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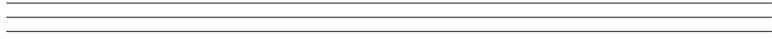
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Traveling the Power Line

Our Sustainable Future

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Traveling the Power Line

From the Mojave Desert to the Bay of Fundy

JULIANNE COUCH

University of Nebraska Press | Lincoln & London

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Set in Sabon by Laura Wellington.

Designed by Roger Buchholz.

For Amy

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Preface

This book tells the story of my travels to various sites of electrical power production across the United States. The trips were made between spring 2008 and spring 2010, with Laramie, Wyoming, serving as my home port. Expedition bulletins that start each chapter acclimate fellow travelers to conditions there.

In Wyoming there exists almost every sort of power plant or form of electrical energy production described in these pages. However, because the population of Wyoming is only around half a million, word of its role in the energy game has not spread nationwide. For that reason, I wanted to visit places where natural resource development and energy production were not typical dinner-table conversation, as they are in Wyoming. In that way I could learn firsthand not only about hydroelectric power, for example, but about how hydroelectric power shapes the lives and landscapes around it.

I chose to visit a wind farm and a coal-fired power plant in Wyoming because these forms of power production are virtually synonymous with that state. Starting from my home base gave me ways to think about approaching my visits to other types of power less familiar to me. The nuclear plant in Nebraska is one of the westernmost plants before the arid Great Plains, where that water-intensive power source is rare.

I could have found a power plant using natural gas as a fuel source, but it would have been much the same experience as my visit to the power plant burning coal as fuel. So I chose to visit Texas and its vast underground Barnett Shale to see firsthand how shale gas was extracted via drilling and fracturing.

Iowa seemed a logical place to see the sorts of possibilities that biomass materials such as corn stover and algae hold as fuels. Also the southern Utah desert is one of the prime areas for geothermal resources nearest to the surface that makes exploration and exploitation of that resource possible.

In the course of my travels I took a public tour of the Hoover Dam on the Nevada-Arizona border, not far from Las Vegas. However, I chose to focus my exploration and research on the Tennessee River Valley, a historically important spot in the development of electrical resources in rural areas of the south. That's how I found Kentucky Lake Dam.

Solar energy in California leads the development pack, but the site I selected in Nevada outside of Las Vegas allowed me to visit both the collection site and to see the connected power plant, fueled by sun-heated fluids.

Visiting the tidal power development site in Maine was a simple choice. No place else developing this sort of technology was anywhere close to having something to show me.

One element that might seem a logical topic for inclusion in this book is oil. Discussion of natural gas' first cousin is included in chapter 6. My decision not to focus specifically on oil was motivated by the fact that oil is used primarily as a transportation fuel. True, many households, especially in the Northeast, use home heating oil to stay warm in winter. But the focus of this book is on fuels used in power plants to create electricity, the sort of thing we use daily in our houses and in industry and agriculture. A short list of excellent resources on oil and other related matters can be found in the back of this book.

One of my goals was to listen to the voices we all have access to every day speaking about electrical energy, whether they are motivated by issues of climate change, national security, or conservation. Rather than pitting these voices against one another, as happens too often in our national discourse, I prefer to blend the smart and sincere positions of scientists, engineers, policy advocates, environmental activists, industry experts, and the folks who work in or live around various sites of energy production. By hearing them, as well as seeing in person what they are talking about, I hope to convey a fuller sense of something as fundamental to our lives as electrical power. In this way I hope to show how our current technologies exist together and what might change as we travel down the power line.

Acknowledgments

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Thanks to those who made valuable suggestions to help make this book worth the read, including Paul Woolf, Peter Ozias, Bill Markley, John Freeman, Laurie Milford, Jeffe Kennedy, Doug Couch, RoseMarie London, Bill Bishop, Julie Ardery, Randy Rodgers, and Ronald Hansen. Additional thanks to Brian Hayes and John McPhee.

The Department of Energy's Energy Information Administration's guidance and prompt replies to my numerous inquiries were always helpful, professional, and prompt. Without them there would literally be no book.

Finally, although I made every effort to write about various forms of energy production clearly and accurately, and sought outside experts to read chapters, technical errors may exist. If errors of fact exist, they are unintentional but are mine alone.

Introduction

“Good luck in the English Dept. Hope this isn’t too confusing.”

With these words, a staff member at the U.S. Department of Energy’s Energy Information Administration (EIA) correctly pegged me as a have-not in the world of technical knowledge. I’d e-mailed her for help interpreting some data on the EIA website. The data was about electricity consumption versus production, and I was admittedly confused about the relationship between the two as presented in a particular table. I signed the e-mail message with my name, taglined “University of Wyoming, Department of English.”

I felt pretty smart for detecting the nuance between energy production and consumption and I admit I wanted to give my perceived smartness some heft by tacking on a few credentials. After all, English departments are better known for producing and consuming poetry than power. The first part of the e-mailed reply gave me a link to another table where my question was answered directly. But the second part, wishing me luck, I interpreted as being delivered with bemusement. Or maybe the line was meant sincerely and in the vacuum of e-mail communication was devoid of context or tone.

That I immediately leapt to the conclusion I did perhaps

speaks to my own embarrassment over how little I know about some very important things. There I was, a generalist trying to pass as someone who belonged in the world of gigawatts and generators. But I'd undercut my own ethos. I might as well have signed my name Julianne Couch, PUBW (Professional Underwater Basket Weaver.)

A 2011 Harris Poll revealed that I am not alone in my ignorance. About 12 percent of Americans indicated they were “very” knowledgeable about where electricity comes from. About half thought they were “somewhat” knowledgeable. Until I started this power research I'm not sure I could have even passed myself off as a somewhat-er. Even now, after personally seeing power produced from the energy of the wind, the sun, and the inside of the earth; after witnessing the potential of natural gas, pulverized coal, and the stover of corn; after seeing atoms split apart, rivers harnessed and tides captured, it still takes all my powers of cogent concentration to explain the industrial process to others. I could never produce electrical power myself or be of much use on a team of folks who do.

