THE NEW YORKER

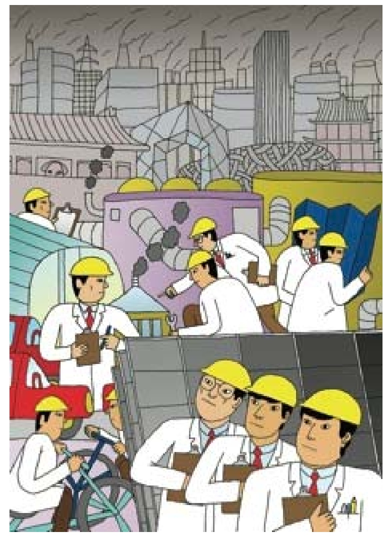
LETTER FROM CHINA

# GREEN GIANT

*Beijing's crash program for clean energy.*

by Evan Osnos

DECEMBER 21, 2009



China's clean-tech advances should be a warning to the U.S.

On March 3, 1986, four of China's top weapons scientists—each a veteran of the missile and space programs—sent a private letter to Deng Xiaoping, the leader of the country. Their letter was a warning: Decades of relentless focus on militarization had crippled the country's civilian scientific establishment; China must join the world's *xin jishu geming*, the "new technological revolution," they said, or it would be left behind. They called for an élite project devoted to technology ranging from biotech to space research. Deng agreed, and scribbled on the letter, "Action must be taken on this now." This was China's "Sputnik moment," and the project was code-named the 863 Program, for the year and month of its birth.

In the years that followed, the government pumped billions of dollars into labs and universities and enterprises, on projects ranging from cloning to underwater robots. Then, in 2001, Chinese officials abruptly expanded one program in particular: energy technology. The reasons were clear. Once the largest oil exporter in East Asia, China was now adding more than two thousand cars a day and importing millions of barrels; its energy security hinged on a flotilla of tankers stretched across distant seas. Meanwhile, China was getting nearly eighty per cent of its electricity from coal, which was rendering the air in much of the country unbreathable and hastening climate changes that could undermine China's future stability. Rising sea levels were on pace to create more refugees in China than in any other country, even Bangladesh.

In 2006, Chinese leaders redoubled their commitment to new energy technology; they boosted funding for research and set targets for installing wind turbines, solar panels, hydroelectric dams, and other renewable sources of energy that were higher than goals in the United States. China doubled its wind-power capacity that year, then doubled it again the next year, and the year after. The country had virtually no solar industry in 2003; five years later, it was manufacturing more solar cells than any other country, winning customers from foreign companies that had invented the technology in the first place. As President Hu Jintao, a political heir of Deng Xiaoping, put it in October of this year, China must "seize preëmptive opportunities in the new round of the global energy revolution."

A China born again green can be hard to imagine, especially for people who live here. After four years in Beijing, I've learned how to gauge the pollution before I open the curtains; by dawn on the smoggiest days, the lungs ache. The city government does not dwell on the details; its daily air-quality measurement does not even tally the tiniest particles of pollution, which are the most damaging to the respiratory system. Last year, the U.S. Embassy installed an air monitor on the roof of one of its buildings, and every hour it posts the results to a Twitter feed, with a score ranging from 1, which is the cleanest air, to 500, the dirtiest. American cities consider anything above 100 to be unhealthy. The rare times in which an American city has scored above 300 have been in the midst of forest fires. In these cases, the government puts out public-health notices warning that the air is "hazardous" and that "everyone should avoid all physical activity outdoors." As I type this in Beijing, the Embassy's air monitor says that today's score is 500.

China is so big—and is growing so fast—that in 2006 it passed the United States to become the world's largest producer of greenhouse gases. If China's emissions keep climbing as they have for the past thirty years, the country will emit more of those gases in the next thirty years than the United States has in its entire history. So the question is no longer whether China is equipped to play a role in combatting climate change but how that role will affect other countries. David Sandalow, the U.S. Assistant Secretary of Energy for Policy and International Affairs, has been to China five times in five months. He told me, "China's investment in clean energy is extraordinary." For America, he added, the implication is clear: "Unless the U.S. makes investments, we are not competitive in the clean-tech sector in the years and decades to come."

