap. For years, Silicon Valley dreamed that government would cultivate nascent but potentially transformative energy ideas by creating an equivalent of the Pentagon's famous Defense Advanced Research Projects Agency (DARPA), which pioneered such things as the Internet and GPS. With an eye toward similar breakthroughs, the stimulus allots $400 million to the Department of Energy for just such an agency.

But the Internet came to fruition only after the right conditions were in place. Its rapid growth and innovation followed from the telecommunications reforms of the 1990s, a consequence few predicted at the time. "The trouble with projections is that they extrapolate from the current reality, and often end up undershooting the mark," Sunil Paul, a founding partner of Spring Ventures, a firm that invests in cleantech, told me. "Over the long haul, dramatic things happen to change the equation. As I like to put it, the history of our future is filled with moon bases, jet packs, and 200-mph cars, but has no cell phones, no Internet, and no laptop computers."

The interplay of technology, policy, and finance has always determined the rate at which clean technologies advance. Today these are aligned for the first time since Jimmy Carter—and more strongly now because the environmental imperative and global concern are so much greater than they were in 1977.

The key to our energy future lies in exploiting two often opposing forces without having them trample or undermine each

other: Silicon Valley's free-market culture of innovation and Washington's power to set the terms by which everyone operates. The challenge will be to establish European-style stability without constraining ourselves to anemic European levels of innovation. And if it turns out that a Nobel-caliber breakthrough is necessary to save the planet, the freewheeling boom-and-bust disruptions of the 1980s might come to be regarded in a much better light—because, really, who else has produced such rapid change? It may seem strange to think so, but the last, best hope for heading off climate change is probably the same country that botched the job so badly once before.
