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REBIRTH OF RENEWABLES

It was the first and only press conference ever held on top of the White House. On June 20, 1979, President Carter, along with his wife, Rosalynn, tramped up onto the roof, entourage and press in tow, in order to dedicate a solar hot water–heater system. "No one can ever embargo the sun," Carter declared. He put the system's cost at $28,000 but quickly added that the investment would pay for itself in seven to ten years, given high energy prices. "A generation from now," he said, this solar heater could 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." Or, he said, it could be "a curiosity, a museum piece."

And there, standing on the White House roof, he set a grand goal: that the United States would get 20 percent of its energy from solar by the year 2000. He promised to spend $1 billion over the next year to get the initiative going.[1]

By the time of Carter's 1979 press conference, the idea that the world needed to transition to what was then called solar energy (and later renewables) had already become a clear trend in energy thinking. The Arab oil embargo earlier that decade, and the then unfolding Iranian Revolution, brought not only disruption in petroleum supplies but also grave fears about the future of world oil. All that combined with a sharpening environmental consciousness to make solar and renewable energy the natural solution. It was clean and it provided stability. And it would never run out. In Washington, incentives were wheeled

into place to jump-start a renewable industry. Research dollars started to flow. Technologists, big companies, small companies, entrepreneurs, activists, and enthusiasts were all getting into the solar game.

But nothing like 20 percent happened. Instead what followed this initial burst of enthusiasm were decades of disappointment, disillusionment, bankruptcies, and sheer stagnation. It was only in the late 1990s that the industry, by then established in Japan and Germany with strong government support, began to revive in the United States, and only around 2004–5 that it started to gain real scale. Even as late as 2010, renewables accounted for only 8 percent of the U.S. energy supply—about the same share it had in 1980. Remove two items—hydropower (which has been constant for many years) and biomass (primarily ethanol)—and renewables in 2009 constituted less than 1.5 percent of the total U.S. energy supply. Much the same holds true around the world.

Yet today renewables are reenergized to become a growing part of energy supply, embraced as a key solution to the triple challenges of energy supply, security, and climate change. China's President Hu Jintao said that China must "seize preemptive opportunities in the new round of the global energy revolution." The European Union has gone further, with a 20 percent renewable goal for 2020. "I want us to be the greenest government ever," declared British prime minister David Cameron, promising "the most dramatic change in our energy policy since the advent of nuclear energy." In 2011, German Chancellor Angela Merkel set a new target for Germany—to move renewables' share of electricity from 17 percent in 2011 to 35 percent by 2020.

More than any other president before him, Barack Obama has invested his administration in remaking the energy system and driving it toward a renewable foundation. Indeed, he has raised the stakes in renewable energy to the level of national destiny. "The nation that leads the world in creating new energy sources," he said, "will be the nation that leads the twenty-first-century global economy." Both companies and investors now see renewables as a large and growing part of the huge global energy market.[2]

Yet reaching the higher targets will be no easy achievement given the scale and complexity of the energy system that supplies the world's economy. Today it is still at the level of policy and politics where the future of renewables is primarily determined. They are, mostly, not competitive with conventional energy, although costs have come down substantially over the years. A global

price on carbon, whether in the form of a carbon tax or a cap-and-trade system, would further augment the competitive economics of renewables against conventional energy.

Still, renewables are set, after a twenty-five-year hiatus, to become a significant and growing part of the energy mix. It is almost as though a time chasm has closed, compressing the decades and conjoining the late 1970s with the second decade of the twenty-first century.

WHAT DOES "RENEWABLES" MEAN?

The idea of "renewables"—an inexhaustible and environmentally friendly energy source—is deeply appealing. But what are renewables? Parse the word "renewables," and one finds a series of disparate technologies:

1. *Wind*—the fastest growing, which powers technologically sophisticated machines, clustered in "farms," that generate electricity.
2. *Direct sunlight*—captured either by photovoltaic cells (PVs) or by mirrors or other technologies that concentrate the light and transform its energy into electric current.
3. *Biofuels*—ethanol, biodiesel, and advanced biofuels (made of algae, cellulose, or other feedstock), all of which substitute for gasoline, diesel, or potentially jet fuel.
4. *Biomass*—wood or other plant material palletized or otherwise treated and burned in a power plant; also wood or dung that people in developing countries burn for heating and cooking.
5. *Geothermal*—either hot water or hot steam that is pumped from beneath the ground to the surface to drive an electricity-producing turbine.
6. *Hydropower*—falling or pressurized water that drives turbines; dams are increasingly criticized on environmental grounds and thus are hard to build in many countries.
7. *Passive solar*—now also known as green buildings, which take advantage of the natural habitat to reduce energy consumption, and which often overlaps with energy efficiency.

There are other technologies, including tidal power. Garbage-to-energy might count as well, if one thinks of garbage as a renewable resource. But those listed above are where most of the effort is focused. What unifies these varied technologies as renewables? They are not based upon finite resources; they are widely distributed; they do not add, at least in theory, to carbon, and thus have a much more restricted carbon footprint.

One other technology needs to be added to the list: batteries for electric cars. These are not strictly renewable in the same way but fall within the same framework. They could count as renewable if the electricity by which they are recharged happens to be the product of wind or sunlight.