Where I live in Wyoming, energy extraction and export is the marrow in our bones, affecting everything from whether we can afford new schools and highways to how our social infrastructure is influenced by itinerant energy workers. It is impossible to open a newspaper, listen to local radio and television, or drive down our byways and back ways without noticing energy development and environmentalism tugging each other from opposite sides of the same rope. Although some claim these two positions are not mutually exclusive, the fact is that arguments over energy issues sound their alarms so loudly they become background chatter, without meaning. If a person like me, living in one of the richest states for reserves of both fossil and renewable energy, doesn't quite have a grasp of the issues involved, odds are people in other locations are at an even greater disadvantage.

I have learned the basics on this power tour: that energy

comes from fuel sources, and power is a measure of the fuel source used for a given amount of time. Some fuels provide plants with baseload power—they run all the time—while others are intermittent. The basic unit of electrical power is the watt. One kilowatt-hour can power one average-sized home for one hour. A megawatt is one million watts of electrical power. That is enough to power about a thousand houses for an hour. A single wind turbine may have a peak capacity of one megawatt, and if it operated continuously at that capacity for every hour of one year, the energy it would produce would be 8,760 megawatt-hours. But it doesn't produce that much because the wind doesn't blow all the time; therefore, its capacity factor is closer to 20 percent. Capacity factor refers to the ratio of power actually generated to the maximum potential generation, expressed as a percentage. In contrast to wind, a coal-fired power plant of 500 megawatts operates at about 80 percent capacity. That's why it takes 2,000 wind turbines to replace one 500-megawatt coal unit. That's a mighty big wind farm.

Being able to recite these facts does not mean I am an expert. Thus, I can't predict whether another rash of nuclear power plants will be built in this country after the disastrous nuclear episode in Japan in 2011, or to what extent carbon emissions will be captured from fossil-fuel plants and whooshed into underground cavities to force out more gas. I don't know whether the desert tortoise in the Southwest will thrive surrounded by concentrated solar power plants. I couldn't say with authority whether dams in the Pacific Northwest should be decommissioned to allow wild fish to migrate. And I still don't know much about the complex and obtuse regulatory environment in which energy policies are shaped. But I'm certain that I now realize how much these questions matter and have a personal connection to them, and I can approach them more thoughtfully than I once did.

Perched as we seem to be on the cliff of a great energy

evolution, it is important to be forearmed with awareness. Yet it is difficult to know what sources of information to believe, whose agendas to trust. Power companies research and develop energy sources, including renewables, while saying very little about conservation. The “people of the oil and gas industry” run advocacy ads during the evening news, explaining that we have all the resources we need in this country to “free ourselves from dependence on foreign oil.” Environmental activists argue there is nowhere we can drill for oil or pipe natural gas or place wind farms that is worth putting wild creatures or pristine landscapes in peril. Little is said about the pressure of an ever-growing number of people in the world and in this country, which strains all our resources, not just energy alone.

Like most of us, when I am armed with information, I am better at analyzing arguments put forth by very smart, persuasive people who appear to believe in what they are saying. Show me a nuclear plant manager who says we also need wind farms in this country, and I’ll show you someone who is listening, not just talking. Show me a coal-plant worker concerned that the reservoir dammed to supply the plant with water is clean for his weekend fishing, and I’ll show you someone credible to speak up if things get sloppy. Show me an environmental group that acknowledges the impracticality of shuttering all coal plants tomorrow, and I’ll be more willing to do what it takes to weatherize my house and conserve energy.

The bottom line is not whether but when our country will be moving to more renewable fuels. In fact, projections by the EIA forecast a slow but steady move toward renewables and fuel options lower in carbon emissions. The hows of this shift will be driven by policymakers, scientists, engineers, and entrepreneurs as states develop their renewable energy goals. The whens will be driven by us, the consumers.

The U.S. Census Bureau tells us that we started 2010 with 308,528,525 of us, an increase of 9.7 percent since 2000. To satisfy this ever-growing population we’ll want more of

everything people generally want: houses and cars, roads and sewers, movie theaters and popcorn, wedding dresses and diapers. We will need commercial-scale agriculture and industry to feed, clothe, and supply us; therefore, we'll need fuel to fire our power plants to get those jobs done.

Let it not be lost that we'll also value low-density and natural spaces to sustain our sense of peace. We won't want to poison our air and land and water with industrial waste, and we might not want to look at spinning wind turbine blades on every hilltop or coastal landscape.

All of these "wants" are not the same as needs. Do we need to cool our homes to 70 degrees when the temperature outside is 90? Do we need that second refrigerator in the basement to chill our surplus soda pop? Do we need the home theater systems that consume so much electricity? These are issues to visit on the individual scale, but they are magnified exponentially when considering the industrial and agricultural practices of our nation.

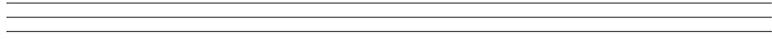
I'm not an expert. But there is a cumulative effect of general firsthand experience, of walking a ridgeline among wind turbines, of standing just a few feet from the used fuel pool of a nuclear plant, of strolling along the top of the geothermal field warmer than the Utah desert that surrounds it. Brian Hayes, author of *Infrastructure: A Field Guide to the Industrial Landscape*, explains that it is important to have at least a rudimentary understanding of the way things work. "Without a sense of how materials and energy flow through an industrial economy, you miss something basic about the world you live in." And he argues that there is a practical value in knowing how things work. "People who have never seen a power plant, who know nothing of how it works, who have never met anyone who works there, are poorly equipped to judge the relative merits of nuclear and coal-fired technologies, or to seek alternatives that might allow us to dispense with both. To make good decisions about such issues, citizens need to get

better acquainted with the technological underpinnings of their own communities.”

We are in a new energy crisis while we choose between the fuels that got us where we are and the ones that will get us where we are going and help us lessen our dependency on fuels of all types. What used to be a fairly straightforward formula of what fuels had what uses has recently become more complicated. For example, automobiles were once powered by petroleum products. Now they can also be powered by electricity, biofuels, or other sources. These other sources aren't environmentally pristine just because they aren't petroleum, although their advocates don't often mention the down sides. In fact, almost all electrical power has traditionally come from the burning of fossil fuels. These days it can also come from generators burning 100 percent used vegetable oil. It can be hard to keep up.

