ALL-ELECTRIC AMERICA

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A Climate Solution and the Hopeful Future

S. David Freeman & Leah Y Parks

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We dedicate this book to

our children and Dave's grandchildren and great-grandchild
Charlie,
William, Eirini,
Carolyn, Kelsey, Tess, Tim, Ben, Alexander, Karen, Nate, Lisa,
Roger, Stanley, and Anita,
and
the children of planet Earth.

About the Authors

The authors, Dave, with over forty years as an energy policy maker and utility CEO, and Leah, a journalist in the electricity industry, formed a partnership because they agree that the time has come for a well-defined twenty-first century solution to our climate change problems. Despite the difference of almost half a century in life experience, they quickly discovered that they had a shared vision of how our energy infrastructure needs to transform. Drawing upon what they have learned from their experiences with the electricity industry and concerned about the lack of any comprehensive strategy by world leaders and many environmentalists to meet the challenges of climate change, they developed the plan of action presented in this book. They provide a clear plan to reach the U.S. and world climate goals and a better All-Electric renewable energy future.

S. David Freeman was the first person in the U.S. government responsible for energy policy back in 1968. He was one of the architects of the EPA during the Nixon administration. He was appointed chairman of the Tennessee Valley Authority by President Jimmy Carter and after seven years at TVA served as CEO of major public utilities for thirty years including: New York Power Authority, Los Angeles Department of Water and Power (LADWP), Sacramento Municipal Utility District, and Lower Colorado River Authority. In 2005 Mayor Antonio Villaraigosa appointed Freeman as the president of the Los Angeles Board of Harbor Commissioners. The board implemented the most aggressive Clean Air Action Plan in the nation. He most recently served as LA's Deputy Mayor for Energy and the Environment, and briefly as interim manager of LADWP until April of 2010.

Mr. Freeman is recognized as an eco-pioneer for advancing energy efficiency and renewable energy and cleaner air for the past forty-five

years. He has written and lectured extensively on energy and the environment and is the lead author of the influential report "A Time to Choose" written in 1974, under the auspices of the Ford Foundation that first documented energy efficiency as a major part of energy policy. He has also authored *Energy: The New Era*, written in 1974, and *Winning Our Energy Independence, an Energy Insider Shows How*, written in 2007.

Freeman was featured in the critically acclaimed documentary *Who Killed the Electric Car?* in 2006. Freeman has won awards from the Los Angeles Coalition for Clean Air, National Wildlife Association, Global Green, CEERT, CalStart 2007 Blue Sky Award, and many other organizations for his devotion to clean air and renewable energy.

Leah Y. Parks is an associate editor for ElectricityPolicy.com and Electricity Daily, a journal and newsletter that examine current events and the state of the electricity industry for utility executives, commissioners, regulators, and other experts in the industry. She has carried out extensive research in the energy field, has been on the advisory committee of Smart Grid Northwest, serves as an advisor for Oregonians for Renewable Energy Progress, has acted as an advisor for technology reports, and has written extensively about innovations in energy storage, smart grid technology, and renewable energy.

Ms. Parks holds a Masters of Science degree from Stanford University in Civil and Environmental Engineering and a BA with Honors from the University of Wisconsin in International Relations. Her professional experience includes work at the civil engineering firm CH2M Hill on projects focusing on water distribution, water planning, and resource allocation. Parks's unique and diverse background encompasses expertise in the technical fields of environmental engineering and science as well as the fields of journalism, international relations, biological sciences, languages, public relations, and fine arts.

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The Promise

CHAPTER 1

An All-Electric Renewable America

When Thomas Edison invented the incandescent light bulb to replace the kerosene lantern, the technology was clearly superior; the light bulb was much safer and produced better light. Even so, many doubted the viability of electric lighting, challenging the electric companies' claims that the cost of electricity would be about the same, or perhaps a bit more, than that of kerosene. The debate went on for years, and a decade after the light bulb was introduced, it still had not made its way into homes.[1]

In our time a host of modern-day Edisons have invented technology that empowers us to make the urgently needed shift from burning fossil fuels to using only clean, renewable energy. We are at a tipping point moment when renewable energy innovations that have been in development for many years have been improved so much that they are viable for mass adoption and can provide us with all the energy we need. They will also be able to do so at decreasing costs.

We can now power all of our energy needs with electricity generated completely by renewable energy. As with the advent of personal computers, when it seemed we woke up one morning and found

computers on every desk and smart phones in everyone's hands, we are poised to wake up to a transformed world in which we are living better electrically. But for that to happen soon enough—in time for us to prevent runaway global warming—consumers, public officials, and our energy companies must wake up to the opportunity.