One of the firms that are part of the 863 Program is Goldwind Science and Technology Company. It operates a plant and a laboratory in a cluster of high-tech companies in an outlying district of Beijing called Yizhuang, which has been trying to rebrand itself with the name E-Town. (China has been establishing high-tech clusters since the late nineteen-eighties, after scientists returned from abroad with news of Silicon Valley and Route 128.) Yizhuang was a royal hunting ground under the last emperor, but, as E-Town, it has the sweeping asphalt vistas of a suburban office park, around blocks of reflective-glass buildings, occupied by Nokia, Bosch, and other corporations. Local planning officials have embraced the vocabulary of a new era; E-Town, they say, will be a model not only of e-business but also of e-government, e-community, e-knowledge, and e-parks.

When I reached Goldwind, the first thing I saw was a spirited soccer game under way on a field in the center of the campus. An artificial rock-climbing wall covered one side of the glass-and-steel research center. I met the chairman, Wu Gang, in his office on the third floor, and I asked about the sports. “We employ several coaches and music teachers,” he said. “They do training for our staff.” A pair of pushup bars rested on the carpet beside his desk. At fifty-one years old, Wu is tall, with wire-rim glasses, rumpled black hair, and the broad shoulders of a swimmer. (“I can do the butterfly,” he said.) For fun, he sings Peking opera. Wu said that he had not been a robust child: “My education was very serious. Just learning, learning, learning. I wanted to jump out of that!”

Wu integrates his hobbies into his work life in the manner of a California entrepreneur. He once led seventeen people, including seven Goldwind employees, on a mountaineering expedition across Mt. Bogda, in the Tian Shan range, in western China. “We Chinese are very weak in this field—teamwork,” Wu said. He recently put his workers on a five-year self-improvement regimen; among the corporate announcements on Goldwind’s Web site, the company now posts its in-house sports reports. (“All the vigorous and valiant players shot and dunked frequently,” according to a recent basketball report on a game between factory workers.)

Wu was born and raised in the far-western region of Xinjiang, home to vast plains and peaks that create natural wind tunnels, with gusts so ferocious that they can sweep trains from their tracks. In the nineteen-eighties, engineers from Europe began arriving in Xinjiang, in order to test their wind turbines, and in 1987 Wu, then a young engineer in charge of an early Chinese wind farm, worked alongside engineers from Denmark, a center of wind-power research. He immersed himself in the mechanics of turbines—“Where are their stomachs, and where are their hearts?” he said. In 1997, state science officials offered him the project of building a six-hundred-kilowatt turbine, small by international standards but still unknown territory in China. Many recipients of government research funding simply used the money to conduct their experiments and move on, but some, like Wu, saw the cash as the kernel of a business. He figured that every dollar from the government could attract more than ten dollars in bank loans: “We can show them, ‘This is money we got from the science ministry.’ ”

Wu saw little reason to start from zero: Goldwind licensed a design from Jacobs Energie, a German company. Manufacturing was not as simple. Early attempts were a “terrible failure,” Wu said. “Whole blades dropped off.” He shook his head. “The main shafts broke. It was really very dangerous.”

Goldwind shut down for three months. The company eventually solved the problems, and, with the help of 863 and other government funding, it expanded into a full range of large and sophisticated turbines. Many of them were licensed from abroad, but, as they were built in China, they sold for a third less than European and American rivals. Goldwind’s sales doubled every year from 2000 to 2008. In 2007, Wu took the company public, and garnered nearly two hundred million dollars.

China has made up so much ground on clean tech in part through protectionism—until recently, wind farms were required to use turbines with locally manufactured parts. The requirement went into effect in 2003; by the time it was lifted, six years later, Chinese turbines dominated the local market. In fact, the policy worked too well: China’s wind farms have grown so fast that, according to estimates, between twenty and thirty per cent aren’t actually generating electricity. A surplus of factories was only part of the problem: local bureaucrats, it turned out, were being rewarded not for how much electricity they generated but for how much equipment they installed—a blunder that is often cited by skeptics of China’s efforts.

They have a point; many factories are churning out cheap, unreliable turbines, because the government lacks sufficient technical standards. But the grid problem is probably temporary. China is already buying and installing the world’s most efficient transmission lines—“an area where China has actually moved ahead of the U.S.,” according to Deborah Seligsohn, a senior fellow at the World Resources Institute. In the next decade, China plans to install wind-power equipment capable of generating nearly five times the power of the Three Gorges Dam, the world’s largest producer.