According to that 2011 Harris Poll, only one in five U.S. adults are “very” interested in keeping current about energy issues, although 53 percent say they are “fairly” interested. I'll put my faith in those fairly interested folks. Only a few of us can be experts. But all of us can look beyond the power switch and see what goes on behind the wall. If we discover enough to ask better questions, perhaps we'll understand the price we pay each time we flick a switch. Somewhere, someone throws another chunk of fuel on our insatiable national fire.

Say, maybe it isn't that confusing after all.



Traveling the Power Line

1

Of Megawatts and Meadowlarks

A Wyoming Wind Farm

JANUARY 1

The Brees reporting station at the Laramie Regional Airport registers 32 degrees Fahrenheit, with steady twenty-five-mile-per-hour winds, gusting to thirty-five. The airport sits at an elevation of 7,266 feet. About seven miles east, my home sits on one of the highest hills in Laramie, Wyoming, at 7,333 feet. The high and low temperatures these last few days have been seasonal, which, after the very cold temperatures in December, seem almost balmy.

This morning I got out of bed ahead of my New Year's Eve-addled neighbors and walked my small dog. Though Archie's pointy ears blew backward as we faced into the wind, his four feet stayed on the ground, two at a time. I timed our outing to avoid the even higher winds that would develop in the afternoon. Powering up my laptop after returning home from our walk, I learned from the National Weather Service website that a high wind advisory had been issued for later today.

A high wind watch remains in effect from 5:00 p.m. MST this afternoon through Friday afternoon. There is the potential for very strong west winds to return again tonight and much of Friday . . . and a high wind watch remains in effect for those times. A high

wind watch means there is the potential for a hazardous high wind event. Sustained winds of at least 40 MPH . . . or gusts of 58 MPH or stronger may occur. Continue to monitor the latest forecast.

Wyoming is one of the windiest spots in the nation, with southern Wyoming, where I live, heading the stats. Paradoxically, blowing winter winds warm the air temperature and melt the packed snow and ice that cover my street. When the wind stops we are in trouble: that's when the cold settles into every nook and cranny, making us as chilly as a chest freezer.

Long ago, before I moved to Wyoming from Missouri, a woman I met who once lived in neighboring Colorado assured me that “all people in Wyoming are crazy”—driven mad by the perpetual wind. It wasn't just her opinion: there's a 1928 silent movie called *The Wind*, in which Lillian Gish slowly goes mad in a dusty town along the Sweetwater River, in south central Wyoming. And a favorite local sight gag involves a heavy gauge chain being blown perpendicular to a post. Attached to the post is a sign identifying the strength of wind as indicated by the angle of the chain. According to the sign, a reading of zero degrees indicates the wind sock is broken and the meteorologist should be notified. A thirty-degree angle indicates a fresh breeze. Forty-five is a gentle zephyr. Sixty alerts us a hurricane is in the area; seventy-five and those in the area should beware of low-flying trains. At ninety degrees, the sign proclaims: Welcome to Big Wonderful Wyoming.

In the winter, wind sends snow blowing in horizontal curtains or snaking across highway pavement where it melts just enough in the high country sun to leave behind a sheet of ice. As the sun sets, that ice lurks beneath the snaking snow forming black ice, treacherous to motorists who do not detect its presence until they hit a patch and go spinning out of control across lanes of oncoming traffic. Wind causes the same conditions in spring, when in much of Wyoming and other mountainous western states the snow falls heavy and wet.

Most areas of the state traversed by I-80, Wyoming's main east-west drag, are breezy regardless of season. Interstate 25, which runs north-south in the eastern section of the state, is not exactly calm, either. The Wyoming Department of Transportation (WYDOT) searches for ways to reduce what are known as blow-overs on the interstates—incidents in which vehicles simply topple when high winds hit them just right, or just wrong. WYDOT reported that between 1998 and 2007, high winds caused 1,544 crashes of trucks and other vehicles on Wyoming highways, or an average of about 150 a year. These are just the crashes due to strong winds; the number does not include accidents to which icy roads, blowing snow, or other dicey weather conditions contribute. Of those wind-only crashes, 623 led to injury, and 19 were fatal.

Although the whole state is breezy, communities with average sustained annual wind speeds below ten miles per hour take smug pride in having less of it. Those towns like to consider themselves the state's garden spots because they clock in with average sustained annual wind speeds of only six or seven miles per hour. Sustained winds in towns most notorious for high wind, such as Casper, Cheyenne, Laramie, and Rawlins, clock in at around twelve miles per hour. Although twelve miles per hour on average doesn't sound like much, factor in the number of hours the wind relaxes, such as after the sun goes down, and you've got enough breeze to fly a cadre of kites. And that's wind speeds in town, not high up on ridges or mountain tops. Go to a place like that, then stick a long moist finger two hundred feet up in the air around the height of a wind turbine, and you will notice that speed has doubled.

Wind has long been used by clever humans to sail ships, grind grain, pump fields, and dry laundry. Henry David Thoreau wrote about the power of wind in "Paradise (To Be) Regained": "Here is an almost incalculable power at our disposal, yet how trifling the use we make of it! It only serves to turn a few mills, blow a few vessels across the ocean, and a

few trivial ends besides. What a poor compliment do we pay to our indefatigable and energetic servant!”

Wind has also been used to create electricity, although until recently widespread use for that electricity was not practical. But now with a burgeoning infrastructure of transmission towers and power lines, wind is touted as a practical renewable source of energy, more abundant and cleaner than coal. In Wyoming, and in other windy locations in the United States and around the world, commercial wind farms are sprouting like corn. The tall towers of a wind farm reach their long blades hundreds of feet into the sky to greet the breezes that power the generators that feed electricity into a transformer and eventually into the power grid and on to consumers across the country.

Wyoming has undergone several boom-and-bust periods in its history, mostly as a result of the extraction industries. When material such as oil, gas, uranium, and coal are removed from the ground and exported to provide power in other states, that's known as extraction. When the various companies that do the extracting take the materials away, they pay a severance tax because they've severed those materials, never to return them.