An all-renewable energy supply will be less expensive and prices will be more stable, free of market manipulation and shocks due to conflict abroad. The U.S. will finally have a robust system of inexpensive "home-grown" fuel sources and will be energy independent.

This vision may come across as a utopian fantasy. After all, despite calls for urgent action on the climate problem for well over a decade, emissions are still growing. The building of our renewable energy infrastructure is following the path of the adoption of the light bulb. Electric cars are now commercial, but they have hardly taken the country by storm. And solar panels still adorn only occasional rooftops in most communities. But we are poised for a twenty-first century energy revolution, and in this book, we will show how possible it is to achieve this renewable-fuel-only future. We'll also show how vital doing so is, not only in order to halt global warming, but because of the great benefits every American household stands to take advantage of.

Much of the argument for moving to renewable energy has been premised on the need to combat the climate challenge, and we agree that doing so is our most urgent mission. But the exciting truth that has gone missing in the debate is the fact that an entirely renewable energy supply will be CHEAPER, more sustainable, and more price stable, as well as cleaner and safer than our existing sources of energy.

Most people believe that we continue to fuel our civilization with poisonous power sources because they are cheaper than renewables. Renewable energy is also characterized as only part-time, an unreliable source of electricity that's also too small in scale to truly replace fossil fuels. The truth is just the opposite. Renewables are cheaper, the sources are superabundant, and it is entirely feasible to produce and

distribute electricity generated by them in massive quantities. In fact, the technology is now available to generate enough electricity to meet all of our energy needs many times over by solar and wind sources alone.

We can build a truly clean and sustainable electric system that can fuel all our transportation, heat all of our buildings, and fuel all industrial processes within the next thirty-five years. Transforming the United States' current electricity capacity, which is roughly one million megawatts, will require developing approximately 60,000 megawatts of new renewable capacity a year over a thirty-five-year timeframe to supply all of our energy needs in 2050.[2] In 2015 China planned to install roughly 40,000 megawatts of new renewable power and by 2030 is committed to add a total of 800,000 to one million megawatts, the equivalent of today's total U.S. electricity capacity.[3] There is no doubt that America can do the same if we decide to.

Transforming our entire energy infrastructure to run on renewable energy by the year 2050 will require a larger effort than solely changing out our current electricity capacity. Investments in coal mining, oil and gas drilling, and building new large coal, gas, and nuclear plants will give way to a massive increase in the construction of solar and wind power plants. The production of electricity will steadily replace the consumption of fossil fuels. Investments will shift—one year at a time—but the total investment in the energy sector will not increase dramatically. The new technologies—solar and wind—will, over three or four decades, replace coal and petroleum just as the cell phone has replaced the old telephone.

Much has been said in recent years about renewables being unreliable. A reasonable person might ask, "What do we do when the sun is down or the wind doesn't blow? We need electricity all the time, so how can all of our electricity come from solar and wind power?" The answer is STORAGE of renewable generated power for when we need it. We can orchestrate the use of solar, wind, geothermal, and hydroelectric energy, with storage systems and smart technology, to provide reliable power

day and night. We already have all of the technology and tools to create a reliable system, and they will keep improving.[4]

Many technologies will be essential components of the transformed energy infrastructure, such as the use of vastly improved heat pumps to tap the enormous resource of heat in the atmosphere and below the Earth's surface, as well as both electric and hydrogen fuel-cell cars, trucks, and trains. But the ensemble of solar and wind power and storage, harnessed in an elegantly balanced system, is the heart of our energy future. This trio could supply all of our needs. When the sun does not shine, the wind often blows, and when neither is generating new power, storage can supply it. Cost-effective technology exists today to achieve this, and there is land aplenty.[5]

Of course the infrastructure will take some years to build. So let's jump ahead to 2050, the time by which a robust renewable-only supply system is achievable, if development is stepped-up now and continues every year. Good estimates are that, with a completely renewable energy infrastructure run on electricity, in that year the total energy demand of the U.S. will be roughly 1.6 terawatts (TW) and the total electric and storage capacity needed will be roughly 6.4 TW.[6] The total new land footprint is estimated to be ~0.42% of the U.S.[7]

We Live in a Solar World

Fossil fuel and oil advocates have portrayed solar power as requiring so many photovoltaic (PV) panels that land requirements make it impractical. They are wrong. The U.S. has more than 150 TW of potential rural solar PV capacity alone on developable land that could be tapped by that time—roughly eighteen times the requirement—and that is excluding areas that should not be developed, such as locations involving critical environmental concern, and federally protected lands.[8]

There is land aplenty in part because of the remarkable potential of our deserts. Our pristine desert land must be preserved, but there are

vast expanses of already disturbed land in our deserts that would not be further harmed by installing solar equipment on them. They are our solar gold mines, where the sun beats twelve hours per day, three hundred sixty-five days per year, with six to seven hours of that being direct sunlight. They produce the lowest-cost sun power, in fact at a cost that is lower than that of fossil fuels when amortized over the life of the solar plant.