After I met with Wu Gang, the company’s director of strategy and global development, Zhou Tong, an elegant woman in her thirties, handed me a hard hat and walked me next door to the turbine-assembly plant, an immaculate four-story hangar filled with workers in orange jumpsuits piecing together turbine parts that were as big and spacey-looking as Airstream trailers. The turbines were astonishing pieces of equipment—large enough so that some manufacturers put helicopter pads on top—and the technical complexity dispelled any lingering image I had of Chinese factories as rows of unskilled workers stooped over cheap electronics. Wandering among the turbines, we passed some Ping-Pong tables, where a competition was under way, and stopped in front of a shiny white dome that looked like the nose of a passenger jet. It was a rotor hub—the point where blades intersect—and it was part of Goldwind’s newest treasure, a turbine large enough to generate 2.5 megawatts of electricity, its largest yet. “Wow, this is a 2.5!” Zhou exclaimed. “I saw the first one in Germany. This is the first one I’ve seen here.” Wu was set to unveil the new turbine at a press conference the next day. A flatbed truck, loaded with turbine parts and idling in the doorway, was bound for wind farms throughout Manchuria.

The prospect of a future powered by the sun and the wind is so appealing that it obscures a less charming fact: coal is going nowhere soon. Even the most optimistic forecasts agree that China and the United States, for the foreseeable future, will remain ravenous consumers. (China burns more coal than America, Europe, and Japan combined.) As Julio Friedmann, an energy expert at the Lawrence Livermore National Laboratory, near San Francisco, told me, “The decisions that China and the U.S. make in the next five years in the coal sector will determine the future of this century.”

In 2001, the 863 Program launched a “clean coal” project, and Yao Qiang, a professor of thermal engineering at Beijing’s Tsinghua University, was appointed to the committee in charge. He said that its purpose is simple: to spur innovation of ideas so risky and expensive that no private company will attempt them alone. The government is not trying to ordain which technologies will prevail; the notion of attempting to pick “winners and losers” is as unpopular among Chinese technologists as it is in Silicon Valley. Rather, Yao sees his role as trying to insure that promising ideas have a chance to contend at all. “If the government does nothing, the technology is doomed to fail,” he said.

Grants from the 863 Program flowed to places like the Thermal Power Research Institute, based in the ancient city of Xi’an, in the center of China’s coal country. “The impact was huge,” Xu Shisen, the chief engineer at the institute, told me over lunch recently. “Take our project, for example,” he said, referring to an experimental power plant that, if successful, will produce very low emissions. “Without 863, the technology would have been delayed for years.”

After lunch, a pair of engineers took me to see their laboratory: a drab eight-story concrete building, crammed with so many pipes and ducts that it felt like the engine room of a ship. We climbed the stairs to the fourth floor and stepped into a room with sacks of coal samples lining the walls like sandbags. In the center of the room was a device that looked like a household boiler, although it was three times the usual size, and pipes and wires bristled from the top and the sides. It was an experimental coal “gasifier,” which uses intense pressure and heat to turn coal dust into a gas that can be burned with less waste, rather than burning coal the old-fashioned way. With a coal gasifier, it is far easier to extract greenhouse emissions, so that they can be stored or reused, instead of floating into the atmosphere. Gasifiers have been around for decades, but they are expensive—from five hundred million to more than two billion dollars for the power-plant size—so hardly any American utilities use them. The researchers in Xi'an, however, set out to make one better and cheaper.

One of the engineers, Xu Yue, joined the gasifier project in 1997. A team of ten worked in twelve-hour shifts, conducting their experiments around the clock. "There was a bed there," he said, pointing to the corner of a soot-stained control room. (The image of China as a nation of engineers toiling for pennies is overstated; Xu Yue works hard, but he earns around a hundred thousand dollars a year.) Beyond salaries, everything about the lab was cheaper than it would have been in the U.S., from the land on which it was built to the cost of heating the building, and when the gasifier was finished it had a price tag one-third to one-half that of the equivalent in the West.

When Albert Lin, an American energy entrepreneur on the board of Future Fuels, a Texas-based power-plant developer, set out to find a gasifier for a pioneering new plant that is designed to spew less greenhouse gas, he figured that he would buy one from G.E. or Shell. Then his engineers tested the Xi'an version. It was "the absolute best we've seen," Lin told me. (Lin said that the "secret sauce" in the Chinese design is a clever bit of engineering that recycles the heat created by the gasifier to convert yet more coal into gas.) His company licensed the Chinese design, marking one of the first instances of Chinese coal technology's coming to America. "Fifteen or twenty years ago, anyone you asked would have said that Western technologies in coal gasification were superior to anything in China," Lin said. "Now, I think, that claim is not true."