Wyomingites live large during those boom times, when severance taxes support our schools, roads, bridges, and other items paid for in many other places by state income taxes, which we do not pay. But when for various economic reasons companies slack off on the extracting and the severing, people in Wyoming start to feel the pinch. Schools and motels and convenience stores and recreation centers built to handle the boom find themselves with hardly any students, guests, shoppers, or recreationalists. In local parlance, that's known as a bust.

Places in the country long on people but short on energy resources have become used to the riches of Wyoming and other energy-exporting states. So when the rest of the country sees fuel costs rising, it makes a certain sense to say, “Why don't we

just drill, baby, drill, for more in Wyoming?” In most cases, the answer both inside and outside of Wyoming has been, “How deep?” Just as dizzying as the boom-and-bust economy has been for Wyoming’s state budget, Wyoming’s environment has also taken a hit. Wyoming once was renowned for clean air, open spaces, plentiful wildlife, healthy streams, and breathtaking scenery. More and more, with booms mostly dependent on the natural gas industry, it appears to many of us that the air and water have been sullied and wildlife have become skittish or downright threatened by human activity. Sure, we received money to fund long-deferred projects. And students have a better chance to attend college due to an in-state scholarship funded by those dollars. But we’ve paid a pretty tough price.

Enter wind.

At last, a chance to develop an energy product without severing it. Much to the chagrin of some people on those gale-force winter days, Wyoming has plenty of breeze to go around. There are those who wouldn’t mind if all these new wind farms would deflect some of the breezes south into Colorado. But I began to wonder if renewable energy, specifically wind power, could meet all our energy and economic needs and yet not damage the environment. I’d noticed a wind farm under construction along the interstate about an hour from my home, but it was difficult to determine how to arrange a visit. There was no sign of an office, or even a shop, where one might inquire about getting a tour. So I picked up the phone and made a call to my local power company. One week, several phone calls, and many e-mails later, I made my way up the chain of command to Jeff Hymas in the external communications office at Rocky Mountain Power, based in Salt Lake City, Utah. After a bit of confusion, I learned that’s how the company is known in Utah, but in Wyoming and other states, it operates as PacifiCorp. Hymas told me that public tours of the wind farm were not allowed, but that I could visit there as a journalist, accompanied by wind-farm staff, at a time of mutual convenience.

He set up a date and time for me, even sending me detailed directions to the small structure where wind-farm employees worked. I'd never noticed the building before because it was on a two-lane side road, rather than the interstate. Both before my trip and after, Hymas made sure I had all the information available about the company's wind development plans for the area, as well as the "clean" nature of the energy produced at Foote Creek Rim.

The Foote Creek Rim wind farm is Wyoming's first commercial facility to generate electricity from wind. It was originally developed by SeaWest, which was then purchased by global energy conglomerate AES Energy. PacifiCorp is one of several wind-farm developers that AES hosts at the location. PacifiCorp's site began commercial operation on Earth Day, April 22, 1999, starting with sixty-nine towers.

PacifiCorp has constructed several additional wind energy projects in this area of Wyoming, including the Glenrock, Rolling Hills, and Glenrock III projects in Converse County, located in eastern Wyoming, and the Seven Mile Hill and Seven Mile Hill II projects located near Foote Creek Rim in Carbon County. These projects were completed and brought into service in December 2008 and January 2009. The company's High Plains wind project was constructed on land spanning the border of Carbon and Albany Counties, and came online in 2009. These projects will add to the 2,000 megawatts of renewable energy resources the utility plans to add to its generation mix by December 2013.

But it isn't enough simply to create wind power. There also have to be transmission lines to carry the electricity to customers. For that reason, PacifiCorp, together with Idaho Power, is engaged in a project dubbed Energy Gateway West. Once completed, transmission towers will string together power lines stretching from eastern Wyoming to western Idaho.

I considered taking the route of the future transmission towers to tour Foote Creek Rim, located about forty miles to the

west of Laramie. That would have taken me along I-80. The weather around the interstate isn't bad in summer, though in winter it lives up to its local nickname, the Snow-Chi-Minh Trail. All year-round the interstate hums with tractor trailers and other large conveyances hauling bulldozers, pieces of pipe as big as my car, and other colossal gadgets to places in Wyoming where energy companies work virtually around the clock. Adding to that mess are a jumble of summer tourist motor homes and motorcycle packs, prompting me to choose the longer but scenic back way north to the town of Rock River, then west through the ranching communities of McFadden and Arlington.

As I approached from a distance of a few miles, it appeared that a white-clad Edward Scissorhands was lying on his back across Foote Creek Rim, lazily waving his blades in the breeze. In fact, that body of swiveling blades that reaches about five miles across this rim is the wind farm, with turbines up to two hundred feet tall slicing the sky. Jeff Hymas had arranged for me to tour the wind farm with Tony Kupilik, team leader for project operations there. Kupilik welcomed me to a modest control room next to his office and showed me how the turbines are run by computers. Operators can turn turbines off when high wind conditions make it necessary, either from the farm or from corporate offices in California, or even from Kupilik's home in Laramie. He showed me how to read data on the monitors, one segment for each turbine and for the two meteorological towers. Wind speed is measured in meter-seconds, which is roughly half of the miles-per-hour measurement. With average wind speeds of twenty-five miles per hour, the monitors show that Foote Creek Rim is one of the windiest spots in the United States.

Next, Kupilik pointed out a topographical map indicating the steepness of the Foote Creek Rim and the width of the flat plateau, with turbine positions superimposed. The land is owned in a checkerboard combination of private owners,

the state of Wyoming, and the Bureau of Land Management (BLM). The public lands are landlocked by private lands, so no one may legally access the site without permission to be there. That's why no one is wandering around the wind farm unaccompanied.