EARTH DAY

In 1951 the Paley Commission, appointed by President Harry Truman to investigate raw material shortages during the Korean War, warned against future oil shortfalls and dependence on Middle Eastern oil. "Direct utilization of solar energy," it declared, "is perhaps the most important contribution technology can make to the solution of the materials shortage." In 1955 President Eisenhower issued what has been described as "the first Presidential message on solar energy development," praising what he called "movement toward a fuller use of virtually unlimited energy of the sun." But not much at all happened for the next decade and a half.[3]

But then a single day, April 22, 1970—Earth Day—crystallized a new environmental consciousness in America and established its political potency.

Denis Hayes, a graduate student at Harvard's Kennedy School of Government, had taken a year off to create Earth Day. It turned into a coast-to-coast "happening" aimed at mobilizing the national consciousness. An estimated 20 million Americans joined in. They demonstrated and marched; they attended symposia and teach-ins; they protested outside polluting factories; they dragged tires and old appliances out of rivers; they buried autos to campaign against smog. The main targets of Earth Day were dirty air, polluted rivers and seas, toxic waste, chemical pesticides, strip mining, noise, oil spills, and overpopulation (a popular button, aimed at prospective parents, was "Stop at Two"). Congress shut down so that members could go back home. ("Everyone I've talked to," commented one congressman, "is making a speech somewhere.")

After Earth Day the nation simply thought differently than it had before. A few months later, the first Clean Air Act was passed, and President Richard Nixon established the Environmental Protection Agency (EPA). *Time* magazine crowned "The Environment" as the "Issue of the Year."

Yet what is striking in retrospect is what was omitted. While aspects of energy production and consumption (for example, smog) were among the targets, energy itself was not part of the agenda on that April day in 1970. "People spoke of oil, gas, coal, nuclear, and hydro," Denis Hayes recalled. "But there was no discussion of 'energy.' "[4]

Until the 1973 oil embargo, the energy business was just that—a business—or, actually, several different businesses. From 1973 on, energy became everybody's business.

"YOU WILL LEARN"

In Washington, energy suddenly went from being a nonissue to being the number one issue. The reasons were the 1973 oil embargo, skyrocketing gasoline prices, and long lines at the gasoline pump. Jacob Javits, a senator from New York, was one of the most prominent of what were called "liberal Republicans." In late 1973, shortly after the first oil embargo, Javits found himself sitting for 90 minutes in a gas line at a Washington, D.C., service station, fuming while he waited to fill his car. Once back on Capitol Hill, he stormed into his office, demanding to know who on his staff did energy. The answer was nobody. His frustration rising, the senator sent for a young staffer named Scott Sklar. Without even looking up, Javits informed Sklar that he would now be the senator's "energy" aide. Sklar protested, though politely, that he was hardly prepared—he had done his graduate degree on Chinese-Russian relations and worked on military issues. To underline the point, he walked over to the hall and flipped the light switch on and off. "I have no idea where this stuff comes from, Senator," said Sklar.

Javits laughed. "Son, you will learn."[5]

In 1974 the first of several solar energy bills went into law, and federal research appropriation jumped substantially. Not coincidentally, that was more or less

when the modern renewables energy industry was really born, although at the time, "solar" was the umbrella term for most renewables. In 1975, the second year of the Gerald Ford presidency, some five thousand people came to Washington, D.C., to participate in a solar energy industry conference. "Solar power has suddenly become respectable," the *New York Times* declared that year, adding, "Only a few years ago, it was treated in the United States as a subject for eco-freaks."

By the mid-1970s the environmental movement was focusing in on energy; it was organizing against nuclear power, and it embraced solar as the answer. One of the major intellectual protagonists was Amory Lovins, an American who had studied physics at Oxford and worked for Friends of the Earth. Lovins wrote an influential article for *Foreign Affairs* on what he called the "soft path." He argued that energy efficiency and renewables would be more productive and much less costly than the "hard path" of oil, gas, coal, and nuclear. In 1977, the founder of Earth Day, Denis Hayes, published his own book, *Rays of Hope: The Transition to a Post-Petroleum World.* By coincidence, its publication date was perfectly timed: New York City was hit just then by a massive power blackout.[6]

But the most important single boost for renewable energy was the arrival in January 1977 of a new man in Washington.

THE "MORAL EQUIVALENT OF WAR"

Jimmy Carter worried about the dangers of dependency on foreign oil and the risks of another energy crisis. Indeed, he saw energy as the great challenge for his new administration, and he looked to coal and energy conservation as the two principal answers. Reinforcing his fears about energy insecurity, the CIA had just completed a study warning that world oil supplies would start to decline within a decade. Less than two weeks after his inauguration in 1977, Jimmy Carter sat down next to a fireplace for his first "fireside chat" from the White House, wearing what would become an iconic sweater—beige with buttons down the middle. He told the American people that "one of our most urgent projects is to develop a national energy policy." The speech was well received.

Two months later, speaking from the Oval Office, Carter warned the

American people that he would be holding "an unpleasant talk with you" about "the greatest challenge that our country will face during our lifetime" with "the exception of preventing war." The energy problem, he explained, will "get progressively worse through the rest of this century . . . We are now running out of oil and gas, we must prepare for a . . . change—to strict conservation and to a renewed use of coal" along with "permanent renewable energy sources like solar power." This "difficult effort," he concluded, was nothing less than the "moral equivalent of war"—forever memorialized by its initials: MEOW.

Whatever the specifics about supply-and-demand, Carter laid out the long-term energy challenge for the United States and the world community. The United States, he made clear, was now, fatefully, tied into a world market.