Even if we focused only on off-ground space in which to install solar panels, such as residential and commercial roofs and building sides, parking lots, along highways, and already disturbed vacant land outside the deserts, we would need to make use of only a small amount of it. According to the National Renewable Energy Laboratory, we have about 140 million acres of this space, and only 7% of that area would be required to meet all of our current electricity needs.[9]

In fact, if you compare solar with coal, we disturb less land in the long run because of one simple fact. To feed a coal-fired power plant with strip-mined coal, you have to strip more and more land every year, which wrenches trees from the ground, devours topsoil, and buries fresh water springs and streams under tons of rubble. With solar, you use the same land year after year, only replacing panels, which last thirty years or more.

Huge Wind Resources

Our wind resources are also bountiful. The U.S. could generate all of its projected 2050 energy needs with wind power alone.[10] And though the cost of wind generation was once prohibitive, we can now realistically view wind as an essential partner to the sun. Not only does it often blow when the sun does not shine, but it is one of the cheapest energy sources today. In the last twenty years, the cost to produce electricity from wind has dropped 85%, with 43% of that being since 2009.[11] Good wind can produce a kilowatt hour (kWh) of electricity at about the same cost or

lower than existing natural gas, nuclear, and coal, and building more wind capacity will in fact cost less than building new coal, nuclear, and gas plants.[12] The National Resource Defense Council has found that in the near term the cost is expected to continue to fall and to be competitive with natural gas and coal even in low wind areas.[13]

We must factor in the opposition from people who don't like the looks of wind turbines as well as complaints about noise and harm to wildlife. The "not in my line of sight" or "not in my backyard" argument, commonly known as NIMBY, has succeeded in killing many projects, and many of the environmentally concerned who might support wind generation oppose it due to the perceived threat to wildlife. These concerns are overblown but must not be dismissed; we can show great consideration for such concerns when siting wind farms. Fortunately, the DOE has determined that we can find more than enough land and coastlines where installing wind turbines would not cause serious problems.[14]

A Comparative Bargain

The 2015 drop in the price of oil has been big news, but the more significant news is that the price of solar and wind power has decreased by a far greater percentage. The long-term difference is crucial; both solar and wind power will keep getting cheaper while the long-term trend for the cost of both oil and gas will be upward, due to both the costs of production and market manipulation.[15]

The concern that solar power costs too much is history. Solar PV module prices dropped by roughly 75% between 2009 and 2014.[16] Today solar costs continue to plummet and have reached a point where utility-scale solar projects are outbidding natural gas generation in places like California, Colorado, and Texas on today's cost basis alone.[17] Residential PV plus energy storage systems are fast becoming cost-effective throughout California and are predicted to become commonplace

throughout the country between 2020-2030.[18]

In fact, if we look at what each type of energy really costs the American people, renewable energy is by far already our lowest cost source, and with more investment in it, and ongoing improvements in technology, costs will continue to decrease. A key factor here is that the cost to produce electricity with solar panels and wind turbines does not rise each year. The cost of the fuel required to extract and convert oil and coal into useable energy accounts for most of the cost of their production, and that cost consistently rises, with occasional short-term dips.

With solar and wind power, once the infrastructure is built, the cost of generating the energy is largely fixed. As long as the sun rises and the wind keeps blowing, the fuel costs remain the same: zero. Renewable power is a comparative bargain over time because it is inflation proof. In fact, as the initial cost is paid off, the cost actually goes down each year. And the initial cost of building renewables installations has gone down dramatically in recent years. As anyone who took Economics 101 will know, those costs will keep going down as more plants are built, the market develops further, and competition heats up. Technological innovation will also keep bringing them down.[19]

We need only consider, by way of comparison, the enormous payoffs of the large dams we built a half a century ago, which today provide us with electricity that costs less than one cent per kilowatt hour to produce. The solar and wind power plants we build will produce comparably low-cost energy once their construction costs are paid off, and they will last decades past that point.[20] Just as with our hydroelectric dams, in those following years, they will provide electricity that is almost free.