Kupilik showed me a schematic drawing and gave me a quick overview of how wind turbines work. He explained that wind turbines create power when wind blows across their blades, which are attached to rotors. Air forces the blades to spin, which drives the shaft to which the rotor is connected, which creates the electricity. In some ways it is similar to the action of a hydroelectric generator found on river dams. But because air is less dense than water, the blades of a wind turbine must be much larger than those in a hydroelectric generator.

I'm no mechanic, but it was a comfort to hear him use some terms I was familiar with: blade, rotor, tower, brake, gearbox, generator. I felt armed with the basic comprehension I needed to head up to the rim and see 134.7 megawatts of electricity generated per hour. Kupilik reminded me that one megawatt is enough to power about one thousand homes. He showed me to the Dodge company pickup and commiserated with me about the difficulty of climbing into a truck that sits high off the ground and lacks running boards. "We get so much snow up here in winter running boards would just get knocked off," he told me. As I gathered the camera and notebook that I'd heaved onto the seat ahead of me, he glided the truck up a gravel road and through a gate, taking us down an access road through private property. We could hear a western meadowlark through the open window, trilling its greeting.

As the truck climbed toward the rim, we took in views of the dark green Medicine Bow National Forest just south of the interstate. Always-snowcapped Elk Mountain loomed in the southwest sky. The wide-open Laramie Basin to the east and north opened up below us. Kupilik pointed out some lakes where he used to fish as a Colorado kid who summered with his

grandfather in Wyoming. He spent much of his time in Rock Creek Canyon, an area we could make out from the truck. Kupilik is about fifty years old, and when he was growing up, this ridge was a short-grass and wildflower plateau during the summer, not bristling with spinning rotor blades on tall towers like it is today. He isn't disturbed about the change in scenery. "I like the way they look," he said about the white turbines. "Their being here doesn't bother me at all—I think they look cool."

Summer is a "low wind season," Kupilik explained, so that is the time they take turbines off-line to perform routine maintenance. Kupilik pointed out a turbine whose white UV reflective paint was marred by some oil seeping from the rotor. "We're going to get that cleaned up. We're pretty respectful of the environment up here," he said. Although summer is a busy time for maintenance, it beats working on the turbines during winter. Not only does the icy wind blow nonstop, and the snow fall almost as vigorously, the towers themselves are extremely chilly. Like lighthouses, the towers have a small door at their base and an interior ladder that workers climb to reach the business end at the top. "If the turbine has been running, it can stay fairly warm up there, but after a few hours it gets very cold inside," explained Kupilik in a voice that said he'd spent a few too many repair sessions in just those conditions. "It's pretty miserable up here in winter."

Kupilik has worked for AES for several years. Once employed at a coal mine at nearby Hanna, Wyoming, he needed a job after the mine shut down. He had no training in wind turbine maintenance at the time but had enough mechanical know-how that he was hired. He learned on the job.

Now Kupilik's experience has landed him on the advisory board for the Laramie County Community College (LCCC) program established to train and certify wind-turbine technicians. LCCC, in Cheyenne, Wyoming, is one of a handful of programs in the nation to offer a wind-energy training program, in which

students can earn an associate of science degree with a concentration in wind energy. Mike Schmidt, an industrial electrician by training, is LCCC's Wind Energy Technical Program director. He came to Wyoming from Iowa Lakes Community College in 2008 after establishing a successful wind-energy training program there. He said LCCC's first class had twenty students, about half of whom were from out of state. The students were a mix of ages, from traditional college age up to age sixty. Several of them already had bachelor's degrees in other fields. Schmidt said they entered the program because, like him, they believe in wind energy. They wanted a career in a field that not only offers a good wage but can make a difference. Schmidt believes that global warming is proven by science and that human activity has added to it. "If we have the technology to reduce global warming, we should do it," he said.

Both the technology and the regulatory environment in Wyoming are combining to make wind energy a major player in nontraditional energy development in the state. Wind energy capacity in Wyoming increased from 288 megawatts in 2007 to over 1,400 megawatts at the end of 2010. In addition, nearly 7,900 megawatts of new wind projects are in some stage of development. Capacity means how much power wind farms are delivering onto the grid. Capacity also means what it sounds like. If the wind blew everywhere, all the time, at an optimal speed for wind power production, power could be produced at the full capacity of the existing wind farms. But wind, being capricious, comes and goes as it pleases. That is why power companies don't just plop wind farms anywhere. The ins and outs of wind-farm siting were explained to me by Jeff Hymas and his boss, Dave Eskelsen. First, developers look for places where the wind is dependable and constant. Then they look to see whether those places are already in close proximity to existing transmission lines. If they have to sink money into infrastructure to move the electricity, the costs rise for them and for their customers. Also important is the ground itself.

It needs to be stable and fairly level. Foote Creek Rim, for example, is constantly windy and reasonably level. And the power infrastructure already in place along I-80 makes clustering other wind power projects there attractive.

On the other hand, environmental groups, government agencies, and various collectives of stakeholders have additional, sometimes contrary ideas about ideal sites. For example, the Laramie-based Biodiversity Conservation Alliance (BCA) applauds the use of wind power but argues for siting wind farms where they will be least disruptive to humans and wildlife. They note the unprecedented surge in wind-energy development proposals both for public lands, such as forests, grasslands, and basins, and for privately owned land.

The BCA undertook an analysis of wind-farm siting, specifically in Wyoming. In 2008, they released the results of their study in a document titled *Wind Power in Wyoming: Doing It Smart from the Start*. BCA Executive Director Erik Molvar, a wildlife biologist and the author of the report, argues that Wyoming should develop wind energy “in a way that protects open spaces and native ecosystems and is an asset to local communities rather than a disruption.” The report was endorsed by the World Wildlife Federation, the Wyoming Wilderness Association, the Earth Friends Wildlife Foundation, the Western Environmental Law Center, the Wild Utah Project, the Sierra Club, and Californians for Western Wilderness. The report includes a color-coded map depicting where wind development is appropriate, and where it is not, based on a variety of conditions.

In addition to the conditions for wind-farm locations most valued by power companies, these groups advocate caution in siting large commercial wind farms near landscapes such as national parks, wilderness areas, and national forests. They argue for the protection of raptors and bats, conservation of sage grouse and big game animals, and general stewardship for sensitive wildlife. Finally, they point out that aesthetics should

be valued. What most of us think of as scenery has become known in this conversation as the “viewshed.” Many people do not want an aesthetically pleasing viewshed cluttered with twirling turbines.