The 863 Program took much of its shape from the American research system used by the National Institutes of Health and the Department of Defense: the government appointed panels of experts, who drew up research priorities, called for bids, and awarded contracts. In 1987, the government gave it an initial budget of around two hundred million dollars a year. That figure was small by Western standards, but the sum went far in China, according to Evan Feigenbaum, an Asia specialist at the Council on Foreign Relations, who studied the program. When I mentioned to Xu Shisen, the coal engineer in Xi'an, that American scientists are dubious of top-down efforts to drive innovation, he suggested that the system is more competitive than outsiders imagine. "It is very intense—like a Presidential election," he joked, and he sketched out the system: "Normally, each project will have five to eight contenders—some less, some more—but there is a broad field of innovators. A lot of companies are doing the same thing, so everyone wants to have a breakthrough." He went on, "It's not possible to have a flawless system, but it makes relatively few mistakes. It combines the will of the state with mass innovation."

R. & D. expenditures have grown faster in China than in any other big country—climbing about twenty per cent each year for two decades, to seventy billion dollars last year. Investment in energy research under the 863 Program has grown far faster: between 1991 and 2005, the most recent year on record, the amount increased nearly fifty-fold.

In America, things have gone differently. In April of 1977, President Jimmy Carter warned that the hunt for new energy sources, triggered by the second Arab oil embargo, would be the "moral equivalent of war." He nearly quadrupled public investment in energy research, and by the mid-nineteen-eighties the U.S. was the unchallenged leader in clean technology, manufacturing more than fifty per cent of the world's solar cells and installing ninety per cent of the wind power.

Ronald Reagan, however, campaigned on a pledge to abolish the Department of Energy, and, once in office, he reduced investment in research, beginning a slide that would continue for a quarter century. "We were working on a whole slate of very innovative and interesting technologies," Friedmann, of the Lawrence Livermore lab, said. "And, basically, when the price of oil dropped in 1986, we rolled up the carpet and said, 'This isn't interesting anymore.' " By 2006, according to the American Association for the Advancement of Science, the U.S. government was investing $1.4 billion a year—less than one-sixth the level at its peak, in 1979, with adjustments for inflation. (Federal spending on medical research, by contrast, nearly quadrupled during that time, to more than twenty-nine billion dollars.)

Scientists were alarmed. The starkest warning came in 2005, from the National Academies, the country's top science advisory body, which released "Rising Above the Gathering Storm," a landmark report on U.S. competitiveness. It urged the government to boost investment in research, especially in energy. The authors—among them Steven Chu, then the director of the Lawrence Berkeley National Laboratory and now the Secretary of Energy, and Robert Gates, the former C.I.A. director and now the Secretary of Defense—wrote, "We fear the abruptness with which a lead in science and technology can be lost—and the difficulty of recovering a lead once lost, if indeed it can be regained at all."

They called for a new energy agency that could spur the hunt for "transformative" technologies. It would inject money into universities and companies and would be called the Advanced Research Projects Agency-Energy, or ARPA-E, modelled on DARPA, the Defense Department unit that President Eisenhower founded in response to Sputnik. (DARPA went on to play a significant role in the invention of the Internet, stealth technology, and the computer mouse, among other things.) ARPA-E, they hoped, would shepherd new energy inventions from the lab to the market, bridging the funding gap that is referred to in engineering circles as the "valley of death." Congress approved the idea in 2007, but President George W. Bush criticized it as an "expansion of government" into a role that is "more appropriately left to the private sector." He never requested funding, and the idea fizzled.

Other plans withered as well. In January, 2008, the Bush Administration withdrew support for FutureGen, a proposed project in Illinois that would have been the world's first coal-fired, near-zero-emissions power plant. The Administration cited cost overruns, saying the price had climbed to $1.8 billion, but an audit by the Government Accountability Office later discovered that Bush appointees had overstated the costs by five hundred million dollars. House Democrats launched an investigation, which concluded, "FutureGen appears to have been nothing more than a public-relations ploy for Bush Administration officials to make it appear to the public and the world that the United States was doing something to address global warming." An internal Energy Department report had warned that cancelling the project would set back the advance of carbon-storage technology by "at least 10 years." An e-mail between officials emphasized that Bush's Secretary of Energy, Samuel Bodman, "wants to kill" FutureGen "with or without a Plan B." (Bodman denies that costs were overstated.)