"I gave the energy message on television and think it came out all right," Carter wrote in his diary. But the speech was not well received. Its brittle tone and pessimism, its emphasis on sacrifice and moral failing, and its expectation of permanent scarcity—all these left a very mixed legacy. Many decades later a senior energy adviser walking through the Old Executive Office Building, next to the White House, observed, "These halls are still haunted by Jimmy Carter's sweater."[7]

Carter put James Schlesinger, formerly director of central intelligence and secretary of defense under Nixon and Ford, in charge of a 90-day crash program to develop a national energy plan. Schlesinger, a master of the complexities of bureaucracy, combined 50 government agencies concerned with energy into a single new organization, the Department of Energy.

Support for solar continued to build, and the Carter administration moved with it. As Schlesinger summarized it, "Solar has captured the public imagination." It was in these years that the Carter administration and Congress laid down the baseboards for today's renewables industry. They did so with tax incentives, grants, regulations, a solar bank, and R&D funding. The administration also established a new national research laboratory devoted to solar energy—the Solar Energy Research Institute—in Golden, Colorado, in the foothills of the Rockies. To head it, Energy Secretary Schlesinger chose, of all people, Denis Hayes, who had been criticizing the Carter administration for not moving fast enough on solar. But Schlesinger had a reasonable theory: if a nuclear proponent headed the nuclear program, and a coal proponent the coal program, then why not a renewables advocate to head the renewables program?[8]

"PURPA MACHINES"

One other policy would prove of critical importance. It is one that has already been cited: Section 210 of the Public Utility Regulatory Policies Act of 1978, otherwise known as PURPA. This may have been obscure at the time, but it turned out to be one of the main foundations on which the renewable industry was born.

Electric utilities were required to contract to buy the power output from what were called qualifying facilities, or QFs. These facilities were mostly meant to be cogeneration projects or small renewable facilities, such as a small dam or wind turbines. The rate that the utilities would pay the owner of the QF was set on a state-by-state basis by the slightly arcane notion of "avoided cost." That is, the utility would guarantee to buy the electric output at what was calculated to be the cost of theoretical oil supplies at some point in the future, plus the high costs of building theoretical new power plants—again against some point in the future. The costs that were avoided were often set at the peak of the market and sometimes, especially in the case of a place like California, on very generous terms. A guaranteed market with guaranteed high prices certainly provides the incentives to get people moving and help jump-start an industry. It worked here. In time, however, many of these facilities became known as "PURPA machines," as they would never have been economic had it not been for what turned out to be those excessively high estimates of the avoided costs.

In addition to creating a market, these PURPA machines had another consequence. By requiring utilities to purchase power from these units, which were not owned by the utilities, the government was taking the first step to erode the natural monopoly that had characterized the power business for more than seventy years. This would give a further boost to renewable energy.

There was in those years much debate over solar policy and the nature of incentives. Some argued that systems had been overdesigned and were too expensive and too complex. "We've built a Cadillac when people want a Volkswagen," complained one critic, George Tenet, the promotion manager of the Solar Energy Industries Association (and many years later the head of the CIA). Yet the momentum continued to build. By 1980 over a thousand companies belonged to the Solar Energy Industries Association. Some of them were start-ups but some were large companies, ranging from Grumman, Boeing, and Alcoa to General Motors and Exxon.[9]

GOOD-BYE SUNSHINE

That shining moment did not last. As quickly as it had emerged, the solar energy industry seemed to fold. The Iranian Revolution led to chaos in the oil market, rapid increases in prices, new gas lines, and a second oil shock, and the Carter administration started to come unwound. In July 1979, just a few weeks after announcing the bold solar goal atop the White House, President Carter delivered what became known as the "malaise speech," warning that the nation faced a crisis of confidence and a "crisis of the American spirit." His own response was to fire much of his cabinet and announce that he was now putting most of his energy chips, and billions of dollars, into synfuels—liquids made either from coal or oil shale—as the way out of the energy crisis.

Confidence was not restored. In November 1980 Ronald Reagan defeated Jimmy Carter for the presidency. Carter's renewables policies went down with him.

"I really believe that the effort I made over those four years was the maximum that a human being could do," Carter said many years later. "I'm not bragging on myself... I made eight or nine speeches on energy, until people got sick of it." His advisers, Carter added, said, "'Look, don't talk about energy anymore, Mr. President. You're hitting your head against a stone wall.'" The political cost in Carter's own estimation proved to be very high. "It sapped away a substantial portion of my domestic influence."

Reflecting on his experience, Carter summed it up this way: "It was like gnawing on a rock."[10]

"PRODUCTION, PRODUCTION, PRODUCTION"

If Jimmy Carter was the energy pessimist, prophesying about the great dangers ahead and warning Americans to change their ways, Ronald Reagan was the opposite, the sunny optimist, the beacon of self-confidence, the proponent of a new "morning in America."

The Reagan administration, which came into office in 1981, was determined to let market principles and price signals shape the energy marketplace. It was also responding to the distortions, bureaucratic nightmare, and endless

litigation that resulted from the oil and natural gas price controls that Richard Nixon had hurriedly put in place a decade earlier. The Carter administration, paying a considerable political price, had already initiated price deregulation that would unfold on a schedule. But the Reagan administration moved swiftly to terminate the system altogether.

Although there was some continuity on the issue of price controls, renewable energy was an entirely different story. It had become a political divide—indeed, an ideological test—and, as such, represented a major discontinuity between the two administrations. The difference was made abundantly clear at the outset of the Reagan administration by Michael Halbouty, the head of the energy transition team and successful Texas wildcatter, as well as the developer of the sprawling Galleria shopping center and hotel complex in Houston. To a visitor at the Department of Energy, Halbouty announced that he could sum up the energy policy of the Reagan administration in just three words—"Production, production, and production"—as in domestic production of oil and natural gas.