Eskelsen notes that the environmental concerns voiced by the BCA often arise when a power company proposes any sort of major project. Power companies are accustomed to entering into lengthy discussions with stakeholders such as citizen groups and governmental entities, in which concerns are expressed and addressed. Seldom does one group get everything it wants, he said, but the conversation is part of the process. “Utilities aren’t welcomed with open arms,” he acknowledged. And even though few people would be satisfied with a modern life without commercially available electricity, Eskelsen said, “It is very difficult for a utility to build infrastructure of any kind.”

In addition to the BCA’s recommendations, another group in Wyoming has developed a set of guidelines for siting wind farms. The state legislature created the Wyoming Infrastructure Association (WIA) in 2004, given the task of “diversifying and growing the state’s economy through the development of electric transmission infrastructure.” They see to the planning, funding, building, maintenance, and operation of interstate electric transmission and related facilities.

Aaron Clark is an adviser to the WIA. He lives and works in Wheatland, in eastern Wyoming, one of those areas where the wind capacity is robust, to say the least. He has worked as a consultant in the energy industry for more than twenty-five years and was the individual responsible for creating the state’s map for appropriate wind energy development. Both the WIA and BCA maps use the color green to show where wind development is appropriate and pink to show where it is not. Both maps use similar criteria for determining where wind development is not appropriate.

According to Clark, both maps demonstrate that critical winter range for big game animals, sage grouse nesting areas,

and highly sensitive visual areas, along with a myriad of other elements, should be off-limits. The BCA would also like a five-mile buffer zone between wind development and towns. Clark says he would prefer to leave that issue to local planners rather than to the state. Bottom line, the maps are in general accord and the “message is the same,” Clark said. Molvar agrees. It isn’t every day that conservation and industrial or governmental organizations agree with one another, without first undergoing court-mediated friendships.

So far, most wind-development projects in Wyoming have been on private land, where the permitting regulations are limited to those established by the state. The developers of any project on federal land, including those managed by the BLM, must also follow guidelines of the National Environmental Policy Act of 1969, which include environmental impact studies. Developers on federal lands must also adhere to the National Historic Preservation Act of 1966, specifically when developers identify cultural artifacts on the land that might make the area eligible for inclusion on the National Register of Historic Places. Significant Native American cultural artifacts were identified at Foote Creek Rim during the course of these studies.

There are approximately six hundred manmade rock features in the area, mostly on the edge of the rim. Walt George, national project manager for the BLM’s office in Cheyenne, explained the sequence of activities this discovery prompted. First, the BLM conducted a literature search to determine what might already be known about historic Native American activity in the area. Then they consulted with leaders from the Northern Arapaho and the Eastern Shoshone tribes who share the Wind River Indian Reservation in Wyoming, to determine what those groups might know about their ancestors’ use of the area. George said that leaders from the tribes examined the site and interpreted the meaning of some of the rock cairns and other rocks arranged in various patterns. Tribal members

reported that some of them were used as navigation tools for nomadic groups to reach important locations around Elk Mountain, considered a sacred site.

Bonni D. Bruce, supervisory archaeologist with the BLM's High Desert District field office in Rawlins, Wyoming, said in addition to the Eastern Shoshone and the Northern Arapaho, other groups had ties to the area as well, such as various Sioux bands and the Southern Cheyenne. "Most tribes don't really know about these types of sites on public lands until we consult with them. They do recognize, however, features that were commonly created by their ancestors when we take them to sites. We've had tribes look at a cairn, for example, and say that it wasn't their ancestors who created it."

After the cultural features were discovered and their significance assessed, the developer, SeaWest, redesigned certain roads and wind-farm infrastructure to create minimal disturbance to the area. In addition to addressing cultural concerns, the impact on area wildlife had to be studied before construction could begin.

"At first people were concerned the wind farm would have a negative impact on wildlife up here, especially the mountain plover," Kupilik told me. "It seems to me, though, that they are doing fine." He's noticed that predators such as coyotes avoid the area more than they once did, perhaps because of the human presence. But he thinks the birds, small mammals, and antelope, are flourishing. "You should see this place during hunting season—it's crazy with antelope," he said. It makes sense that antelope would head to places off-limits to hunters—no one is shooting at them on Foote Creek Rim.

Impact on wildlife is of primary concern when determining wind-farm sites. In some of the earliest wind projects in the United States, such as the one at Altamont Pass in California, wind towers were concentrated in areas frequented by raptors, thousands of which were killed annually by collisions with whirling rotor blades. According to Walt George, the

mortality numbers from that site were all that were available to use as a comparison for what would happen at Foote Creek Rim, simply because there were few other large-scale wind farms. But the environments of the two locations are quite different, he said. The Altamont Pass site is surrounded by areas of dense development in the San Francisco Bay Area. Therefore, the underdeveloped area at Altamont Pass was the chief place where birds concentrated. But at Foote Creek Rim, as in much of Wyoming, there is little urban development to force birds into unnatural concentrations. Because the BLM knew the numbers at Altamont were not a good comparator, they initiated a raptor survey at the Wyoming site.

The National Academy of Sciences determined in 2006 that an average of three out of one hundred thousand human-caused bird or bat deaths were due to wind energy activity in the United States. However, migration pathways for birds and bats can be highly traveled at certain times and so mortality numbers at specific sites can rise much higher. For two years before developers constructed the Foote Creek Rim wind farm, wildlife experts studied the way birds used the area around the rim. They learned that bird activity concentrated around the lee side of the rim, where birds sat on rock formations or soared in the thermals of the gently rising land. As a result of their findings, SeaWest located the turbines away from the edge of the rim. Once the turbines were in place, consultants studied avian mortality levels at the site for five years after that. Their research was reviewed by a technical committee including Wyoming Game and Fish and the U.S. Fish and Wildlife Service. At the end of that period the committee determined that mortality levels were in keeping with avian mortality in general for the area, and that there was no reason for further study.