If we made investments on the basis of the cost over the life of the plant, as we should, all new power plants would be renewable, even if there were no climate change. That's not even factoring in the costs of the damage of our climate, the health costs of air pollution, such as asthma and lung disease, and other externalities, which the marketplace doesn't take account of. One estimate of these costs is that they will

reach 865 billion dollars per year by 2050.[21] And while much complaint has been made about governmental subsidies to the renewables sector, we must not forget that the fossil fuels industries receive subsidies that good estimates indicate are twenty-five times larger than those for renewables.[22]

There are leaders who know the value of transitioning to a renewable energy infrastructure. Cities, provinces, states, and countries from across the globe are beginning to implement 100% renewable goals for all of their electricity, heating/cooling, and transportation by 2050.[23] Denmark's energy strategy is to achieve 100% renewable electricity and heat by 2030 and 100% for all energy sources, including transportation by 2050. A bill was passed in the Hawaiian state legislature and signed into law in June 2015 by the governor David Ige to have the electricity in the state run completely on renewables by 2045.[24] As we write this book more than fifty cities have announced the goal of being 100% renewable by midcentury or earlier including, San Diego; San Francisco; Sydney, Australia; Copenhagen, Denmark; and Vancouver, Canada.[25] President Obama, also knowing the importance of getting to near zero, pledged to reduce greenhouse gas emissions 80% by 2050 compared with 2005 levels.[26]

The long-term steady increase in the cost of fossil fuel favors not only building renewables plants going forward, but over time replacing all the machines that now use fossil fuels so that they run on renewable electricity. As Saudi Arabian Sheik and former Saudi oil minister Ahmed Zaki Yamani once said, "We didn't end the Stone Age because we ran out of stones." We must not let the fact that we still have adequate supplies of fossil fuels, in particular the boom in natural gas, deter us from making the transition. As we will show, natural gas contributes as much or more to greenhouse gas buildup than the burning of coal—in total, considerably more.

The Remarkable Power of Increasing Efficiency

Converting our national ground transportation fleet, including cars, trucks, buses, and railroads to one that runs directly on renewable produced electricity is a giant step to an all-renewables future, a conversion which would earn us impressive savings from efficiency. Electric vehicles are much more efficient than combustion engines and effectively utilize about 59–62% of the electrical energy from the grid to power at the wheels, while conventional gasoline vehicles only convert about 17–21% of the energy stored in gasoline to power at the wheels. Thus substituting electricity for oil and natural gas will dramatically reduce total energy needs in America and save American consumers many billions of dollars a year.[27] This is especially true because the price of electricity is regulated on a cost basis—meaning that it must be priced at an amount based on the cost of generation determined by regulators—while the prices of oil and gas are subject to market manipulation, such as by the OPEC cartel, that can keep them artificially high.

There is no doubt that America can build an all-electric train system over the next thirty-five years. Electric trains are commonplace throughout the world and are demonstrably more efficient than diesel-powered ones. And it is now equally clear that electric cars, trucks, and buses are commercially viable and can be the vehicles of the future, a future that can begin right now with the proper mandates and incentives.

Another important source of greater efficiency is the ongoing dramatic improvement in ordinary consumer products and appliances such as, lighting, refrigeration, air conditioning, heating, and the buildings themselves. The LED light is a good example of energy efficiency. Heat pumps, a renewable heating and cooling source, can replace natural gas and oil furnaces and will also be an important part of increasing efficiency in the home.

All together an all-electric energy supply is projected be about 39% more efficient than the present system. The vast majority of this efficiency will be due to converting our system from running on fossil fuels to electricity. The remainder will be from energy efficiency. The greater efficiency should more than offset increased energy use due to growth in the economy in the decades ahead.[28]

Anyone who doubts that such an offset of increased demand is possible should take note that from 1973 to 1985, the United States GNP grew 40% with near-zero growth in energy use.[29] We did it in large part by passing a law in 1975 that required automakers to build cars with better gas mileage. And many other laws and regulations mandated that buildings be better insulated and that utilities make investments in efficiency.[30]

When Dave Freeman, a coauthor of this book, took over as general manager of the Sacramento Municipal Utility District (SMUD) in 1990, he set the goal of zero growth in electricity for the 1990s, even though the population and the economy were projected to grow at a healthy pace. It was not just a goal on paper. The necessary efficiency programs to make it happen were initiated. In one program SMUD paid people to trade in their old refrigerators for very efficient new ones. SMUD destroyed thousands of these electricity wasters and shipped the dangerous chemicals inside them to DuPont. Another program planted a million trees near homes to provide shade, which led to a substantial reduction in air conditioning usage.