Renewables had little place in that paradigm, and they quickly fell by the wayside. As far as the Reaganites were concerned, renewables were much too identified with the Carter administration and its travails and, even worse, with California Governor Jerry Brown. He was not only Reagan's successor as governor, but was seen as the very embodiment of the anti-Reagan liberal. Nicknamed "Governor Moonbeam," he had become the nation's most vigorous champion of power from wind and the sun.

There were also practical problems. These were new technologies; there was hype, and there were things to criticize. Many of the PURPA machines were never going to be economic—indeed, some were highly uneconomic, miniature white elephants. Some never functioned properly. Under Reagan, the funding and incentives for renewables were slashed or eliminated altogether. (So was the Carter administration's multibillion-dollar program in synthetic fuels.) Denis Hayes, the director of the Solar Energy Research Institute, was abruptly summoned to the Denver airport to meet the head of the organization that oversaw the institute. Hayes was told that his budget was being slashed and 40 percent of the staff would be fired immediately. Hayes resigned on the spot.[11]

But solar and other renewables would have in any event faced a much rockier road because of the marketplace. The sky-high interest rates and deep recession of the early 1980s, the consequences of the battle against inflation, would

have slowed solar sales, mostly rooftop water heaters, in any event, as people stopped spending and real estate went into a bust.

Solar just lost its luster as a business. In 1981 Exxon sold its solar thermal business. "Our view of solar had changed," recalled A. L. Shrier, the president of the Exxon unit at the time. "It was going to take longer and would be harder to make it widespread. We didn't see the costs coming down or the technology developing fast enough." With Reagan elected, it was also clear that the heady Carter objective of 20 percent solar by the end of the century was gone. Most other large companies came to the same conclusion.[12]

In 1986, in the face of a large oversupply of oil on the world market, oil prices plummeted from a high of $34 a barrel to as little as $10 a barrel. That completely knocked the economic legs out from under the nascent solar industry. Price, it turned out, mattered enormously, and solar, as it was then, just could not compete. A solar architect who had thought he was "battling" OPEC found instead that his business was on the ropes without the support—and expectation—of relatively high energy prices.

THE EPITAPH?

In 1986, the same year as the price collapse, the solar hot water system on the roof of the White House sprung a leak. Instead of being repaired, the system was dismantled. Its designer would later explain that White House Chief of Staff Donald Regan "felt that the equipment was just a joke, and he had it taken down." The disassembled equipment was eventually shipped off as surplus government property to a college in Maine, which used it to produce hot water for its cafeteria. Eventually the system outlived its usefulness on campus. In 2006 it was dismantled again, and part of it was packed up and shipped to Atlanta where—as Carter had speculated at his rooftop press conference twenty-seven years earlier—it ended up a museum exhibit. And, where else, but in the Carter Presidential Library.

The "rays of hope" for solar power dimmed, at least in the United States, into a very faint glow. Or, as the *New York Times* put it, "The promise of renewable power has become a distant hope." Companies went bankrupt or disappeared altogether. Activists and entrepreneurs moved on into other fields. The

Economist described this once buoyant solar industry as "a commercial graveyard for ecologically minded dreamers." Within the nascent renewables industry, the decades of the 1980s and 1990s were to be recalled as the Valley of Death—companies struggled just to stay alive.

By this time, Scott Sklar, the former aide to Senator Javits, was head of the Solar Energy Industries Association, and the solar industry's chief lobbyist in Washington. He remembered all too well the mood in those times.

"We were really morose," he said.[13]

JAPAN: STAYING ALIVE

The end of the "solar dream" in the United States would pretty much have seemed to mean the end of the road for renewables. If the United States, the global leader in technology and R&D, had more or less given up on renewables, who else would stick with it? The answer was Japan.

In the early 1970s, Kotaro Ikeguchi was a rising young official in MITI, Japan's powerful Ministry of International Trade and Industry. Assigned to a department dealing with energy and mining, he became alarmed that Japan had become dangerously overreliant on Middle East oil and was oblivious to the risks. The consequences of a cutoff of supply could be disastrous.

But Ikeguchi could not stir much interest. For Japan's high-speed economic growth in the 1960s and early 1970s had been fueled by Middle Eastern oil, and there was little expectation that would change.

So as an outlet for his anxieties, Ikeguchi decided to write a novel that might wake up both officialdom and the public to Japan's vulnerability. His imaginary crisis was a Middle Eastern war that resulted in a cutoff of imports. His hero? By coincidence, it was a spry, incisive, but very pragmatic MITI bureaucrat with an understanding of Japan's precarious energy dependence. Since he was a working bureaucrat, he needed a pen name. He came up with "Taichi Sakaiya," which means, loosely, "Big Man on the Roof of the World."

But before he could find a publisher, reality intruded. His fiction became nonfiction. With the 1973 oil crisis, the Japanese suddenly feared that their whole edifice of economic growth might collapse. Ikeguchi decided it would

be inappropriate to publish his novel while the Japanese people were suffering through a real energy shortage, and he put it into a drawer.