Governmental and environmental groups have both worked to prohibit the placement of wind turbines in locations where wildlife could be disturbed or harmed. Walt George of the BLM says most stakeholders agree that the ideal spot for siting

a wind farm is on private, rather than public, land. That's because on rangeland, for example, some habitat disturbance may have already occurred, and wildlife using the area may already be habituated to human activity. Erik Molvar, with the BCA, categorizes some views on public land as "sensitive landscapes." According to his report, "Wyoming is known throughout the world for its iconic western landscapes. Many of these, like national parks, wilderness areas, and wilderness study areas, have been placed off-limits to industrial activities by federal law or regulation. Others, such as roadless areas and BLM Areas of Critical Environmental Concern, have limited protective designations, which would tend to frustrate the timely development of wind projects and might preclude them in some cases."

Foote Creek Rim is far away from national parks. In fact, casual observers would not notice anything unique or special about the windswept hills of Wyoming's basin-and-range country, where it is located. But as Tony Kupilik drove me around the project on that summer day, along private roads far off the interstate, I renewed my appreciation for the location's sage and rabbit brush prairie. I could see why humans had been attracted to the area for so many centuries, surrounded as it was by bountiful mountains and plenty of water. Aside from the few ranch fences and the wind farm itself, the view of Elk Mountain from Foote Creek Rim has remained much the same as it was for the Native Americans historically traveling through the area.

After Kupilik and I took in some of these grand views from the truck, we passed the substation that receives power from all the turbines. Regardless of their height, he explained, the turbines each produce 600 volts. A step-up transformer converts that low-voltage electricity to a high voltage so that it can travel more efficiently for long distances down power lines, he told me. To start that process, a transformer next to each turbine steps the voltage up to 34,000 volts. Power enters the

substation through a buried cable and is boosted to 230,000 volts, which travels down transmission lines to another substation in Hanna, about thirty miles away. Electricity traveling along power lines encounters friction to a degree that depends on the type of transmission lines it is on. The EIA estimates that loss of efficiency is at less than 7 percent. They measure efficiency based on the discrepancy between the energy that power plants report they produce and the amount of energy sold to end customers.

Experts note that the capacity for generating power from wind in Wyoming and other western states will outstrip the transmission infrastructure if more is not built. Mike Schmidt at LCCC notes that wind potential in Iowa, where he once taught, is much less than in Wyoming. However, the amount of wind energy Iowa actually adds to the mix of power sources going to consumers is much higher than in Wyoming. That's because in Iowa, which is more populous and developed than Wyoming, there is easy access to transmission towers for moving wind-generated electricity. But in Wyoming, Schmidt says, "If we can't move power somewhere to sell it, it isn't going anywhere."

That's why PacifiCorp and other developers endeavor to engineer large-scale transmission projects. Rocky Mountain Power's Gateway West project that is planned to stretch from eastern Wyoming into western Idaho will add roughly 1,200 miles of transmission line. The company's proposed Gateway South project will move power generated in Wyoming into Utah and eventually Nevada. That's depressing news for those who don't want Wyoming to look like a place where we ranch metal instead of cattle. But it's good news for anyone who wants to make use of Wyoming's abundant winds and help keep carbon particles out of the air.

Even though renewable energy such as wind is considered clean and is being clamored for in many locations around the country, its use is not without consequence. As Walt George

noted, “Nothing that people do is without some change or effect. Even solar and wind power change the landscape.” Wind-farm installation is a major construction project, complete with roads and heavy equipment and dust blowing in the air. These projects kill, displace, or at least alarm, wildlife. They alter the view. They are worthless without adequate transmission towers to deliver the electricity where it is needed, to places where people live in large numbers and demand cheap, plentiful power. Laurie Milford, director of the environmental advocacy group Wyoming Outdoor Council, understands why many of us have a hard time leaping with both feet onto the wind bandwagon. She’s an outdoors lover who never looks wind whipped or sunburned, quite a feat in Wyoming. She told me she’s made it one of her missions to teach her group’s members that wind power isn’t without its costs. She uses the sage grouse as an example. The bird, a little larger than a quail, has been in decline due to habitat fragmentation, much of it a result of energy development. If the grouse were to be placed on the endangered species list, so would be their sagebrush-dwelling companions, such as pronghorn antelope, ferruginous hawks, pygmy rabbits, and Wyoming pocket gophers.

“All of this is a dilemma for environmentalists,” Milford said.

We’ve been calling for decades for our country to develop renewable energy. Now that it is about to happen on a big scale, we cite sage grouse concerns, and threats to bats, raptors, and viewsheds as reasons to slow down. So which is it? Is commercial-scale wind development part of the answer to our power conundrum? Or are wind farms the new bane of Wyoming residents who are tired of giving up our landscapes and our wildlife to export energy elsewhere? In reality, of course, it doesn’t have to be an either/or proposition. We’re hopeful we can work toward increased energy efficiency as a country, encourage more renewable energy development in this state, and at the same time protect Wyoming’s natural resources.

Understanding the complexity of these competing positions is the job of Aaron Clark of the WIA. Wyoming creates much more energy, renewable and otherwise, than its population of just over half a million people could ever use, and much of it is exported elsewhere. Many in this state wonder why we are taking chances with our environment and coping with the upheaval in our communities by shouldering the burdens of energy production. Clark says there could be no meaningful shift from nonrenewable to renewable energy sources in this country without Wyoming. That's one reason the state has put in place strict regulations for permitting. As Clark notes, "We want to be responsive to the energy needs of others but not trash our state."

One person who knows a lot about the drive to develop wind is Grant Stumbough. An outdoorsman with a mustache and white cowboy hat, he is the area coordinator of the South-eastern Wyoming Development Council. Many developers have noticed that Wyoming has great untapped wind potential, much of it located in southeastern Wyoming, an area mostly already developed by ranches or small communities. Stumbough helps landowners understand the potential that developers are busily tapping into their calculators even as they drive through the gate.