After FutureGen foundered, China broke ground on its own version: GreenGen. If it opens as planned, in 2011, China will have the most high-tech low-emissions coal-fired plant in the world.

Two summers ago, a truckload of Beijing municipal workers turned up in my neighborhood and began unspooling heavy-duty black power lines, which they attached to our houses, in preparation for a campaign to replace coal-burning furnaces with electric radiators. Soon, the Coal-to-Electricity Project, as it was called, opened a small radiator showroom in a storefront around the corner, on a block shared by a sex shop and a vender of funeral shrouds. My neighbors and I wandered over to choose from among the radiator options.

Two-thirds of the price was subsidized by the city, which estimates that it has replaced almost a hundred thousand coal stoves since the project began, five years ago, cutting down on sulfur and dust emissions. I settled on a Marley CNLS340, a heater about the size of a large suitcase, manufactured in Shanghai. It had a built-in thermostat preprogrammed to use less electricity during peak day hours and then store it up at night, when demand was lower—a principle similar to the "smart meters" that American utilities plan to install in the next decade.

Neighbors began cutting their electricity bills by climbing up to their rooftops and installing solar water heaters—simple pieces of equipment with a water tank and a stretch of glass tubing to be heated by the sun. (China, which produces fifty per cent of the world's solar heaters, now uses more of them than any other country.) And in the hardware stalls of the raucous covered market nearby, where the inventory ranges from live eels to doorbells, coiled high-efficiency light bulbs began crowding out traditional bulbs for sale. The government, it turned out, had instituted a thirty-per-cent wholesale subsidy on efficient bulbs. Without anybody really noticing, China sold sixty-two million subsidized bulbs in ten months.

When Hu Jintao called on China to adopt a "scientific concept of development," in 2003, he was making a point: China's history of development at all costs had run its course. And, in ways that were easy to overlook, China had embarked on deep changes.

In the summer of 2005, Edward Cunningham, a Ph.D. student researching energy policy at M.I.T., was travelling in the Chinese countryside when he noticed something peculiar: the government was allowing the price of coal to rise sharply, after decades of controls. "I said, 'How the hell?' " he recalled. " 'That can't be right. Maybe this is just some freak anecdotal evidence.' " It was in fact a pivotal change: Manipulating the price of coal had always insured that Chinese utilities would produce ever more electricity, but the unhappy side effect was that utilities needed to build nothing more efficient than the cheapest, dirtiest plants. Coal prices had begun to rise, however, and that would leave power plants no choice but to install cleaner, more efficient equipment. Cunningham, now a postdoctoral fellow at Harvard, said that the effect had broad consequences. "We are going to see a huge amount of learning that we have not seen in the U.S."

Learning, in technology terms, is another way of saying "reducing cost." The more a technology is produced, the cheaper it becomes, and that can lead to change as revolutionary as dreaming up an invention in the first place: Henry Ford invented neither the automobile nor the assembly line. He simply perfected their combination to yield the world's first affordable cars.

In the same way, technology that is too expensive to be profitable in the West can become economical once China is involved; DVD players and flat-screen televisions were luxury goods until Chinese low-cost production made them ubiquitous. So far, many of the most promising energy technologies—from thin-film solar cells to complex systems that store carbon in depleted oil wells—are luxury goods, but the combination of Chinese manufacturing and American innovation is powerful; Kevin Czinger, a former Goldman Sachs executive, called it "the Apple model." "Own the brand, the design, and the intellectual property," he said, and then go to whoever can manufacture the technology reliably and cheaply. A few years ago, Czinger began looking at the business of electric cars. Detroit was going to move slowly, he figured, to avoid undermining its main business, and U.S. startups, including Tesla and Fisker, were planning to sell luxury electric cars for more than eighty thousand dollars each. Czinger had something else in mind.

"These cars should be far simpler and far cheaper than anything that's manufactured today," he told me when we met last spring in Beijing. At fifty, Czinger has brown hair swept back, sharp cheekbones, and an intensity that borders on the unnerving. ("Kevin Czinger was the toughest kid to play football at Yale in my thirty-two years as head coach," Carm Cozza, the former Yale coach, wrote in a memoir. "He was also the most unusual personality, probably the outstanding overachiever, maybe the brightest student, and definitely the scariest individual.")