Like his fictional hero, Ikeguchi was drafted to help formulate Japan's response to a real energy crisis. He was tapped to head Japan's Sunshine Project, the all-out national initiative to find a way to reduce Japan's dependence on Middle Eastern oil. He parceled out grants, hammered out industry research partnerships on a wide variety of technological ventures, and pushed through bureaucratic changes in government research institutes.[14]

THE "BUREAUCRAT-NOVELIST"

After the first oil crisis eased, Ikeguchi pulled his manuscript out of the drawer and in 1975 published it as *Yudan!* The title can be translated as "Cut Off!" or more evocatively, "Starvation in Winter!" It became a huge best-seller—over a million copies. Ikeguchi became famous. Thereafter he was much better known by his pen name Taichi Sakaiya. Highly prolific, he continued to publish books, ranging from an enormously influential treatise called *The Knowledge-Value Revolution,* which presaged today's information economy, to a four-volume historical novel on Genghis Khan. One Japanese publication described his "unique position" as "bureaucrat-novelist." When the second oil crisis hit in 1979, he was recruited to establish an entire new bureaucracy—the New Energy and Industrial Technology Development Organization, NEDO. With a dedicated budget and staff, NEDO continued to propel Japanese research on renewables, even when the rest of the world, including the United States it seemed, had lost interest.

"I thought that the age of oil was over," recalled Sakaiya. "It was the age of the knowledge revolution."[15]

After a flirtation with geothermal—partly abandoned because many of these resources were in environmentally sensitive areas—MITI turned to solar energy. Japan's experience with semiconductors was applicable to the manufacture of solar cells, as silicon was the main building block for both. It appeared to the Japanese government that there was some chance of making solar photovoltaics competitive as a source of primary energy if costs could be cut massively.

The solar market took off, fueled by large government subsidies that helped consumers purchase solar panels, along with the most expensive domestic electricity rates in the world, plummeting costs, efficiencies of scale, and increased competition. Led by such companies as Sharp, Kyocera, and Sanyo, Japan was by the beginning of this century the world's dominant solar manufacturer.

The original MITI vision that Taichi Sakaiya had articulated—of creating a new knowledge-based industry with strong export potential—seemed to be on the cusp of realization. But by then the renewable mandate was passing to another country.

FEEDING INTO GERMANY

It was drilled into the East German guards at the Berlin Wall that their prime mission, above all else, was to keep their fellow citizens from crossing from communist East Berlin into democratic West Berlin. Over the course of 1989 they had become increasingly jumpy. The Soviet grip on Eastern Europe was weakening, and the Berlin Wall was the front line in the East-West stand-off. Any East German attempting to breach the wall risked being shot dead on the spot by the border guards.

But on the night of November 9, 1989, after an ambiguous message by the East German leadership during a televised press conference, hundreds of thousands of East Berliners surged toward the wall, expecting it to come down, demanding that it be opened. Confused and uncertain, the guards hesitated, but finally did allow the wall to open, changing the course of history. People poured across the border. The division of Germany was over, as soon would be the Cold War itself.

Thereafter, the entire nation was to be preoccupied with reunification—the difficult incorporation of a ramshackle, dilapidated East Germany into a West Germany that had a vastly higher standard of living. Unification would end up a trillion-dollar-plus project.

As their part in reunification, the West German electric utilities focused on integrating East Germany's power system and modernizing its generation, which was based on a type of coal called lignite. While they were preoccupied with the East, a diverse coalition representing a new kind of movement

was stealthily promoting a renewable energy law whose adoption was "almost accidental." And so, as it turned out, the opening of the Berlin Wall also opened a door that turned Germany into the world's leader in renewable energy for a decade, and as such, did much to lay the basis for today's global renewable energy industry.[16]

At the tip point of this environmental coalition was the Green Party. The Greens had emerged in the late 1970s to protest the environmental degradation that had come with Germany's economic miracle—polluted rivers, dirty air, and later, of special significance, ecological damage to forests. One thing that unified the entire movement was opposition to nuclear power. The movement also encompassed a New Left, anticapitalist, anti-American strain.

Indeed, what really mobilized the Green movement and helped turn it into a political party was, in the early 1980s, the proposed deployment of new nuclear weapons in Europe and then American missiles in Germany, which were intended to counterbalance new Soviet missiles. Ronald Reagan became the perfect foil, and vast anti-Reagan and anti-American demonstrations across Germany established the Greens as a real political force.

In April 1986 came the terrible nuclear accident at Chernobyl. The winds blew westerly from Soviet Ukraine, carrying radiation toward Central Europe, stirring alarm and even panic, and fueling antinuclear activism in Germany and other countries. This fueled lasting antinuclear opposition across the German political spectrum. Former German Chancellor Gerhard Schroeder recalled that the real turning point in coalescing opposition to nuclear power was in 1986. "For me, it was the catastrophe at Chernobyl," he said. "Mothers of young children kept them inside and did not send them to kindergarten. You need the support of society, and we had it." In the aftermath of the accident, the Greens gained great credibility, and, in 1990, for the first time, they won seats in the Bundestag.

Renewable energy was at the top of their agenda. But they were not alone. The environment leader for the Social Democrats was Hermann Scheer, a former researcher on the nuclear fuel cycle, and many years later to be celebrated by *Time* magazine as a "solar crusader" of the "Green Century." He opposed nuclear power on the grounds that the world should not depend on "an electricity source which cannot be allowed to make a major failure." His aim became "to introduce a new paradigm into the energy policy," beginning with a new type of energy law.

In the late 1980s a few cities began to experiment with what would become known as the feed-in law—or "feed-in tariff"—which ranks with PURPA for its central importance in creating the economic basis for the modern renewables industry. Germany's feed-in tariff gave the renewables industry its first commercial scale, bigger than in Japan. The feed-in tariffs set prices that subsidized renewable generators.