It all worked. People would stop Dave on the street and give him a big hug and say, "Thanks for cutting the electric rate." SMUD didn't cut the rates at all; it cut the people's usage and their bills were lower.

Hydrogen in the Mix

Whatever happened to the promise of hydrogen power? Where does it fit in the mix of renewables?

A decade ago, the auto companies fell in love with a device called the hydrogen fuel cell. The exciting prospect was a car that ran on hydrogen, the most plentiful element on Earth and emitted only water vapor. When burned, hydrogen recombines with oxygen in the air to form water (H2O) vapor. No carbon or other greenhouse gases are released. Imagine if the only emission from tailpipes of motor vehicles was a faint mist of benign water vapor? So promising was the prospect that President George W. Bush declared his dedication to pursuing a hydrogen future in a State of the Union address.

What happened? Though one-million-dollar demonstration-model hydrogen fuel-cell cars were built that proved the technology works, there are only a handful of these cars available to the general public in 2015 and hydrogen fuel-cell cars are not going to be available in mass production by most manufacturers for years to come. A few years ago, President Bush said that, "Performance and reliability of hydrogen technology for transportation and other uses must be improved dramatically. . . ." This is still true, however, since that time dramatic improvements have been made. Hydrogen-powered bus fleets are on the road around the world and Toyota recently announced that it plans to release a hydrogen fuel-cell car in California by 2016 for roughly $45,000. Nevertheless, there is no hydrogen infrastructure and cost is a challenge.[31]

We are emphasizing an All-Electric America, but we also advocate the launch of a Manhattan Project-style research effort to find a way to separate hydrogen from water using the combination of the heat of the sun directly and a benign catalyst. The promise is too important for us to fail to make a major push. Hydrogen produced from solar power directly can be a huge new GHG free source of energy.[32] But even today we can convert solar power and wind-powered electricity to hydrogen so that it becomes a form of storage, enabling us to put sun and wind power in the gas tank and feed it into the electrical grid. Hydrogen can also replace fossil fuels for all industrial uses, power airplanes and

ships, and can be used for heating and cooking. What's more, hydrogen is superabundant; in fact, it's the most plentiful element on earth and in the universe. It makes up about 75% of all matter.

The bad news is that there are no hydrogen wells; it doesn't exist in its pure form in nature. It must be created by separating the hydrogen molecules from the other elements in water or fossil fuels, and doing so today takes additional energy. Creating hydrogen from fossil fuels or with nuclear-generated electricity, with the goal of producing clean energy, is therefore like a dog chasing its tail, or putting lipstick on a pig.

Fortunately, research is underway to discover how to produce hydrogen more efficiently and a breakthrough in those efforts could help usher in the true golden age of plentiful clean energy that is upon us. Renewable hydrogen produced by separating it from water with the heat of the sun would be a viable replacement for all the forms of energy we now use. It could completely replace both fossil fuels and atomic power. Renewable hydrogen alone could end the climate crisis.[33]

Rather than pouring more money into nuclear power, subsidizing research, and building new fossil fuel plants, we should dedicate those funds to hydrogen research, while simultaneously pushing ahead with vigor on the development of solar and wind generation, energy storage, electric vehicles and other renewables, such as geothermal energy.

A View of the Future

An "All-Electric America" in 2050 would give new meaning to the electric power industry's slogan from the 1950s that we should "Live Better Electrically." The most important added value would be that the danger of runaway global warming would be averted if all nations followed our lead. But there would also be many other important benefits.

The air in American cities would be clean, and the cost of fuel—electric or hydrogen—for our cars would be about the equivalent of paying one dollar per gallon for gas. The solar power panels on just about every roof

would be sending electricity to minigrids in neighborhoods. A smart meter and smart panel would turn off your lights and control your thermostat for optimal savings. Your overall energy bill would be lower, even though you'd be using more electricity, in part because you would be producing some, or all of it, and the price will have been regulated to remain steady. You wouldn't need to stop at filling stations anymore because you'd be charging your car at home while you sleep or whenever it is parked in the garage. For shorter trips where you might normally take an airplane, you would be able to ride on high-speed trains at cheaper prices and about as fast.