In the spring of 2008, Czinger signed on as the C.E.O. of Miles Electric Vehicles, a small electric-car company in Santa Monica that was looking to expand, and he went searching for a Chinese partner. He ended up at Tianjin Lishen Battery Joint-Stock Company. A decade ago, Japan dominated the world of lithium-ion batteries—the powerful, lightweight cells that hold promise for an electric-car future—but in 1998 the Chinese government launched a push to catch up. Lishen received millions in subsidies and hundreds of acres of low-cost land to build a factory. The company grew to two hundred and fifty million dollars in annual sales, with customers including Apple, Samsung, and Motorola. Last year, the 863 Program gave Lishen a $2.6-million grant to get into the electric-car business. That is when Czinger showed up. "We hit it off immediately," Qin Xingcai, the general manager of Lishen, said.

Czinger, who by now was heading up a sister company called Coda Automotive, added components from America and Germany and a chassis licensed from Japan. If all goes as planned, the Coda will become the first mass-produced all-electric sedan for sale in the United States next fall, with a price tag, after government rebates, of about thirty-two thousand dollars. The Coda looks normal to the point of banal, a Toyota-ish family car indistinguishable from anything you would find in a suburban cul-de-sac. And that's the point; its tagline, "A model for the mainstream," is a jab at more eccentric and expensive alternatives.

The race to make the first successful electric car may hinge on what engineers call "the pack"—the intricate bundle of batteries that is the most temperamental equipment on board. If the pack is too big, the car will be too pricey; if the pack is too small, or of poor design, it will drive like a golf cart. "Batteries are a lot like people," Phil Gow, Coda's chief battery engineer, told me when I visited the Tianjin factory, a ninety-minute drive from Beijing. "They want to have a certain temperature range. They're finicky." To explain, Gow, a Canadian, who is bald and has a goatee, led me to one of Lishen's production lines, similar to the car-battery line that will be fully operational next year. Workers in blue uniforms and blue hairnets were moving in swift precision around long temperature-controlled assembly lines, sealed off from dust and contamination by glass walls.

The workers were making laptop batteries—pinkie-size cylinders, to be lined up and encased in the familiar plastic brick. The system is similar for batteries tiny enough for an iPod or big enough for a car. Conveyor belts carried long, wafer-thin strips of metal into printing-press-like rollers, which coated them with electrode-active material. Another machine sandwiched the strips between razor-thin layers of plastic, and wound the whole stack together into a tight "jelly roll," a cylinder that looked, for the first time, like a battery. (Square cell-phone batteries are just jelly rolls squashed.)

A slogan on the wall declared "Variation Is the Biggest Enemy of Quality." Gow nodded at it gravely. A bundle of batteries is only as good as its weakest cell; if a coating is five-millionths of a metre too thin or too thick, a car could be a lemon. The new plant will have up to three thousand workers on ten-hour shifts, twenty hours a day. "When you get down to it, you can have ten people working in China for the cost of one person in the U.S.," Mark Atkeson, the head of Coda's China operations, said.

It was easy to see China's edge in the operation. Upstairs, Gow and Atkeson showed me America's edge: their prototype of the pack. For two years, Coda's engineers in California and their collaborators around the world have worked on making it as light and powerful as possible—a life of "optimizing millimetres," as Gow put it. The result was a long, shallow aluminum case, measured to fit between the axles and jam-packed with seven hundred and twenty-eight rectangular cells, topped with a fibreglass case. It carried its own air-conditioning system, to prevent batteries from getting too cold or too hot. Rattling off arcane points, Gow caught himself. "There's hundreds of things that go into it, so there's hundreds of details," he said. "It's really a great field for people with O.C.D."

Czinger, in that sense, had found his niche. By November, he was crisscrossing the Pacific, leading design teams on both sides; in the months since we first met, he had grown only more evangelical in his belief that, if Americans would stop feeling threatened by China's progress on clean technology, they might glimpse their own strengths. Only his American engineers, he said, had the garage-innovation culture to spend "eighteen hours a day for two years to develop a new technology." But only in China had he discovered "the will to spend on infrastructure, and to do it at high speed." The result, he said, was a "state-of-the-art battery facility that was, two years ago, an empty field!"

America has a tradition of overestimating its rivals, and China is a convenient choice these days. But, as with Japan's a generation ago, China's rapid advances in science and technology obscure some deeper limitations. In 2004, a group of U.S.-based Chinese scientists accused the 863 Program of cronyism, of funnelling money into pet projects and unworthy labs. (A proverb popular among scientists goes, "Pavilions near the water receive the most moonlight.") When critics published their complaints in a Chinese-language supplement to the journal *Nature*, the government banned it. Less than two years later, Chen Jin, a star researcher at Shanghai Jiaotong University, who had received more than ten million dollars in grants to produce a Chinese microchip to rival Intel's, was discovered to have faked his results. It confirmed what many Chinese scientists said among themselves: the Chinese science system was riddled with plagiarism, falsified data, and conflicts of interest.