One of the pioneers in the town of Hamelburg was a high school physics teacher named Hans-Josef Fell, who had been convinced by the 1972 Club of Rome study *Limits to Growth* that the world would soon start running out of resources. "Most people thought the feed-in tariffs were much too expensive, and that a crash would happen," said Fell. "Our argument was that you needed a market. You needed private capital."

In 1990 Fell and the other Greens won election to the Bundestag. They collaborated with Scheer and his faction of the Social Democrats to broaden the feed-in tariffs. To do so, they formed an unlikely alliance with conservative members of the Bundestag, who represented small hydro generators in Bavaria that were frustrated that they could not sell their power into the grid. Scheer and Fell took advantage of the general preoccupation of unification with the East to maneuver their plans into law.

"The German utilities were totally concentrated on East Germany," said Scheer. "They could not imagine how our program could succeed, and they did not take it seriously. They started to organize, but they were too late."

This feed-in tariff was notable not only for what it did for the renewable industry. It was also the very last law of the West German parliament, before unification came into force on January 1, 1991. "And yes," said Scheer, "it was, indirectly, the result of the fall of the Berlin Wall."[17]

The Feed-In Law of 1991 borrowed from America, specifically PURPA. Its model required German utilities to buy electricity from renewable generators at higher fixed rates—or very much higher fixed rates—and then subsidize those rates by spreading them across the system so that the costs blended into the overall price. In this way, the otherwise uncompetitive renewable energy would be fed into the grid, and the renewable producers could make a profit.

By 1993 wind turbines were going up across Germany. In 1998 national elections took the Greens from opposition and sent them into a new ruling Red-Green coalition government with the Social Democrats. Renewables, at

the insistence of the Greens, were a key part of the coalition agreement. "I have to say that the Green Party pushed the Social Democrats to see that this was a need," said Schroeder, who became chancellor in the new coalition. "It was a ten-year discussion."

In turn, the coalition pushed through the more aggressive Renewable Energy Law in 2000. The rates varied according to the technology. Photovoltaics received the most preferential feed-in rates, as much as seven times that of conventional electricity. Again, the costs were spread out across the entire system, with power companies passing on the extra costs to customers.

"With the law supporting the use of renewable energy," said Schroeder, "we forced the electricity companies to accept renewable energies. That was the main step."[18]

Two years later the governing coalition—reaching back to the origins of the Greens and the impact of Chernobyl—adopted a program to phase out all nuclear power, currently providing over a quarter of Germany's total electricity. This provided a further urgency to the development of renewables.

Wind, with over 90 percent of the new renewable capacity, has been by far the biggest winner from the feed-in laws. But Germany also became the world's biggest market for photovoltaics. The feed-in tariffs, said one solar executive, have "basically been a turbocharger." The development of high feed-in tariffs in other countries, notably Spain, has similarly stimulated very significant renewable development.[19]

Critics said that the subsidies in the feed-in tariffs were excessive and that as the volume of subsidized renewables increases, the costs would eventually lead to a consumer backlash. They also argued that paying different rates for different forms of renewable power, and even different subrates for different versions of the same technology, was economically irrational. Indeed, some backlash exactly along those lines was to occur.

Spain instituted particularly generous subsidies for renewables. Eventually, however, the program spun wildly out of control. Far more capacity was built than was targeted, costing the government much more than it ever intended. In the end, the financial burden was simply too much for an overburdened government. In 2008 Spain substantially reduced its feed-in tariffs, and did so again in 2010 amid fiscal austerity brought on by excessive government debt.

However, the feed-in laws did bring renewable power on much faster than

some might have imagined. "No one forecast in 2000 what would happen," said Hans-Josef Fell. Subsidies of this magnitude and a guaranteed market provided very powerful incentives. In 2009 renewables' share of German electricity consumption reached 14 percent, exceeding its 2010 goal, and the government raised the renewable electricity target for the year 2020.

Germany's feed-in laws also proved popular outside Germany—indeed, wildly popular. This was particularly true in China, as German feed-in tariffs turned Germany into one of the biggest export markets for China's fast-growing photovoltaic industry.[20]

FROM "SOLAR" TO "RENEWABLES": RECOVERY AND REBRANDING

In the early 1990s life began to creep back into the American solar industry. Environmentalism was already firmly established as a political force. The twentieth anniversary of the first Earth Day was marked by Earth Day 1990. Organized with a budget 25 times bigger than the first one, it included events in 3,600 U.S. communities and 140 other countries and mobilized upward of 200 million people for a day of activities around the world. Of more immediate impact was the passage of the Clean Air Amendments of 1990, which gave a major boost to environmental concerns. The administration of George H. W. Bush also restored some of the tax incentives for renewable energy. Solar was once again part of the portfolio.

"Solar" also got rebranded. Around this time, "solar energy" gave way to "renewable energy" as the all-encompassing term. "It was a response to the visceral antisolar rhetoric of the Reagan years," said Scott Sklar, who at the time headed the Solar Energies Industry Association. "Specific industries tried to rename themselves so as not to have a target on their heads." The wind industry wanted its own identity. So did geothermal and ethanol. None of them fit very comfortably under the heading of "solar." But they were all comfortable under the umbrella of "renewables." The Bush administration not only put additional money into the Solar Energy Research Institute but also participated in the general rebranding, rechristening it the National Renewable Energy Laboratory, NREL.