"We have a tremendous wind resource here, and developers are recognizing that and knocking on doors," he said. "I was talking to some of these guys and they said, 'These guys are coming and we have no idea what our wind resources are worth.'" So Stumbough brought landowners together to consolidate parcels of land to make it more marketable to developers compared to negotiating with many individual property owners. The idea is to offer what developers want—wind power—and locate it in a place that is appropriate and acceptable to most parties.

To those who object to wind development, Stumbough points out that when ranchers have difficulties meeting payments on

loans or property taxes, they sometimes end up selling off parts of their property. And the buyers are often real estate developers who will sell the land in parcels for ranchettes of just a few acres. These ranchettes break up the undeveloped land with roads and fences, which disturb wildlife and are not aesthetically pleasing to people who appreciate Wyoming's open spaces. "Would you rather have wind farms or subdivisions?" he asked.

The developed land that Stumbough is concerned with in southeastern Wyoming sits on abundant wind resources on topography that is appropriate for wind development. It is near existing transmission towers and roads. It has appropriately gentle terrain with windy ridge crests. It isn't surrounded by sensitive environmental areas. Its existing functions, such as cattle ranching, can still be continued even under the shadows of wind turbines. But developing commercial wind farms on land owned by individuals is costly to power companies. Landowners must be paid for the use of their land, sometimes in a lump sum and other times in royalty payments, according to the *Commercial Wind Energy Development Resource Guide* produced by the University of Wyoming.

Wyoming's governor during much of this wind rush, Dave Freudenthal, organized a coalition of state leaders and interested citizens to make sure Wyoming develops its wind potential in a smart way. He has stood with one foot in the stirrup of two runaway horses, bringing together both pro- and anti-development people. During a symposium at the University of Wyoming, he recalled a period after the oil embargo of 1973, when Wyoming was poised as a key player in the national energy policy. Wyoming up to that time had mined only a modest amount of coal underground. Then technology arrived to make strip mining of Powder River coal economical. "Suddenly Wyoming was action central for development of coal," he said. Fast forward thirty years. "Now some people come into my office and say it'll be the end of the world if we develop

wind.” Other visitors to his office are developers who say that if the state isn’t “nicer” to them, they’ll pull out, he said.

Freudenthal tries to find a middle road between these pro- and antidevelopment positions, saying, “I don’t think we ought to be rushed. We’ll be at this for several years.” He stresses the importance in developing ground rules for development. Wind is the most highly subsidized form of energy production in the country, far larger than oil and gas, or coal, he said.

“We’re glad to host the turbines but we’re expecting the people who put them up to do a little more. It is not the case that we’re going to be happy being some colony with a bunch of towers sticking up in the air, and no jobs,” he said.

Even though the governor sees tremendous potential in wind development, he still must make its proponents play by the same rules that guide coal, gas, and oil. For example, they need to be sure their activities do not harm sage grouse. If they do, and the sage grouse becomes listed as endangered, Wyoming’s economy and way of life would be seriously disrupted. This was an issue also raised by Molvar and Milford in their descriptions of environmental concerns.

The governor’s office says if the sage grouse were to be listed, nearly 80 percent of coal production would be subject to additional reviews; 83 percent of natural gas production, 64 percent of gas production, and almost 40 percent of activity on private land would be reviewed as well. Some folks would see this slowdown of development as a very good thing, indeed. But it also means that if a rancher wanted to move his cattle from one pasture to another, a federal wildlife manager would have to be called in to search for sage grouse breeding areas before the rancher could continue. That would mean delays in even the most mundane of daily ranch operations.

Freudenthal concurs with Mike Schmidt, Laurie Milford, and others that the entire wind conversation in Wyoming would be moot without determining how to transmit the power to the power plants in the right way. The most

pro-economic-development people in the state suddenly acquire a bad case of not in my backyard—or NIMBYism—when faced with the prospect of wind farms and transmission towers on their own turf, he said. As a result of these discussions, in 2011 Wyoming passed the Wind Energy Rights Act, which codifies regulations, tax structures, and procedures for developers and landowners interested in hosting wind farms.

It was in the early period of wind development in Wyoming that I took my tour of the Foote Creek Rim facility. On the day Tony Kupilik and I stepped out of the Dodge truck, we stood in a relatively modest breeze at the top of the rim. We gazed out across the wide open basin, our eyes following the power transmission lines to the northwest. We could almost make out the closed coal mines at Hanna, along with the tiny towns of Rock River and Medicine Bow. The ground under our feet was pricked with early June wild flowers, and the first of the Indian paintbrush poked up their red heads to welcome the buzzing bees. A moment later we spotted, literally in the shadow of a spinning wind turbine, an hours-old pronghorn antelope that lay so still I first took the small gray form for a rock. We'd seen a doe antelope trot off a few moments before so we took a few cautious steps for a closer look. She stood staring at us from about one hundred yards away, keeping watch over the scene. The little fawn never moved a muscle nor blinked one of its prominent eyes while we whispered and snapped pictures. We had no doubt the doe would return as soon as we drove off.

Kupilik is a booster of wind energy but doesn't believe it will answer all our nation's energy problems. "Is wind the solution?" he asked rhetorically. "Probably not. Is it part of the solution? Probably so." One problem he sees is the large footprint of a wind farm. He explained that a coal-burning power plant would take up far less space than this facility. The footprint could be smaller if there were taller towers, but then other problems both environmental and aesthetic would need

to be solved. He thinks nuclear power is the way the country will need to go.

Eventually Kupilik and I meandered back to the truck, both of us stopping to photograph wildflowers and barely noticing the low swooshing hum of the wind turbines. I took pictures of wind turbines but not of the sensitive cultural artifacts that Kupilik asked me to avoid. We discussed the various types of wind turbines and chatted about “pitch” and “yaw” as he explained the fine points of variable-pitch versus fixed-pitch turbines. Before climbing back in the truck I asked if he ever felt like throwing a tent in its bed and making camp up here some nights. “Yes,” he replied. “Really?” I asked? “Yes,” he said again. I wasn’t sure if he meant yes he thought about it or yes he did it. We both knew he is lucky to find himself working in a place he so treasures as an outdoorsman. “It makes you think you had it planned all along, the way things work out.”