After the Chen Jin scandal, the 863 Program made changes. It began publishing tenders on the Web, to invite broader participation, and, to cut down on conflicts of interest, it started assigning evaluators randomly. But those measures couldn't solve a larger problem: the system that allowed China to master the production of wind turbines and batteries does not necessarily equip China to invent the energy technology that nobody has yet imagined. "Add as many mail coaches as you please, you will never get a railroad," the economist Joseph Schumpeter once wrote. Scale is not a substitute for radical invention, and the Chinese bureaucracy chronically discourages risk. In 1999, the government launched a small-business innovation fund, for instance, but its bureaucratic DNA tells it to place only safe bets. "They are concerned that, given that it's a public fund, if their failure rate is very high the review will not be very good and the public will say, 'Hey, you're wasting money,' " Xue Lan, the dean of the school of public policy at Tsinghua University, told me. "But a venture capitalist would say, 'It is natural that you'll have a lot of failures.' " Financing is not the only barrier to innovation. As an editorial last year in *Nature* put it, "An even deeper question is whether a truly vibrant scientific culture is possible without a more widespread societal commitment to free expression."

The Obama Administration is busy repairing the energy legacy of its predecessor. The stimulus package passed in February put more than thirty-eight billion dollars into the Department of Energy for renewable-energy projects—including four hundred million for ARPA-E, the agency that Bush opposed. (It also allocated a billion dollars toward reviving FutureGen, though a final decision is pending.)

In announcing the opening of ARPA-E, in April, Obama vowed to return America's investment in research and development to a level not seen since the space race. "The nation that leads the world in twenty-first-century clean energy will be the nation that leads in the twenty-first-century global economy," he said. "I believe America can and must be that nation."

An uninspiring version of that message is gaining currency in Congress; it frames American leadership as manifesting not so much the courage to seize the initiative as the determination to prevent others from doing so. Senator Charles Schumer, one of several lawmakers who have begun to cast China's role in environmental technology as a threat to American jobs, has warned the Obama Administration not to provide stimulus funds to a wind farm in Texas, because many of the turbines would be made in China. ("We should not be giving China a head start in this race at our own country's expense," Schumer said in a statement.) Senators John Kerry and Lindsey Graham, in an Op-Ed in the *Times*, vowed not to "surrender our marketplace to countries that do not accept environmental standards," and suggested a "border tax" on clean-energy technology.

The larger fact, however, is that no single nation is likely to dominate the clean-energy economy. Goldwind, Coda, and the Thermal Power Research Institute are hybrids of Western design and Chinese production, and no nation has yet mastered both the invention and the low-cost manufacturing of clean technology. It appears increasingly clear that winners in the new-energy economy will exploit the strengths of each side. President Obama seems inclined toward this view. When he visited Beijing in November, he and Hu Jintao cut several deals to share energy technology and know-how which will accelerate progress in both countries. This was hardly a matter of handing technology to China; under one of the deals, for instance, the Missouri-based company Peabody Energy purchased a stake in GreenGen, so that it can obtain data from, and lend expertise to, a cutting-edge Chinese power plant.

More important, the two Presidents reignited hopes that climate negotiations this month in Copenhagen, which had been heading for failure, might reach a meaningful compromise. Days after the Beijing summit, China and the U.S. provided specific targets for controlling emissions. Their pledges were far from bold, and left both sides open to criticism: China's emissions, after all, will continue to grow over time, and cuts pledged by the U.S. still fall far short of what scientists say is required to avert the worst effects of warming. Yet the commitments, for all their weakness, serve a crucial function: They prevent each side from using the other as a foil to justify inaction.

For the U.S. and China, the climate talks boil down to how much money the rich world will give poorer nations to help them acquire the technology to limit emissions and cope with the droughts, rising sea levels, and other effects caused by those who enjoyed two hundred years of burning cheap fossil fuels. Without sharing costs and technology, it is not at all clear, for instance, that China will invest in the holy grail of climate science: funnelling greenhouse gases underground. The process, known as carbon capture and storage, or C.C.S., is so difficult and expensive that nobody has yet succeeded in using it on a large scale. Like electric cars and coal gasification, C.C.S. would be cheaper to develop in China than in the U.S., but China is not interested in paying for it alone. As long as a Chinese citizen earns less than one-seventh what his counterpart in America earns, China is unlikely to back down on the demand that it should be paid to slow down its economy and invest even more in energy technology. And on that point the sides remain far apart.