The welcome was even warmer under the Clinton administration. On a hot summer day, Bill Clinton was slated to give a speech on the White House lawn announcing an environmental initiative. Among those invited was Scott Sklar in his capacity as head of the solar trade association. Since it was hot and Sklar is bald—and something of a solar showman—Sklar decided to wear an unusual hat, a cross between a pith helmet and a beanie, with a solar-powered fan. It was only with some difficulty that he was able to persuade the White House guards to let him in. When Clinton caught sight of this odd contraption on the head of one of the guests in the crowd, it caught his interest. The president, to the distress of his staff, made his way over and asked Sklar what it was. Sklar explained. The president said he should have been wearing one too. He pulled out a business card and gave it to Sklar, telling him that if he had any other things like that, he should make a point to drop by the White House.[21]

THE STATES AS LABORATORIES

One of the most important reasons for the rebirth of renewables took place at the state level, bearing out the famous adage of Supreme Court Justice Louis Brandeis that states can serve as the laboratories of democracy. Without a particular innovation introduced by individual states—what are called renewable portfolio standards—it is doubtful that renewable energy in the United States would have seen the growth it has experienced since the new century began.

These standards—nicknamed RPS—require that utilities' generation portfolios include a certain amount of renewables by a specified date. The first small steps were in Iowa and Minnesota. But it was not until the late 1990s and early years of this century that a number of states imposed renewable standards. In many of the states, these portfolios were largely driven by the growing concern about climate change.

That was not the case in Texas. In fact, climate change was deliberately not part of the discussion there at all. The main reasons were anxieties about the adequacy of electric power, a desire for diversity, and mounting worries about poor air quality in a number of cities. The RPS was signed into law by Texas Governor George W. Bush in 1999. The RPS provision turned out to be wildly successful in stimulating wind development, more so than anyone had imagined, setting

off what became known as the Texas Wind Rush. The state had excellent wind resources, the requirements encouraged scale, and federal tax credits helped make wind economically competitive. (Indeed, so much wind was developed that, later, the costs of new transmission capacity would become a major issue.)

By 2011 29 states and Washington, D.C., had renewable portfolio standards in place, and most of the new capacity came on line in the RPS states. The results have been disproportionately weighted to wind. Some of the states have very significant targets: New York at 29 percent by 2015. Illinois, Oregon, and Minnesota all are aiming at 25 percent by 2025. In 2011 Jerry Brown, back as governor of California, signed an ambitious bill lifting the state's requirement from 20 percent, by 2020, to 33 percent. "You can't be afraid to be called a moonbeam, weird, deviant, interesting, unexpected," Governor Brown said as he signed the bill. As he put it, "I didn't get my name 'Governor Moonbeam' for nothing."

These standards will continue to be a major driver for renewable power in the United States. They also provide the mechanism for folding higher-cost renewable energy into the overall power portfolio, although some foresee a reaction to rate shock on the part of consumers owing to the higher costs of renewables.[22]

CLEANTECH

The rising prices for energy, beginning around 2003 and 2004, helped propel accelerated growth of, and support for, renewables in the United States. It also, at least for a time, narrowed the cost gap between renewable and conventional energy. Climate change became a much more explicit part of energy policy. As a result of all these factors, investment in renewables increased dramatically. As venture capital began investing in the sector, renewables gained yet another new name—"cleantech." And providing confirmation that renewables were moving into the mainstream, investment banks established "clean energy" teams and began to distribute cleantech research.[23]

But as the Great Recession of 2008 broke, it hit renewables hard. Financing became increasingly difficult to arrange. Moreover, even with the subsequent rebound in prices from the lows of late 2008, renewables were still at a competitive disadvantage.

This time, however, unlike the 1980s, there was no Valley of Death for the

renewable industry. Renewables were now a much bigger industry with a strong constituency, it was international, and it had continuing policy support, including in the United States, energy legislation in 2005 and 2007. By now, renewables really were a global business.[24]

THE "THREE DENCHI BROTHERS"

Japan continued to be preoccupied with its high dependence on energy imports, and more than any other country. MITI—now the Ministry of Economy, Trade and Industry, or METI—continues to play an important role in steering Japan's industrial policy. It has promoted a very distinctive agenda for renewables. It is the "three Denchi brothers"—or *San Denchi Kyodai,* as Takayuki Ueda, a vice minister at METI, called them.

In Japan, fuel cells, solar cells, and batteries are all referred to as "batteries." METI sees these three technologies as pivotal to its triple mandates of ensuring Japan's industrial competitiveness, improving energy security through diversification, and tackling the problem of climate change. For each of these devices, new materials and fabrication techniques will be required to improve efficiency and reduce cost. "One day we will reach a point where all our electricity generation is renewables," says Ueda.

Japanese companies are laboring methodically to realize this dream, but they are also counting on another METI assumption—that, as Ueda said, cutting emissions by 80 percent will be "almost impossible without those three technologies. The three denchi brothers are very important not only for Japan, but for the world."[25]

GREEN DRAGON

China has over the last years embraced renewables with a fervor that has pushed it into the lead as a market, as a manufacturer—and as a competitor. In 1973 China had already introduced an agricultural law that called for solar and wind energy. In 1988 the first wind-power project was hooked up to the grid in the far west. Yet for many years renewables were largely considered antipoverty

measures for the benefit of the rural poor. By the turn of the century, renewables were starting to get more serious attention. China also recognized that if it was going to be a player in renewables, it needed to put a priority on acquiring technology and know-how—and on supporting entrepreneurs.[26]