The country would be free from the need to support dictators in the Middle East. We'd have no need to despoil our environment further by continuing to mine for coal, drill for more oil, build enormous pipelines for its transport, and build fracking wells.

An "All-Electric America" would preserve "America the Beautiful" while also maintaining the high-energy-use way of life we enjoy and making us healthier—all at a lower cost.

The Forces of Resistance

Most utility companies are reacting defensively to the recent advances in renewable power generation. They complain that the electricity generated by large solar fields and wind farms and solar-equipped homes is unreliable and terribly expensive. Some have even called it "junk energy" because of its variable nature. To dissuade people from installing panels, some utilities pile on as many charges as possible in agreements with solar customers. Some require solar users to pay what the companies argue is their share of costs for maintenance of the grid in addition to still paying the full cost of the power they purchase from the utility, so they are effectively charging twice for maintenance. Many utilities also refuse to pay for surplus power from the solar owner.[34]

This rearguard reaction is understandable, though not defensible.

The solar threat in particular is the first seriously disruptive technology the industry has faced. Utilities will be forced either to accept a sea change in their business model or to adjust to the loss of more and more customers as they bypass the utilities. The solar bypass threat is so real in the West and the Sunbelt that some analysts are already warning about a "death spiral" and "stranded assets," meaning power plants and other expensive infrastructure that may not be needed any longer.

It does not have to be like this.

Storage Is the Solution

One of the most exciting developments in the energy industry in recent years is the improvement of energy storage technology. The total storage capacity today is comprised of a mix of mature technologies, technology in demonstration projects with strong developmental potential, and brand-new, cutting-edge technologies.[35] Fortunately, even as many utilities dig in their heels, others see the value of these technologies and are investing in them, especially in California, where the public utility commission is requiring 1,300 MW of storage capacity to be purchased by utilities to "get started." They understand that storage is the essential partner to wind and solar that will make renewable power reliable and efficient and allow them to widen coverage.[36]

Both the energy advisory firm Navigant and the investment firm Barclays are reporting that storage prices are plummeting. Deutsche Bank expects the cost of storage to decrease from fourteen cents per kWh today to approximately two cents per kWh within the next five years, with lithium-ion batteries achieving 20-30% yearly cost reductions. Goldman Sachs is betting good money on prices coming down, investing $40 billion in the renewable industry.[37] They are not alone. Other investment companies, as well as think-tank centers such as the Rocky Mountain Institute, also predict lower costs and see the

combination of renewable generation and storage for residential customers as the most likely scenario for the future.[38] The announcement of lower prices for batteries by Tesla on April 30, 2015, is resulting in making these predictions come true much sooner than expected.[39]

An old Chinese adage tells us that every threat is also an opportunity. Electric utilities have a choice: They can continue fighting a losing battle and frustrating customers who want to install solar panels. Or they can get aboard and offer to install rooftop solar as efficiency measures. Better still, they can start promoting heat pumps and electric cars that can utilize the electricity they purchase from large solar projects. The electric industry once advocated for a massive expansion of the electricity infrastructure. It was the industry's goal for a couple of decades starting sixty-five years ago when they expanded into rural America and began promoting the "All-Electric Home" in which one could "Live Better Electrically." That forward-looking vision must be restored.

Natural Gas—The Route to Climate Hell

Only a few short years ago, most environmentalists and energy enthusiasts alike were excited by the prospects of natural gas. The promise of a fuel that produces half the carbon dioxide of coal when burned appeared to be the answer to our climate problems.

The public debate about the dangers of natural gas has focused primarily on the possible damage caused by fracking—hydraulic fracturing—in which the gas is released from deep within rock formations by injecting chemically treated water at extremely high pressure into cracks, further opening them and releasing the gas. What is not widely understood is that the gas released is made up largely of methane—the most potent of the greenhouse gases—and that not all of the methane being pumped out of the earth is burned; a significant amount leaks into the atmosphere from the wellheads as well as from the old pipes that transport natural gas to almost seventy million homes and two

hundred thousand industrial plants.[40] The fundamental problem is that the federal government counts carbon, but not methane, when Mother Nature actually does. We really don't know how much is emitted.