In November, I was spending much of my time at Tsinghua University, a center of clean-tech research, seeing a string of new energy projects that might or might not succeed someday. (My favorite, science aside, is a biofuel based on the process of producing Chinese moonshine.) In a giant, bustling convention hall across town, models in slinky evening gowns and white fur stoles arrayed themselves around mockups of wind turbines as if they were hot rods. Beijing was so overrun with visiting MacArthur geniuses and Nobel laureates and Silicon Valley eminences, all angling to influence China's climate-change policy, that I had to triage conferences.

Traffic alone made it hard to get around. This year, China overtook the United States as the world's largest car market, and much of Beijing is gridlocked every day. (Impossibly, the number of cars in the city is expected to double in seven years.) In desperation, I decided to buy an electric bicycle. China has put a hundred million of them on the road in barely ten years, an unplanned phenomenon that, energy experts point out, happens to be a milestone: the world's first electric vehicle to go mass market. The 863 Program noticed, and last year it added a program to build a micro-electric car, inspired by bicycle components, for commuters. Researchers at Tsinghua did just that, by attaching four electric-bike motors to a chassis. "We call it the Hali," Ouyang Minggao, the Tsinghua professor in charge of it, told me. They took the name from the Chinese translation of "Harry Potter." The car is tiny and bulbous, and is being road-tested near Shanghai.

Hunting for an e-bike, I ended up at a string of shops near the Tsinghua campus, where each storefront offered a competing range of prices and styles to a clientele dominated by students and young families. I settled on a model called the Turtle King—a simple contraption, black and styled like a Vespa, with a five-hundred-watt brushless motor and disk brakes. Built of plastic to save weight, it was more akin to a scooter than to a bicycle, and it ran on a pair of lead-acid batteries, similar to those under the hood of a car. The salesman said that the bike would run for twenty to thirty miles, depending on how fast I went, before I would need to plug its cord into the wall for eight hours or lug the batteries inside to charge. With a top speed of around twenty-five miles per hour, it would do little for the ego, but, at just over five hundred dollars, it was worth a try.

The manager rang up the sale, and I chatted with two buyers who were students at the Beijing University of Aeronautics and Astronautics. "You must have tons of these in the U.S., because you're always talking about environmental consciousness," one of them, an industrial-design major wearing a Che Guevara T-shirt, said. Not really, I told him; American drivers generally use bikes for exercise, not transportation. He looked baffled. Around his campus and others in Beijing, electric bikes are as routine as motorcycles are in the hill towns of Italy.

I eased the Turtle King down over the curb and accelerated to full speed, such as it was. I threaded through an intersection clotted with honking traffic, and the feeling, I discovered, was sublime. The Turtle King was addictive. I began riding it everywhere, showing up early for appointments, flush with efficiency and a soupçon of moral superiority. For years, people had abandoned Beijing's bicycle lanes in favor of cars, but now the bike lanes were alive again, in an unruly showcase of innovation. Young riders souped up their bikes into status symbols, pulsing with flashing lights and subwoofers; construction workers drove them like mules, laden down to the axles with sledgehammers and drills and propane tanks; parents with kids' seats on the back drifted through rush-hour traffic and reached school on time. Before long, I was coveting an upgrade to a lithium-ion battery, which is lighter and runs longer. (Lithium-ion batteries have sparked interest in electric bikes in the West. They are a high-minded new accessory in Paris, and more than a few have even turned up in America.)

As a machine, the Turtle King was in desperate need of improvement. The chintzy horn broke the first day. The battery never went as far as advertised, and it was so heavy that I narrowly missed breaking some toes as it crashed to the ground on the way into the living room. Soon, the sharp winter wind in Beijing was testing my commitment to transportation al fresco. And yet, for all its imperfections, the Turtle King was so much more practical than sitting in a stopped taxi or crowding onto a Beijing bus that it had become what all new-energy technology is somehow supposed to be: cheap, simple, and unobtrusive enough so that using it is no longer a matter of sacrifice but one of self-interest. ♦

ILLUSTRATION: JORDAN AWAN