The decisive change came with the Renewable Energy Law of 2005, which jump-started renewables in China. A host of factors had suddenly raised the salience of renewables. Rapid economic growth, particularly for heavy industry, was leading to even more rapid growth in energy consumption. The country had been going through its internal energy crisis, with electricity demand outrunning the availability of coal and electricity, resulting in bottlenecks in supply and brownouts in power. Energy security had become an urgent issue for the top leadership because of growing oil imports and rising oil prices. China would soon start becoming an importer of coal as well. "Based on our current consumption, our fossil energy reserve could not support our economy," said the chief engineer of China's National Energy Administration. "We were too large now. So China made the decision to accelerate new and renewable technologies. We need to have the golden momentum of economic growth and the green momentum of clean energy." The "clean" part was very important. Pollution was a pervasive problem throughout the country. Climate change, emissions from burning coal in particular, was becoming an ever more contentious international issue. And it looked as though renewables would become a global growth industry, and China wanted to be at the forefront.[27]

The 2005 Renewable Energy Law was followed in 2007 by the Medium- and Long-Term Development Plan for Renewable Energy, which set out specific targets and called for renewables to reach 15 percent of total energy by 2020. With these policies, bolstered by the government's massive stimulus spending during the global financial crisis, China's renewable energy moved into high gear. Wind capacity doubled each year between 2005 and 2009.[28]

China also used its renewables push to promote the cleantech industry, which it had identified as a key growth industry for the twenty-first century. "We will accelerate the development of a low-carbon economy and green economy so as to gain an advantageous position in the international industrial competition," said China's Premier Wen Jiabao. As low-cost manufacturers, and bolstered by strong national and local government support, including attractive financing

from state-owned banks, Chinese companies have come to dominate the solar panel market and have made significant inroads into the wind-turbine industry. One reason for the latter was China's decision to insist that 50 percent, and then 70 percent, of the components for domestic wind installations had to be made in China. Although the requirement ended in 2009, this policy gave Chinese wind-turbine suppliers time to expand the scale and sophistication of their operations and building on China's comparative advantage in manufacturing costs, to be more competitive with foreign companies at home and abroad.[29]

Yet even with China's strong support for its renewables industry, the country's push to boost renewables faces challenges. Hydropower has by far the largest share of any of the renewables, and will likely continue to have such. Though wind and solar are growing at a much faster rate than hydropower, they may together account for just 5 percent of China's total electricity generation in 2020. Even as China's renewable generating capacity rapidly expands, so too does its fossil fuel capacity, for China must rapidly expand its electricity capacity to meet a 10 percent annual growth in power demand. This puts a premium on projects that can supply a large amount of power—which still points to coal. It also explains why China is putting a lot of funding into research on clean coal.[30]

The commitment to renewables will grow stronger. But it will be in the framework of what Chinese government planners call an "emerging energy policy" that encourages not just renewables but more broadly any fuel that is not coal or oil, including nuclear and natural gas. The 12th Five Year Plan, adopted in 2011, emphasizes this policy. Of the seven Strategic Emerging Sectors identified by the plan, three are energy focused: energy conservation and environmental protection; new energy; and new energy vehicles. As it is, however, in a few short years China has become both the biggest market for wind in the world and the largest manufacturer and exporter of solar cells.

"NO AREA'S MORE RIPE"

With the Obama administration, the push for renewable energy became the top energy priority. The administration responded to the financial crisis and ensuing recession with a massive economic stimulus program, a significant part

of which was aimed at renewables and cleantech. Other countries rushed to support their own faltering economies through fiscal stimulus—or government spending—and that also included building up their renewable energy sectors.

In the United States, the energy stimulus was sometimes described as the largest energy bill ever passed. Renewable energy became a significant theme of the recovery. The promise of green jobs and cleantech jobs was a major component in the promotion of the stimulus package. Even more than Jimmy Carter, Obama focused on transforming America's energy system. "We need to encourage American innovation," Obama told Congress in his 2010 State of the Union Address. "And no area's more ripe for such innovation than energy."[31]

The scale of renewable energy can be measured in terms of dollars. Total global investment in renewable energy capacity reached $150 billion in 2009, about four times what it had been just four years earlier. Renewables are currently only about three percent of the world's total installed electric capacity. But they accounted for almost 50 percent of the new capacity added in 2007–9. In short, renewables are becoming a substantial business. But it did take longer than might have been imagined since the first time renewables were born.[32]

"The world right now in terms of renewables is about where I expected it to be in 1985," somewhat ruefully said Denis Hayes, who created the first Earth Day on a shoestring in 1970 and then became the director of the Solar Energy Research Institute. "We weren't in error about what it would take to get there, but in error about the political process that we counted on to facilitate it."[33]

Yet, one must add, it has also taken decades for the technologies to develop and mature. Moreover, the questions about scale and cost are still being answered.

Still, when it comes to renewables, the time chasm has been closed. No longer is there a great ideological divide over renewables. It is a business, it is popular, and it is international. And solar energy has come back to the White House. It first came back in a small way, and quietly, in 2003, with the installation of solar cells on a little building on the White House grounds called the Pony Shed. In 2010 the Obama administration announced that solar panels and a solar water heater would be reinstalled on the roof of the White House residence—from where Jimmy Carter's solar hot water heater had been removed in 1986.[34]

If a transition to renewables is really made on a large scale, it will rival the importance of the world's transition to reliance on oil in the twentieth century,

whether seen from a geopolitical or economic or environmental perspective. However, it will likely be a long road. Historically, energy transitions have occurred over many decades.

Thus even with rapid growth, renewables in 2030 are likely to still be far from being a dominant energy resource. Their actual role and market share will be determined by the interplay of policy, economics, and innovation. There is not a single scenario for the future of renewables. Rather it is a narrative of very different technologies, each with its own story and its own distinctive prospects. And its own challenges.