The latest scientific studies have shown leakage rates of methane from 1.5% of the total natural gas produced to as high as 10-17%.[41] Leaked methane is 120 times as damaging to the climate as carbon dioxide when released. Its impact reduces with time, but is still 84 times as damaging over twenty years and 34 times over one hundred years.[42] So when you add the methane to the significant carbon emissions from natural gas, it becomes clear that natural gas is as bad, or worse, than coal as a greenhouse gas emitter.[43]

In order to address the problem, President Obama created a task force to draft regulations to control and measure the leakage, but, to date, the recommendations made are purely voluntary and even when finally implemented will apply only to new construction after August, 23, 2011. They also do not cover massive leakage in the old natural gas pipes beneath our cities. For the foreseeable future any shift from coal to natural gas will not reduce total emissions.

However, even if all of the leaks were sealed, natural gas would not solve our climate change problems. Because we now use twice as much total natural gas as coal, we actually produce almost as much carbon dioxide alone from our total natural gas use as we do from coal.[44]

Substituting all of our coal plants for natural gas plants in the electricity industry would still result in our producing enough carbon dioxide to put us squarely on a path to disaster. Without leakage we are on a road to ruin and with leakage it is a whole lot worse.[45]

The bottom line is that the continued use and extrapolation of natural gas is the road to climate hell.

"All of the Above" Is a Road to Ruin

Despite all of the public campaigning about the urgency of the global

warming problem, the prospects of containing warming, and eventually stopping it, are dimmer every year that we fail to vigorously pursue an all-renewables strategy.

The best way to think about the climate challenge is to consider our emissions as another form of national debt. Because the carbon and methane that is causing climate change stays in the atmosphere for many years, all the greenhouses gases we emit each year add to that buildup. Just as with our staggering national financial debt, every year the buildup grows larger and the task of halting warming becomes more daunting. We must achieve near zero greenhouse gas emissions by the year 2050—this gives us about thirty-five years. We should think of zero emissions as achieving a "greenhouse balanced budget."[46]

During the 2009 Copenhagen Conference, the United States and other participating nations agreed that we should not heat our earth more than two degrees Celsius above preindustrial levels.[47] They have chosen this temperature as a target because a wide range of high-quality scientific studies have indicated that if we are to contain warming, stopping it from escalating out of control and causing massive planet-wide destruction, we must keep the temperature rise within two degrees Celsius. In order to achieve this, the entire world must emit no more than 270 gigatons of carbon from greenhouse gasses into the air this century. Two hundred seventy gigatons is our remaining world budget and if we stay on our current path we will blow past our budget by 2033![48] [Note: "The 270 gigatons of carbon accounts for the impact from carbon dioxide as well as other warming agents such as methane. It is derived from carbon dioxide equivalents (CO_2eq) — e.g. the concentration of CO_2 that would cause the same level of warming as a given type and concentration of different greenhouse gases.][49]

The only way to achieve a balanced budget is to reach zero greenhouse gas emissions by the year 2050.[50] This means that we have to keep our fossil fuels "in the ground."[51] Fossil fuel companies surely want to burn it all.

The tragedy of the existing climate debate is that not only our political leaders, but most of the environmental community as well, are not even proposing measures that would ever achieve a balanced greenhouse gas budget. As a result, we are getting deeper "in debt" every year.

The "All of the Above" policy of the Obama administration, which favors expanding the use of natural gas, oil, and nuclear power, is fundamentally flawed. That approach will not only fail to achieve zero emissions, it will seriously impede any real progress toward that goal. The core problem with this approach is that it is geared toward achieving carbon reductions by shifting from coal to natural gas rather than by realizing that all new energy production must be of renewables. "All of the Above" instead ignores methane releases and funds improvements in nuclear power and "clean coal."

The endorsement of the pursuit of "safe nuclear power" is a fool's errand. Nuclear power plants, which are piling up radioactive waste with no safe disposal plan in sight, are a failed experiment that, as we will describe in greater detail, will not only remain highly dangerous but much too expensive. Nuclear power plants are also a path to making nuclear bombs, an example we must stop setting. The Obama administration has argued for a new subsidy for research into improving nuclear technology, but that money would be much better spent on promoting accelerated adoption of renewable generated electricity.

Another cornerstone of the "All of the Above" policy, to move to "clean coal" by funding the installment of equipment on old plants that captures carbon emissions and stores them in the ground, is unfortunately another false god. The costs are so high and carbon storage is so uncertain that no such new coal plant is even planned that is not part of a plan to produce more oil. Unfortunately, the Obama administration has used the patently false label of "clean coal" and supported that falsehood with large sums of federal dollars.[52]

The Leadership Gap

Rapid progress toward an all-renewables future is being stymied not by lack of technology, or even by cost or market demand, but by lack of vision on the part of our political and business leaders, and lobbying and persuasive advertising by the oil, gas, coal, and nuclear industries. President Obama, environmentally minded political leaders, and most of the major environmental organizations have been promoting both the "green revolution" and the "brown surge," supporting both renewables and the continued use of fossil fuels. They have failed to hammer home the message that a completely renewable future will be lower in cost, as well as necessity if we are to halt global warming, much less propose programs to make it happen. This is despite the fact that a long-sought bipartisan goal of U.S. energy policy has been to achieve energy independence. An all-renewable supply is the best way to do so.

Many political leaders take pride in saying they believe the climate science and are concerned about climate change, unlike the folks who deny that the problem exists. But even those concerned about climate change are not proposing actions that will control the greenhouse gases to reach our ultimate climate goals before it is too late. We respectfully suggest that the failure of most of our political and environmental leaders to propose actions that will, in fact, reduce total greenhouse gas emissions sufficient to stay under the 2°C limit puts them in a group that can be considered "intelligent deniers." Let us be specific.

The greenhouse gases from our energy infrastructure are emitted by four major sources:

- Electric power production
- Heating of buildings
- Industrial uses
- Transportation

However, major policy actions to assure that emissions are reduced to meet climate goals are only being discussed for electric power. Heating

of buildings and transportation, fueled by oil and natural gas are not even part of most of the debate. To be sure, mandates are making new cars more efficient and a few electric cars are now being sold. Yet, both the "intelligent" and the "regular" deniers in effect are saying, "frack baby frack," bragging about discovering more oil and gas, while the scientists tell us we can't safely burn more than 25% of what's already been discovered.

The science requires that over the next thirty-five years—starting no later than NOW—we reduce to zero our use of oil and natural gas. At the same time climate leaders ignore the science and support the largest cause of our climate problem, the burning of petroleum and natural gas.

Let's not be deceived. The majority of greenhouse gas emissions are from natural gas and oil. They are well over 50% of the problem. And climate action leadership has yet to show the political courage to start reducing, not enlarging, the use of oil and natural gas that is already reaching havoc on earth.

The great irony of this situation is that cost-effective technology exists to replace most all of the oil and gas we use today for all of our transportation, industrial, and heating needs.

Investment in the Future

As we will show in more depth in the following chapters, the inescapable and stark truth is that all approaches that detract from investment in renewables are impediments to the much more realistic, efficient and cost-effective goal of an all-renewable, greenhouse-gas-free supply. There is no question that the costs of investment in the infrastructure and the research required are significant, in the trillions of dollars. But they are well within what we are capable of and the costs of failing to make the investment dwarf them. Making the transition will create millions of jobs and provide us with a reliable, entirely independent energy supply that is cheaper in the long run.

We must appreciate that the choice we face today is both a challenge and an opportunity. And it is the American public who will demand we seize that opportunity. Later in this book we will propose a program for outlawing the building of any new fossil fuel plants in the U.S., electrifying the railroads, and implementing an all-electric energy supply by 2050. At the heart of the plan is the eminently practical goal of steadily reducing the use of fossil fuels—by 3% a year—while building alternative greenhouse-gas-free electricity generating capacity at a pace to meet our future 2050 energy needs.

We know full well that this program would not be adopted by the U.S. Congress, or proposed by the president, this year, next year, or any year if left to their own devices. But if the test for responding to climate change is what the U.S. Congress will pass, or the regulations the presidents will put in place of their own volition, we are surely doomed to failure. Yet individuals, cities, and states are acting now. The driving force is concerned citizens who demand plug-in electric and hydrogen fuel-cell vehicles; who purchase only ENERGY STAR appliances; who install electric heat pumps and solar water heaters in their homes; who demand green power from their utility companies; who install solar panels on their roofs and storage capacity as backup; and who lobby and elect senators and representatives to enact requirements and incentives to assure attainment of the all-renewable All-Electric America.

That is why we've written this book; to inform the engaged public about how hopeful the prospects are, how substantial the payoffs would be, both for individual households and the public at large—not to mention the whole planet—and how urgent the need to change course is. The best estimates indicate that achieving zero emissions will take thirty-five years from when we begin the transition in earnest, and thirty-five years is all the time we have.

In the past, when this nation faced up to a deadly threat or an exciting challenge, we took action collectively. If it was poisonous, we outlawed it, as with DDT. If it saved lives, we mandated it, as with seat belts and

airbags. And if it was a challenge, like going to the moon, we funded NASA to build a spaceship to get there. Greenhouse gases are our greatest challenge yet. We will only meet the challenge if the public demands vigorous action by our government now.